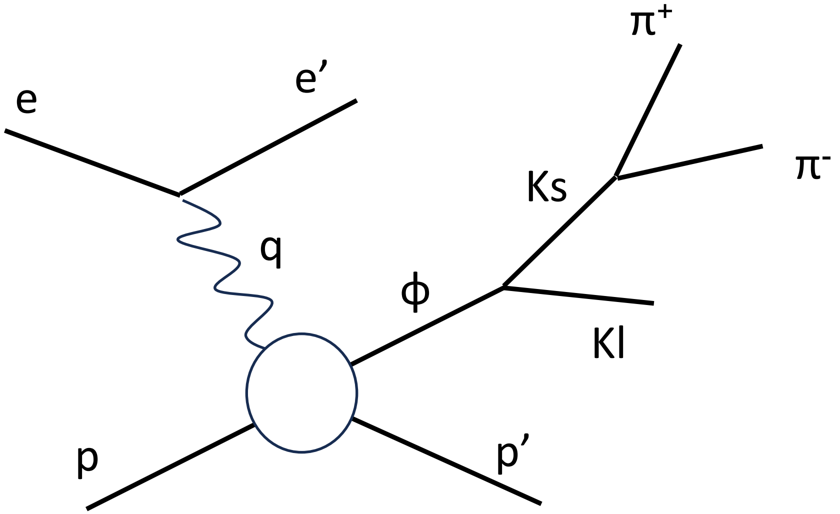
Analysis objective :

- Measurement of the cross section and diferential cross section of the electroproduction of ϕ in the K_s K_L channel

- Datas : nSidis RG-A inbending and outbending fall 2018 + spring 2019



General informations

Datas :

nSidis Rg-A datas : fall2018 inbending

Cuts :

→ Selection of events with one e^- , p , π^+ and π^- in the final state.

→ Cut on invariant mass of $\pi^+ \pi^-$ with $0.4 < M_{inv}(\pi^+ \pi^-) < 0.6$ GeV.

→ Cut on Missing Mass in the reaction $e\ p \rightarrow e'\ p'\ K_s\ X$ with $0.4 < M_{issMass} < 0.6$ GeV.

Correction on π^+ π^- vertex :

Vertex of π^+ π^- are recalculated with the code of Veronique Ziegler

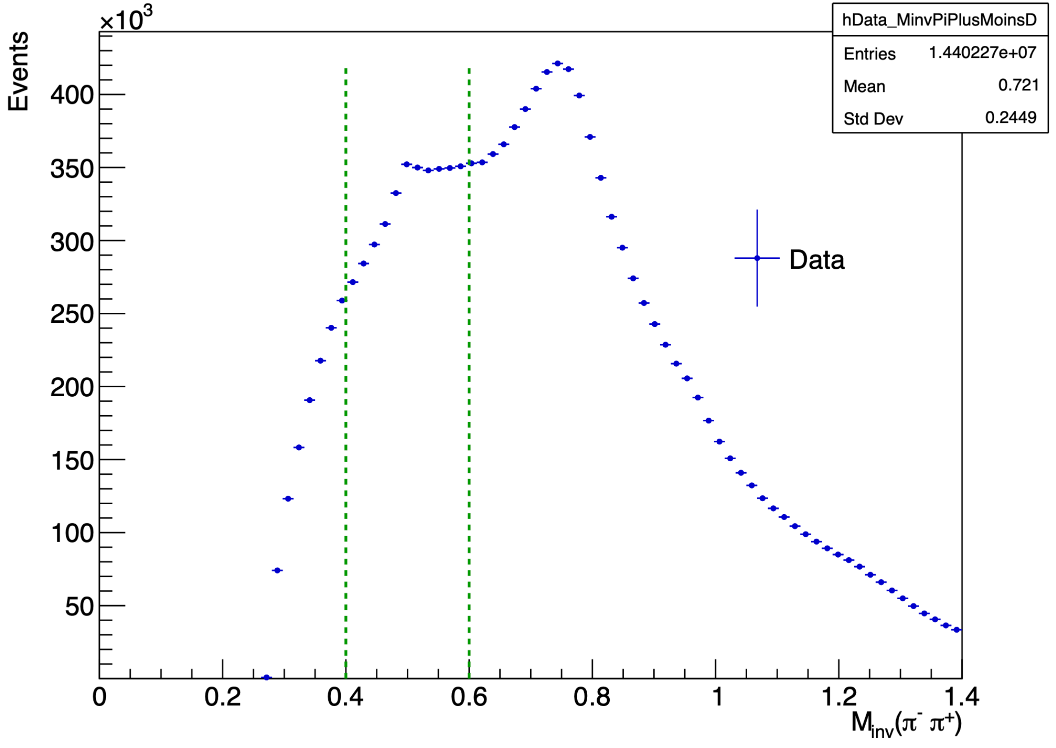
Add some cut on :

→ Distance between vertex of π^+ π^- < 2.5 cm

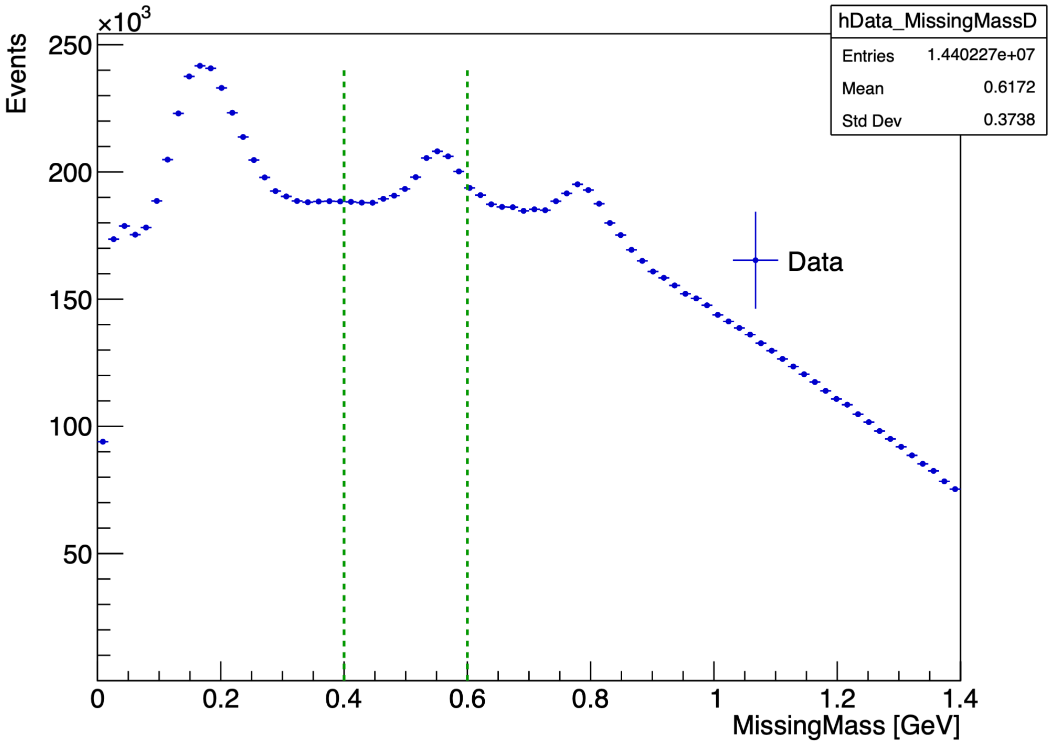
→ Distance between vertex Ks and e^- (1.5 < Dist < 5.0 cm) because $c\tau_{Ks} = 2.68$ cm

Details of cuts on datas

Invariant Mass π⁺ π⁻

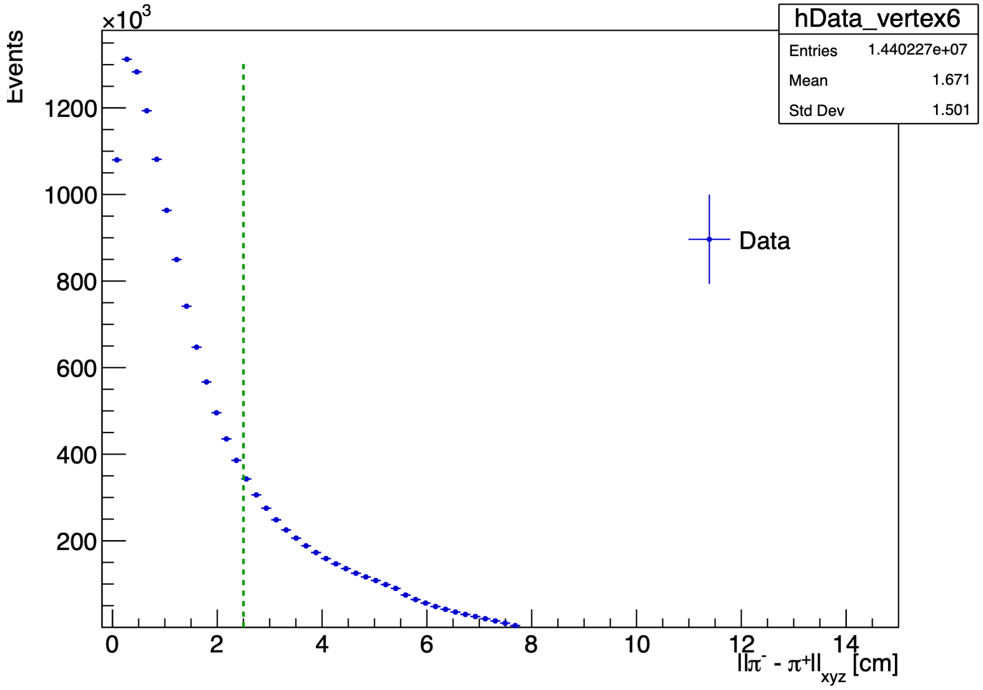


Missing Mass

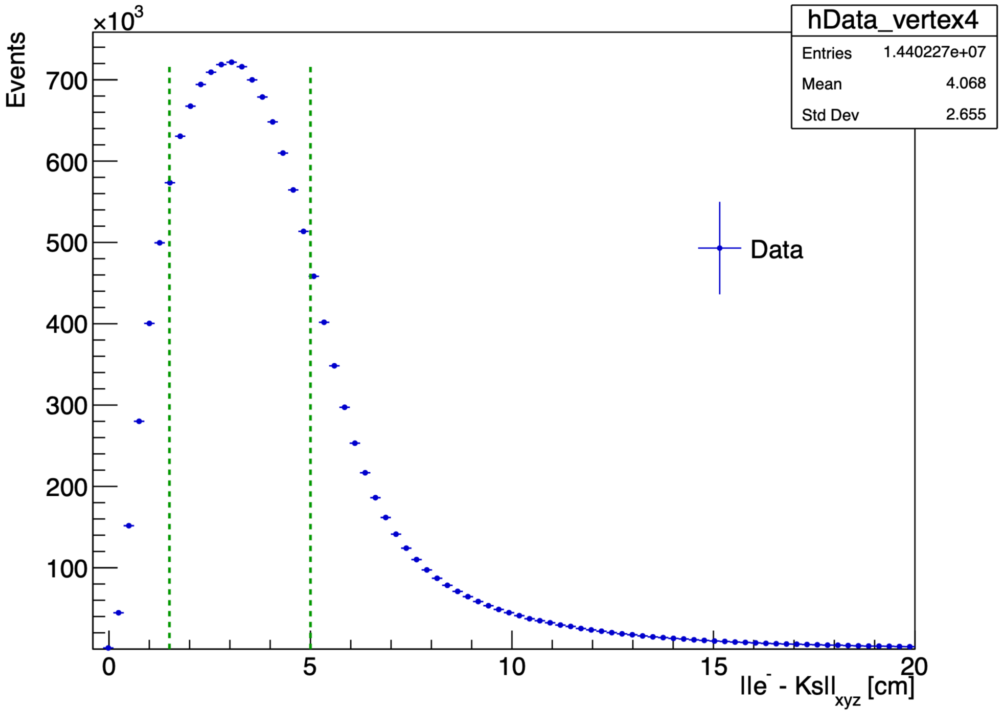


Details of cuts on datas

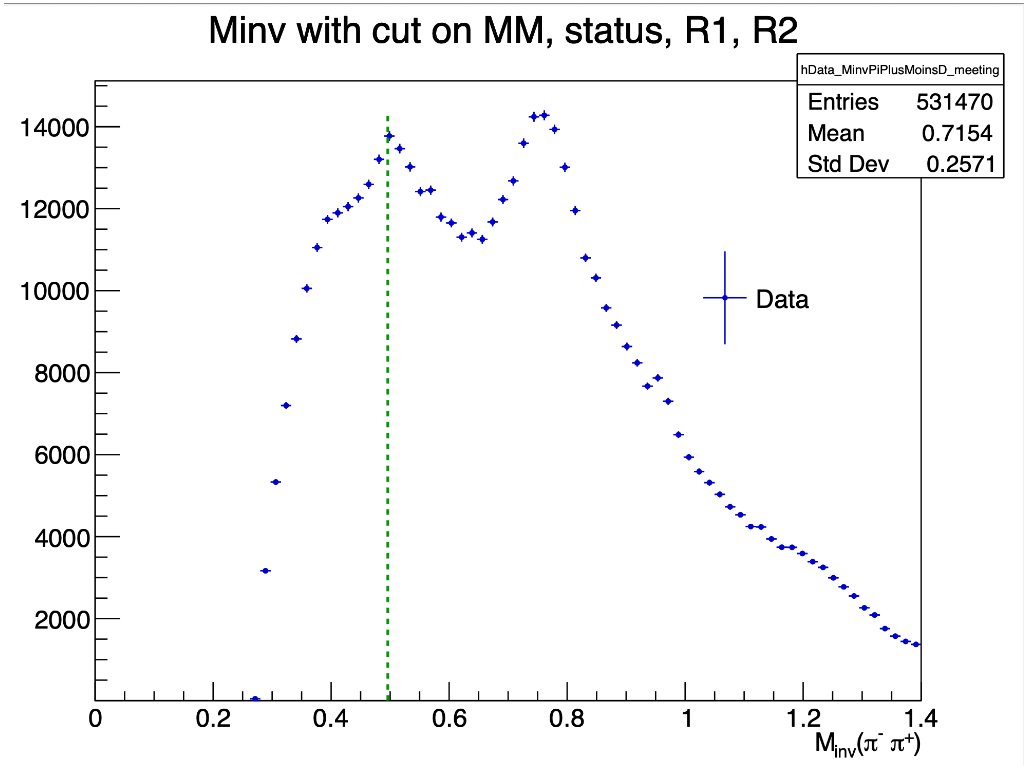
Distance vertex π $^+$ and π $^-$

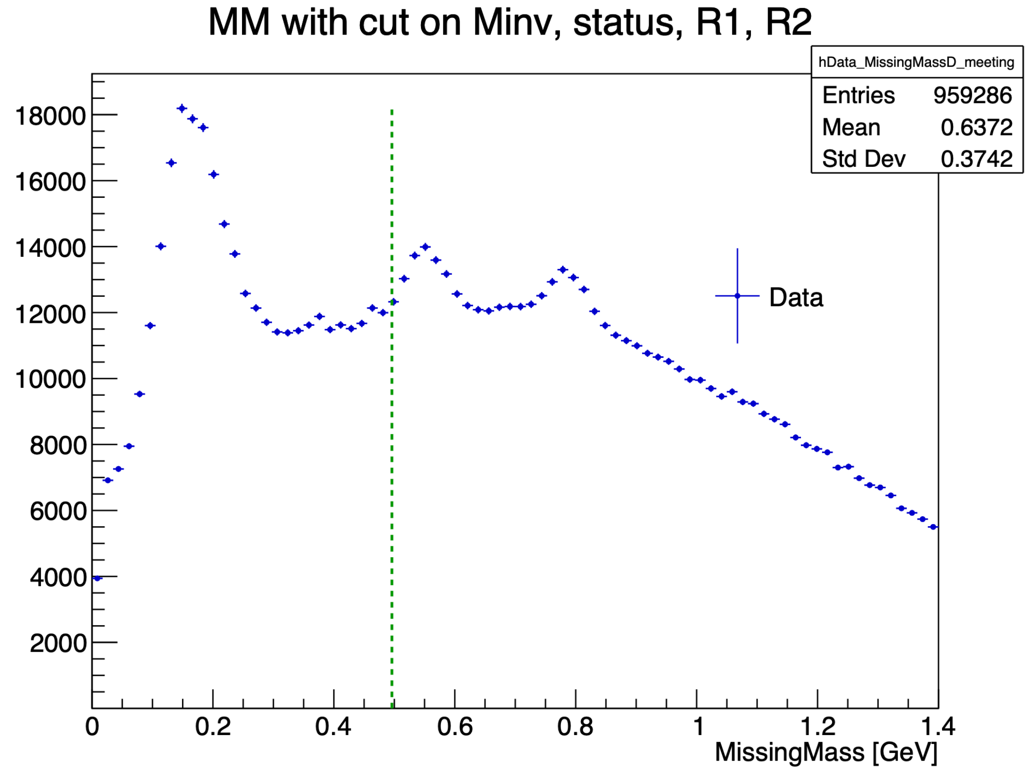


Distance vertex e$^-$ and Ks

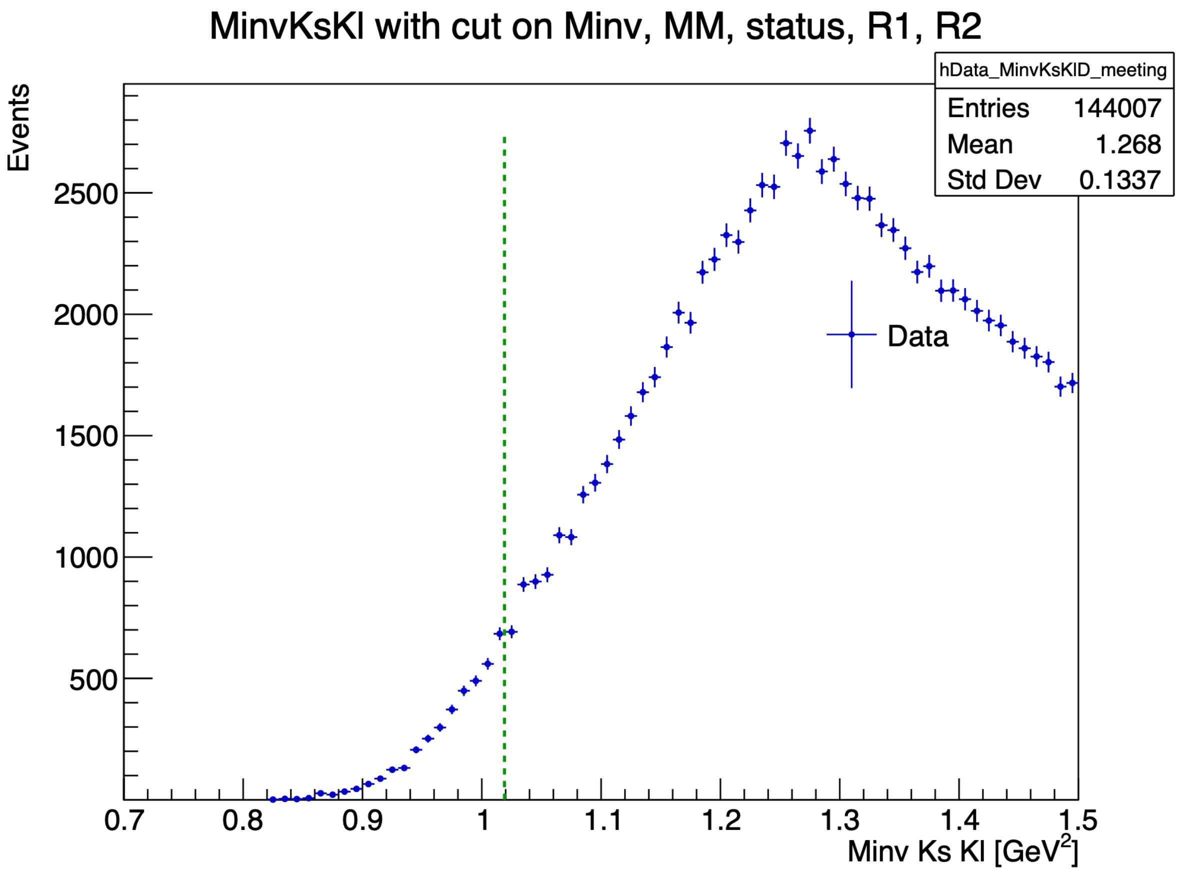


Influence of cuts on datas





Influence of cuts on datas



Simulation Monte Carlo : ϕ generator

$$weight_{PhaseSpace} = |Q^2_{max} - Q^2_{min}| * |xb_{max} - xb_{min}| * |t_{max} - t_{min}|$$

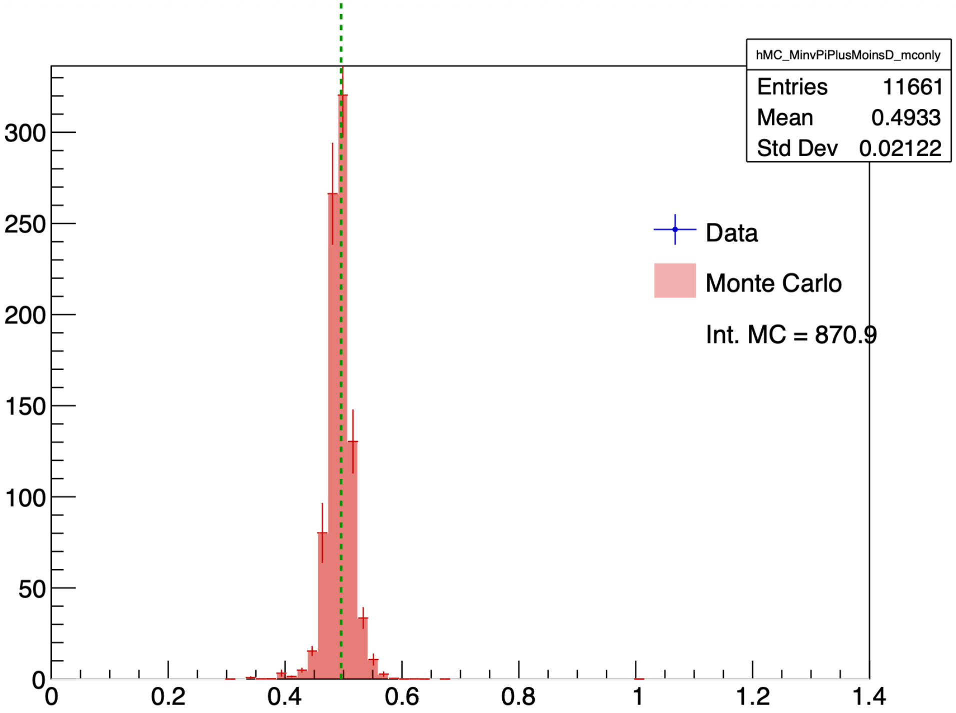
$$\frac{d^3\sigma}{dQ^2 dx_B dt}$$ *From Proposal to Jefferson Lab PAC39 Exclusive Phi Meson Electroproduction with CLAS12*

Branching ratio Ks → π^+ π^- = 69%

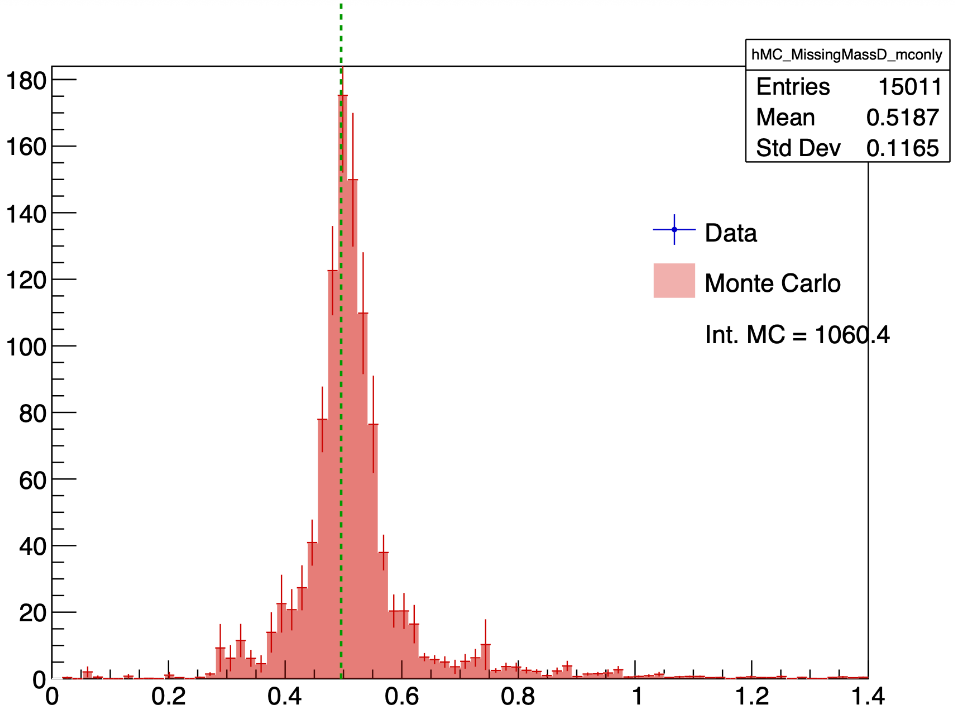
Branching ratio ϕ → Ks Kl = 34%

$$totalweight = weight_{PhaseSpace} * weight_{crosssection} * BR_{KsKl} * BR_{\pi^+\pi-}$$

Pions in the FT ?



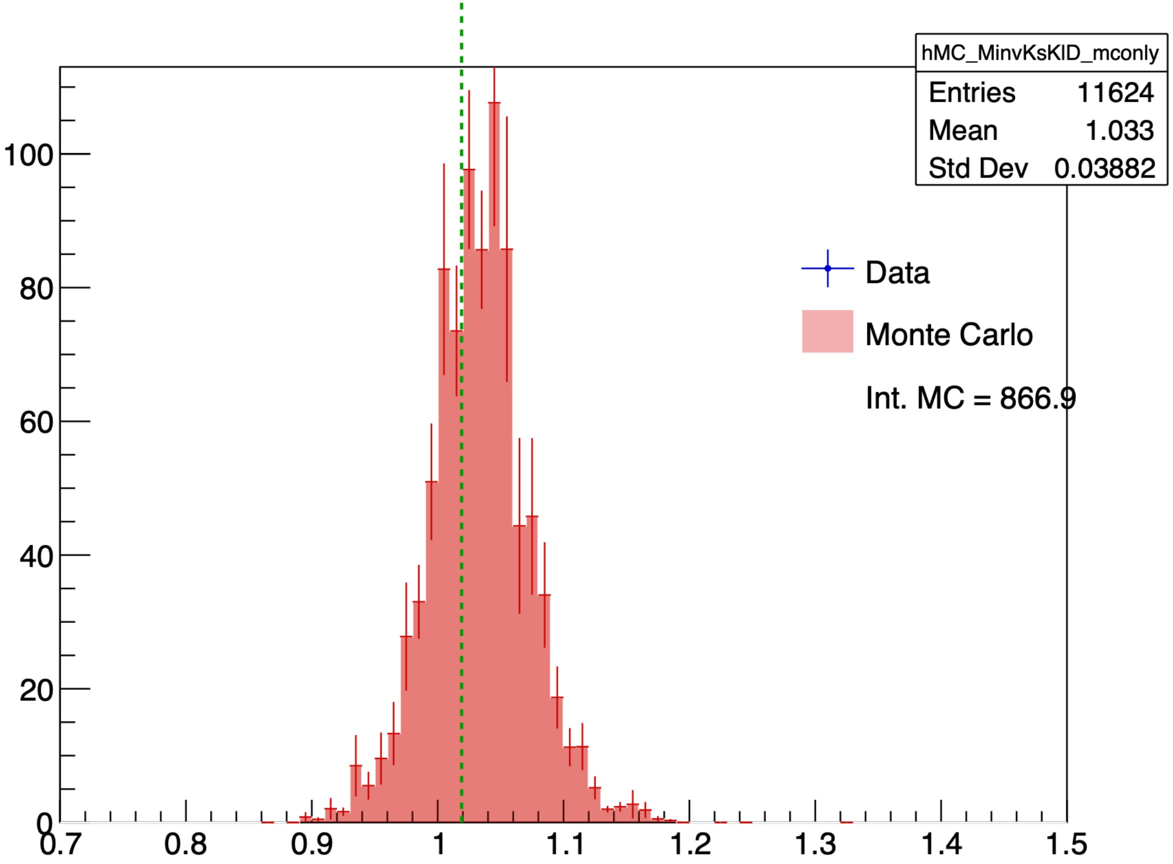
Minv pi+pi-



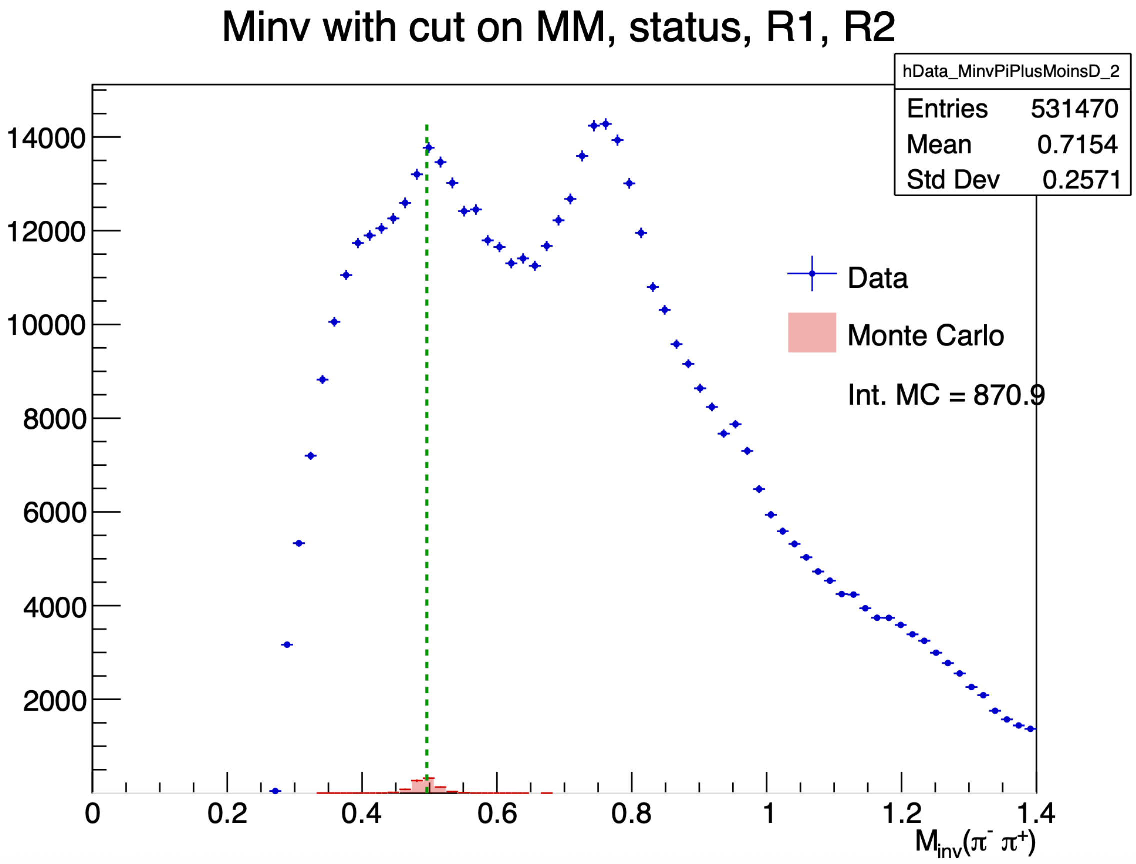
Missing Mass

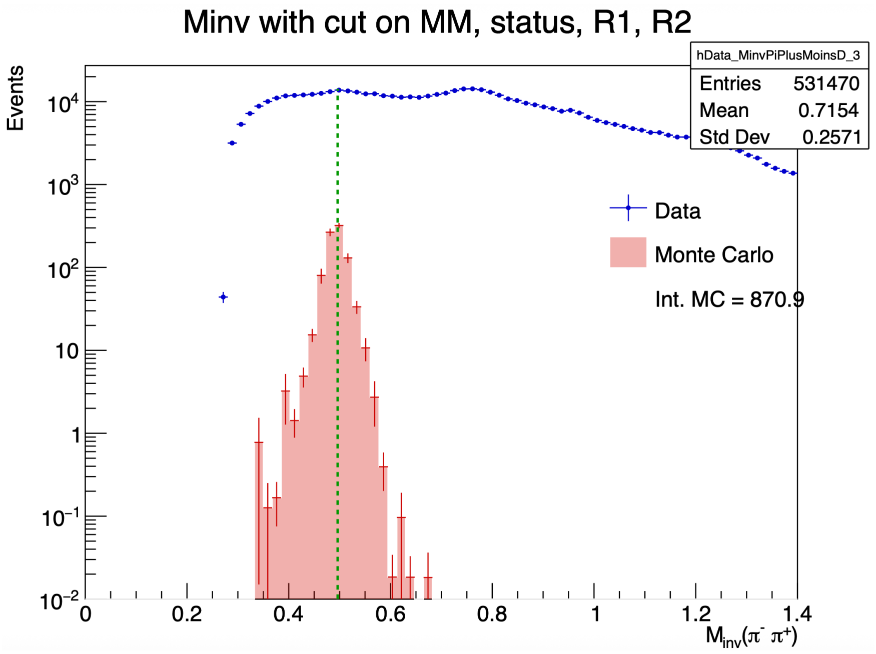
Pions in the FT ?

Minv Kskl

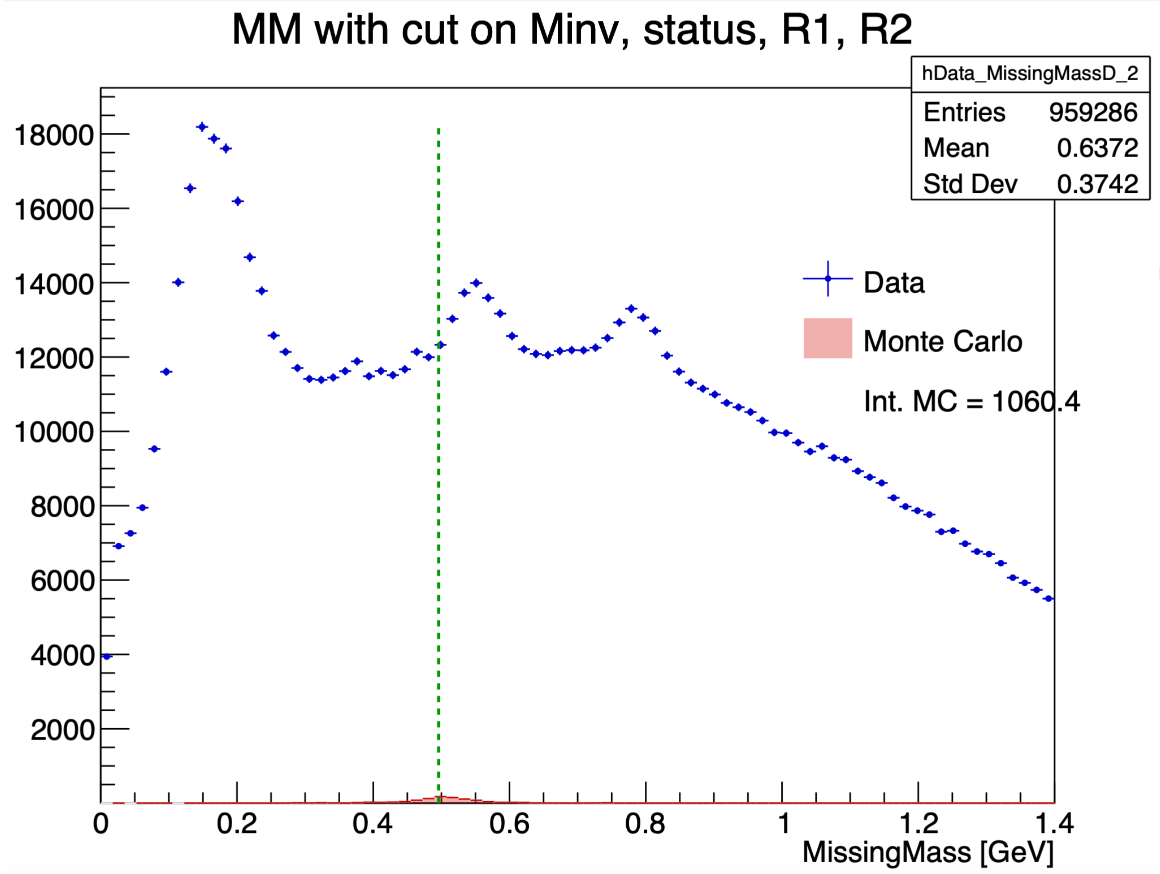


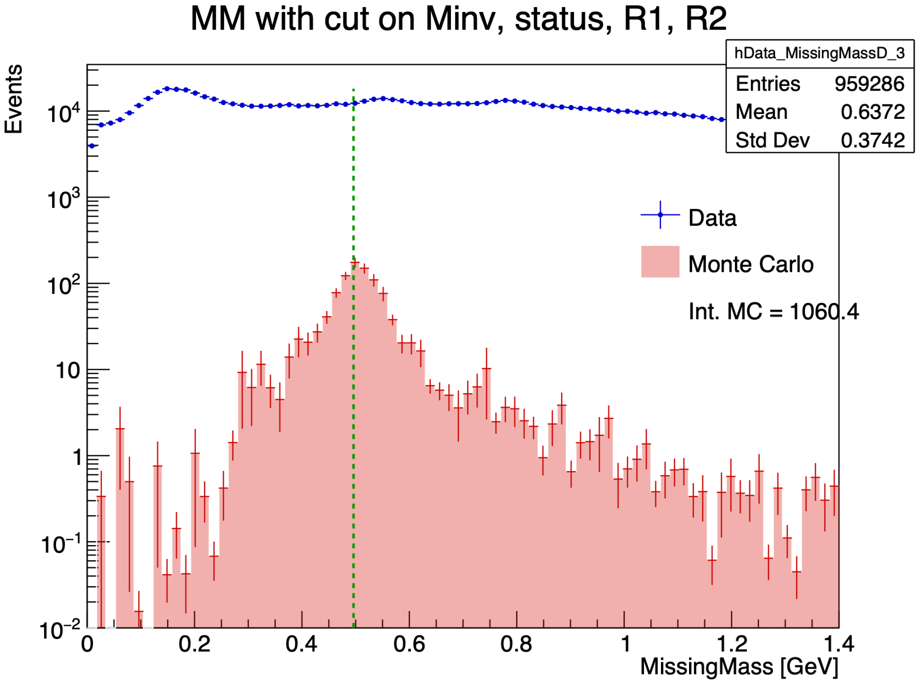
Simulation Monte Carlo with datas



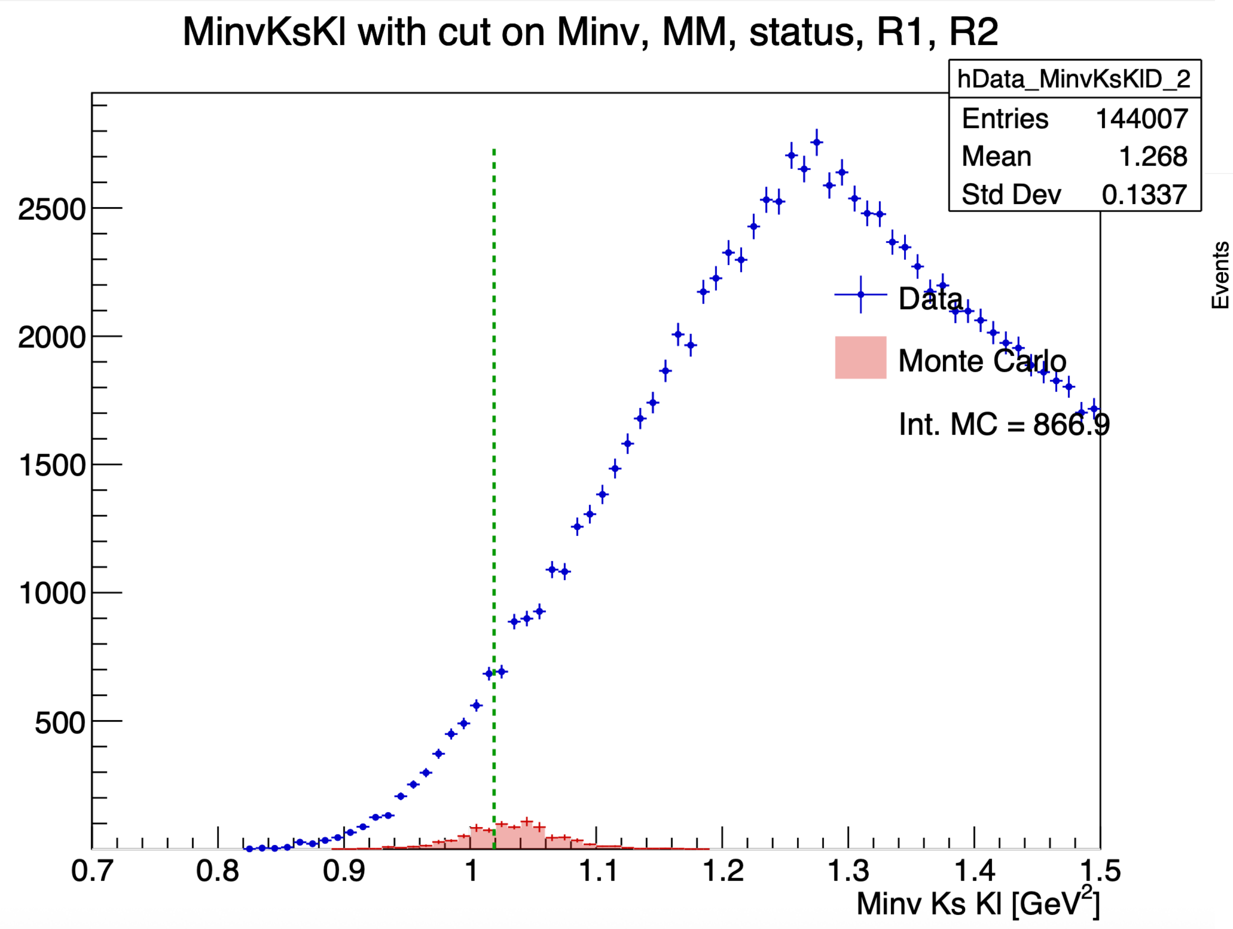


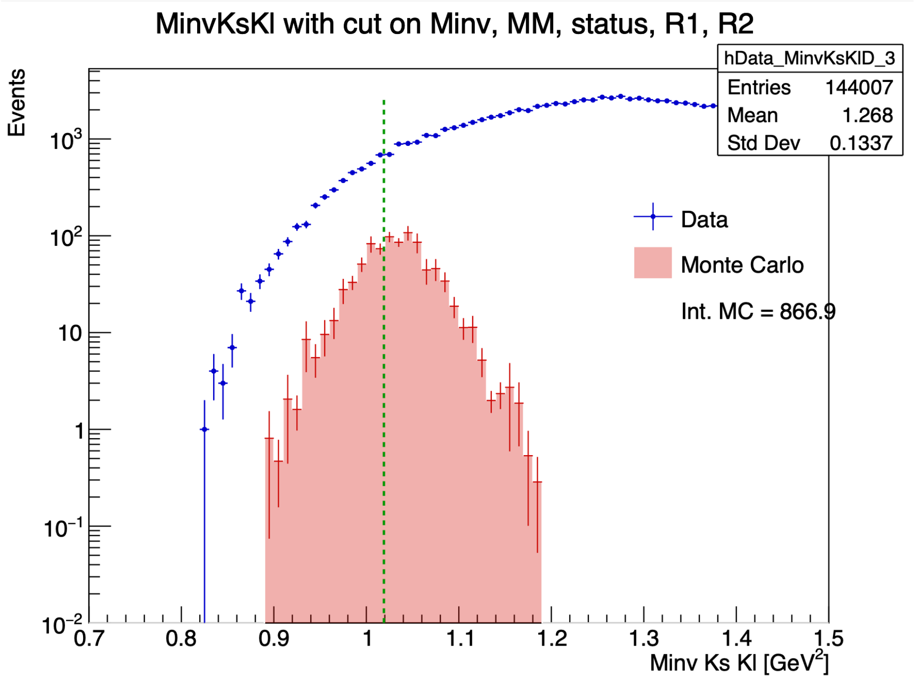
Simulation Monte Carlo with datas



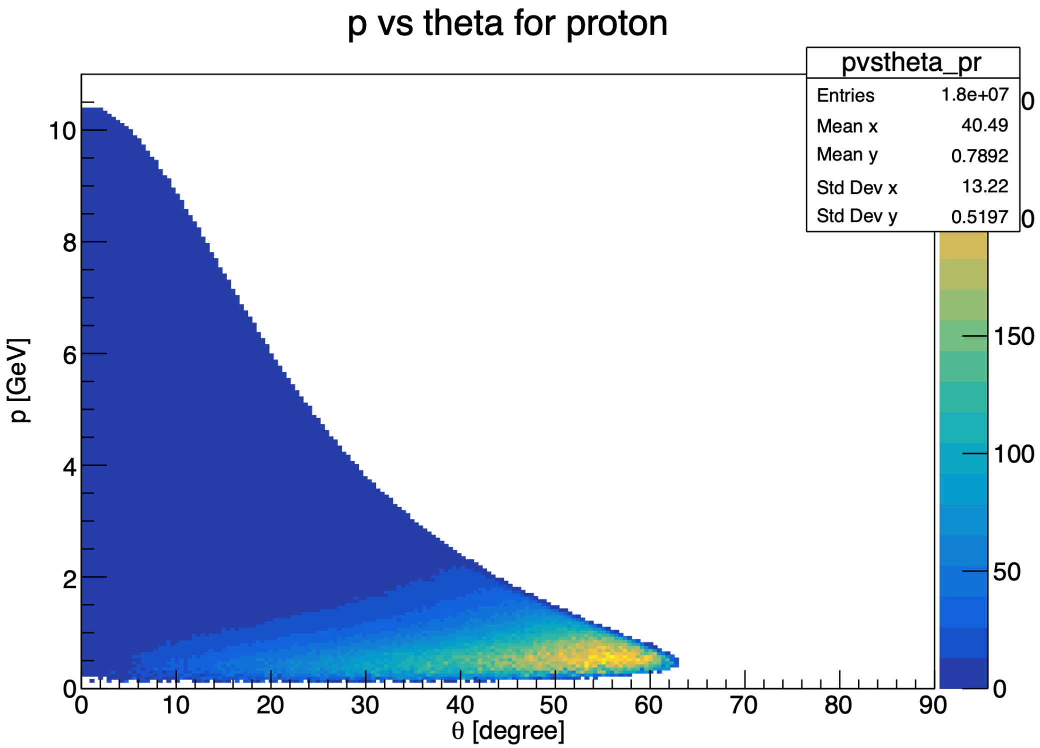


Simulation Monte Carlo with datas

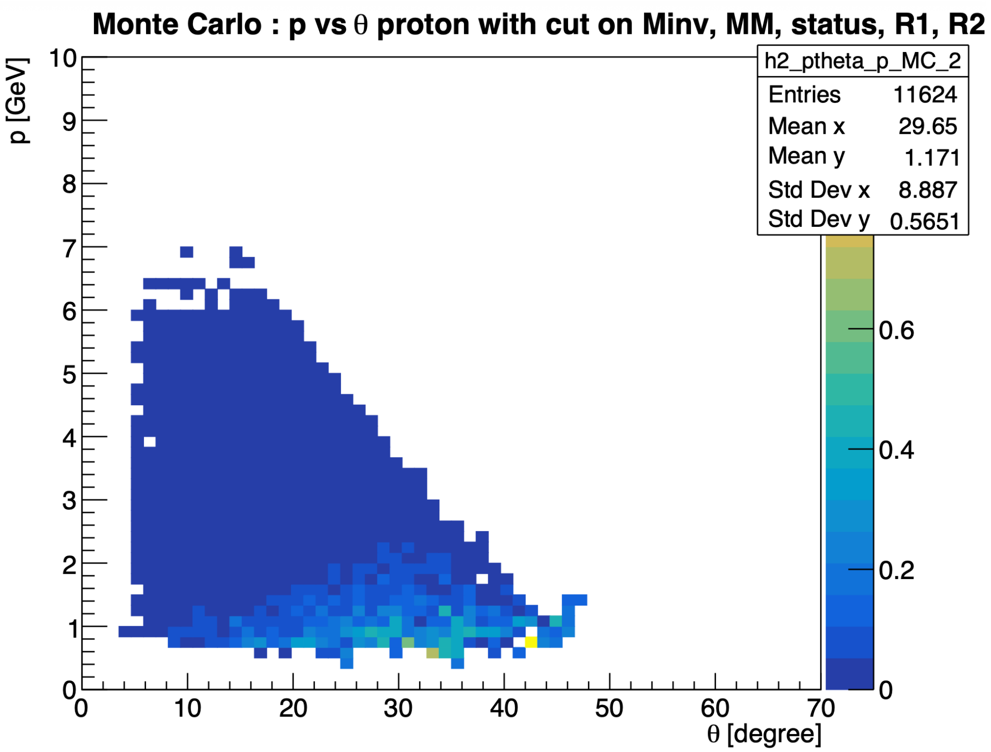




Simulation Monte Carlo with datas

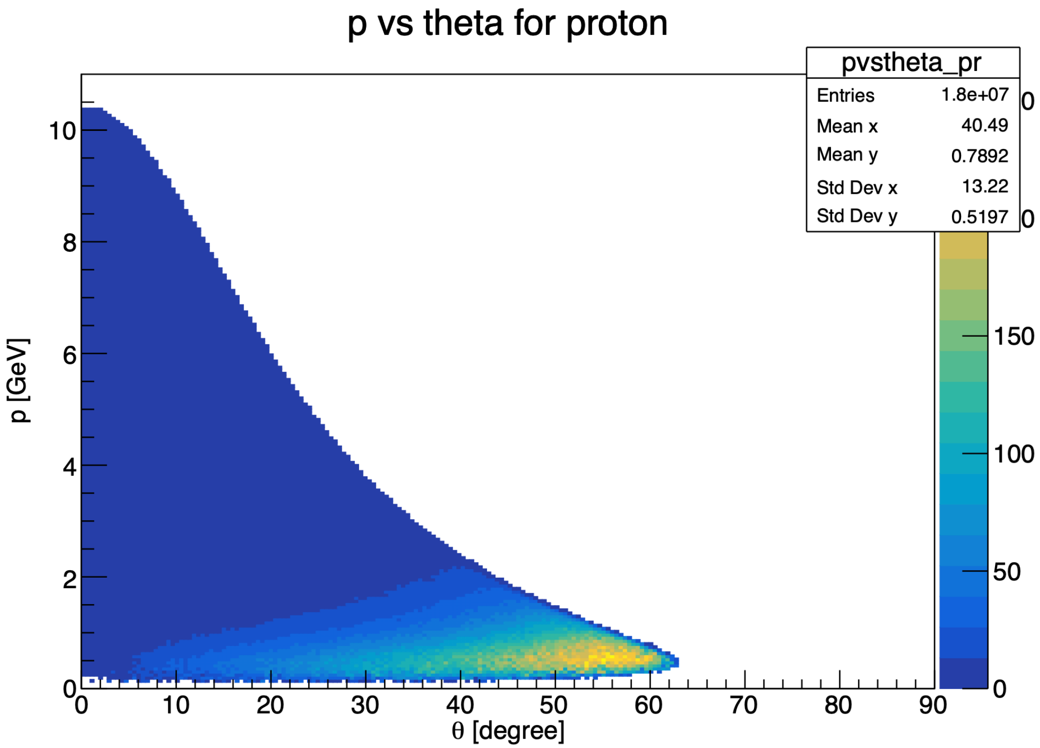


Events generated

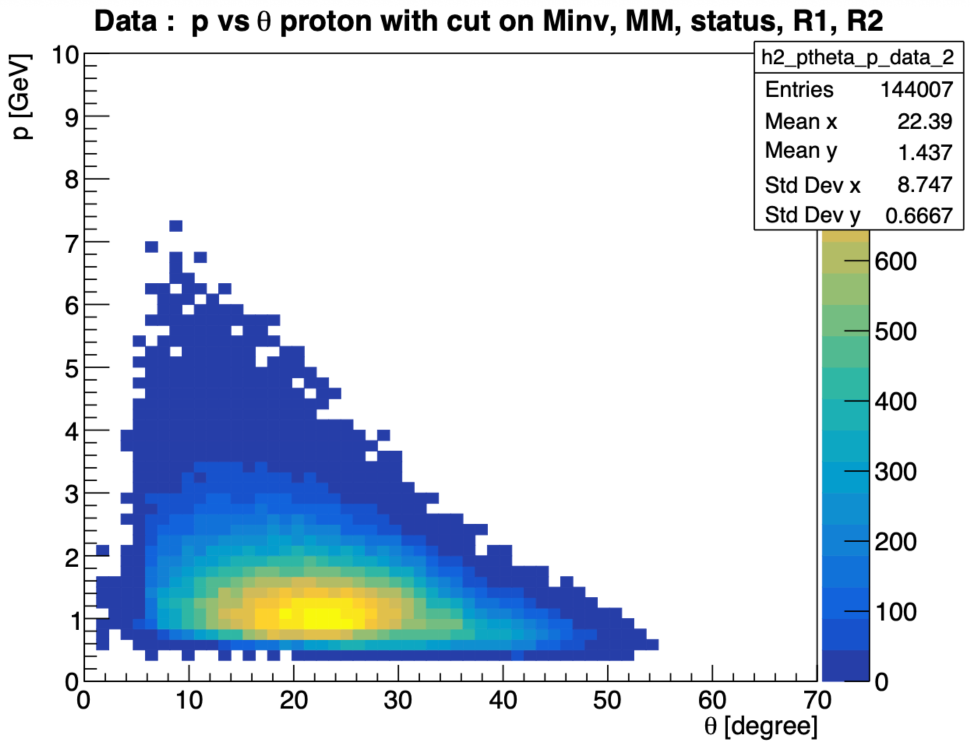


Events reconstructed (after cuts)

Simulation Monte Carlo with datas

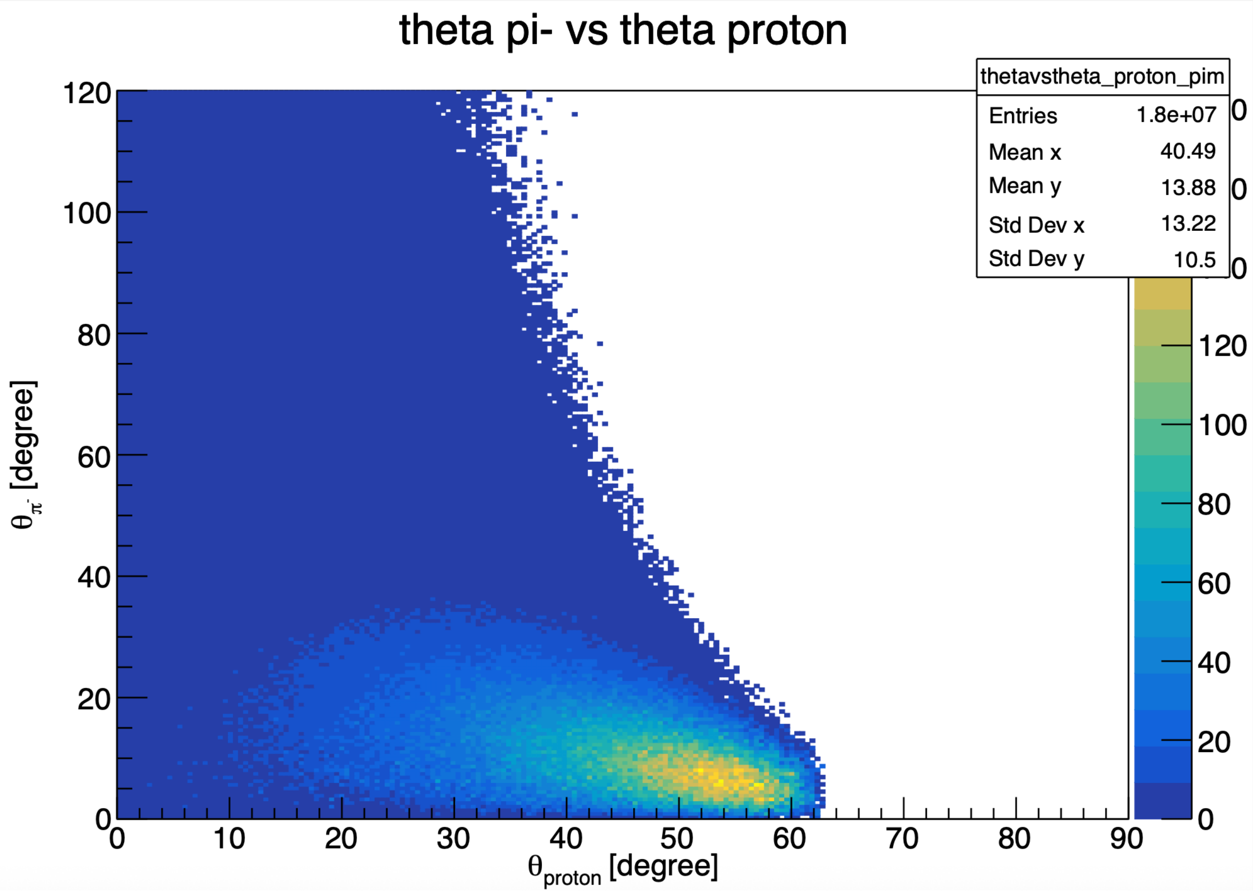


Events generated



Events from data (after cuts)

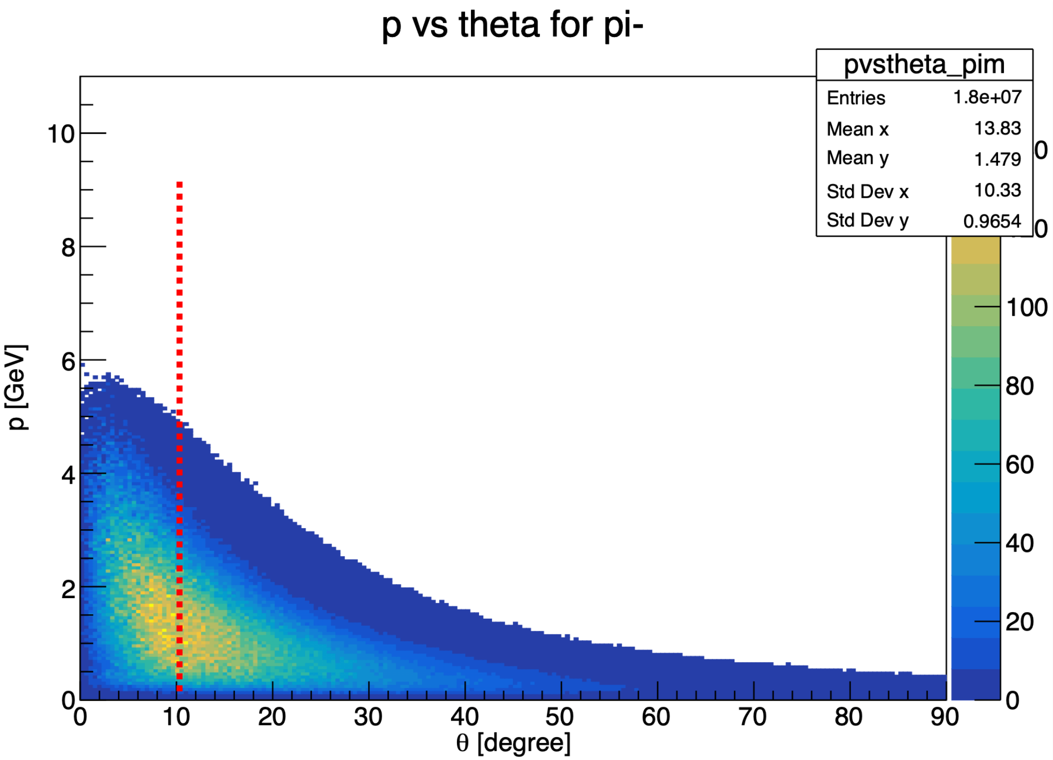
Simulation Monte Carlo with datas

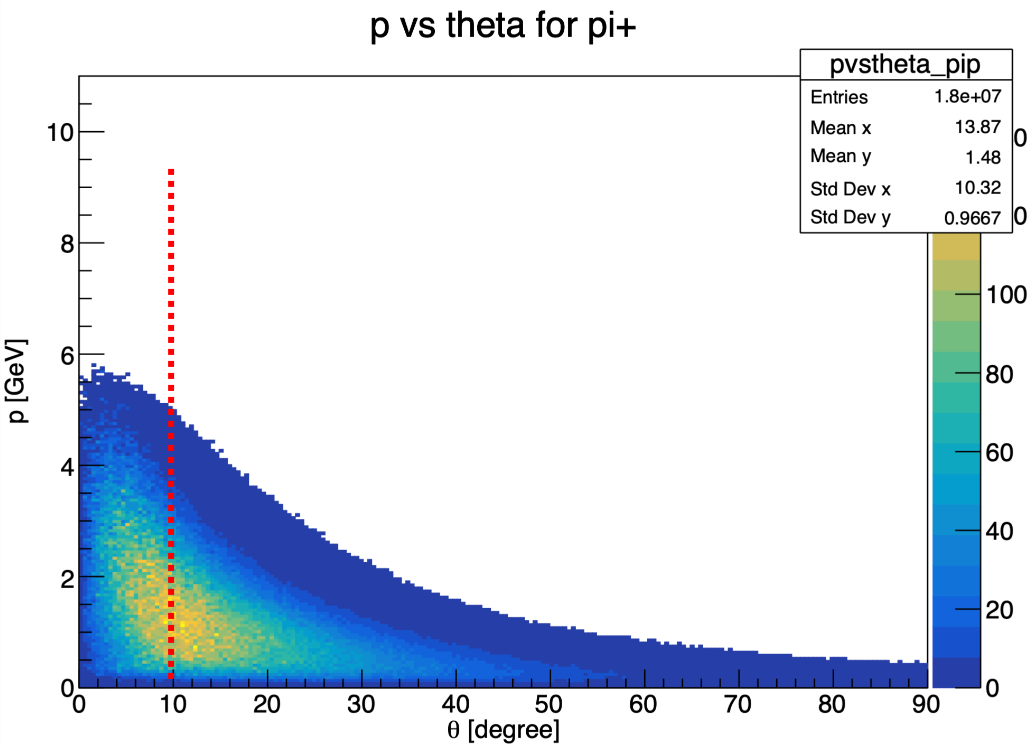


Events generated

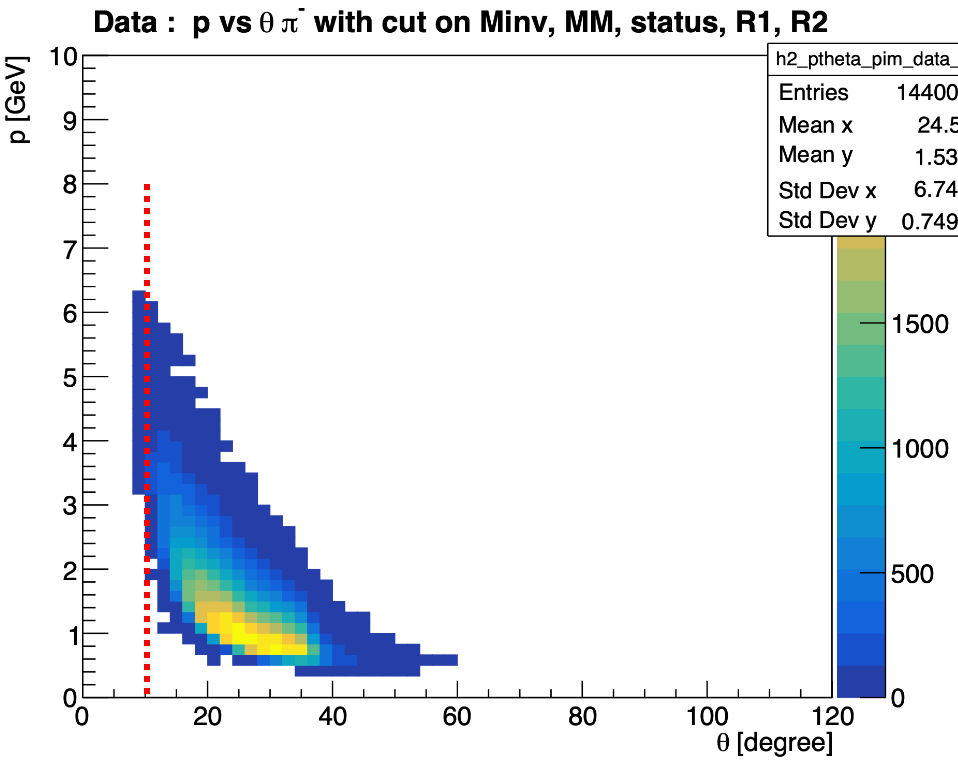
(same figure with pi+)

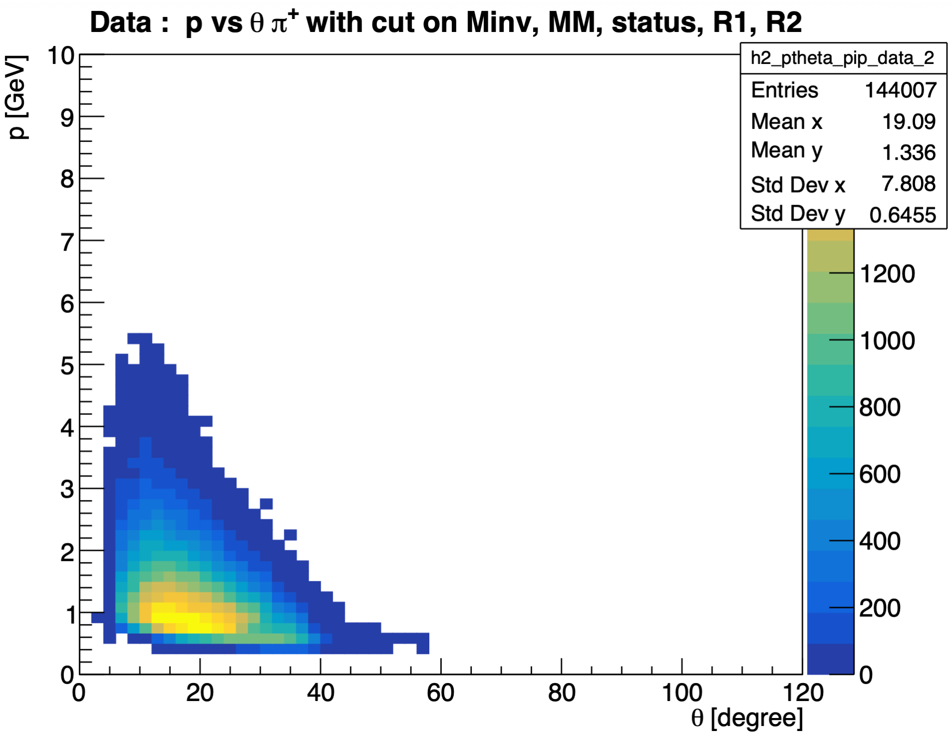
Simulation Monte Carlo with datas





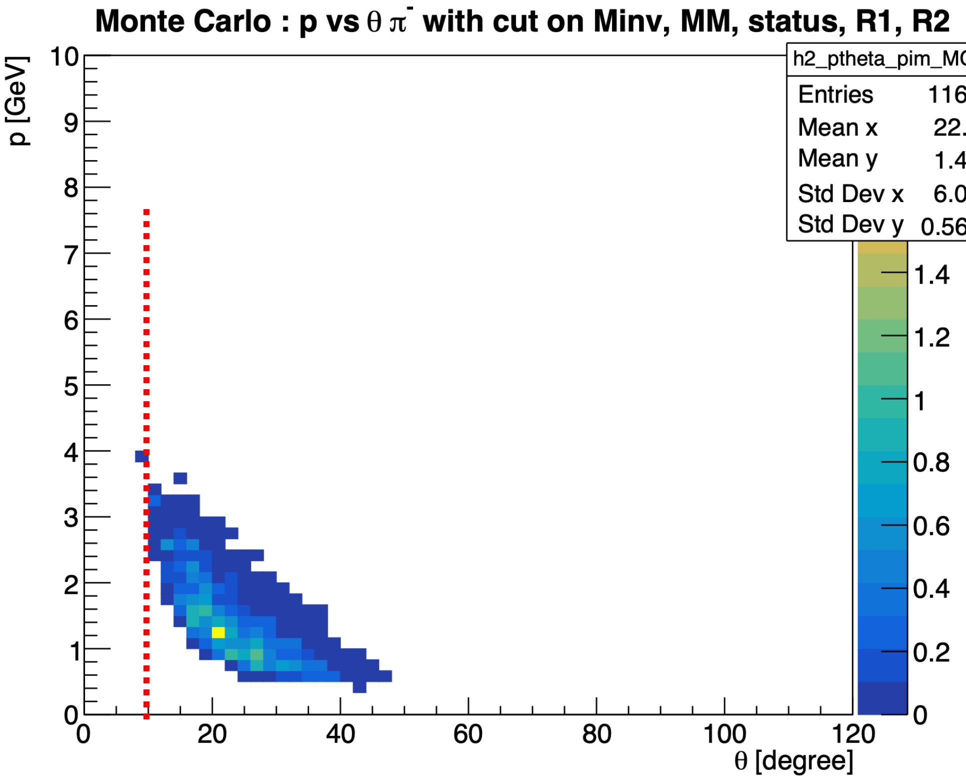
Simulation Monte Carlo with datas

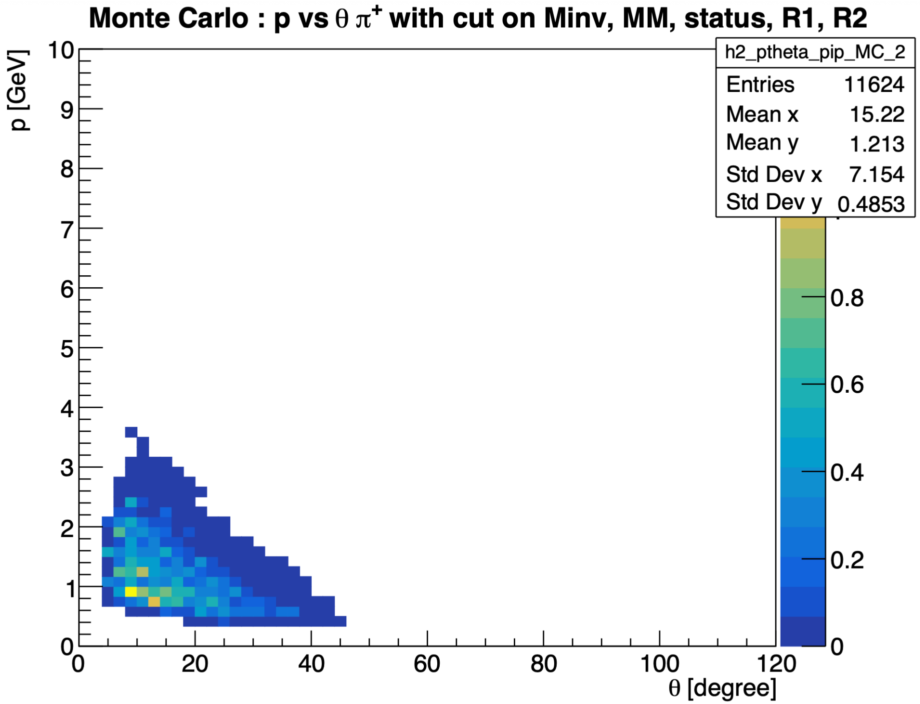




DATA Inbending

Simulation Monte Carlo with datas





MC Inbending

Pions in the FT ?

For inbending : events with 1 proton 1 π^+ and 2 e^-

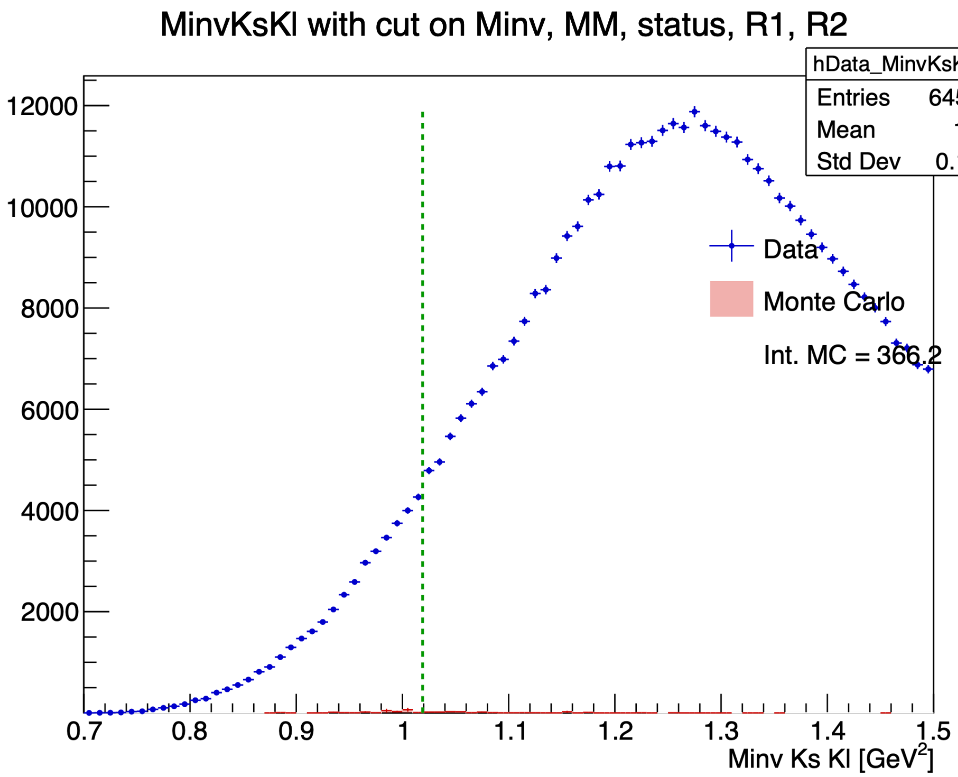
→ one e^- in the FD (real e^-)
→ one e^- in the FT (π^- identified like an e^-)

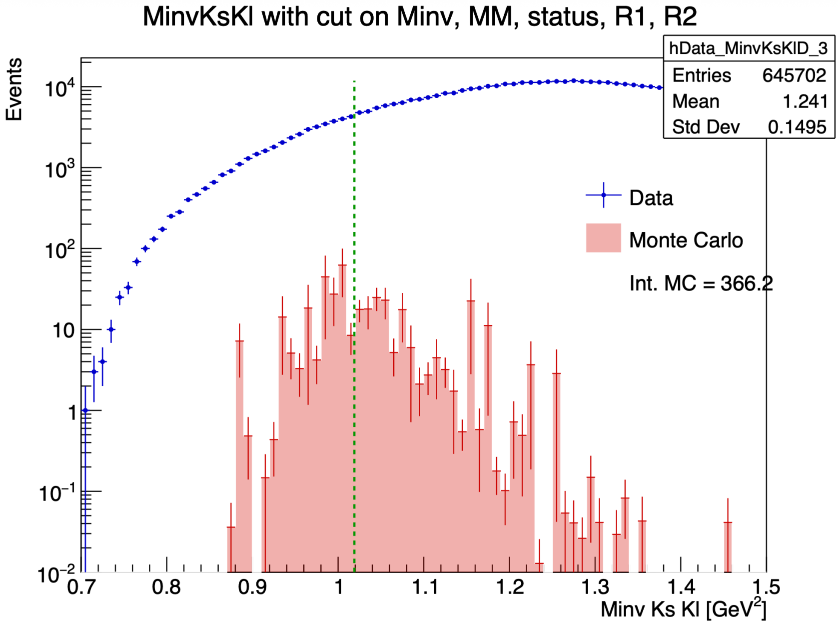
For outbending: events with 1 proton 1 π^- and 2 e^-

→ one e^- in the FD (real e^-)
→ one e^- in the FT (π^+ identified like an e^-)

No correction with veronique zigler code
→ no cuts on vertex

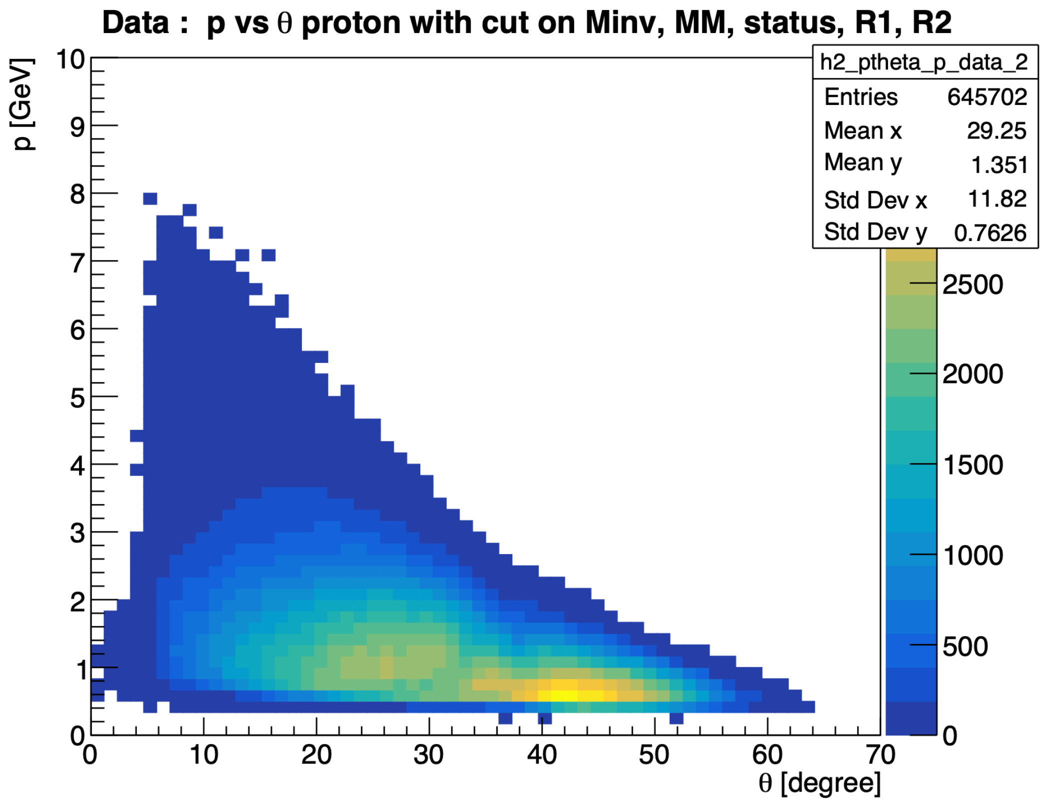
Pions in the FT ?

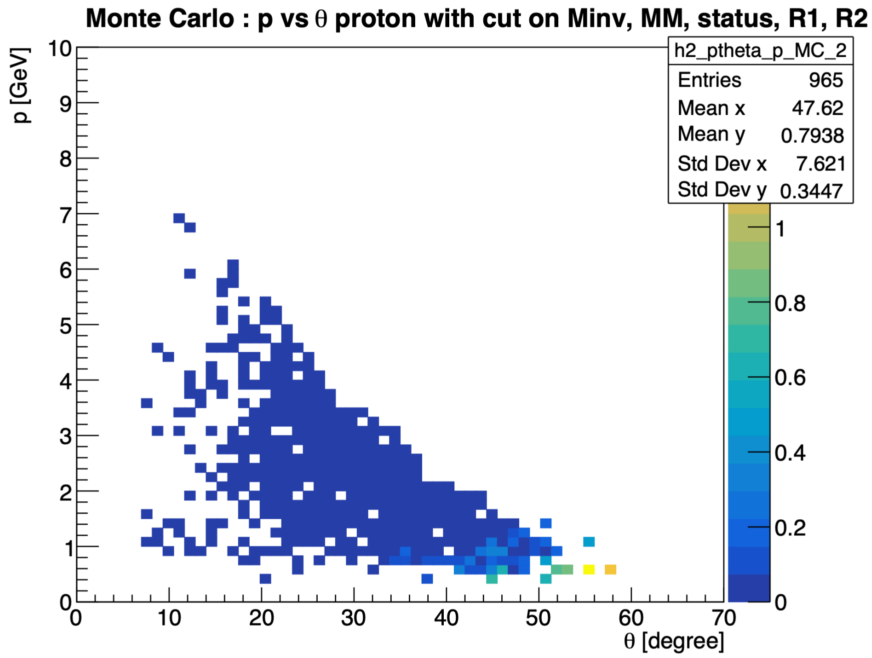




inbending

Pions in the FT ?





inbending

Pions in the FT ?

Hypothesis :

This method make it possible to recover some events in the region where the π^- (in inbending) is at a small angle, but with very poor efficiency.

There may be no energy deposited in the FT calorimeter → no detection ?

Update on ϕ generator

Backup ϕ generator

Update on ϕ generator

Simulation objectives :

- Estimate the expected number of ϕ with

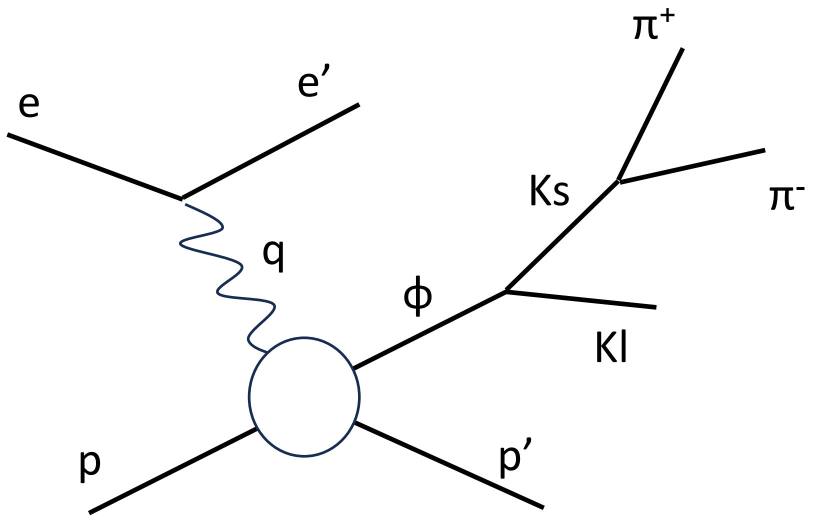
$$N_{expected} = \frac{\sum w_{rec}}{N_{gen}} * \mathcal{L}$$

- Find interresting cuts

Previously with TGenPhasespace (root module) :

- Generate automatically quadri-impulsion in the phasespace
- But problems with the weight associated with the phasespace

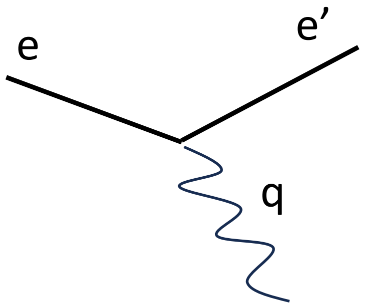
→ In the next slides the generator that we implemented without TGenPhaseSpace



Update on ϕ generator

1. Initially :

$Target = (0, 0, 0, Mp)$
$Beam = (0, 0, E_b, E_b)$
Q^2 generated in $[1, 6.5]$ GeV



2. Scattering electron kinematics :

- Find W^2_{min} and W^2_{max}. Formula in *Byckling, E., and Kajantie, K. (1973b). Particle kinematics. Wiley-Interscience.*
- Find xb_{min} and xb_{max} (wich depend on $W^2_{min/max}$ and Q^2)
- Generate xb in $[xb_{min},\, xb_{max}]$
- Find $E' = E - \nu$ with $\nu = \frac{Q^2}{2*Mp*xb}$
- Find $\theta_{e'} = 2 * arcsin(\sqrt{\frac{Q^2}{4EE'}})$
- Generate $\phi_{e'}$ in $[0,\, 2\pi]$

Update on ϕ generator

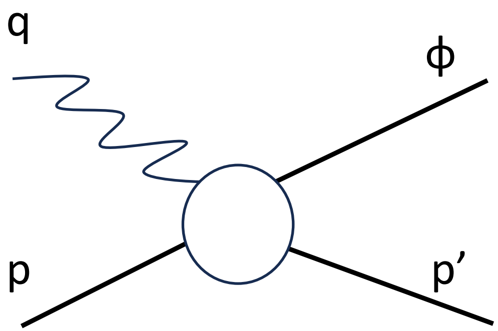
3. Virtual photon kinematics :

$q = e - e'$

4. Scattering proton kinematics :

- Find t_{min} and t_{max}
- Generate t in $[t_{min}, t_{max}]$
- Find $E_{p'} = \frac{-t+2*Mp^2}{2Mp}$
- Find $\theta_{\gamma p}$ between proton and photon
- Generate ϕ_p (relative to the photon axis) in $[0,\ 2\pi]$

Formula for $t_{min/max}$ and $\theta_{\gamma p}$ in *Byckling, E., and Kajantie, K. (1973b). Particle kinematics. Wiley-Interscience.*



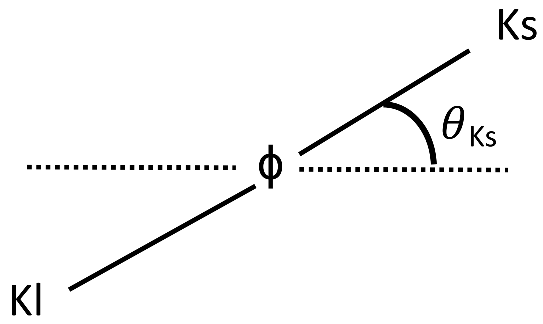
5. Meson ϕ kinematics :

$\phi = p + q - p'$

Update on ϕ generator

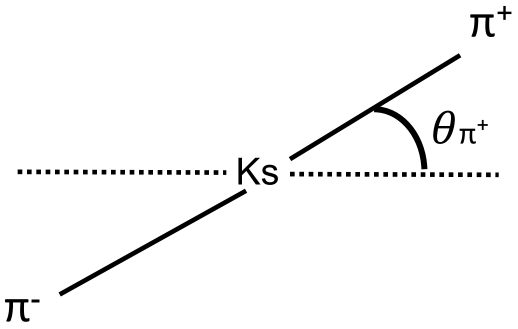
6. Kinematics of second decay ϕ → Ks Kl :

- Uniform decay in θ (and ϕ) in first approximation (in CM)
- Generate $cos(\theta_{Ks})$ in [-1 , 1]
- Generate ϕ_{Ks} in $[0, 2\pi]$
- Find $E_{Ks} = m_\phi/2$ and $p_{Ks} = \sqrt{E_{Ks}^2 - m_{Ks}^2}$
- $p_{Kl} = -p_{Ks}$ in CM
- Boost in order to find Ks and Kl in the lab



7. Kinematics of thrid decay Ks → π⁺ π⁻ :

- Same method than in step 6.
- Vx Vy Vz shifted by 2.8 cm in the direction of Ks emmision to simulate the flight of Ks



Update on ϕ generator

$$weight_{PhaseSpace} = |Q^2_{max} - Q^2_{min}| * |xb_{max} - xb_{min}| * |t_{max} - t_{min}|$$

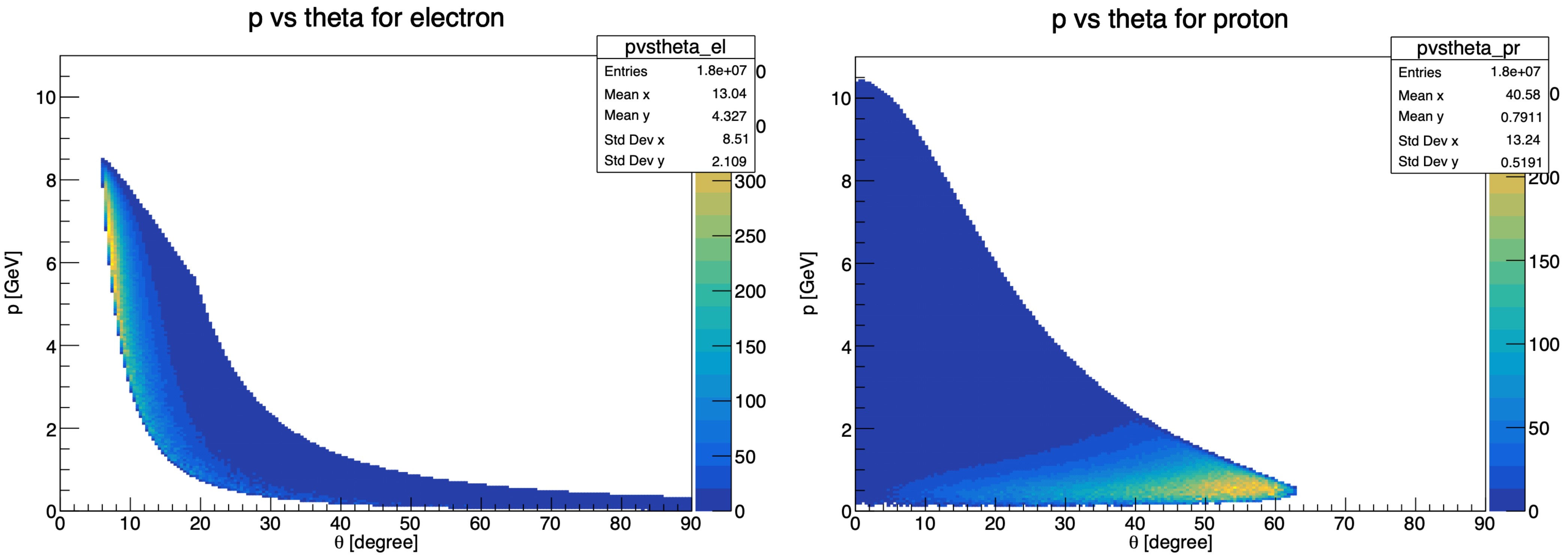
$$\frac{d^3\sigma}{dQ^2 dx_B dt}$$ *From Proposal to Jefferson Lab PAC39 Exclusive Phi Meson Electroproduction with CLAS12*

Branching ratio Ks → $\pi^+ \pi^-$ = 69%

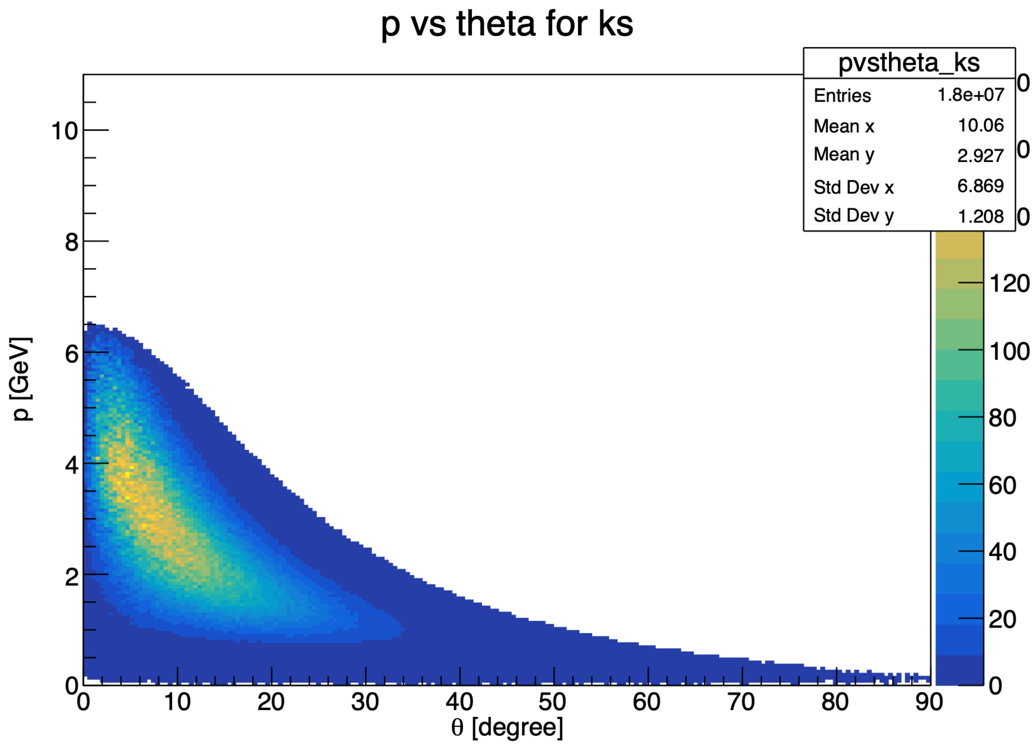
Branching ratio ϕ → Ks Kl = 34%

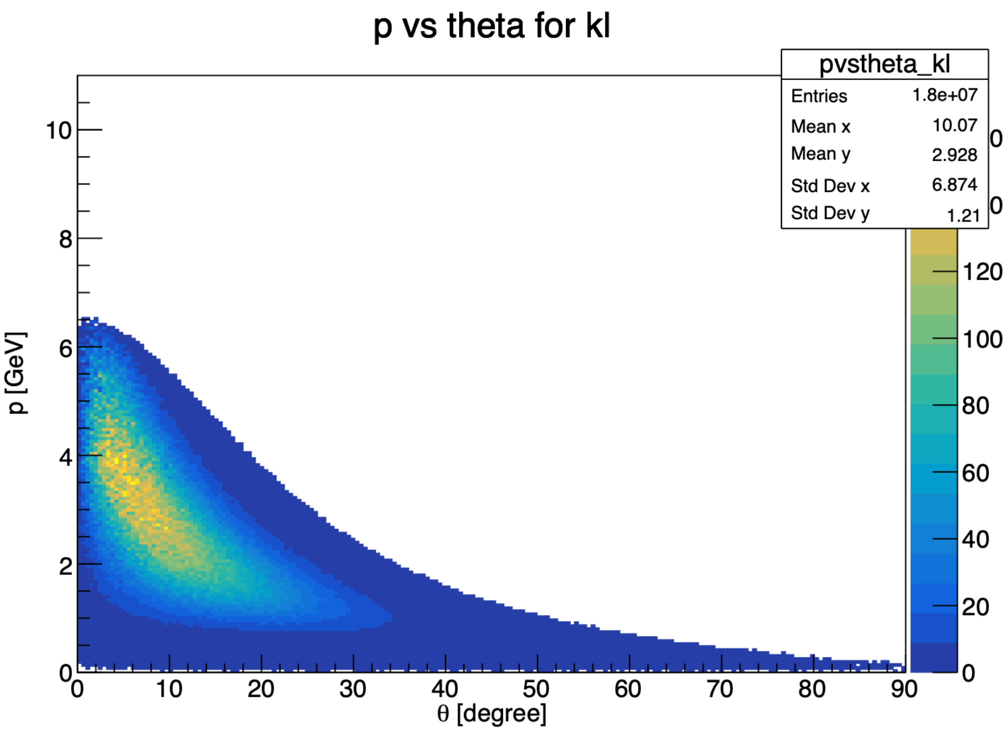
$$totalweight = weight_{PhaseSpace} * weight_{crosssection} * BR_{KsKl} * BR_{\pi^+\pi^-}$$

Update on ϕ generator

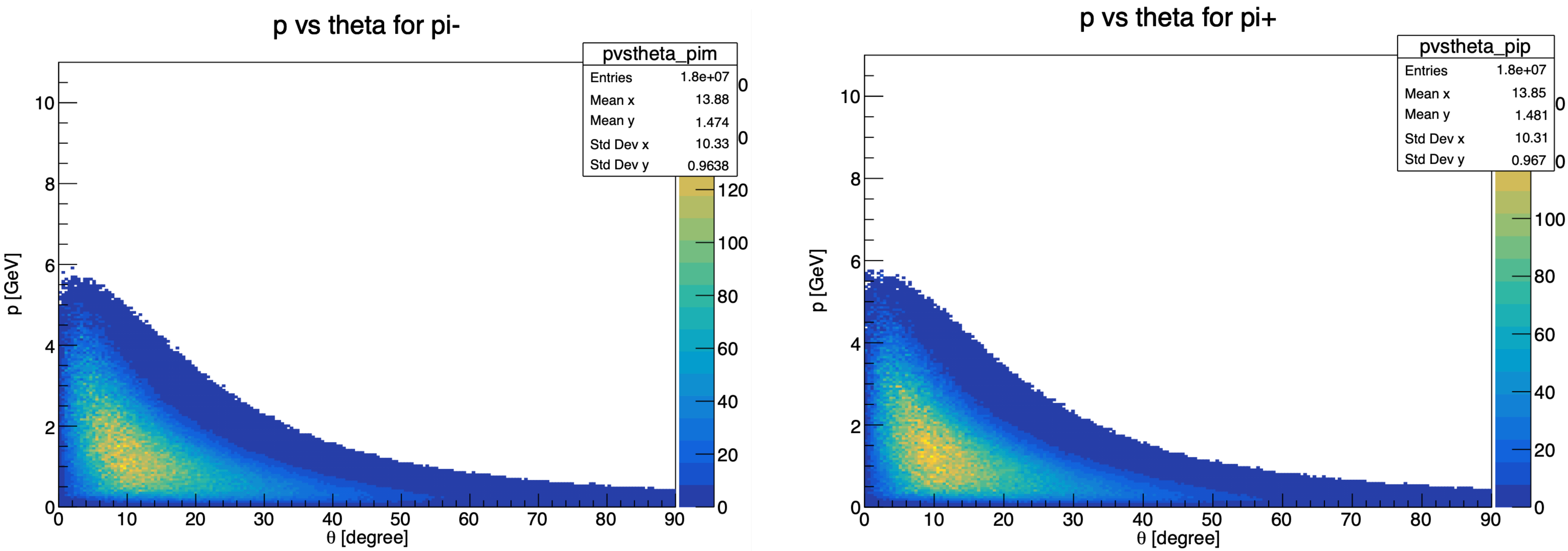


Update on ϕ generator

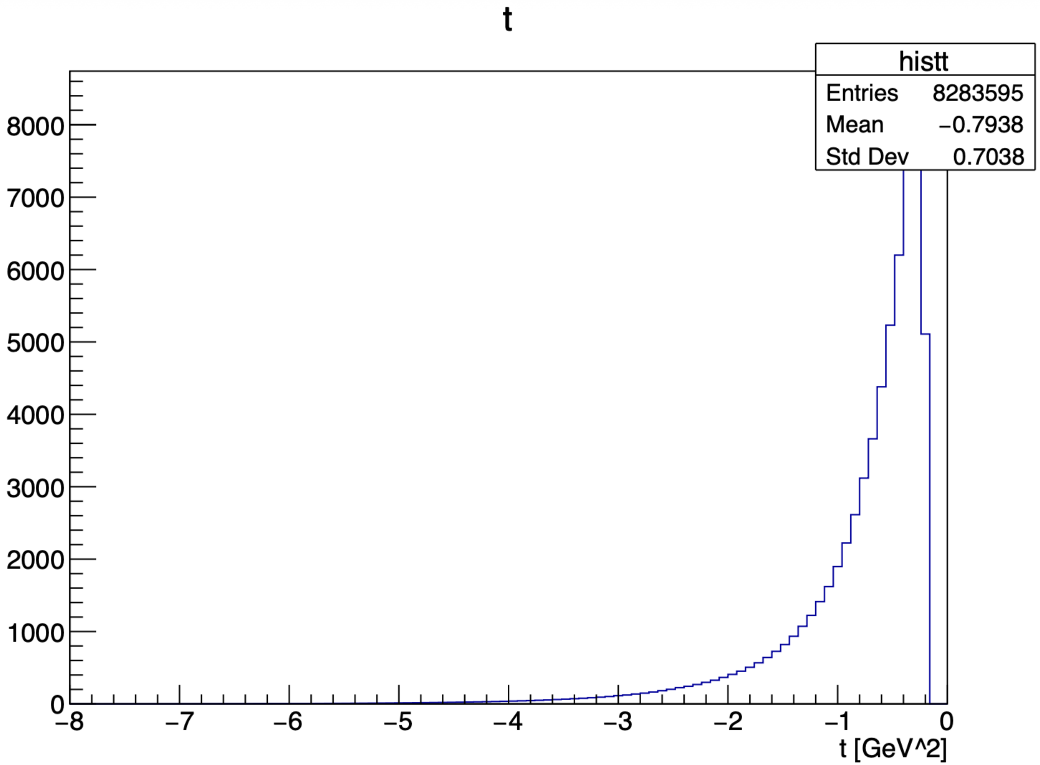


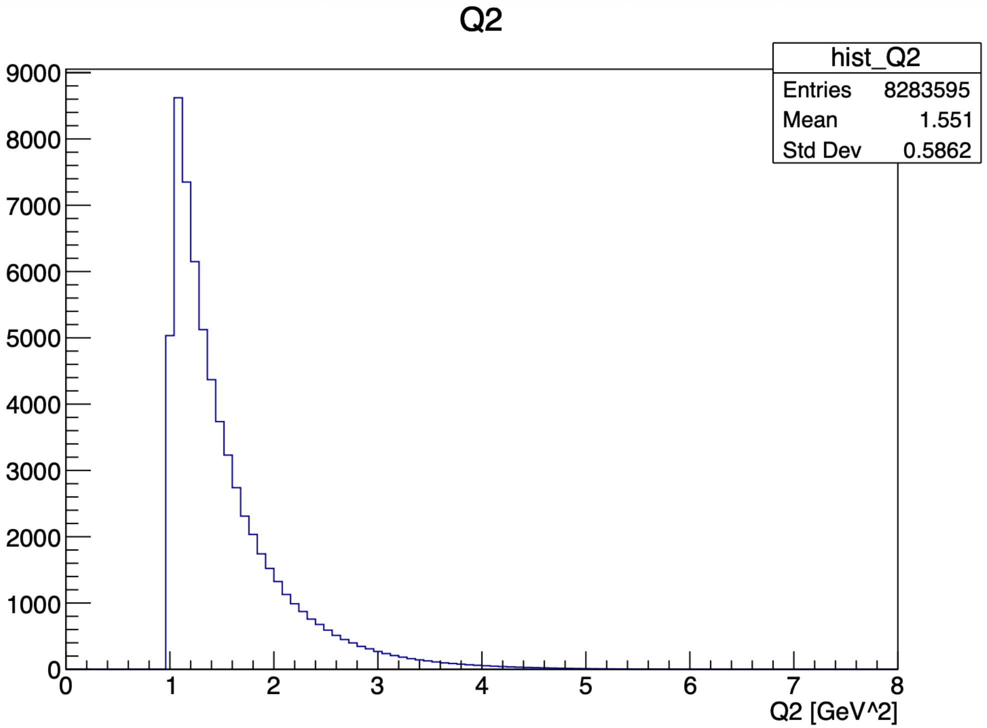


Update on ϕ generator

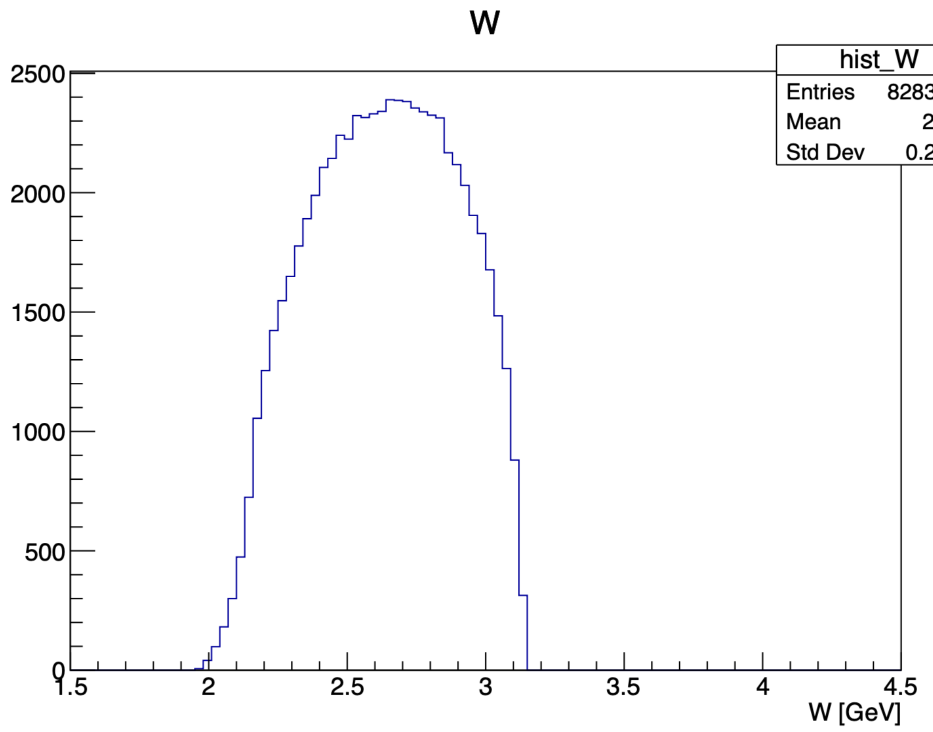


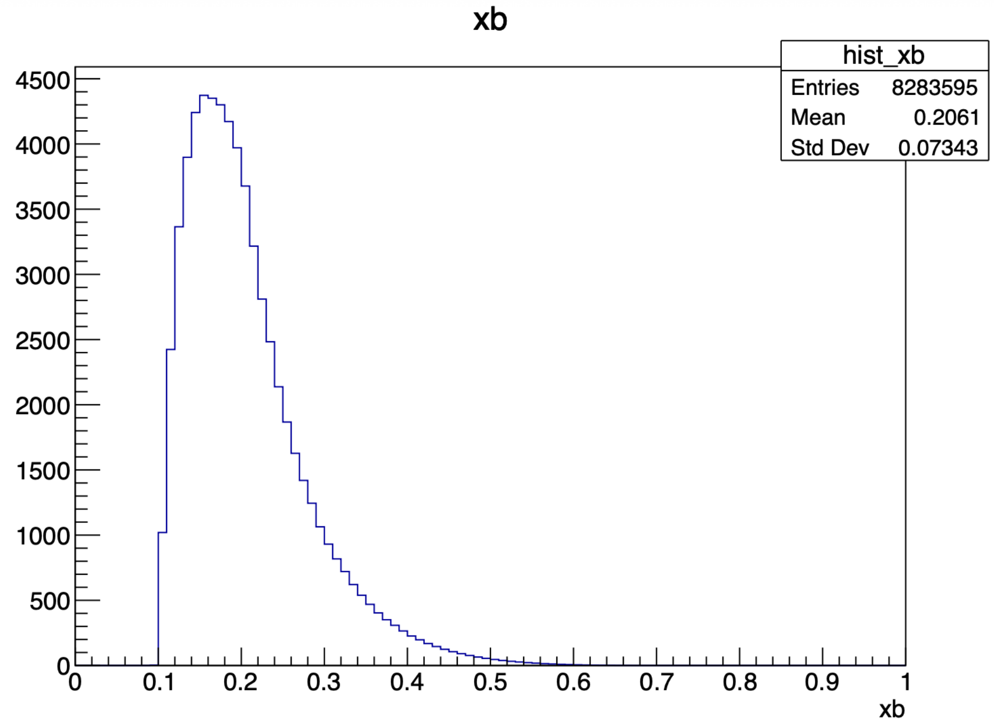
Update on ϕ generator





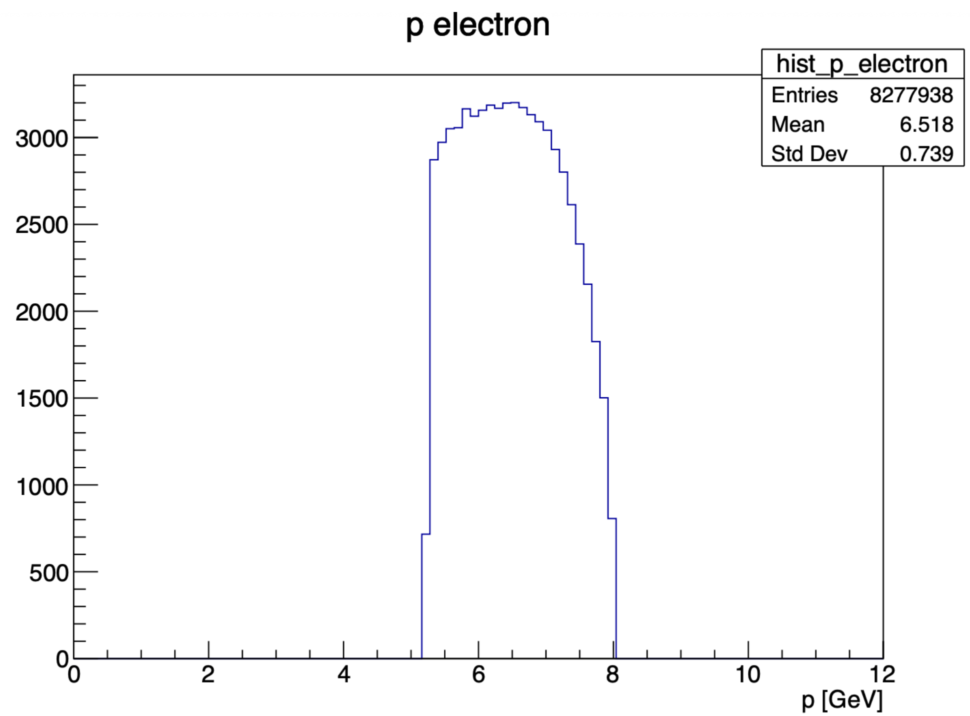
Update on ϕ generator



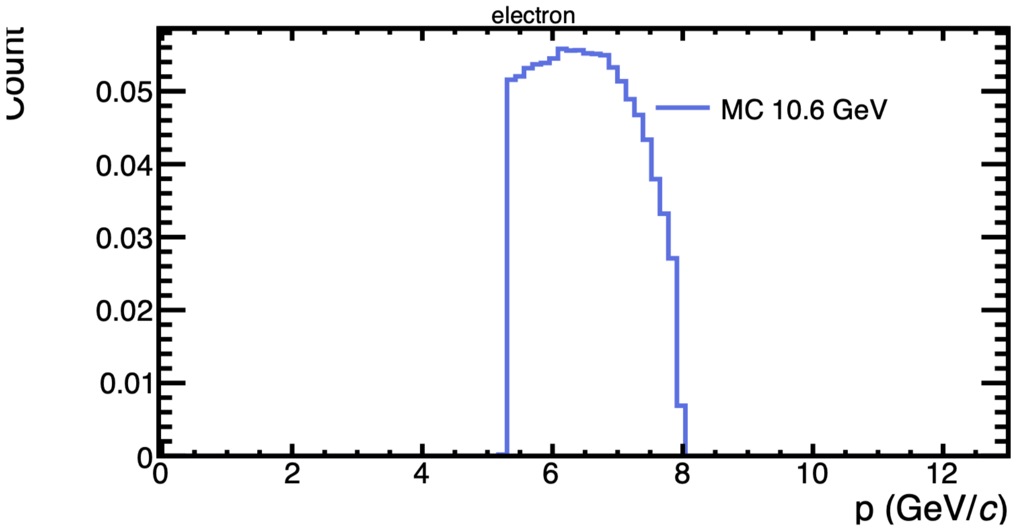


Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



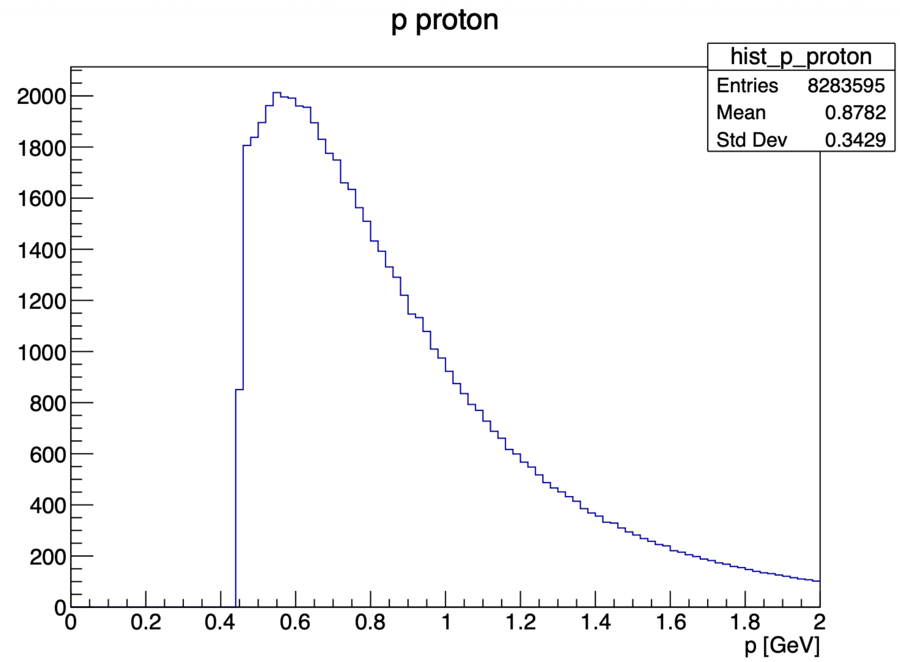
my generator



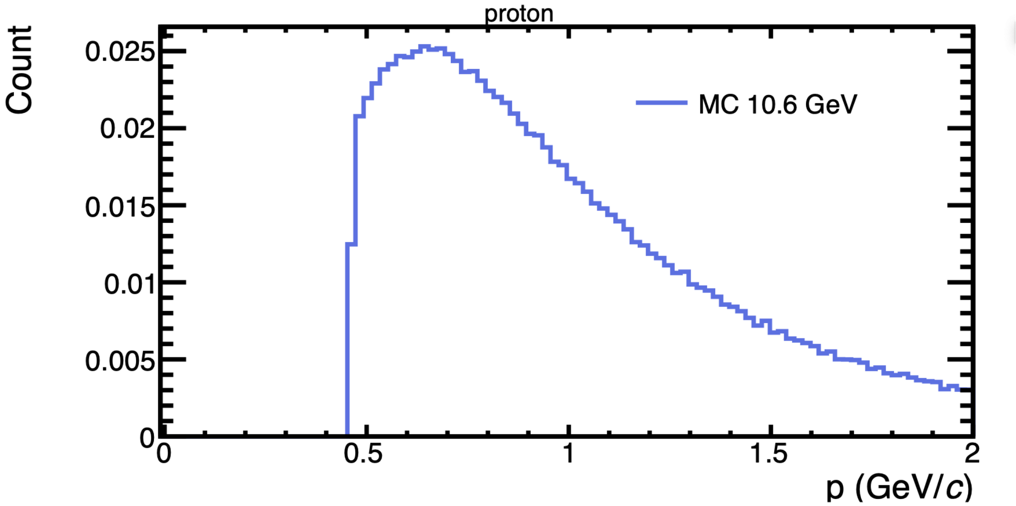
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



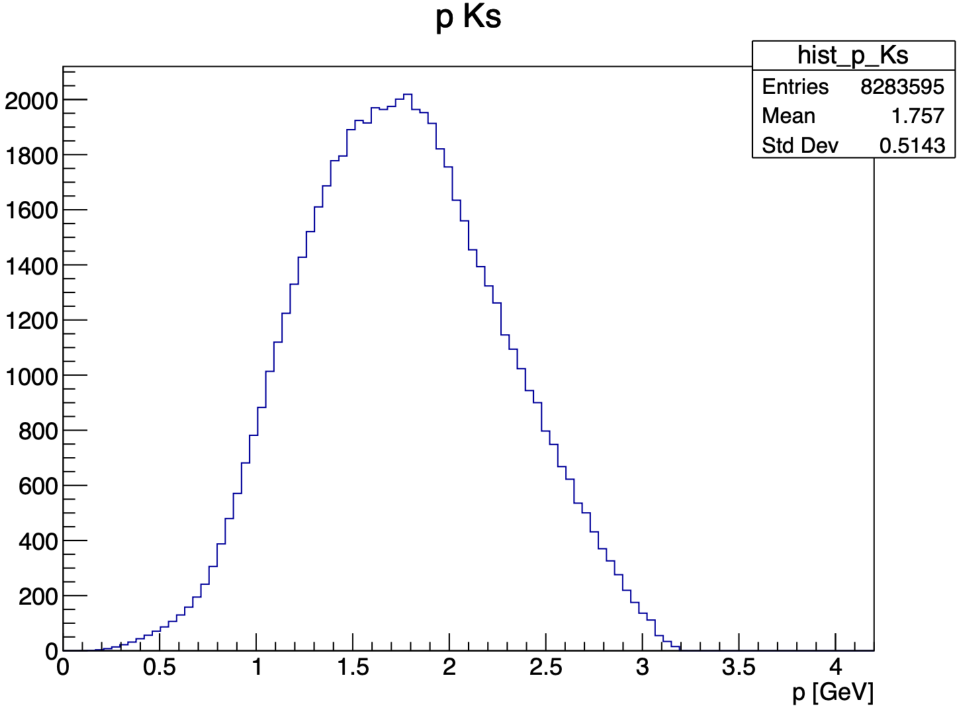
my generator



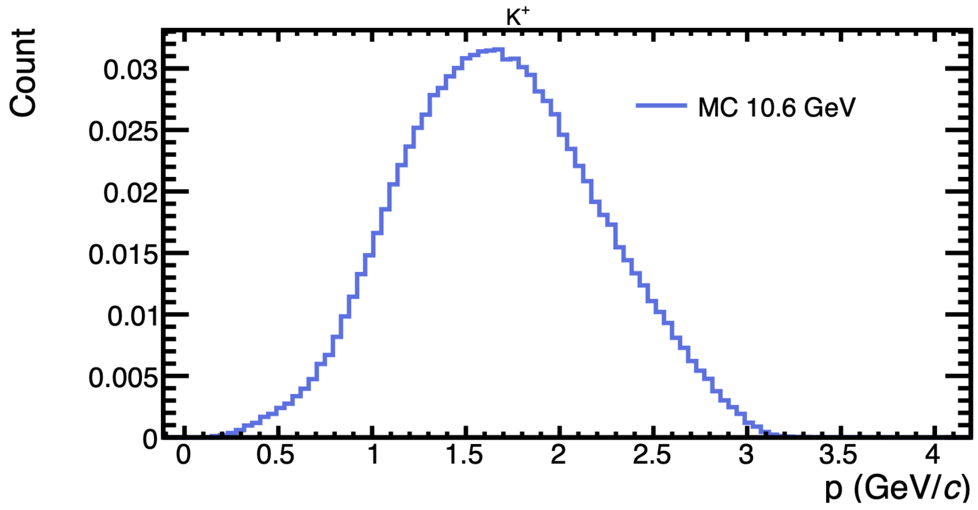
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



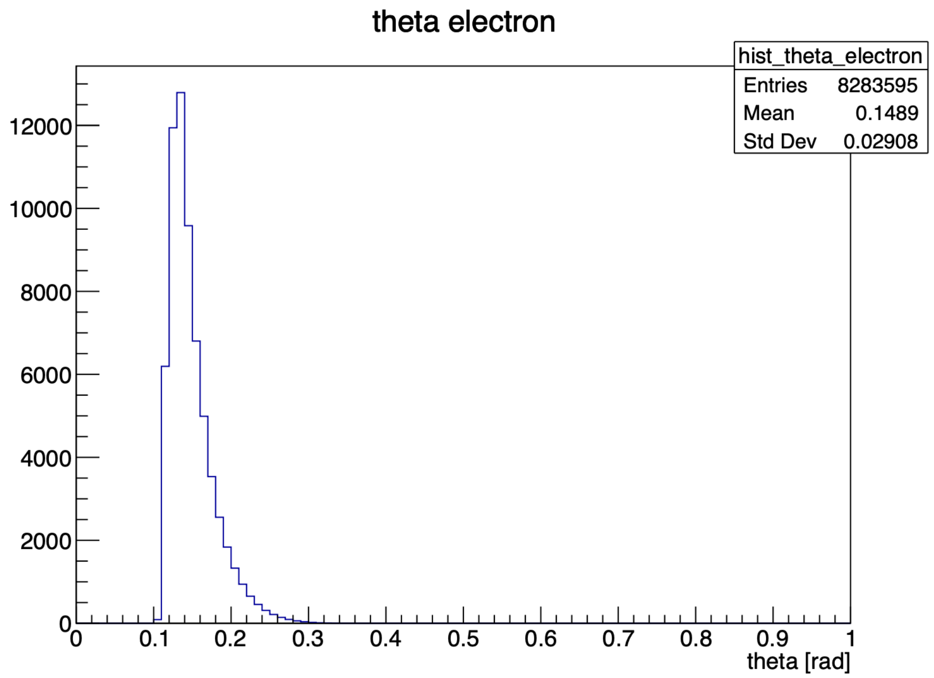
my generator



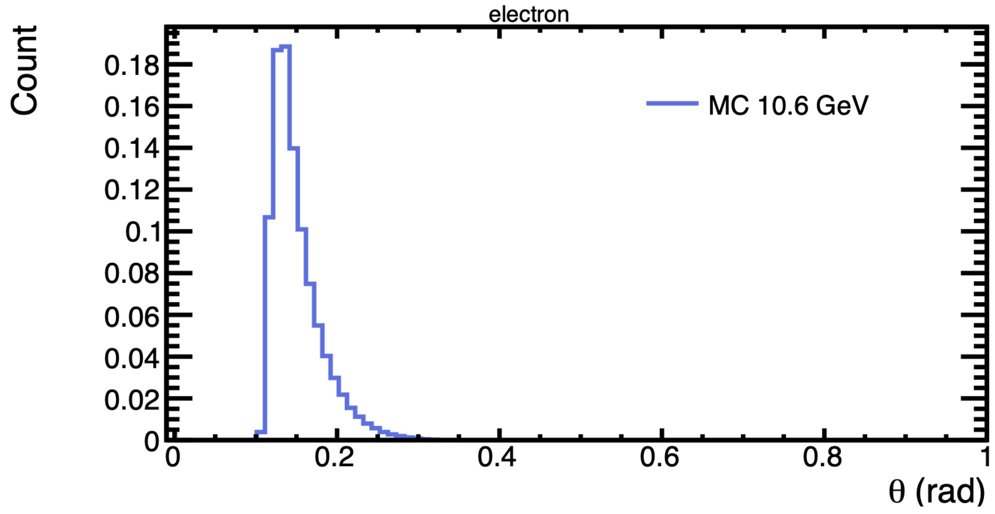
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



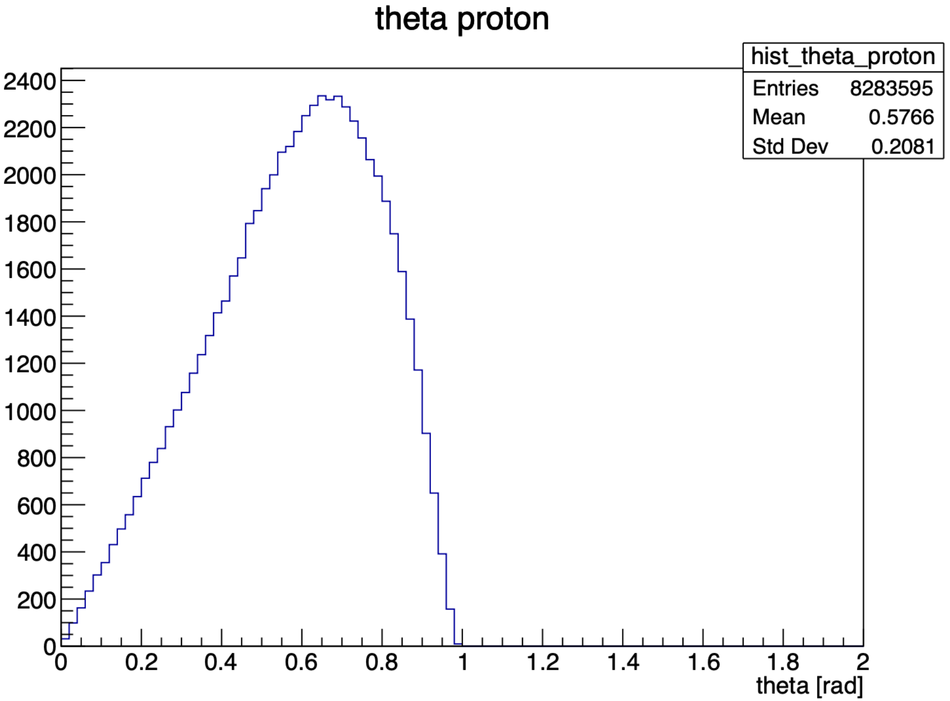
my generator



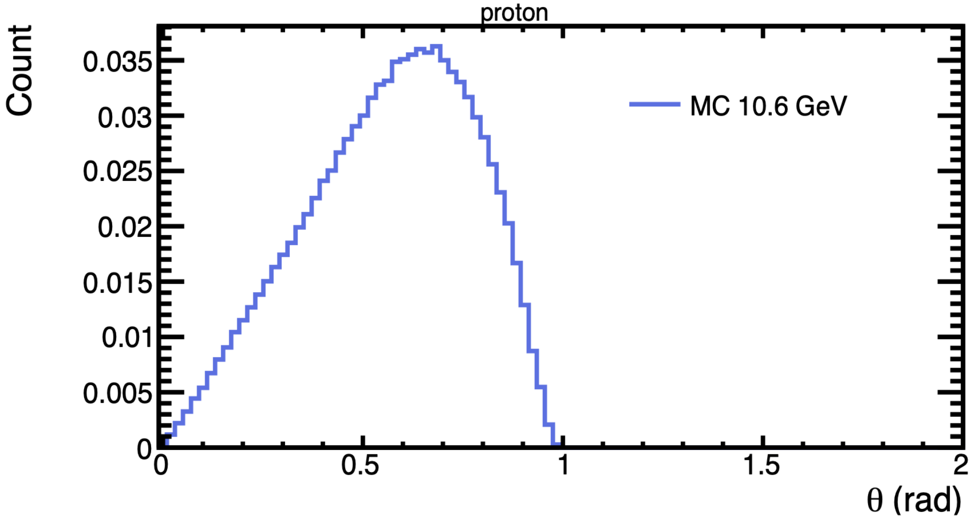
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



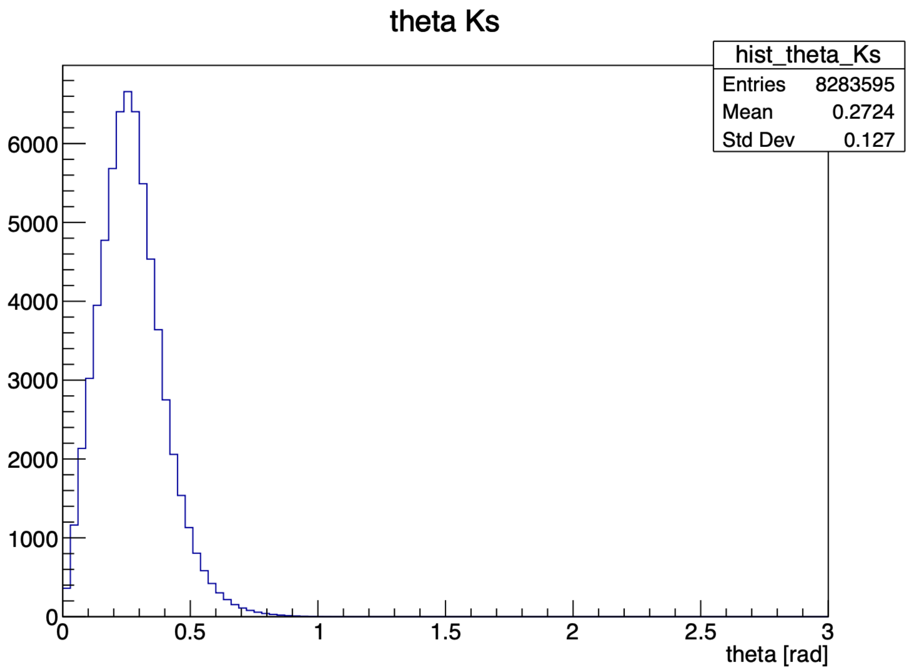
my generator



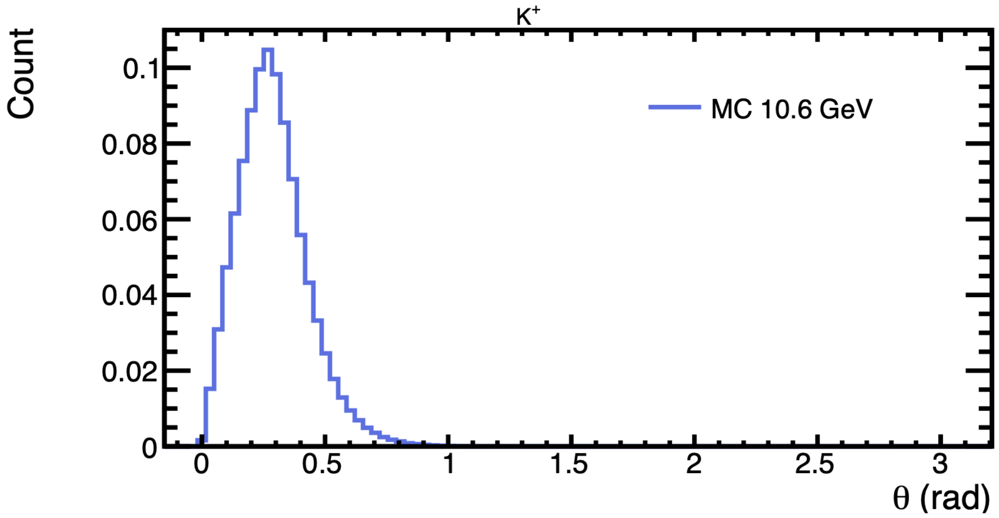
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



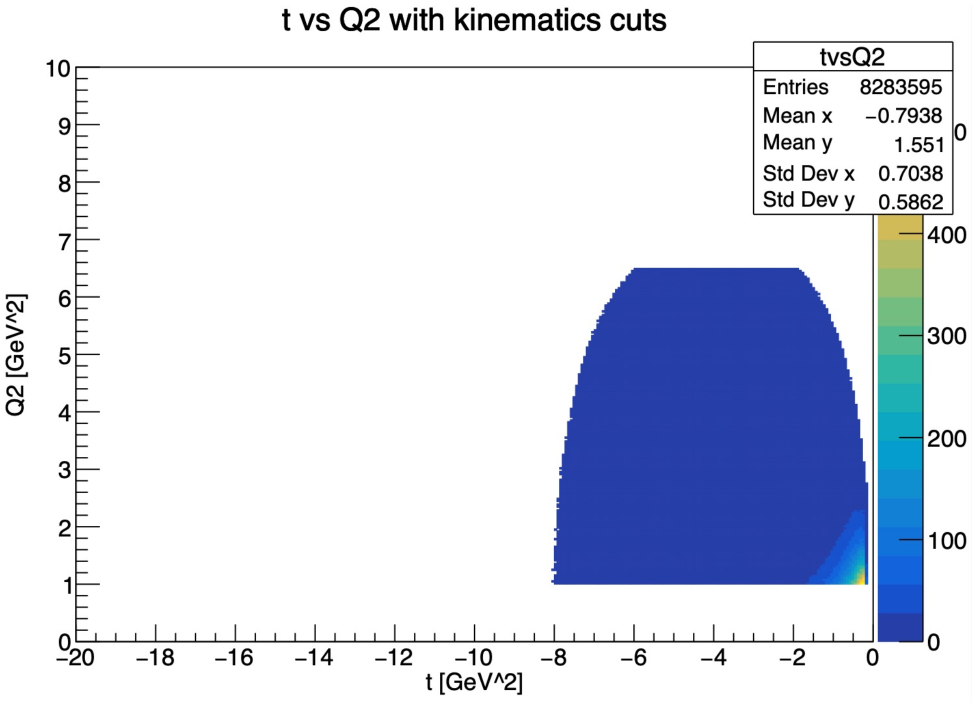
my generator



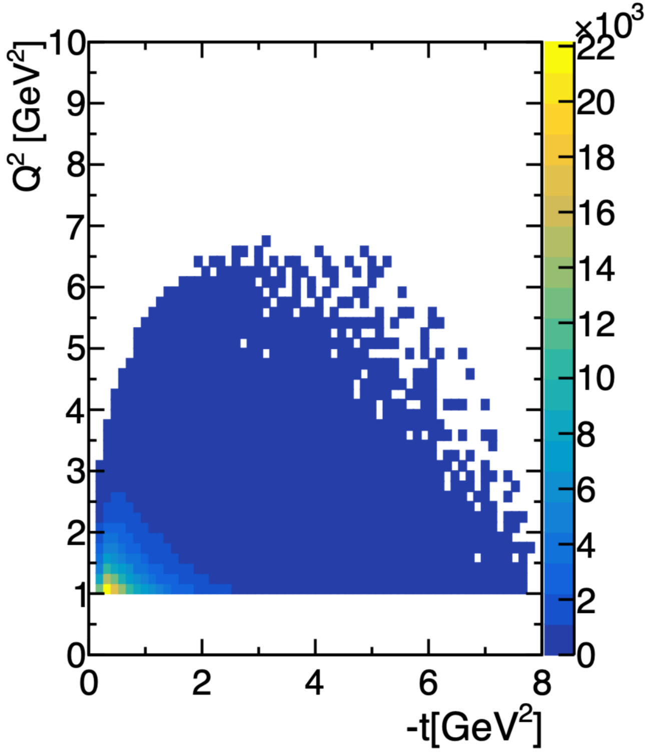
Bhawani plot

Update on ϕ generator

With this cuts : $5.25 < P_{electron} < 8$ GeV and $P_{proton} > 0.45$ GeV



my generator



Bhawani plot

Backup cross section

Update on ϕ generator

Details on cross section :

σ_T and σ_L ($\gamma^* p \to \phi\, p$) :

$$\sigma_T(W,Q^2) = \frac{c_T(W)}{(1+Q^2/m_\phi^2)^{\nu_T}}$$

$$R = \sigma_L(W,Q^2)/\sigma_T(W,Q^2)$$

$$R(W,Q^2) = \frac{c_R Q^2}{m_\phi^2}$$

t-dependence (dipole) :

$$\frac{d\sigma_{L,T}}{dt} = \frac{\sigma_{L,T}\, F(t)}{F_{\text{int}}}$$

$$F(t) = \frac{m_g^8}{(m_g^2 - t)^4}$$

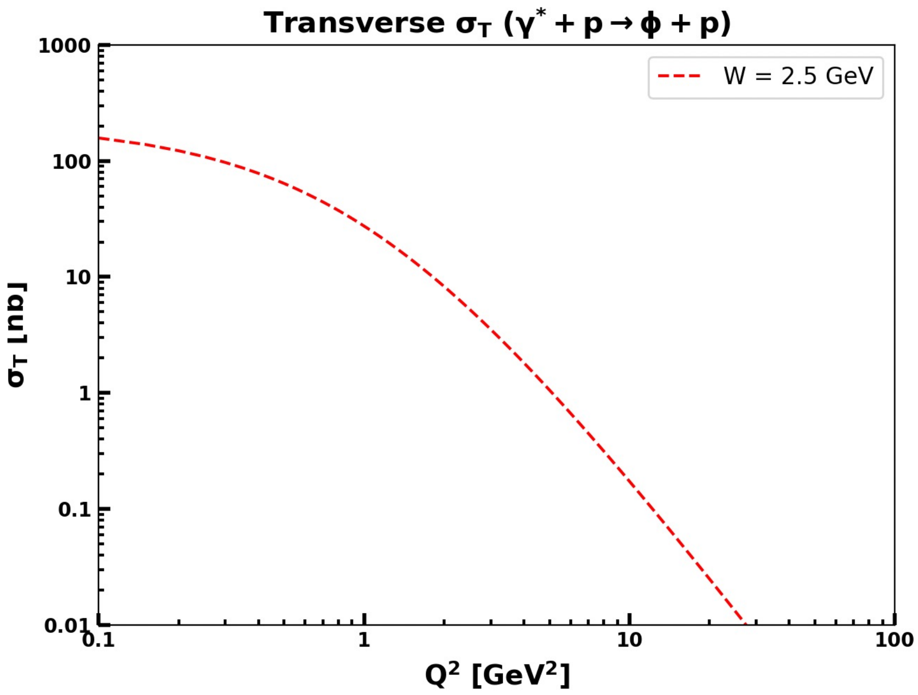
Update on ϕ generator

Cross section (ep $\longrightarrow$ ϕ p) :

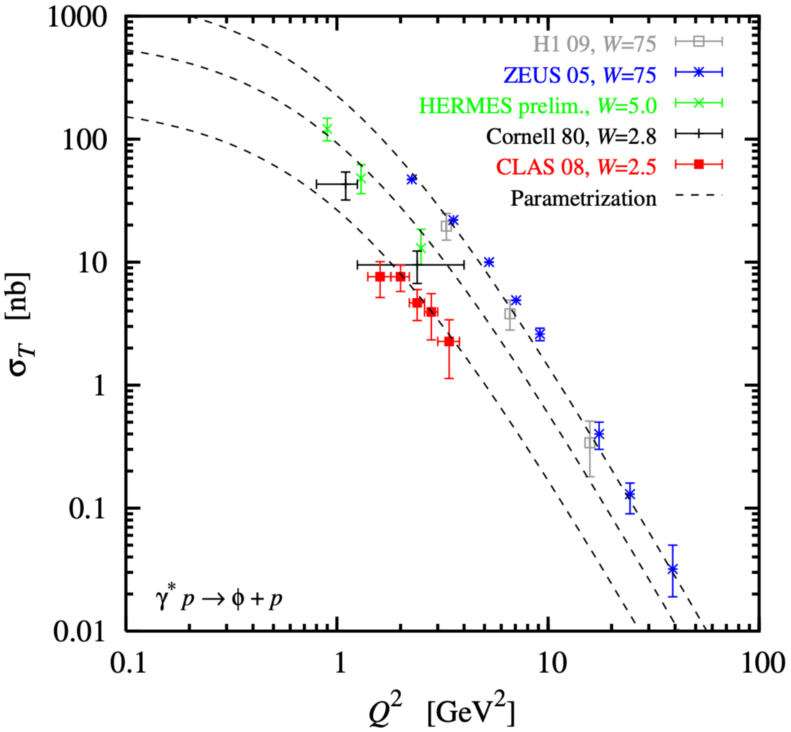
$$\frac{d^3\sigma}{dQ^2 dx_B dt} = \Gamma(Q^2, x_B, E)\left[\frac{d\sigma_T}{dt}(Q^2, x_B, t) + \epsilon\frac{d\sigma_L}{dt}(Q^2, x_B, t)\right]$$

The virtual photon flux : $\Gamma \equiv \frac{\alpha}{8\pi}\frac{Q^2}{m_N^2 E^2}\frac{1-x_B}{x_B^3}\frac{1}{1-\epsilon}$

Update on ϕ generator

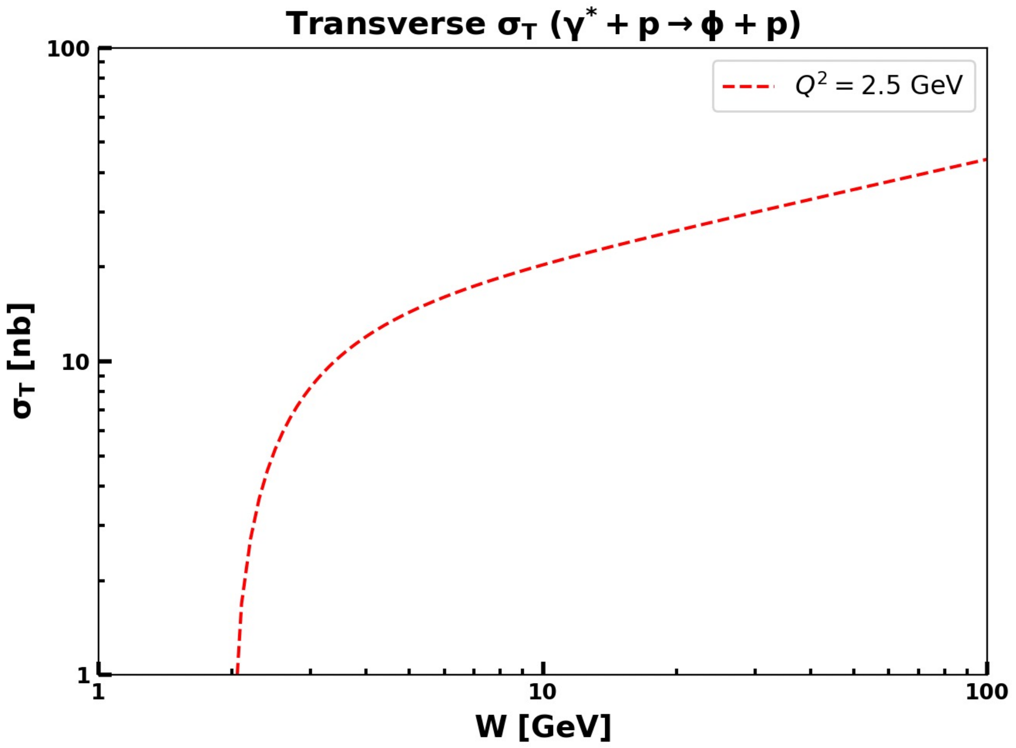


Implemented in the generator

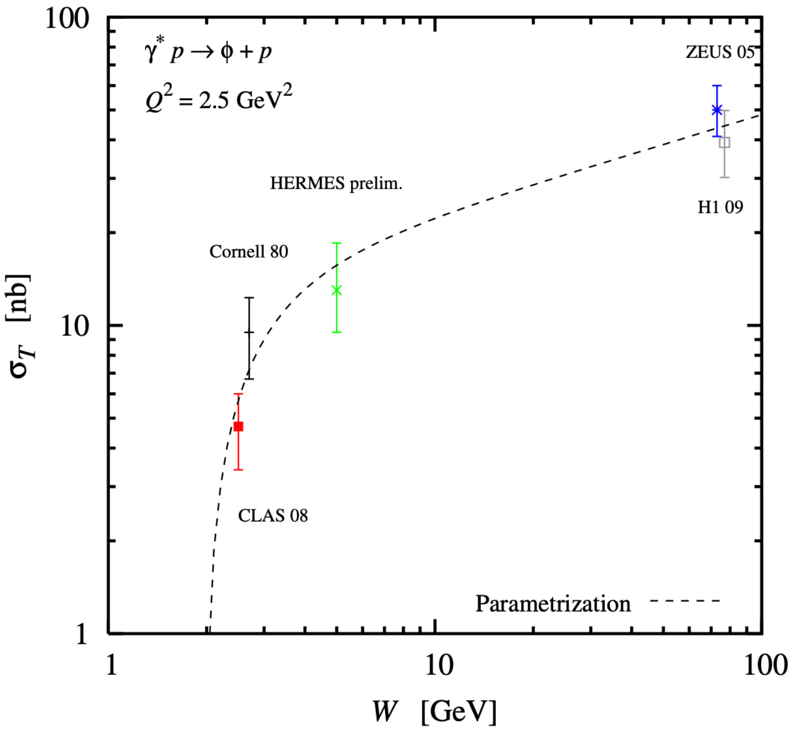


From Proposal to Jefferson Lab PAC39

Update on ϕ generator

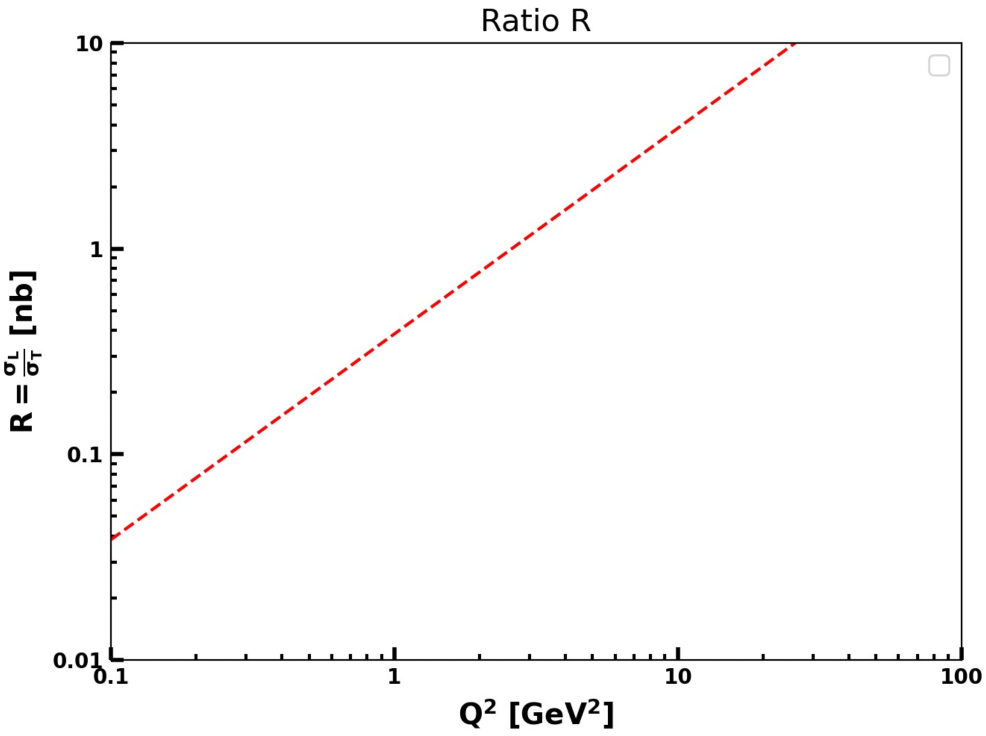


Implemented in the generator

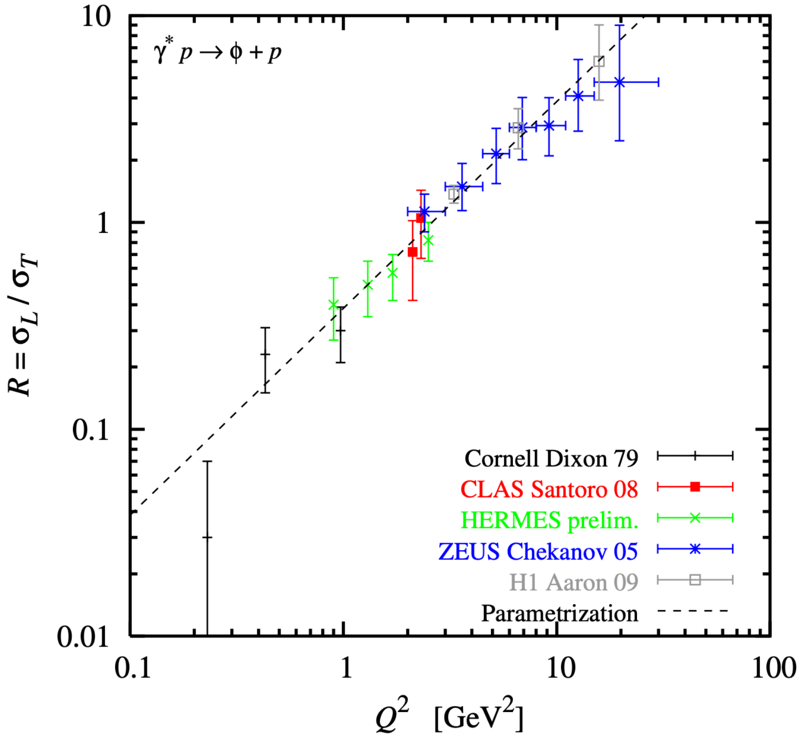


From Proposal to Jefferson Lab PAC39

Update on ϕ generator

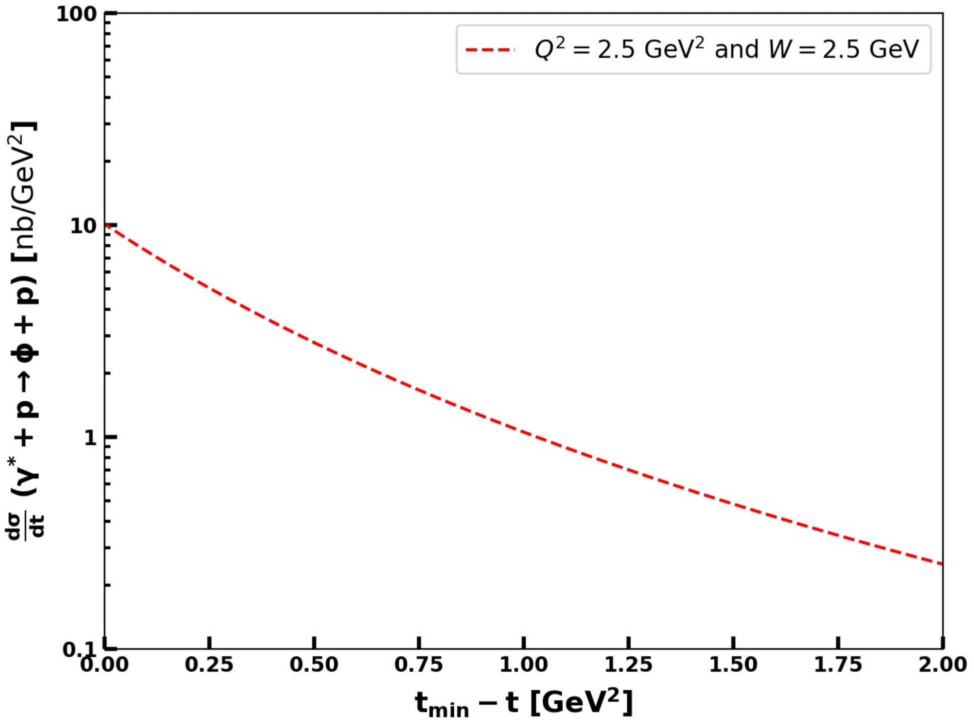


Implemented in the generator

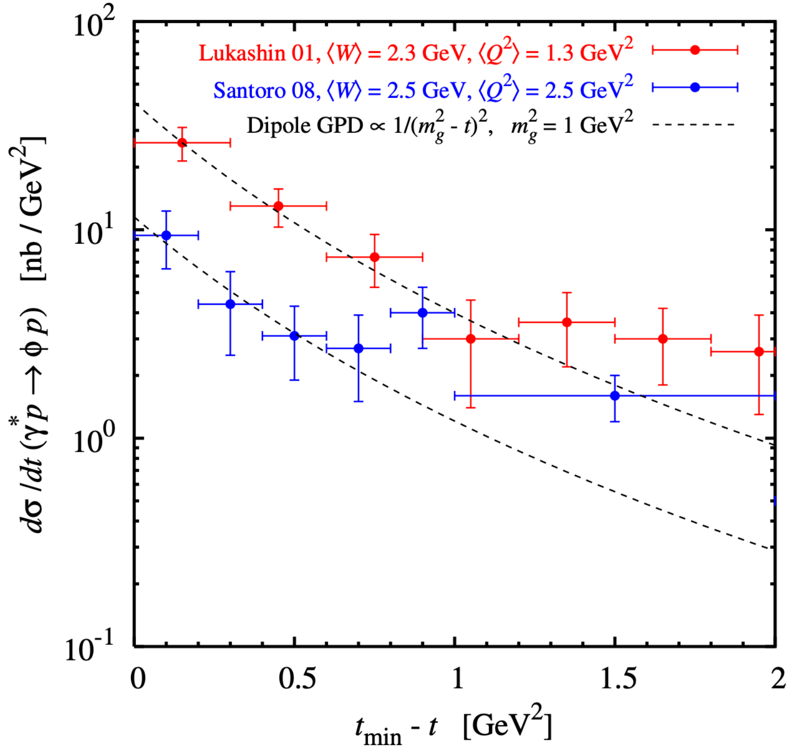


From Proposal to Jefferson Lab PAC39

Update on ϕ generator



Implemented in the generator



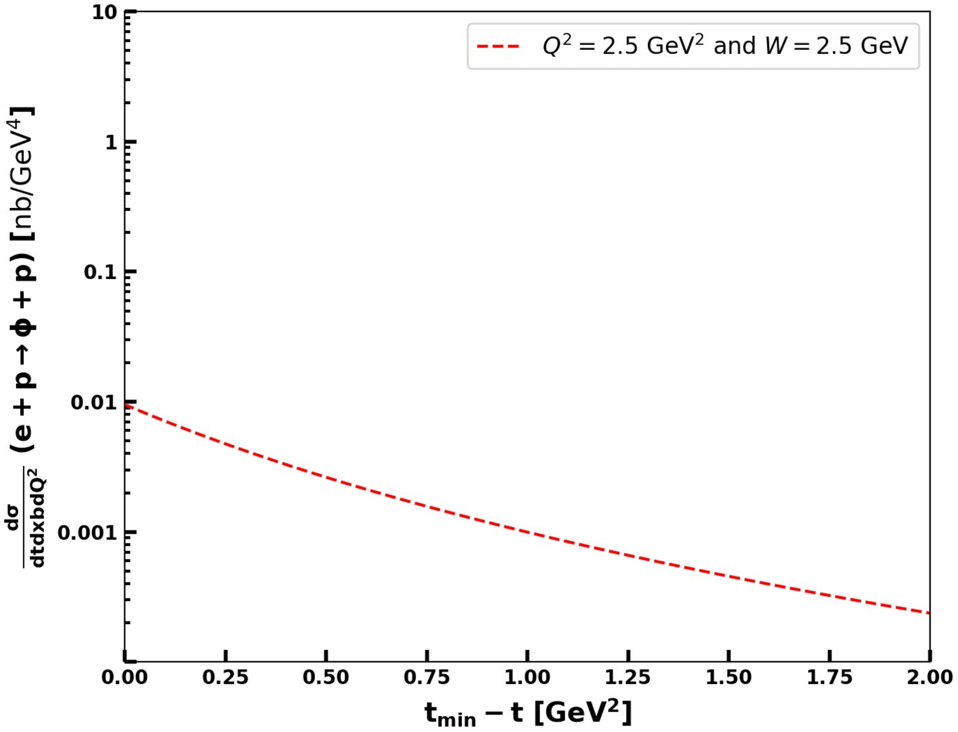
From Proposal to Jefferson Lab PAC39

Update on ϕ generator

Cross section (ep → ϕ p) (with the virtual photon flux) :

$$\frac{d^3\sigma}{dQ^2 dx_B dt} = \Gamma(Q^2, x_B, E)\left[\frac{d\sigma_T}{dt}(Q^2, x_B, t) + \epsilon\frac{d\sigma_L}{dt}(Q^2, x_B, t)\right]$$

$$\Gamma \equiv \frac{\alpha}{8\pi}\frac{Q^2}{m_N^2 E^2}\frac{1-x_B}{x_B^3}\frac{1}{1-\epsilon}$$



Implemented in the generator