ALICE crossing angle in Pb-Pb for nominal 100 ns

ALICE Crossing Angle

When the beams are colliding, the vertical half-crossing angle at the ALICE experiment is [14]

$$\theta_{y_c} = \frac{\pm 490\,\mu\text{rad}}{E_b/(7Z\,\text{TeV})} + \theta_{y\text{ext}} \tag{22}$$

where the first term is the angle created by the orbit bump (entirely inside the innermost quadrupoles) required to compensate the detector's muon spectrometer magnet (whose field can vary in polarity but not magnitude) and the second term is the contribution of an "external" bump created by orbit correction dipoles further out.

In order to provide an unimpeded path for "spectator" neutrons emerging from the collisions to the Zero-Degree Calorimeter (ZDC) [34, 35], the condition

$$|\theta_{y_c}| < 60\,\mu\text{rad} \tag{23}$$

has been imposed in heavy-ion operation up till now. With bunch spacings, $S_b/c = 100\,\text{ns}$, as foreseen in the original LHC design [4], this provides adequate separation at the parasitic beam-beam encounters around the IP.

Minimum separation in IR2 for 50 ns bunch spacing

From RLIUP workshop 2013.

Since then the 50 ns basic bunch spacing has become the baseline for HL-LHC Pb-Pb collisions.

N.B. HL-LHC Pb-Pb starts after LS2.

For safety, we should have several sigma separation at the closest encounters which means larger crossing angles.

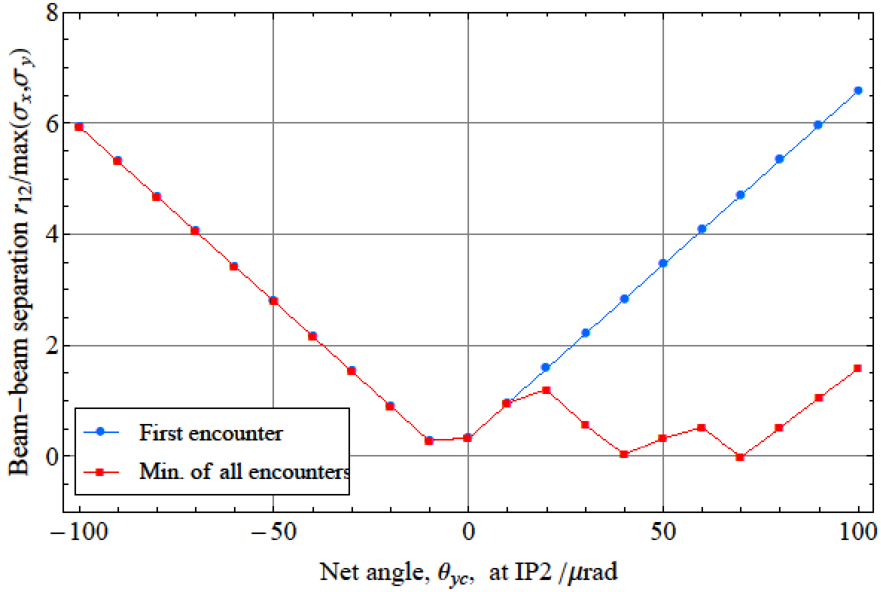


Figure 24: Beam-beam separation in IR2 as a function of the net half-crossing angle at the IP, θ_{yc}, for $E_b = 7Z$ TeV with $\beta^* = 0.5$ m, the design Pb normalised emittance of $\varepsilon_n = 1.5\,\mu$m and a regular bunch spacing of 50 ns and with the ALICE spectrometer polarity such as to contribute a positive crossing angle at the interaction point. At $\theta_{yc} = +70\,\mu$rad, the external angle is zero and parasitic head-on collisions occur. Separations are shown in units of the larger of the horizontal and vertical beam sizes, both at the first parasitic encounter (on either side of the IP) and at the minimum over all encounters excluding the IP itself.

Previous changes to avoid ZDC shadowing

CERN-ATS-Note-2011-014

2 March 2011

John.Jowett@cern.ch

Moving the Recombination Chambers to Replace the Vertical Tertiary Collimators in IR2

R.B. Appleby, J.M. Jowett, J. Uythoven
CERN, CH-1211 Geneva 23

Keywords: LHC, aperture, ALICE

Summary

Recent studies have shown that the vertical tertiary collimators (TCTs) in IR2 of the LHC shadow a significant fraction of the spectator neutrons produced at the interaction point and detected by the forward region Zero-Degree Calorimeter (ZDC) of the ALICE experiment. A solution to this problem is to add an additional TCT beyond the ZDC so that the jaws of shadowing TCT can be opened, allowing the neutrons to pass. This requires moving the beam recombination chamber to vacate sufficient space for the additional collimator, creating a possible aperture restriction where the beams are close to the wall of the recombination chamber. Eventually, the original shadowing TCT can be removed. In this note, we report mechanical aperture calculations for this region in terms of the quantity n_1, conventionally used at the LHC, for a variety of circulating beam and injection scenarios. We find that the smallest aperture occurs when the injection kicker does not fire, and the resulting n_1 for the moved chamber is large enough according to the customary criterion for the LHC. Therefore, from this aperture perspective, the move of the recombination chamber by 1.36 m is permissible.

The Problem

The ZDC is at a distance of 114m and has an acceptance size of 7cmx7cm i.e. seen from the IP it has an angular size of +-307 microRad in x and y direction.

For a given crossing angle the ZDC is moved such that the straight line prolongation from the beam at the IP is passing through the center of the ZDC. If a collimator is now inside +-307 microRad of this line, i.e. if a collimator is sticking into the line of sight between the IP and the ZDC, we say that this collimator is shadowing the ZDC.

Slide by Werner Riegler (2014)

Interferences

Collimator	Max full gap (mm)	Distance from IP (mm)	Half angle of shadow free region (uRad)	ZDC acceptance half angle (uRad)	Resulting max crossing angle (uRad)	Crossing angle PbPb nominal (uRad)	crossing angle pp nominal (uRad)	interference PbPb (uRad)	interference pp (uRad)
TDI	110	83533	658.4	307	351.4	80	150	-271.4	-201.4
TCDD	84	71728	585.5	307	278.5	80	150	-198.5	-128.5
TCTVB	56	74488	375.9	307	68.9	80	150	11.1	81.1
TCLIA	56	76508	366.0	307	59.0	80	150	21.0	91.0
TCLIA maximal displacement	56	72748	384.9	307	77.9	80	150	2.1	72.1
TCLIA at TCTVB position	56	74488	375.9	307	68.9	80	150	11.1	81.1

Moving the TCTVB behind the ZDC (i.e. installing a new different collimator behind the ZDC) is necessary because the TCTVB must stay closed during collisions and cannot be fully opened for ion operation beyond 2011.

Removing the 'old' TCTVB and displacing the TCLIA to the maximum would minimize the shadowing of TCTLIA.

If such a large displacement is not possible, moving it to the 'old' TCTVB position represents the best possible solution at this time.

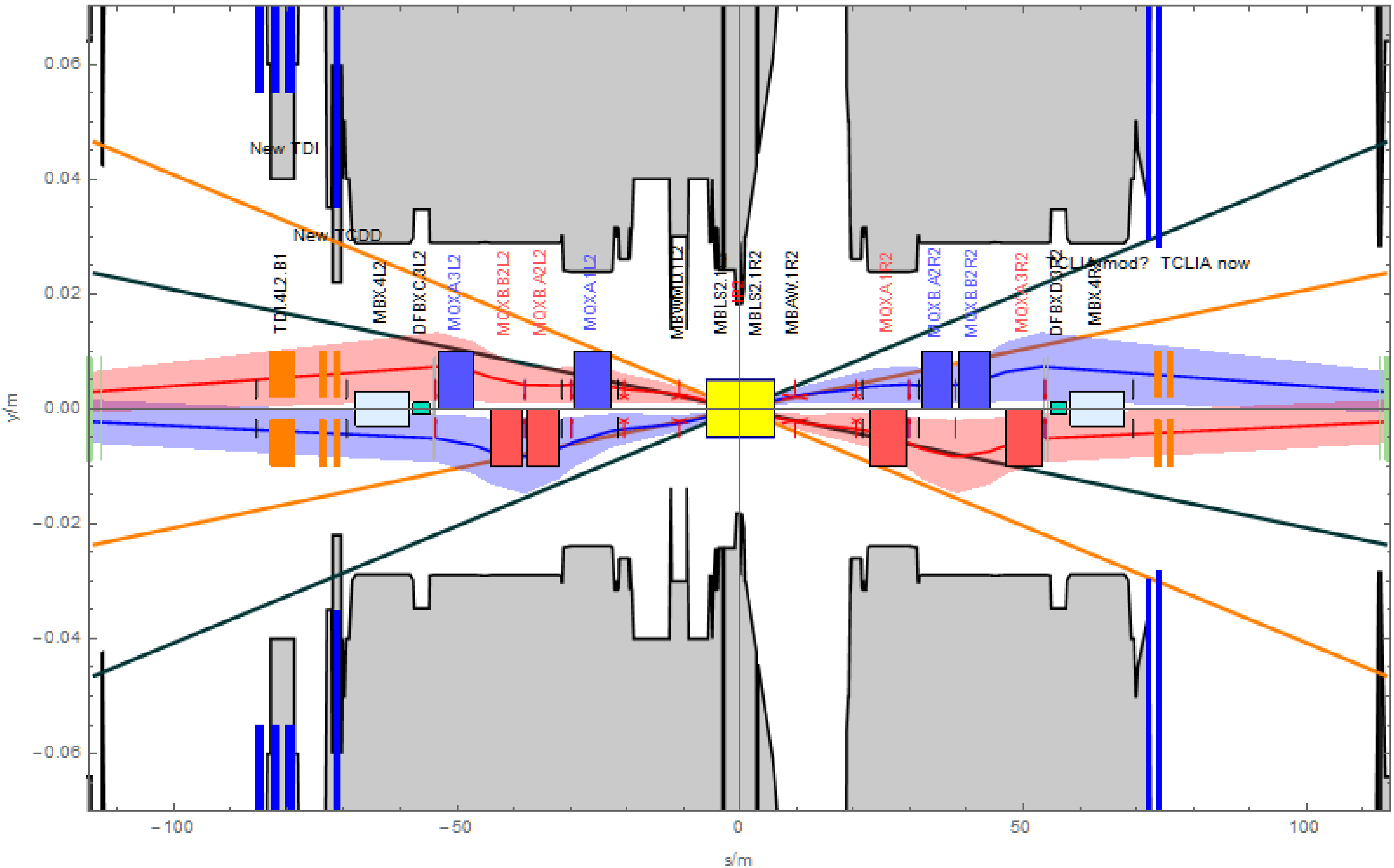
Slide by Werner Riegler (2014)

Following slides will show…

- Show aperture in IR2
  – Not perfectly up to date?
- Beam envelopes for illustration (HL-LHC optics)
  – Present discussion not too dependent on optics
- ZDC spectator neutron shadowing limits (according to WR) for extreme crossing angles , ±100 μrad, (green and orange) as we will reverse ALICE spectrometer polarity
- Schematic representation of new TCLI (59 mm full gap), new TDI jaws (information from A. Lechner), TCDD model with 70 mm full gap of flange when open (latest info from Anton in early 2015)

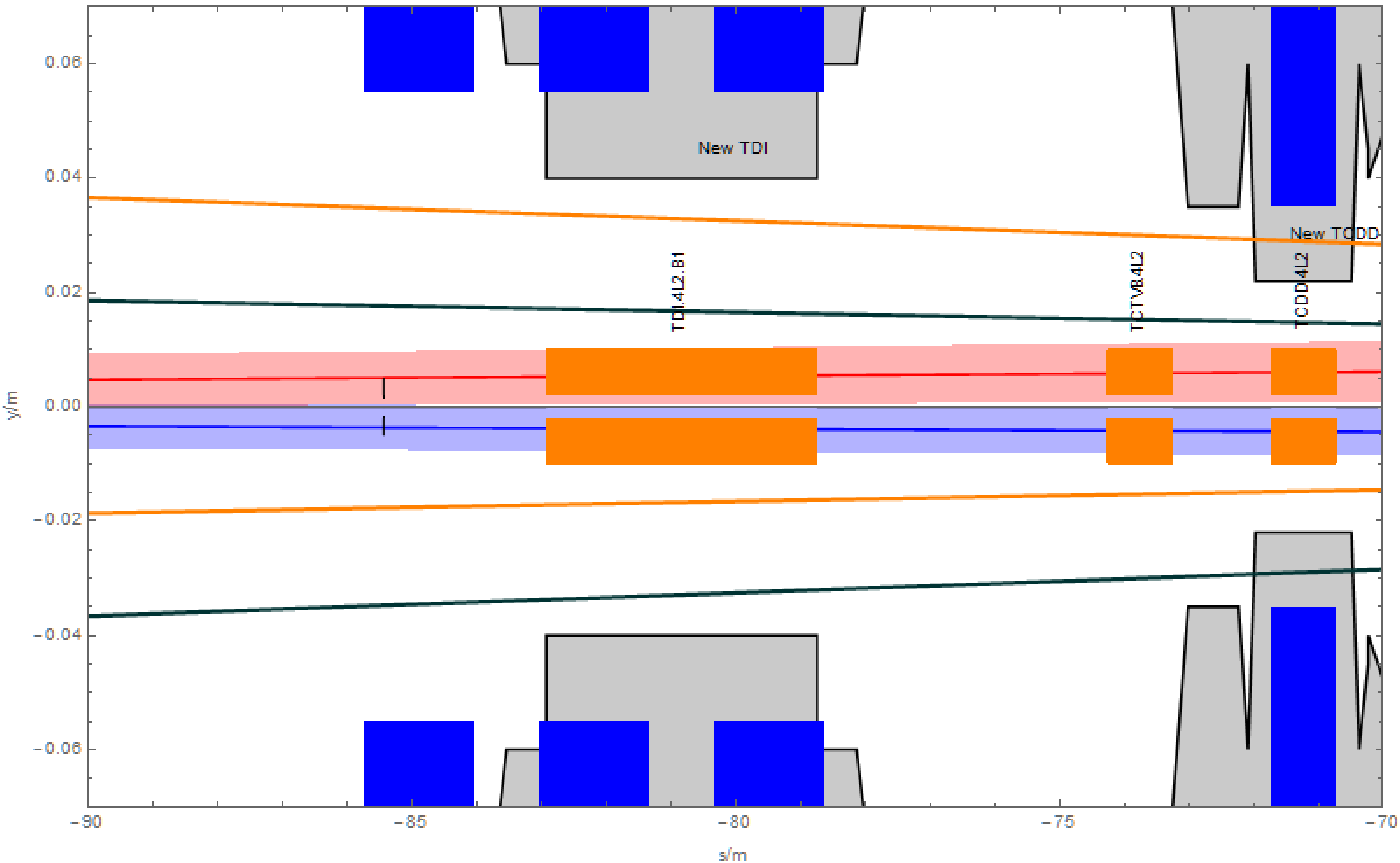
Vertical plane

Extreme positions of ZDC, ±100 µrad



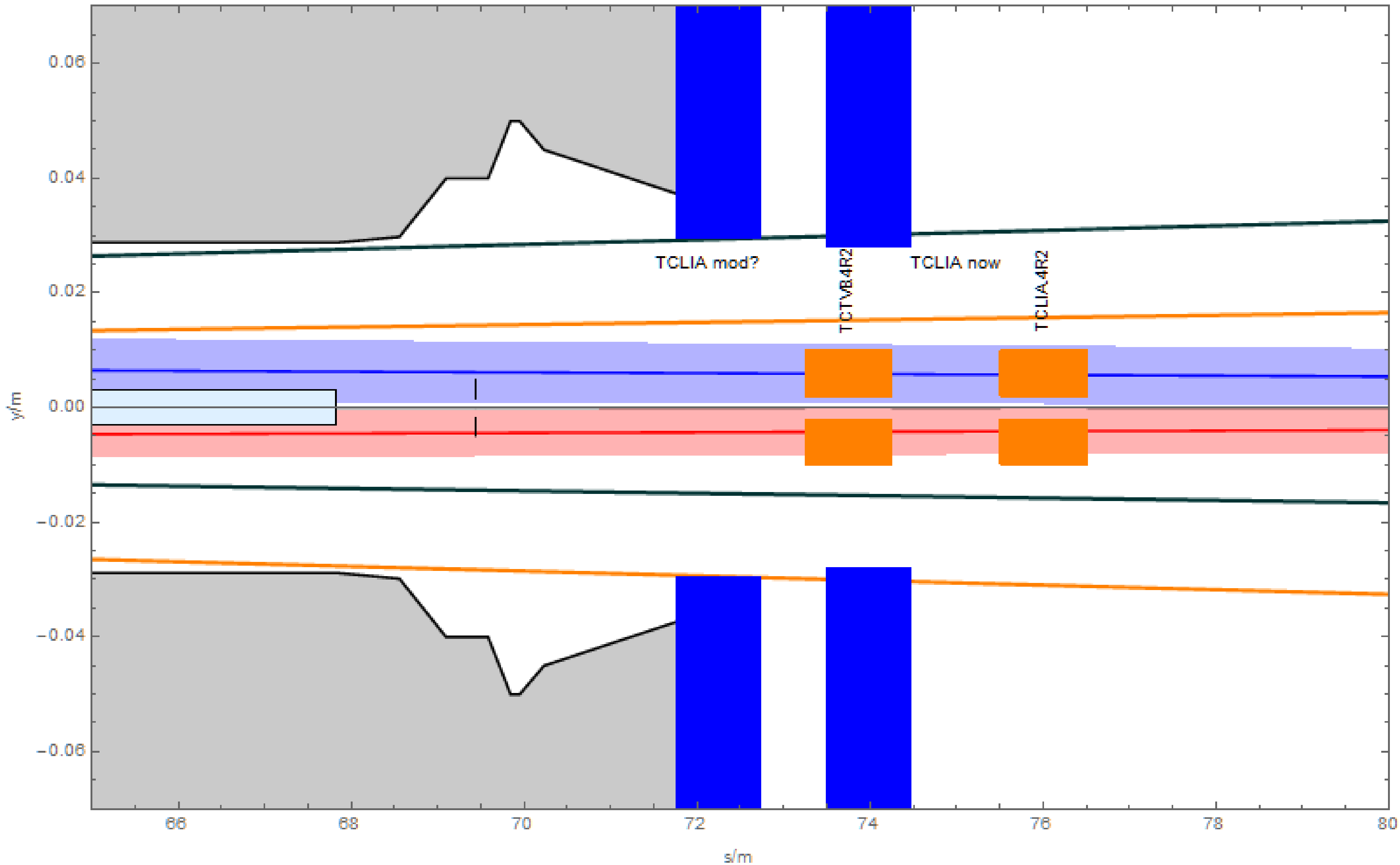
Showing 100 µrad neutron cones

Vertical plane (left detail)



New versions of devices in blue

Vertical plane (right detail)



New versions of devices in blue

Proposal (TREX meeting 21/1/2015)

- Discussion following presentation by J. Uythoven, A. Lechner with input from O. Aberle, V. Baglin

- Modify TCLIA:
  - Stretch the open half-gap by 3 mm
  - Move as close as possible to IP at suitable moment

- Replace TDI for other reasons
  - Under discussion, will be longer and extend further from IP
  - Make sure that it does not shadow ZDC either

- This should leave us with maximum flexibility to choose crossing angle

Conclusion (21/1/2015)

- If
  - half-gap of 29.5 mm is feasible for TCLIA and
  - it can be moved to **72.748 m from IP (end of jaw)**

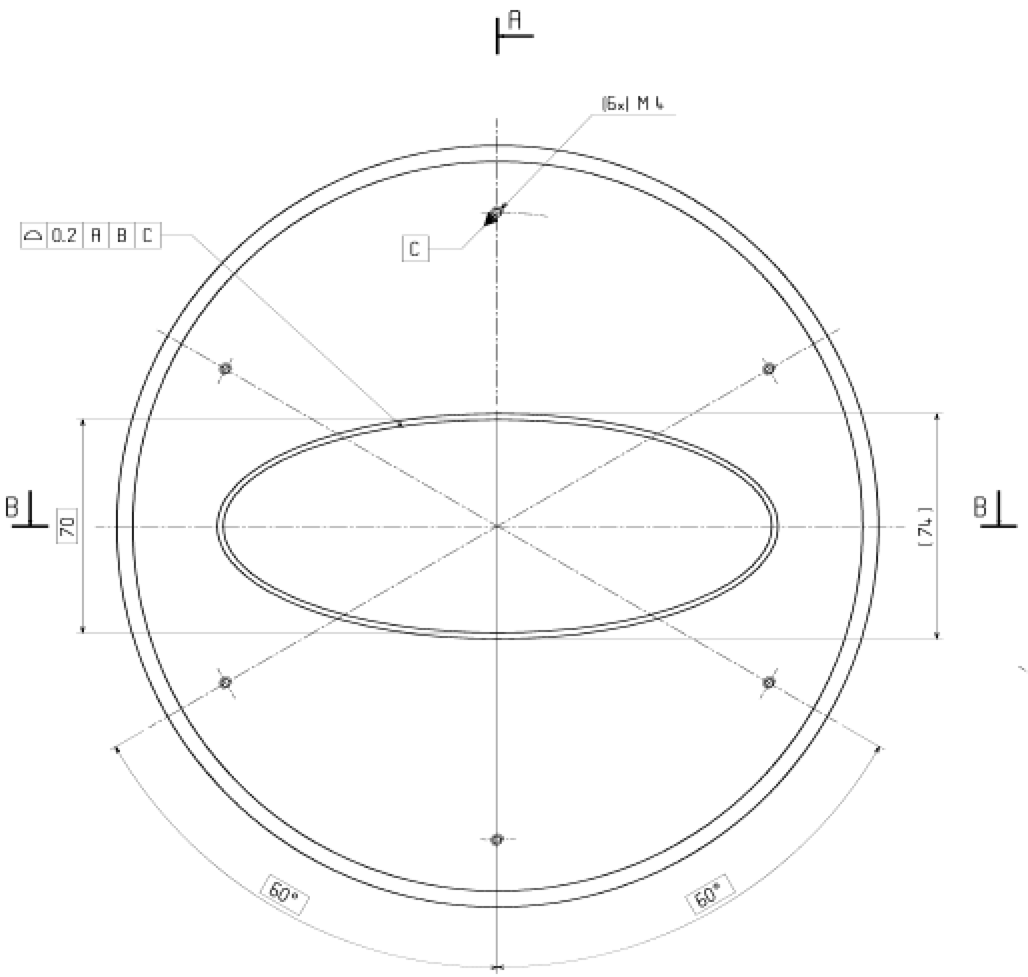
  then we can have ±100 μrad half-crossing angle at IP2 giving ~6σ separation with 50 ns bunch spacing (and nominal emittance)
- New TDI proposal comfortable
- TCDD seems OK if ±35 mm vertical clearance is available in flange, open position
- This gives maximum flexibility available given other chamber restrictions.

BACKUP SLIDES

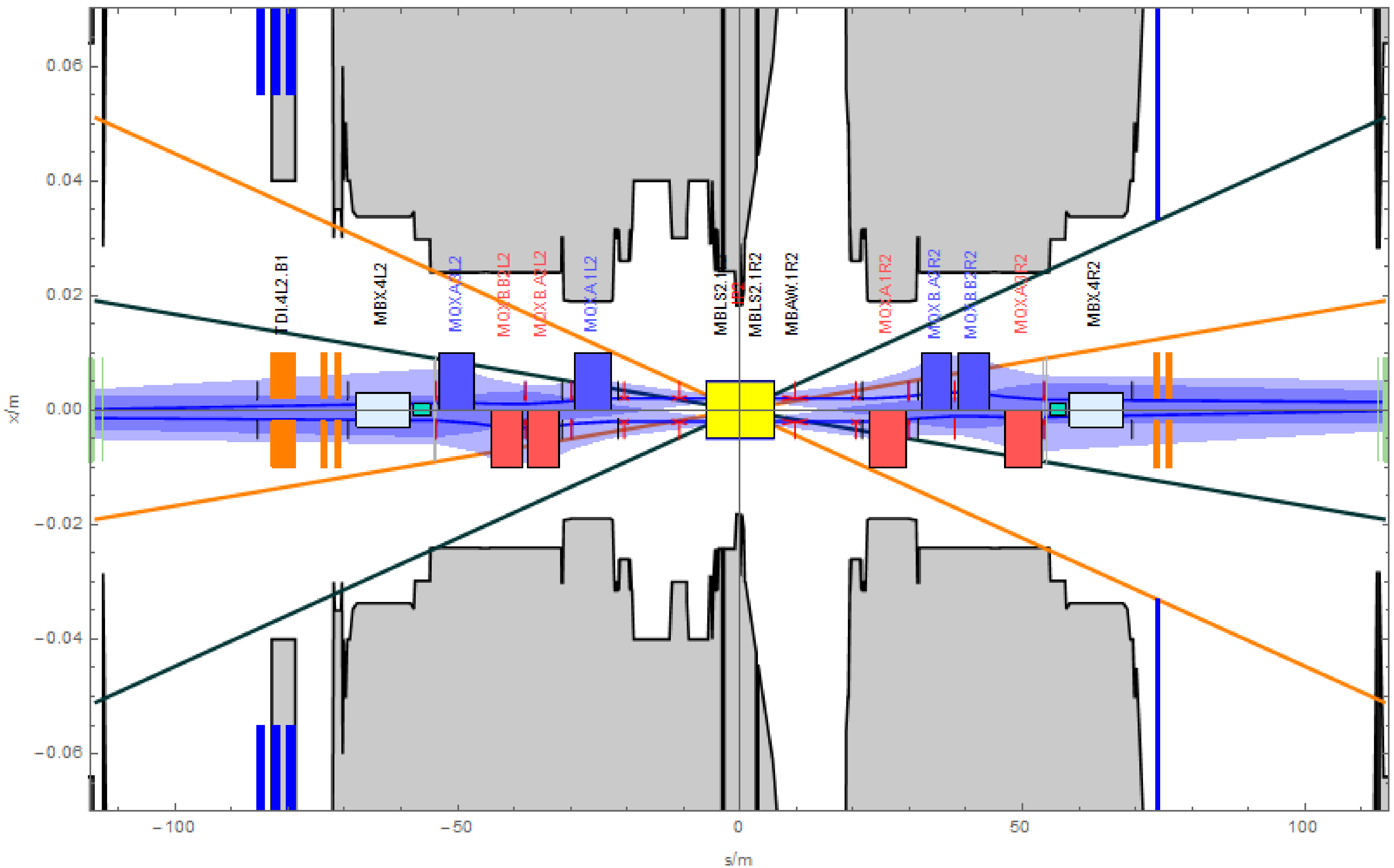
Latest on TCDD (from Anton Lechner)

Vertical aperture limit is not the jaw but the adjacent flange.

Closed position shown in present aperture model data but it appears that a vertical half-gap of 35 mm is available in open position.



Horizontal plane



TCLI, TCDD jaws shown just to locate (not real)

Problem with TCDD (collimator for D1 protection)?

<LAYOUT DATABASE> - Functional Position Type Extra Properties 07/01/15 22:25

Functional Position Type Apertures

Aperture	Offset S	Offset U	Offset V	Shape	Inner Diameter u / v	Ellipse Parameters a/b/c/d
	0	0	0		0.18 / 0.07	0.09 / 0.035 / 0.09 / 0.035
	0.143	0	0	CIRCLE	0.12 / 0.12	0.06 / 0.06 / 0.06 / 0.06
	0.259	0	0		0.06 / 0.06	0.03 / 0.022 / 0.03 / 0.03
	1.741	0	0		0.06 / 0.06	0.03 / 0.022 / 0.03 / 0.03
	1.857	0	0	CIRCLE	0.12 / 0.12	0.06 / 0.06 / 0.06 / 0.06
	2	0	0	CIRCLE	0.08 / 0.08	0.04 / 0.04 / 0.04 / 0.04

6 Entries

SmarTeam references

DETAIL	TRSF	DOC NUMBER - DOC REVISION
MODELE SIMPLIFIE	IDENTITY	ST0212475_01 - a
VACUUM TOP VIEW	IDENTITY	ST0212475_02 - a.00

Extra Functional Position Type Properties

ID	Label	Description	Value

0 Entry

CLOSE

Wed 07/01/2015 22:27

Massimo Giovannozzi

Re: Aperture files

To John Jowett

Message LAYOUT DATABASE - Functional Position Type Extra Properties.pdf (66 KB)

Hello John,
Please find enclosed the aperture information for the TCDD as recorded in the official LHC layout database. It seems that the value of 35 mm for the vertical aperture is confirmed...

Cheers
Massimo

https://layout.web.cern.ch/slottyp... Page 1 of 1