# Strange Resonance Production in p+p and Au+Au Collisions at RHIC energies.

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**for the STAR Collaboration**

- Motivation
- Resonance Analysis
- Results and Theory
- Summary and Future Plans



**QM2004, 11-17 January, Oakland**

# Resonances

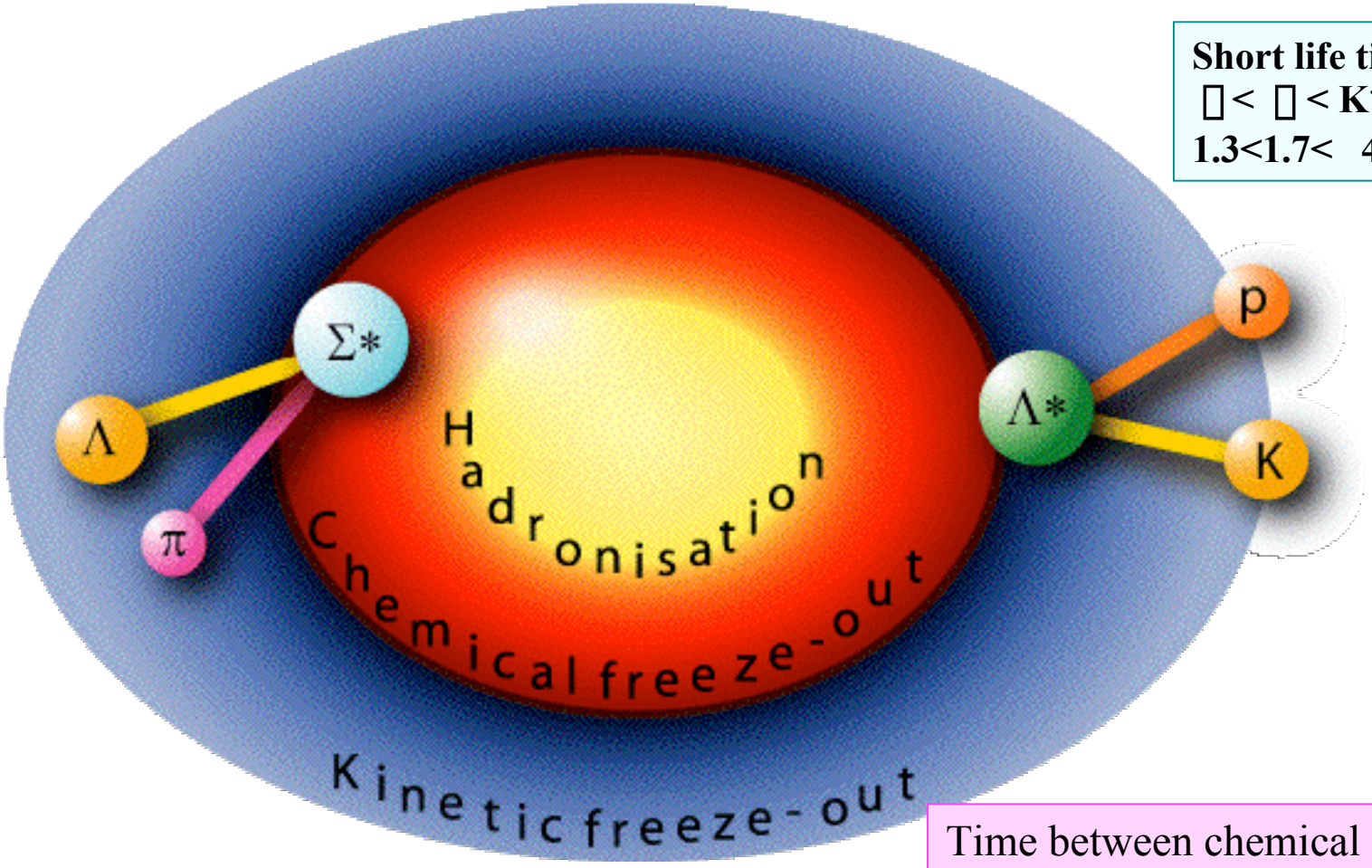
- Excited state of ground state particles with same quark content and higher mass
- Short lifetime on the order few fm/c (lifetime of fireball)
- Decay strongly

| **Resonance** | **K(892)** | **□(1020)** | **□(1385)** | **□(1520)** | **□(1530)** |
|---|---|---|---|---|---|
| Decay channel | K + □ | K+K | □ + □ | p + K | □ + □ |
| Width [MeV] | 50.8 | 4.5 | 35.8 | 15.6 | 9.9 |
| Life time [fm/c] | 3.9 | 44 | 5.6 | 13 | 20 |

Jingguo Ma: □ meson production
□aibin Zhang: □(1232), K*(892) and □(770) resonance production
Sevil Salur: □(1385)

**Posters !!!**

# Resonances in Medium




**Short life time [fm/c]**

□ < □ < K* < □* < □* < □* < □

1.3<1.7< 4 < 6 < 13 < 20 < 40

**Comparison of p+p and A+A collisions show effects of interactions in an expanded reaction volume.**

Time between chemical and kinetic freeze-out ?

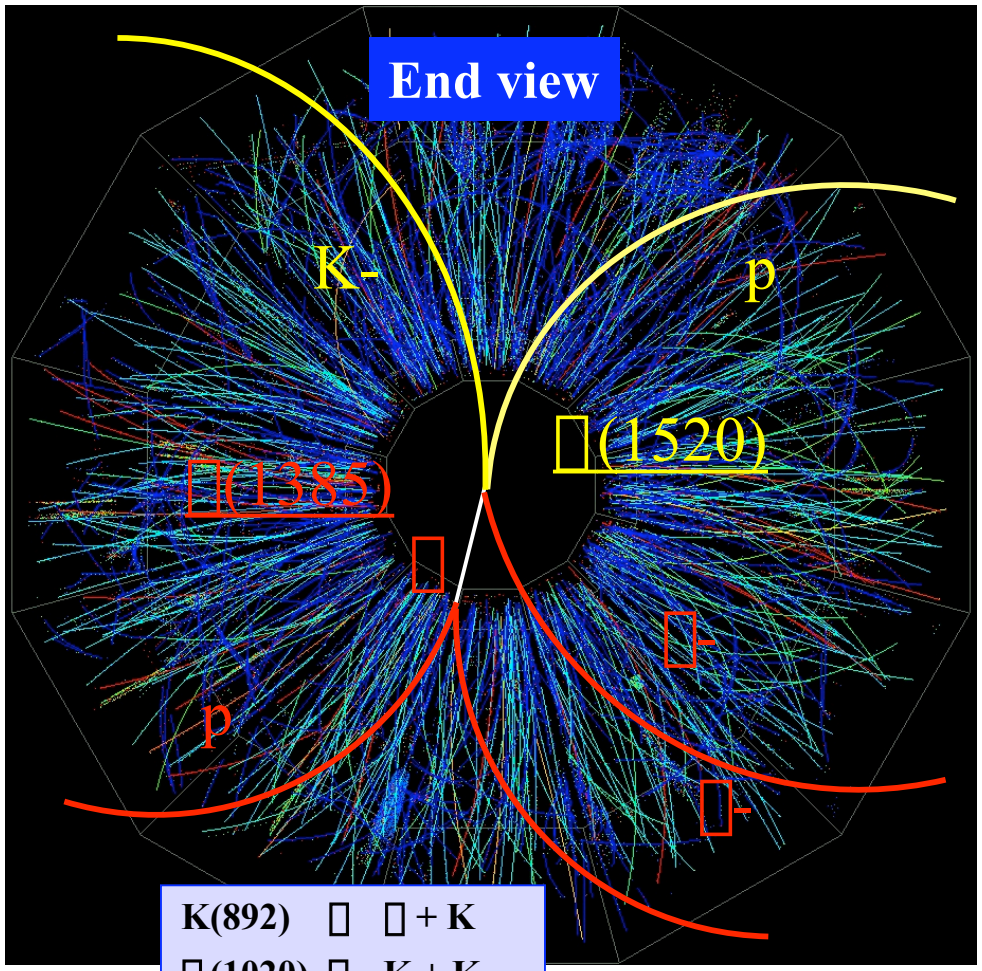
Rescattering and regeneration of resonances

→ Yield and $p_T$ spectra (Microscopic models)

Rescattering of decay daughters → signal loss

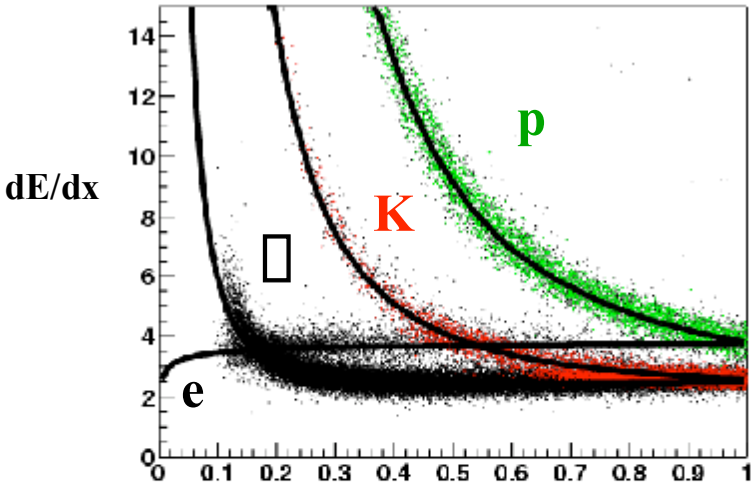
Regeneration of resonance → signal gain

# Resonance reconstruction in STAR TPC




| | | |
|---|---|---|
| K(892) | | + K |
| (1020) | | K + K |
| (1520) | | p + K |
| (1385) | | + |
| (1530) | | + |

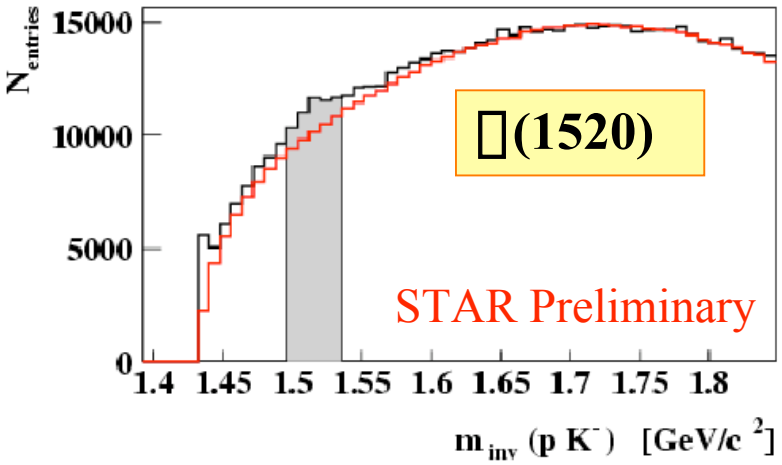
Energy loss in TPC dE/dx

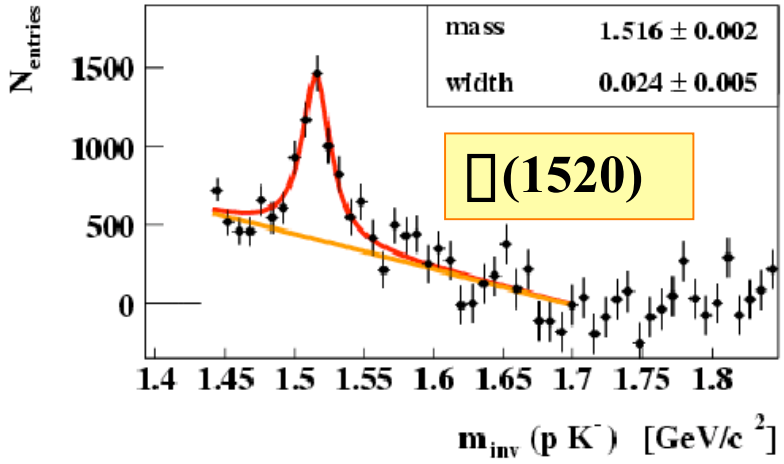


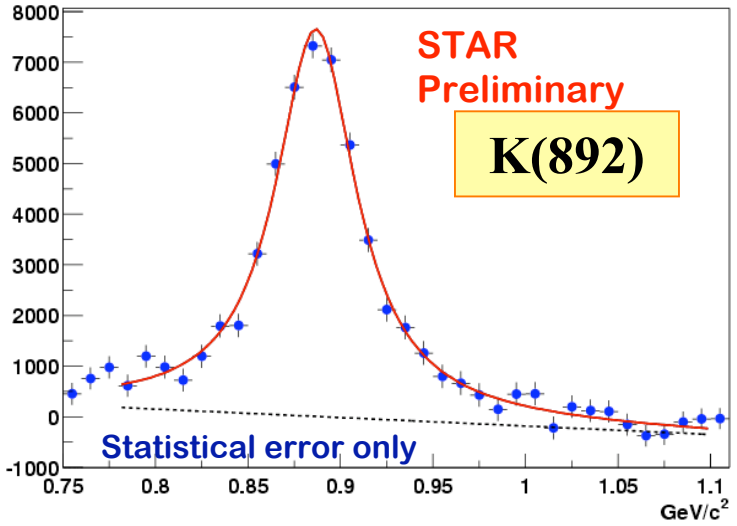

**Invariant mass:**

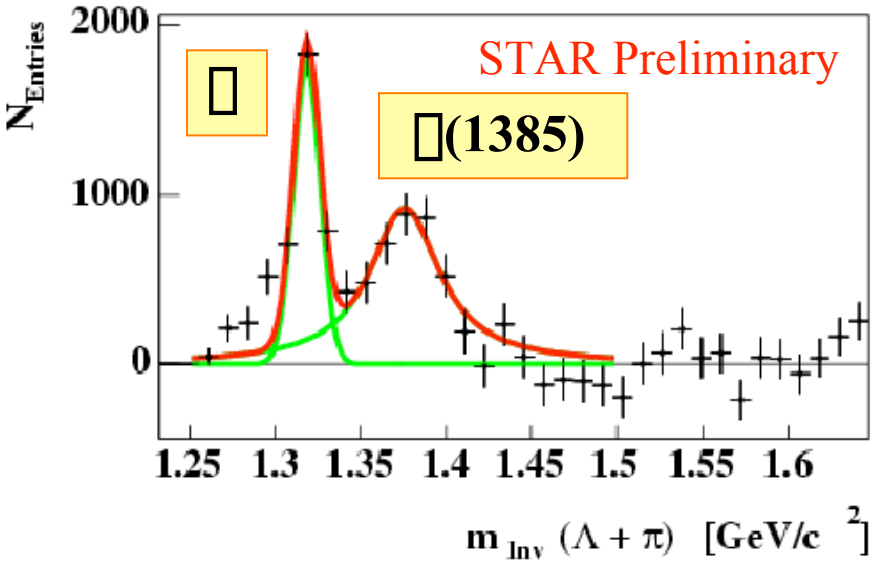
$$m_{inv} = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}$$

# Strange Resonances in p+p at 200 GeV

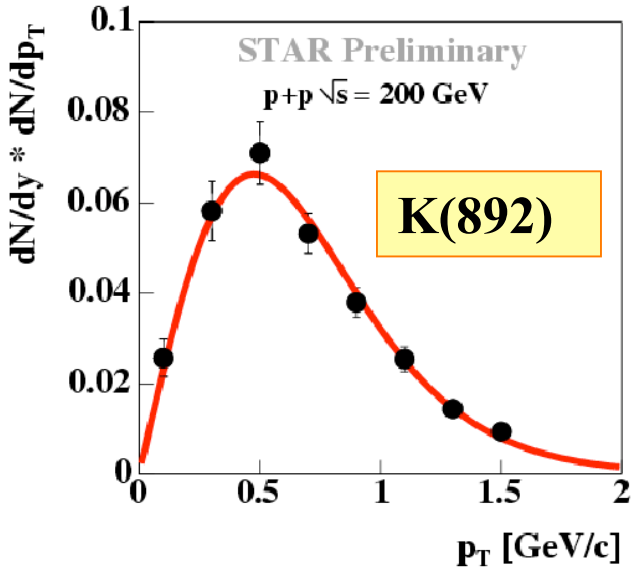


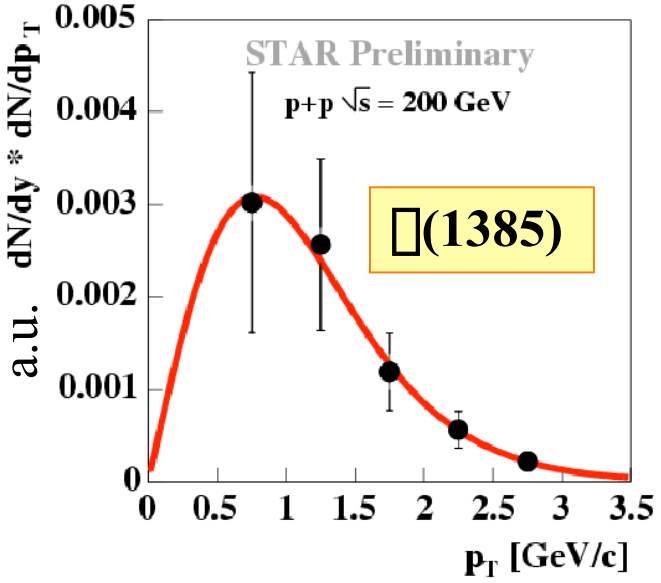



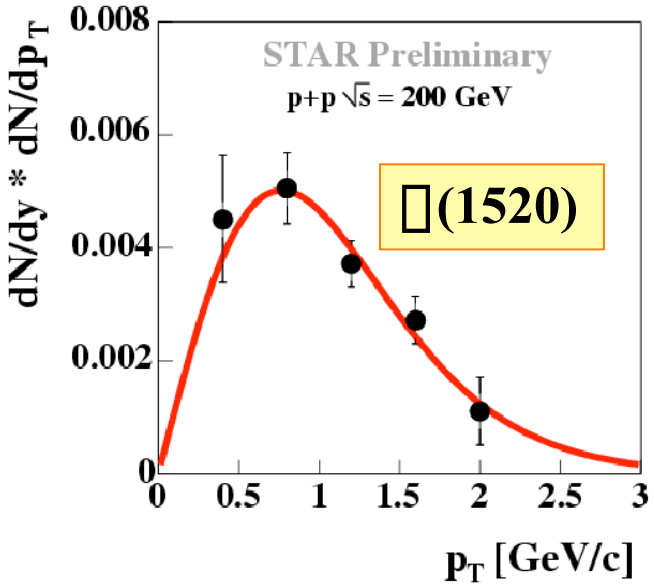



# Resonance $p_T$ Spectra in p+p at 200 GeV at mid Rapidity



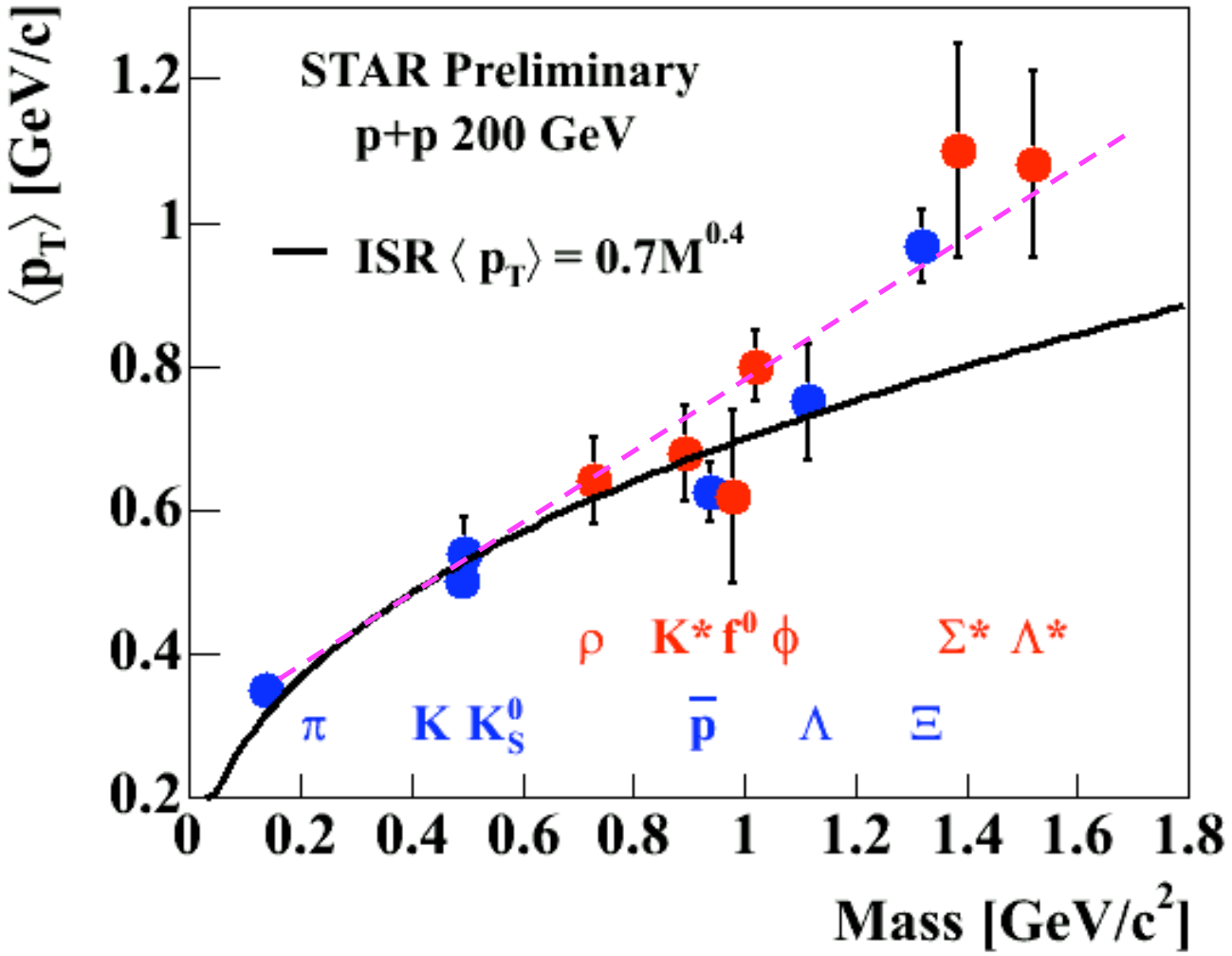

| | $p_T$-coverage (yield) | $\langle p_T \rangle$ (integrated) |
|---|---|---|
| K(892) | 95% | 680 ± 30 ± 30 MeV |
| Λ(1385) | 81% | 1100 ± 20 ± 100 MeV |
| Λ(1520) | 91% | 1080 ± 90 ± 110 MeV |

**dN/dy at y=0**

**K(892) = 0.059 ± 0.002 ± 0.004**

**Λ(1520) = 0.0037 ± 0.004 ± 0.006**

# Mean $p_T$ in p+p at 200 GeV

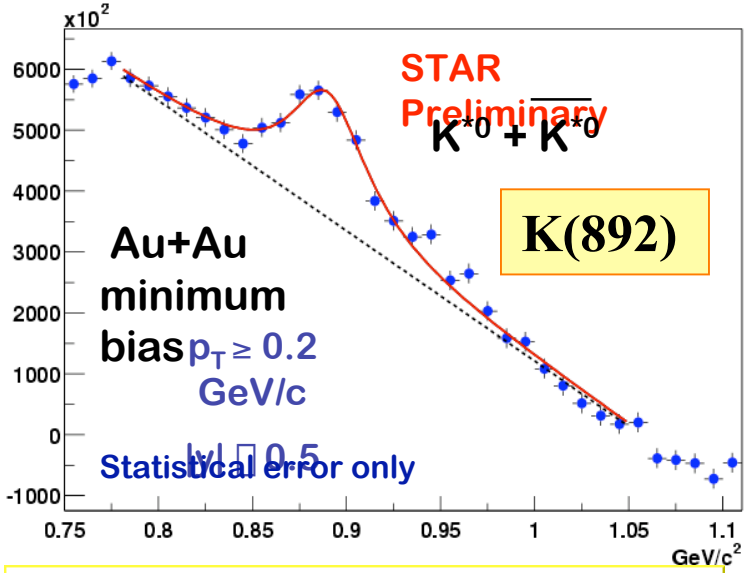


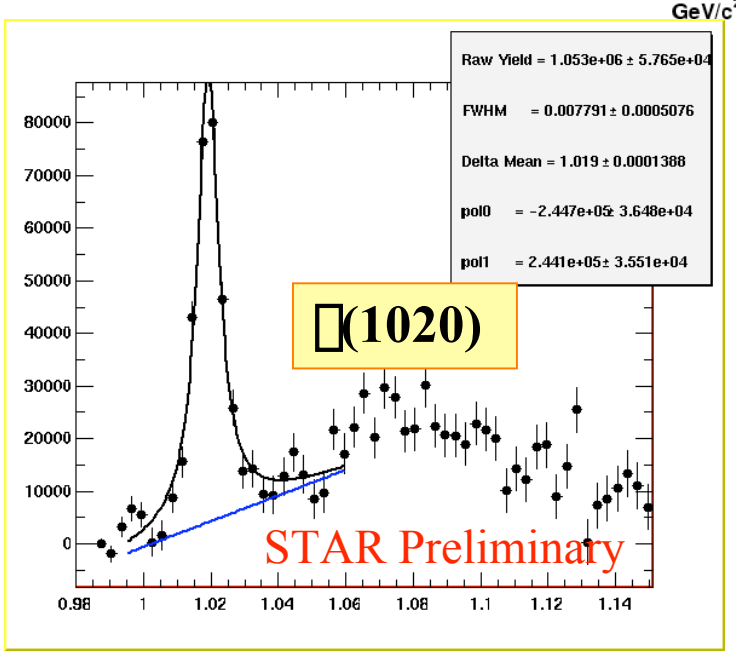

Bourquin and Gaillard
Nucl. Phys. B 114 (1976)

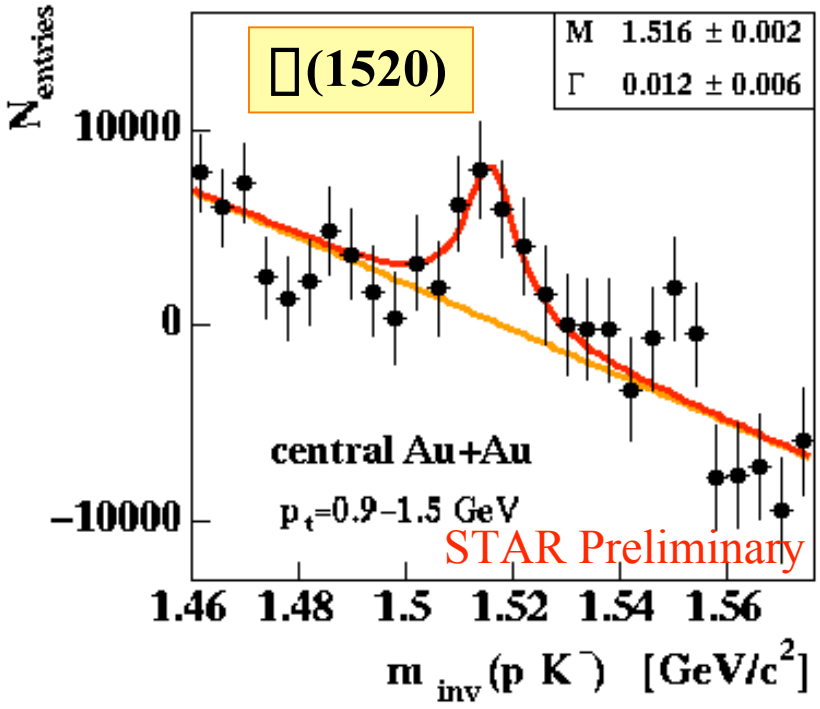
p+p at 23 GeV

High mass particles are not following the mean $p_T$ trend of ISR (□,K,p).
Stronger mass dependence.

# Strange Resonance Production in Au+Au Collisions



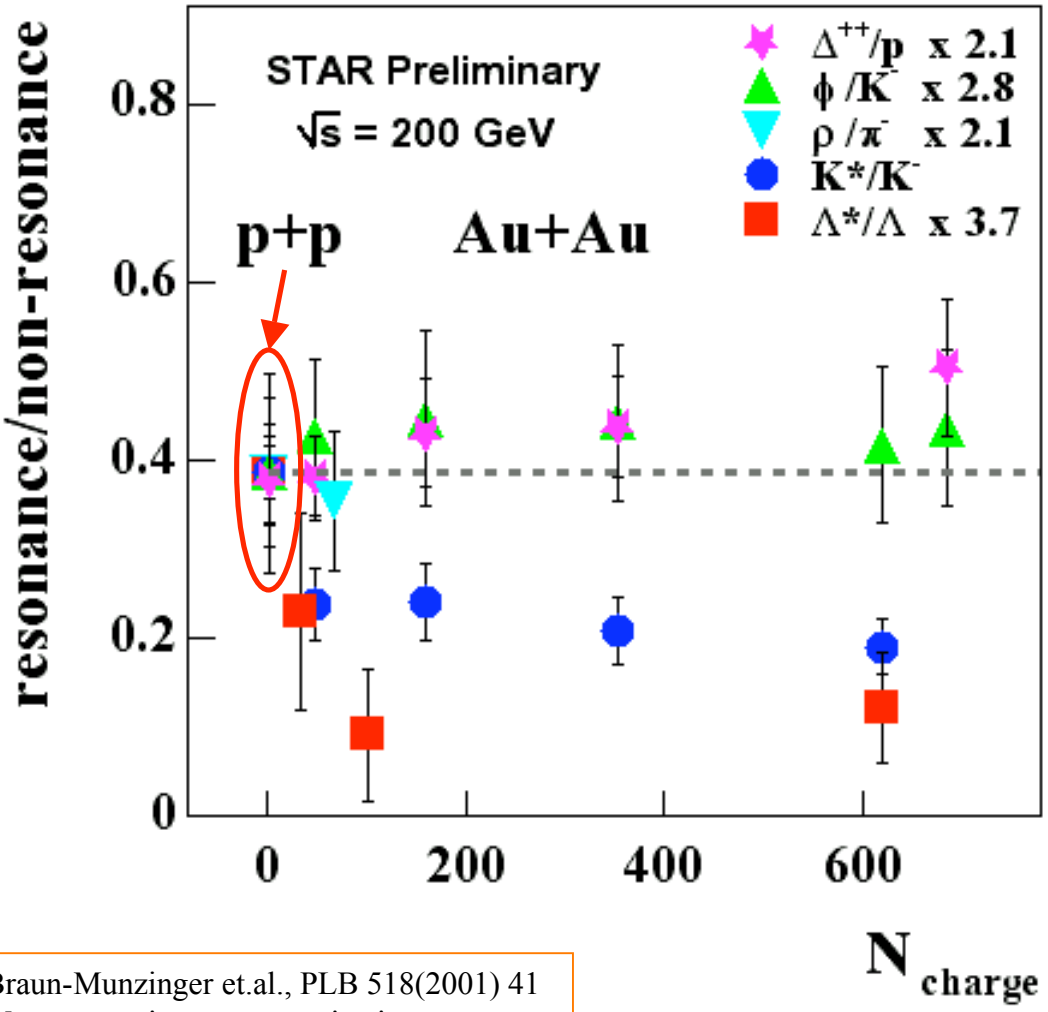

**dN/dy at y=0 central Au+Au**

**K(892)+Anti-K(892)/2 = 10.2 ± 0.5 ± 1.6 (poster H. Zhang)**

**φ(1020) = 7.70 ± 0.30 ± 10% (poster J. Ma)**

**Λ(1520) = 0.58 ± 0.21 ± 40% (assuming T=350-450MeV)**

# Resonance Production in p+p and Au+Au




**Life time [fm/c] :**
□(1020) = 40
□(1520) = 13
K(892) = 4
□++ = 1.7

**Thermal model [1]:**
T = 177 MeV
□B = 29 MeV

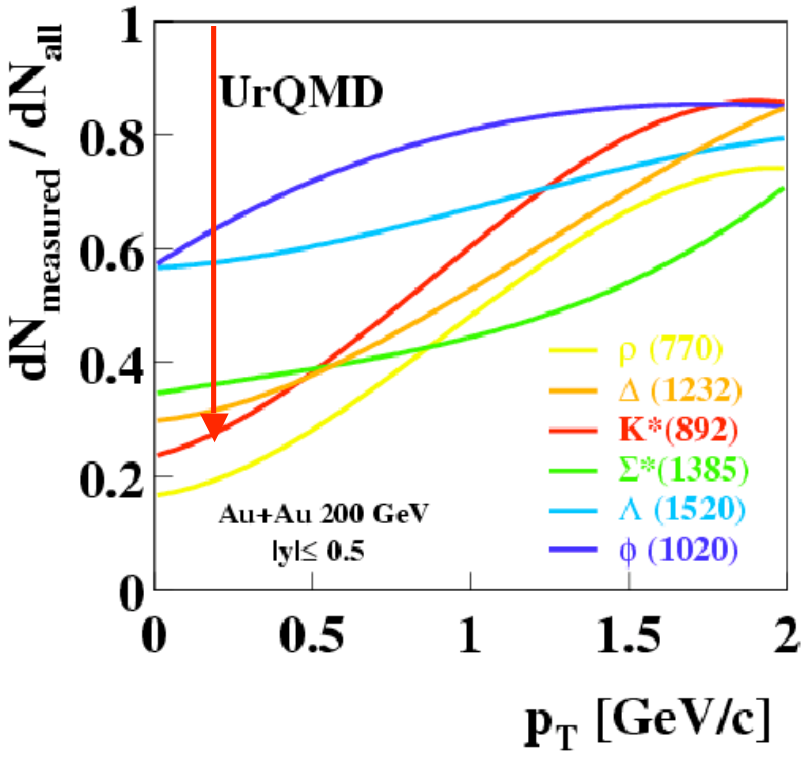
**UrQMD [2]**

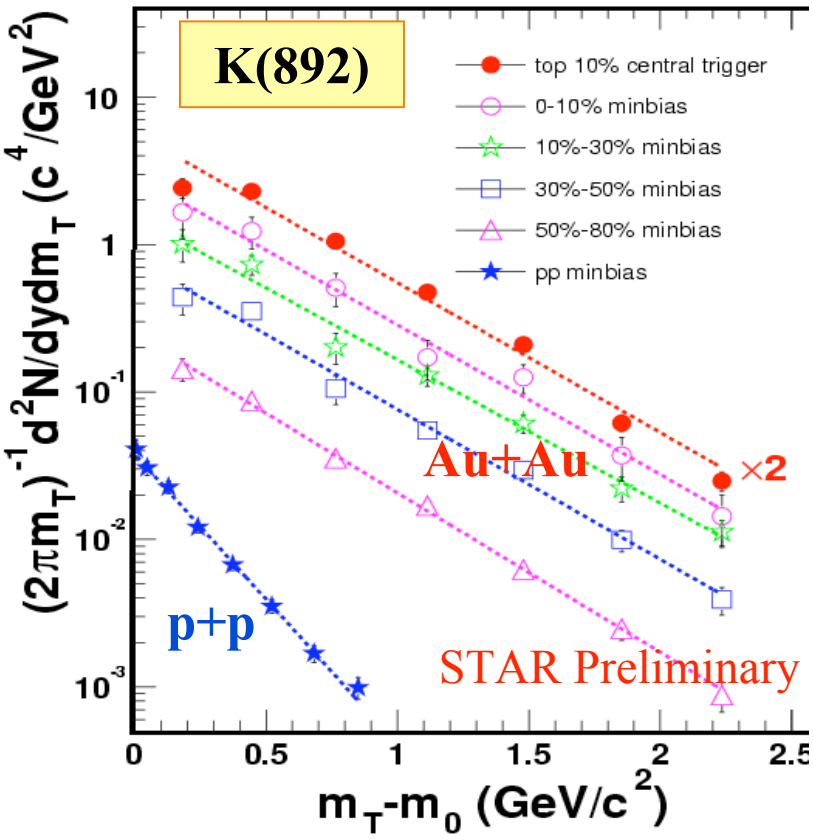
[1] P. Braun-Munzinger et.al., PLB 518(2001) 41
D.Magestro, private communication
[2] Marcus Bleicher and Jörg Aichelin
Phys. Lett. B530 (2002) 81-87.
M. Bleicher, private communication

Rescattering and regeneration is needed !

# Signal loss in low $p_T$ Region

Signal loss of ~70% for K(892)




**Inverse slope increase from p+p to Au+Au collisions.**
UrQMD predicts signal loss at low $p_T$ due to rescattering of decay daughters.
→ Inverse slopes and mean $p_T$ are higher.
UrQMD has long lifetime (□□5-20fm/c)

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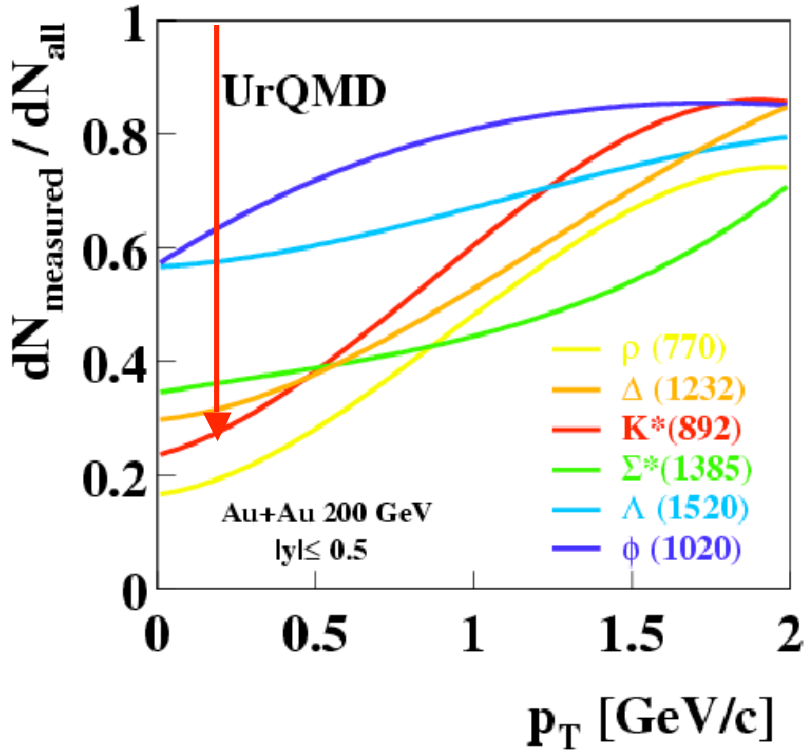


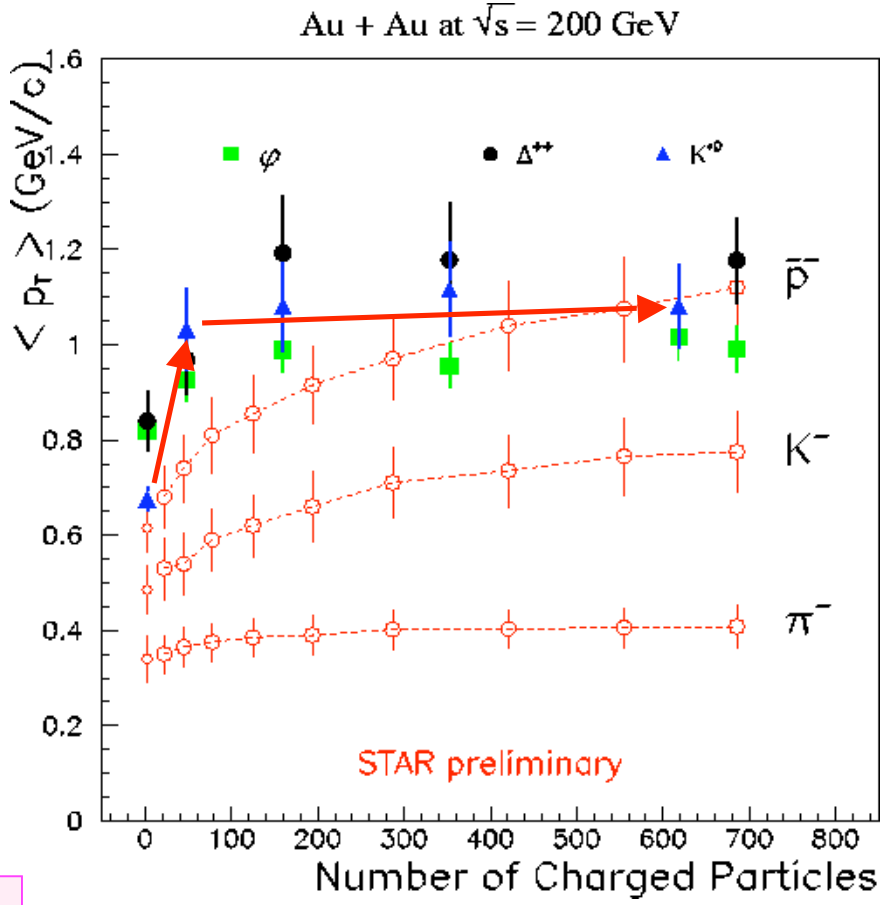


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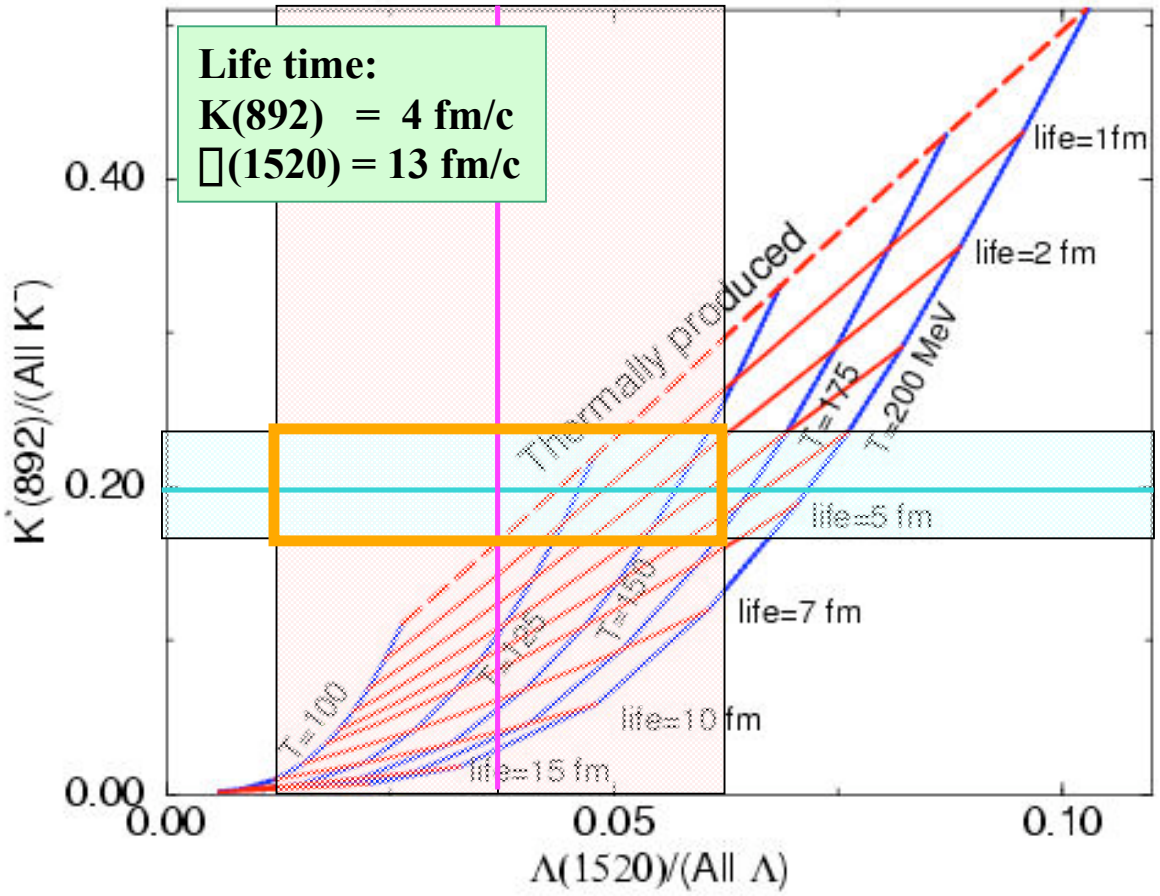
| | K(892) | Proton |
|---|---|---|
| Centrality | <pT> (GeV/c) | <pT> (GeV/c) |
| 0% - 10% | 1.080 ± 0.120 | 1.090 ± 0.110 |
| 50% - 80% | 1.030 ± 0.120 | 0.760 ± 0.050 |
| pp | 0.680 ± 0.040 | 0.620 ± 0.040 |

# Temperature, lifetime, and centrality dependence from □(1520) /□ and K(892)/K




G. Torrieri and J. Rafelski, Phys. Lett. **B509** (2001) 239

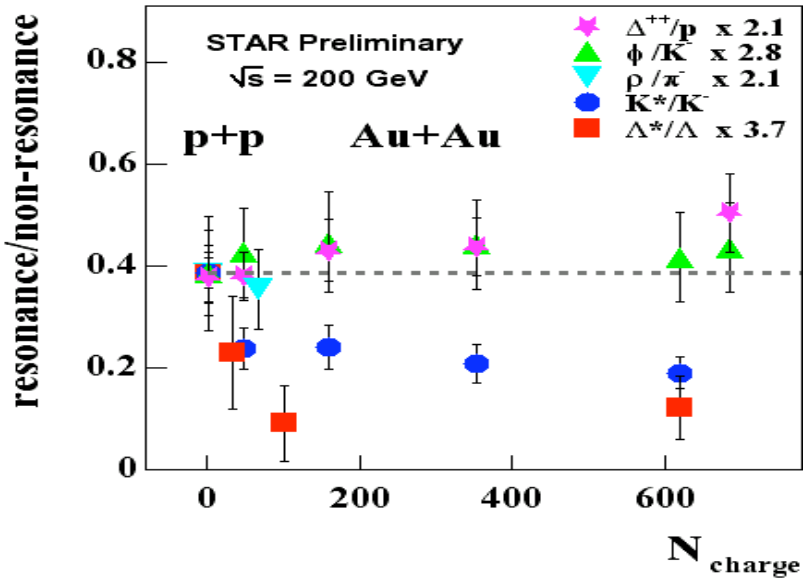
**Model includes:**

- Temperature at chemical freeze-out
- Lifetime between chemical and thermal freeze-out
- By comparing two particle ratios (no regeneration)

**results between :**

**T= 160 MeV => □□ > 4 fm/c (lower limit !!!)**

**□□= 0 fm/c => T= 110-130 MeV**

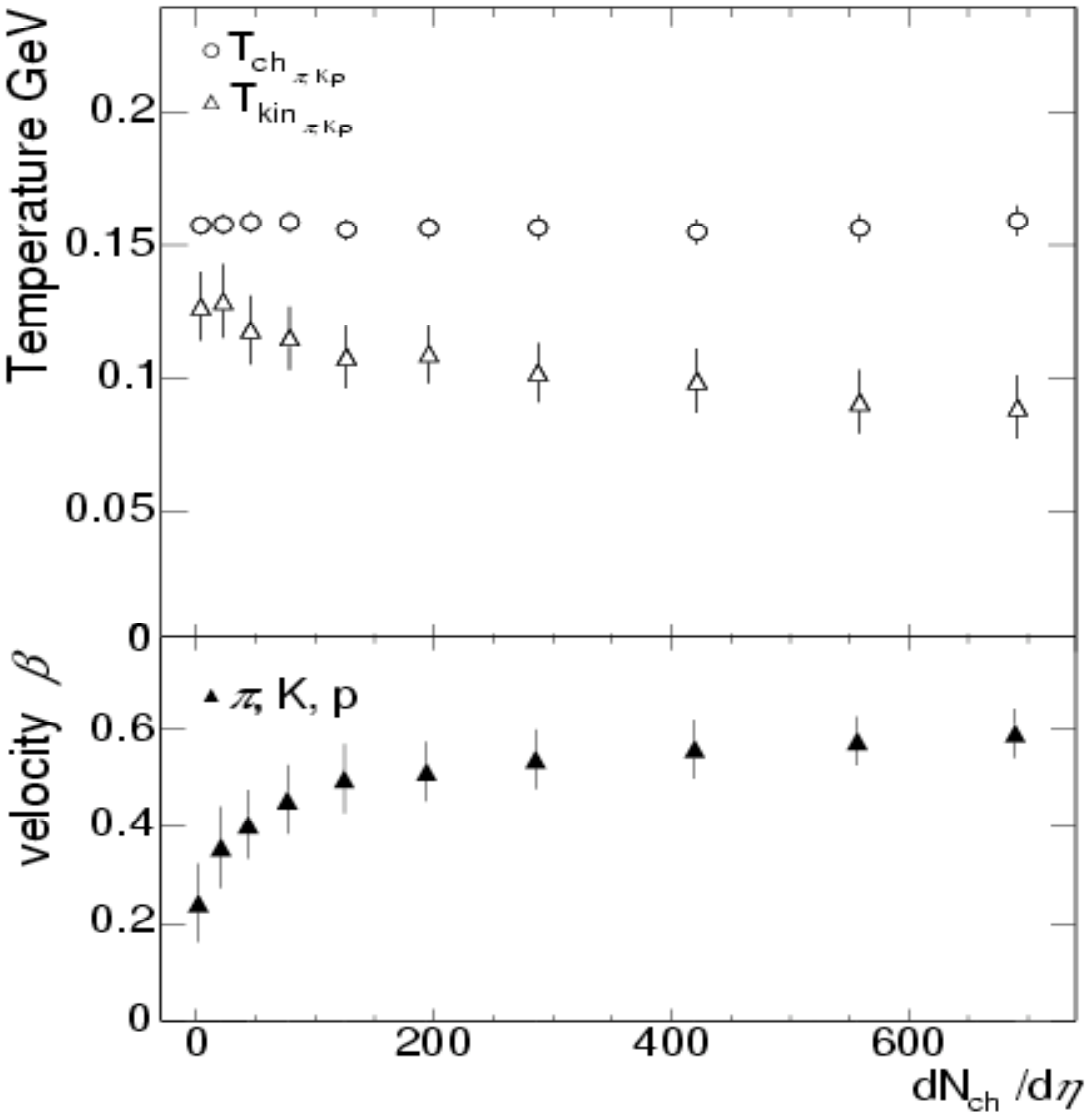



**□(1520)/□ = 0.034 ± 0.011 ± 0.013**

**K*/K⁻ = 0.20 ± 0.03 at 0-10% most central Au+Au**

More resonance measurements are needed to verify the model and lifettimes

# Temperature, lifetime, and centrality dependence from □(1520) /□ and K(892)/K

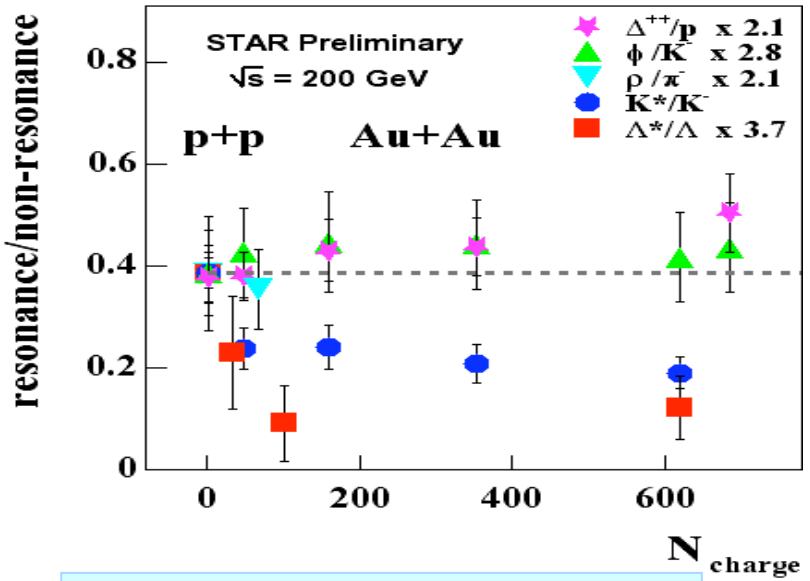



G. Torrieri and J. Rafelski, Phys. Lett. **B509** (2001) 239

**Blast wave fit of □,K,p ($T_{kin}$ +□) + $T_{chem}$**
**→ □□~ 6 fm/c** (see poster Olga Barannikova)

**□□does not change much with centrality because slight □T reduction is compensated by slower expansion velocity □ in peripheral collisions.**

**UrQMD → □□~ 5-20 fm/c**




More resonance measurements are needed to verify the model and lifettimes

# Summary

• Higher mass resonances (and □) show high mean $p_T$ in p+p collisions.

• K(892)/K and □(1520)/□ ratios are smaller in Au+Au than in p+p collisions. Thermal model predictions are higher than data. Rescattering and regeneration in hadronic source after chemical freeze-out.
→Microscopic model calculations are needed (e.g. UrQMD).

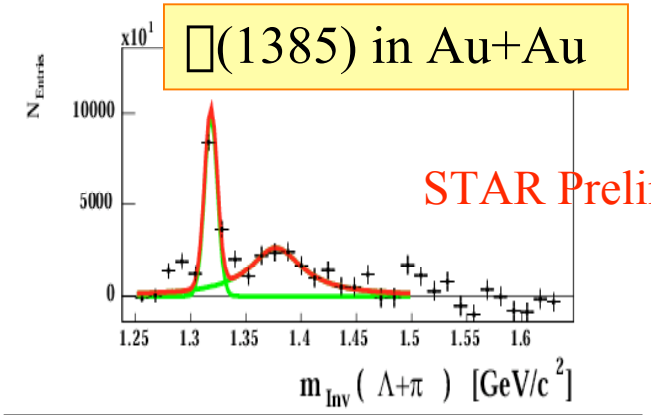
• Lifetime between chemical and kinetical freeze-out (□□) is greater than 4 fm/c. In agreement with results from blast wave fits of □,K,p spectra.

• Small centrality dependence in K(892)/K and □(1520)/□ ratios.
Suggest same lifetime (□□) for peripheral and central Au+Au collisions.

# Future Plans

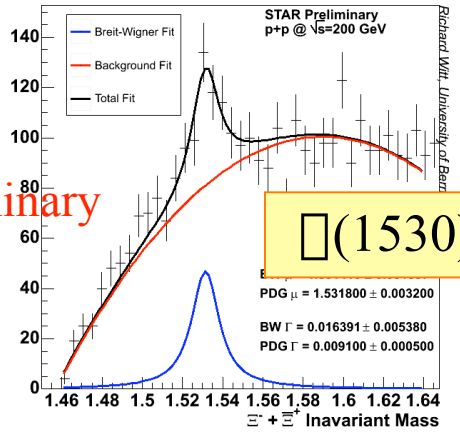
- More resonances measurements to come for Au+Au and p+p: □(1385), □(1530)

□(1385) in Au+Au



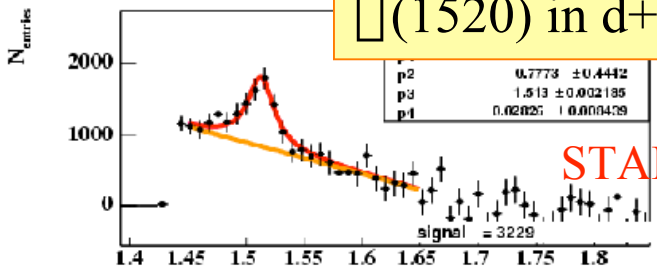

STAR Preliminary

□(1530) in p+p



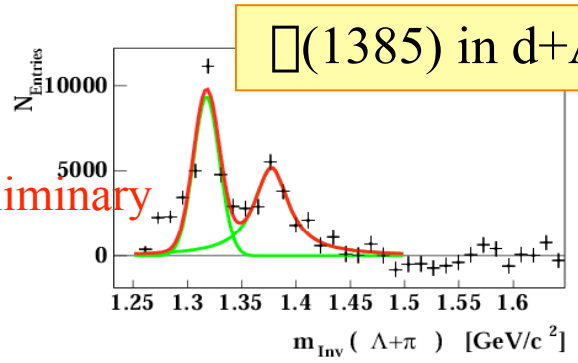

- Smallest medium with d+Au collision

□(1520) in d+Au



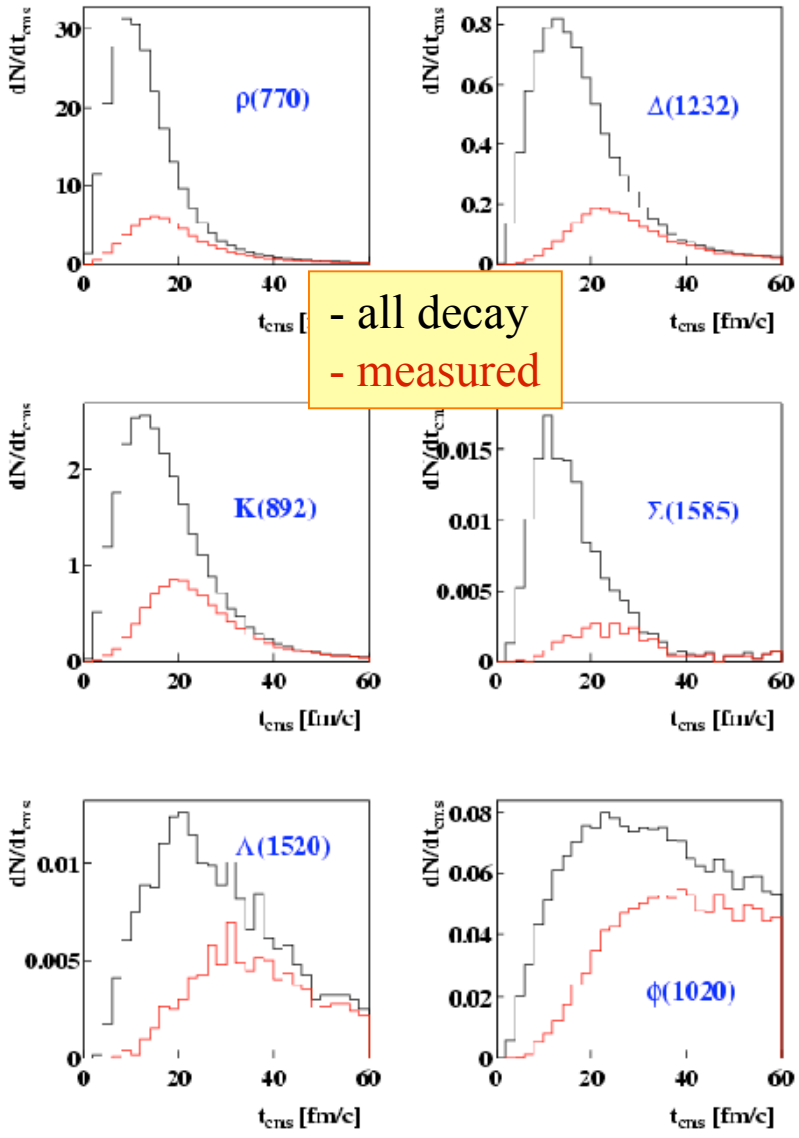

STAR Preliminary

□(1385) in d+Au




- Investigation of exotic particles with resonance technique
  Poster:Sevil Salur: Pentaquark searches with STAR at RHIC

# Surviving probability of Resonances in UrQMD

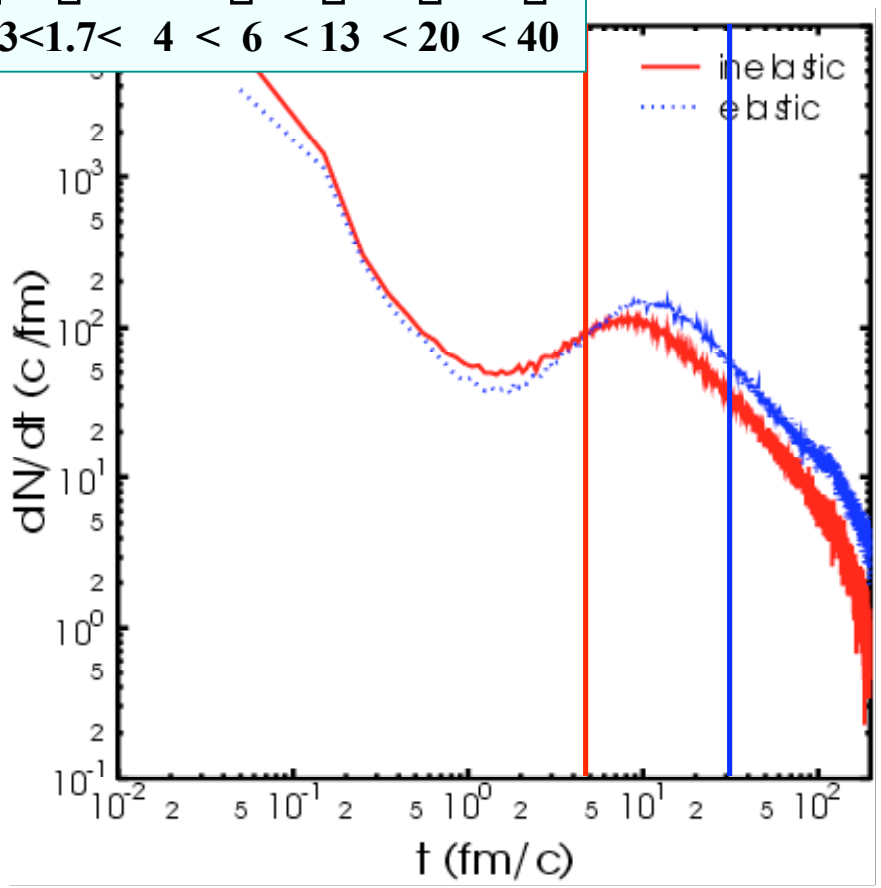



- all decay
- measured

**Short life time [fm/c]**

□< □< K* < □* < □* < □* < □

**1.3<1.7< 4 < 6 <13 <20 <40**




chemical freeze out ~ 5fm/c

thermal freeze out ~30 fm/c (long life time !)

# Invariant mass histogram