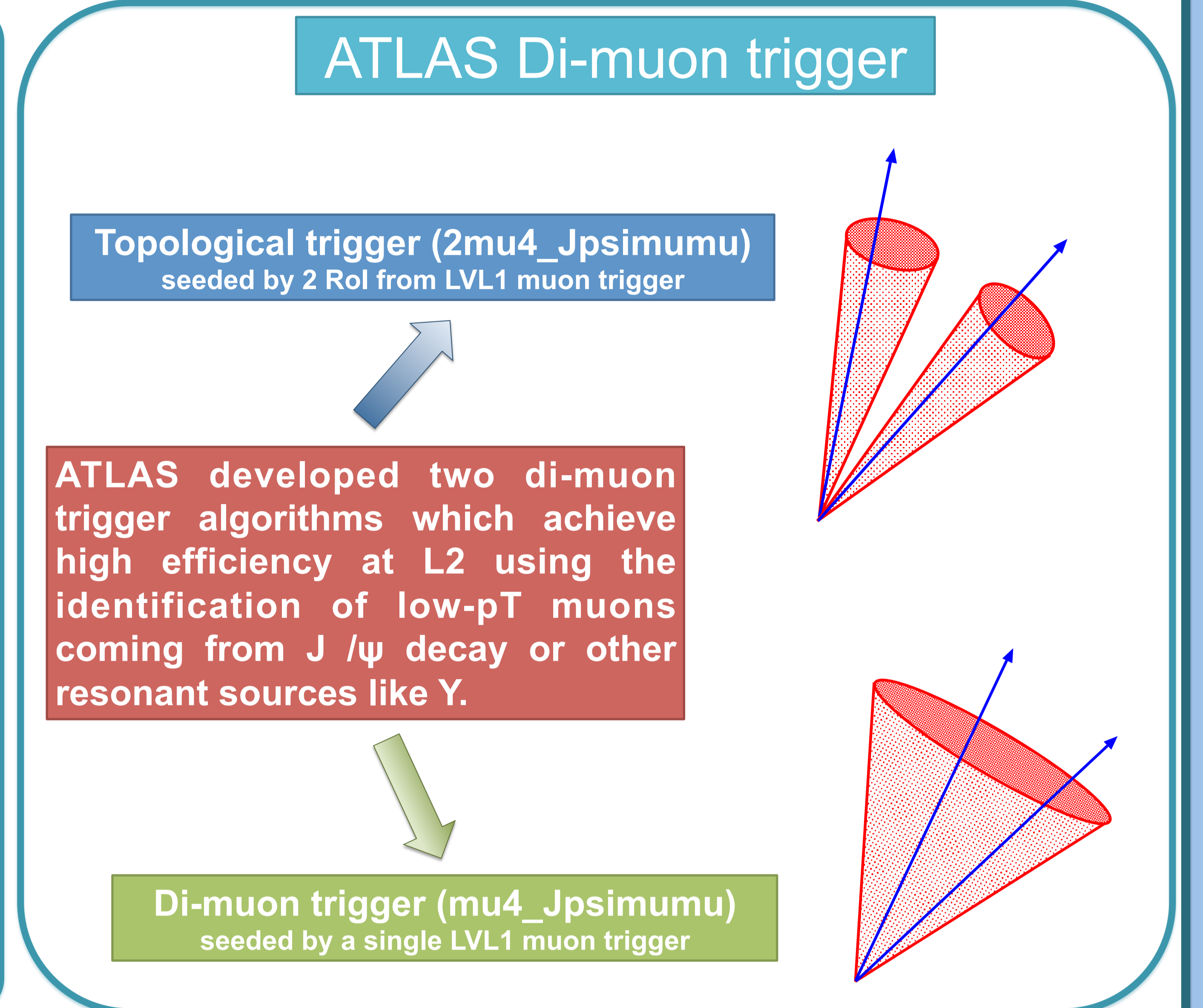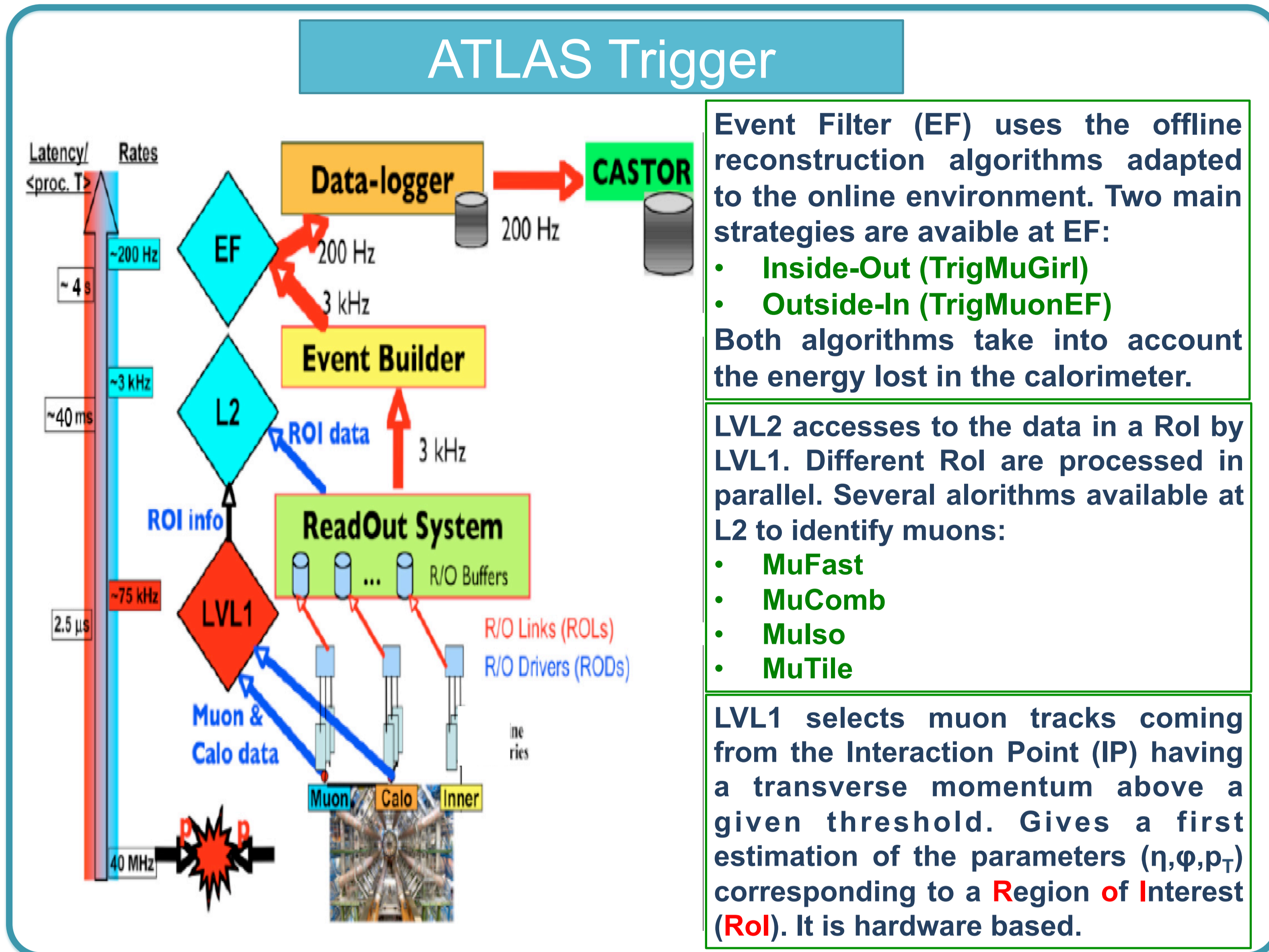# A Measurement of the ATLAS Di-Muon Trigger Efficiency in Proton-Proton Collisions at $\sqrt{s}$ = 7 TeV

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The B physics program of the ATLAS experiment includes the study of the production cross sections, the searches for rare b decays signatures which are sensitive to new physics at the TeV energy scale and the measurements of CP violation effects in B-events, such as $B_s^0 \to J/\psi\ \phi$ and $B_d^0 \to J/\psi\ K_s^0$. The key to the detection of these B signals in ATLAS is to achieve a high trigger efficiency for low-pT di-muon events, keeping an acceptable trigger rate. ATLAS developed two separate approaches for triggering on di-muon events from resonances such as a $J/\psi$ and Upsilon (Y). The first approach is to start from a di-muon trigger selected by the Level-1 trigger while the second is based on dedicated Level-2 algorithm. The performance for di-muon trigger has been studied using collision data at $\sqrt{s}$=7TeV collected in 2011.

## ATLAS Trigger



Event Filter (EF) uses the offline reconstruction algorithms adapted to the online environment. Two main strategies are avaible at EF:
- Inside-Out (TrigMuGirl)
- Outside-In (TrigMuonEF)

Both algorithms take into account the energy lost in the calorimeter.

LVL2 accesses to the data in a RoI by LVL1. Different RoI are processed in parallel. Several alorithms available at L2 to identify muons:
- MuFast
- MuComb
- MuIso
- MuTile

LVL1 selects muon tracks coming from the Interaction Point (IP) having a transverse momentum above a given threshold. Gives a first estimation of the parameters ($\eta,\varphi,p_T$) corresponding to a **R**egion **o**f **I**nterest (**RoI**). It is hardware based.

## ATLAS Di-muon trigger

**Topological trigger (2mu4_Jpsimumu)**
seeded by 2 RoI from LVL1 muon trigger

ATLAS developed two di-muon trigger algorithms which achieve high efficiency at L2 using the identification of low-pT muons coming from $J/\psi$ decay or other resonant sources like Y.

**Di-muon trigger (mu4_Jpsimumu)**
seeded by a single LVL1 muon trigger



## Efficiency Evaluation

**Basic Idea:** to use the Bayes theorem to measure the di-muon trigger efficiencies

$$P(Trigger\_2\mu) = \frac{P(Trigger\_1\mu) \otimes P(Trigger\_2\mu | Trigger\_1\mu)}{P(Trigger\_1\mu | Trigger\_2\mu)}$$

Trigger_1μ = Single-muon trigger item
Trigger_2μ = Di-muon trigger item

### $P(Trigger\_1\mu)$

We use the single-muon trigger results obtained with standard Tag and Probe method*

\* A measurement of the ATLAS muon reconstruction and trigger efficiency using J/psi decays ATLAS-CONF-2011-021



Efficiency vs pT for single muon trigger EFmu4 and EFmu6
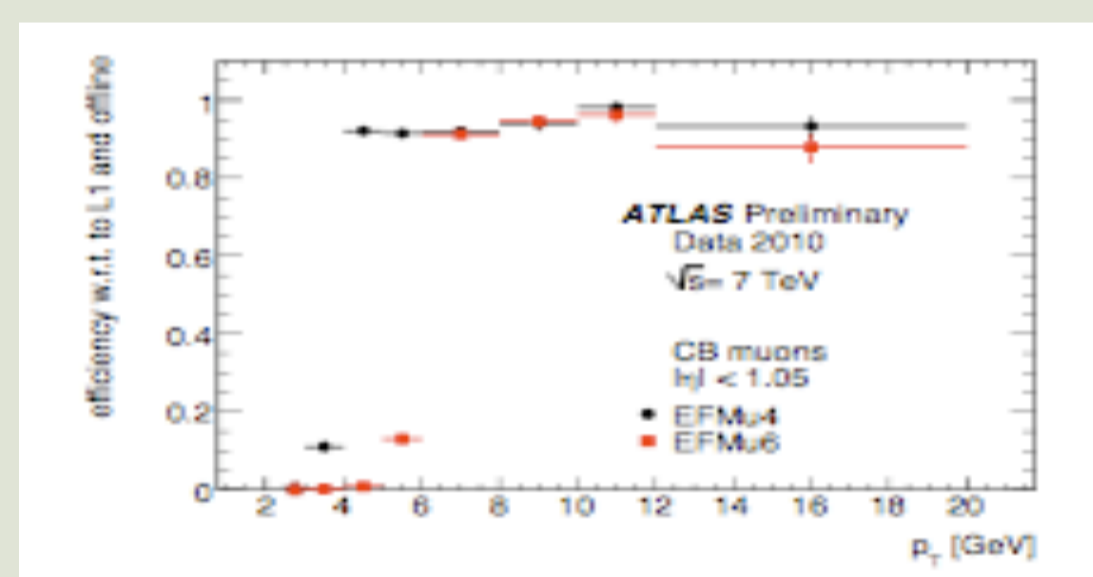
### $P(Trigger\_2\mu | Trigger\_1\mu)$

Ratio between all the events that fired the Trigger_1μ and the ones that fired the Trigger_1μ AND the Trigger_2μ

### $P(Trigger\_1\mu | Trigger\_2\mu)$

Ratio between all the events that fired the Trigger_1μ AND the Trigger_2μ and the ones that fired the Trigger_1μ

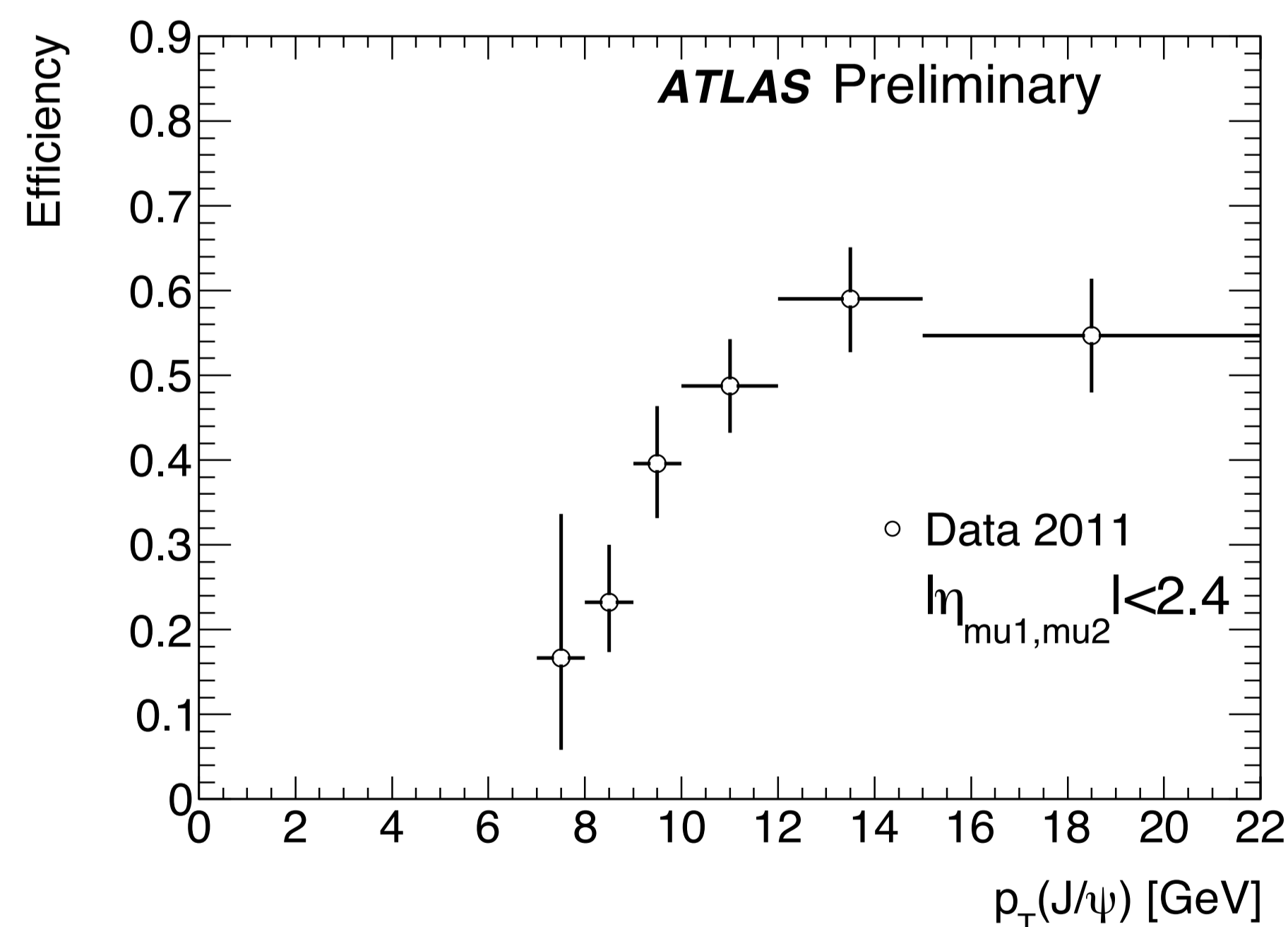## Efficiencies for the topological trigger EF_2mu4_jpsimumu



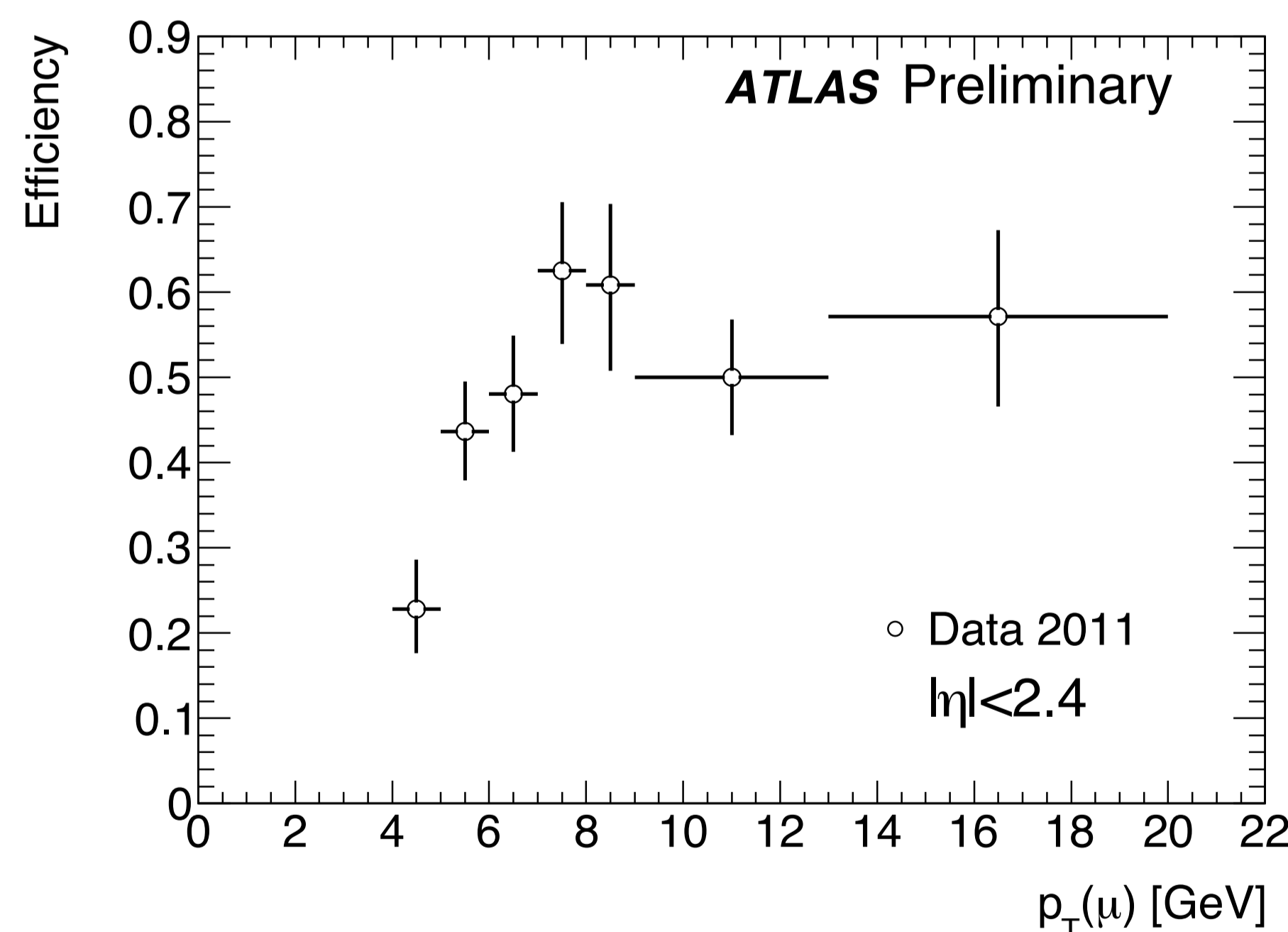Figure 1: Efficiency of the EF_2mu4_Jpsimumu vs J/ψ candidate $p_T$.



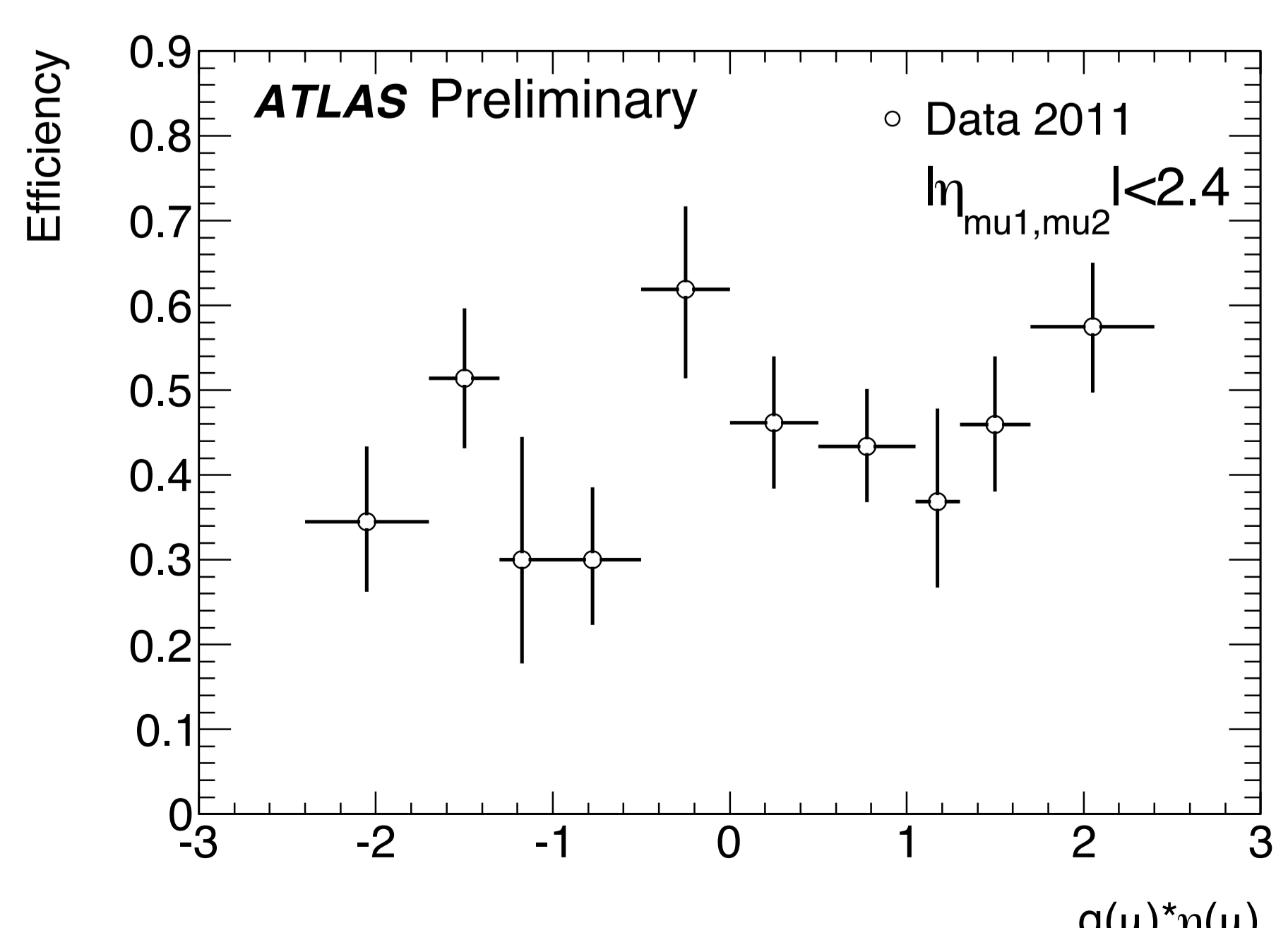Figure 2: Efficiency of the EF_2mu4_Jpsimumu vs μ1 reconstructed $p_T$.

**Data sample:**
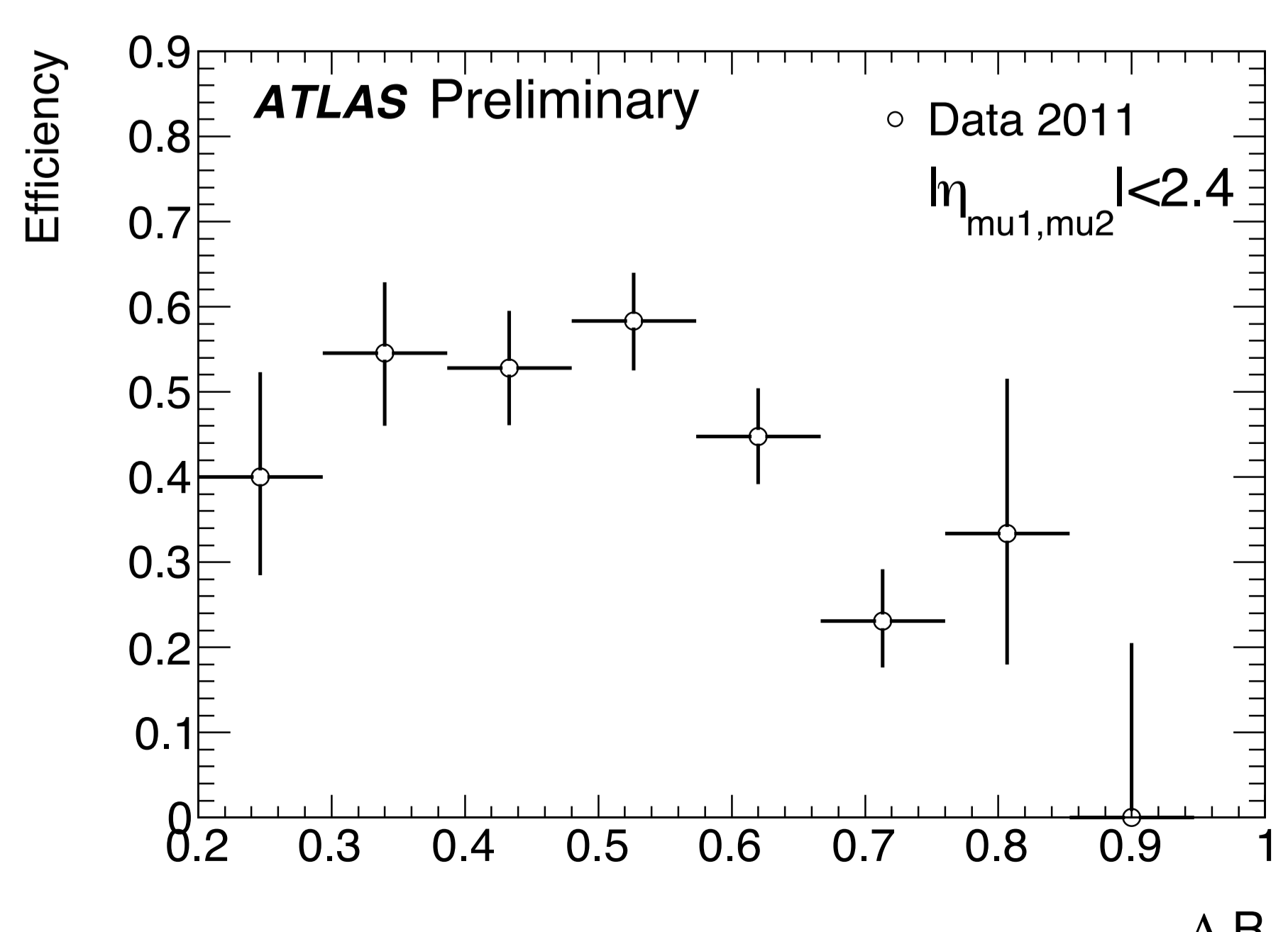- **Two Opposite sign fully combined muons**
- **Di-muon invariant mass range (2800-3340 MeV/c²)**
- **Muons $p_T$>4 GeV/c**
- **Muons |η|<2.4**

- μ1 is the muon with higher $p_T$ inside the di-muon pair
- μ2 is the muon with lower $p_T$ inside the di-muon pair



Figure 3: Efficiency of the EF_2mu4_Jpsimumu vs μ1 reconstructed q*η



Figure 4: Efficiency of the EF_2mu4_Jpsimumu vs ΔR between the two muons.