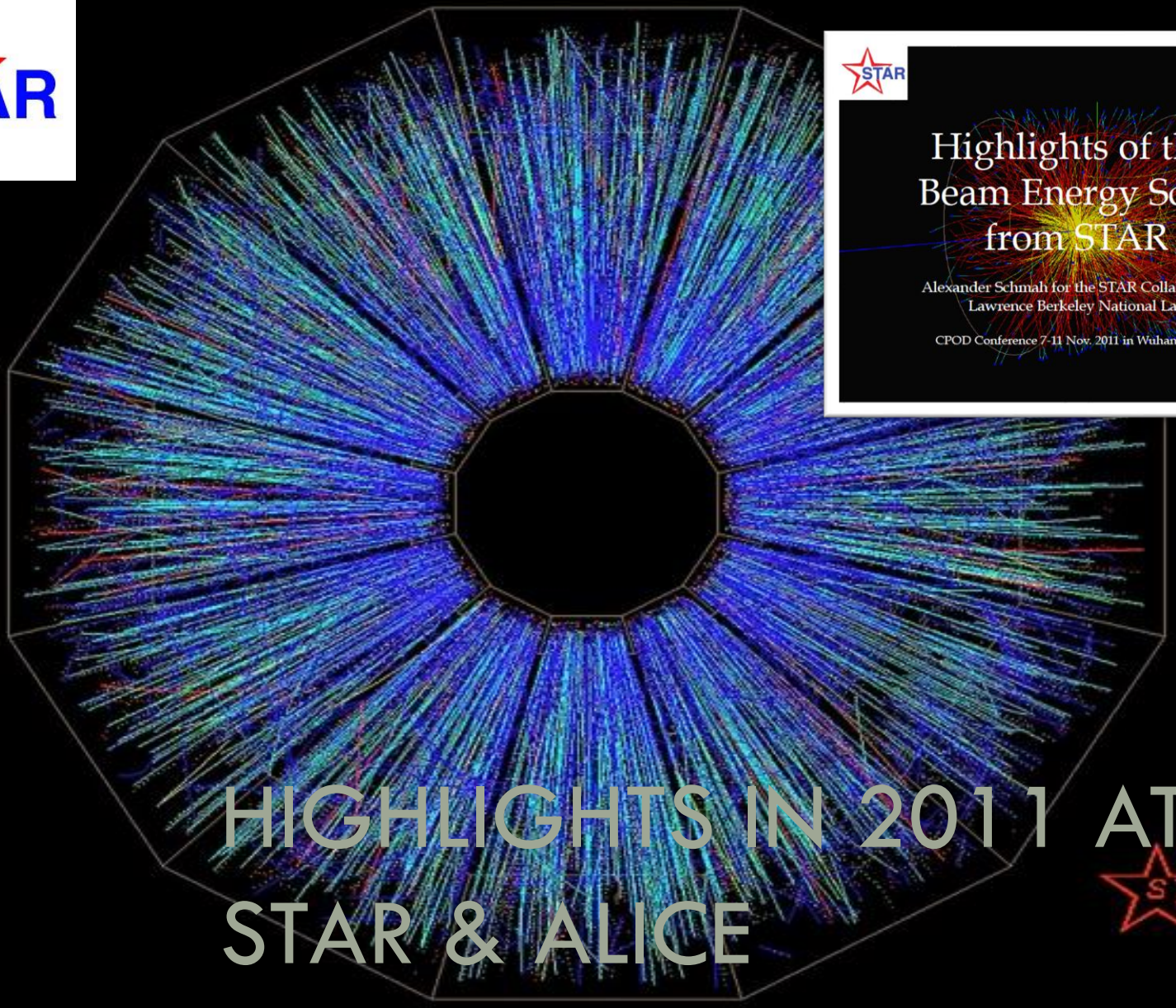


HIGHLIGHTS IN 2011 AT STAR & ALICE

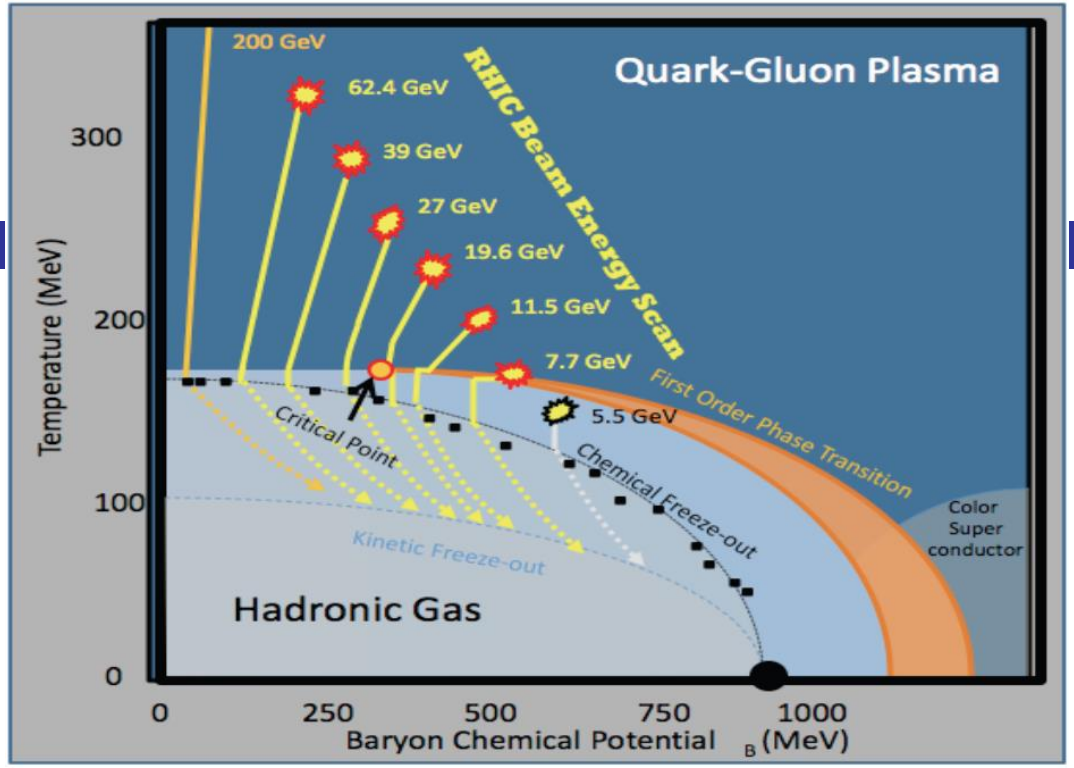
In-Kwon Yoo

Outline

- STAR BES Results
  - BES runs and STAR general
  - Charged Meson
  - Λ and Ξ
  - Freeze-out Conditions
  - ϕ
  - Flow
  - E-by-E
- ALICE Recent Results
  - ALICE general
  - Particle Production
  - RHIC vs. LHC
  - Freeze-out Volume
  - Particle Ratios
  - Flow
  - Jet Quenching
  - Miscellaneous ..

STAR BES

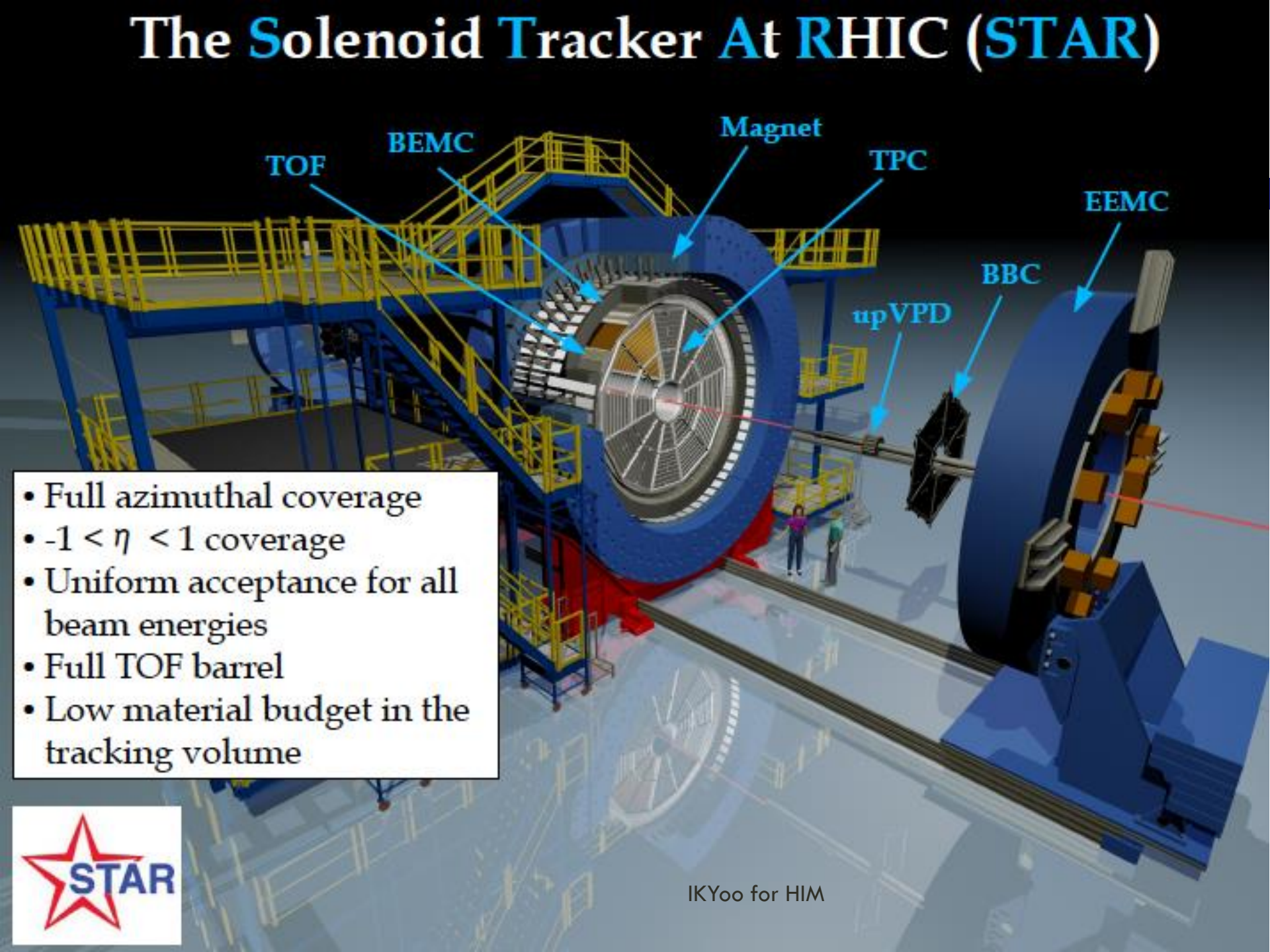
- Beam Energy Scan
  - Signature of Onset
  - Critical Point
- T-mB scan
- Looking for
  - anomalies
  - testing theories
  - RHIC vs. LHC



$\sqrt{s_{NN}}$ (GeV)	MB Events in 10^6
7.7	4.3
11.5	11.7
19.6	35.8
27	70.4
39	130.4
62.4	67.3

IKYoo for HIM

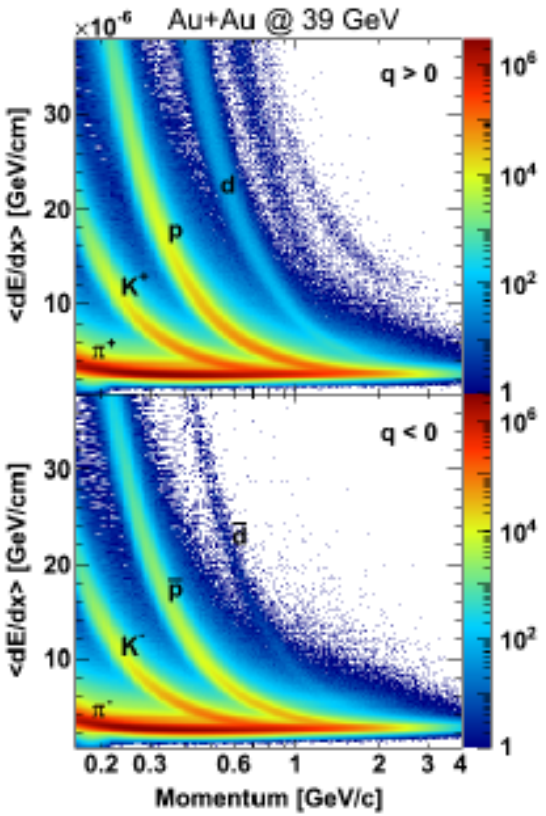
The Solenoid Tracker At RHIC (STAR)



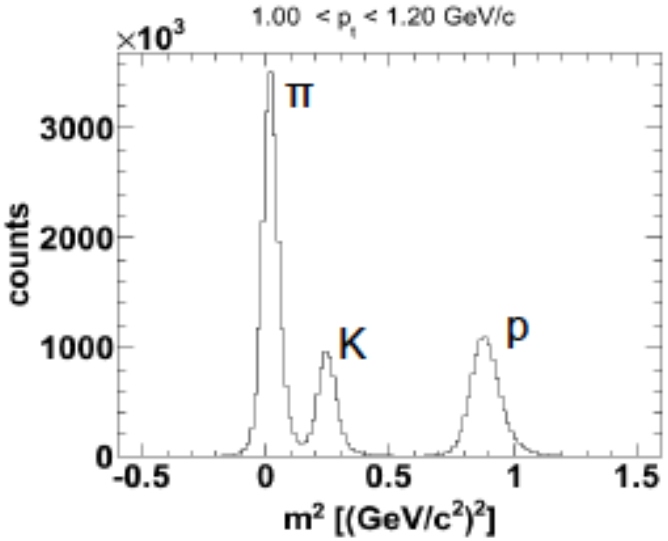
- Full azimuthal coverage
- $-1 < \eta < 1$ coverage
- Uniform acceptance for all beam energies
- Full TOF barrel
- Low material budget in the tracking volume

PID at STAR

dE/dx in the TPC

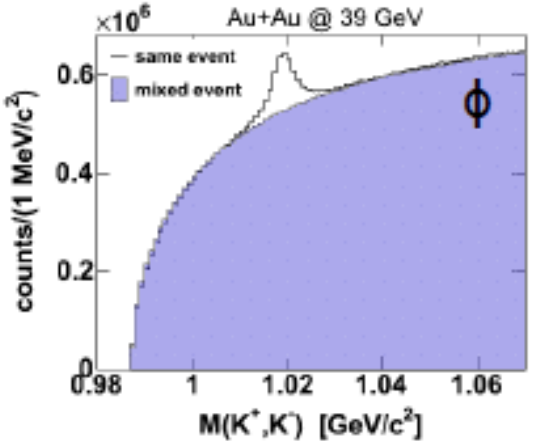


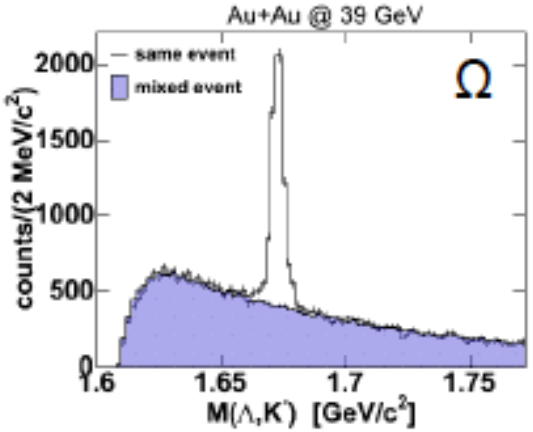
m² from TOF



- Direct (dE/dx + TOF) proton PID up to ~ p = 3 GeV/c
- Kaon, pion and high p_T: statistical signal extraction

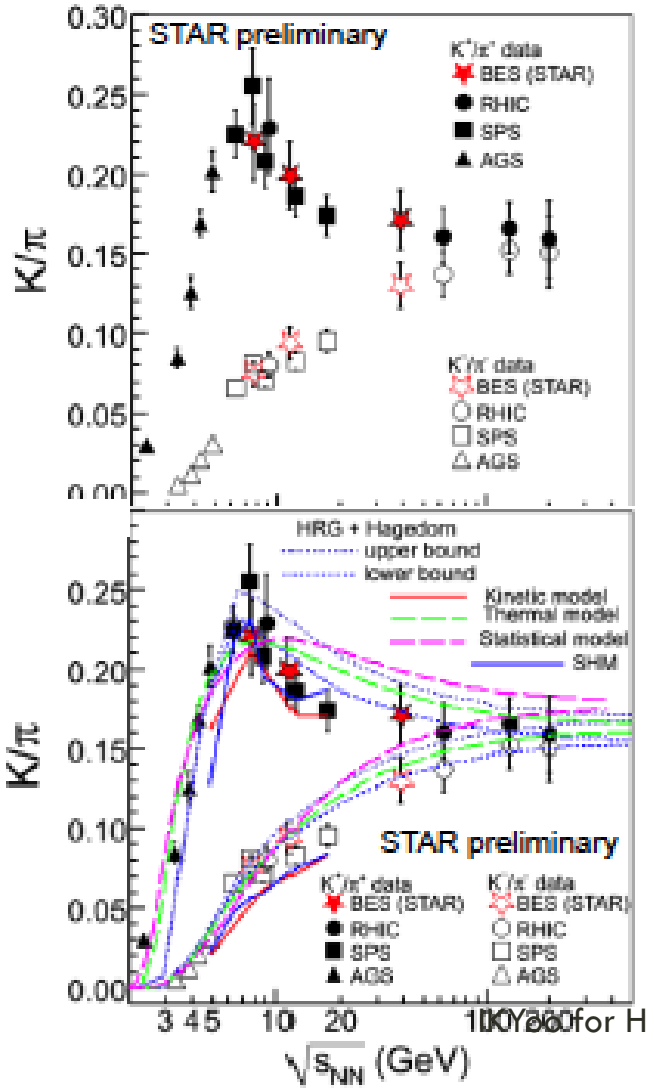
Invariant mass and topological PID

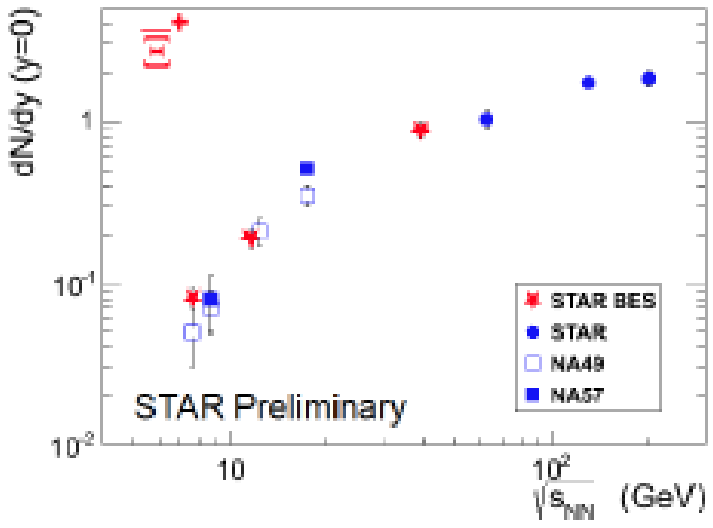


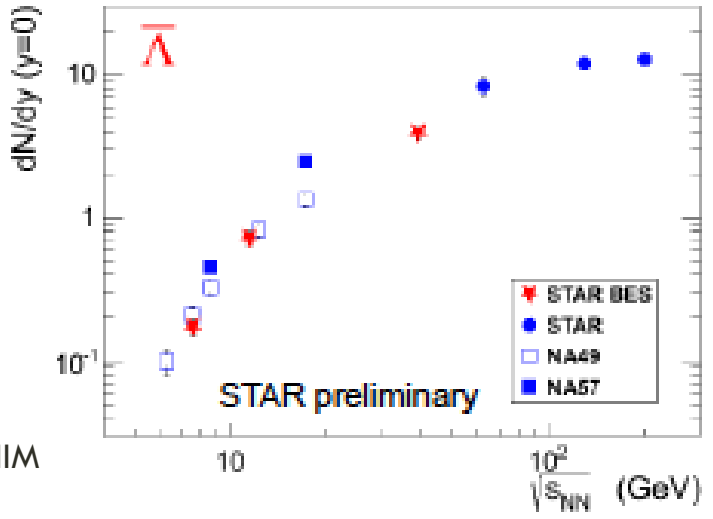


K/π, Λ, Ξ vs. E_{CM}

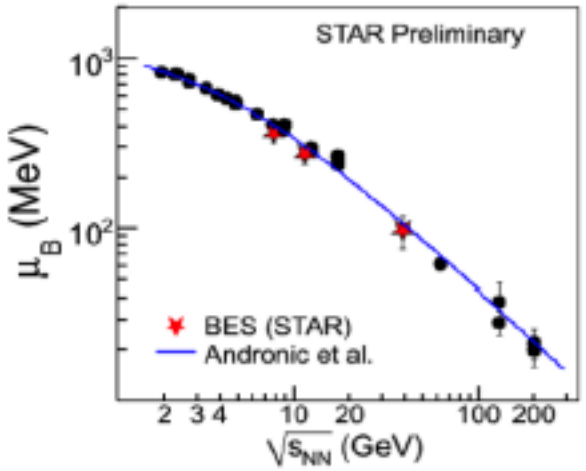
- Excellent agreement with SPS results

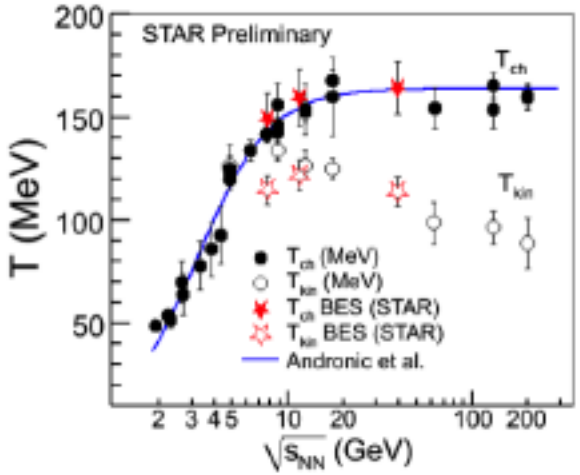


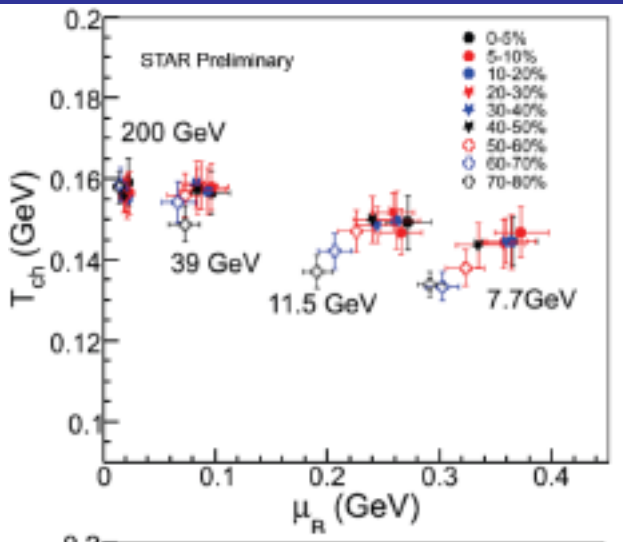


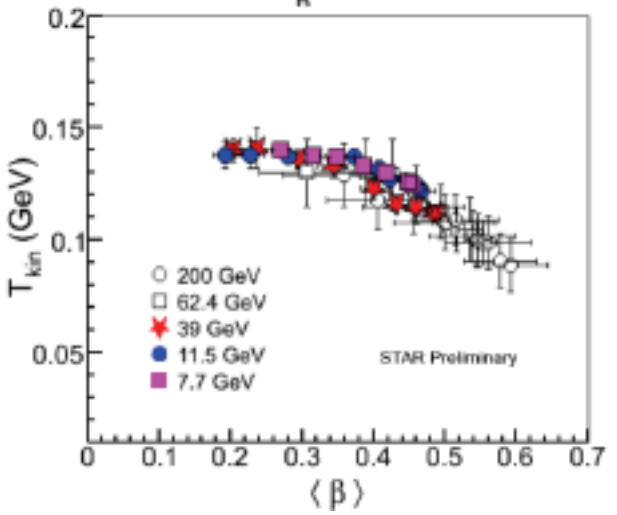


Freeze-Out Conditions





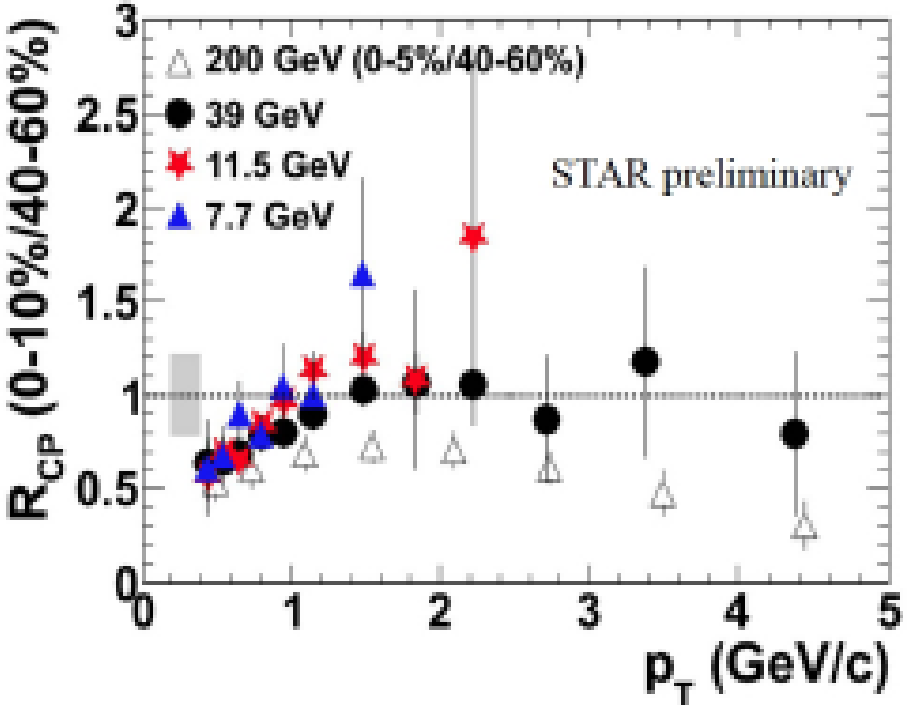


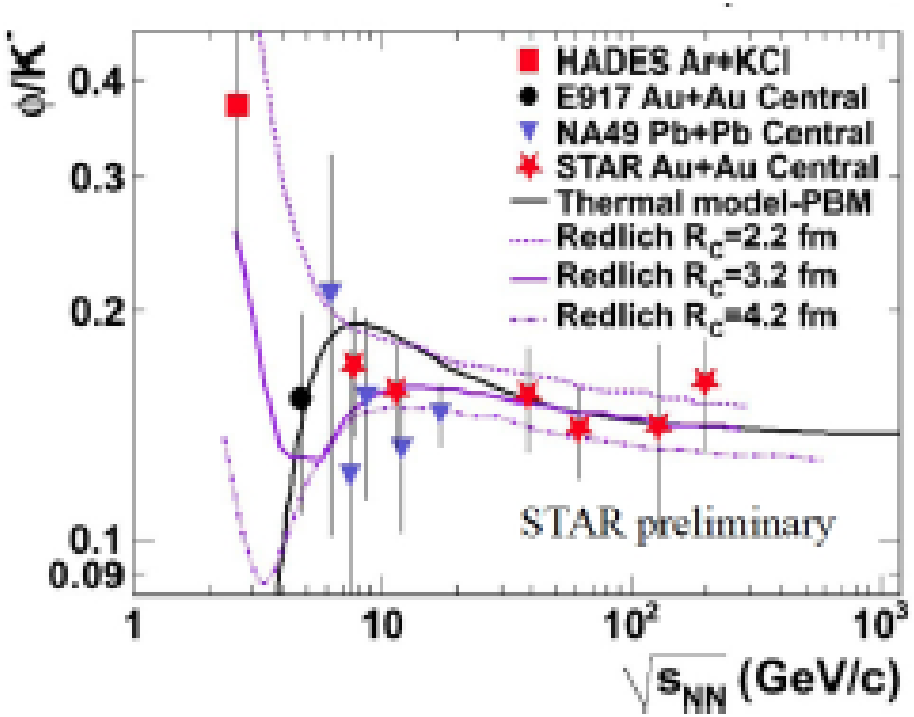


- Statistical model fit to π, K, p
- Excellent agreements with pub.data
- Clear centrality dependence of T

$\phi \rightarrow KK$

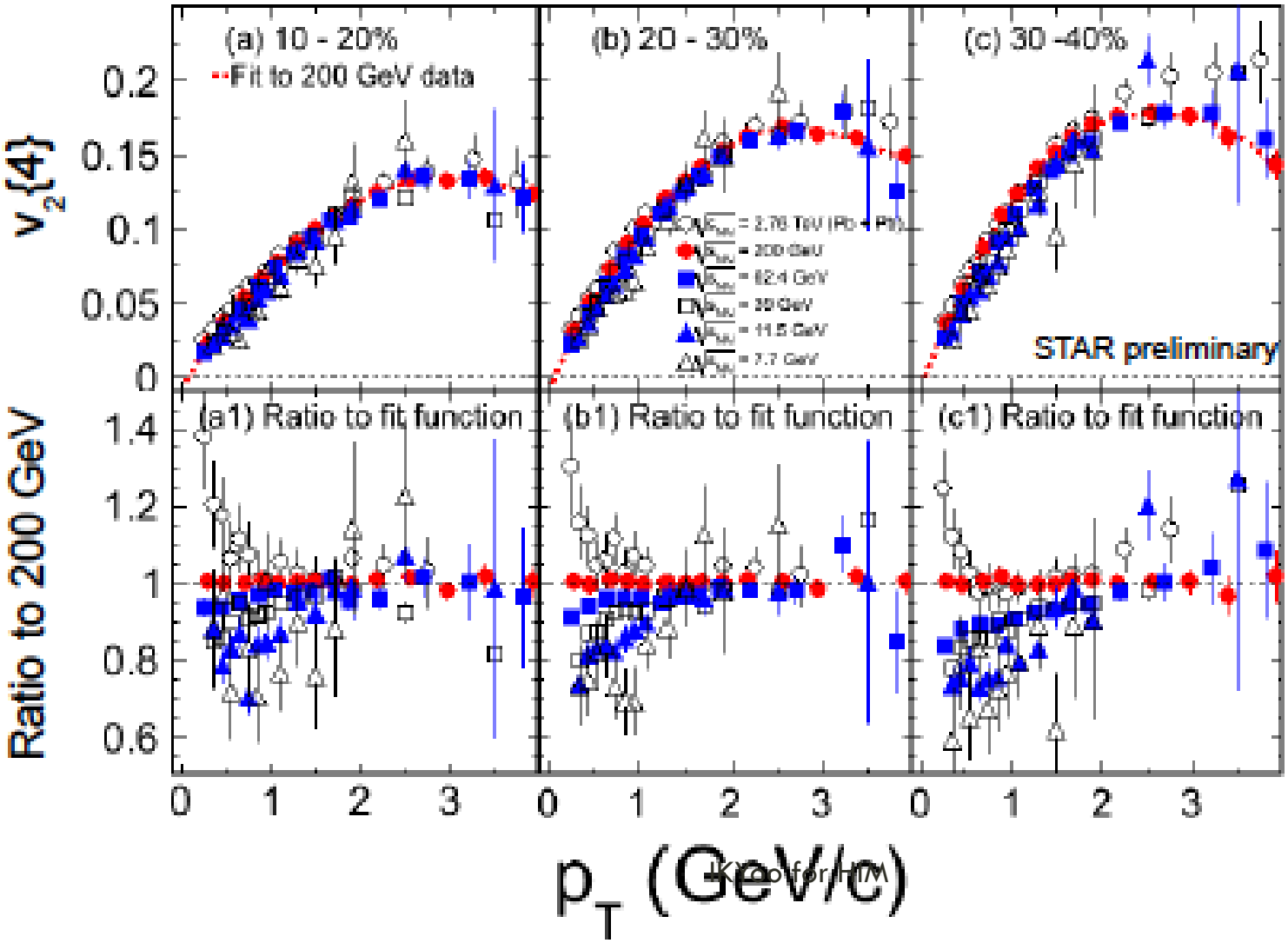
- R_{CP} in E_{CM} dependence
- ϕ/K ratio vs. theories



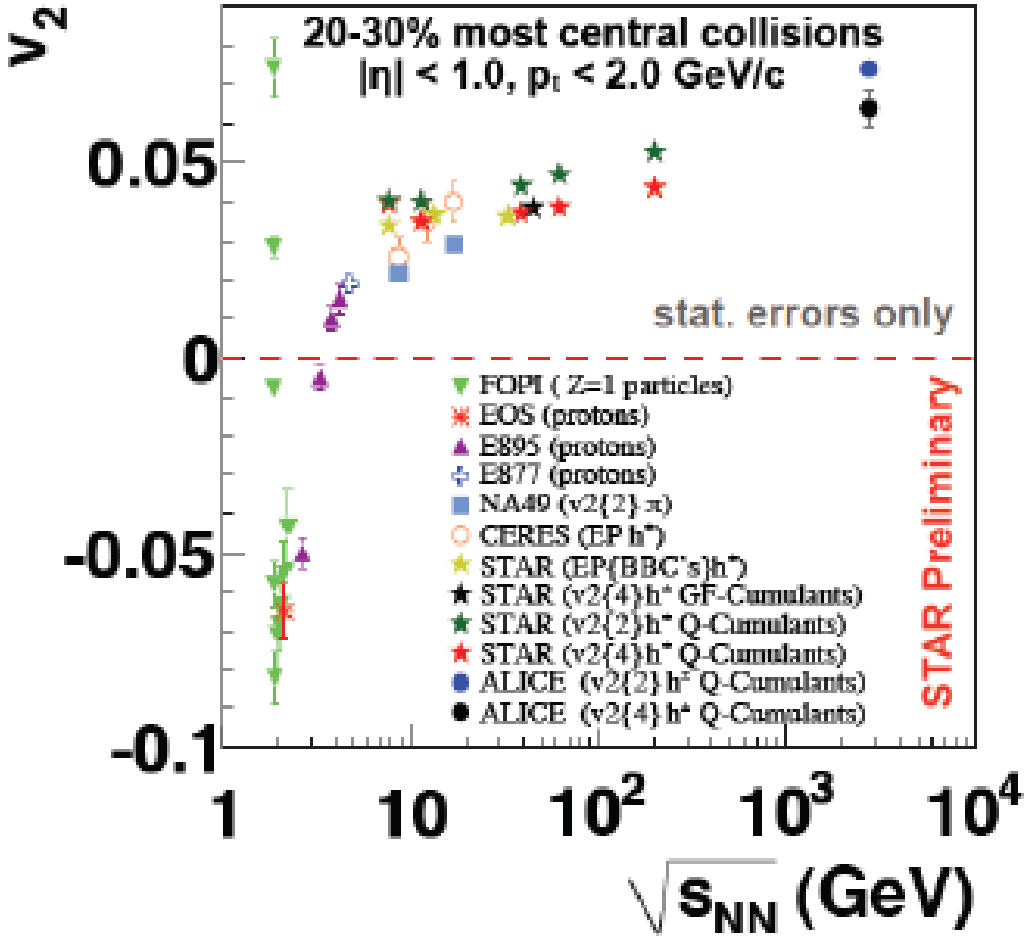


IKYoo for HIM

Flow (v_2) of Charged Hadrons

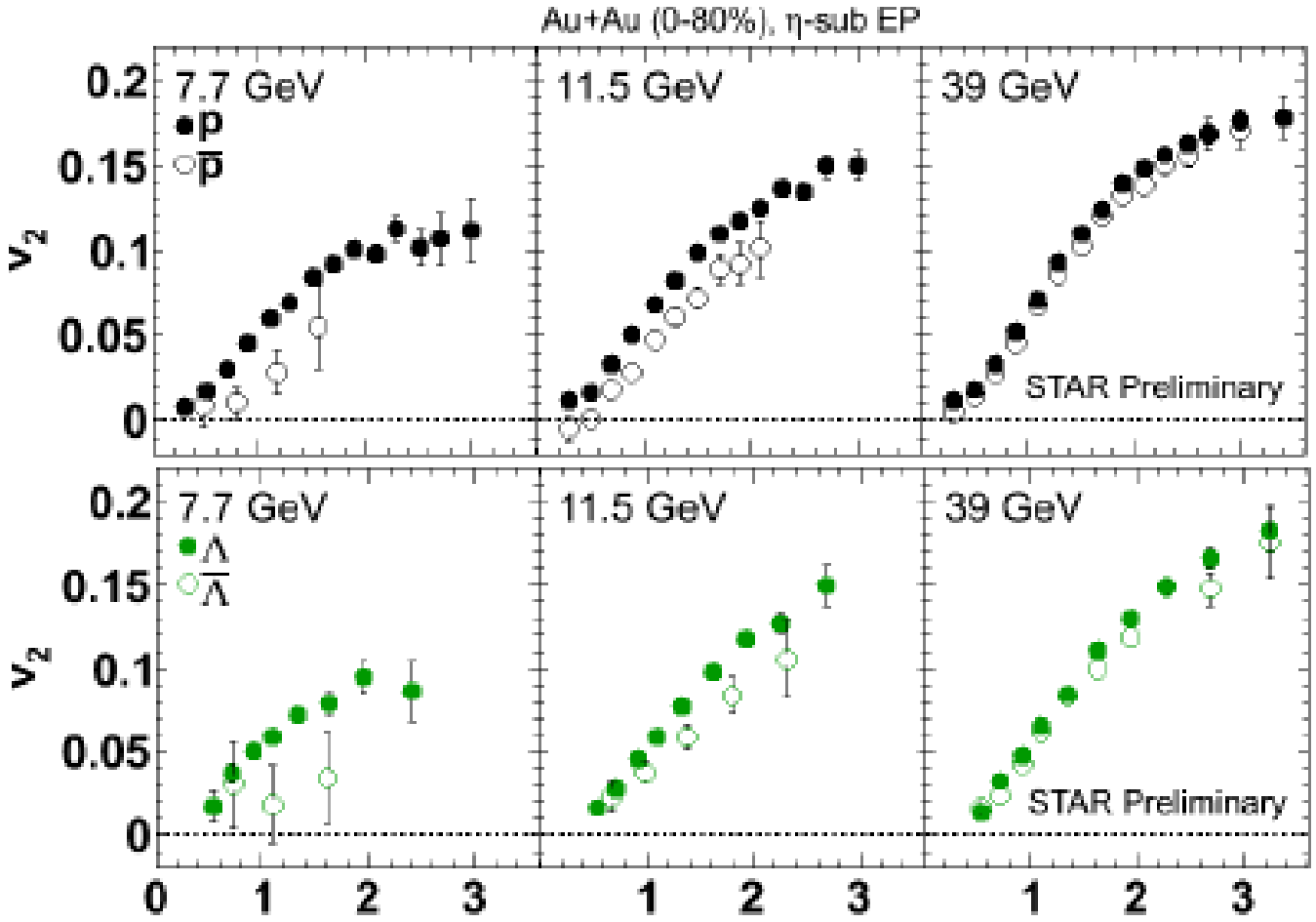


Integrated v_2 vs. E_{CM}

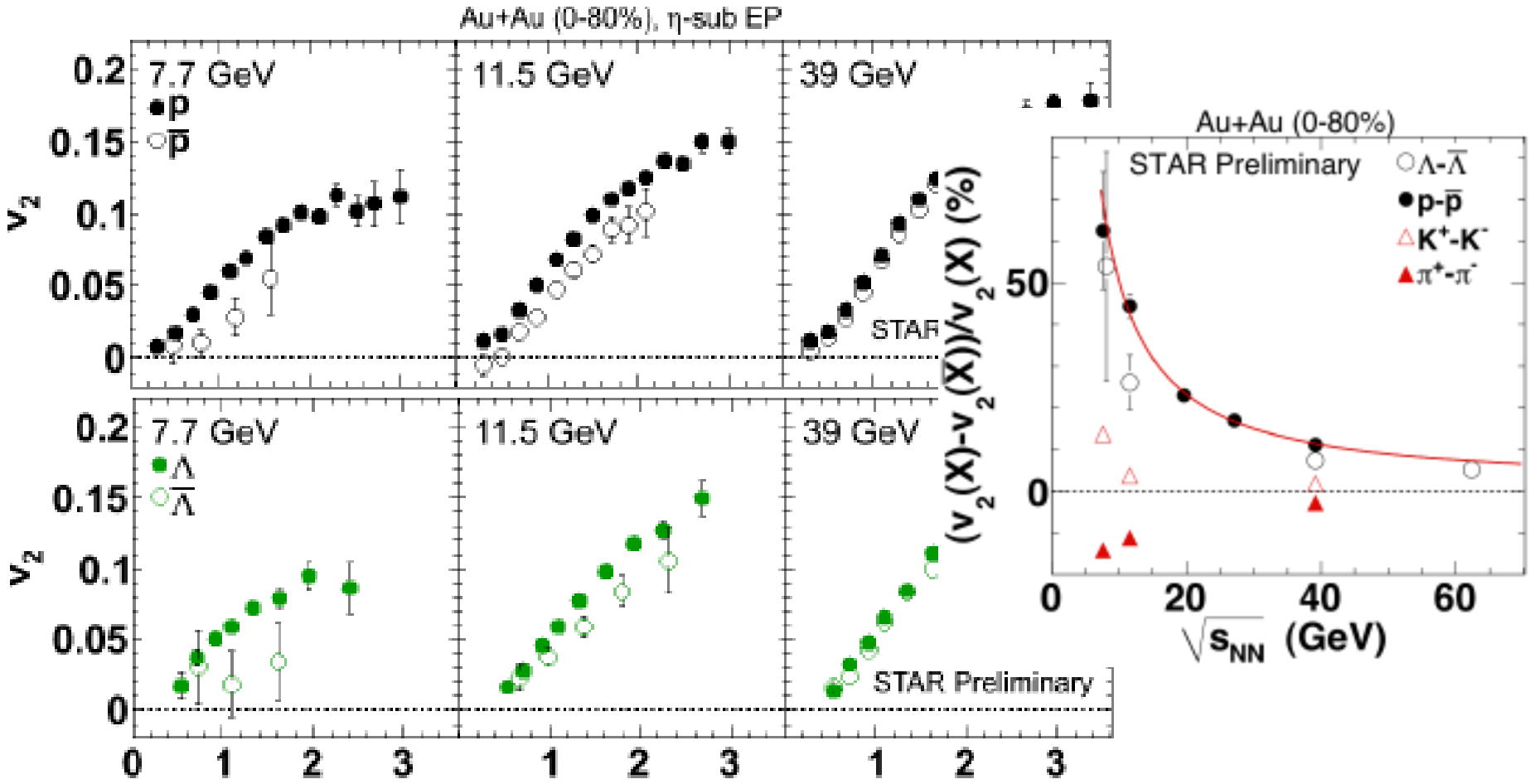


- BES results fill gap between NA49 and 200GeV/u

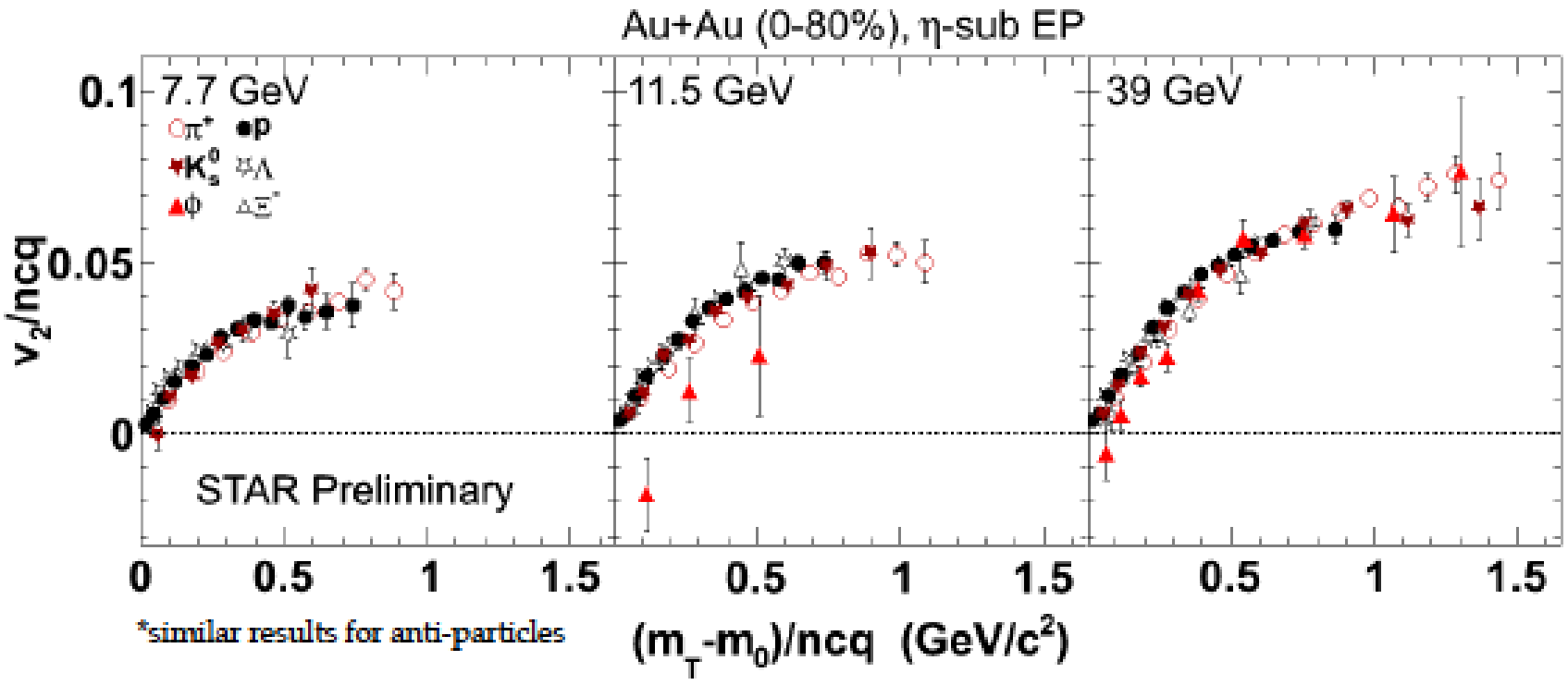
Particle – Antiparticle v2



Particle – Antiparticle v2

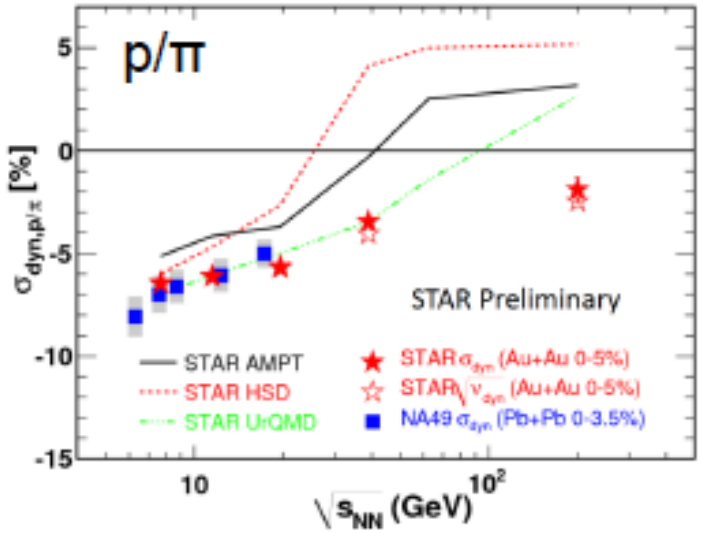


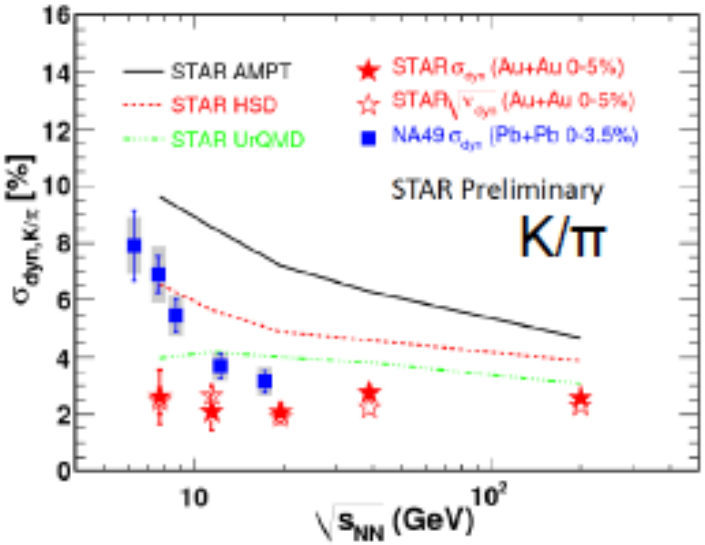
v_2/ncq scaling



- ncq-scaling for all particles holds up to 7.7 GeV
- ϕ-meson results deviates from others at 11.5 GeV

K(p)/π E-by-E fluctuations

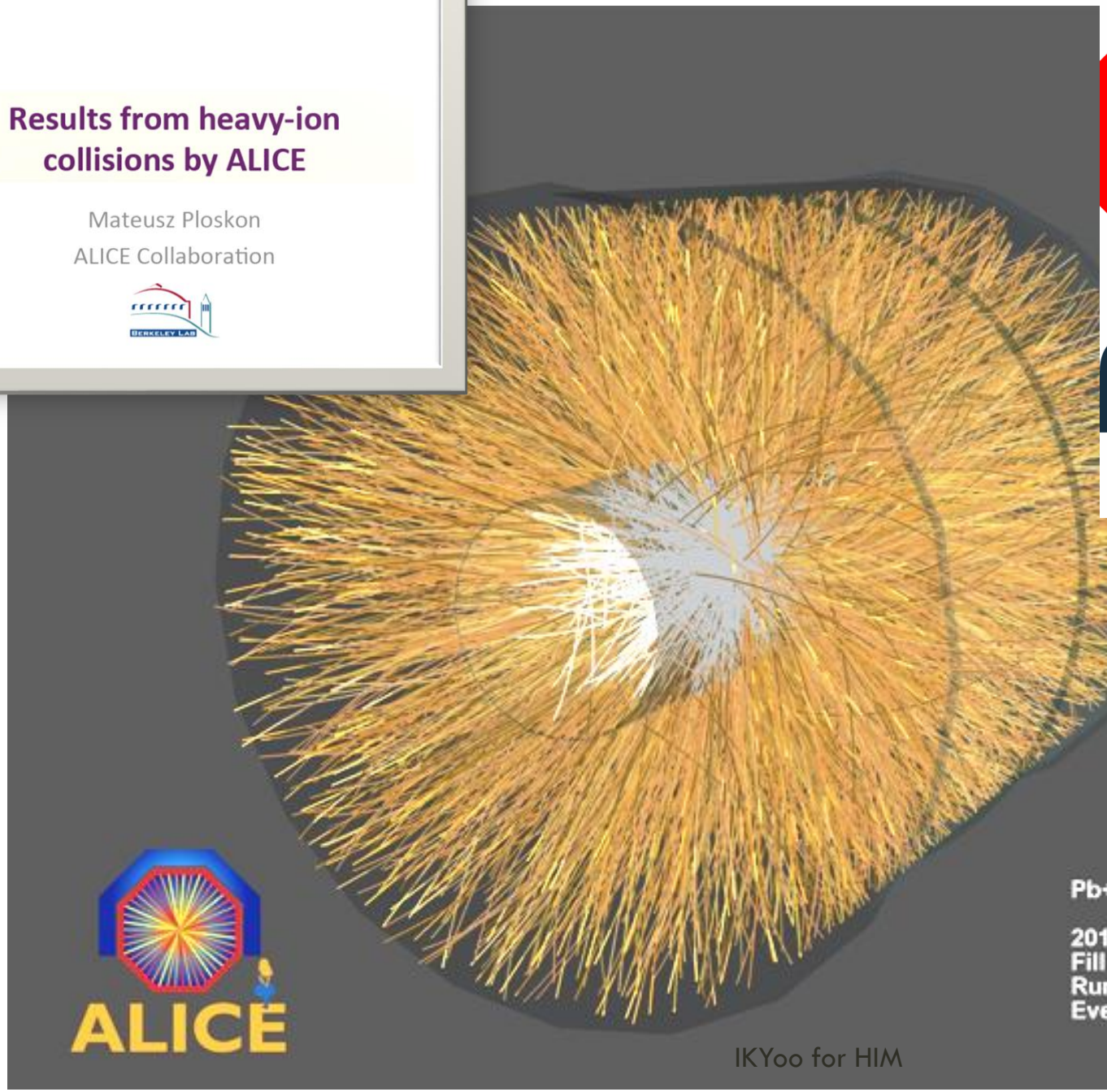




- σ(p/π): monotonic increase
- s(K/p): almost constant ; disagree with NA49

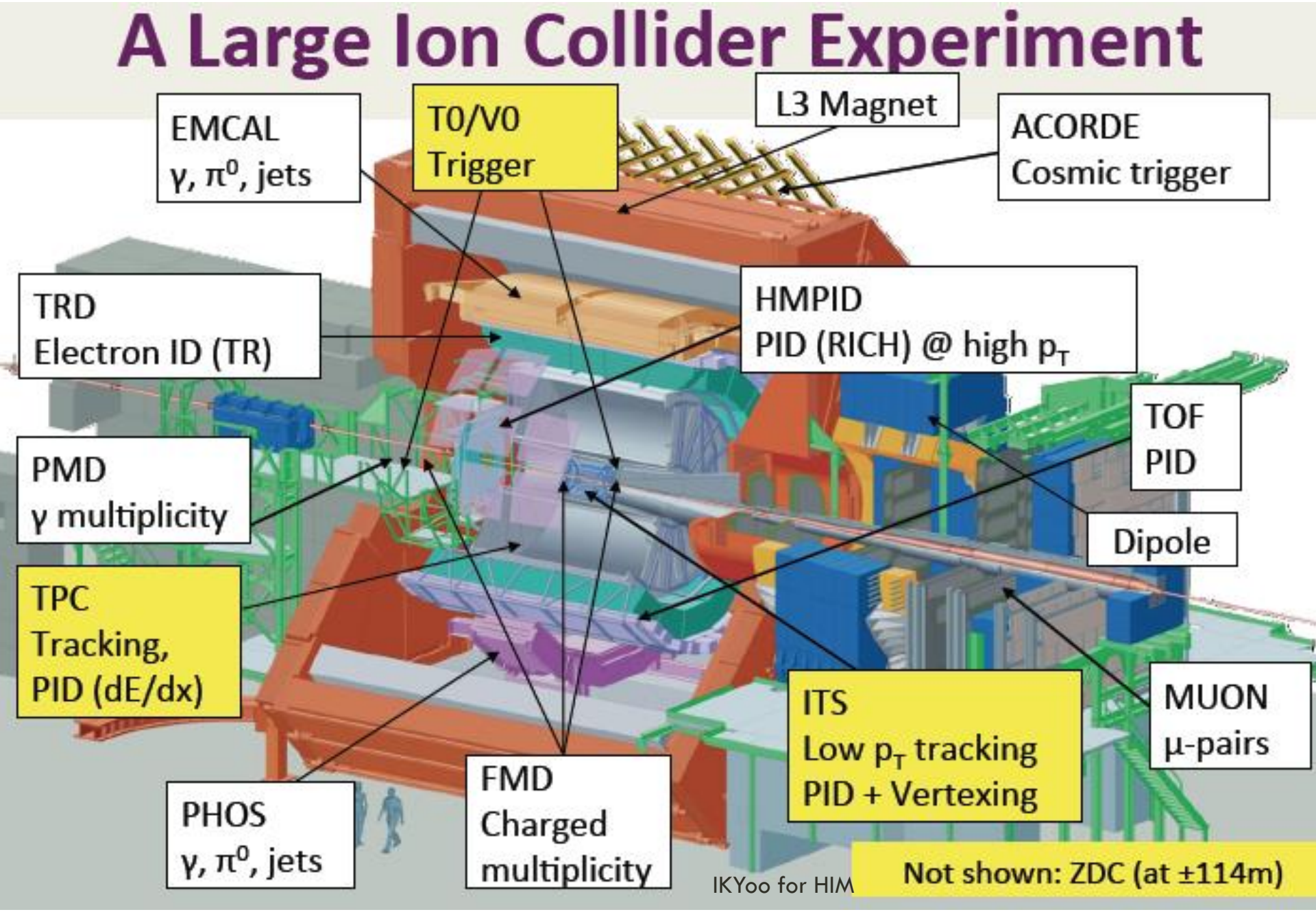
Results from heavy-ion collisions by ALICE

Mateusz Ploskon
ALICE Collaboration



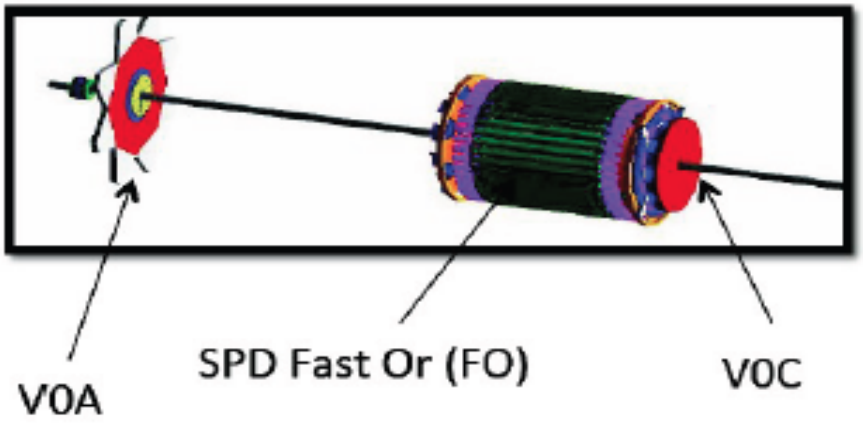
ALICE

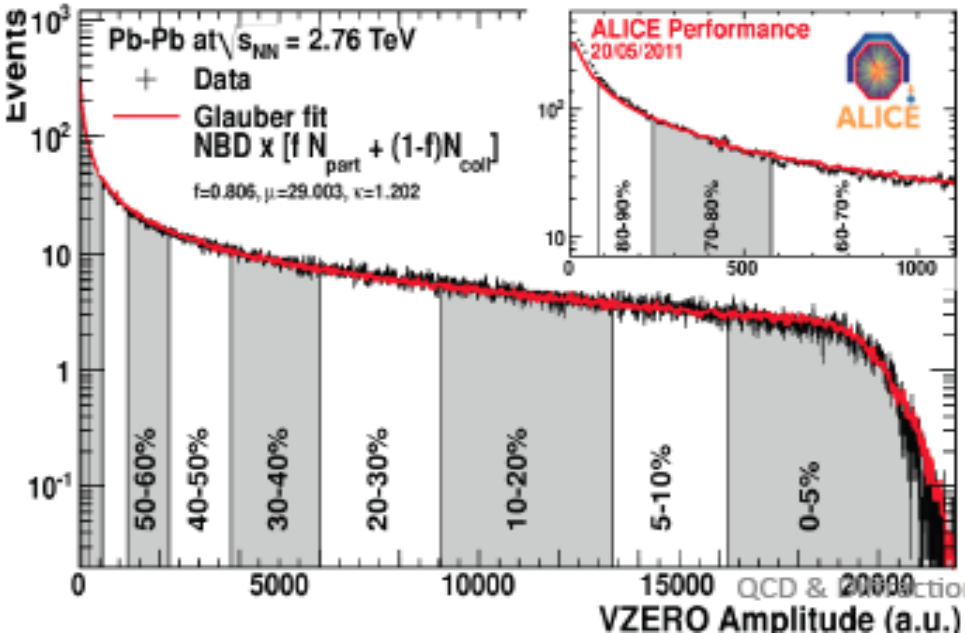
A Large Ion Collider Experiment



ALICE Data

System	E (TeV)	Trigger	Events	∫Ldt
pp	7	MB Rare	1500M 200M	25 nb^{-1} 2 pb^{-1}
pp	2.76	MB Rare	65M ~9M	1.1 nb^{-1} ~20 nb^{-1}
PbPb	2.76	MB	30M	3 μb^{-1}



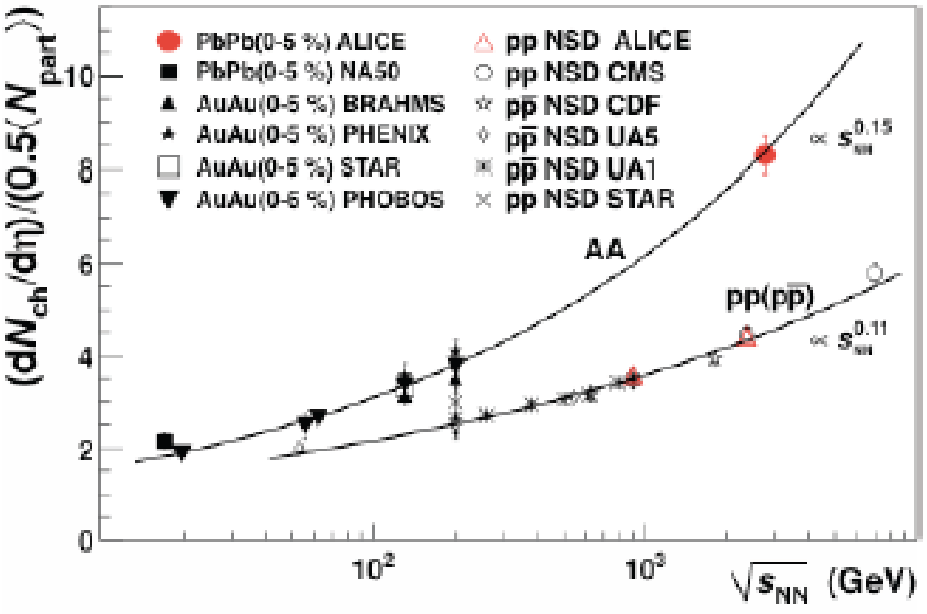


- MB triggers: Coincidences
  - SPD Fast-Or (≥2 chip hits)
  - V0 (A side, -1.7<η<-3.7)
  - V0 (C side, 2.8<η< 5.1)
- Centrality in PbPb
  - Amplitudes in V0 scintillators
  - Reproduced with Glauber Model

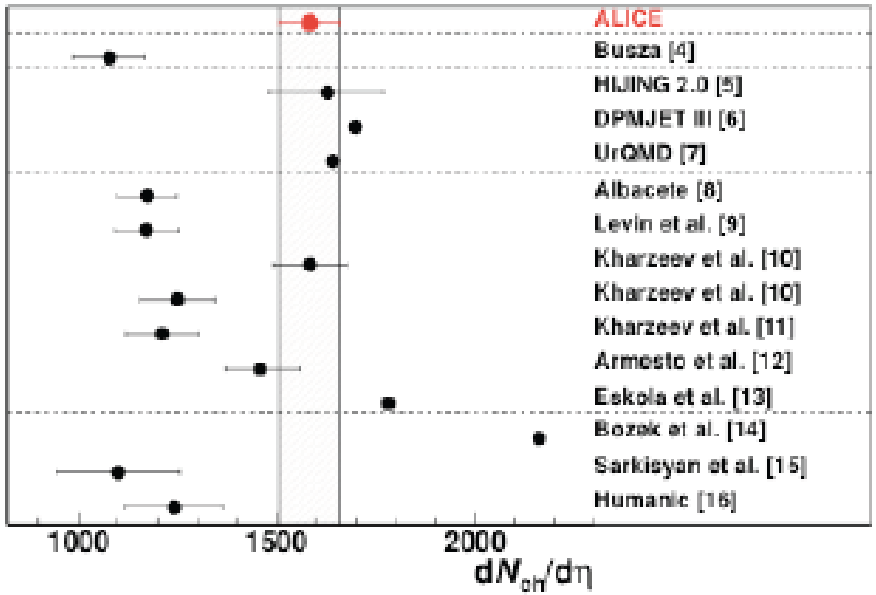
IKYoo for HIM

Particle Production in pp/PbPb

Energy dependence



Comparison to predictions



PRL 105, 252301 (2010)

Energy dependence

p-p ~ $s_{NN}^{0.11}$

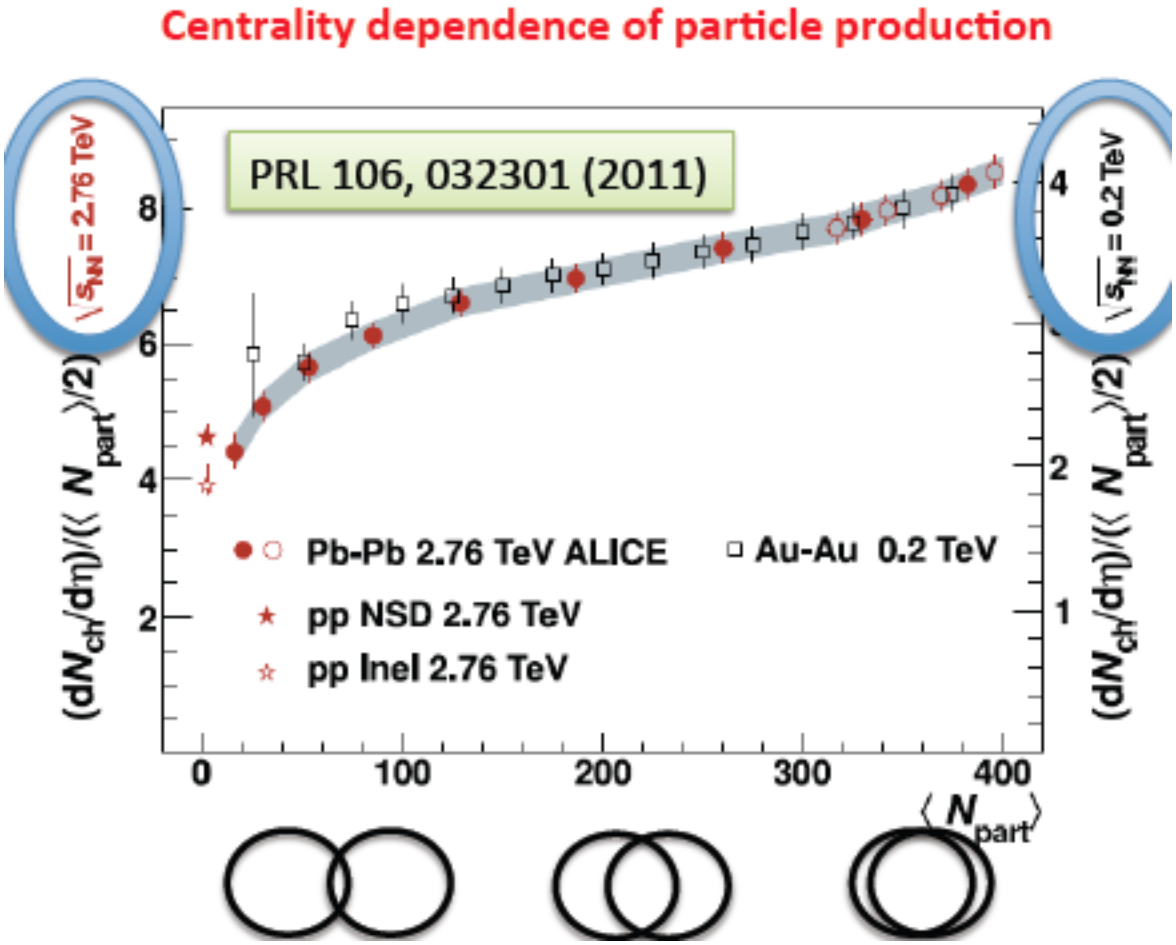
A-A ~ $s_{NN}^{0.15}$ (most central - 2x RHIC)

– stronger rise than log extrapolation

IKYoo for HIM

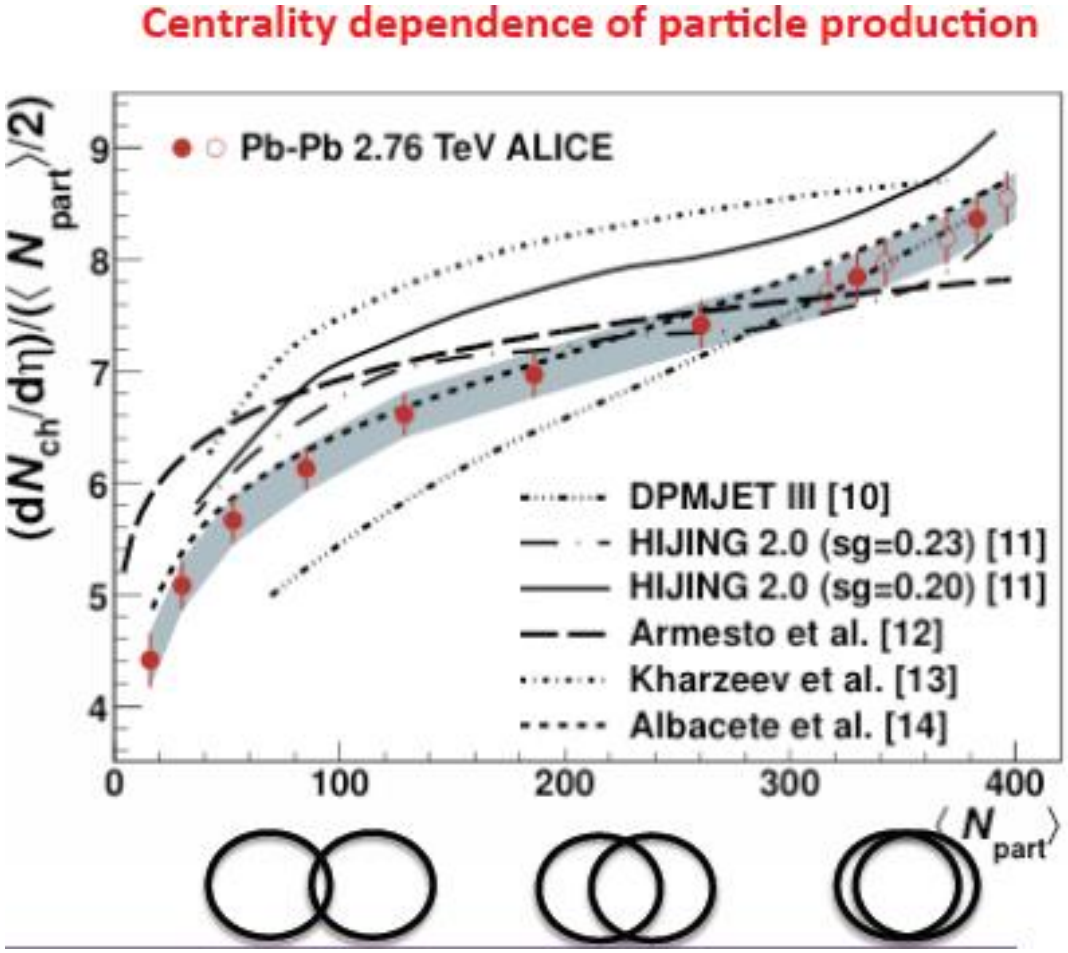
RHIC vs. LHC

- The same experiment under vastly different conditions

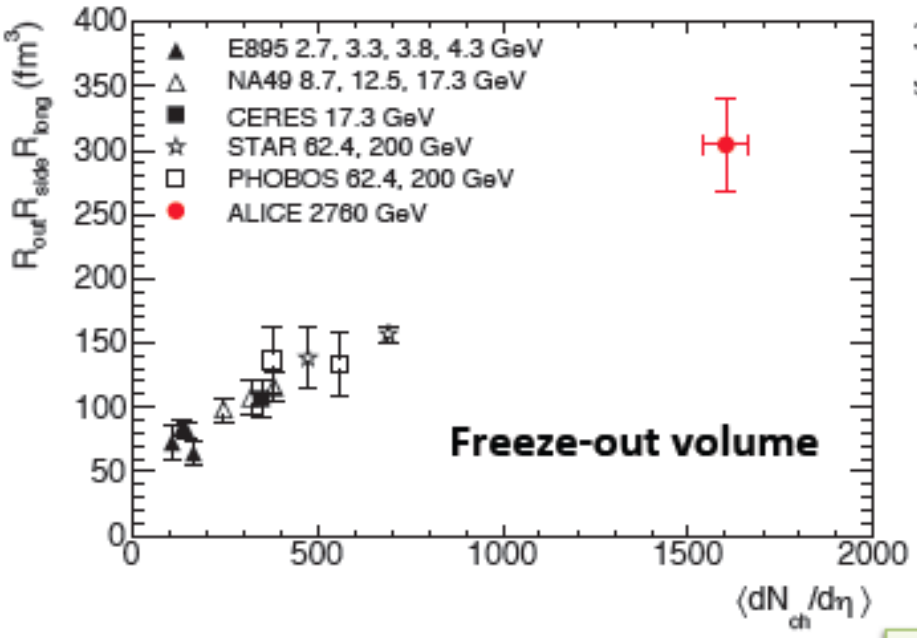


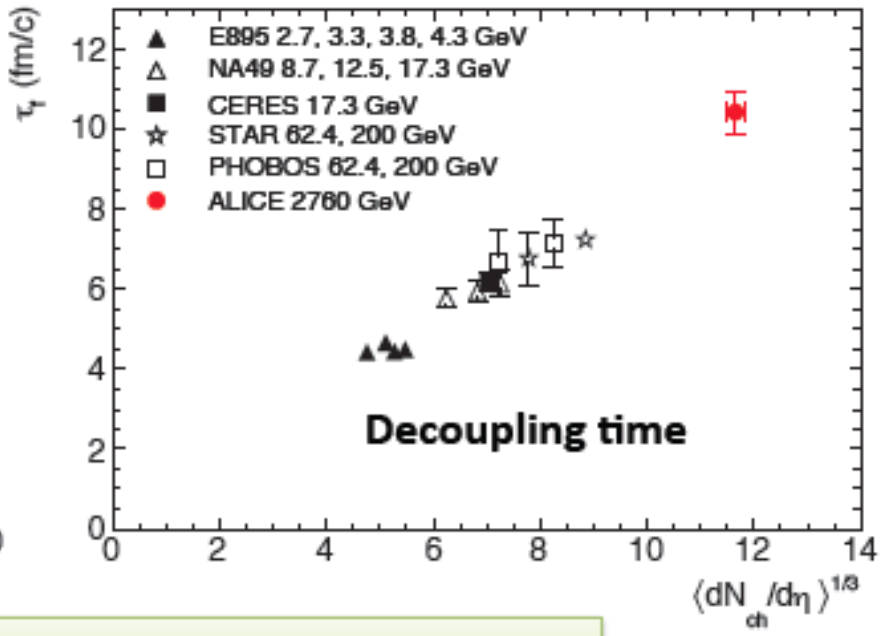
System-size dependence vs. Theories

- identical variation of particle production with system-size at RHIC and LHC
- Global features of the system : independent on collision Energy



Freeze-out Volume : Source-size

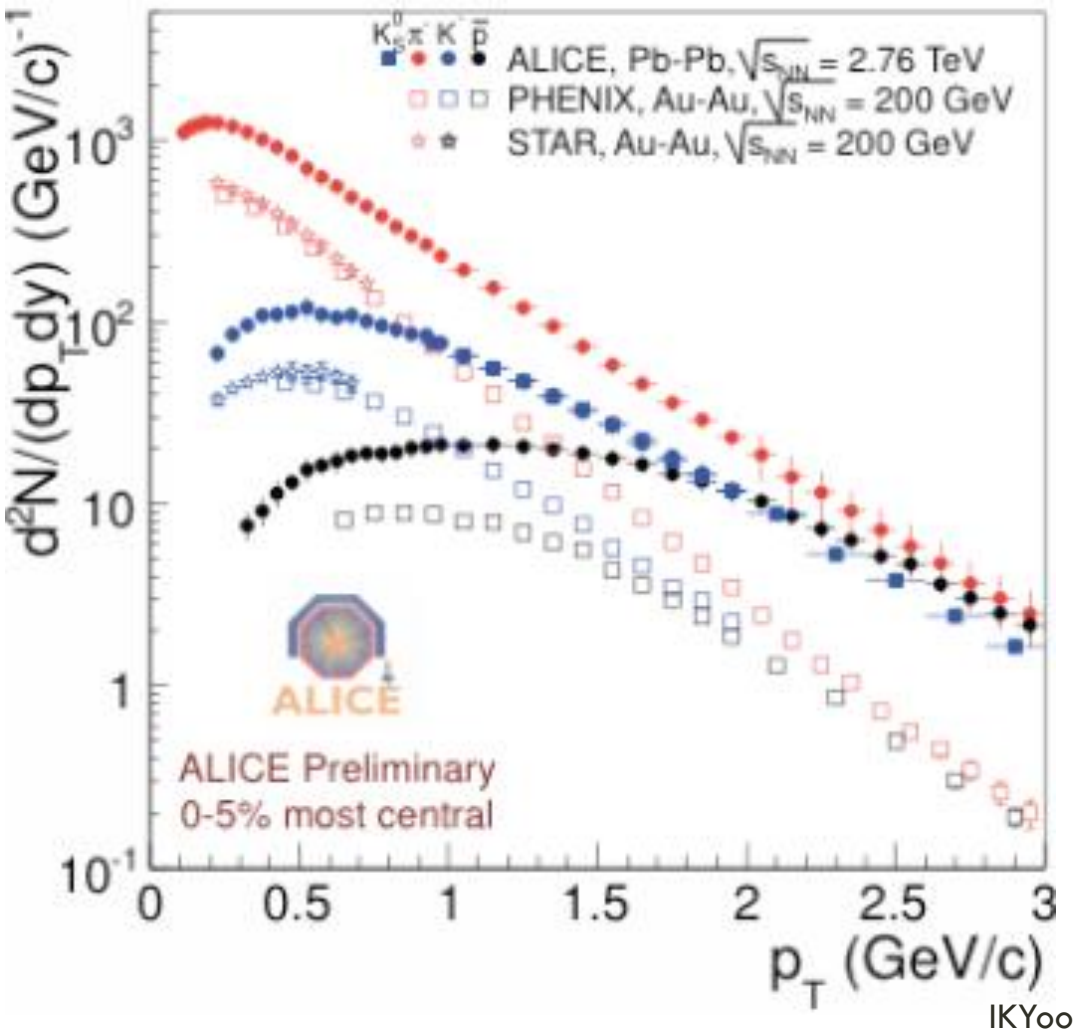




Phys.Lett.B 696:328-337,2011

1. Energy dependence:
   - system with larger (2x) volume and (1.4x) lifetime (w.r.t RHIC); follows the trend of multiplicity; faster expansion <=> larger collective flow
2. Pair momentum dependence:
   - larger radii, strong dependence on kT; Rout/Rside smaller than at RHIC; overall agreement with extrapolations IKYoo for HIM
3. Important constrains to [hydrodynamical] modelling

Identified particle spectra

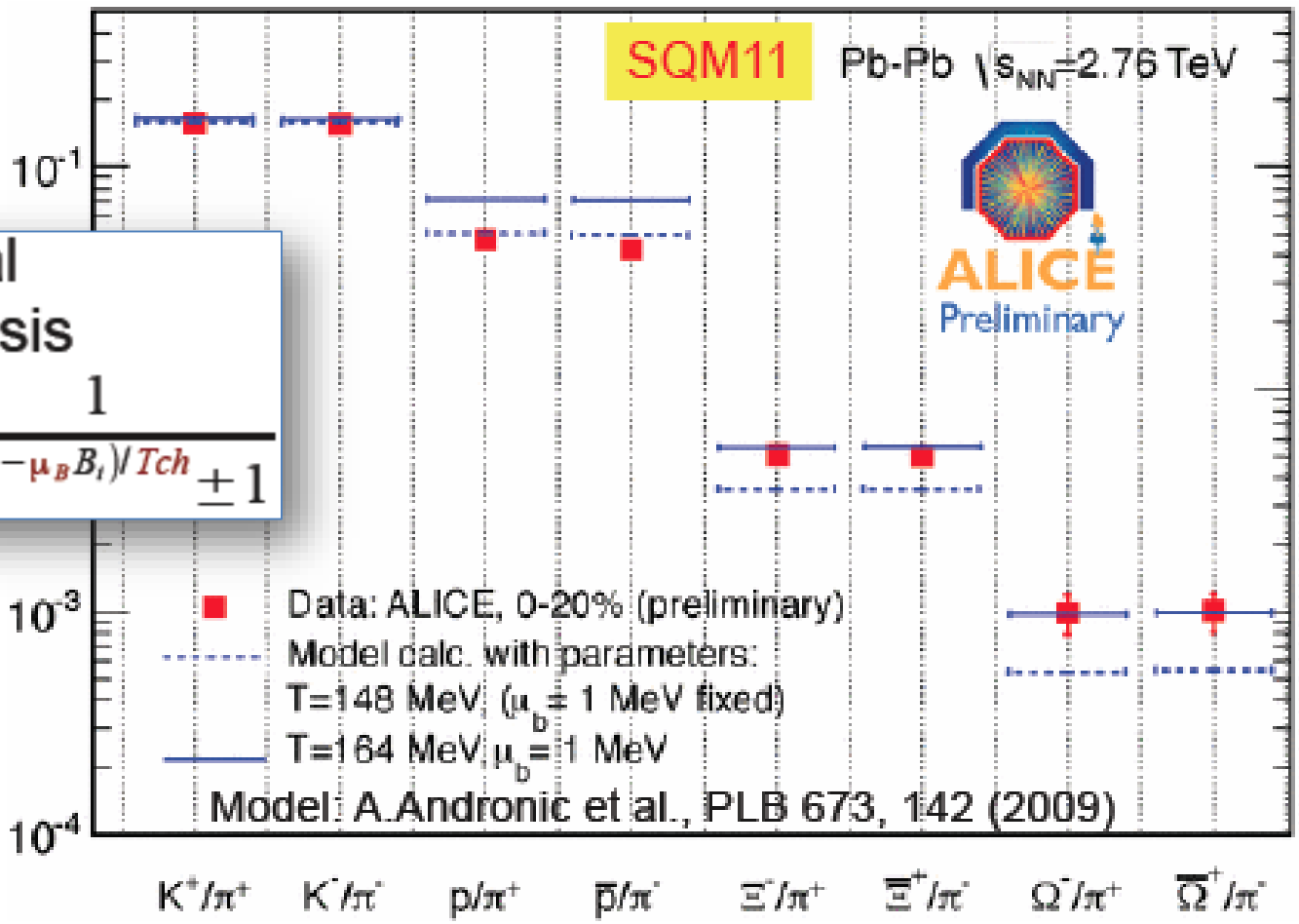


- much harder spectra
  - inv.slope parameter
  - expanding T

Particle Ratios vs. Thermal model

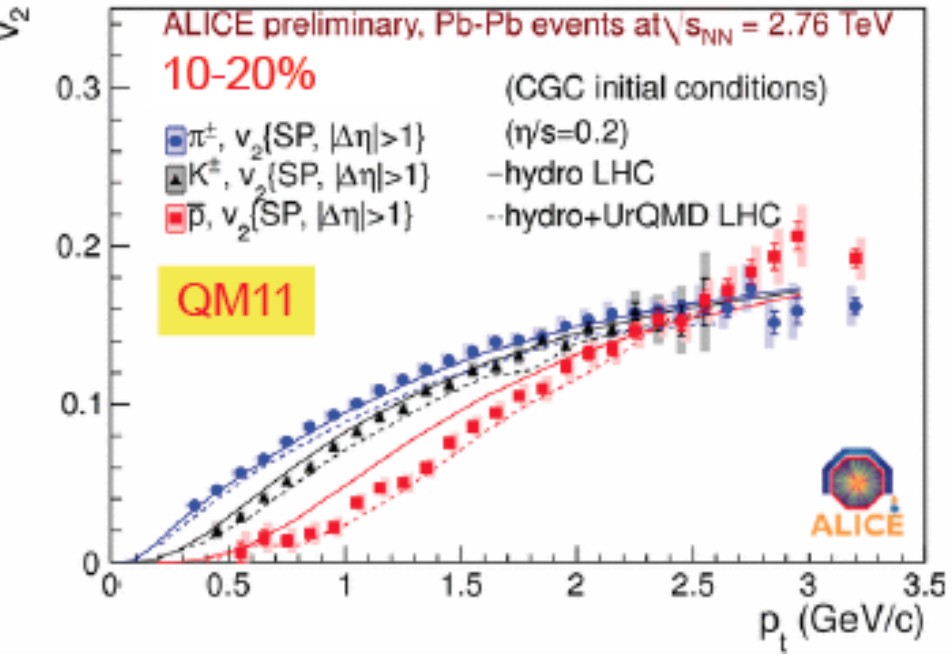
Grand-canonical ensemble analysis

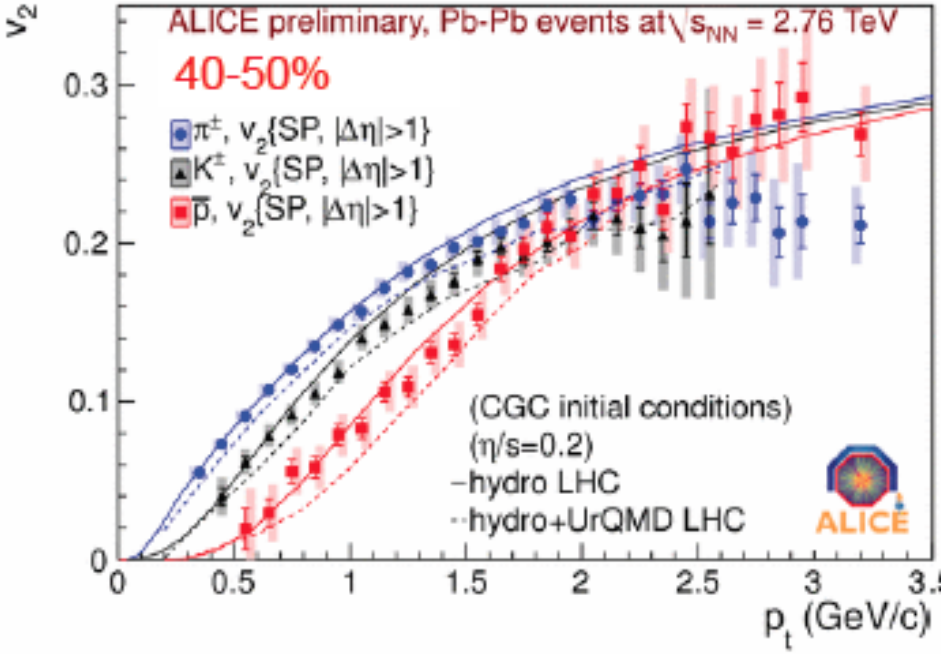
$$N_i \propto V \int \frac{d^3p}{2\pi^3} \frac{1}{e^{(E_i - \mu_B B_i)/Tch} \pm 1}$$



Similar temperature as at RHIC , $T_{Ch} \simeq 164$MeV

Elliptic flows





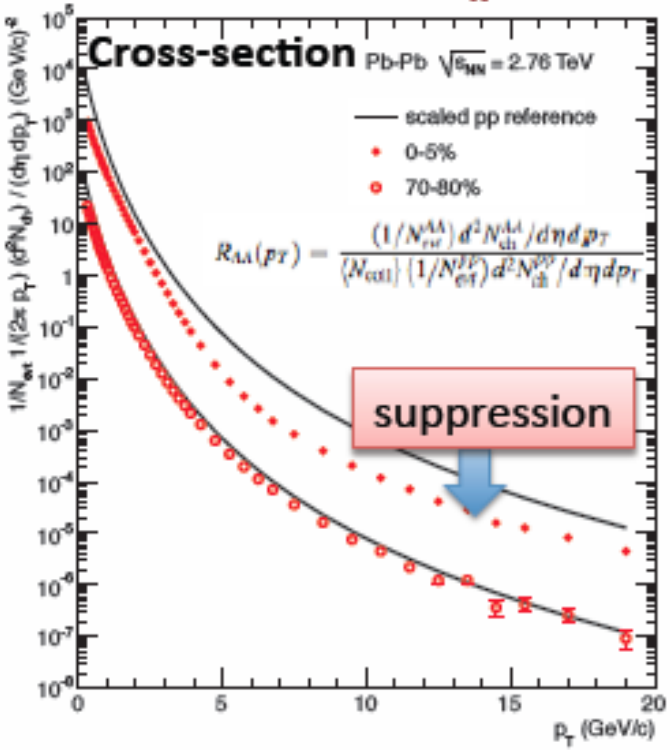
mass dependence due to the radial flow

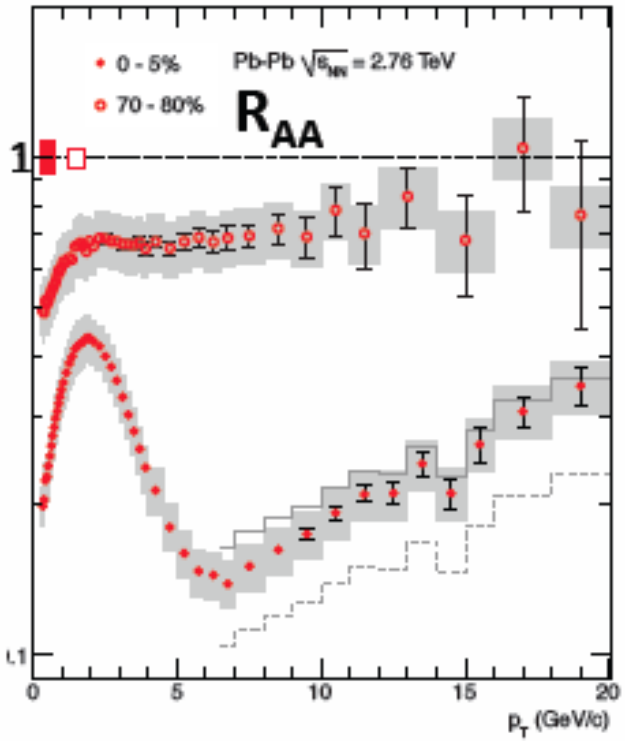
viscous hydro predictions describe the data

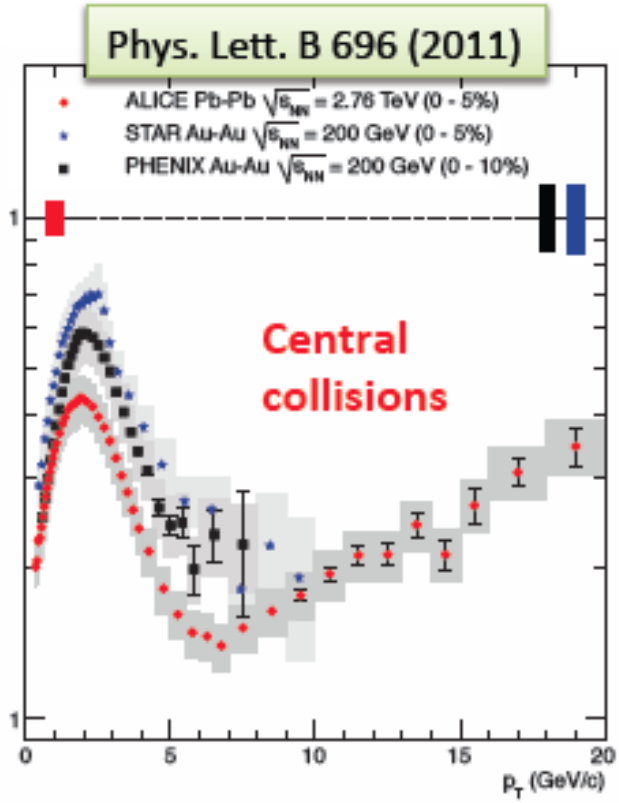
similar to RHIC : hydro+UrQMD (rescattering) for antiproton

Jet quenching

Ratio = #(particles observed in AA collision per N-N (binary) collision) / #(particles observed per p-p collision)

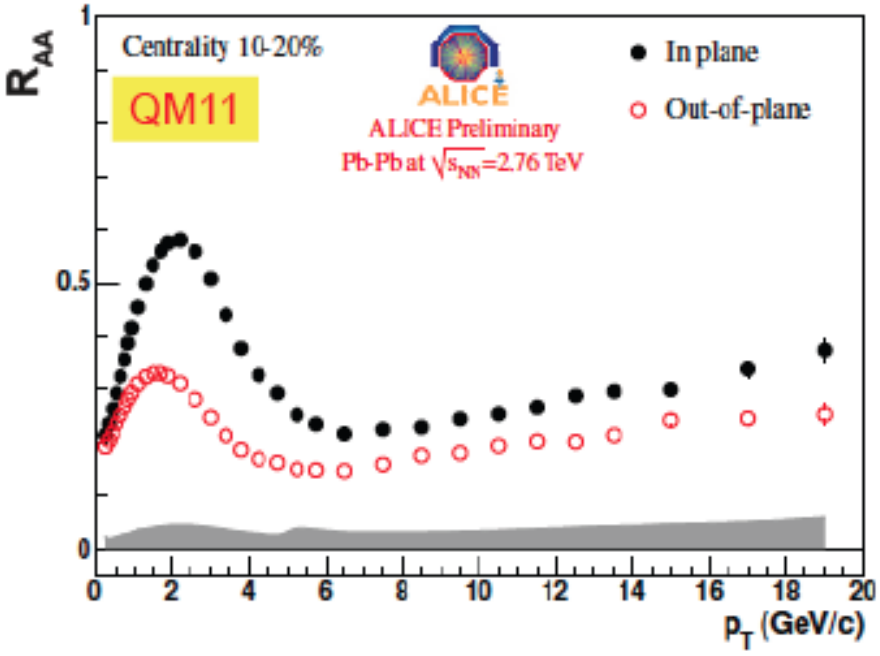




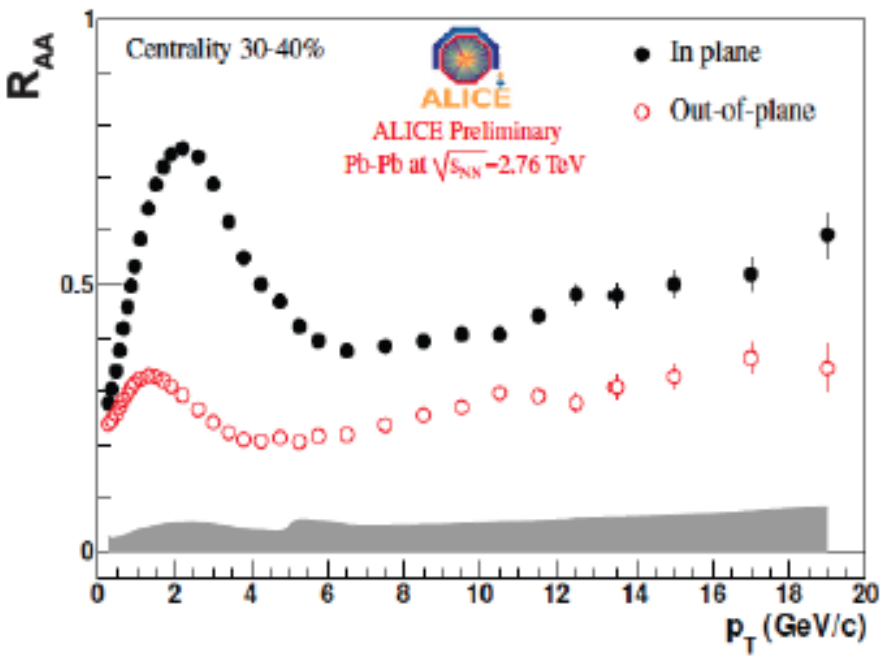


RAA in- vs. out-of-plane

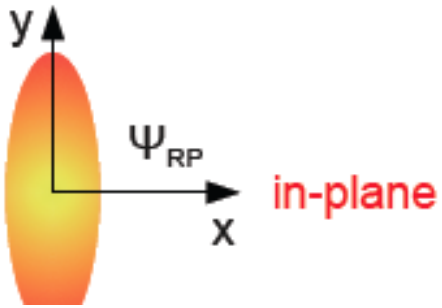
10-20% central



30-40% central



out-of-plane



Suppression out-of-plane stronger <= longer in-medium path length - significant effect even at 20 GeV/c

=> Path length dependence of energy loss

Additional constraints to energy loss models (?) - similar information from v2 at high p_T

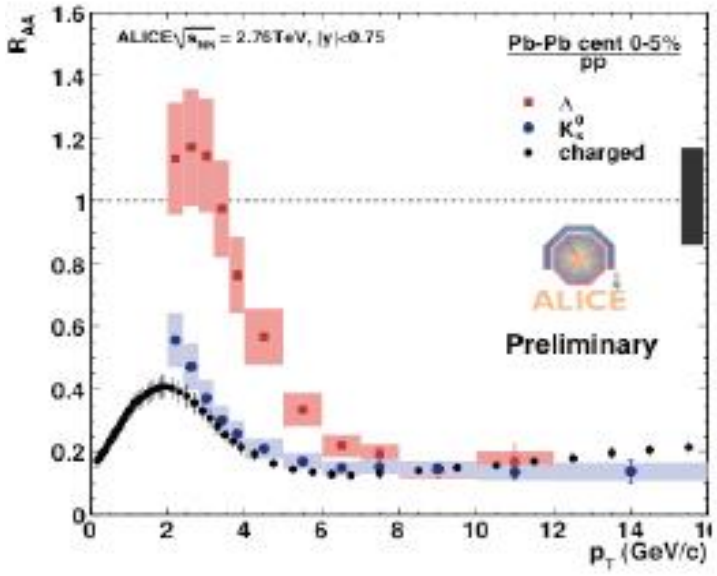
Flavor dependence

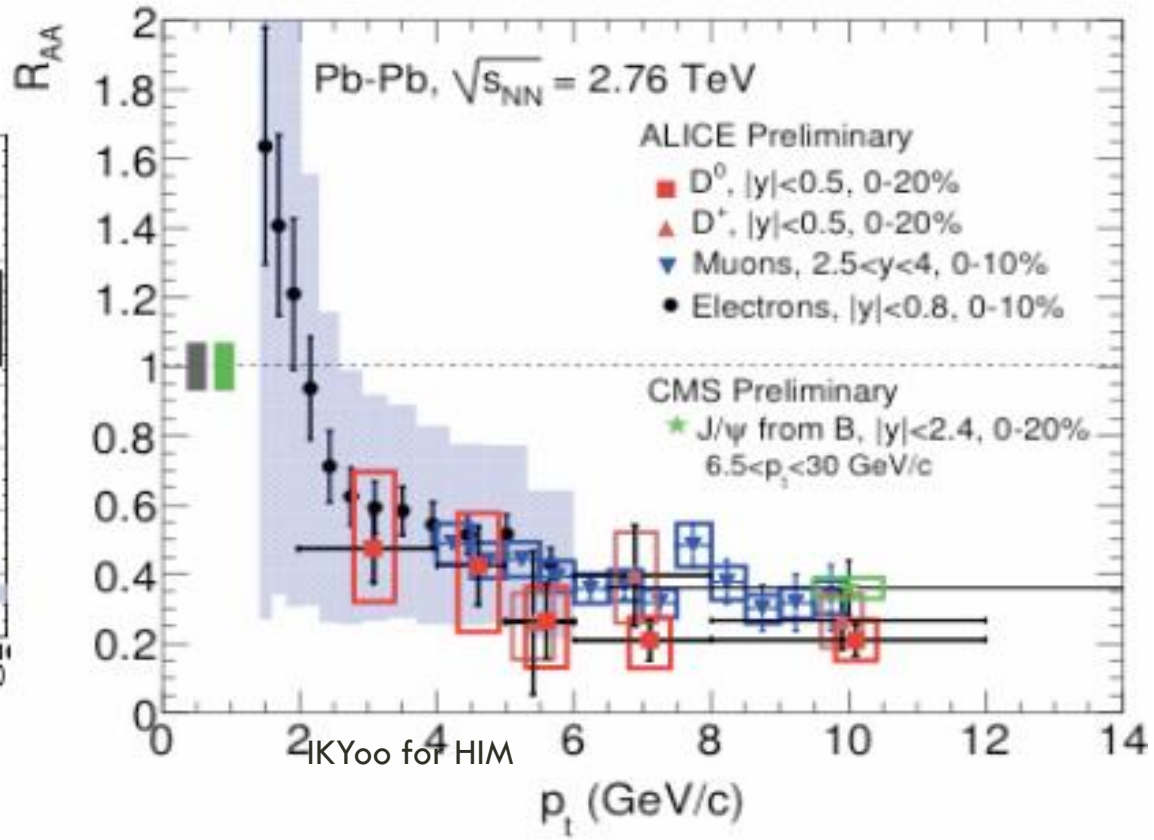
$$\Delta E_{gluon} > \Delta E_{light\text{-}q} > \Delta E_{heavy\text{-}q}$$

A hint of the above only at low p_T

New insight to theory? Better precision measurements needed…

Strange baryons vs mesons





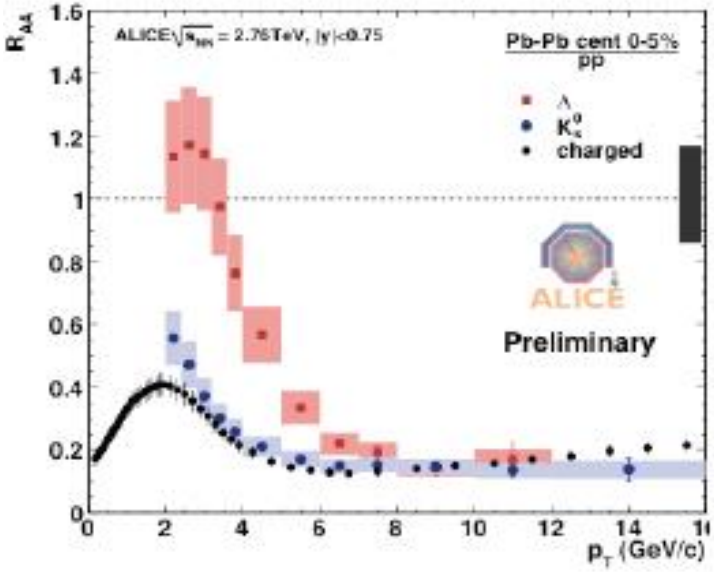
Flavor dependence

$$\Delta E_{gluon} > \Delta E_{light\text{-}q} > \Delta E_{heavy\text{-}q}$$

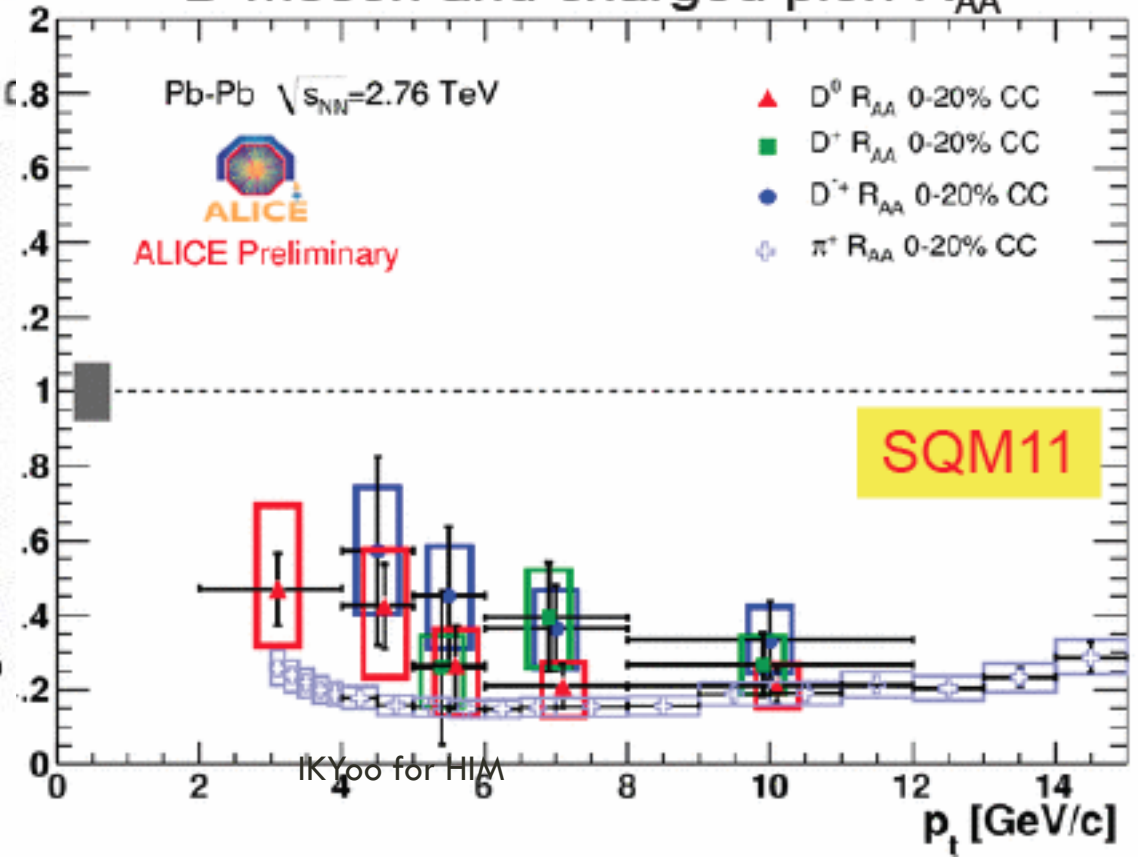
A hint of the above only at low p_T

New insight to theor

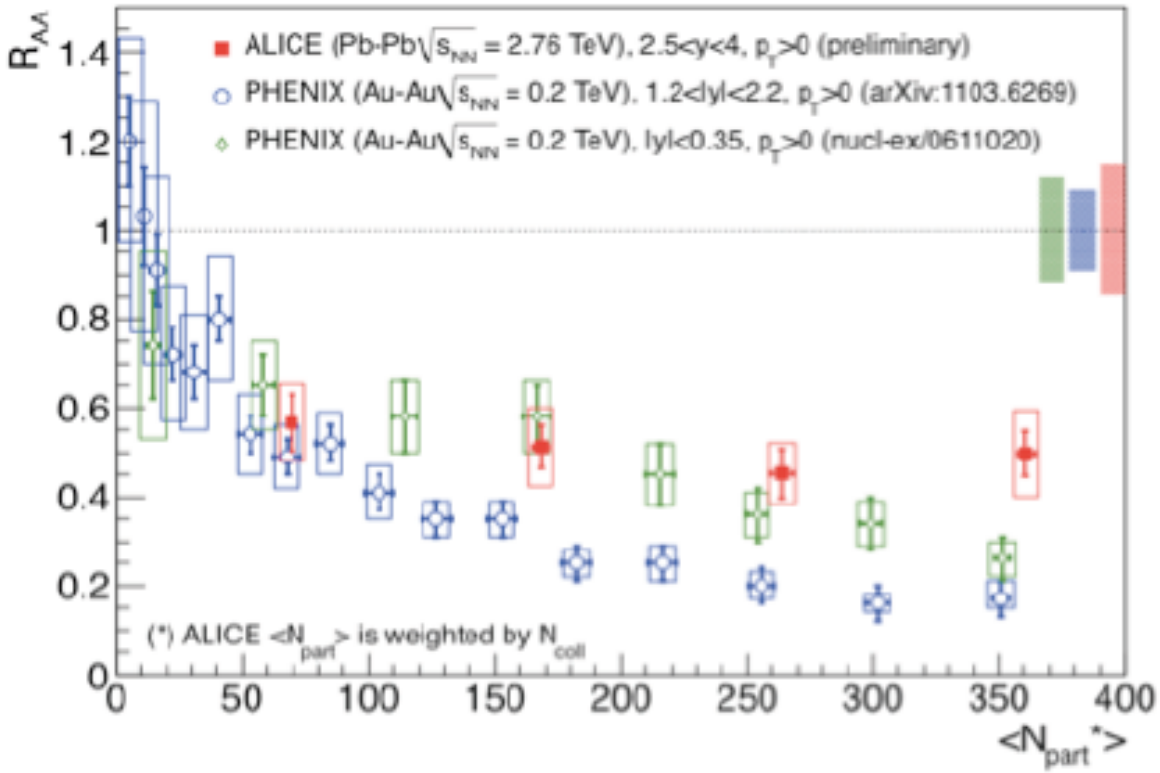
Strange baryons vs mesons



D-meson and charged pion R_{AA}



J/Psi RAA



J/ψ LHC vs RHIC

$p_T > 0$

ALICE 2.5 < y < 4 (~forward)

PHENIX y < 0.35 (mid-y)

PHENIX 1.2 < y < 2.2 (forward)

Less suppression than at RHIC at forward rapidity: RAA(ALICE) > RAA(PHENIX, 1.2<y<2.2)

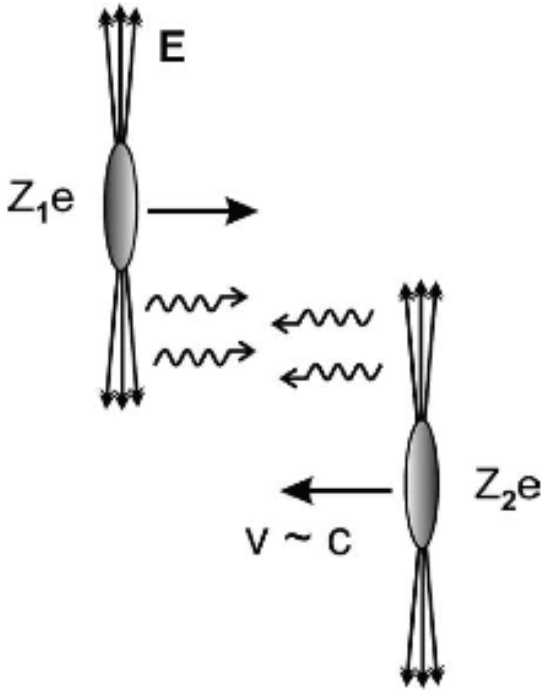
Similar suppression as at RHIC at midrapidity : RAA(ALICE) ≈ RAA(PHENIX, |y|<0.35)

Contribution from B is not substracted ; Cold nuclear matter effect at RHIC vs. LHC ; pA@LHC needed

UPC with ALICE

$$Pb + Pb \rightarrow Pb + Pb + \rho^0$$

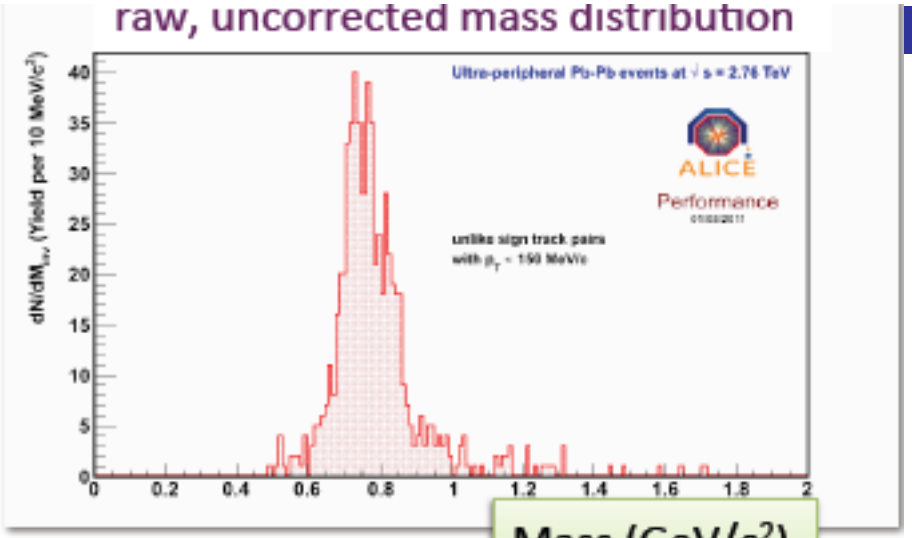
- Invariant mass of **unlike sign** (2-track) events with **event p_T<0.15 GeV/c**
- Pion mass is assumed.
- **Trigger: both tracks with hits in Silicon-Pixel-Detector and Time-Of-Flight**
- **Expect a low mean p_T**

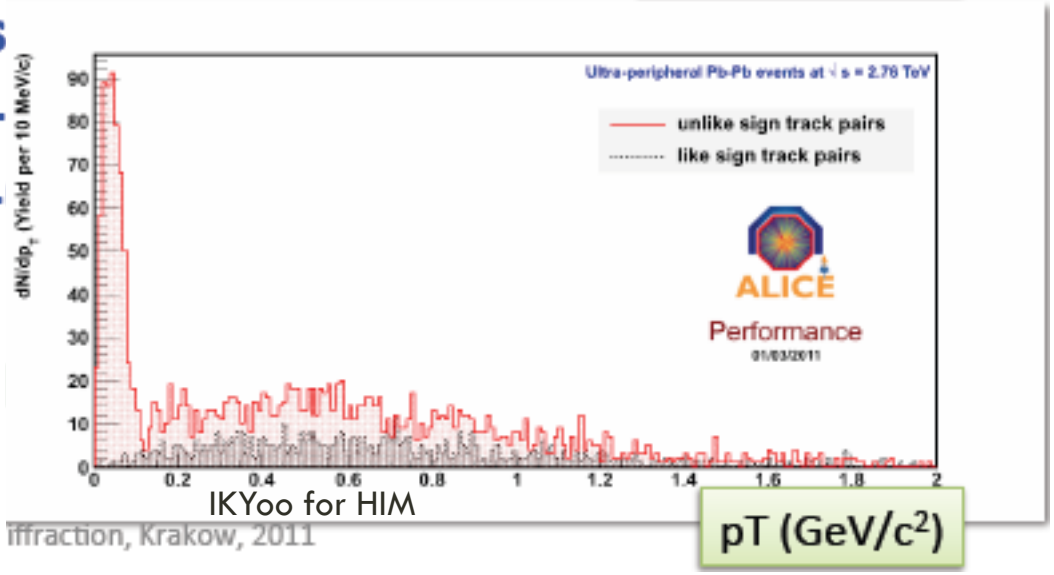


UPC with ALICE

$$Pb + Pb \rightarrow Pb + Pb$$

- Invariant mass of ur
  sign (2-track) events
  event p_T<0.15 GeV/
- Pion mass is assume
- **Trigger: both tracks hits in Silicon-Pixel-Detector and Time-Flight**
- **Expect a low mean**

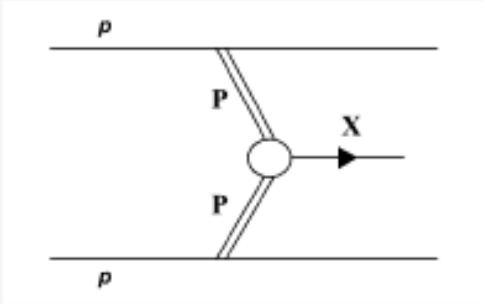


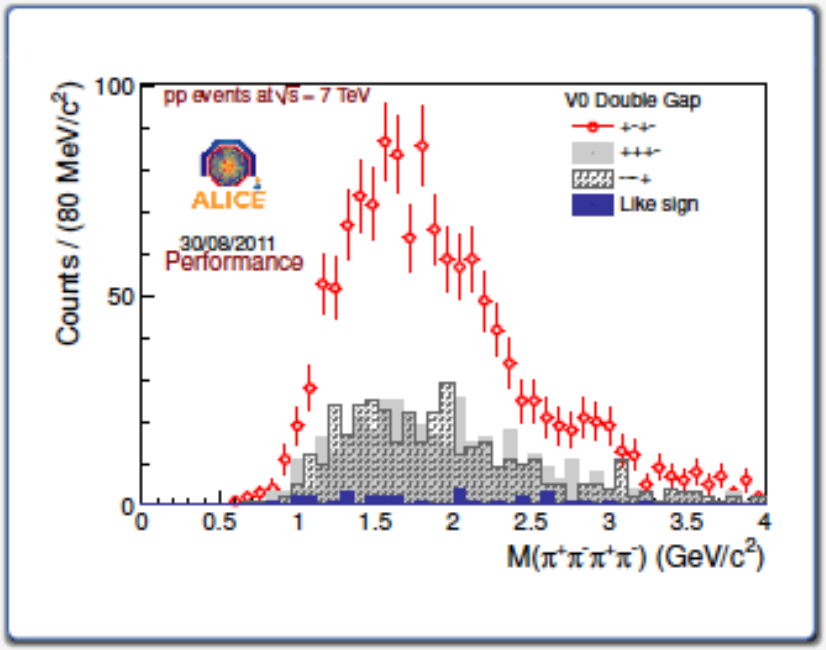


UPC with ALICE

Process of pp collision in ALICE

- Double-Pomeron Exchange(DPE) is dominant process in pp collision
- $X \rightarrow \pi^+\pi^-$, $\pi^+\pi^-\pi^+\pi^-$, KKπ ...
- G-parity $= +1, C = +1 \rightarrow I = 0$ ($\because G = C(-1)^I$)



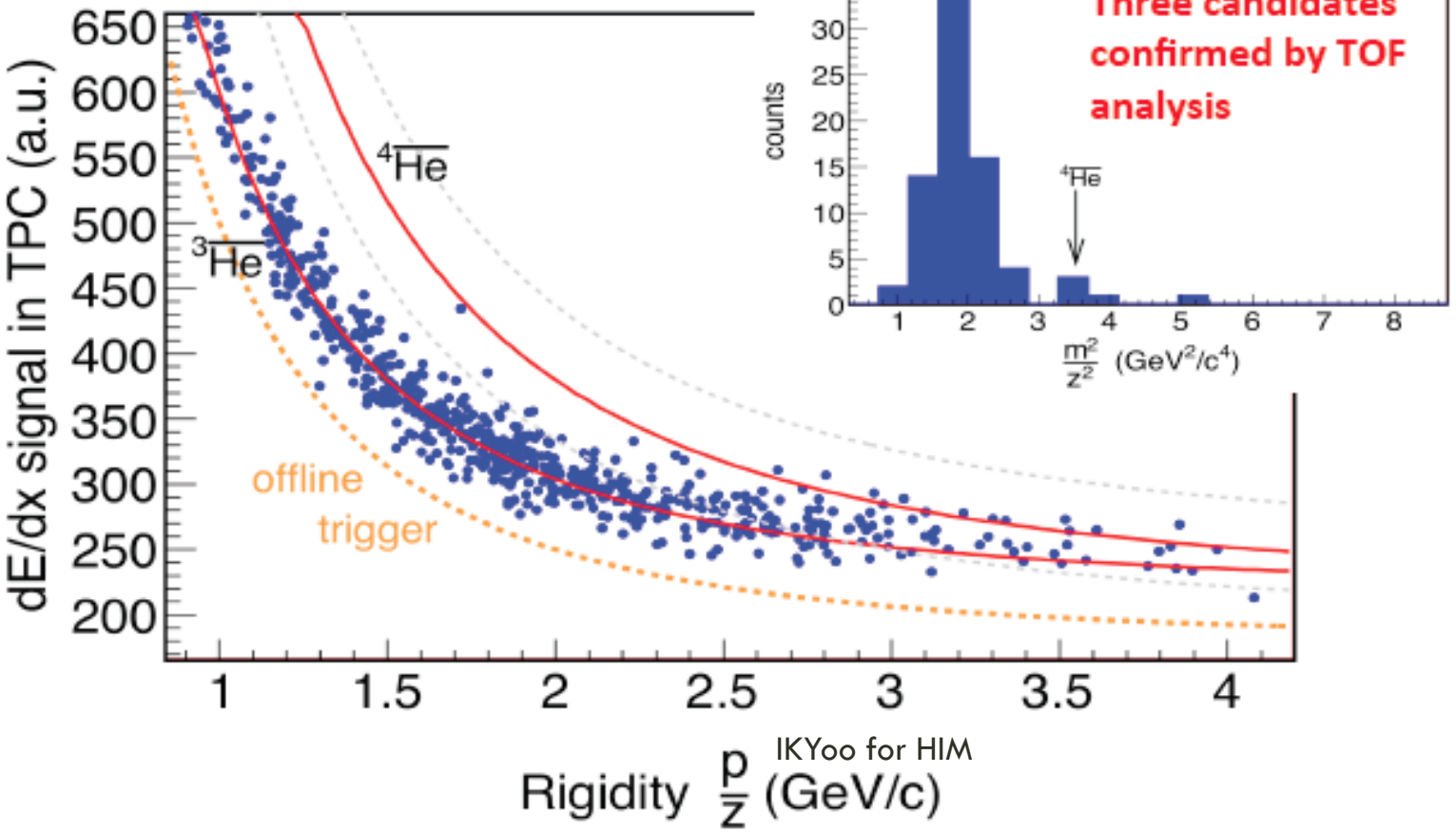


- 6% of 2010 pp data at 7 TeV
  L_{int}(MB)= 460 μb^{-1}
- Statistical error only
- Similar to BNL result
- 1350 events $p+p \rightarrow p+\pi^+\pi^-\pi^+\pi^-+p$ out of 28M events
- ~ 20k events: expected for whole 7 TeV pp data

Anti-Alpha with ALICE

Time of flight (sensitive to m/z-ratio): $m = \frac{z \cdot R}{\sqrt{\gamma^2 - 1}}$

$$< \frac{dE}{dx} >= \frac{4\pi N e^4}{mc^2} \frac{z^2}{\beta^2} \left(\frac{1}{2} \ln \frac{2mc^2 E_{max} \beta^2 \gamma^2}{I^2} - \frac{\beta^2}{2} - \frac{\delta(\beta)}{2} \right)$$



IKYoo for HIM

Conclusions and Outlook

- Excellent agreements of STAR BES results with NA49
- Scanning and Filling up the gap between SPS and RHIC

- Even more strongly interacting matter at LHC than RHIC?
- Rich data with high precisions and PID to be continued
- pA program at LHC?
- What to be expected at 5.5TeV in 2014?