Baryon - antibaryon asymmetry in the central rapidity region at 0.9 and 7 TeV with ALICE

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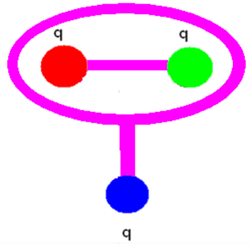
Outline

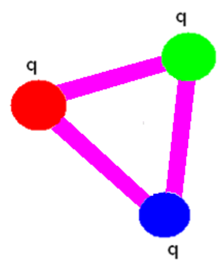
- Baryon number transport
  - Theoretical models
  - Previous experimental results
- Data Analysis
  - Data sample
  - Event selection
  - Track selection
- Corrections
  - Absorption
  - Background
  - Feed down
- Results

Baryon number transport

Constituent quark model

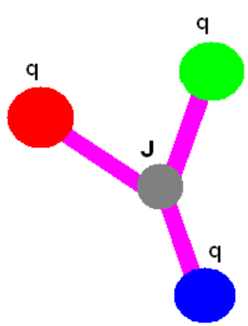
- Baryons are described as quark-diquark pairs





String junction model

- Valence quarks are connected via nonperturbative configuration of gluon field (SJ)



- Probability of BN transfer thorough rapidity interval is $\approx \exp{(\alpha-1).\Delta y}$
- α depends on configuration in which BN is transported
  - Diquark (CQM)
  - SJ accompanied by diquark
  - SJ accompanied by quark
  - SJ itself

$\alpha \approx$	
Diquark	-1/2
SJ accompanied by diquark	-1/2
SJ accompanied by quark (Rossi&Veneziano)	1/2
SJ itself	1/2
SJ itself (Kopeliovich)	1

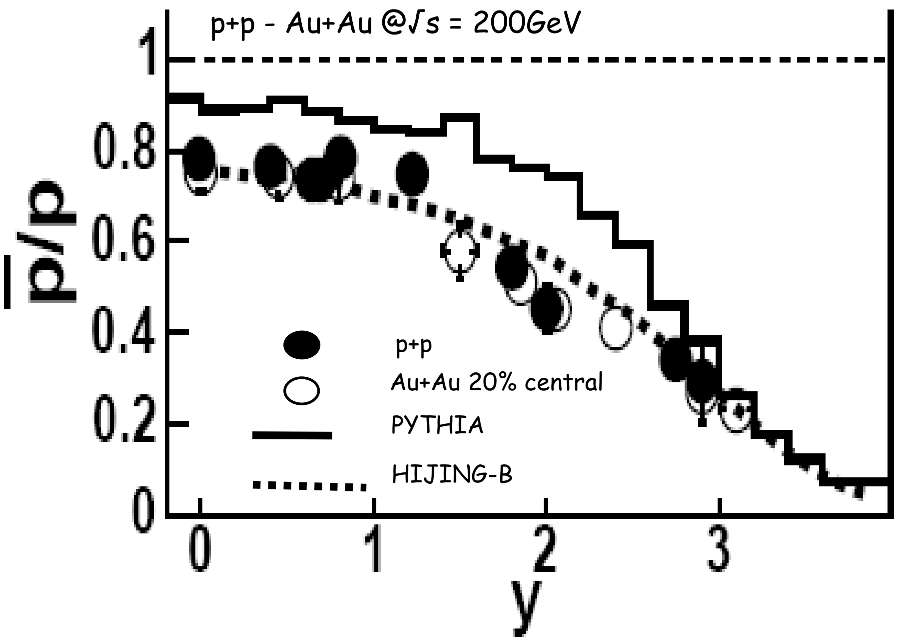
B.Z.Kopeliovich, Sov. J. Nucl. Phys. 45, (1987) 1078

G.C.Rossi, G.Veneziano, Nucl. Phys. B123, (1977) 507

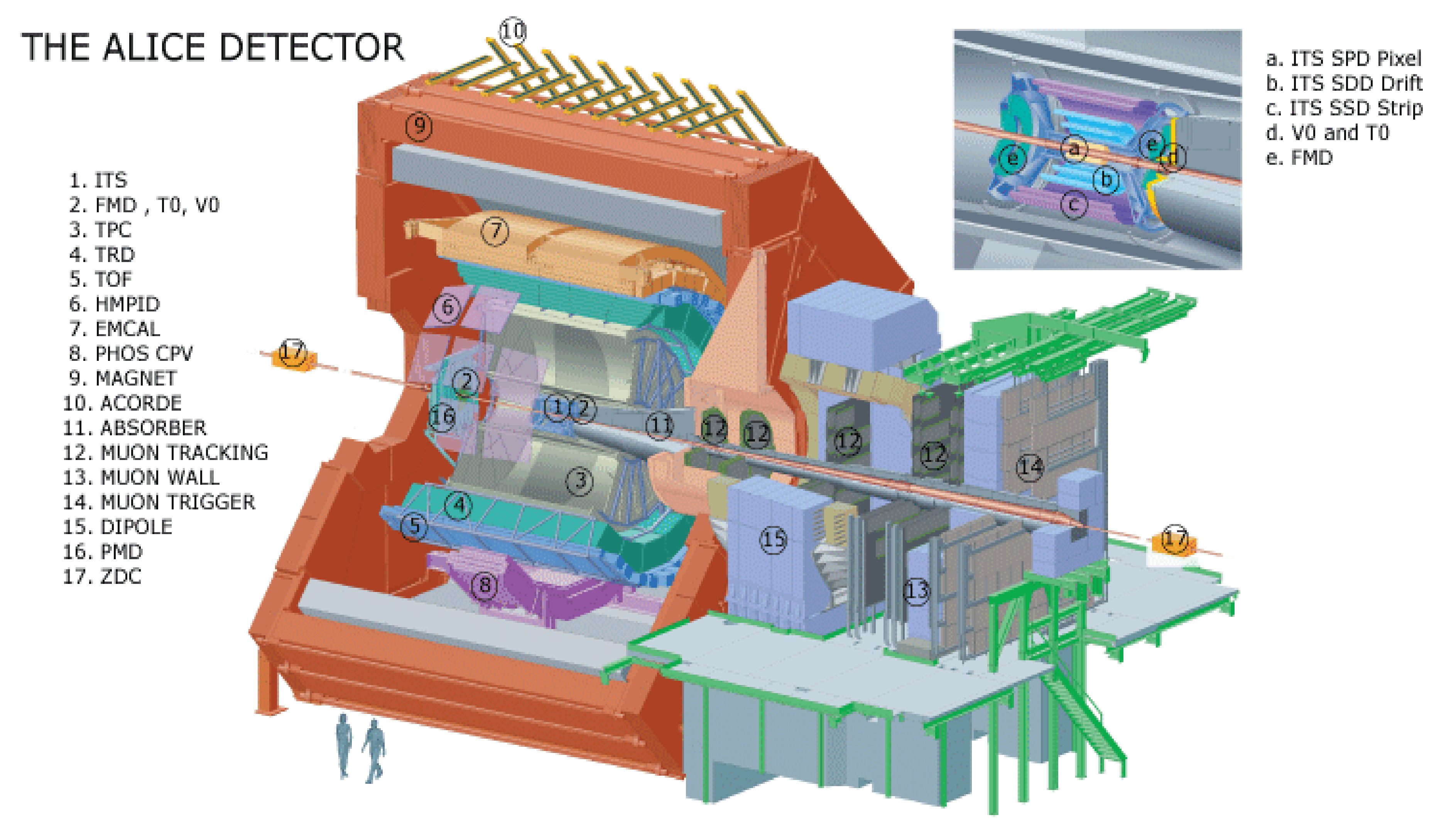
Previous experimental results

Results from RHIC

- Proton excess at mid-rapidity can be attributed to the BN transport from the beam at RHIC energies (√s=200GeV, Δy=5.4)
- PYTHIA (old version without multi parton interaction) systematically overestimates the proton ratio
- HIJING-B describes the experimental data



BRAHMS: Phys. Lett. B607 (2005) 42


THE ALICE DETECTOR
1. ITS
2. FMD , T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCAL
8. PHOS CPV
9. MAGNET
10. ACORDE
11. ABSORBER
12. MUON TRACKING
13. MUON WALL
14. MUON TRIGGER
15. DIPOLE
16. PMD
17. ZDC
a. ITS SPD Pixel
b. ITS SDD Drift
c. ITS SSD Strip
d. V0 and T0
e. FMD

Data sample

900 GeV

- The data collected during the first LHC p+p run in December 2009 at 900 GeV.
- About 750 K minimum bias p+p events were recorded with the magnetic field B = 0.5 T
  - Data taken from the official list of good runs

7 TeV

- The data were collected in March 2010 at 7 TeV.
- About 3.1 M minimum bias p+p events were analyzed with the magnetic field B = 0.5 T

- Events with proper online & offline trigger were selected
- Trigger was based on the combination of the information provided by the SPD and the two sides of the V0 detectors
- Cut on primary vertex was applied

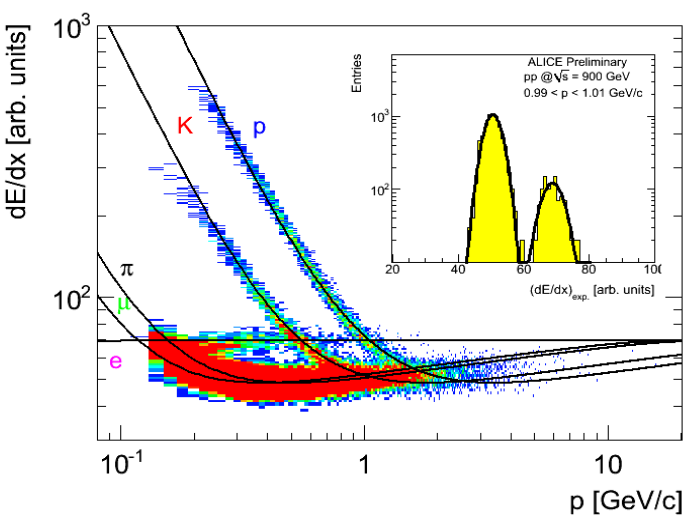
Event Selection	
Online Trigger	Yes
Offline Trigger (AliPhysicsSelection)	Yes
$\|V_z\|$	<10
$\|V_x\|$	<1
$\|V_y\|$	<1

Offline Trigger	
Two chips with a hit in the SPD	Yes
One chip with a hit in SPD and beam-beam flag in either V0A or V0C	Yes
Beam - beam flags on bothV0A and V0C	Yes
Beam - gas flag by either V0A or V0C	No

Track selection criteria

Dca = Distance of closest approach

Track Selection – Quality cuts	
Number of TPC clusters	80
Number of TPC clusters (dE/dx)	80
$x^2/N_{TPCclusters}$	3.5
Number of ITS clusters	2
Hit on SPD1 || SPD2	Yes

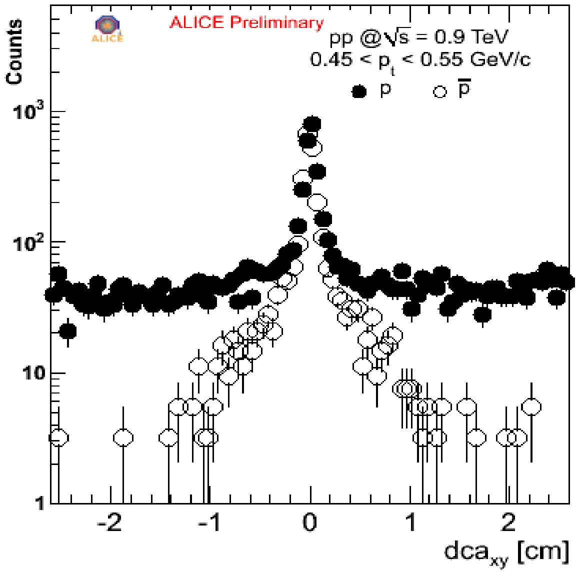


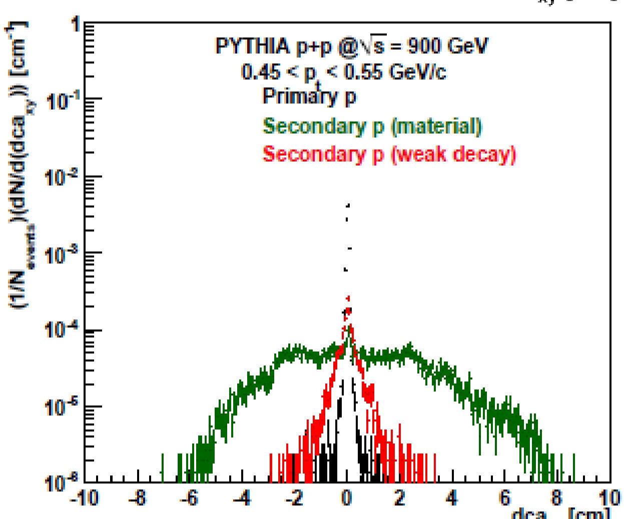
Track Selection – Primary like cuts	
dca_{xy}	p_t dependent

Track Selection – PID	
N - sigma	< 3

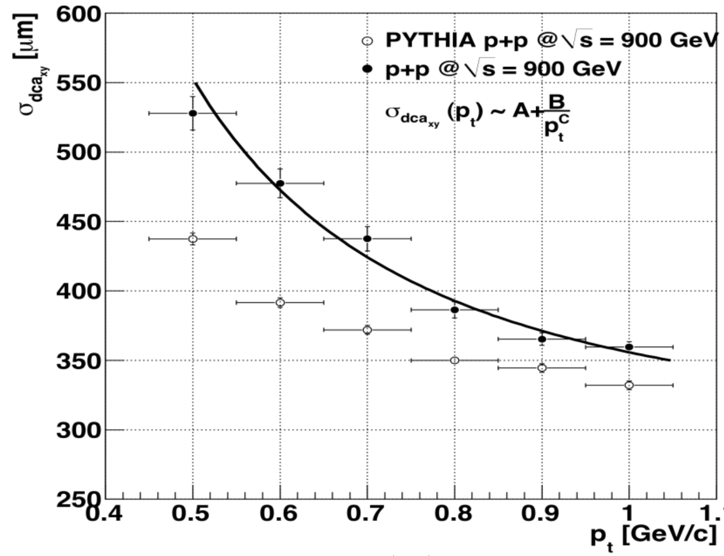
Track Selection – Phase space	
|y|	< 0.5
p_t	$0.45 < p_t < 1.05$

p_t dependent dca cut





- Fit the dca distribution of (anti)protons in $|dca_{xy}| < 0.2$ cm for both MC and data
- Extract the "resolution" from the fit



p_t range [GeV/c]	σ [µm]	5σ [µm]
0.45 – 0.55	530	2650
0.55 – 0.65	490	2450
0.65 – 0.75	440	2200
0.75 – 0.85	385	1925
0.85 – 0.95	365	1825
0.95 – 1.05	360	1800

Corrections

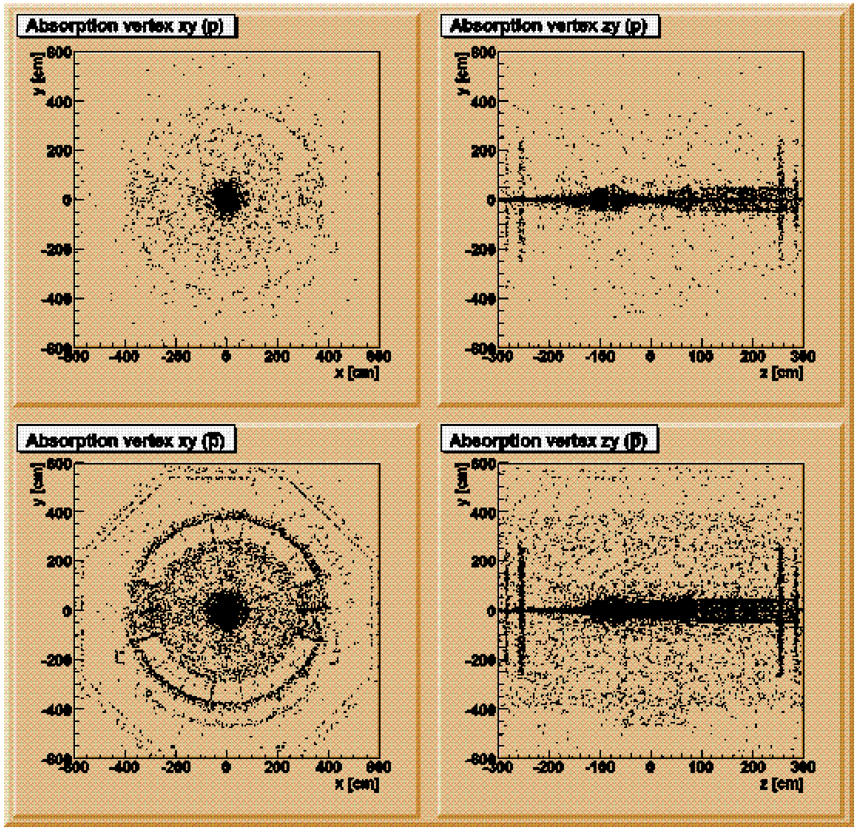
- The TPC of the ALICE experiment is symmetric around mid-rapidity and has full azimuthal coverage.
- As a consequence, many detector effects such as the acceptance, the reconstruction and the particle identification ones are the same for particles and anti-particles and thus cancel out in the ratio.
- Effects which we need to correct for is absorption, background, feed down and cut efficiencies

$$\left(\frac{N_{\bar{p}}}{N_p}\right)_{corrected} = \left(\frac{N_{\bar{p}}}{N_p}\right)_{raw} \times C_{absorption} \times C_{background-p} \times C_{cuts} \times C_{feed-down}$$

Corrections summary					
Source	Mode	p [%]		pbar [%]	
		0.9 TeV	7 TeV	0.9 TeV	7 TeV
Absorption	MC	5.3	5.4	18.8	18.6
Background	Data	2.1 – 3.8	1.5 – 3.8	0	0
Cuts	MC	18.2	16.7	23.5	22.0
Feed-down	Data	12.3	12.0	12.6	12.3

Absorption correction

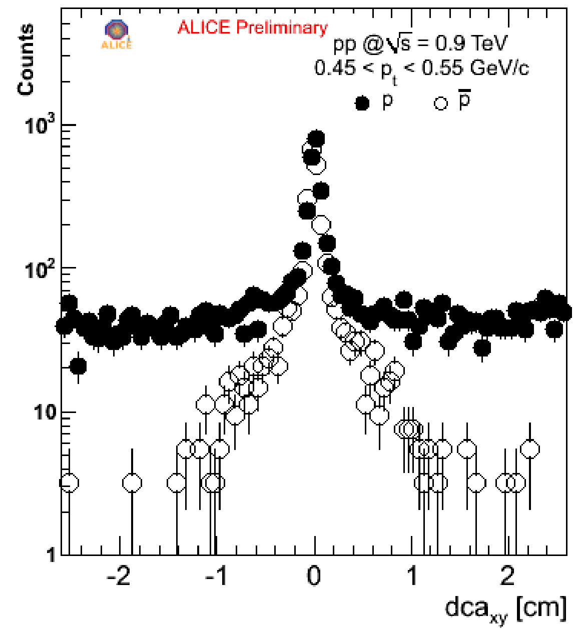
- By absorption we mean the interaction of either the proton or the anti-proton with material resulting in the disappearence of the first.
- This mechanism is directly related to the interaction cross section of protons and anti-protons with the material.
- Correction factors was extracted from MC
    - Rely on proper description of material budget
    - Still working on finalizing the systematics for the absorption

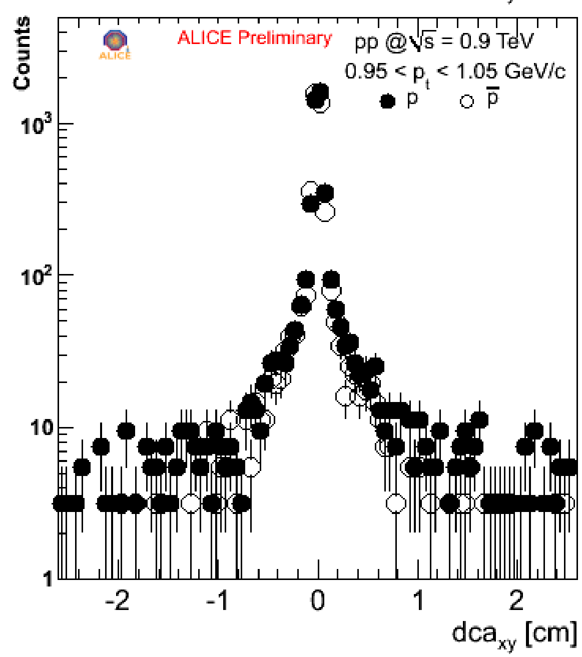


Correction for background

- Correcting for the contamination from background, implies the knowledge of the corresponding dca distribution at small values
- The distinct feature of the distribution of protons is the long tail that comes mainly from the background protons. The effect is more pronounced at low pt values.
- Corresponding distribution of the anti-protons is background free
- The correction factor was extracted using fitting functions on real data.

$$f_p(dca) = \frac{f_{\bar{p}}(dca)}{R(\bar{p}/p)} + A \times f_{p-background}(dca)$$





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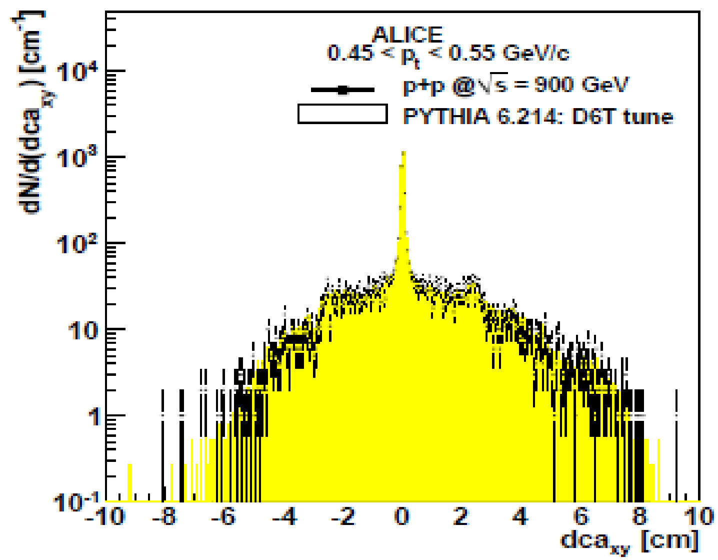
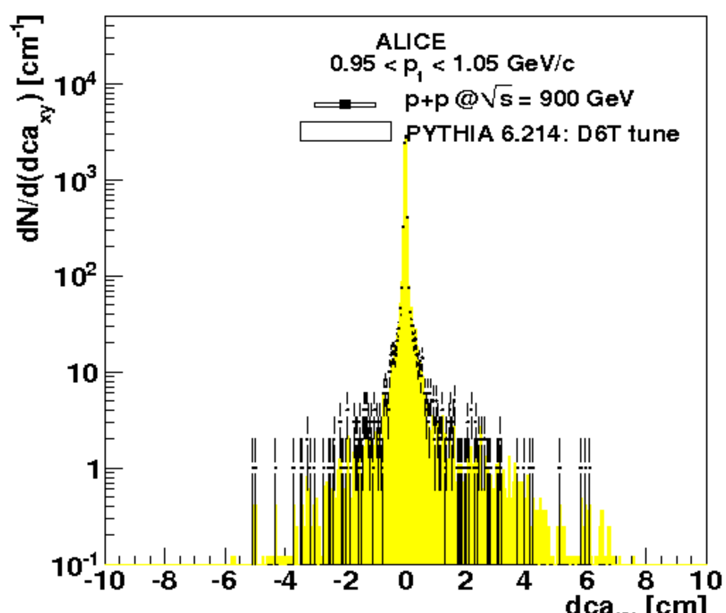
Correction for background – MC Templates

- The estimation of correction for background is performed using different functional form for the fitting functions or by using MC templates
  - Differences seen in the corrected values are atributed in the systematic uncertainty
- Fit data dca distribution by sum of MC template histograms
- Fit is searching for fractions corresponding to MC template histograms
- Then part of primary like protons in selected dca interval is evaluated
- This is done for each p_t bin

$$f(dca) = A \times h_{p-primary}(dca) + B \times h_{p-background}(dca)$$





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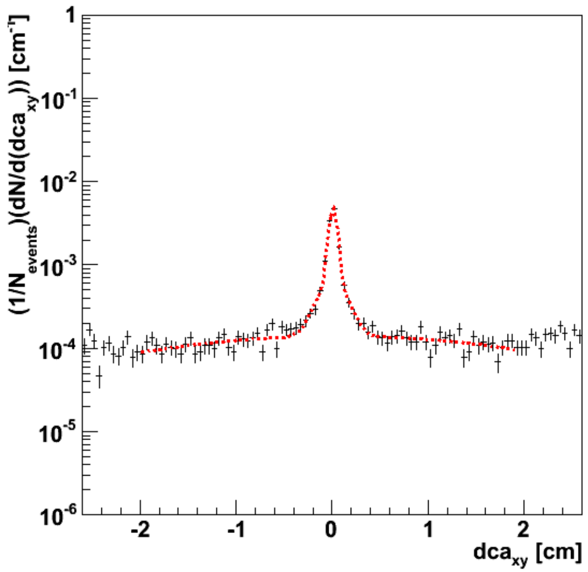
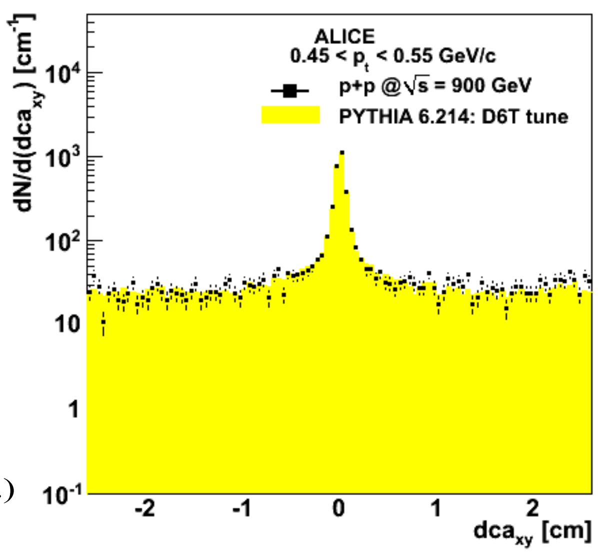
Feed down correction

- Take advantage of the experience gained from the correction for background protons (based on data). Attempt to extract the contamination for feed-down (anti)protons using different methods:
  - Looking at MC, applying all the quality criteria at the track level (including the dca cut) and extracting the contamination from the survived track sample.
  - Fit data with MC templates
  - Fit data with a sum of three Gaussians

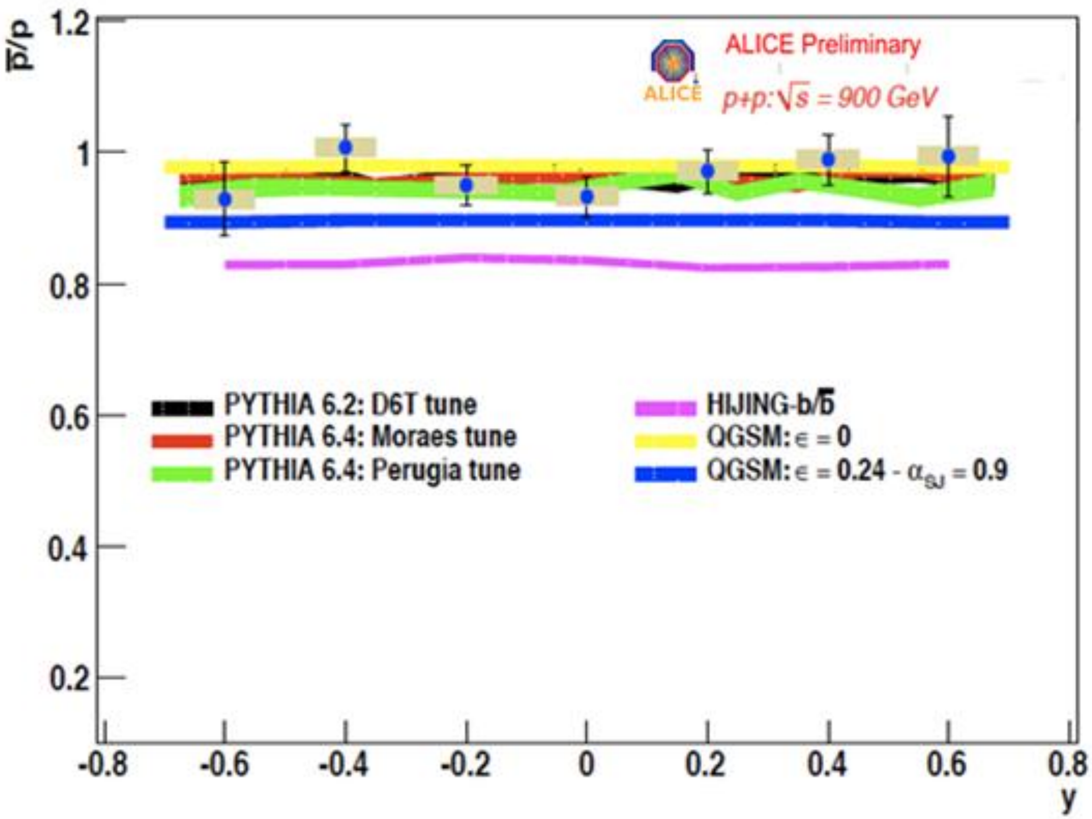




$$f_{p-data}(p_t, y) = A_1 \cdot g_{1(prim.)} + A_2 \cdot g_{2(\Lambda)} + A_3 \cdot g_{3(backg.)}$$

Rapidity dependence

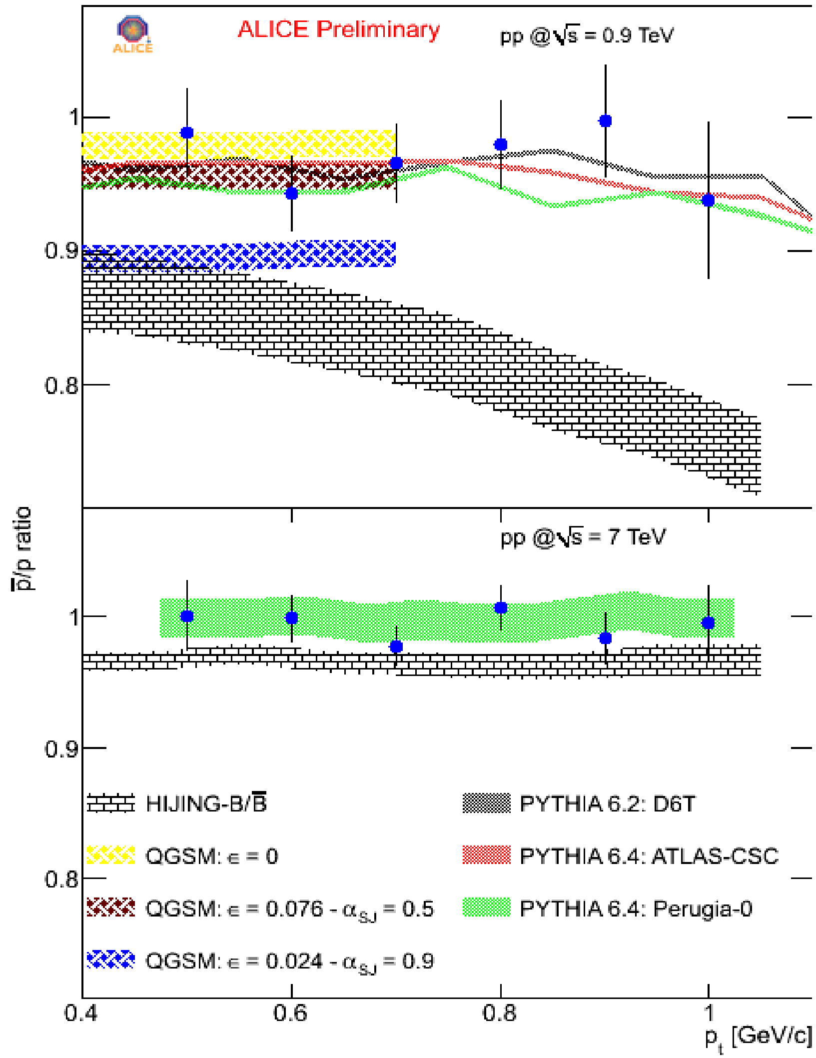
- Preliminary result show no sign of rapidity dependence
- Experimental points are compared with different model predictions that include variation of BN transport mechanisms:
  - HIJING-B clearly underestimates the y dependence
  - QGSM's (only longitudinal information) version with $\alpha_{SJ} \approx 1$ is systematically below the data points
  - The different PYTHIA tunes describe the data well.



Fully corrected ratio: stat. error – lines, syst. Error – are shaded around data points

Transverse momentum dependence

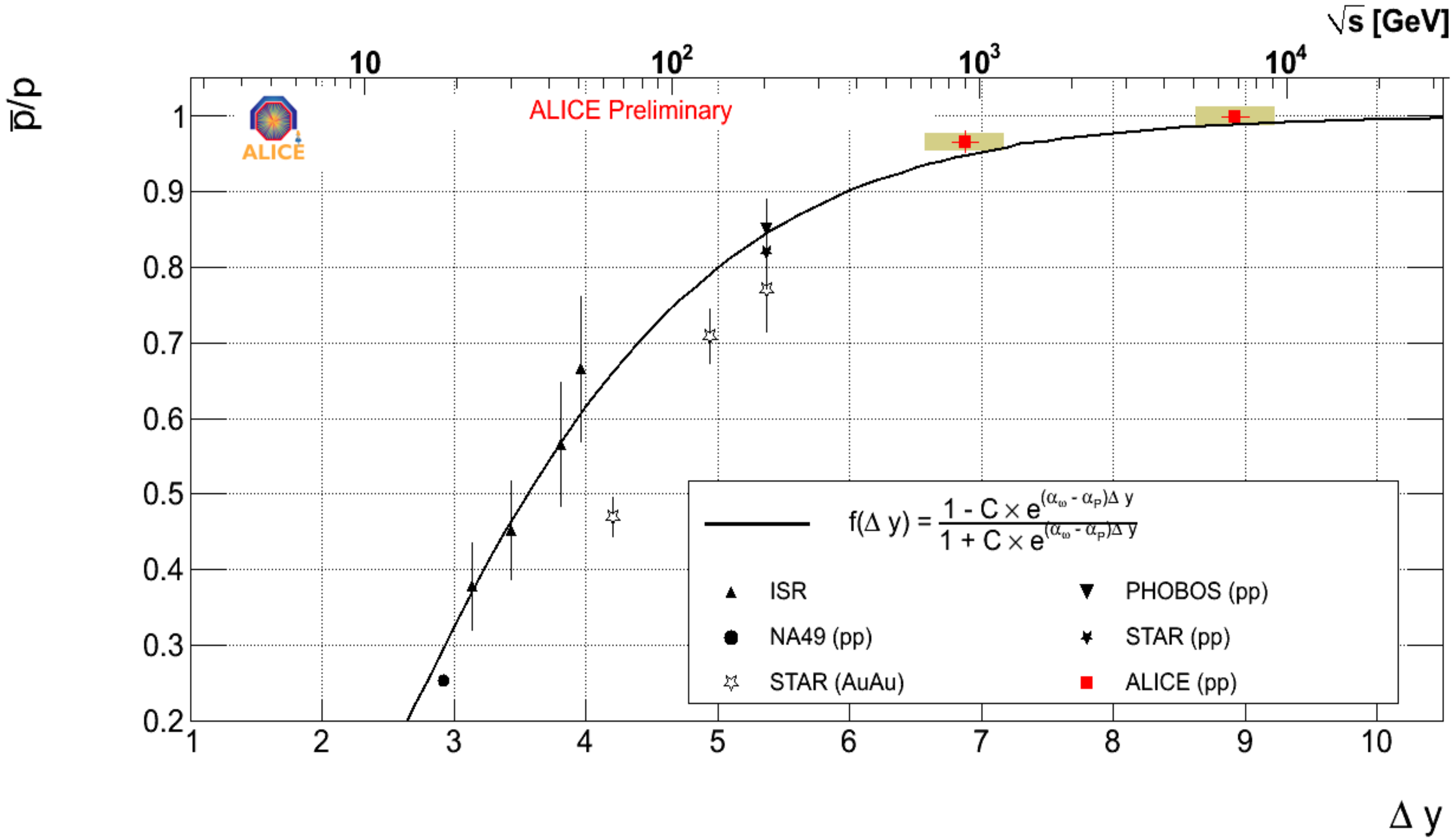
- Preliminary result show no sign of transverse momentum dependence
- Experimental points are compared with different model predictions that include variation of BN transport mechanisms:
  - HIJING-B predicts a decrease of the ratio with increasing p_t not seen in p+p collisions.
  - The different PYTHIA tunes describe the data well.



Fully corrected ratio: stat. error – lines, syst. Error – are shaded around data points

Energy dependence of mid rapidity ratio

- Results at 900 GeV show still small excess of baryons over antibaryons.
- At 7 TeV mid rapidity ratio goes to unity
- Results are well described with BN transfer via Regge trajectory using α ≈ ½.
- No significant contribution with constant BN transport with $\alpha_J \approx 1$ is needed.



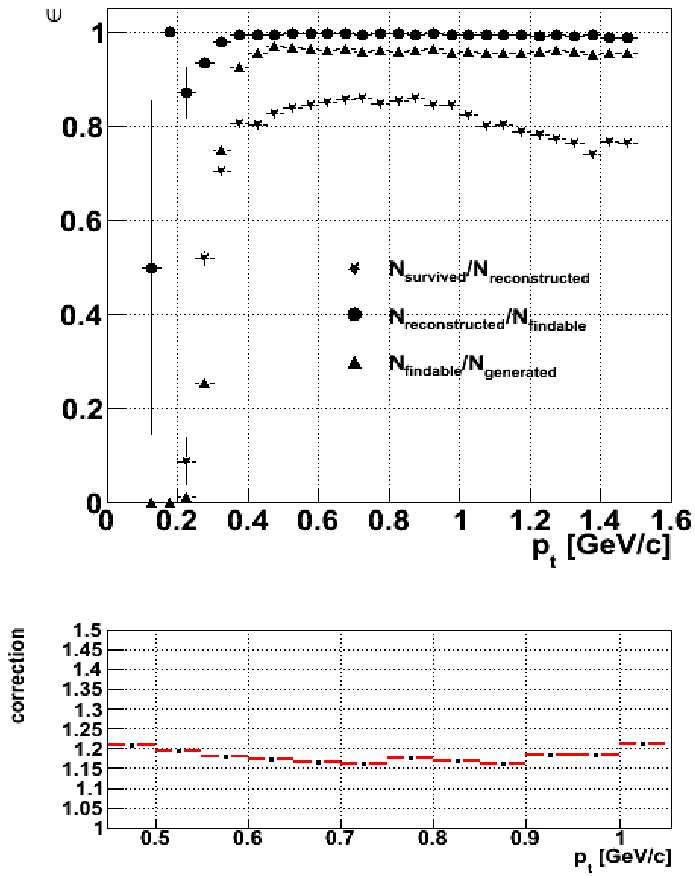
Summary

- We measured the antiproton – proton ratio for 900 GeV and 7 TeV LHC.
- Results at 900 GeV show still small excess of baryons over antibaryons.
- At 7 TeV mid rapidity ratio goes to unity.
- Results are well described with BN transfer via Regge trajectory using $\alpha \approx ½$.
- No significant contribution with constant BN transport with $\alpha_J \approx 1$ is needed.

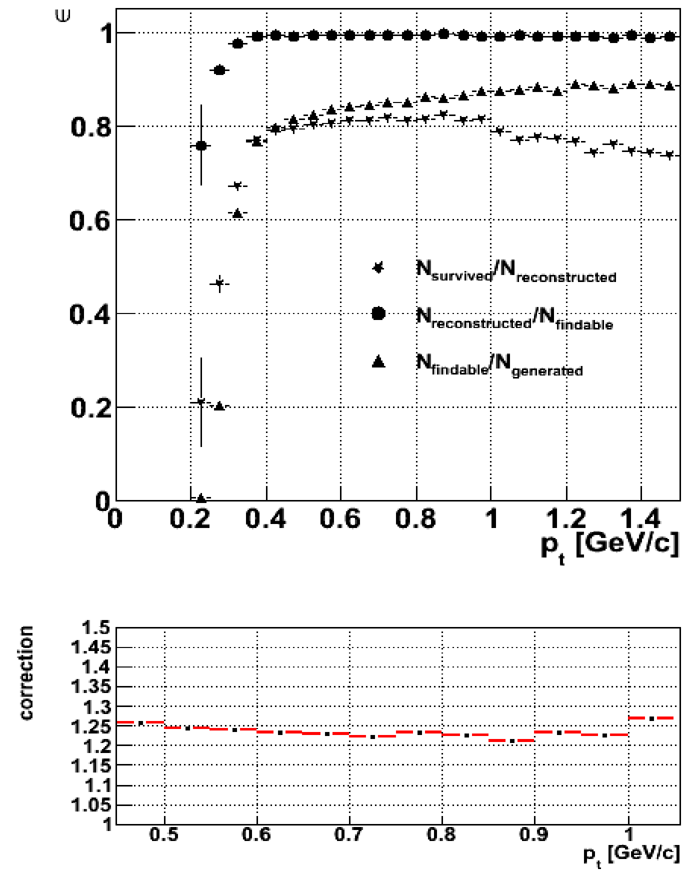
Backup

Cut efficiencies

Efficiency: p



Efficiency: $\bar{p}$

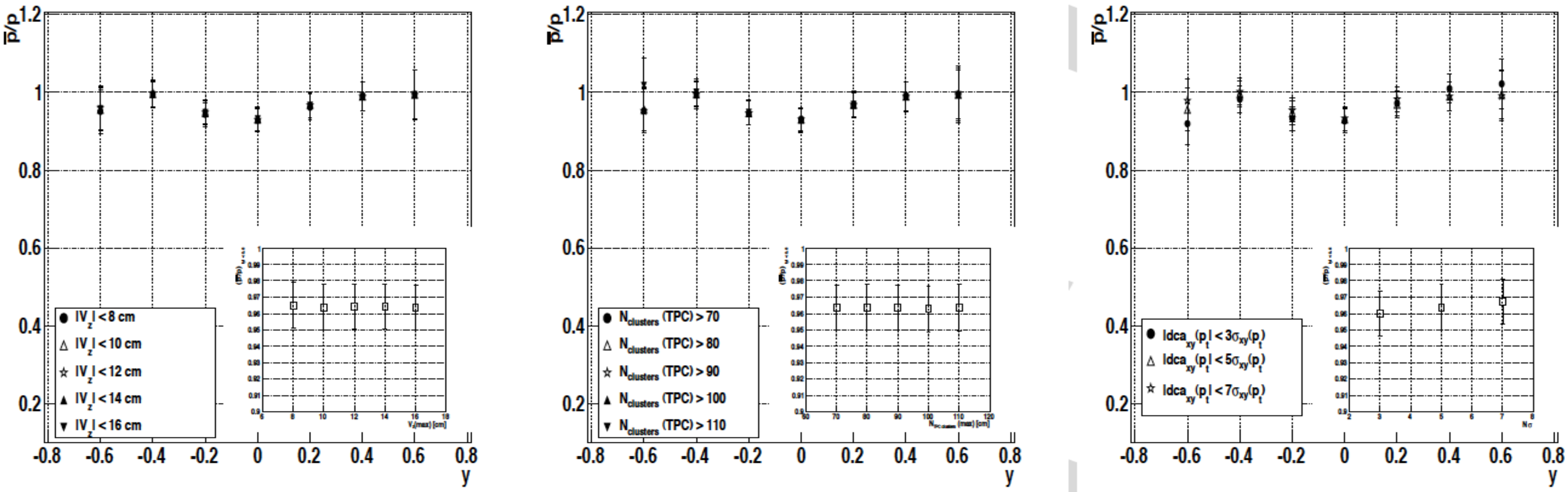


Charge asymmetry in the cut efficiency ➔ correction to be included in the ratio

Tracking scenario

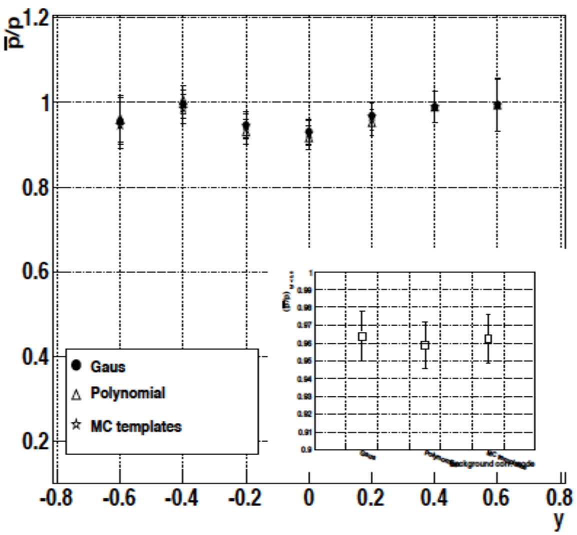
- Standalone TPC
  Used for cross checks (systematics)
  - Momentum determination from the TPC
  - Primary vertex from the TPC
- Hybrid TPC
  Used for cross checks (systematics)
  - Standalone-TPC tracks (momentum determination)
  - ITS clusters for each track (reduction of secondaries)
  - Primary vertex from the SPD
- Full hybrid TPC
  Default used for analysis
  - Standalone-TPC tracks (momentum determination)
  - ITS clusters for each track (reduction of secondaries)
  - Primary vertex from the SPD
  - Update parameters of the global track (better impact parameter resolution)

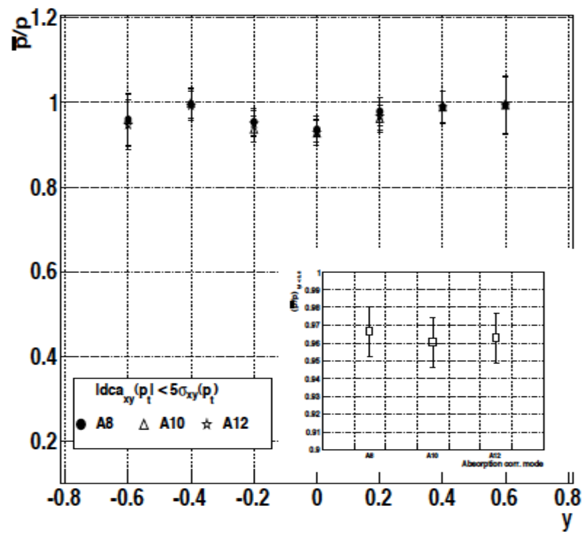
Systematics – Variation of cuts

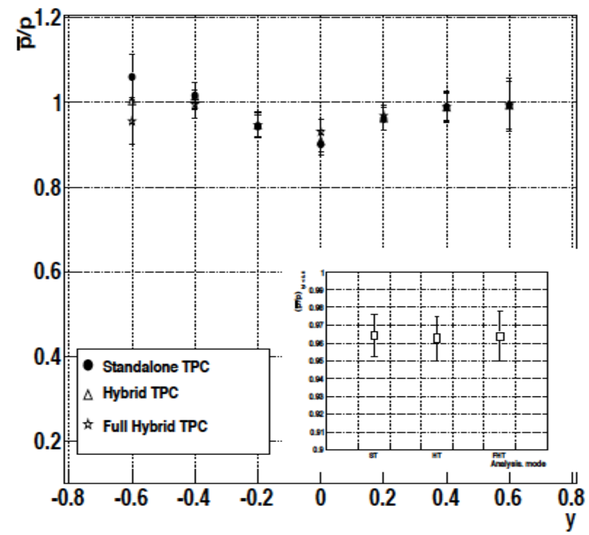


- Vary cut ranges for Vz, Nclusters (TPC) and dca
- For each analysis, a new set of corrections was calculated and applied to the raw values.
- The differences are attributed to the systematic uncertainty (see table)

Systematics – Corrections & Analysis mode







- Use different ways to extract the correction for secondaries (MC templates, polynomial fit)
- Use different MC productions to extract the absorption correction maps
- Analysis using ST, HT, FHT

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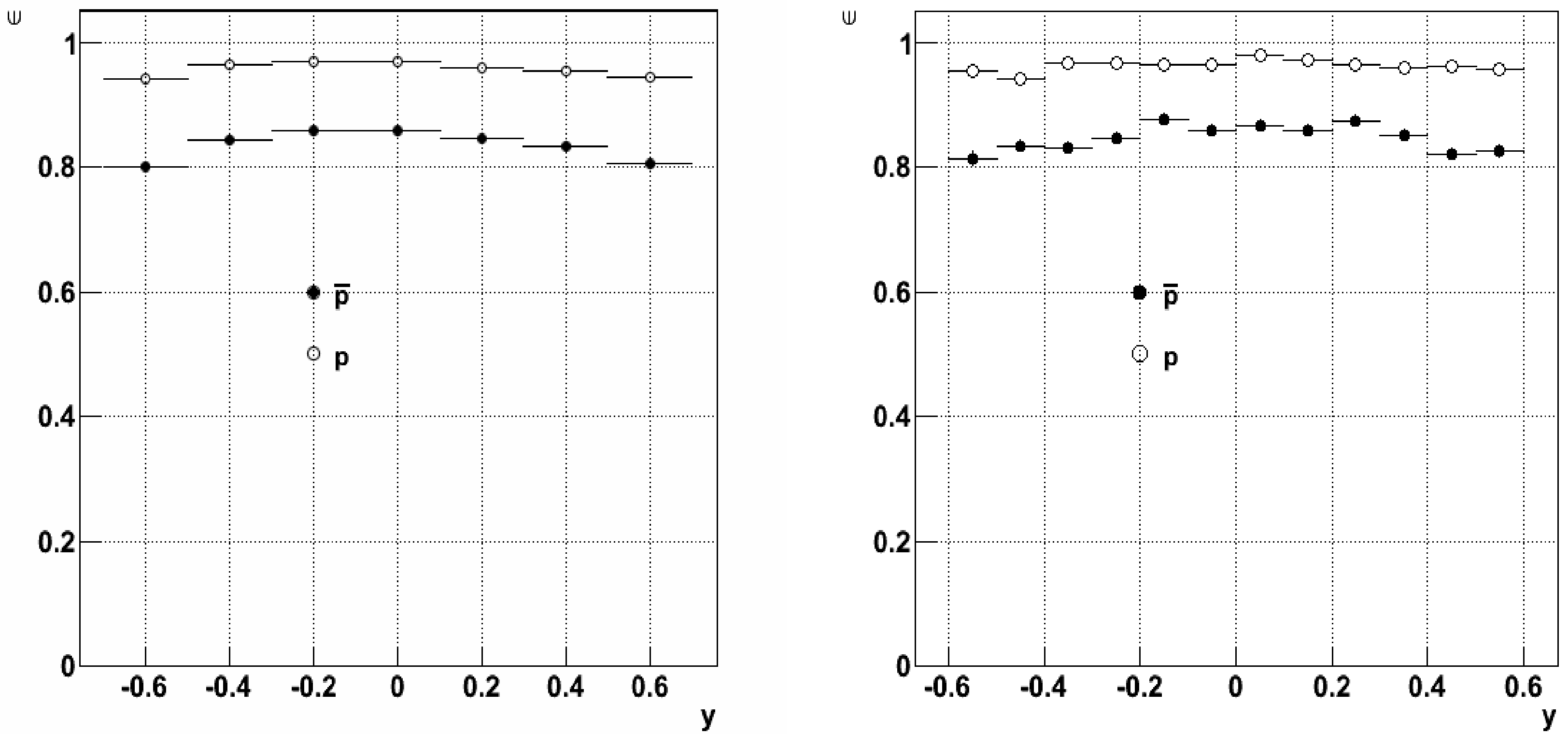
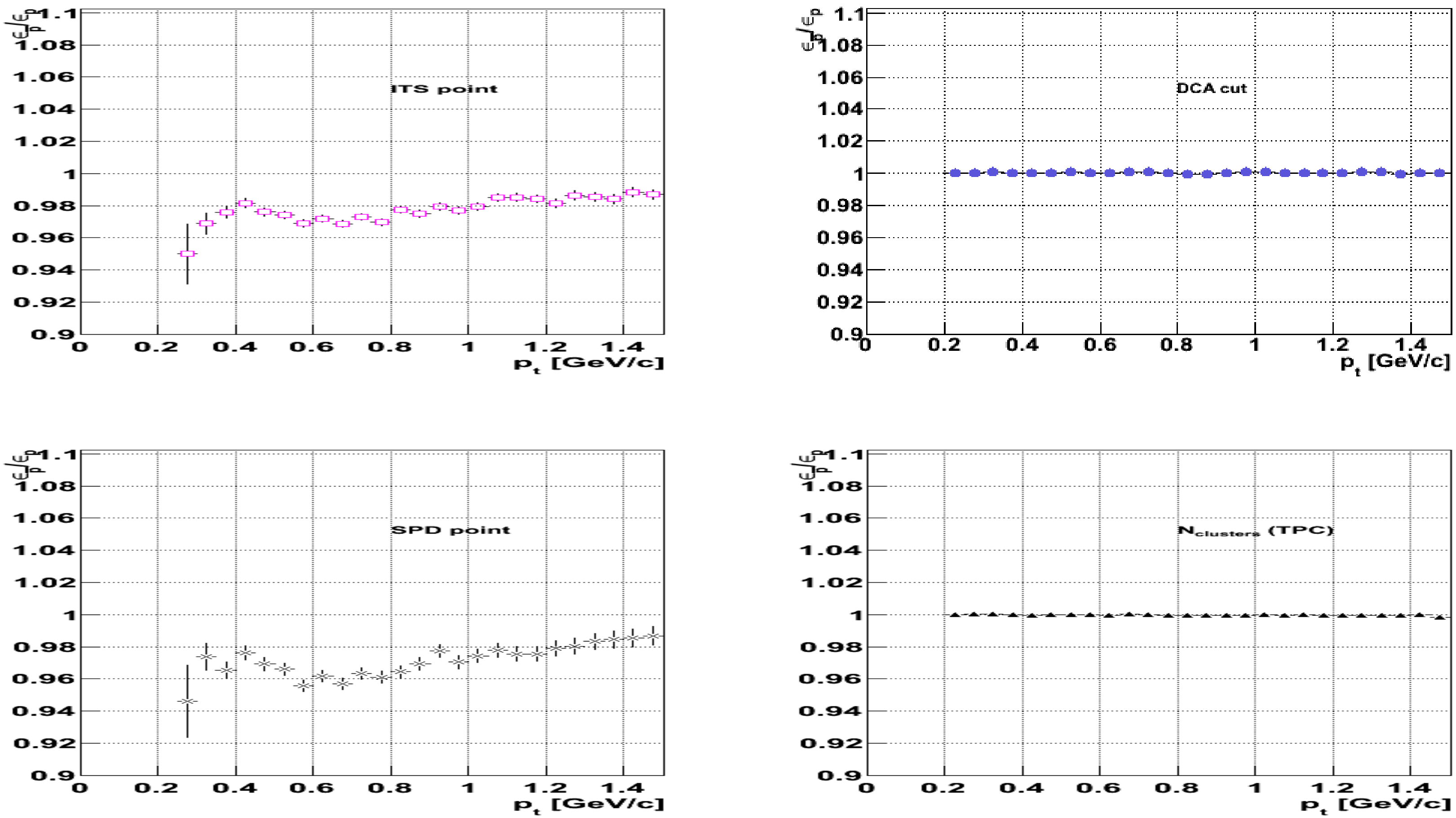
Absorption correction

900 GeV

7 TeV



Cut efficiencies



Charge asymmetry originating from the cuts related to the ITS

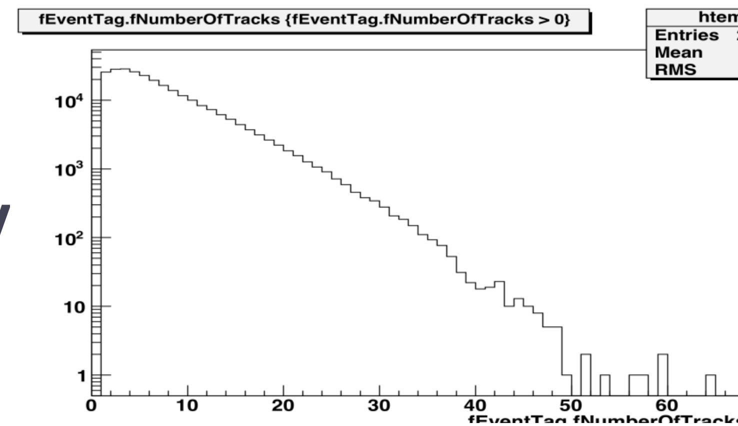
Systematic uncertainties

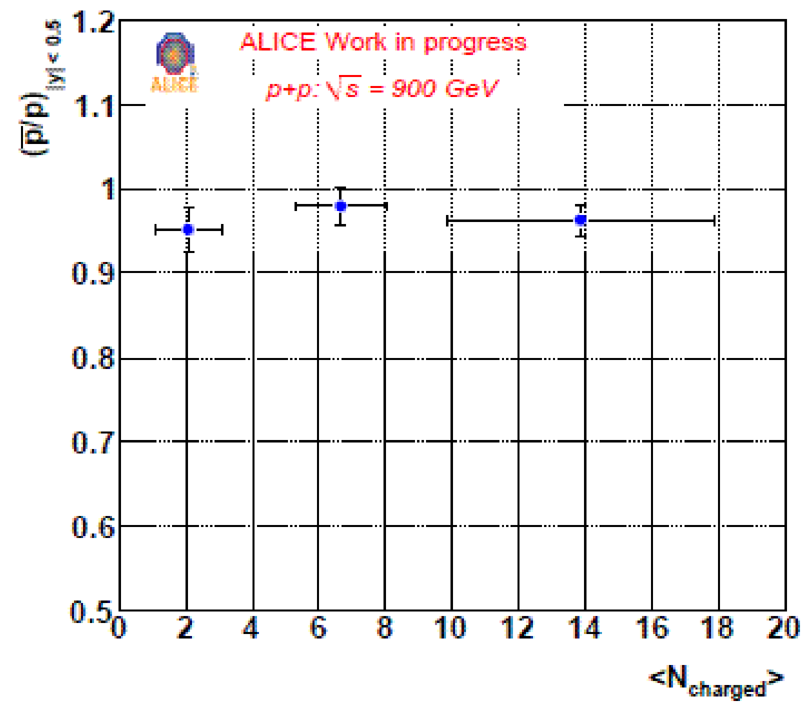
Source		Action	0.9 TeV	7 TeV
Material budget		MC production with the material budget variation	0.5%	
Cross-section		Bendiscioli and Kharzeev, Riv.Nuovo Cim.17N6, 1-142 (1994)	1.0%	
Variation of the cut ranges	dca	3σ, 5σ, 7σ dca cut	0.4%	0.5%
	$N_{clusters}$(TPC)	70-110	< 0.1%	< 0.1%
	Vz	$\vert V_z \vert < 8 - 16$ cm	< 0.1%	< 0.1%
Corrections	Secondaries	MC templates, different functional forms for the background	0.4%	0.4%
	Absorption	Maps from different productions	0.2%	0.1%
	Cut efficiency	Maps from different productions	0.5%	
	Feed-down	MC templates, Gaussian fits	0.5%	
Background		Run the analysis including all the available triggers	< 0.1%	< 0.1%
Different analysis modes		Run the analysis chain + corrections using the standalone TPC, hybrid-TPC, full hybrid-TPC modes	0.1%	0.1%
Event classes		Contamination of SD and DD in the event sample	<0.1%	

- Different contributions are added quadratically and results into $\sigma_{sys} = 1.4$ %

Multiplicity dependence - 900 GeV

- The multiplicity distribution of charged particles (extracted after applying the standard quality cuts) was divided in three multiplicity bins
- For each bin, the entire analysis & correction chain, described on the previous slides, was applied
- Preliminary result show no sign of multiplicity dependence





Error bars corresponds to the statistical ones