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Low Mass Dilepton Measurements in ALICE

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on behalf of the ALICE Collaboration

Outline

- Physics Motivations
- The ALICE detector
- Results from the Pb-Pb runs
- 

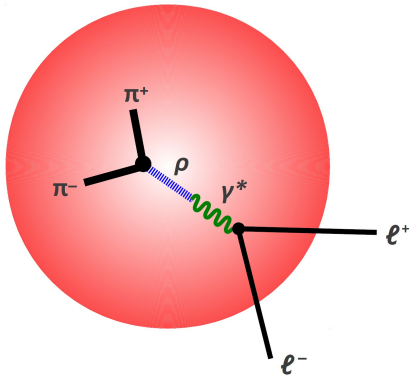
Highlight from the p-Pb run: R_{pPb} for the ϕ meson
- Summary & Outlook

Physics Motivations

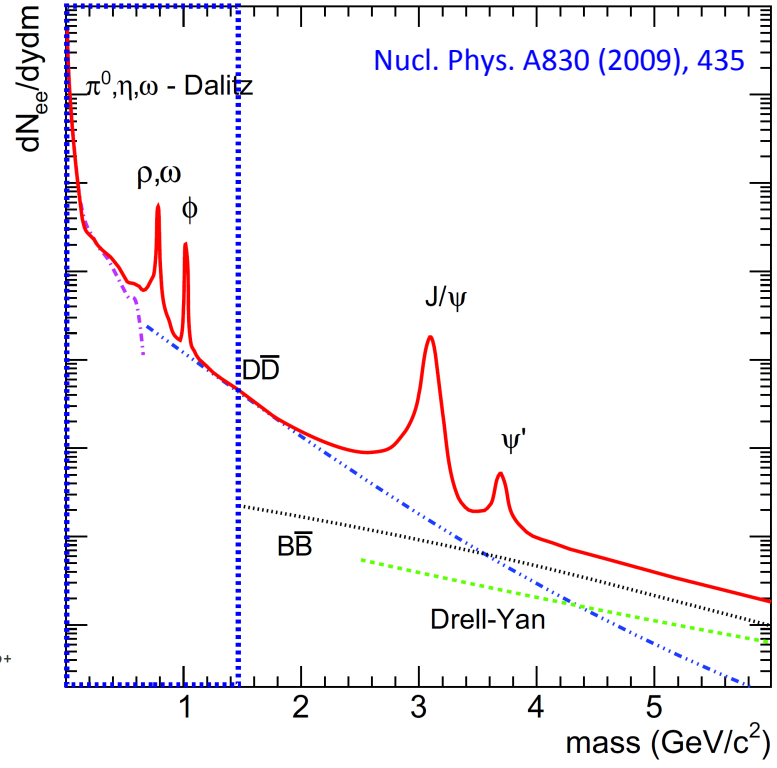
Low mass dilepton production in heavy-ion → key information on the hot and dense state of strongly interacting matter produced in high-energy nucleus-nucleus collisions

Insights on **non-perturbative QCD**:

- Strangeness production investigated via ϕ meson production
- In-medium modifications of hadron properties accessed through ρ spectral function: possible link to chiral symmetry restoration



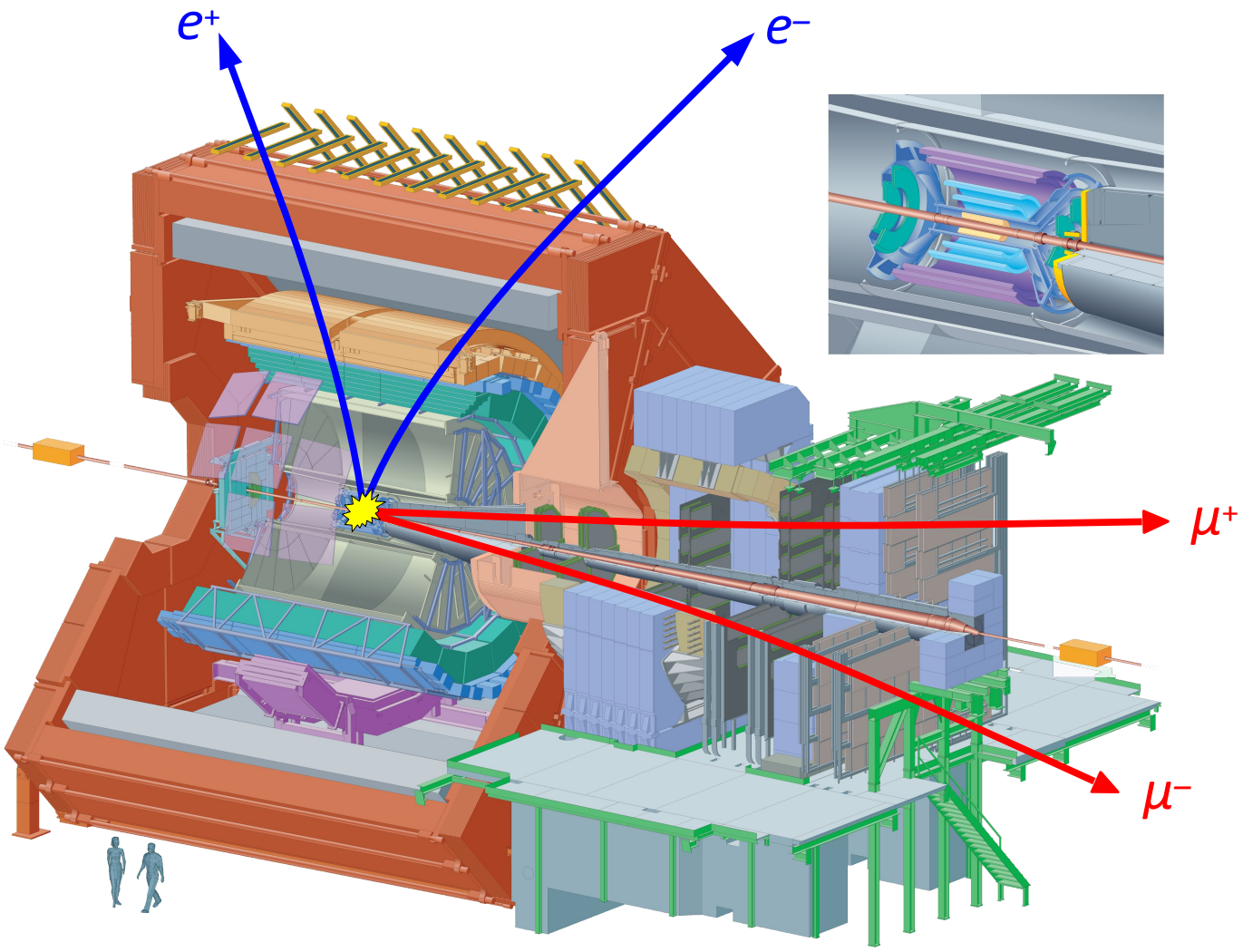
Dileptons (dielectrons, dimuons) → Negligible final-state effects



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

Measuring Dileptons in ALICE

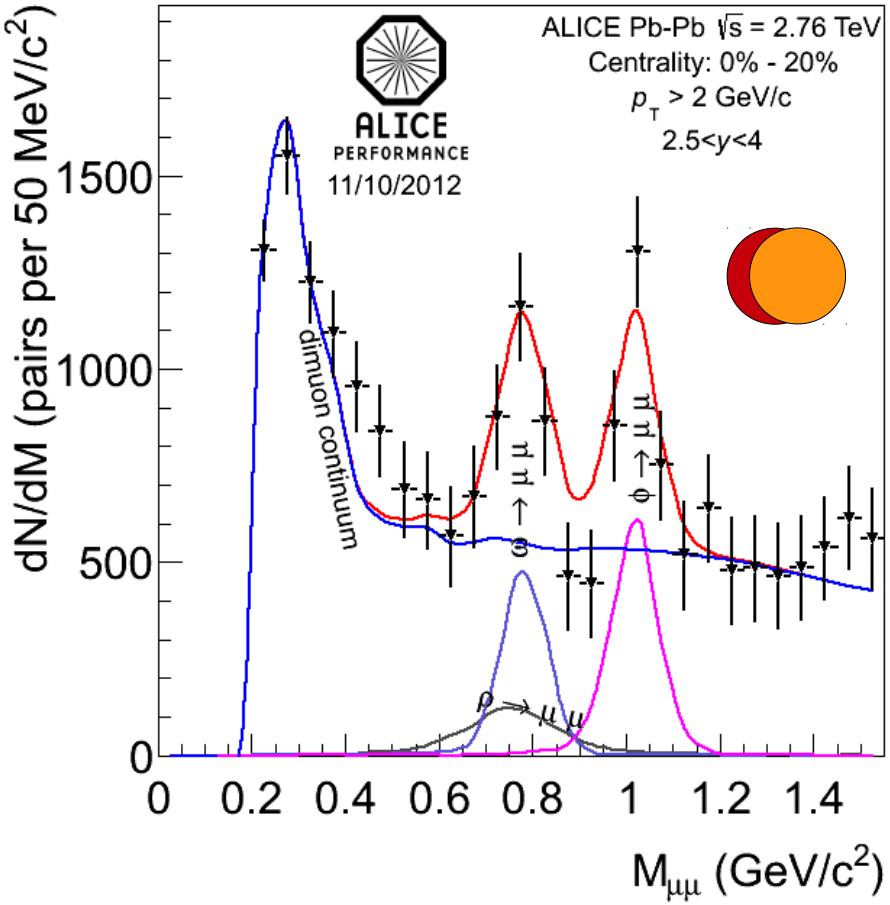
- **Dimuons** → **$2.5 < \eta < 4$**
  Muon Arm: Tracking Chambers + Muon Trigger
- **Dielectrons** → **$|\eta| < 0.9$**
  Central Barrel: Inner Tracking System + Time Projection Chamber + Time Of Flight

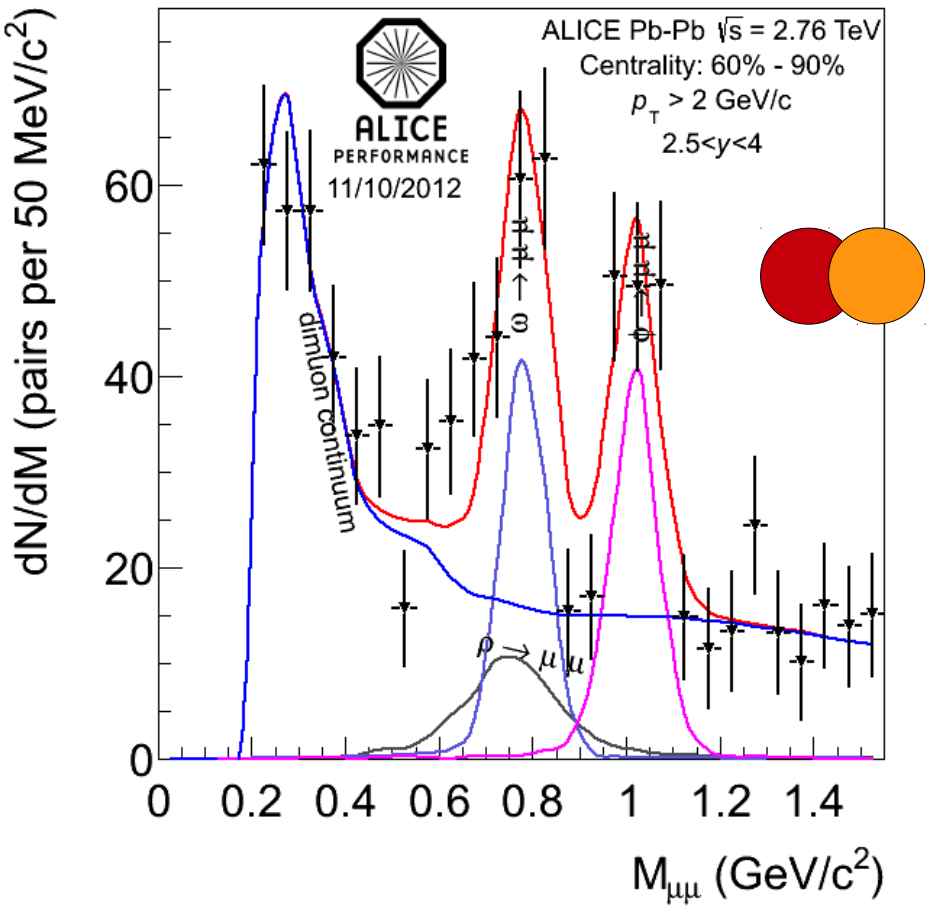


- pp collisions at **2.76 TeV** and **7 TeV** [→ PLB 710 (2012) 557]
- Pb-Pb collisions at **2.76 TeV** per nucleon pair
- p-Pb and Pb-p collisions at **5.02 TeV** per nucleon pair

Low Mass Dimuons in Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV (I)

- **ρ/ω and ϕ signals can be extracted w.r.t. continuum** (open charm/beauty and Dalitz decays). The large statistical uncertainties do not allow a precision study of the underlying continuum. Acceptance from $p_T(\mu\mu)$ ~2 GeV/c

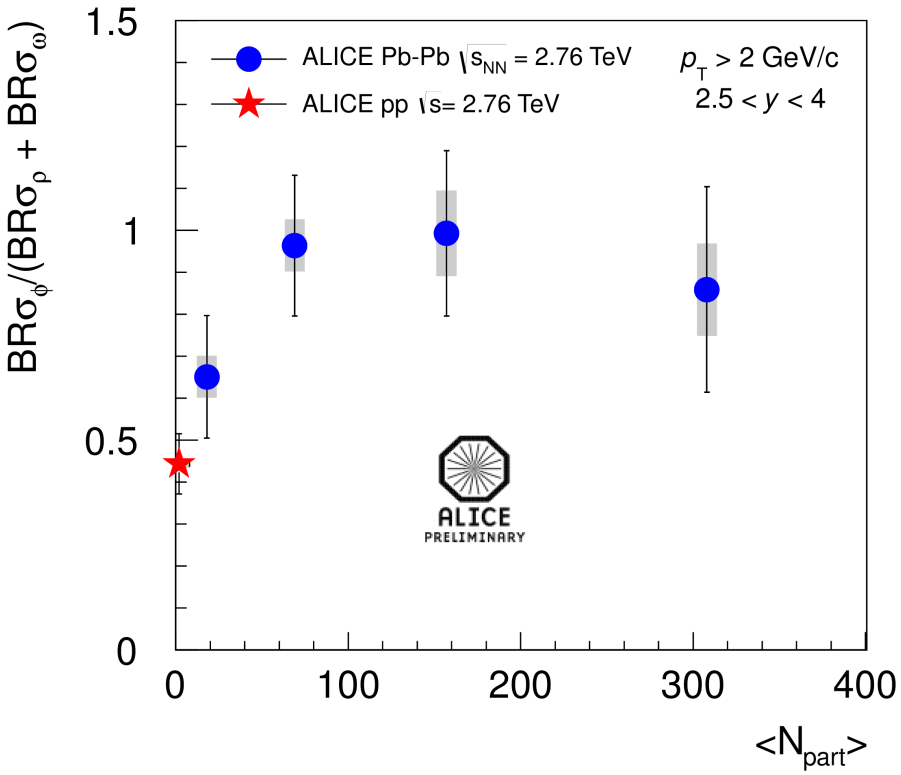


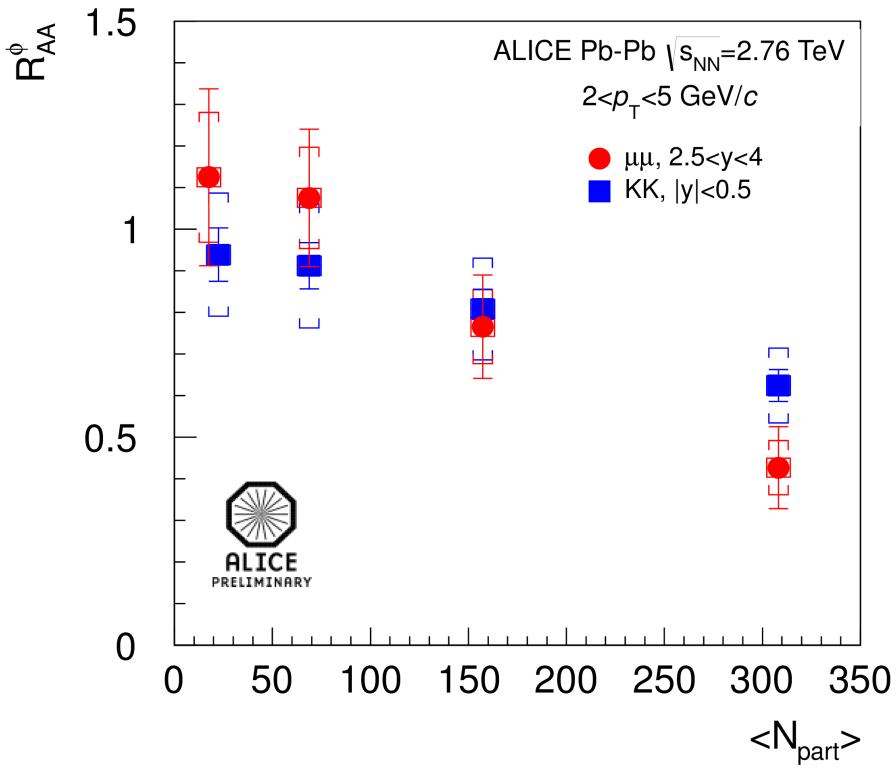


Low Mass Dimuons in Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV (II)

- **ϕ/(ρ+ω) increases with respect to pp collisions**: ratio tends to saturate from semiperipheral to central collisions

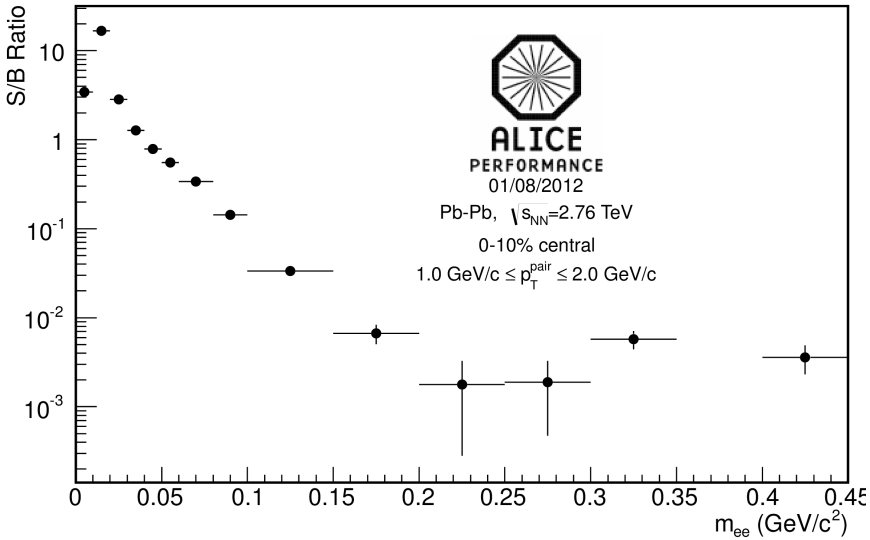
- **R_{AA} measured for the ϕ meson vs centrality.** Dimuon measurement at forward rapidity and in KK at mid rapidity in agreement within the errors: no indication for strong absorption/rescattering effects in the KK channel

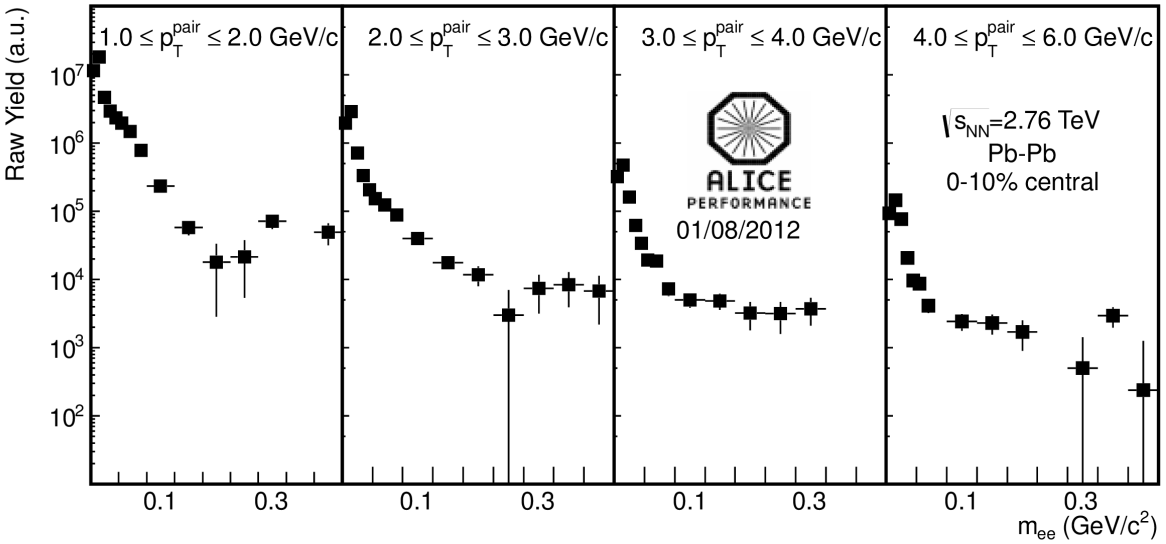


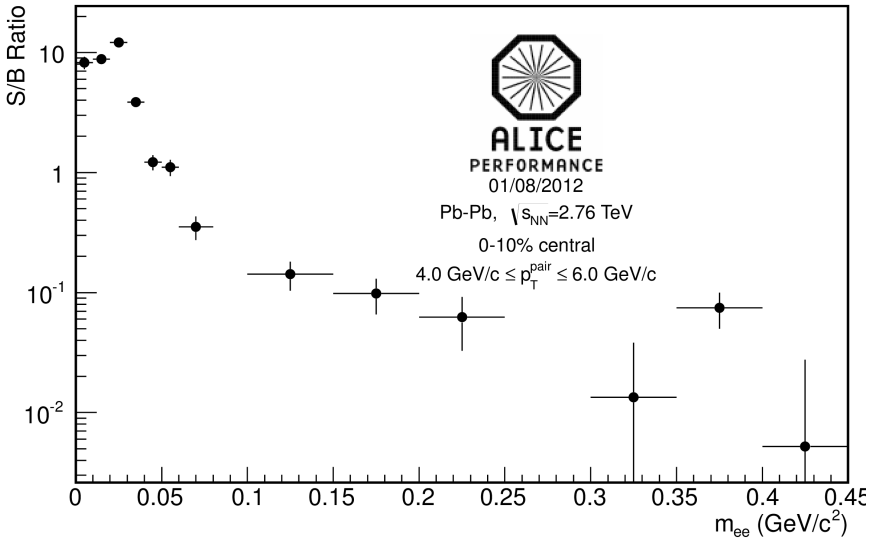


Low Mass Dielectrons in Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV

- **Challenging electron identification:** Time Projection Chamber and Time Of Flight
- S/B ratio of few ‰ in the lowest p_T bin: accurate combinatorial background evaluation needed
- **Analysis ongoing**

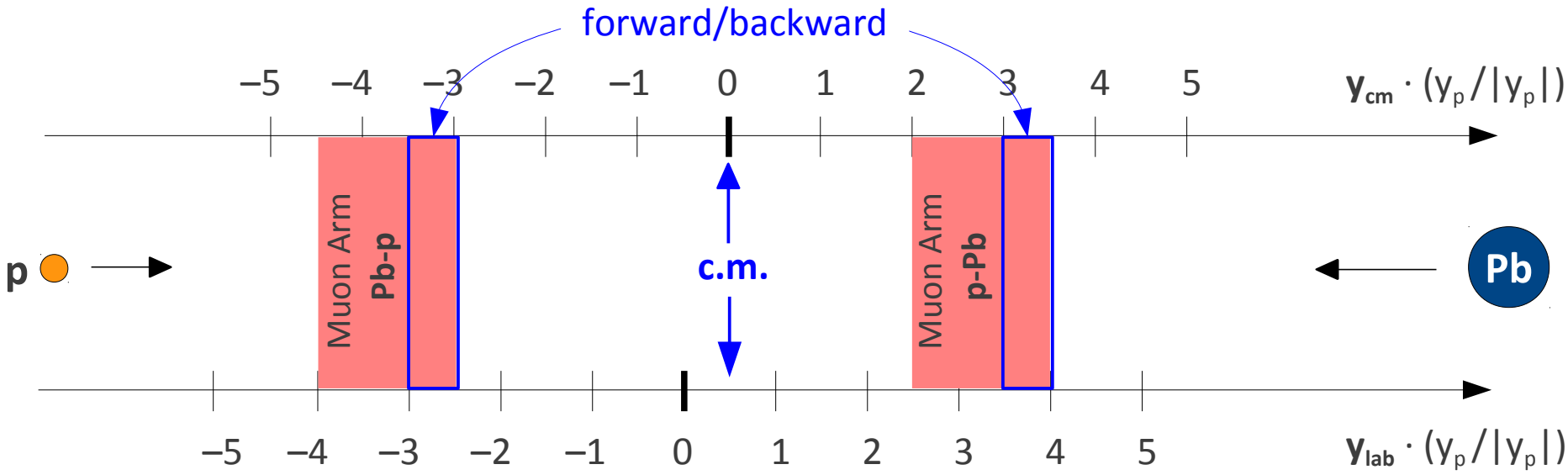






Low Mass Dimuons in p-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV

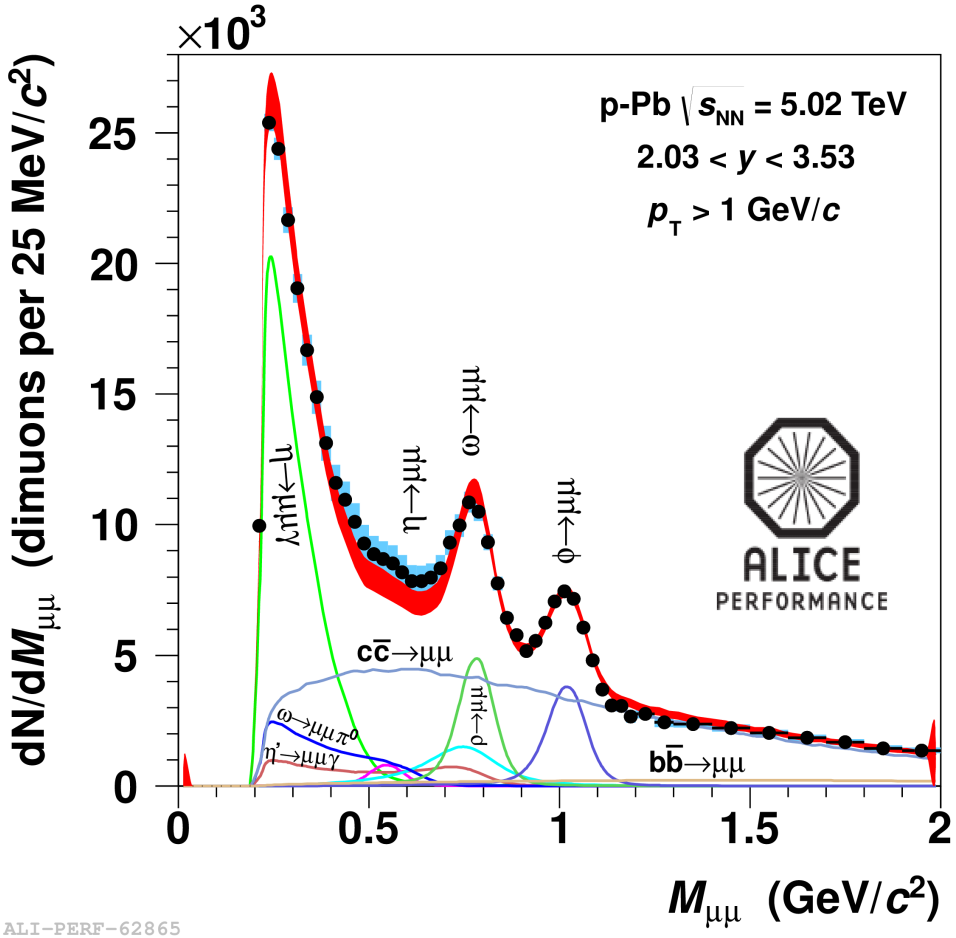
- **LHC p-Pb run in 2013: nearly 11 nb^{-1} integrated luminosity for dimuon triggers**
- LHC provides different energies for p (4 TeV) and Pb (1.58 × A TeV) beams → **c.m. moves with rapidity +0.46 in the laboratory**
- **Asymmetric system** → interest in looking both forward and backward hemispheres with the Muon Arm ($2.5 < y_{lab} < 4.0$): switch from p-Pb to Pb-p (much easier than flipping the Muon Arm!)
- Direct forward/backward comparisons only available in **$2.96 < |y_{CM}| < 3.53$**

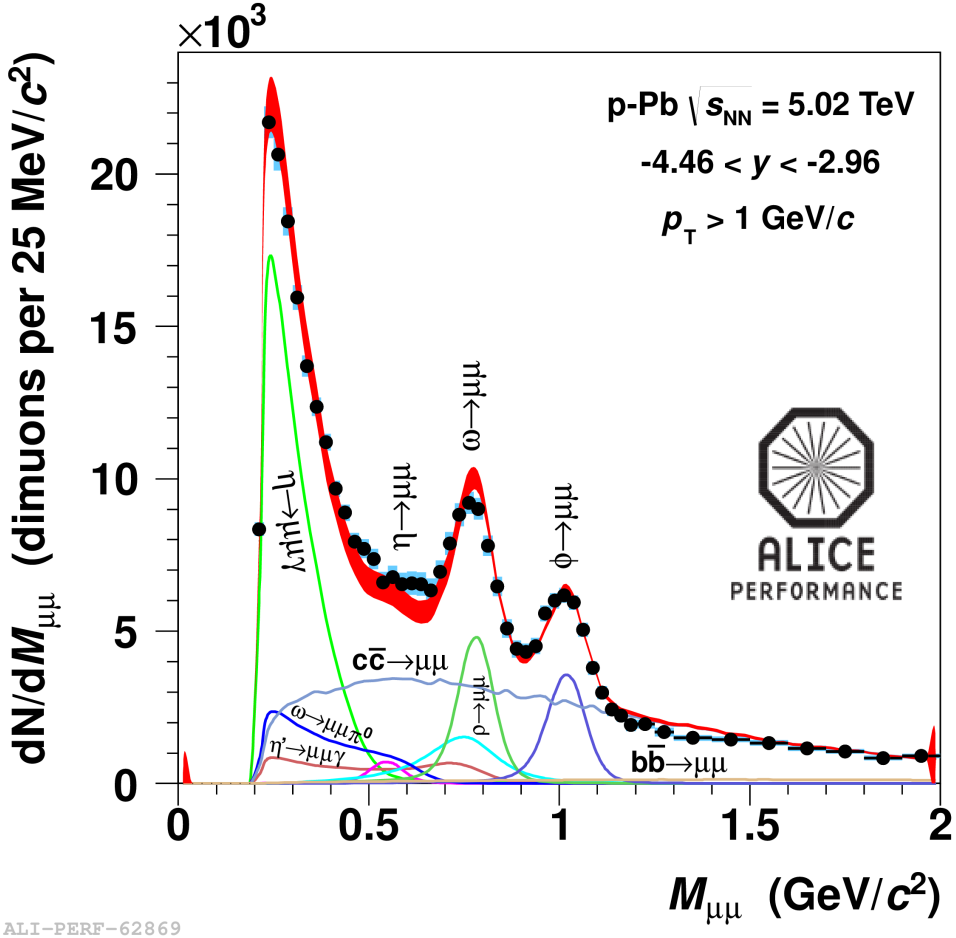


Hadronic Cocktail Fits

- Favorable dimuon trigger scheme: **acceptance down to dimuon p_T = 1 GeV/c**
- **Fair agreement between data and hadronic cocktail + open heavy flavors**
- **Focus on ϕ meson**: systematics on signal extraction within ~7%

NEW

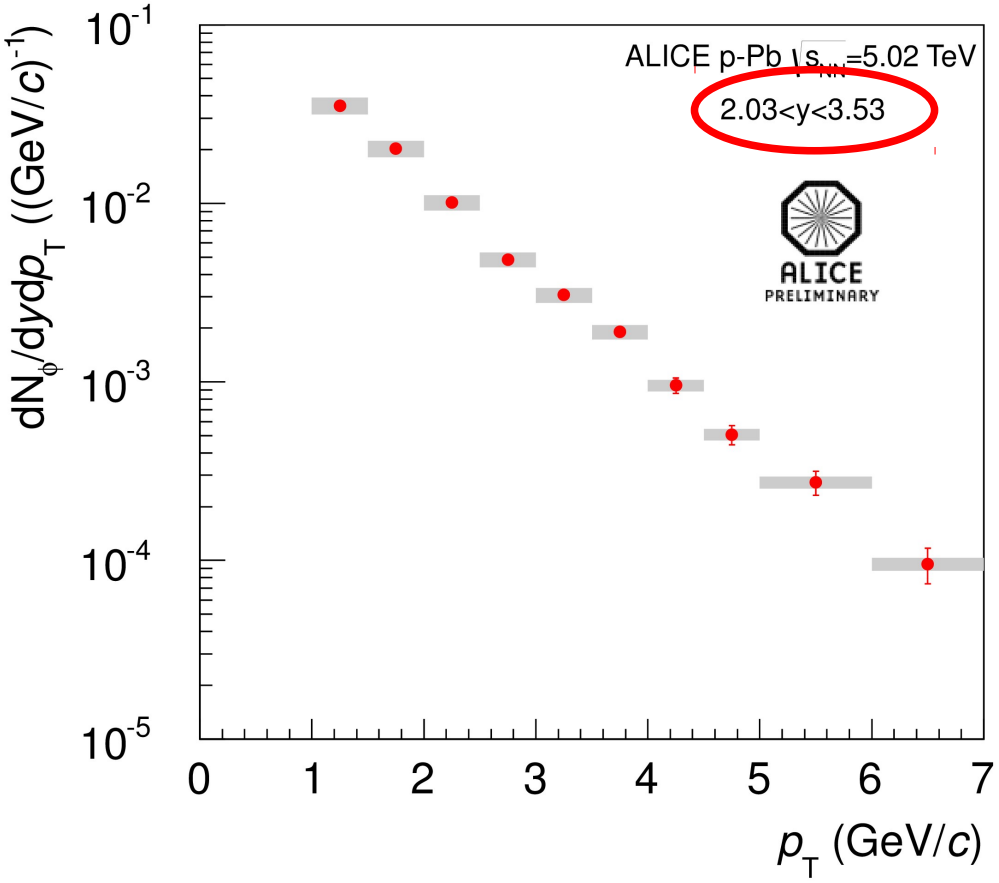




ϕ Meson p_T-differential Yield

NEW

After correction by Acc × Eff: corrected yields in the c.m. rapidity regions covered by the Muon Arm in p-Pb and Pb-p. **Yield larger when the Pb beam is directed towards the Muon Arm**



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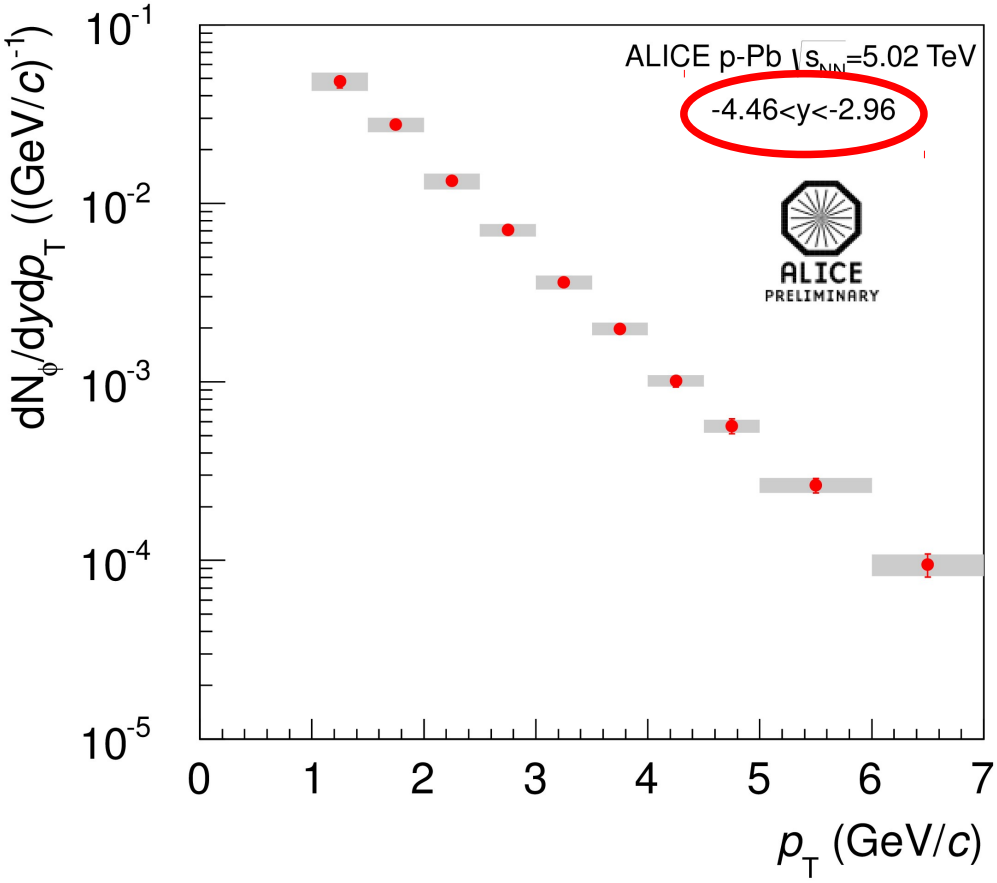

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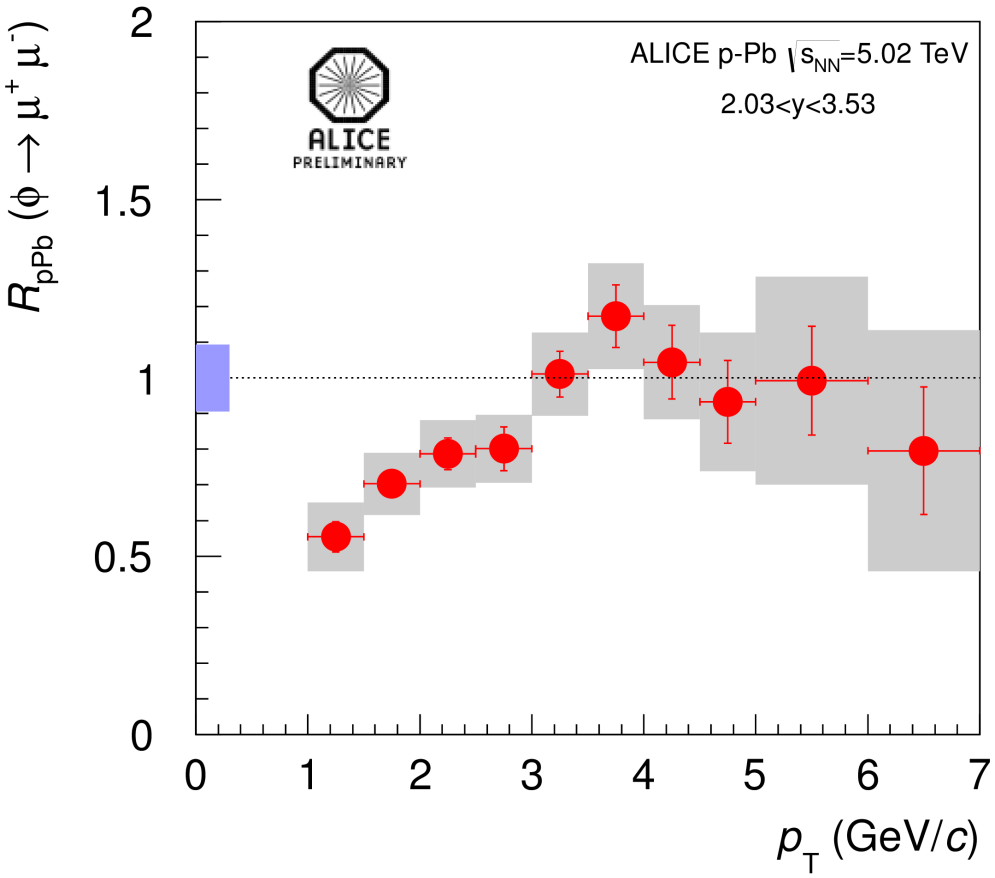
Low Mass Dimuons in p-Pb at $\sqrt{s_{NN}}$ = 5.02 TeV

NEW

- **R_{pPb} vs p_T for the ϕ meson at forward** (p-going) **and backward** (Pb-going) **rapidities:** peak at p_T = 3-4 GeV/c
- **R_{pPb} is larger for backward rapidities**, similar trends vs p_T



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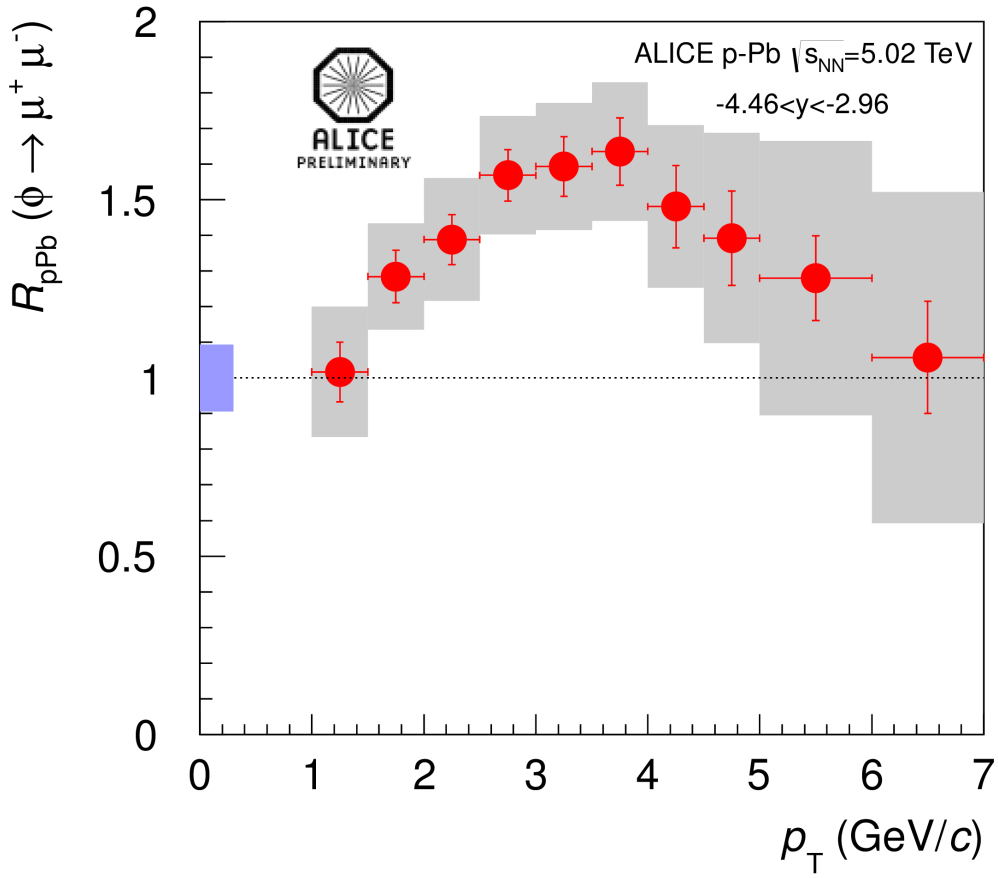

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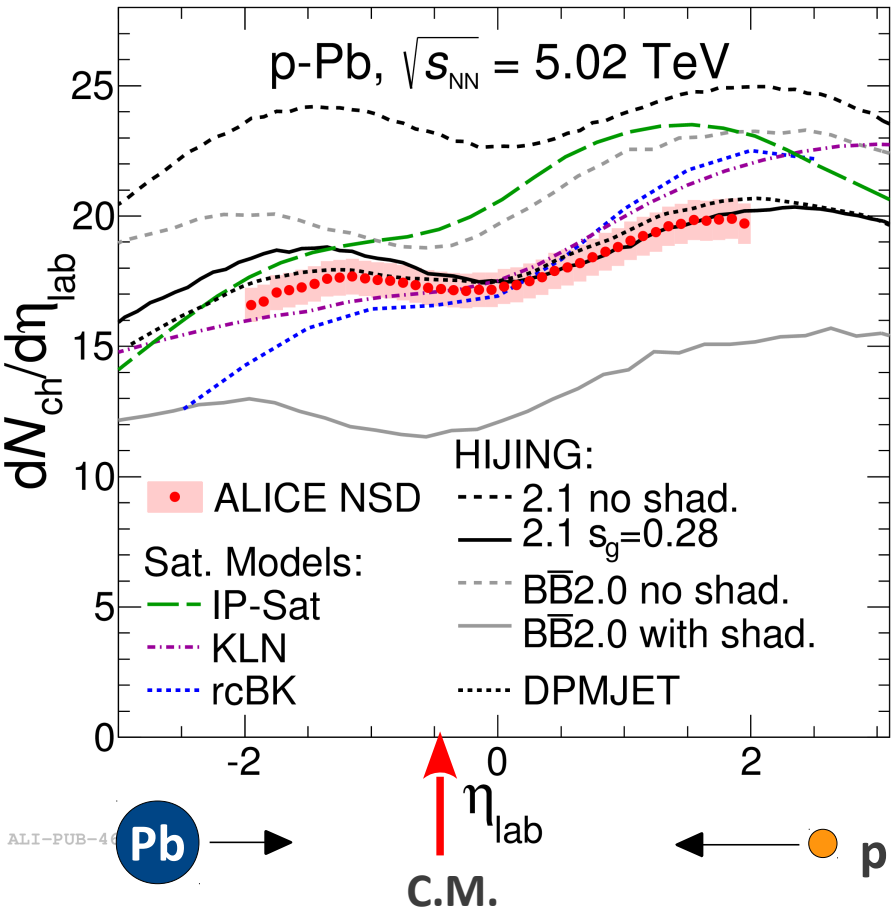
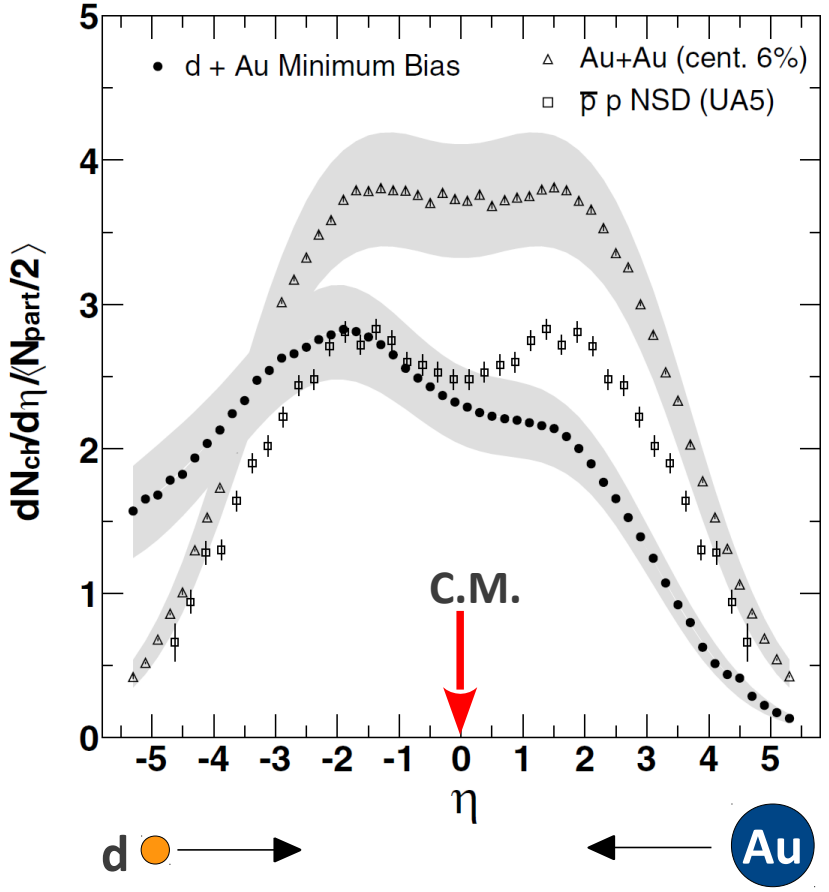
Forward vs Backward

- **ϕ yield larger at backward rapidities (Pb hemisphere) than at forward rapidities (proton's hemisphere)**: expected from soft particle production measurements

ALICE Coll. Phys. Rev. Lett. 110, 032301 (2013)



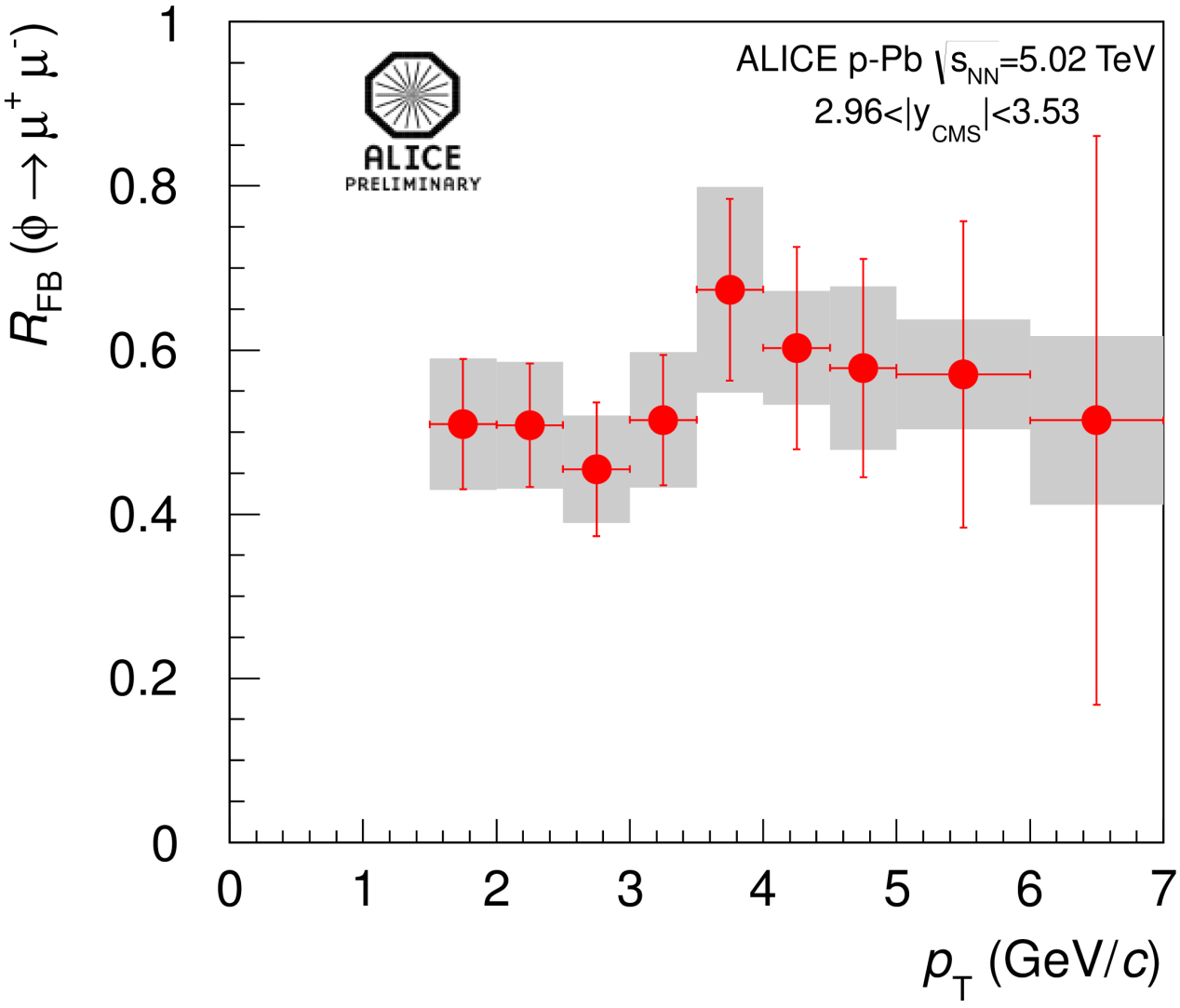
PHOBOS Coll. Phys. Rev. Lett. 93, 082301 (2004)



Forward/Backward Ratio

- A good way to compare forward and backward production is to **compare the yields in the common c.m. rapidity range: $2.96 < |y_{CM}| < 3.54$**

- **Trend vs p_T: flat within fluctuations.** Differences in the observed yields at forward and backward rapidities → related to the known asymmetries in soft particle production



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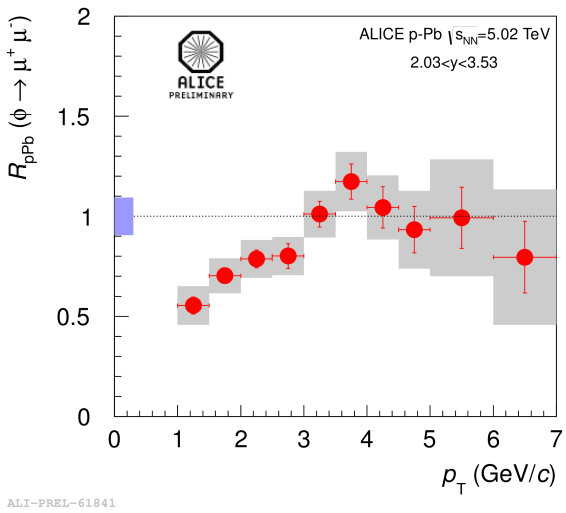
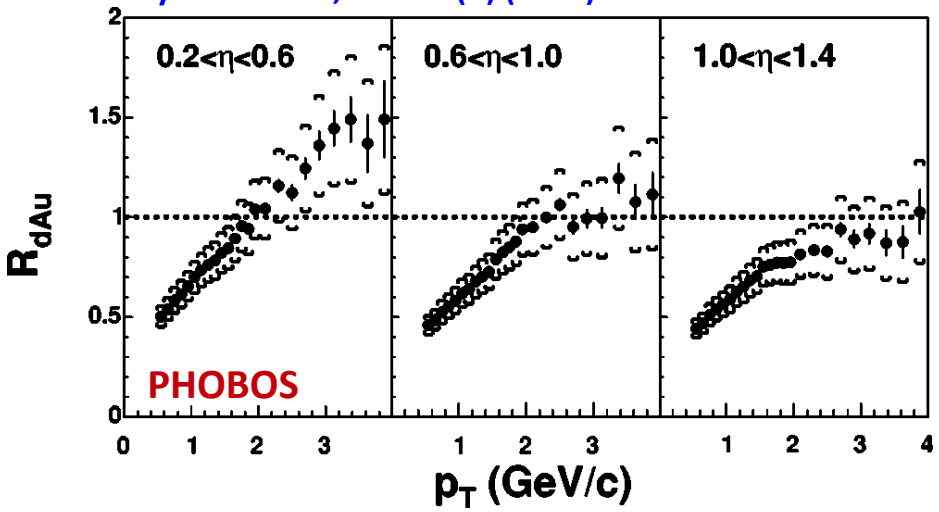
Comparison with Previous Results at RHIC

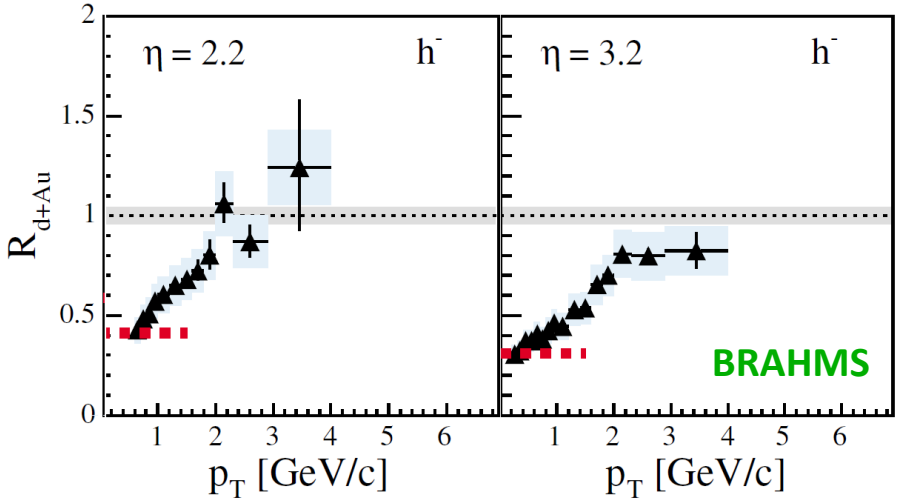


Phys. Rev. C 70, 061901(R) (2004)



- **Comparison with observations at forward (pseudo)rapidities: charged particles from BRAHMS and PHOBOS at RHIC**
- Results from RHIC available at positive (= deuteron's) pseudorapidities only → comparison with ALICE R_{pPb} at forward y
- Results are consistent with $R_{pA} < 1$ for $\eta > 1$

Phys. Rev. Lett. 93, 242303 (2004)



Summary & Outlook

- Low-mass dileptons are measured in ALICE in the dimuon and the dielectron channels
- **pp at 2.76 and 7 TeV [not shown here]:**
  - dimuon measurements published at 7 TeV, analysis finalized at 2.76 TeV → baseline for Pb-Pb and p-Pb
  - dielectron measurement: good agreement between signal and hadronic cocktail + open charm
- **Pb-Pb at 2.76 TeV: R_{AA} dimuon measurement available for the ϕ meson,** agreement with mid-rapidity measurement in the KK channel. Dielectron analysis is ongoing
- **New result from the recent p-Pb run at 5.02 TeV: measurement of the nuclear modification factor R_{pPb} for the ϕ meson, peaked at p_T = 3-4 GeV/c.**
  Forward/backward asymmetry observed, essentially flat vs p_T → coherent with the asymmetry measured in soft particle production at RHIC and LHC
- **In the future:**
  - Extension of the dimuon p-Pb analysis to lighter mesons η and ω. Finalization of the ongoing analyses in the dielectron channel
  - **Preparation of the LHC Run2:** new measurements in pp and Pb-Pb at higher energies → larger statistics and more precise studies

Backup Slides

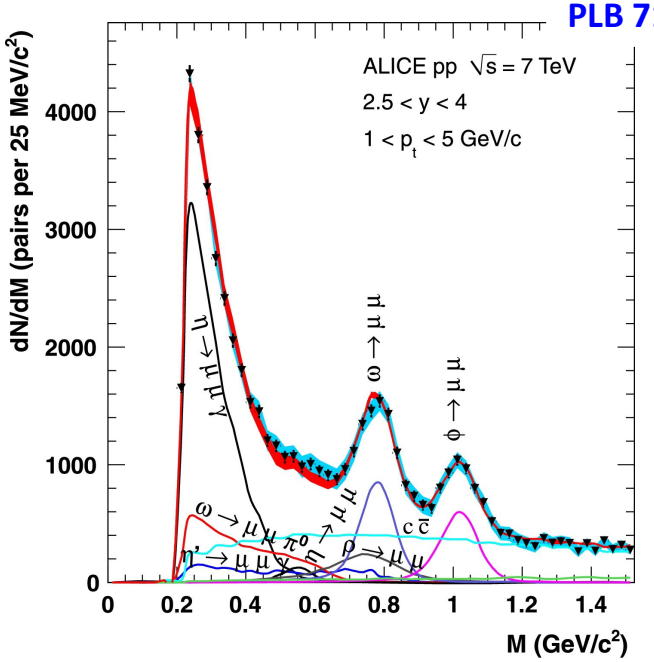
Low Mass Dimuon Results in pp at 2.76 and 7 TeV

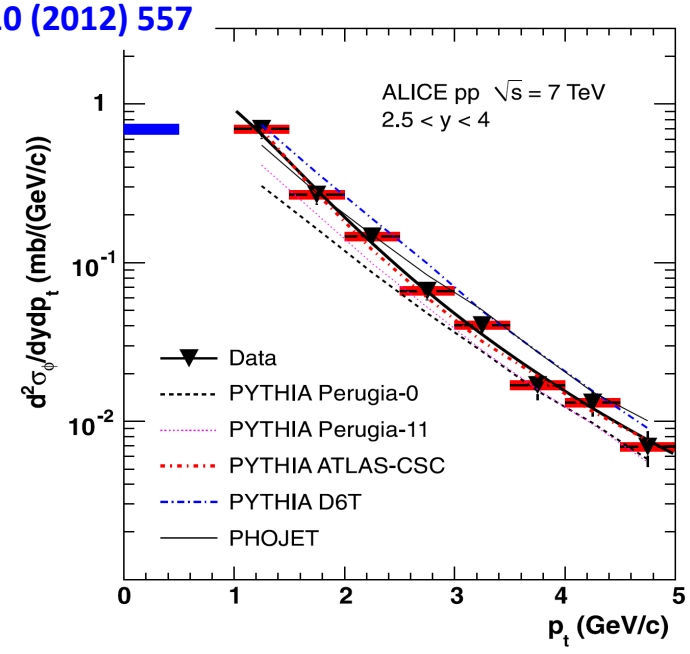
- Low Mass Dimuon Spectrum: **good agreement between signal and MC sources**

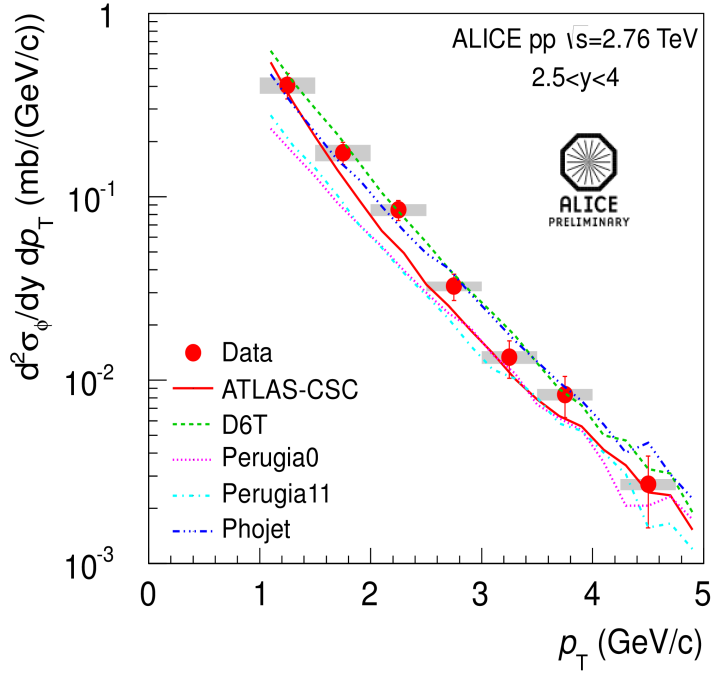
- **p_T differential cross sections measured for ω and ϕ mesons** → reference for the interpolation at ~5 TeV energies

- ϕ meson → PYTHIA tunes Perugia0 and Perugia11 underestimate the data by about a factor of 2 both at 2.76 and 7 TeV

PLB 710 (2012) 557





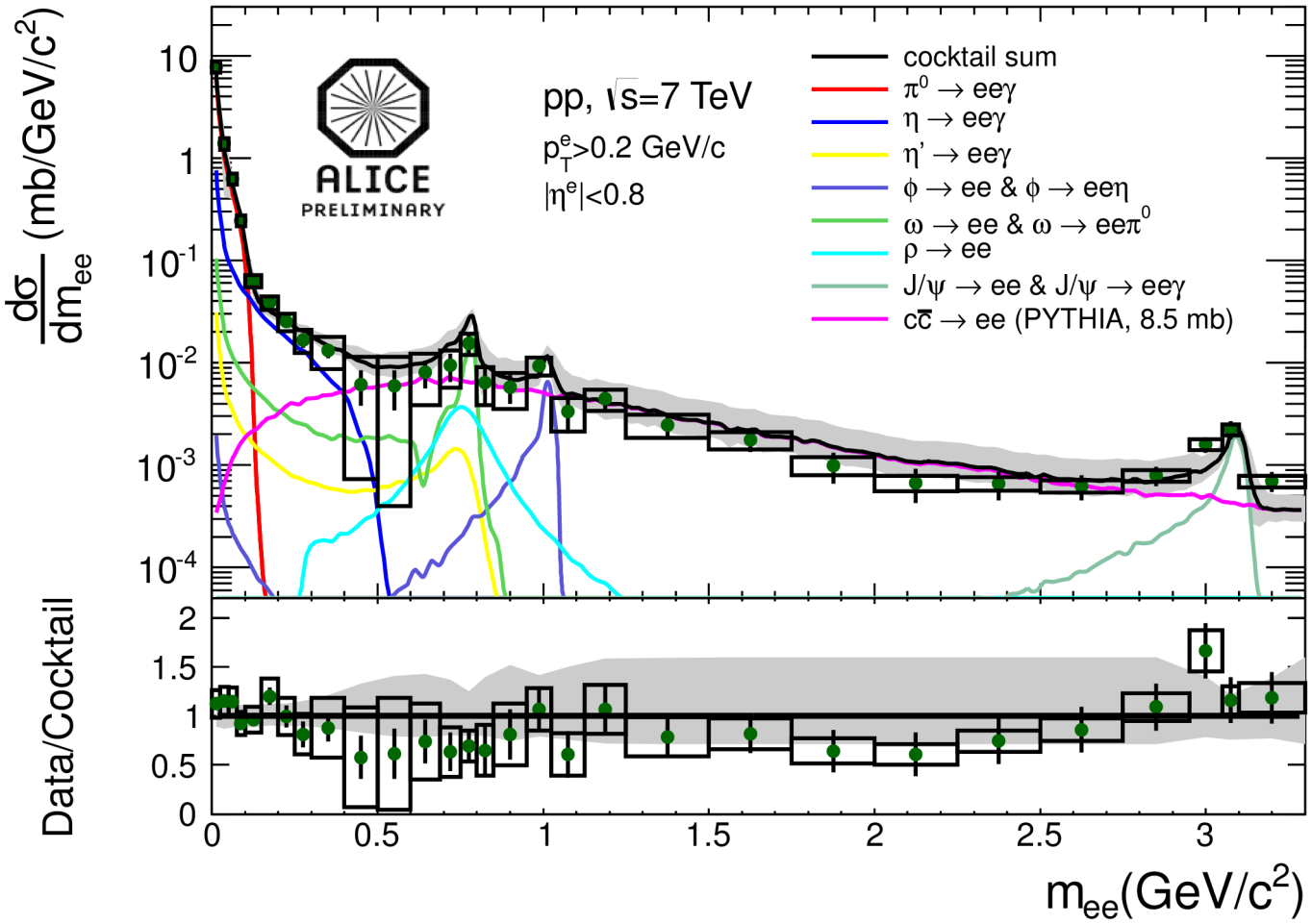


ALI-DER-51822

Low Mass Dielectron Results in pp at 7 TeV

- Low Mass Dielectron Spectrum: **good agreement between signal and MC sources**

- Transverse momentum distributions of π^0 as baseline
- Other particle contributions are scaled correspondingly by model or measurements
- Open charm contribution based on PYTHIA kinematics (with measured cross section by ALICE)



ALI-PREL-43484

pp Reference at 5.02 TeV

- **Reference yield in pp collisions is needed** to evaluate the nuclear modification factor. **However, no pp measurement is available at 5.02 TeV**

- Starting from the measured p_T-differential cross sections measured in pp at 2.76 TeV and at 7 TeV, **we interpolate at 5.02 TeV**. Various hypotheses for the interpolating function → systematic uncertainty

- **Resulting interpolated distribution is parameterized** → get rid of bin-to-bin fluctuations and extend to the full p_T range accessible in p-Pb

- Obtained in this way, the reference is relative to the nominal Muon Arm acceptance ($2.5 < y_{lab} < 4.0$) → **MC models allow a translation to the two rapidity regions covered in the analysis**

Forward vs Backward

- **We observe a larger ϕ yield in backward than in forward rapidity, even if this asymmetry should be partially masked by the C.M. rapidity shift:**
  - The rapidity of the C.M. is not zero, so that when measuring forward rapidities the Muon Arm acceptance is $2.04 < y_{CM} < 3.54$, while when measuring backward rapidities we have $-4.46 < y_{CM} < -2.96 \rightarrow$ the Muon Arm is more at mid-rapidity in first case

- **Evaluating the R_{pPb} factors we already correct for this effect**, since the pp reference is evaluated in the appropriate rapidity region

- **However,** a better way to compare forward and backward production is to **evaluate the yields in the common c.m. rapidity range: $2.96 < |y_{CM}| < 3.54$** and take the ratio