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

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WP1---EENP2 Meeting

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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 Reconstruction and Identification

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 that are also PF muons.

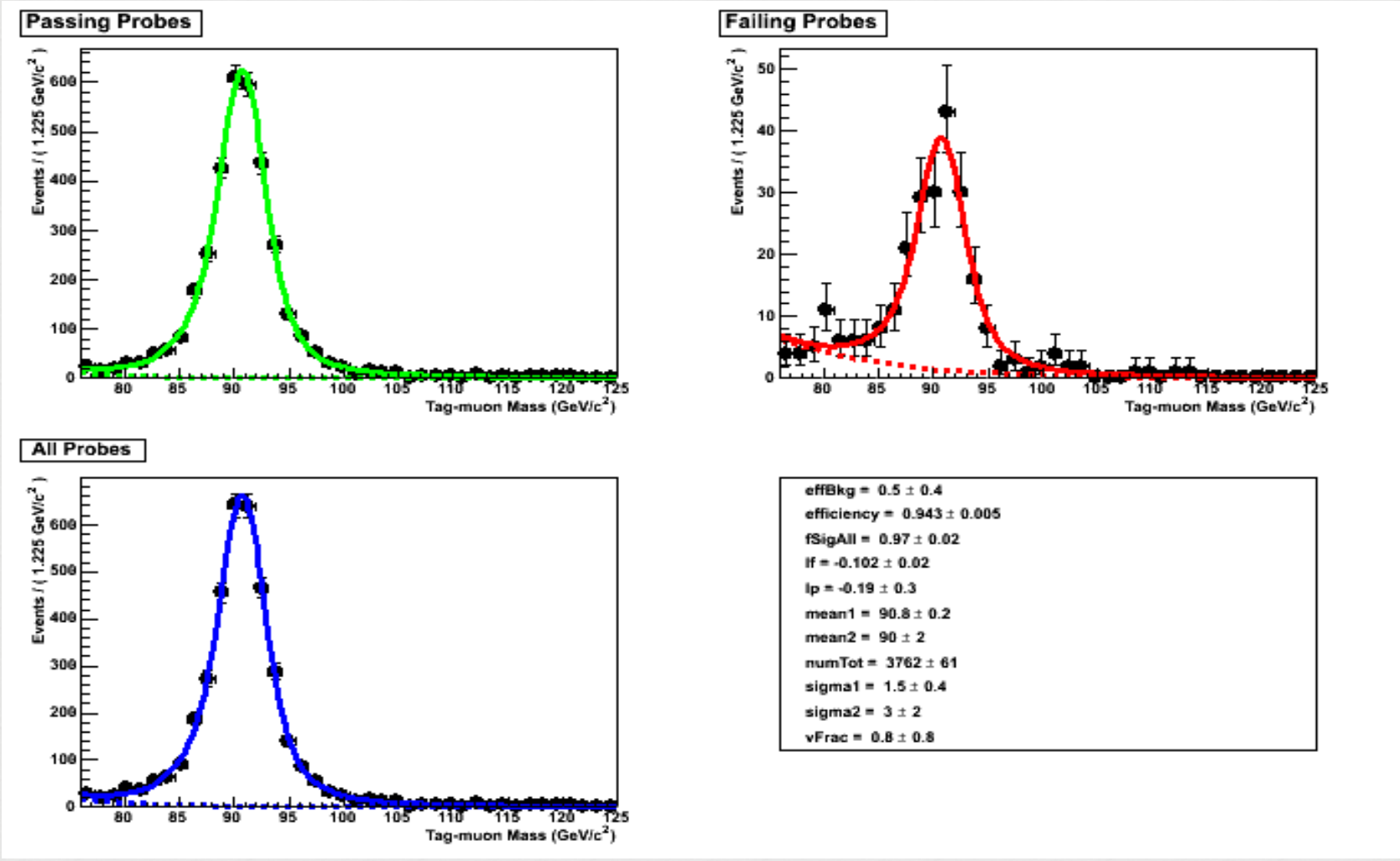
The Selection for Tag & Probe muon

- **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 & $|\eta| < 2.5$ & **track .isNonnull).**
- **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



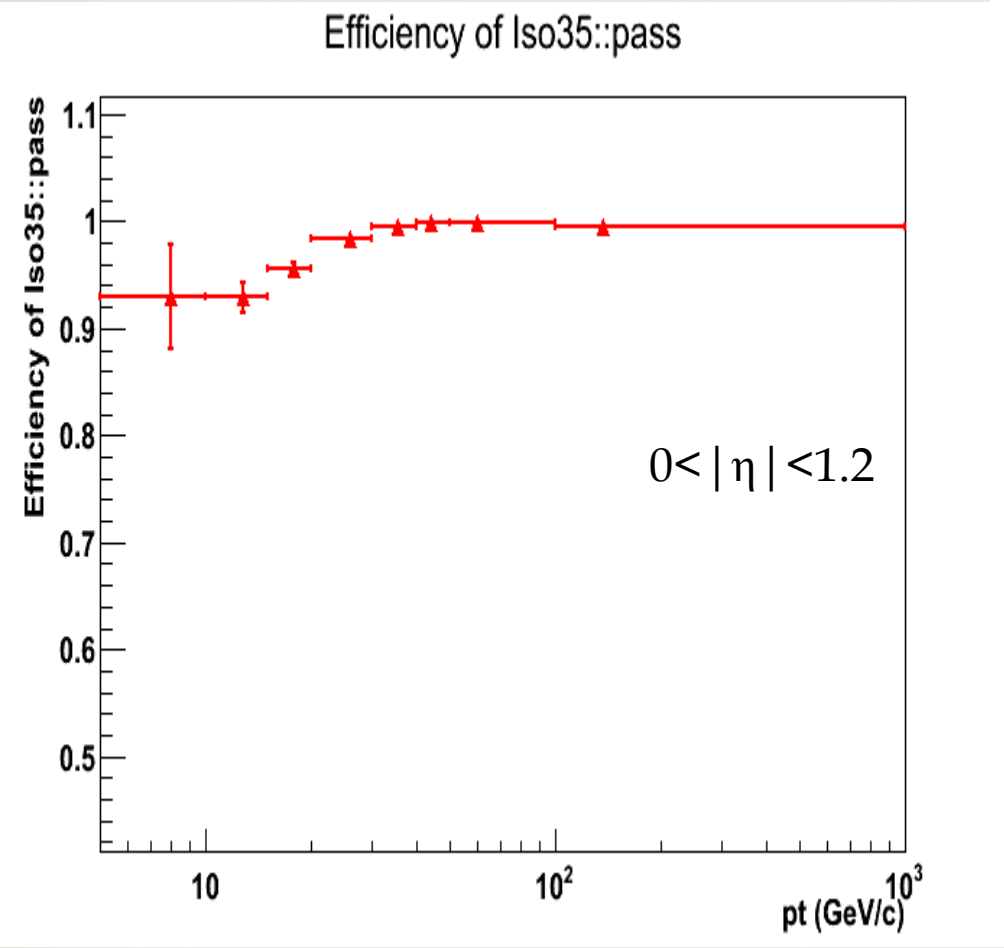
Efficiency of tight ID muons passing isolation.

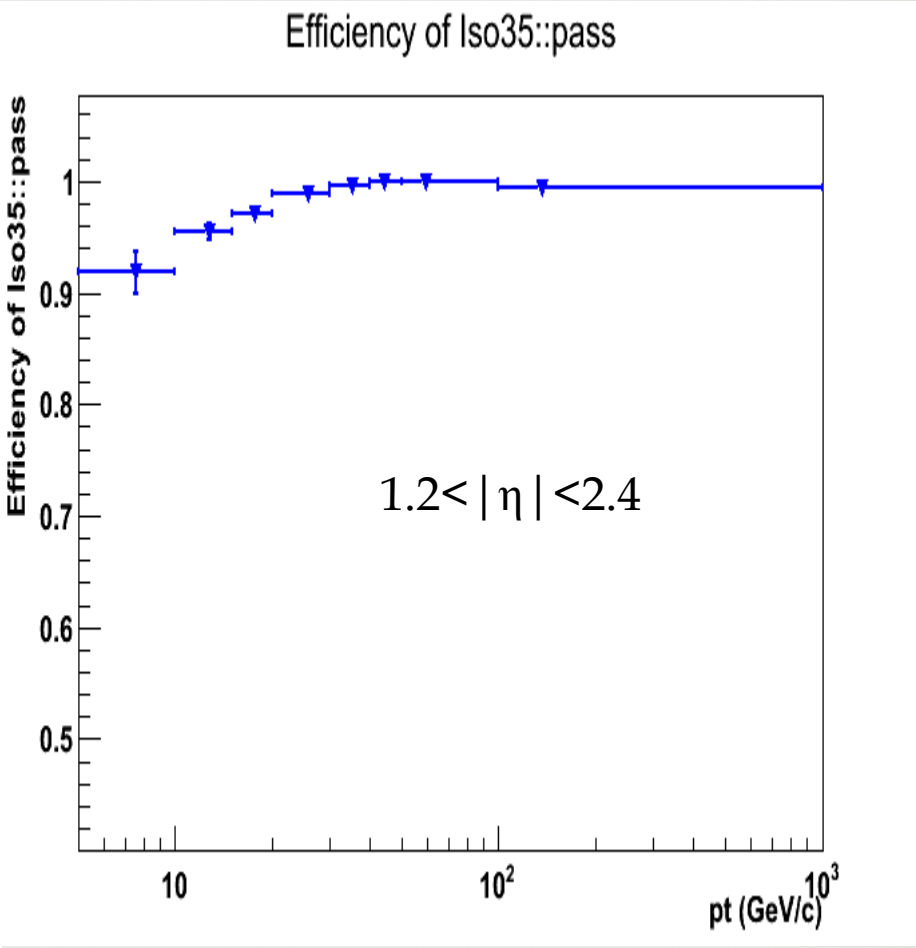
❑Particle-flow relative isolation in a $\Delta R = 0.3$ cone with delta Beta correction (PF Iso Tight< 0.35).

PT		0<|η|<1.2	1.2<|η|<2.4
5-10	Data	0.93± 0.05	0.92 ±0.02
	MC	0.95 ± 0.04	0.92 ±0.02
	Scale Factor	0.980 ± 0.067	1.000 ± 0.031
10 - 15	Data	0.93±0.01	0.955±0.008
	MC	0.92 ± 0.01	0.953 ±0.009
	Scale Factor	1.010 ± 0.015	1.000 ± 0.013
10 – 20	Data	0.956±0.006	0.971±0.004
	MC	0.961 ±0.006	0.974 ±0.005
	Scale Factor	0.995 ± 0.0088	0.997 ±0.0066
20 – 30	Data	0.983±0.001	0.990±0.001
	MC	0.983± 0.002	0.990±0.001
	Scale Factor	1.000 ±0.0023	1.000 ±0.0014

PT		0<|η|<1.2	1.2<|η|<2.4
30 – 40	Data	0.9948±0.0004	0.9961±0.0005
	MC	0.9950±0.0005	0.9946±0.0007
	Scale Factor	0.9998 ± 0.00064	1.0015 ±0.00087
40 - 50	Data	0.9987±0.0002	0.9989±0.0002
	MC	0.9991±0.0002	0.9989±0.0003
	Scale Factor	0.9996 ±0.00028	1.0000 ±0.00036
50 -100	Data	0.9986±0.0003	0.9991±0.0004
	MC	0.9981±0.0005	0.9984±0.0006
	Scale Factor	1.0005 ±0.00058	1.0007 ±0.00072
100 -1000	Data	0.995±0.003	0.995±0.004
	MC	0.998±0.002	0.995±0.005
	Scale Factor	0.997 ±0.0036	1.000 ±0.0064

Isolation efficiencies



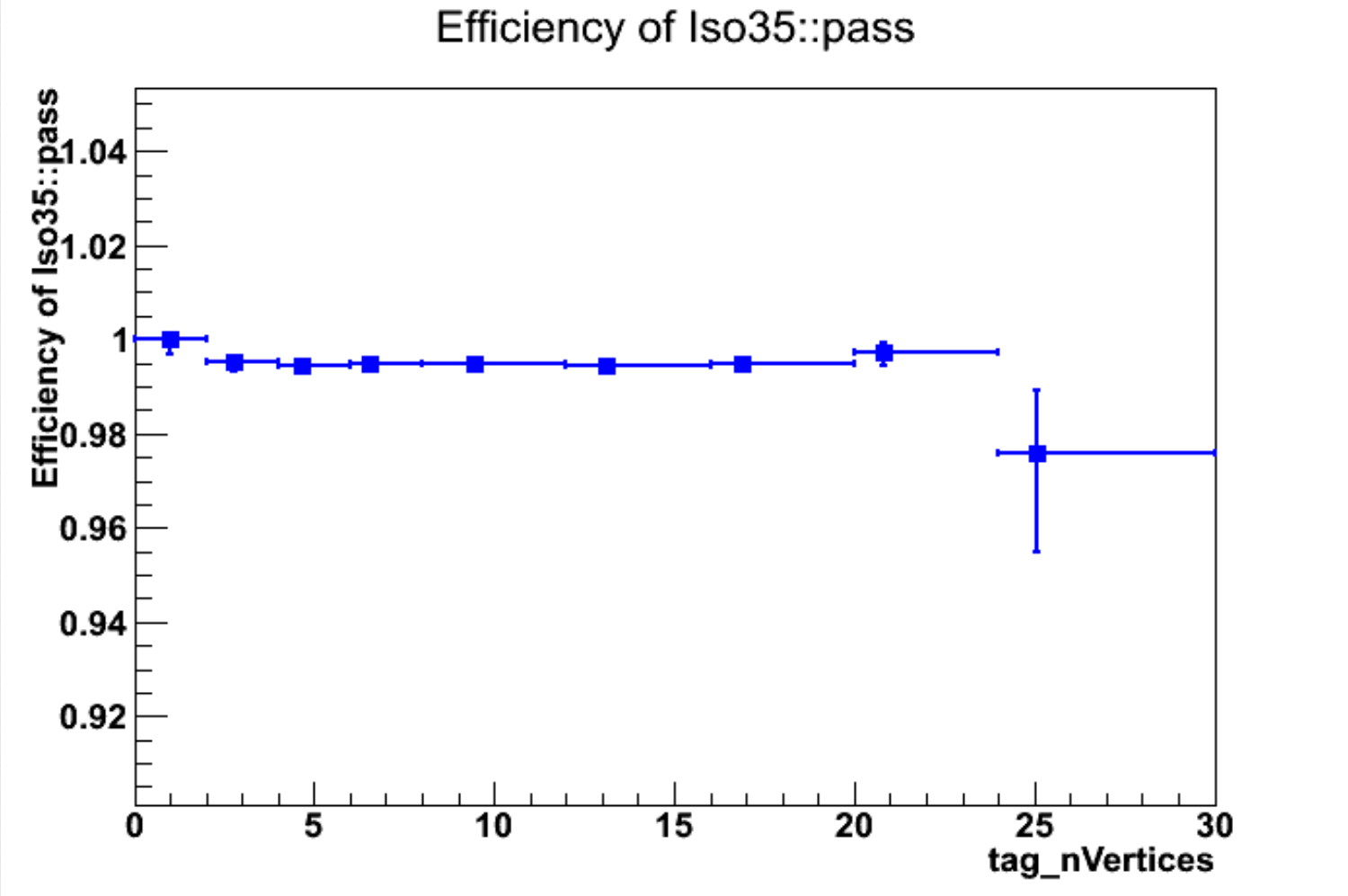


Isolation efficiencies

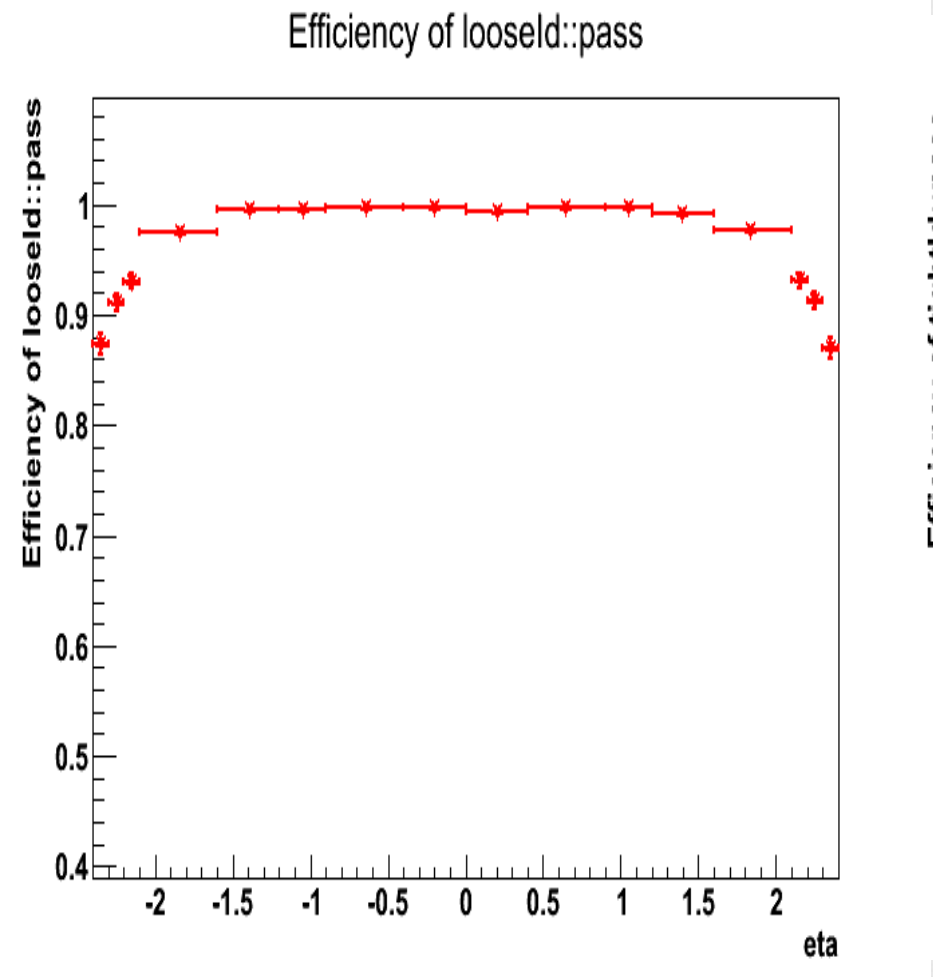
❑Particle-flow relative isolation in a $\Delta R = 0.3$ cone with delta Beta correction (PF Iso Tight< 0.35).

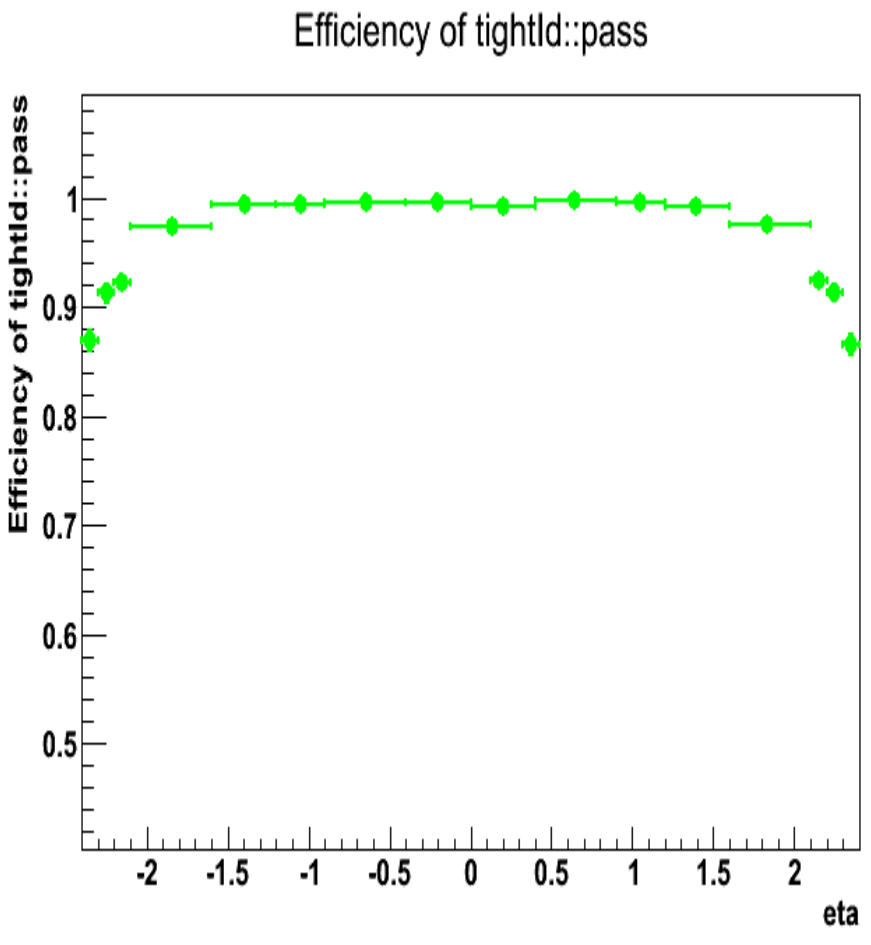
#vtx		Iso tight (PF in ΔR = 0.3) < 0.35
0 - 2	Data	1.000±0.003
	MC	1.000±0.006
	Scale Factor	1.000 ± 0.0067
2 - 4	Data	0.995±0.002
	MC	0.993±0.002
	Scale Factor	1.002 ±0.0029
4 - 6	Data	0.9943±0.0008
	MC	0.9945±0.0010
	Scale Factor	1.000 ±0.0013
6 - 8	Data	0.9950±0.0005
	MC	0.9958±0.0006
	Scale Factor	0.9992 ±0.00078
8 - 12	Data	0.9949±0.0003
	MC	0.9945±0.0004
	Scale Factor	1.0004±0.00050
12 - 16	Data	0.9944±0.0005
	MC	0.9945±0.0005
	Scale Factor	0.9999±0.00071
16 - 20	Data	0.995±0.001
	MC	0.9965±0.0008
	Scale Factor	0.998 ±0.0013
20 - 24	Data	0.997±0.002
	MC	0.992±0.003
	Scale Factor	1.005 ±0.003
24 - 30	Data	0.98±0.02
	MC	0.998±0.003
	Scale Factor	0.98 ±0.020

Isolation efficiencies

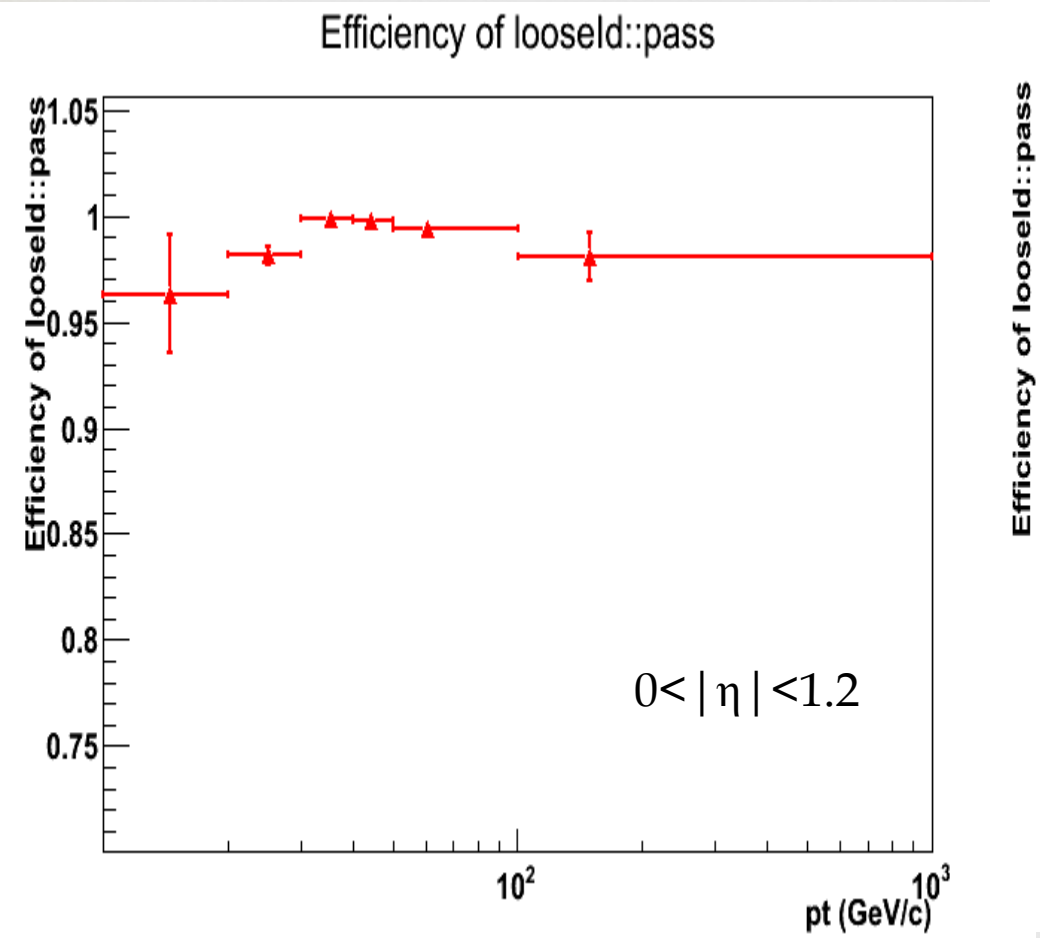


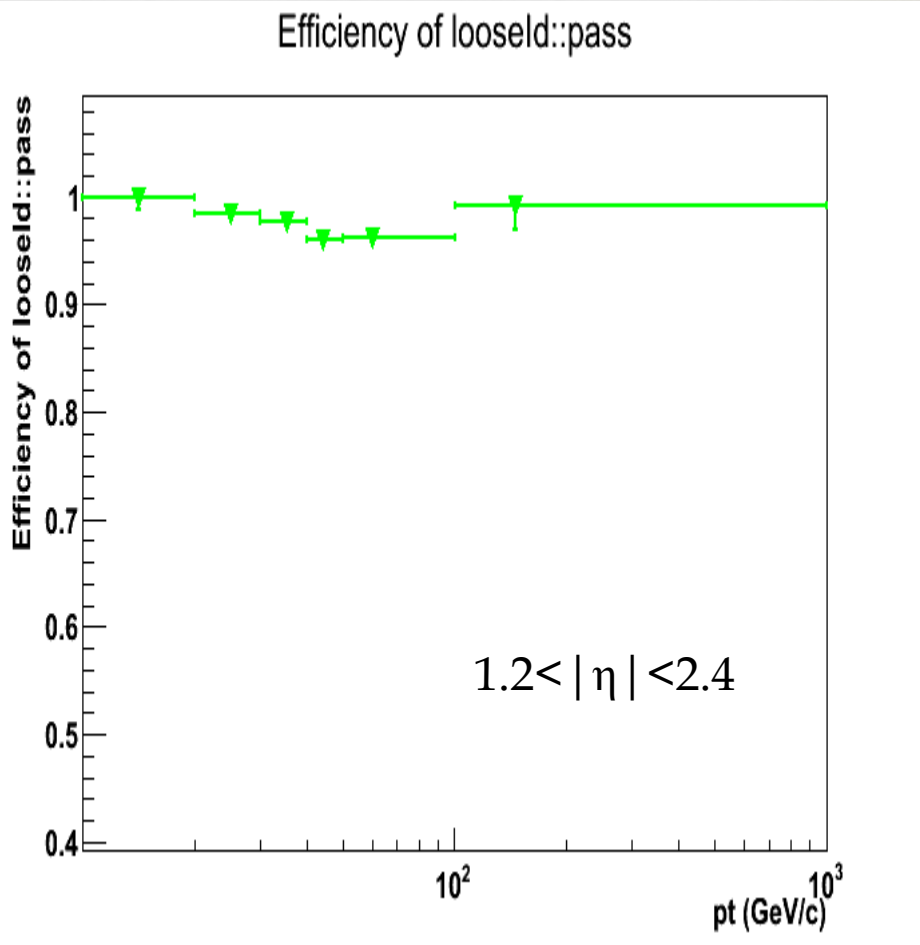
Muon Identification efficiency

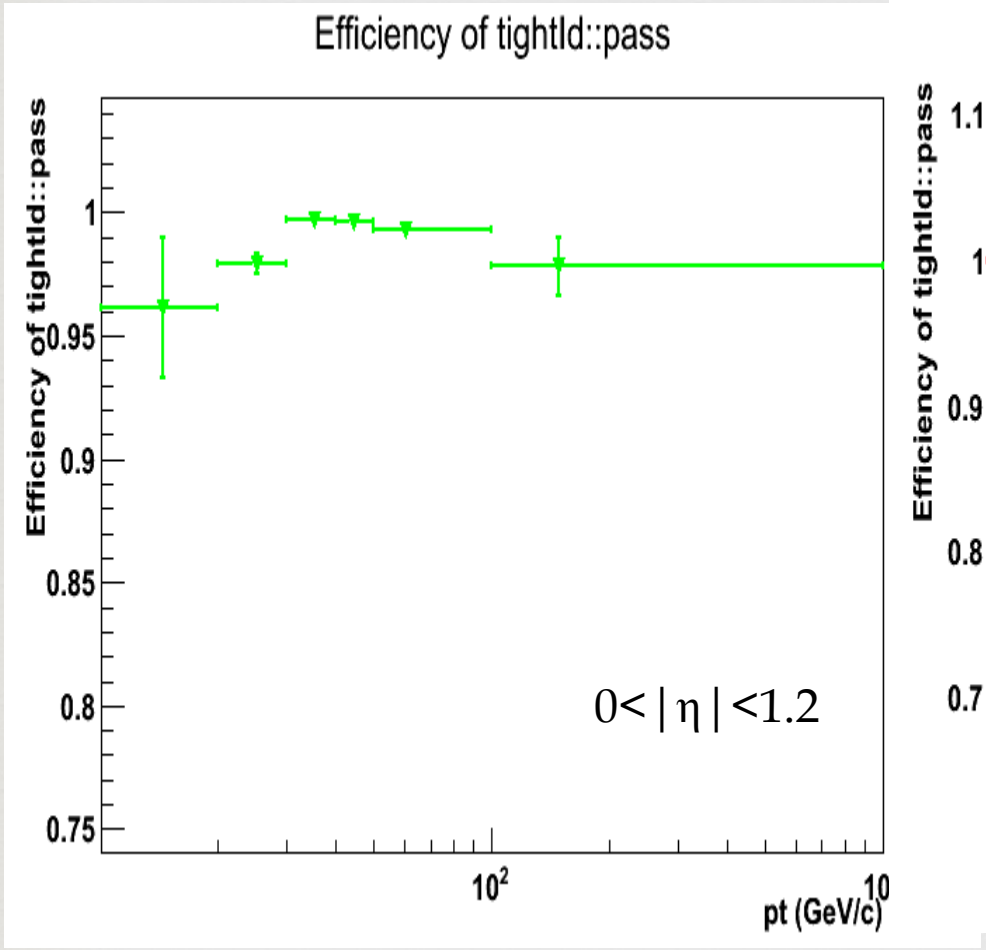


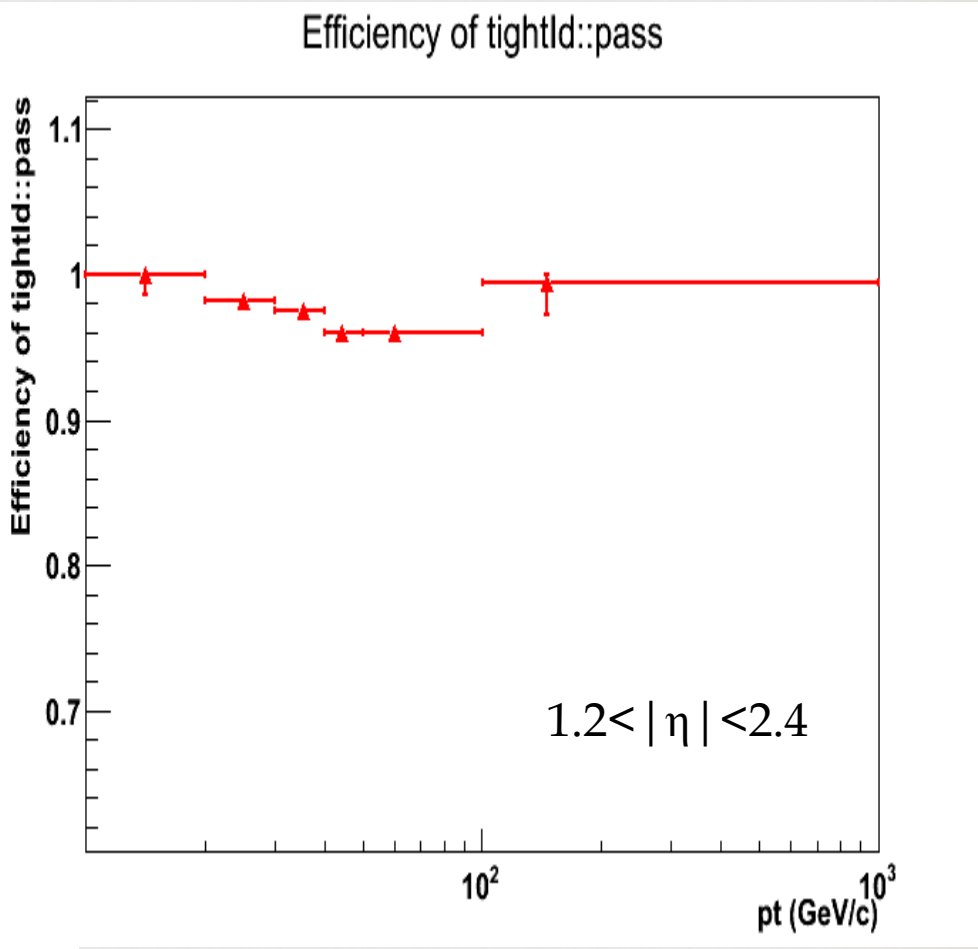


Muon Identification efficiency






Efficiency of tightId::pass
Efficiency of tightId::pass
1
0.95
0.9
0.85
0.8
0.75
10^2
10
pt (GeV/c)
0< | η | <1.2


Efficiency of tightId::pass
Efficiency of tightId::pass
1.1
1
0.9
0.8
0.7
10^2
10^3
pt (GeV/c)
1.2< | η | <2.4

Conclusion

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

- **We measure the Muon efficiency for tight ID 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.**