Neutral meson production in pp and Pb-Pb collisions at the LHC

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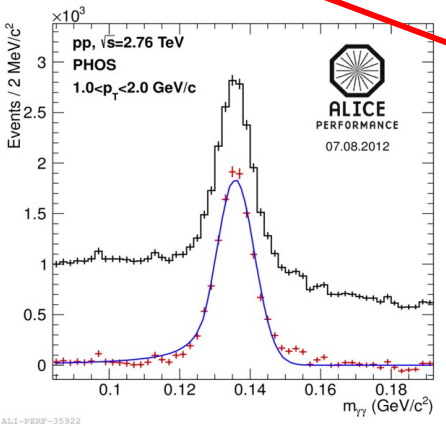
for the ALICE collaboration

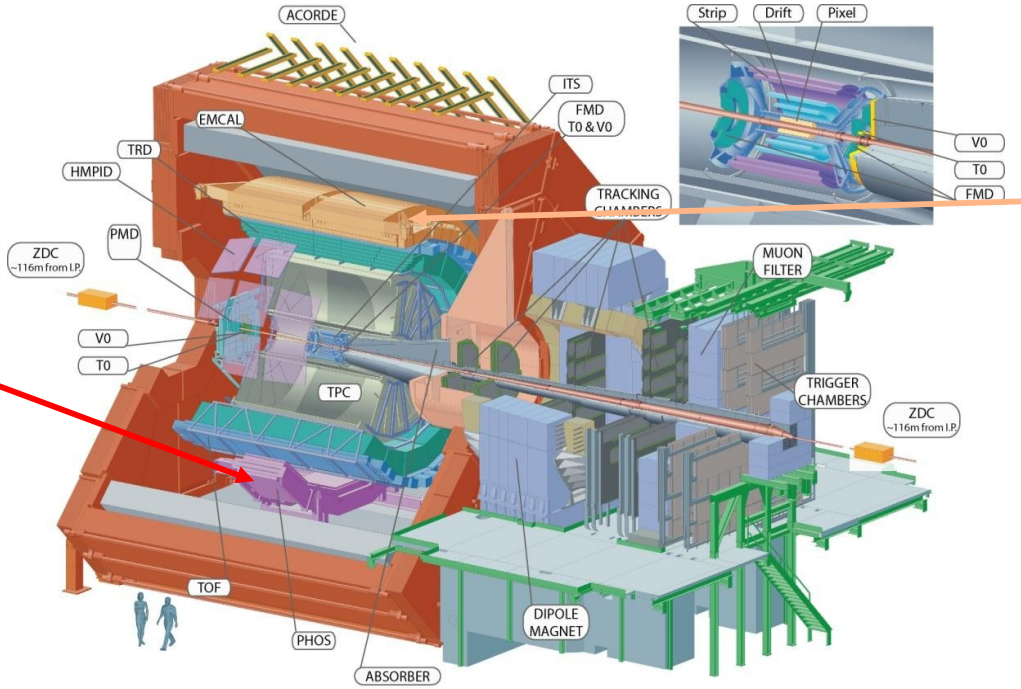
Physics motivation: why neutral mesons?

- Inclusive indentified hadron production is a reliable **probe for NLO pQCD.**
- Precise measurement of neutral meson spectra is important for studying the decay photon (electron) background for a **direct photon (charm and beauty) measurement.**
- Neutral pion spectrum in AA collisions, reveal **medium-induced modifications** of hadron properties.
- Neutral pion v_2 is subject to different particle production mechanisms in different kinematic ranges.

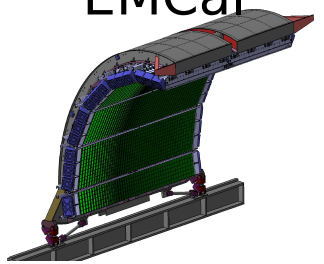
Detectors used in analysis

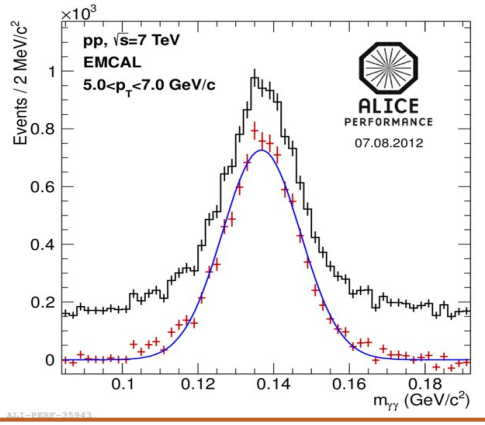
PHOS



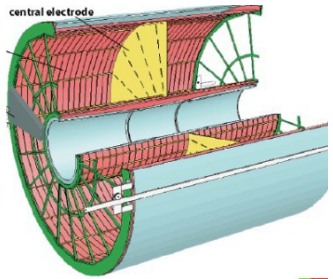


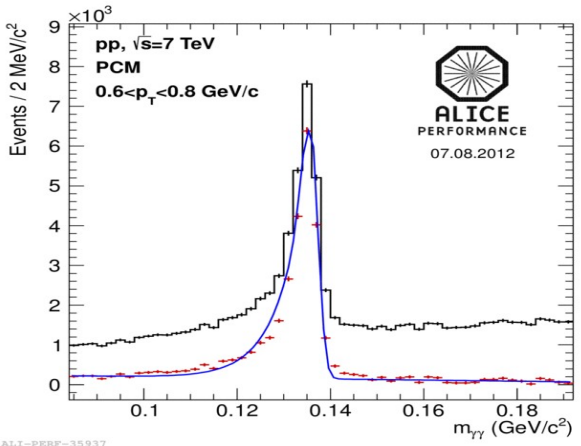
EMCal





Central tracker





Three detectors provide complementary methods with different resolution and different systematic uncertainties.

π^0 detection via ALICE calorimeters

PHOS

- **Active element**: crystal of lead tungstate ($PbWO_4$) 2.2×2.2×18 cm2.
- **Geometry**: 3 modules 64×56 crystals each; distance from IP to active surface: 460 cm.
- **Aperture**: $|\eta|<0.13$, $260°<\varphi<320°$.
- **Energy range**: 0<E<100 GeV.
- **Material budget** from IP to PHOS: $0.2X_0$.

EMCAL

- **Active element**: tower of 77 layers 1.4mm lead + 1.7 mm scintillator 6×6×25 cm2.
- **Geometry**: 10 modules 24×48 towers each; distance from IP to active surface: 450 cm.
- **Aperture**: $|\eta|<0.7$, $80°<\varphi<180°$.
- **Energy range**: 0<E<250 GeV.
- **Material budget** from IP to EMCAL: $0.8X_0$.

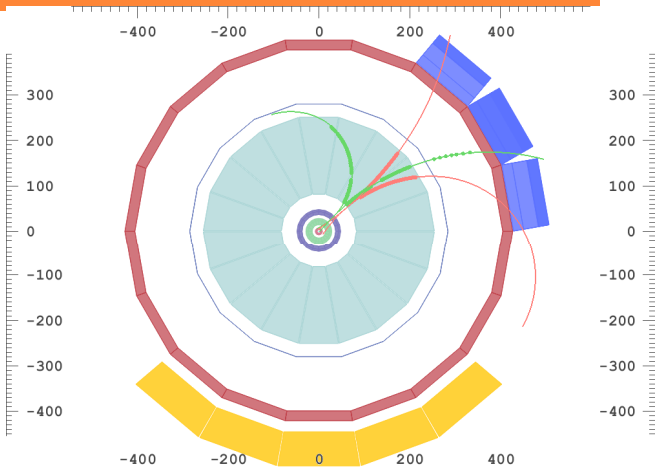
π^0 spectrum can be measured via invariant mass method up to p_t~50 GeV/c in PHOS and ~25 GeV/c in EMCAL.

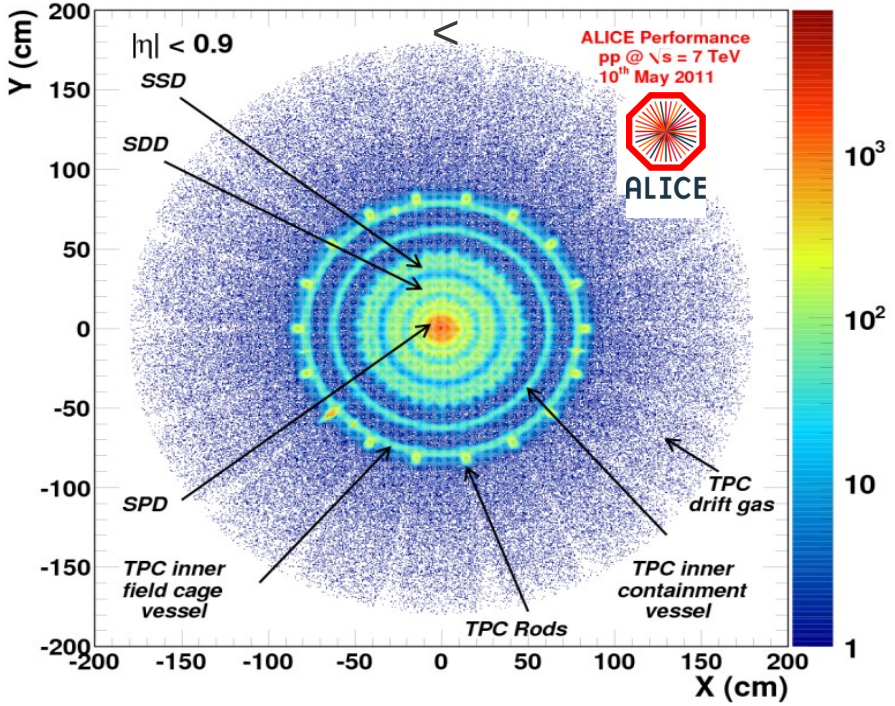
π^0 detection via conversions

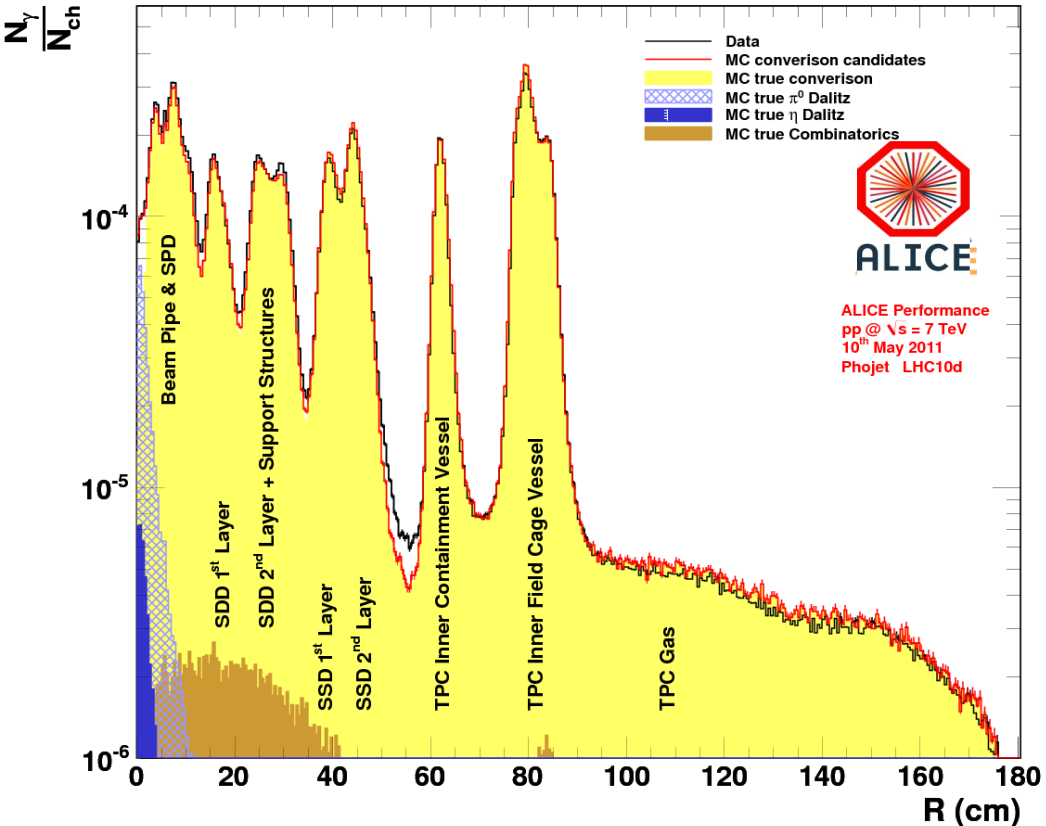
$pp \rightarrow \pi^0 X$

$\pi^0 \rightarrow \gamma\gamma \rightarrow e^+e^- + e^+e^-$

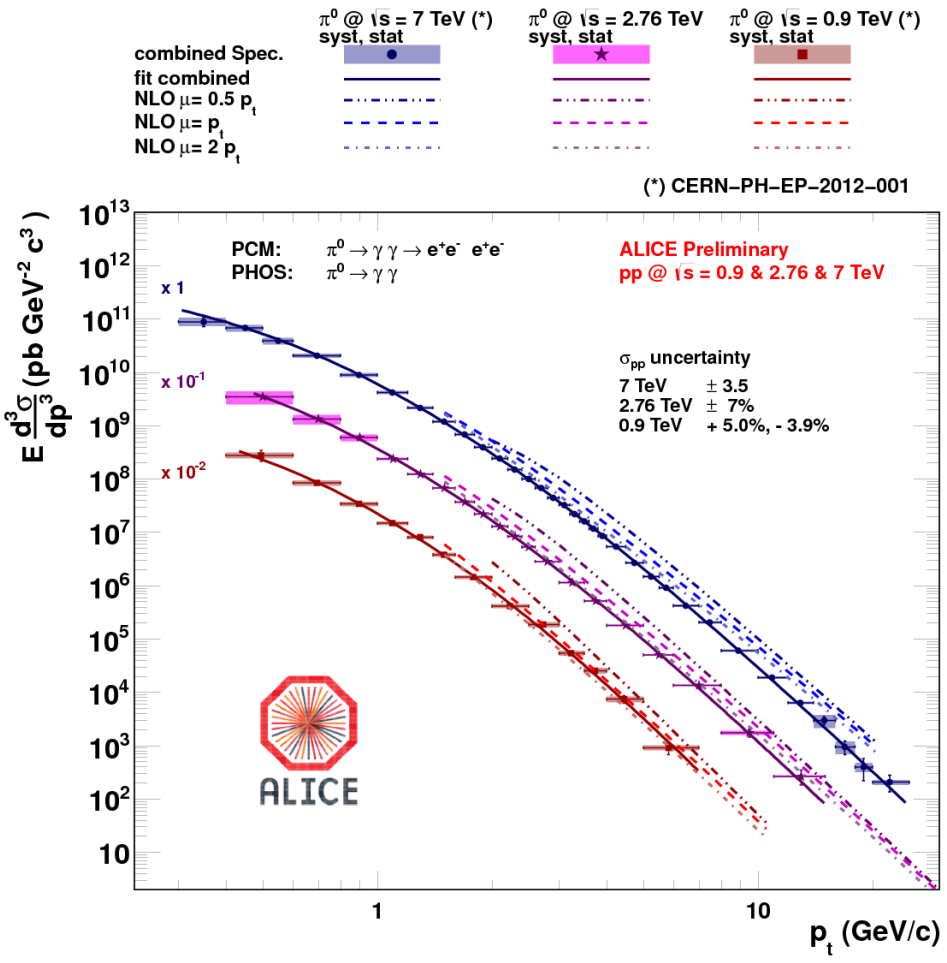
- Photons convert in the medium of the ALICE detectors.
- Reconstructed converted photons ⇒ gamma tomography of the ALICE medium.
- ALICE material budget (11.4%X_0 up to middle of TPC) is well described in GEANT.
- π^0 is reconstructed via invariant mass spectra of photon pairs.

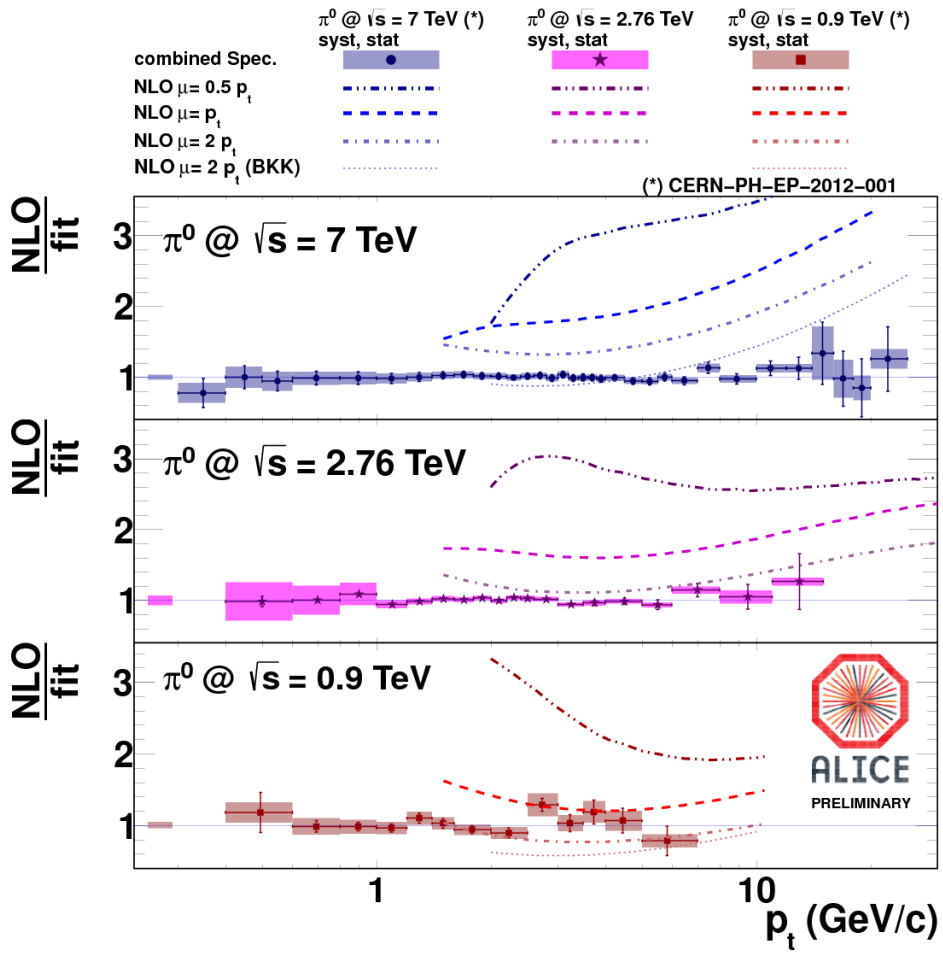






π^0 spectrum in pp @ 0.9, 2.76, 7 TeV



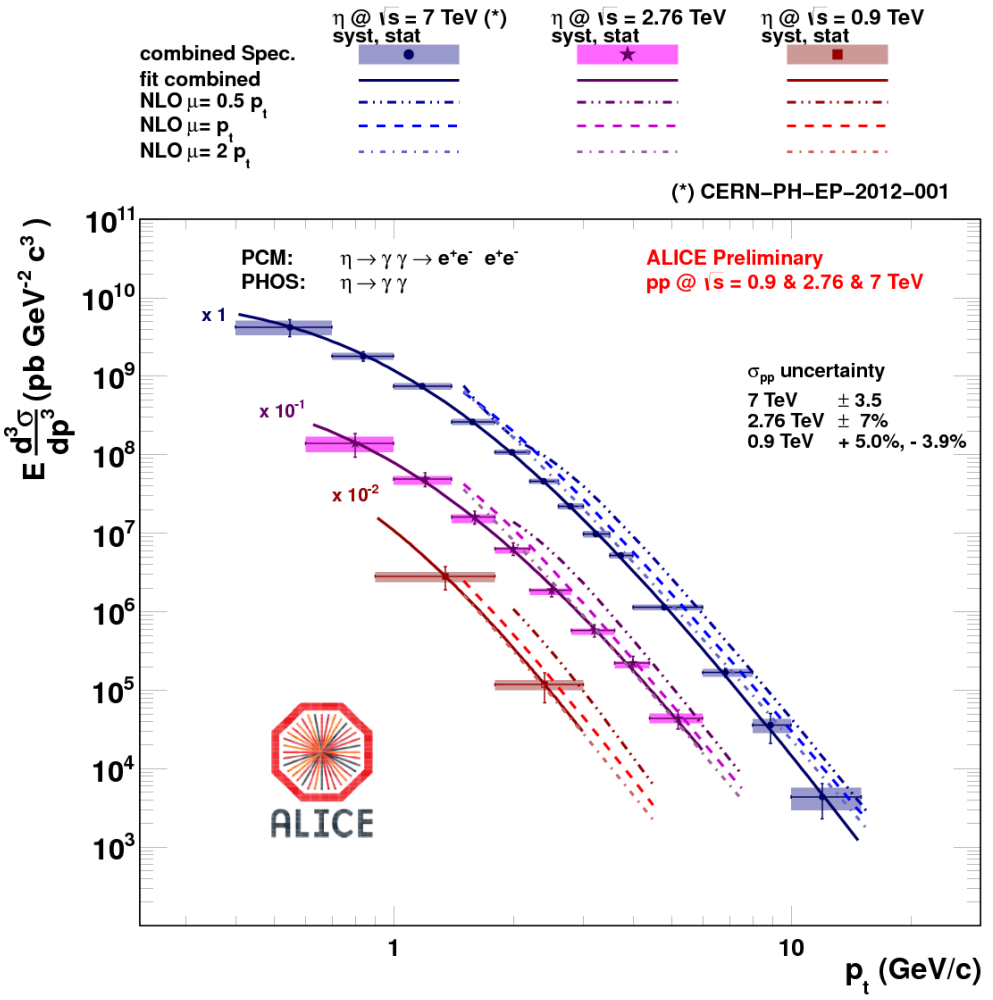


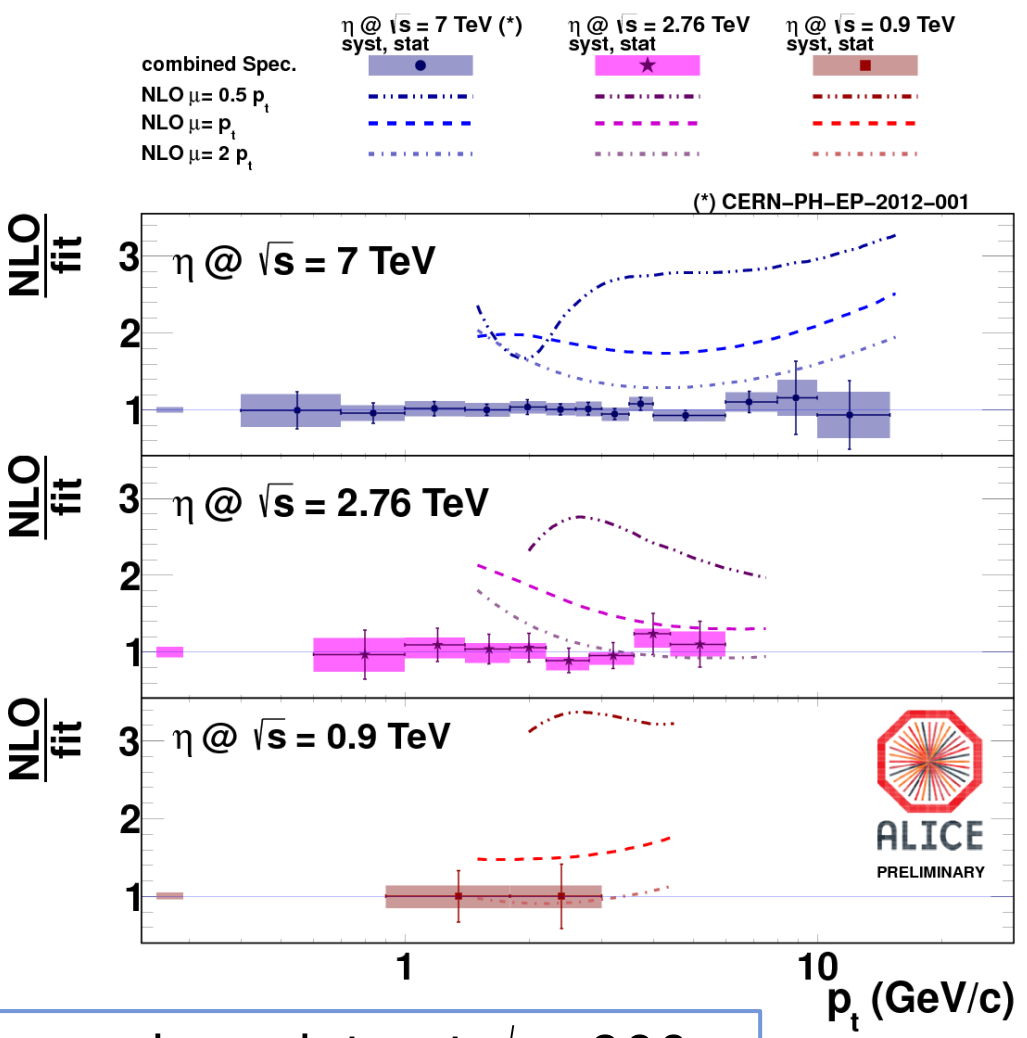
pQCD NLO calculations [*] can reproduce data at √s=900 GeV, but overestimate π^0 spectrum at √s=2.76 and 7 TeV.

[*] P. Aurenche et al., Eur. Phys. J. C13, 347-355 309 (2000).

ALICE data: CERN-PH-EP-2012-001, arXiv.1205.5724

η spectrum in pp @ 0.9, 2.76, 7 TeV





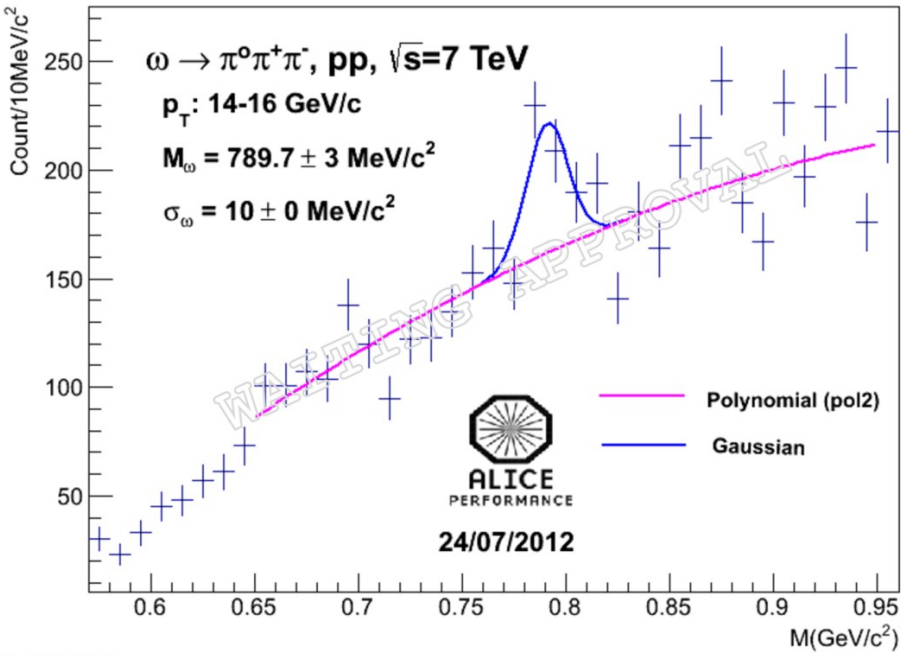
pQCD NLO calculations can reproduce data at √s=900 GeV, but overestimate η spectrum at √s=2.76 and 7 TeV.

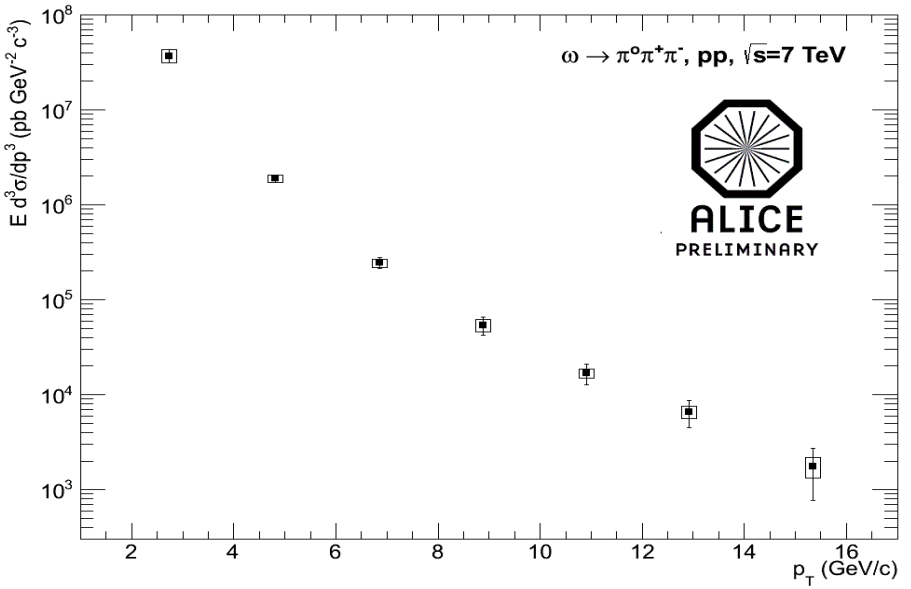
ω reconstruction in pp @ 7 TeV

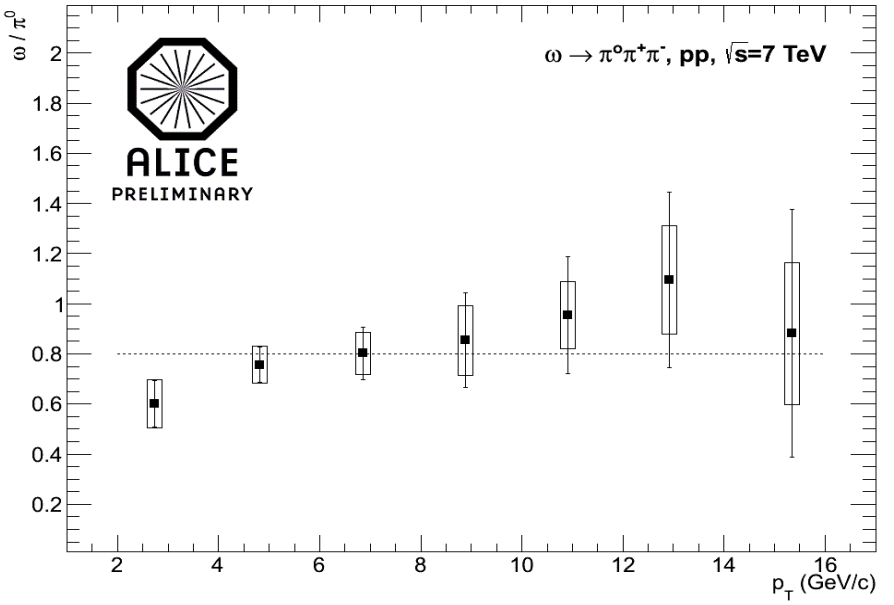
$\omega \rightarrow \pi^+\pi^-\pi^0$

Using charged pions reconstructed in Central Tracking system and π^0 – in PHOS

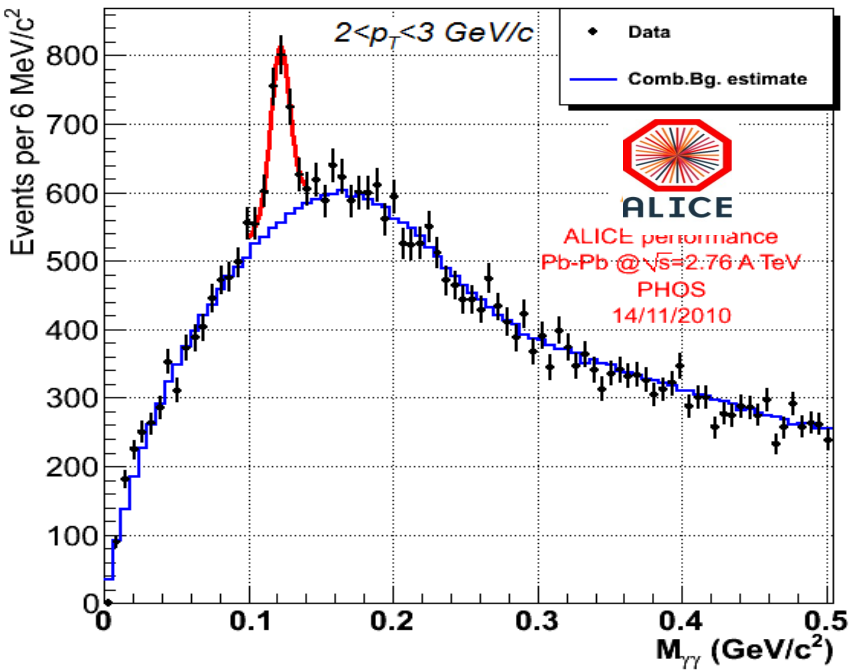
Data collected in 2010:
~400 M, ~ 6 nb-1.



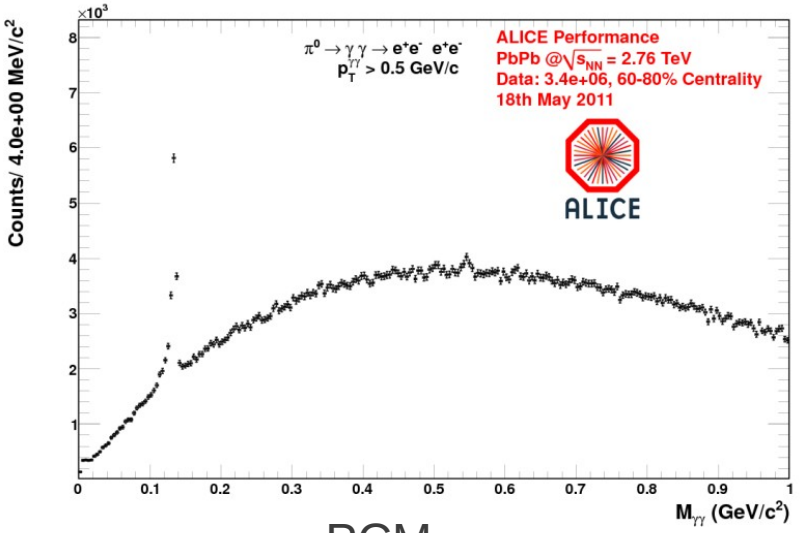




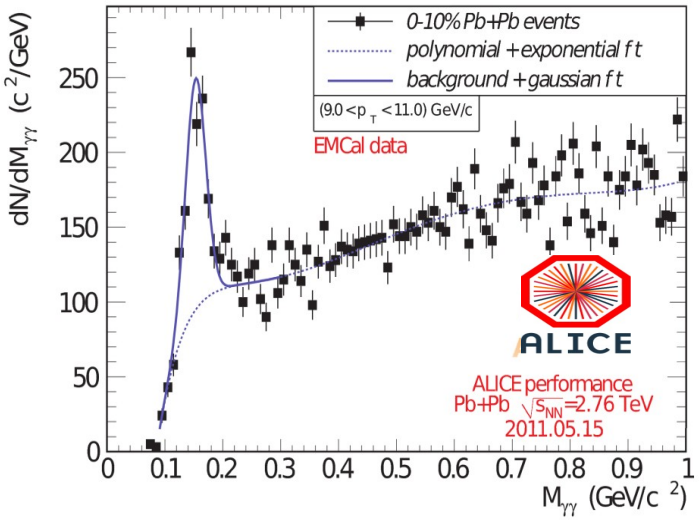
Pb-Pb collisions



PHOS



PCM

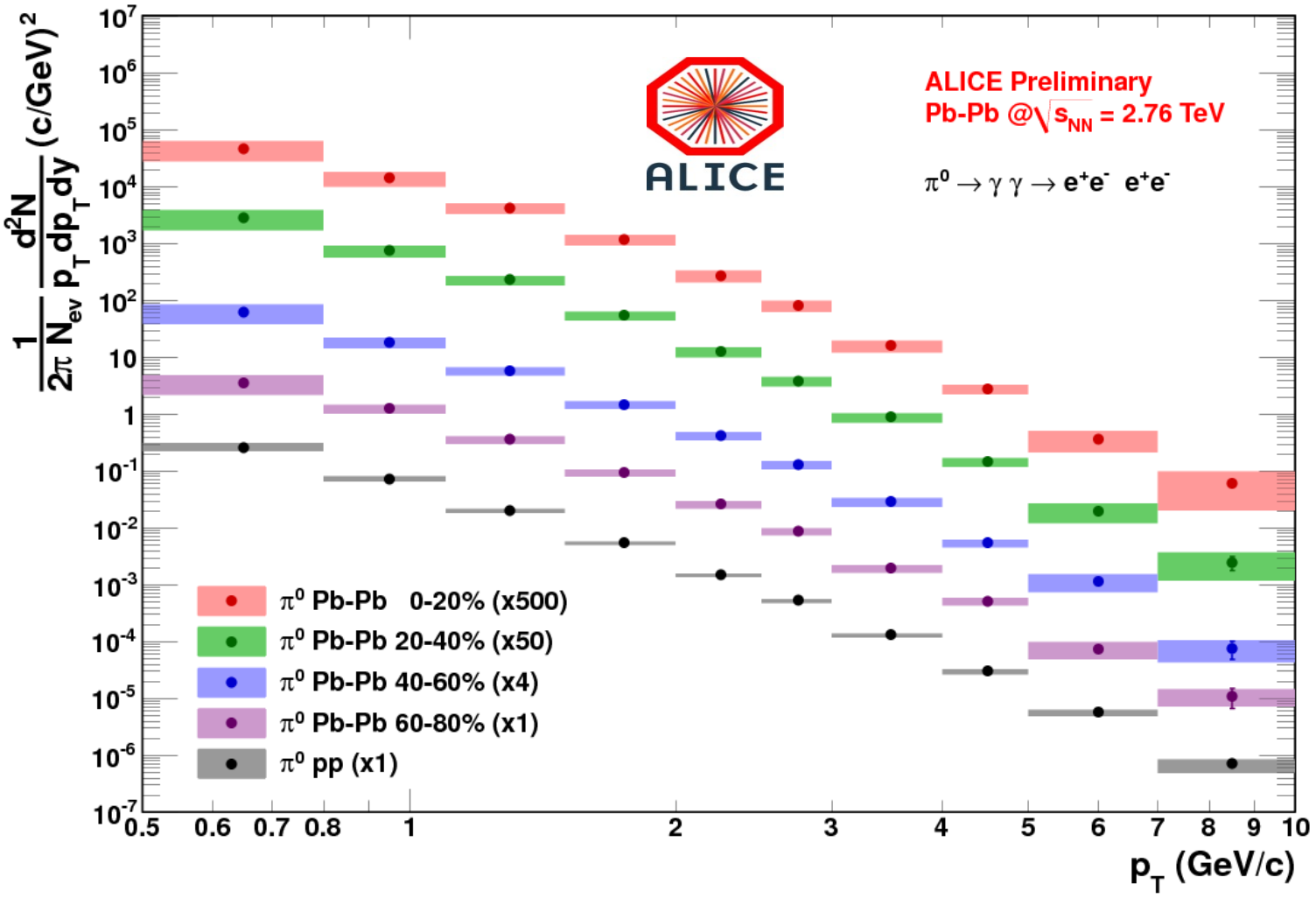


EMCAL

In the Pb-Pb collisions:

- High detector occupancy.
- High combinatorial background in invariant mass spectra.

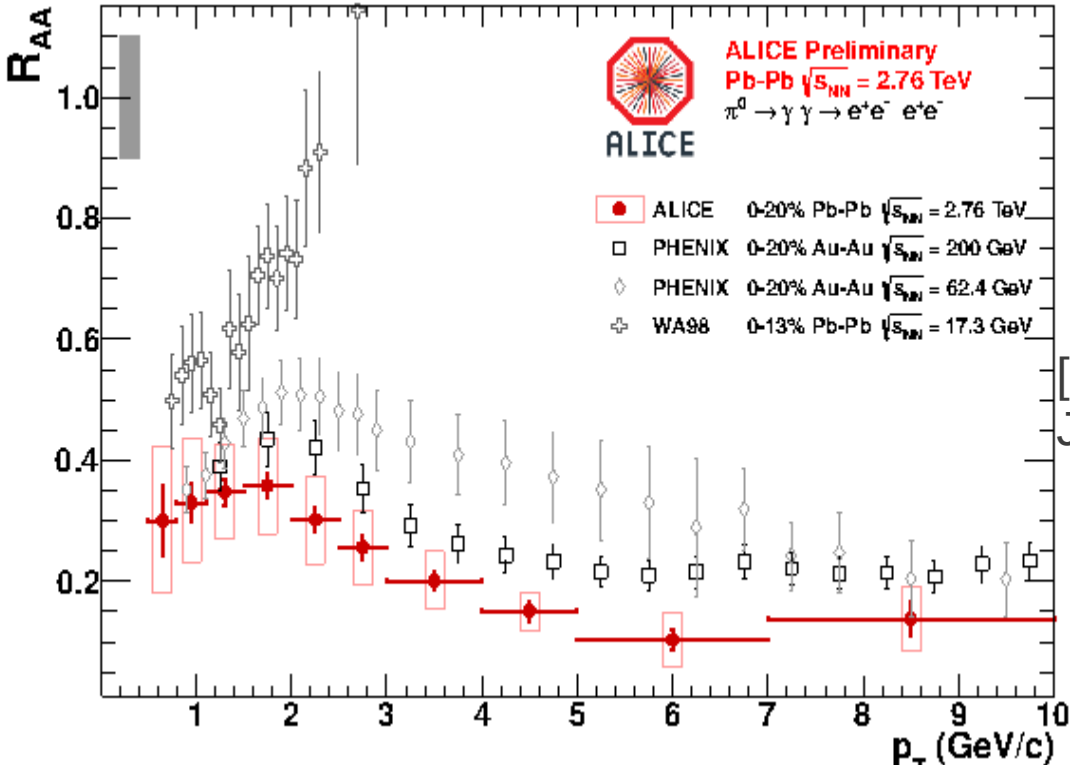
π^0 spectra in Pb-Pb @ 2.76 TeV

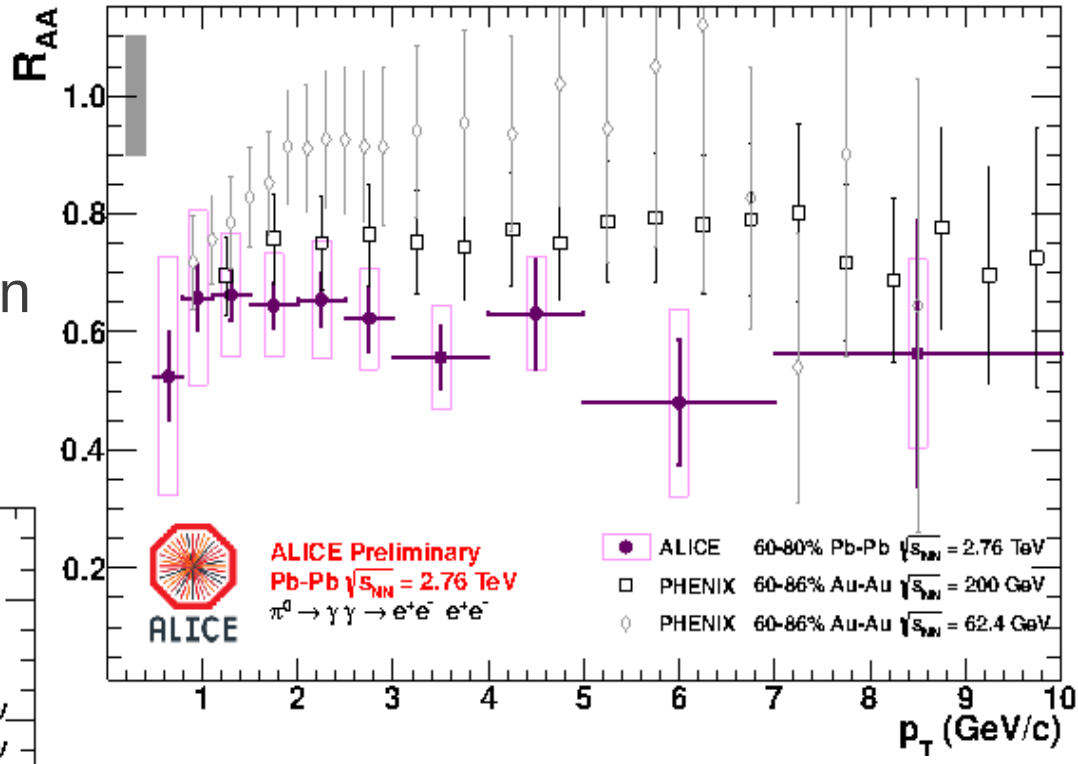


The first result on π^0 production in 4 centrality classes was obtained via photon conversion [G.Conesa Balbastre et al., ALICE collaboration. J. Phys. G: Nucl. Part. Phys. 38 (2011) 124117]

π^0 R_{AA} in Pb-Pb @ 2.76 TeV

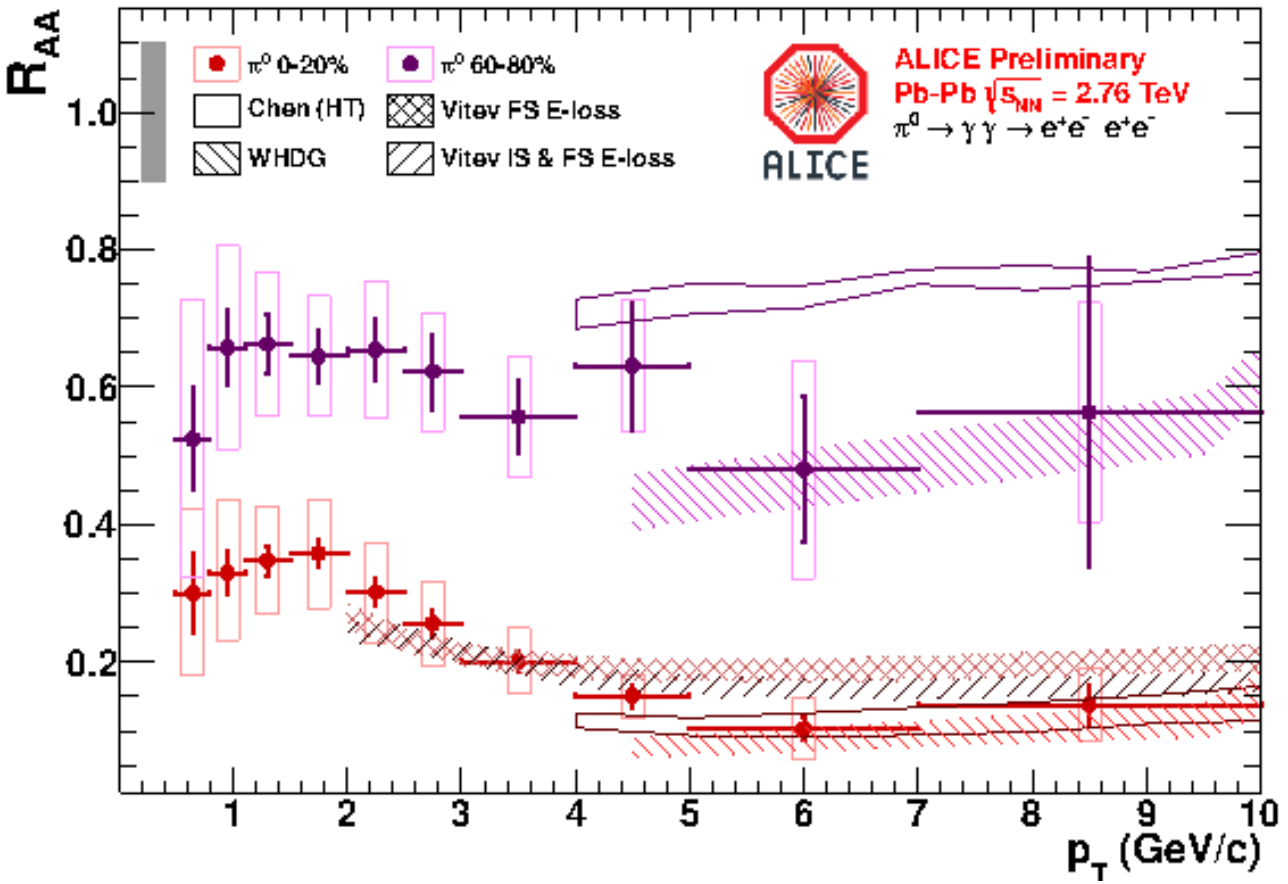
- Suppression follows the energy dependence seen at RHIC energies.
- Suppression agrees with charged pion R_{AA} within errors.





[S.Bathe et al., PHENIX collaboration.
J. Phys. G: Nucl. Part. Phys. 38 (2011) 124001]

Comparison to theory predictions

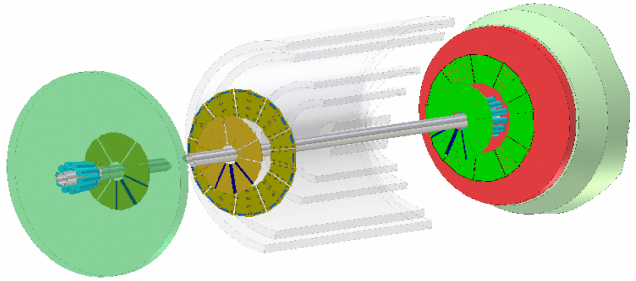


- WHDG model reproduces both strength and centrality dependence.
- Chen (HT) fails to reproduce centrality dependence.
- Vitev's model agrees with data in central collisions.

- W. A. Horowitz. Int.J.Mod.Phys. E16 (2007) 2193–2199, arXiv:nucl-th/0702084 [NUCL-TH].
- X.-F. Chen, T. Hirano, E. Wang, X.-N. Wang, and H. Zhang. Phys.Rev. C84 (2011) 034902, ArXiv:1102.5614 [nucl-th].
- R. Sharma, I. Vitev, and B.-W. Zhang. Phys.Rev. C80 (2009) 054902, arXiv:0904.0032[hep-ph].

π^0 v_2 : Ongoing work

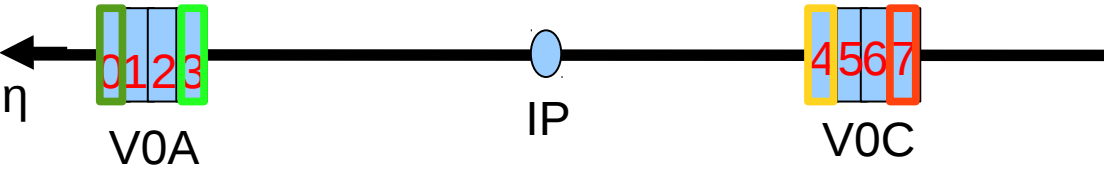
- Event plane reconstruction using VZero:



Two arrays of scintillator counters "(4 rings each one)" installed on each side of the ALICE interaction point.

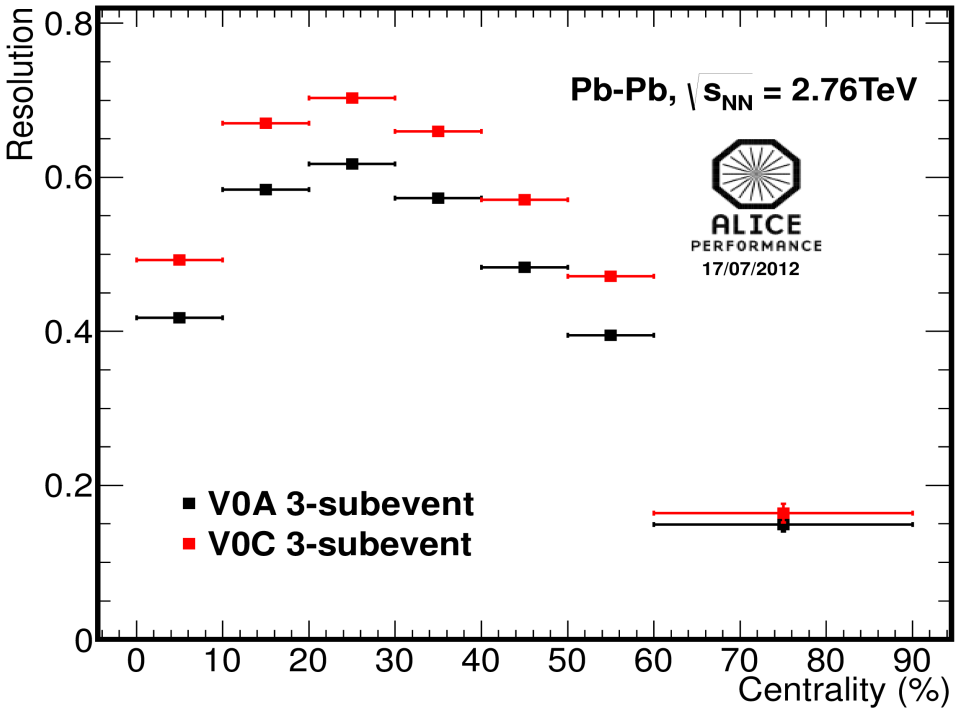
V0A
2.8 > η > 5.1

V0C
–3.7 < η < –1.7



$$R_{V0A} = \sqrt{\frac{\langle \cos[2(\psi^{V0A} - \psi^{ring0})] \rangle \langle \cos[2(\psi^{V0A} - \psi^{ring3})] \rangle}{\langle \cos[2(\psi^{ring0} - \psi^{ring3})] \rangle}}$$

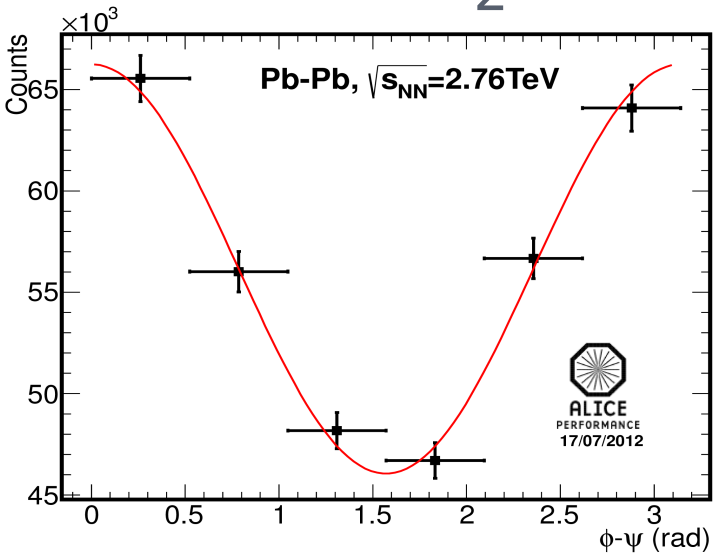
$$R_{V0C} = \sqrt{\frac{\langle \cos[2(\psi^{V0C} - \psi^{ring4})] \rangle \langle \cos[2(\psi^{V0C} - \psi^{ring7})] \rangle}{\langle \cos[2(\psi^{ring4} - \psi^{ring7})] \rangle}}$$



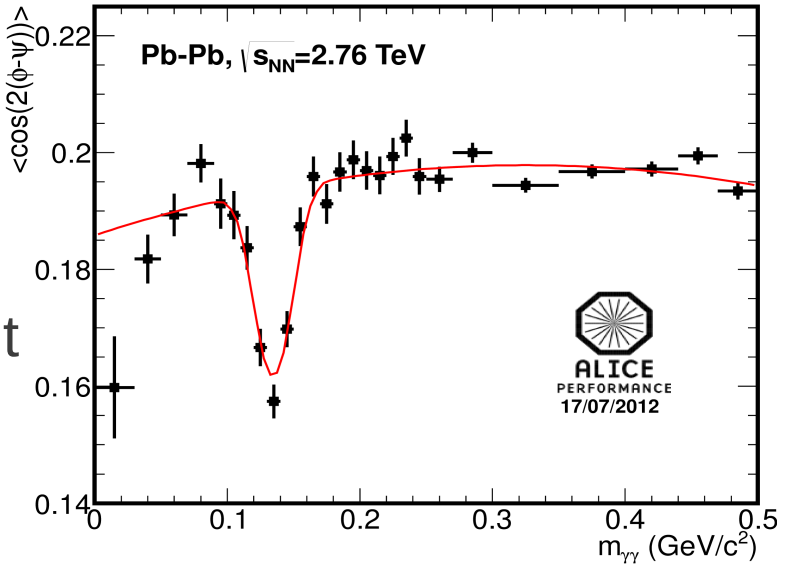
π^0 v_2 : Ongoing work

- Extracted π^0 v_2 :

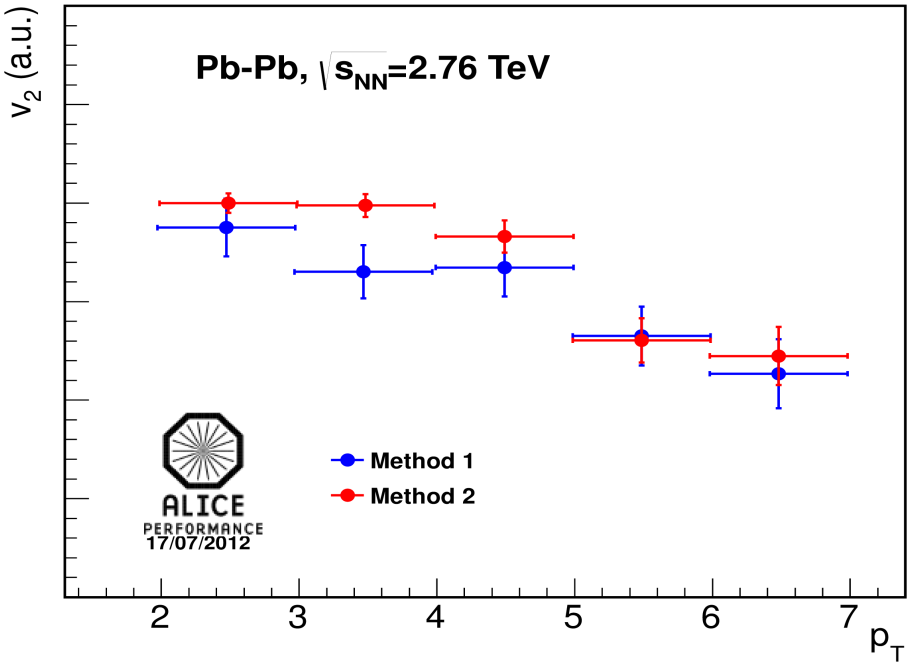
1: dN/dφ



2: Invariant Mass method



Implement the methods to extract π^0 v_2:

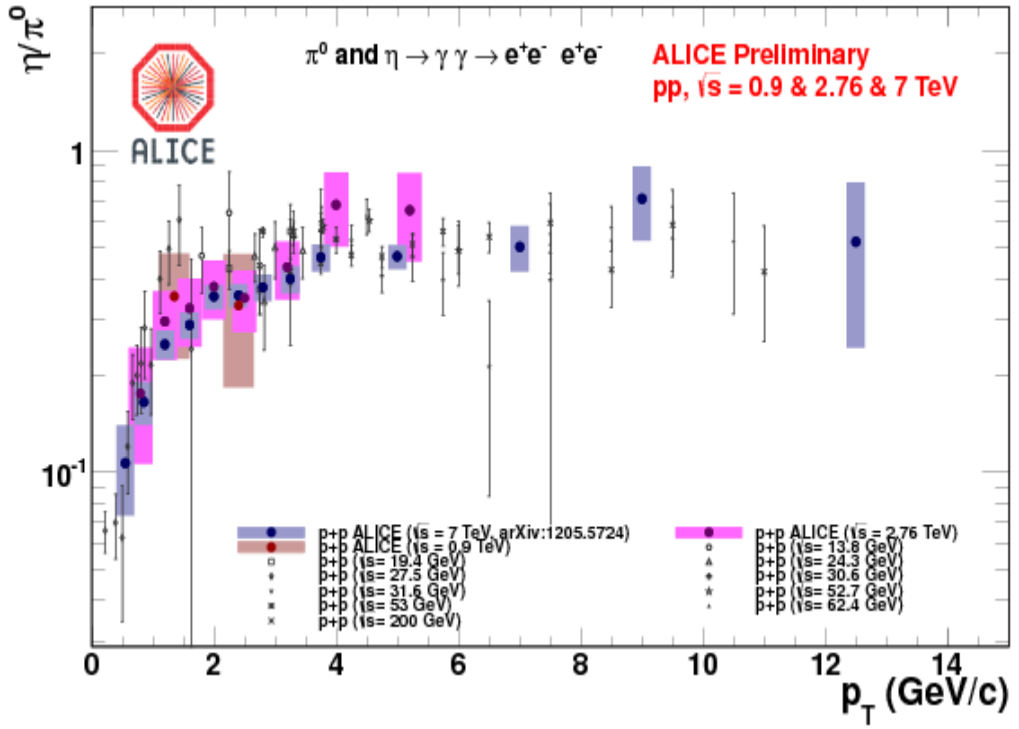


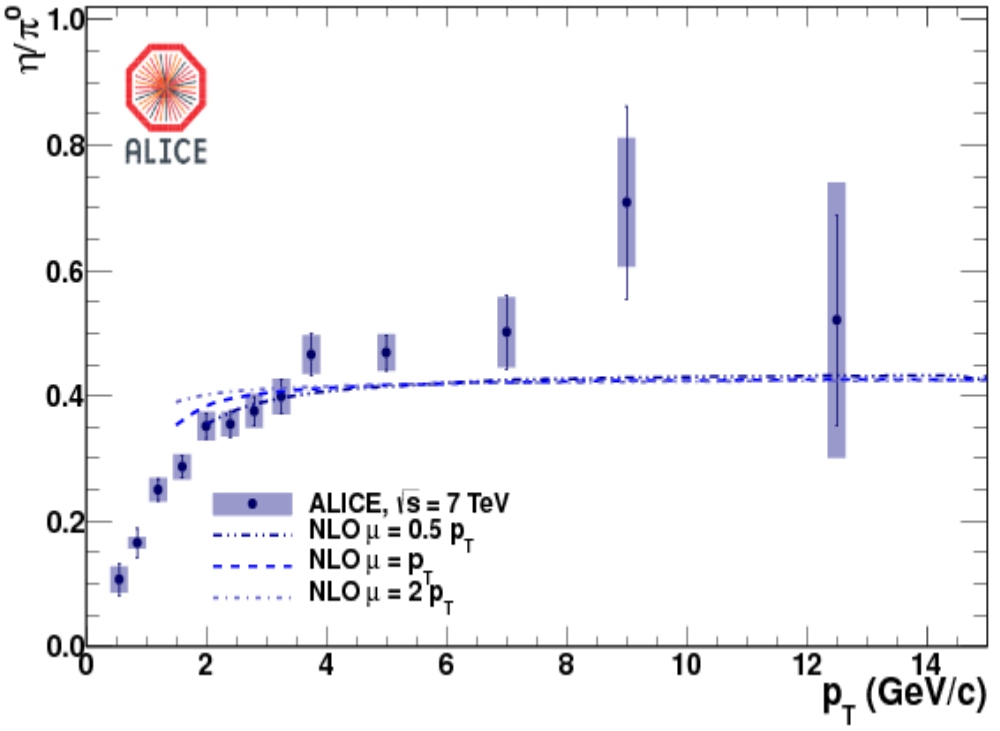
Summary

- π^0 , η and ω spectra are measured over a wide p_T range.
  - Several complementary subsystems.
  - NLO pQCD describes π^0, η production in pp at $\sqrt{s}$=0.9 TeV.
  - Overestimates π^0, η production in pp at $\sqrt{s}$=2.76 and 7 TeV.
- Suppression of π^0 in Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV is stronger than one observed in RHIC.
- We implement two method to extract π^0 v_2. We are still working on this analysis.

Back up

η/π^0 ratio in pp at 0.9, 2.76, 7 TeV





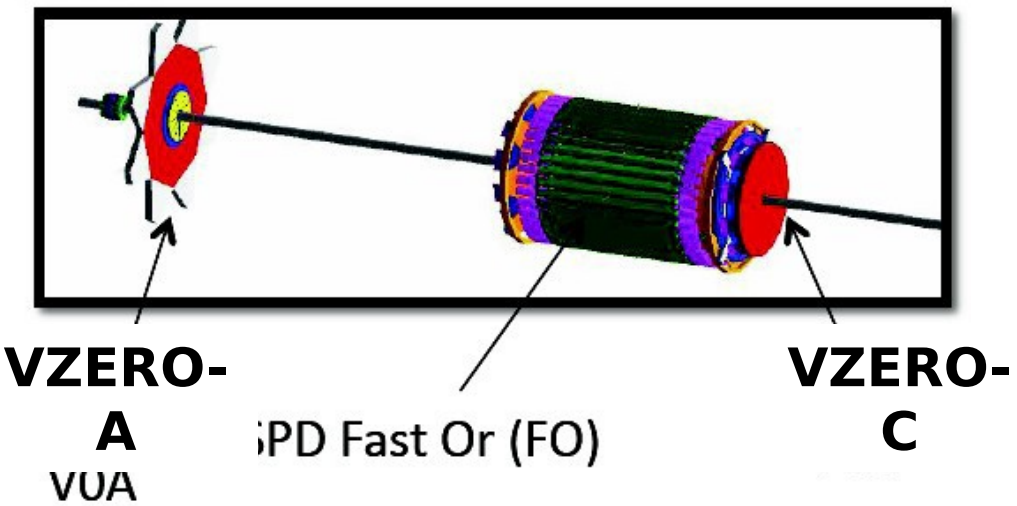
- ALICE measurement of the η/π^0 ratio is consistent with world results in pp collisions at all energies.

- The measured η/π^0 ratio is reproduced by pQCD.

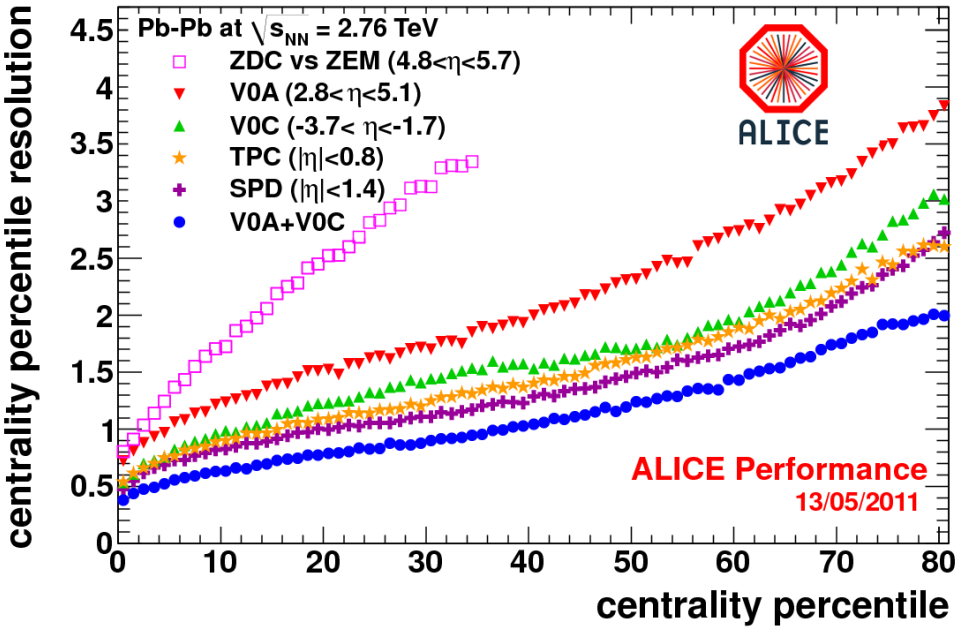
Data samples and trigger

Collision system	∫LdT	Run #
pp at √s=0.9 TeV	0.14 nb-1	May 2010
pp at √s=2.76 TeV	0.7 nb-1	Apr 2011
pp at √s=7 TeV	5.5 nb-1	Jun-Aug 2010
Pb-Pb at √sNN=2.76 TeV	2 μb-1	Nov 2010

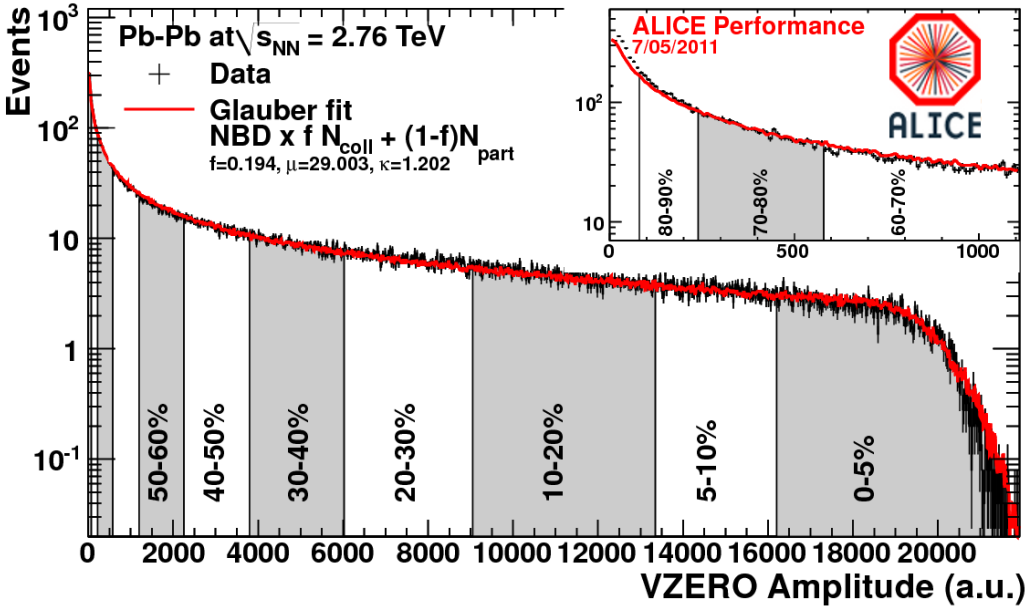
- Triggers: minimum bias in pp and Pb-Pb.
  - Trigger detectors: **SPD | VZERO-A | VZERO-C**



Pb-Pb collisions: event characterization



- Centrality can be determined in ALICE by various estimator.
  [A.Toia et al., ALICE collaboration. J. Phys. G: Nucl. Part. Phys. 38 (2011) 124007]



The best centrality accuracy is provided by VZERO: from 0.5% in most central to 1.5% in most peripheral events
[K.Aamodt et al., ALICE collaboration. PRL, 106, 032301 (2011)]
See M.Floris talk at HP2012