Lambda(1520) production in Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV in STAR

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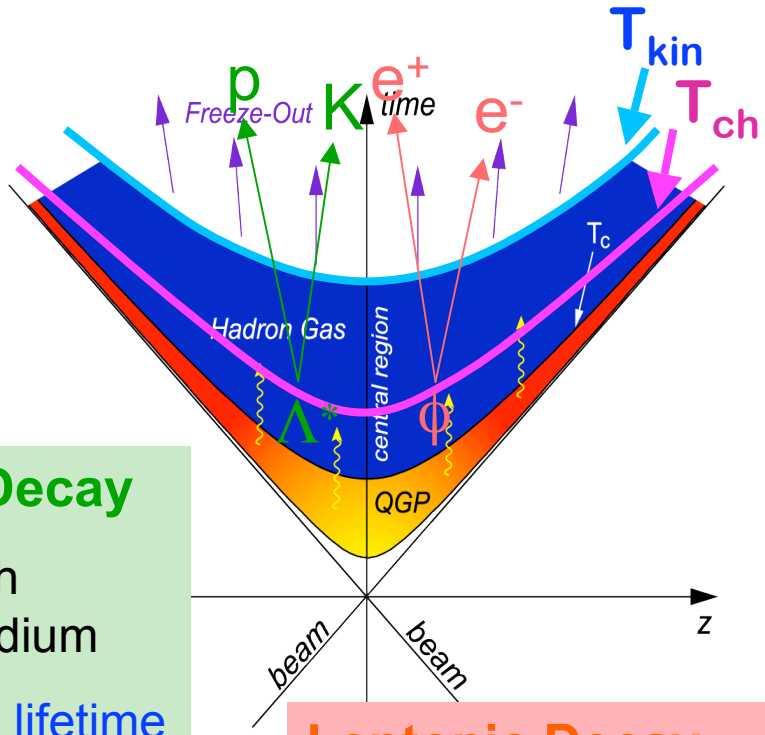
For the STAR Collaboration

Resonances In Medium

Resonance particles are extremely short lived particles (strong interaction).

- decay inside medium
- sensitive to hadronic medium life time
  - yields suppression
  - mean pt shift



Hadronic Decay

- Interact with hadronic medium
- sensitive to lifetime of hadronic medium

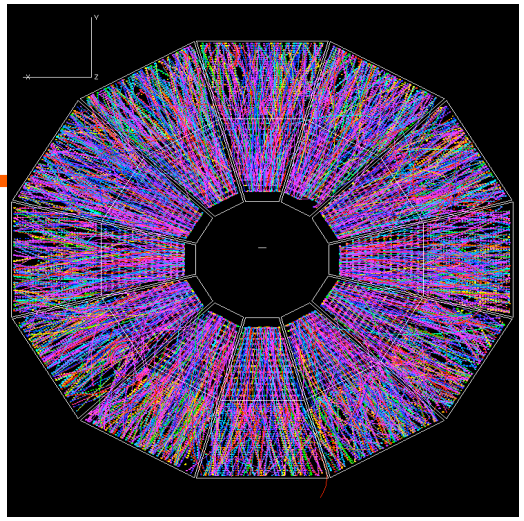
Leptonic Decay

- Less interaction with hadronic medium
- Small branching ratio~10^{-4}

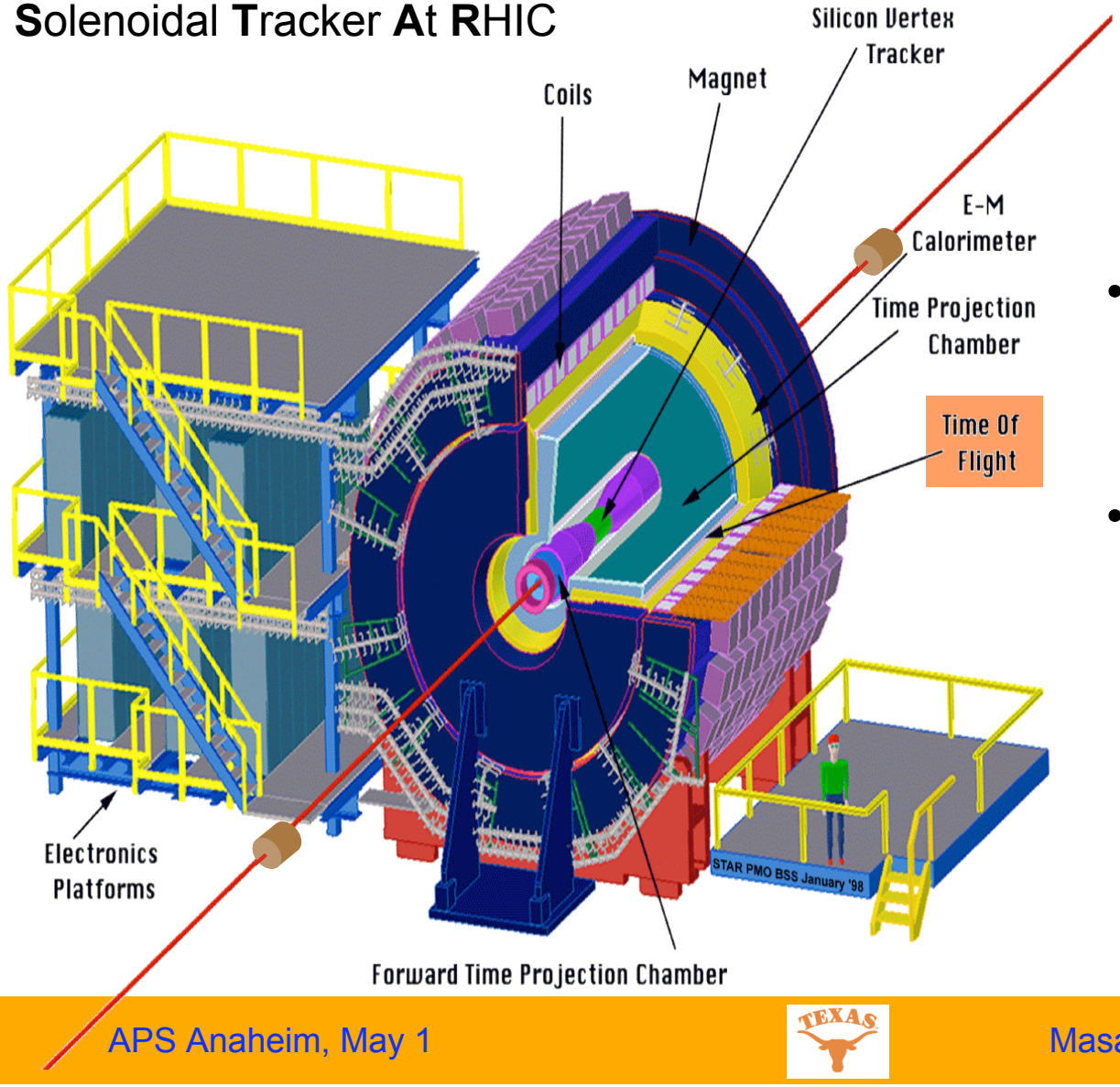
Resonance	Mass [MeV/c2]	Lifetime [fm/c]	decays (BR)
$\Lambda^*(uds)$	1520	13	p+K
$\phi\ (s\bar{s})$	1020	44	K+K , $e^+ + e^-$ (10^{-4})

hadronic decay — leptonic decay

STAR Detector



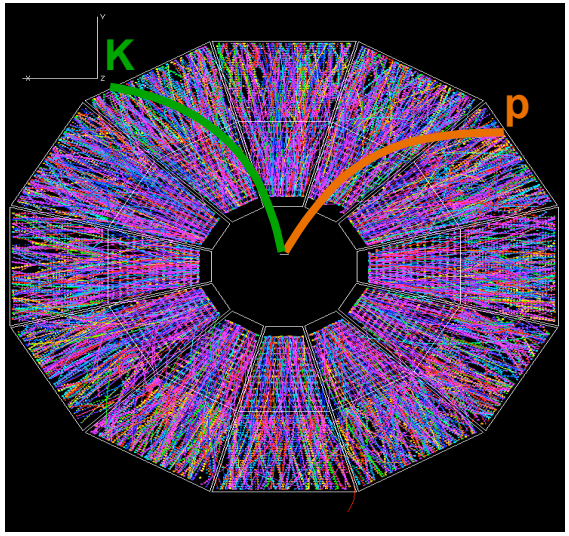
Solenoidal **T**racker **A**t **R**HIC



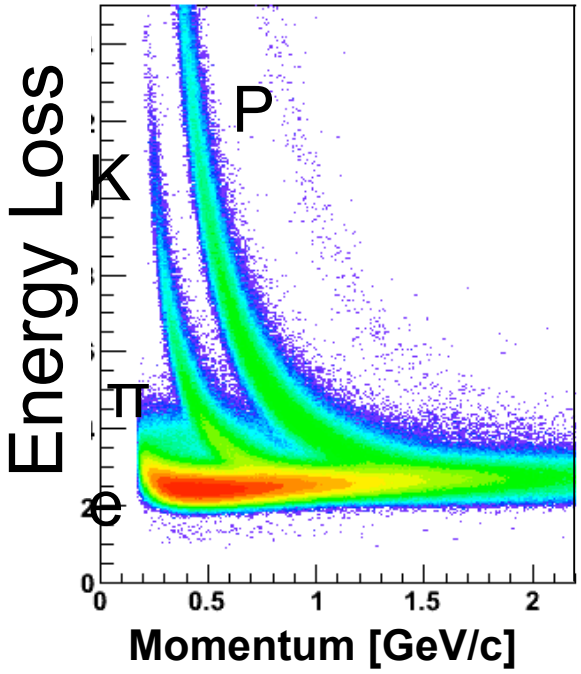
- **Time Projection Chamber (TPC)** is a main detector.
- **Time of Flight System(TOF)**
  - 120 trays
  - ~70% (2009)
  - ~100% (2010)

Resonance Reconstruction

$\Lambda(1520) \rightarrow p + K^-$



- Kaons from 0.2-0.7 GeV/c
- Protons from 0.2-10 GeV/c



Calculate invariant mass with every pair in the same event.

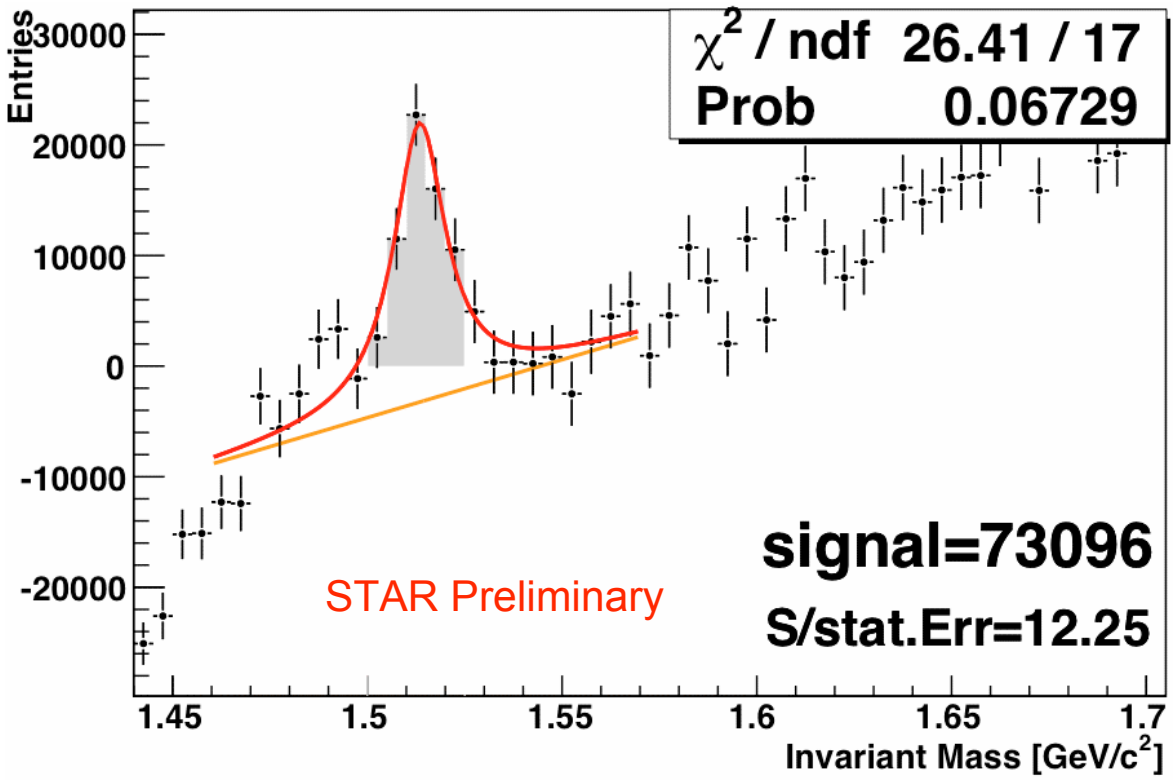
Invariant Mass $M^2 = (E_p + E_K)^2 - (\vec{p}_p + \vec{p}_K)^2$

Background is estimated by Event Mixing technique.

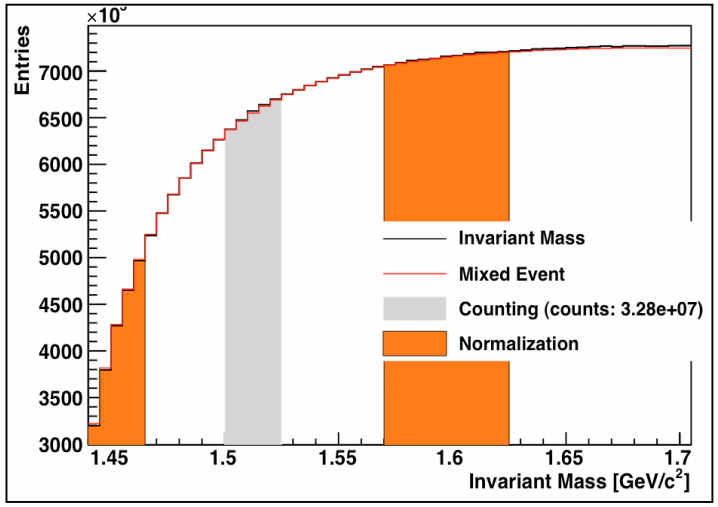
- Take two different events and calculate invariant mass with kaon from one event and proton from the other.
- Events are mixed with 10 bins in vertex dist. and reaction plane.

Invariant Mass Signal

$\Lambda(1520) + \bar{\Lambda}(1520)$ **Pt : 0.4-3.2 [GeV/c]**



~20M Min. Bias events
(after event selection)



Fit with the Breit-Wigner func. + background.

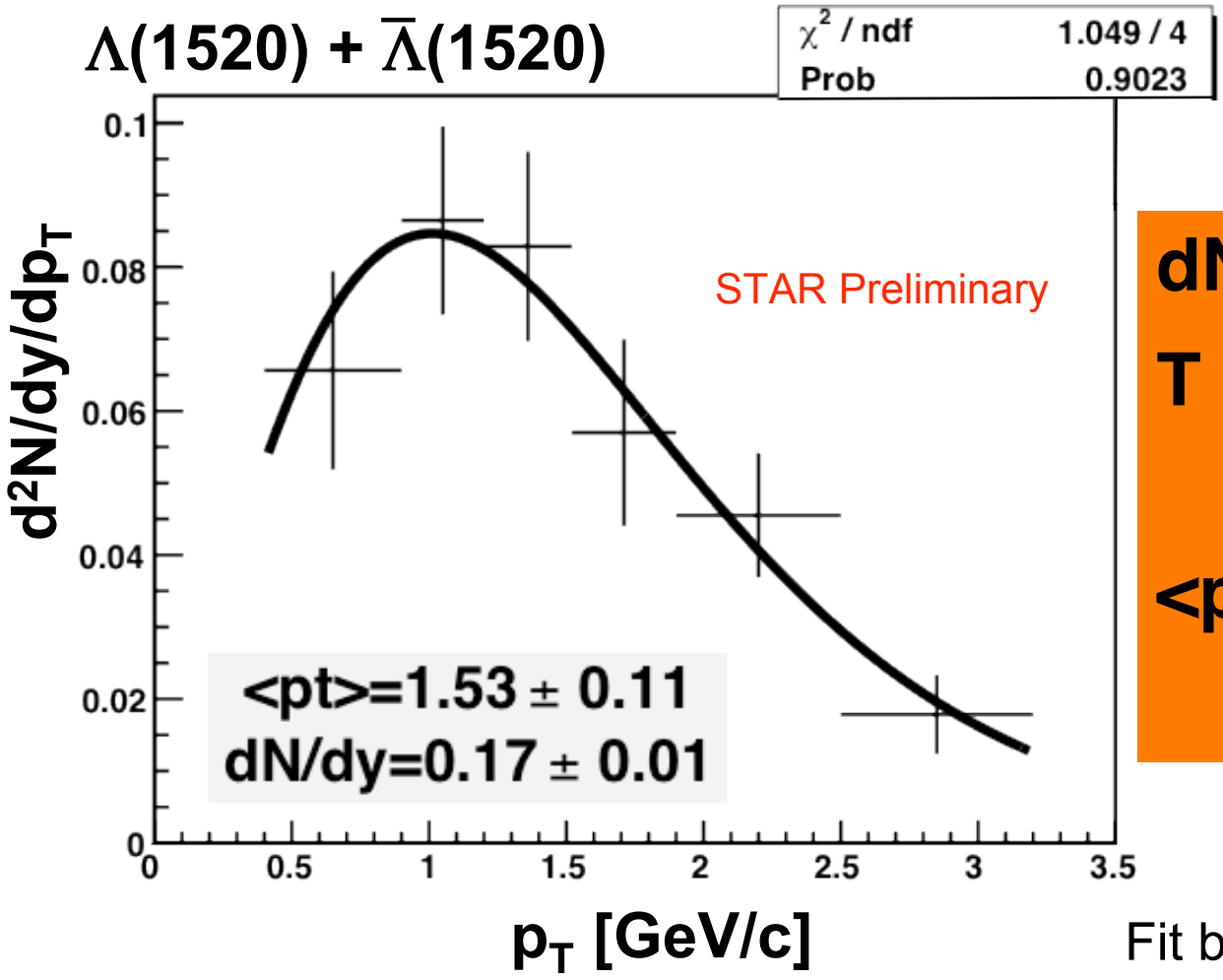
Error is statistic only. Systematic is under study.

Fit: mass = 1513 ± 1 ± sys. MeV/c^2
width = 16 ± 3 ± sys. MeV/c^2
Simulation:
mass = 1518 ± 0.1 MeV/c^2
width = 16.3 ± 0.1 MeV/c^2
Particle Data Group:
mass = 1519.5 ± 1.0 MeV/c^2
width = 15.6 ± 1.0 MeV/c^2

Momentum Spectrum

Corrected

$\Lambda(1520) + \bar{\Lambda}(1520)$



dN/dy = 0.17 ± 0.01

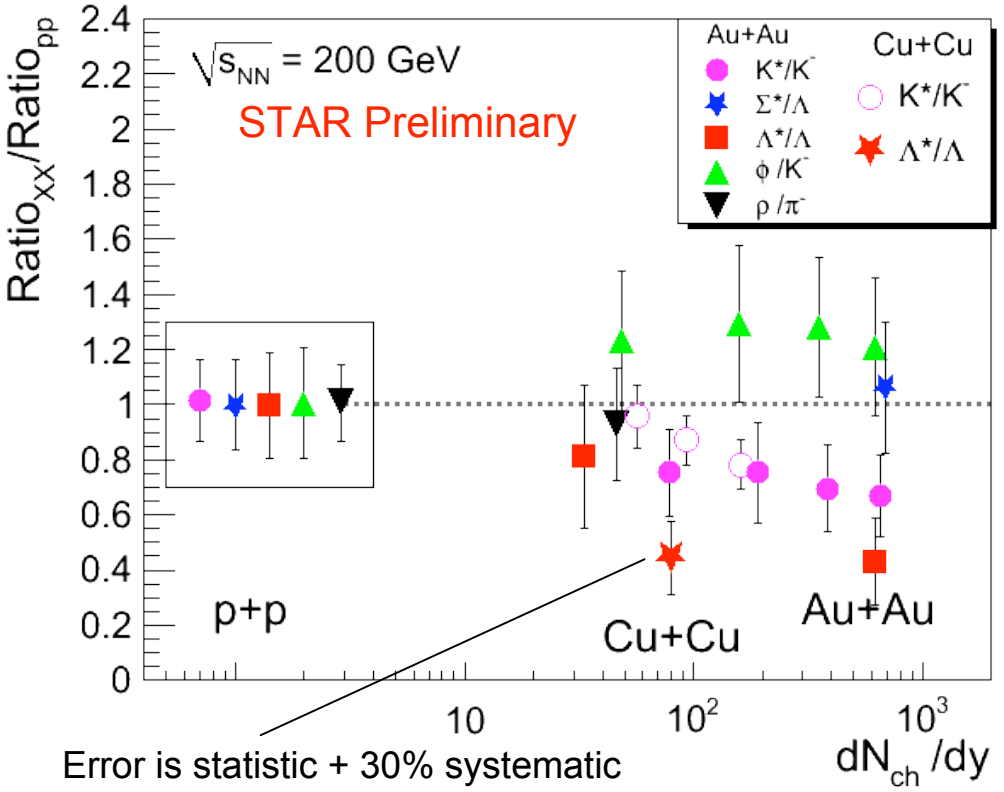
T = 0.56 ± 0.055 [GeV]

$\langle p_T \rangle$ = 1.53 ± 0.11 [GeV/c]

Fit by Maxwell-Boltzmann dist.
Error is statistics error only.

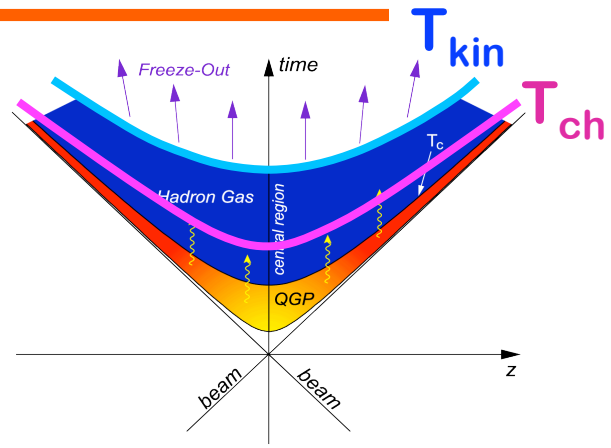
Suppression of Resonance Yields

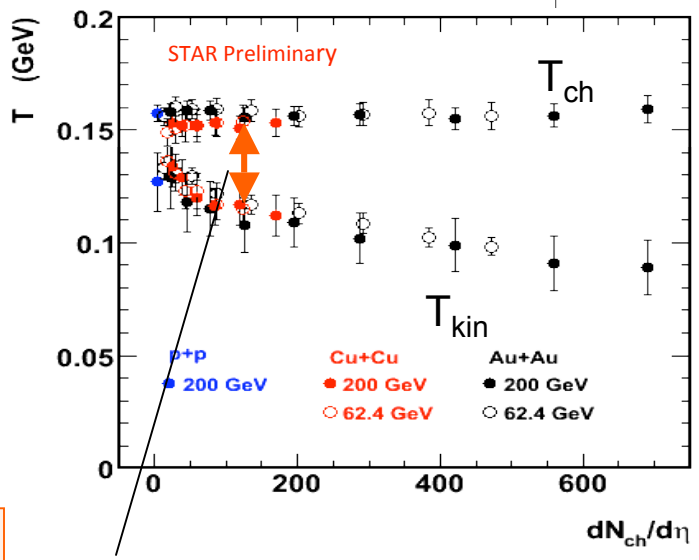
(in Hadronic Medium)



Error is statistic + 30% systematic

- In p+p, no hadronic medium, $T_{ch} \approx T_{kin}$
- The suppression means that resonance yields is lost due to re-scattering of daughters in hadronic medium.



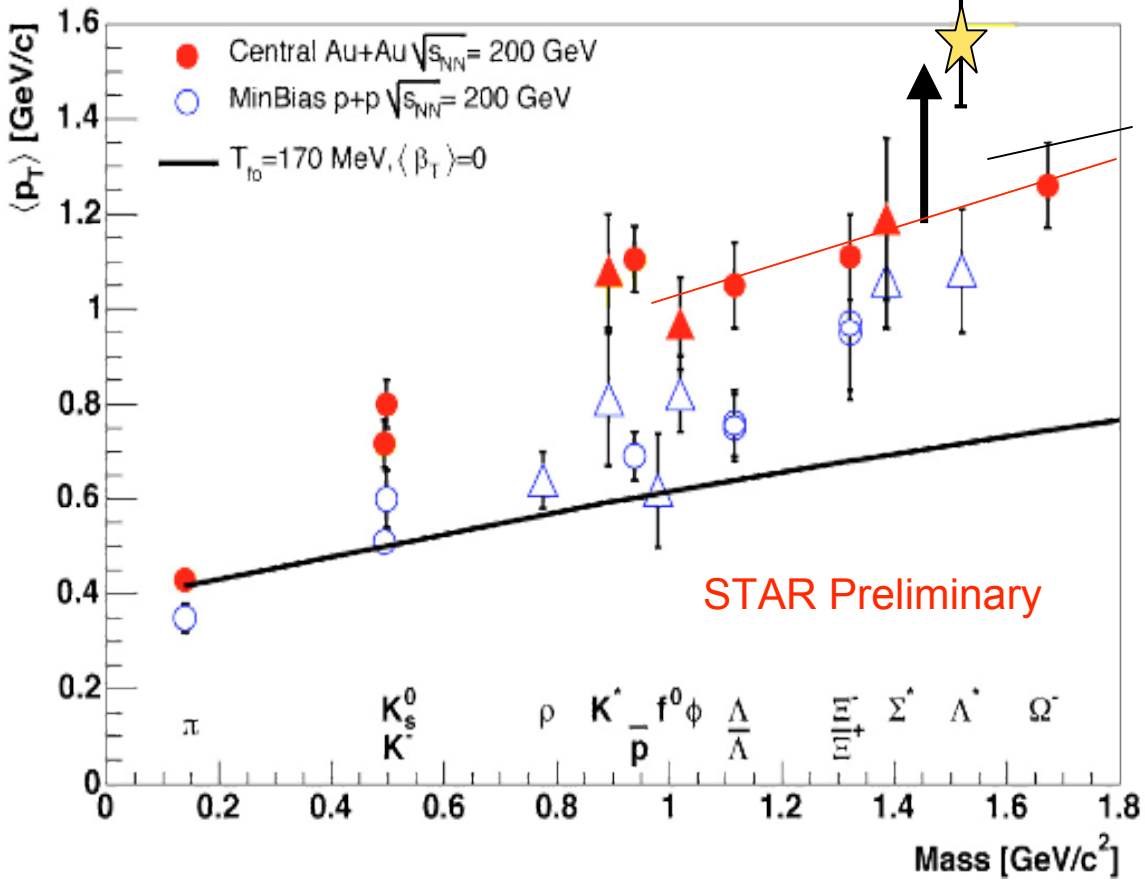


T_{ch}-T_{kin} ∝ hadronic medium lifetime > 4 fm/c from Rafelski's model.

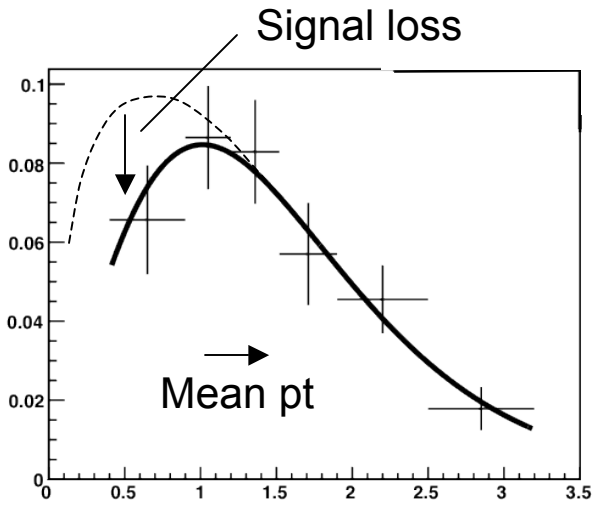
G. Torrieri and J. Rafelski, Phys. Lett. B 509 (2001) 239

Mean Transverse Momentum

$\langle p_T \rangle = 1.53 \pm 0.11$ [GeV/c]
(statistics error only)



Increase in $\langle p_T \rangle$ due to re-scattering in hadronic medium.



Signal loss at low momentum
=> Higher mean pt

Summary

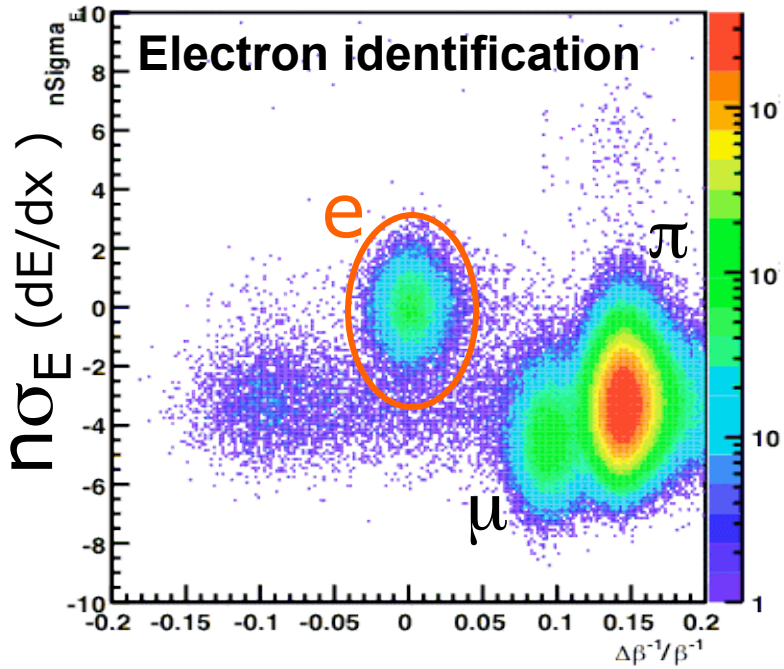
- Resonance particles are sensitive to medium effects.
- $\Lambda(1520)/\Lambda$ ratio is suppressed compared to the p+p data. This is likely due to re-scattering of daughter particles in hadronic medium. The hadronic life time is estimated > 4fm/c.
- Mean pt is shifted due to signal loss at low momentum.

Outlook

Study leptonic decay resonances

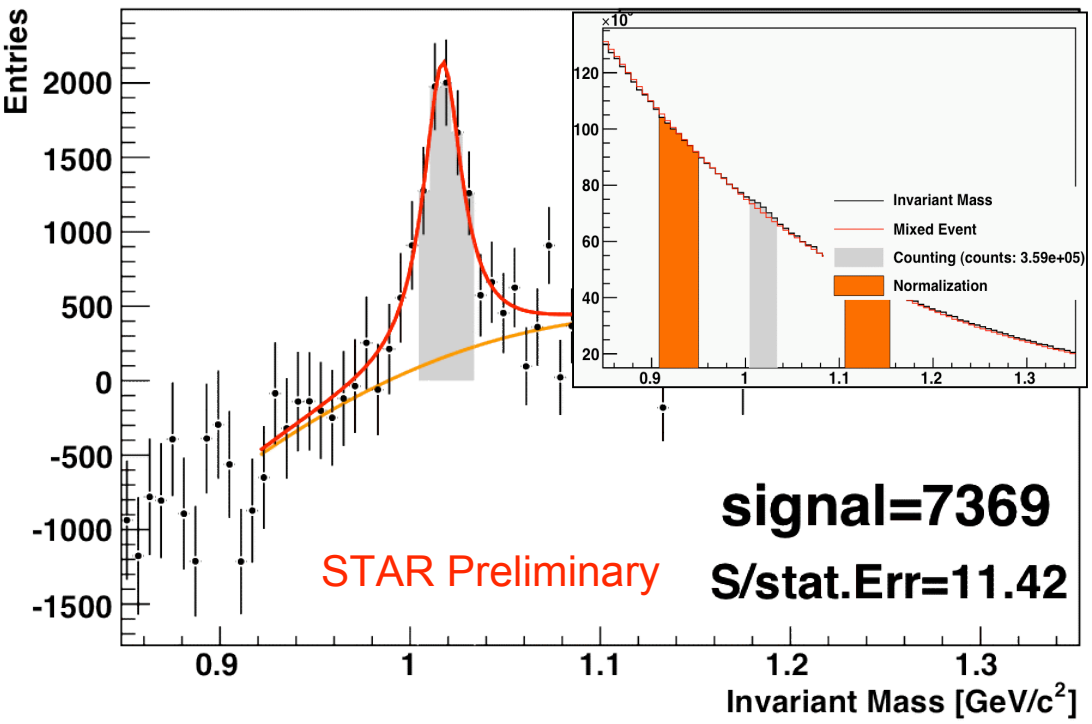
=> direct information

New TOF Detector



$\Delta\beta^{-1}/\beta^{-1}$ (TOF)

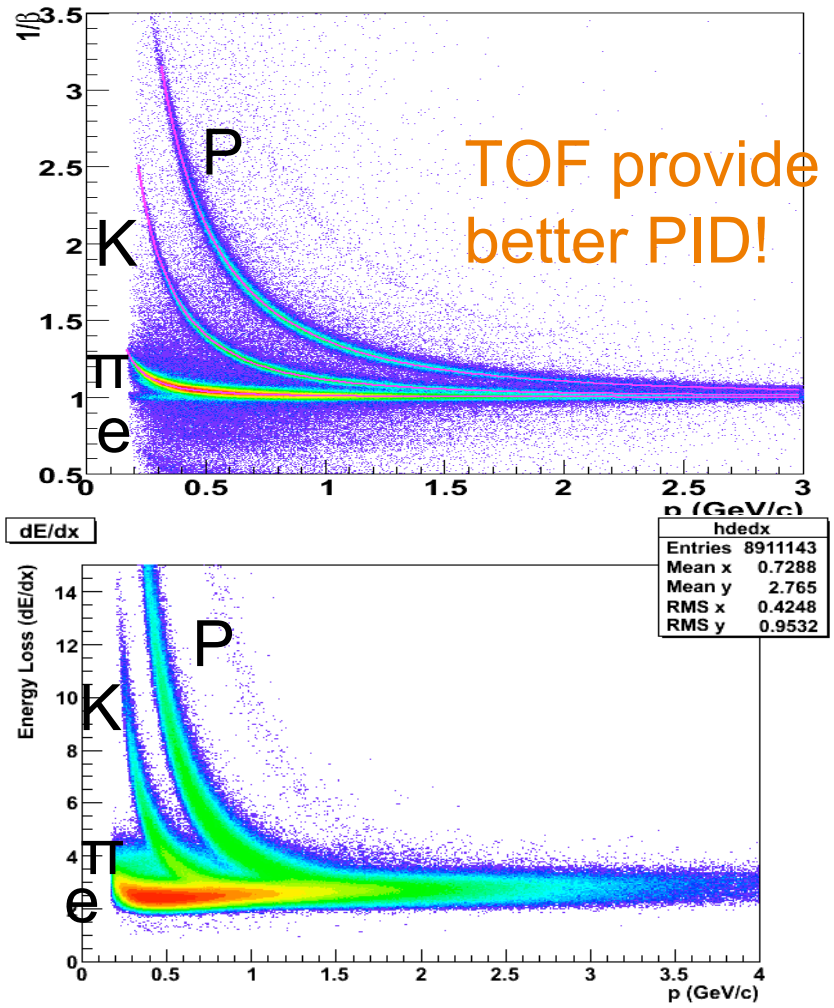
Raw $\phi \rightarrow e^+ + e^-$ signal in Au+Au



Mass = 1017 ± 1 ± 2 MeV (1019.5 PDG)

BACKUP

Particle Identification



Momentum dependency

$$\frac{1}{\beta}_{ideal} = \sqrt{m^2/p^2 + 1}$$

Depend on mass of particles

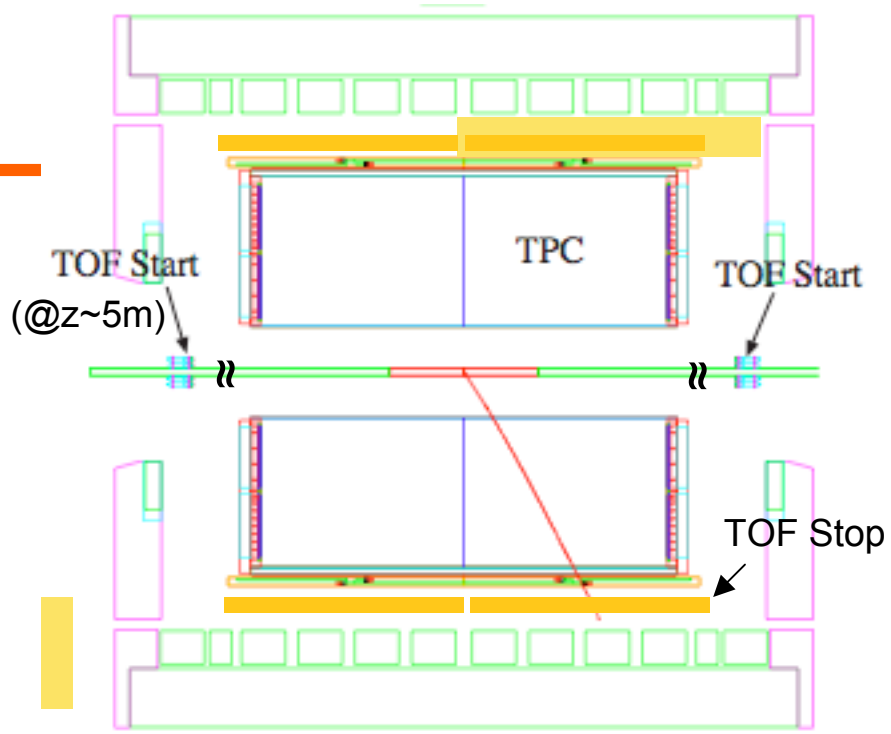
In Experiment

$$\frac{1}{\beta}_{\exp} = c\frac{TOF}{length}$$

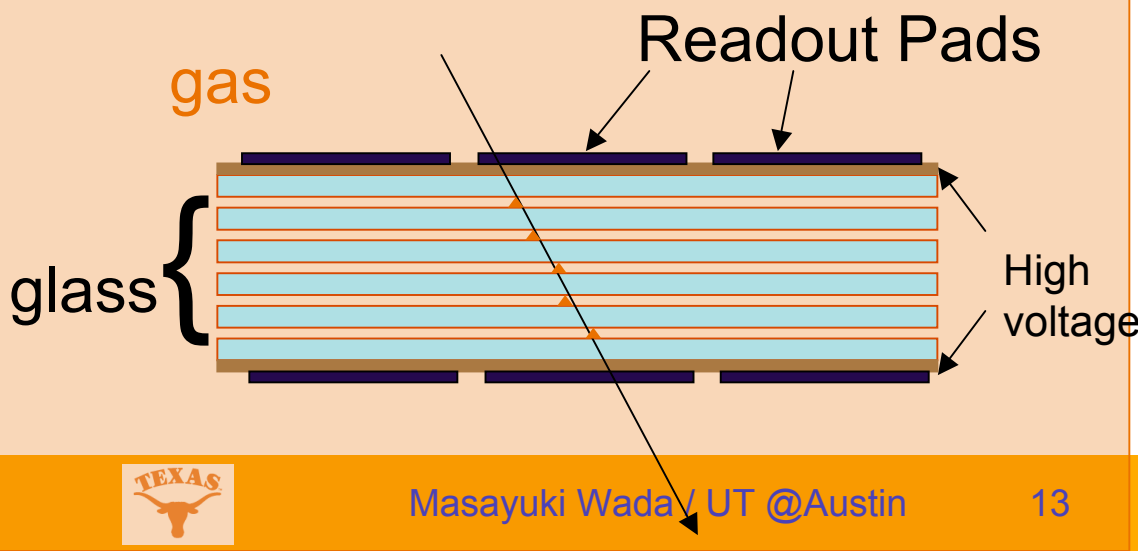
from TPC

TOF System

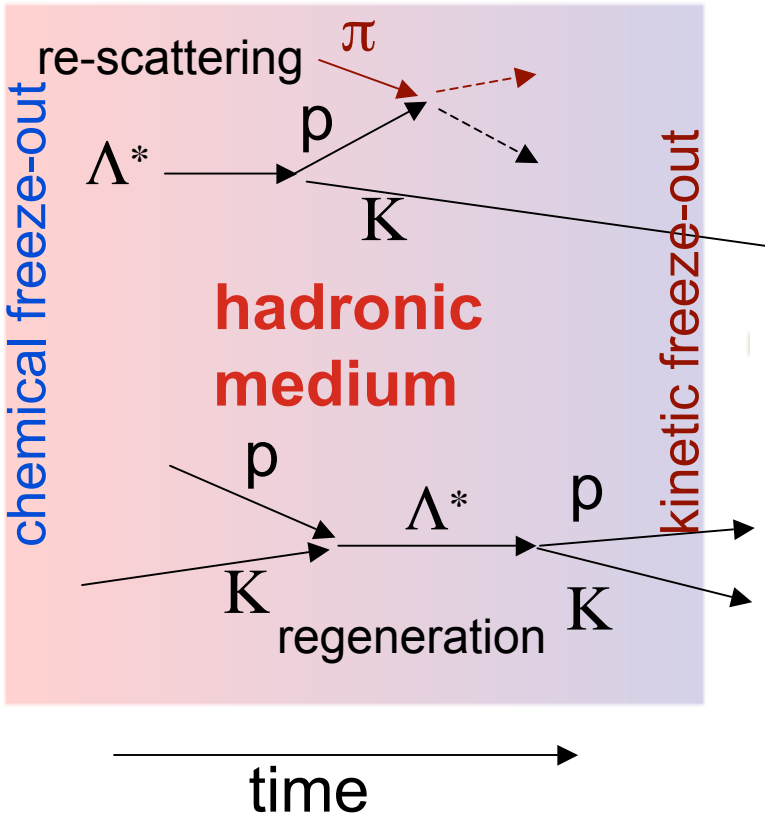
- 120 trays in total
- Each tray has 32 MRPCs
- Time resolution Δt ~80 ps in Au+Au



The Multigap Resistive Plate Chamber



Medium Effects

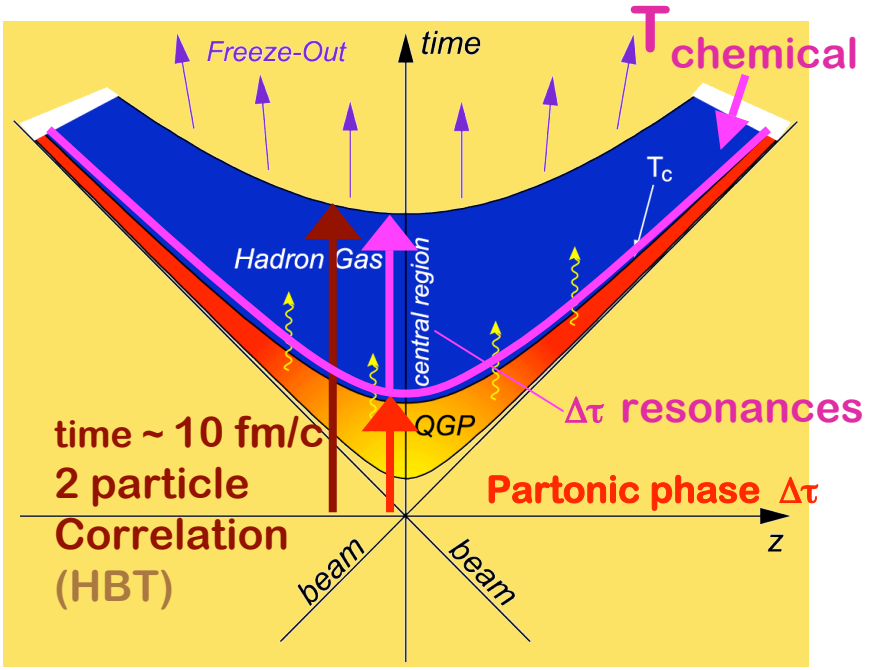


- **Re-scattering**: loss of signal $\propto \sigma_{\text{daughter-medium}}$
- **Re-generation**: increase resonance yields $\propto \sigma_{\text{daughter-daughter}}$

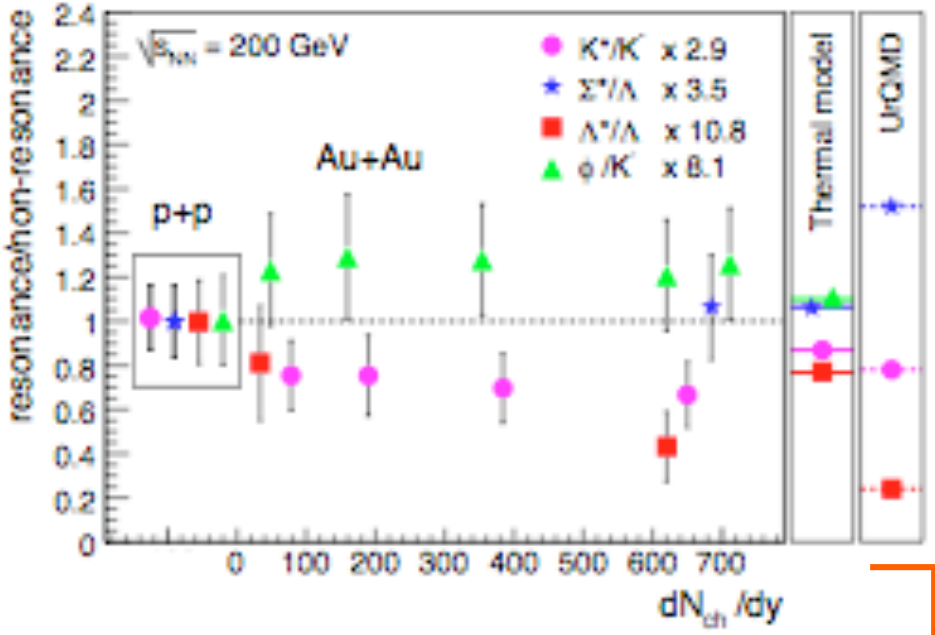
Estimate time span between chemical and kinetic freeze out.

Medium Effects

- From HBT study, the shape of the system can be estimated.
- Time span of partonic phase can be estimated.



Medium Effects



- pp = no medium
- Suppression :
  rescattering > regeneration
- Increase :
  regeneration > rescattering

Signal loss at low momentum due to re-scattering of daughter particles in hadronic medium.
=> Mean pt goes higher.