

Light Nucleus Production in $p+p$ & $d+Au$ (& the BES!)



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☆ *Collaboration Meeting, BNL*
November 13, 2010

Outline:

- Older Results...
- Datasets, cuts, PID...
- Results...

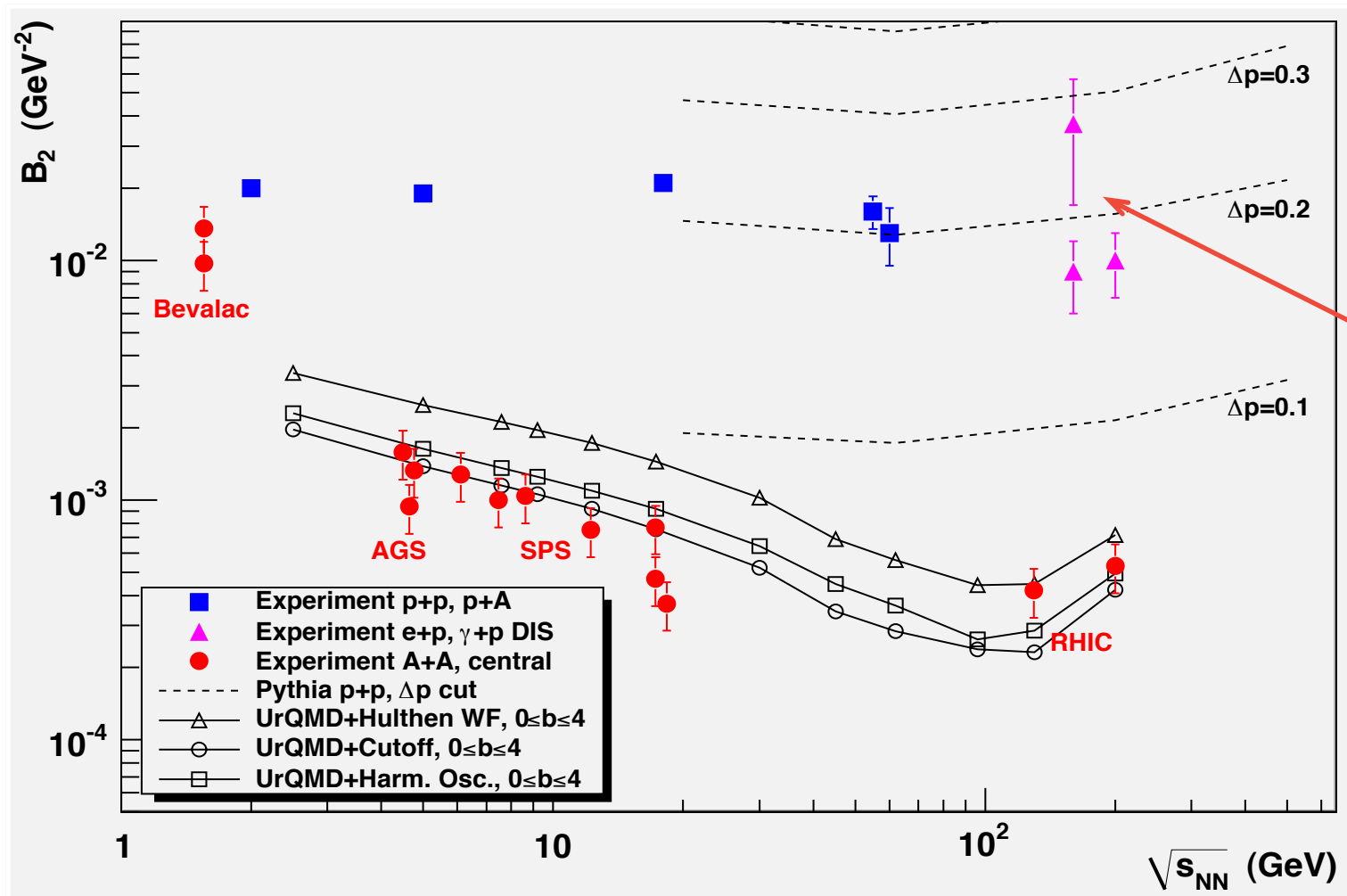
Existing Results on B_2

$$B_A = \sigma_A / [\sigma_N]^A$$

where the cross-sections are evaluated at same momentum

$$B_A = d/p^2$$

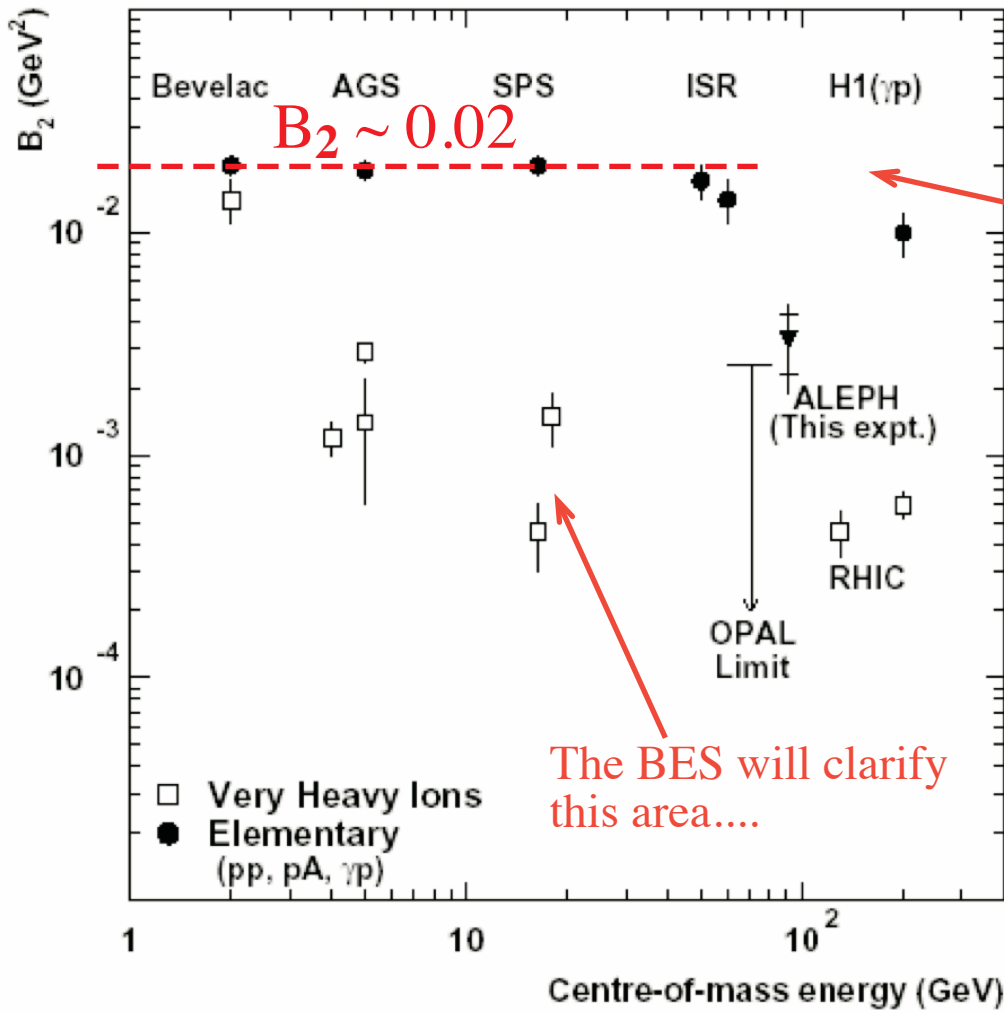
where cross-sections are formed at same P_T/A & $y=0, \Delta y=1.0$



where's the
RHIC results?!?

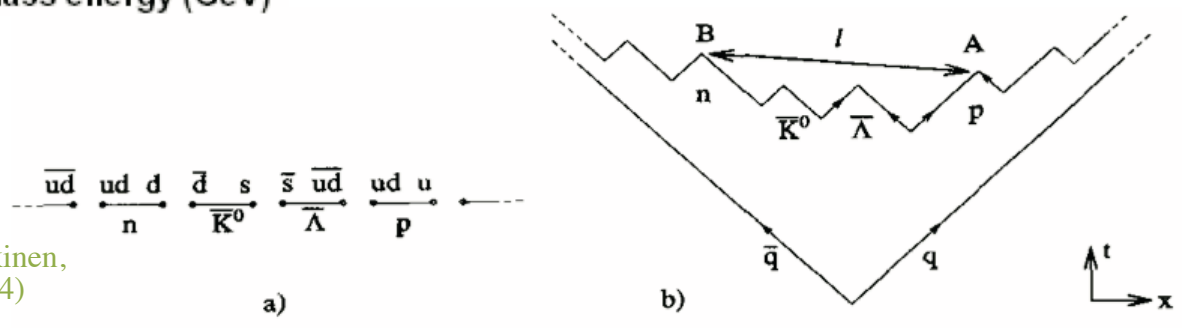
deuterons relative to protons is largest in “elementary collisions”...

- factor of ~ 40 larger than in A+A according to the trend (blue squares)
- essentially independent of beam energy ... also unlike A+A



where does the RHIC data fall?
 ...we have p+p @ 62, 200, & 500 GeV
 & d+Au @ 200 GeV

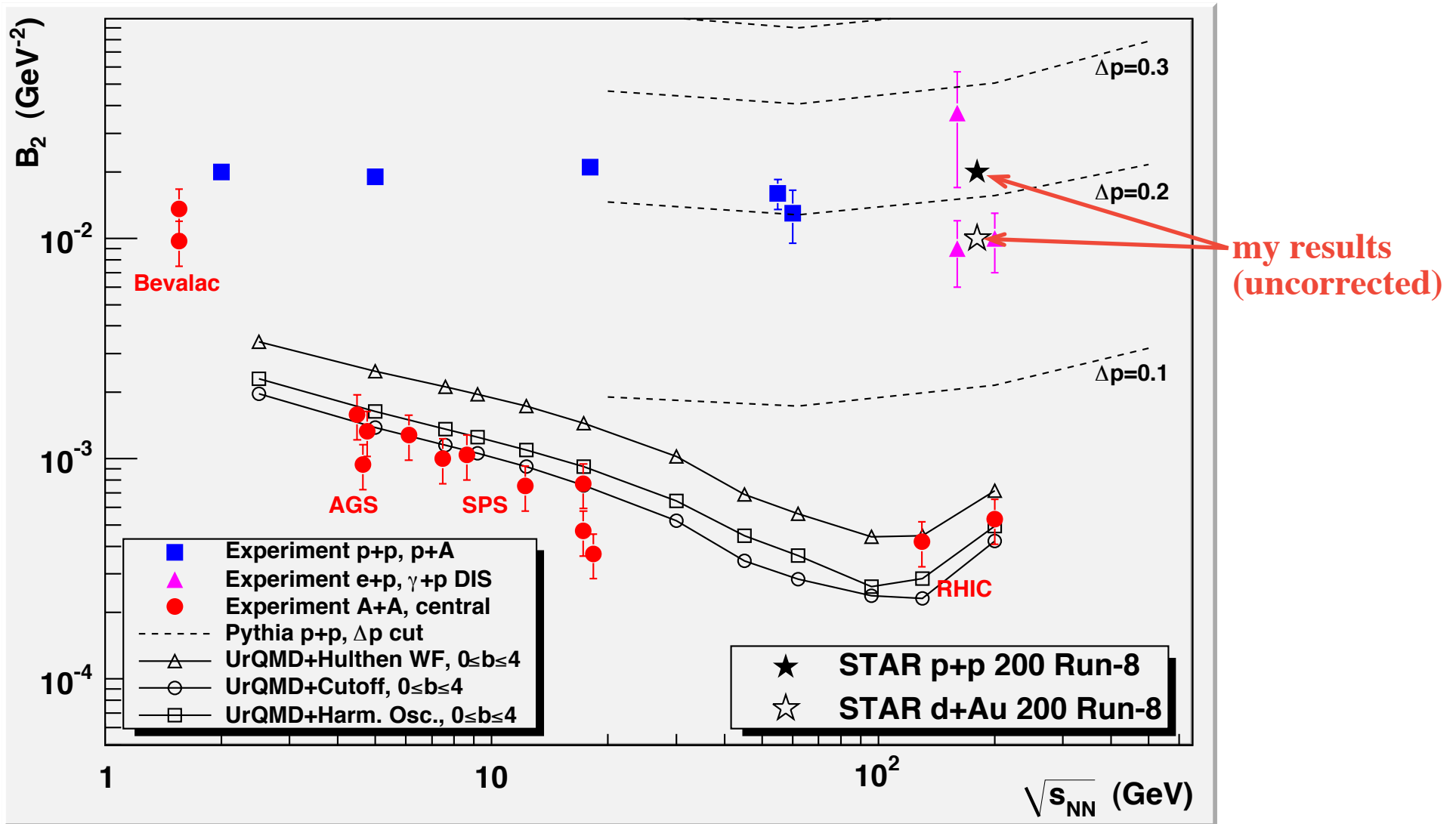
Conventional Wisdom:
 p+p: several strings stretched between 2 hadrons
 ... $B_2 \sim 0.02$
 γ +p: fewer strings
 ... $B_2 \sim 0.01$
 e+e: only one string
 ... $B_2 \sim 0.003$
 A+A: lots of strings, but strong rescattering kills all d's except those that form very late
 ... $B_2 \sim 0.0003$



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

Comparisons to world's data.....



Summary* so far:	Experiment	Coalescence Picture:	Pythia+ Δp
p+p, 200 GeV, Run-8:	$B_2 = 0.02 \text{ GeV}^2$	$R \sim 3.3 \text{ fm}, p_0 \sim 180 \text{ MeV}$	$\Delta p \sim 210 \text{ MeV}$
d+Au, 200 GeV, Run-8:	$B_2 = 0.01 \text{ GeV}^2$	$R \sim 4.2 \text{ fm}, p_0 \sim 150 \text{ MeV}$	$\Delta p \sim 180 \text{ MeV}$

(*) No tracking & PID efficiency, absorption, or feeddown corrections yet!

Light nucleus production & Jets in p+p and d+Au....

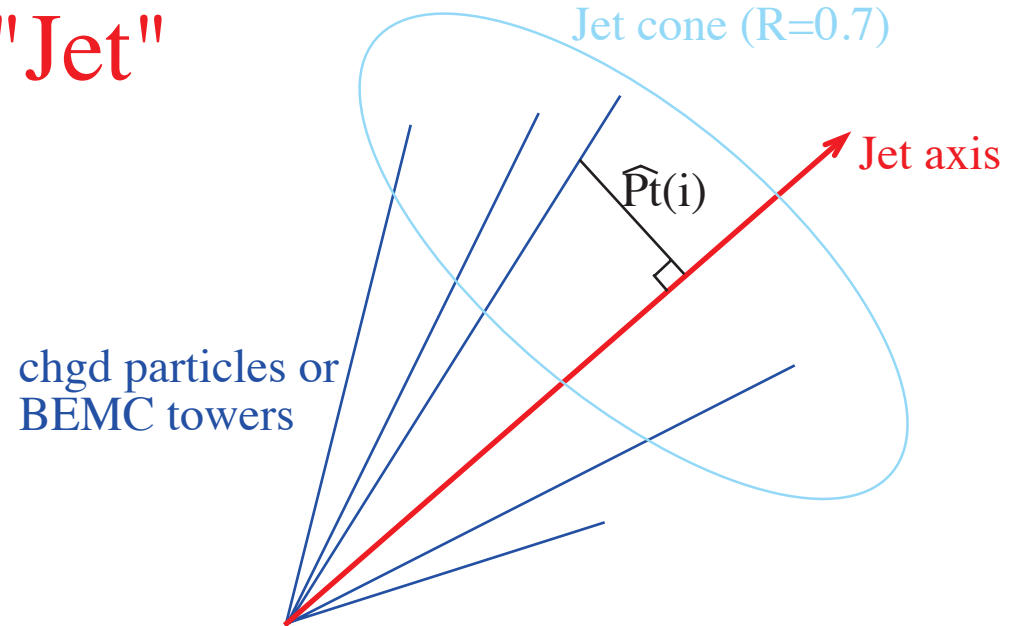
Plot proton & deuteron cross-sections and B_A values separately for

- events in which no jet(s) reconstructed... "UE"
- tracks not associated with a Jet... "Jet"
- tracks associated with a Jet...

Does B_A depend on UE vs Jets?

Different nucleus production mechanisms?
Are R & p_0 different?

"Jet"

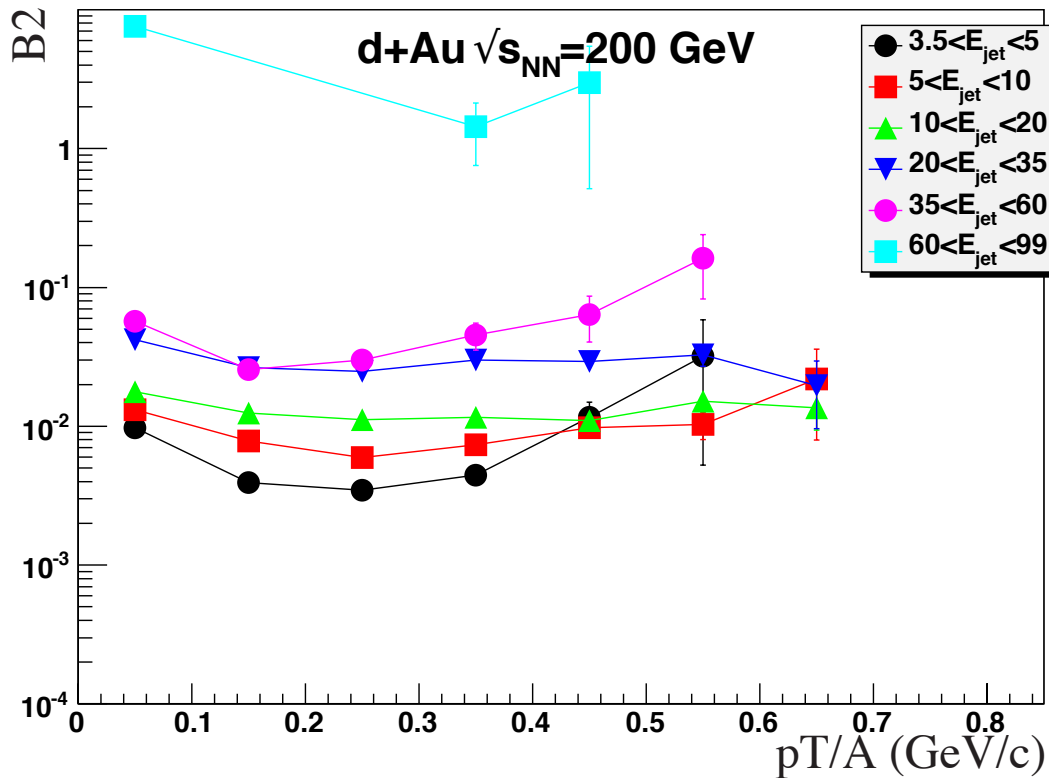
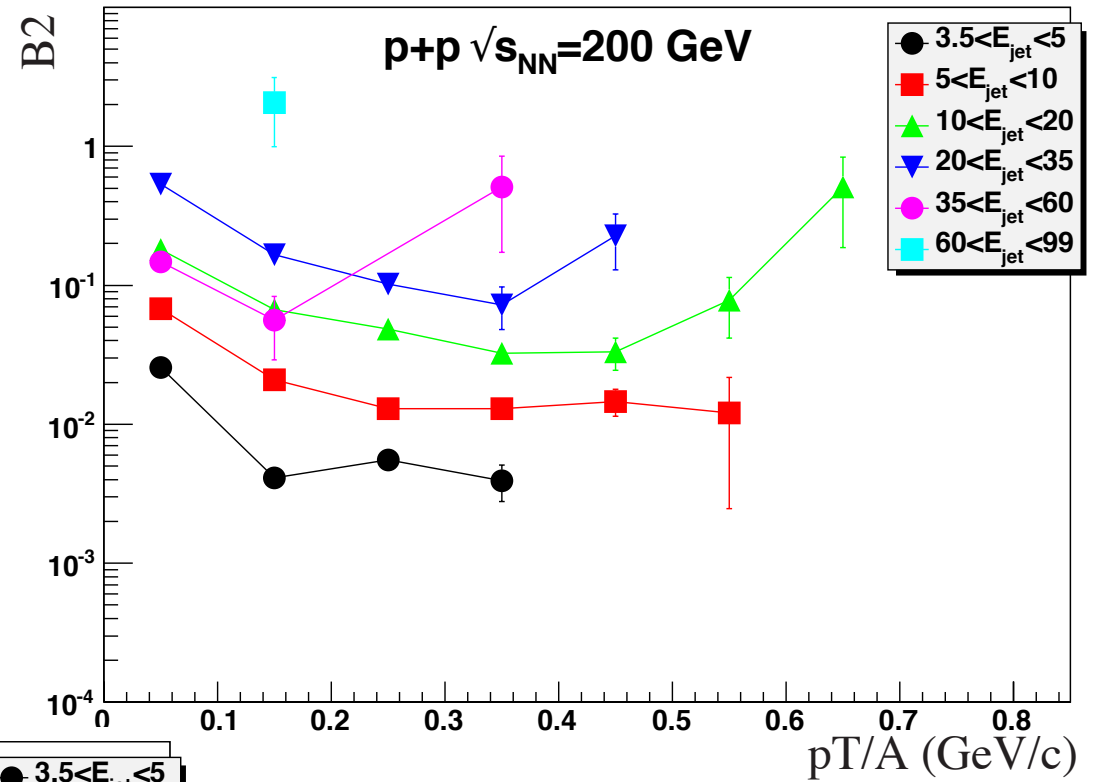


Must calculate B2 via invariant cross-sections vs $Pt\text{-hat}$...
the same analysis strategy is typically used when doing HBT in jets...
can also use $1/(Pt.Nev.d\phi)dN/dPt/d\phi$ and set ϕ via jet axis

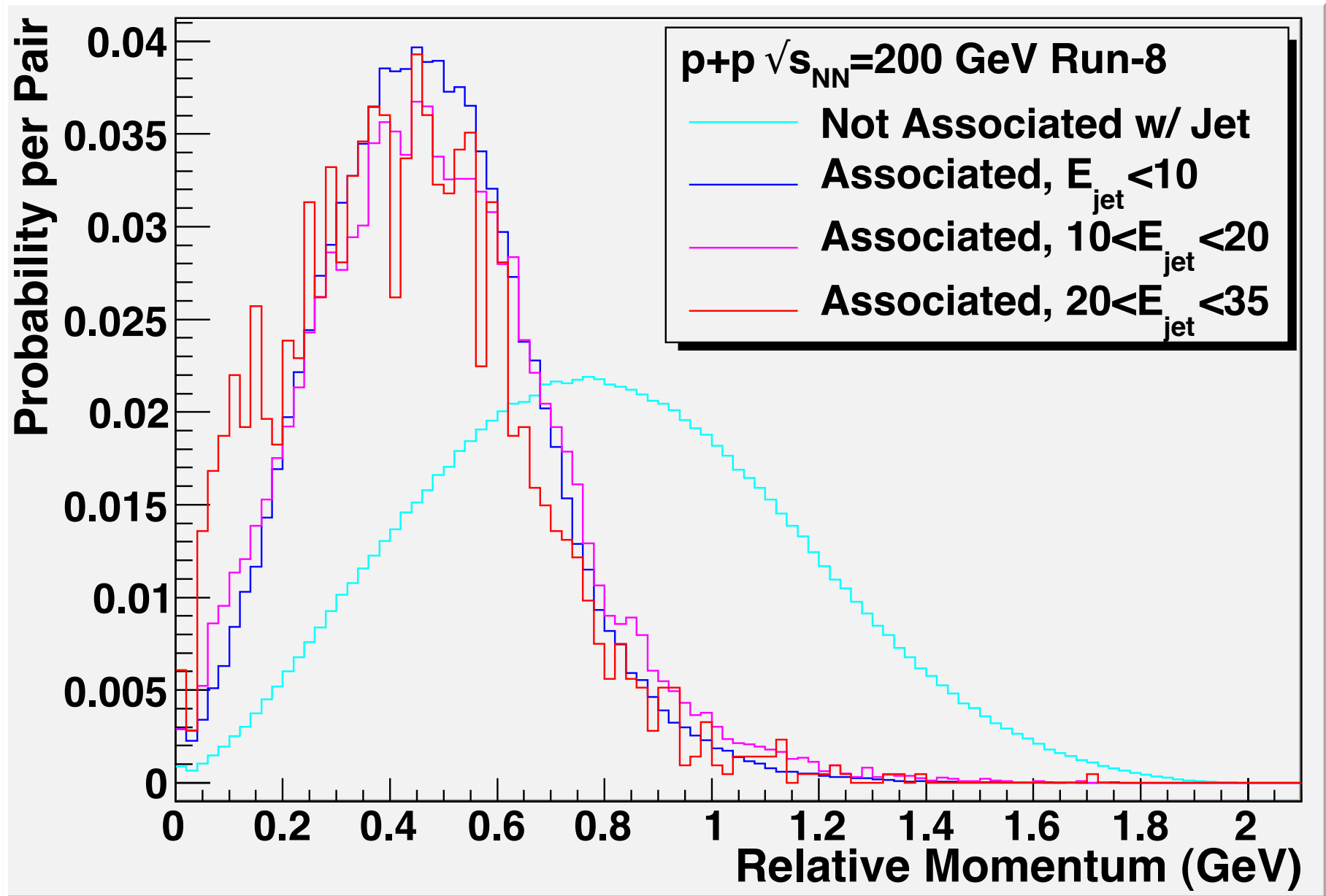
Need to respin the data: Jet Makers not set up exactly as this analysis requires...

1. StVpdCalibMaker (locate vertex that VPD/TOF sees)
2. JetMakers with Modified StBET4pMaker (use consistent vertex!)
see <http://www.star.bnl.gov/HyperNews-star/protected/get/jetfinding/1003.html> and replies
3. Call StBTofCalibMaker and MyAnalysisMaker to analyze Jets and Tracks

Large increase in BA
with increasing Jet Energy
for (anti)nucleons & nuclei
in Jets remains!



Pair Normalized 2 “proton” relative momentum distributions, gated on Jet Energy



Higher-energy Jets \rightarrow proton pairs more “focussed” (decreasing $\langle \Delta p \rangle$)
 \rightarrow Consistent with observed increasing B2 vs E_{jet}

Embedding Request.....

- | | | | | |
|----|--------------------|------|----------------|-------|
| 1. | pbar, dbar, & tbar | p+p | 62 GeV, Run-6 | P06ie |
| 2. | pbar, dbar, & tbar | p+p | 200 GeV, Run-8 | P08ie |
| 3. | pbar, dbar, & tbar | d+Au | 200 GeV, Run-8 | P08ie |

1 particle per event...

Max pT: 1.5 GeV for pbar
3.0 GeV for dbar
4.5 GeV for tbar

Eta range includes EEMC: $-1.5 < \eta < 2.0$

No special treatment of jets in terms of placing simulated particles in specific events....

Need to specify run numbers in specific periods of each run (see following pages)...

When it comes up, will likely request **p+p 200 GeV Run-9 P10ic** first
Then **p+p 500 GeV Run-9 P10ic**, then the BES Data.....

This is to take advantage of the significant TOF coverage in Runs-9, 10,

Will need to drastically increase the Max pT values above...

Request submitted 4/30/2010..... No idea when it will start.....

Datasets and Cuts

kDataSet	Run	Data	Library	TOF%	Nevents
11	6	p+p 62 GeV		0	will redo
12	8	d+Au 200 GeV		0	will redo
13	8	p+p 200 GeV		0	will redo
14	9	p+p 500 GeV	P09ig	~ 70%	13,978,257
15	9	p+p 200 GeV	P10ic	~ 70%	241,641,081
16	10	Au+Au 200 GeV	P10ih	~100%	839,499*
17	10	Au+Au 62 GeV	P10ih	~100%	
18	10	Au+Au 39 GeV	P10ih	~100%	22,317,408
19	10	Au+Au 7.7 GeV	P10ih	~100%	34,309,055
20	10	Au+Au 11 GeV	P10ih	~100%	10,585,882

Cuts

Event:

Rvtx < 1.2cm
|Zvtx| < 70cm (<100cm for p+p)
| η -asym| < 0.9 (only applied for 7.7 & 11 GeV)
NTofHits > 10 (only applied for 7.7 & 11 GeV)

Track:

Nfitpts > 15
Nfitpts/Npossible > 0.52
DCA of global < 2cm

Run-6 and 8

no TOF, but significant results w/ dE/dx, best available d+Au data, jet finding

Run-9

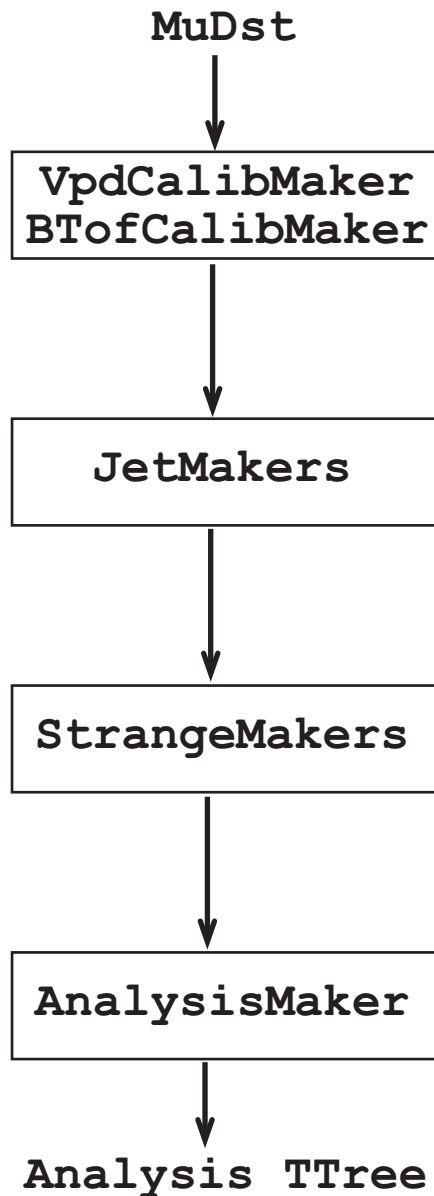
most of TOF, plus 500 GeV p+p data, jet finding
direct comparison of run-8 and run-9 p+p 200

Run-10

all of TOF
direct comparisons to the SPS/AGS data vs root-s.

Quite easily the richest
light nucleus dataset ever
collected by a single experiment.

Analysis Approach



Calibrates VPD & Calculates **ZvtxVPD**

Requires **ZvtxVPD** and **ZvtxTPC** are consistent

If not, Find a vertex that is and **SetVertexIndex(i)**

Analysis thus concentrates on Primary Tracks...

Calibrates TOF w/ or w/out VPD

Cone algorithm, $R=0.7$, parameters from JetFinding Group

Changed **StBet4Maker** to use just the one vertex found above

I completely failed to get these makers to work recently...

Collects VPD, TOF, & Jet Information in single maker

Cross-references: links primaries in Jet #i, or V0 #i...

Includes full trigger, file, and event information...

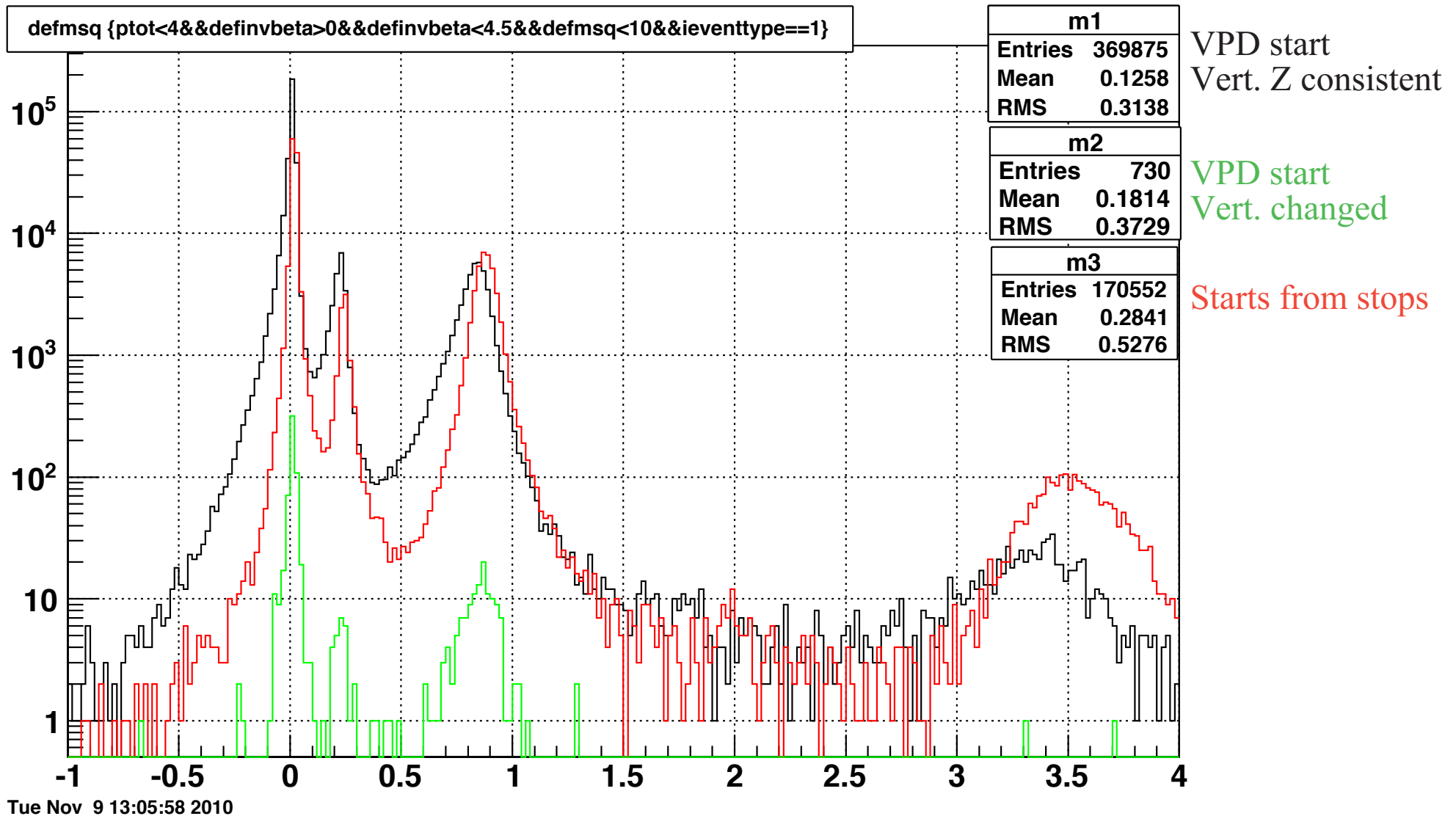
Read by analysis code "aread" to do PID, cross-sections, BA...

One analysis code for all 10 datasets.

VPD Starts vs. Startless Comparison for the 11 GeV Data

Fixed VpdCalibMaker flag overwrite problem

Compare PID when using VPD start-time to start-time from the stops....

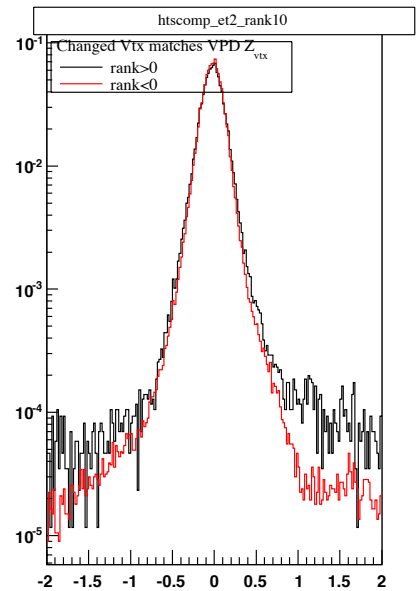
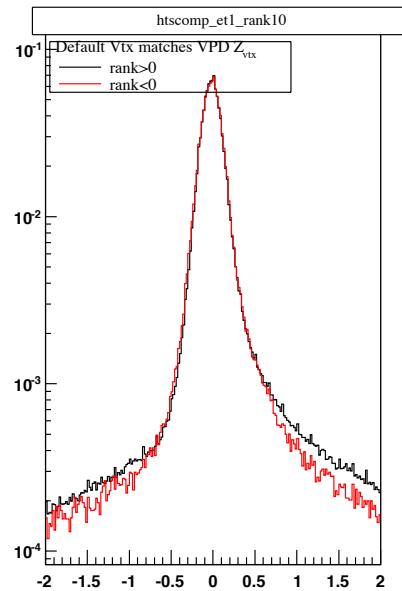
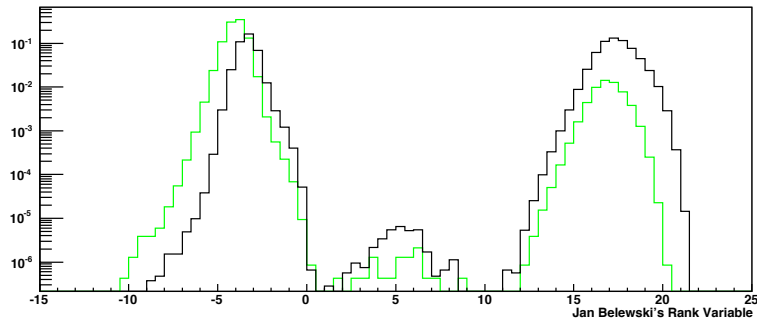
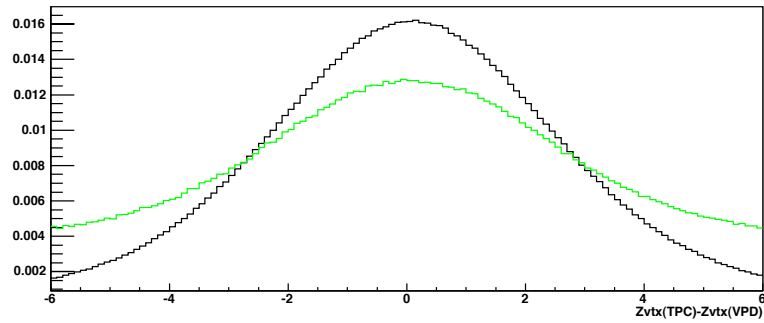
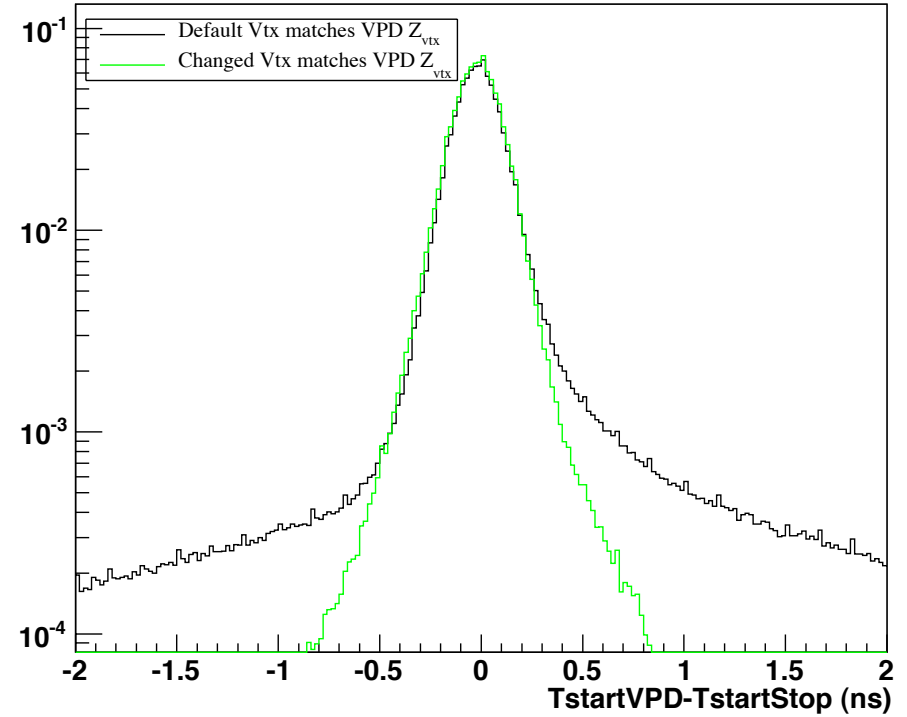
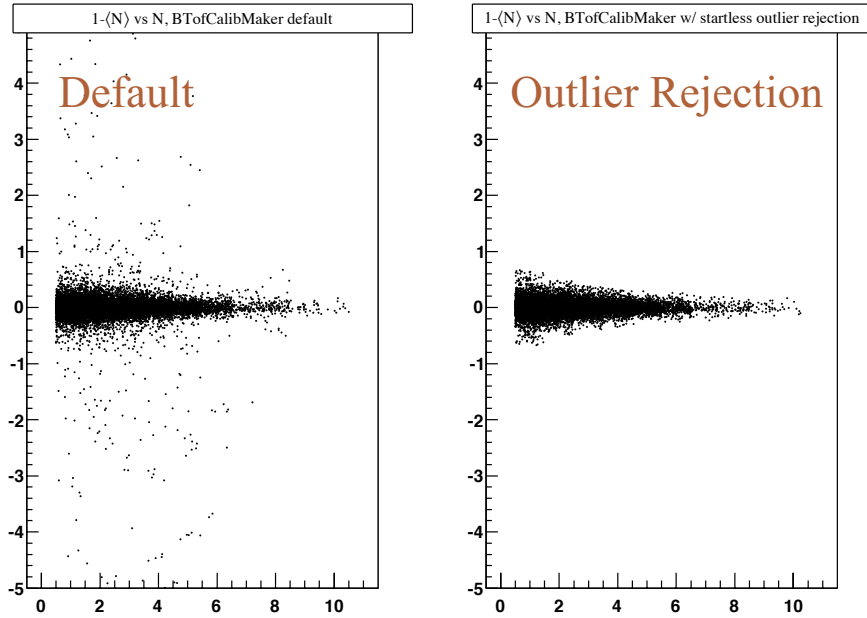


Start-time from the stops has a better resolution, and is more symmetric, than does VPD starts
But, there seems to be a **mass dependence of the efficiency**.... (problem? or just centrality?)

VPD Starts vs. Startless Comparison for the p+p 200 GeV Run-9 Data

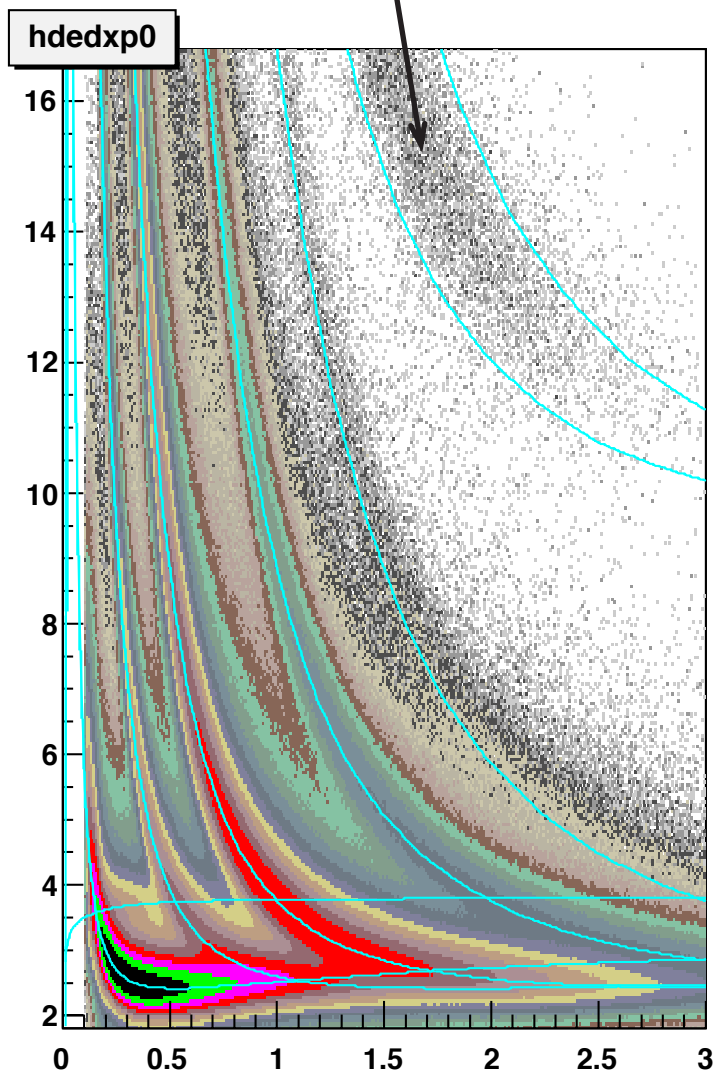
Call Startless code in every event but include careful outlier rejection

Compare PID when using VPD start-time to start-time from the stops....

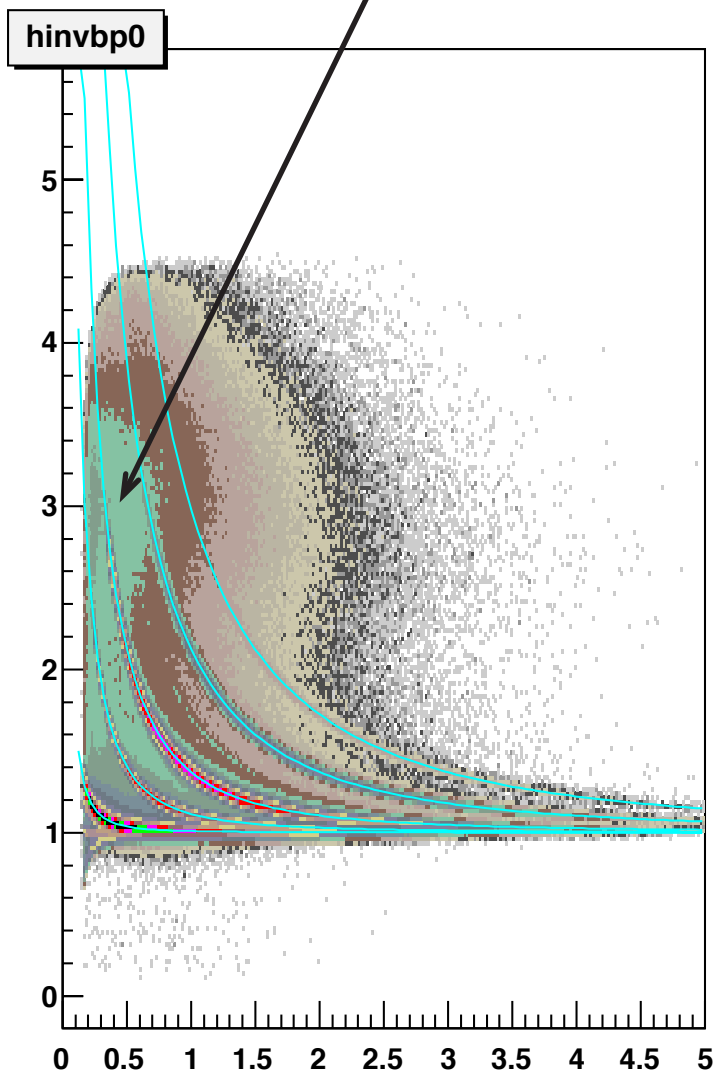


Two more strange PID issues in the 7.7 GeV Data

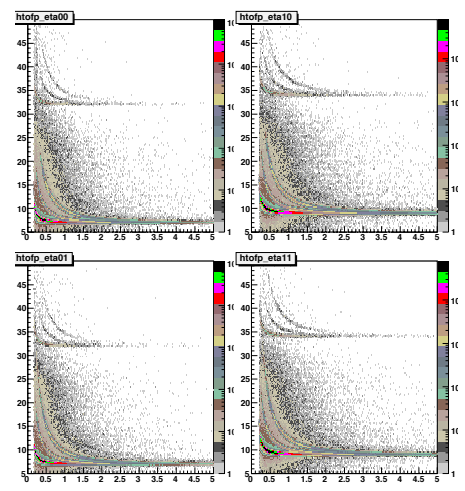
He3/alpha are off



strange late blob (also in TOF itself)



not obviously BunchID errors
(although startless was used)



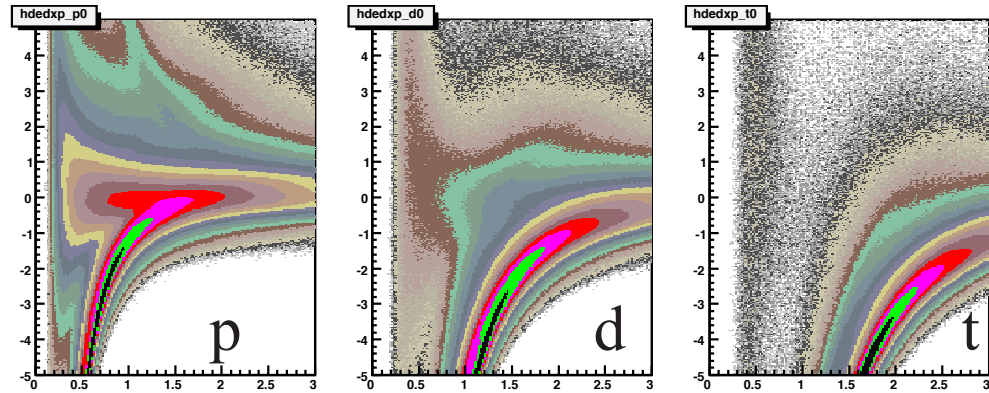
...not nTzero either...

PID....

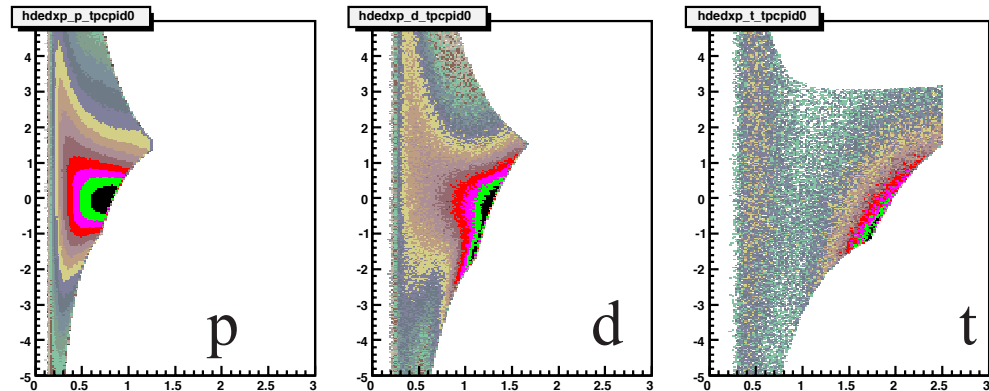
dE/dx alone: windows on $dE/dx - dE/dx_{POI}$, lower limit on dE/dx itself, upper limit on mom'n

open dE/dx+TOF: windows on $dE/dx - dE/dx_{POI}$ w/out dE/dx lower, or mom'n upper, limits set $1/\beta - 1/\beta_{POI}$ cuts on tracks surviving appropriate open dE/dx cut...

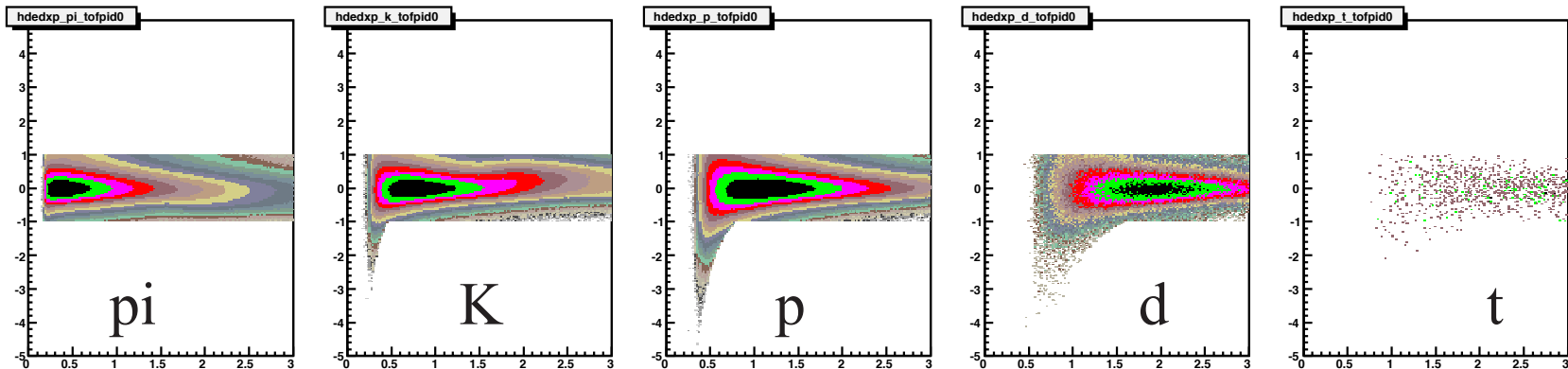
all dE/dx values by POI



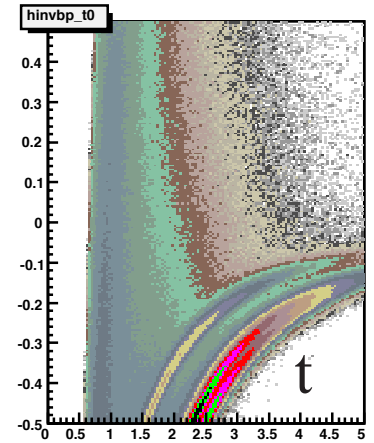
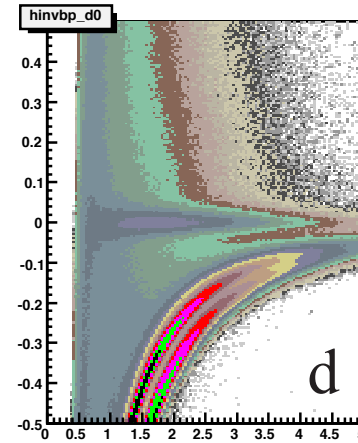
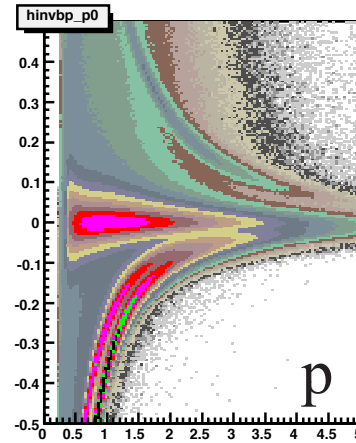
post-cut dE/dx values by POI



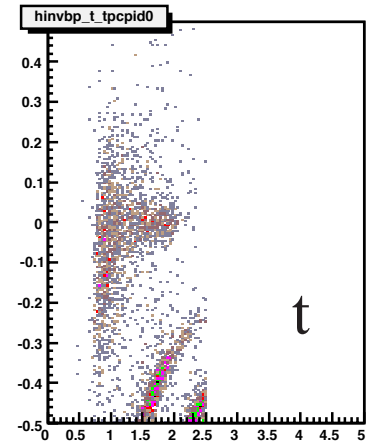
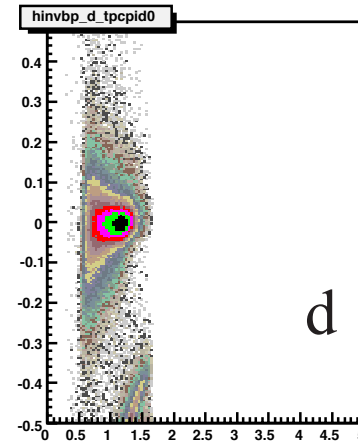
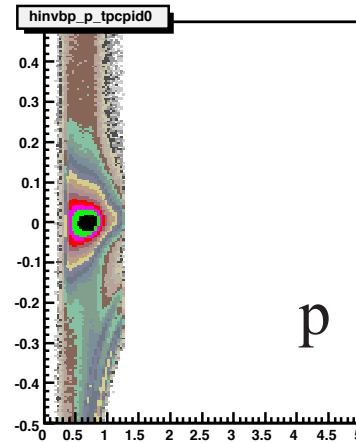
dE/dx values w/ TOF PID



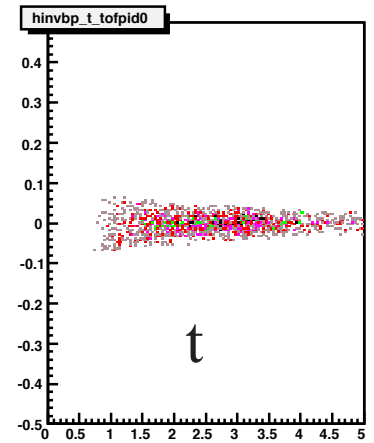
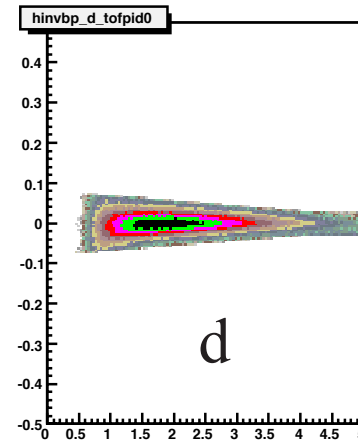
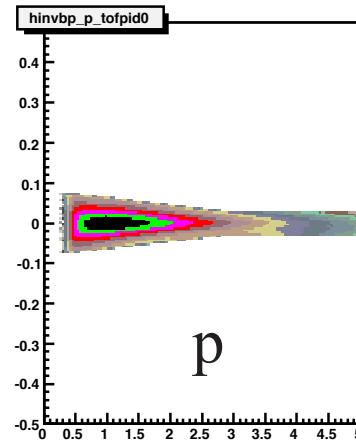
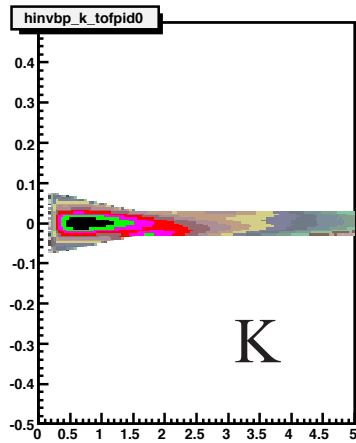
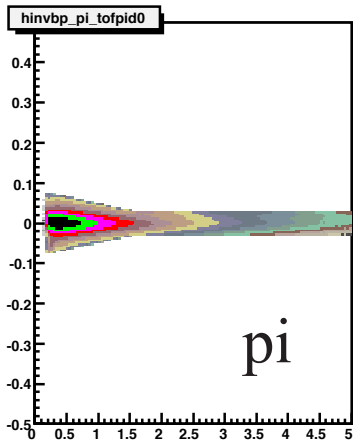
all $1/\beta$ values by POI



$1/\beta$ values by POI, dE/dx PID

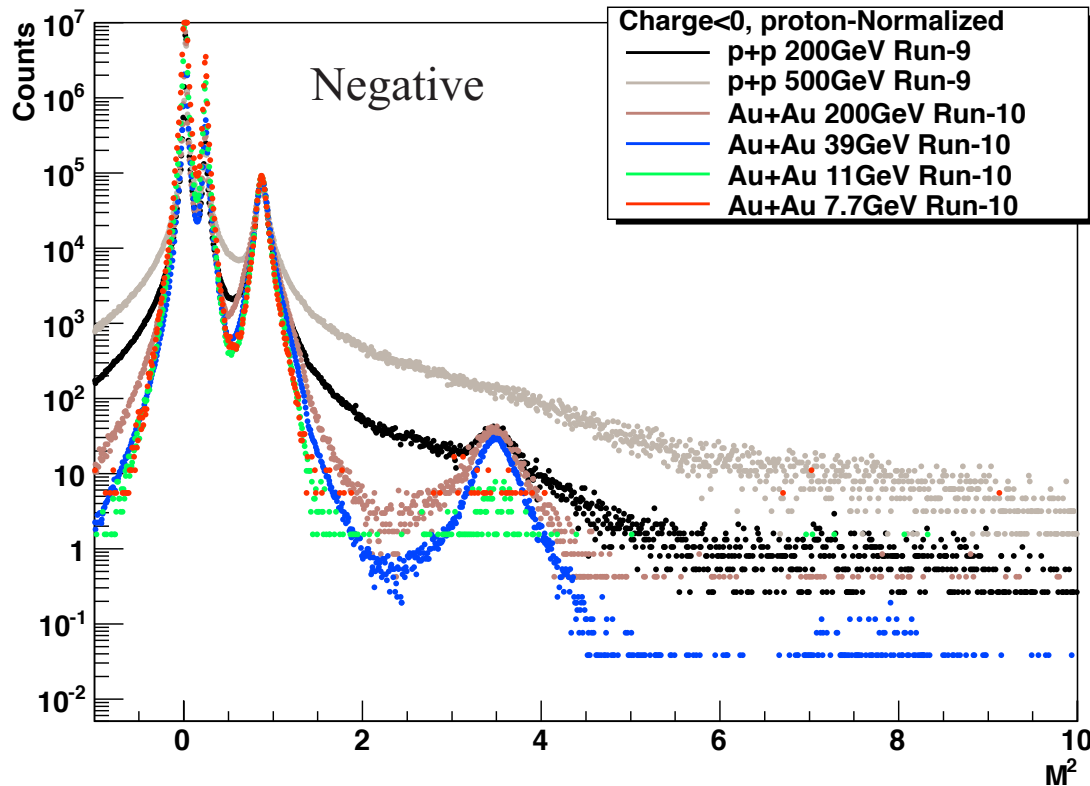
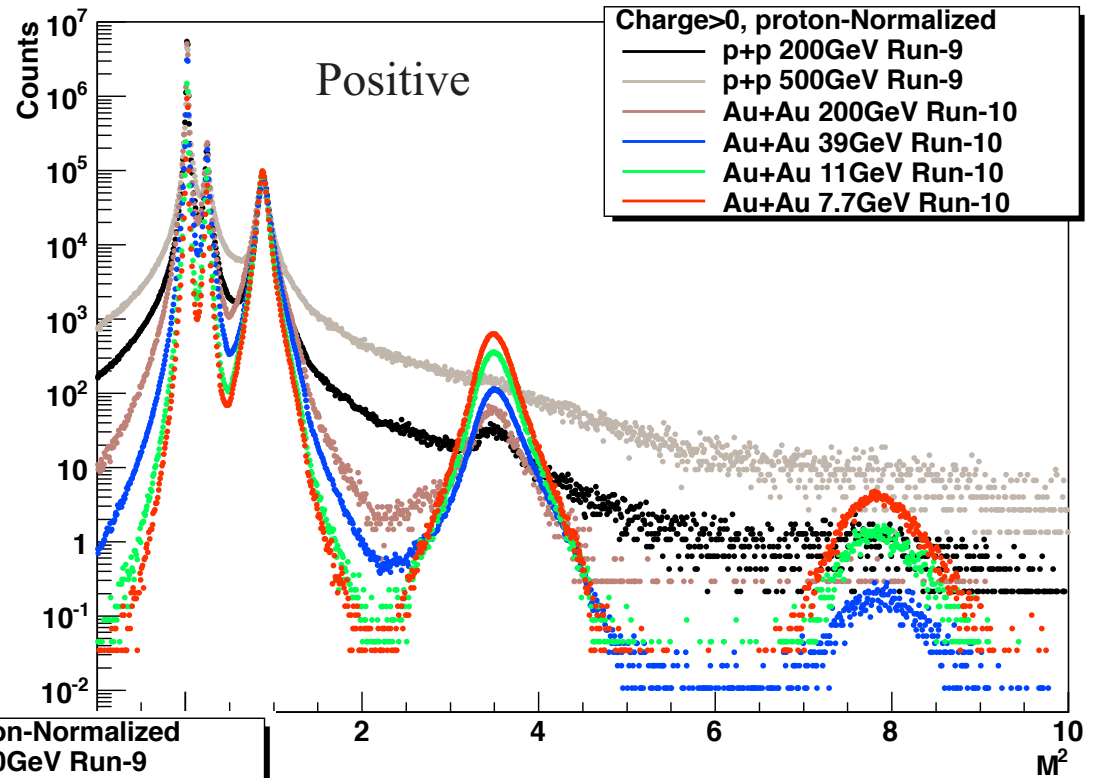


$1/\beta$ values by POI, dE/dx+TOF PID



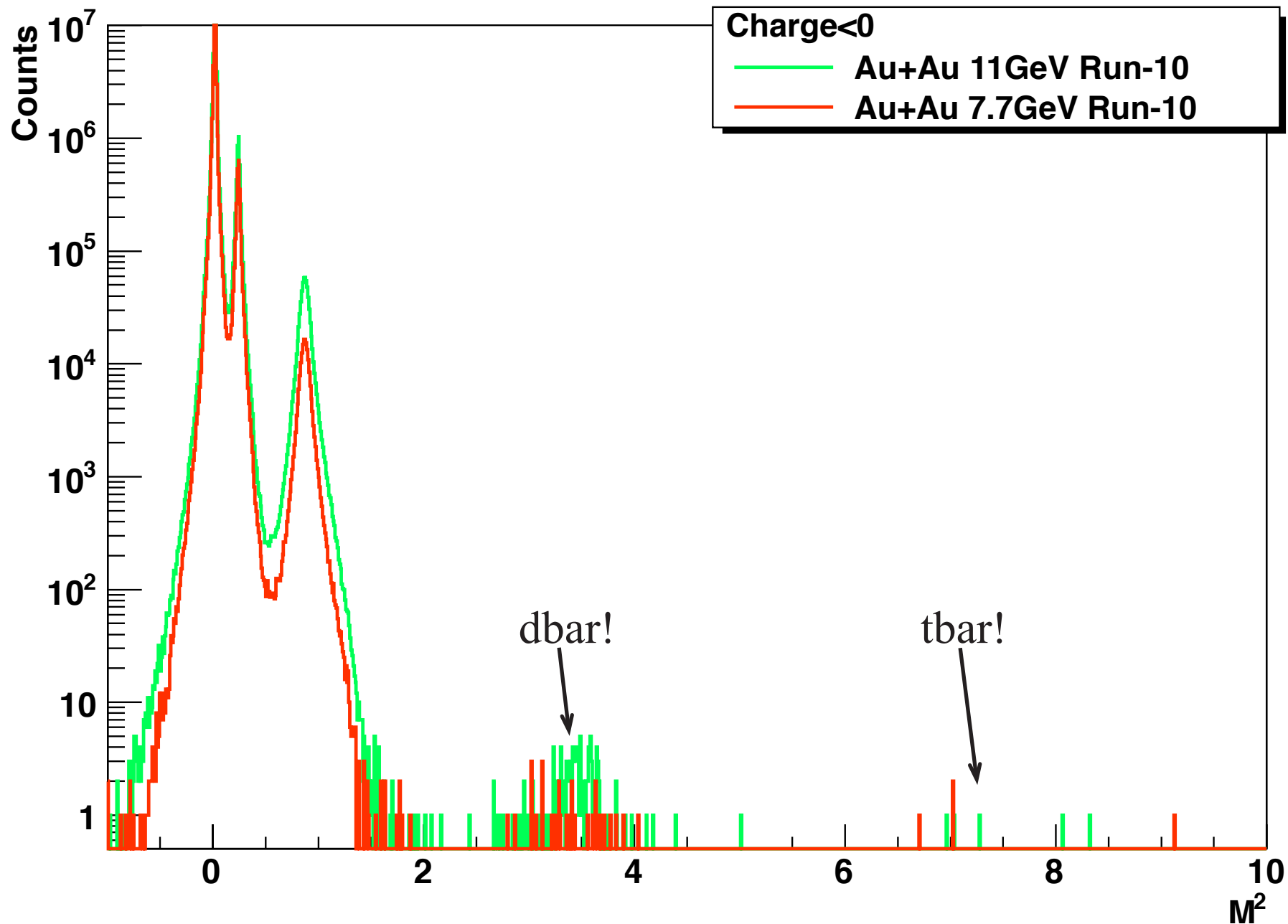
Mass-squared distributions
over all datasets...

proton peak normalized
for clarity....



as root-s decreases....
d/p increases
anti-d/p decreases

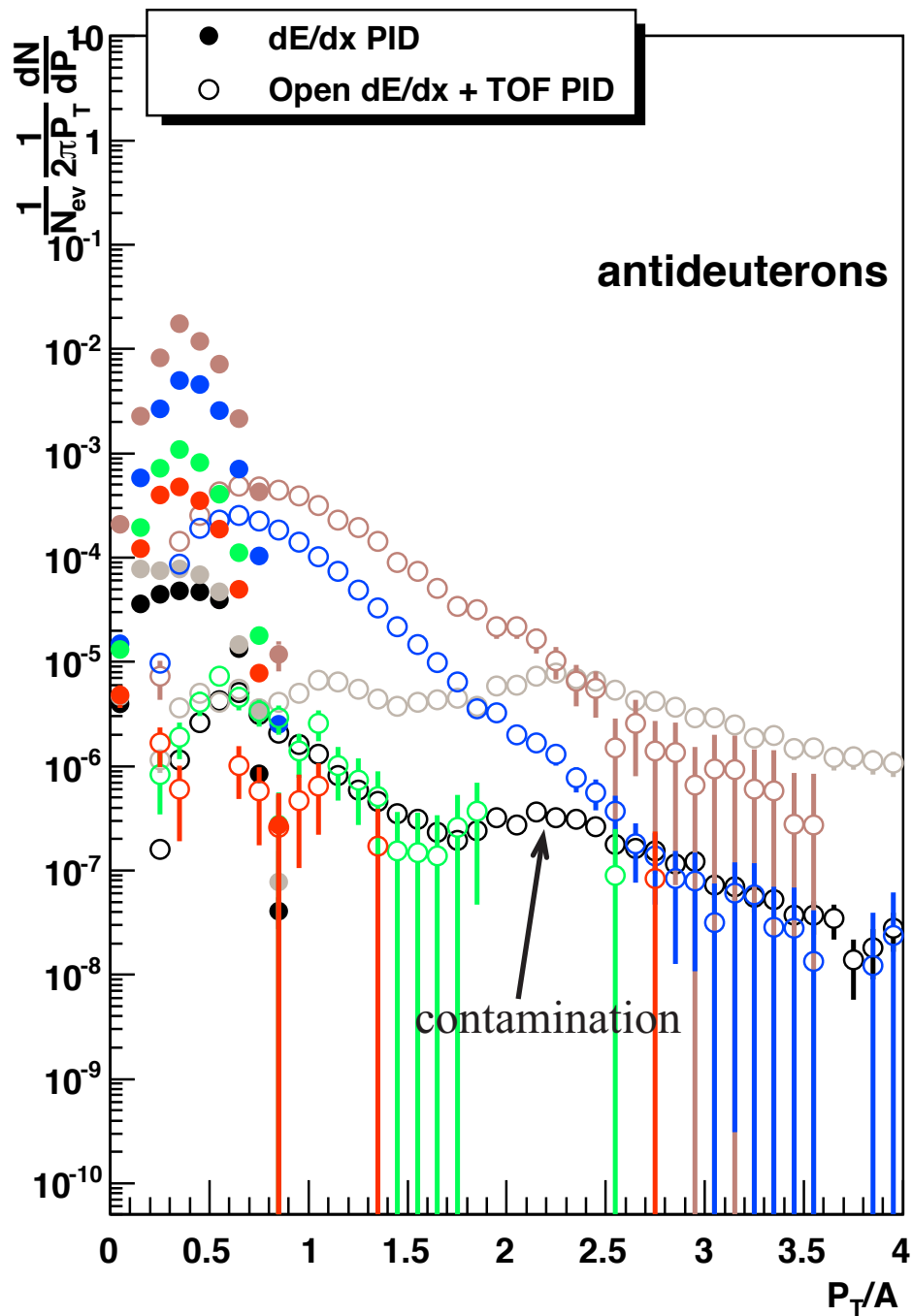
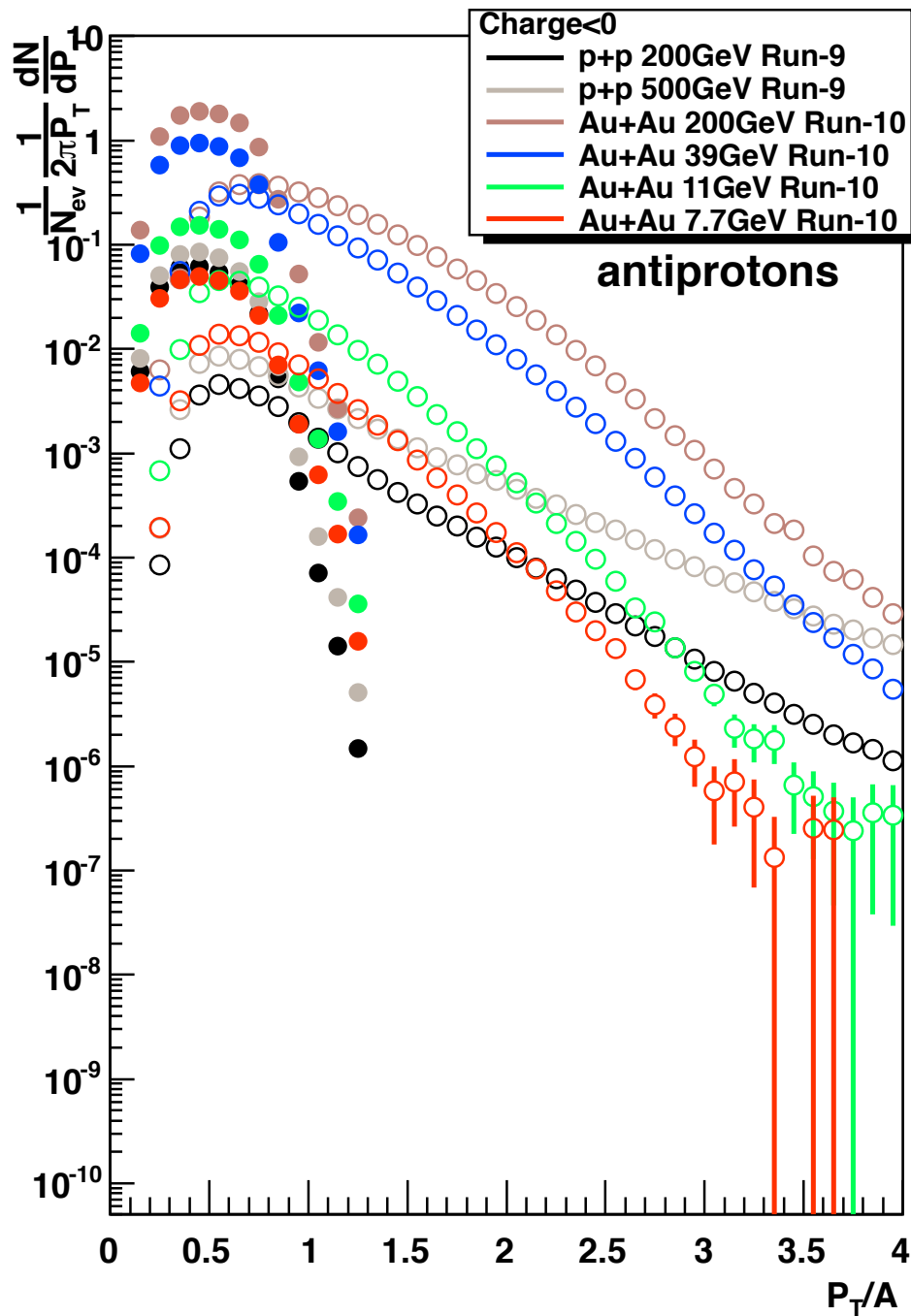
Antinuclei at 7.7 & 11 GeV...

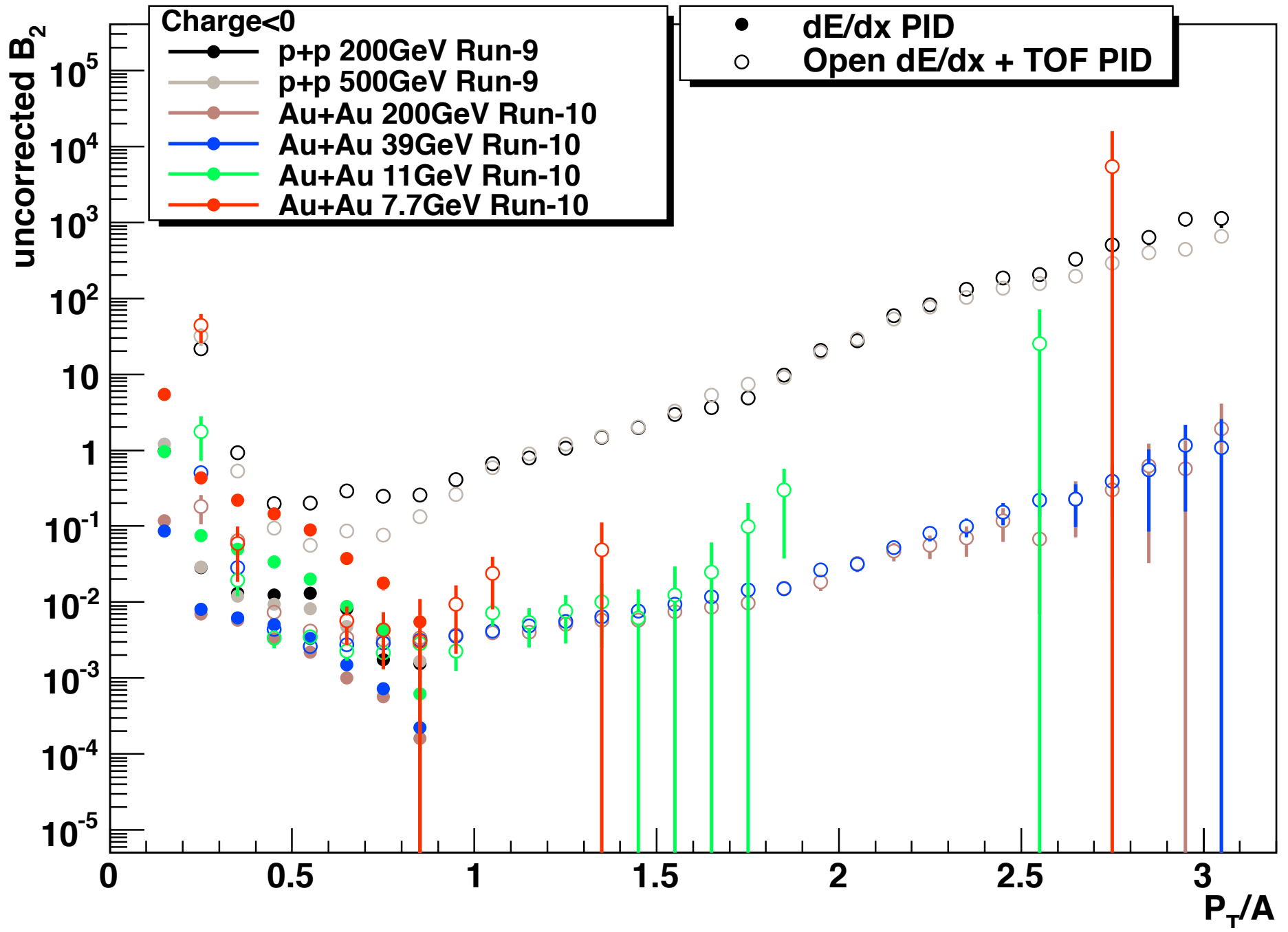


dbar and tbar total cross-sections themselves are publishable!

only have NA44 result at 158 AGeV ($\sqrt{s} = 17.3$ GeV), and a few counts from NA52

Antiproton and Antideuteron cross-sections (uncorrected!)



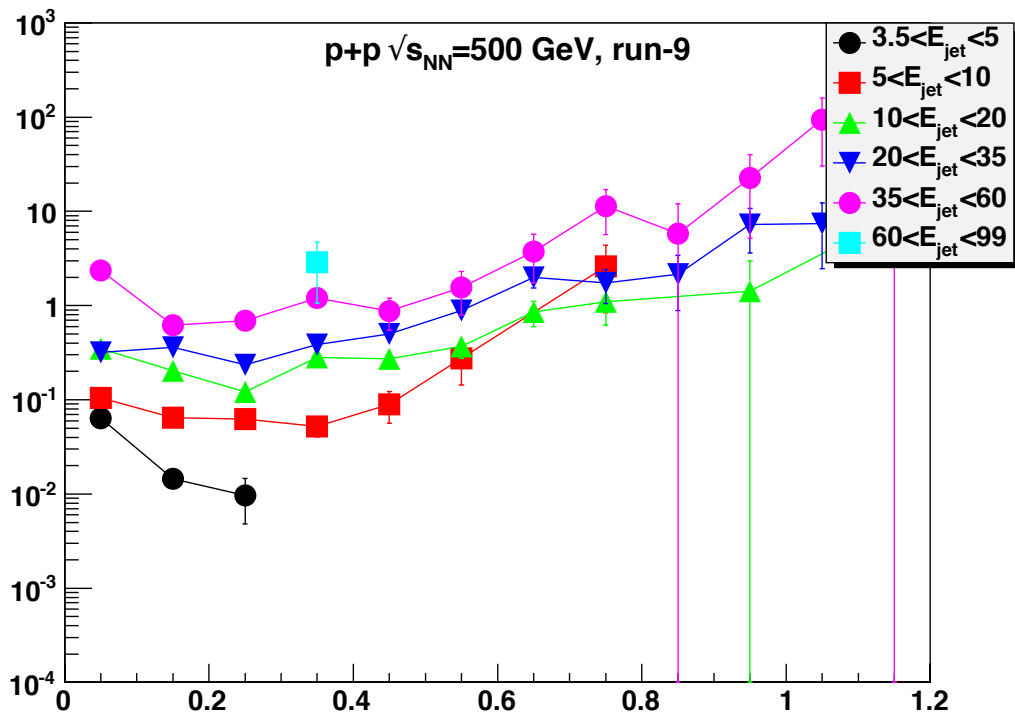
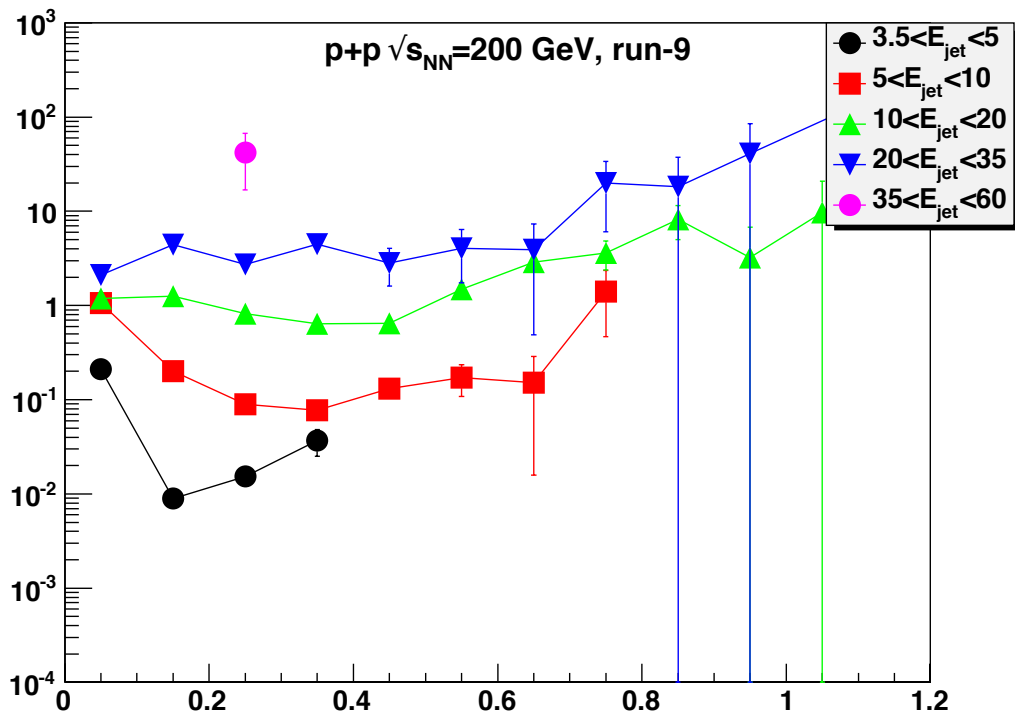


p+p B2 at 200 and 500 GeV are very similar....

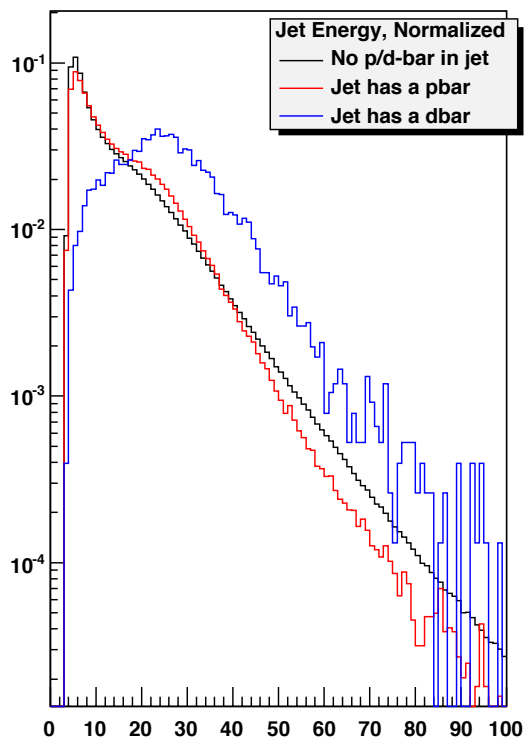
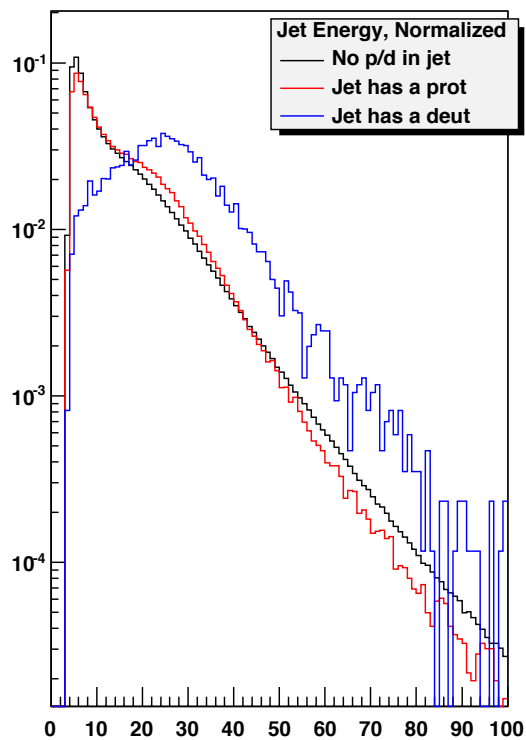
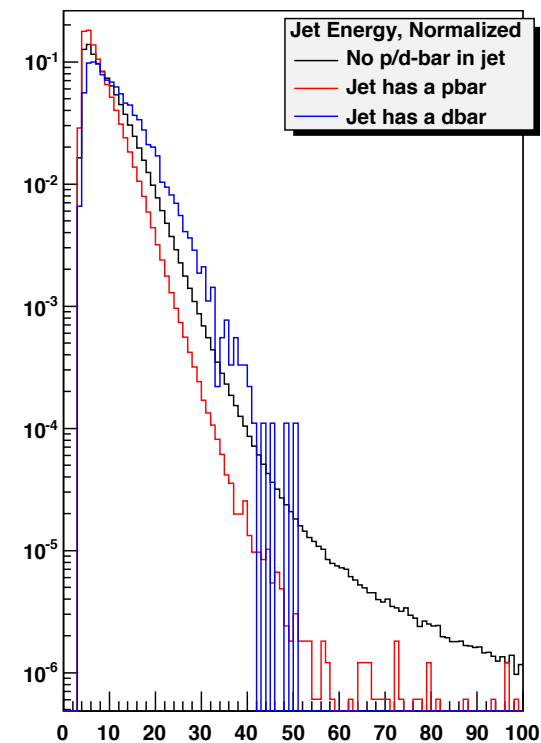
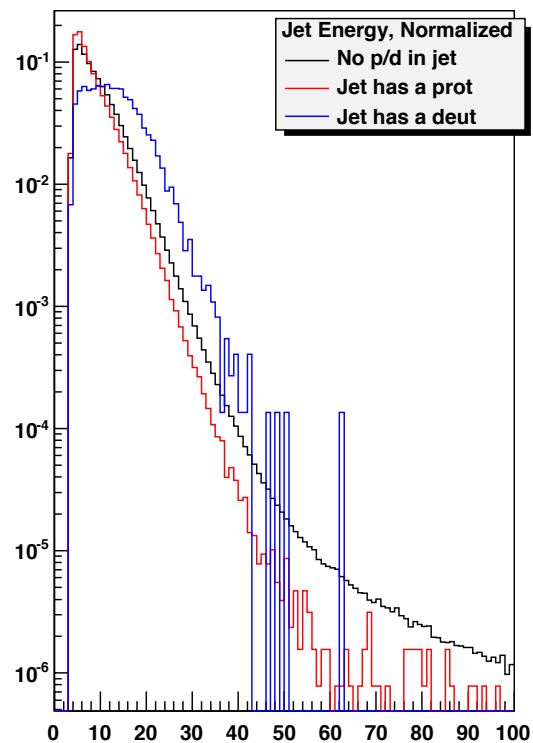
Au+Au B2 at 200 and 39 GeV are very similar...

B2 at 7.7 & 11 GeV are intermediate

Updated B_2 vs P_T/A
gated on Jet Energy



Jet Energy Gated on
presence of p or d in the jet.....



Jets w/ a d or dbar are
...slightly harder at 200 GeV
...~20 GeV harder at 500 GeV

Summary

Extremely rich dataset - I am analyzing it all w/ a single code.

Light nuclei-in-jet correlations in p+p and d+Au are interesting unto themselves (and new).

New directions:

touch base with HBT (discussions w/ Mike) and d+pi correlations (Ron)....

deuteron multiplicity fluctuations at lowest energies of the BES...

possibly also deuteron flow (v_1 ? - Chitrasen is doing the quadrupole AFAIK)...

Minor Roadblocks

- Embedding. 9 requests in queue, will add 3+3 for pp 500, plus $5*3*2$ more for BES data.
I see no near-term end in sight here - maybe try to push more towards Abar/A physics?
- V0's - can't get the StStrangeMakers to work
will try to chat with experts, not sure who is the maintainer these days...
perhaps just do a local sim of Np from Hyperons with DCA cuts and scale to published data

To-Do

- Process run-6 pp 62, run-8 dAu 200, run-8 pp 200 (and directly compare to run-9 pp 200)...
- Fine-tune PID cuts...
- sort results by trigger ID, & in Au+Au by centrality bins...
- understand differences btw VPD starts and Starts from Stops...
- understand late time background in run-10 AuAu 7.7 and 11...
- XS and BA of particles too (p,d,t,He3,a) but w/ pT lower limit scut...
- strong He3 signals at the lowest BES energies, but the dE/dx is "off"....