Once more unto the breach, dear friends, once more

IP8 Vertical Crossing Angle

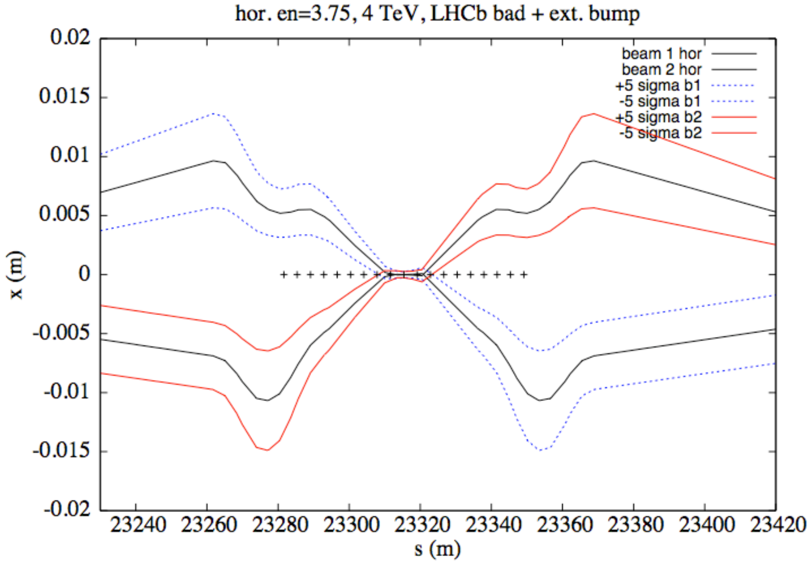
Present situation at LHCb:

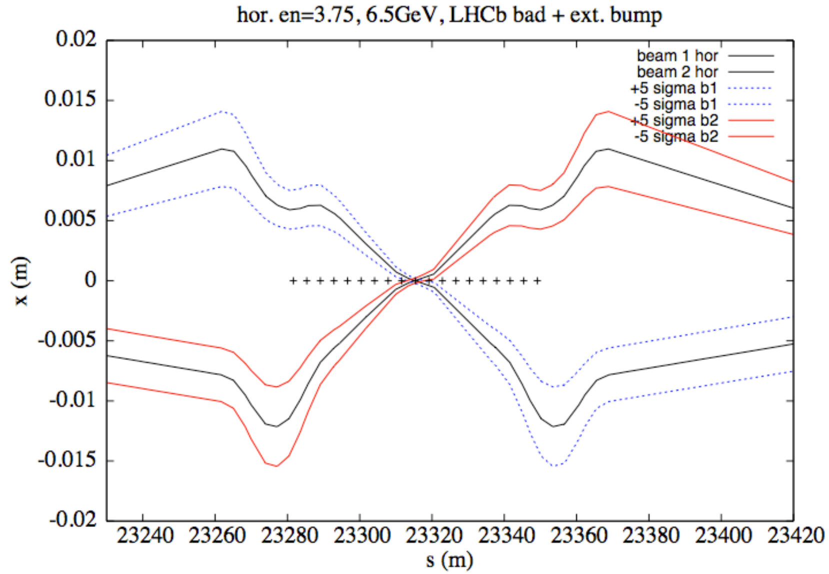
following the data analysis of 2011 (hic) a systematic effect is observed and a vertical crossing angle is desired even for 6.5 TeV after LS1.
2012 data still to be included ...

... for the time being the scenario to rotate the crossing planes at flat top is still needed after LS1.

Comparison 4 TeV / 6.5 TeV

* LHCb is running on constant field, angle scales down linearly with γ
* beam emittance shrinks as 1/γ due to Liouville.
 -> orbits & envelopes for a hor. crossing ...





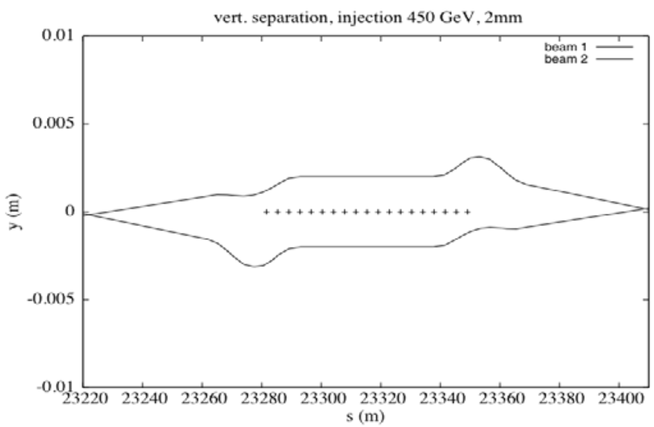
4 TeV:
LHCb=bad -> +236 μrad
on_x8 = -220 μrad
eff. angle = +16 μrad

6.5 TeV:
LHCb=bad -> +145 μrad
on_x8 = -250 μrad
eff. angle = -105μrad

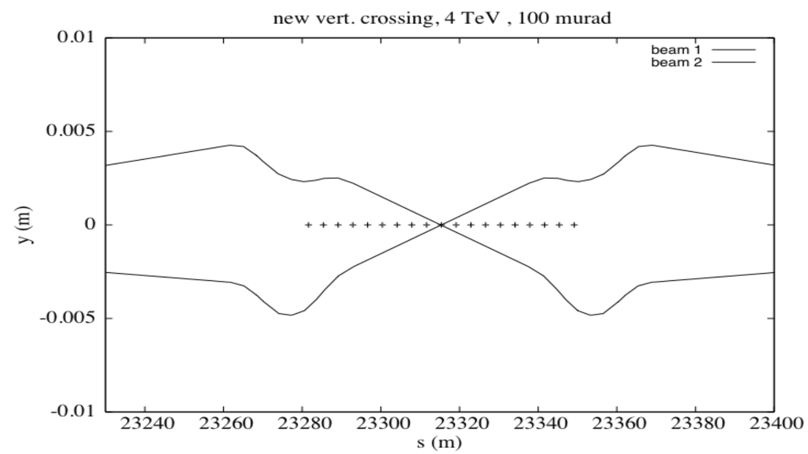
... concerning LHCb and beam energy ... the higher the better

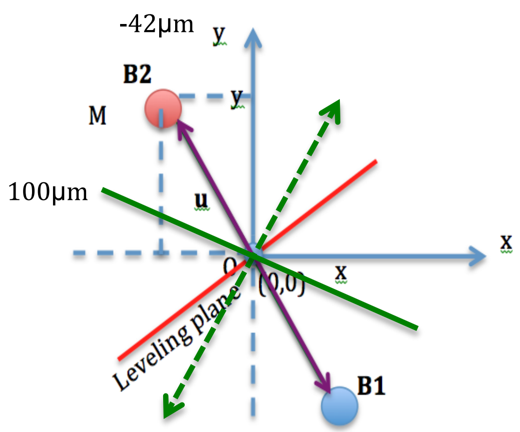
The “Gymnastics” until now

***we have to go** from a vertical parallel separation (2mm)*
at injection / ramp / flat top ...



to a vertical crossing angle (100 μm) ***at luminosity***
to obtain beams that are separate in the diagonal “leveling” plane.



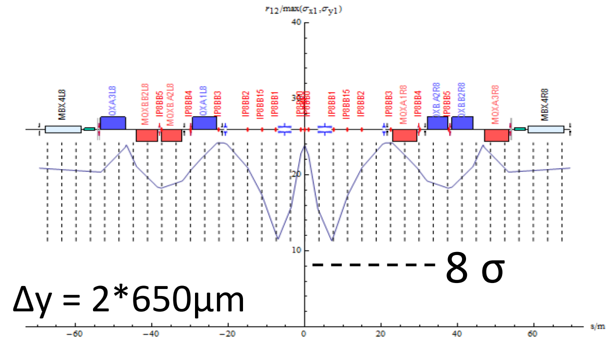


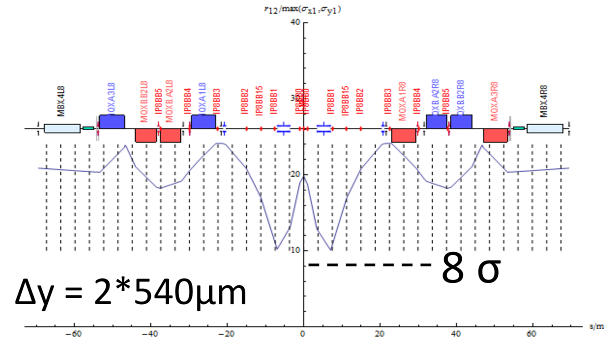
Operational procedure:
arrive with correct crossing angles,
and apply the offsets
that define the starting points for the luminosity leveling.

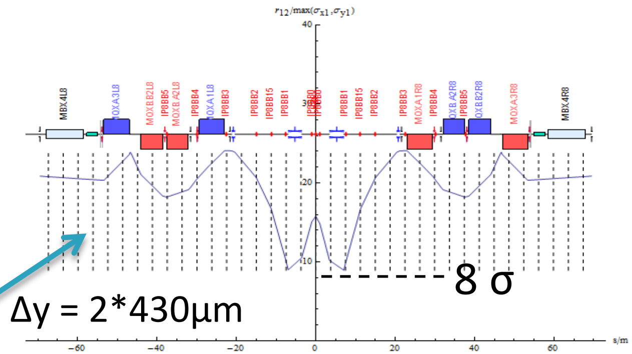
2012 Situation: operational procedure

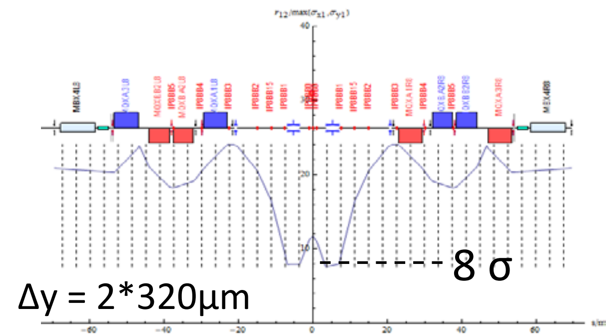
1. **Create the verticla crossing angle** α_{ext}^{V} ➔ **100 μrad;**
2. **Collapse the horizontal crossing** α_{ext}^{H} ➔ **0 μrad;**
3. **Move the beams to the leveling direction**

1st Step

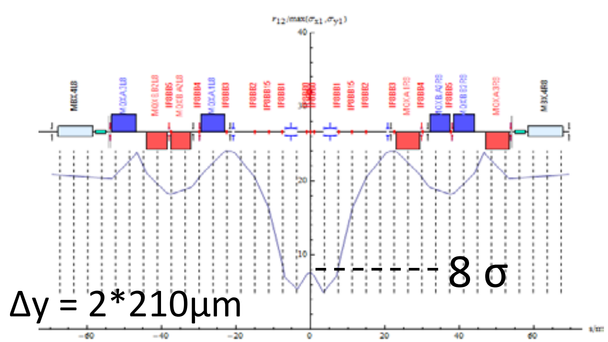


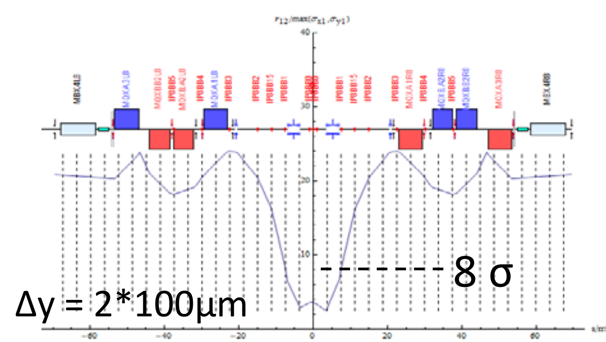






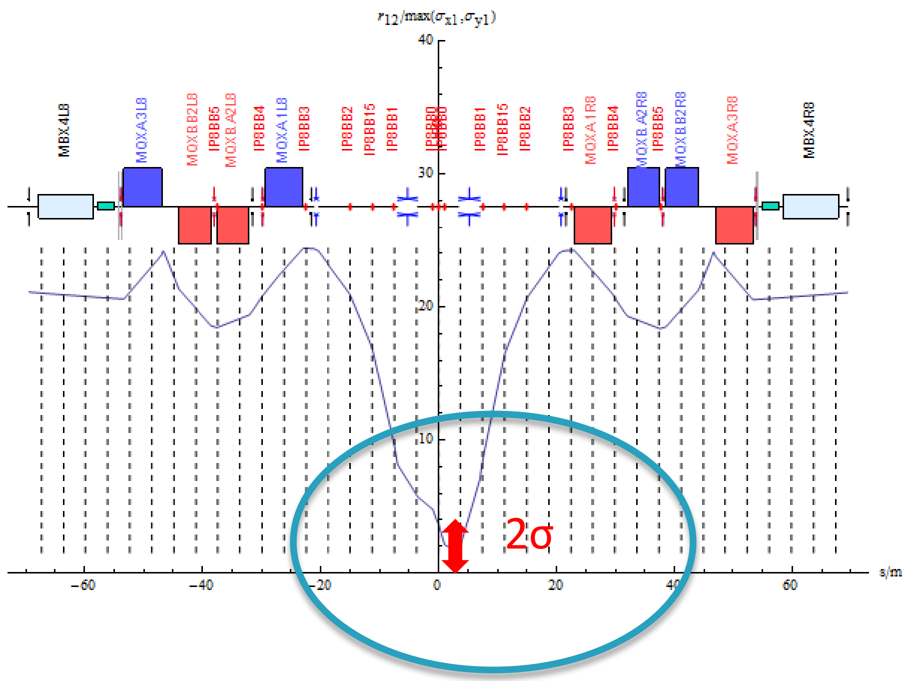
25ns encounters





2012 Situation: operational procedure

2nd Step small bam separation obtained for 25ns encounters ...



Scheme 2012:
for 25ns operation a bit critical ...

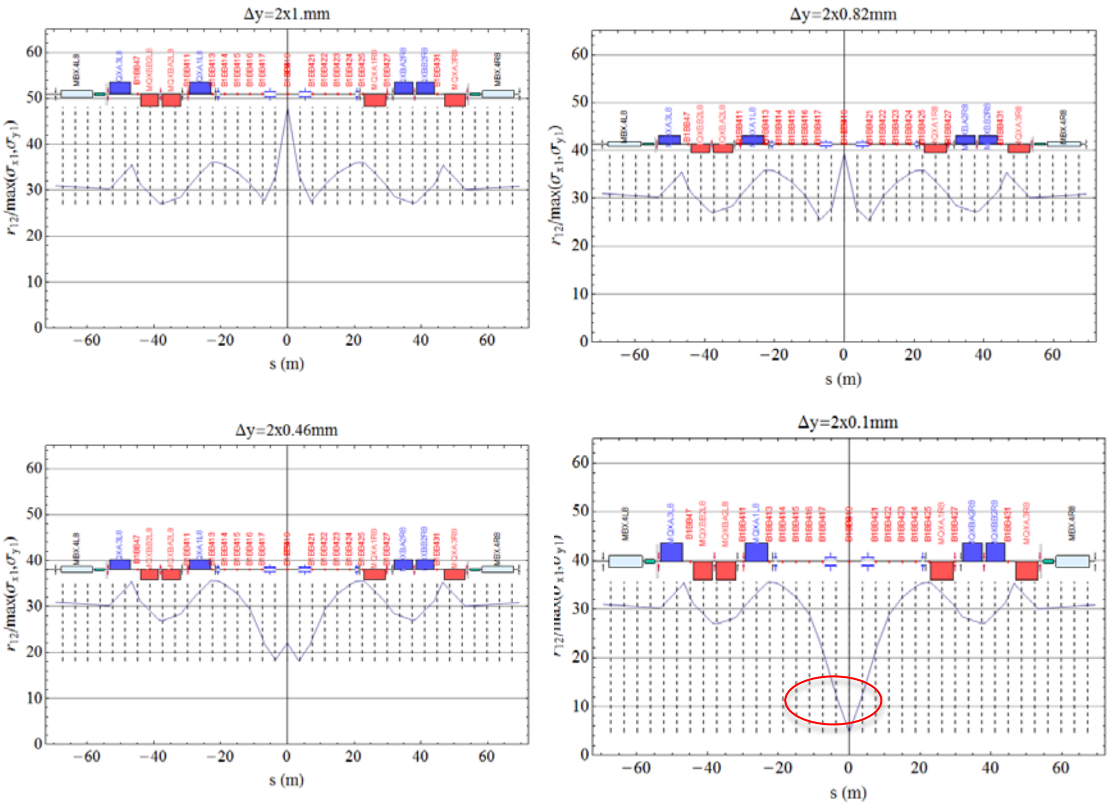
Situation after LS1:

Operation at 6.5 TeV

court: Reine Versteegen

If a vertical crossing is preferred, same procedure as in 2012 works (>9σ separation) at 6.5 TeV even for **25ns bunch spacing**, for normalized emittance of **4 μm**.
(signs on the plots are given for Beam 1, calculations are done for positive Beam 1 angle resulting from the spectrometer ⇔ "bad" polarity)

1st step:
reducing the vertical parallel separation
αx = -250μrad, Δx = 0 μm, αy = 0μrad,
decreasing Δy from -2*1mm to -2*0.1mm



2nd step:

applying the vertical crossing angle

αx = -250 μrad, Δx = 0mm

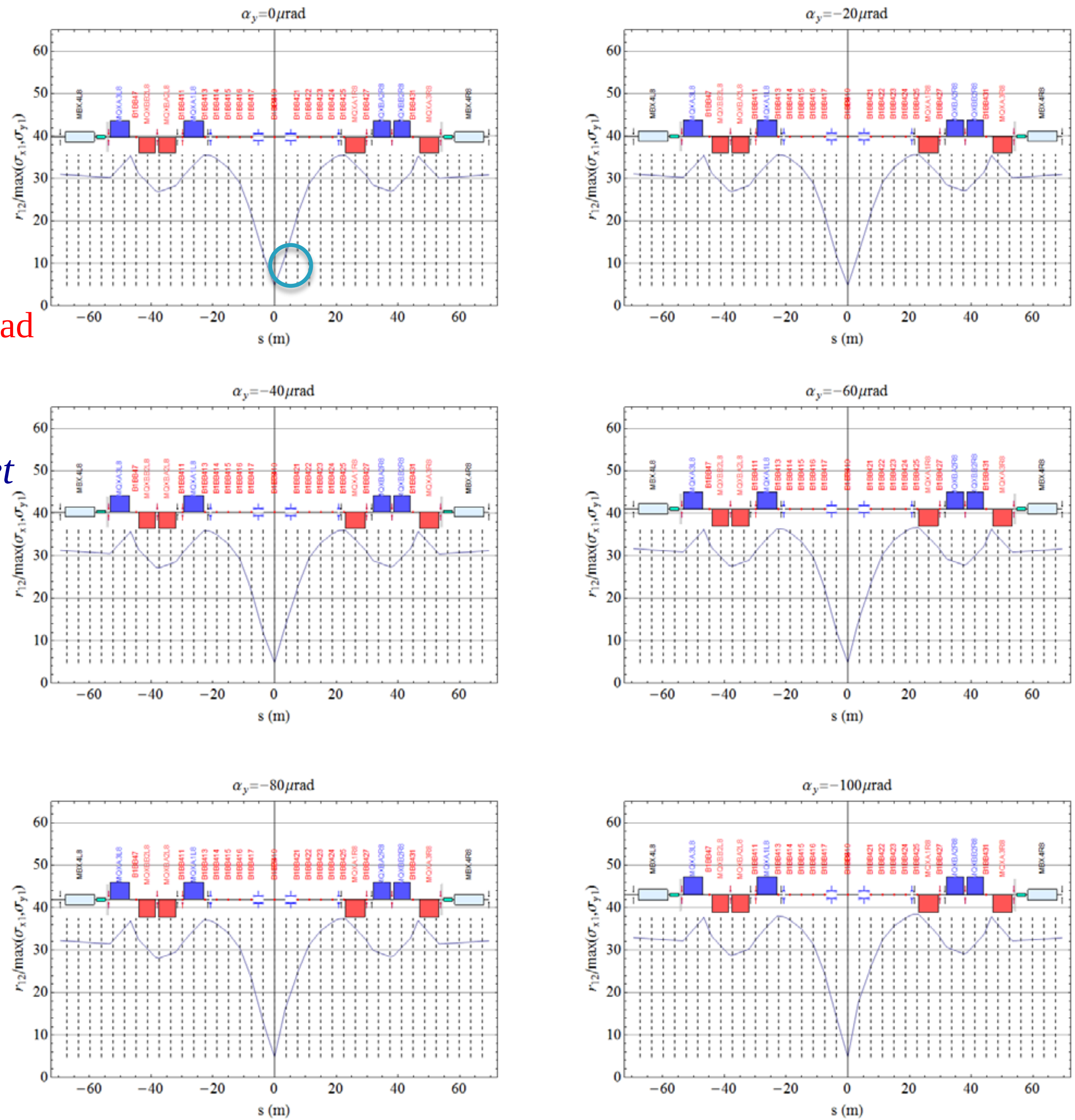
Δy = -2*100 μm

increasing αy from 0 to -100μrad

Nota bene:

Due to higher energy we get a smaller beam emittance and weaker LHCb "field" and the whole procedure is relaxed

... compared to 4 TeV !!

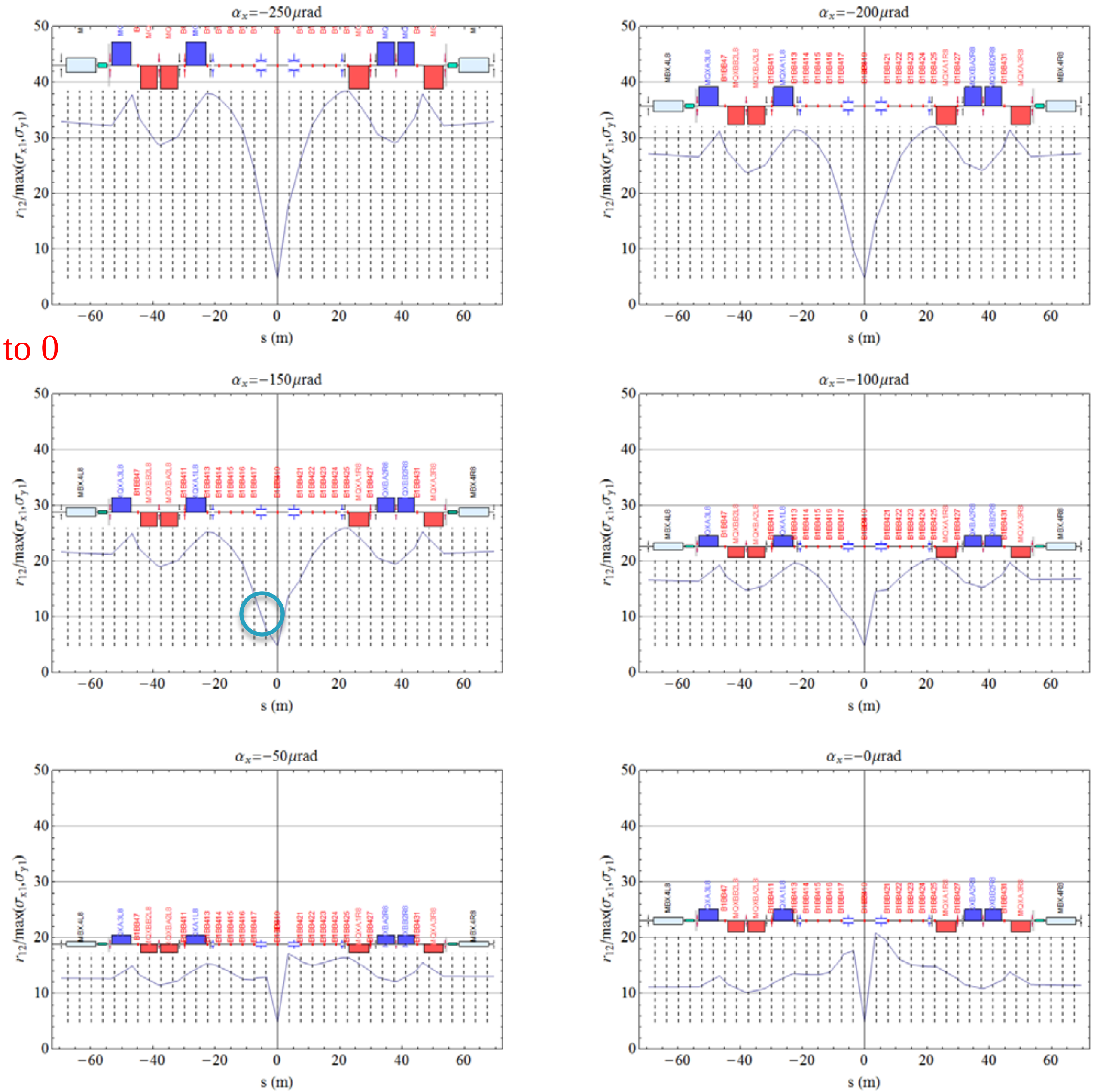


3rd step:

decreasing αx from -250 μrad to 0

Δx = 0 μm, αy = -100 μrad,

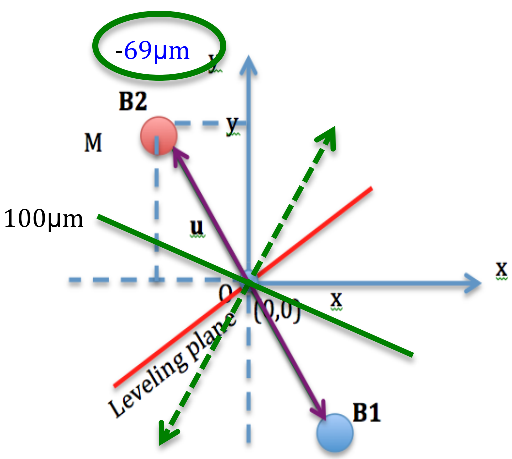
Δy = -2*100 μm,

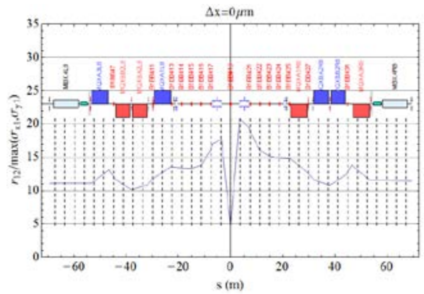


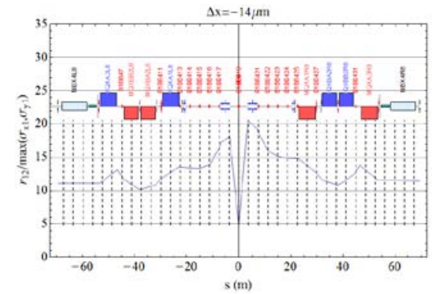
4^{th} step: moving the beams to the leveling diagonal

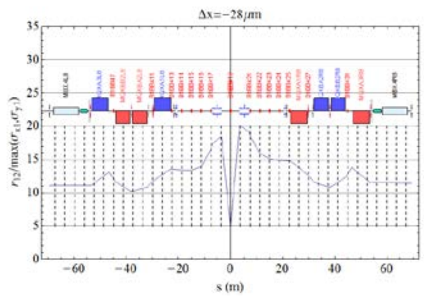
$\alpha x = 0$,
increasing Δx to -69 µm,
$\alpha y = -100$ µrad, $\Delta y = -2*100$µm

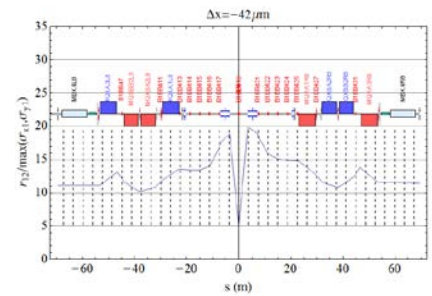
Which brings us back to the well know situation … but clearly with new beam positions at IP8

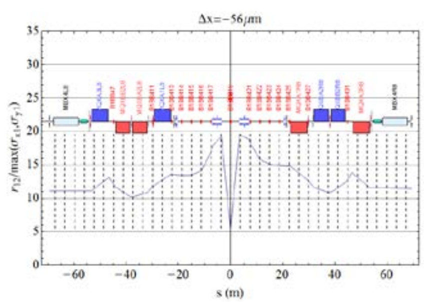


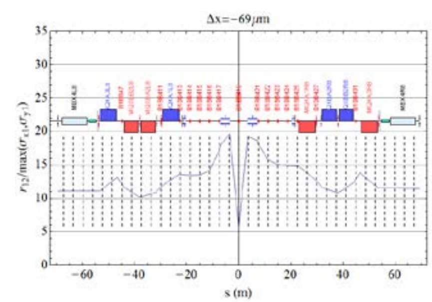








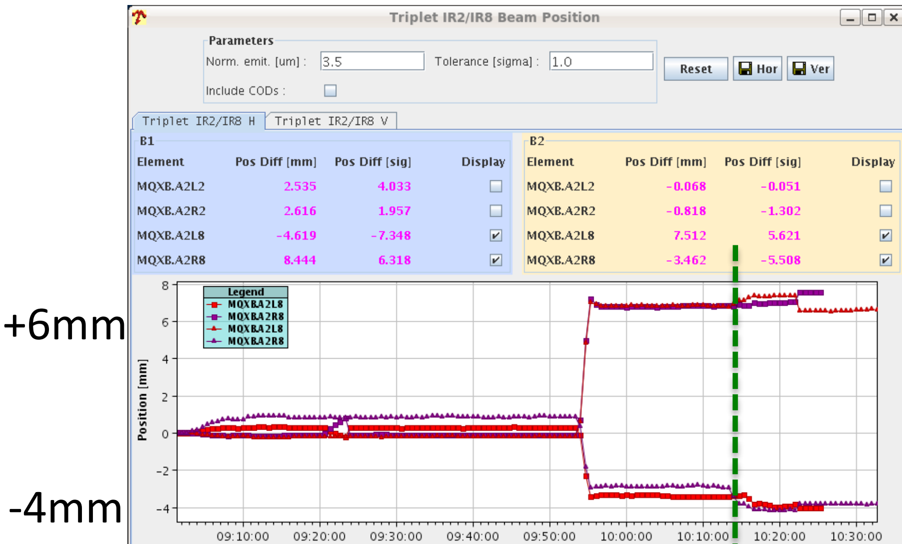




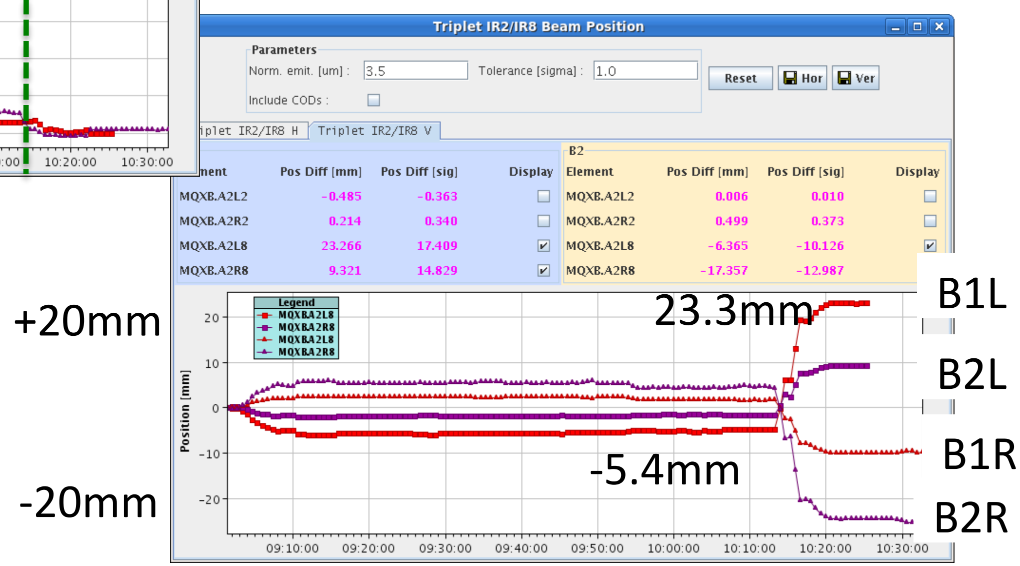
Aperture Measurements in IR8

R. Bruce, P. Hermes, B. Holzer, M. Giovannozzi, A. Nosysch, S. Redaelli

Method: put primary collimators to 4σ (ε = 3.5μrad) to obtain a well defined beam size
move the beam with vert. symmetric bumps until losses are observed
move with hor asym bump and repeat th vertical one.



hor. VdM bump ...
to avoid artificial limitations
of vert. aperture.



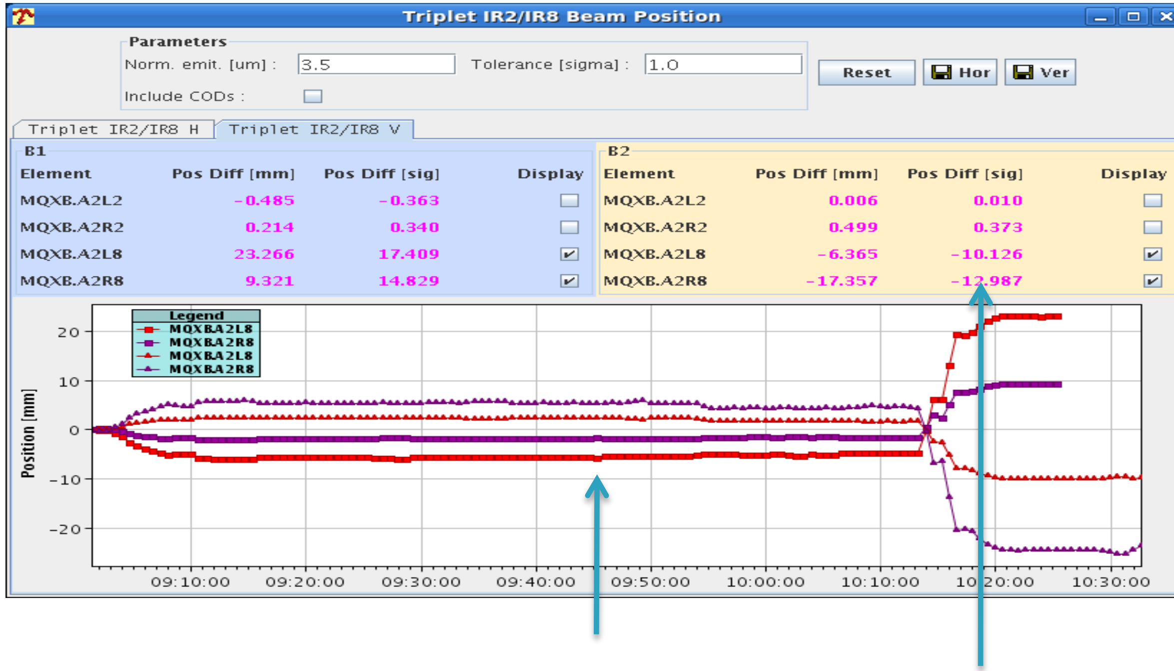
vert. VdM bump ...
to measure vert. aperture.

Aperture from BPM readings

YASP-Extraction:

MD: 29-Nov-2012, 9:00-10:34h
Logbook plots: 6-Dez-2012

(vert.) orbits beam1



overall amplitude measured at triplet BPMs

$28.7\text{mm} + 2^* \, 4\sigma$

β=270m, ε_n=3.5 -> σ=1.5mm

→ aperture radius = 20.4 mm

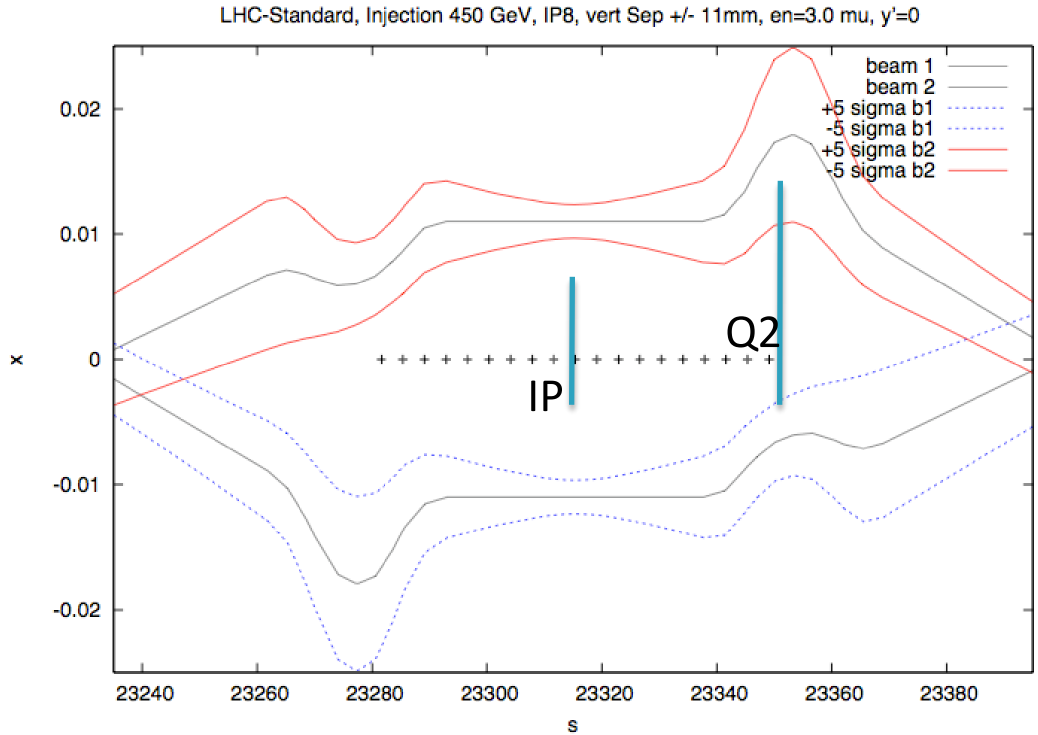
reaching the aperture
limit in 1st direction
-5.4mm

reaching the apertur
limit in 2nd direction
+23.3mm

Nota bene: BPM suffer from non-linearities et cetera

Aperture from ***Theory***

vert. Separation Bump applied
losses observed at
Δy = +/- 11 mm referring to IP.



Referring to the IP settings of the bump:

aperture limits obtained at $\Delta y \approx$ + / - 11mm

corresponds to + / - 17.8mm at Q2.

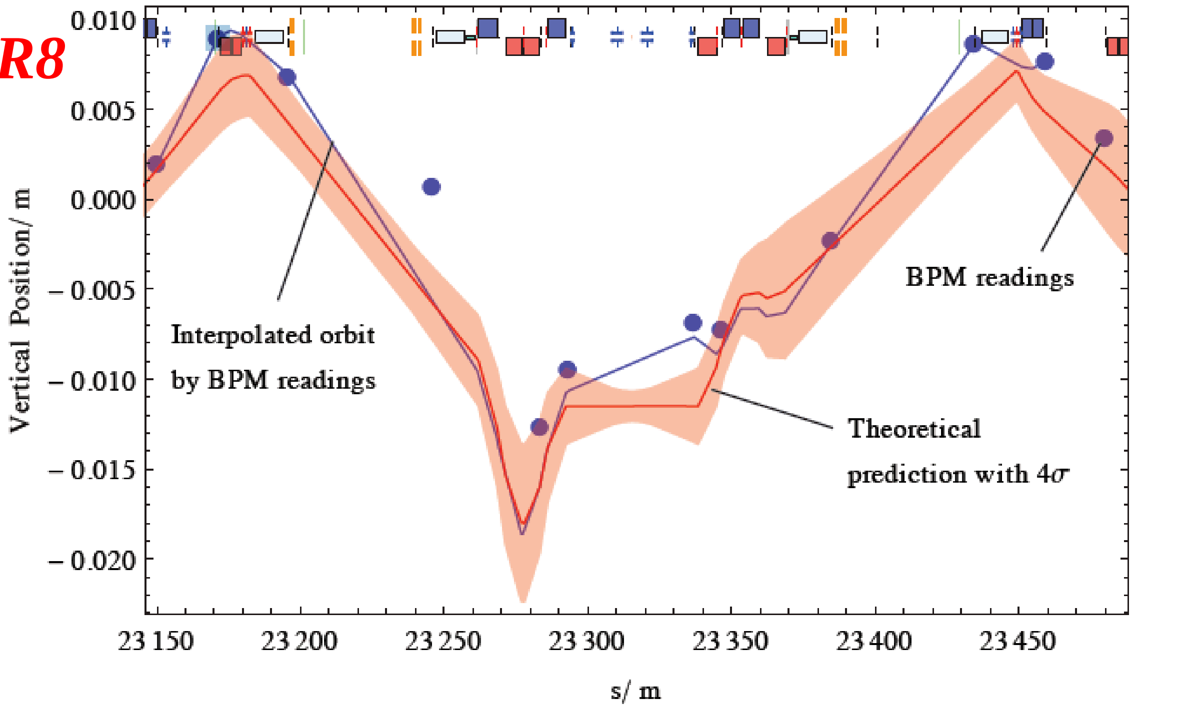
Overall Aperture Radius:

17.8mm + 4σ = 23.8mm

Aperture Measurements in IR8

combining the information

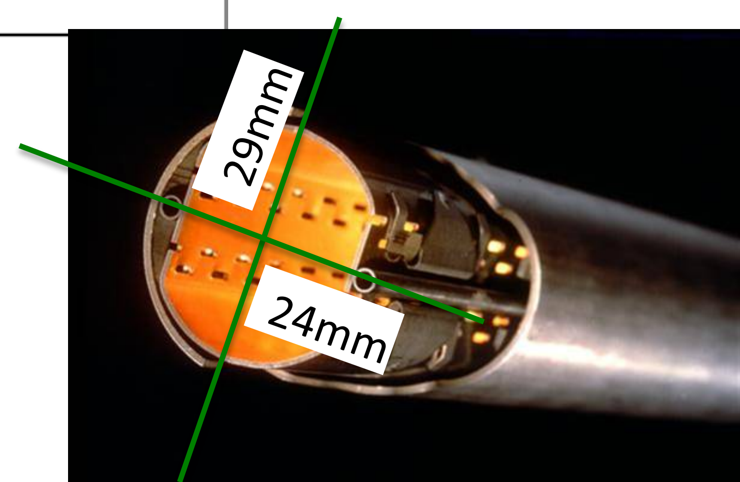
court. Pascal Hermes



Results:

	crossing bump	Aperture Beam1 (mm)	Aperture Beam2 (mm)
Theory	on / off	23.8	23.8
BPM uncorrected	on / off	21.7	20.6
BPM corrected	on	25.4	25.1
	off	24.4	23.2

Within the tolerances we get the aperture in IR8 that we expect



further reading:
CERN-ATS-Note- on "Aperture Measurement in IR8", CERN-BE-2013-003

Conclusion:

Measured aperture in IR8 fits to the beam screen dimension.

LHCb sees a systematic effect

... we have to be prepared for a vertical crossing angle at IP8

Applying the same procedure as in 2012 is a solid solution,
the reduced beam separation during step2 is cured via the smaller beam emittance.
and larger effective hor. crossing angle (4µm, separation > 9σ)

The calculations done refer to E=6.5 TeV.
If a 4 TeV run should be needed (??) after LS1 with 25ns beams and LHCb "bad"
we should re-check the procedure.

... Alles wird gut