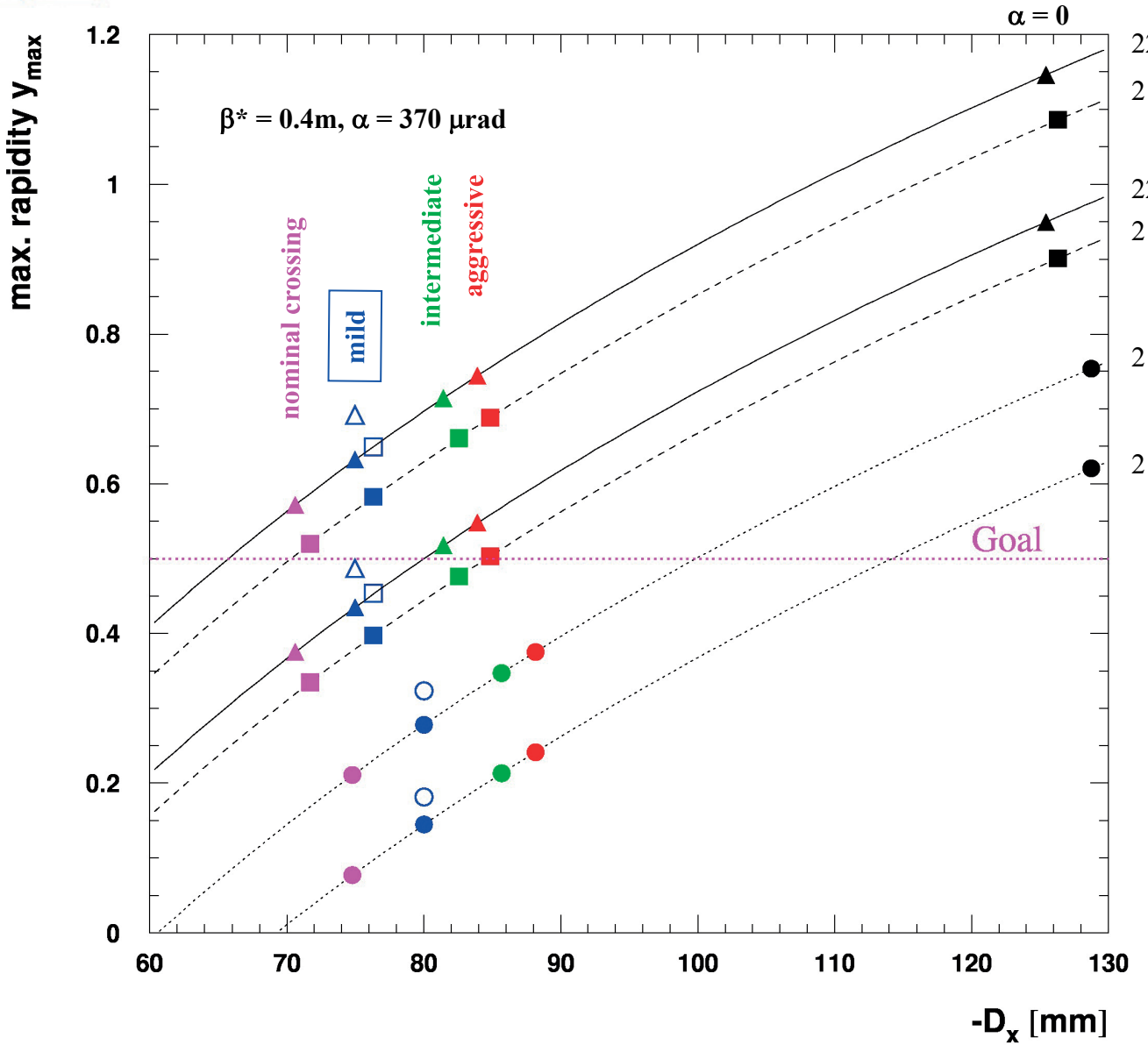
RP insertions 2016

MPP Meeting
3rd June 2016

Mario Deile

Rapidity Reach versus Dispersion



220-C @ 15 σ
210-F @ 15 σ
220-C @ 15 σ + 0.5 mm
210-F @ 15 σ + 0.5 mm
210-N @ 15 σ
210-N @ 15 σ + 0.5 mm

All curves and solid markers: B1, open markers: B2.

2016 Optics: RP Positions and Diffractive Mass Acceptance Limits (New)

Strategy agreed with MPP:

- During intensity ramp-up before TS1: 15 σ + 0.5 mm; end-of-fill tests of removing 0.5 mm margin
- After TS1 (if tests successful): 15 σ

$\sqrt{s}$ = 13 TeV, β^* = 0.4 m, α_X = 370 μrad, ε_n = 3.5 μm rad, mild orbit bump

Sector 5-6 (Beam 1):

		Roman Pot position:	Detector position:			
Horiz. RP	$\sigma_{x,beam}$	15 σ + **orbit margin** (0.5 mm)	... + window + gap (0.3 or 0.5 mm)	D_x	ξ_{min}	$M_{min} = \sqrt{\xi_1 \xi_2 s}$
210-N	213 μm	3.695 mm = 17.3 σ	3.995 mm = 18.8 σ	–80.0 mm	0.050	650 GeV
210-F	144 μm	2.660 mm = 18.5 σ	2.960 mm = 20.6 σ	–76.3 mm	0.039	507 GeV
220-C	120 μm	2.300 mm = 19.2 σ	2.800 mm = 23.3 σ	–75.0 mm	0.037	485 GeV

Horiz. RP	$\sigma_{x,beam}$	15 σ	... + window + gap (0.3 or 0.5 mm)	D_x	ξ_{min}	$M_{min} = \sqrt{\xi_1 \xi_2 s}$
210-N	213 μm	3.195 mm	3.495 mm = 16.4 σ	–80.0 mm	0.044	572 GeV
210-F	144 μm	2.160 mm	2.460 mm = 17.1 σ	–76.3 mm	0.032	416 GeV
220-C	120 μm	1.800 mm	2.300 mm = 19.2 σ	–75.0 mm	0.031	399 GeV

RP Insertions 2016

Programme for insertions in intensity ramp-up

- Agreed settings:
  15 σ + 0.5 mm until TS1, then removal of 0.5 mm margin if demonstrated to be possible

- Insertion in which fills?
  2nd fill of each intensity step, then – if successful – insertions in all subsequent fills

- Insertion at what time in the fill?
  2 hours after declaration of Stable Beams in validation fill, then immediately in later fills

→ Insertions with up to 1824 bunches successfully completed ($L \leq 6.4 \times 10^{33}$ cm^{-2} s^{-1})

- Tests of removal of the 0.5 mm margin:
  - in addition to orbit stability studies by collim. WG
  - End-of-fill tests before TS1:

√ √ √ √

3 – 12 – 49 – 313 – 601 – 889 – 1177 – 1752 – 2300 – 2800

2244 (max. in 2015)

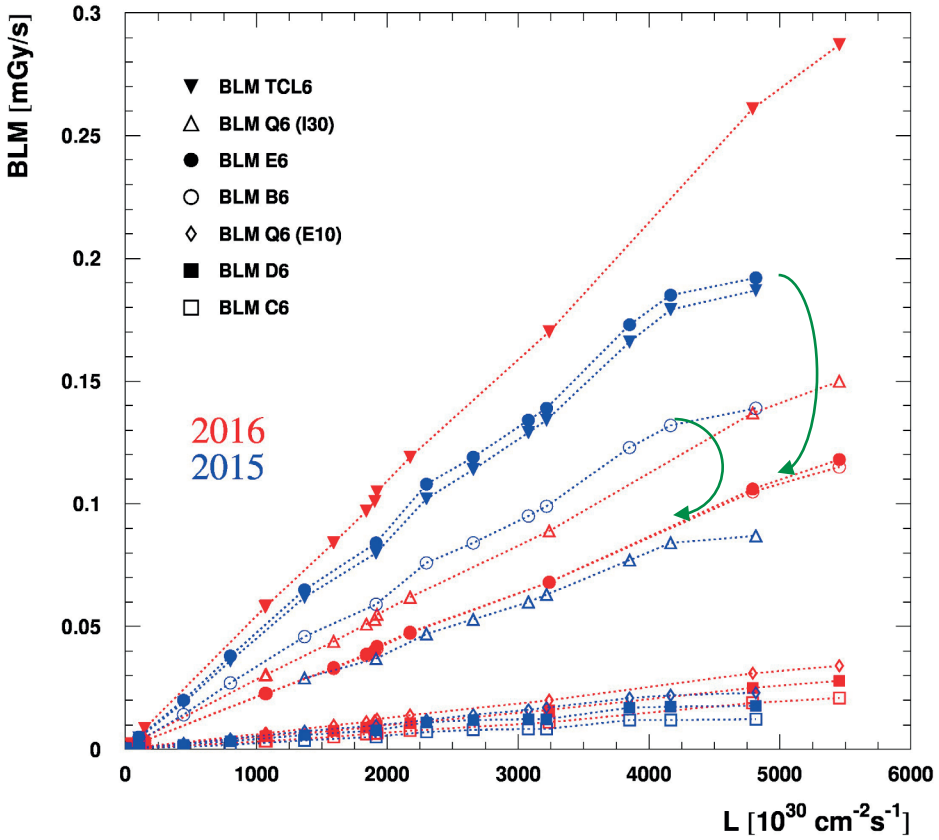
  - tests done in Stable Beams → transparent

Removal of 0.5 mm margin to be discussed in CWG+MPP on 3rd June.

BLM Response 2015 and 2016

(20.7 σ + 0.5 mm and 15 σ + 0.5 mm, respectively)

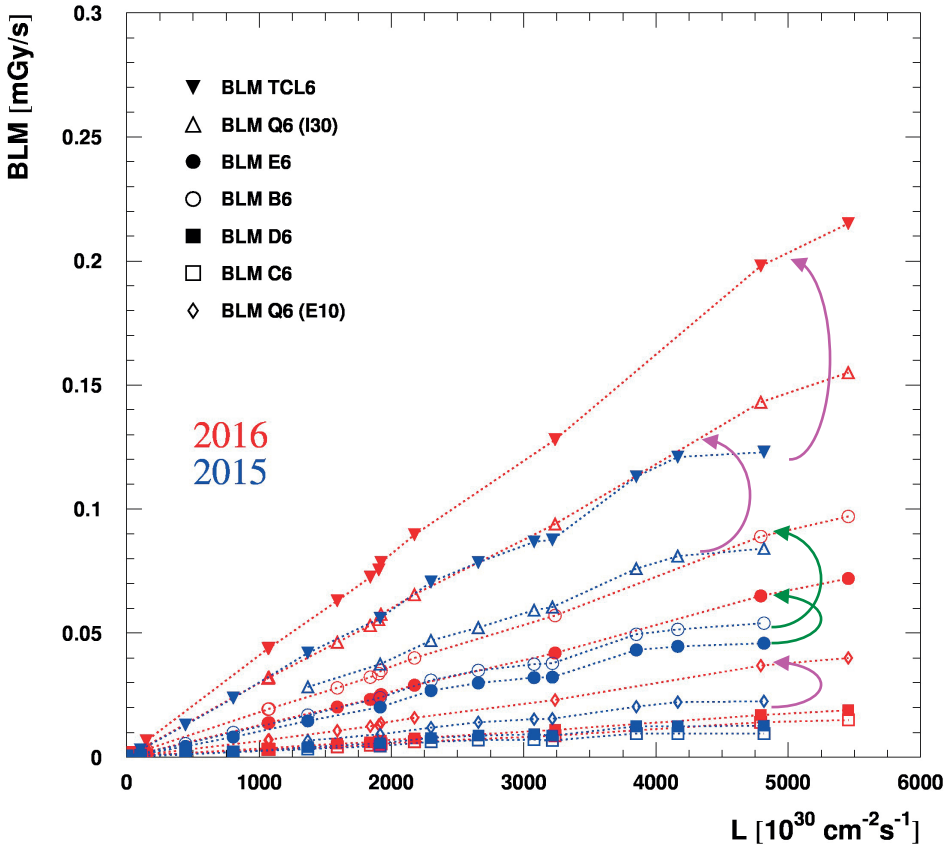
Sector 5-6



Dummy quartz bar removed from E6R5

→ losses reduced by factor ~½ in BLM E6, slight reduction in BLM B6 (that sees no other pot)

Sector 4-5



No dummy quartz bar ever in sector 4-5

→ configuration unchanged

→ 2015 and 2016 directly comparable

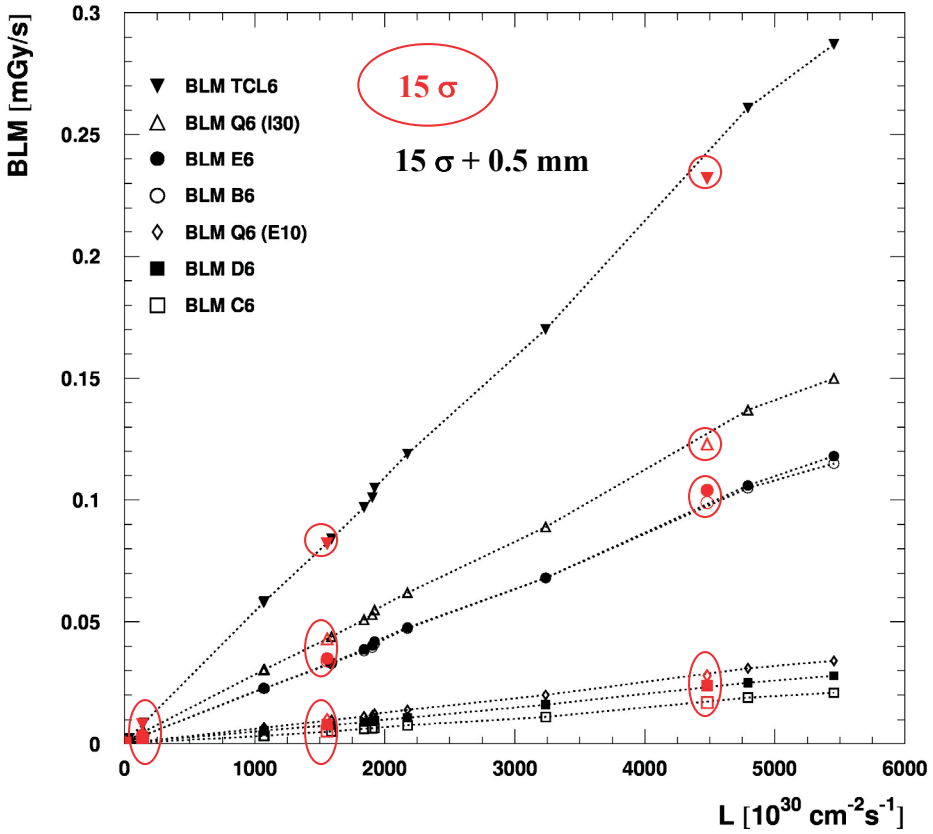
→ slight increase of losses from E6L5 due to closer distance

- TCL6 @ 20 σ instead of 25 σ → slight increase in BLM TCL6, BLM Q6(I30), BLM Q6(E10)
- Almost no increase of losses from box-shaped pots at 210m (C6, D6)

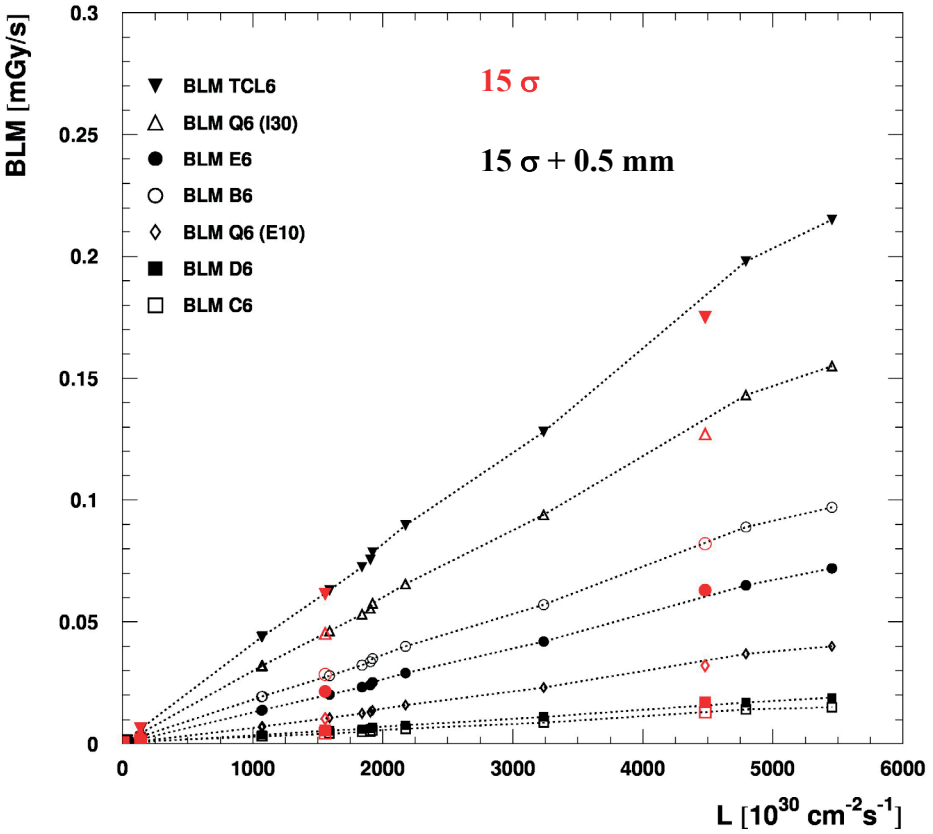
BLM Response 2016 with and without Margin

(15 σ + 0.5 mm and 15 σ)

Sector 5-6



Sector 4-5

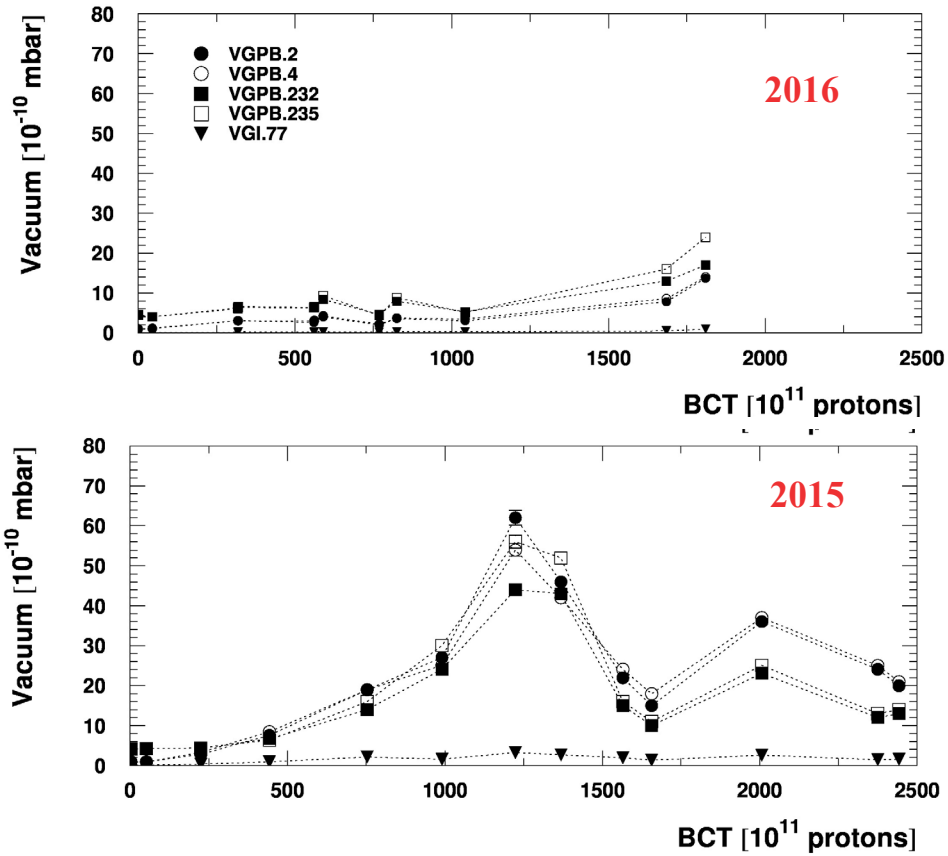


Very little effect from removing the 0.5 mm margin !

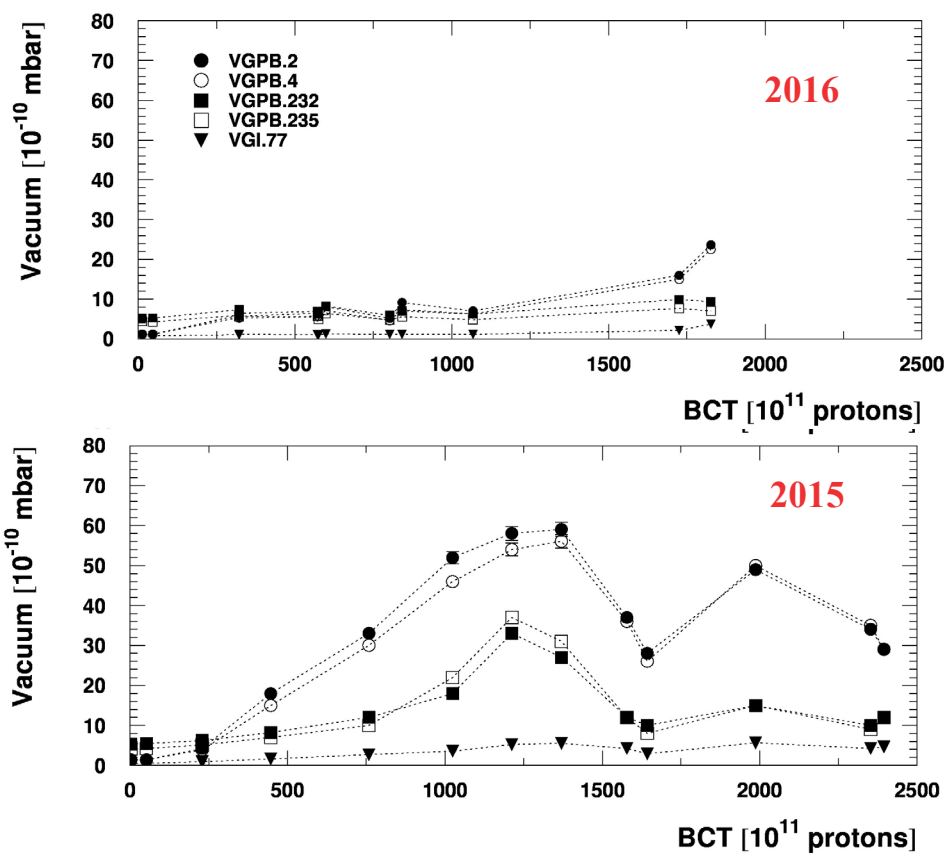
Vacuum (2016)

Equilibrium pressure after RP insertion:

Sector 5-6



Sector 4-5



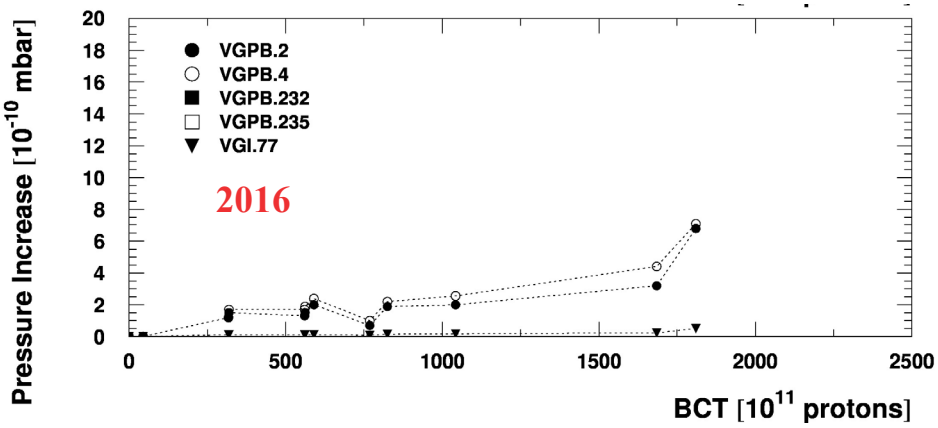
Until now: generally better vacuum than in 2015

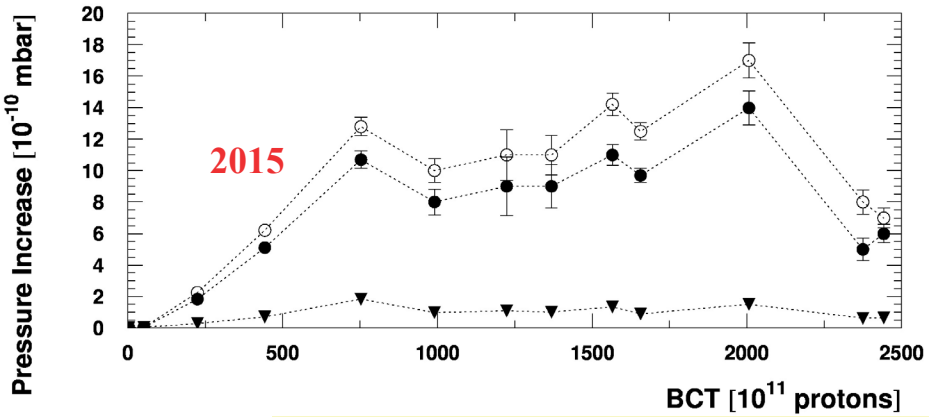
Vacuum Pressure Rise @ RP Insertion

Most of the pressure rise with lumi is not related to RP insertion.

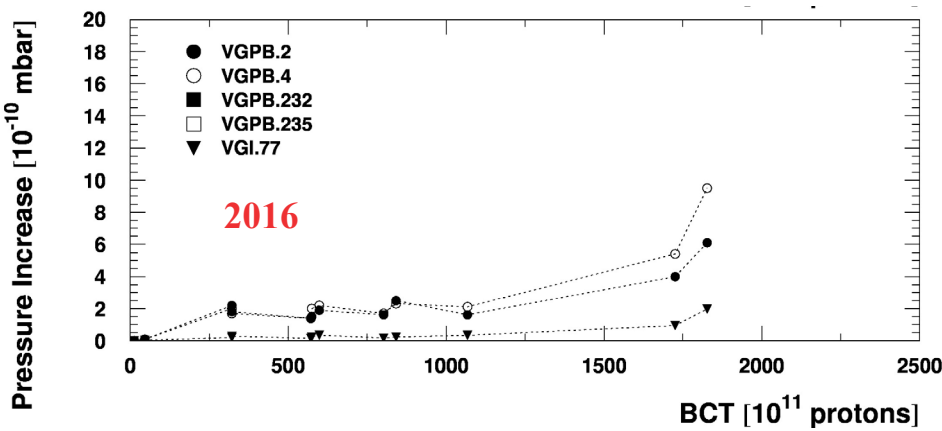
→ isolate RP effect by measuring only the pressure step at insertion time

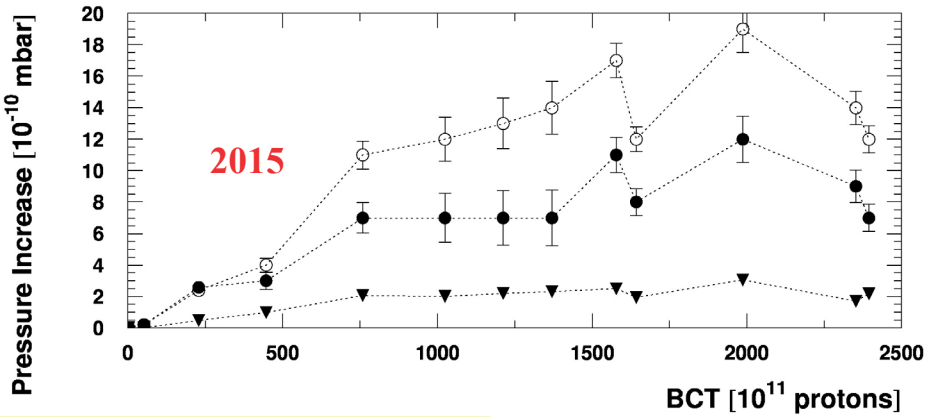
Sector 5-6





Sector 4-5





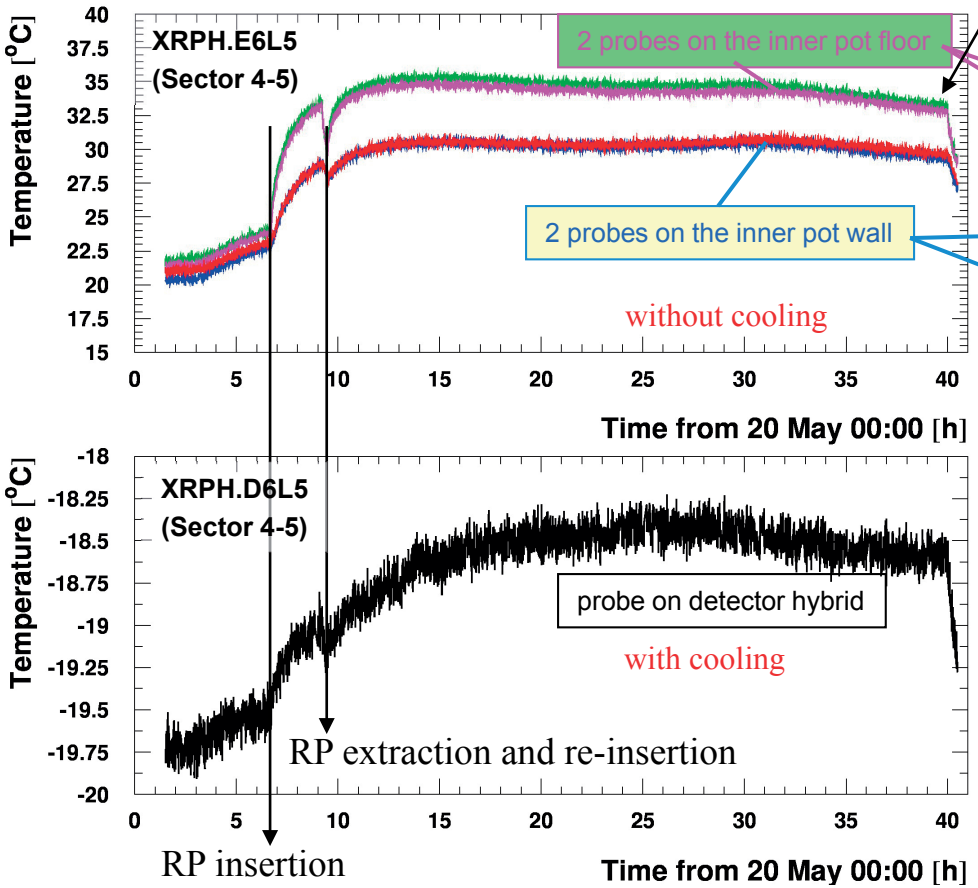
No dangerous pressure rise in machine vacuum observed.

EOF movements to 15 σ have no vacuum response (not shown here)**.**

Temperature Response

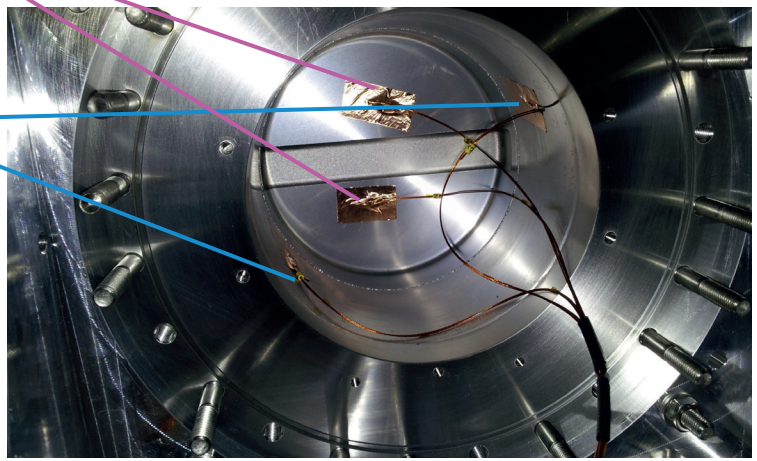
Example fill 4947 (the record fill), **L ~ 3.2 x 10^{33} cm^{-2} s^{-1}** @ RP insertion

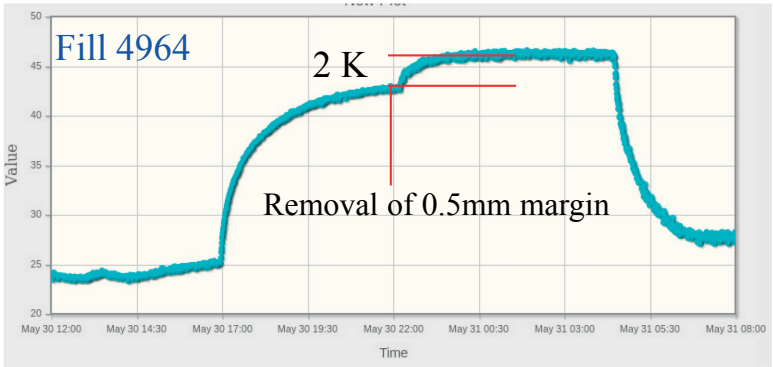
Time evolution of temperature in 2 pots:



lumi @ dump: 1.3 x 10^{33} cm^{-2} s^{-1}

Temperature sensors on cylindrical pot:
hottest spot = pot floor (towards beam) !

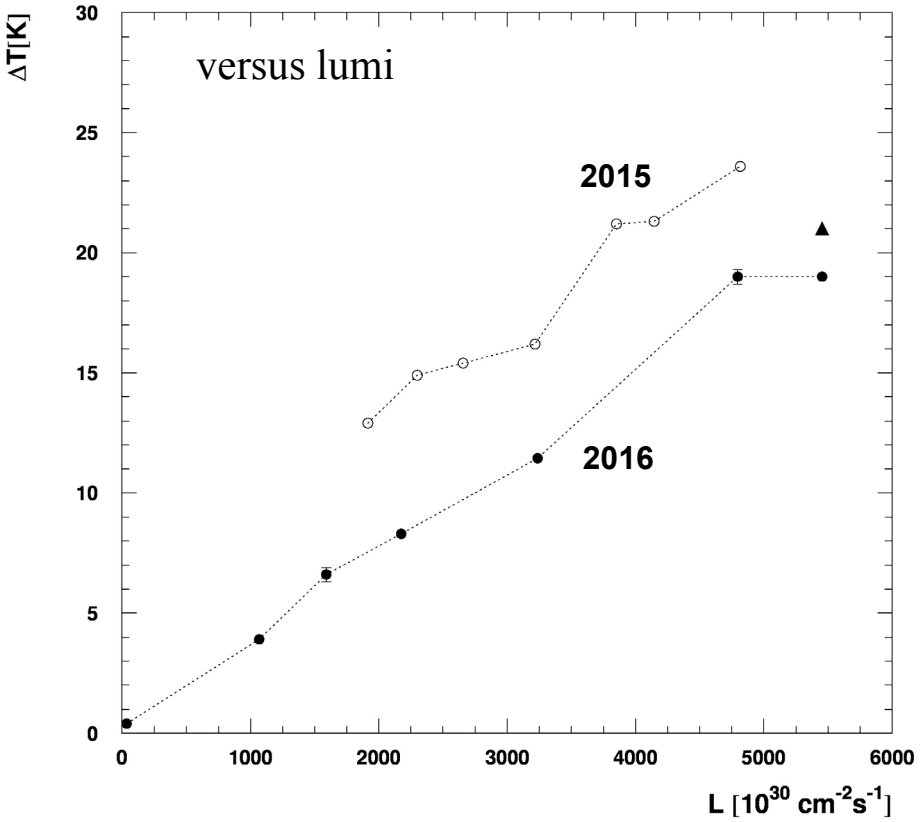


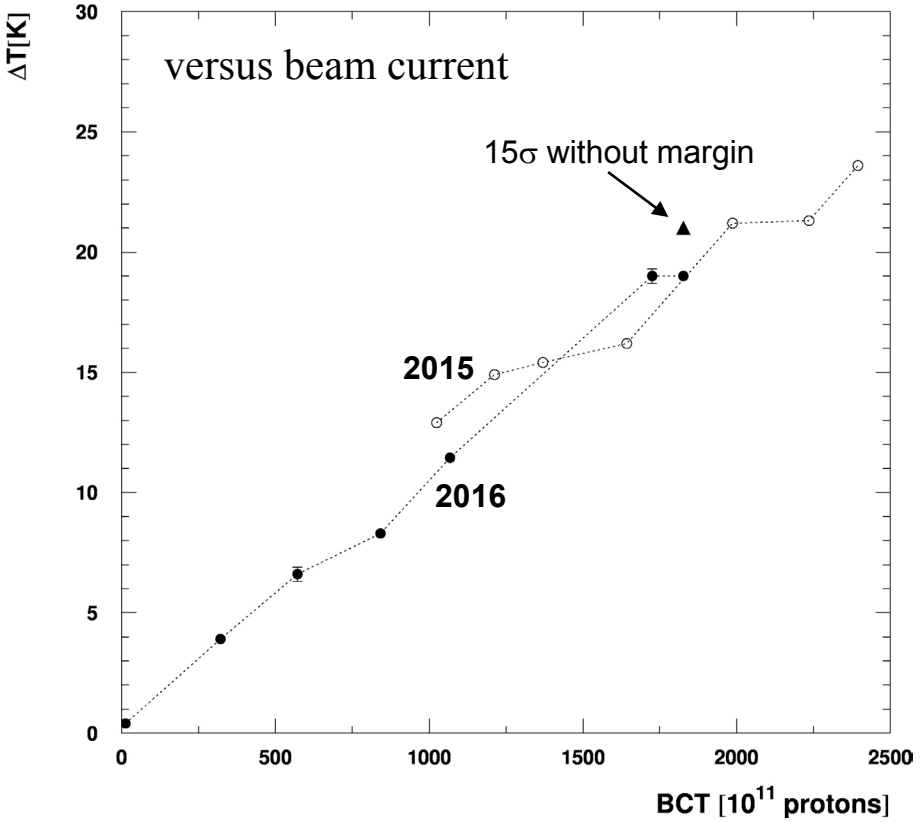


Slow temperature increase approaching an equilibrium value, then decay with luminosity magnitude unproblematic: up to 12 ºC at RP floor 2.8 mm from beam centre without cooling, ~ 1 ºC at detector hybrid (with cooling)

Pot Floor Temperature Rise versus Lumi

Temperature increase relative to RP insertion at maximum or asymptote
(Probe on the floor of the cylindrical XRPH.E6L5.B2)





ΔT proportional to beam current !

Linear extrapolation to 3000 x 10^{11} protons / beam:

ΔT ≈ 30 K → temperature reached: T ≈ 25 ºC + 30 K = 55 ºC

Beam Position @ RPs versus Fill

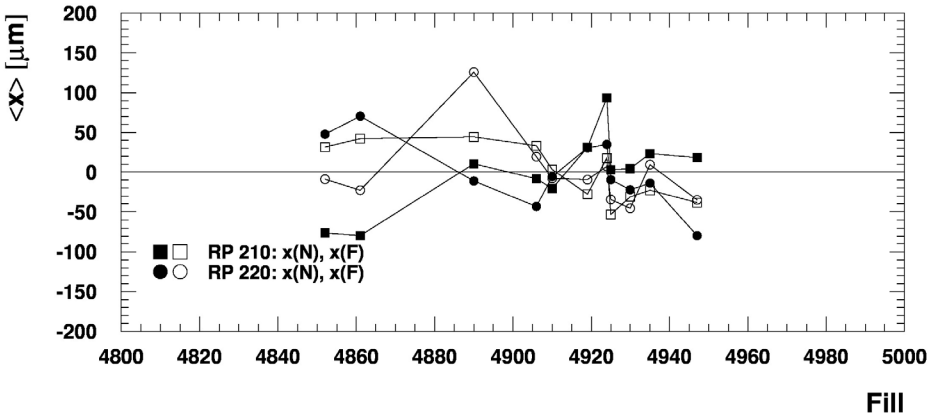
Thanks to David Lucsanyi

Orbit Reproducibility

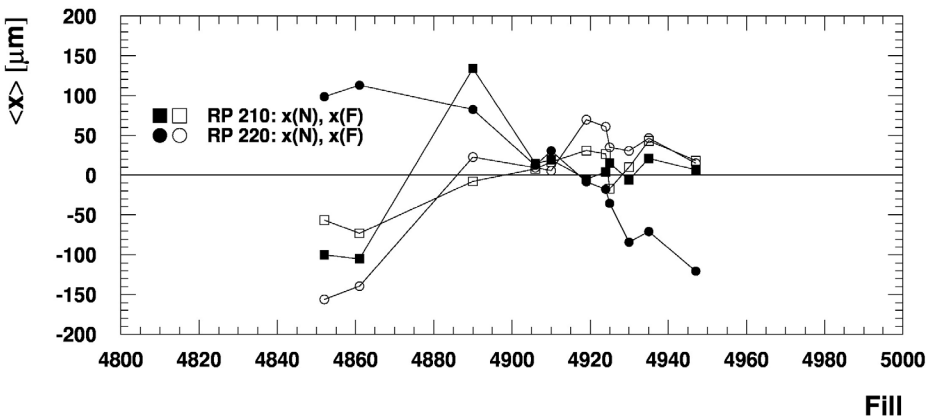
beam position averaged over each fill, global offset suppressed

$$\langle x(t)\rangle_{fill} - \langle\langle x(t)\rangle_{fill}\rangle \;,\; \langle y(t)\rangle_{fill} - \langle\langle y(t)\rangle_{fill}\rangle$$

Mean Position (Beam 1)

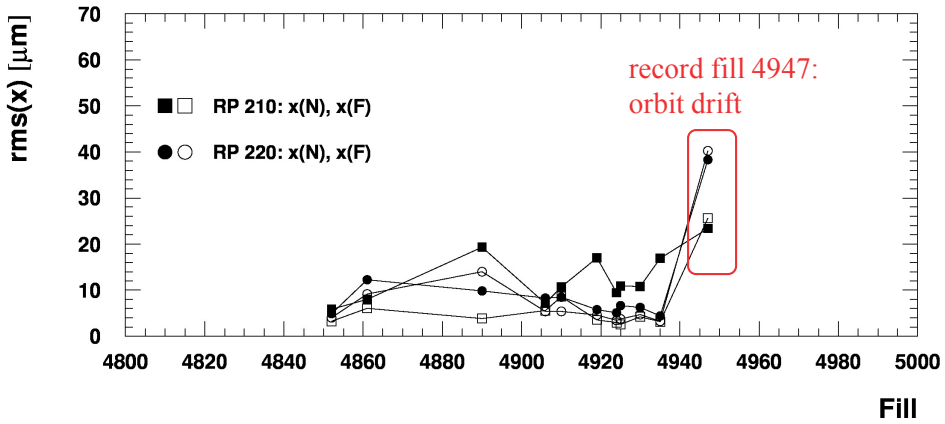


Mean Position (Beam 2)

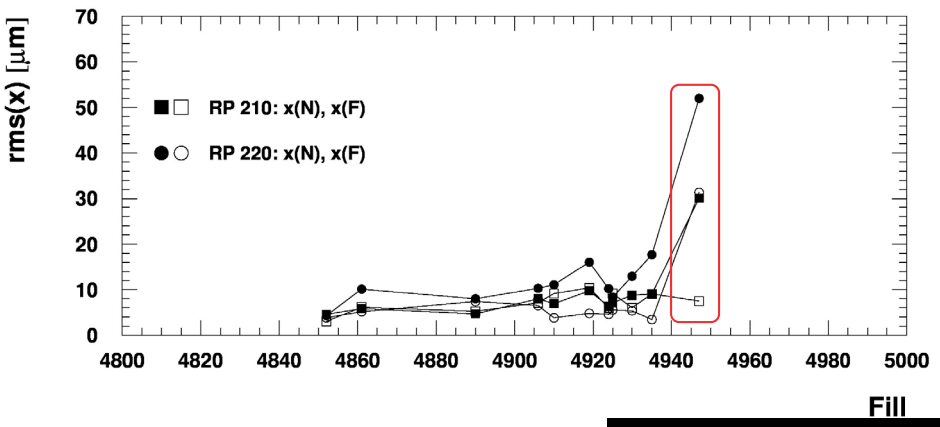


Orbit Fluctuations during Fills

Position RMS (Beam 1)



Position RMS (Beam 2)



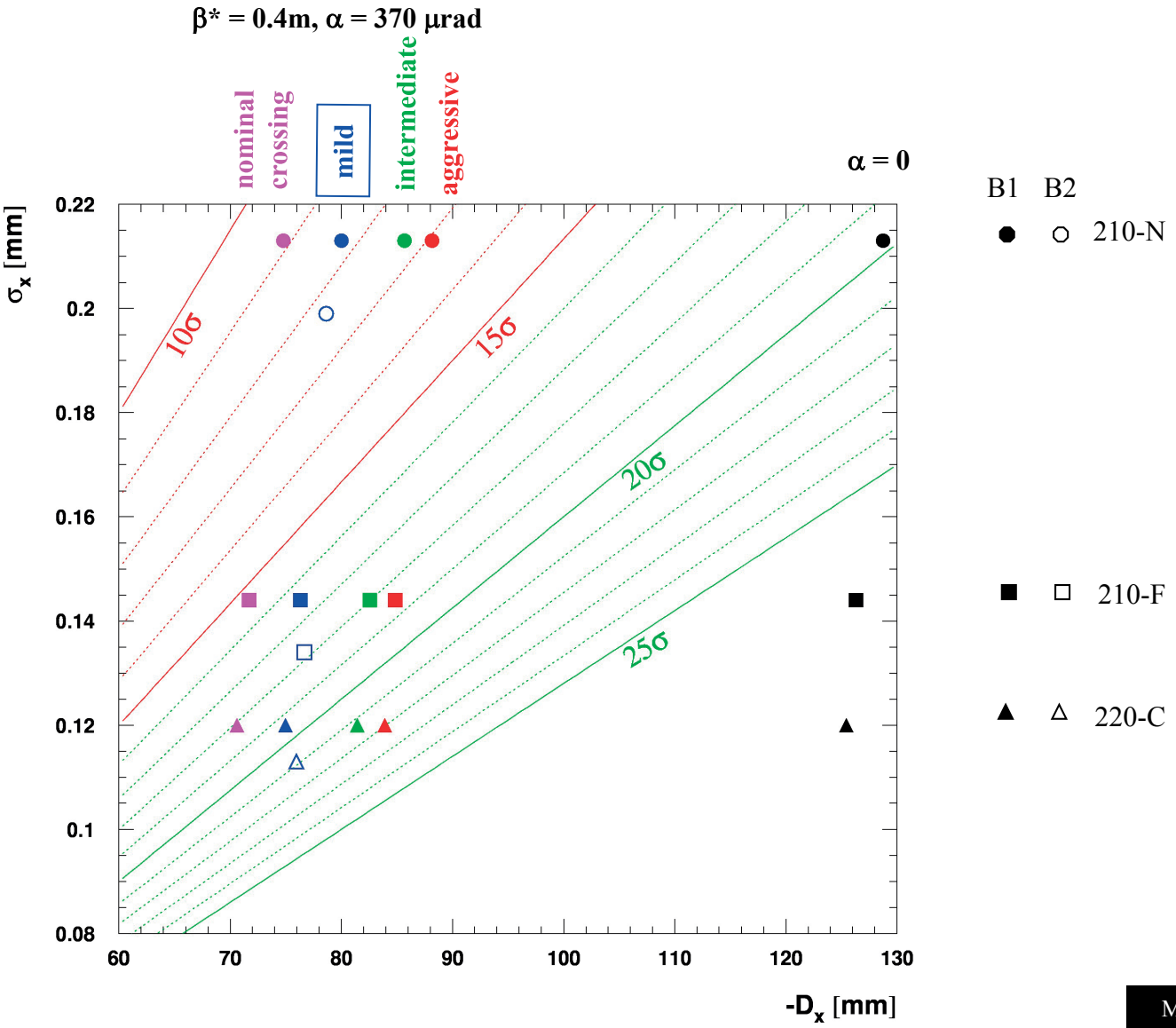
Conclusions

- BLM response: linear with luminosity,
  extrapolation to 10^{34}: no problem expected.
- Vacuum pressure: moderately rising with beam current or luminosity,
  subject to other strong systematic effects,
  no problems observed.
- Temperature in RP: increasing with luminosity,
  no problems observed.
  In final operation with detectors: active cooling
- No beam instabilities observed
- Test insertions to 15 σ without margin:
  no problems in observables monitored by RP team

Backup Material

Phase Space of RP Approach (New)

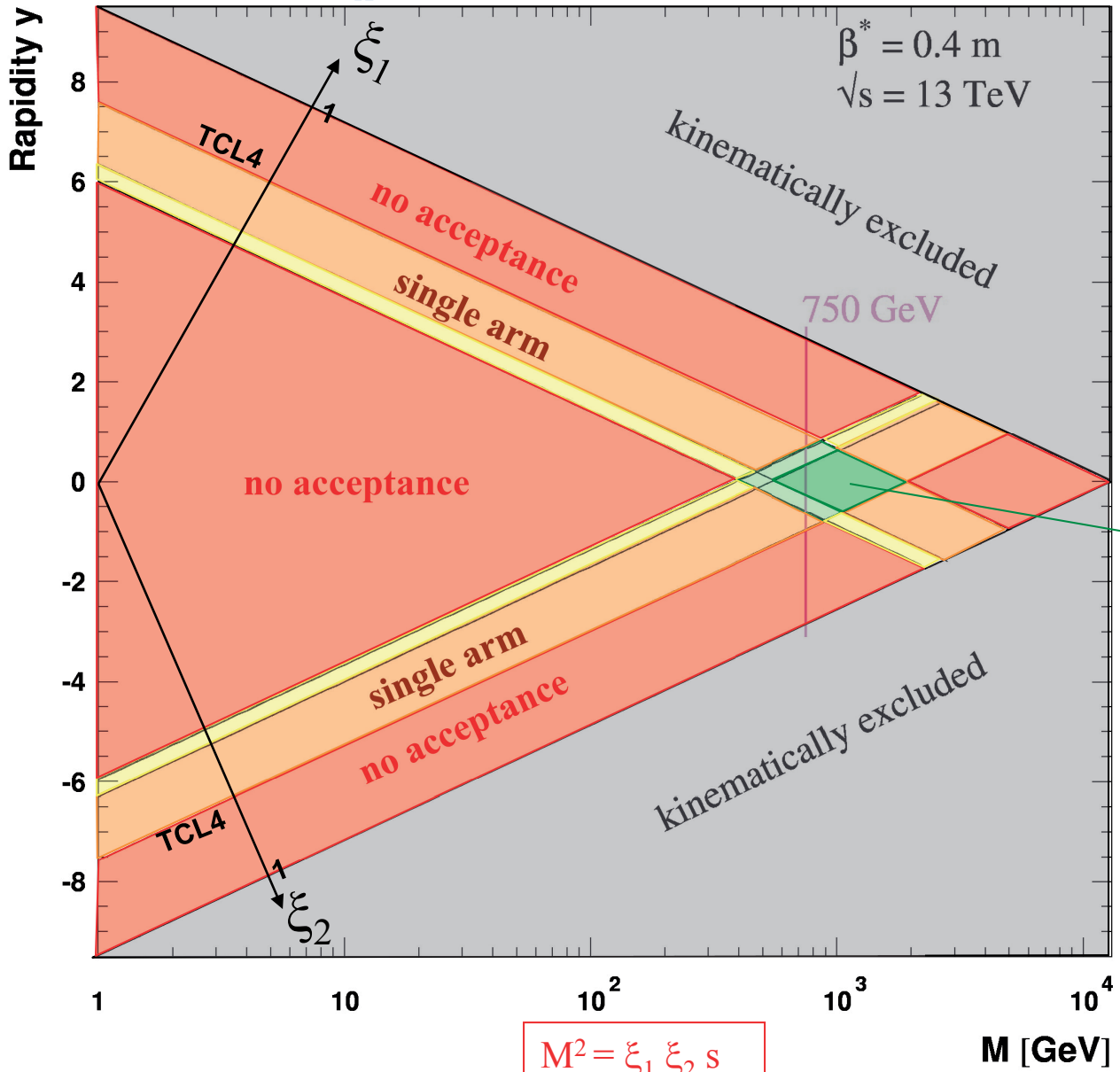
Contour lines: Horizontal RP approach to N σ_x needed to reach rapidity $y_{max} = 0.5$ for M = 750 GeV



Mass – Rapidity Space

$\beta^* = 0.4$ m, $\alpha_X = 370$ µrad, mild orbit bump, RPs @ 15 σ

$$y = \frac{1}{2} \ln \frac{\xi_1}{\xi_2}$$



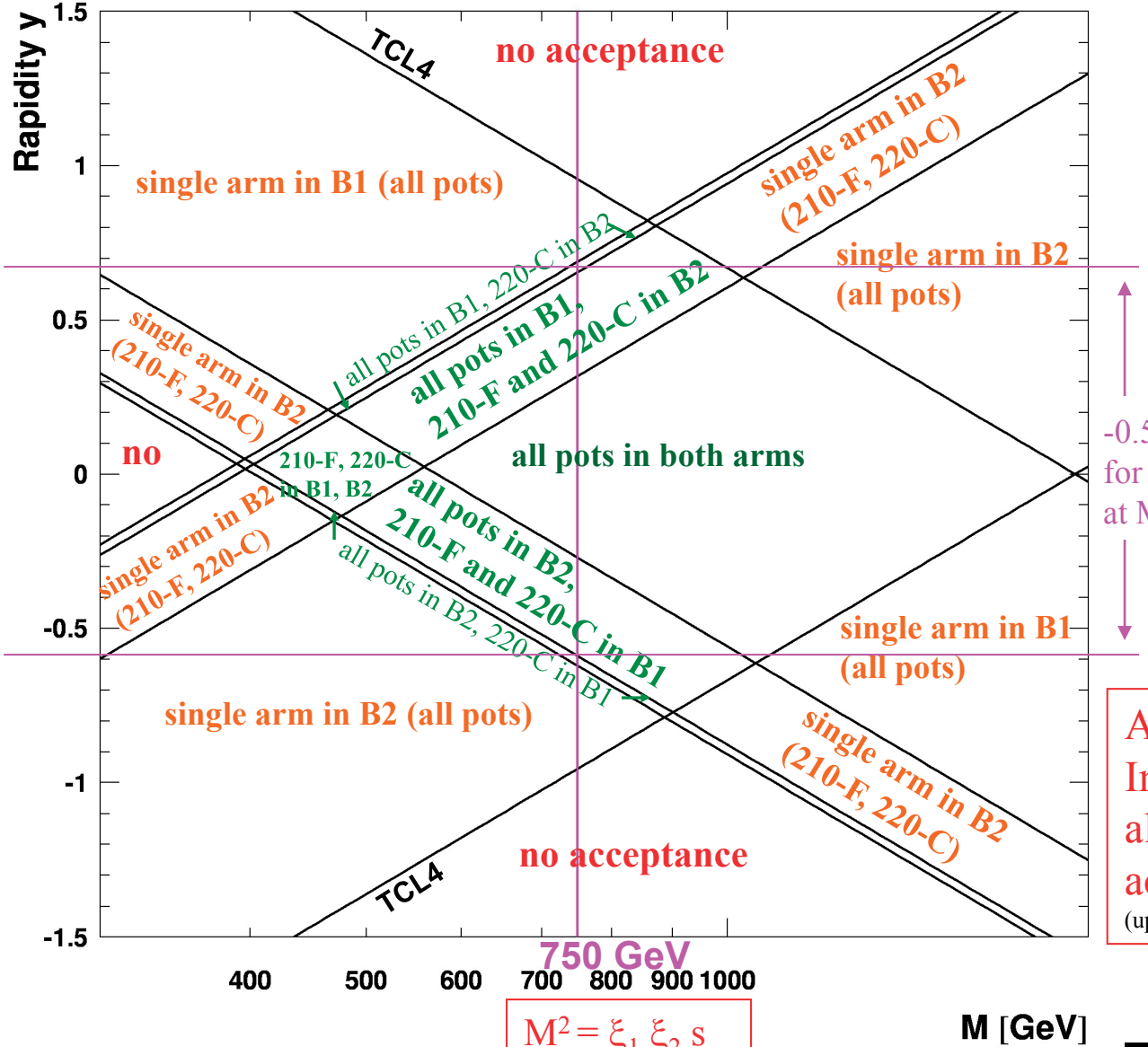
$$M^2 = \xi_1 \, \xi_2 \, s$$

light green,
light orange:
acceptance only
in 210-F and 220-C

Mass – Rapidity Space: Zoom

$\beta^* = 0.4$ m, $\alpha_X = 370$ μrad, mild orbit bump, RPs @ 15 σ

$$y = \frac{1}{2} \ln \frac{\xi_1}{\xi_2}$$



$M^2 = \xi_1 \, \xi_2 \, s$

$-0.58 < y < 0.65$ for double-arm tracking at M = 750 GeV

Always:
In at least 1 arm all 3 pots are in acceptance !
(up to the TCL mass cut)

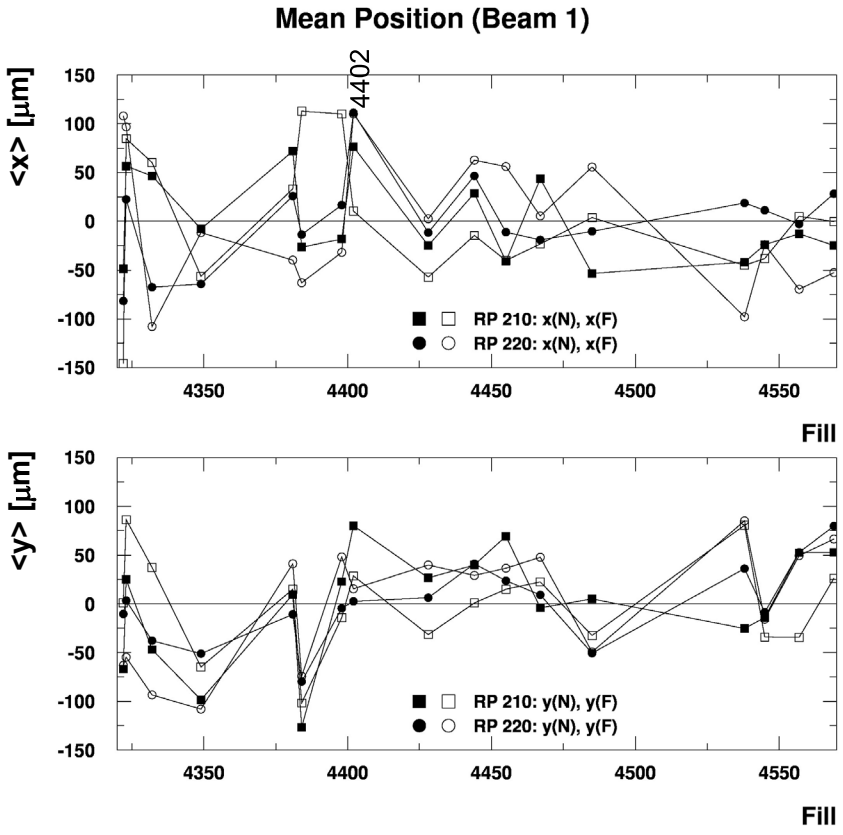
2015: BPM versus Fill (Beam 1)

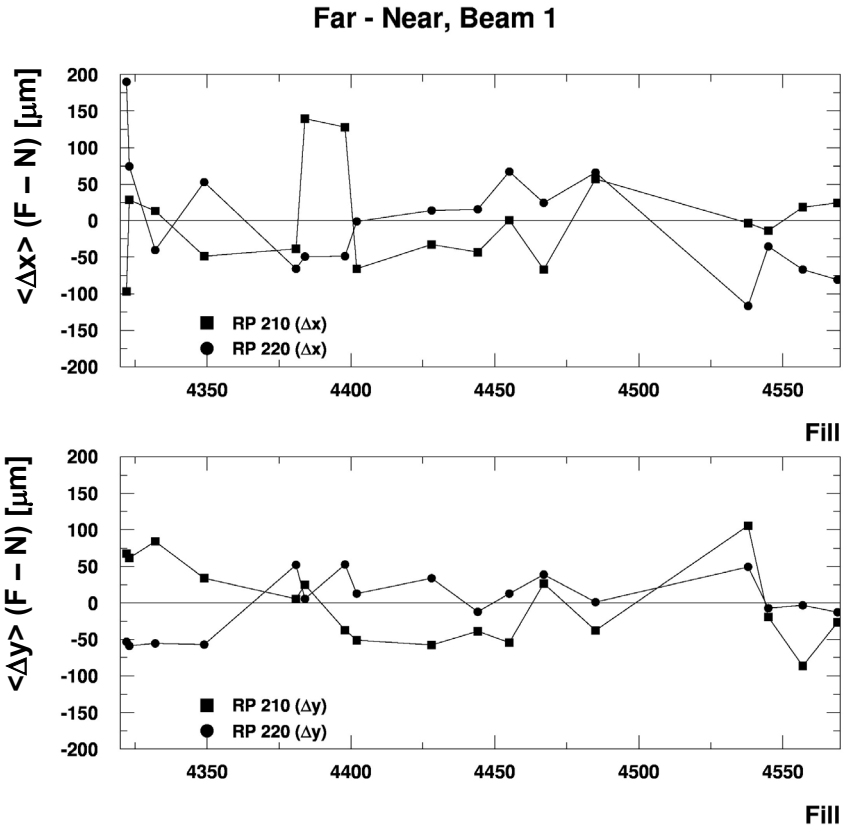
Thanks to David Lucsanyi who did the real work !

beam position averaged over each fill, global offset suppressed

$$\langle x(t)\rangle_{fill} - \left\langle \langle x(t)\rangle_{fill} \right\rangle \ , \ \langle y(t)\rangle_{fill} - \left\langle \langle y(t)\rangle_{fill} \right\rangle$$

beam position difference Far – Near for each fill, global offset suppressed



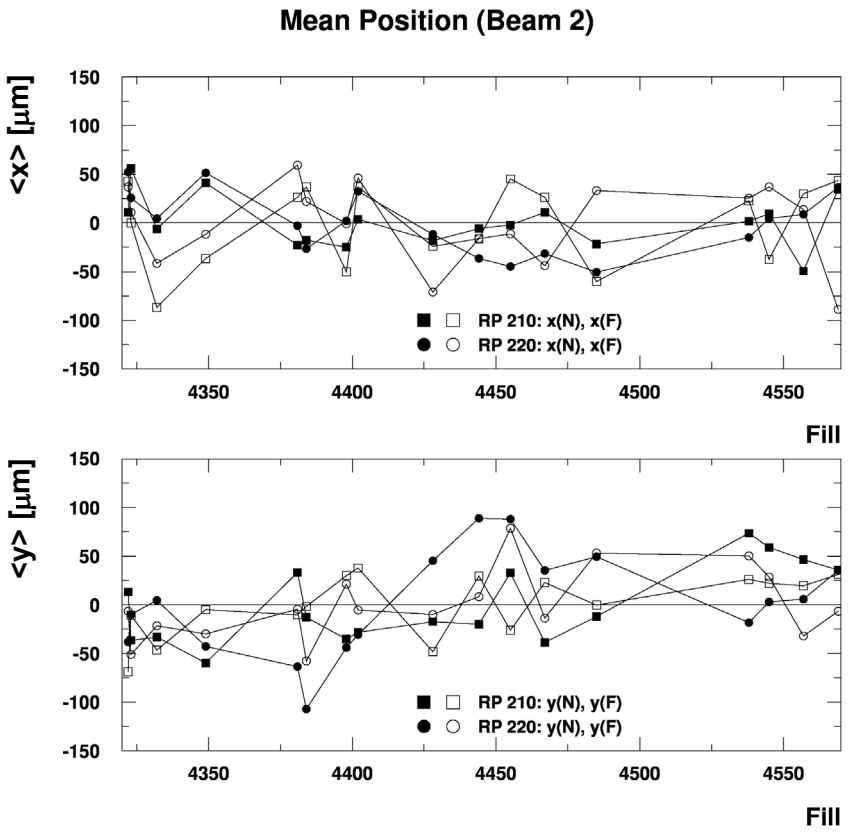


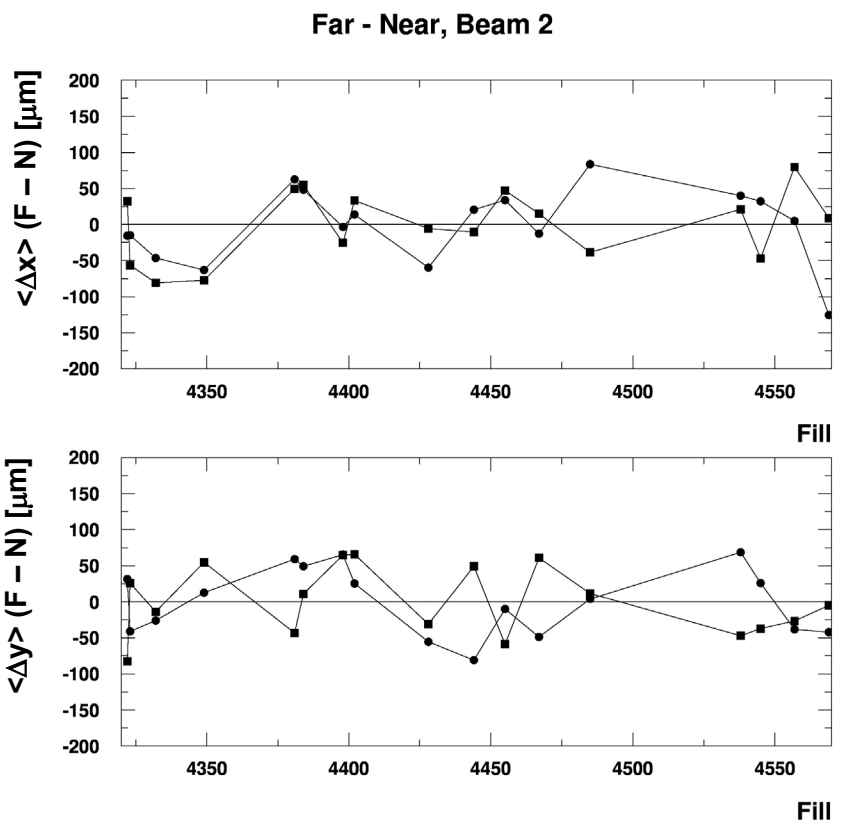
2015: BPM versus Fill (Beam 2)

beam position averaged over each fill, global offset suppressed

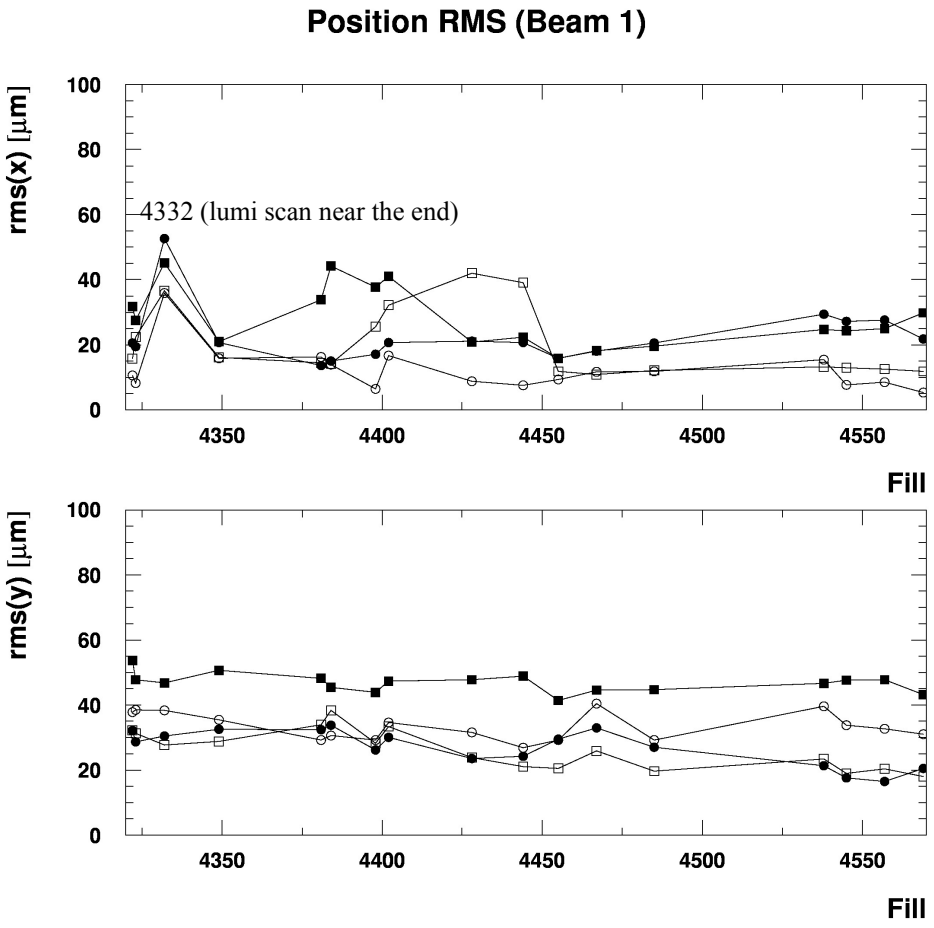
$$\langle x(t)\rangle_{fill} - \left\langle \langle x(t)\rangle_{fill} \right\rangle \;,\quad \langle y(t)\rangle_{fill} - \left\langle \langle y(t)\rangle_{fill} \right\rangle$$

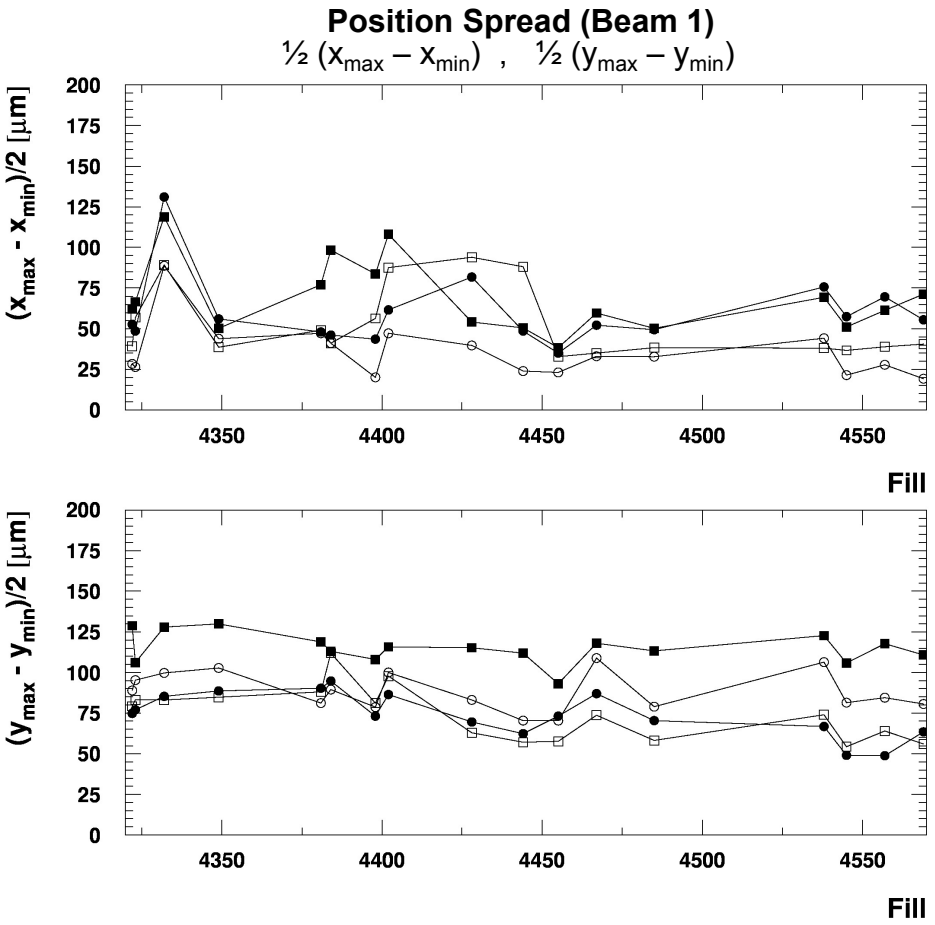
beam position difference Far – Near for each fill, global offset suppressed





2015: Beam Position Spread (Beam 1)





2015: Beam Position Spread (Beam 2)