Beam Position Stability

DØ Workshop Beaune

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Beam Position (Stability)

- Knowledge of real-time beam position
  - Interesting for accelerator operation
  - Mandatory for L2STT, L3 (primary vertex)
- Quality of Data (trigger efficiency/purity) depends on stability of beam position !

$\Rightarrow$ Stability of beam position crucial

- During a run for L2STT, L3
- From store to store for L1CTT

Beam Position

- Vertices on a line $\begin{cases} x = X_0 + A_x z \\ y = Y_0 + A_y z \end{cases}$
- Extra contribution to track impact parameter due to beam offset:

$$d(\phi_i, z_i) = (X_0 + A_x z_i)\sin\phi_i - (Y_0 + A_y z_i)\cos\phi_i$$

- Collect tracks from several events, and minimize average impact parameter (one matrix inversion):

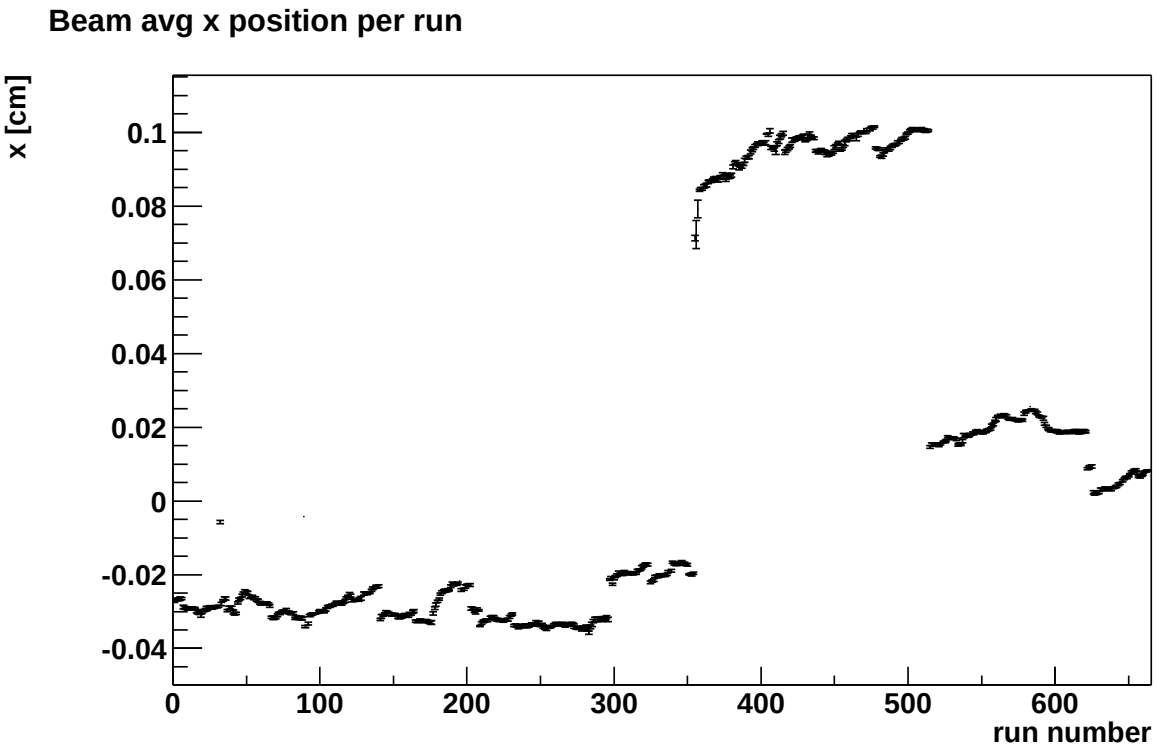
$$\chi^2 = \sum_{i=1}^{n} \frac{(d_i - d(\phi_i, z_i))^2}{\sigma_i^2 + 2\sigma_{\text{beam}}^2}$$

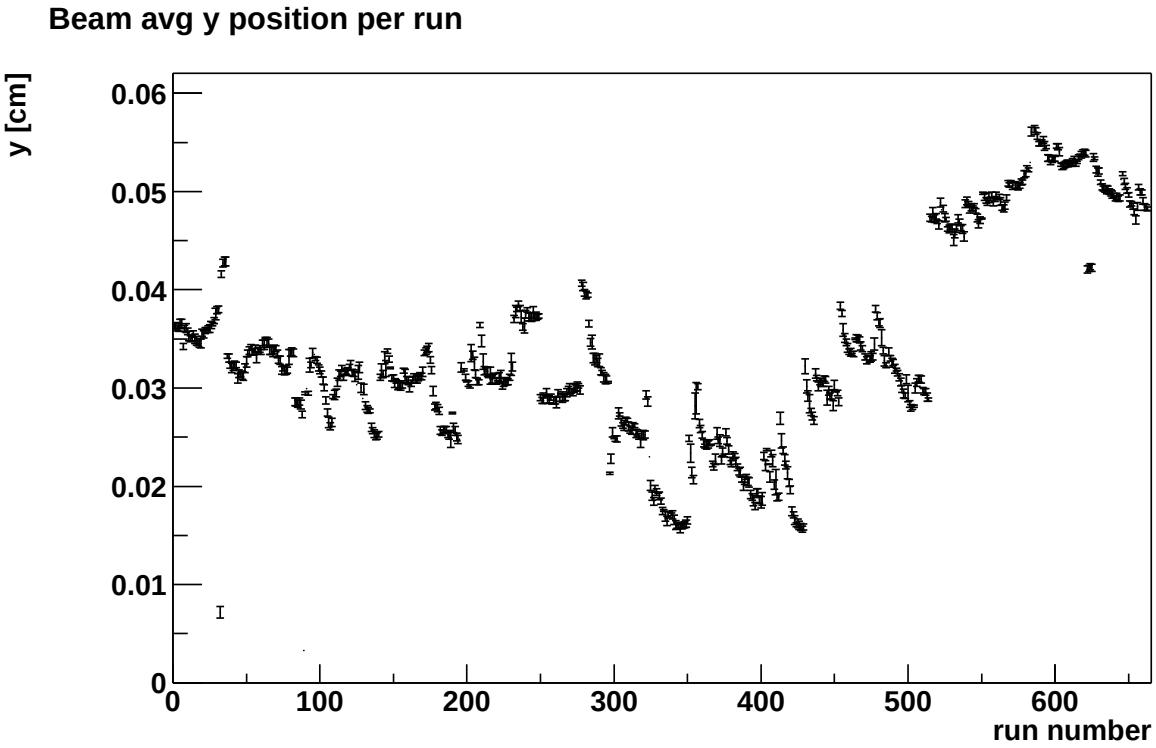
- First iteration: all tracks
- Further iterations: tracks with $|d_i| < 0.1$ cm with respect to beam position from previous iteration, until no more tracks removed or less than 10% of tracks left

Real Time Beam Position

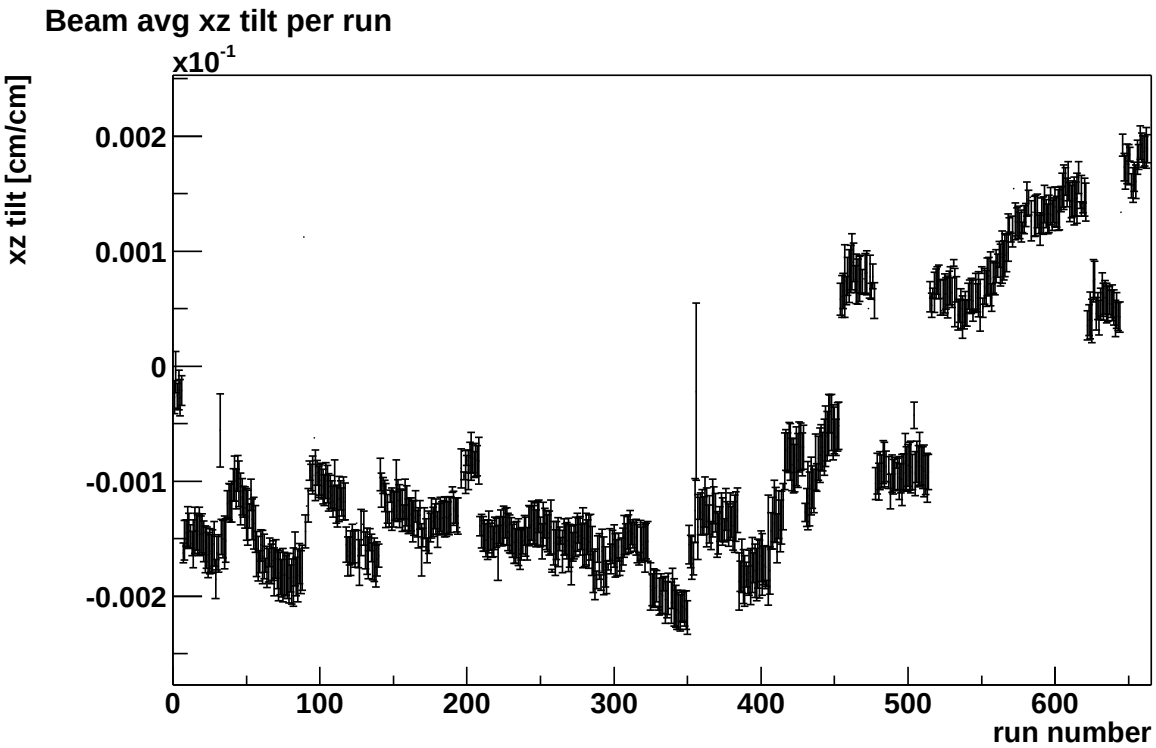
- Vertex Examine:
  - L3 tracking, offline vertexing
  - Beam position from dca-vs-ϕ fit on large collection of tracks ($\sim$ 15000)
  - Currently operated by Shift Captain
- Every $\sim$ 5 ($\sim$ 15) minutes at low (high) luminosity:
  - Position x, y at $z = 0$
  - Tilt in xz and yz planes
- Beam position measured in real time since 13 Sep
- Following plots:
  - Run 166992 (29 Oct) until 177788 (6 June), 663 runs
  - Average position / tilt per run
  - RMS of position / tilt per run
  - Maximum deviation from last measurement in previous run

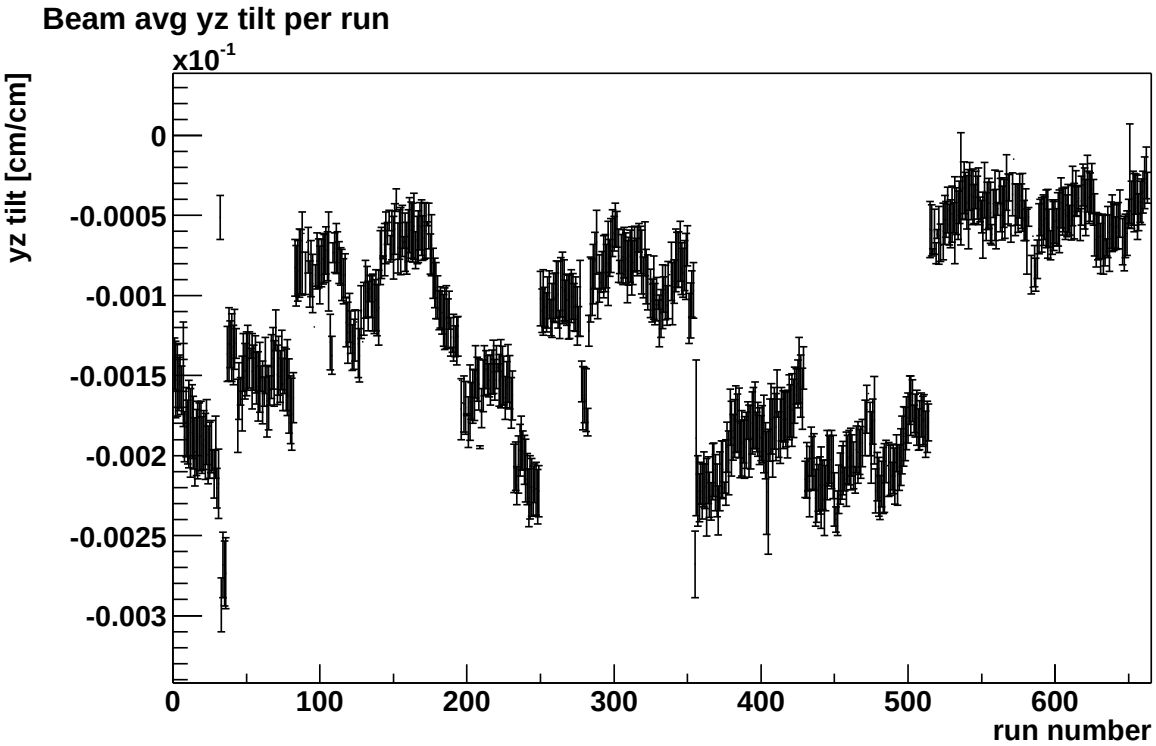
Position


Beam avg x position per run
x [cm]
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
100
200
300
400
500
600
run number

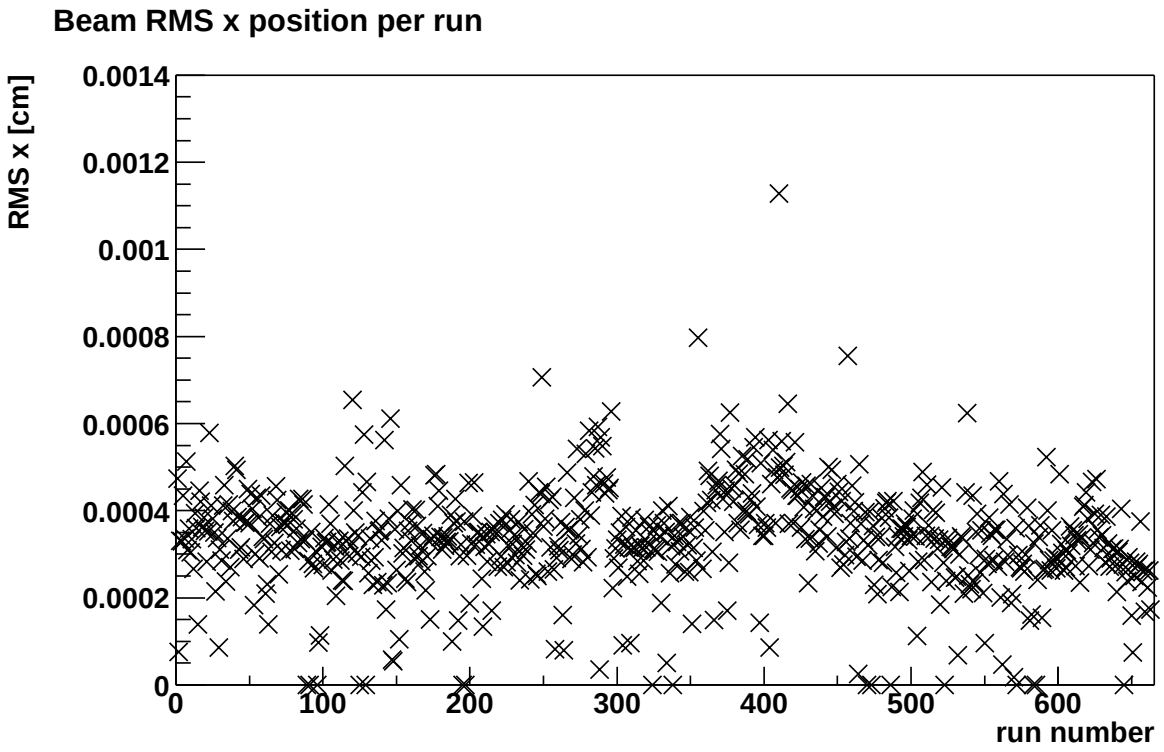

Beam avg y position per run
y [cm]
0.06
0.05
0.04
0.03
0.02
0.01
0
0
100
200
300
400
500
600
run number

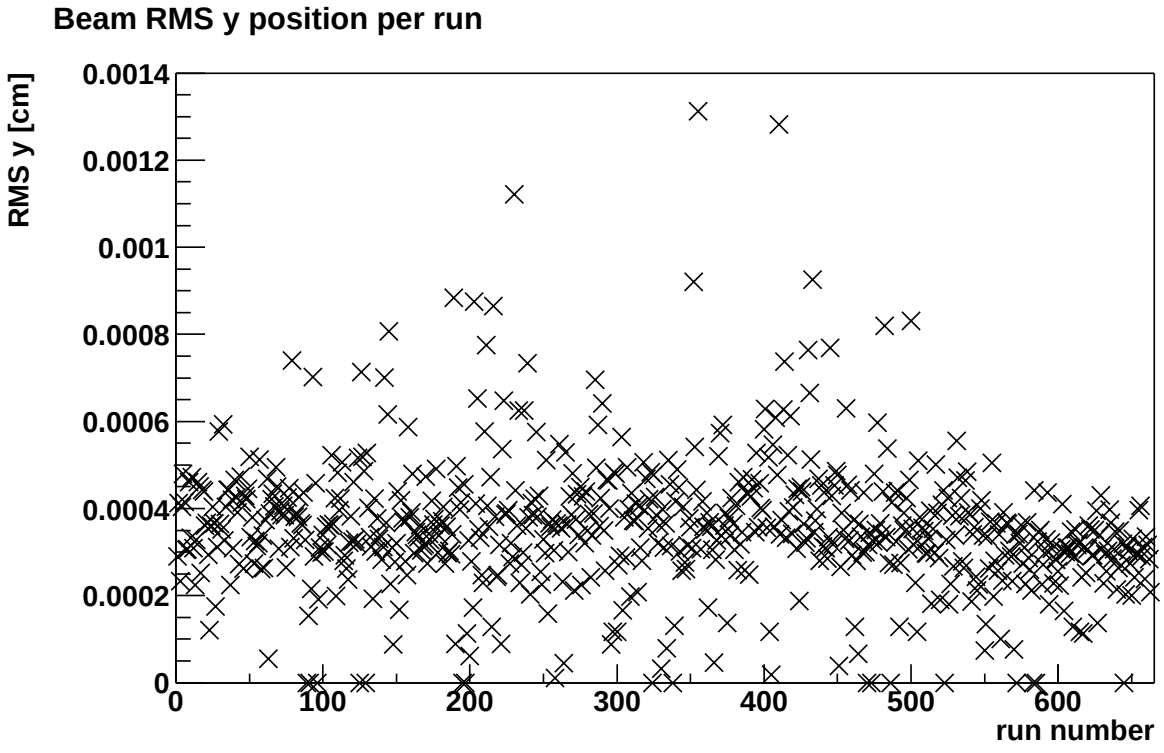
Tilt


Beam avg xz tilt per run
x10^-1
xz tilt [cm/cm]
0.002
0.001
0
-0.001
-0.002
0
100
200
300
400
500
600
run number

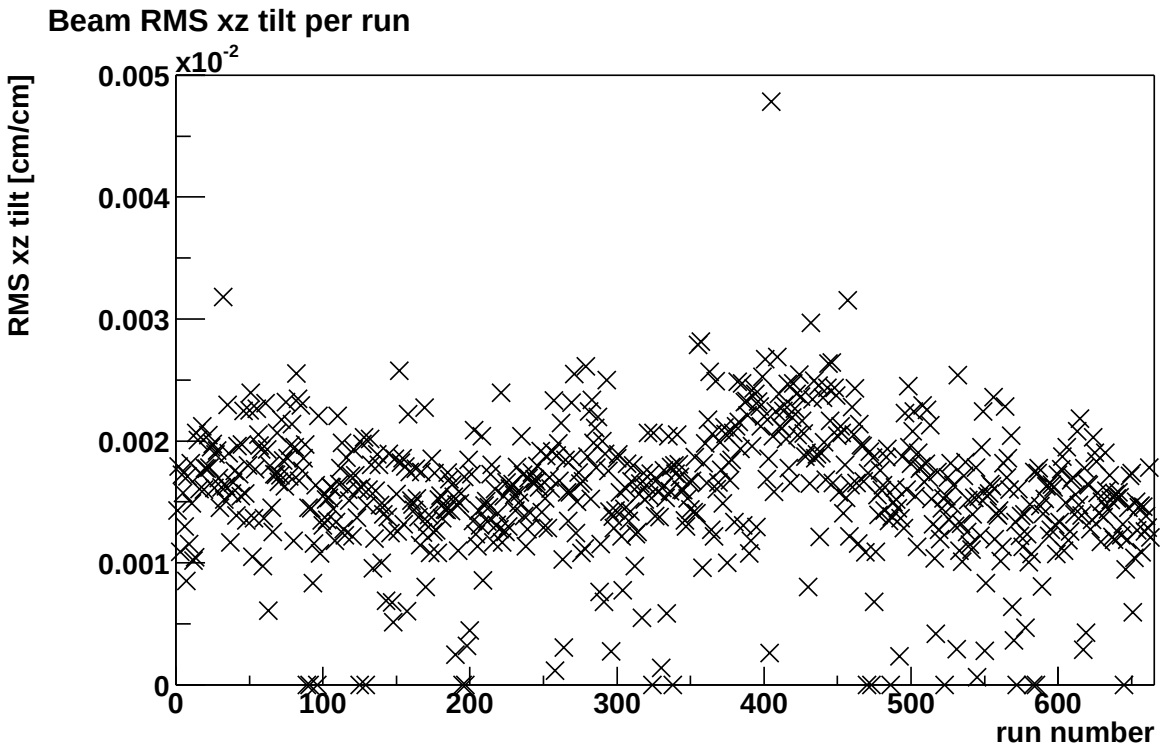

Beam avg yz tilt per run
x10^-1
yz tilt [cm/cm]
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
0
100
200
300
400
500
600
run number

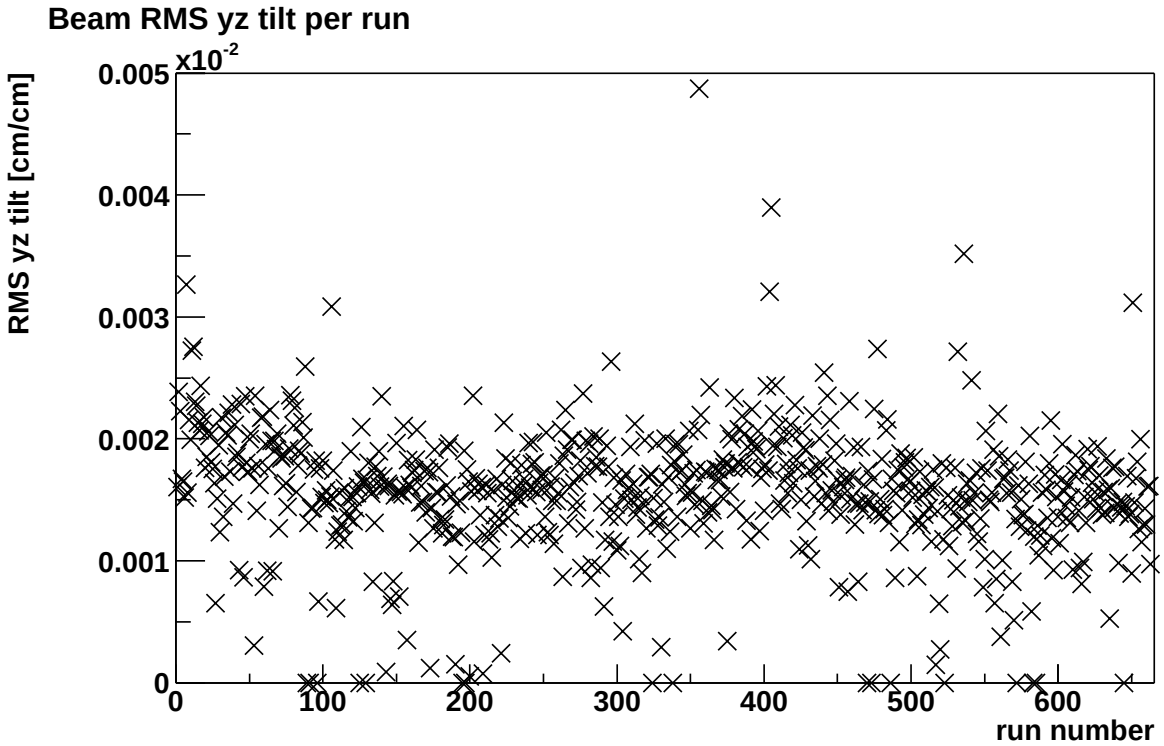
Position RMS



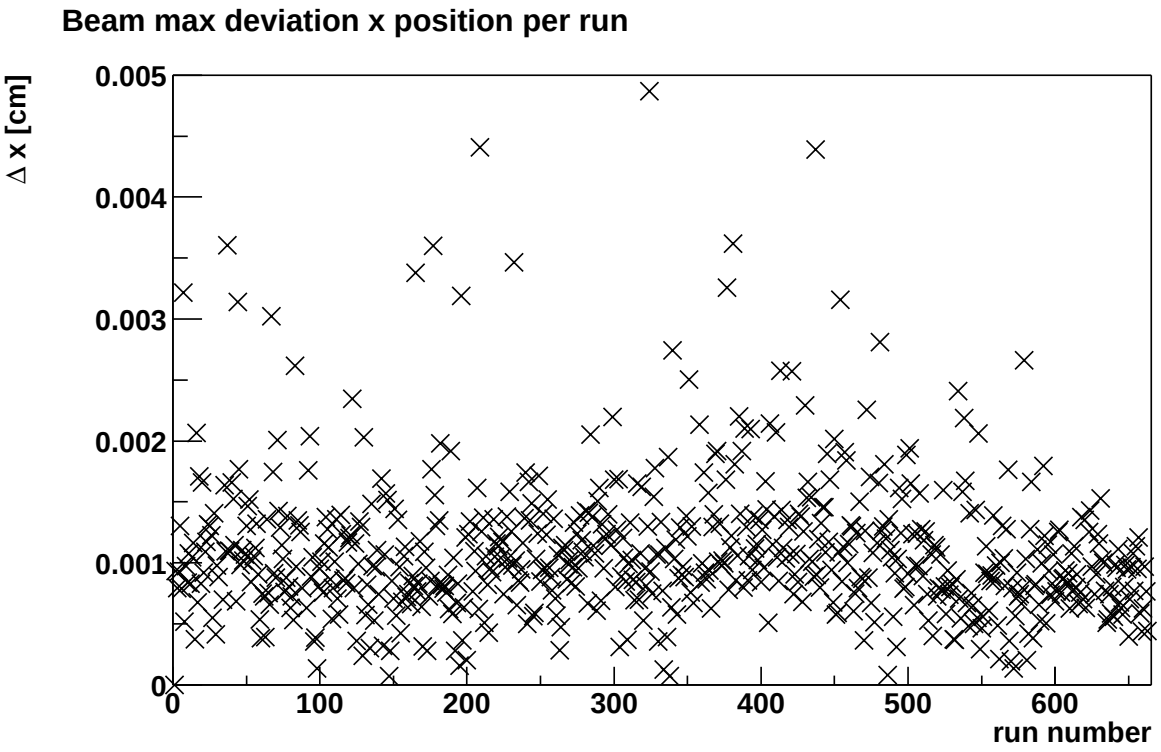


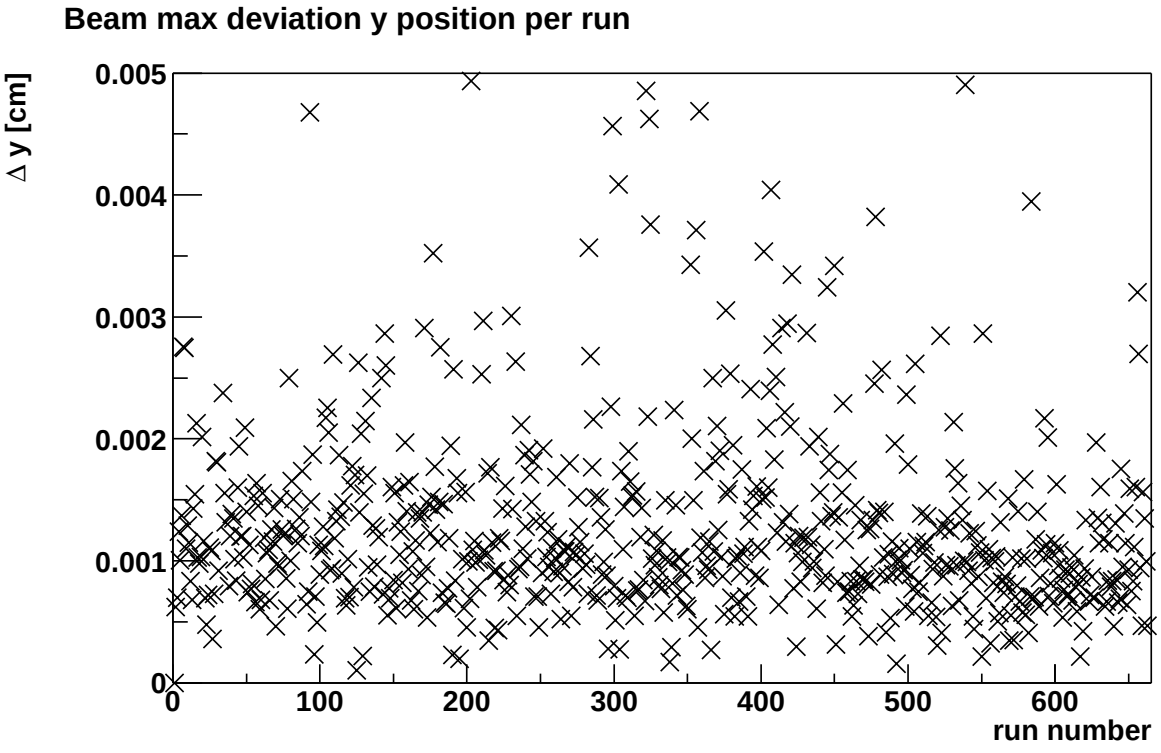
Tilt RMS


Beam RMS xz tilt per run
x10^-2
0.005
0.004
0.003
0.002
0.001
0
RMS xz tilt [cm/cm]
0
100
200
300
400
500
600
run number

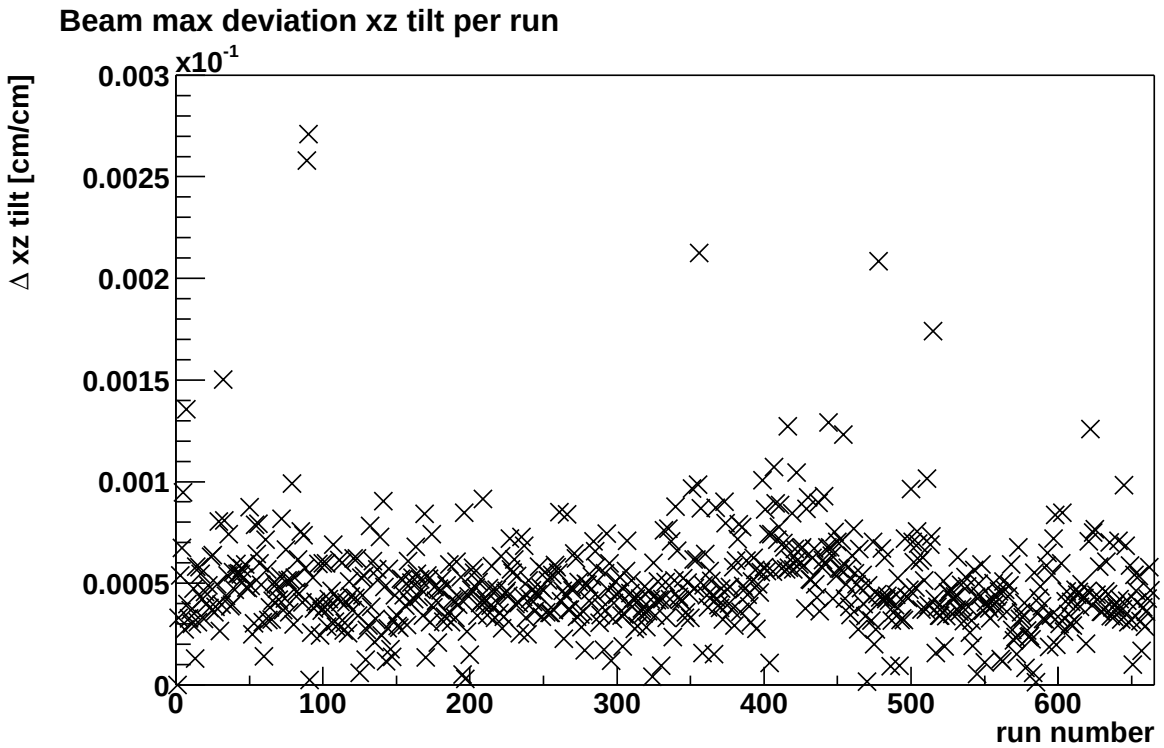

Beam RMS yz tilt per run
x10^-2
0.005
0.004
0.003
0.002
0.001
0
RMS yz tilt [cm/cm]
0
100
200
300
400
500
600
run number

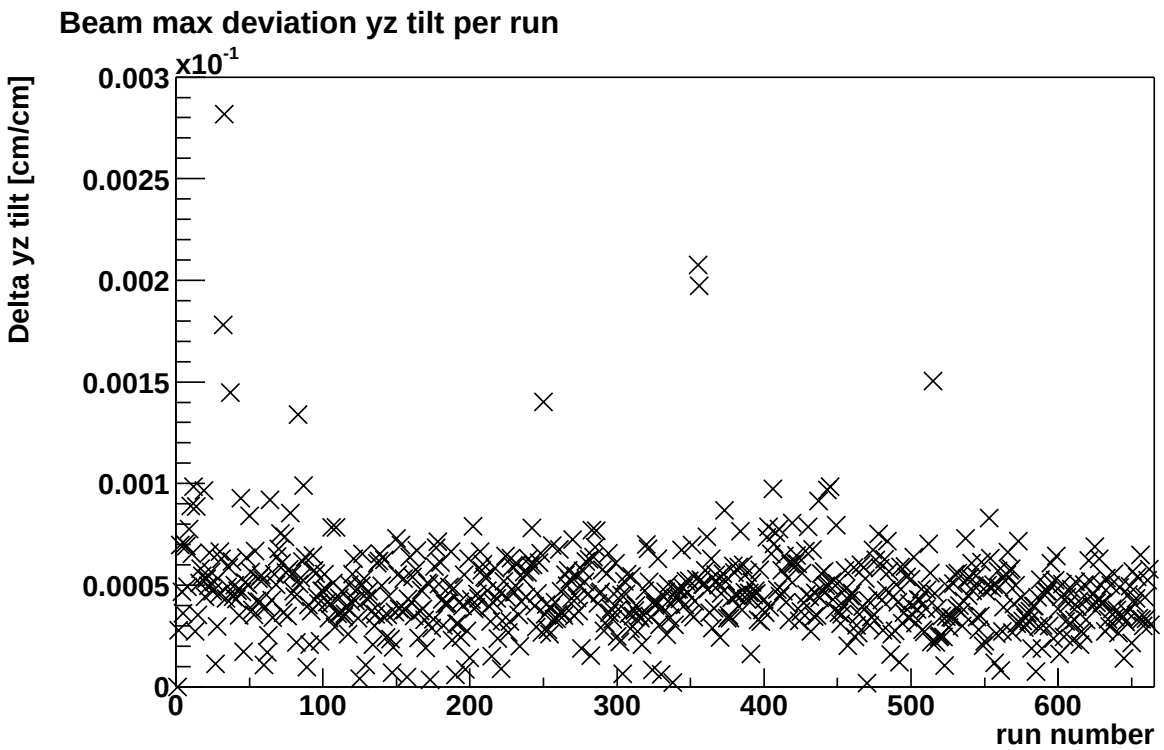
Position Deviation



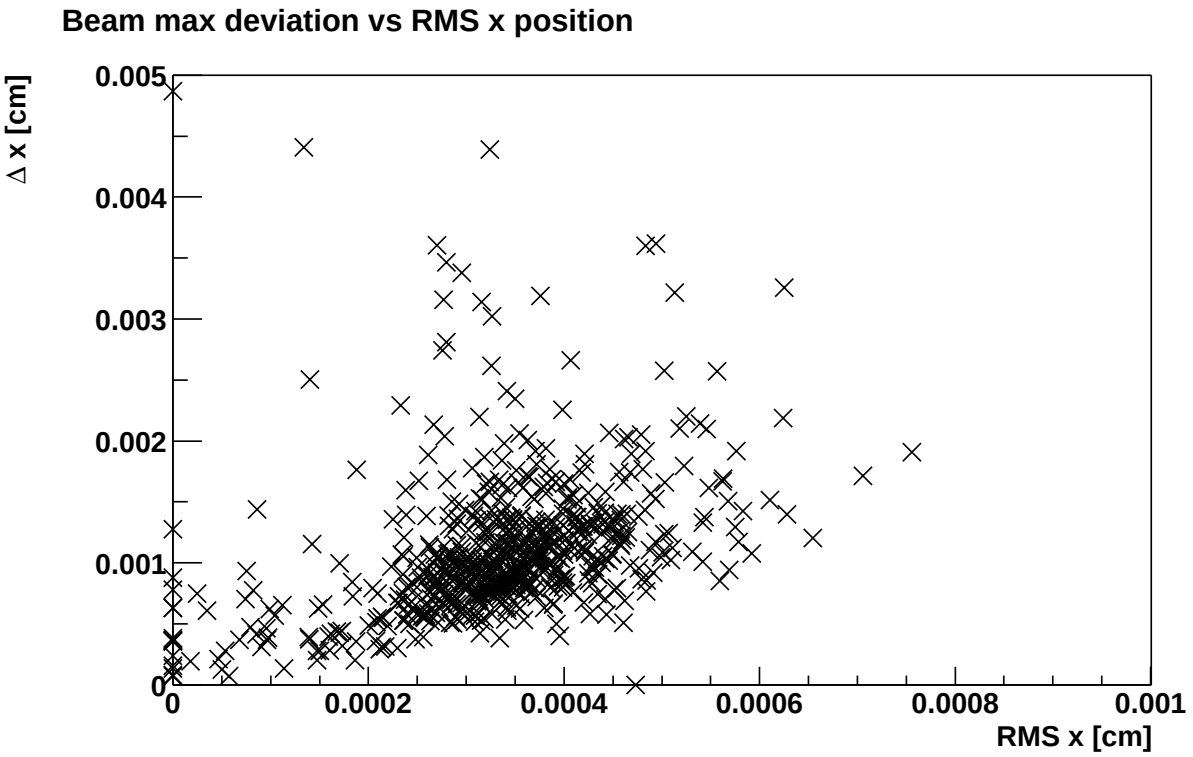


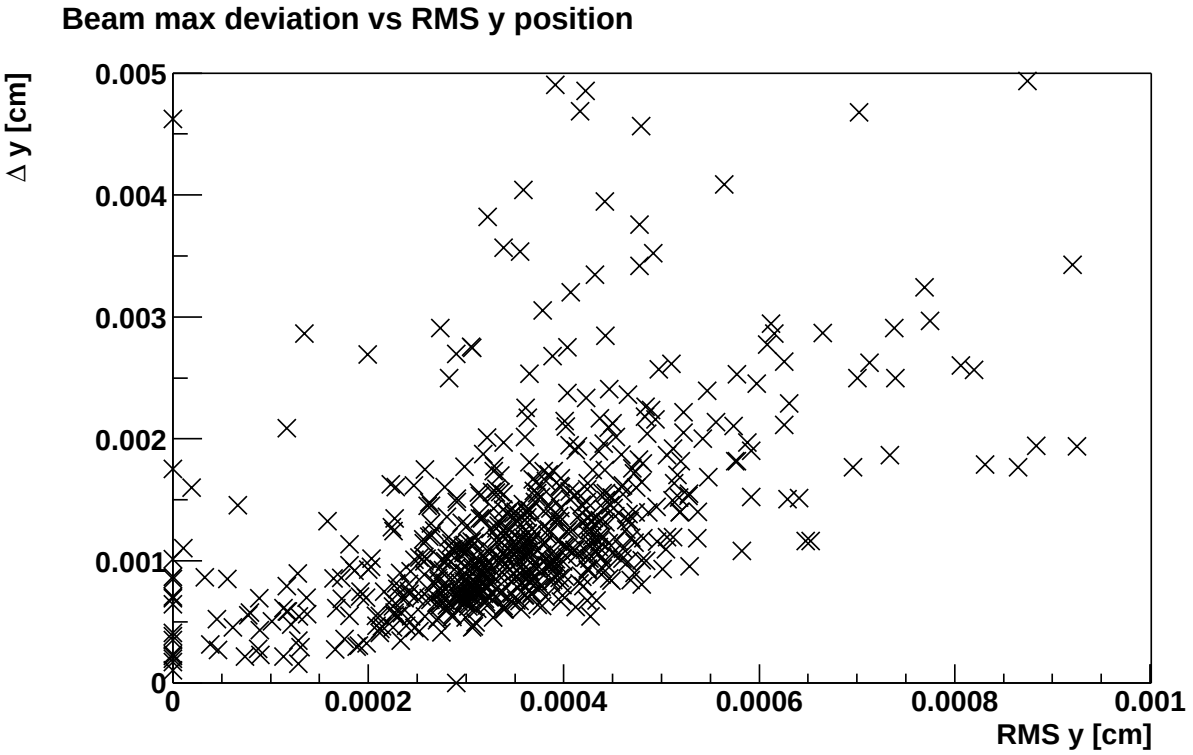
Tilt Deviation



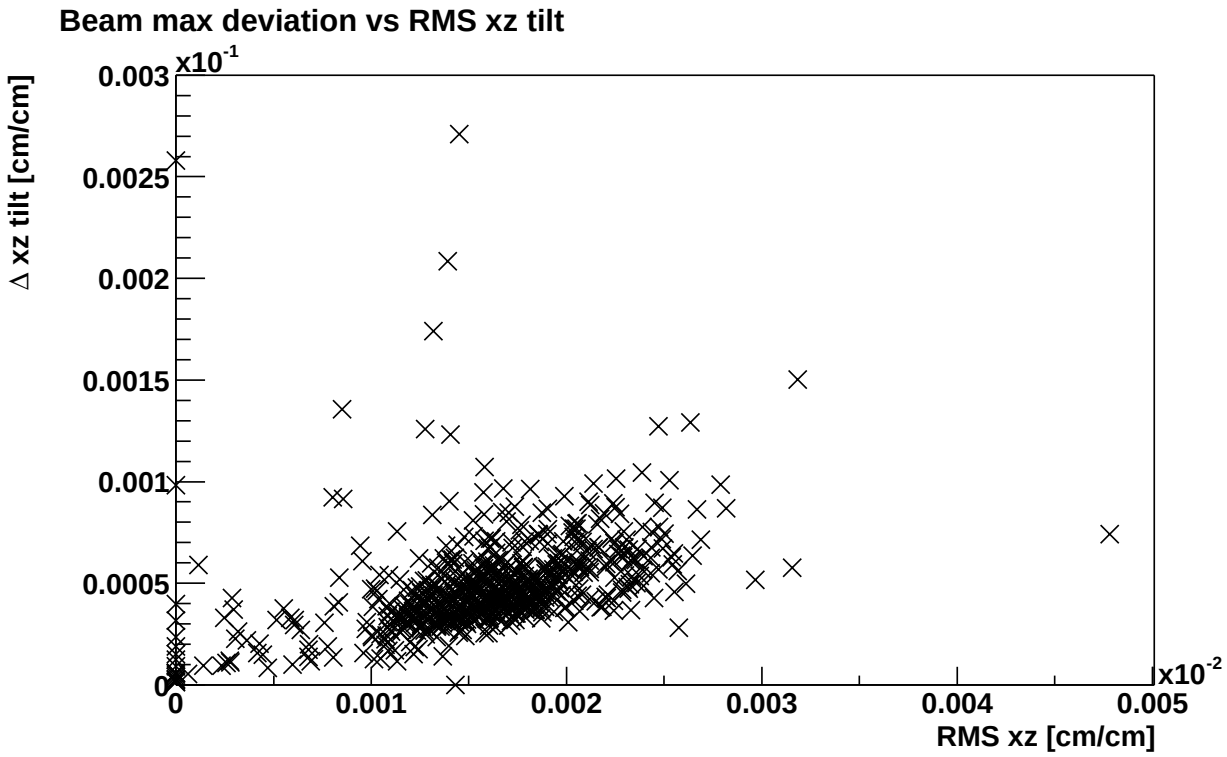


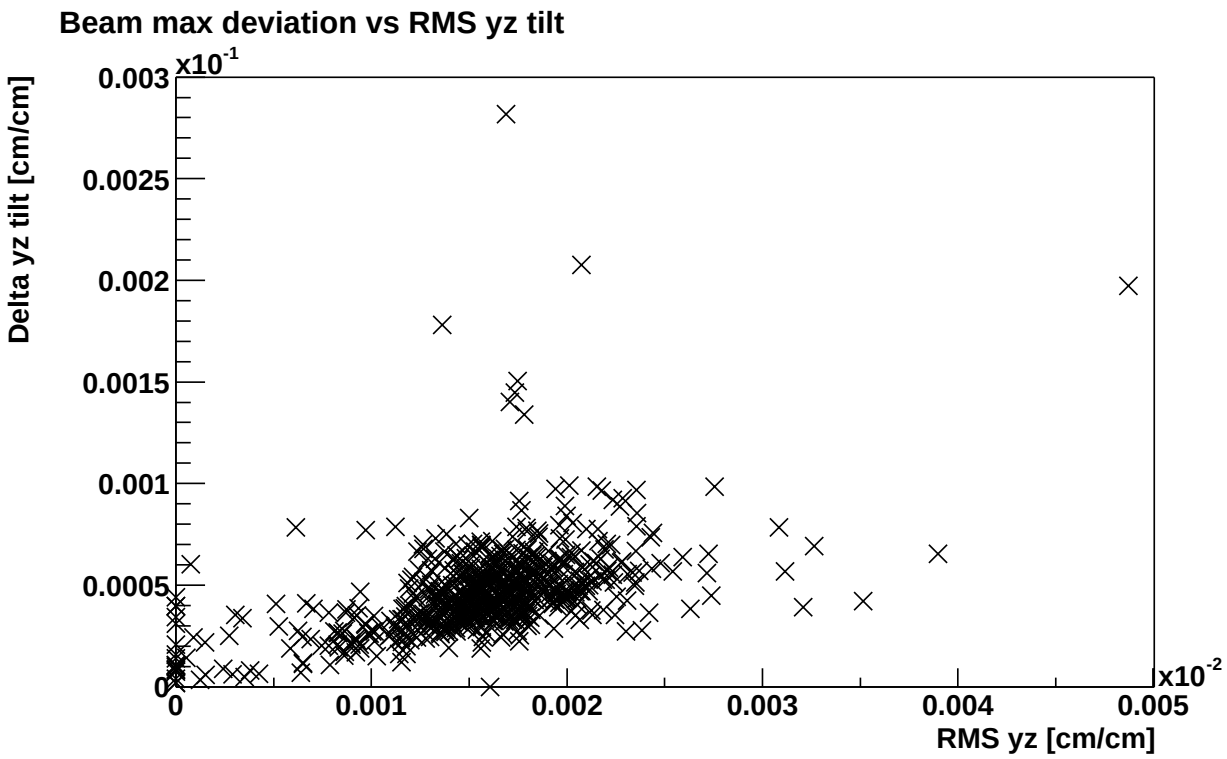
Position Deviation vs RMS





Tilt Deviation vs RMS





Conclusion

- Precision: $\sigma_{x,y} \sim 3.5$ μm, $\sigma_{xz,yz} \sim 15$ μrad
- Deviations in general within $\Delta_{x,y} \sim 20$ μm, $\Delta_{xz,yz} \sim 80$ μrad ($\sim 5 \times$ precision)
- Large jumps ($\Delta_{x,y} > 50$ μm) happen on store boundaries only

$\Rightarrow$ Beam is quite stable

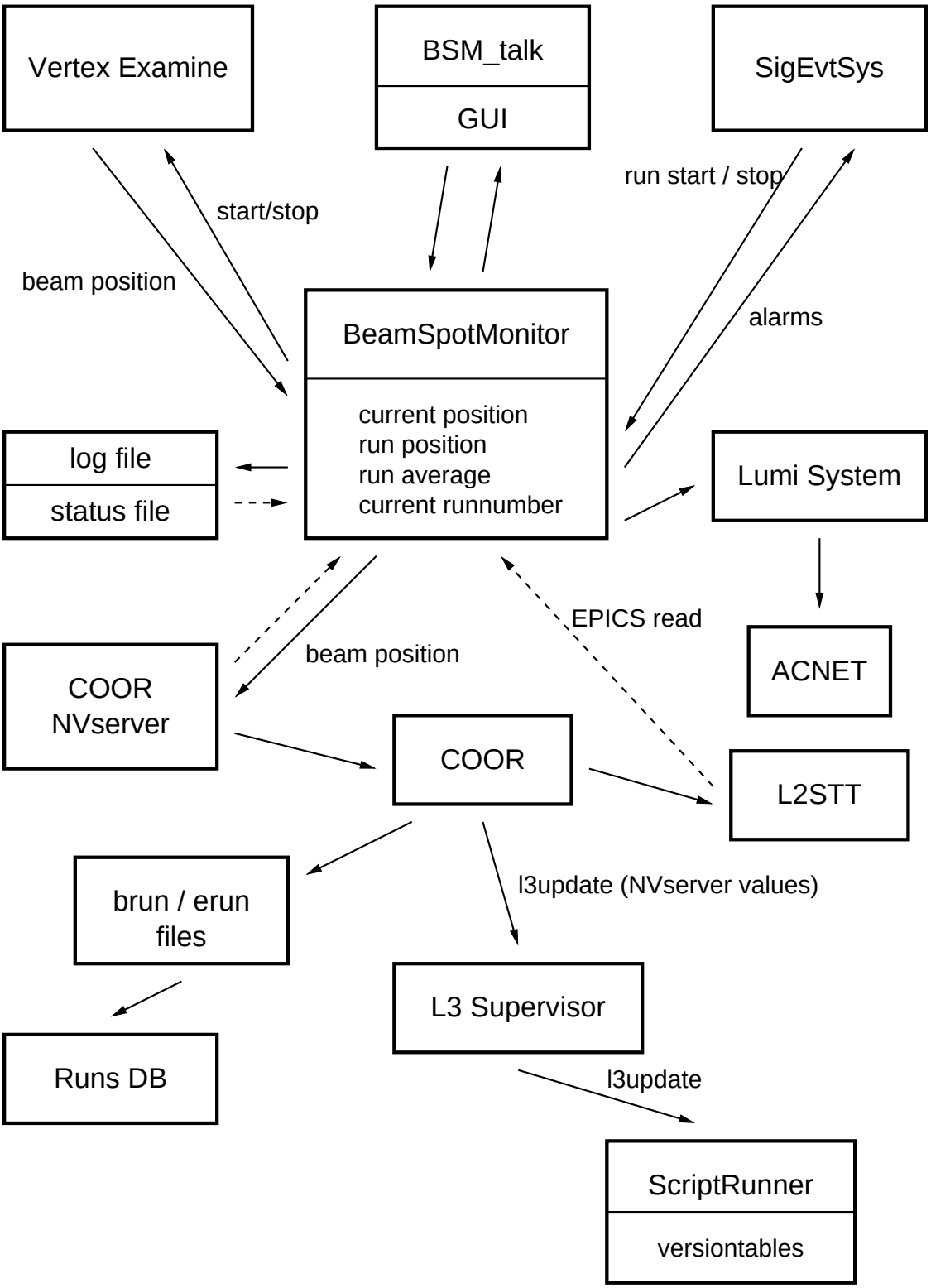
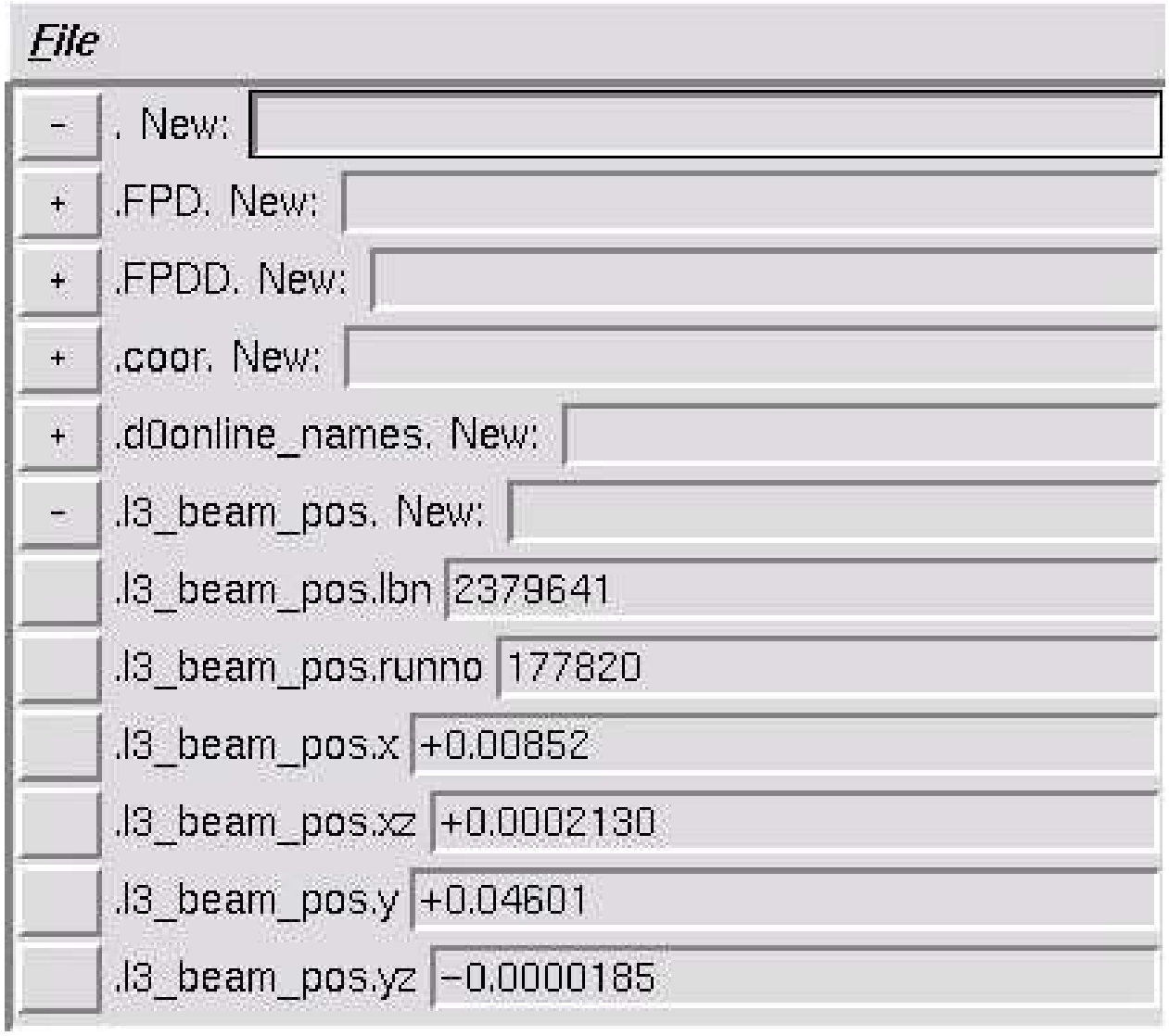
Future

- Possible improvement in L3 tracking due to fix in calibration file $\rightarrow$ smaller uncertainty on measurement

- `BeamSpotMonitor`
  - Run Vertex Examine automatically
  - Monitor beam position
  - Provide beam position to L2STT / L3
  - Save run values in Runs DB
  - Send info to Beams Division $\rightarrow$ auto-adjustment

- Additional beam quality information to BD:
  - Average vertex z position
  - Average number of vertices per event
  - Beam width (longer term)

Beam Spot Monitor



Coor NV Example