Low mass vector meson production in pp, p-Pb and Pb-Pb collisions measured with the ALICE detector

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SQM2013 21-27/07/2103 Birmingham, UK

- pp collisions
  - ϕ cross section at 2.76 TeV (new) and at 7 TeV (PLB 710 (2012) 557)
  - Comparison with models
- Pb-Pb collisions
  - $\phi/(\rho+\omega)$
  - ϕ R_{AA}
  - comparison with results in KK at midrapidity
- Data sample in p-Pb collisions

ϕ production in pp and heavy-ion collisions

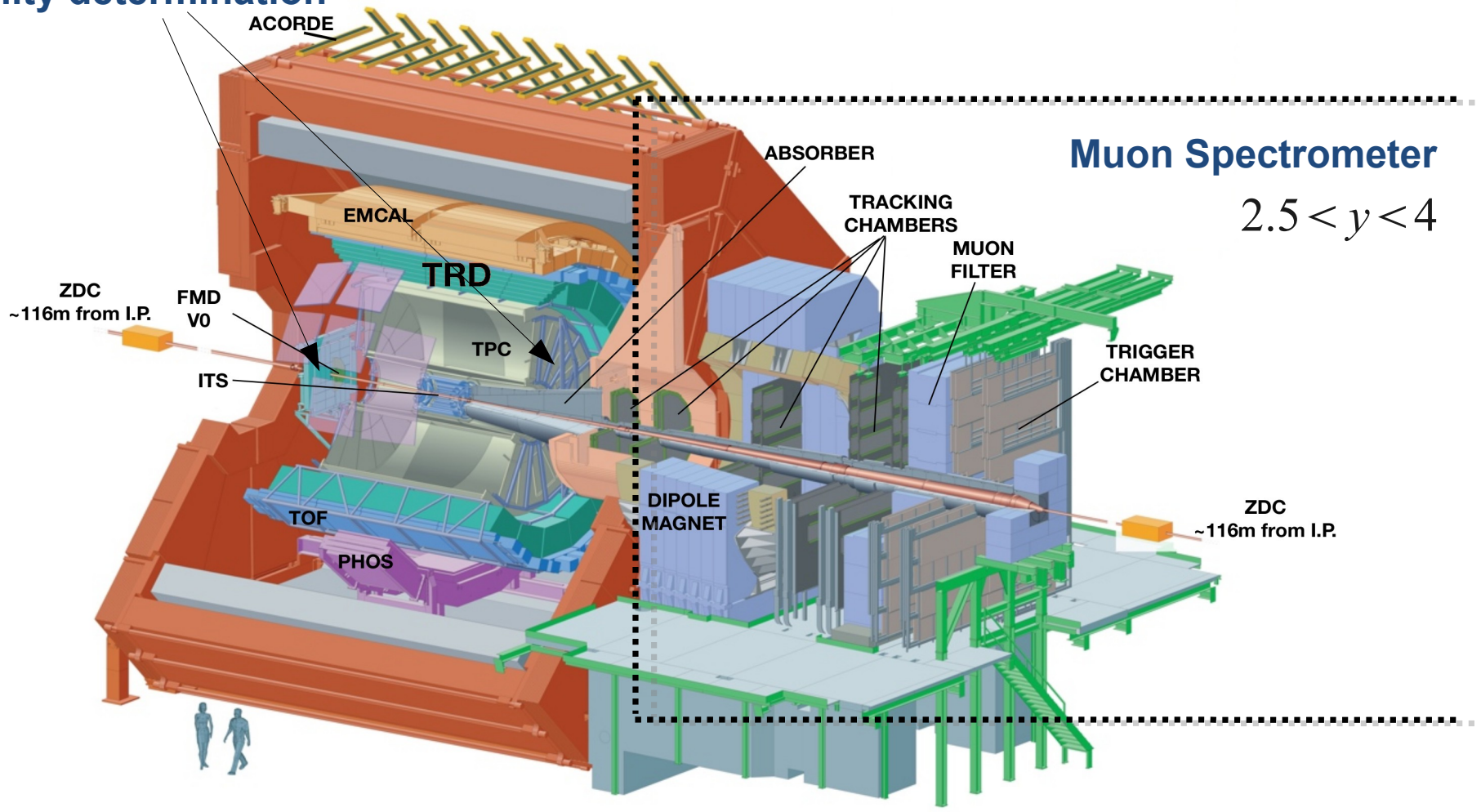
- Strangeness production accessed through ϕ meson
- Dileptons are not influenced by final state interactions
  - No rescattering / absorption on decay products

- Nuclear modification factor for $2<p_T<5$ GeV/c shows the influence of the medium at intermediate transverse momenta

- ϕ production in pp collisions $\rightarrow$ reference for Pb-Pb collisions
- Interesting by itself:
  - tune QCD-inspired phenomenological models to the data
  - determine dependence on $\sqrt{s}$

ALICE detector

VZERO scintillators
centrality determination



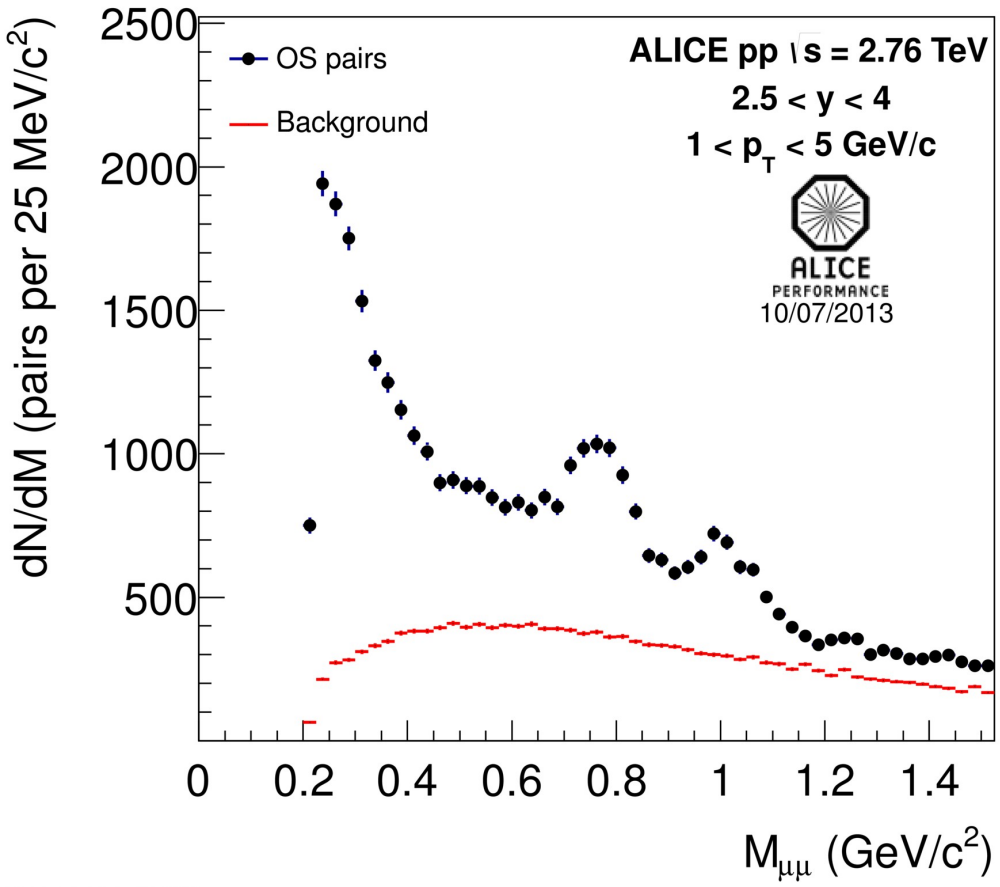
Dimuon trigger provided by the coincidence of two single muon trigger signals with a $p_{T,\mu}$ threshold at about 0.5 GeV/c (pp) or 1 GeV/c (Pb-Pb)

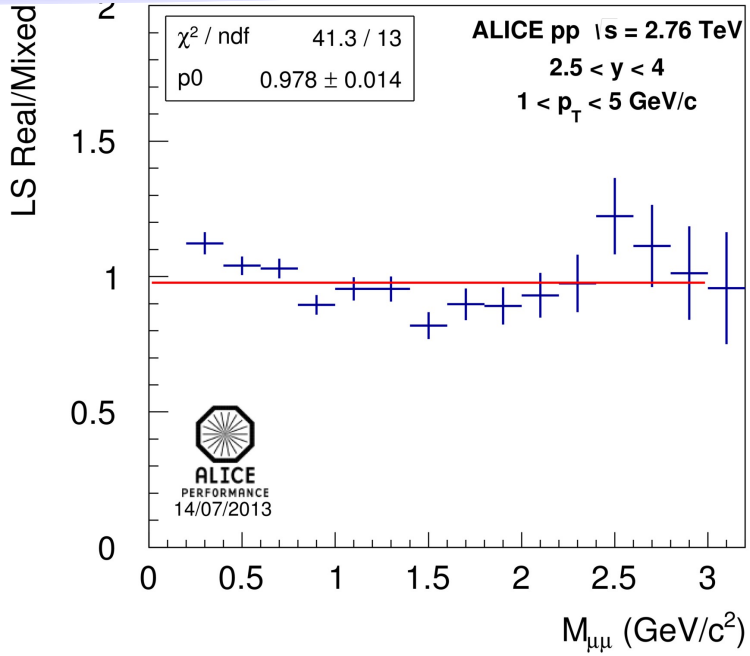
pp collisions at 2.76 TeV

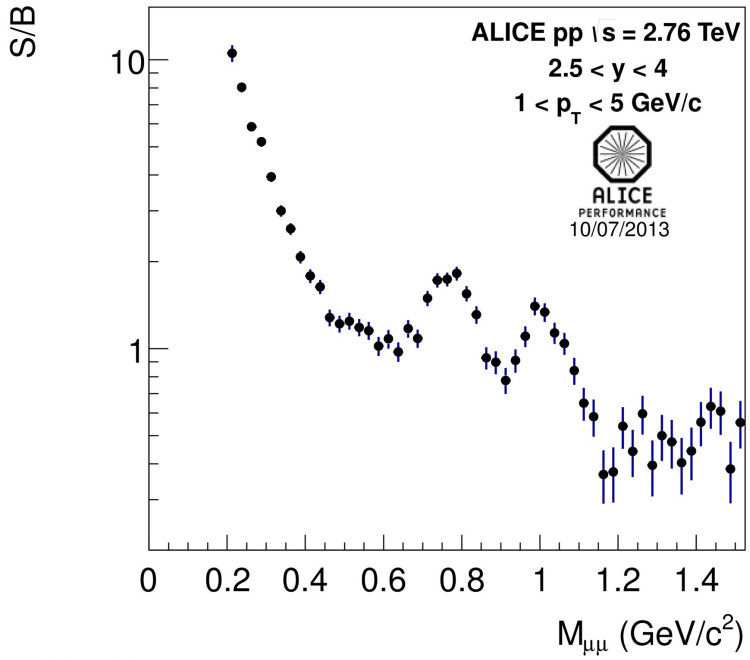
- Data taken in 2011 (17.6 nb^{-1}) and in 2013 (81.1 nb^{-1})
- Analysis of opposite sign muon pairs
  - Cuts for beam-gas interactions
  - Each muon track is required to match a tracklet in the muon trigger (trigger threshold ~ 0.5 GeV/c)
  - Cut on the acceptance borders: $2.5 < \eta_\mu < 4$
- Like-sign muon pairs are used for background normalization
- Number of muon pairs satisfying the selections
  - in 2013: $N_{OS} \sim 98000$, $N_{LS} \sim 48000$
  - in 2011: $N_{OS} \sim 19500$, $N_{LS} \sim 10000$
- Combinatorial background evaluated through event mixing

OS mass spectrum in pp collisions (2013 data)

- Quality of combinatorial background subtraction estimated using the ratio between LS real and mixed pairs
  Uncertainty of ~2% on bkg normalization
- S/B at the ϕ and $\rho+\omega$ mass peaks ~ 2

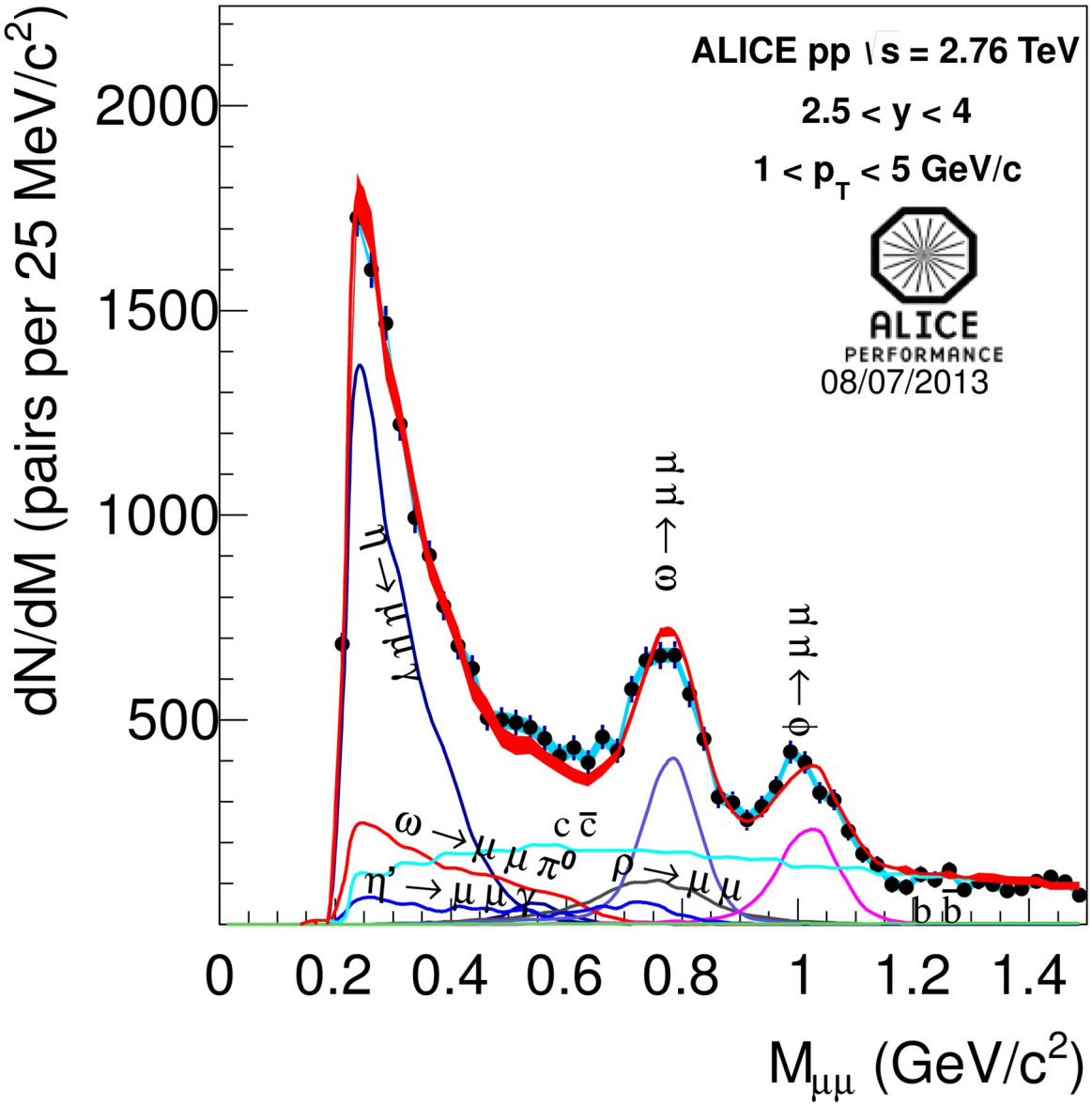






Fit to the invariant mass spectrum (2013 data)

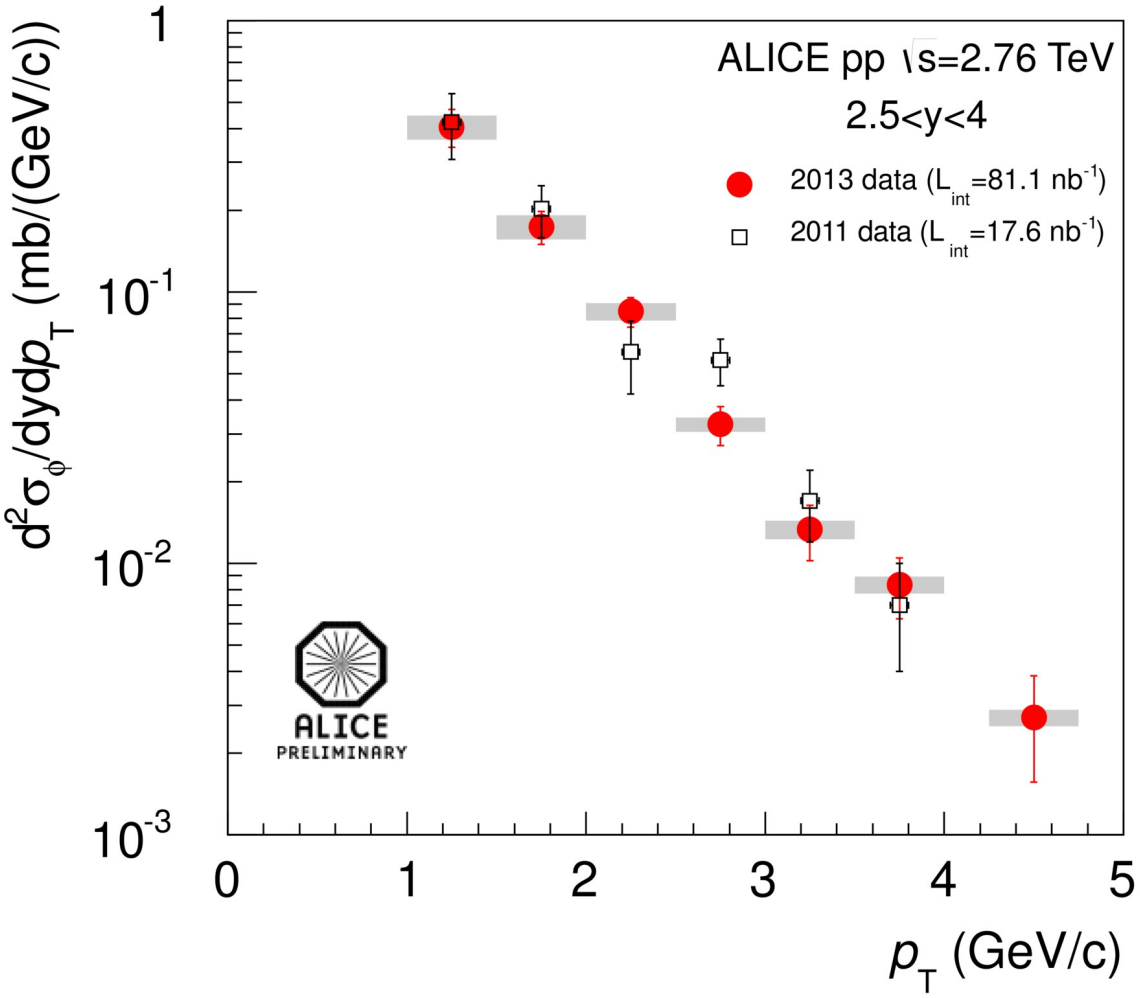
- **Free parameters of the fit:**
  - $\eta \rightarrow \mu\mu\gamma$ normalization
  - $\omega \rightarrow \mu\mu$ normalization
  - $\phi \rightarrow \mu\mu$ normalization
  - open charm normalization
- $\sigma(\rho)/\sigma(\omega)$ ratio fixed to 1
- $\eta \rightarrow \mu\mu$ / $\eta \rightarrow \mu\mu\gamma$ and $\omega \rightarrow \mu\mu\pi^0$ / $\omega \rightarrow \mu\mu$ fixed to the BR ratios
- Light blue band: systematic uncertainty on signal (BKG normalization)
- Red band: systematic uncertainty on sources



$$N_{\phi} = 1373 \pm 97$$

ϕ differential cross section in pp

- Good agreement between measurements in 2011 and 2013



ALI-DER-51818

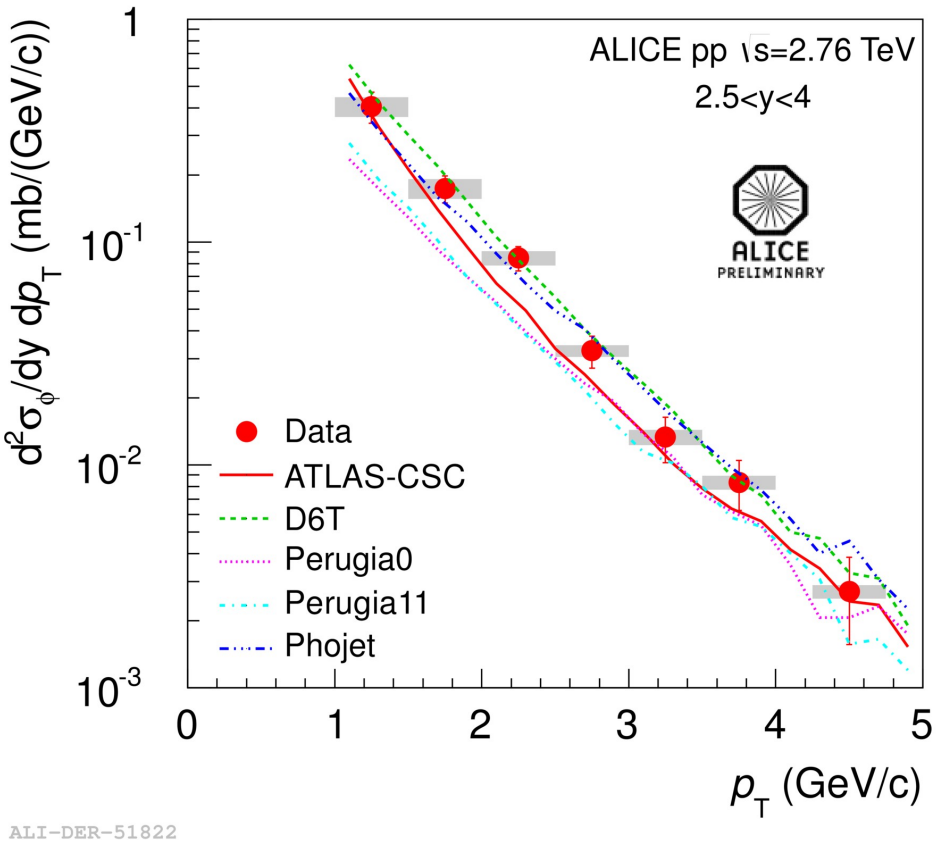
$$\sigma_{\phi}(1<p_T<5\,\mathrm{GeV}/c,\,2.5<y<4)=0.542\pm0.052\,(\mathrm{stat.})\pm0.043\,(\mathrm{syst.})\ \mathrm{mb}$$

$$\sigma_{\phi}(2<p_T<5\,\mathrm{GeV}/c,\,2.5<y<4)=0.1082\pm0.0095\,(\mathrm{stat.})\pm0.0071\,(\mathrm{syst.})\ \mathrm{mb}$$

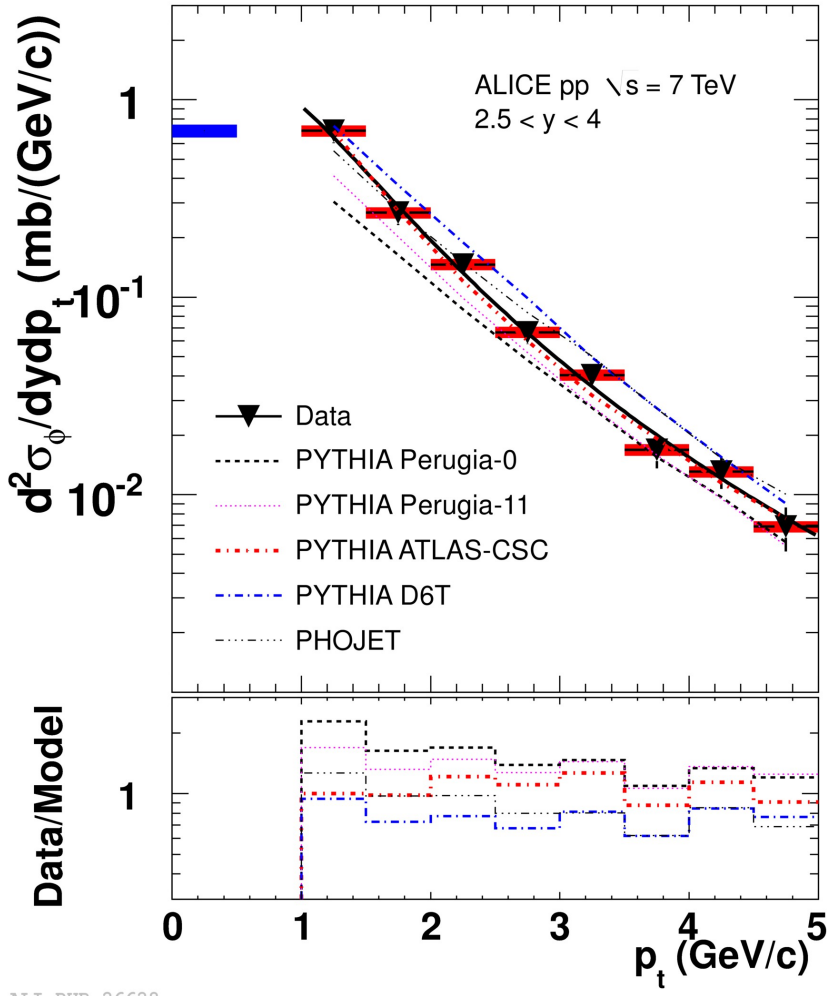
Grey boxes: systematic uncertainty

ϕ differential cross section in pp vs models

pp collisions √s=2.76 TeV



pp collisions √s=7 TeV

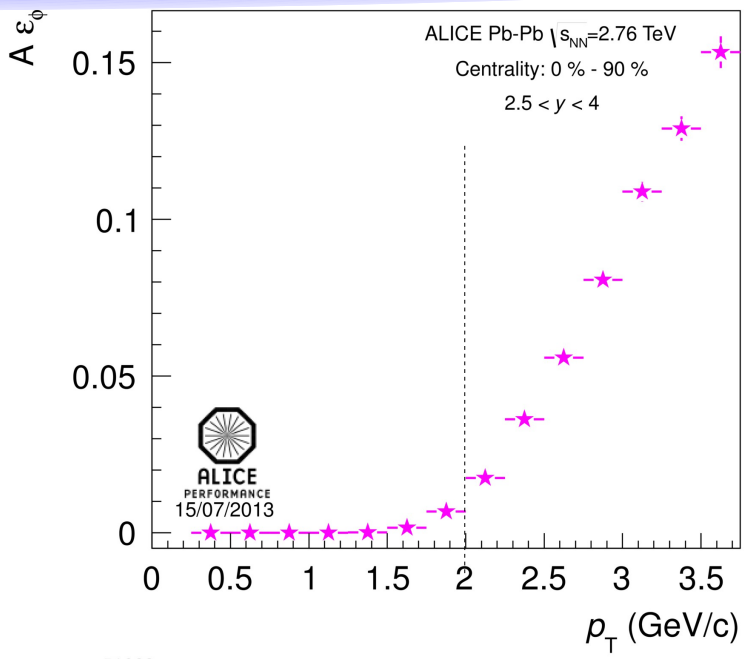


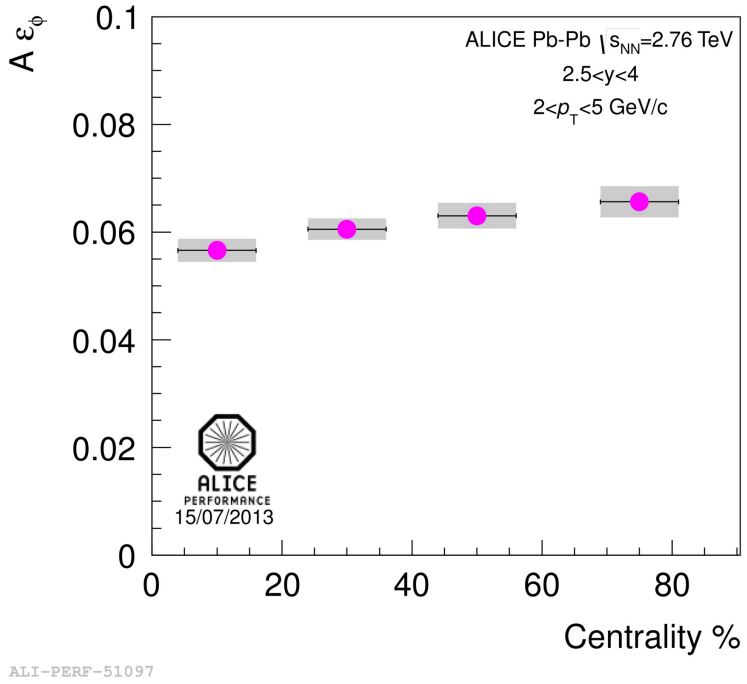
Phys. Lett. B 710 (2012), pp. 557-568

PYTHIA tunes Perugia-0 and Perugia-11 underestimate the data by about a factor of 2 both at 2.76 and 7 TeV
PHOJET and PYTHIA tunes ATLAS-CSC and D6T agree with the measurement within ~15%

Data sample and selection in Pb-Pb collisions

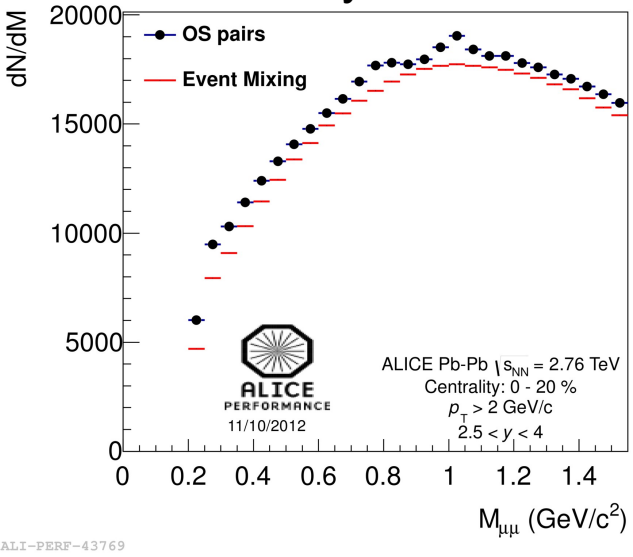
- Data sample collected in Pb-Pb collisions at 2.76 TeV in 2011
- Analysis of opposite sign muon pairs similar to the one in pp, but:
  - Trigger threshold in $p_{T,\mu}$ at ~ 1 GeV/c
  - Cut on single muons: $p_{T,\mu} > 0.85$ GeV/c
  - Low acceptance at low p_T: analysis limited to dimuon p_T>2 GeV/c
- Number of muon pairs satisfying the selections: $N_{OS} \sim 2 \cdot 10^6$, $N_{LS} \sim 1.9 \cdot 10^6$



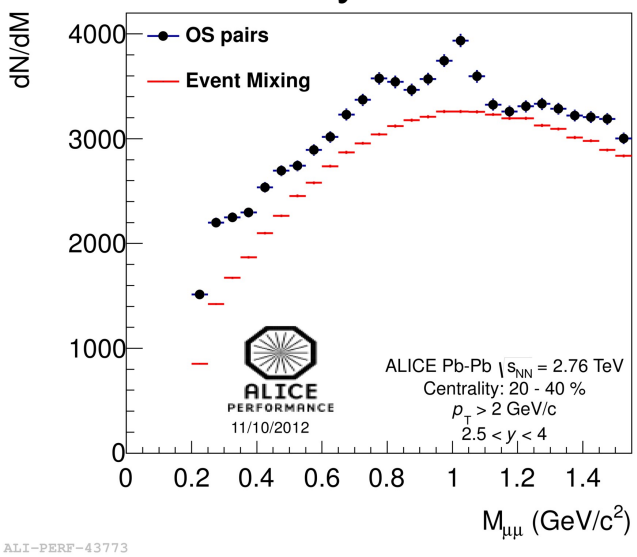


OS mass spectrum and background in Pb-Pb

Centrality: 0-20%



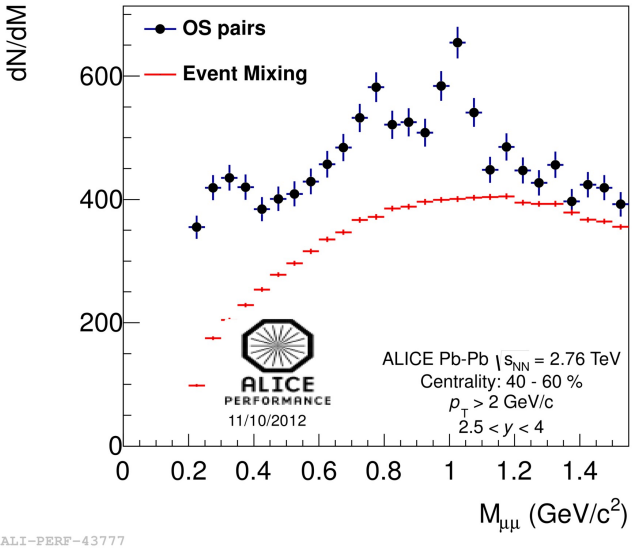
Centrality: 20-40%



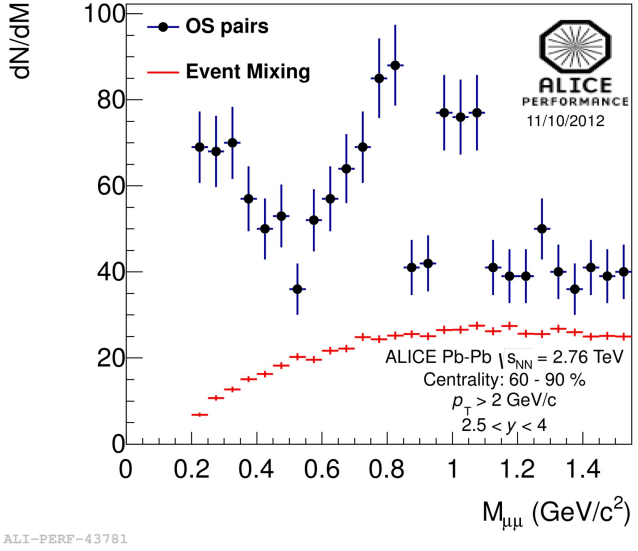
OS dimuon mass spectra and background for p_T>2 GeV/c

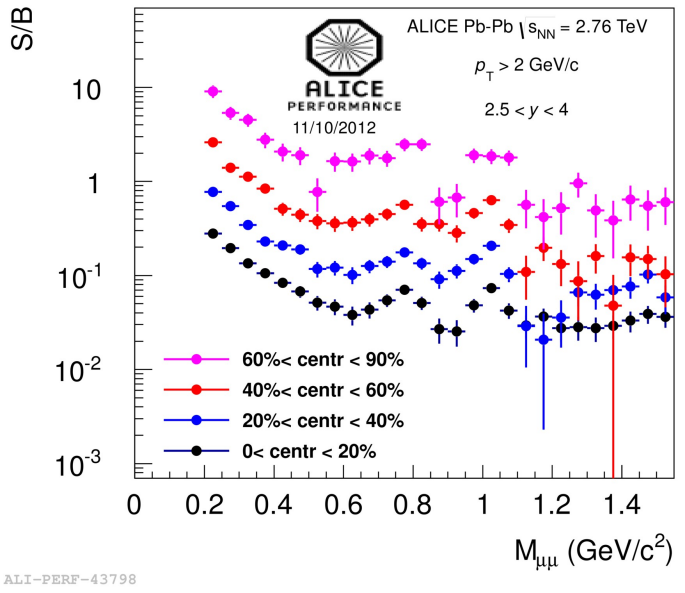
S/B at the ϕ mass ranges from less than 10% (central collisions) to ~3 (peripheral collisions)

Centrality: 40-60%



Centrality: 60-90%

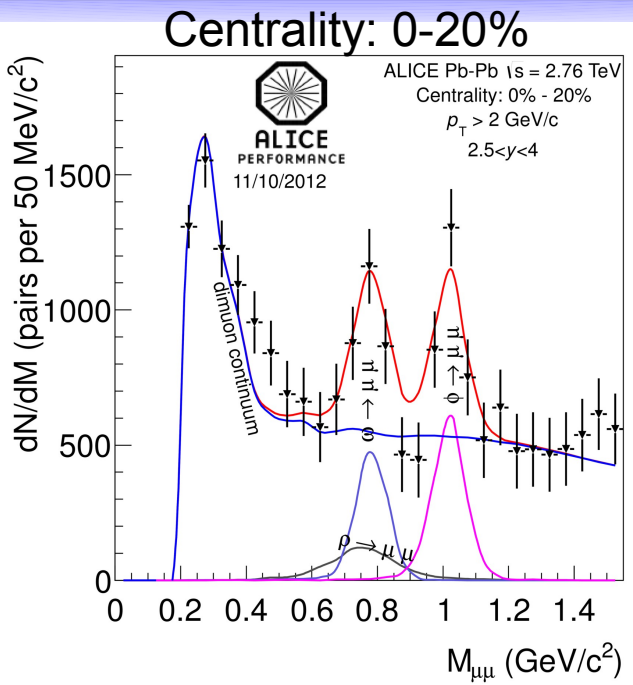


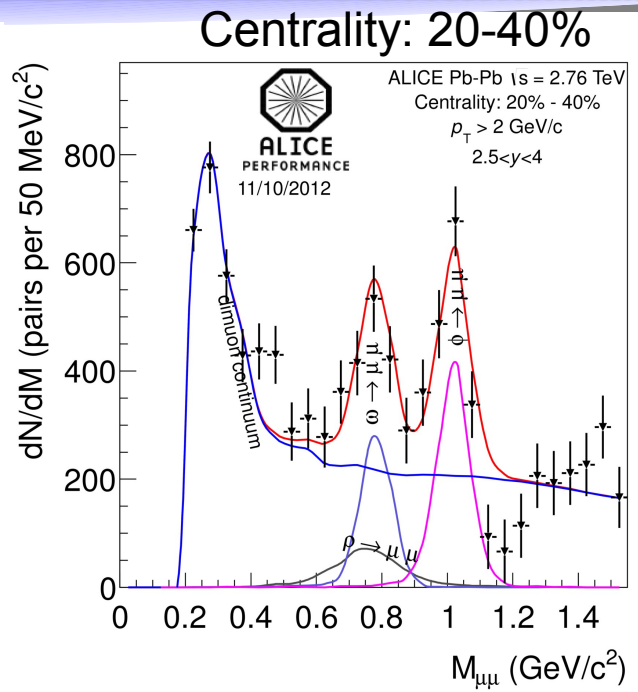


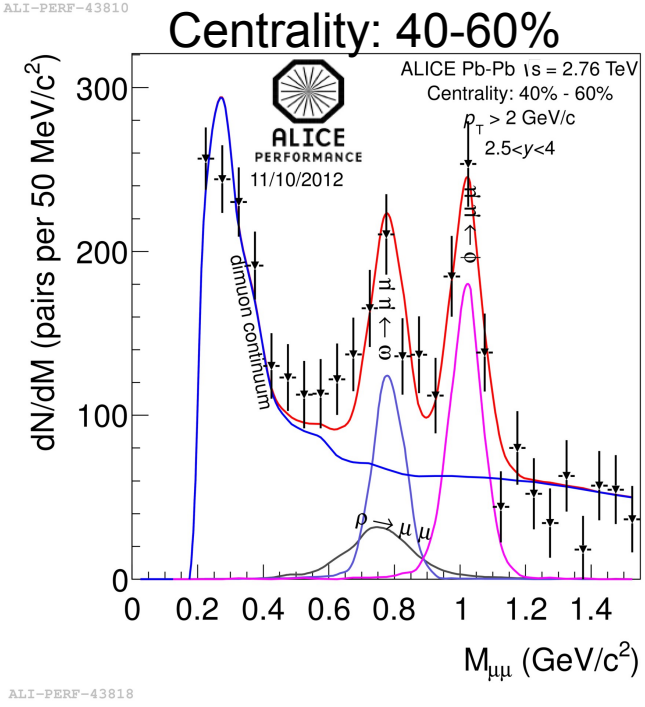
Raw signal mass spectra vs centrality

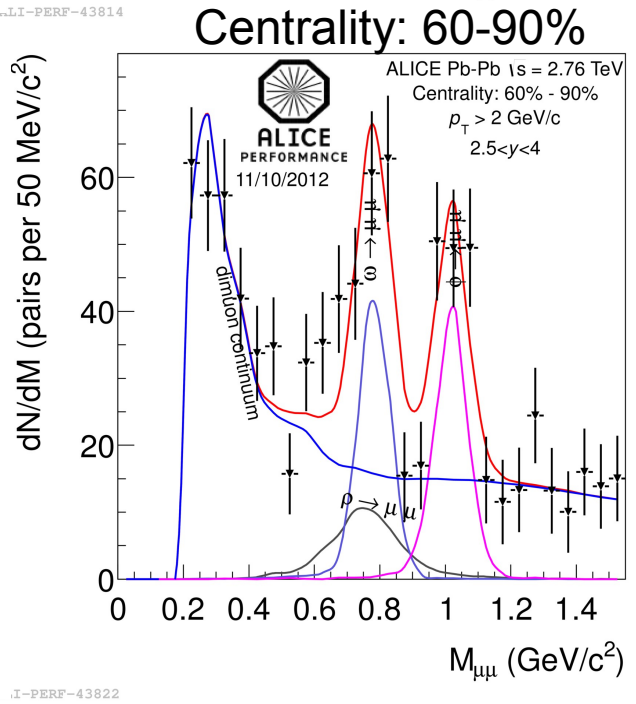
Mass spectra in different centrality bins for dimuon p_T > 2 GeV/c

Correlated background (blue line) described as an empirical continuum



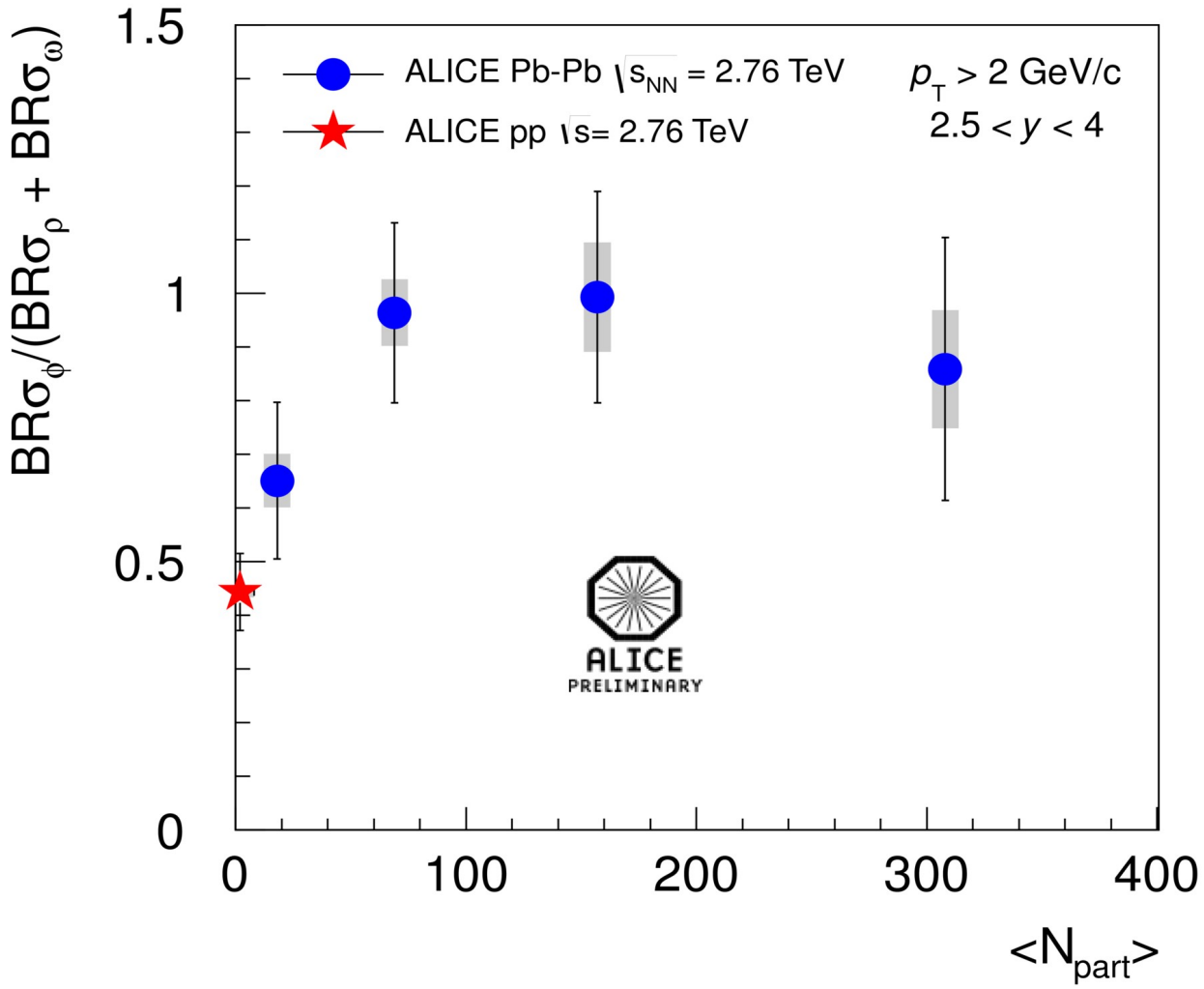






$N_{(\phi\rightarrow\mu\mu)}/N_{(\rho+\omega\rightarrow\mu\mu)}$

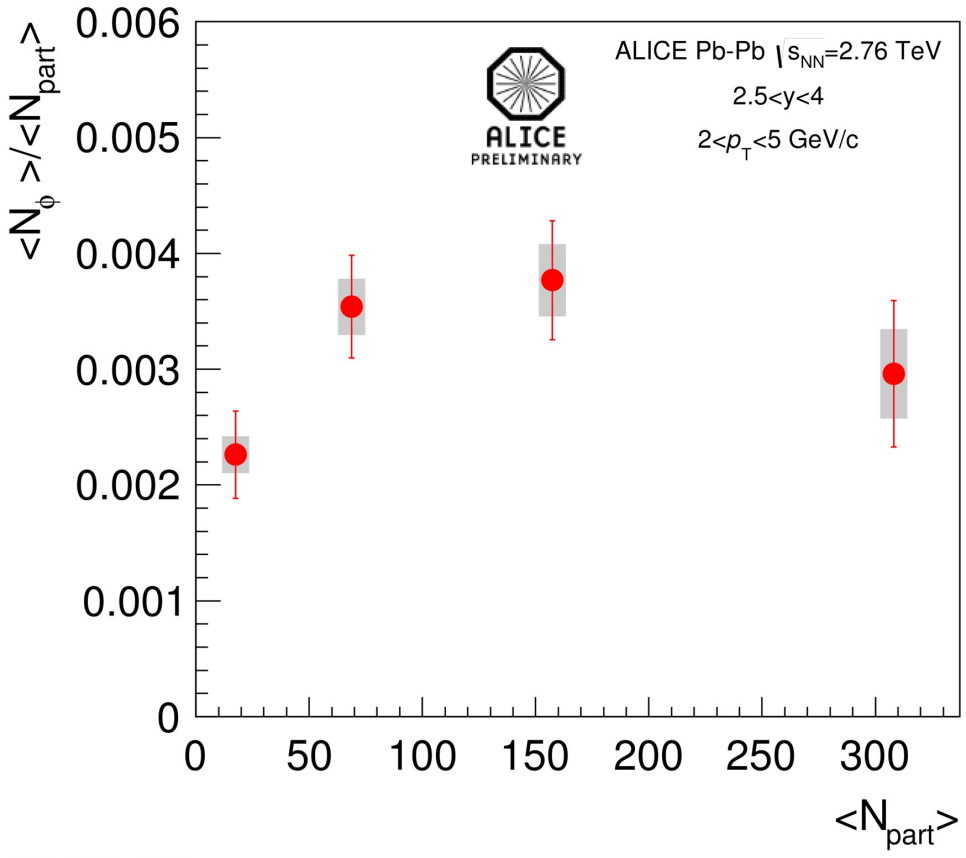
- Increase of the ratio BR σ_ϕ/(BR σ_ρ + BR σ_ω) with respect to pp collisions
- Ratio tends to saturate from semiperipheral to central collisions



ALI-PREL-43838

ϕ yield vs centrality and p_T

- Yield/N_{part} vs N_{part} for $2<p_T<5$ GeV/c: increase from peripheral to semi-central collisions
- Centrality-integrated yield vs p_T: within the errors, same trend as in KK at midrapidity, shown by the fit function



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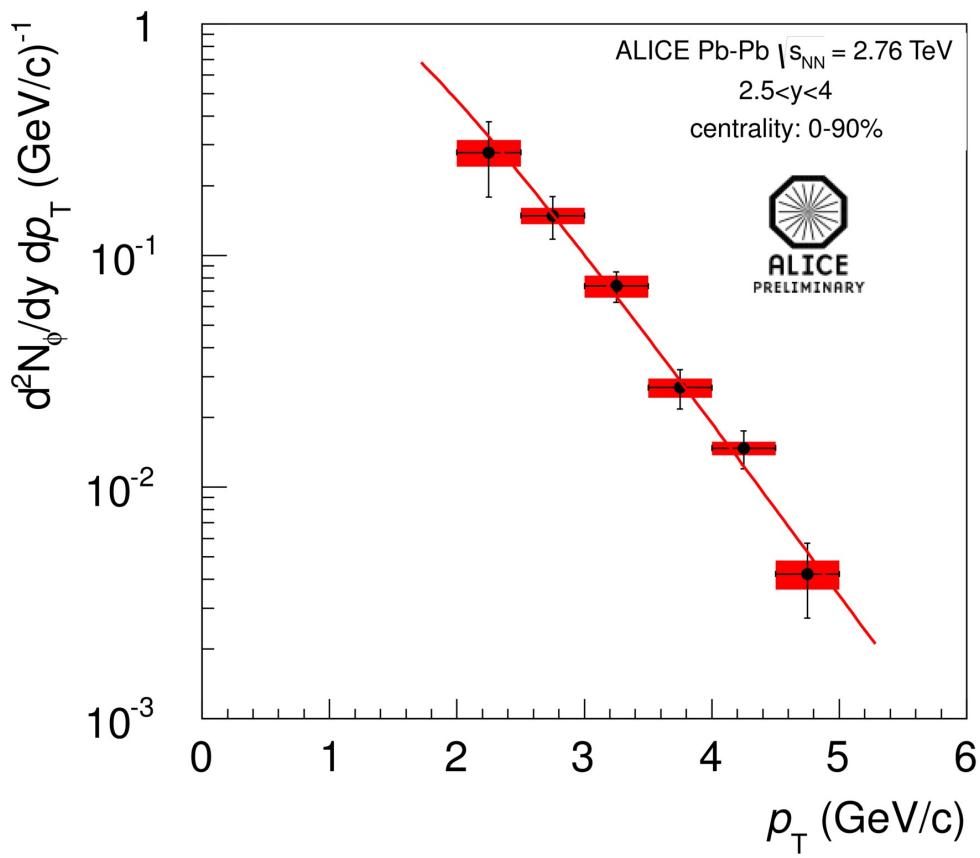

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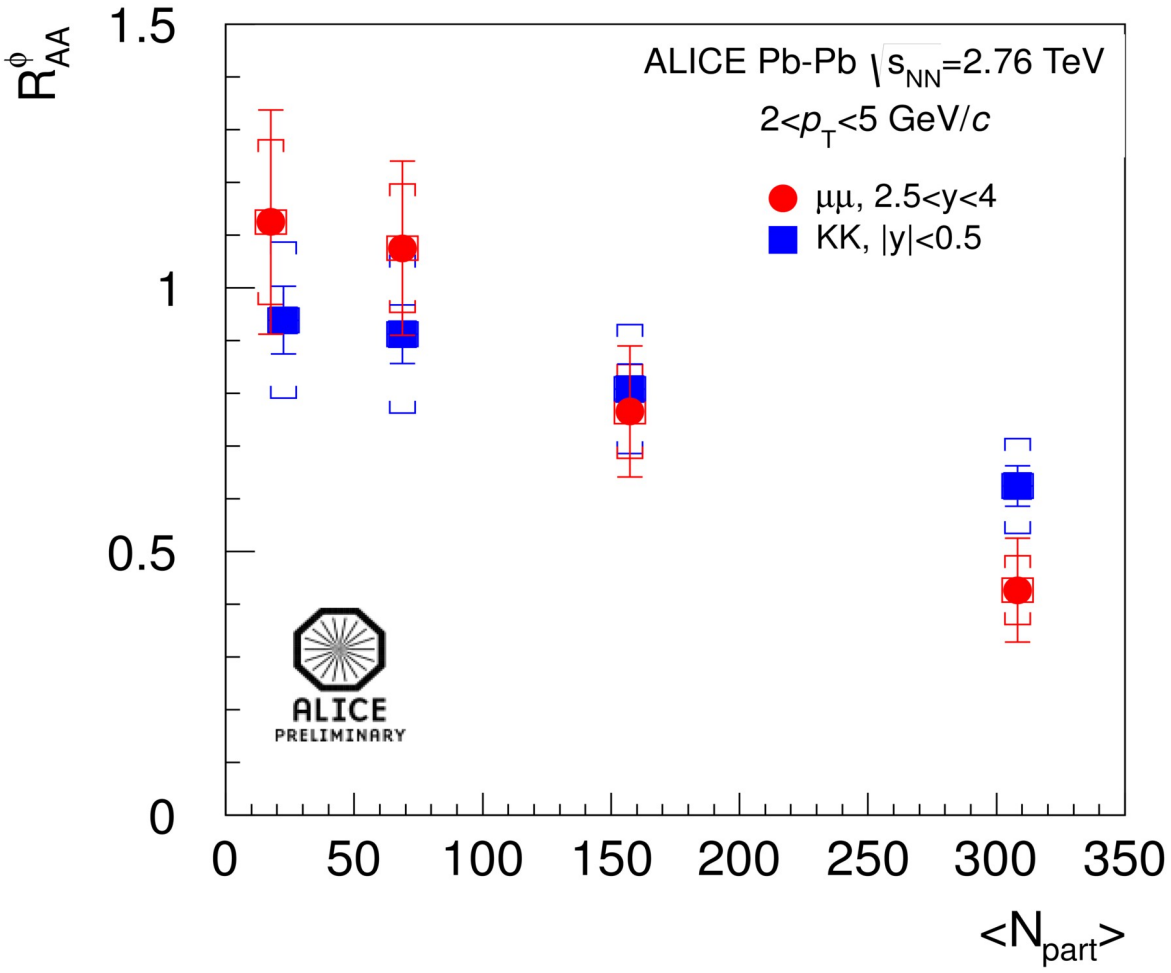
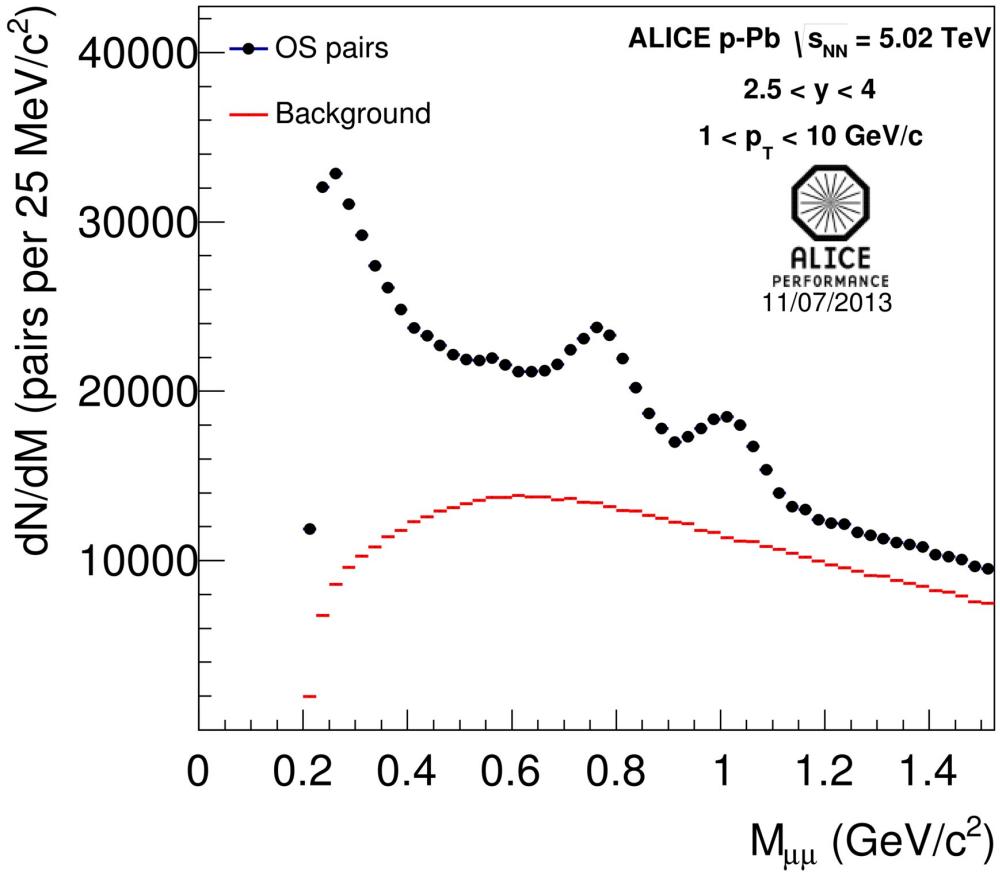
ϕ R_{AA}

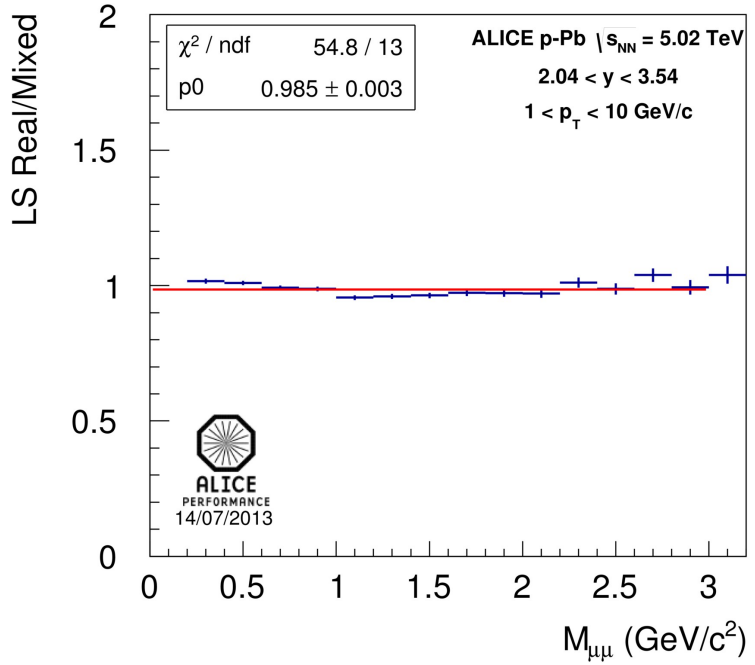
- Measurements in $\mu\mu$ at forward rapidity and in KK at midrapidity in agreement within the errors
- No indication for strong absorption/rescattering effects in the KK channel

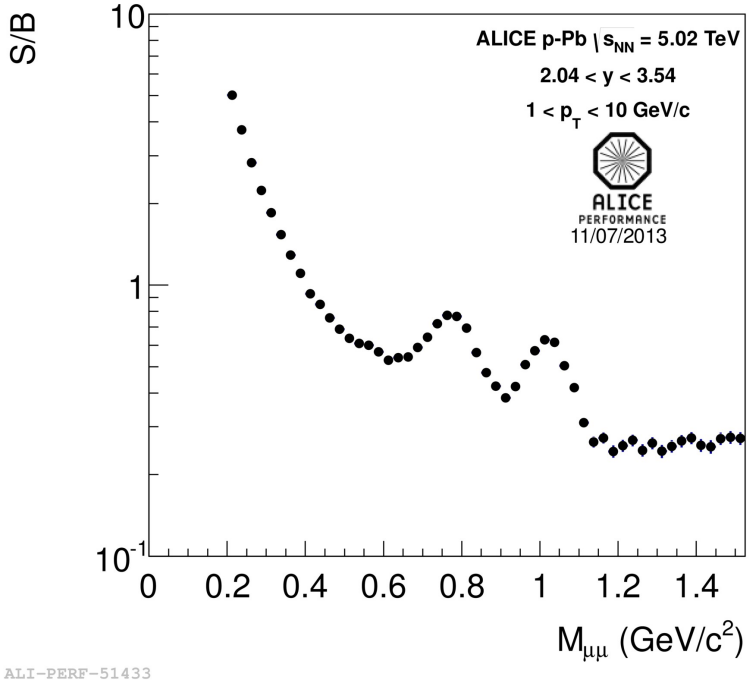


p-Pb collisions

- High statistics sample from p-Pb run
- Good control of background through event mixing
- Trigger p_T threshold at ~ 0.5 GeV/c allows to reach dimuon p_T down to 1 GeV/c







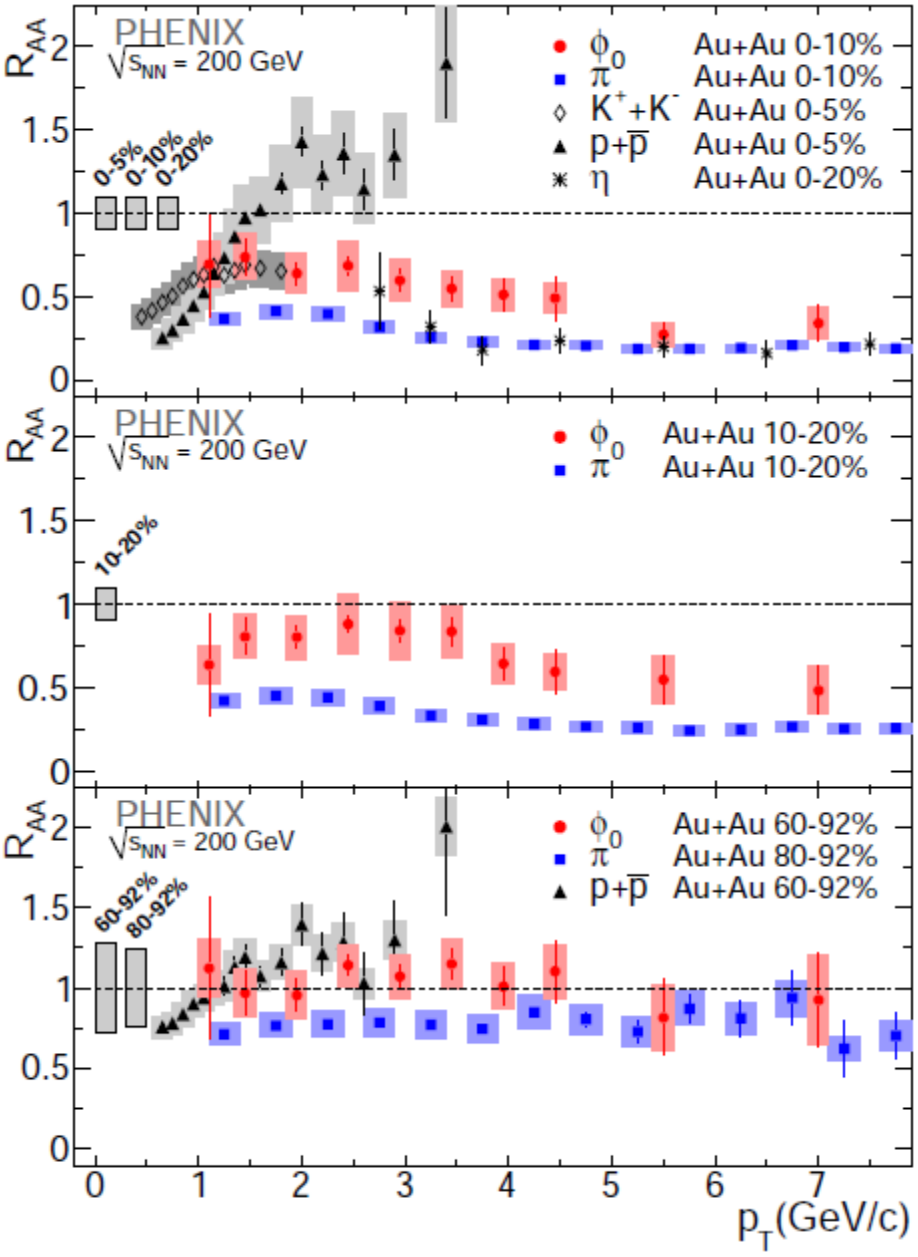
Summary

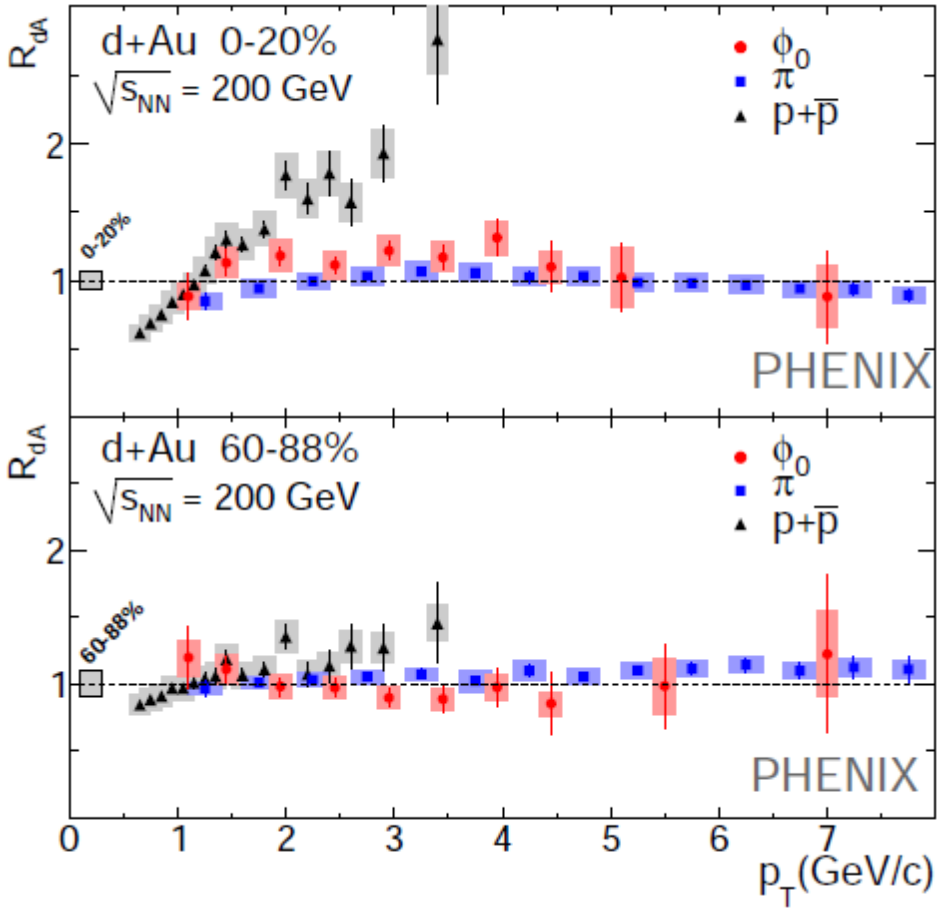
- Measurement of ϕ production cross section in pp collisions at 2.76 TeV
- PHOJET and PYTHIA with ATLAS-CSC and D6T reproduce the results within ~15%. Perugia-0 and Perugia-11 lower by a factor ~2

  Comparison with models shows similar results as at 7 TeV
- Pb-Pb collisions
- Ratio $\phi/\rho+\omega$ in central collisions ~2 times higher than the corresponding one in pp
- ϕ yield/N_{part} increases from peripheral to semiperipheral collisions and then saturates
- ϕ R_{AA} for $2<p_T<5$ GeV/c: decrease from ~1 in peripheral collisions to ~ 0.5 in central collisions
- Results compatible with the ones in KK at midrapidity: no strong effects related to the decay channel
- p-Pb
- High-statistics sample and good data quality: stay tuned

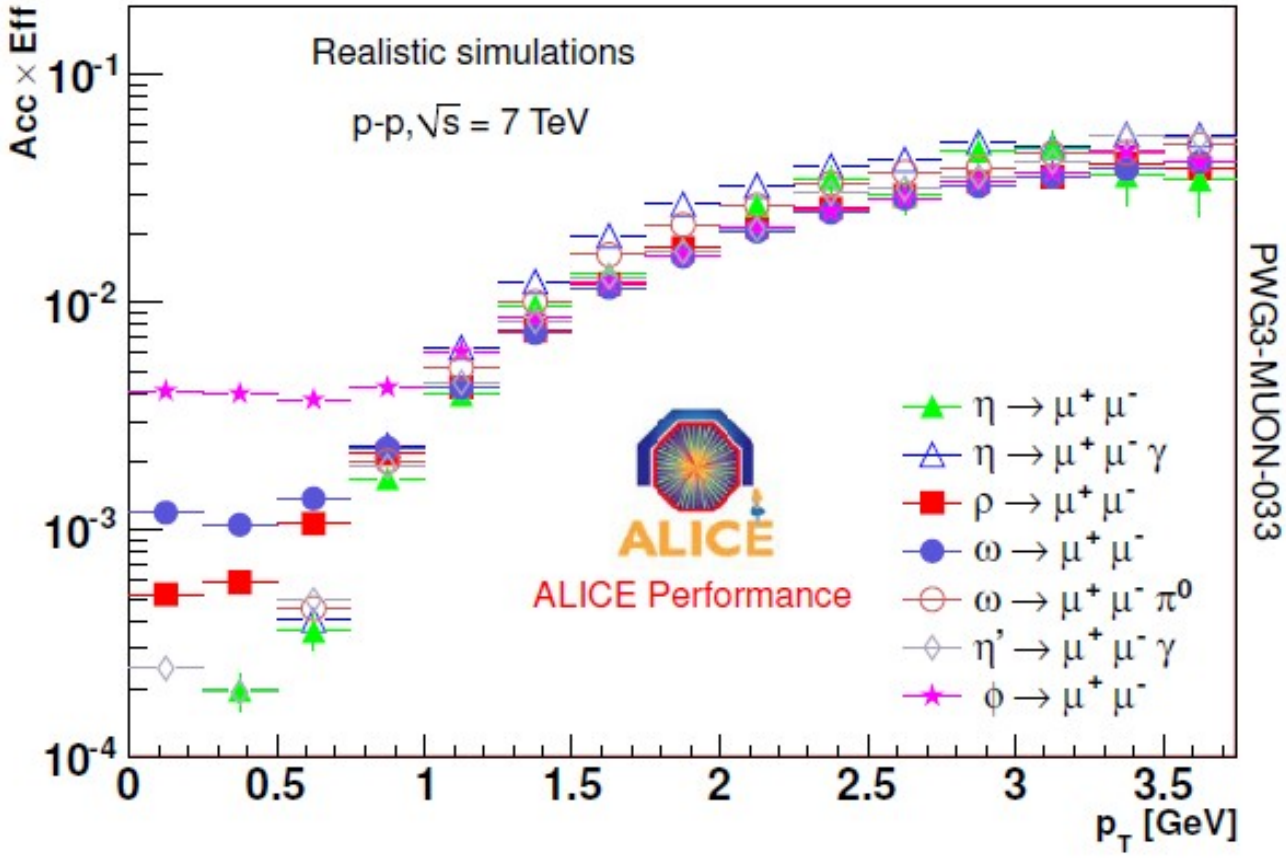
Backup slides

Previous measurements by PHENIX



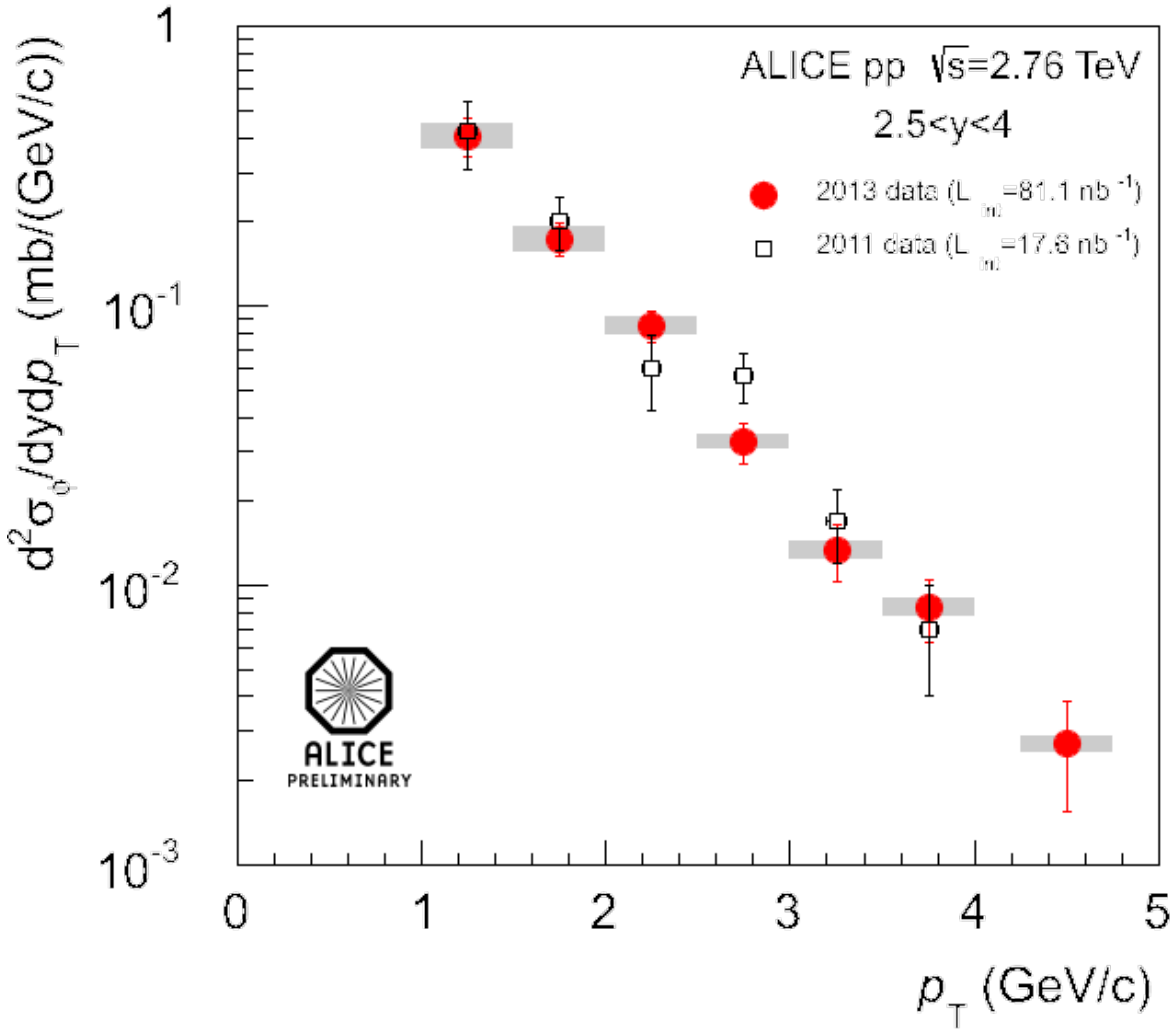


A*ε in pp


Realistic simulations
p-p, √s = 7 TeV
Acc × Eff
ALICE
ALICE Performance
PWG3-MUON-033
p_T [GeV]
η → μ⁺ μ⁻
η → μ⁺ μ⁻ γ
ρ → μ⁺ μ⁻
ω → μ⁺ μ⁻
ω → μ⁺ μ⁻ π⁰
η' → μ⁺ μ⁻ γ
φ → μ⁺ μ⁻

ϕ differential cross section in pp

- Good agreement between measurements in 2011 and 2013



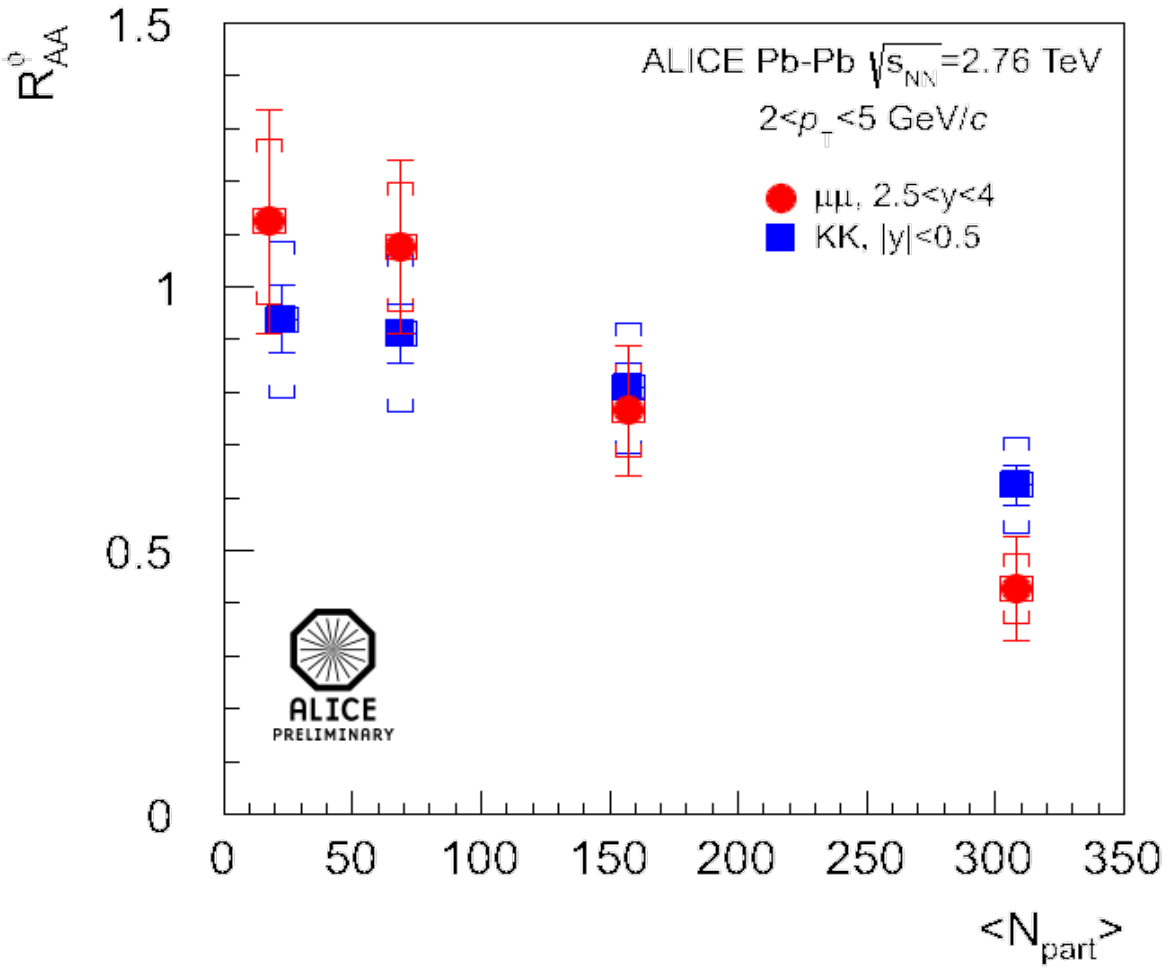
Main systematic uncertainties:

- N_ϕ: from 3.5% - 7.5%
- BR: 1%
- ε_{TRACK}: 4.5%
- ε_{TRIG}: 2% (intrinsic) + 2% (matching)

$$\sigma_\phi(1<p_T<5\,\mathrm{GeV}/c,\,2.5<y<4)=0.542\pm0.052\,(\mathrm{stat.})\pm0.043\,(\mathrm{syst.})\ \mathrm{mb}$$
$$\sigma_\phi(2<p_T<5\,\mathrm{GeV}/c,\,2.5<y<4)=0.1082\pm0.0095\,(\mathrm{stat.})\pm0.0071\,(\mathrm{syst.})\ \mathrm{mb}$$

ϕ R_{AA}

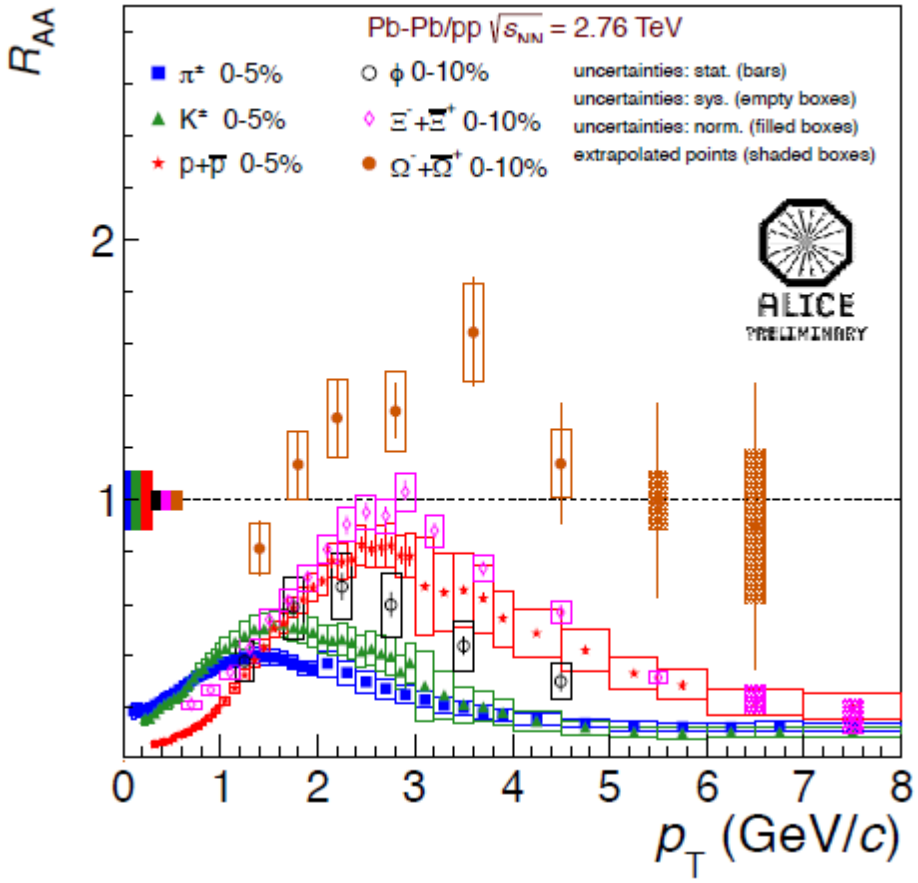
- Measurement in $\mu\mu$ at forward rapidity and in KK at midrapidity in agreement within the errors
- No indication for strong absorption/rescattering effects

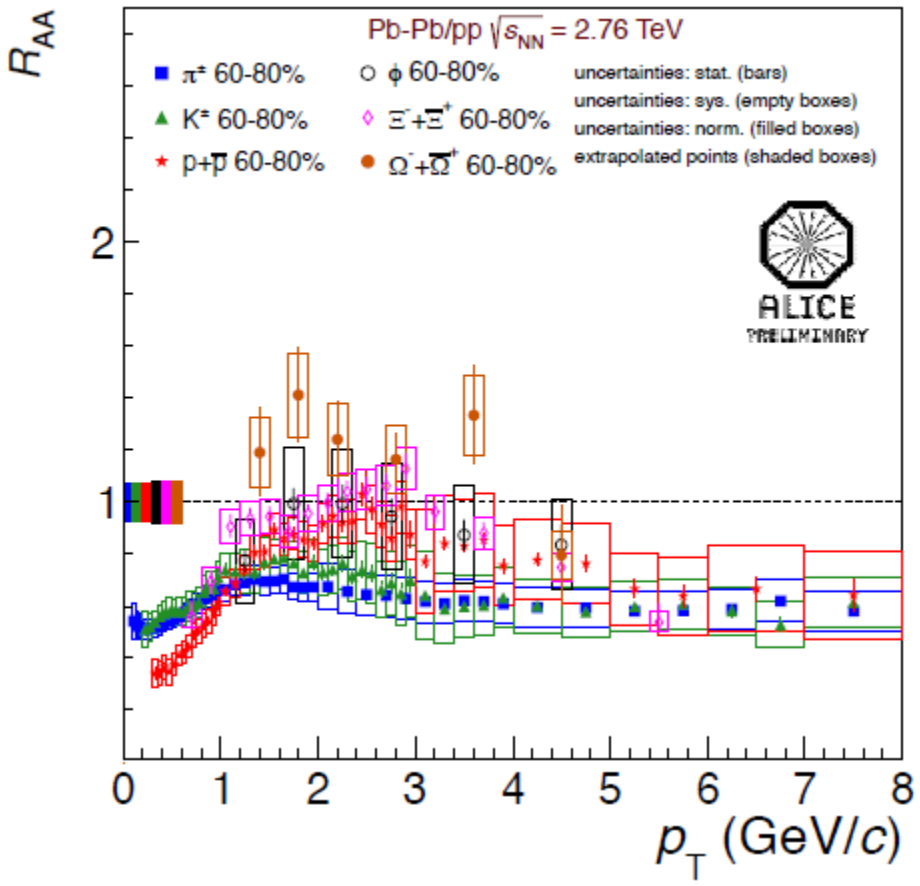


Main systematic uncertainties in $\mu\mu$:

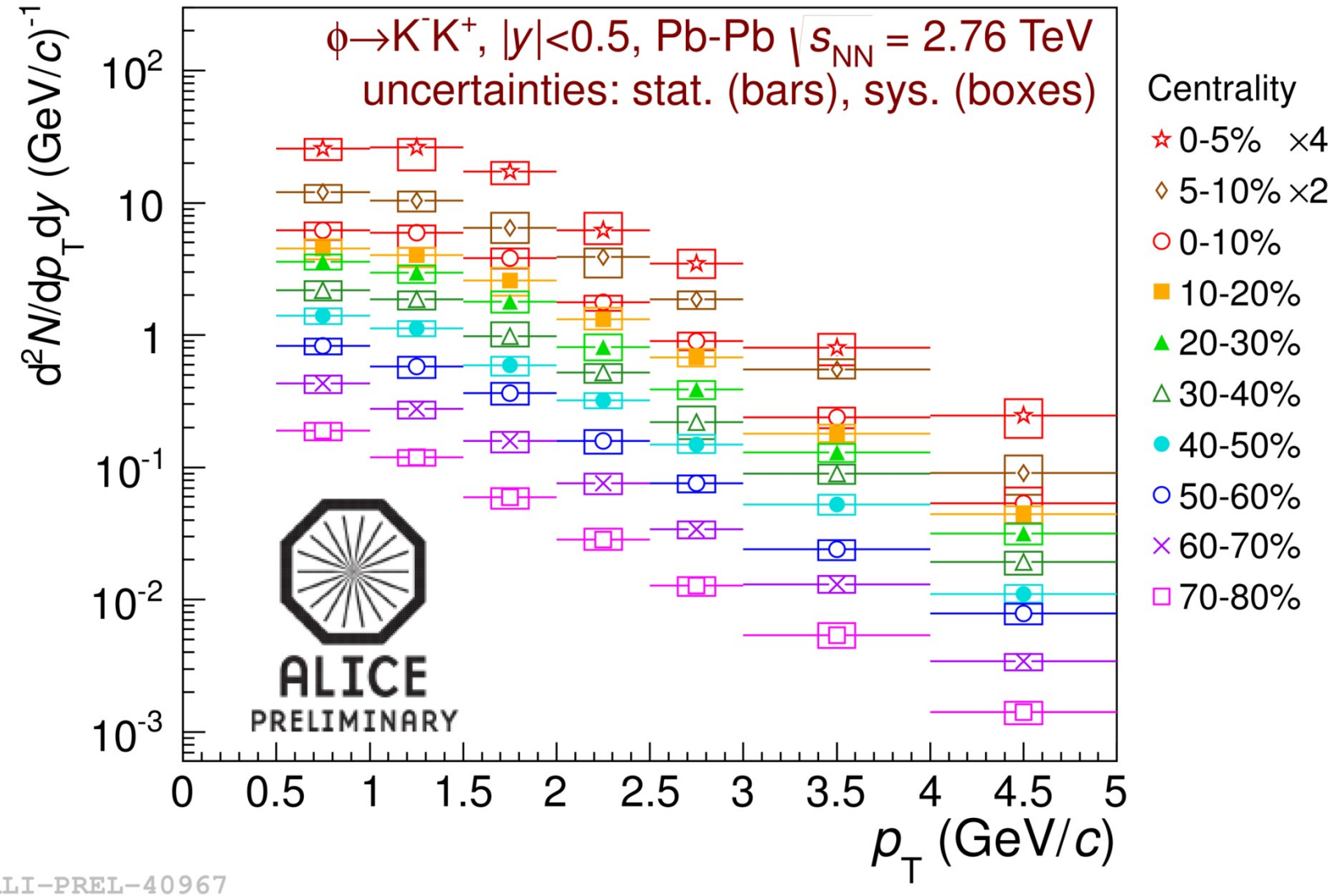
- BKG subtraction: 3.8% for 0<centr<20%, <1% for centr>20%
- N_{ϕ}: from 6.7% to 2.1%
- $p_{T\mu}$ cut: from 9% to 4%
- BR: 1%
- ε_{TRACK}: 4.5%
- ε_{TRIG}: 2% (intrinsic) + 0.5%-1.8% (matching)

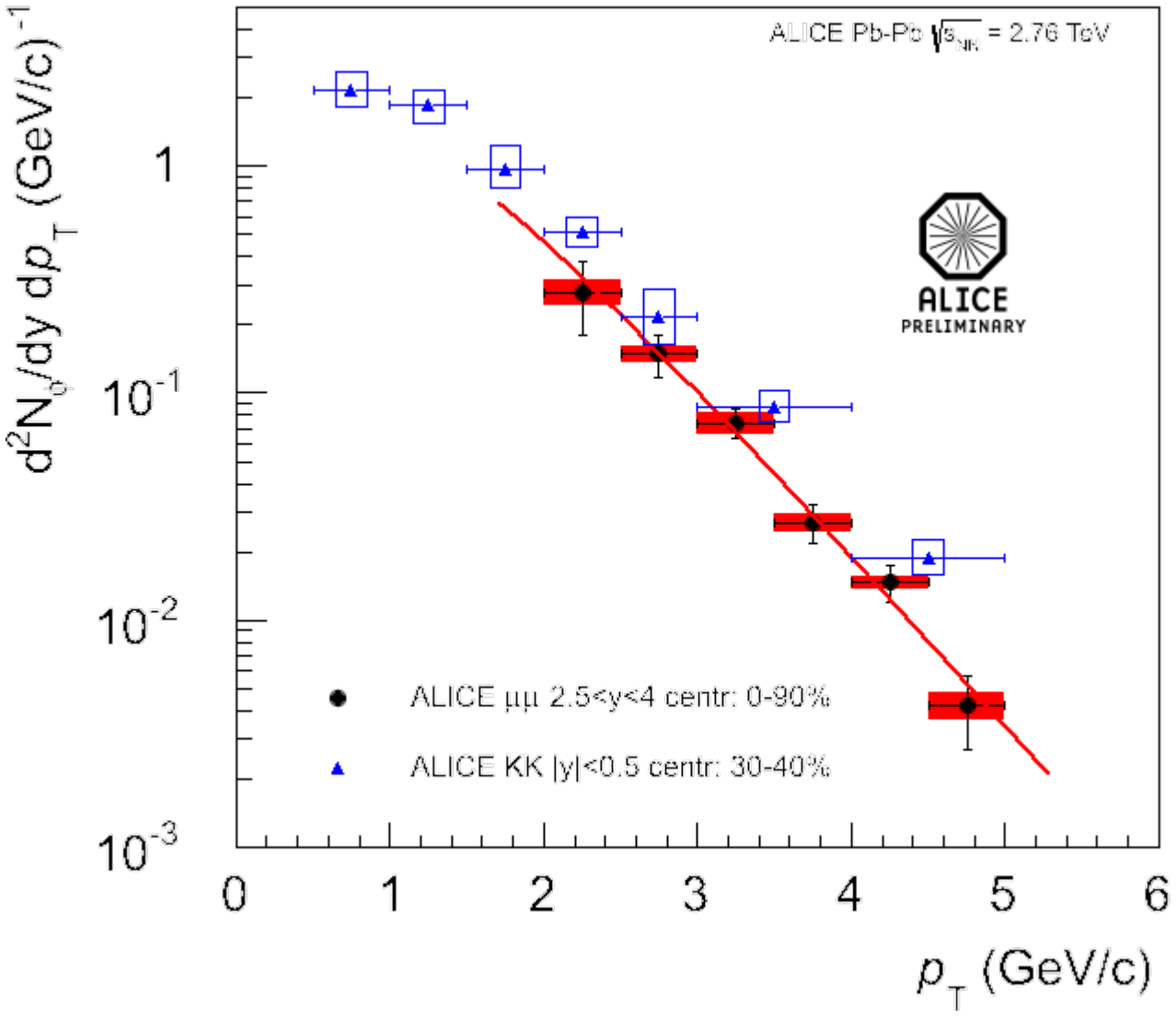
(see previous presentation, A. Knospe)





Yields vs p_T in KK




ALICE Pb-Pb $\sqrt{s_{NN}}$ = 2.76 TeV
ALICE
PRELIMINARY
ALICE μμ 2.5<y<4 centr: 0-90%
ALICE KK |y|<0.5 centr: 30-40%
$d^2N_\psi/dy\ dp_T\ (GeV/c)^{-1}$
p_T (GeV/c)
1
10^{-1}
10^{-2}
10^{-3}
0
1
2
3
4
5
6