ϕ meson production at forward rapidity in pp and Pb-Pb collisions with ALICE at the LHC

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SQM 2017
10-15/07/2017
Utrecht, the Netherlands

Utrecht 2017

Outline

- Introduction
- The ALICE detector
- Dimuon analysis
  - Dimuon mass spectra and background subtraction
  - Signal extraction
- New results in pp
  - ϕ cross section at $\sqrt{s}$ = 5.02 TeV and $\sqrt{s}$ = 8 TeV
  - Comparison with models and evolution with $\sqrt{s}$
- New results in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV
  - ϕ R_{AA} vs N_{PART} and p_T

ϕ meson as a probe of the QGP

- Excellent probe of strangeness production in heavy-ion collisions
  - small inelastic cross section for interaction with non-strange hadrons
  - Long lifetime (~45 fm/*c*) compared to the fireball (~10 fm/*c*)
    Rescattering effects should be negligible

- Observables considered in nucleus-nucleus collisions:
  - Evolution of p_T spectra vs centrality
  - Nuclear modification factor R_{AA}

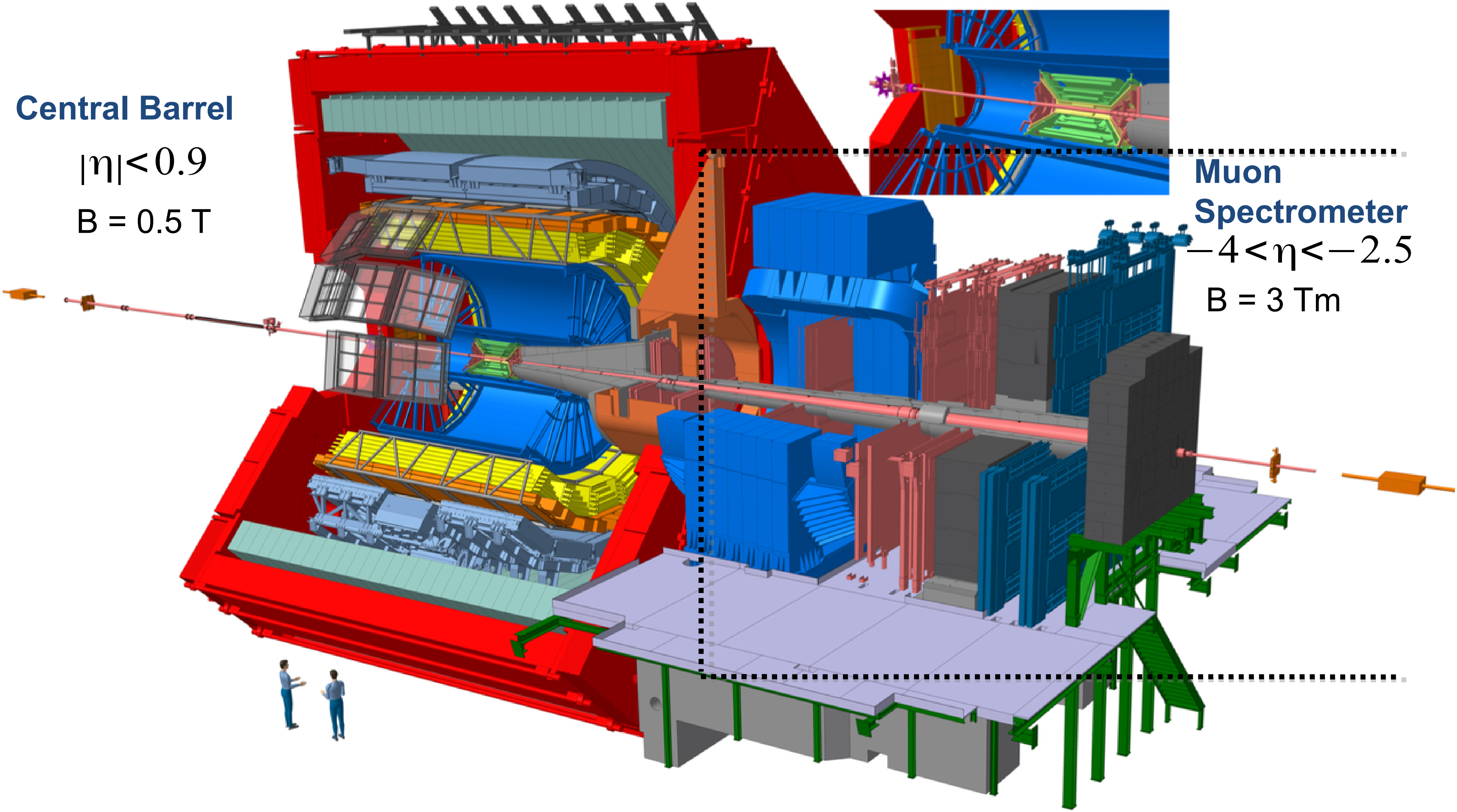
- pp collisions provide the baseline

The ALICE detector

Central Barrel

$|\eta| < 0.9$

B = 0.5 T



Muon Spectrometer

$-4 < \eta < -2.5$

B = 3 Tm

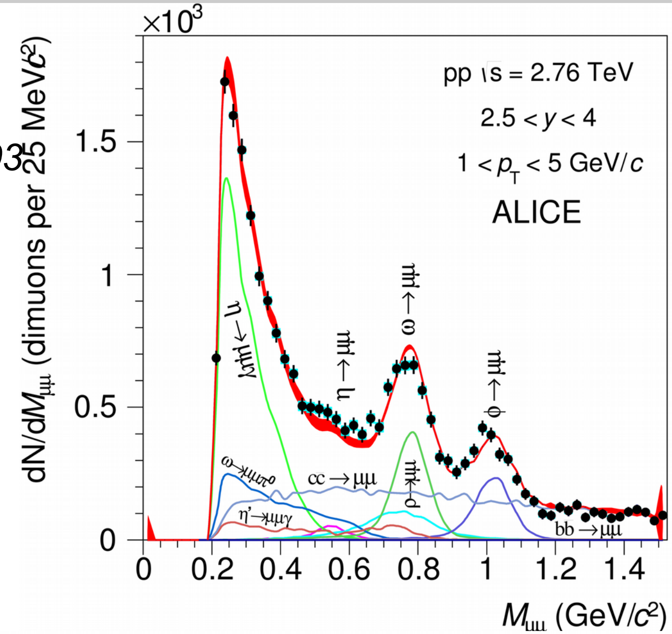
Measurements in pp collisions

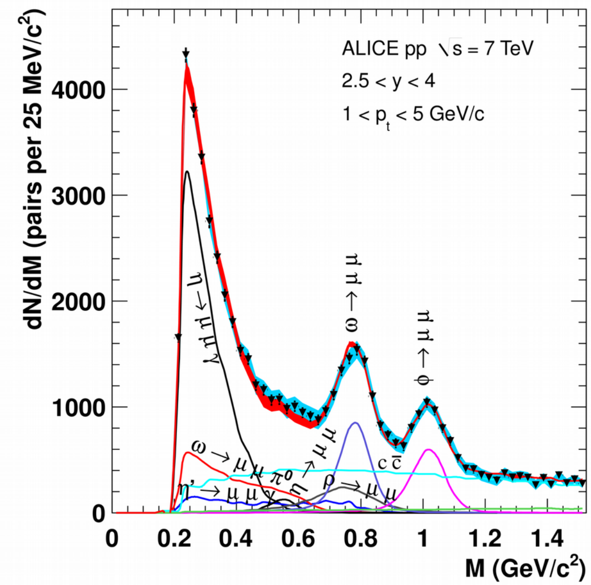
- Dimuon analysis performed on the opposite-sign mass spectra
  - Like-sign dimuons used for background normalization
- Combinatorial background subtraction: event mixing technique
- Data selection
  - Matching between muon tracks reconstructed in the tracking chambers and track segments in the trigger chambers
  - $-4 < \eta_{\mu} < -2.5$
  - $2.5 < y_{\mu\mu} < 4$
- Integrated luminosity:
  - L_{INT}=106.3 nb^{-1} at $\sqrt{s}$ = 5.02 TeV
  - L_{INT}=2.4 pb^{-1} at $\sqrt{s}$ = 8 TeV

Different trigger selections: lower p_T can be reached at 5.02 TeV
Larger statistics at 8 TeV: higher p_T-reach

Measurements in pp collisions

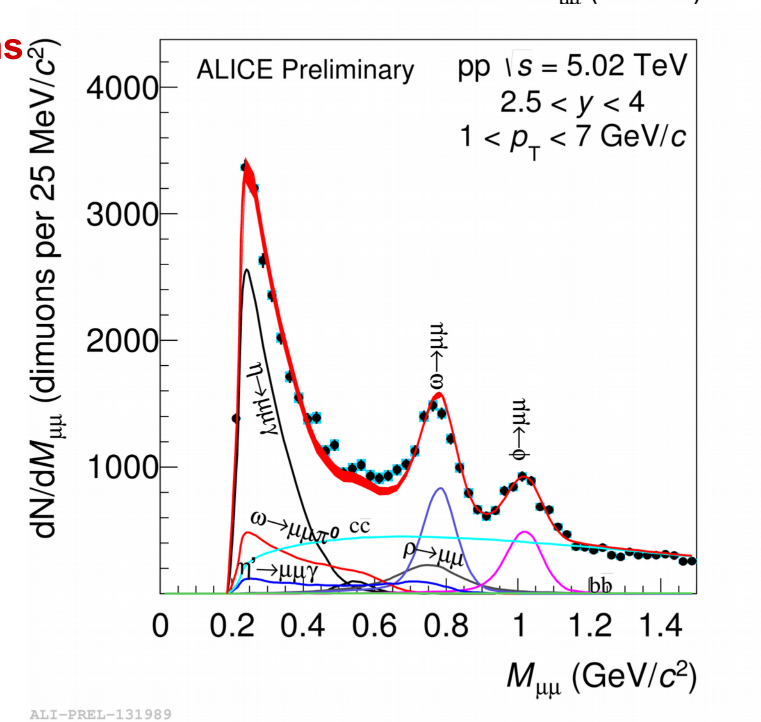
pp collisions
2.76 TeV
Phys. Lett. B
***768** (2017) 203*

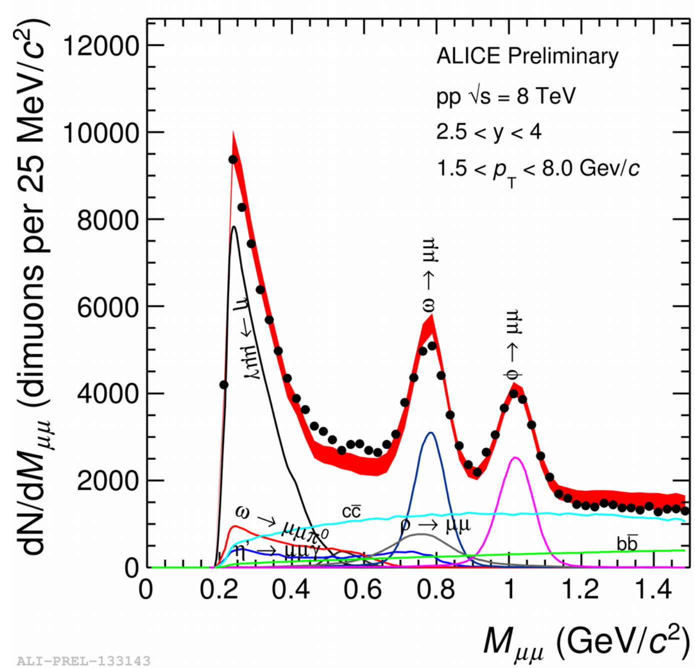




pp collisions
7 TeV
Phys. Lett. B
***710** (2012) 557*

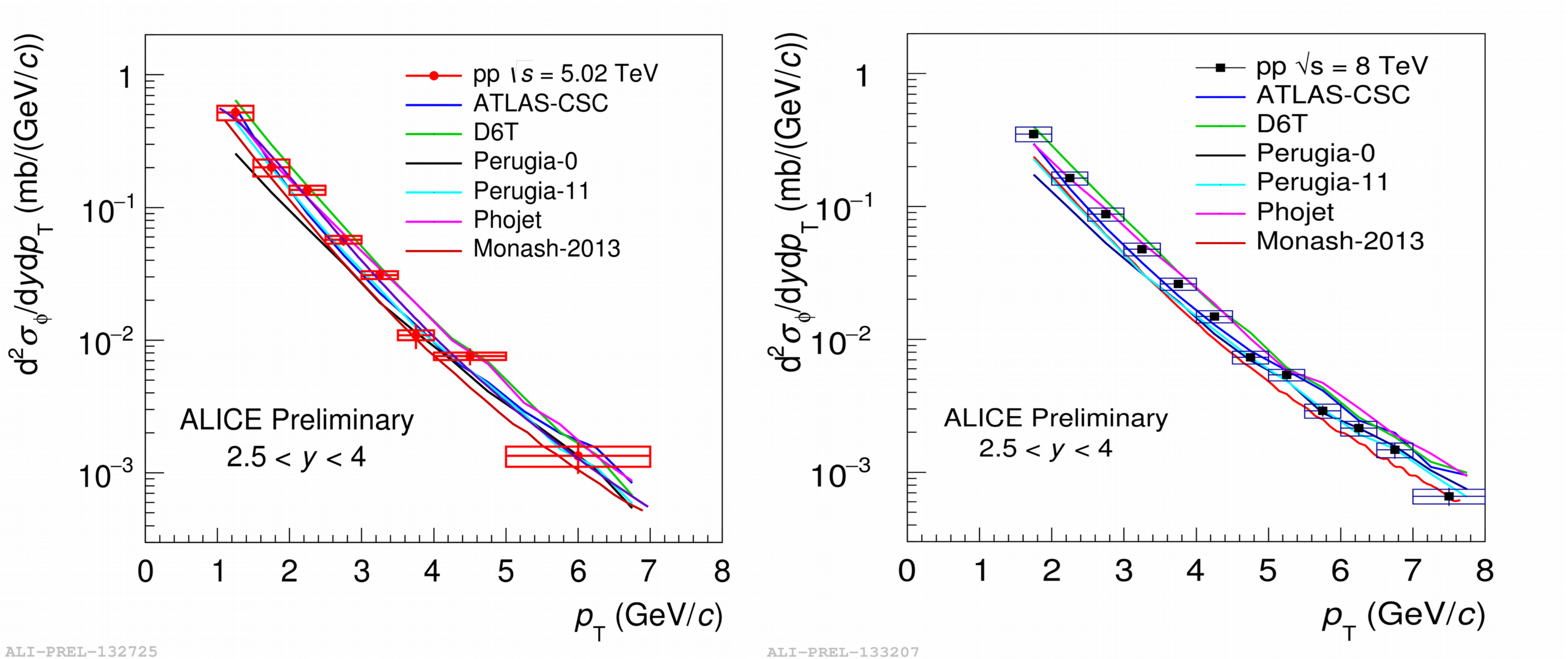
pp collisions
5.02 TeV
NEW





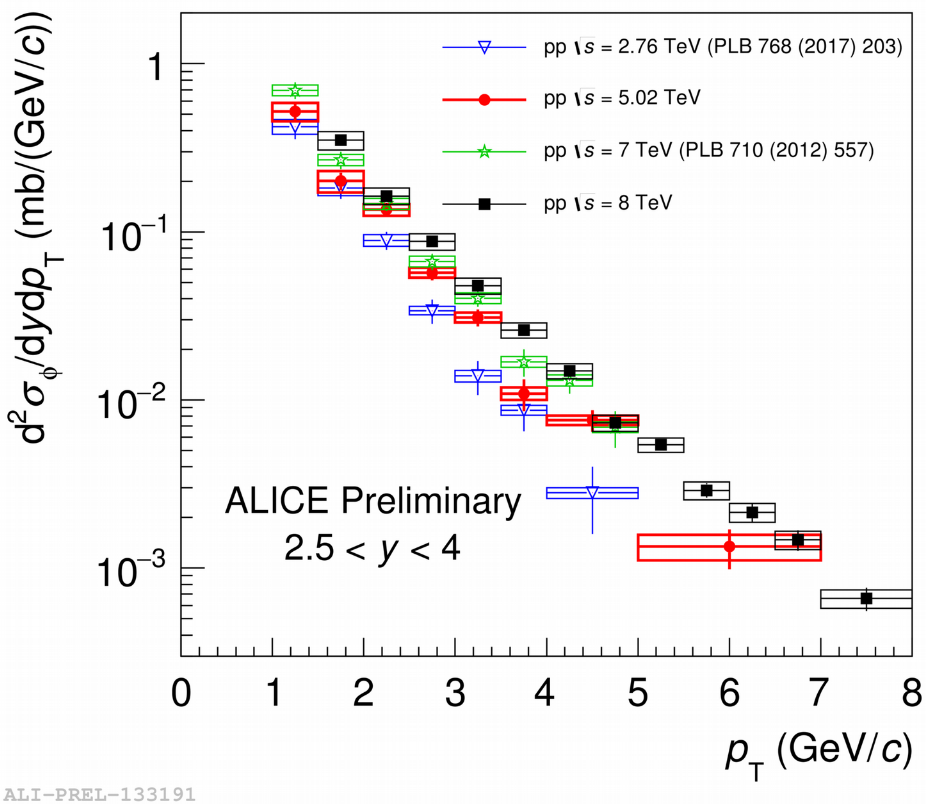
pp collisions
8 TeV
NEW

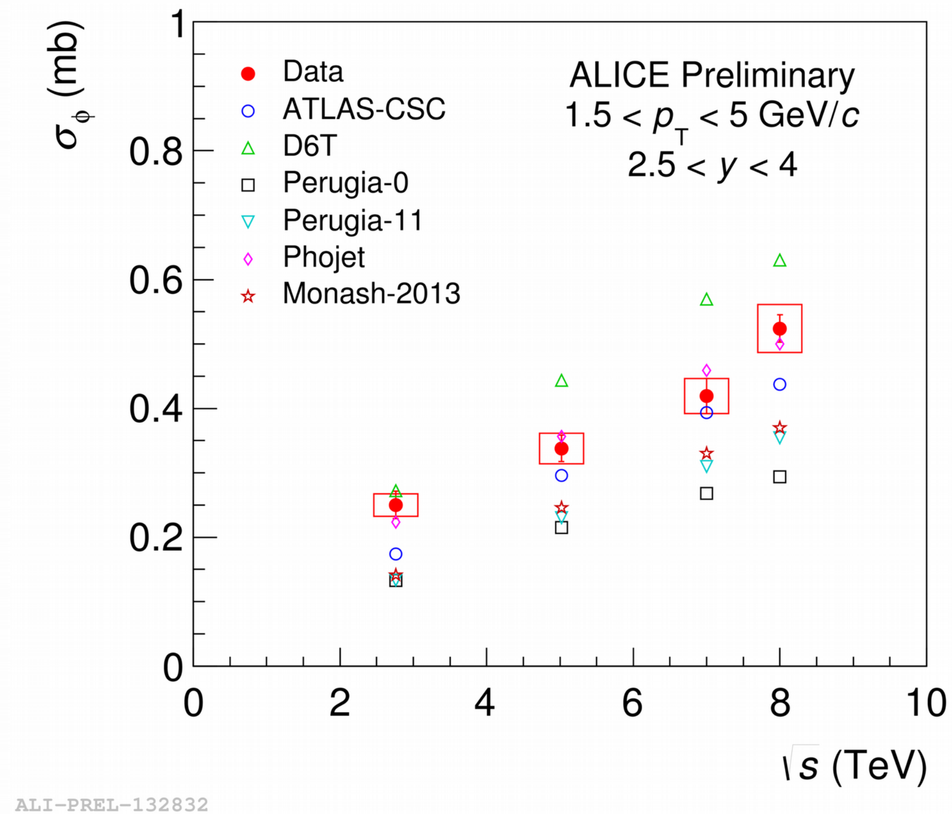
Differential cross sections in pp



- Differential cross sections measured for $1 < p_T < 7$ GeV/c at $\sqrt{s} = 5.02$ TeV and for $1.5 < p_T < 8$ GeV/c at $\sqrt{s} = 8$ TeV
- Data best described by Phojet

Evolution with √s of the pp cross section





- Differential cross section hardens when increasing √s
- Cross section integrated in the common p_T range well described by Phojet
- Ongoing analysis at √s = 13 TeV will complete the picture of ϕ production at forward rapidity at the LHC energies

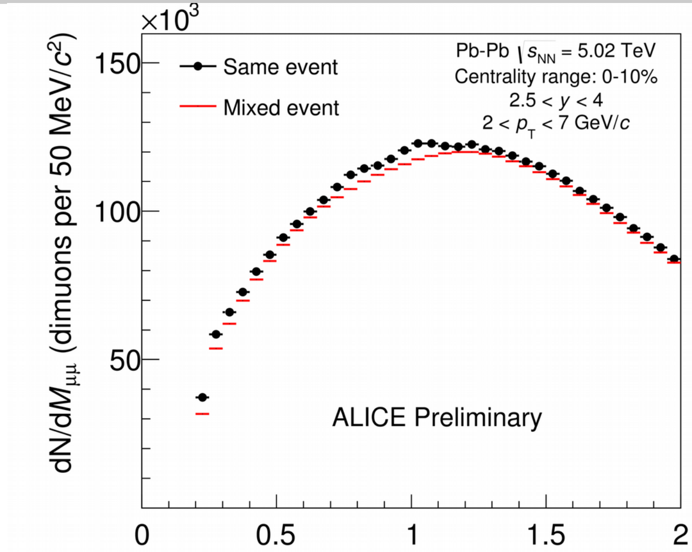
Data sample in Pb-Pb collisions at 5.02 TeV

- Data sample collected in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV in 2015
- Integrated luminosity: 225 μb^{-1}
- Same analysis criteria as in pp
- Data selection
  - Matching between muon tracks reconstructed in the tracking chambers and track segments in the trigger chambers
    - High $p_{T(\mu)}$ trigger threshold limits the analysis to p_T > 2 GeV/c
  - $-4 < \eta_\mu < -2.5$, $p_{T(\mu)} > 0.85$ GeV/c
  - $2.5 < y_{\mu\mu} < 4$

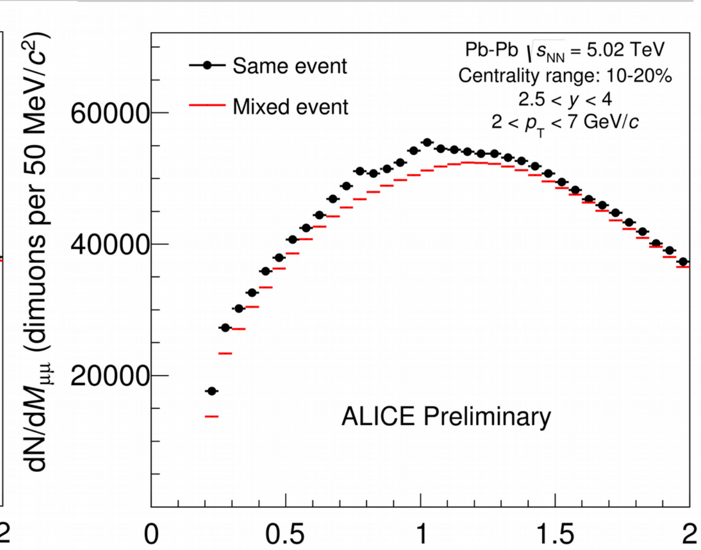
Dimuon mass spectra and combinatorial background

Dimuon mass spectrum and combinatorial background in five centrality bins for $2 < p_T < 7$ GeV/c

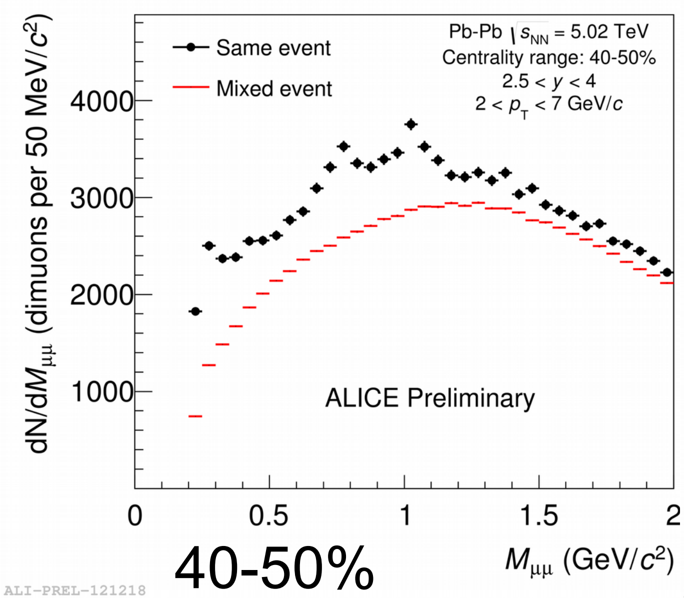
φ and ρ+ω peaks become more defined going from central to peripheral collisions



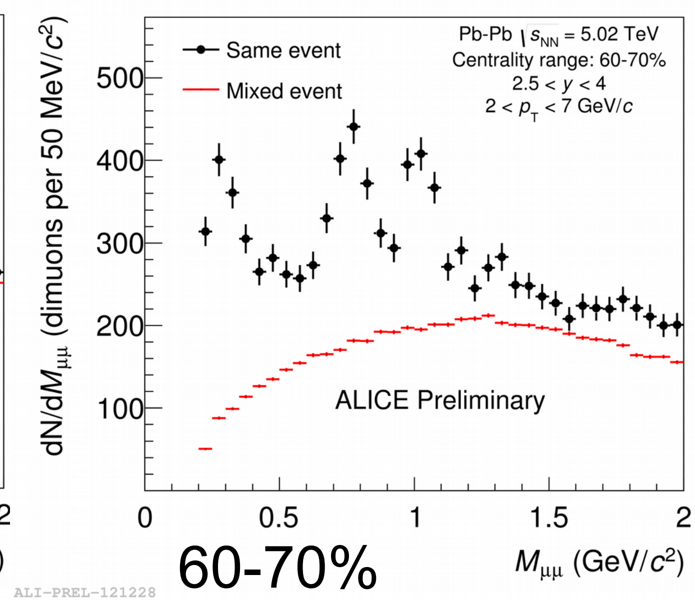
0-10%



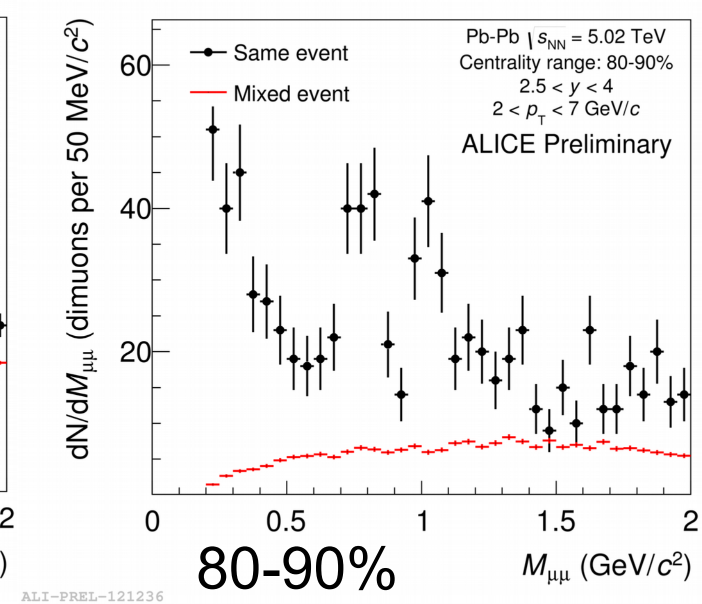
10-20%



40-50%

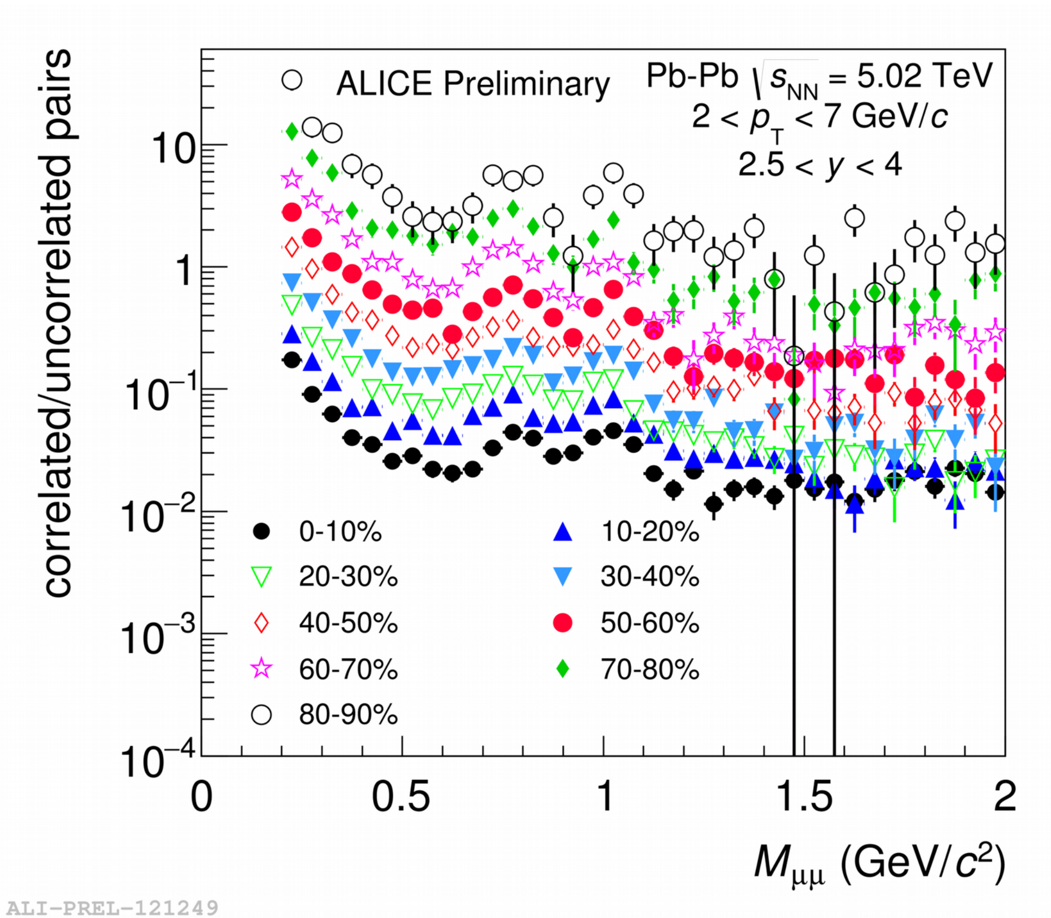


60-70%



80-90%

Correlated/uncorrelated pairs



Ratio between correlated pairs and combinatorial background at the ϕ mass grows from ~0.05 in the most central bin (0-10%) to ~5 in the most peripheral one (80-90%)

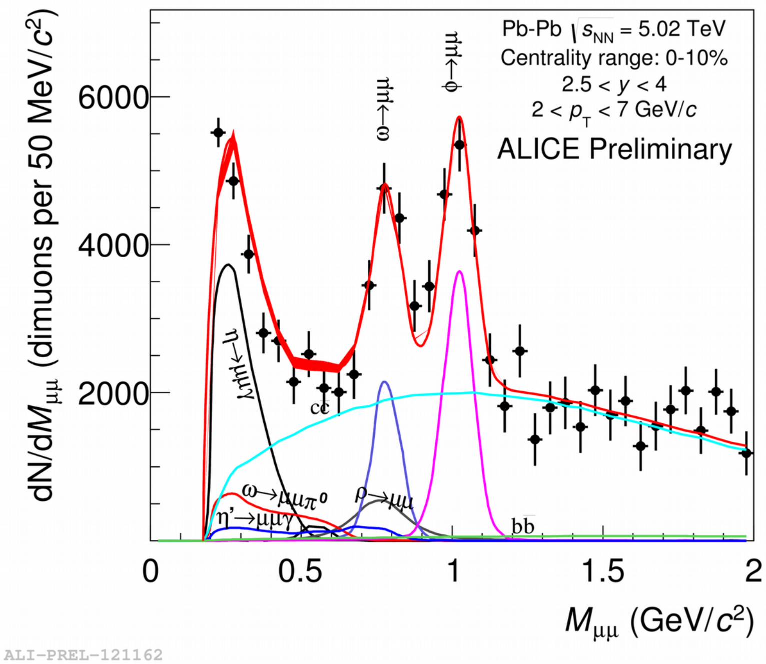
Fit to the mass spectra in Pb-Pb collisions

Mass spectra after background subtraction in several centrality bins for $2 < p_T < 7$ GeV/c

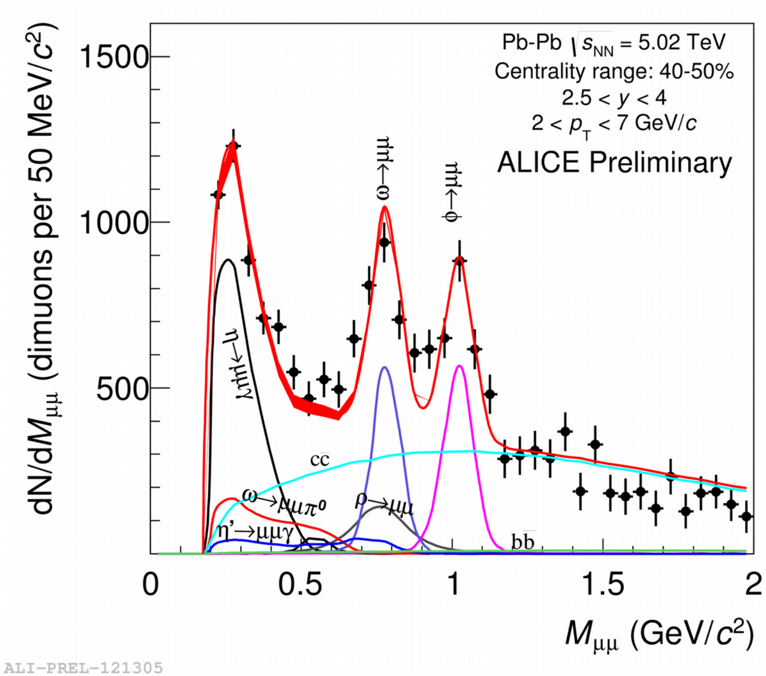
Fit up to $M_{\mu\mu} = 2$ GeV/c^2

Ingredients of the fit: dimuon decays of light resonances and semi-leptonic decays of open heavy flavours

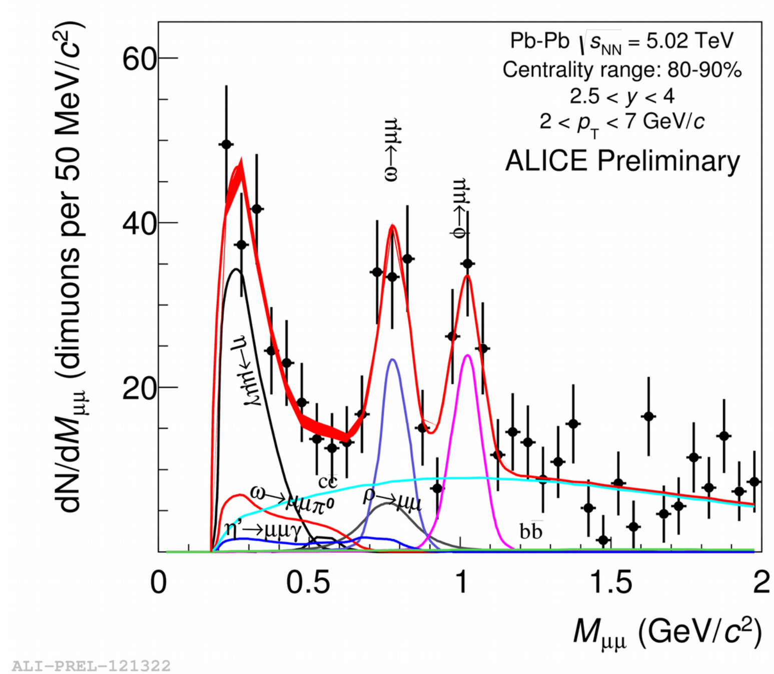
Free parameters in the hadronic cocktail: η, ω, φ and open charm normalizations



0-10%

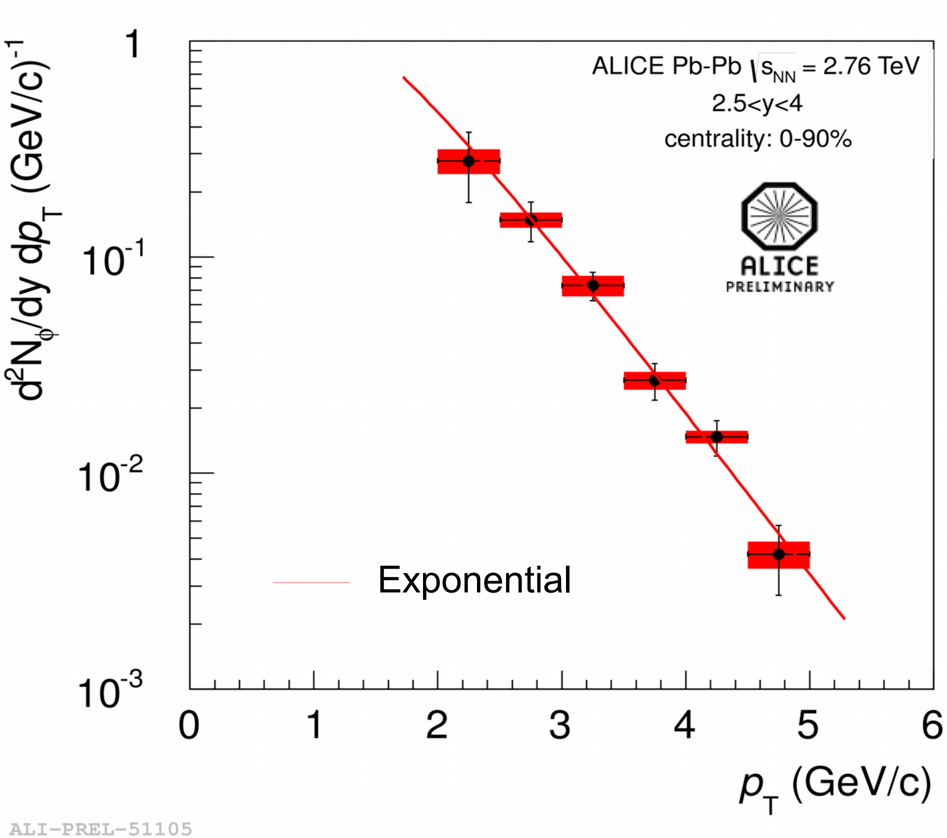


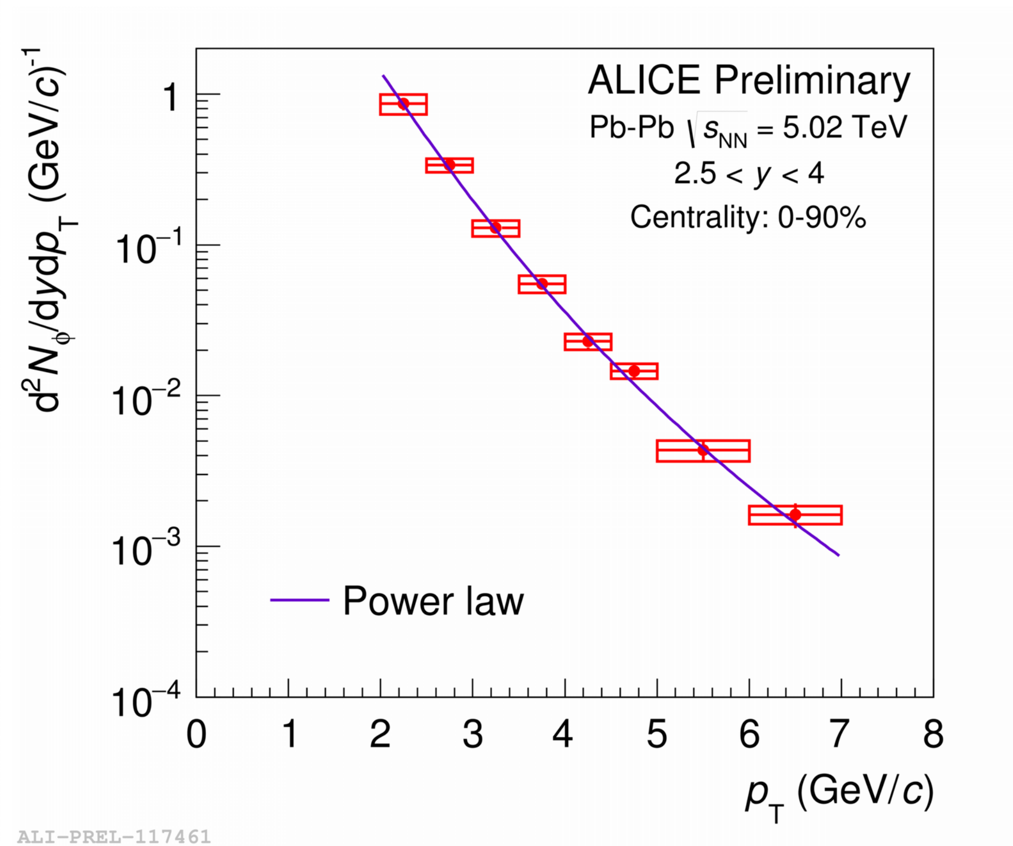
40-50%



80-90%

ϕ p_T spectrum integrated over centrality





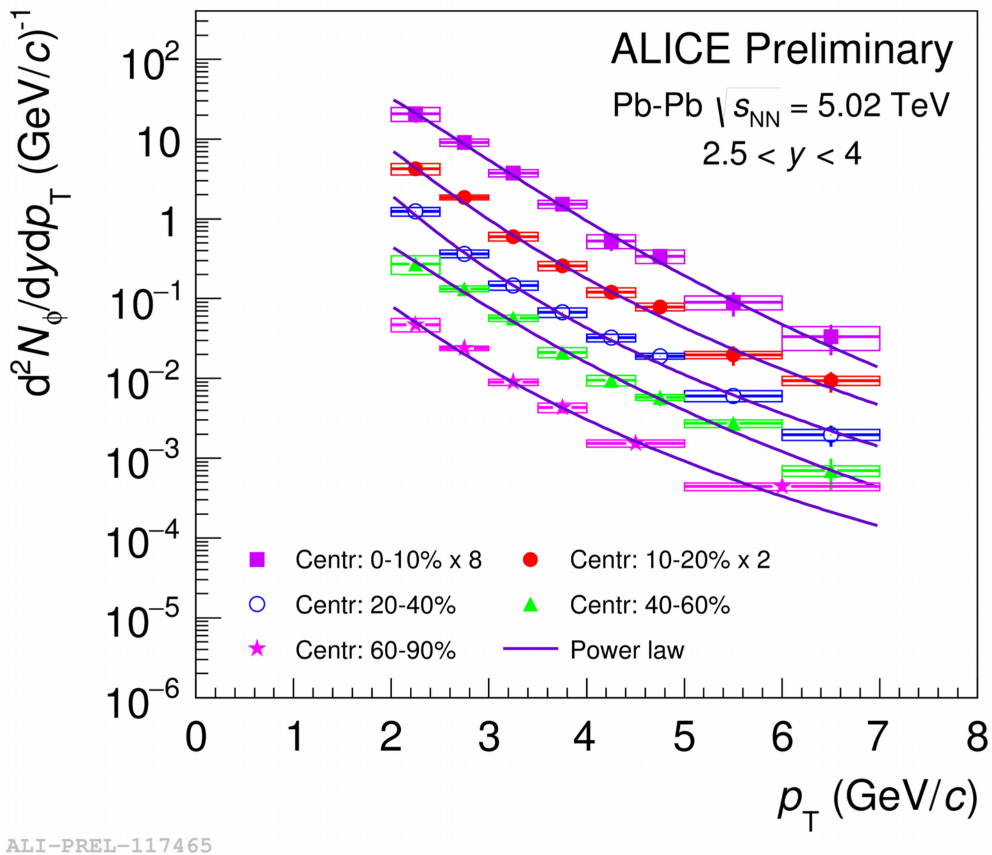
At 2.76 TeV, p_T spectra limited to the range $2 < p_T < 5$ GeV/c

Fitted with an exponential function $\frac{dN}{dp_T} \propto p_T e^{-m_T/T}$

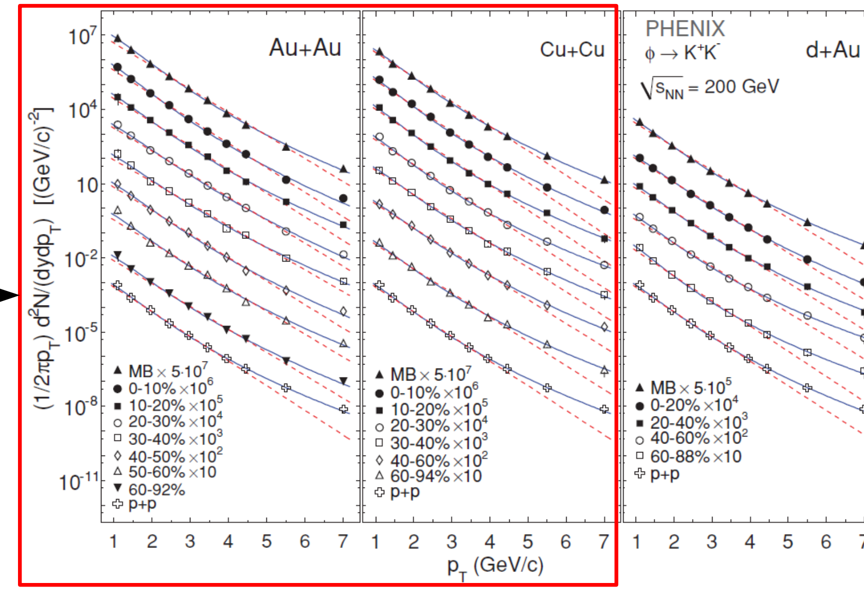
At 5.02 TeV: better statistics allows a larger p_T range: $2 < p_T < 7$ GeV/c

Power-law function $\frac{dN}{dp_T} \propto \frac{p_T}{\left[1+\left(p_T/p_0\right)^2\right]^n}$ needed to fit the high-p_T tails

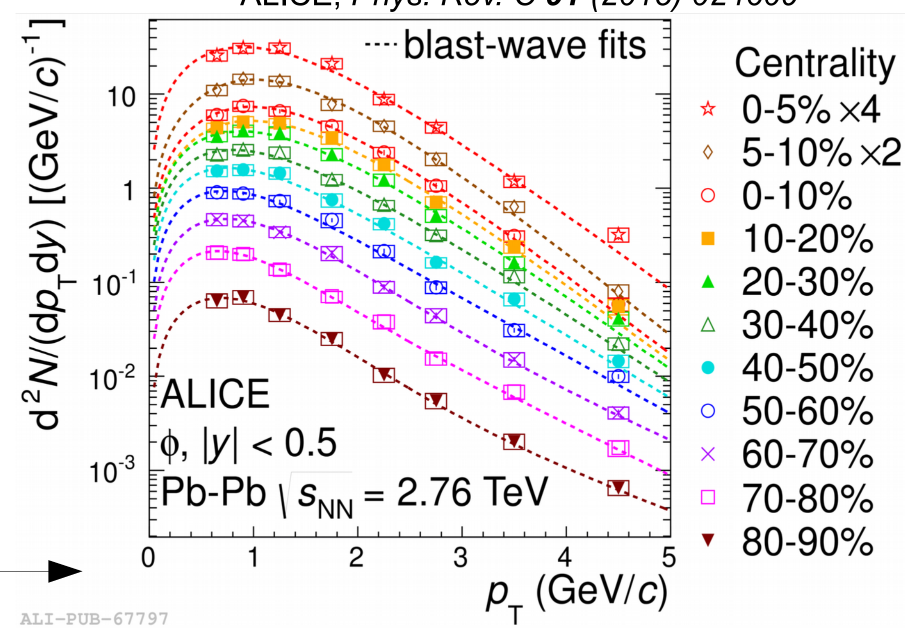
Evolution of the p_T spectrum with the collision centrality



PHENIX, *Phys. Rev. C* **83** (2011) 024909

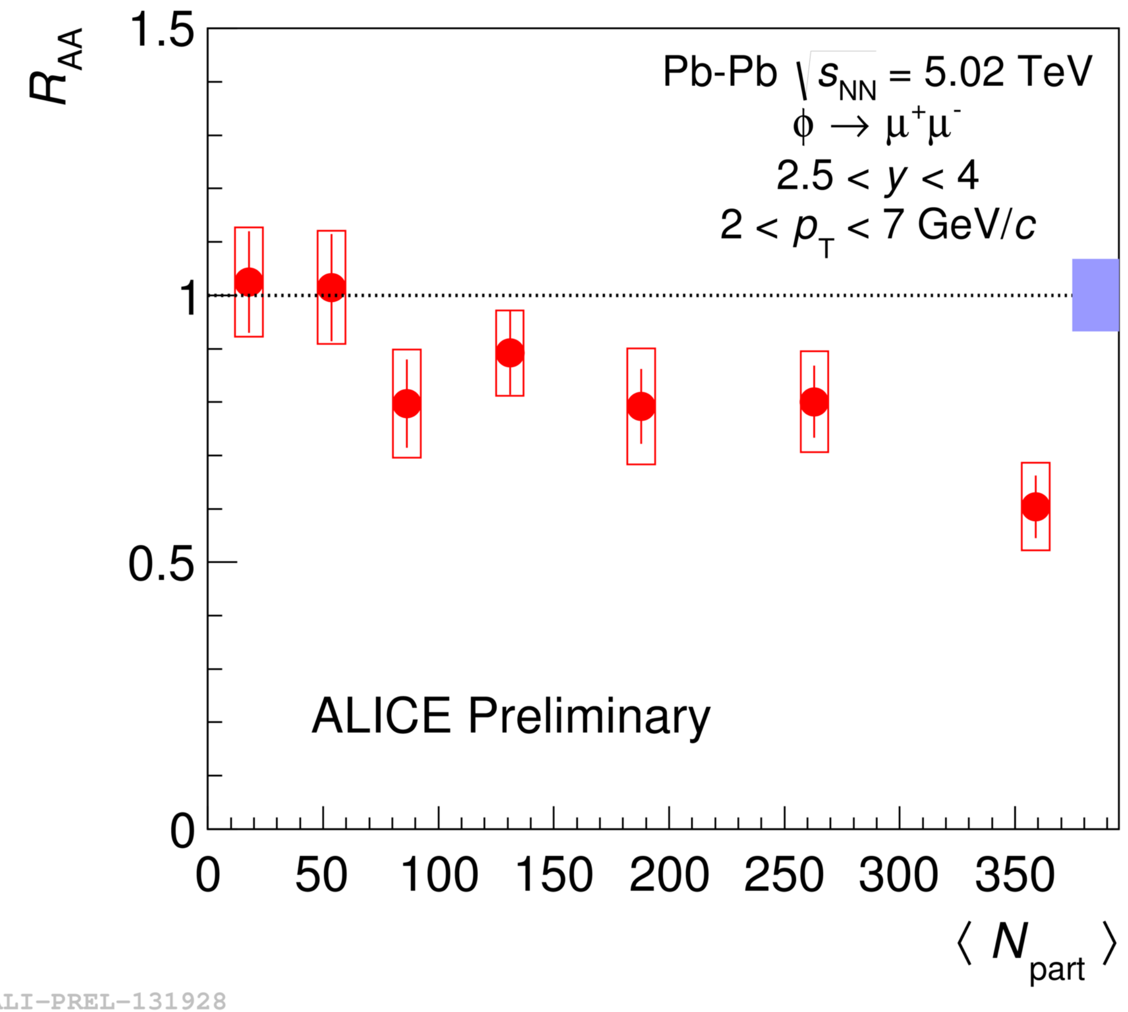


ALICE, *Phys. Rev. C* **91** (2015) 024609



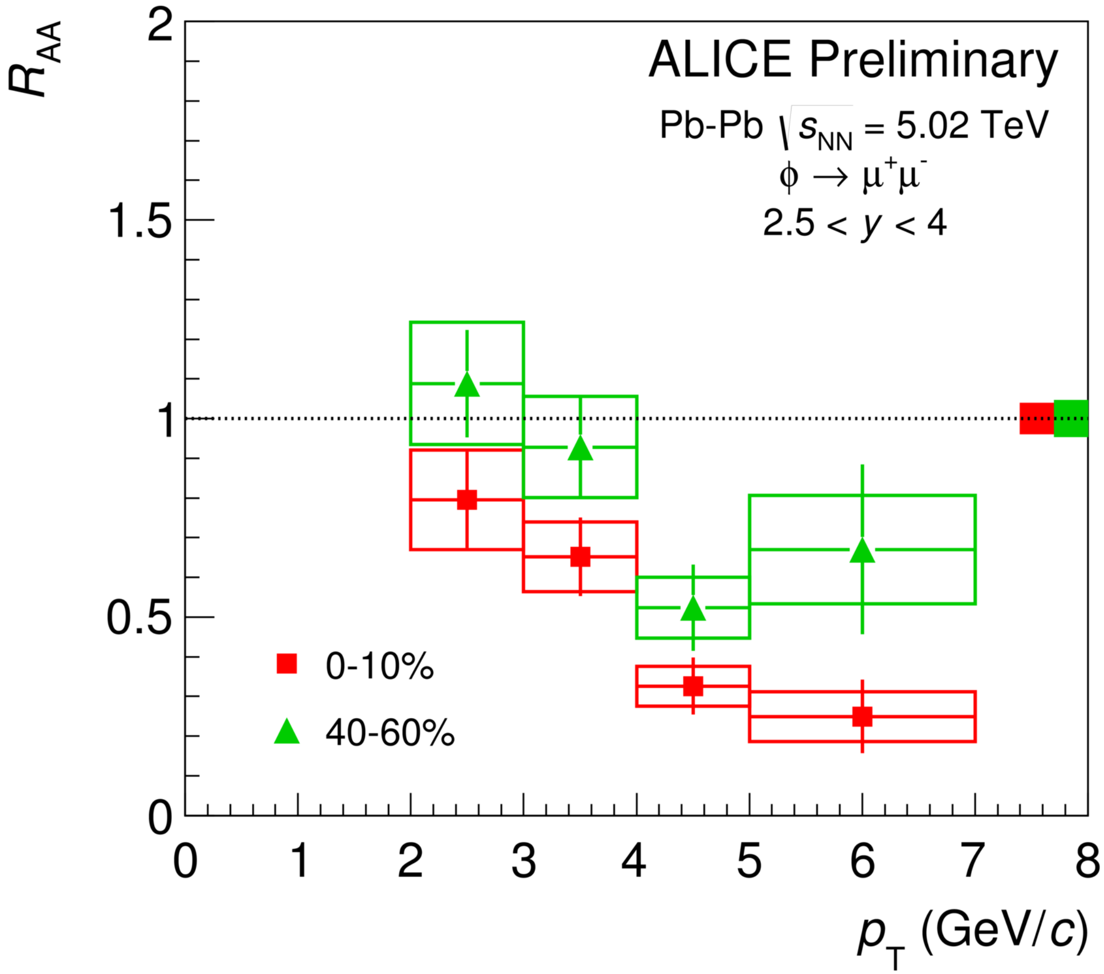
- Pb-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV: power law function fits well all centralities
- p_T distributions of peripheral collisions have a harder tail than the central ones
- Similar behavior observed by PHENIX in Au-Au and Cu-Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV (Levy-Tsallis fits) and by ALICE in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV (blast wave fits)

ϕ R_{AA} vs N_{PART}



- R_{AA} ~ 1 in peripheral collisions
- Small decrease from semiperipheral to (semi)central collisions in the intermediate p_T region

ϕ R_{AA} vs p_T



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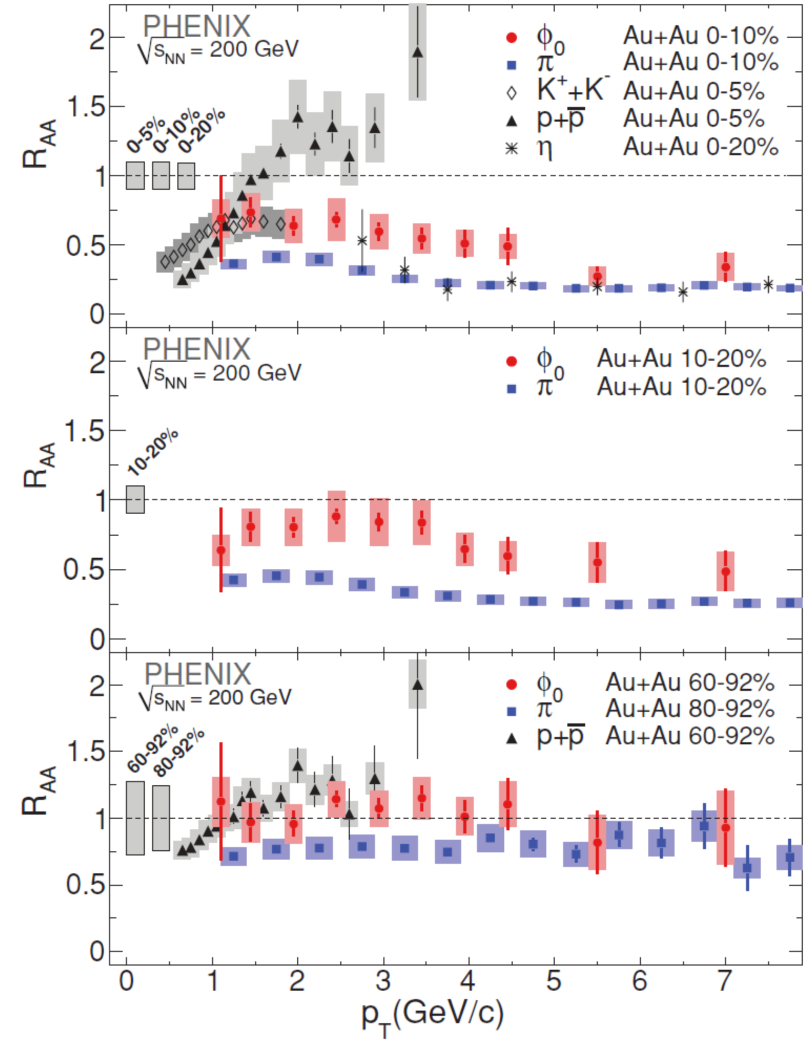


- Clear decrease for p_T>4 GeV/c in central collisions. Onset of the hard-p_T regime
- Effect less pronounced for semi-peripheral collisions
- Results similar to measurements at RHIC

Summary

pp collisions:

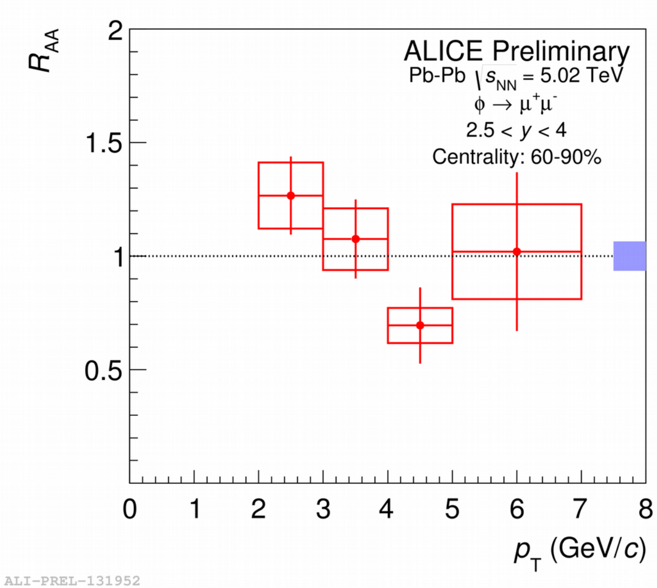
- Two new measurements of ϕ production give an overall picture at the LHC energies
- Phojet best describes ϕ production at all energies

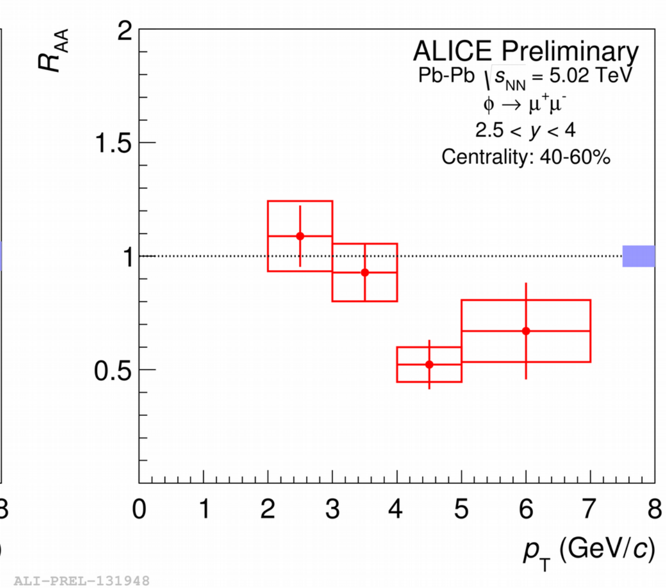
Pb-Pb collisions:

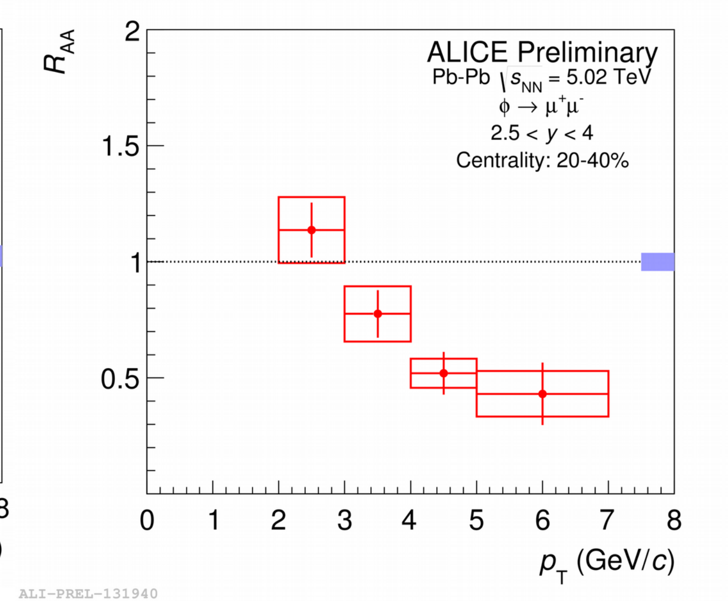
- Signal extracted in 9 centrality classes, for $2 < p_T < 7$ GeV/c
- R_{AA} at intermediate p_T shows a small decrease as a function *of* N_{PART}
- Dependence on p_T
  - p_T spectra well described by a power-law function
  - Tails in p_T distributions harder in peripheral collisions wrt central
  - R_{AA} vs p_T decreases to less than 0.5 for p_T>4 GeV/c in central collisions
  - Decrease at high p_T less pronounced for semicentral, semiperipheral collisions
  - Qualitative agreement with results at RHIC

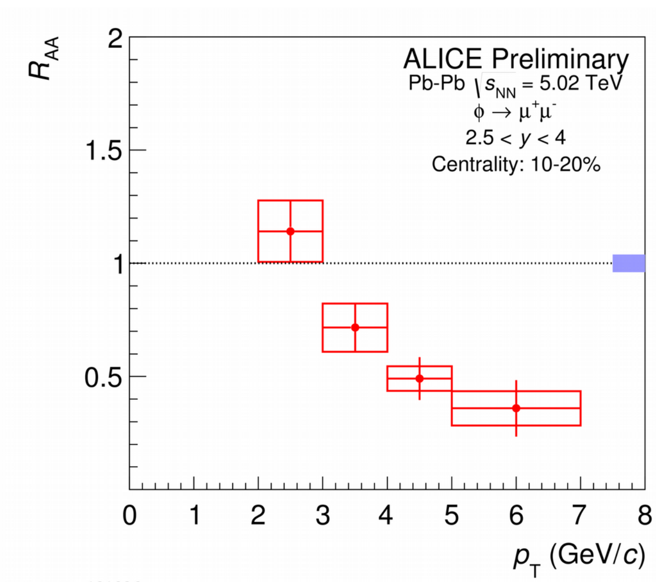
Backup slides

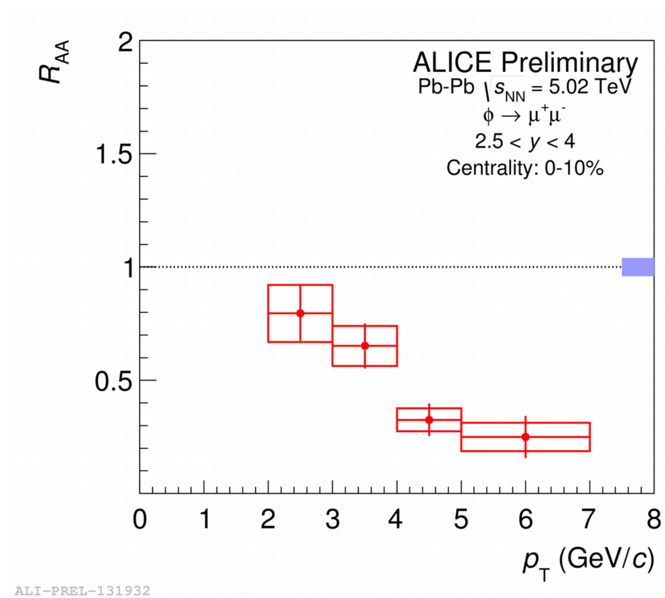
R_{AA} vs p_T in several centrality bins











ϕ R_{AA} at forward and mid-rapidity

- Comparison with ALICE measurement at midrapidity in the $\phi \rightarrow KK$ channel