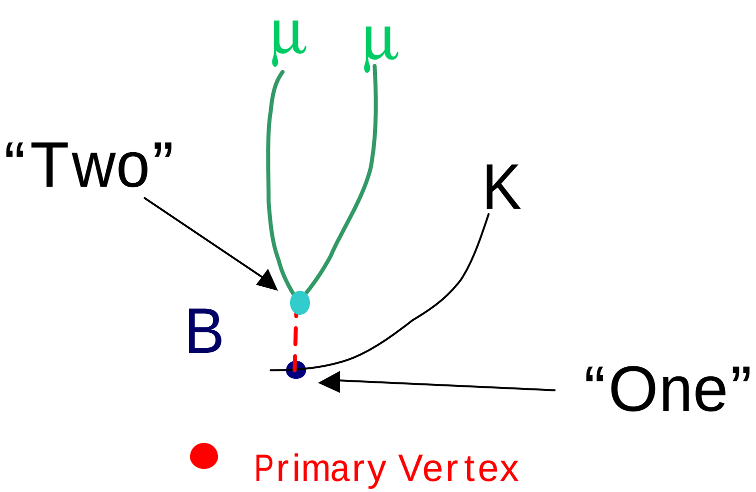
EbE Vertexing for Mixing

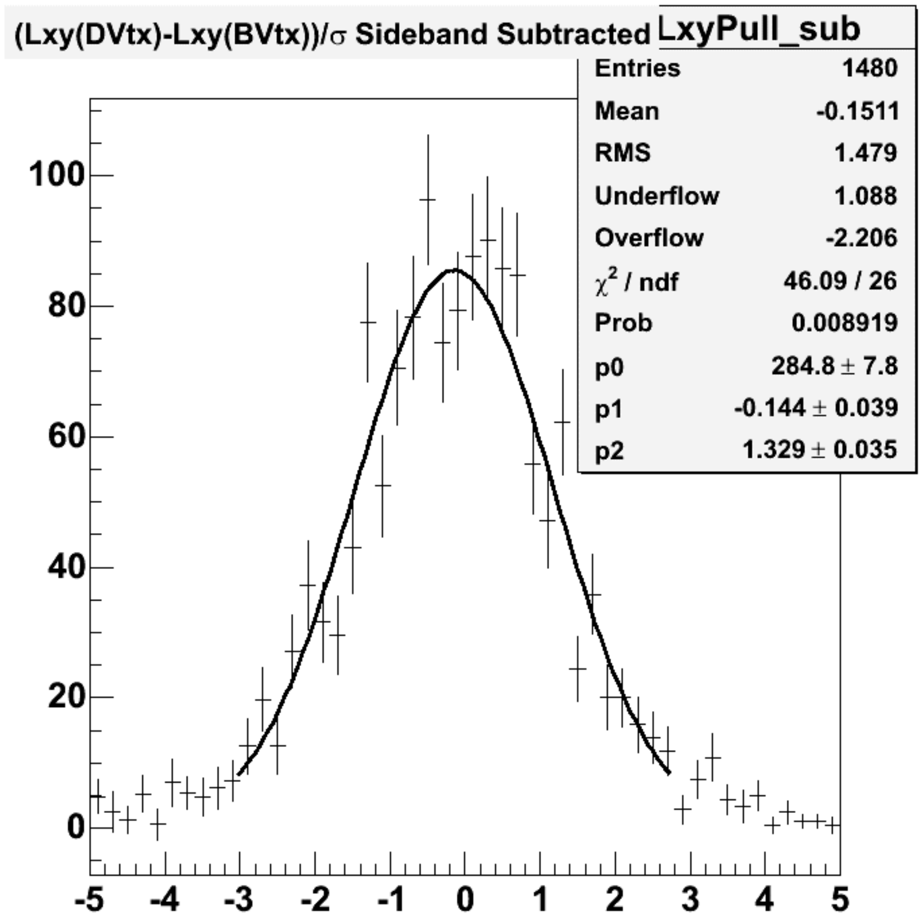
Alex
For the LBLB group

Scale factor from B decays

Example: $B \rightarrow \psi K^+$

- Fit ψ to a single vertex
- "point" ψ back to K
- Measure L_{xy} wrt B vertex
- Pull is a proxy for a "seconday vertex" pull!

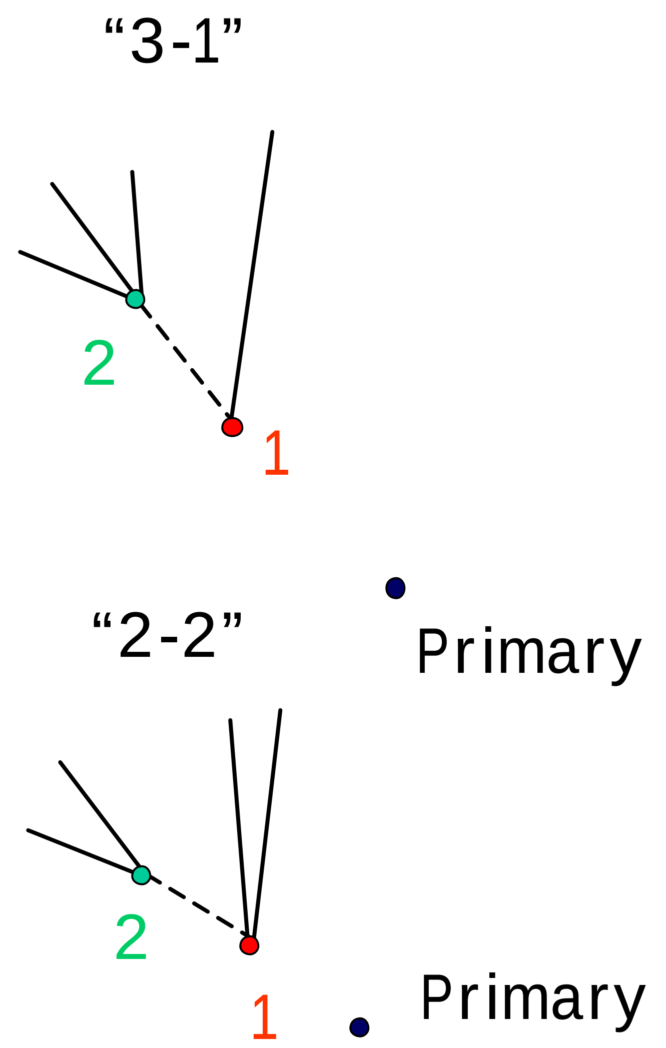




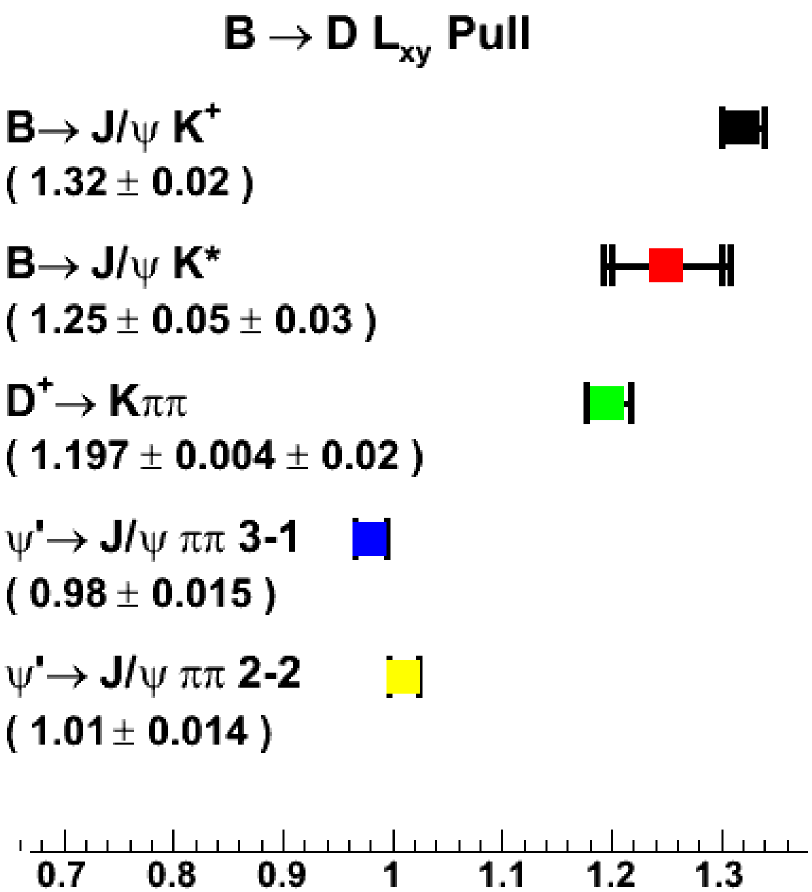
Samples and Topologies used:

- $B \to \psi K^+$ (1:K 2:$\mu\mu$)
- $B \to \psi K^*$ (1:$K\pi$ 2:$\mu\mu$)
- $D^+ \to K\pi\pi$ (1:π 2:$K\pi$)
- $\psi' \to \psi\pi\pi$ (1:μ 2:$\mu\pi\pi$)

  (1:$\mu\pi$ 2:$\mu\pi$)



The SV scale factor problem



- Pull grows as a function of lifetime!@#^$!
- Hidden dependencies!
  - Detector acceptance?
  - Kinematics?
  - Multiplicity? (no: ψK*)

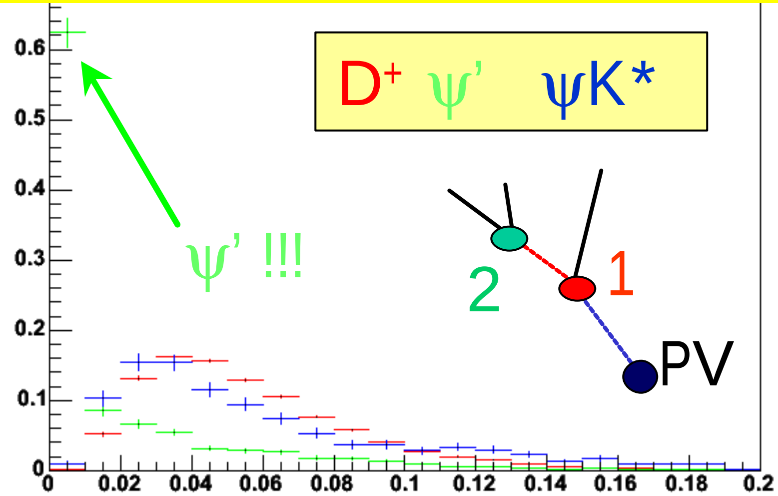
1. Figure out which distributions are different
2. Check dependency!

Course of Action

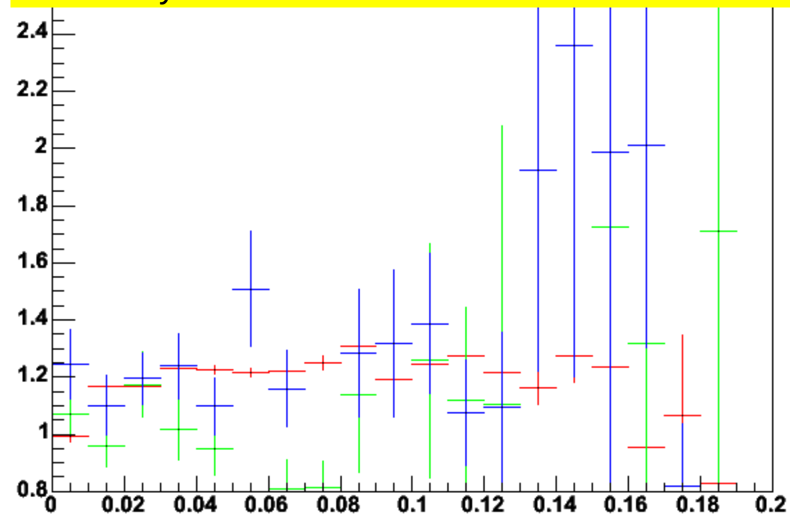
- Trying to attack the problem from as many angles as I can!
- Take samples with sufficient statistics (ψ' and D^+) and squeeze all the information I can out of them:
- Bin pull in several variables to test likely dependencies (ϕ, η, z, P_t, $\Delta\phi$, ΔR, Isolation, ct, L_{xy}, Si properties)
- ... not much success so far with this!

Pull vs Ct / L_{xy}

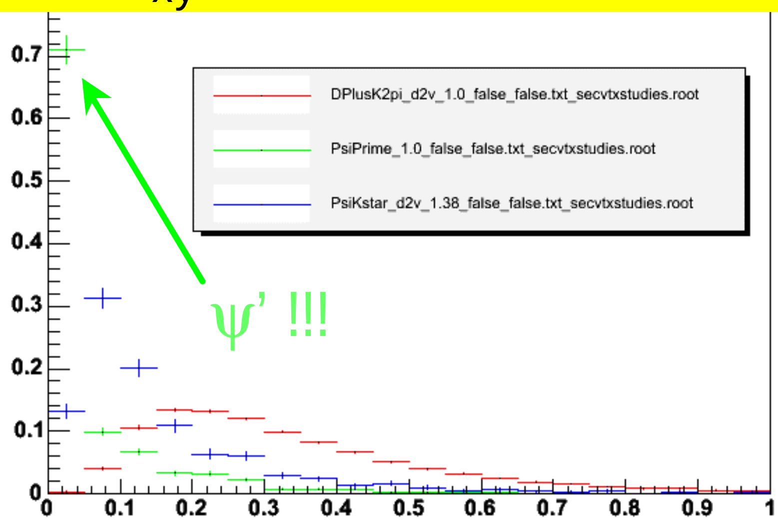
Ct(one) distribution



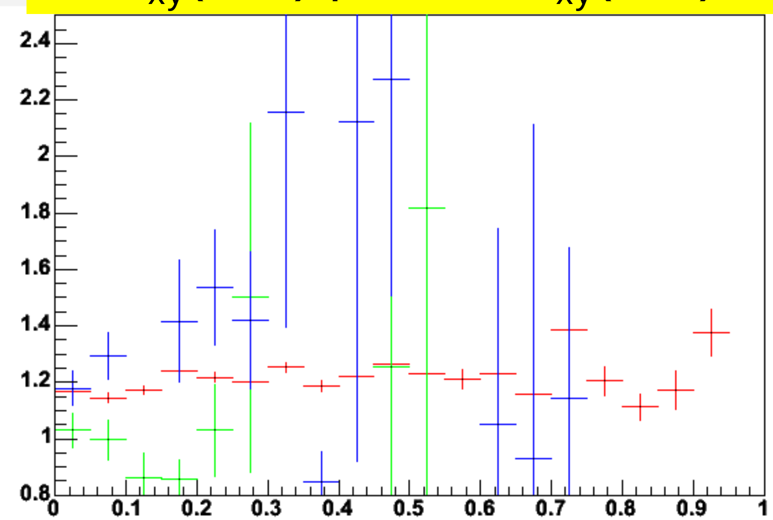
L_{xy}(two) pulls vs ct(one)



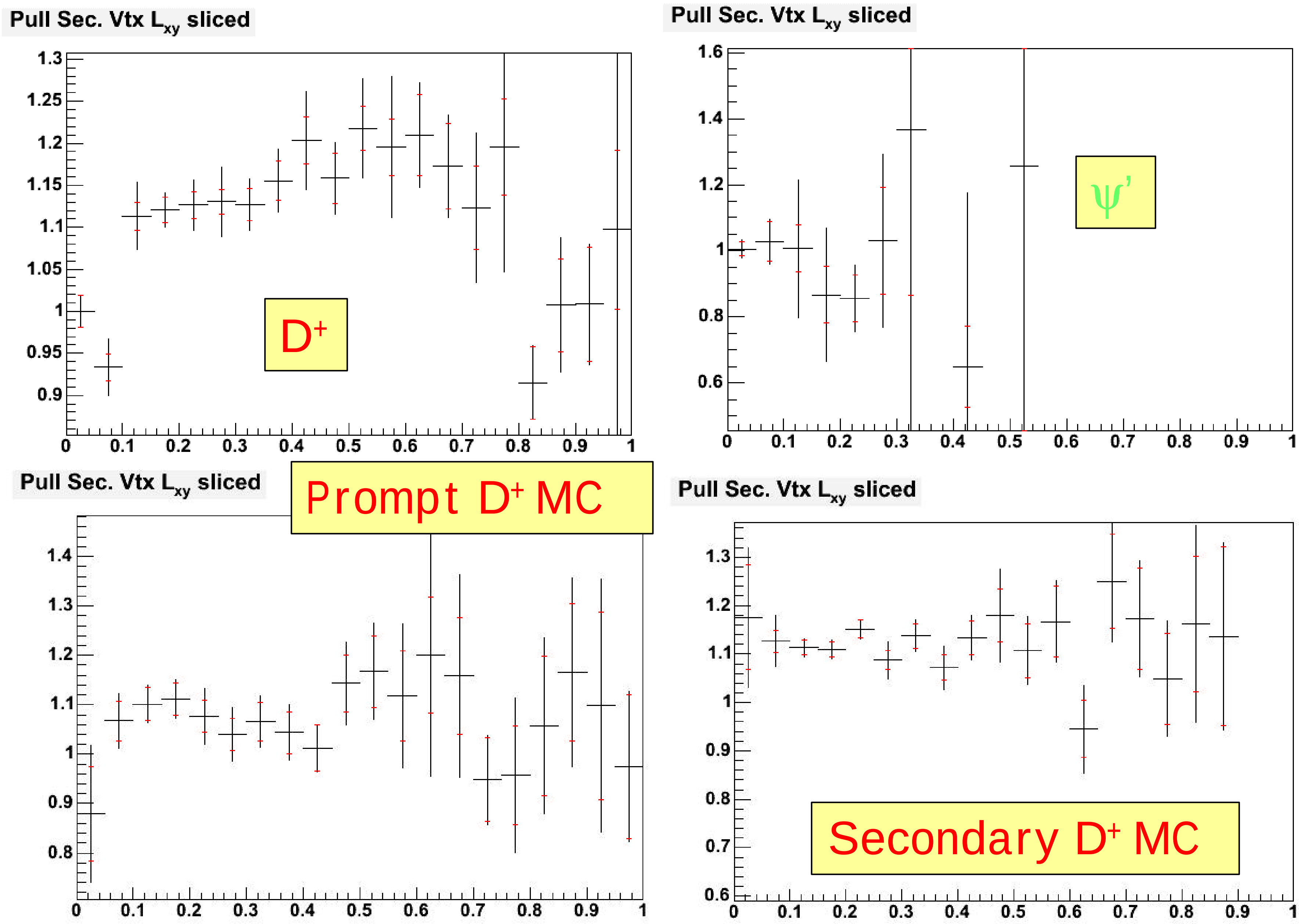
L_{xy}(one) distribution



L_{xy}(two) pulls vs L_{xy}(one)



Including fit systematics

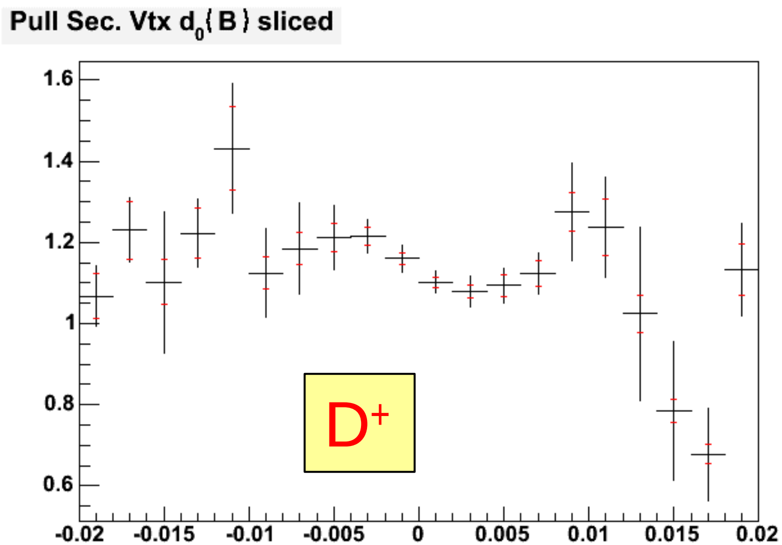


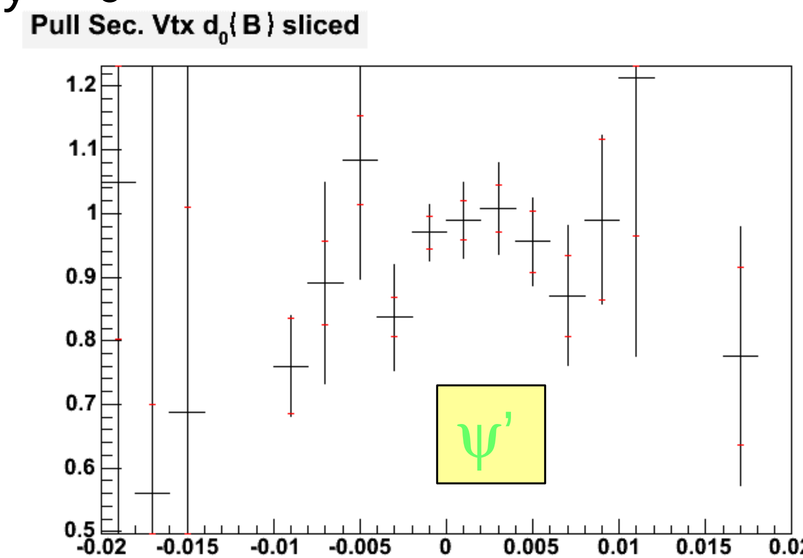
Bottomline

- The only significant effect is visible in ct/L_{xy} of the object with respect to the PV!
- BUT the two samples are basically complementary in those variables:
  - ψ' are mostly prompt
  - "My" D^+ sample is mostly from secondaries (trigger biases are excluded, since the effect shows up also in the $J\psi/K^{(*)}$ samples)
- Vertex position in space seems to play a role. What could explain that?

Vertex Position and CTVMFT

- In principle the vertex is determined by two parameters (x,y) or (L_{xy},d_0)...





- d_0 plays no clear role... L_{xy} seems to be relavant though...
- While looking into this we realized there was a likely candidate for this type of problem: CTVMFT does not swim the track error matrices to the vertex when computing the vertex resolution (next slide)
- Reprocessed samples with a kludge: no significant change

CTVMFT and covariance swimming

- Vertex covariance in fit is computed using the track covariance matrix as-is
- In principle should correct, propagating the covariance at the vertex coordinate
- How big? Easiest way is reprocess data fixing the issue!
- Kludge on CharmMods (it would be nice to test what this does to lifetime fits!)
- No significant difference found in the pulls: still same dependancy on ct

... one step forward?

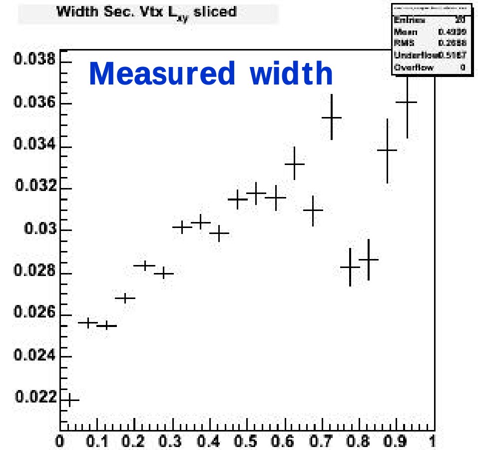
Is the effect coming from $\sigma_{measured}$ or $\sigma_{predicted}$?

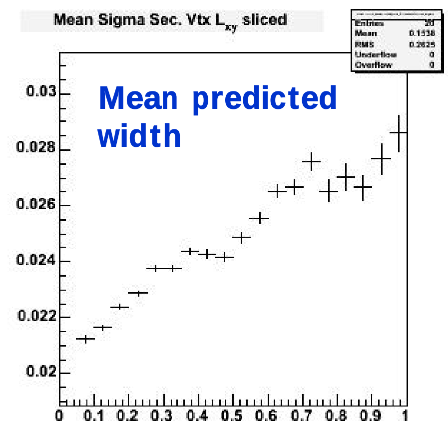
Measured:

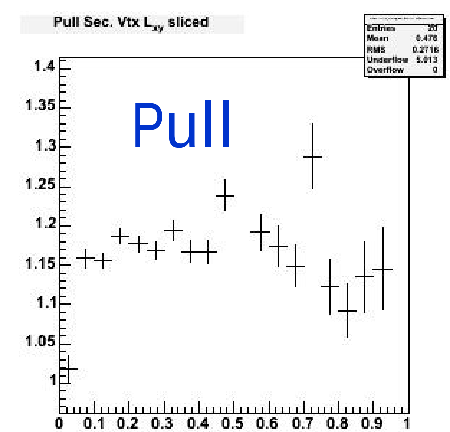
- Assessed fit systematics using different models (1 gaus, 2 gaus, gaus + expo): discrepancy holds

Predicted:

- CTVMFT seems ok:
  - Above bug has no effect
  - Tested on toy MC (two tracks at fixed kinematics, sliding in L_{xy})
- Input: track covariances?
  - Two terms dominate: d_0 and ϕ
  - Scaled overall covariance terms by large factors: no effect
  - Scaled COT covariance: no effect
  - Planning to compare ϕ pull with covariance term using pions from D* (skim in progress as we speak)



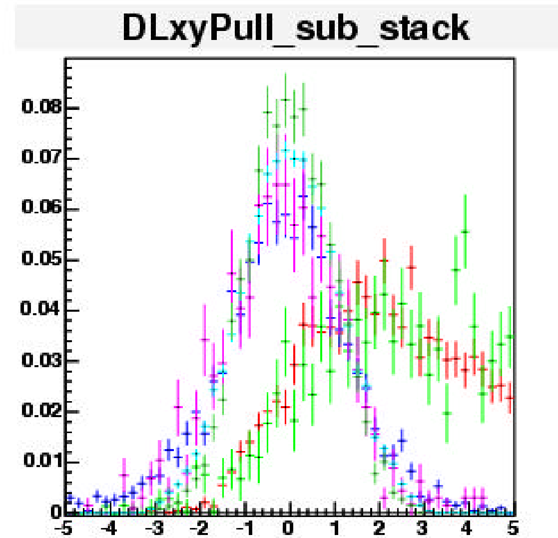


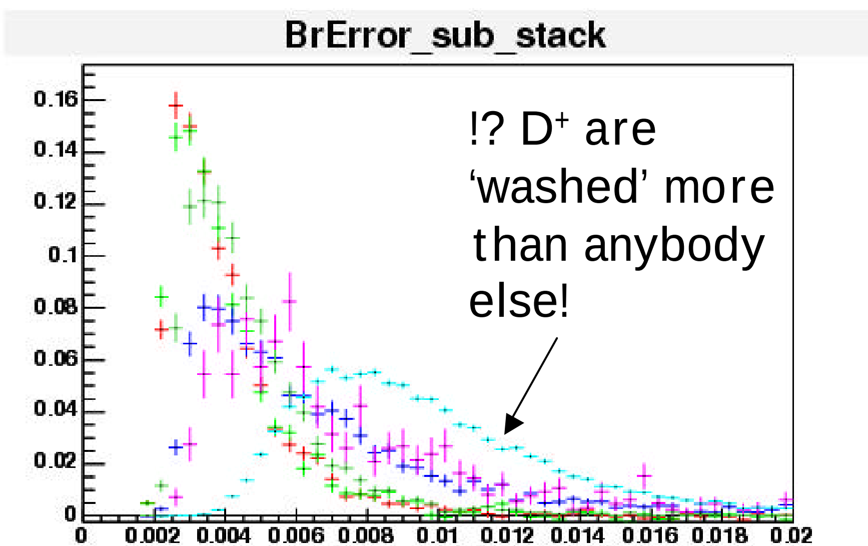


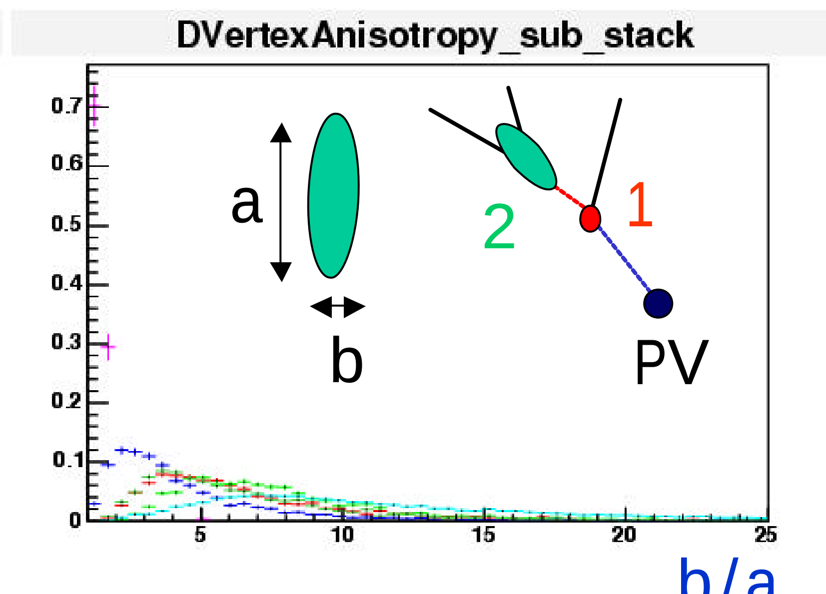
Shift in perspective

- Focus so far has been on the low bin for D^+ Maybe we are chasing a misleading evidence?
- There is room for other possibilities:
  - Bin is low for other reasons (stat. Fluctuation, selection bias)
  - Overall behavior is not completely consistent: pulls vs L_{xy} grow for D^+ and decrease for ψ'!
  - Let's keep our mind open for other options!
  - Next step: trying to break down contribution to the L_{xy} width
- Besides ct, what other qualitative differences are there between the samples?

Samples are qualitatively different!

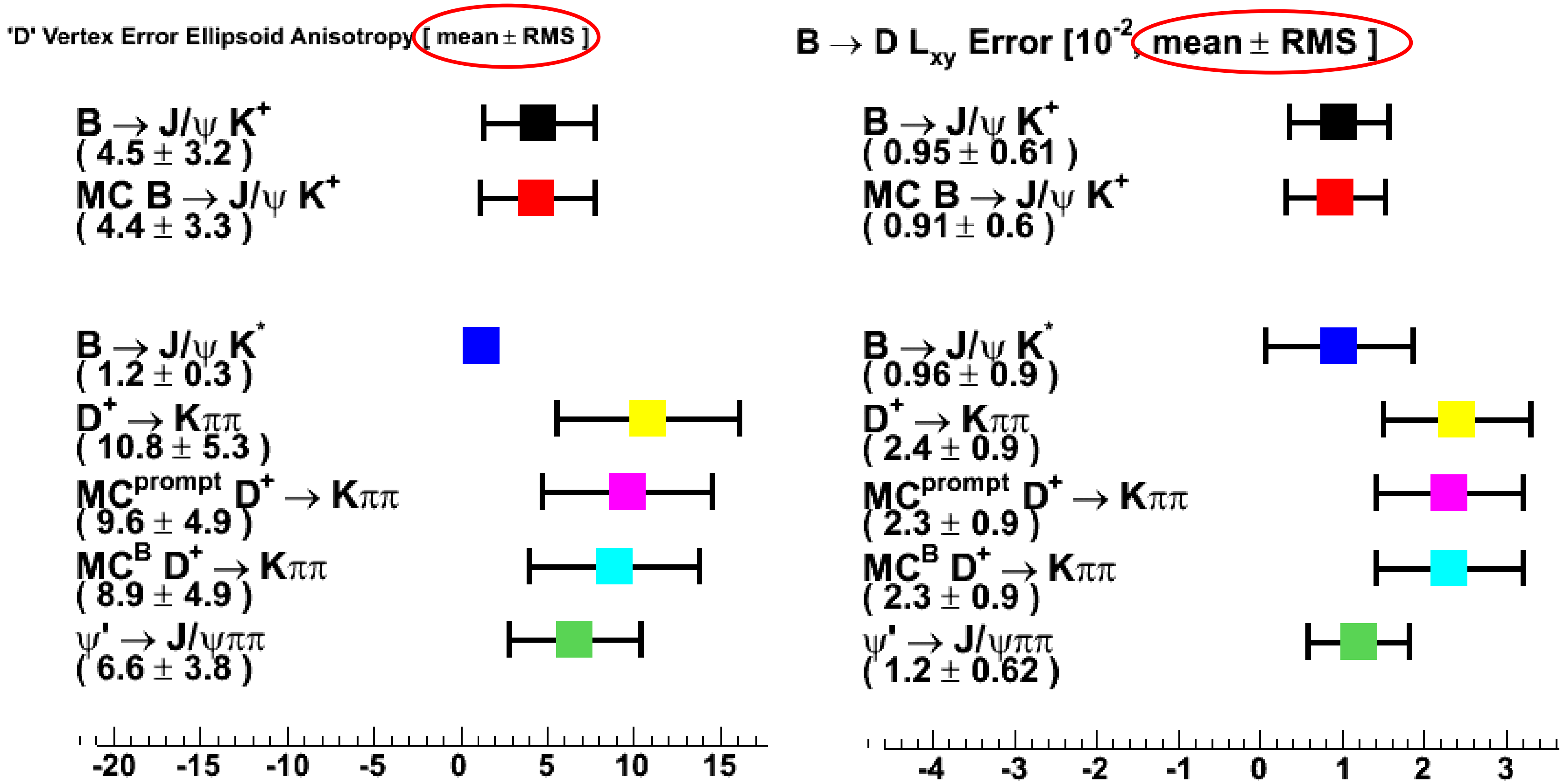






Quantifying the difference

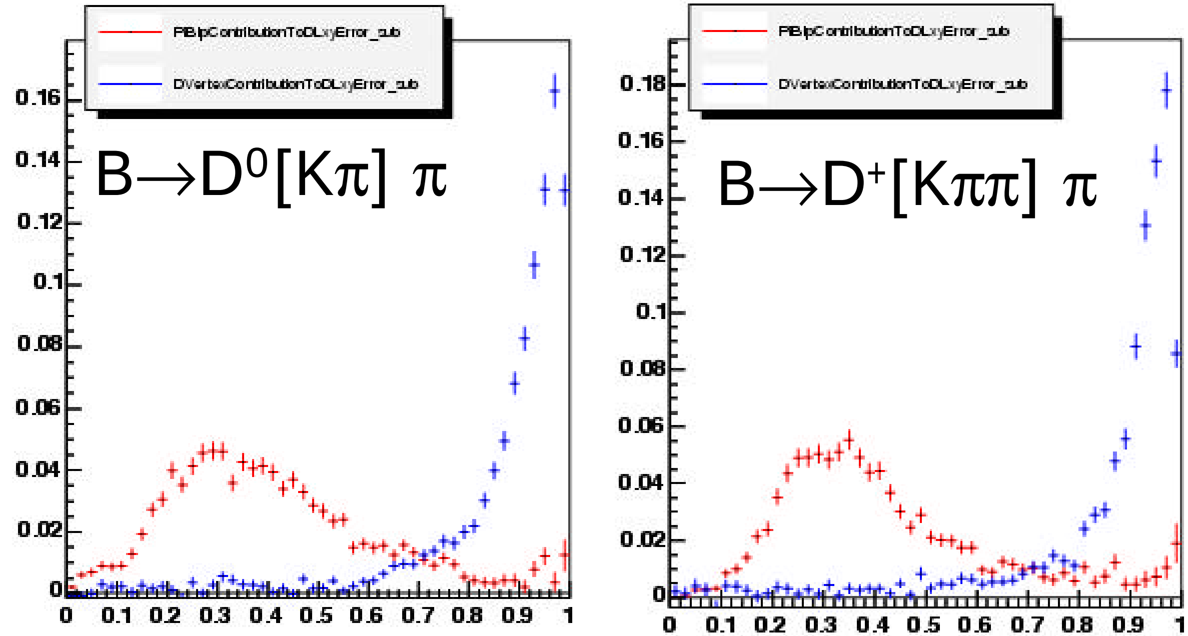
"error bars" show RMS

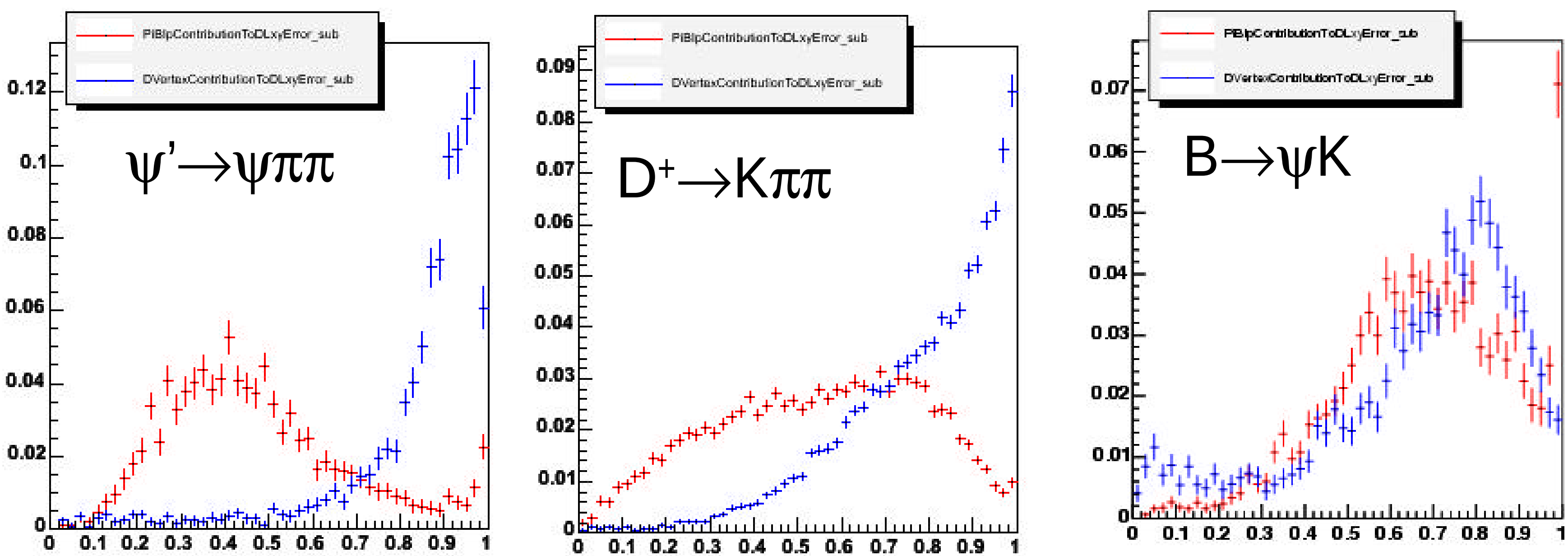


The samples look really different with respect to the size and shape of the error ellipsoid for the 'D' vertex, but no clear correlation emerges with the behavior of the L_{xy} pulls!

Track and vertex errors have different roles in the various samples!

Contribution of $d_0(\pi)$ and 'D' vertex error to π's I.P. wrt 'D' vertex





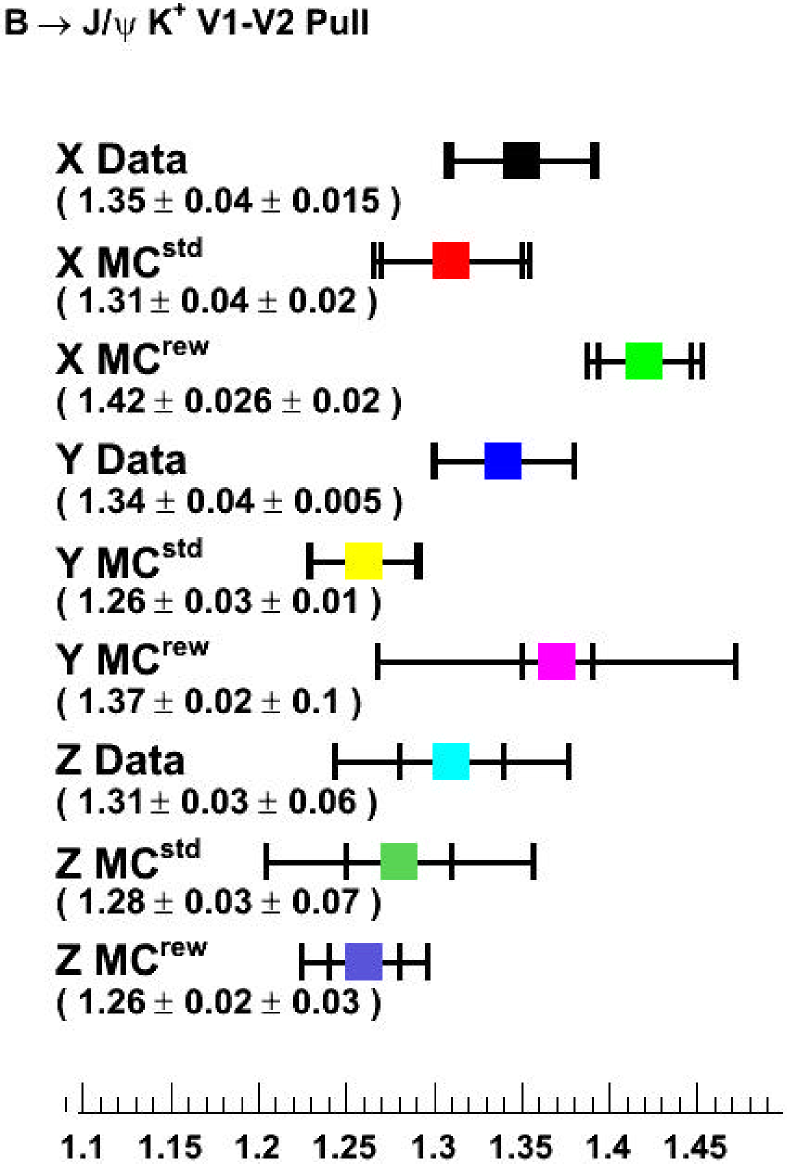
Montecarlo Plans

In parallel to data studies we are carrying on a study to compare/complement data:

- Toy montecarlo to study pull of fixed kinematics vs L_{xy}
- We need several samples:
  - As many of the modes we study on data as possible
    - ψ, ψK^{+}, ψK^{*}, D^{+}
  - Pythia (preferable to evaluate the PV pulls)
  - Bgen (suitable for most SV studies)
- We are generating and analyzing most of those
- Some preliminary results in the next 2 pages

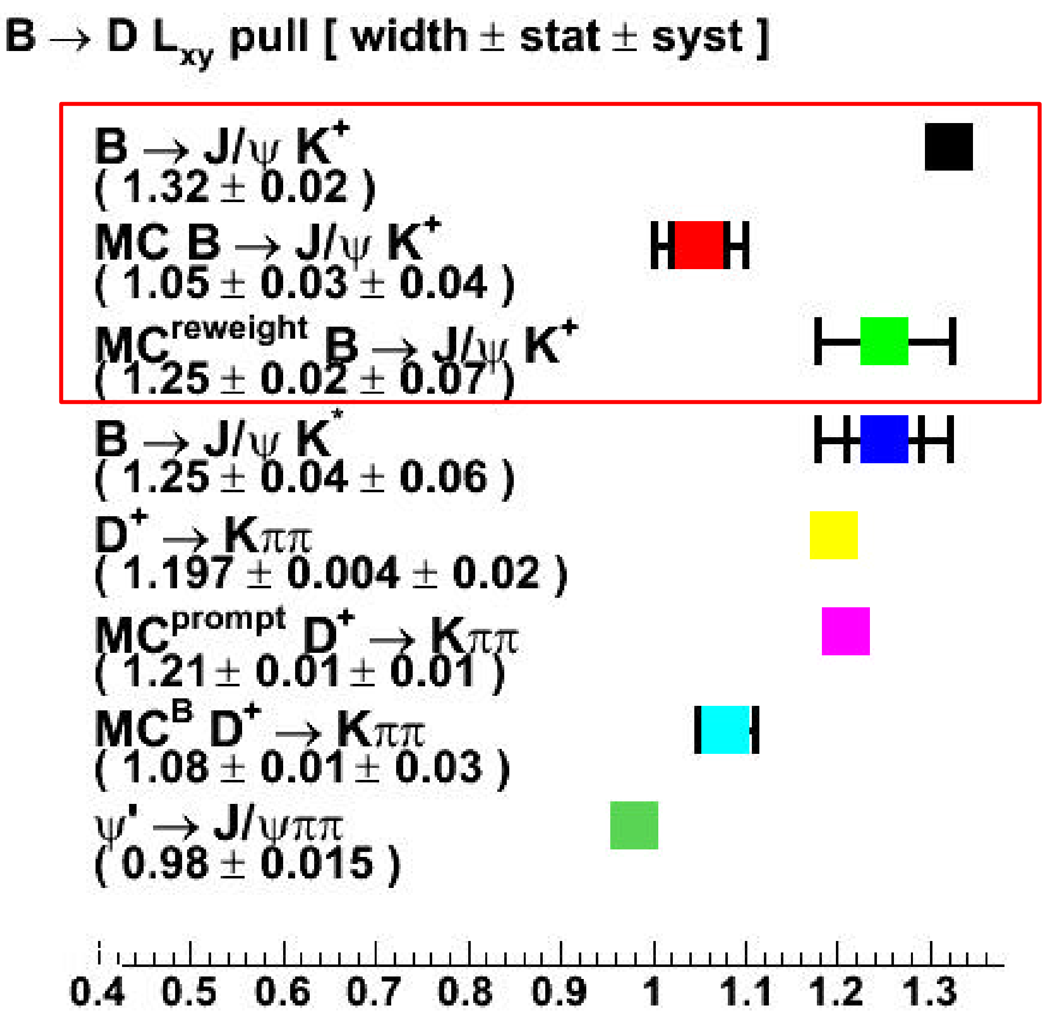
L00 Reweighting on PV

- L00 efficiency and resolution in 'out of the box' MC not well reproduced
- Stephanie advertised last week a module that automatically shims the montecarlo distributions
- I am testing it on various MC samples
- In this case PV reconstruction in $J/\psi K$ PYTHIA
- Reweighted MC consistently shifts towards larger pulls in (x,y), compatible with data



L00 Reweighting on SV

- L00 reweighting has an even larger effect on SV
- Effect seems to go in the direction of explaining our 'problem'
- Need more samples (D^+, ψ', ψK^*) to have a more complete picture
- If we find consistency with data, we can dissect the MC and get another tool to investigate the problem!



Conclusions

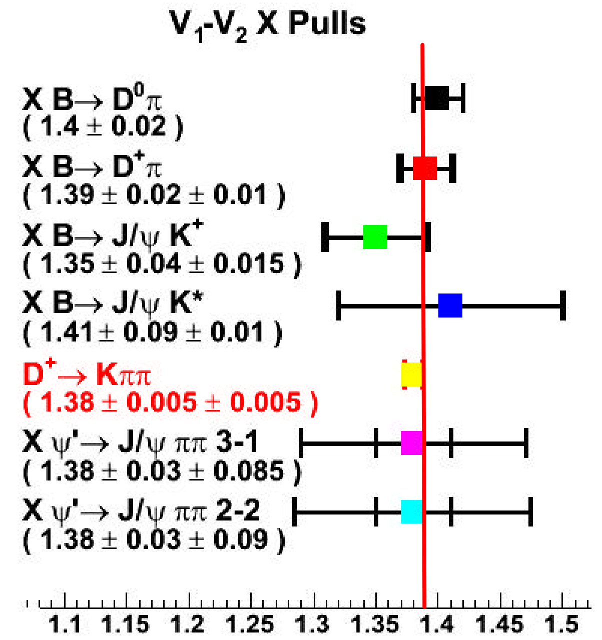
- Still on our way to understand the lifetime-dependent SV scale factor
- Several sources ruled out
- Comparisons of ψ' and D^+ samples not as conclusive as we hoped
- MC studies are on their way!

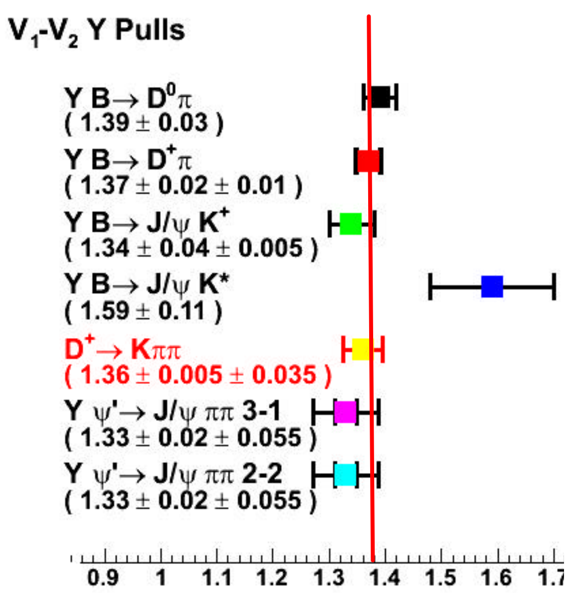
Backup

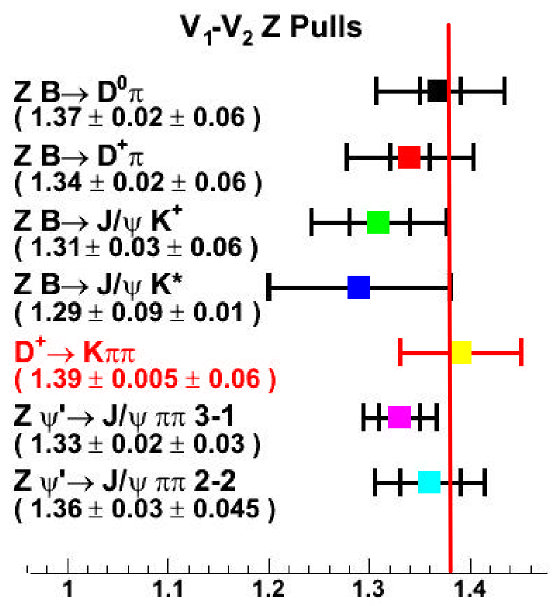
Scale Factor from V1-V2

- Fit two independent subsets of 'primary' [I.e. non-B] tracks
- Measure (x_1,y_1,z_1) and (x_2,y_2,z_2)
- Obtain Δ/σ for x, y and z
- Fit core with single gaussian (central value)
- Repeat fit with two gaussians ('syst.')
- Still using 1.38

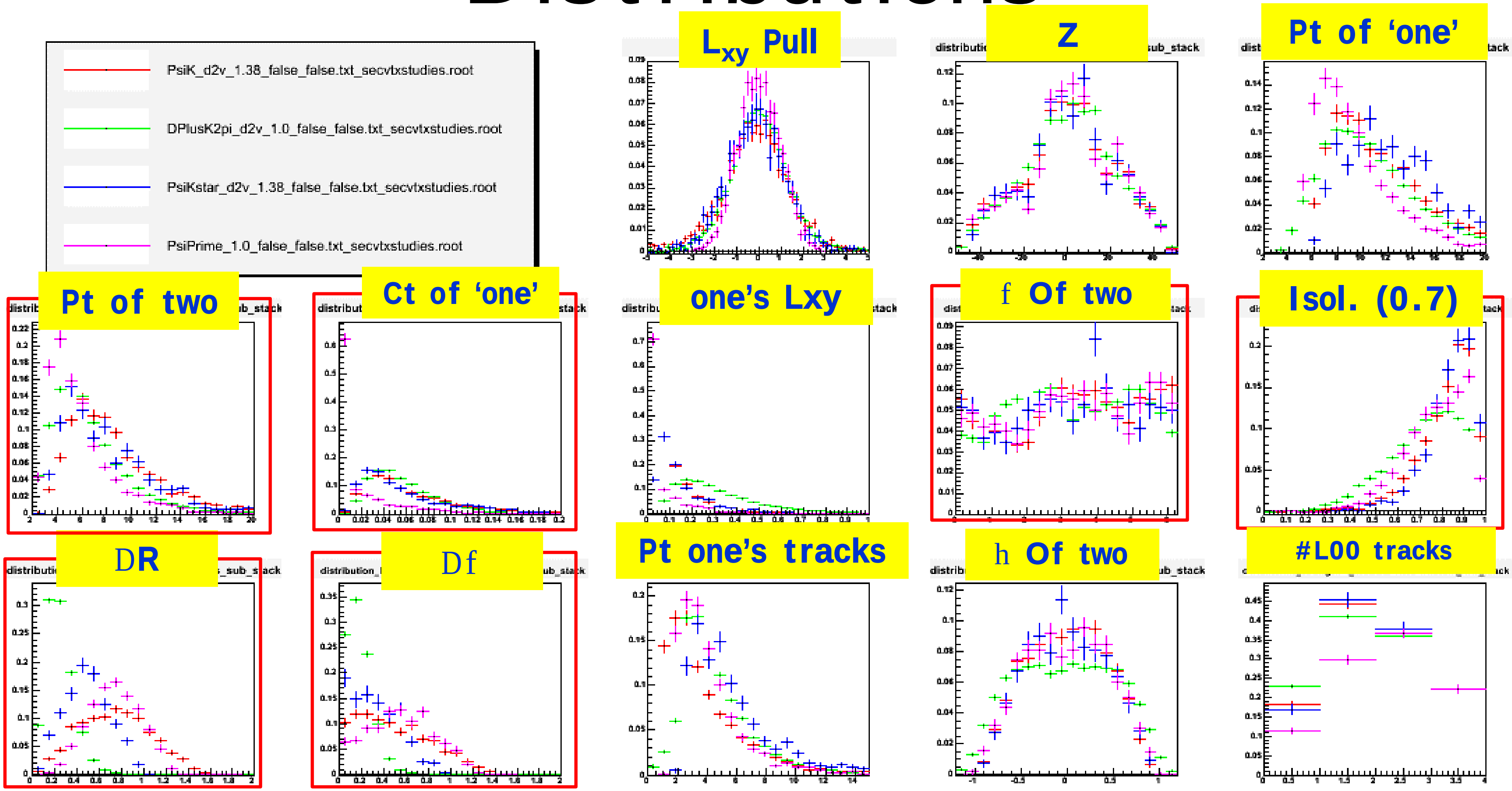
For what follows

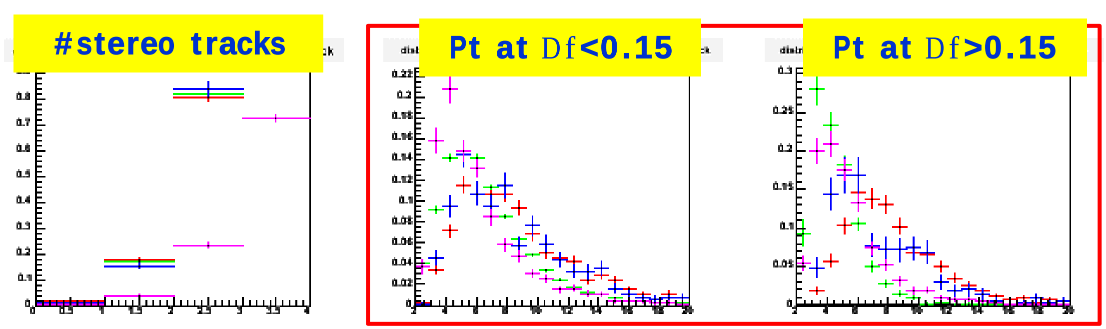






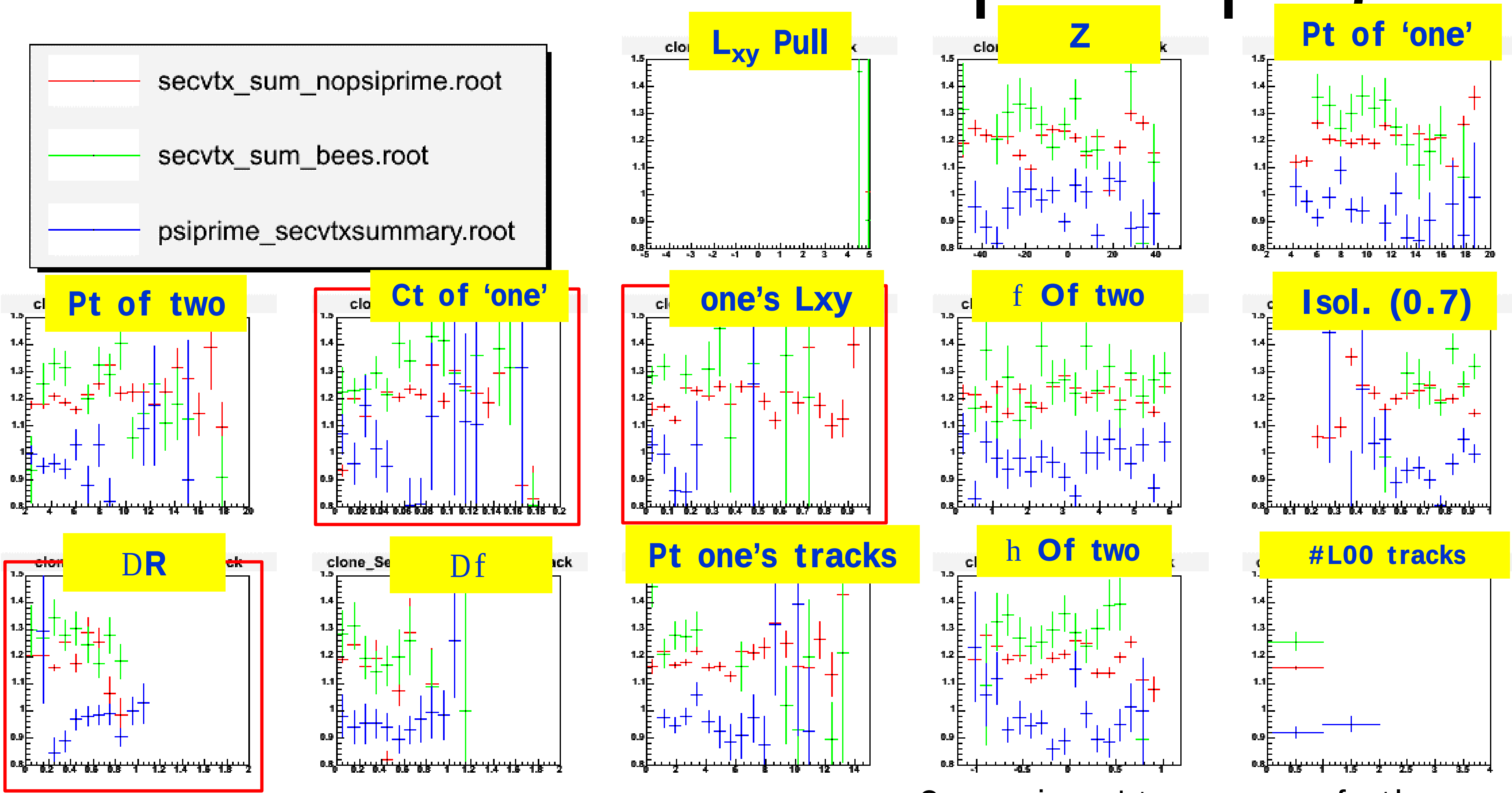
Distributions

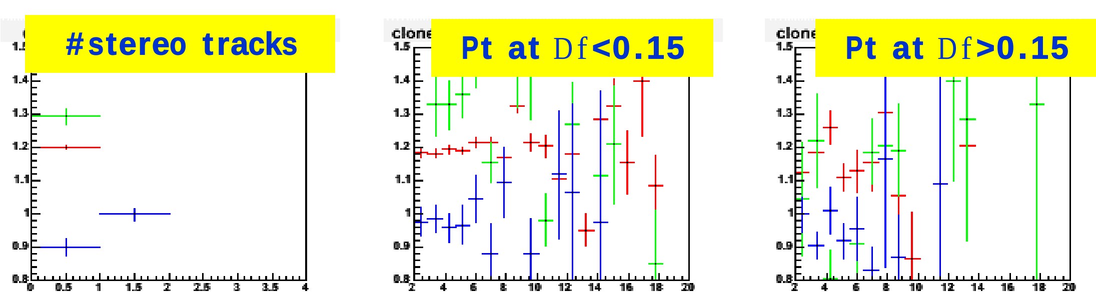




- Detector acceptance (φηz) pretty similar
- No clear difference in Si properties
- Kinematics differs (Δφ ΔR P_t)

Pulls vs variables in prev. page

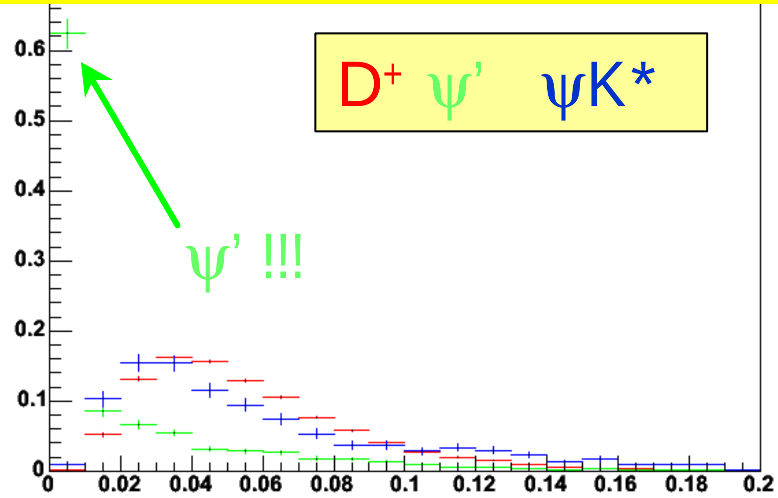




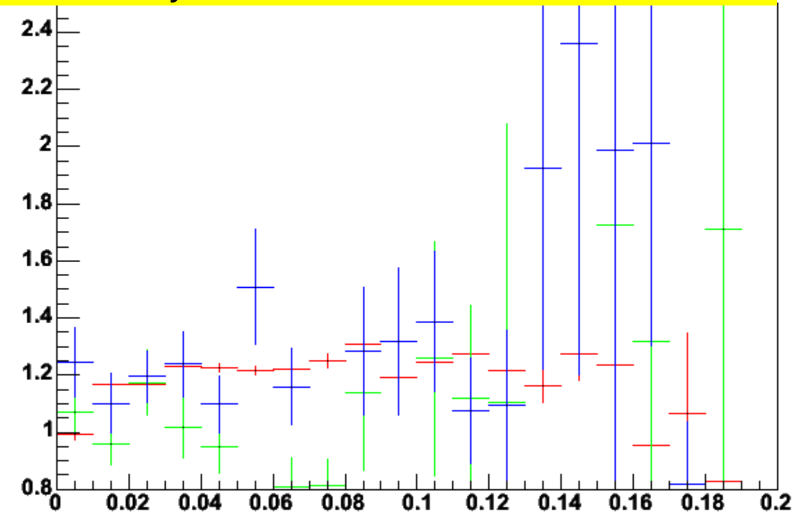
- Comparing ψ' to average of other samples in each bin
- Everything excluded except ct
- Why? I can think of possible reasons, but in terms of bugs mostly! WORK IN PROGRESS

Ct and L_{xy}

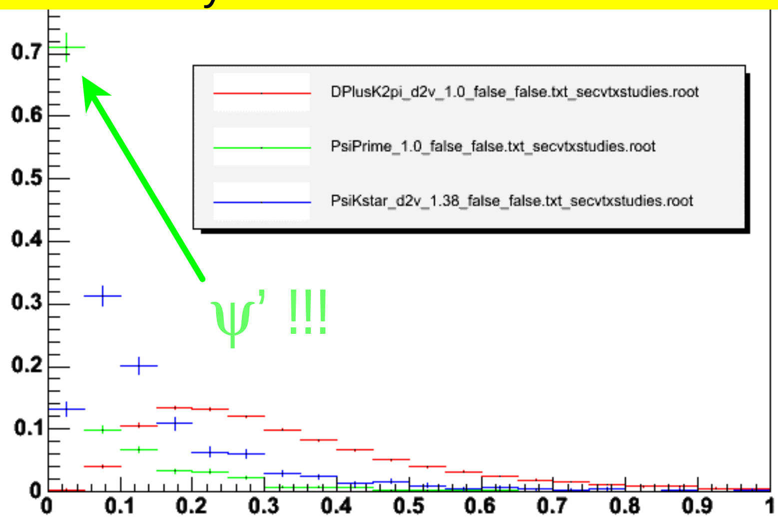
Ct(one) distribution



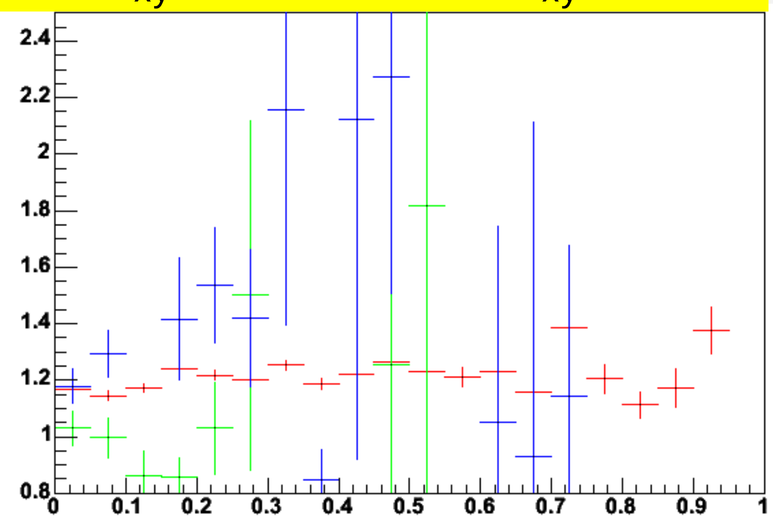
L_{xy}(two) pulls vs ct(B)



L_{xy} distribution



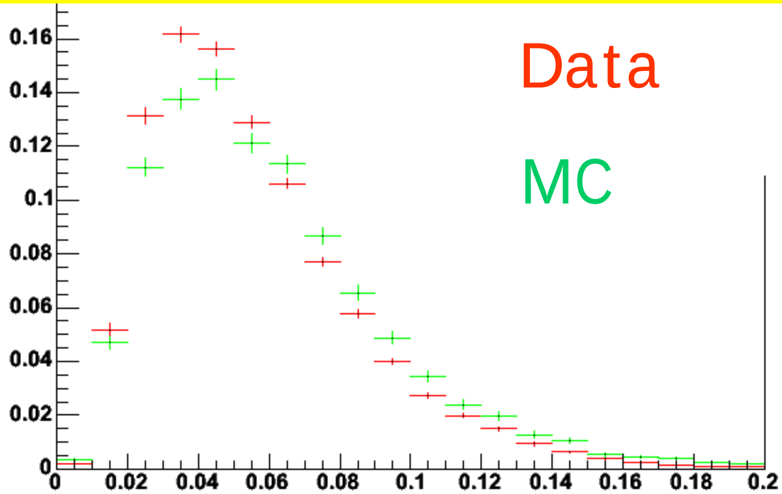
L_{xy}(two) pulls vs L_{xy}(B)



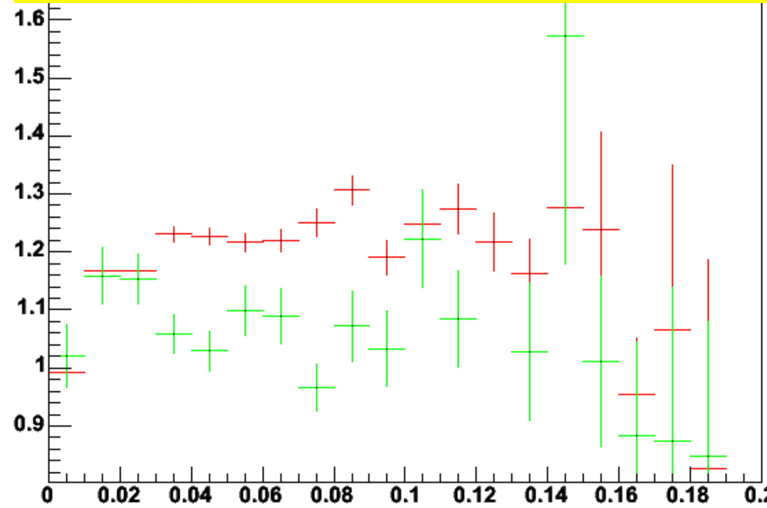
The problem does not show up with prompt objects!

D^+ Montecarlo vs data

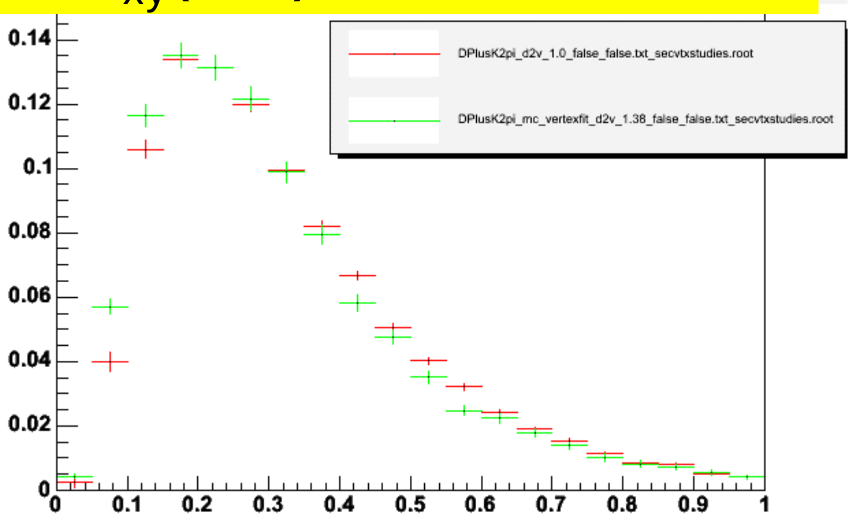
Ct(one) distribution



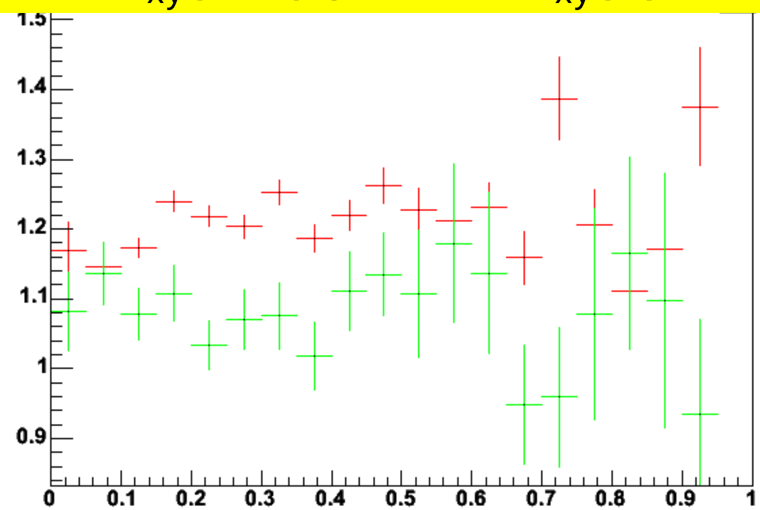
L_{xy}(two) pulls vs ct(B)



L_{xy}(one) distribution

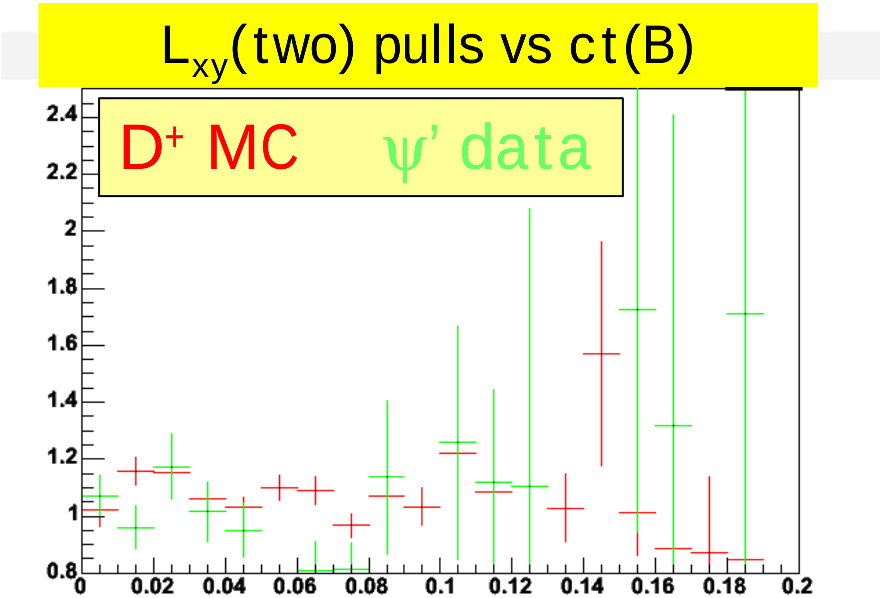


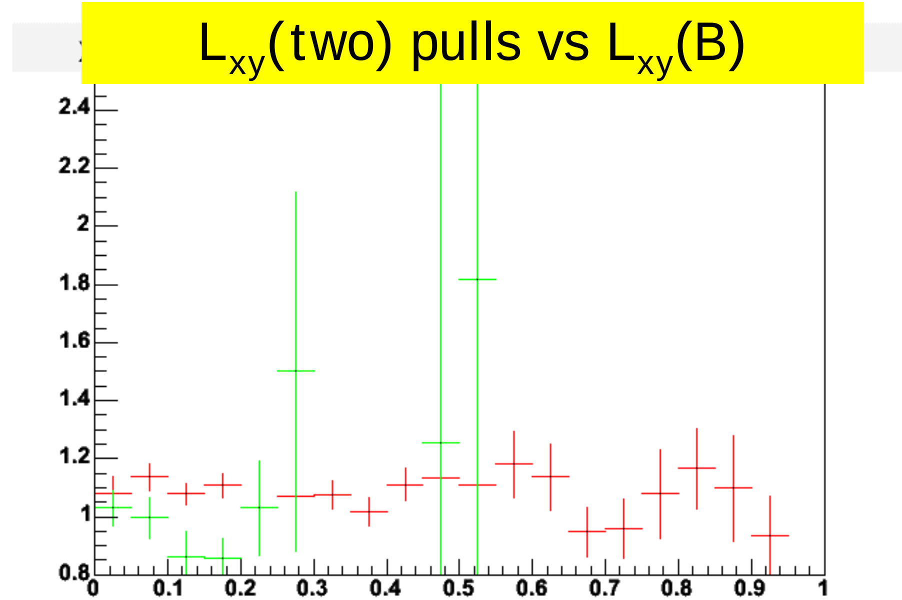
L_{xy}(two) pulls vs L_{xy}(B)



The problem does not show up in montecarlo!

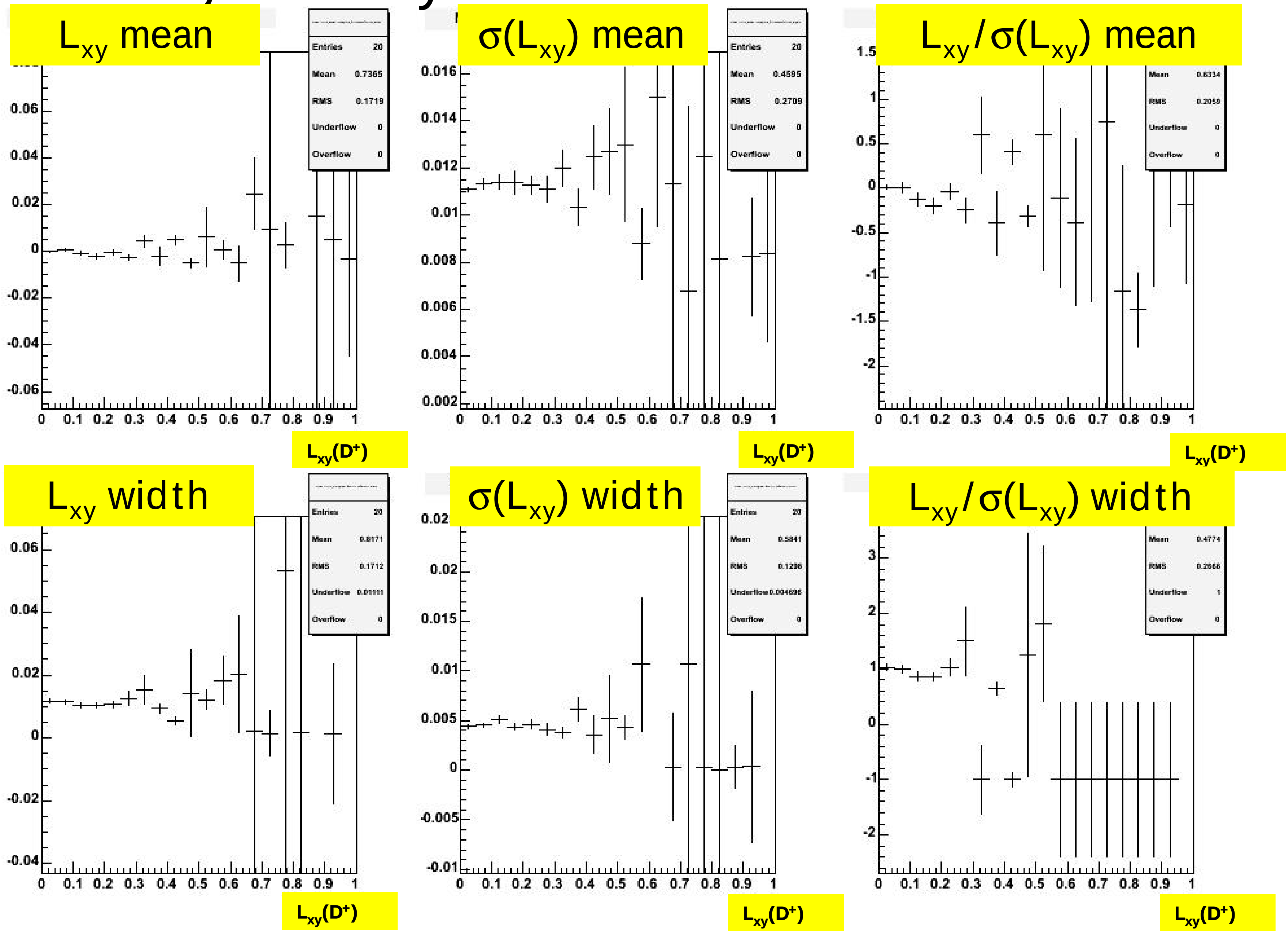
ψ’ data vs D^+ MC





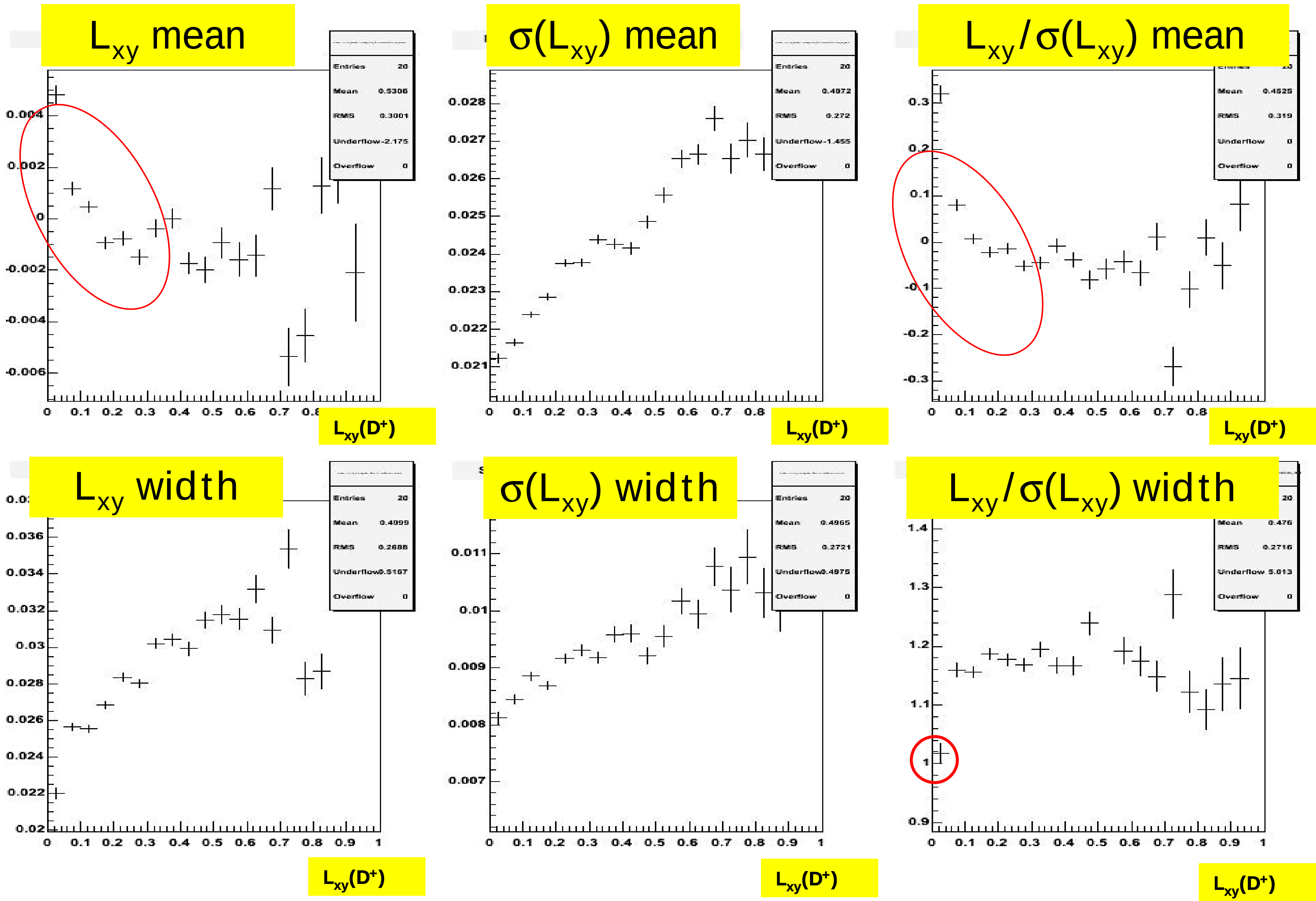
- They are much more similar!
- The ‘bug’ affects non-prompt data only!!!

L_{xy} $\sigma(L_{xy})$ and pulls for ψ'

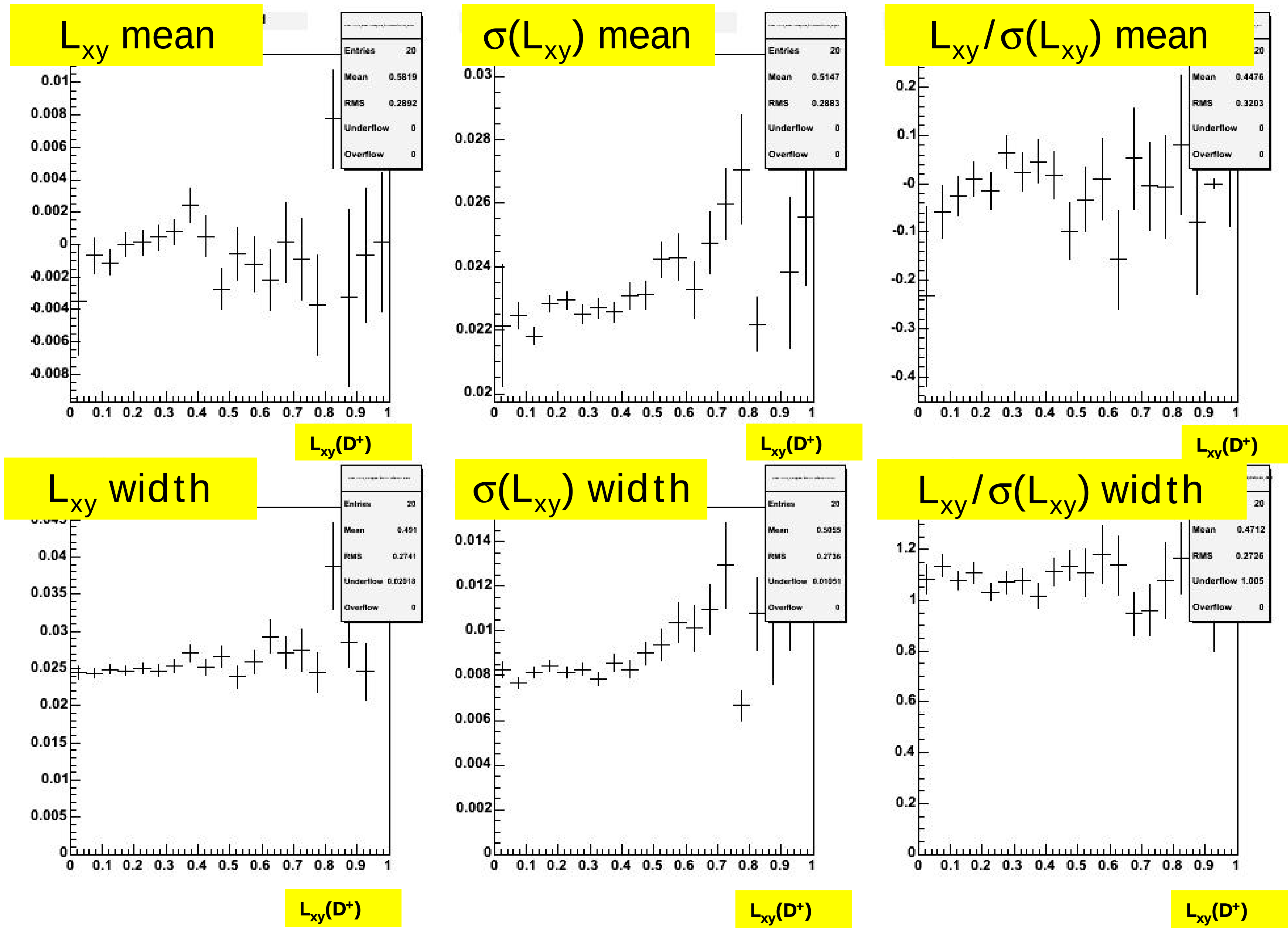


Same plots in D^+ data:

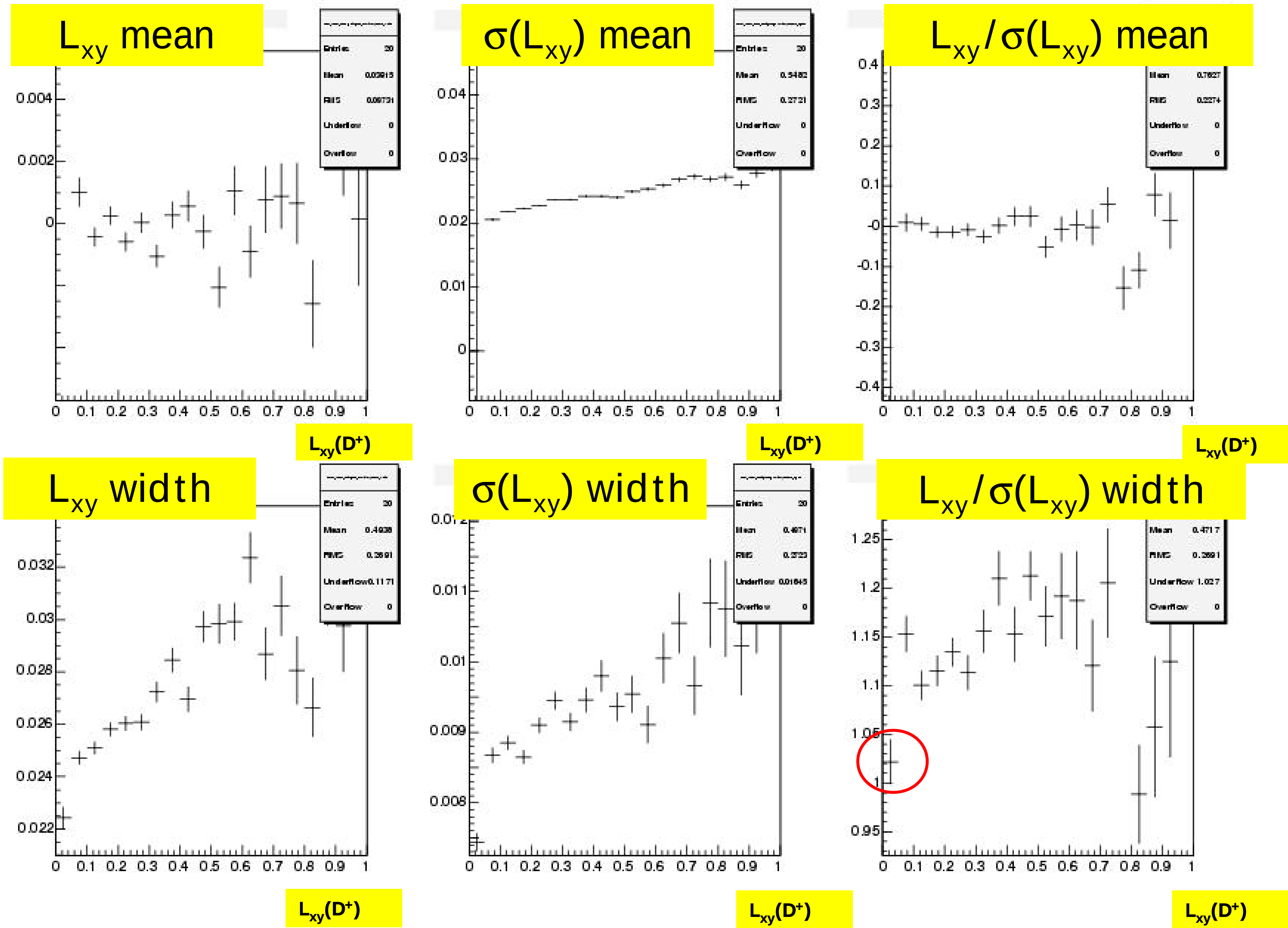
Is it in $\sigma(L_{xy})$ or in L_{xy}?



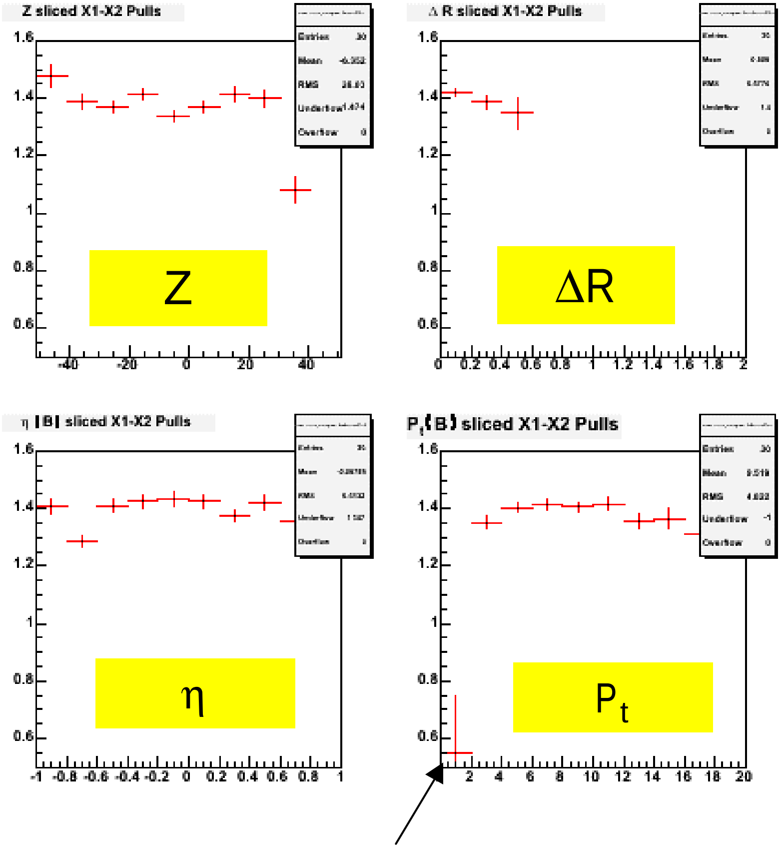
Same plots for MC D^+



Same plots for D^+ without L_{00}



Plots a la 7500

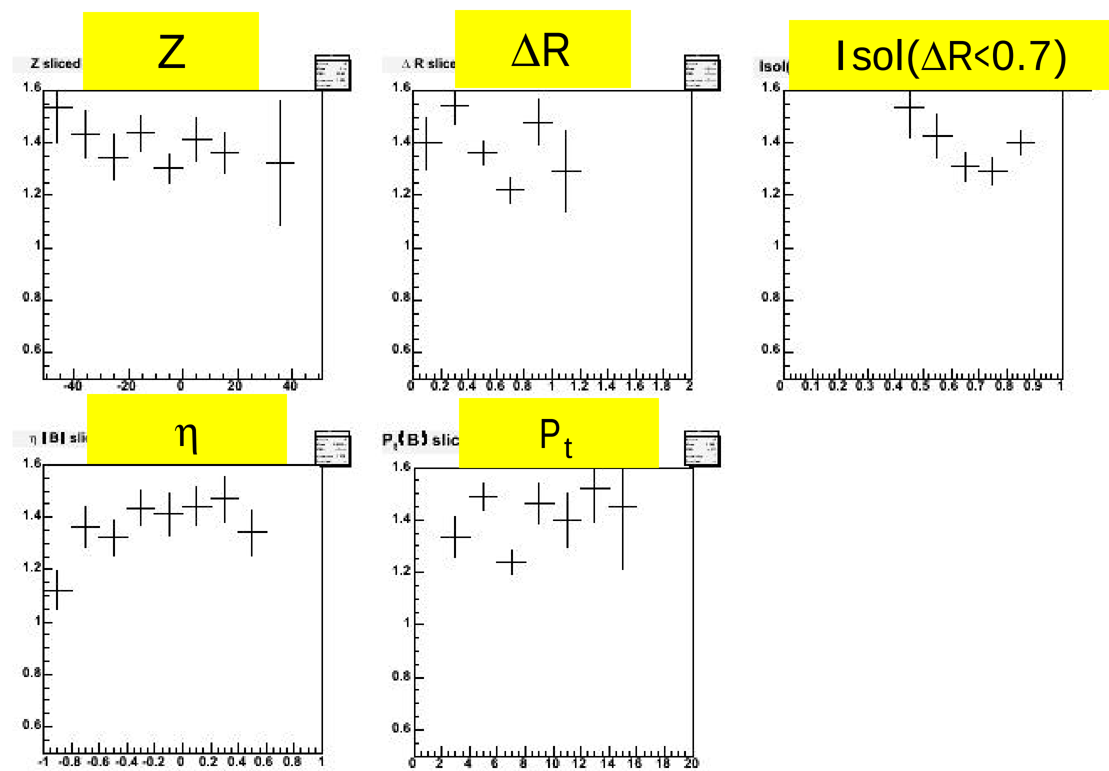


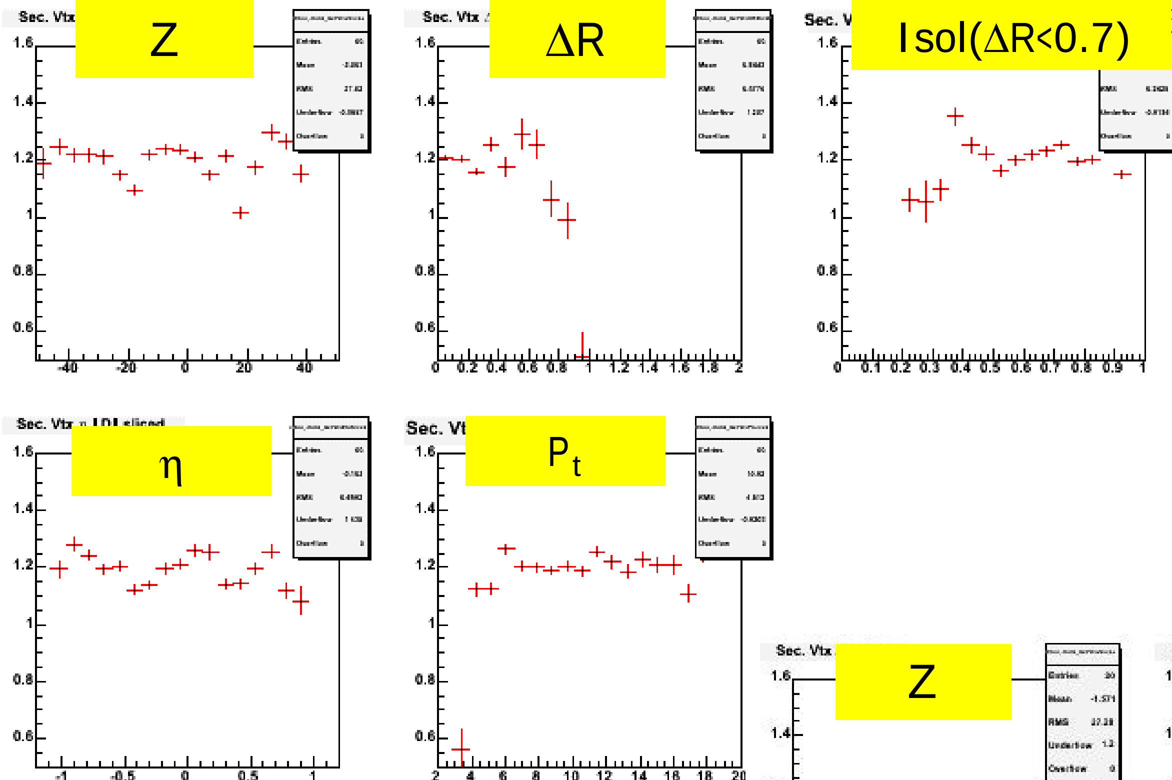
Primary Vertex Pulls for:

- All B signals (left)
- ψ' (below)

Just no statistics!

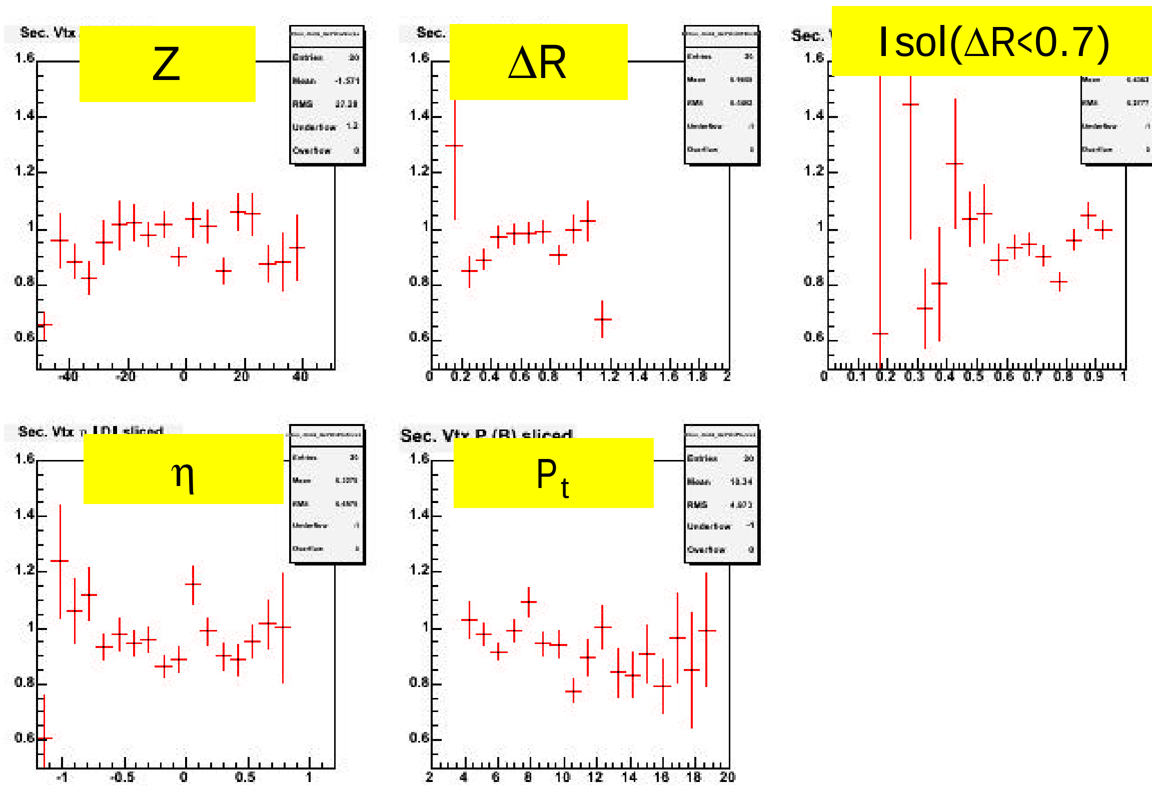
Non-statistical fluctuations dominated by fit model!





Secondary Vertex Pulls for:

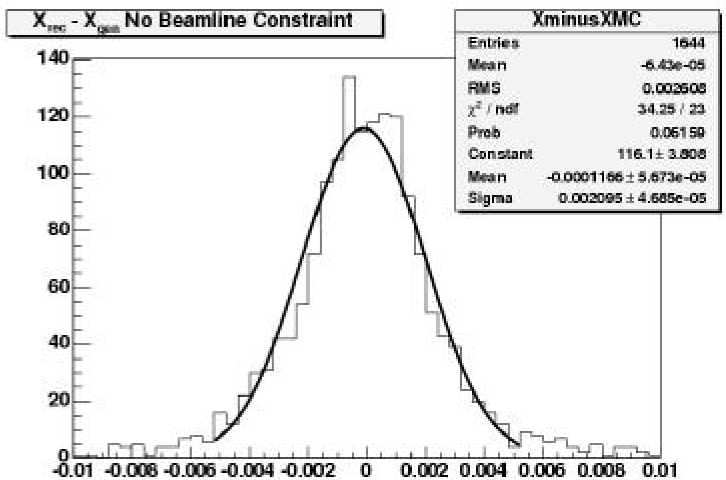
- All B signals (left)
- ψ' (below)

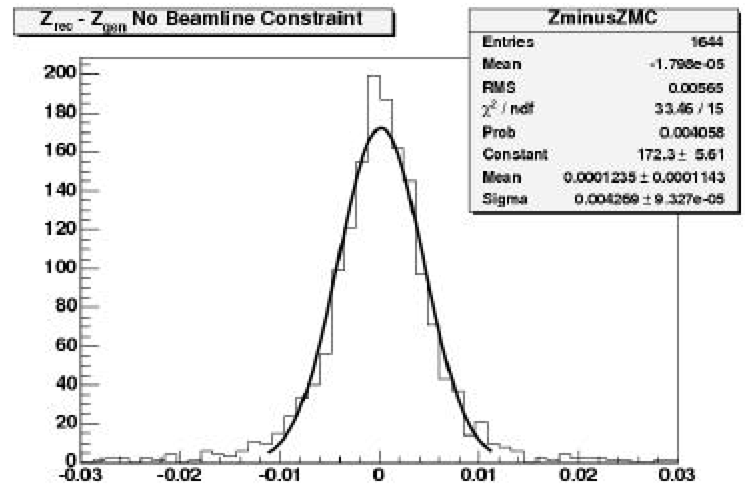


All ψ' have pulls of ~1, all the B have pulls of ~1.2.. There seems to be no significant dependence except from ct!!!

What do we know about EbE?

- Unbiased estimator of PVTX





Reasonable (~5%) control of systematics

Mode	x scale	y scale	z scale
$B^{\pm} \to \psi K^{\pm}$	1.327 ± 0.035	1.399 ± 0.035	1.375 ± 0.029
$B^{\pm} \to D^0 \pi^{\pm}$	1.408 ± 0.030	1.398 ± 0.031	1.367 ± 0.29
$B^0 \to D^{\pm} \pi^{\mp}$	1.426 ± 0.034	1.336 ± 0.029	1.288 ± 0.027

	Transverse	**Z**
Data (V_1-V_2)	1.33±0.035	1.37±0.035
MC (V_1-V_2)	1.192±0.034	1.26±0.035
MC (V-truth)	1.24±0.036	1.23±0.032
J/y Prompt Peak	1.236±0.024	~ND~
J/y d_0/s	1.176±0.019	~ND~

Cross checks using I.P.(B)

Pull on Impact Parameter

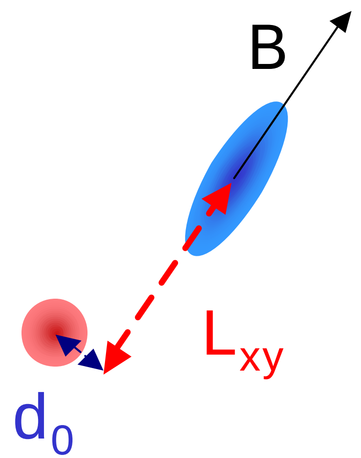
Mode	Beamline $\sigma = 25\mu$	Beamline z dependent σ	Event-by-Event w/beam constraint	Event-by-Event w/o beam constraint
$B^{\pm} \rightarrow D^0\pi^{\pm}$	1.297 ± 0.025	1.178 ± 0.039	1.202 ± 0.021	1.050 ± 0.025
$B^0 \rightarrow D^{\pm}\pi^{\mp}$	1.256 ± 0.026	1.118 ± 0.027	1.163 ± 0.020	1.046 ± 0.027

Z dep. Beamline improves pulls!

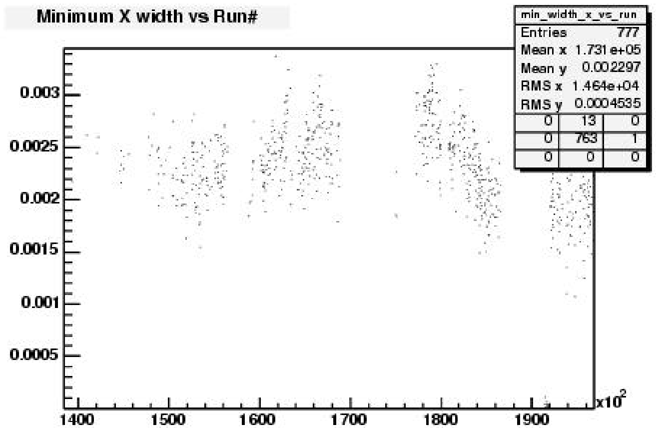
Something funny when beamline is used!

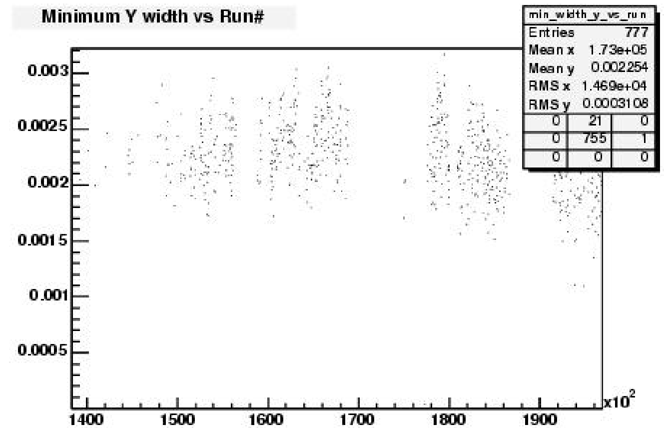
Scale factors work!

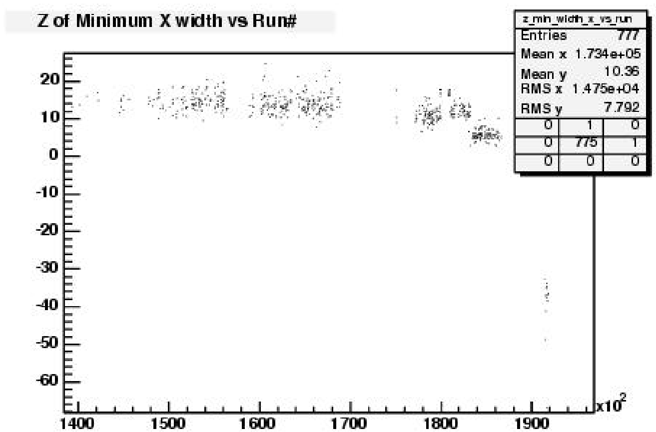
- L_{xy} involves three ingredients:
  - EbE
  - Secondary vertex
  - Beamline (in beamline constrained fits)

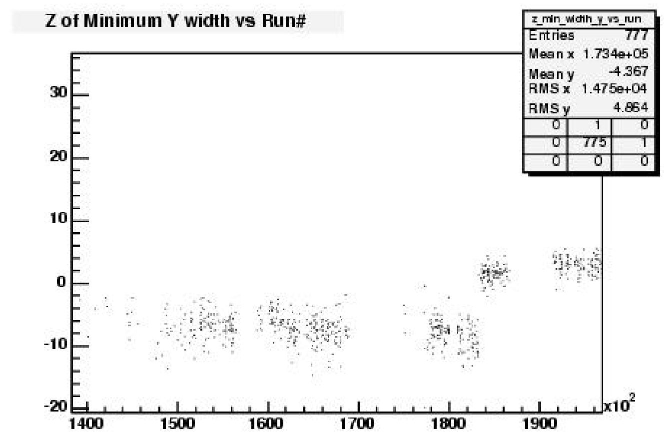


Time dependence of Hourglass parameters





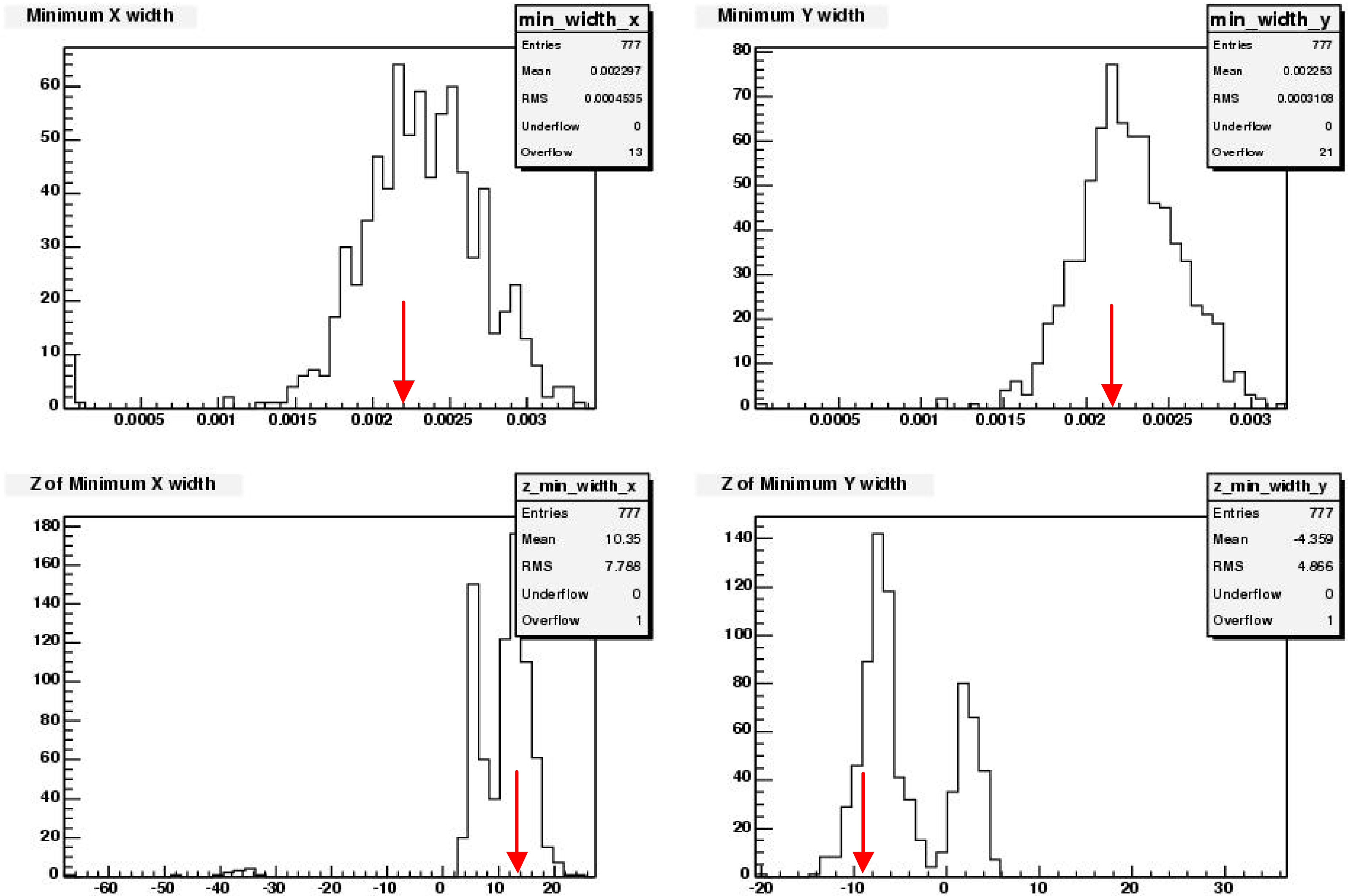




Implementing DB access of time-dependent parameters

Hourglass parameters from DB

Profiles



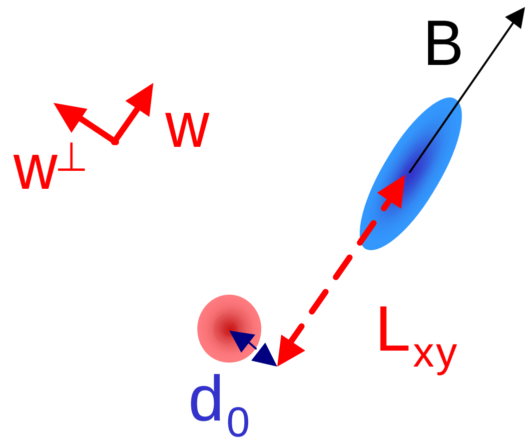
Relative PV/BV contribution to d_0 and L_{xy} pulls

$$\sigma^2_{L_{xy}} = {}^t w \sigma^2_{PV} w + {}^t w \sigma^2_{SV} w$$

$$\sigma^2_{d_0} = {}^t w^\perp \sigma^2_{PV} w^\perp + {}^t w^\perp \sigma^2_{SV} w^\perp$$

$$w = (x, y)$$

$$w^\perp = (y, -x)$$



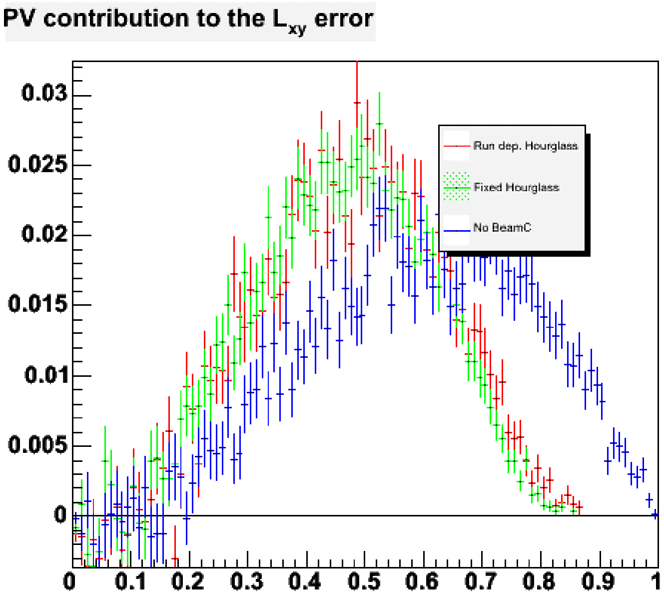
- PV and BV are linear combinations of the same covariances (σ_{PV}, σ_{SV}), with different coefficients
- L_{xy} sensitive to the major axis of σ_{SV}
- Relative weight of PV and SV covariances different for L_{xy} and d_0
- Look at:

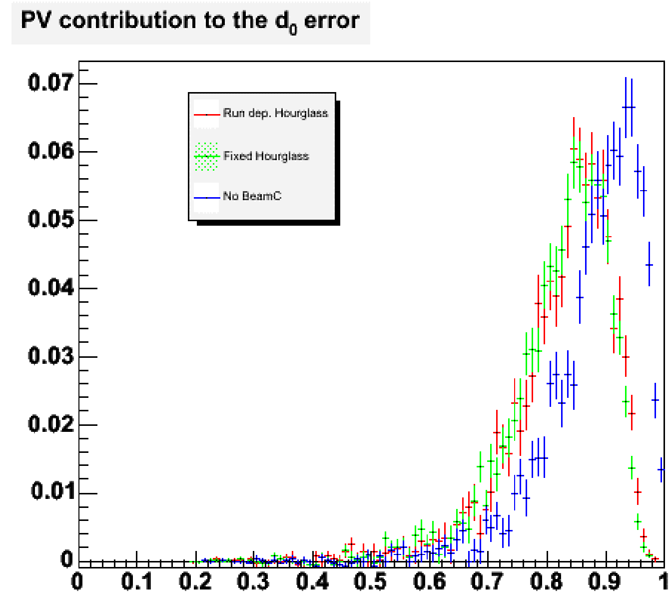
$$\sqrt{\frac{{}^t w \sigma^2_{PV} w}{\sigma^2_{L_{xy}}}} \quad \sqrt{\frac{{}^t w^\perp \sigma^2_{PV} w^\perp}{\sigma^2_{d_0}}}$$

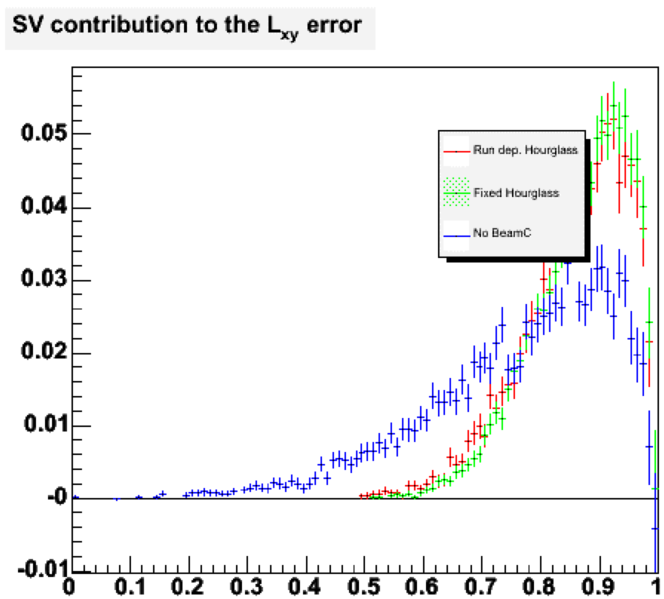
$$\sqrt{\frac{{}^t w \sigma^2_{SV} w}{\sigma^2_{L_{xy}}}} \quad \sqrt{\frac{{}^t w^\perp \sigma^2_{SV} w^\perp}{\sigma^2_{d_0}}}$$

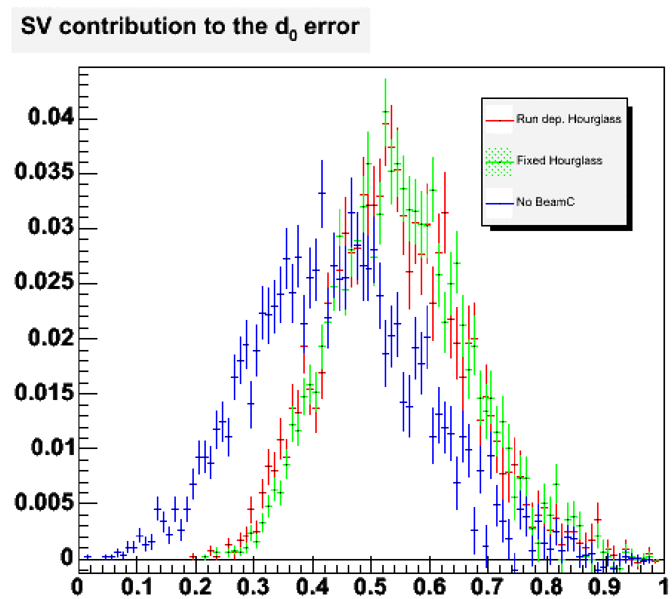
Note: the two L_{xy} (or d_0) pieces do not linearly add to 1!

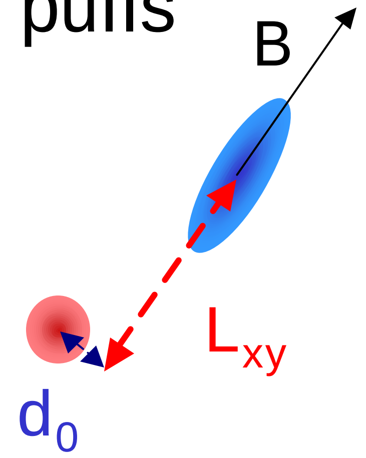
Relative PV/BV contribution to IP and Lxy pulls











- Not Beam Constrained
- Beam constrained
- Beam constrained with run-dep. hourglass