

## Annexe X

### Distributions de contrôle – $H \rightarrow \tau\tau$

Cette annexe présente des distributions de contrôle avant ajustement des paramètres de nuisance sur les événements utilisés dans l'analyse des événements  $H \rightarrow \tau\tau$  présentée dans le chapitre 4. La sélection est « inclusive », les événements sont ceux sélectionnés par la définition de la région de signal, sans coupure sur  $m_T^\ell$  (canaux  $\mu\tau_h, e\tau_h$ ) ni  $D_\zeta$  (canal  $e\mu$ ).

Pour chacune des trois années de prise de données (2016, 2017, 2018) et chacun des quatre canaux ( $\tau_h\tau_h, \mu\tau_h, e\tau_h, e\mu$ ), les distributions de plusieurs variables sont données.

Dans chacun des graphiques, les données observées (points noirs) sont comparées à la modélisation des bruits de fond (histogrammes remplis en couleur et empilés). Les bandes grisées correspondent à l'incertitude statistique totale sur le bruit de fond. Le rapport au bruit de fond est donné dans la partie inférieure des graphiques.

Ces distributions montrent un bon accord entre données observées et estimations des bruits de fond, à l'exception :

- des pseudo-rapidités des  $\tau_h$ ,  $\eta(\tau_h)$ ;
- du nombre de vertex d'empilement  $N_{PU}$ .

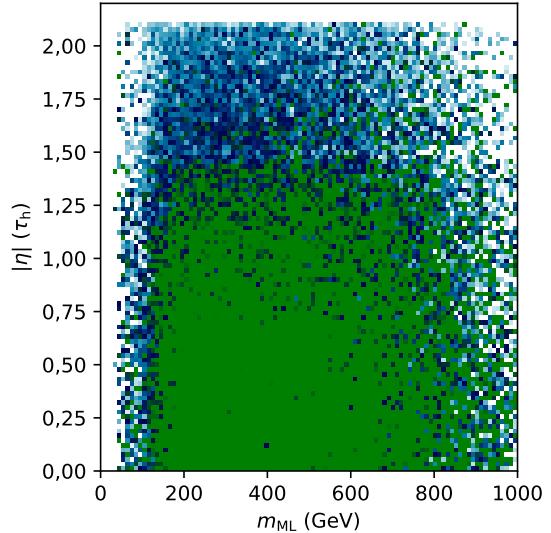
**Pseudo-rapidités des  $\tau_h$**  L'écart observé pourrait être réduit en utilisant des facteurs de faux dépendants de  $\eta(\tau_h)$ , ce qui n'est pas le cas actuellement. D'autres variables dépendant directement de la pseudo-rapidité d'un  $\tau_h$  telles que la distance  $\Delta R$  entre les deux éléments du dilepton montrent également des écarts entre données observées et estimation des bruits de fond, potentiellement dus à ceux sur  $\eta(\tau_h)$ .

L'écart sur  $\eta(\tau_h)$  pourrait avoir un effet sur  $m_T^{\text{tot}}$ , cette dernière étant fonction d'impulsions transverses et d'angles azimutaux, car la projection des impulsions dans le plan transverse,

$$p_T = \frac{p}{\cosh \eta}, \quad (\text{X.1})$$

fait intervenir  $\eta(\tau_h)$ . Cependant, les modélisations des impulsions transverses et des angles azimutaux sont satisfaisantes. Les valeurs de  $m_T^{\text{tot}}$  ne sont donc pas affectées par la mauvaise modélisation de  $\eta(\tau_h)$ .

Le réseau de neurones B" utilisé afin d'obtenir  $m_{ML}$ , présenté au chapitre 5, exploite les valeurs de  $\eta(\tau_h)$ . La figure X.1 montre la distribution de  $|\eta|(\tau_h)$  en fonction de  $m_{ML}$ . Bien que les hautes valeurs de  $|\eta|(\tau_h)$  soient moins représentées à haute  $m_{ML}$ , ce qui peut s'expliquer par l'effet de la projection mentionnée précédemment, aucune corrélation n'apparaît entre  $|\eta|(\tau_h)$  et  $m_{ML}$ . Les valeurs de  $m_{ML}$  ne semblent donc pas affectées par la mauvaise modélisation de  $\eta(\tau_h)$ .



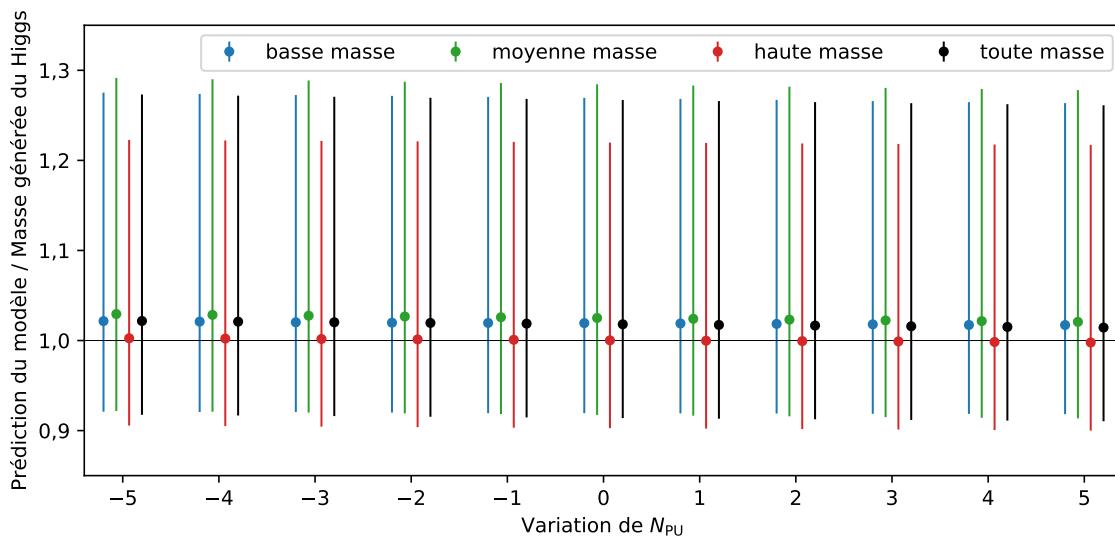
**Figure X.1** – Distribution de  $|\eta|(\tau_h)$  en fonction de  $m_{ML}$ .

**Nombre de vertex d'empilement** L'effet de la mauvaise modélisation de  $N_{PU}$  constatée dans les distributions de contrôle devrait être marginal sur  $m_T^{\text{tot}}$ , car cette observable ne dépend pas de  $N_{PU}$ . Les autres sources d'incertitudes sur  $m_T^{\text{tot}}$  permettent alors de couvrir cet effet.

Les valeurs de  $m_{ML}$ , c'est-à-dire des prédictions du réseau de neurones présenté au chapitre 5, dépendent de  $N_{PU}$ . Les bons accords entre observations et estimations des bruits de fond obtenus sur les distributions de  $m_{ML}$  montrent que cette observable semble peu affectée par la mauvaise modélisation de  $N_{PU}$ . La figure X.2 confirme cette hypothèse. Elle représente l'évolution de la réponse du réseau de neurones, à basse, moyenne et haute masse ainsi que sur toute la gamme de masse, ces ensembles étant définis au chapitre 5, lorsque les valeurs de  $N_{PU}$  sont modifiées selon

$$N_{PU} \rightarrow N_{PU} + \Delta N_{PU} \quad (\text{X.2})$$

avec  $\Delta N_{PU}$  compris entre  $-5$  et  $+5$ . Les modifications induites sur la réponse du réseau de neurones sont inférieures à  $1\%$  alors que sa résolution relative est de l'ordre de  $20\%$ .



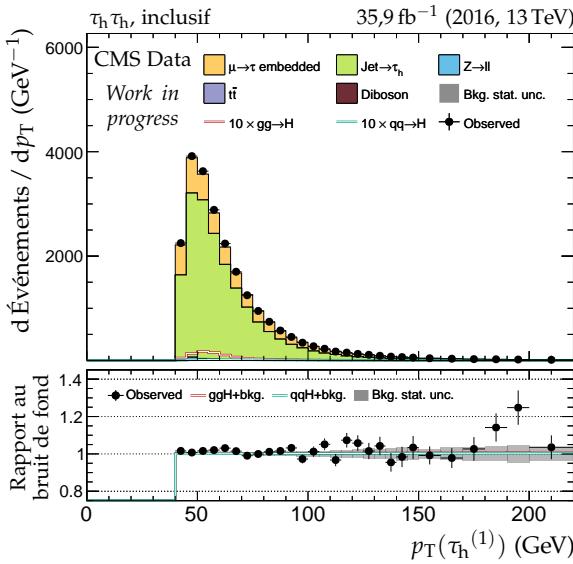
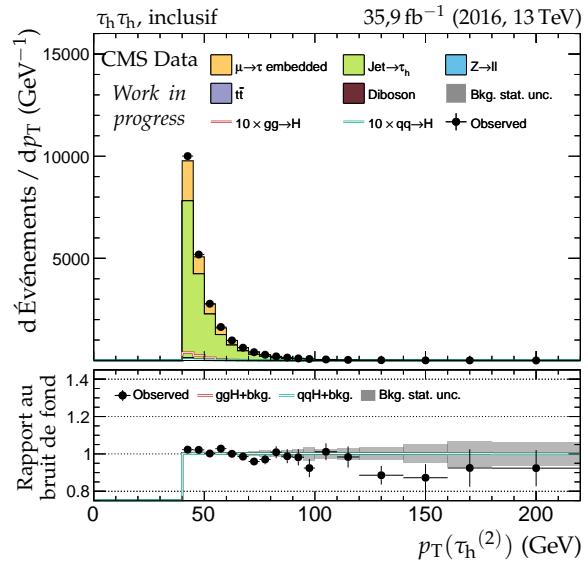
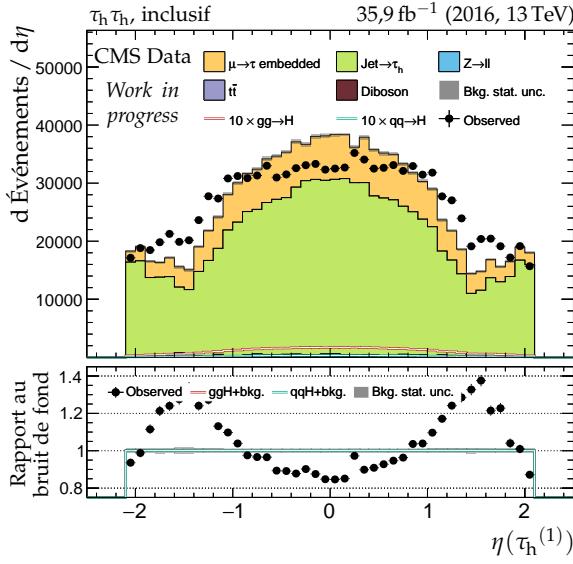
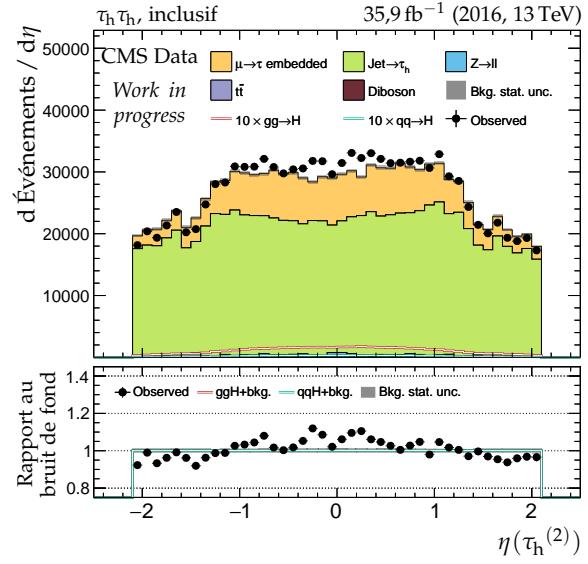
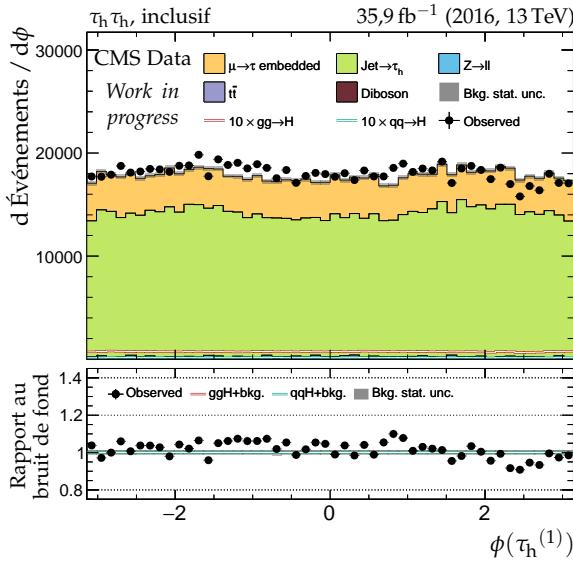
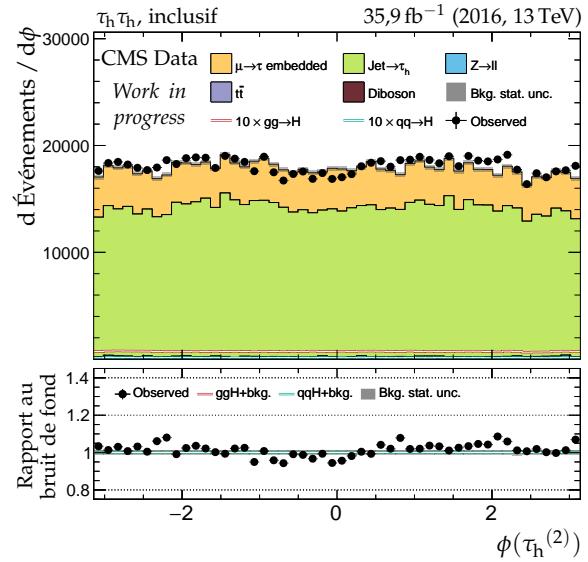
**Figure X.2** – Variations de la réponse du réseau de neurones en fonction de  $\Delta N_{PU}$  à basse, moyenne et haute masse ainsi que sur toute la gamme de masse. La résolution à  $\pm 1\sigma$  est renseignée par les barres verticales.

Ainsi, l'effet limité de  $N_{PU}$  sur les variables discriminantes utilisées permet de conserver des résultats finaux pertinents bien que l'écart sur  $N_{PU}$  entre observations et estimations des bruits de fond puisse être de l'ordre de  $40\%$ . Plusieurs effets peuvent causer cet écart sur  $N_{PU}$  :

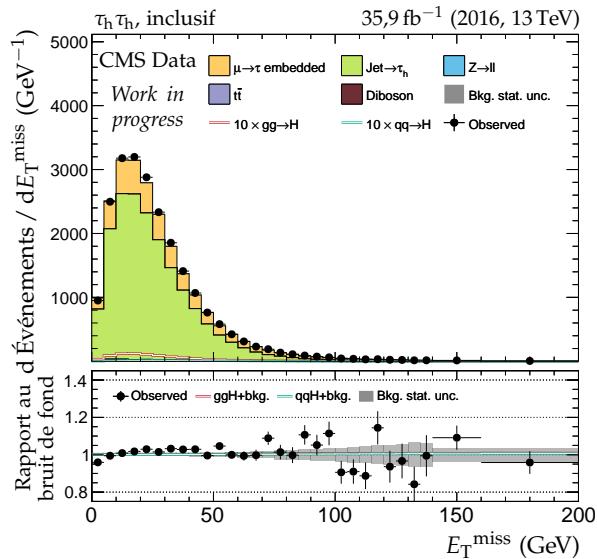
**Modélisation des chemins de déclenchement dans les données encapsulées** Les données encapsulées, introduites dans le chapitre 4, sont des hybrides entre données réelles et simulées. Les chemins de déclenchement activés proviennent de la partie simulée uniquement, c'est-à-dire d'un événement vide à l'exception des leptons  $\tau$  qui remplacent les muons. Or, l'empilement provient de la partie réelle des données encapsulées et l'acceptation des chemins de déclenchement en dépend. Actuellement, des facteurs correctifs sont appliqués en fonction des propriétés cinématiques des  $\tau$  mais ils ne dépendent pas de  $N_{PU}$ . Ainsi, les distributions de  $N_{PU}$  peuvent être biaisées dans les données encapsulées.

**Dépendance en  $N_{PU}$  de l'identification des  $\tau_h$**  L'identification d'un  $\tau_h$  dépend de son isolation, elle-même sensible à l'empilement. Différents points de fonctionnement d'identification des  $\tau_h$  sont utilisés dans le cadre des facteurs de faux, introduits au chapitre 4. Ces derniers ne sont pas déterminés en fonction de  $N_{PU}$ , ce qui peut introduire un biais.

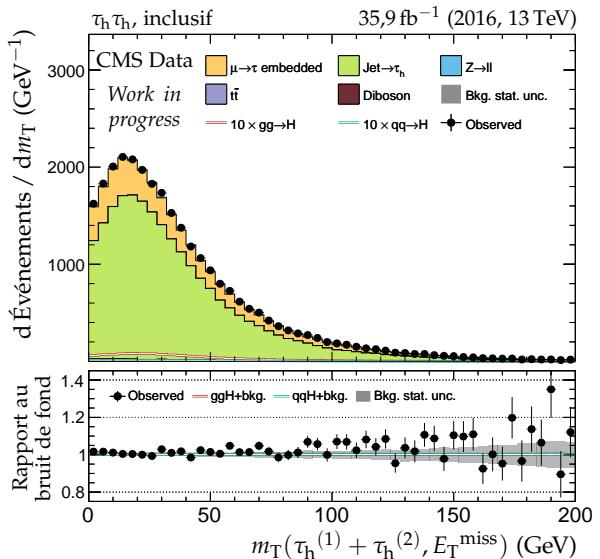
**Modélisation de  $N_{PU}$  dans les données simulées** Un désaccord sur  $N_{PU}$  est bien attendu entre données réelles et simulées et ces dernières sont pondérées afin de le corriger, comme exposé au chapitre 2. Toutefois, cette pondération ne permet pas d'obtenir un accord parfait.

(a) Impulsion transverse du lepton 1 ( $\tau_h^{(1)}$ ).(b) Impulsion transverse du lepton 2 ( $\tau_h^{(2)}$ ).(c) Pseudo-rapidité du lepton 1 ( $\tau_h^{(1)}$ ).(d) Pseudo-rapidité du lepton 2 ( $\tau_h^{(2)}$ ).(e) Angle azimutal du lepton 1 ( $\tau_h^{(1)}$ ).(f) Angle azimutal du lepton 2 ( $\tau_h^{(2)}$ ).**Figure X.3 – Canal  $\tau_h\tau_h$ , 2016 : cinématique des leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).**

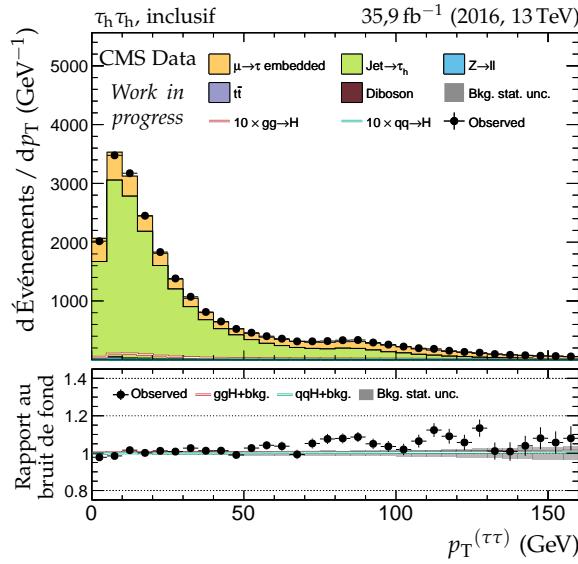
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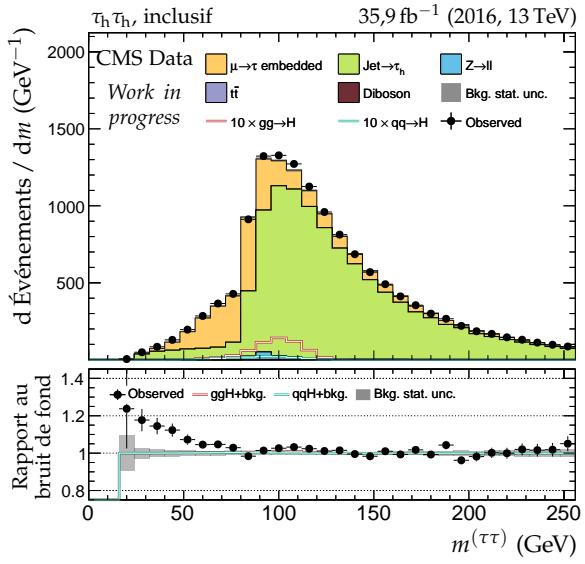
(a) Énergie transverse manquante.



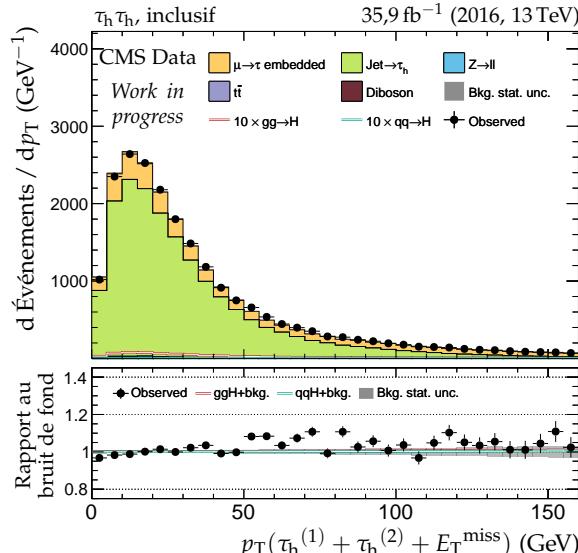
(b) Masse transverse du dilepton.



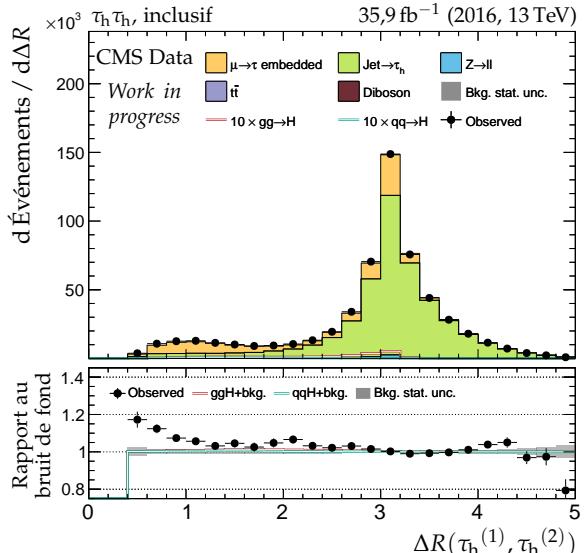
(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

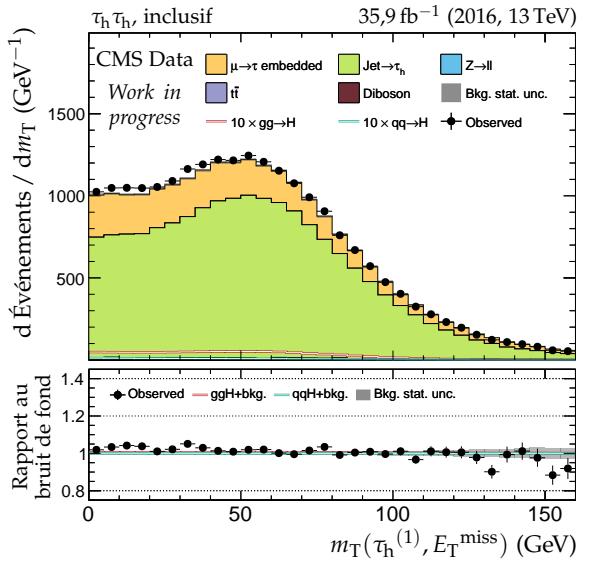
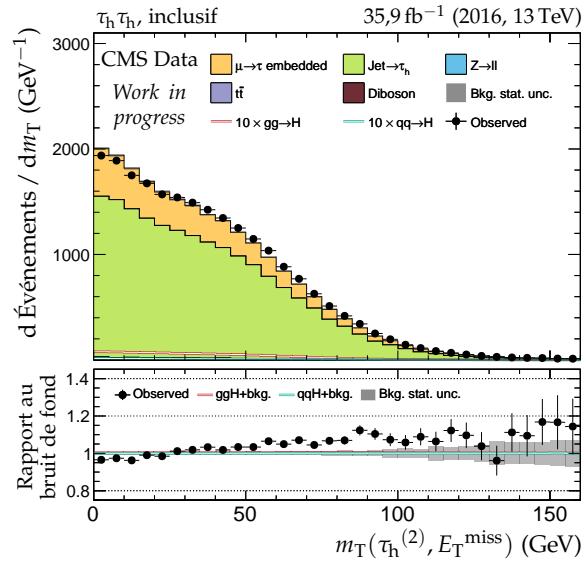
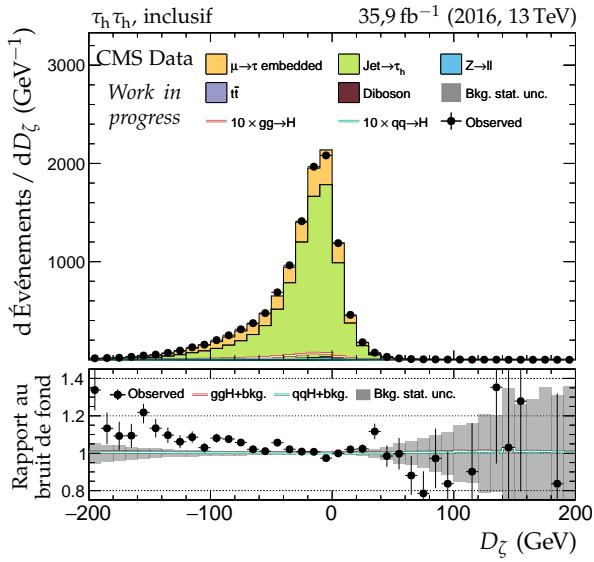
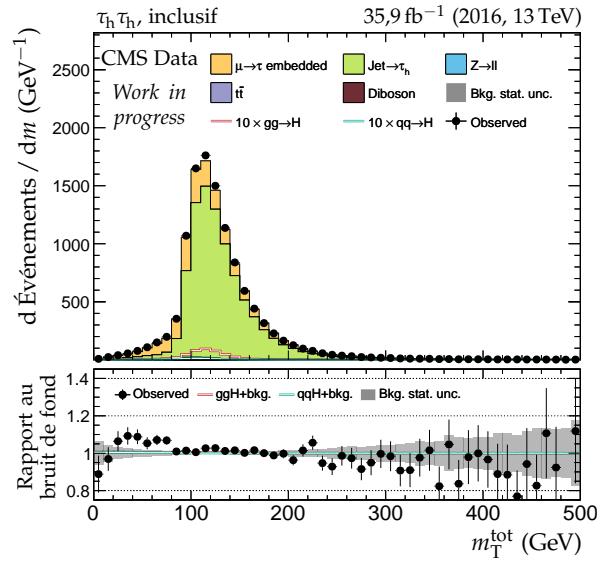


(e) Impulsion transverse du système di- $\tau$ .

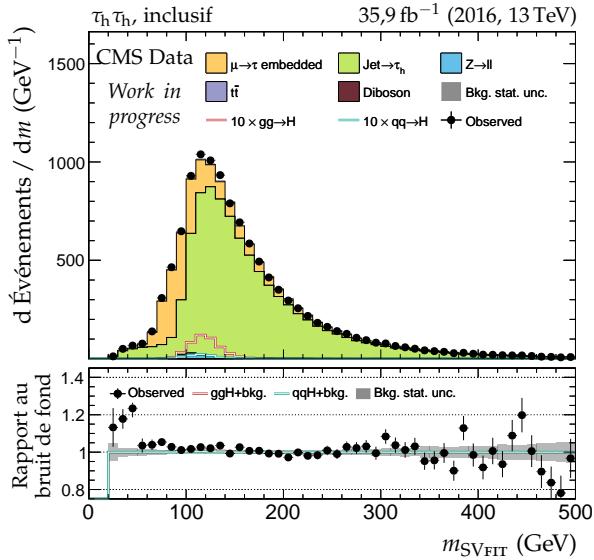
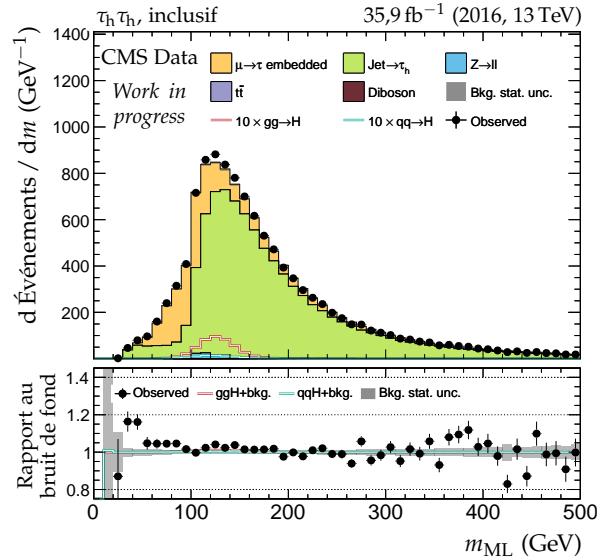


(f) Distance  $\Delta R$  entre les leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).

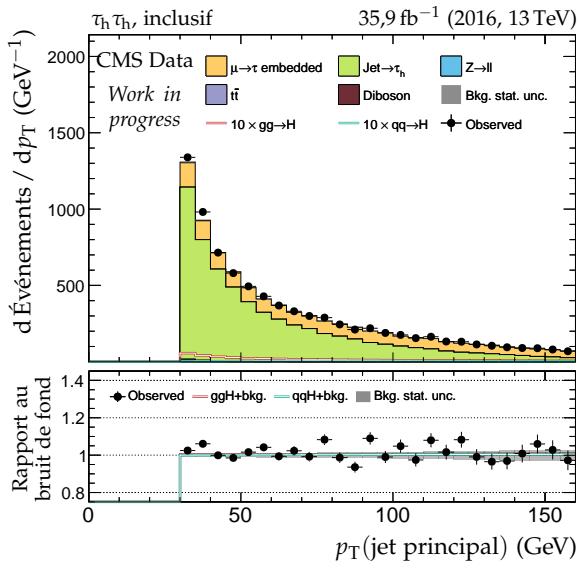
Figure X.4 – Canal  $\tau_h \tau_h$ , 2016 : dilepton et énergie transverse manquante.

(a) Masse transverse du lepton 1 ( $\tau_h^{(1)}$ ).(b) Masse transverse du lepton 2 ( $\tau_h^{(2)}$ ).(c) Valeur de  $D_\zeta$ .

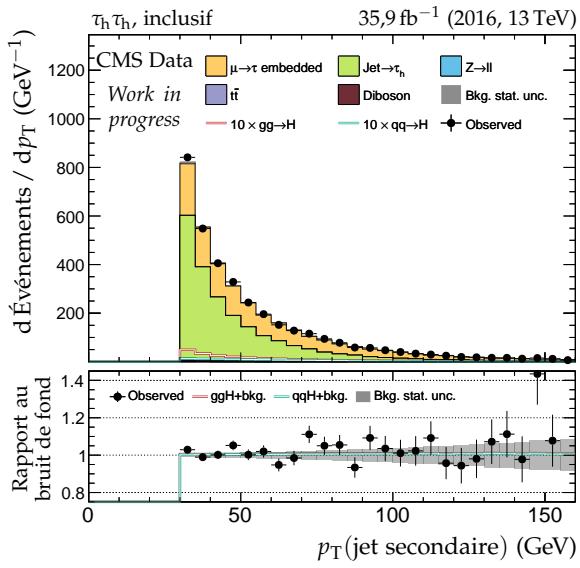
(d) Masse transverse totale.

(e) Masse du système di- $\tau$  d'après SVFIT.(f) Masse du système di- $\tau$  d'après le ML.**Figure X.5 – Canal  $\tau_h\tau_h$ , 2016 : masses transverses,  $D_\zeta$  et masses.**

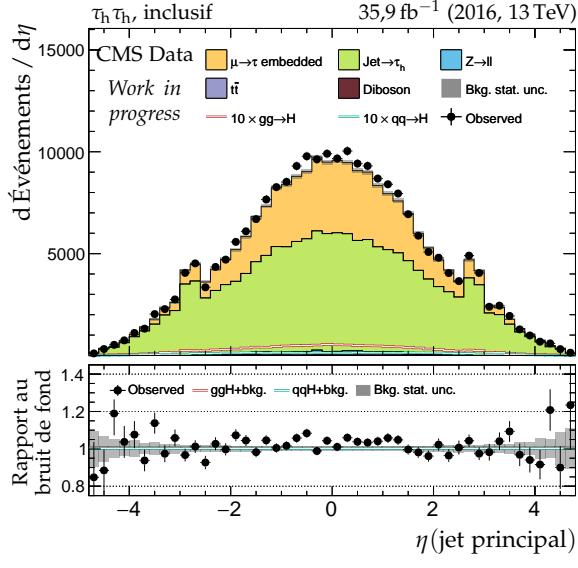
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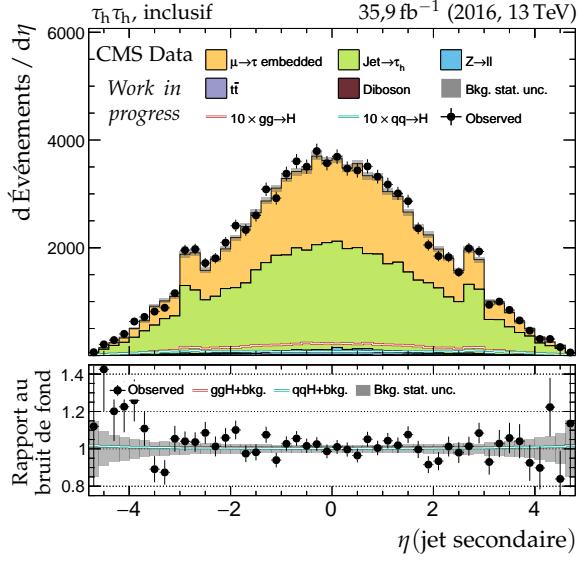
(a) Impulsion transverse du jet principal.



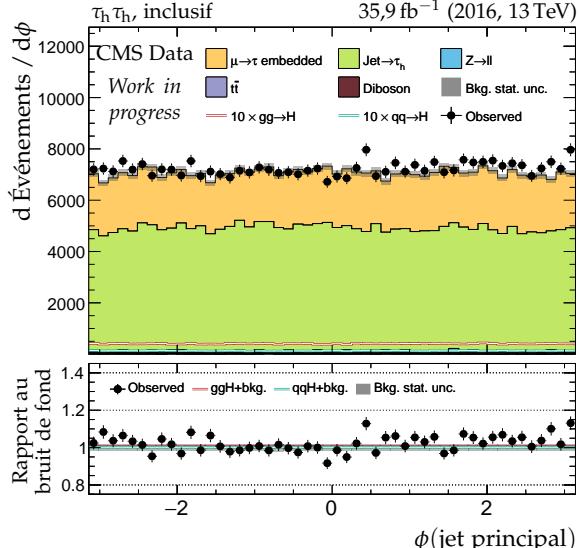
(b) Impulsion transverse du jet secondaire.



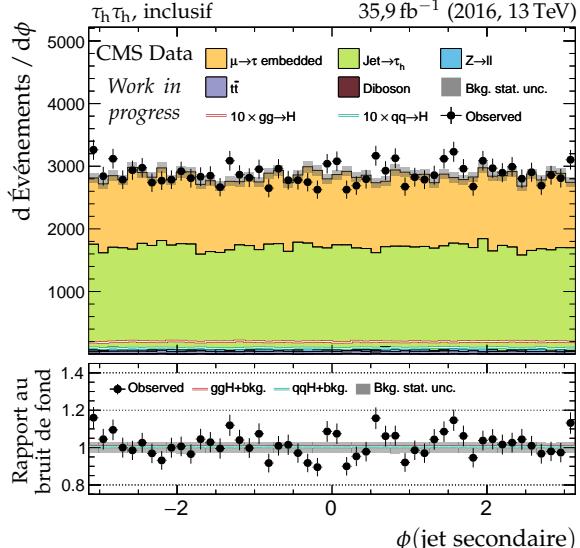
(c) Pseudo-rapidité du jet principal.



(d) Pseudo-rapidité du jet secondaire.

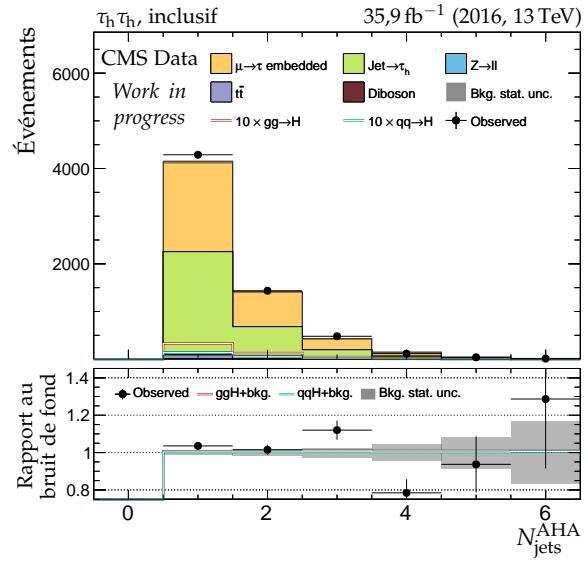
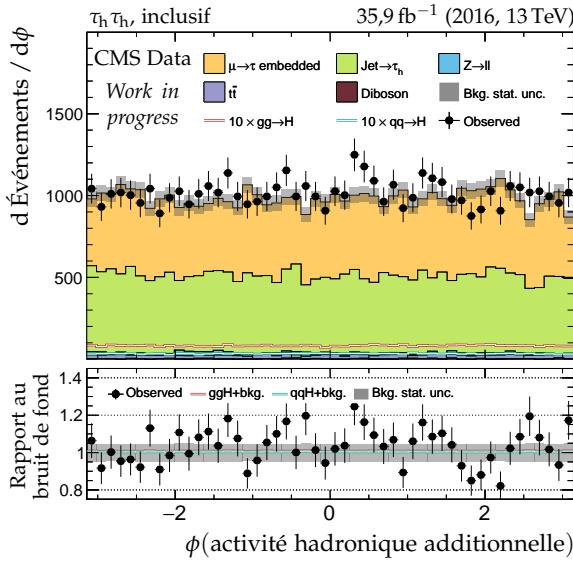
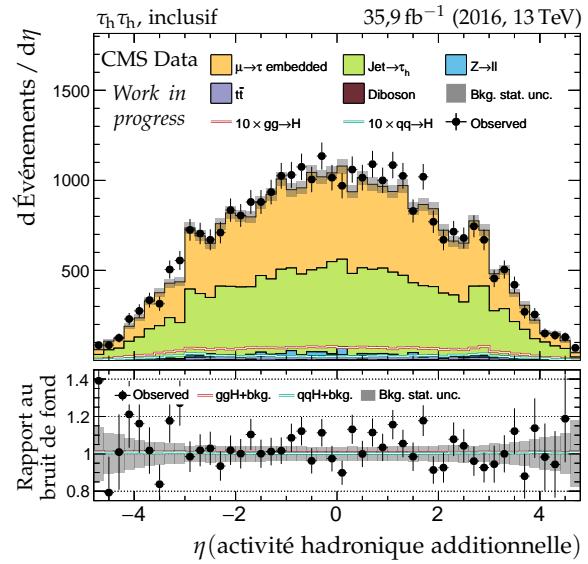
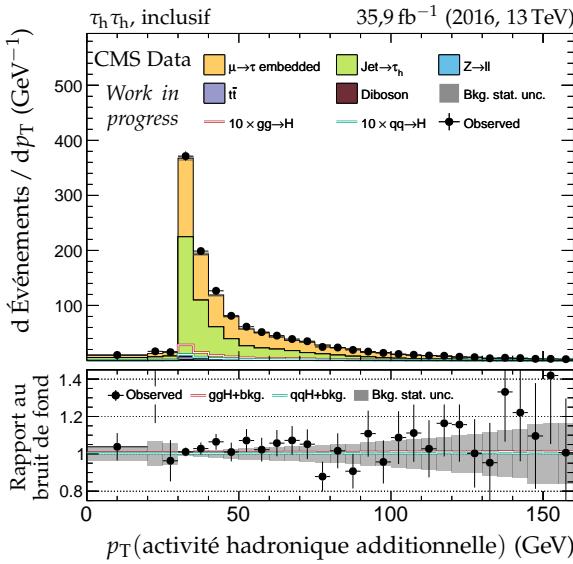
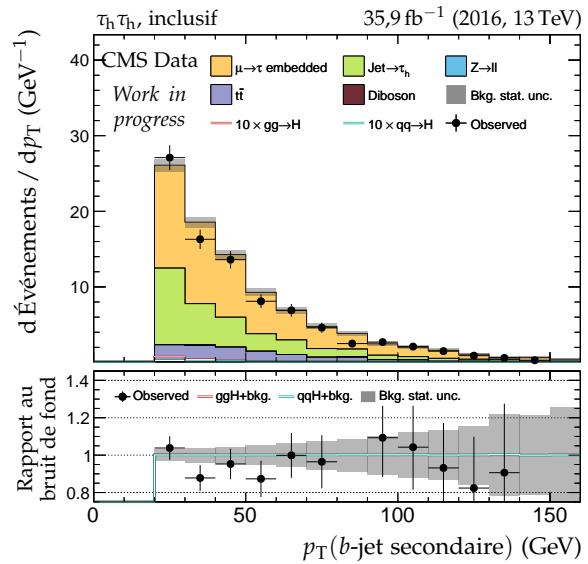
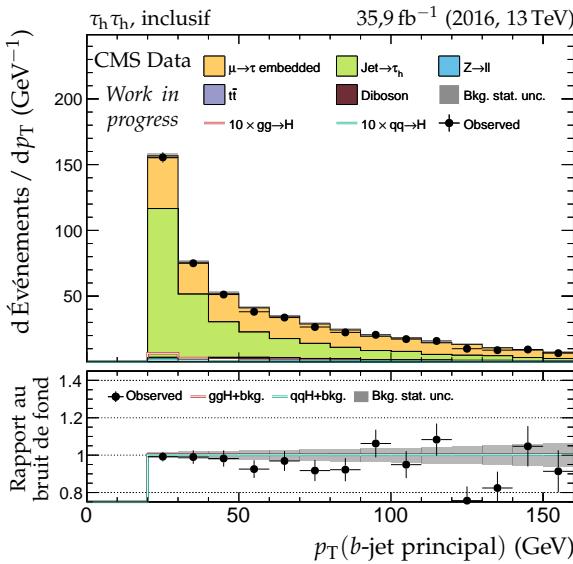


(e) Angle azimutal du jet principal.



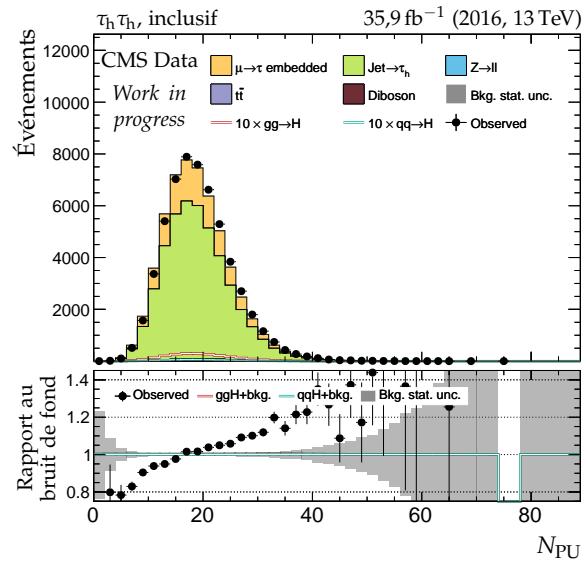
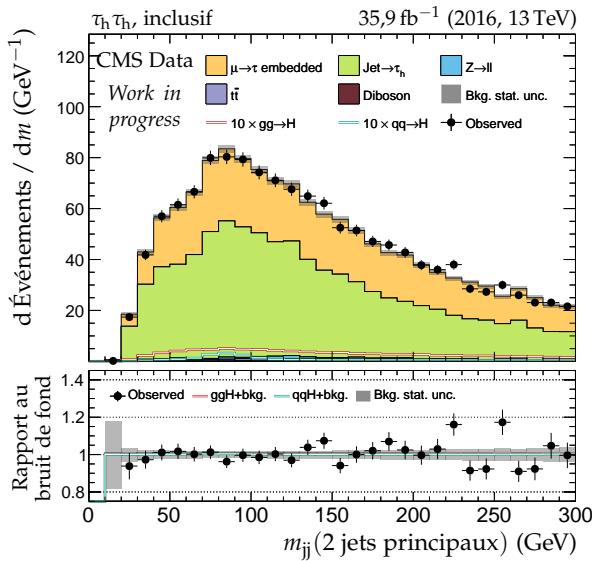
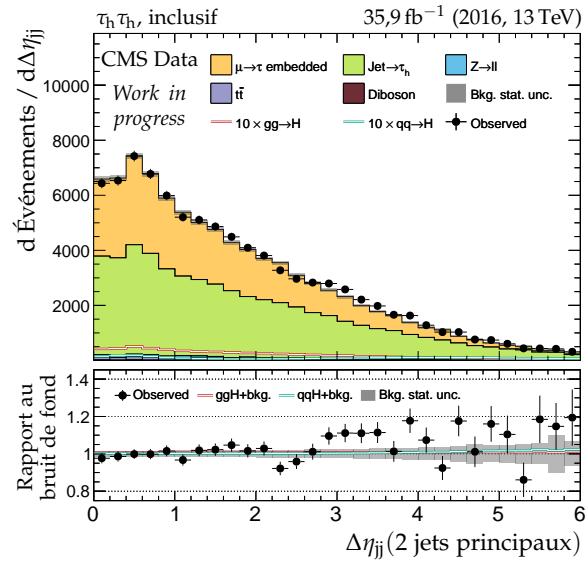
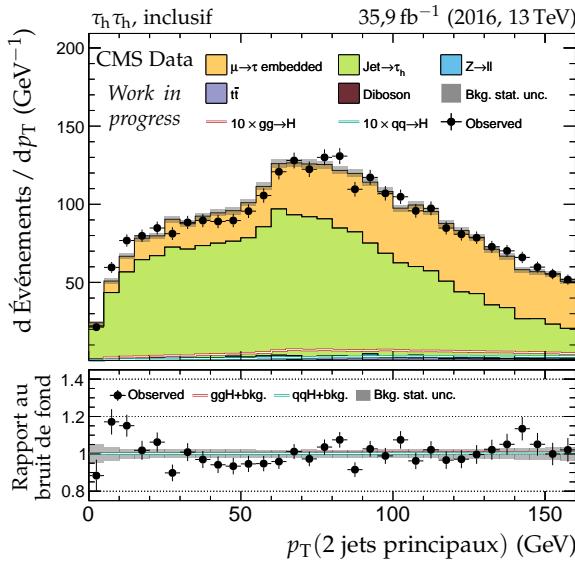
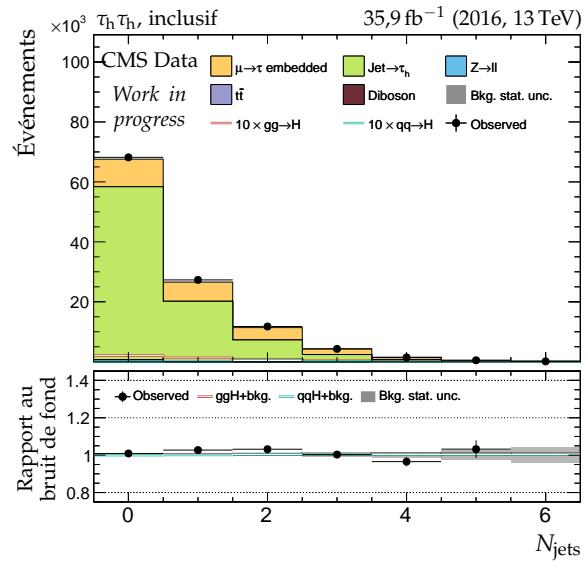
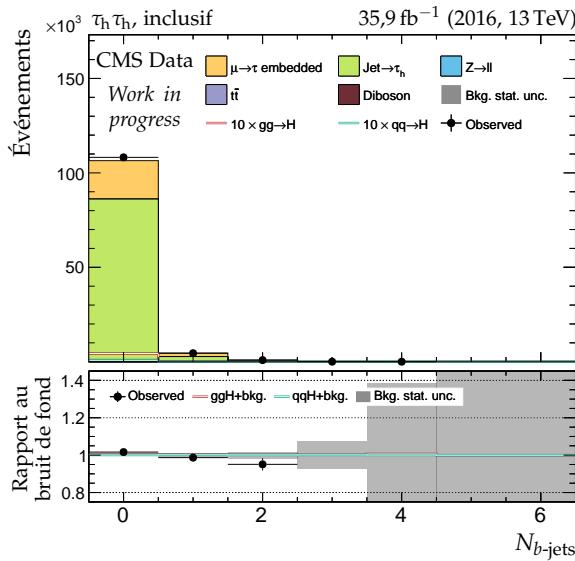
(f) Angle azimutal du jet secondaire.

Figure X.6 – Canal  $\tau_h \tau_h$ , 2016 : cinématique des deux jets principaux.

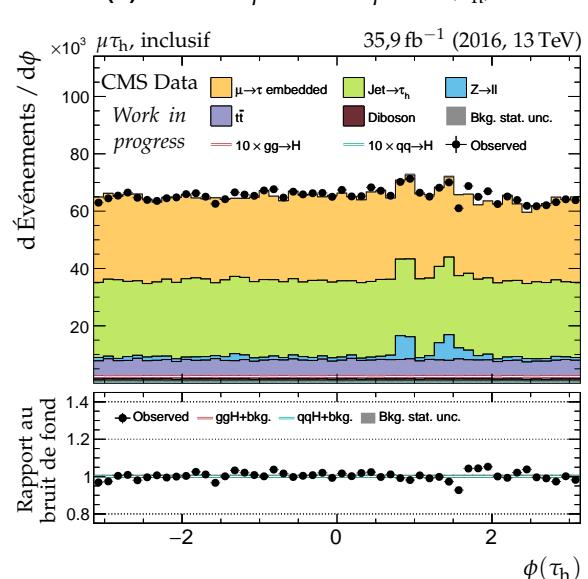
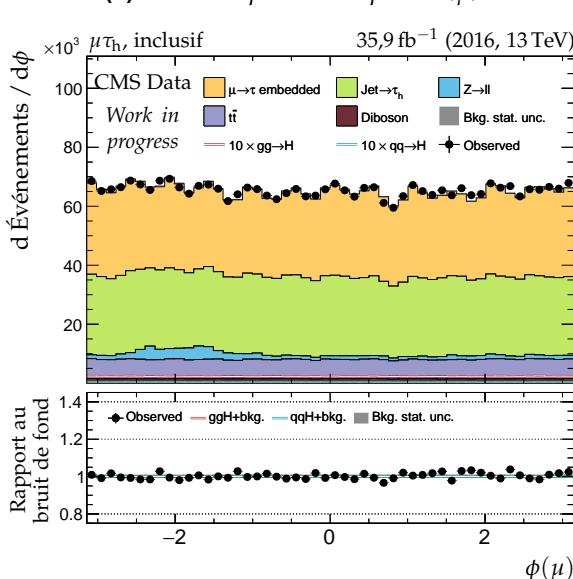
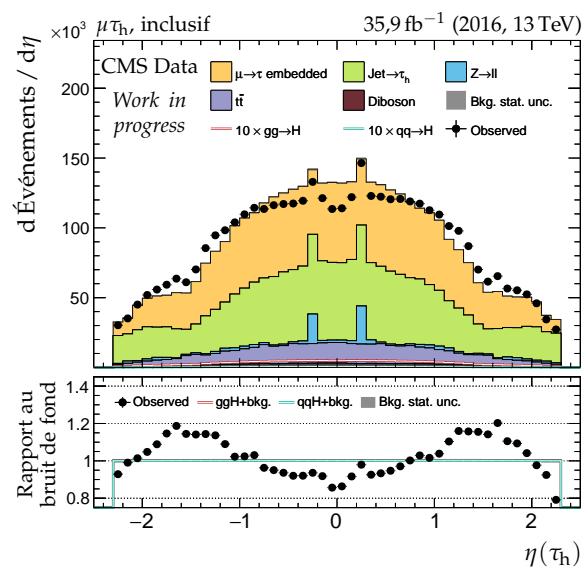
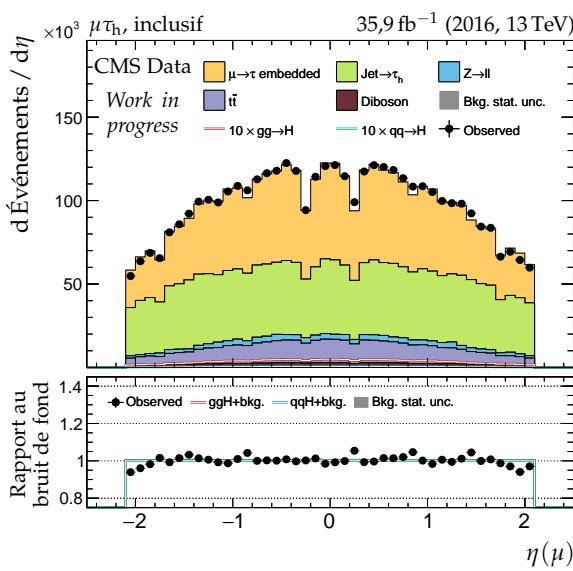
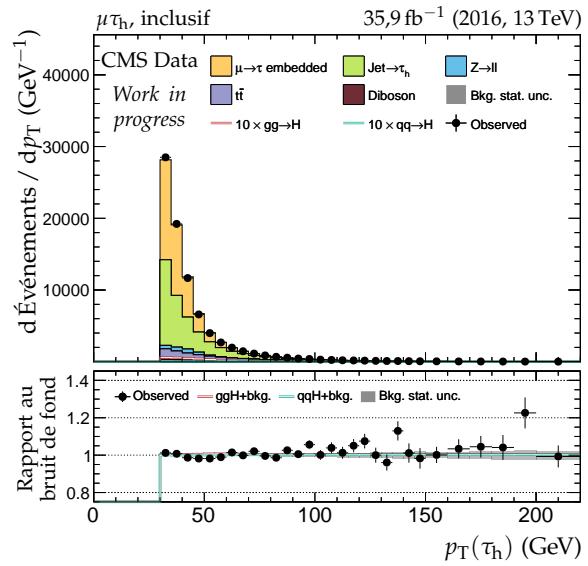
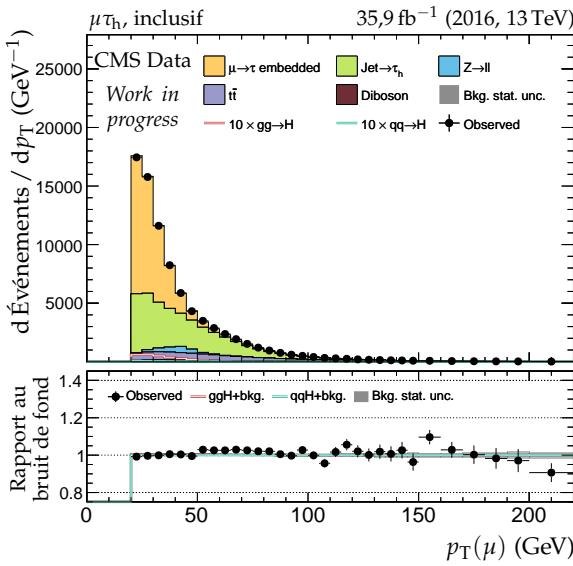


**Figure X.7 – Canal  $\tau_h \tau_h$ , 2016 : b-jets et activité hadronique additionnelle.**

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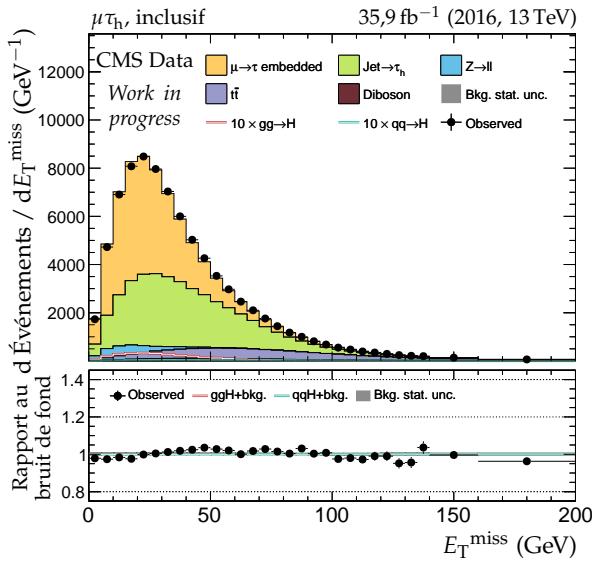


**Figure X.8 – Canal  $\tau_h \tau_h$ , 2016 : nombre de jets, système des deux jets principaux et empilement.**

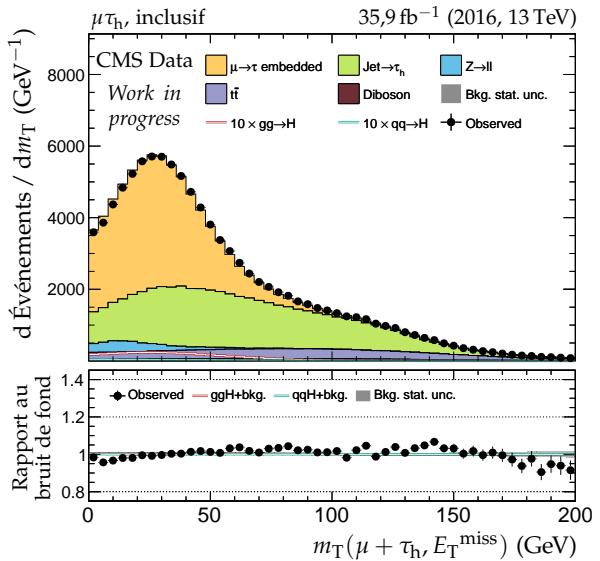


**Figure X.9 – Canal  $\mu\tau_h$ , 2016 : cinématique des leptons ( $\mu, \tau_h$ ).**

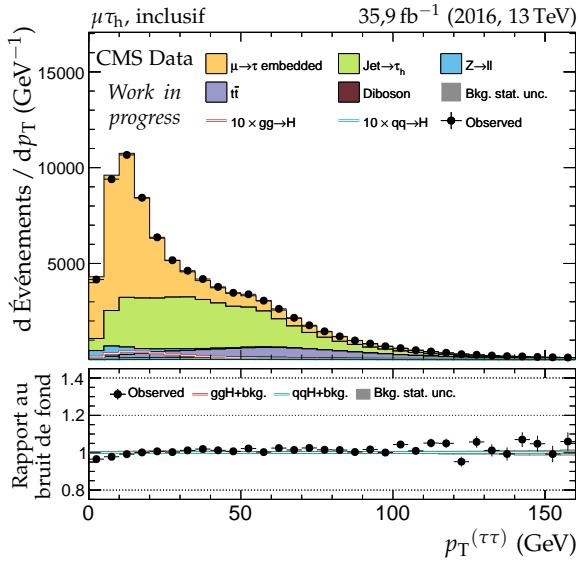
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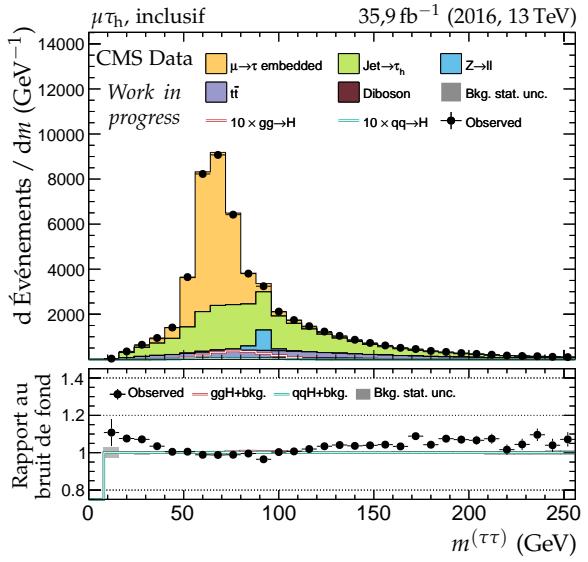
(a) Énergie transverse manquante.



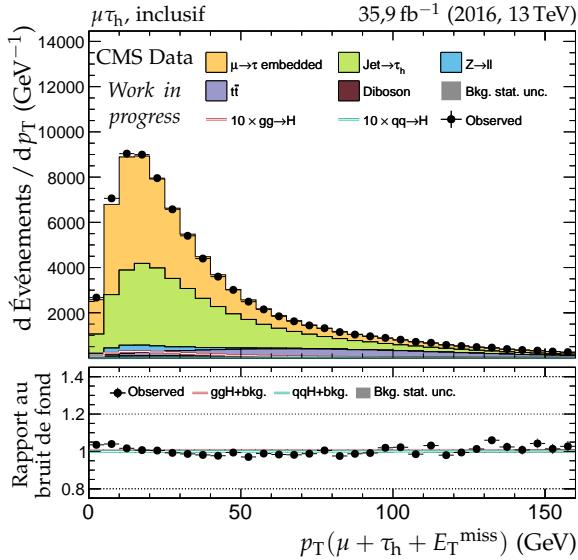
(b) Masse transverse du dilepton.



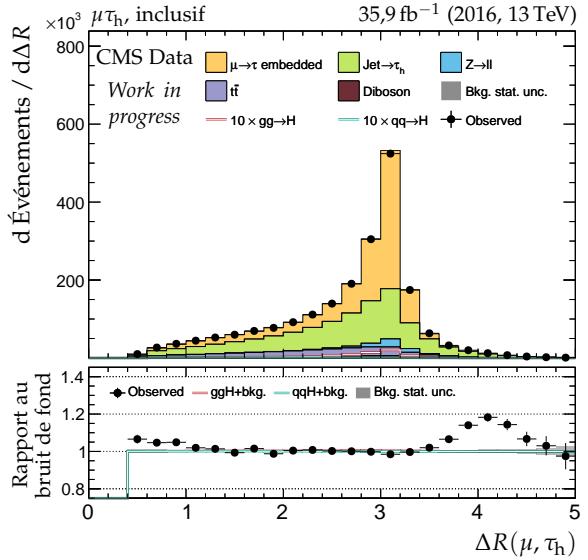
(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

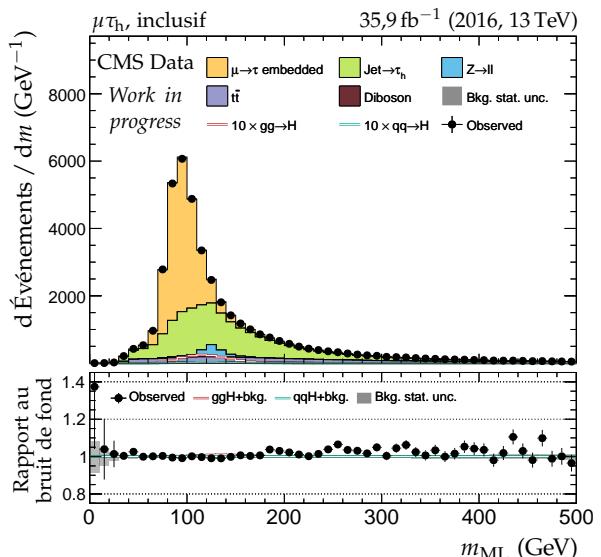
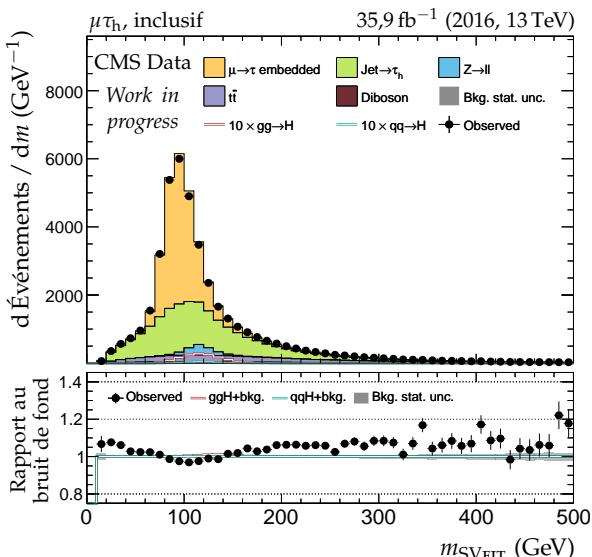
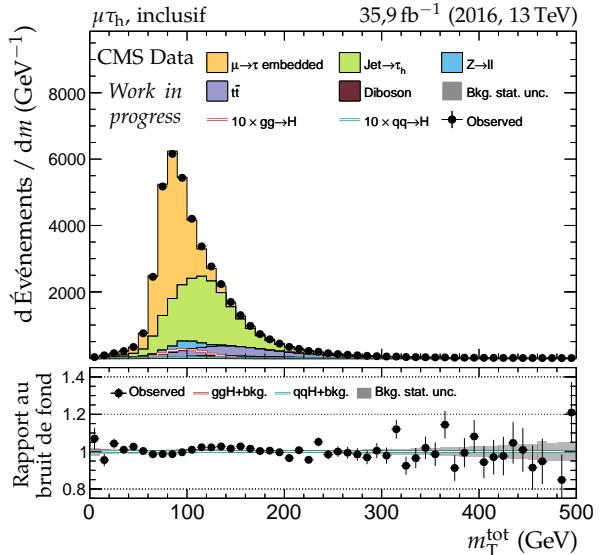
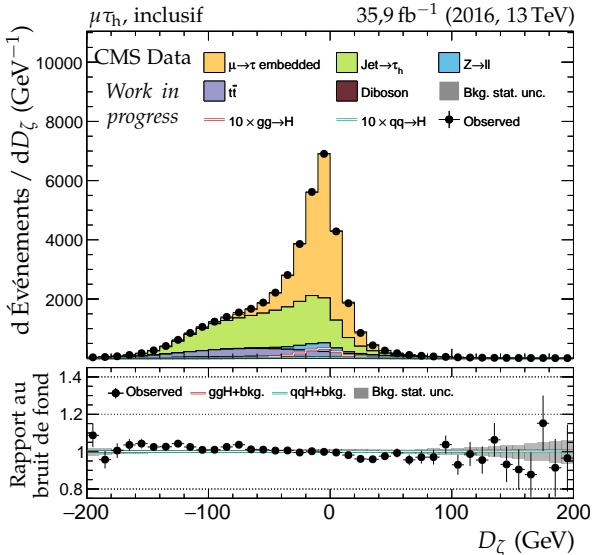
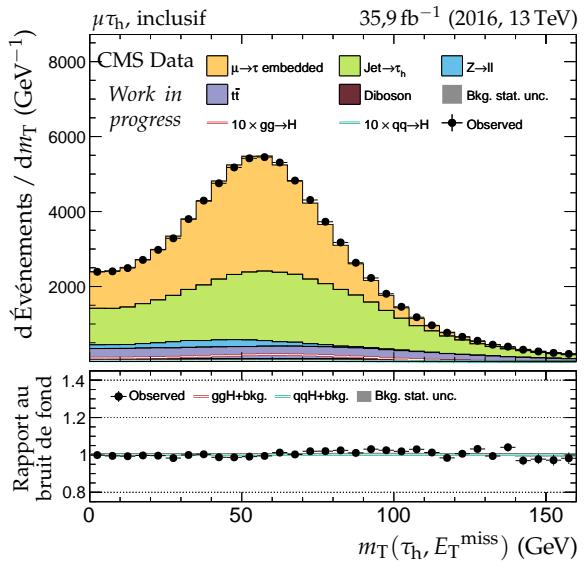
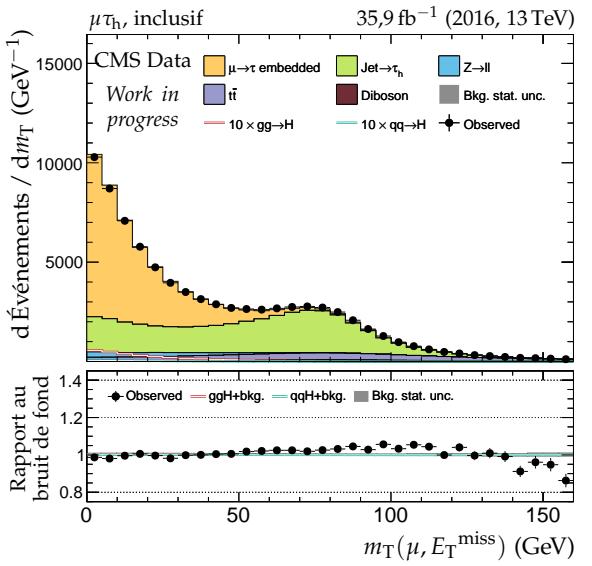


(e) Impulsion transverse du système di- $\tau$ .

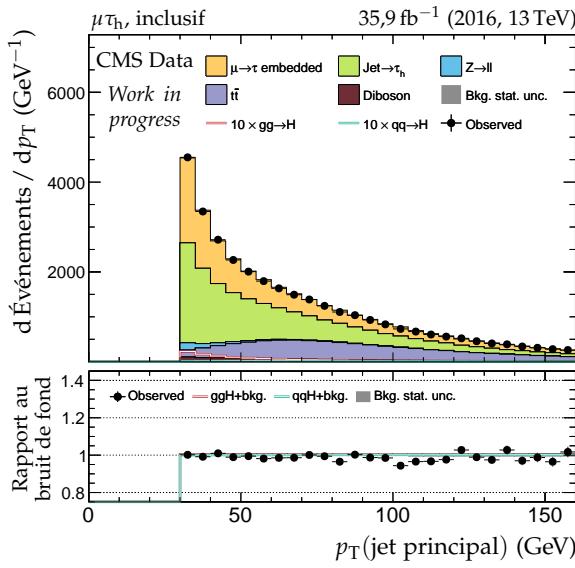


(f) Distance  $\Delta R$  entre les leptons ( $\mu, \tau_h$ ).

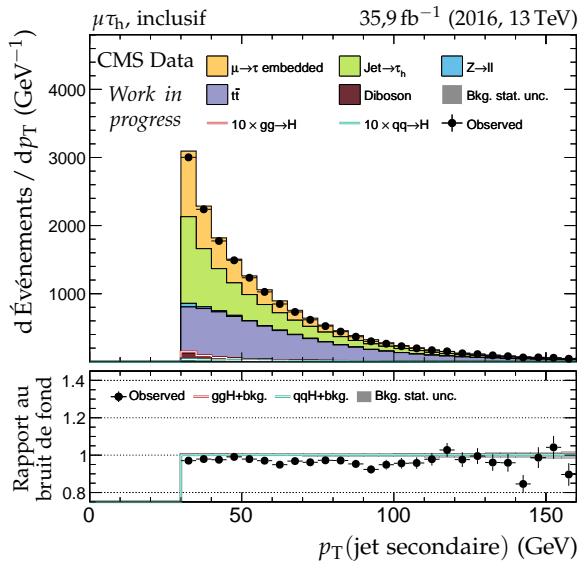
Figure X.10 – Canal  $\mu\tau_h$ , 2016 : dilepton et énergie transverse manquante.



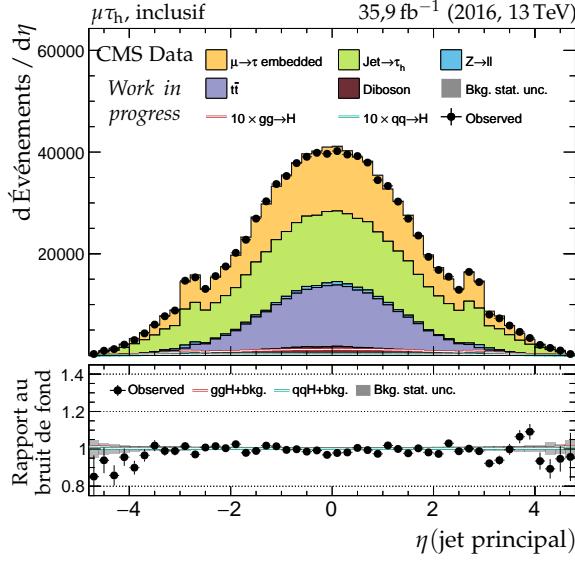
**Figure X.11 – Canal  $\mu\tau_h$ , 2016 : masses transverses,  $D_\zeta$  et masses.**



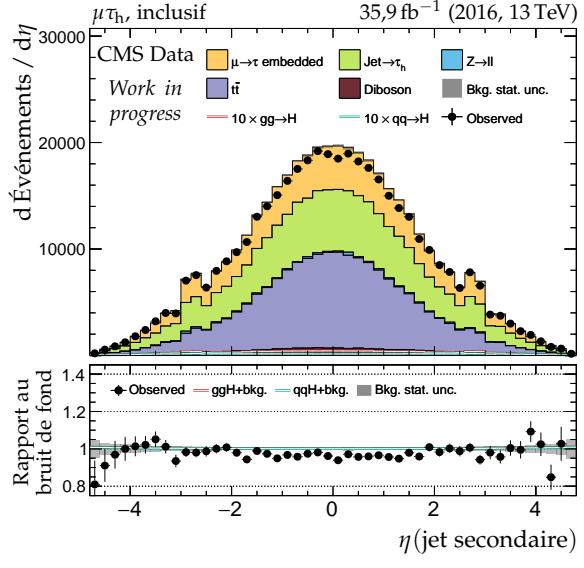
(a) Impulsion transverse du jet principal.



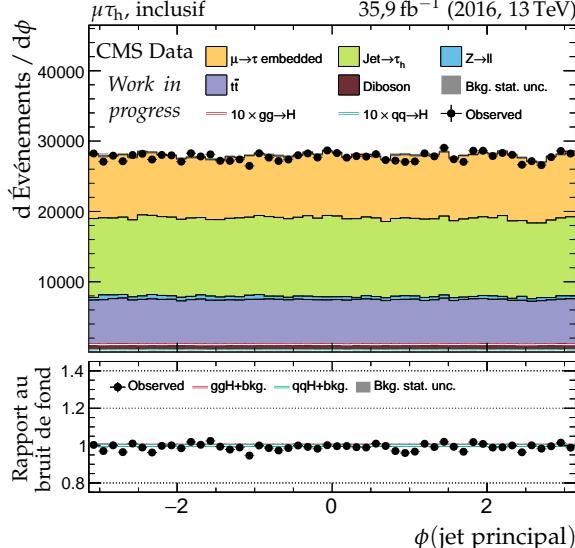
(b) Impulsion transverse du jet secondaire.



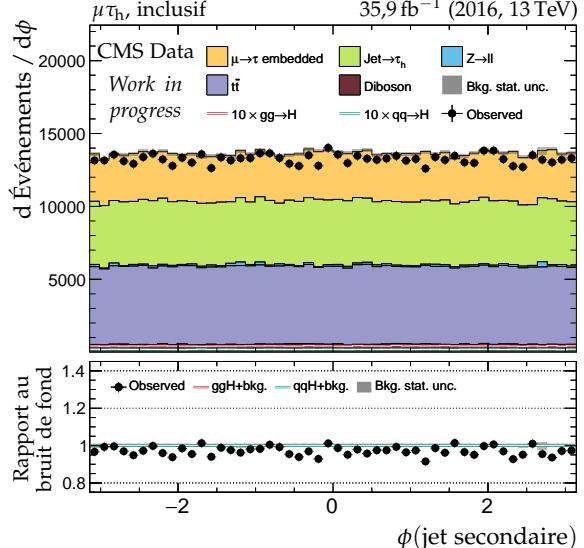
(c) Pseudo-rapidité du jet principal.



(d) Pseudo-rapidité du jet secondaire.

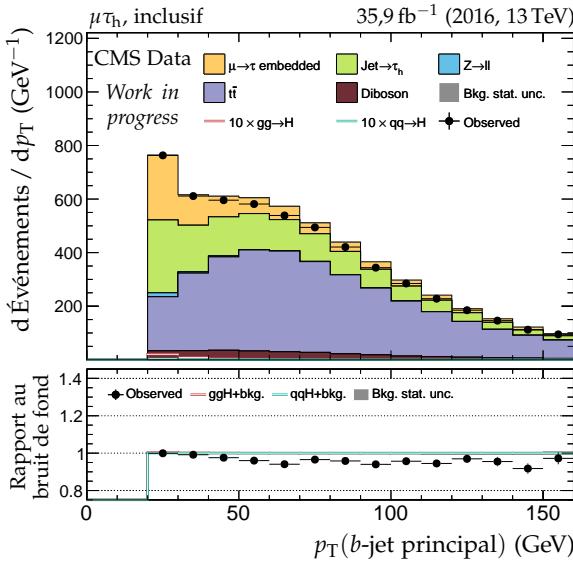


(e) Angle azimutal du jet principal.

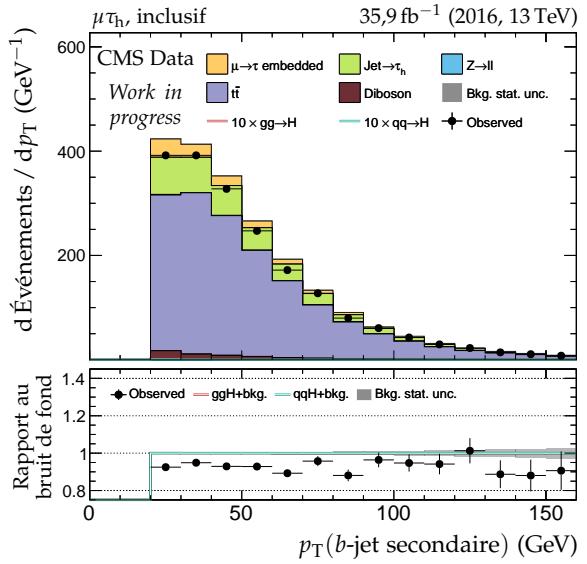


(f) Angle azimutal du jet secondaire.

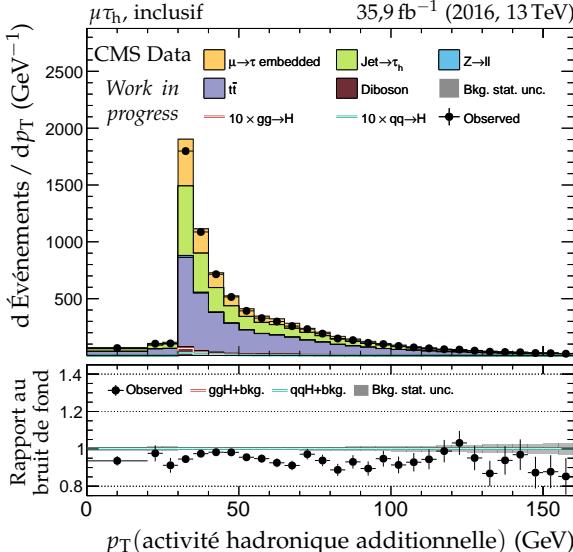
Figure X.12 – Canal  $\mu\tau_h$ , 2016 : cinématique des deux jets principaux.



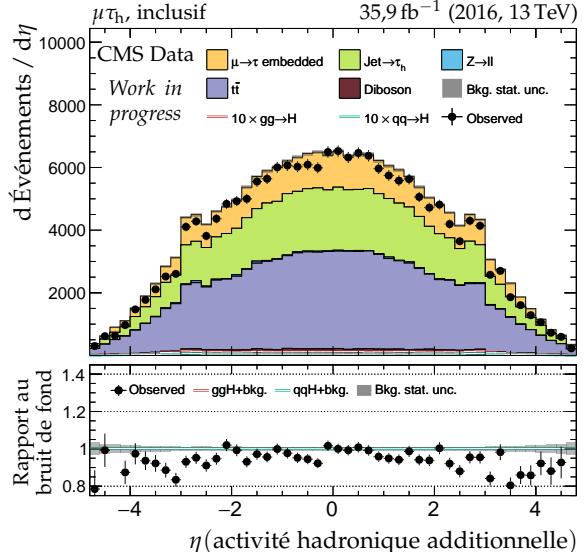
(a) Impulsion transverse du b-jet principal.



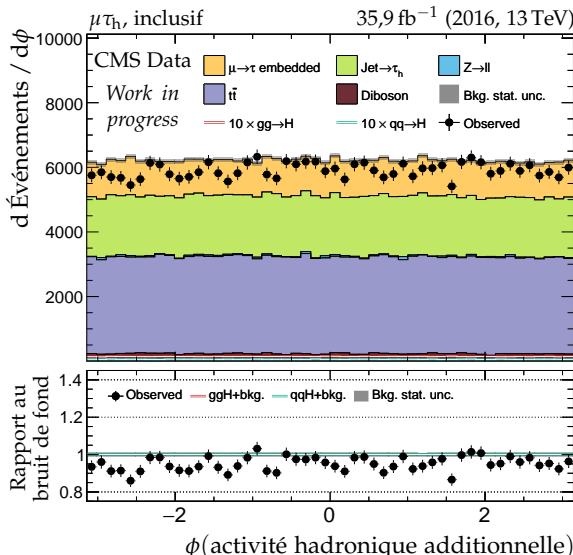
(b) Impulsion transverse du b-jet secondaire.



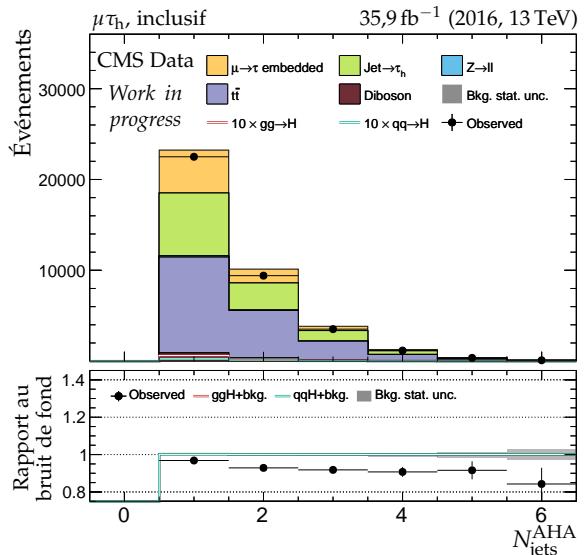
(c) Impulsion transverse de l'AHA.



(d) Pseudo-rapidité de l'AHA.

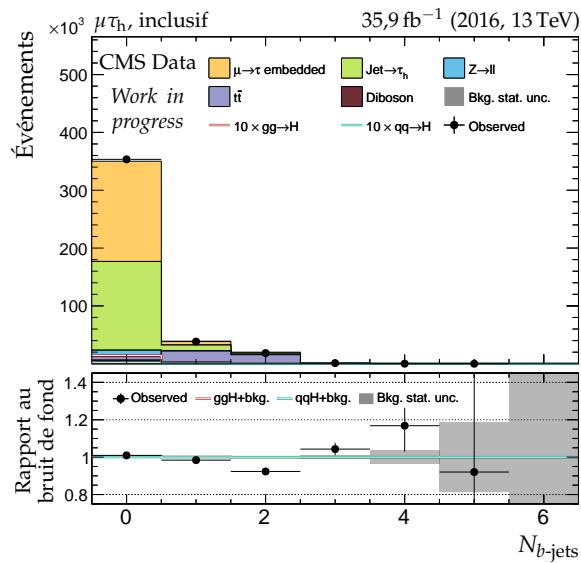
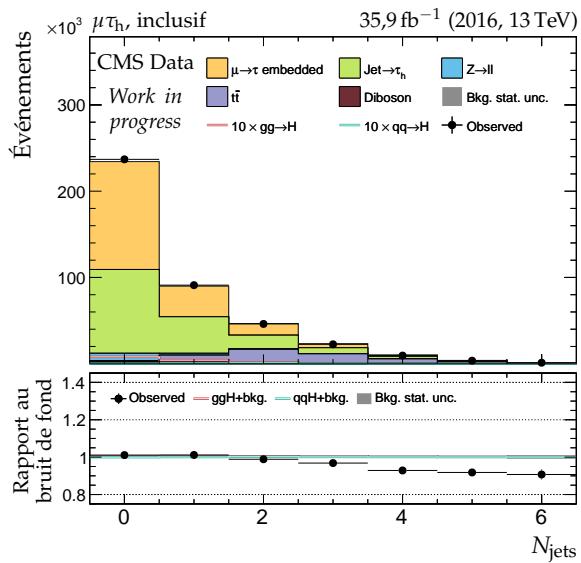


(e) Angle azimutal de l'AHA.

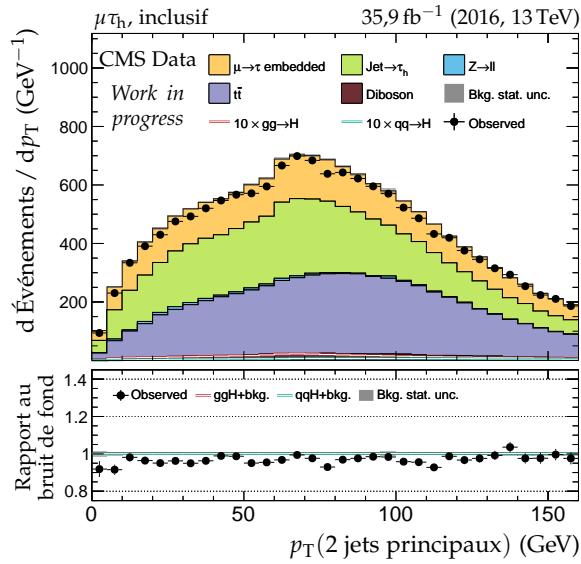


(f) Nombre de jets dans l'AHA.

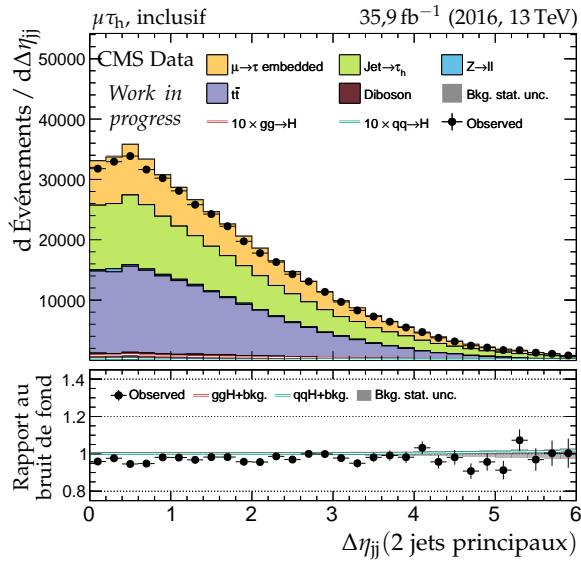
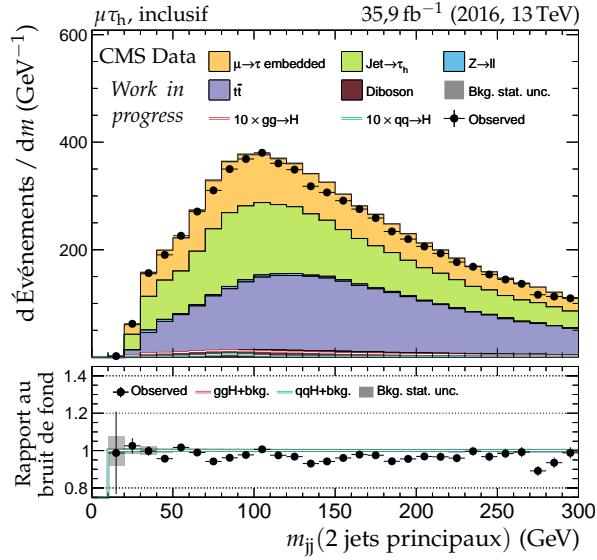
**Figure X.13 – Canal  $\mu\tau_h$ , 2016 : b-jets et activité hadronique additionnelle.**


 (a) Nombre de  $b$ -jets.


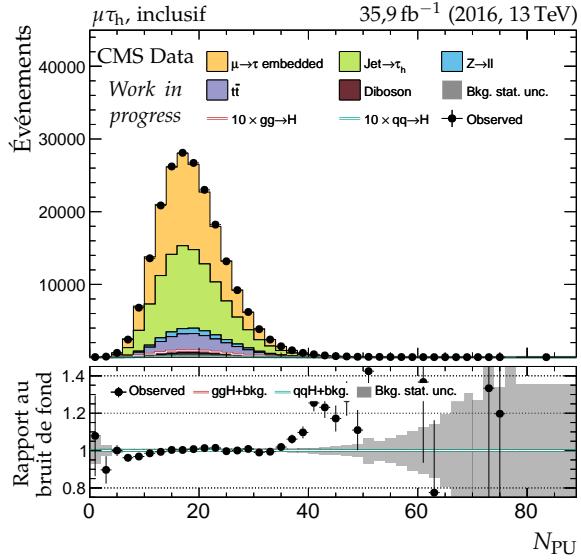
(b) Nombre de jets.



(c) Impulsion transverse du système des deux jets.

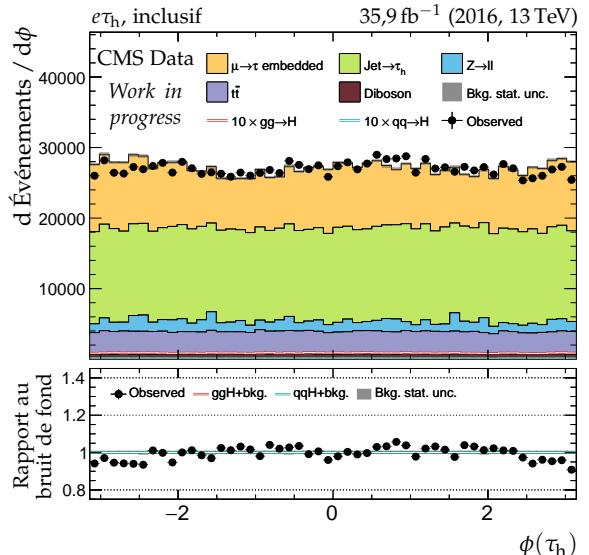
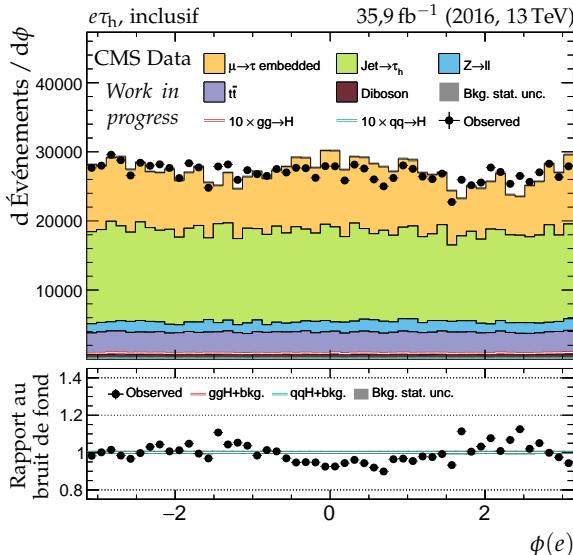
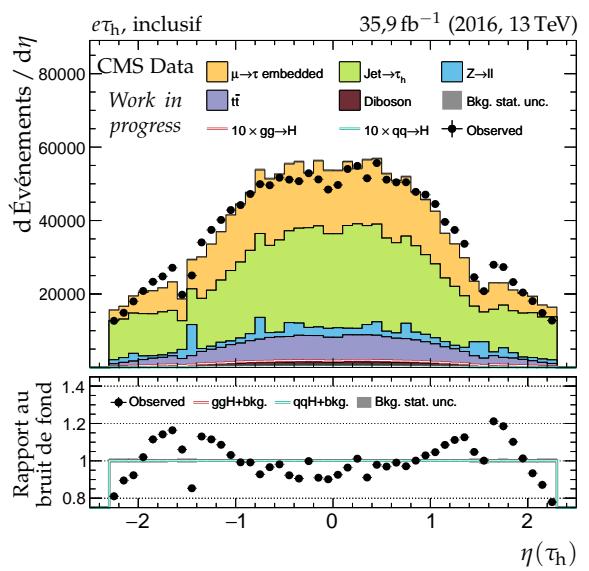
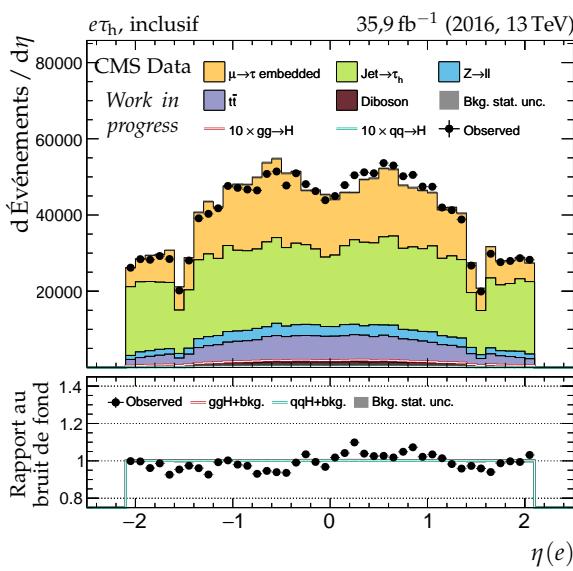
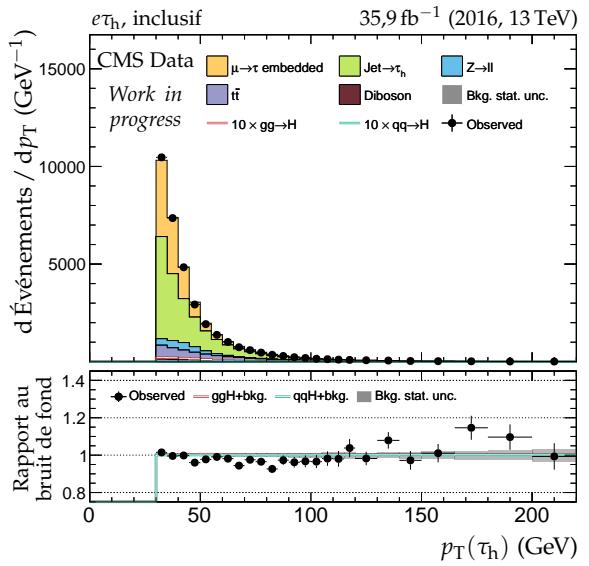
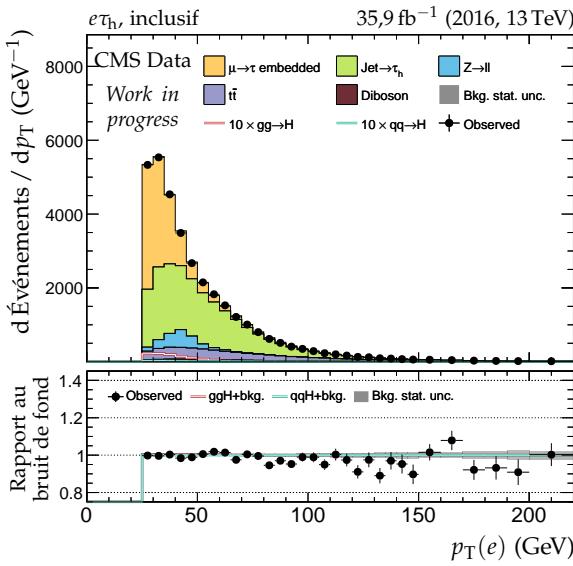

 (d) Distance en  $\eta$  entre les deux jets.


(e) Masse invariante du système des deux jets.

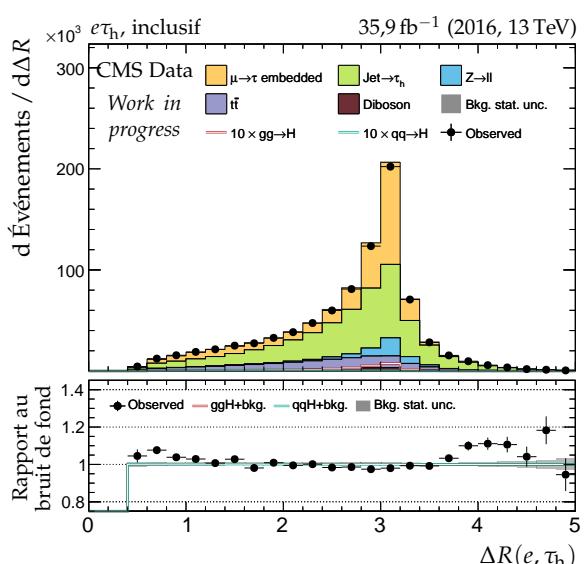
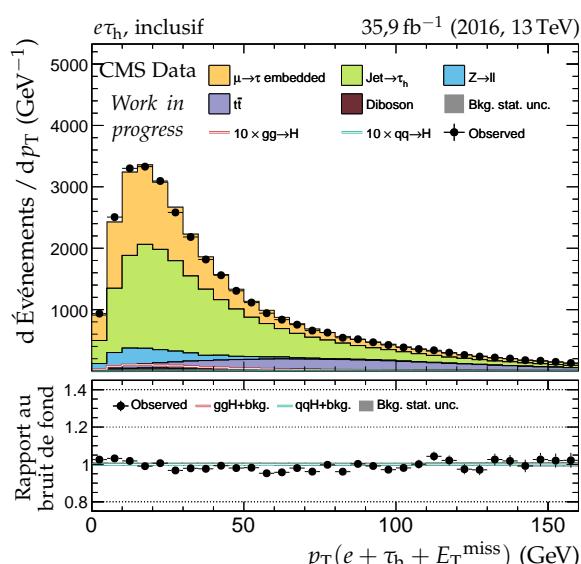
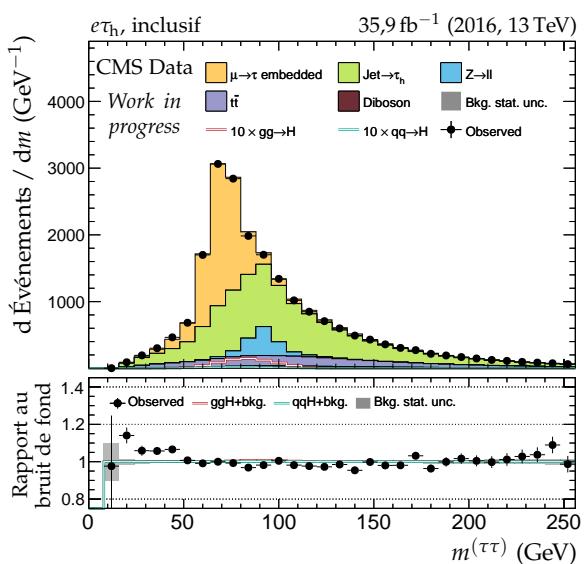
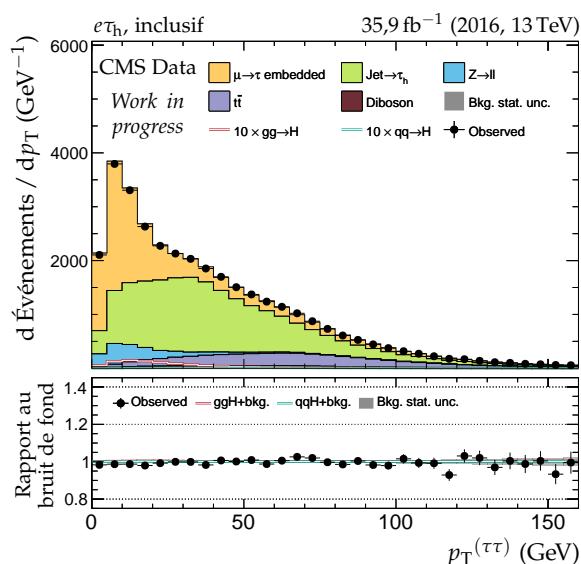
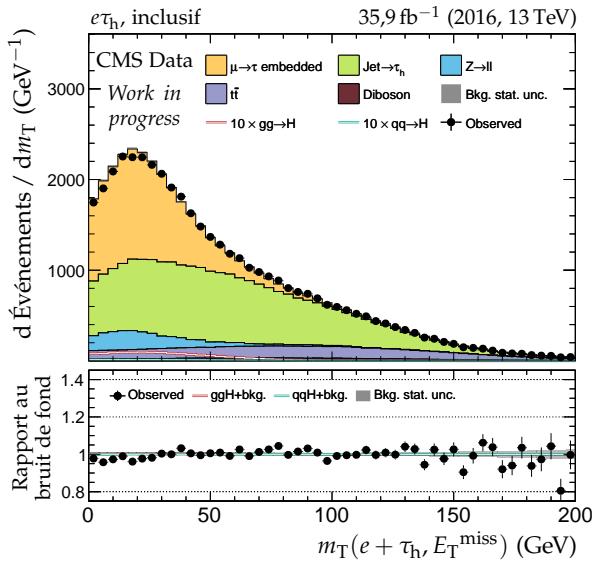
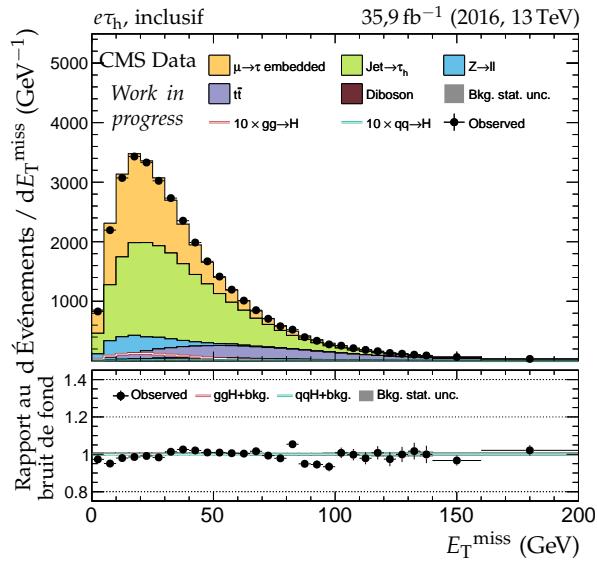


(f) Nombre de vertex d'empilement.

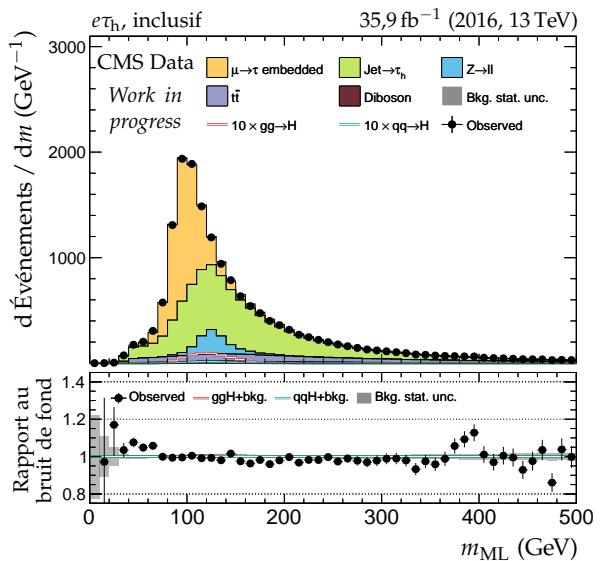
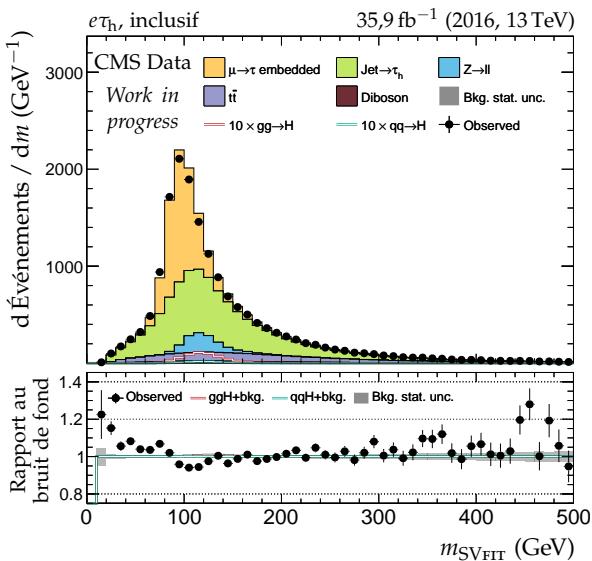
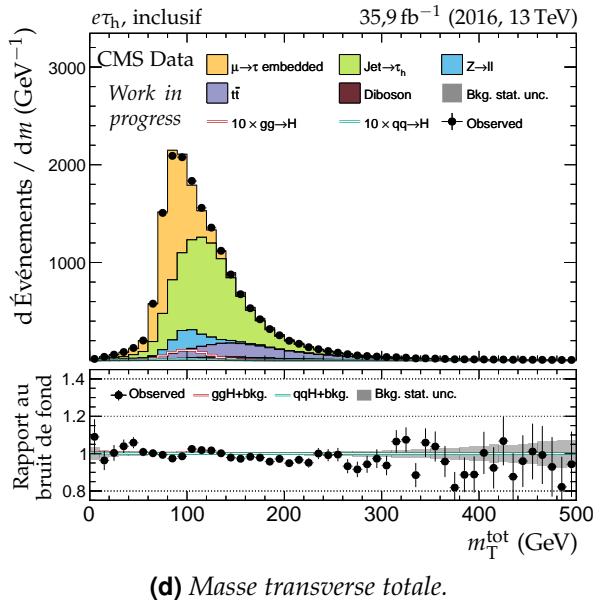
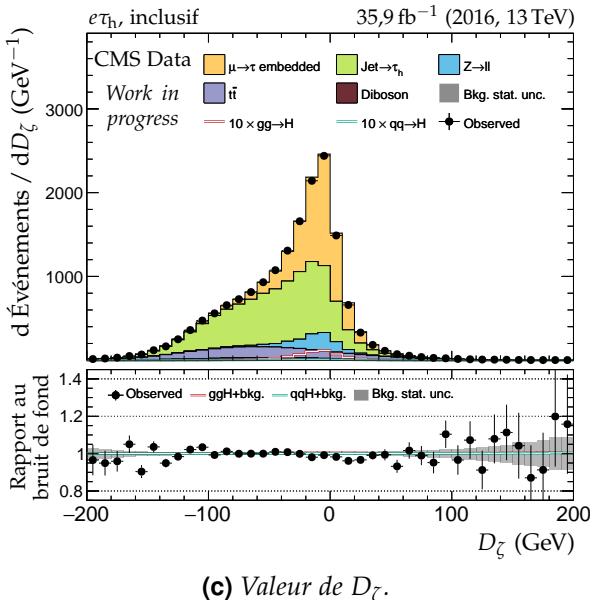
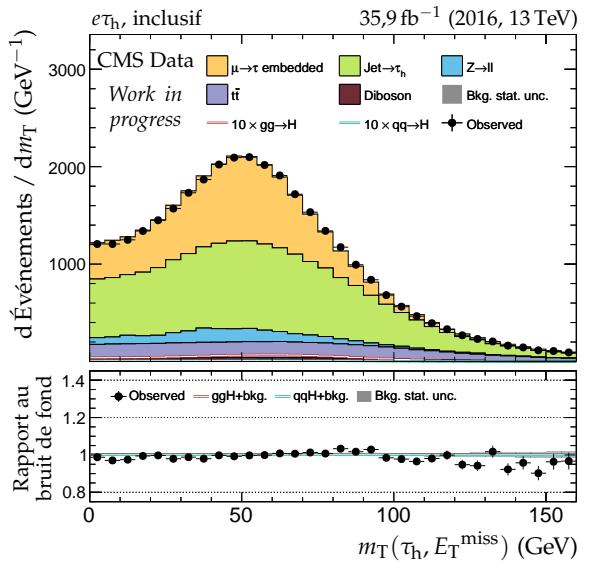
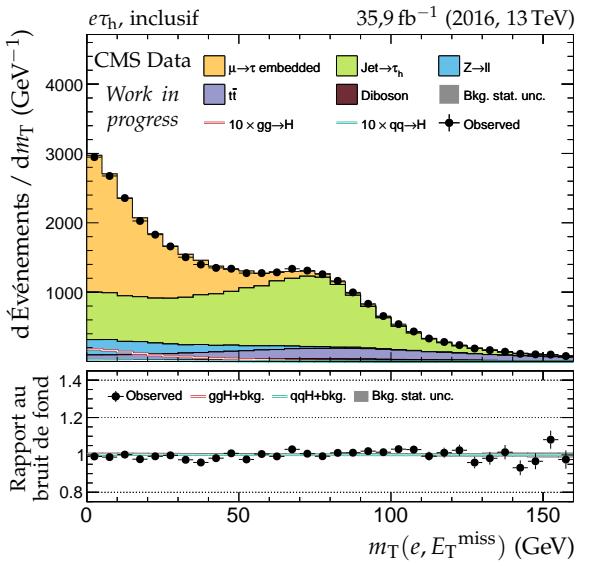
 Figure X.14 – Canal  $\mu \tau_h$ , 2016 : nombre de jets, système des deux jets principaux et empilement.



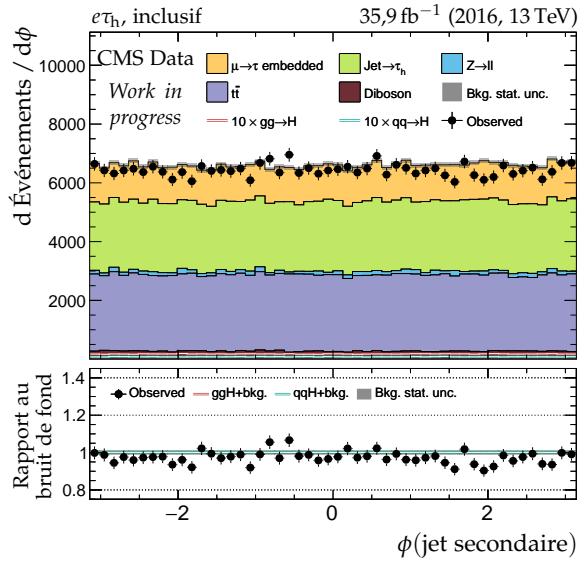
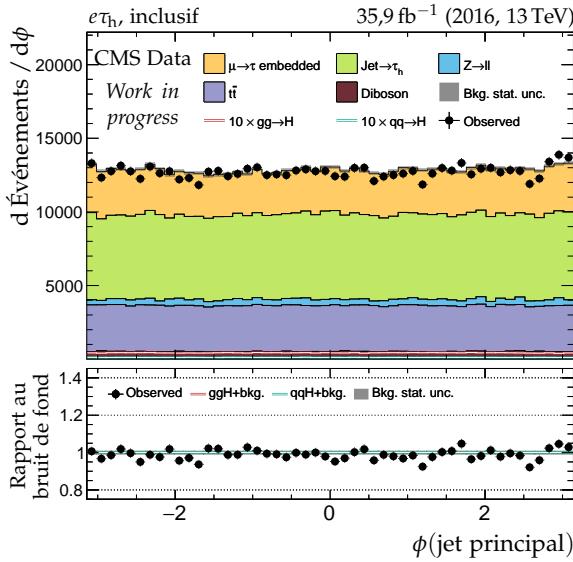
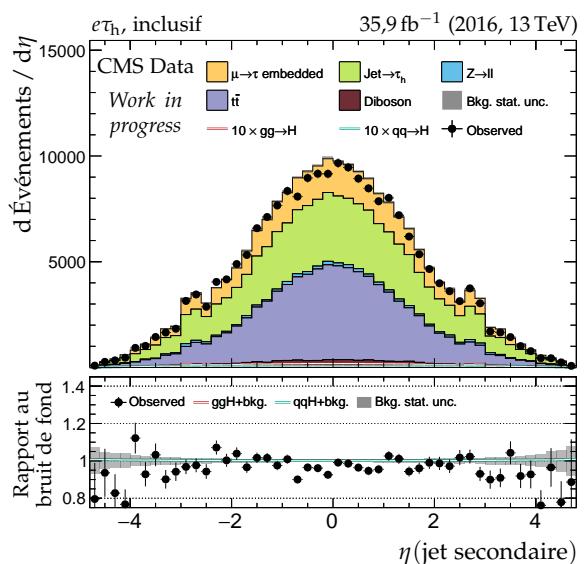
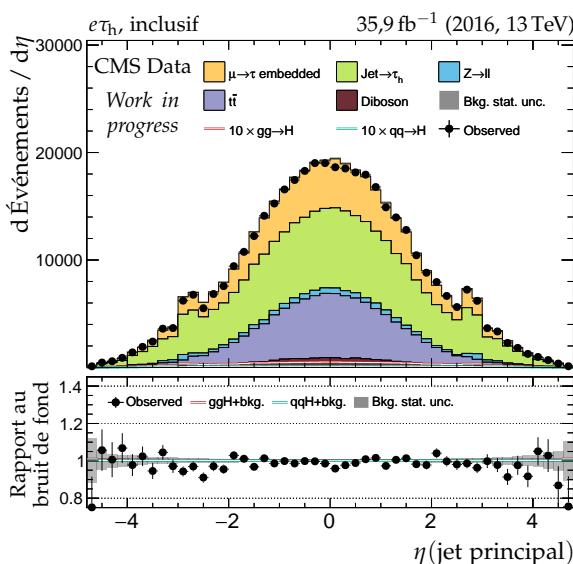
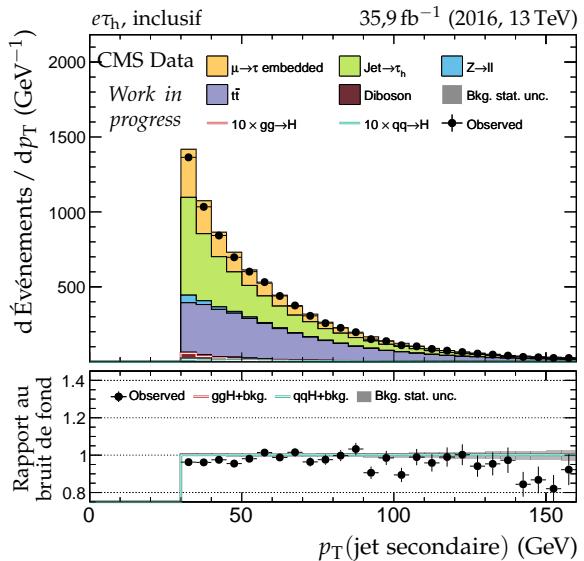
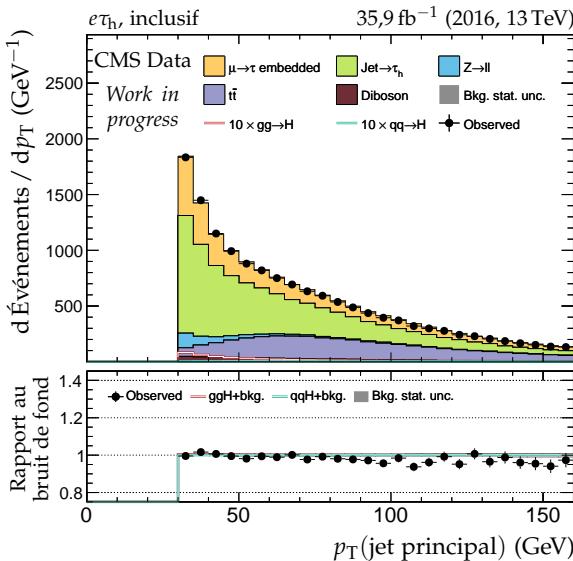
**Figure X.15 – Canal  $e\tau_h$ , 2016 : cinématique des leptons ( $e, \tau_h$ ).**



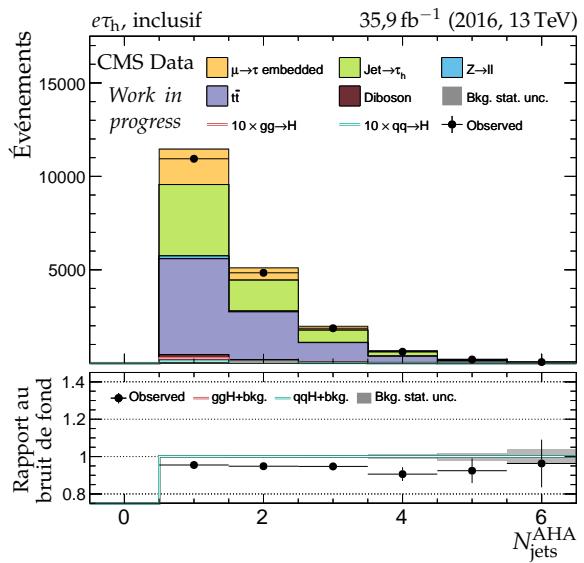
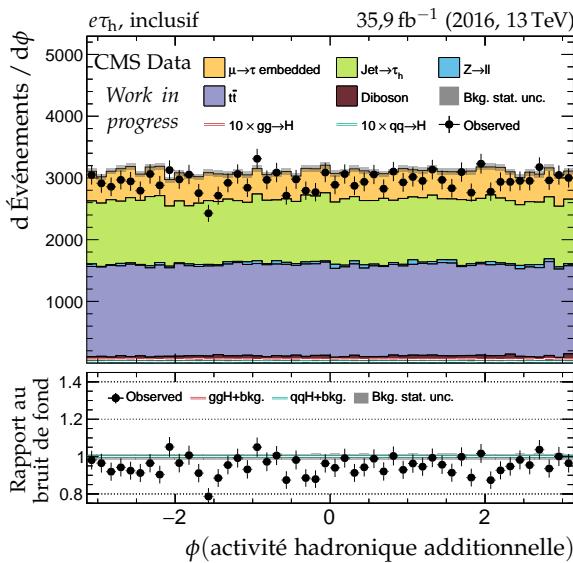
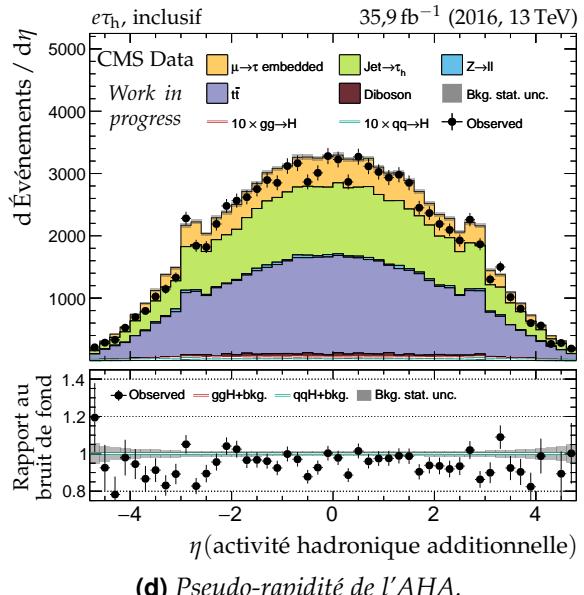
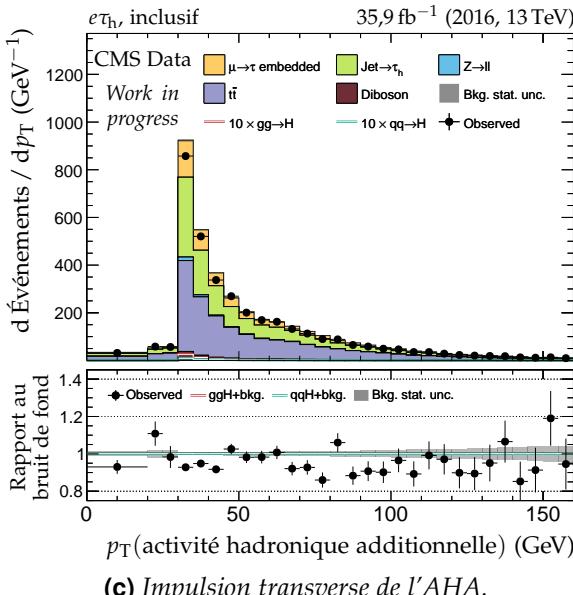
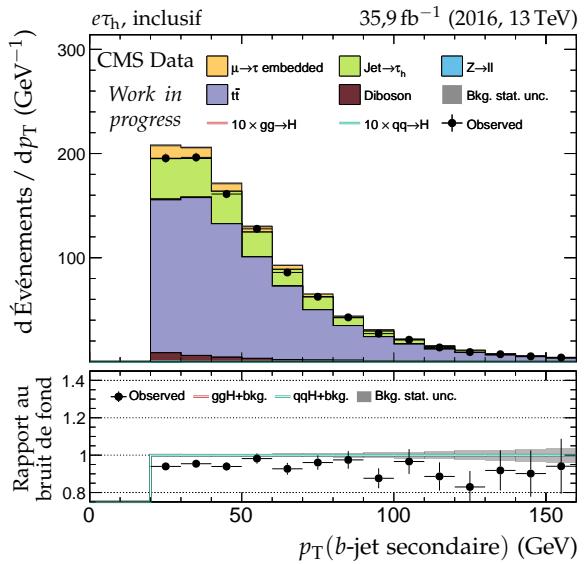
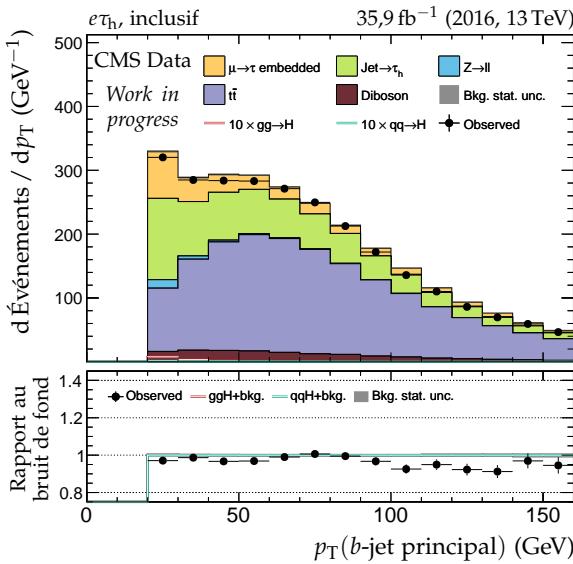
**Figure X.16 – Canal  $e\tau_h$ , 2016 : dilepton et énergie transverse manquante.**



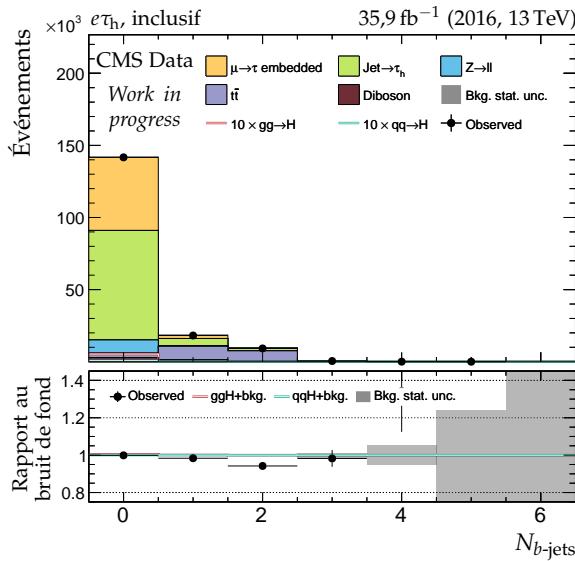
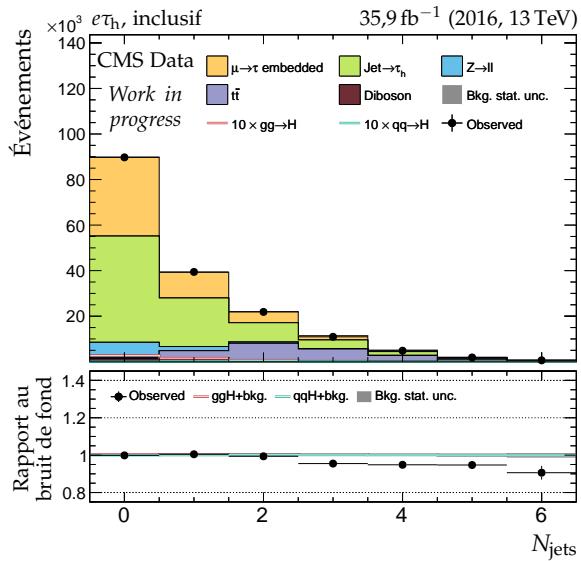
**Figure X.17 – Canal  $e\tau_h$ , 2016 : masses transverses,  $D_\zeta$  et masses.**



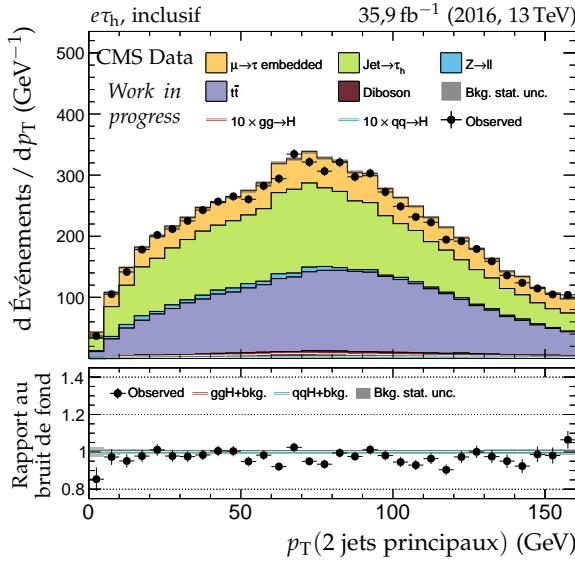
**Figure X.18 – Canal  $e\tau_h$ , 2016 : cinématique des deux jets principaux.**



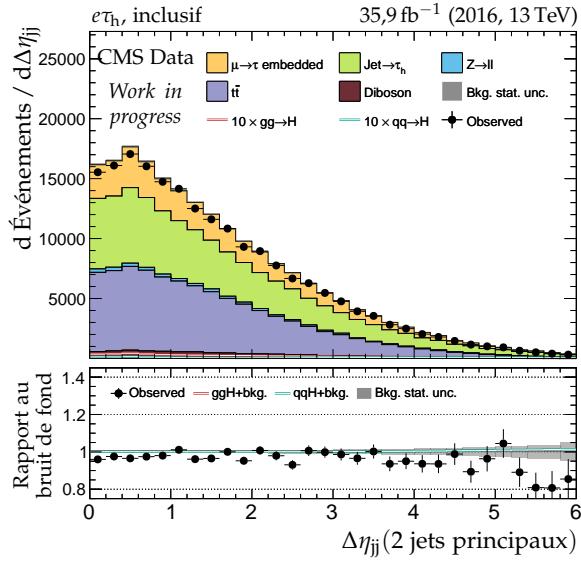
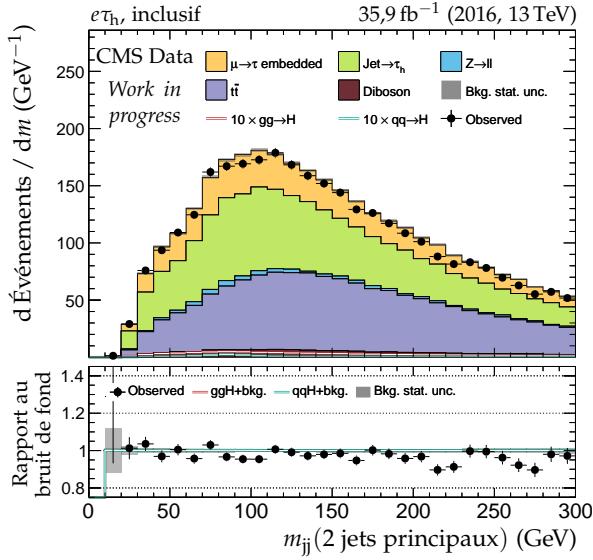
**Figure X.19 – Canal  $e\tau_h$ , 2016 :  $b$ -jets et activité hadronique additionnelle.**


 (a) Nombre de  $b$ -jets.


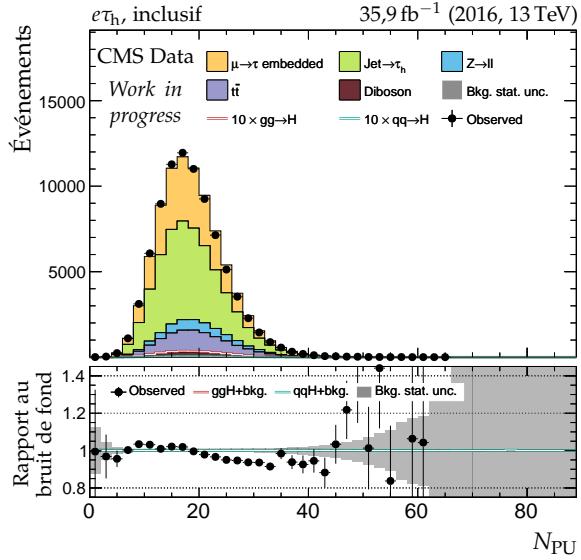
(b) Nombre de jets.



(c) Impulsion transverse du système des deux jets.

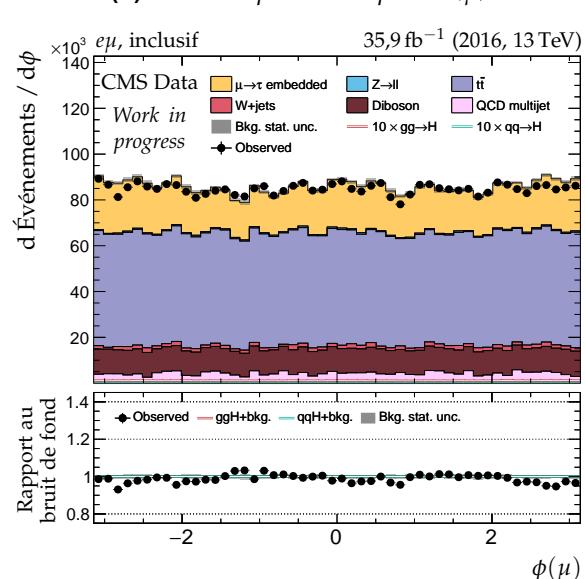
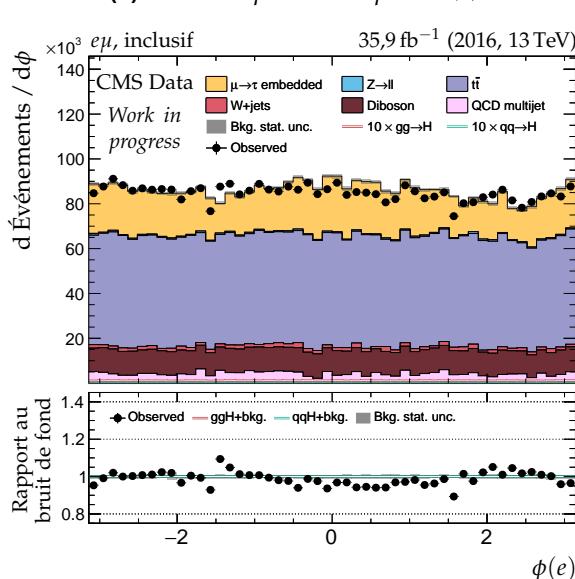
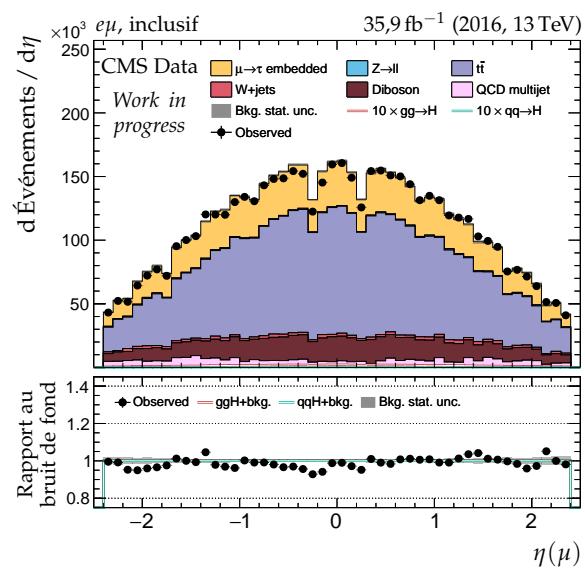
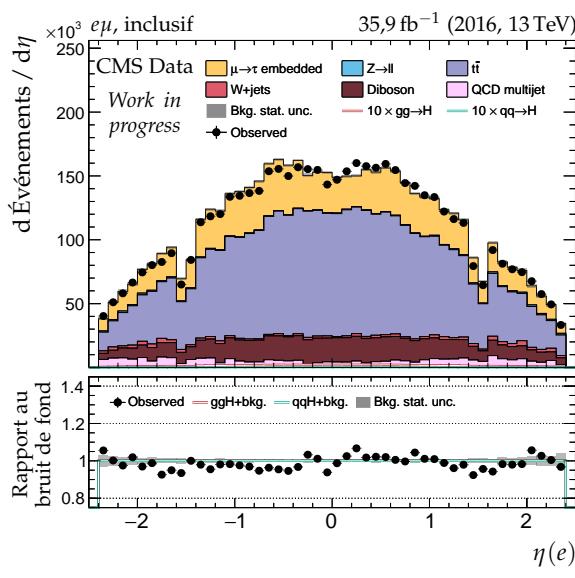
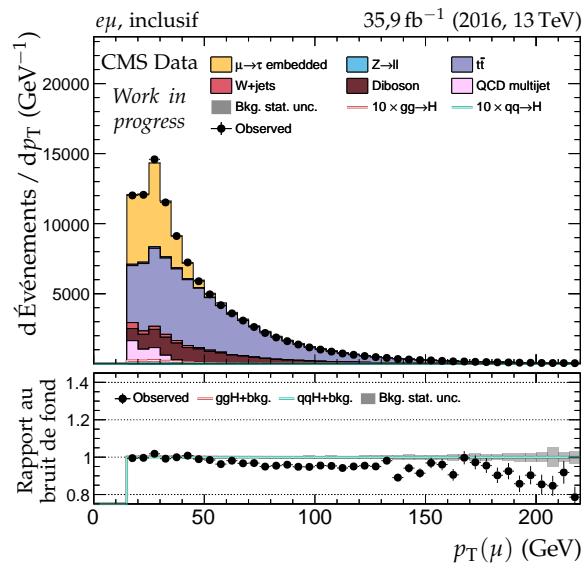
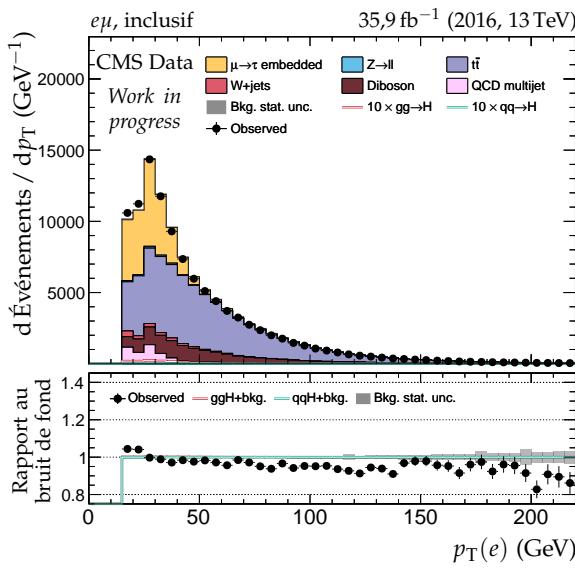

 (d) Distance en  $\eta$  entre les deux jets.


(e) Masse invariante du système des deux jets.

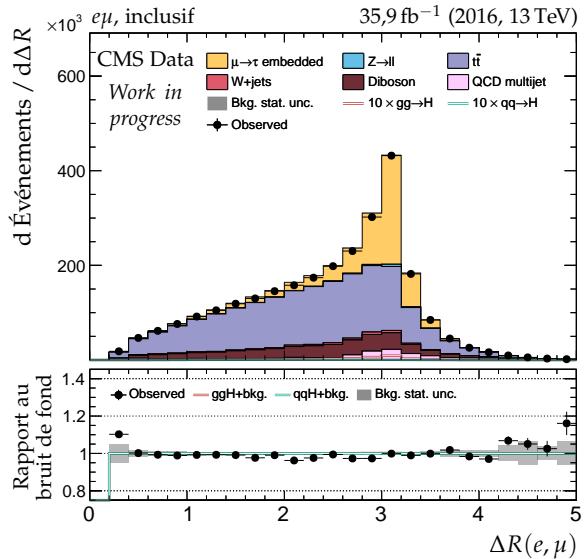
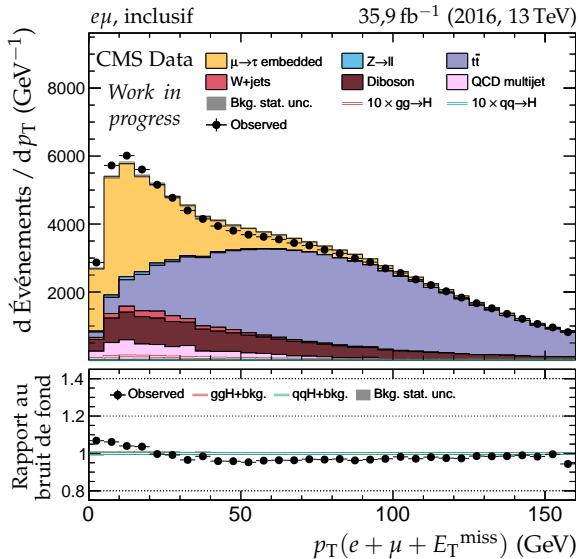
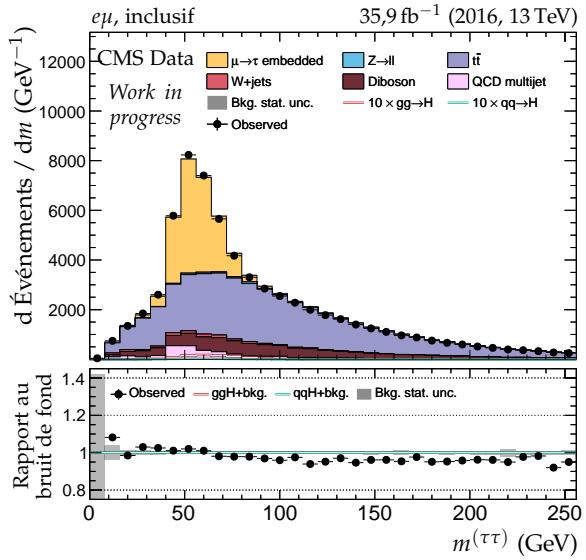
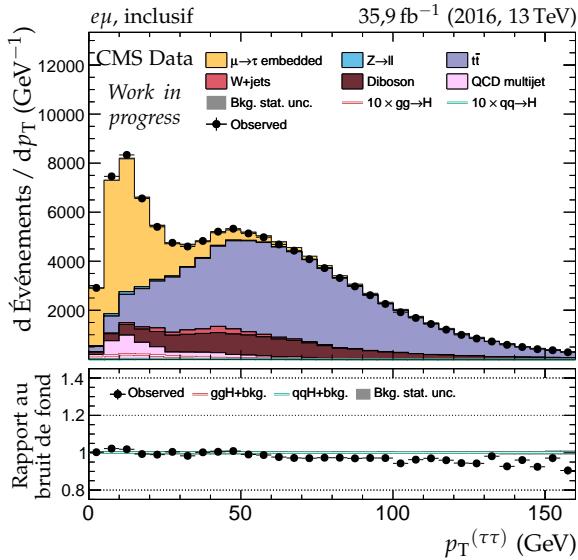
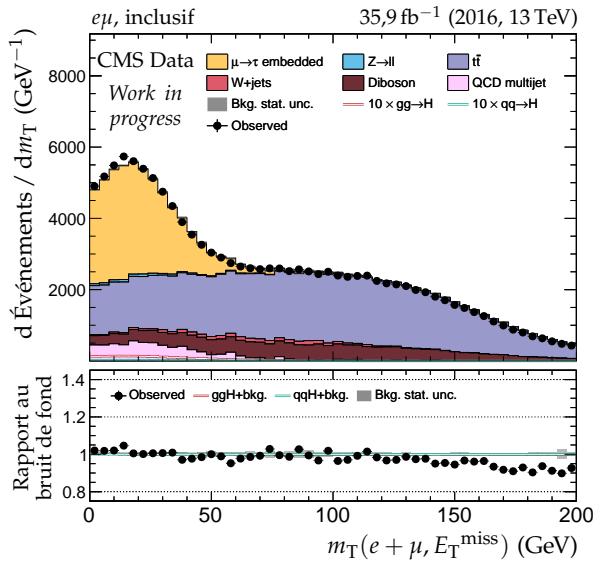
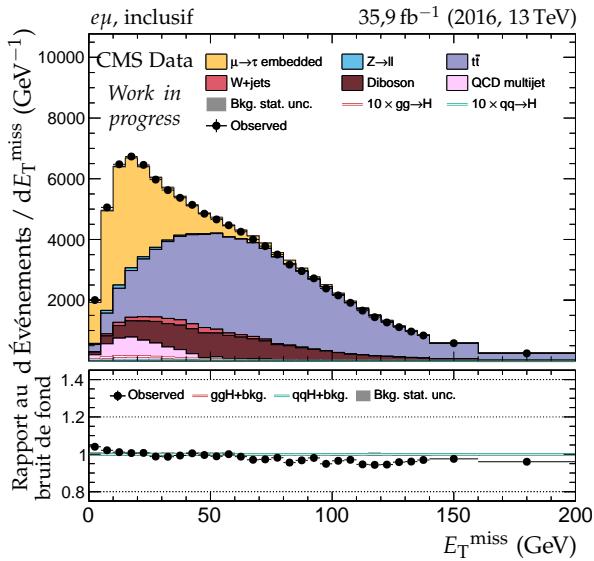


(f) Nombre de vertex d'empilement.

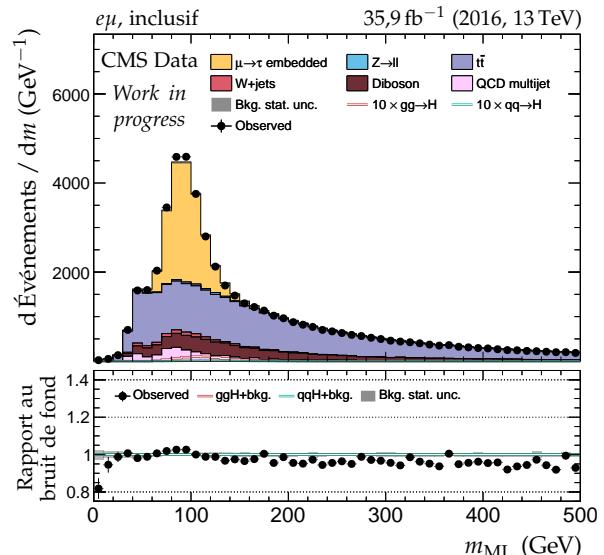
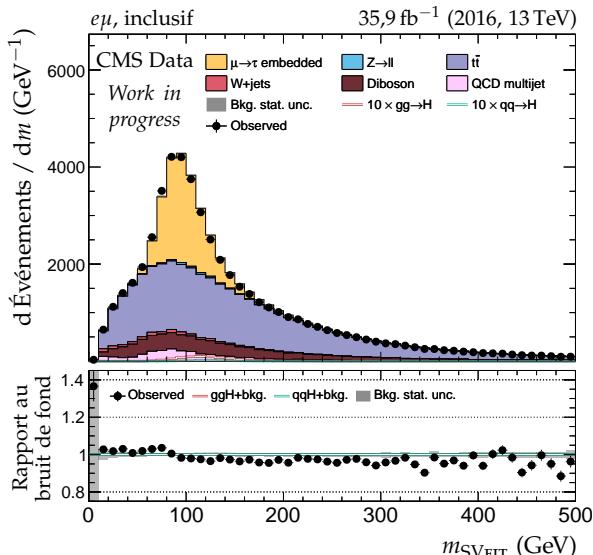
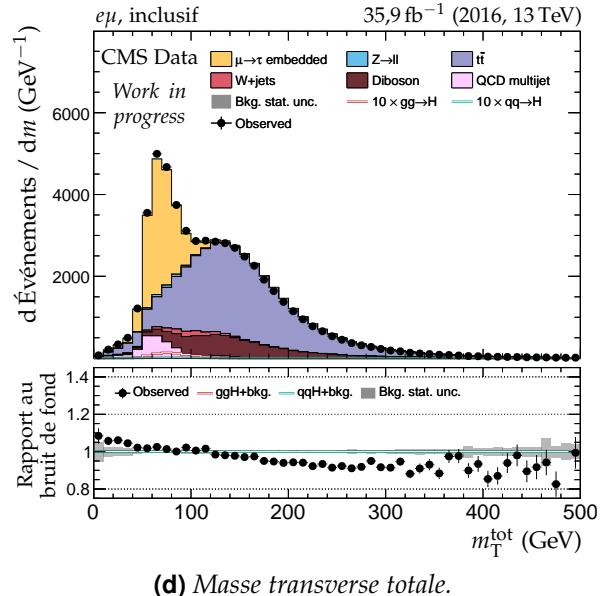
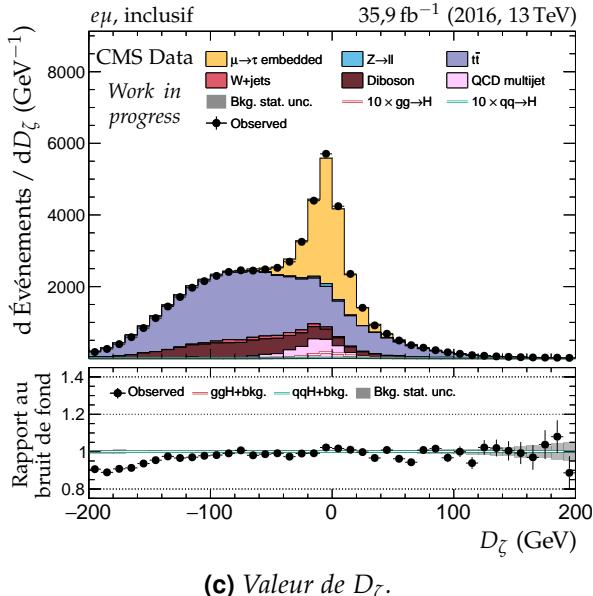
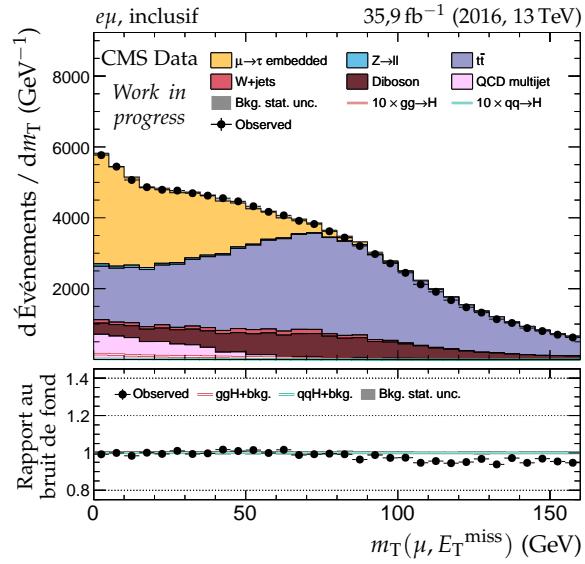
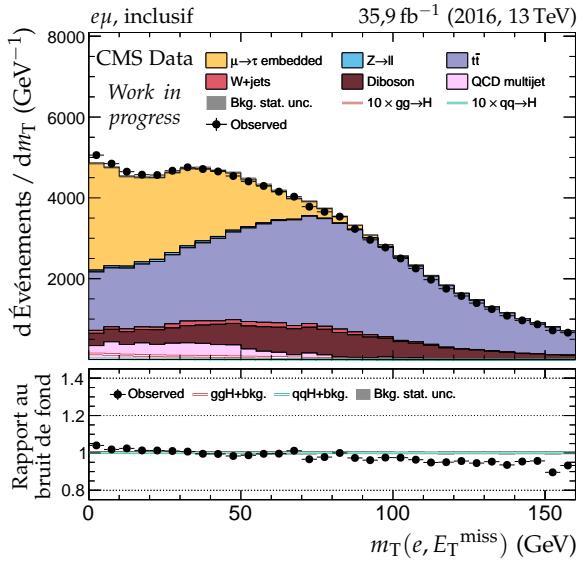
 Figure X.20 – Canal  $e\tau_h$ , 2016 : nombre de jets, système des deux jets principaux et empilement.



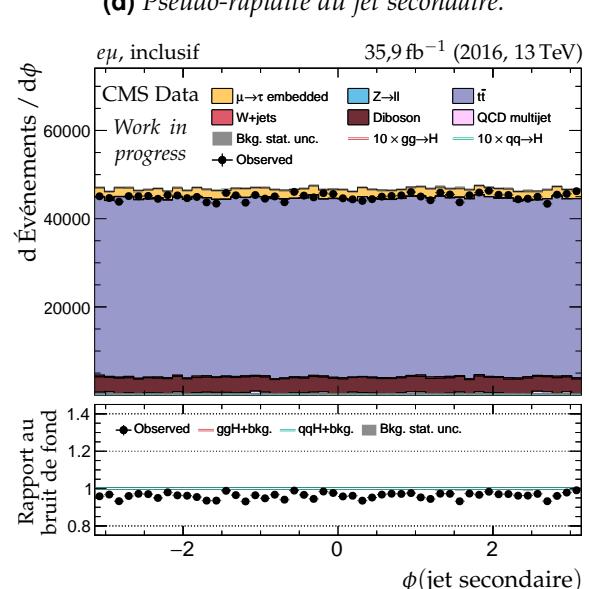
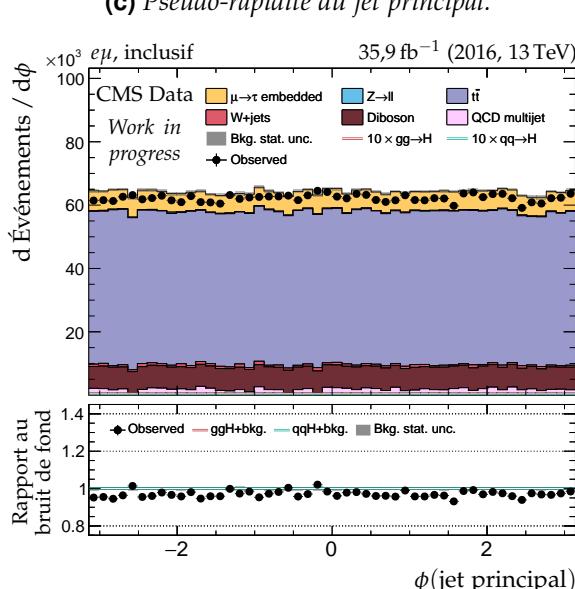
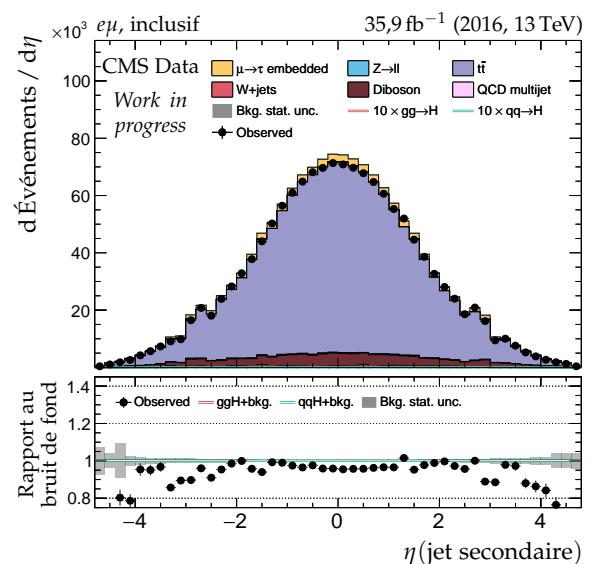
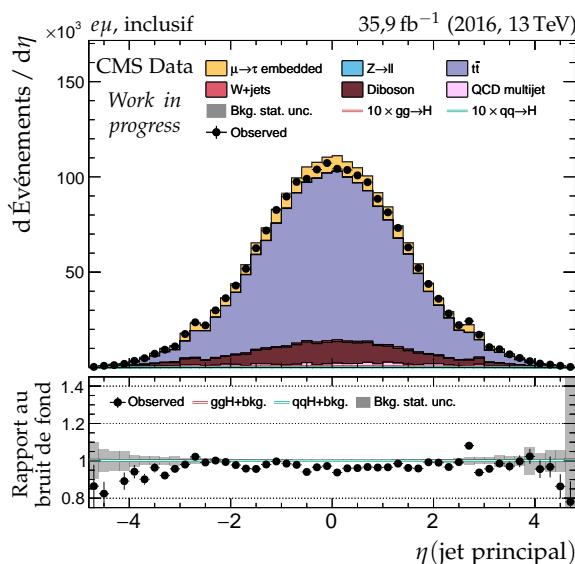
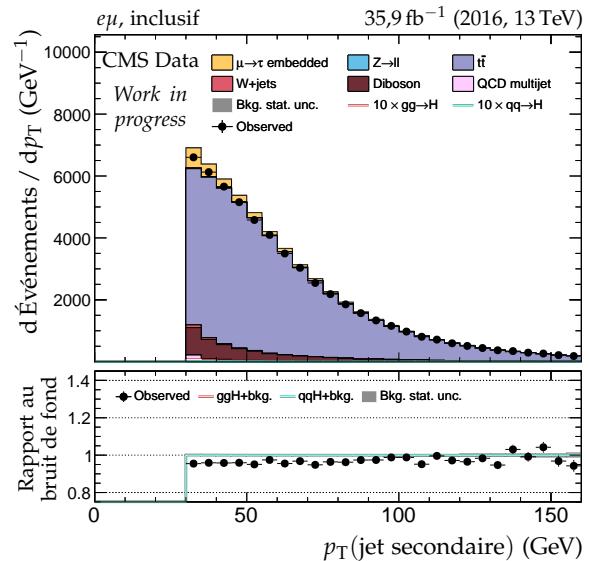
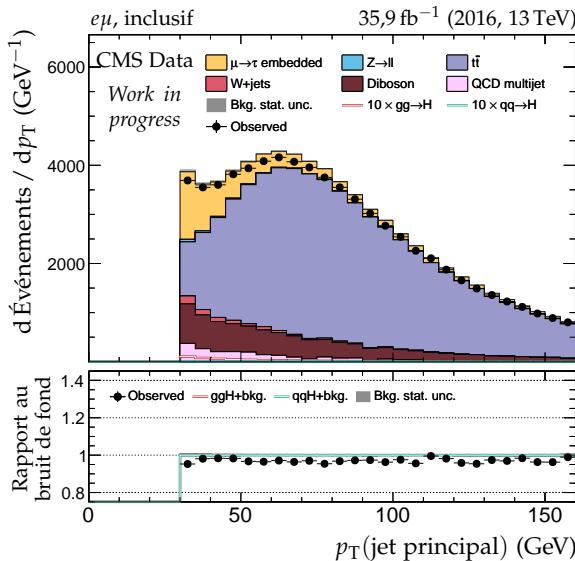
**Figure X.21 – Canal  $e\mu$ , 2016 : cinématique des leptons ( $e, \mu$ ).**



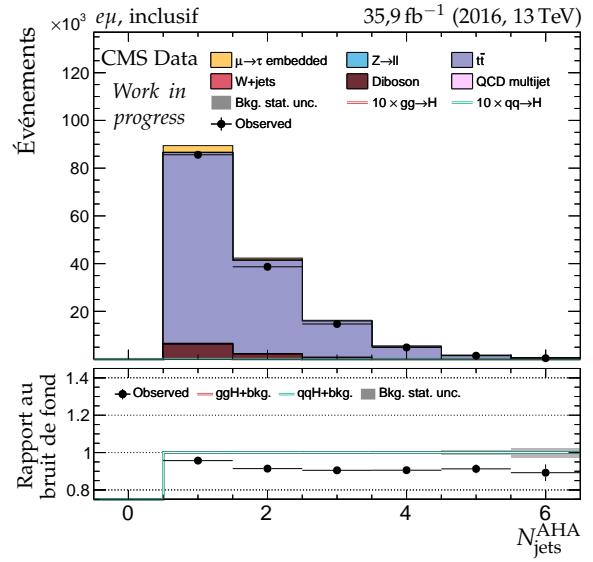
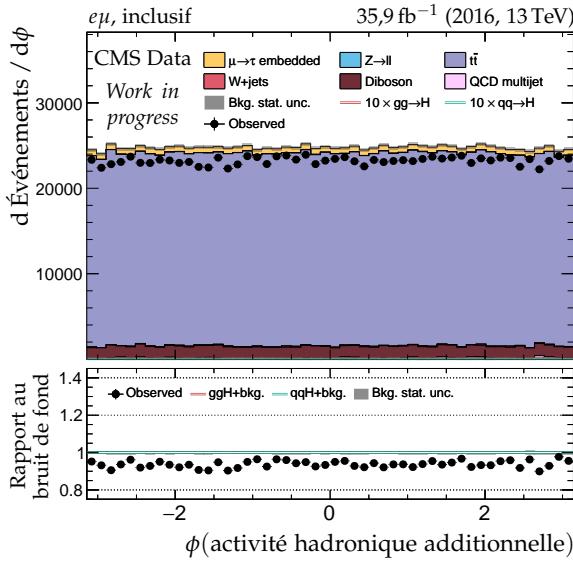
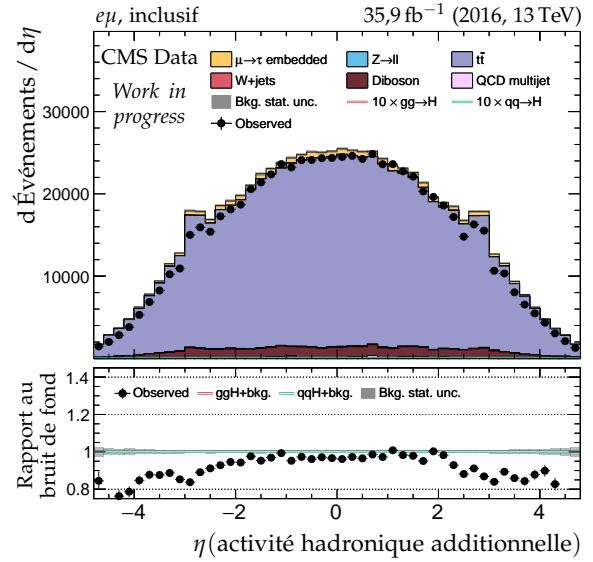
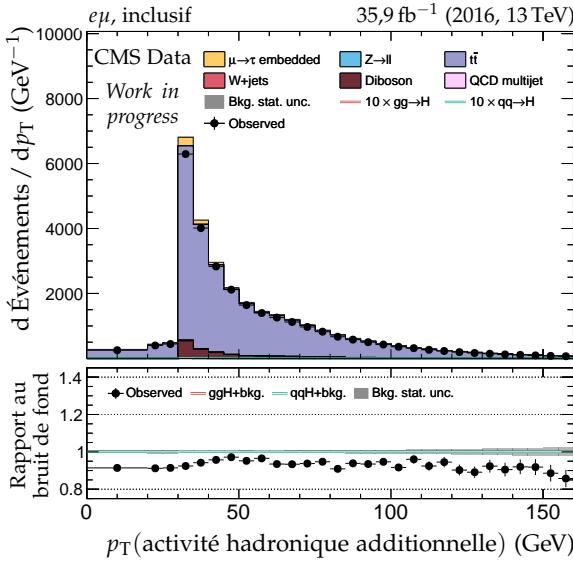
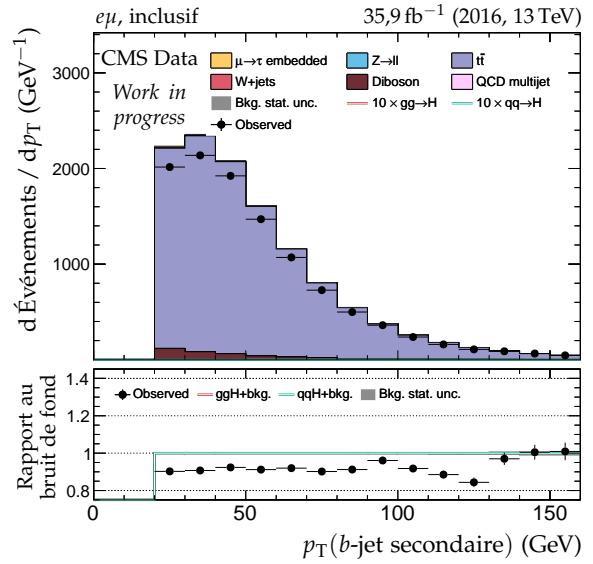
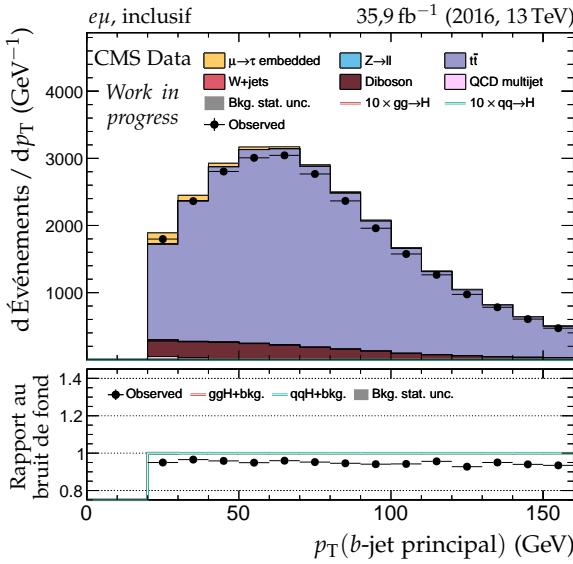
**Figure X.22 – Canal  $e\mu$ , 2016 : dilepton et énergie transverse manquante.**



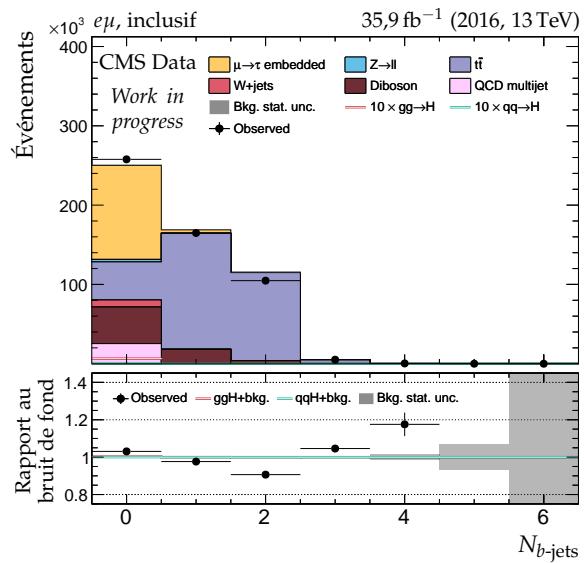
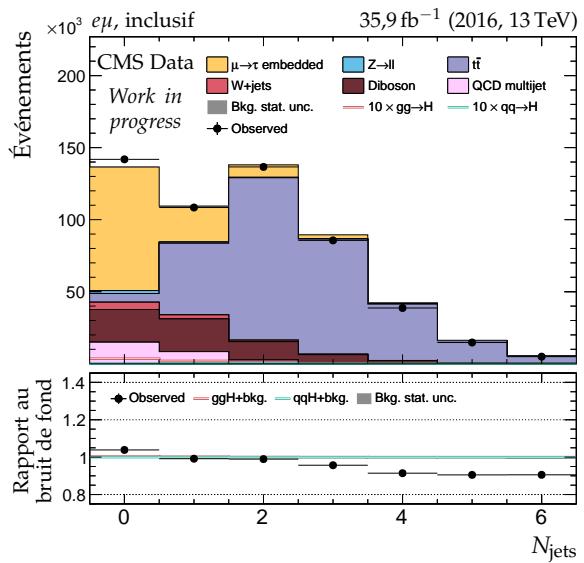
**Figure X.23 – Canal  $e\mu$ , 2016 : masses transverses,  $D_\zeta$  et masses.**



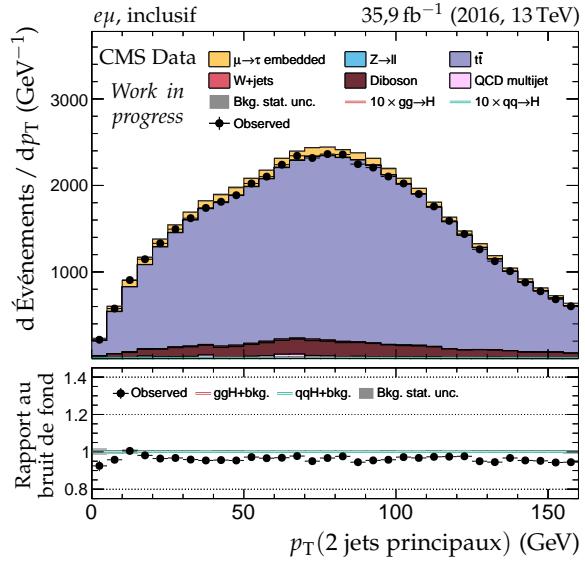
**Figure X.24 – Canal  $e\mu$ , 2016 : cinématique des deux jets principaux.**



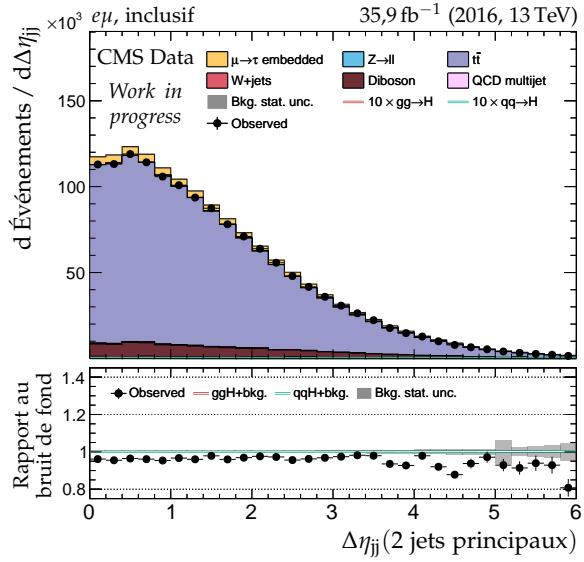
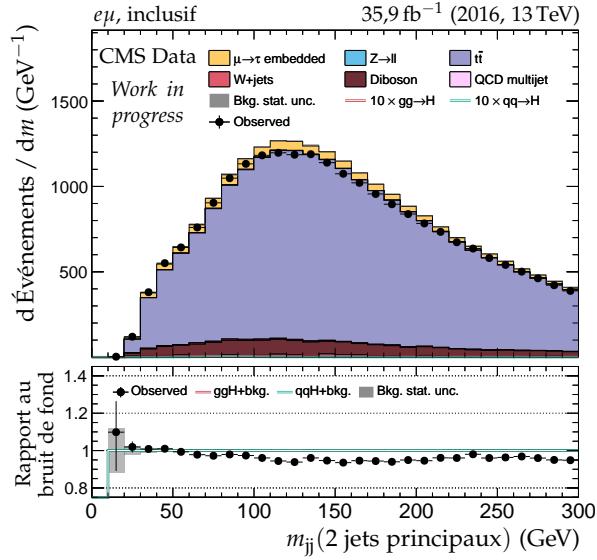
**Figure X.25 – Canal  $e\mu$ , 2016 : b-jets et activité hadronique additionnelle.**


 (a) Nombre de  $b$ -jets.


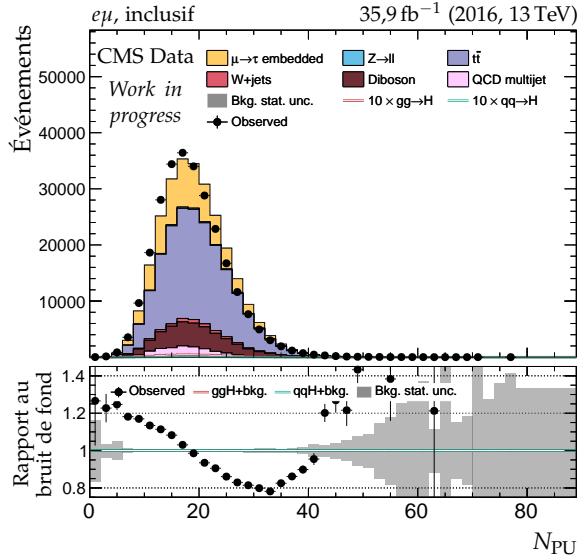
(b) Nombre de jets.



(c) Impulsion transverse du système des deux jets.

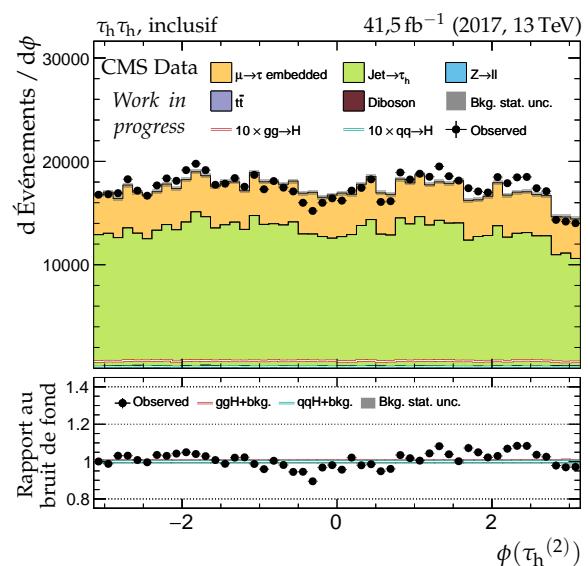
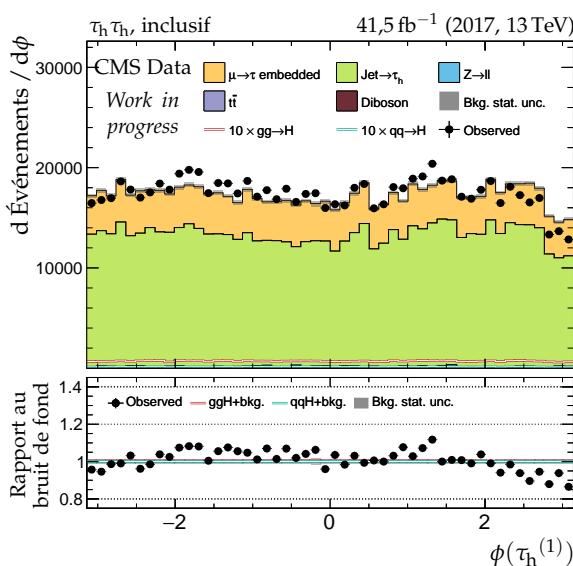
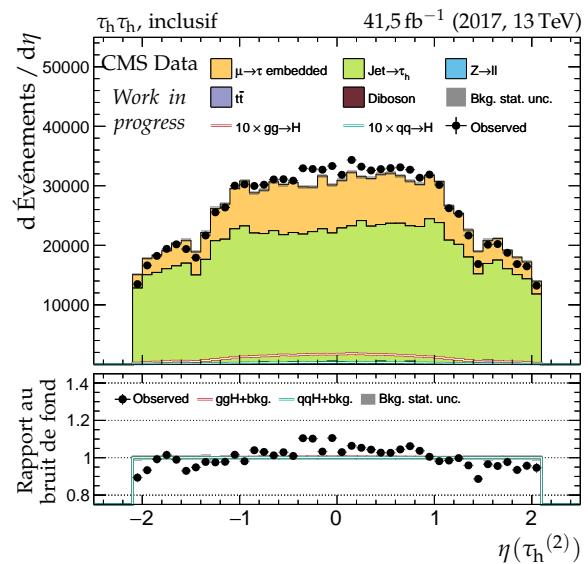
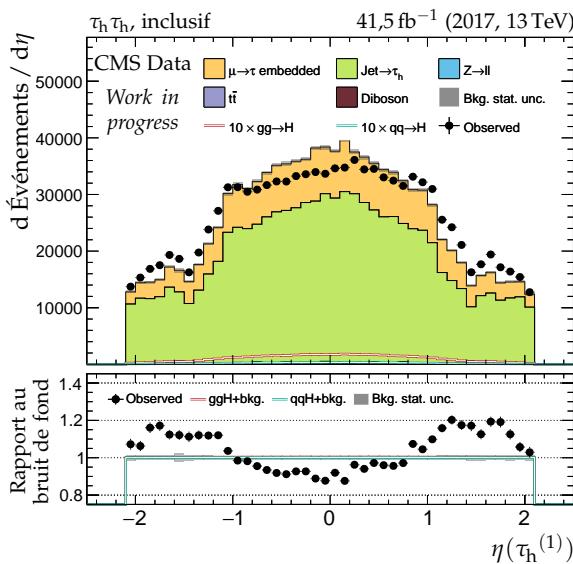
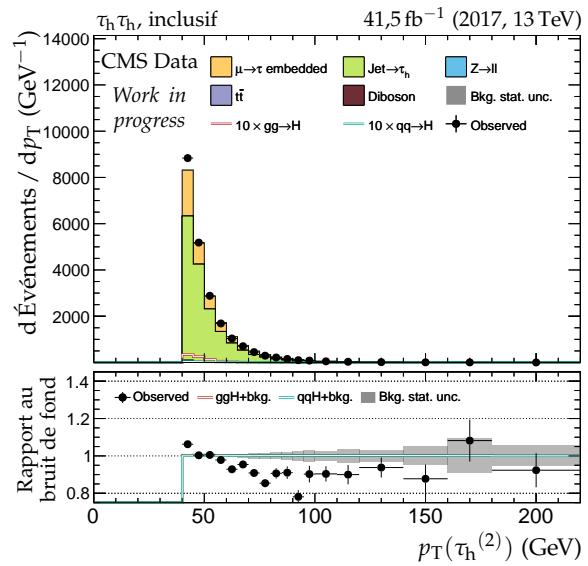
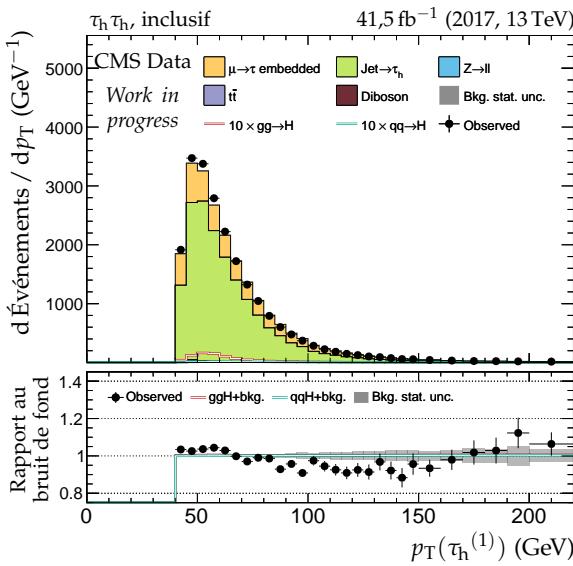

 (d) Distance en  $\eta$  entre les deux jets.


(e) Masse invariante du système des deux jets.

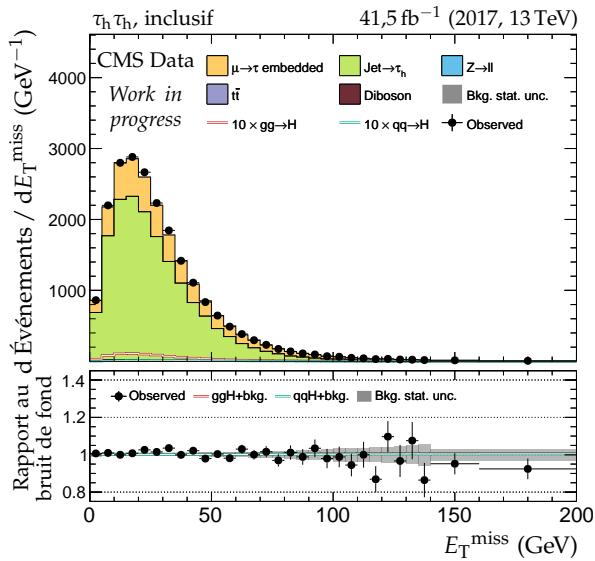


(f) Nombre de vertex d'empilement.

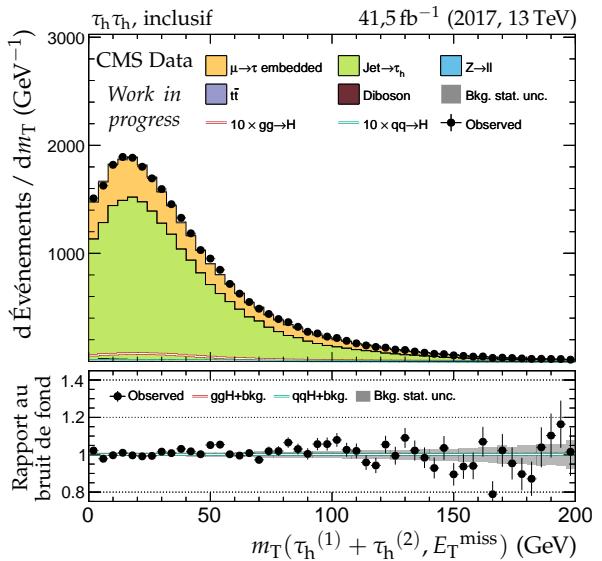
 Figure X.26 – Canal  $e\mu$ , 2016 : nombre de jets, système des deux jets principaux et empilement.



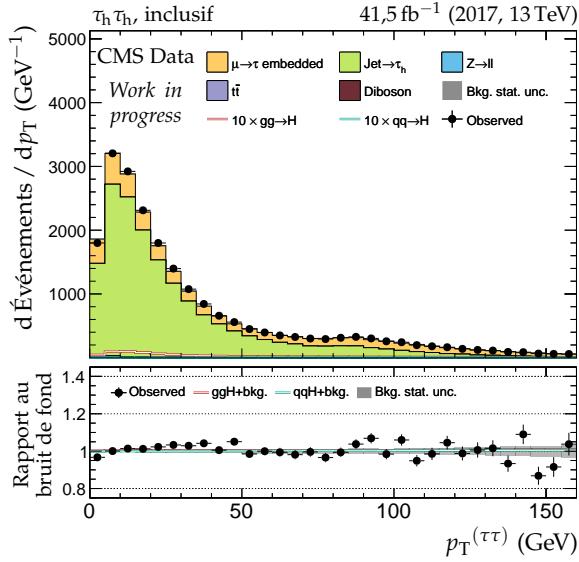
**Figure X.27 – Canal  $\tau_h \tau_h$ , 2017 : cinématique des leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).**



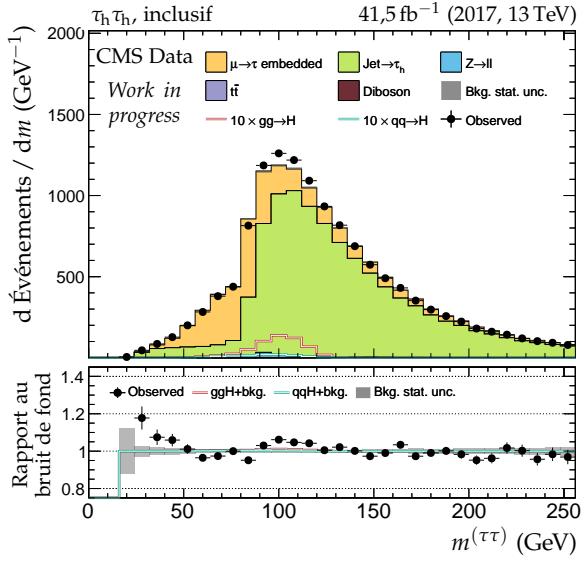
(a) Énergie transverse manquante.



(b) Masse transverse du dilepton.



(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

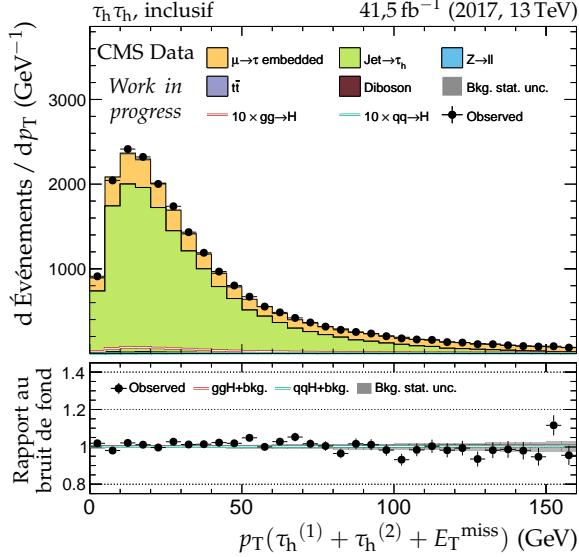
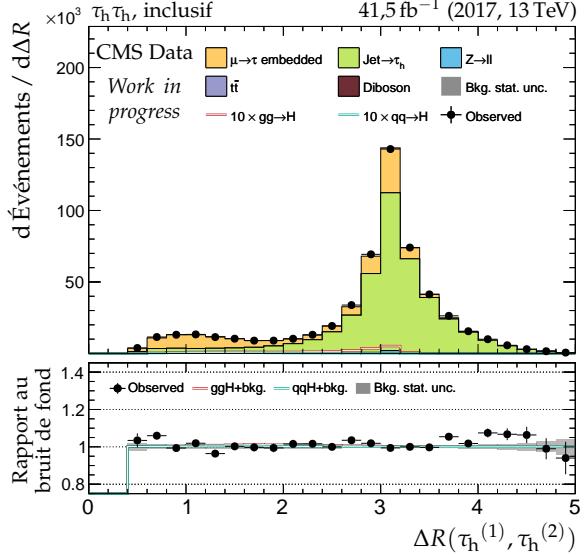
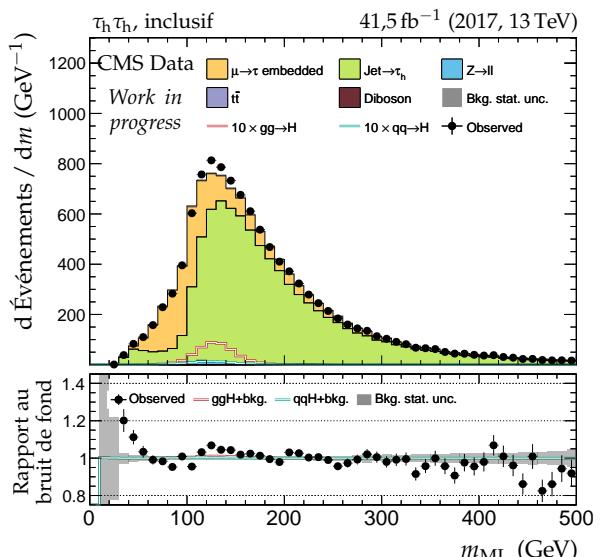
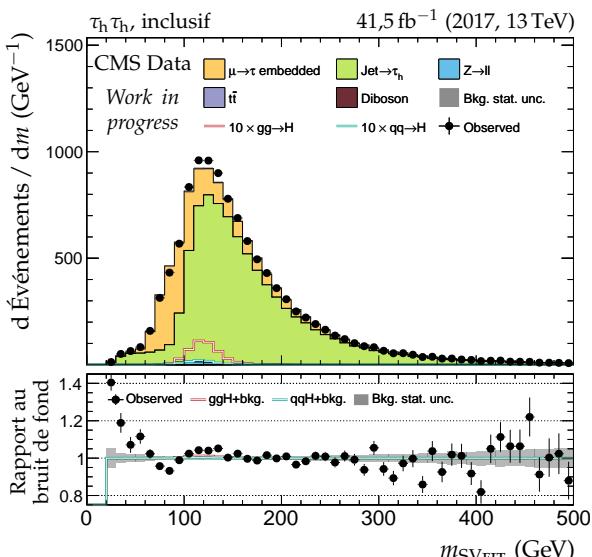
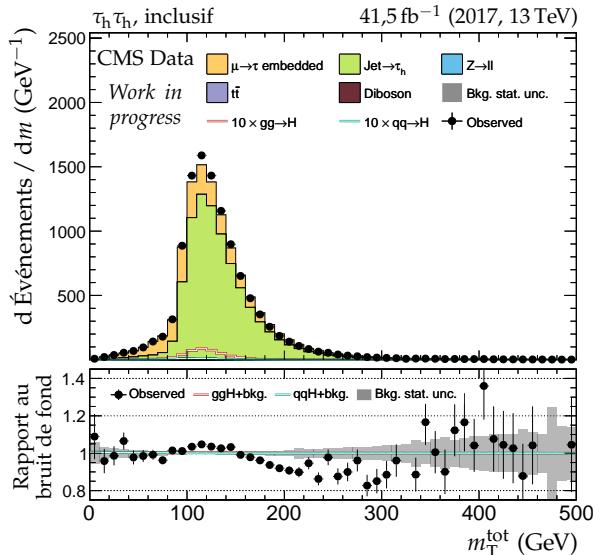
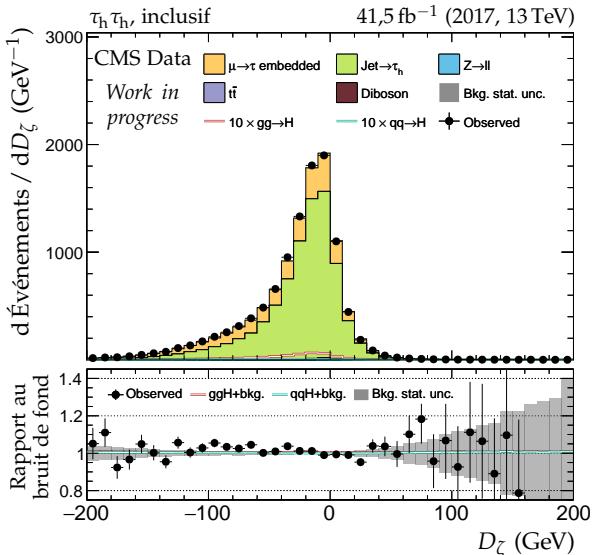
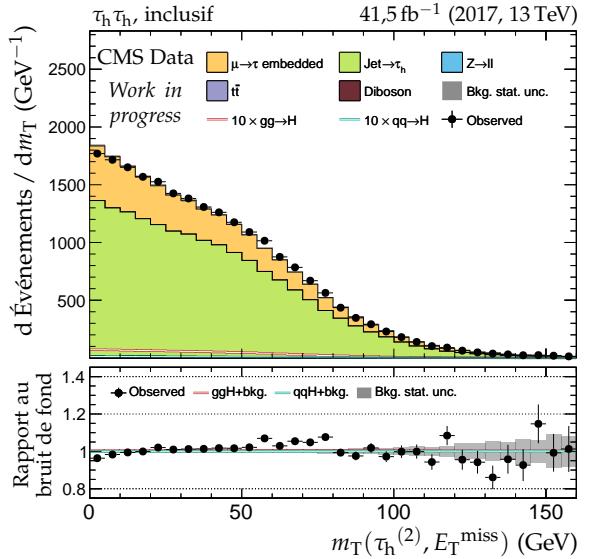
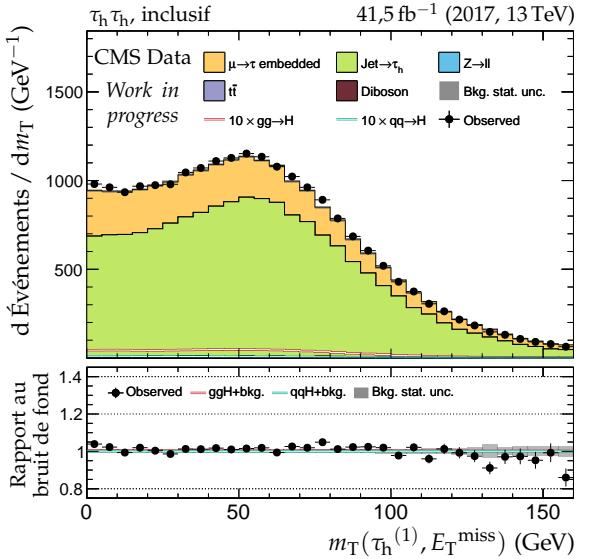
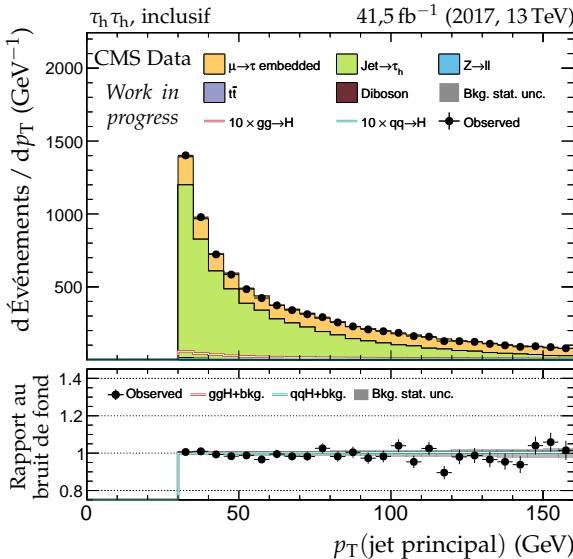

 (e) Impulsion transverse du système di- $\tau$ .

 (f) Distance  $\Delta R$  entre les leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).

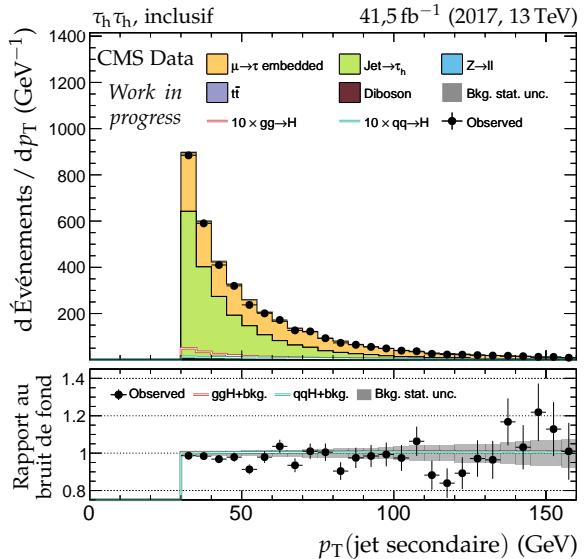
 Figure X.28 – Canal  $\tau_h \tau_h$ , 2017 : dilepton et énergie transverse manquante.



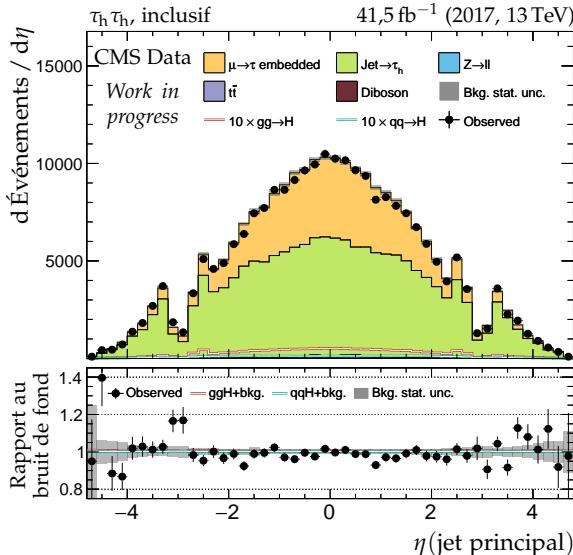
**Figure X.29 – Canal  $\tau_h \tau_h$ , 2017 : masses transverses,  $D_\zeta$  et masses.**



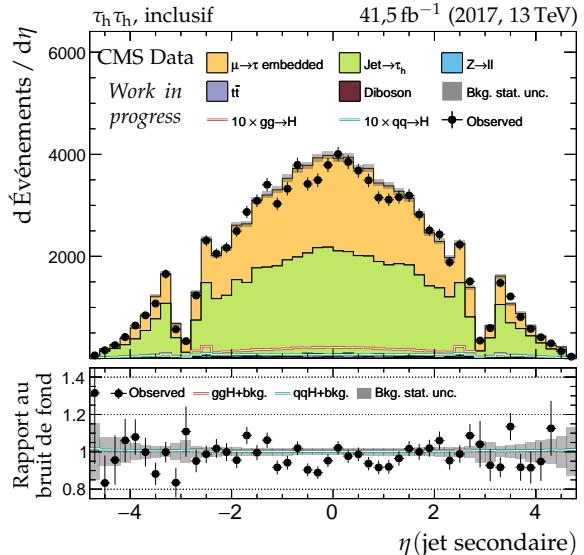
**(a)** Impulsion transverse du jet principal.



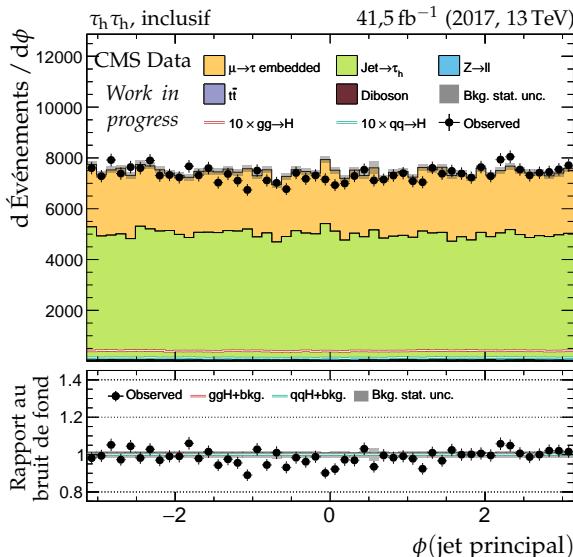
**(b)** Impulsion transverse du jet secondaire.



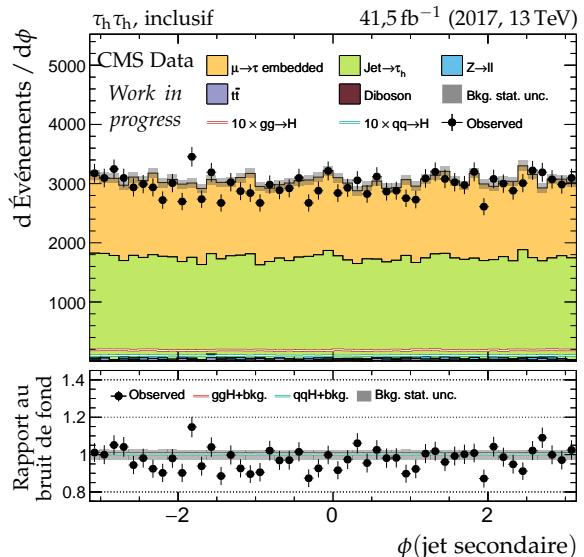
**(c)** Pseudo-rapidité du jet principal.



**(d)** Pseudo-rapidité du jet secondaire.

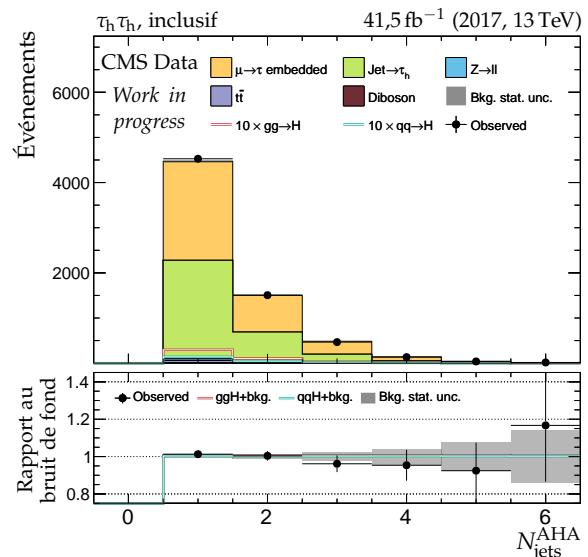
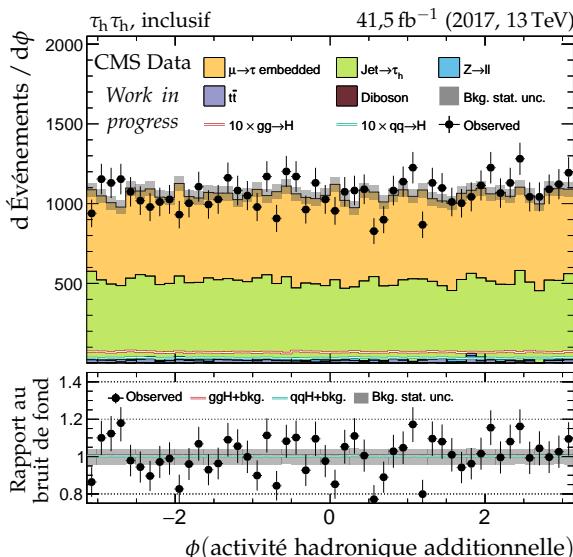
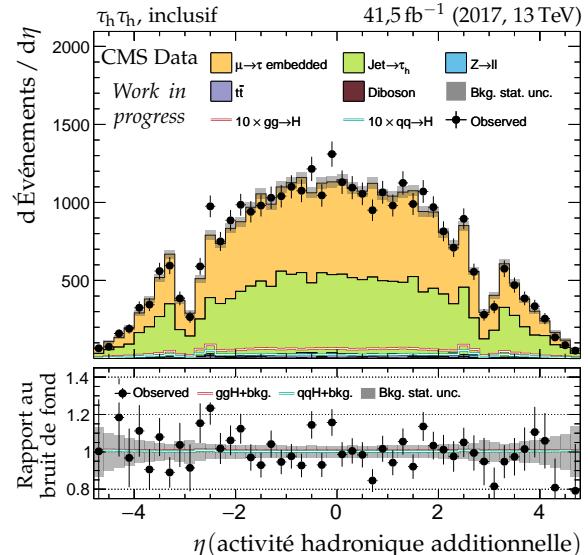
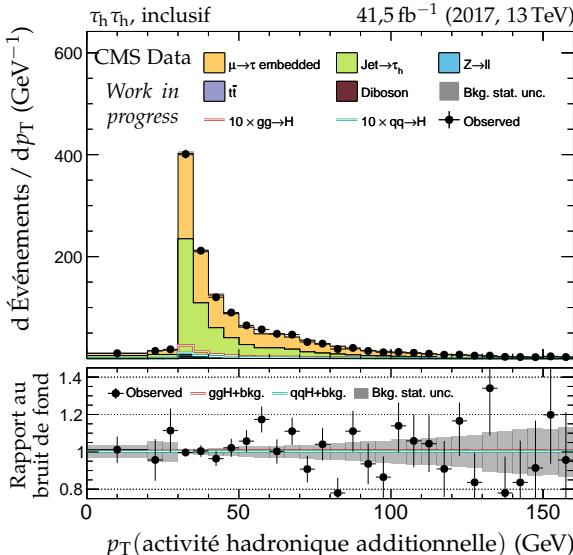
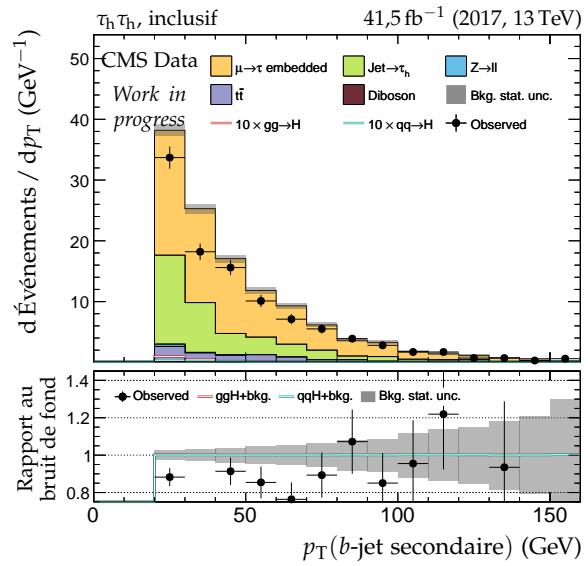
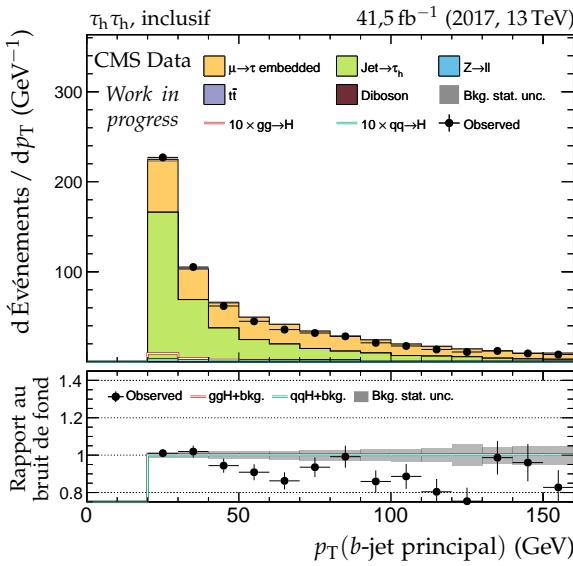


**(e)** Angle azimutal du jet principal.

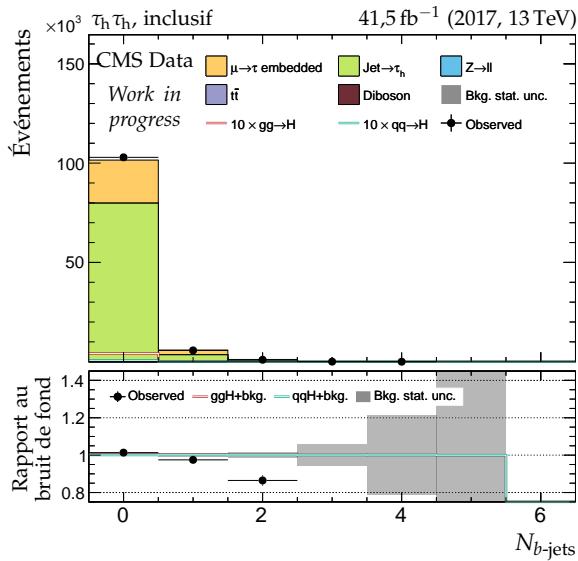


**(f)** Angle azimutal du jet secondaire.

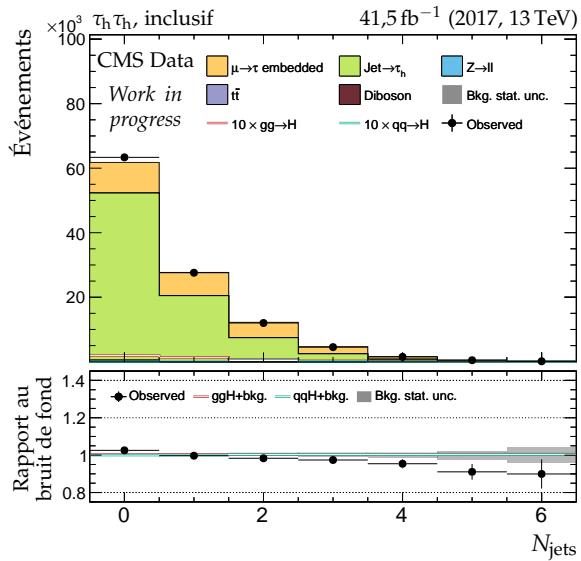
**Figure X.30 – Canal  $\tau_h \tau_h$ , 2017 : cinématique des deux jets principaux.**



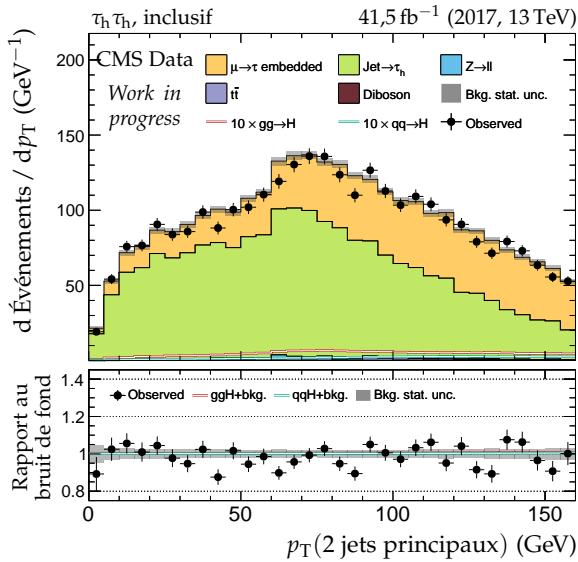
**Figure X.31 – Canal  $\tau_h \tau_h$ , 2017 : b-jets et activité hadronique additionnelle.**



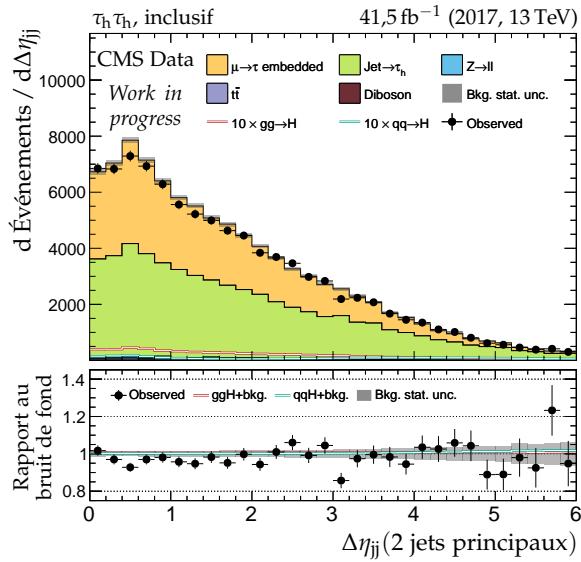
(a) Nombre de  $b$ -jets.



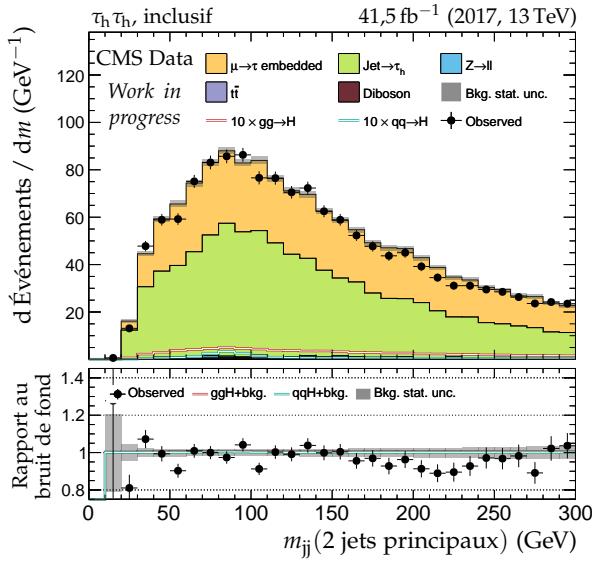
(b) Nombre de jets.



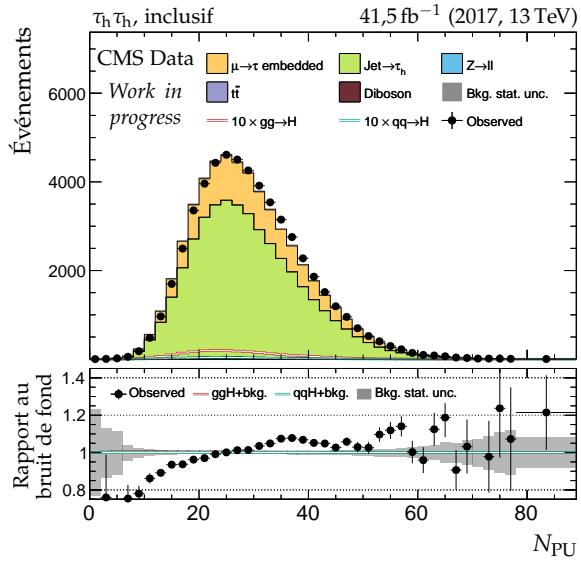
(c) Impulsion transverse du système des deux jets.



(d) Distance en  $\eta$  entre les deux jets.

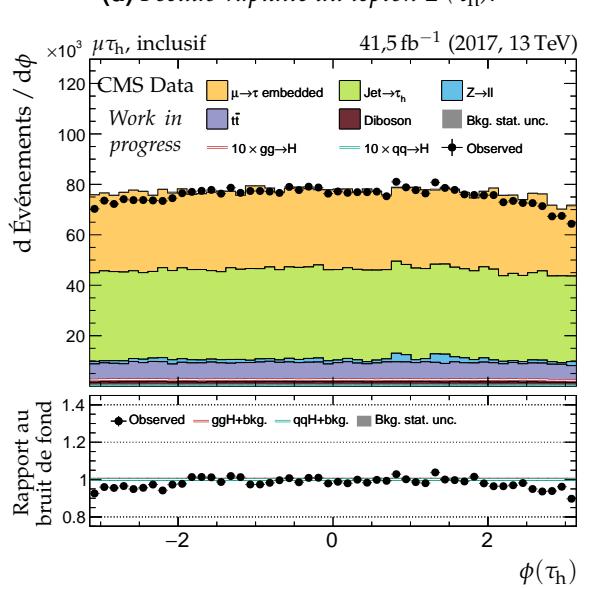
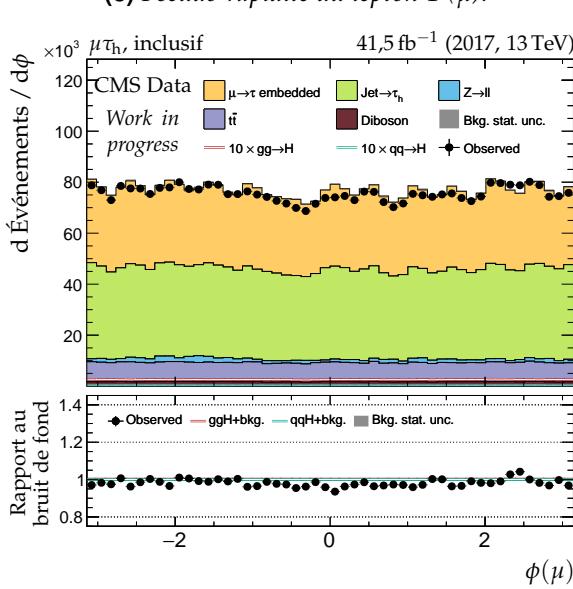
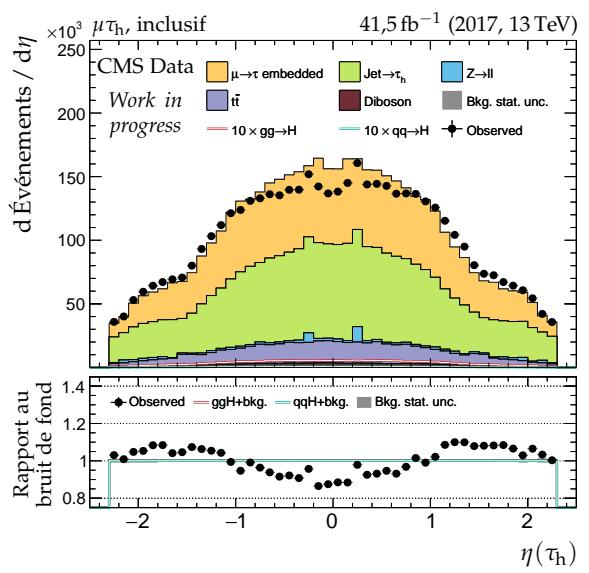
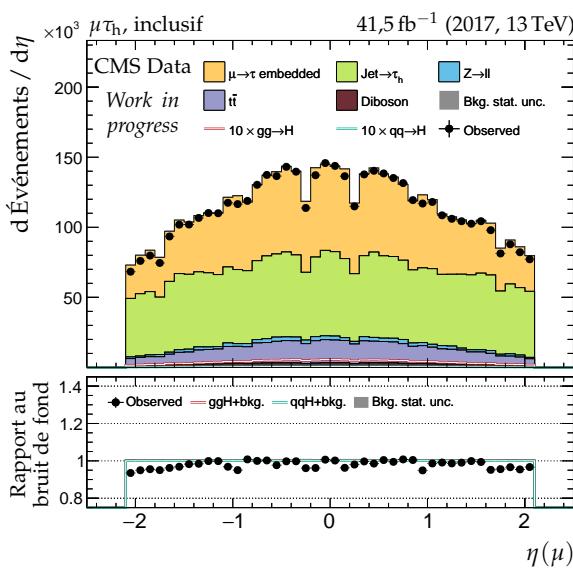
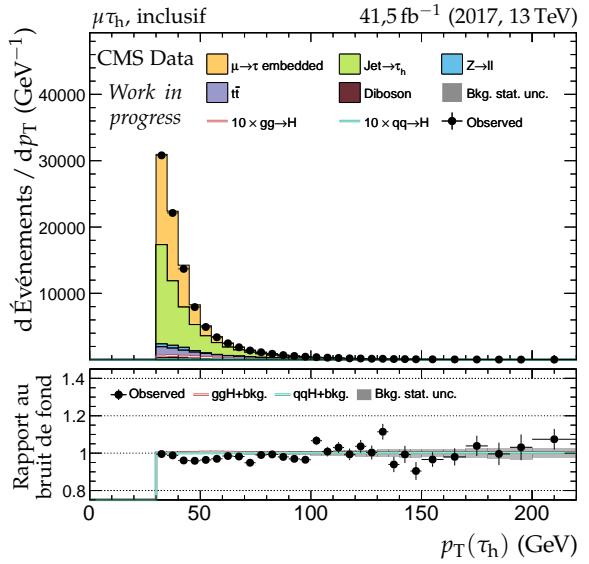
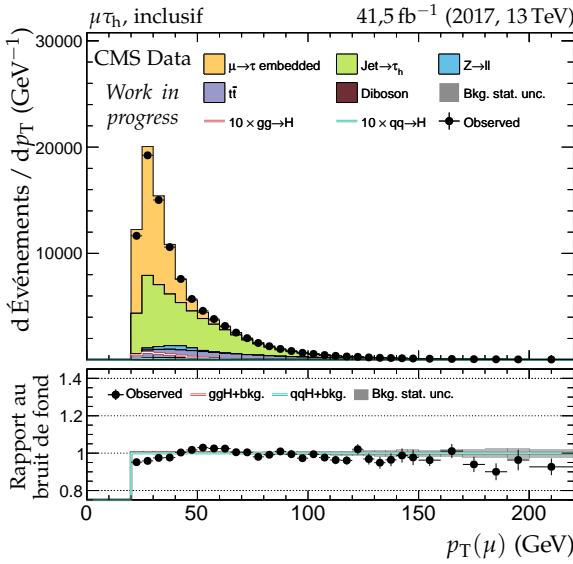


(e) Masse invariante du système des deux jets.

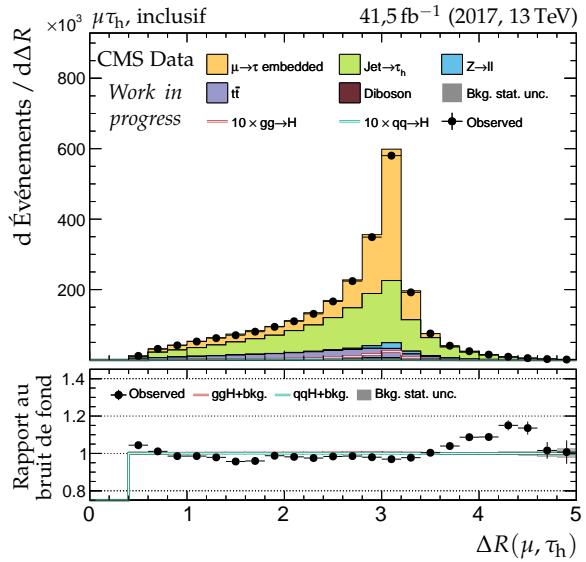
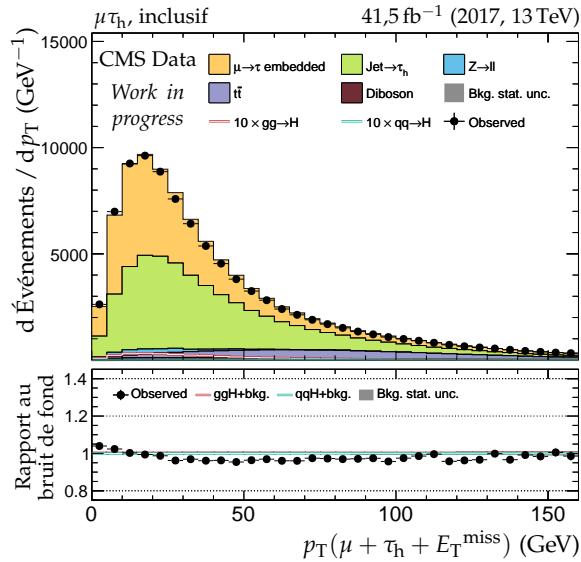
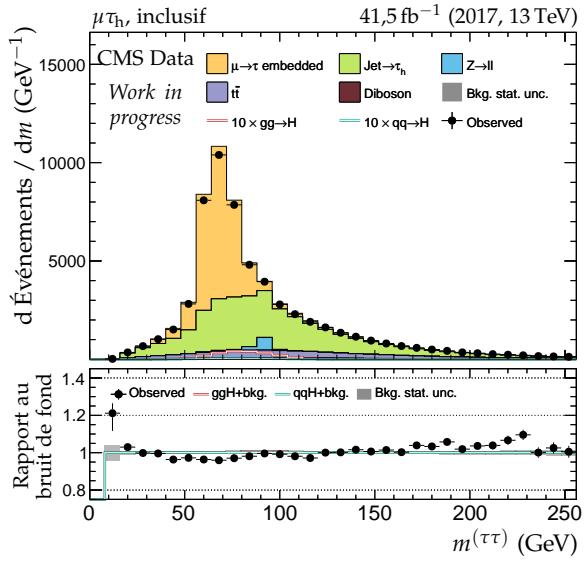
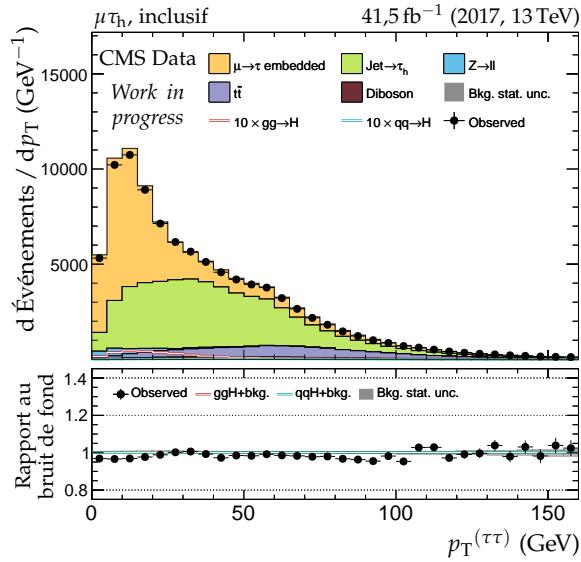
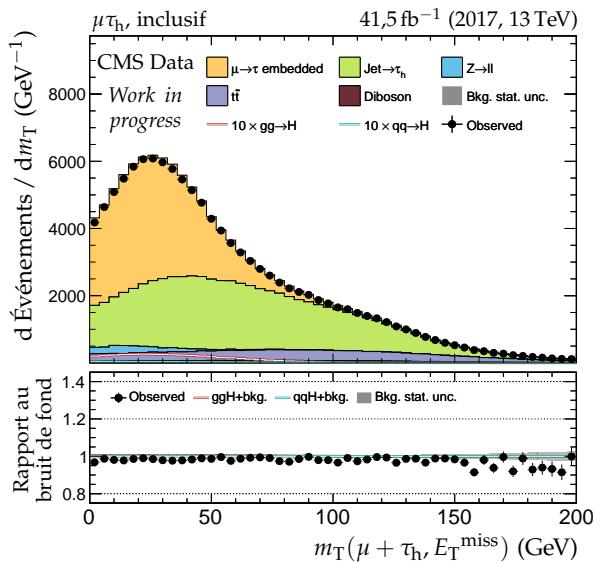
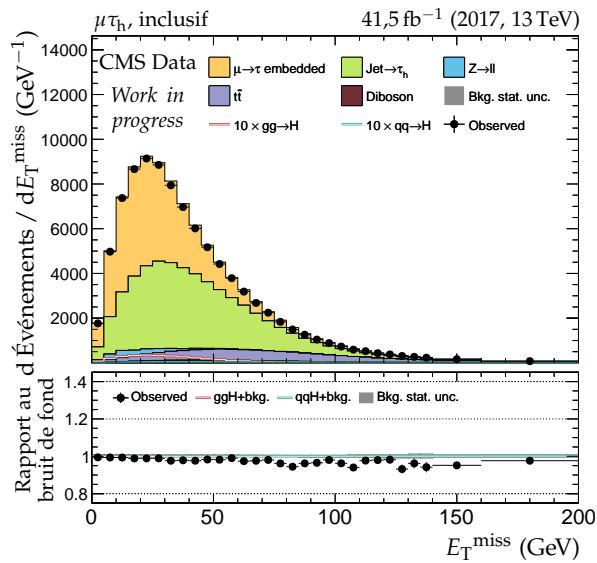


(f) Nombre de vertex d'empilement.

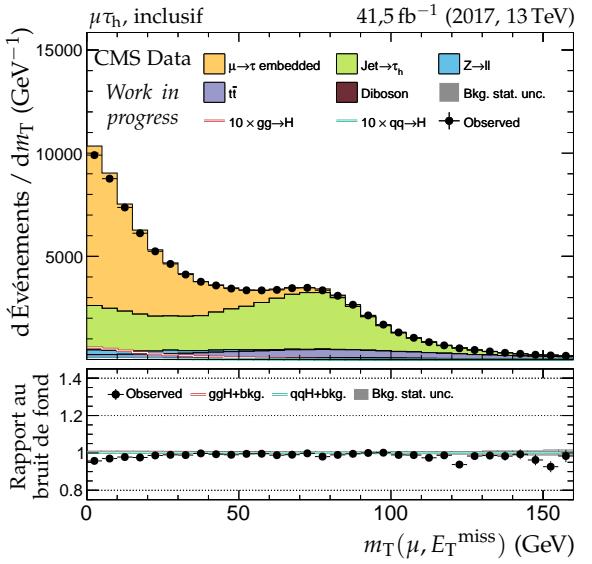
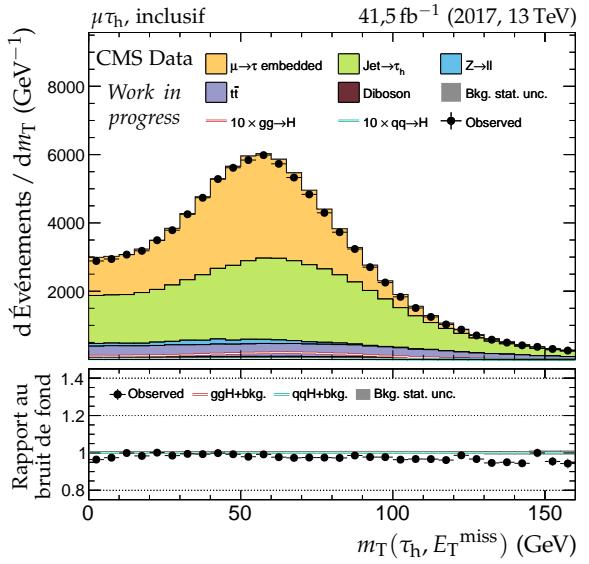
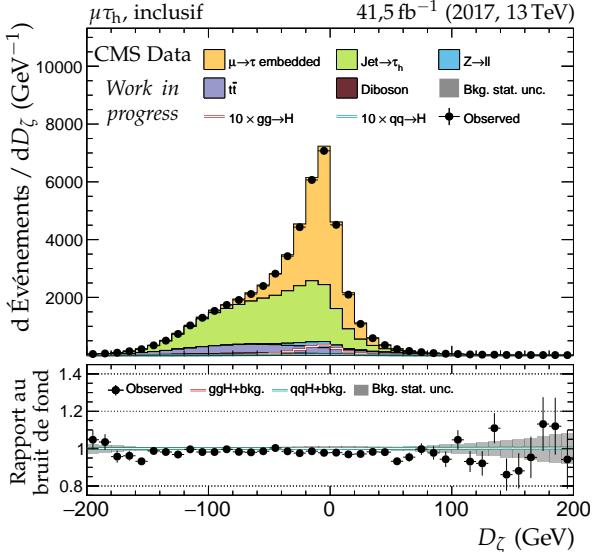
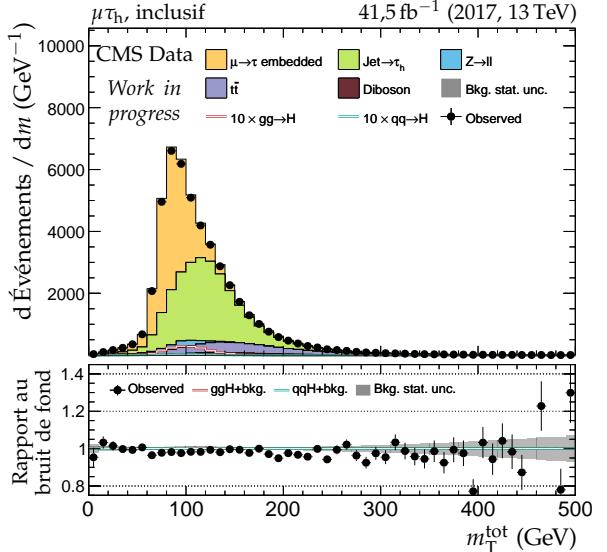
**Figure X.32 – Canal  $\tau_h \tau_h$ , 2017 : nombre de jets, système des deux jets principaux et empilement.**



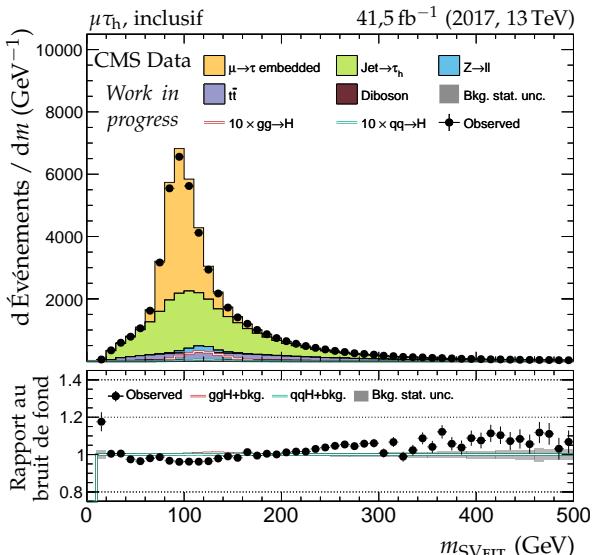
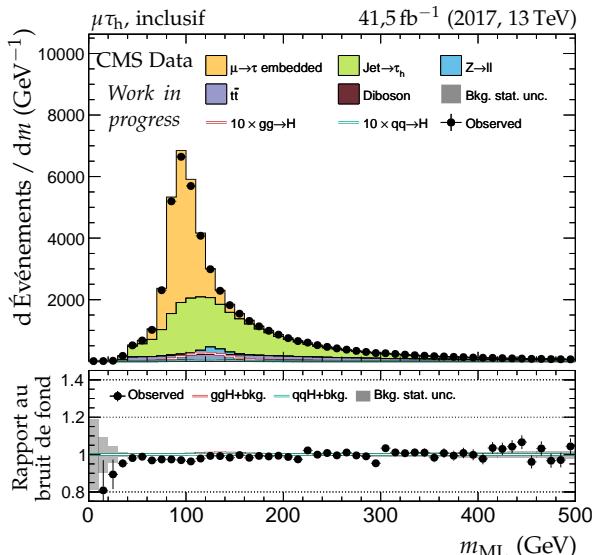
**Figure X.33 – Canal  $\mu\tau_h$ , 2017 : cinématique des leptons ( $\mu, \tau_h$ ).**

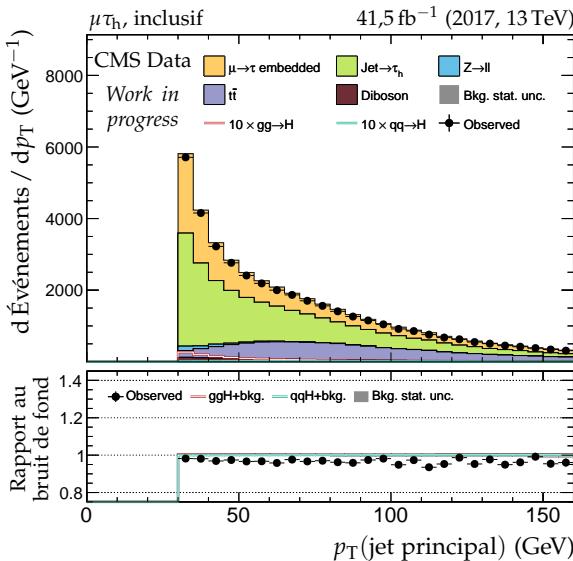


**Figure X.34 – Canal  $\mu\tau_h$ , 2017 : dilepton et énergie transverse manquante.**

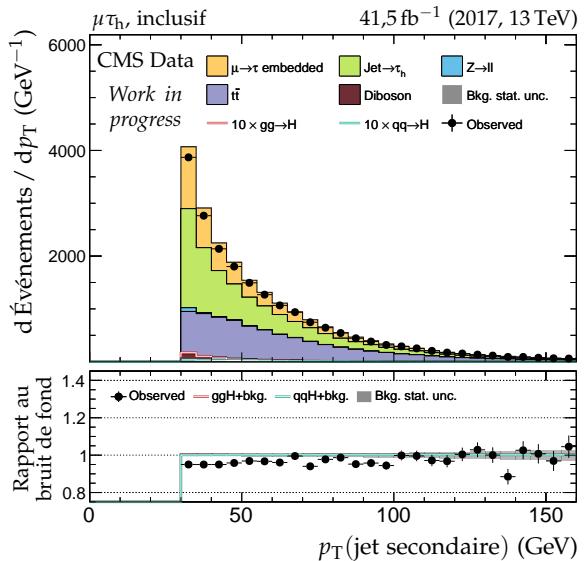
(a) Masse transverse du lepton 1 ( $\mu$ ).(b) Masse transverse du lepton 2 ( $\tau_h$ ).(c) Valeur de  $D_\zeta$ .

(d) Masse transverse totale.

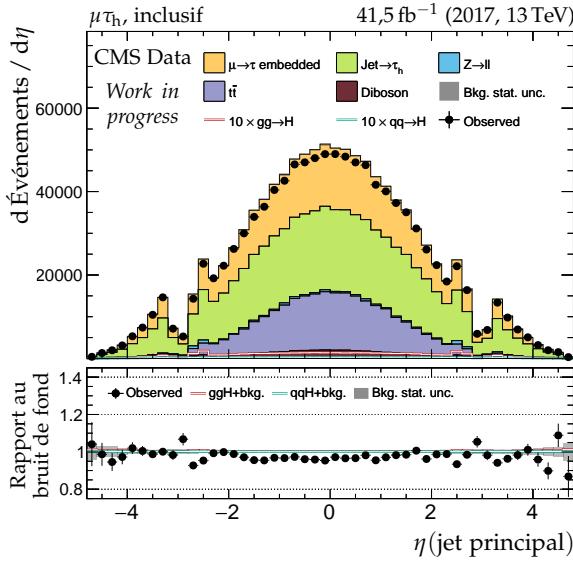
(e) Masse du système di- $\tau$  d'après SVFIT.(f) Masse du système di- $\tau$  d'après le ML.**Figure X.35 – Canal  $\mu\tau_h$ , 2017 : masses transverses,  $D_\zeta$  et masses.**



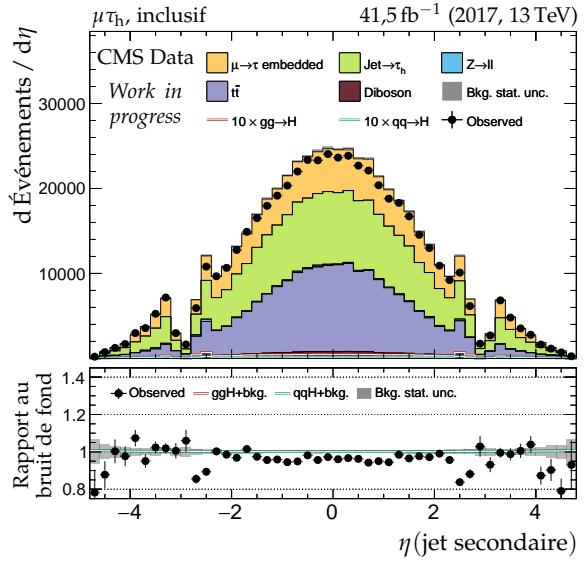
(a) Impulsion transverse du jet principal.



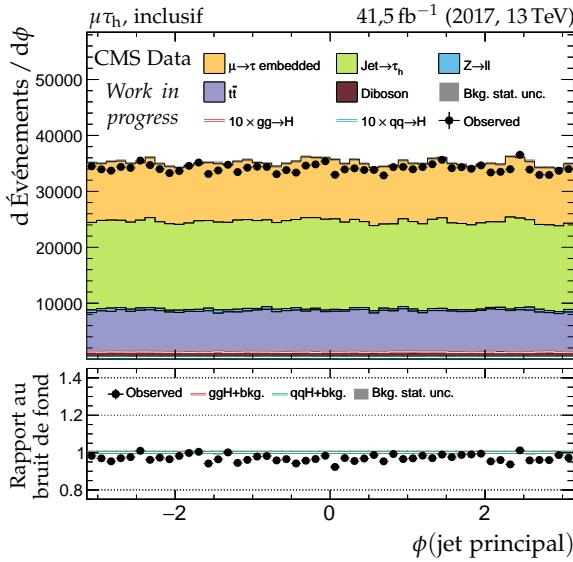
(b) Impulsion transverse du jet secondaire.



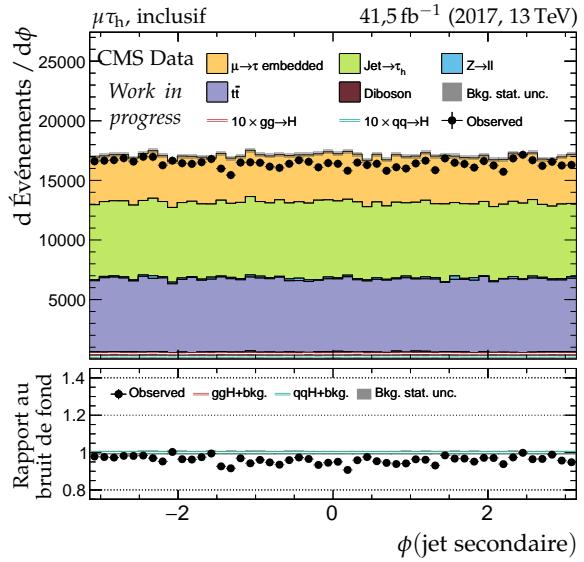
(c) Pseudo-rapidité du jet principal.



(d) Pseudo-rapidité du jet secondaire.

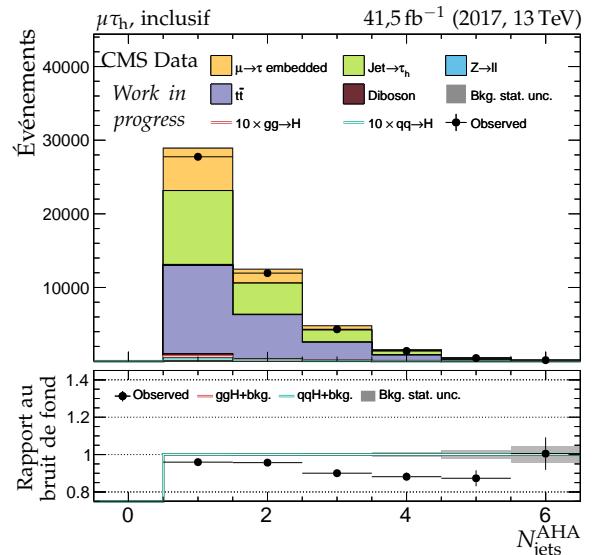
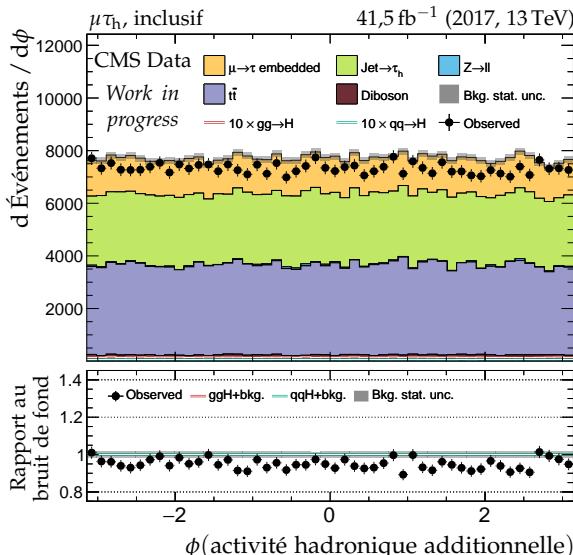
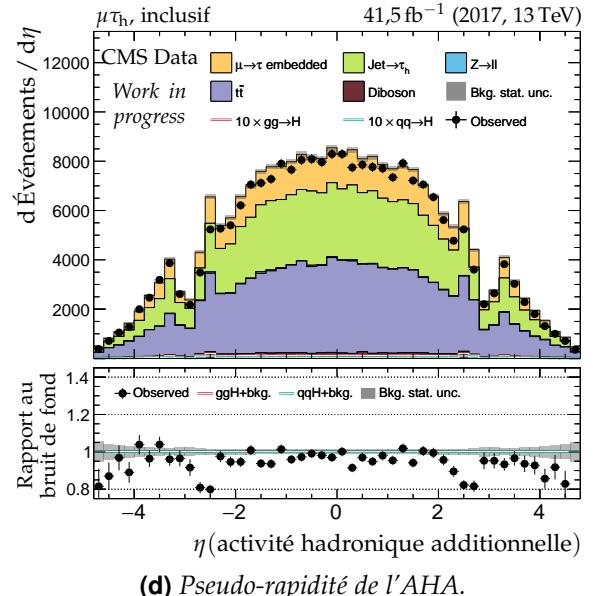
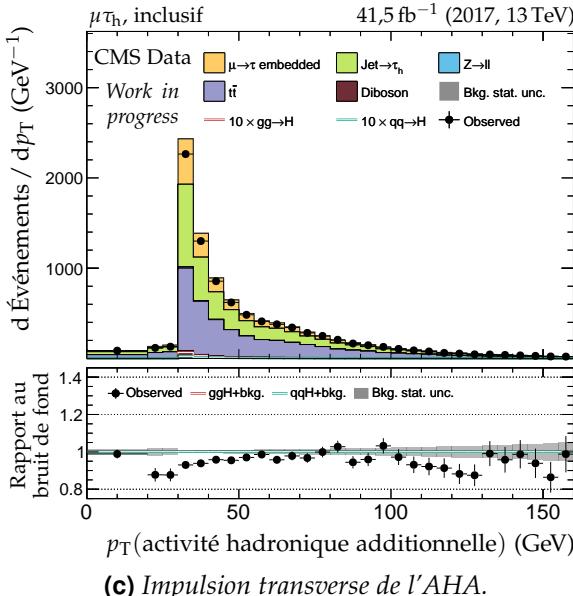
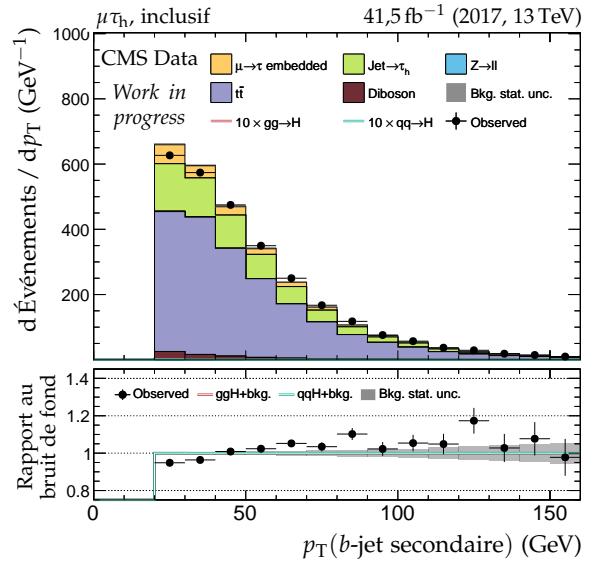
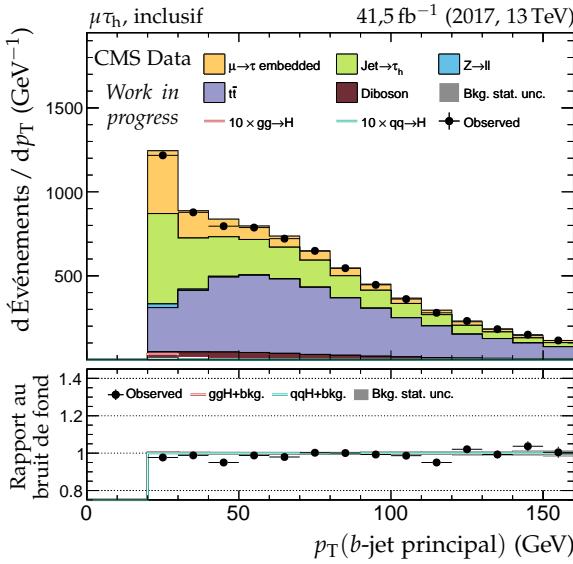


(e) Angle azimutal du jet principal.

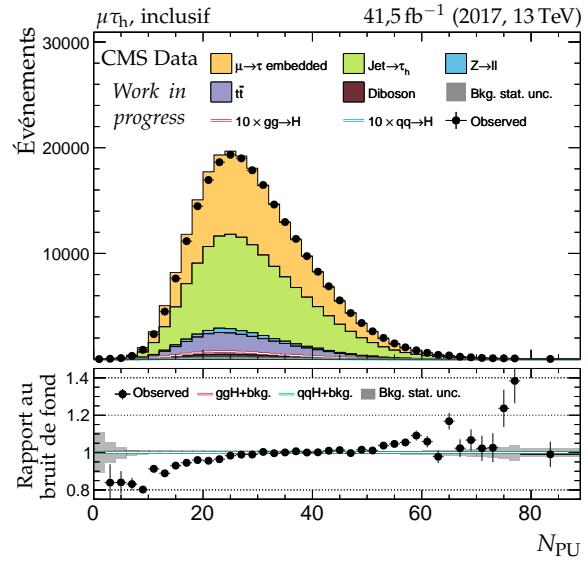
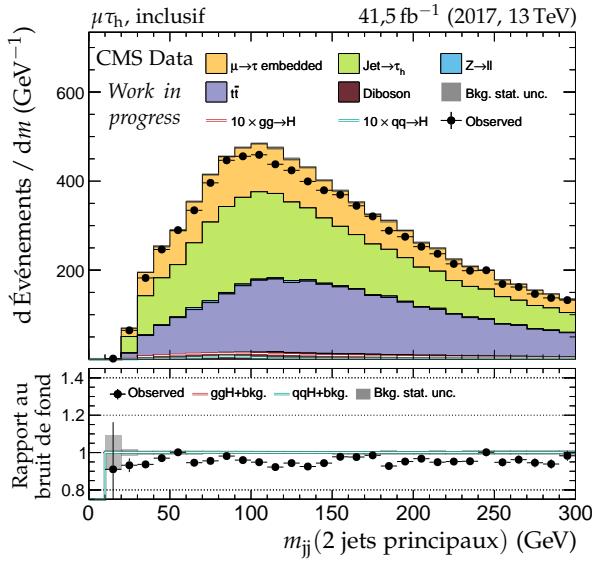
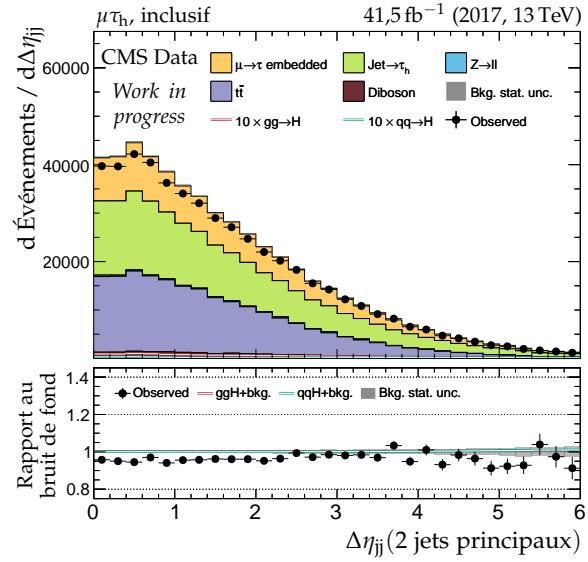
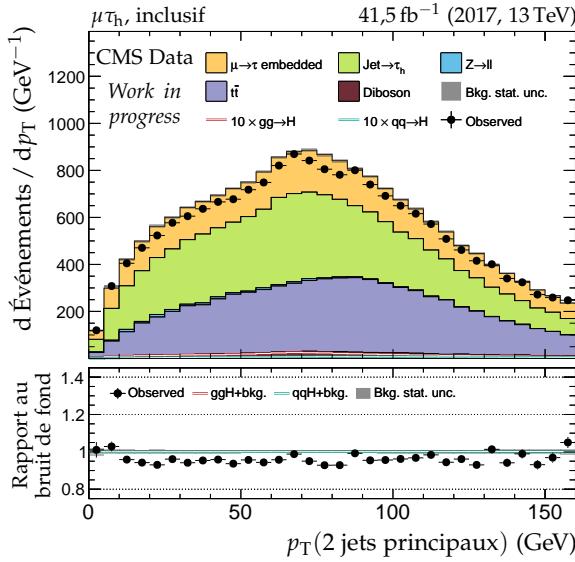
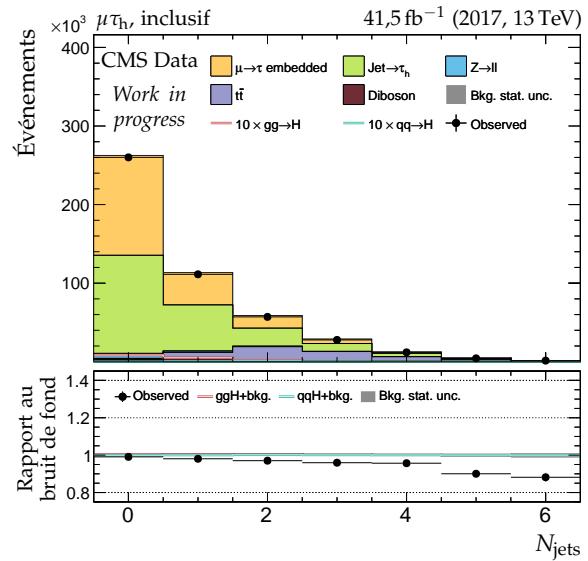
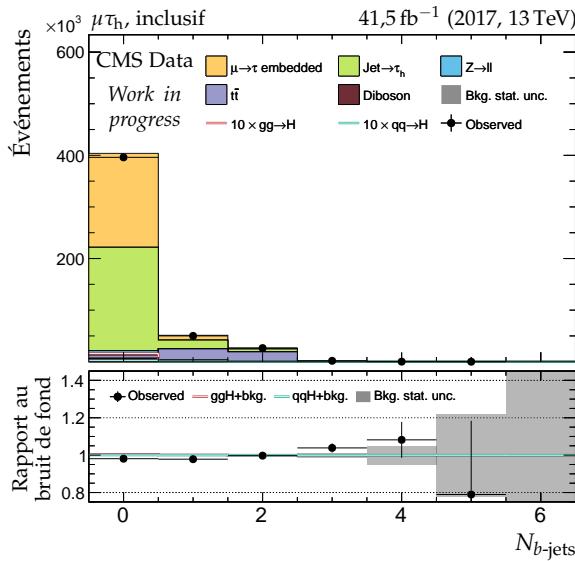


(f) Angle azimutal du jet secondaire.

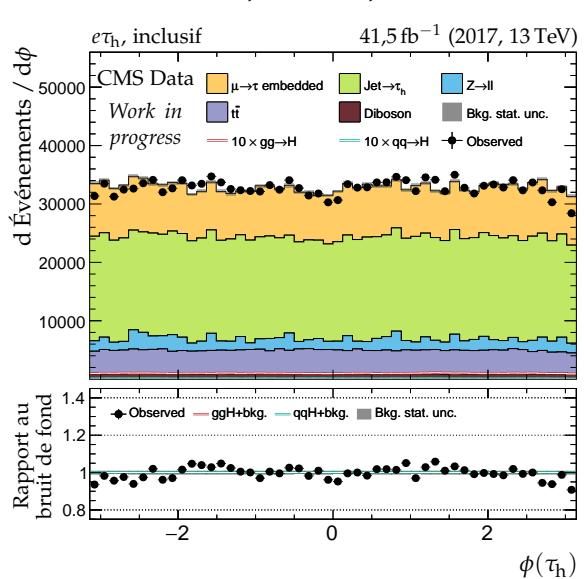
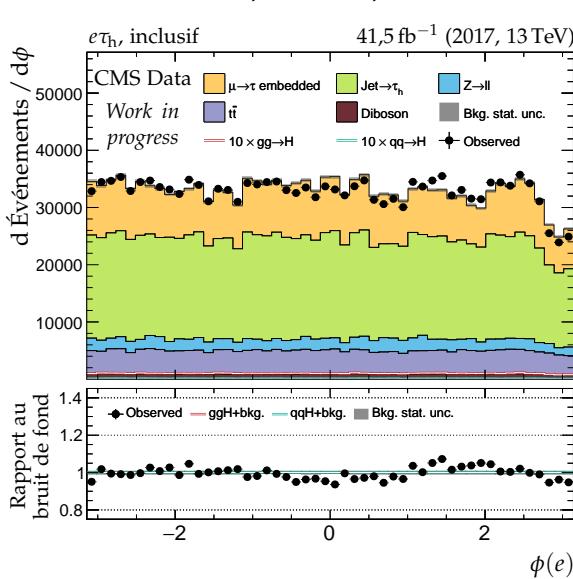
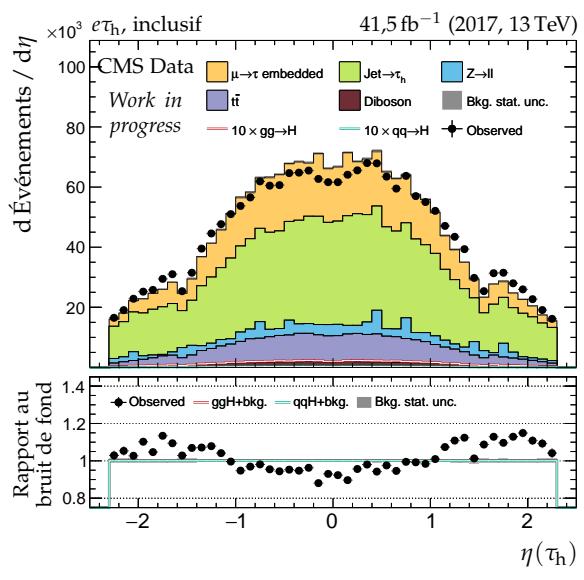
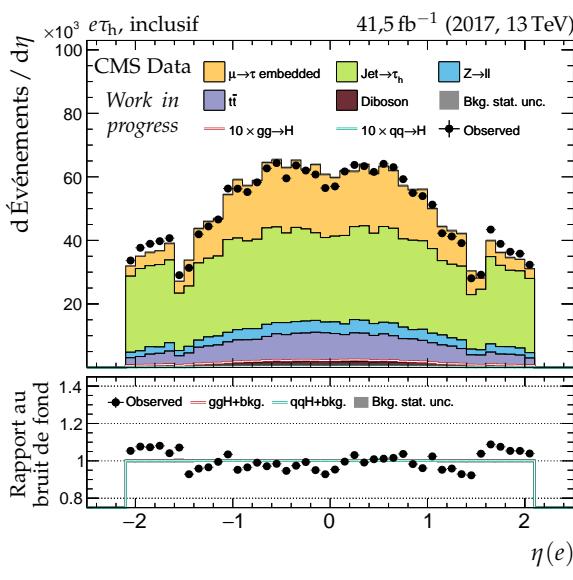
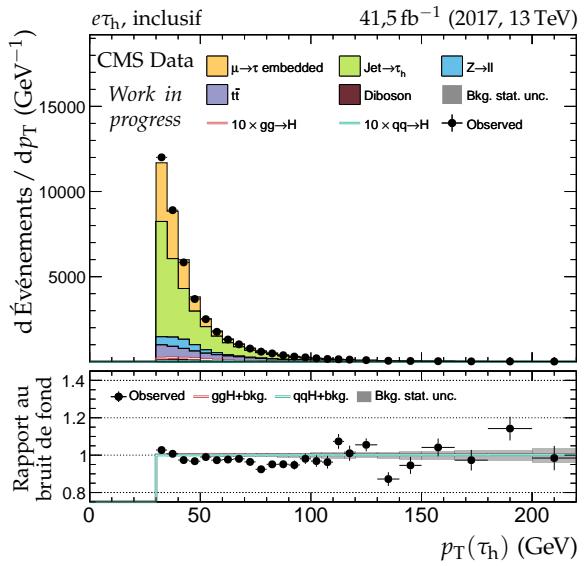
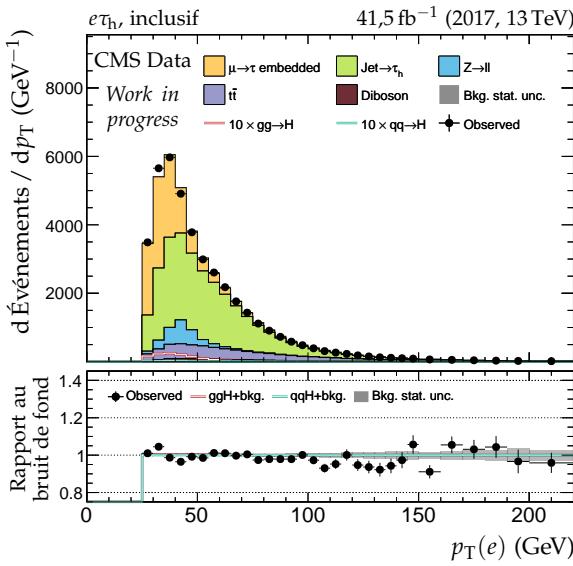
Figure X.36 – Canal  $\mu\tau_h$ , 2017 : cinématique des deux jets principaux.



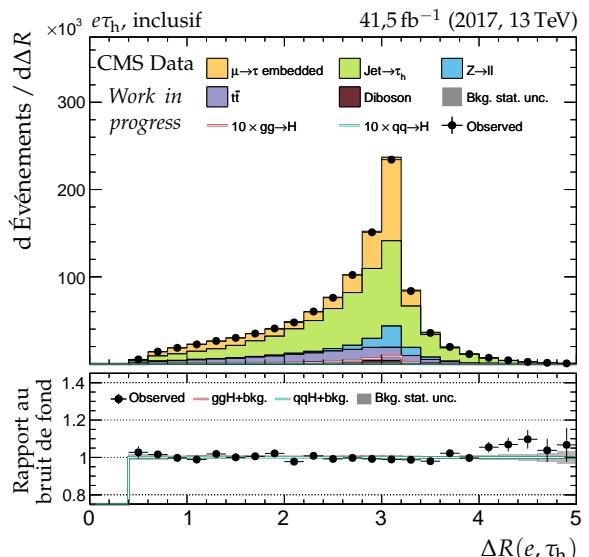
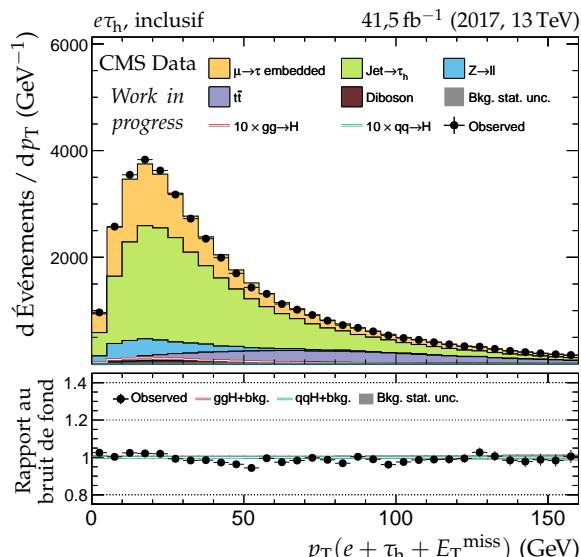
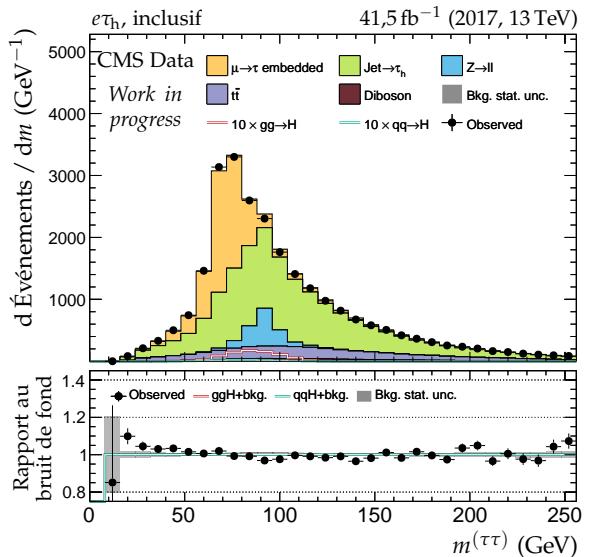
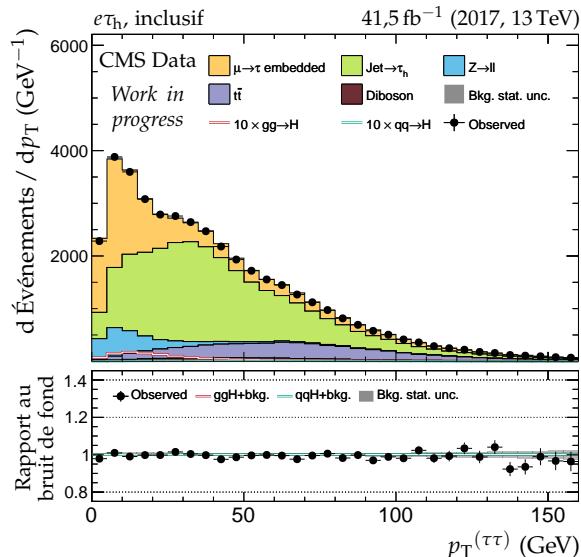
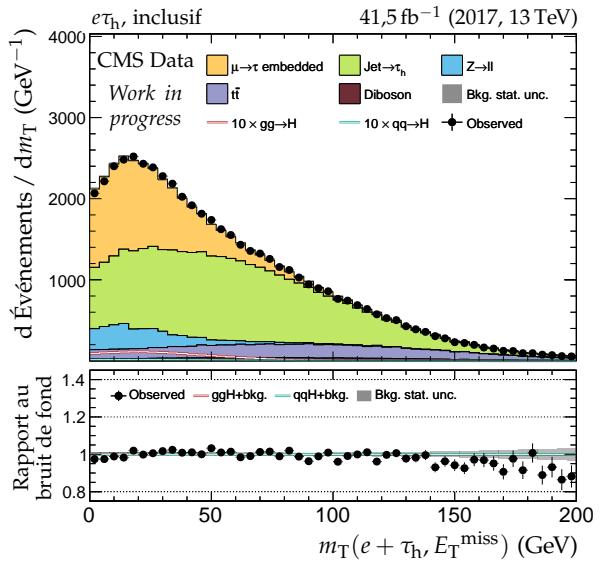
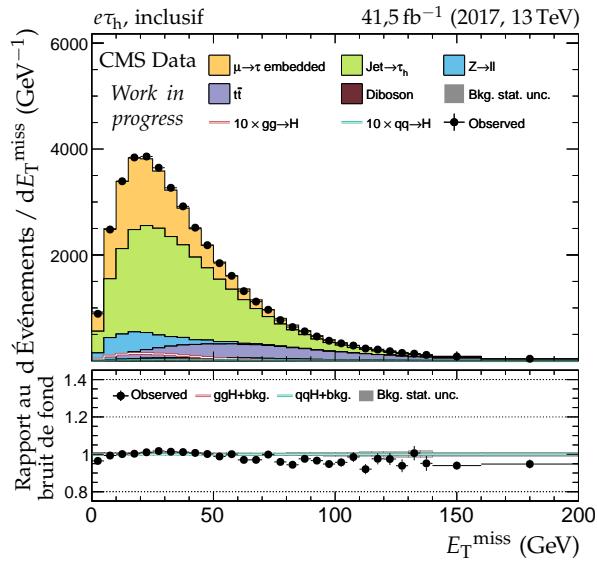
**Figure X.37 – Canal  $\mu\tau_h$ , 2017 : b-jets et activité hadronique additionnelle.**



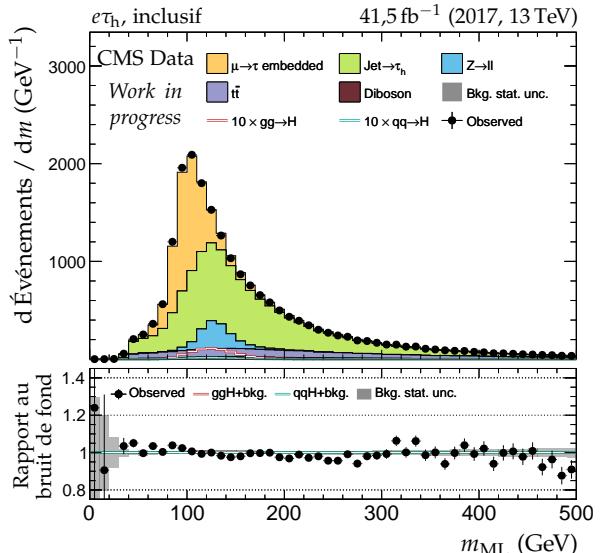
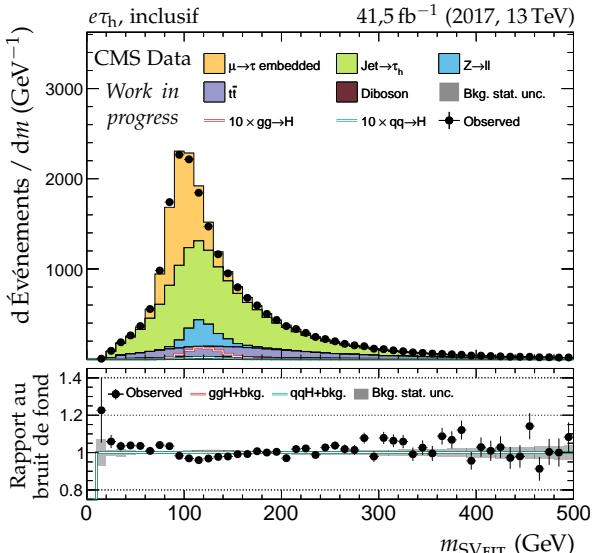
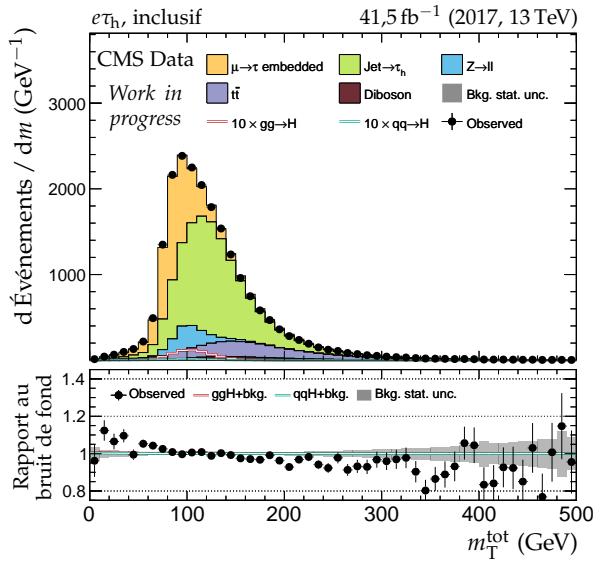
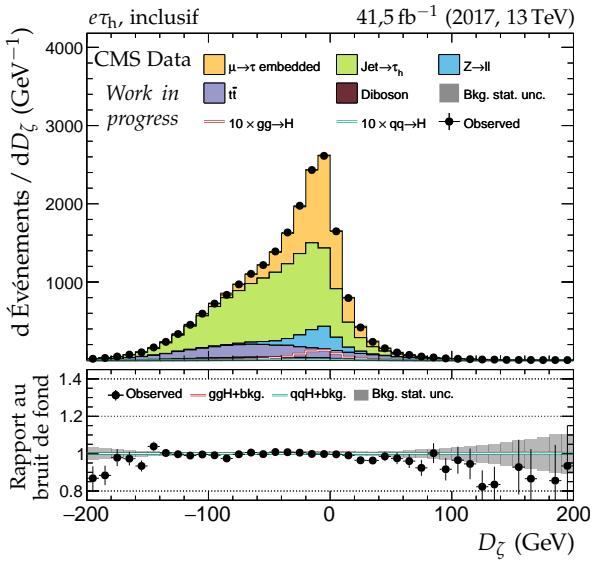
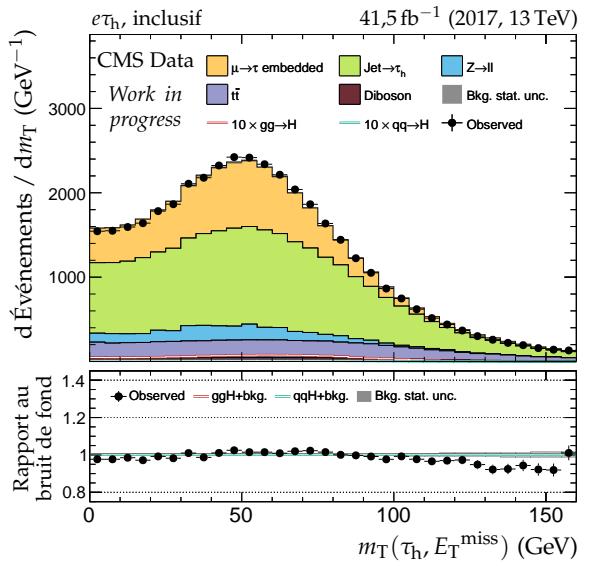
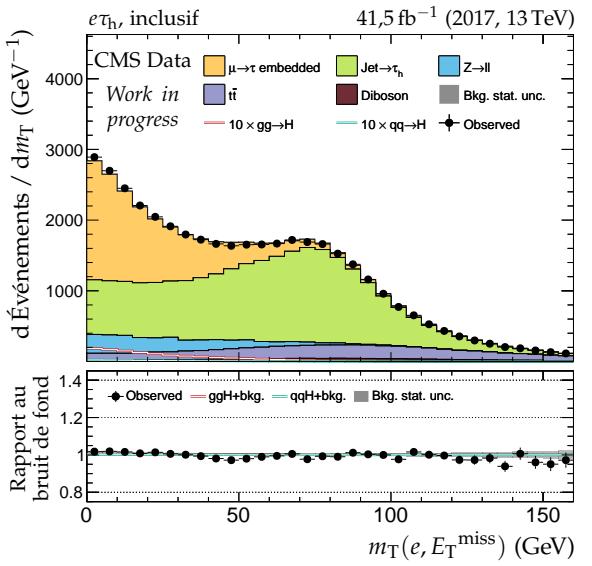
**Figure X.38 – Canal  $\mu\tau_h$ , 2017 : nombre de jets, système des deux jets principaux et empilement.**



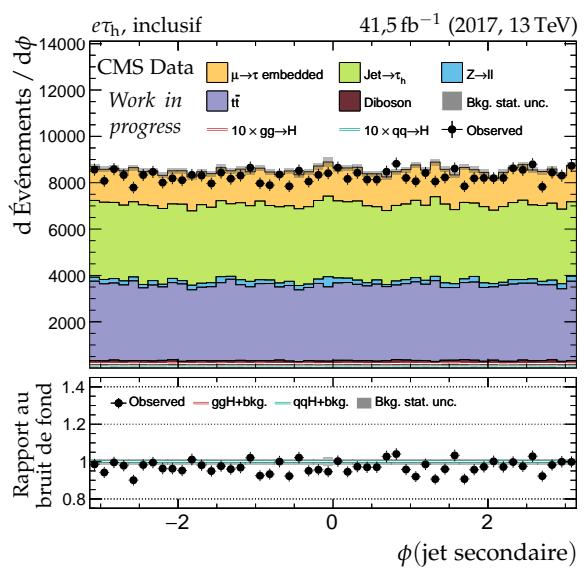
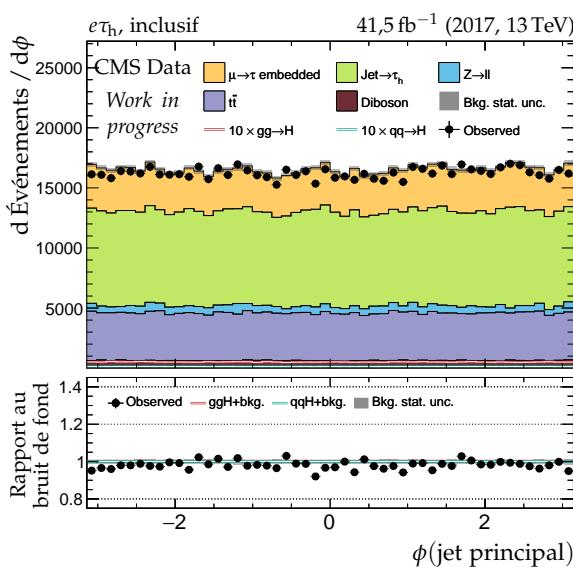
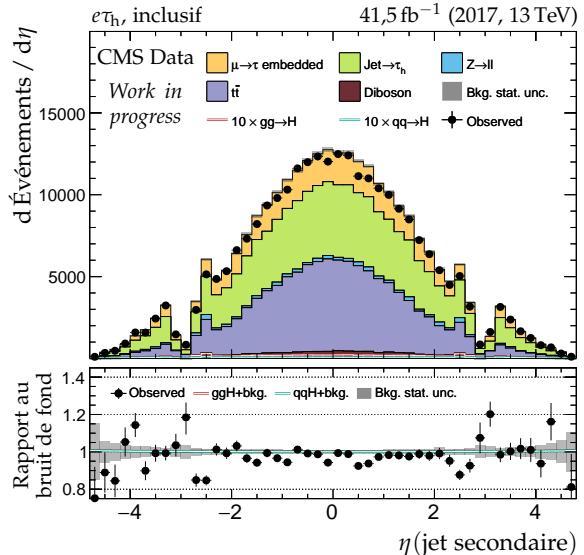
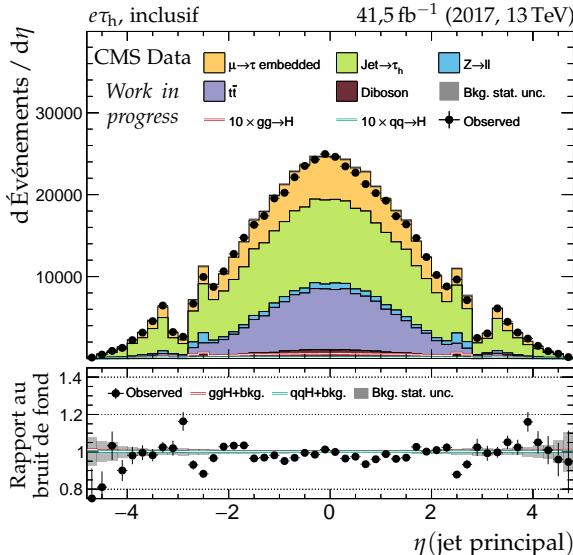
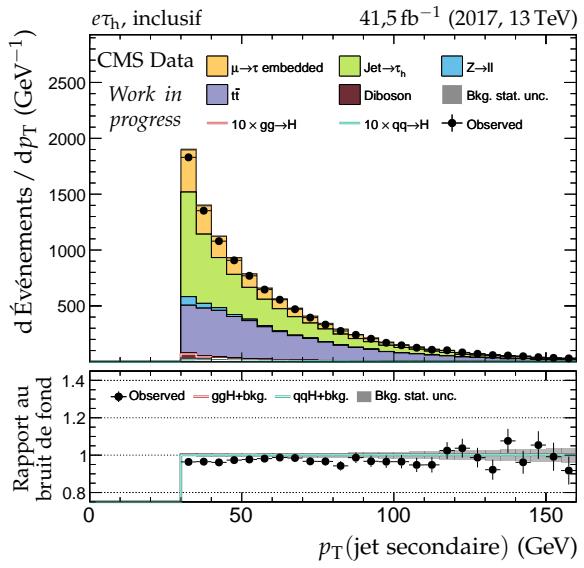
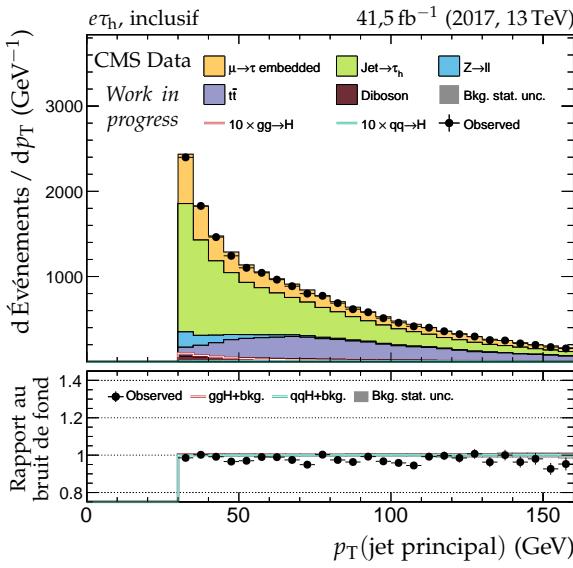
**Figure X.39 – Canal  $e\tau_h$ , 2017 : cinématique des leptons ( $e, \tau_h$ ).**



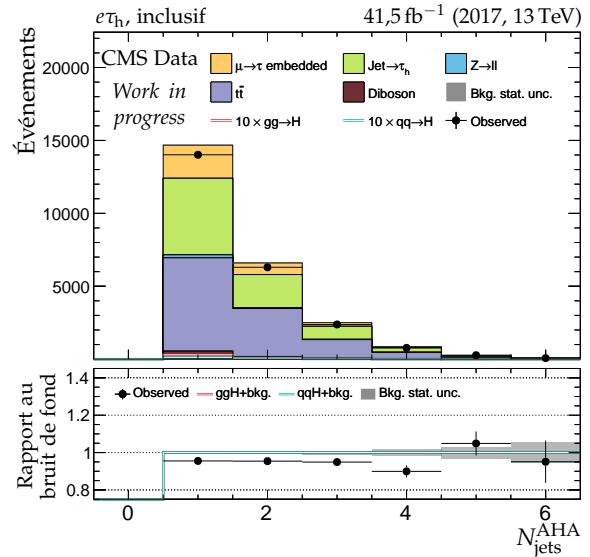
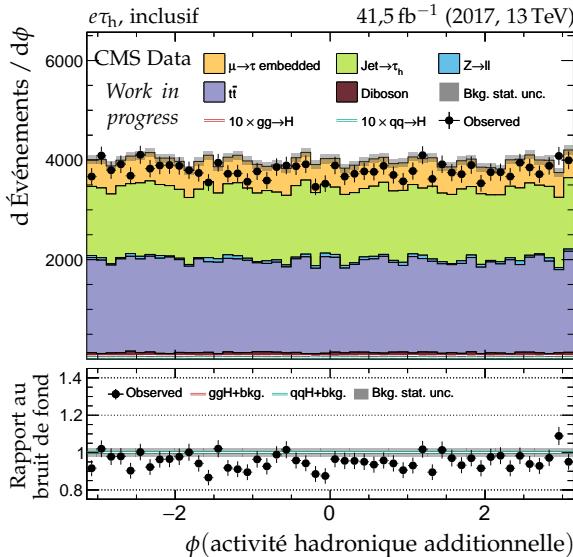
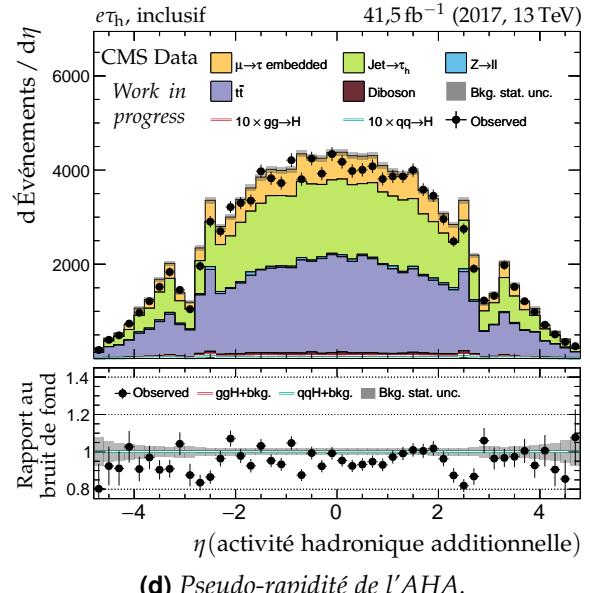
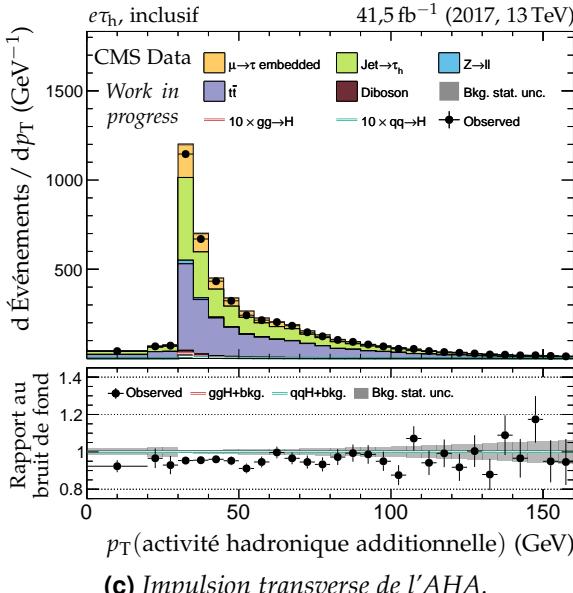
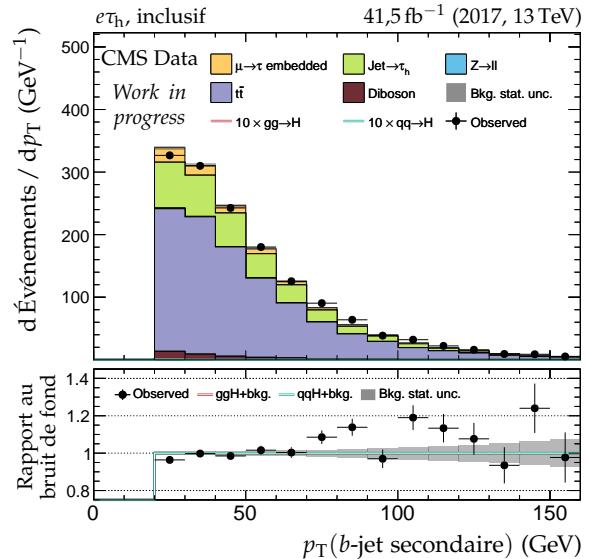
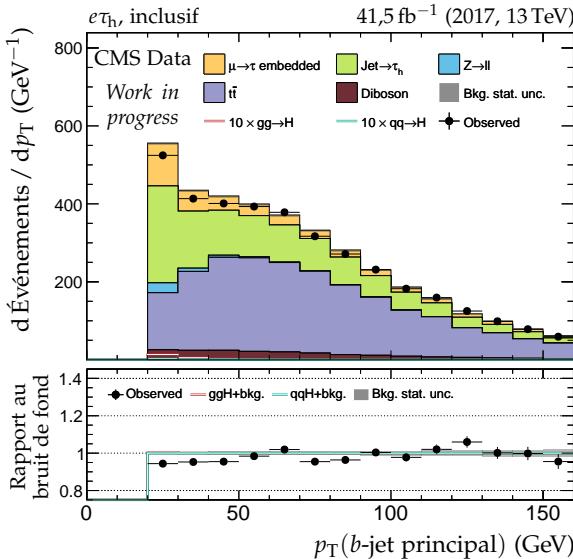
**Figure X.40 – Canal  $e\tau_h$ , 2017 : dilepton et énergie transverse manquante.**



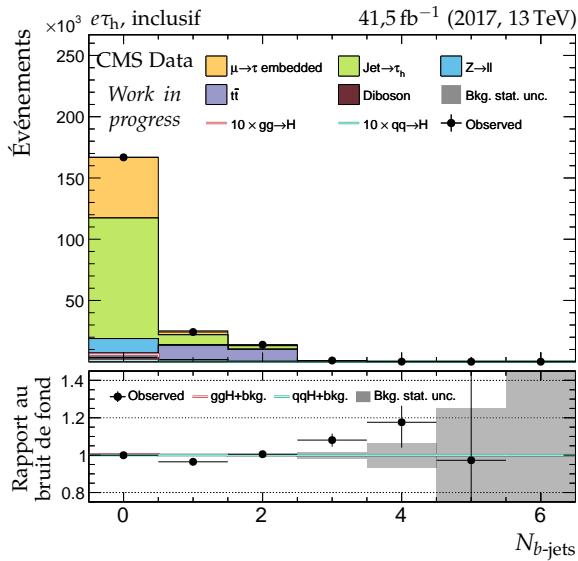
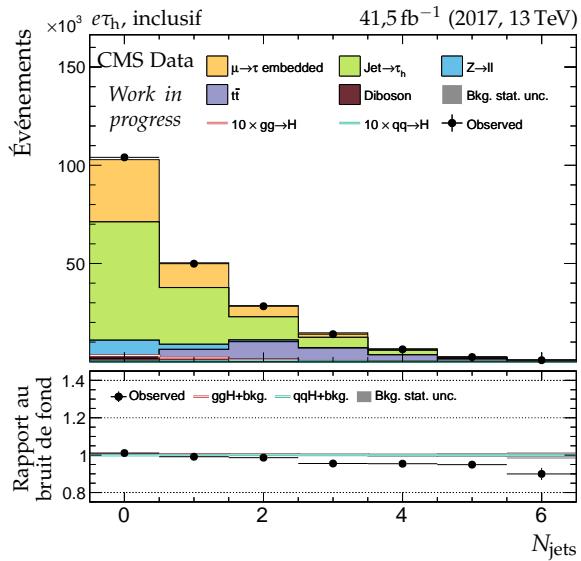
**Figure X.41 – Canal  $e\tau_h$ , 2017 : masses transverses,  $D_\zeta$  et masses.**



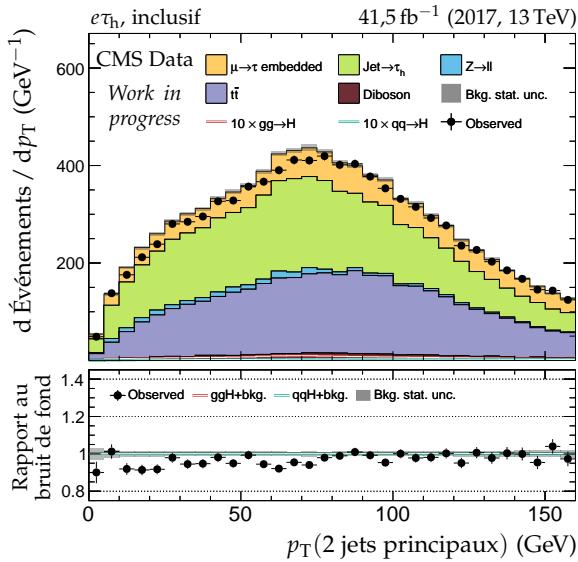
**Figure X.42 – Canal  $e\tau_h$ , 2017 : cinématique des deux jets principaux.**



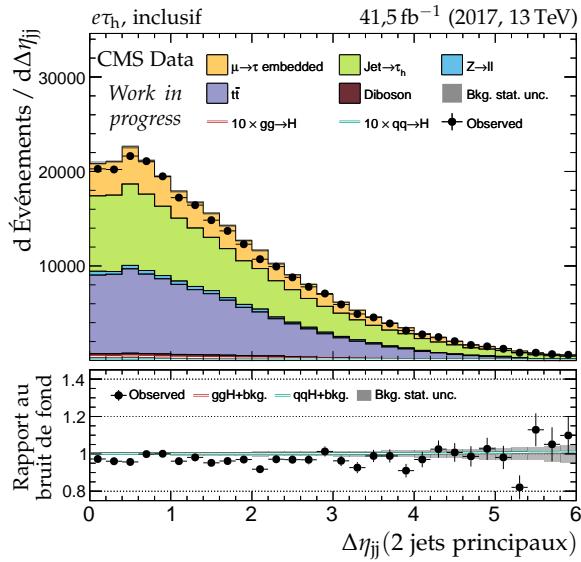
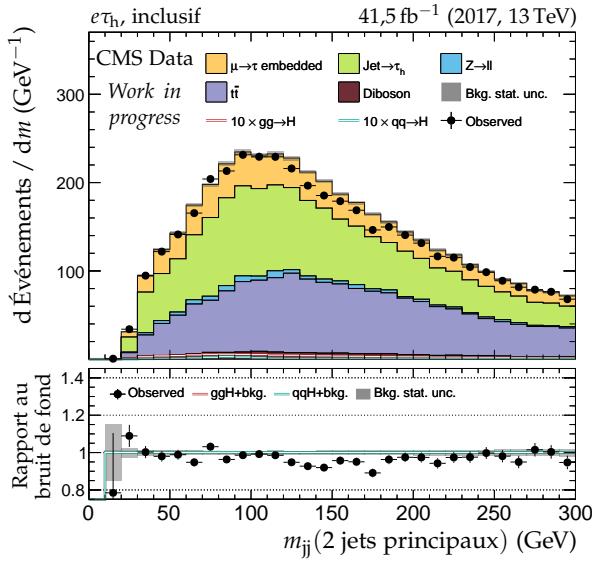
**Figure X.43 – Canal  $e\tau_h$ , 2017 :  $b$ -jets et activité hadronique additionnelle.**


 (a) Nombre de  $b$ -jets.


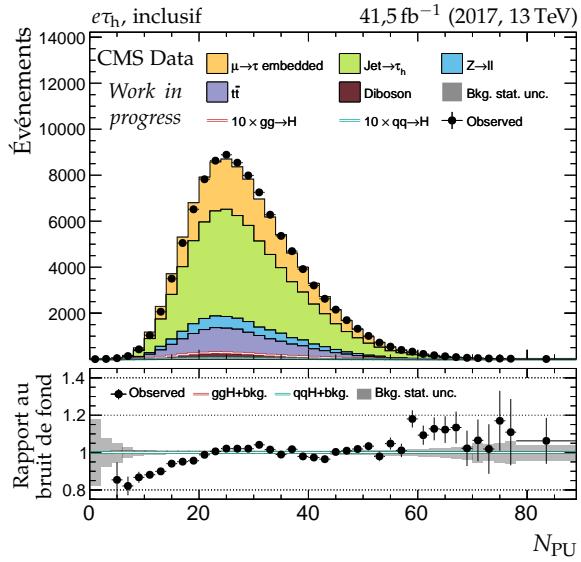
(b) Nombre de jets.



(c) Impulsion transverse du système des deux jets.

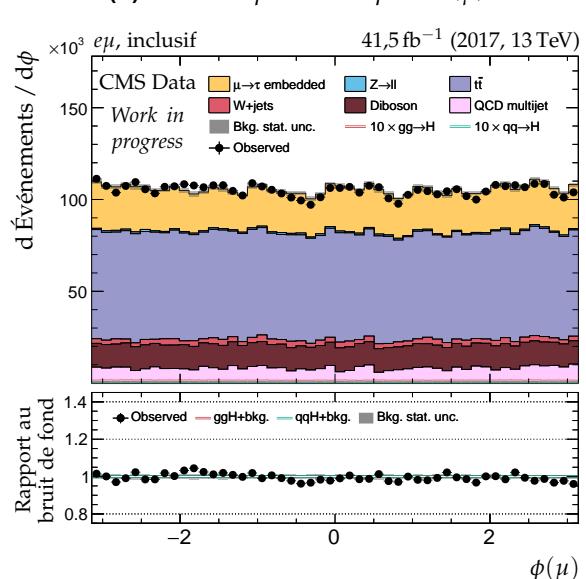
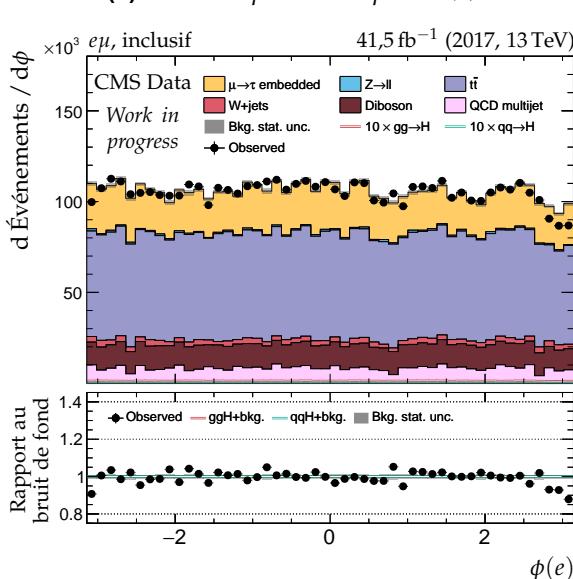
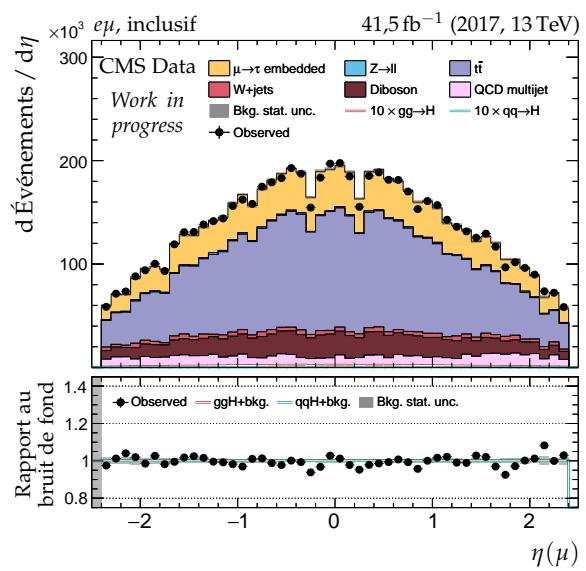
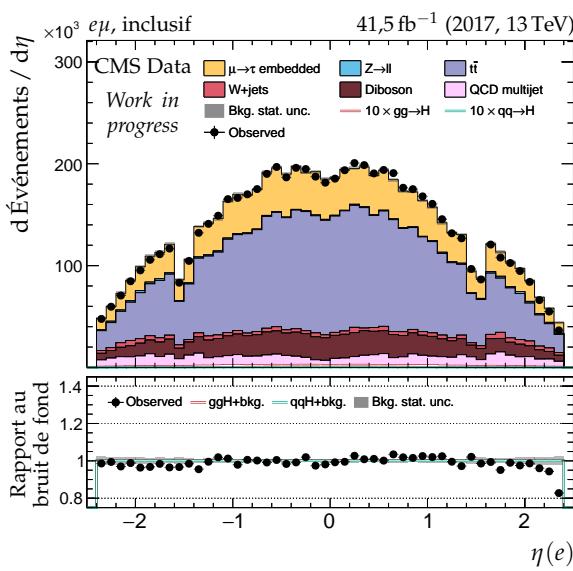
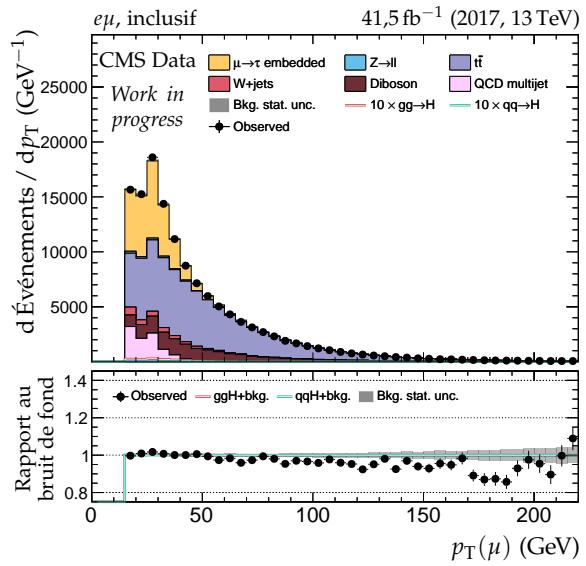
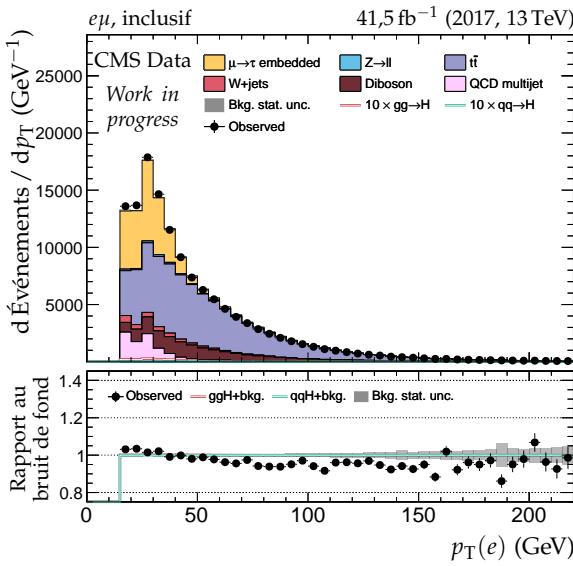

 (d) Distance en  $\eta$  entre les deux jets.


(e) Masse invariante du système des deux jets.

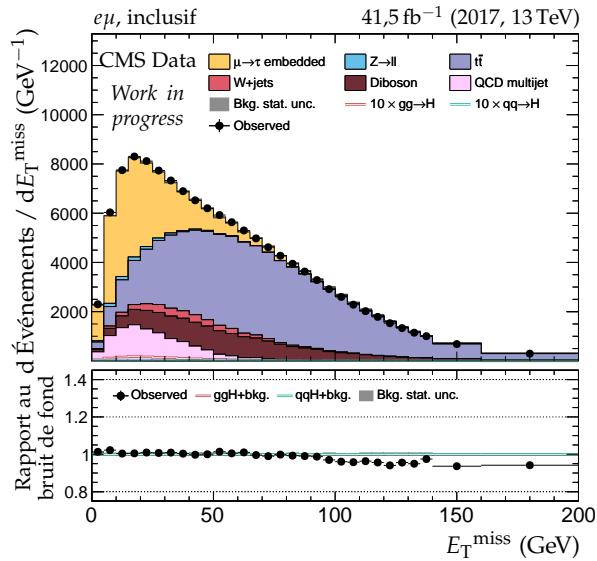


(f) Nombre de vertex d'empilement.

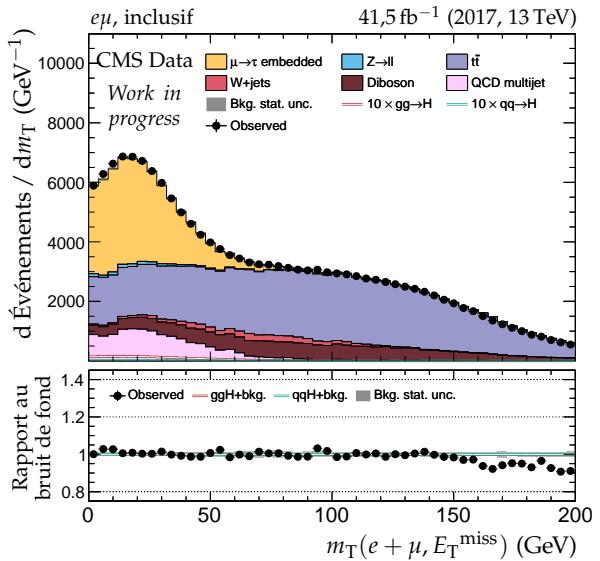
 Figure X.44 – Canal  $e\tau_h$ , 2017 : nombre de jets, système des deux jets principaux et empilement.



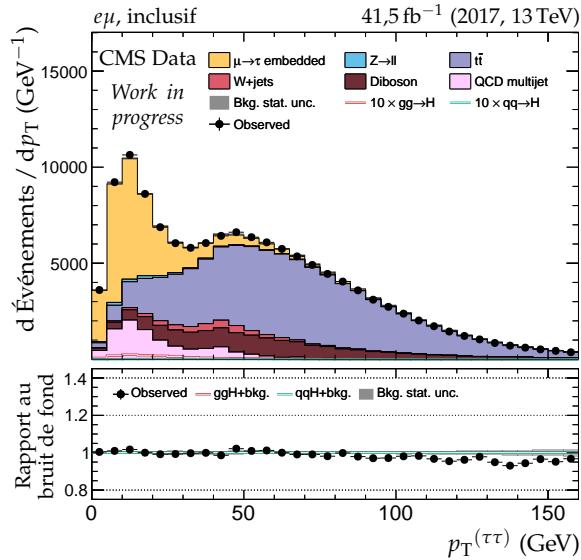
**Figure X.45 – Canal  $e\mu$ , 2017 : cinématique des leptons ( $e, \mu$ ).**



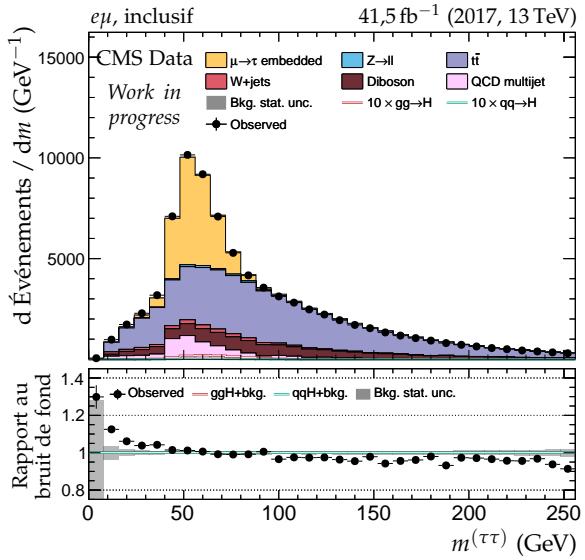
(a) Énergie transverse manquante.



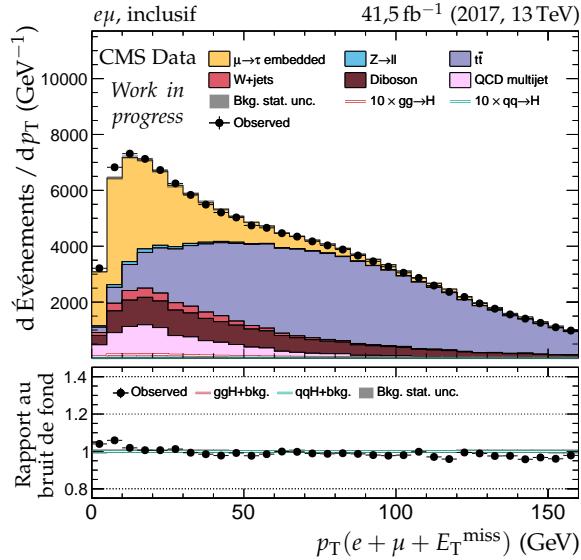
(b) Masse transverse du dilepton.



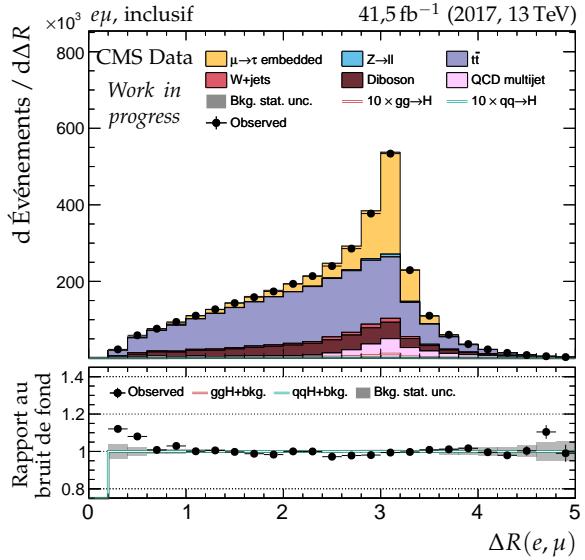
(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

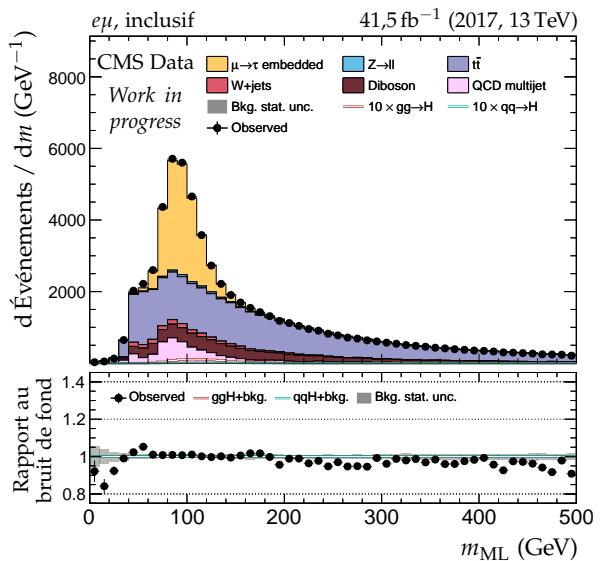
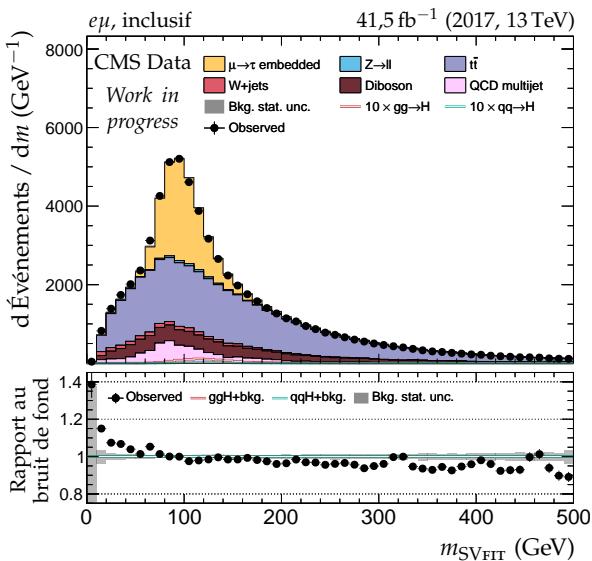
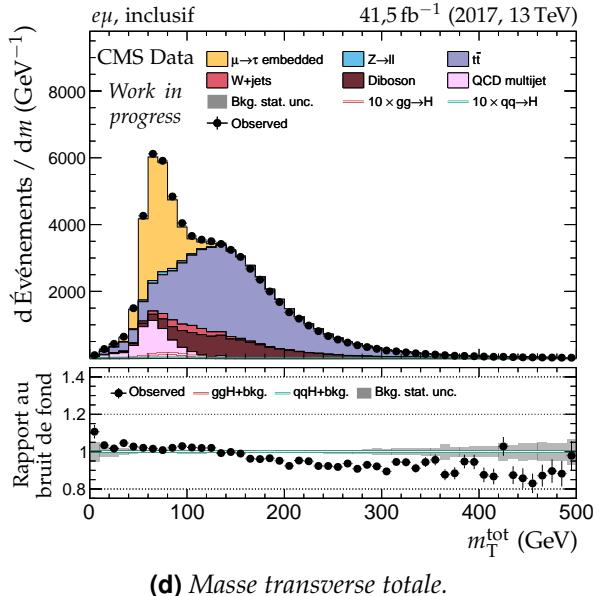
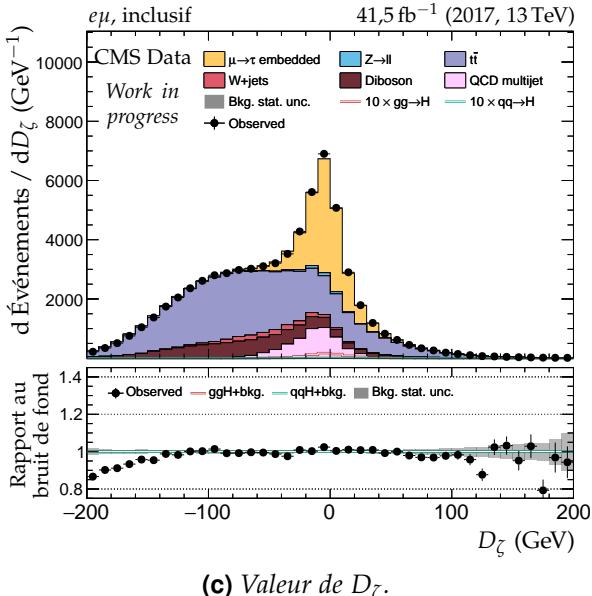
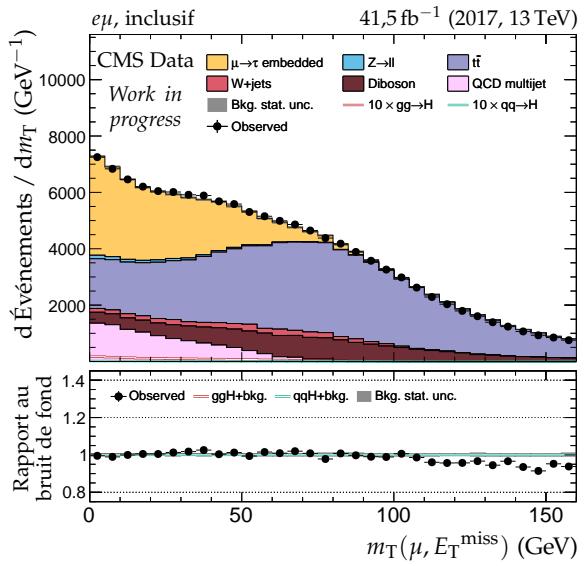
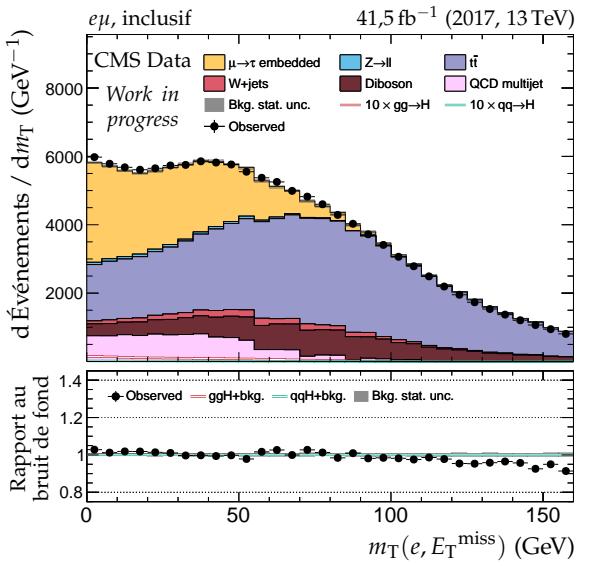


(e) Impulsion transverse du système di-τ.

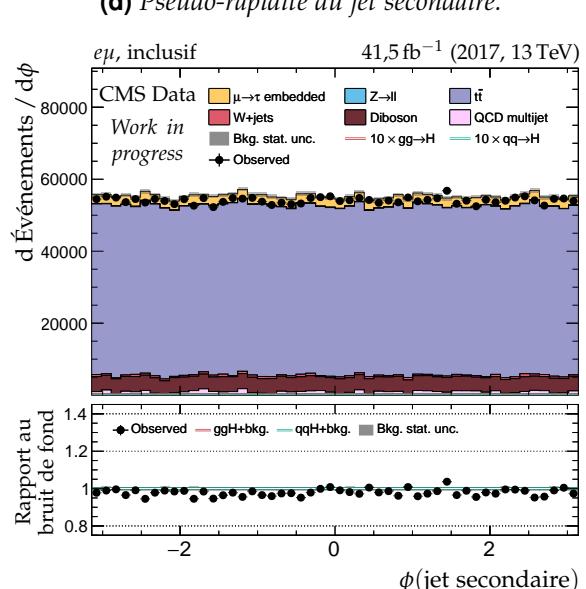
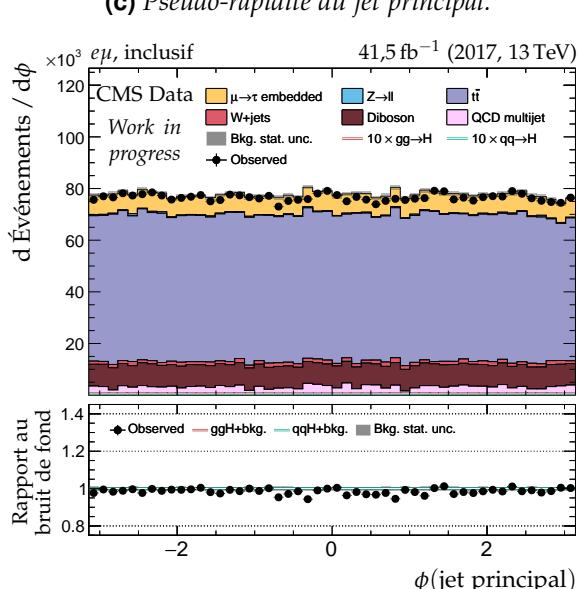
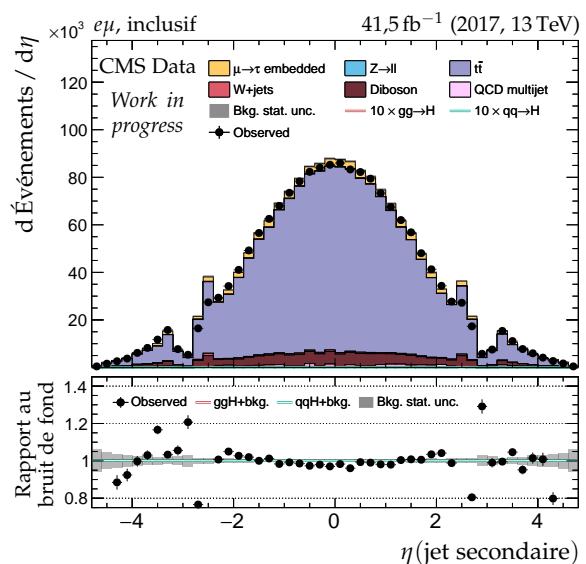
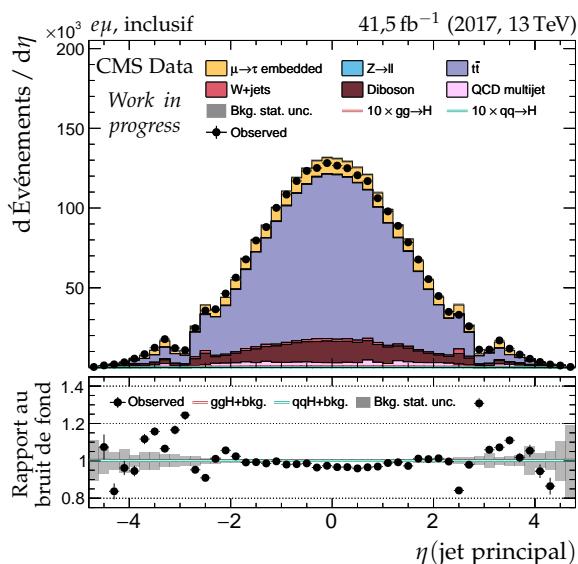
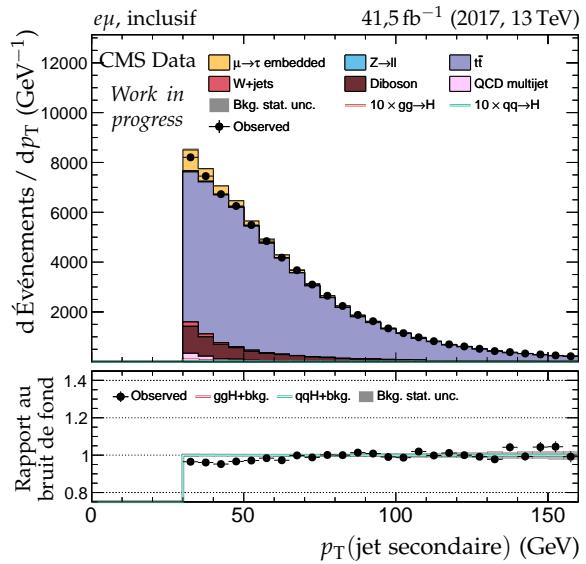
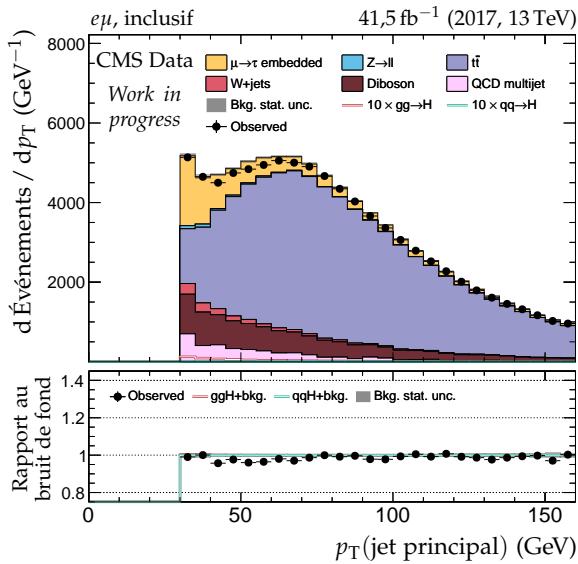


(f) Distance ΔR entre les leptons (e, μ).

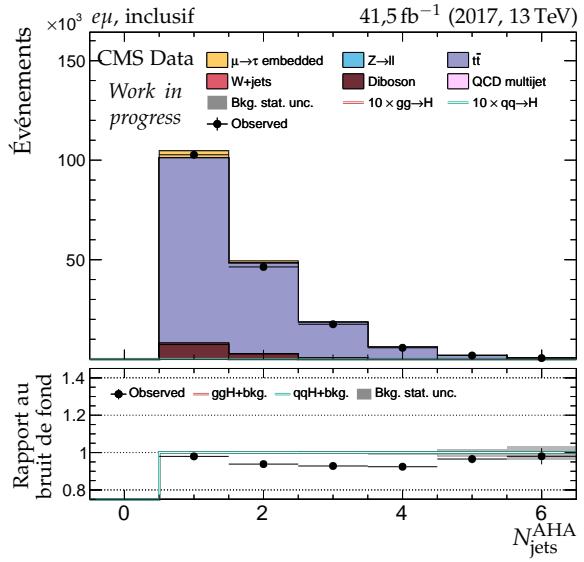
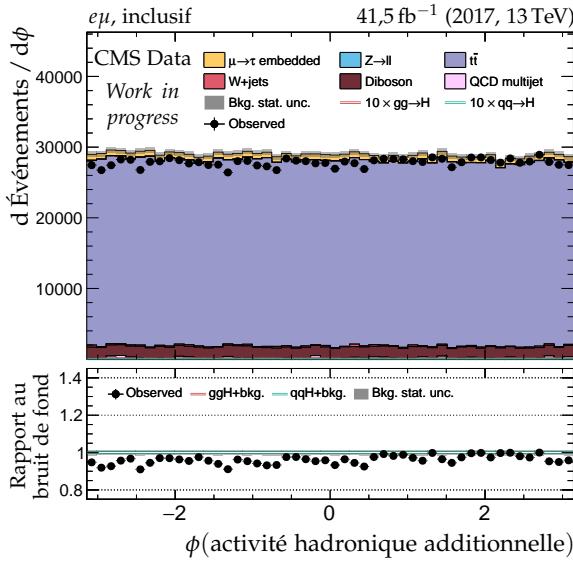
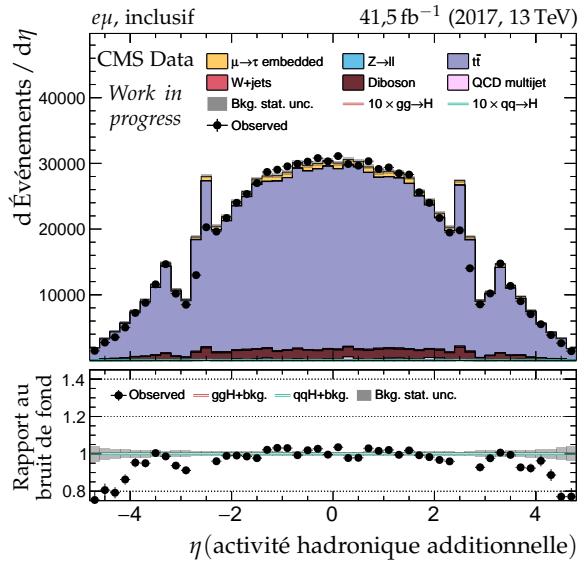
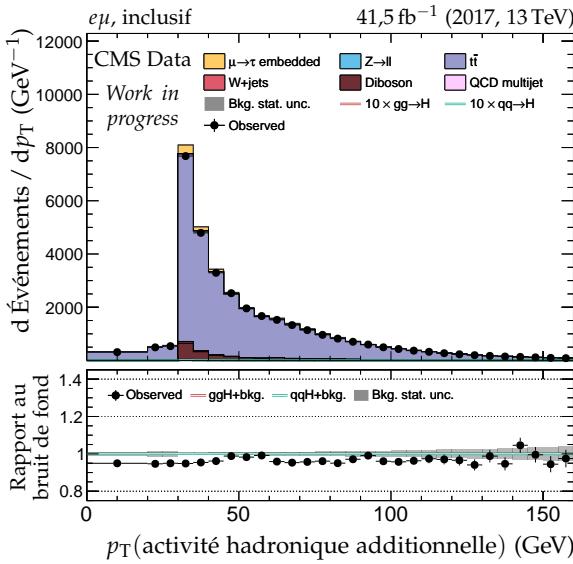
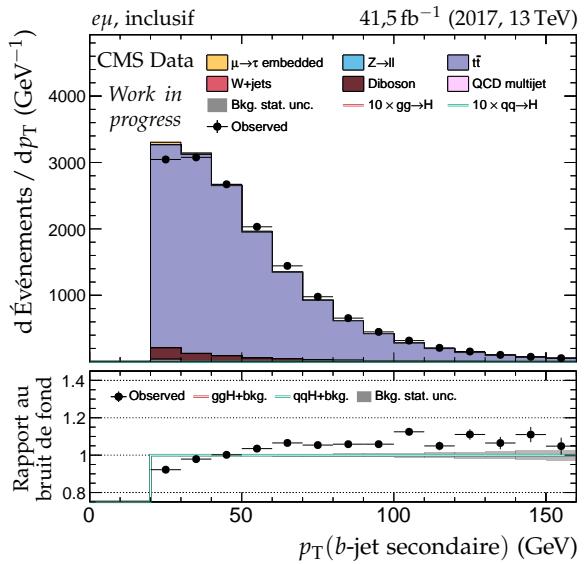
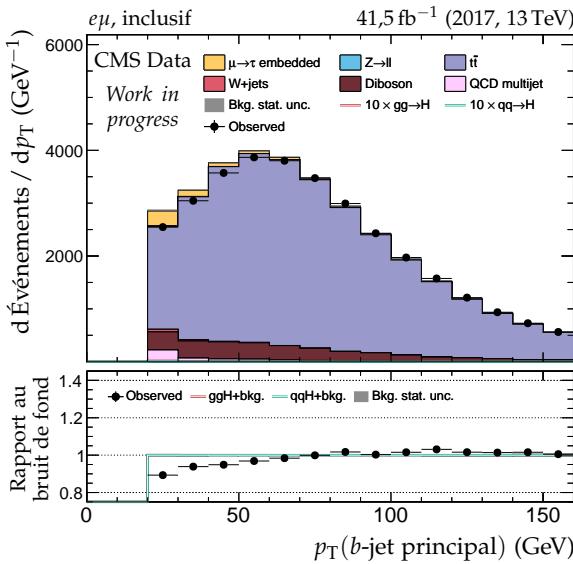
Figure X.46 – Canal eμ, 2017 : dilepton et énergie transverse manquante.



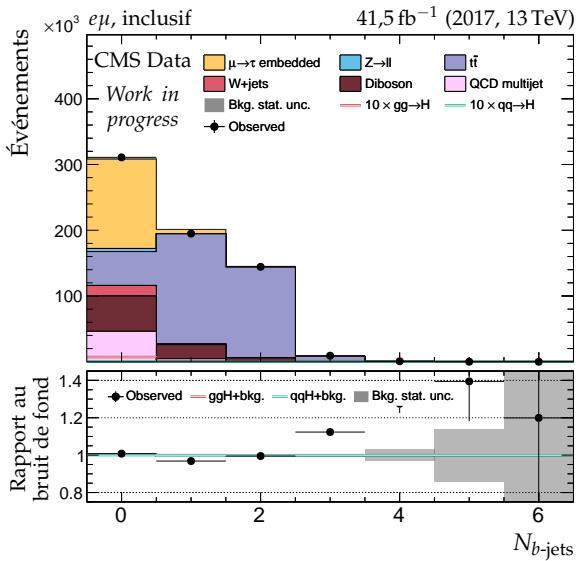
**Figure X.47 – Canal  $e\mu$ , 2017 : masses transverses,  $D_\zeta$  et masses.**



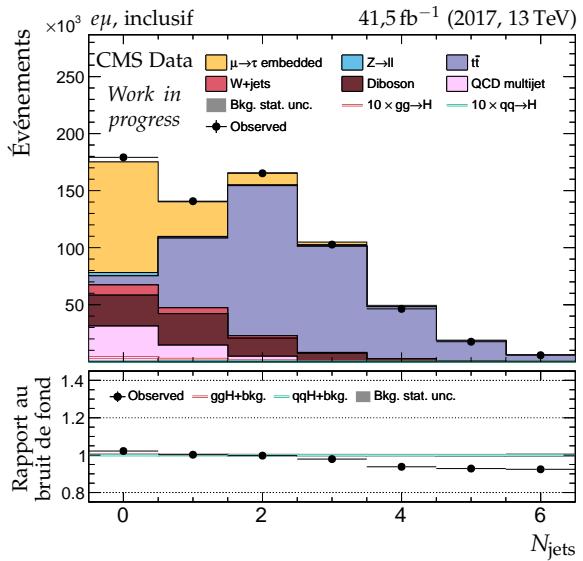
**Figure X.48 – Canal  $e\mu$ , 2017 : cinématique des deux jets principaux.**



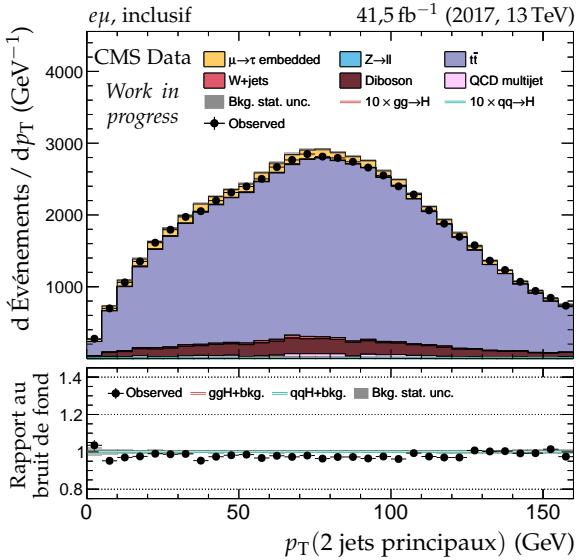
**Figure X.49 – Canal  $e\mu$ , 2017 : b-jets et activité hadronique additionnelle.**



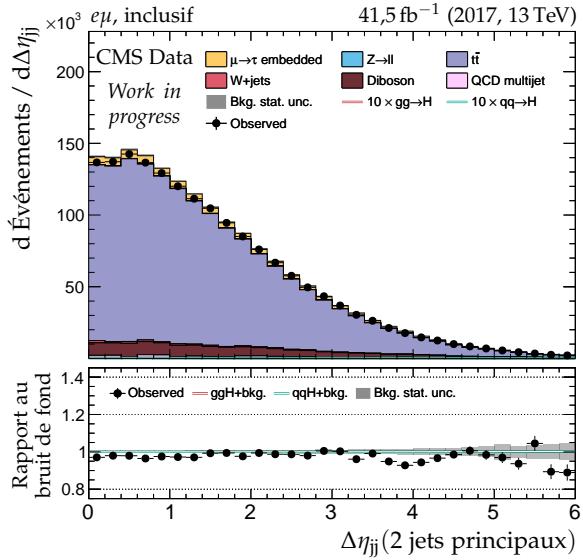
(a) Nombre de  $b$ -jets.



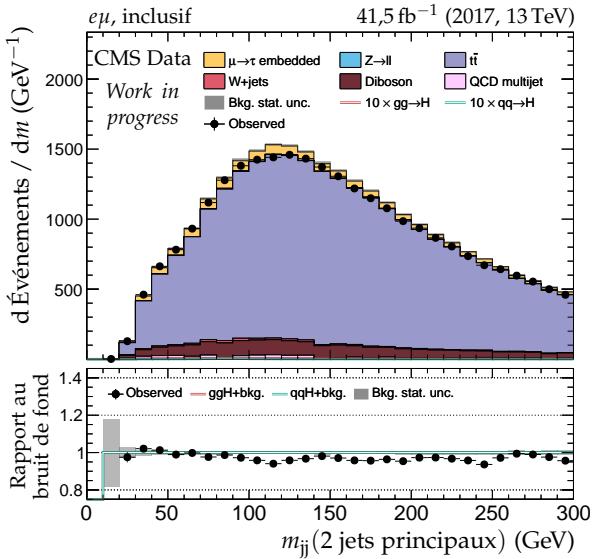
(b) Nombre de jets.



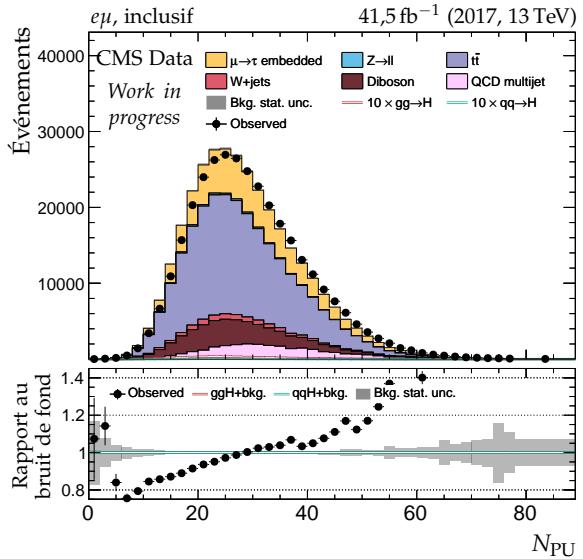
(c) Impulsion transverse du système des deux jets.



(d) Distance en  $\eta$  entre les deux jets.

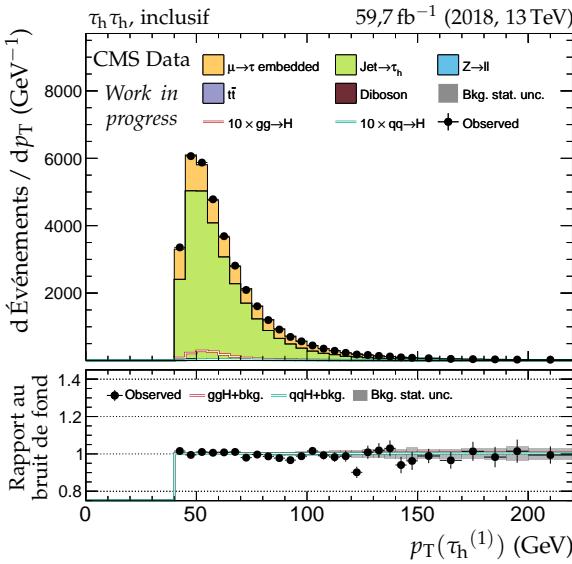
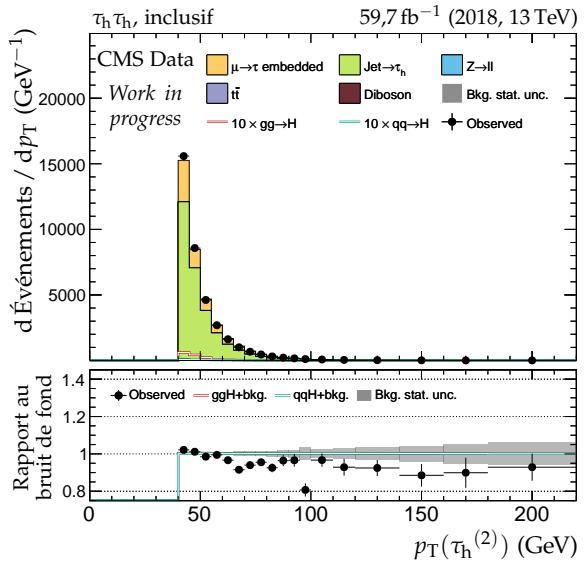
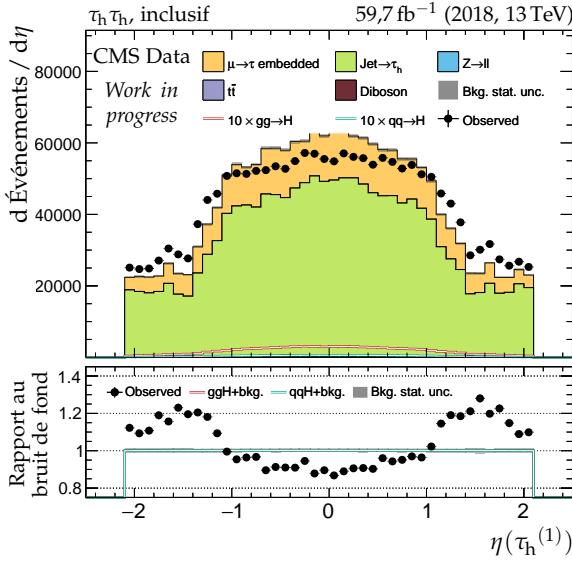
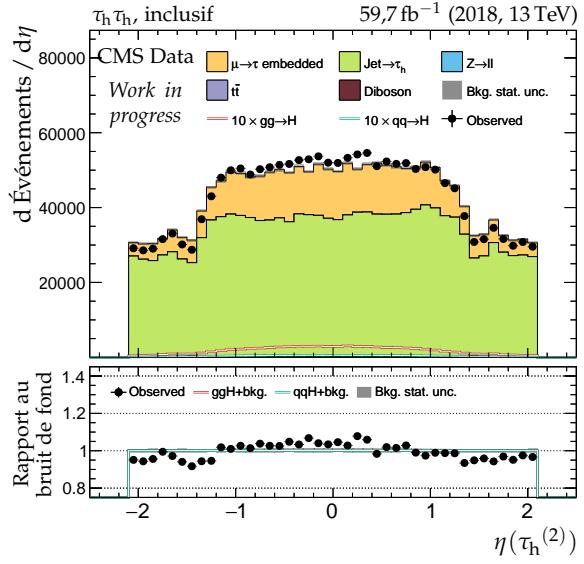
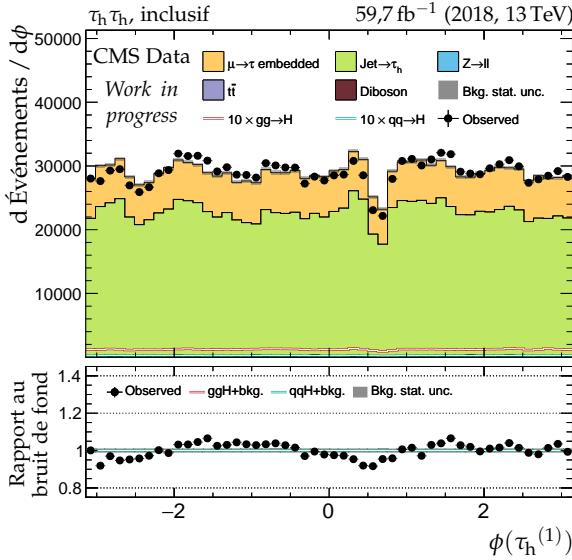
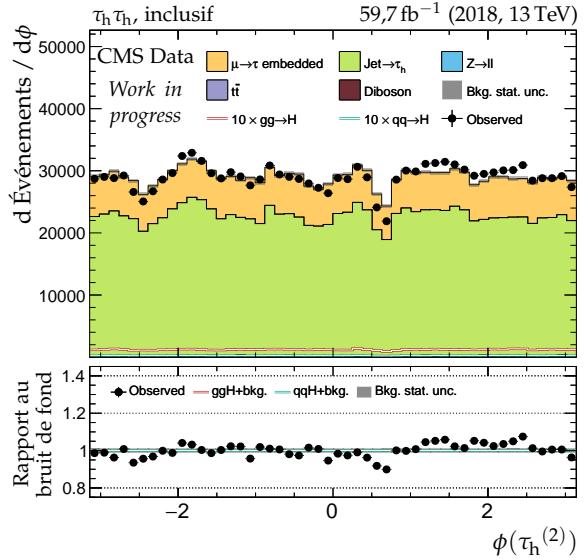


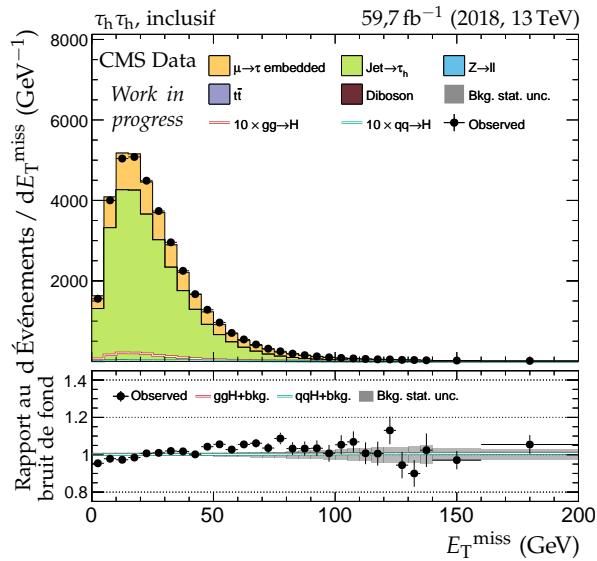
(e) Masse invariante du système des deux jets.



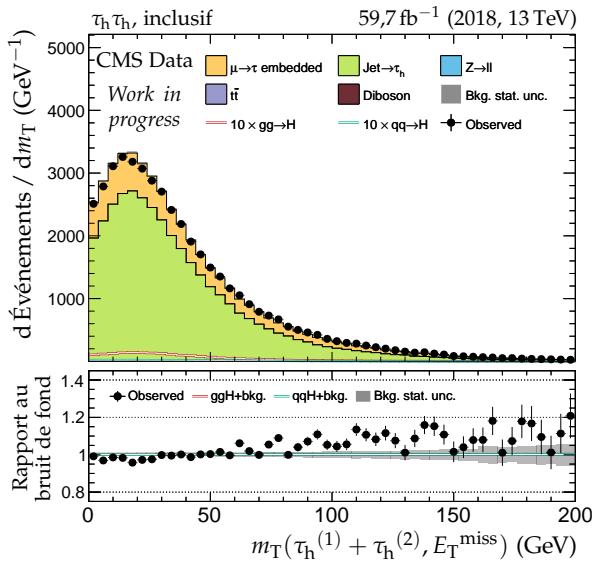
(f) Nombre de vertex d'empilement.

Figure X.50 – Canal  $e\mu$ , 2017 : nombre de jets, système des deux jets principaux et empilement.

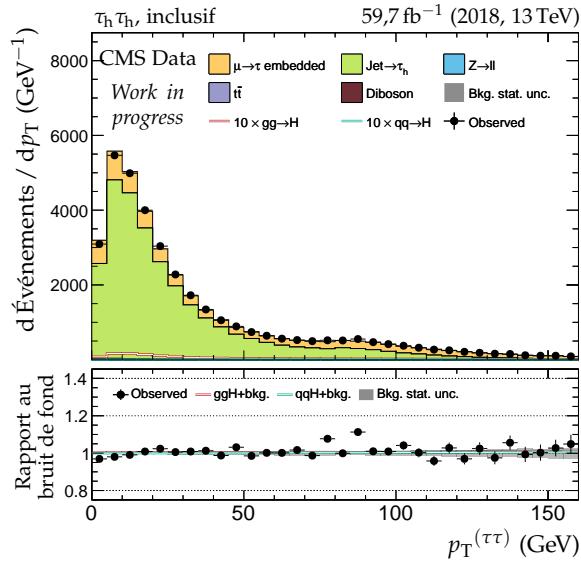
(a) Impulsion transverse du lepton 1 ( $\tau_h^{(1)}$ ).(b) Impulsion transverse du lepton 2 ( $\tau_h^{(2)}$ ).(c) Pseudo-rapidité du lepton 1 ( $\tau_h^{(1)}$ ).(d) Pseudo-rapidité du lepton 2 ( $\tau_h^{(2)}$ ).(e) Angle azimutal du lepton 1 ( $\tau_h^{(1)}$ ).(f) Angle azimutal du lepton 2 ( $\tau_h^{(2)}$ ).**Figure X.51 – Canal  $\tau_h \tau_h$ , 2018 : cinématique des leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).**



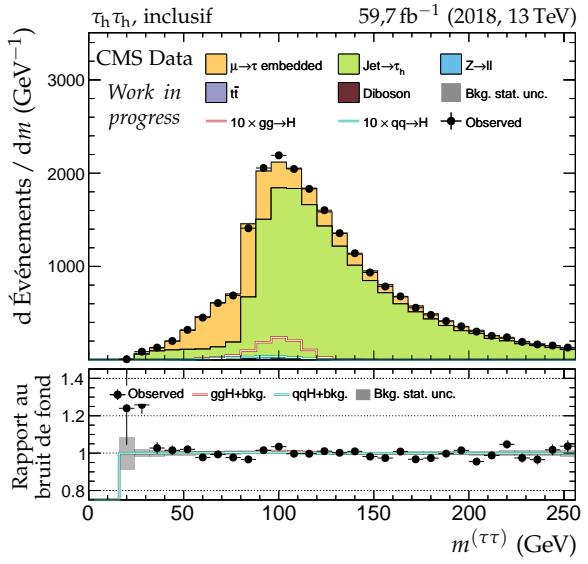
(a) Énergie transverse manquante.



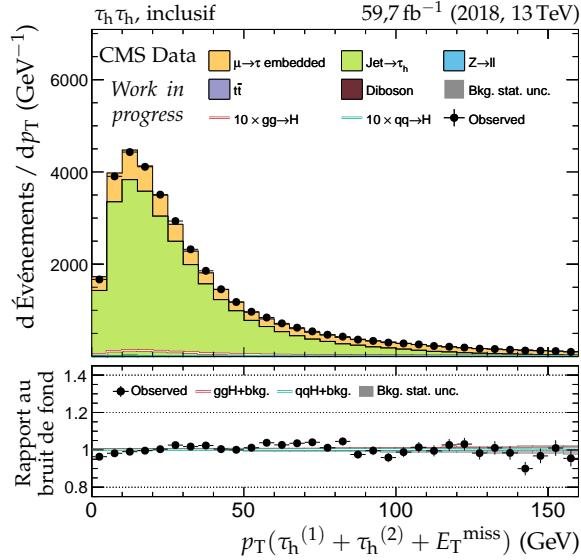
(b) Masse transverse du dilepton.



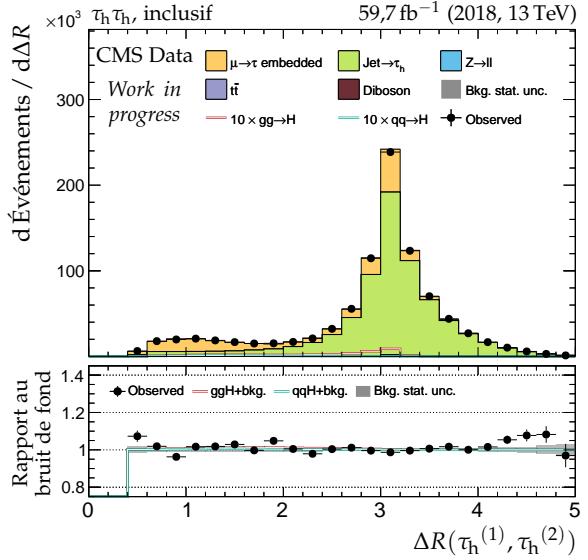
(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

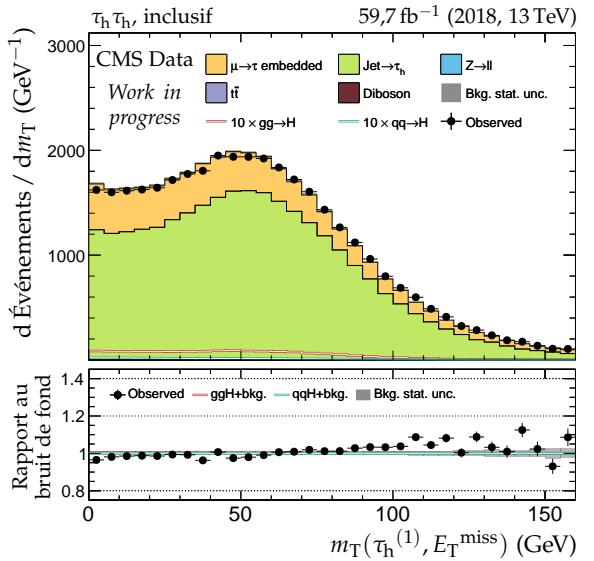
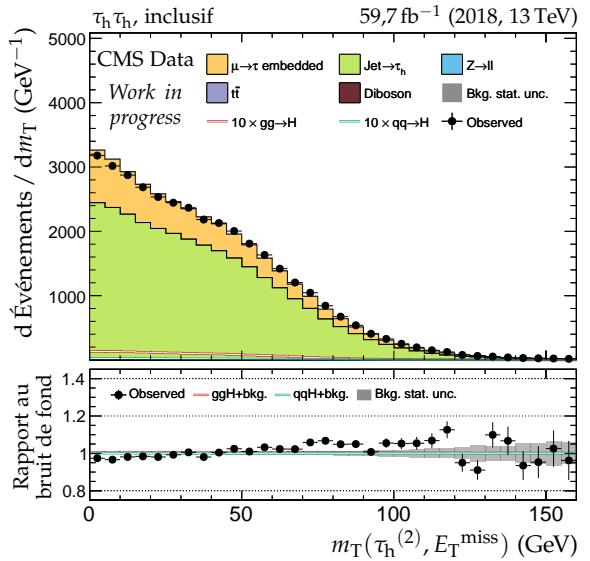
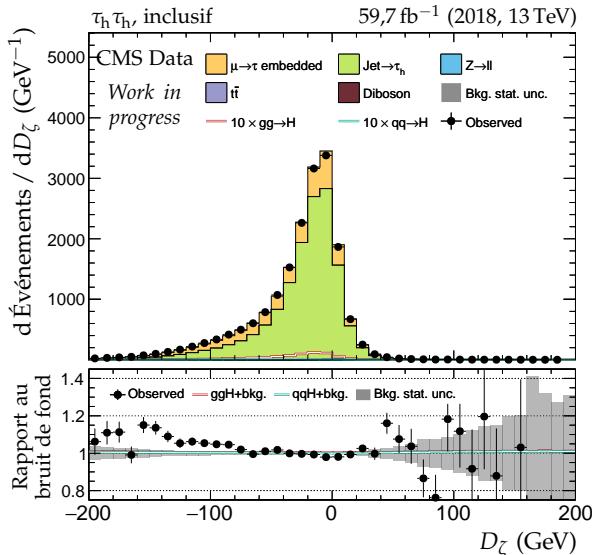
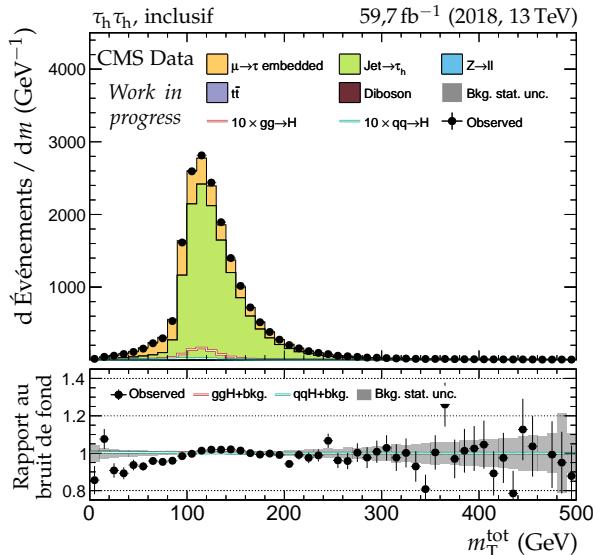


(e) Impulsion transverse du système di- $\tau$ .

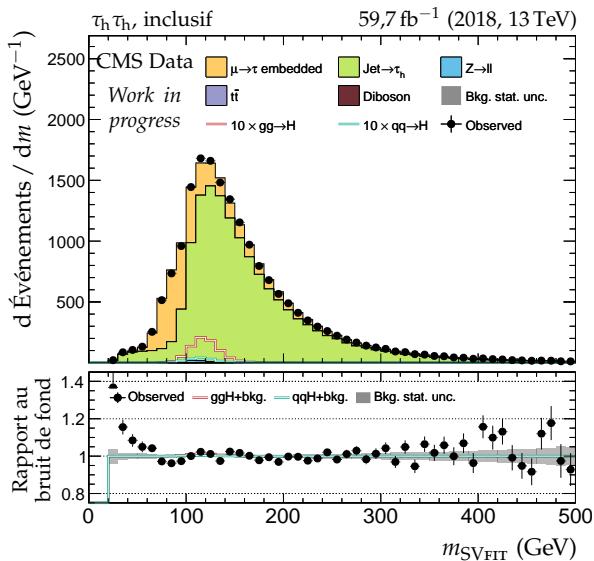
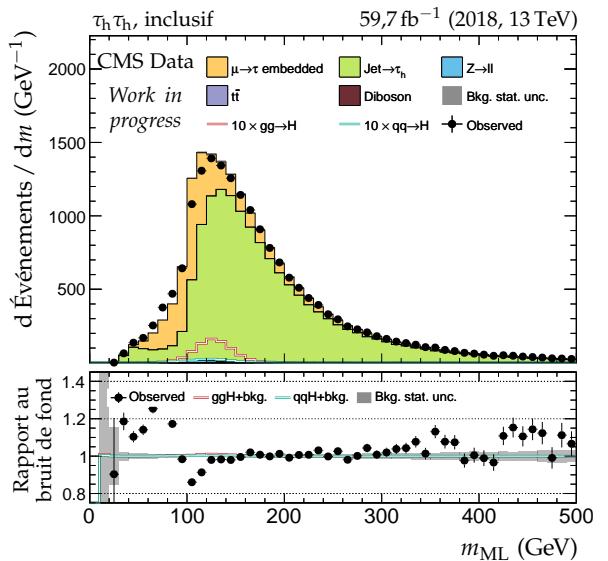


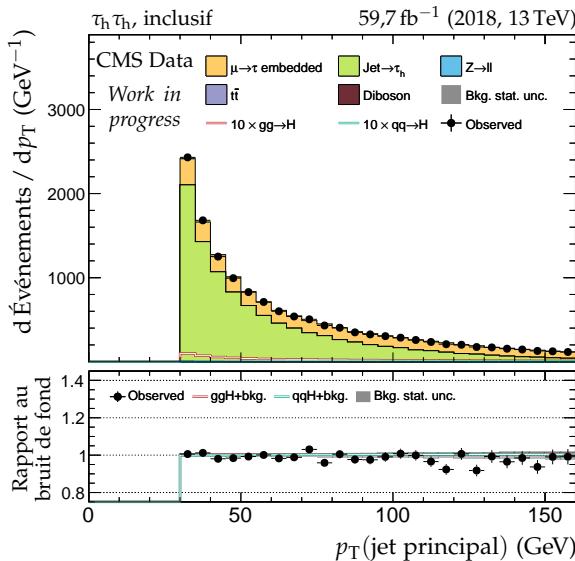
(f) Distance  $\Delta R$  entre les leptons ( $\tau_h^{(1)}, \tau_h^{(2)}$ ).

Figure X.52 – Canal  $\tau_h \tau_h$ , 2018 : dilepton et énergie transverse manquante.

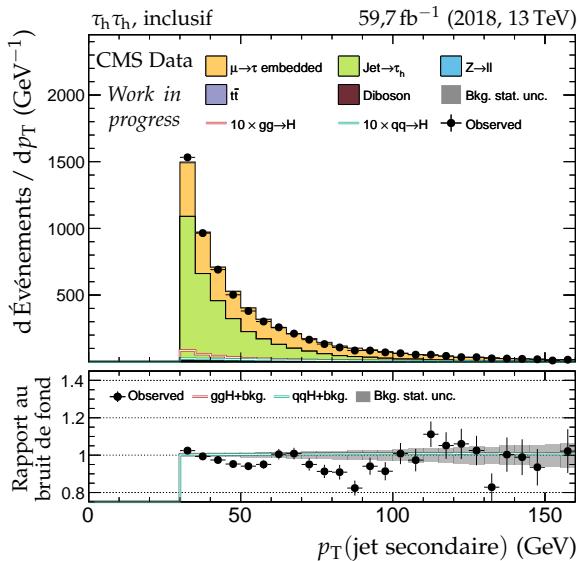
(a) Masse transverse du lepton 1 ( $\tau_h^{(1)}$ ).(b) Masse transverse du lepton 2 ( $\tau_h^{(2)}$ ).(c) Valeur de  $D_\zeta$ .

(d) Masse transverse totale.

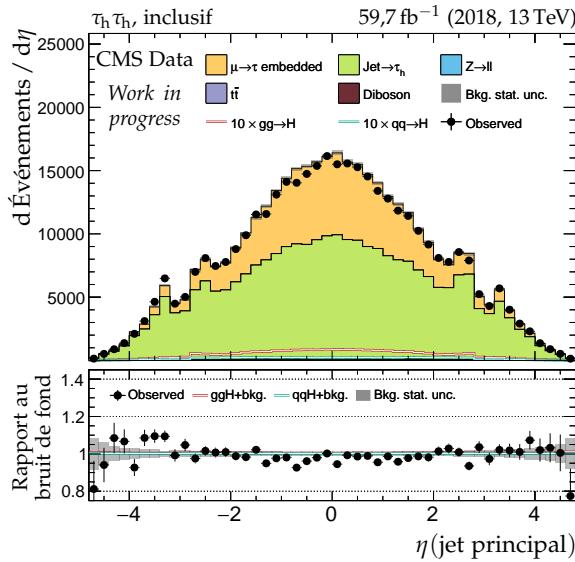
(e) Masse du système di- $\tau$  d'après SVFIT.(f) Masse du système di- $\tau$  d'après le ML.**Figure X.53 – Canal  $\tau_h \tau_h$ , 2018 : masses transverses,  $D_\zeta$  et masses.**



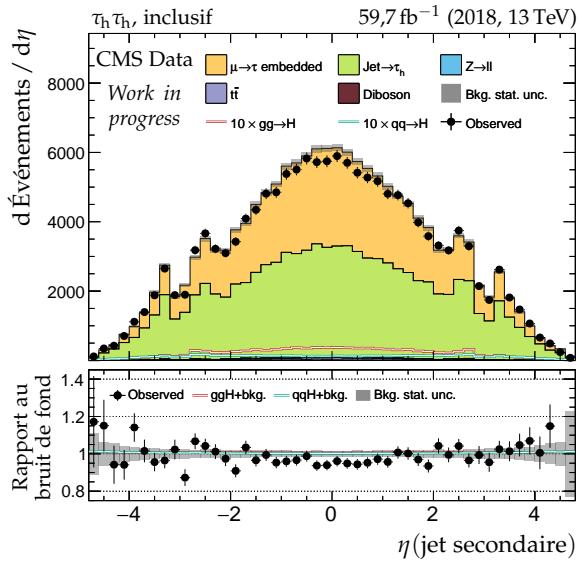
(a) Impulsion transverse du jet principal.



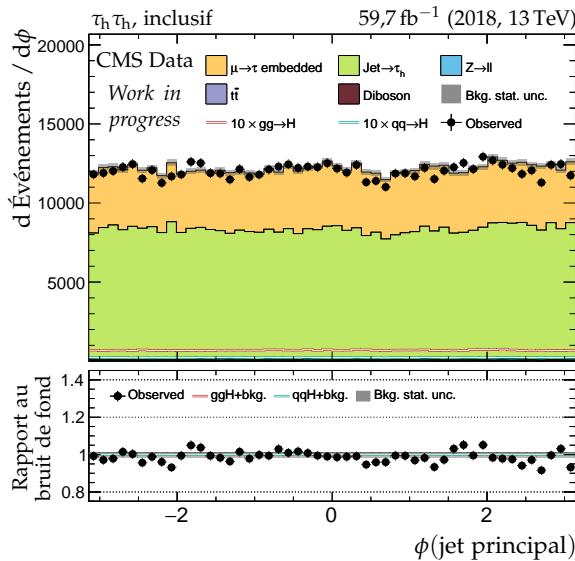
(b) Impulsion transverse du jet secondaire.



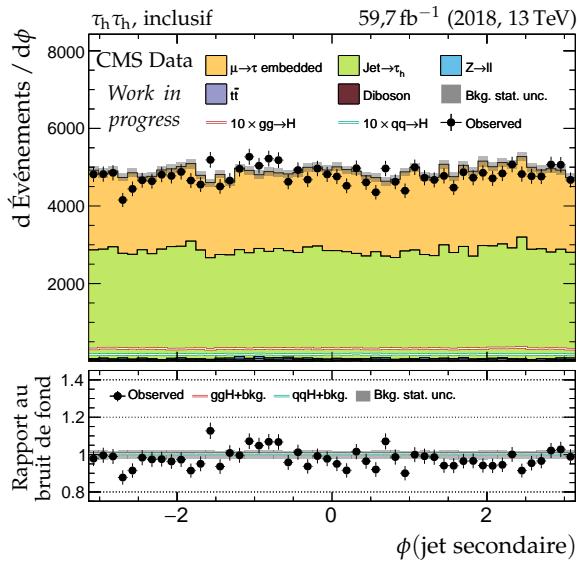
(c) Pseudo-rapidité du jet principal.



(d) Pseudo-rapidité du jet secondaire.

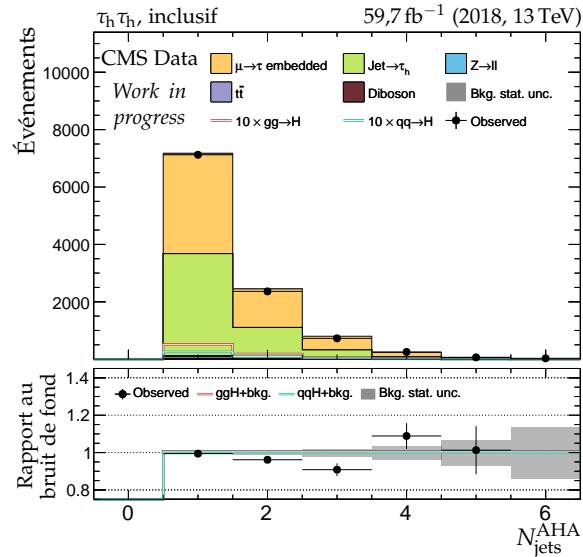
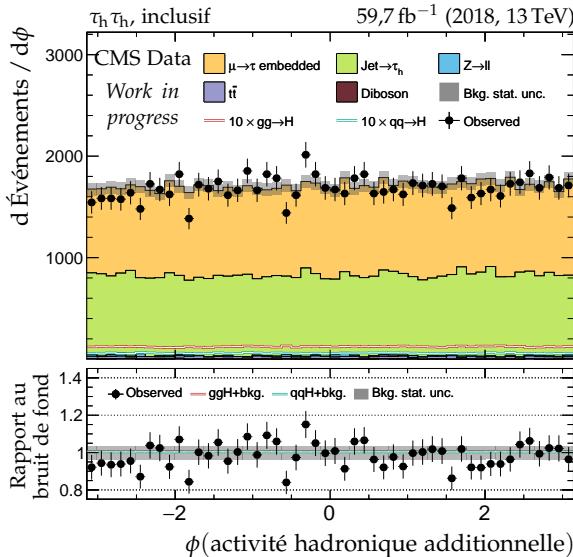
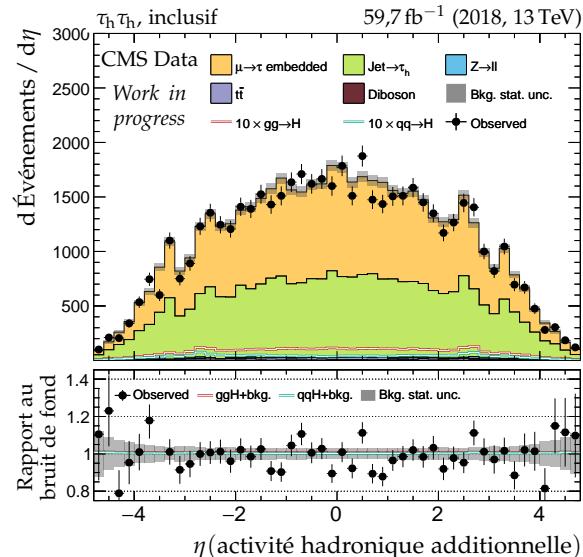
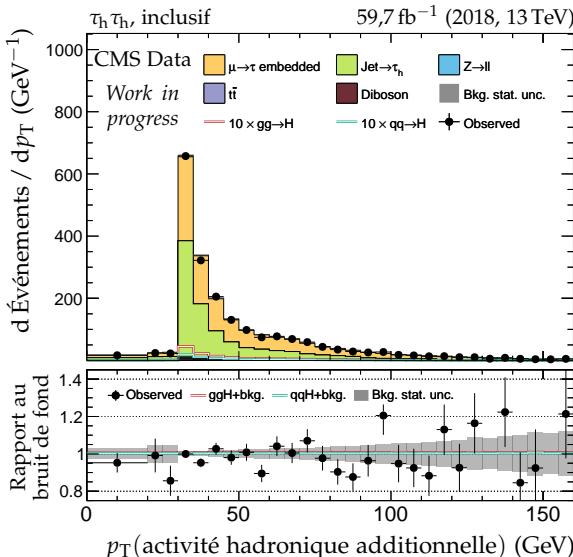
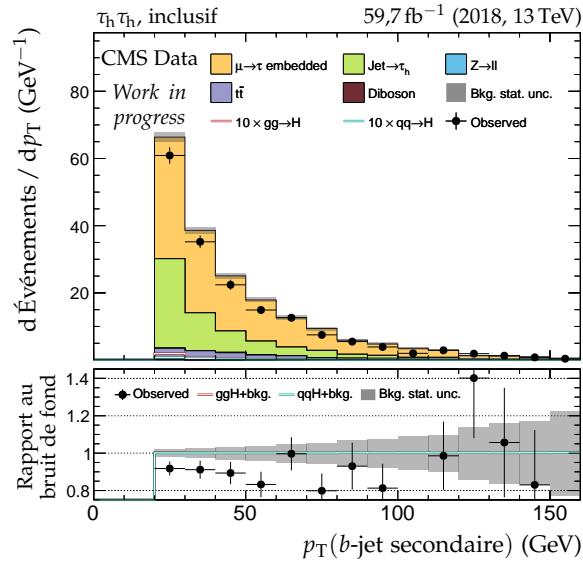
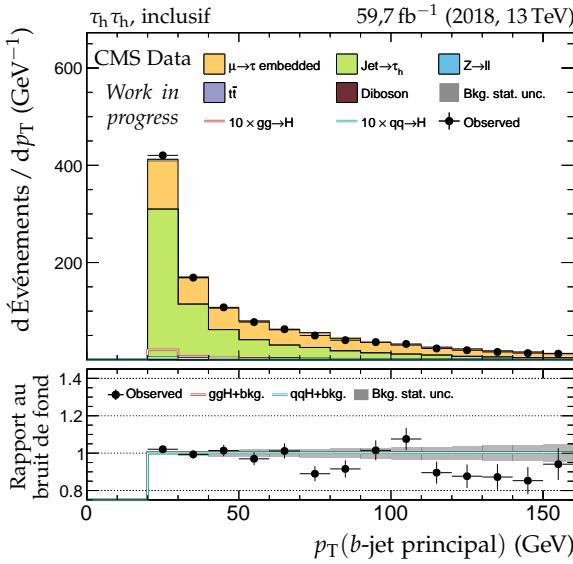


(e) Angle azimutal du jet principal.

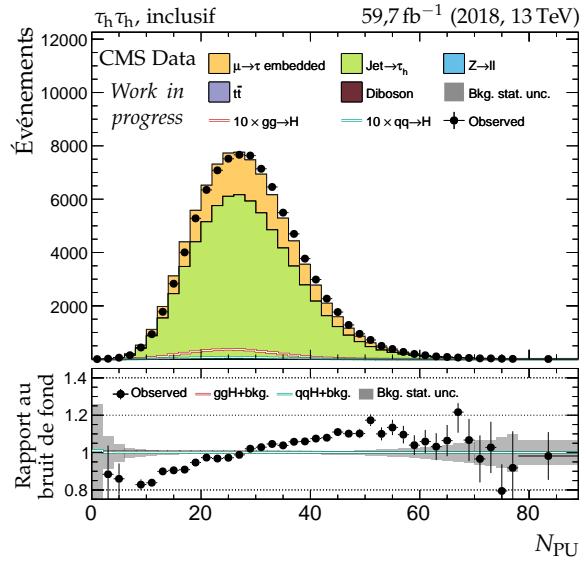
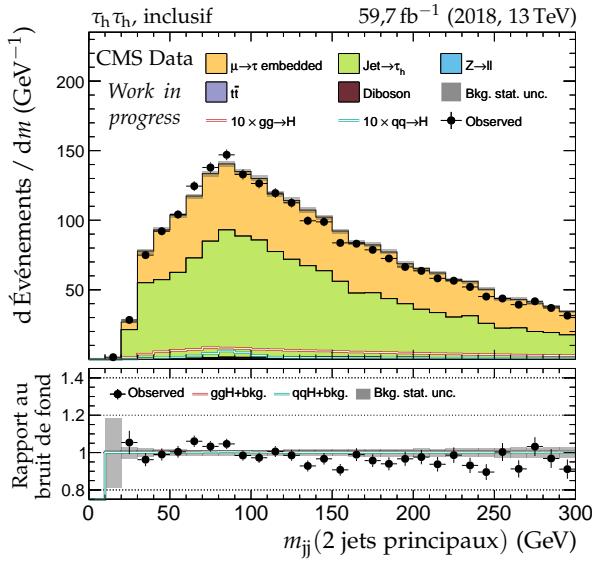
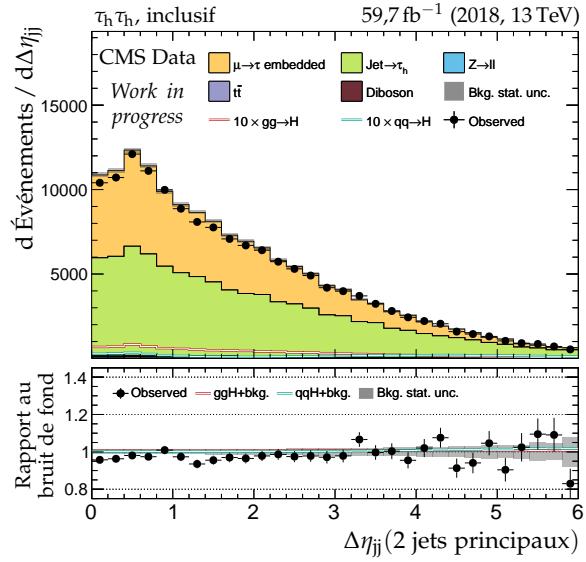
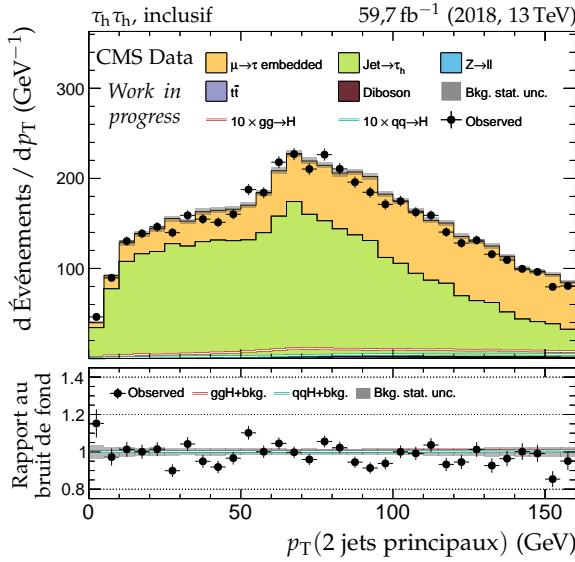
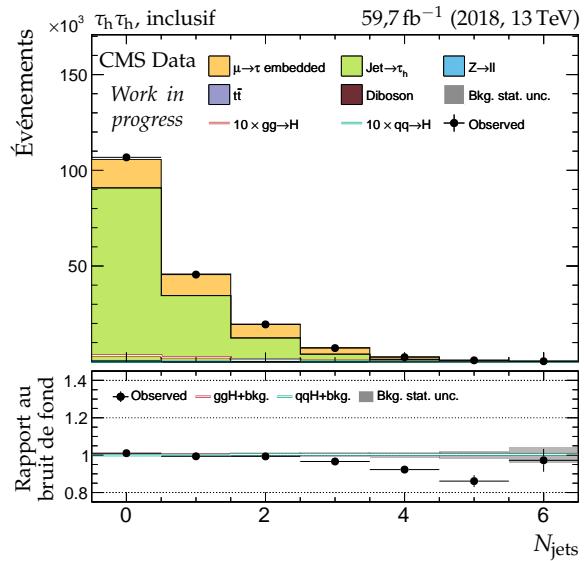
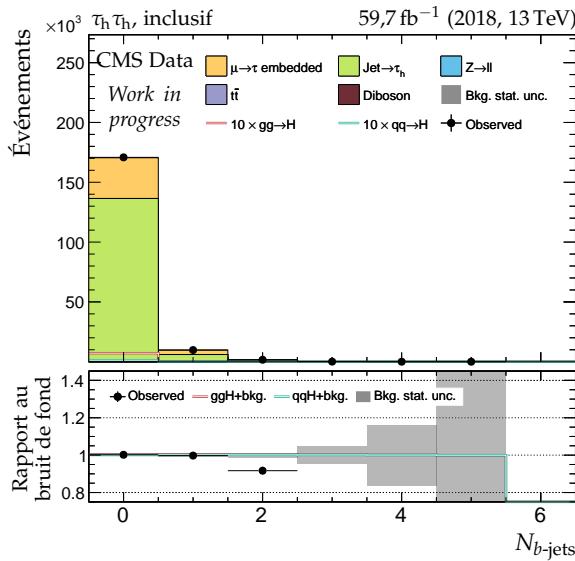


(f) Angle azimutal du jet secondaire.

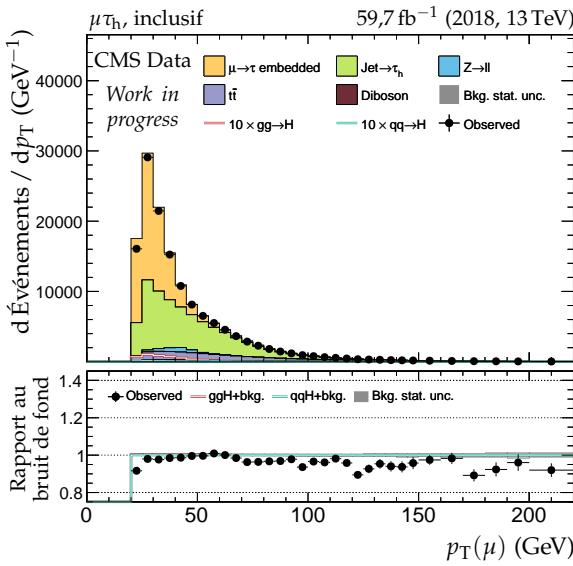
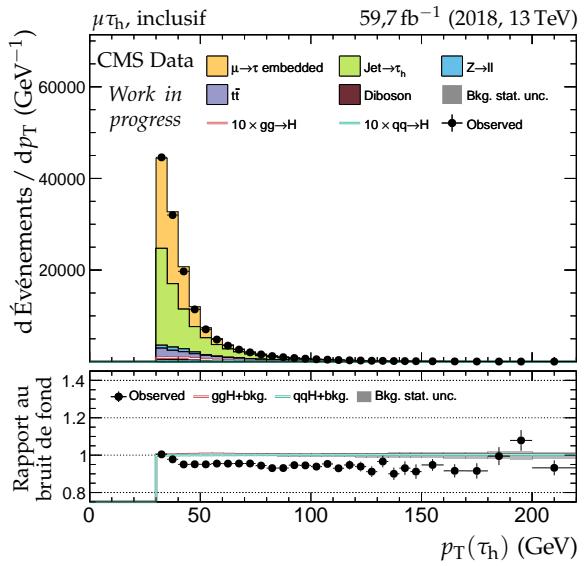
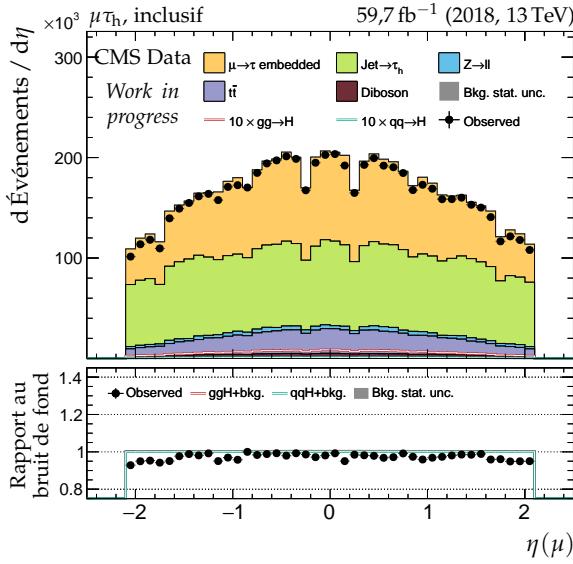
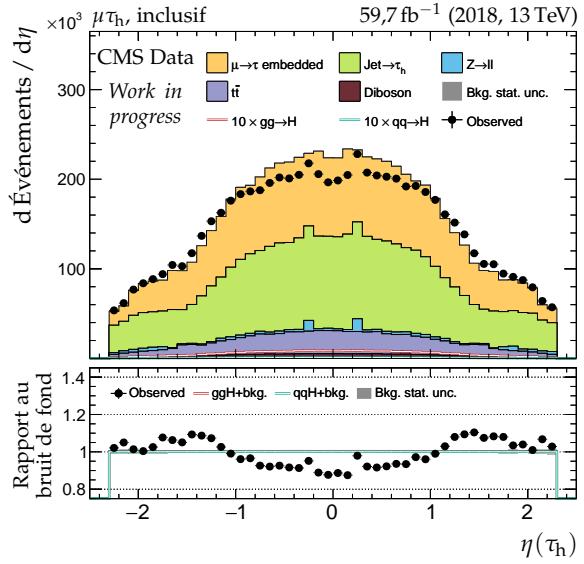
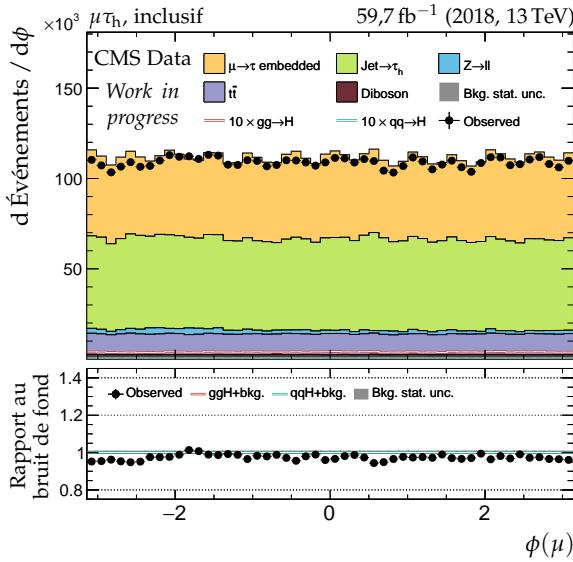
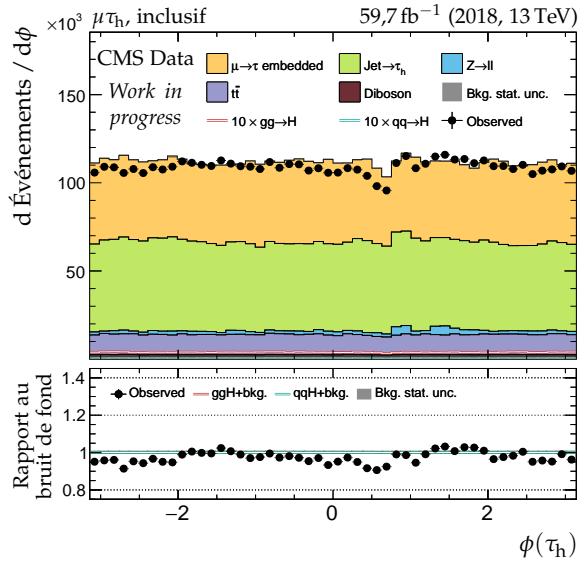
Figure X.54 – Canal  $\tau_h \tau_h$ , 2018 : cinématique des deux jets principaux.

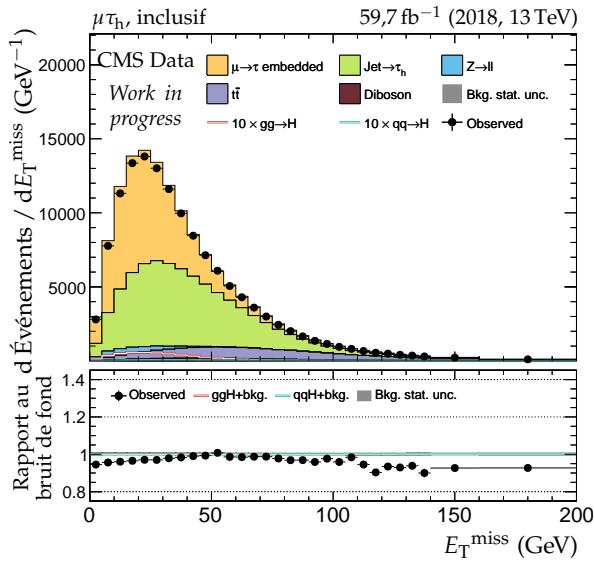


**Figure X.55 – Canal  $\tau_h \tau_h$ , 2018 : b-jets et activité hadronique additionnelle.**

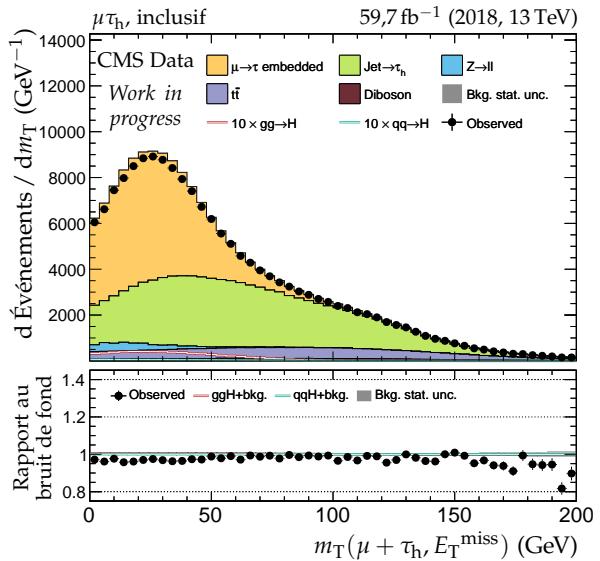


**Figure X.56 – Canal  $\tau_h \tau_h$ , 2018 : nombre de jets, système des deux jets principaux et empilement.**

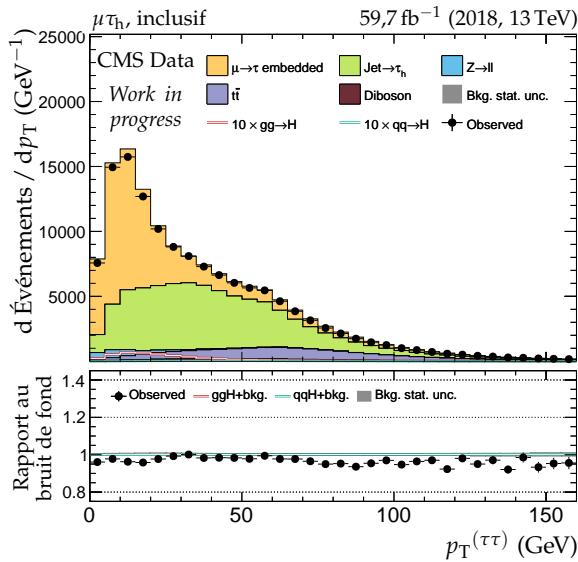
(a) Impulsion transverse du lepton 1 ( $\mu$ ).(b) Impulsion transverse du lepton 2 ( $\tau_h$ ).(c) Pseudo-rapidité du lepton 1 ( $\mu$ ).(d) Pseudo-rapidité du lepton 2 ( $\tau_h$ ).(e) Angle azimutal du lepton 1 ( $\mu$ ).(f) Angle azimutal du lepton 2 ( $\tau_h$ ).**Figure X.57 – Canal  $\mu\tau_h$ , 2018 : cinématique des leptons ( $\mu, \tau_h$ ).**



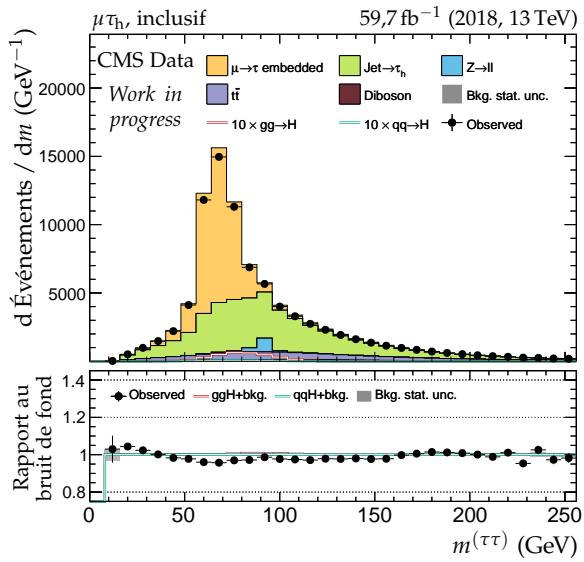
(a) Énergie transverse manquante.



(b) Masse transverse du dilepton.



(c) Impulsion transverse du dilepton.



(d) Masse visible du dilepton.

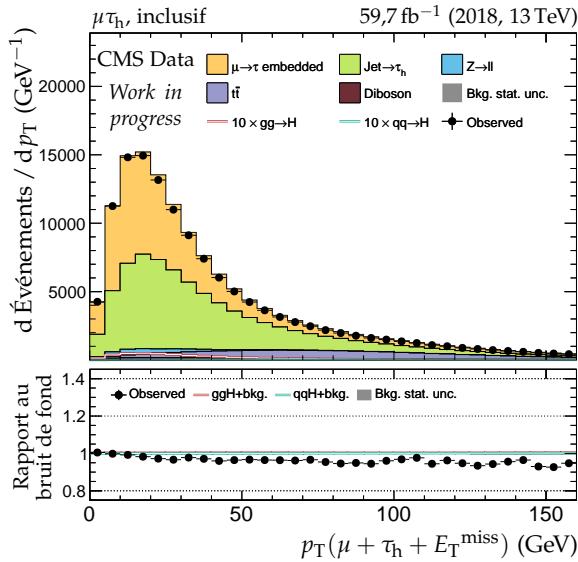
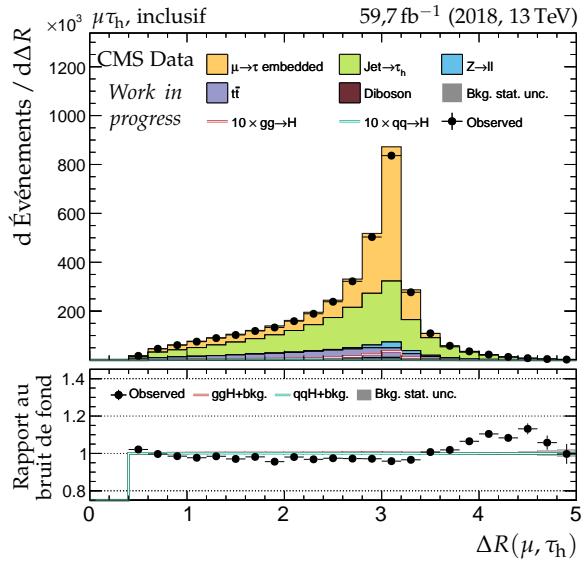
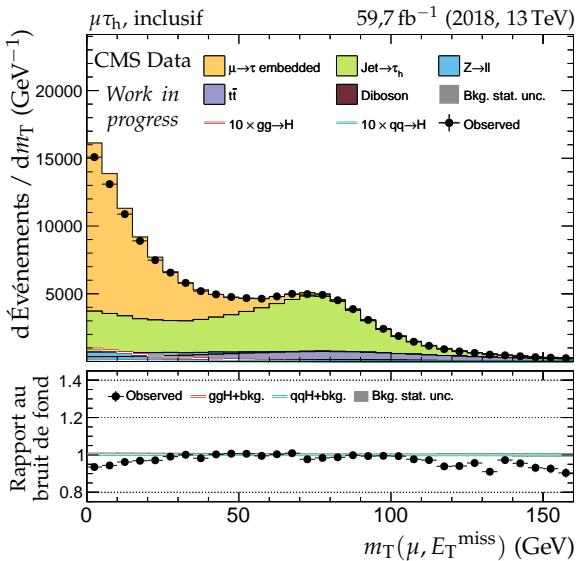
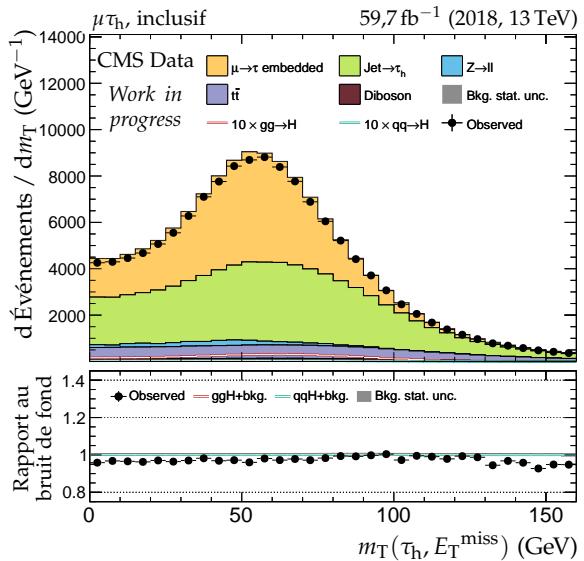
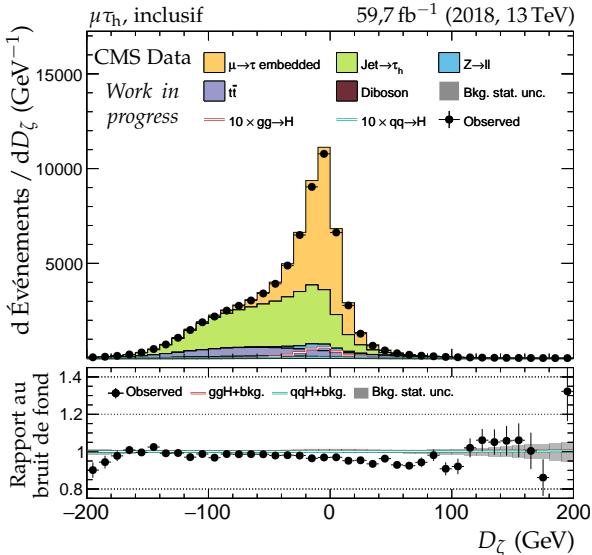
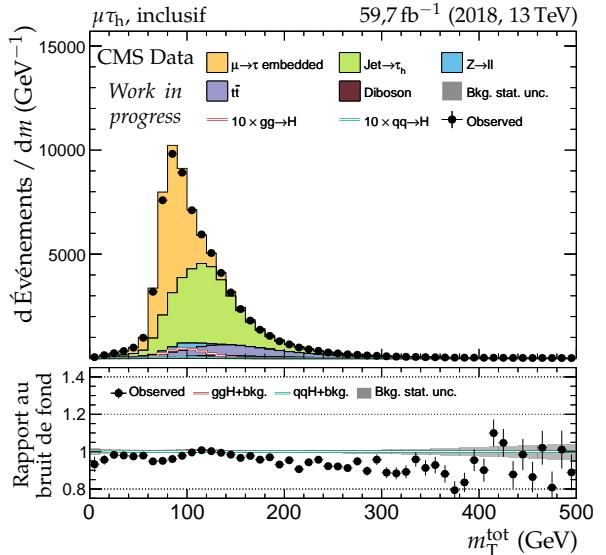
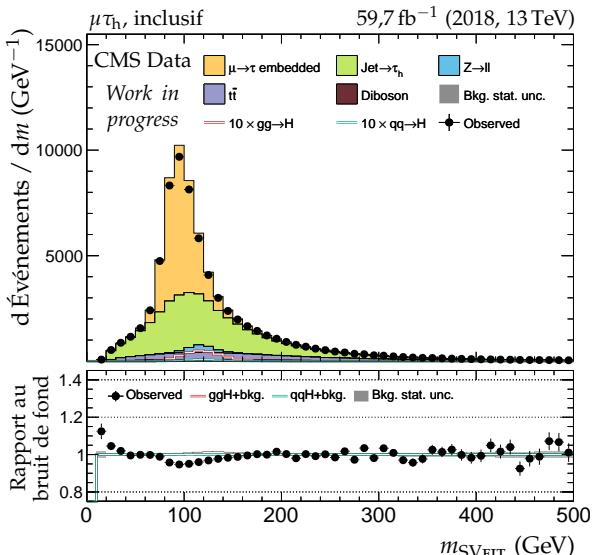

 (e) Impulsion transverse du système di- $\tau$ .

 (f) Distance  $\Delta R$  entre les leptons ( $\mu, \tau_h$ ).

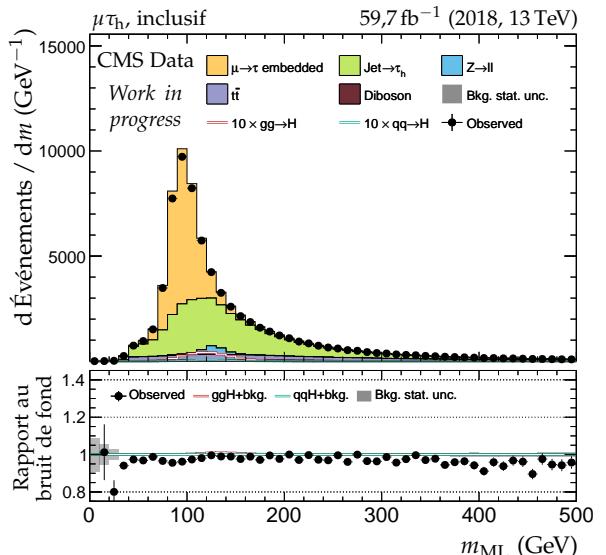
 Figure X.58 – Canal  $\mu\tau_h$ , 2018 : dilepton et énergie transverse manquante.

(a) Masse transverse du lepton 1 ( $\mu$ ).(b) Masse transverse du lepton 2 ( $\tau_h$ ).(c) Valeur de  $D_\zeta$ .

(d) Masse transverse totale.

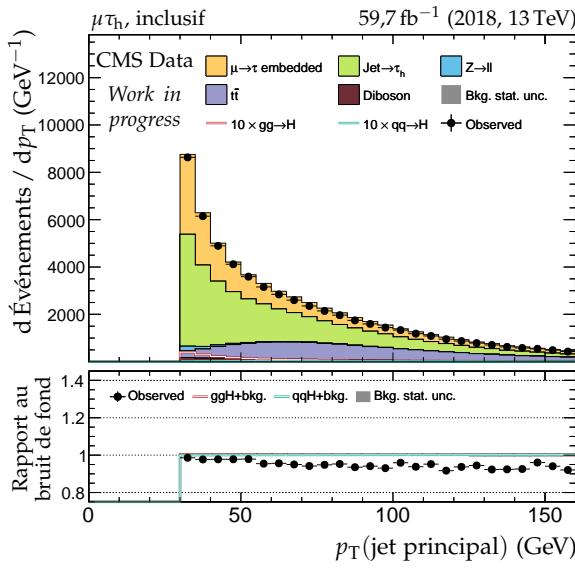


(e) Masse du système di-τ d'après SVFIT.

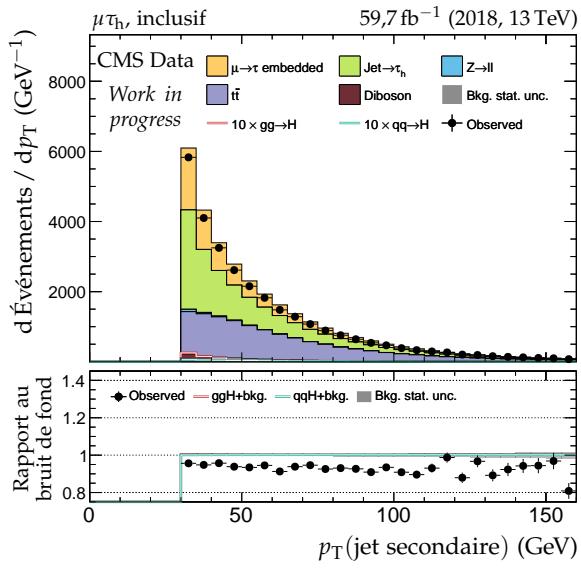


(f) Masse du système di-τ d'après le ML.

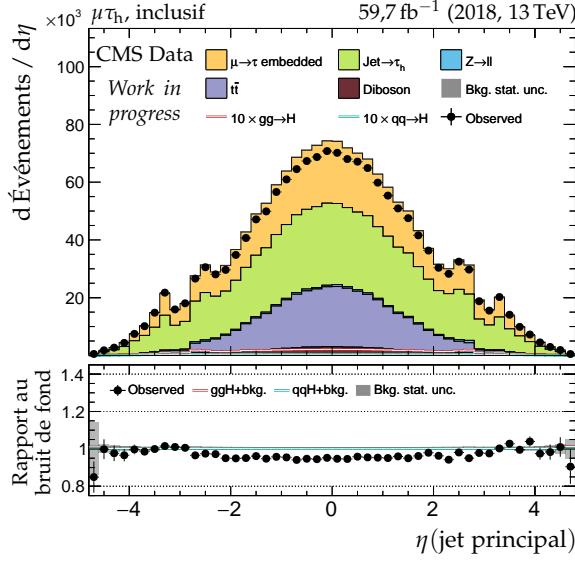
**Figure X.59 – Canal μτ<sub>h</sub>, 2018 : masses transverses,  $D_\zeta$  et masses.**



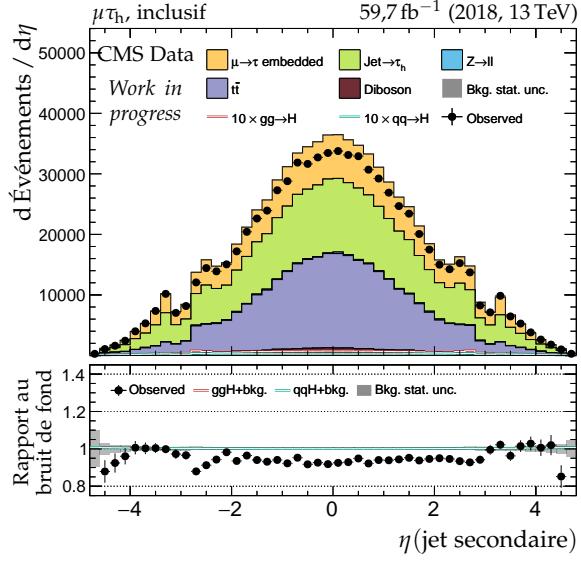
(a) Impulsion transverse du jet principal.



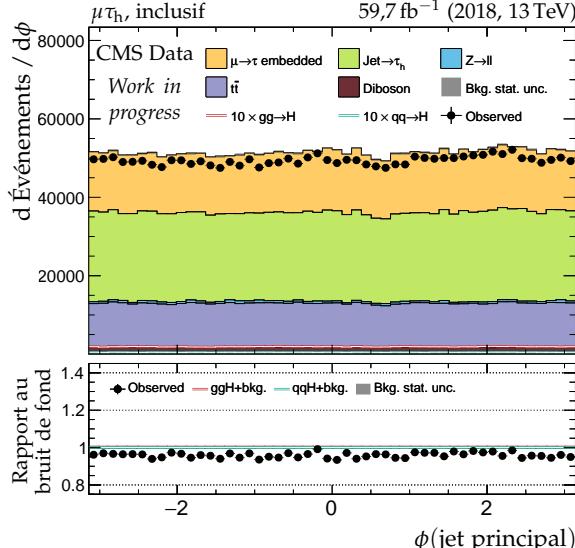
(b) Impulsion transverse du jet secondaire.



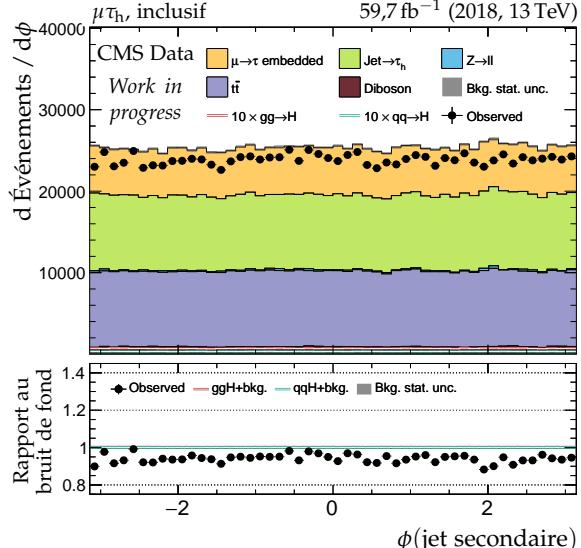
(c) Pseudo-rapidité du jet principal.



(d) Pseudo-rapidité du jet secondaire.

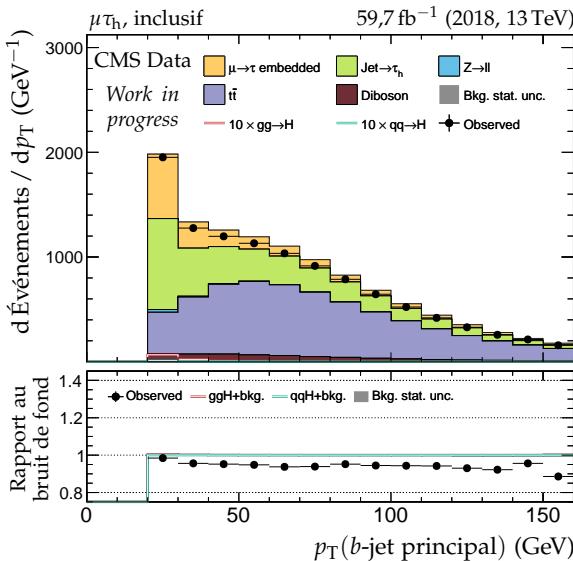


(e) Angle azimutal du jet principal.

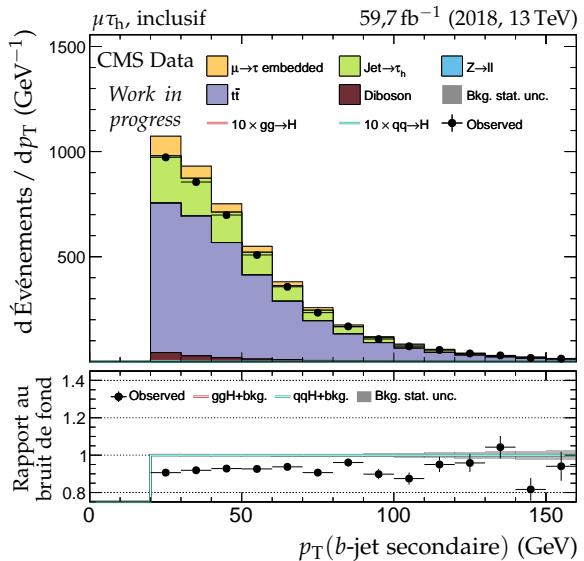


(f) Angle azimutal du jet secondaire.

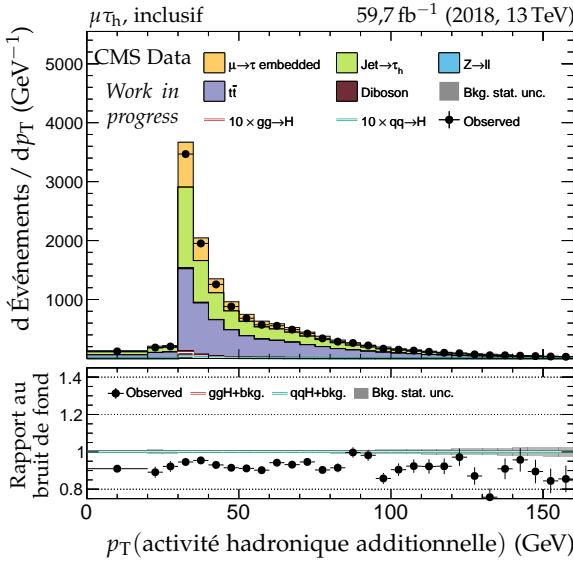
Figure X.60 – Canal  $\mu\tau_h$ , 2018 : cinématique des deux jets principaux.



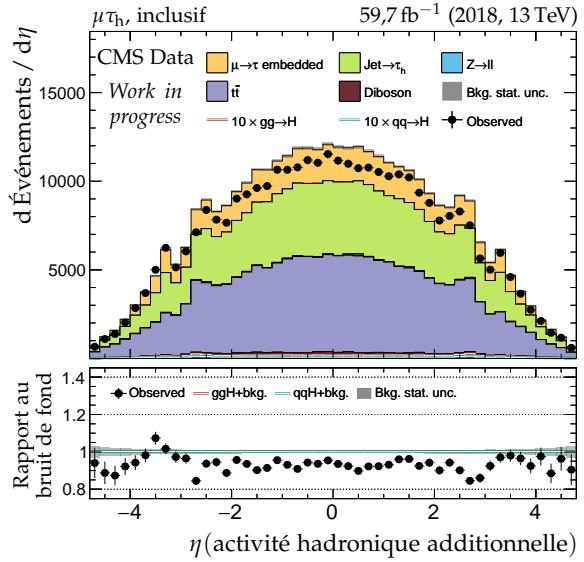
(a) Impulsion transverse du b-jet principal.



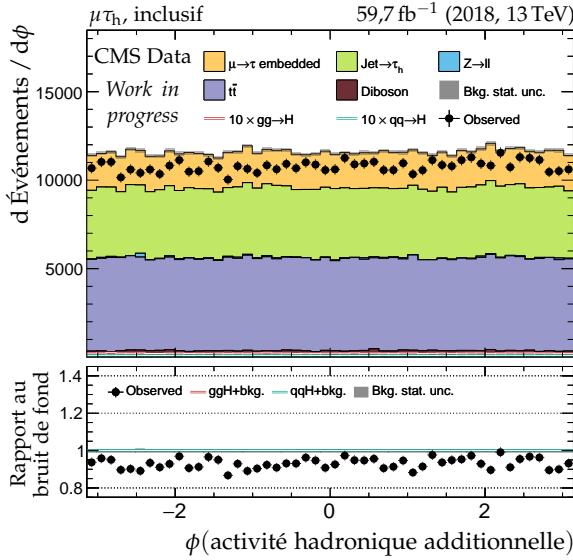
(b) Impulsion transverse du b-jet secondaire.



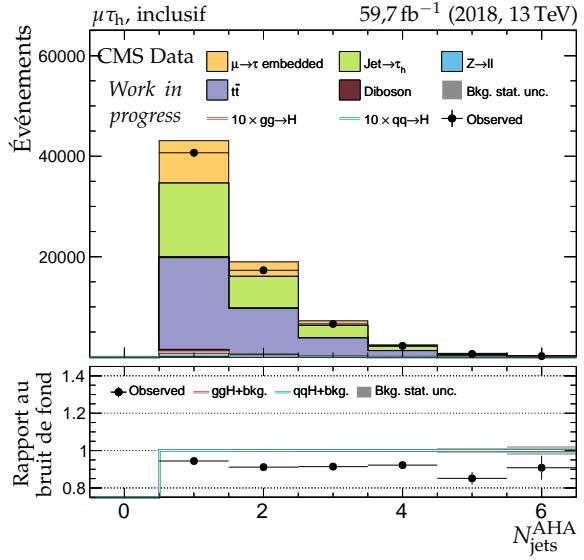
(c) Impulsion transverse de l'AHA.



(d) Pseudo-rapidité de l'AHA.

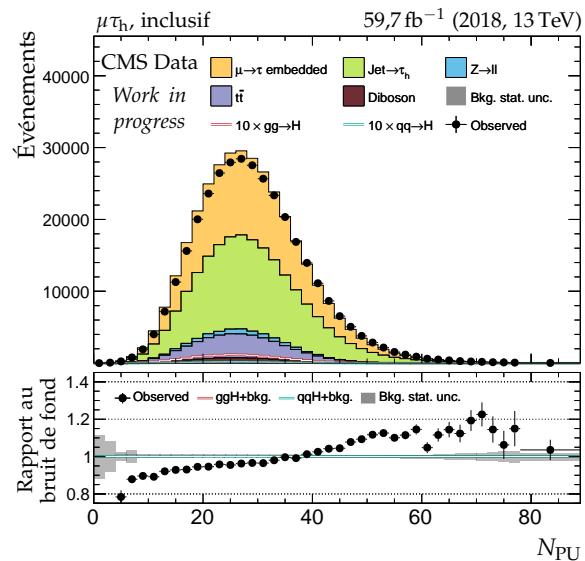
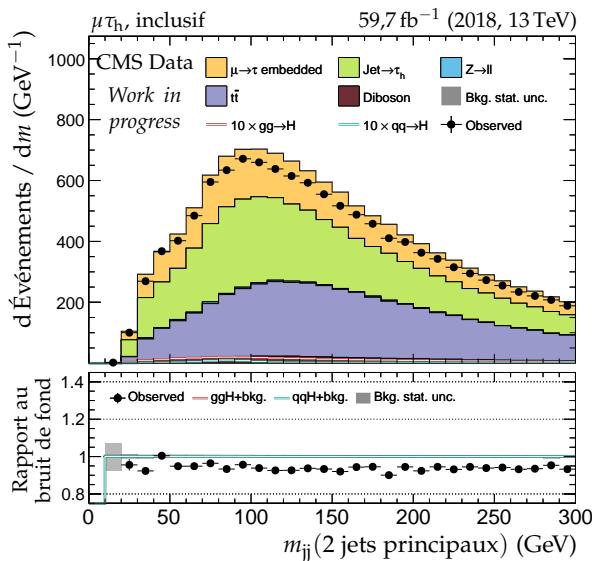
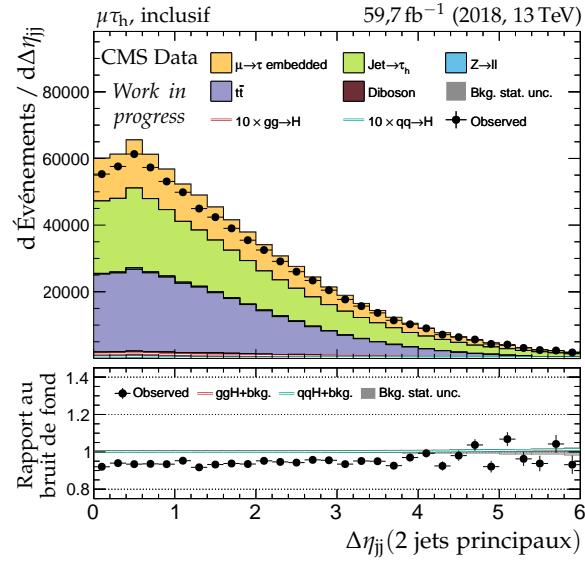
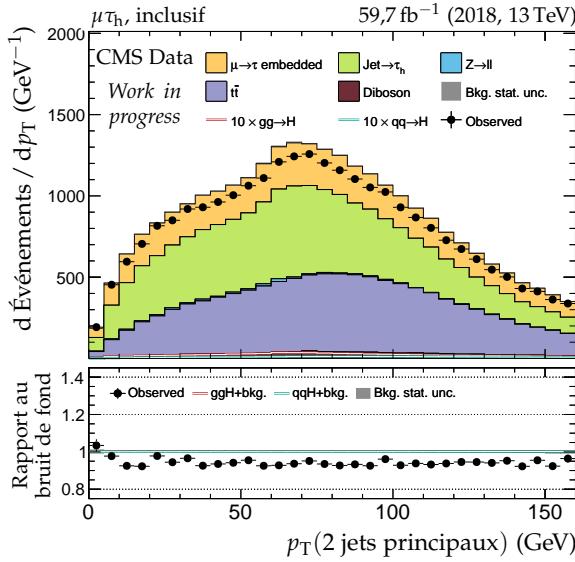
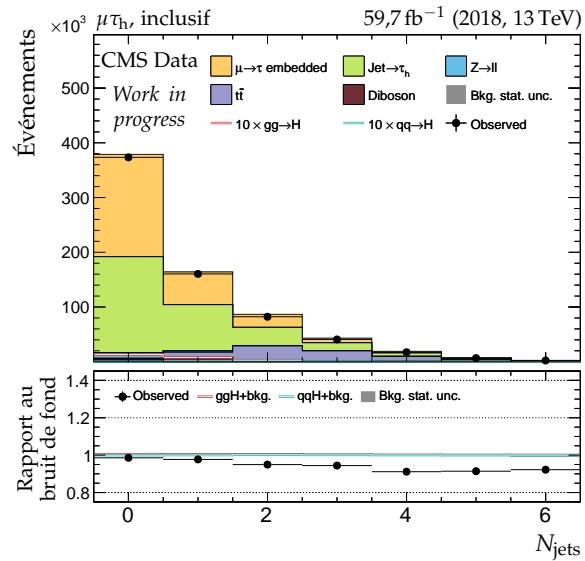
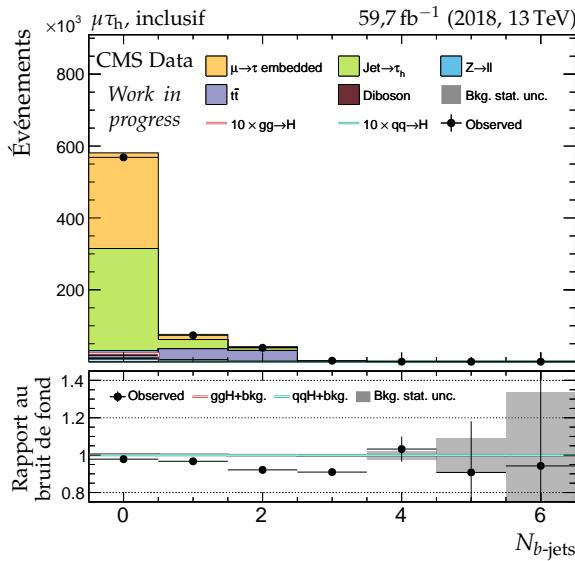


(e) Angle azimutal de l'AHA.

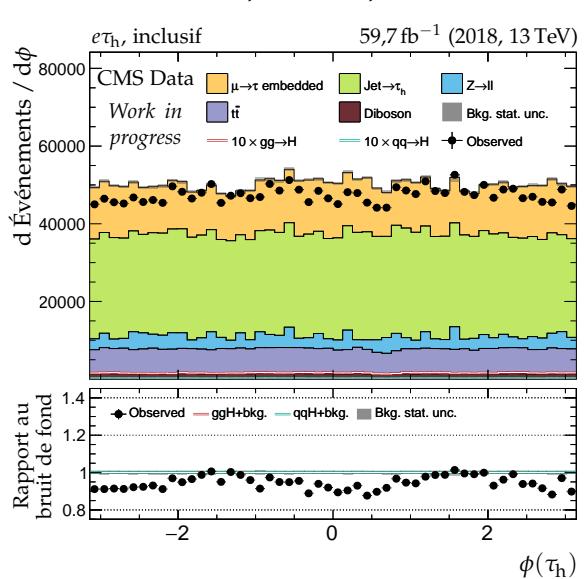
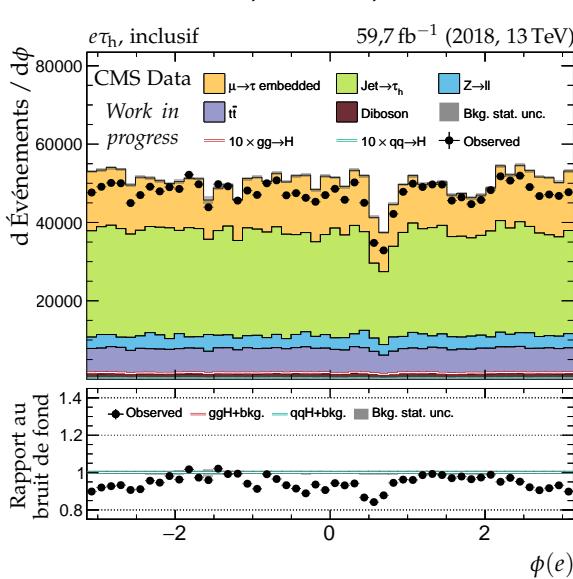
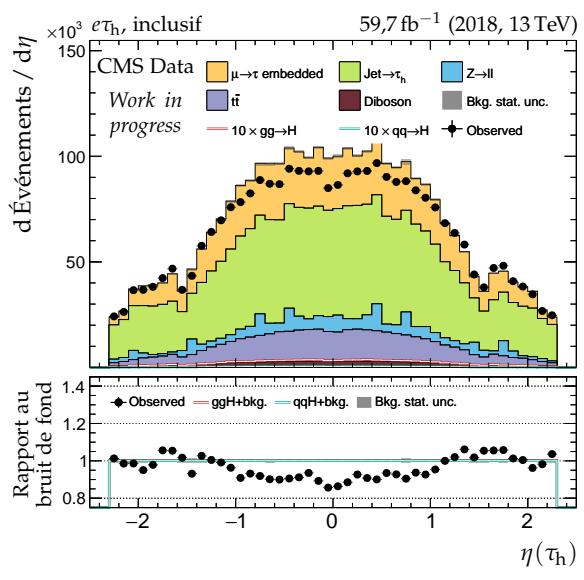
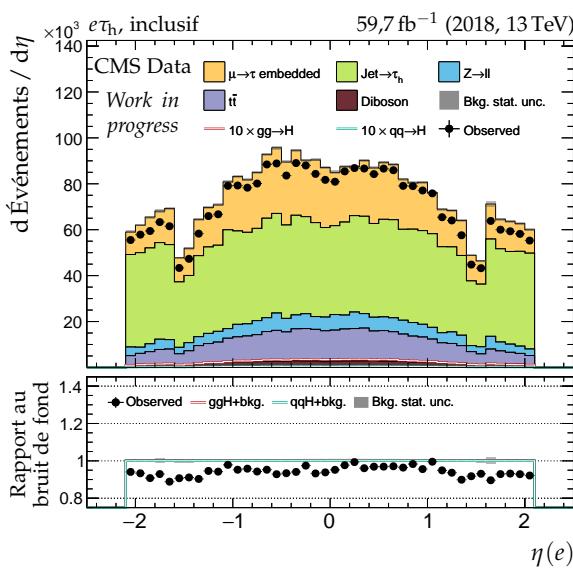
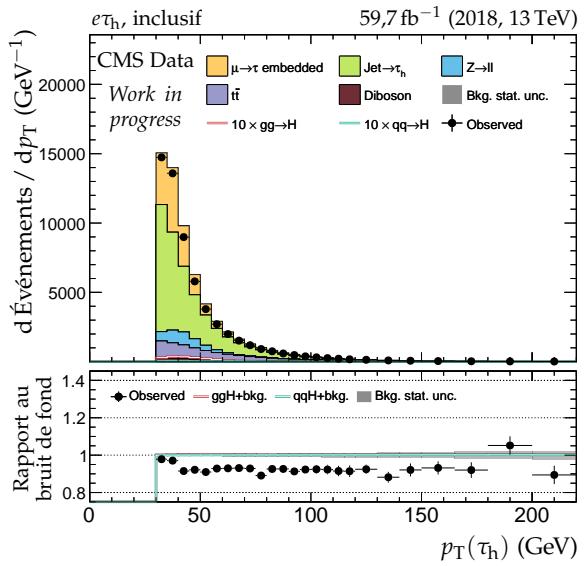
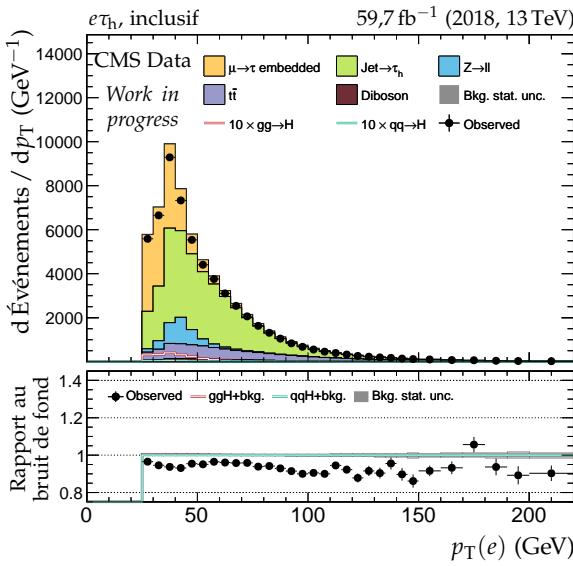


(f) Nombre de jets dans l'AHA.

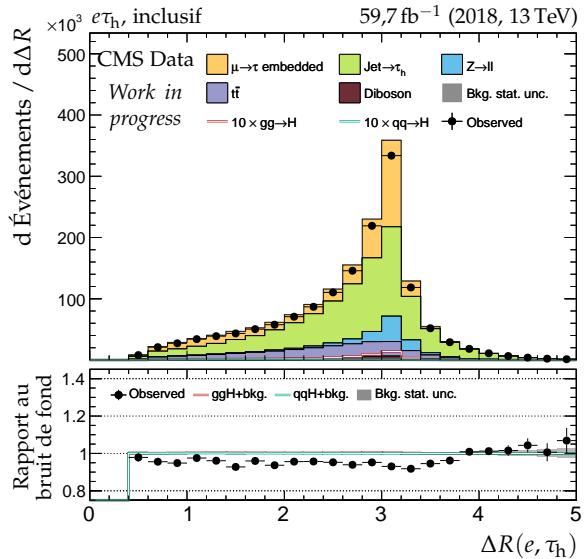
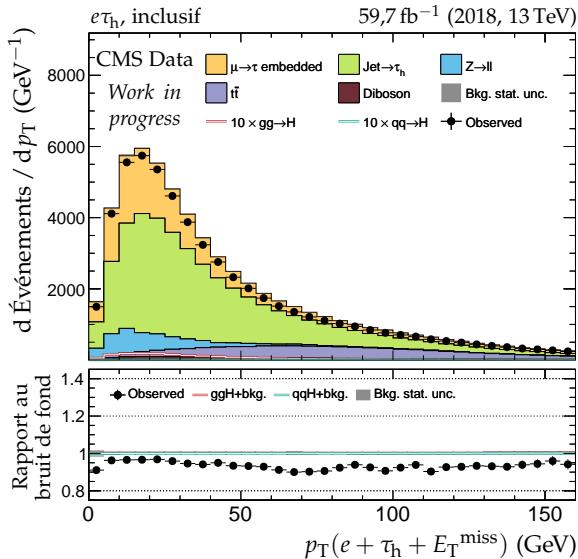
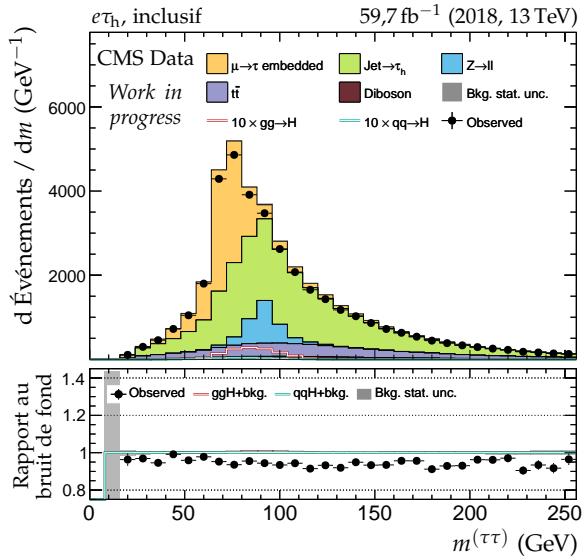
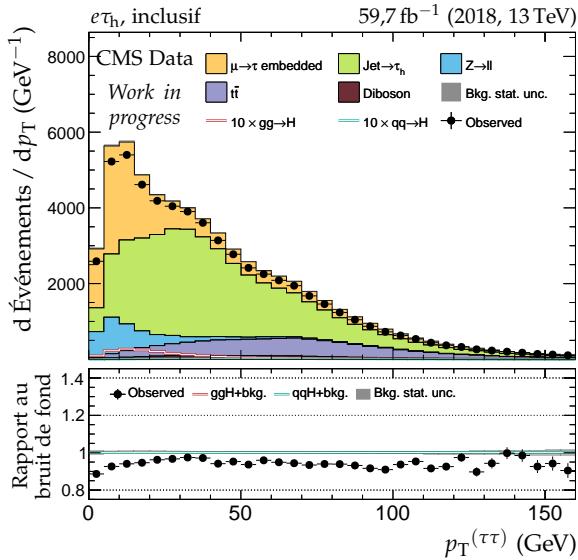
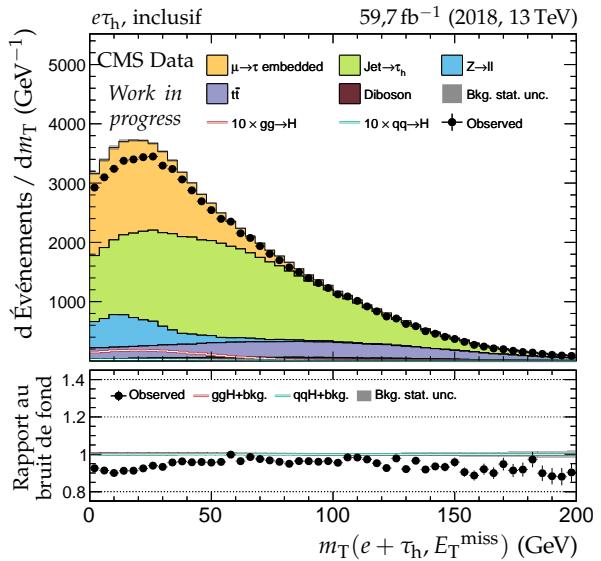
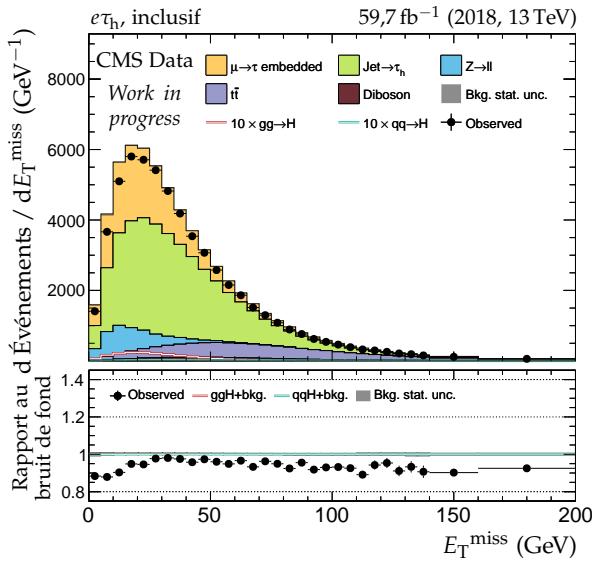
**Figure X.61 – Canal  $\mu\tau_h$ , 2018 : b-jets et activité hadronique additionnelle.**



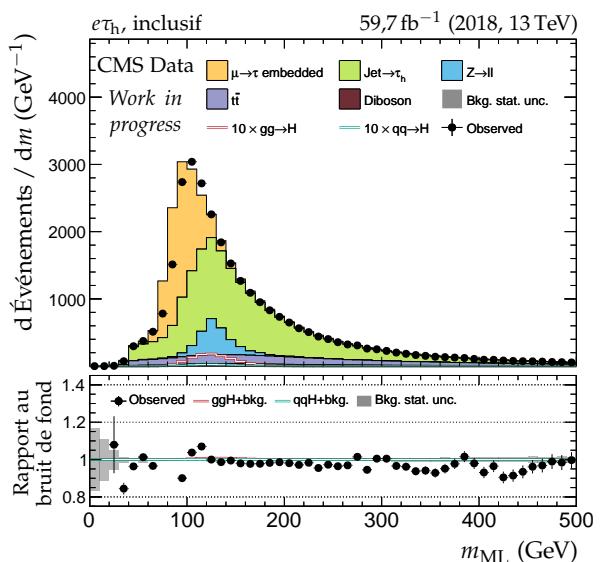
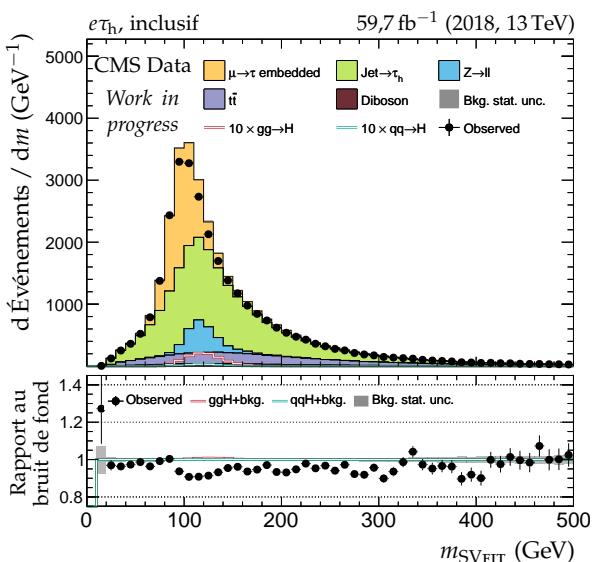
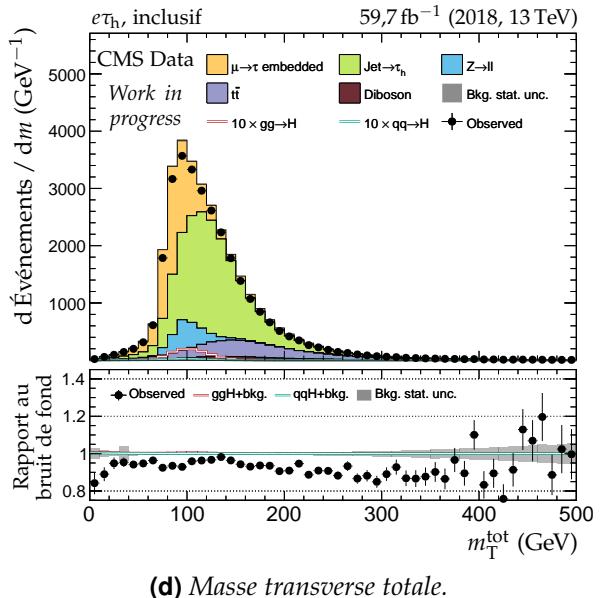
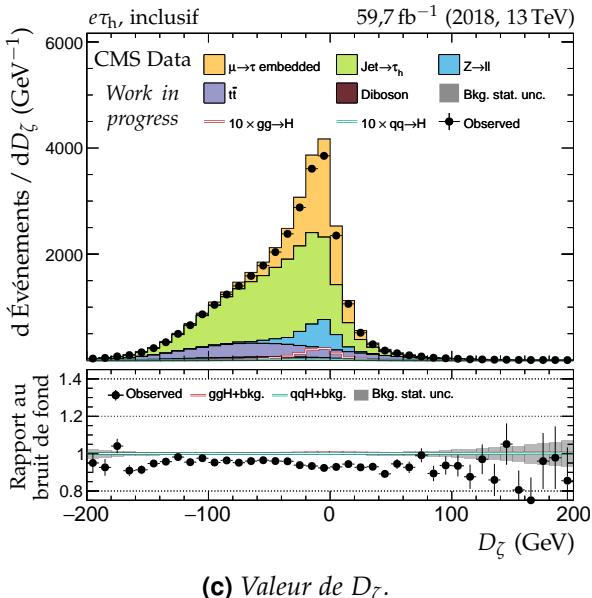
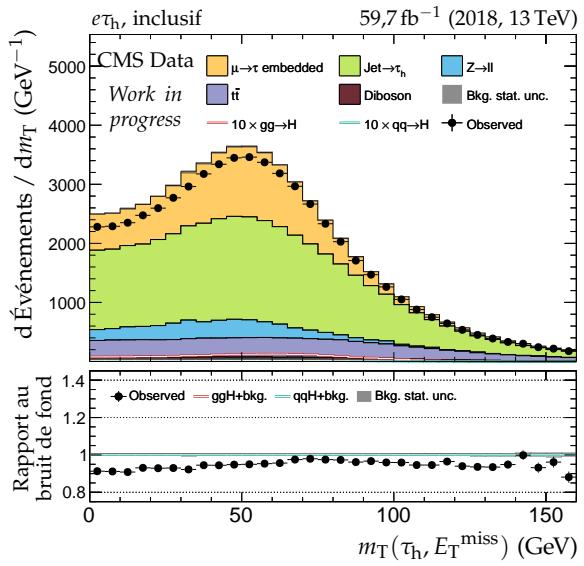
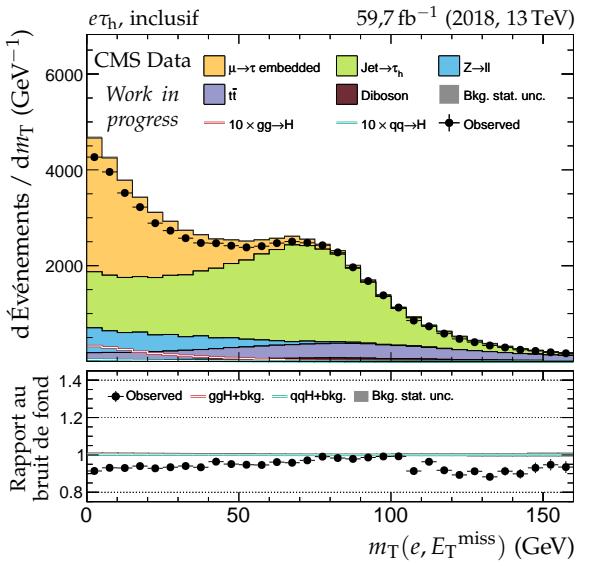
**Figure X.62 – Canal  $\mu\tau_h$ , 2018 : nombre de jets, système des deux jets principaux et empilement.**



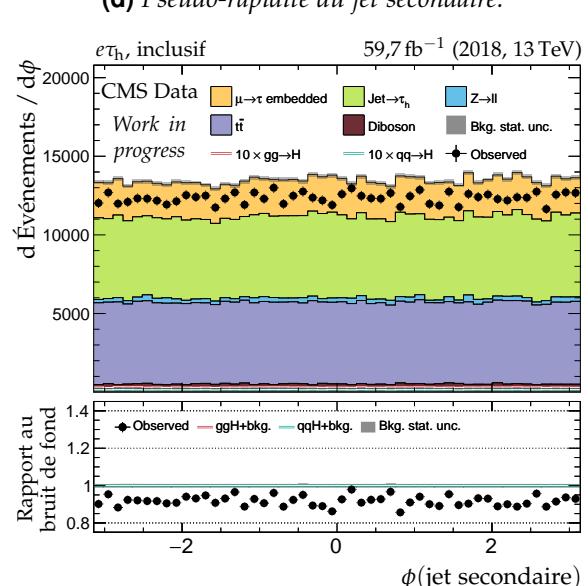
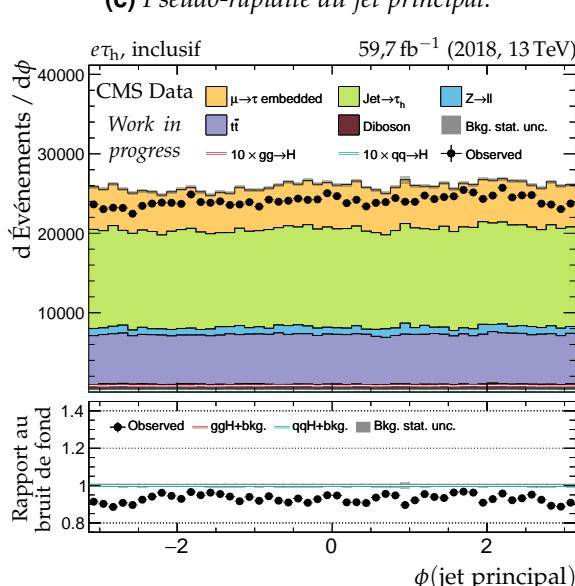
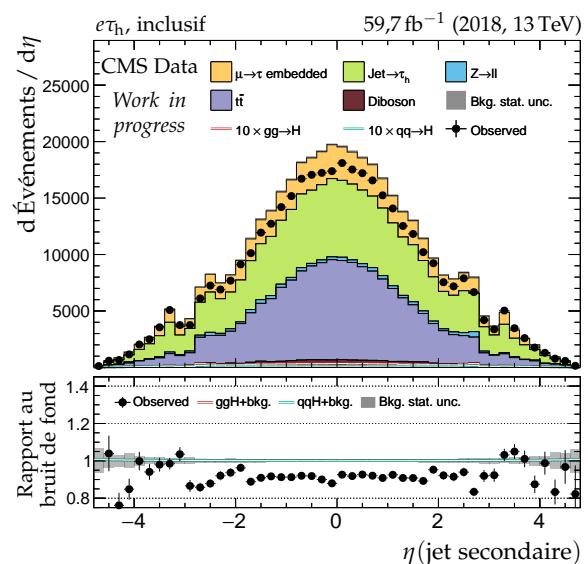
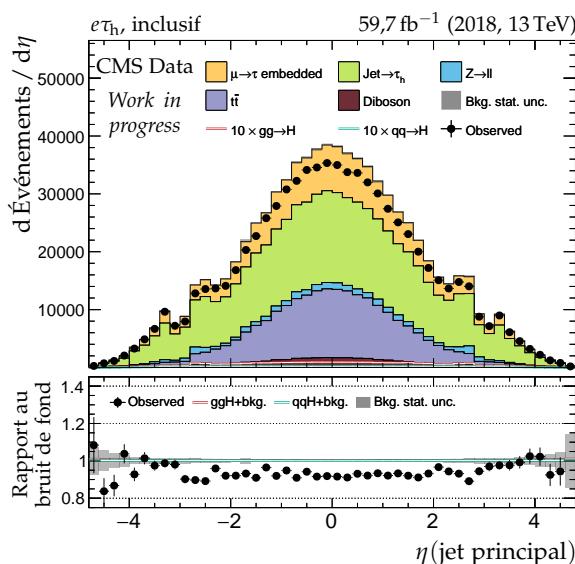
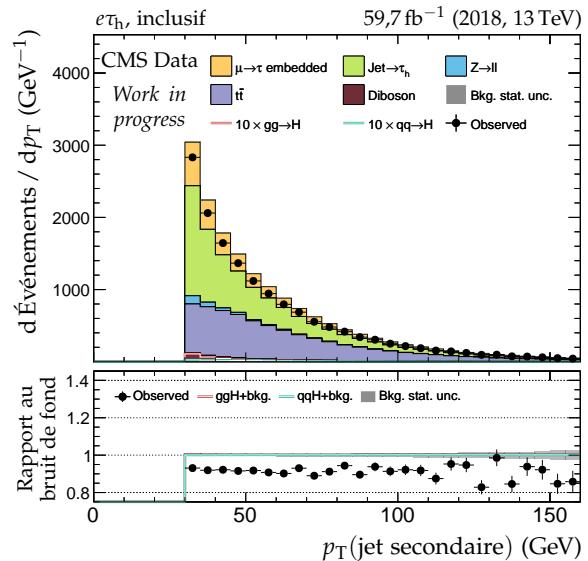
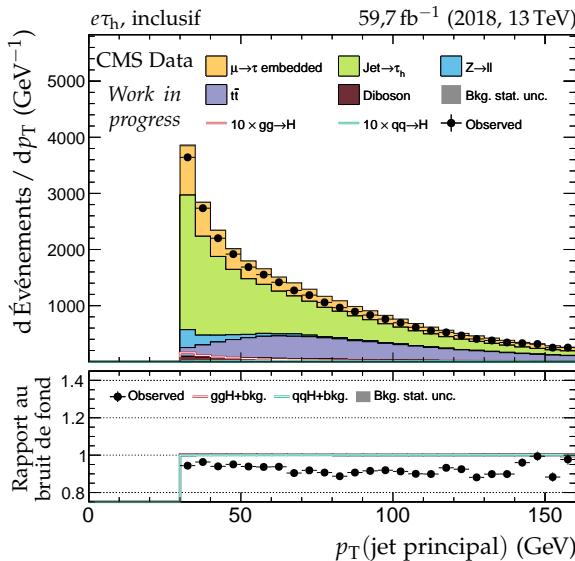
**Figure X.63 – Canal  $e\tau_h$ , 2018 : cinématique des leptons ( $e, \tau_h$ ).**



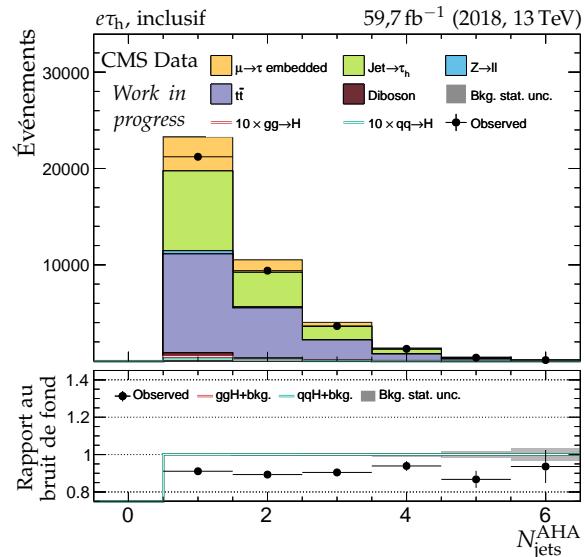
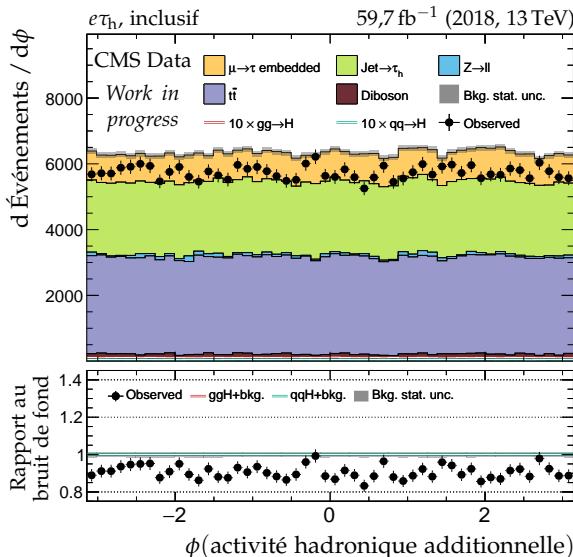
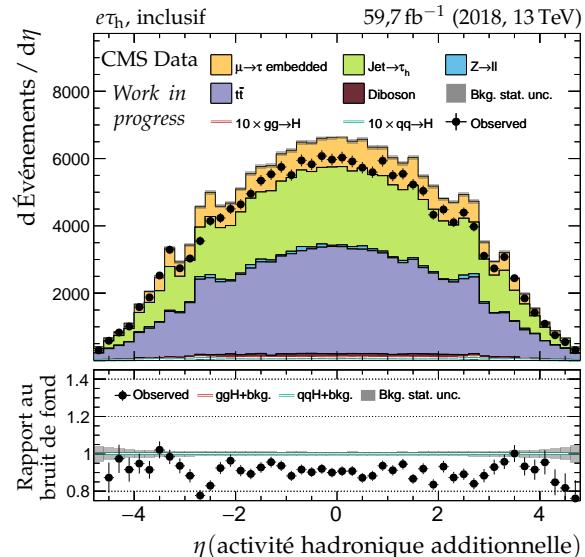
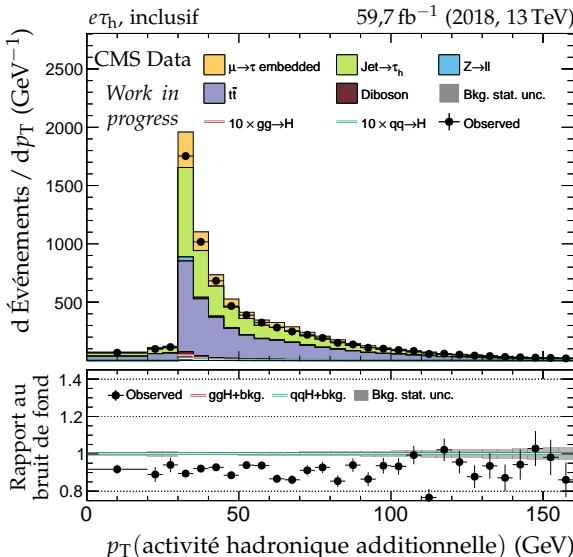
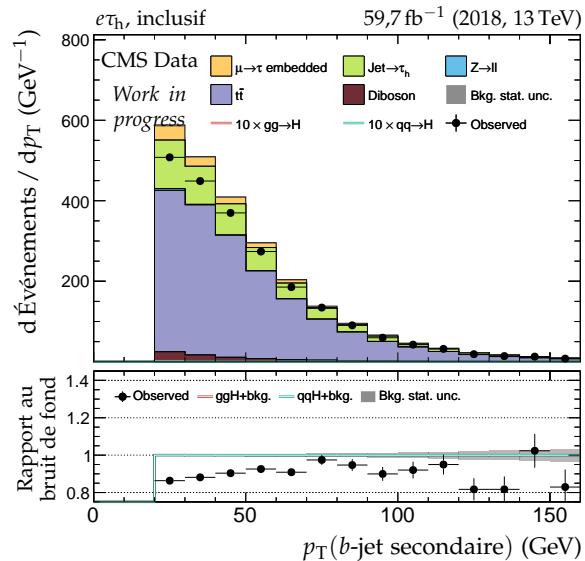
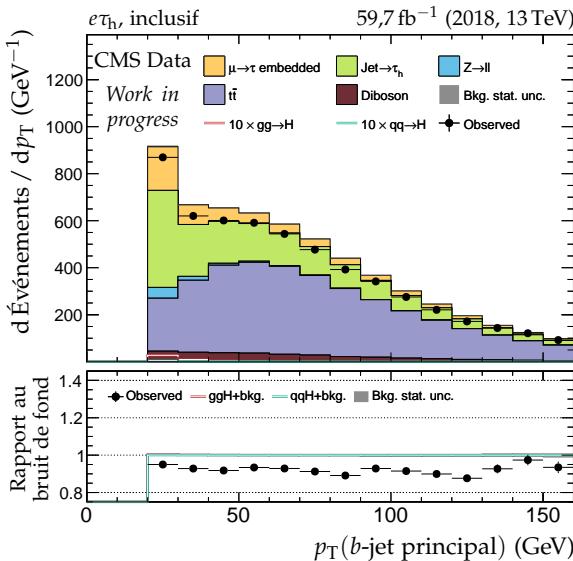
**Figure X.64 – Canal  $e\tau_h$ , 2018 : dilepton et énergie transverse manquante.**



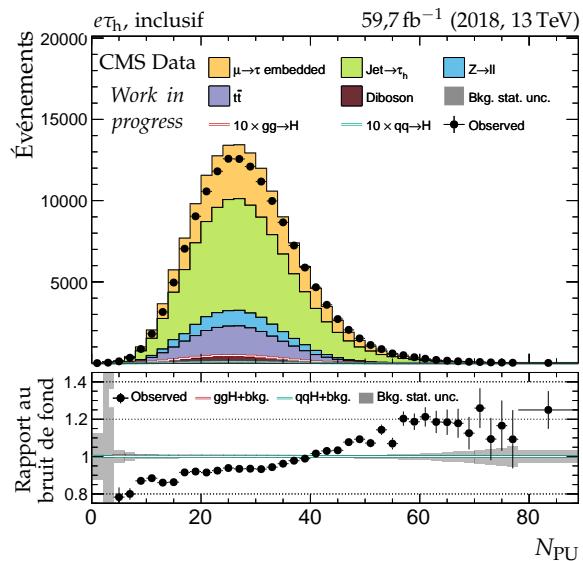
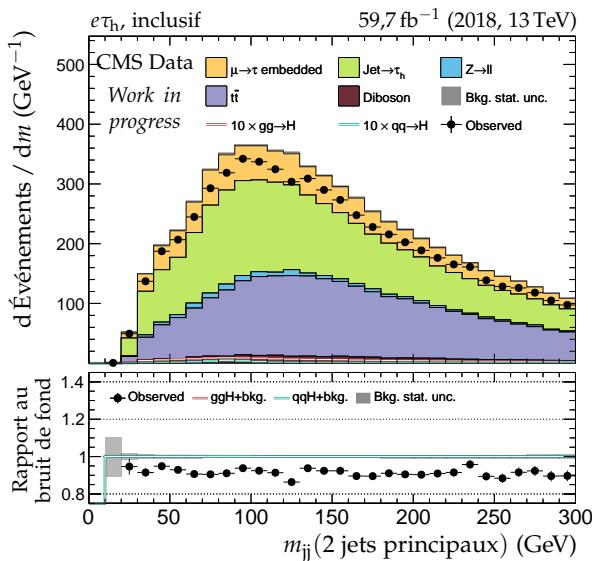
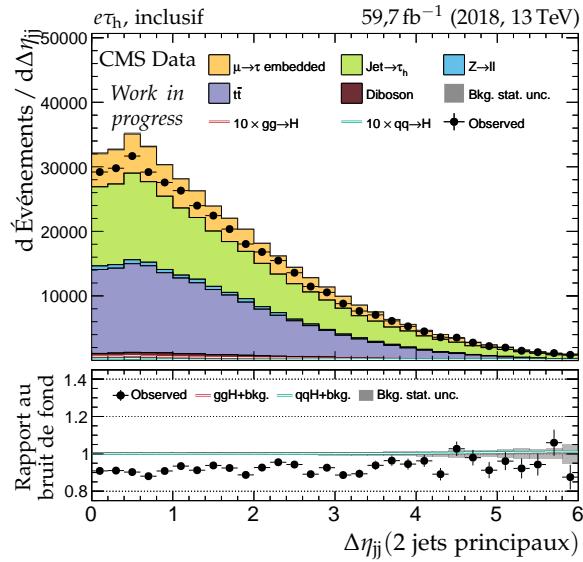
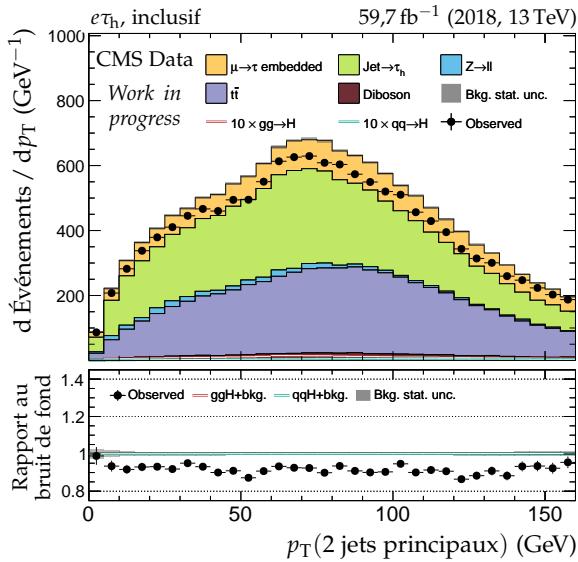
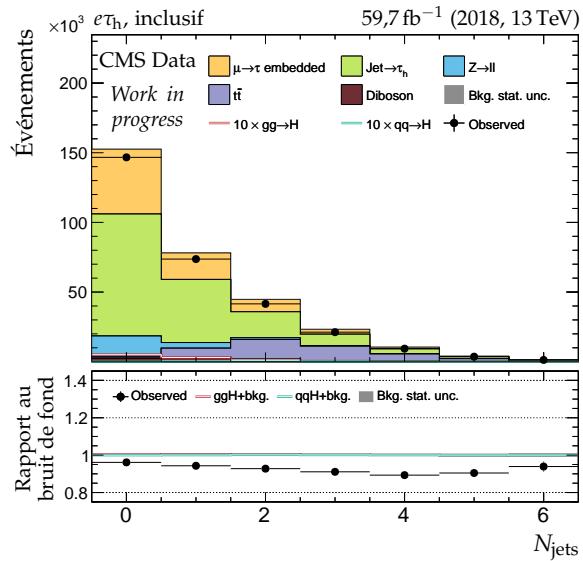
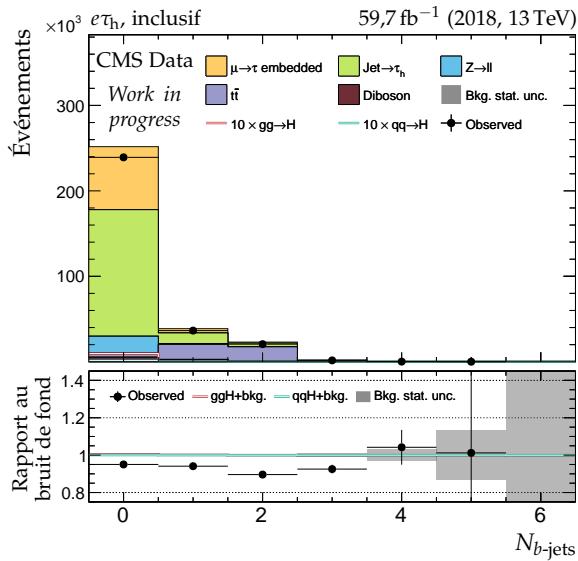
**Figure X.65 – Canal  $e\tau_h$ , 2018 : masses transverses,  $D_\zeta$  et masses.**



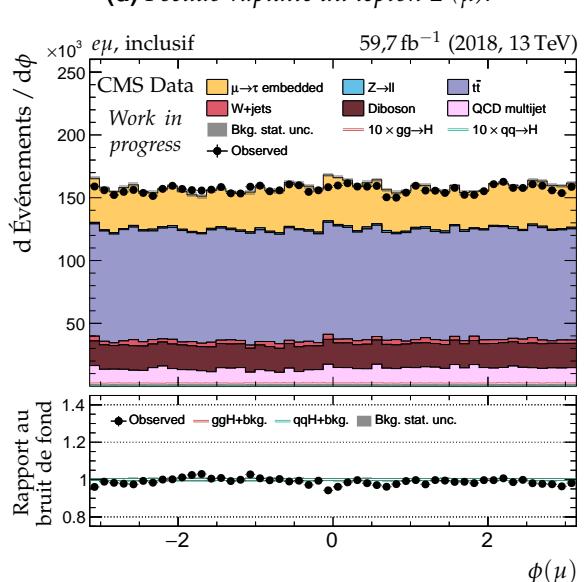
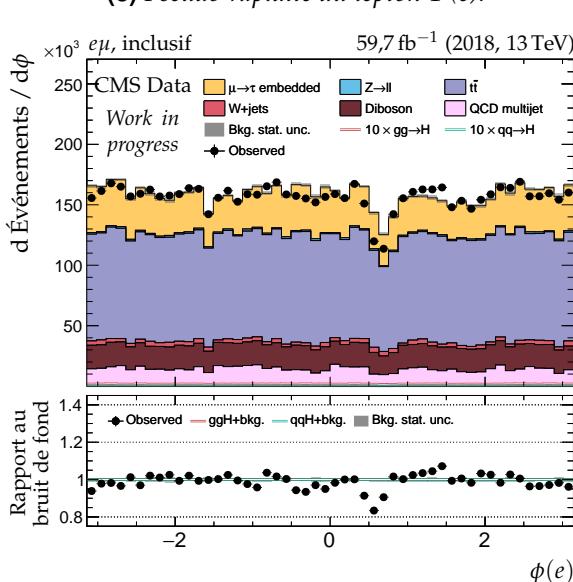
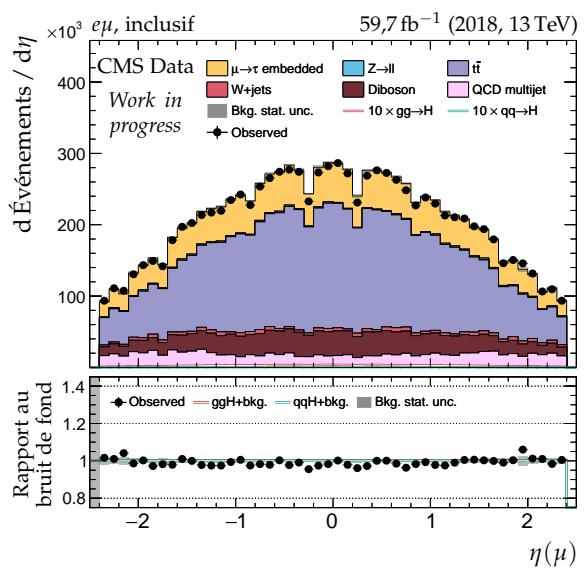
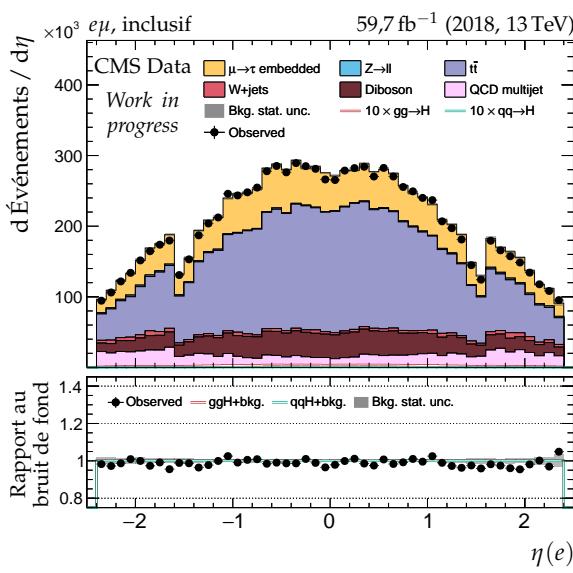
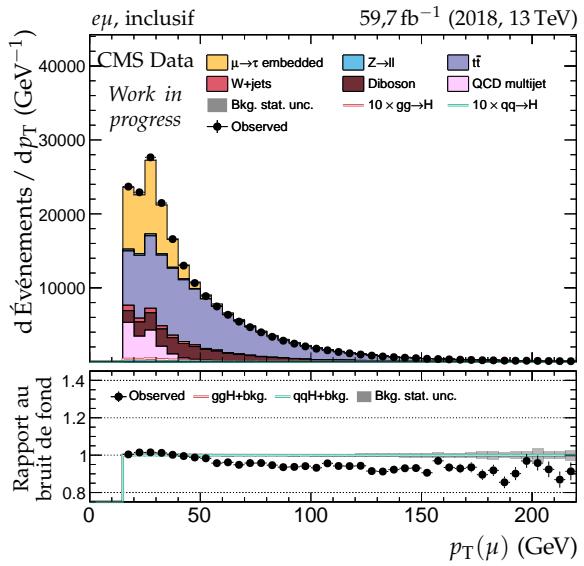
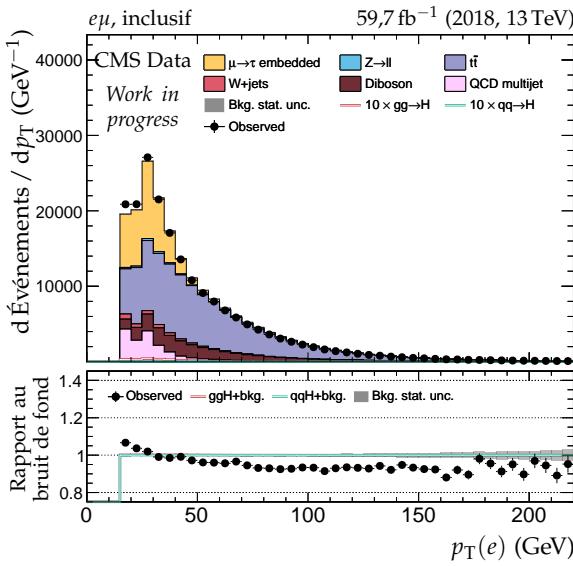
**Figure X.66 – Canal  $e\tau_h$ , 2018 : cinématique des deux jets principaux.**



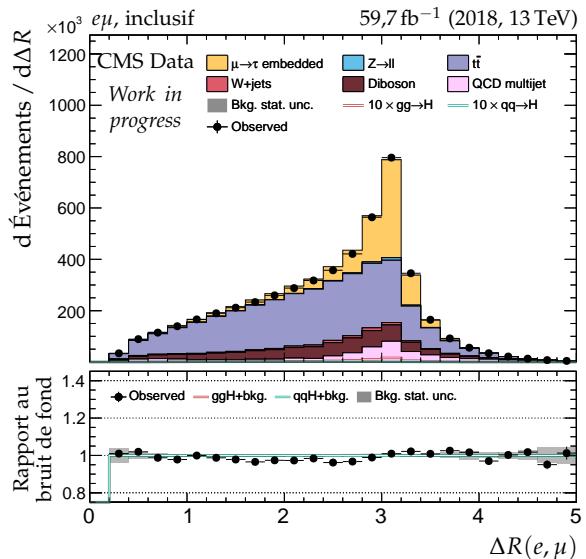
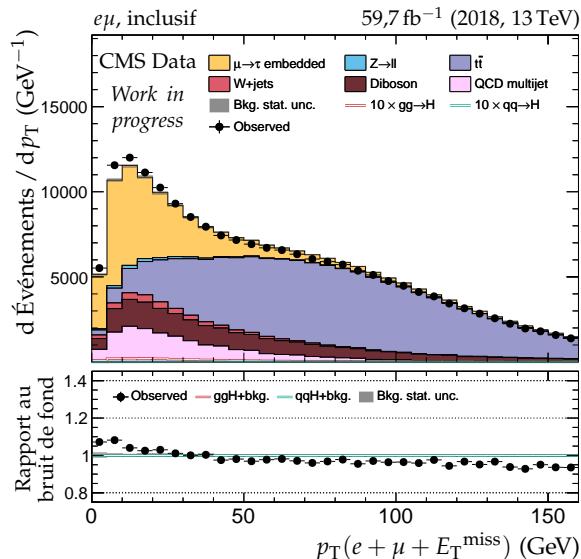
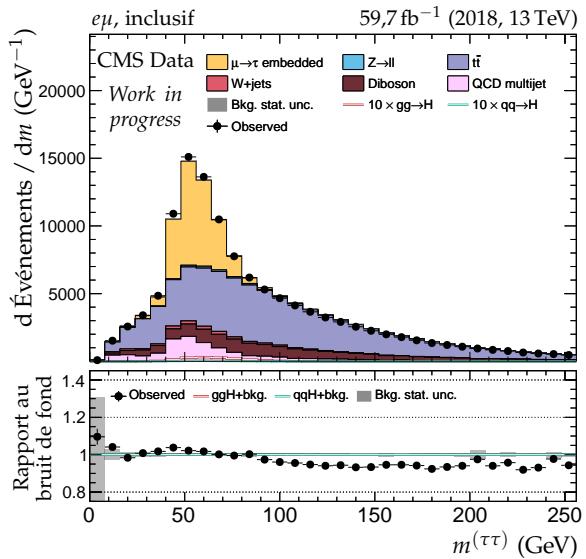
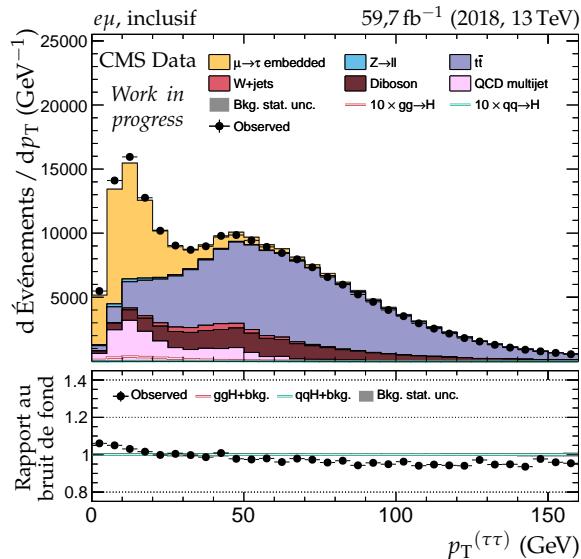
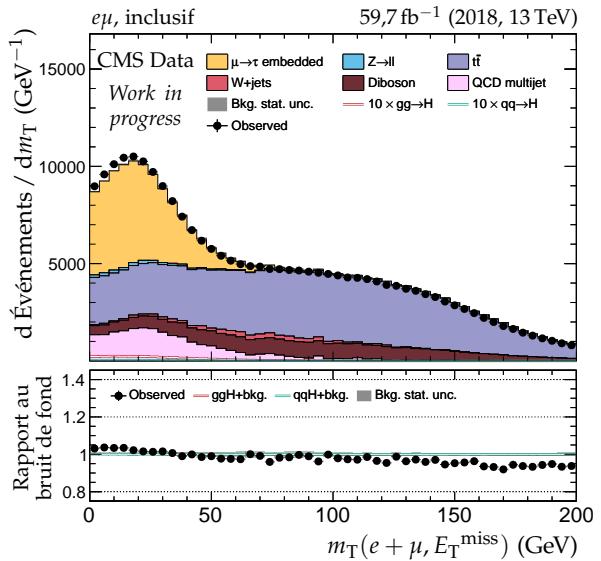
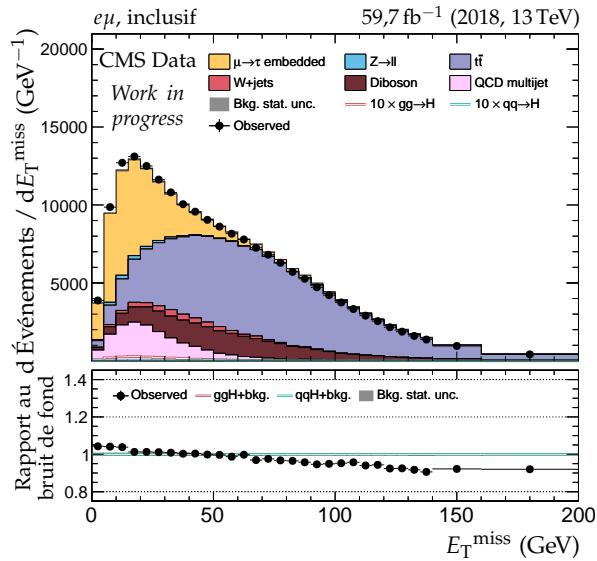
**Figure X.67 – Canal  $e\tau_h$ , 2018 :  $b$ -jets et activité hadronique additionnelle.**

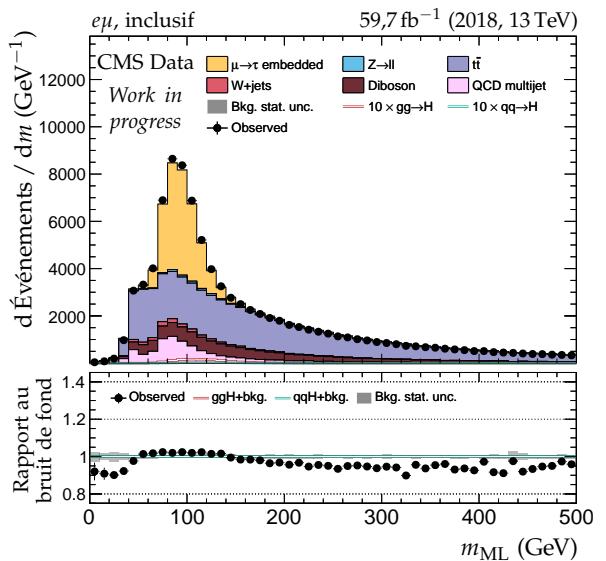
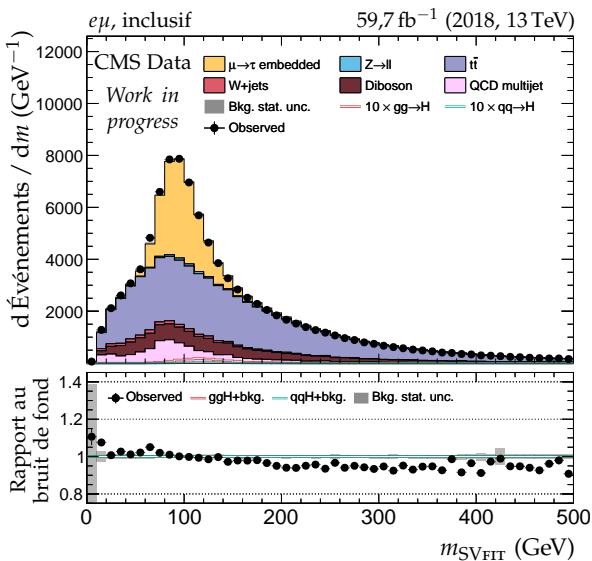
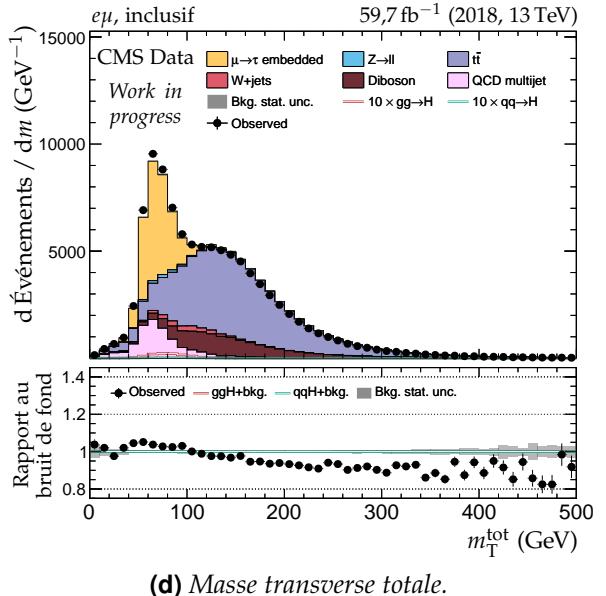
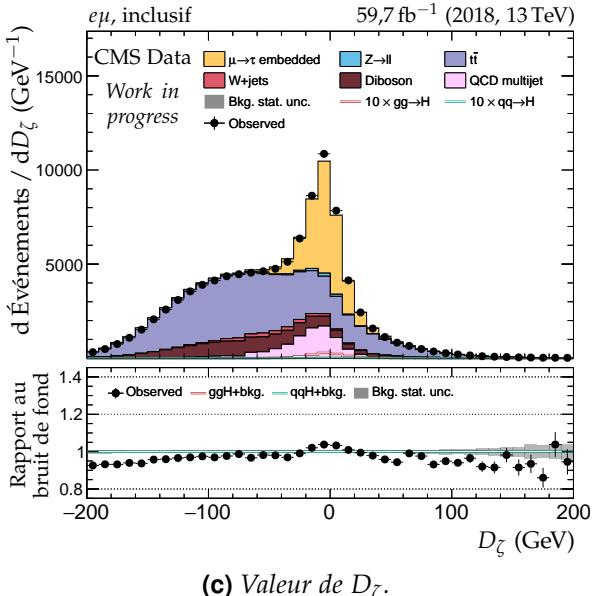
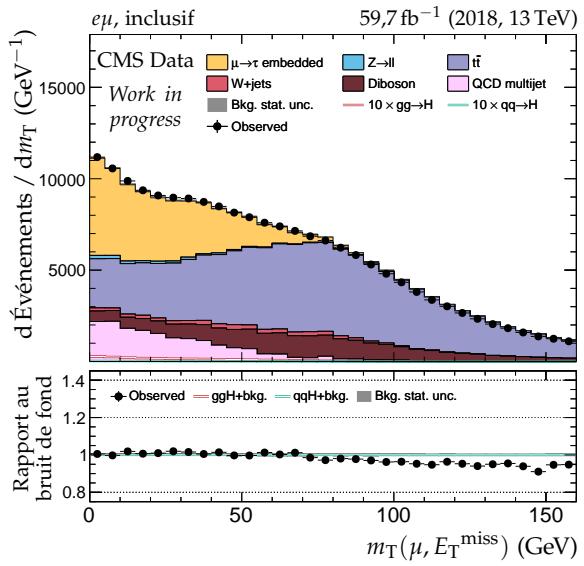
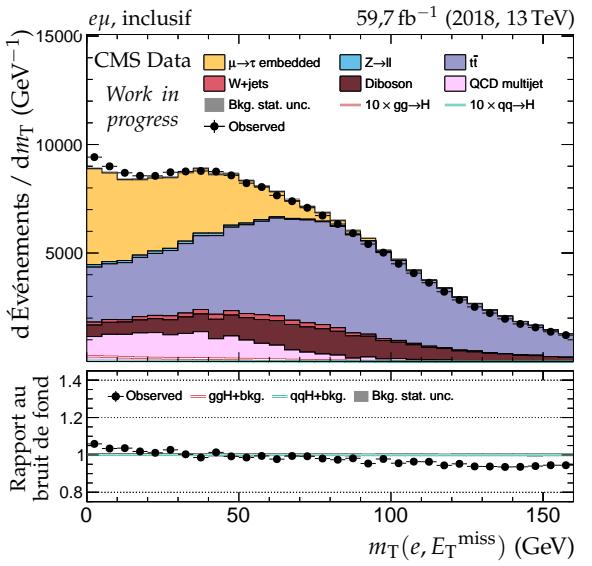


**Figure X.68 – Canal  $e\tau_h$ , 2018 : nombre de jets, système des deux jets principaux et empilement.**

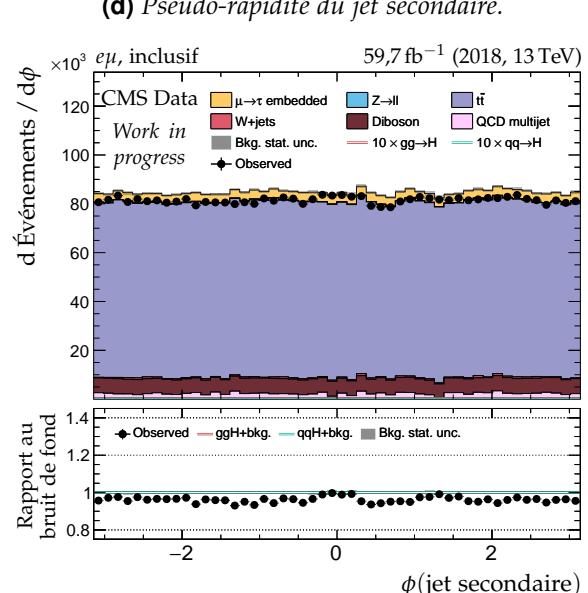
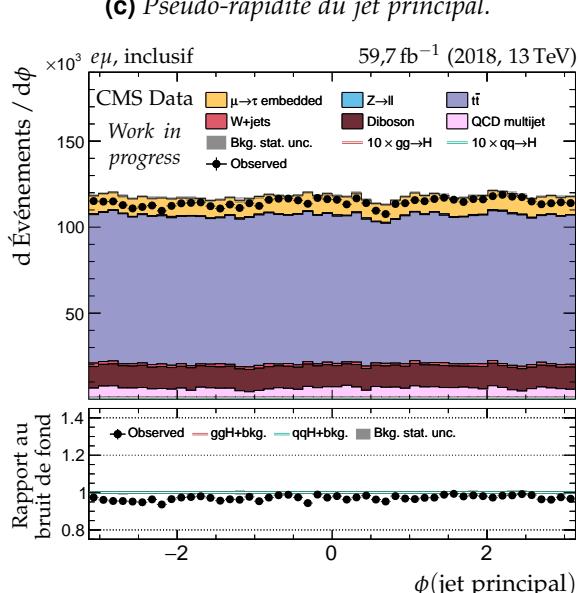
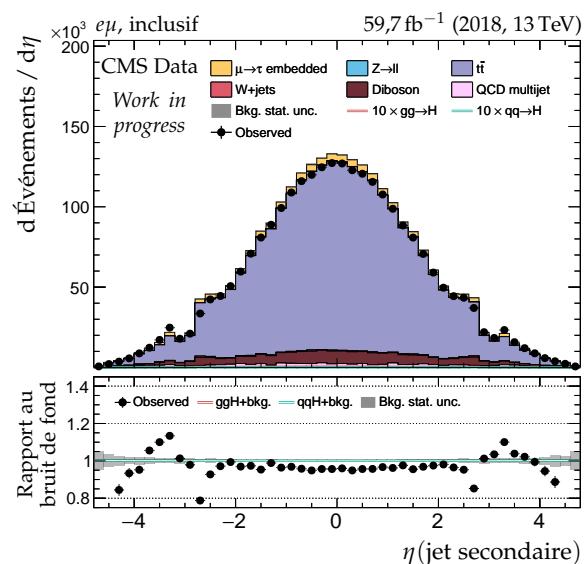
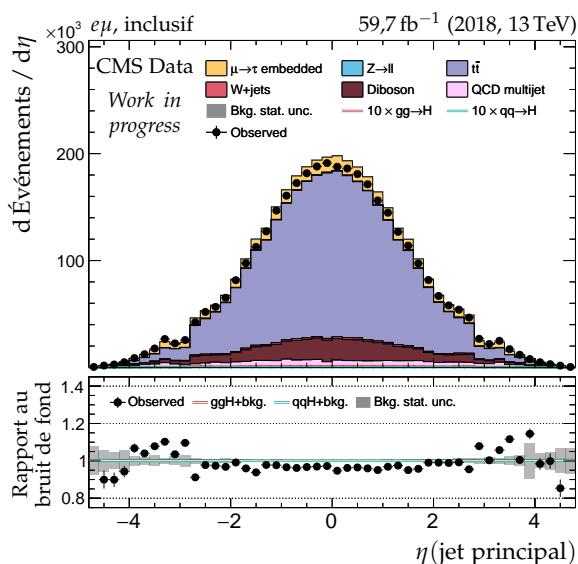
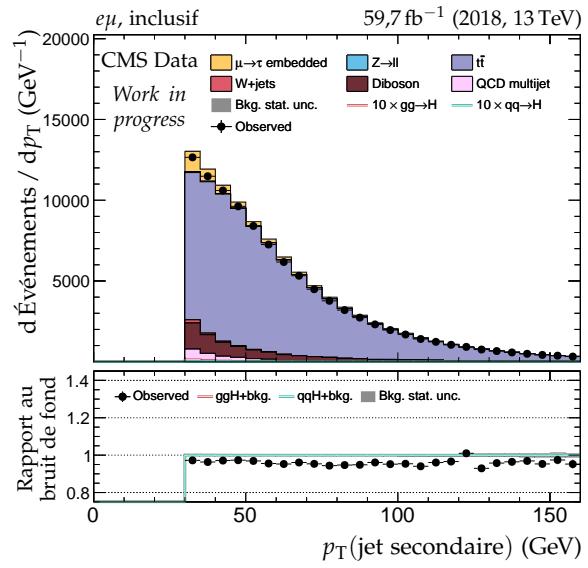
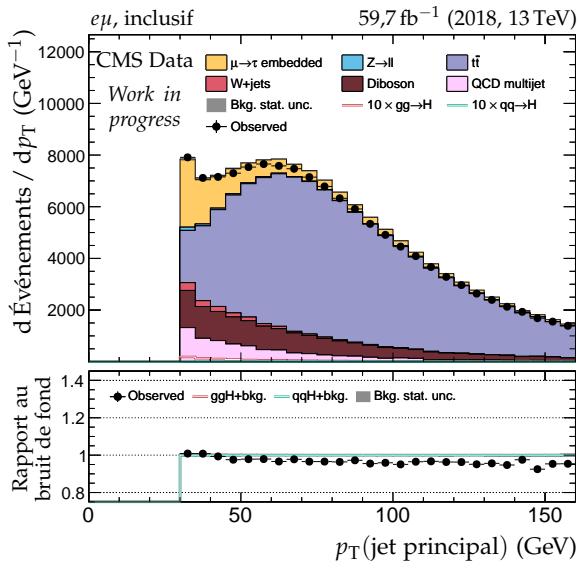


**Figure X.69 – Canal  $e\mu$ , 2018 : cinématique des leptons ( $e, \mu$ ).**

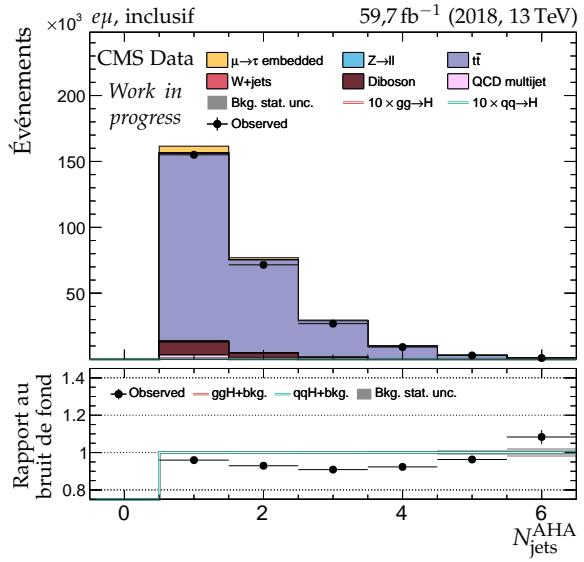
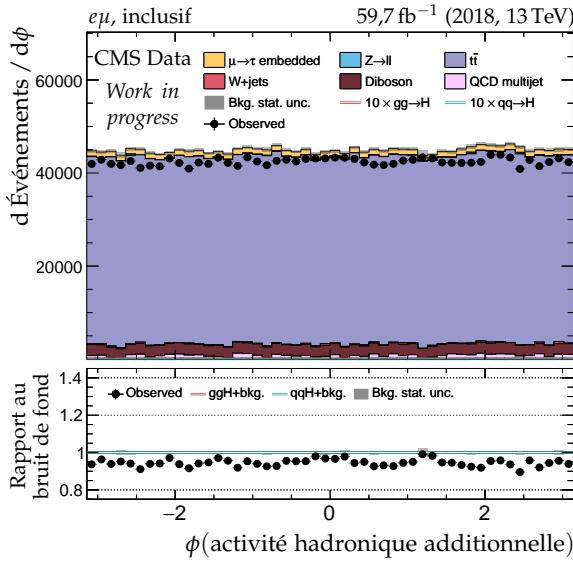
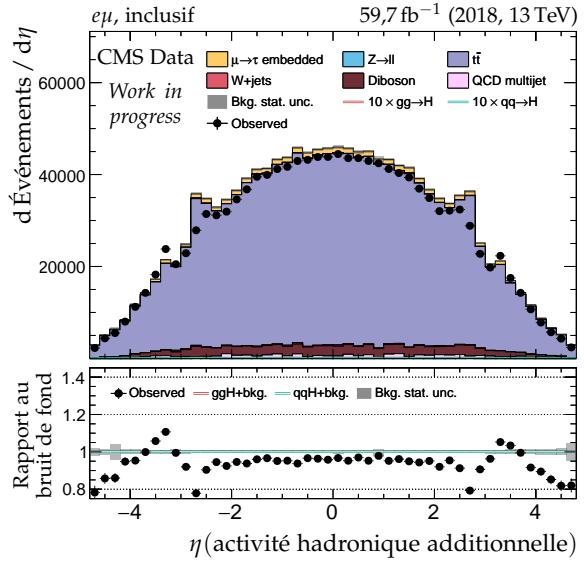
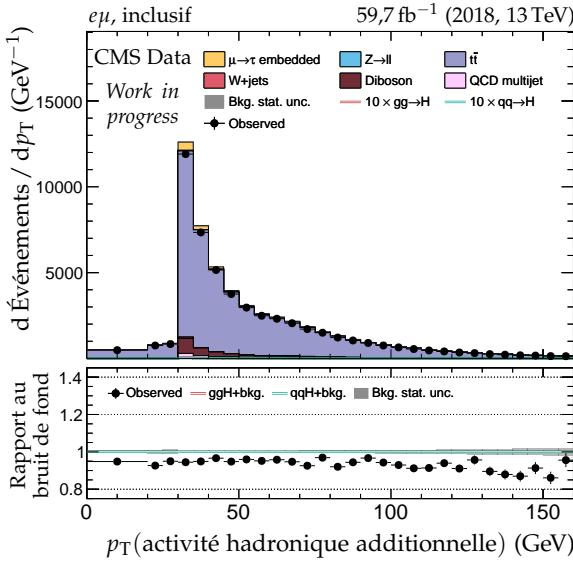
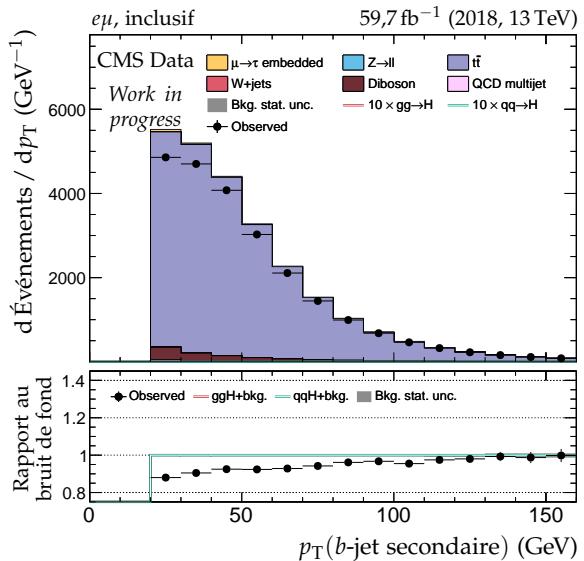
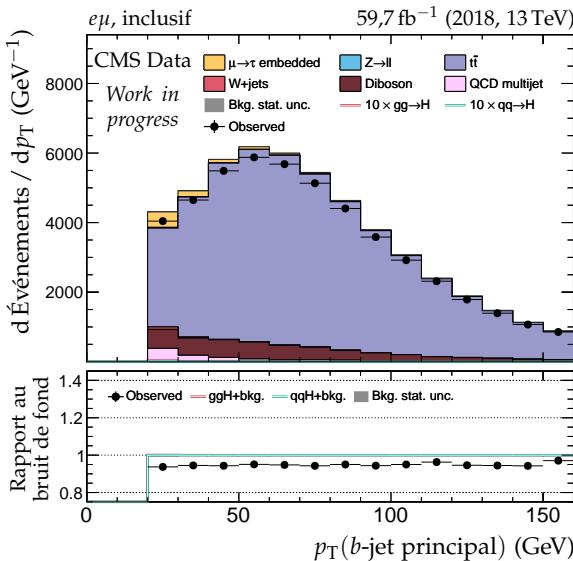
**Figure X.70 – Canal  $e\mu$ , 2018 : dilepton et énergie transverse manquante.**



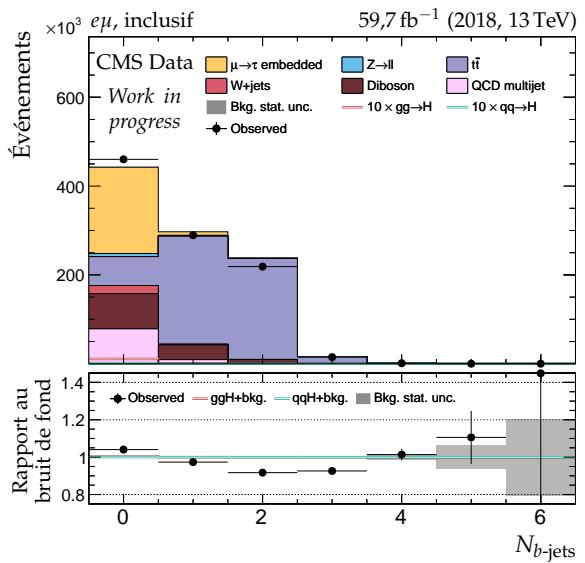
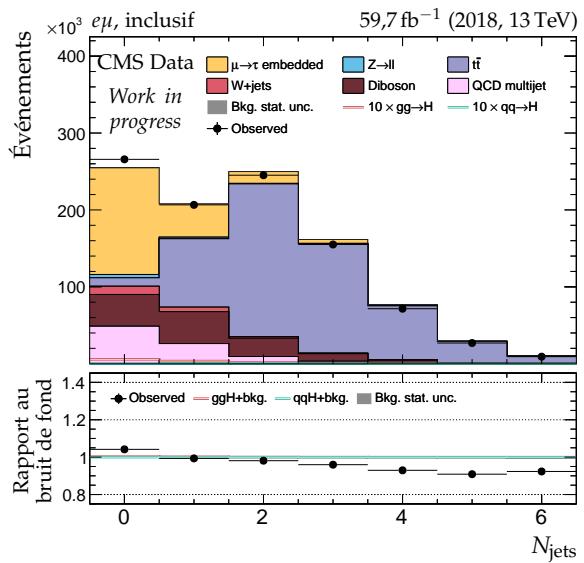
**Figure X.71 – Canal  $e\mu$ , 2018 : masses transverses,  $D_\zeta$  et masses.**



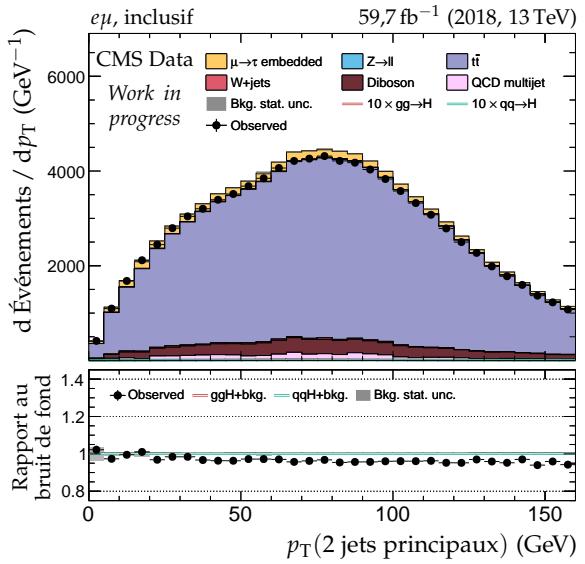
**Figure X.72 – Canal  $e\mu$ , 2018 : cinématique des deux jets principaux.**



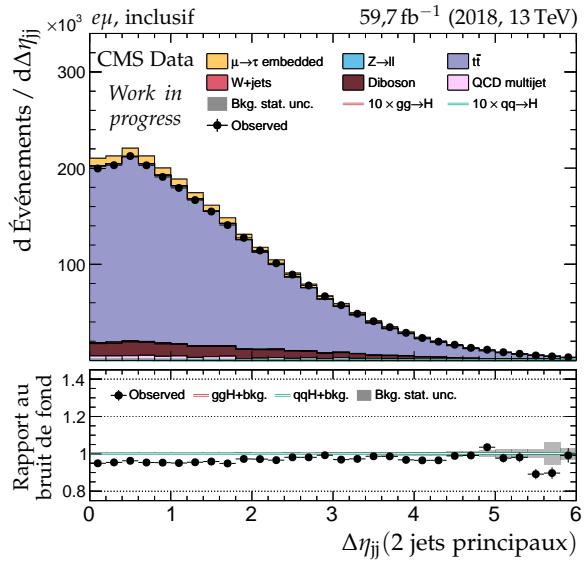
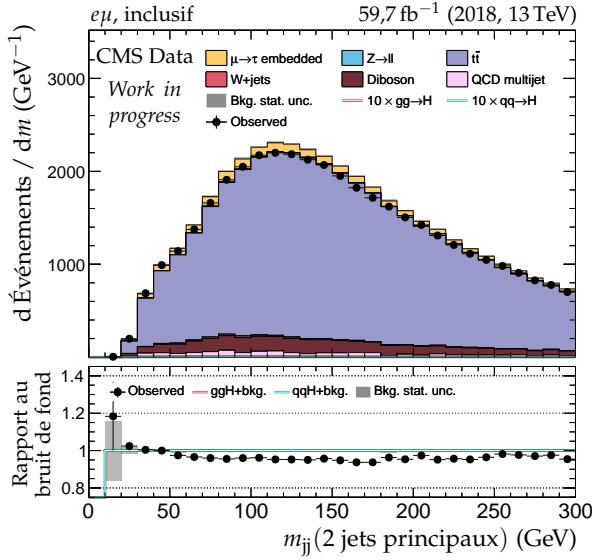
**Figure X.73 – Canal  $e\mu$ , 2018 : b-jets et activité hadronique additionnelle.**

(a) Nombre de  $b$ -jets.

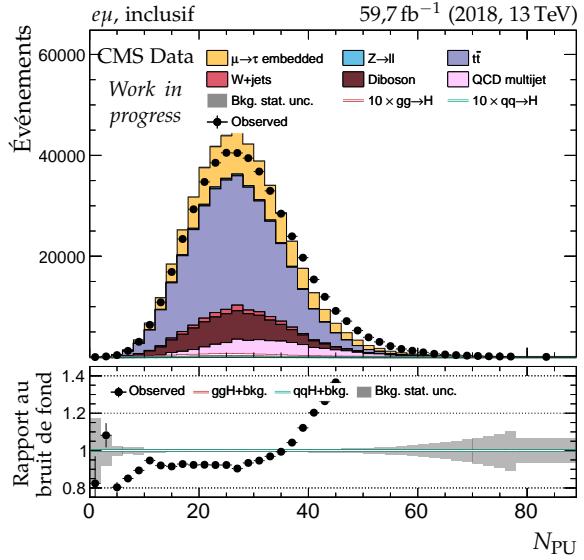
(b) Nombre de jets.



(c) Impulsion transverse du système des deux jets.

(d) Distance en  $\eta$  entre les deux jets.

(e) Masse invariante du système des deux jets.



(f) Nombre de vertex d'empilement.

**Figure X.74** – Canal  $e\mu$ , 2018 : nombre de jets, système des deux jets principaux et empilement.

