Light Nucleus Production in p+p & d+Au

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Light Flavor Spectra PWG Presentation
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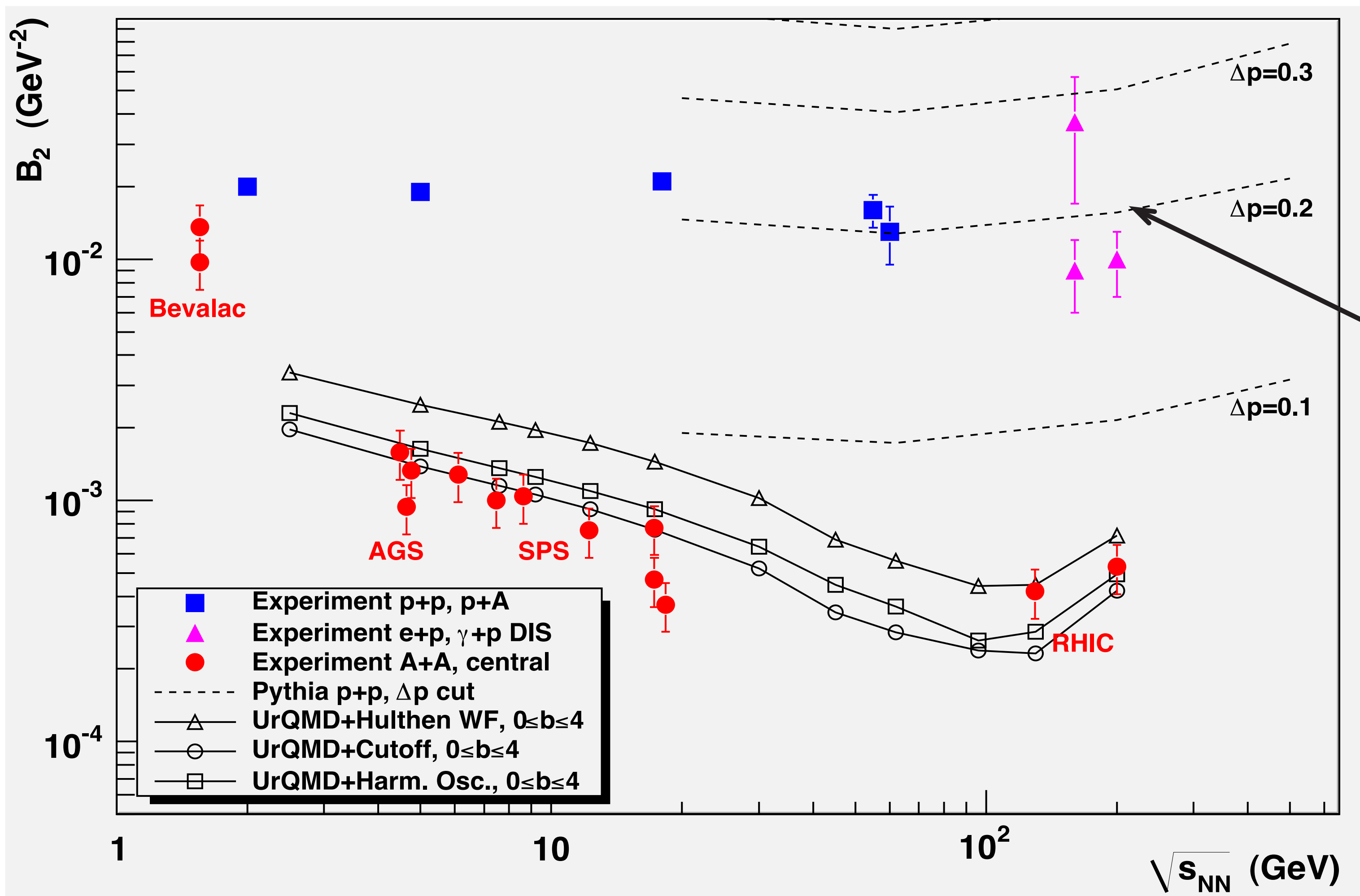
Existing Results on B_2

$B_A = \sigma_A / [\sigma_N]^A$ where the cross-sections are evaluated at same momentum

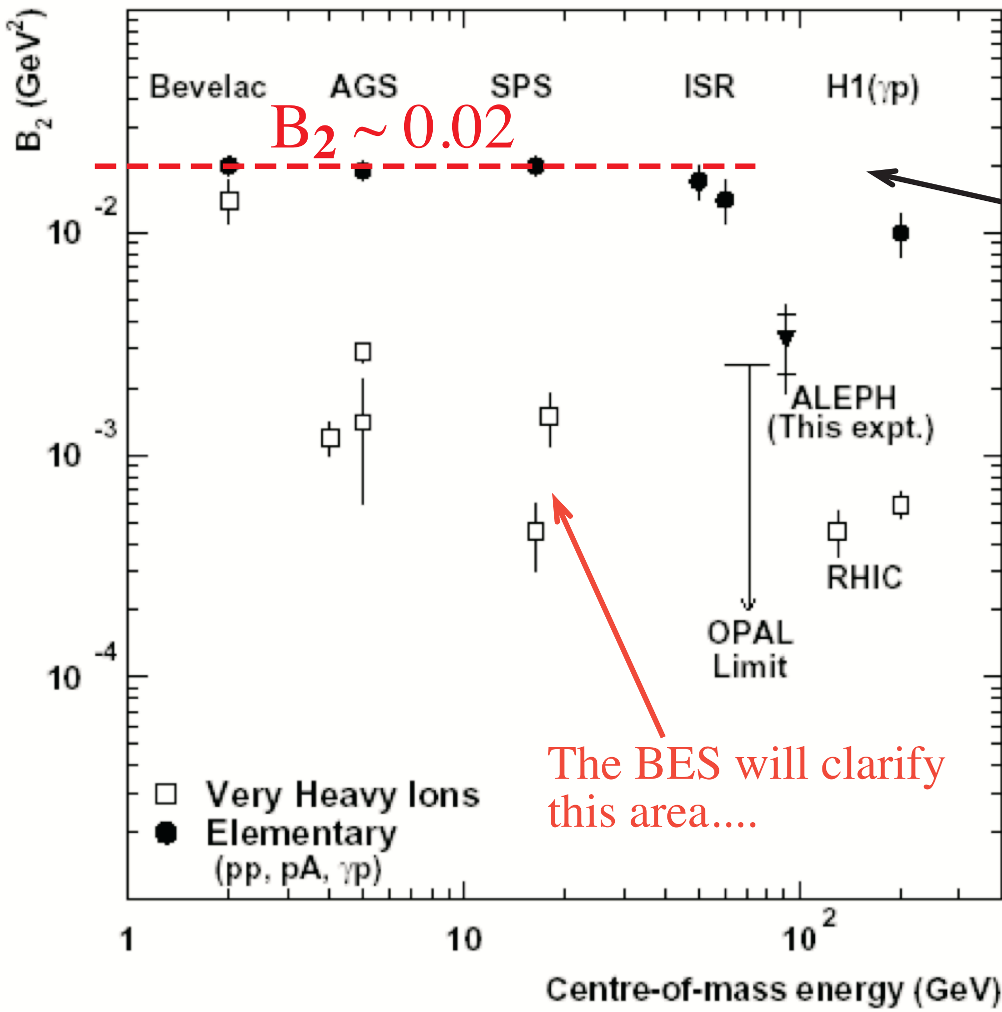
$B_A = d/p^2$ where cross-sections are formed at same P_T/A & $y=0$, $\Delta y=1.0$



where's the RHIC results?

deuterons relative to protons is largest in "elementary collisions"...

- factor of ~40 larger than in A+A according to the trend (blue squares)
- essentially independent of $\sqrt{s_{NN}}$ ... also unlike A+A



T. Sloan, GDR Meeting Paris April 2006
http://www.lpta.univ-montp2.fr/GDR/documents/reunion2_2006/sloan.ppt

where does the RHIC data fall?

...we have p+p @ 62, 200, & 500 GeV
& d+Au @ 200 GeV

Conventional Wisdom:

p+p: several strings stretched between 2 hadrons
→ B2 ~ 0.02

γ+p: fewer strings
→ B2 ~ 0.01

e+e: only one string
→ B2 ~ 0.003

A+A: lots of strings, but strong rescattering kills all d's except those that form very late
→ B2 ~ 0.0003

Gosta Gustafson, Jari Haikkinen,
Z. Phys. C 61,683-687 (1994)

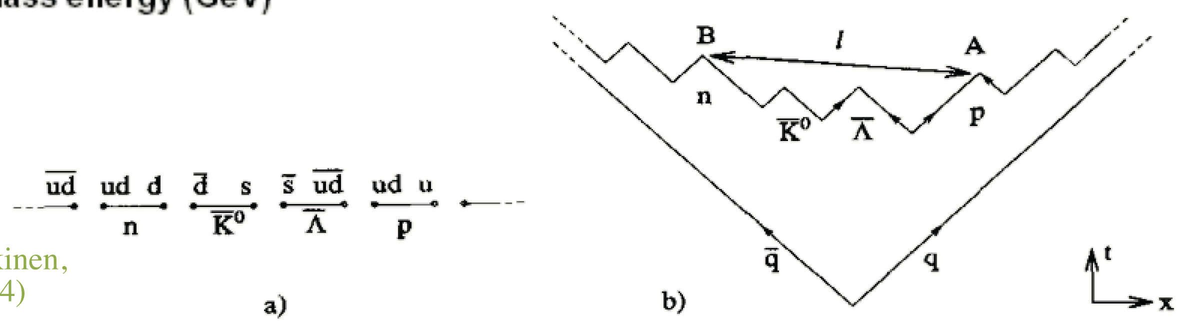
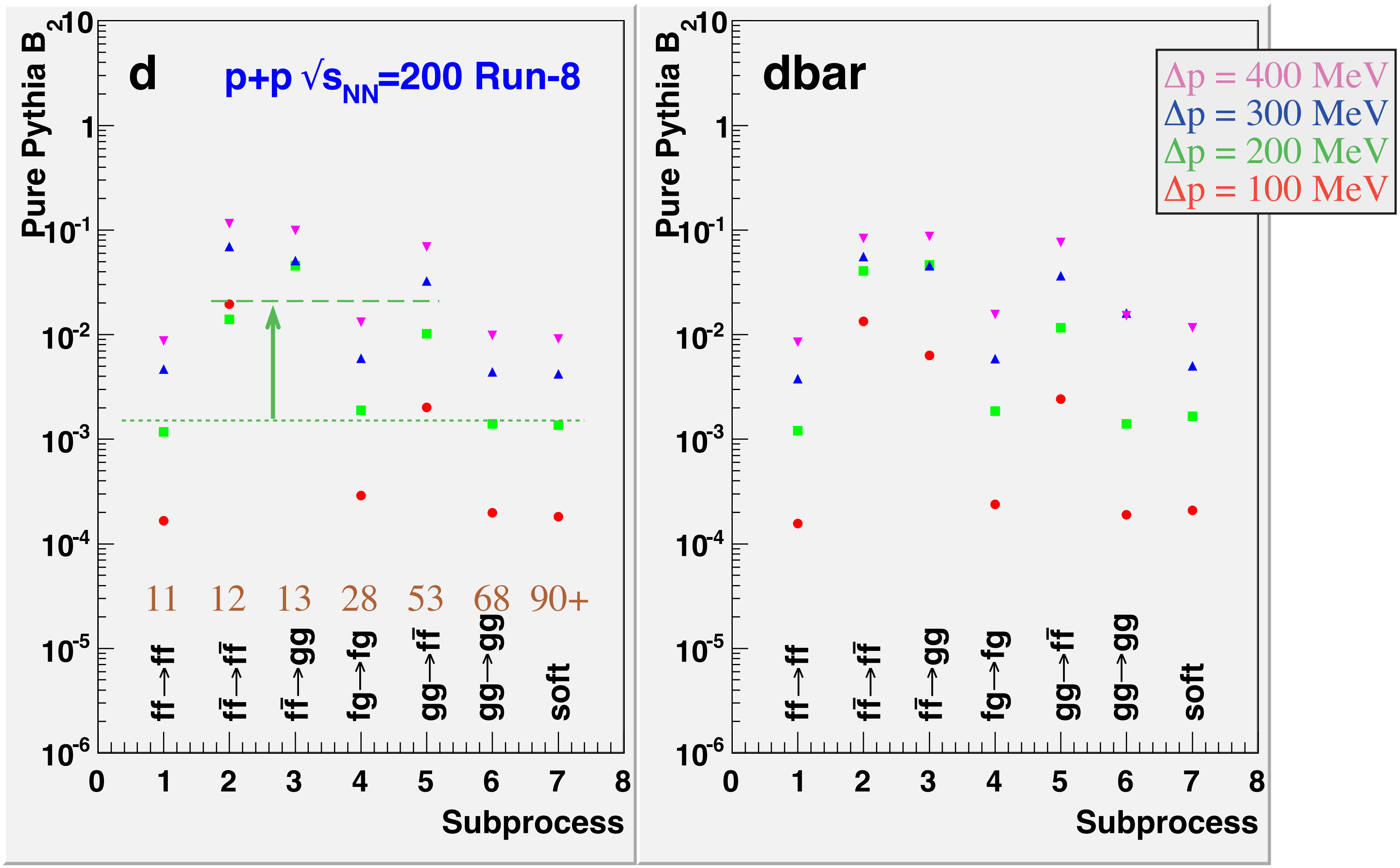


Fig. 3a, b. a Possible string breakup process with a *pn* pair. **b** Space-time structure of the breakup

Coalescence Afterburner + pure Pythia events.....

define Δp - the relative momentum cutoff for p+n pair forming a deuteron ($k = \Delta p/2$)

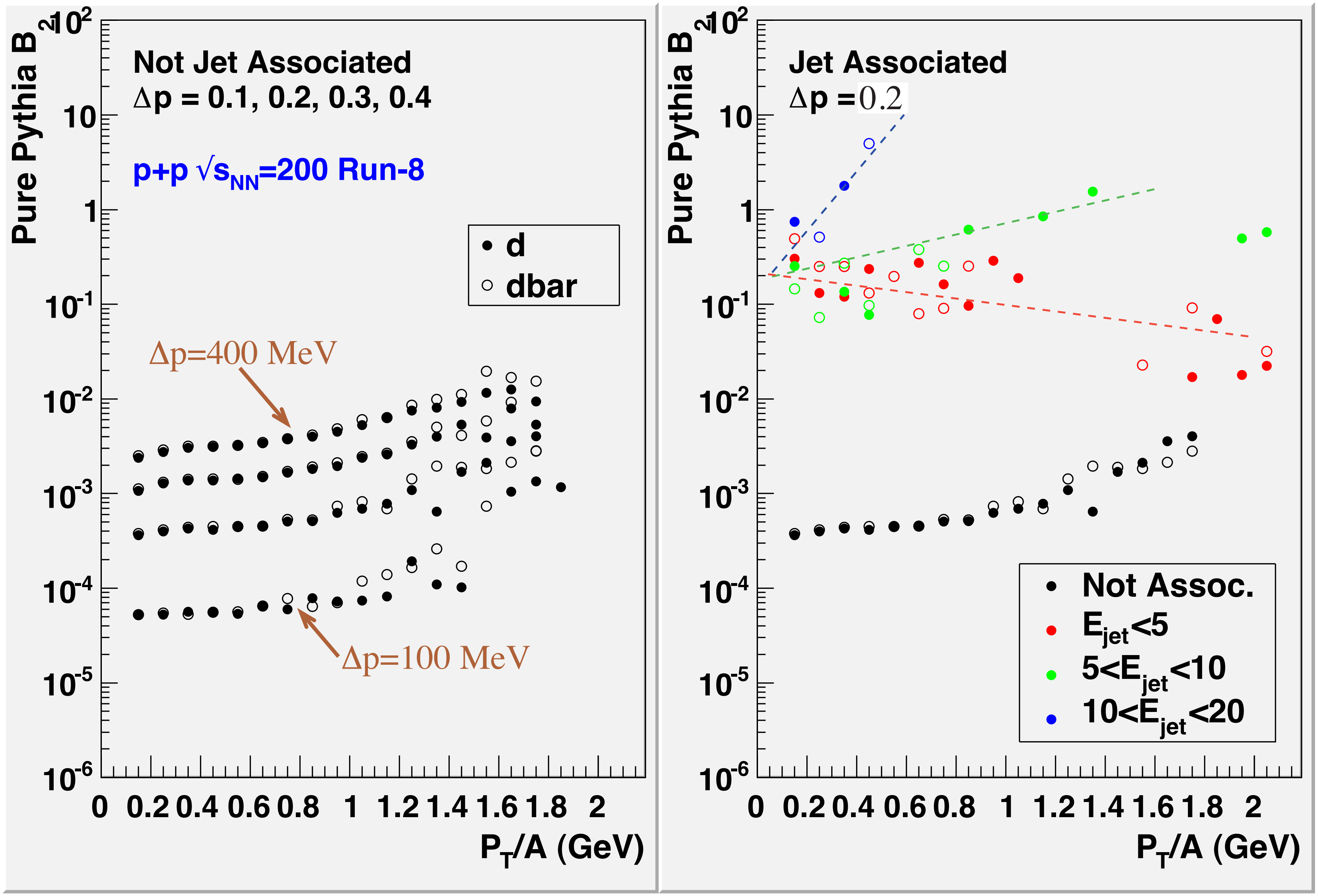
Δp ~ 120-140 MeV implied by earliest Bevalac A+A results...
(somewhat larger value required to match existing p+p data - see previous pages)



Factor ~10 differences in d/p^2 depending on Pythia subprocess......

Jets and deuteron production.....

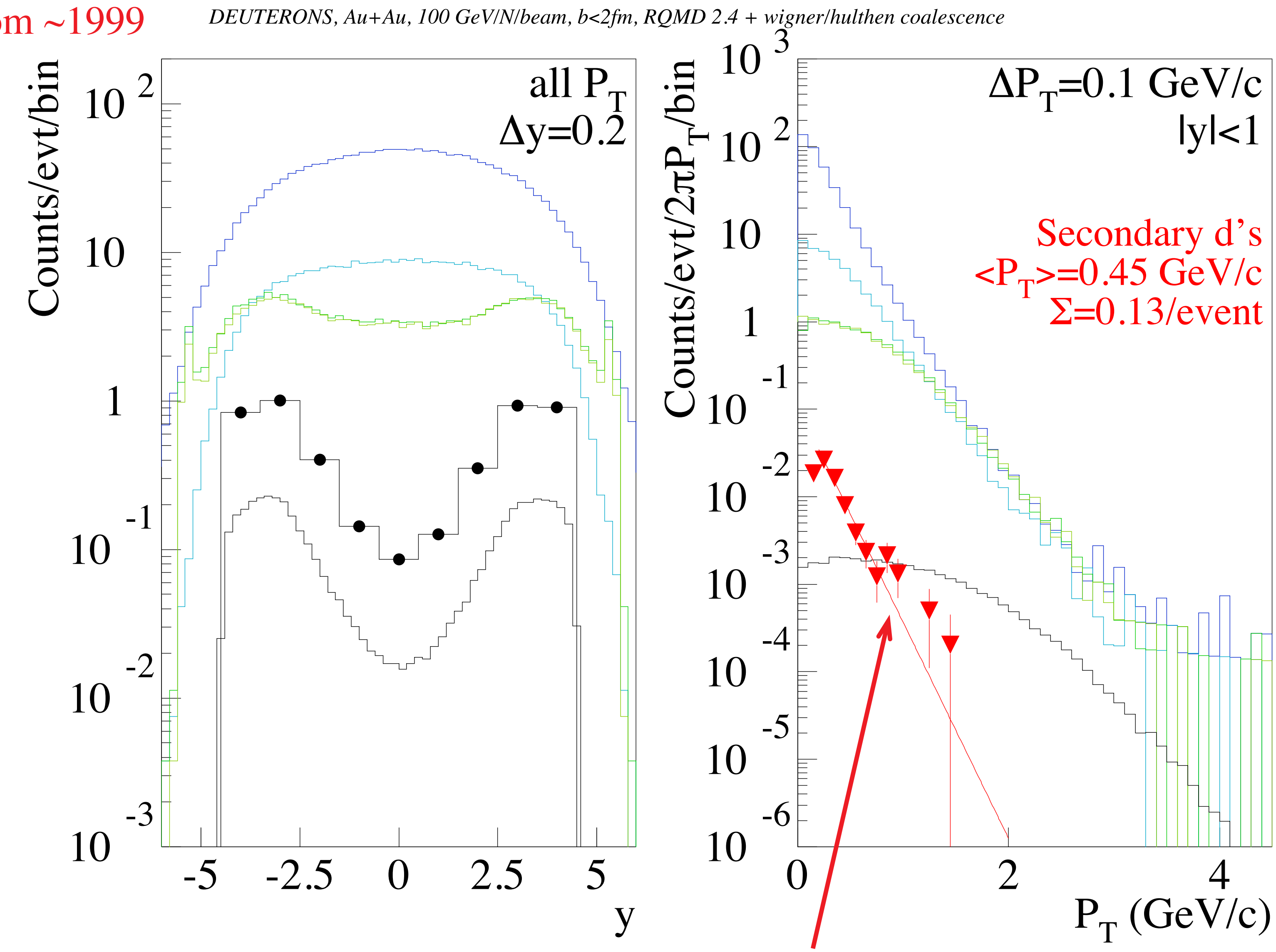
use Pythia's PYCELL (simple seeded cone) to find jets....



B2 values hugely increased in Jets... (and also increase with the jet energy?)

Significant spallation backgrounds are well-known....

from ~1999



background d calculation by Dave Hardtke

see also J. Nystrand, DIS2004, nucl-ex/0409006

High production rate (relative to p) and low track densities

→ elementary collisions as a test-bed to optimize cuts & background calculations?

Goals:

- learn how to use ☆ MuDsts & offline software...
- investigate DCA-type cuts to suppress spallation backgrounds
  - track densities are relatively low...
  - primary vertex not as precisely defined...
- extract cross-sections and coalescence parameters for d and t production & compare to:
  - trends implied by the existing lower-energy data....
  - UrQMD or Pythia calculations with coalescence afterburner...
- Include direct Jet-finding & investigate fragment production mechanisms...

Data:

Run-6	p+p	$\sqrt{s_{NN}} = 62$ GeV	4.8 M events
Run-8	p+p	$\sqrt{s_{NN}} = 200$ GeV	36.1 M events
Run-8	d+Au	$\sqrt{s_{NN}} = 200$ GeV	75.8 M events

Cuts:

Require that a Primary Vertex was found...

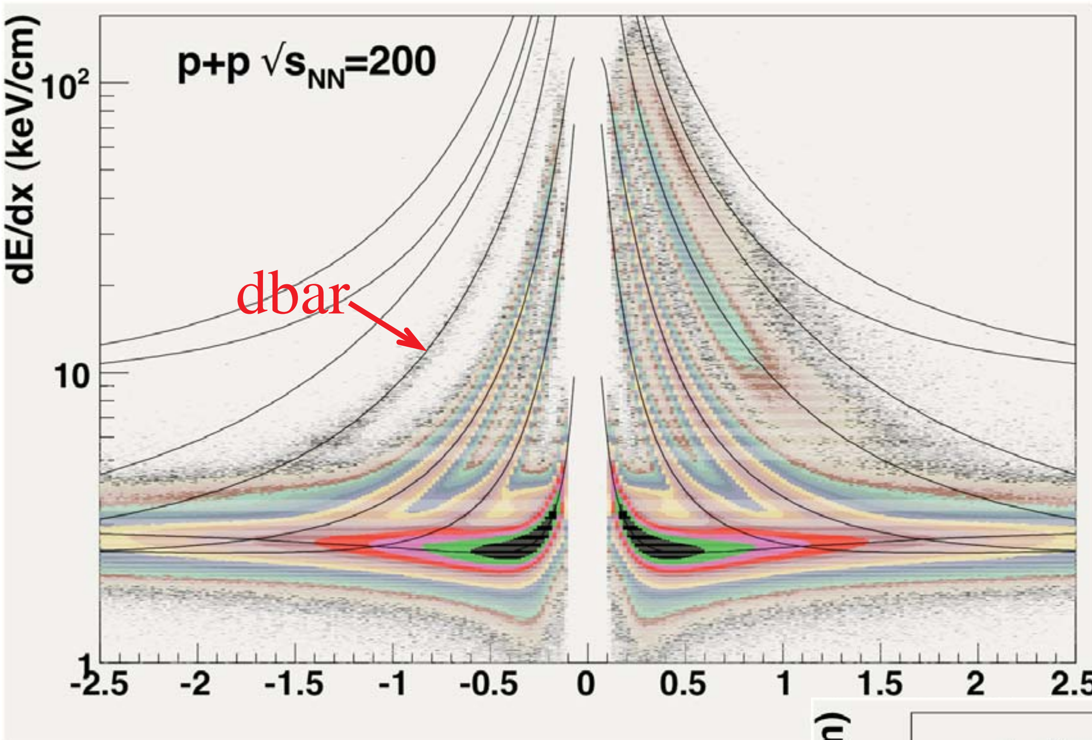
Nfitpts > 15, Nfitpts/Nhitsposs > 0.52, DCAglobal < 1.0cm

Presently, use only TPC dE/dx for PID....

A.S.A.P....

Include PID from the significant TOF coverage in the Run-9 data....

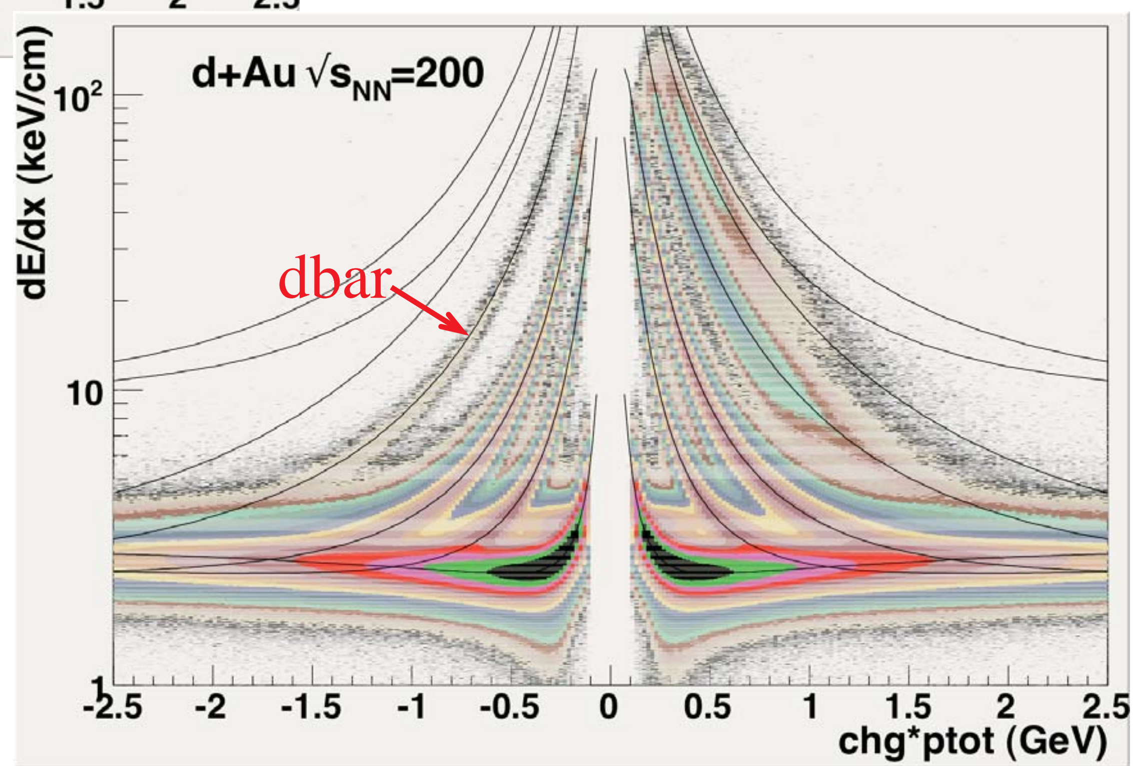
Produce plots for the new $\sqrt{s_{NN}} = 500$ GeV data....



d/dbar is huge... (spallation in ☆)

Significant dbar signal in our p+p and d+Au data.....

Some tbars and He-3's too...
(hard to see here though)

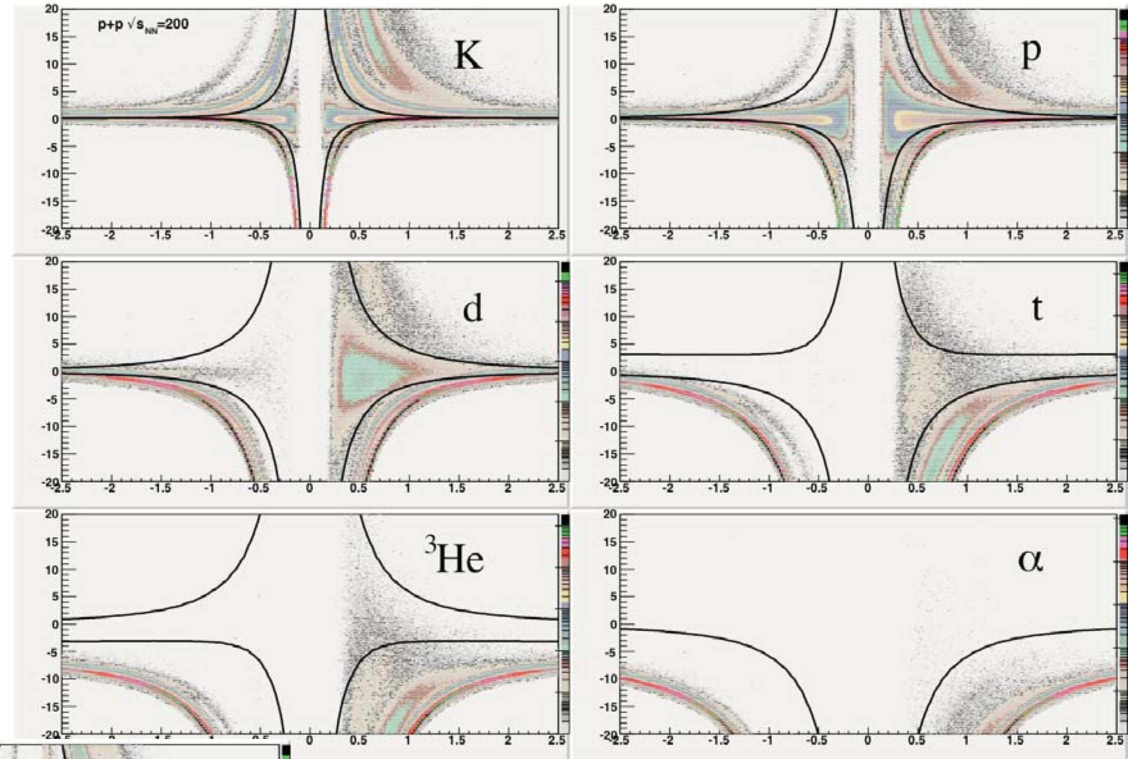


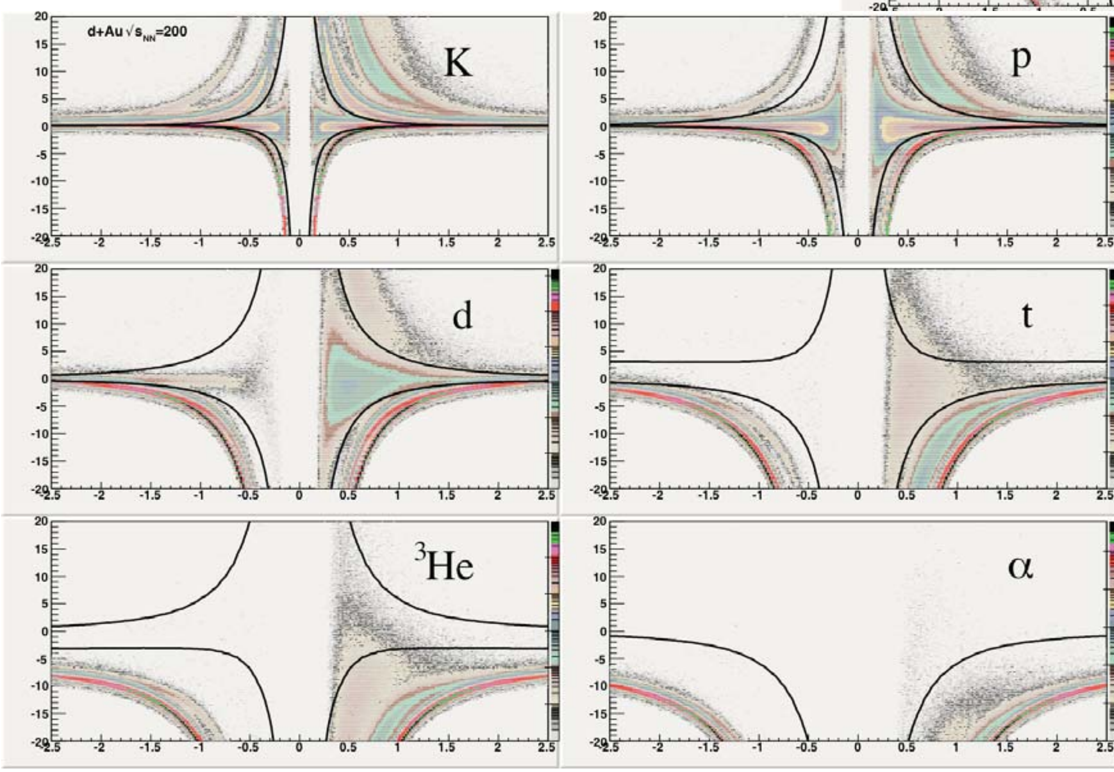
At present, simply do the PID
by “Splitting the differences”
of the dE/dx curves....

Momentum cut-offs used:

p → 1.0 GeV
d → 1.5 GeV
t → 2.0 GeV

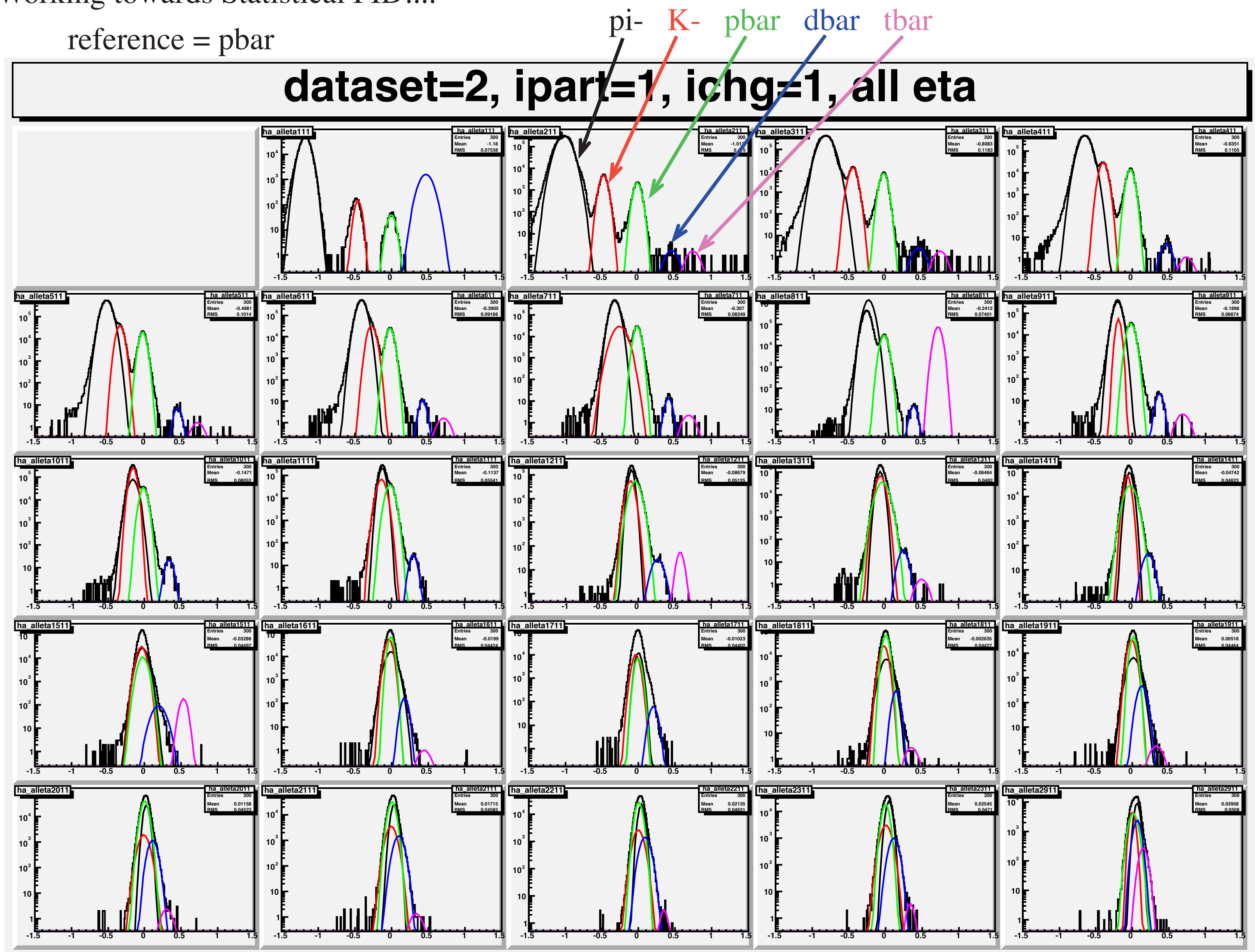
...fairly crude at the moment
& can be improved
& TOF will help a lot too



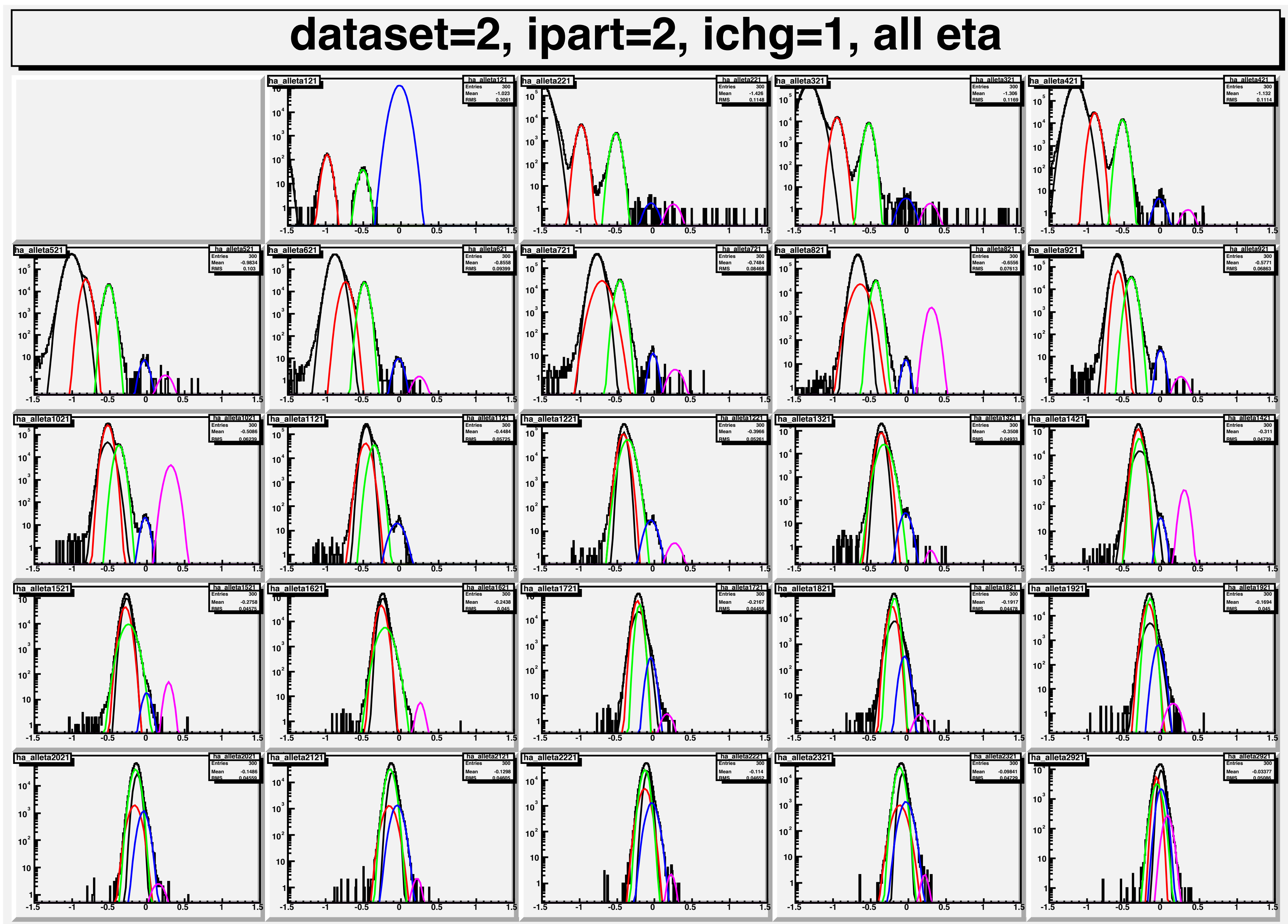


Working towards Statistical PID....

reference = pbar

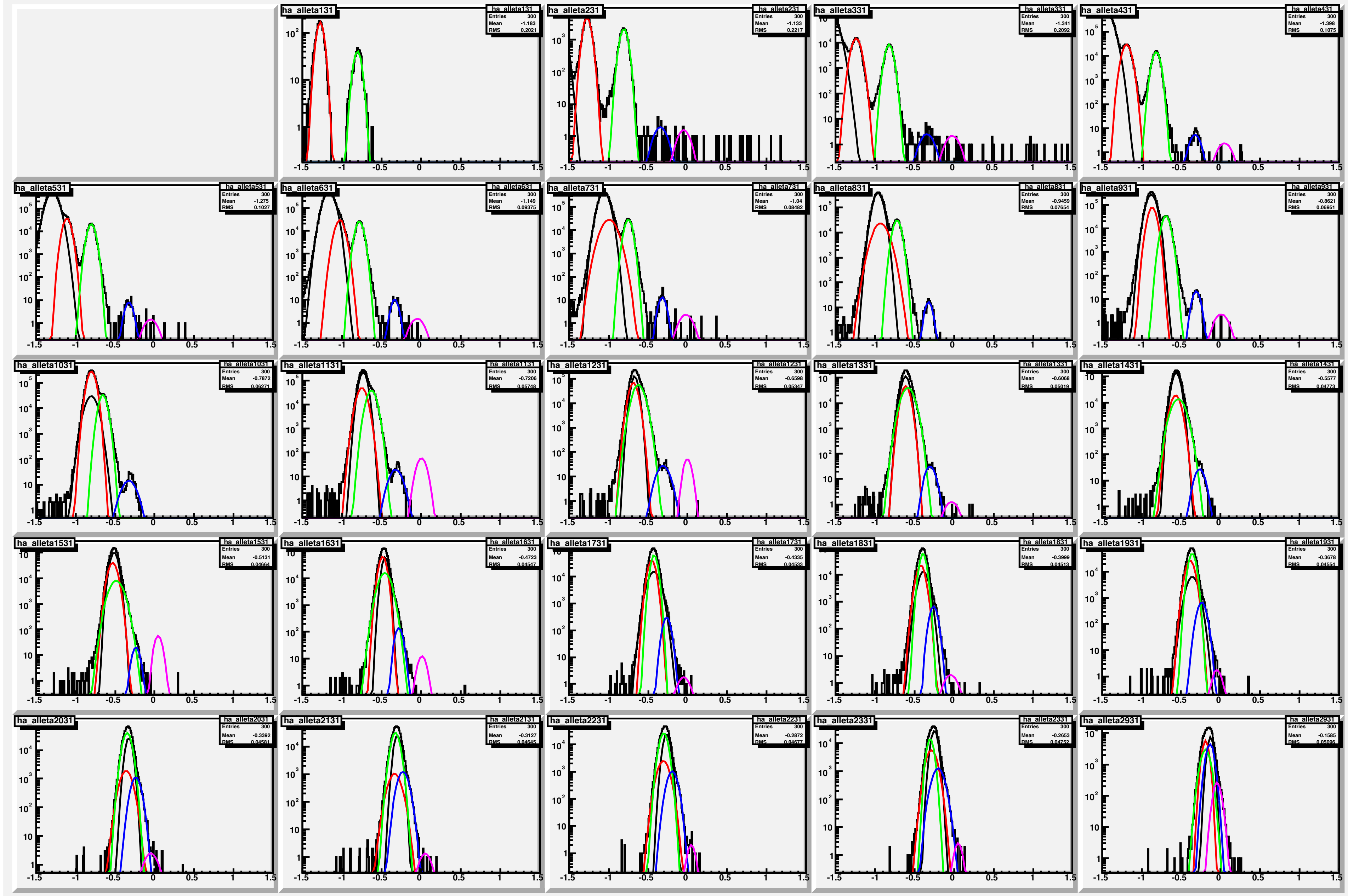


reference = dbar

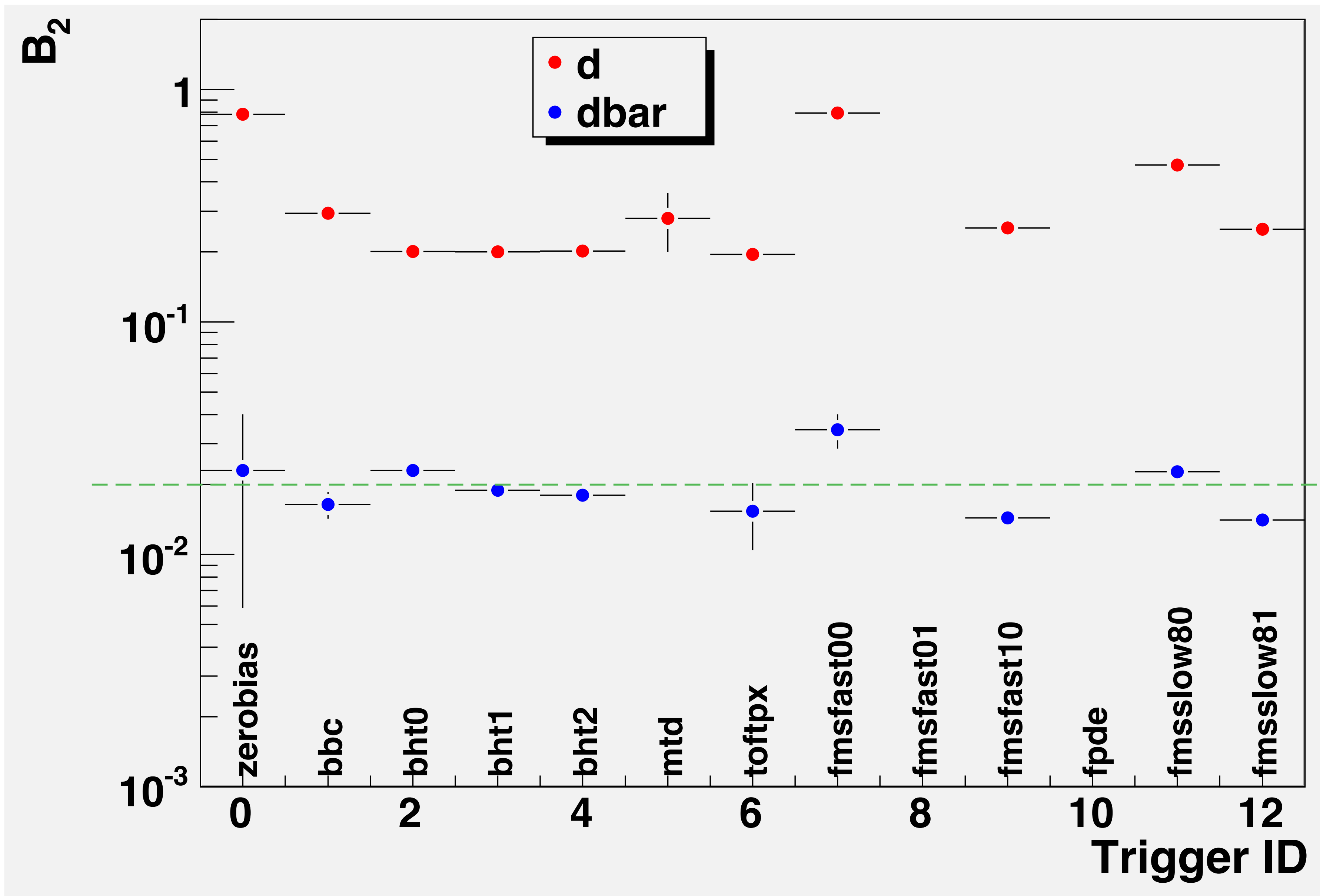


reference = tbar

dataset=2, ipart=3, ichg=1, all eta

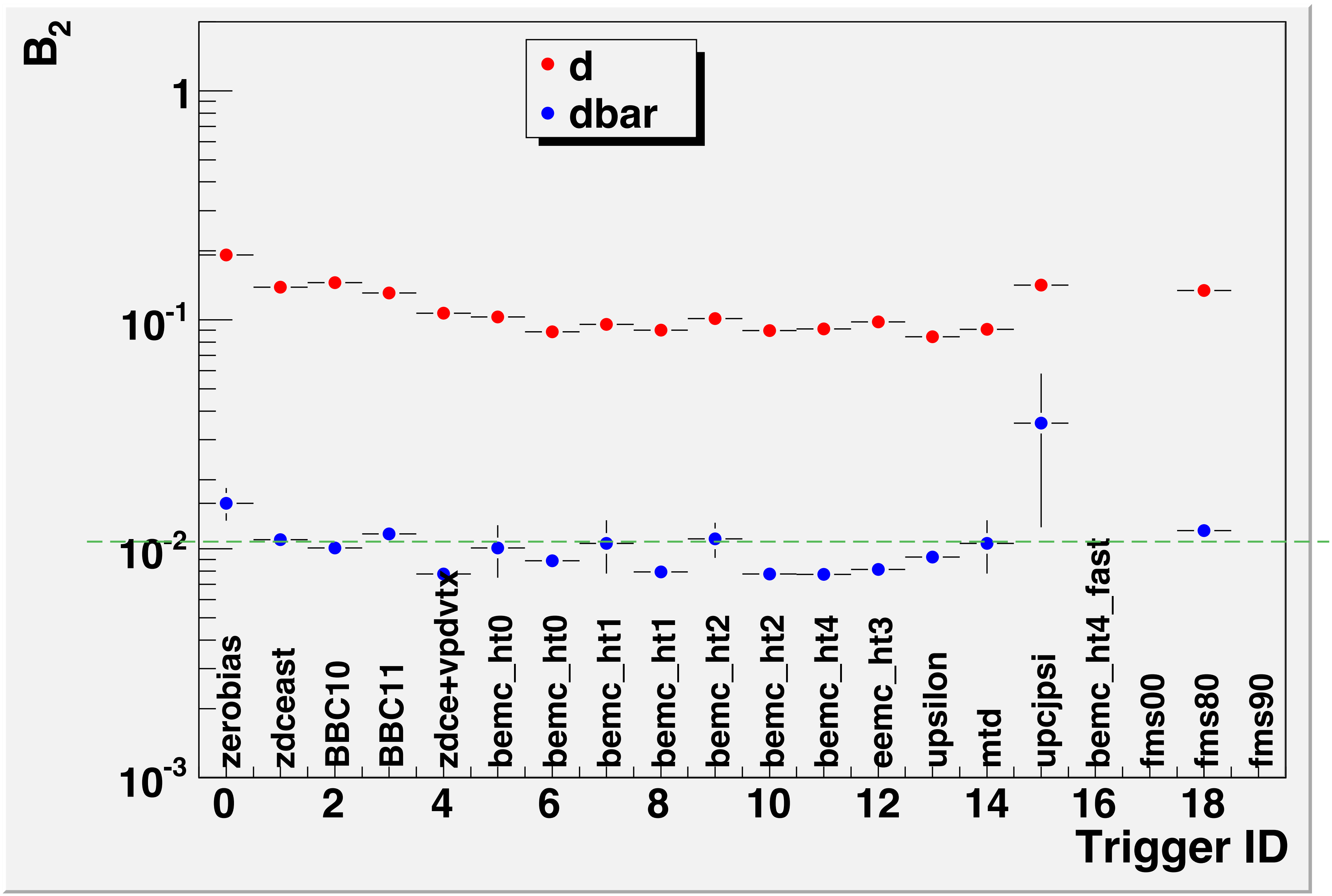


Run-8 p+p 200 GeV



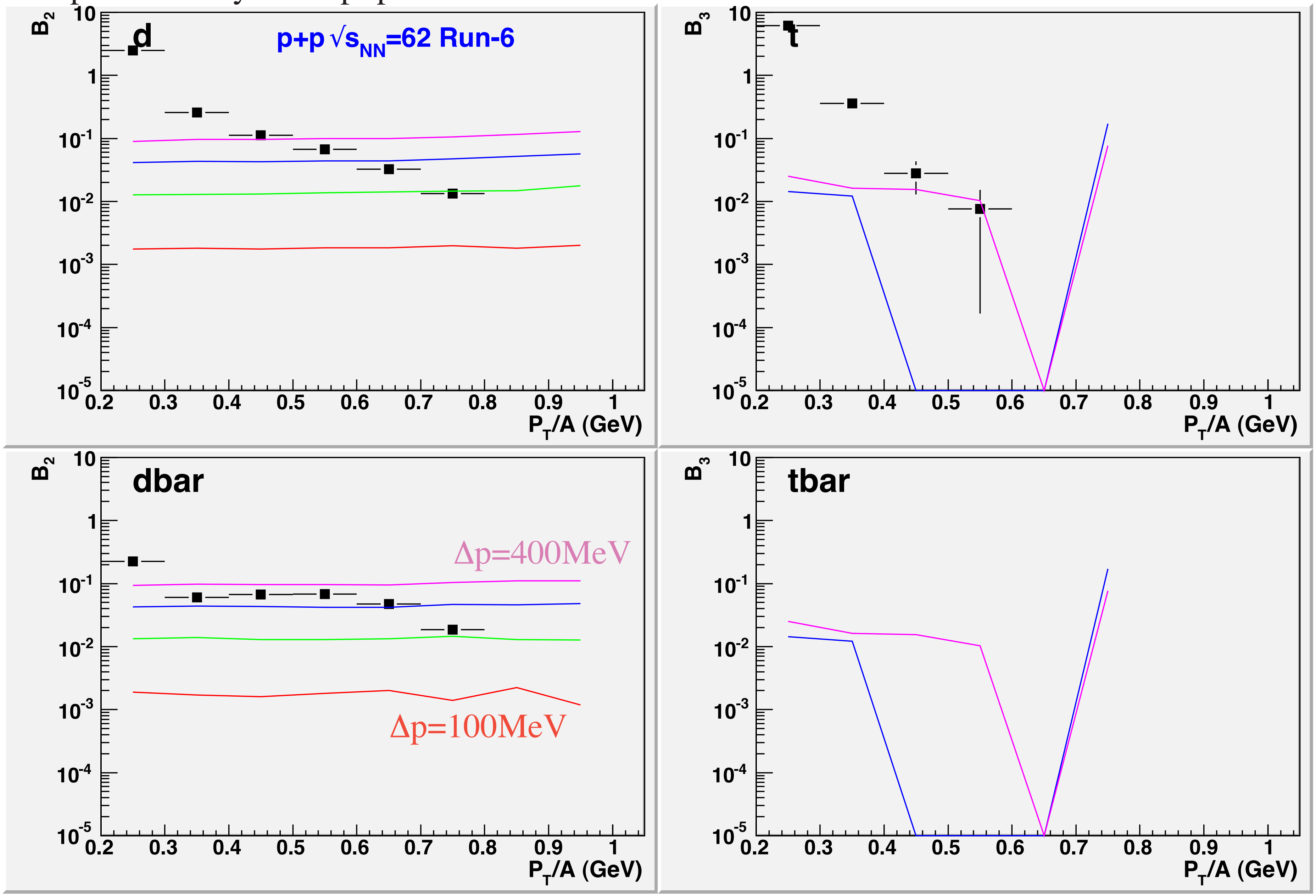
Our dbar B2 is close to that in the lower-energy p+p data: B2 ~ 0.02

Run-8 d+Au 200 GeV



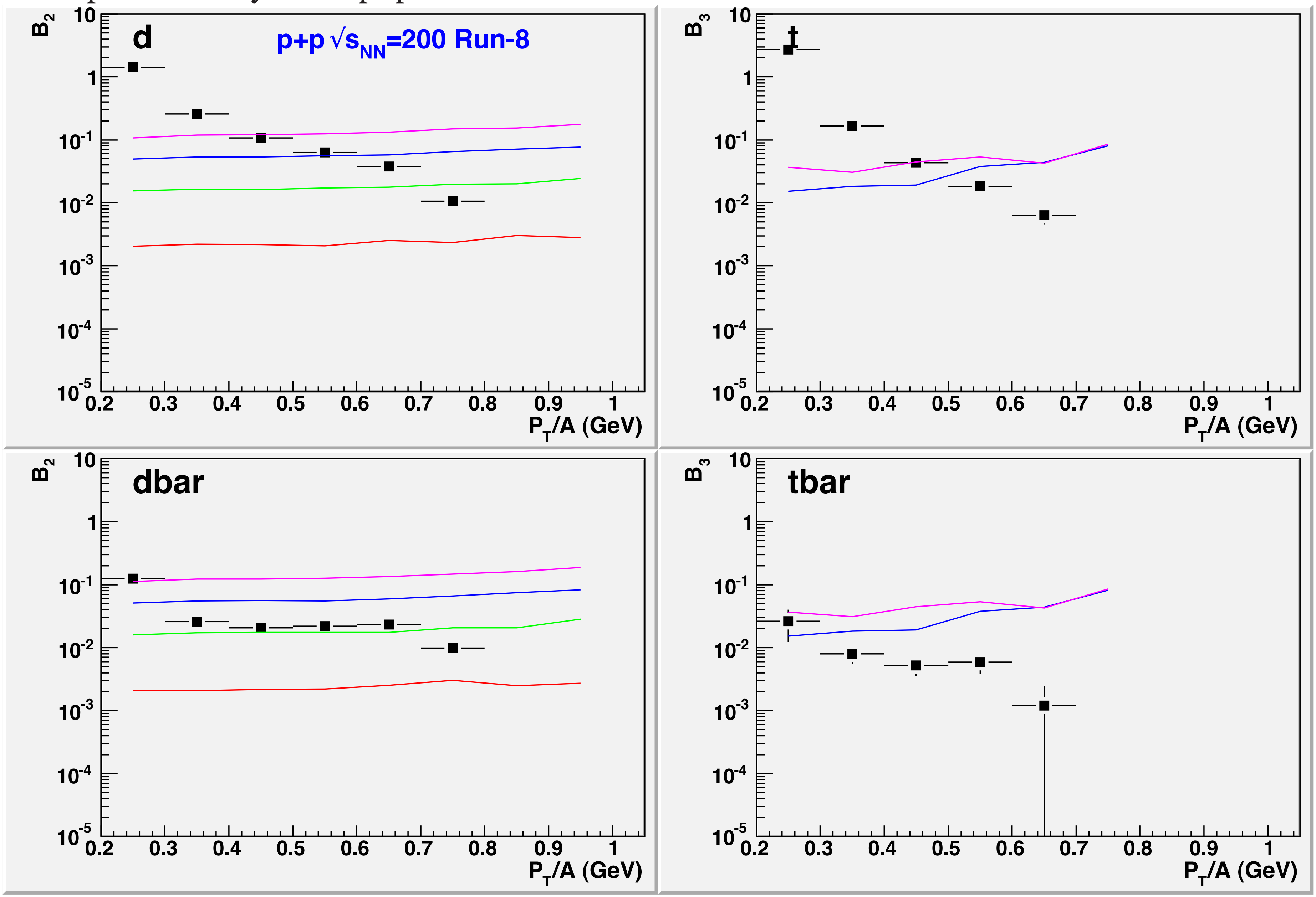
....Here B2 ~ 0.01

Comparison to Pythia -- p+p 62 GeV



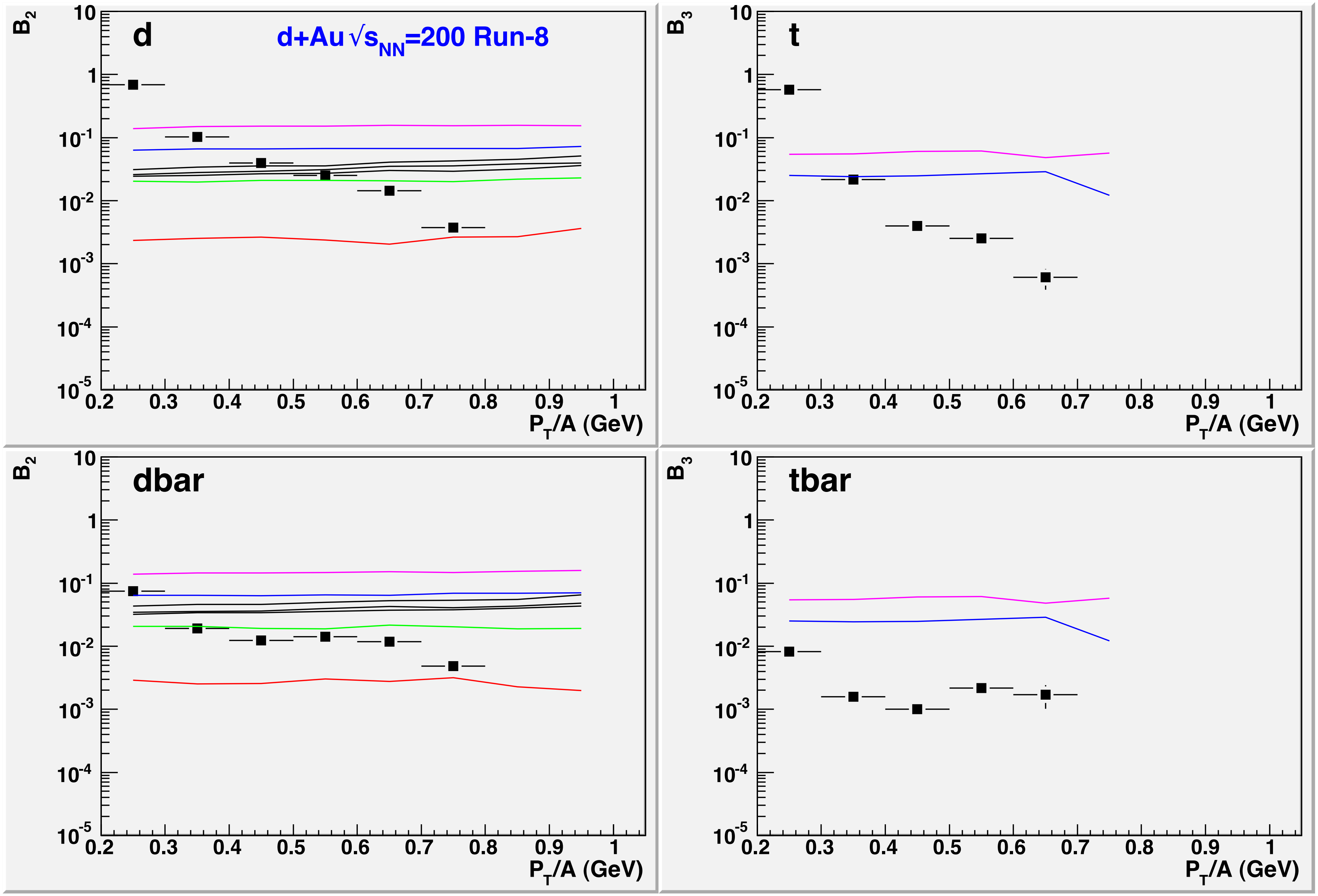
dbar B2 implies Δp ~ 350 MeV for p+p, 62 GeV

Comparison to Pythia -- p+p 200 GeV



dbar B2 implies Δp ~ 200 MeV for p+p, 200 GeV

Comparison to UrQMD -- d+Au 200 GeV



dbar B2 implies Δp ~ 200 MeV for d+Au, 200 GeV

Lots of other DCA plots made - could not find a “magic cut” that brought d/dbar near ~1......

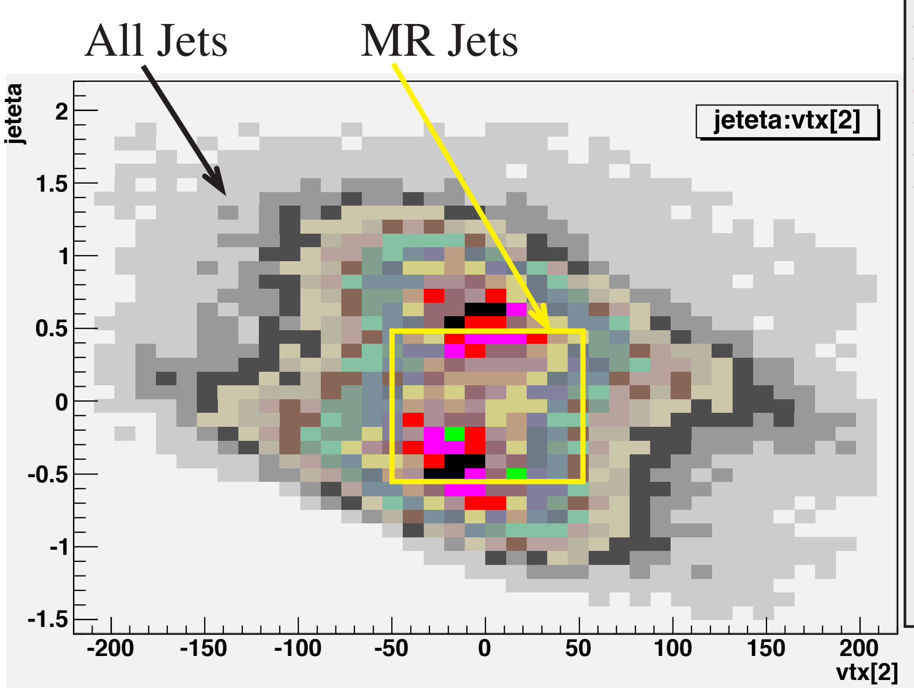
options:
1. concentrate on dbar and tbar, and give up on d and t....
2. “standard” P_T>1 GeV cut... ...only productive for Run-9 data including TOF PID?
3. PHENIX simulation method & subtract spallation background.

Light nuclei & Jets

(thanks to Renee, Ilya, and David for helpful comments!)

Plot proton & deuteron cross-sections and B2 values separately for

- events in which no Jet was found...
- tracks not associated with a Jet...
- tracks associated with a Jet...

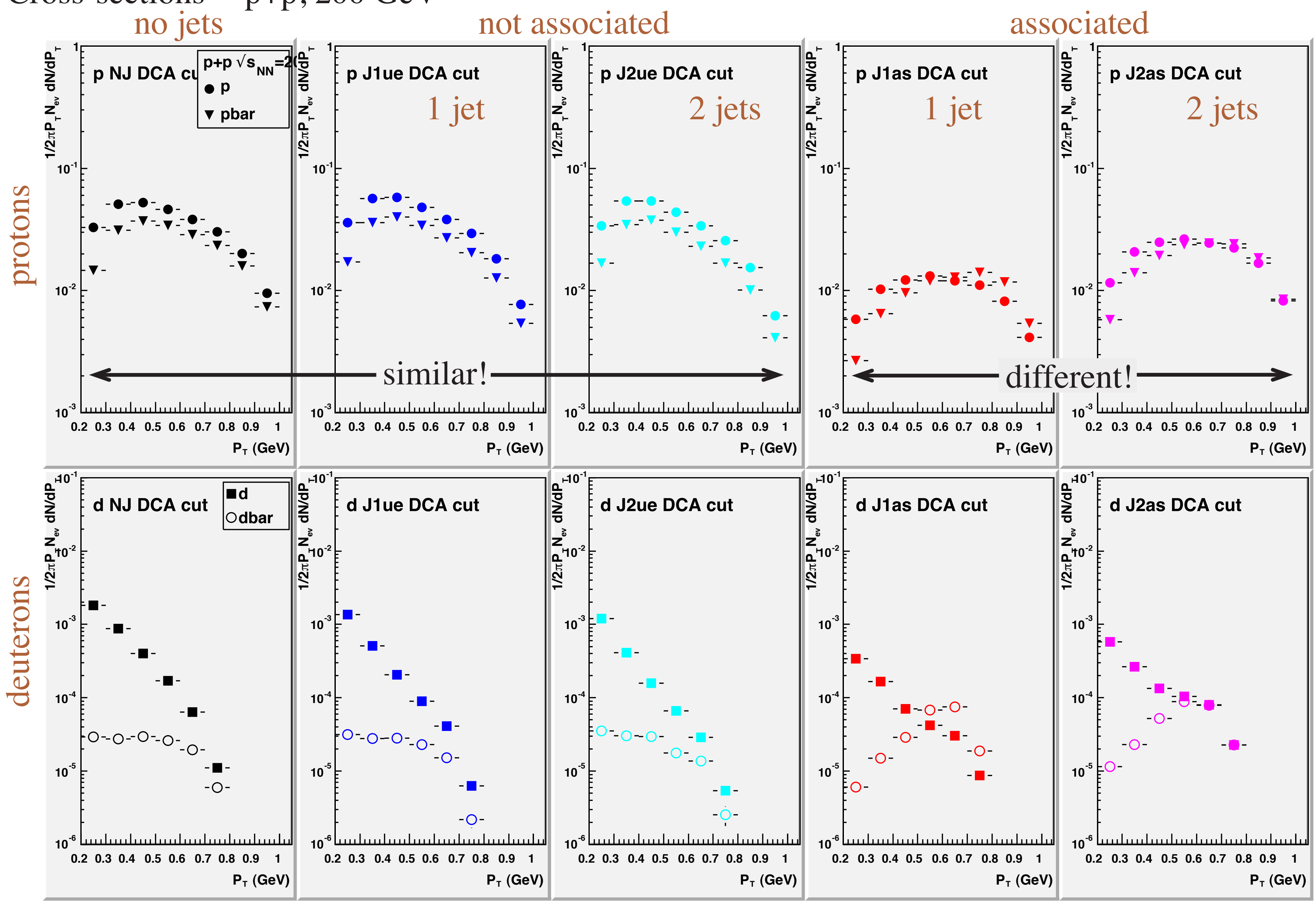



```
StppAnaPars* anapars = new StppAnaPars();
anapars->setFlagMin(0);          // track->flag() > 0
anapars->setNhits(12);           // track->nHitsFit()>12
anapars->setCutPtMin(0.2);       // track->pt() > 0.2
anapars->setAbsEtaMax(2.0);      // abs(track->eta())<2.0
anapars->setJetPtMin(3.5);
anapars->setJetEtaMax(100.0);
anapars->setJetEtaMin(0);
anapars->setJetNmin(0);
//
//---- Setup the cone finder for measured particles
StConePars* cpars = new StConePars();
cpars->setGridSpacing(105, -3.0, 3.0, 120, -pi, pi);
cpars->setConeRadius(0.7);
cpars->setSeedEtMin(0.5);
cpars->setAssocEtMin(0.1);
cpars->setSplitFraction(0.5);
cpars->setPerformMinimization(true);
cpars->setAddMidpoints(true);
cpars->setRequireStableMidpoints(true);
cpars->setDoSplitMerge(true);
cpars->setDebug(false);
```

Some Raw Counts.....

	p+p 62 GeV Run-6	d+Au 200 GeV Run-8	p+p 200 GeV Run-8
Nev all	4.75121e+06	7.58645e+07	3.61101e+07
Nev NJ	4.39813e+06	2.51635e+07	2.16753e+07
Nev J1	306197	1.44996e+07	8.63504e+06
Nev J2	44865	1.10162e+07	4.30746e+06
Nev J E1	134510	17729475	4007314
Nev J E2	218270	43533859	9665726
Nev J E3	19137	19191889	4028187
Nev J E4	2329	2812450	640132
Nev J E5	1676	123232	38086
Nev J E6	614	3216	1775
Nev MRjet	104071	29545104	4821026
Nev J E1 MR	55216	10885190	1812479
Nev J E2 MR	47514	20610915	2721945
Nev J E3 MR	2984	6753361	759762
Nev J E4 MR	1051	521236	75746
Nev J E5 MR	798	16360	3387
Nev J E6 MR	302	393	244

Cross-sections -- p+p, 200 GeV

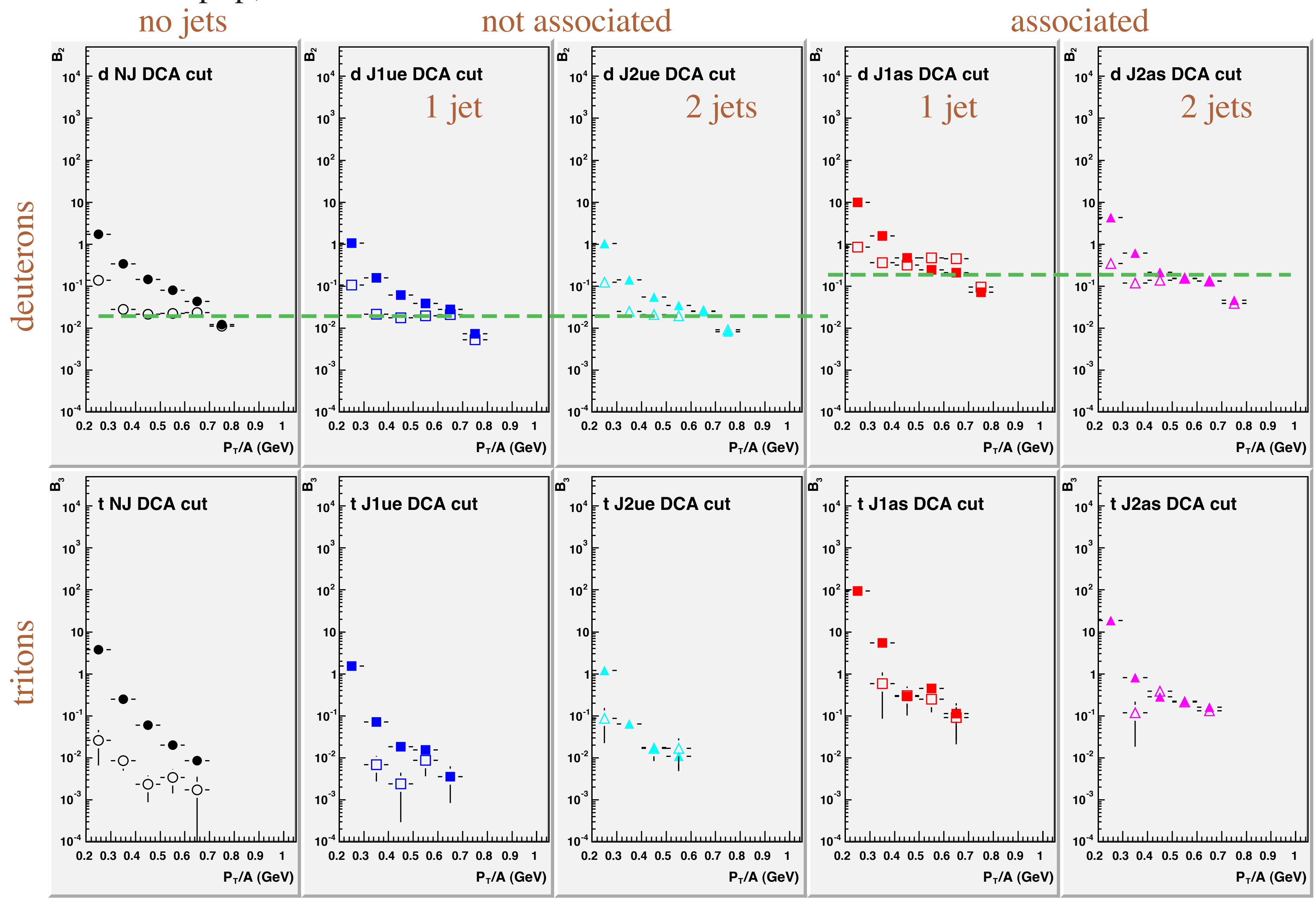


NJ, J1ue, J2ue are very similar. J1as & J2as are different!

particle and antiparticle cross-sections "meet" above $P_T \sim 1$ GeV

pbar & dbar cross-sections considerably harder for in-jet compared to not in-jet

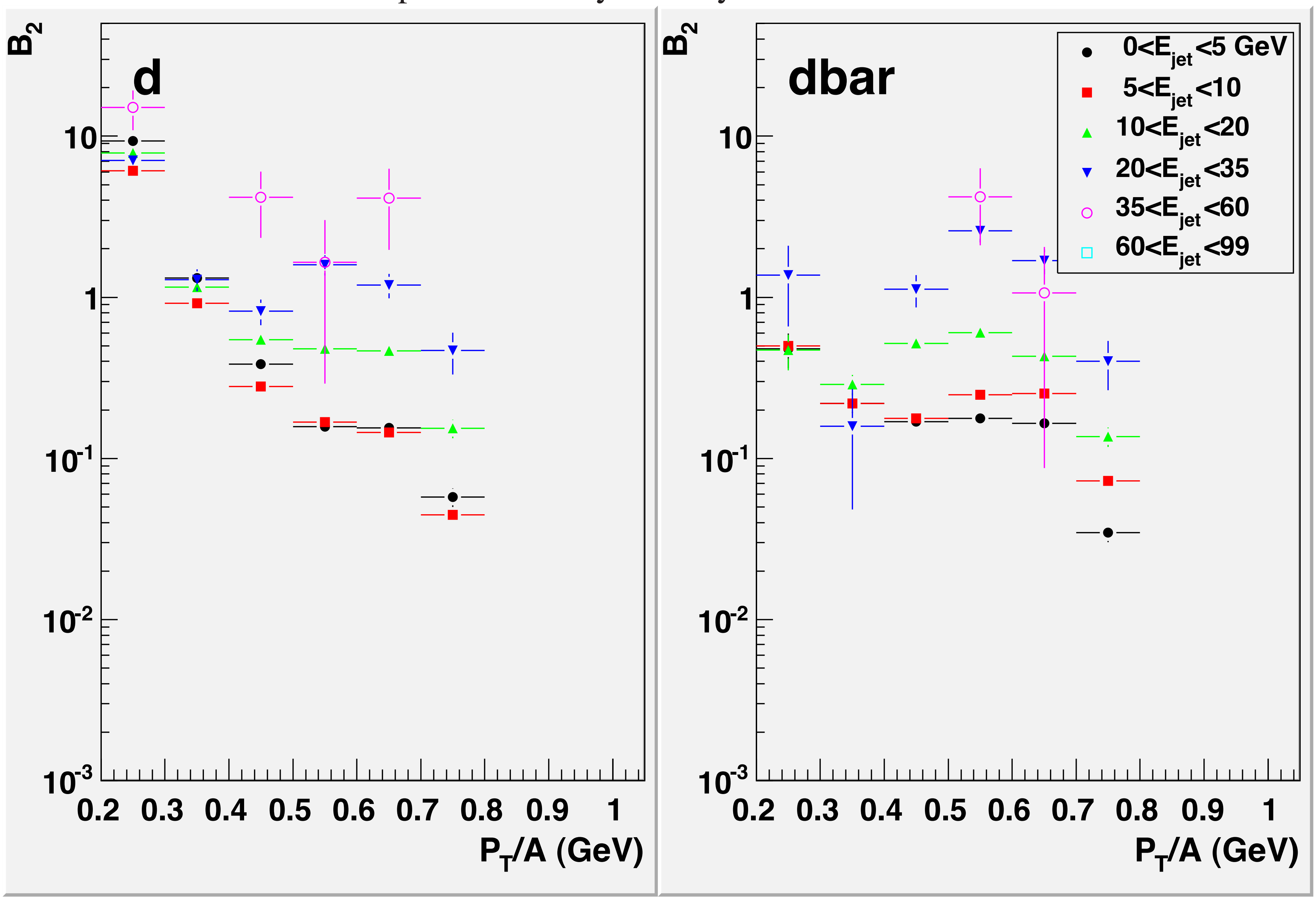
B2 & B3 -- p+p, 200 GeV



B2 & B3 significantly larger for particles associated with Jets
antiparticle B2 and B3 essentially flat for increasing P_T/A

B2 for jet-associated particles gated on Jet Energy -- p+p 200 GeV

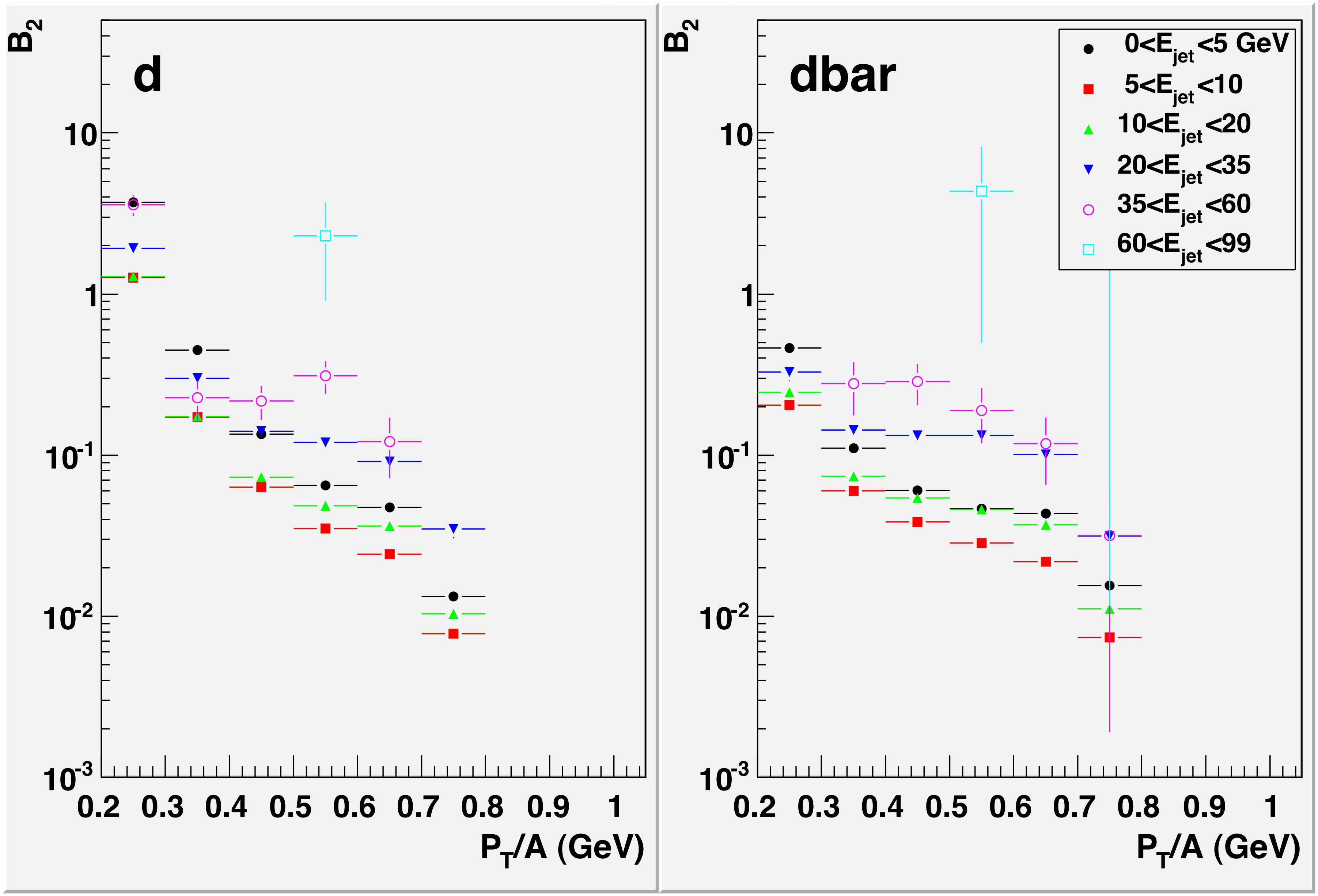
Here - “All Jets” and d/p² formed for y=0 & Δy=1.0



B2 increases with jet-energy (also suggested by Pythia)

B2 for jet-associated particles gated on Jet Energy -- d+Au 200 GeV

Here - "All Jets" and d/p^2 formed for y=0 & Δy=1.0



Summary

simple first attempt at light nucleus analysis for p+p and d+Au data (Runs 6 & 8)

looking forward to analyzing the Run-9 data
- significant TOF coverage
- 500 GeV data

Preliminary results:

- Significant dbar signal in the p+p and d+Au data, some tbars too.
- evt-avg dbar B2 in 200 GeV p+p = ~0.02.... (consistent with lower energy p+p data)
  evt-avg dbar B2 in 200 GeV d+Au = ~0.01....
- Need corrections, but results consistent with Models & Δp~200 MeV so far (reasonable)
- σ for pbar and dbar in No Jet events similar to that in Jet events but not associated w/ a Jet
  σ for pbar and dbar associated with a Jet are different (and harder with P_T)
- Significant increase in B2 for jet-associated particles compared to "UE" particles
  suggested by pythia

To-Do List

- Respin MuDsts (include more vtx information and retry investigation of spallation BGs)
- continue to contribute to TOF calibrations & get onto Run-9 data w/ TOF PID A.S.A.P....
- better simulations (use gstar and "real" jetfinders on simulated events)...
- + your suggestions!

Thanks in advance for your comments...