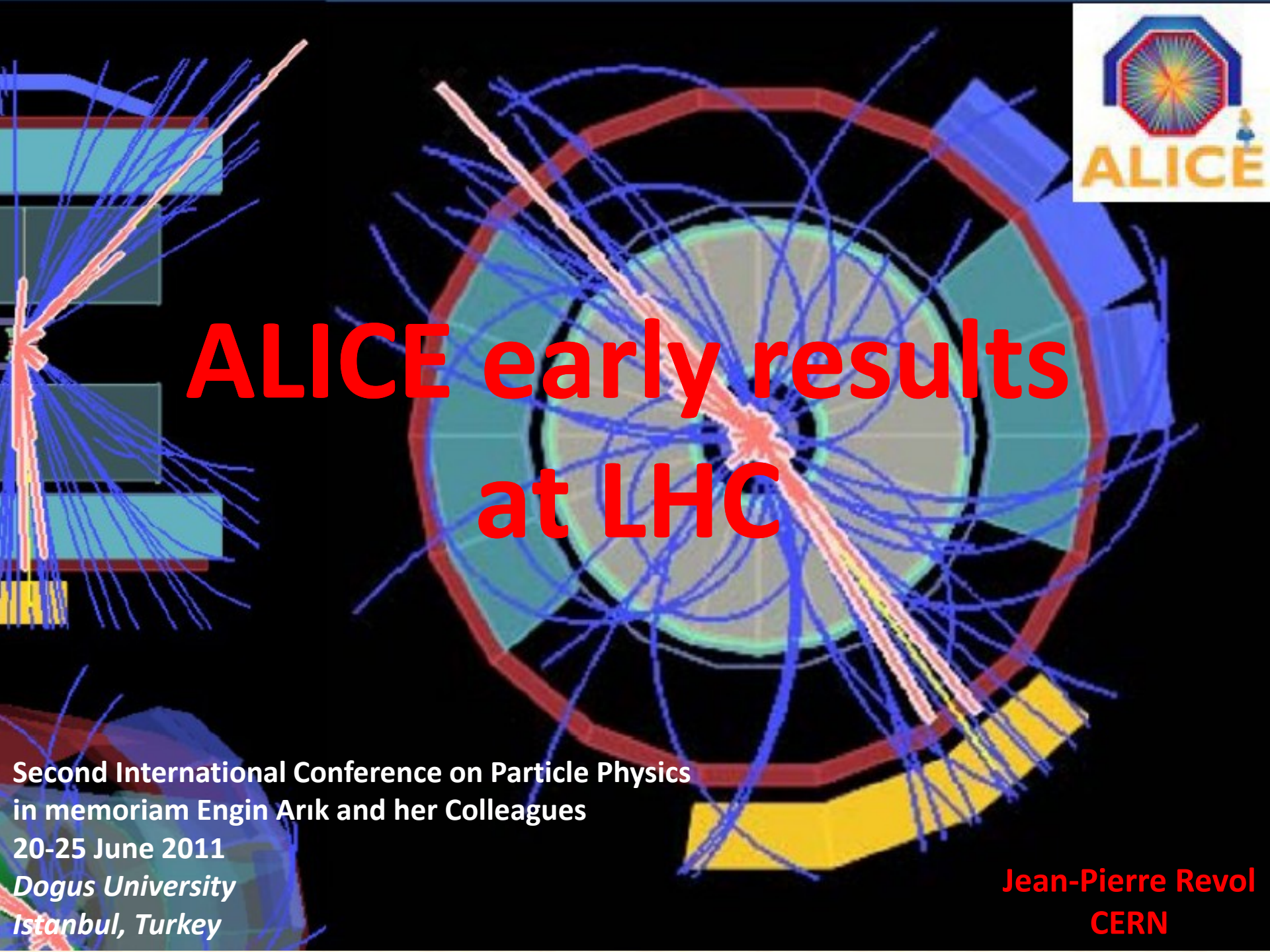


ALICE early results at LHC

Second International Conference on Particle Physics
in memoriam Engin Arık and her Colleagues
20-25 June 2011
Dogus University
Istanbul, Turkey

Jean-Pierre Revol
CERN

Turkey and ALICE

- Nizam ERDURAN and **Engin ARIK** promoted the idea of Istanbul University joining ALICE – I met Engin both at CERN (she was interested in n_TOF) and in Istanbul.
- I remember very well my visit here in 2003, and the discussions and dinner with Engin.
- Ozgur Cobanoglu (DAQ), Birkan Belin (HMPID) worked with us for sometime.
- Yildiz Technical University, Istanbul, became an **associate member of the ALICE Collaboration** (Team Leader: Prof. Metin SUBASI)
- Ayben Karasu, Metin's student, defended successfully, at the beginning of June, her Ph.D. thesis on the production of Δ^{++}/Δ^{--} in pp collisions with ALICE. Ozgur Akcali (postdoc).
- ICFA Instrumentation School organized here by current spokesperson of ALICE (Paolo GIUBELLINO) in 1999 and 2002.

With Turkey joining CERN, my wish is to have soon a Turkish group as full member of ALICE.

The ALICE Collaboration

1183 Members – 33 Countries – 118 Institutes

158 MCHF capital cost (as 31/12/2010)

TURKEY

→ 3 Members

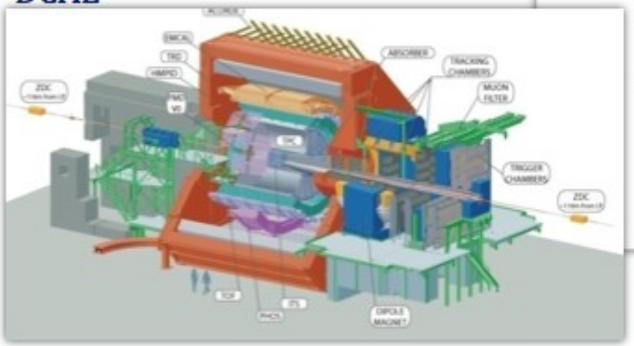
→ 1 Institute

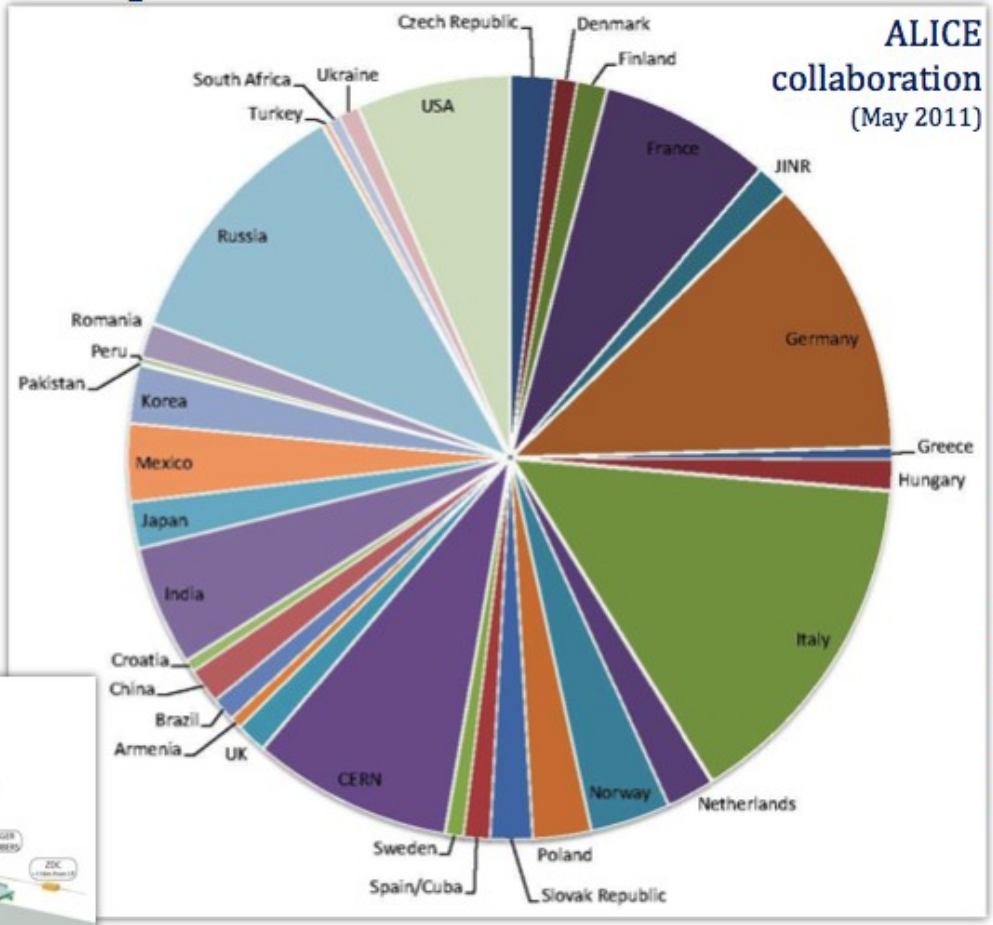
History of the ALICE Experiment:

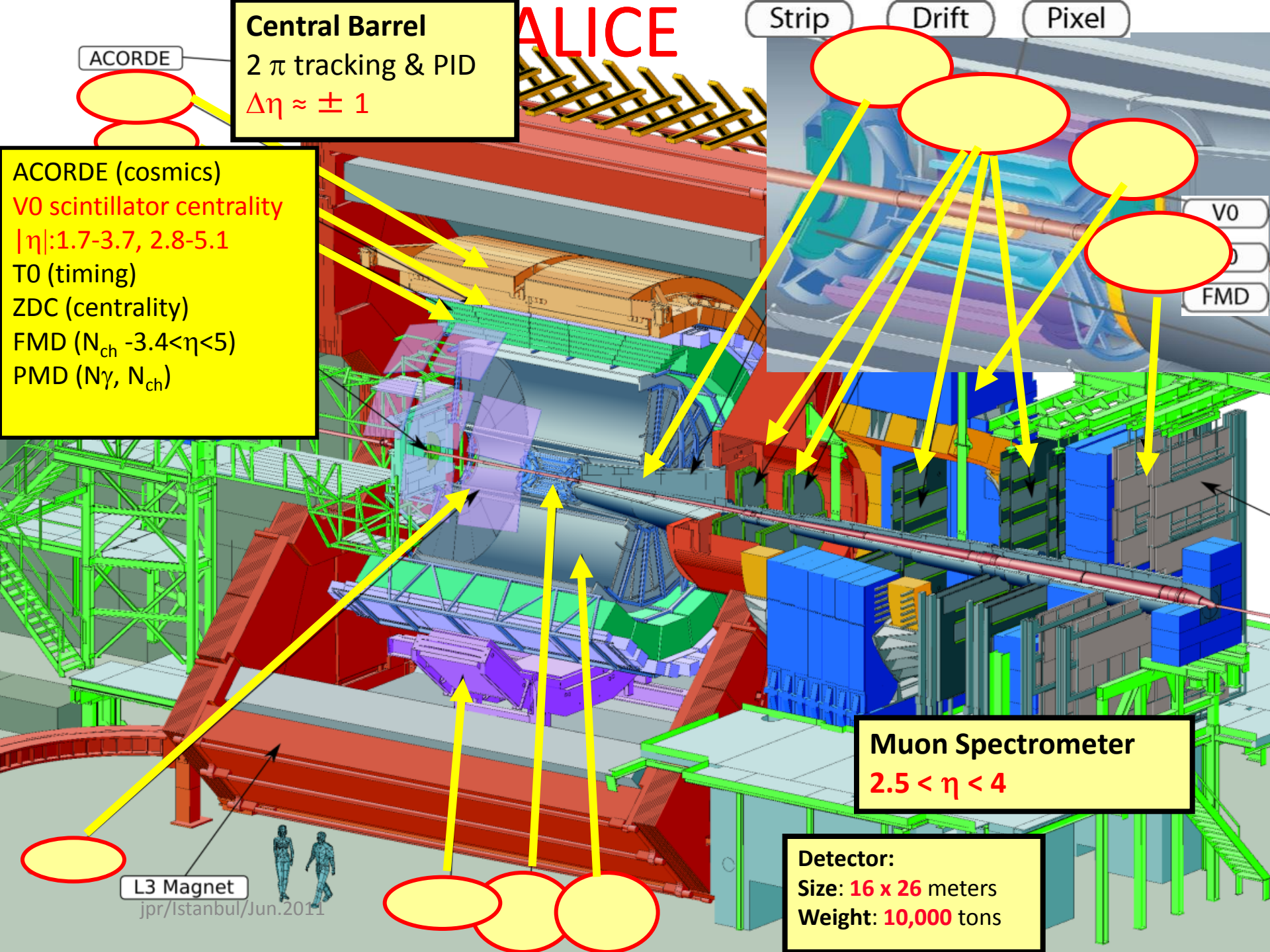
1990-1996 Design
1992-2002 R&D
2000-2010 Construction
2002-2007 Installation
2008 -> Commissioning

4 TP addenda along the way:

1996 Muon spectrometer
1999 TRD
2006 EMCAL
2010 DCAL





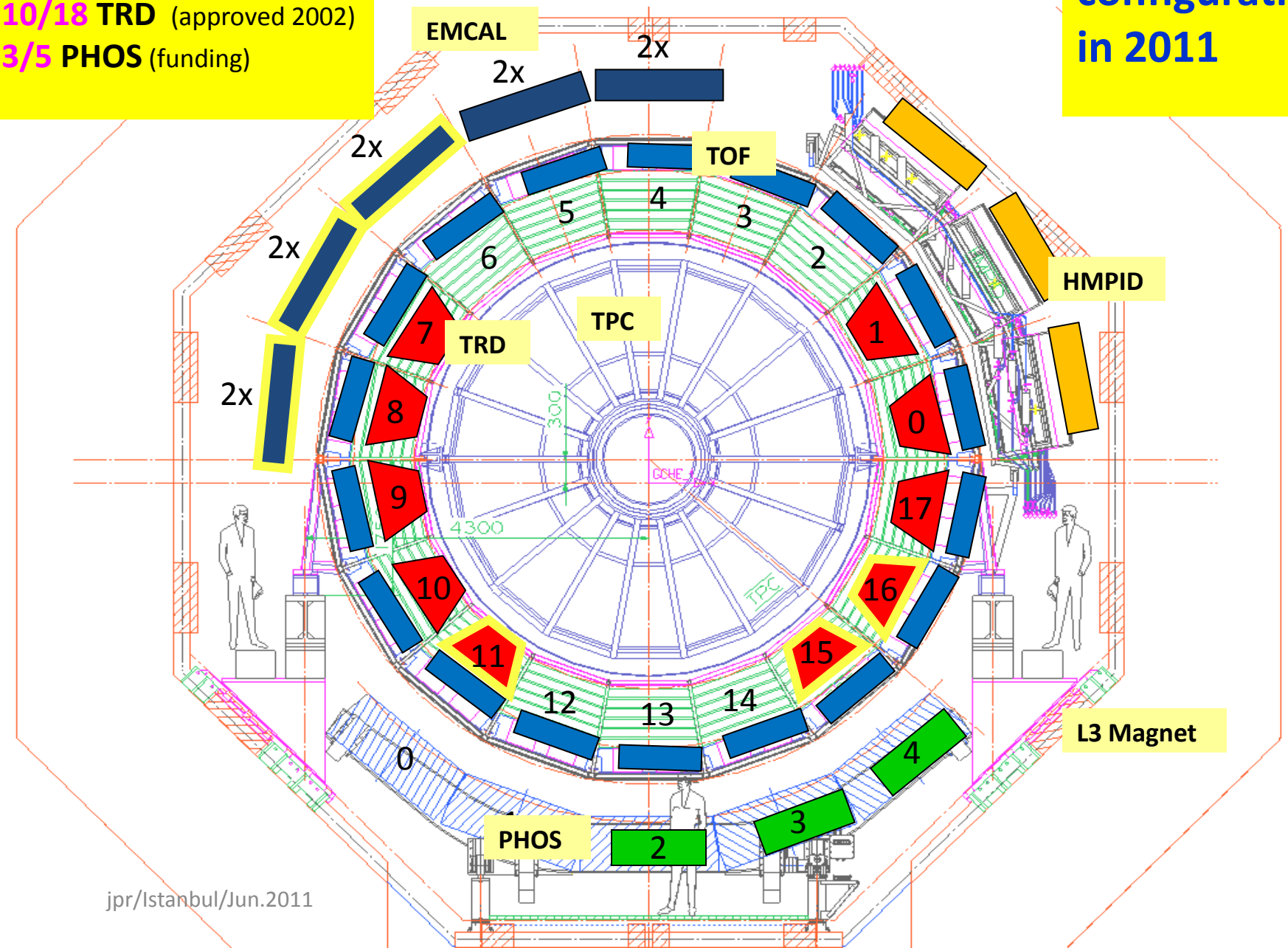

ALICE
Central Barrel
2 π tracking & PID
Δη ≈ ± 1
ACORDE
ACORDE (cosmics)
V0 scintillator centrality
|η|:1.7-3.7, 2.8-5.1
T0 (timing)
ZDC (centrality)
FMD (N_ch -3.4<η<5)
PMD (Nγ, N_ch)
Strip
Drift
Pixel
V0
FMD
Muon Spectrometer
2.5 < η < 4
Detector:
Size: 16 x 26 meters
Weight: 10,000 tons
L3 Magnet
jpr/Istanbul/Jun.2011

ALICE detector complete except for:

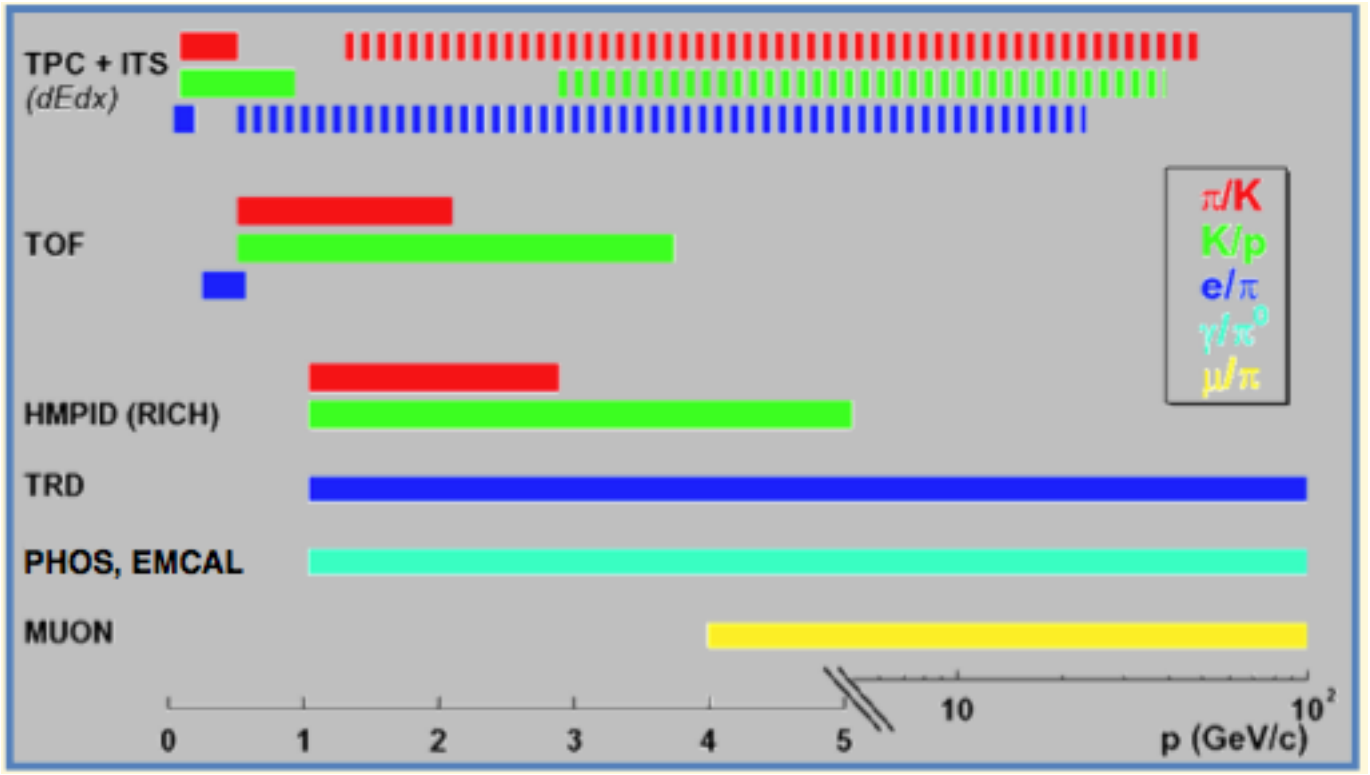
10/18 TRD (approved 2002)

3/5 PHOS (funding)

ALICE configuration in 2011



Particle identification capability

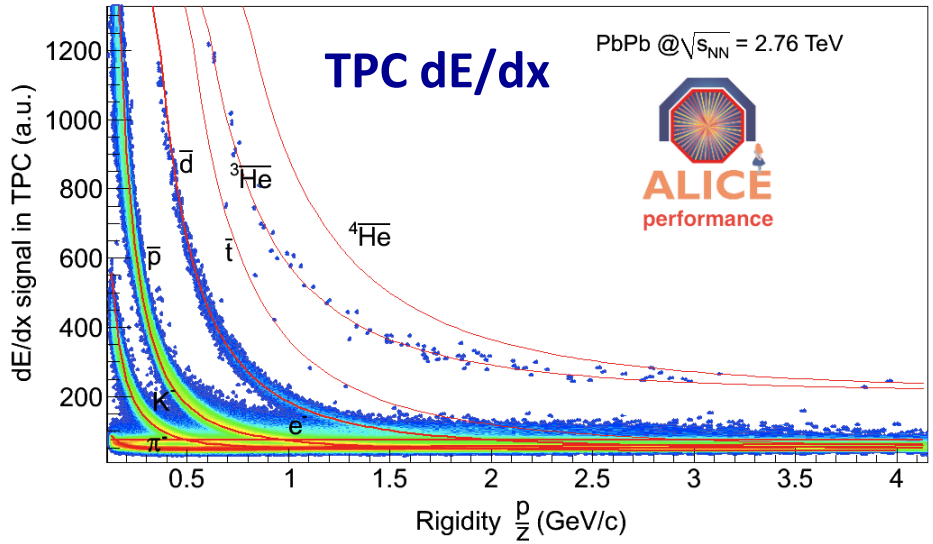


Redundency for cross checks

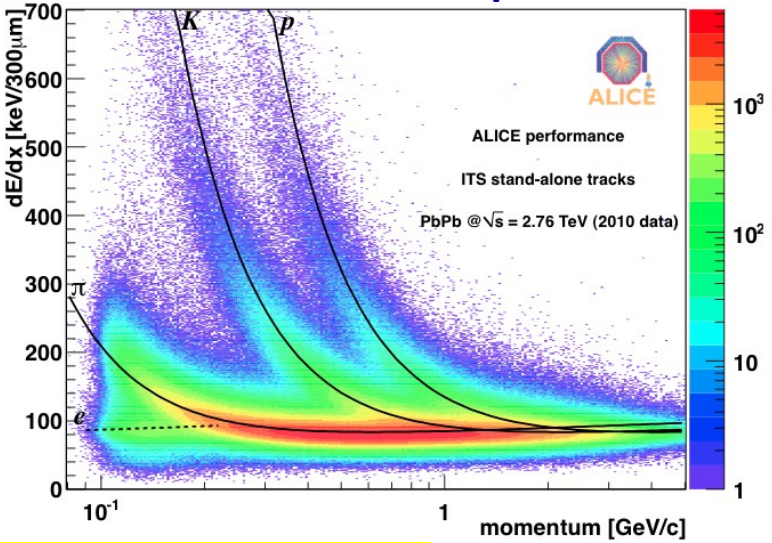
- **hadrons** ($\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$) down to 100 MeV/c
  - **dE/dx** in silicon (ITS) and gas (TPC) + **time-of-flight** (TOF) + **Cherenkov** (HMPID)
- **muons** (p ≥ 4 GeV/c) **muon spectrometer**; **π^0, γ** in **PHOS, EMCAL**; **electrons TRD & TPC**: 1 < p < 80 GeV/c
- **K^0, $K^{\pm}$ (kink), Δ^{++}, Λ□□□, $\Xi^{\pm}$, $\Omega^{\pm}$□□$D^{\pm}$, D^0, π^0, η, etc.,** through **decay topology**)
- **γ** also through **conversions**

See A. Karasu, "short lived resonances"

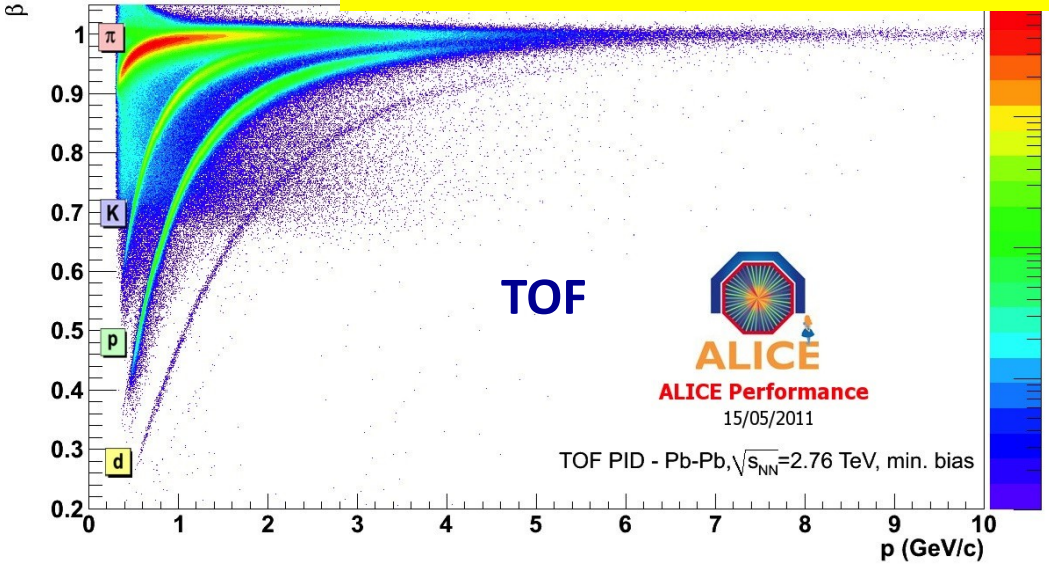
Particle identification in PbPb

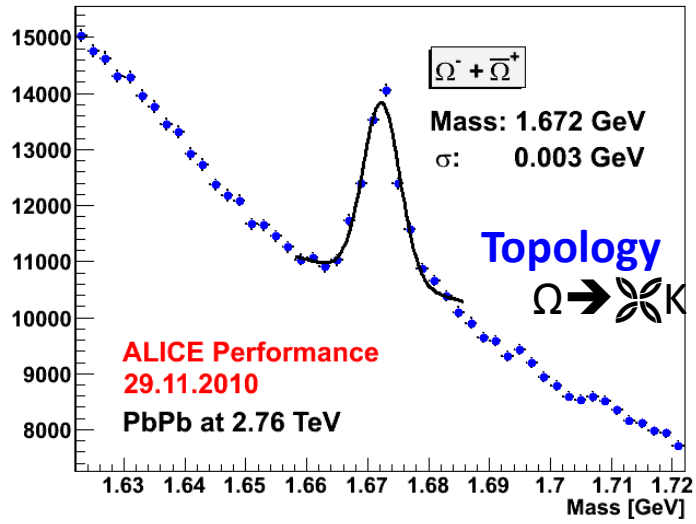


ITS Silicon Drift/Strip dE/dx



Excellent performance in PbPb with a particle density ≈ 400 times higher

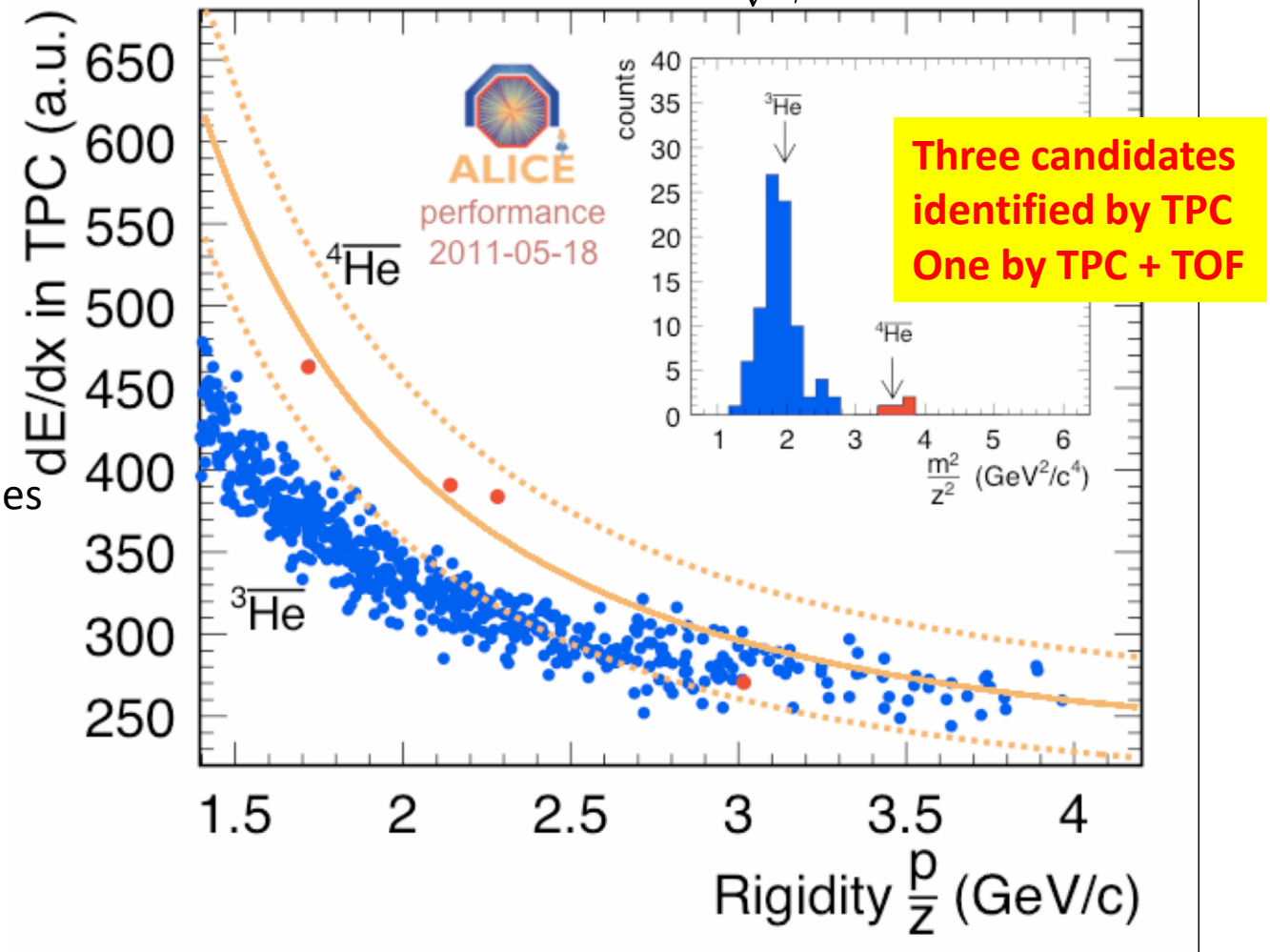




Anti-^{4}He production in Pb-Pb collisions

Combine tracking (R), Time of flight (velocity) and dE/dx information:

$$< \frac{dE}{dx} >= \frac{4\pi N e^4}{mc^2}\frac{z^2}{\beta^2}\left(\frac{1}{2}\ln\frac{2mc^2E_{max}\beta^2\gamma^2}{I^2} - \frac{\beta^2}{2} - \frac{\delta(\beta)}{2}\right) \qquad m = \frac{z \cdot R}{\sqrt{\gamma^2 - 1}}$$



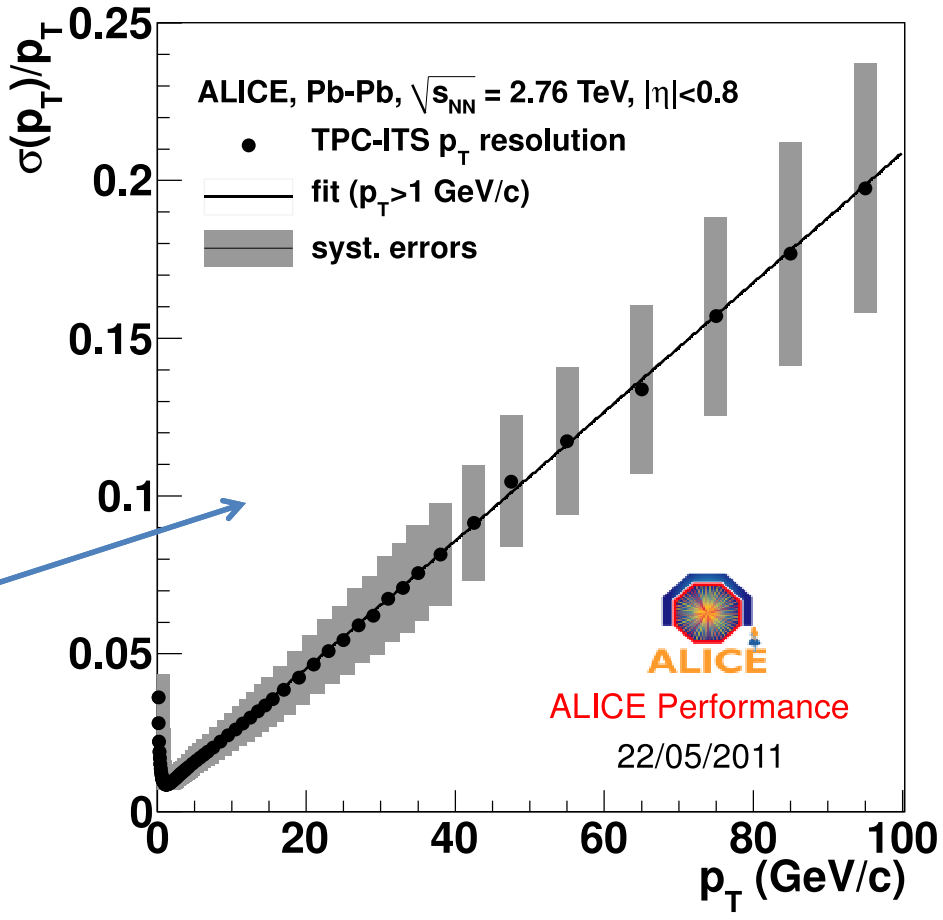
Three candidates identified by TPC
One by TPC + TOF

Rate of ^{4}He production at LHC more than 10 times higher than at RHIC

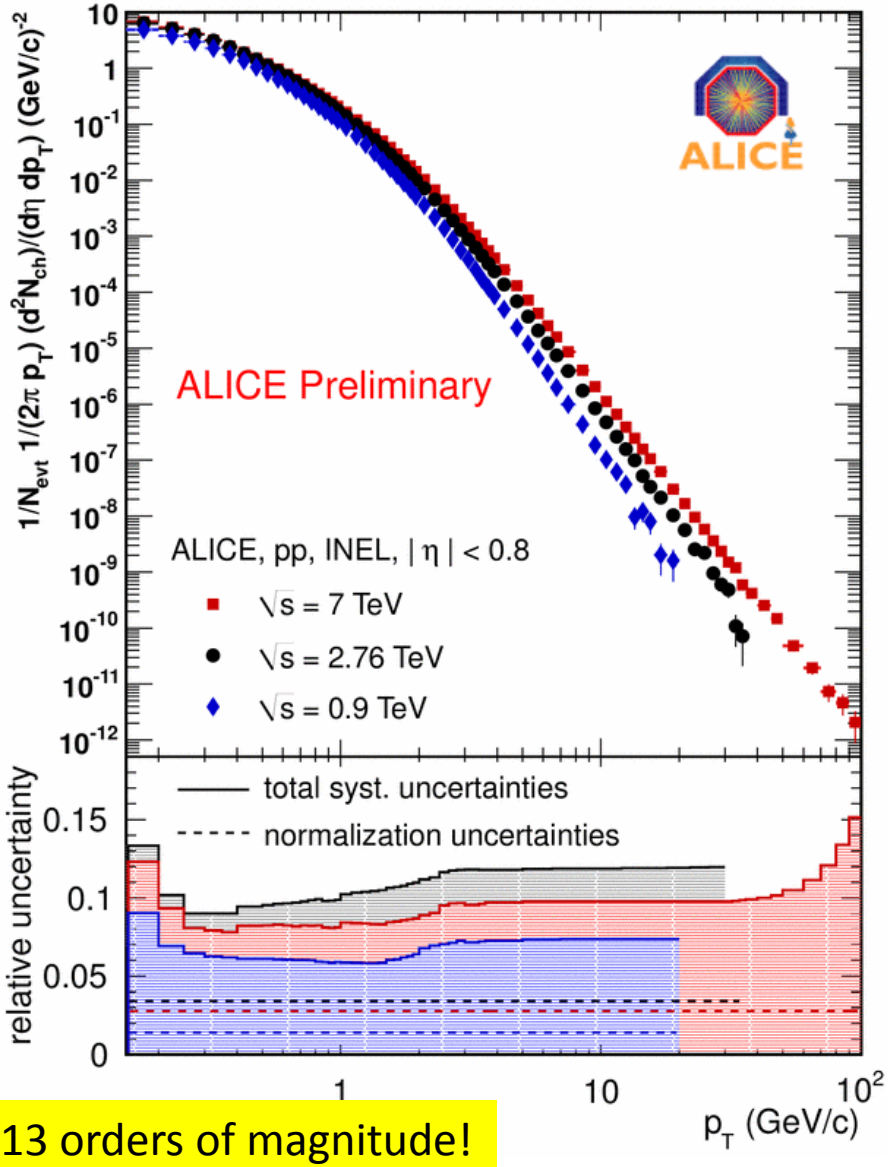
How is antimatter created in a medium, which existed in the first 10μs after the Big Bang?

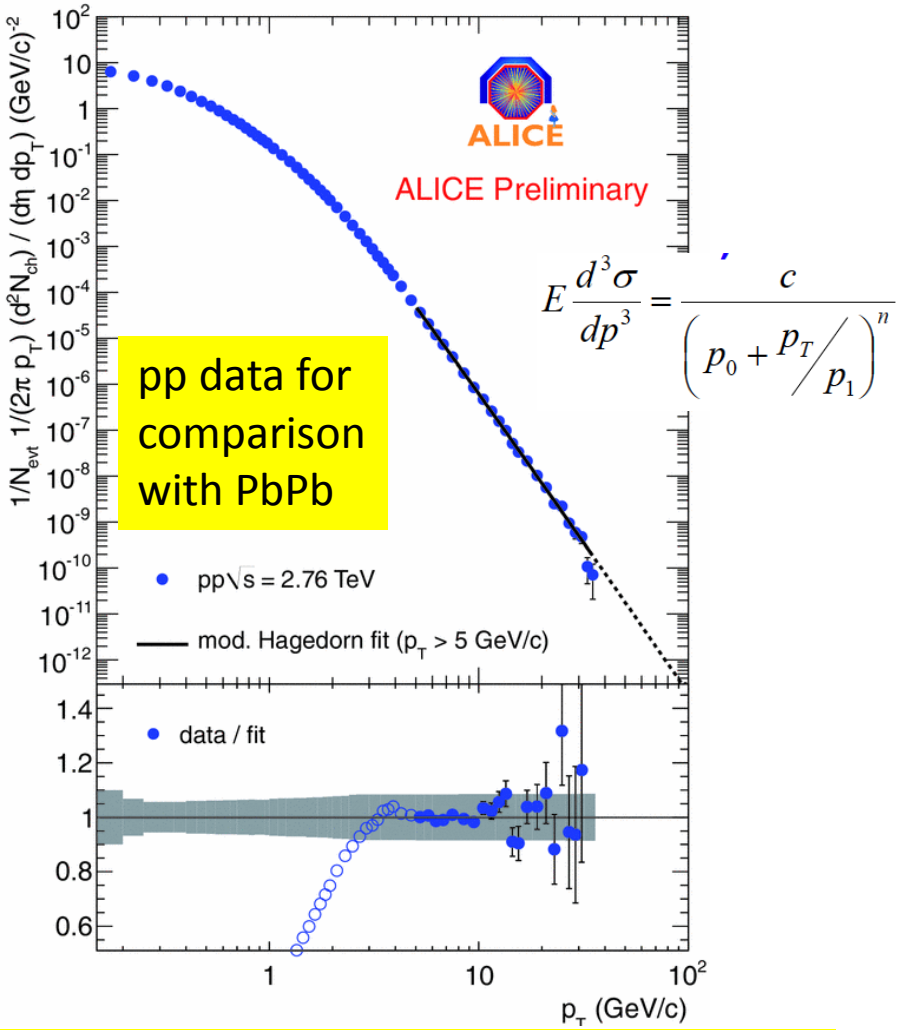
Momentum resolution

- Best measurement from combined ITS and TPC fit in $|\eta| < 0.8$
- Resolution checked from track residuals, cosmics, and reconstructed decays widths and position (absolute)
- Resolution in Pb-Pb collisions approaching that of pp collisions
- Expected to be improved with better modelling of TPC corrections



Charged particle p_T spectra (pp)



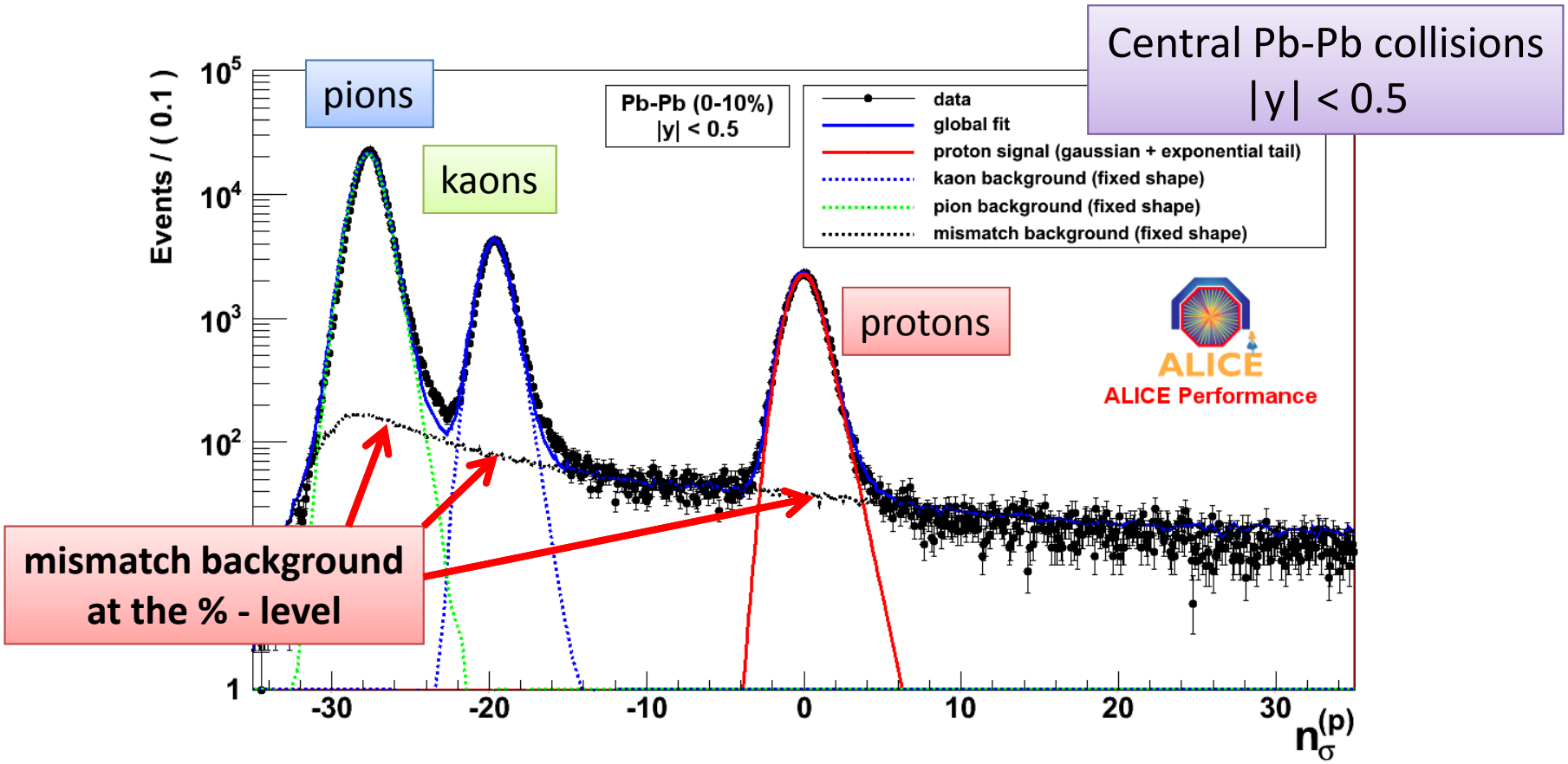


13 orders of magnitude!

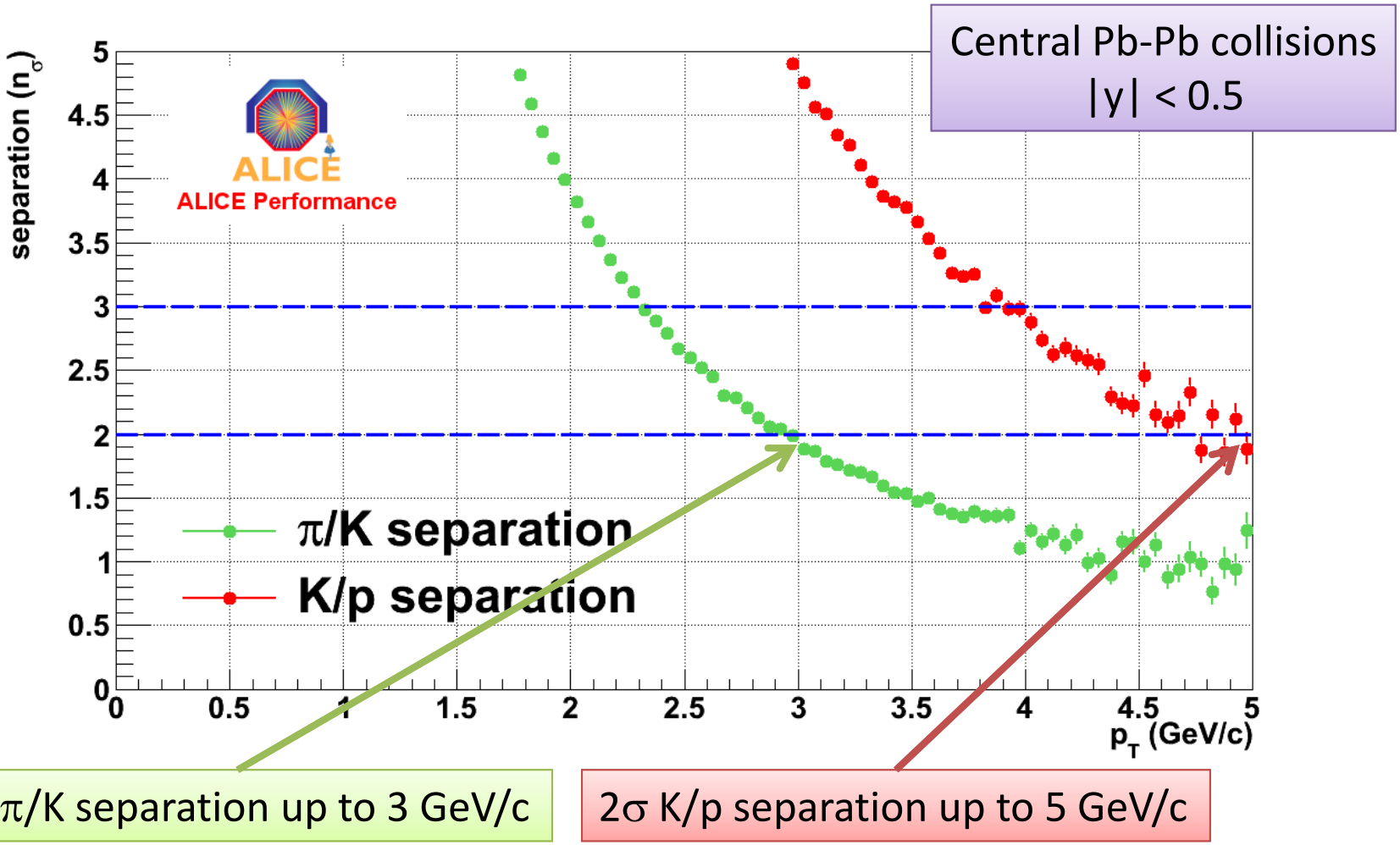
Charged particle p_T spectra at 900 GeV: Phys. Lett. B 693 (2010) 53-68

Particle identification with TOF

- Time of flight signal – signal for (p) mass hypothesis in extreme conditions with PbPb collisions



Particle identification with TOF



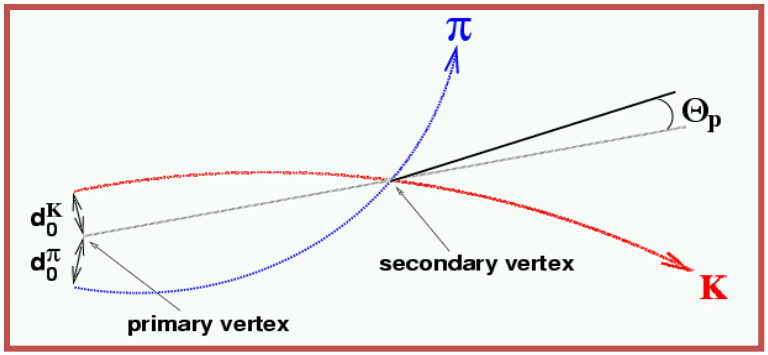
2σ π/K separation up to 3 GeV/c

2σ K/p separation up to 5 GeV/c

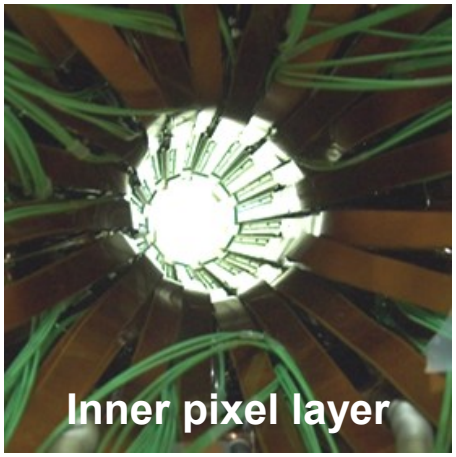
system time resolution in Pb-Pb (≈85ps) – better than in p-p (≈110ps)

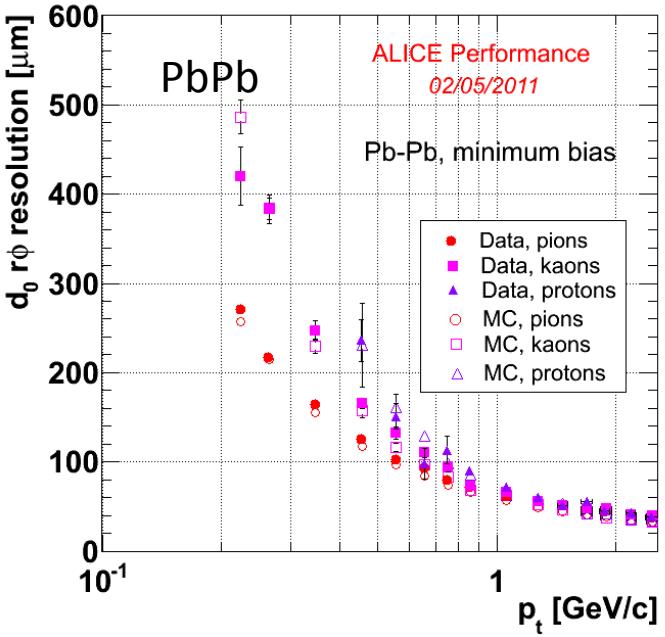
Reconstruction of weak decays

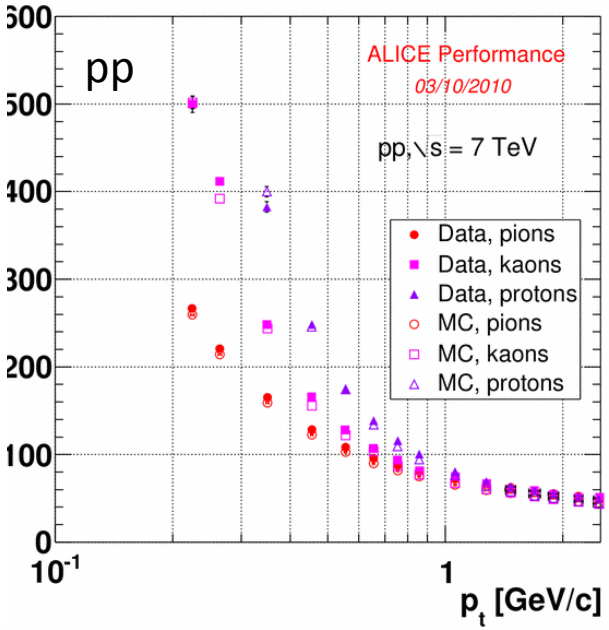
- Resolution on the impact parameter (d_0) crucial to the reconstruction of weak decays of D-mesons



ITS aligned withcosmics and collisions; current resolution for pixels: 14 μm (nominal: ≈11 μm)







Same dca precision in pp and Pb-Pb, well described by MC, incl. particle dep.

Decay length (cτ):
– 300-500 μm ($D^{+,-}$)
– 124 μm (D^0)

70 μm resolution at 1 GeV/c

ALICE upgrade aiming for a factor 2-3 better

π^0, η and photon reconstruction

- Three independent measurements:
  PHOS, EmCal, and conversions

$pp \longrightarrow \pi^0 X$

$\pi^0 \rightarrow \gamma\gamma$

$\gamma \rightarrow e^+e^-$

$e^+e^-e^+e^-$

($m_{\pi 0}$ = 135 MeV/c^2; Br. = 0.988)

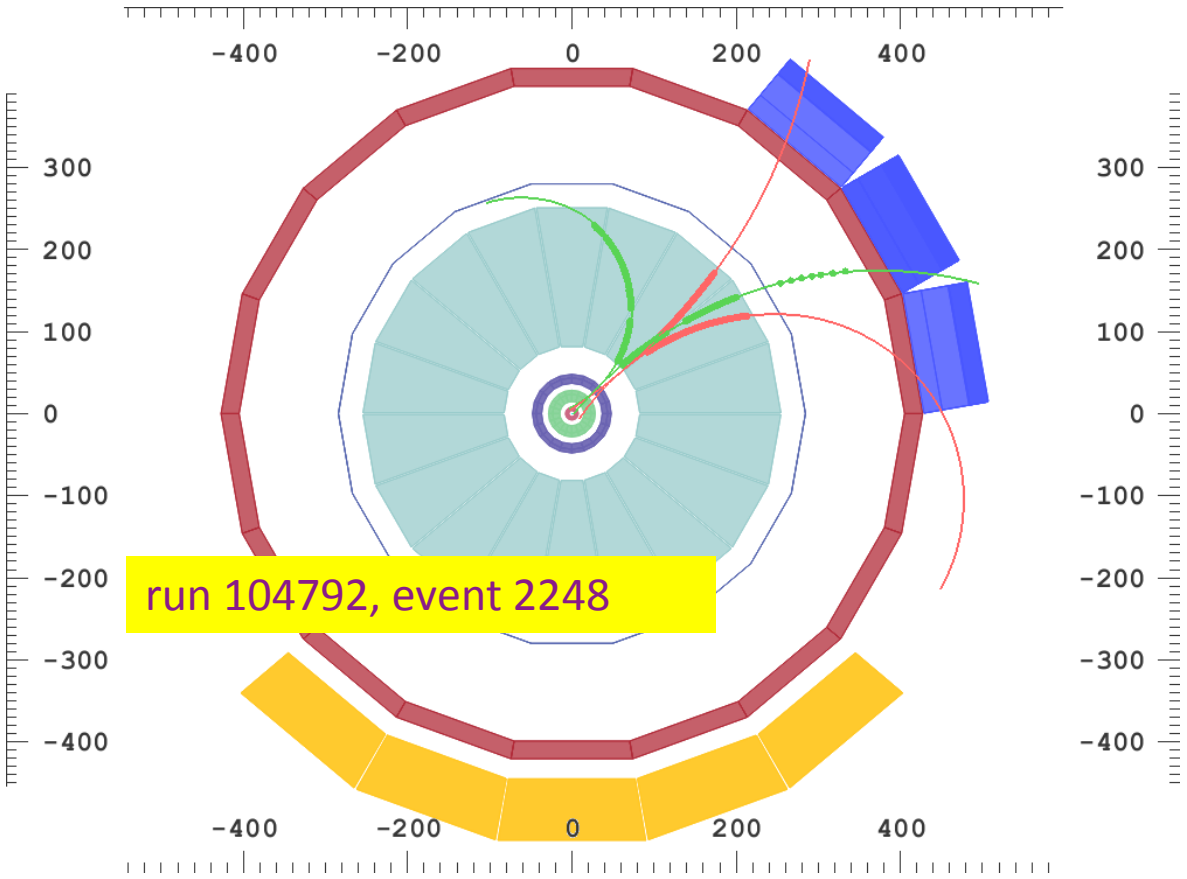
$pp \longrightarrow \eta X$

$\eta \rightarrow \gamma\gamma$

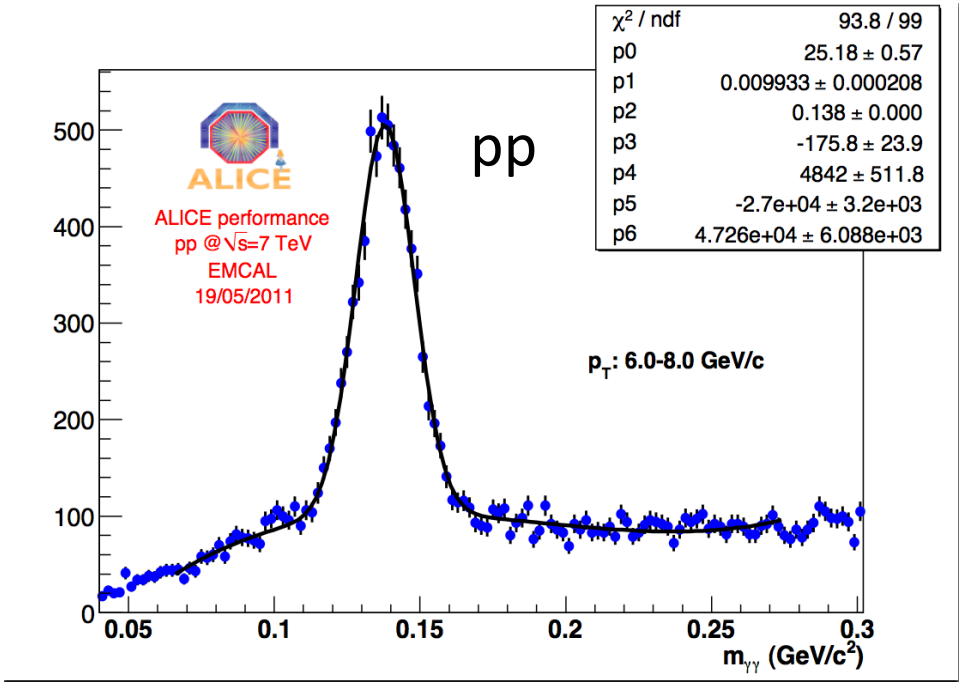
$\gamma \rightarrow e^+e^-$

$e^+e^-e^+e^-$

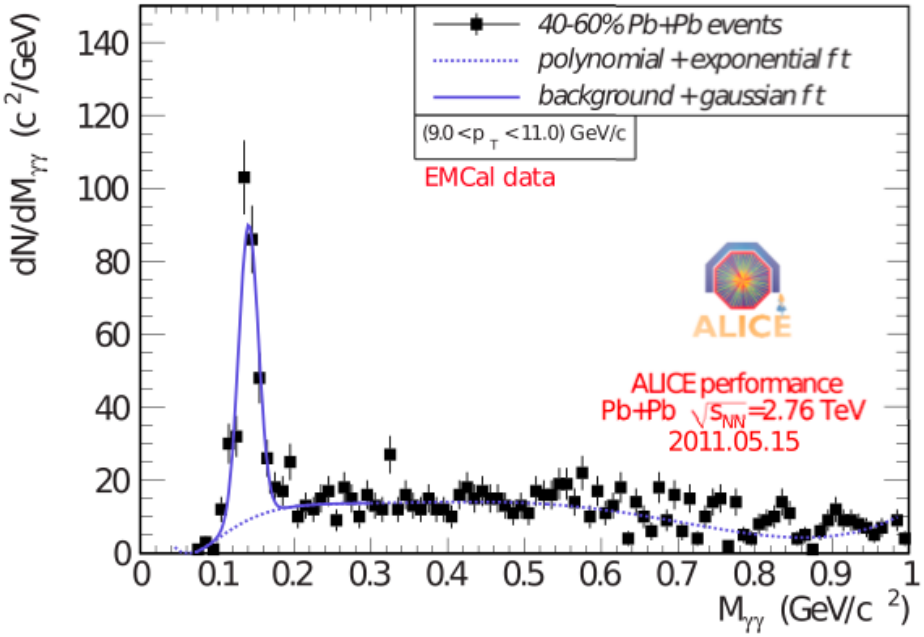
(m_η = 548 MeV/c^2; Br. = 0.393)



π^0 reconstruction in EmCal

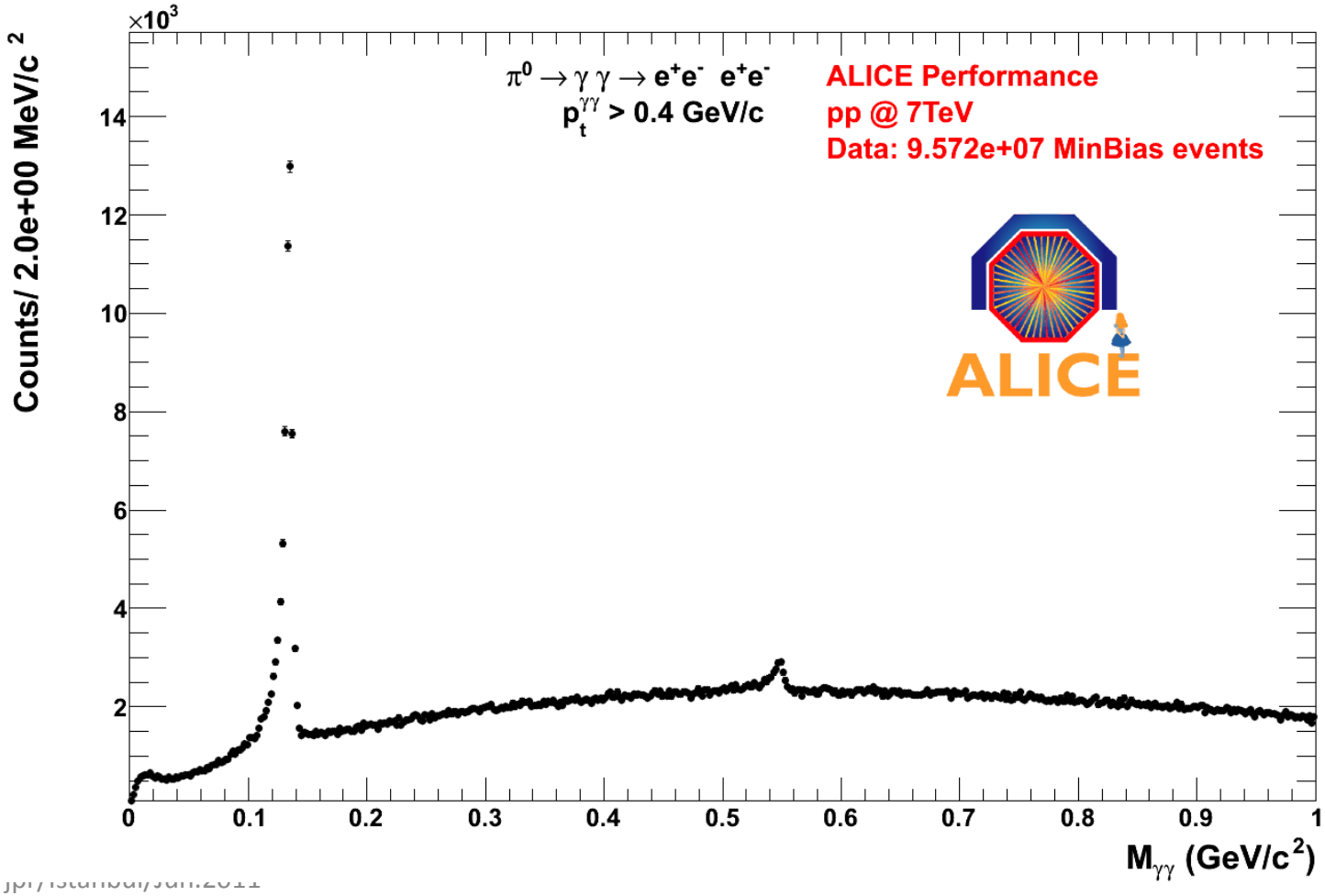


Semi-central PbPb



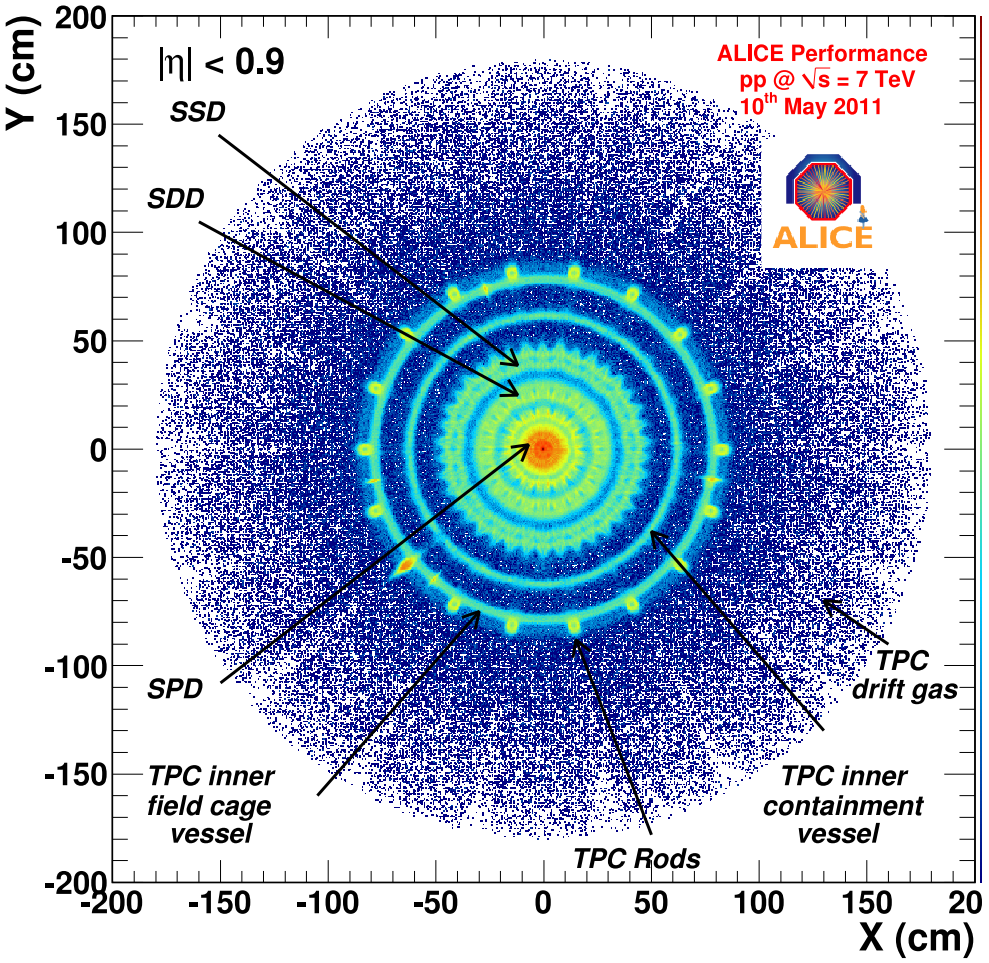
Preliminary EmCal resolution ~ 7%

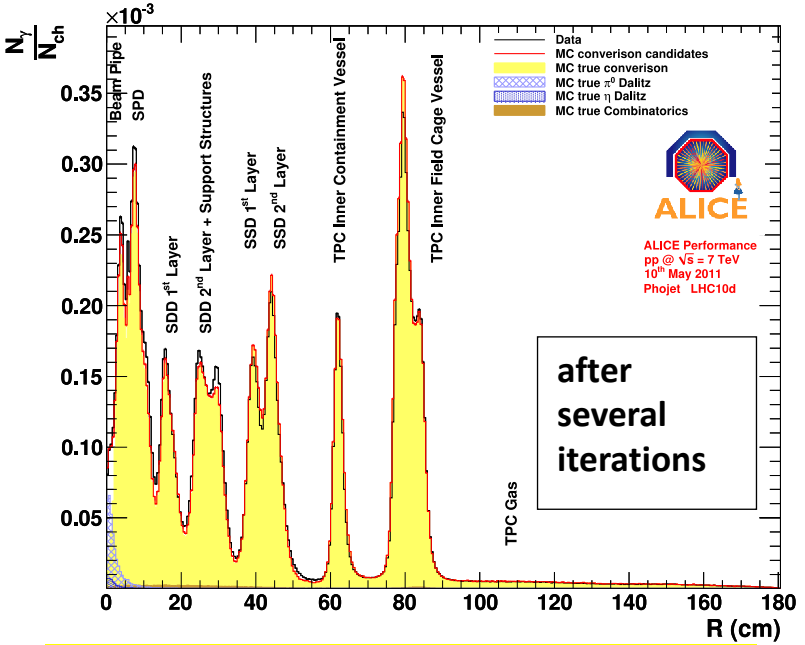
π^0 and η from conversions



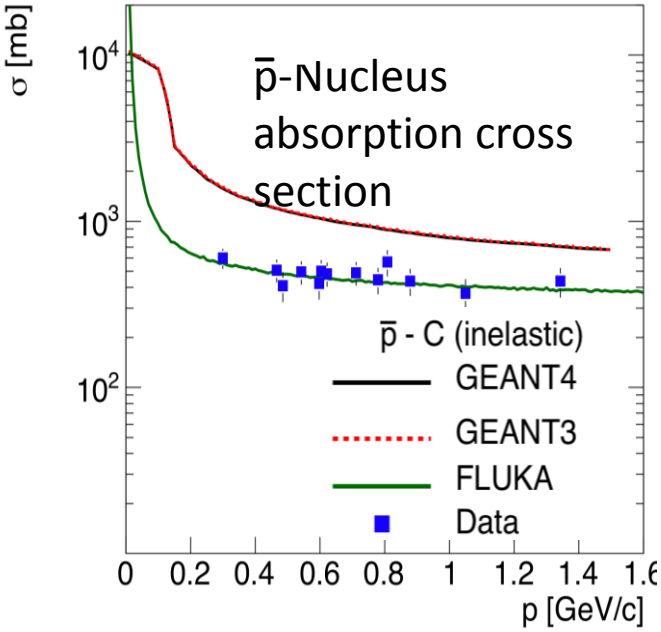
ALICE material budget

γ-graphy of ALICE detector:
photon conversion vertices



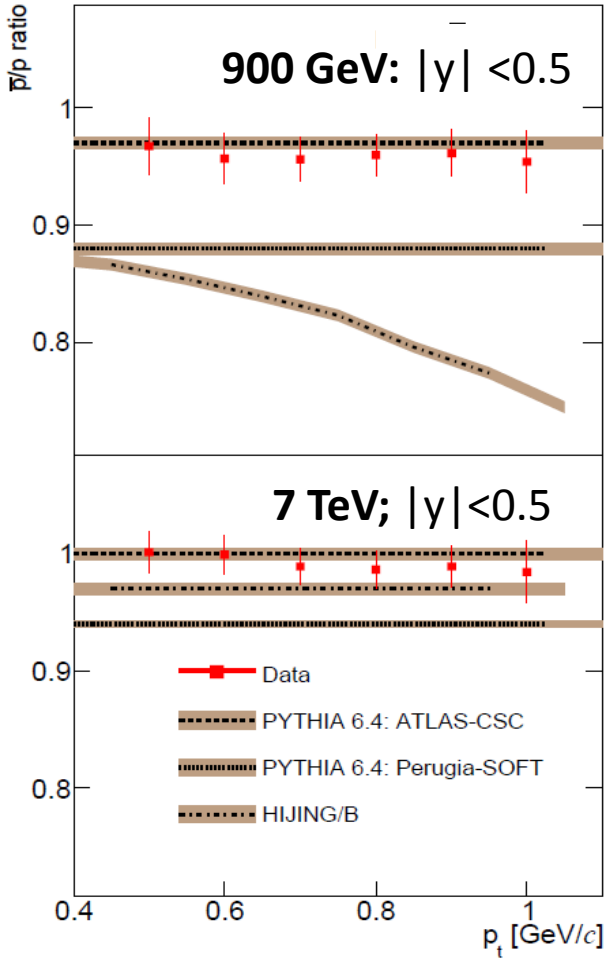


Material budget to better than 5%



Proton-antiproton ratio

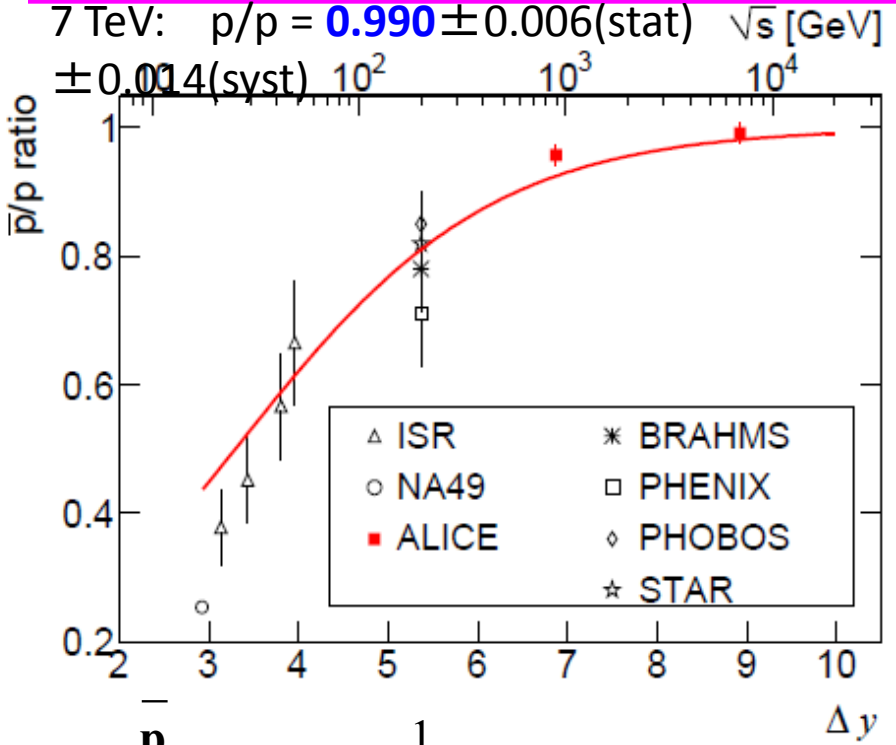
Related to probability to transport baryon number from η= 8.9 to 0



Phys Rev Lett Vol.105, No.7, (2010)

0.9 TeV: $\bar{p}/p$ = **0.957** ± 0.006(stat) ± 0.014(syst)

7 TeV: $\bar{p}/p$ = **0.990** ± 0.006(stat) ± 0.014(syst)



$$\frac{\bar{p}}{p} = \frac{1}{1 + C \times e^{(\alpha_{SJ} - \alpha_P)\Delta y}}$$

α_{SJ} = 0.5, and α_P = 1.2, C ~ 9 (Red curve)

– Most precise ratio measurements so far
– For the first time, compatible with no asymmetry, in central region

ALICE data summary

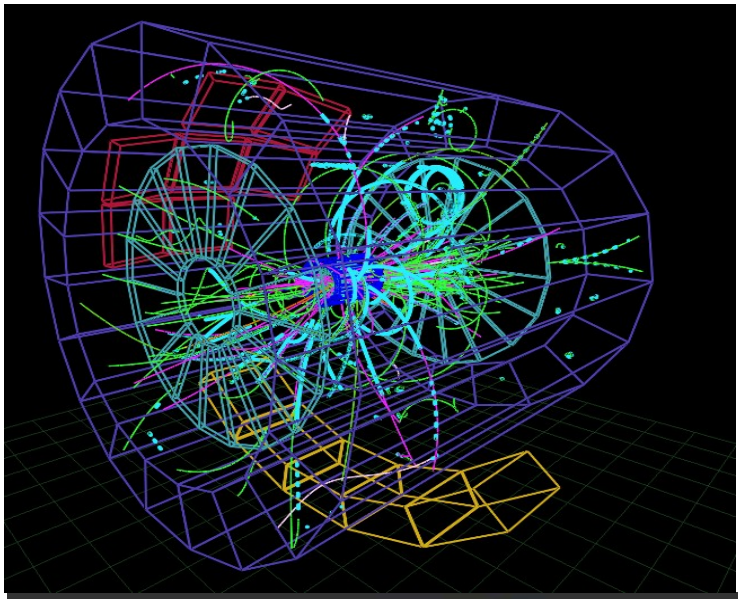
Beam	Energy (TeV)	Events	Status
pp	0.9	300 k	2009 / Analysis completed
pp	0.9	7.4 M	2010 / Partially analysed
pp	2.36	40 k	2009 / ITS only; $dN_{ch}/d\eta$
pp	7	800 M (MB) 100 M (muons) 20 M (High Mult.)	2010
PbPb*	**2.76/NN**	**30 M (MB)**	**2010 (9.5μb^{-1})**
pp	2.76	70 M (MB) 20 nb^{-1} (rare triggers)	2011

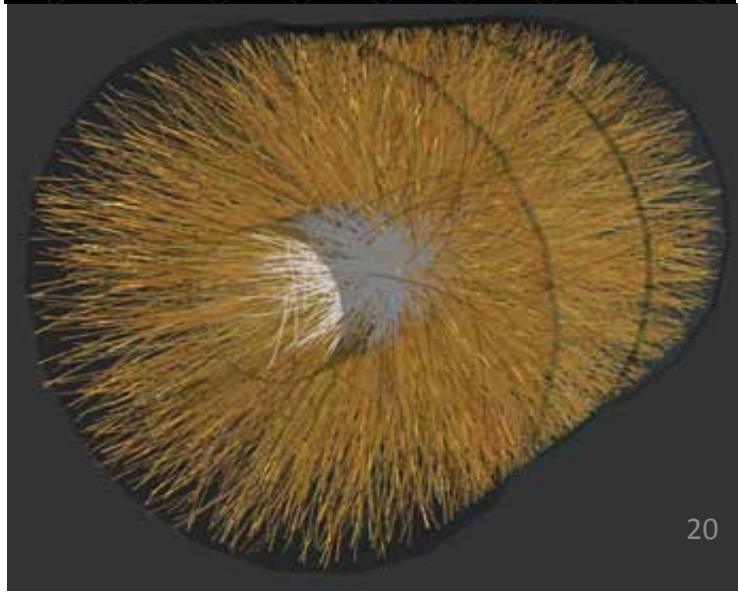
* First PbPb collisions November 7, 2010

Presently collecting pp data at 7 TeV

PP physics in ALICE

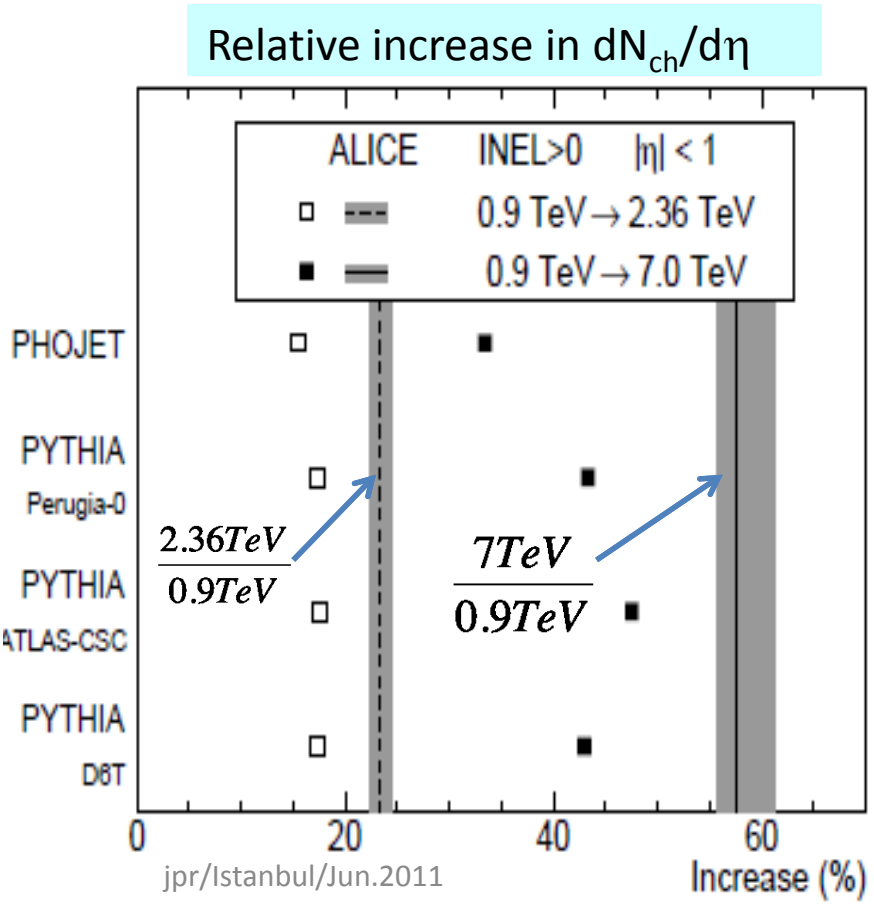
- **Comparison data** for heavy ion program
  - many signals measured ‘relative’ to pp
- Systematic **study of MB event properties at LHC:**
  - transition between perturbative and non-perturbative regimes of QCD
  - tuning of Monte Carlo generators
- **High multiplicity** pp events
  - $dN_{ch}/d\eta$ reaching energy density of HI collisions at RHIC

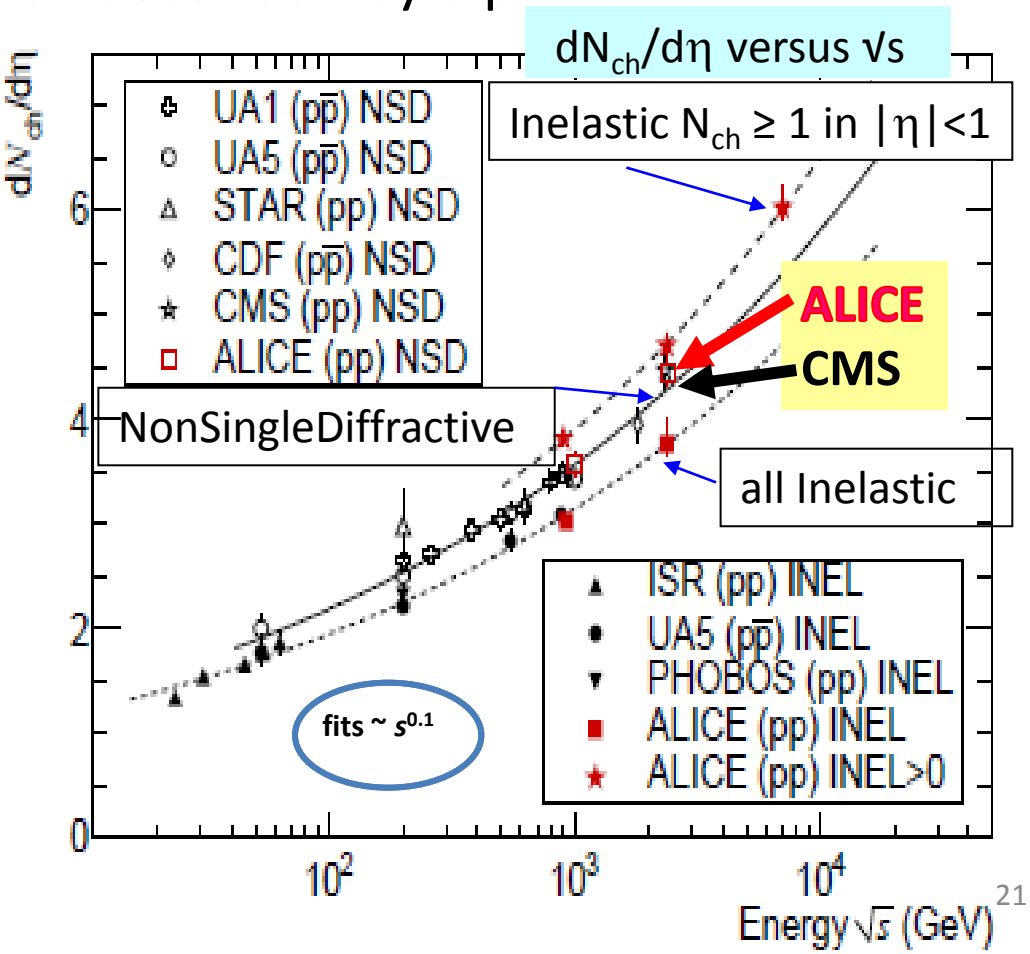




Charged particle production vs √s

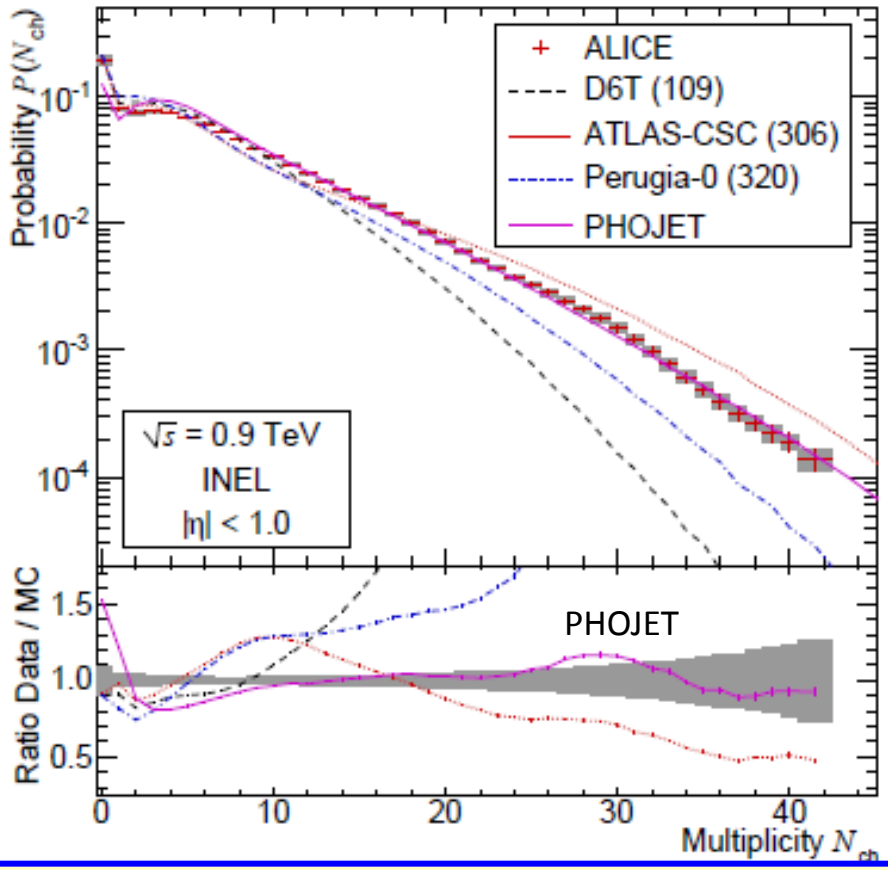
- Increase with energy significantly stronger in data than in MC's
- ALICE & CMS agree to within 1 σ (< 3%) [NSD at 2.36 TeV]
- $dN_{ch}/d\eta$ increase with √s well described by a power law



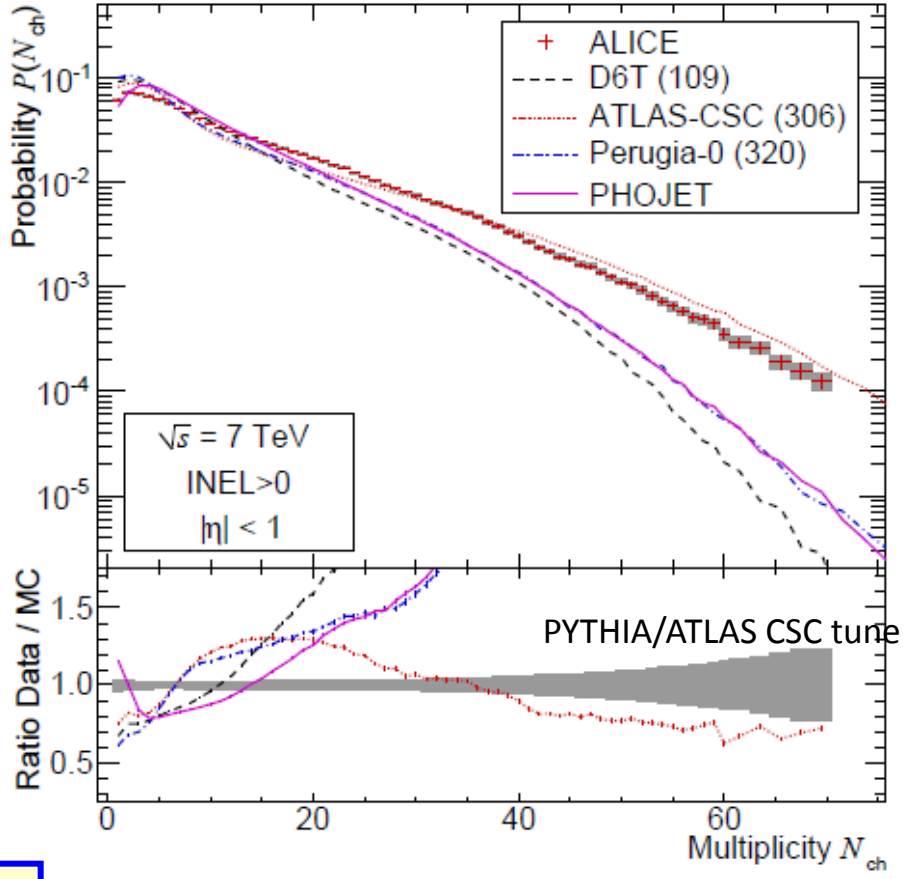


Multiplicity Distributions

Multiplicity Distribution 900 GeV



Multiplicity Distribution 7 TeV



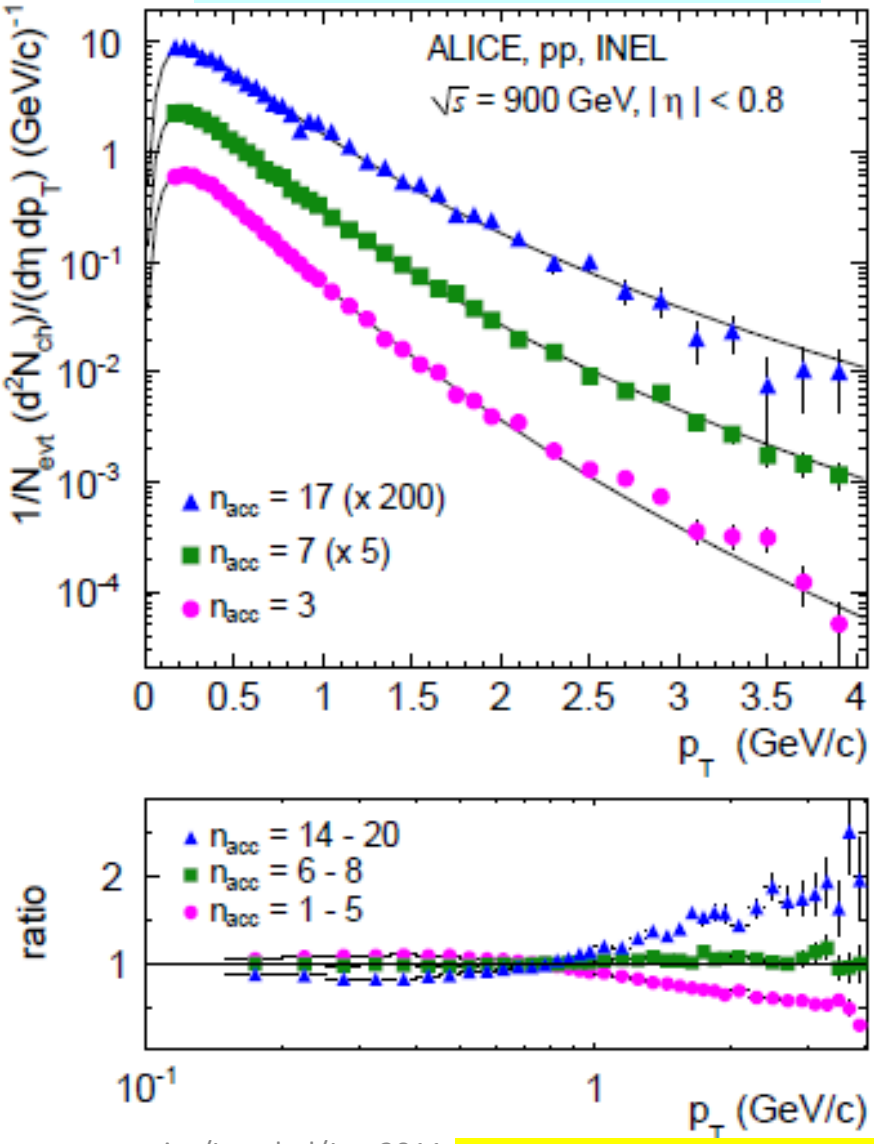
– no model describes correctly the data
– most of the 'stronger increase' is in the tail of N_{ch}

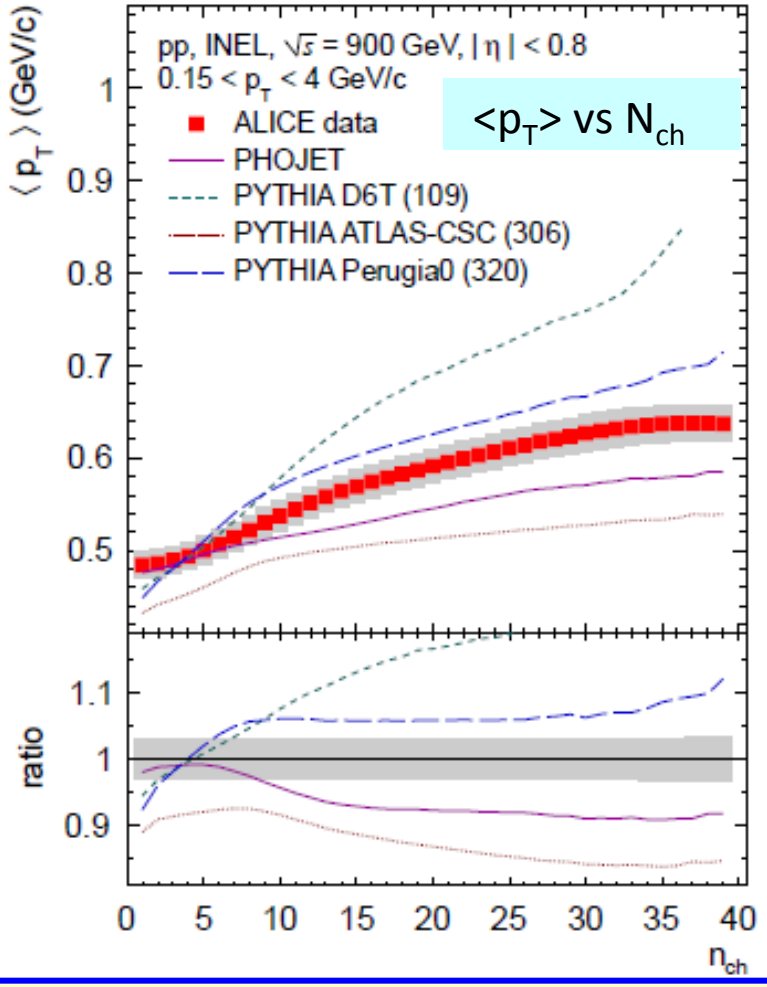
INEL>0 = at least one particle in |η| < 1)

For instance, PHOJET OK at 900 GeV not at 7 TeV, …
Presently extending measurements to high multiplicities

$\langle p_T \rangle$ versus Multiplicity

p_T for different Multiplicities

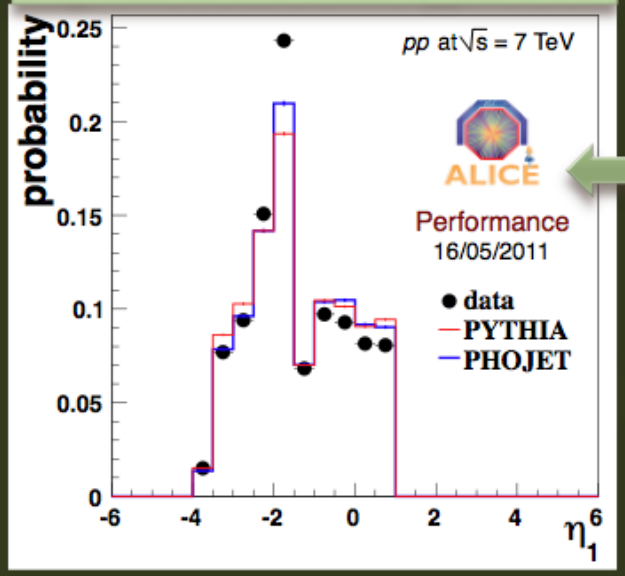


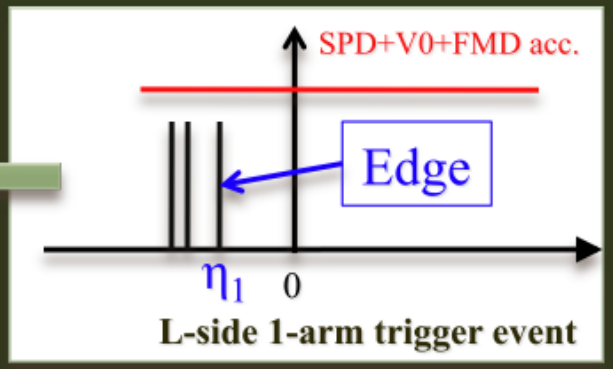


– Change concentrated at $p_T > 1$ GeV/c (pQCD)
(surprisingly little change below 1 GeV/c)
– MC's have hard time… again!

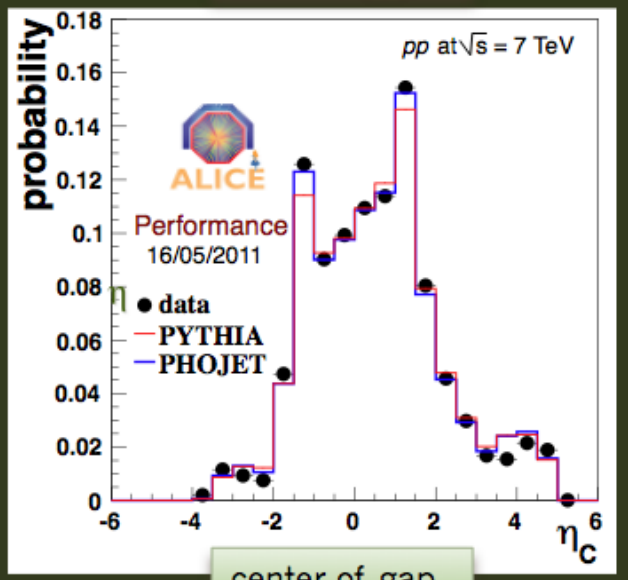
Study pioneered by UA1

edge of left-side 1-arm trigger event



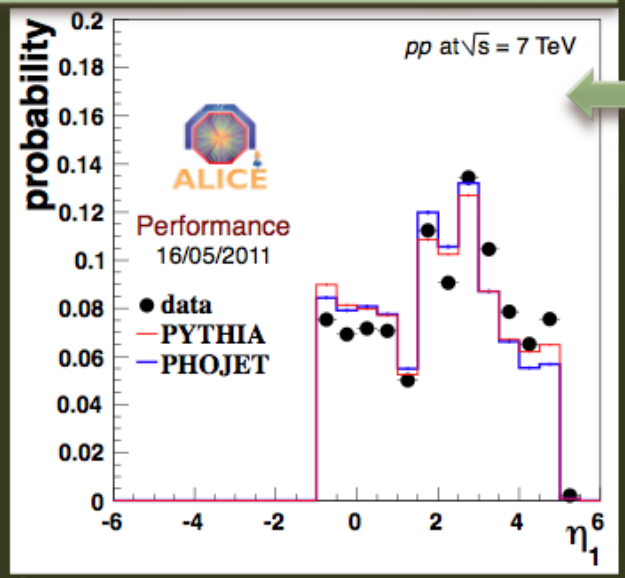


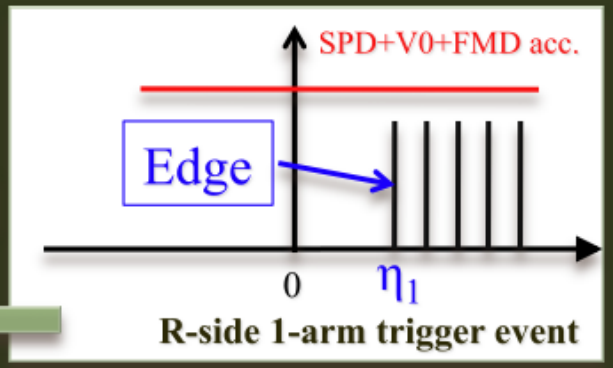
2-arm trigger

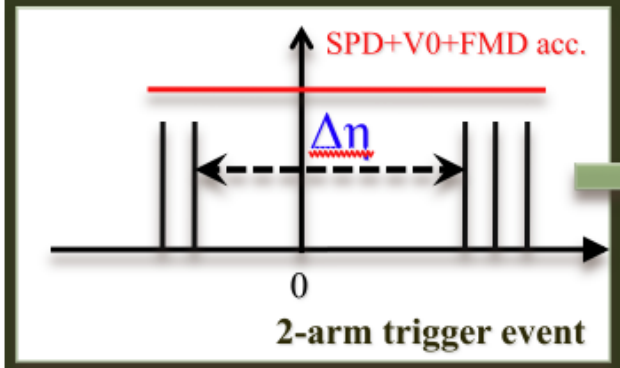


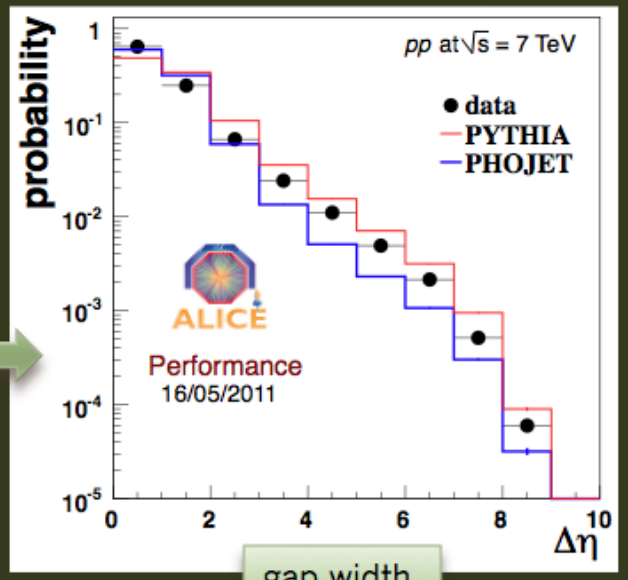
center of gap

edge of right-side 1-arm trigger event









gap width

SD and DD cross sections measurements important for normalization of inclusive measurements to INEL or NSD

PYTHIA and PHOJET tuned to measured ratios and to proper diffracted mass distributions

Diffractive cross sections

0.9 TeV

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = \mathbf{0.202} \quad \mathbf{\pm 0.034(syst.)}$$

$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.102 \quad \pm 0.019(syst.)$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.100 \quad \pm 0.015(syst.)$$

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.113 \pm 0.029$$

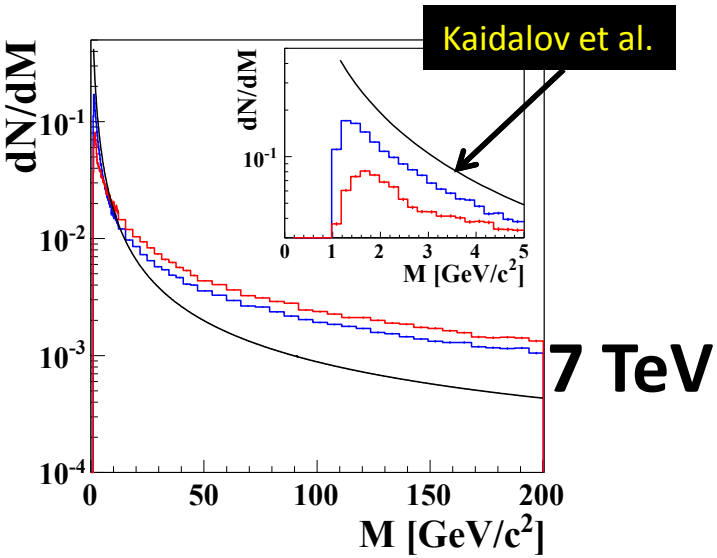
2.76 TeV

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = \mathbf{0.187} \quad \mathbf{\pm 0.054(syst.)}$$

$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.097 \quad \pm 0.026(syst.)$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.090 \quad \pm 0.028(syst.)$$

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.125 \pm 0.052$$



7 TeV

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = \mathbf{0.201} \quad \mathbf{\pm 0.039(syst.)}$$

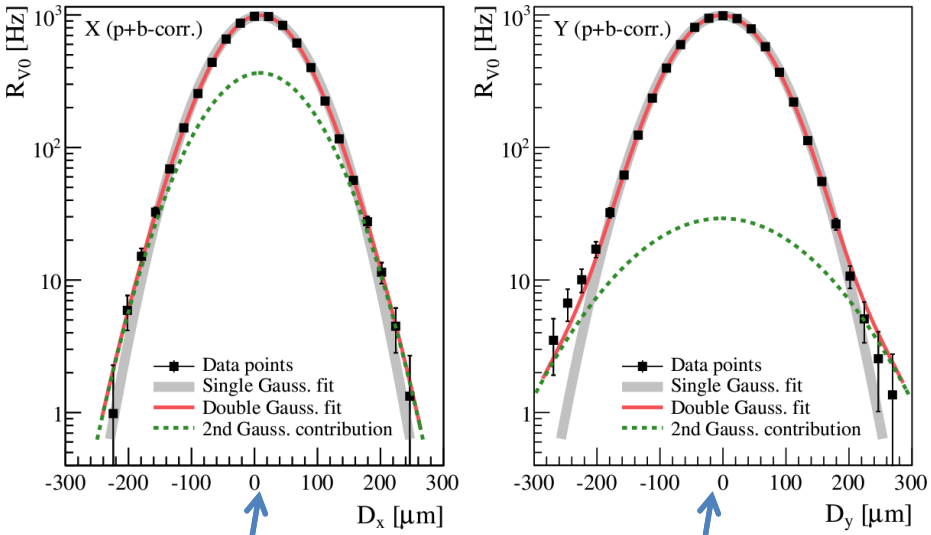
$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.101 \quad \pm 0.019(syst.)$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.100 \quad \pm 0.020(syst.)$$

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.122 \pm 0.036$$

Inelastic cross sections

- Van der Meer scans were used to measure beam areas

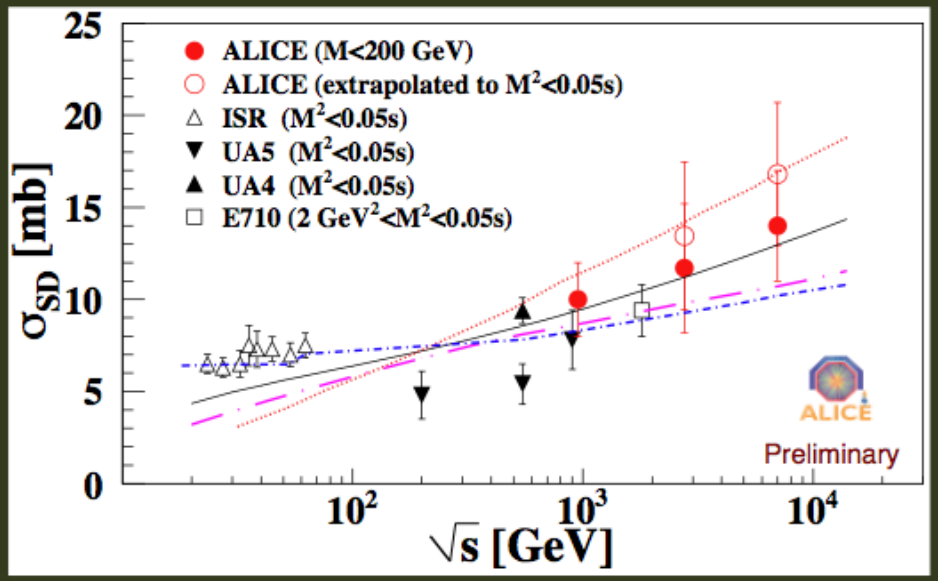


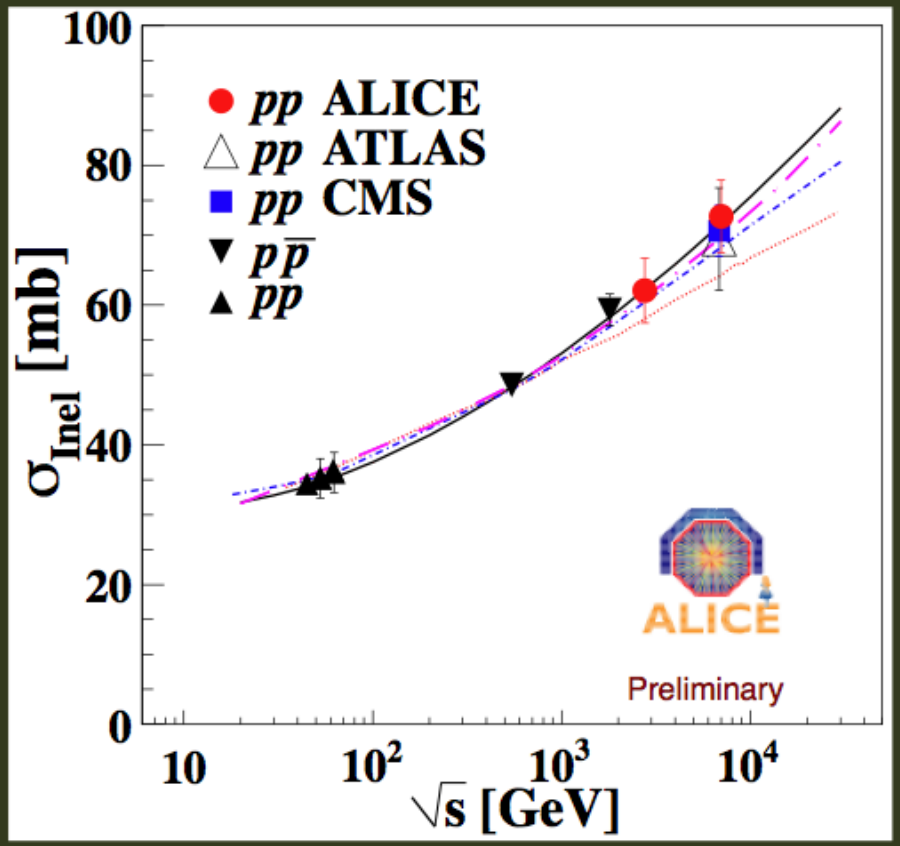
$$\mathbf{L} = \frac{\mathbf{f} \times \mathbf{k} \times \mathbf{N}_1 \times \mathbf{N}_2}{\sqrt{2\pi}\sqrt{\sigma_{1\mathbf{x}}^2 + \sigma_{2\mathbf{x}}^2} \times \sqrt{2\pi}\sqrt{\sigma_{1\mathbf{y}}^2 + \sigma_{2\mathbf{y}}^2}}$$

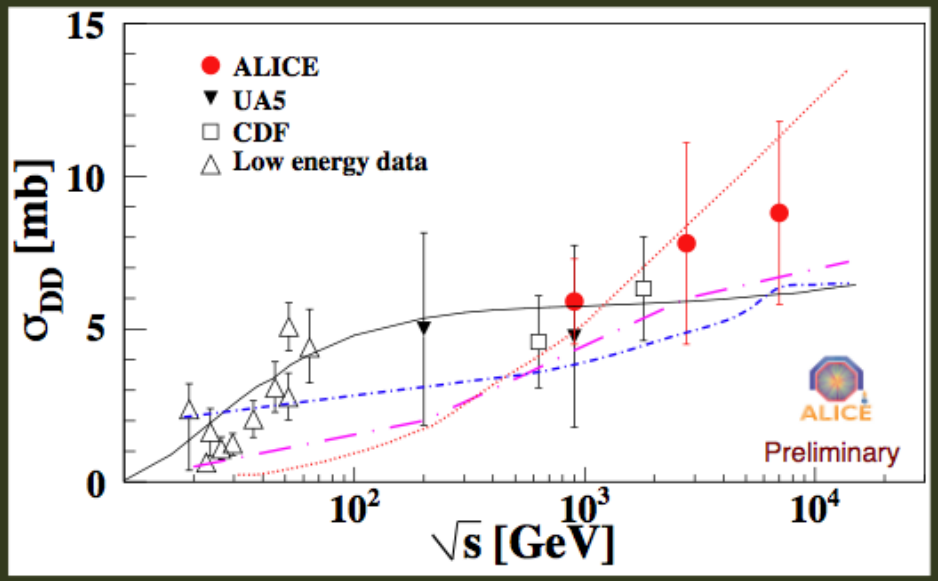
- Preliminary results:

$$\sigma_{INEL}\,(2.76\ TeV\ ) = 62.1 \pm 1.6(\mathbf{model}\ ) \pm 4.3(\mathbf{lumi}\ )\ mb$$

$$\sigma_{INEL}\,(7\ TeV\ ) = 72.7 \pm 1.1(\mathbf{model}\ ) \pm 5.1(\mathbf{lumi}\ )\ \mathrm{mb}$$

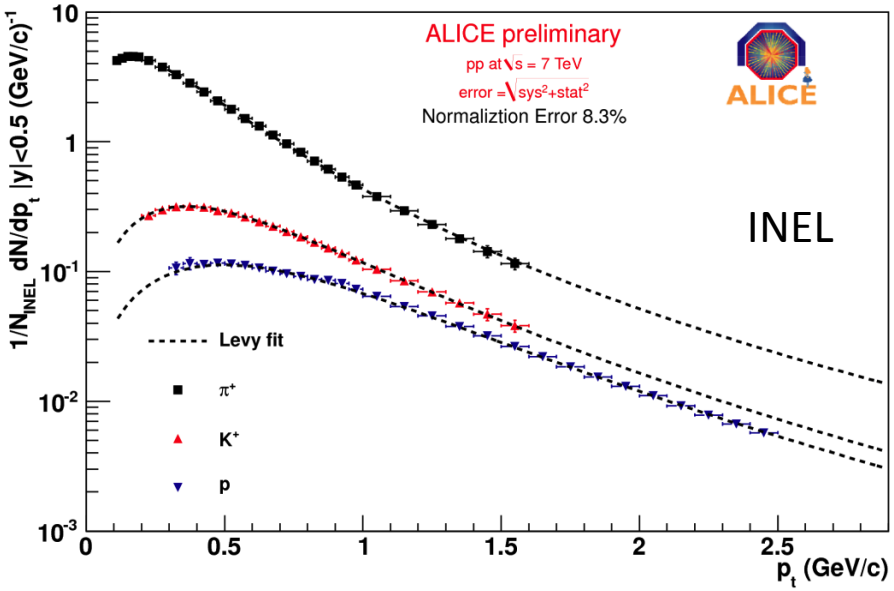


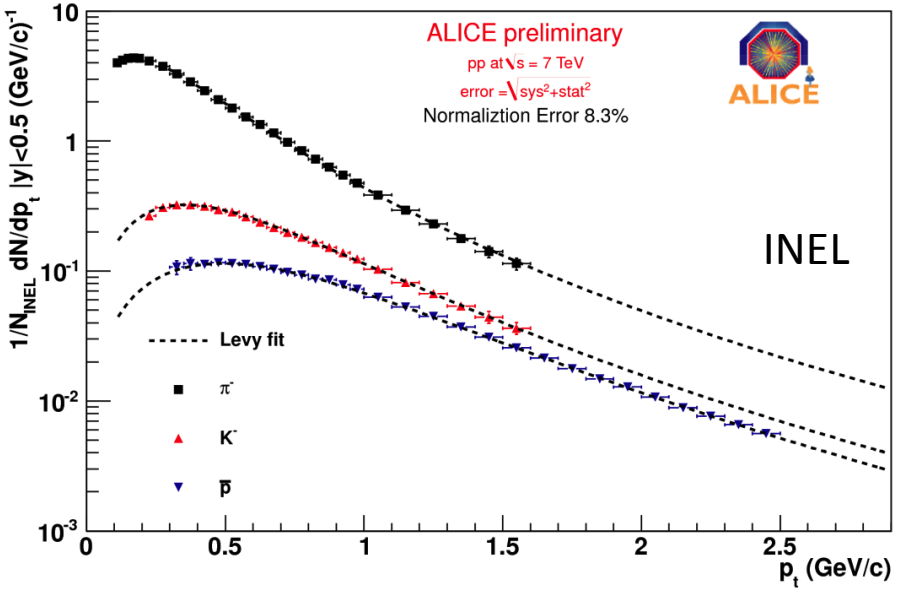




Gotsman et al., arXiv:1010.5323, EPJ. C74, 1553 (2011)
Kaidalov et al., arXiv:0909.5156, EPJ. C67, 397 (2010)
Ostapchenko, arXiv:1010.1869, PR D83 114018 (2011)
Khoze et al., EPJ. C60 249 (2009), C71 1617 (2011)

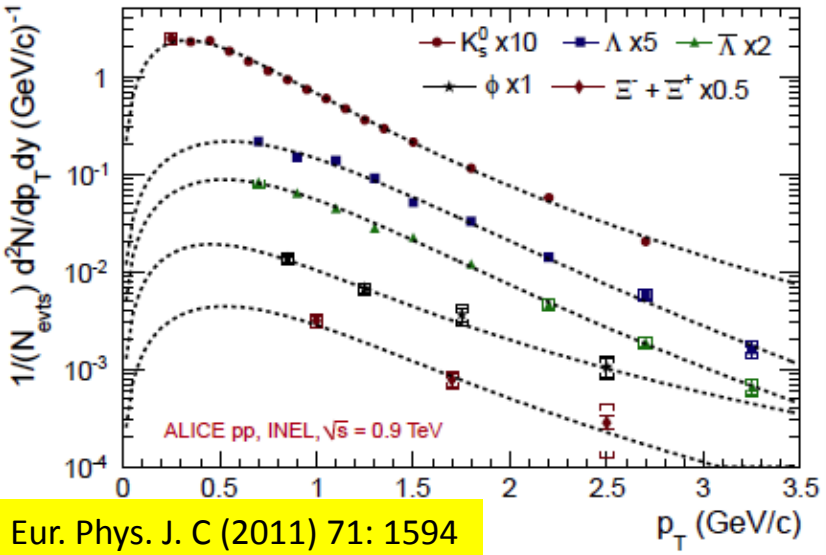
Model predictions:
SD ➔ $M^2 < 0.05s$
DD ➔ $\Delta\eta > 3$

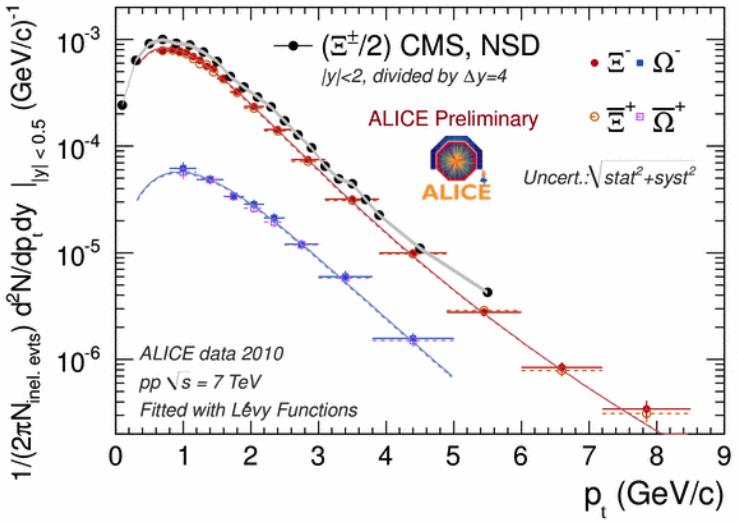




- All spectra fitted by Lévy (Tsalis) function to extrapolation to $p_T = 0$ (10%–20 %). and extract dN/dy.

$$\frac{d^2N}{dydp_T} = \frac{(n-1)(n-2)}{nT[nT+m(n-2)]} \times \frac{dN}{dy} \times p_T \times \left(1 + \frac{m_T - m}{nT}\right)^{-n}$$





Total data yield, dN/dy, extrapolation: ~22% for $\Xi^{\pm}$ ~26% for $\Omega^{\pm}$.

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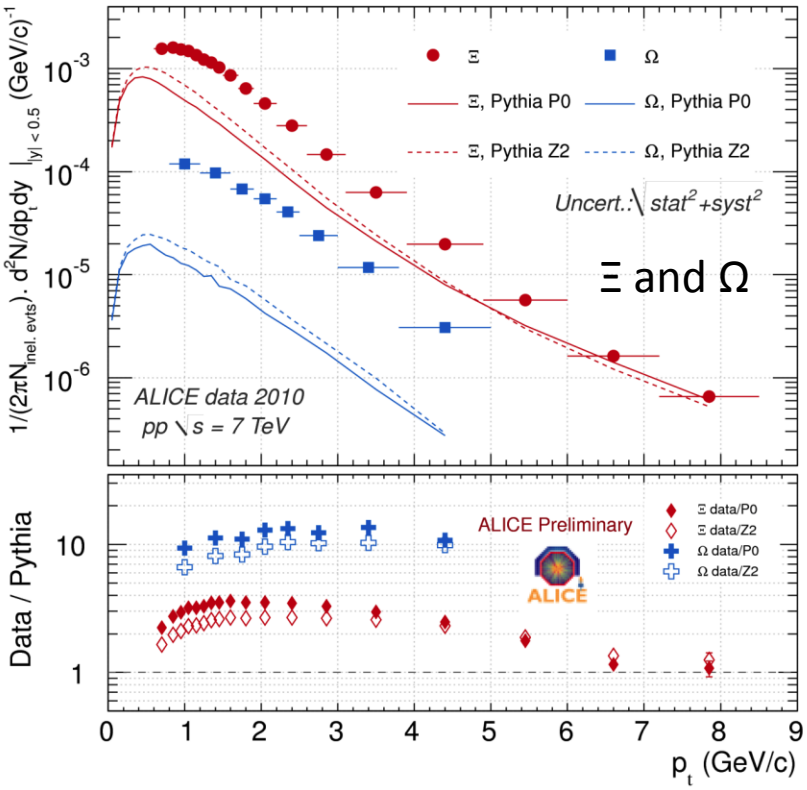
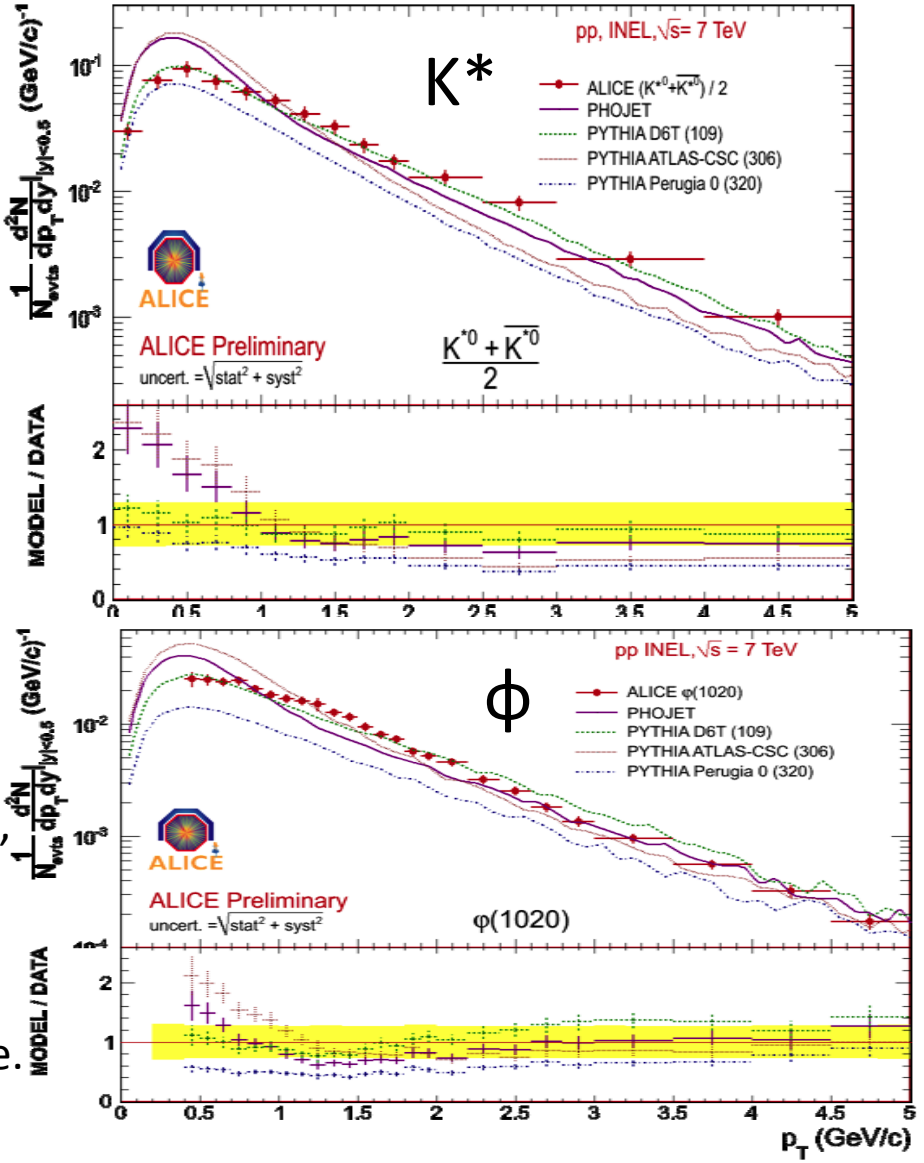
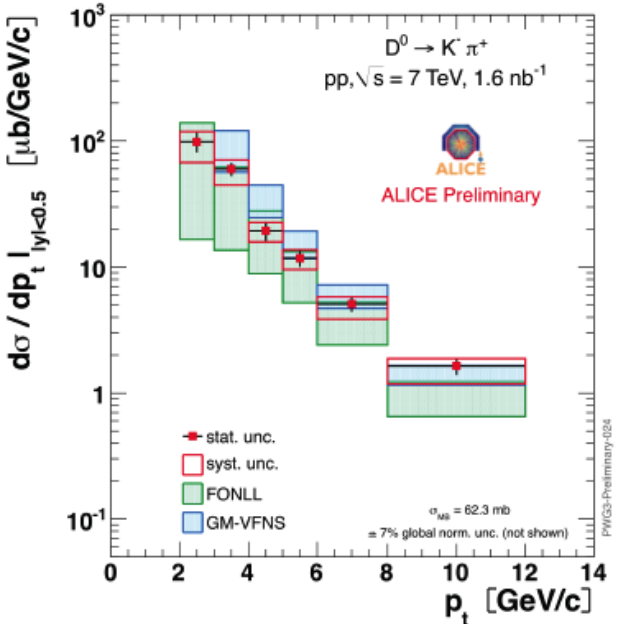
Monte Carlo tuning

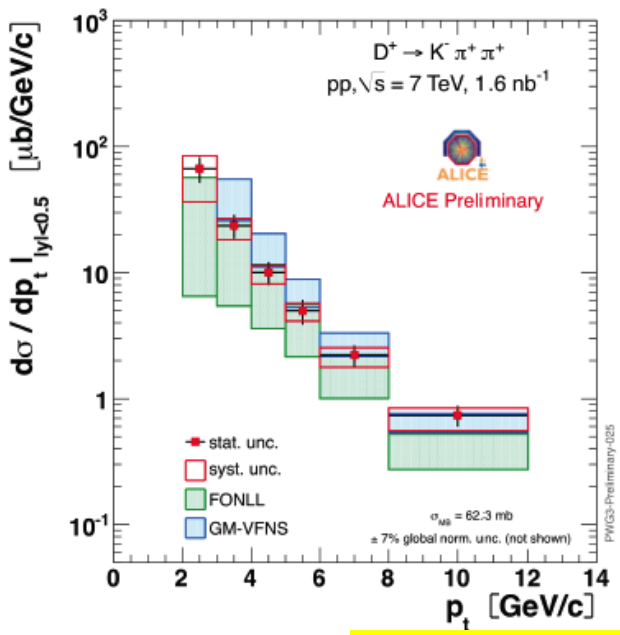


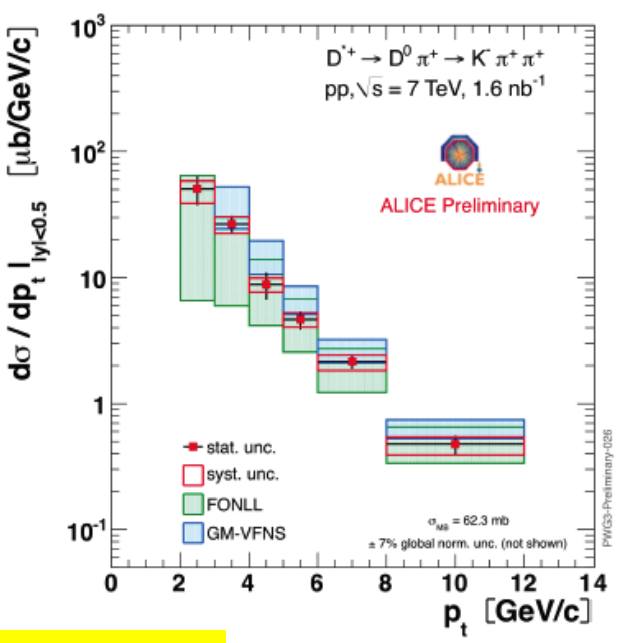


Combining information from all LHC experiments, will make pp collisions at LHC the best known collisions in high energy physics, and will bring an improved understanding of the strong interaction, down to the non-perturbative regime.

Charmed mesons





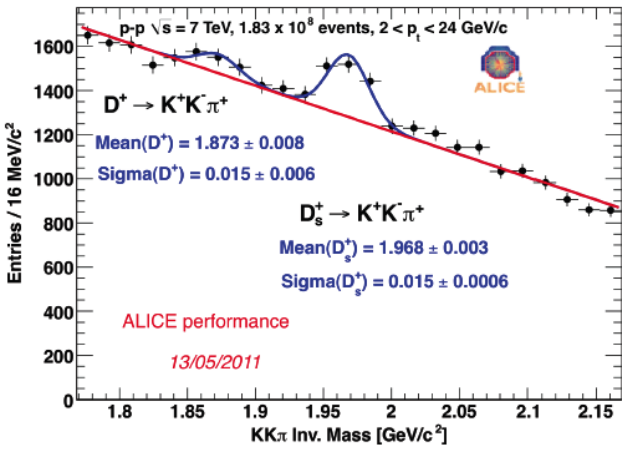


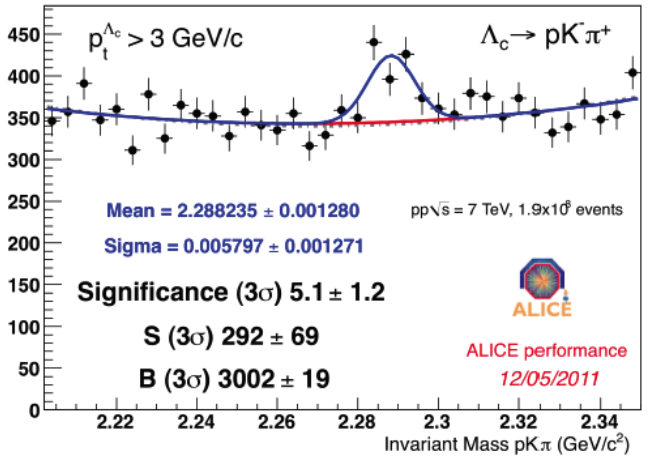
– D^0, $D^{\pm}$ p_T range: $2 < p_T < 12$ GeV/c, with 1.6 nb^{-1} (~20% of 2010 statistics – low p_T end statistics limited)

– y acceptance is p_T-dependent ($\Delta y \approx 1.0$ to 1.6): data scaled to $|y|<0.5$

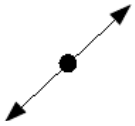
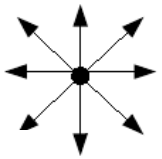
– pQCD predictions [FONLL (Cacciari et al.) and GM-VFNS(Kniehl et al.,)] compatible with data

First glance at D_s and Λ_C





Event shape analysis

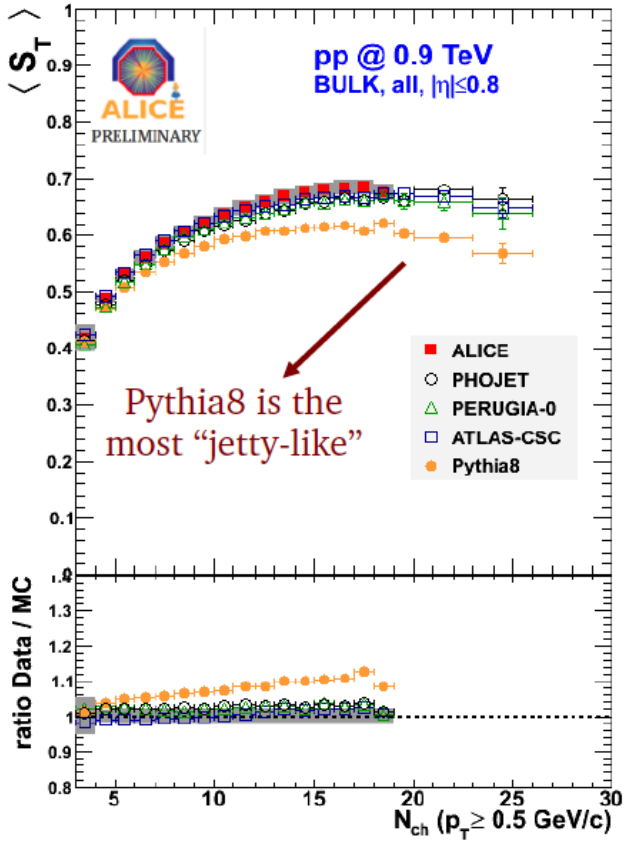
small $S_\perp$:  large $S_\perp$: 

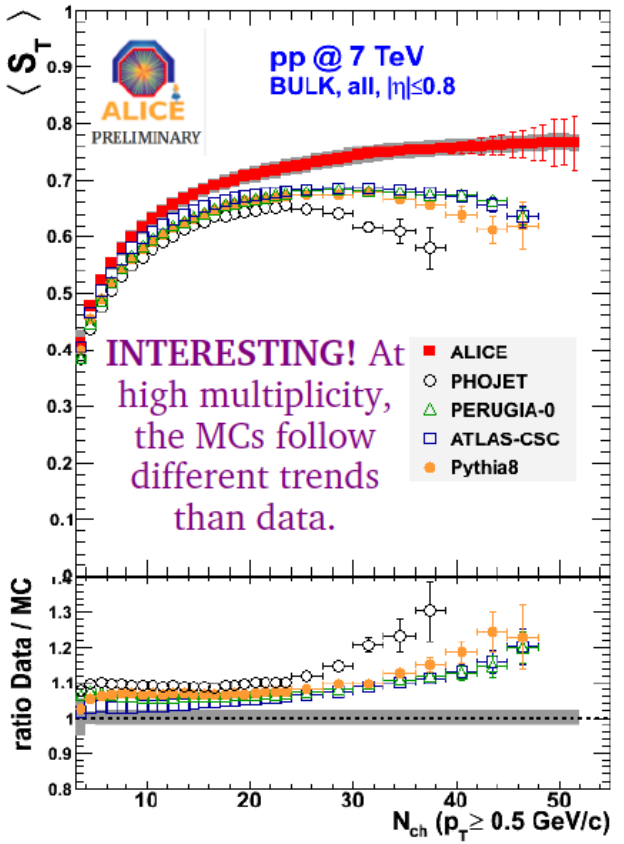
Transverse sphericity $S_\perp$, defined as a function of eigenvalues of the momentum tensor S_{xy}

$$\mathbf{S_{xy}} = \sum_i \begin{pmatrix} p_x^{(i)2} & p_x^{(i)} p_y^{(i)} \\ p_x^{(i)} p_y^{(i)} & p_y^{(i)2} \end{pmatrix}$$

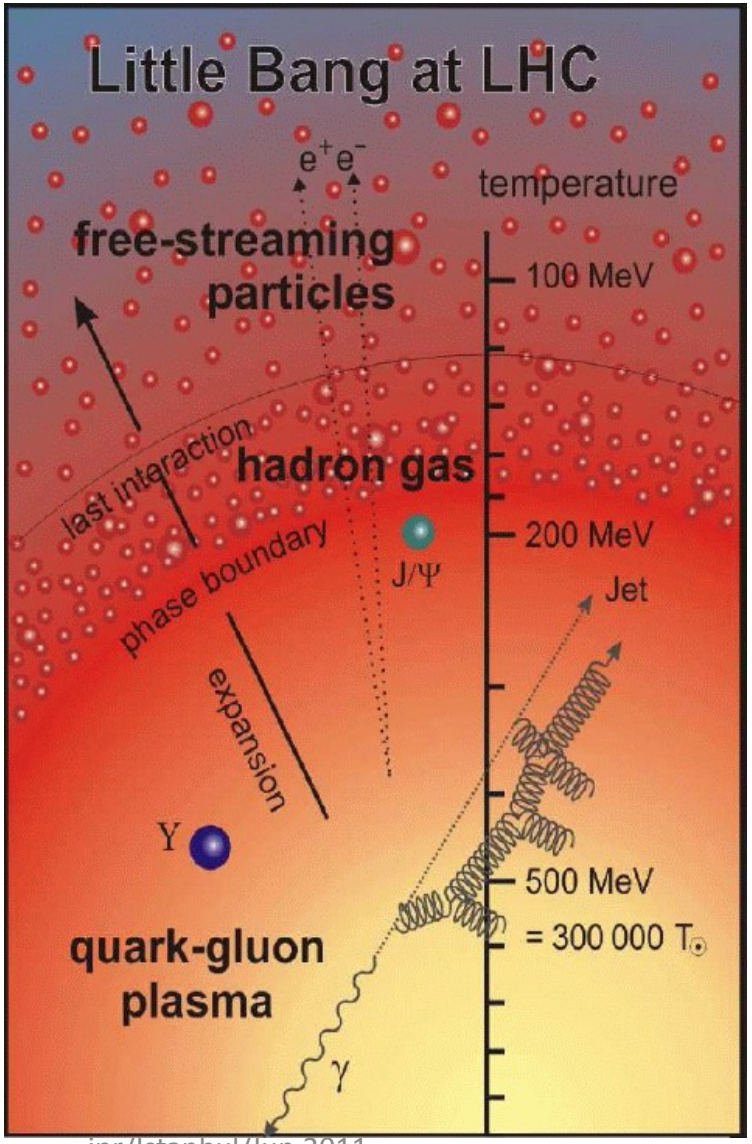
$$S_\perp \equiv \frac{2\lambda_2}{\lambda_2 + \lambda_1}$$

HM events more spherical than models
To be pursued with HM triggers





Heavy Ion collisions



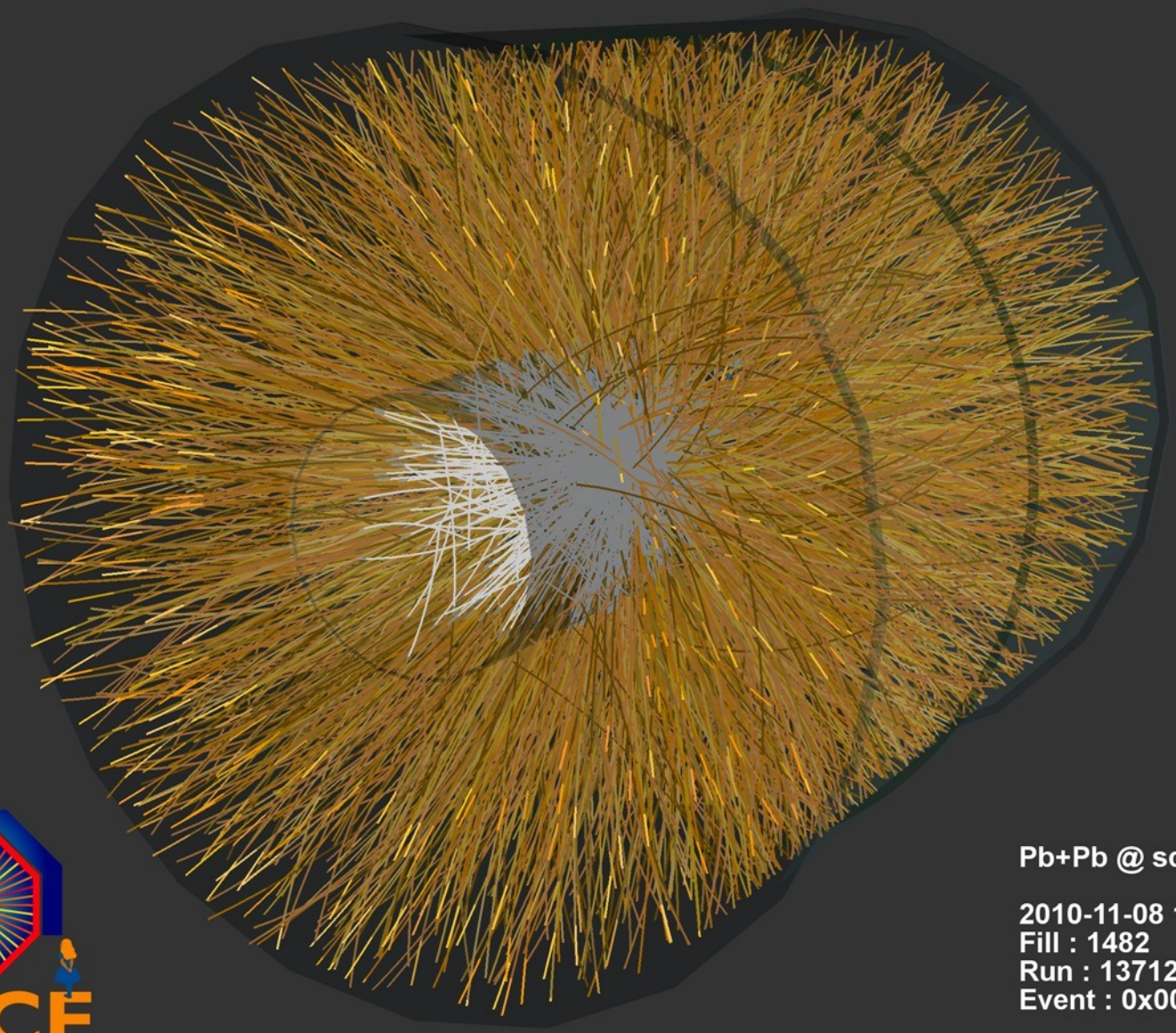
soft

hard probes

Main purpose of ALICE Complex system

- **global properties:**
  multiplicities, rapidity distributions
- **geometry of the emitting source:**
  Bose-Einstein interferometry, impact parameter via zero-degree energy flow
- **early state collective effects:**
  elliptic flow
- **chiral symmetry restoration:**
  neutral to charged ratios, resonance decays
- **fluctuation phenomena - critical behavior:**
  event-by-event particle composition and spectra
- **degrees of freedom as a function of T:**
  hadron ratios and spectra, dilepton continuum, direct photons
- **deconfinement:**
  charmonium and bottonium spectroscopy
- **energy loss of partons in QGP:**
  jet quenching, high p_t spectra, open charm and open beauty

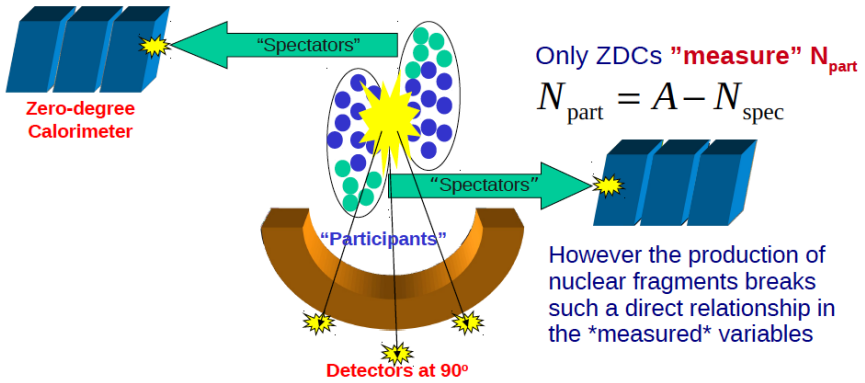
A challenging environment!

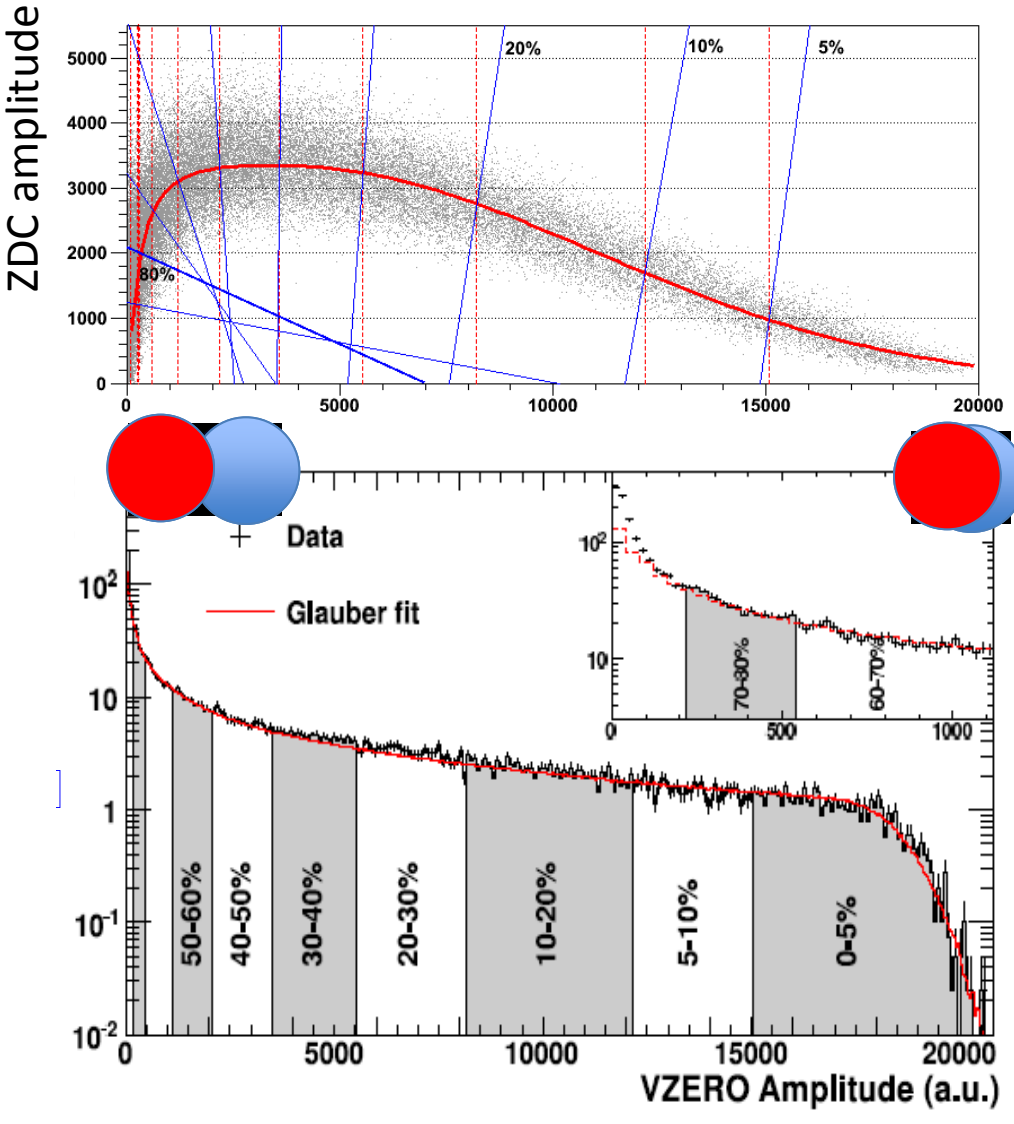


ALICE

Centrality selection

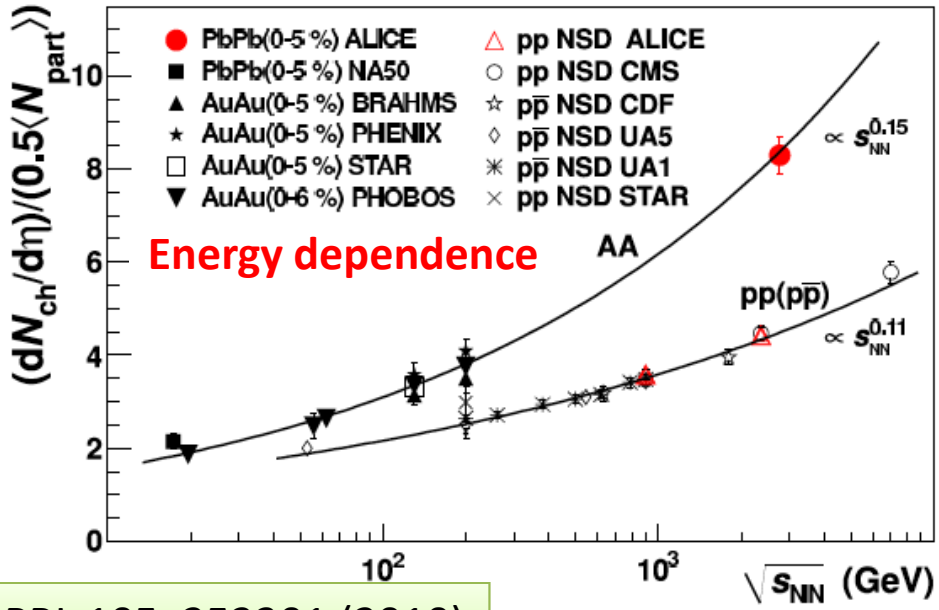
- In PbPb collisions events can be classified as a function of the collisions impact parameter
- Glauber models needed to define centrality classes to avoids effects of electromagnetically induced reactions overwhelming at low multiplicity (factor 10)



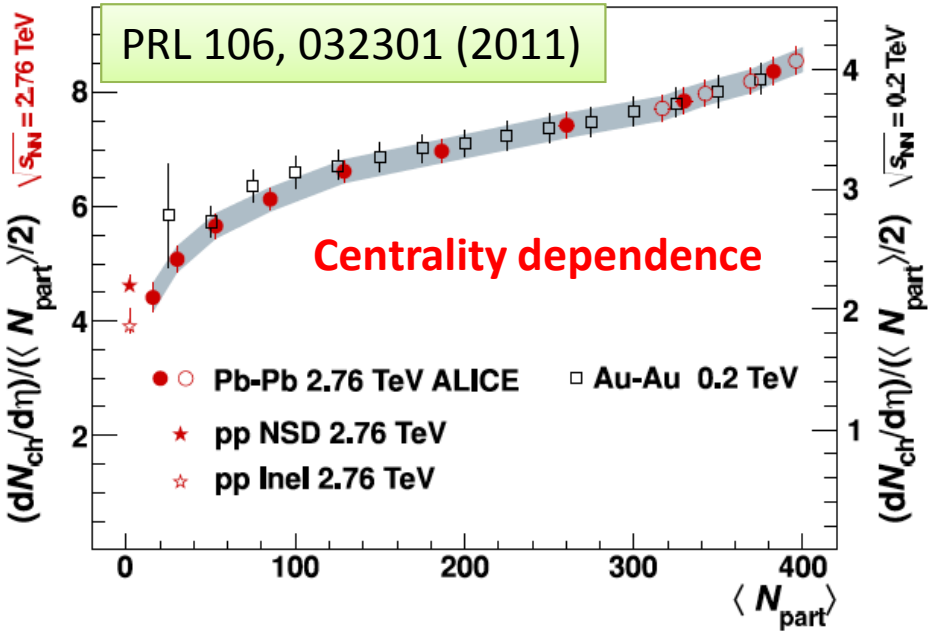


Particle production in PbPb

$dN/d\eta|_{\eta=0}$ = 1584 ± 4(stat.) ± 76 (syst.) for most central 5% fraction



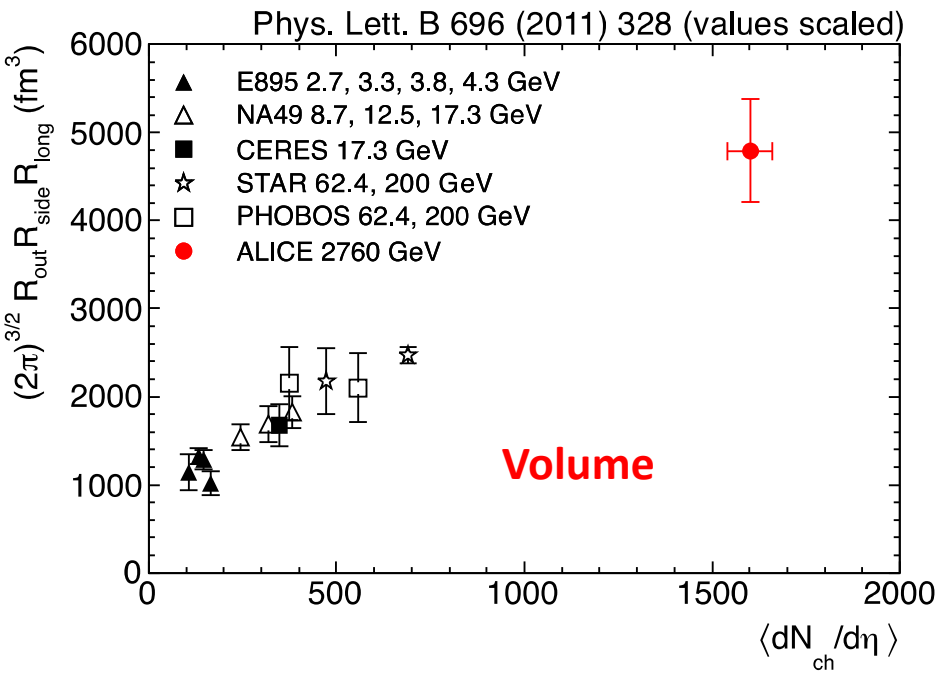
PRL 105, 252301 (2010)

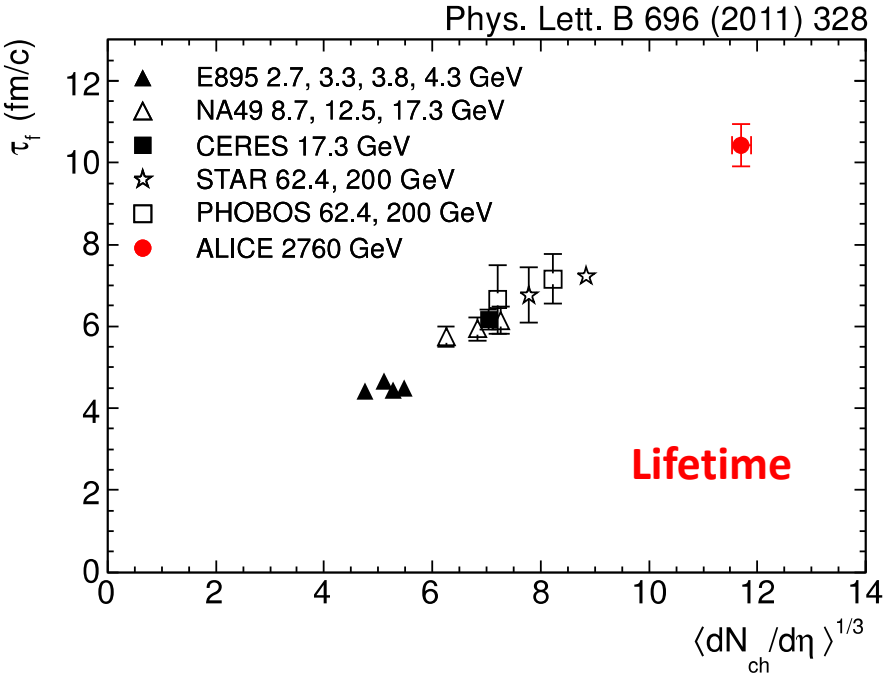


Charged-particle multiplicity density per participant of most central PbPb collisions increases faster than in pp NSD events (**volume effect? medium effect?**)

Charged-particle multiplicity density per participant has similar dependence on N_{part} at $\sqrt{s_{NN}}$ = 0.2 TeV and 2.76 TeV

Size of particle emitting source

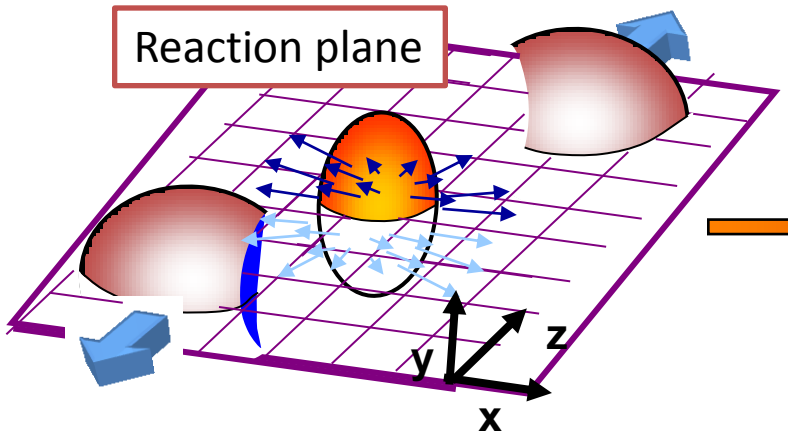




Derived from 3D-Bose-Einstein-Interferometry of identical bosons (ππ)

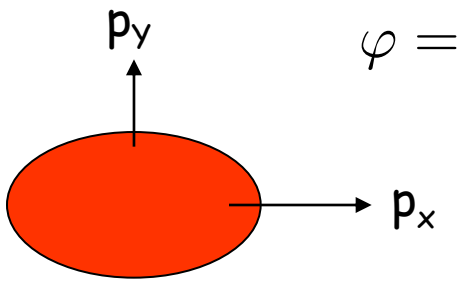
- **Energy dependence:**
  - **– system twice the volume and 30% longer lived w.r.t RHIC (decoupling time: 10 fm/c)**
  - **– follows the trend of multiplicity**
- **Important constraints on [hydrodynamical] modelling**

Hydrodynamic properties of the medium: Azimuthal Anisotropy – Elliptical Flow



$$\varepsilon = \frac{\langle y^2 \rangle - \langle x^2 \rangle}{\langle y^2 \rangle + \langle x^2 \rangle}$$

Initial spatial anisotropy for non-central collisions



$$\varphi = \arctan \frac{p_y}{px}$$

$$v_2 = \frac{\langle p_x^2 \rangle - \langle p_y^2 \rangle}{\langle p_x^2 \rangle + \langle p_y^2 \rangle}$$

Final momentum anisotropy

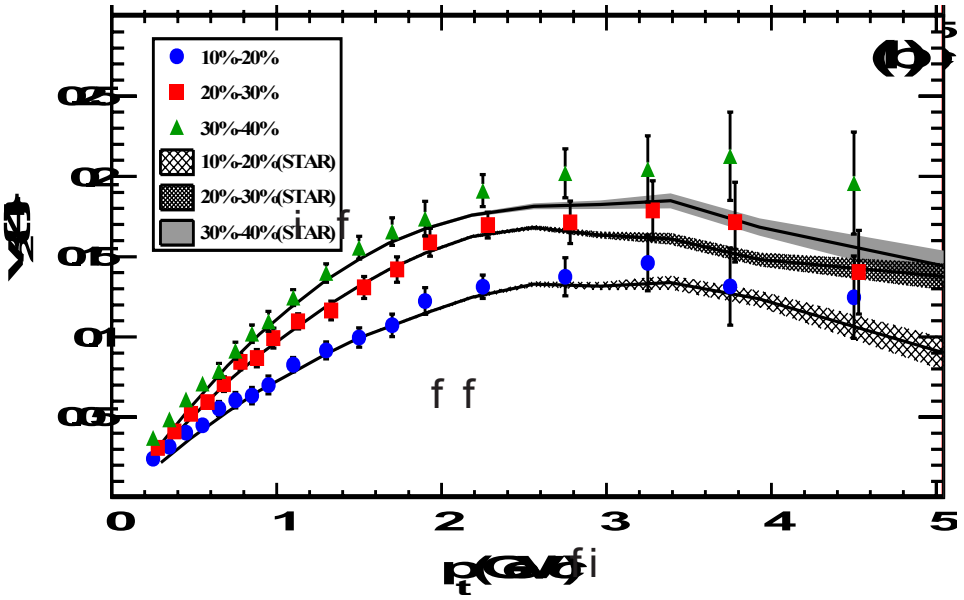
Reaction plane defined by "soft" (low p_T) particles

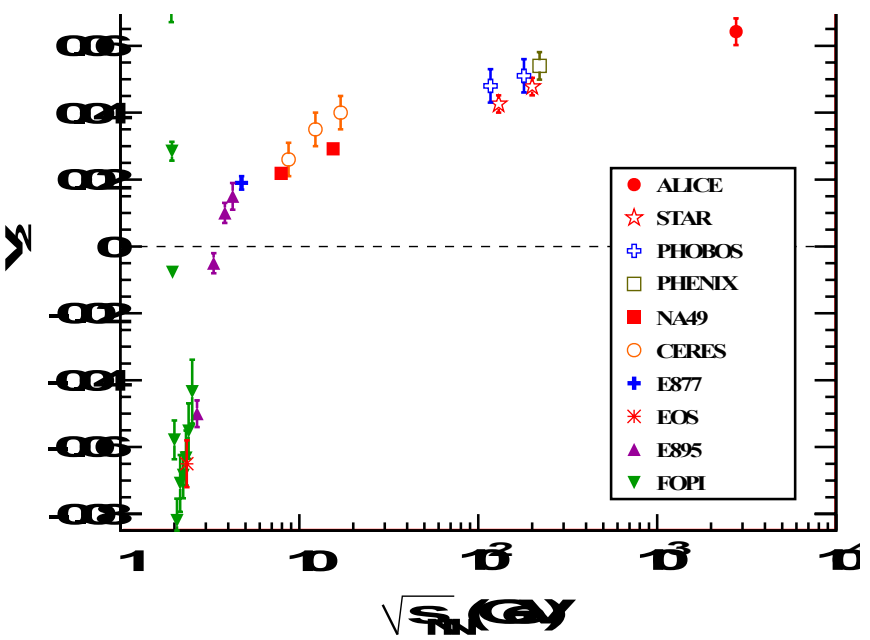
$$\Delta\varphi = \varphi - \varphi^{Reaction\ Plane}$$

Elliptical flow $$\frac{dN}{d\Delta\varphi} \propto 1 + 2v_2 \cos(2\Delta\varphi)$$

Elliptic flow parameter v_2

PRL 105, 252302 (2010)





- Collective behavior observed in Pb-Pb collisions at LHC ($1.3 \times v_2^{RHIC}$) **–> ideal fluid behavior**
- **Testing hydrodynamical evolution of the system**
- **Goal: precision measurement for viscosity/entropy** (η/s) **ratio current RHIC limit:** $\eta/s < (2\text{-}5) \times (1/4\pi)$

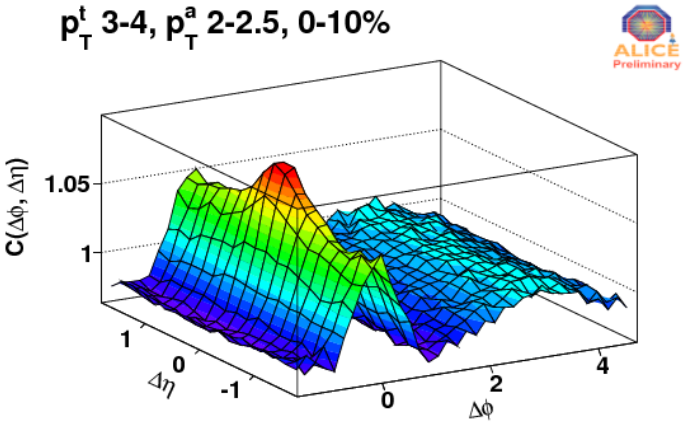
One of the main highlights at Quark Matter 2011

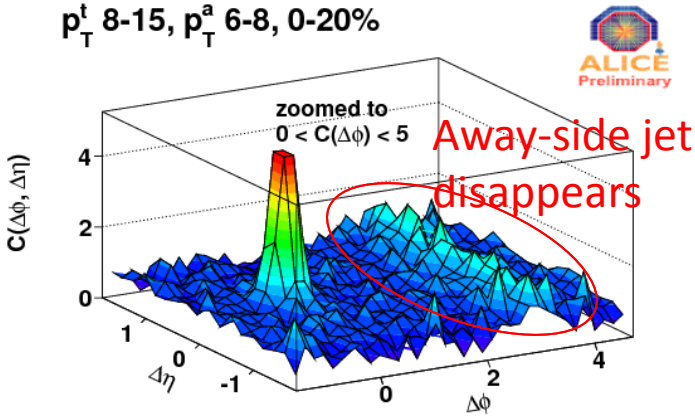
Triggered Azimuthal Correlations

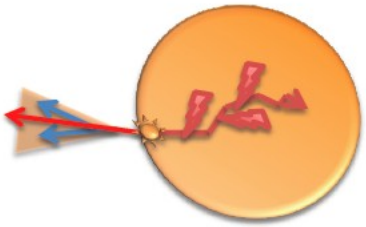
- Triggered correlations: choose a particle from one p_T region ("trigger particle") and correlate with particles from another p_T region ("associated particles") where $p_{T,assoc} < p_{T,trig}$ in bins of $p_{T,trig}$ and $p_{T,assoc}$

- Lower p_T
  - Assess the bulk of the correlations
  - Dominated by hydrodynamics and flow
  - Ridge

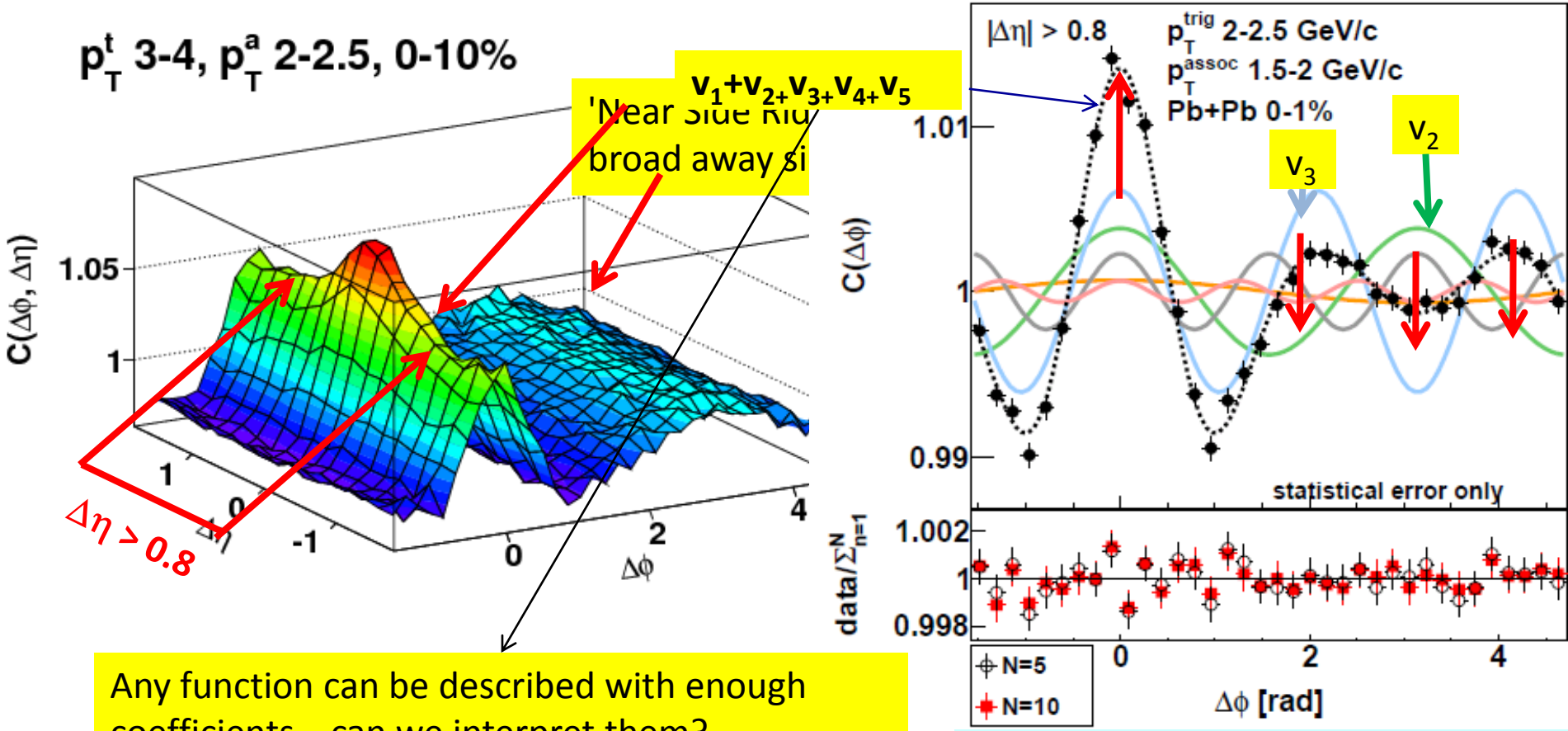
- Higher p_T
  - Dominated by jets
  - Quenching/suppression, broadening







Triggered Azimuthal Correlations



Any function can be described with enough coefficients… can we interpret them?

Projection on $\Delta\phi$ for $\Delta\eta > 0.8$

Clean double Hump (Mach Cone?) appears for ultra-central – intriguing but yet to be explained (without any flow subtraction !)

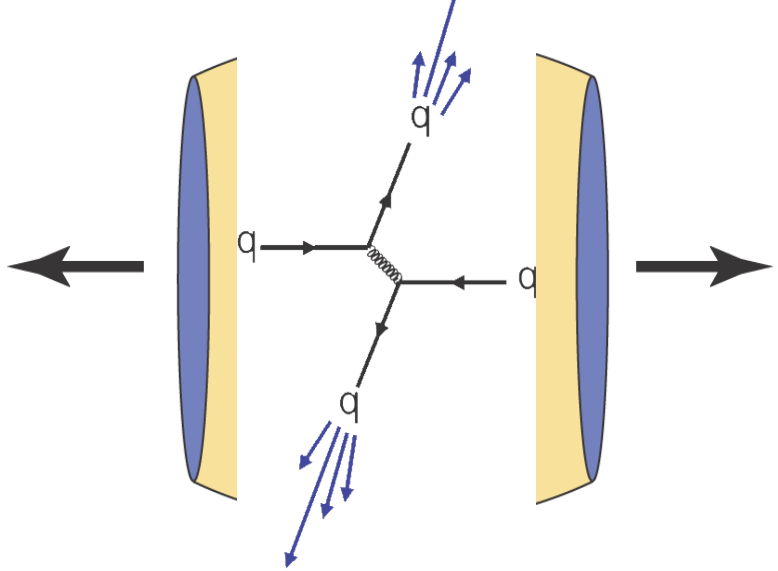
Full correlation structure described by Fourier Coefficients v_1,**v_2**, **v_3**, v_4,v_5 **(for $|\eta|>0.8$)**

v3 very visible, indeed, v3 ≈ v2 for very central

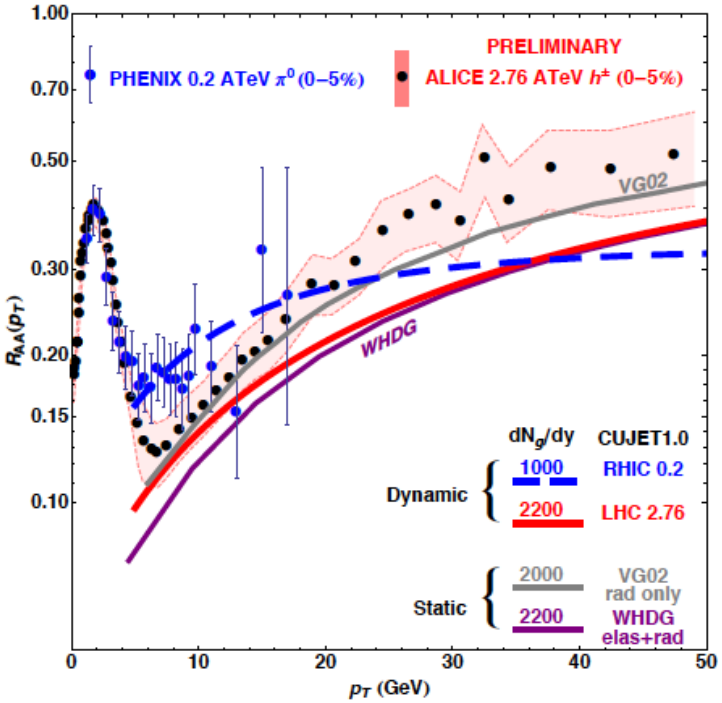
'Mach Cone' & 'Near Side Ridge' shapes evolve smoothly with the magnitude of v_2 and v_3

Charged Particle R_{AA}

$$R_{AA}(p_T) = \frac{(1/N_{evt}^{AA})\, d^2N_{ch}^{AA}/d\eta dp_T}{\langle N_{coll}\rangle\,(1/N_{evt}^{pp})\, d^2N_{ch}^{pp}/d\eta dp_T}$$



Hard scattered partons probe medium properties



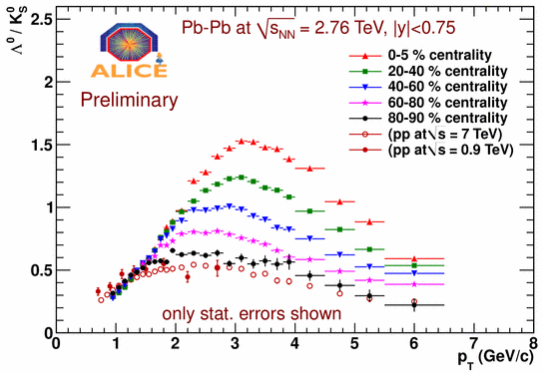
Dynamically enhanced jet quenching at RHIC (blue dashed) and LHC (red solid) (Miklos Gyulassy, LBL); Previous LHC predictions from IV02(grey) and WHDG (purple) based on static Debye screened jet medium interaction.

R_{AA}: spectacular medium induced modification:

– change of slope beyond p_T>30-40 GeV

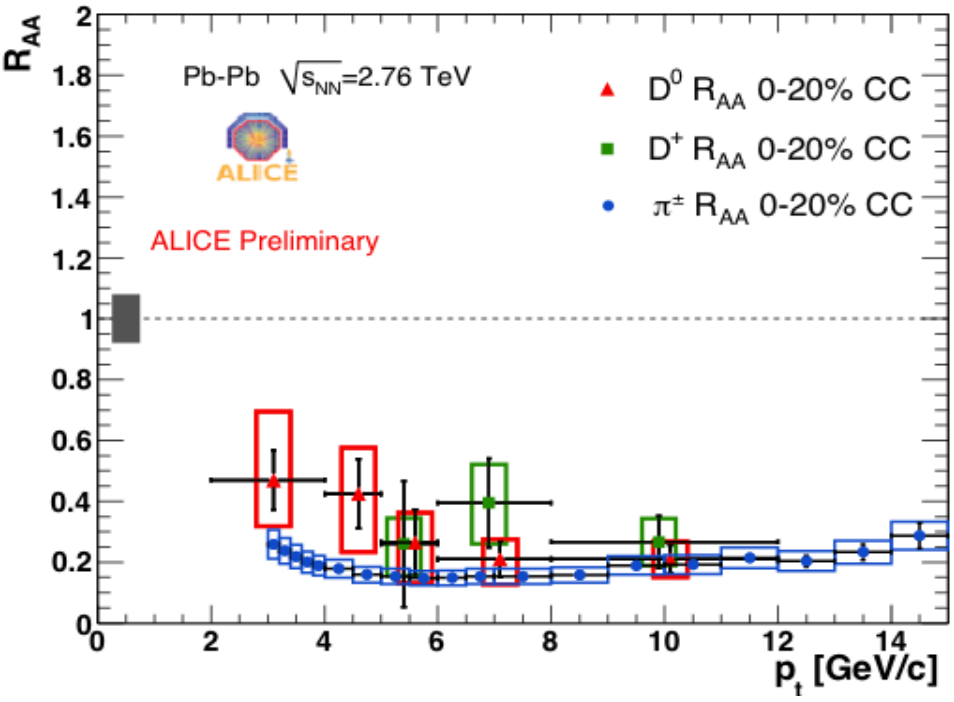
– decreasing dependence on centrality and on p_T with increasing p_T

– similar behavior as at RHIC, minimum R_{AA} lower than at RHIC



ALI-PREL-884

Heavy Quark R_{AA}: D-Mesons



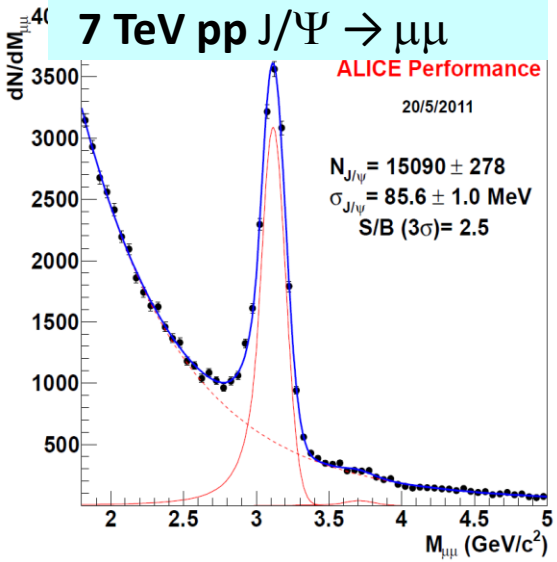
R_{AA} <u>prompt</u> charm ≈ R_{AA} <u>pions</u>
for p_T > 5-6 GeV
R_{AA} charm > R_{AA} π for p_T < 5 GeV ?

Qualitative expectation:
R_{AA} Charm > R_{AA} pion
– ΔE gluon > ΔE quark (**Casimir factor**)
– ΔE massless parton > ΔE massive quark
('dead cone')

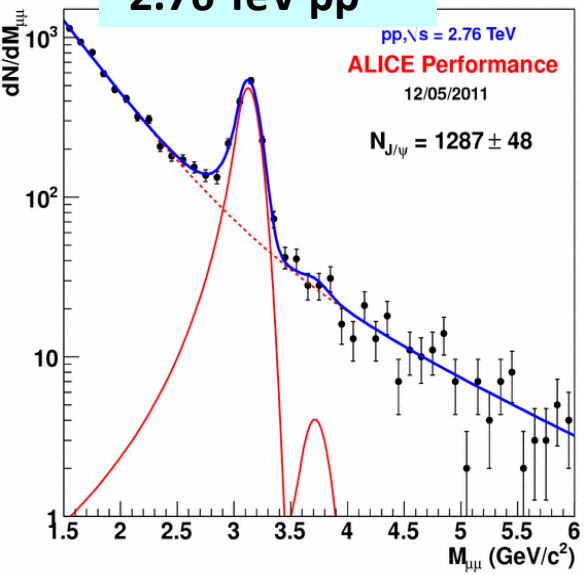
Interesting issue!

J/Ψ Suppression: Ingredients

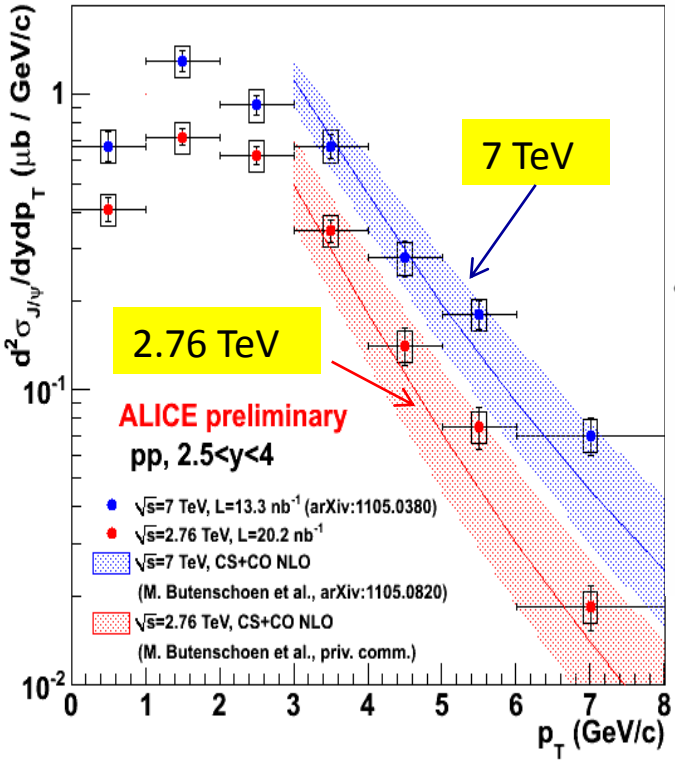
7 TeV pp J/Ψ → μμ



2.76 TeV pp



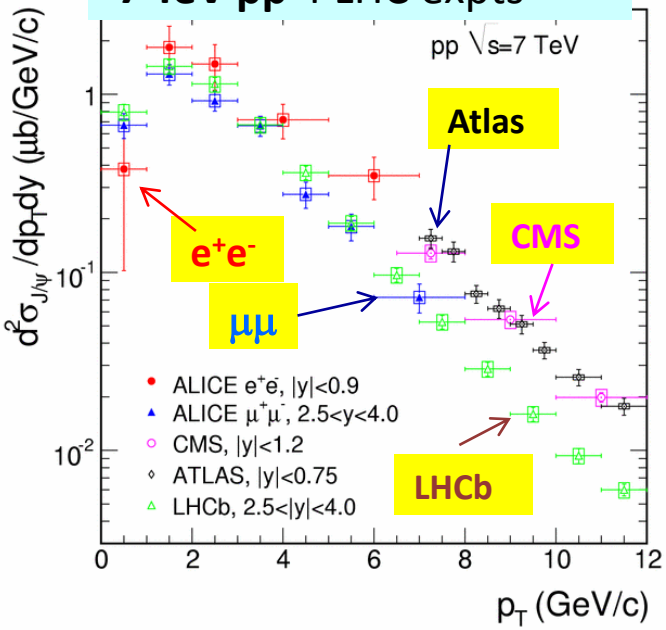
pp J/Ψ Cross Section



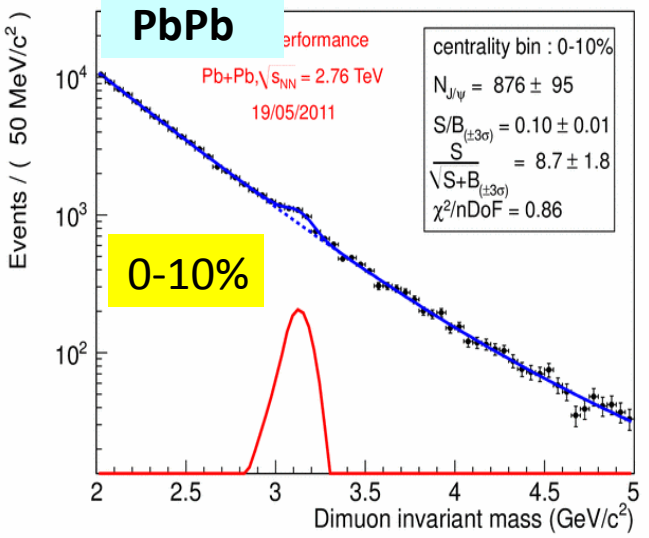
J/Ψ cross section dσ/dydp$_T$
7 TeV & 2.76 TeV
agreement with pQCD

ALICE≈ATLAS≈CMS≈LHCB
(in region of overlap)

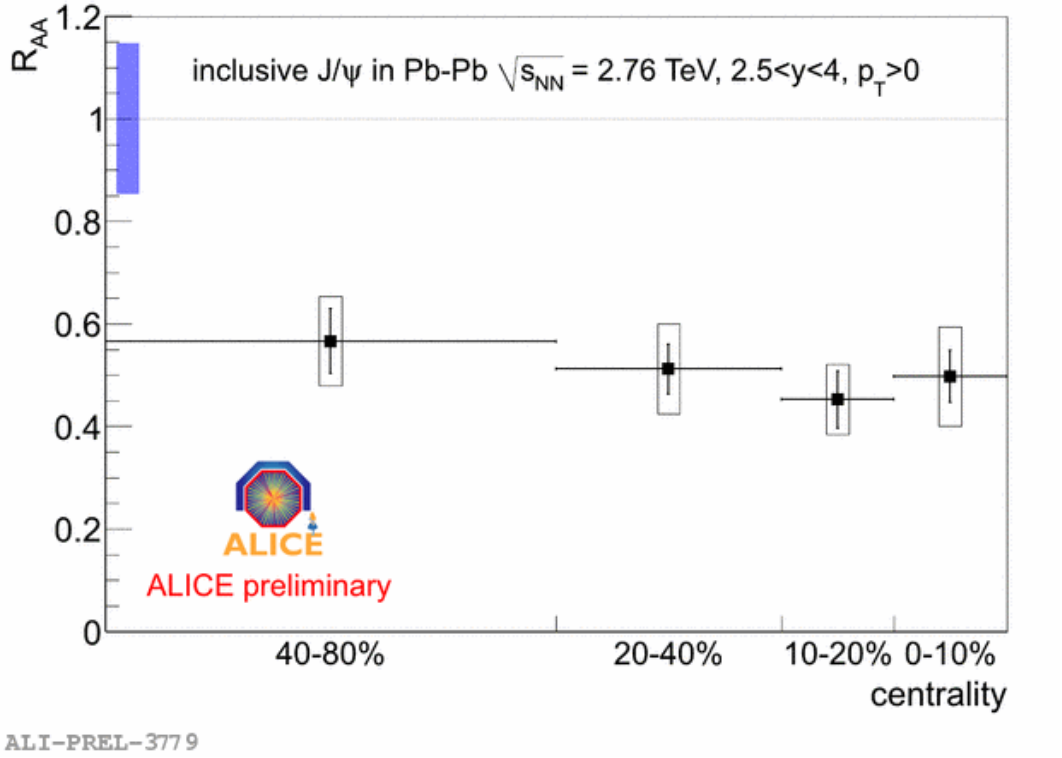
7 TeV pp 4 LHC expts



PbPb



J/Ψ R_{AA}



- **Relatively small suppression for inclusive J/ψ production**
- **little centrality dependence**

Another interesting issue! 25 years after the article of H. Satz and Matsui!

Inclusive J/ψ $R_{AA}^{0\text{-}80\%}$ = 0.49 ± 0.03 (stat.) ± 0.08 (sys.)

Future plans

- 2011
  - Large pp MB sample at √s = 7 TeV (pp physics + reference data for PbPb)
  - Pb-Pb collisions at √s = 2.76 TeV, at higher luminosity (~10^{26} $cm^{-2}s^{-1}$)
  - Feasibility test for p-Pb running
- 2012
  - Either p-Pb/Pb-p or further Pb-Pb running
- 2013/14
  - Shutdown
- pp, p-Pb and PbPb at new energy (pp: √s = 14 TeV; PbPb: √s = 5.5TeV)
  - Shutdown
- d-Pb and lighter ions

Conclusion

- The ALICE Detector is performing according to specifications
- Many signs that pp collisions are not yet well understood (All current MC generators need tuning):
  - Global event properties (Multiplicity, p_T spectra, sphericity, etc.)
  - √s dependence of multiplicity
  - Identified particle production
- pp reference data are well measured (√s = 2.76 TeV)
- The first PbPb collisions brought a wealth of results:
  - Fireball at LHC larger and longer-lived compared to RHIC
  - Confirmed very low viscosity of QGP (next step is determination of shear viscosity η/s)
  - Strong leading hadron suppression found out to very large p_T
  - Charm quark energy loss similar to that of light partons

ALICE publications in pp collisions

- **Mostly on large cross-section phenomena:**
  - **Multiplicity density and distributions of charged particles**
    - 900 GeV: EPJC: Vol. 65 (2010) 111
    - 900 GeV, 2.36 TeV: EPJC: Vol. 68 (2010) 89
    - 7 TeV: EPJC: Vol. 68 (2010) 345
  - ratio (900 GeV & 7 TeV) PRL: Vol. 105 (2010) 072002
  - **Momentum** distributions (900 GeV) PL B: Vol. 693 (2010) 53
  - Bose-Einstein **correlations** (900 GeV) PRD: Vol. 82 (2010) 052001
  - Strangeness production (900 GeV) EPJC: Vol. 71, (2011) 1594
- Identified charged particle spectra (900 GeV)
  - http://arxiv.org/abs/1101.4110 accepted by EPJC
- Pion Bose-Einstein correlations at 0.9 and 7 TeV
  - http://arxiv.org/abs/1101.3665v1 submitted to Phys. Rev. D
- J/Ψ production at 7 TeV :
  - http://arxiv.org/abs/arXiv:1105.0380 submitted to Phys. Lett. B

+ many in preparation

ALICE publications in PbPb collisions

- **Higher harmonic anisotropic flow measurements of charged particles in Pb-Pb collisions at 2.76 TeV,** arXiv:1105.3865v1 [nucl-ex], to be published in Physical Review Letters
- **Two-pion Bose-Einstein correlations in central PbPb collisions at sqrt(s_NN) = 2.76 TeV,** Phys.Lett.B 696:328-337,2011 DOI:10.1016/j.physletb.2010.12.053
- **Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at sqrt(sNN) = 2.76 TeV,** Phys. Rev. Lett. 106, 032301 (2011), DOI: 10.1103/PhysRevLett.106.032301
- **Suppression of Charged Particle Production at Large Transverse Momentum in Central Pb-Pb Collisions at √sNN = 2.76 TeV,** Phys. Lett. B 696 (2011) 30-39, DOI:10.1016/j.physletb.2010.12.020
- **Elliptic flow of charged particles in Pb-Pb collisions at 2.76 TeV,** Phys. Rev. Lett. 105, 252302 (2010), DOI:10.1103/PhysRevLett.105.2523
- **Charged-particle multiplicity density at mid-rapidity in central Pb-Pb collisions at sqrt(sNN) = 2.76 TeV,** Phys. Rev. Lett. 105, 252301 (2010), DOI:10.1103/PhysRevLett.105.252301