Tag &Probe
Muon Efficiency Measurements For Higgs analysis At 13TeV

Walaa Mohamed - Ahmed Abdelalim - Nicola De Filippis

WP1---EENP2 Meeting

outlines

- Introduction.
- Details on Samples.
- Muon Reconstruction and Identification.
- The Selections for Tag & Probe muon.
  - For the Reconstruction and ID efficiencies.
  - For the Isolation efficiencies.
- The Reconstruction for TP Pairs.
- Results for Isolation efficiencies.
- Results for Reconstruction and ID efficiencies.
  - Loose ID.
  - Tight ID.
- Conclusion.

Tag & probe

❑The Tag and Probe Tool is a generic tool developed to measure any user defined object efficiency from data or MC at CMS by exploiting di-object resonances like Z or J/Psi.

➢resonances are reconstructed as pairs with one leg passing a tight identification (tag) and one passing a loose identification (probe).

➢"passing probes" are defined according to whatever is the efficiency to measure.

➢the (tag + passing probe) and (tag + failing probe) line shapes are fit separately with a signal + background model, then the efficiency is computed from the ratio of the signal yields.

❑ In this work muon efficiencies are measured with the Tag and Probe (T&P) method performed on Z →μμ events in bins of pT and |η|.

Details on samples

Data:

- Collision data at 13 TeV and 25 ns bunch spacing.
- Single Muon dataset.
- Run D Integrated luminosity 2.25/fb.
- Run C Integrated luminosity 17.2 /pb.
- The JSON file: Cert_13TeV_16Dec2015ReReco_Collisions15_25ns_JSON.txt.

•/SingleMuon/Run2015D-16Dec2015-v1/AOD
•/SingleMuon/Run2015C_25ns-16Dec2015-v1/AOD

MC:

- Drell–Yan + Jets sample generated with MadGraph_aMC@NLO

•/DYJetsToLL_M-50_TuneCUETP8M1_13TeV-madgraphMLM-pythia8/RunIIFall15DR76-PU25nsData2015v1_76X_mcRun2_asymptotic_v12-v1/AODSIM/

Muon Identification and Isolation

Efficiencies are computed for the following ID criteria:

❑Loose Muon ID:

- **PT > 5 GeV & |η| < 2.4**
- **isGlobalMuon || (isTrackerMuon && numberOfMatches>0)**
- **dxy < 0.5, dz < 1.**
- **Standalone Muon tracks that are only reconstructed in the muon system are rejected** (muonBestTrackType !=2).

❑Tight muons ID:

- **defined as loose muons**
- **also PF muons.**

❑Muon Isolation:

- **Particle-flow relative isolation in a ΔR = 0.3 cone with delta Beta correction to be less than 0.35**

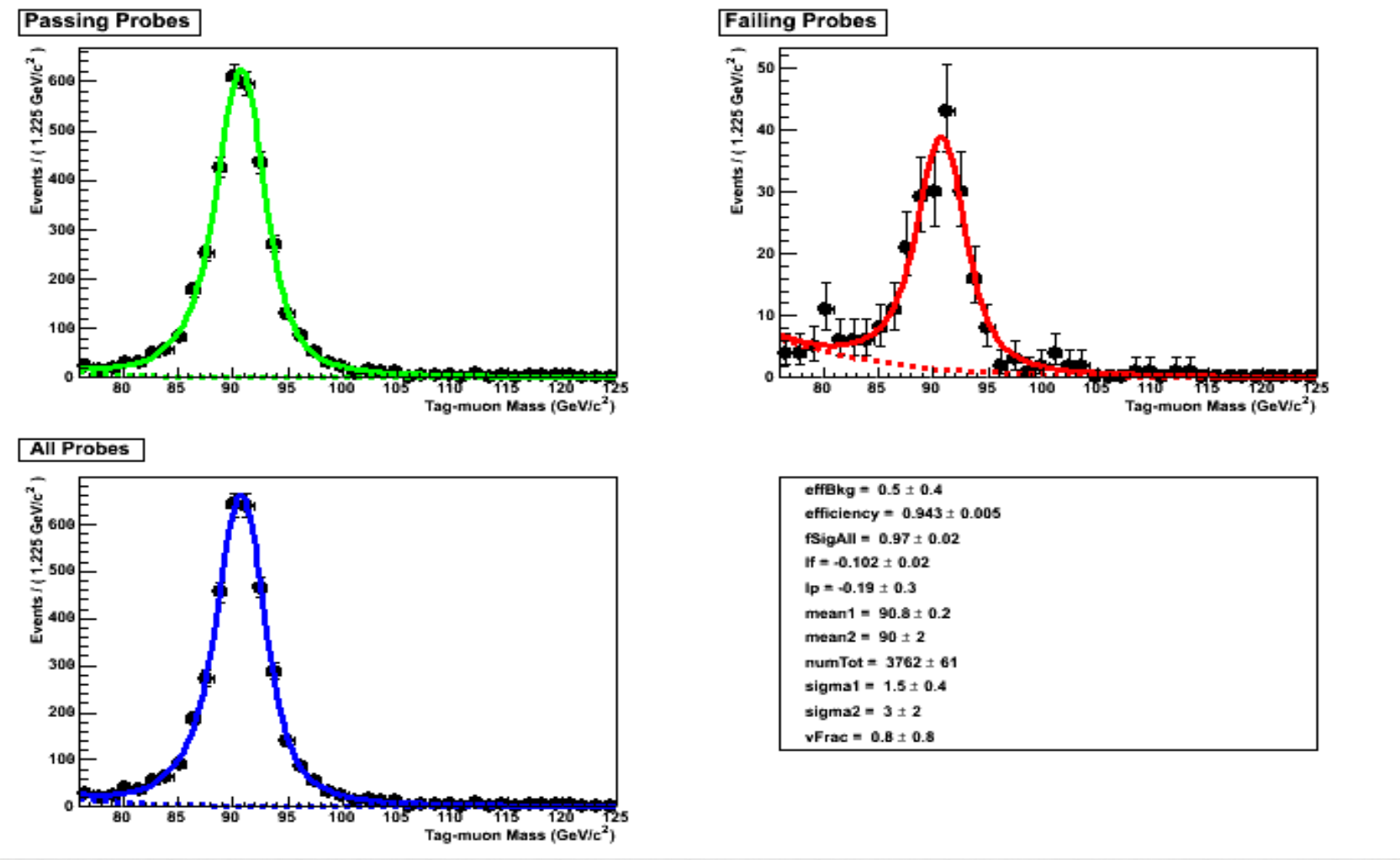
The Selection for Tag & Probe muon

- **The tag muon** is reconstructed according to the "Tight muon ID" as defined by muon POG.
- The Tag muon PT >25 GeV & $|\eta| < 2.1$
- Geometrically matched to the leg of single muon trigger object.
  "the trigger path HLT_IsoMu20"
- Geometrically matched to the leg of generator level object i.e. MC truth matching.
- **The probe muon for ID eff: (**PT >3 GeV & $|\eta| < 2.5$ & isTrackerMuon).
- **The probe muon for ISO eff:** are muons passing tight ID requirements.

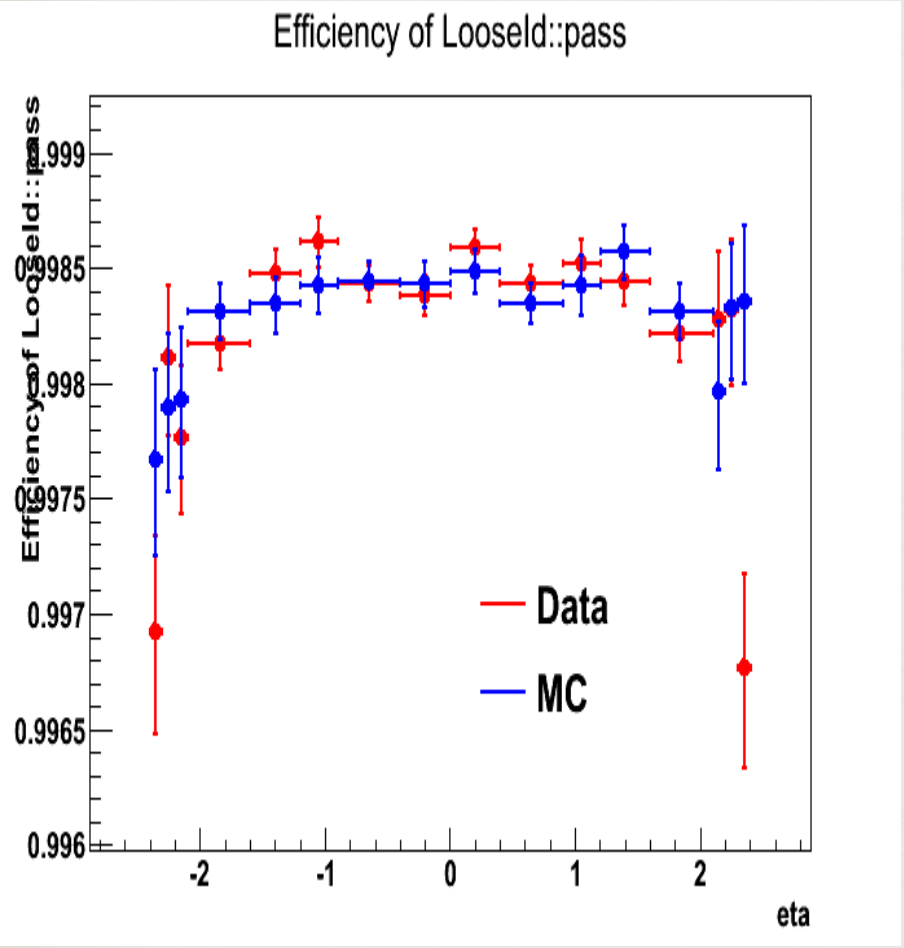
The Reconstruction for TP Pairs

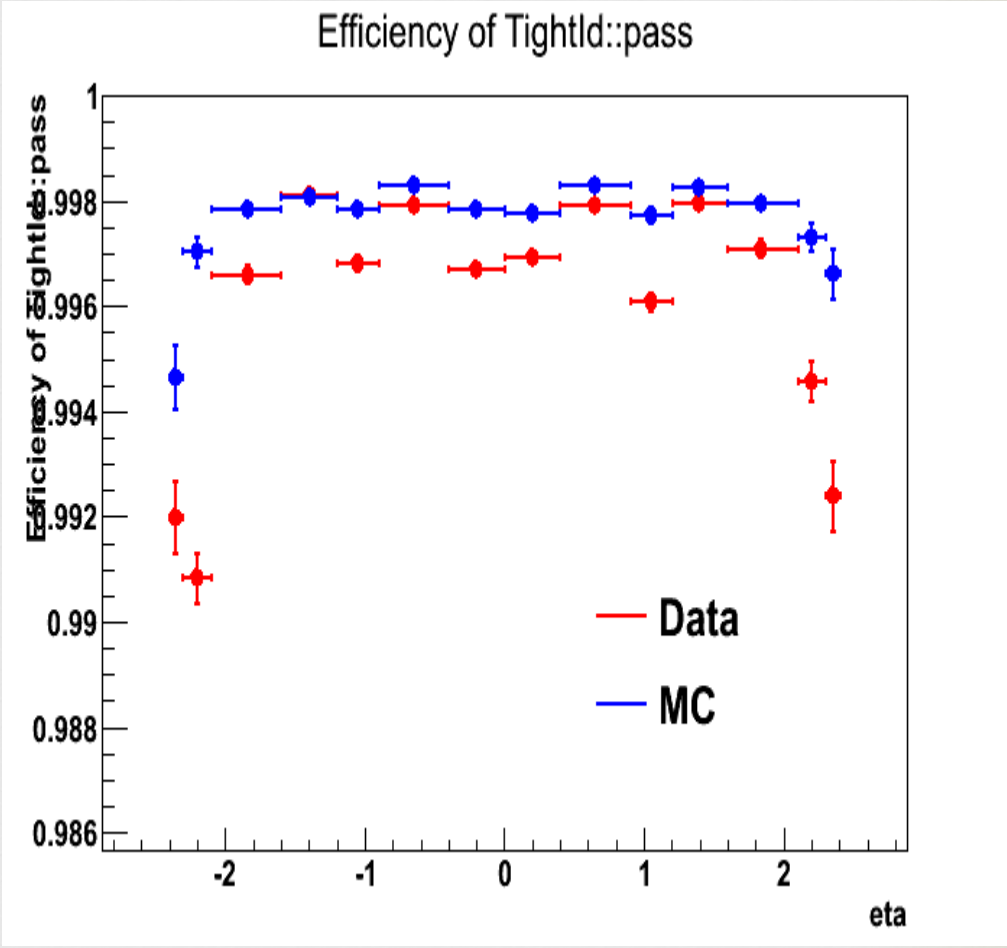
- The tag and probe muons must be oppositely charged to avoid a double choice of tags (TT pair).
- Mass of tp pair is $60 < m(\mu\mu) < 120$ GeV.
- δz between tag and probe muon $|\delta z| < 1$.

Example of di-muon invariant mass distributions obtained in the tag-and-probe measurements of the muon reconstruction/identification efficiency



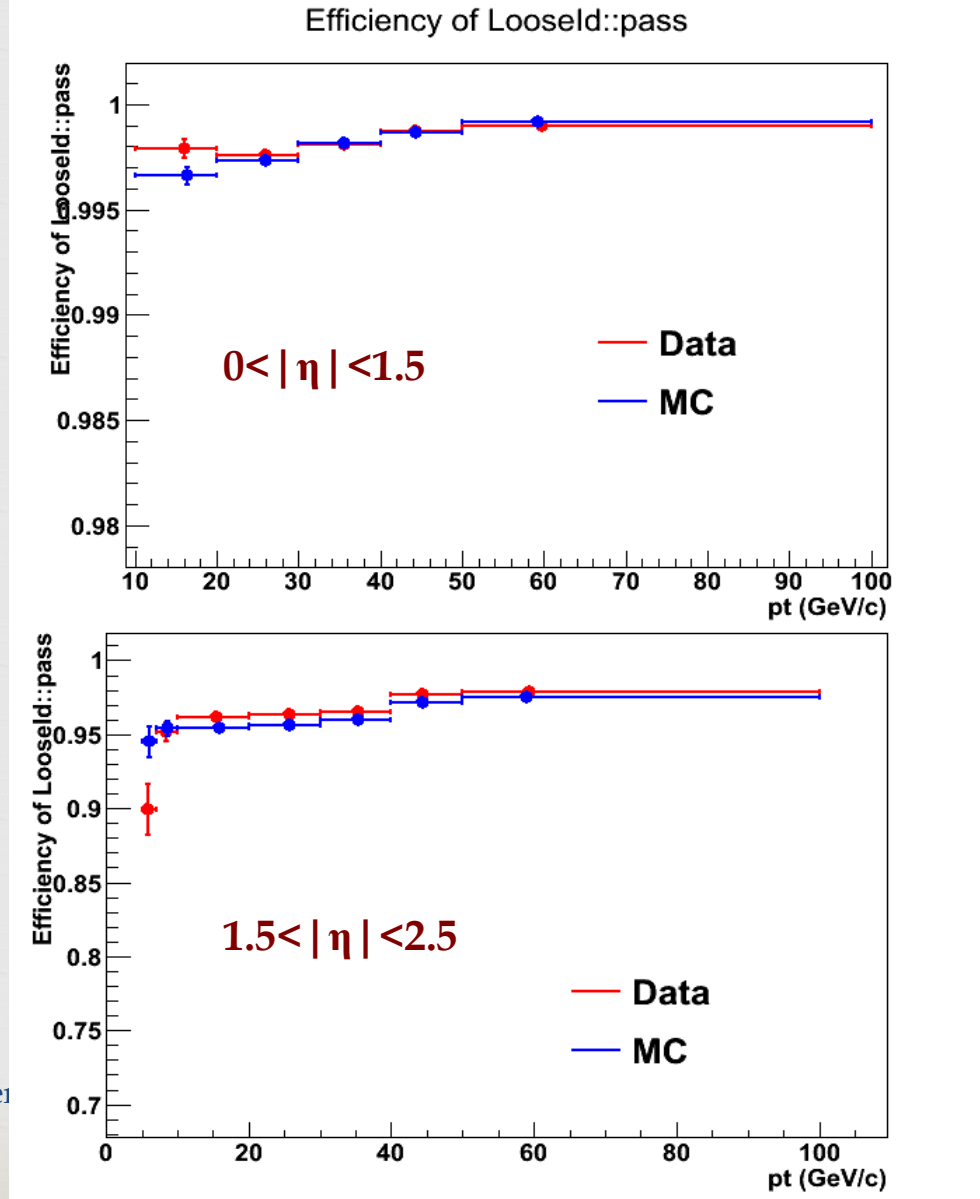
Muon Identification efficiency





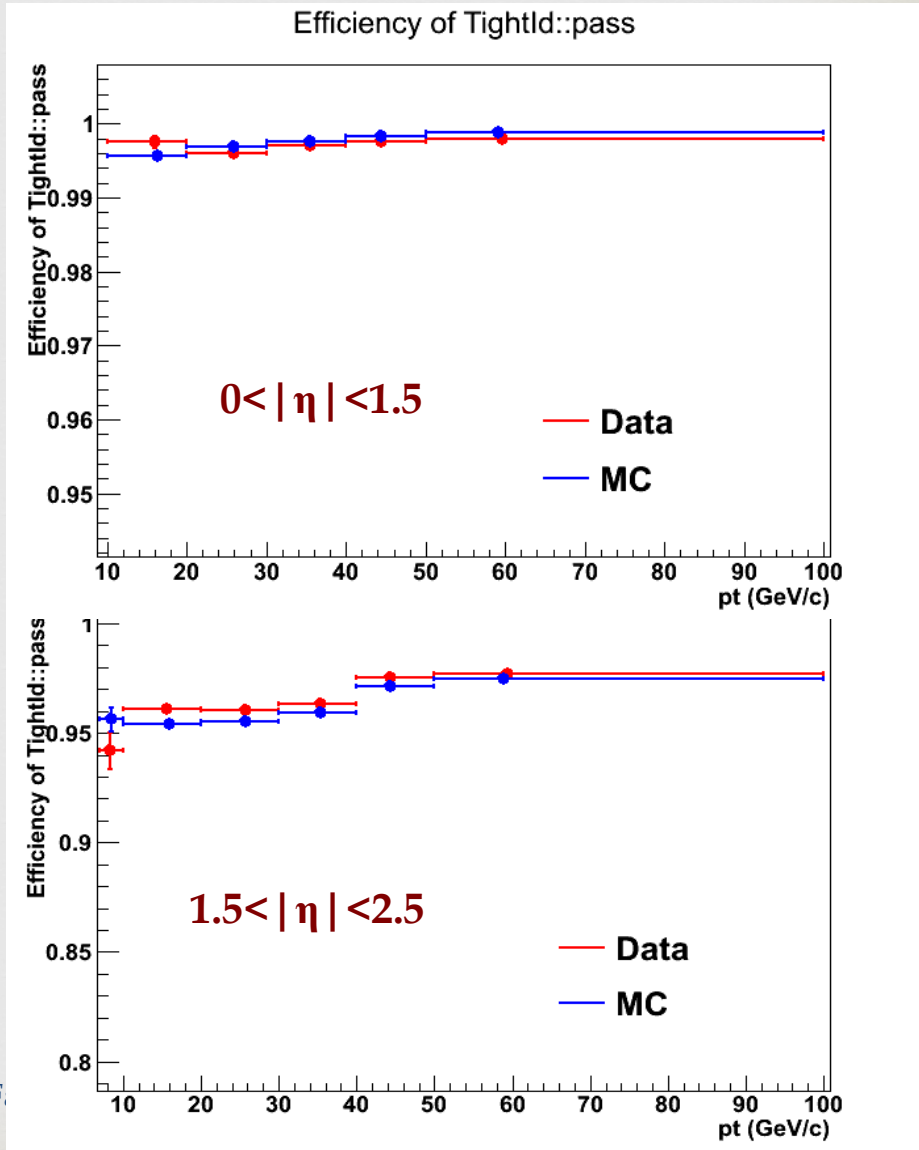
Muon efficiency for Loose ID

PT	loose	0<|η|<1.5	1.5<|η|<2.5
7- 10	Data	0.998±0.005	0.951±0.006
	MC	0.999±0.002	0.954±0.005
	Scale Factor	0.999±0.0054	0.997±0.0082
10 – 20	Data	0.9979±0.0004	0.962±0.001
	MC	0.9966±0.0004	0.954±0.002
	Scale Factor	1.0013±0.00057	1.008±0.0024
20 – 30	Data	0.9976 ±0.0001	0.9631 ±0.0006
	MC	0.9973±0.0002	0.9565±0.0008
	Scale Factor	1.0003±0.00022	1.007±0.0011
30 – 40	Data	0.99809±0.00006	0.9652±0.0004
	MC	0.99814±0.00007	0.9600±0.0005
	Scale Factor	0.99995±0.000092	1.0054±0.00067
40 - 50	Data	0.99870±0.00004	0.9769±0.0003
	MC	0.99866±0.00005	0.9714±0.0004
	Scale Factor	1.00004±0.000064	1.0057±0.00052
50 -100	Data	0.99895±0.00007	0.9790±0.0006
	MC	0.99914±0.00008	0.9748±0.0007
	Scale Factor	0.9998±0.00011	1.0043±0.00095
100 -1000	Data	0.9998±0.0002	0.989±0.003
	MC	0.9997±0.0002	0.977±0.004
	Scale Factor	1.0001 ±0.00028	1.012±0.0052

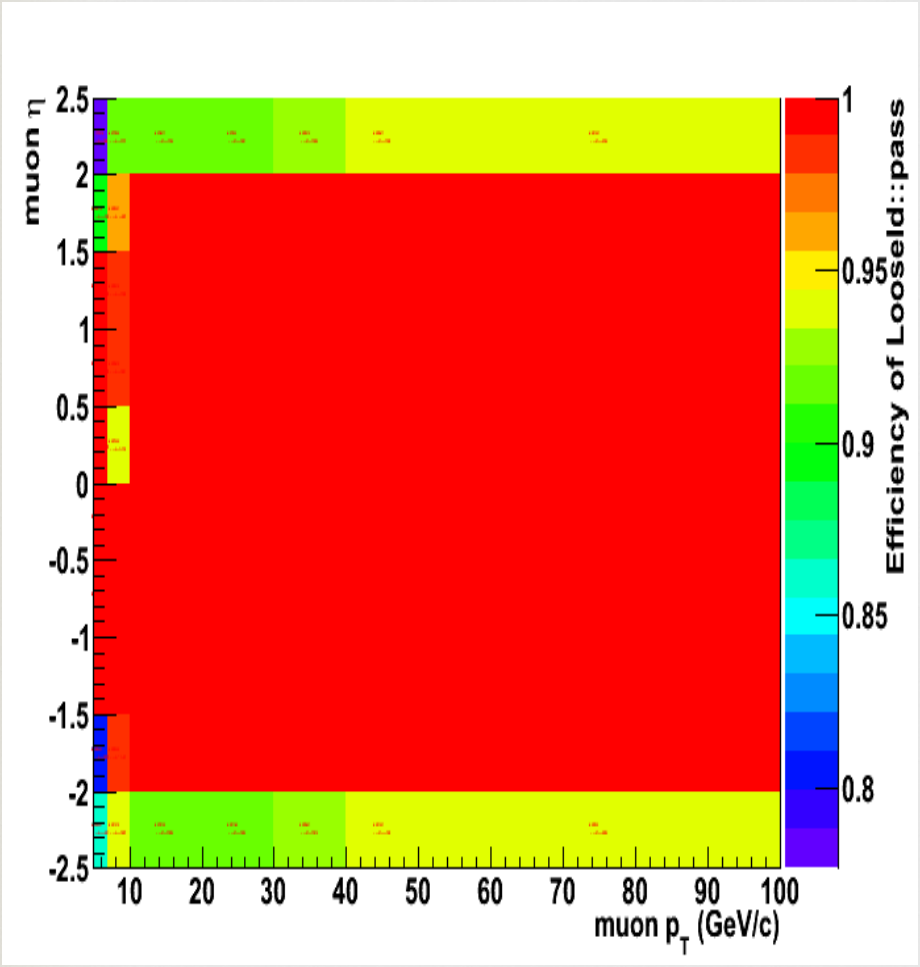


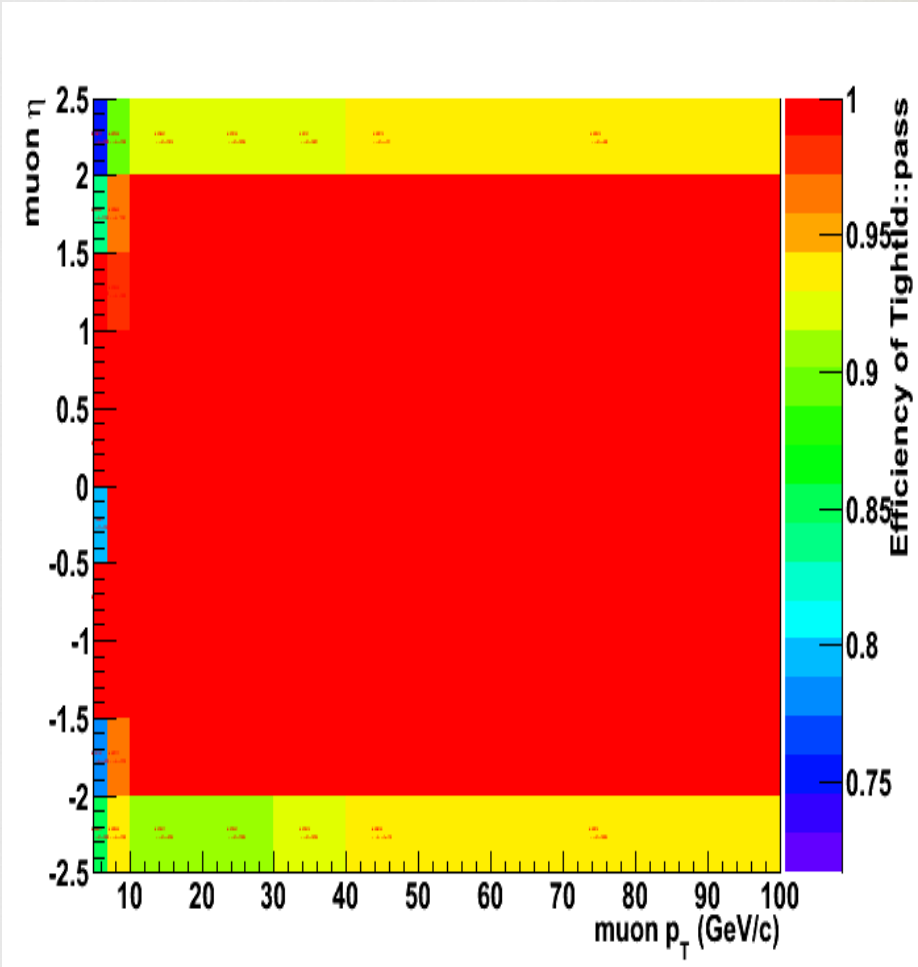
Muon efficiency for tight ID

PT	Tight	0<|η|<1.5	1.5<|η|<2.5
7- 10	Data	1.000±0.003	0.942±0.008
	MC	1.0±0.1	0.956±0.006
	Scale Factor	1.0±0.10	0.99±0.010
10 – 20	Data	0.9975 ±0.0008	0.961 ±0.002
	MC	0.9957±0.0005	0.954±0.002
	Scale Factor	1.0018±0.00095	1.007±0.0030
20 – 30	Data	0.9960 ±0.0002	0.9606 ±0.0007
	MC	0.9969±0.0002	0.9553±0.0008
	Scale Factor	0.9991±0.00028	1.006±0.0011
30 – 40	Data	0.99698 ±0.00008	0.9630 ±0.0004
	MC	0.99763±0.00008	0.9592±0.0005
	Scale Factor	0.9993±0.00011	1.0040±0.00067
40 - 50	Data	0.99759 ±0.00006	0.9752 ±0.0003
	MC	0.99826±0.00006	0.9710±0.0004
	Scale Factor	0.99933±0.000085	1.0043±0.00052
50 -100	Data	0.9979±0.0001	0.9773 ±0.0006
	MC	0.99879±0.00009	0.9745±0.0007
	Scale Factor	0.9991±0.00013	1.0029±0.00095
100 -1000	Data	0.9983±0.0006	0.989±0.003
	MC	0.9992±0.0004	0.977±0.004
	Scale Factor	0.9991±0.00072	1.012±0.0052



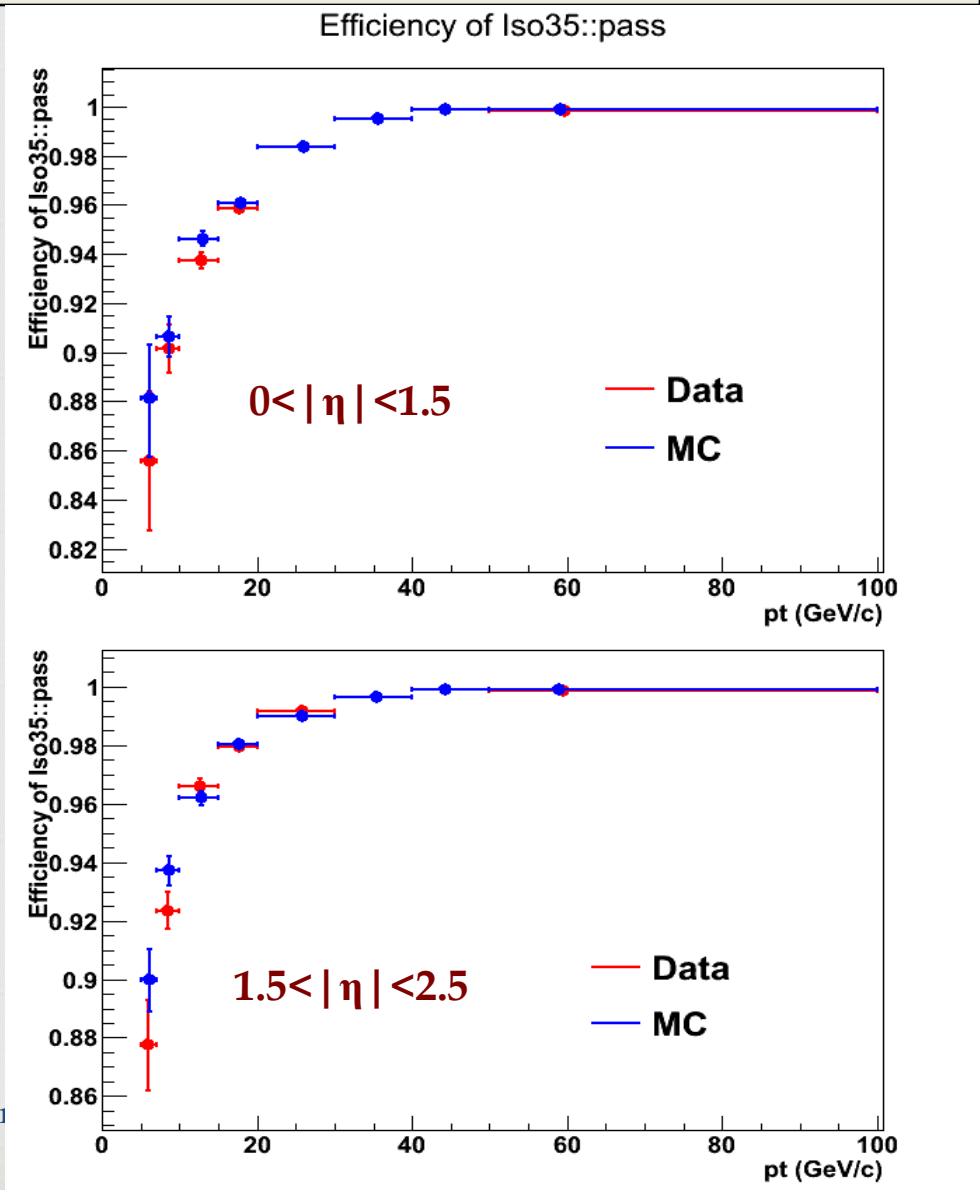
Muon efficiency for loose & tight ID



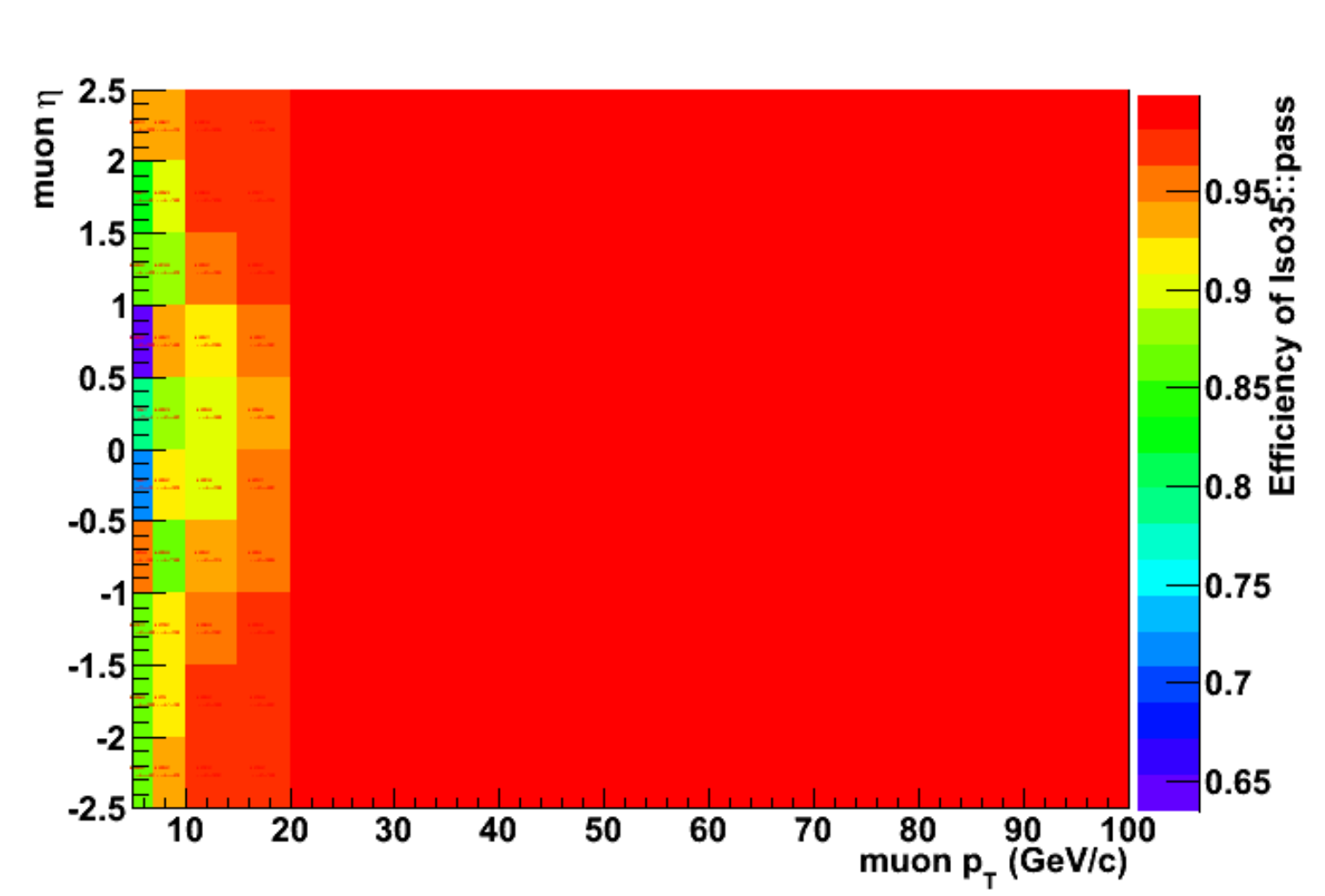


Efficiency of tight ID muons passing isolation.

ISO		0<|η|<1.5	1.5<|η|<2.5
5-7	Data	0.86 ±0.03	0.88 ±0.02
	MC	0.88±0.02	0.90±0.01
	Scale Factor	0.98±0.041	0.98±0.025
7-10	Data	0.901 ±0.010	0.923 ±0.006
	MC	0.906±0.008	0.937±0.005
	Scale Factor	0.99±0.014	0.985±0.0083
10 - 15	Data	0.937 ±0.003	0.966 ±0.002
	MC	0.946±0.003	0.962±0.002
	Scale Factor	0.990±0.0045	1.004±0.002
15 – 20	Data	0.959 ±0.001	0.979 ±0.001
	MC	0.961±0.002	0.980±0.001
	Scale Factor	0.998±0.0023	0.999±0.0014
20 – 30	Data	0.9838 ±0.0004	0.9917 ±0.0004
	MC	0.9835±0.0004	0.9900±0.0004
	Scale Factor	1.0003±0.00058	1.0017±0.00057
30 – 40	Data	0.9952 ±0.0001	0.9966 ±0.0002
	MC	0.9950±0.0001	0.9967±0.0002
	Scale Factor	1.0002± 0.00014	0.9999±0.00028
40 - 50	Data	0.99866 ±0.00005	0.998941 ±0.000007
	MC	0.998771±0.000009	0.99892±0.00009
	Scale Factor	0.99989±0.000051	1.00002±0.000090
50 -100	Data	0.99849 ± 0.00010	0.9988 ±0.0001
	MC	0.9986±0.0001	0.9989±0.0002
	Scale Factor	0.9999±0.00014	0.9999±0.00022
100 -1000	Data	0.9982 ±0.0005	0.997 ±0.001
	MC	0.9962±0.0008	0.998±0.001
	Scale Factor	1.0020±0.00095	0.999±0.0014

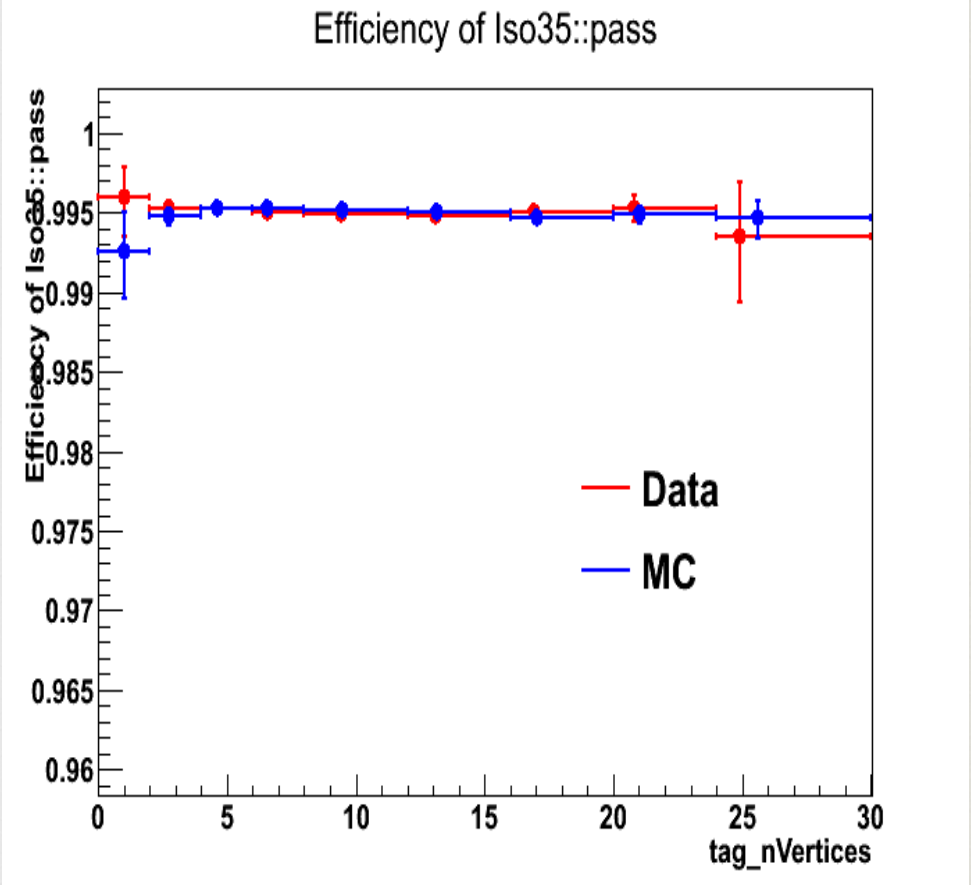


Efficiency of tight ID muons passing isolation.



Efficiency of tight ID muons passing isolation.

#vtx		Iso tight
0 - 2	Data	0.996±0.002
	MC	0.993±0.003
	Scale Factor	1.003±0.0036
2 - 4	Data	0.9952±0.0005
	MC	0.9947±0.0006
	Scale Factor	1.0005±0.00079
4 - 6	Data	0.9952±0.0002
	MC	0.9952±0.0002
	Scale Factor	1.0000±0.00028
6 - 8	Data	0.9951±0.0001
	MC	0.9953±0.0002
	Scale Factor	0.9998 ±0.00022
8 - 12	Data	0.99496±0.00009
	MC	0.99511±0.00010
	Scale Factor	0.9998±0.00014
12 - 16	Data	0.9948±0.0001
	MC	0.9950±0.0001
	Scale Factor	0.9998±0.00014
16 - 20	Data	0.9950±0.0003
	MC	0.9947±0.0003
	Scale Factor	1.0003±0.00043
20 - 24	Data	0.9953±0.0008
	MC	0.9949±0.0006
	Scale Factor	1.000±0.0010
24 - 30	Data	0.994±0.004
	MC	0.995±0.001
	Scale Factor	0.999±0.0041



Conclusion

Using the Tag and Probe (T&P) method performed on Z →μμ events:

- **We measure the Muon efficiency for Muon Identification events in bins of pT and |η| for both Loose Muon ID & Tight Muon ID.**

- **We measure the Muon efficiency of Particle-flow relative isolation in a ΔR = 0.3 cone with delta Beta correction (PF Iso Tight< 0.35) in bins of pT and |η| and also in bins of #of vertices.**