Study of J/ψ polarization in pp collisions at 8 TeV.

Performance of a new front-end electronics for the muon trigger system of ALICE.

Arianna Batista Camejo LPC Clermont Ferrand

for the ALICE Collaboration

JRJC 2015

Outline

- J/ψ polarization
  - Motivation
  - Introduction to the methods
  - The ALICE detector
  - Analysis procedure
  - Results
- The muon trigger system of ALICE. Performance studies.
  - Trigger system description
  - Motivation for the upgrade strategy
  - Performance of RPC with new FEE

Part 1

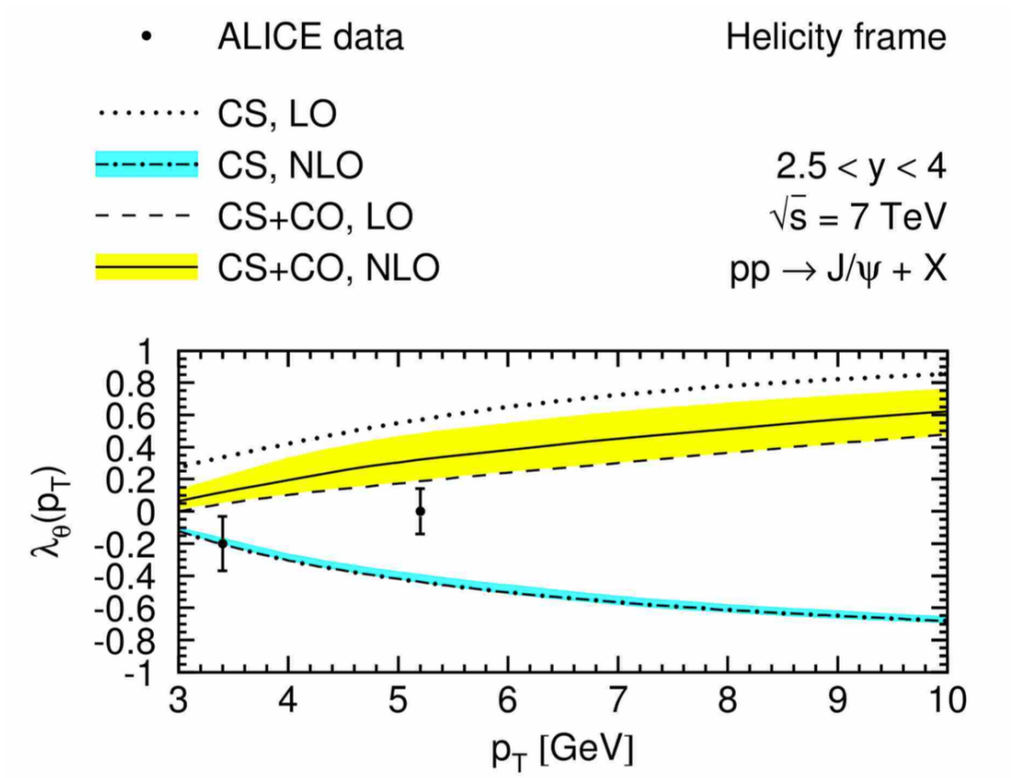
Study of J/ψ polarization in pp collisions at 8 TeV.

Motivation

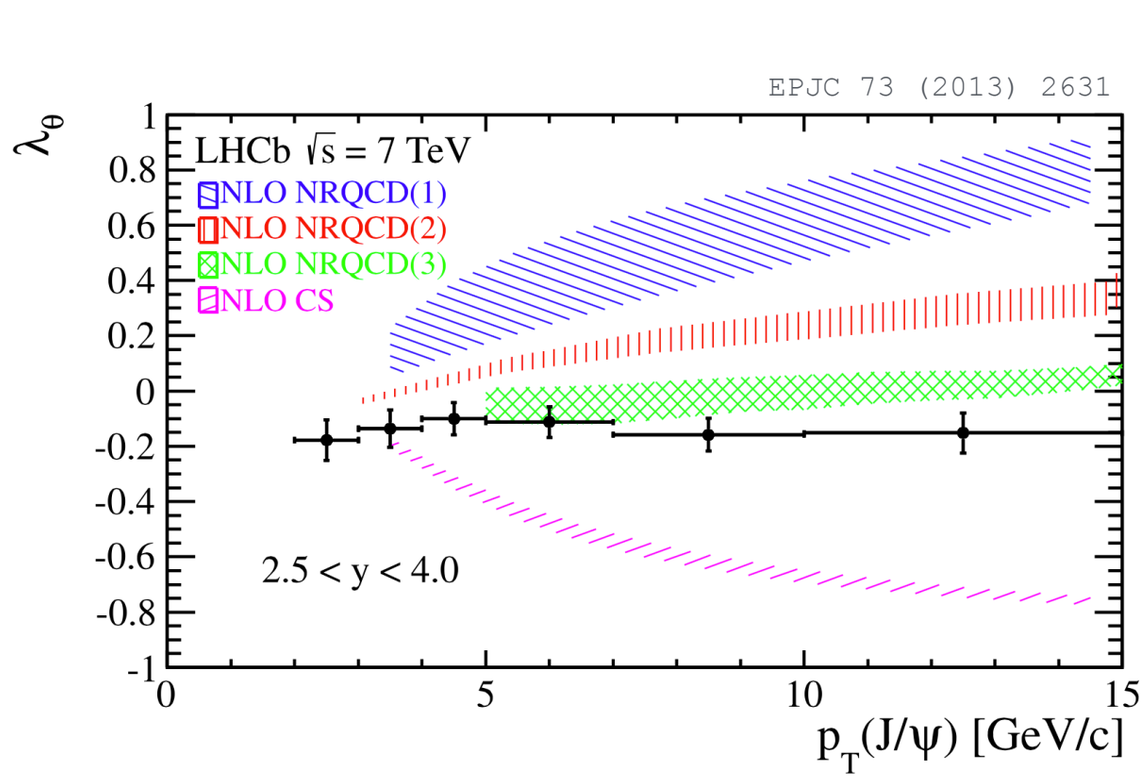
Quarkonium production measurements in pp collisions constitute a test of QCD.

production of the heavy-quark pair (**perturbative** treatment)	x	evolution into the physical quarkonium state (**non-perturbative**)

Different theoretical models (CEM [1], CSM [2], COM [3]) are not able to simultaneously describe quarkonium production and polarization [4].



PRL 108, 082001



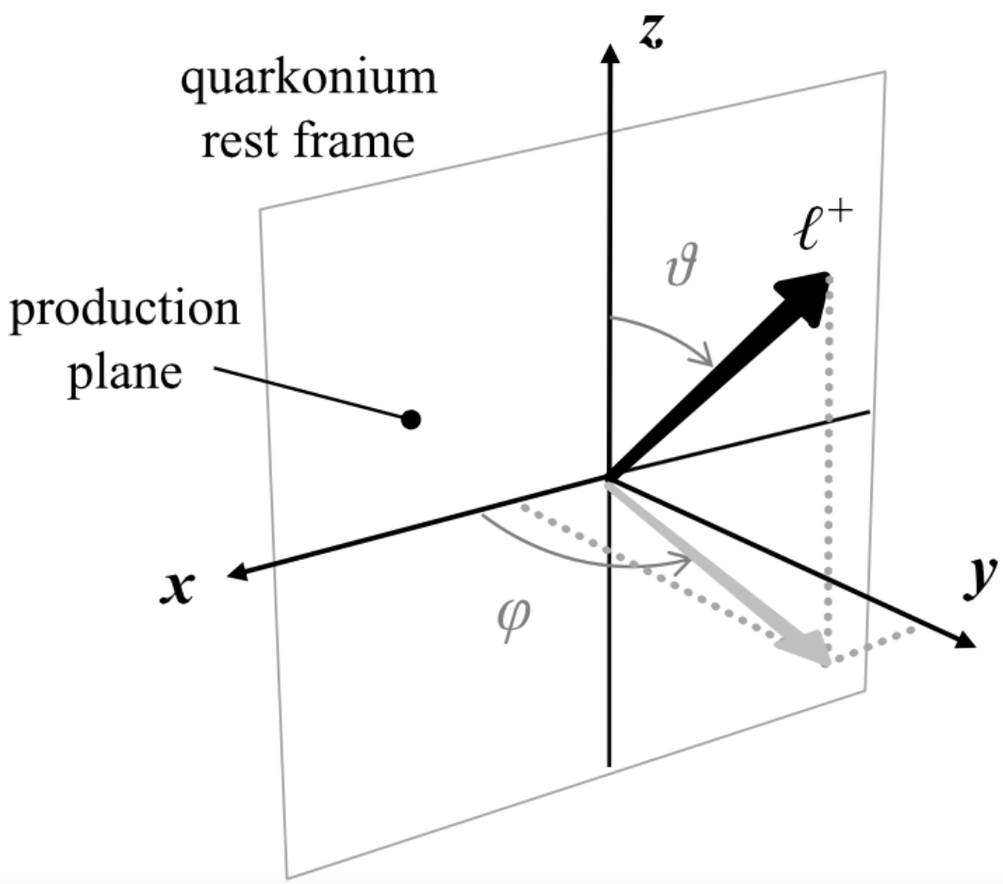
EPJC 73 (2013) 2631

[1] Phys. Lett. B 67 (1977) 217
[2] Phys. Rev. D. 12 (1975) 2007
[3] Phys. Rev. D 51 (1995) 1125
[4] Eur. Phys. J. C 61 (2009) 693

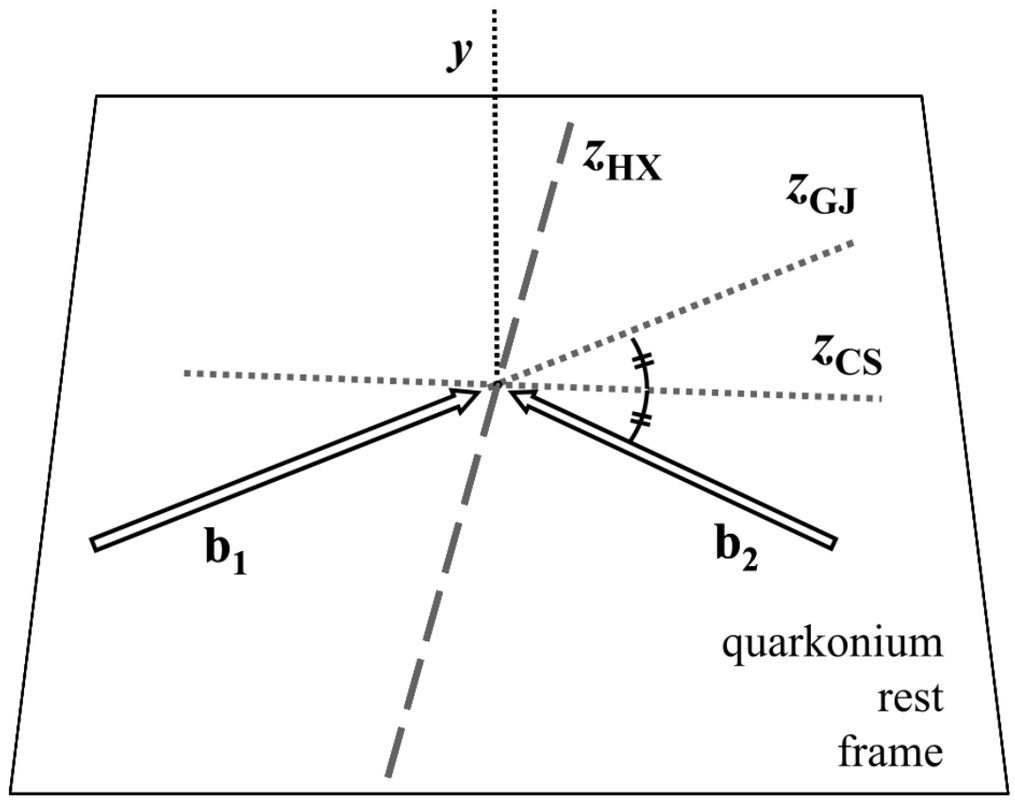
Introduction

- Polarization is referred to the degree of alignment of the J/ψ total angular momentum (J=1) with respect to a quantization axis.
- The information can be retrieved from its decay products ($J/\psi \rightarrow \mu^+\mu^-$).

Coordinate system:



Eur. Phys. J. C (2010) 69



Conventions for choosing the quantization axis in the J/ψ rest frame for colliding systems.

Methods

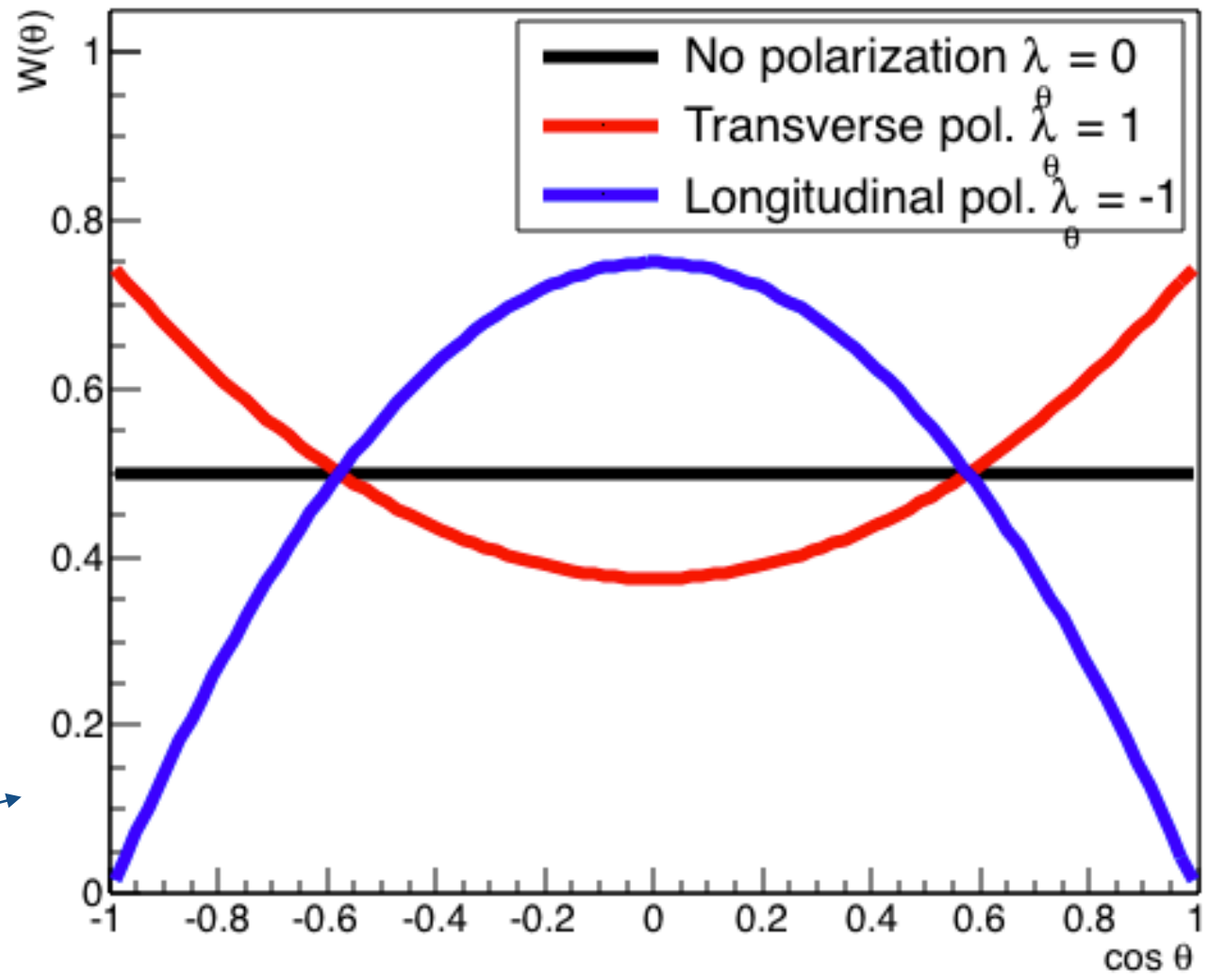
Angular distribution of decay muons:

$$W(cos\theta,\varphi) \propto \frac{1}{3+\lambda_\theta}(1 + \lambda_\theta cos^2\varphi + \lambda_\varphi sin^2\theta cos2\varphi + \lambda_{\theta\varphi} sin2\theta cos\varphi$$

λ_θ, λ_φ and $\lambda_{\theta\varphi}$ are the polarization parameters

Integrating over φ:

$$W(\cos\theta) \propto \frac{1}{3+\lambda_\theta}(1 + \lambda_\theta \cos^2\theta)$$



Eur. Phys. J. C (2010) 69

Methods

Angular distribution $$W(\cos\theta) \propto \frac{1}{3+\lambda_\theta}(1+\lambda_\theta \cos^2\theta)$$

Procedure:

- Split the data in cosθ and p_T bins and reconstruct the J/ψ from the unlike sign muon pairs (invariant mass distribution)
- Correct by the acceptance and efficiency of the detector (MC simulation)
- Get the polarization parameter by fitting the corrected distribution

Alternatively, **counting populations** method:

$$\frac{P(|\cos\theta|>1/2)-P(|\cos\theta|<1/2)}{P(|\cos\theta|>1/2)+P(|\cos\theta|<1/2)} = \frac{3}{4}\frac{\lambda_\theta}{3+\lambda_\theta}$$

- Only 2 cosθ bins
- Less sensitive to Axε
- No estimator of correctness of the method

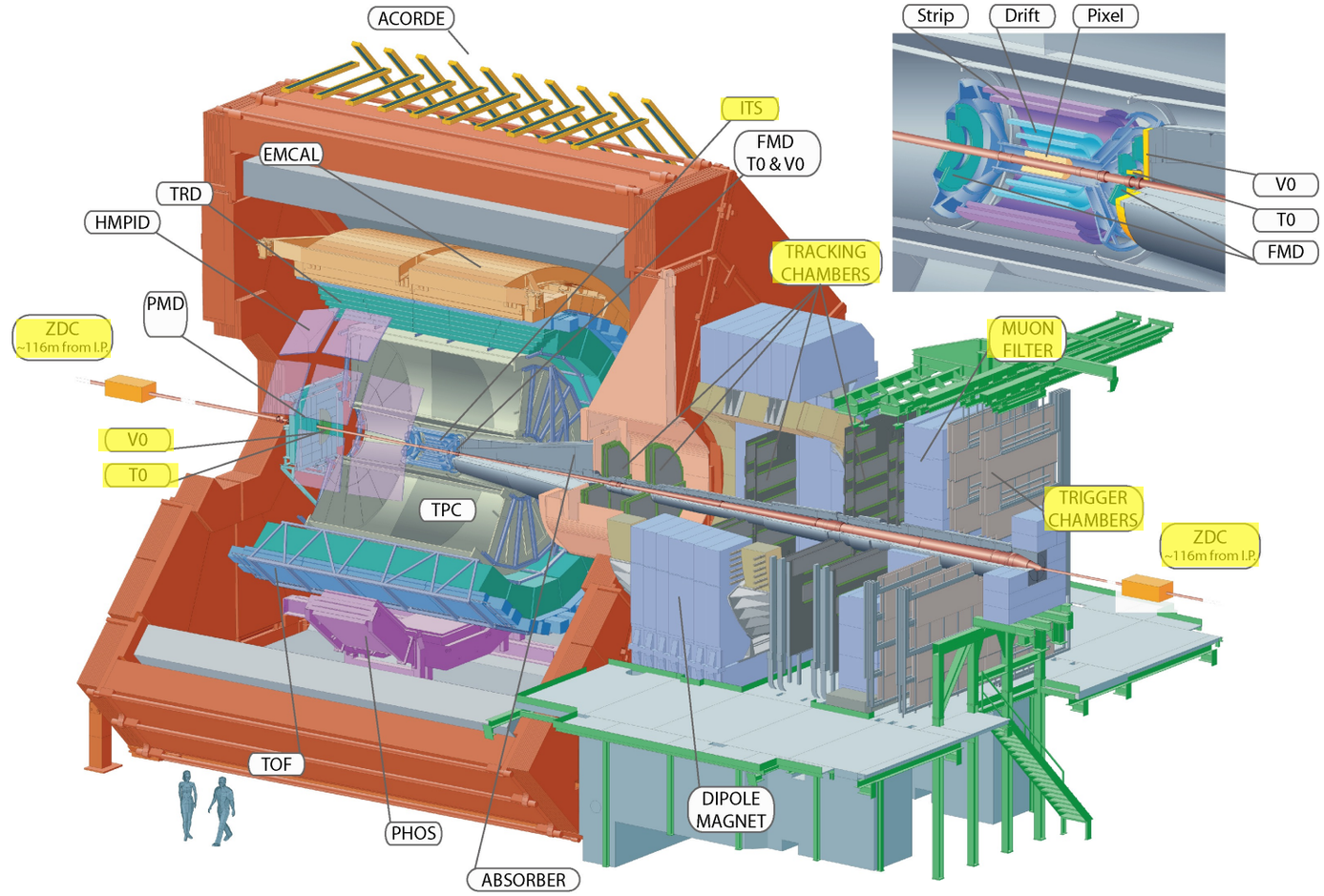
The ALICE detector

J/ψ identification at forward rapidity **$\mu^+\mu^-$ decay channel**

Forward Muon Spectrometer reconstruction of charmonia in the rapidity range **2.5 < *y* < 4** and down to $p_T = 0$.

The **Silicon Pixel Detector** is used for primary vertex reconstruction.

V0, **T0** and **Muon Trigger** are used for triggering purposes.



JINST 3 (2008) S08002

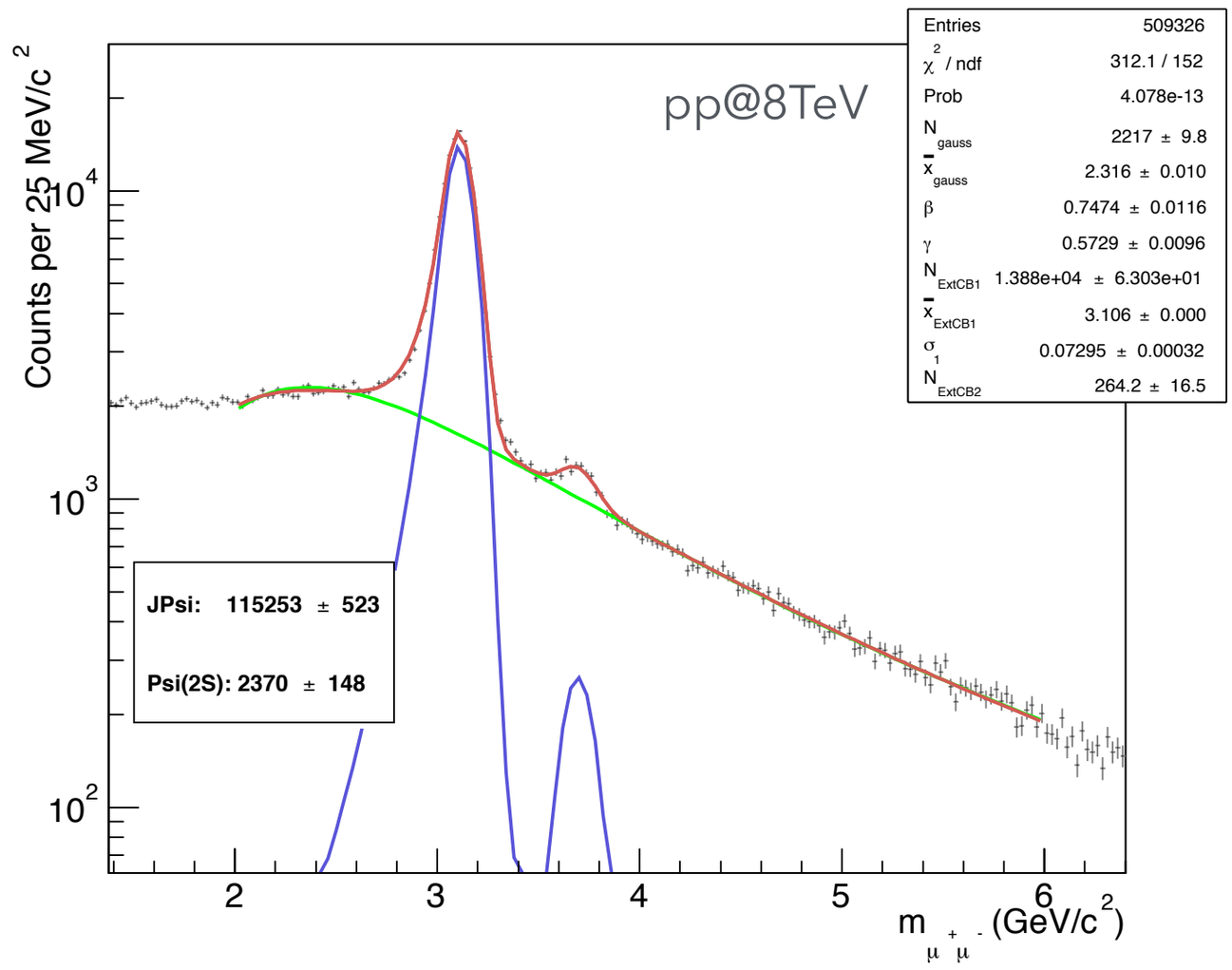
J/ψ reconstruction

Selection

- Muon tracks in the pseudo rapidity acceptance of the muon spectrometer: $-4 < \eta < -2.5$
- Transverse radius of the track at the end of the front absorber: $17.6 < R_{abs} < 89.5$ cm
- Muon tracks in the tracking chambers must match a track reconstructed in the trigger system.

Signal extraction

- Two extended Crystal Ball or two pseudo-Gaussian functions for J/ψ and ψ(2S) signals.
- Variable Width Gaussian or 4th order polynomial multiplied by an exponential function for background.

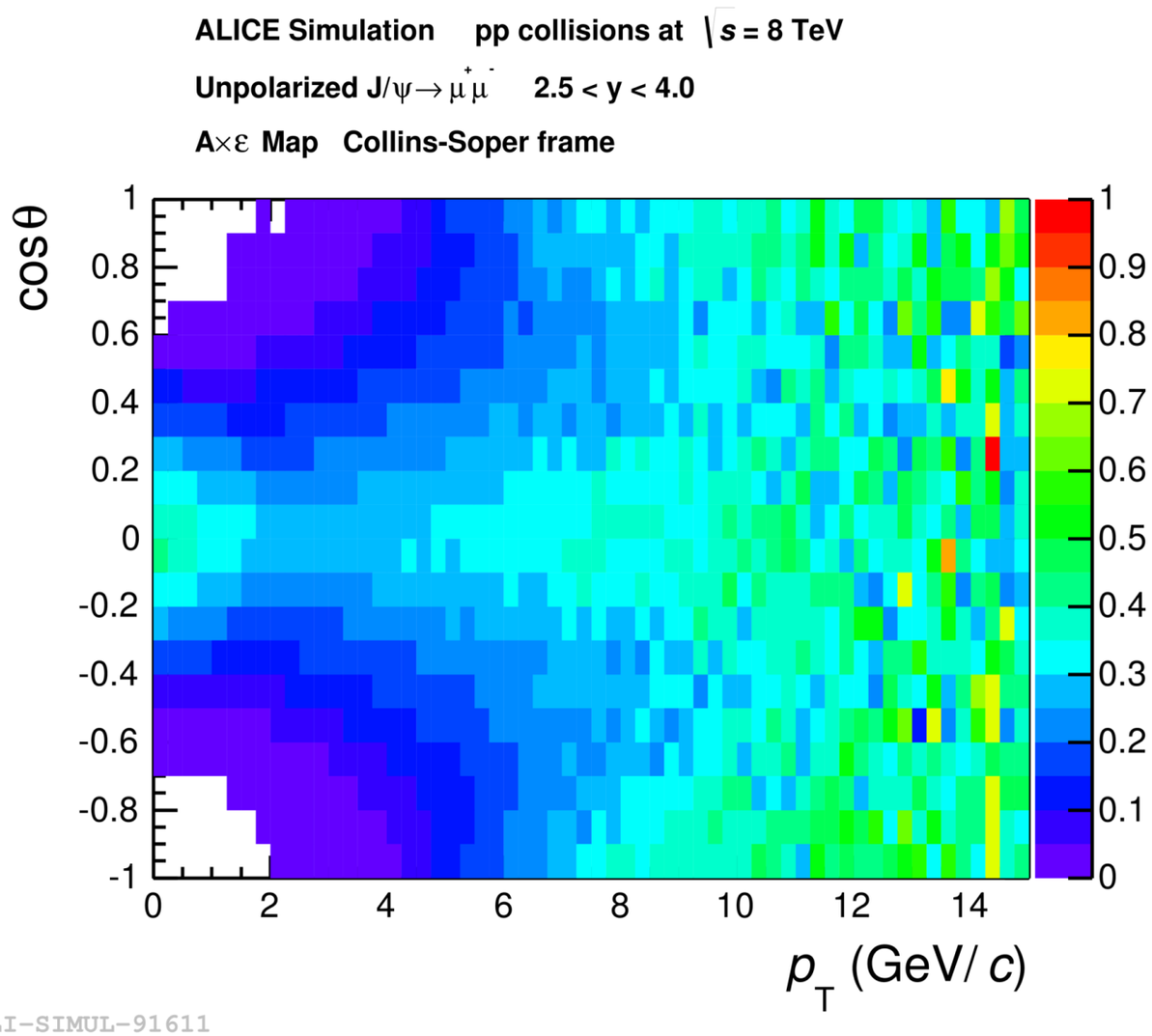


Inclusive measurements

direct **J/ψ**
+ feed down (from ψ(2S) and χ_C states)
+ non-prompt (b-decays)

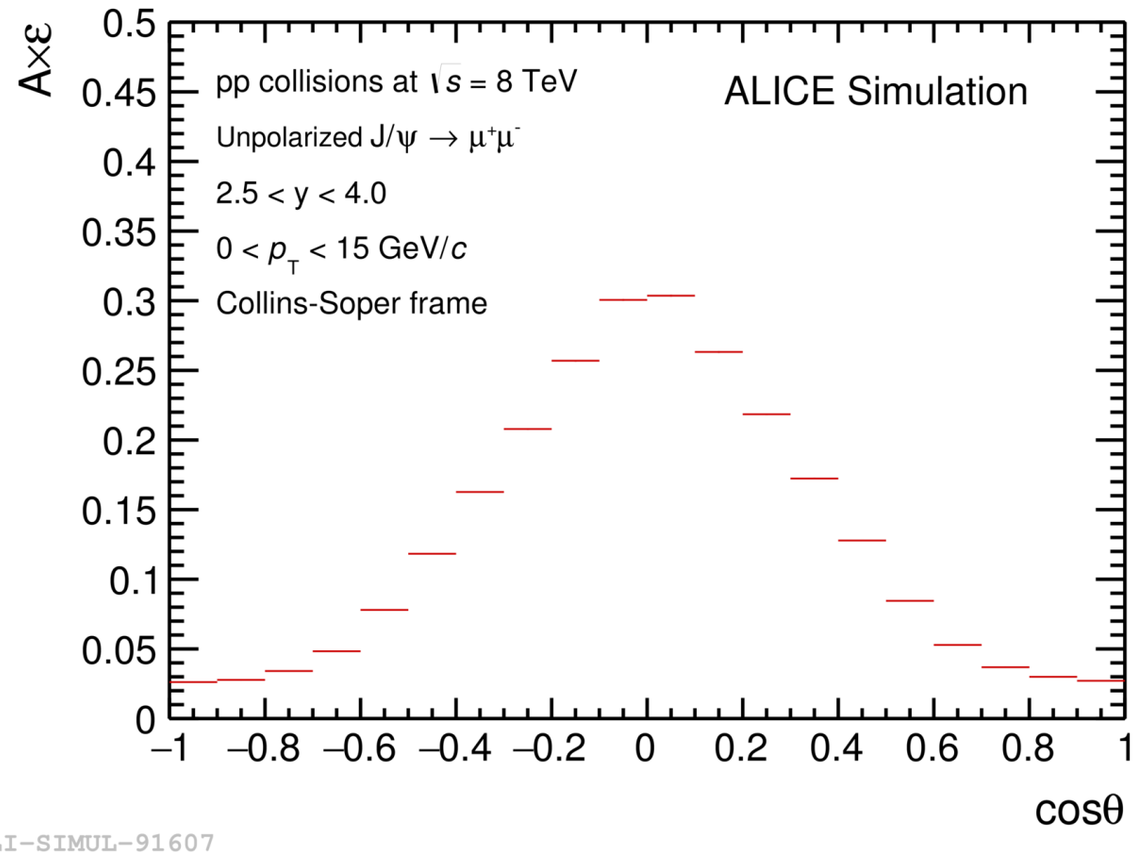
Simulation

Axε values are obtained from a pure J/ψ simulation under the assumption of non-polarized J/ψ.



ALI-SIMUL-91611

p_T integrated Axε CS system

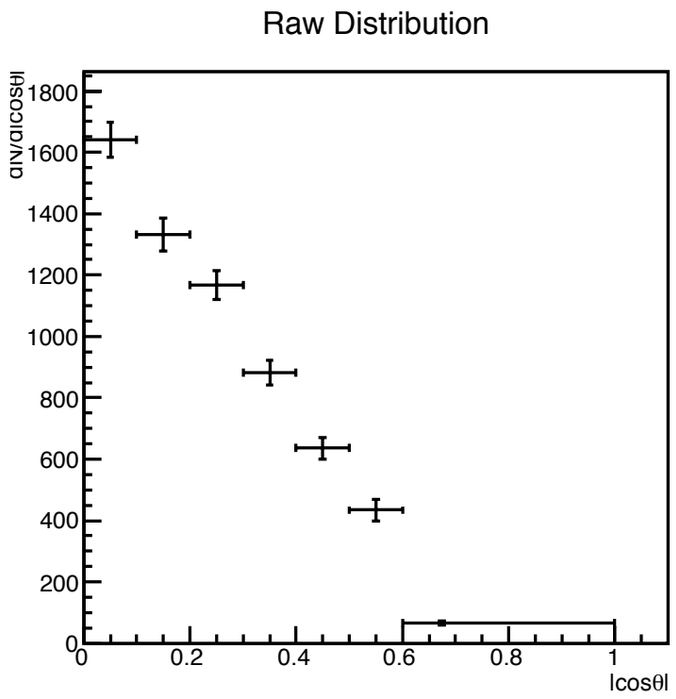


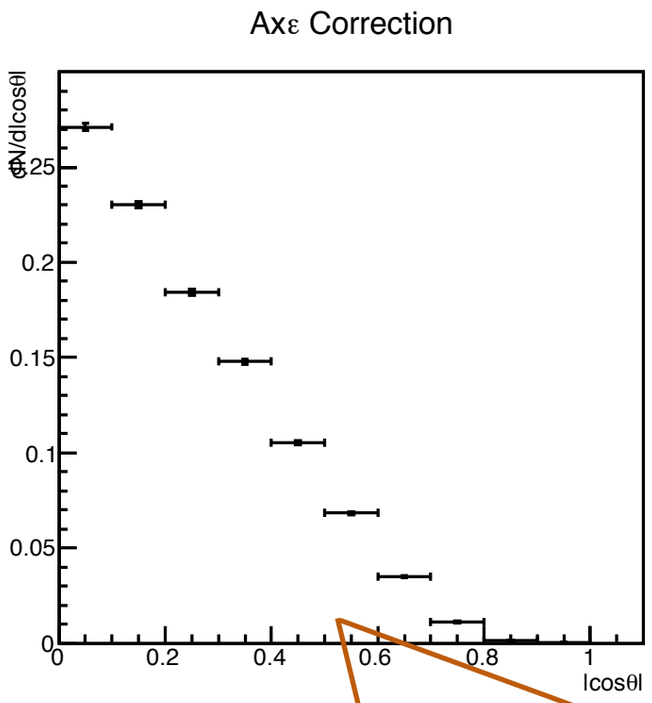
ALI-SIMUL-91607

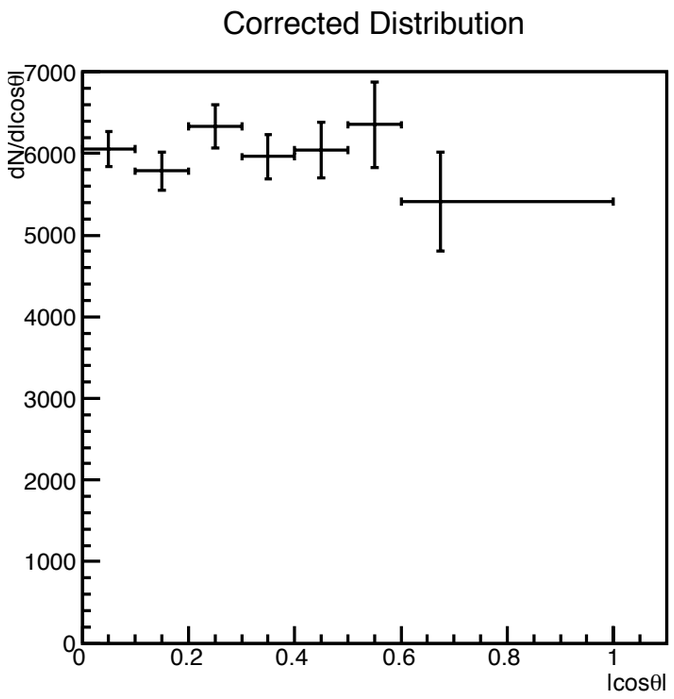
Axε is very low in the low-p_T range (below 2 GeV/c) and for extreme cosθ values what makes difficult the analysis in that region. At high-p_T our statistics limits the signal extraction.

Axε correction

p_T bin: 2-3 GeV/c

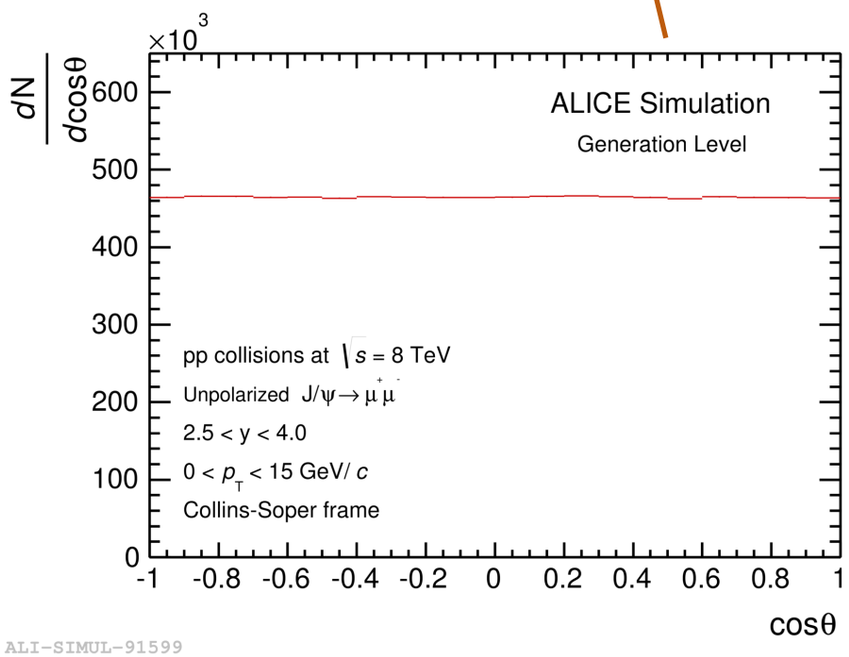


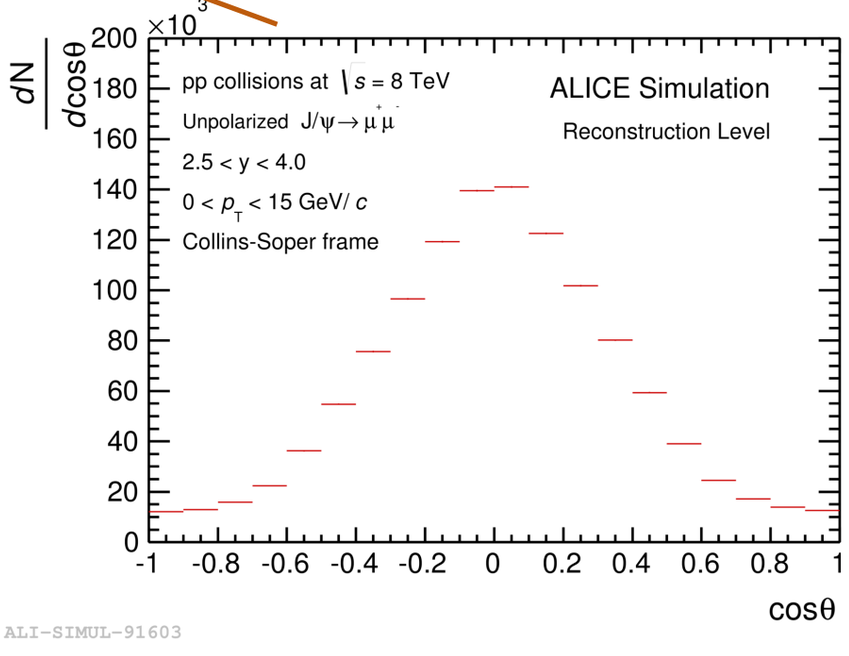




We also use MC at generation level to validate our method.

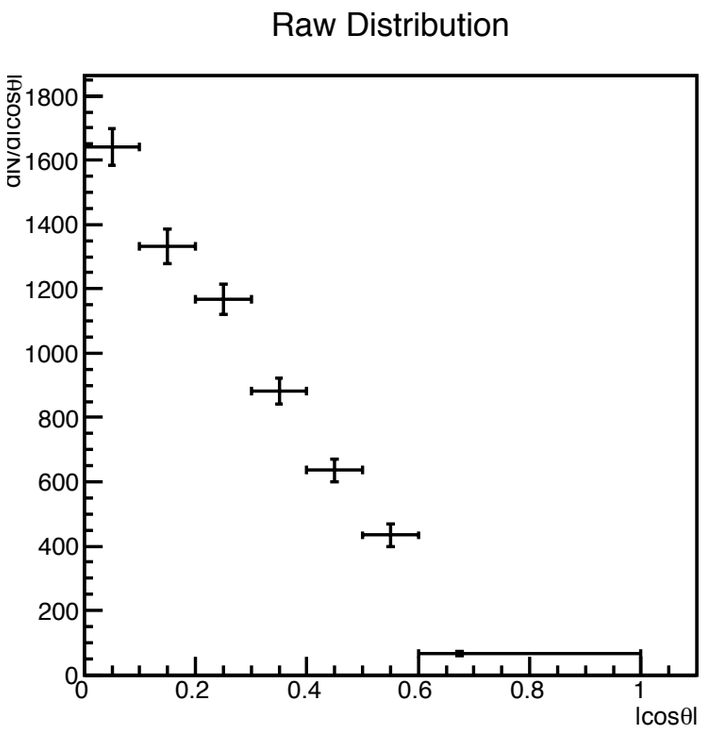
We should obtain $\lambda_\theta = 0$ from the fit.

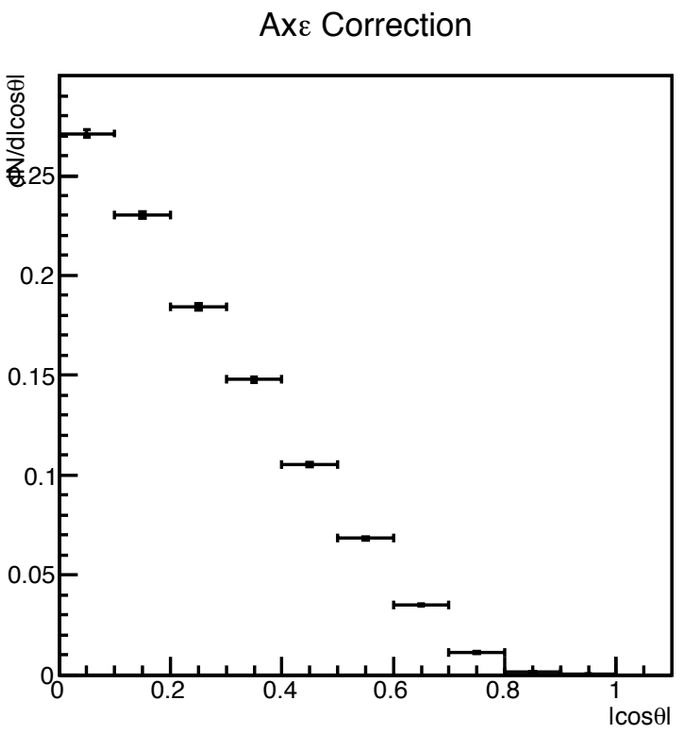


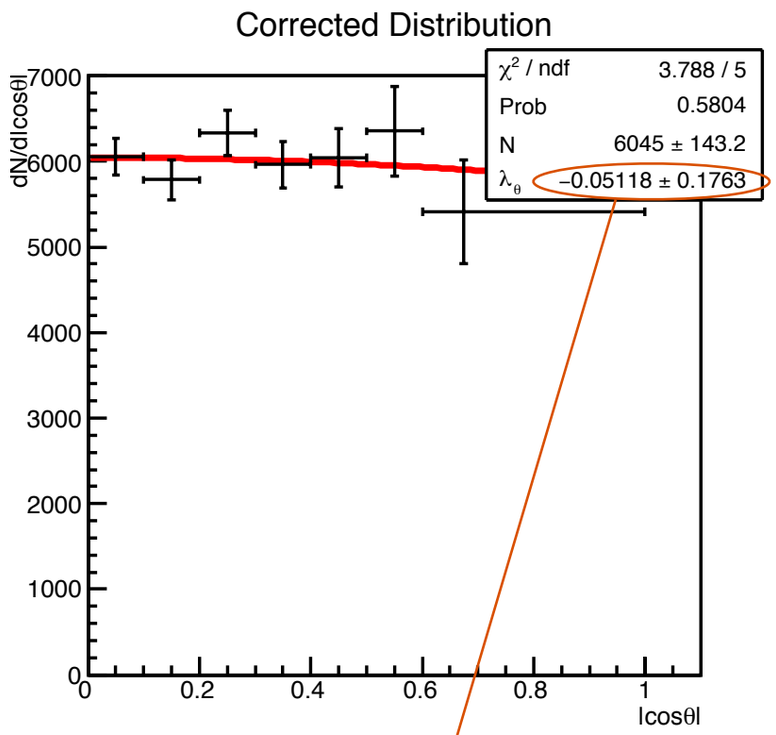


Axε correction

p_T bin: 2-3 GeV/c







Counting of populations

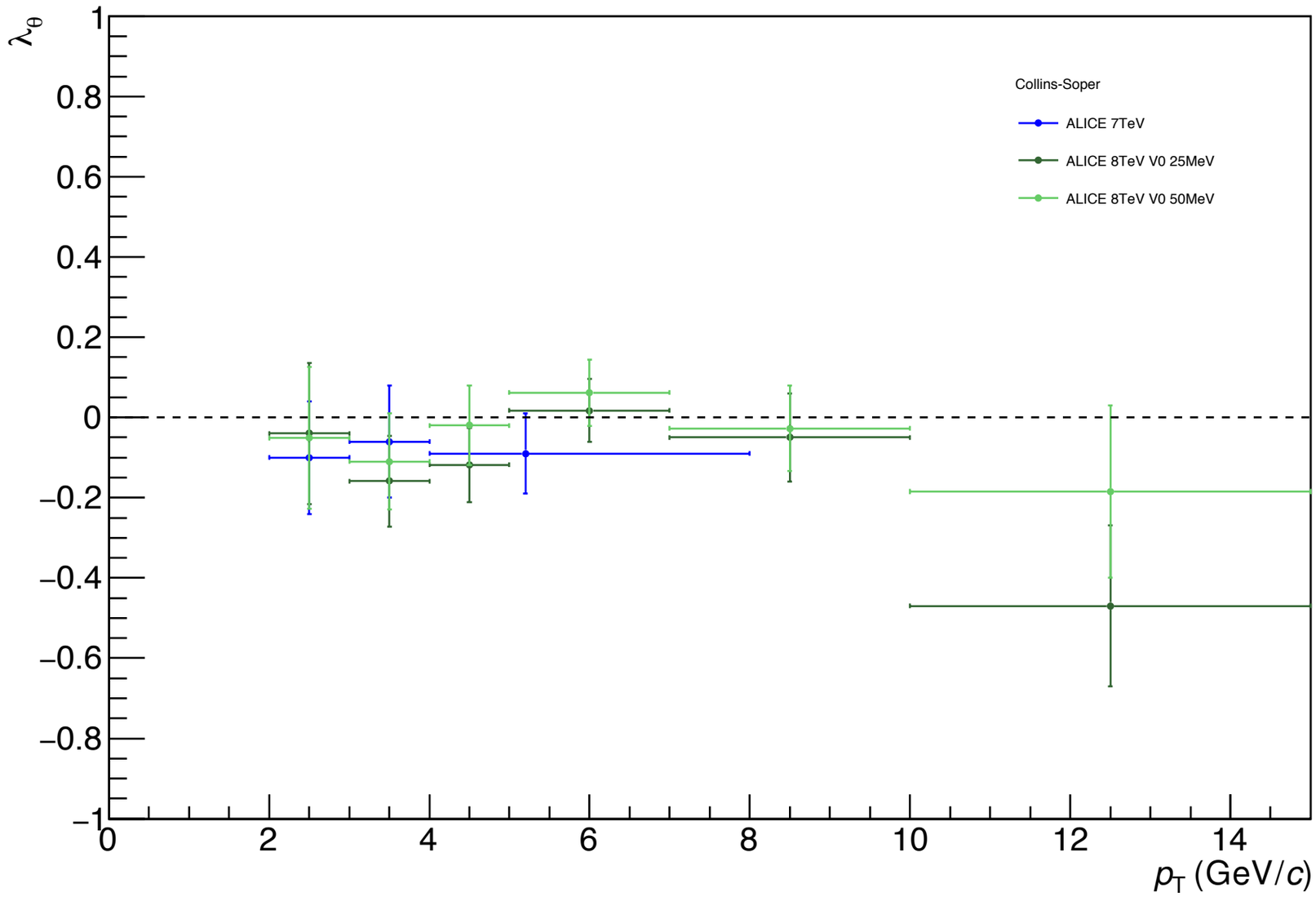
$$\lambda_\theta = 0.00 \pm 0.13$$

$$\lambda_\theta = -0.05 \pm 0.18$$

Both methods give compatible results.

Results

p_T dependence of λ_θ - Method 1 (fit of the angular distributions of decay muons) -



Results are shown for two bin widths for the invariant mass distribution in a first attempt to look at the systematics.

Conclusions and perspectives

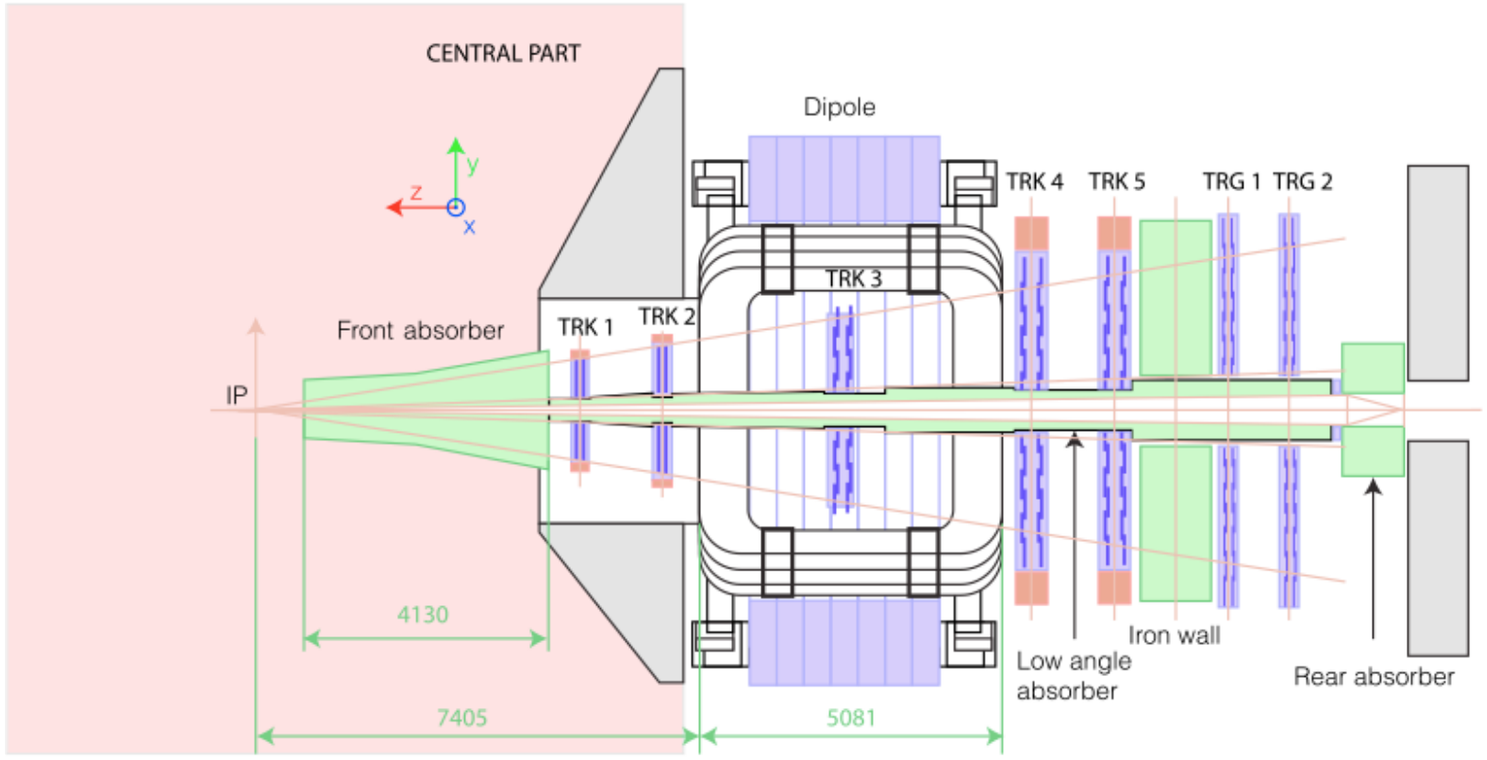
- Preliminary results indicate J/ψ polarization compatible with zero. First look into alternative method gives compatible results.
- The p_T dependence of the λ_θ parameter is in line with previous ALICE [1] and LHCb [2] measurements.
- Systematics uncertainties (signal extraction, trigger efficiency) are under estimation.

[1] PRL 108, 082001
[2] EPJC 73 (2013) 2631

Part 2

Performance of a new front-end electronics for the muon trigger system of ALICE.

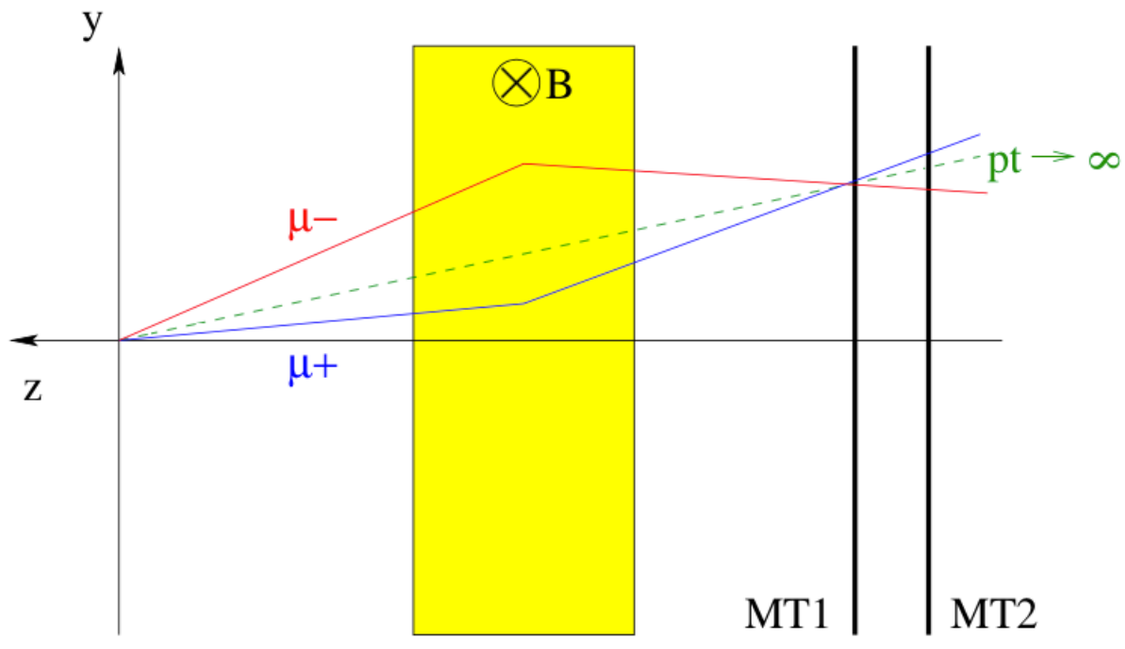
The Muon Spectrometer. Trigger System.



Muon Spectrometer

- front absorber
- beam shield
- 5 tracking stations
- dipole magnet
- muon filter
- 2 trigger stations

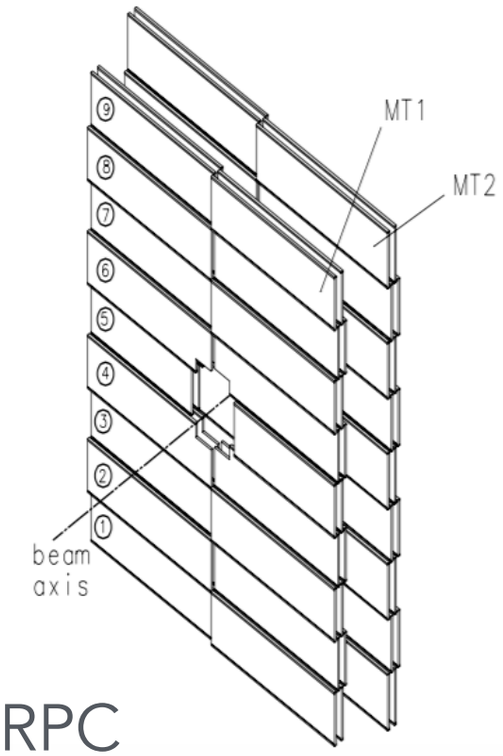
The L0 cut on the transverse momentum of each muon is based on the deviation induced by the dipole magnet.

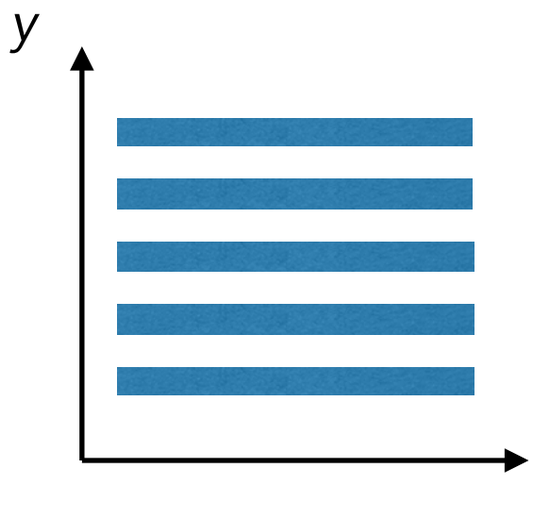


Trigger System

Two trigger stations
(1 m separation)

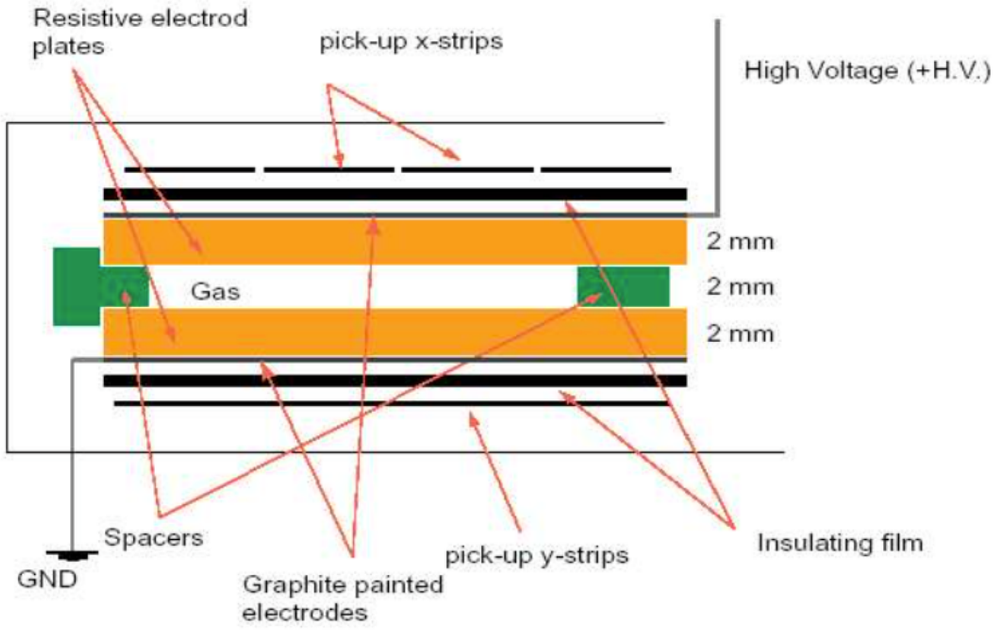
Each station has 2
planes of 18 RPCs.

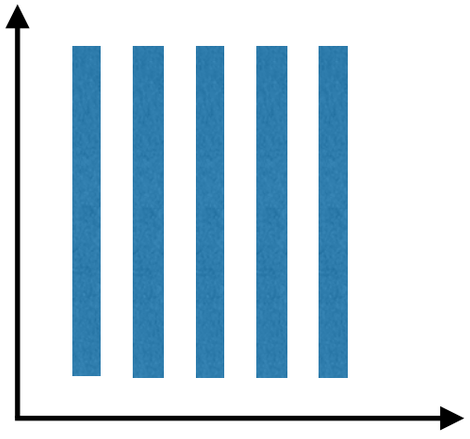




X-strips
Bending Plane

Cross-sectional view of RPC





Y-strips
Non-bending Plane

Different strip widths:
1 cm, 2 cm and 4 cm.

Motivation for a new FEE

Run I

Highly-saturated avalanche mode: signals discriminated without amplification (ADULT FEE)

HV applied to the RPCs: 10.1 - 10.2 kV

Total charge released in the gas gap: ~100 pC / hit

Discrimination thresholds: 7 mV

Run 2

RPC working conditions will be more or less the same

One of the 72 RPCs is already equipped with the new FEE (FEERIC)

Run 3

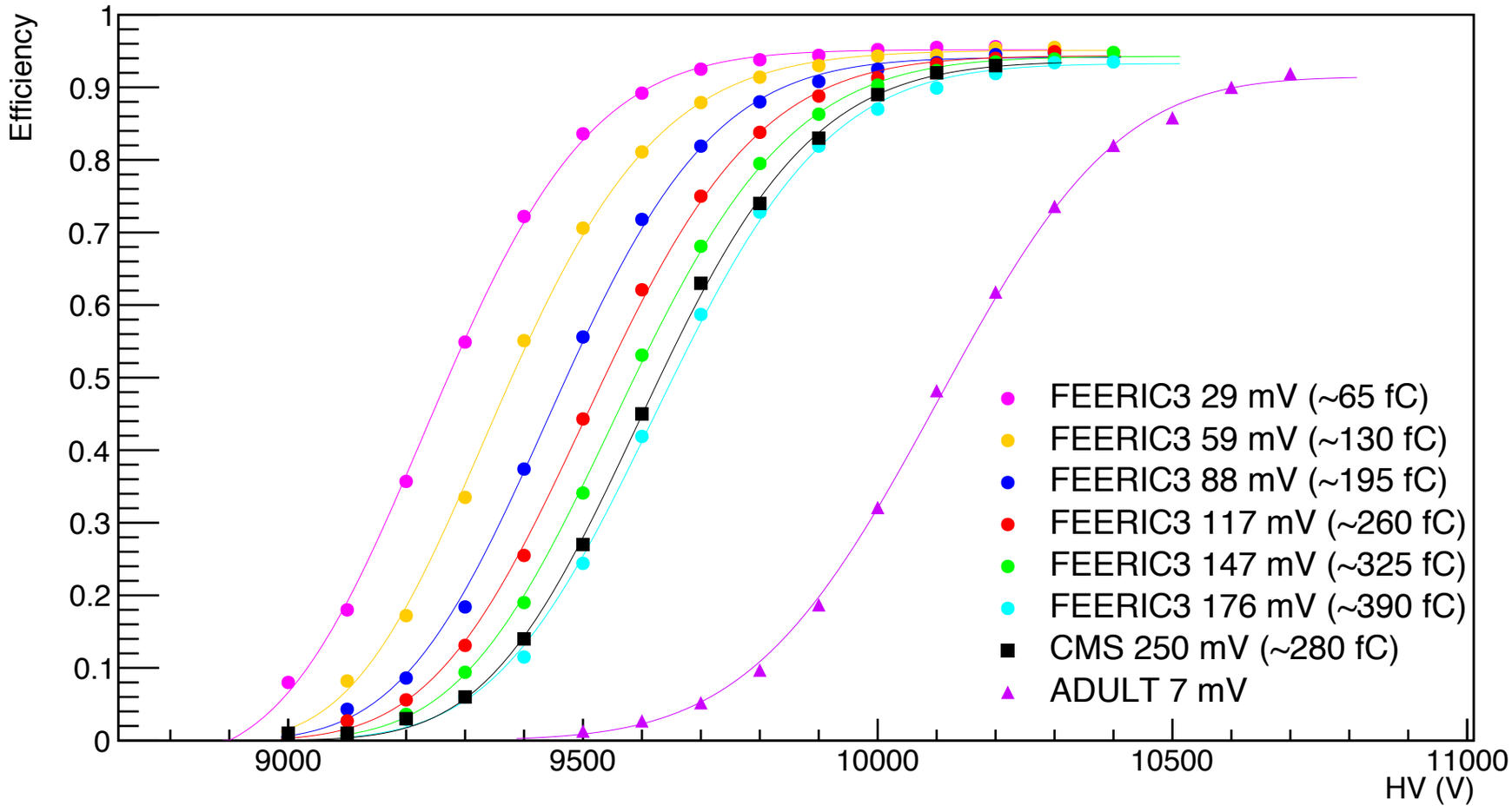
Higher hit rates expected ⇒ it is necessary to prevent RPC ageing

The aim is to use an amplified FEE in order to be able to **decrease the HV** and therefore the **total charge released in the detector gas** (by a factor of 3-5)

First results with the new FEE

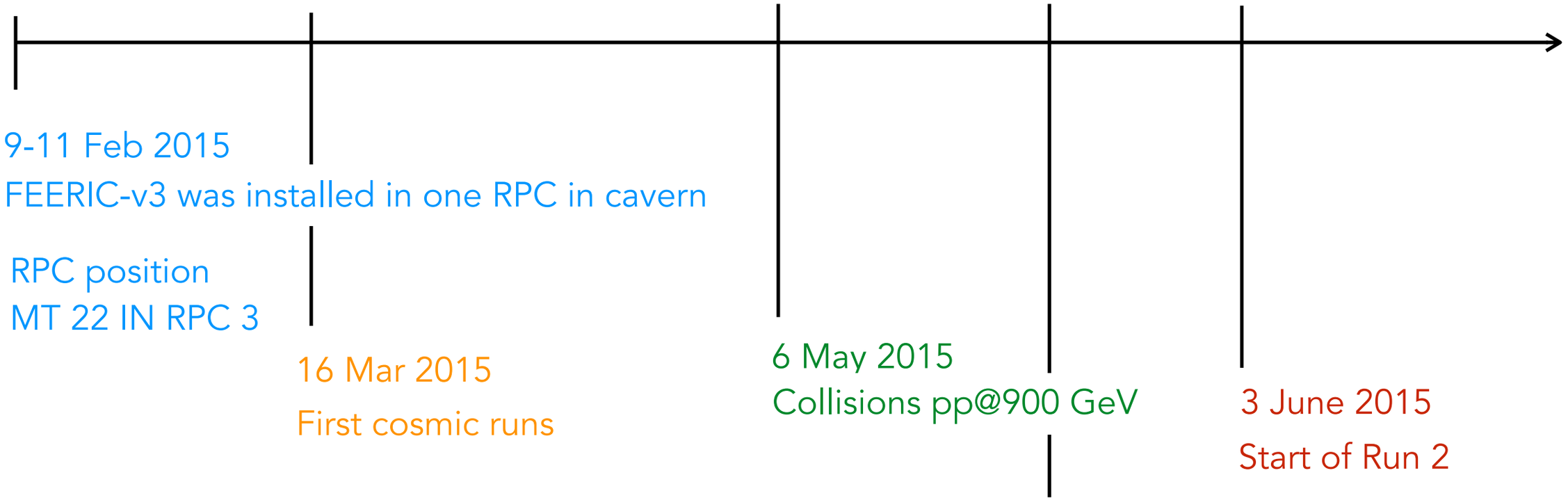
Development of the new front-end electronics FEERIC (Front-End Electronics Rapid Integrated Circuit) started in 2012 at the LPC in Clermont-Ferrand

Current FEERIC-v3 was tested with cosmic rays in Turin



600 - 700 V shift in the efficiency curve with FEERIC-v3 (depending on the threshold) as compared to present conditions with ADULT.

Overview of data taking conditions



Different working conditions were tested:

- **HV in the range ~9-10 kV**
- **Thresholds: 70 mV (~130 fC), 105 mV (~200 fC), 140 mV (~270 fC)**

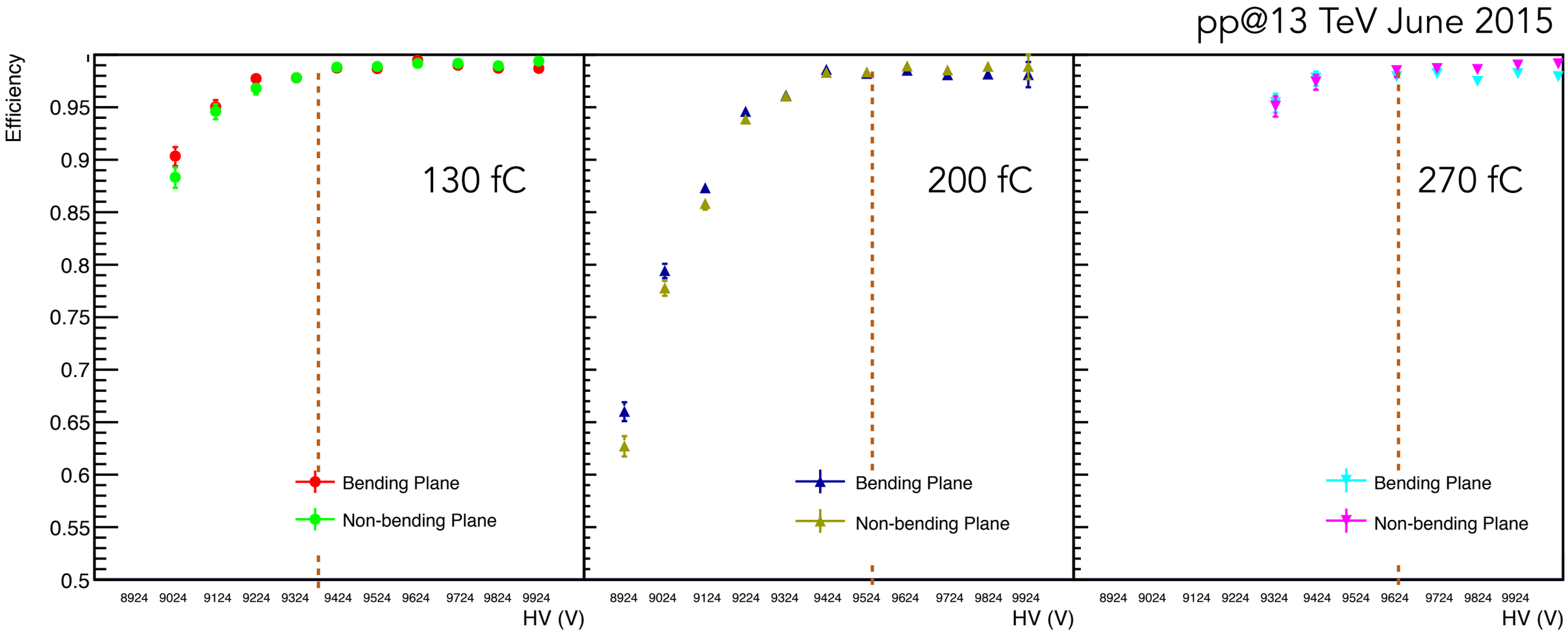
Optimized working conditions:

- **HV = 9375 V**
- **Threshold 130 fC**

Efficiency vs high voltage

Choosing the working conditions:

The plot shows the efficiency as a function of HV for three different values of discrimination thresholds.

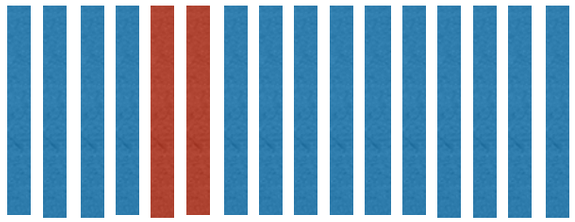


The HV to reach the efficiency plateau increases as a function of the FEE threshold.

Cluster Size

The plot shows the cluster size estimation for strips of 2 cm and 4 cm wide in both, bending and non-bending planes, as a function of HV for the different discrimination thresholds tested.

Cluster size: number of adjacent strips fired

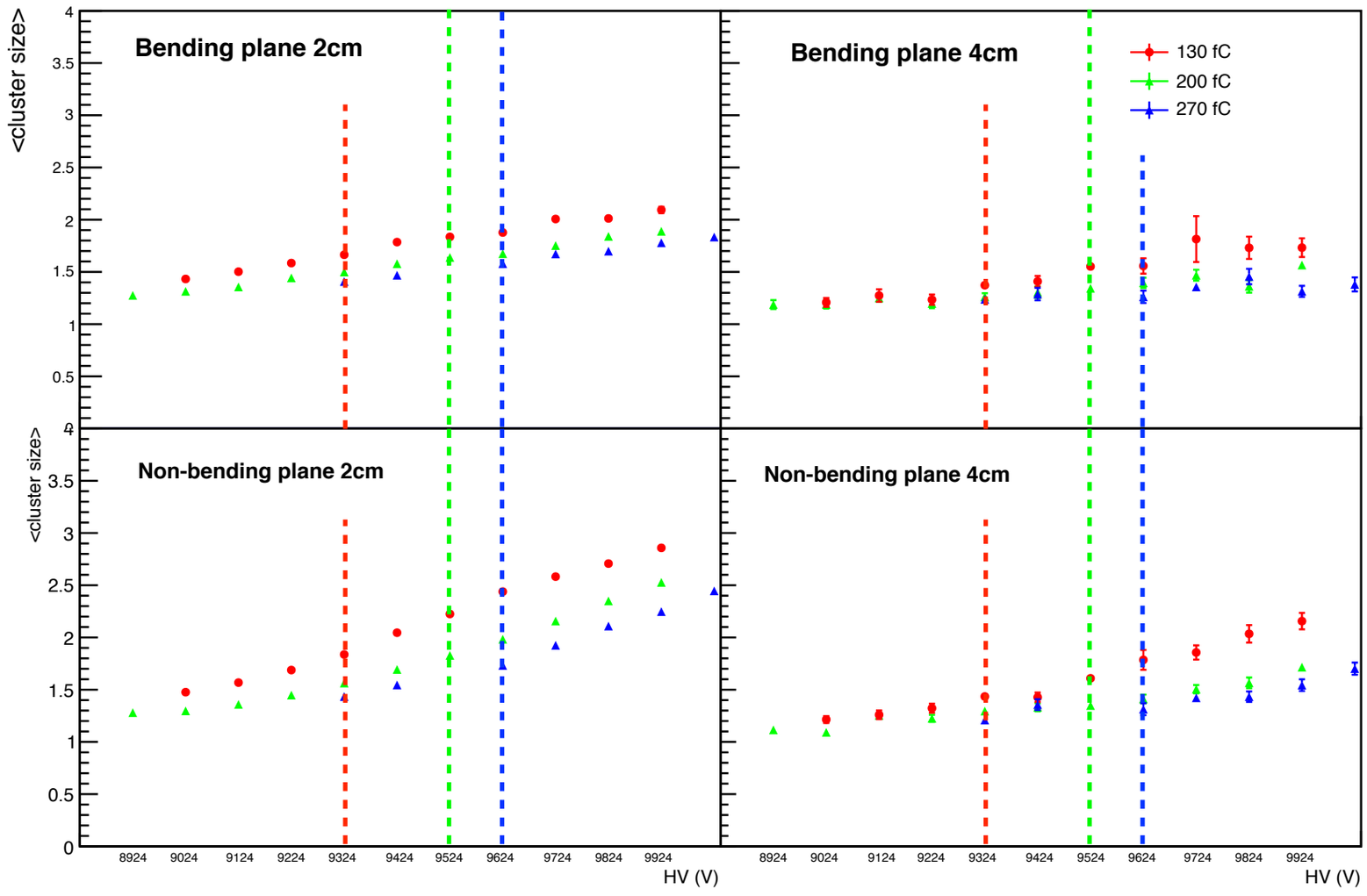


0000110000000000

CS for RPC with ADULT in PbPb collisions during Run 1

Width	⟨Cluster size⟩
1 cm	2.08 ± 0.06
2 cm	1.46 ± 0.02
4 cm	1.15 ± 0.01

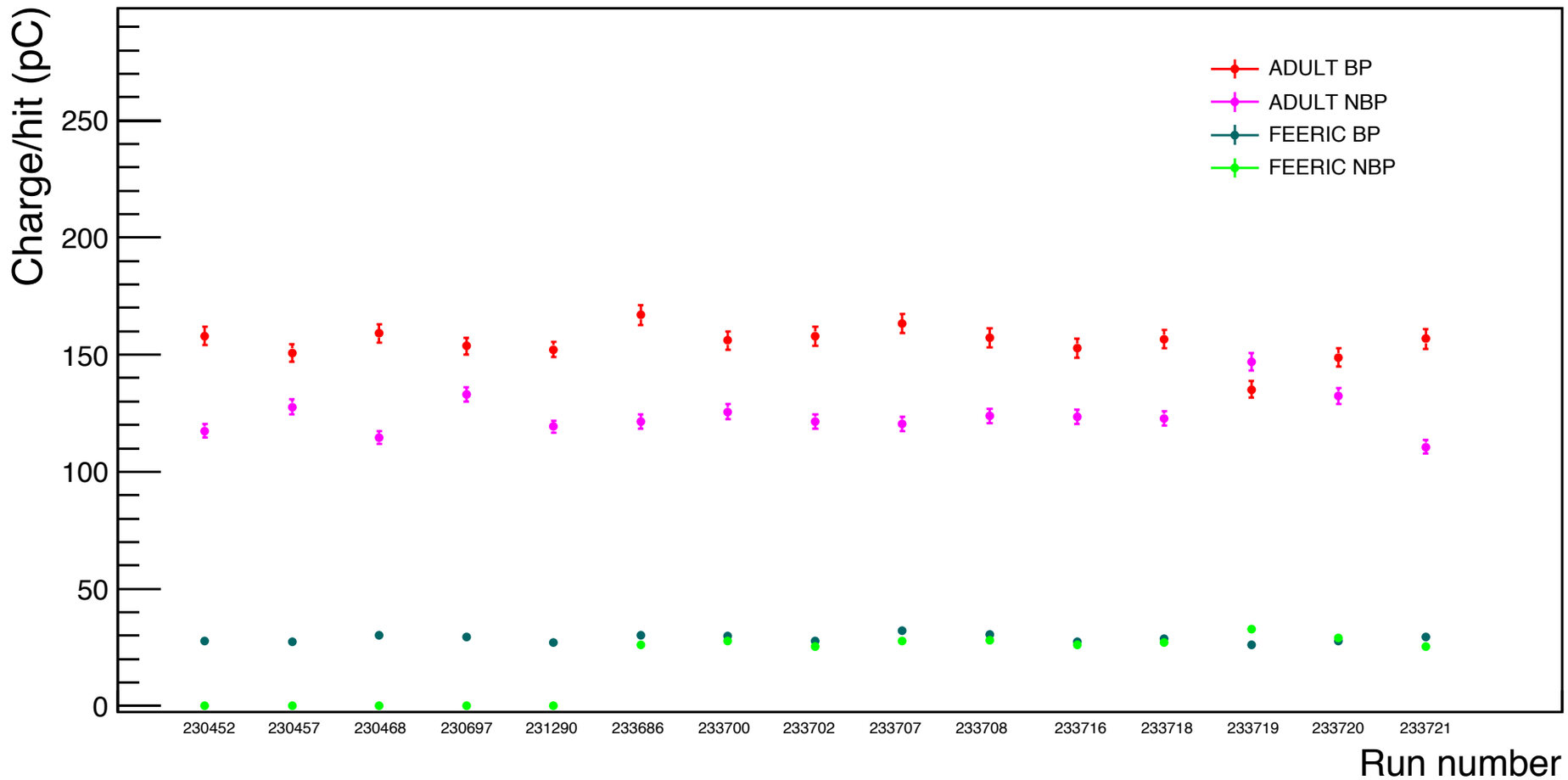
pp@13 TeV June 2015



For a given HV and strip width, the cluster size decreases as the discrimination threshold increases.

Charge per hit

Average charge per hit in time (run numbers shown)



The charge released in the RPC with FEERIC is 5 times lower than the charge released in the rest of RPCs.

Charge/hit produced in the RPC with FEERIC: ~20 pC. ATLAS reports ~30 pC for an RPC with close operating conditions.

Conclusions on the performance study

- Optimal working conditions were established after the evaluation of efficiency curves and cluster size values.
- High efficiency at nominal working voltage for both bending and non-bending planes.
- The charge per hit released in the RPC equipped with the new front-end electronics is ~20 pC, a factor 5 lower than for the rest of RPCs.

Thank you!

Backup slides…