ALICE activities by Yonsei

Ju Hwan Kang

(Yonsei University)

Heavy Ion Meeting 2012-12

Dec. 7 - 8, 2012,

Chonnam National University, Gwangju

Students

- Total 8 PhD program students
- 3 students at CERN for ALICE
- 1 student at BNL for PHENIX
- 4 students at Yonsei (ALICE or PHENIX)

Students at CERN

Analysis efforts made by the following students staying currently at CERN will be introduce

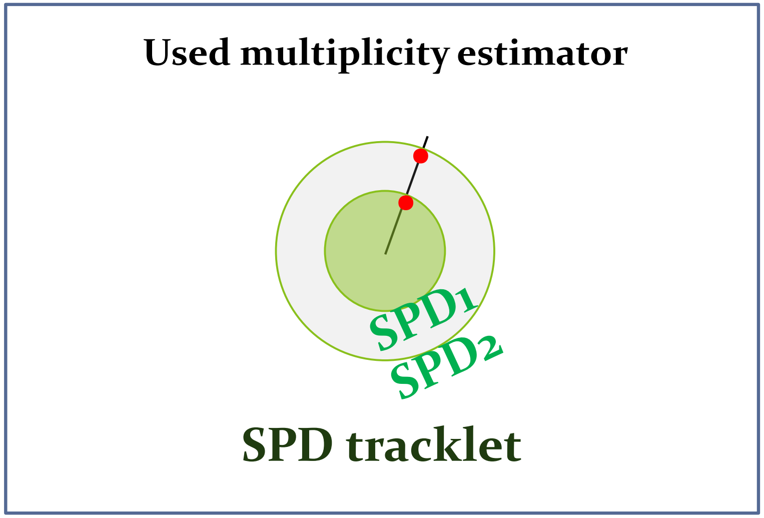
- Beomkyu Kim: 1) dN/dEta of p+p, 2) Diffractive Physics, 3) “maybe” high multplicity p+p events
- Myunggeun Song: Flow Measurement of High Pt Particle
- Minwoo Kim: Modification of Fragmentation Function

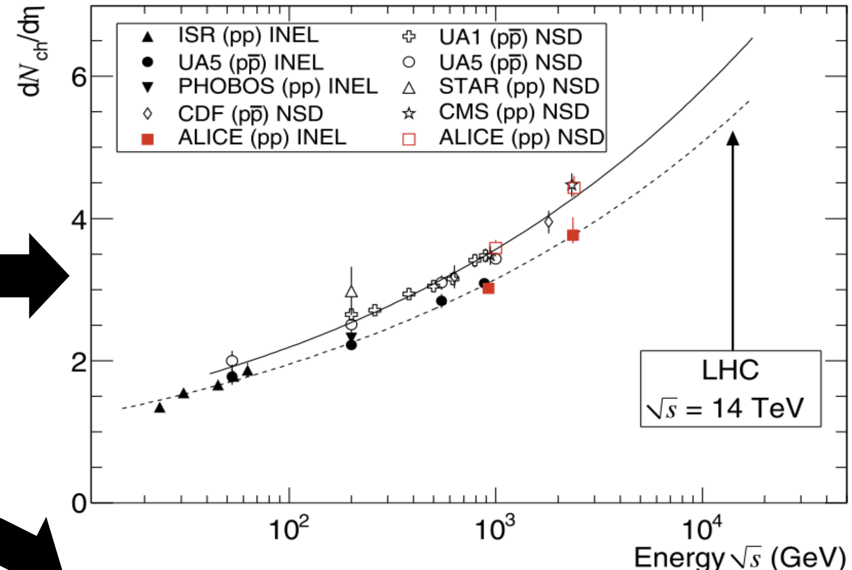
Central barrel $\frac{1}{N_{event}}\frac{dN_{ch}}{d\eta}$

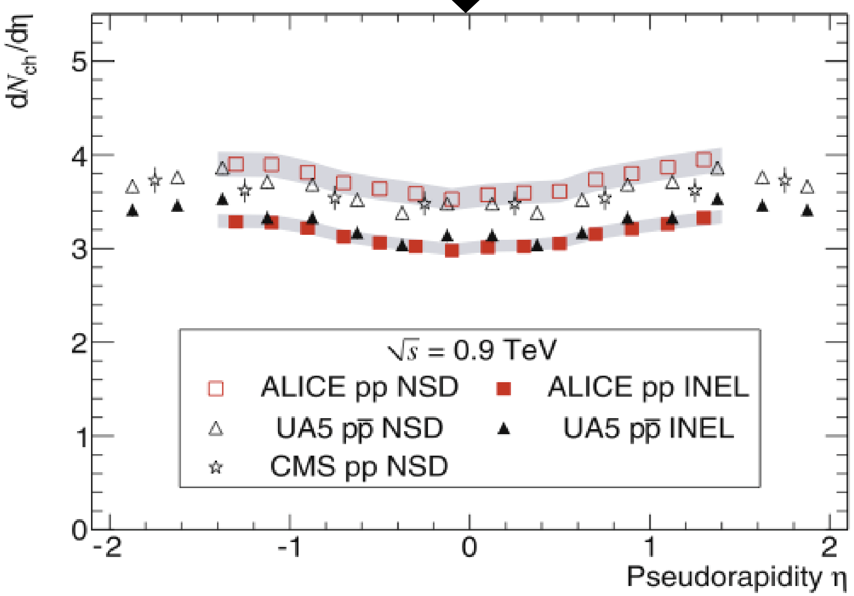
Beomkyu Kim

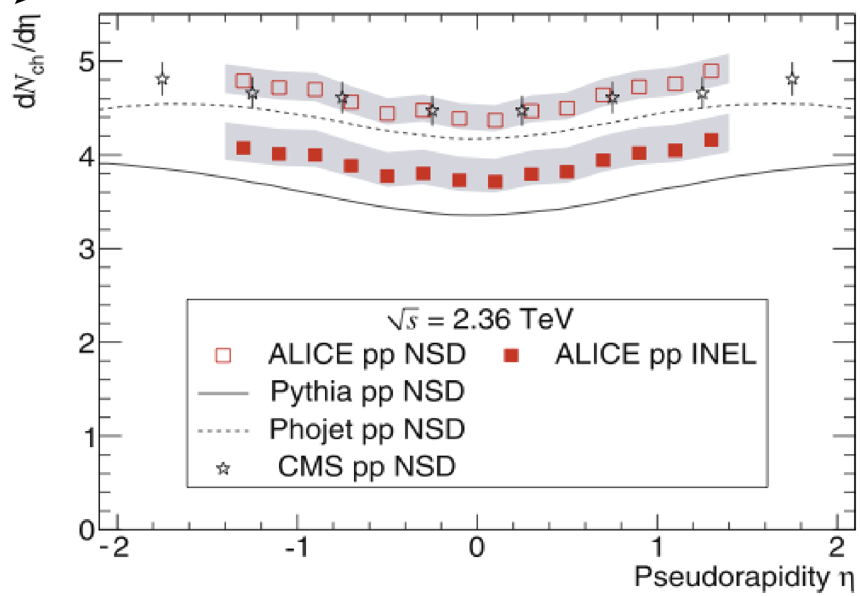
연세대학교
YONSEI UNIVERSITY

dN/dEta data in previous papers









Motivations

- New results for 2.76TeV, 7TeV(INEL, NSD) and 8TeV

✓ Published papers for pseudo rapidity & multiplicity in p+p collisions

– $\sqrt{s}$ = 900GeV (INEL, NSD)	EJC: Vol. 65 (2010) 111	ALICE
– $\sqrt{s}$ = 2.36TeV (INEL , NSD)	EPJC: Vol. 68 (2010) 89	ALICE
– $\sqrt{s}$ = 900GeV, 2.36TeV and 7TeV (INEL>1)	EPJC: Vol. 68 (2010) 345	ALICE
– $\sqrt{s}$ = 900GeV, 2.36TeV and 7TeV (NSD)	arXiv:1005.3299v2(2010)	CMS
– $\sqrt{s}$ = 900GeV (INEL, NSD)	Z,Phys.C, 33,1-6(1986)	UA5

– Data update : dN/dEta for all energies with INEL,NSD and INEL>0

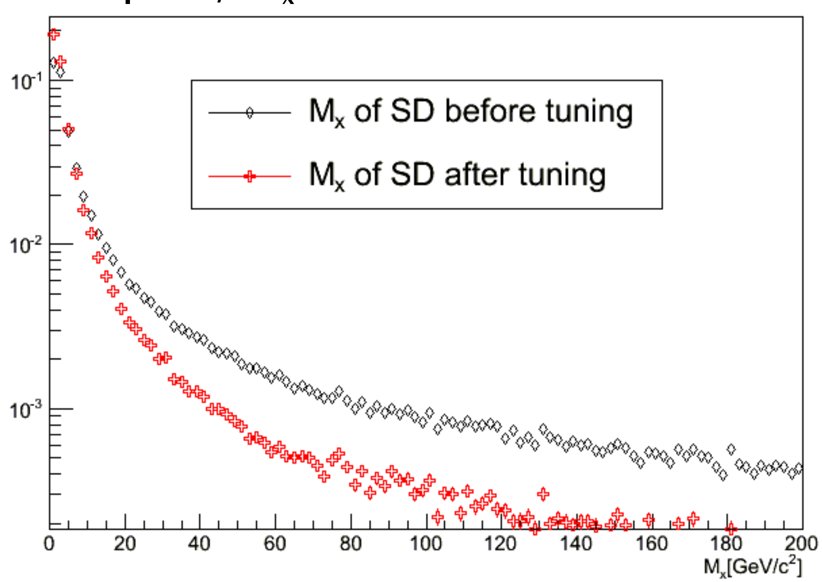
- Extending the pseudo-rapidity interval from $\eta = \pm 1.4$ to ± 1.8 to approach to the FMD acceptance range.
- Diffractive tuned MC is used to correct data

Diffractive tuned pythia and phojet

- PYTHIA and PHOJET were tuned to be consistent with ALICE and previous data on diffraction
  - If there does not exist a official tuned pythia and phojet, a post tuning method was used for a default pythia and phojet by using these functions,

    AliGenPythia::CheckDiffraction()

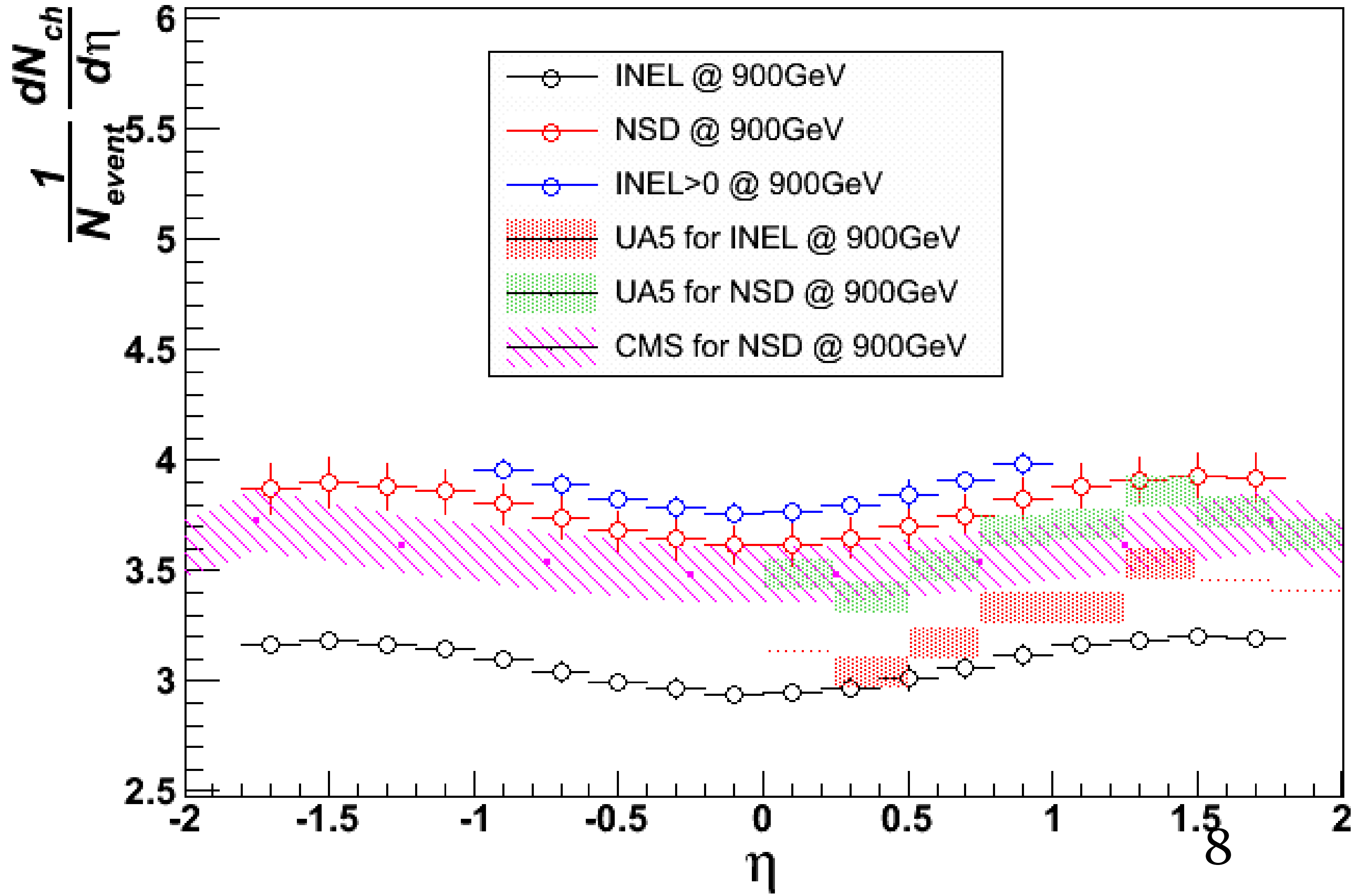
    AliGenDPMjet::CheckDiffraction()
  - First role : modifying the diffractive rates
  - Second role : modifying the diffractive mass distribution for single diffractive events (Changing the single diffractive event cross-section corresponding the steeper $1/M_X$ distribution to be more fit to the measured result)



2.76 TeV	Default pythia	Tuned pythia
SD(%)	20.6	13.3
DD(%)	12.8	12.8

Result @ 900GeV

- Final dN/dEta with the total systematic errors @ 900GeV
- Comparable data : UA5 and CMS's data



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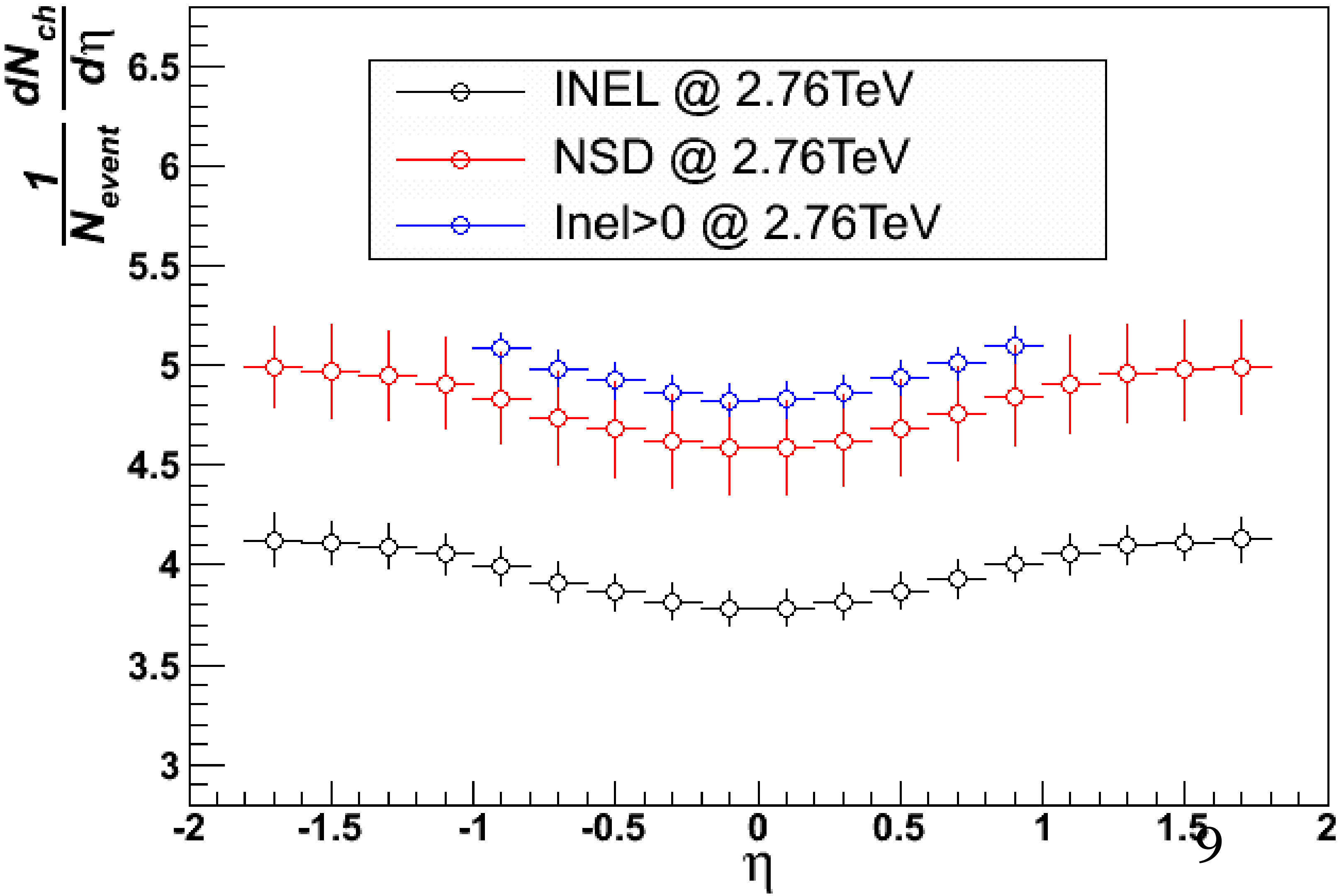
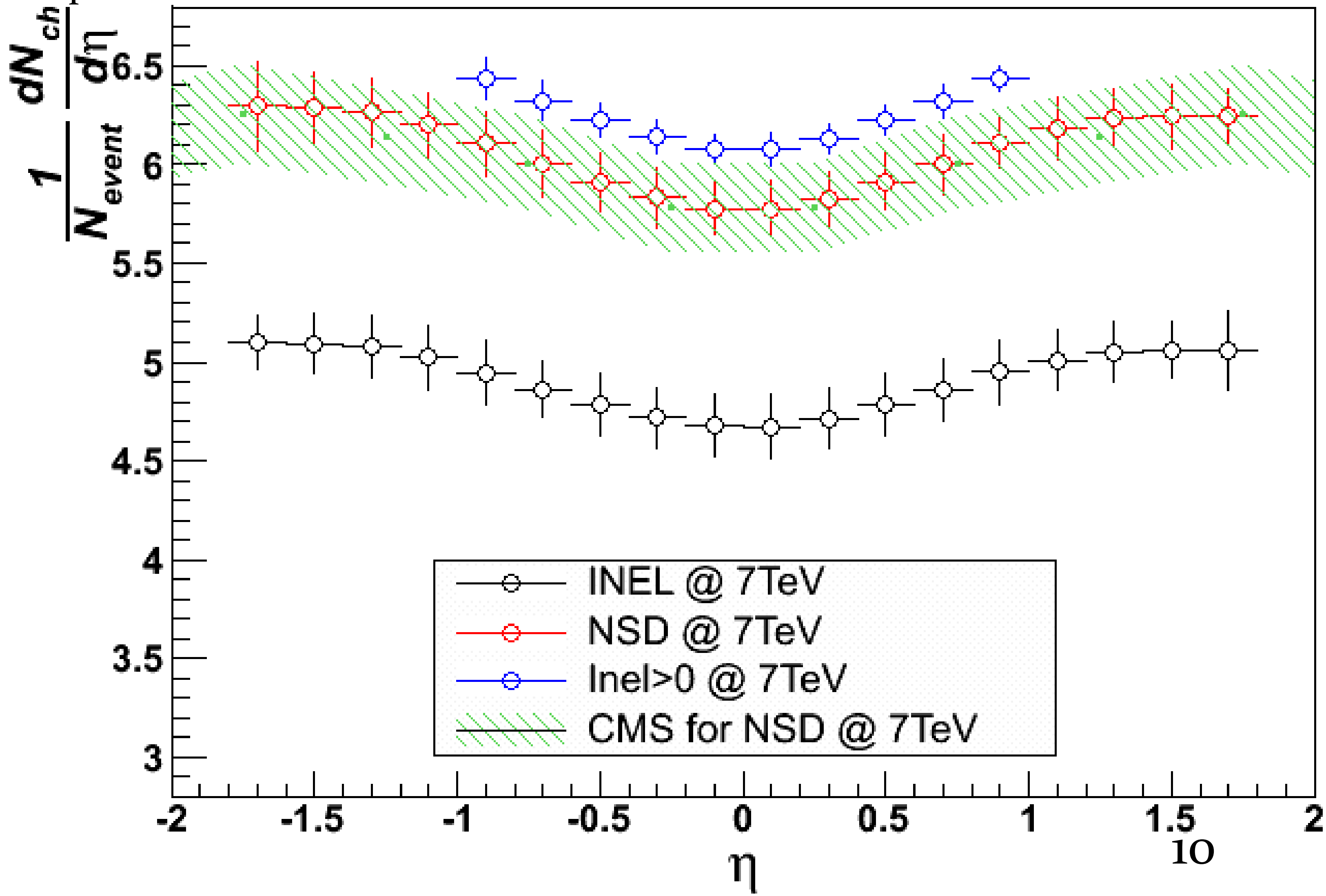
Result @ 2.76TeV

- Final dN/dEta with the total systematic errors @ 2.76TeV
- Larger systematic error for NSD because MC is not fully tuned



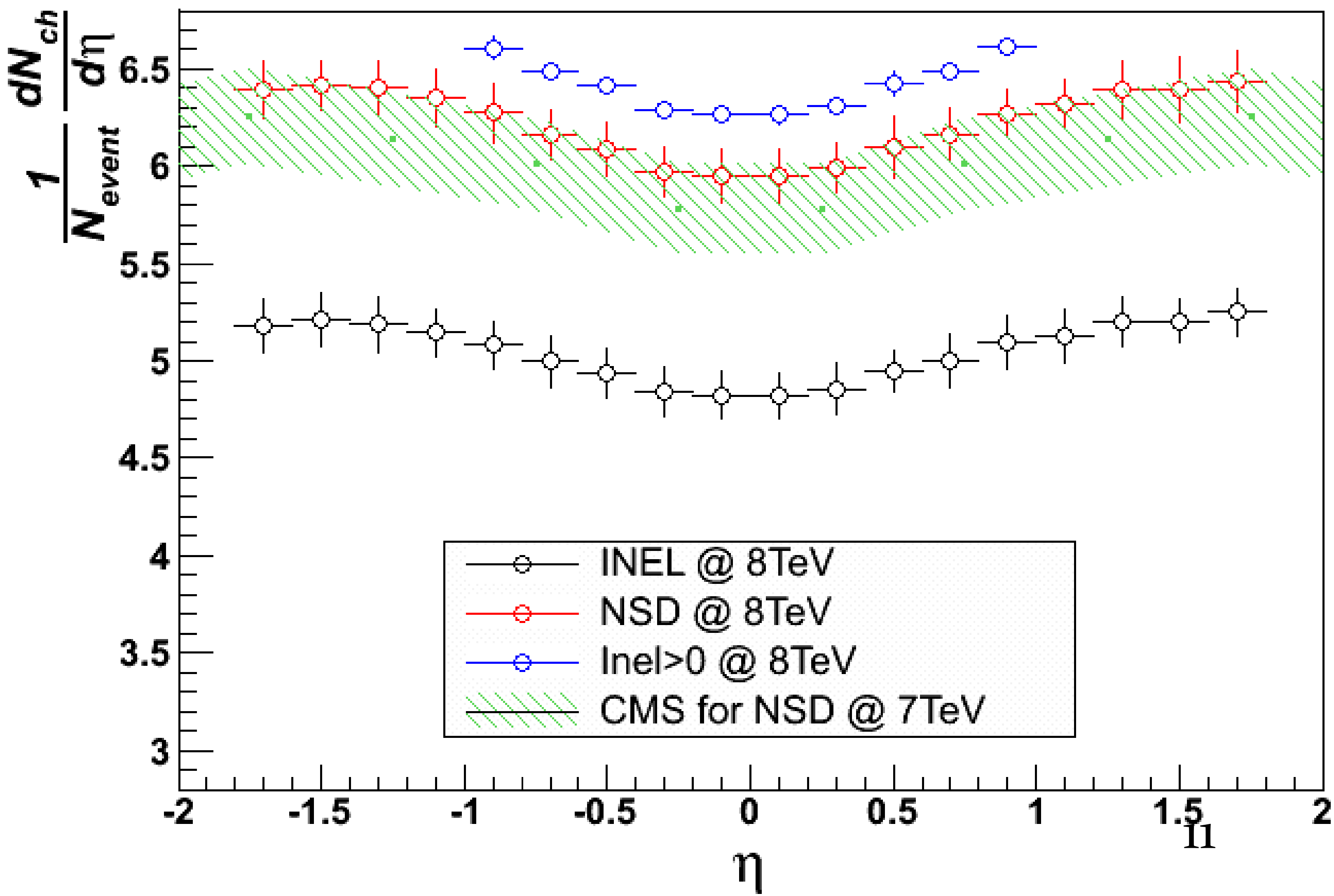
Result @ 7TeV

- Final dN/dEta with the total systematic errors @ 7TeV
- Comparable data : CMS's data



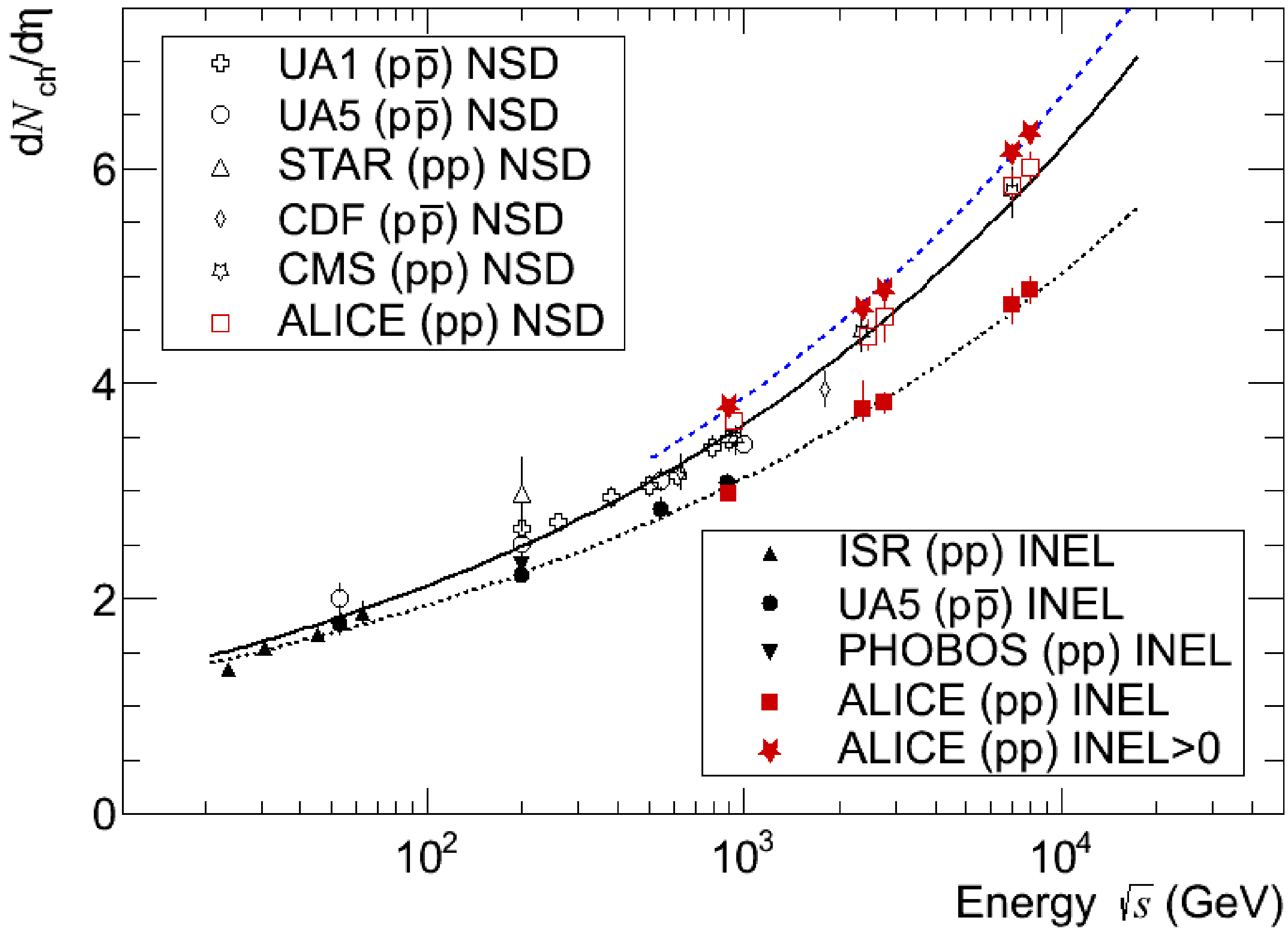
Result @ 8TeV

- Final dN/dEta with the total systematic errors @ 8TeV
- MC of 8TeV was tuned with the diffractive information of 7TeV



dN/dEta at η=0

- INEL $\propto s^{0.103}$, NSD $\propto s^{0.116}$, INEL>0 $\propto s^{0.117}$
- The results of 2.36TeV are from the published ALICE paper



Summary

- New data points update @ 2.76 & 8TeV
- Update all INEL and NSD data points by using tuned MC
- Eta range was extended to ± 1.8

$\sqrt{s}$	**INEL**	**NSD**	**INEL>0**
900GeV	2.975±0.001±0.037	3.650±0.001±0.095	3.797±0.001±0.045
2.76TeV	3.823±0.001±0.087	4.631±0.001±0.237	4.873±0.001 ±0.093
7TeV	4.725±0.001±0.159	5.839±0.002±0.141	6.148±0.001±0.082
8TeV	4.871±0.001±0.119	6.007±0.002±0.140	6.327±0.001±0.044

Diffractive physics

Beomkyu Kim

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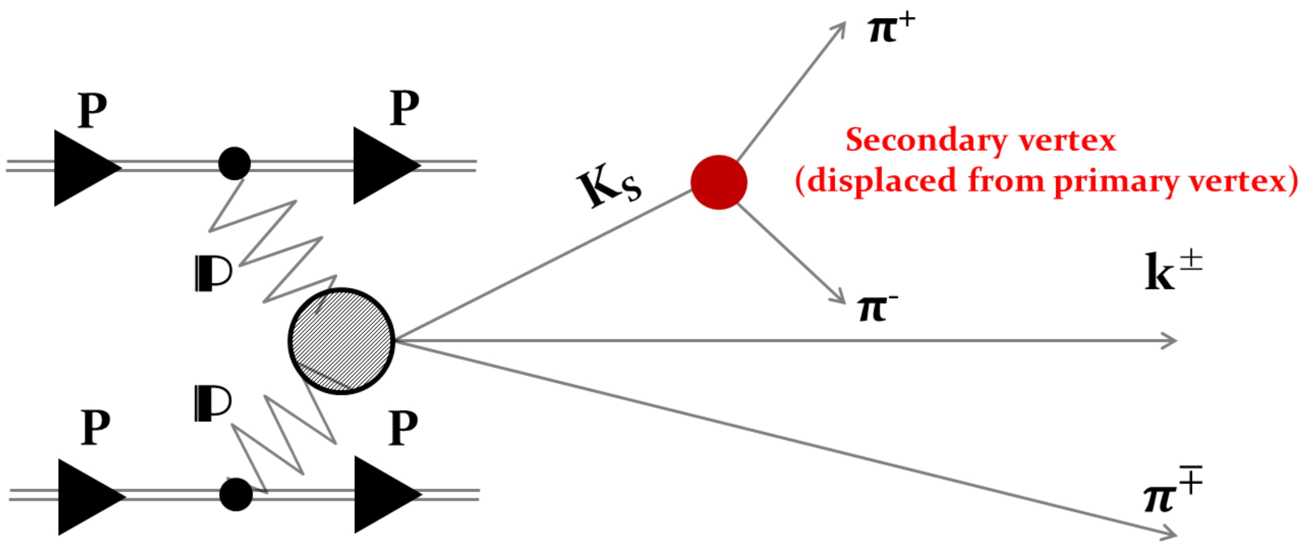
YONSEI UNIVERSITY

Physics motivation

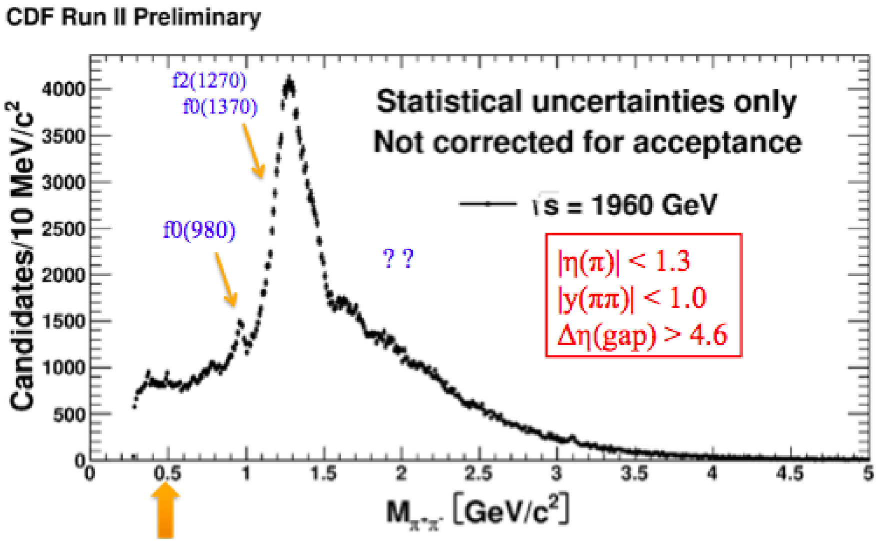
- Double-Pomeron (color singlet) exchange restricts quantum numbers of the centrally produced system(exclusive production)

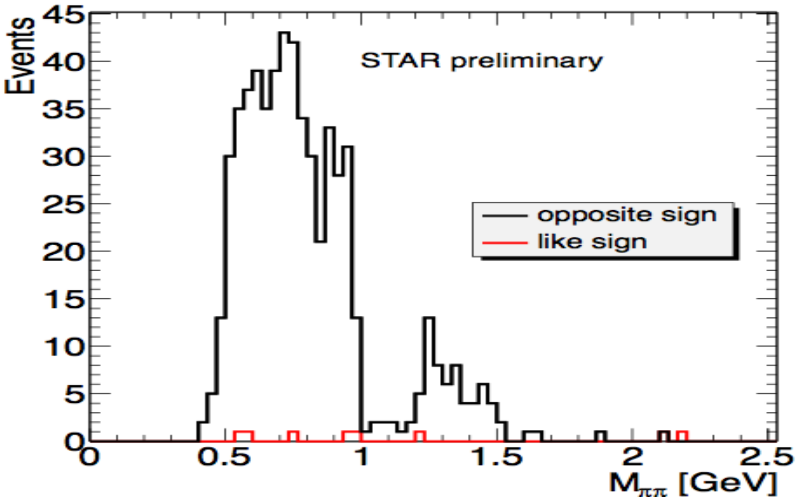
  e.g single $\rho(770)$ with $J^{PC}=1^{--}$ is forbidden while $f_0(980)$ and $f_2(1270)$ with 0^{++} and 2^{++}, respectively, allowed

- Color-singlet exchange assumed to be pomeron dominated at high energies
  - Gluon-rich environment
  - Possible production of pure glueballs according to predictions(lattice QCD, QCD sum rules), mass of the lightest scalar glueball between 1.0GeV and 1.7GeV



Results from other experimental group



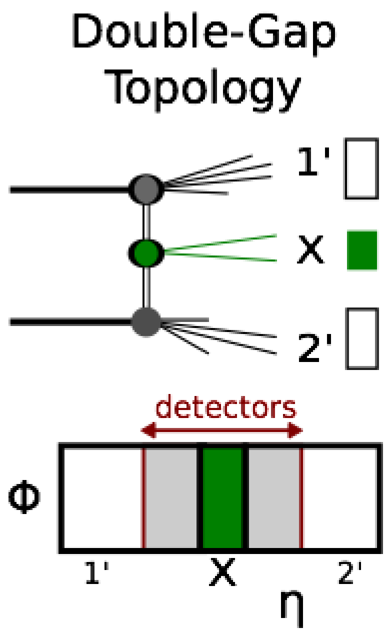


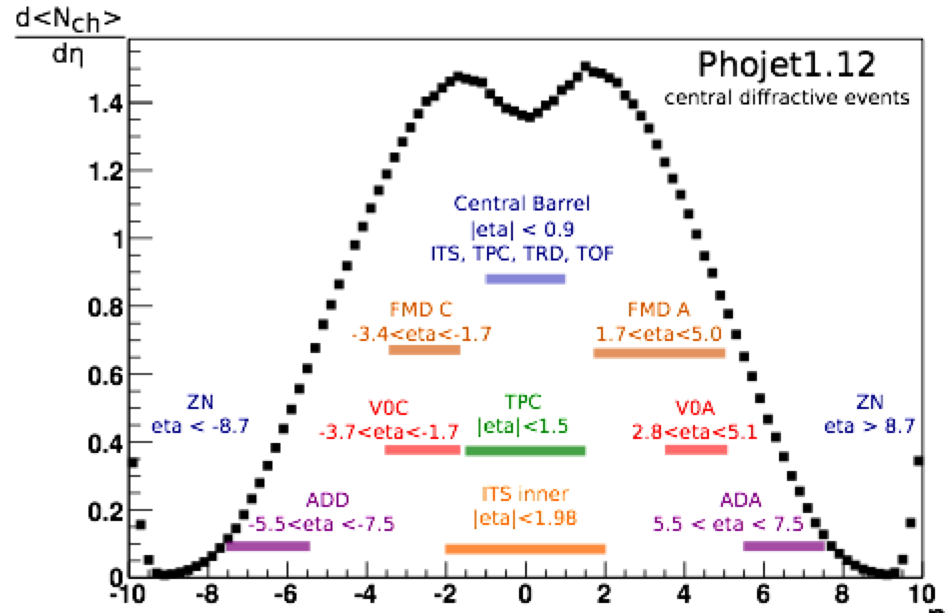
Mike Albrow, Fermilab, Diff 2012 sept 2012
300,000 2track

Mike Albrow, STAR, Diff 2012 sept 2012

Central diffractive events in pp collisions

- Central-diffractive event(theoretic) = double gap event(experimentally)





Picture taken from Felix's material

- – Hadronic activity in the central barrel **(-0.9<η<0.9)**
  involved detectors : SPD, TPC and TOF
- – Two gaps(no activity) outside of central barrel
  (A-side : 0.9<η<5.1, C-side : -3.7<η<-0.9)
  involved detectors : V0, FMD, SPD and TPC

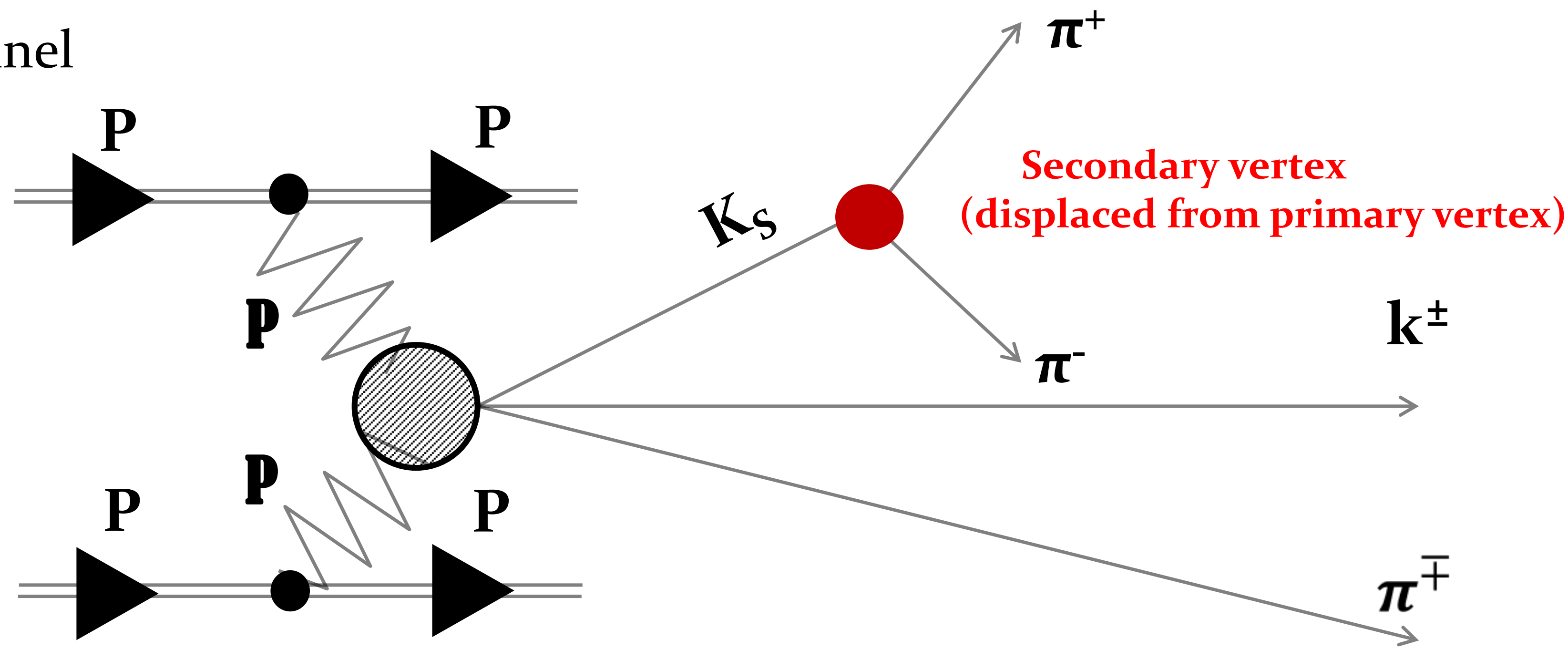
All events of double gap events for 7TeV

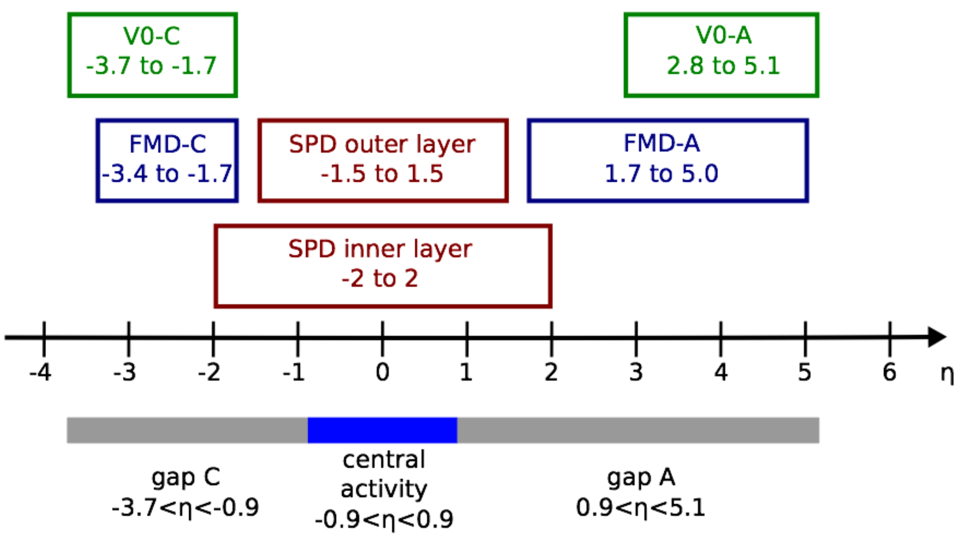
Data	LHC10b,c,d,e pass2		LHC10f6(phojet)		LHC10f6a(pythia6)	
Double gap	Events	Fraction	Events	Fraction	Events	Fraction
None(Min bais)	271×10^6		62×10^6		105×10^6	
V0, FMD, SPD, TPC	0.13×10^6	0.05%	7×10^3	0.01%	4.5×10^4	0.04%

- All pp data
- Phojet contains central diffraction, pythia6 doesn't
- LHC10b,c,d,e are all 7TeV data

decay channel involved

- Channel





Studies to be done

- Events scans with this decay channel
  - With the help of displaced vo vertices, we expect that the signal will be clean. However there is the bad possibility that 4 prong events are very small.
  - If events selection is finished, pulling out meaningful results is straight-forwards

FLOW measurement with V0 Detector

Myunggeun Song

Motivation

- Measure Flow of High Pt particle with EP(SP) Method using V0 detector
  - EP(SP) method have advantage when we measure High Pt particles having low statistics
  - V0 detector placed in forward region can get rid of jet bias effect of event plane measurement

- The measurement of High Pt particle (from Jet) can help to study path dependence of jet

Flow in Heavy ion collision

- A geometry shape of overlap region may generate collective motion in particle production
- Particle distribution in transvers direction with Fourier transformation called FLOW

$$
\begin{aligned}
\frac{dN}{d\phi} &= \frac{x_0}{2\pi} + \frac{1}{\pi}\sum_n (A_n \cos n\phi + B_n \sin n\phi) \\
&= \frac{x_0}{2\pi} + \frac{1}{\pi}\sum (v_n \cos n\Psi_n \cos n\phi + v_n \sin n\Psi_n \sin n\phi) \\
&= \frac{x_0}{2\pi} + \frac{1}{\pi}\sum v_n \cos n(\phi - \Psi_n) \\
&= \frac{x_0}{2\pi} + \frac{1}{2\pi}\sum 2v_n \cos n(\phi - \Psi_n)
\end{aligned}
$$

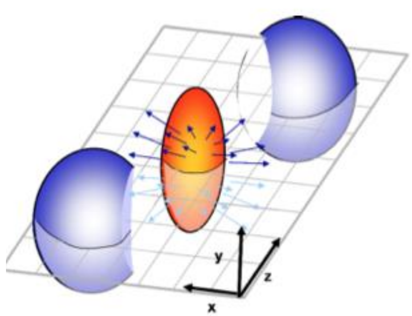


Figure: overlap region(red) after heavy ion collision

Event plane Method

- In EP method
  - 1. Measure event plane with Flow Q-Vector (P. Danielewicz, G. Odyniec, Phys. Lett. 157B, 146 (1985))

The event flow vector Qn is a 2d vector in the transverse plane

$$Q_{n,x} = \sum W_i \cos(n\phi_i) = Q_n \cos(n\psi_n)$$
$$Q_{n,y} = \sum W_i \sin(n\phi_i) = Q_n \sin(n\psi_n)$$

  - 2. Measure Flow(Vn) with event plane

$$v_n = \langle \cos n(\phi - \psi_n) \rangle$$

  - 3. Correct Flow(Vn) with Resolution (Error when measure event plane)

$$\begin{aligned} v_n^{obs} &= \langle \cos n(\phi - \psi_n^{obs}) \rangle \\ &= \langle \cos n(\phi - \psi_n + \psi_n - \psi_n^{obs}) \rangle \\ &= \langle \cos n(\phi - \psi_n) \rangle \langle \cos n(\psi_n - \psi_n^{obs}) \rangle \\ &= v_n \langle \cos n(\psi_n - \psi_n^{obs}) \rangle \end{aligned}$$

$$v_2 = \frac{v_2^{obs}}{\mathrm{Res}\{\Psi_n\}}$$

EP Method in ALICE

- And past HIM meeting 2012 @ Pyungchang, Myunggeun Song shows, Event Plane measurement with V0 detector which place in forward direction can remove non-flow effect from jet

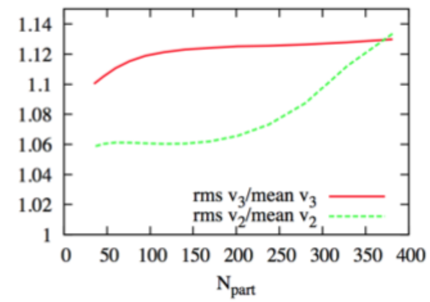
- But measure event plane with V0 detector can cause another problem related to resolution. Because V0 detector has only 8 sector in azimuthal direction.

- And, in EP method, if resolution is not perfect, Flow value is not <Vn>. It is somewhat between <Vn> and rms of Vn

Limit of EP method

- In EP method we assume Flow and Fluctuation(resolution) is independent
- But, in reality, there some relation between them. In case of very low resolution limit, we have to treat resolution correction as two particle correlation

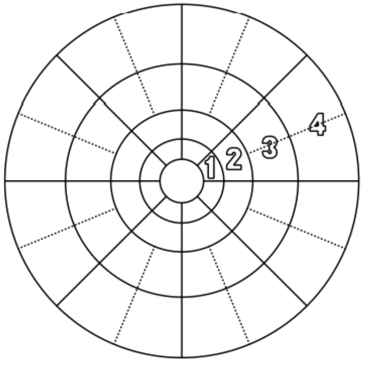
$$
\begin{aligned}
v_n &= \frac{\langle \cos n(\phi - \Psi_n^{measured}) \rangle}{Res} \\
&= \frac{\langle v_n \bar{v}_n \rangle}{\sqrt{\langle \bar{v_n^2} \rangle}} = \sqrt{\langle v_n^2 \rangle}
\end{aligned}
$$



- In this limit, measured flow is not mean flow (<vn>), is rms of flow
- And, what we get with EP with low resolution is somewhat between <vn> and rms vn

V0 detector and SP Method

- V0 detector
  - V0A : $2.8 < \eta < 5.1$
  - V0C : $-3.7 < \eta < -1.7$
  - Divided in 8 Sectors and 4 rings

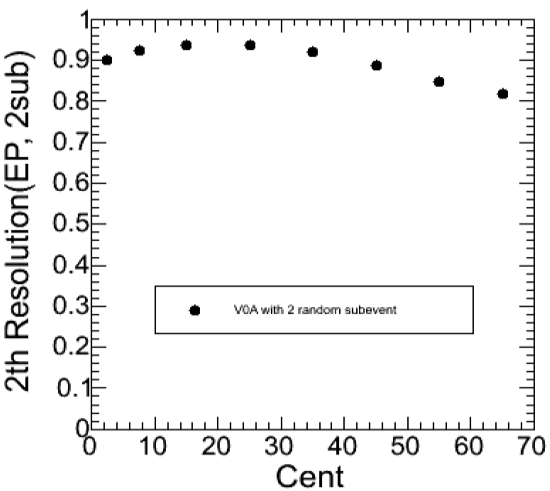


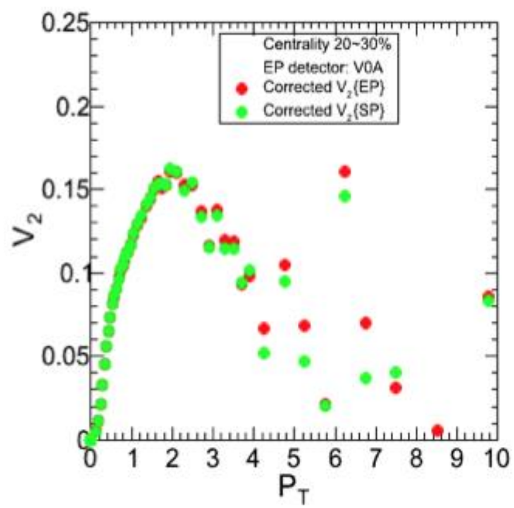
- V0 detector has low resolution due to its design, so EP method is not available to measure Flow. So now we introduce SP method which is using magnitude of Flow Q-vector when average flow.

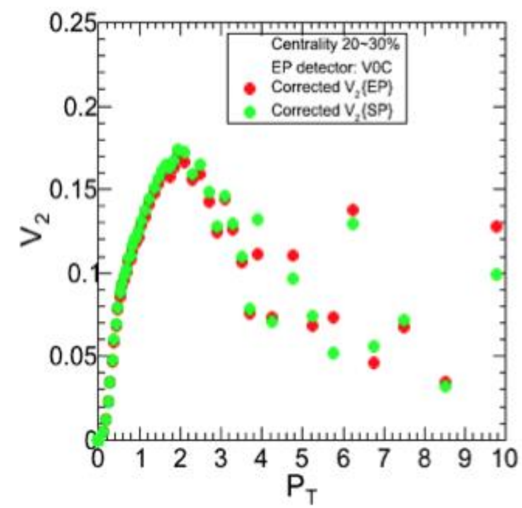
$$v_n = \frac{\langle |Q_n| \cos n(\phi - \Psi_n^{measured}) \rangle}{\bar{Q}_n}$$

AMPT Simulation result

- Before detector smearing (High resolution)
  - Statistical error is not calculated
  - Use 2sub event method to calculate resolution
- Result with SP Method and EP Method are almost same

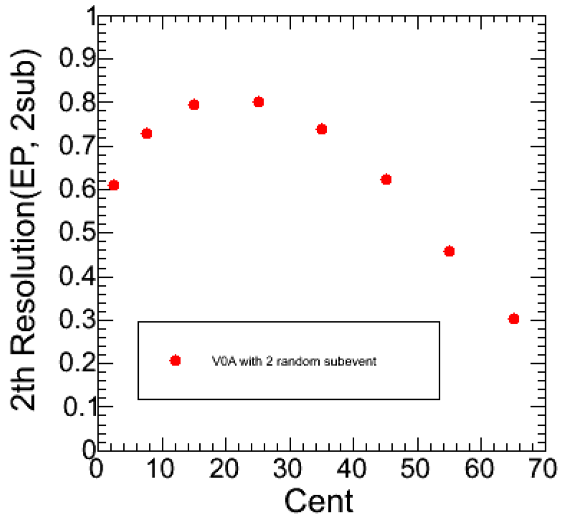


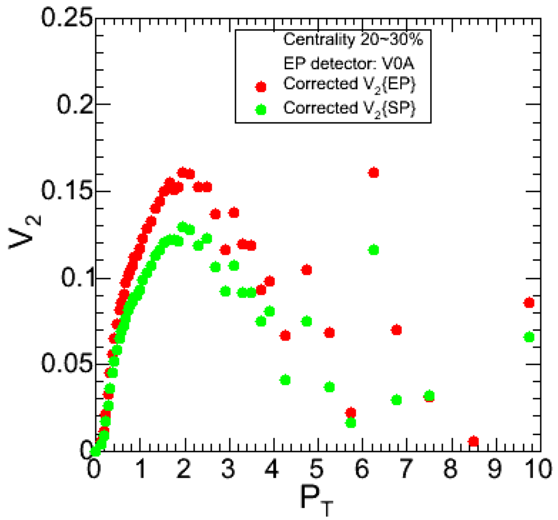


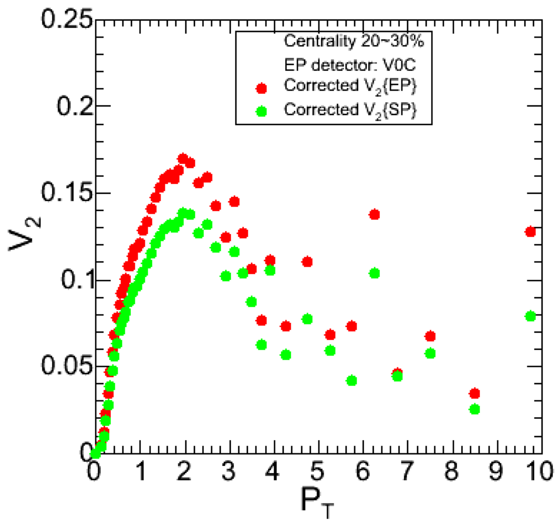


AMPT simulation result

- After detector smearing (low resolution)
  - Statistical error is not calculated
  - Use 2sub event method to calculate resolution
- Result with SP method is about 10% lower then result of EP method







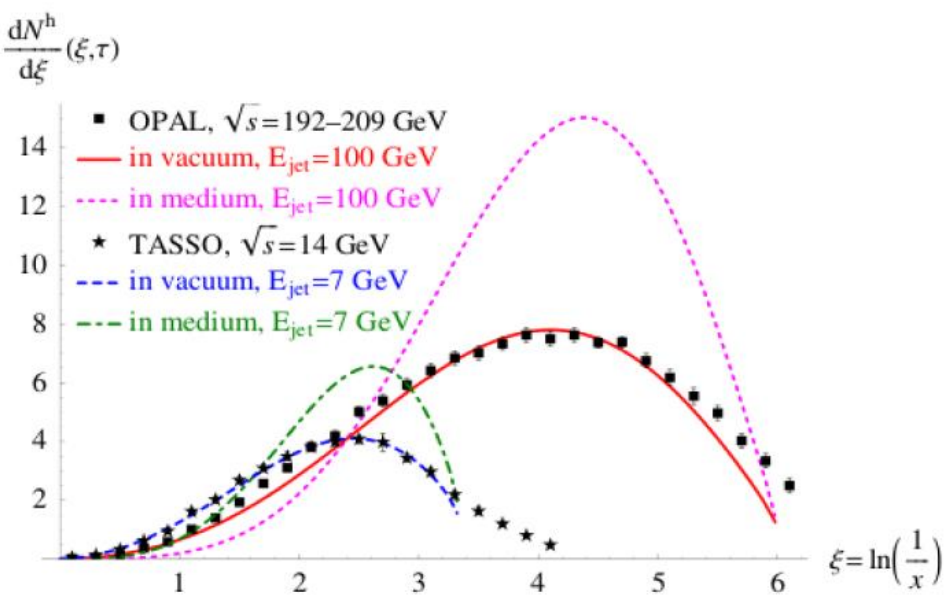
Modification of Fragmentation Function - Hadrons

Modification of Fragmentation Function - Hadrons

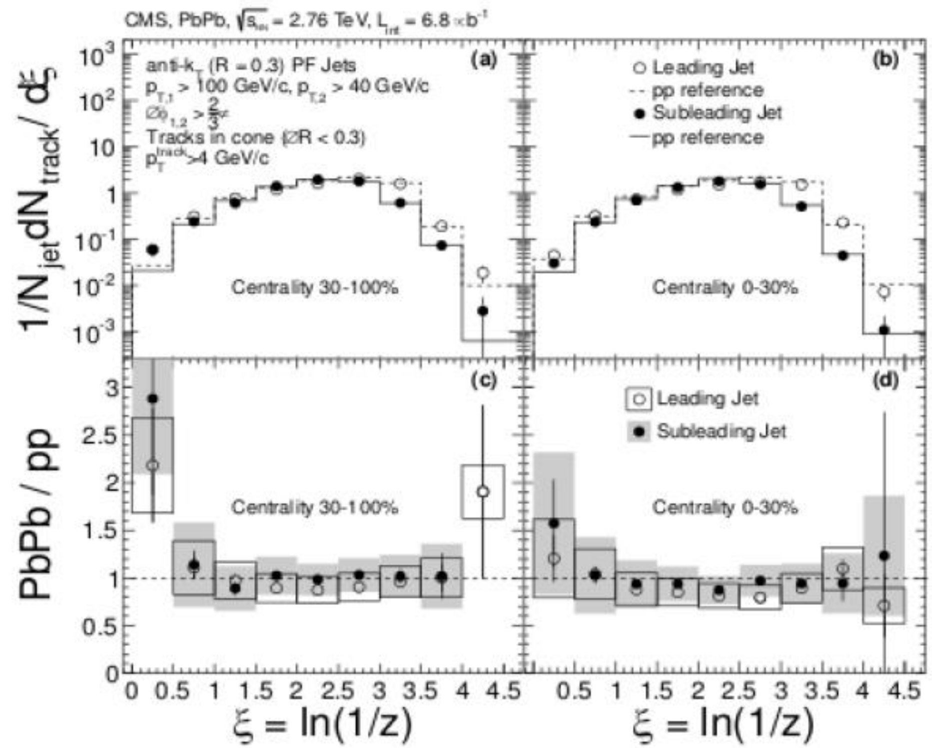
Minwoo Kim

Modification of Fragmentation Function - Hadrons

- Particle correlation measurements are good tool to
  - ✓ Study the jet properties in p+p
  - ✓ **Probe jet medium interaction in Heavy Ion collisions (Di-Hadron tomography)**



$\xi = \ln[E_{jet}/p]$



N. Borghini, U.A Wiedemann arXiv:hep-ph/0506218

Modification of Fragmentation Function in Heavy Ion collisions

⟺

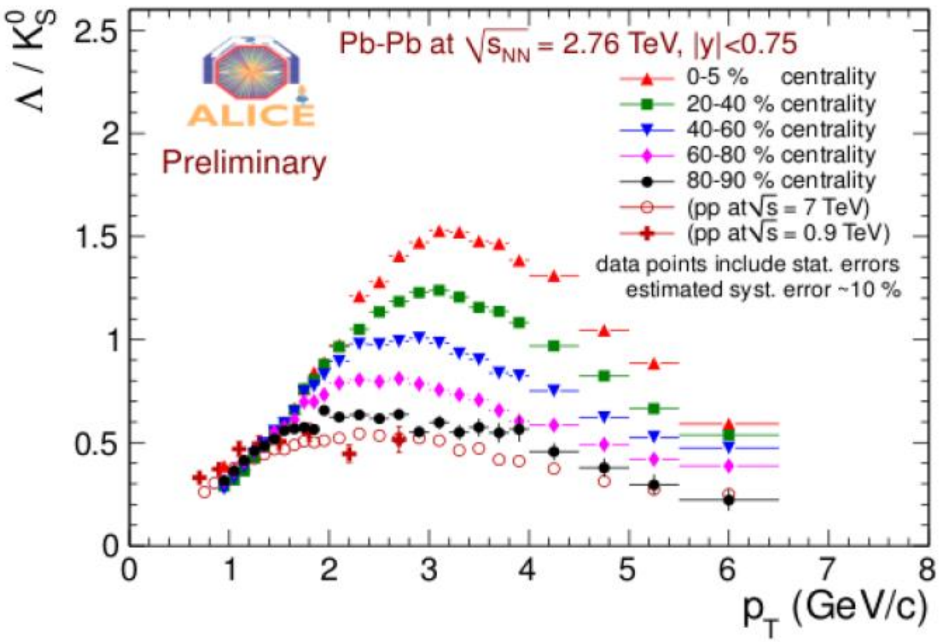
CMS (arXiv:1205.5872)

No indication of modification of the fragmentation function

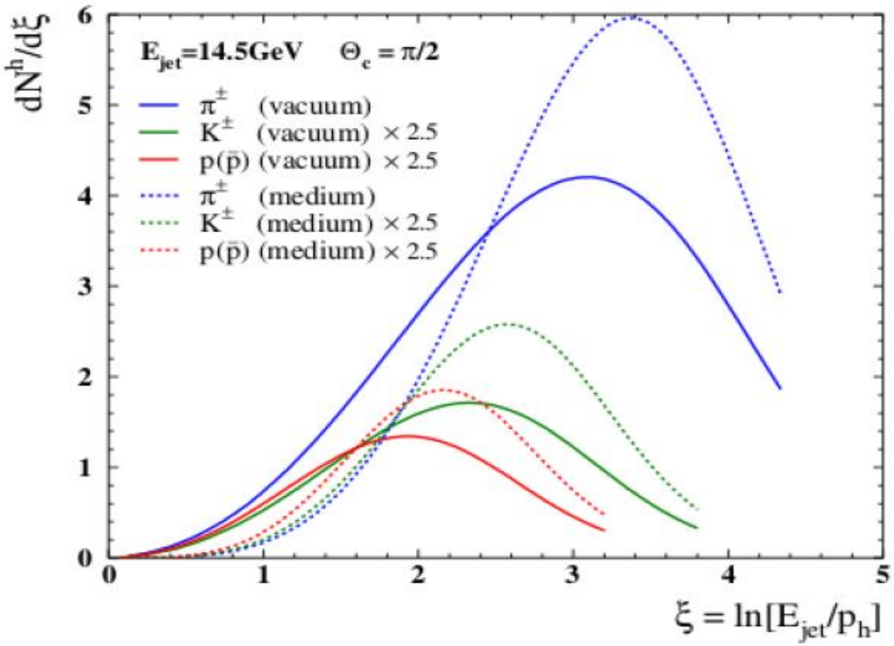
p_T = 4 GeV/c → ξ ~ 3 for 100 GeV jet

Modification of Fragmentation Function – ID particles

- Baryon over Meson ratios differ significantly between AA and pp collisions
  - ✓ Attributed to radial flow and coalescence / recombination
- How do these ratio behave in a jet in AA collisions?
  - ✓ Medium-modification of the parton shower can result in significant changes in jet hadrochemistry
- To explore this topic, we need to have
  1. Independence from Flow **2. Good PID performance for wide p_T** 3. Jet Reconstruction



ALICE : Baryon over Meson ratio in Pb-Pb



arXiv:0707,3494
Medium modification fragmentation function for protons and pions (S. Sapeta, U.A Wiedemann)

Which method will be chosen?

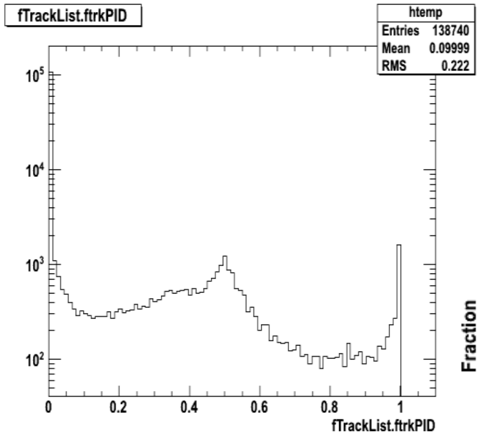
- The list of various PID methods which have been checked

✓ Default PID : few people use it currently because of poor performance

✓ Bayesian method : calculate Bayesian Probability by combined detector & select P_i>0.90

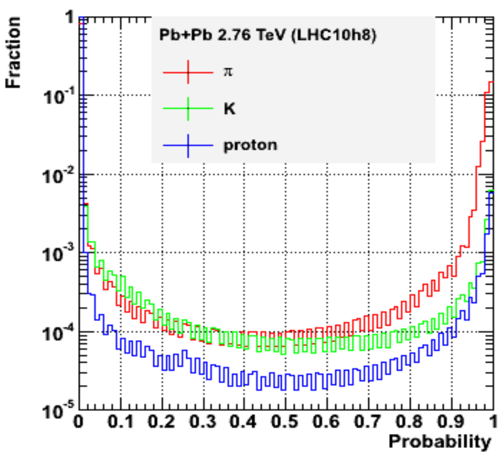
✓ n-σ method : Used in PID Flow analysis

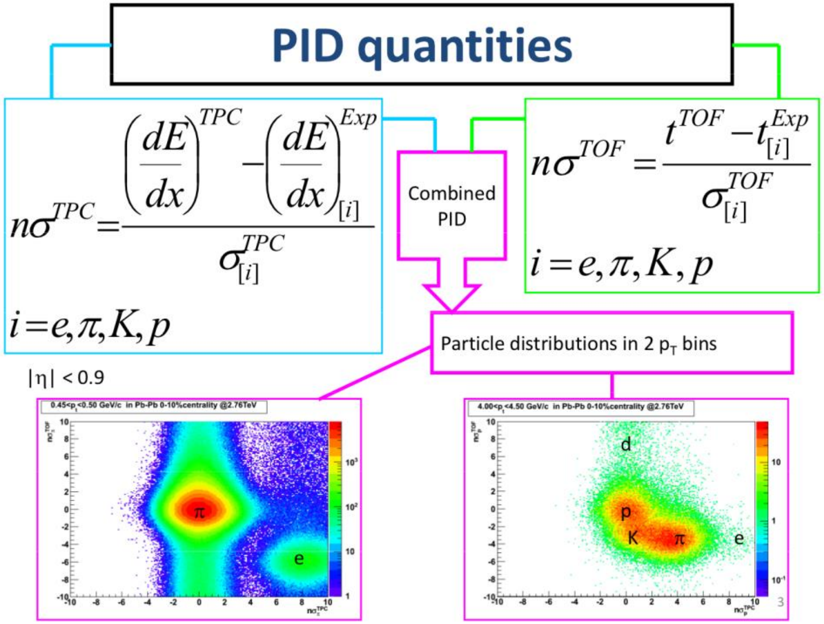
✓ $\Delta_{detector}$ method : Δ_{TPC} used in High p_T R_{AA} analysis and commonly used in PWG-CF



Default PID

TPC+ TOF Bayesian PID





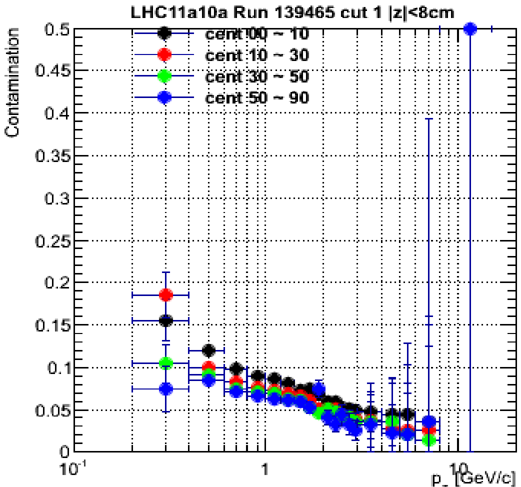
n-σ method and $\Delta_{detector}$ method

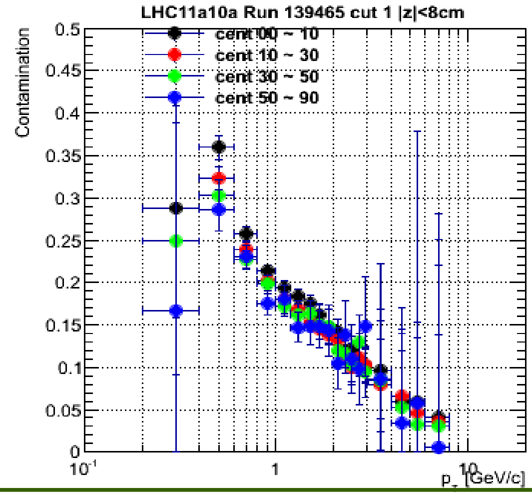
How to choose : An Example of the comparison between methods

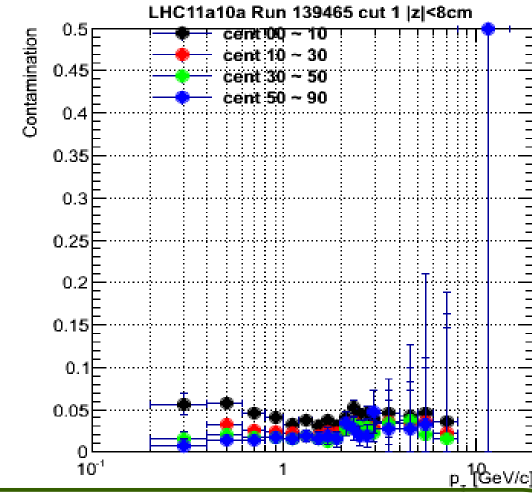
The comparison of Contamination (the rate of Fake tracks)

pion proton kaon

Prob cut (ITS+TPC+TOF) > 0.90

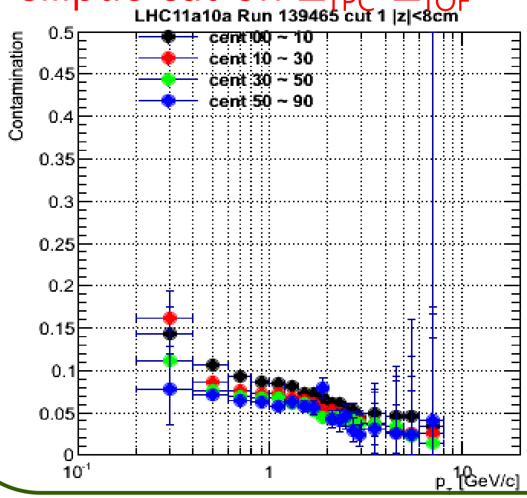


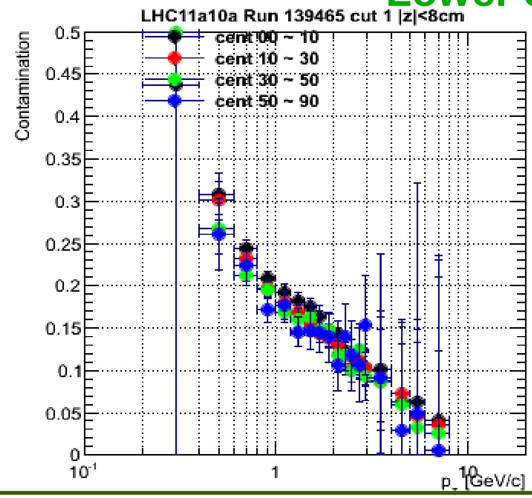


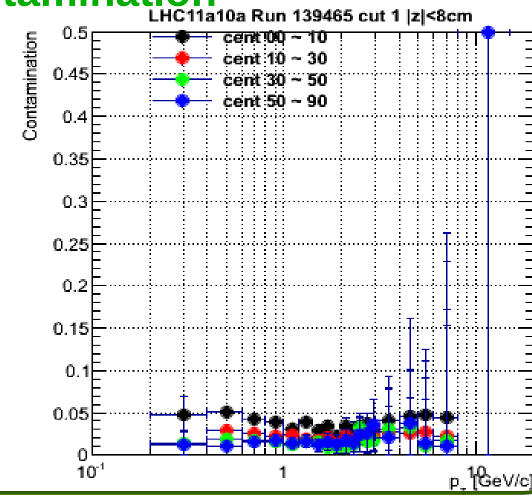


elliptic cut on Δ_{TPC}-Δ_{TOF}

Lower contamination

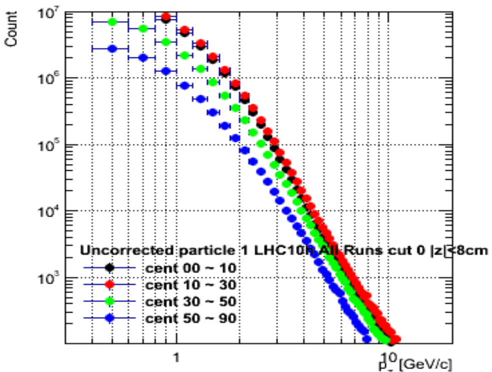






The Procedure of Corrections

Raw p_T yield



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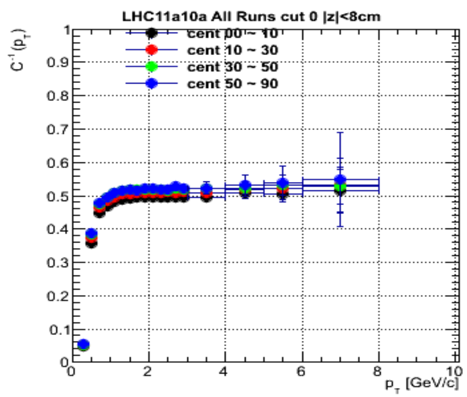
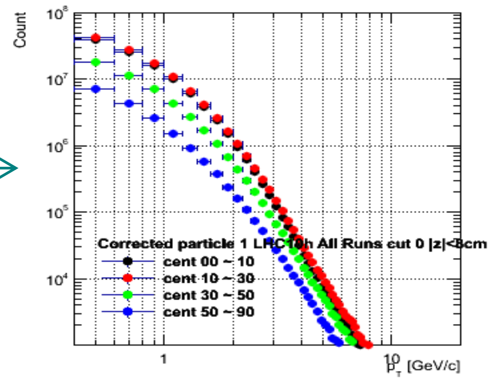
Correction Factor from MC



2σ cut on Δ_{TPC}- Δ_{TOF} has been applied for both, Real data and MC

→

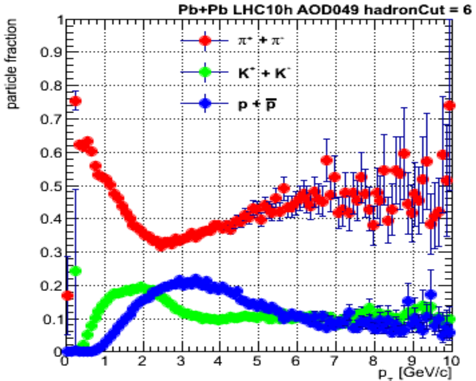
Corrected p_T yield



Due to the discrepancy of the Δ-2D distribution between Real data and MC, Additional correction for shifted center has been done

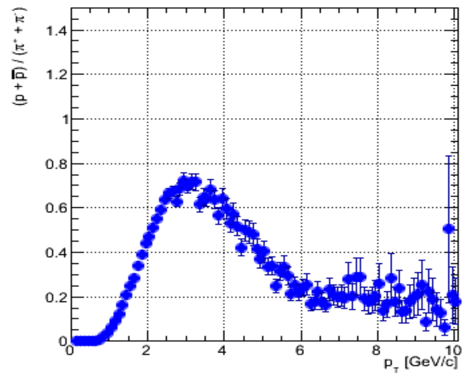
→

Particle Fraction



+

proton - pion Ratio

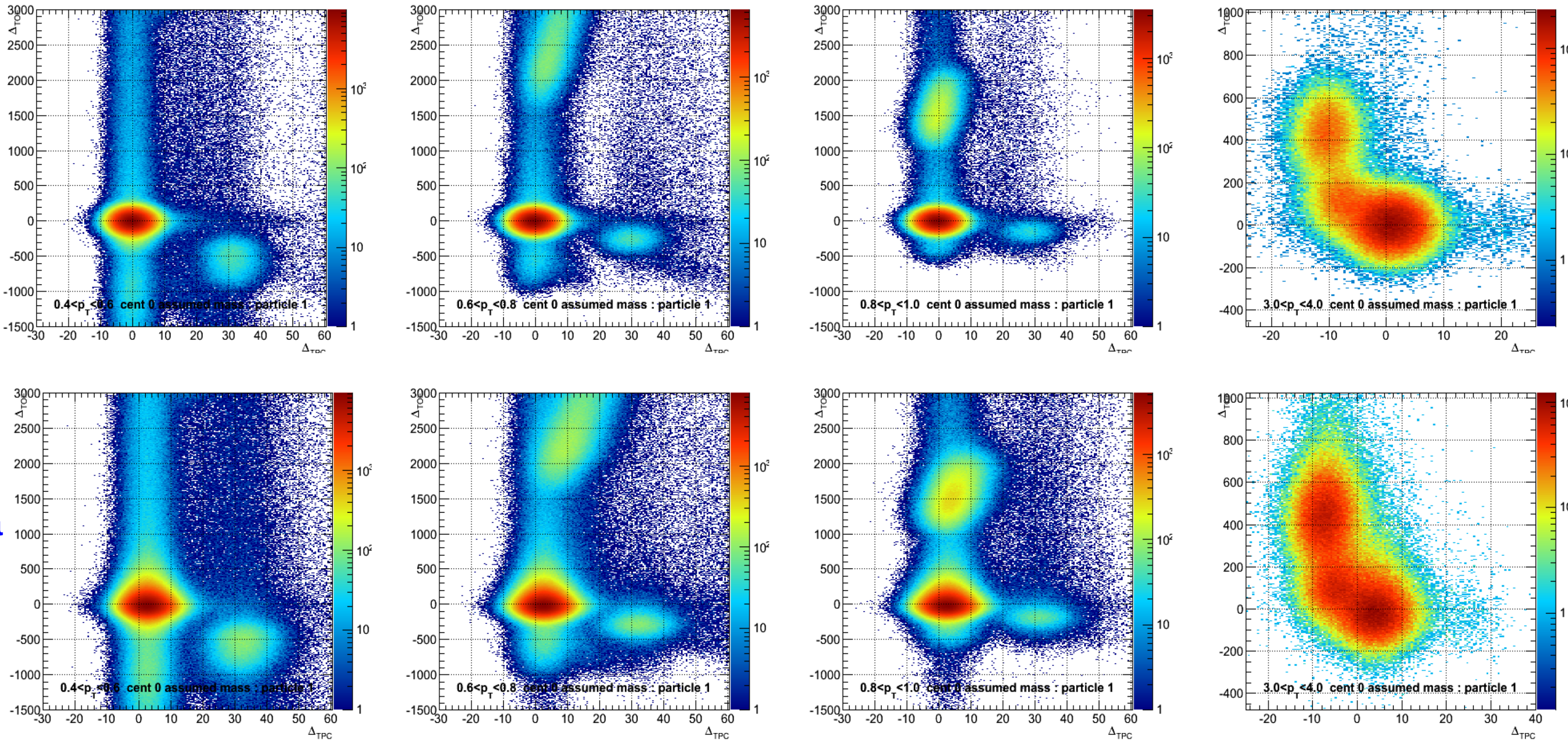


Discrepancy between Real data and MC – pion mass assumption

- Data sample : LHC10h AOD049
- MC sample : LHC11a10a_bis AOD090
- Track cuts : hadronCut = 0 (Default) , $|\eta| < 0.8$
- PID cuts : without cut to see the distribution from all charged particles
- 0~10% centrality in below plots

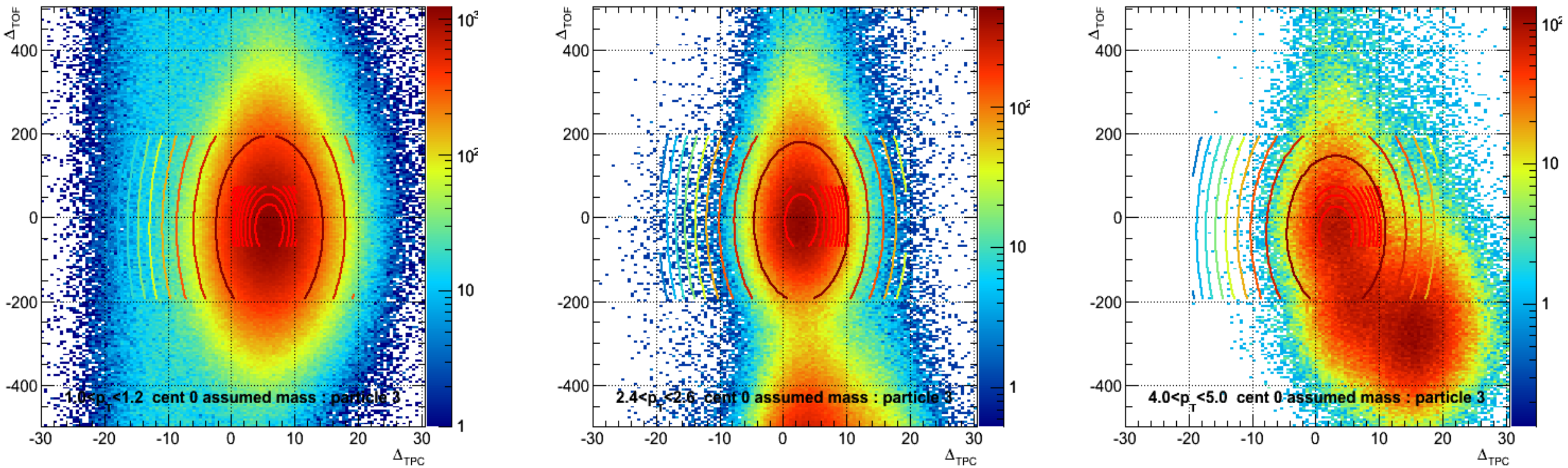
MC

Data



Correction for shifted center in Real Data

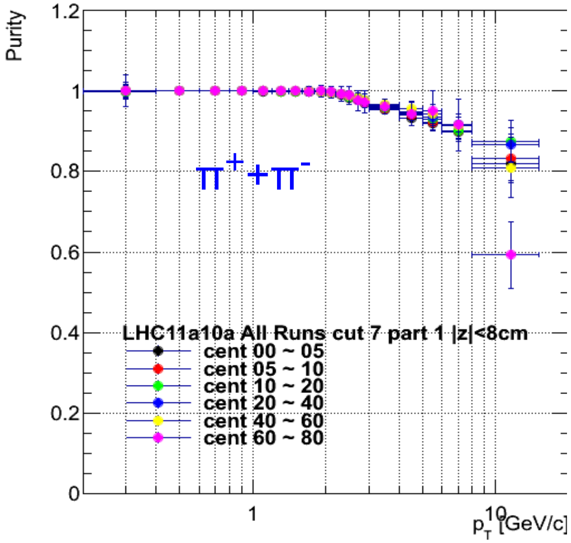
By 2D Gaussian Fit on Δ_{TPC}-Δ_{TOF}

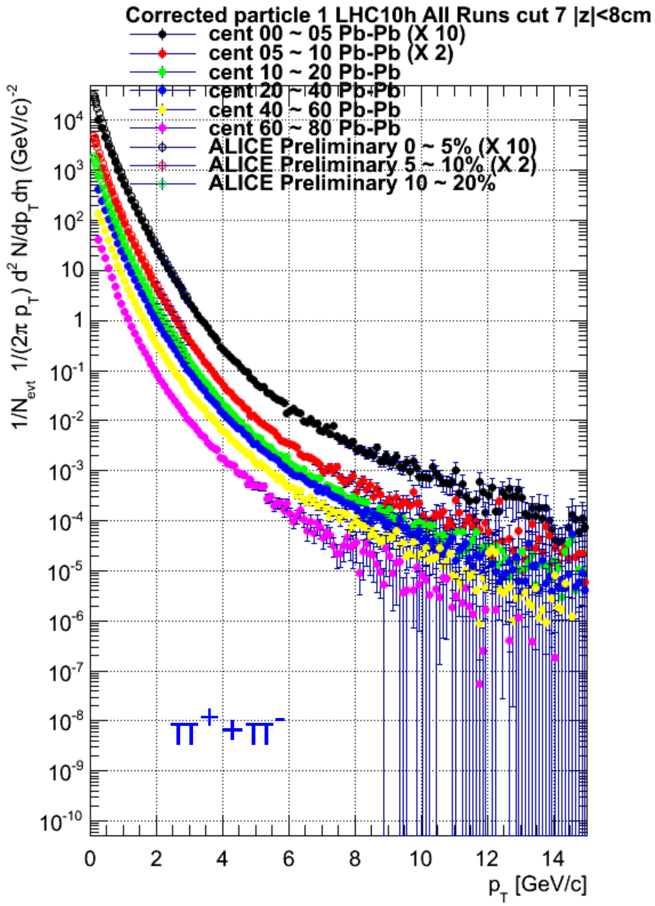


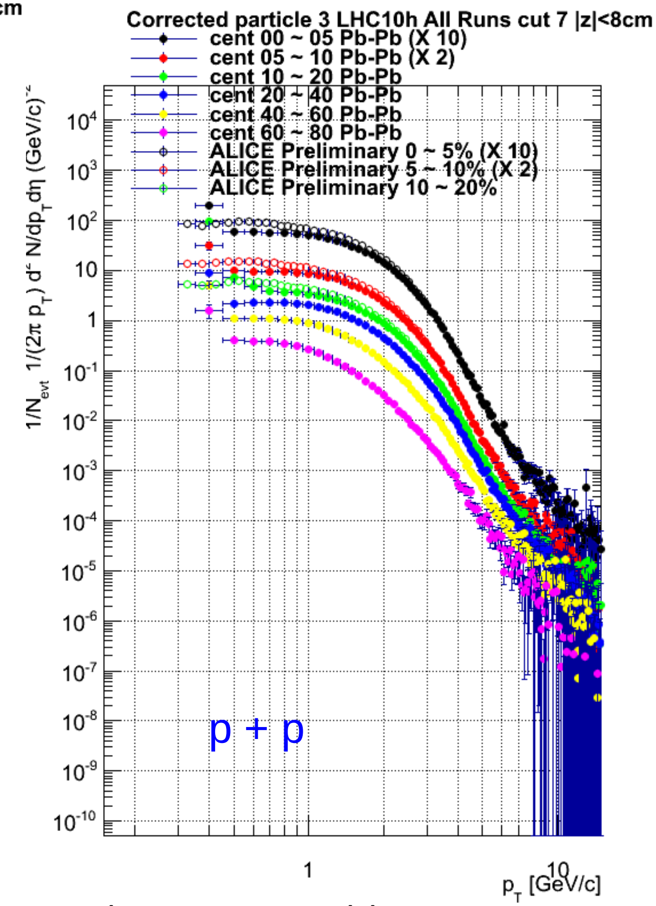
from Proton mass assumption, 3 p_T bins

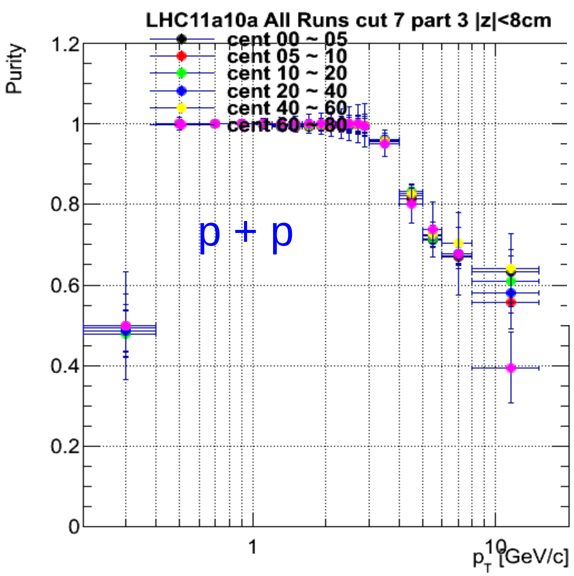
- Two dimensional Gaussian fits have been done for each centralities, each p_T bins and each particle species (different mass assumption)
- The information about shifts of the centers and corresponding sigma have been extracted from Gaussian fits for correct PID in real data
- At very high p_T region, the fitting failed because of overlapping with other particles

PID : Pions and Protons by 2σ cut from TPC+TOF









- Invariant Yield extracted from 2-σ cut shows reasonable agreement with preliminary points within the error bar
- PID works well to get the clear candidates for further analysis

(Purity of pions) > 0.9 for $0.2 < p_T < 8$ GeV/c

(Purity of protons) > 0.8 for $0.4 < p_T < 5$ GeV/c

Summary and Future Plan

- A variety of PID methods has been tested for quality assurance to find the way which gives the highest purity with reasonable efficiency in wide p_T range
- 2-σ cut on TPC+TOF combine PID becomes final and the corrections using two dimensional Gaussian fit are done to resolve the discrepancy between MC and Real data
- TPC+TOF combined PID method provides clean candidates which have high purity for further analysis
- Based on this PID method, the flow analysis with forward detectors of ALICE will be done to estimate the contributions only from the bulk particles
- Understanding of the flow of identified particles and reconstructed jets will be important ingredients for the analysis about “Jet Fragmentation into identified particles in Pb-Pb collisions”