Fragments and Antifragments in STAR

Fragments are more sensitive to **flow** than particles.

effects due to baryonic mean fields?

Relationships between net baryon density and $d/\bar{d}$.

Rich information on nucleon sources at freeze-out (FO) via **coalescence** analyses.

At RHIC:
-T>>B_I
-meson dominated, and
net baryon-poor systems
-non-spherical FO geometries?

- shape of nucleon FO surface
  complementary to interferometry
- comparison of nucleon and antinucleon FO volumes
- isotopic resolution & P_T dependence → Temperatures, times
  complementary to spectra and interferometry
- effects on fragment rates from plasma formation?
  QGP→FO later→FO volume larger→fewer d's?
  what happens to $d/\bar{d}$?!?
- FO volumes for pions via scaling *vs.* dN_{chgd}/dy or dN_π/dy
- with "matched" models → v_T profiles, ρ profiles, ...

*Mattiello et al., PRC **55**, 1443 (1997*

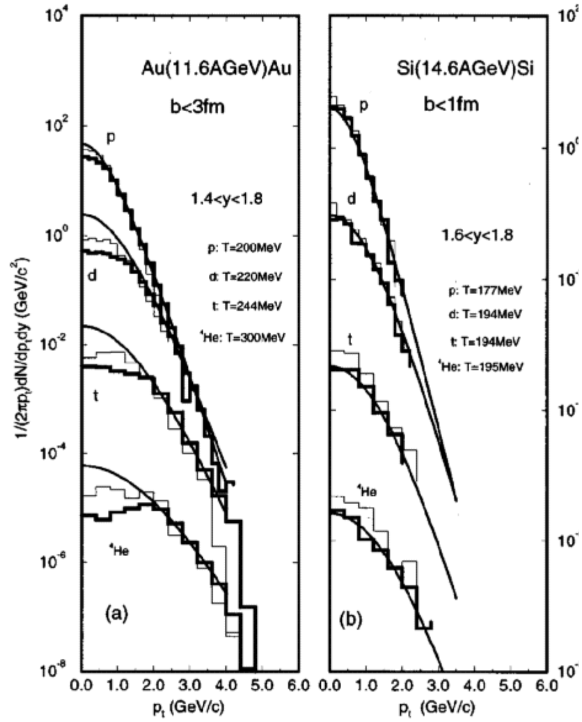

FIG. 4. Transverse momentum spectra for p, d, t, and ^{4}He Au(11.6A GeV)Au, b<3 fm (a) and Si(14.6A GeV)Si, b< fm (b) at central rapidities. Calculations including baryon potenti (bold solid histograms) are compared with cascade simulations (tl solid histograms). The smooth solid lines show Boltzmann parai etrizations adjusted to the high momentum part of the spectra (s text) in calculations with a potential interaction.

Do present models imply measurable (anti-)fragment production in central Au+Au at RHIC?

How well can STAR measure (anti-)fragments?

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Coalescence: EMPIRICAL, THERMODYNAMIC, DENSITY MATRIX, WIGNER, DYNAMIC

For extraction of source information from *measured* nucleon and fragment distributions, only last two approaches apply at RHIC.

WIGNER APPROACH:	DYNAMIC APPROACH:
Mattiello *et al.*, PRL **74**, 2180 (1995)	Nagle *et al.*, PRC **53**, 367 (1996)
Llope *et al.*, PRC **52**, 2004 (1995)	Kahana *et al.*, PRC **54**, 338 (1996)

For *predicting* fragment production rates in the absence of data, only avenue is "dynamic coalescence".

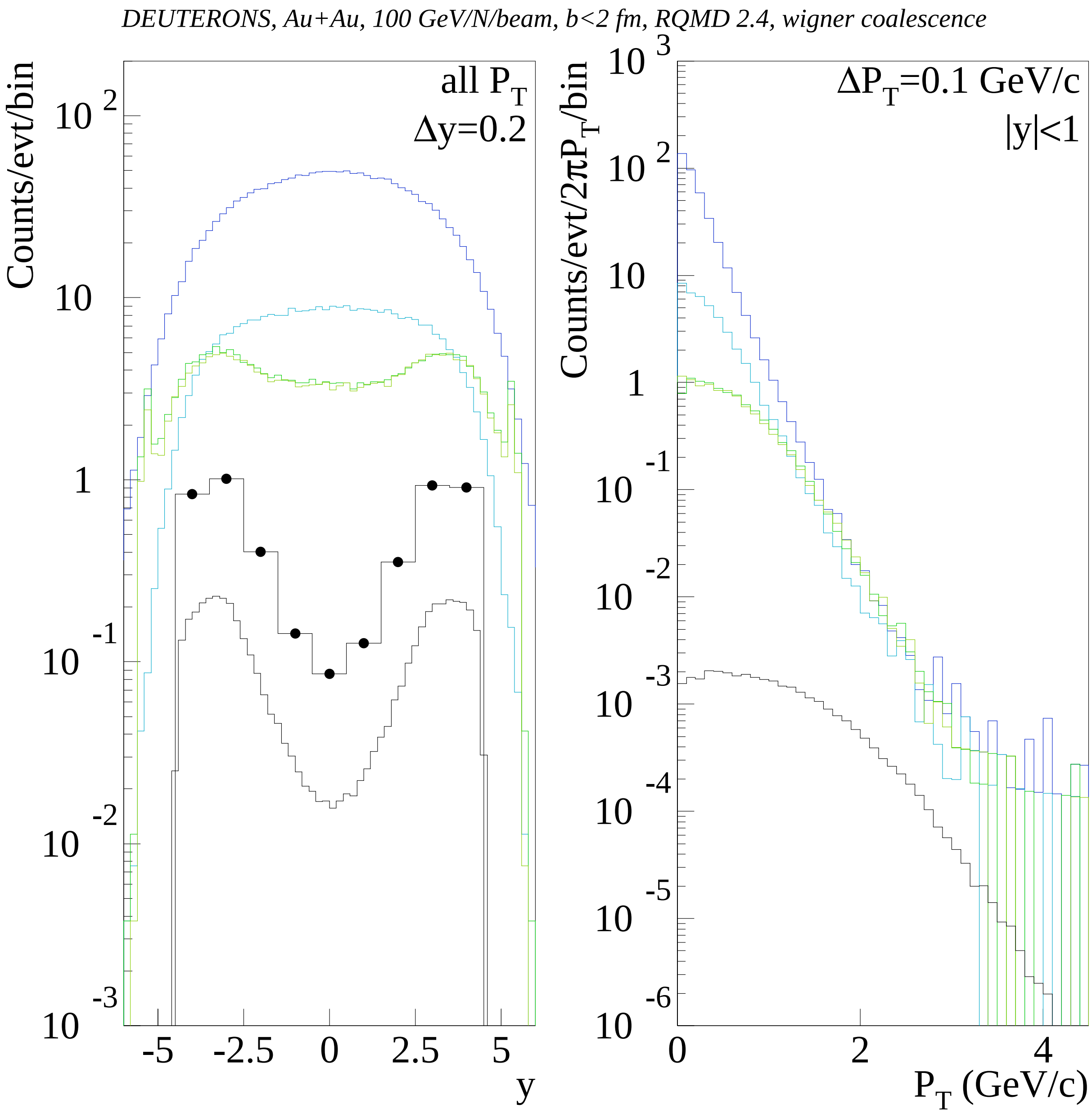
Dynamic Coalescence:

- don't approximate phase space density; take it from a model.
- stop the model at time step for which: MAX($E_{i,j}^{strong}$)<2 MeV
- for each particle in the event, the model gives time, position, and momenta at last strong interaction for each particle.

```
for every n-p pair per event   (or n̄-p̄ pair...)
   propagate to common time
   calculate ΔX and ΔP in the 2 particle CM
   if RAN() < Prob(ΔX,ΔP) → formed a d
      → save composite time, position, momentum
      → remove this p and n from the event.
```

```
                Cut-off
  Prob(ΔX,ΔP):  Harmonic Oscillator
                Hulthen Wave Function
```

Deuterons



→ **~0.1 deuterons** per central event per unit rapidity at mid-rapidity

→ **STAR collects >26k deuterons per RHIC day…**

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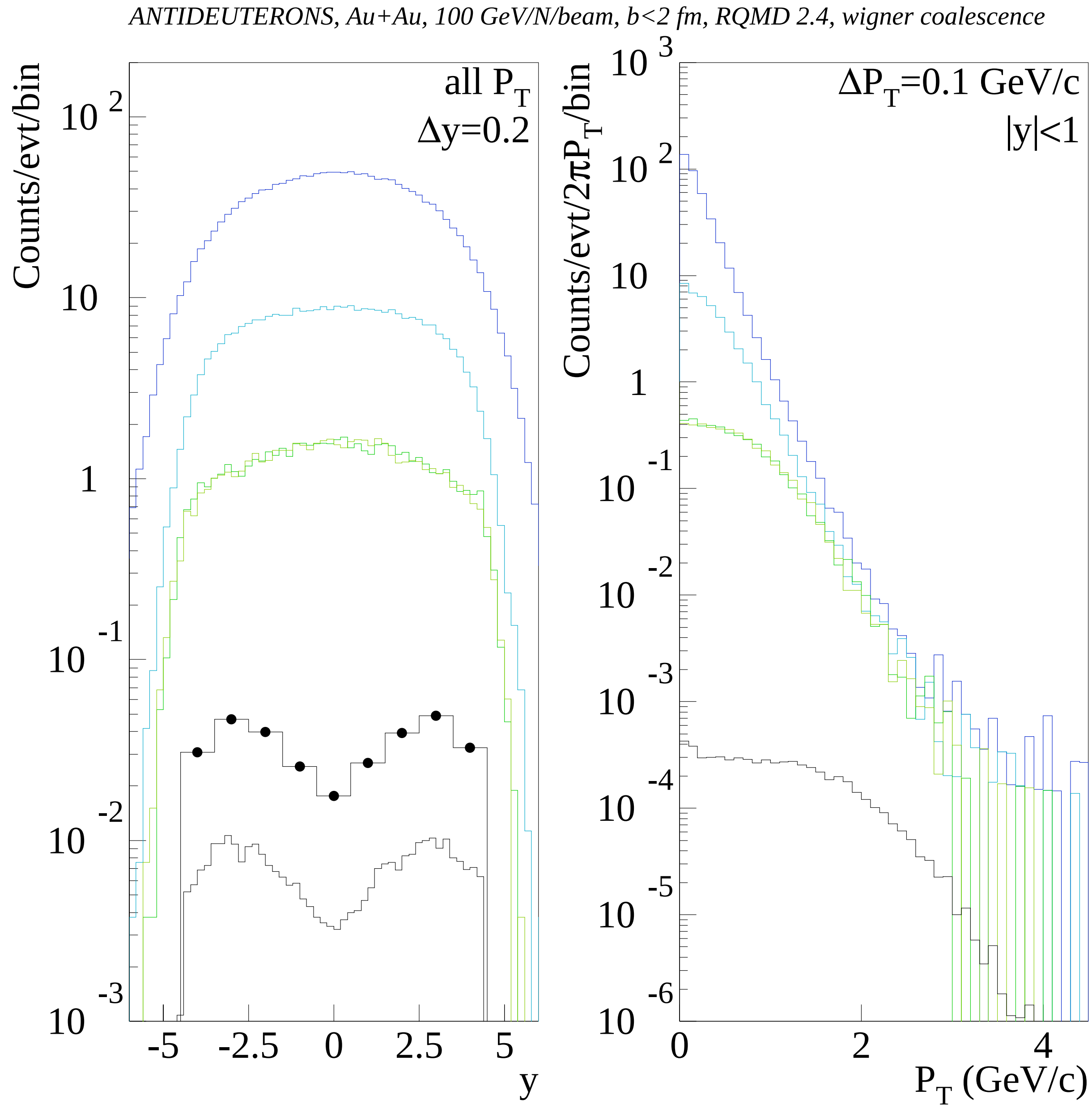
Anti-Deuterons



→ **~0.02 antideuterons** per central event per unit rapidity at mid-rapidity

→ **$d/\bar{d}$ ~ 5** at mid-rapidity…

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Nucleon Freeze-out Radii via coalescence arguments

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$$(\mathbf{R}^2 + \frac{\rho_c^2}{2})^{3/2} = \pi^{3/2} \frac{(2S_c+1)}{(2S_a+1)(2S_b+1)} \frac{(d^3\mathbf{N_a}/d^3p_a)(d^3\mathbf{N_b}/d^3p_b)}{(d^3\mathbf{N_c}/d^3p_c)} e^{(B_c - B_a - B_b)/T}$$

where

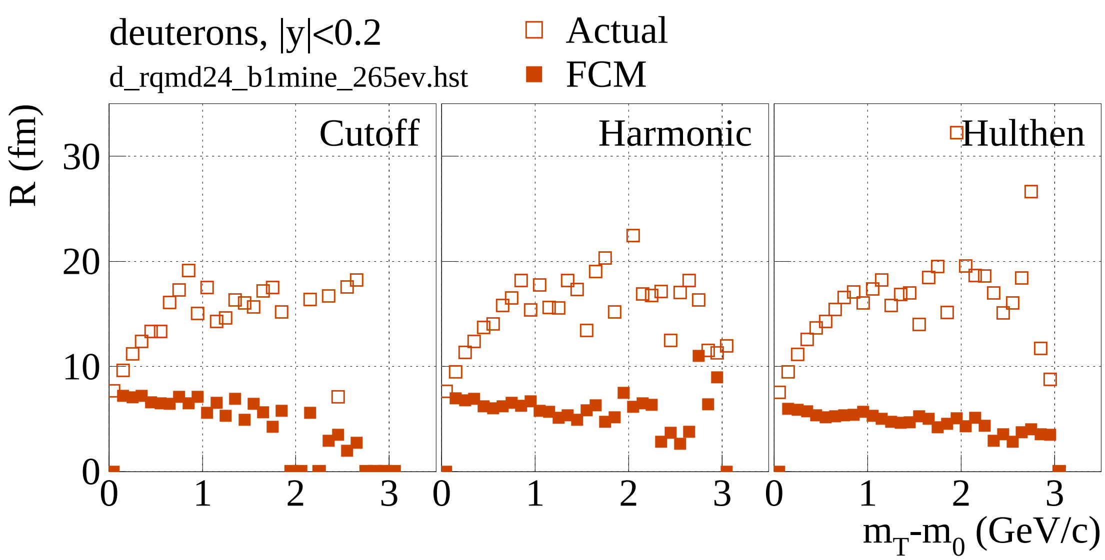
$(d^3\mathbf{N}/d^3p)$ is an invariant cross section (*e.g.* $d^2N/2\pi/m_T/\Delta m_T/\Delta y$ or $d^2N/m/\beta^2/\Delta\beta/\Delta\Omega$)

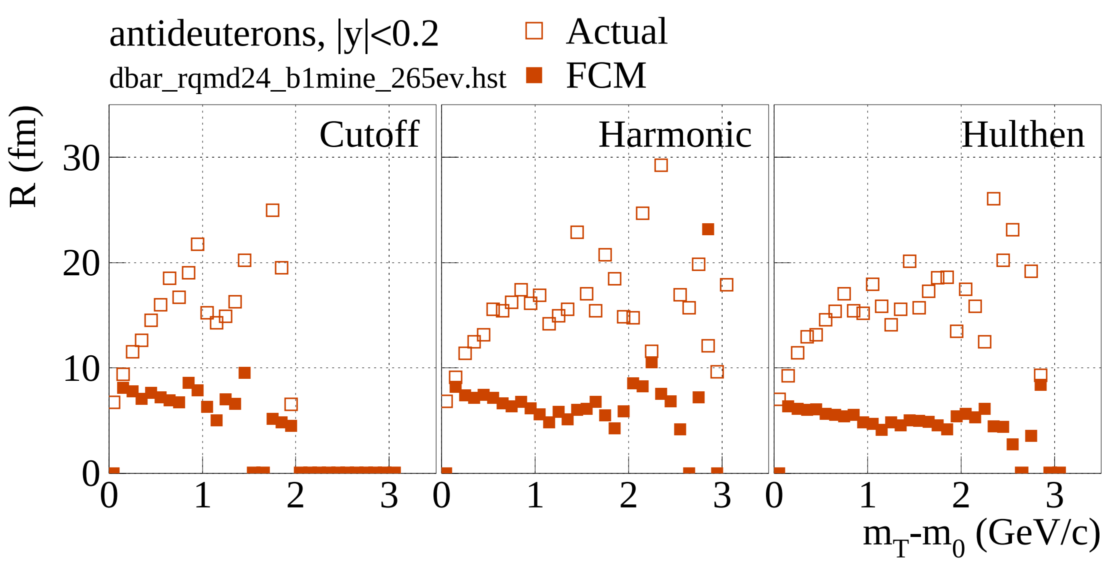
The cross - sections are evaluated at the same velocity...

Spins are Sa, Sb, and Sc, Binding energies are Ba, Bb, and Bc

Temperature is T, Fragment finite size correction is ρ $\rightarrow$ Gaussian radius **R** in fm...

*W.J. Llope, S. Pratt et al. Phys. Rev. C 5**2**, 2004 (1995).*





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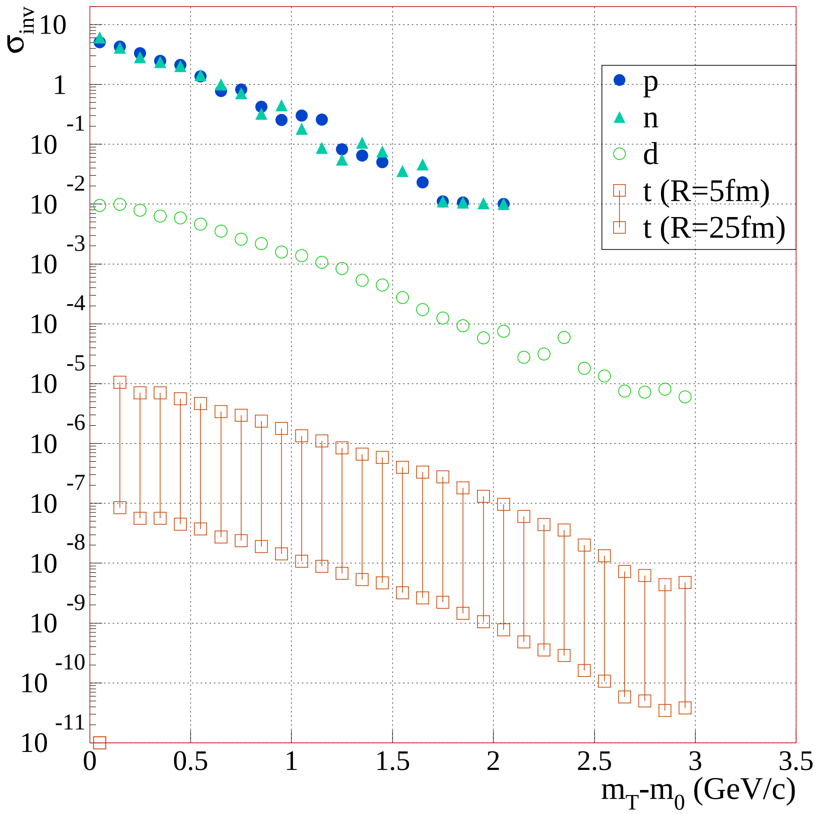
Triton prediction using coalescence arguments



n + d ↔ t

$R_G^3 \propto N_n N_d / N_t$

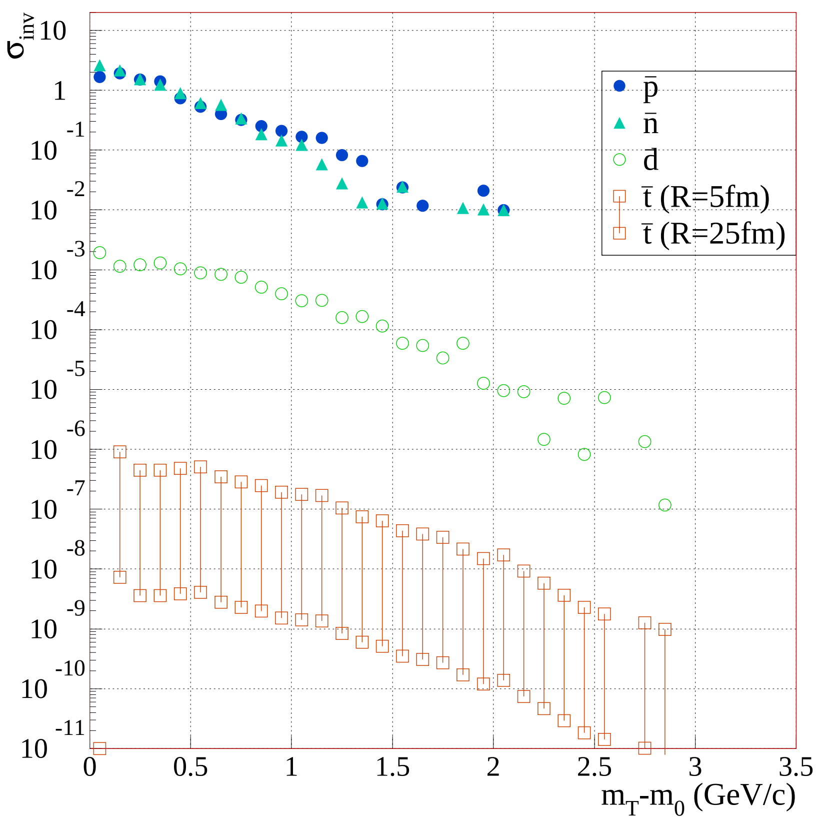
N_n from RQMD

N_d from dynamic coalescence

Assume R_G

Calculate N_t

a p + d ↔ ^{3}He prediction is also possible in the same way…



p/d ~ 370

d/t > 1150

pbar/dbar ~ 840

dbar/tbar > 2400

d/dbar ~ 5

t/tbar ~ 11

(Au+Au, 100 GeV/N/beam, b<2fm, RQMD)

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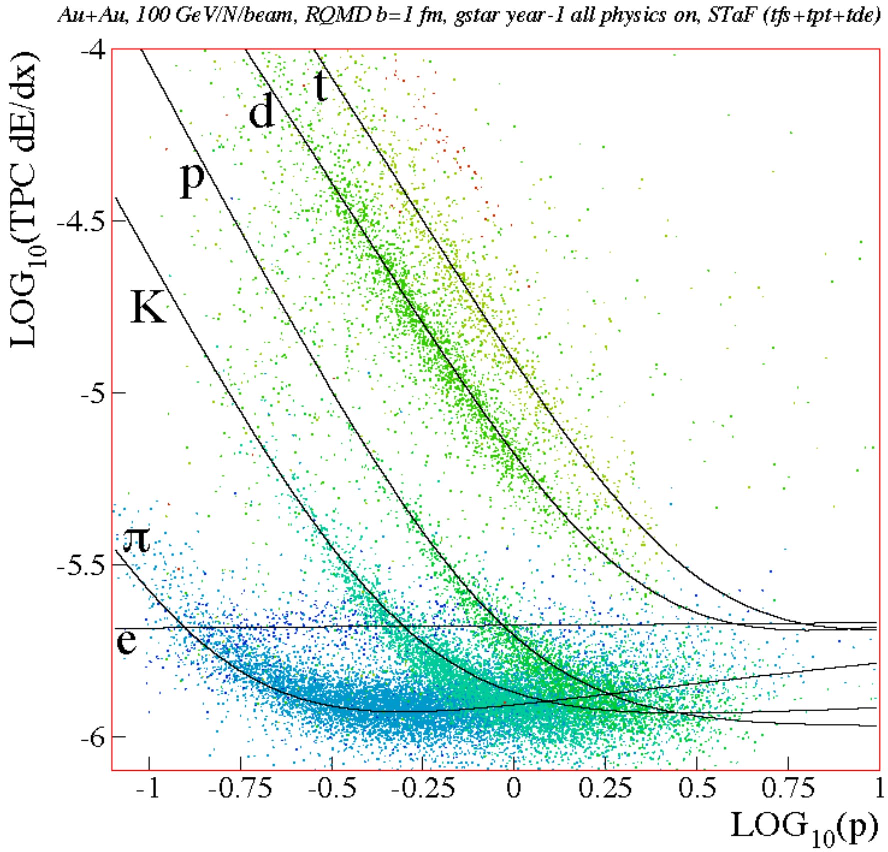
Fragment measurements in STAR

Track ⟨dE/dx⟩ versus momentum from the TPC…



Dynamic range of dE/dx ADCs introduces low-momentum cutoff…

Normal runs – deuteron P_T > ~0.4 GeV/c don’t overflow

– triton P_T > ~0.56 GeV/c

Special runs – reduce gas gain and magnetic field…

Significant evaporation backgrounds in x+Be → d + X

~0.2 d/central event *(Preliminary)* after some cuts…

Presently studying “d.c.a.” and P_T dependences…

Antideuteron sample necessarily purer…

Larger corrections/backgrounds for particle spectra and ratios

than for antiparticle spectra and ratios…