

# $\Xi^{*0}$ production in $p$ -Pb and Pb-Pb collisions at the LHC with ALICE

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Heavy Ion Physics Experiment

Pusan National University

PIP2015 on 15 Jan. 2015





# Outline



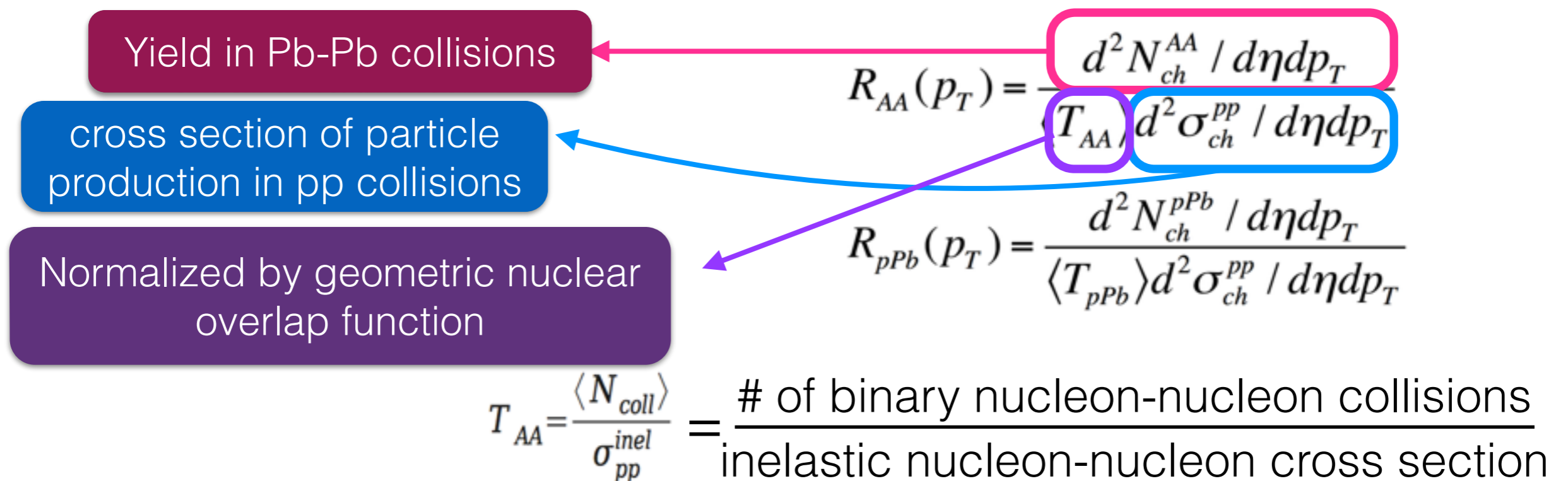
- Physics motivation
- The **ALICE** (A Large Ion Collider Experiment) @ **LHC** (Large Hadron Collider)
- Results from **p-Pb** collisions
- (Upcoming) Results from **Pb-Pb** collisions
- Summary and Outlook

# Physics Motivation

- In **Pb-Pb** collisions resonances probe the evolution of the fireball
  - resonances with their **short lifetime** & **strong coupling** to the dense and hot medium are suggested as **a signature of the early stage of the fireball** created in a heavy ion collision.
- **pp** and **p-Pb** collisions provide reference for heavy ion measurement
  - **pPb** : contribute to the study of the system size dependence of re-scattering
  - **pp** : are used to build reference spectra for  $R_{AA}$  and  $R_{pPb}$

Nuclear modification factor :  $R_{AA}$

- to learn about particle production mechanism

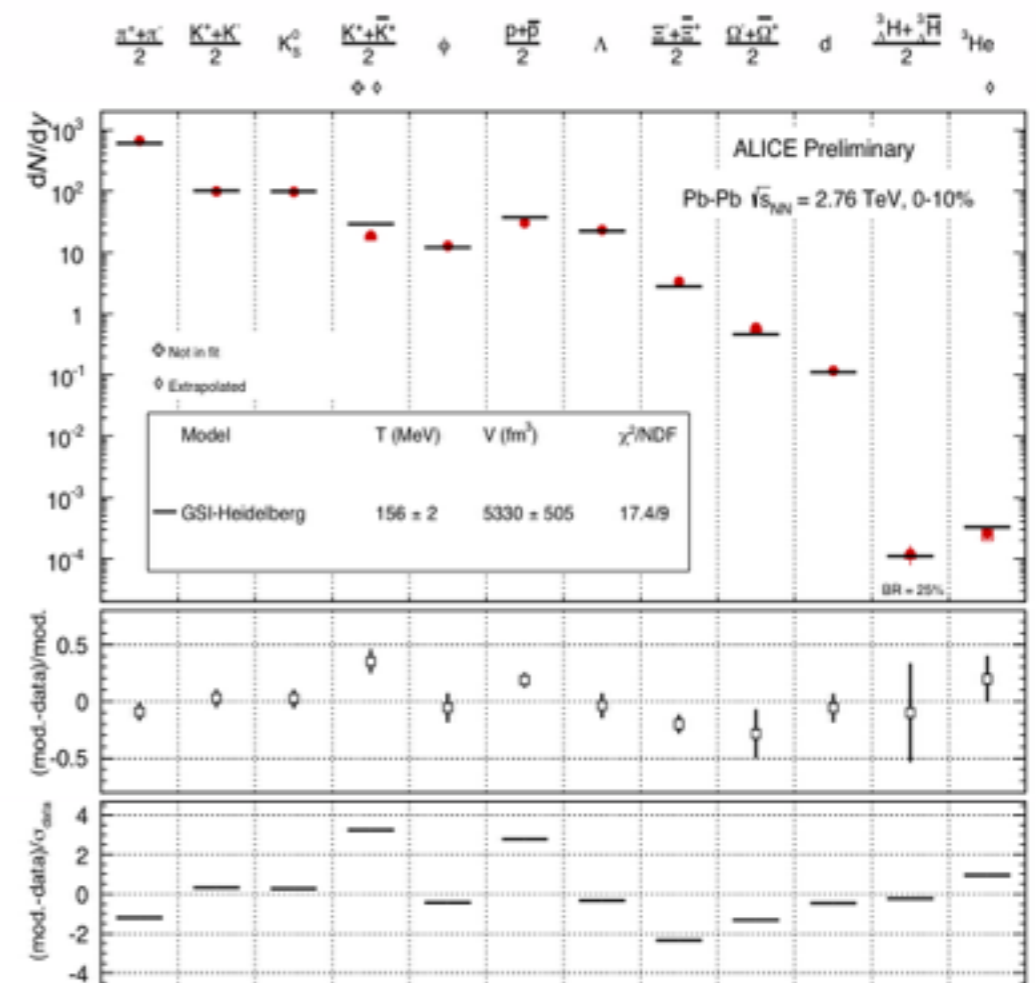


# Physics Motivation

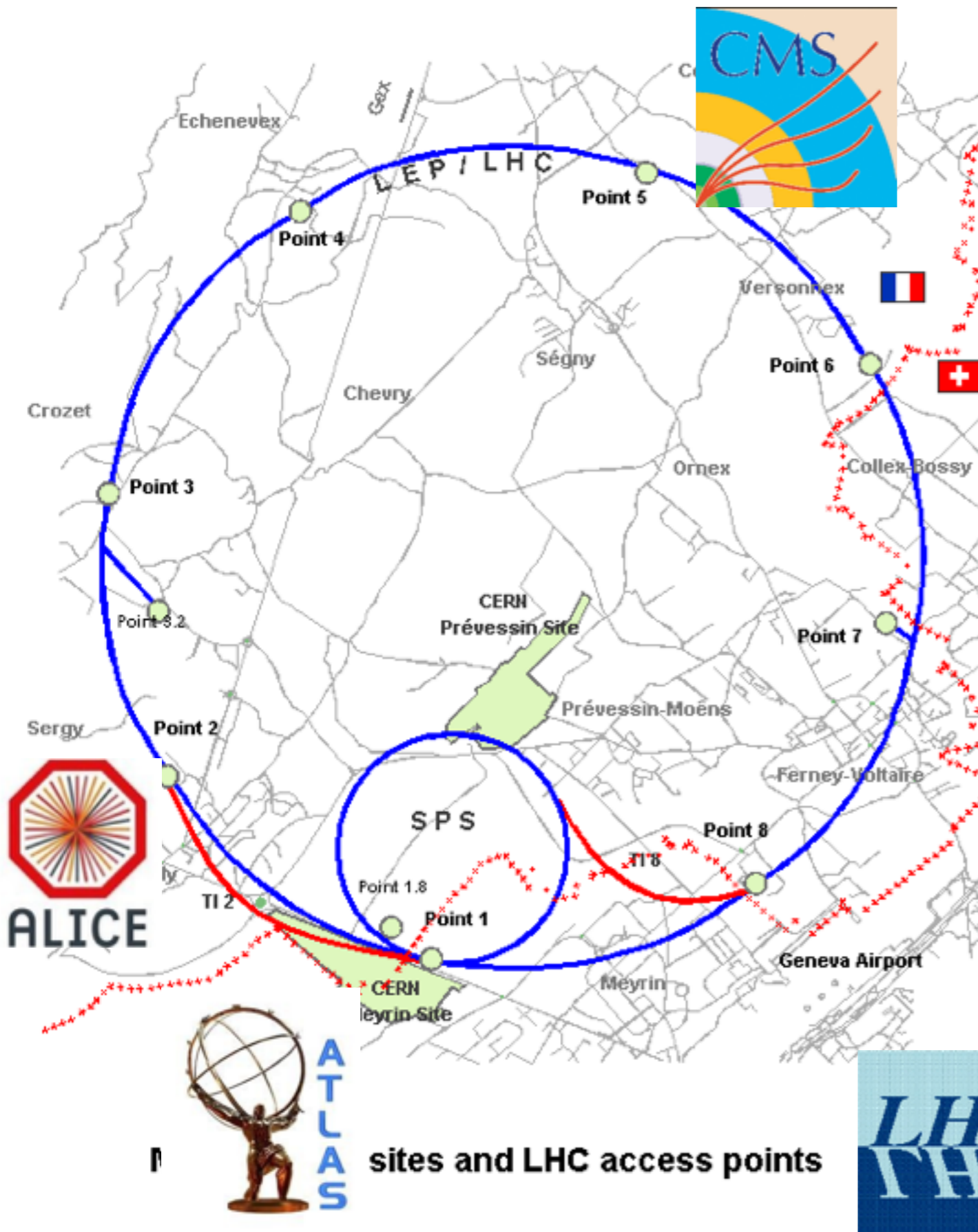
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Data to be compared with thermal model predictions. Yield of  $\Xi^{*0}$  will be between  $\Xi$  and  $\Omega$ .

(J.Stachel,A.Andronic,P.Braun-Munzinger,K.Redlich,J.Phys.: Conf. Series 509 (2014) 012019).

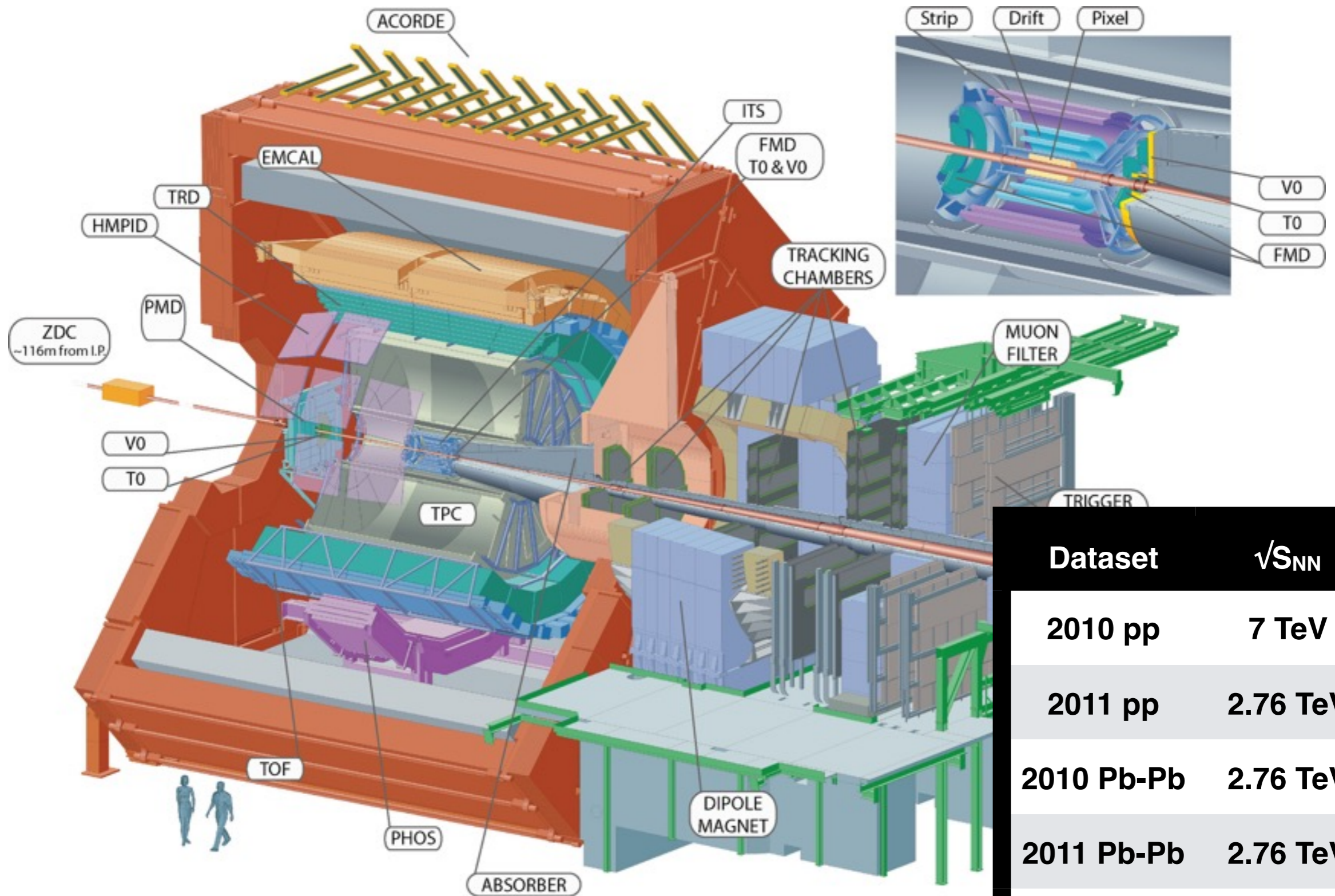


# The ALICE at LHC



- Heavy-ion experiment designed to study strongly-interacting matter at very high energy density
- Explores..
  - phase transition to the QGP
  - its phase diagram & properties
- Particle identification capability
- Measurement from very low transverse momenta

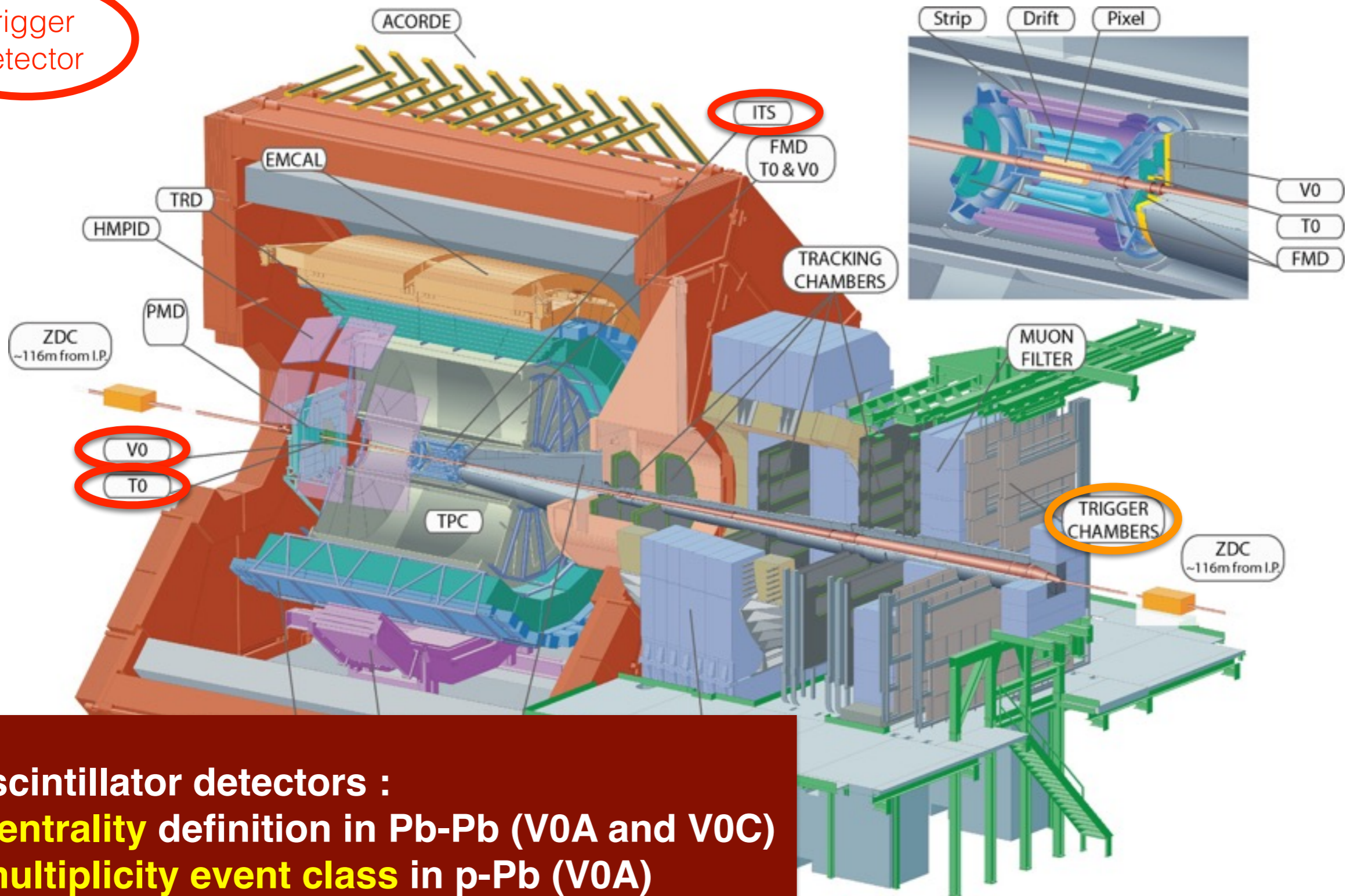
# The ALICE experiment



Dataset	$\sqrt{s_{NN}}$
2010 pp	7 TeV
2011 pp	2.76 TeV
2010 Pb-Pb	2.76 TeV
2011 Pb-Pb	2.76 TeV
2013 p-Pb	5.02 TeV

# The ALICE experiment

Trigger detector

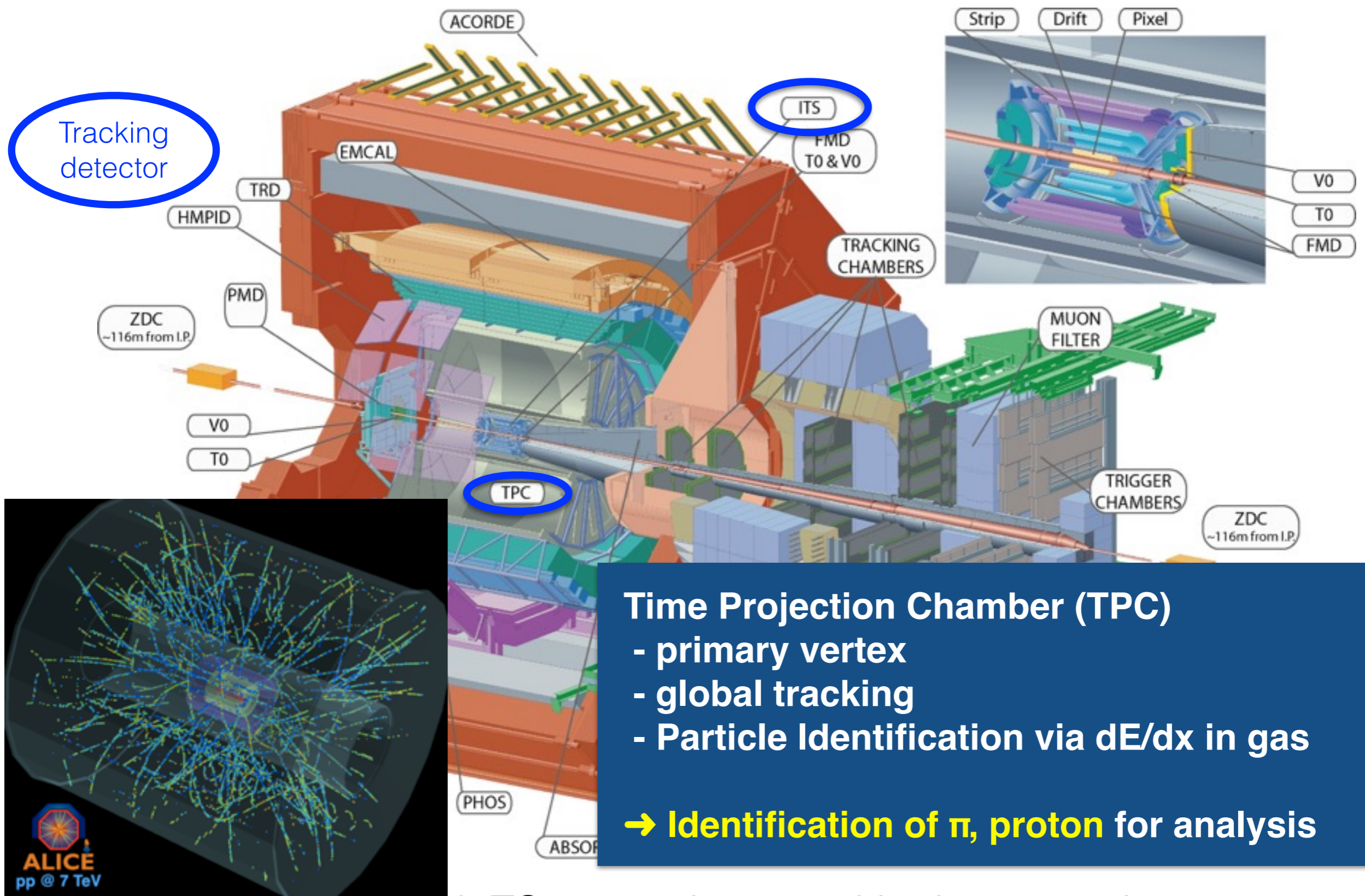


V0 scintillator detectors :

- **centrality** definition in Pb-Pb (V0A and V0C)
- **multiplicity event class** in p-Pb (V0A)

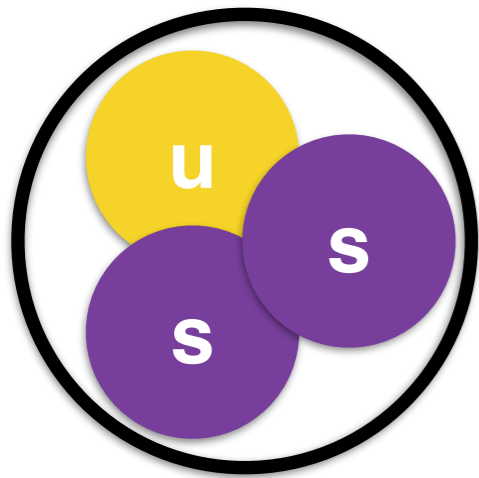
TPC and ITS are mainly used in the analysis

# The ALICE experiment



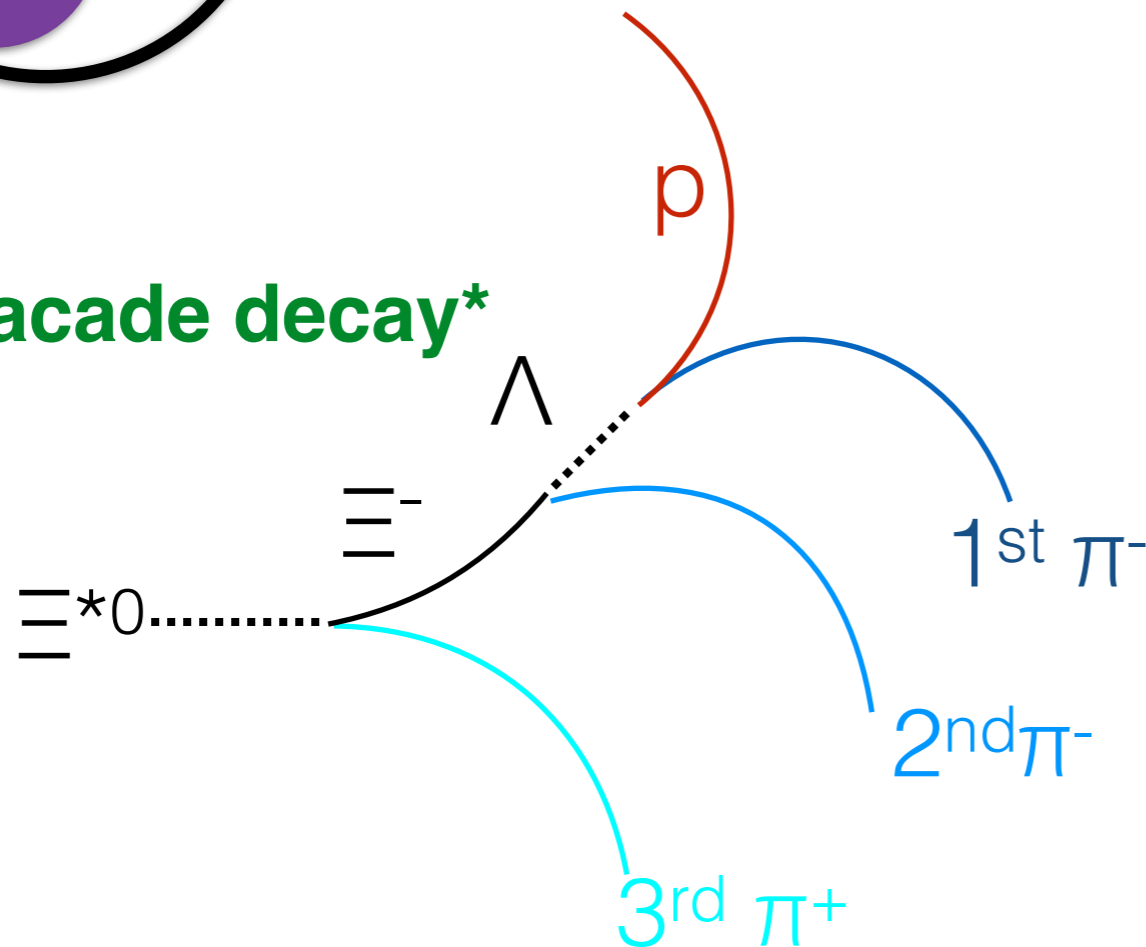
TPC and ITS are mainly used in the analysis





# $\Xi^{*0}$ baryon

**\*Casacade decay\***



- Called the cascade particles because of their unstable state
- They decay rapidly into lighter particles through a chain of decays

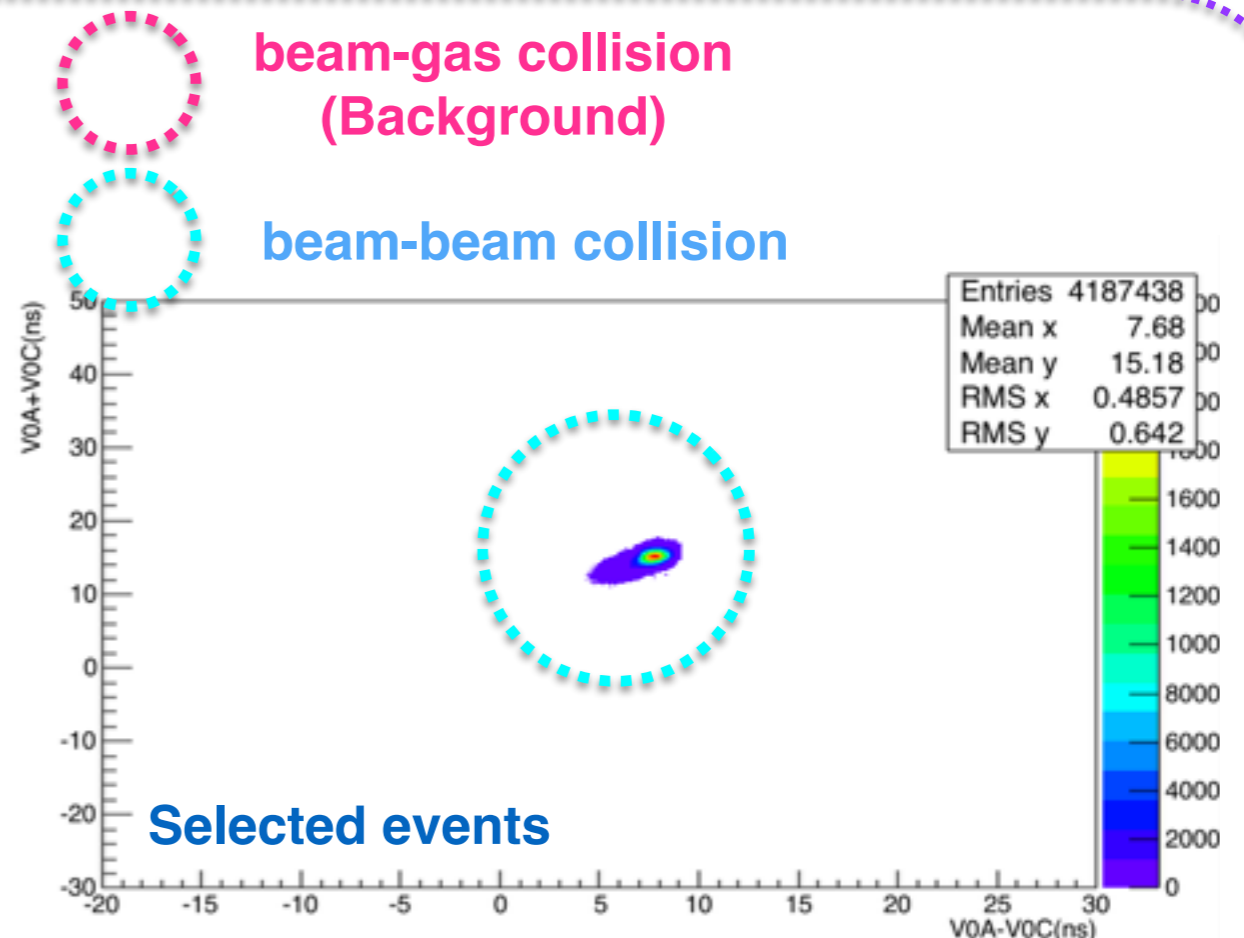
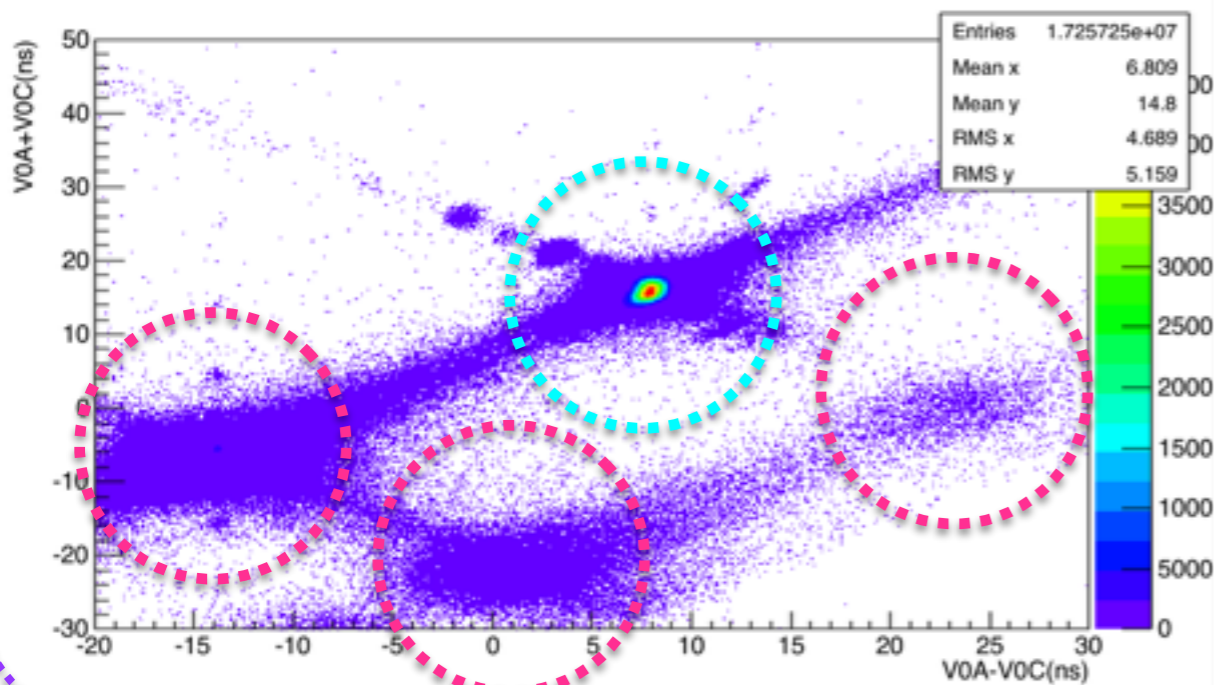
	quarks	Mass (MeV/c <sup>2</sup> )	Width/cτ (MeV/c <sup>2</sup> )	Decay channel	Branching ratio (%)
$\Xi(1530)^0$	uss	1531.80 ± 0.32	9.1 ± 0.5	$\Xi^- + \pi^+$	66.7

# Candidates selections

## Event selection

- Minimum bias events is selected (p-Pb)  
MB, Central, SemiCentral events are selected (Pb-Pb)
- Pile-up events are rejected  
- via SPD detector
- $-10 < V_z < 10$  cm

MB : V0A & V0C  
tool to reject background



beam-gas collision  
(Background)

beam-beam collision

Selected events

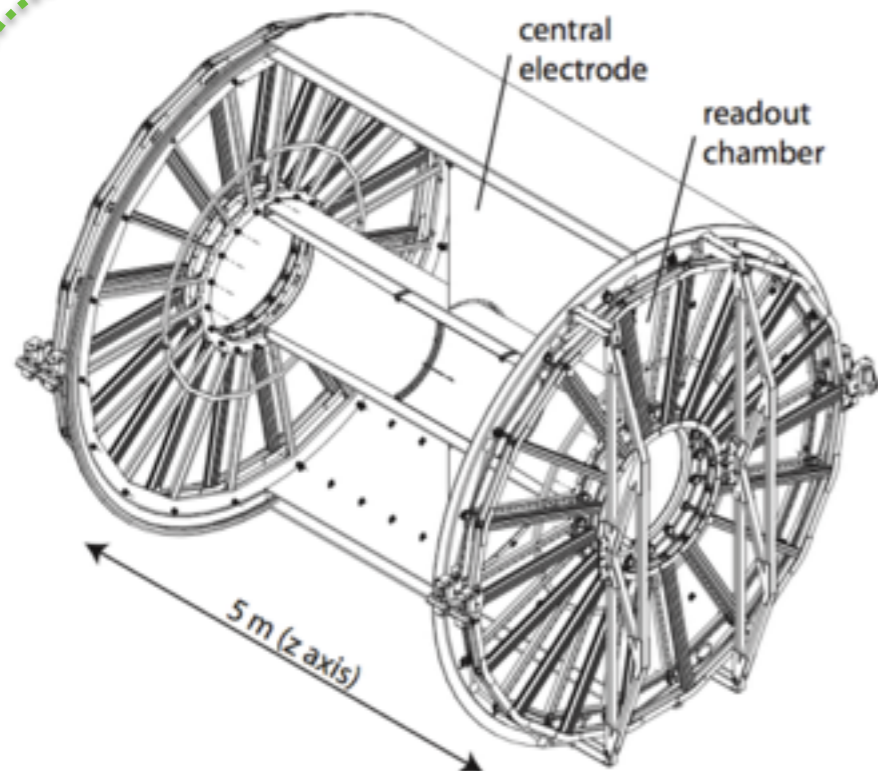
# Candidates selections

## Event selection

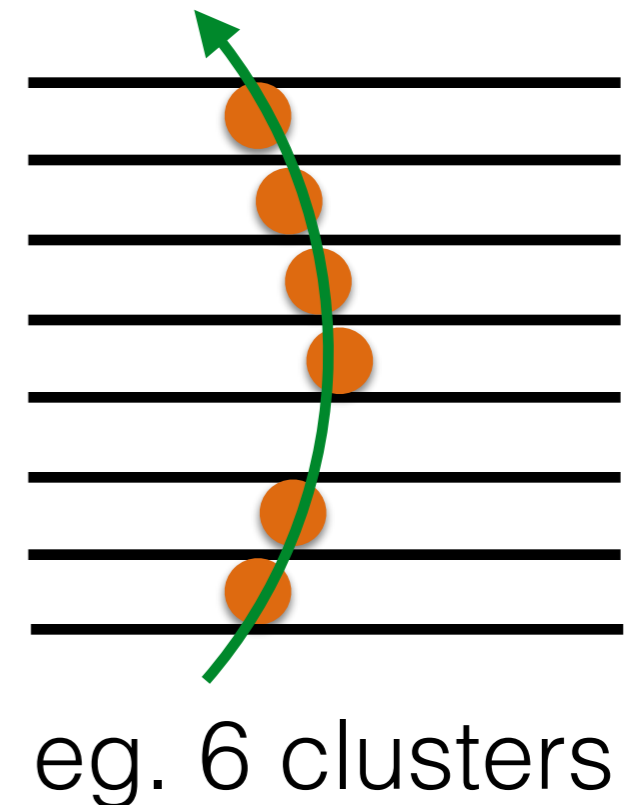
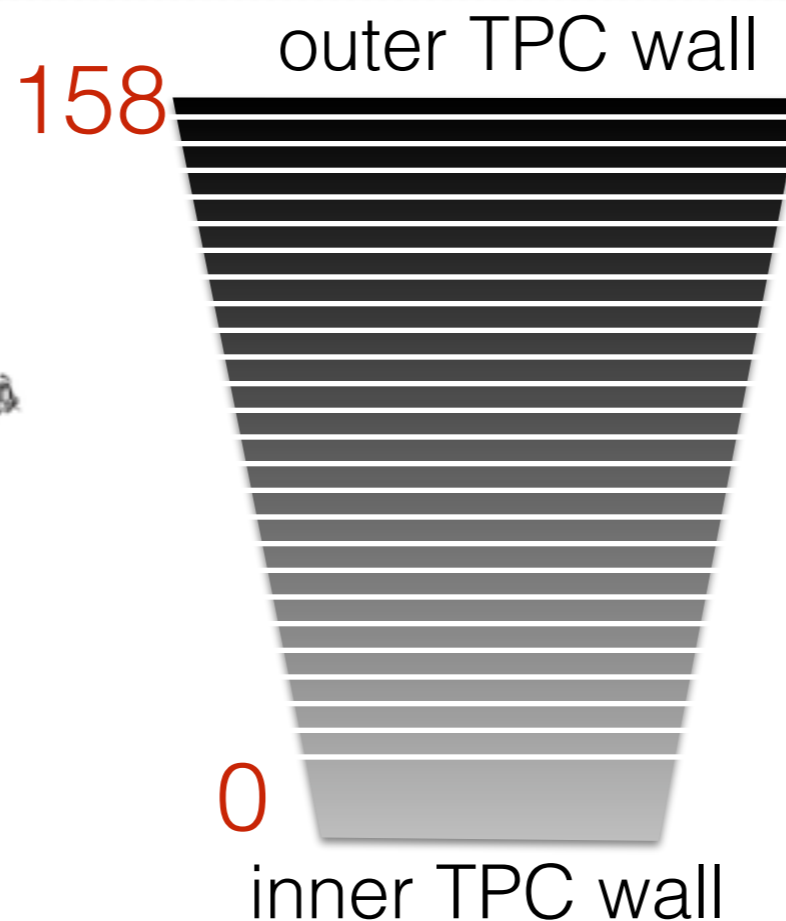
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## Track Cuts

- $P_t > 0.15$  GeV/c
- SetTPCminNClusters proton (60)
- SetTPCminNClusters 1st pion (60)
- SetTPCminNClusters 2nd pion (60)
- SetTPCminNClusters 3rd pion (60)



Scheme view of TPC



# Candidates selections

## Event selection

- Minimum bias events is selected (p-Pb)  
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## Track Cuts

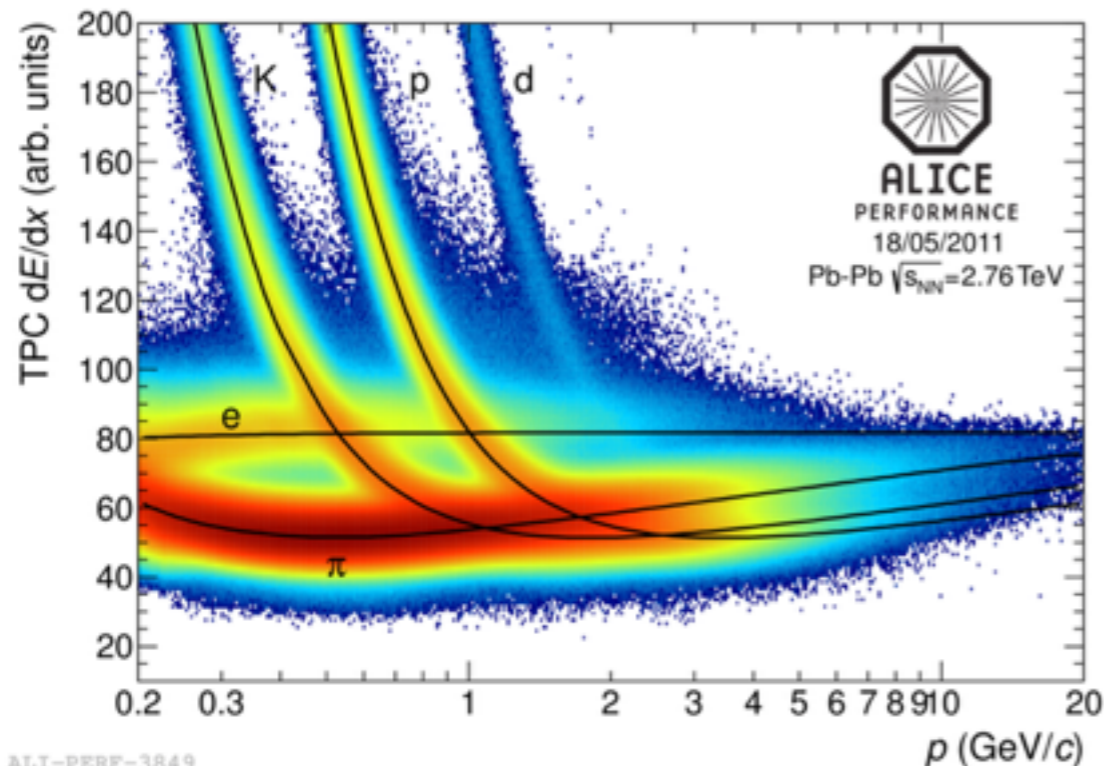
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- SetTPCminNClusters proton (60)
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- SetTPCminNClusters 3rd pion (60)

## PID

- Using TPC  
-  $N(\sigma) \text{ dE/dx} < 3$

for all tracks

## Particle Identification



- Specific energy loss in TPC as a function of momentum for Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV
- The Bethe-Bloch curves for various particle species are superimposed with black line

# Data samples

**p-Pb @ 5.02TeV**

## Data

LHC13b + LHC13c

- After physical selection :  
~ 91.6 M events

## MC

LHC13b2\_efix\_p1,p2,p3,p4

- After physical selection :  
~ 98 M events

**Pb-Pb @ 2.76TeV**

## Data

LHC11h (20runs, total ~100runs)

- After physical selection :  
Central (0-10%) 4 M events  
SemiCentral(10-50%)3.5 M events

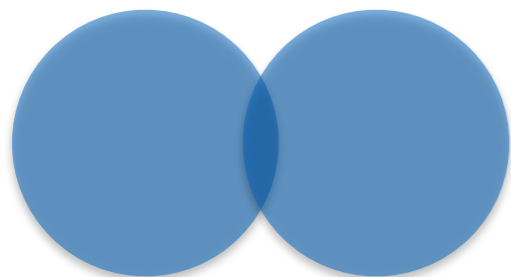
## MC

LHC14a1a (0 -10%)

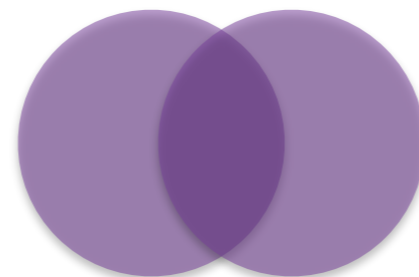
LHC14a1b (10 -50%)

LHC14a1c (50 -90%)

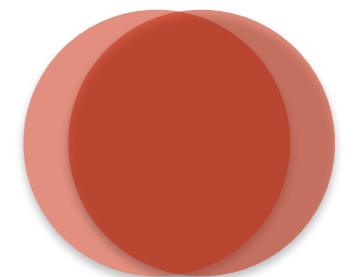
*Not yet*



(peripheral)



10-50% (Semi-central)



0-10% (Central)

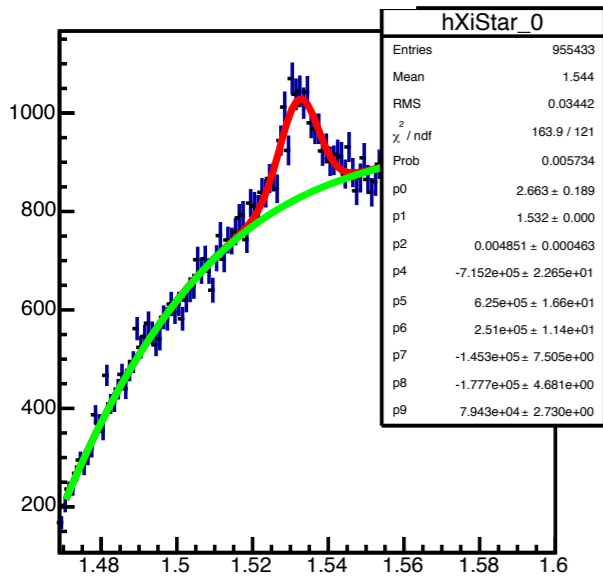
p-Pb  
@ 5.02TeV

# $\equiv * 0$ $P_T$ dependence

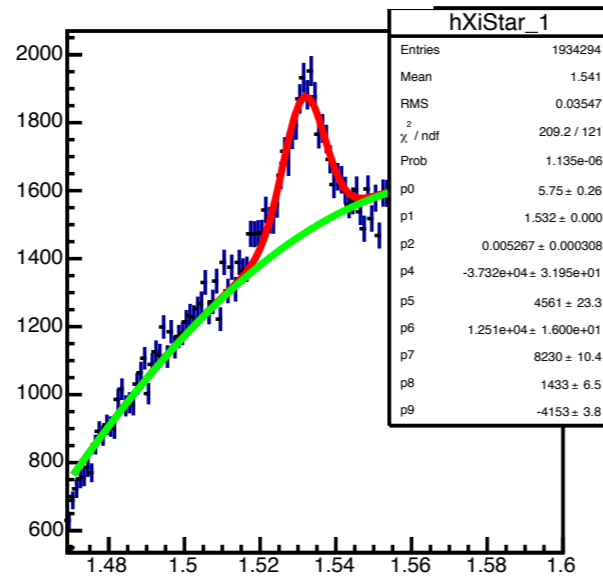
$0 < y_{CMS} < 0.5$

Centrality **total**

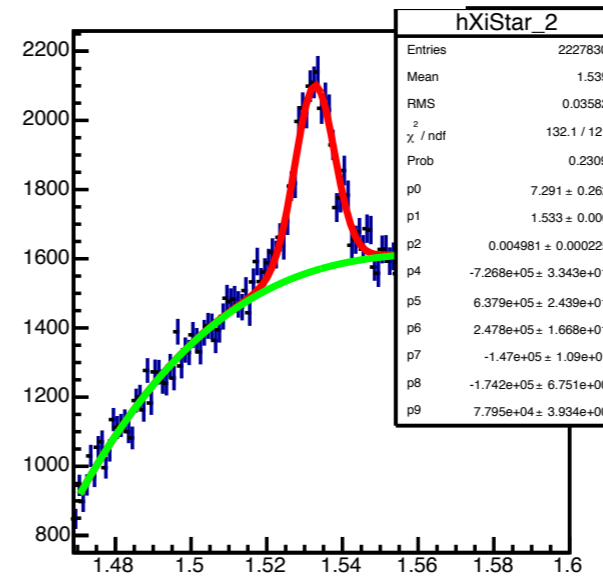
$P_T$  0.8-1.2



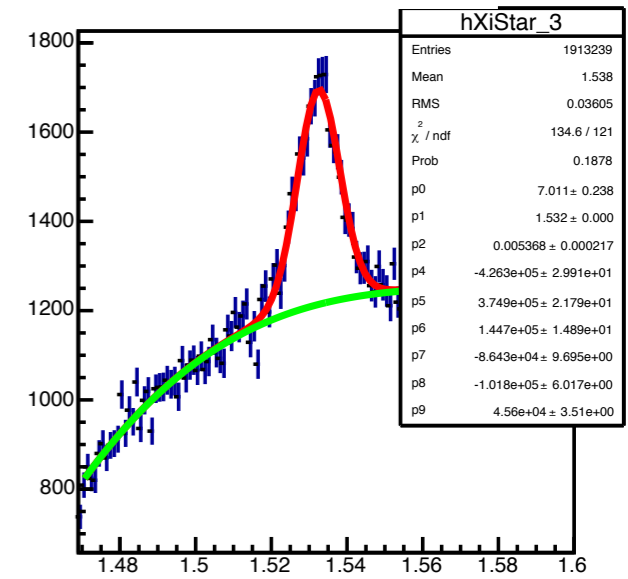
$P_T$  1.2-1.6



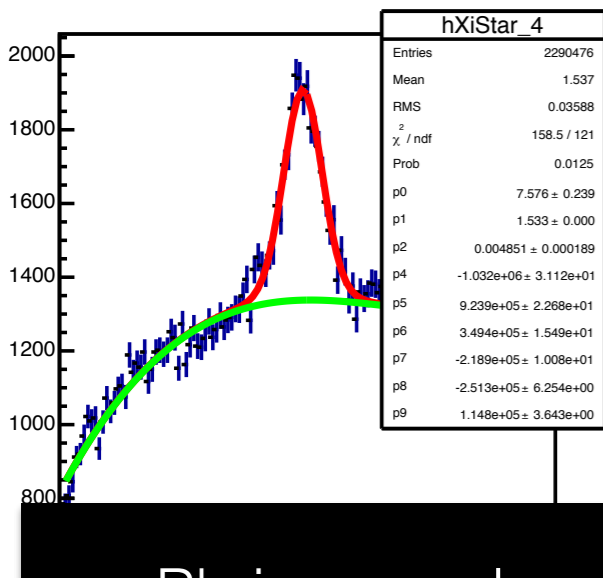
$P_T$  1.6-2.0



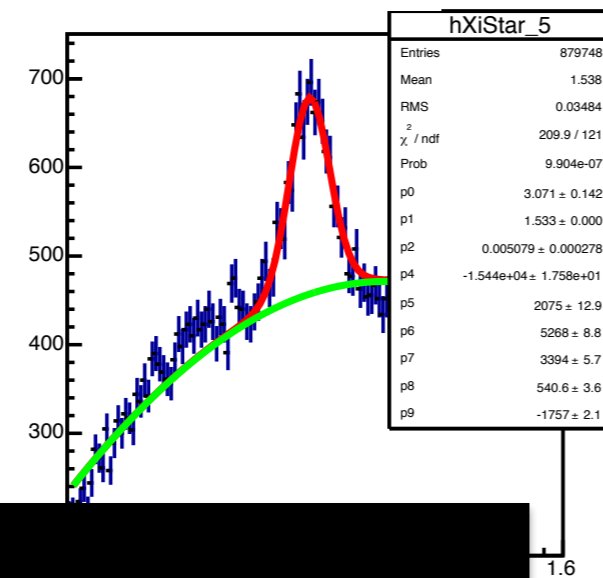
$P_T$  2.0-2.4



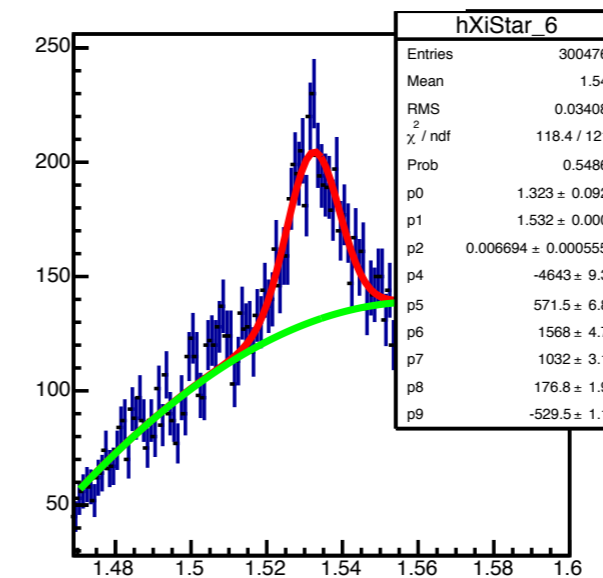
$P_T$  2.4-3.2



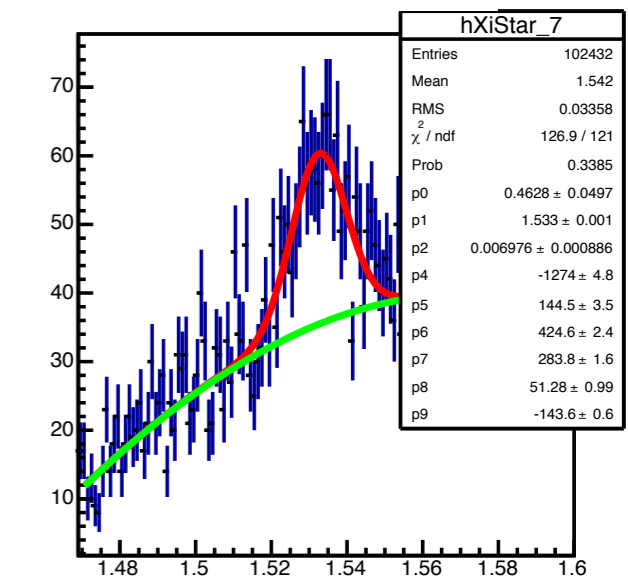
$P_T$  3.2-4.0



$P_T$  4.0-4.8



$P_T$  4.8-5.6

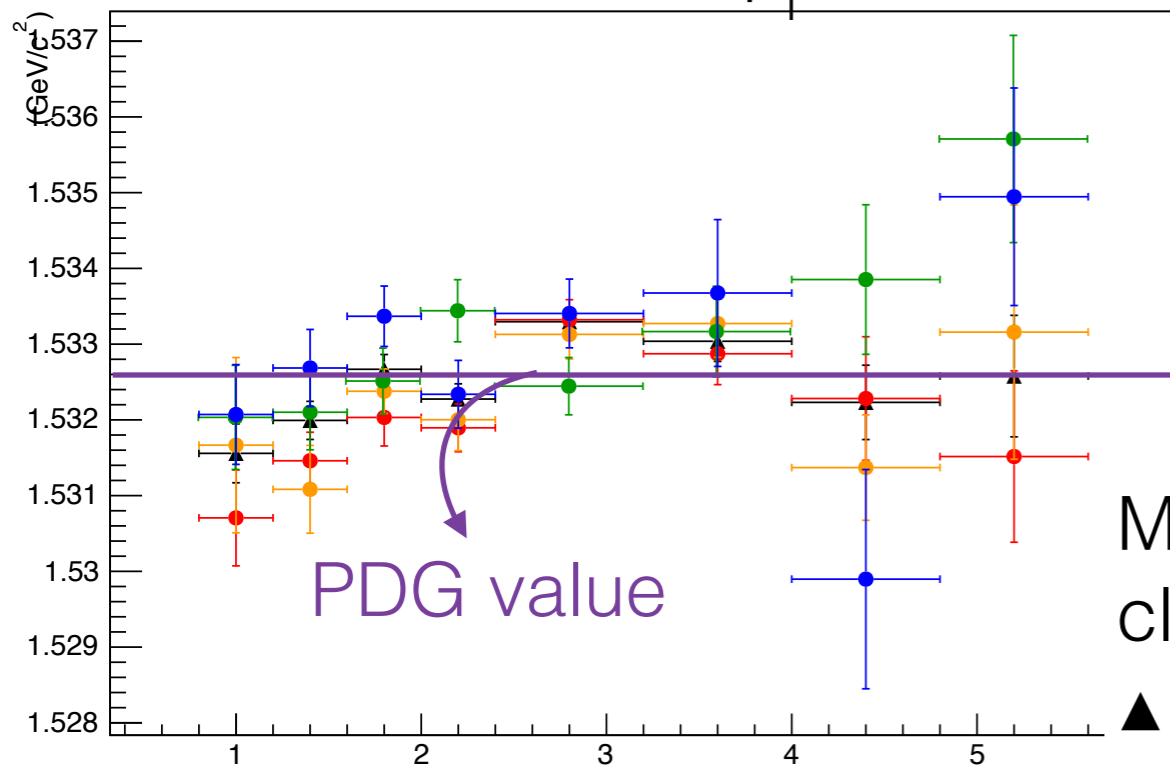


- p-Pb is very clean
- Signal visible before BG subtraction

**p-Pb  
@ 5.02 TeV**

# $\Xi^*0$ Mass & $\sigma$

$\Xi^0$  mass vs  $p_T$



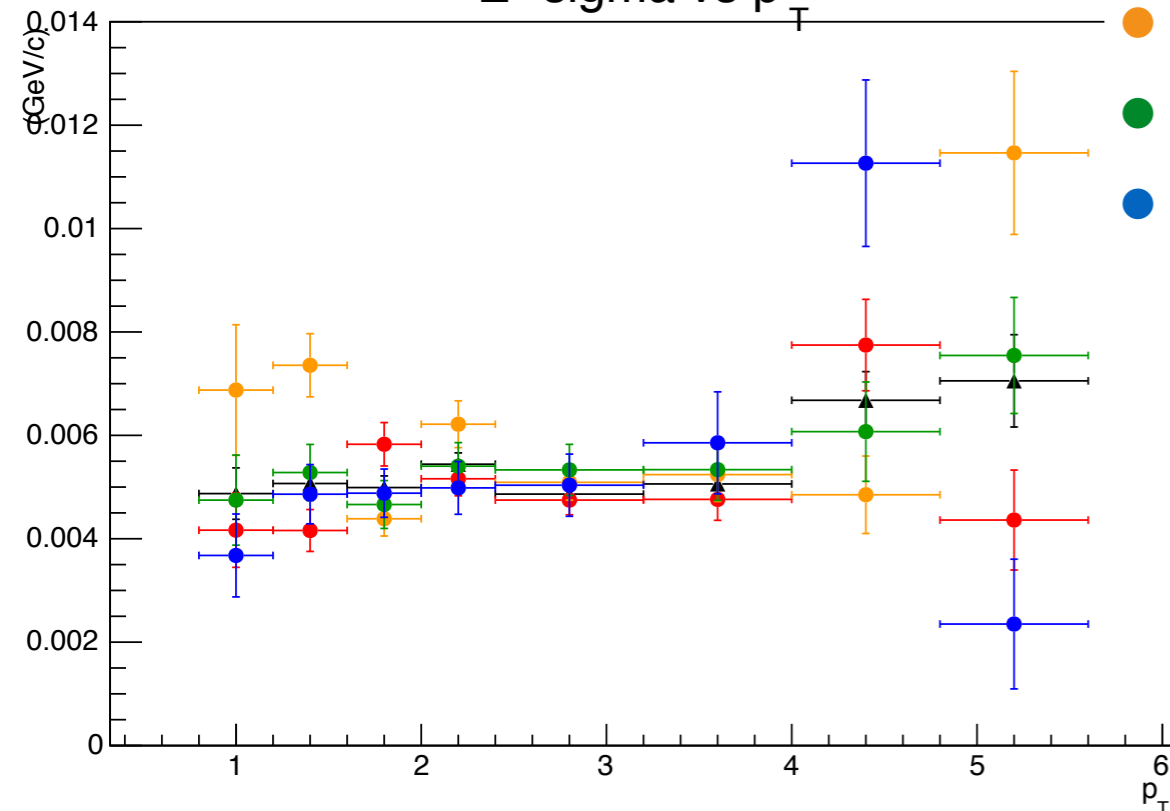
Multiplicity class

- ▲ 0 - 100
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 100

- Uncertainties on fit parameter only

- Mass : small tendency
  - $p_T < 2 \text{ GeV}/c$ : less than PDG
  - $2 < p_T < 4 \text{ GeV}/c$  : higher than PDG

$\Xi^0$  sigma vs  $p_T$



- Sigma
  - in pp : around 0.0025
  - need detailed fit study

## PDG

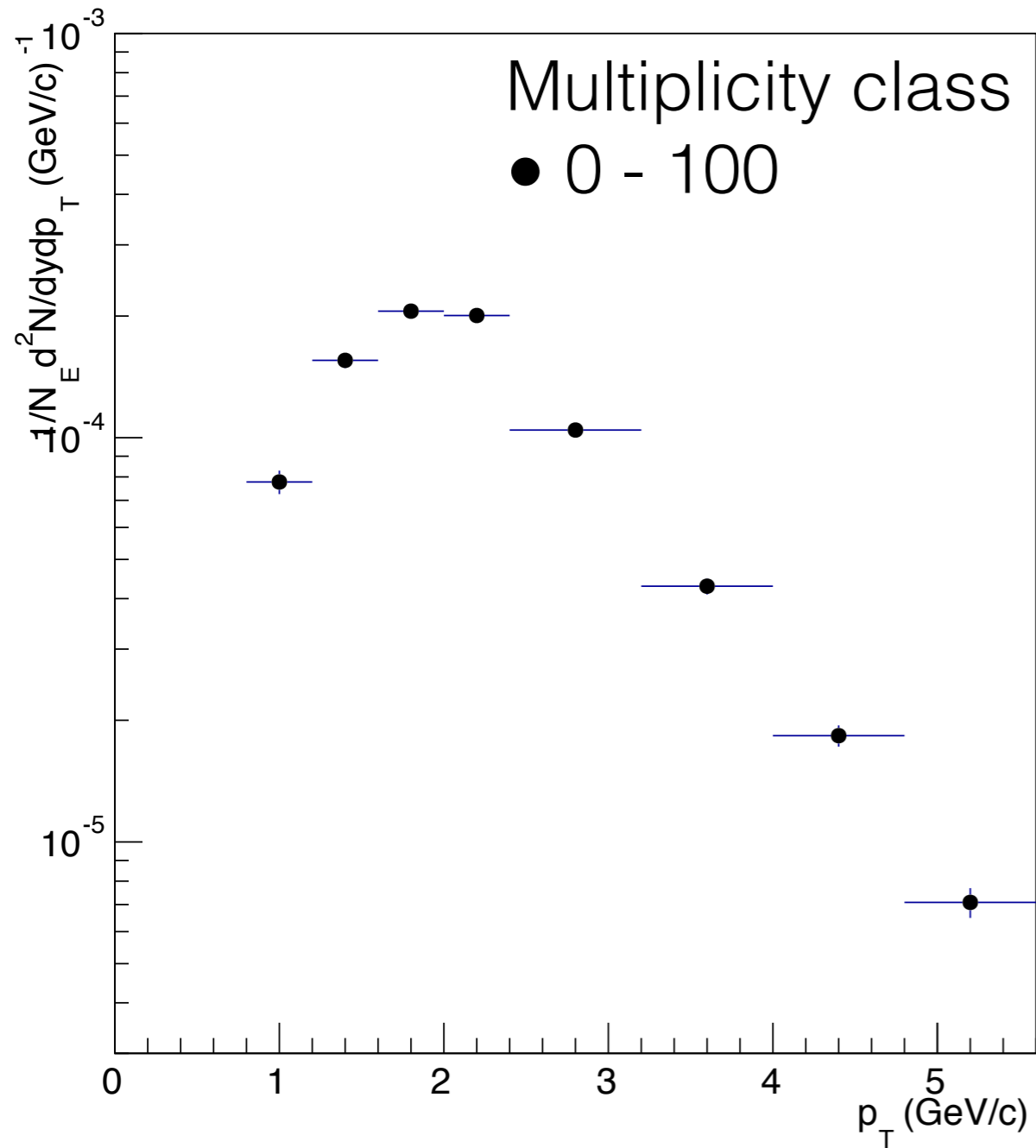
$\Xi(1530)^0$  Mass :  $1531.80 \pm 0.32 \text{ MeV}$

$\Xi(1530)^0$  Width :  $9.1 \pm 0.5 \text{ MeV}$

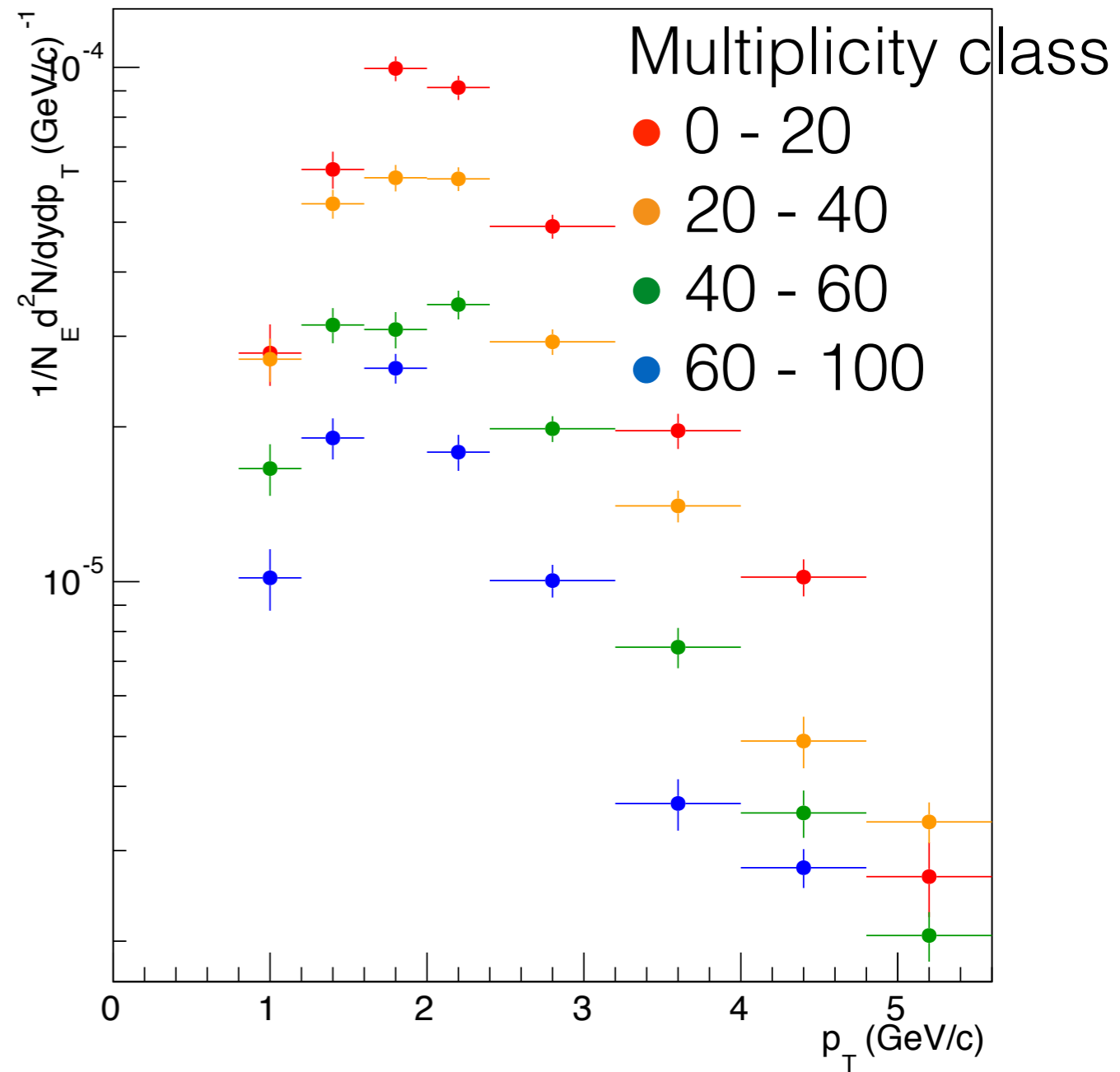
p-Pb  
@ 5.02 TeV

# ≡\*0 Spectrum

pPb  $\sqrt{s} = 5.02$  TeV

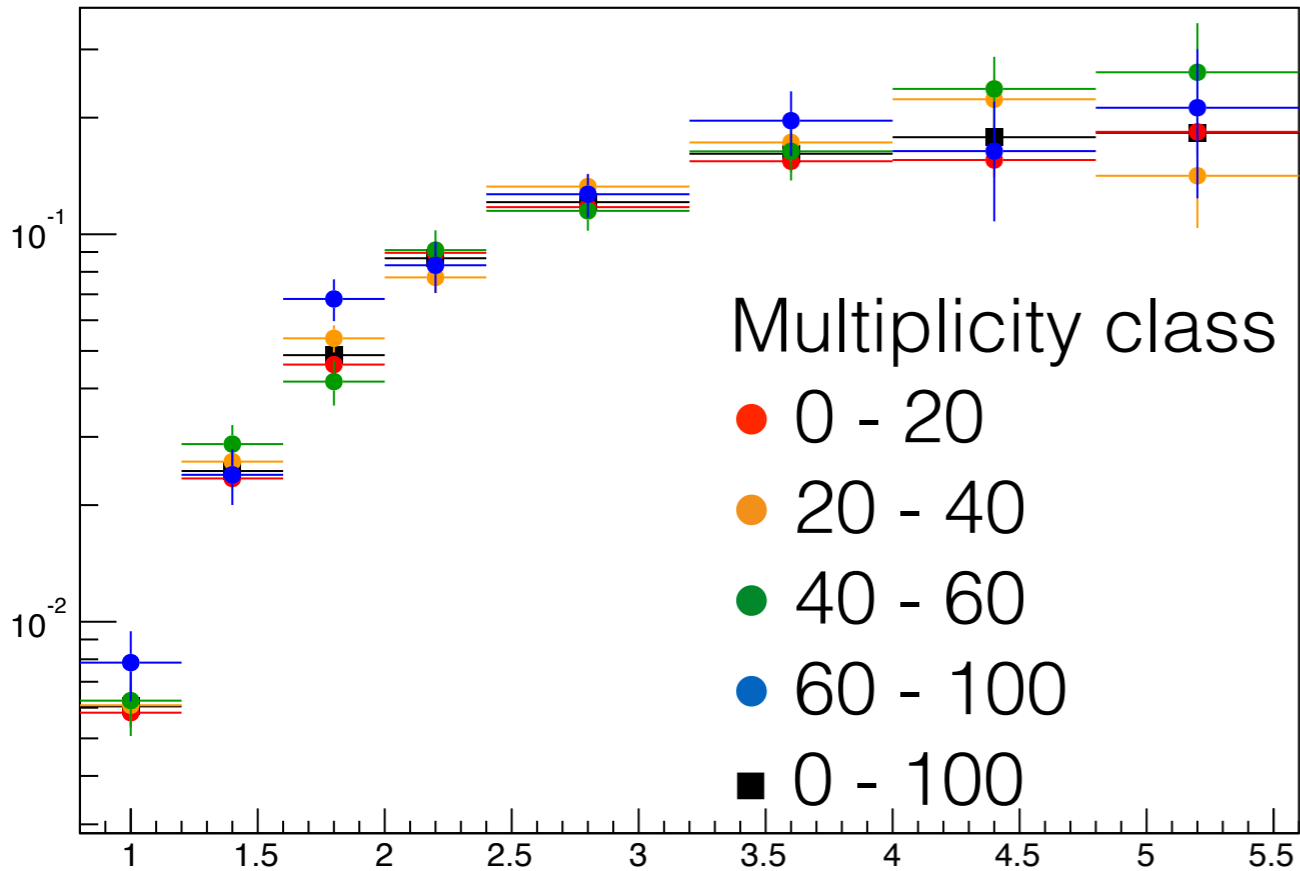


pPb  $\sqrt{s} = 5.02$  TeV



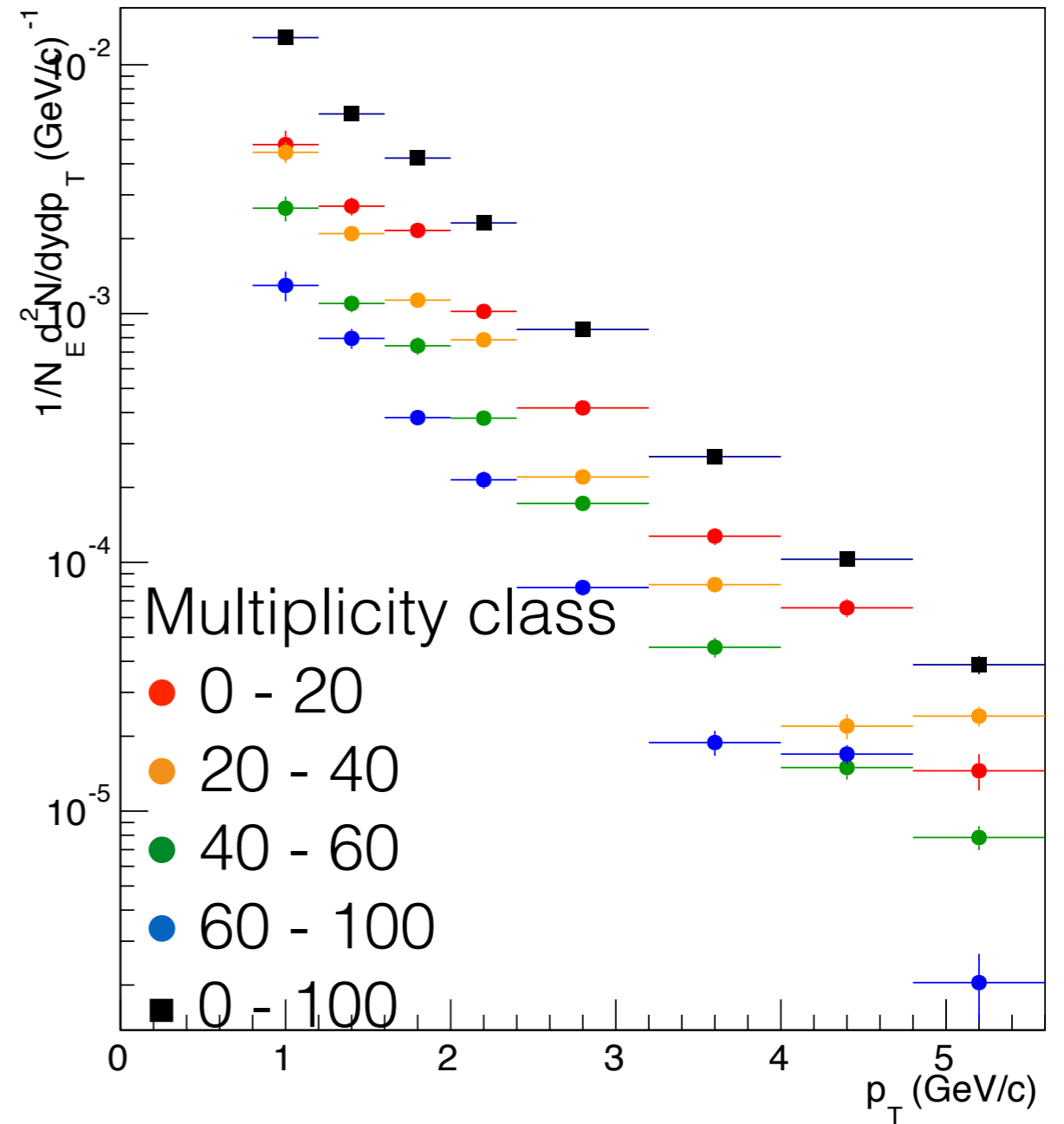


Efficiency



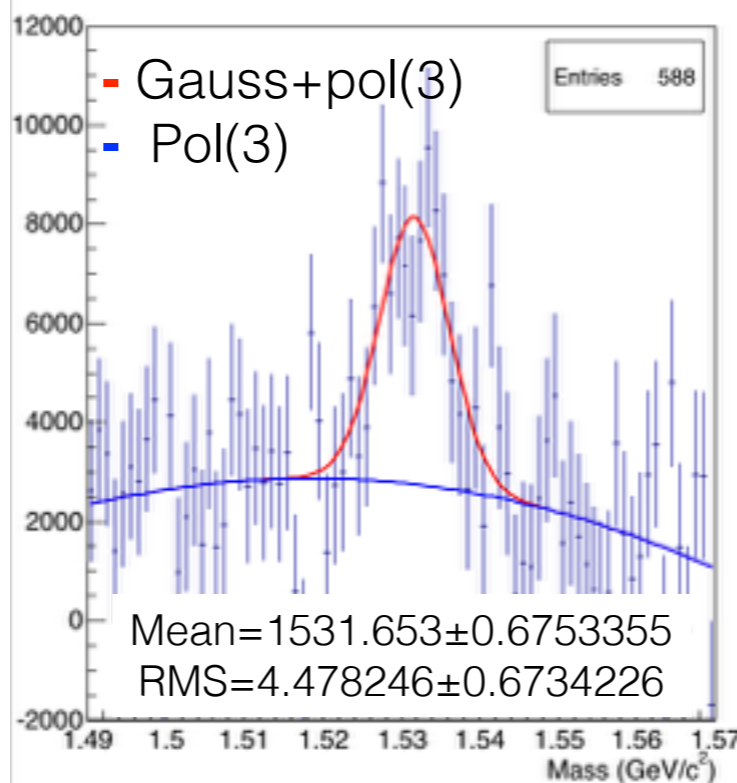
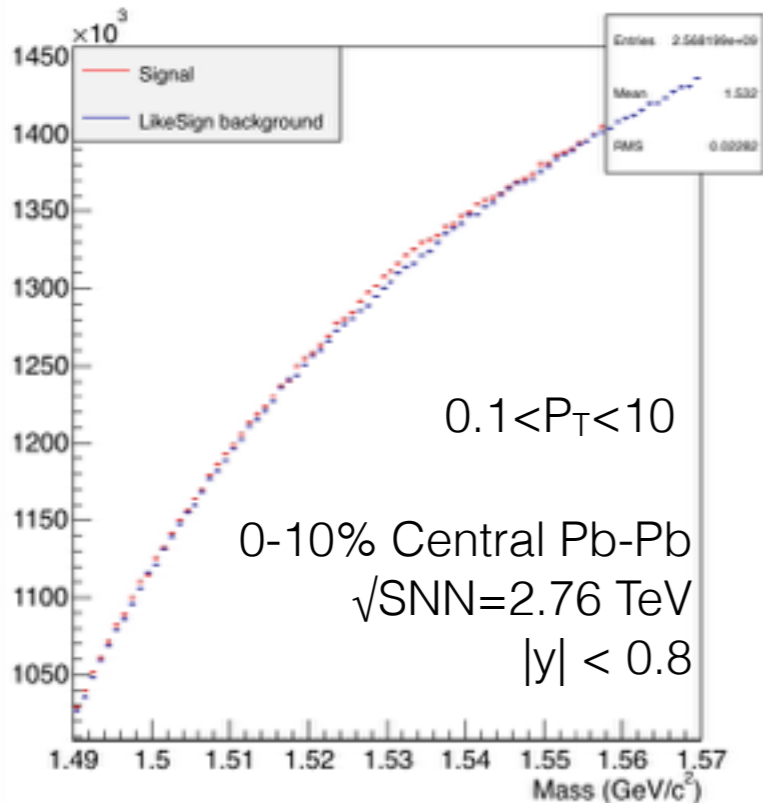
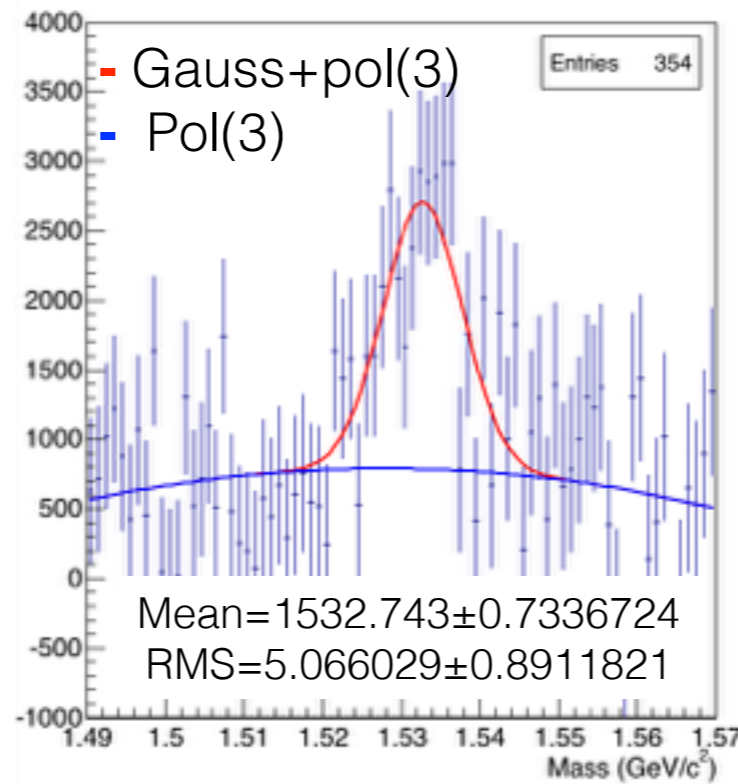
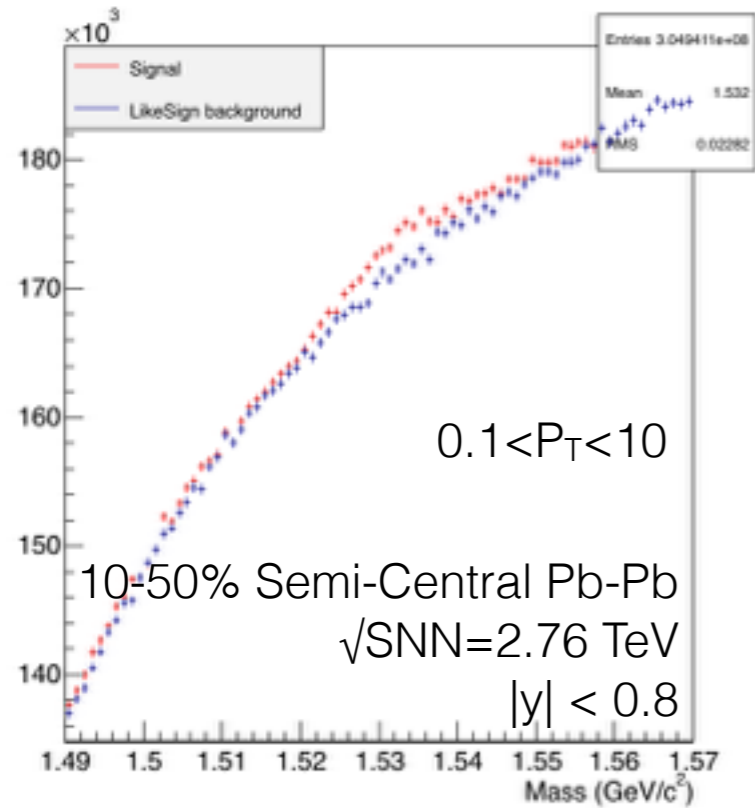
$$\text{Efficiency} = \frac{N_{\text{reconstructed}}}{N_{\text{generated}}}$$

pPb  $\sqrt{s} = 5.02$  TeV

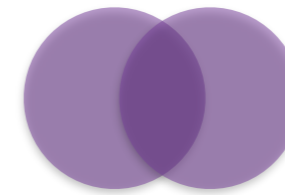


**Pb-Pb @  
2.76 TeV**

# Signal extraction

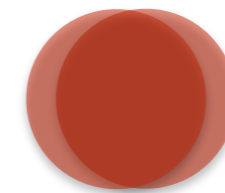
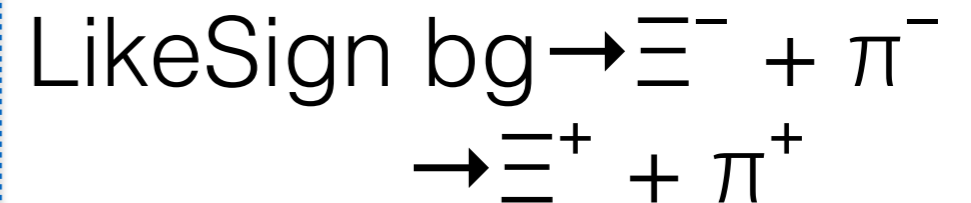
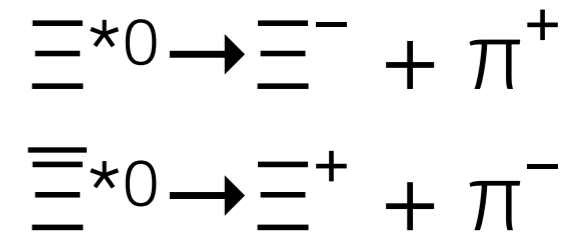


Integrated  $P_T$



10-50% (Semi-central)

Signal

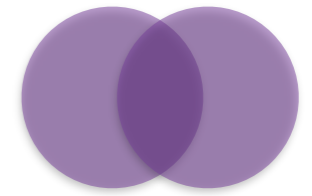


0-10% (Central)

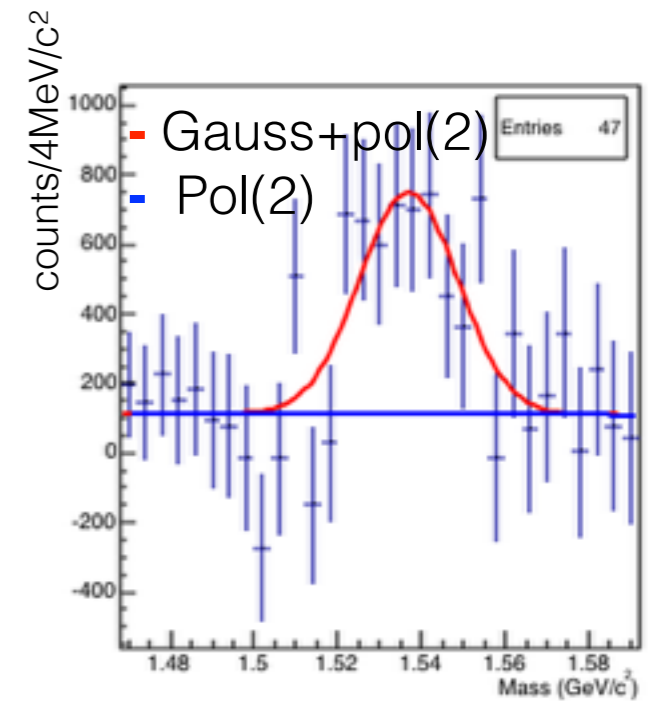
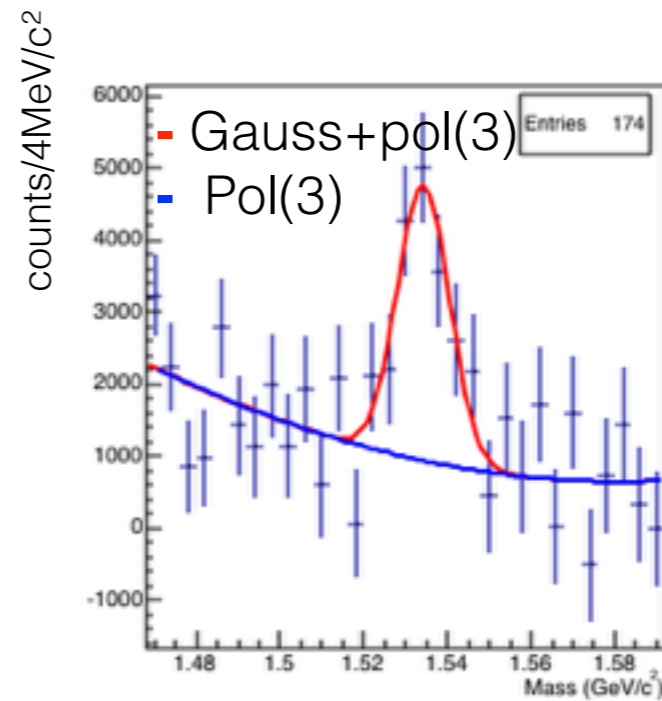
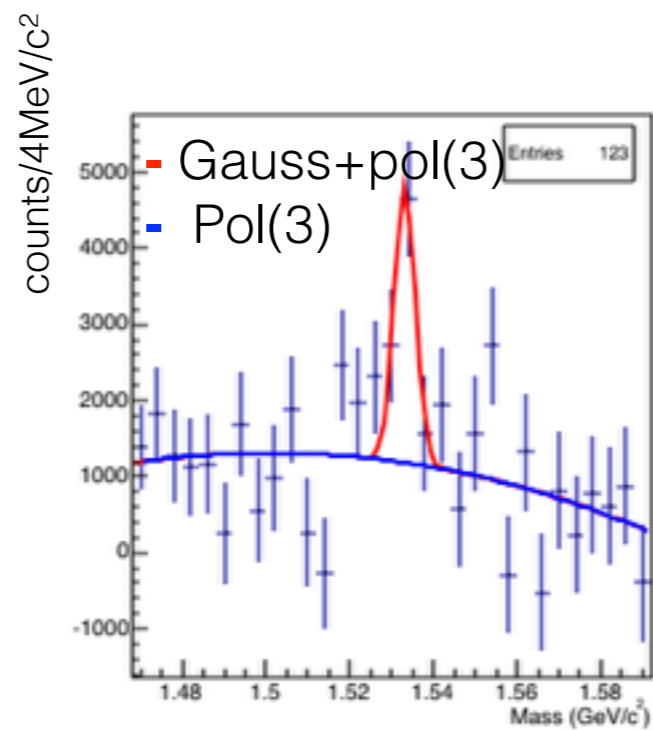
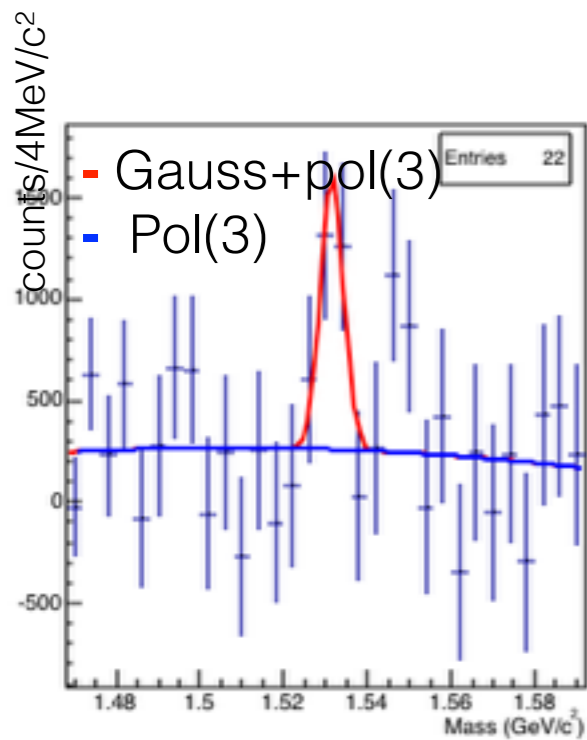
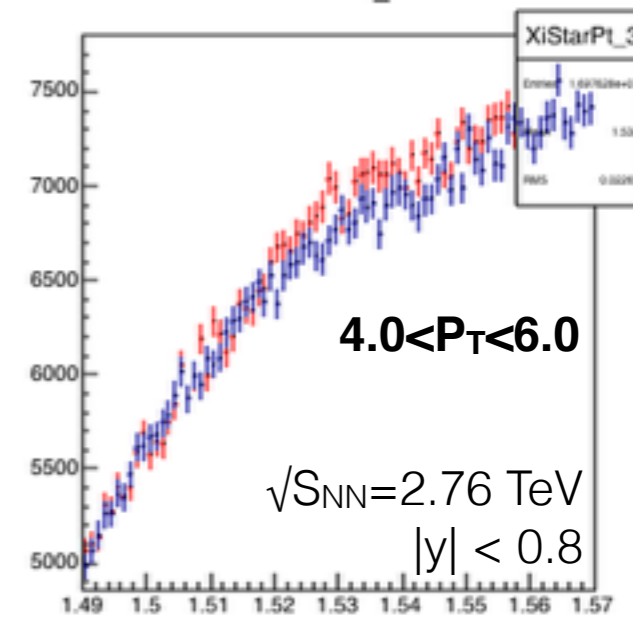
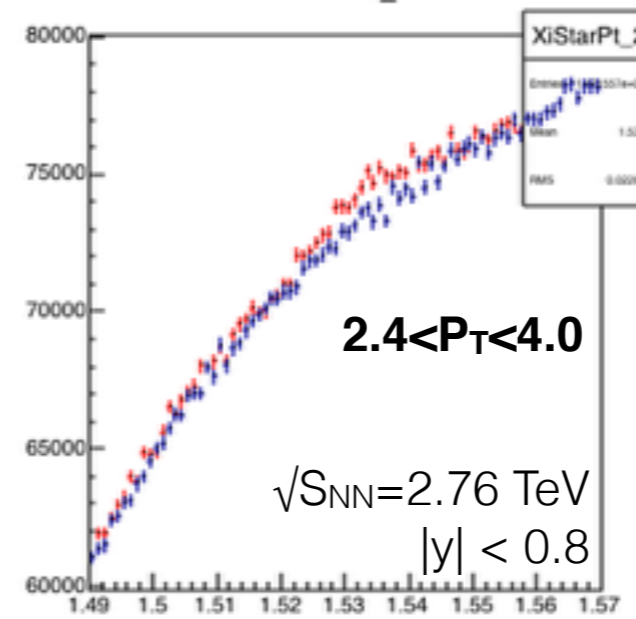
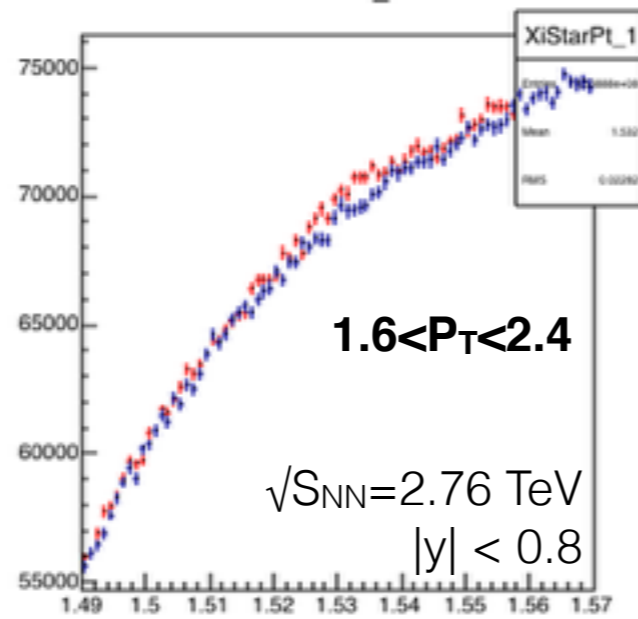
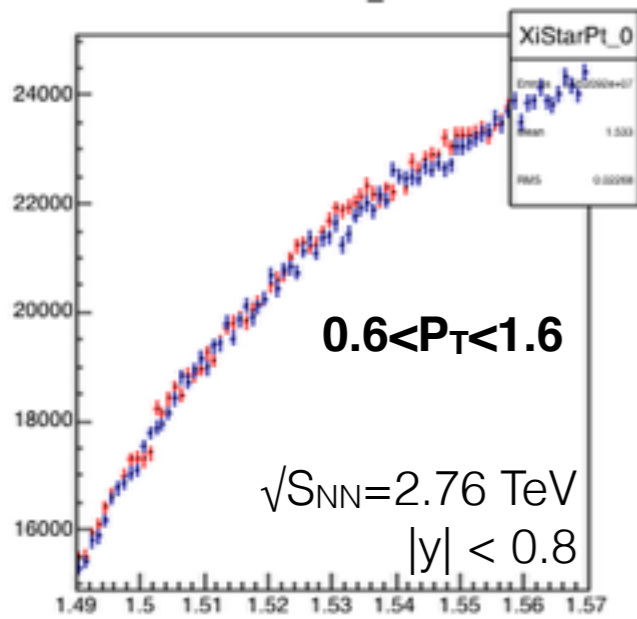
$\phi(1860)$   
pentaquark

**Pb-Pb @  
2.76 TeV**

# Signal extraction

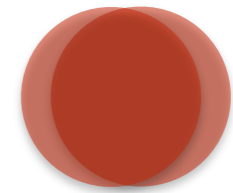


10-50% (Semi-central)

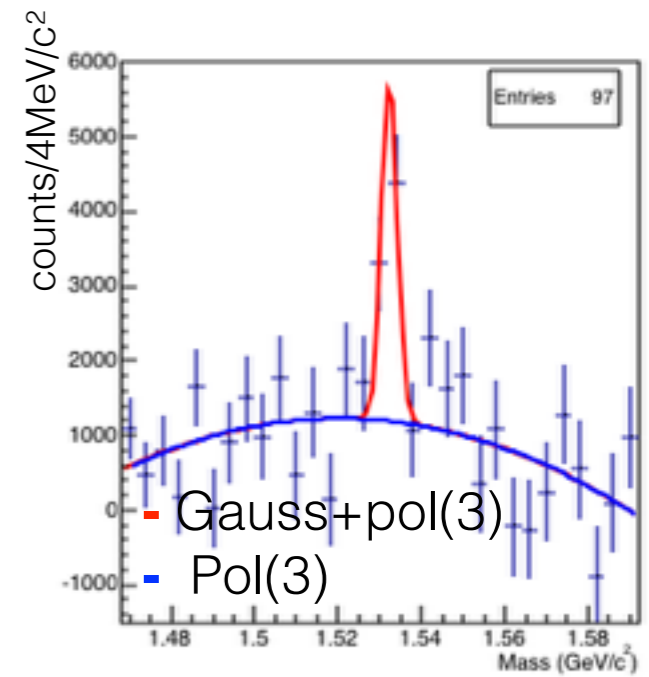
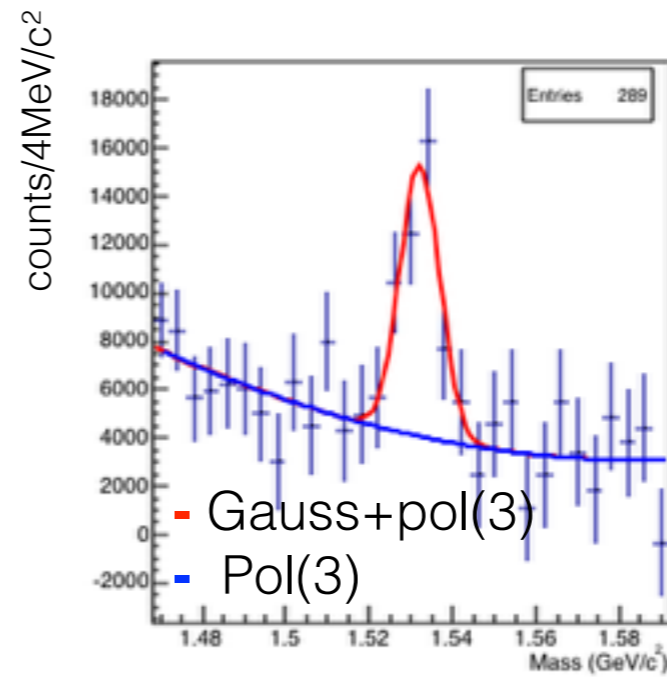
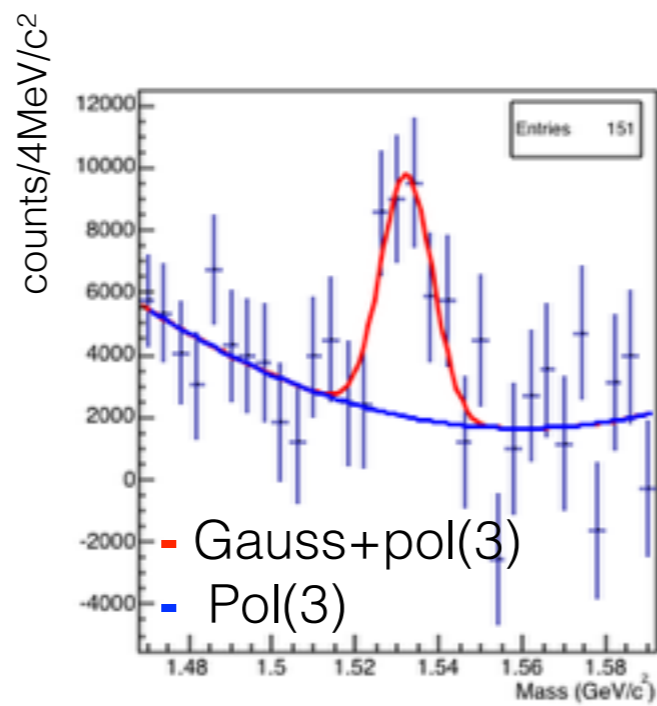
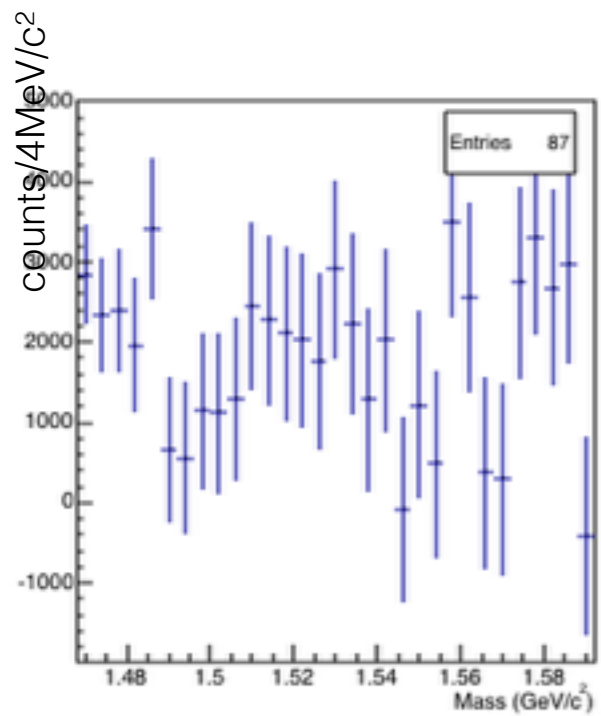
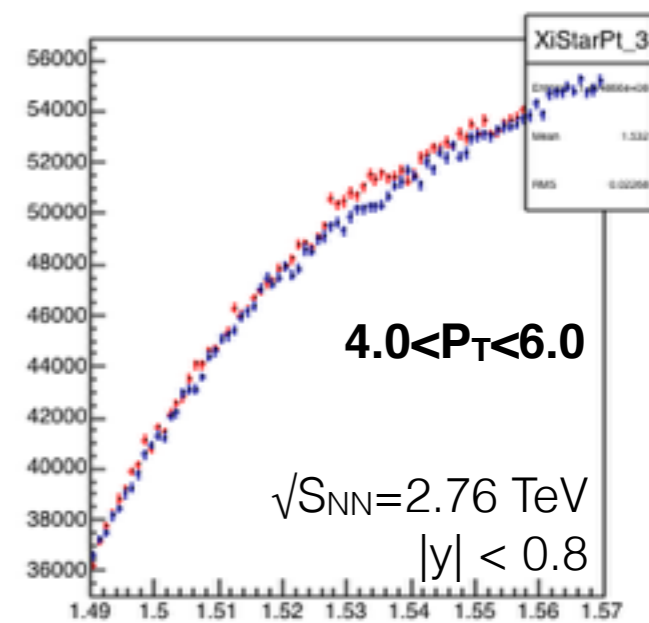
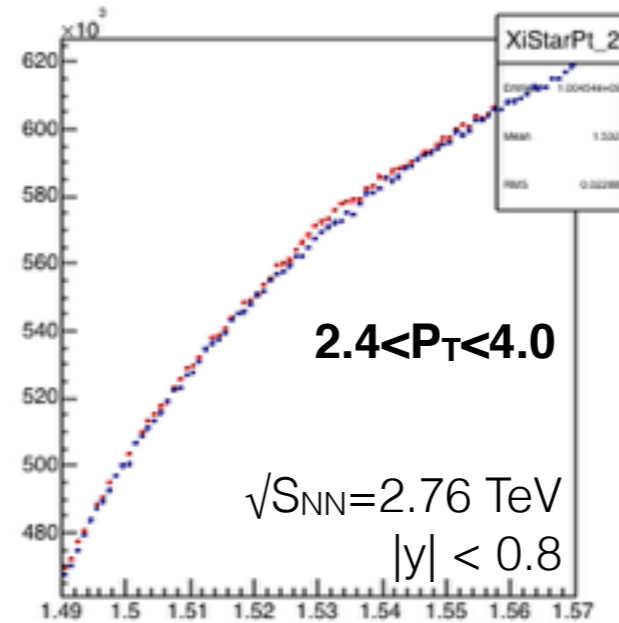
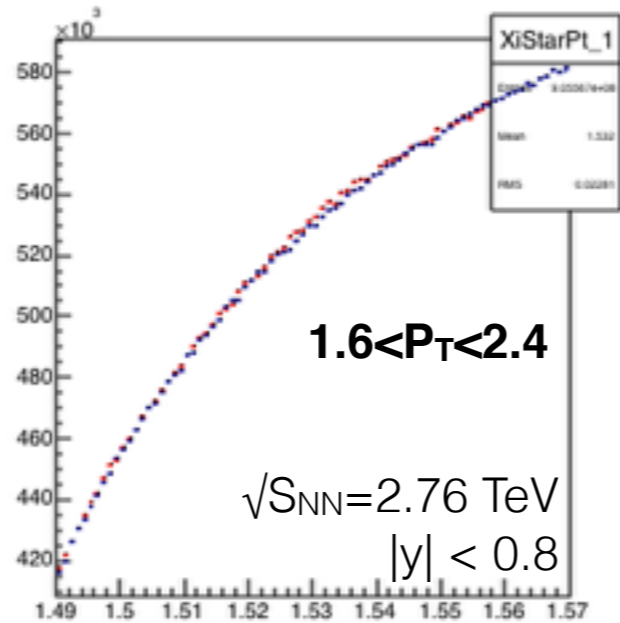
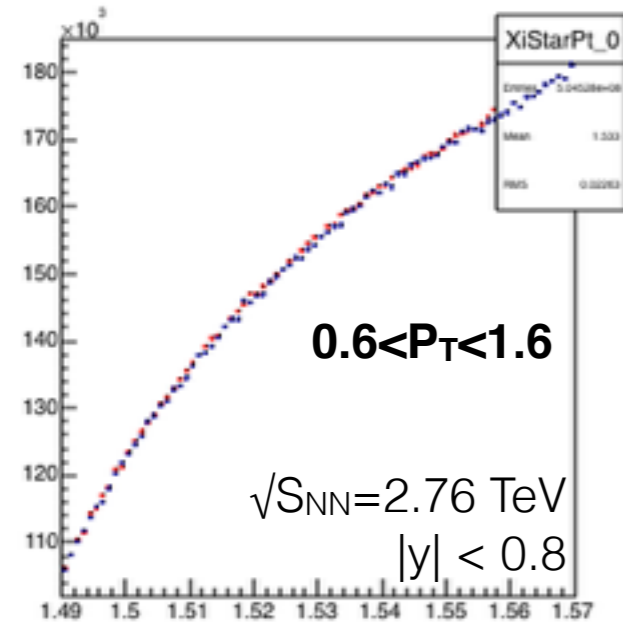


**Pb-Pb @  
2.76 TeV**

# Signal extraction

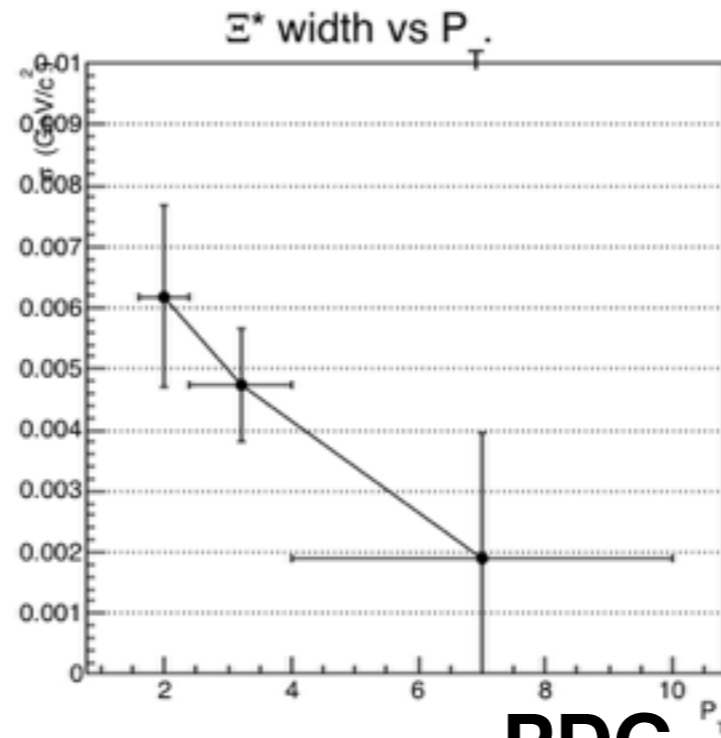
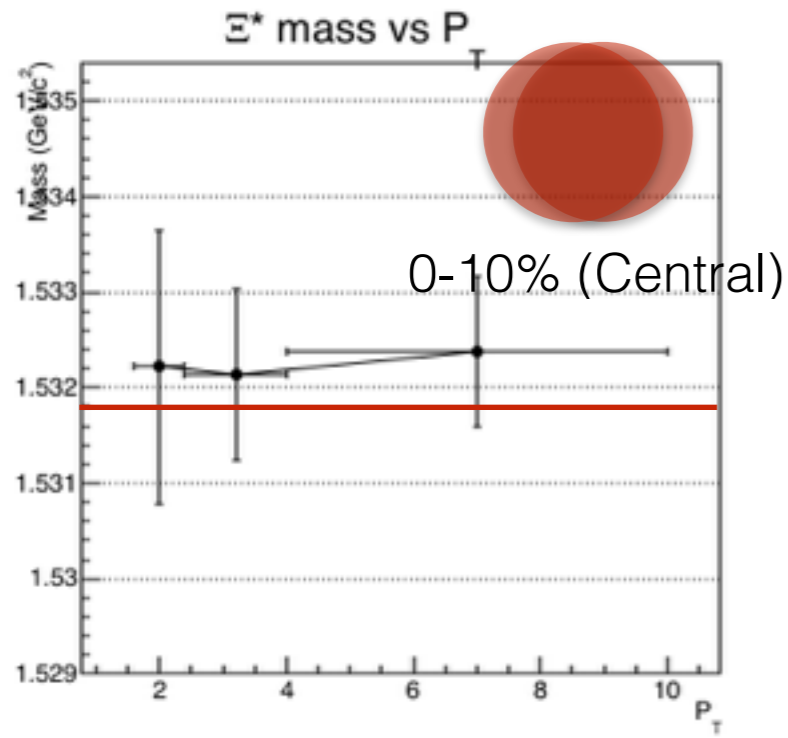
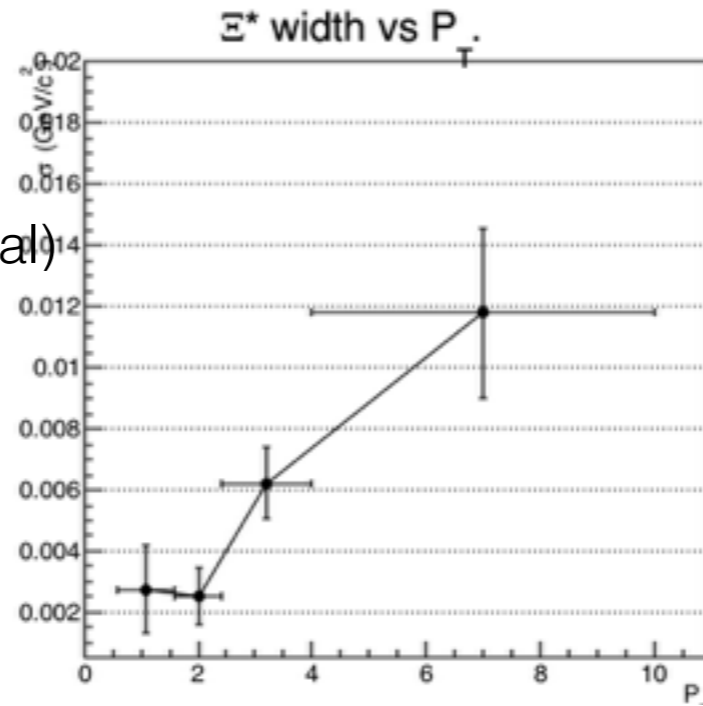
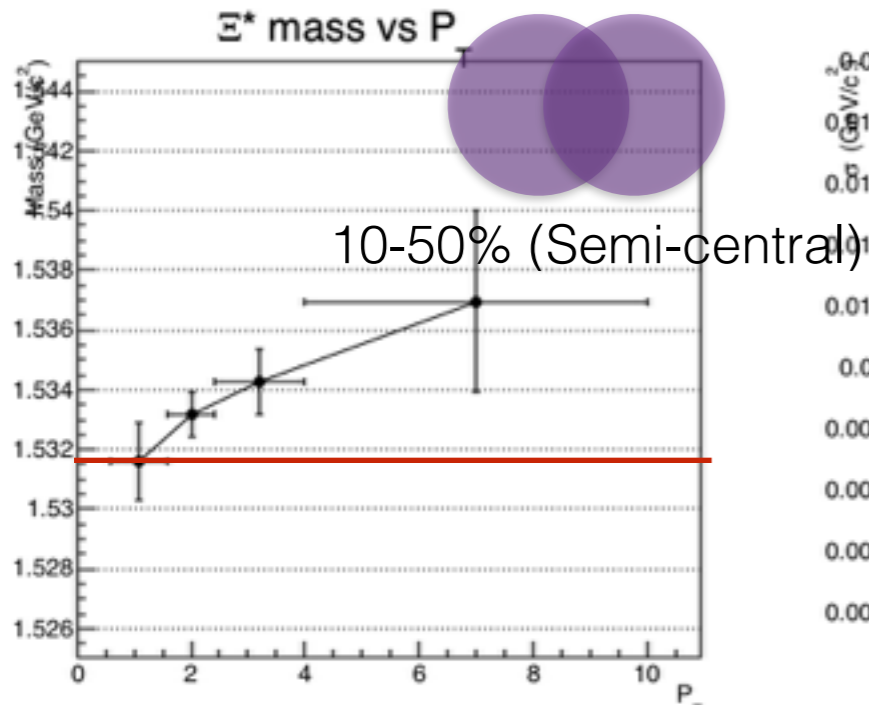


0-10% (Central)



**Pb-Pb @  
2.76 TeV**

# $\Xi^*0$ Mass & $\sigma$



These results are very !!  
first look.  
Need deeper & detailed  
analysis

**PDG**

$\Xi(1530)^0$  Mass :  $1531.80 \pm 0.32$  MeV

$\Xi(1530)^0$  Width :  $9.1 \pm 0.5$  MeV

# Summary & Outlook

- $\Xi^{*0}$  analysis with p-Pb collisions and Pb-Pb collisions to get  $R_{AA}$  and  $R_{pPb}$

**p-Pb  
@ 5.02TeV**

- Under cross checking
- Systematic study is feasible

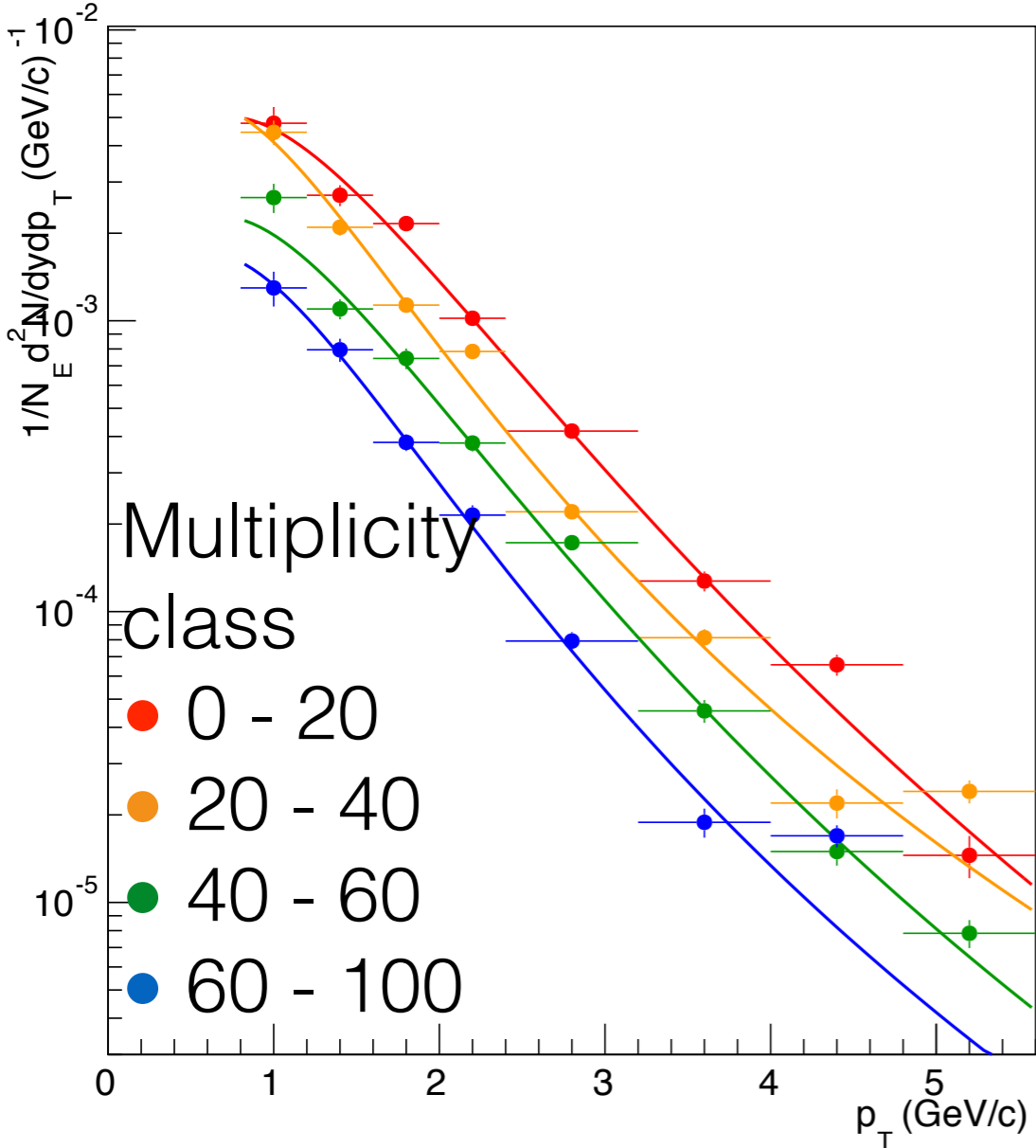
**Pb-Pb @  
2.76 TeV**

- 1st look on Pb-Pb (2011) datasets
- Promising results
- Full statistics are deduced
- MC simulation is on the way

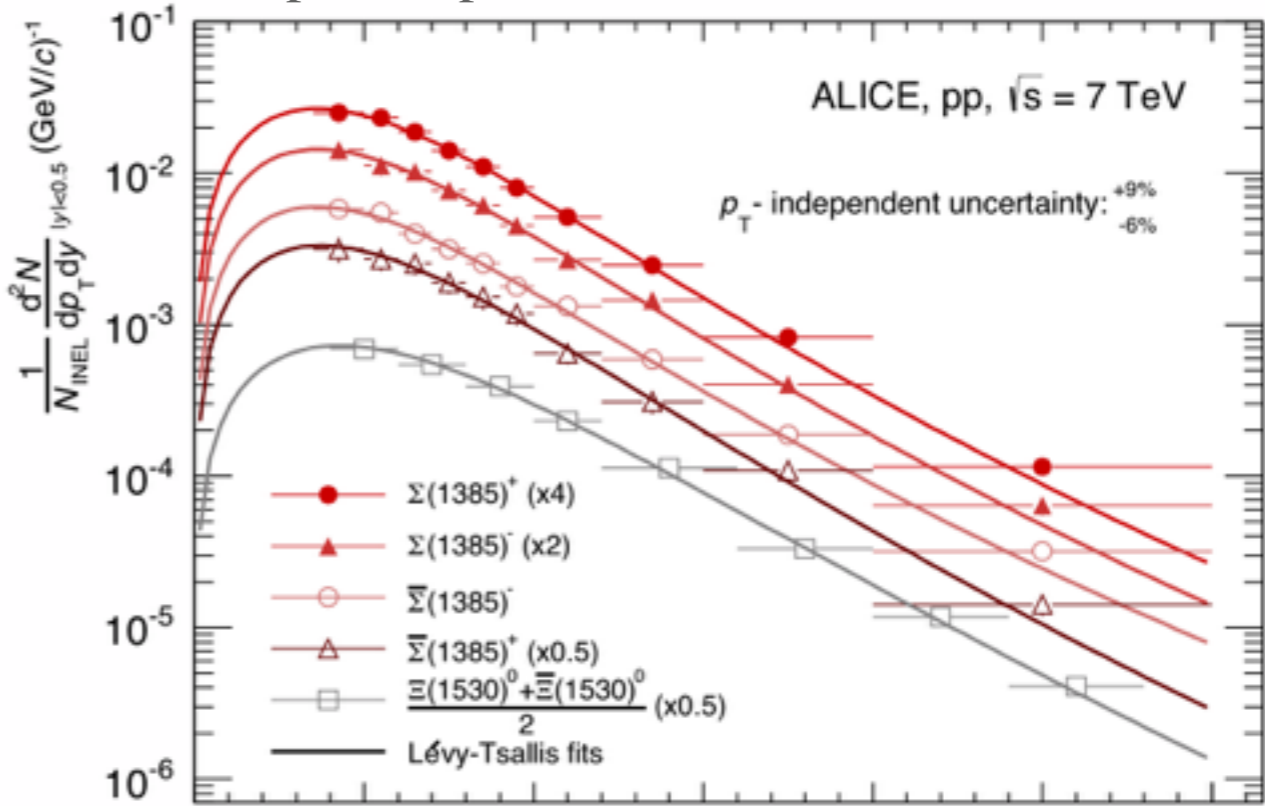
# Backup

# Levy fit of $\Xi^{*0}$ yields

pPb  $\sqrt{s} = 5.02$  TeV



Production of  $\Sigma(1385)_{\pm}$  and  $\Xi(1530)_0$  in proton-proton collisions at  $\sqrt{s}=7$  TeV



	$dN/dy(10^{-3})$	$C$ (MeV)	$n$
pp	$2.48 \pm 0.07 \pm 0.24$	$404 \pm 20 \pm 21$	$16.9 \pm 3.9 \pm 1.9$
p-Pb	$18.25 \pm 0.82$	$259 \pm 10$	$7.97 \pm 0.54$

$$\frac{1}{N_E} \frac{d^2N}{dy dp_T} = \frac{dN}{dy} p_T \frac{(n-1)(n-2)}{nC(nC + M(n-2))} \left[ 1 + \frac{\sqrt{p_T^2 + M^2} - M}{nC} \right]^{-n}$$

**p-Pb**  
**@ 5.02 TeV**





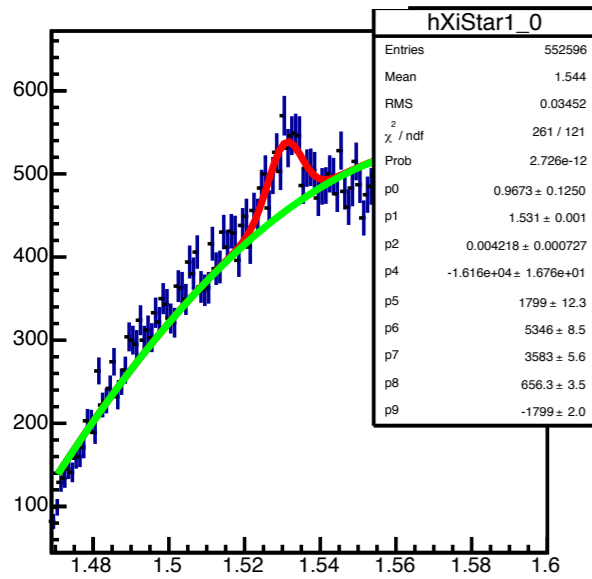
Data

# $\Xi^*$ & $\Xi^*$ $P_T$ dependence

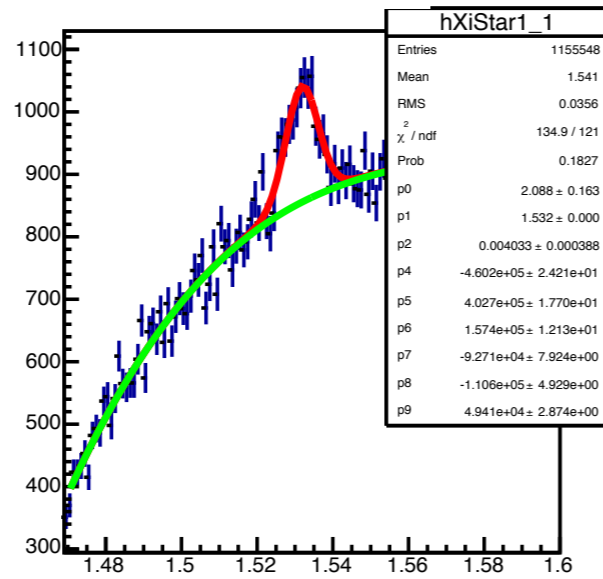
$0 < y_{CMS} < 0.5$

Centrality **0-20%**

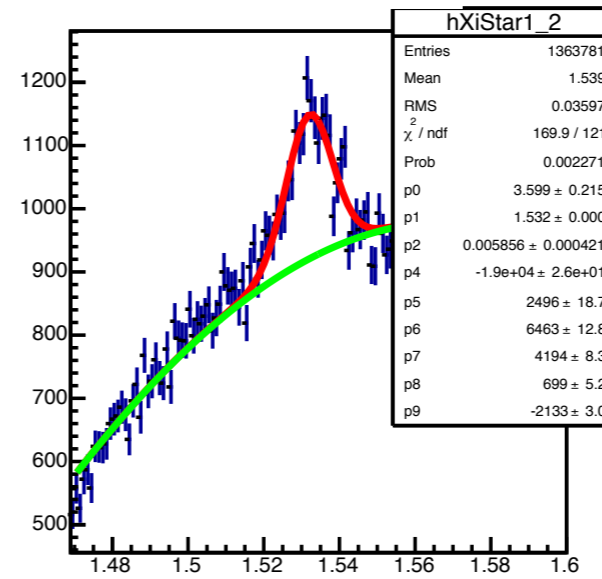
$P_T$  0.8-1.2



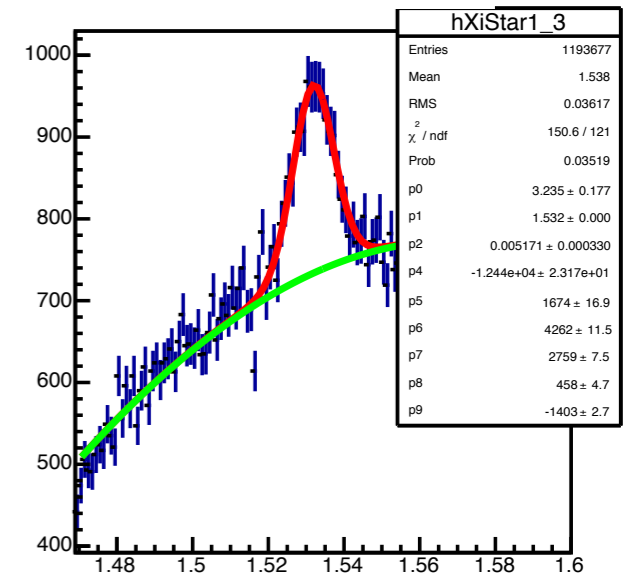
$P_T$  1.2-1.6



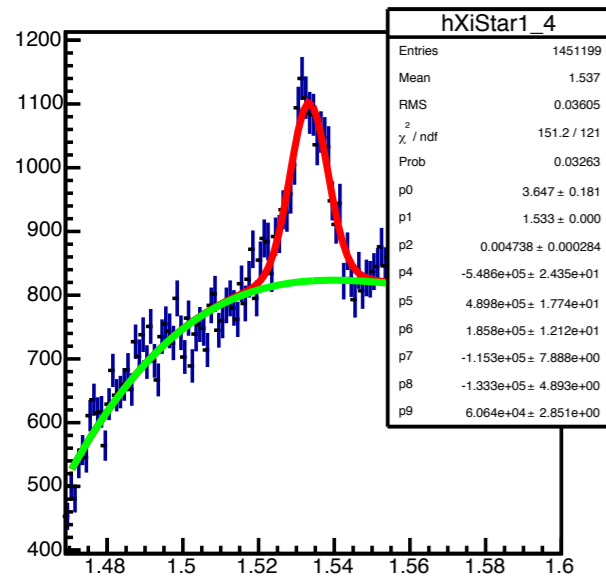
$P_T$  1.6-2.0



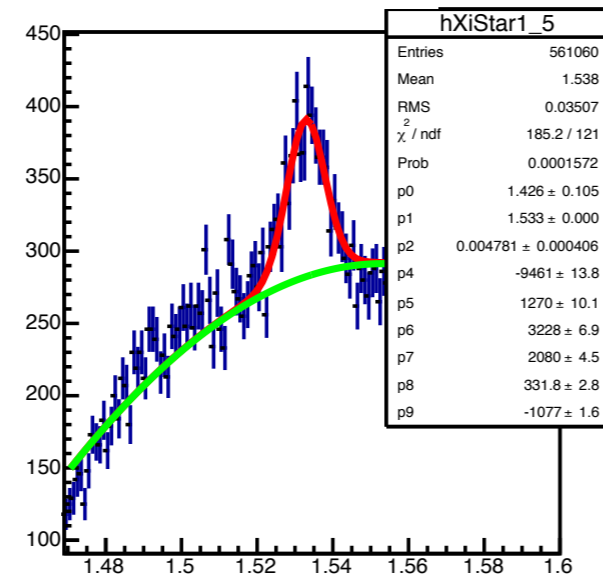
$P_T$  2.0-2.4



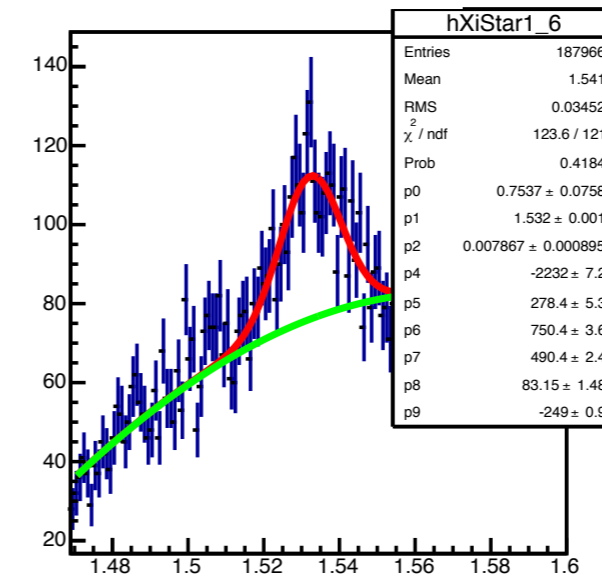
$P_T$  2.4-3.2



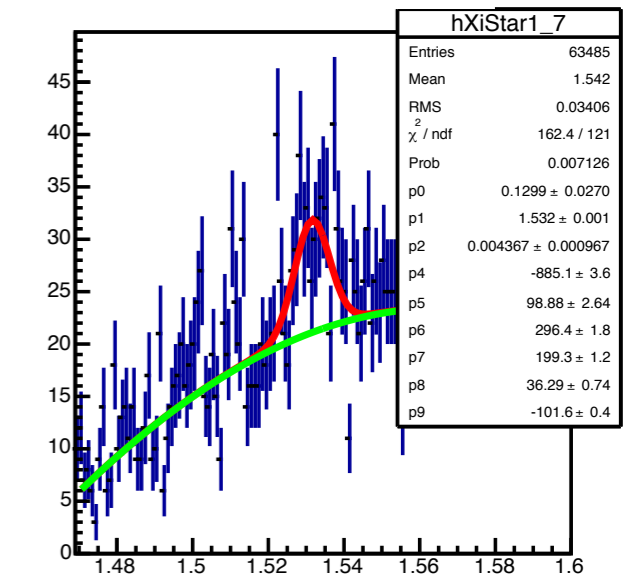
$P_T$  3.2-4.0



$P_T$  4.0-4.8



$P_T$  4.8-5.6



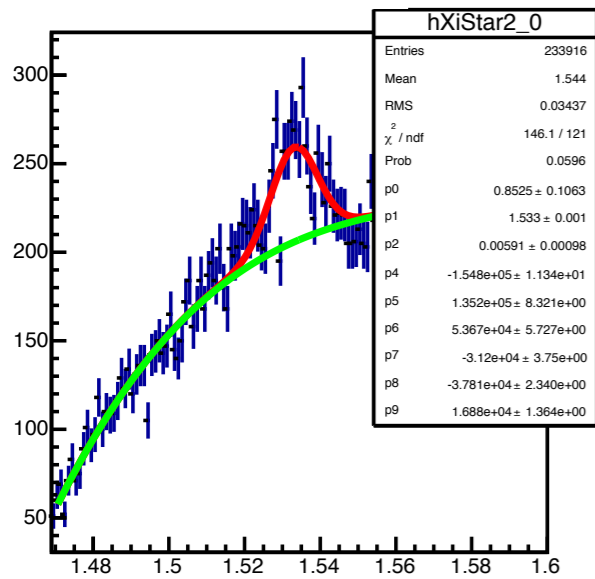
Data

# $\Xi^* & \Xi^*$ $P_T$ dependence

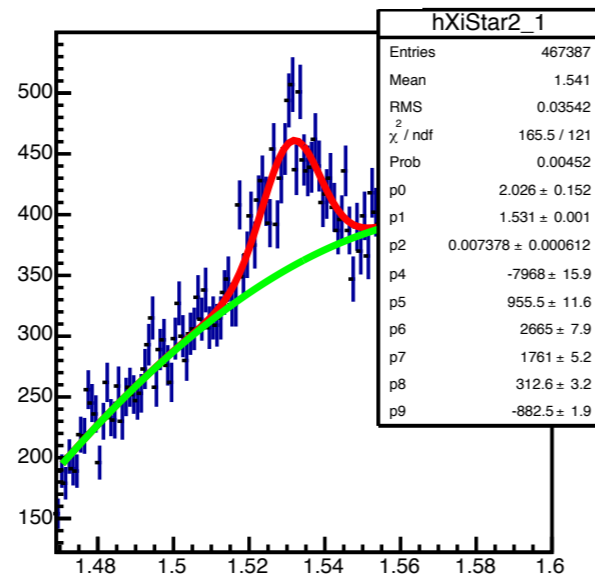
$0 < y_{CMS} < 0.5$

Centrality **20-40%**

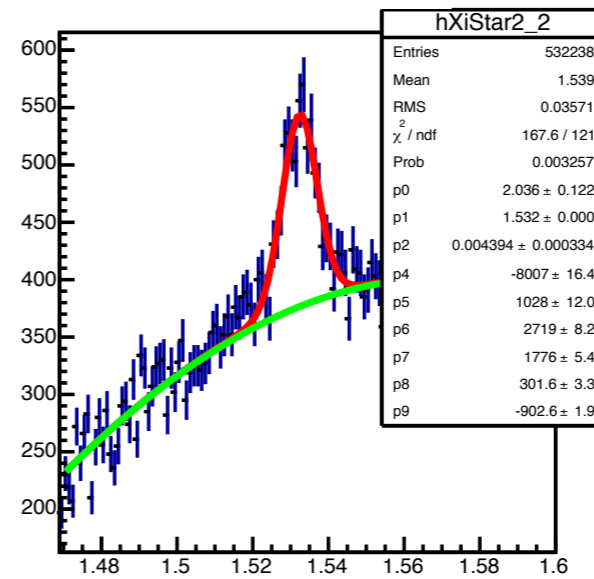
$P_T$  0.8-1.2



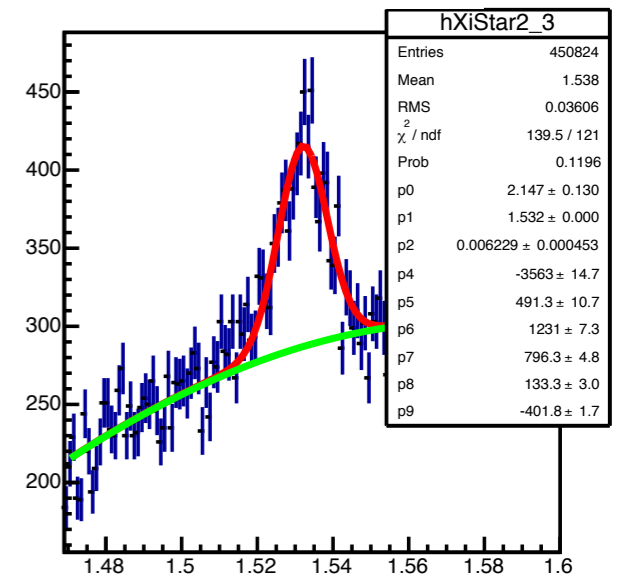
$P_T$  1.2-1.6



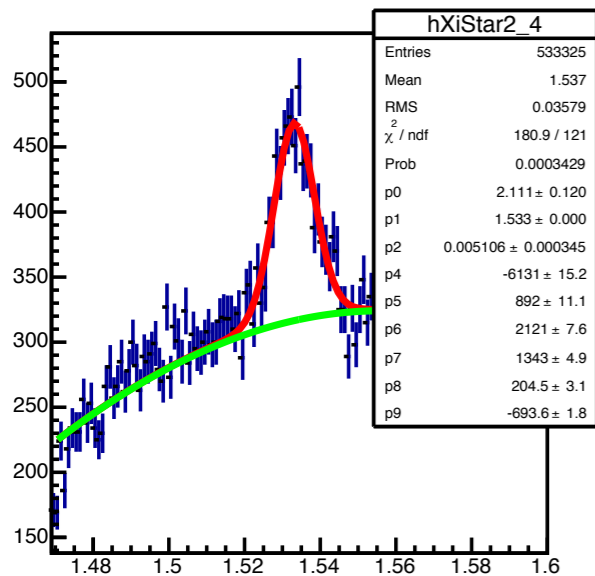
$P_T$  1.6-2.0



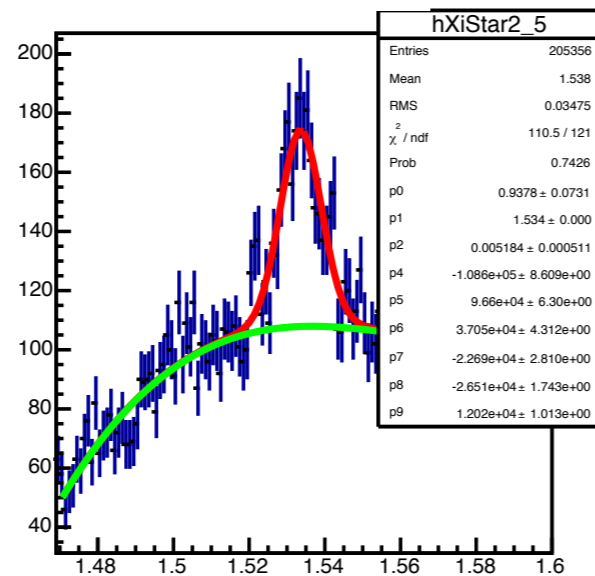
$P_T$  2.0-2.4



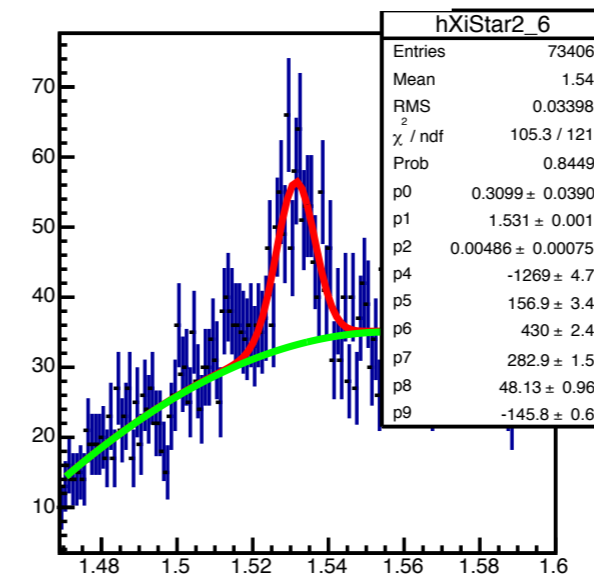
$P_T$  2.4-3.2



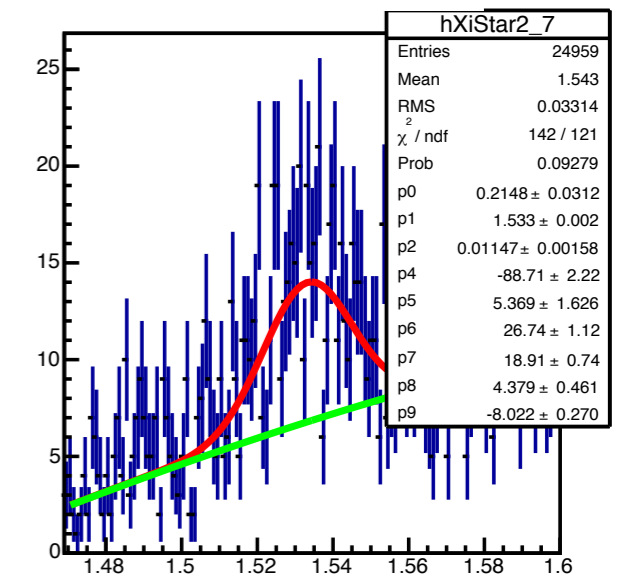
$P_T$  3.2-4.0



$P_T$  4.0-4.8



$P_T$  4.8-5.6



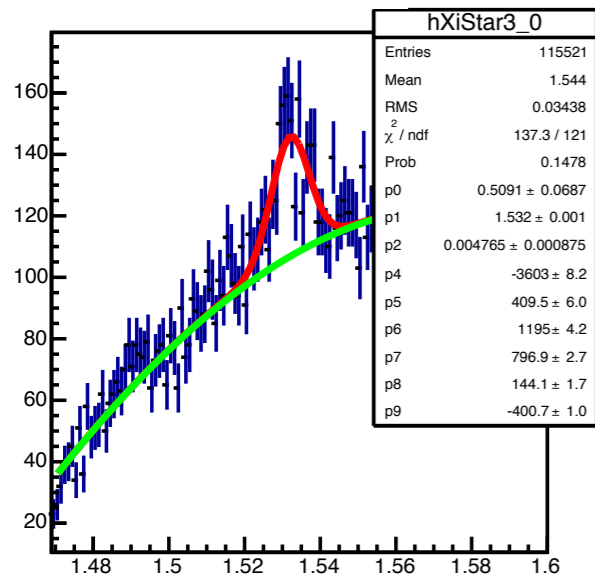
Data

# $\Xi^* & \Xi^*$ $P_T$ dependence

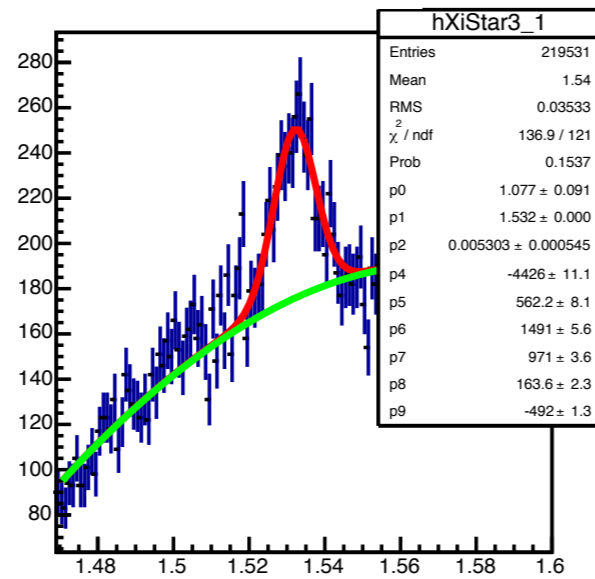
$0 < y_{CMS} < 0.5$

Centrality **40-60%**

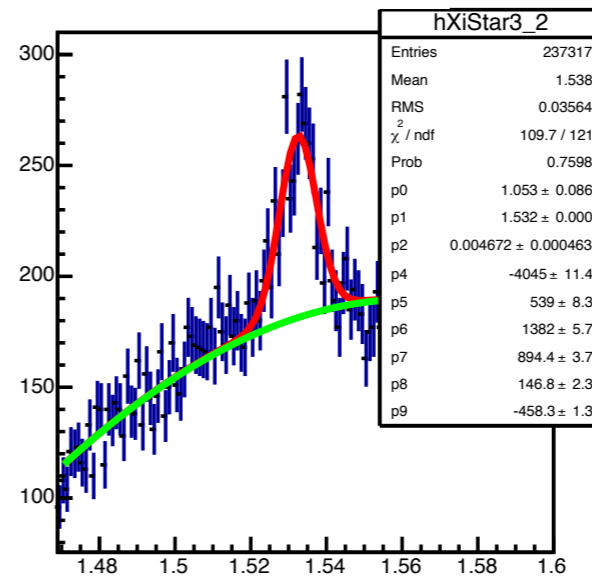
$P_T$  0.8-1.2



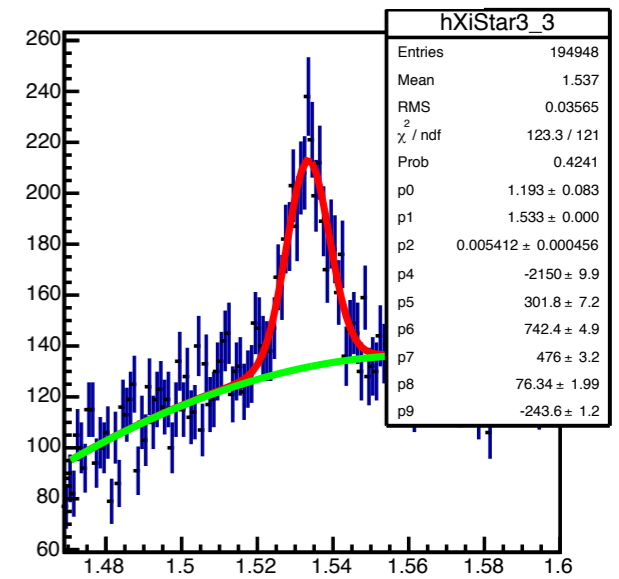
$P_T$  1.2-1.6



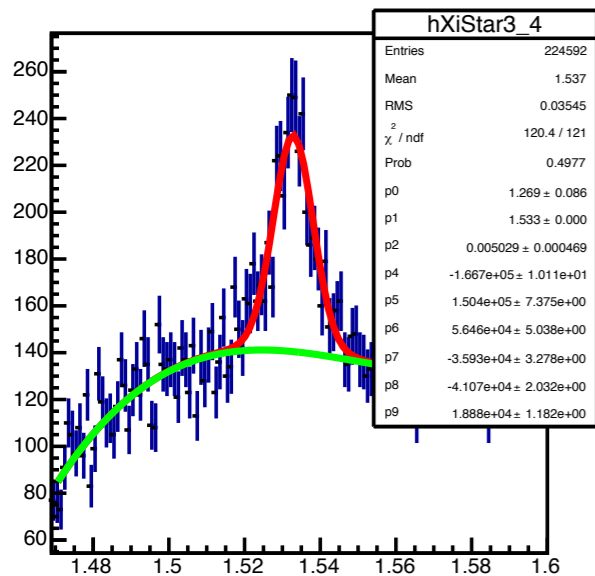
$P_T$  1.6-2.0



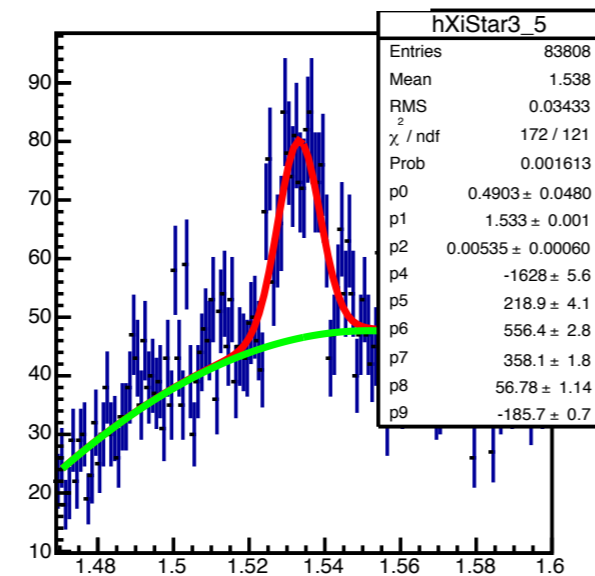
$P_T$  2.0-2.4



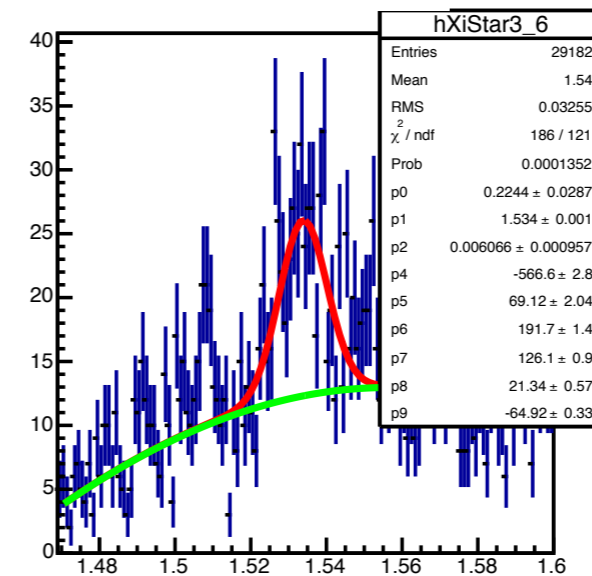
$P_T$  2.4-3.2



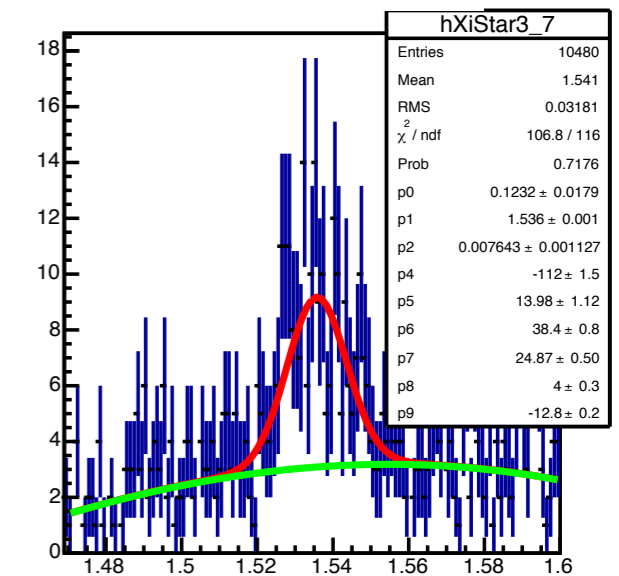
$P_T$  3.2-4.0



$P_T$  4.0-4.8



$P_T$  4.8-5.6



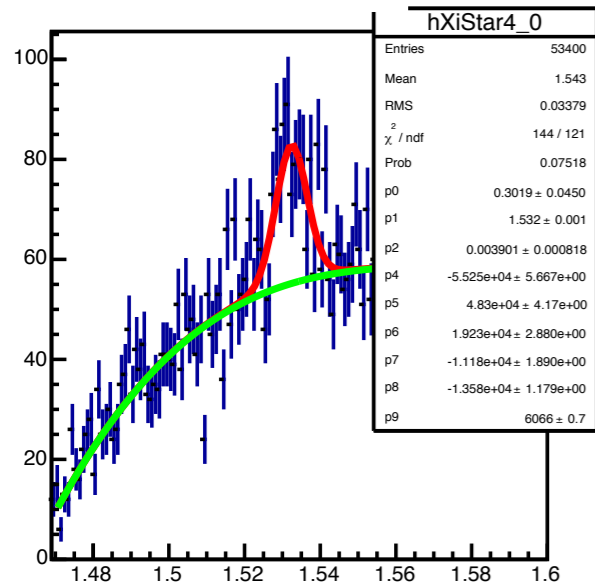
Data

# $\Xi^*$ & $\Xi^*$ $P_T$ dependence

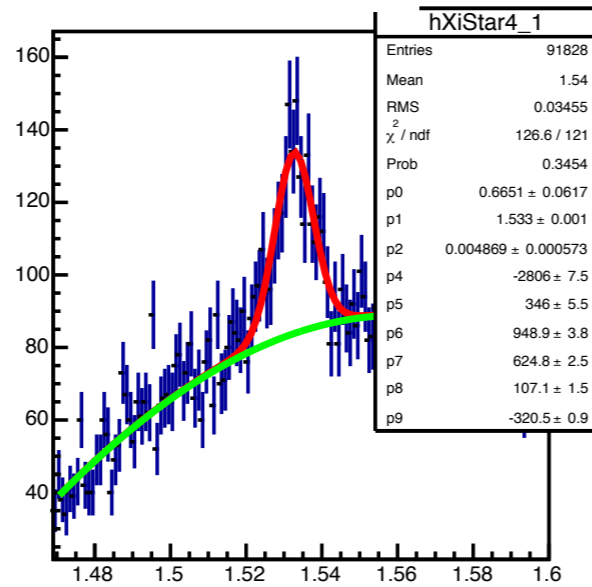
$0 < y_{CMS} < 0.5$

Centrality **60-100%**

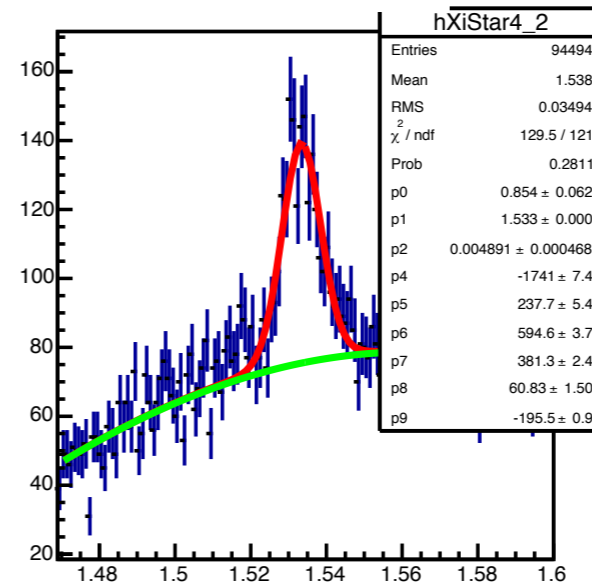
$P_T$  0.8-1.2



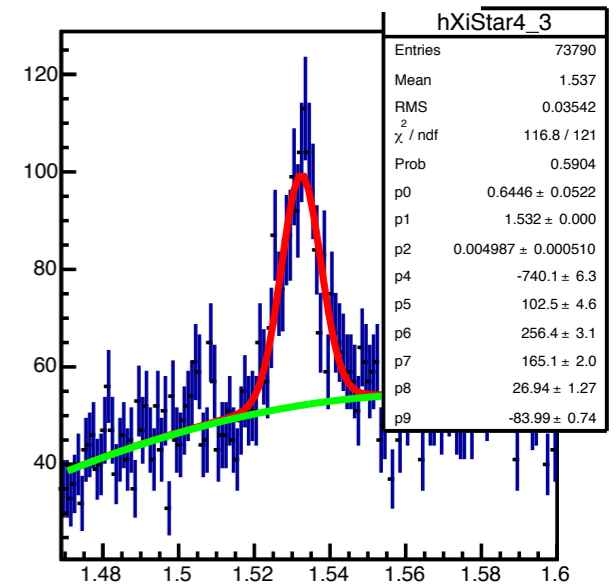
$P_T$  1.2-1.6



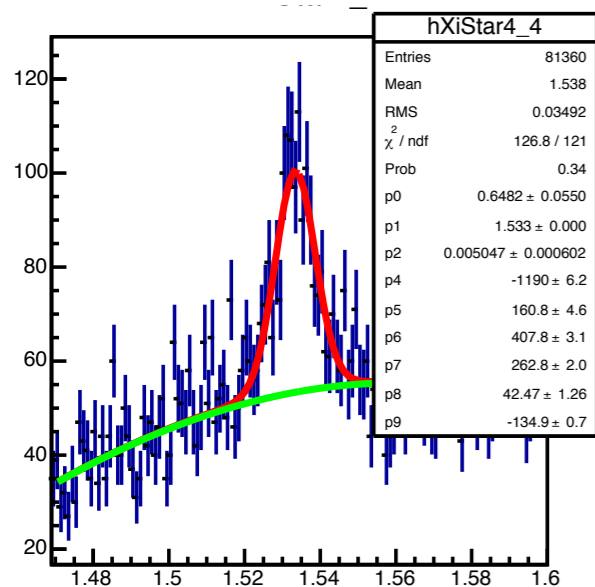
$P_T$  1.6-2.0



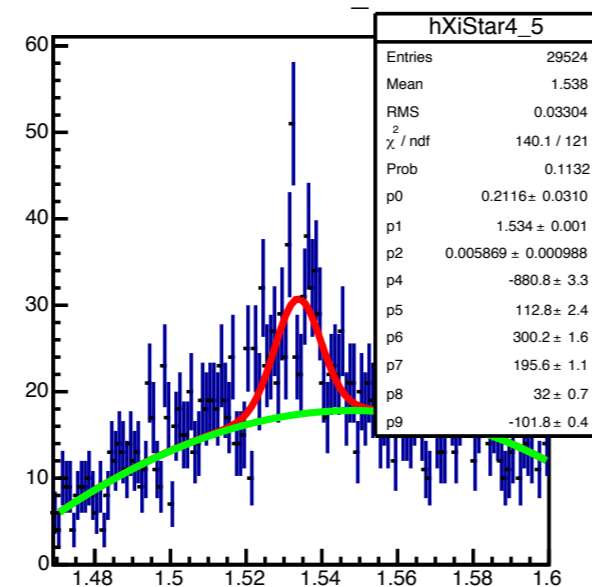
$P_T$  2.0-2.4



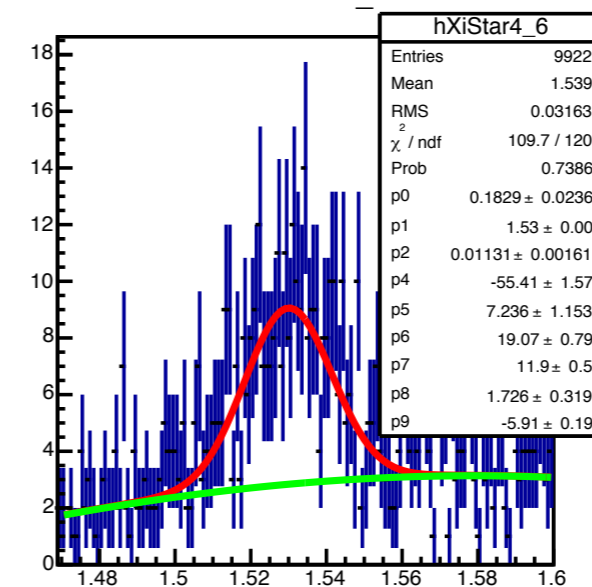
$P_T$  2.4-3.2



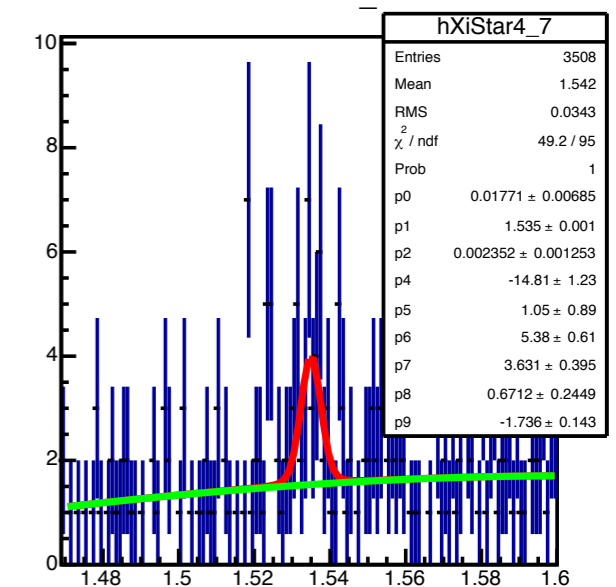
$P_T$  3.2-4.0



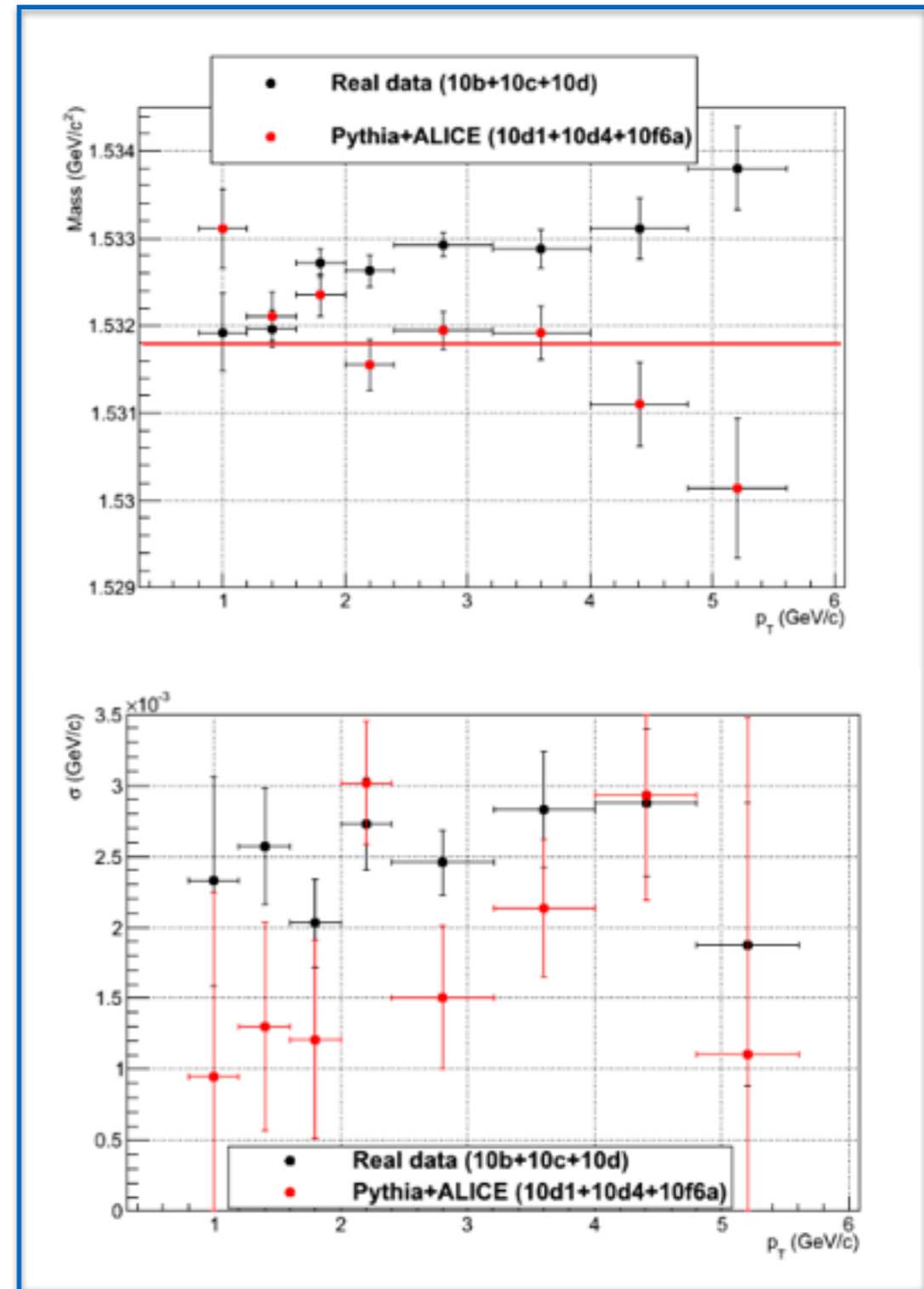
$P_T$  4.0-4.8



$P_T$  4.8-5.6



pp



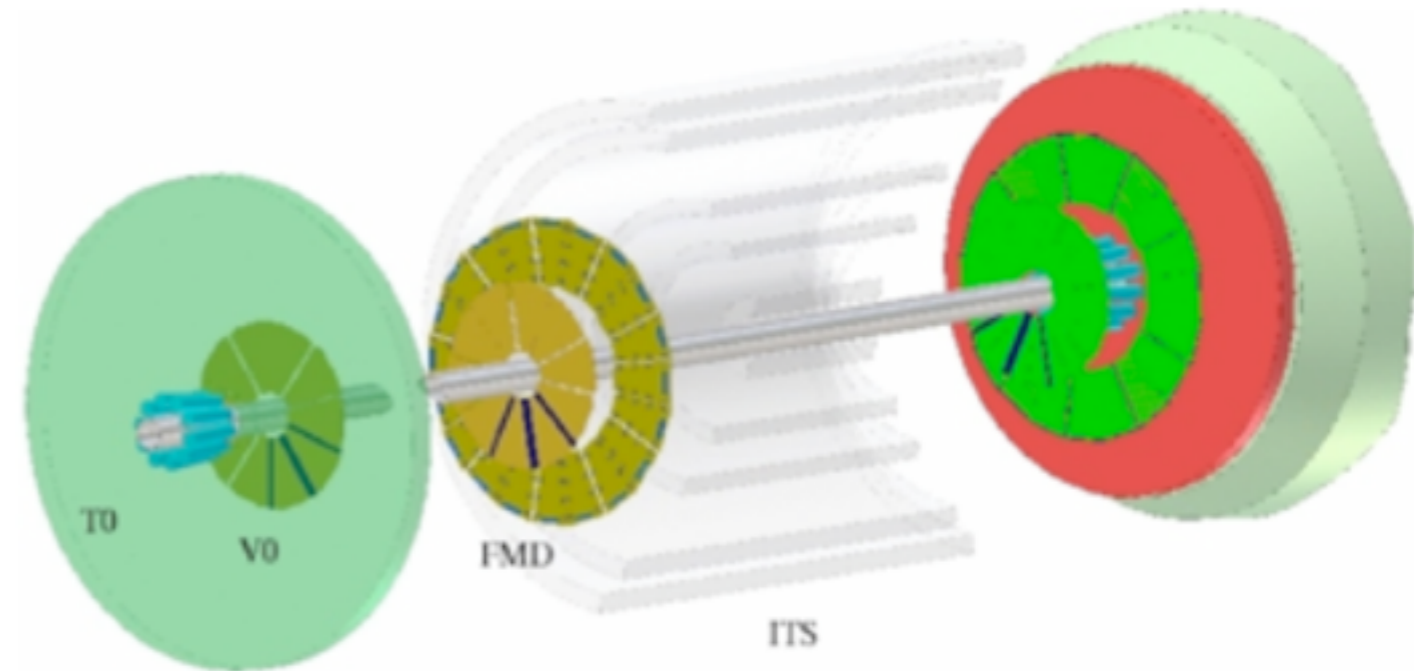
# ALICE trigger detectors

## The VZERO detector

- Two arrays of scintillator hodoscopes
  - Located at  $z \sim 340\text{cm}$  (V0A) and  $-90\text{cm}$  (V0C)
  - Segmented in four rings and eight sectors each
- Trigger algorithm / criteria:
  - minimum number of clusters on V0A | V0C
  - minimum number of clusters on V0A & V0C
  - on HIC (2011) two thresholds were considered (increased) to use it as centrality trigger
    - 0-10% CC maximum stats
    - 0-50% CC downscaling



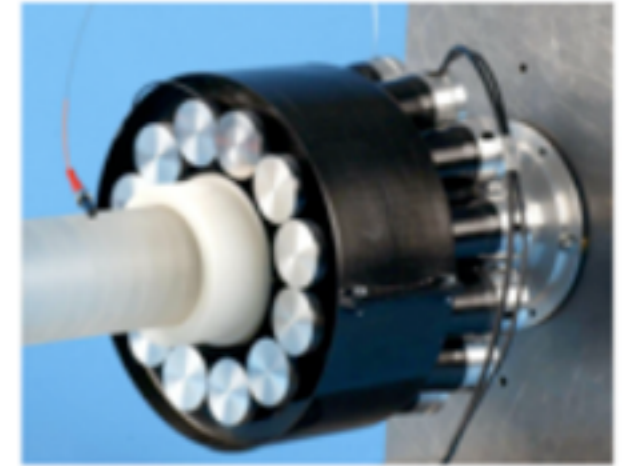
V0 scheme.



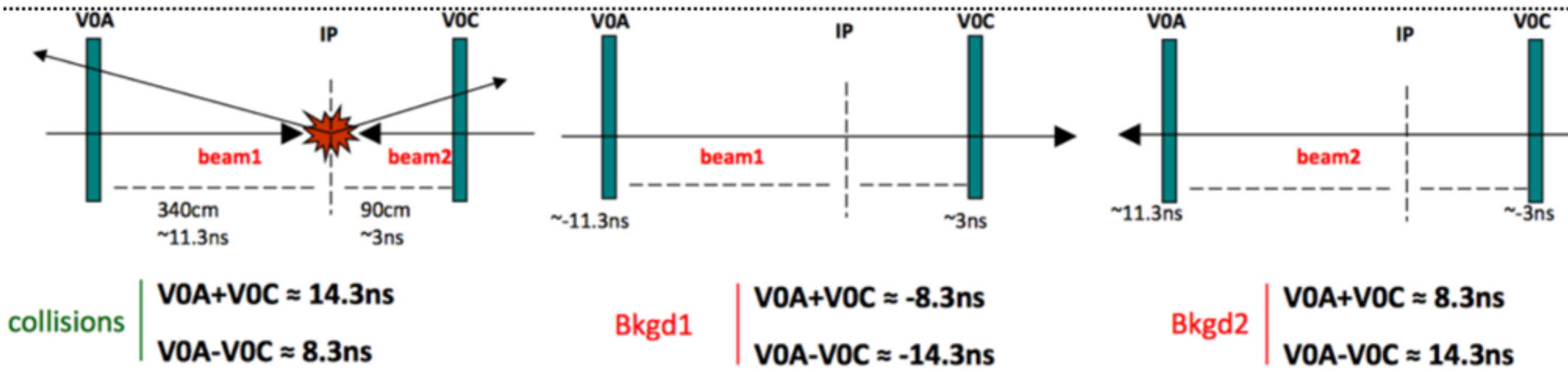
# ALICE trigger detectors

## The T0 detector

- Two arrays of Cherenkov counters
  - 12 counters (photomultiplier + radiator) per array
  - located at  $z \sim 350\text{cm}$  (T0A) and  $-70\text{cm}$  (T0C)
- Trigger algorithm / criteria:
  - Measurement of the particles arrival time at T0A & T0C evaluates the vertex position (time of the interaction)
  - Interaction time should match the



T0 prototype.



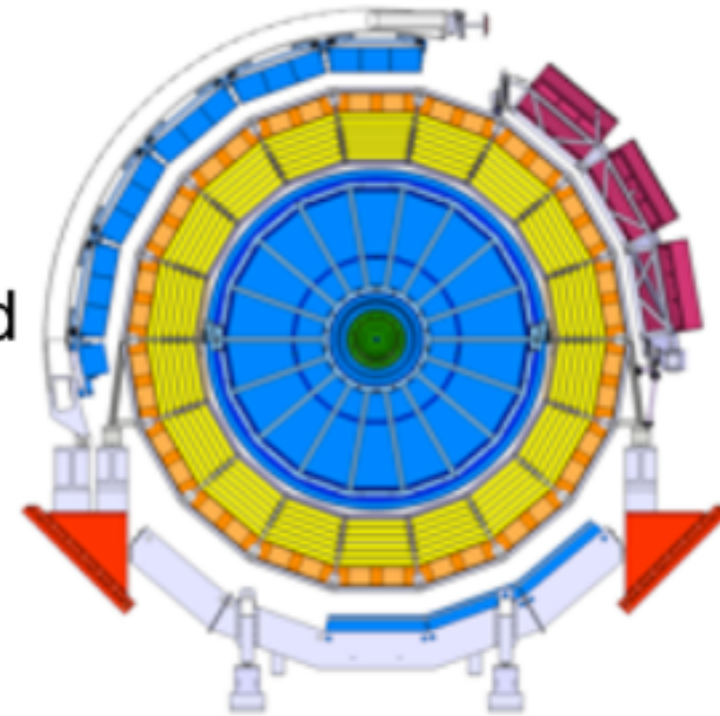


# ALICE trigger detectors

## The TRD & EMCAL detectors

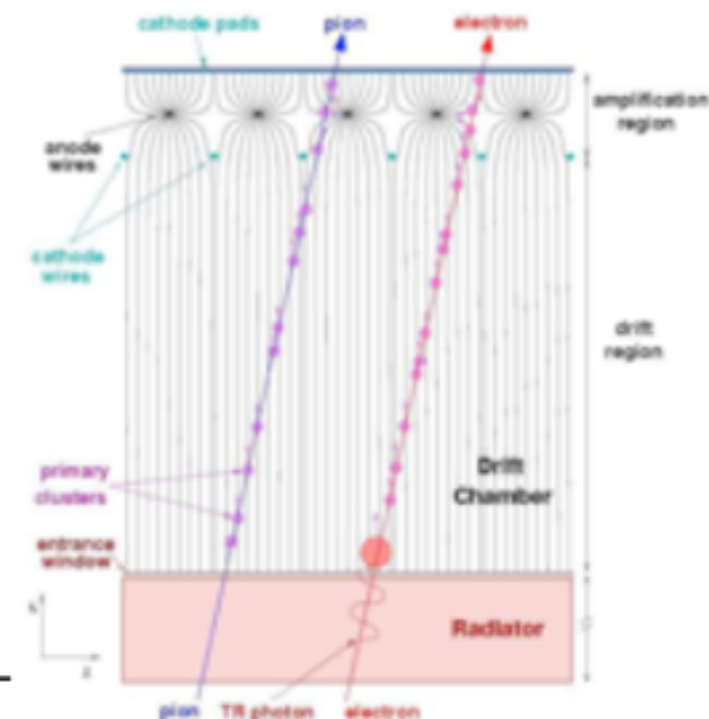
- EMCAL

- Lead-scintillator sampling calorimeter ( $|\Delta\eta| < 0.7$ ,  $100^\circ$  in azimuth, towers of  $\Delta\eta \times \Delta\phi = 0.014 \times 0.014$ )
- Trigger algorithm / criteria: threshold on the energy deposited
  - Gamma (single shower) trigger (2x2 towers)
  - Jet trigger (8x8, 16x16... towers)
  - Energy thresholds are adapted per data taking period



- TRD

- 18 sectors (x 6 layers x 5 segments along z) of a radiator of  $\sim 4.8\text{cm}$  and a multi-wire proportional chamber (MRPC)
- Trigger algorithm / criteria: threshold on the track pt
  - Single electron and di-electron triggers
  - Jet-like trigger also present
- Energy thresholds are adapted per data taking period



Schema of a TRD.