# Trigger efficiency measurement using Z➜μ⁺μ⁻

C. Bini, S. Borroni, S. Rosati
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# Outline

- Efficiency measurement with a Tag&Probe method
- Analysis with samples v13
- Analysis of FDR2 data
- Signal v13 vs v14
- Plans

# Tag and Probe Method (1)

- **Tag**:
  - MuCombined ($p_t$ > 5 GeV, |eta| < 2.5)
  - Impact Parameter $|d_0|$ < 0.1 mm
  - ID and Calo Isolation (cone width=0.3; E<4.5 GeV)
  - Trigger EF (*EF_mu20*)

  **If Ntag>1 analyze each tag independently;**
- **Probe**:
  - Loop on all ID tracks [($p_t$ > 5 GeV, |eta| < 2.4) *and* Dphi (w.r.t. tag) = $\pi \pm 1$ rad *and* $\Delta z_0$ (w.r.t. tag) < 0.5 mm]
  - Impact Parameter $|d_0|$ < 0.1 mm
  - ID and Calo Isolation (cone width=0.3; E<1.6 GeV)
  - M(tag-probe) = M(Z) $\pm$ 12 GeV

  **If Nprobe>1 choose the one with M(tag-probe)-M(Z) smaller.**

# Tag and Probe Method (2)

- Once you have a Probe -> look if trigger is ON: matching between ID track and trigger sector: DR < 0.3 [Lvl1], 0.05 [Lvl2], 0.02 [EF] (to be optimized)

- Efficiency plots as function of **$p_t$** , **eta**, **phi** with a binning dependent on the statistics available

- Comparison between Lvl1 – Lvl2 – EF efficiency and MC truth

- In FDR2 only Lvl1 is active (problems in AOD for Lvl2 and EF) and no comparison with MC truth is possible

# Results: Number of Probes

| Sample | Xsec [pb] | probe/pb$^{-1}$ (pt > 5 GeV) | probe/pb-1 (pt > 20 GeV) | Sample # |
|---|---|---|---|---|
| Zmumu | 1854 | 987 | 946.3 | 5145 |
| Wmunu | 14490 | 17 | 4.9 | 5105 |
| Ztautau | 104.15 | 0.2 | 0.2 | 5146 |
| Zbb | 0.68 | 0.2 | 0.1 | 5177 |
| ttbar | 5.83 | 0.02 | 0.01 | 5205 |
| bbmu15 | 270000 | 1.6 | – | 5701 |
| bbmu5mu15 | 1000 | 0.0 | 0.01 | 5714 |

Zmumu with pileup probe/pb$^{-1}$ = 797

Signal/Background  2.2% (pt>5GeV) e 0.7% (pt>20GeV)

NLO Xsec x filter efficiency (LO for bb samples)

# Results: Probe distributions
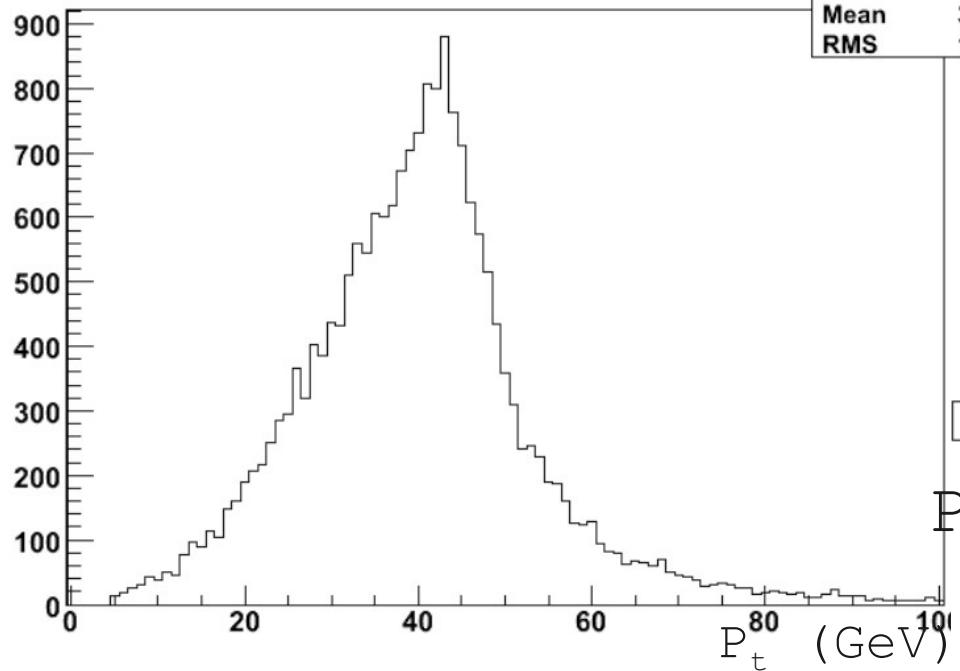


P$_t$ distribution of selected probes
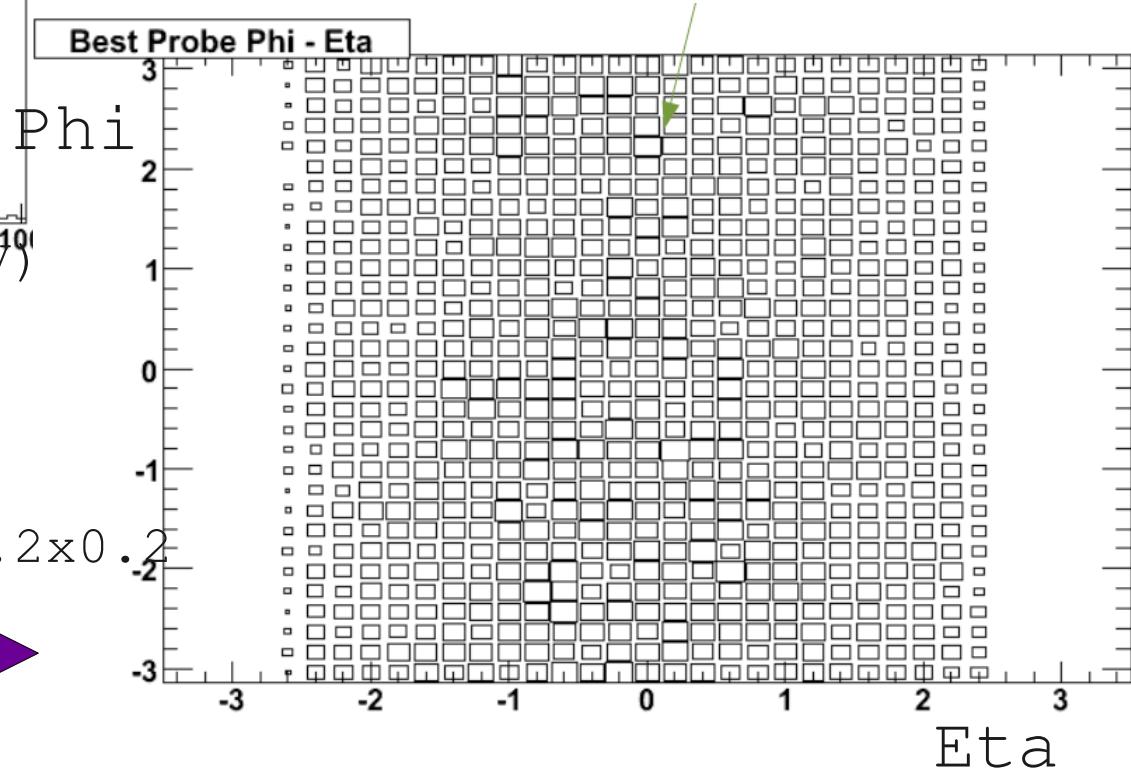
Pt, eta-phi distribution of the probes:
- quite uniform illumination;
- about 1 evt / pb$^{-1}$ in bins 0.2x0.2

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# Results: Background Wmunu

$P_t$ and eta-phi distributions of the
surviving W->mu nu fake probes
– low $P_t$ bkg
– uniform in the detector
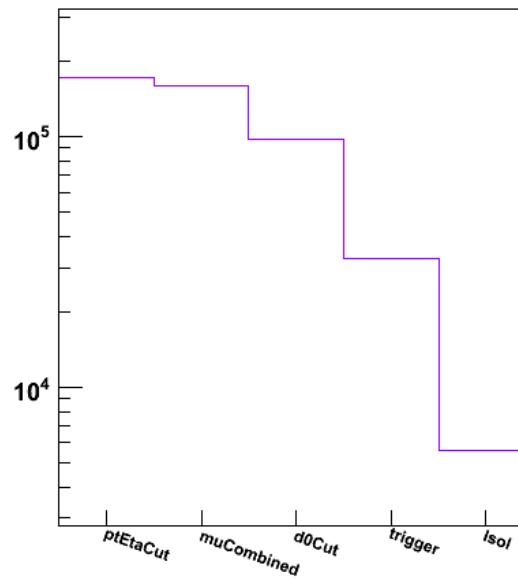


**Best Probe Pt**

**Best Probe Phi - Eta**

| bestProbePhiEta | |
|---|---|
| Entries | 60 |
| Mean x | 0.2413 |
| Mean y | 0.1537 |
| RMS x | 1.371 |
| RMS y | 1.909 |

Pt [GeV]

# Results: Background bbmu15X

# Results: Background bbmu5mu15X
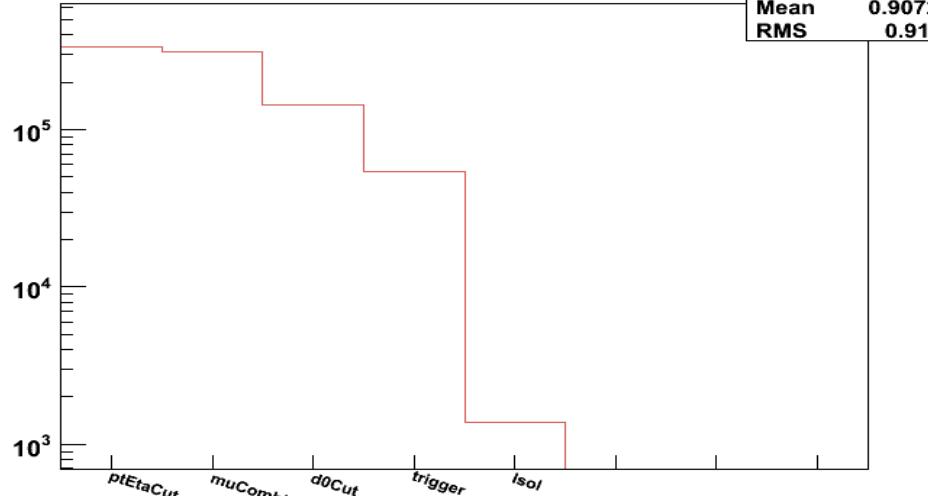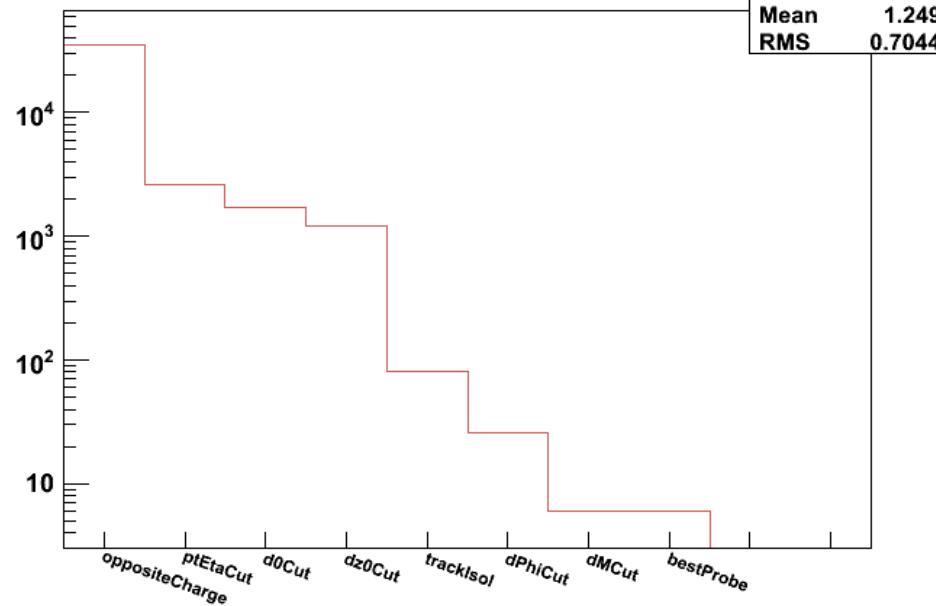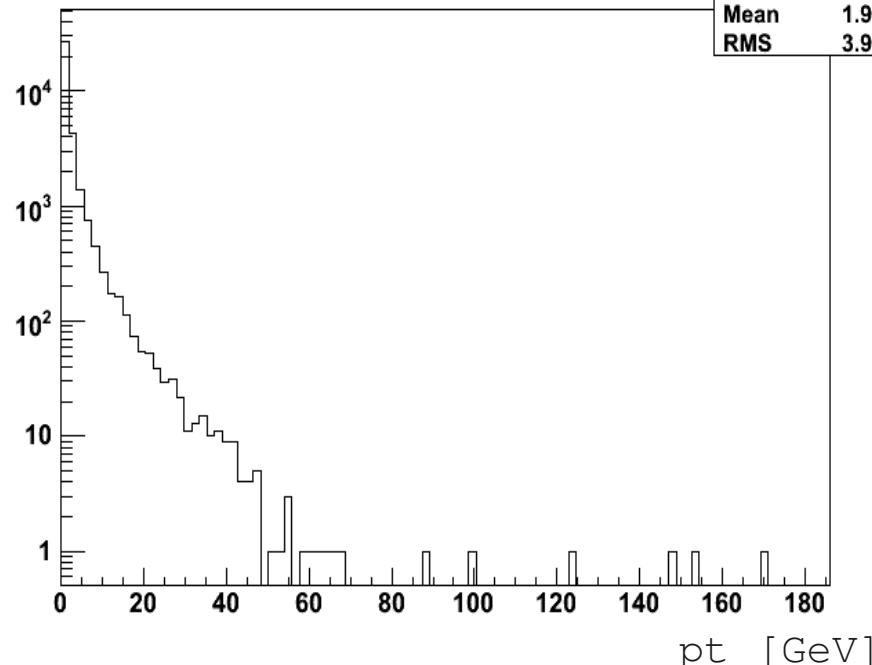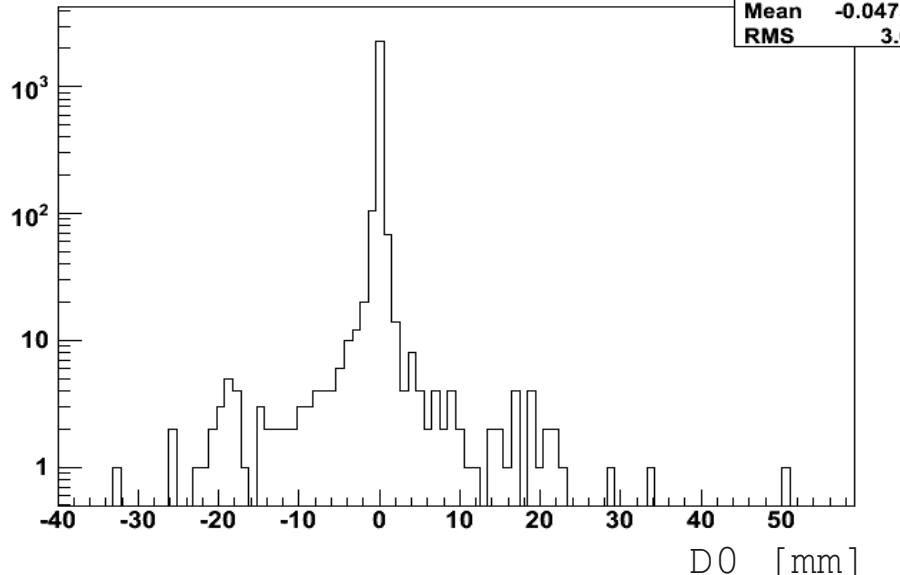
# Results: Trigger Efficiency Signal Only
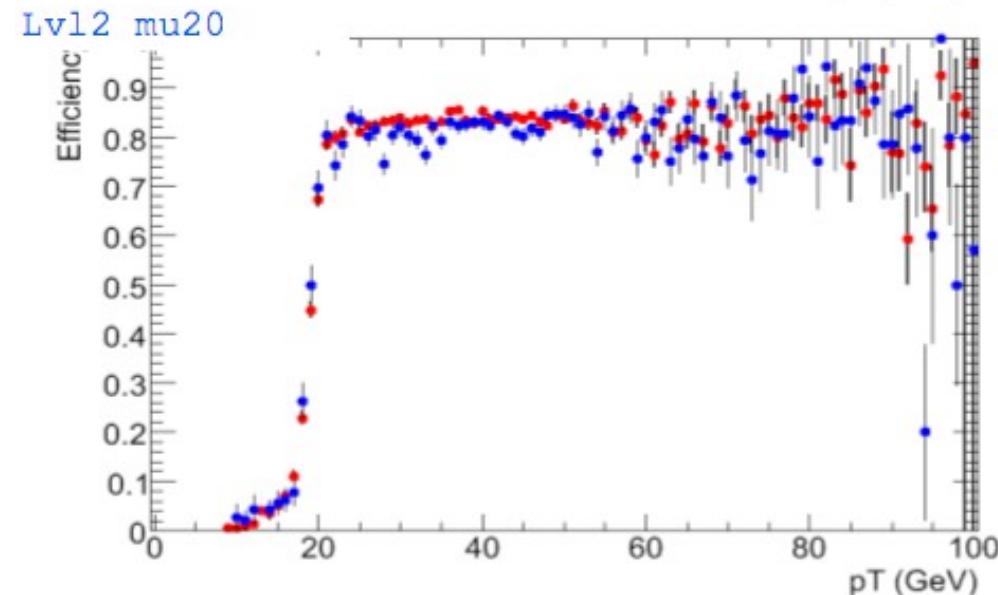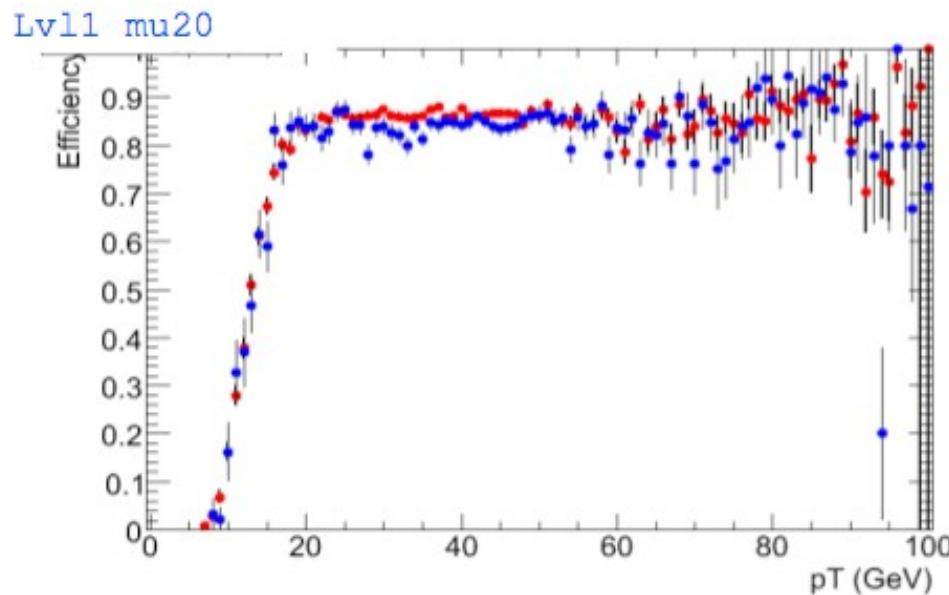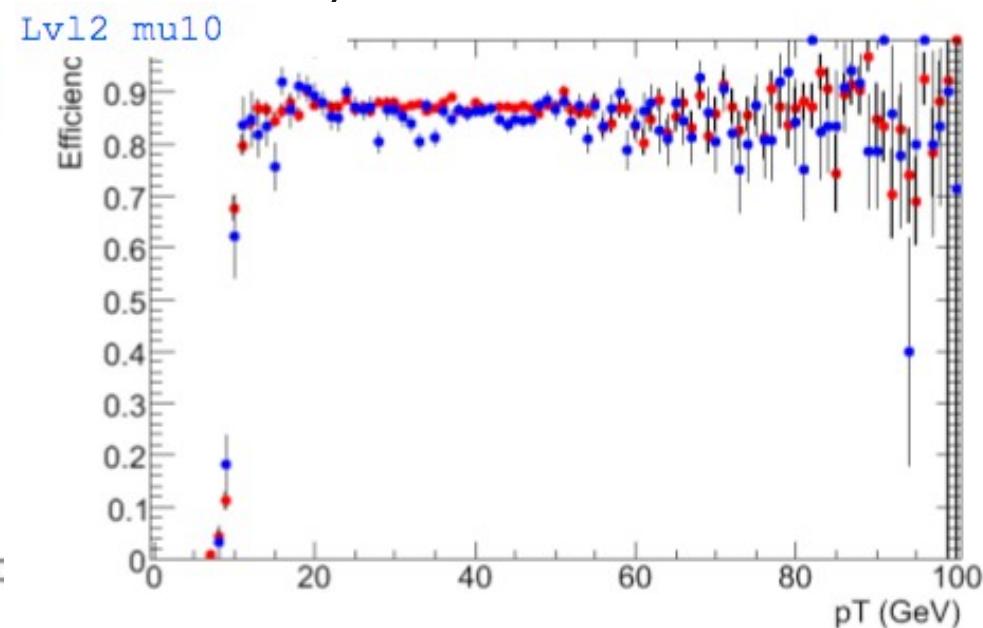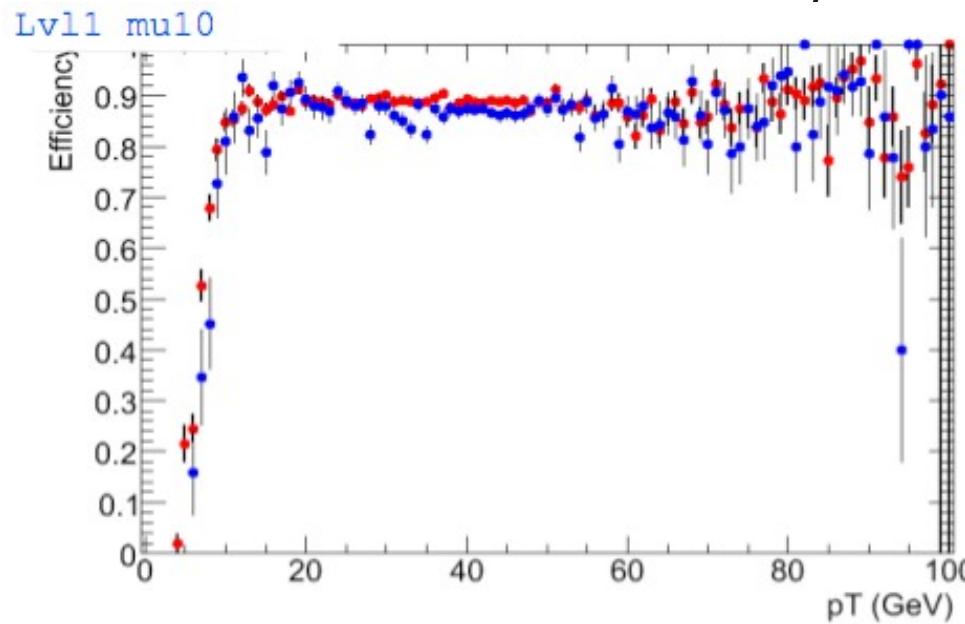


Blue = tag and probe analysis, Red = MC truth: about 40 pb⁻¹ equivalent

# Results: Trigger Efficiency Signal Only



Phi

eta
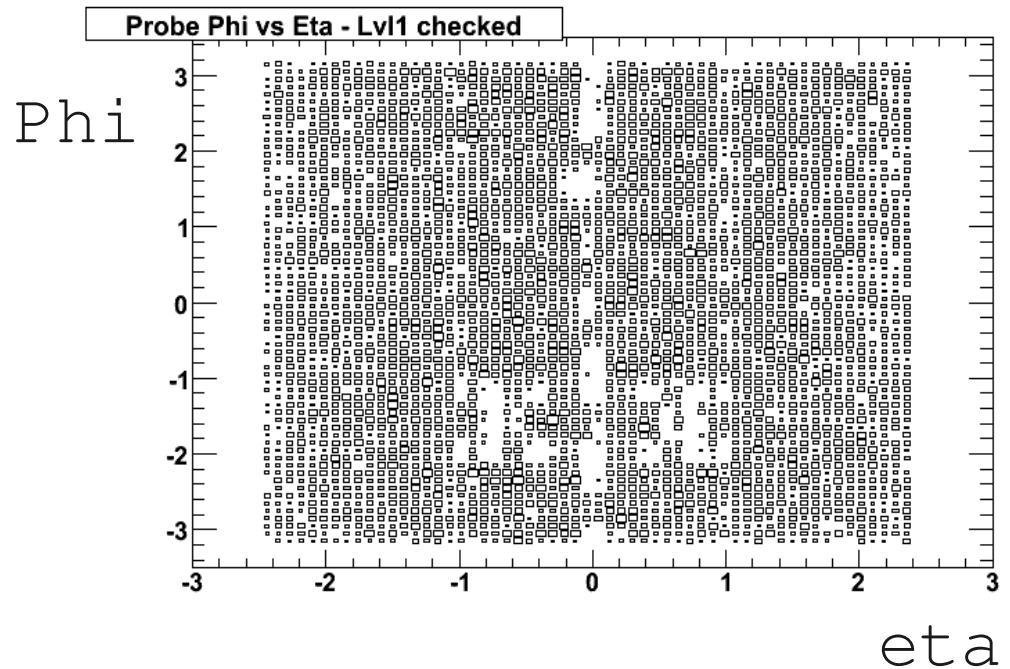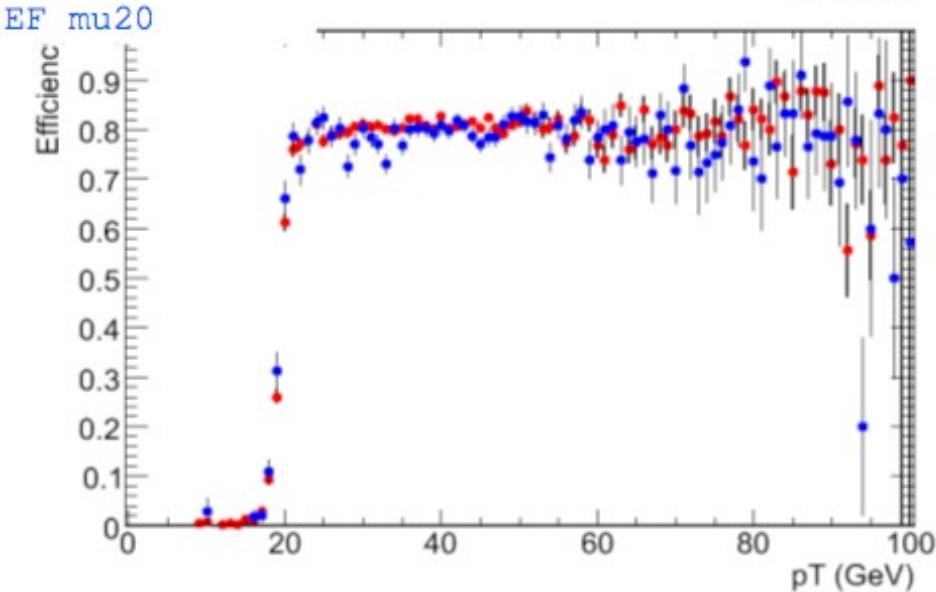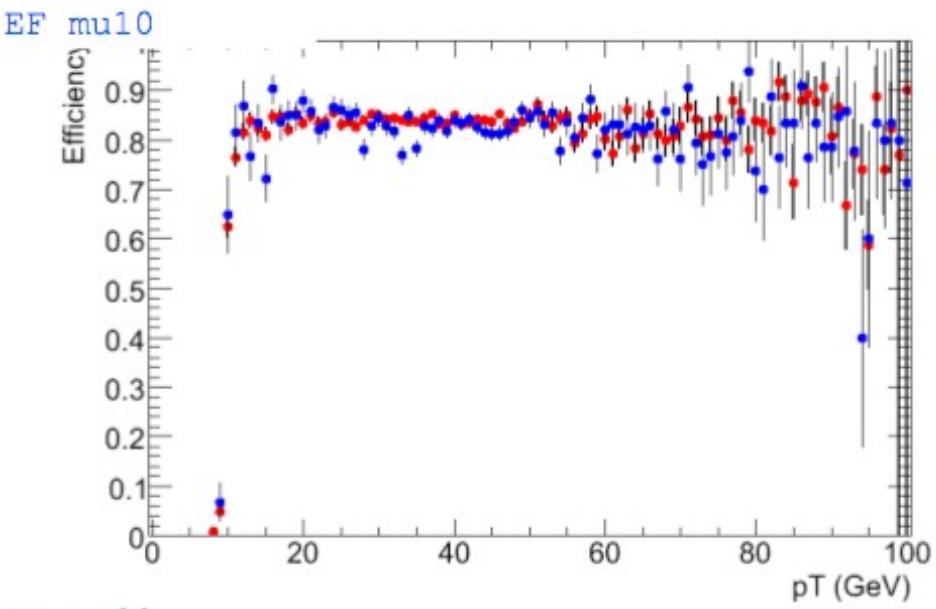
Phi – eta distribution of probes matching Lvl1

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# Results: Trigger Efficiency with Wmunu Background
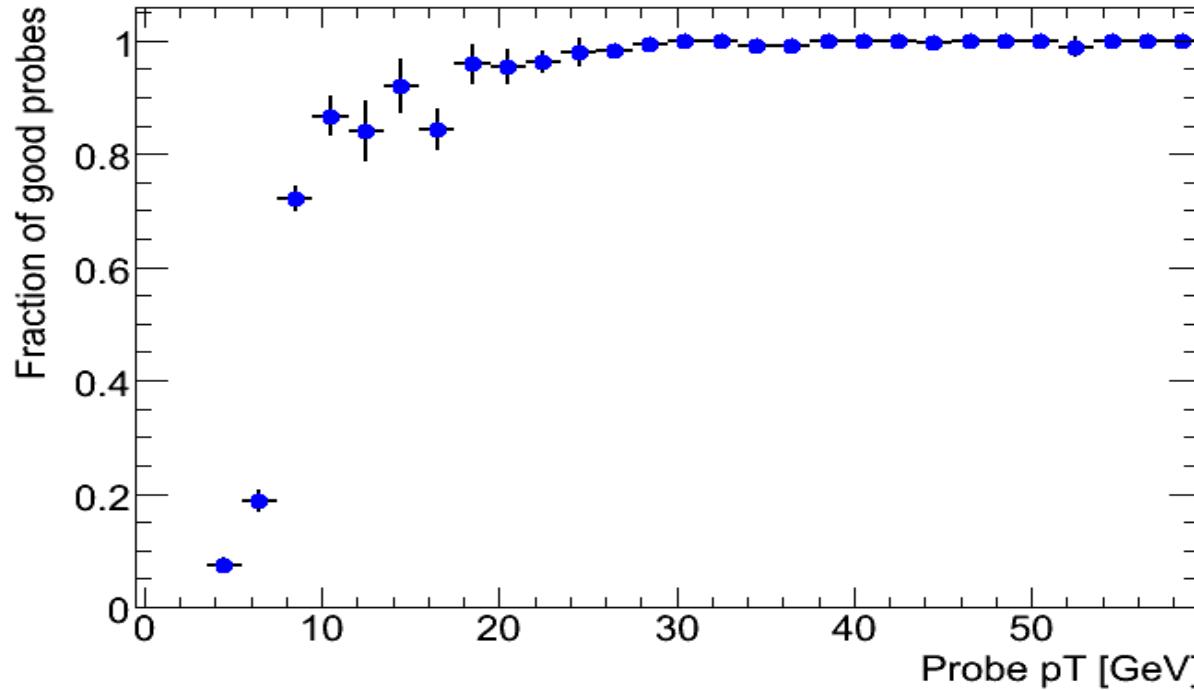


Adding Wmunu background we obtain this fraction of signal and..

**Signal / (Signal + Background)**

# Results: Trigger Efficiency with Wmunu Background
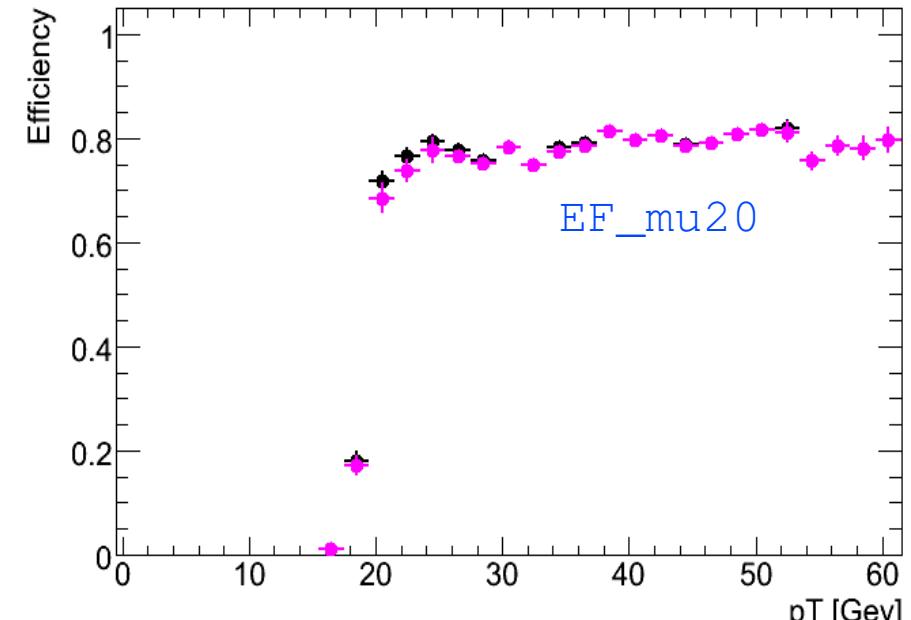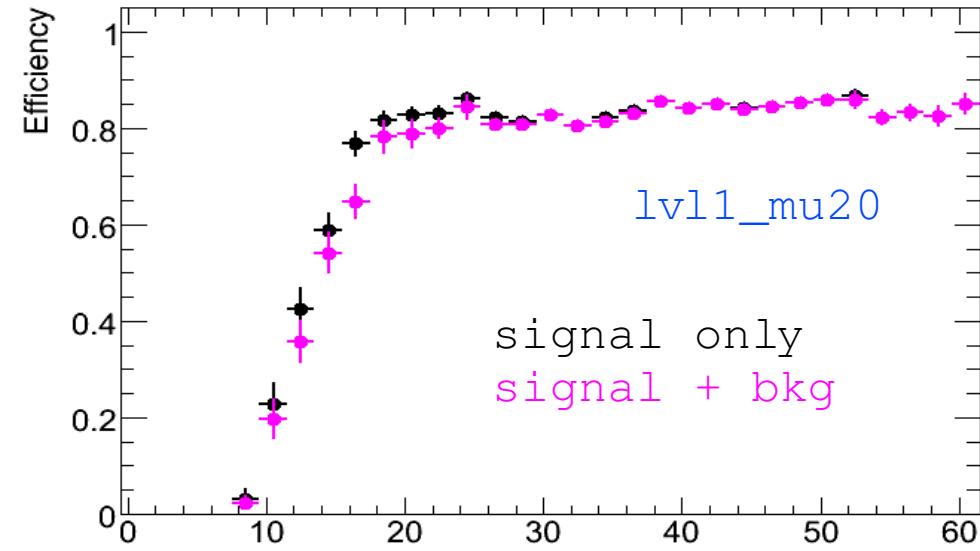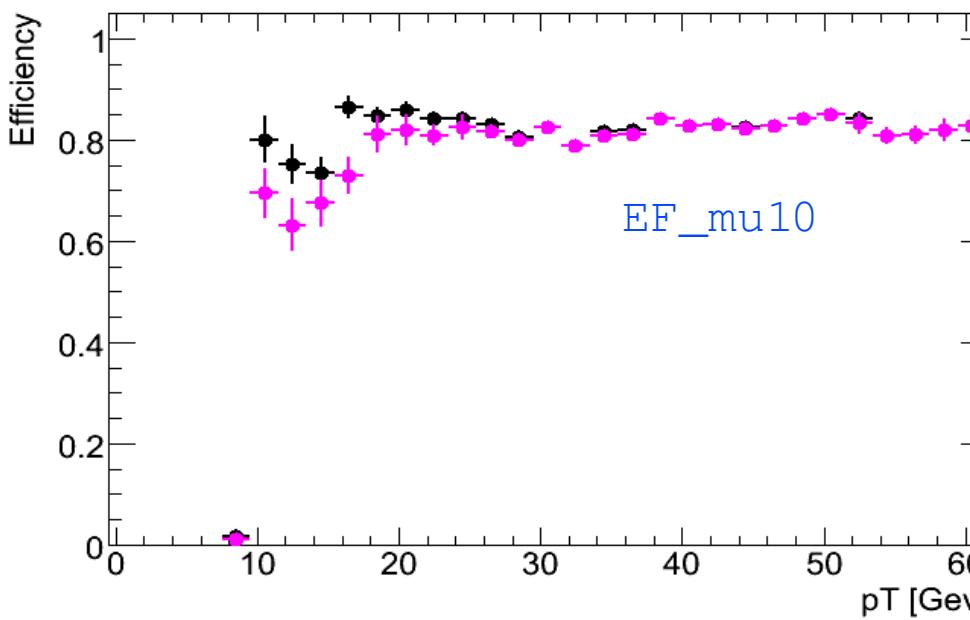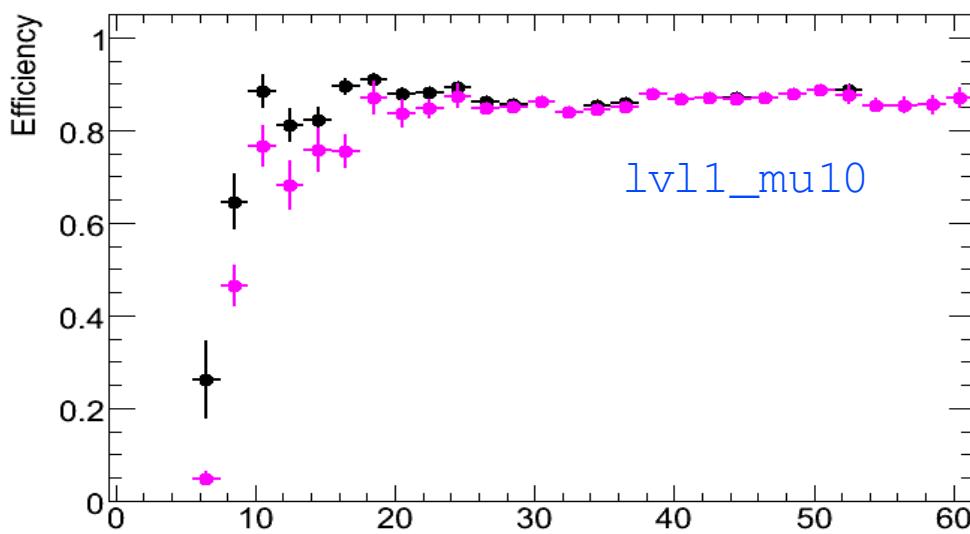
# Analysis of FDR2 data

⭐Applied on muon stream of runs:
 52280 – 52283 (misaligned sample)
 52290 – 52293 (aligned sample)

⭐$L_{eq}$ = 0.72 pb$^{-1}$ (2 hours @ $10^{32}$ cm$^{-2}$s$^{-1}$)
 expected number of probes $N_{exp}$:
 $N_{exp}=(N_{probe}/pb^{-1})$ x $L_{eq}$ x (si(FDR2)/ sigma(Zmumu))

⭐$N_{probe}$ found:
 -> **658** (in misaligned sample (*) ) **$N_{exp}$ = 1100**
 -> **993** (in aligned sample)          **$N_{exp}$ = 850**

 (*) less events in misaligned samples files.

# Analysis of FDR2 data: aligned vs misaligned



red: misaligned
blue: aligned

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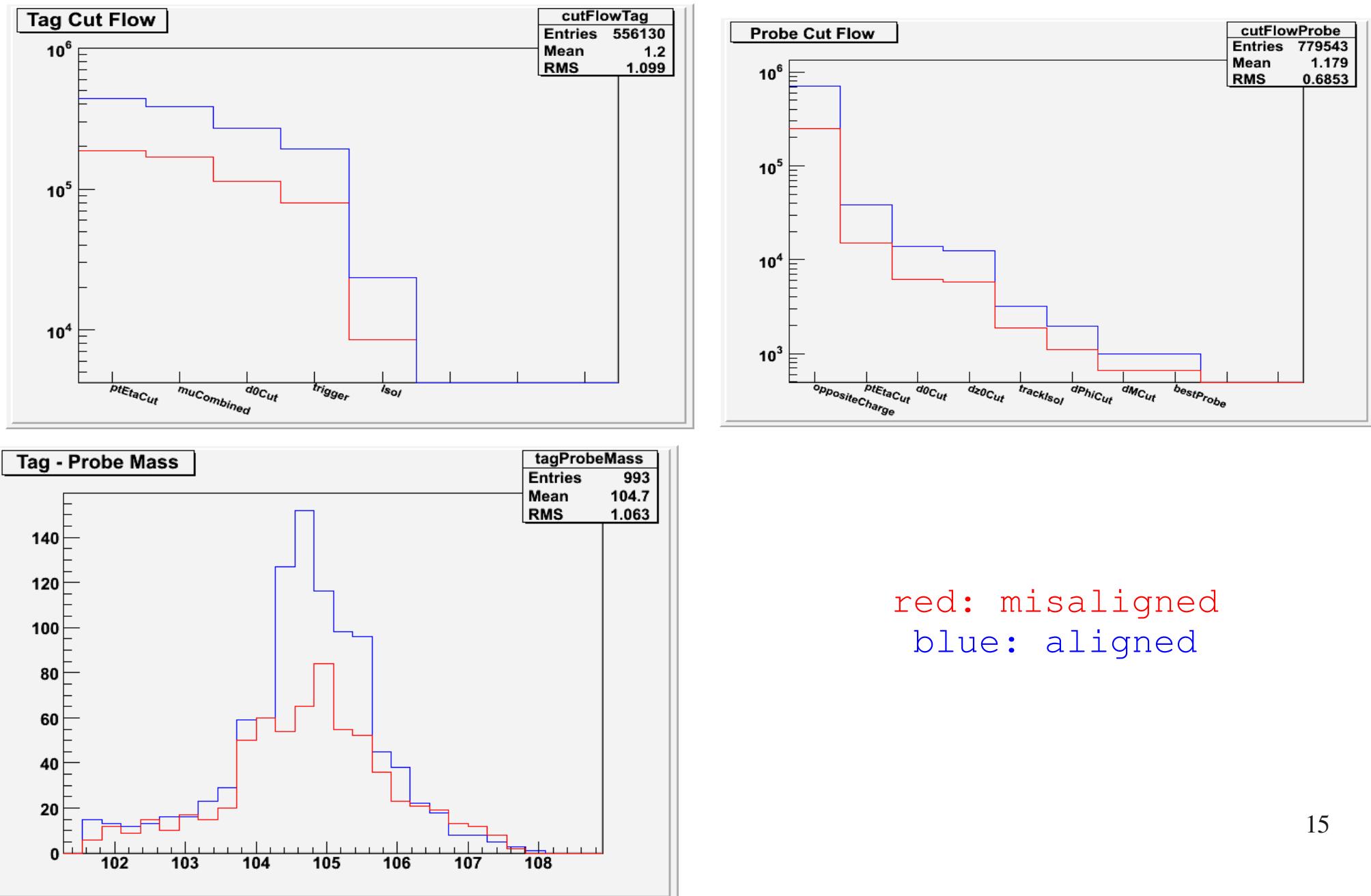
# Analysis of FDR2 data
# Aligned Sample
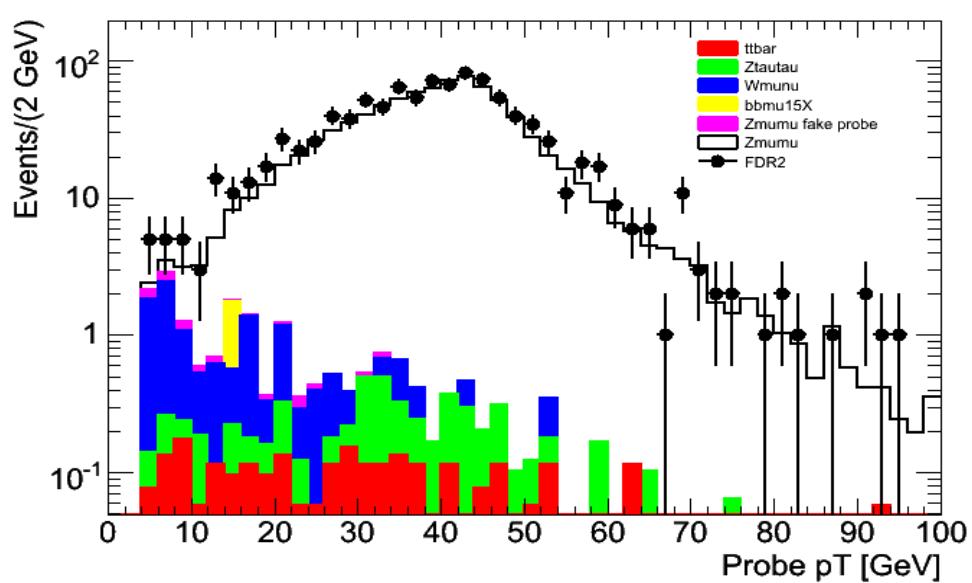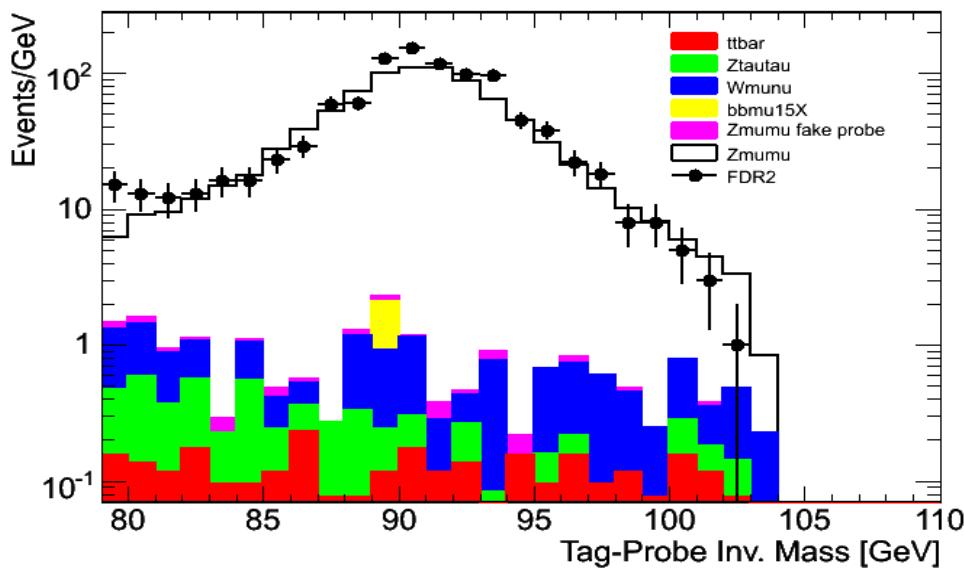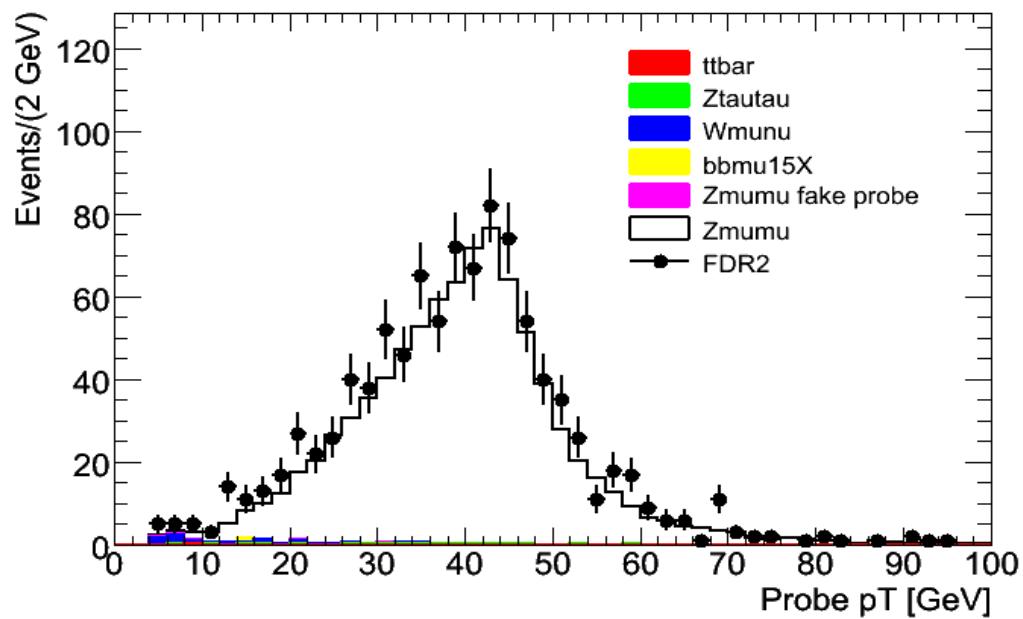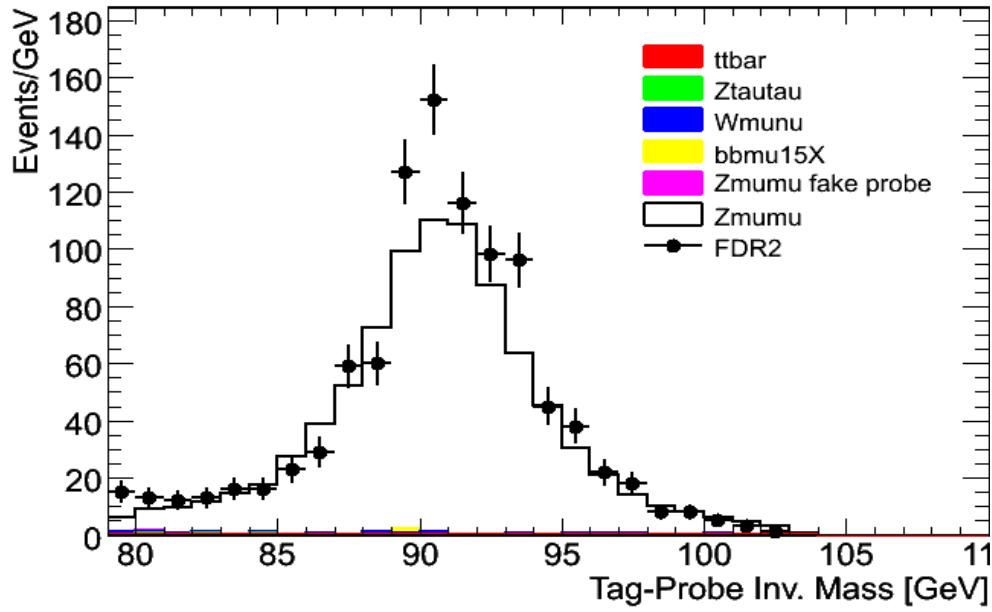
Samples are normalized to FDR2 luminosity and cross-sections

# Signal: v13 vs v14



**Tag Cut Flow**

| cutFlowTag | |
|---|---|
| Entries | 62468 |
| Mean | 1.704 |
| RMS | 1.379 |

red: v13
blue: v14

**Probe Cut Flow**
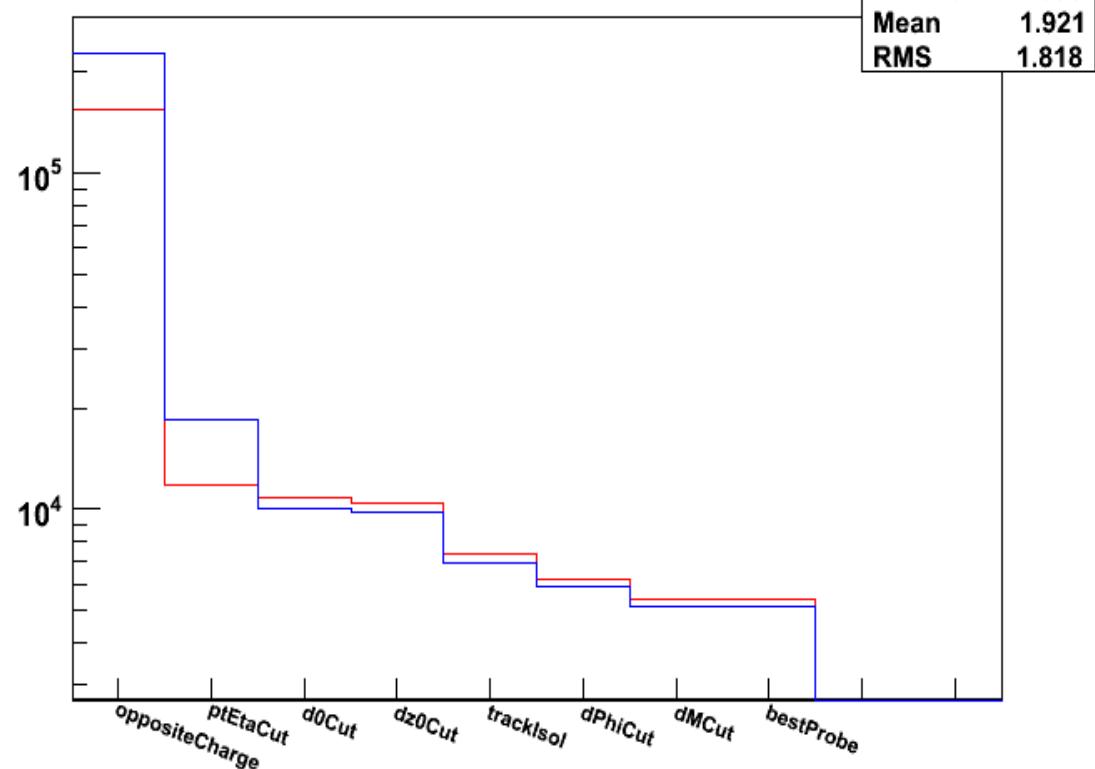
| cutFlowProbe | |
|---|---|
| Entries | 212585 |
| Mean | 1.921 |
| RMS | 1.818 |

$10^4$

ptEtaCut  muCombined  d0Cut  trigger  Isol

$10^5$

$10^4$

oppositeCharge  ptEtaCut  d0Cut  dz0Cut  trackIsol  dPhiCut  dMCut  bestProbe

probe/pb$^{-1}$ = 960
probe/pb$^{-1}$ = 987

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# Signal: v13 vs v14



Discrepanze:
  d0
  pt

Probe D0

| htemp | |
|---|---|
| Entries | 18513 |
| Mean | -1.571 |
| RMS | 56.98 |

Probe Pt

Probe D0[mm]

Probe Pt[GeV]

red: v13
blue: v14

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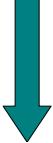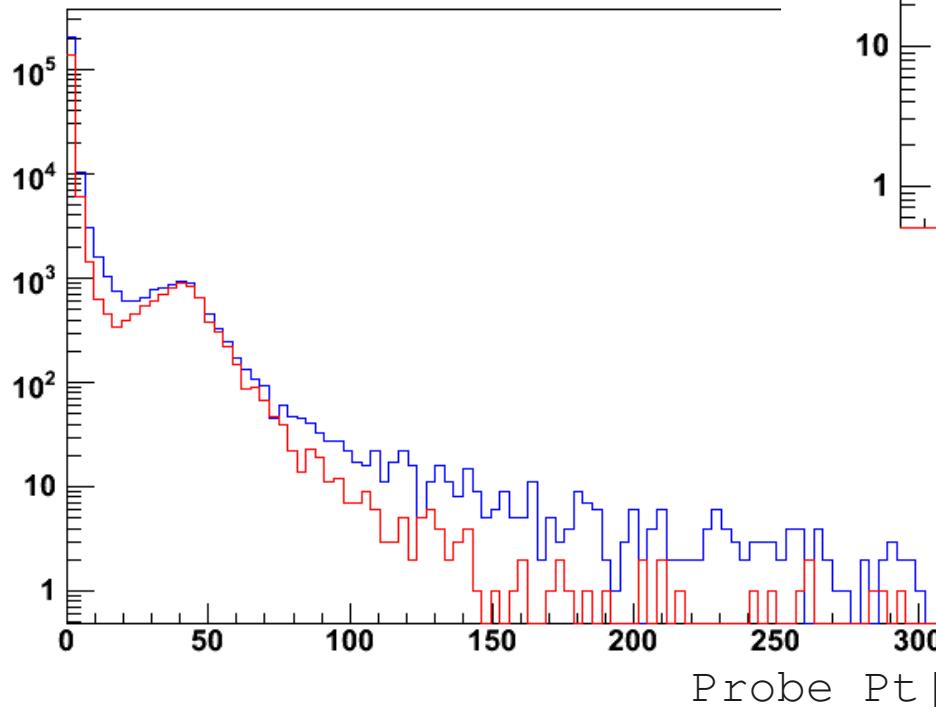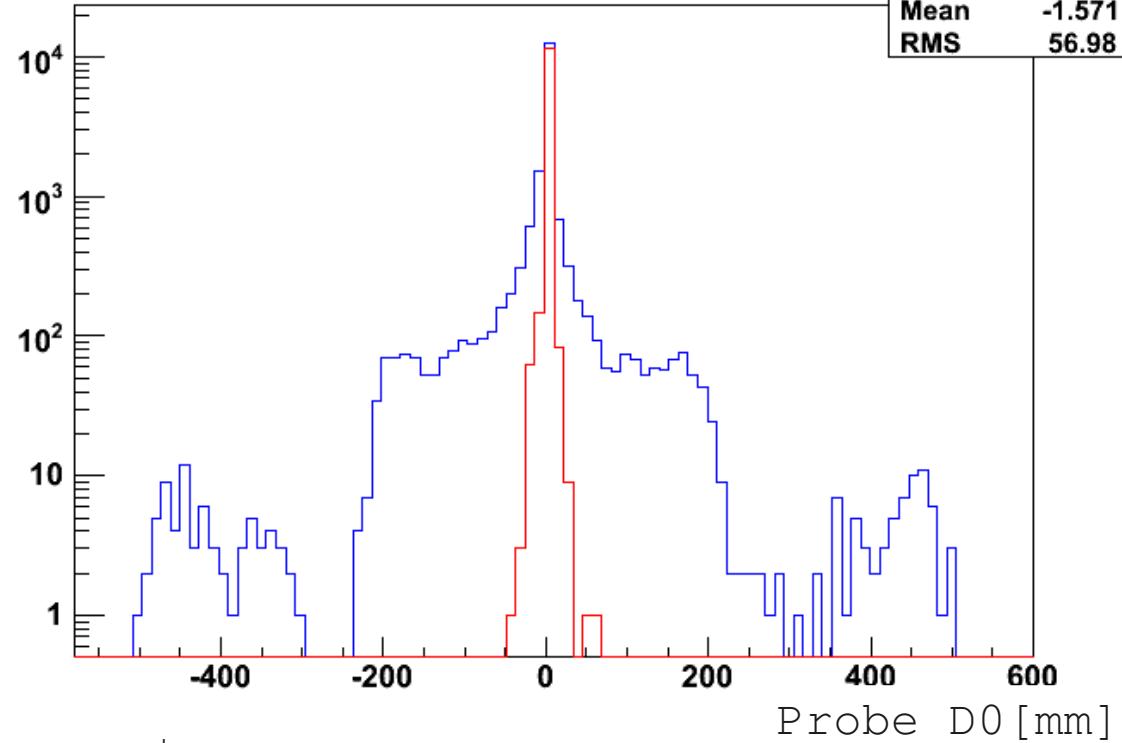
# Signal: v13 vs v14

You obtain the
same result

Tag&Probe mass



BestProbe Pt



Tag&Probe mass
[GeV]

BestProbe Pt[GeV]

red: v13
blue: v14
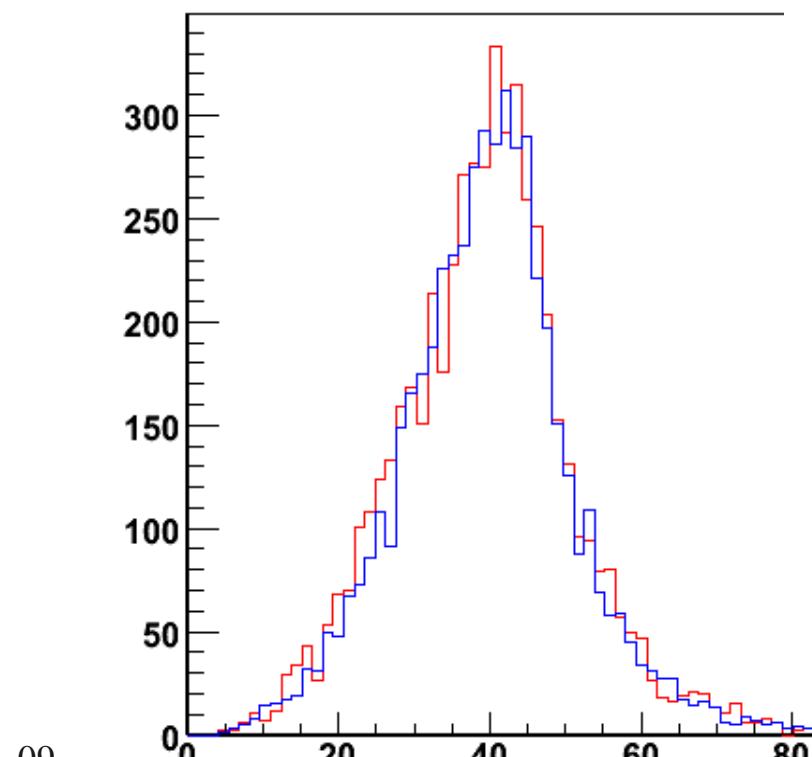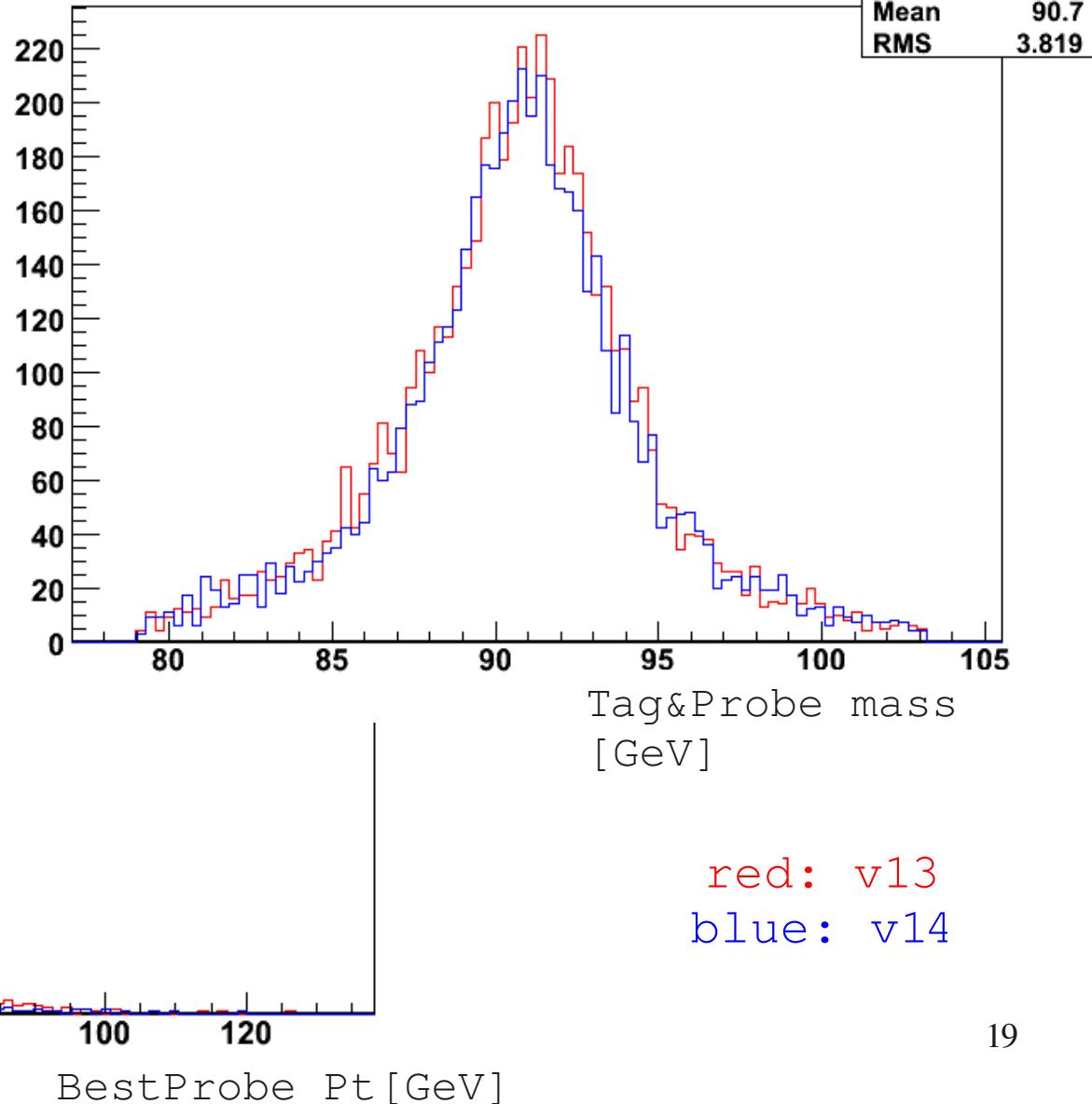
# Conclusions

- **Release 13 check complete:**
  Wmunu is the main background, especially below 20 GeV (Missing Et cut can improve?)

- **FDR2 result:**
  some distributions not well understood; region below 20 GeV still dominated by background

- **Rel 13 vs Rel 14:**
  Different beaviour of ID tracking (pt and d0) but the tag&probe method is not affected