Beamspot for September VdM scan and comparison to April

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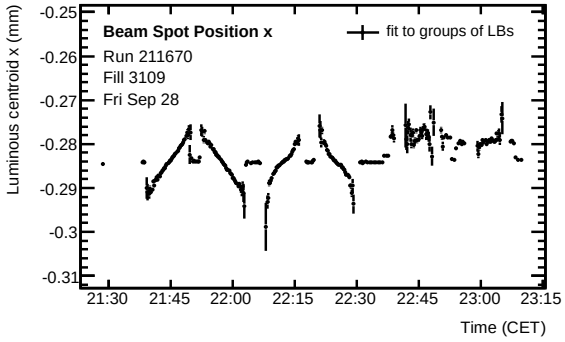
(on behalf of the beamspot group)

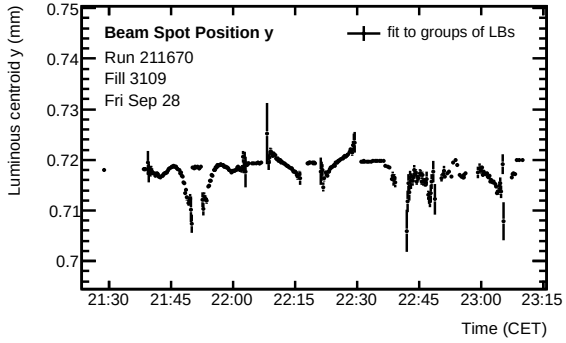
25th October 2012
Luminosity Meeting

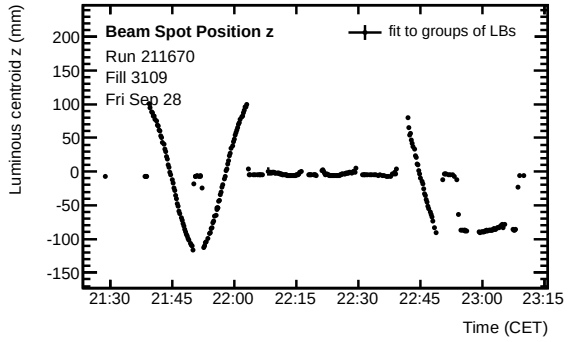
Introduction

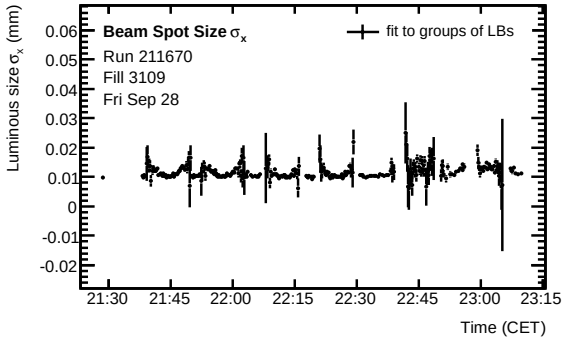
- September: 3 sets of VdM scans during run 211670 (fill 3109)
  - Pairs of y and x scans; opposite movement direction
  - Last pair are offset scans
  - $\langle \mu \rangle = 23$
  - Trains $\rightarrow$ possibilty of parasitic interactions
- April: 3 sets of VdM scans during run 201351 (fill 2520)
  - Alternating x and y scans
  - $\langle \mu \rangle = 5$
- Will present a first look at beamspot during September scans and comparison to April scan
  - Both averaged over BCIDs and per-BCID

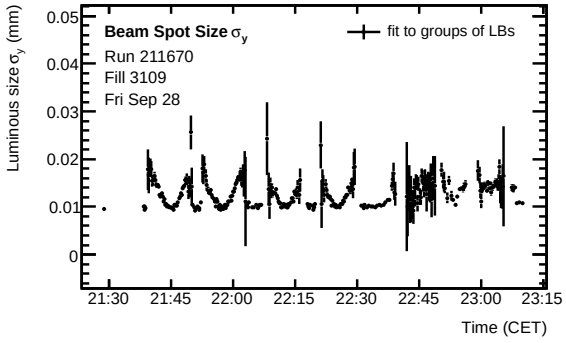
September Overview

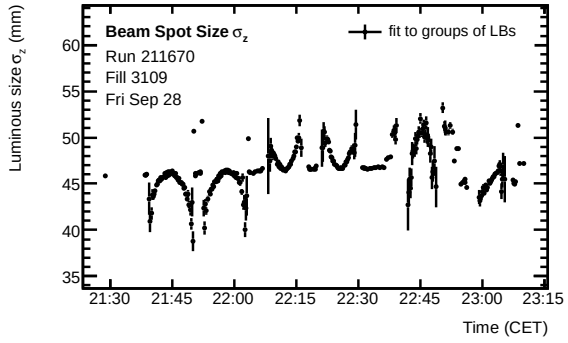


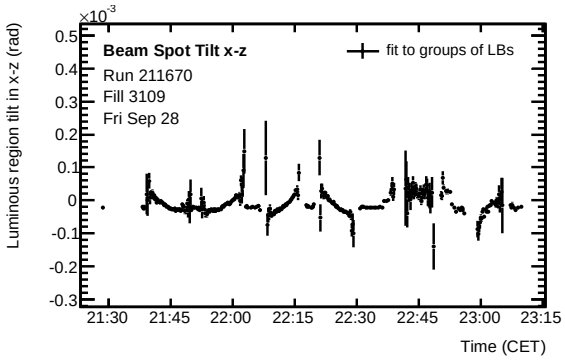


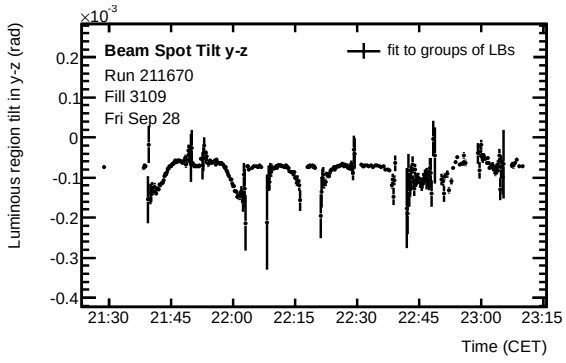


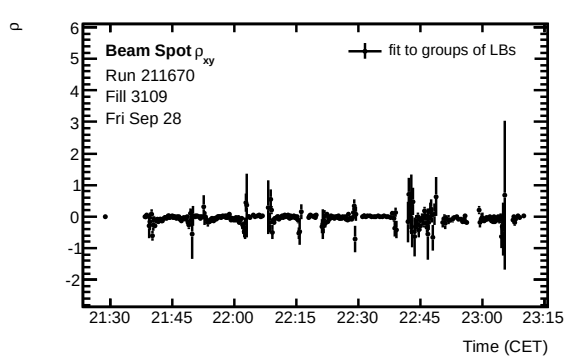








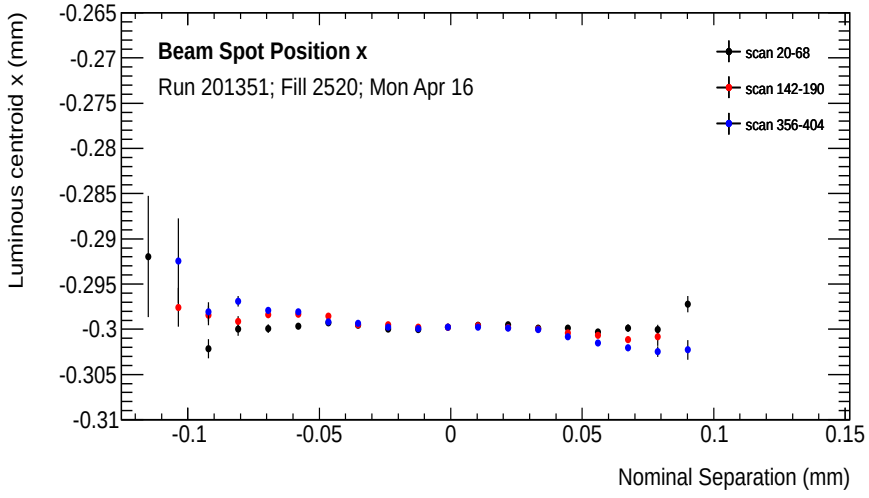


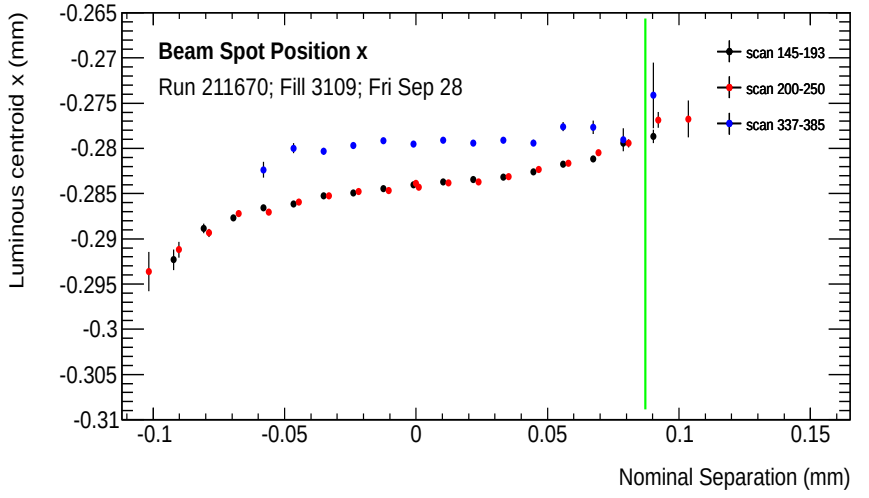


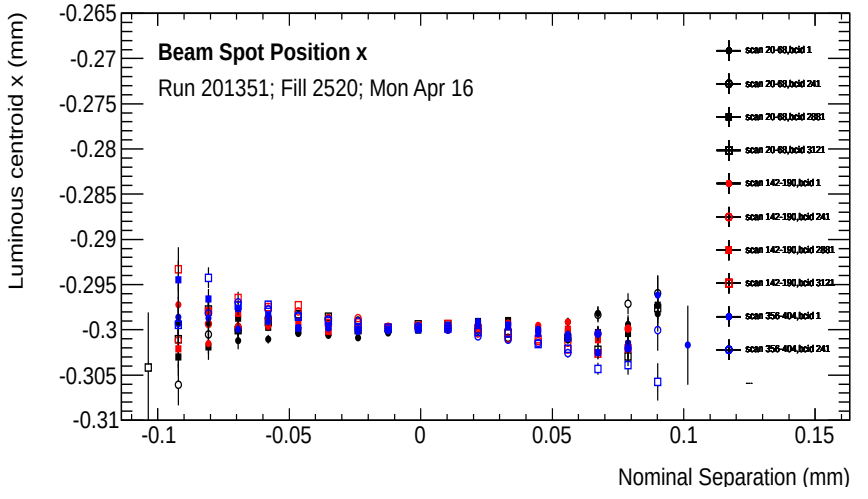
x-scan

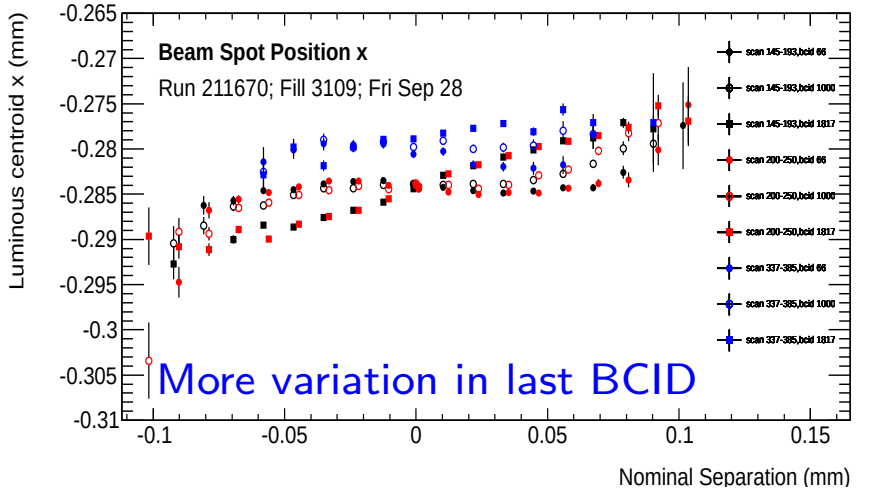
x-scan: x position

- $x \approx$ const for April; follows scan in Sept $\rightarrow$ diff beam size
  - Offest scan shifted $\rightarrow$ ratio $\sigma_x^{b1} : \sigma_x^{b2}$ depends on $y \rightarrow$ non factorisation



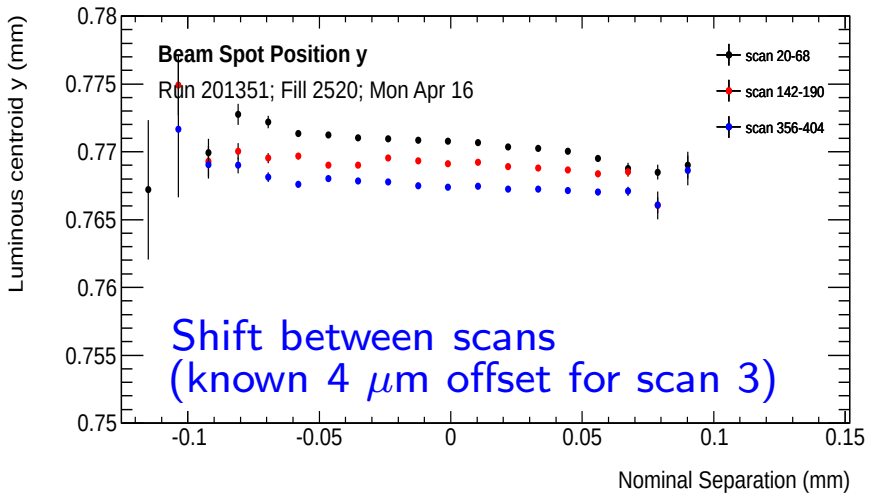


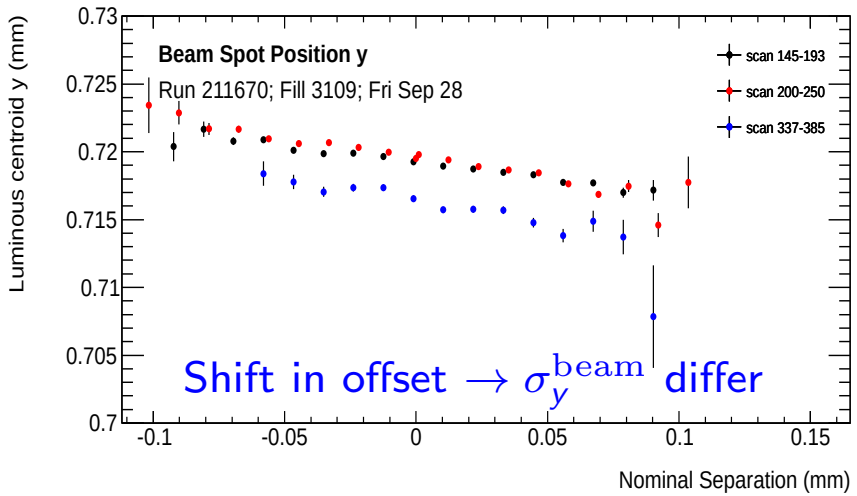


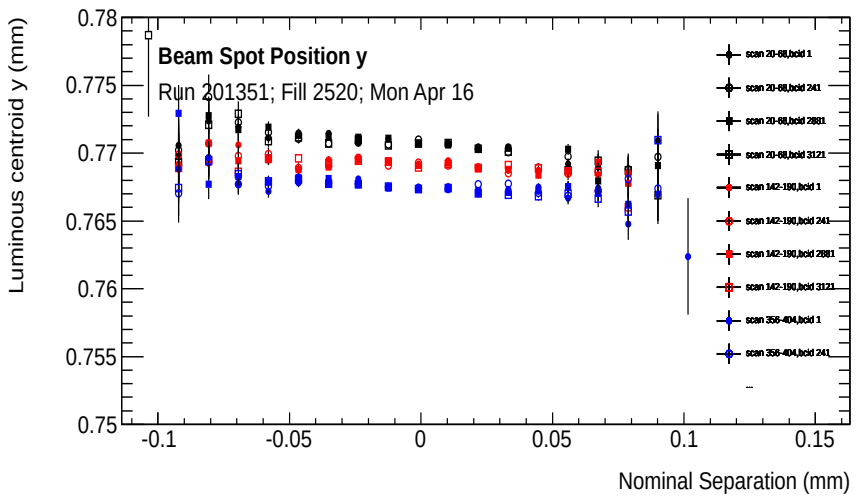


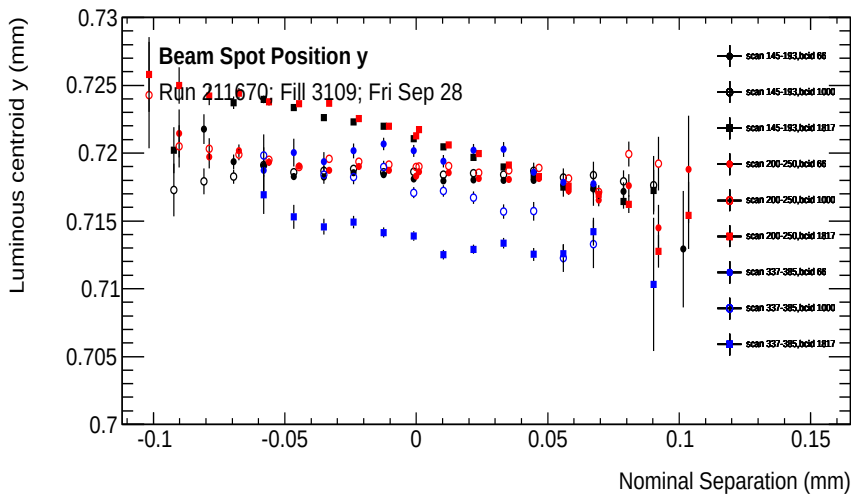
x-scan: y position

- $y \approx$ const in April; moves in Sept for last BCID
  - Sept: varies over BCIDs; attribute to difference in parasitic interactions



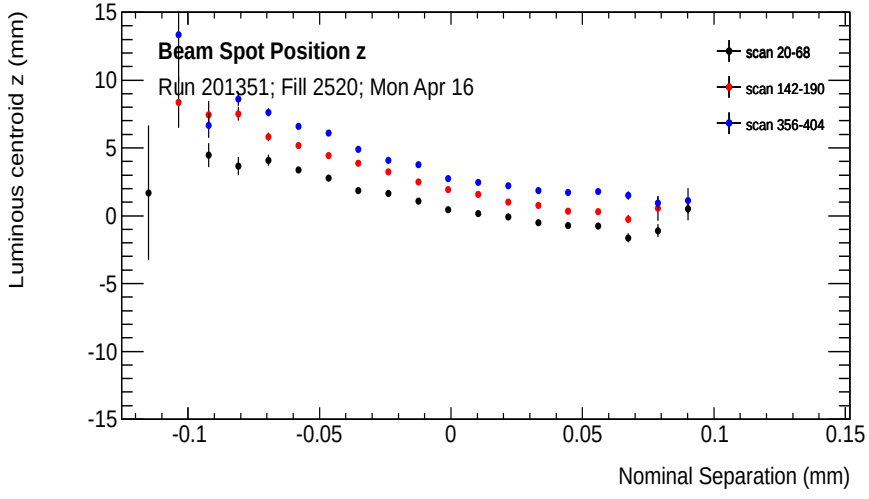


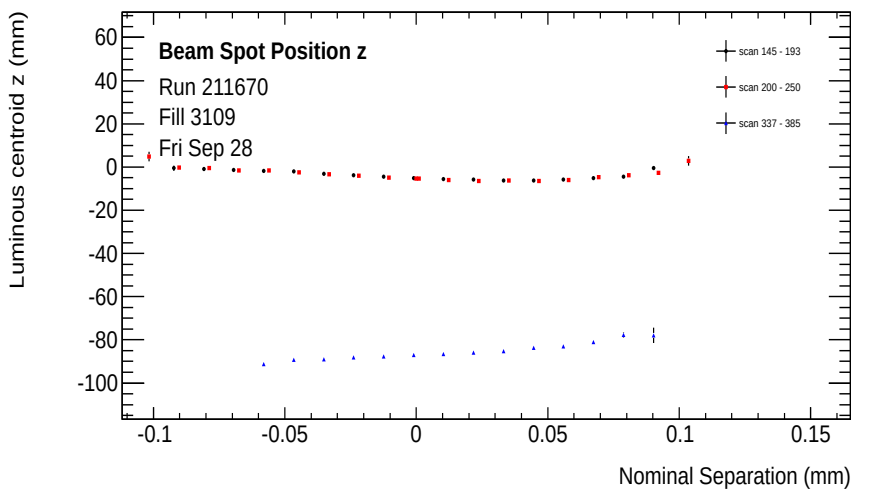


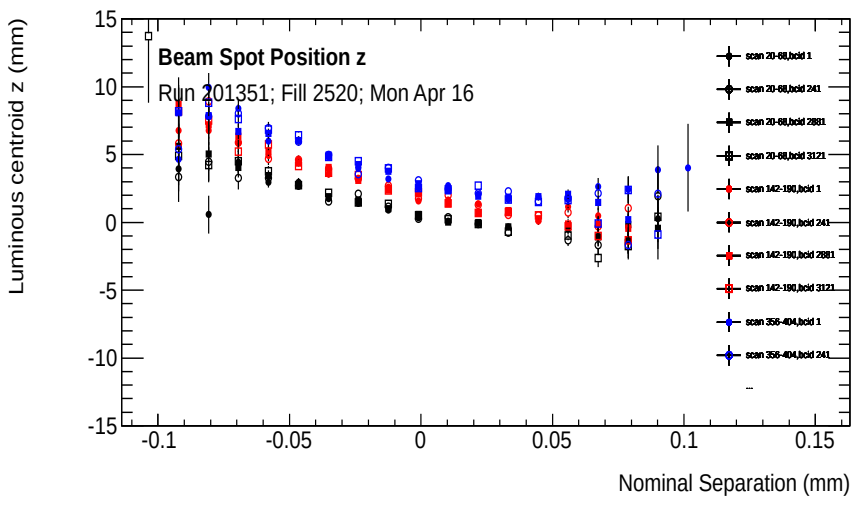


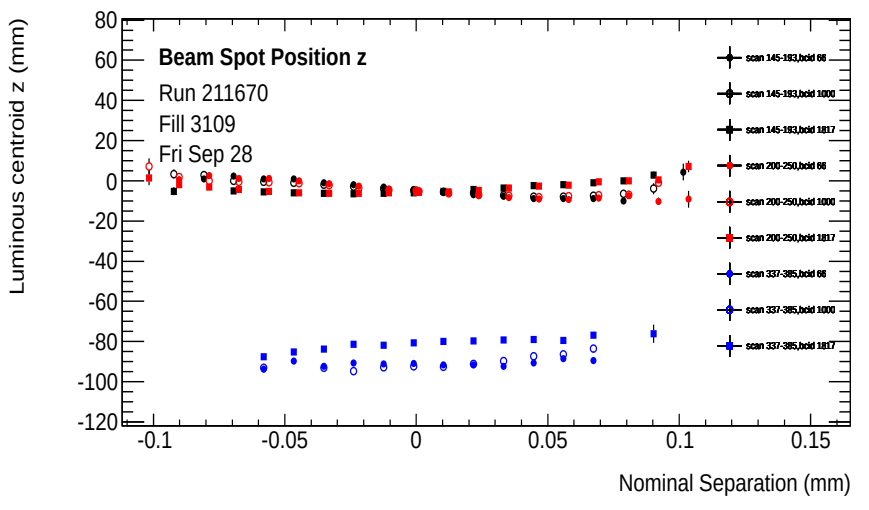
x-scan: z position

- Shift in z for offset due to crossing angle (see slide 22)



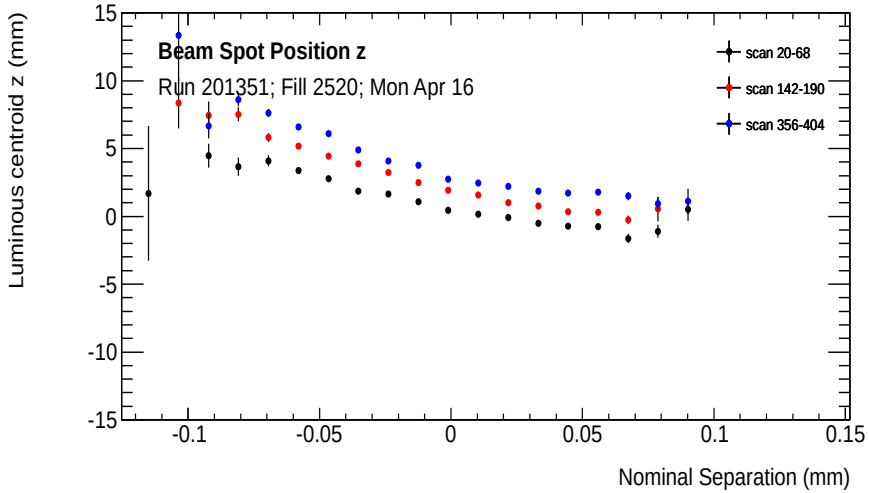


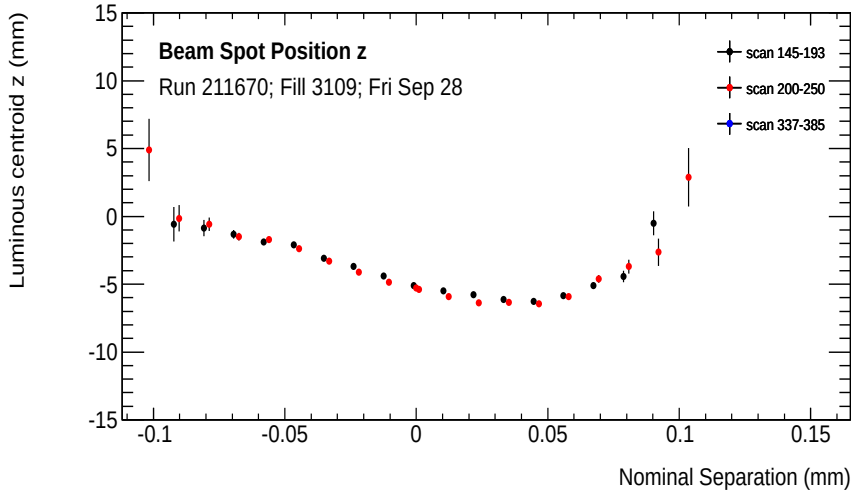


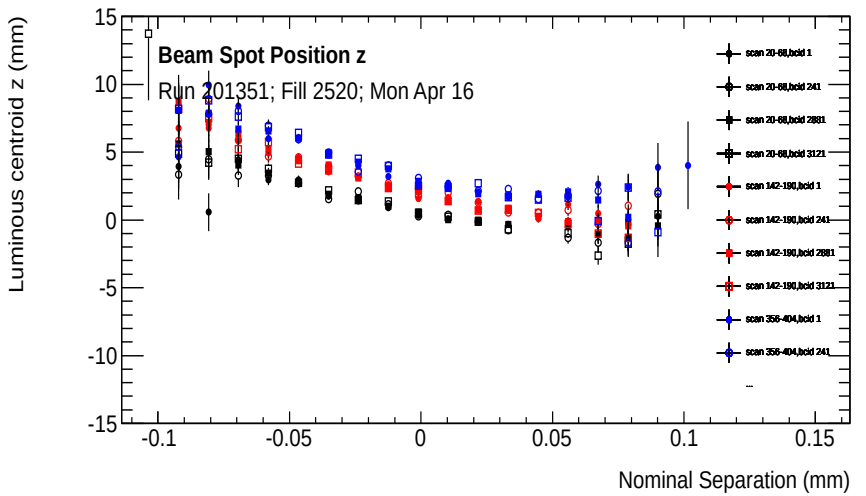


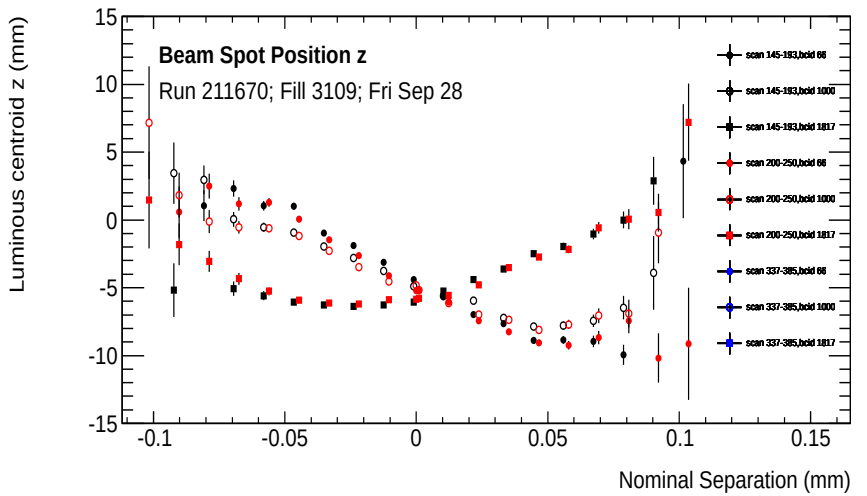
x-scan: z position

- z varies with scan $\rightarrow$ few μm residual x-angle; non-linear in Sept
  - Sept: last BCID again different





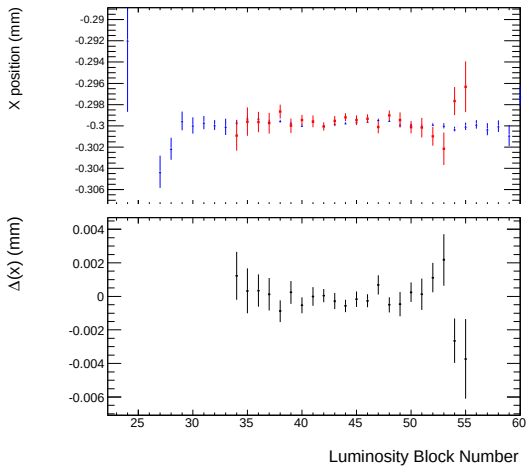


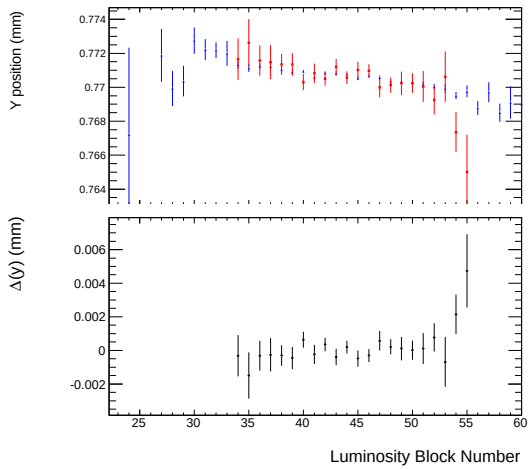


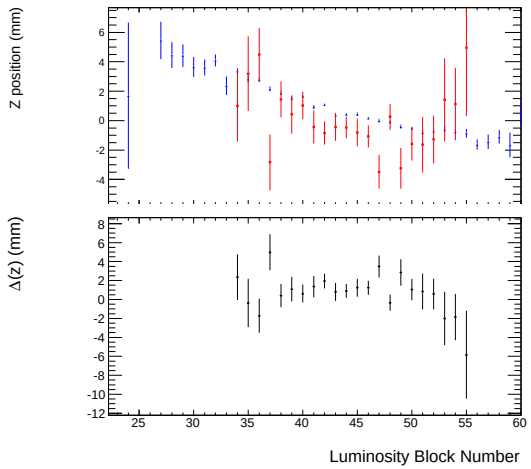
Width: a word of caution

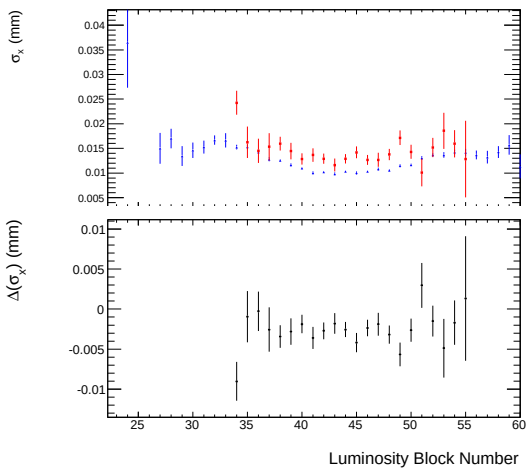
- VdM stream is dominated by poor resolution vertices with large transverse errors
  - Mostly soft tracks due to trigger configuration
- Resulting vertex errors are much larger than transverse beamspot size $\Rightarrow$ width of vertex distribution dominated by vertex resolution so little sensitivity to beamspot size
  - Similar effect seen in low-μ run at start of 2012 data-taking
- Can improve determination by using only good resolution vertices, but significant reduction in statistics
- Checked for April scans that low resolution vertices don't bias position and trend in width is similar
  - But absolute transverse size is underestimated by $\approx 2 - 3\mu$m
  - Still to check for September scan
- Also, some reasonably large variations in k-factor for September

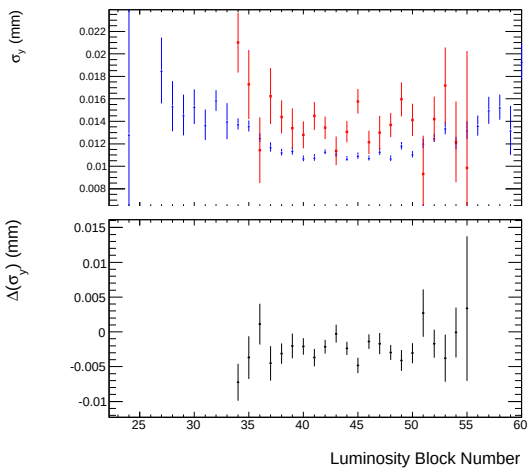
Width: April comparison

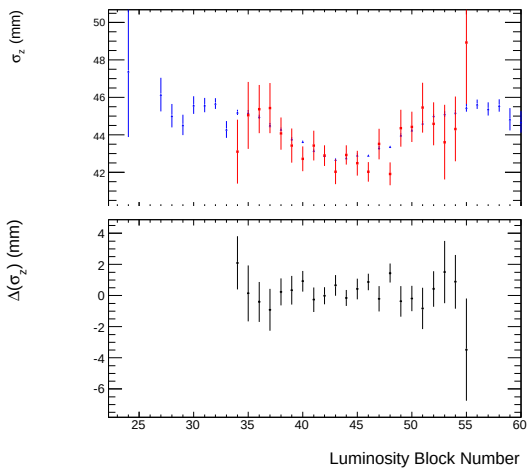








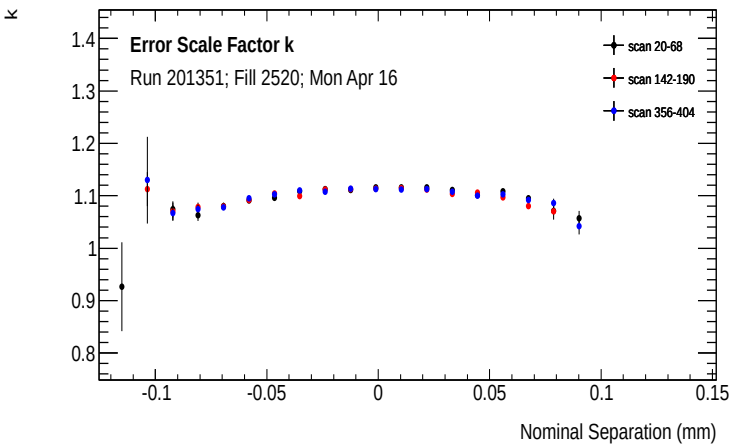


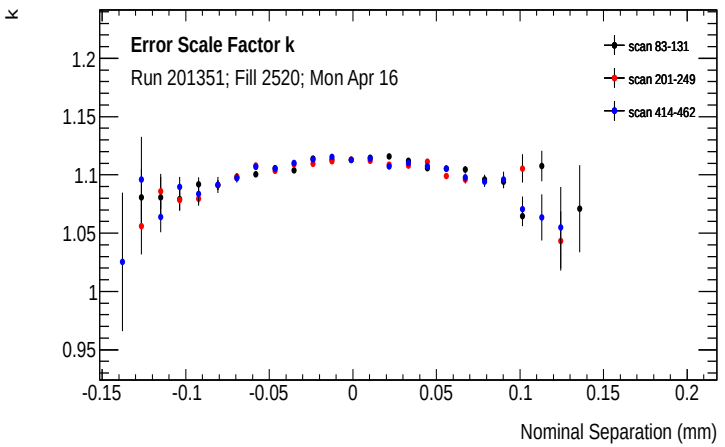


– All vertices – High-resolution vertices – Difference

Width: vertex k-factor

- Beamspot fit includes a scale factor, k, to account for the difference between the actual and expected tracking errors
  - Covariance matrix $V_i^{xy} = V^{xy\ beam} + k \cdot V_i^{xy\ vertex}$
- The larger k the bigger the vertex resolution correction and the smaller the resulting beamspot width
- April (+ previous): See variation in k at level of < 0.1
  - Maybe an artifact of single Gaussian fit to double-Gaussian distribution

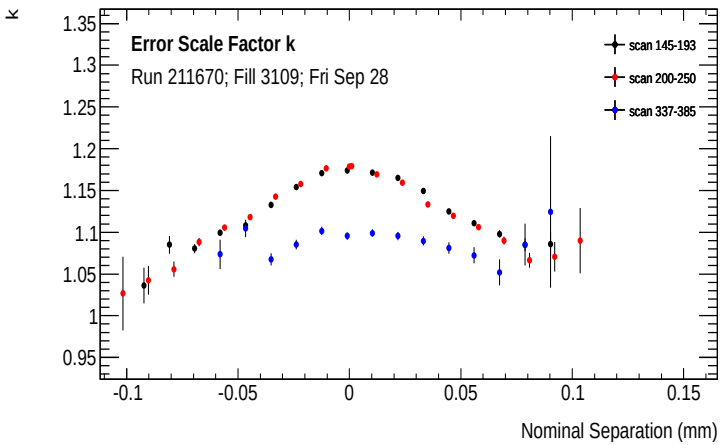


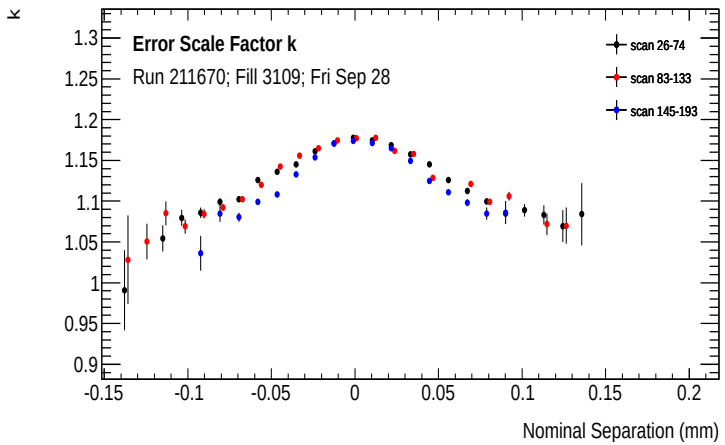


- Fixing k to central value has little effect

Width: vertex k-factor

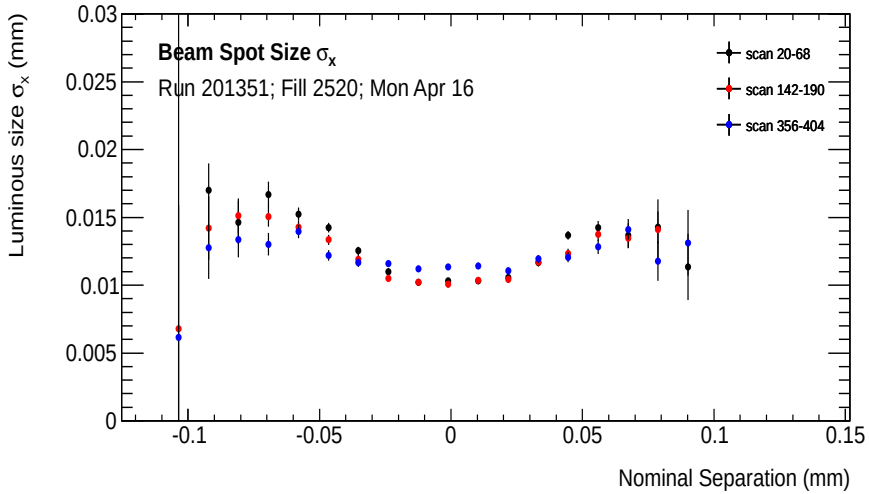
- Beamspot fit includes a scale factor, k, to account for the difference between the actual and expected tracking errors
  - Covariance matrix $V_i^{xy} = V^{xy\ beam} + k \cdot V_i^{xy\ vertex}$
- The larger k the bigger the vertex resolution correction and the smaller the resulting beamspot width
- Sept: significantly larger than previous scans (≈ 0.2) + more peaked
  - Possibly due to more pile-up
  - Lower k for offset in x-scan but not y-scan

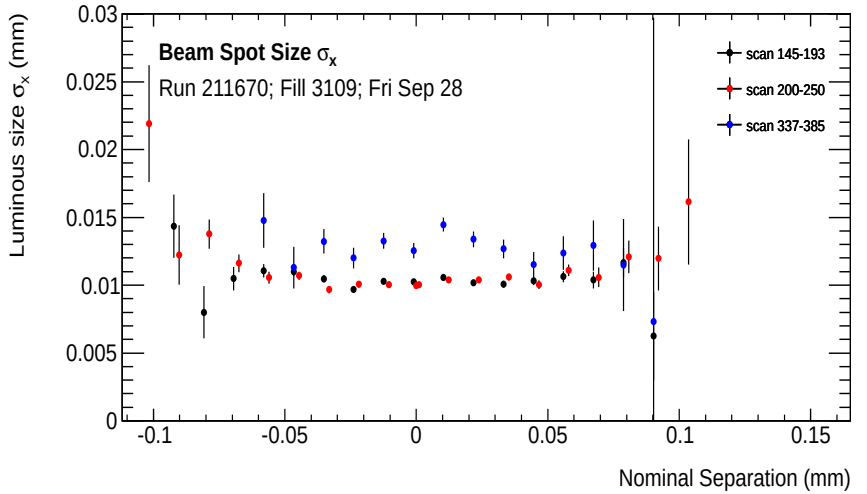


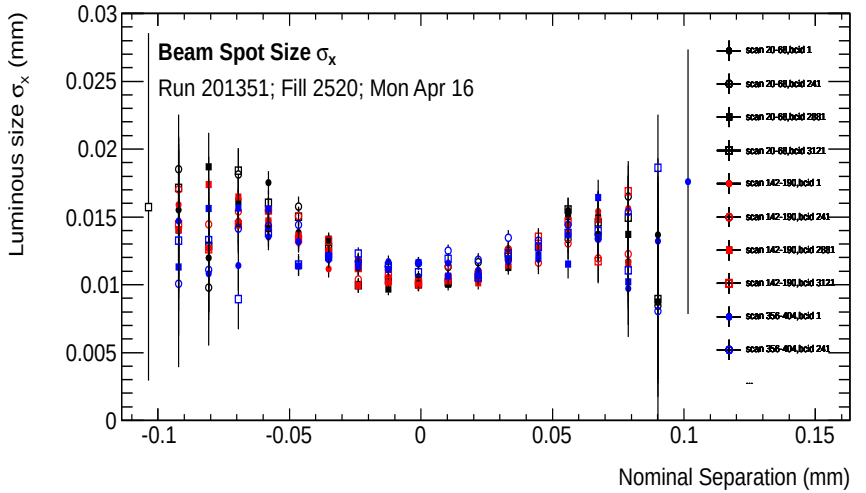


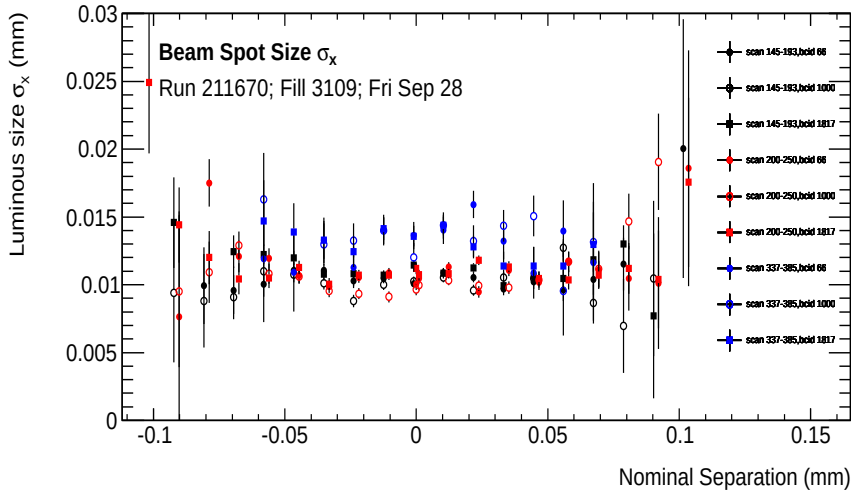
x-scan: x width

- σ_x varies in "double-bump" with scan in April; less in Sept
  - Offset shifted $\rightarrow$ again beam size in x depends on y $\rightarrow$ non-factorisation



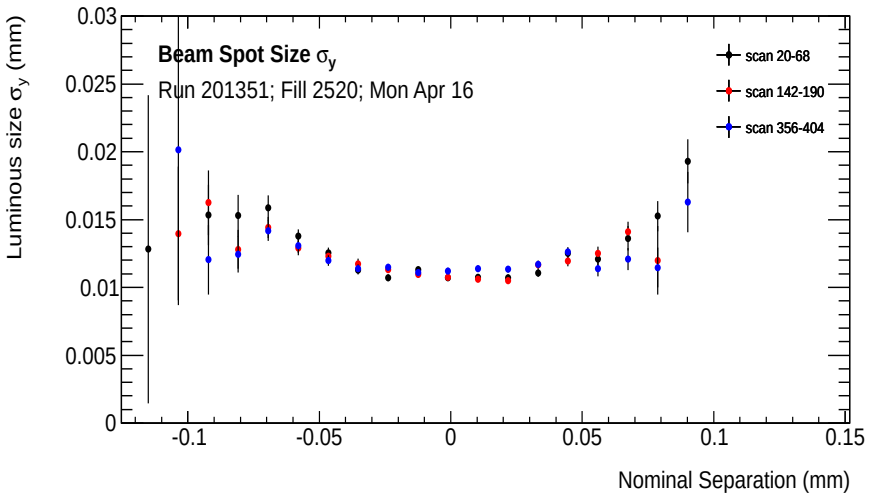


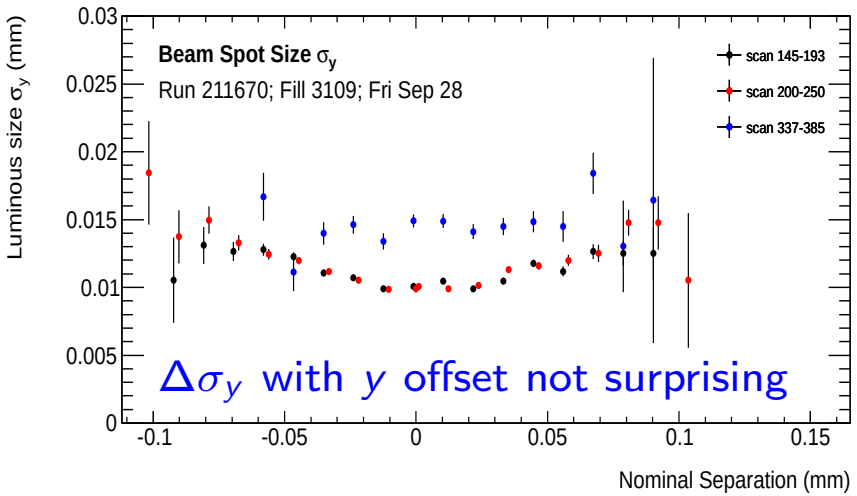


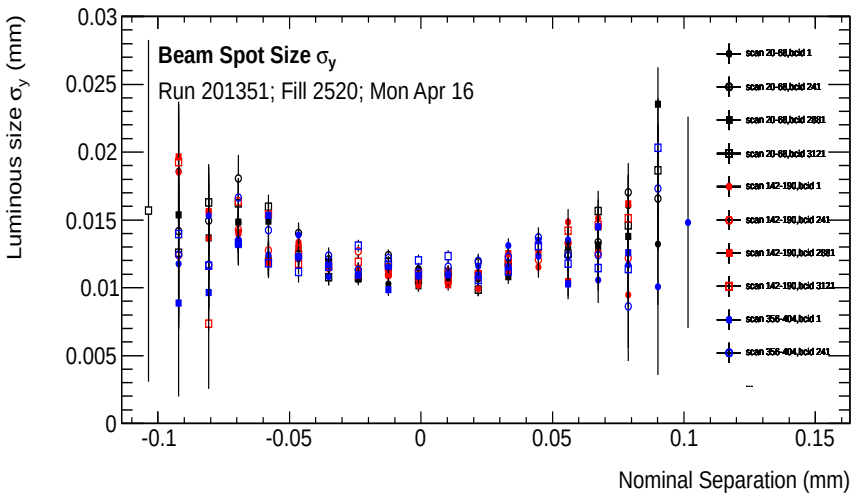


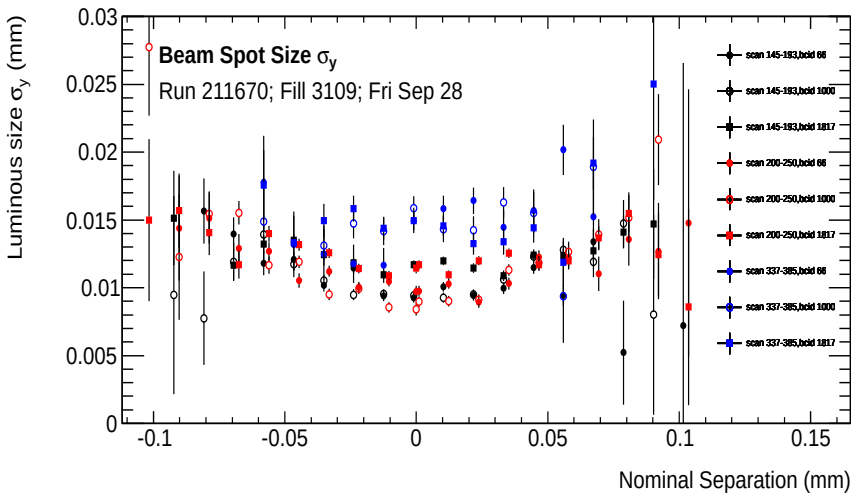
x-scan: y width

- σ_y varies by $\approx 40\%$ in nominal (not offset) scans $\rightarrow$ non-factorisation
  - Sept: some variation over BCIDs



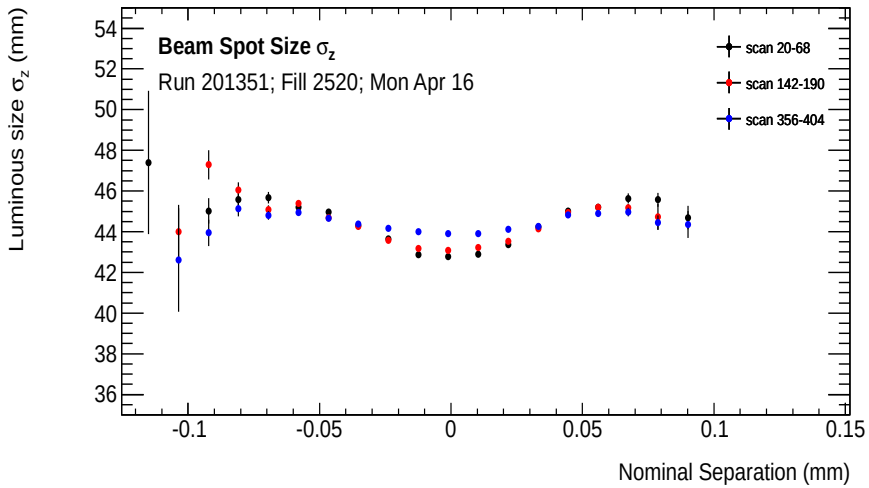


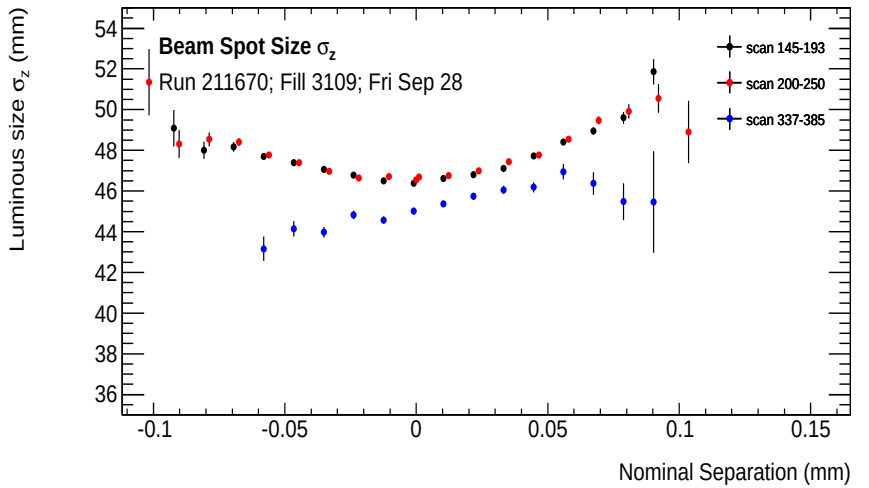


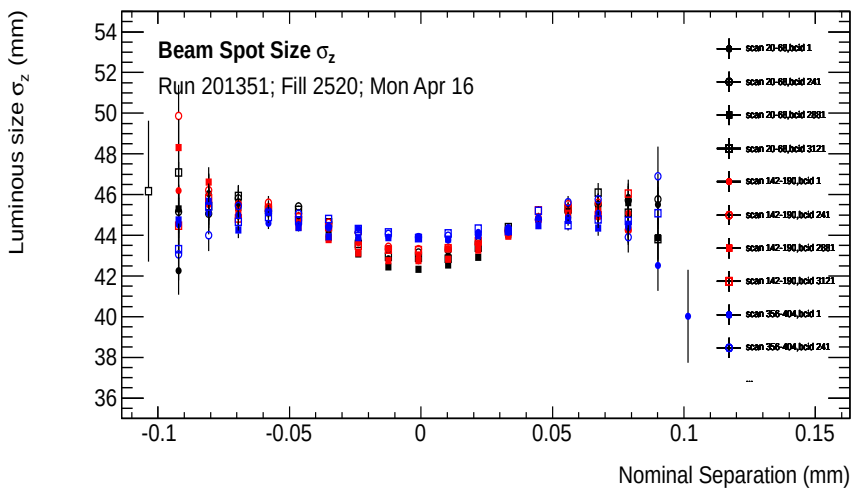


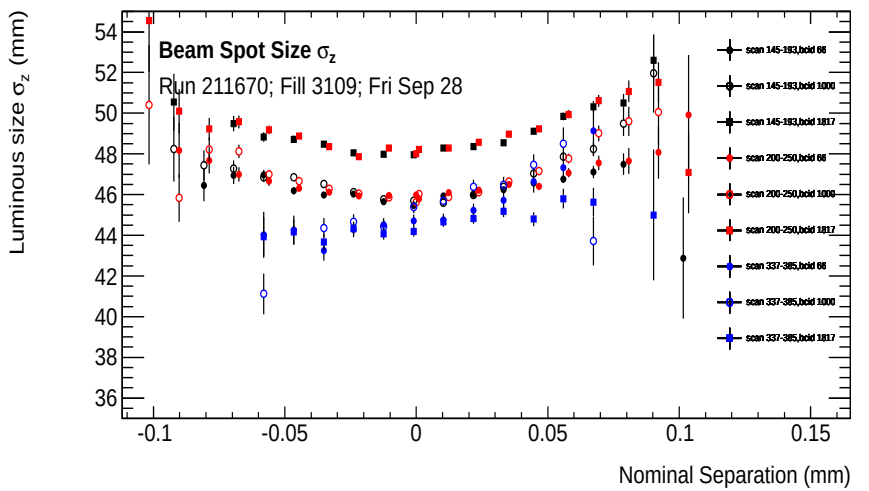
x-scan: z width

- σ_z also varies but no down-turn in Sept; offset trend very different!
  - Sept: last BCID again different



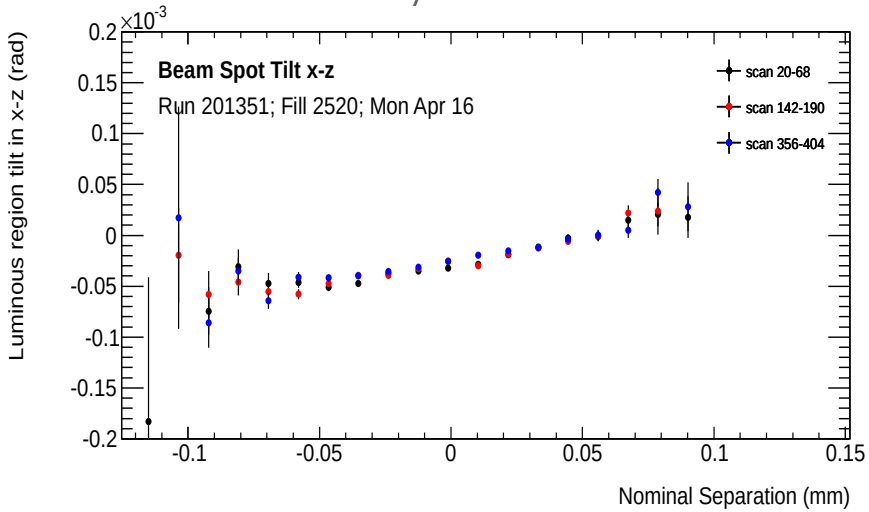


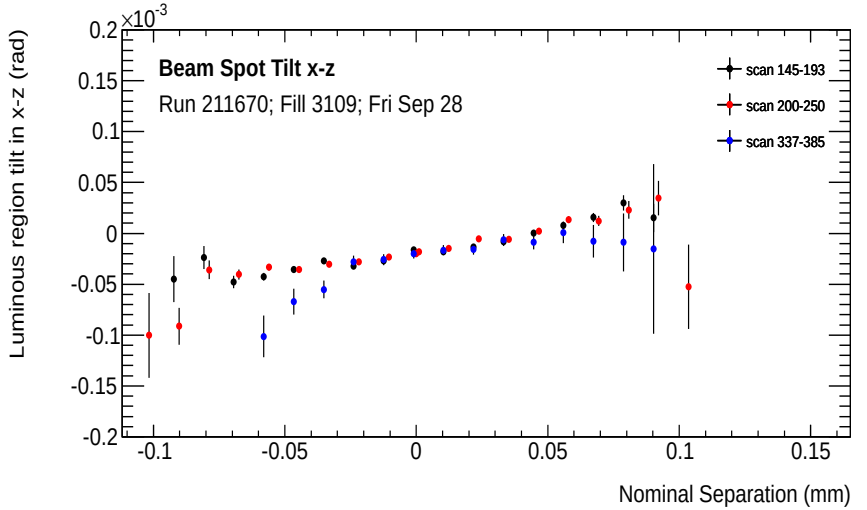


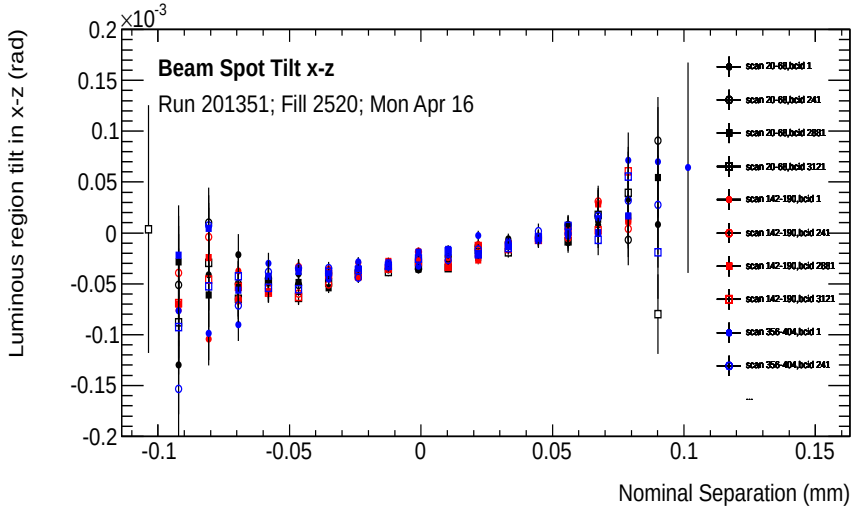


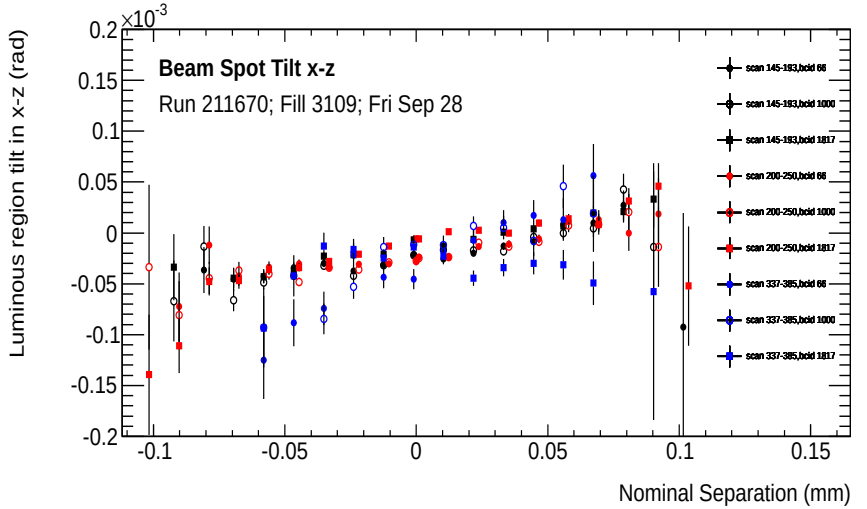
x-scan: x tilt

- Some linear variation of luminous region tilt in $x - z$ (scan direction)
  - Not sure why



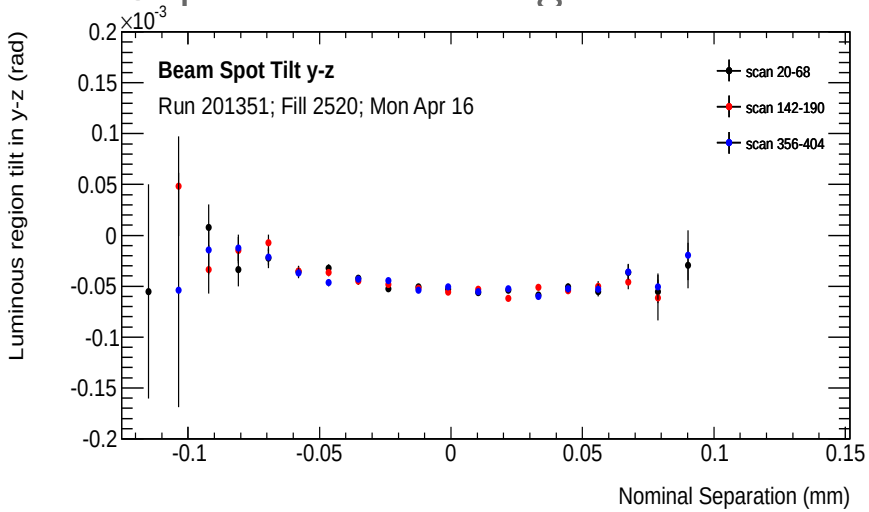


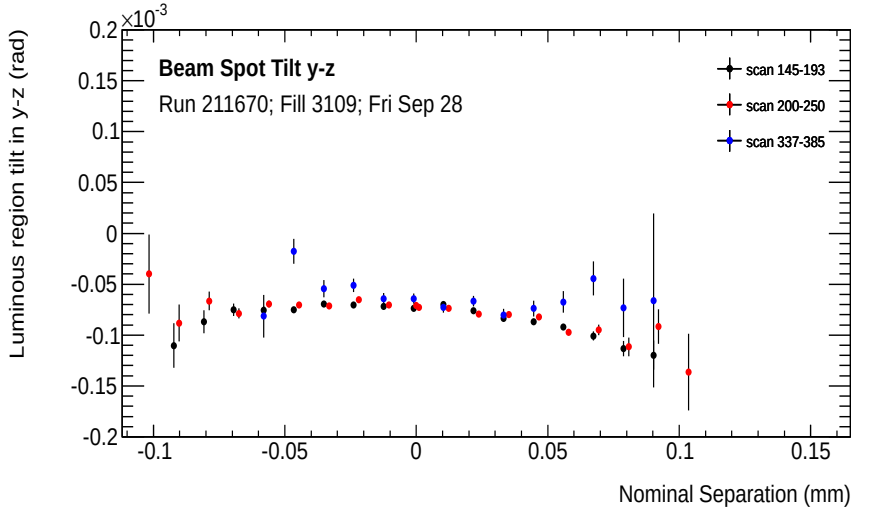


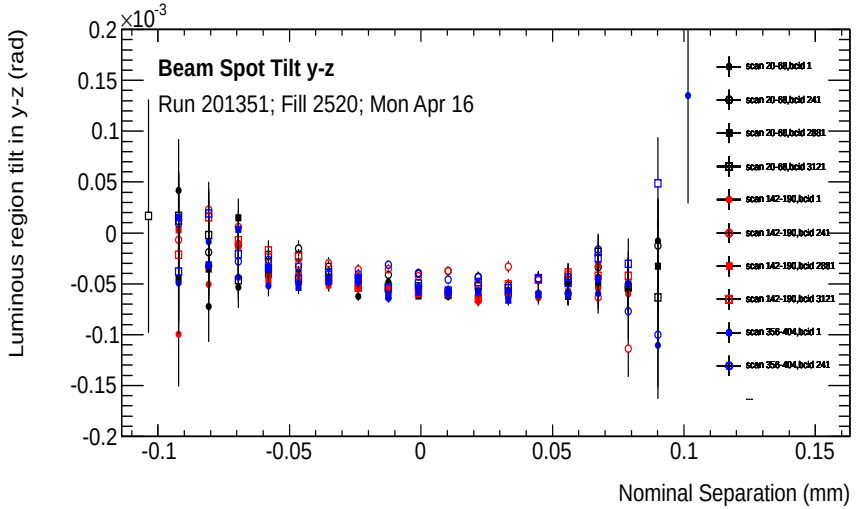


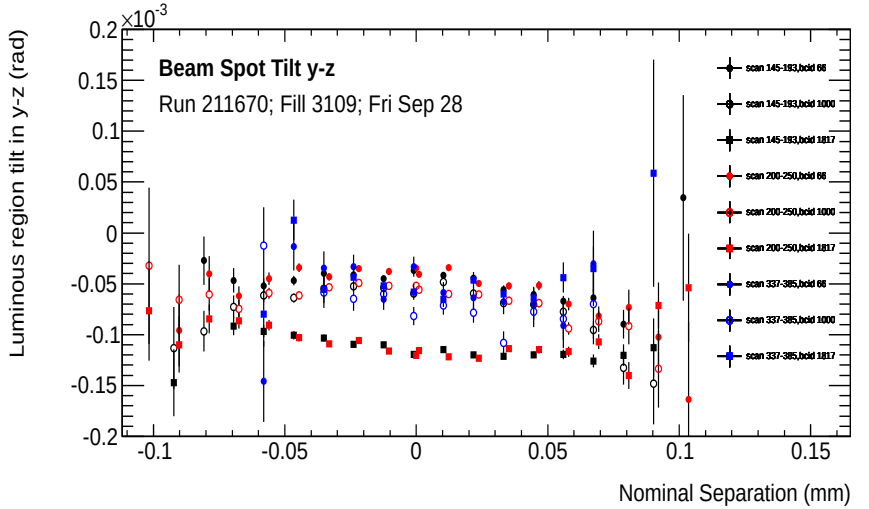
x-scan: y tilt

- Little variation of tilt in $y - z$ in April; some variation in Sept
  - Sept: last BCID again different



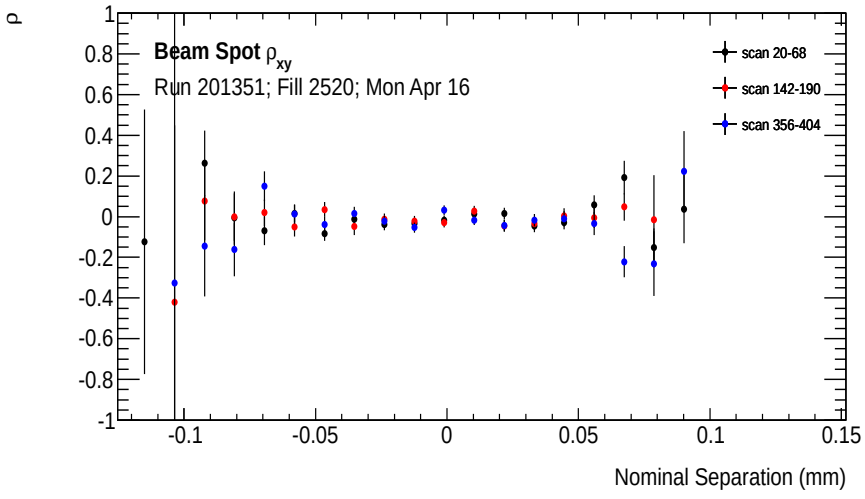


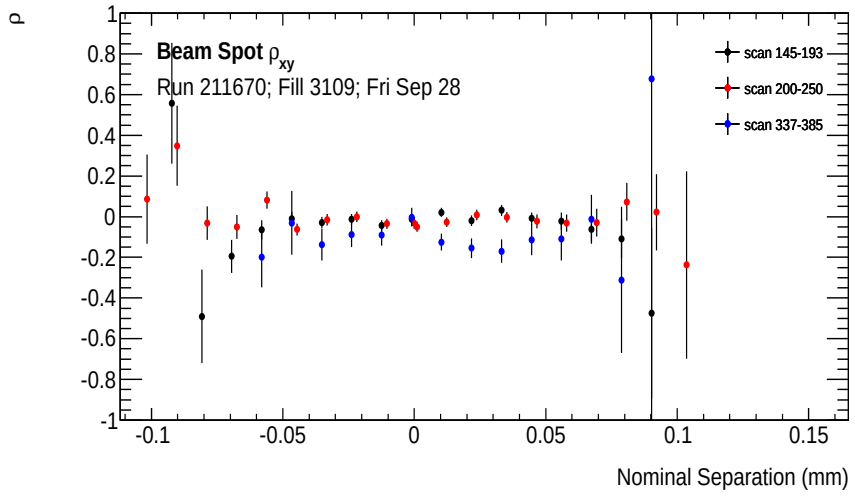


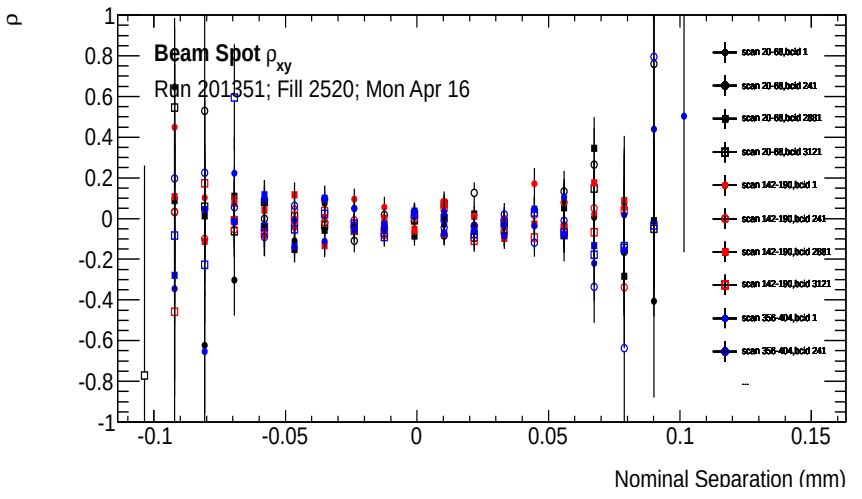


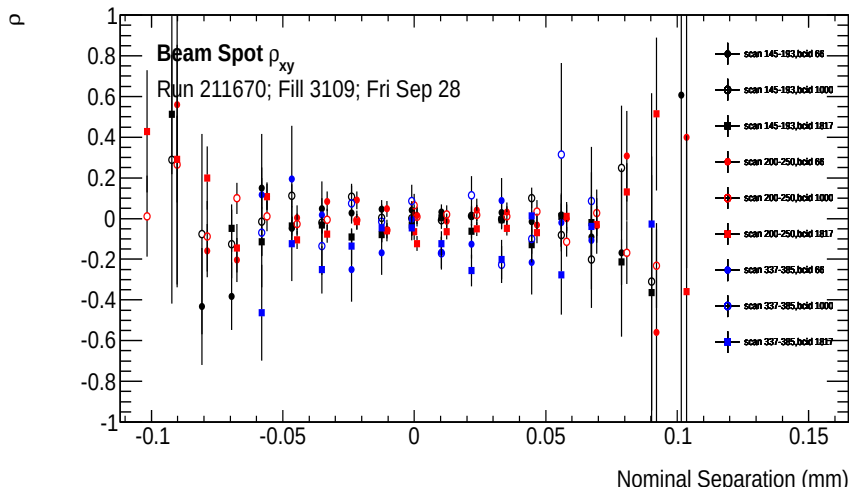
x-scan: ρ_{xy}

- No variation in ρ_{xy}
  - ρ_{xy} = rotation of non-circular beam in transverse plane





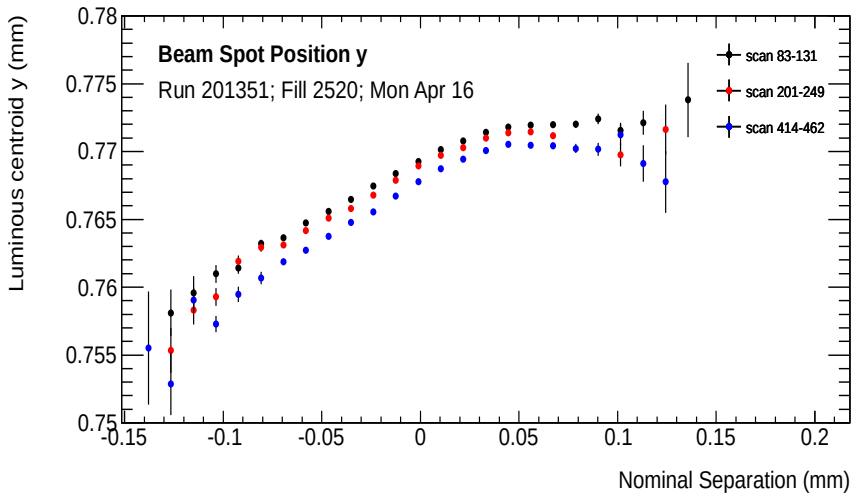


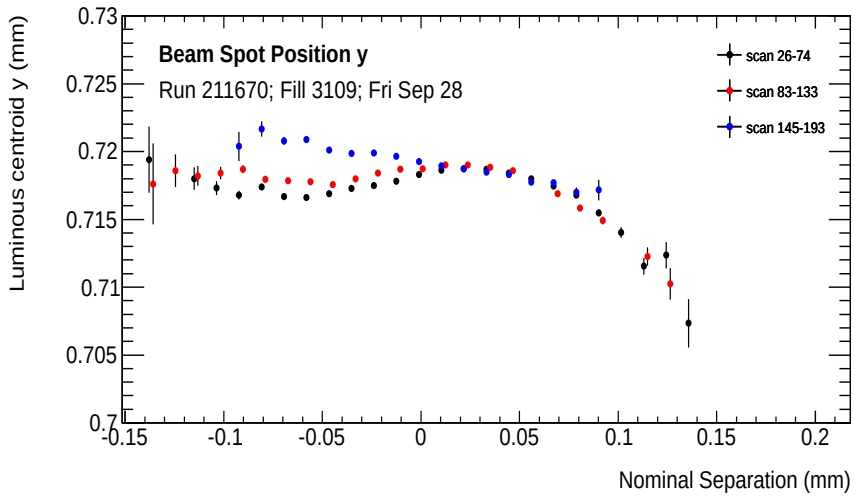


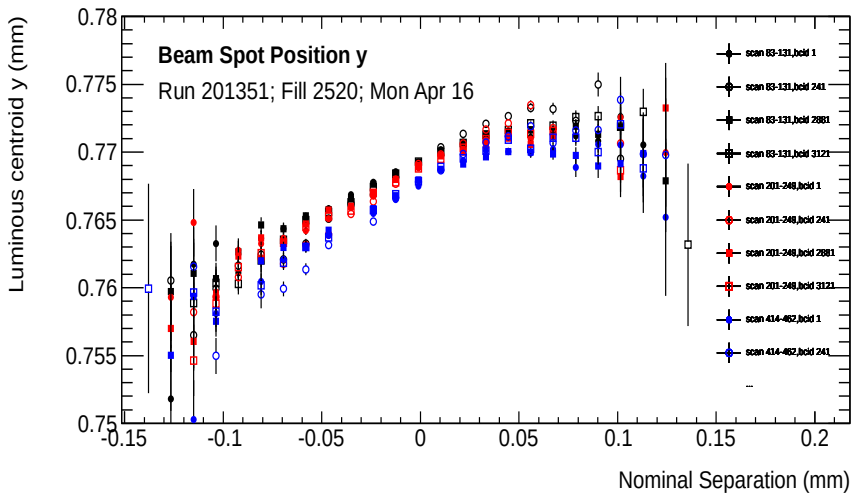
y-scan

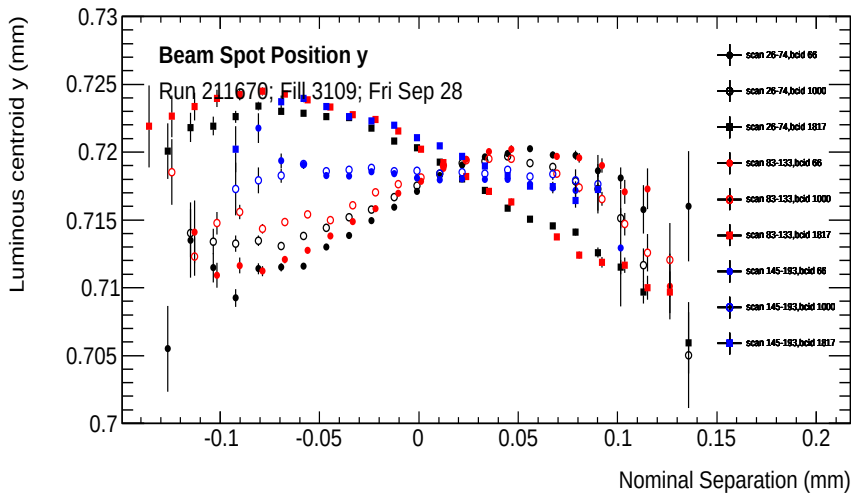
y-scan: y position

- y follows scan $\rightarrow$ diff beam size; asymmetric about rest position
  - Sept: Last BCID has opposite direction; less movement in offset scan



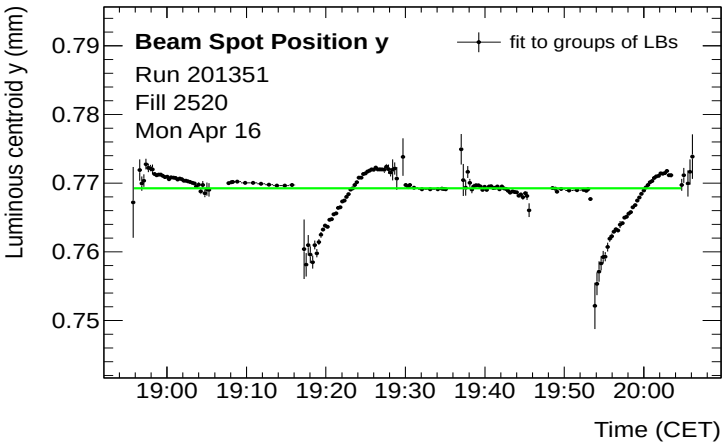


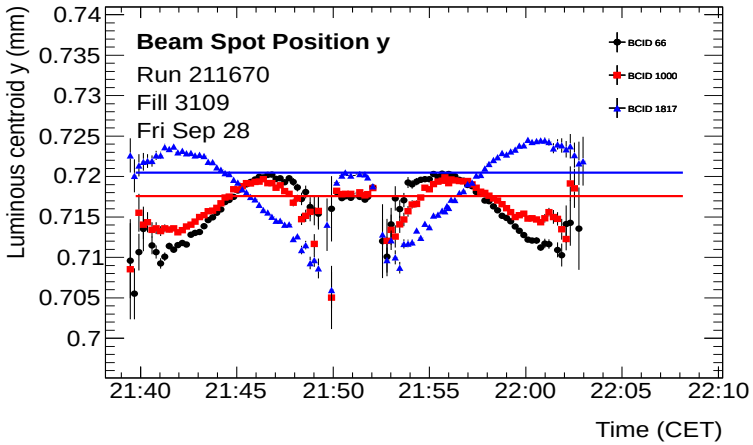




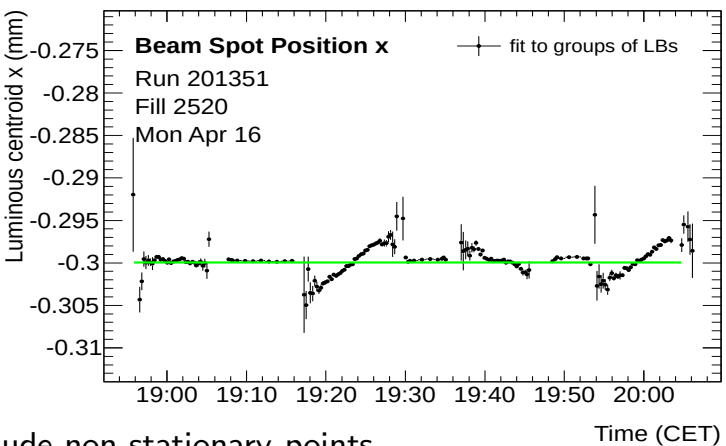
Asymmetric Movement

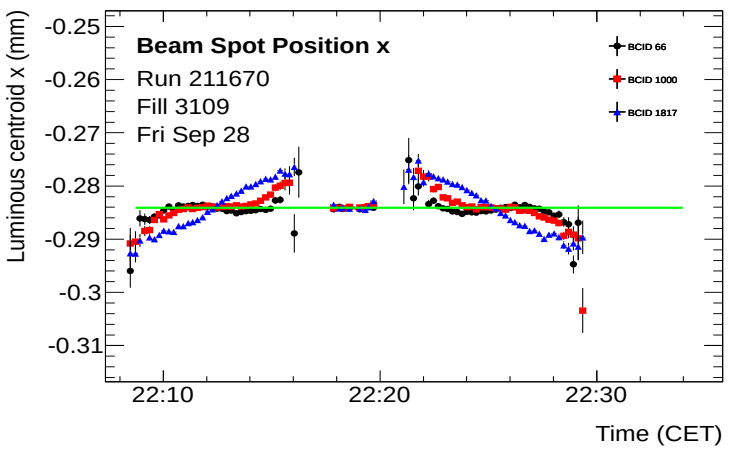
- During y scan, movement of beamspot in y seems to be asymmetric about rest position





- x movement more symmetric

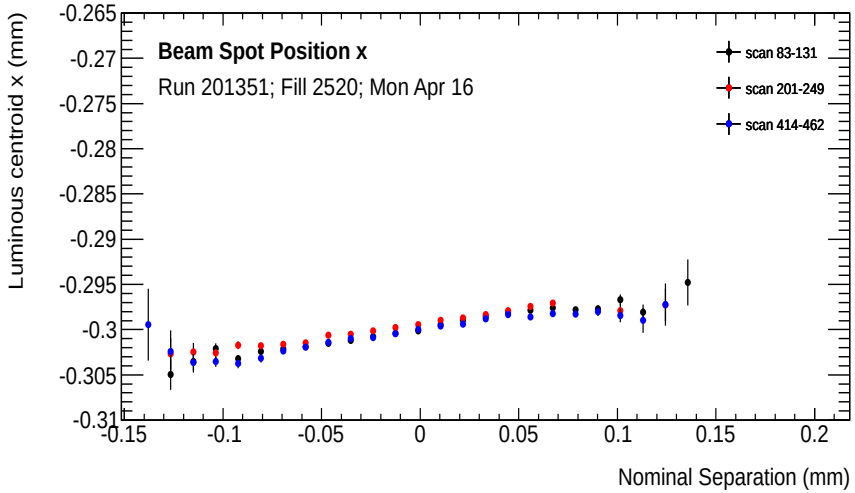


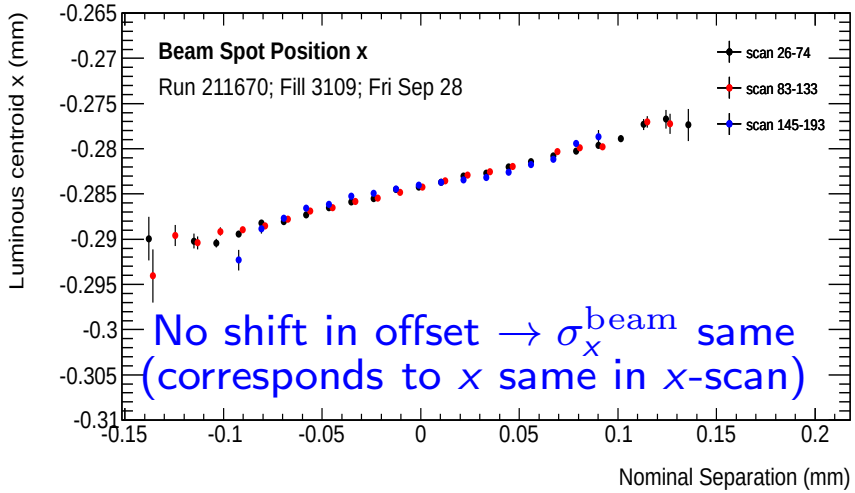


† plots include non-stationary points

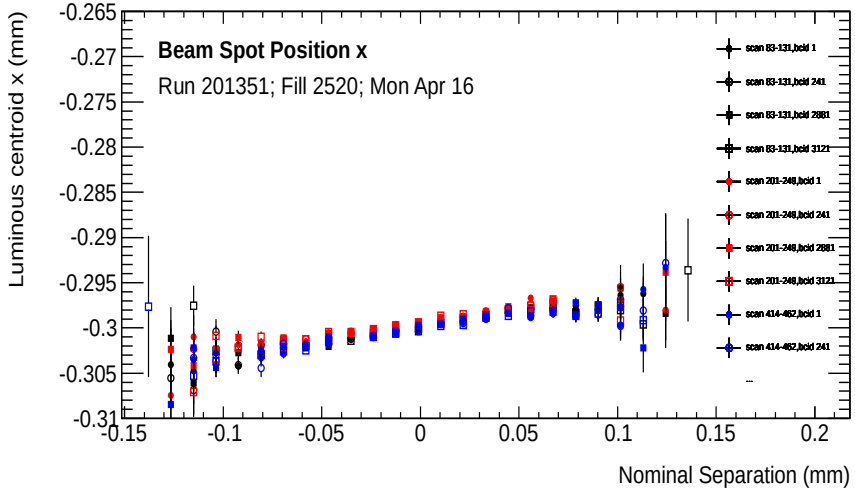
y-scan: x position

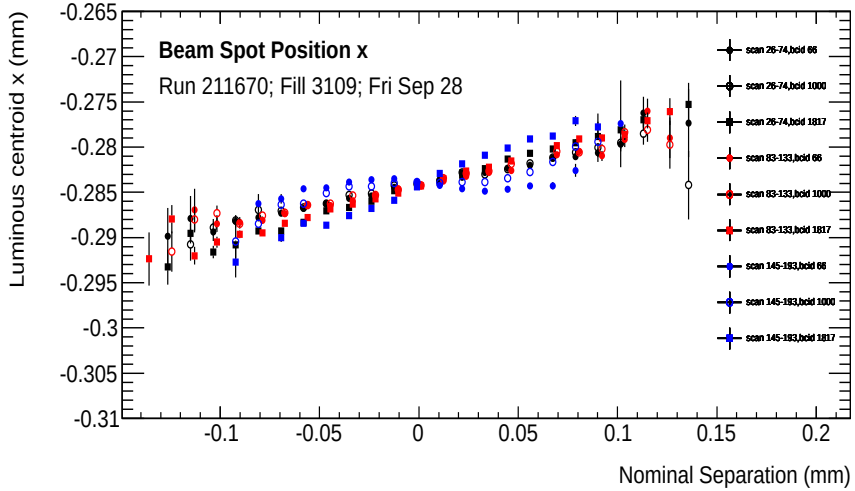
- Movement in x, which is larger in Sept
  - Some expected due to x-angle + $x - z$ tilt





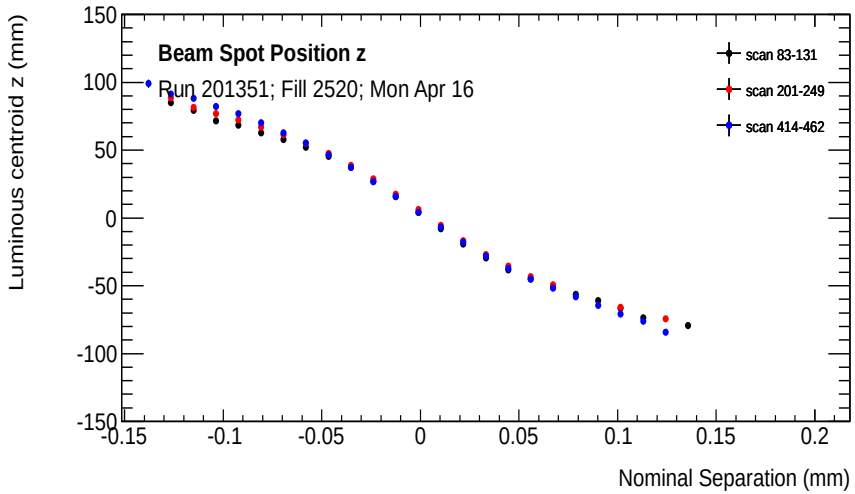
No shift in offset $\rightarrow \sigma_x^{\text{beam}}$ same
(corresponds to x same in x-scan)

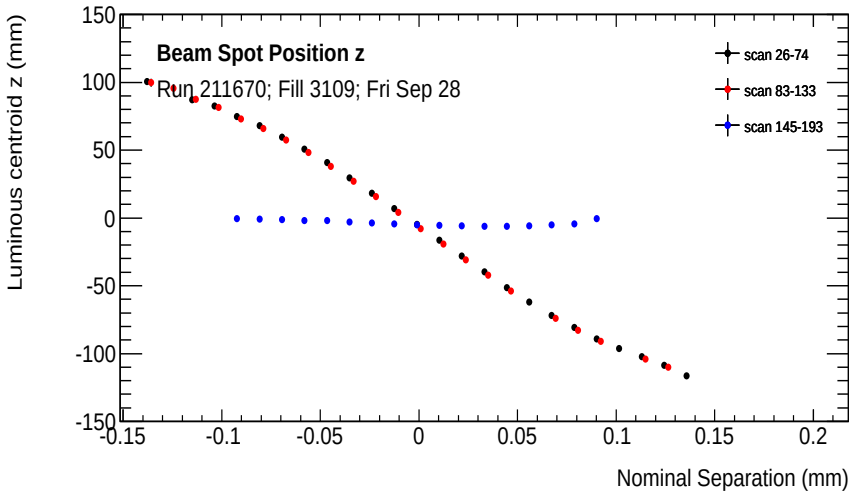


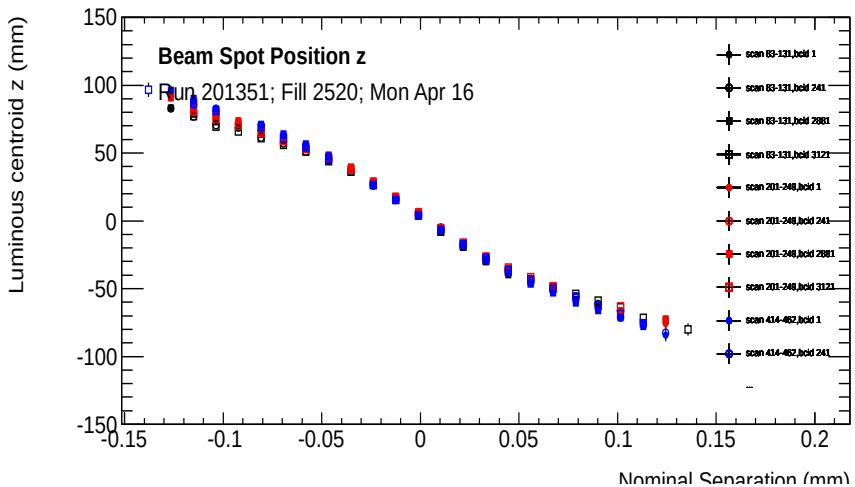


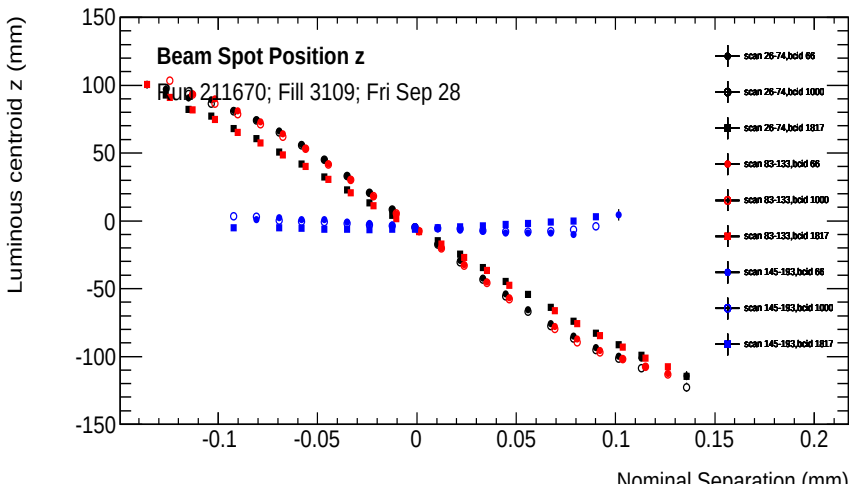
y-scan: z position

- z varies with scan due to crossing angle; not in offset
  - No change in offset suggests huge tail in σ_y^{beam} (so doesn't see x-angle)?









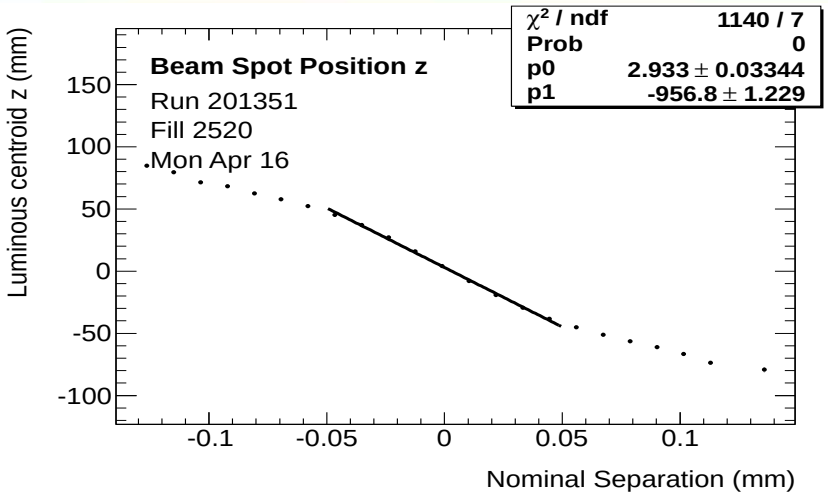
y-scan: crossing angle (April)

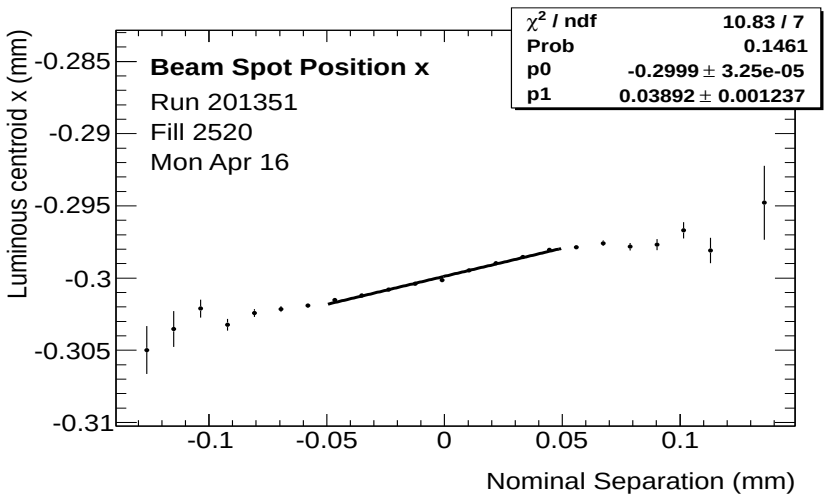
- Can predict variation in z with y given $\alpha = 145$ μrad:

$$\frac{dz}{d(\Delta_y)} = \frac{-\sin 2\alpha}{4} \frac{\sigma_z^2 - \sigma_y^2}{\sigma_y^2 \cos^2\alpha + \sigma_z^2 \sin^2\alpha}$$

  - Assuming circular beams:
    $\sigma_y \approx \sigma_x \approx \Sigma_x/\sqrt{2} \approx 18.4$ μm
  - BQM length: $\sigma_z = 300 * 1.2/4$ mm

- Prediction of ≈ -1150 somewhat larger than measured value
- Variation in z will translate into movement in x due to non-zero tilt between LHC and ATLAS frames
  - From beamspot fit, xz tilt ≈ 30 μrad
- $dx/d(\Delta_y) = \text{tilt}_{xz} \times dz/d(\Delta_y) \approx 0.03$ (c.f 0.04)





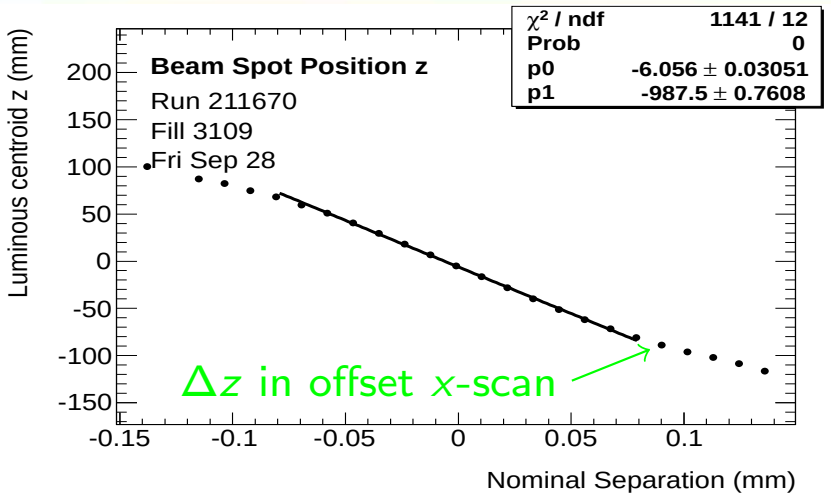
y-scan: crossing angle (Sept)

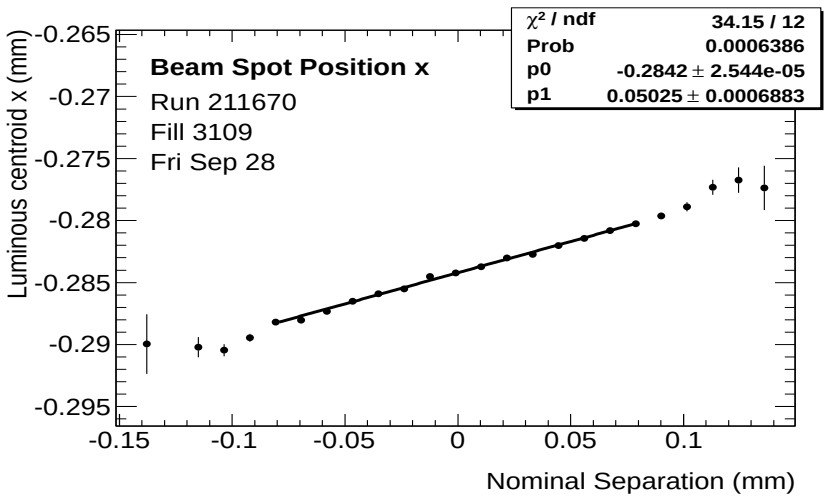
- Can predict variation in z with y given $\alpha = 145$ μrad:

$$\frac{dz}{d(\Delta_y)} = \frac{-\sin 2\alpha}{4} \frac{\sigma_z^2 - \sigma_y^2}{\sigma_y^2 \cos^2\alpha + \sigma_z^2 \sin^2\alpha}$$

  - Assuming circular beams:
    $\sigma_y \approx \sigma_x \approx \Sigma_x/\sqrt{2} \approx 18.4$ μm
  - BQM length: $\sigma_z = 300 * 1.2/4$ mm

- Prediction of ≈ -1150 somewhat larger than measured value
- Variation in z will translate into movement in x due to non-zero tilt between LHC and ATLAS frames
  - From beamspot fit, xz tilt ≈ 20 μrad

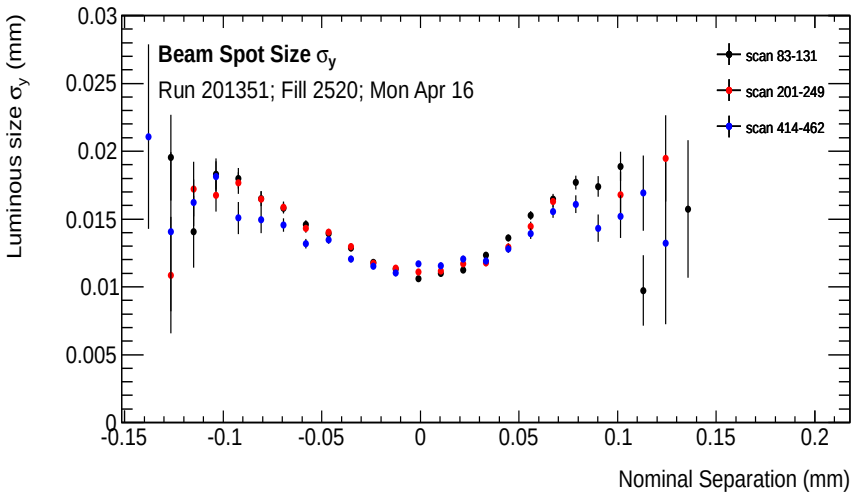


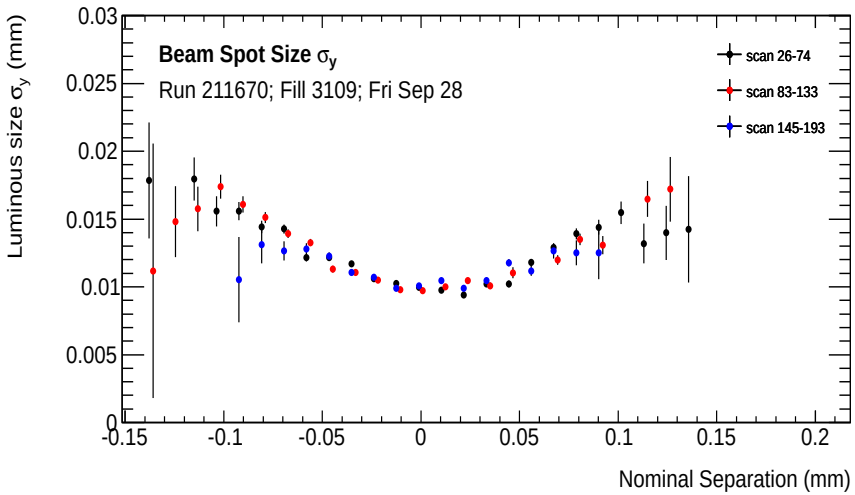


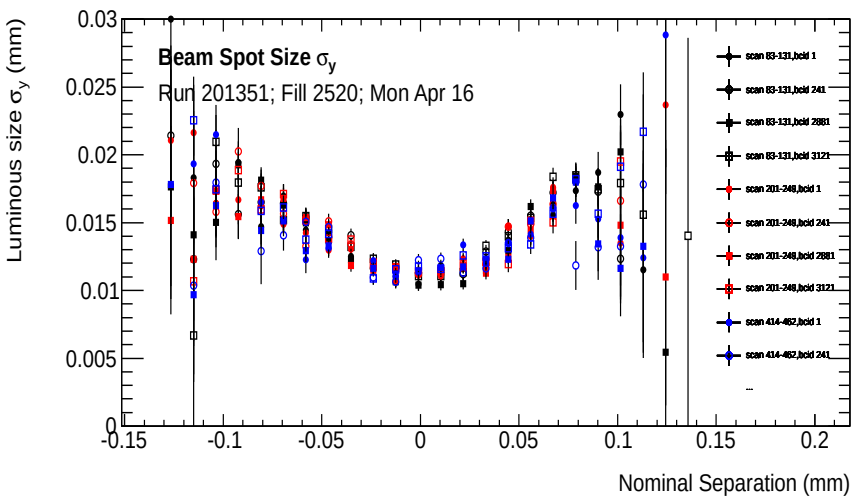
- $dx/d(\Delta_y) = \mathrm{tilt_{xz}} \times dz/d(\Delta_y) \approx 0.02$ (c.f 0.05 $\rightarrow$ maybe a bit high?)

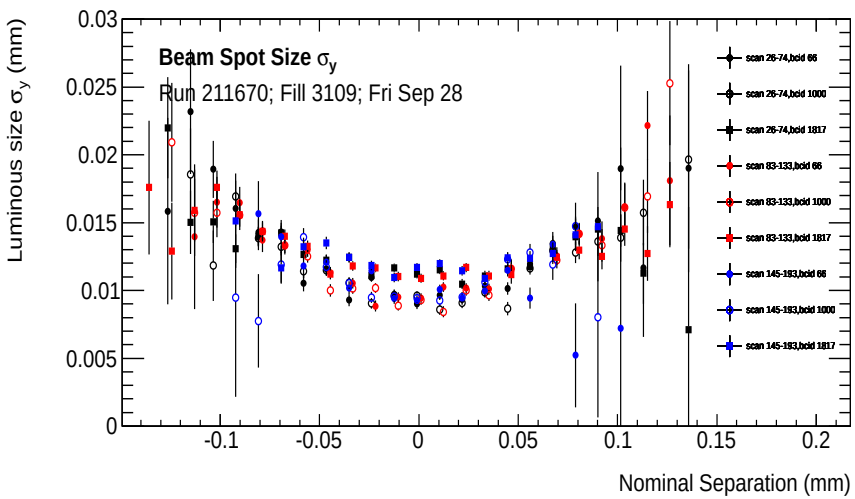
y-scan: y width

- σ_y varies with scan (as for σ_x in x scans)



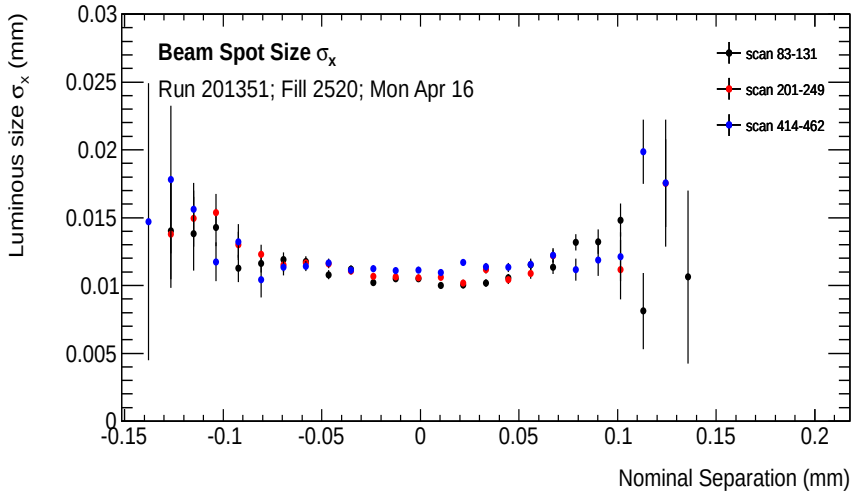


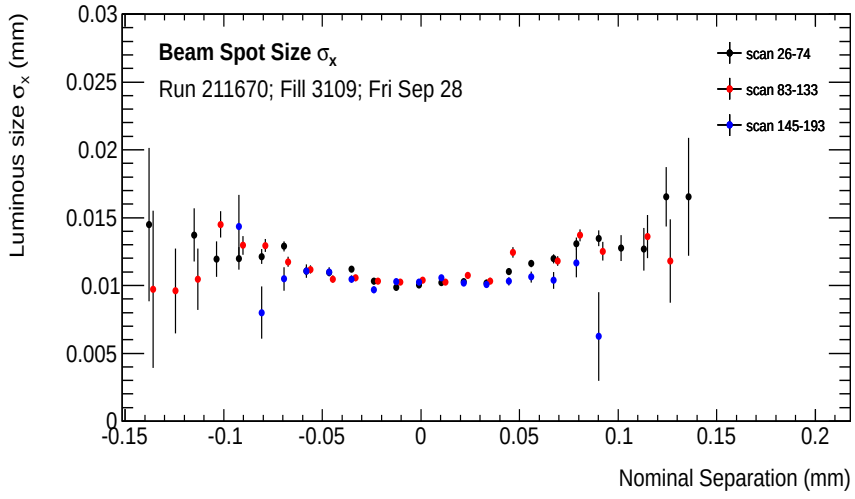


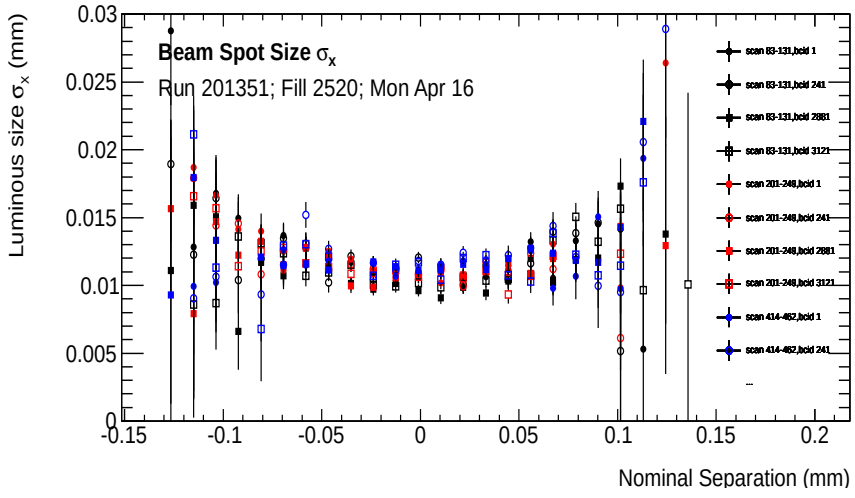


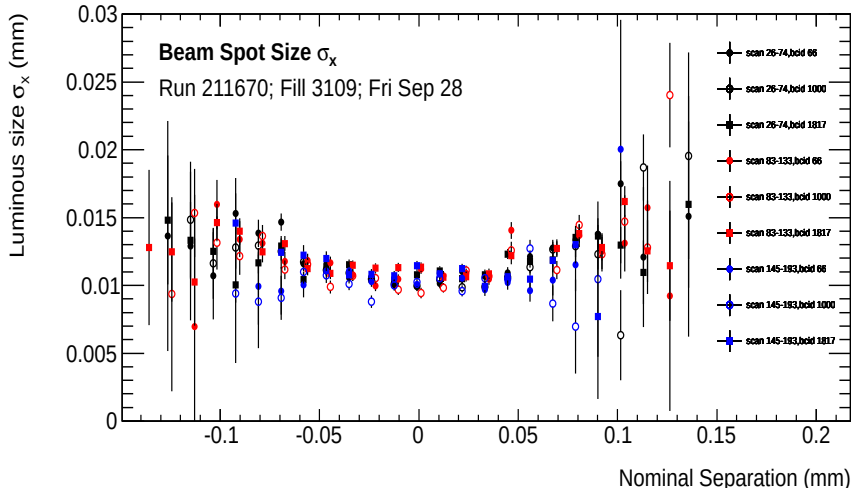
y-scan: x width

- σ_x varies by $\approx 20\%$ ($< \Delta\sigma_y$ in x scans) $\rightarrow$ non-factorisation
  - No shift for offset unlike x-scan (since σ_x flatter versus nominal x)



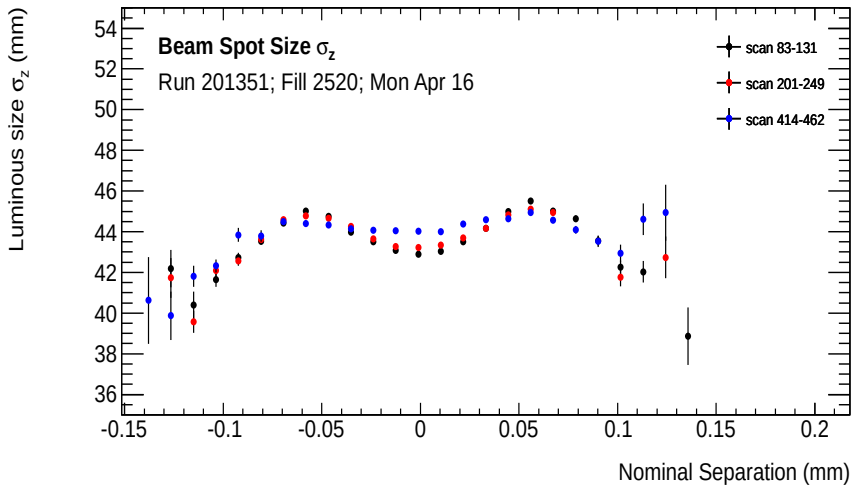


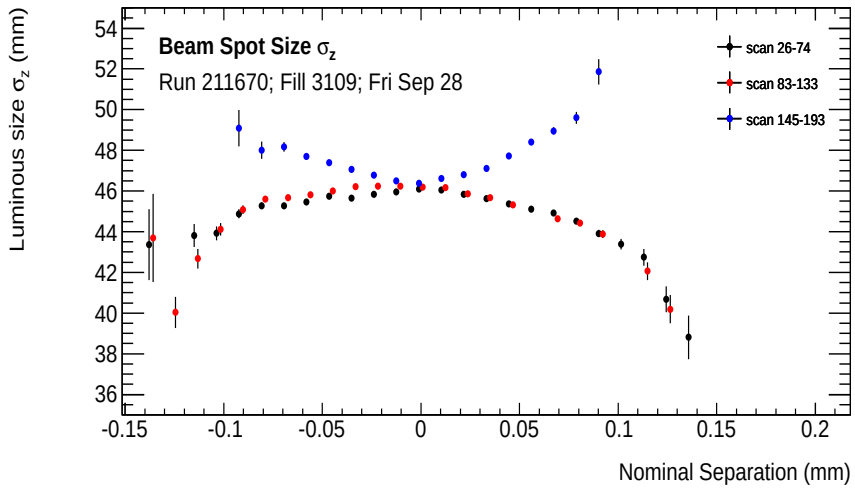


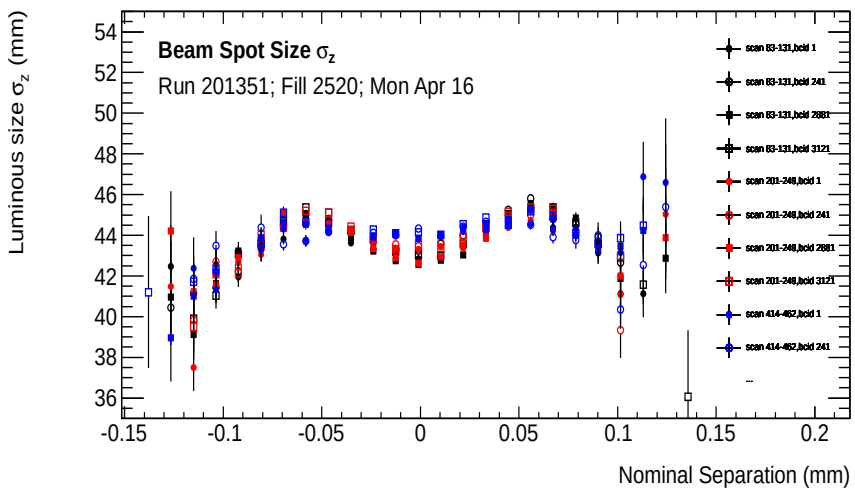


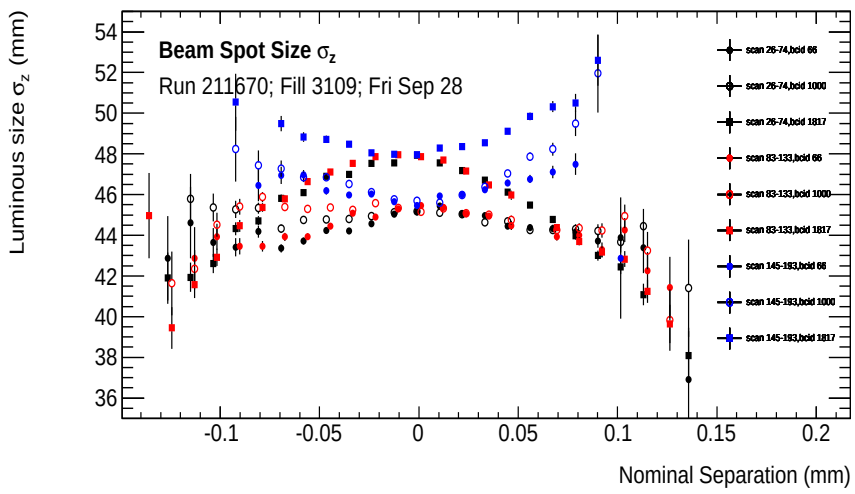
y-scan: z width

- σ_z varies but "double-bump" only in April
  - Sept: Last BCID again different; offset scan has opposite variation!



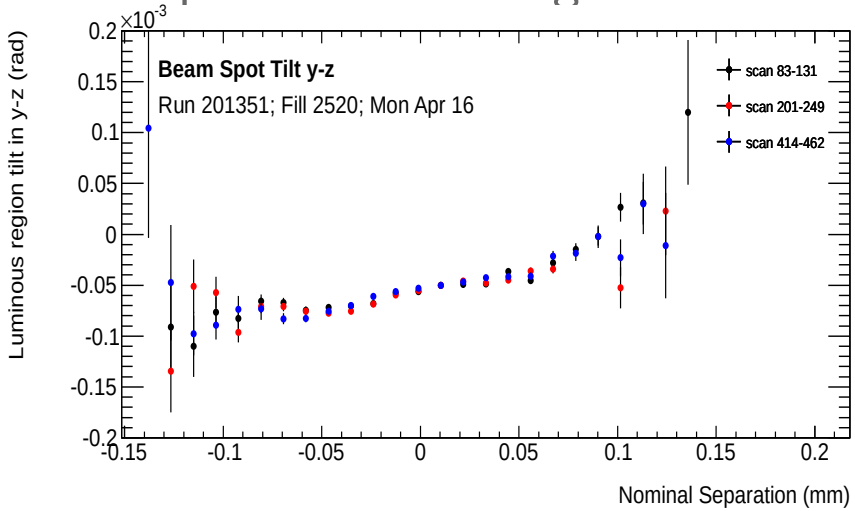


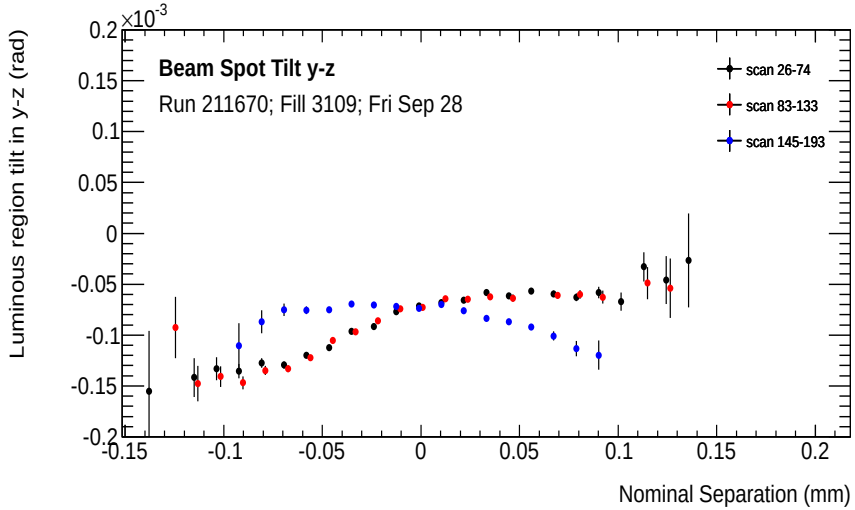


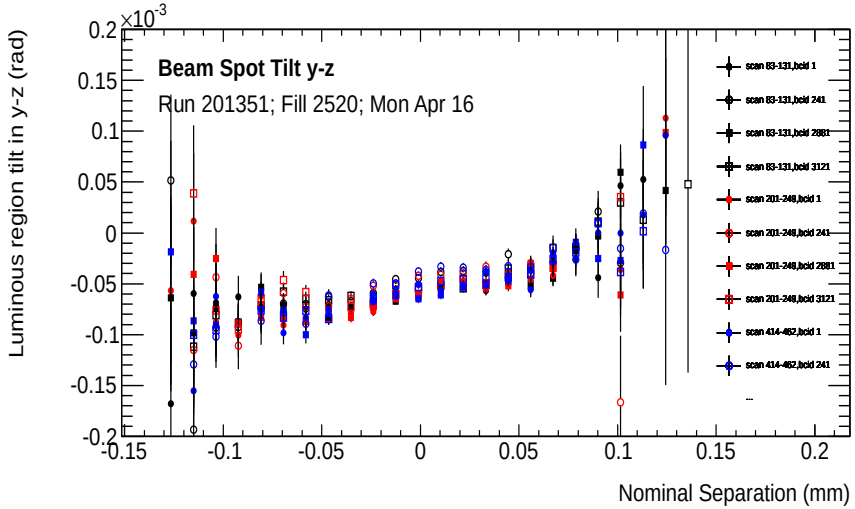


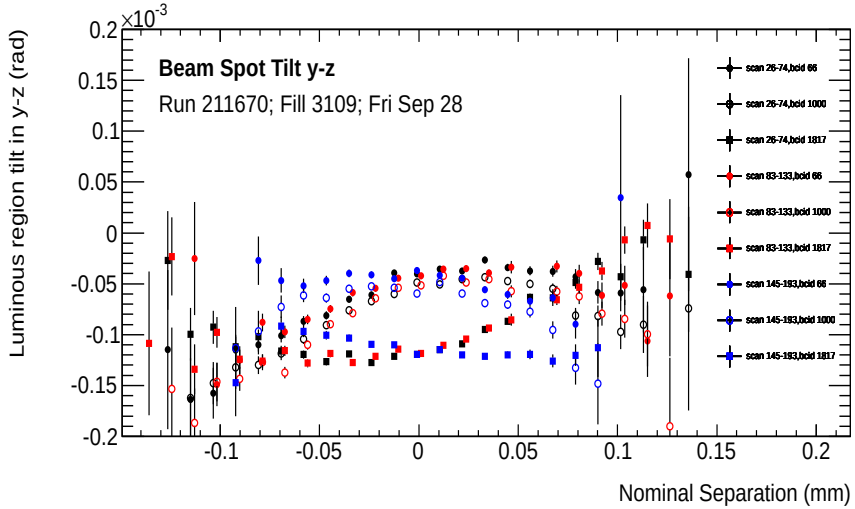
y-scan: y tilt

- Some variation in $y - z$ tilt (scan dir); non-linear in Sept
  - Sept: Last BCID again different; offset scan different!



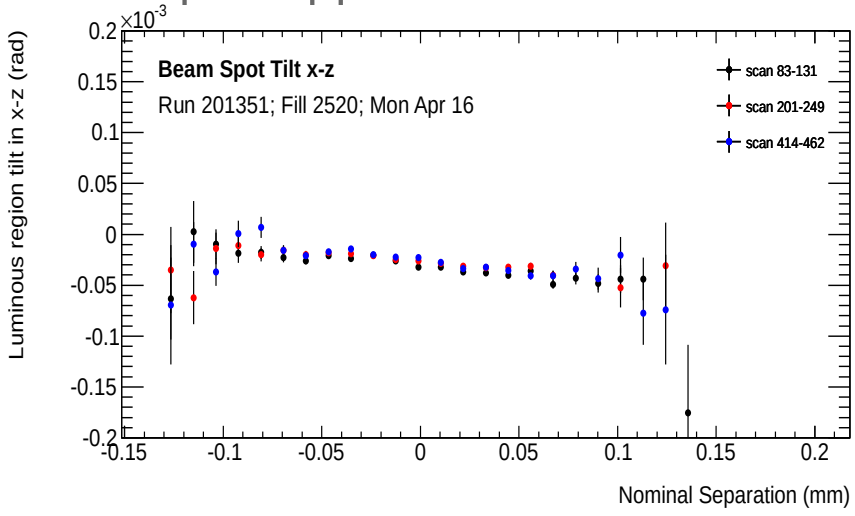


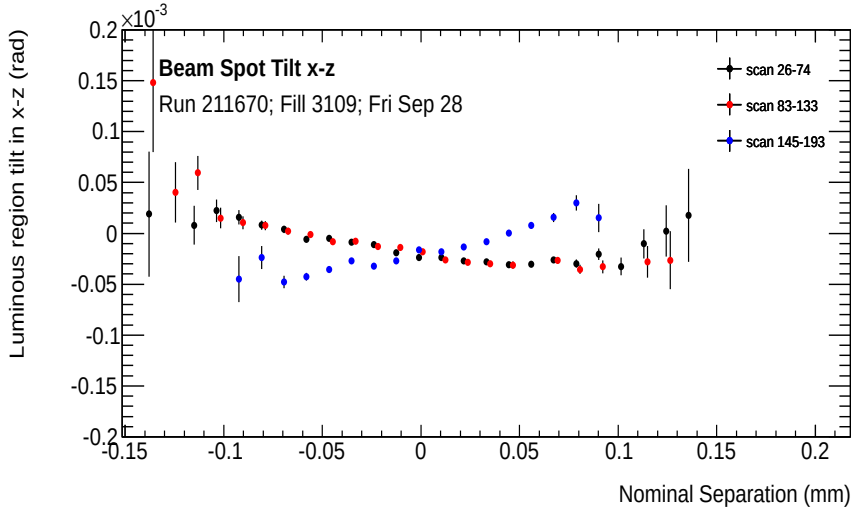


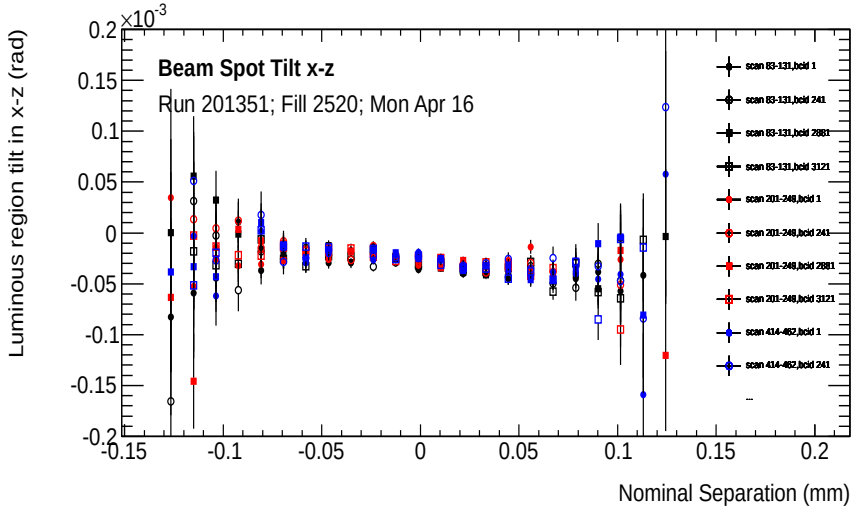


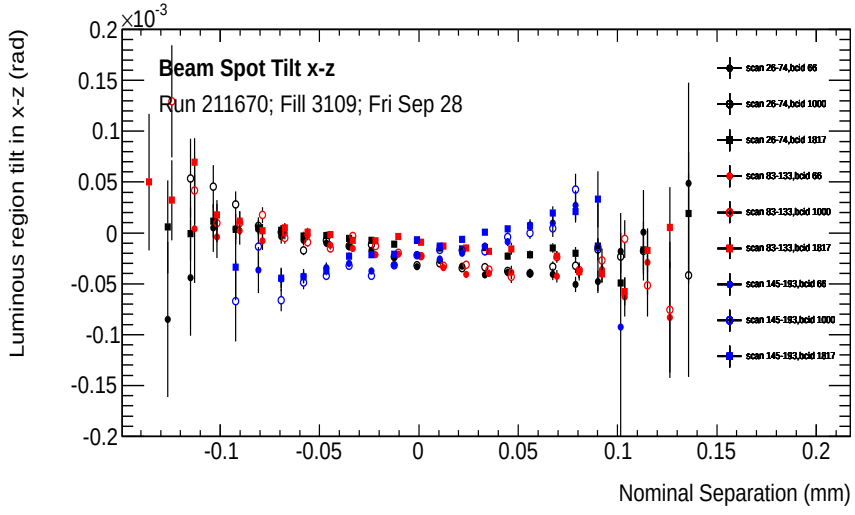
y-scan: x tilt

- Little variation of tilt in $y - z$ in April; some variation in Sept
  - Sept: Opposite direction for offset scan!



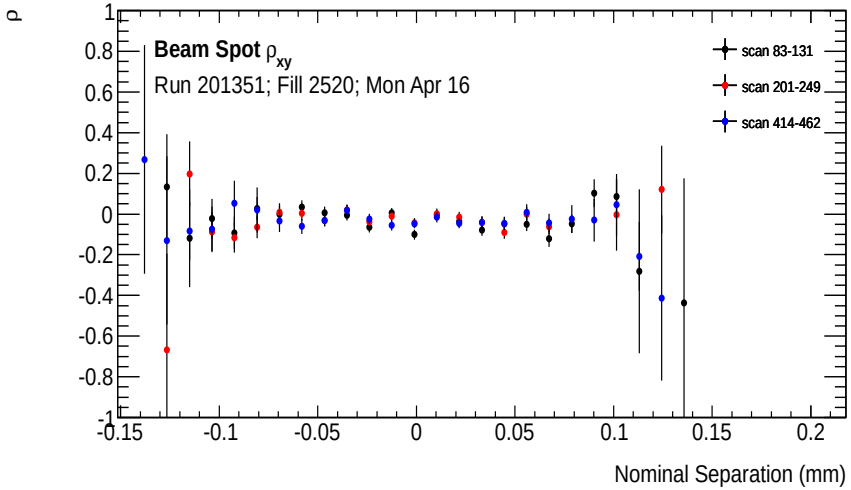


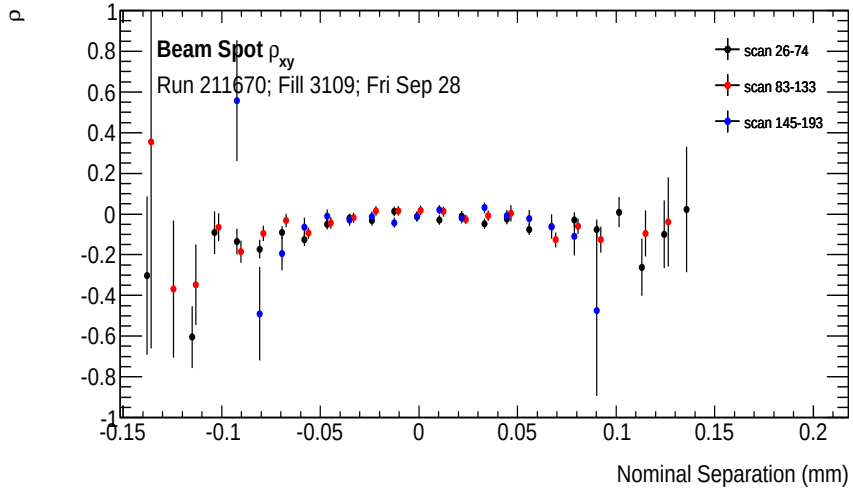


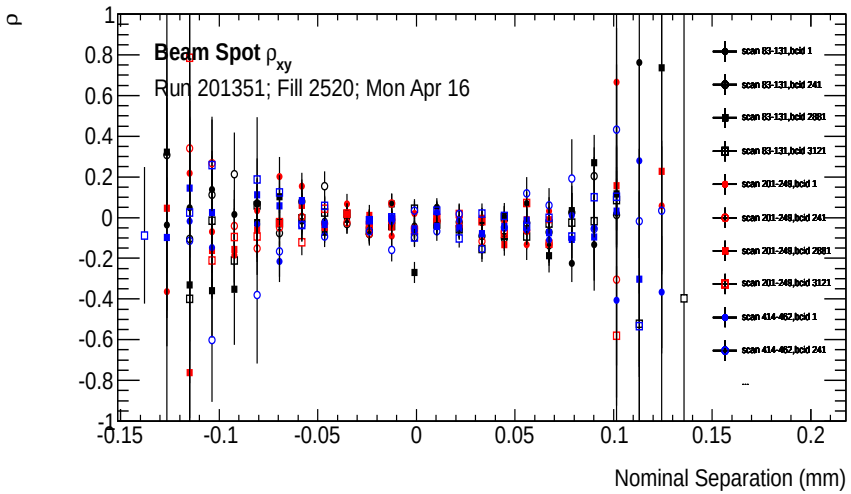


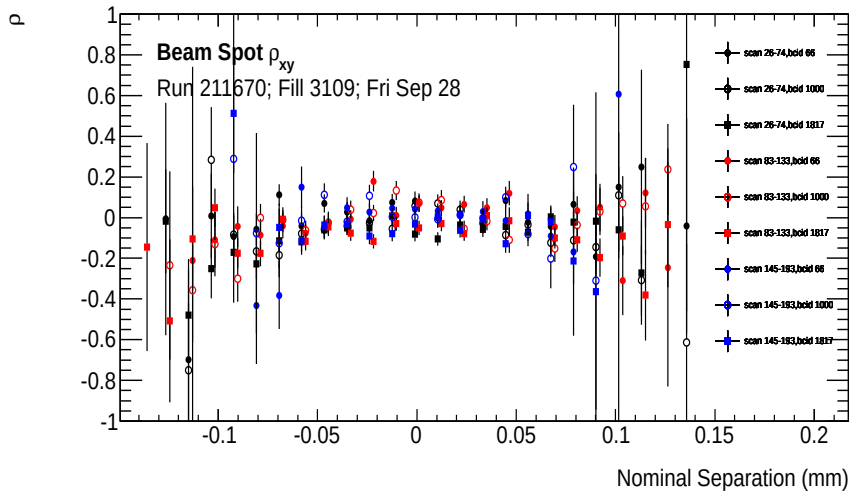
y-scan: ρ_{xy}

- Again, no variation in ρ_{xy}









Links

- April beamspot ntuples:
  - BCID-blind
    https://atlas-beamspot.cern.ch/jobfiles/data12_8TeV.00201351.calibration_VdM/VdM_split_1pLB/data12_8TeV.00201351.calibration_VdM-VdM_split_1pLB.BeamSpotNt-nt.root
  - per-BCID
    https://atlas-beamspot.cern.ch/jobfiles/data12_8TeV.00201351.calibration_VdM/VdM_1pLB_perBCID/data12_8TeV.00201351.calibration_VdM-VdM_1pLB_perBCID.BeamSpotNt-nt.root
- **Preliminary** September beamspot ntuples:
  - BCID-blind
    https://atlas-beamspot.cern.ch/jobfiles/data12_8TeV.00211670.calibration_VdM/VdM_split_1pLB_8nd/analysis/data12_8TeV.00211670.calibration_VdM-VdM_split_1pLB_8nd.BeamSpotNt-nt.root
  - per-BCID
    https://atlas-beamspot.cern.ch/jobfiles/data12_8TeV.00211670.calibration_VdM/VdM_split_1pLB_perBCID_1nw/analysis/data12_8TeV.00211670.calibration_VdM-VdM_split_1pLB_perBCID_1nw.BeamSpotNt-nt.root

Summary

- Initial beamspot results for September VdM scan and comparison to effect seen in Arpil scan
  - Both globally and per-BCID
- Non-factoriation at $\approx$ same level as April
  - σ_y varies with x and likewise σ_x with y
  - Beamspot position in scan direction shifts for offset scan (at least for x-scan)
- Some variation in BCIDs, particularly for last BCID
  - Attribute to difference in parasitic interactions (trains)
- Some very strange differences between nominal/offset scan