Preliminary study of the placement of a neutral absorber for High-Lumi LHCb

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Why the LHCb upgrade?

The LHCb upgrade aims to **reach experimental precisions of the order of the theoretical uncertainties**

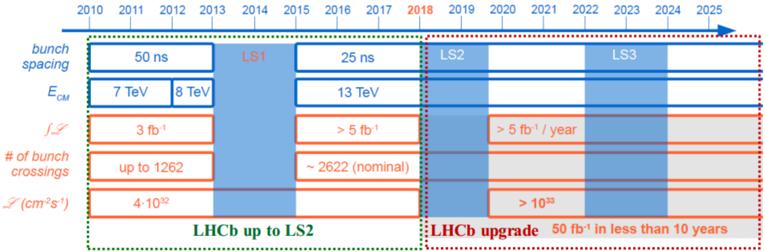
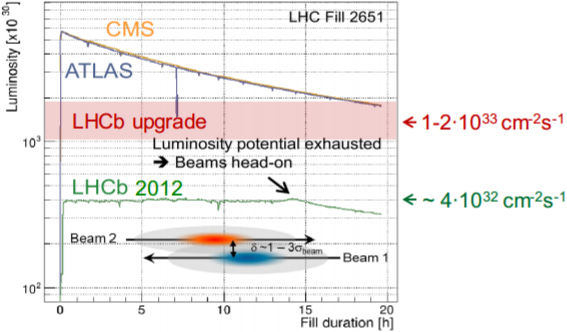


Figure : Expected evolution of luminosity in LHCb. [1]

[1] A. Schopper: *The LHCb Upgrade Program (October '13)*

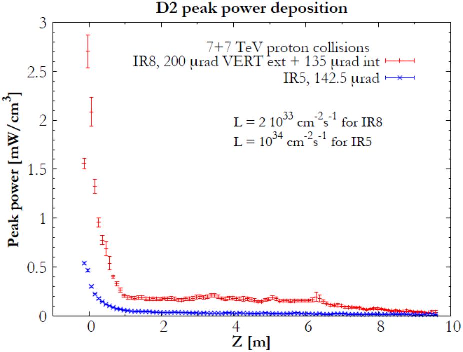
Luminosity evolution



LHCb	Levelled luminosity	Pile up
Up to LS2	$\sim 4 \times 10^{32}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$	~ 1
Upgrade	$1 - 2 \times 10^{33}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$	~ 5

Why a minimal TAN?[2]

D2: P8 left vs P5 (where the TAN absorbs 190W)



29 vs 3 W

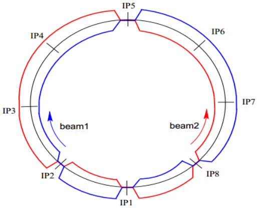
Table 1: Total heat load

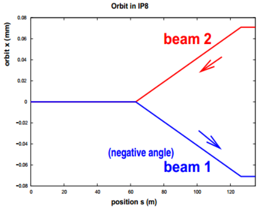
Magnet	IR8 Power [W] at $\mathcal{L}_{\max-\mathrm{LHCb}}$	IR1/5 Power [W] at $\mathcal{L}_0$
Q1	30	43
D2	30	3
IT		150
IT & D1 (left/right)	50/60	

A warm protection is recommended

[2]L. S. Esposito, F. Cerutti et al: *Power load from collision debris on the LHC point 8 insertion magnets implied by the LHCb luminosity increase* (2013)

Horizontal crossing scheme for LHCb





Will use beam 1 as reference beam

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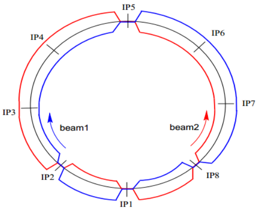

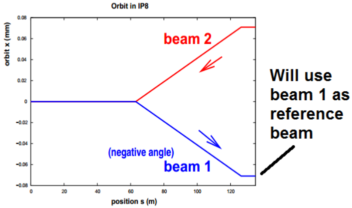

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  ➜ $\pm 2100 \mu$rad at injection and $\pm 135 \mu$rad at collision

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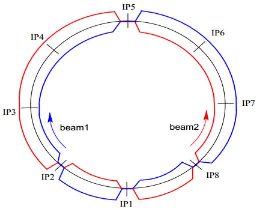

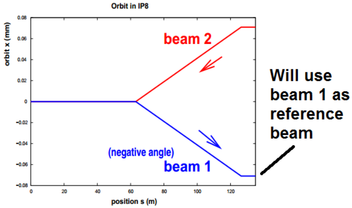

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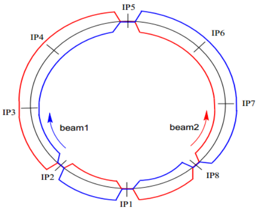

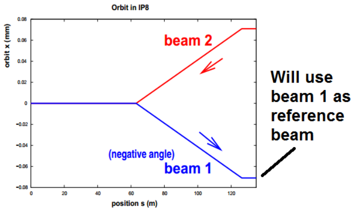

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- **Parallel vertical bump**: beam separation at the IP during injection, acceleration and squeeze to avoid collisions at the IP.

Horizontal crossing scheme for Run II & III [3]

What we need:

[3] S. Fartoukh *LHCb crossing scheme for Run II & III* (August '13)

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- Collision: ext. horizontal crossing angle linearly $\nearrow$ to 250 μrad.
  - MCBX/Y/C strength ✓
  - Aperture n1 $\sim$ 10 ✓

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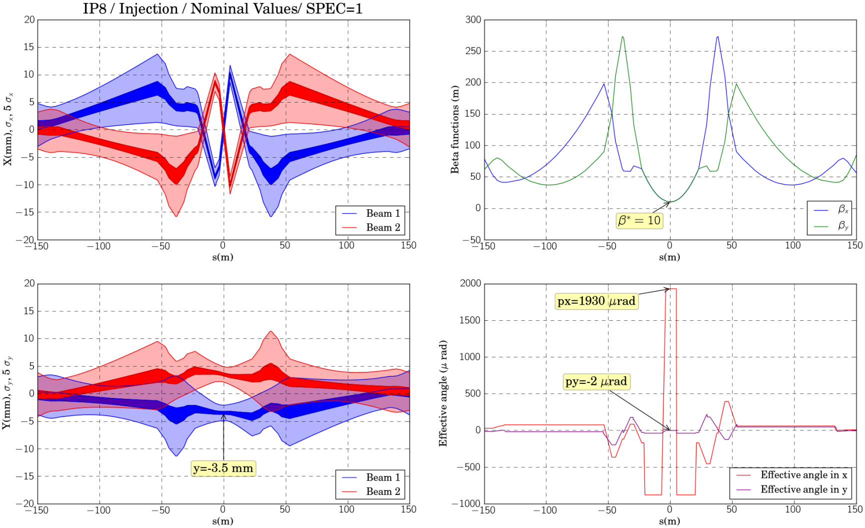
LHCb horizontal crossing scheme summary

Spectrometer	Injection (μrad)	Collision (μrad)
0	px=-170 py=-30	px=-250 py=0
1	px=1930 py=-2	px=-115 py=-1.8
-1	px=-2270 py=-58	px=-385 py=-1.8

Energy	Injection	End of Squeeze	Collision
β^* (m)	10	3	3
Vertical separation (mm)	3.5	1.0	0.0

[4] Spectrometer dipole $\rightarrow$ internal angle = 2100 μrad for inj. and 135 μrad for coll.

LHCb horizontal crossing scheme



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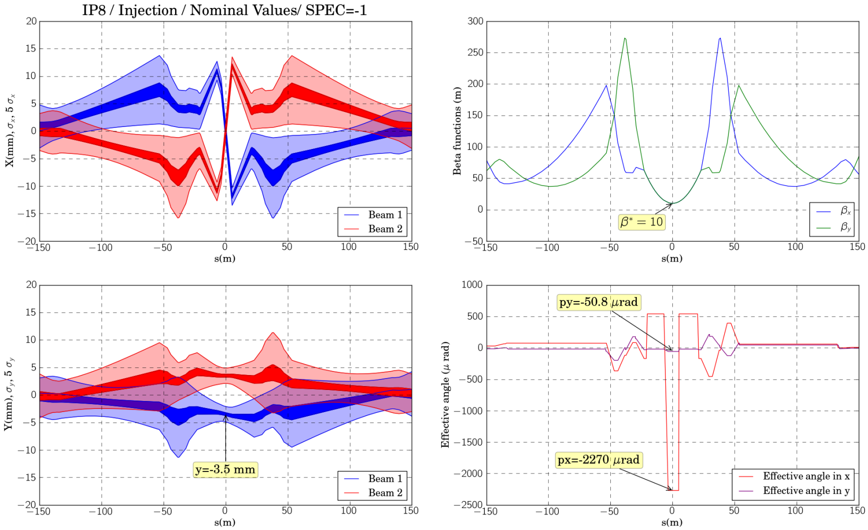

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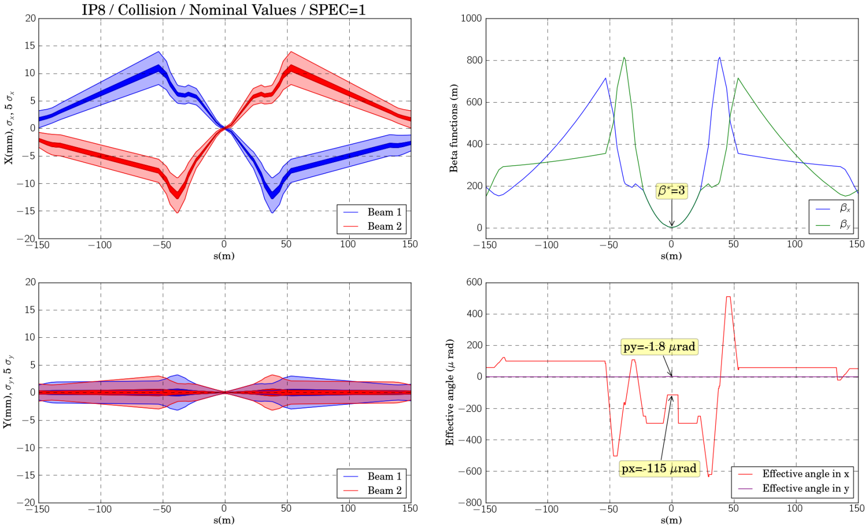

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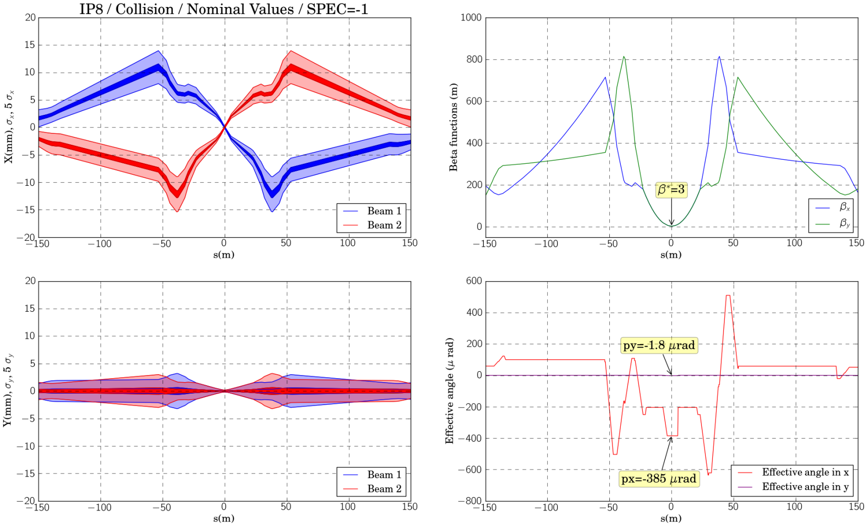
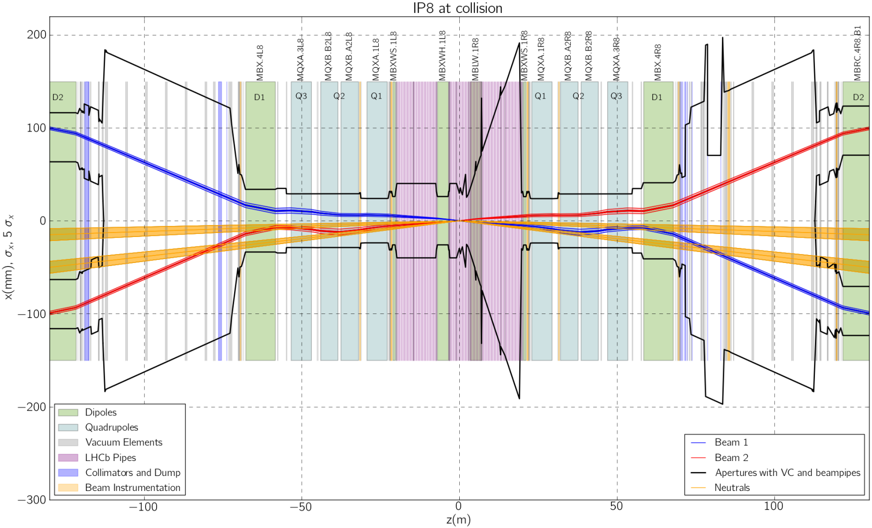


Overview of the beams of neutrals, both polarities



Vertical crossing scheme

Ideally the effective horizontal crossing angle should be the same independently of the LHCb polarity, in order to **avoid any systematic uncertainty in the vertex reconstruction** of the LHCb detector.

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- Has to be done in several steps, takes more time [5]

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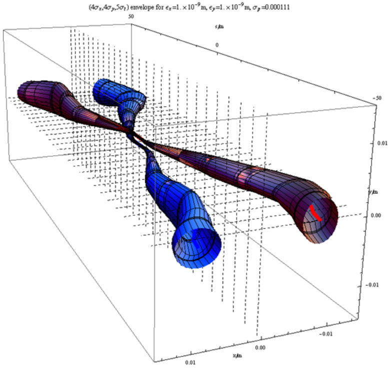
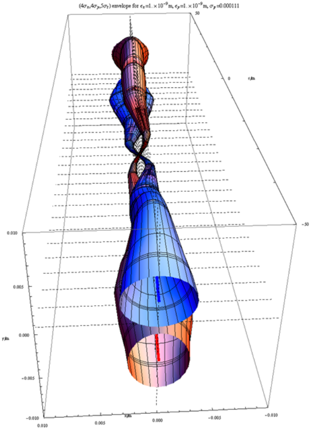
Will there be a vertical crossing angle at collision energy?

Maybe! So just in case...some first values (**bump not optimized!**):

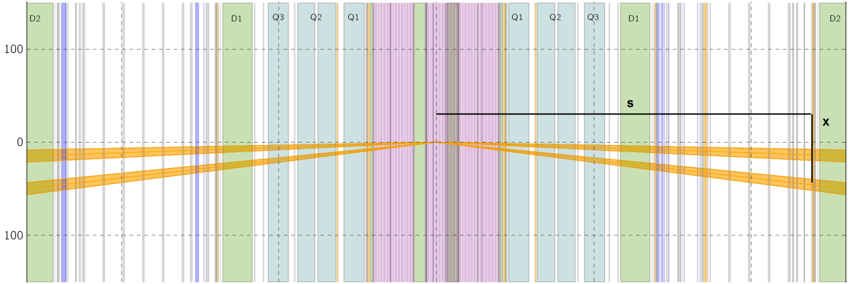
$$\Delta x = -0.69\text{mm} \;\; ; \;\; \Delta y = -0.2\text{mm} \;\; ; \;\; p_x = 0\mu\text{rad} \;\; ; \;\; p_y = 100\mu\text{rad}$$





[6] Courtesy of Reine Versteegen

Dimensions of the absorber



$$\tan(\theta) = \frac{x}{s} \rightarrow x = \overbrace{s}^{=121.7m} \times \underbrace{\tan(\theta_{max})}_{\approx\theta_{max}=(385+100)\mu rad} \rightarrow \boxed{x_{max} = 0.06m}$$

$$\tan(\theta) = \frac{y}{s} \rightarrow y = \overbrace{s}^{=121.7m} \times \underbrace{\tan(\theta_{max})}_{\approx\theta_{max}=(100+100)\mu rad} \rightarrow \boxed{y_{max} = 0.025m}$$

Very rough approximation of the length

Nuclear interaction length = the mean path length required to reduce the numbers of relativistic charged particles by the factor $\frac{1}{e}$ or 0.368, as they pass through matter.

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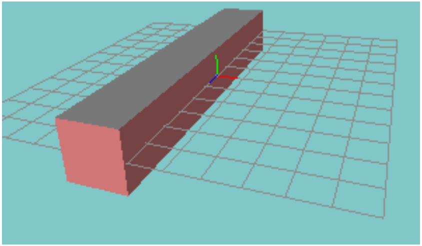
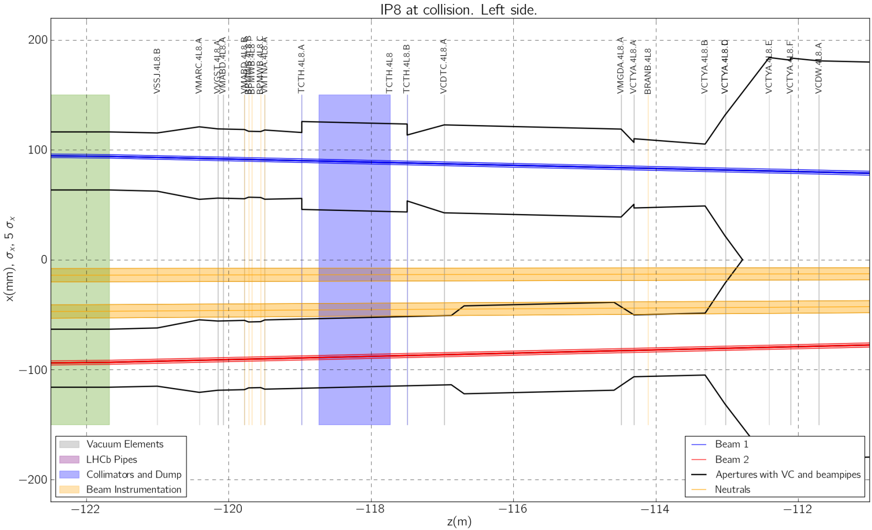


Placement of the TAN



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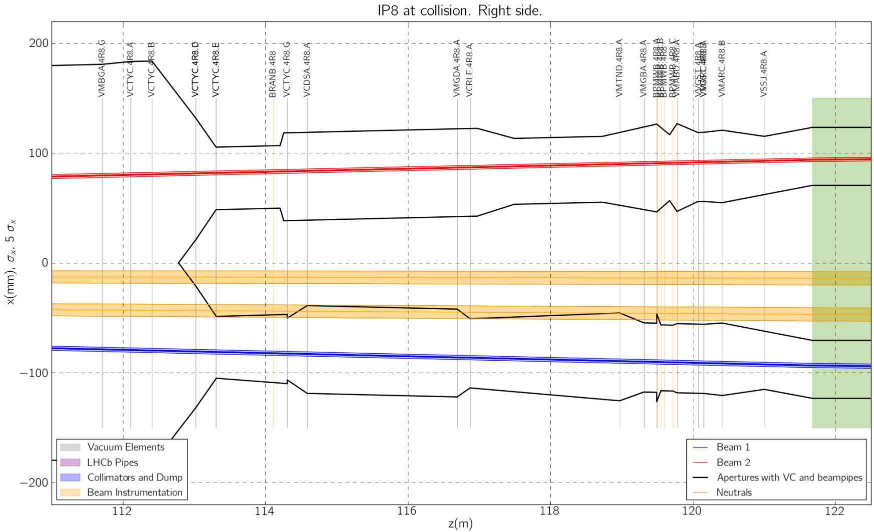
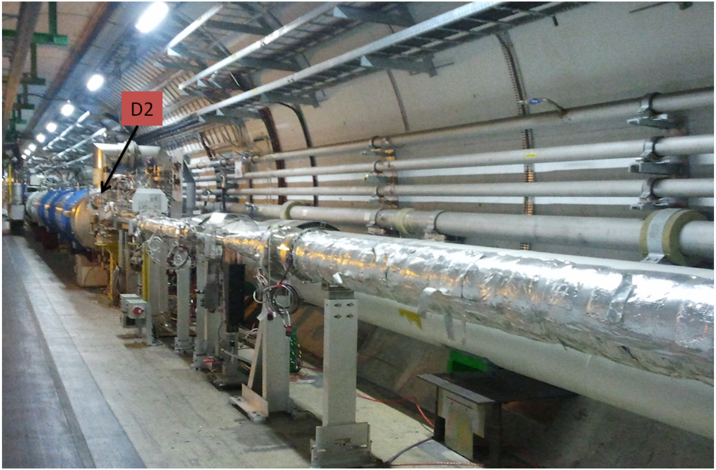


The tunnel



[7] Courtesy of Reyes Alemany

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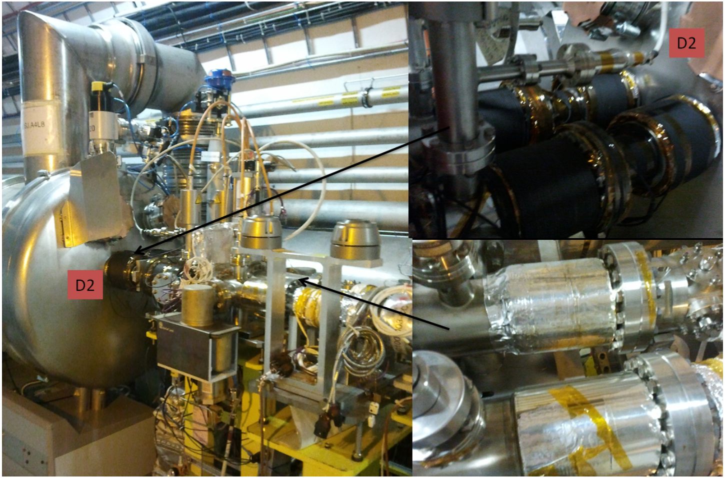

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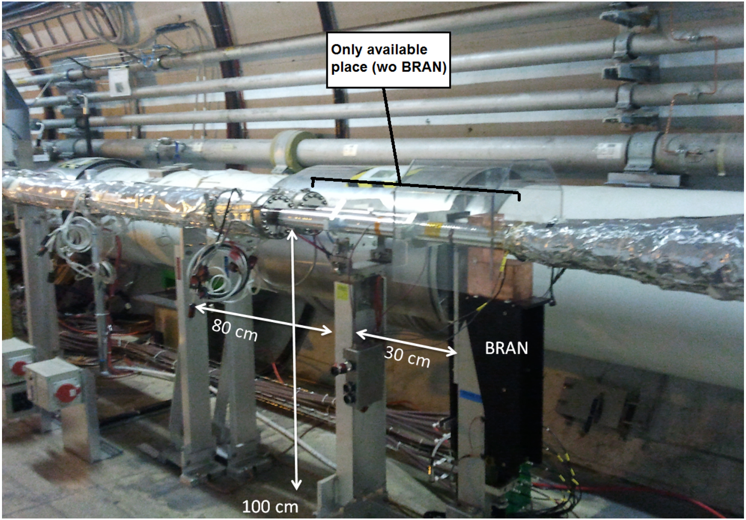

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Placement of the absorber

We have a few videos showing the situation in the tunnel:

- ▸ Video 1 : Left side of IP8. We can see that a possible place is just after the BRAN. Possibility of $\sim$ 60 cm in z.
- ▸ Video 2 : close to D2 there is not enough place in x for the absorber (needs to be 6 cm from the z axis towards us). In the bext place showed in the video we still don't have enough place in x. Only possibility near the BRAN.
- ▸ Video 3 : Rigth side of IP8.

First suggestion

- Place it just after the BRAN (or even in place of the BRAN if it is finally removed)
- Do a first FLUKA simulation of a copper block of 60cm $\times$ 12cm $\times$ 10cm $(z \times x \times y)$, at a position of $\pm$114m of IP8 (block starting at 114, so finishing at 114.60)

Conclusions

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[8] S. Fartoukh and R. Versteegen

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- FLUKA simulation of the block suggested in slide 22

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Acknowledgements

Thank you!

R. Alemany, F. Bouly, H.Burkhardt, S. Fartoukh,
M. Fitterer, M. Giovannozzi, R. Versteegen

References (I)

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