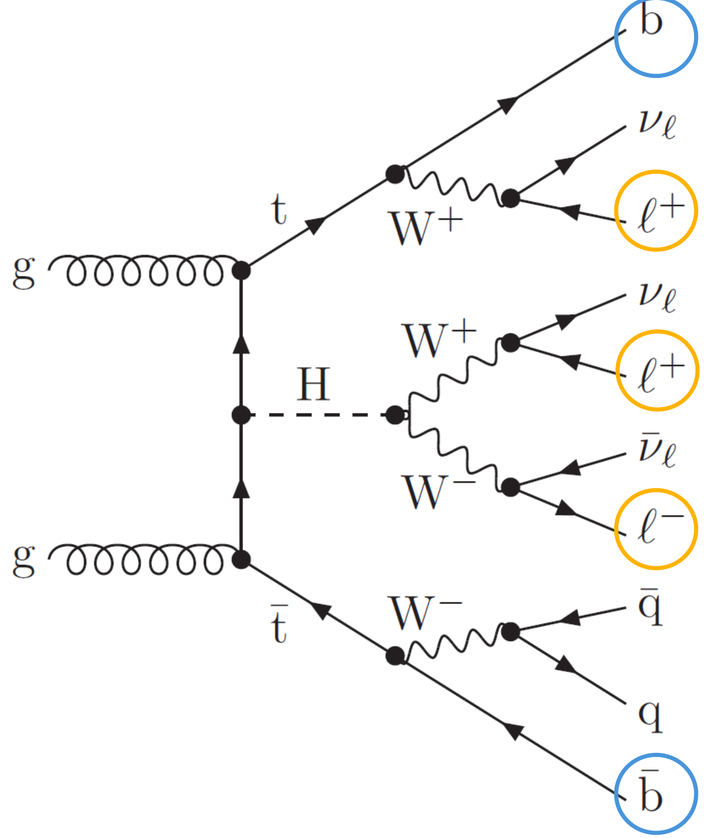
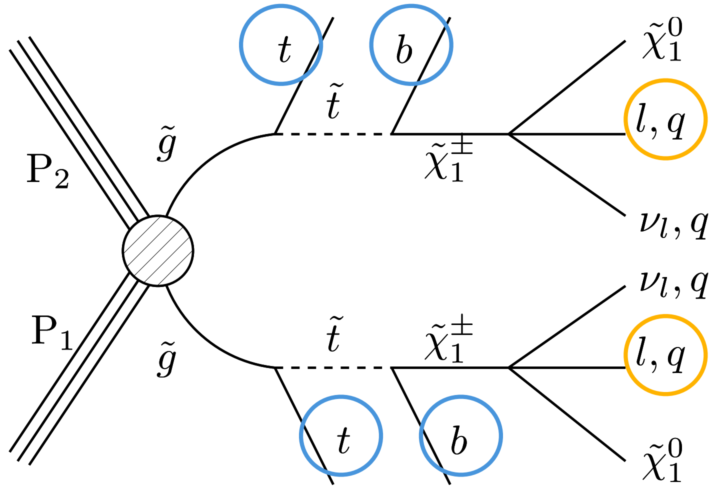
Two Step Prompt Muon Identification

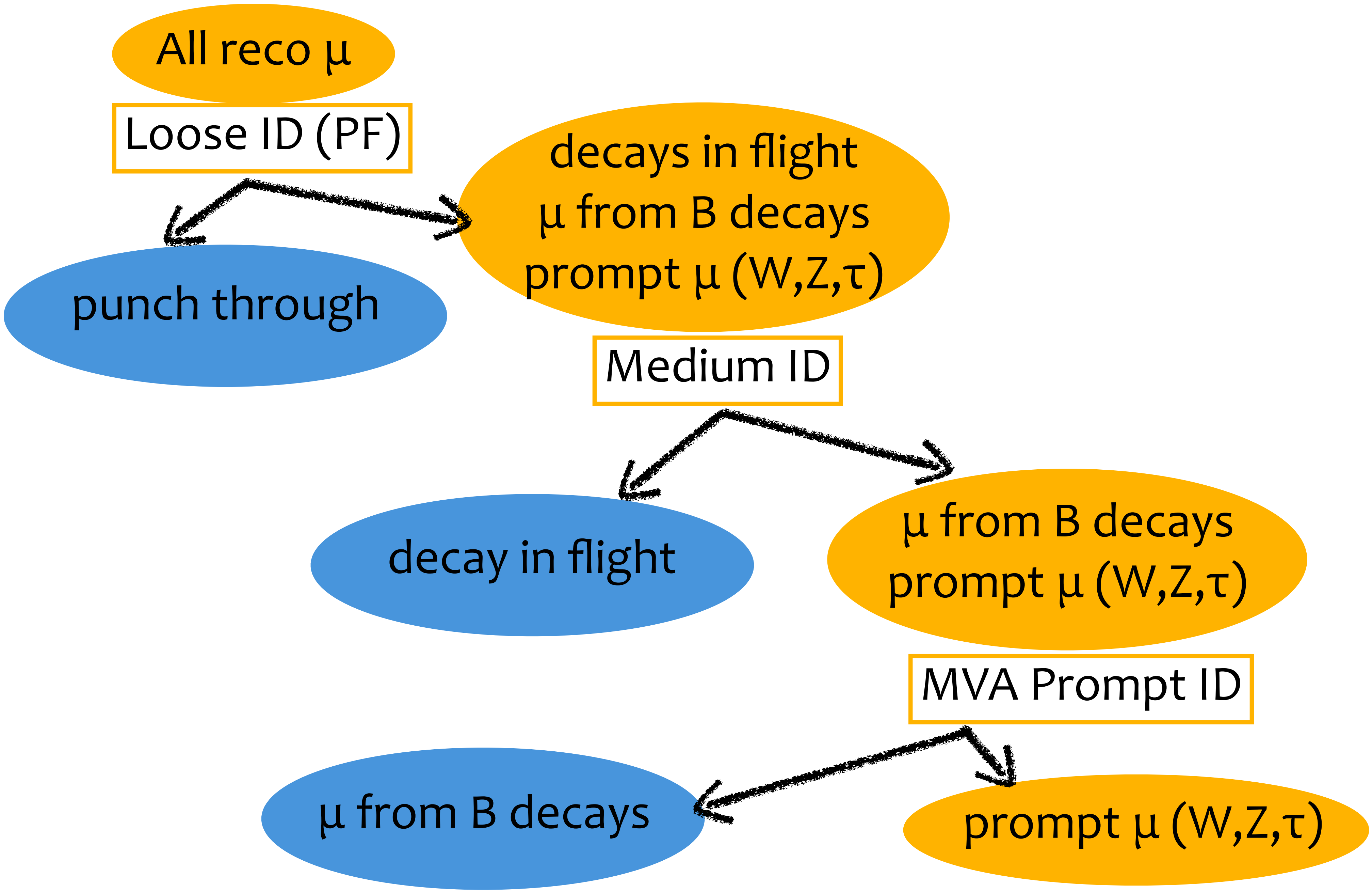




Cristina Botta, Giovanni Petrucciani

Muon POG, 22.01.15

2 step prompt μ identification

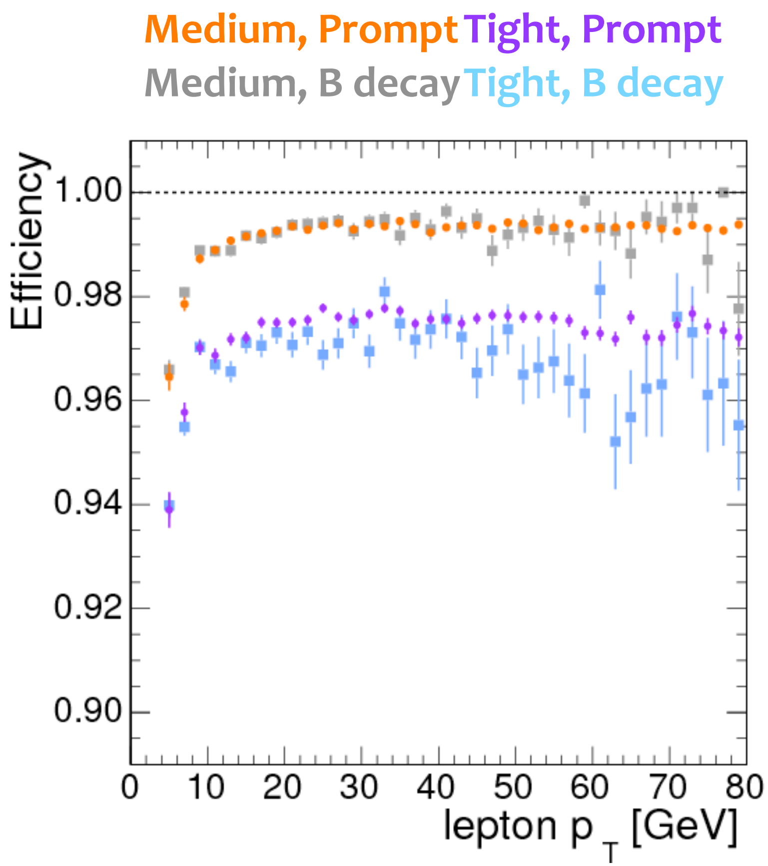


Reminder: Medium ID

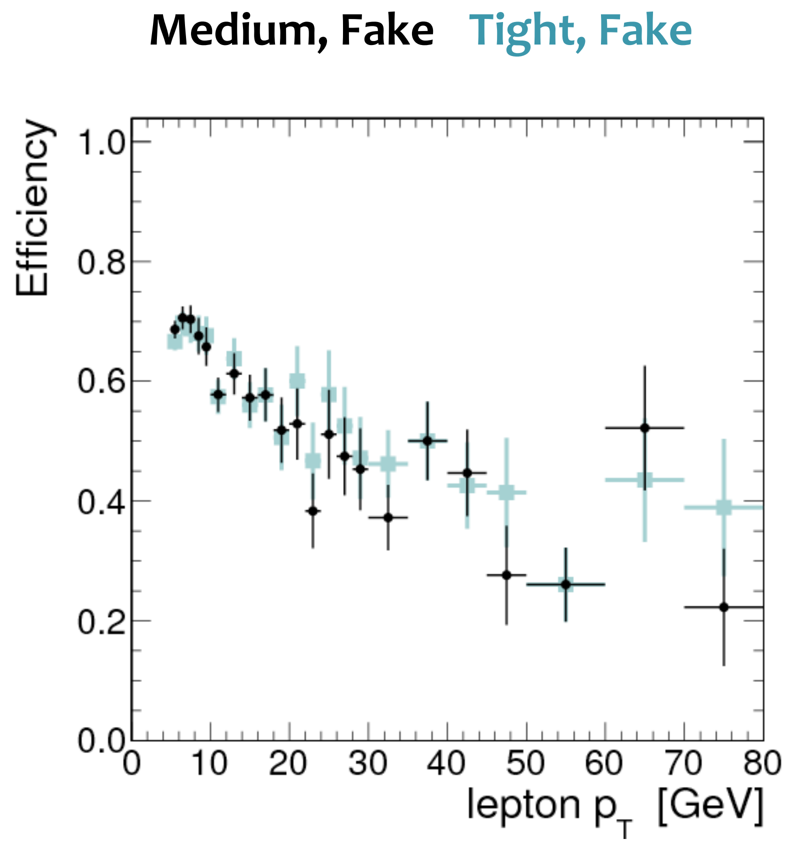
- It explores all purely ID variables
  - Loose preselection: valid hit fraction ≥ 0.8
  - Define a category of "good global muons" with cuts on kink, global track χ^2 and matching
  - Apply a segment compatibility cut, loose for good global muons, and tight for the others.
- Leaves out variables related to prompt vs non-prompt muon separation, as they are more specific of the physics analysis
- Performances on CSA14 samples already discussed
  - https://www.dropbox.com/s/0n975i5kdmjdeuz/muonid-pog081214.pdf?dl=0
- Provides the same fake rate as the Tight Muon ID but a higher efficiency on prompt and B-decays muons

Performances on Phys14 MC

*Comparison of **medium muon id***
***and tight muon id** in TTbar MC*



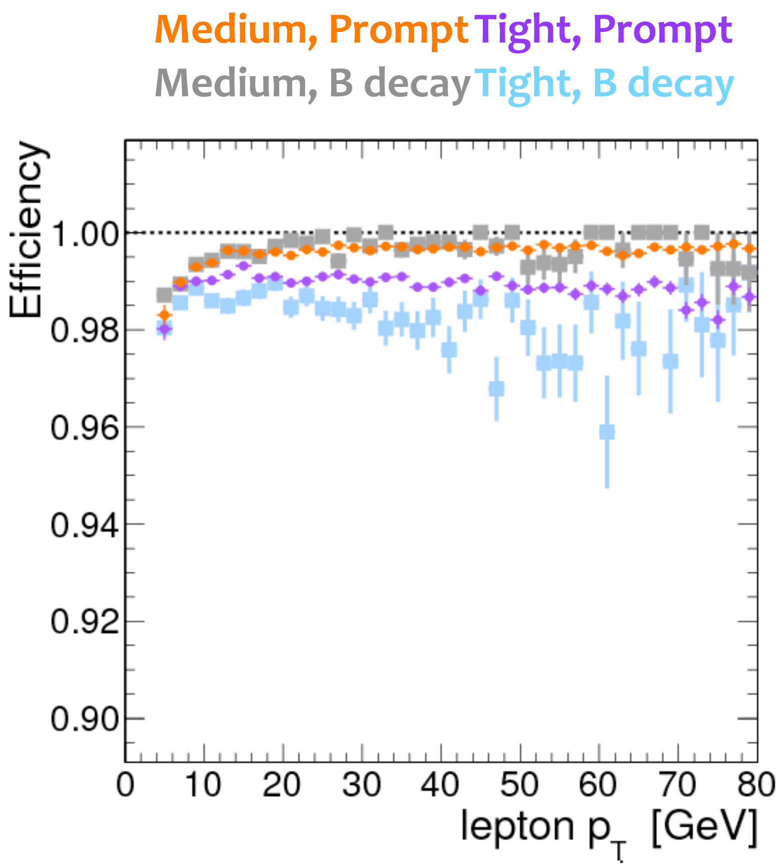
$|\eta| < 1.2$



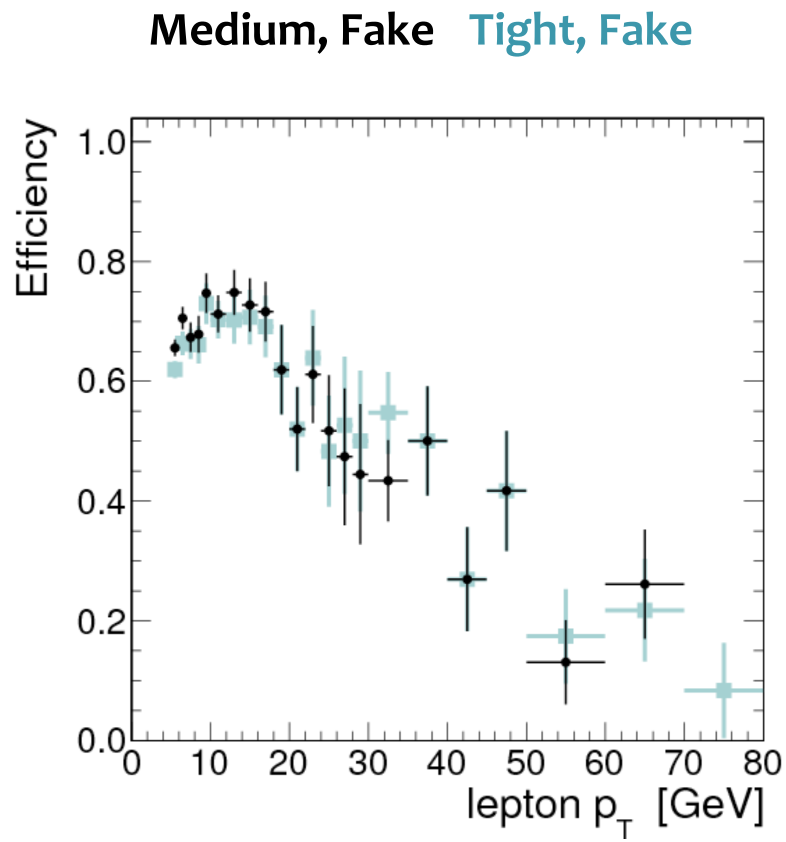
Efficiency of Medium ID wrt Preselection:
Loose Muon ID, p_T > 5 GeV, PFRelIso(R=0.3)<0.5 with EA corrections derived for PHYS14
dxy<500 μm, dz<1 mm

Performances on Phys14 MC

Comparison of ***medium muon id and tight muon id*** *in TTbar MC*



$|\eta| > 1.2$



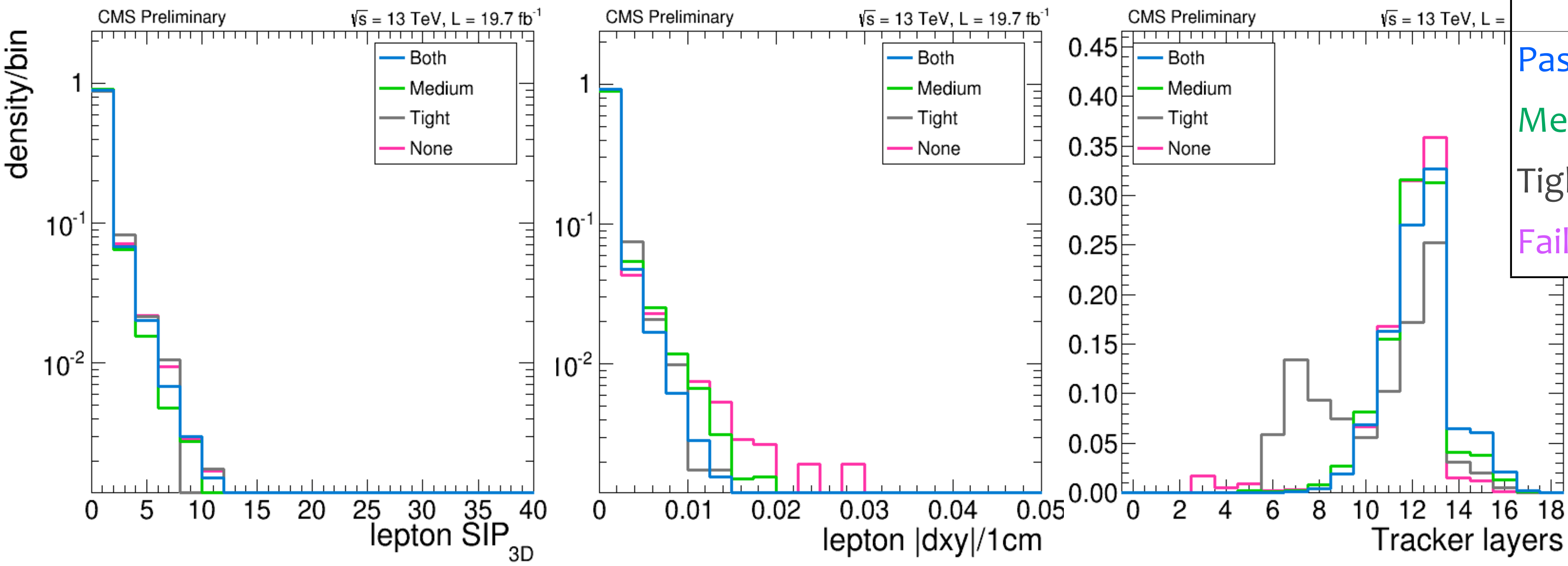
Efficiency of Medium ID wrt Preselection:

Loose Muon ID, $p_T > 5$ GeV, PFRelIso(R=0.3)<0.5 with EA corrections derived for PHYS14

dxy<500 μm, dz<1 mm

Medium ID Check #1

- Compare the properties of muons that pass/fail the medium/tight id, to see what is the quality of muons we recover:
  - Look at normalized distributions of some track quality variables for the four classes of muons, for prompt muons from ttbar (plots here are for $p_T > 20$, but behaviour is the same also below)
- Muons recovered by the medium Id (wrt tight Id) have the same impact parameter quality, and more tracker layers



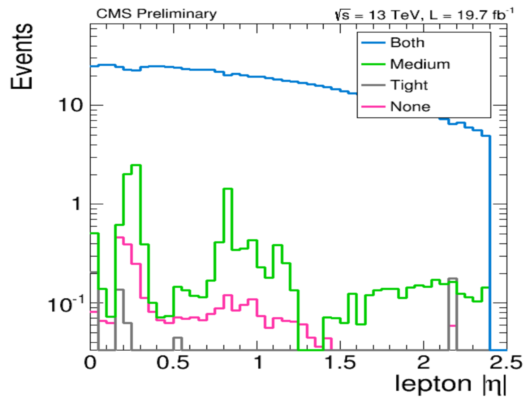
Efficiencies	
Pass both ids	97.8%
Medium only	1.69%
Tight only	0.16%
Fail both ids	0.39%

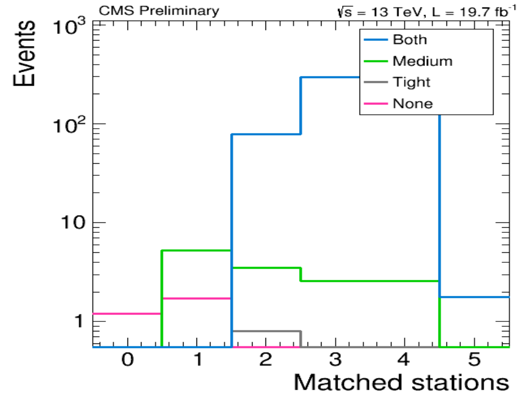
Medium ID Check #2

- Check what cuts of the tight Id are not satisfied by the muons that are recovered by the medium Id:
  - Main sources of inefficiency are the request of two stations and of the muon to be also a global muon.
  - Medium id recovers mostly muons in the detector gaps and in the forward

sequential cuts	inefficiency
tracker layers > 5	0.00%
pixel hits > 0	0.09%
Tracker mu, >= 2 stations	**0.64%**
Global muon	**0.63%**
Glb track X^2/ndf < 10	0.32%
Valid muon hits > 0	0.07%

prompt muons, p_T > 20
(plots are normalized to efficiency of each class)





Medium id check #3

- Check whether the efficiency gain remains also after the trigger
  - Select Phys14 Z → μμ MC events with two leptons of $p_T > 25/10$ GeV, well isolated, $60 < m(\mu\mu) < 120$ GeV
  - Check the per-event efficiency of applying medium id and tight id to the muons, both inclusively and after requiring the event to pass the OR of the two DoubleMuon paths:
    - HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL_v*
    - HLT_Mu17_TrkIsoVVL_TkMu8_TrkIsoVVL_v*
- As expected, the tight id efficiency is a bit higher if the event is required to pass the trigger, but the medium id still recovers some

	inclusive	**after HLT**
Medium id	99.0%	99.2%
Tight id	96.5%	97.7%
difference	*2.5%*	*1.5%*

MVA Prompt ID

- Goal: discriminate signal leptons (Z, W, τ) from those from b-jets
  - tt main reducible bkg in almost all the final states being investigated in ttH and leptonic-SUSY
- BDT trained using simulated events
  - tt sample for source of signal leptons from W
  - ttH sample for source of signal leptons from W,Z, τ
  - tt sample for source of bkg leptons (mainly from B)
  - Wjets sample for source of bkg leptons (mainly from light-jets)
- Separately for electrons/muons in η/p_T regions:

muons	**η**	**p_T**
low		< 10
medium b	< 1.5	10-25
medium e	> 1.5	10-25
high b	< 1.5	> 25
high e	< 1.5	> 25

MVA Prompt ID: variables

- Input variables:

Isolation

- **PF relIso, charged** had. (R=0.3)
- **PF relIso, neutral** had. & photon (R=0.3, with EA corrections)
  - EA derived for PHYS14 samples

Vertexing

- **3d IP significance** (SIP_{3D})
- **|dxy|** and **|dz|**

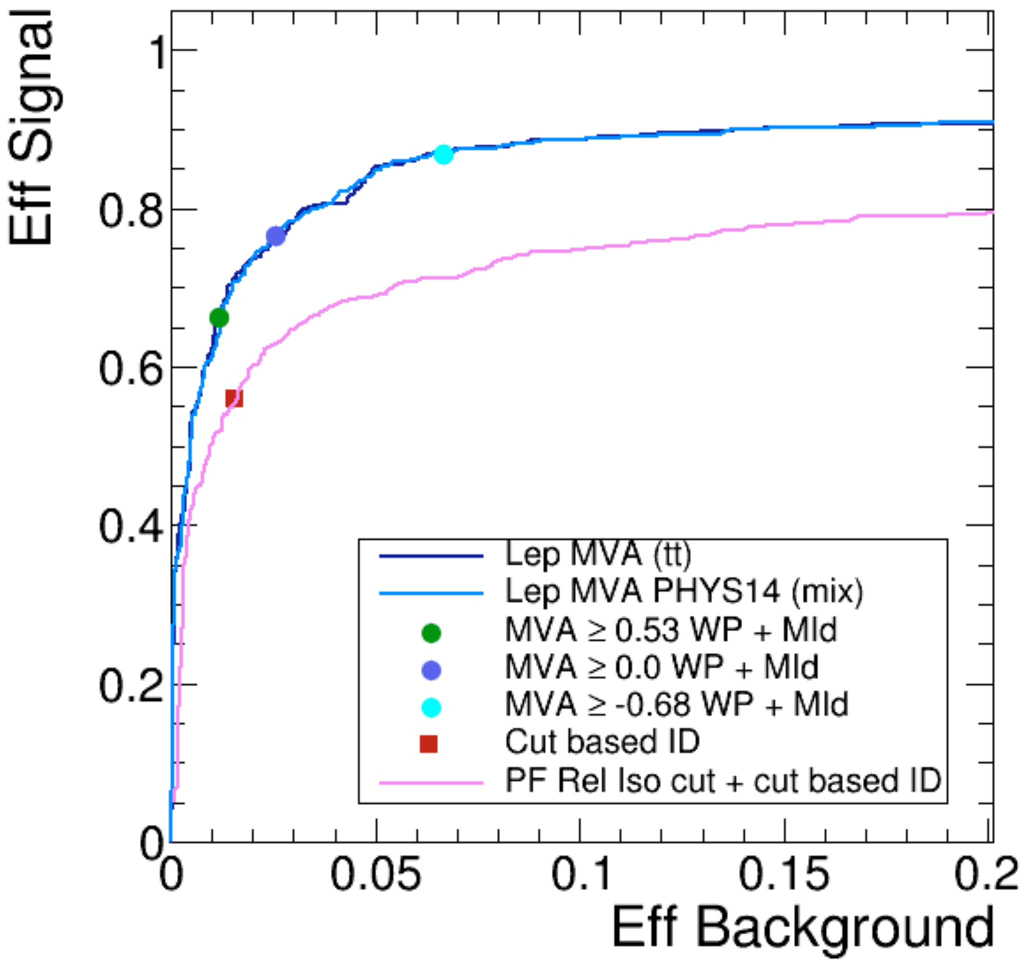
Lep-Jet

- **Lepton's closest jet** (leptons are not removed from jet collection)
  - $p_T(\ell)/p_T(\text{jet})$
  - $\Delta R(\ell,\text{jet})$
  - jet CSV b-tag

ID

- **Segment compatibility**

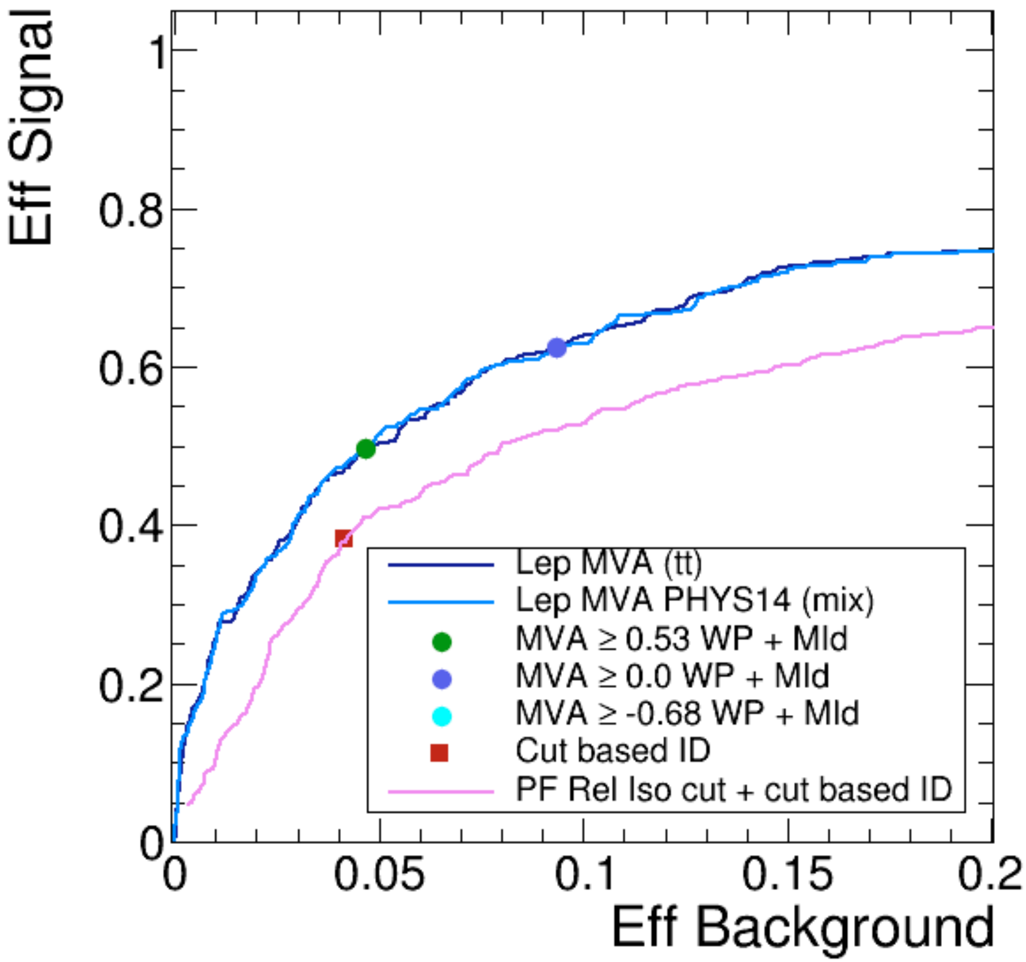
SUSY 2 same-sign μ (high p_T)



Cut based ID:
Tight Muon ID, PFRelIso(R=0.3)<0.1 with EA corrections derived for PHYS14
SIP3D < 4

- Performances of **MVA + Medium ID** vs Cut Based ID
- Denominator: SUS-13-013 baseline region with **N_{Bjets} >= 1** (H_T > 80 GeV, E_T^{miss} > 30 GeV if H_T < 500, N_{Jets40} >= 2), 2 same-sign μ with preselection and **p_T > 25/25** GeV
- Per event efficiencies of **T1tttt**(1.2/0.8) vs **Bkg with non prompt leptons (tt)** for same cut applied to both leptons

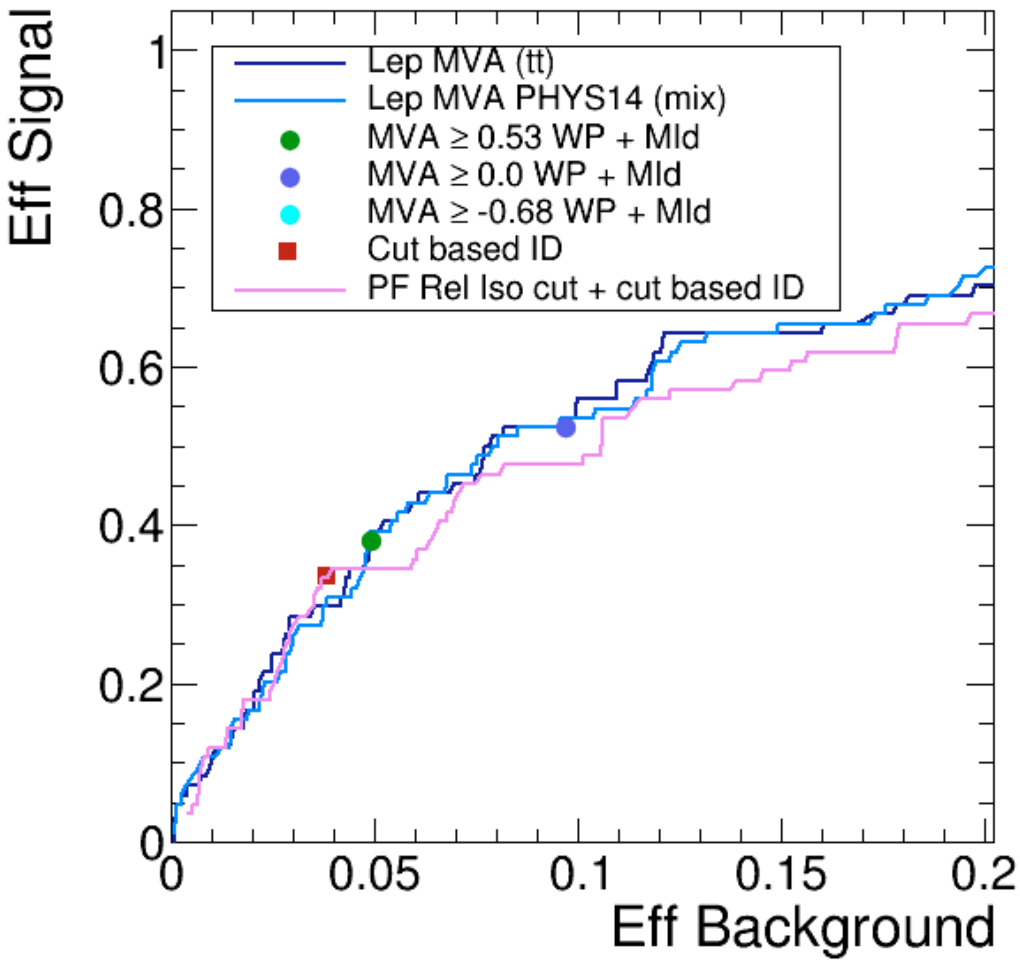
SUSY 2 same-sign μ (mid p_T)



Cut based ID:
Tight Muon ID, PFRelIso(R=0.3)<0.1 with EA corrections derived for PHYS14 SIP3D < 4

- Performances of **MVA + Medium ID** vs Cut Based ID
- Denominator: SUS-13-013 baseline region with **N_{Bjets} >= 1** (H_T > 80 GeV, E_T^{miss} > 30 GeV if H_T < 500, N_{Jets40} >= 2), 2 same-sign μ with preselection and **$p_T(1)$ > 25; $p_T(2) \in$ 10-25 GeV**
- Per event efficiencies of **T1tttt**$_{(1.2/0.8)}$ vs **Bkg with non prompt leptons (tt)** for same cut applied to both leptons

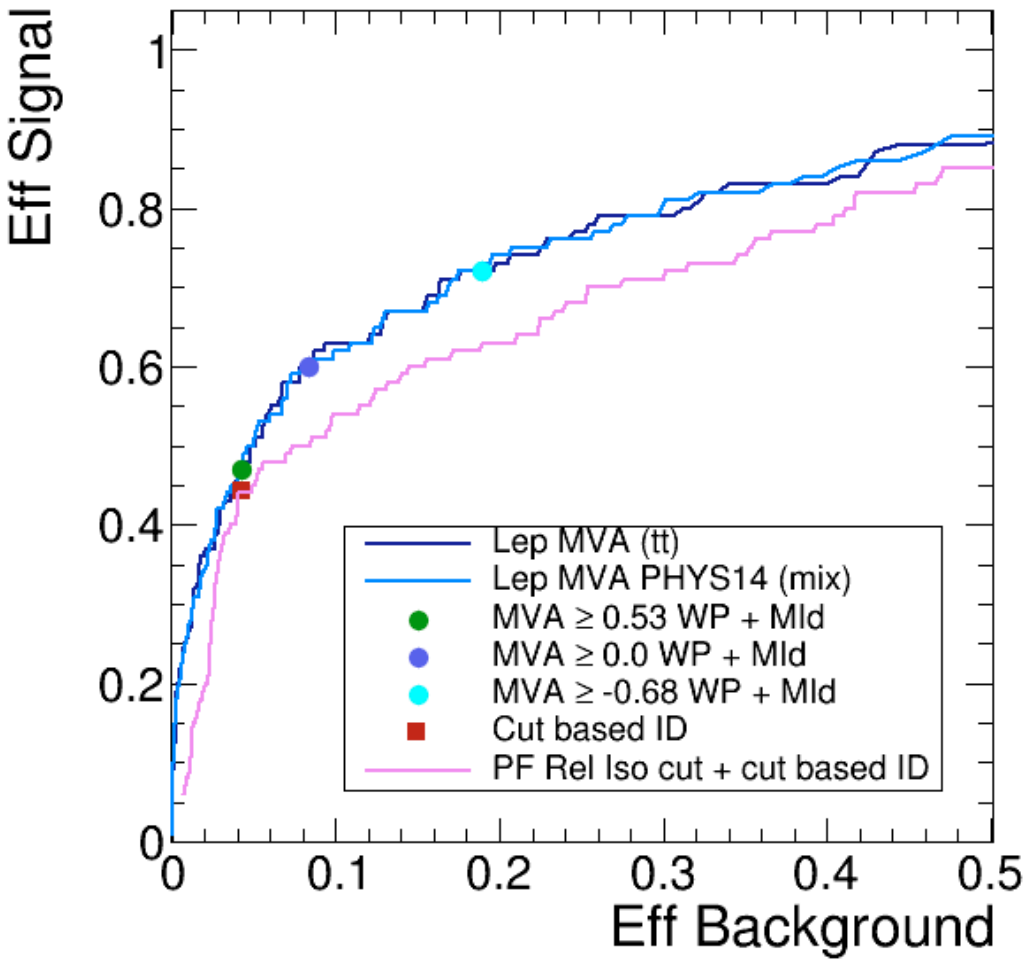
SUSY 2 same-sign μ (low p_T)



Cut based ID:
Tight Muon ID, PFRelIso(R=0.3)<0.1 with EA corrections derived for PHYS14 SIP3D < 4

- Performances of **MVA + Medium ID** vs Cut Based ID
- Denominator: SUS-13-013 baseline region with **N_{Bjets} >= 1** (H_T > 80 GeV, E_T^{miss} > 30 GeV if H_T < 500, N_{Jets40} >= 2), 2 same-sign μ with preselection and **both p_T ∈ (10-25, 10-25)** GeV
- Per event efficiencies of **T1tttt**$_{(1.2/0.8)}$ vs **Bkg with not prompt leptons (tt)** for same cut applied to both leptons

SUSY 2 same-sign μ (high p_T)

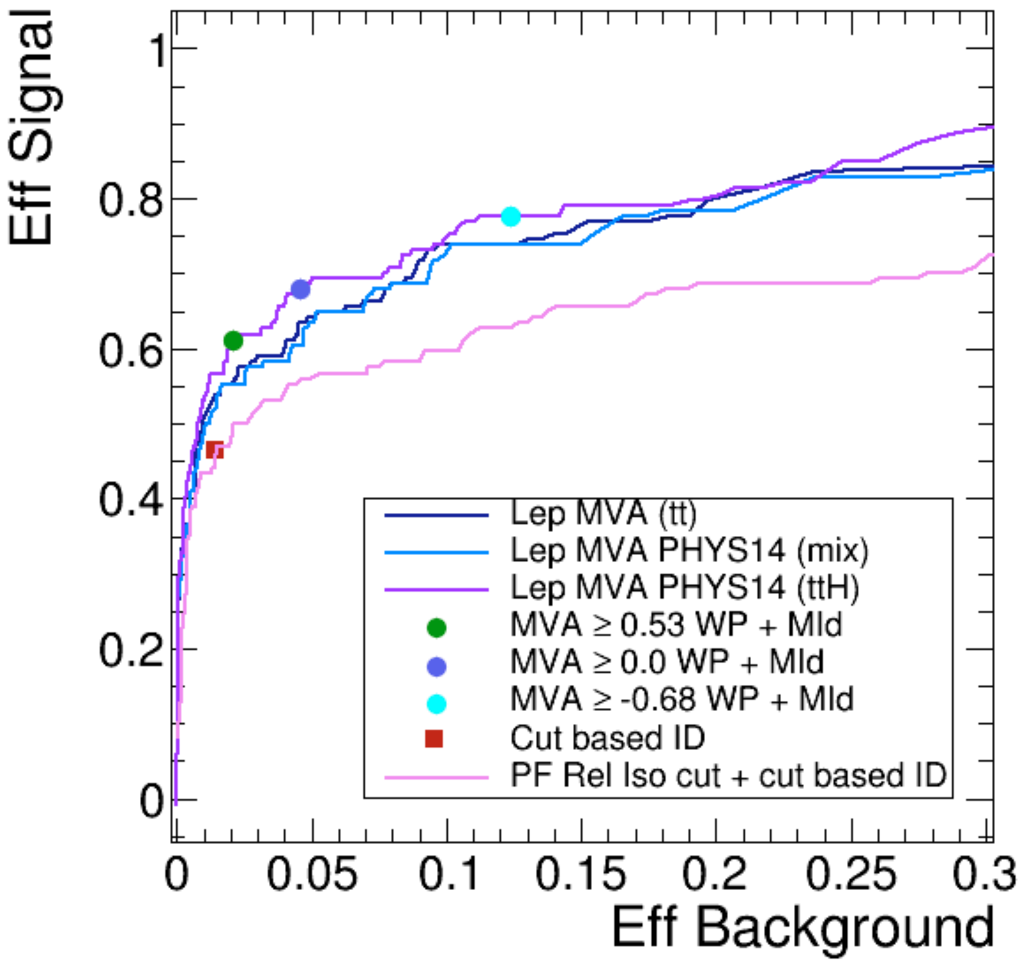


Cut based ID:

Tight Muon ID, PFRelIso(R=0.3)<0.1 with EA corrections derived for PHYS14 SIP3D < 4

- Performances of **MVA + Medium ID** vs Cut Based ID
- Denominator: SUS-13-013 baseline region with **N_{Bjets} == 0** (H_T > 80 GeV, E_T^{miss} > 30 GeV if H_T < 500, N_{Jets40} >= 2), 2 same-sign μ with preselection and **p_T > 10/10** GeV
- Per event efficiencies of **T1tttt**$_{(1.2/0.8)}$ vs **Bkg with non prompt leptons (WJets, tt)** for same cut applied to both leptons

ttH 2 same-sign μ



Cut based ID:

Tight Muon ID, PFRelIso(R=0.3)<0.1 with EA corrections derived for PHYS14
SIP3D < 4

- Performances of **MVA + Medium ID** vs Cut Based ID
- Denominator: ttH HIG-13-020 baseline region with **N_{Bjets} >= 2 CSVL || 1 CSVM**, 2 same-sign μ with preselect. and **p_T > 25/25** GeV
- Per event efficiencies of **ttH** vs **Bkg with non prompt leptons (tt)** for same cut applied to both leptons

Performances and prospects

- We have checked the expected performances of the medium ID + prompt MVA for the ttH and SUSY analyses in 2 same-sign muon final state
    - we expect 10-20% improvement in sensitivity with respect to the analyses which make use of the tight ID and standard isolation and vertexing requirements on the muons
- More gain is expected in the 3(4) lepton final states (ttH, SUSY)
- We would like to provide also a dedicated tuning for low p_T muons (5-10) GeV to be used in:
    - adding the third lepton in the ttH analysis (soft leptons from W*)
    - access compressed spectra in SUSY models (soft leptons from W*)
    - vetoing leptons across different lepton multiplicity final states

Validation

- We would like to validate the Medium ID and the Prompt MVA ID with RunI data using the PHYS14 72X reco
- To do that we would like to request (PPD next week) a small PHYS14@50ns production with PU scenario similar to 8 TeV data
    - for DY, TT, WJets MC samples and SingleMuD data

Developments

- Being discussed within the ttH-leptonic group (F. Romeo):
    - additional variables to be consider as inputs to the prompt MVA: N_{tracks} of closest jet, max(signed SIP_{3D} of closest jet's tracks), ...
- The prompt MVA is being studied in PHYS14 also for electrons with similar input variables