



Hadronic resonance production measured by the ALICE experiment at LHC

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for the ALICE collaboration

Outline

- Motivations
- Resonance reconstruction in ALICE
- Results on $K(892)^*0$ and $\phi(1020)$ production
 - ✓ p_T spectra
 - ✓ Mean transverse momentum
 - ✓ Ratios of resonances to stable hadrons
 - ✓ Resonances nuclear modification factors
- Summary

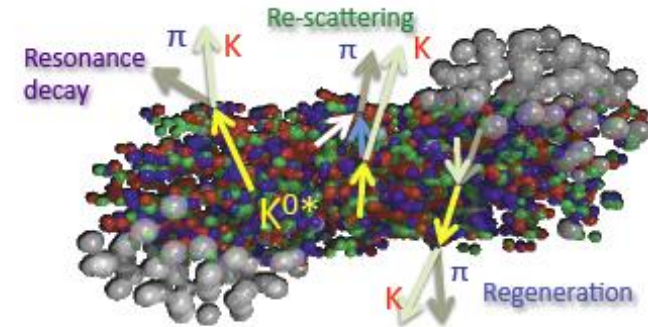
Motivations

pp and p-Pb measurements

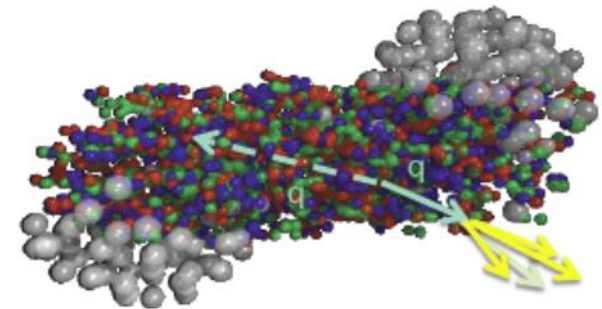
- ✓ Reference for heavy-ion collisions
- ✓ System size dependence
- ✓ Cold nuclear matter effects
- ✓ Precision tests of the pQCD and of the currently available parameterizations of fragmentation functions

Pb-Pb measurements

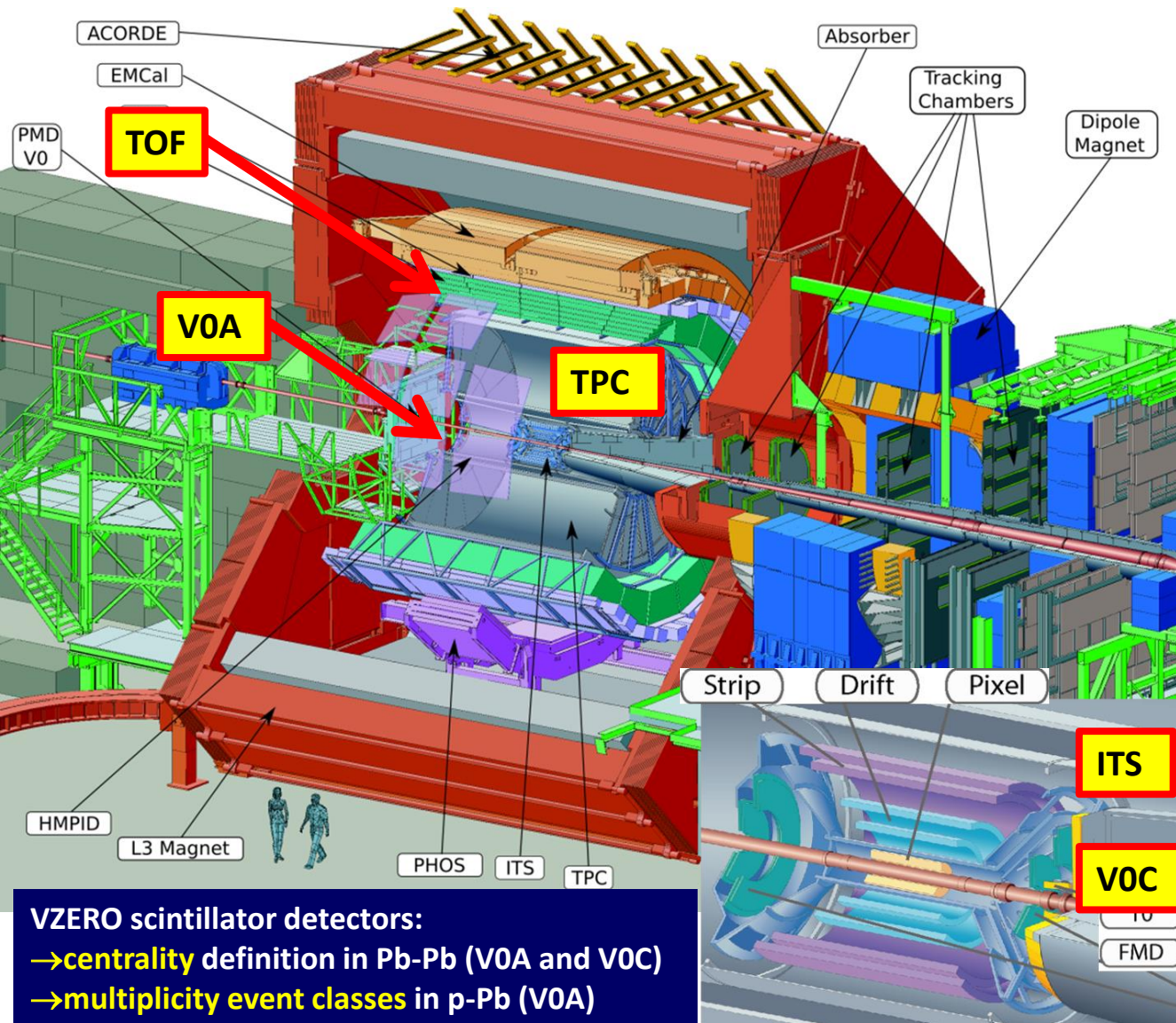
- ✓ Comparison with particles that differ by mass, baryon number, strangeness content → **particle production mechanisms**
- ✓ Modification of yields and mean p_T , particle ratios → **rescattering and regeneration in the hadronic phase**
- ✓ Nuclear modification factors → **in-medium energy loss study**



	τ (fm/c)
K^{*0}	4
ϕ	45

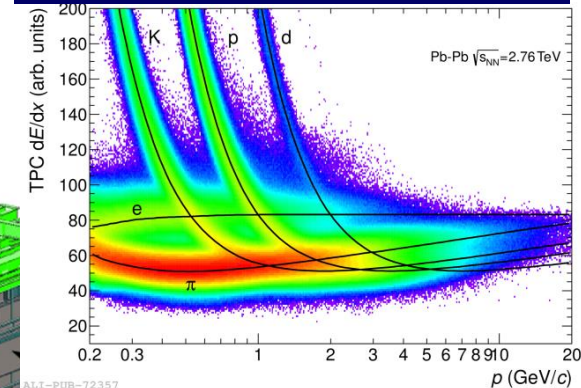


ALICE experiment

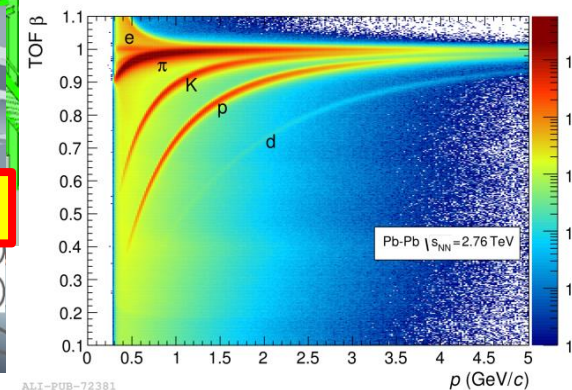


arXiv:1402.4476

Particle identification (π , K from resonance decay) by:



- dE/dx in gas (Time Projection Chamber)
- Time-of-flight measurements (Time-Of-Flight)



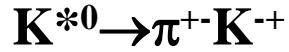
VZERO scintillator detectors:

- centrality definition in Pb-Pb (VOA and V0C)
- multiplicity event classes in p-Pb (VOA)

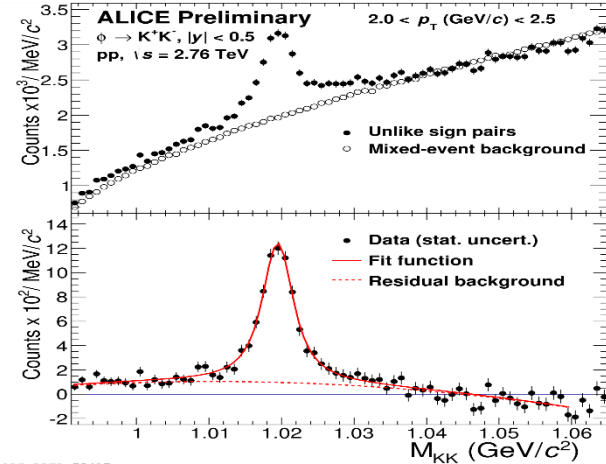
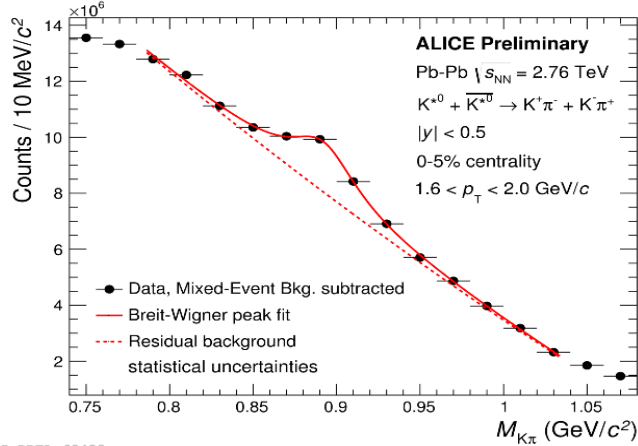
8-12 Sept 2014, St. Petersburg, Russia

XIth Quark Confinement and the Hadron Spectrum

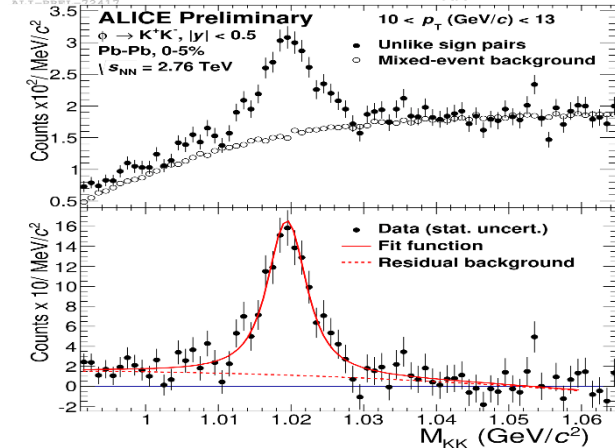
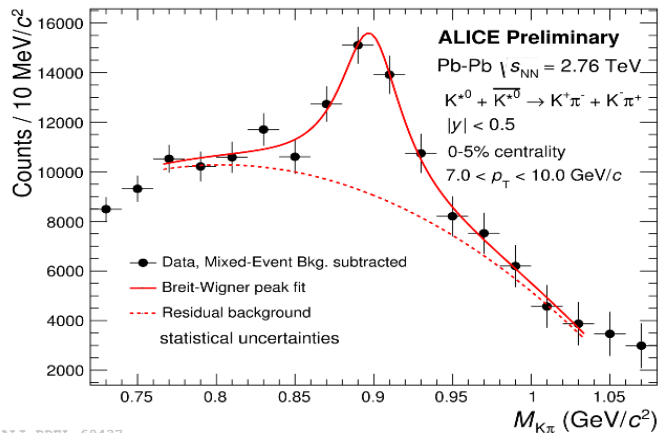
Resonance reconstruction in ALICE



Low p_T

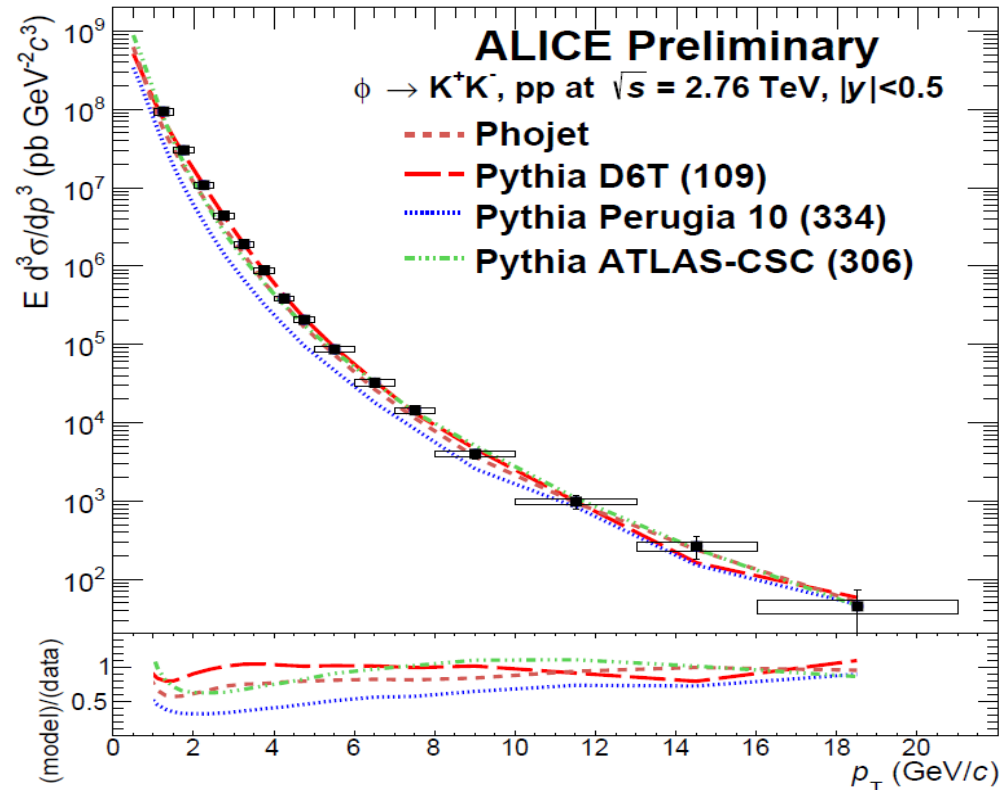


High p_T



Extracted mass and width consistent with PDG values

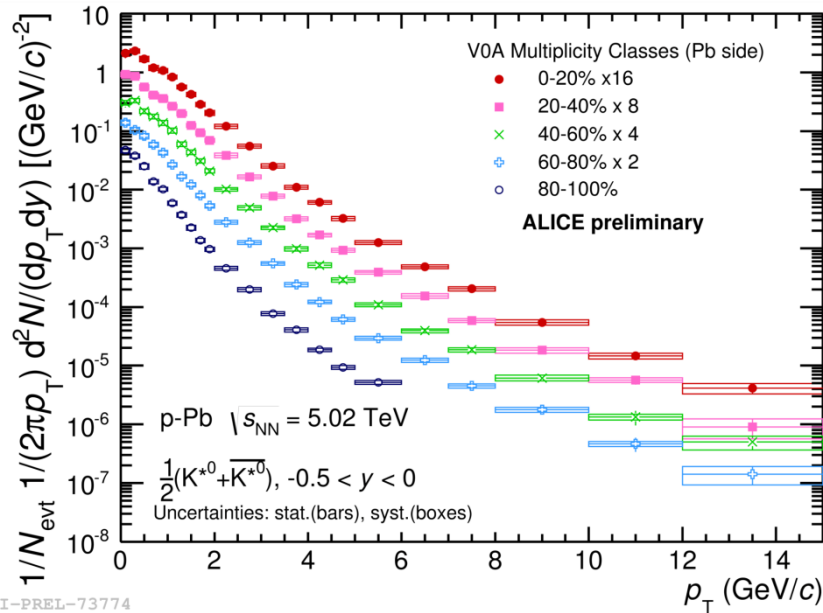
$\phi(1020)$ p_T spectra in pp@2.76 TeV



- First measurement of ϕ meson production at high p_T ($p_T > 7$ GeV/c)
- Production spectrum in pp at $\sqrt{s_{NN}} = 2.76$ TeV is consistent with Pythia/Phojet predictions at high p_T
- ϕ spectra measured also in pp at $\sqrt{s_{NN}} = 7$ TeV (Eur.Phys.J. C72:2183, 2012)
- Used as a reference for calculation of nuclear modification factors: R_{AA} and R_{pPb}

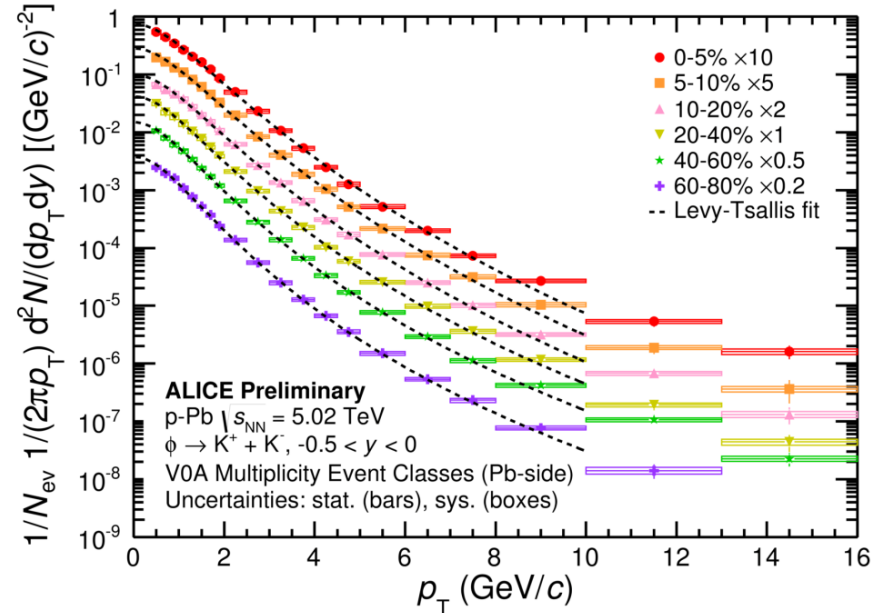
K(892)*⁰ and $\phi(1020)$ p_T spectra in p-Pb@5.02 TeV

$$K^{*0} \rightarrow \pi^+ K^-$$



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$$\phi \rightarrow K^+ K^-$$



ALI-PREL-71153

Analysis 2013 p-Pb data

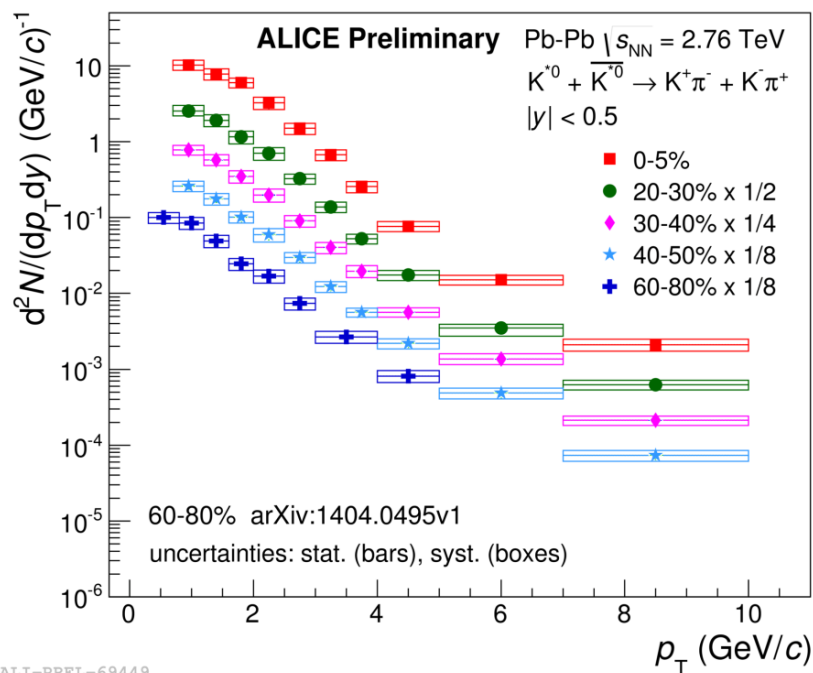
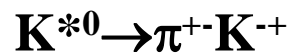
K^{*0} and ϕ p_T spectra measured in various multiplicity bins

Range K^{*0} : $0 < p_T < 15$ GeV/c (TPC+TOF pid)

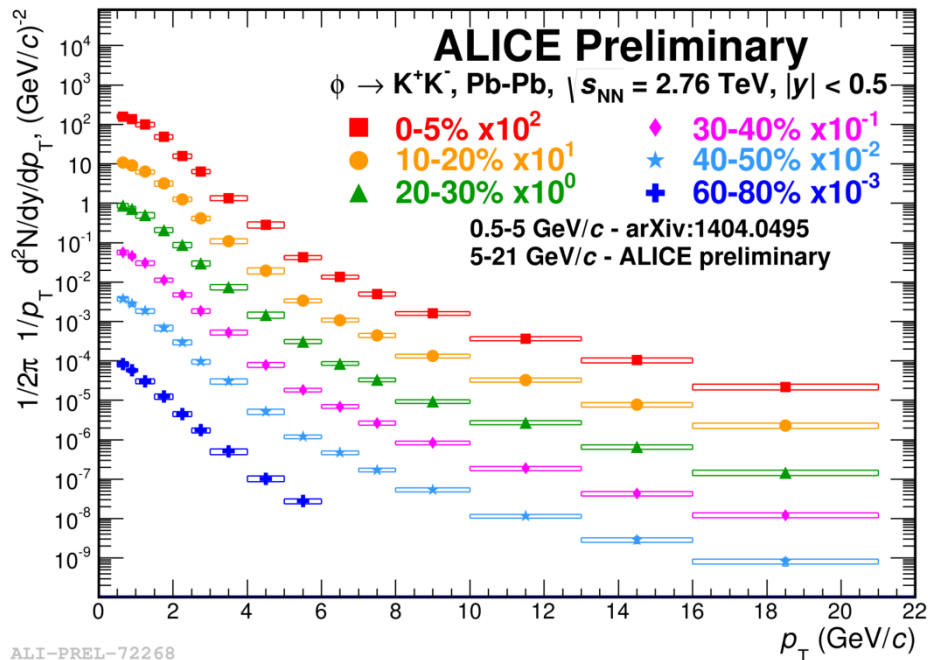
Range ϕ : $0.2 < p_T < 5$ GeV/c (TPC+TOF pid)

$5 < p_T < 16(21 \text{ for MB})$ GeV/c (No pid)

K(892)^{*0} and $\phi(1020)$ p_T spectra in Pb-Pb@2.76 TeV



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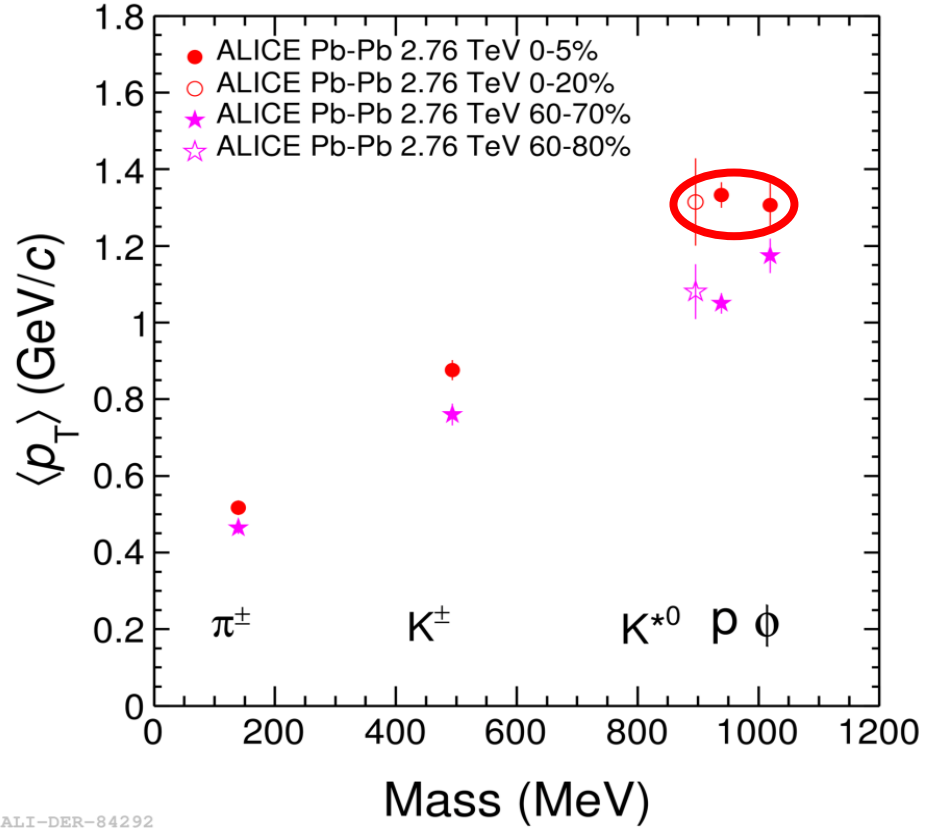
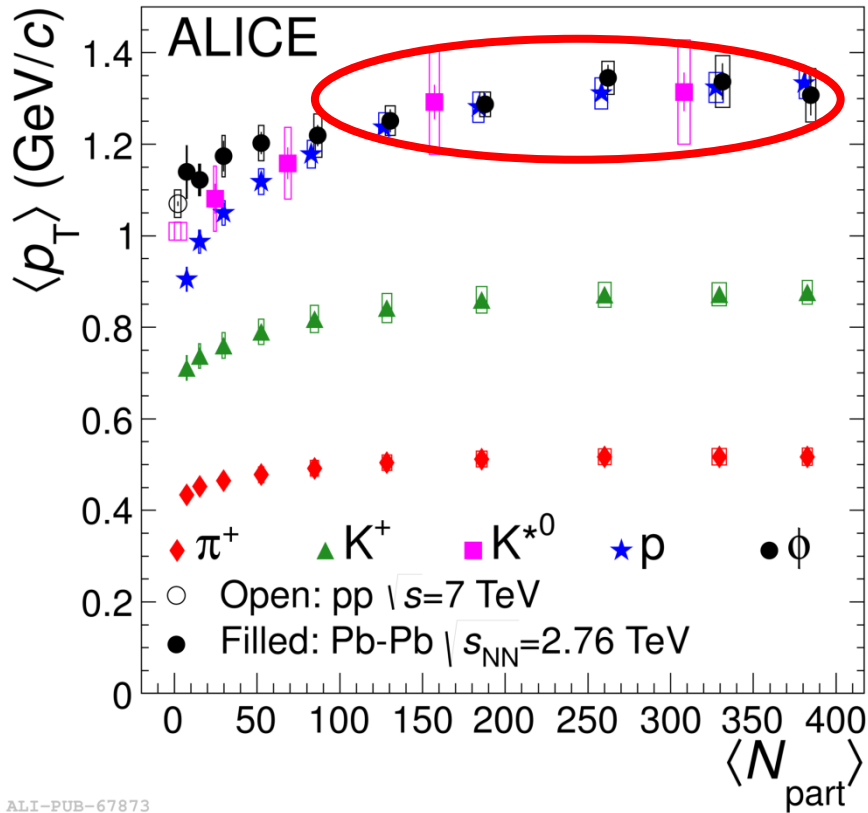
ALI-PREL-72268

2010 Pb-Pb data analysis : $p_T \leq 5$ GeV/c (arXiv:1404.0495)

Analysis of Pb-Pb 2011 data extends measured p_T up to 10 GeV/c (TPC+TOF pid) for K^{*0} and up to 21 GeV/c (NO pid) for ϕ

Resonance mean p_T in Pb-Pb

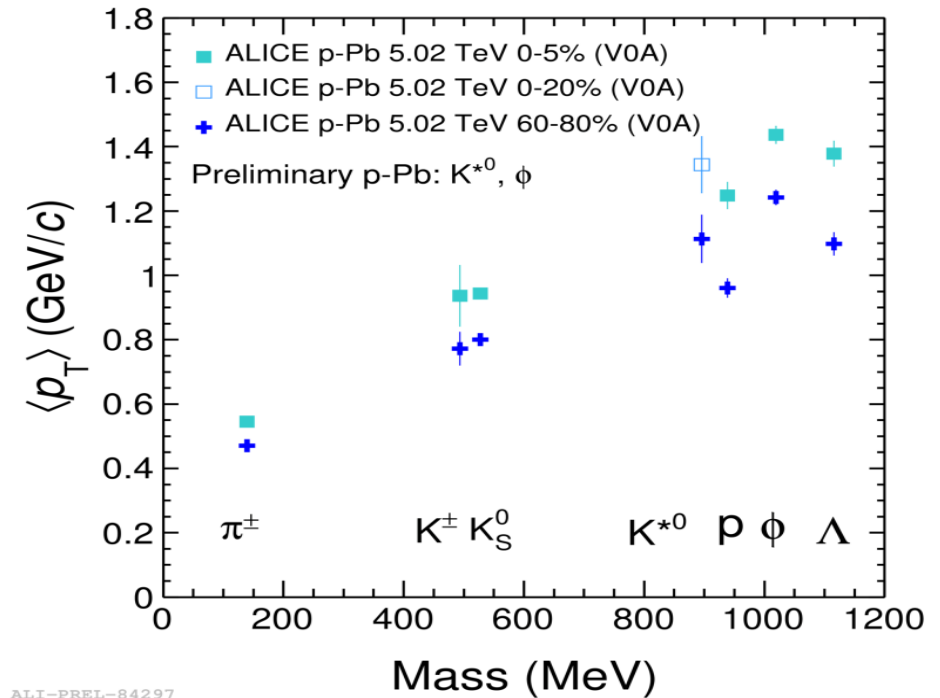
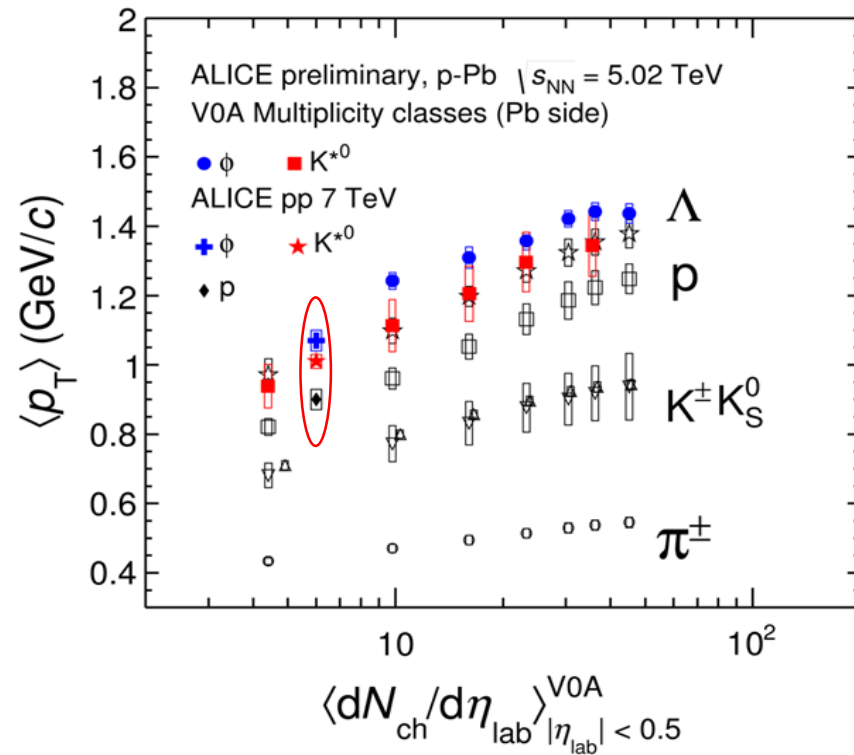
ALICE coll: arXiv:1404.0495



In central Pb-Pb collisions **particles with similar mass (K^* , p and ϕ) have similar $\langle p_T \rangle$** \rightarrow consistent with hydrodynamical picture, i.e. p_T distribution determined by particle mass

Resonance mean p_T in p-Pb

Phys.Lett.B728 25-38, 2014



ALI-PREL-84297

ALI-PREL-83903

- Similar increasing trend for K^{*0} and ϕ with the multiplicity class as in Pb-Pb
- $\langle p_T \rangle$ for p and Λ follow mass ordering, but **meson resonances $\langle p_T \rangle$ is larger than p and Λ**
- Similar deviation from mass ordering **observed also in pp**

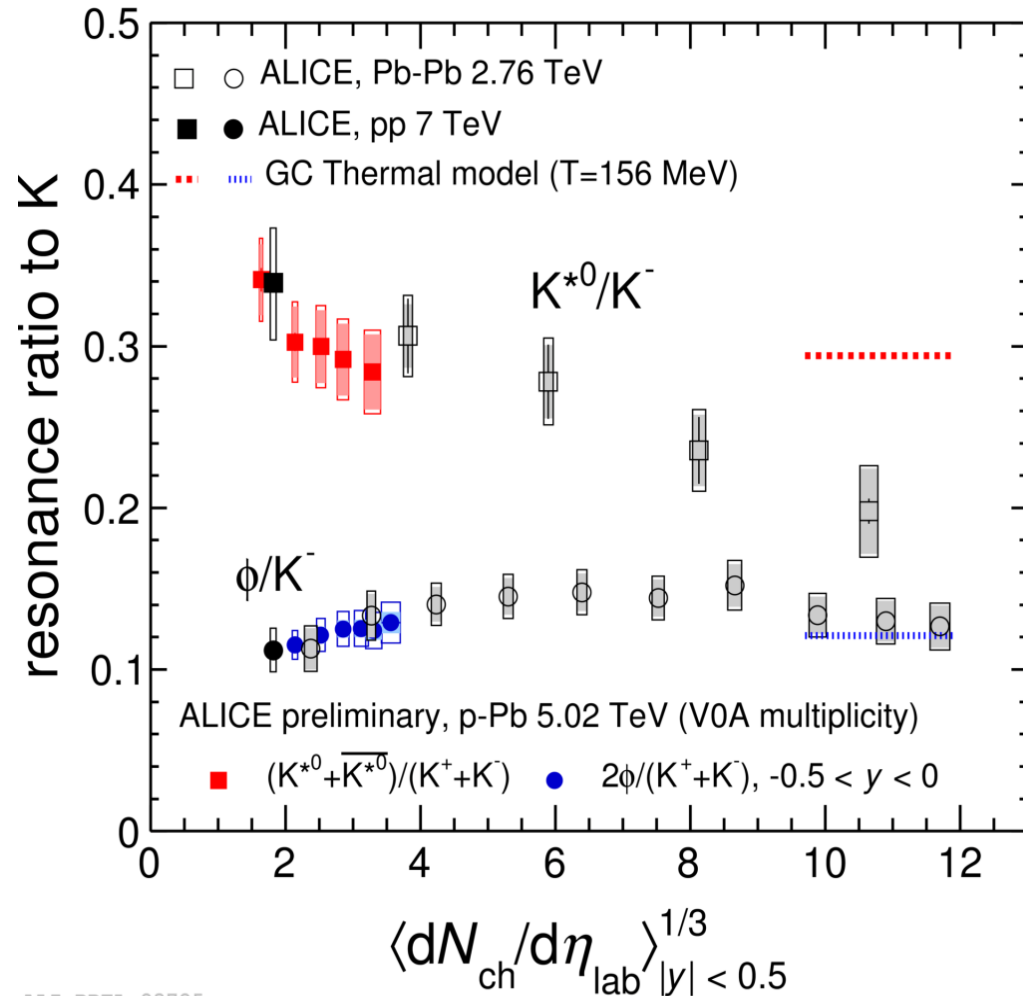
- **Do resonances not follow mass ordering or do protons deviate?**

K^*/K , ϕ/K system size dependence

- ϕ/K in central Pb-Pb collisions consistent with the value measured in pp collisions and with thermal model prediction (Andronic et al., J. Phys. G38(2011)124081)
- K^*/K exhibits a strong suppression going from peripheral to most central Pb-Pb collisions (i.e. increasing system size) \rightarrow **consistent with K^* rescattering as the dominant effect (for $p_T < 2$ GeV/c)**

In p-Pb collisions

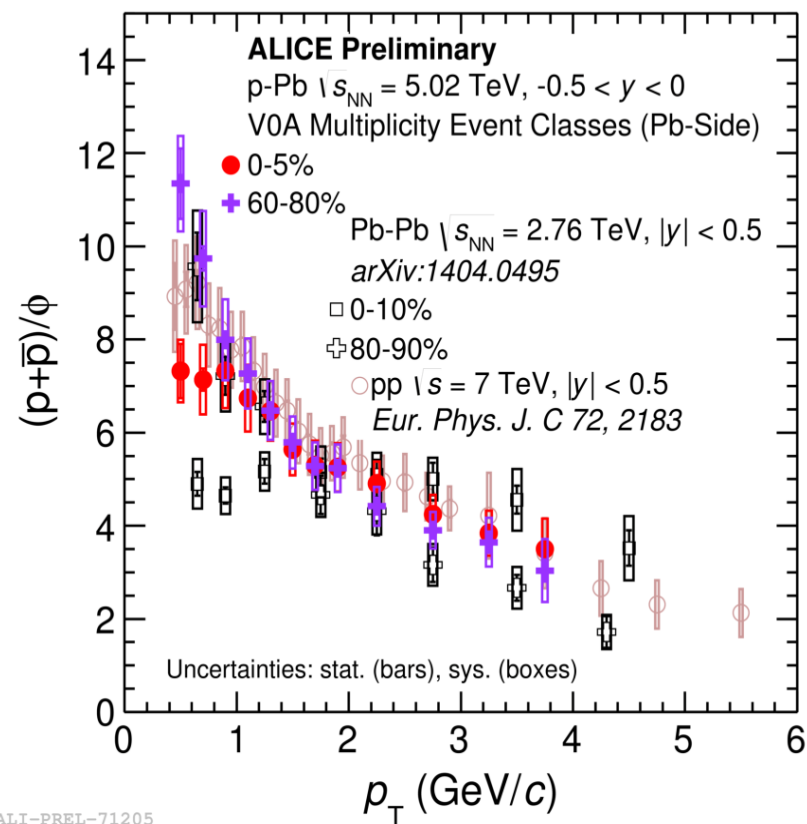
- ϕ/K rather independent from event multiplicity class
- Ratios are consistent with peripheral Pb-Pb



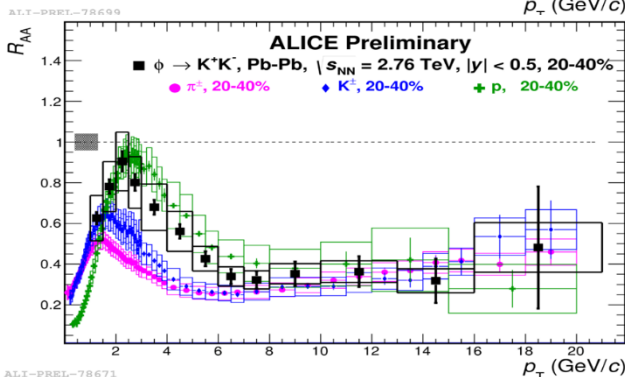
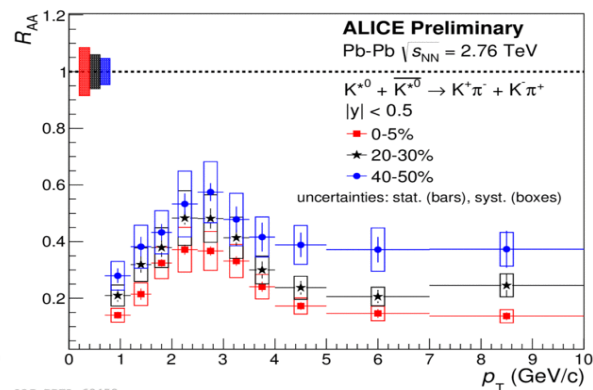
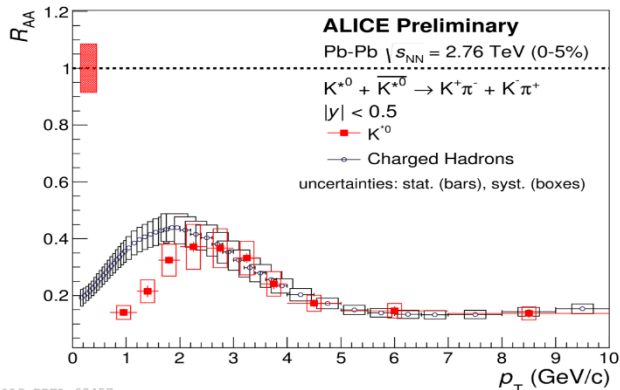
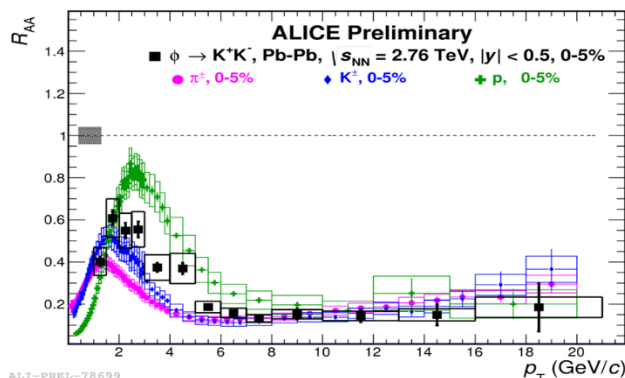
ALI-PREL-83725

p/ϕ in different systems

- p/ϕ ratio is flat for $p_T < 4$ GeV/c in central Pb-Pb collisions \rightarrow similar spectral shapes of p and ϕ \rightarrow **low- p_T spectral shape determined by particle mass, i.e. consistent with hydrodynamic description**
- p/ϕ in p-Pb 60-80% is similar to 80-90% Pb-Pb and pp
- p/ϕ in p-Pb 0-5% is similar to 60-80% Pb-Pb but indication for flattening of the ratio for $p_T < 1.5$ GeV/c \rightarrow **hint of the onset of collective behaviour in p-Pb?**

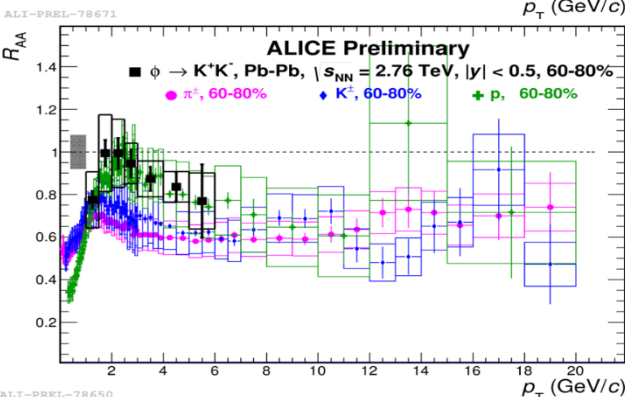


Nuclear modification factor: R_{AA}



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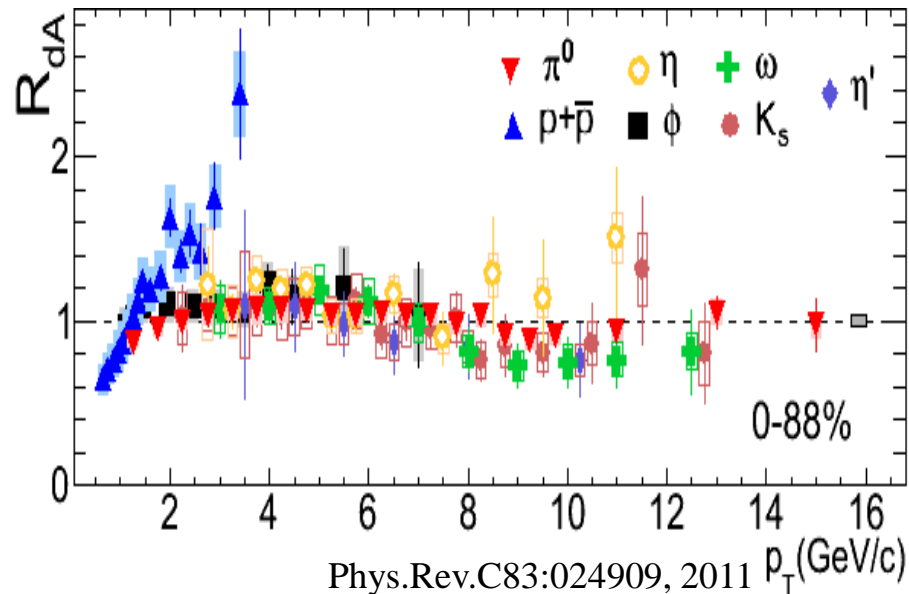
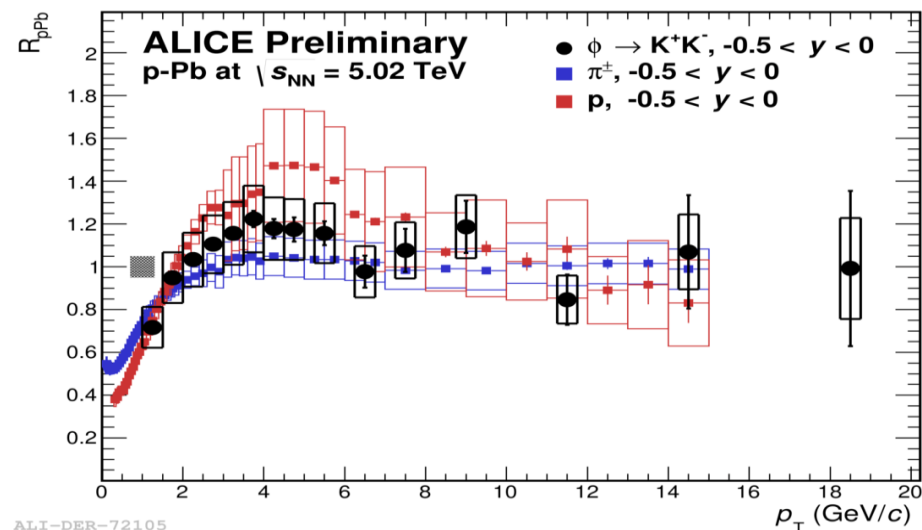
ALI-PREL-78650

- At high p_T all hadrons are similarly suppressed
- Observe clear species dependence of R_{AA}
- R_{AA} of ϕ becomes closer to that of a proton as centrality evolves from central to peripheral collisions
- In most central collisions difference in the RAA factors for ϕ and p is governed by pp reference (p/ϕ ratio in Pb-Pb is flat)
- below 2 GeV/c larger suppression of K^{*0} production with respect to charged hadrons can be explained in terms of rescattering effects

Nuclear modification factor: R_{pPb}

$\phi \rightarrow K^+K^-$

PHENIX d+Au $\sqrt{s} = 200$ GeV



Phys.Rev.C83:024909, 2011 p_T (GeV/c)

High p_T :

- R_{pPb} is consistent with unity for all hadrons

Intermediate p_T :

- Similar to RHIC production of baryons is significantly enhanced while for mesons there is only a modest hint of Cronin-like enhancement
- Cronin enhancement seems to be larger at RHIC

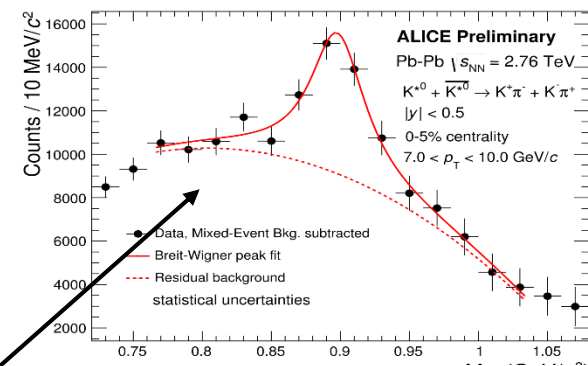
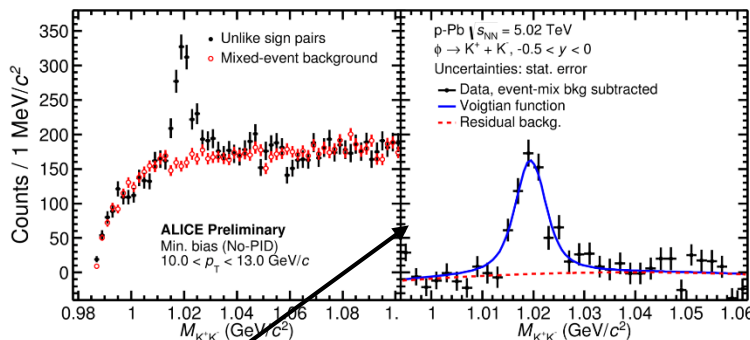
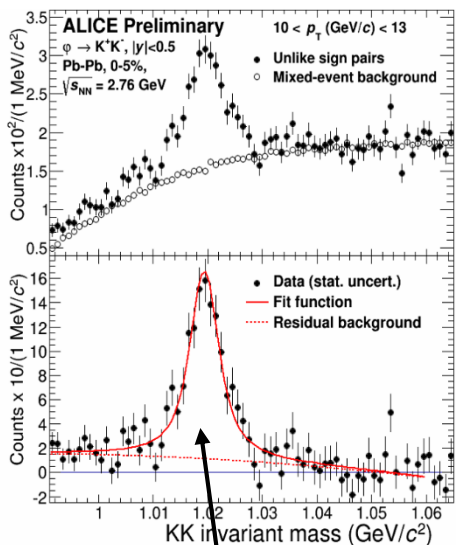
Summary

$K^*(892)^0$ and $\phi(1020)$ resonance production has been measured in a wide momentum range in p-Pb and Pb-Pb collisions at the LHC, as a function of multiplicity (centrality)

- ✓ In pp and in p-Pb resonance $\langle p_T \rangle$ does not follow the same mass ordering as in central Pb-Pb, where it is compatible to that of stable hadrons with similar mass
- ✓ K^*/K exhibits a strong suppression going from peripheral to most central Pb-Pb collisions (i.e. increasing system size) \rightarrow K^* yield affected by rescattering in the hadronic phase, while ϕ behaves as a long-lived particle
- ✓ In central p-Pb, indication for flattening of the ϕ/p ratio for $p_T < 1.5$ GeV/c \rightarrow hints of the onset of a collective behaviour?
- ✓ In central Pb-Pb collisions, at high p_T all hadrons are similarly suppressed
- ✓ In p-Pb no suppression with respect to pp at high p_T and hint of Cronin enhancement at intermediate p_T

Backup slides

Resonance reconstruction in ALICE



ALI-PREL-71221

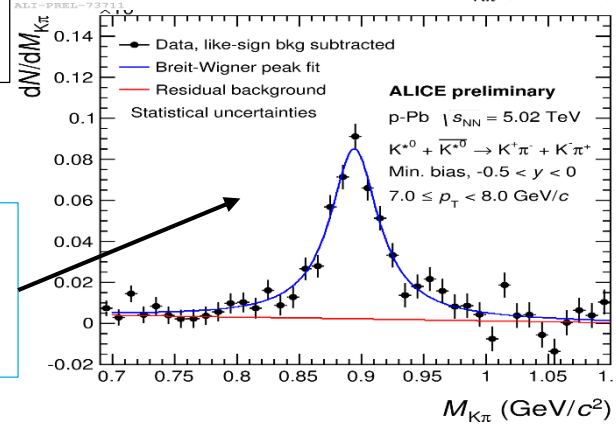
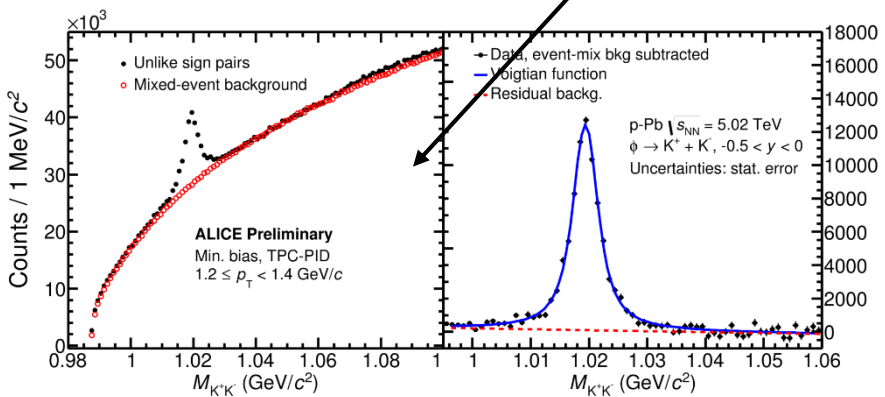
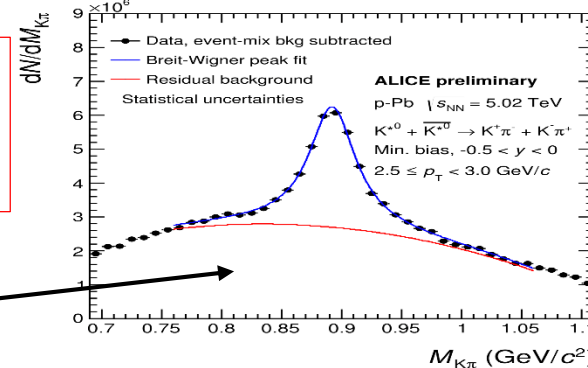
$\phi \rightarrow KK$, p-Pb, No pid, high p_T

$K^{*0} \rightarrow \pi K$, Pb-Pb, TPC+TOF pid, high p_T

$\phi \rightarrow KK$, p-Pb, TPC pid, low p_T

$K^{*0} \rightarrow \pi K$, p-Pb, TPC+TOF pid, low p_T

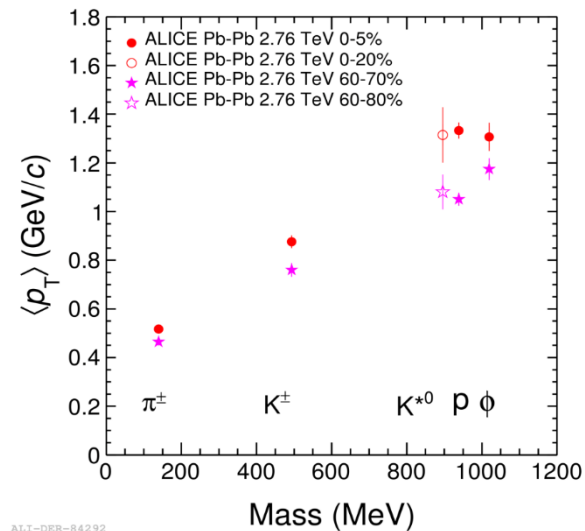
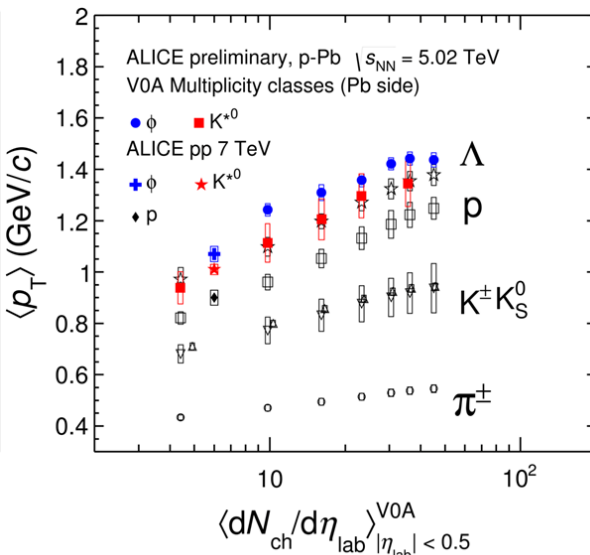
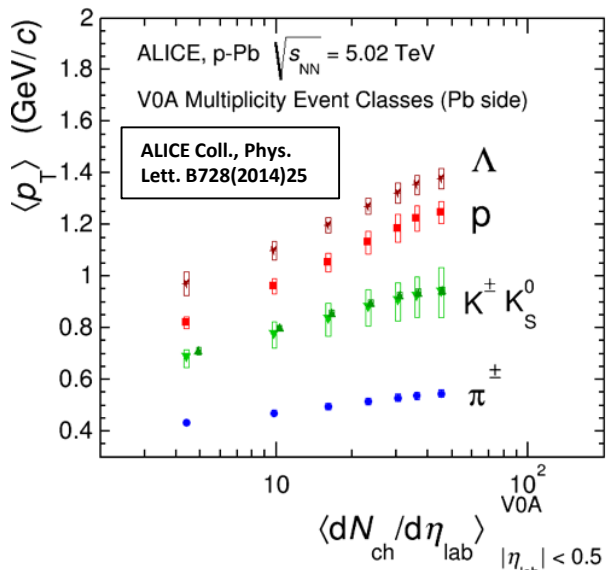
$\phi \rightarrow KK$, Pb-Pb, No pid, high p_T



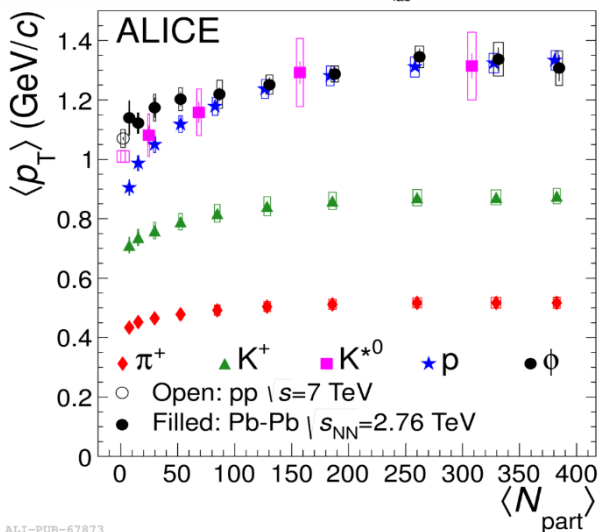
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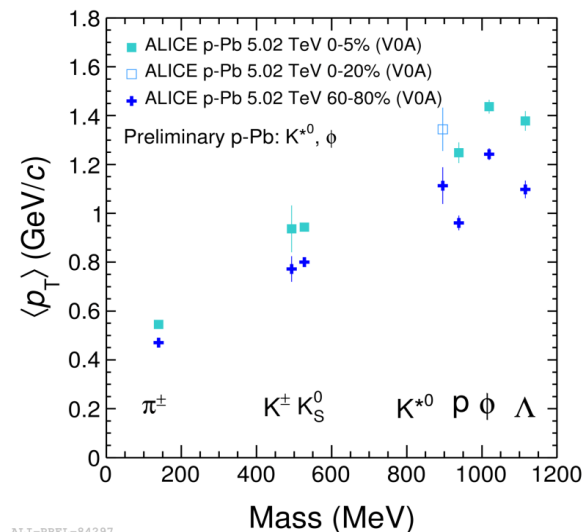
Resonance mean p_T in p-Pb and Pb-Pb



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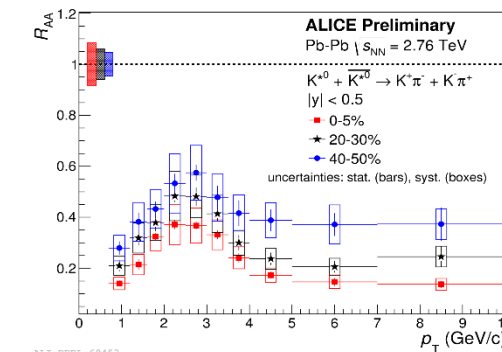
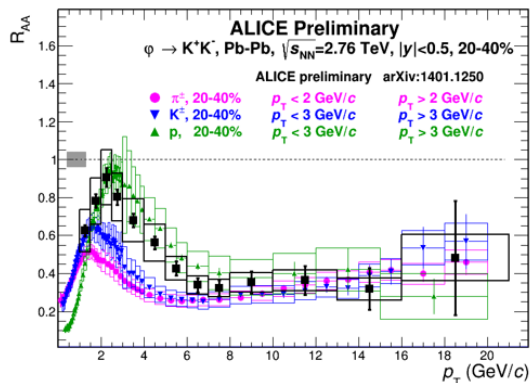
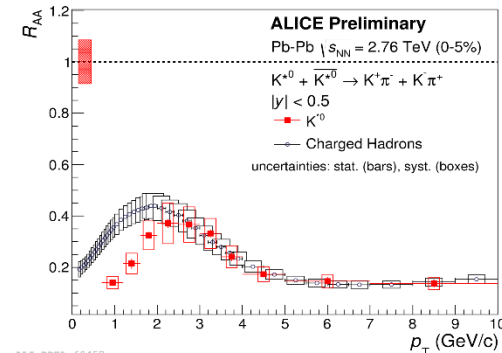
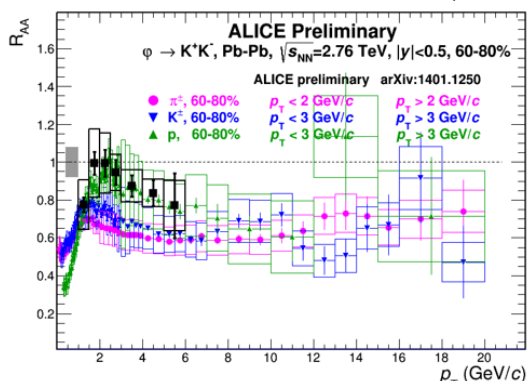
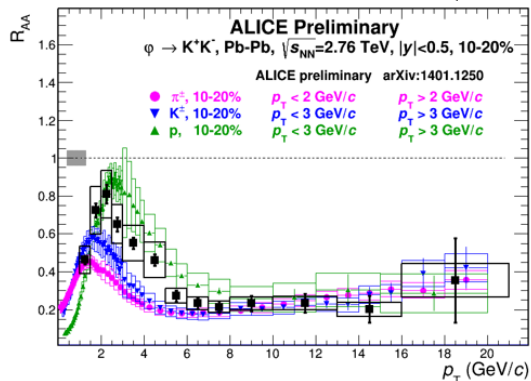
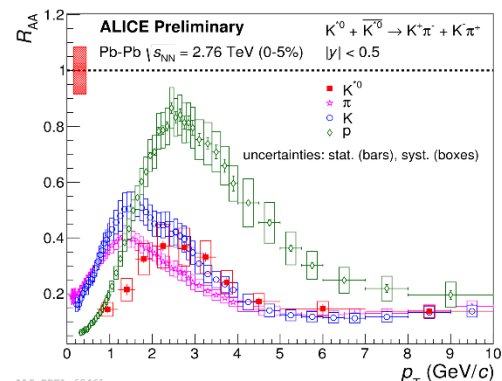
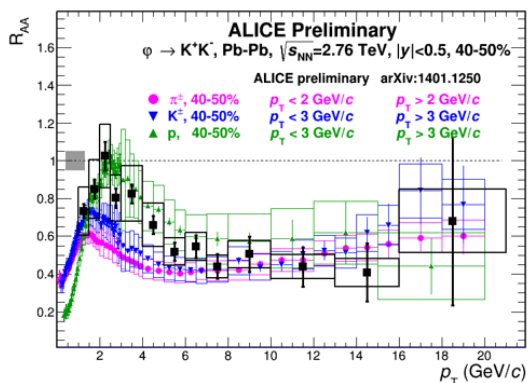
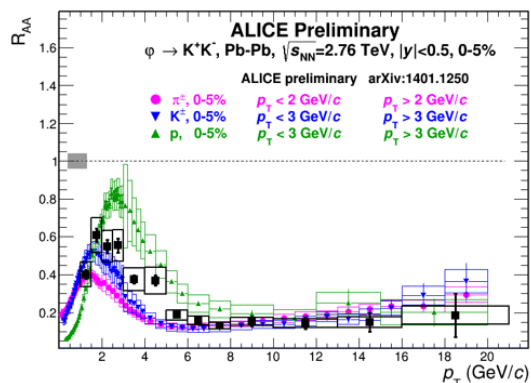


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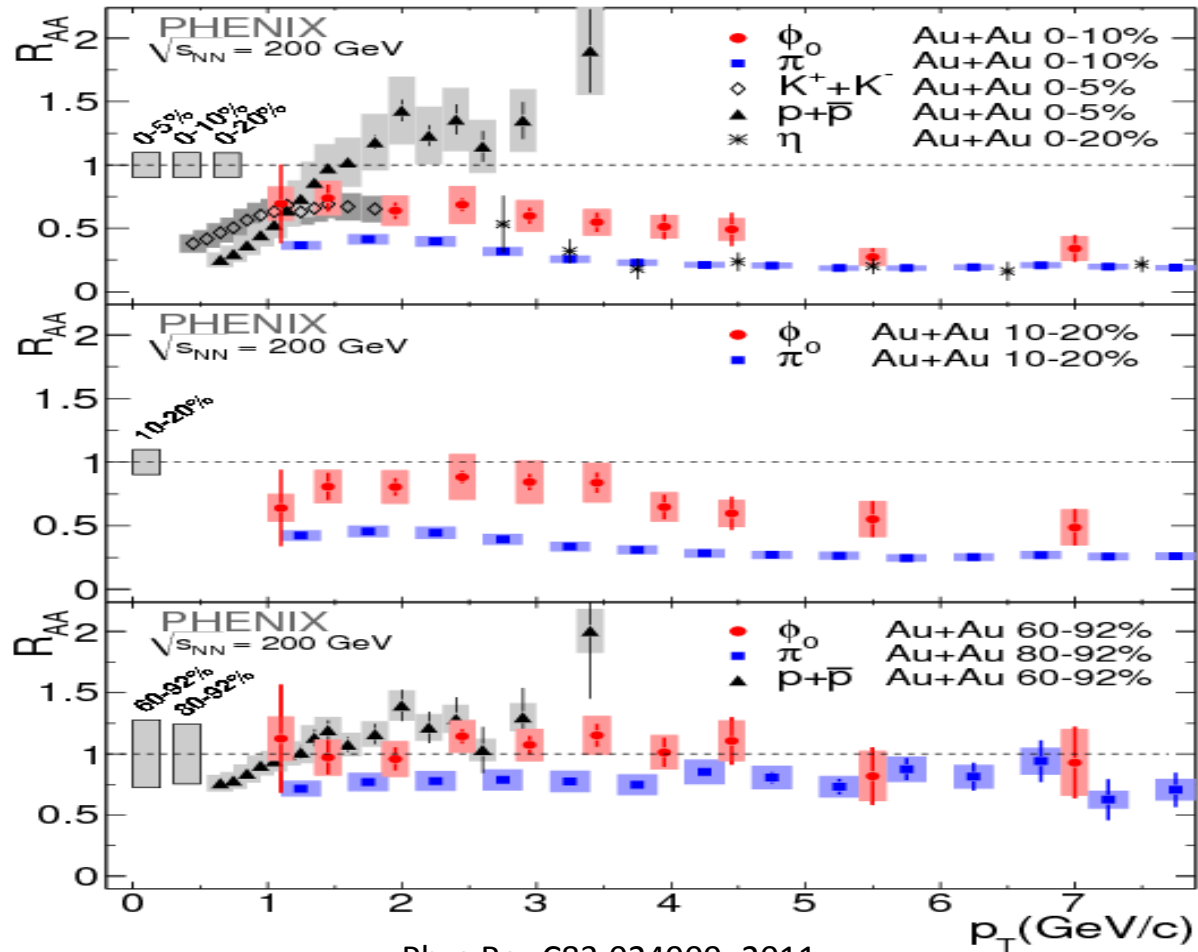


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Nuclear modification factor: R_{AA} ALICE



Nuclear modification factor: R_{AA} PHENIX



Phys.Rev.C83:024909, 2011