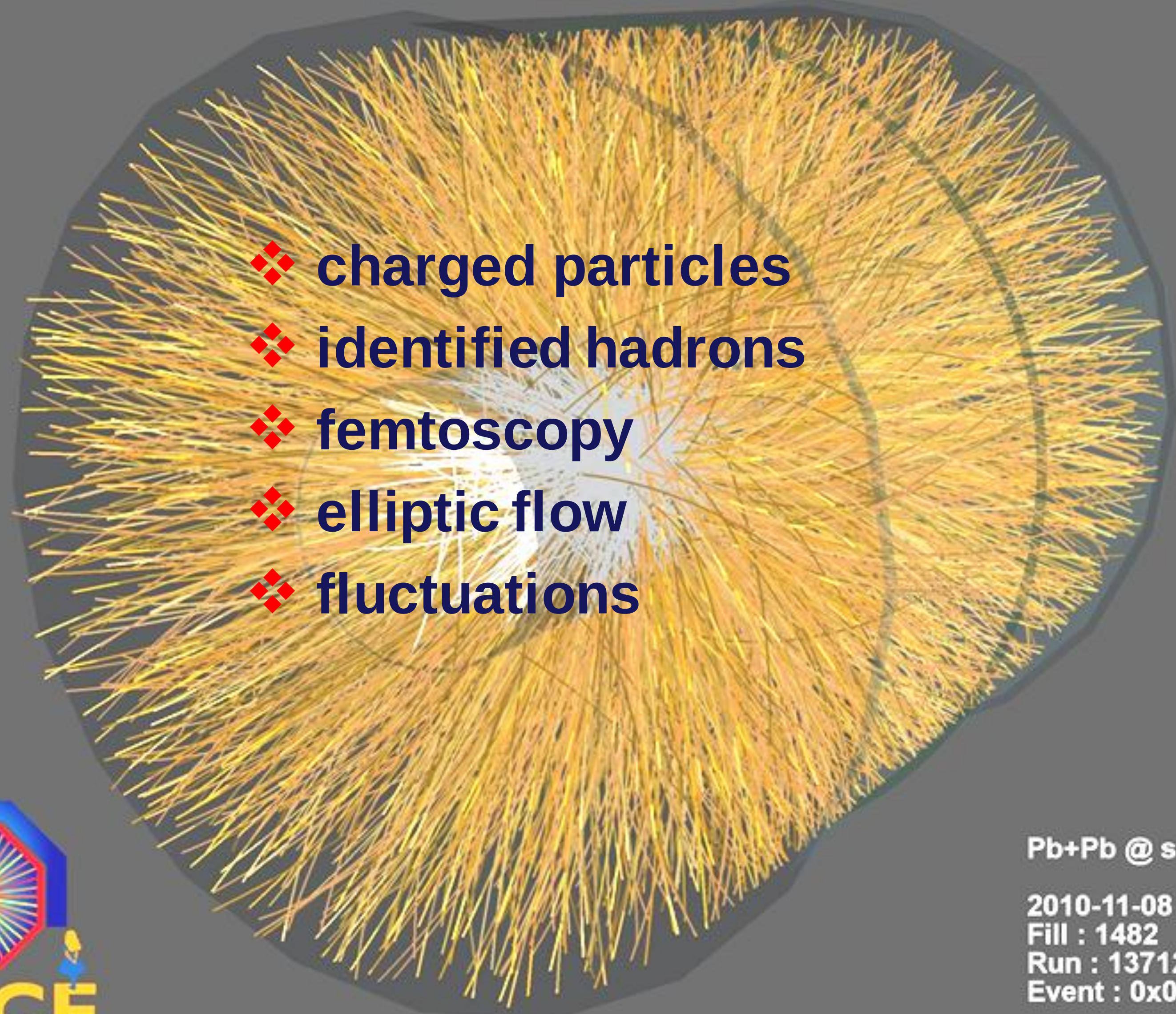
ALICE soft physics summary

Dariusz Miskowiec, GSI / EMMI / CERN



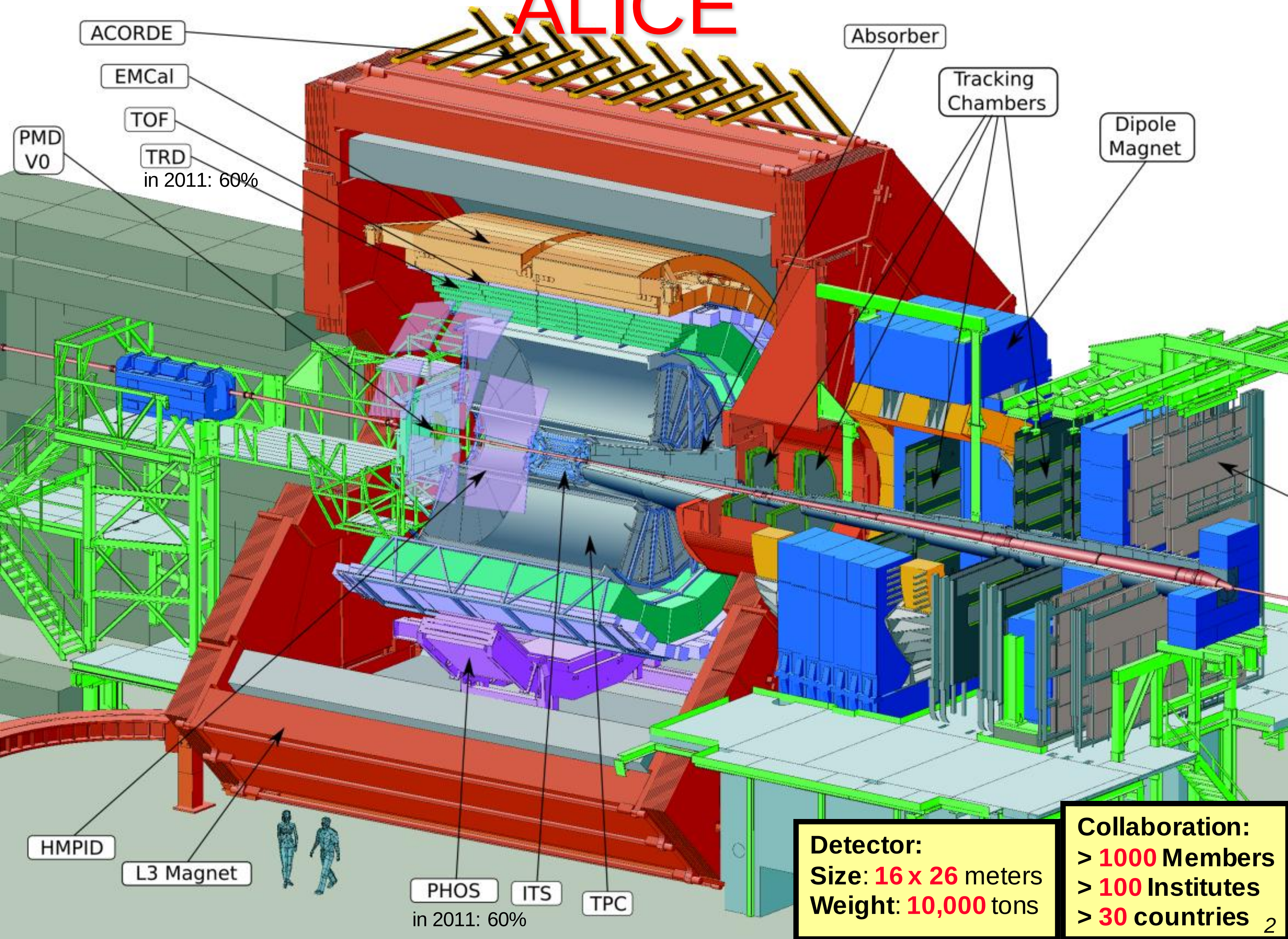
- charged particles
- identified hadrons
- femtoscopy
- elliptic flow
- fluctuations

Pb+Pb @ sqrt(s) = 2.76 ATeV

2010-11-08 11:30:46
Fill : 1482
Run : 137124
Event : 0x00000000D3BBE693

ALICE

ALICE

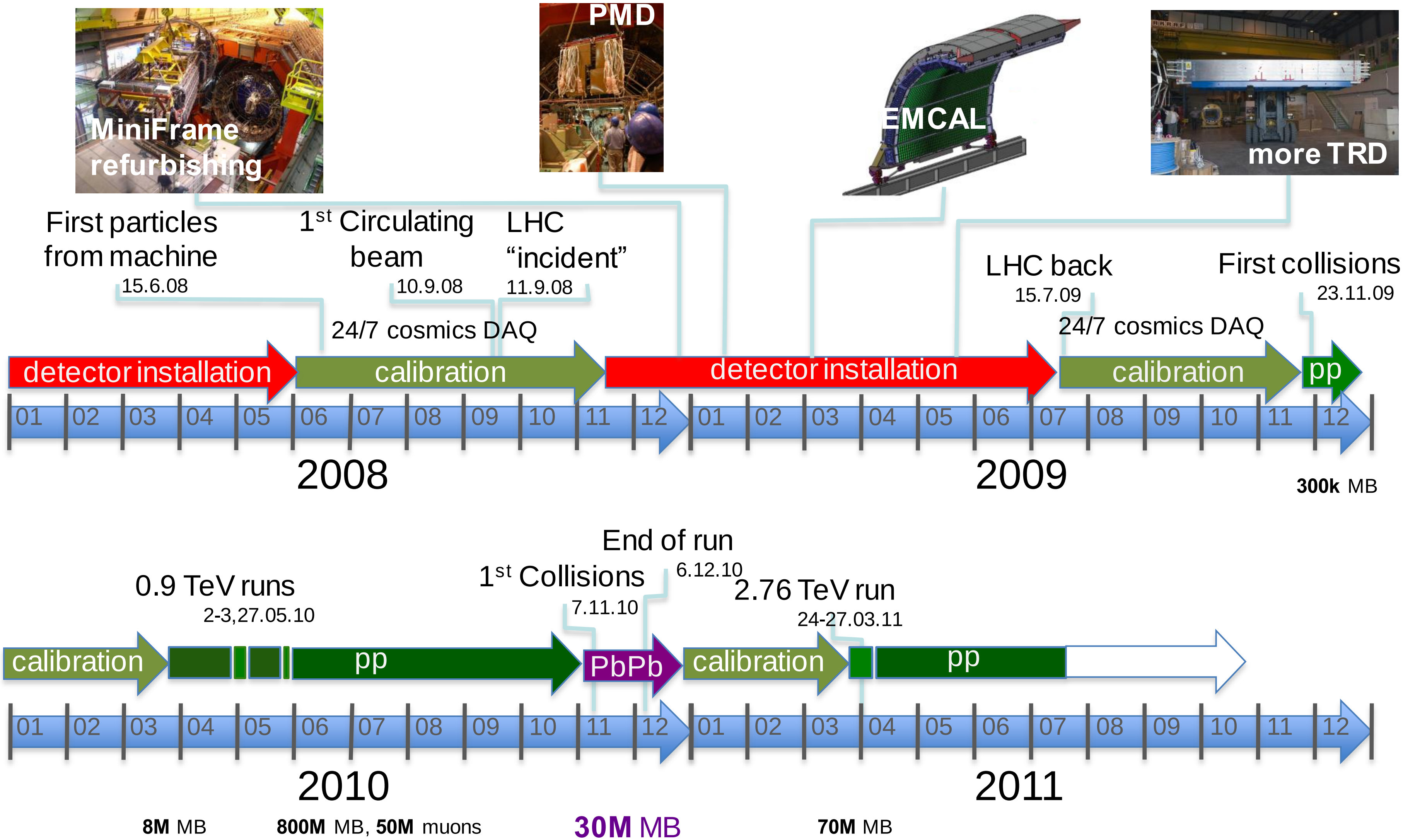


Detector:
Size: **16 x 26** meters
Weight: **10,000** tons

Collaboration:
> 1000 Members
> 100 Institutes
> 30 countries

ALICE commissioning, calibration, and data taking

slide by Hannes Wessels and Boris Hippolyte



ALICE data sets

year	system	energy (TeV)	trigger	# events / 106 or int. lumi
2009	pp	0.9	min bias	0.3
2009	pp	2.36	min bias	0.04 (no stable beams)
2010	pp	0.9	min bias	8
2010	pp	7.0	min bias	800
			high multiplicity	50
			muons	50
2010	PbPb	2.76	min bias	30
2011	pp	2.76	min bias	70
			rare triggers	20 nb^{-1}
2011	pp	7.0	min bias	~700 (ongoing)
			rare triggers	2 ps^{-1} (ongoing)
2011	PbPb	2.76	central	5-20 (planned)
			centr. 30-50%	25 (planned)
			rare triggers	3-6 μb^{-1} (planned)

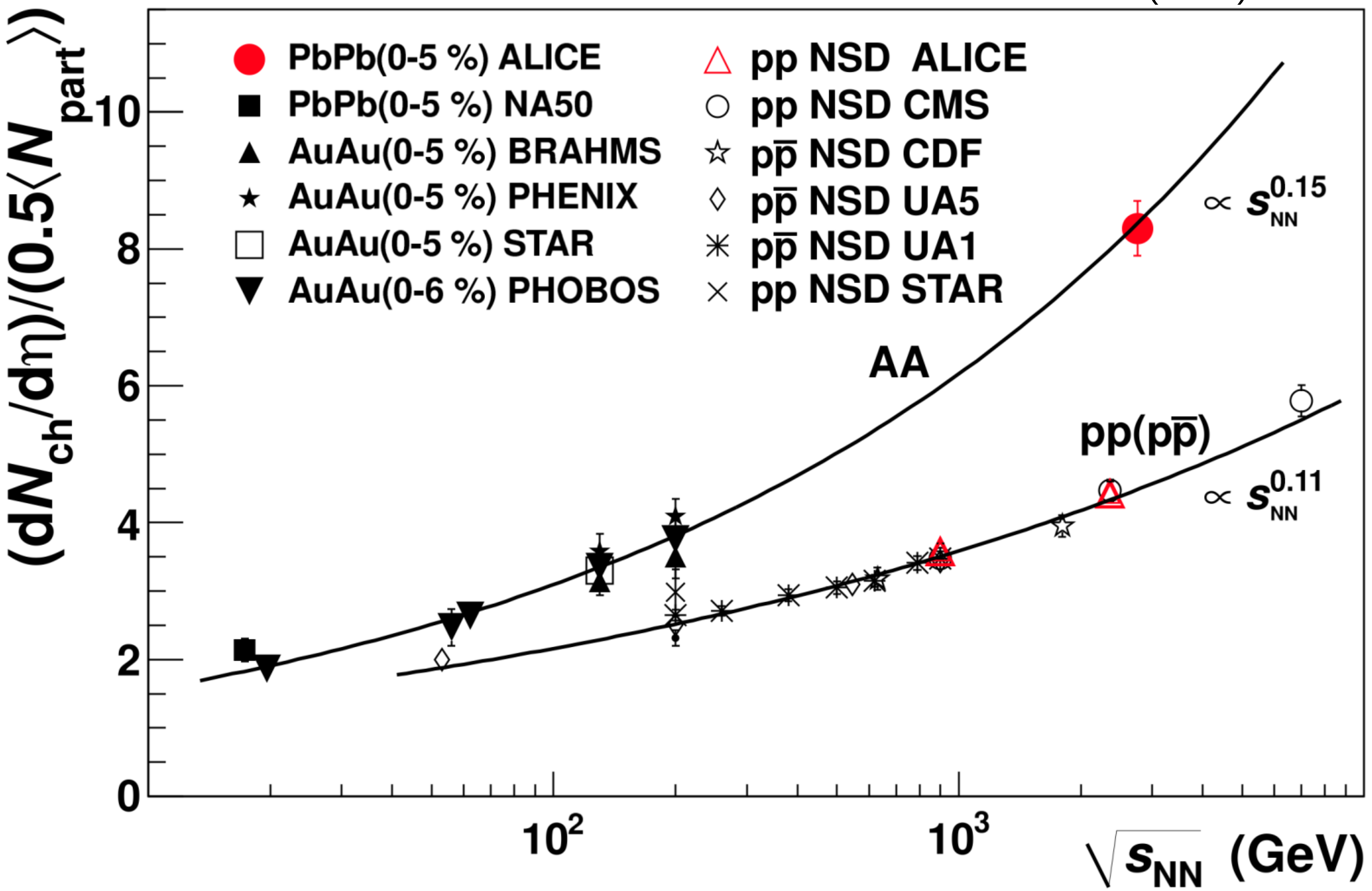
ALICE physics publications

	arxiv date	system	energy (TeV)	observable	published in
1	28/11/09	pp	0.9	charged particle dN/deta	EPJC 65(2010)111
2	18/04/10	pp	0.9, 2.36	charged particle dN/deta, mult. distr.	EPJC 68(2010)89
3	20/04/10	pp	7	same	EPJC 68(2010)345
4	28/06/10	pp	0.9, 7	antiproton/proton ratio	PRL 105(2010)072002
5	03/07/10	pp	0.9	pion HBT	PRD 82(2010)052001
6	05/07/10	pp	0.9	charged particle pt spectra	PLB 693(2010)53
7	17/11/10	PbPb	2.76	charged particle dN/deta	PRL 105(2010)252301
8	17/11/10	PbPb	2.76	charged particle v2	PRL 105(2010)252302
9	05/12/10	PbPb	2.76	charged particle RAA	PLB 696(2011)30
10	08/12/10	PbPb	2.76	centrality dependence of Nch	PRL 106(2011)032301
11	15/12/10	pp	0.9	K0, phi, lambda, cascade	EPJC 71(2011)1594
12	17/12/10	PbPb	2.76	pion HBT	PLB 696(2011)328
13	19/01/11	pp	0.9, 7	pion HBT	arXiv:1101.3665v1
14	21/01/11	pp	0.9	pion, kaon, proton	EPJC 71(2011)1655
15	02/05/11	pp	7	J/Psi	arXiv:1105.0380v1
16	19/05/11	PbPb	2.76	charged particle v3, v4,v5	arXiv:1105.3865v1
17	12/09/11	PbPb	2.76	angular correlations	arXiv:1109.2501v1

charged particle production

charged-particle production: collision energy dependence

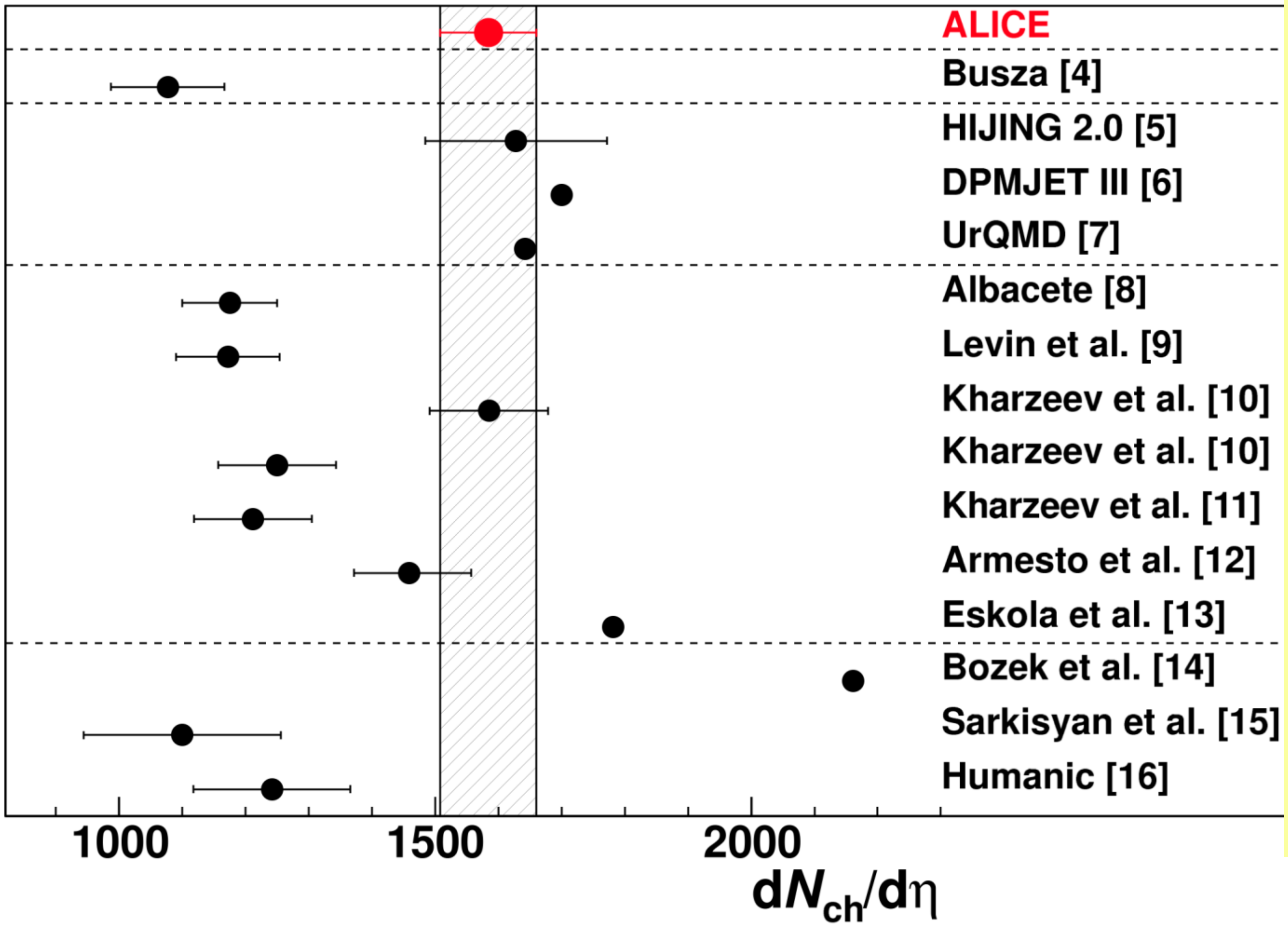
PRL 105 (2010) 252301



2 times higher than at RHIC
2 times higher than in pp
steeper growth in AA than in pp

charged-particle production: comparison with models

PRL 105 (2010) 252301



extrapolation in sqrt(s)

adj. to pp, no jet quench.
pQCD

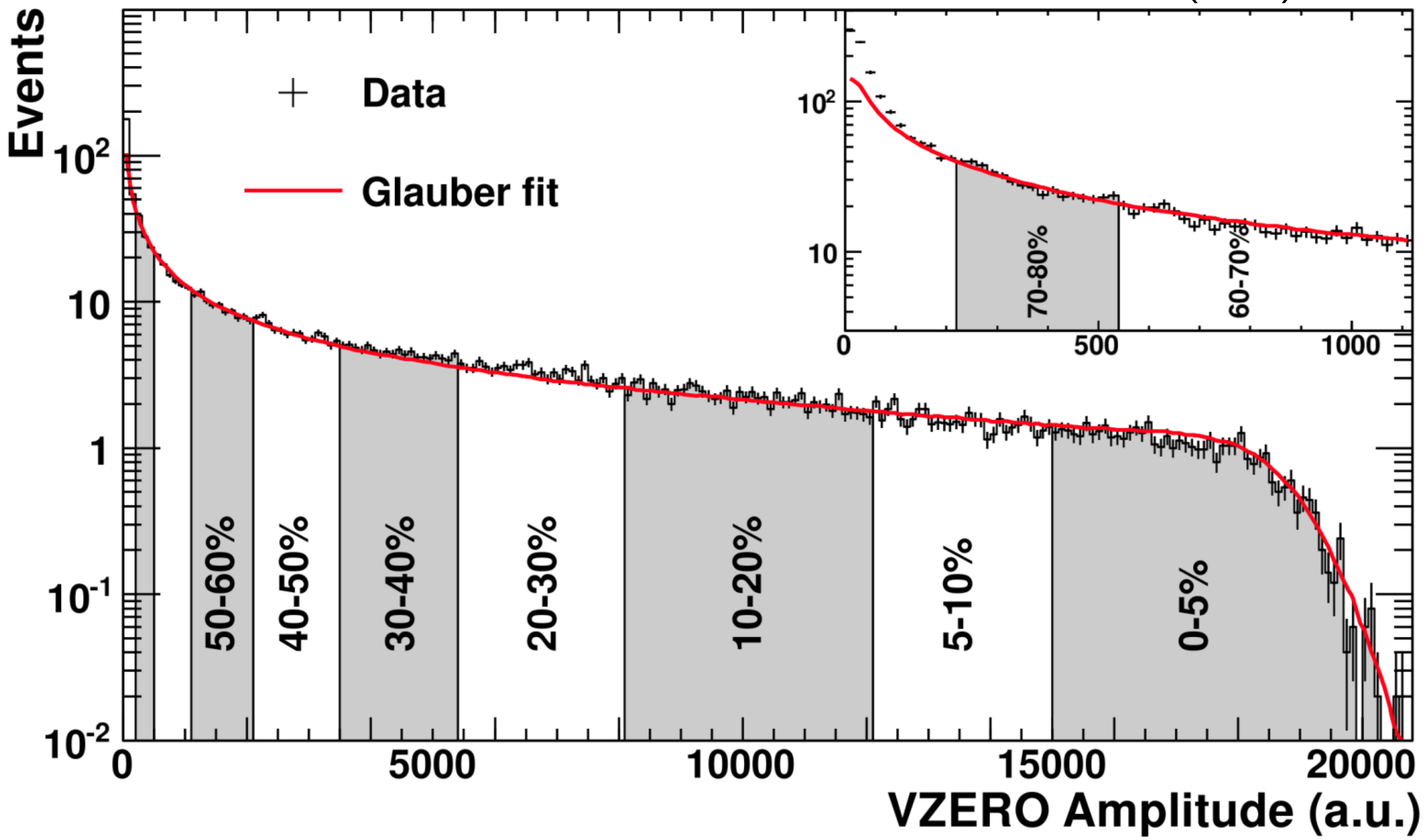
initial state gluon
saturation

hydro + final parton sat.
extrapolation from pp
Landau hydro
Pythia+ rescattering

higher yield than expected (by most)

centrality determination

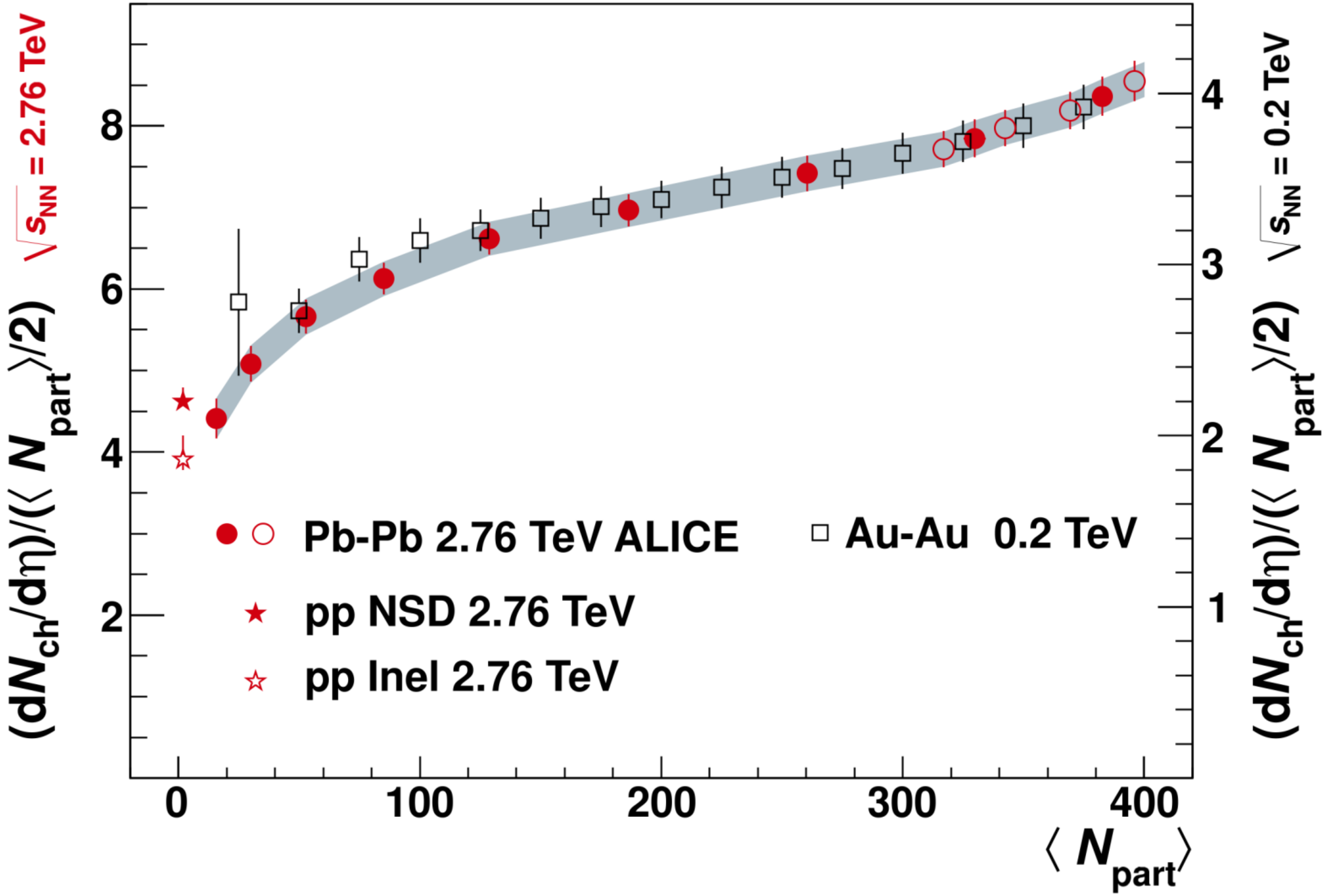
PRL 106 (2010) 032301



- VZERO covers -3.7< η<-1.7 and 2.8<η<5.1, signal ~ multiplicity
- fit function: a Ncoll + b Npart sources, each source producing particles following a negative binomial distribution
- centrality resolution better than 1%

charged-particle production: centrality dependence

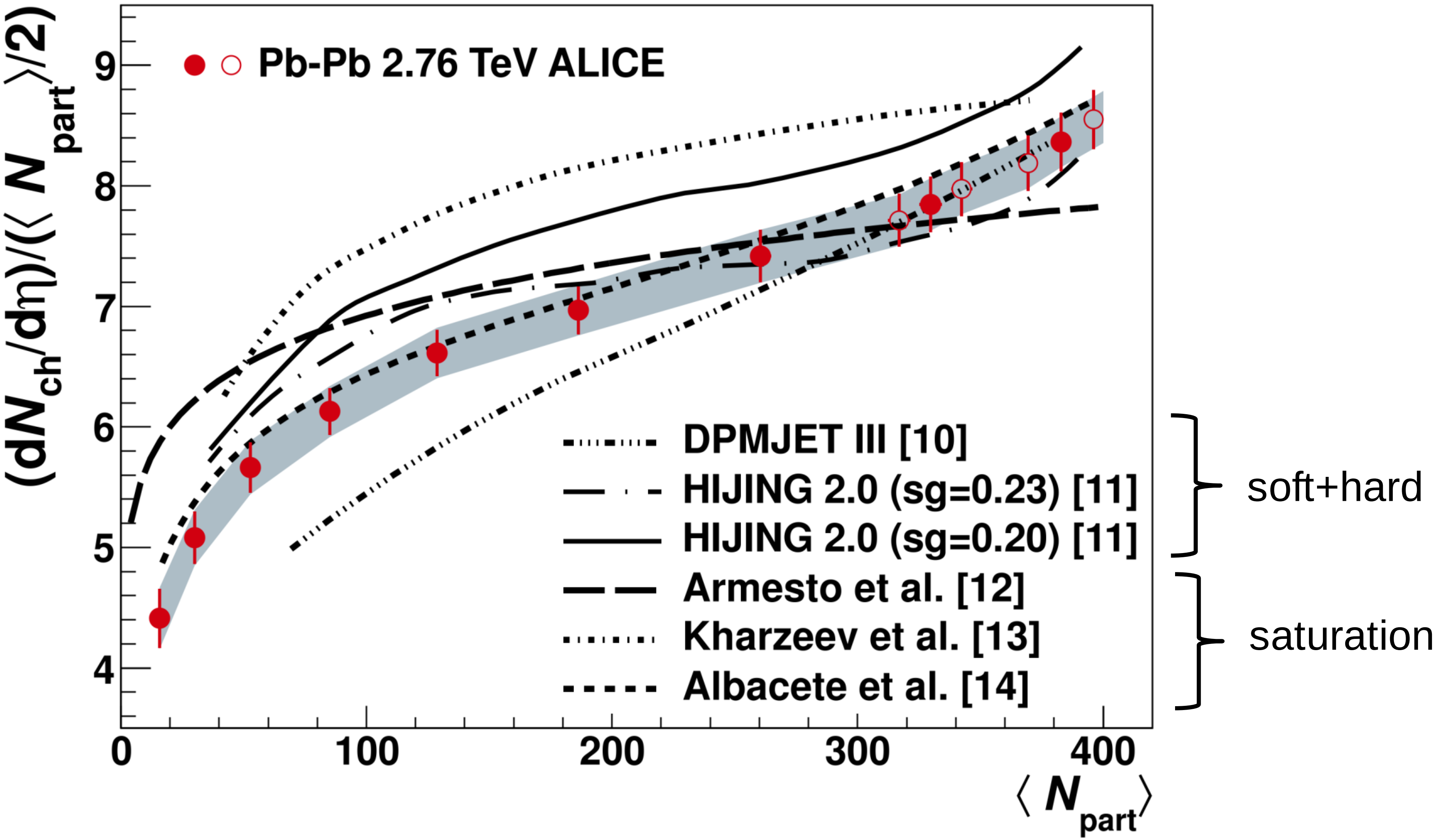
PRL 106 (2010) 032301



~2 times more particles than at RHIC, same centrality dependence

charged-particle production: centrality dependence

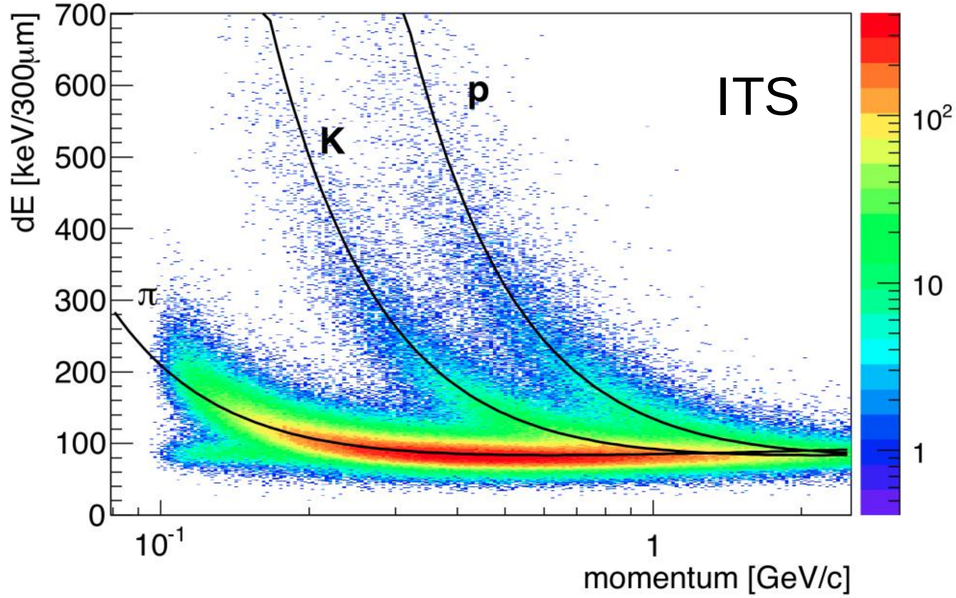
PRL 106 (2010) 032301

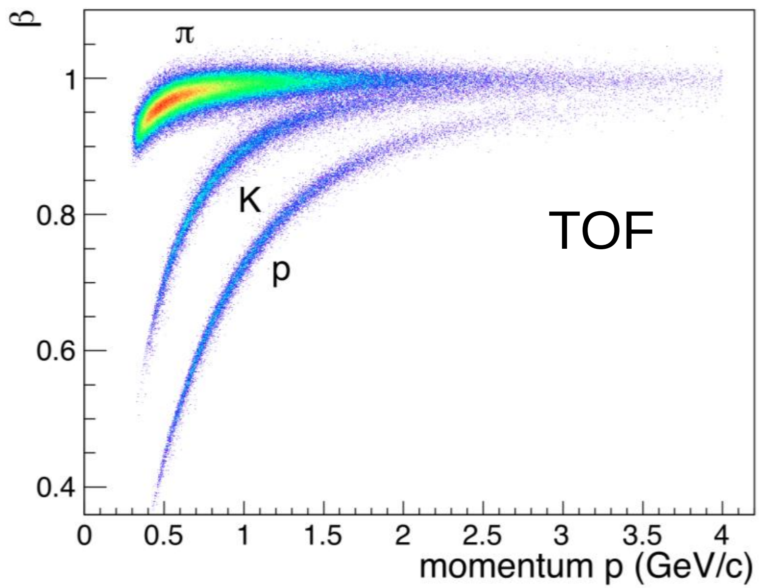


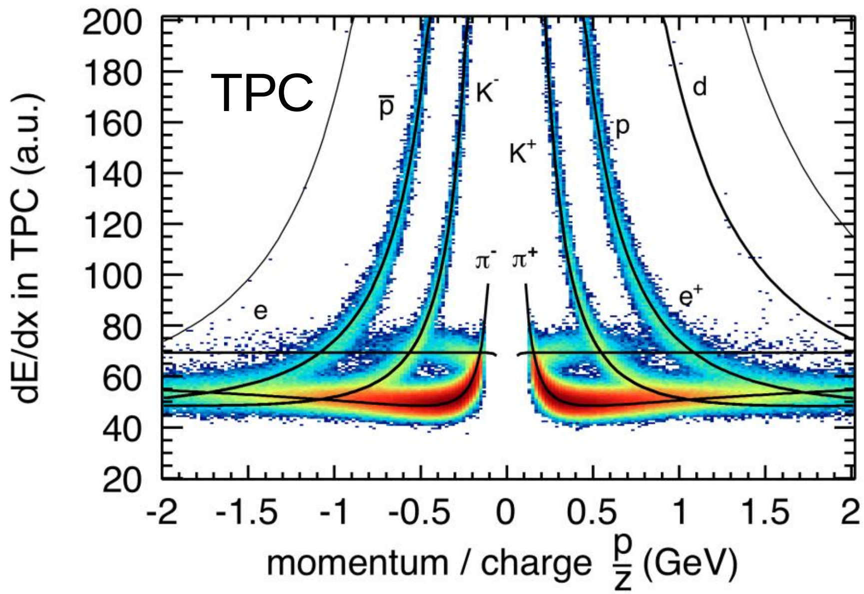
general trend reasonably reproduced by majority of the models
individual differences larger than the difference between the two groups

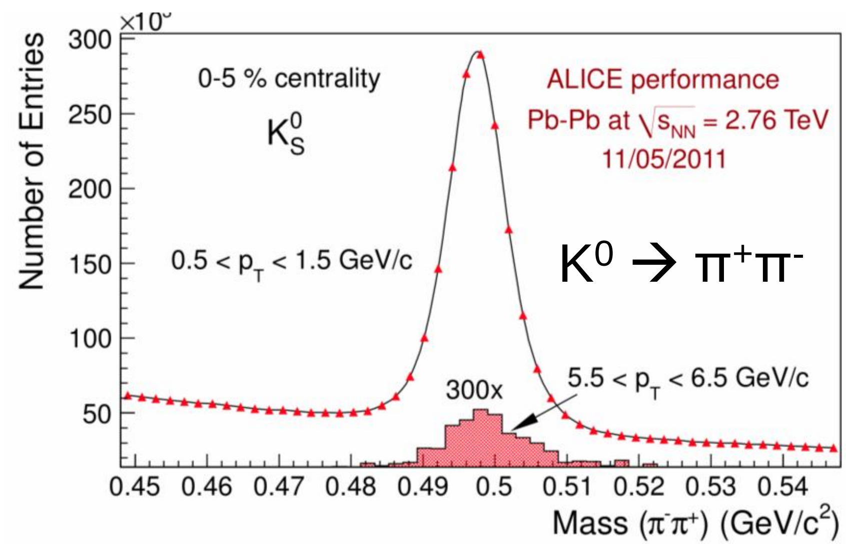
identified particles

hadron identification



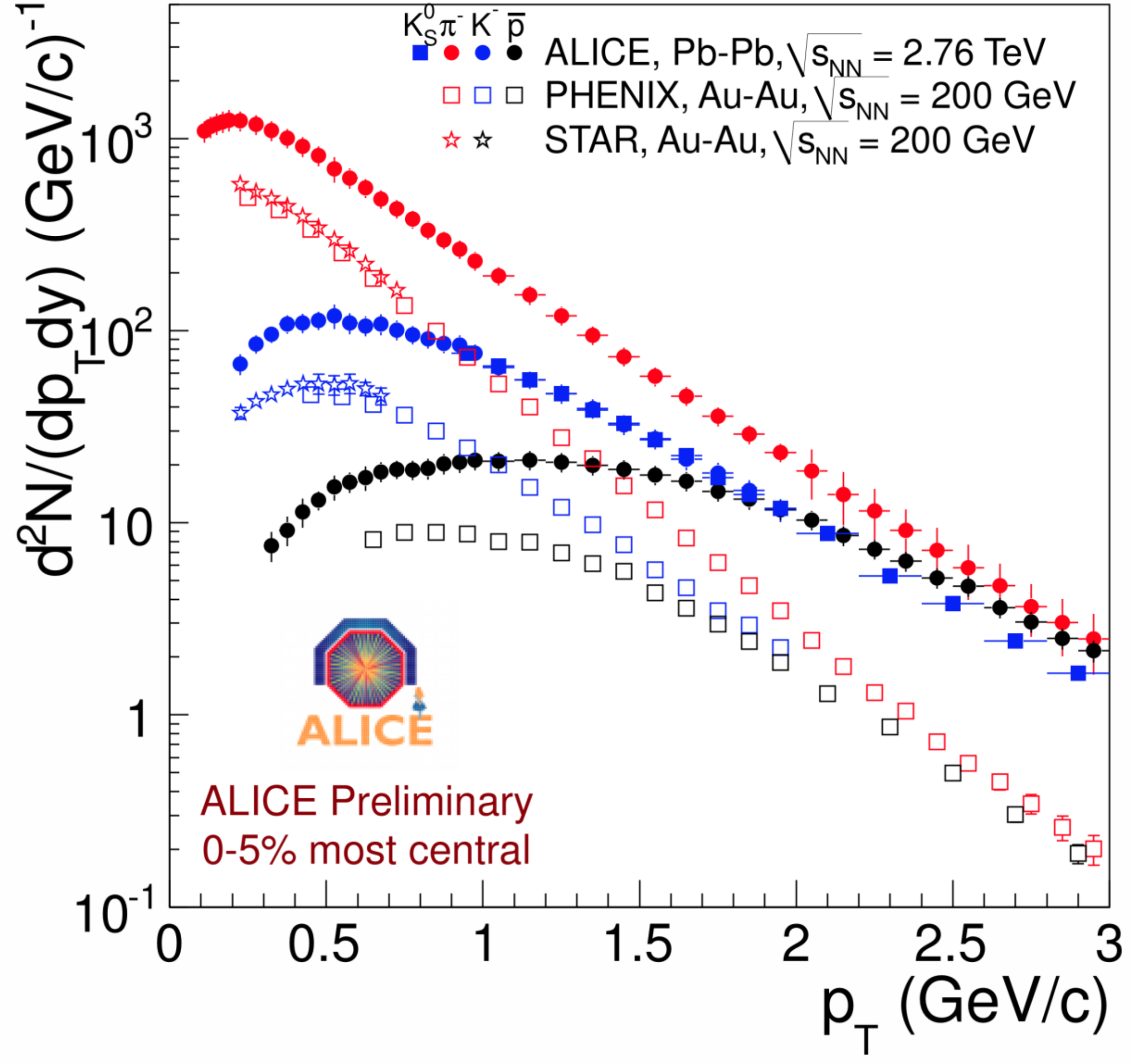






identified hadron spectra

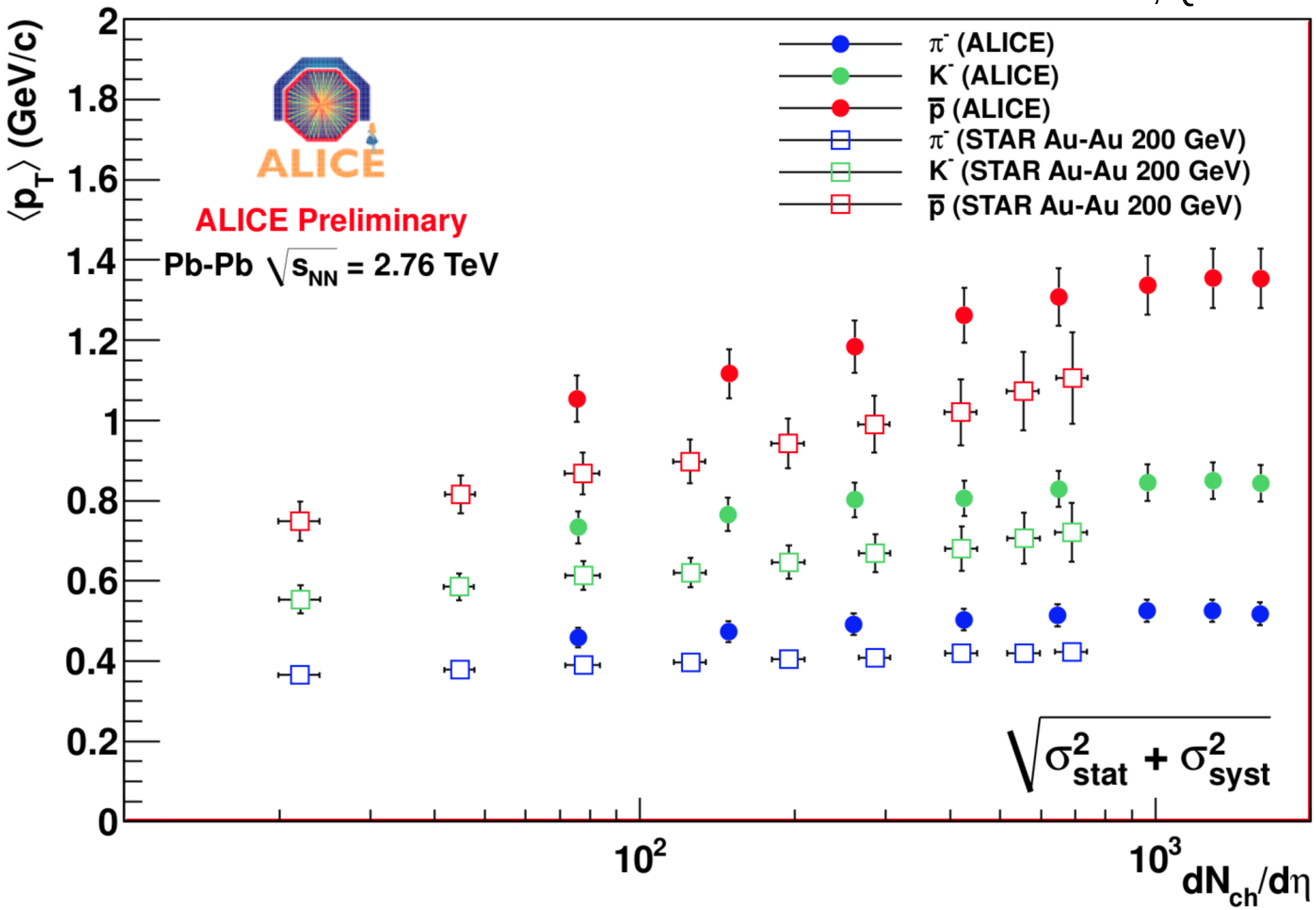
M. Floris, QM2011



harder than at RHIC

mean p_T of identified hadrons

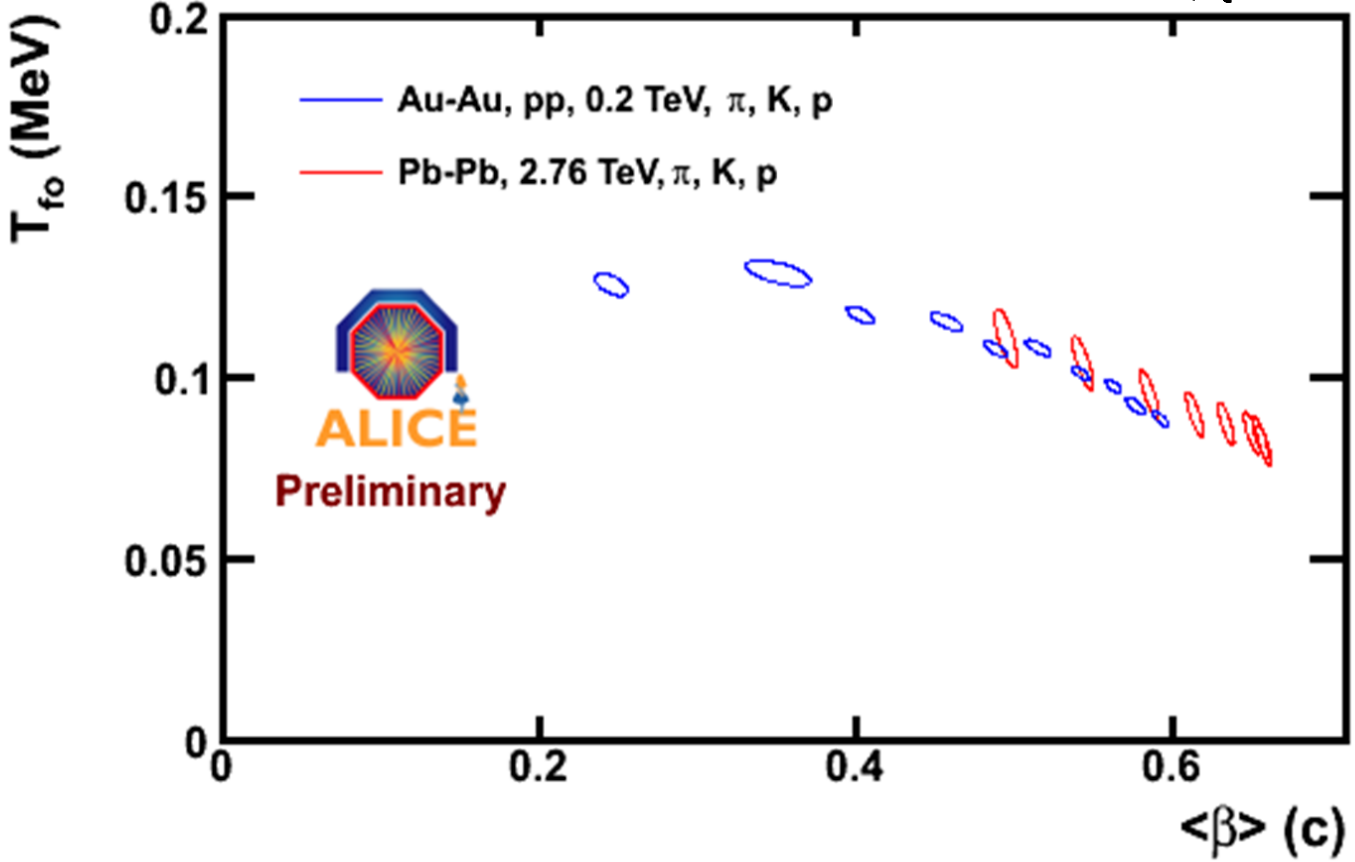
M. Floris, QM2011



$<p_T>$ ~20% higher than at RHIC

identified hadron spectra: blast wave fit

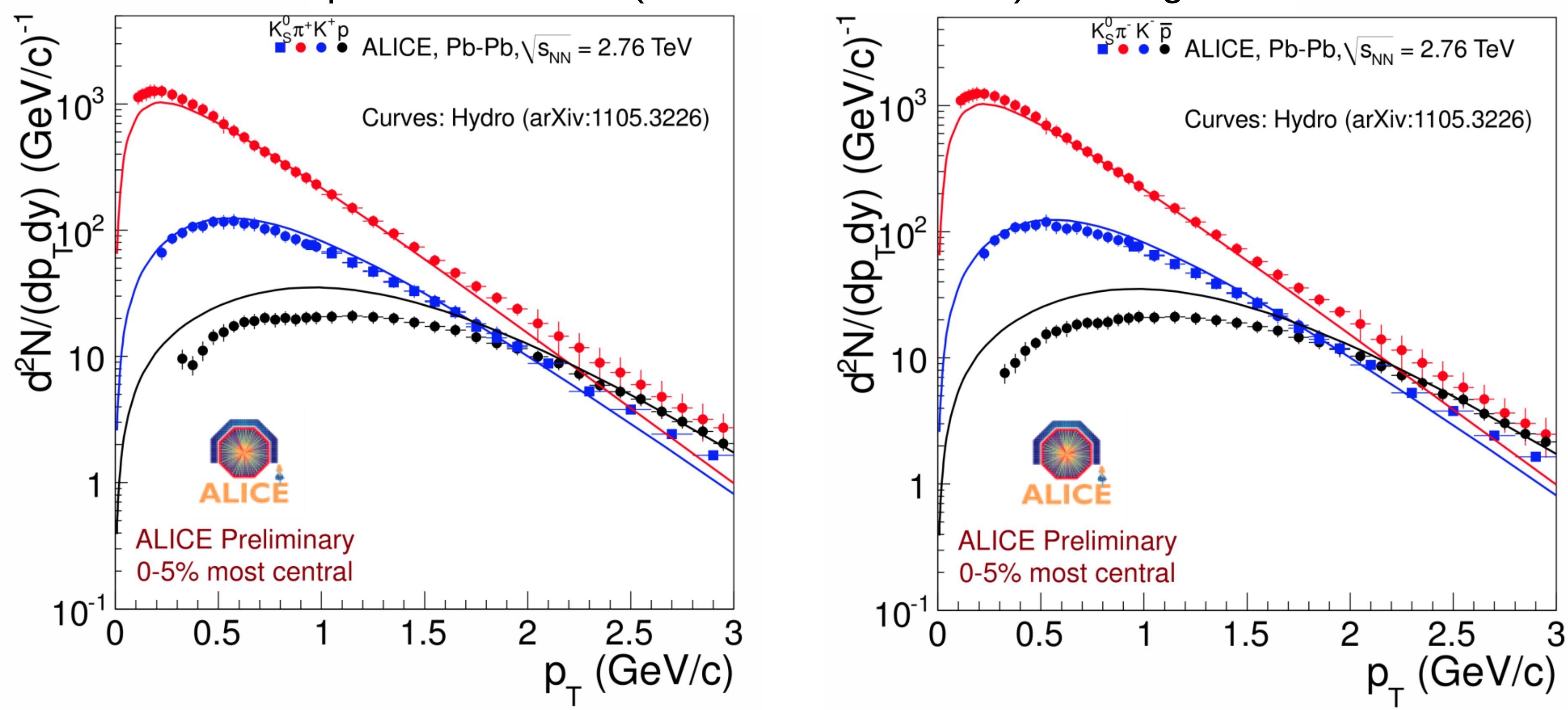
M. Floris, QM2011



10% more transverse flow than at RHIC

identified hadron spectra: comparison with hydro

positive (feed-down corrected) negative



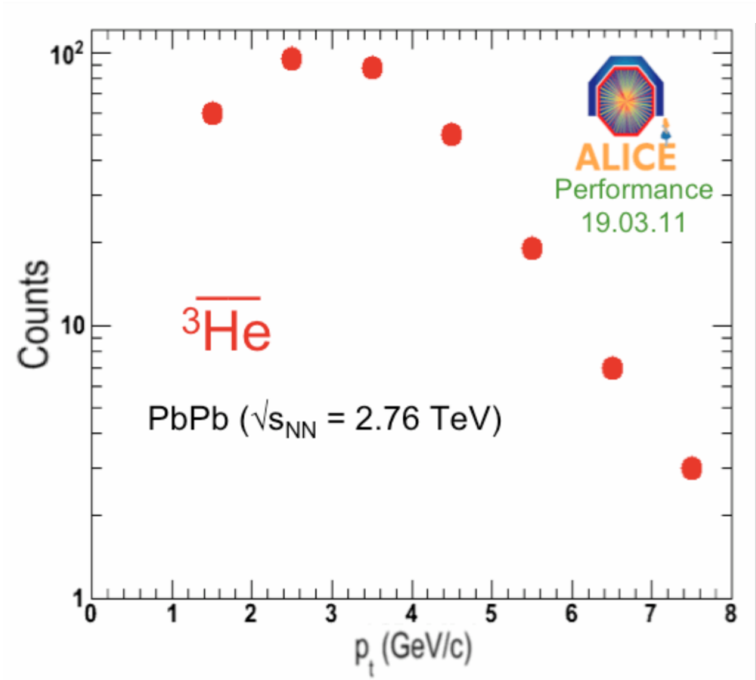
M. Floris, QM2011

harder spectra and less protons than predicted by hydro; suggests a lower chemical freeze-out temperature T_{ch}

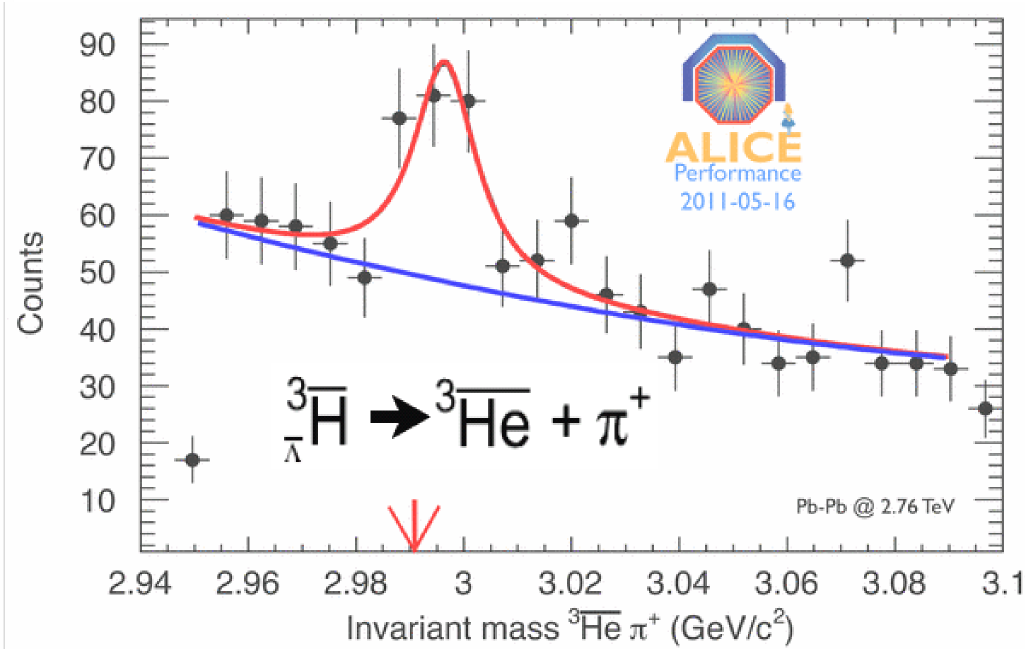
same in thermal model; but lower T_{ch} there excluded by Ξ and Ω

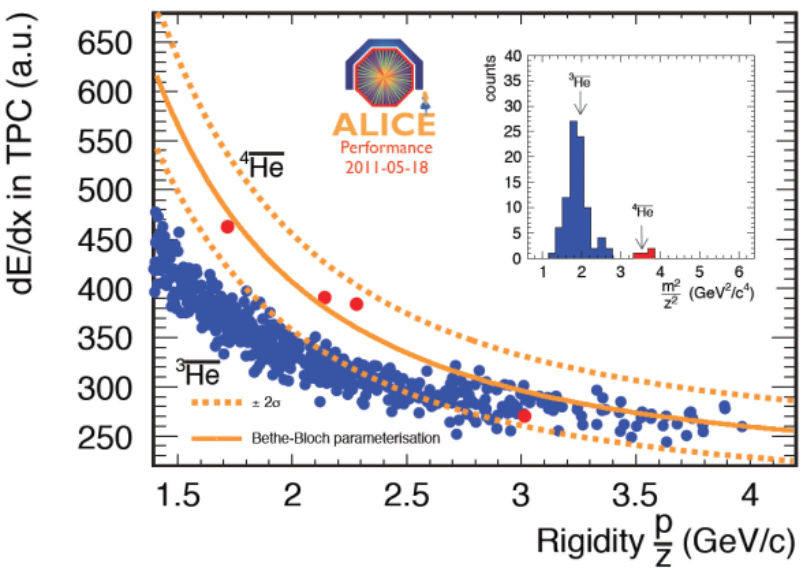
“antimatter” production

antihelium3



antihypertriton





antialpha

anti-chemistry possible

HBT

see talks by

→ Adam Kisiel (Tue 10:50)

→ Lukasz Graczykowski (Tue 16:05)

→ Tom Humanic (Tue 16:25)

first question to LHC: HBT radius

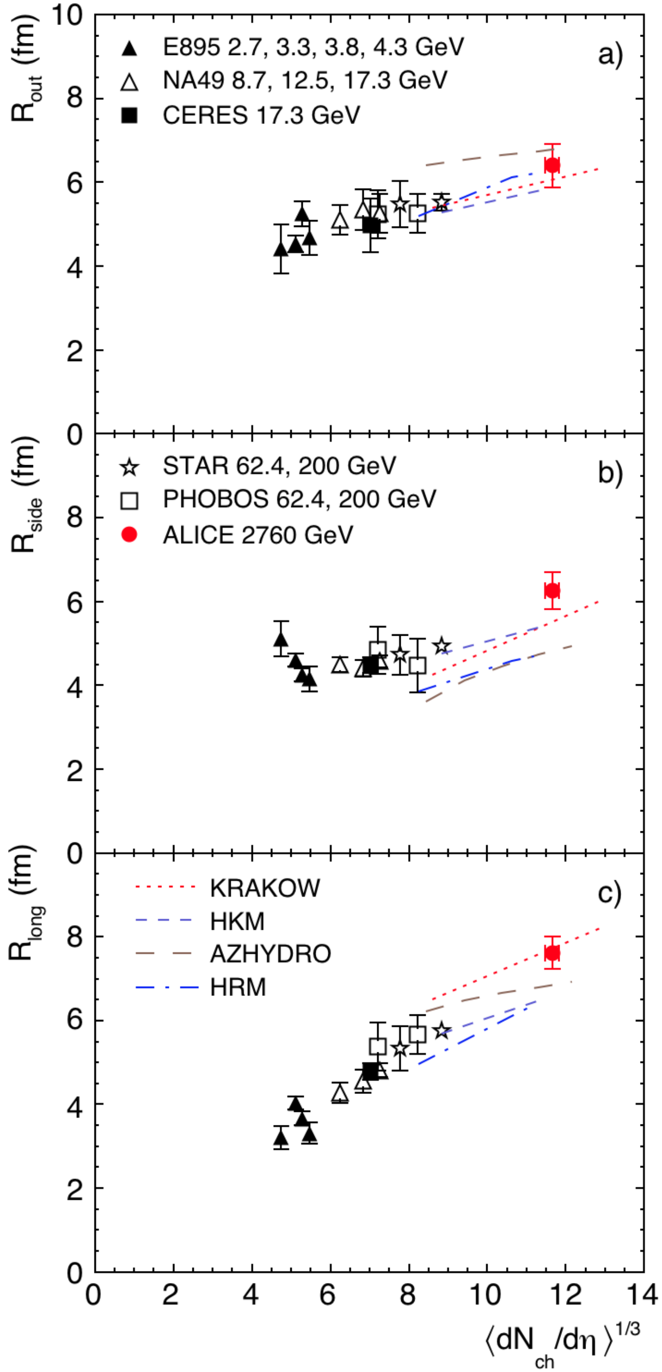
5 Three Questions to the LHC

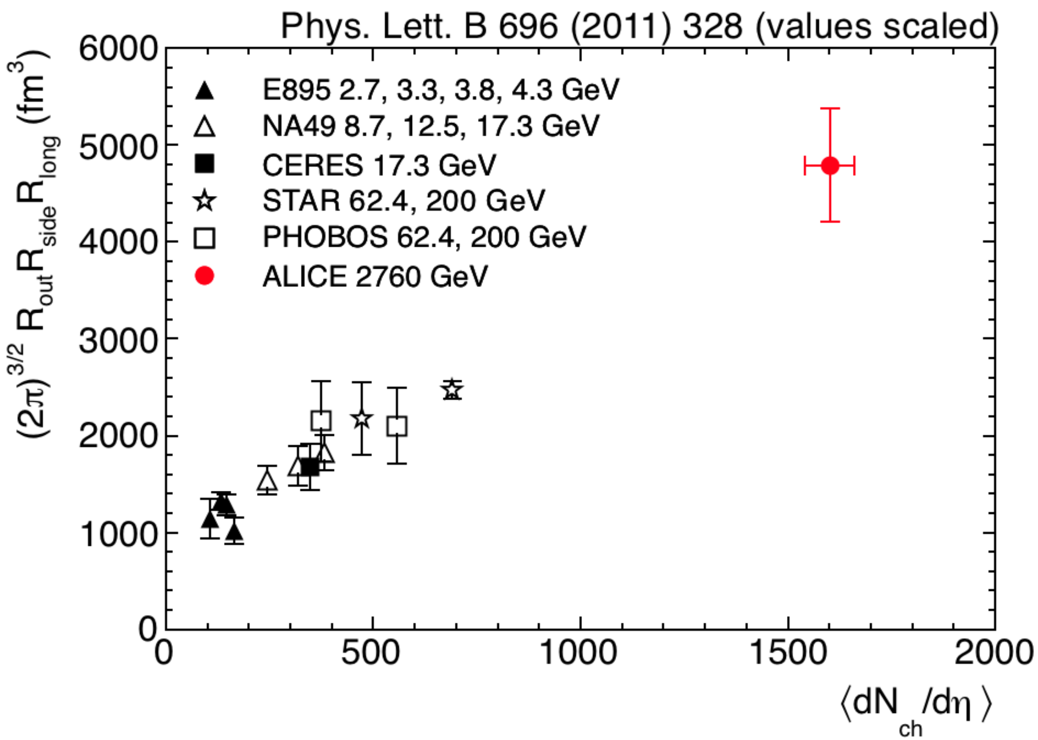
The QGP predicted by statistical QCD is the ultimate state of matter to be studied in high energy nuclear collisions. This is a speculative endeavor, since it is not clear to what extent such collisions can produce something to be called matter. We therefore close our survey with three questions to the next generation of experiments which might help us in finding an answer to this fundamental enigma.

If an increase of collision energy indeed leads to the production of a hotter bubble of deconfined primordial matter, then this must expand more in order to reach the hadronization temperature, and hence the source size for hadron emission must become larger. In particular, it is expected to increase as a power of the hadron multiplicity, since this in turn grows with the initial energy density [24]. So far, from AGS to RHIC, the source size for hadron emission, as determined by Hanbury-Brown–Twiss (HBT) methods [25] used in astrophysics, has not shown a significant increase [26]. This "HBT-puzzle" has been accounted for in terms of the relative role of meson and baryon production [27], but at LHC energies, a clear increase of the source volume is predicted. Such an increase seems necessary in a model-independent way, if the concept of hot primordial fireball production in nuclear collisions is to make any sense.

Helmut Satz, "The Quark-Gluon Plasma", Student Day Lecture, Goa, Dec 2010

pion HBT

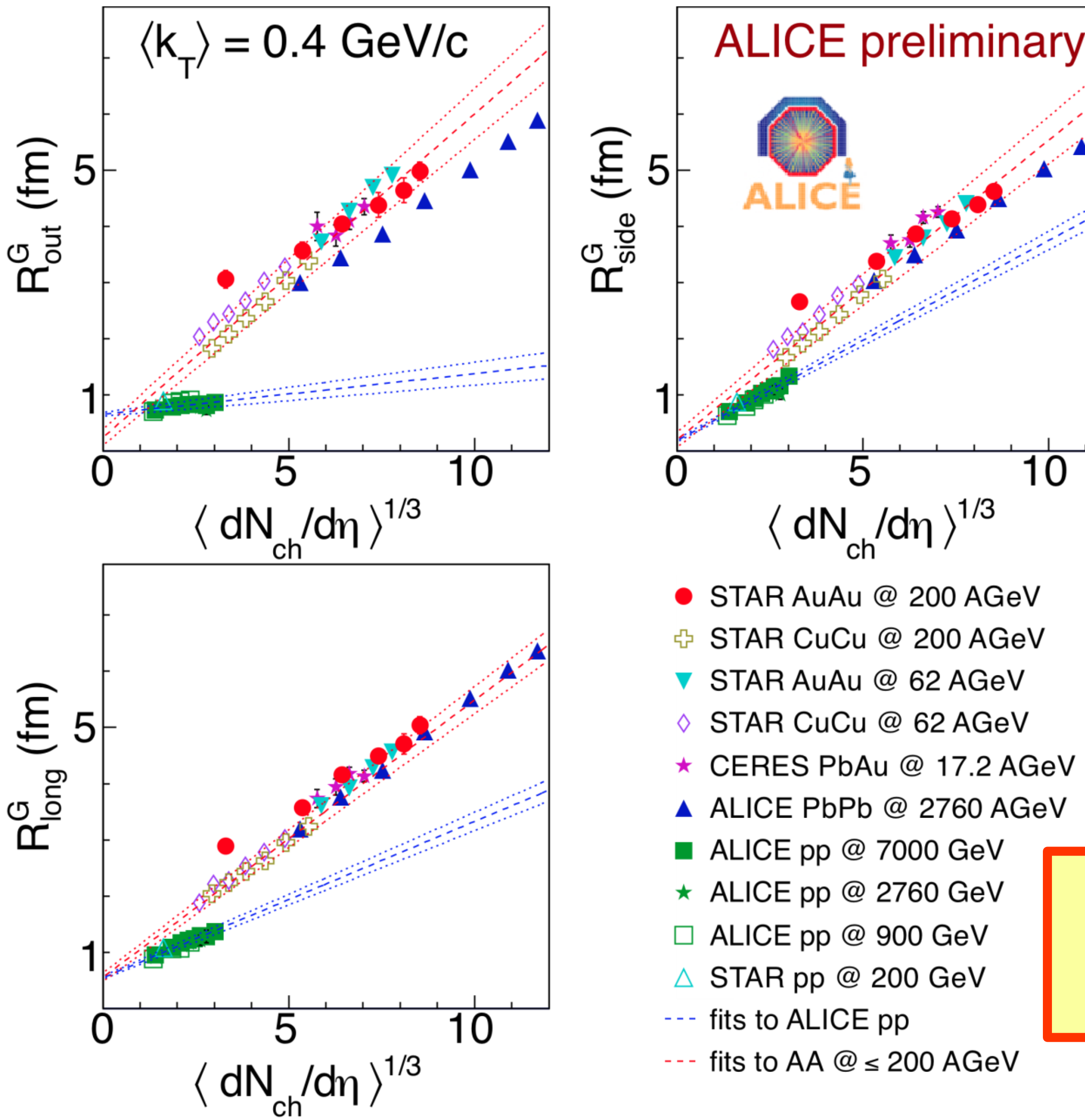




homogeneity volume 2 x larger than at RHIC

growth with energy reasonably well described by models tuned to RHIC data, containing early flow, cross-over, realistic EOS, and resonances

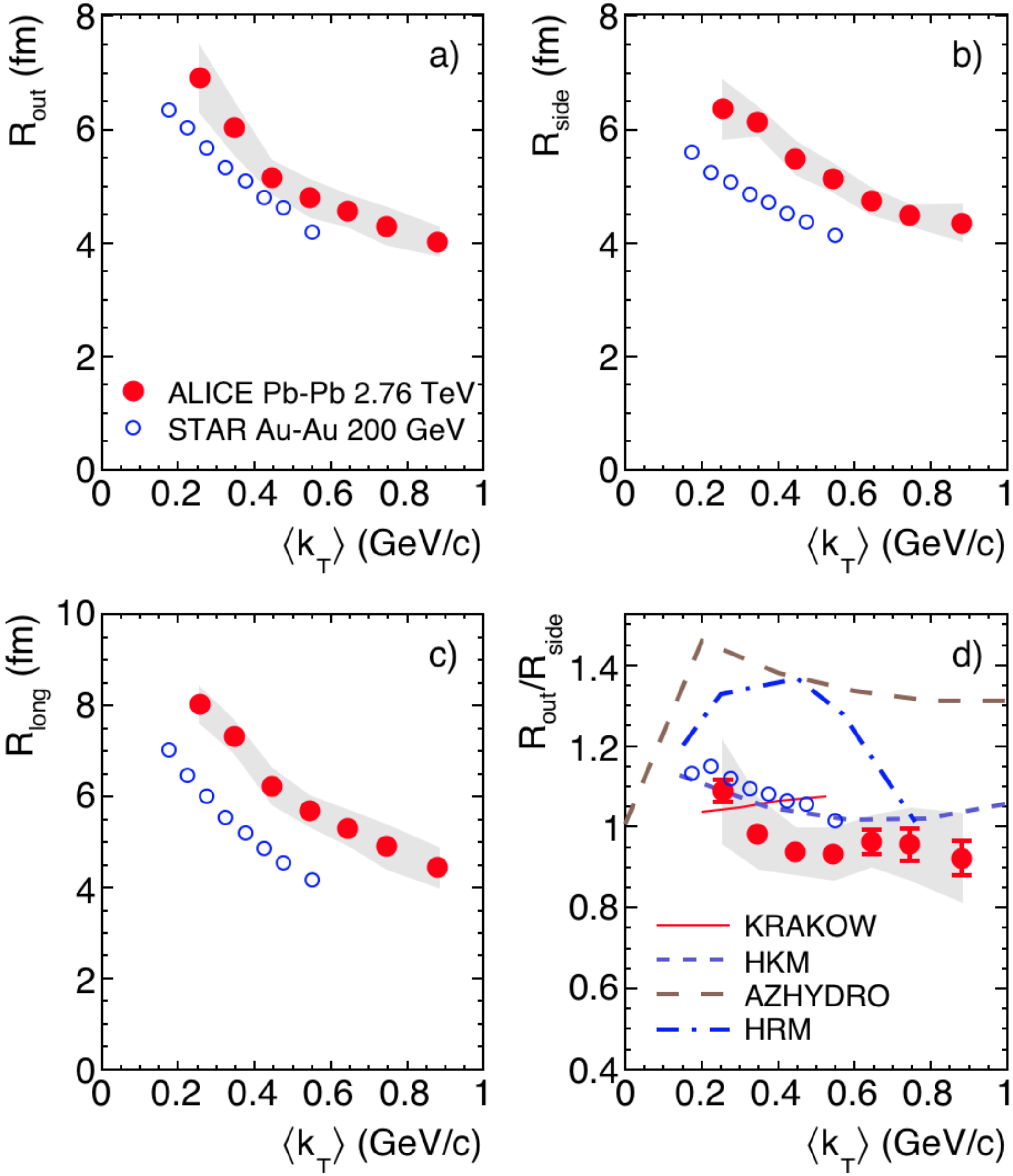
pion HBT



radii increase with multiplicity both in pp and Pb-Pb but with different slopes

pion HBT

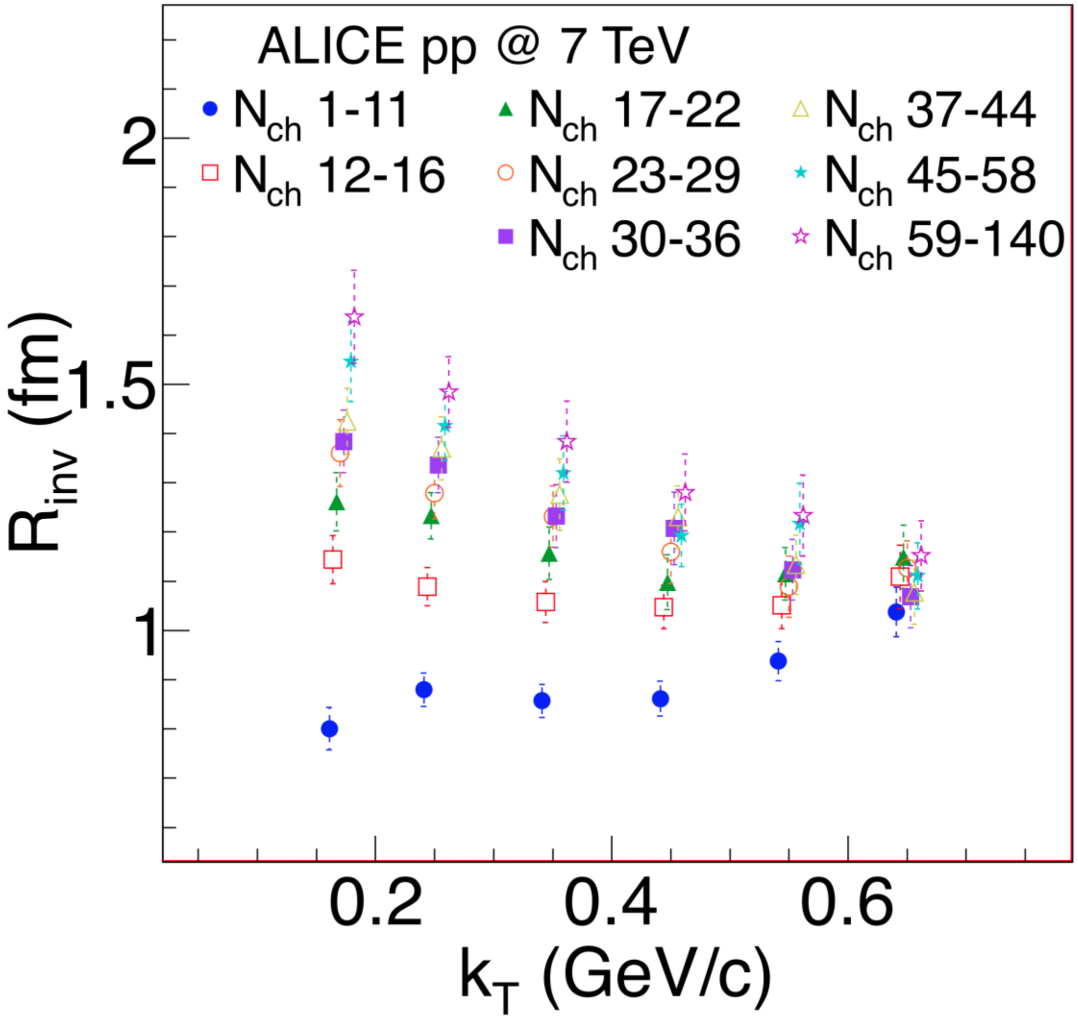
Phys. Lett. B 696 (2011) 328



k_T dependence – sign of transverse flow

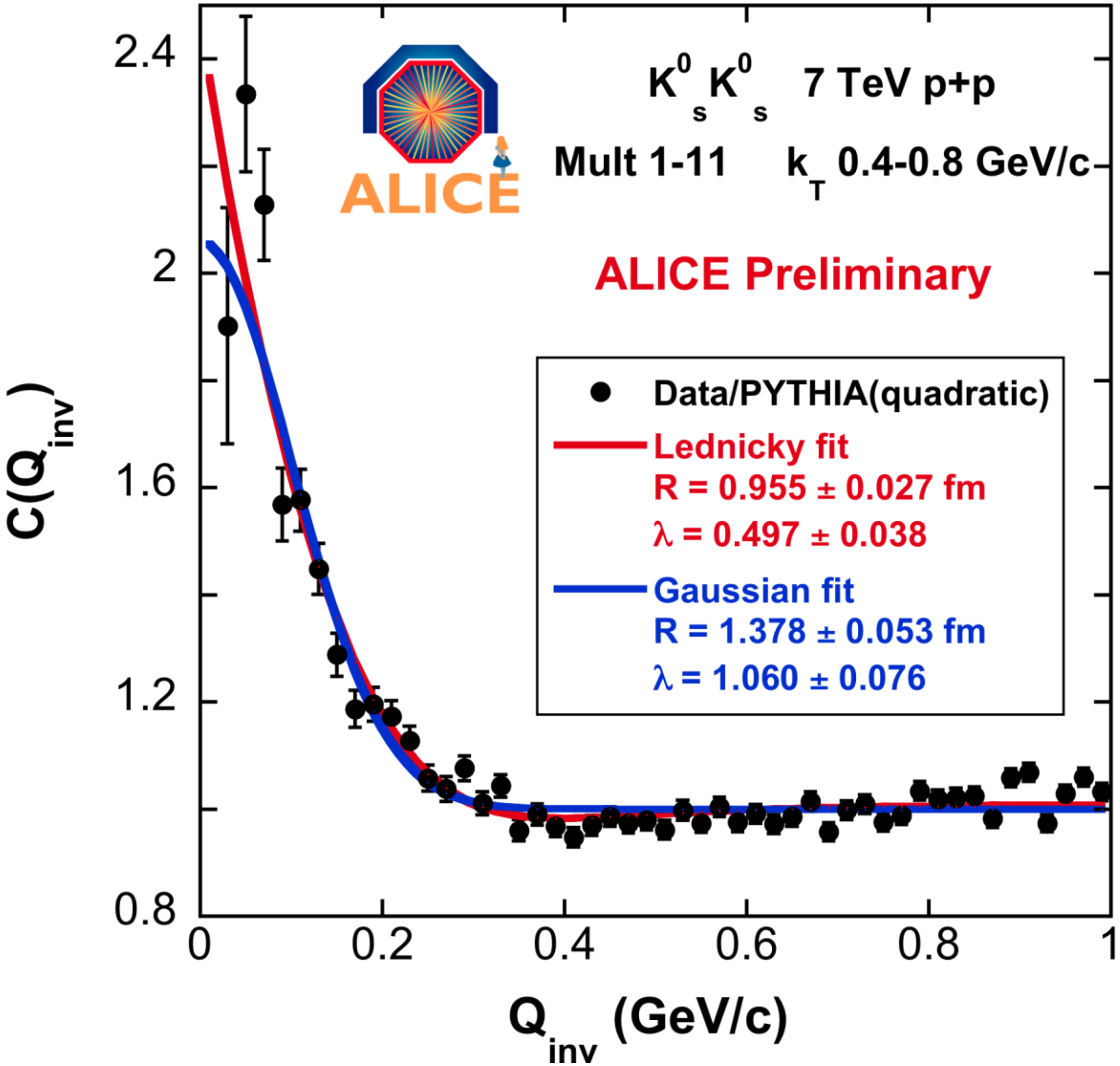
pion HBT

arXiv:1101.3665v1 [hep-ex]



in pp, a similar k_T dependence develops with increasing multiplicity

neutral kaon HBT



$K^0_S K^0_S$: Bose-Einstein and strong interaction, reaching higher k_T than with pions

see talk by Tom Humanic (Tue 16:25)

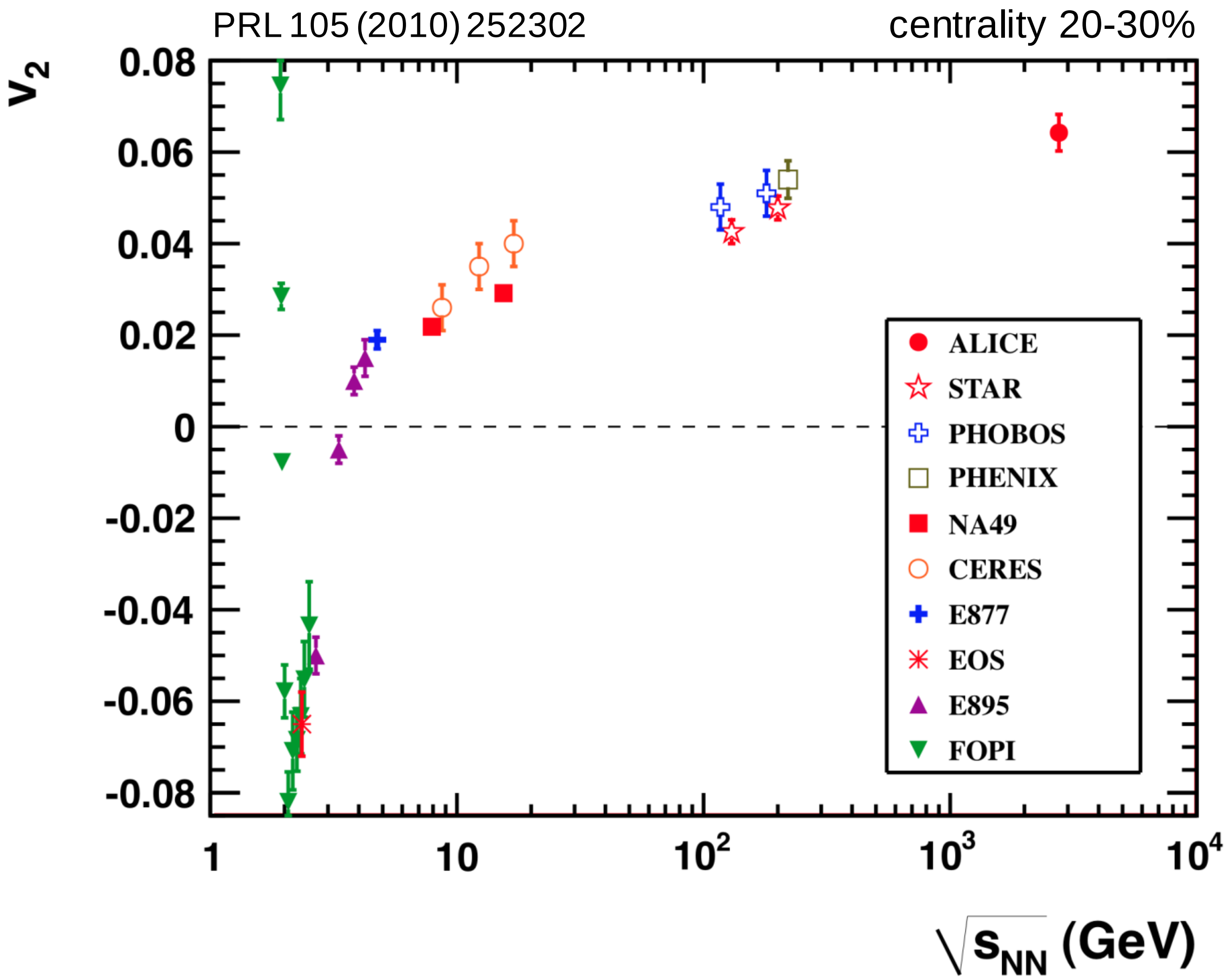
flow

see talks by

→ Masato Sano (Sat 11:00)

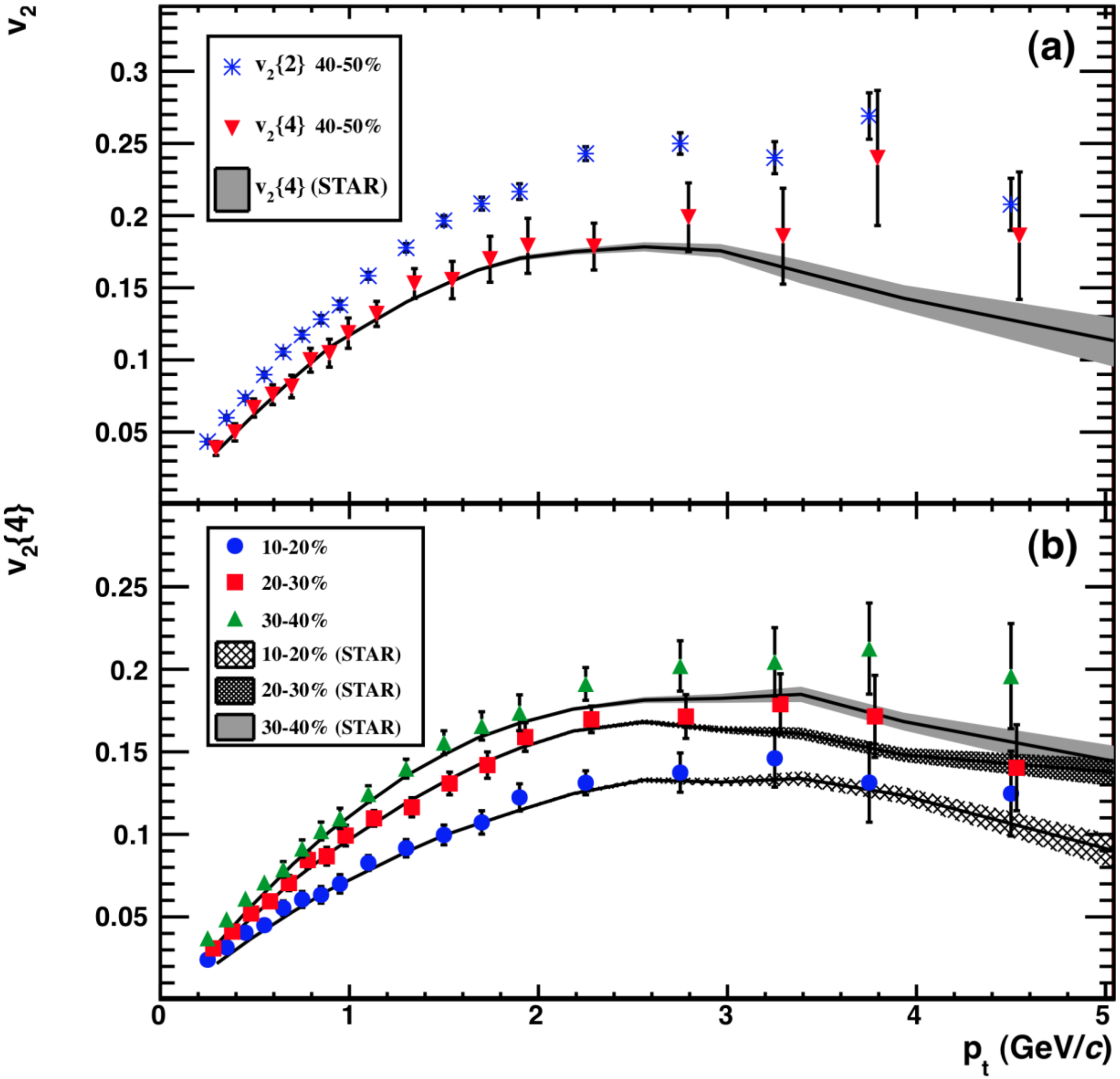
→ Cristian Ivan (Sat 09:00)

elliptic flow



hydrodynamic behavior continues at LHC energies

elliptic flow

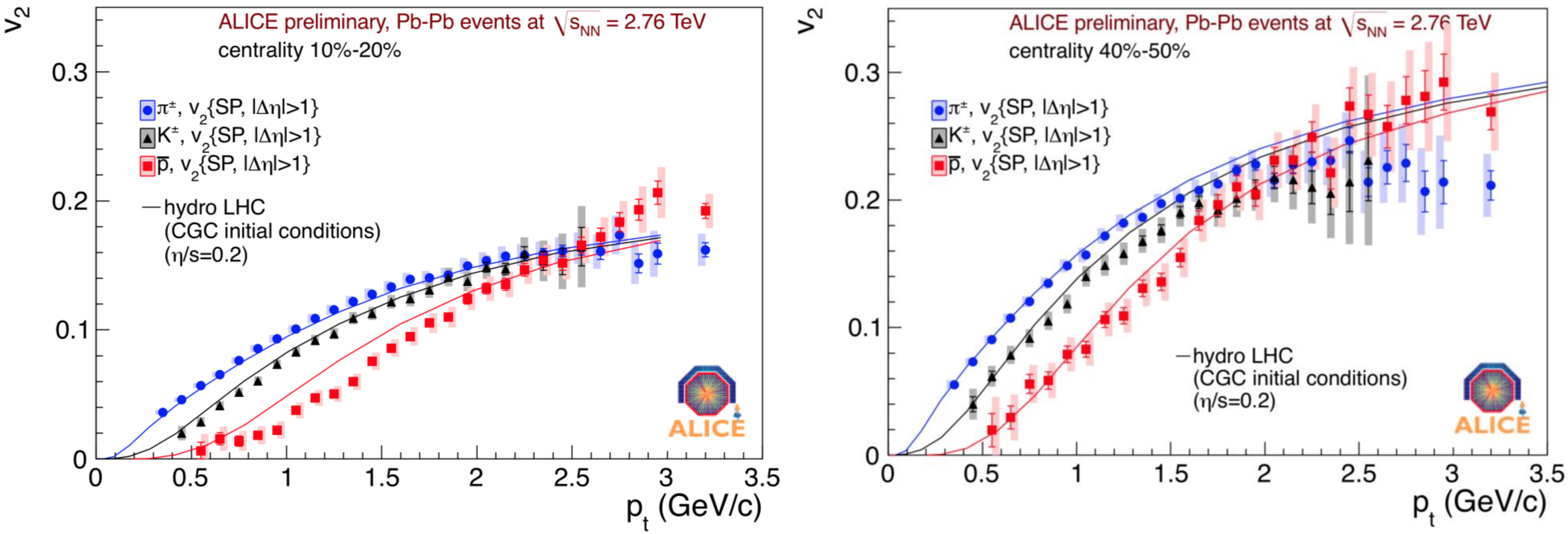


PRL 105 (2010) 252302

same pt dependence as at RHIC (and below, down to 40 GeV!)
inclusive v_2 at LHC higher only because <pt> higher

elliptic flow of identified hadrons

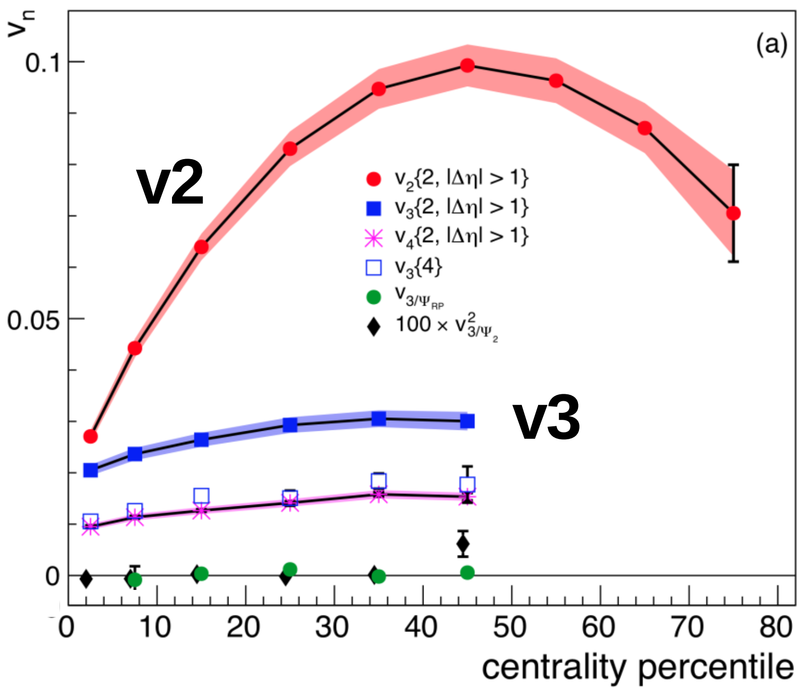
M. Krzewicki, QM2011

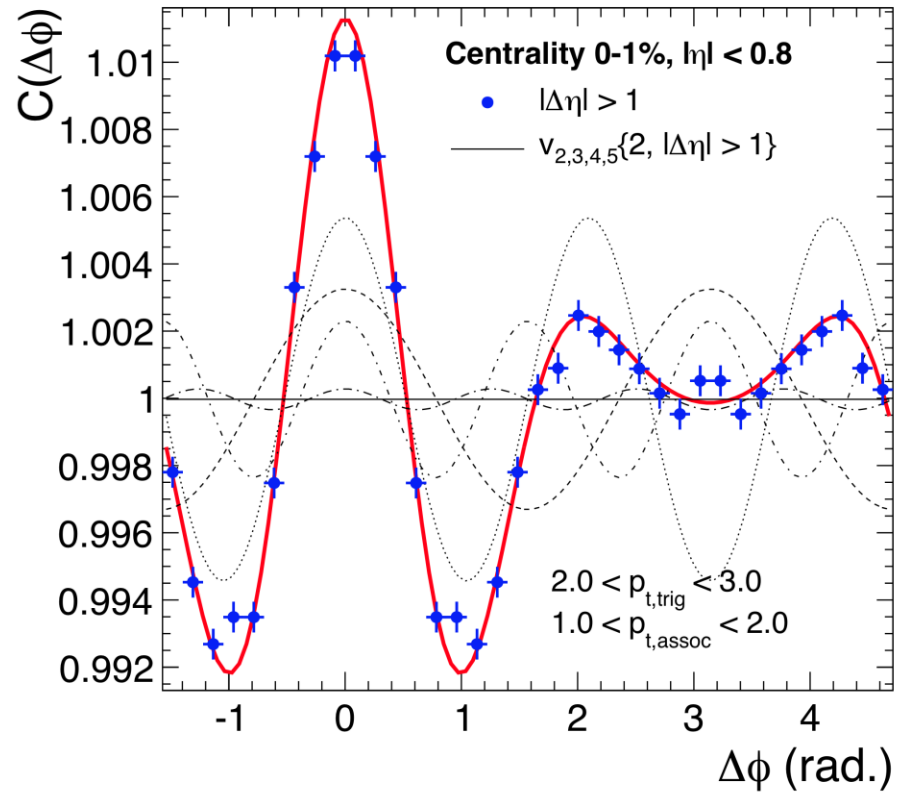


discrepancy for antiprotons – can be fixed by adding rescattering (UrQMD) to hydro (Heinz, Shen, Song, arXiv:1108.5323v1)

higher harmonics of flow

arXiv:1105.3865v1





v_3 is not related to reaction plane
v_3 only weakly depends on centrality
v_2 and v_3 magnitudes reasonably well described by hydro
the azimuthal correlations at high p_T fully described by the flow coefficients

the peaks come from hydrodynamic flow

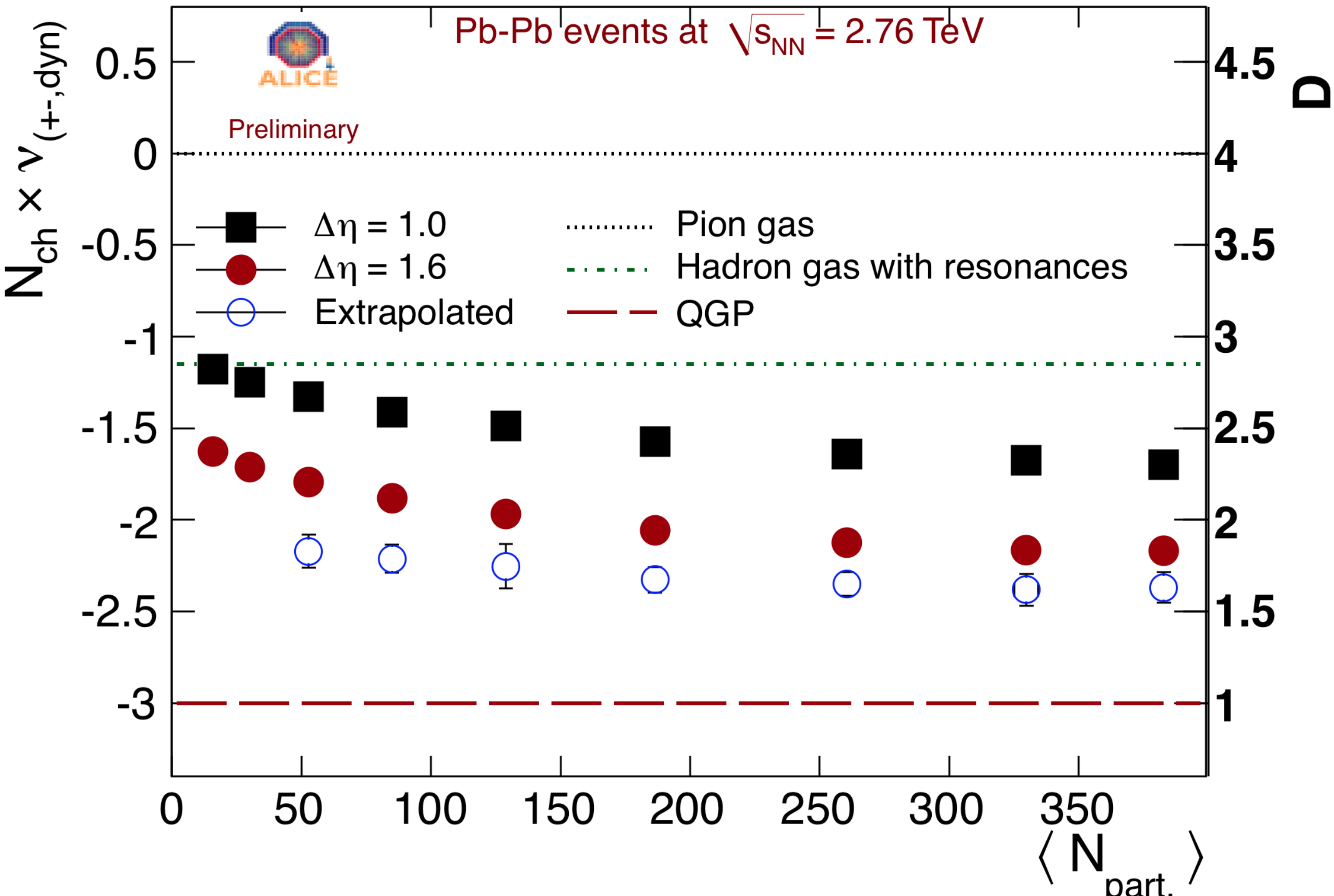
fluctuations

see talks by

→ Satyajit Jena (Fri 11:40)

→ Ilya Selyuzhenkov (Fri 11:00)

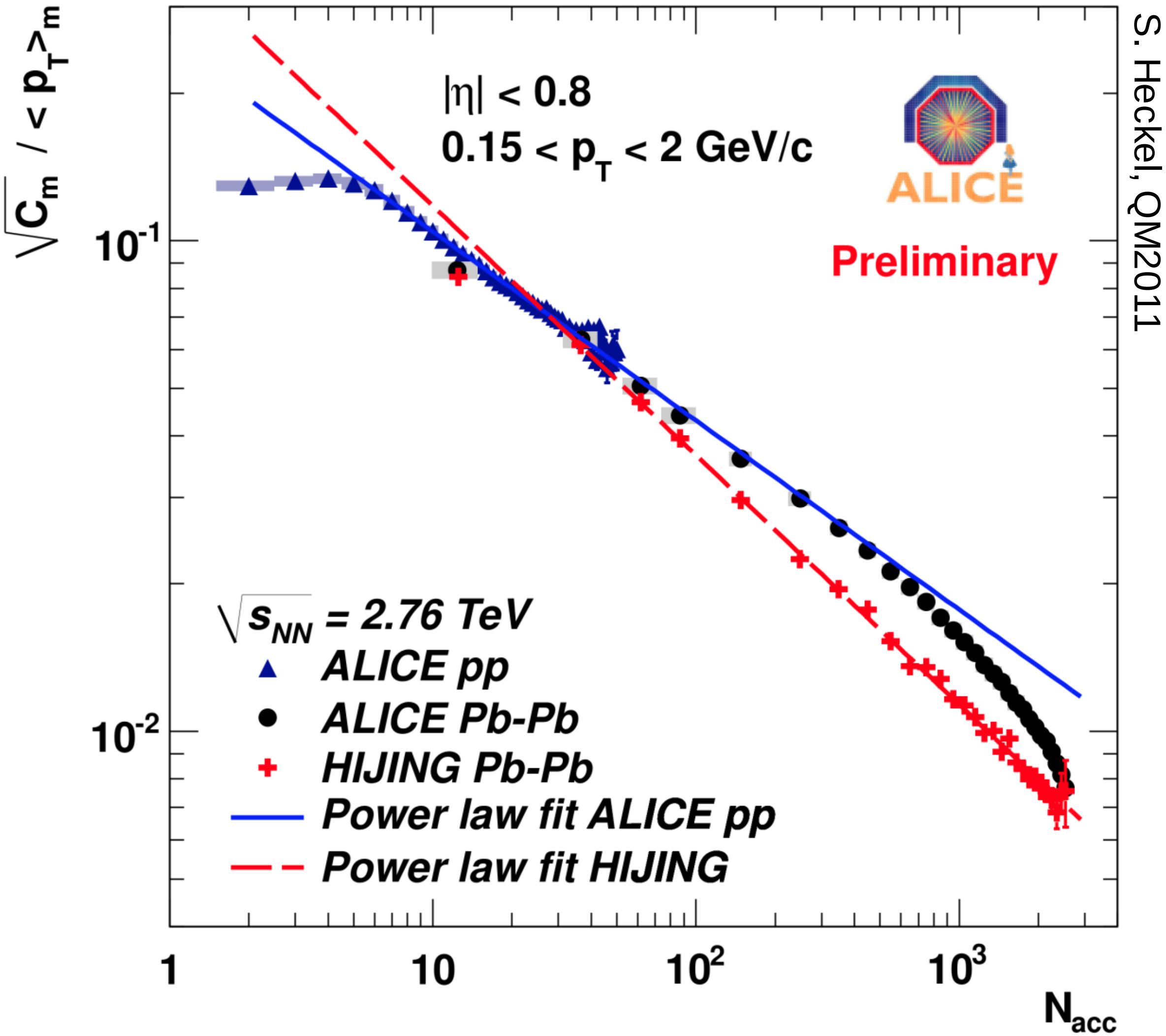
charge fluctuations



charge fluctuations approaching the level expected for QGP

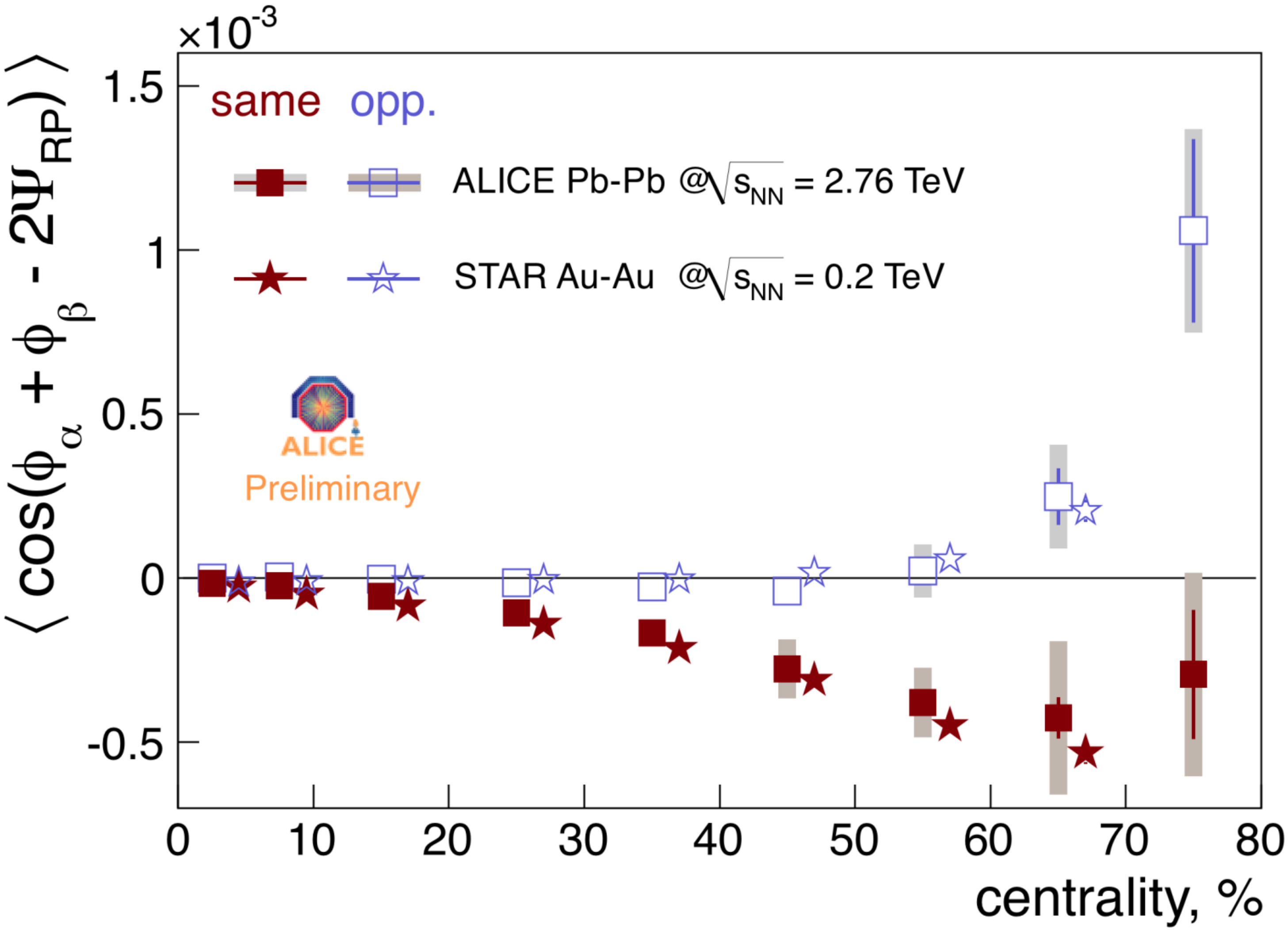
see talk by Satyajit Jena (Fri 11:40)

pt fluctuations



universal scaling
suppression in central collisions
absent in HIJING

charge dependent azimuthal correlations



similar shape and magnitude as at RHIC

see talk by Ilya Selyuzhenkov (Fri 11:00)

summary

new insight into the reaction dynamics from LHC

- Mach cone and ridge challenged
- HBT $R(k_T)$ dependence developing with multiplicity in pp
- proton puzzle: lower yield, lower v_2 than expected

~2 x higher than at RHIC

- particle production
- homogeneity volume

~10-30% higher than at RHIC

- transverse flow
- mean transverse momentum
- integrated elliptic flow
- mass-splitting of v_2

like at RHIC

- centrality dependence of particle production
- centrality dependence of v_2
- multiplicity dependence of HBT radii
- multiplicity dependence of particle ratios
- transverse momentum dependence of v_2
- charge and p_T fluctuations
- charge dependent azimuthal correlations

working at CERN - requirements

always wear safety equipment

full concentration

be prepared for the unexpected