NEUTRAL MESON PRODUCTION IN PP AND PB-PB COLLISIONS AT LHC

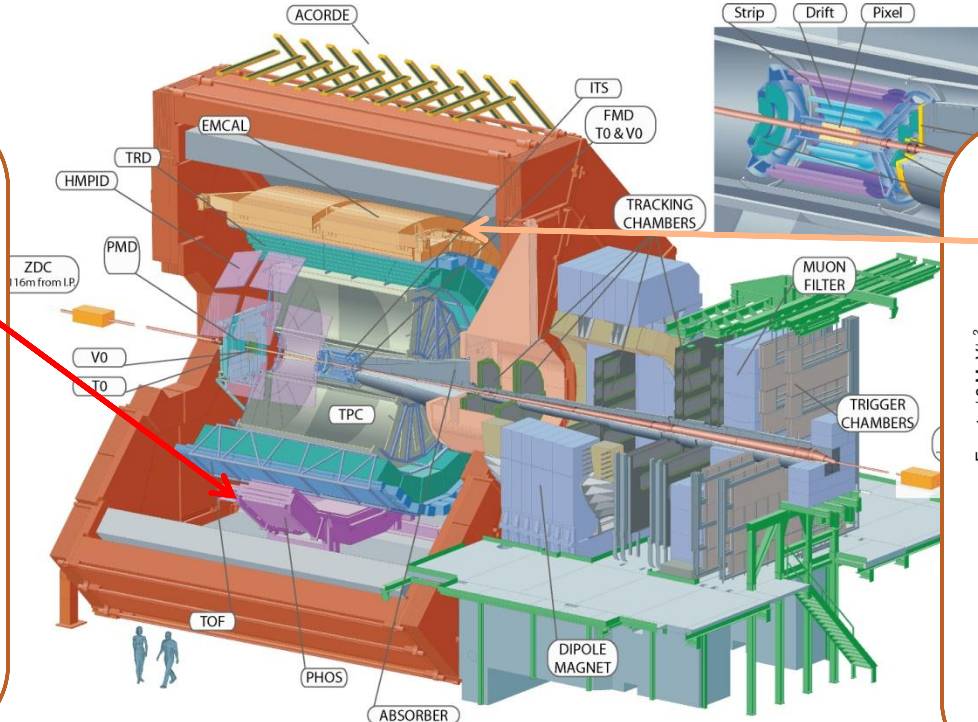
LHC on the March
21.11.2012

Dmitry Blau, for the ALICE collaboration
NRC “Kurchatov Institute”

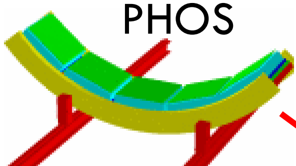
Physics motivation: why neutral mesons?

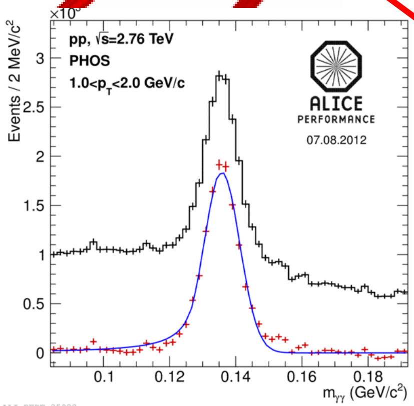
- Inclusive identified hadron production is a probe for NLO pQCD
  - π^0, η and ω can be detected and identified via photonic decay channels in a wide p_T range.
  - At LHC, the PDF and FF can be probed at lower x and z than it was at previous colliders, and thus provide further constraints on these functions, which are crucial for pQCD predictions for LHC energies.
  - Meson production at LHC energies is dominated by gluon fragmentation at $p_T < 100$ GeV/c: Constraints on gluon FF
  - η meson spectrum imposes constraints on strange quark FF.
- Precise measurement of neutral meson spectra is important for studying the decay photon (electron) background for a direct photon (charm and beauty) measurement
- Neutral meson spectra in AA collisions, and R_{AA} provide constraints on the energy loss models.

Detectors used in analysis

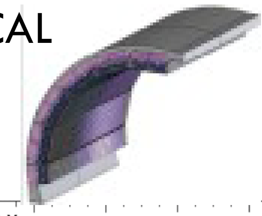


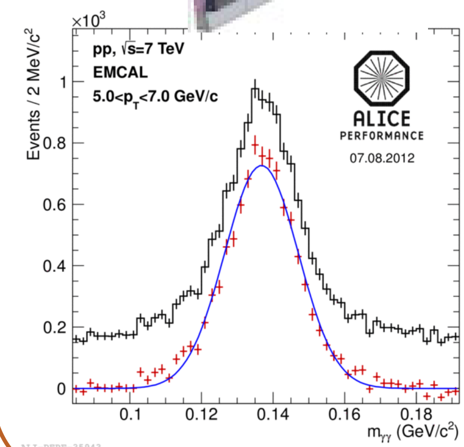
PHOS



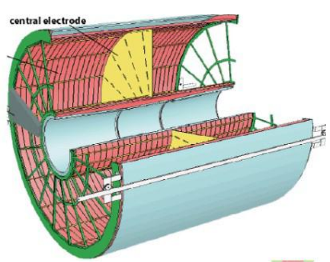


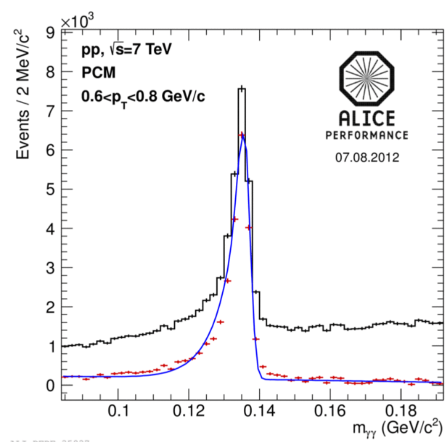
EMCAL





Central tracker





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

π^0 detection in ALICE calorimeters

PHOS

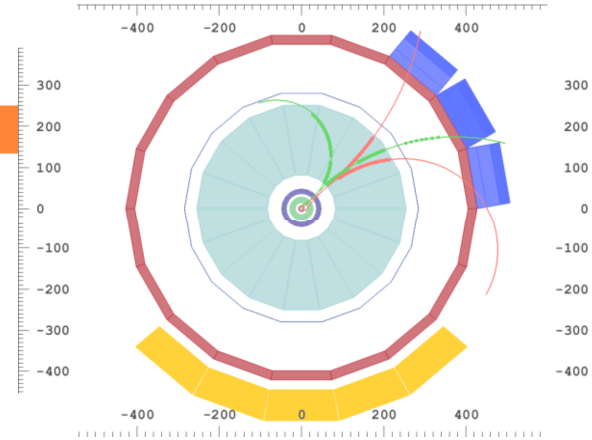
- **Active element**: crystal of lead tungstate ($PbWO_4$)
  $2.2\times2.2\times18$ cm^3
- **Geometry**: 3 modules 64×56 crystals each; distance from IP to active surface: 460 cm
- **Aperture**: $|\eta|<0.13$, $260°<\varphi<320°$
- **Energy range**: 0<E<100 GeV
- **Material budget** from IP to PHOS: $0.2X_0$
- **π^0 reconstruction** via invariant mass method is possible up to $p_T\sim50$ GeV/c

EMCAL

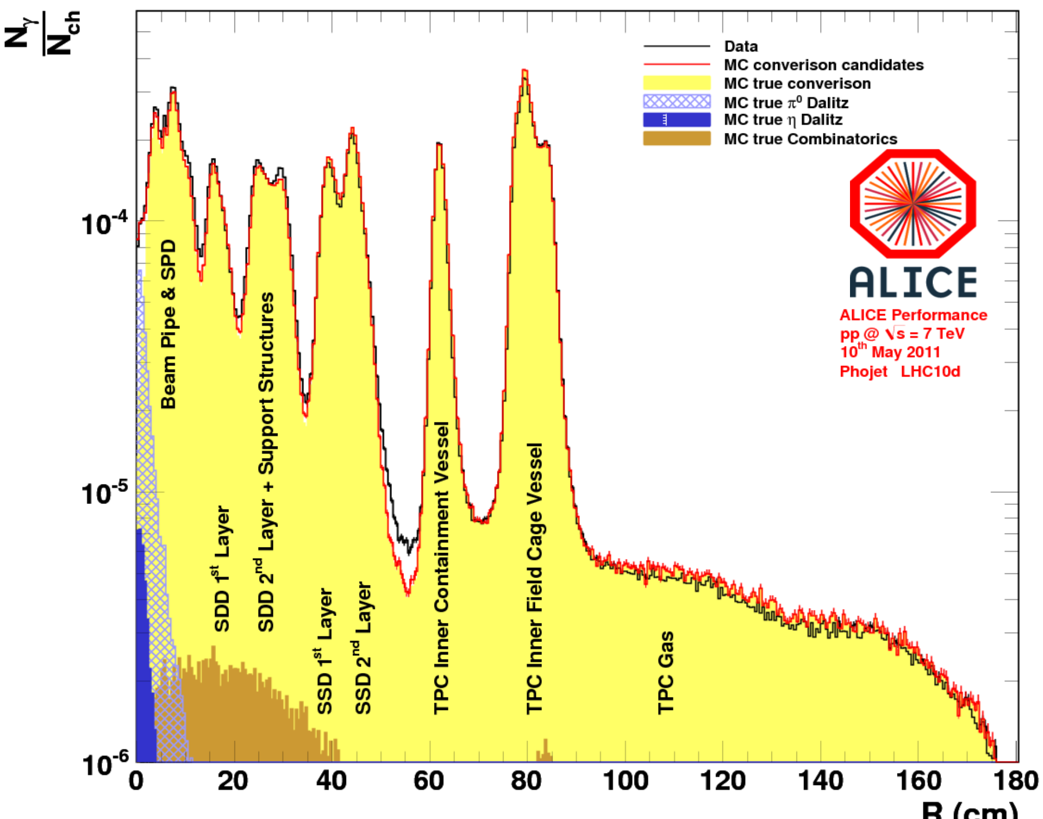
- **Active element**: tower of 77 layers 1.4mm lead + 1.7 mm scintillator
  $6\times6\times25$ cm^3
- **Geometry**: 10 modules 24×48 towers each; distance from IP to active surface: 450 cm
- **Aperture**: $|\eta|<0.7$, $80°<\varphi<180°$
- **Energy range**: 0<E<250 GeV
- **Material budget** from IP to EMCAL: $0.8X_0$
- **π^0 reconstruction** via invariant mass method is possible up to $p_T\sim25$ GeV/c

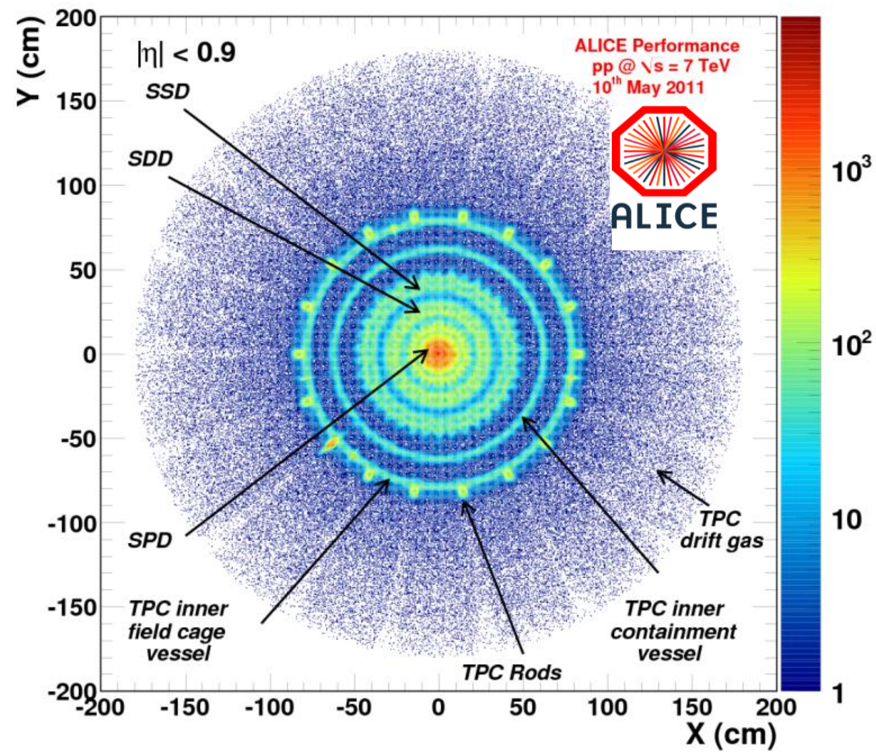
π^0 detection via converted photons

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



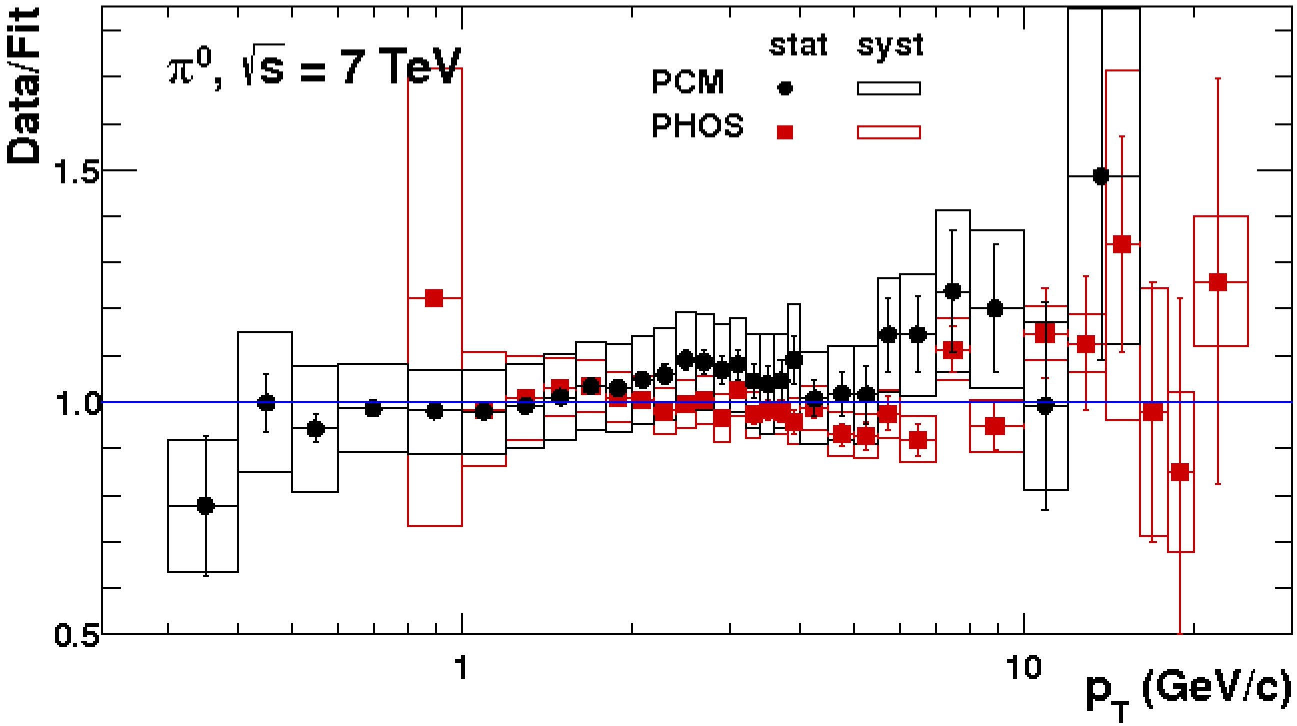
- Photons convert in the medium of ALICE detectors
- Reconstructed converted photons ⇒ tomography of ALICE
- ALICE material budget is well described in GEANT
- π^0 is reconstructed via invariant mass spectra of photon pairs.





Comparison of spectra measured in PHOS and with conversion method

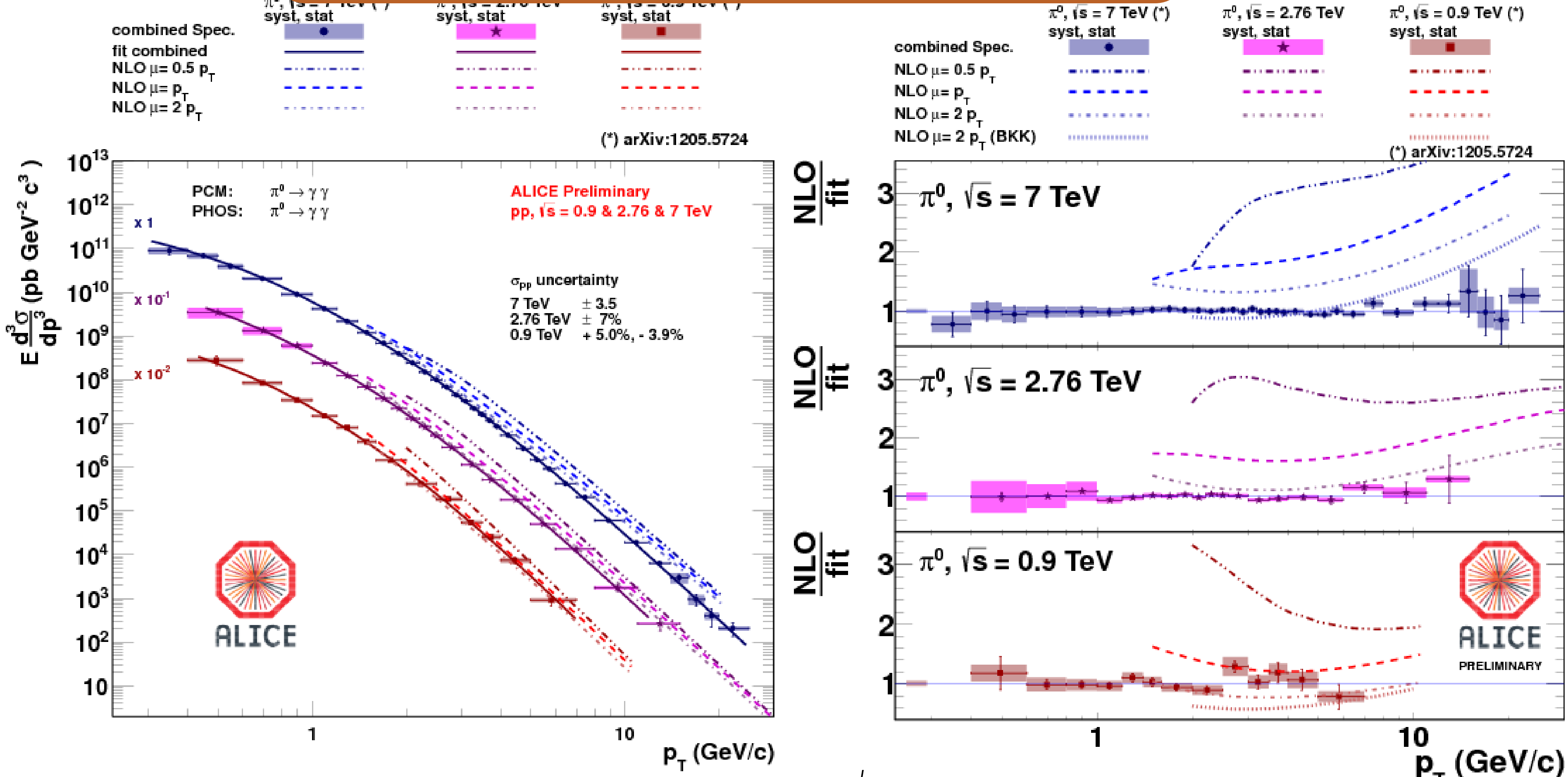
ALICE data: CERN-PH-EP-2012-001, **Phys.Lett. B717 (2012) 162-172**



Neutral pion spectra measured in PHOS and Photon Conversion Method (PCM) agree within errors

π^0 spectrum in pp at 0.9, 2.76, 7 TeV

ALICE data: CERN-PH-EP-2012-001, **Phys.Lett. B717 (2012) 162-172**

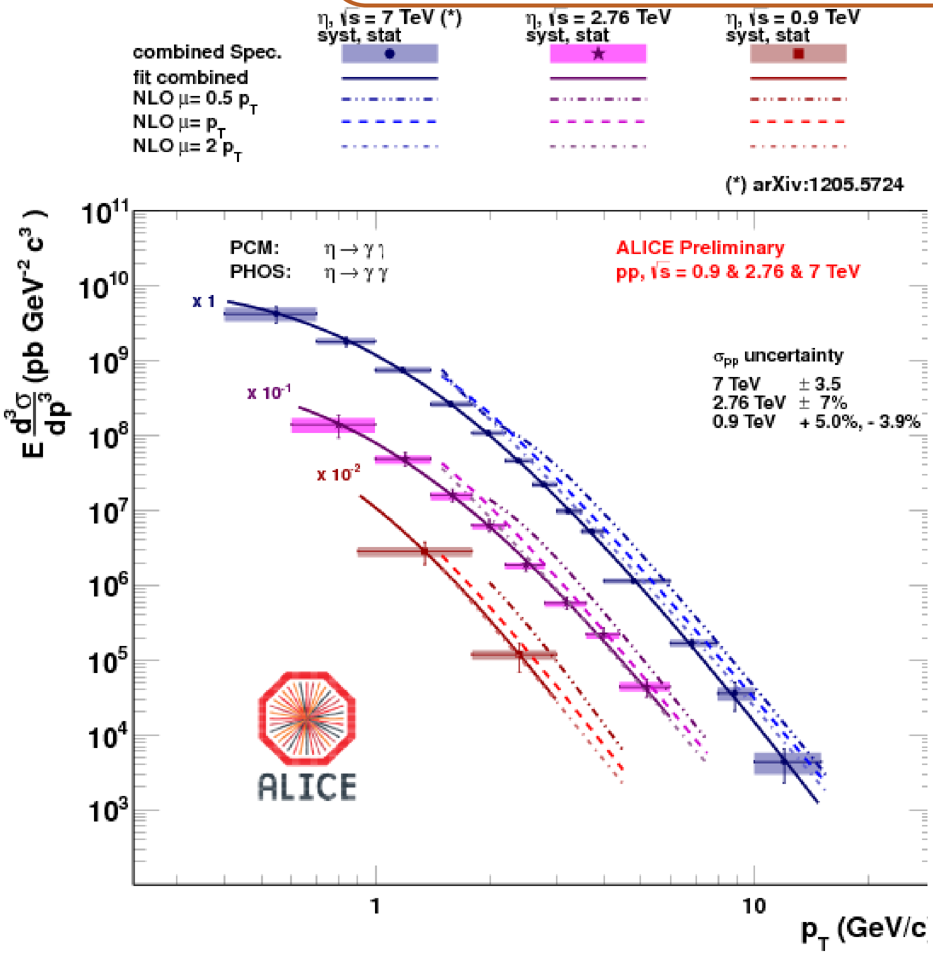


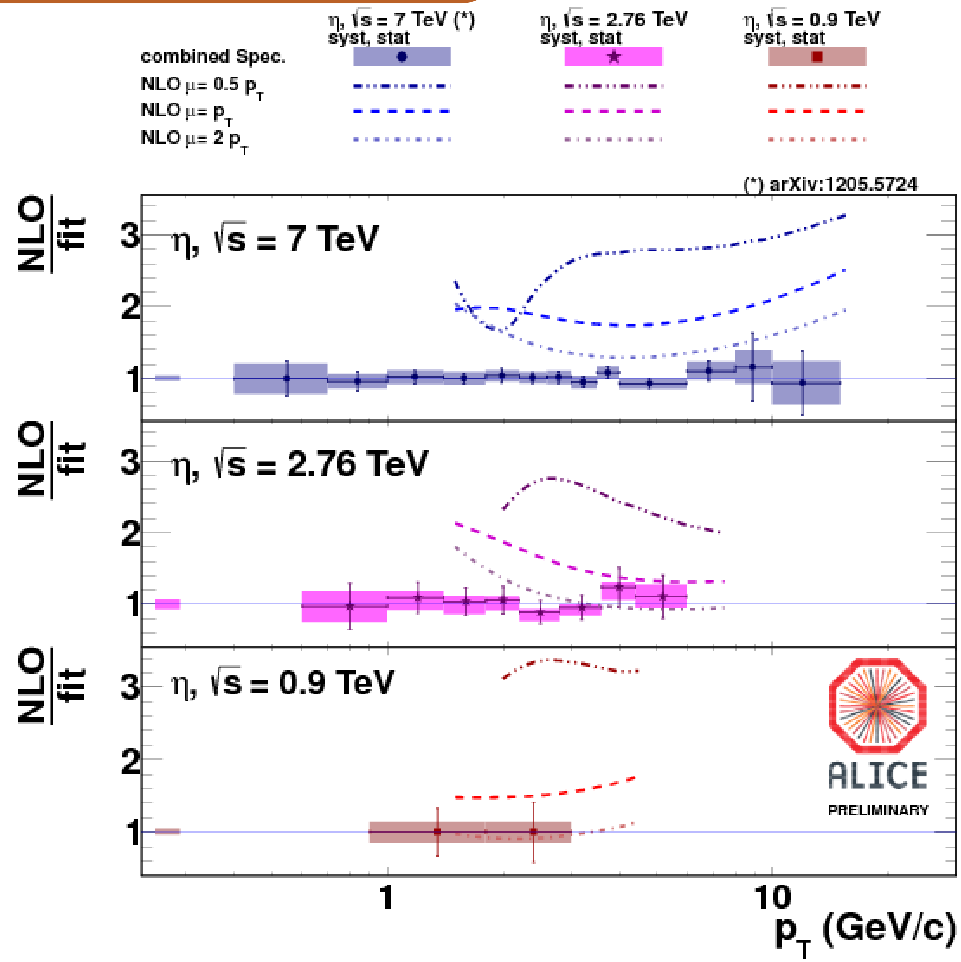
pQCD NLO calculations [*] reproduce data at √s=0.9 TeV, but overestimate π^0 spectrum at √s=2.76 and 7 TeV.

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

η spectrum in pp at 0.9, 2.76, 7 TeV

ALICE data: CERN-PH-EP-2012-001, **Phys.Lett. B717 (2012) 162-172**



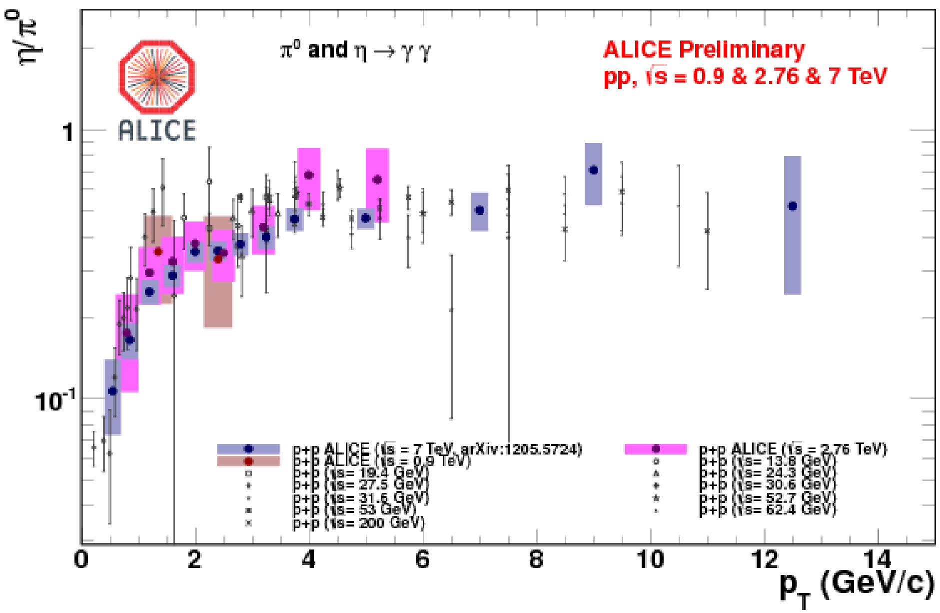


pQCD NLO calculations can reproduce data at √s=0.9 TeV, but overestimate η spectrum at √s=2.76 and 7 TeV.

η/π^0 ratio in pp at 0.9, 2.76, 7 TeV

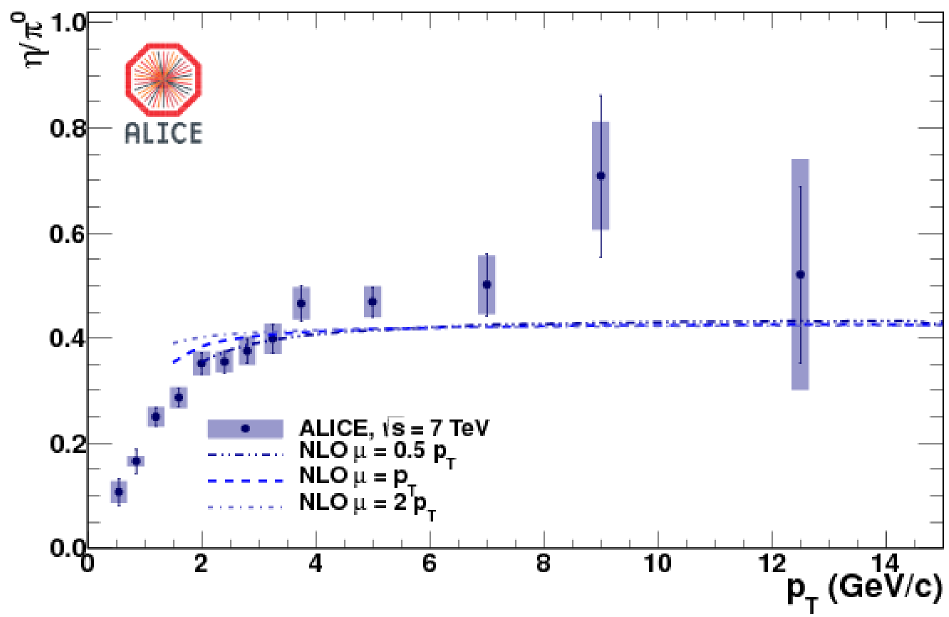
ALICE data: CERN-PH-EP-2012-001, **Phys.Lett. B717 (2012) 162-172**

Compilation of η/π^0 in pp at $\sqrt{s}$=13-7000 GeV



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

Comparison with NLO pQCD



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

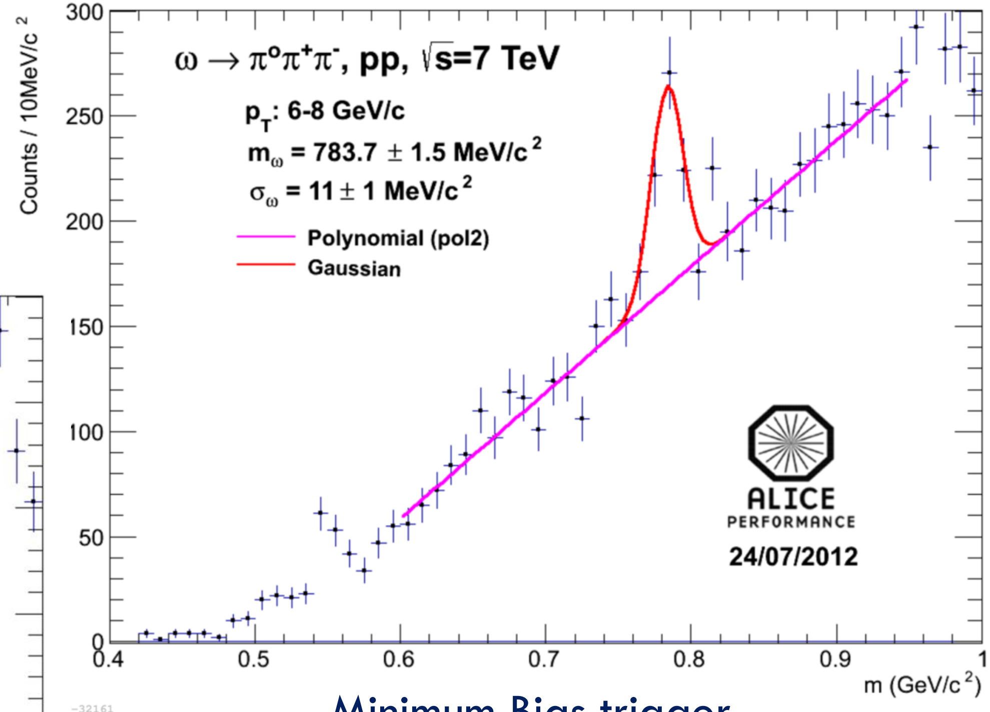
ω reconstruction in pp at 7 TeV

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

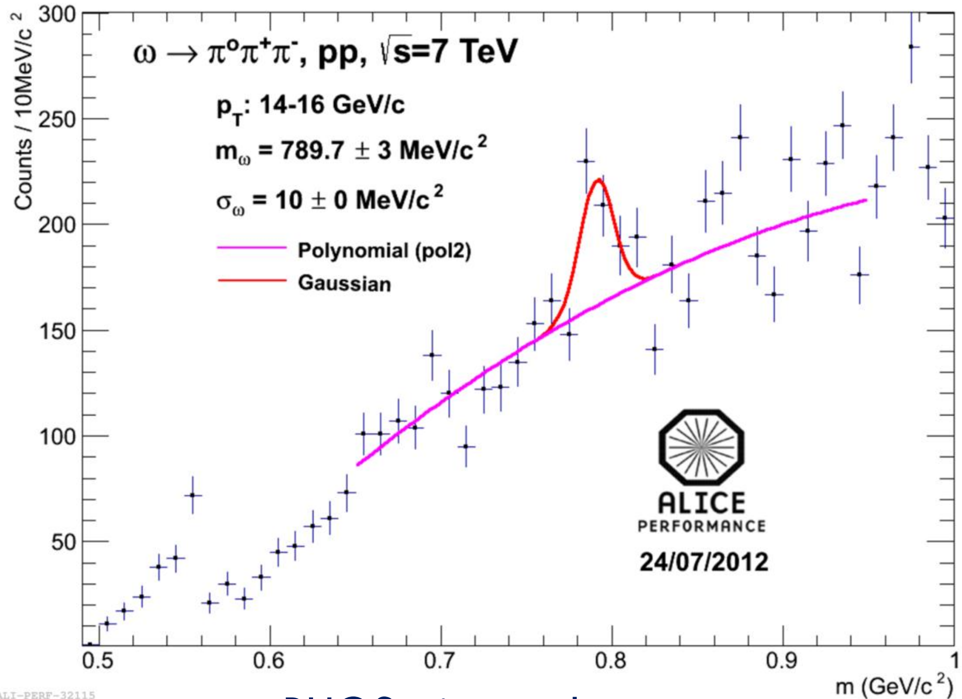
Using $\pi^{\pm}$ reconstructed in Central Tracking System and π^0 – in PHOS

Data collected in 2010:

~400 Mevents, ~ 6 nb^{-1}

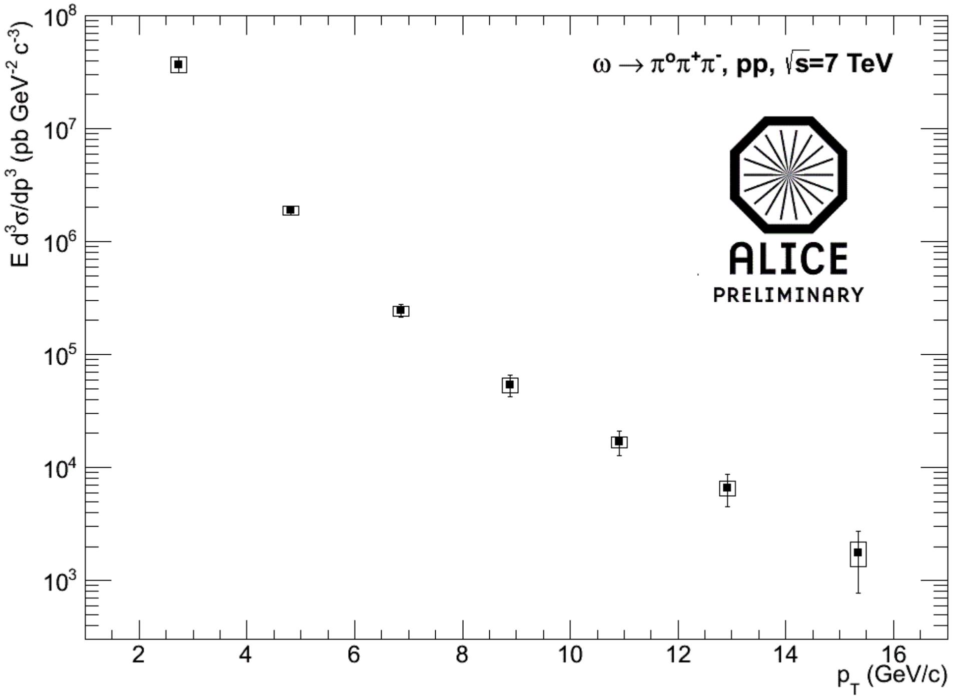


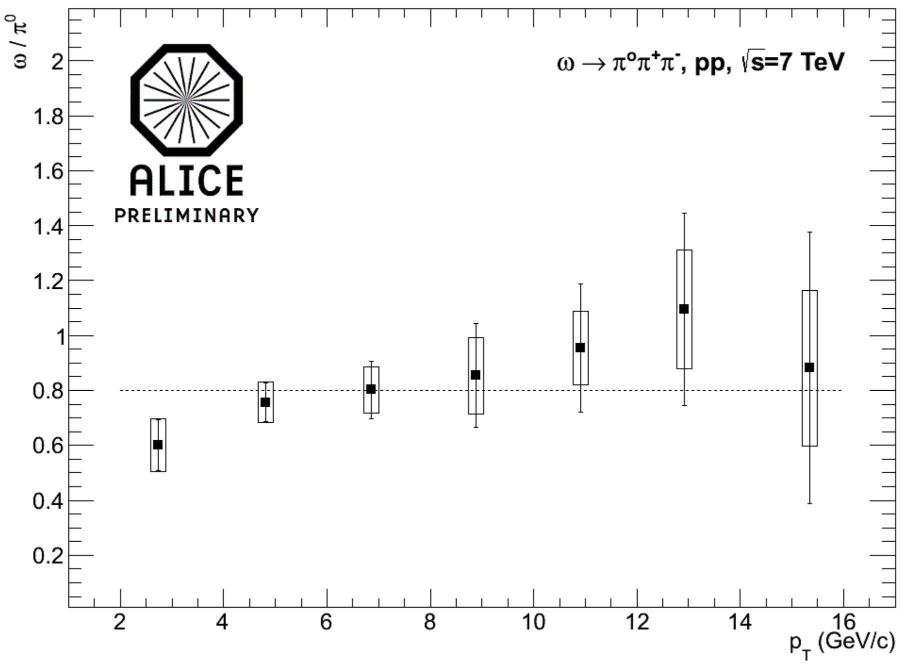
Minimum Bias trigger



PHOS trigger data

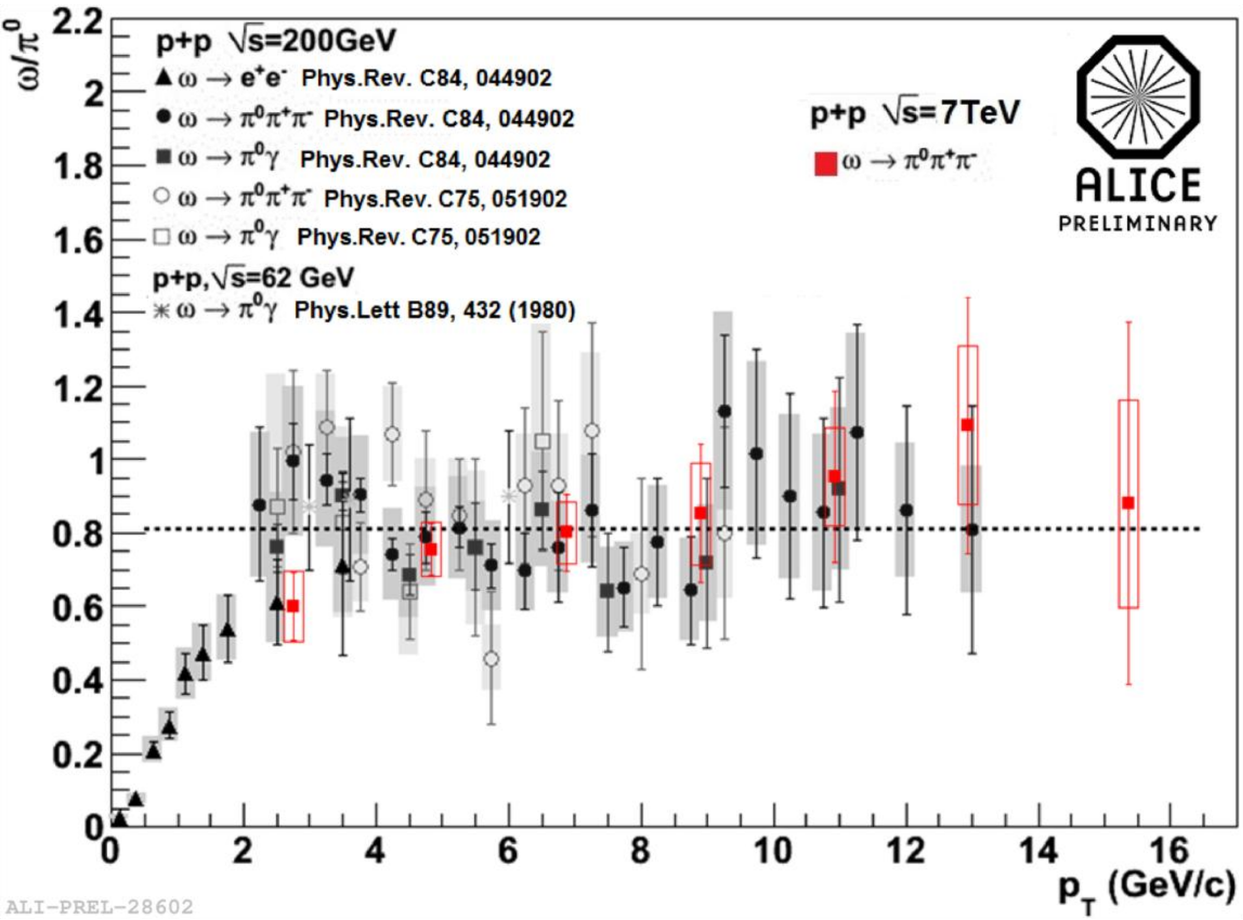
ω spectrum in pp at 7 TeV





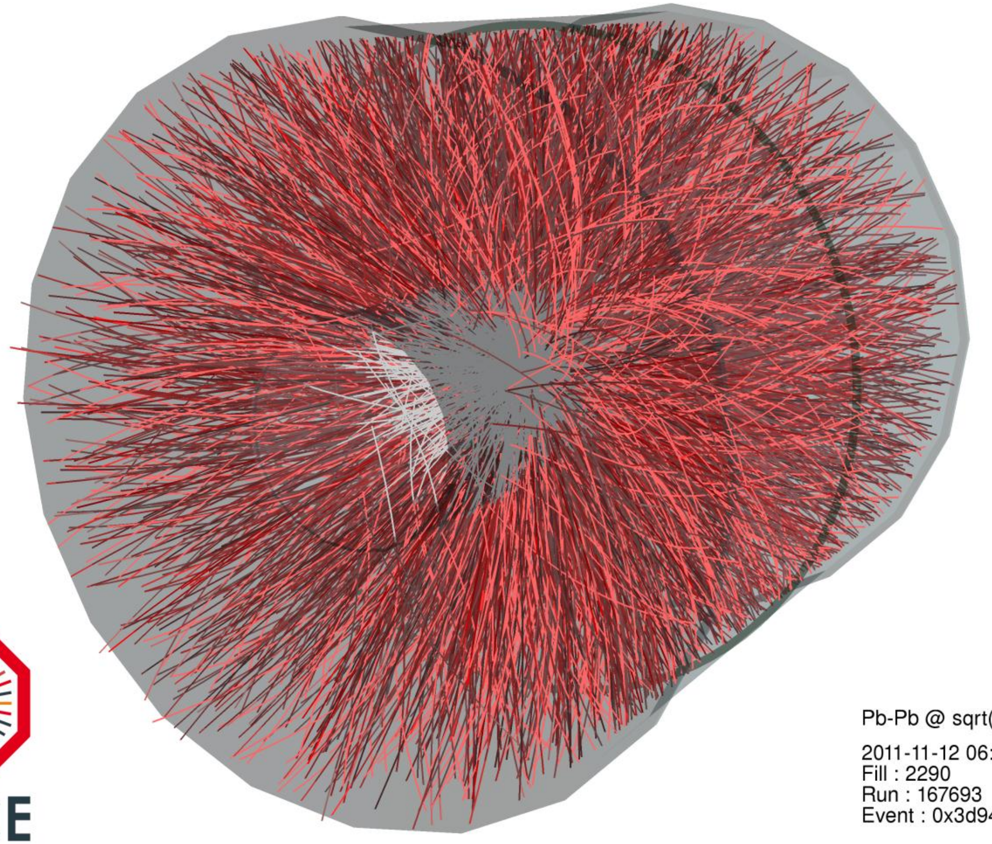
Spectrum of ω has a slope consistent with that of π^0 above 4 GeV/c

Comparison of ω/π^0 ratio

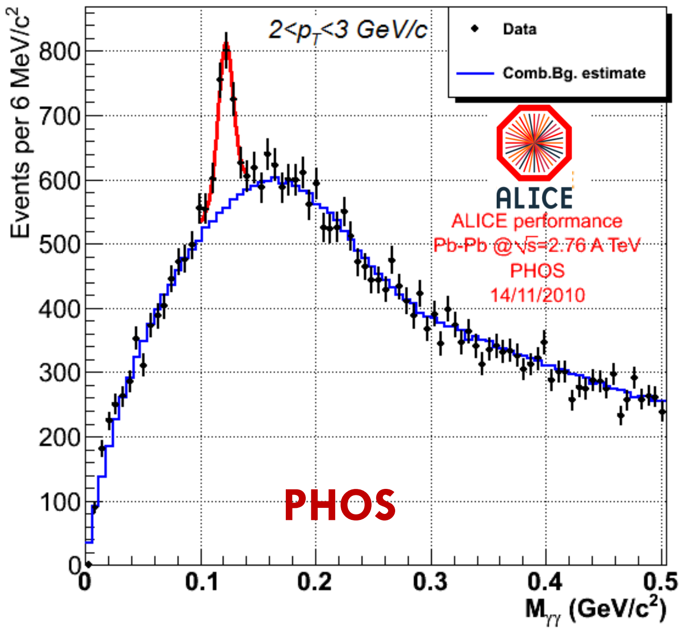


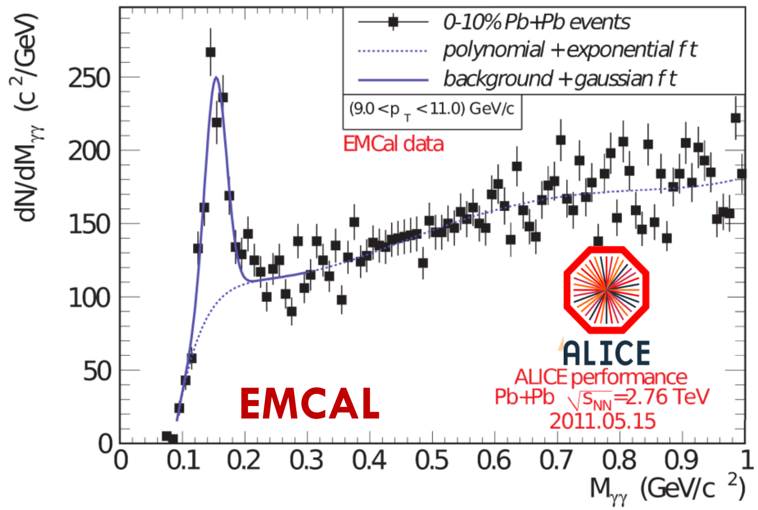
- ALICE measurement of the ω/π^0 ratio is consistent with world results in pp collisions at all energies.
- Comparison to theory prediction would be interesting (NLO Fragmentation Function for ω is missing…)

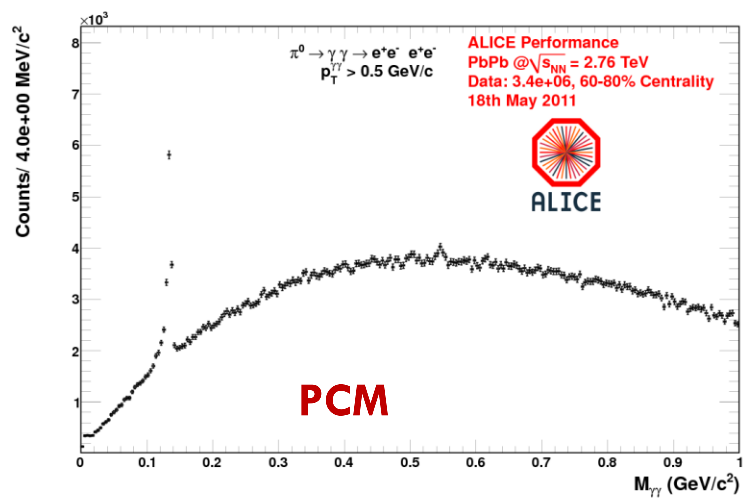
Pb-Pb collisions



π^0 in Pb-Pb

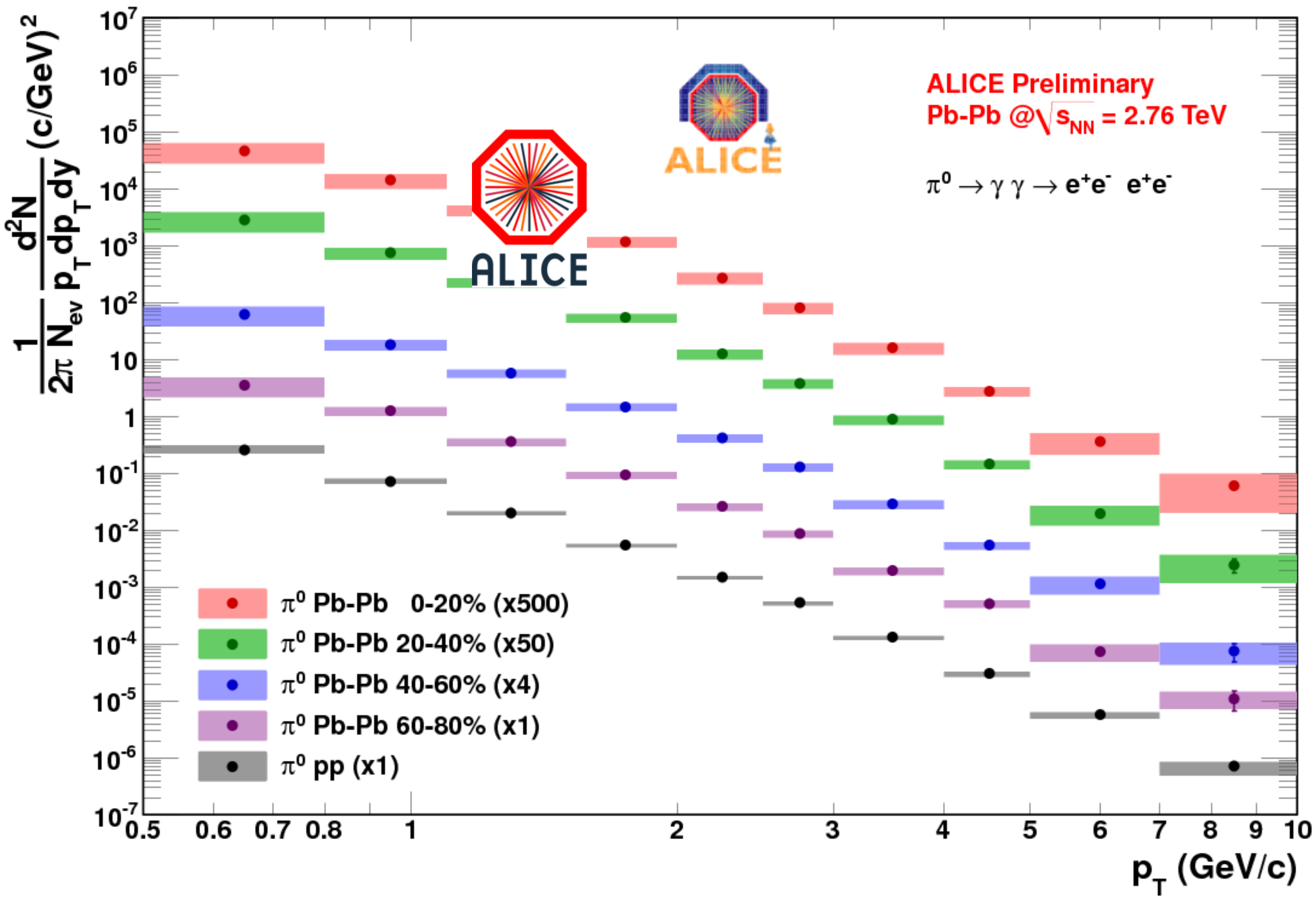






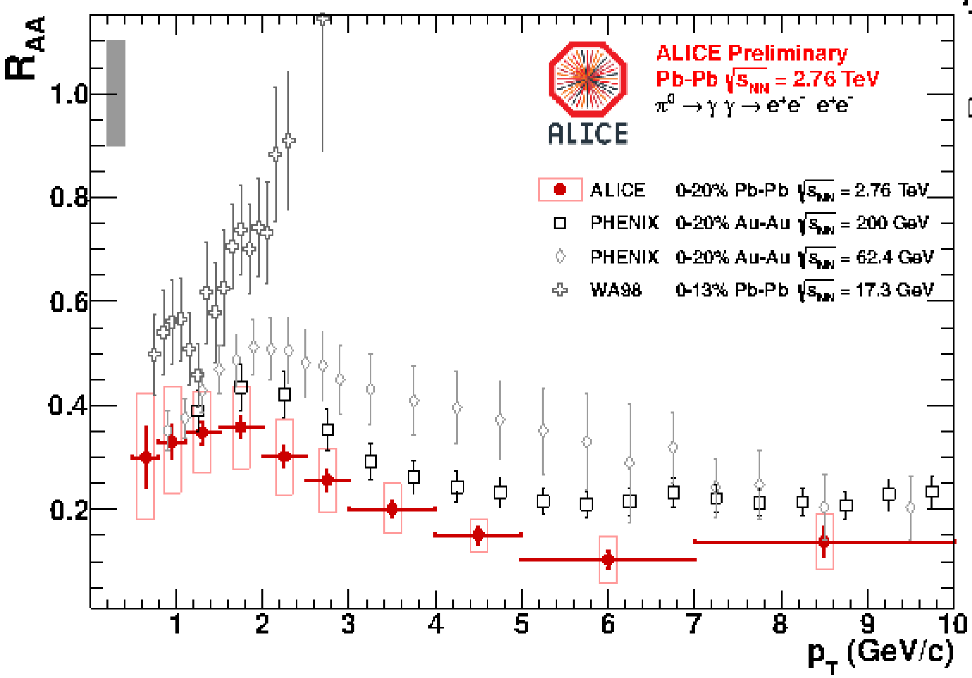
- High combinatorial background in invariant mass spectra.
- Background is evaluated using mixed event technique.
- [PHOS] Efficiency is calculated via embedding.

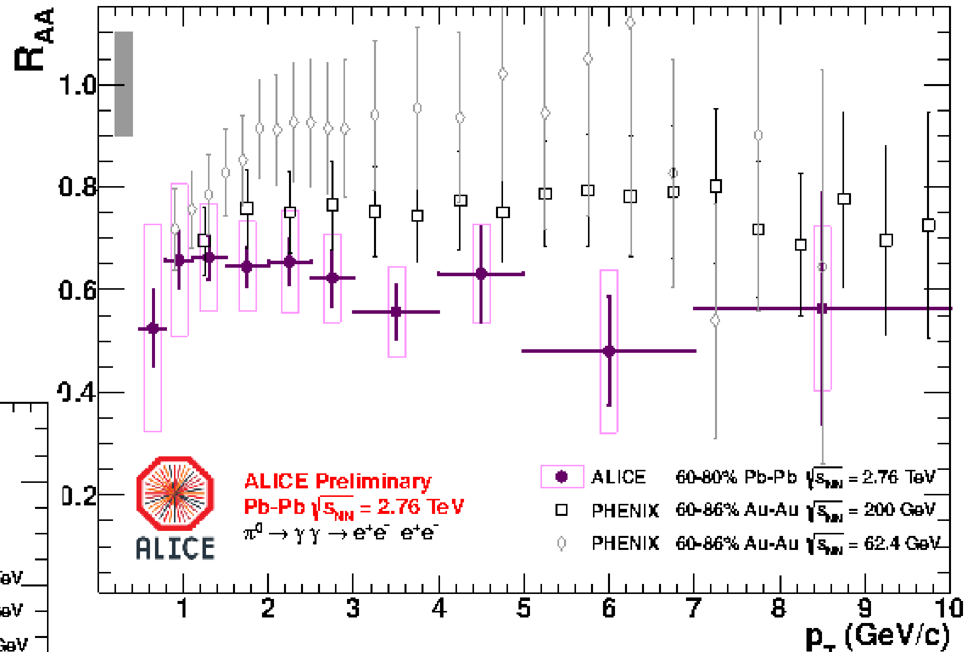
π^0 spectrum in Pb-Pb at 2.76 TeV



π^0 R_{AA} in Pb-Pb at 2.76 TeV

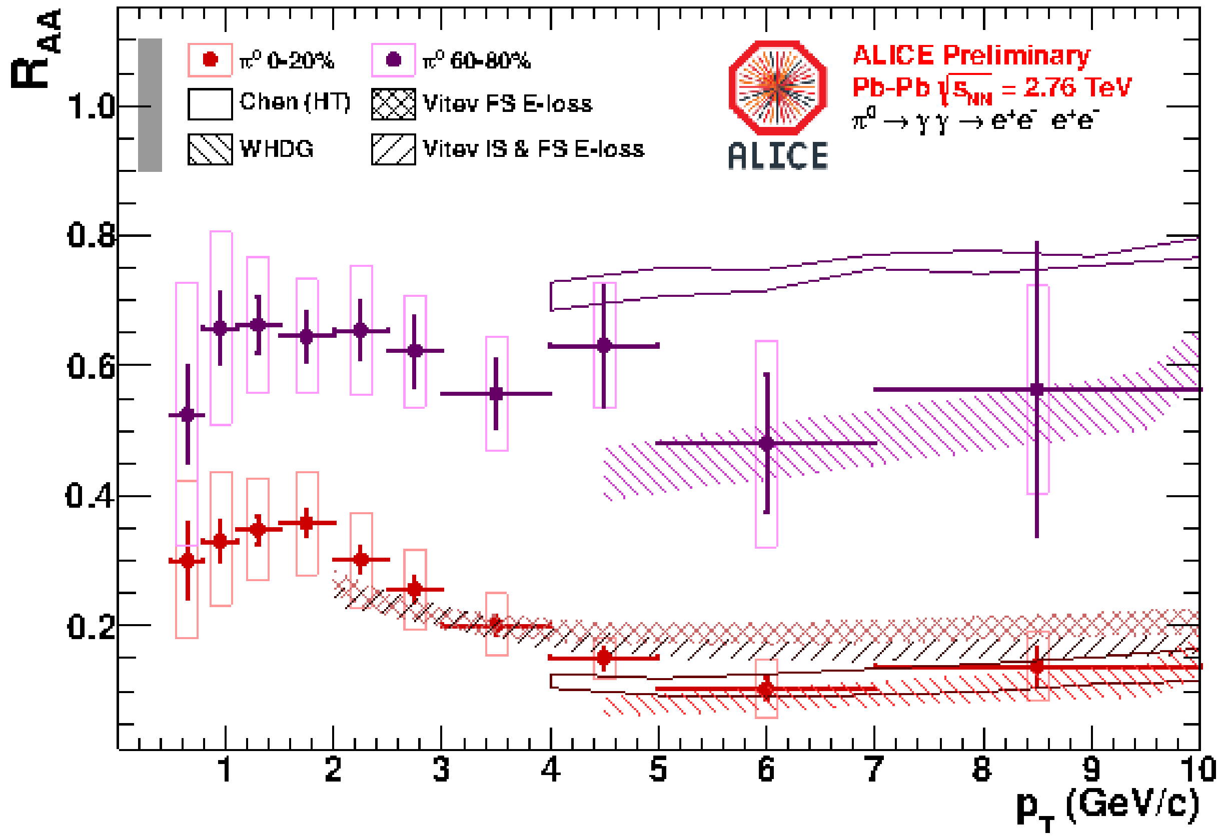
- Suppression follows the energy dependence seen at RHIC energies
- Suppression agrees with charged pion R_{AA} within errors





[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].

Summary

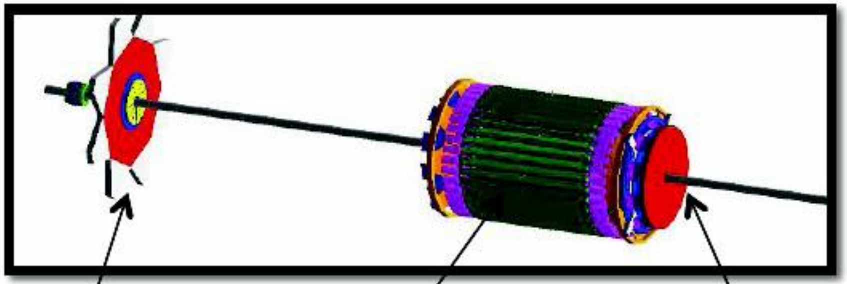
- π^0, η and ω spectra are measured over a wide p_T range
  - Measurements performed by several complementary subsystems
  - NLO pQCD describes π^0, η production in pp at $\sqrt{s}$=0.9 TeV
  - NLO pQCD overestimates π^0, η production in pp at $\sqrt{s}$=2.76 and 7 TeV
  - NLO pQCD describes η/π^0 ratio at all energies
- Suppression of π^0 in Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV is stronger than one observed at RHIC

Backup slides

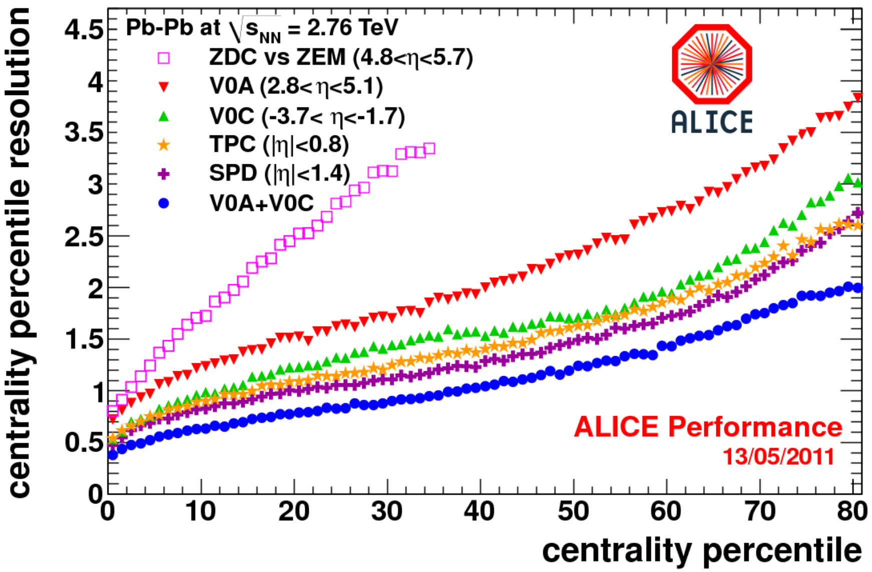
Data samples and trigger

Collision system	$\int L dT$	Run #
pp at $\sqrt{s}$=0.9 TeV	0.14 nb^{-1}	May 2010
pp at $\sqrt{s}$=2.76 TeV	0.7 nb^{-1}	Apr 2011
pp at $\sqrt{s}$=7 TeV	5.5 nb^{-1}	Jun-Aug 2010
Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV	2 μb^{-1}	Nov 2010

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

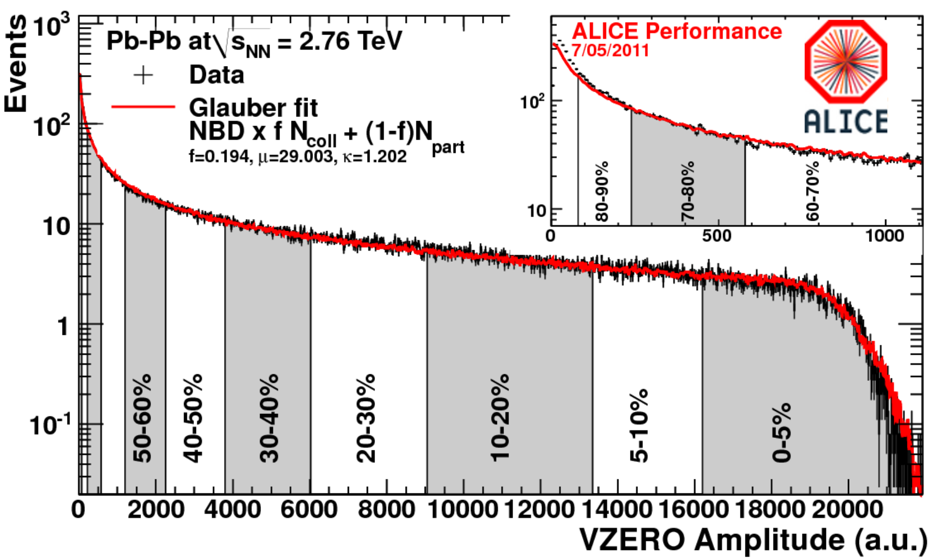


Pb-Pb collisions: event characterization



- Centrality can be determined in ALICE by various estimator.

  [A.Toia et al., ALICE collaboration. J. Phys. G: Nucl. Part. Phys. 38 (2011) 124007]

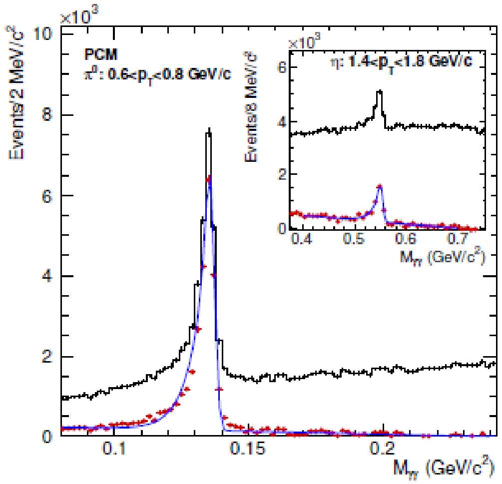


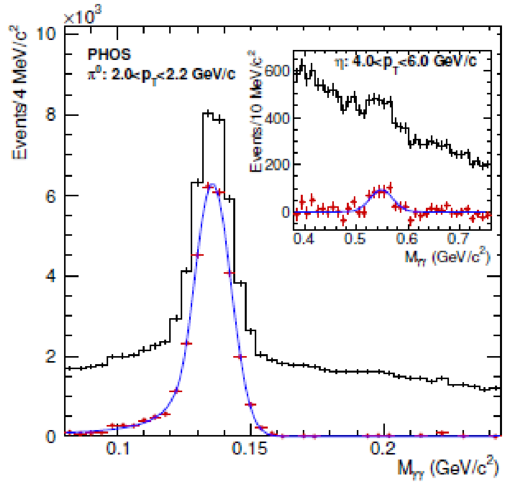
The best centrality accuracy is provided by VZERO: from 0.5% in most central to 1.5% in most peripheral events

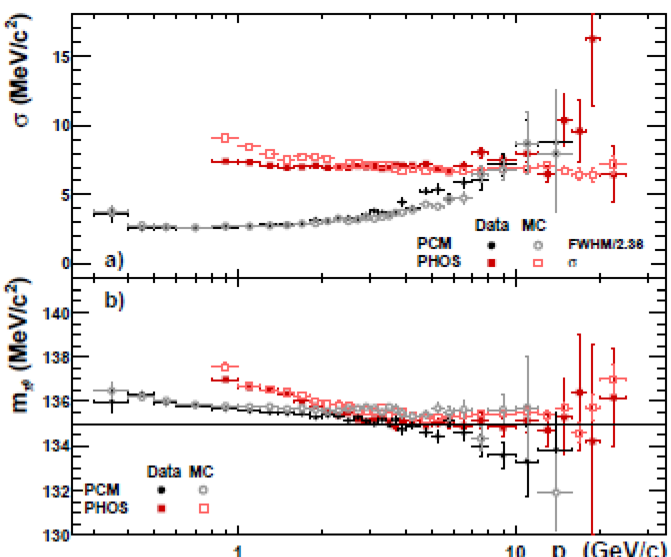
[K.Aamodt et al., ALICE collaboration. PRL, 106, 032301 (2011)]

See M.Floris talk at HP2012

Efficiency and Monte Carlo tuning







- Detailed description of the ALICE environment is important for precise efficiency calculation
- Residual de-calibration and alignment is also taken into account in simulations
- Peak position and width of π^0 and η mesons on invariant mass spectra were used to tune Monte Carlo simulations.

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