M. Biglietti
(Univ. Roma3 & INFN)

F. Conventi, A. Picazio, E. Rossi
(Univ. Napoli & INFN)

Study on the Dimuon Trigger Efficiency in the Muon Stream

Low-p_T selection: $J/\psi \rightarrow \mu\mu$

Athena release 16.6.0
Data period used: G –H –I
MC sample: $J/\psi \rightarrow \mu_0 \mu_0$
mc10_7TeV.108496.Pythia_directJpsimu0mu0.merge.AOD.e574_s933_s946_r1655_r1700

Selection:

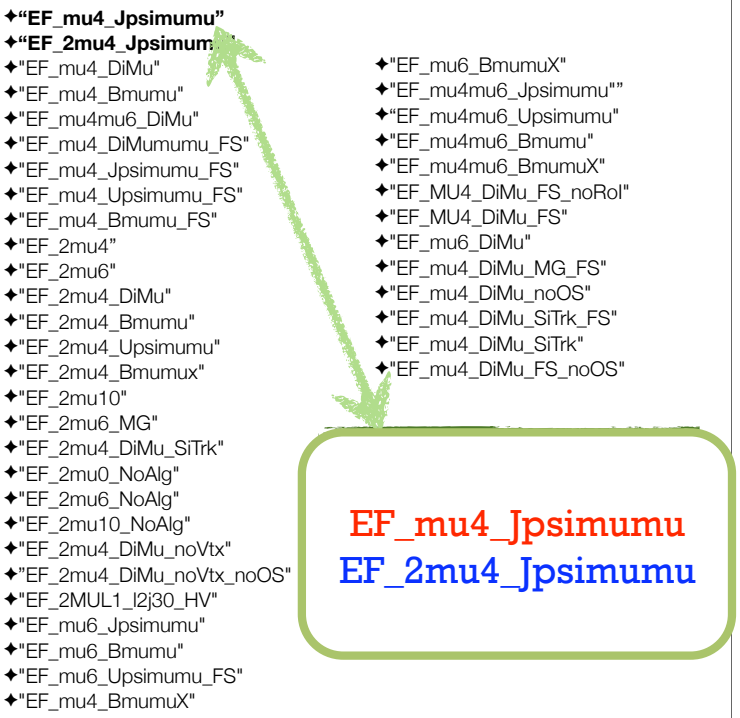
- 2 OS combined muons in the [2.86-3.34] GeV mass range
- nPixels>0, nSCT>5, nTRT>10 (if $|\eta|<2$)
- At least a Primary Vertex with 3 associated "good" ID tracks
- Starndard GRL from the data quality groups

Tools Used

TrigEffJpsiTool (release 01-00-18) - To retrieve Trigger Object
JpsiIt - The same tool already used for single object muon trigger studies

Reconstruction algorithm: STACO

Di-Muon Trigger Item available:



Bayes Theorem

$$P(B) = \frac{P(A)P(B|A)}{P(A|B)}$$

Using the Bayes Theorem we can produce an unbiased measurement of the ε (EF_mu4_Jpsimumu) and ε (EF_2mu4_Jpsimumu) using the data muon stream

$$P(EF\_mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_mu4\_Jpsimumu)}$$

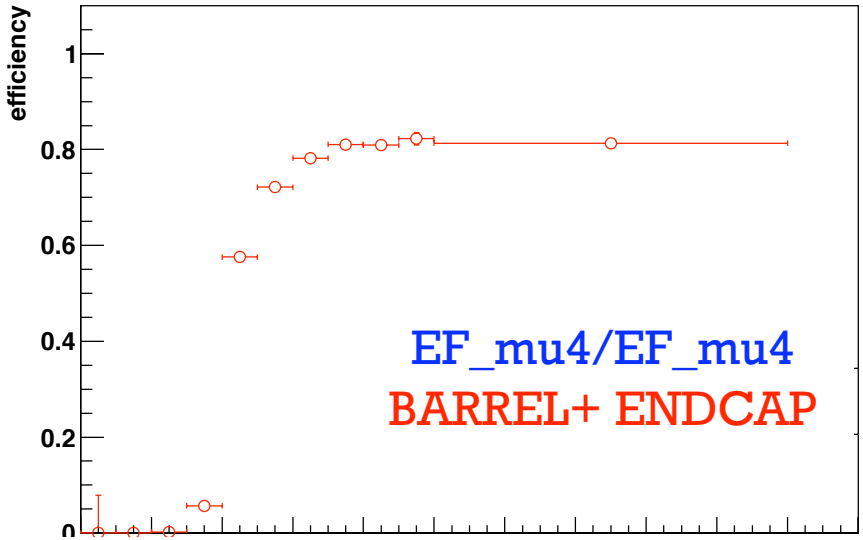
Tag&Probe

$$\frac{events\ that\ passed\ (EF\_mu4\_Jpsimumu\ \&\&\ EF\_mu4)}{Events\ that\ passed\ EF\_mu4}$$

It can't be evaluated by DATA because of the prescale

EF_mu4 with Tag & Probe: Turn-On

$$P(EF\_mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_mu4\_Jpsimumu)}$$



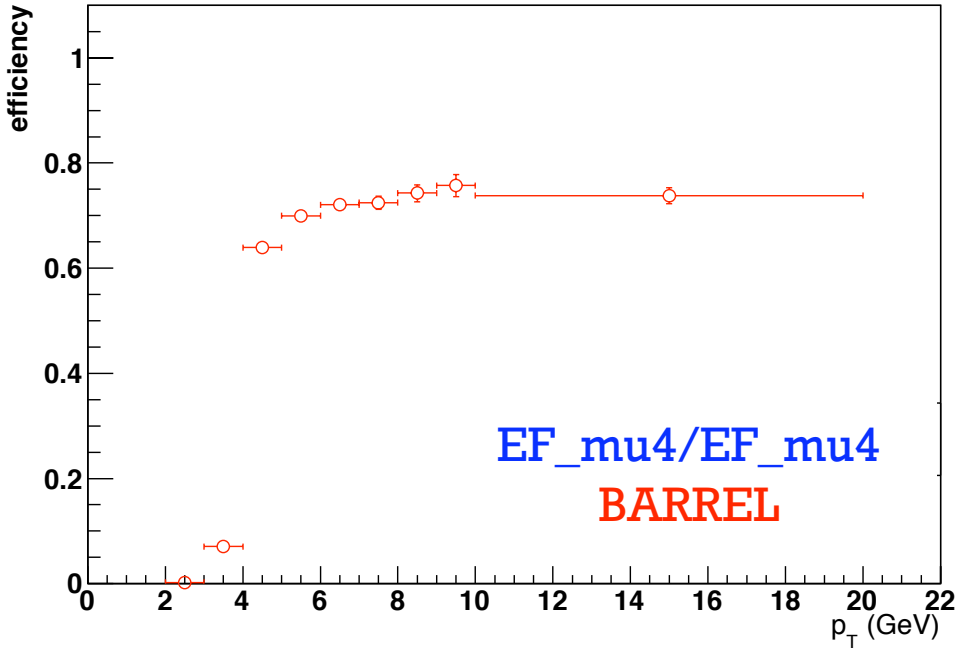
Tag & Probe Method

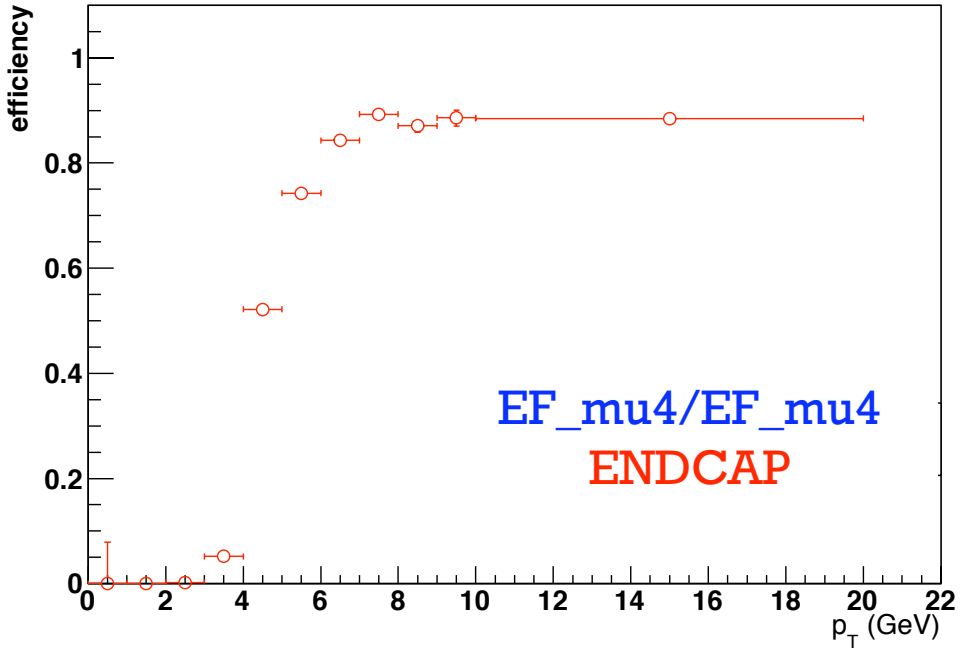
period E - F - G - H – I

Invariant Mass range [2-100GeV]

"Tag": EF_mu4

"Probe": EF_mu4

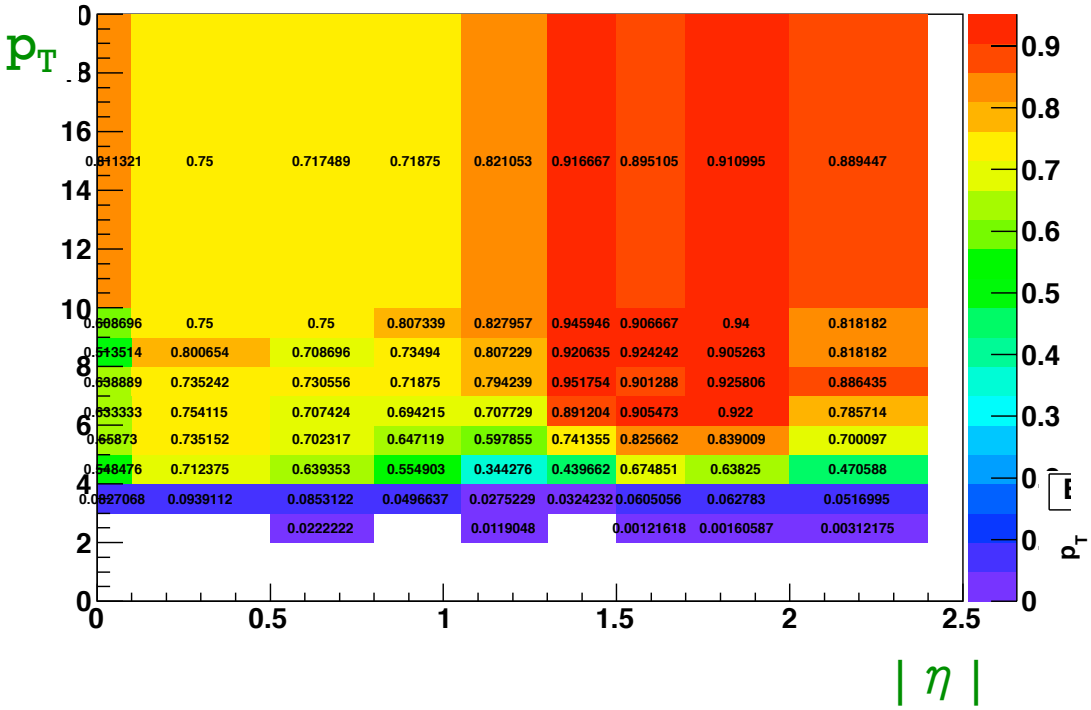




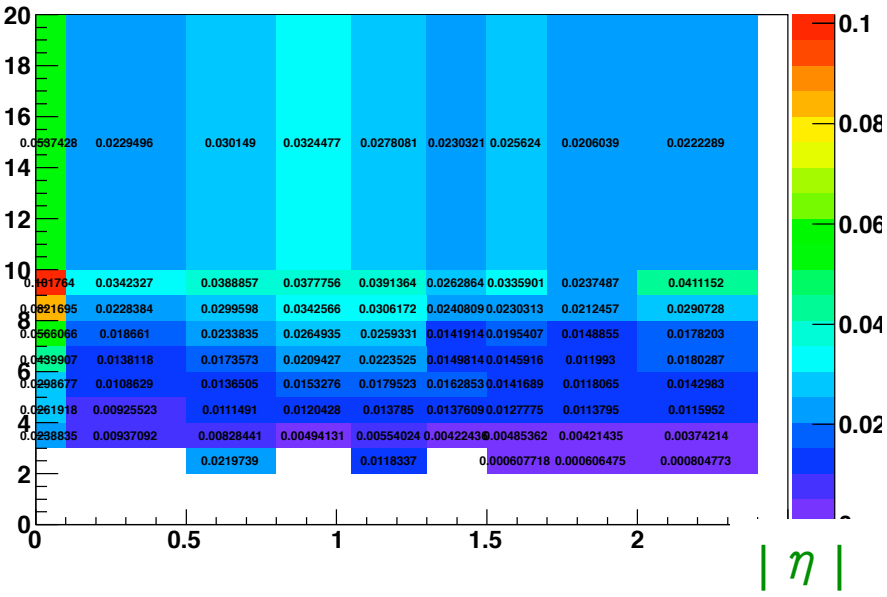
EF_mu4 with Tag & Probe: p_T - η maps

$$P(EF\_mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_mu4\_Jpsimumu)}$$

EFFICIENCY MAP



MAP OF THE ERRORS on EFFICIENCY



+ EF_mu4_Jpsimumu - Overview

Trigger algorithm based on **L2 TrigDiMuon** algorithm

- L1MU0 search for a muon in wider η and Φ region
- L1 RoI confirmed at L2 (muFast and "possibly also" muComb), then the RoI is extended ($\Delta\eta \times \Delta\phi = 0.75 \times 0.75$)
- Searching for 2 ID tracks in Ex-RoI ➔ M > 2.8 , opposite sign
- Selected ID tracks extrapolated to MS ➔ **depending on η and Φ**, different **formulas parameterizing the expected bending in the magnetic field**
- Search for muon hits in MS within the road around extrapolated track
- If sufficient number of muon hits in MS for both tracks ➔ 2 Muons
- Finally the tracks are refitted to a common vertex and the following requirements are applied ➔ $2.5<M<4.3$, $\chi^2_{vtx}<20$

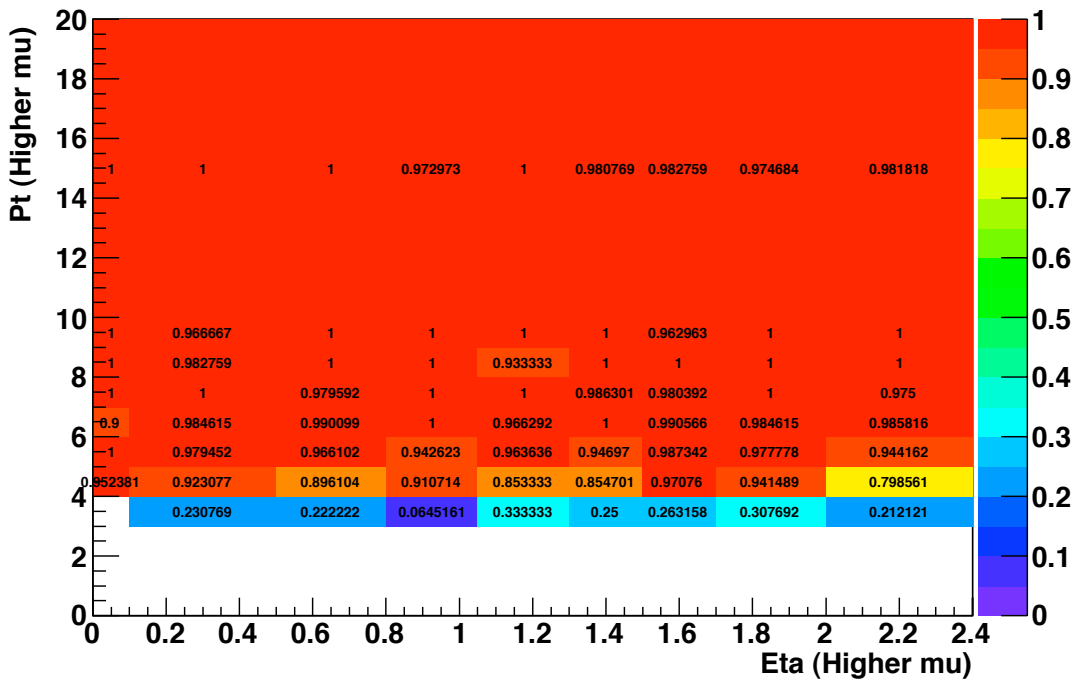
We have **not the requirement of an EF_mu4** fired

↳ $P(EF\_mu4 | EF\_mu4\_Jpsimumu) \neq 1$

$$P(EF\_mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_mu4\_Jpsimumu)}$$

MC J/ψ

P(EF_mu4 | EF_mu4_Jpsimumu)



It is not identically 1
Studies on MC are needed!!

EF_mu4_Jpsimumu is only confirmed at the EF

P(EF_mu4 | EF_mu4_Jpsimumu) estimated with MC

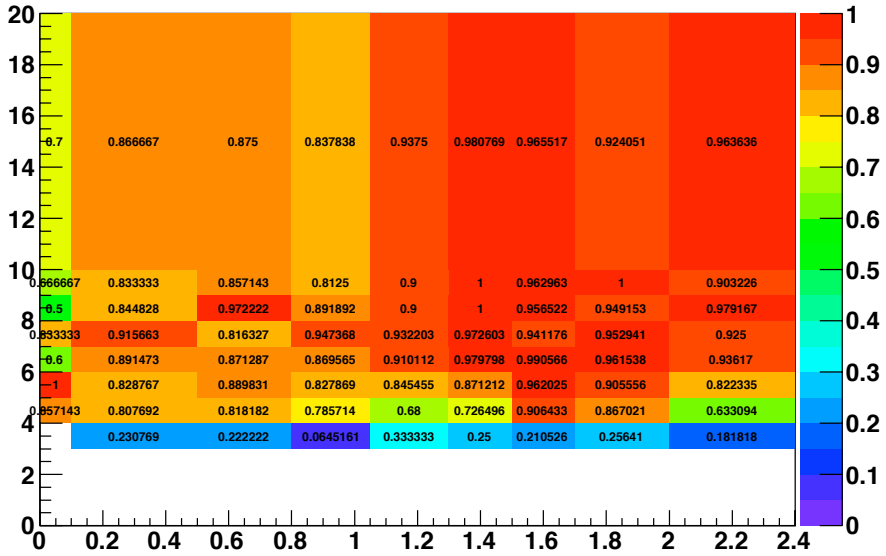
It can't be evaluated by DATA because of the prescale…

How to solve this problem?

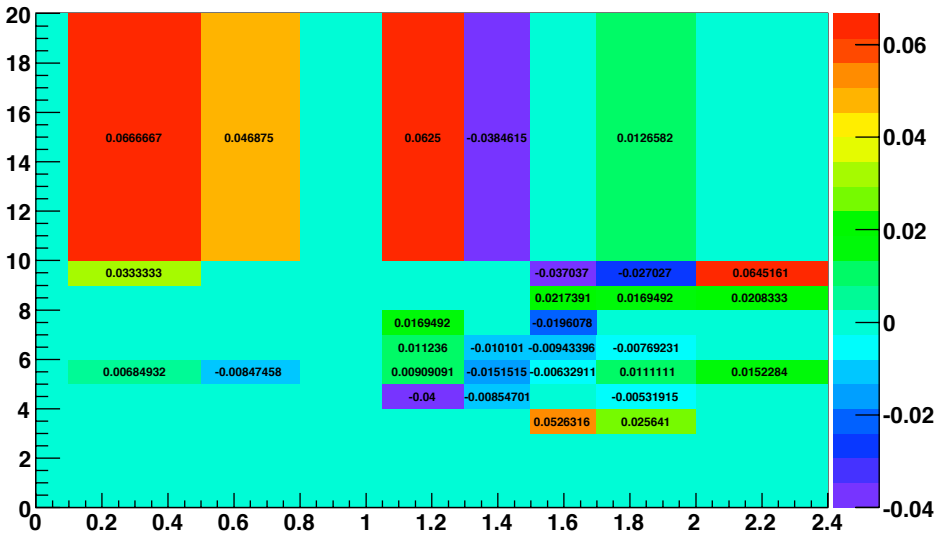
We retrieve the online L2 and EF tracks and we emulate the effects of the EF_mu4 trigger selection

➔Re-run the Hypo

P(EF_mu4_emu | EF_mu4_Jpsimumu)



Difference between the conditioned probability obtained with emulated EF_mu4 and EF_mu4

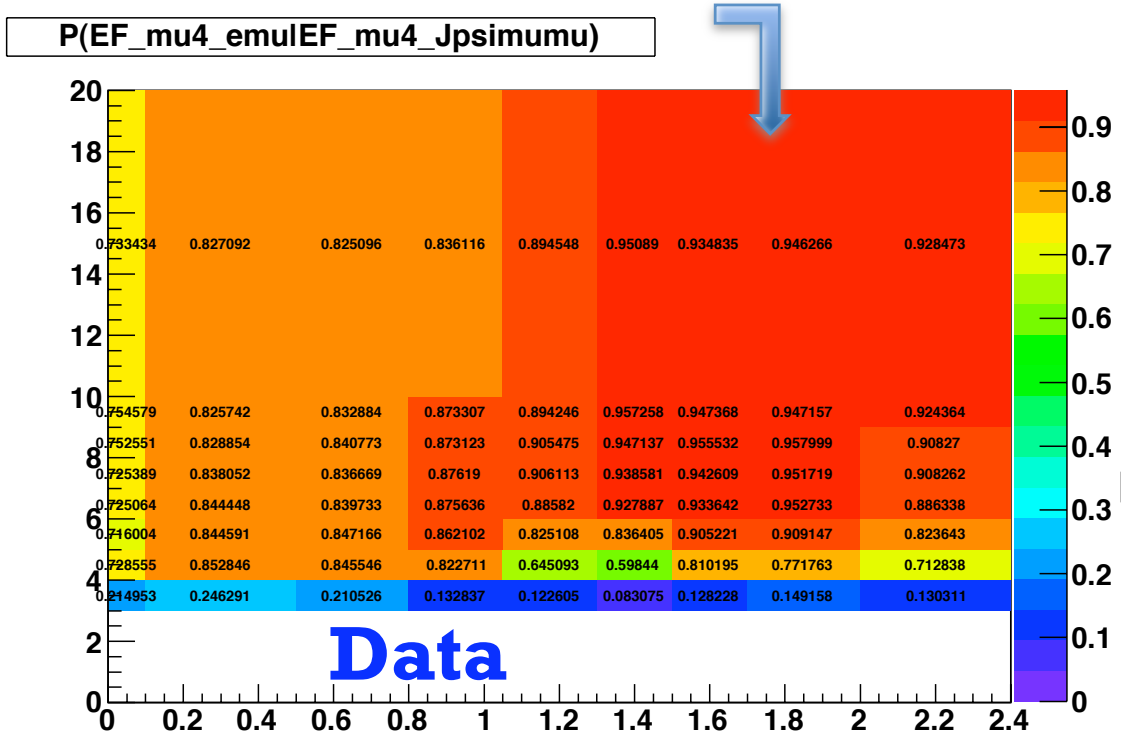


MC J/ψ

P(EF_mu4 | EF_mu4_Jpsimumu)

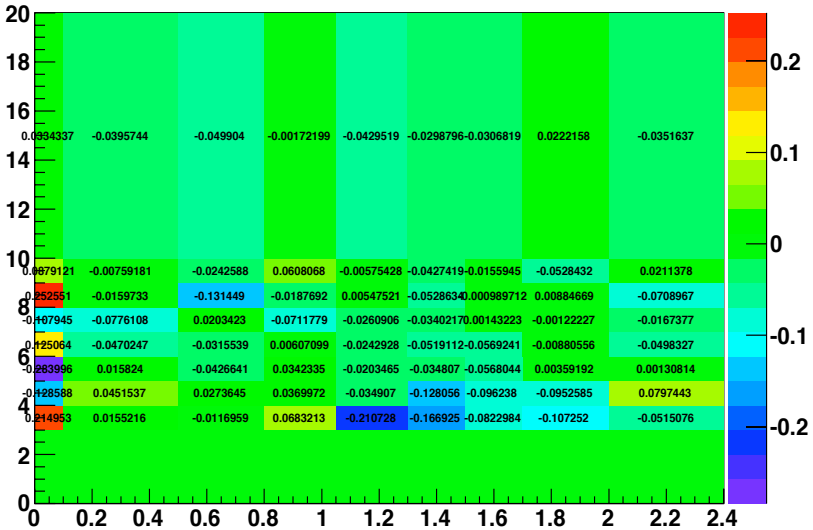
Data

P(EF_mu4_emu | EF_mu4_Jpsimumu)

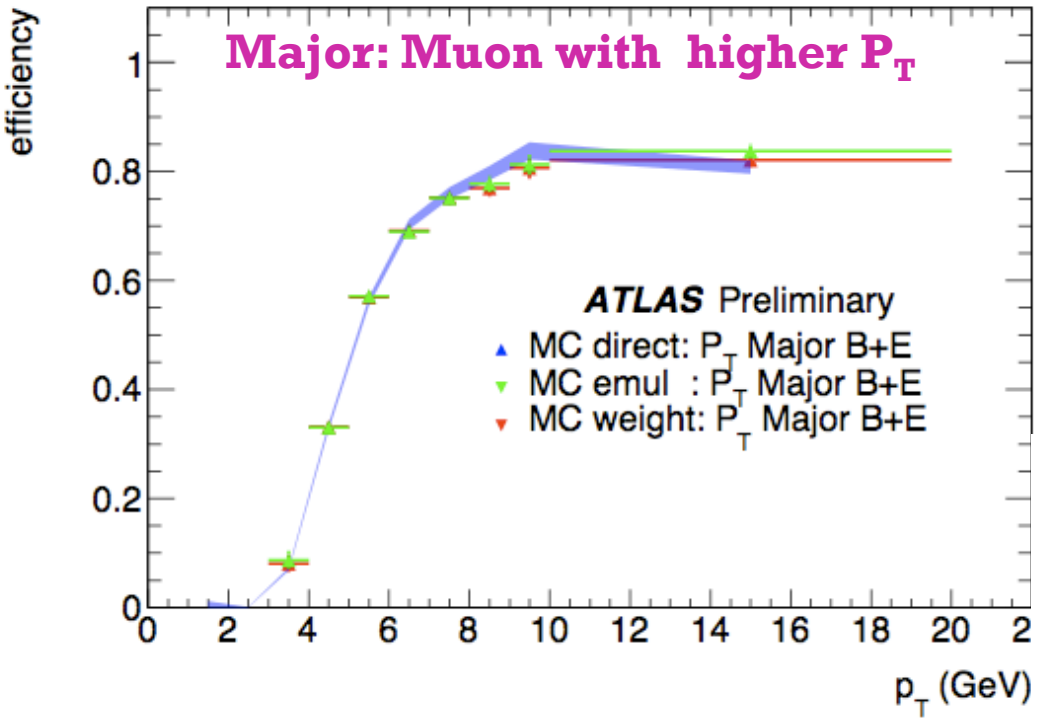


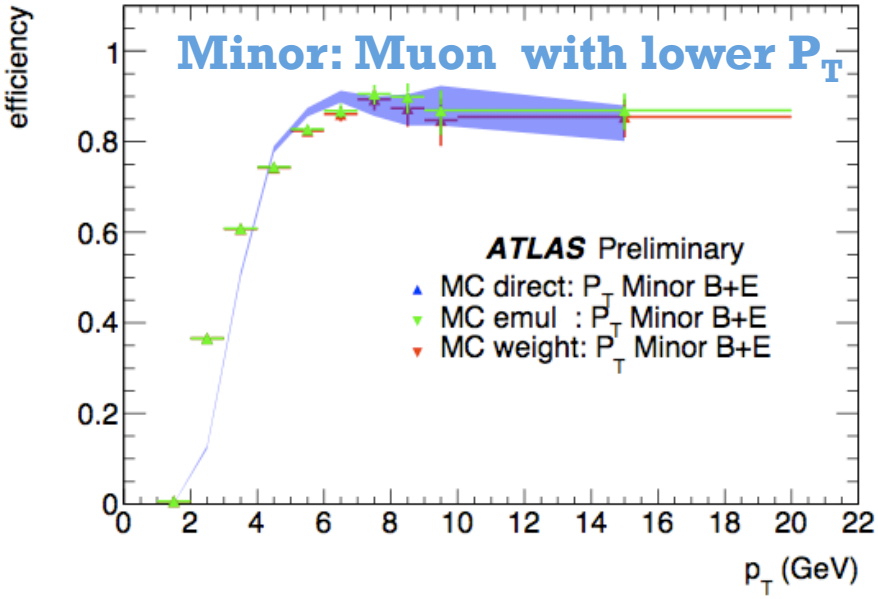
Difference between MC and DATA:

P_{Data}-P_{MC}



MC Turn-On: EF_mu4_Jpsimumu





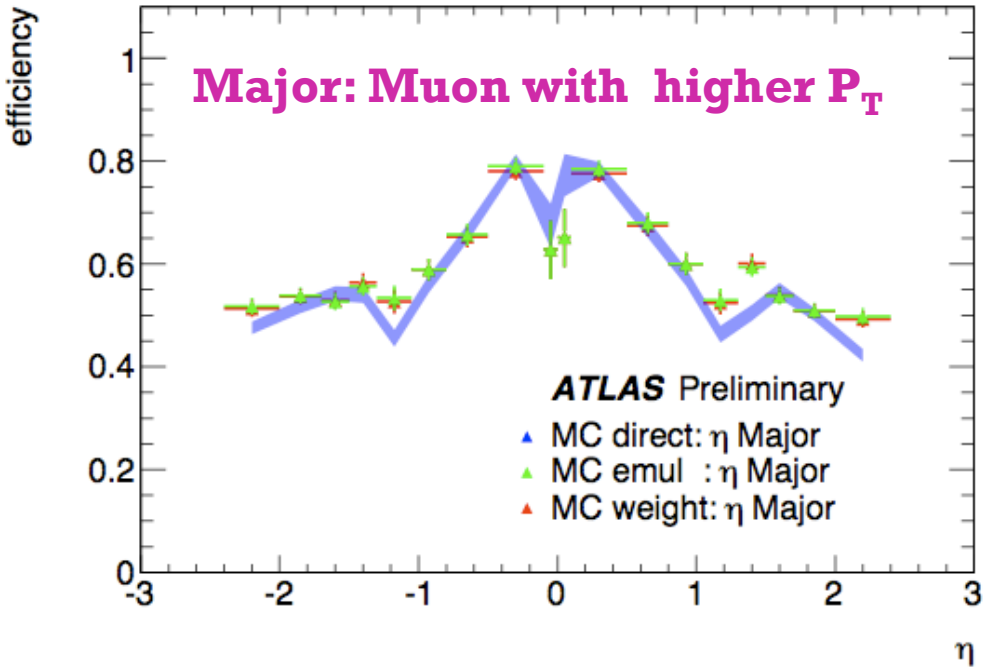
direct: N(EF_mu4_Jpsimumu)/N(Reco)

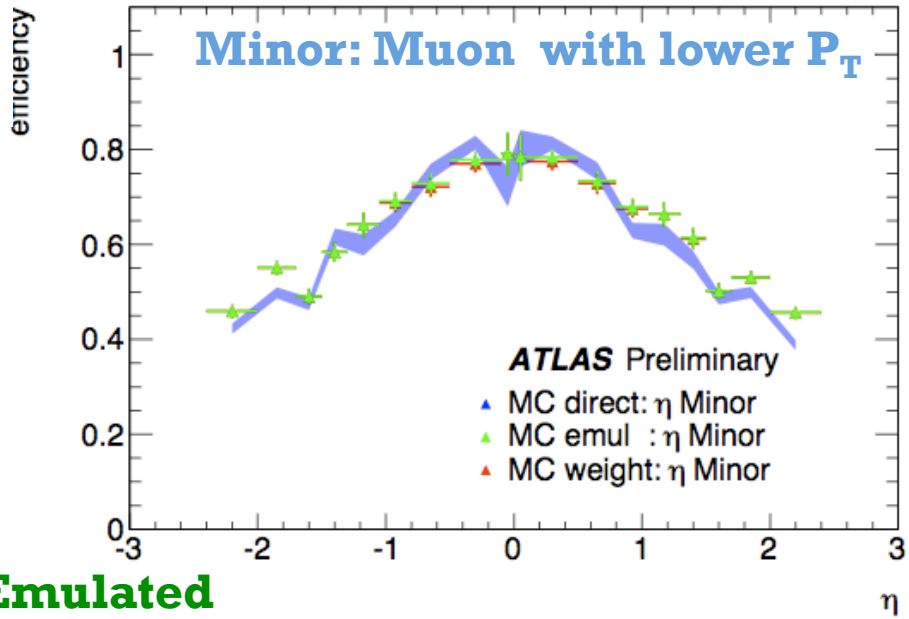
emulated: Bayes Theorem with EF_mu4 Emulated

Bayes Theorem with EF_mu4

E. Rossi

EF_mu4_Jpsimumu: MC Efficiency in η





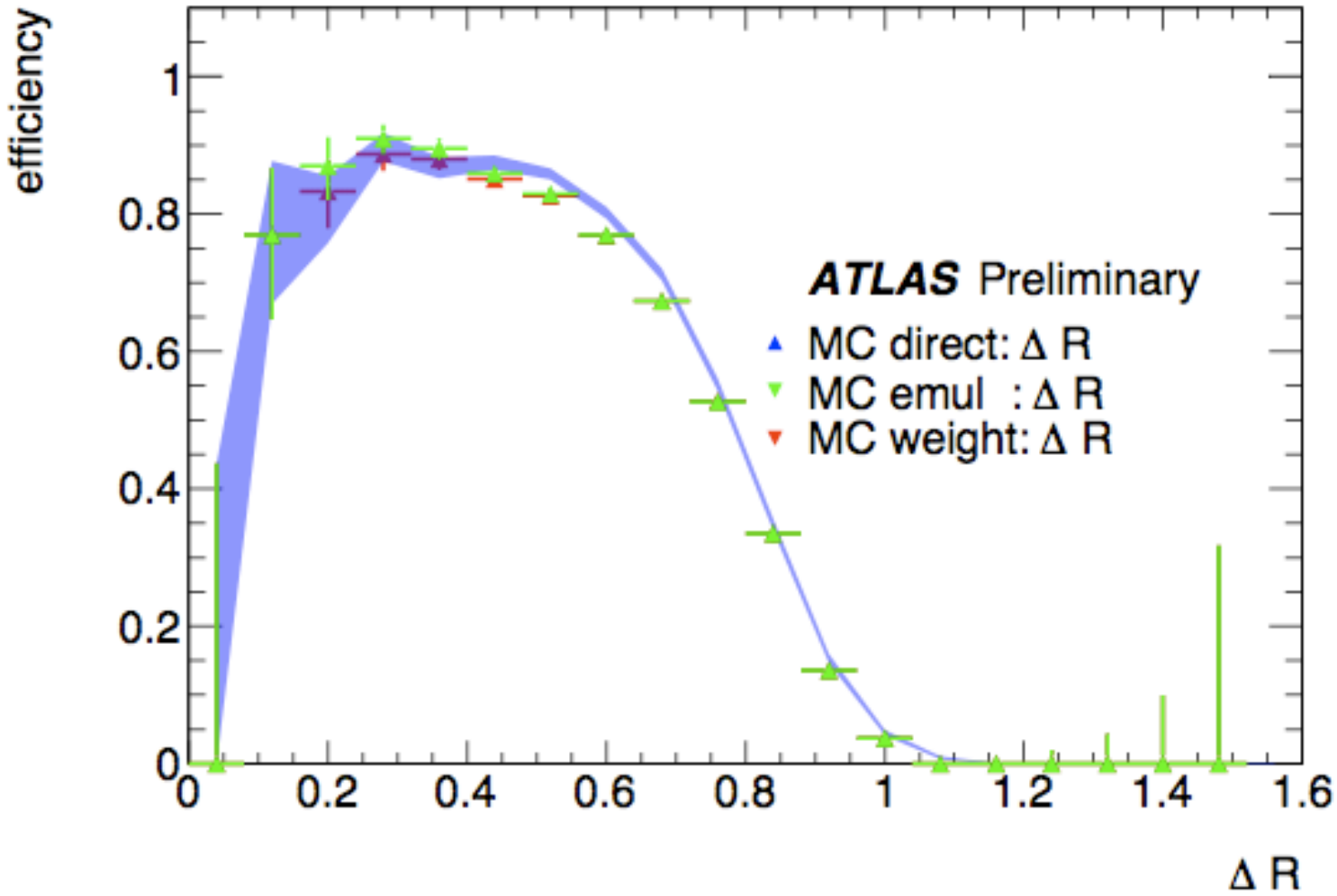
direct: N(EF_mu4_Jpsimumu)/N(Reco)

emulated: Bayes Theorem with EF_mu4 Emulated

Bayes Theorem with EF_mu4

E. Rossi

EF_mu4_Jpsimumu: MC DeltaR

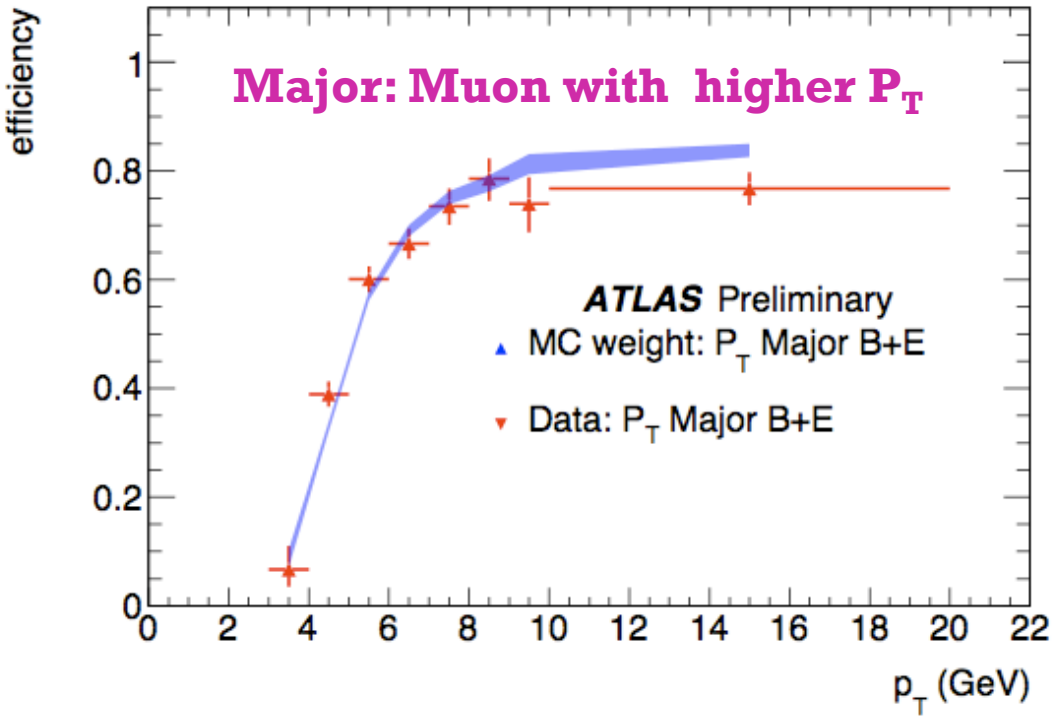


direct: N(EF_mu4_Jpsimumu)/N(Reco)

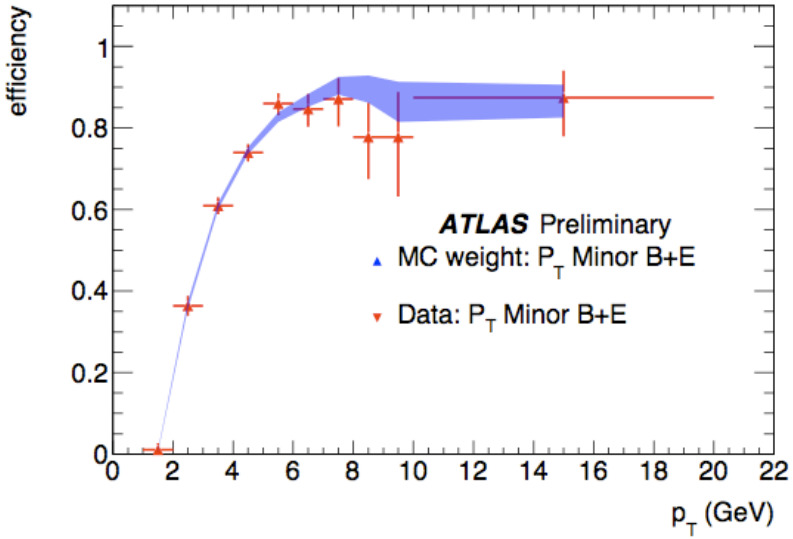
emulated: Bayes Theorem with EF_mu4 Emulated

Bayes Theorem with EF_mu4

EF_mu4_Jpsimumu: DATA/MC Comparison



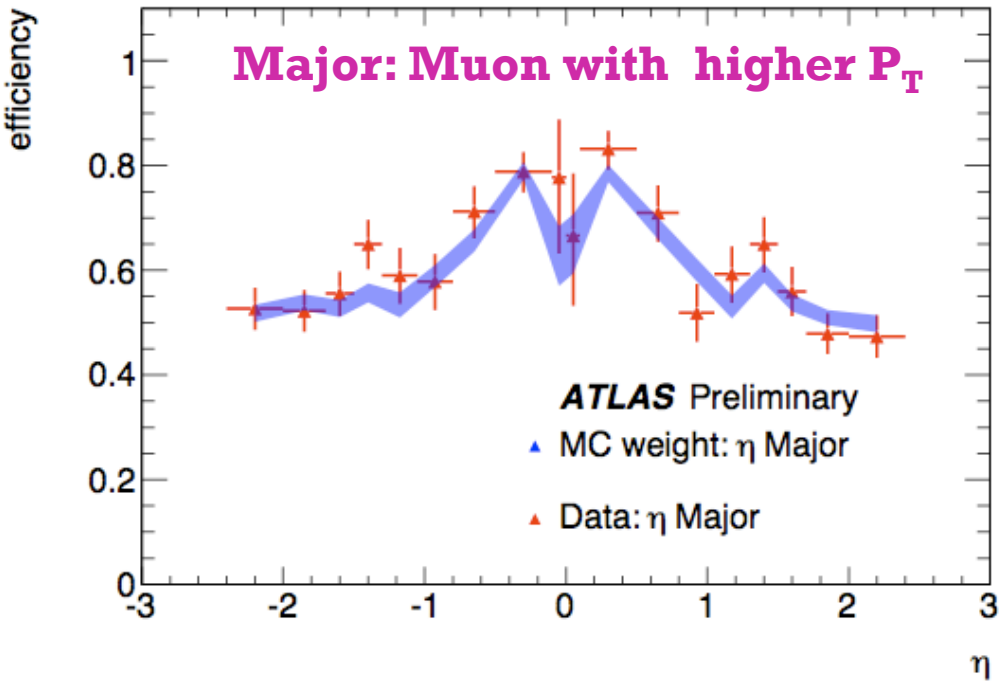
Minor: Muon with lower P_T

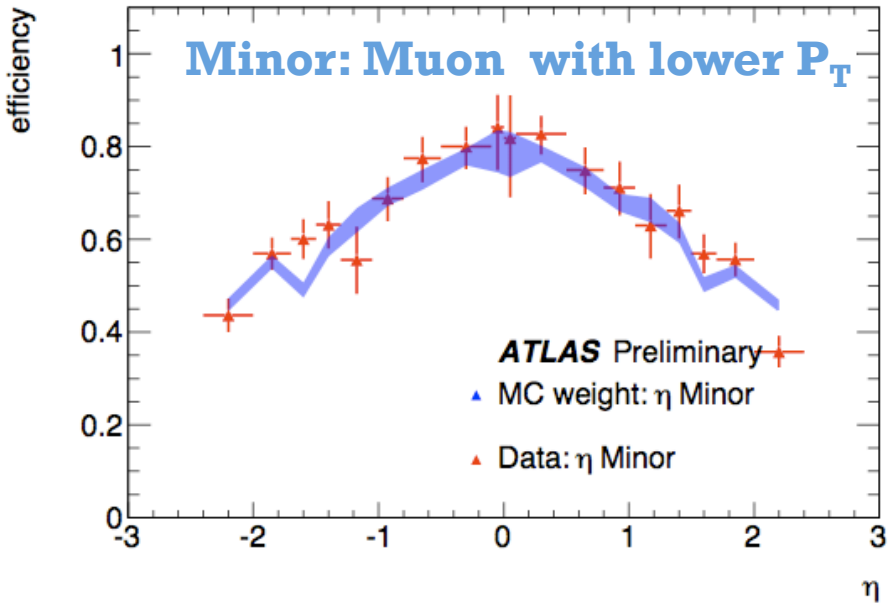


MC : Bayes Theorem with EF_mu4

Data: Bayes Theorem with EF_mu4 Emulated

EF_mu4_Jpsimumu MC/DATA: Efficiency in η

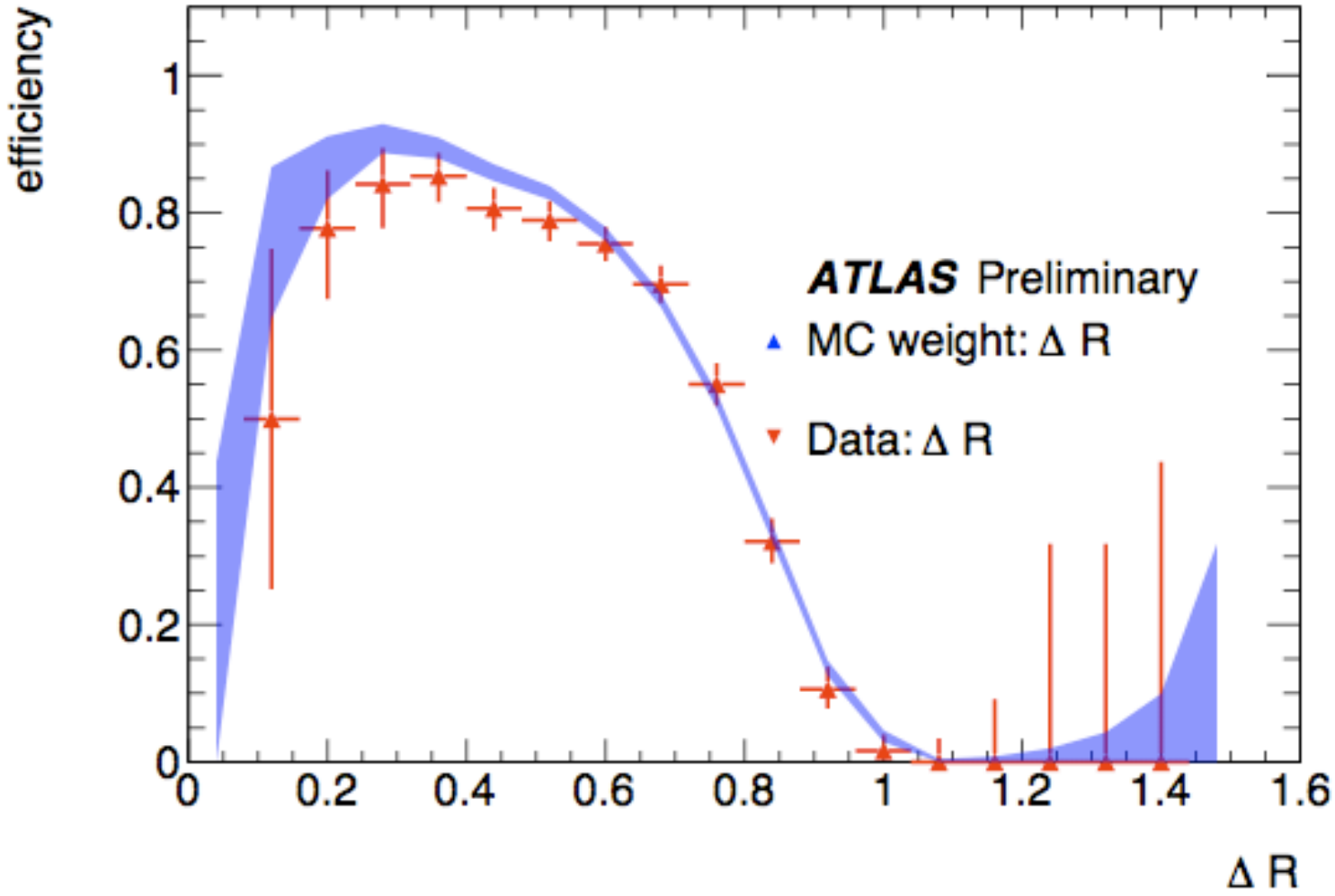




MC : Bayes Theorem with EF_mu4

Data: Bayes Theorem with EF_mu4 Emulated

EF_mu4_Jpsimumu: DeltaR DATA/MC Comparison



MC : Bayes Theorem with EF_mu4

Data: Bayes Theorem with EF_mu4 Emulated

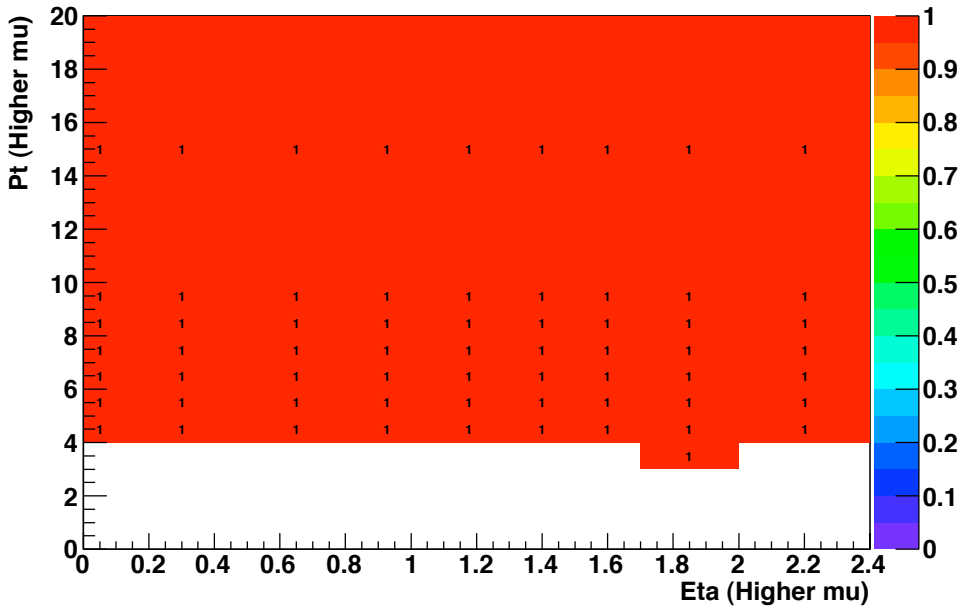
Efficiency for EF_2mu4_Jpsimumu

"Topological" Trigger

- Select 2MU0 at L1
- Reconstruction is confirmed separately in each RoI
- The muon subsequently combined to form a resonance and to apply a mass cut.

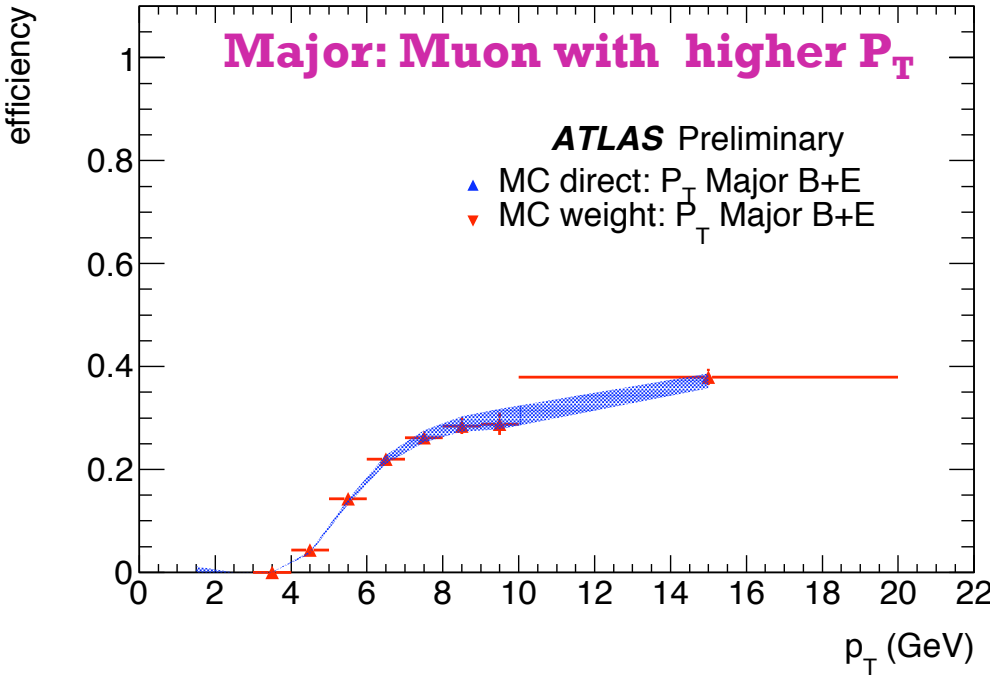
$$P(EF\_2mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_2mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_2mu4\_Jpsimumu)}$$

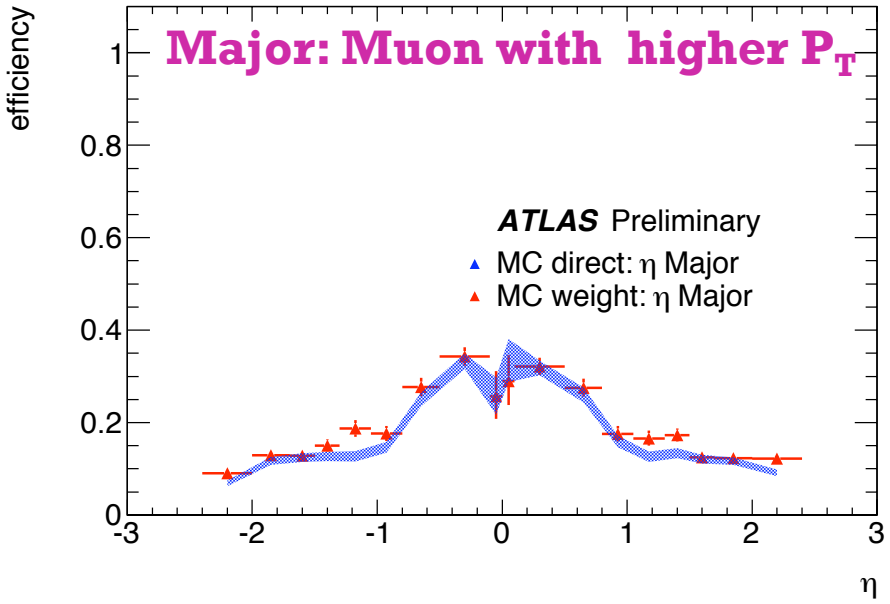
P(EF_mu4 | EF_2mu4_Jpsimumu)



It is identically 1

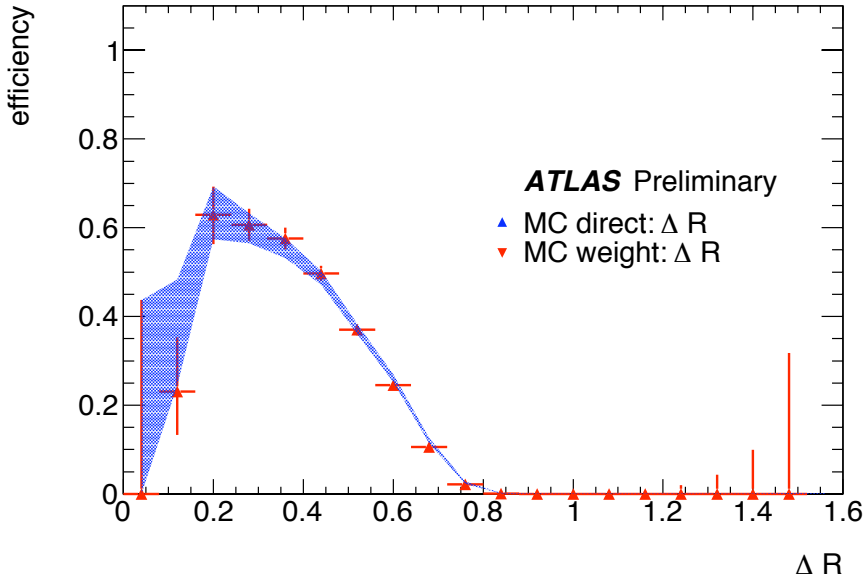
EF_2mu4_Jpsimumu: MC efficiency estimation



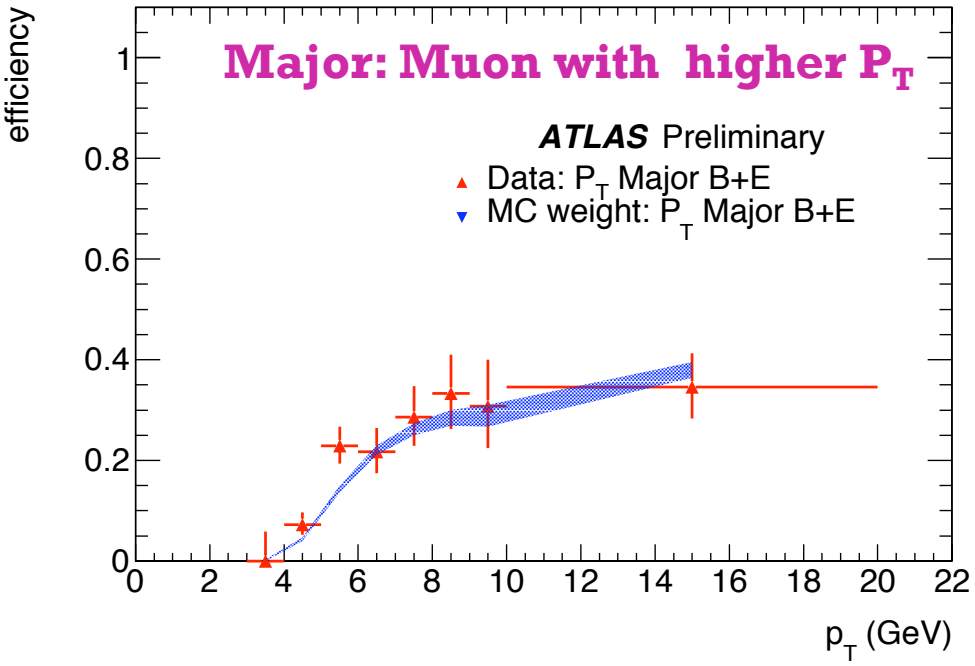


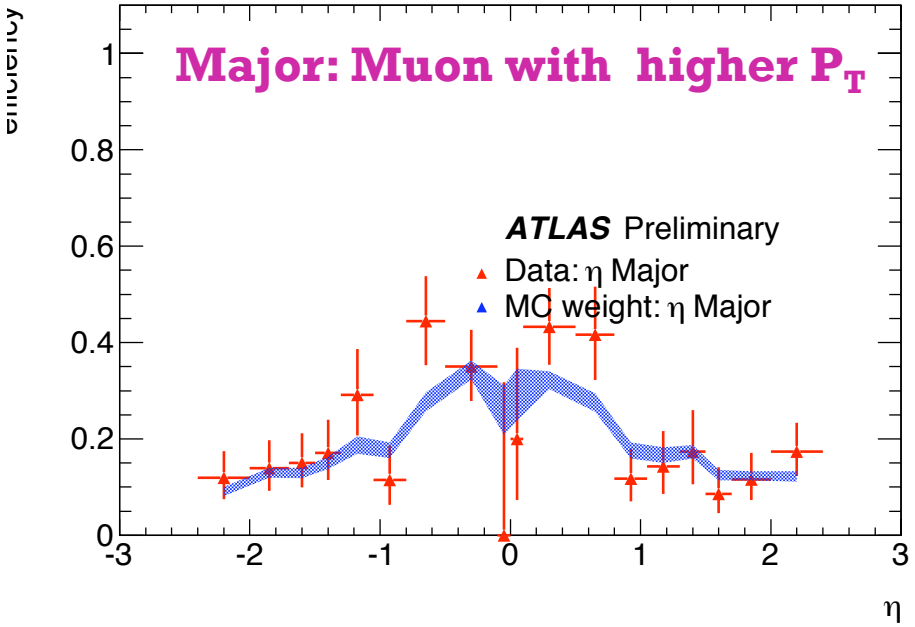
direct: N(EF_2mu4_Jpsimumu)/N(Reco)

Bayes Theorem with EF_mu4



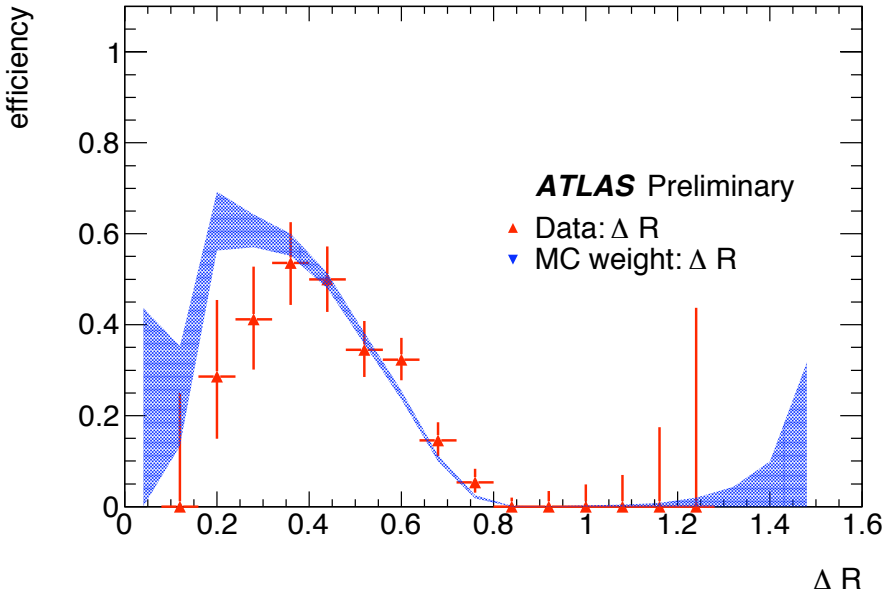
EF_2mu4_Jpsimumu: MC/DATA Comparison





MC: Bayes Theorem with EF_mu4

Data: Bayes Theorem



How to use this method in 2011?

- The method rely on the measurements of EF_mu4 efficiency (with Tag & Probe method)

$$P(EF\_mu4\_Jpsimumu) = \frac{P(EF\_mu4)\,P(EF\_mu4\_Jpsimumu \mid EF\_mu4)}{P(EF\_mu4 \mid EF\_mu4\_Jpsimumu)}$$

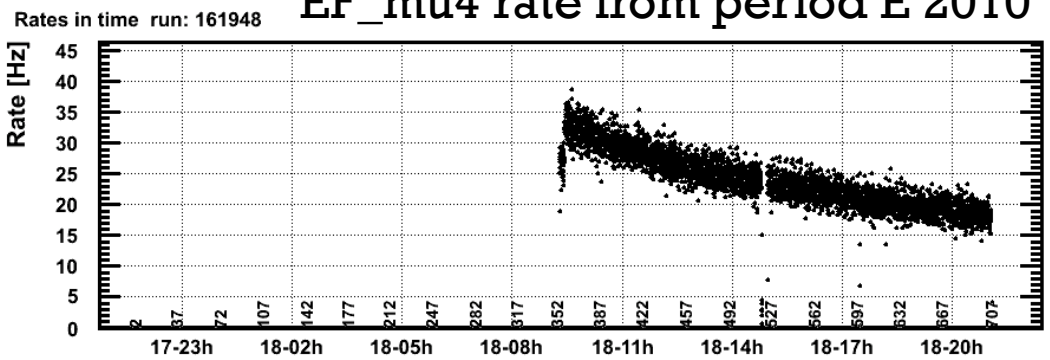
Tag&Probe

- The errors on the EF_mu4 efficiency map are the main source of uncertainty. We would like to avoid the risk that such errors completely dominate the measurements itself

How to use this method in 2011?

- **With 2010 data the errors are O(1%) with > O(5x10^9) EF_mu4 trigger.**

EF_mu4 rate from period E 2010



· EF_mu4_raw 15-30 Hz

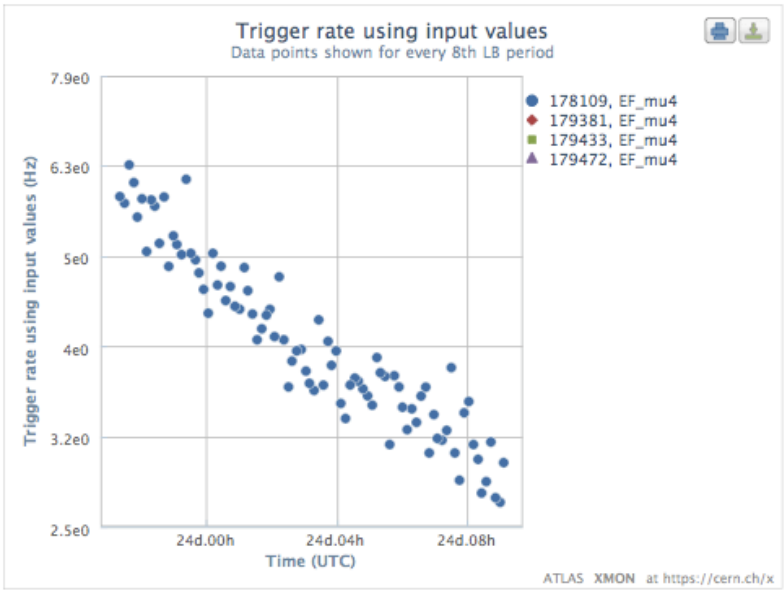
With a minimum request of O(1x10^9) EF_mu4 trigger which is the possible scenario for the allowed bandwidth??

- Fixed but very small O(1Hz)??

- Increase to the maximum Bphys bandwidth at the end of the fill??

- Other possibilities?

EF_mu4 rate from 2011



O(5) Hz

Conclusions and outlooks

- We are running the same procedure on the other dimuon trigger items
- Start to evaluate systematics
- Discussing with the Bphys group for the trigger strategy for the 2011
- Bphys group asked us a note for the dimuon items