EbE Vertexing for Mixing

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For the LBLB group

Improved studies on pulls

- Increased sample's statistics
  - Full ~350 pb^{-1}
  - Working on including $K3\pi$ and ψK
- Tested the effect of run# dependent hourglass parameters

- Improved fit (core of pulls now defined as $\pm 2\sigma$)
- G3X refit: no difference in pulls

New this week!!!

- Started work on SV pulls

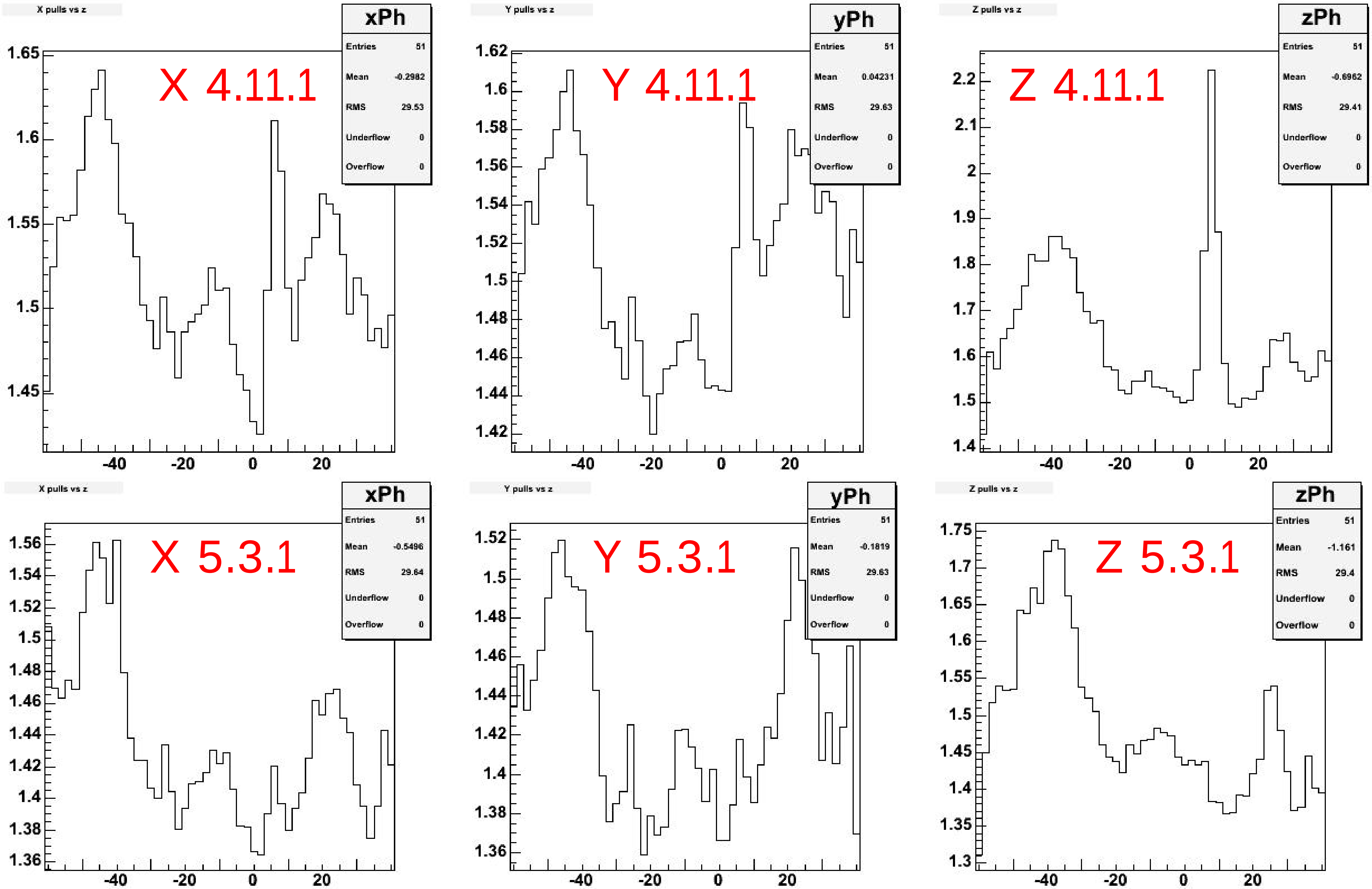
The current situation is summarized in the next table… (same trends, slightly different numbers)

Extended x-checks

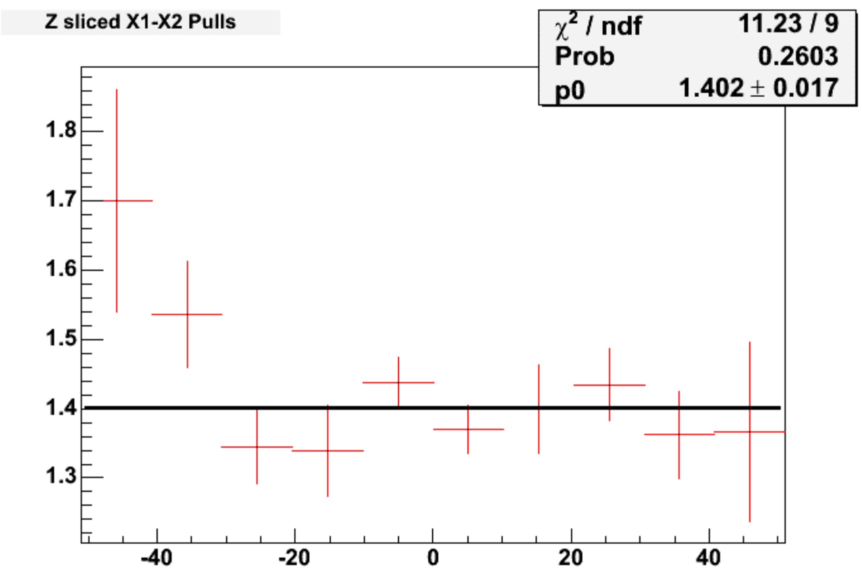
	$B\to D^0[\to K\pi]\pi$					$B\to D^+[\to K\pi\pi]\pi$				
Beam constr.			√	√	√			√	√	√
Hourglass from DB				√	√				√	√
Exclude DB-less					√					√
PV scale factor	1.0	1.38	1.38	1.38	1.38	1.0	1.38	1.38	1.38	1.38
d_0 Beam (hourglass)	1.17	1.17	1.19	1.13	1.12	1.15	1.1	1.12	1.07	1.05
d_0 EbE	1.33	1.07	1.18	1.17	1.15	1.30	1.11	1.15	1.14	1.13
d_0 EbE (SV rescale)	1.24	1.02	1.10	1.10	1.09	1.26	1.06	1.09	1.08	1.07
X_1-X_2	1.40	1.02				1.39	1.02			
Y_1-Y_2	1.40	1.01				1.36	1.0			
Z_1-Z_2	1.39	1.00				1.31	1.1			

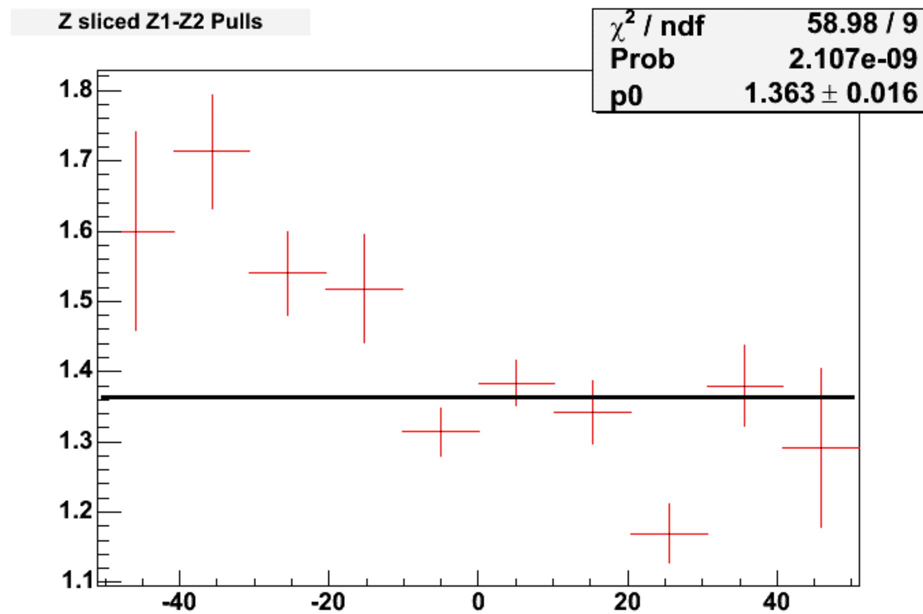
How universal is the PV Scale Factor?

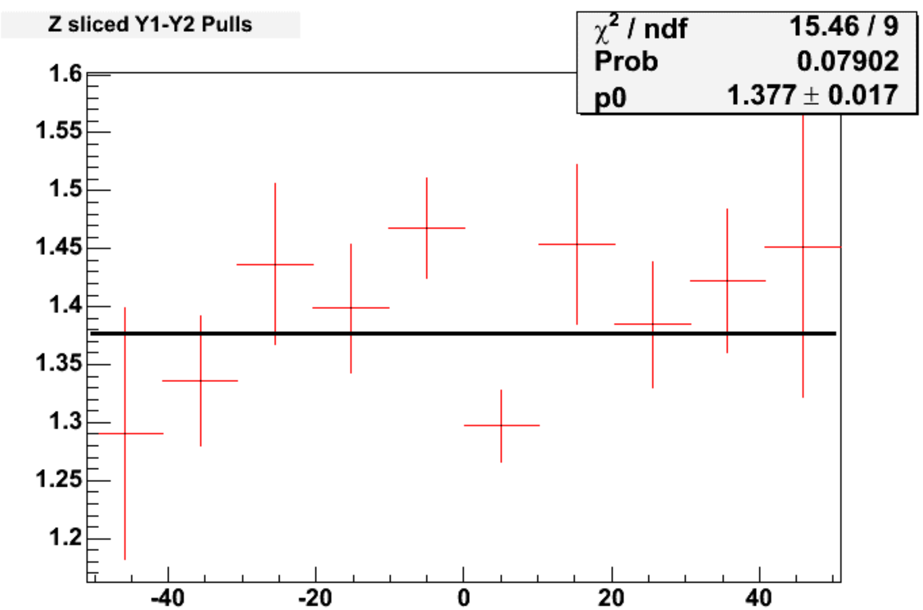
Scale factors From SecVtx code



Z dependency in Dπ samples

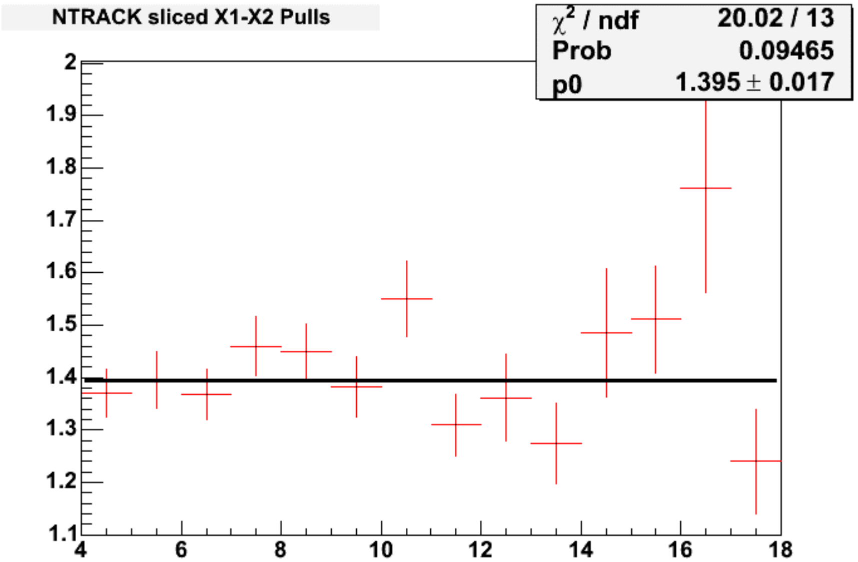


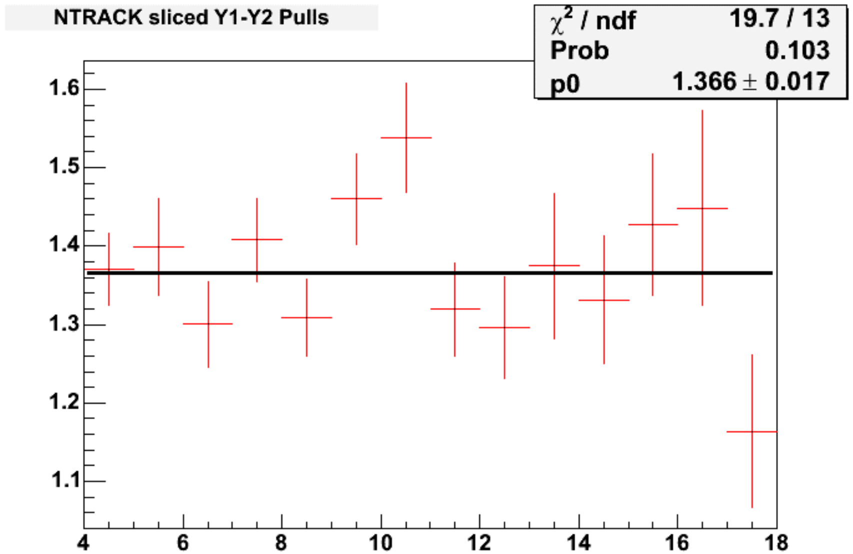


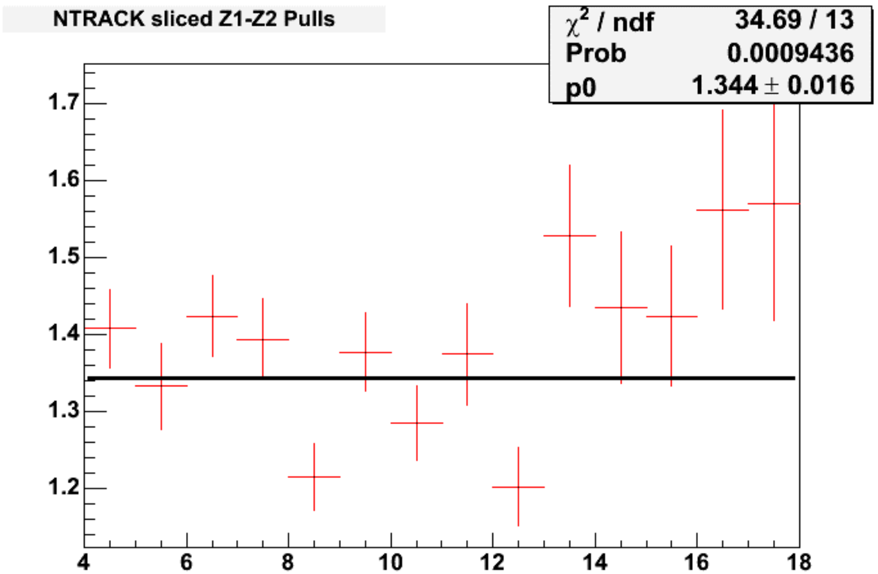


- D^+ and D^0 samples
- No indication of a structure (flat?)
  - Smaller statistics, but main features should be visible!
- Final statistics will be ~2x

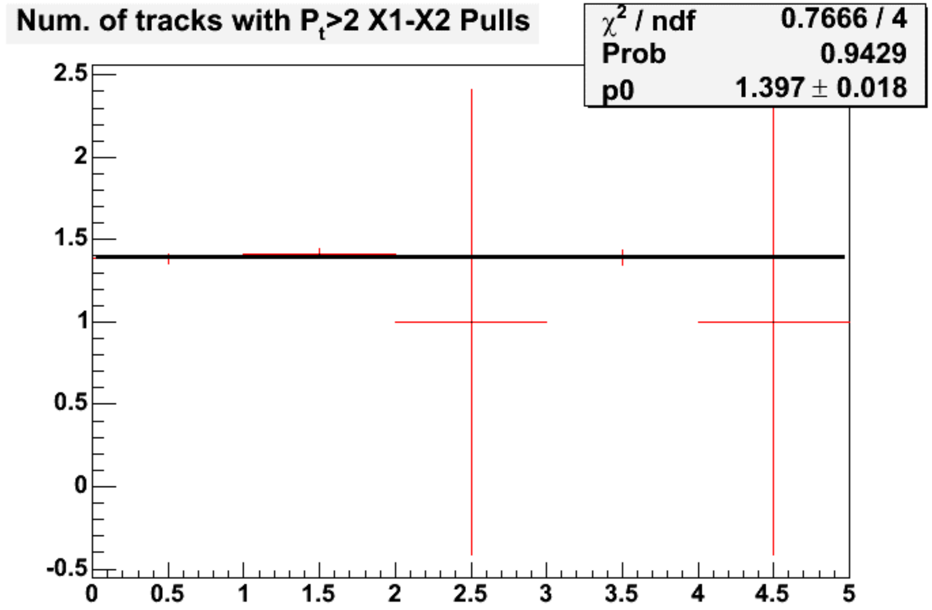
tracks dependency in Dπ samples

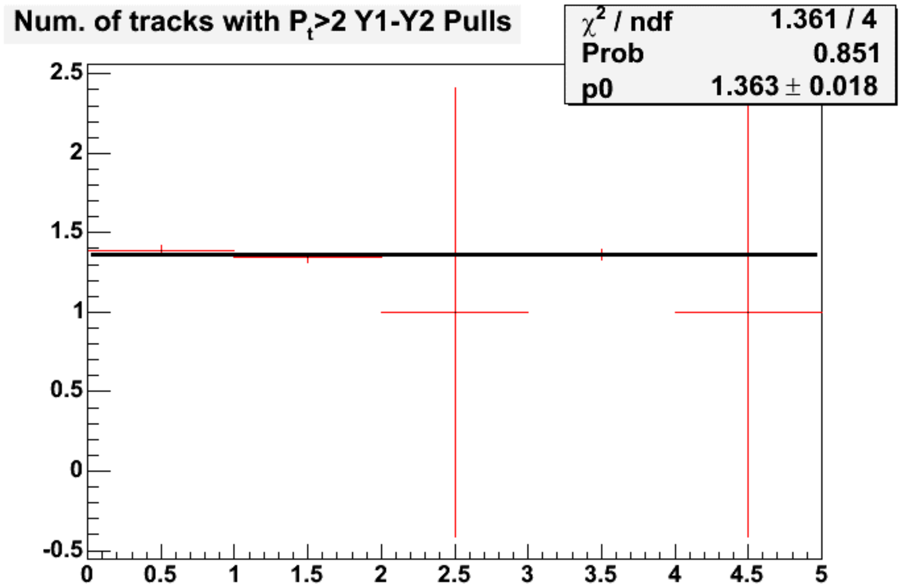


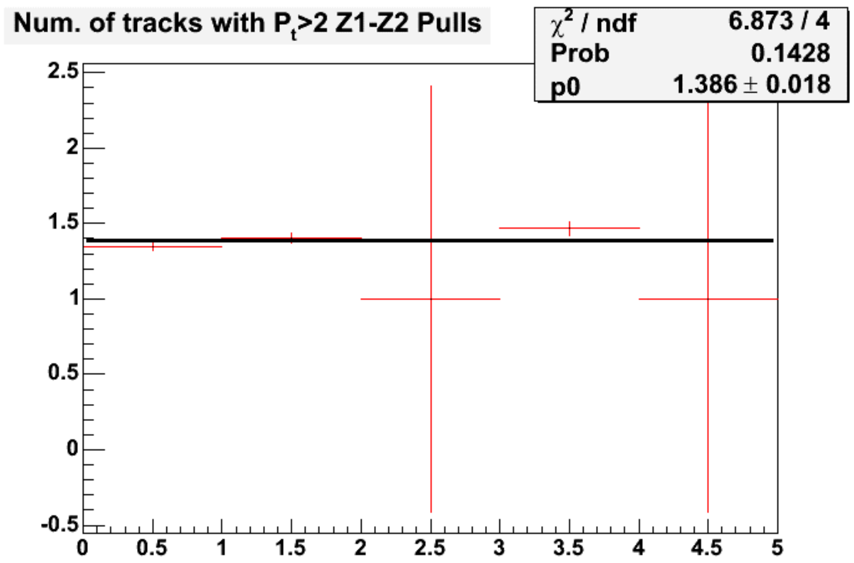




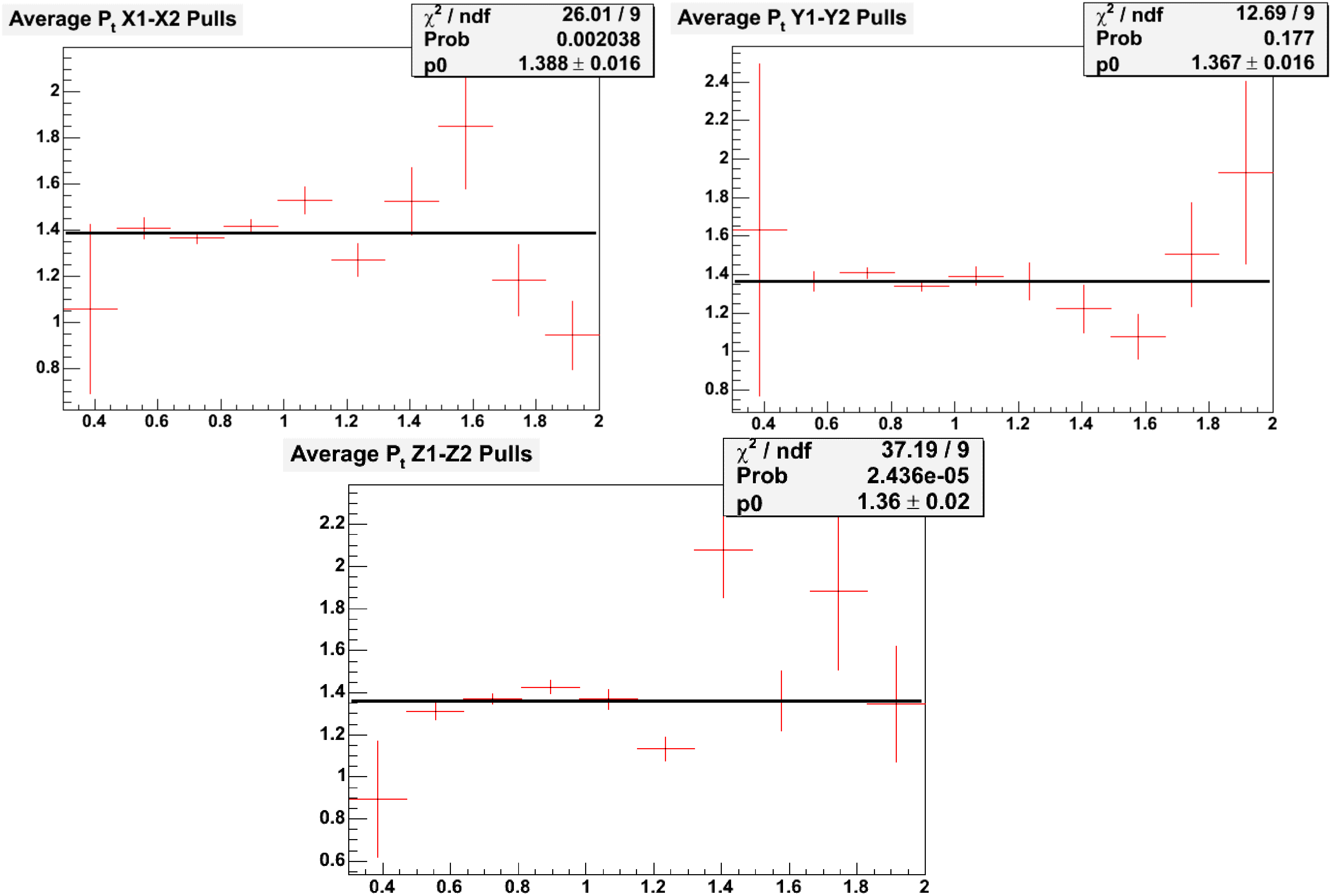
tracks Pt>2 dependency in Dπ samples







<Pt> dependency in Dπ samples



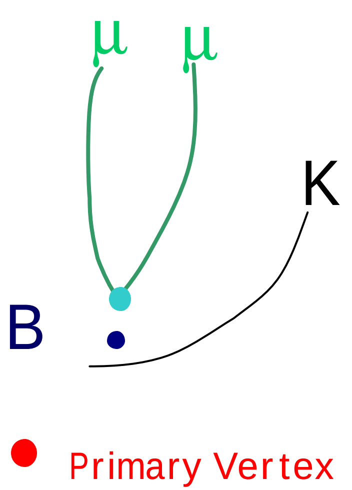
Bottomline for PV scale factor

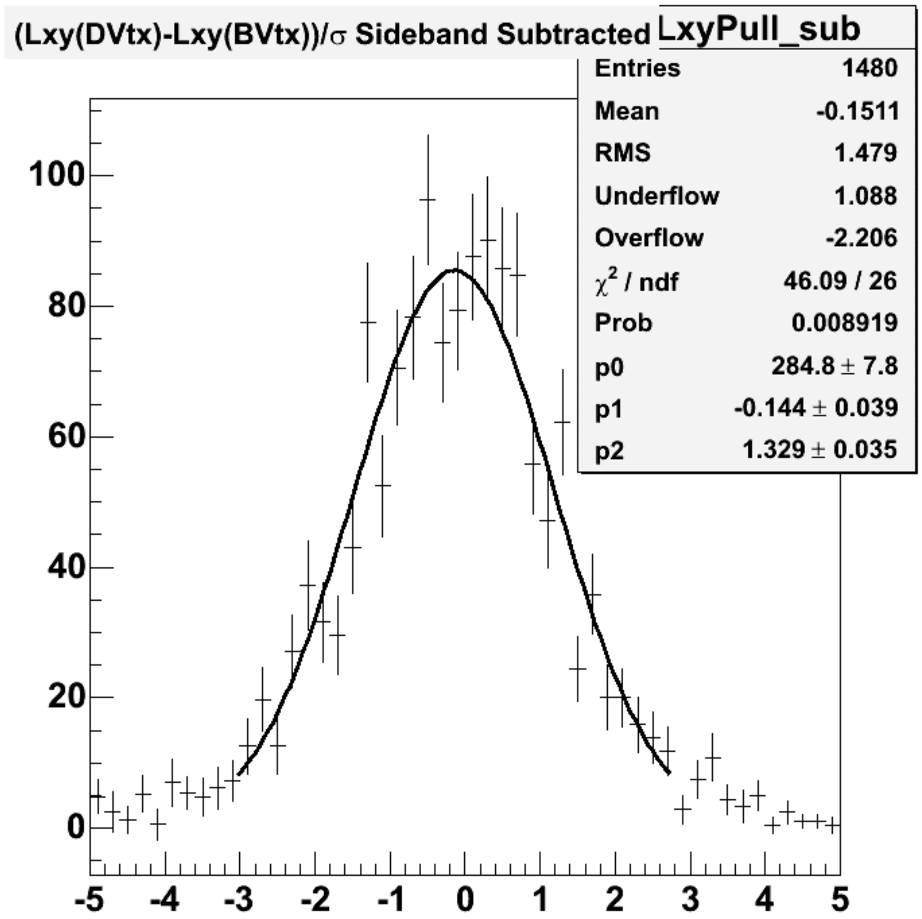
- The scale factor seems pretty universal
- No dependency on:
  - Z, # tracks, momentum
- Will improve statistics ($D^0 \rightarrow K\pi\pi\pi$, $B \rightarrow \psi K^{(*)}$
- Contribution to L_{xy} scale factor from the PV seems pretty consolidated at this point
- ...on to the Secondary Vertex!

Secondary Vertex

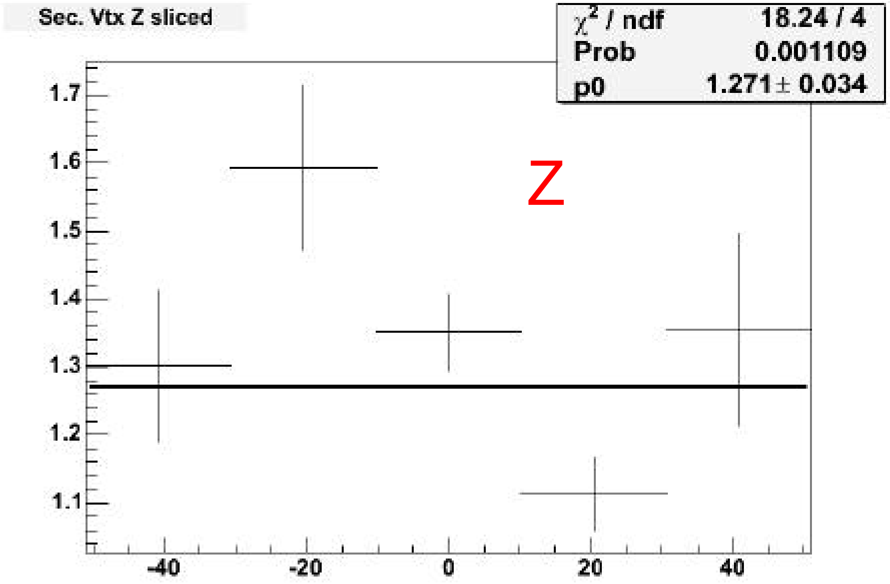
Scale factor from B decays

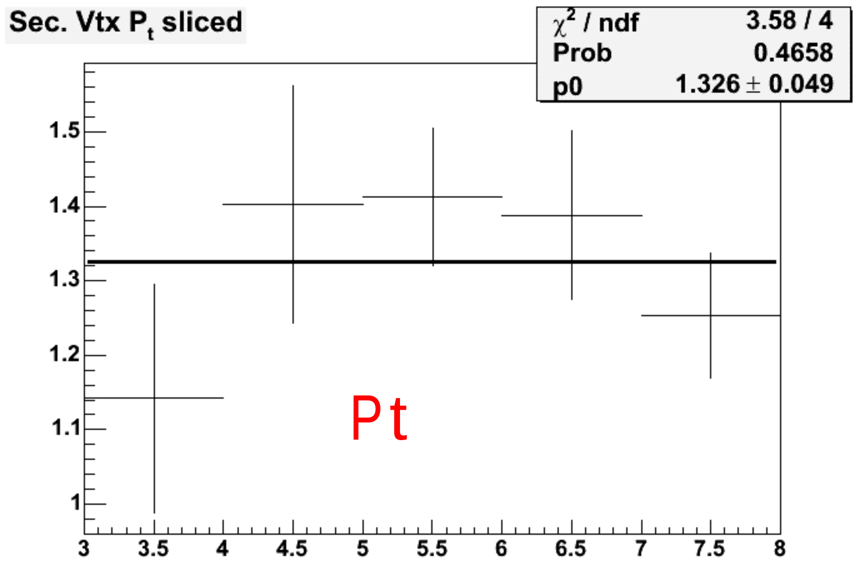
- $B \to \psi K^+$
- Fit ψ to a single vertex
- Measure L_{xy} wrt B vertex
- Pull is a proxy for a "seconday vertex" pull!

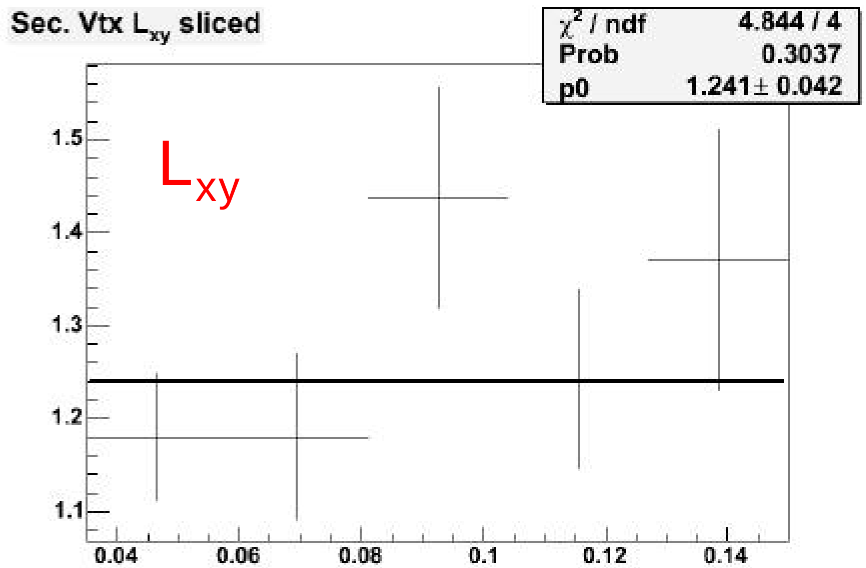




First look at dependancies







Conclusions, so far

- A scale factor is needed for SV too
- Not too different from the PV sf
- Statistics of sample too small to get dependencies!
- Alternative samples:
  - D^+, $B \to \psi K^*$, tracks from primary

Moving along the plans for improvements!

1. Understand beamline parameterization:
   I. Is it modeled correctly
   II. Is it measured correctly

   $\Rightarrow$ Include our best knowledge of it!
2. Are secondary vertex pulls ok?
   I. Check with montecarlo truth
   II. Use n-prong vertices ($J/\psi K$, $K\pi\pi^{+/0}$, $K\pi\pi\pi^{+/0}$)
3. Investigate dependencies (Pt, z, multiplicity, η) with full statistics

Backup

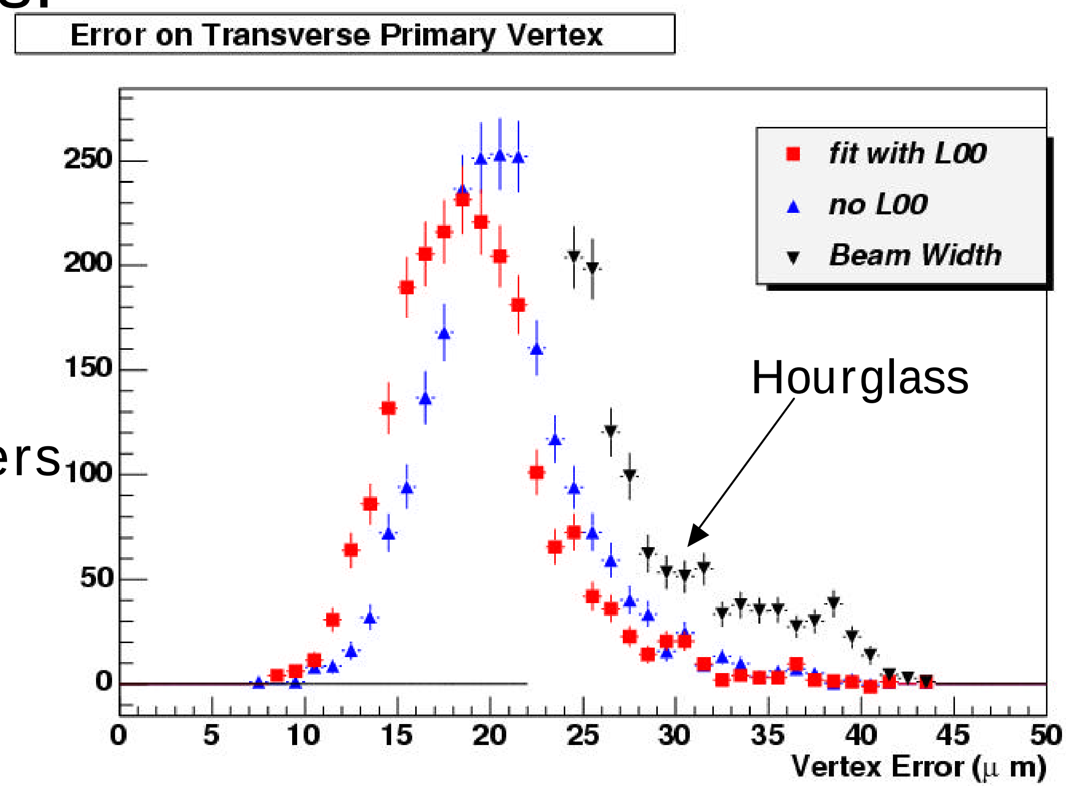
Outline

- Current status
  - What was used for the mixing results
  - What is the current understanding of Ebe
- Plans for improvements
  - How can we improve?

Current status

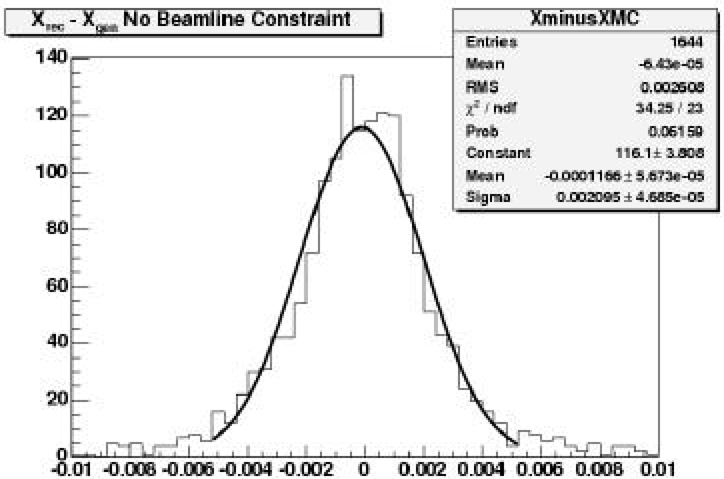
EbE: itearative track selection/pruning algorithm to provide an unbiased estimate of the PV position on an Event-by-Event basis

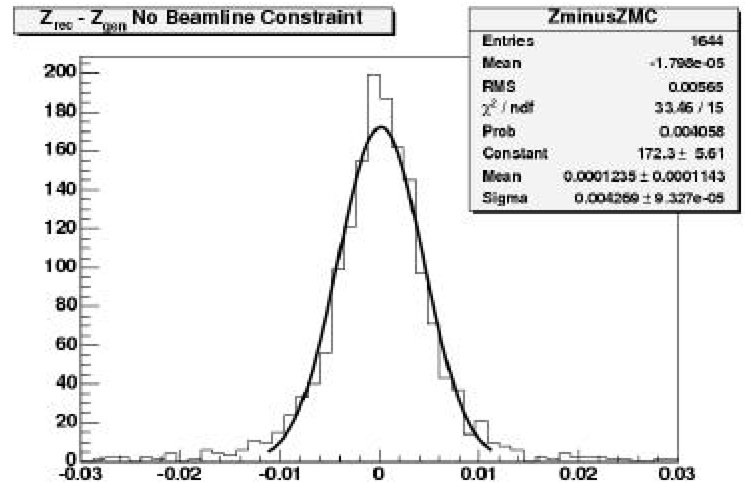
- Hadronic analyses used a flat ~25um beamline!
- Possible improvements:
  - Move to “hourglass”
  - Move to EbE
  - EbE + Hourglass
    - One of the ½ leptonic analyses used this with fixed hourglass parameters



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

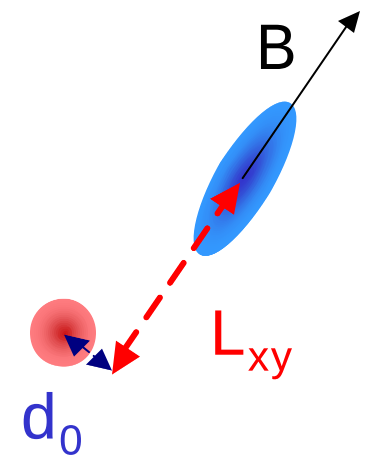
Mode	Beamline $\sigma = 25\mu$	Beamline z dependent σ	Event-by-Event w/beam constraint	Event-by-Event w/o beam constraint
$B^{\pm} \to D^0\pi^{\pm}$	1.297 ± 0.025	1.178 ± 0.039	1.202 ± 0.021	1.050 ± 0.025
$B^0 \to D^{\pm}\pi^{\mp}$	1.256 ± 0.026	1.118 ± 0.027	1.163 ± 0.020	1.046 ± 0.027

Z dep. Beamline improves pulls!

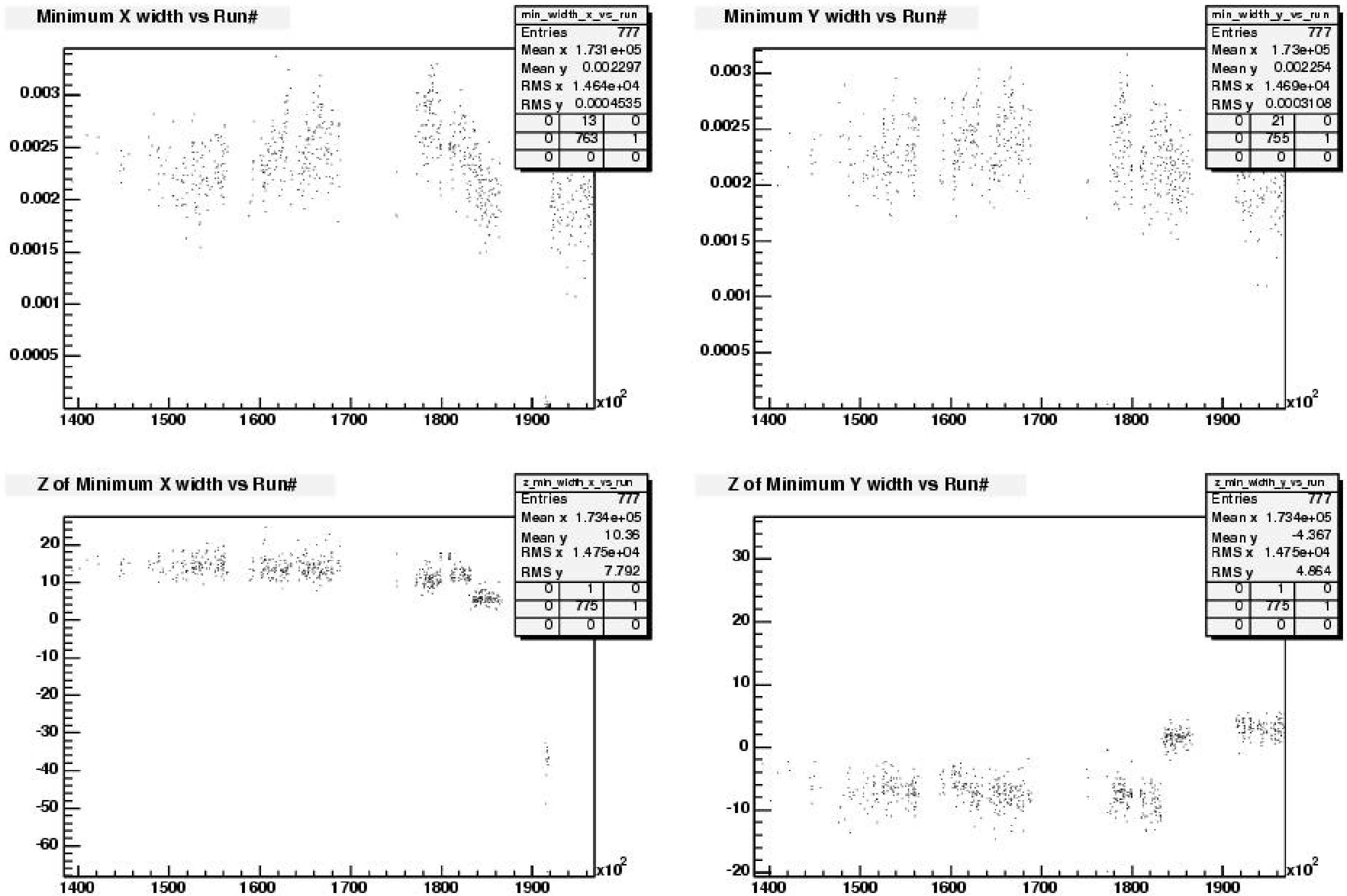
Something funny when beamline is used!

Scale factors work!

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



Time dependence of Hourglass parameters

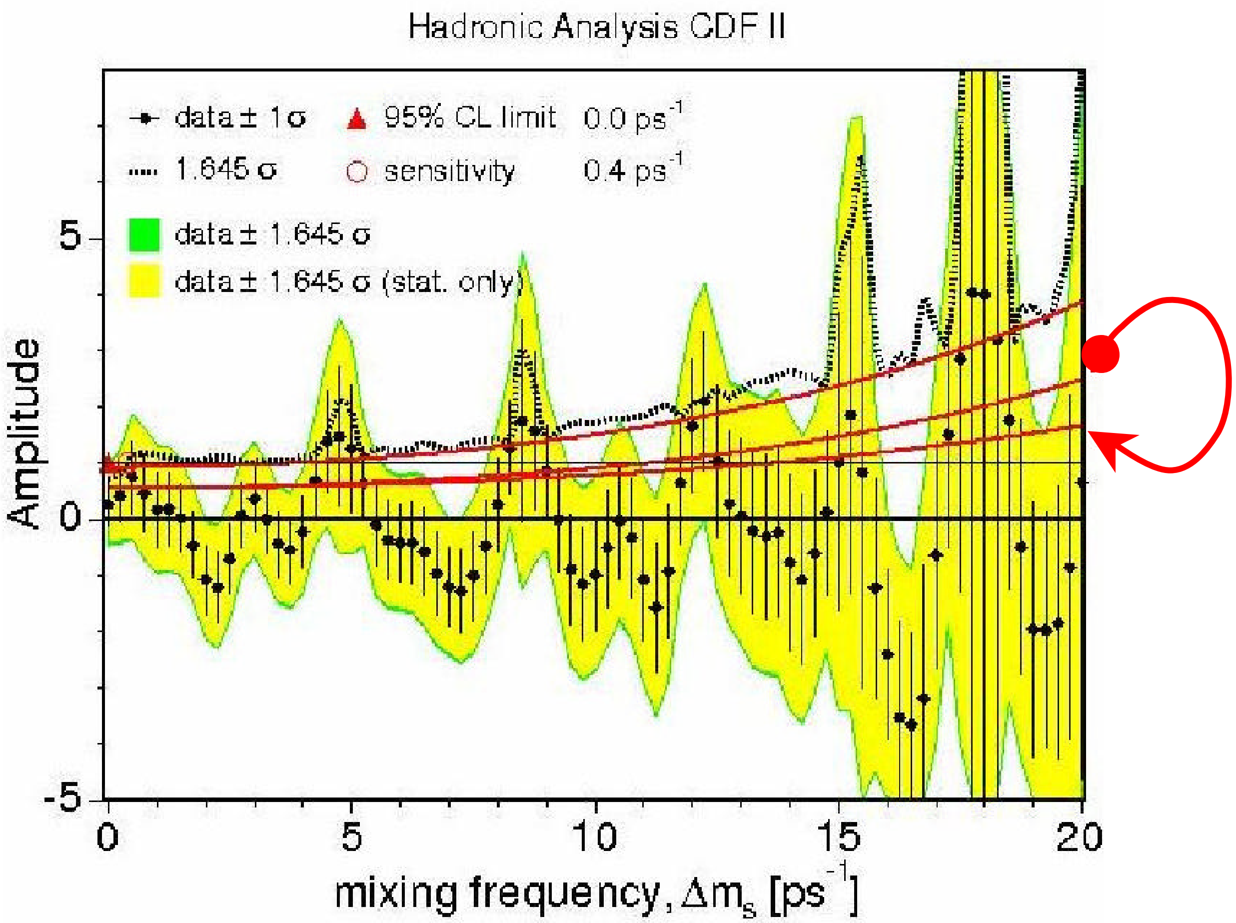


Implementing DB access of time-dependent parameters

What do we gain?

Euphemism

1. 15-20% In vertex resolution!
2. Better control of systematics (hard to evaluate)
3. Correct EbE resolution (it is not clear that it is correct now)



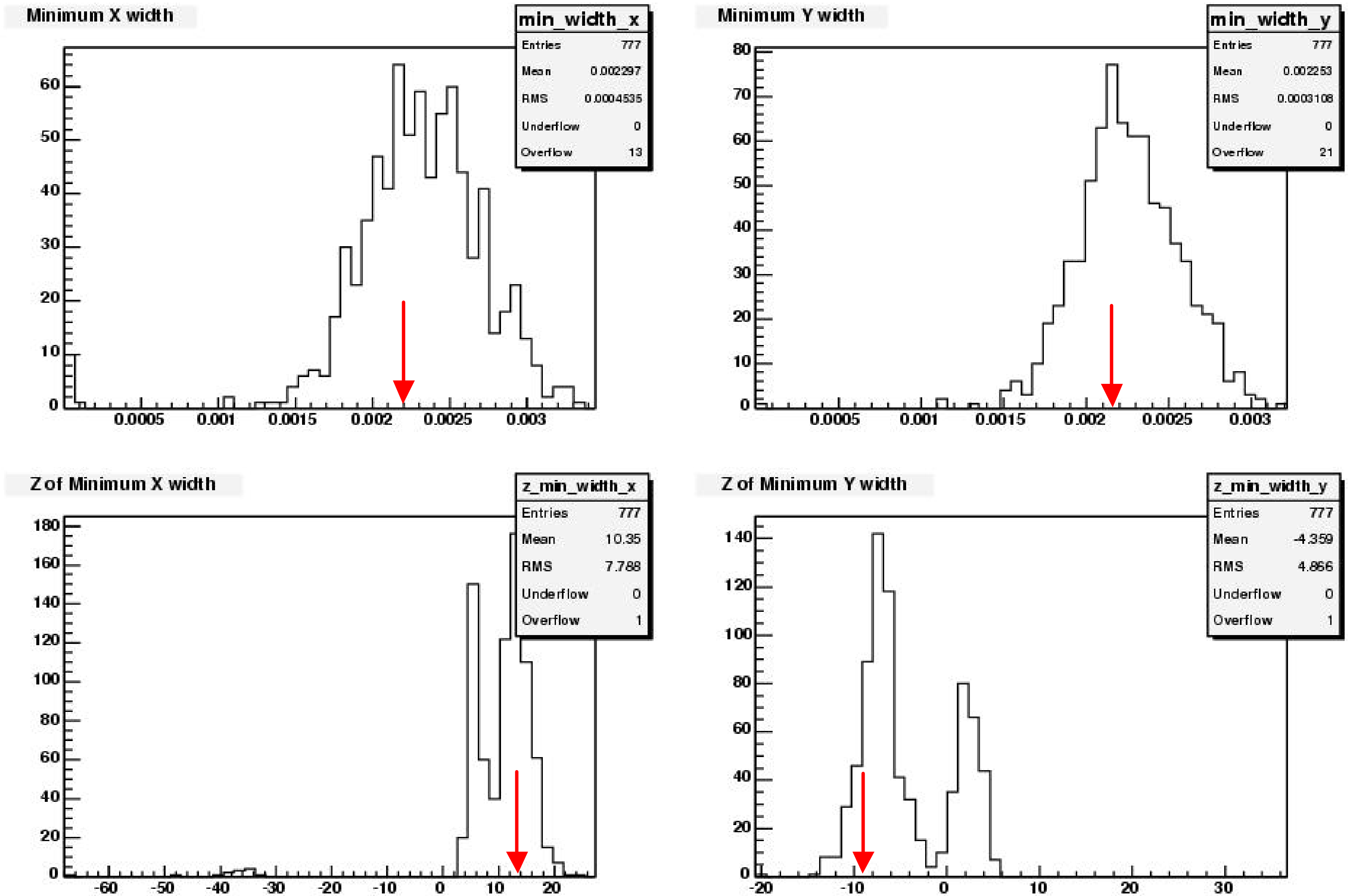
- Red arrow is the effect of 1. Only
- Point 2. Affects mostly the green area (tiny ?)
- Point 3. Has an effect qualitatively similar to 1., but hard to evaluate

Hadronic analysis systematics

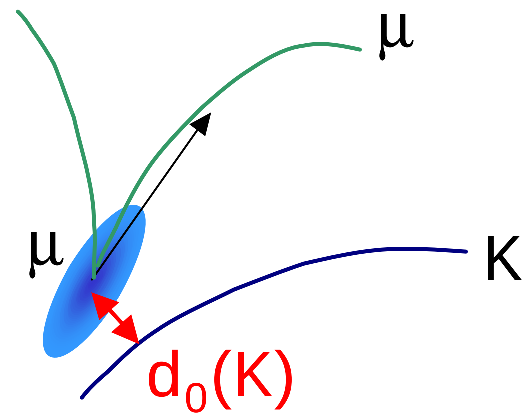
source	selected Δm_s scan points				
	0.0	5.0	10.0	15.0	20.0
$B_s \to D_s K$ level	0.019	0.024	0.030	0.037	0.047
dilution scale factors	0.143	0.168	0.205	0.254	0.314
dilution templates	0.119	0.147	0.178	0.211	0.246
fraction of Λ_b	0.014	0.009	0.009	0.011	0.012
Punzi term for σ_{ct}	0.009	0.008	0.022	0.033	0.030
dilution of $B \to DX$	0.025	0.001	0.000	0.000	0.001
σ_{ct} scale factor	0.000	0.024	0.061	0.090	0.144
usage of L00 in bias curve	0.001	0.001	0.001	0.001	0.001
Bs lifetime uncertainty	0.001	0.001	0.001	0.001	0.001
reweighted p_t spectrum	0.001	0.001	0.001	0.001	0.001
non-Gaussian tails in ct resol.	0.001	0.027	0.052	0.078	0.104
neglect B^0 in fit	0.039	0.036	0.033	0.031	0.028
effect of $\Delta\Gamma/\Gamma = 0.2$	0.028	0.028	0.028	0.028	0.028
Total systematic	0.195	0.232	0.289	0.357	0.443
Statistical	0.393	1.129	1.010	2.652	5.281

Hourglass parameters from DB

Profiles

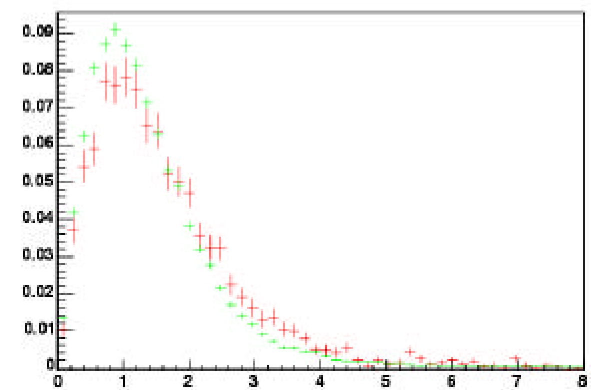


SV contribution

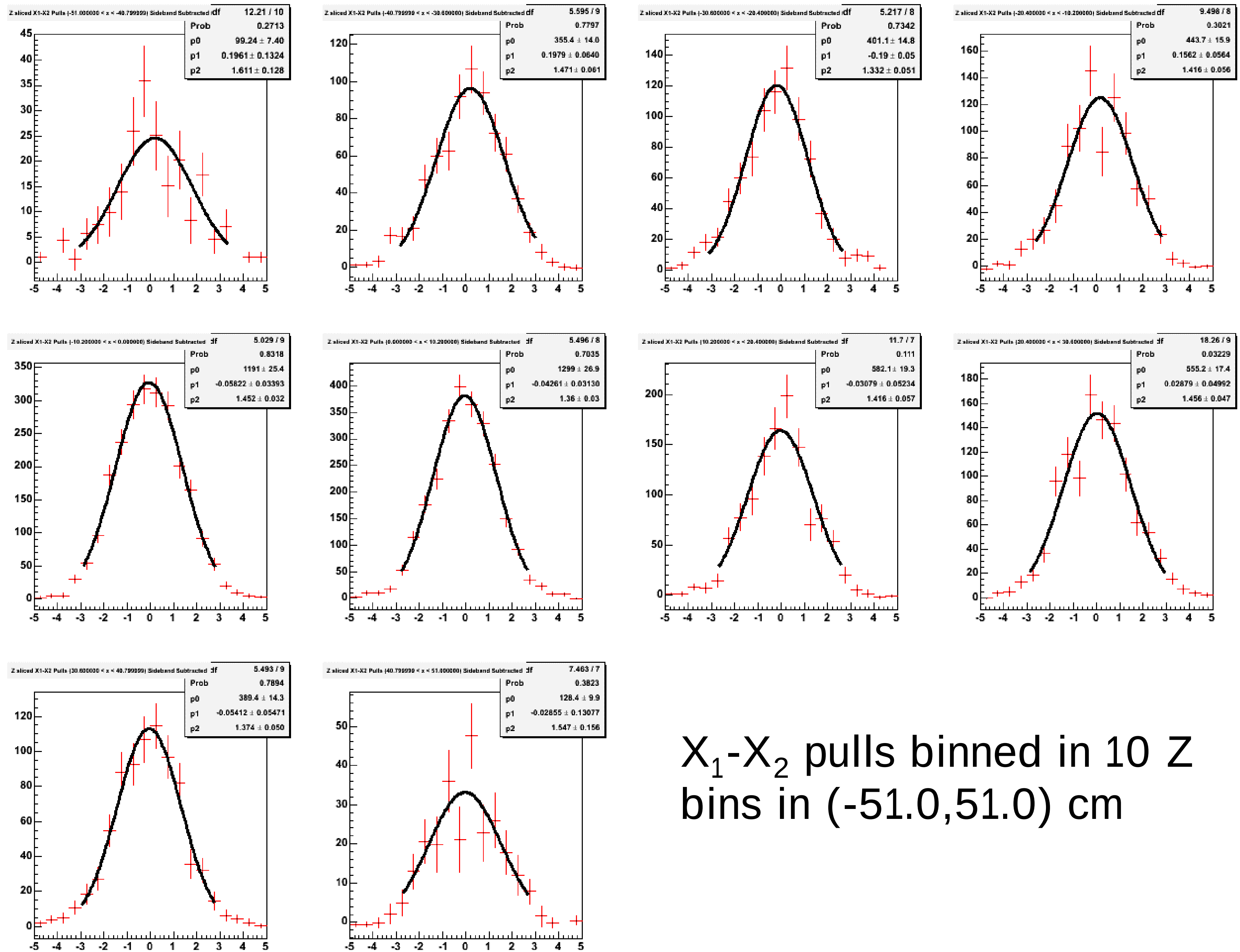


Moments to the rescue:

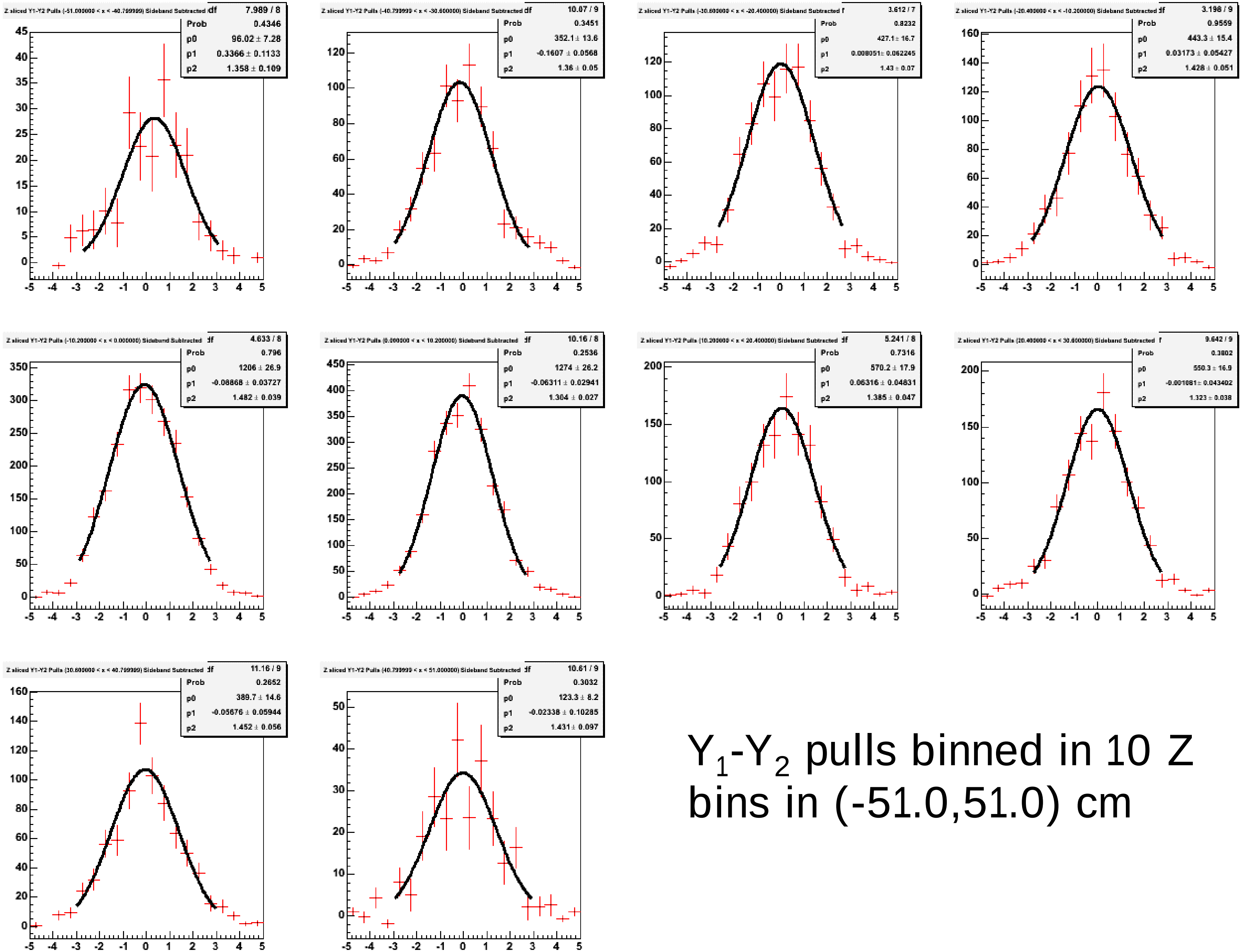
- Example $B \rightarrow \psi K$
  - Fit ψ vertex alone
  - Look at $d_0(K)$ wrt ψ vertex
- Can repeat this study with other multi-prong vertices (D^+, D^0 etc.). Result might depend on:
  - Momentum
  - Vertex multiplicity
- Plenty of statistics to study all this



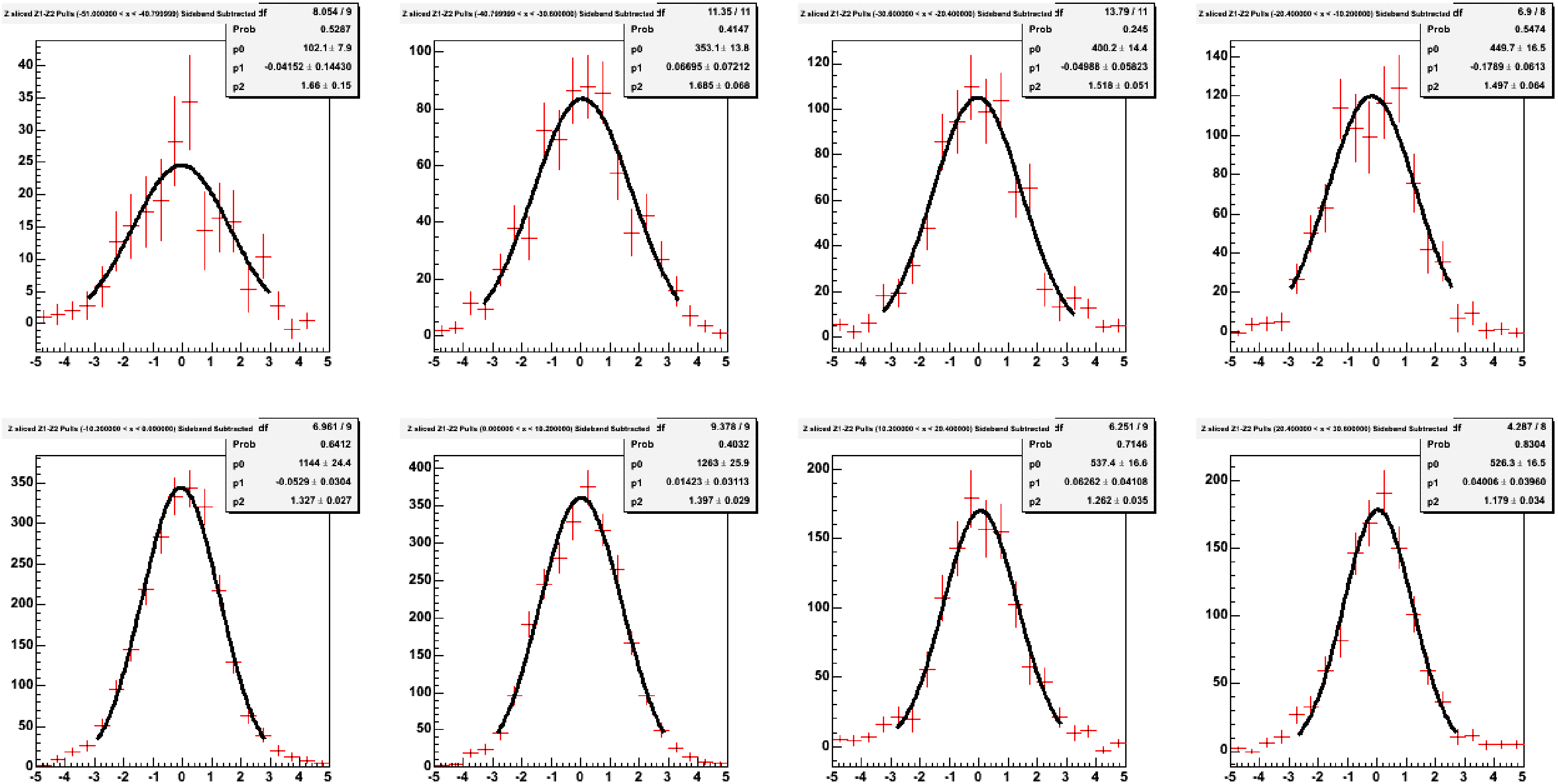
- Cross check the study on MC, after shimming L_{00} efficiency

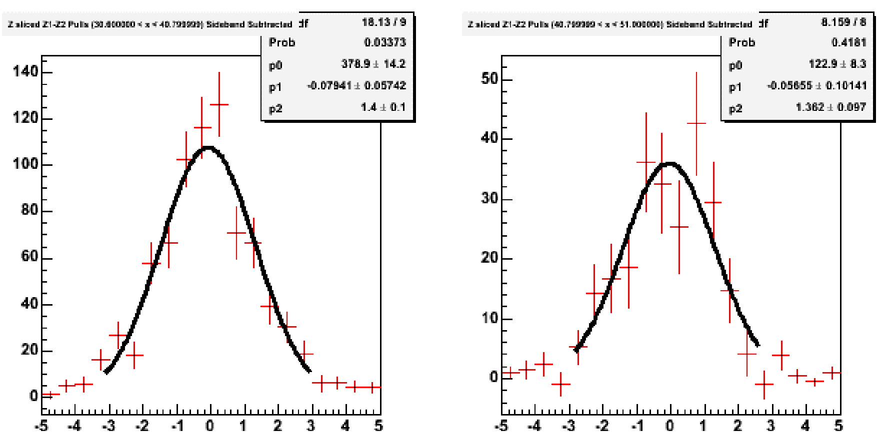


X$_1$-X$_2$ pulls binned in 10 Z bins in (-51.0,51.0) cm



Y_1-Y_2 pulls binned in 10 Z bins in (-51.0,51.0) cm





Z_1-Z_2 pulls binned in 10 Z bins in (-51.0,51.0) cm

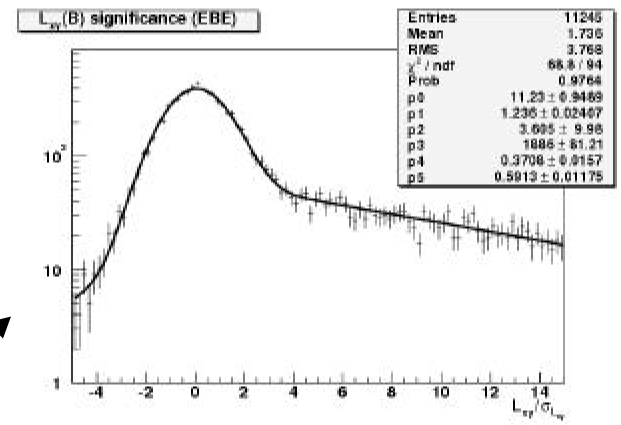
Planned Improvements:

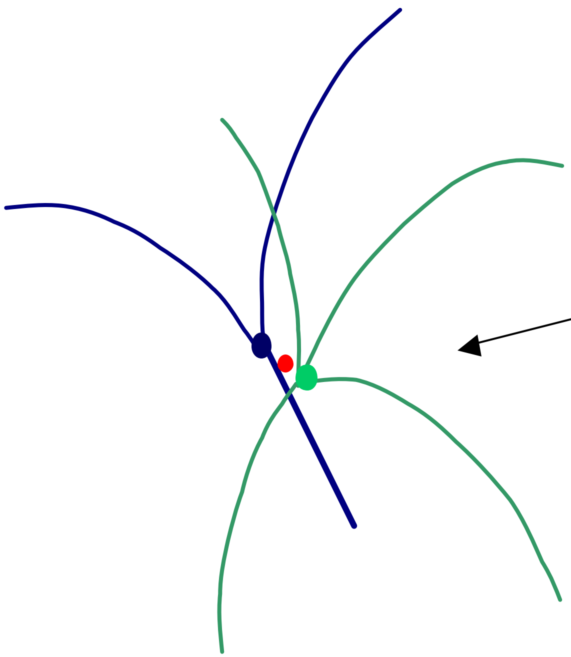
- PV pulls w Beam Constraint $\Rightarrow$ need to revisit modeling of beamline
  - Use of run dependent hourglass parameters
- Hints of difference in the relative contributions of PV/SV to L_{xy} and d_0 $\Rightarrow$ need additional methods to study SV resolution

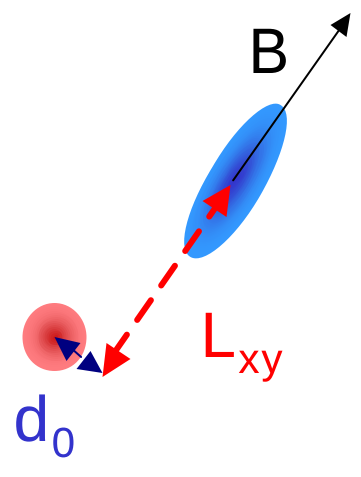
Where are we?

The tools

- Prompt peak
- V-truth
- V1-V2
- d_0/σ







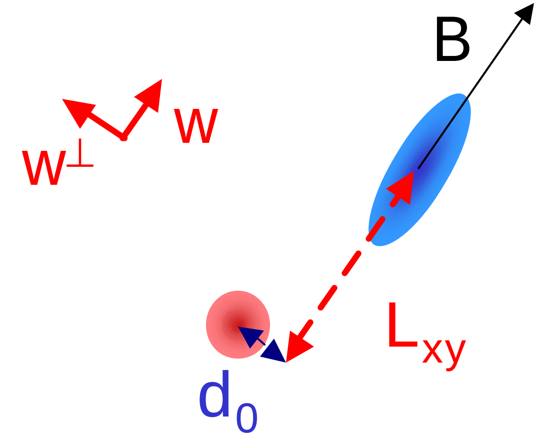
Relative PV/BV contribution to d_0 and L_{xy} pulls

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

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

$$w = (x, y)$$

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



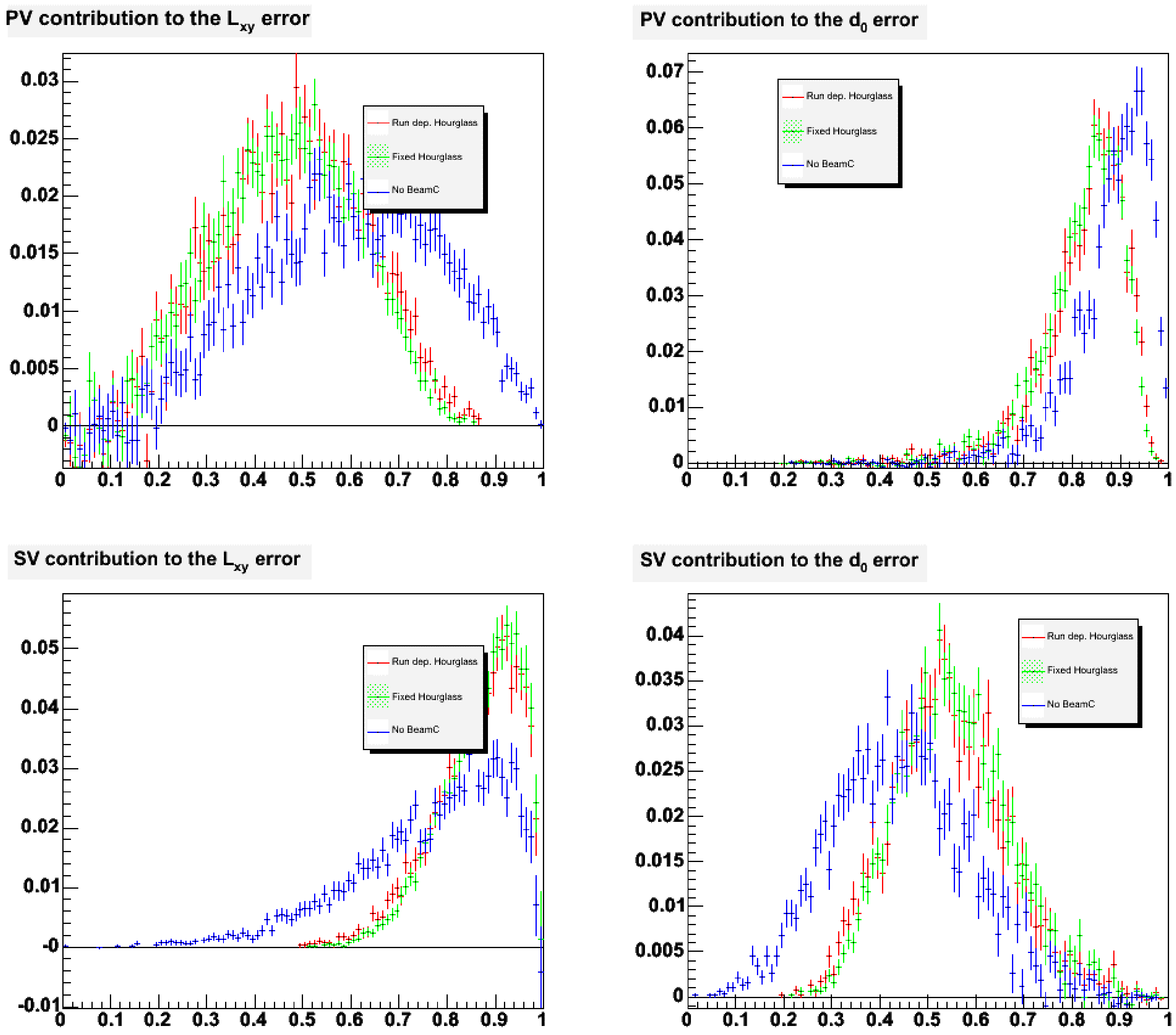
- PV and BV are linear combinations of the same covariances (σ_{PV}, σ_{SV}), with different coefficients
- L_{xy} sensitive to the major axis of σ_{SV}
- Relative weight of PV and SV covariances different for L_{xy} and d_0
- Look at:

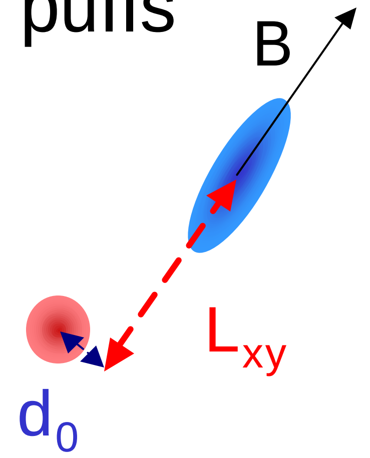
$$\sqrt{\frac{{}^t w s^2_{PV} w}{s^2_{L_{xy}}}} \qquad \sqrt{\frac{{}^t w^{\perp} s^2_{PV} w^{\perp}}{s^2_{d_0}}}$$

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

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

Bottomline:

- SV and PV enter very differently in L_{xy} and d_0
- Relative contribution depends strongly on PV and SV scales
- Beam constraint squeezes the PV resolution significantly. Becomes second order on L_{xy}!
- We are in a regime where the SV scale factor is critical!

... now let's get more quantitative!