Low-mass dimuon measurements in Pb-Pb, p-Pb and pp collisions in ALICE

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1 Physics motivation

2 Pb-Pb collision

3 p-Pb collisions

4 pp collisions

5 Summary

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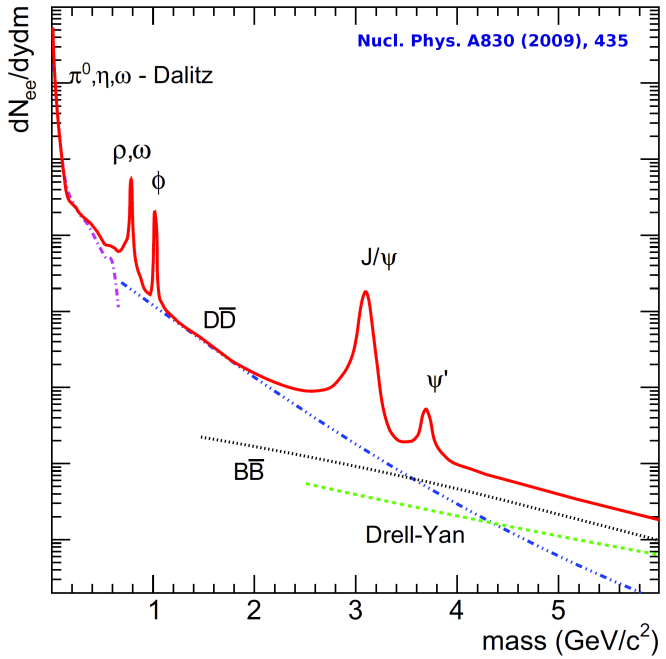
ALICE

Low-Mass dilepton physics

Low mass dilepton production in AA collisions → information on the hot and dense state of strongly-interacting matter produced in high energy nucleus nucleus collisions

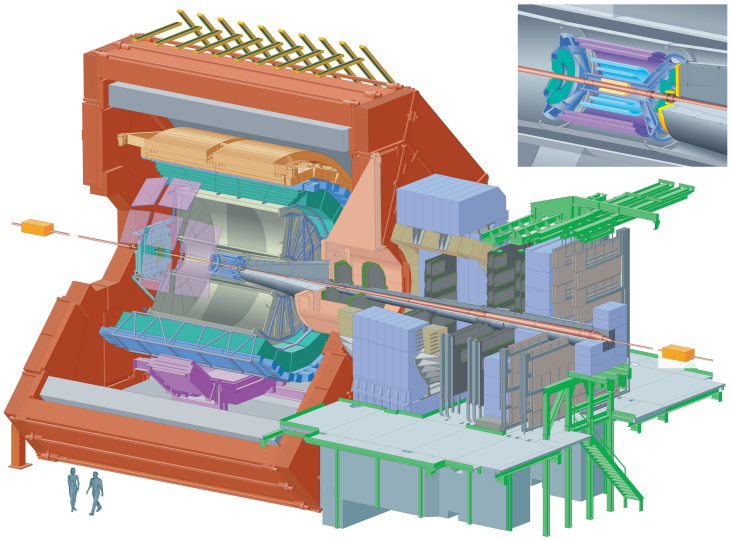


- Strangeness production via the ϕ meson
- Modification of ρ spectral function linked to the chiral symmetry restoration

Dileptons (dielectrons, dimuons)

→ negligible final-state effects

Measurements in pp and p-A collisions : Soft particle production in Cold Nuclear Matter, needed reference for correctly interpreting heavy-ion observations.



Two dilepton channels

- e^+e^- in mid rapidity : $|y| < 0.9$ in the central barrel
- $\mu^+\mu^-$ in forward rapidity : $-4.0 < y < -2.5$ in the muon arm. **channel of interest for this talk**

Collision systems:

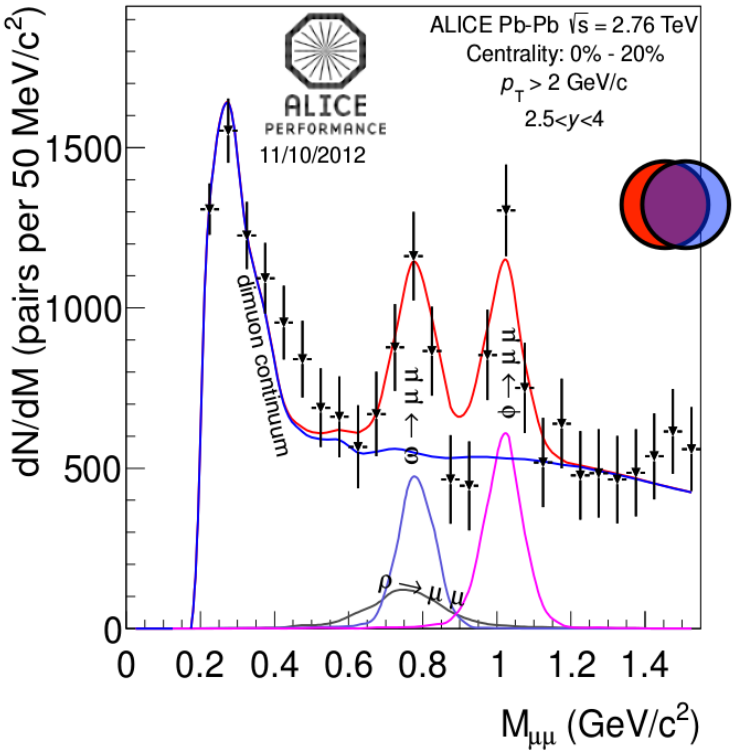
Pb-Pb : $\sqrt{s_{NN}} = 2.76$ TeV

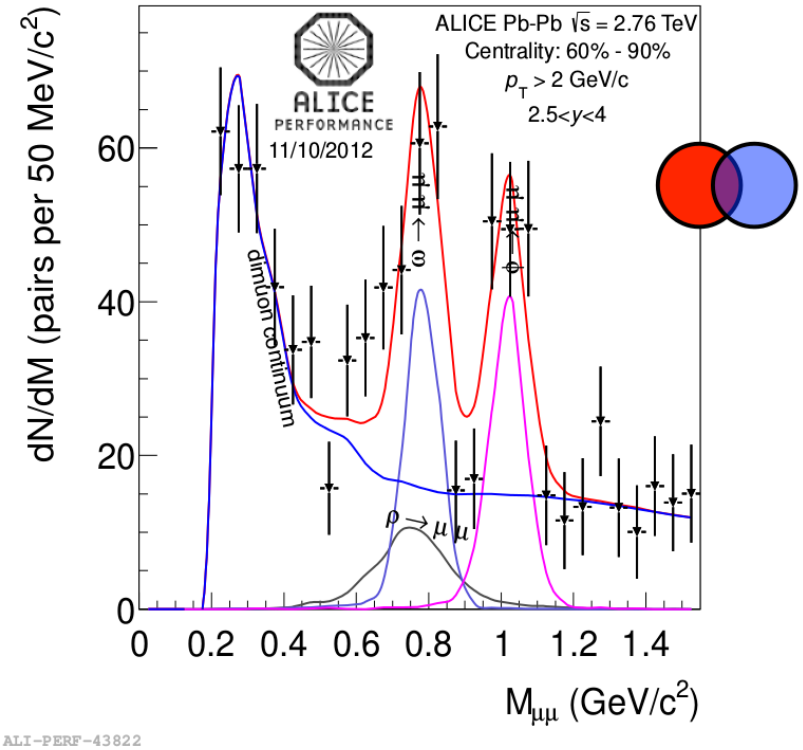
p-Pb : $\sqrt{s_{NN}} = 5.02$ TeV

pp : $\sqrt{s} = 2.76 - 7 - 13$ TeV

Pb-Pb collision : $\sqrt{s} = 2.76$ TeV

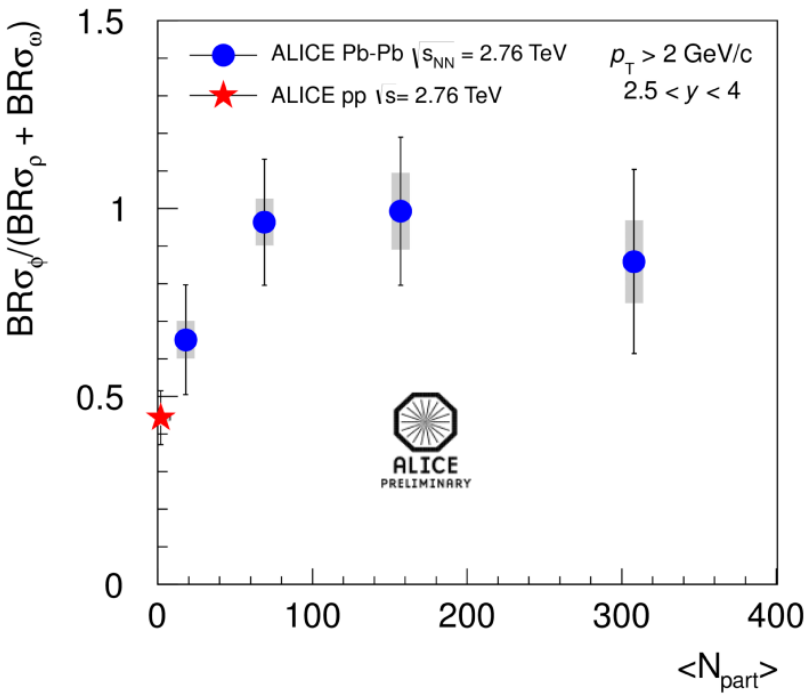
- $\rho + \omega$ and ϕ signals can be extracted with respect to continuum (open charm/beauty and Dalitz decays). The large statistical uncertainties do not allow a precision study of the underlying continuum.

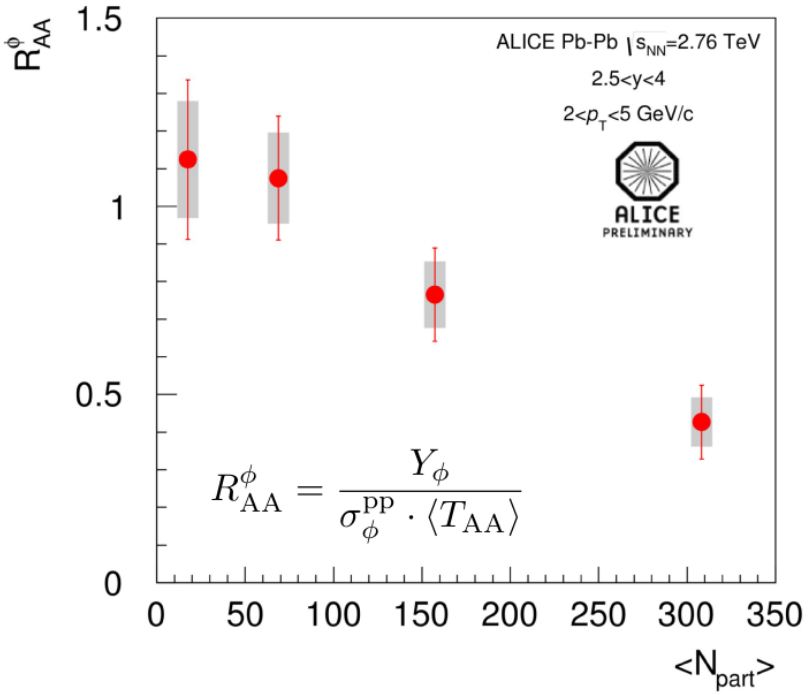




Pb-Pb collision : $\sqrt{s} = 2.76$ TeV

- $\phi/(\rho + \omega)$ increases with respect to pp collisions: ratio tends to saturate from semiperipheral to central collisions
- R_{AA} measured for the ϕ meson vs centrality: compatible with unity for peripheral collisions, suppressed going towards central collisions



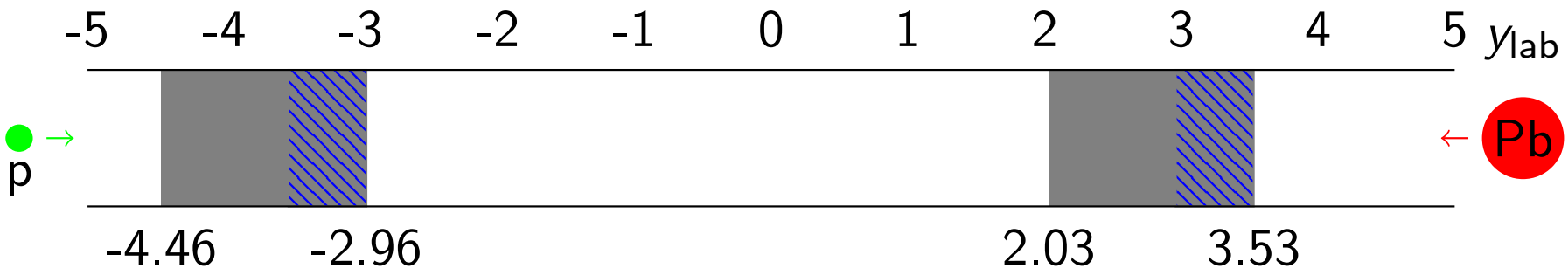


p-Pb collisions $\sqrt{s} = 5.02$ TeV : Rapidity ranges in muon arm for p-Pb collisions

Asymmetric system

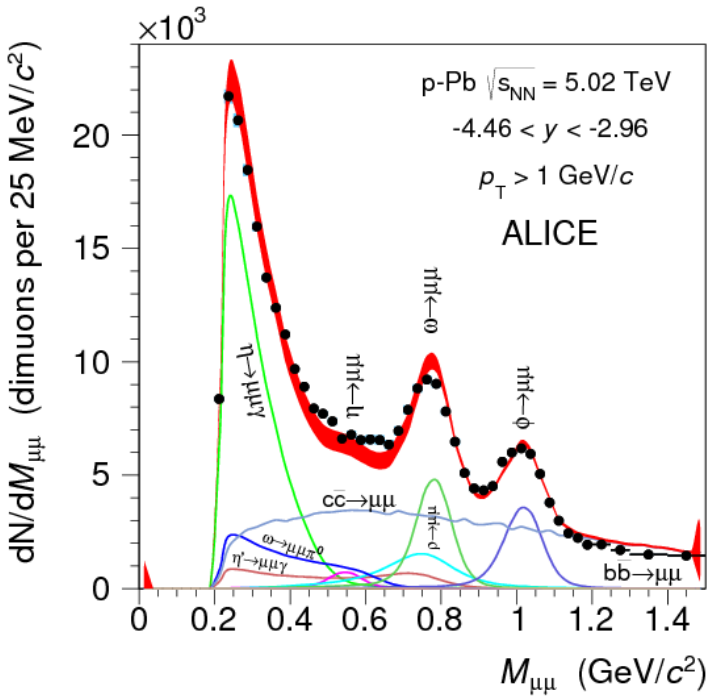
Center of mass not at rest in the laboratory

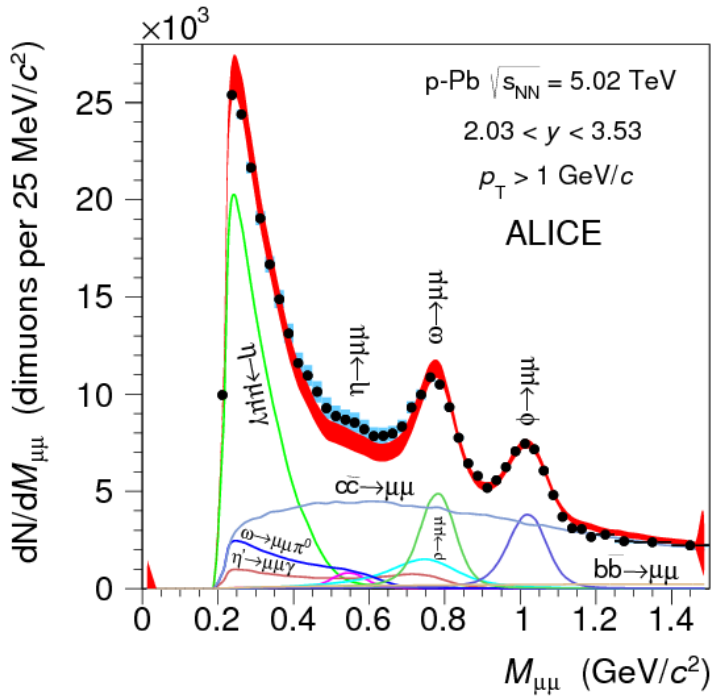
- backward range : $-4.46 < y < -2.96$
- forward range : $2.03 < y < 3.53$
- common range : $2.96 < |y| < 3.53$



p-Pb collisions $\sqrt{s} = 5.02$ TeV :

- Favorable trigger for low-mass dimuon analysis : good acceptance down to $p_T = 1$ GeV/c
- systematics in ϕ meson extraction within 7%





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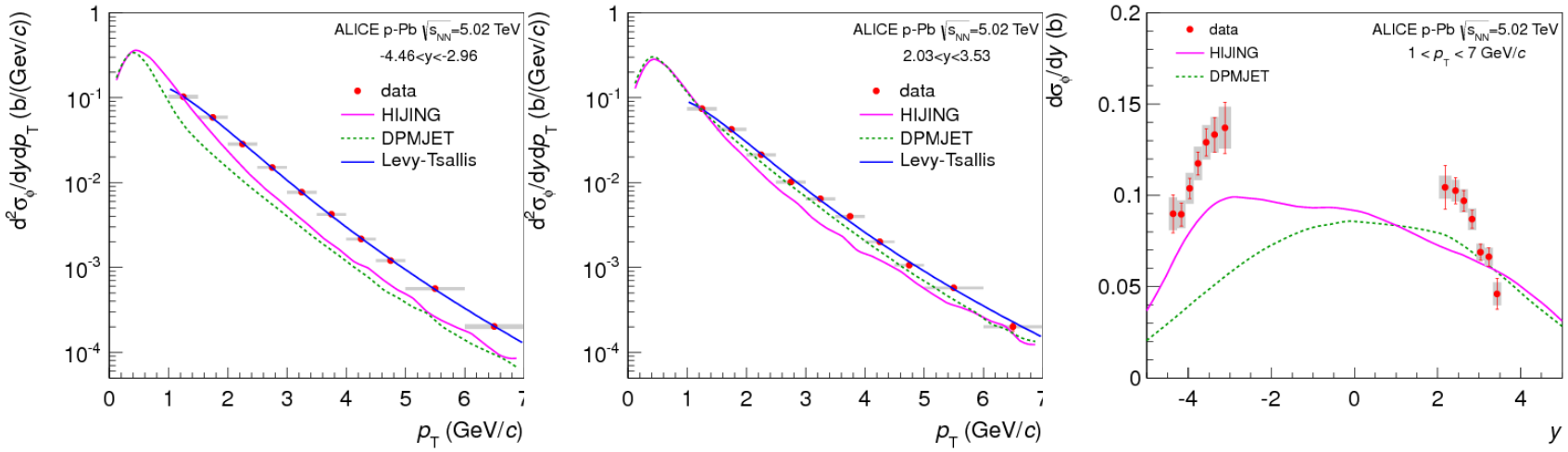
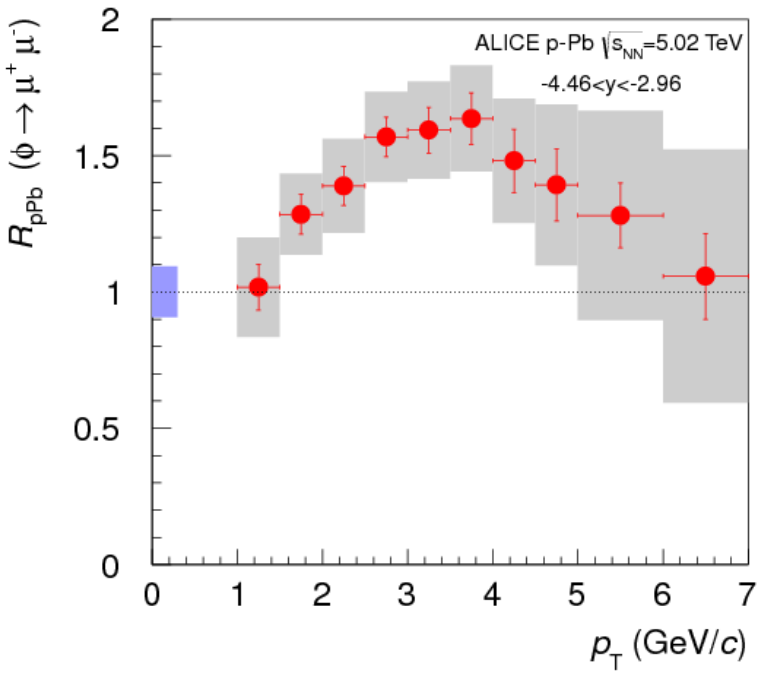
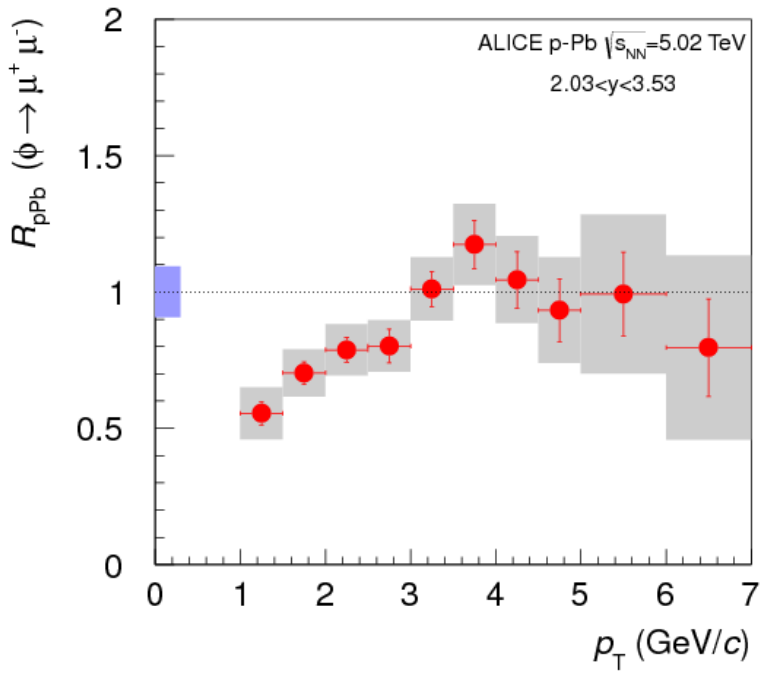


ϕ meson cross section:

- p_T dependence : compatible trends in forward and backward directions
- y dependence : clear forward/backward asymmetry
- HIJING and DPMJET predictions : large deviations with respect to data, especially for the cross section normalization in backward rapidity region and the description of rapidity dependence.

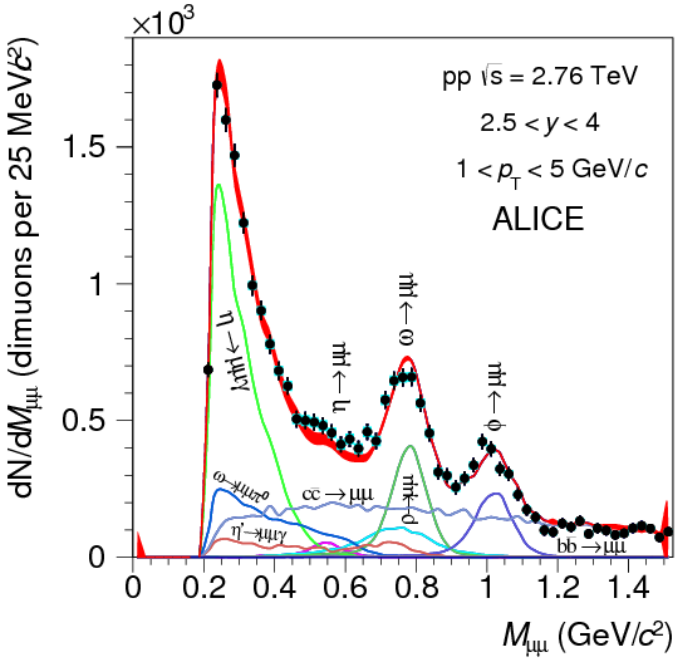
p-Pb collisions $\sqrt{s} = 5.02$ TeV :

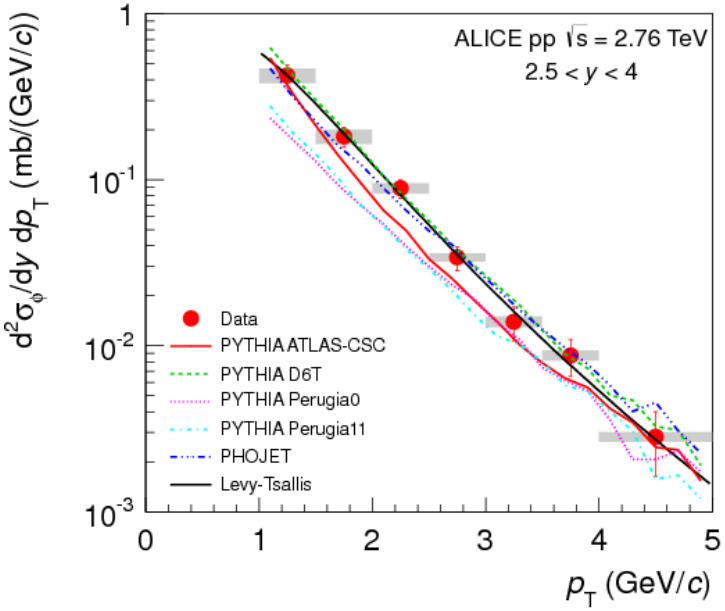




- R_{pPb} vs p_{T} for the ϕ meson at forward and backward rapidity:
  - larger for backward rapidity, but similar trends vs p_{T}
- R_{pPb} enhancement at backward rapidity. Cronin effect or flow ? Specific model predictions are needed

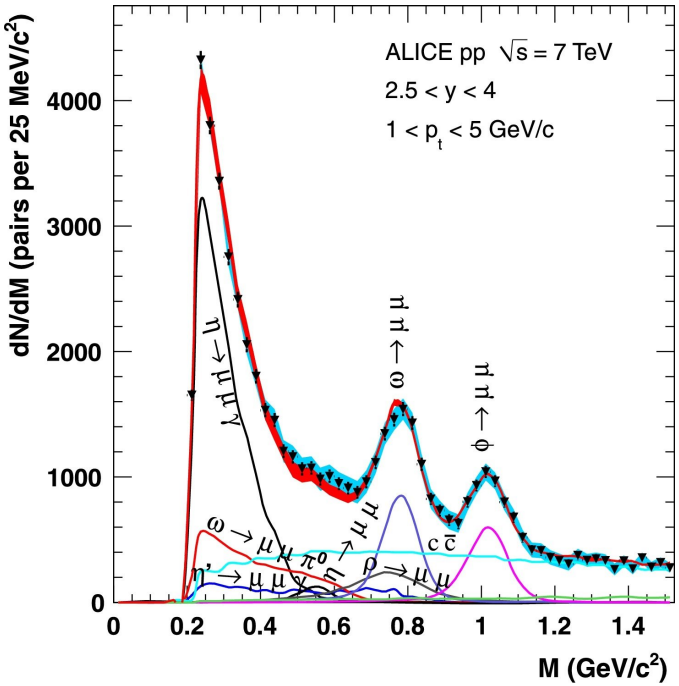
pp collisions - $\sqrt{s} = 2.76$ TeV

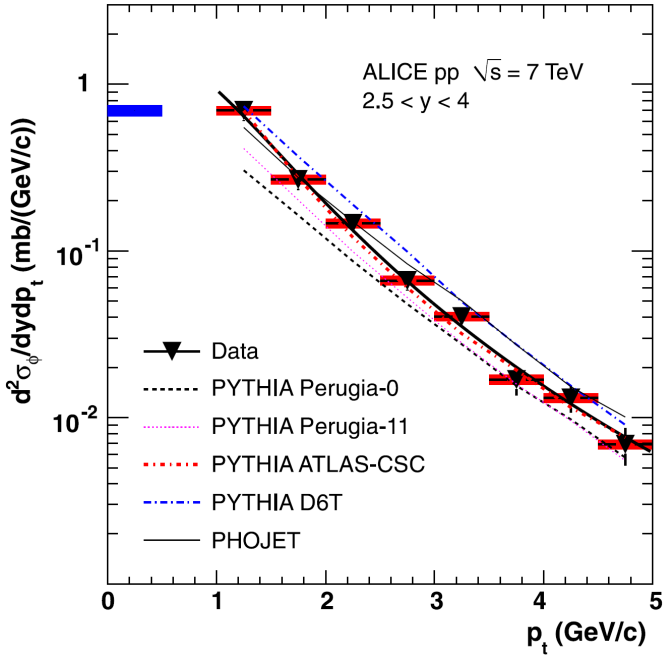




- Good agreement between data and MC for low mass dimuon spectrum
- p_T-differential cross section measured for ω and ϕ
  $\rightarrow$ reference for Pb-Pb and p-Pb (interpolation at 5.02 TeV)
- ϕ meson : `PYTHIA Perugia0` and `Perugia11` tunes underestimate the data by about a factor 2

pp collisions - $\sqrt{s} = 7$ TeV





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pp collisions - $\sqrt{s} = 13$ TeV

$\sqrt{s} = 13$ TeV : Raw mass spectrum

Using LHC15 (g, h & i) periods separately with criteria:

- LHC status: stable beams
- Triggered by CMUL7-B- and CMLL7-B- Downscaling factor is automatically read in OCDB and propagated through the analysis
- Number of triggered events larger than 100
- vertex event : $|v_z| < 10$ cm

Final list of runs may slightly change according to the QA

$\sqrt{s} = 13$ TeV : ratio of raw mass spectrum

Ratio of integrated statistics between LHC15g and h : 1.44

Ratio of integrated statistics between LHC15i and h : 3.78

$\sqrt{s} = 13$ TeV : Combinatorial background estimation

Background estimation from data:

$$N^{\text{dir}}_{bkg}(M) = 2R(M)\sqrt{N^{\text{dir}}_{++}(M) \cdot N^{\text{dir}}_{--}(M)}$$

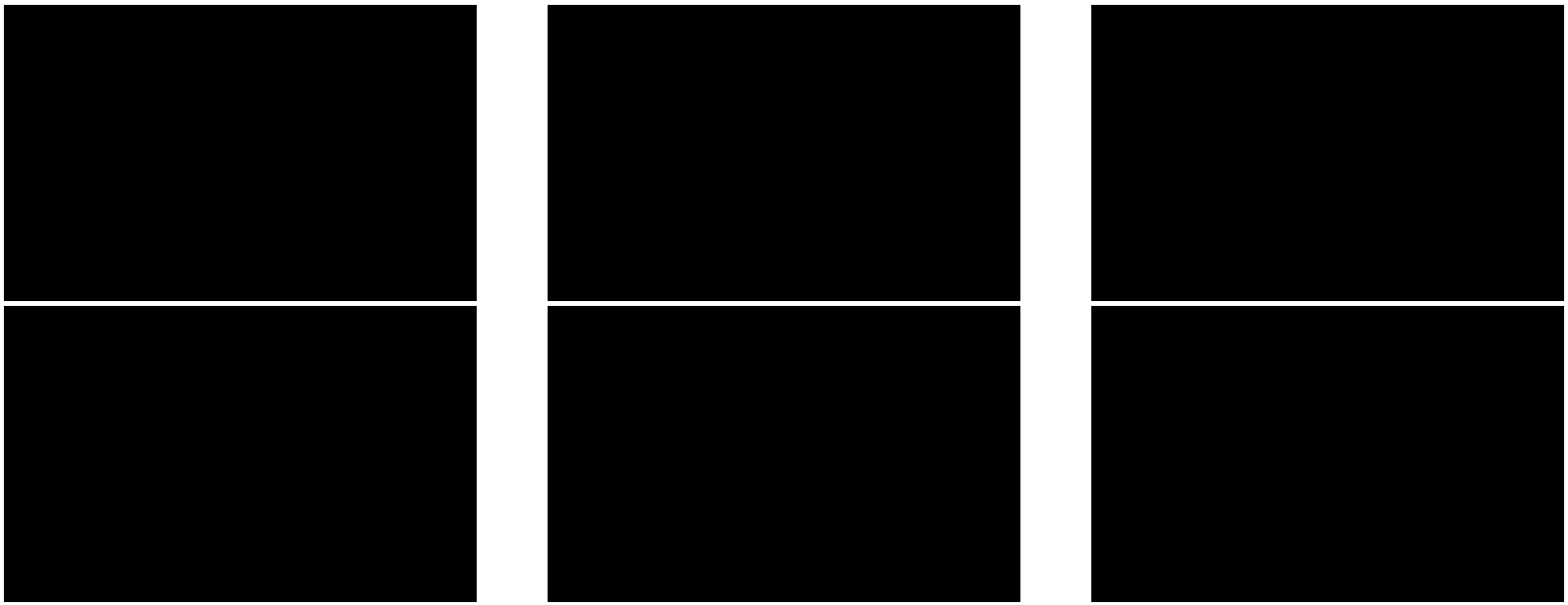
with R factor estimated with mixing

$$R(M) = \frac{N^{\text{mix}}_{+-}(M)}{2\sqrt{N^{\text{mix}}_{++}(M) \cdot N^{\text{mix}}_{--}(M)}}$$

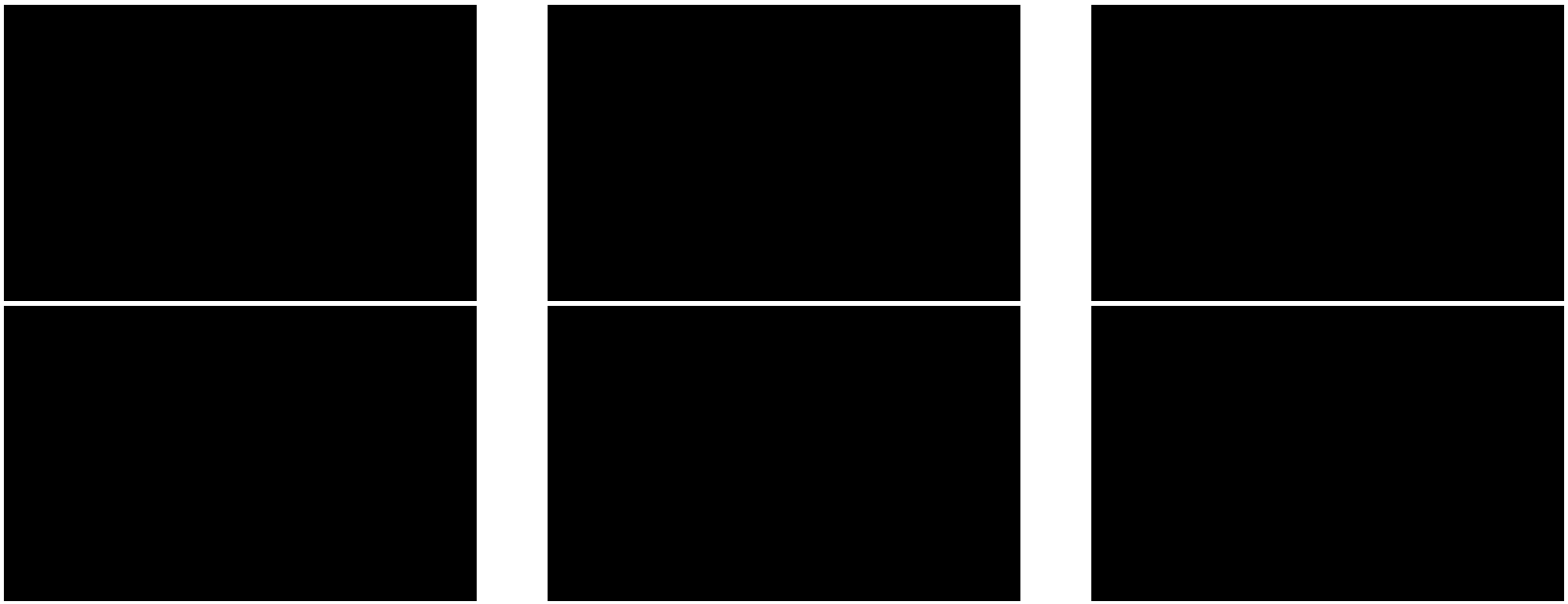
Integral of $N^{\text{dir}}_{bkg}(M)$ [direct background] can be used to normalize the background estimated by the mixing procedure [mixed background]

$\sqrt{s} = 13$ TeV : signal mass spectrum

$\sqrt{s} = 13$ TeV - Signal



$\sqrt{s} = 13$ TeV : ϕ number estimation by simple fit (waiting for the full MC cocktail)



Outlook

- Full MC simulation
- Acceptance correction
- Measurement of p_T spectra for ϕ, $\omega + \rho$ and η

Summary

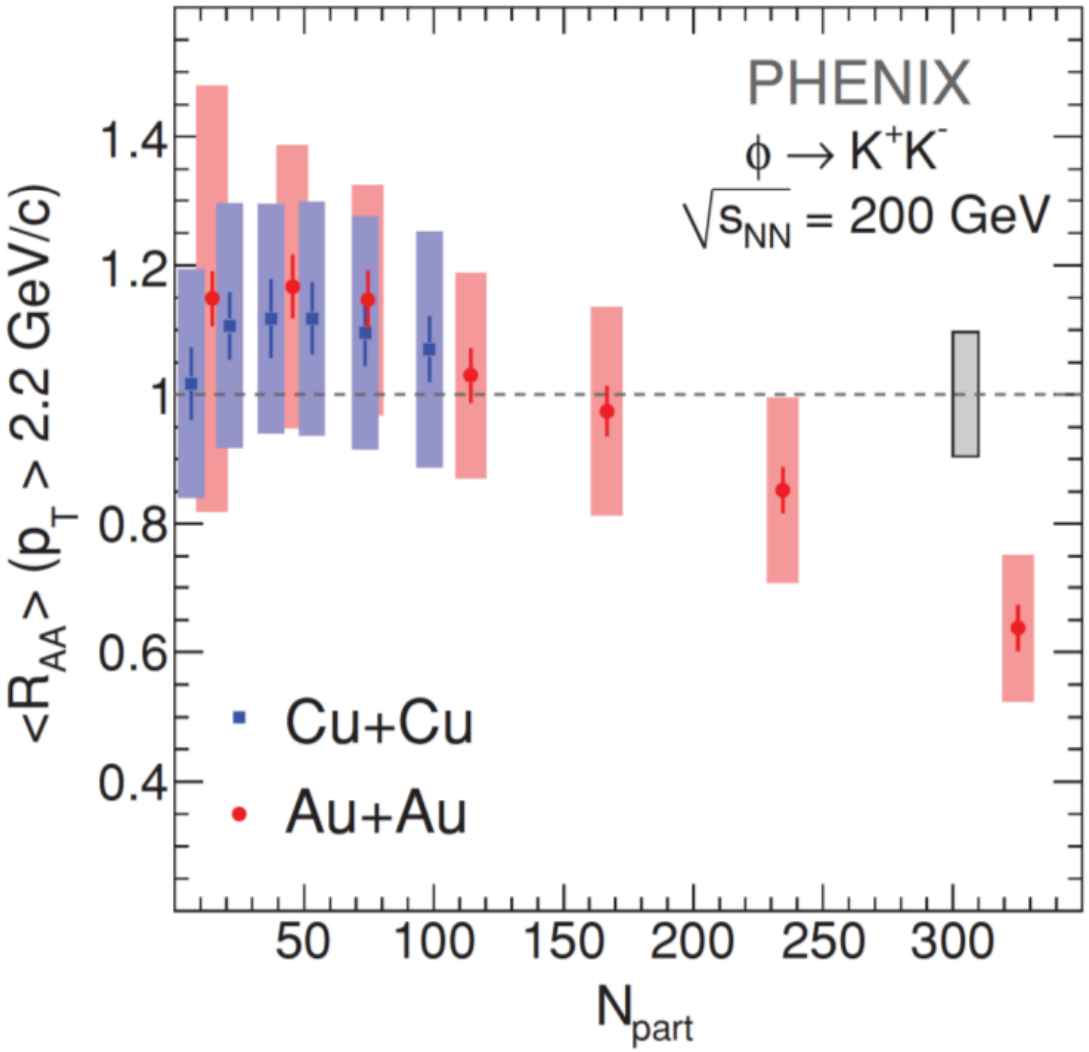
- Pb-Pb : For ϕ meson R_{AA}, suppression is observed with increasing centrality. Large statistical uncertainties do not allow a precision study of the underlying continuum.
- p-Pb : Forward/backward asymmetry observed for the ϕ meson, not well reproduced by models. R_{pPb} observed to be peaked around $p_T = 3$ - $4\ \mathrm{GeV/c}$ at backward rapidity. No prediction available from theoretical models
- pp:

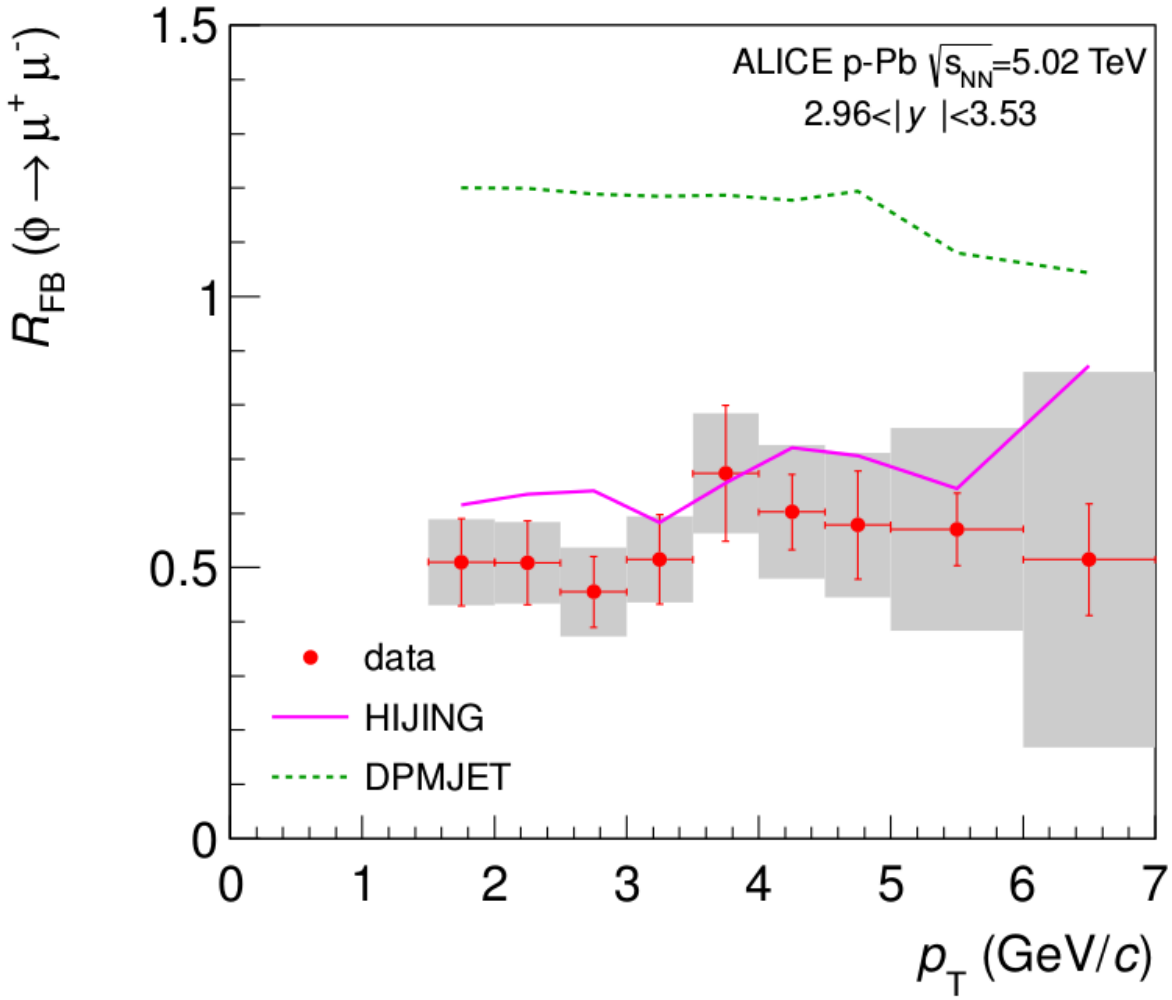
2.76 - 7 TeV : Low mass dimuon spectrum successfully described by the hadronic cocktail - baseline for Pb-Pb and p-Pb collisions.

13 TeV : Promising statistics for the low mass region : extraction of ϕ (& η, $\rho + \omega$) meson signal $\rightarrow$ work in progress .

Backup

Phys. Rev. C 83 (2011) 024909




ALICE p-Pb $\sqrt{s_{NN}}$=5.02 TeV
2.96<|y|<3.53
R_{FB} ($\phi \rightarrow \mu^+ \mu^-$)
data
HIJING
DPMJET
p_T (GeV/c)
ALI-PUB-94063

R factor

LS corresponding to:

$$LS^{++} + LS^{--}$$

The average difference between the (parametrized) ratio and the unity is taken as the relative error for the background subtraction.
To be discussed ...

Normalisation of mixing background shape

Normalizations are equalized in full mass range