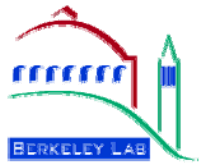
CIPANP 2009, May 26-31, San Diego, CA



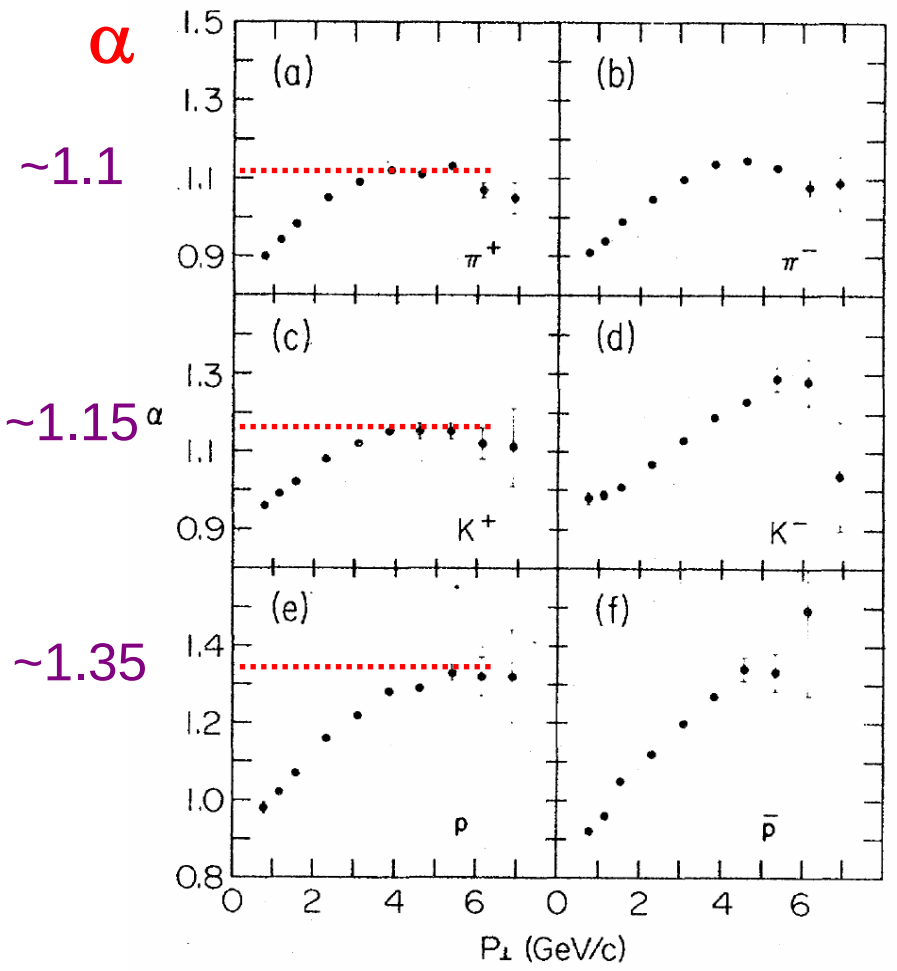
ϕ meson production and cold nuclear matter effect in *d*+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in STAR

Xiaoping Zhang (*LBNL*)

For the STAR Collaboration

- Introduction
- ϕ meson measurements and nuclear modification factor
- Summary and outlook

Introduction: Cronin effect in p+A collisions



√ s = 27.4 GeV

➢Enhanced production of high p_T hadrons in proton-nucleus collisions

$$I_i(p_\perp, A) = I_i(p_\perp, 1) A^{\alpha_i(p_\perp)}$$

✓α is larger than 1 at high p_T

✓Indicating the cold nuclear matter has extra effect on particle production

✓Enhancement of proton is larger than pion and kaon

Phys. Rev. D **11**, 3105 (1975)

Phys. Rev. D **19**, 764 (1979)

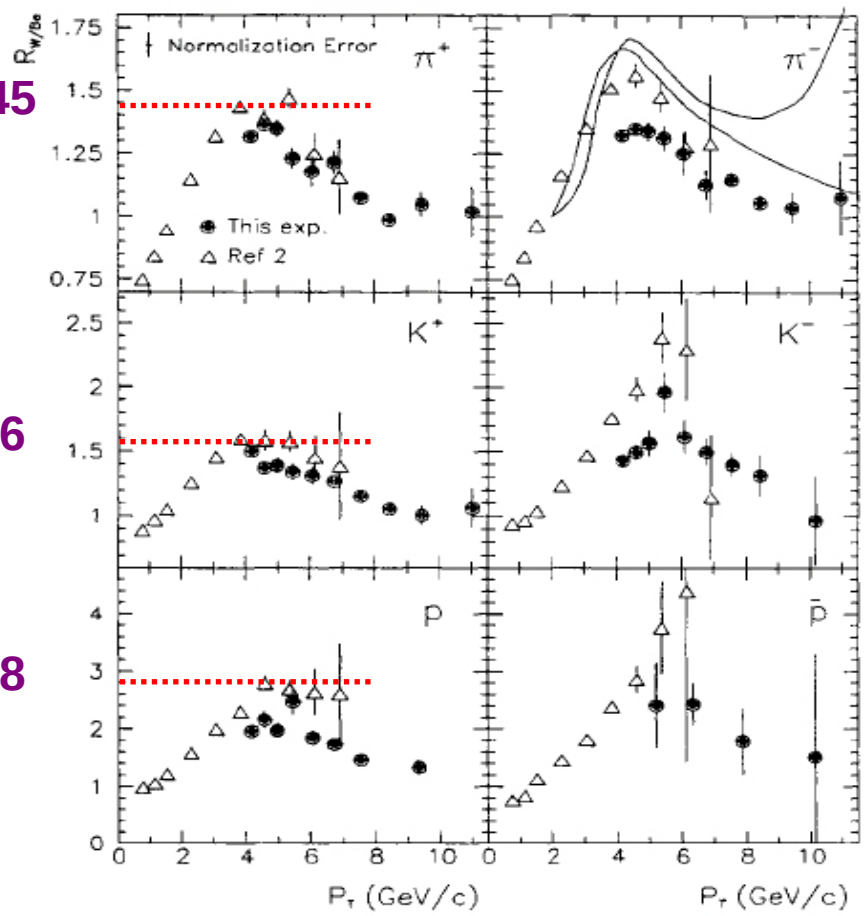
R_{AB} in low energy p+A collisions

$R_{W/Be}$

~1.45

~1.6

~2.8



W: tungsten Be: beryllium

$R_{w/Be}$: p+W to p+Be reaction per nucleon cross section ratio

$\sqrt{s}$ =27.4GeV

pion ~ 1.45
kaon ~1.6
proton ~ 2.8

● $\sqrt{s}$ =38.8GeV △ $\sqrt{s}$ =27.4GeV

P.B Straub,PRL 68, 452(1992)

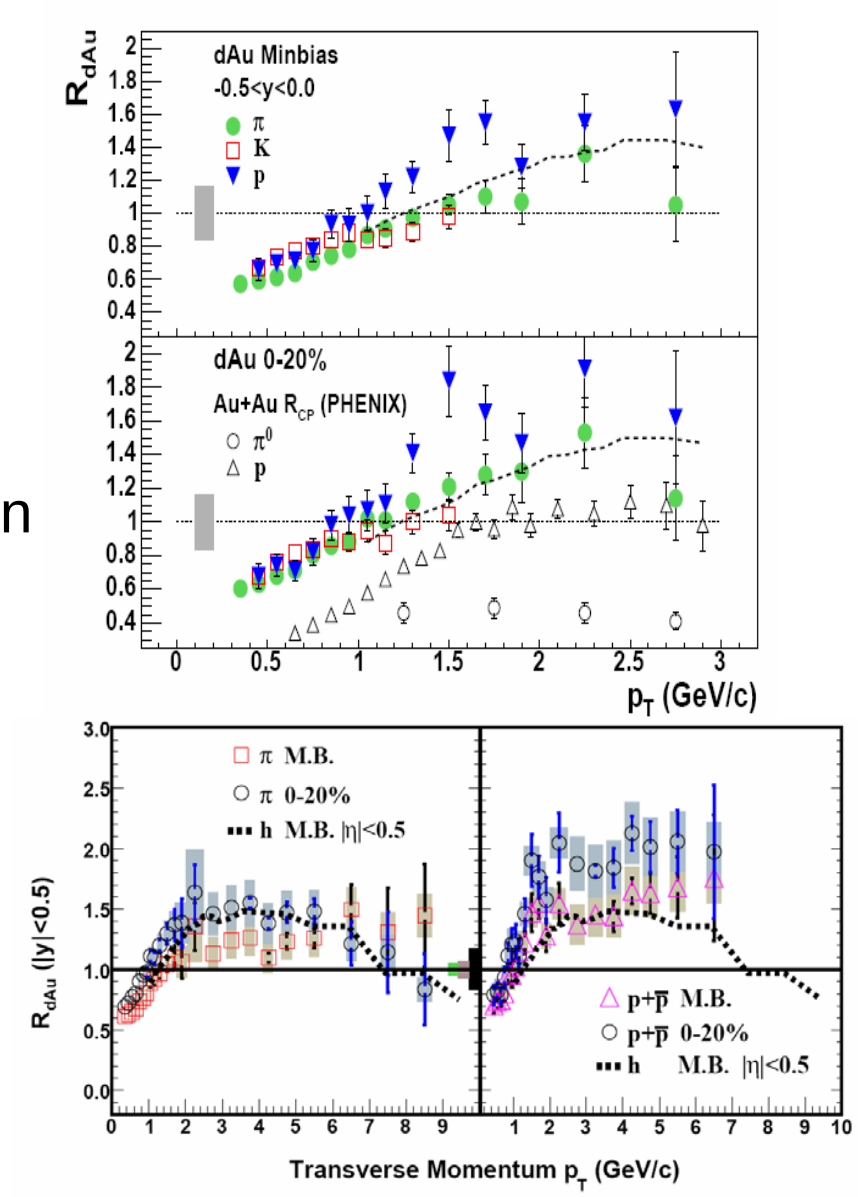
Results from d+Au collisions at RHIC

Mid-rapidity && $\sqrt{s}$ =200 GeV:

$$R_{dAu}(p_T) = \frac{d^2N/(2\pi p_T dp_T dy)}{T_{dAu} d^2\sigma_{inel}^{pp}/(2\pi p_T dp_T dy)}$$

$$T_{dAu} = \langle N_{bin} \rangle / \sigma_{inel}^{pp}$$

- Intermediate p_T hadron production enhanced relative to p+p collisions
- R_{dAu} (p) > R_{dAu} (π)
- Particle species dependence is significantly smaller than that from collisions at lower energy



Phys. Lett. B 616 (2005) 8

Phys. Lett. B 637 (2006) 161

Initial state versus final state effect

➢Traditional models: initial state effect before hard scattering

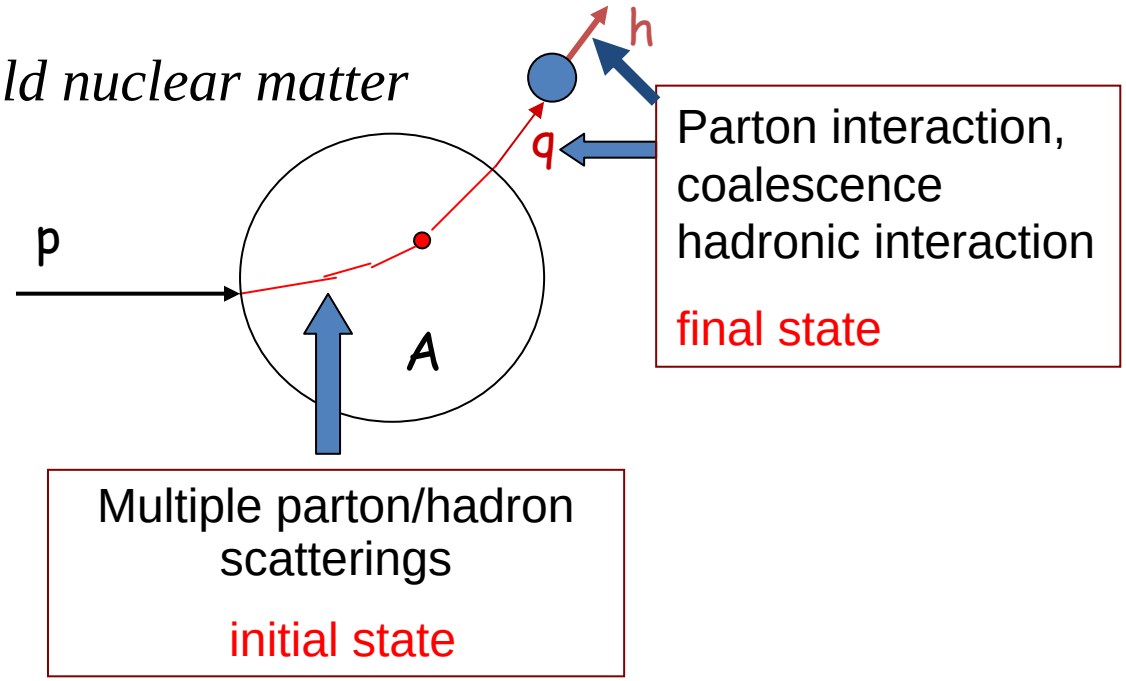
- *partonic multiple rescatterings with target nucleons*
- *transverse momentum broadening of the projectile parton*

➢Final state models: after hard scattering

- *parton coalescence*
- *hadronic interaction with cold nuclear matter*

➢**Measurements:**

- **particle type dependence**
- **centrality dependence**



X.N. Wang, Phys. Rev. C 61, 064910 (2000)

R.C. Hwa et al., PRL 93, 082302 (2004)

ϕ meson production and cold nuclear matter effect

➢**Two possibilities:** mass effect or meson/baryon effect?

➢**Mass** ϕ: 1.019 GeV/c^2, Λ : 1.1157 GeV/c^2, proton: 0.938 GeV/c^2

Λ (uds) and proton (uud) ϕ ($s\bar{s}$)

~ Distinguish meson/baryon effect or mass effect

➢ϕ decouples early, provides early time information

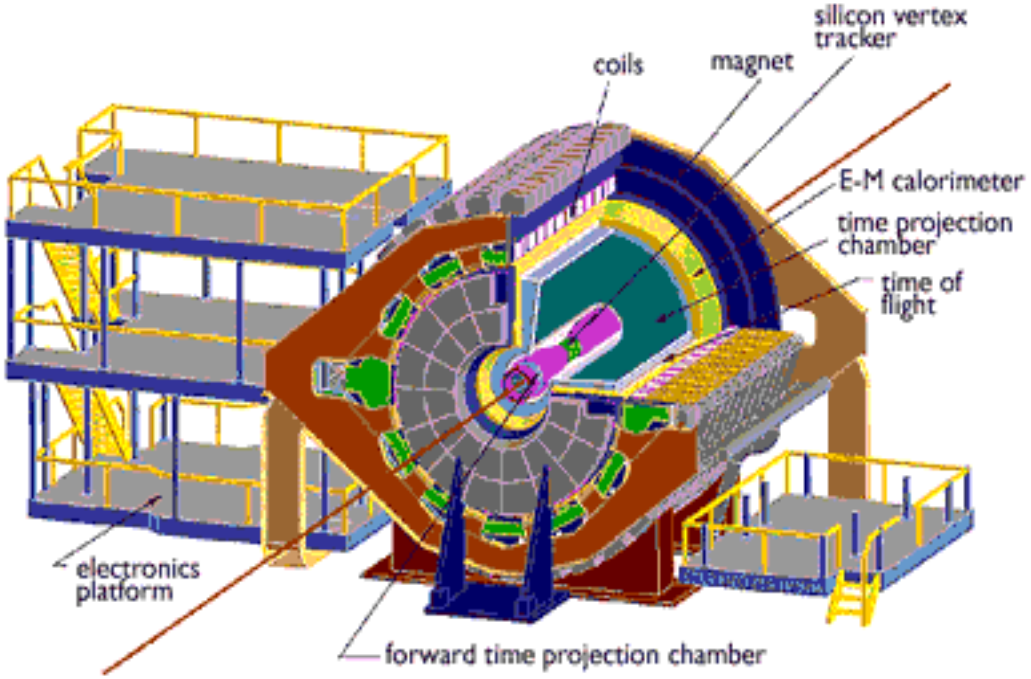
ϕ is thought to have small cross section with other non-strange particles

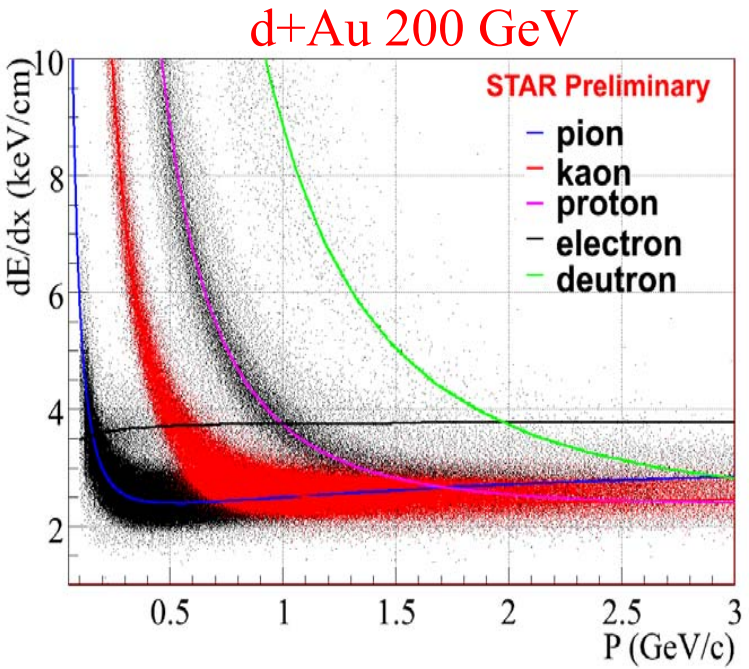
~ Provide information of early stage

➢Dataset: STAR year 2008 *d*+Au 200 GeV run

A factor of 3 higher statistics compare to year 2003 run

ϕ meson measurements
- Detector and Particle Identification





Particle identification: ($\phi \rightarrow K^+K^-$ decay, branching ratio 49.2%)

Measure the momentum v.s. energy loss of particles with Time Projection Chamber

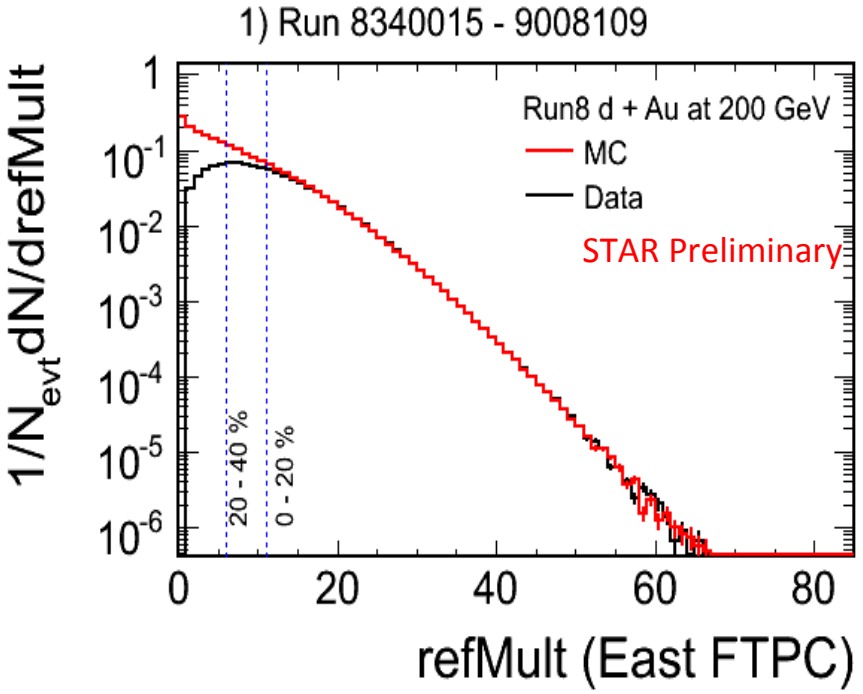
Identification of pion, kaon, proton and electron etc.

Large acceptance: 2 π azimuthal coverage, $-1.5 < \eta < 1.5$

Reduced material: inner tracker removed, lower γ conversion background

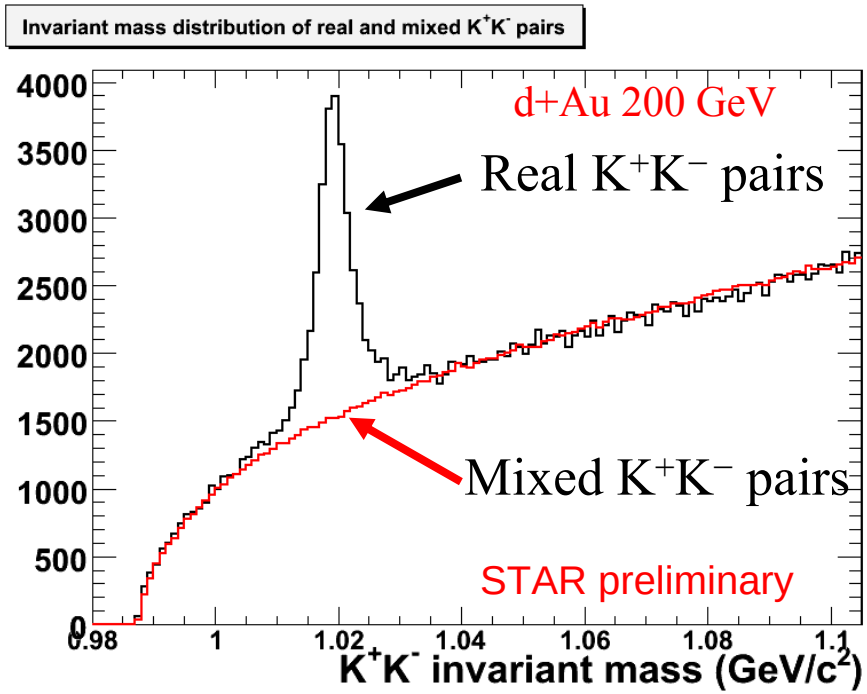
The data set

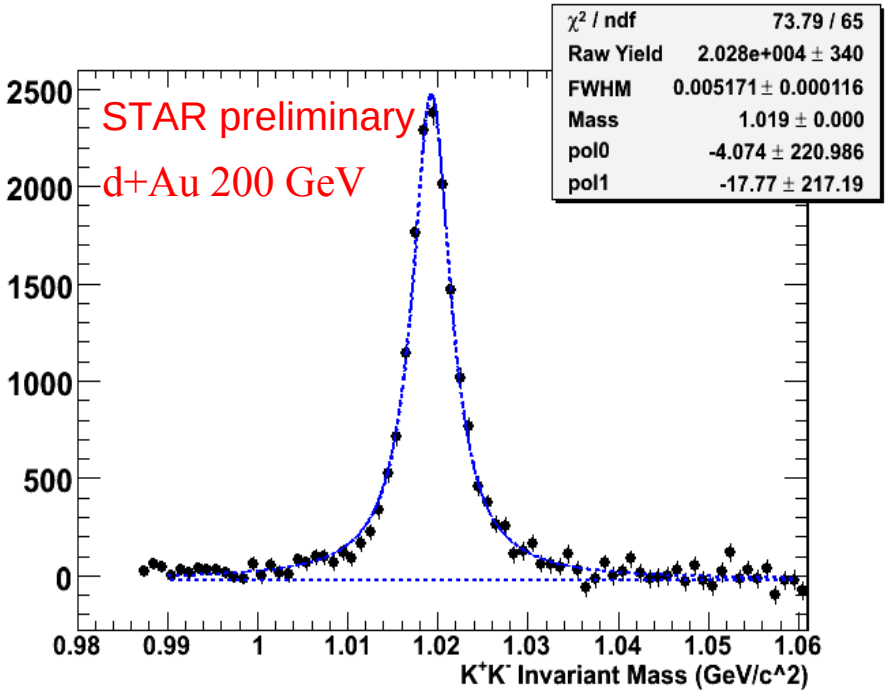
- **STAR year 2008 d+Au 200GeV Minimum Bias data**
- **Event Selection:**
  - ✓ |VertexZ| < 30cm
  - ✓ ~ 33M events after the event selection cuts.
- **Centrality definition in d+Au:**
  - ✓ refMult: number of charged hadrons used for centrality measurement (see right plot)
  - ✓ In this report, only the most central (0-20%) events are used for spectra analysis



ϕ meson reconstruction

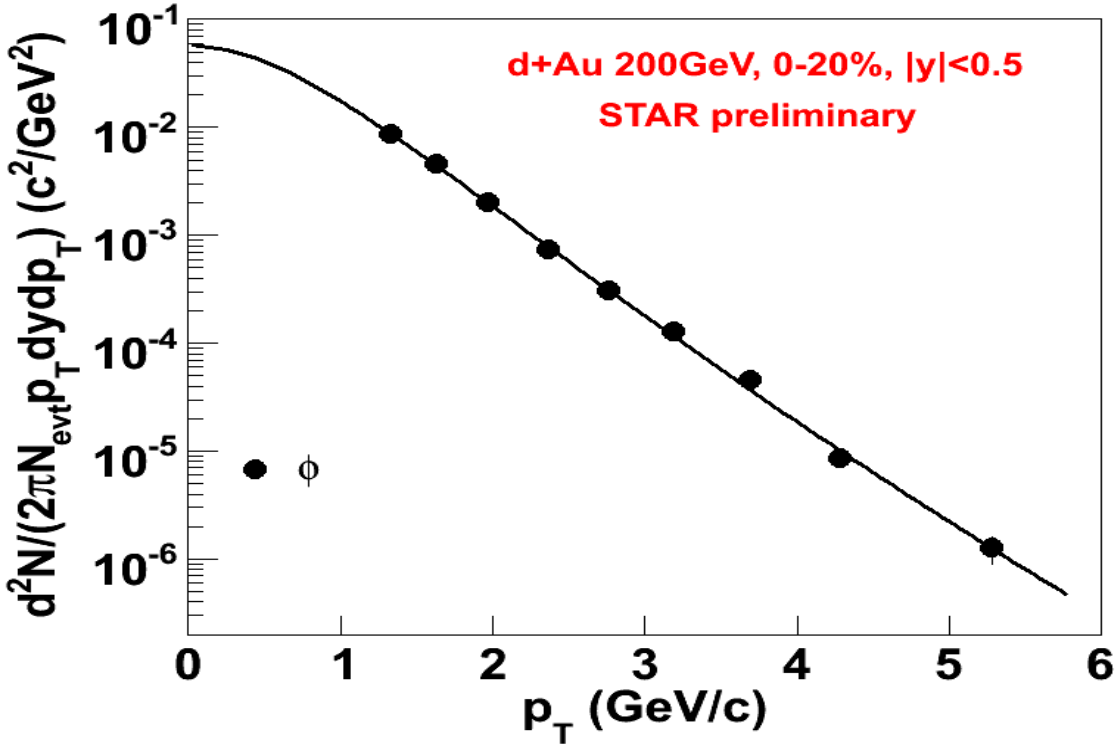
Reconstruct background by mixed event method





Breit-Wigner + linear function is used to fit ϕ invariant mass distribution after background subtraction

ϕ meson spectra



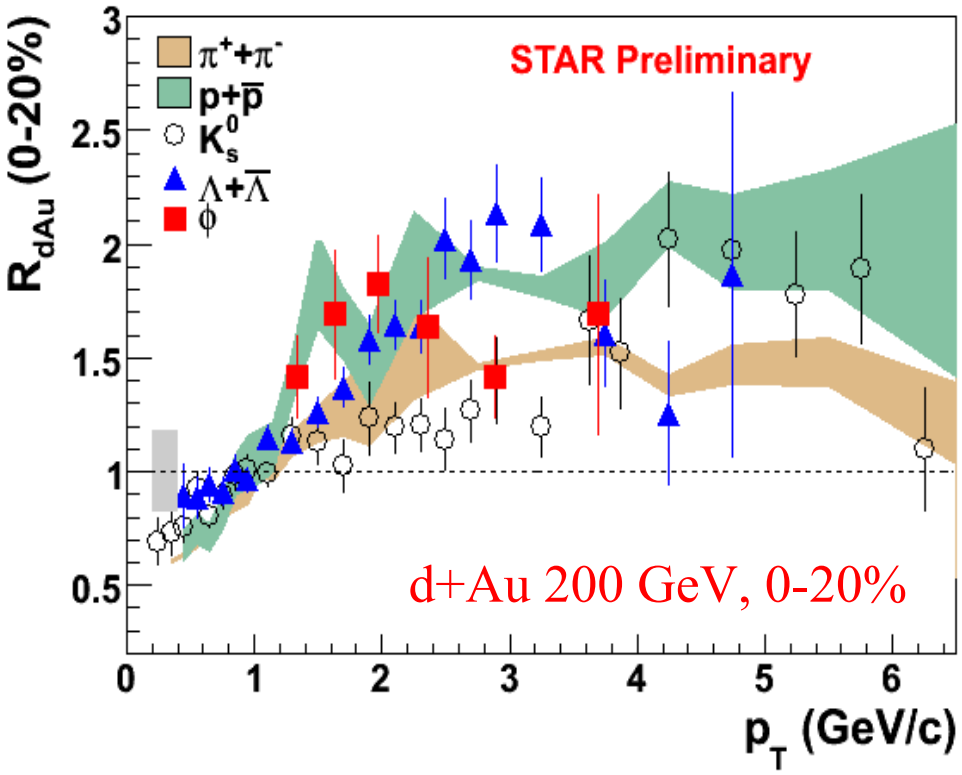
Spectra can be fitted with Levy function

$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy} = dN/dy \frac{(n-1)(n-2)}{2\pi nT(nT+m(n-2))}\left(1+\frac{\sqrt{p_T^2+m^2}-m}{nT}\right)^{-n}$$

	dN/dy	n	T (GeV)	χ^2/ndf
ϕ	0.169$\pm$0.008	29.9$\pm$9.5	0.337$\pm$0.017	7.168/6

Statistical error only

Nuclear modification factor R_{dAu}



- Mid-rapidity (|y|<0.5), statistical error only
- Particle type (baryon/meson) dependence of R_{dAu} for p_T from 2.5 to 4.0 GeV/c
- ϕ meson R_{dAu} seems to fall into the meson band from 2.5 to 4.0 GeV/c

π, p data: STAR, Phys. Lett. B616, (2005) 8;
Phys. Lett. B637, (2006) 161;
K^0_s, Λ : STAR preliminary data, QM09, statistical error only

Summary

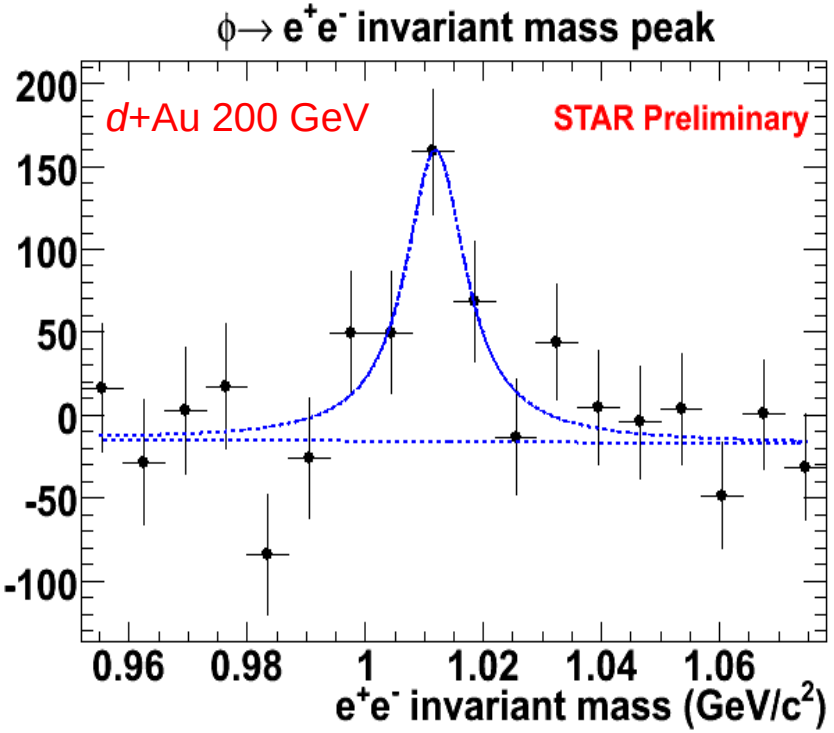
STAR preliminary results of ϕ meson productions in 200 GeV d+Au collisions are presented:

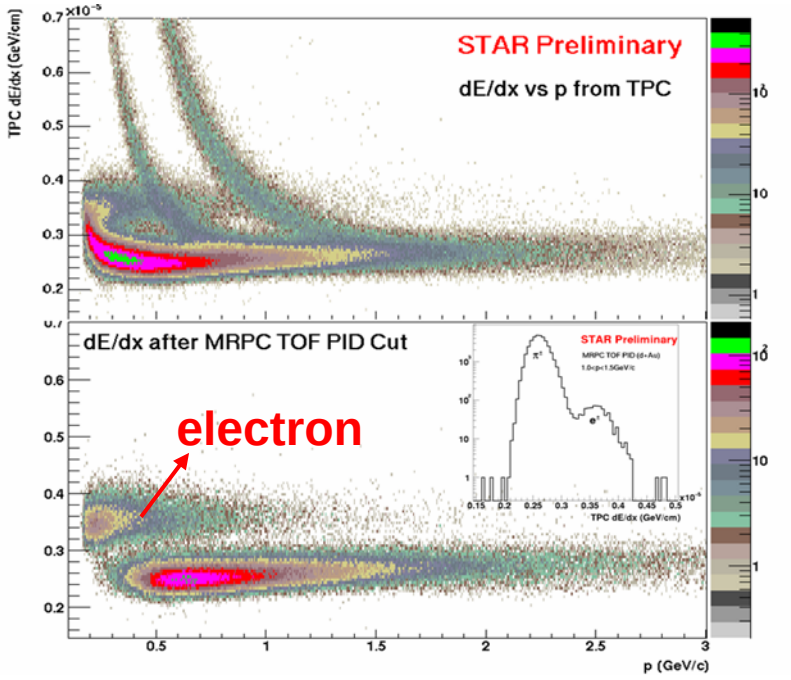
For $p_T \sim 2.5-4$ GeV/c at mid-rapidity ($|y|<0.5$), d+Au 0-20% nuclear modification factor of ϕ meson seems to follow other mesons. This shows the particle type (baryon/meson) dependence rather than hadron mass dependence, namely, mesons (K^0_s , π , ϕ) versus baryon (p, Λ). The results favor the coalescence as the mechanism for the mid-rapidity particle production in d+Au 200 GeV collisions.

Outlook

- $\phi \rightarrow e^+e^-$ decay channel study as an independent check would provide more information of d+Au collisions. After Time of Flight detector upgrade, electron identification will be greatly enhanced.

- Extend present rapidity range, by using Forward TPC to extract ϕ meson signal, explore possible gluon saturation region.





Thank all STAR collaborators

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Thank you!