*Workshop on Collider-Experiment interface*
*November 30th, 2012*
*CERN, Geneva, Switzerland*

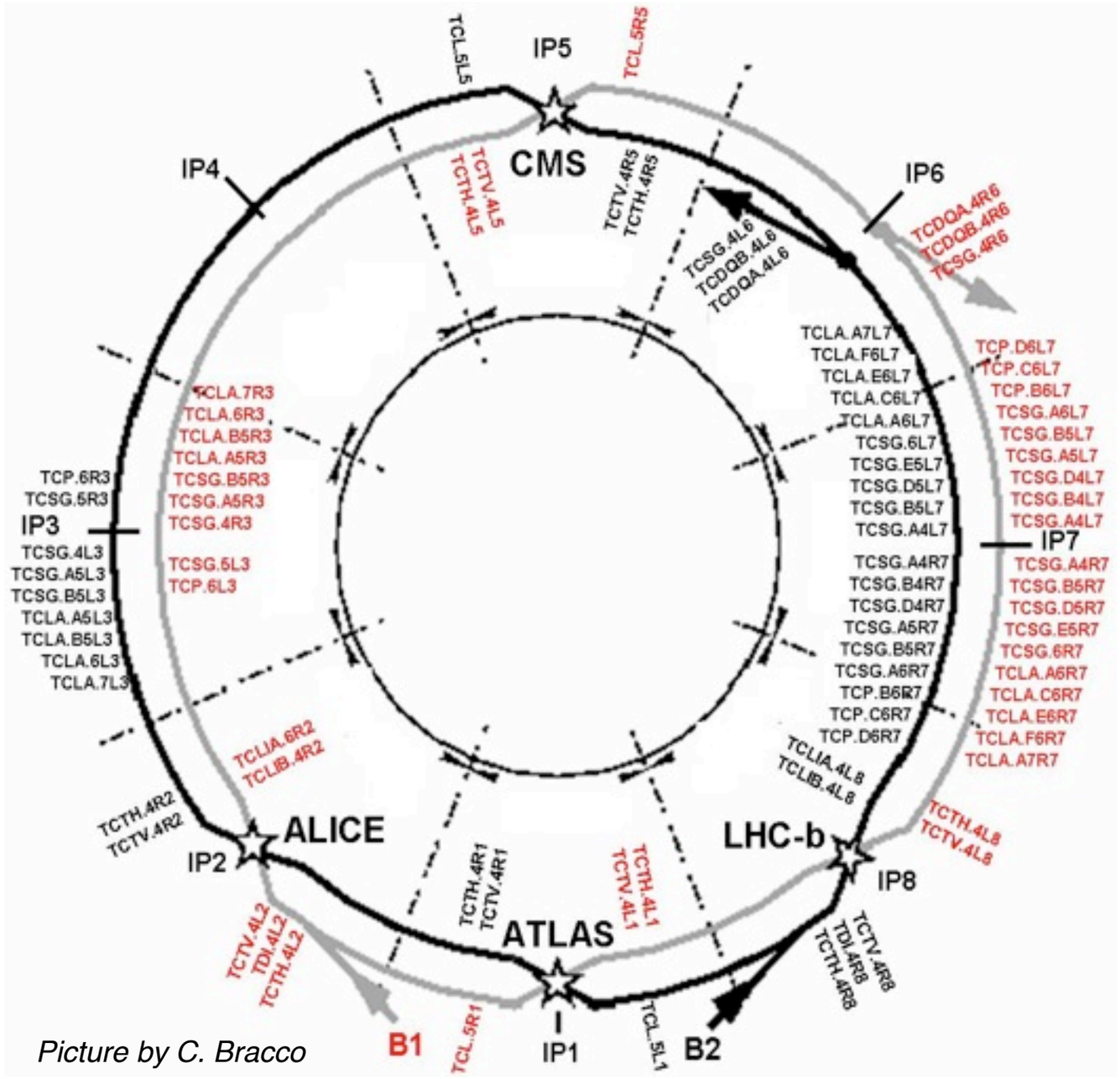
# Mobile collimators in the experimental regions

*S. Redaelli for the LHC collimation project*
*Inputs from: R. Bruce, F. Cerutti, L. Esposito, A. Marsili, A. Rossi*
*Acknowledgements: O. Aberle, R. Assmann, A. Ball, J. Beachler, M. Brugger, S. Chemli, J. Coupard, R. De Maria, M. Deile, S. Fartoukh, K. Foraz, B. Goddard, R. Losito, D. Macina, B. Salvachua, et al.*




*The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.*

# Introduction




*Picture by C. Bracco*

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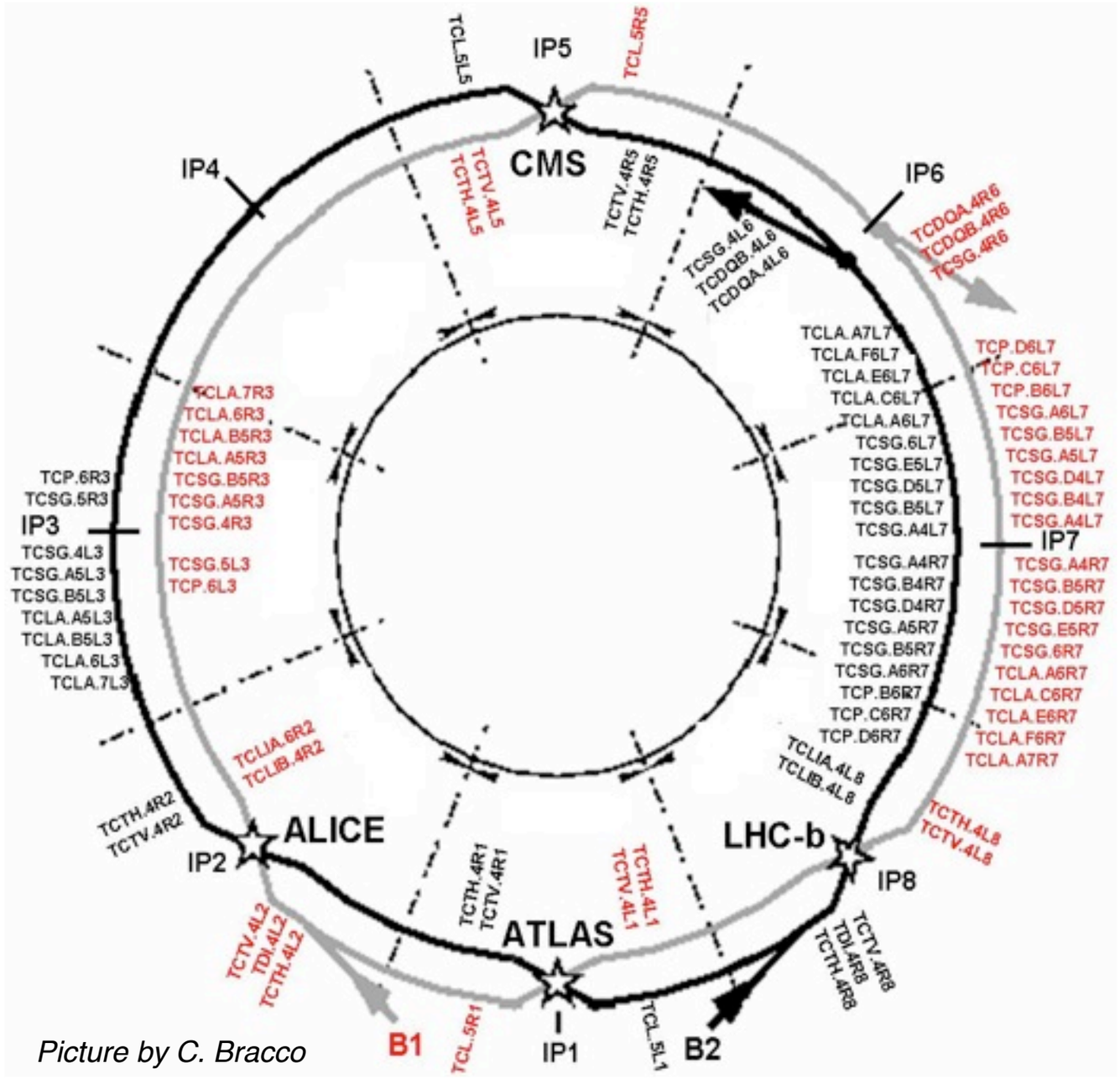


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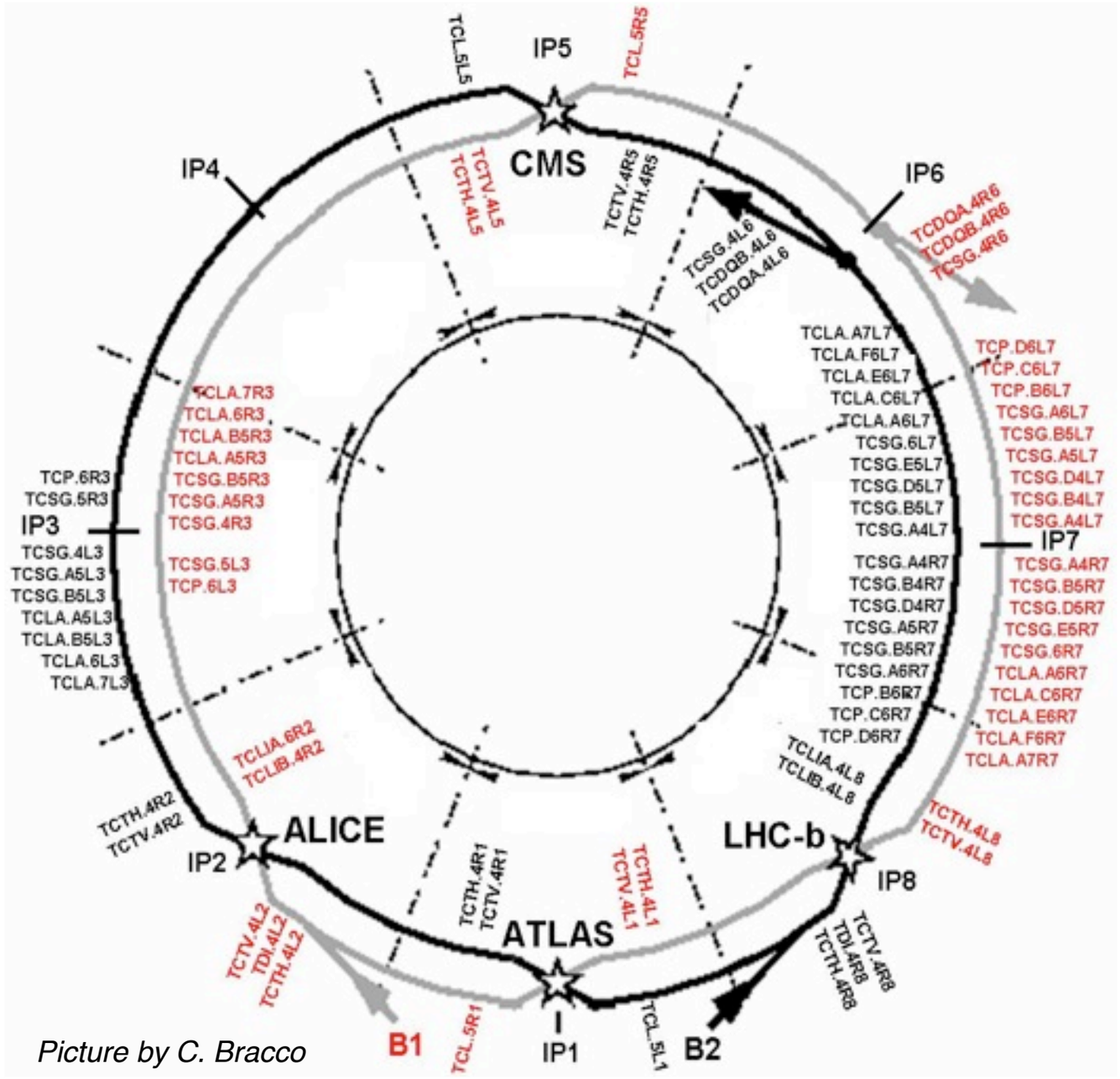


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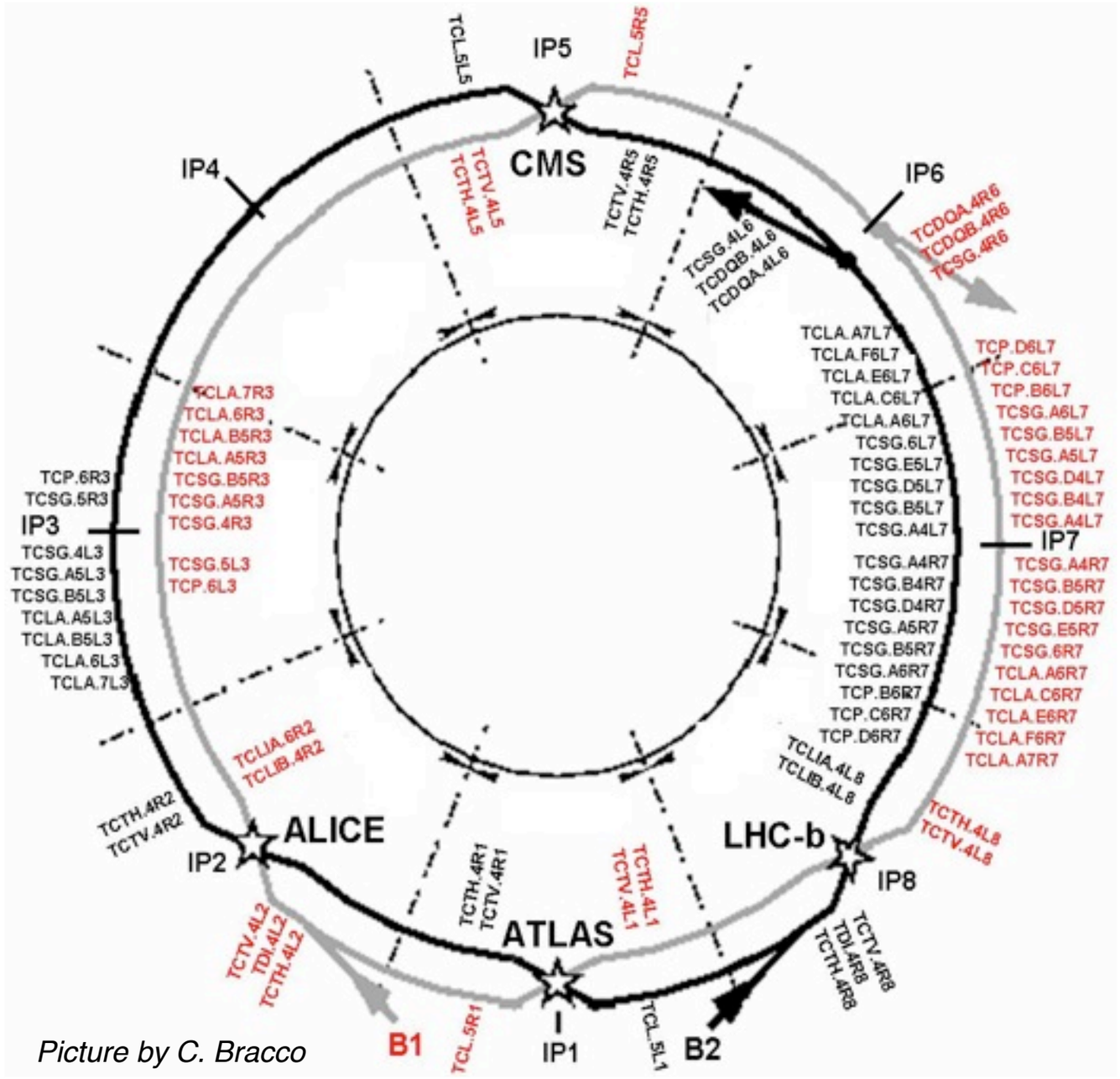


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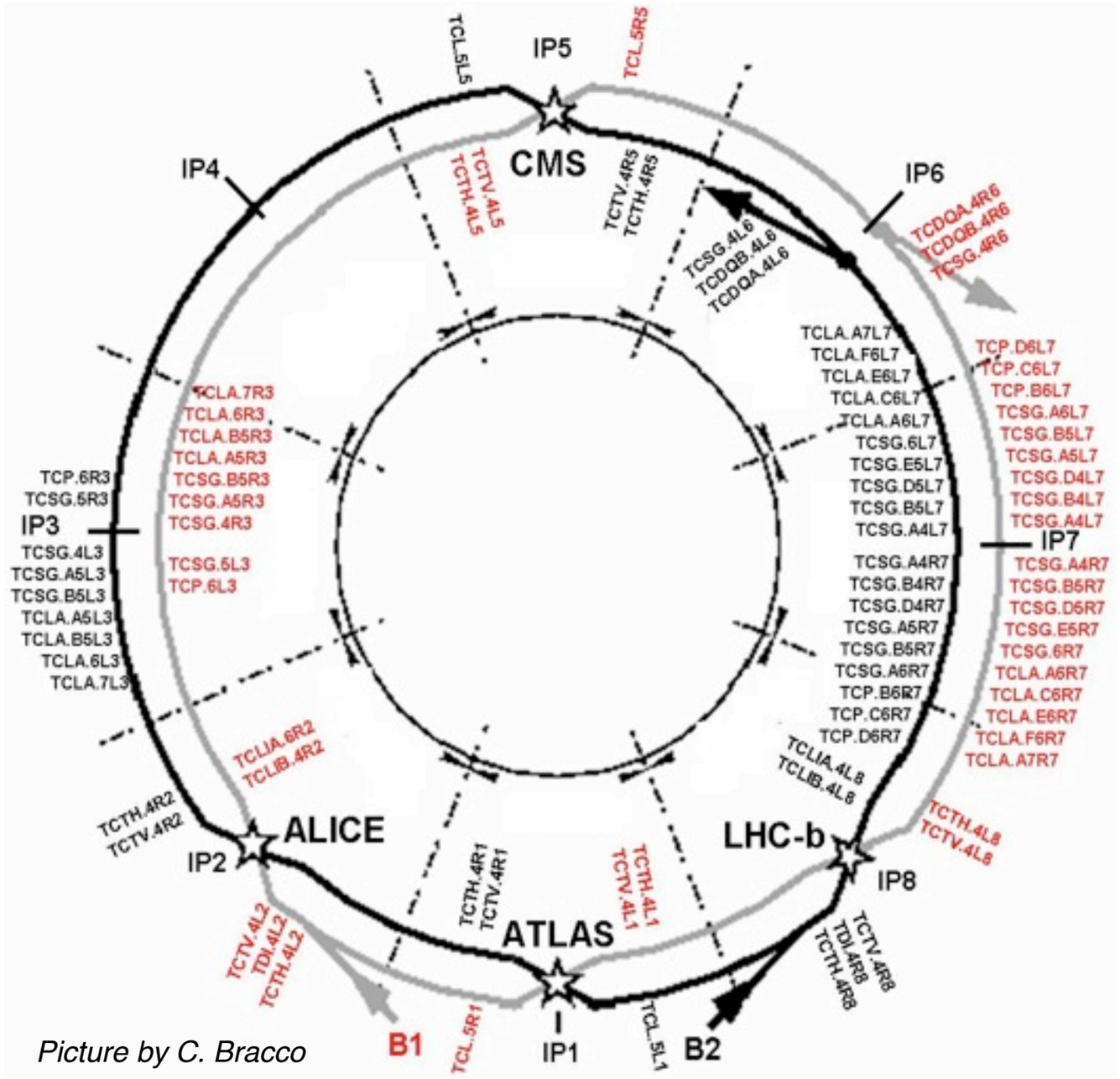


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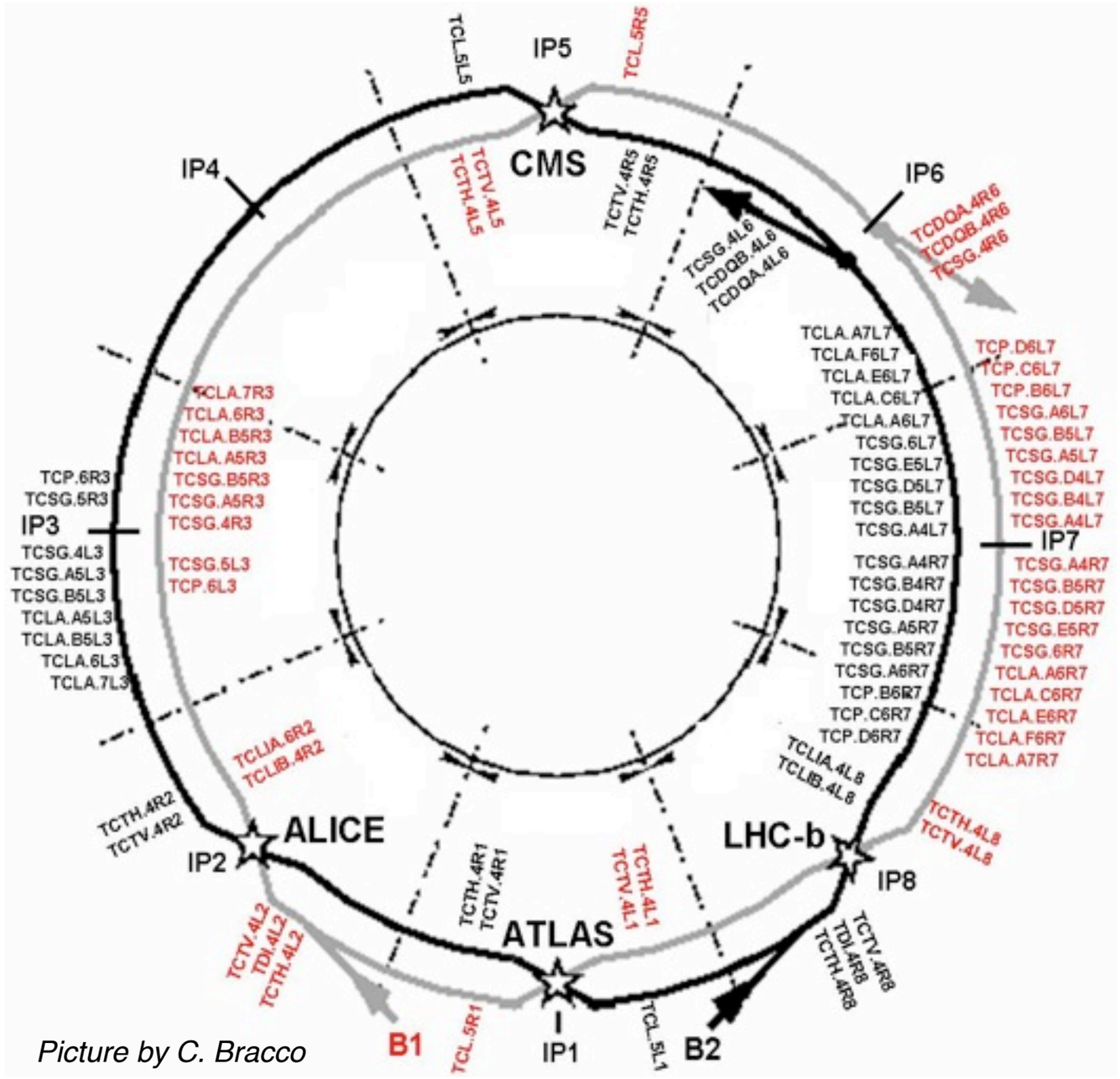


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Scope of this talk *(WP5: incoming beam + collimators downstream TAN)*:
Review the present layouts of the experimental interaction regions (IRs).
Discuss the choices that will determine the layouts between LS1 and LS2.
Discuss various considerations on the strategy for the HL-LHC era.

# Outline

- ☑ Introduction
- ☑ Present designs
- ☑ IR collimation after LS1
- ☑ Considerations for HL-LHC
- ☑ Conclusions

# Collimators in the experiment regions

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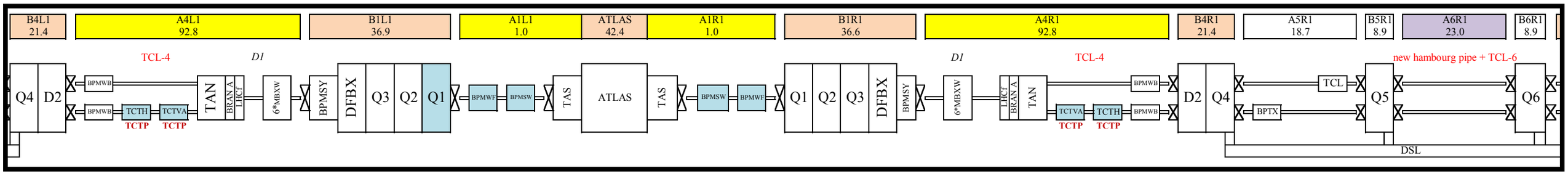
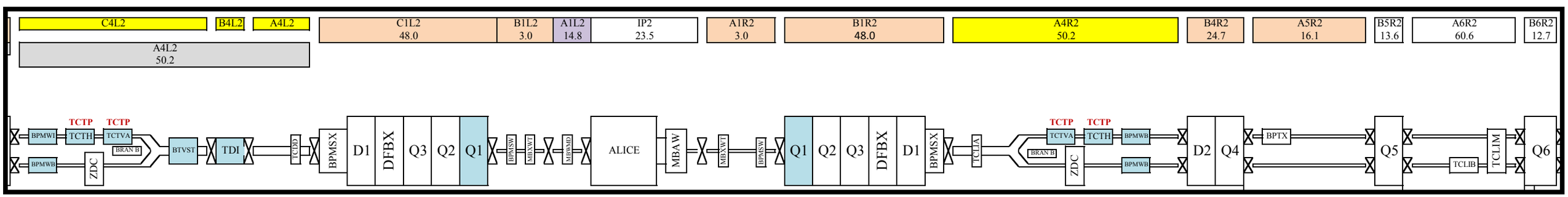



## IR2 - ALICE



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**Three functionalities** for the collimation in the experimental regions:

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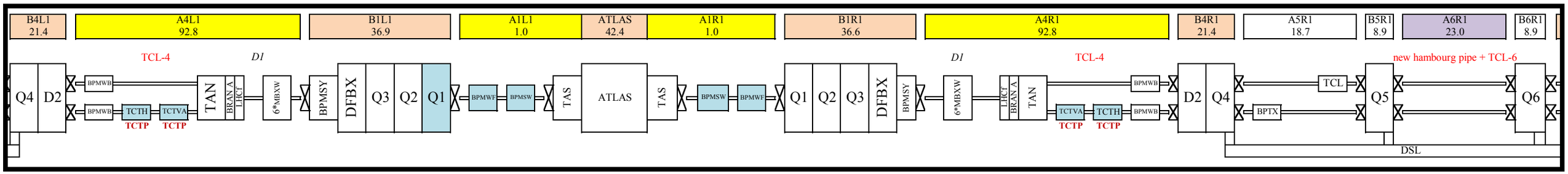


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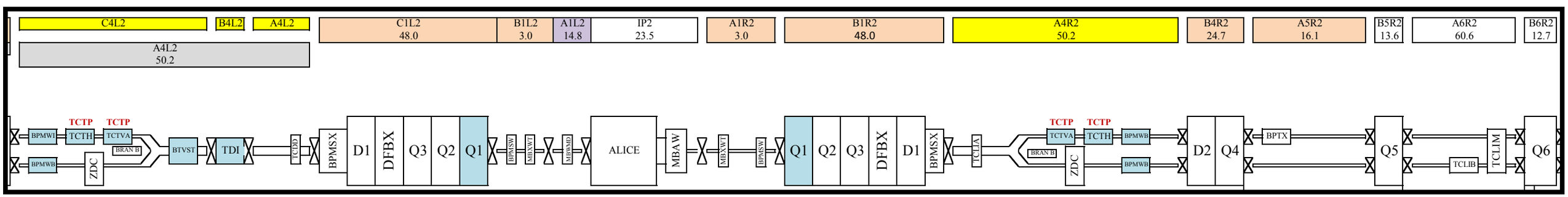

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**Three functionalities** for the collimation in the experimental regions:

1. **Protect** the machine from injection errors
   - TDI, **TCLIA**, **TCLIB**, TCDD in IR2 and IR8 *(**bold**: part of collimation project)*

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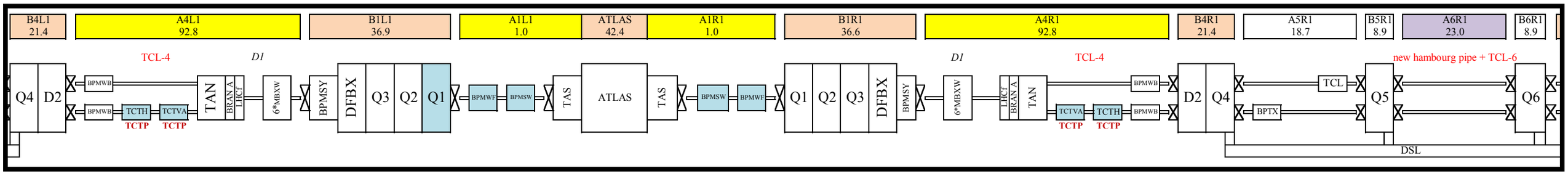


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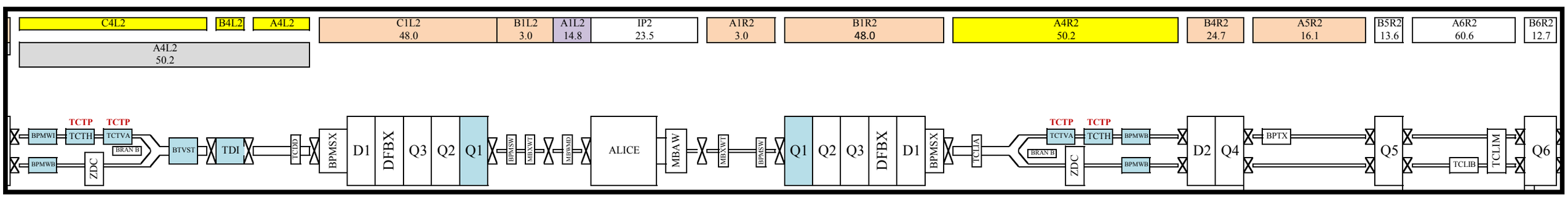

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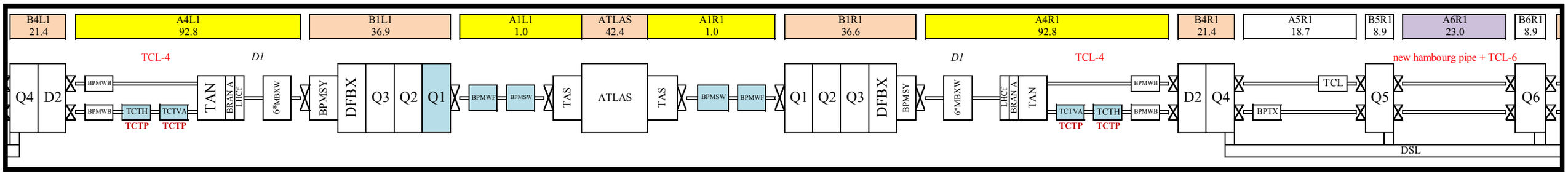


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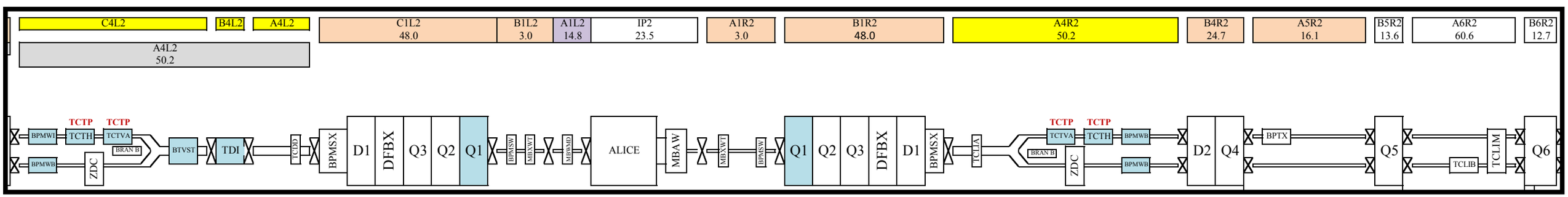

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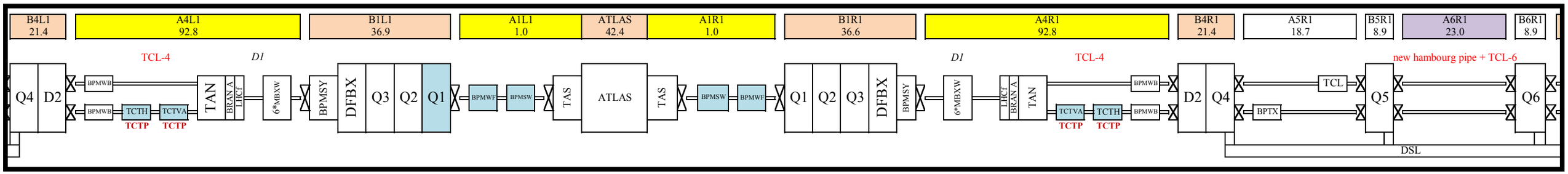


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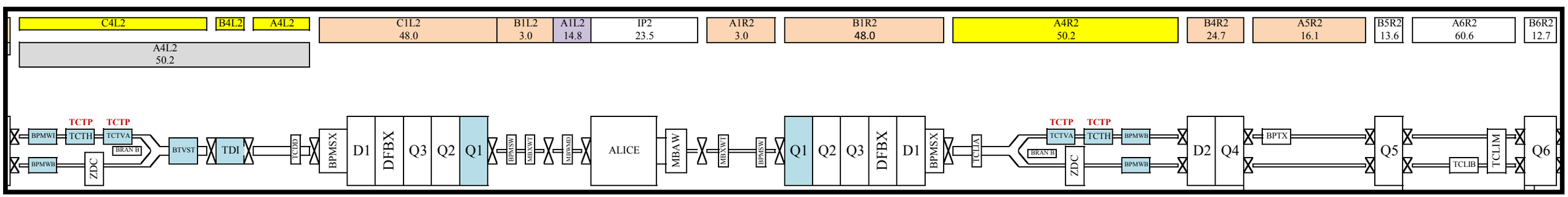

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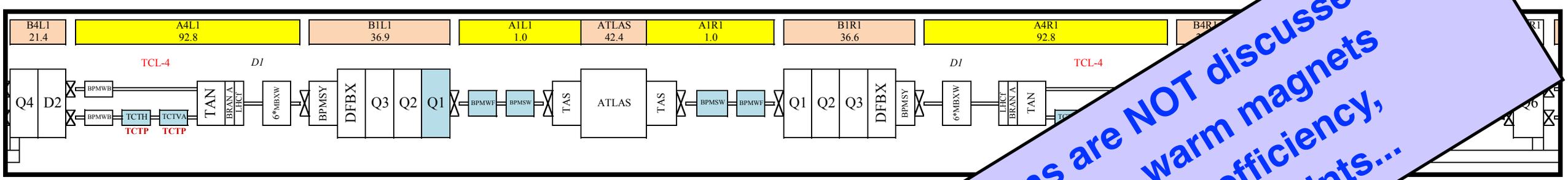


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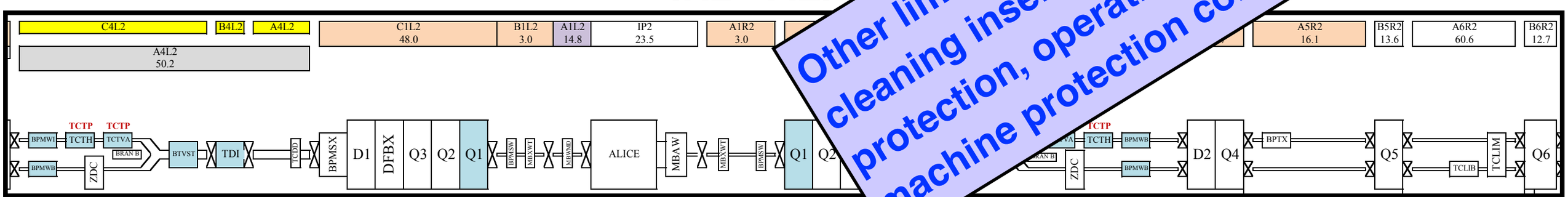


**Other limitations are NOT discusses here: cleaning insertions, warm magnets protection, operational efficiency, machine protection constraints...**

# LHC collimator

1.0m+0.2m tapering

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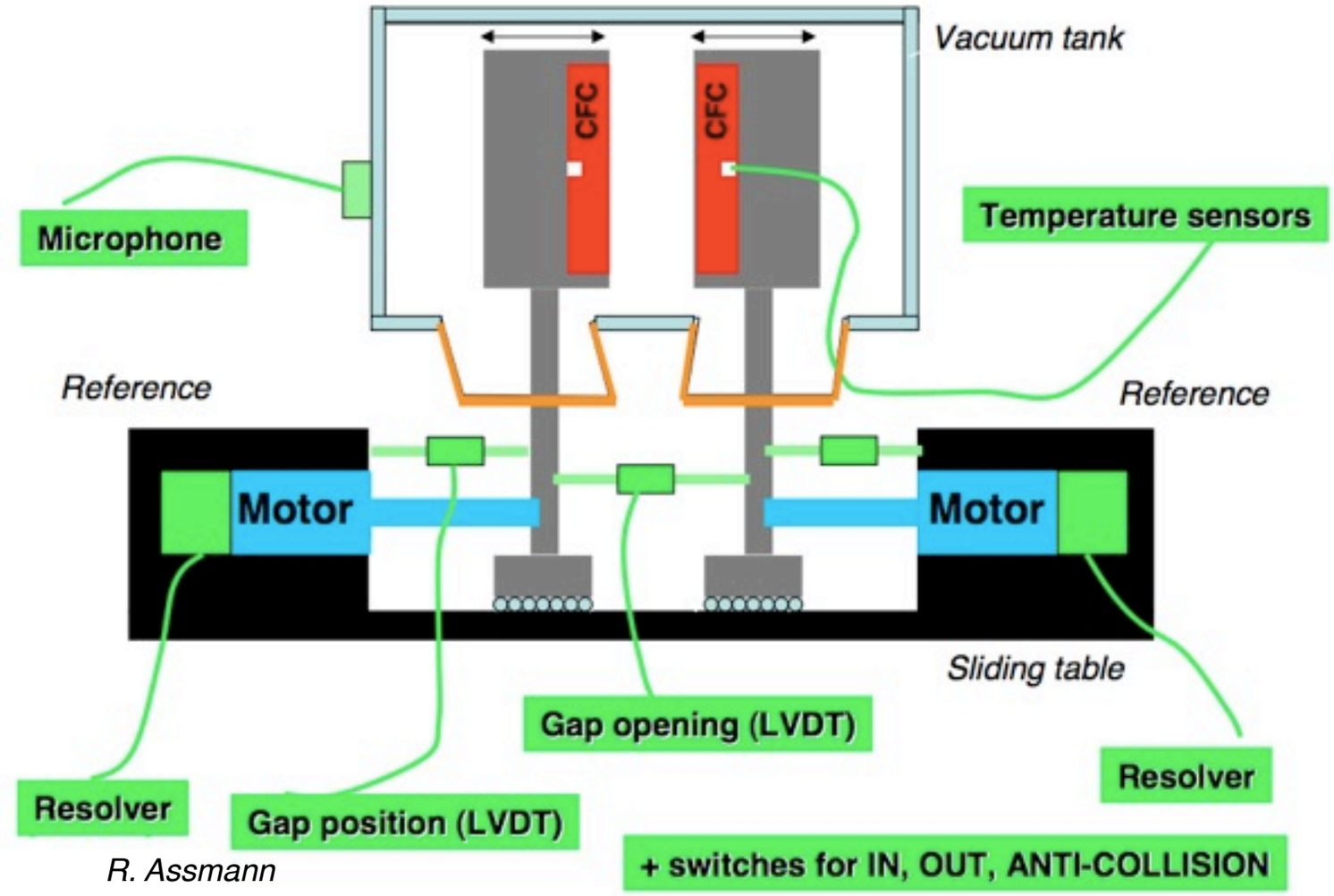
**Cleaning collimators (IR3/7):**

*Primary and secondary: Carbon composite jaws;*
*Absorbers made of Tungsten.*

High-Z materials for the **experimental regions:**

*TCT's: Tungsten; TCL: Copper.*
*Same design for both types.*

# Collimator design and controls




Settings: 2 jaws → 4 motor positions; 1 motor for tank position. Resolution: **5 µm**.

Survey: 7 position measurements (4 corners + 2 gaps + tank)
4 motor resolvers; 10 switch statuses (full-in, full-out, anti-collision)

Dump thresholds (functions+discrete) per collimator (continuously active with beam):
24 warning/dump functions versus time (in/out for 4 jaws + 2 gaps);
2 gap limits versus energy; 4 gap limits $\beta^*$.

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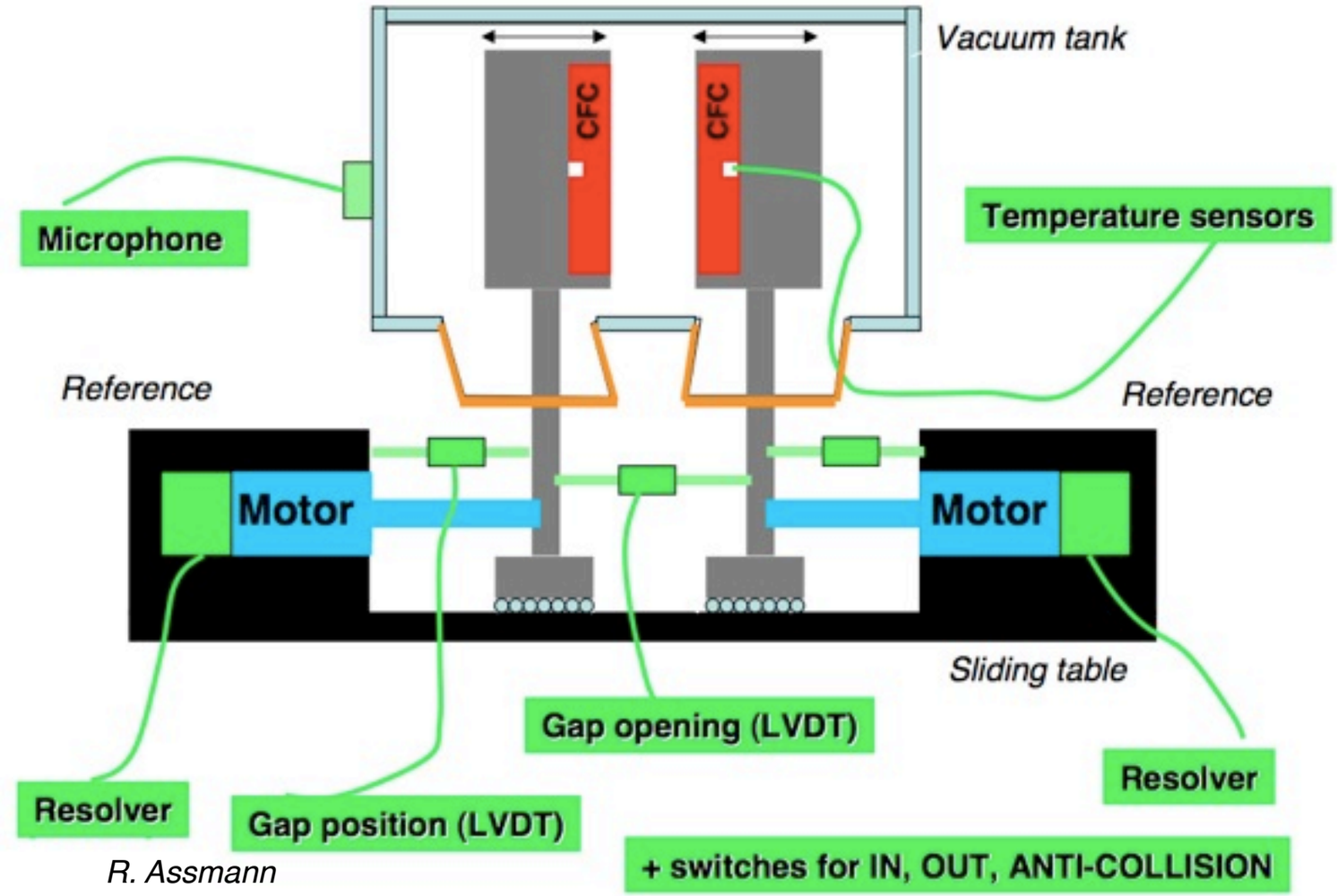


**All** LHC movable devices that can intercept the beams must be treated as collimators:
- Closest positions determined by the collimator hierarchy;
- Controls implementations must comply to machine protection standard in terms of redundancy, accuracy and precision.
- Remote control by OP from CCC.

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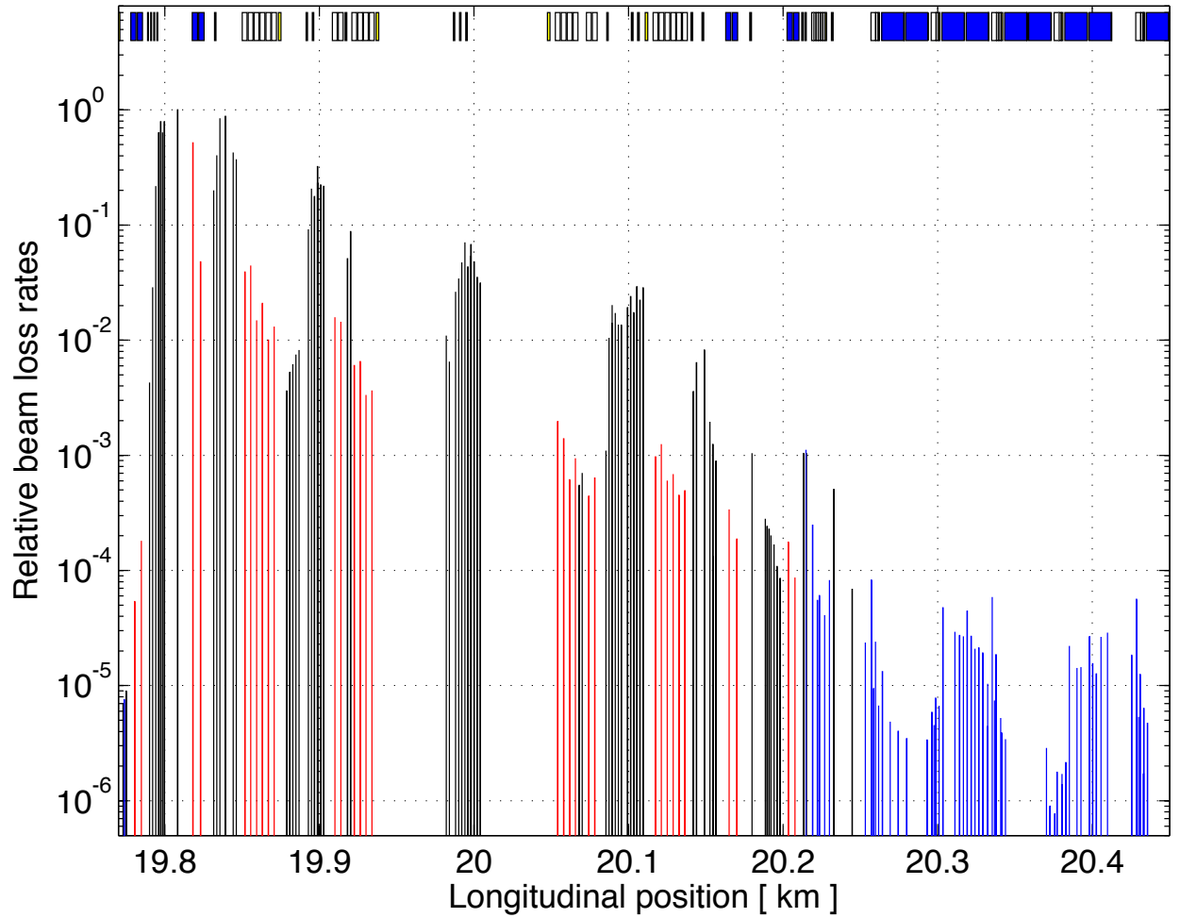

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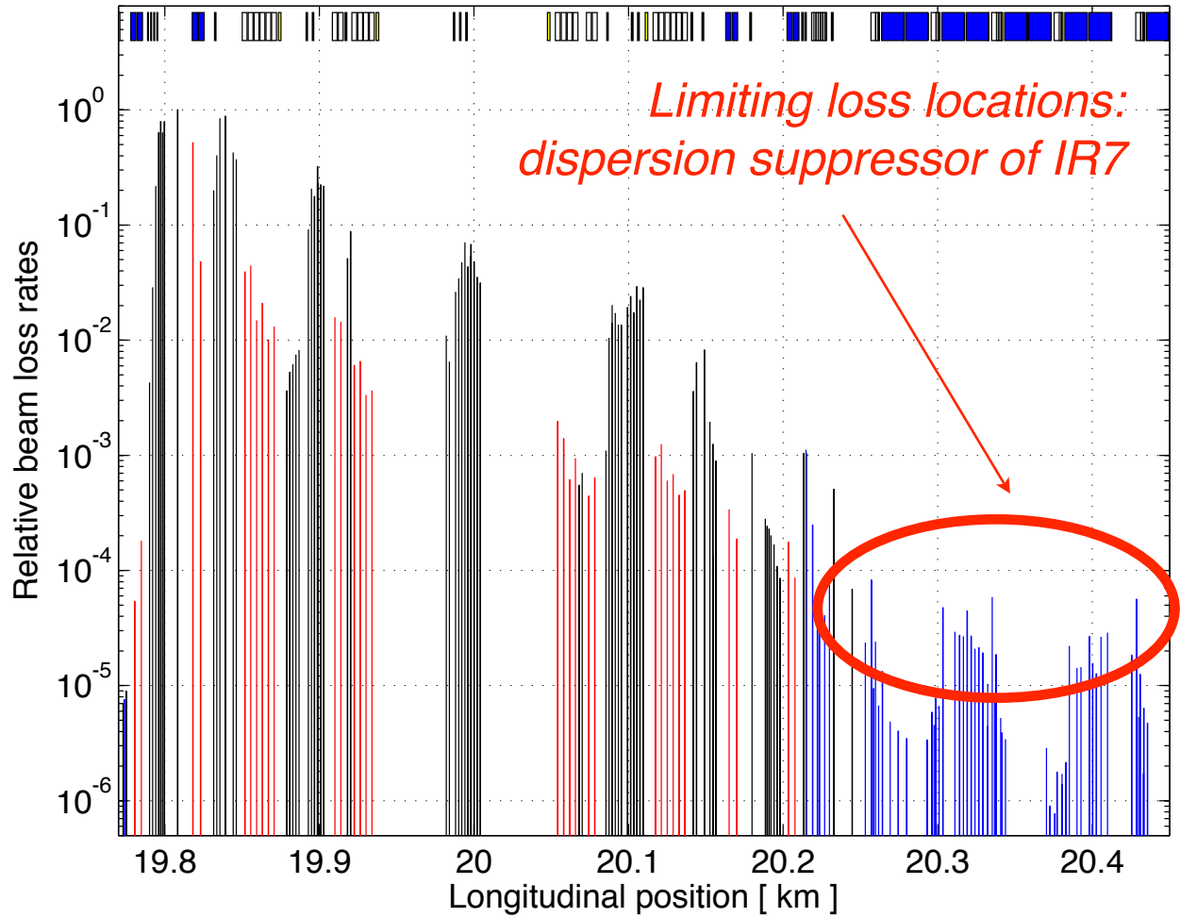

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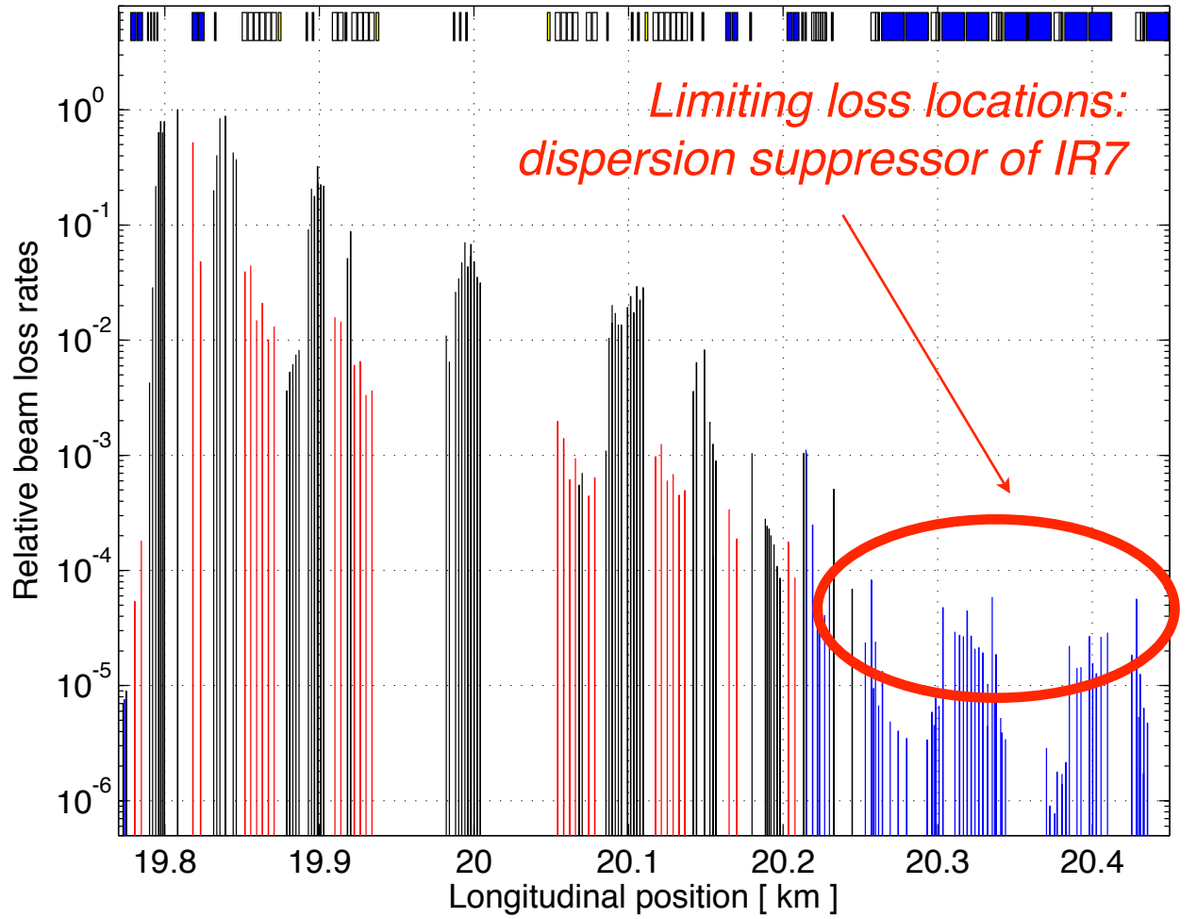


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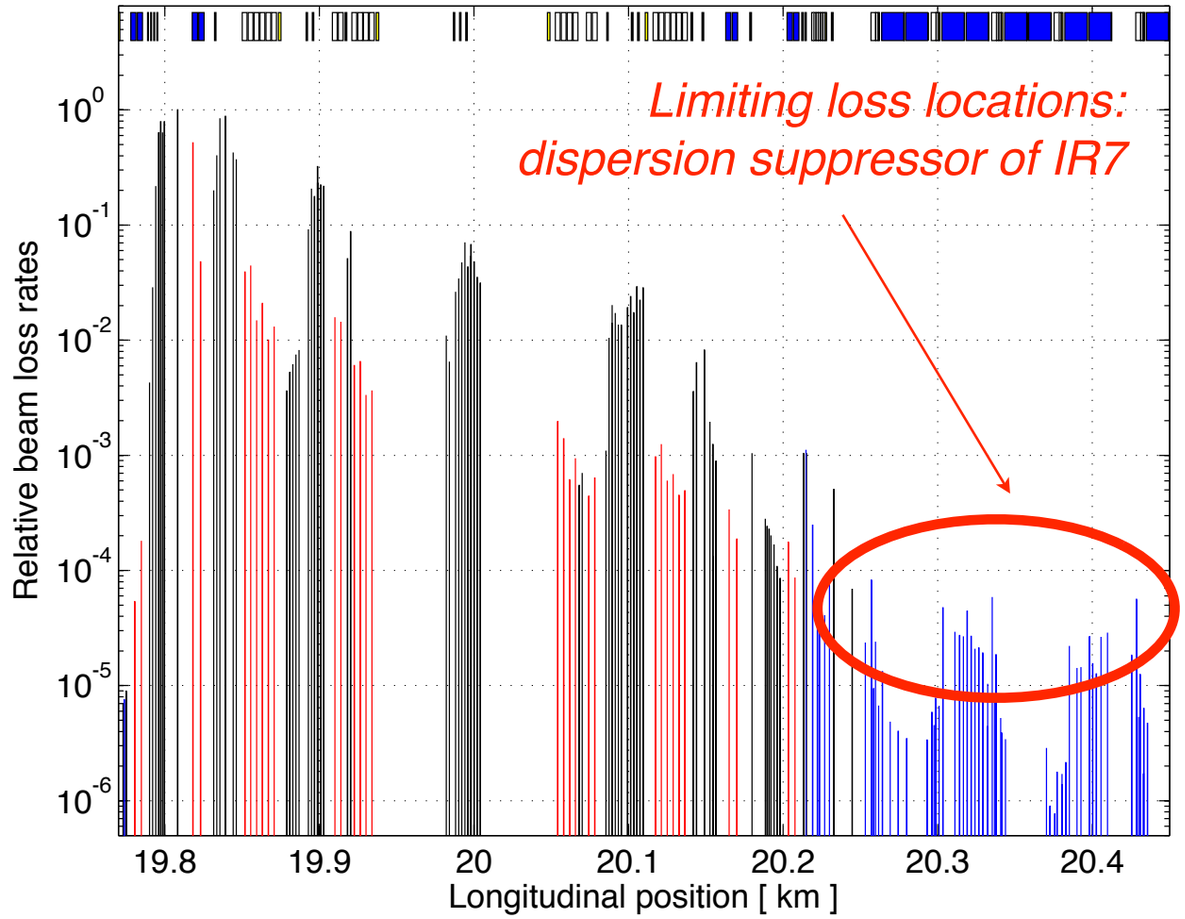


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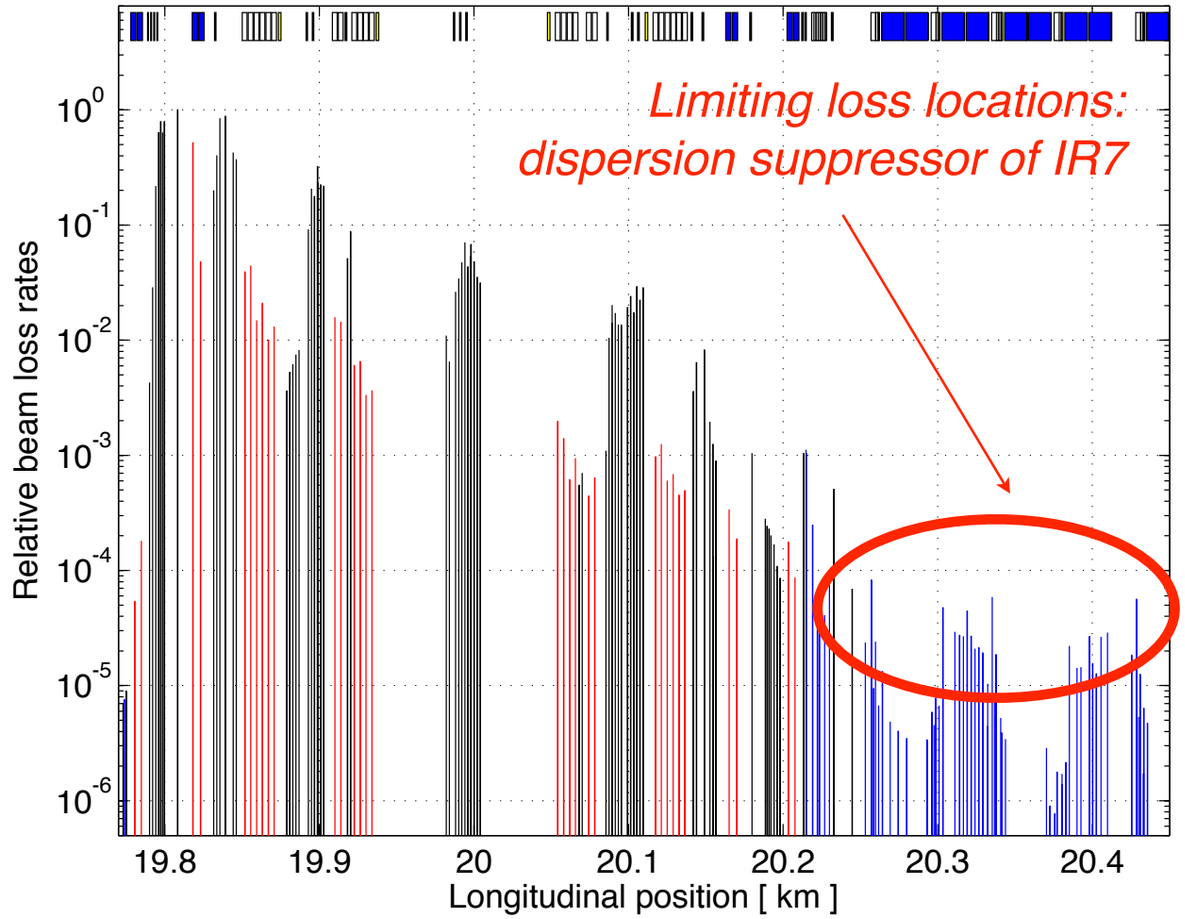


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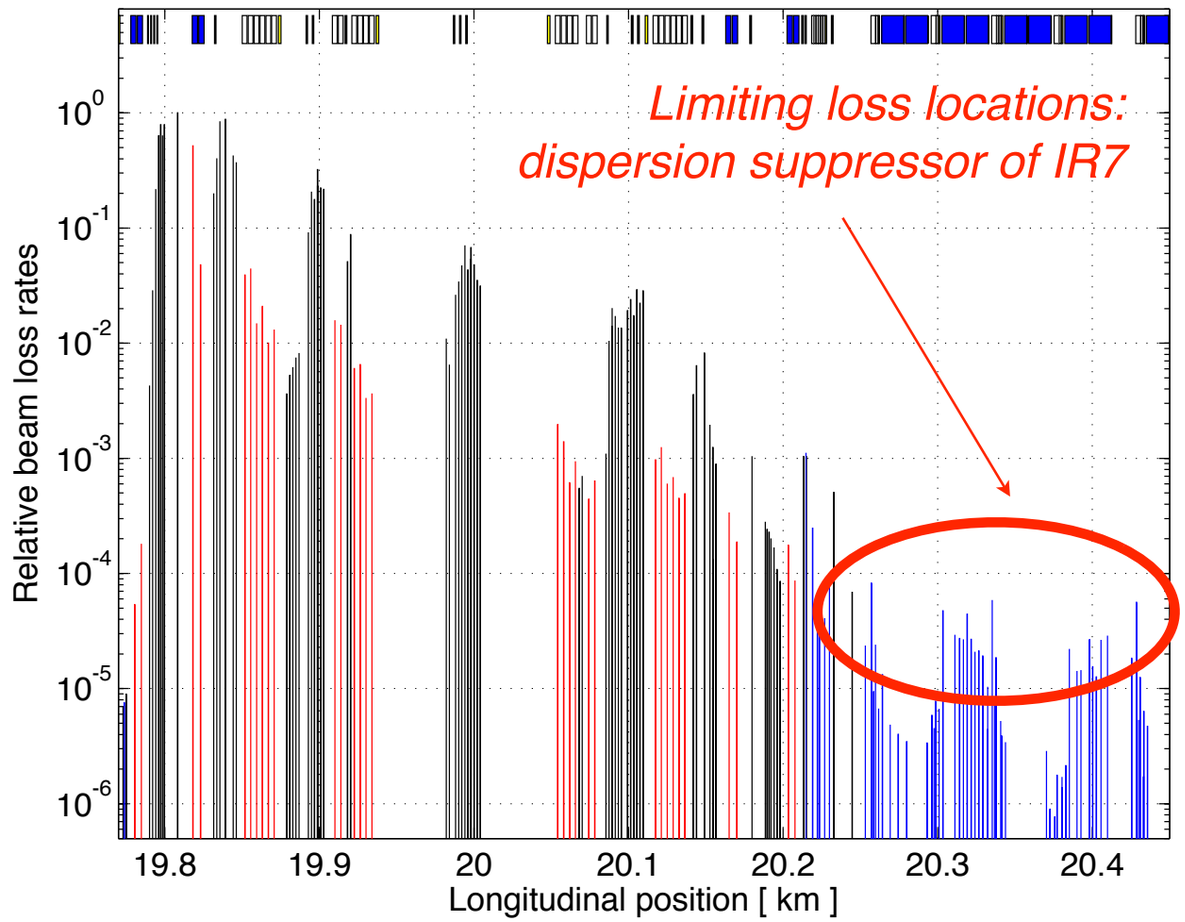


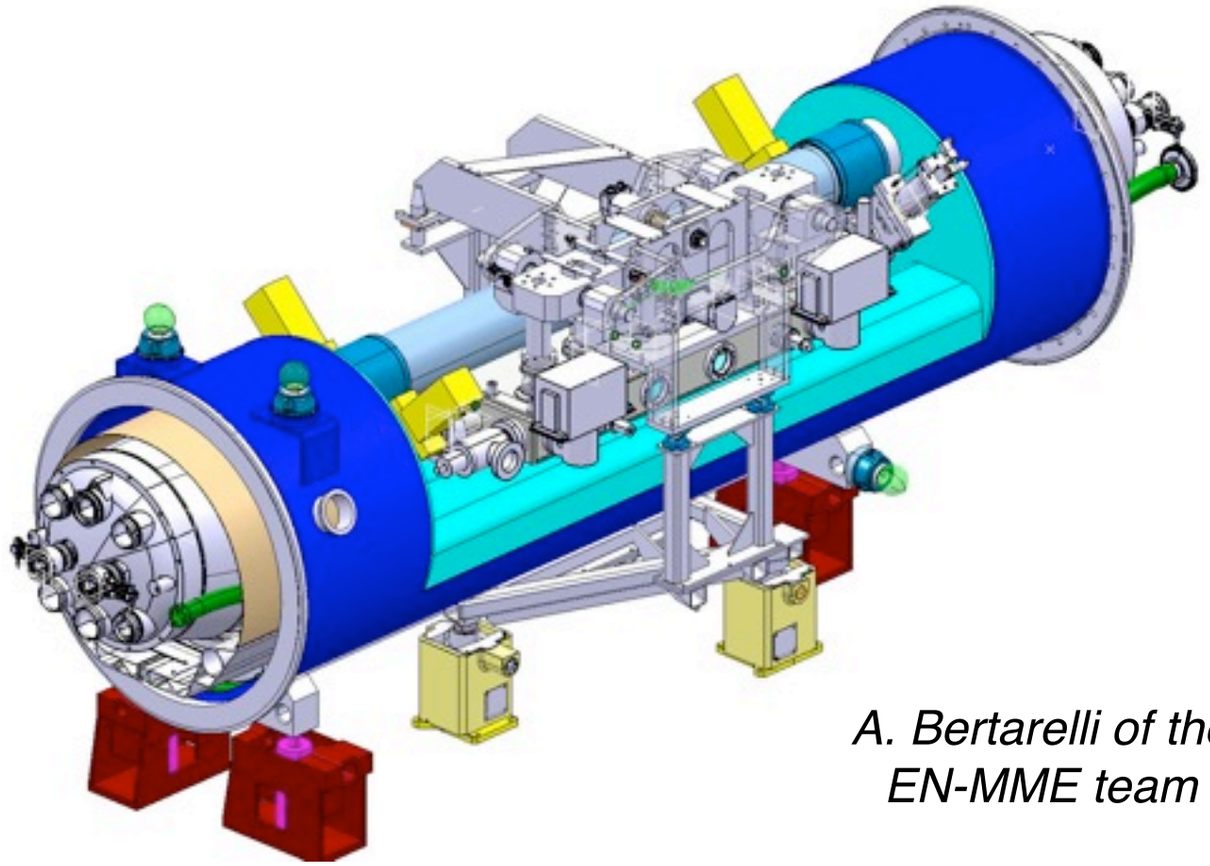

*A. Bertarelli of the EN-MME team*

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**Two main changes affect IRs:**
- New tertiary collimators with BPMs;
- Improved TCL layouts in IR1/5.

# New collimators with integrated BPMs

- **16 Tungsten TCTs** in all IRs and the **2 Carbon TCSGs in IR6** will be replaced by new collimators with **integrated BPMs**.

  **Gain**: can align the collimator jaw without "touching" the beam ➞ no dedicated low-intensity fills.

  ➞ *Drastically reduced setup time => more flexibility in IR configurations*

  ➞ *Reduced orbit margins in cleaning hierarchy => more room to squeeze β*: ≥* ***35 cm (R. Bruce)***

- Solid experimental validation of this concept from **prototype SPS beam tests** (2010-2012).

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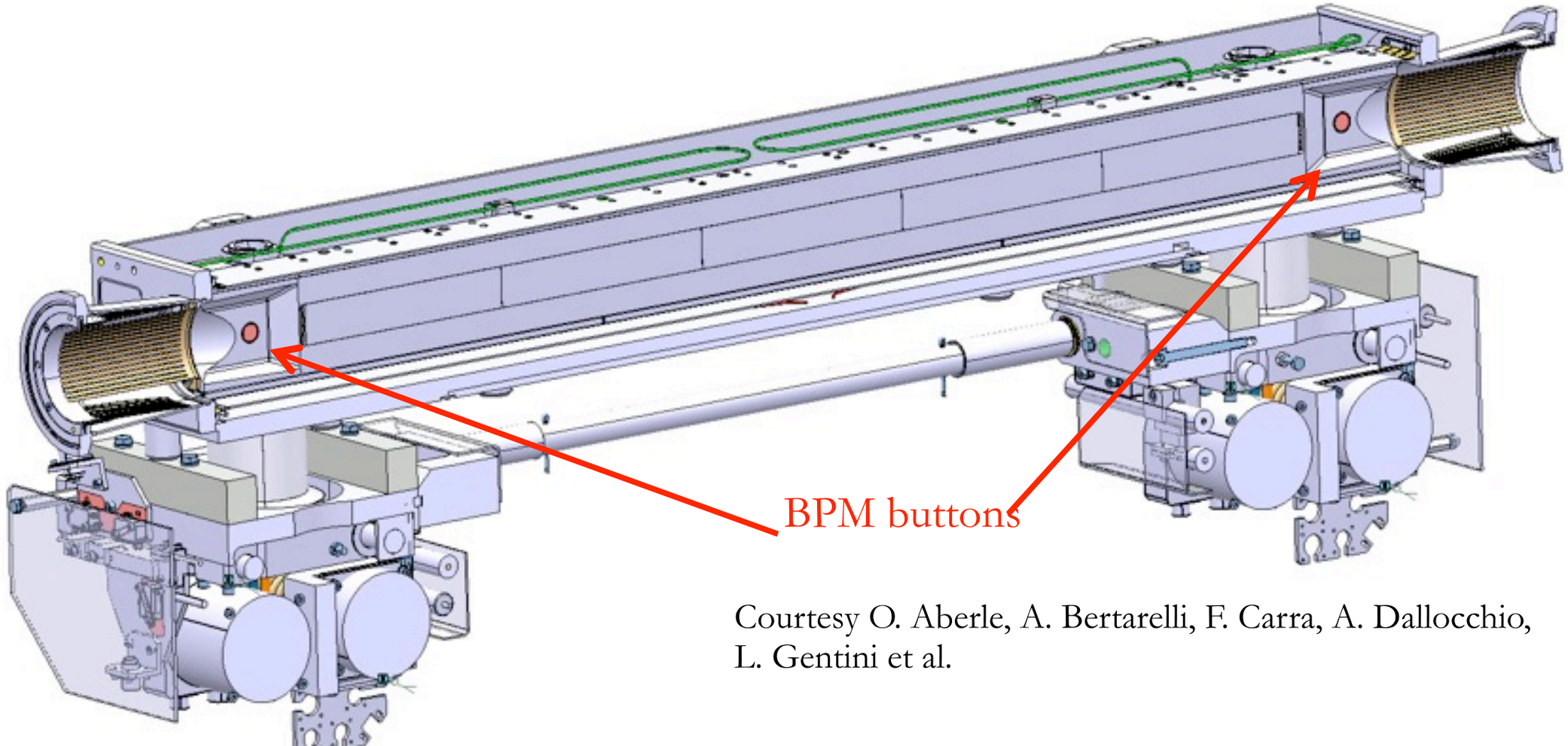


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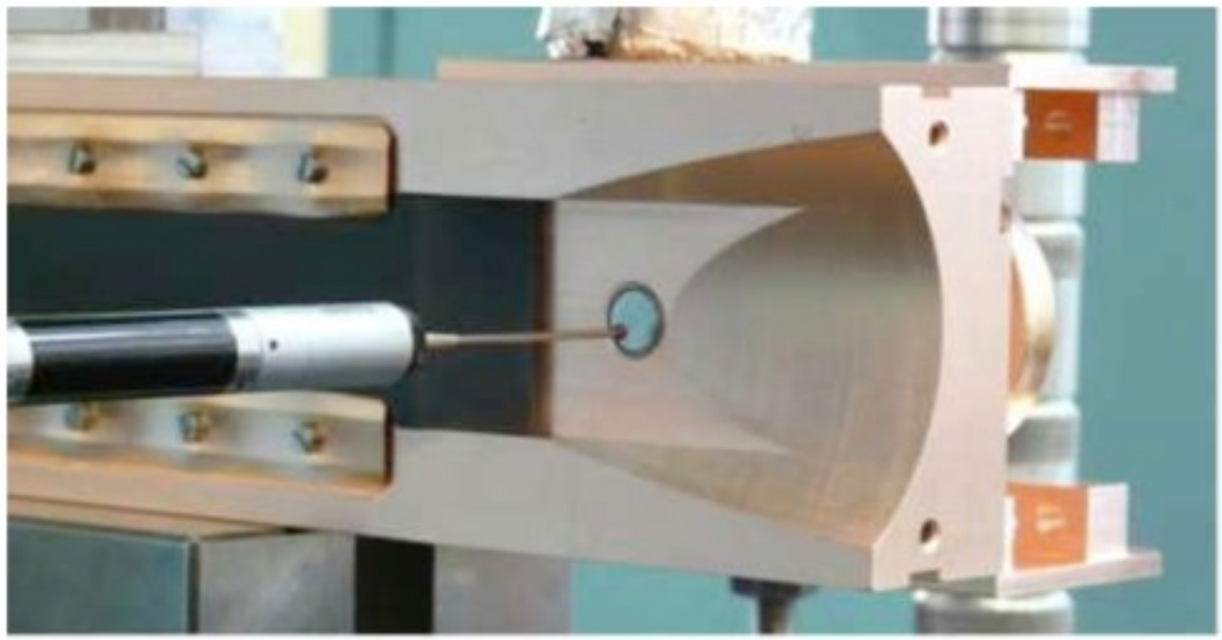

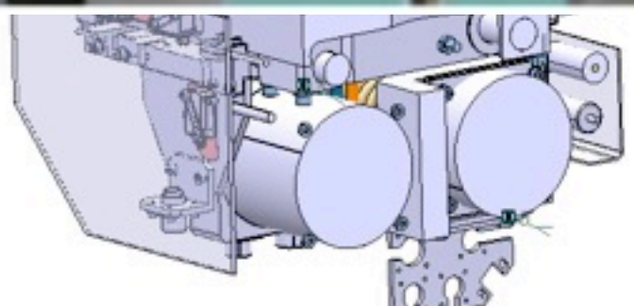

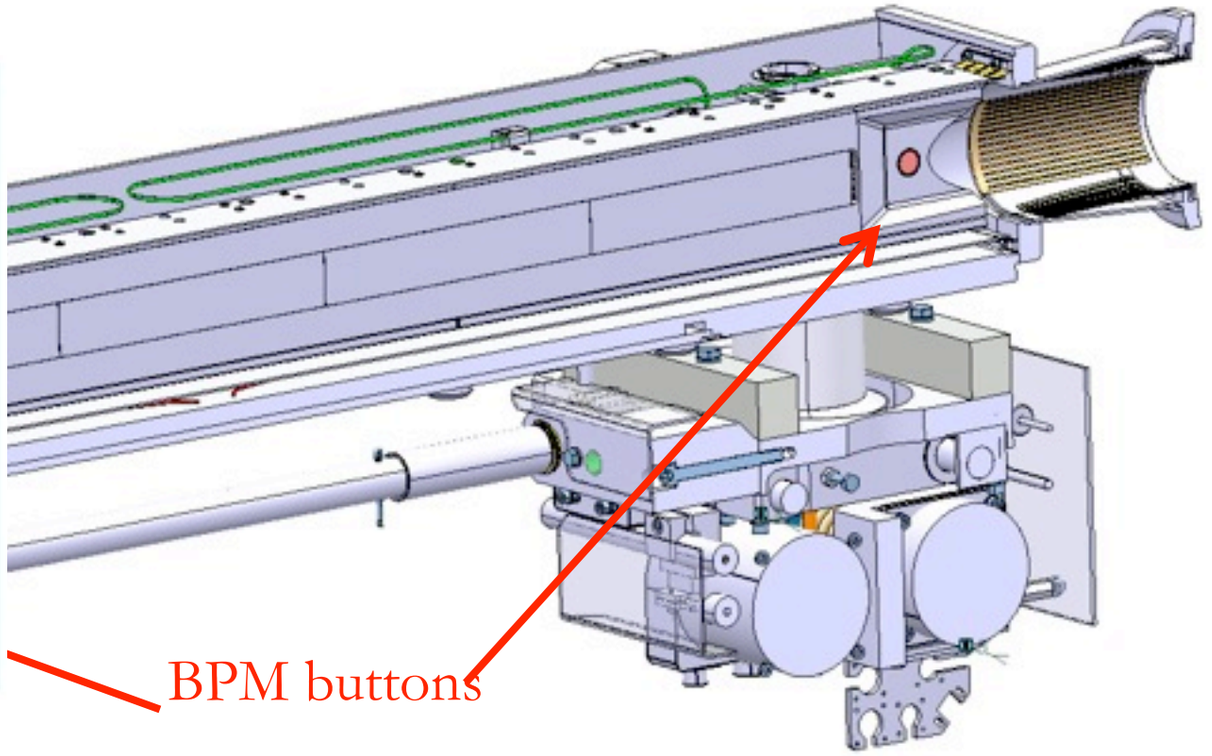


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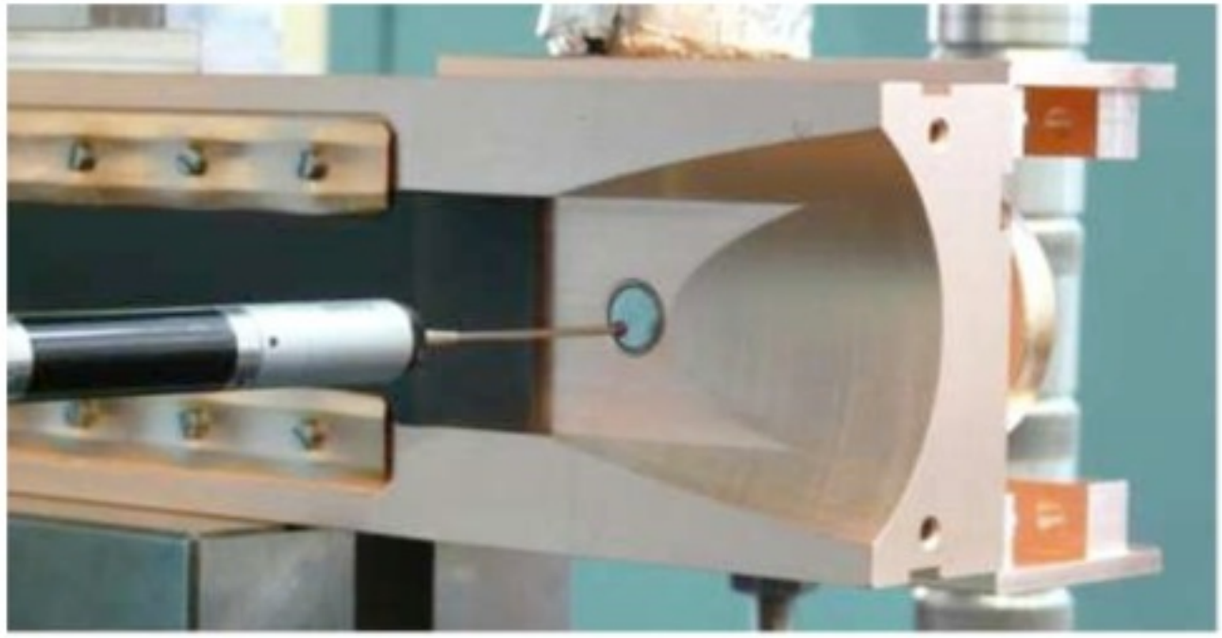
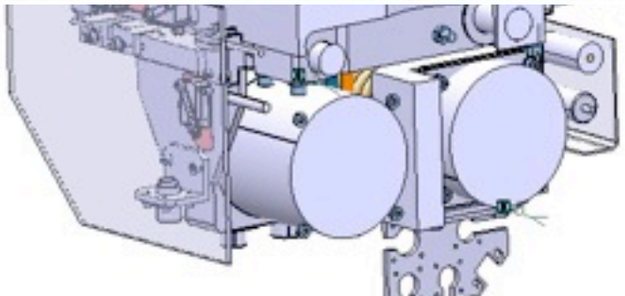




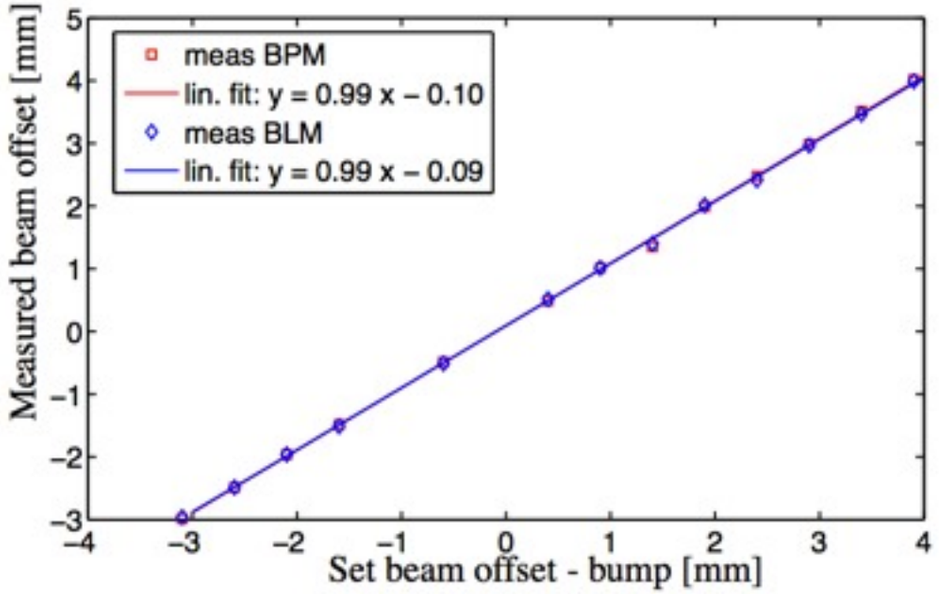
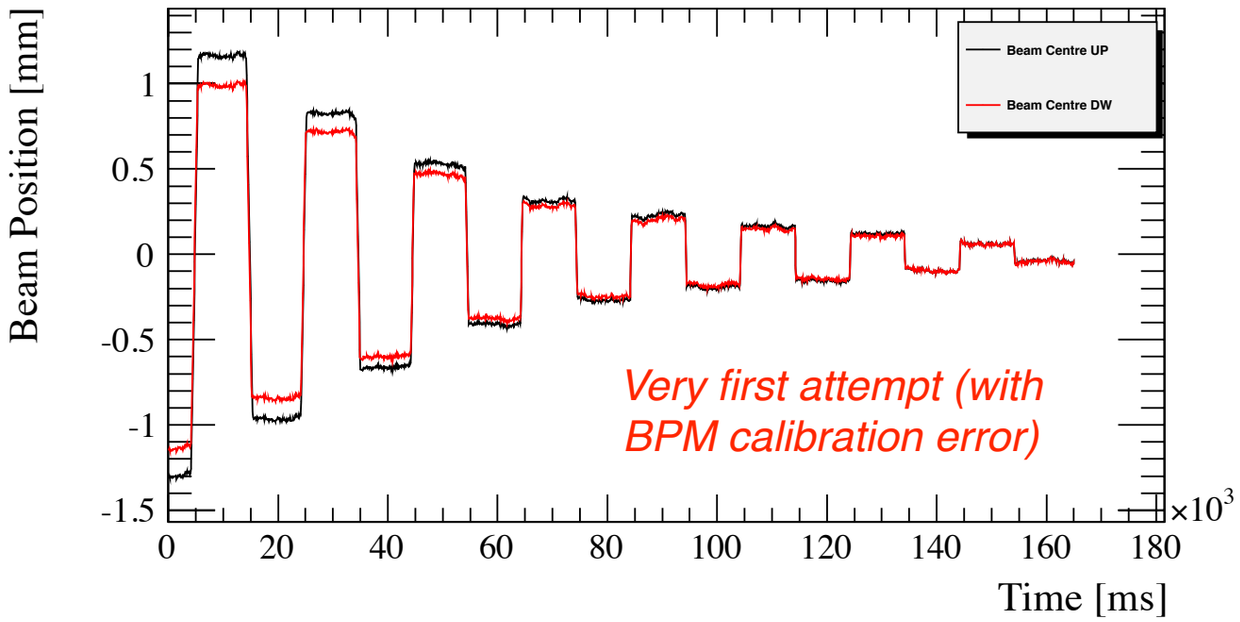


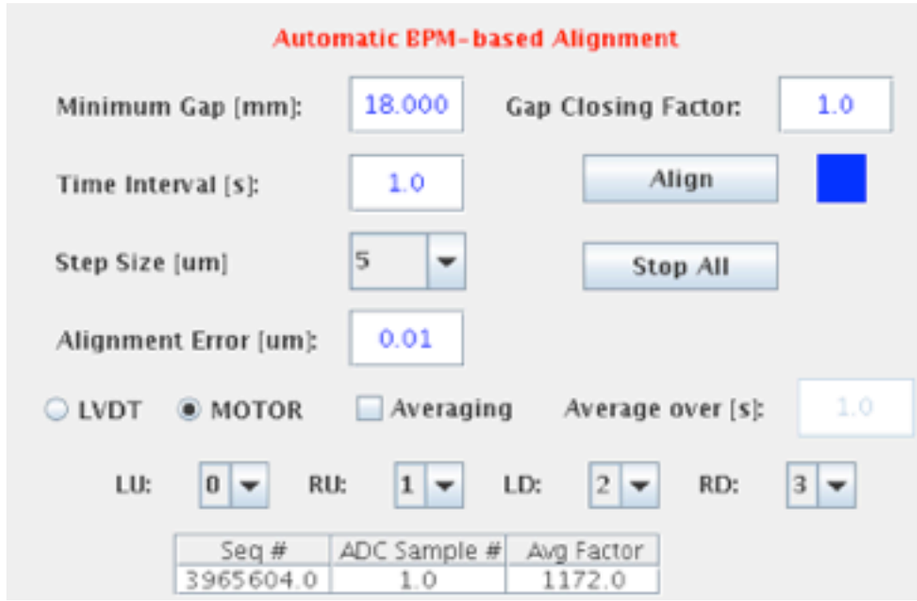

Figure 8: Correlation between measured beam centres (BPMs - red, BLM based method - blue) and the bump settings for the orbit offset at the collimator. The error in the bump settings was estimated to about 10% of the movement increment.

C
L

# Recent results from SPS beam tests

*First BPM-based alignment (MD of Oct. 18th, 2012)*




*G. Valentino/M. Gasior for the collimation and BI teams*

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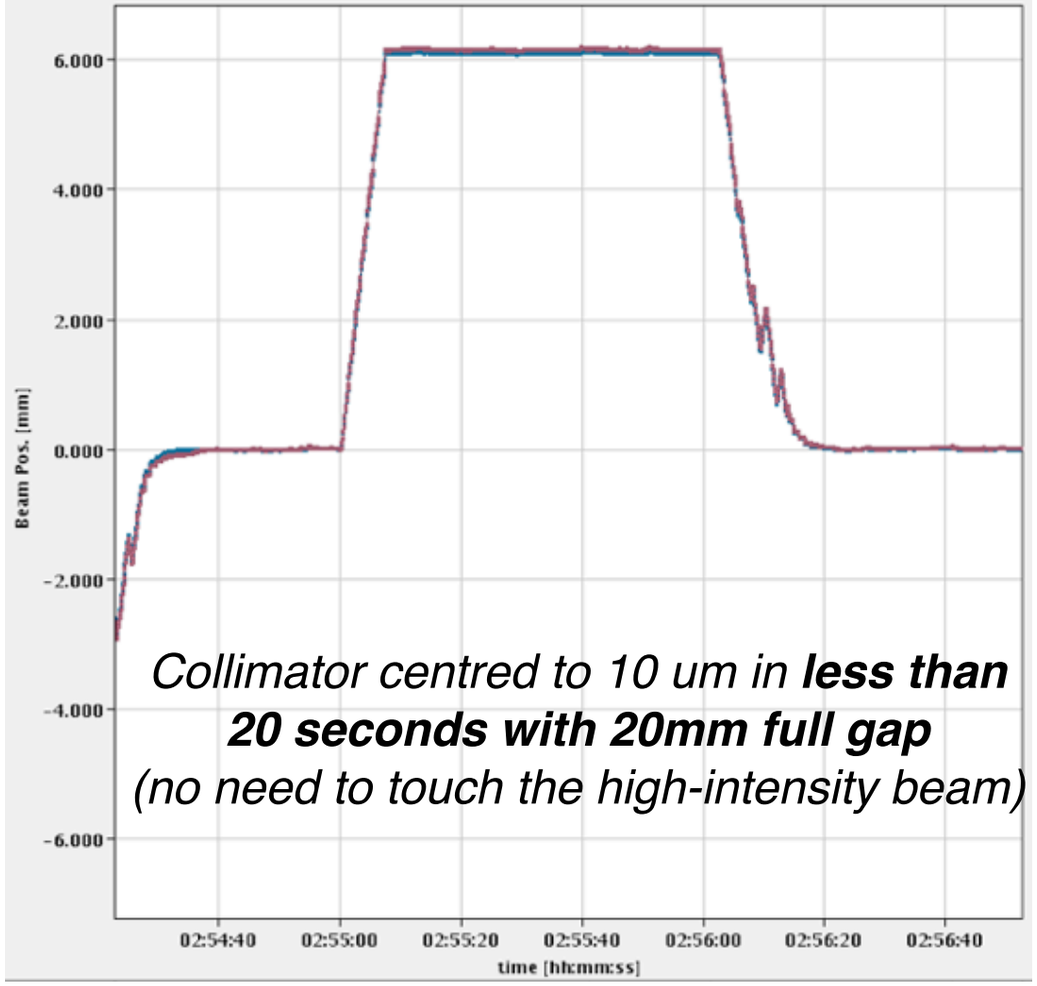

# Recent results from SPS beam tests

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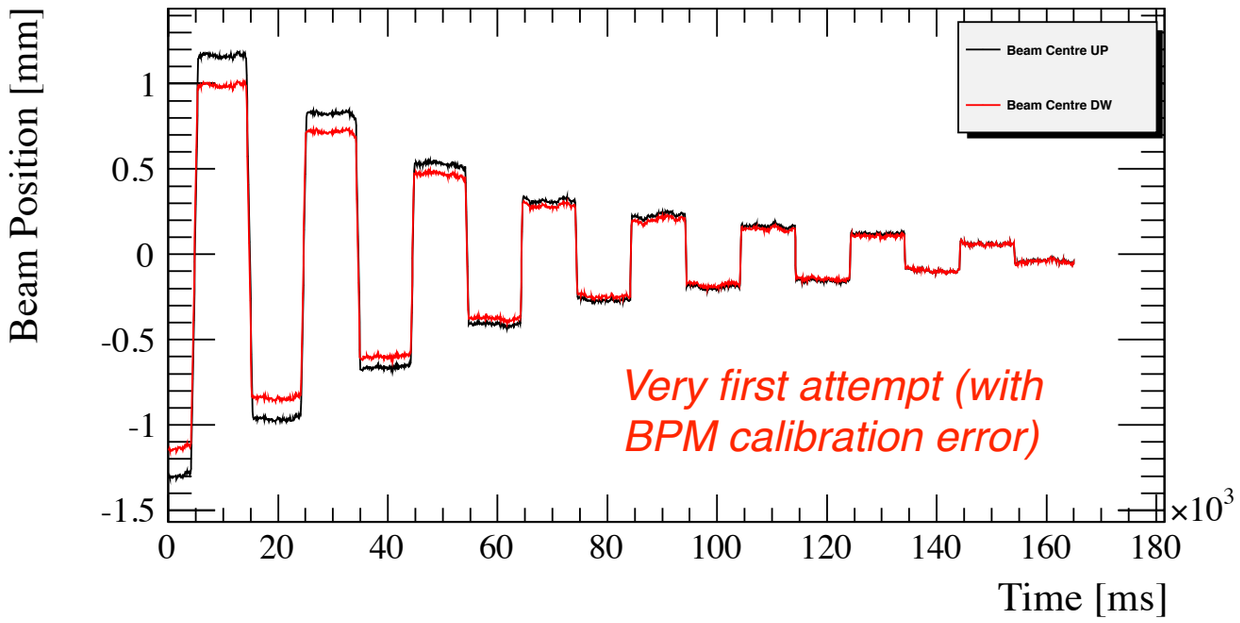


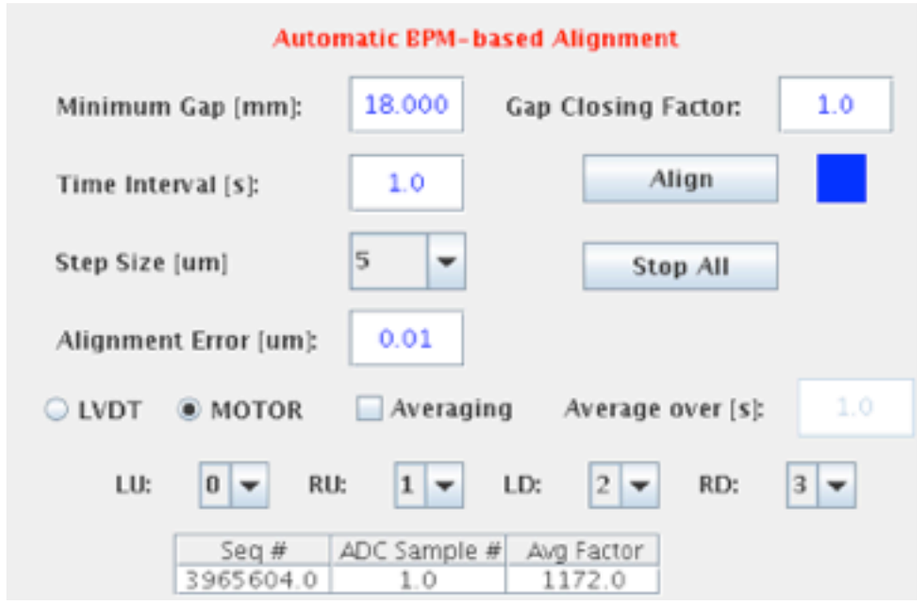


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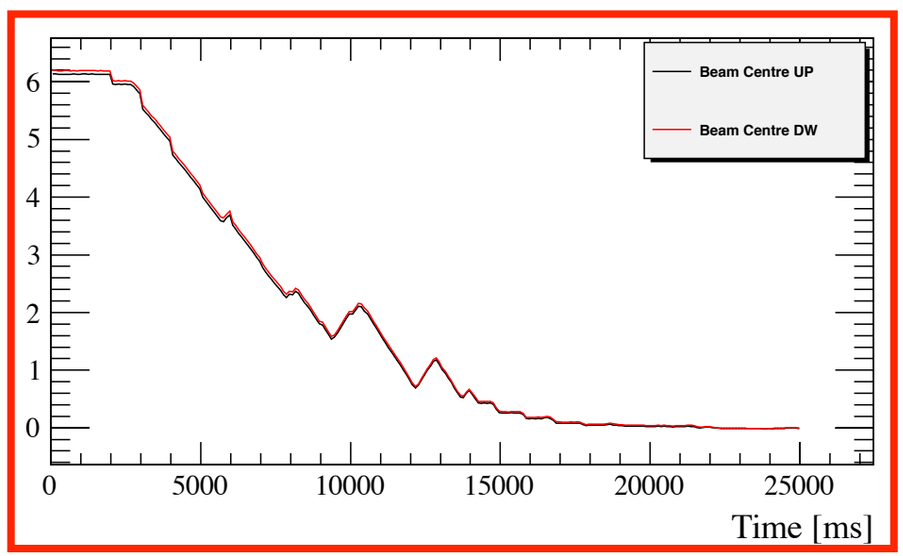
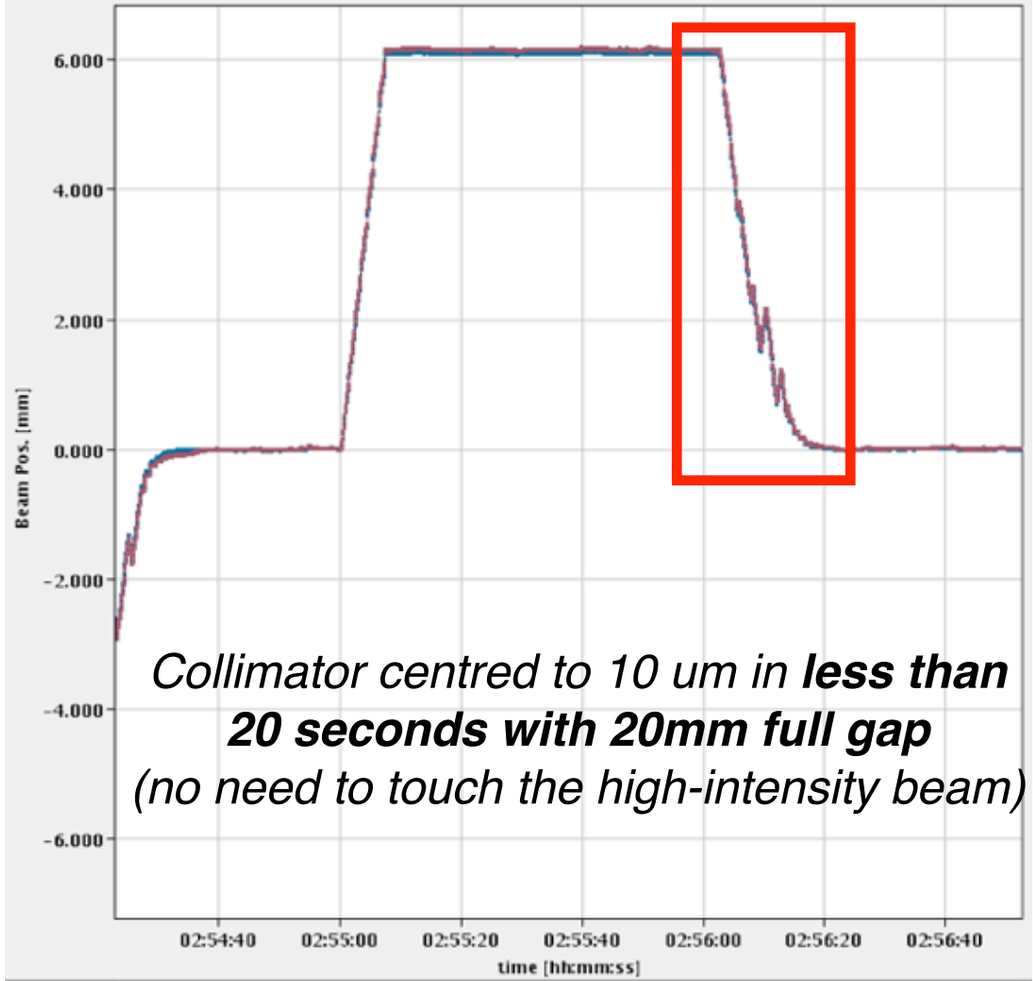
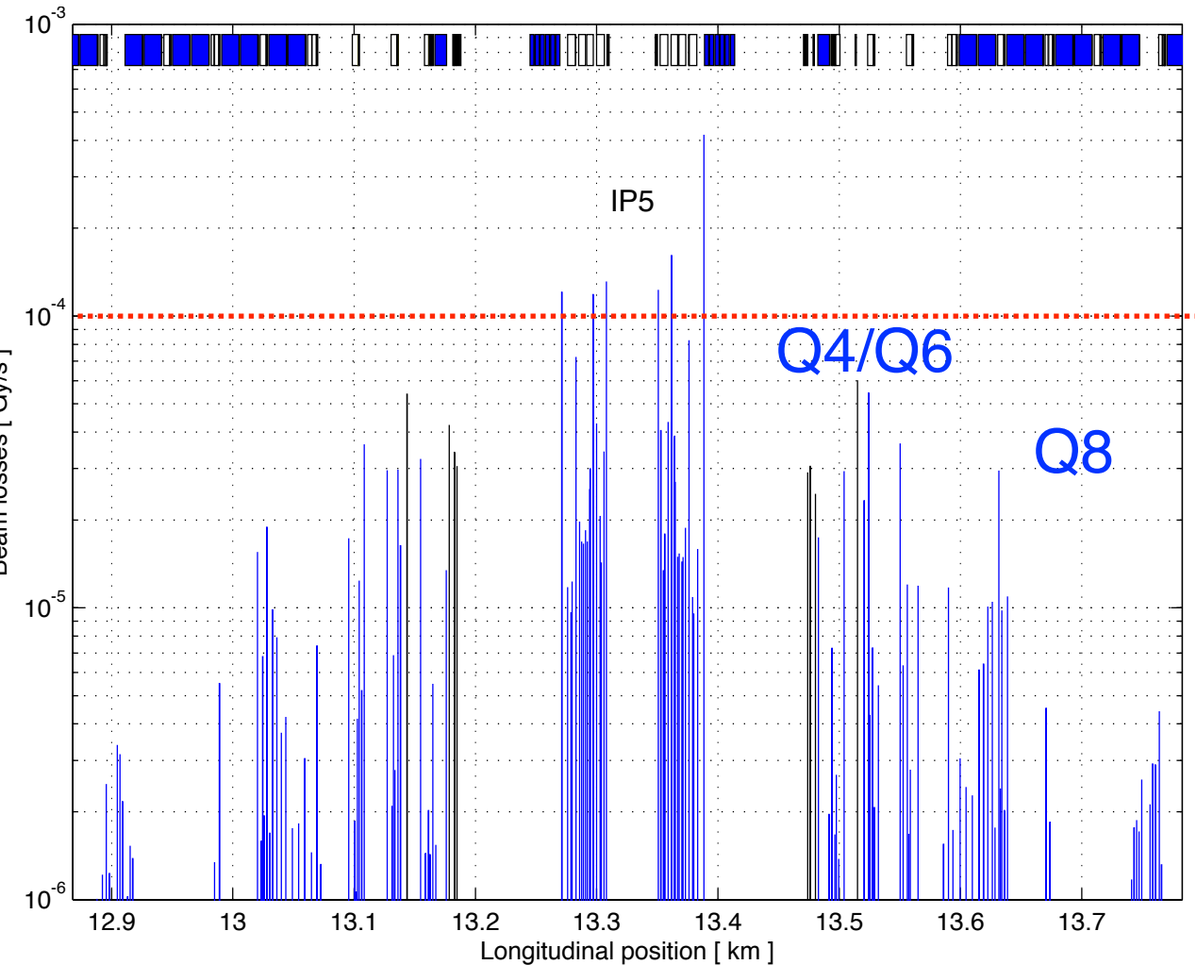



Measured beam position within jaws [mm]



# Losses from luminosity debris

## Proton operation in 2011

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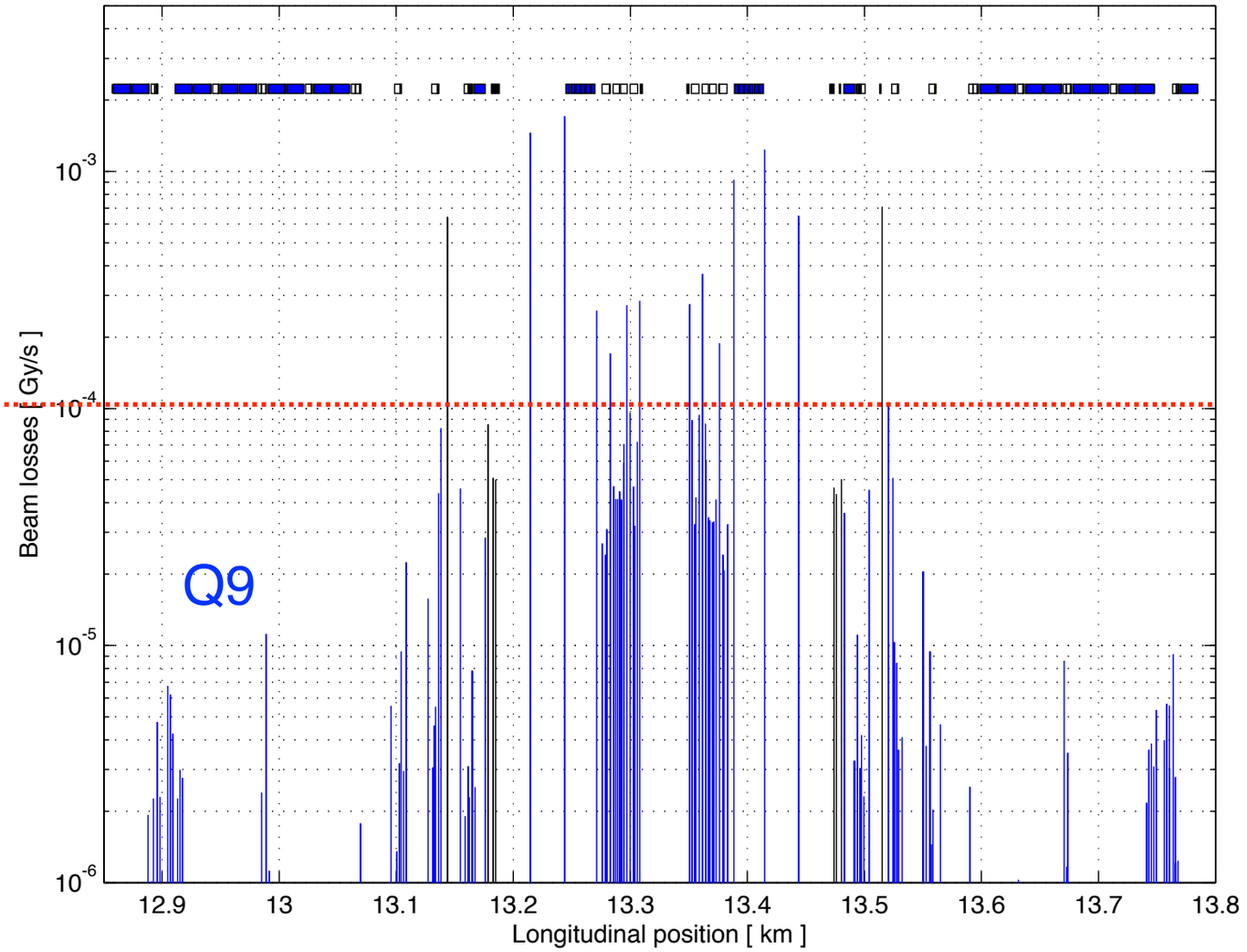


In 2012, we have started using the TCL collimators in cell 5 (TCL-5) to catch physics debris!
Set to 10 sigmas since the start of the run.

# Role of present TCL-5

Working on understanding the present limitations from luminosity losses:

- *Scans of TCL collimator in physics;*
- *Measurements of beam losses and loads in the magnets;*
- *Benchmarking simulation tools.*

*A. Marsili for the collimation team*

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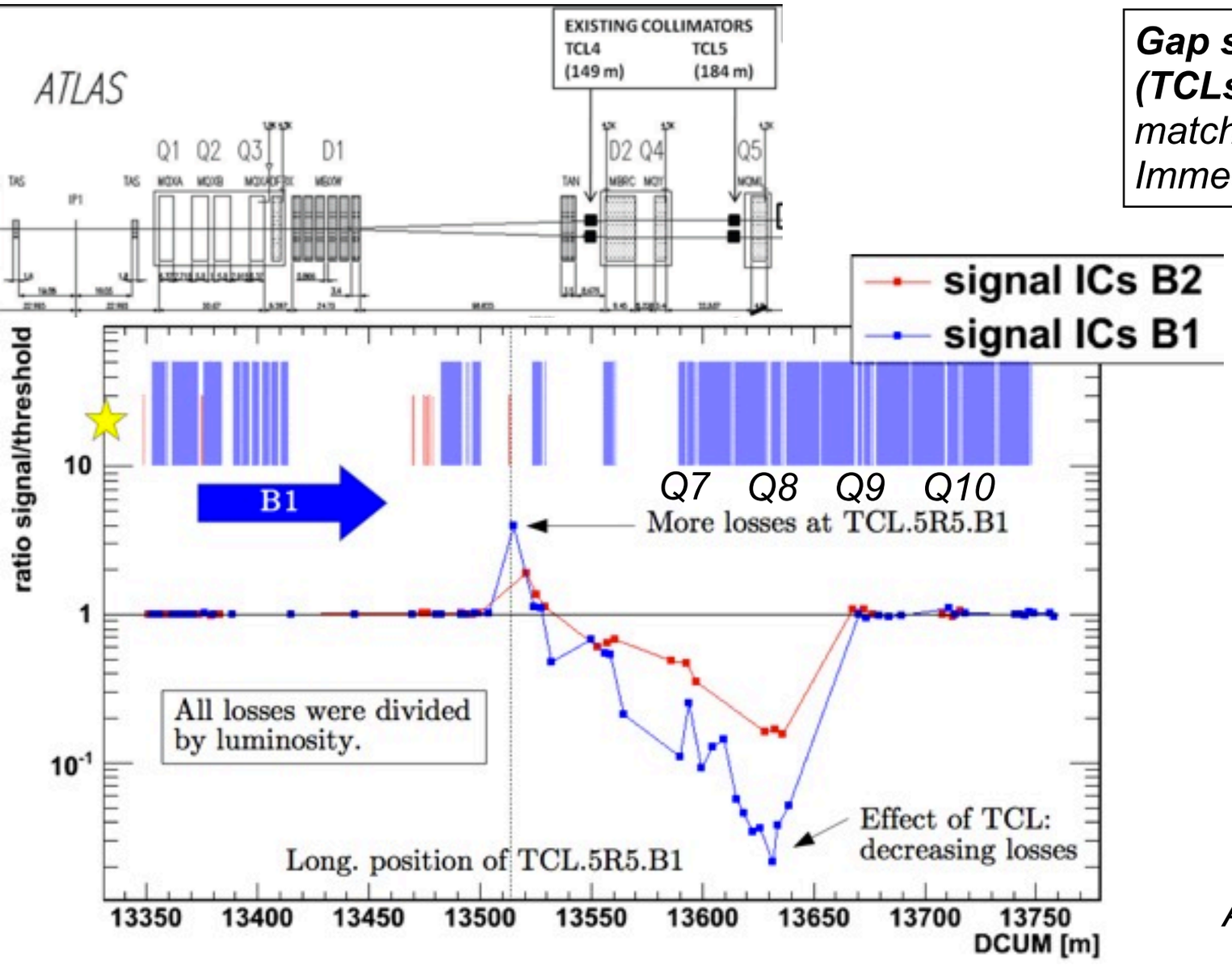


***Gap scans with the physics debris collimators (TCLs) in IR1/5:*** *direct measurements of loads in matching section and DS; simulation benchmark. Immediate interest: update of IR1/5 layout in LS1.*

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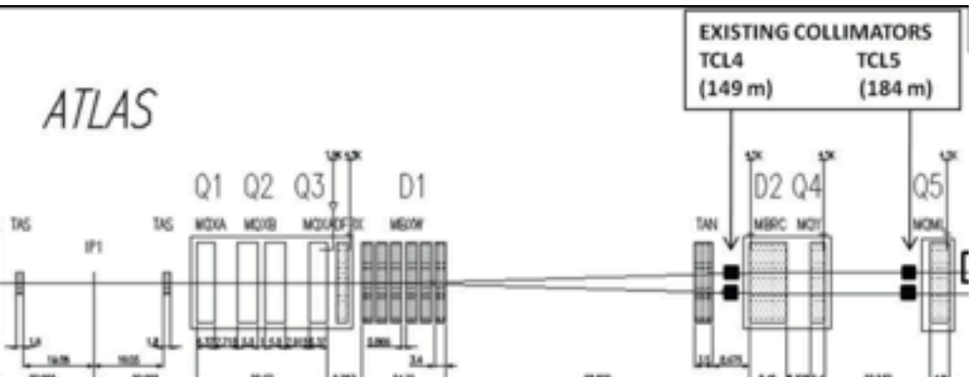


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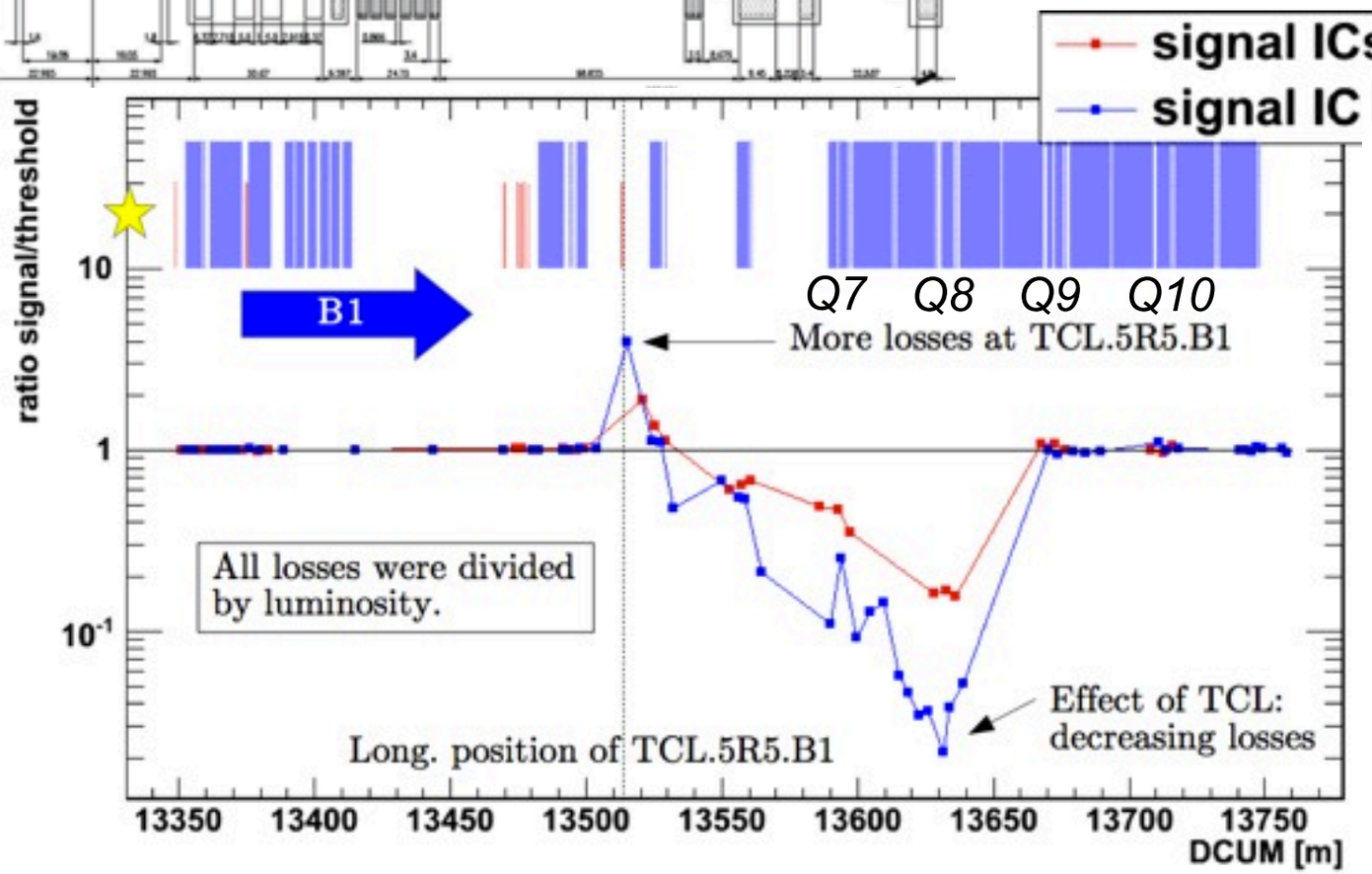


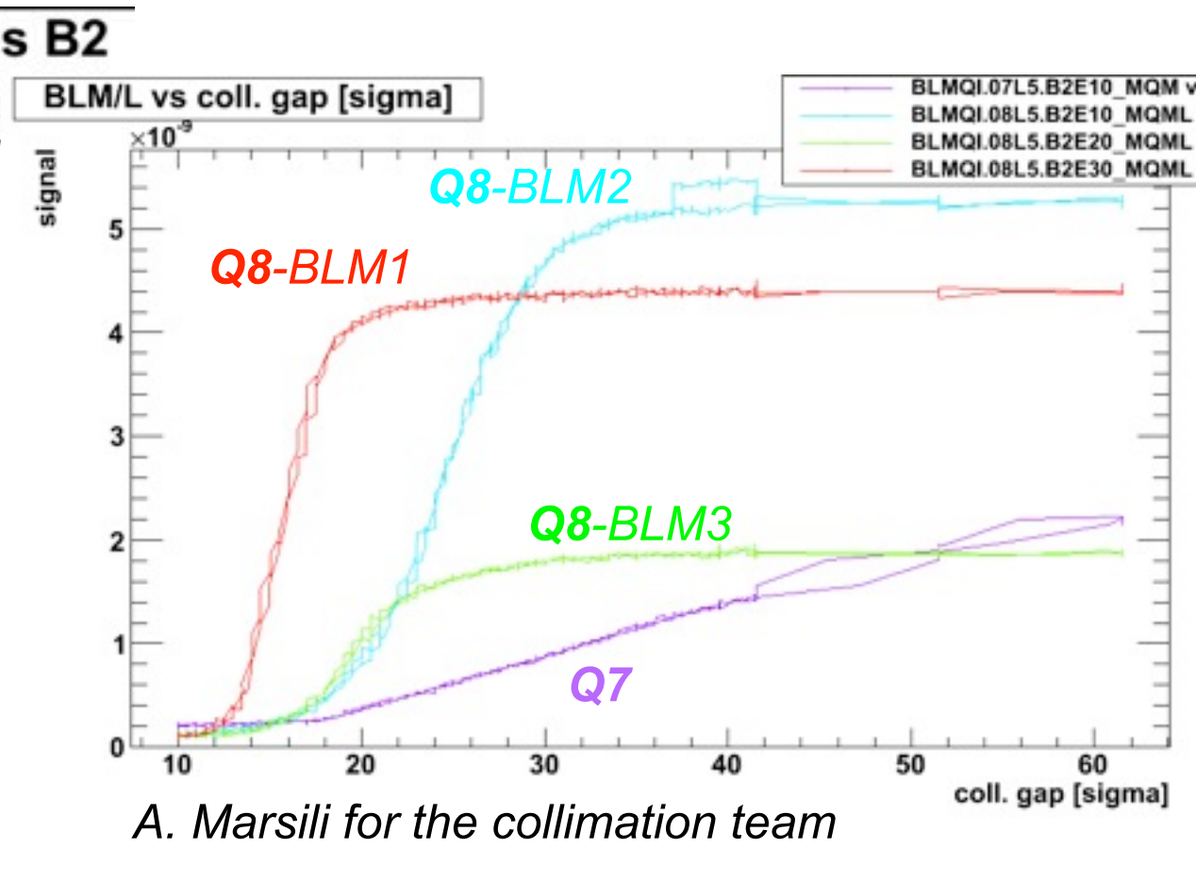


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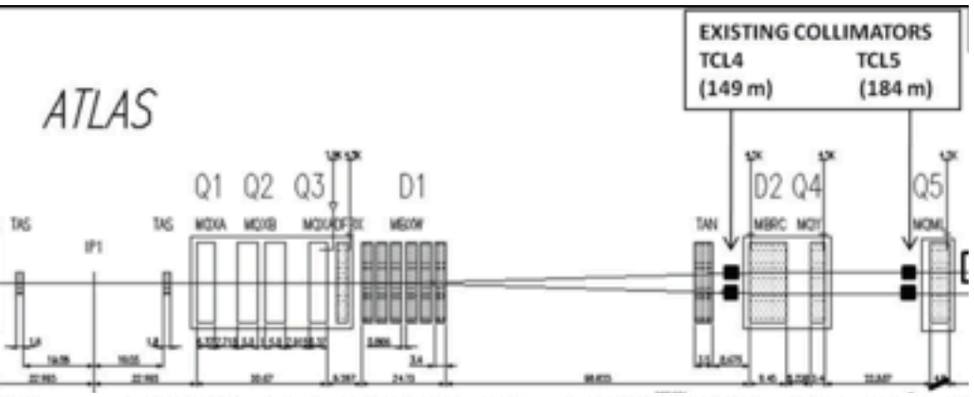


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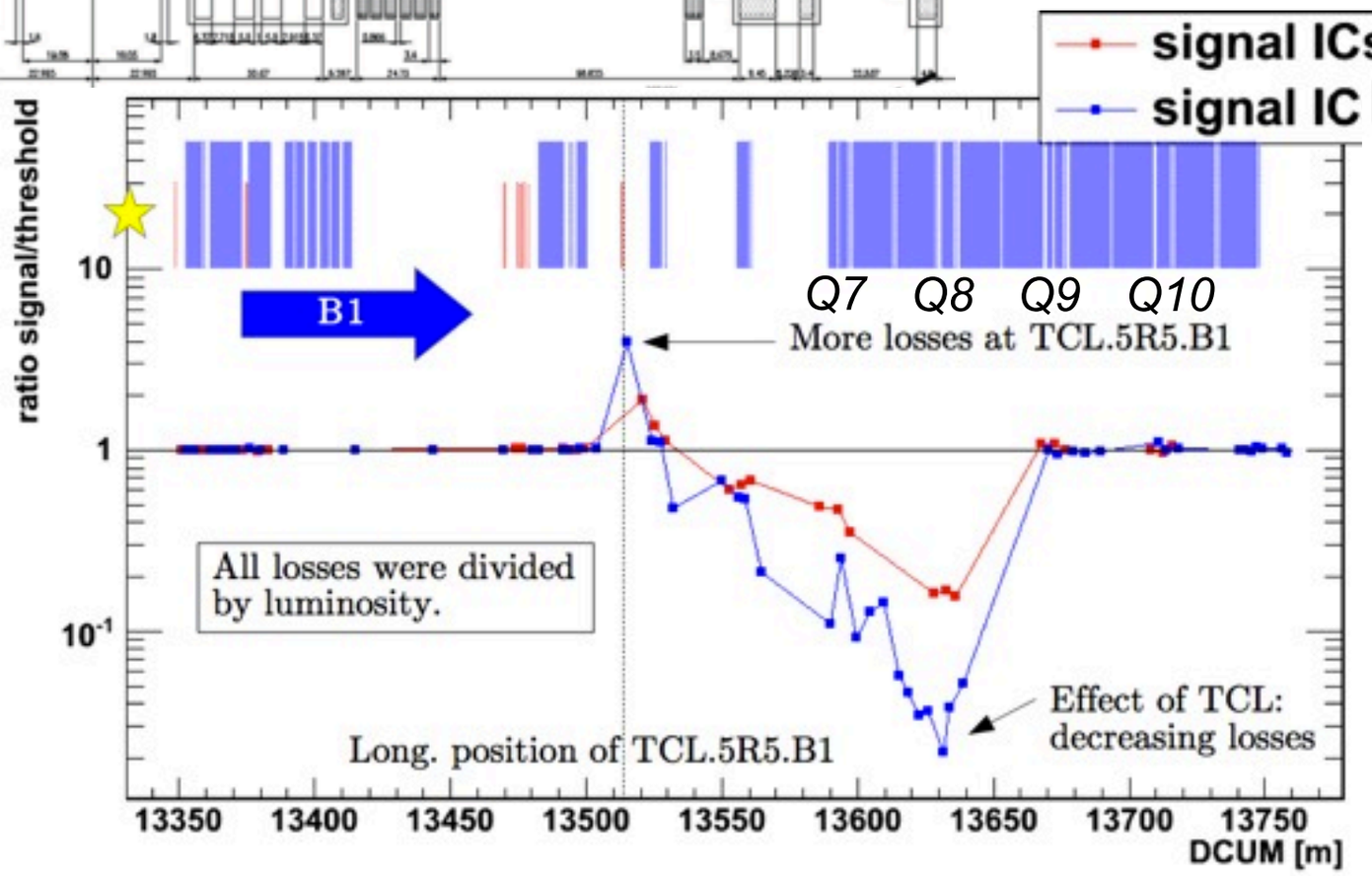
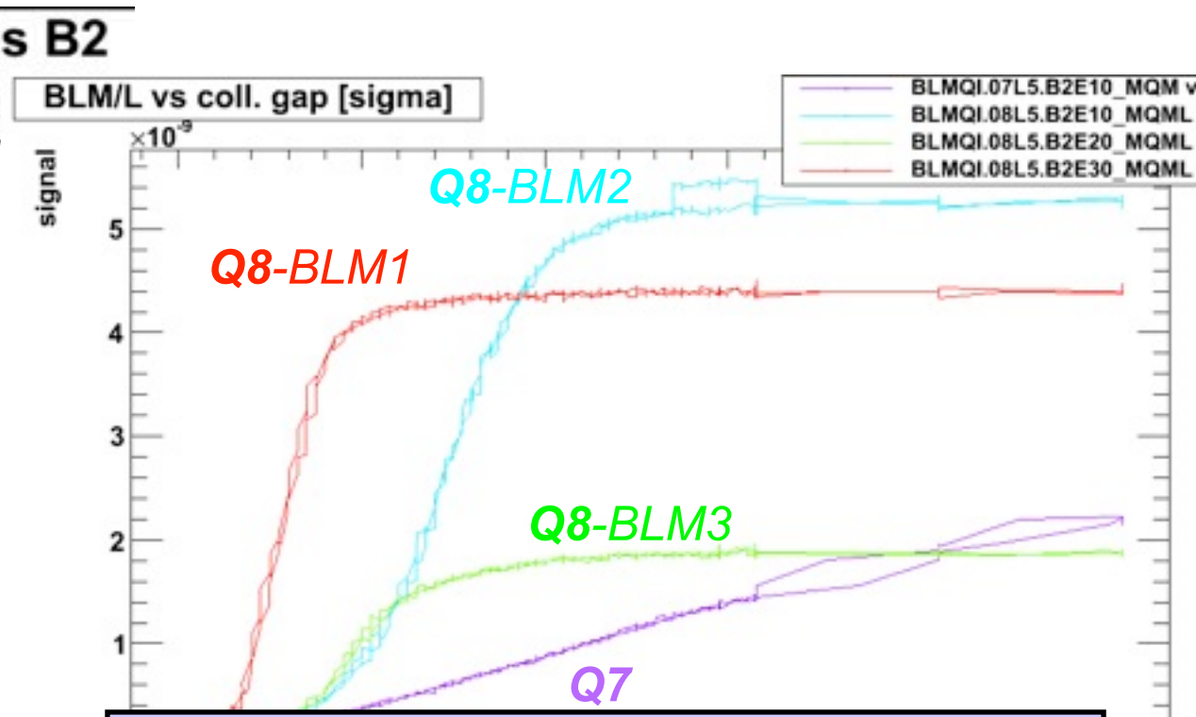
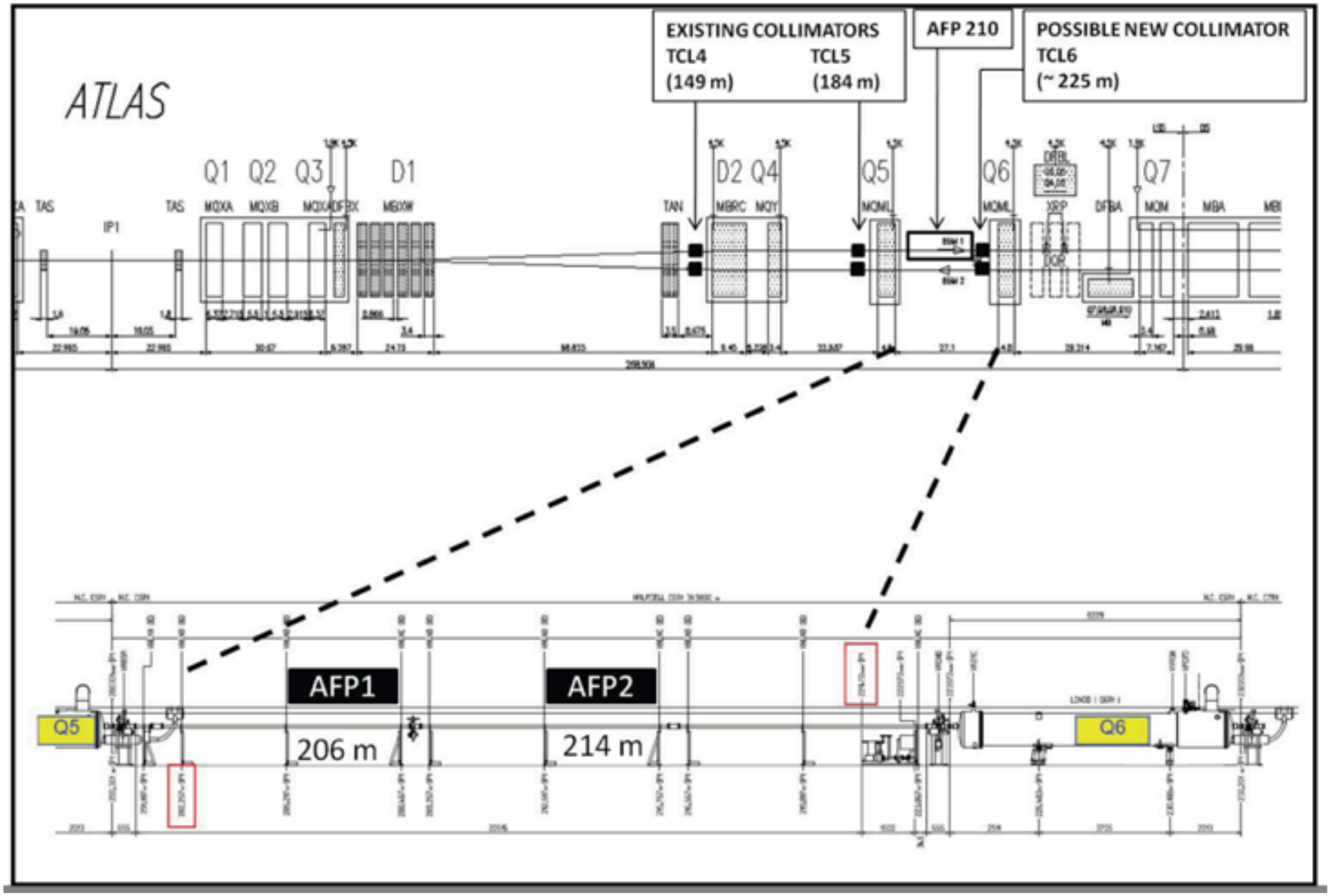



These observations motivated recent study of energy deposition for different TCL layouts.

# New experiment requirements

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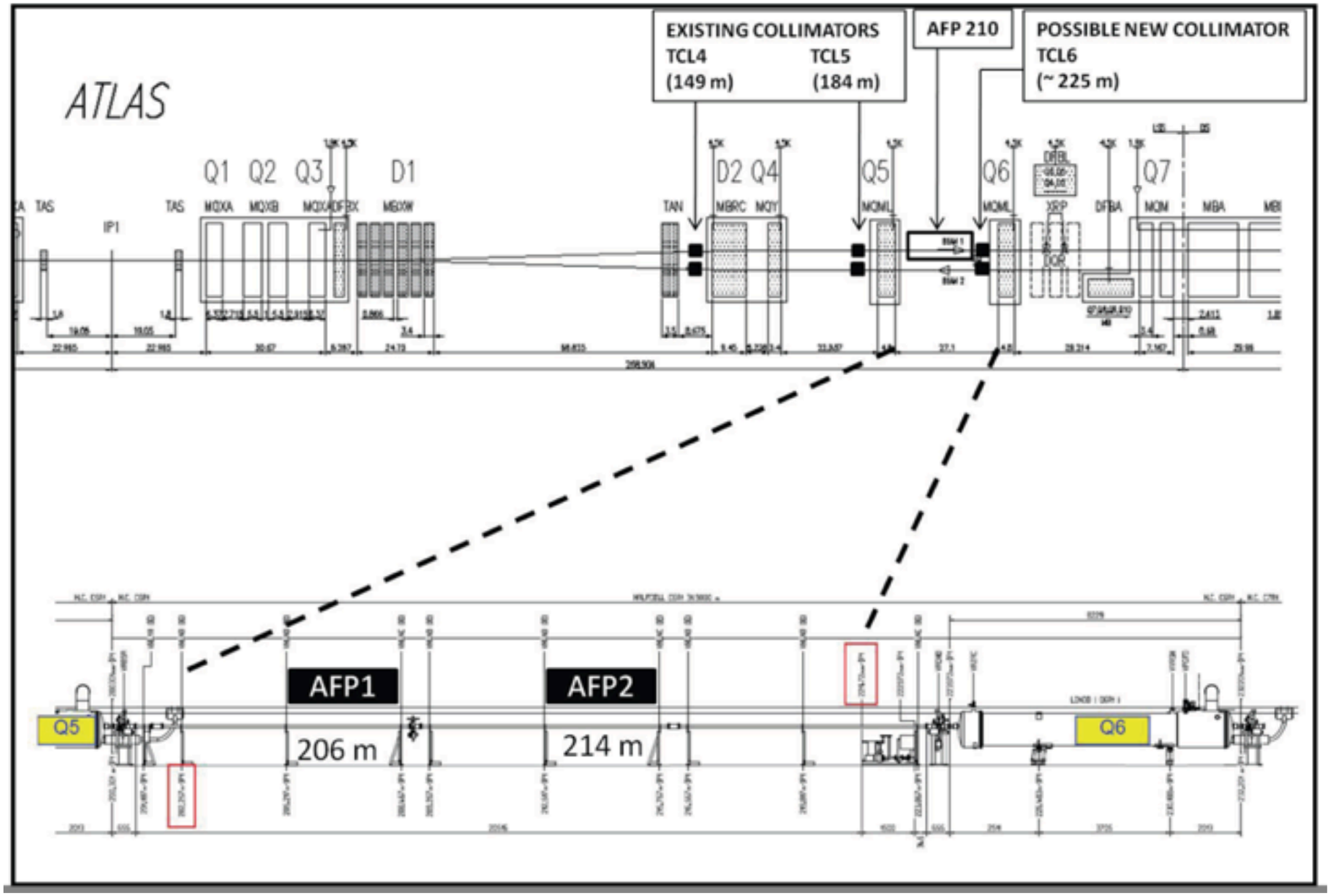


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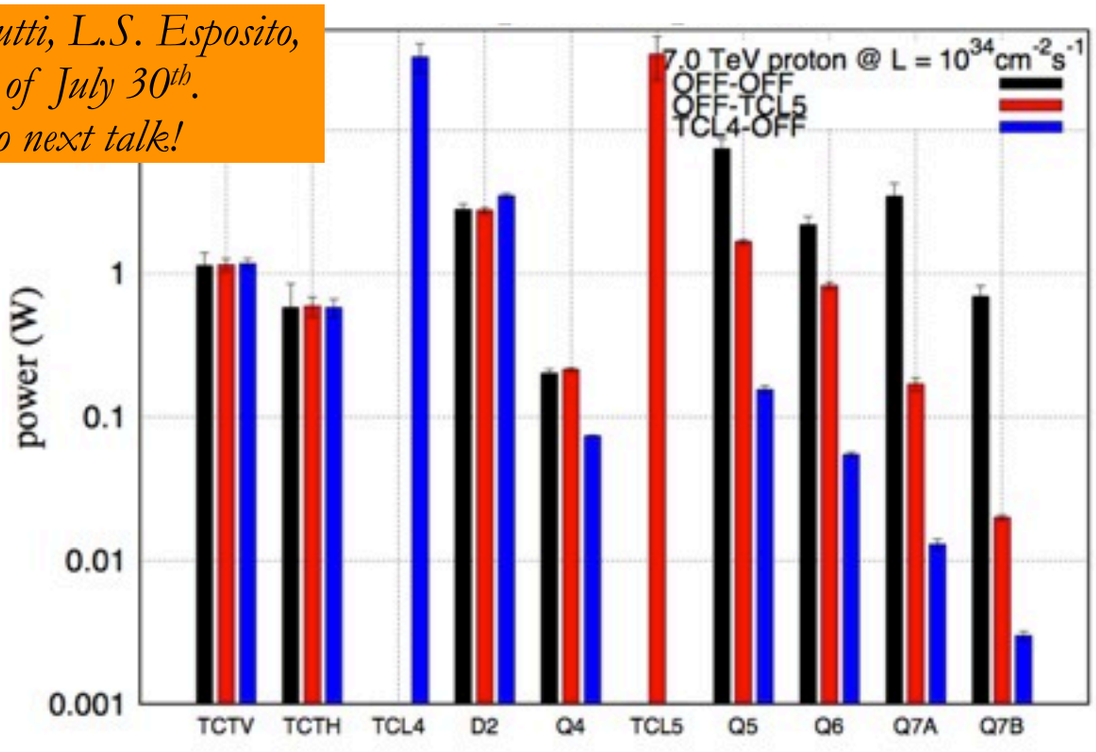
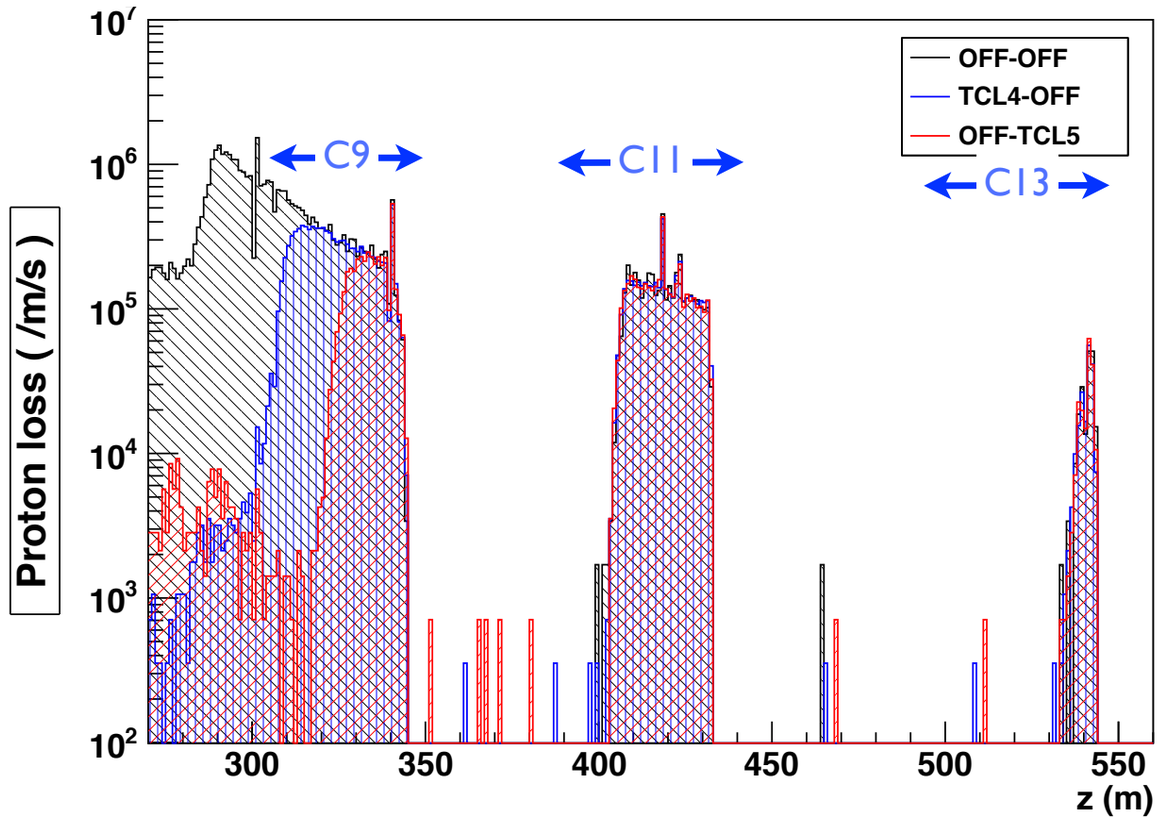
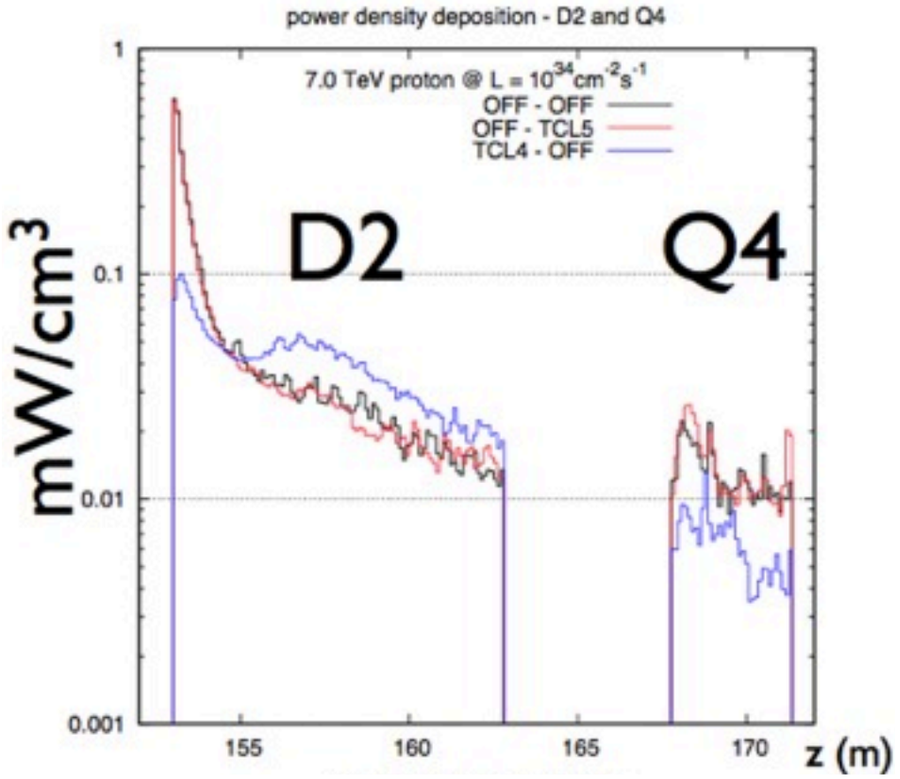
Similar requests in the physics CMS program - see talks of this morning!

# Updated simulation results

*F. Cerutti, L.S. Esposito, CWG of July 30th. See also next talk!*



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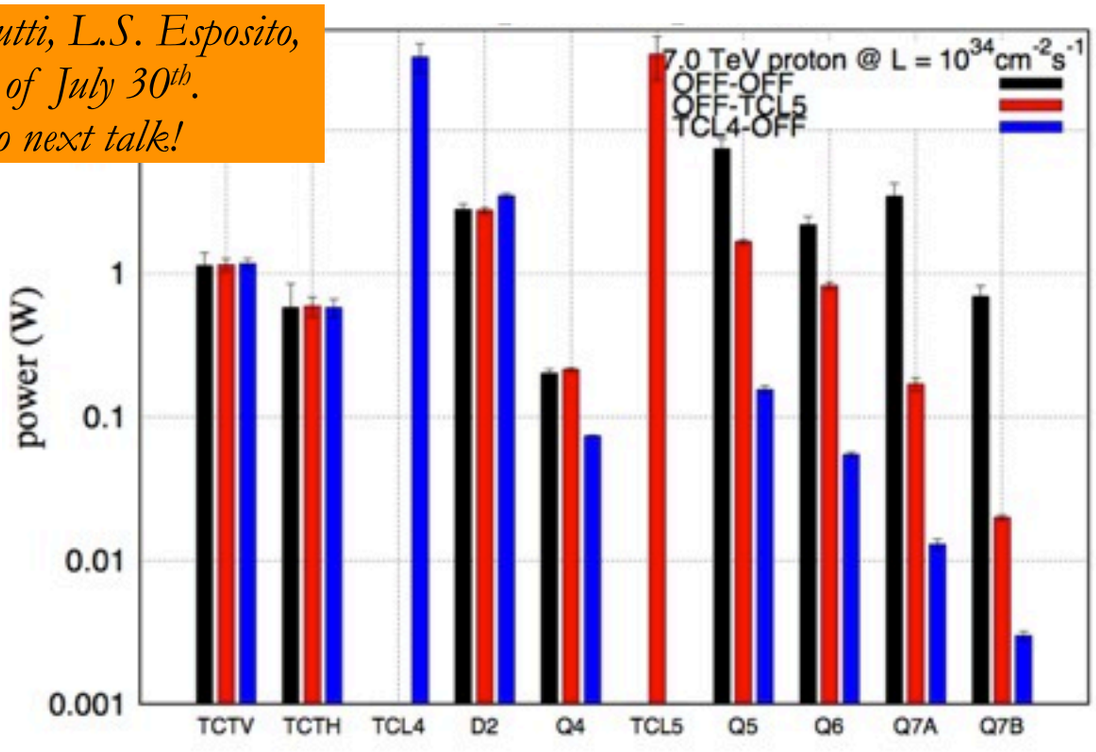


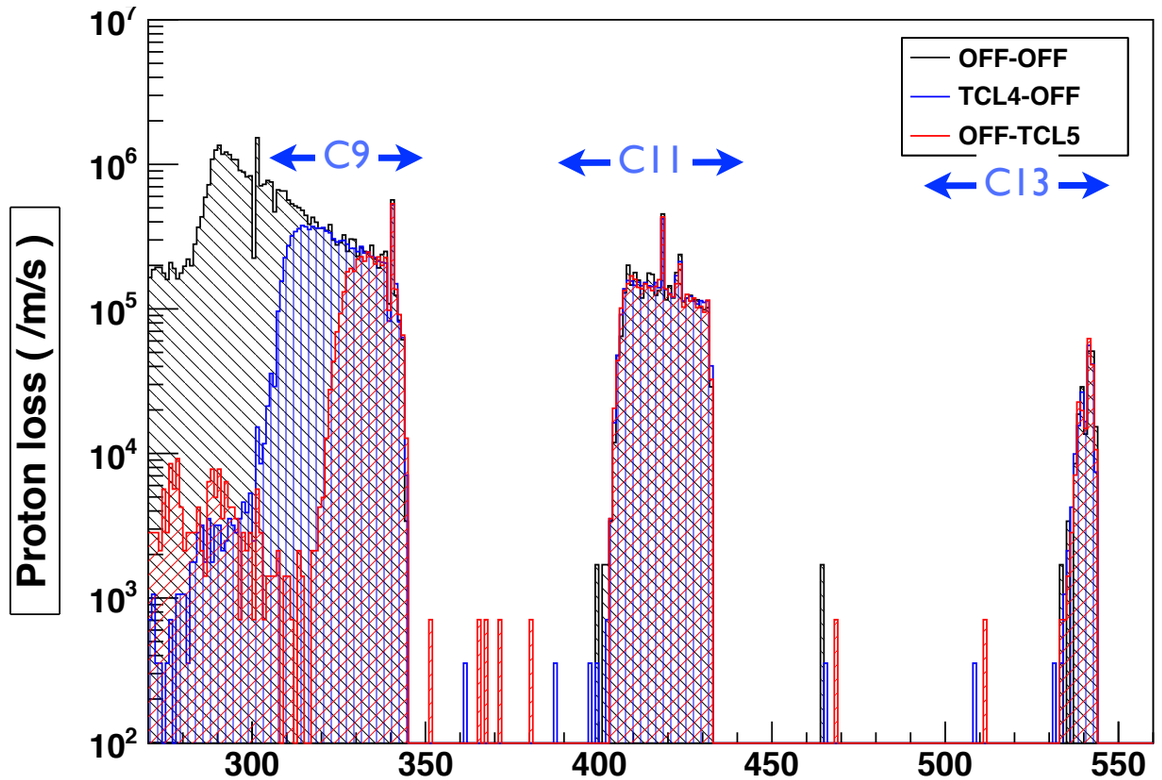


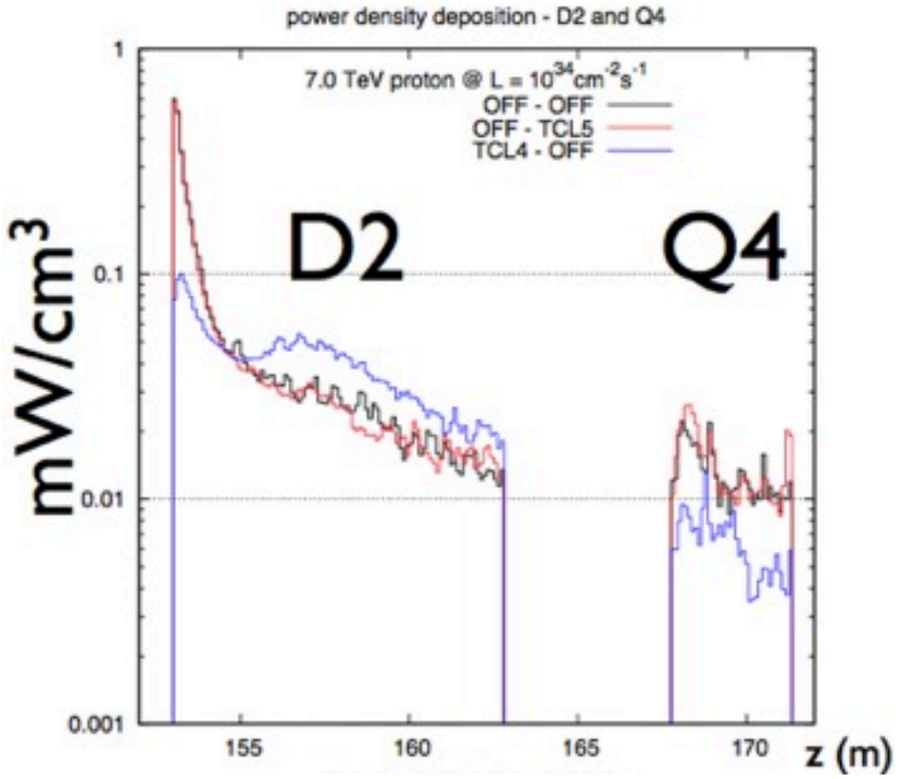


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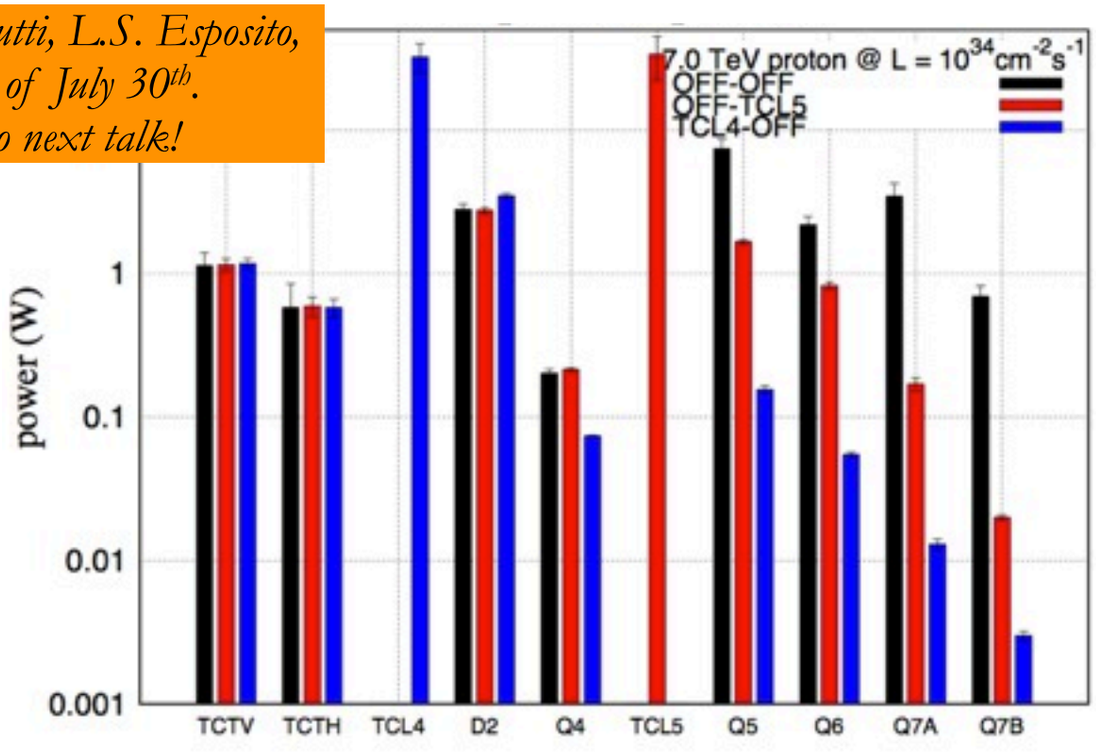


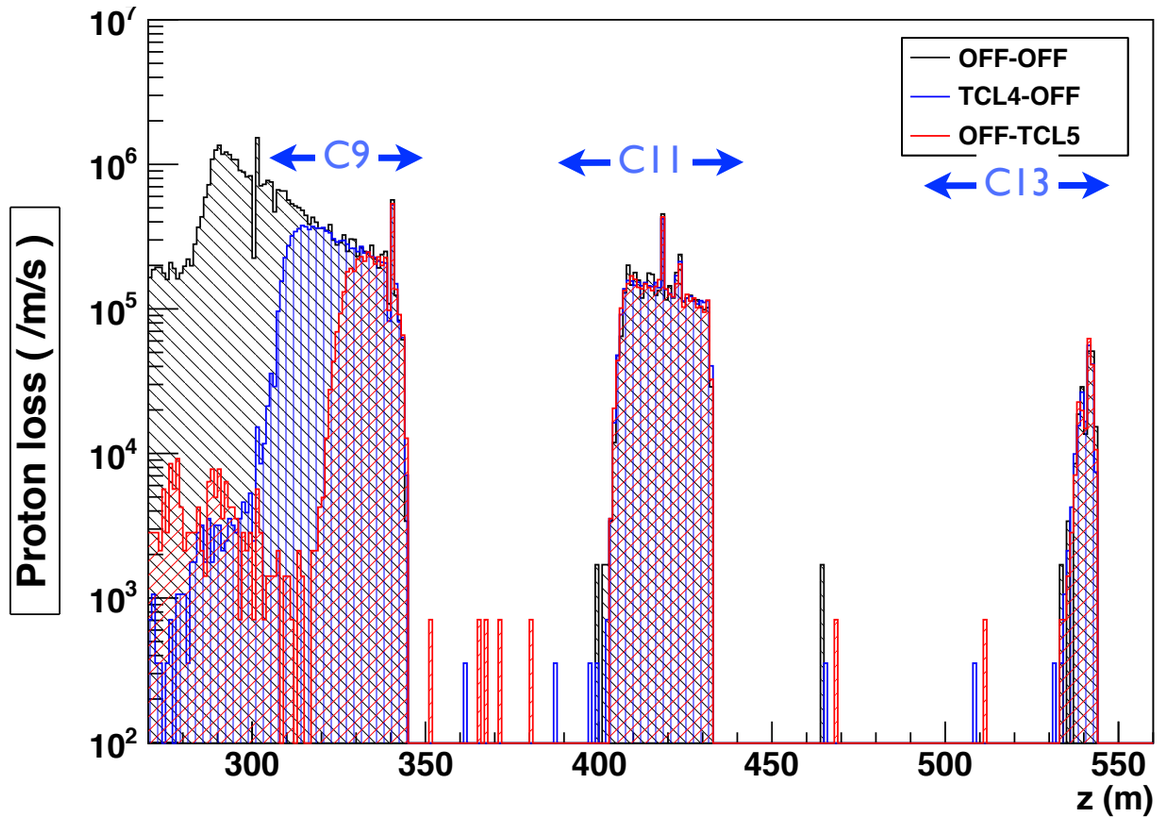


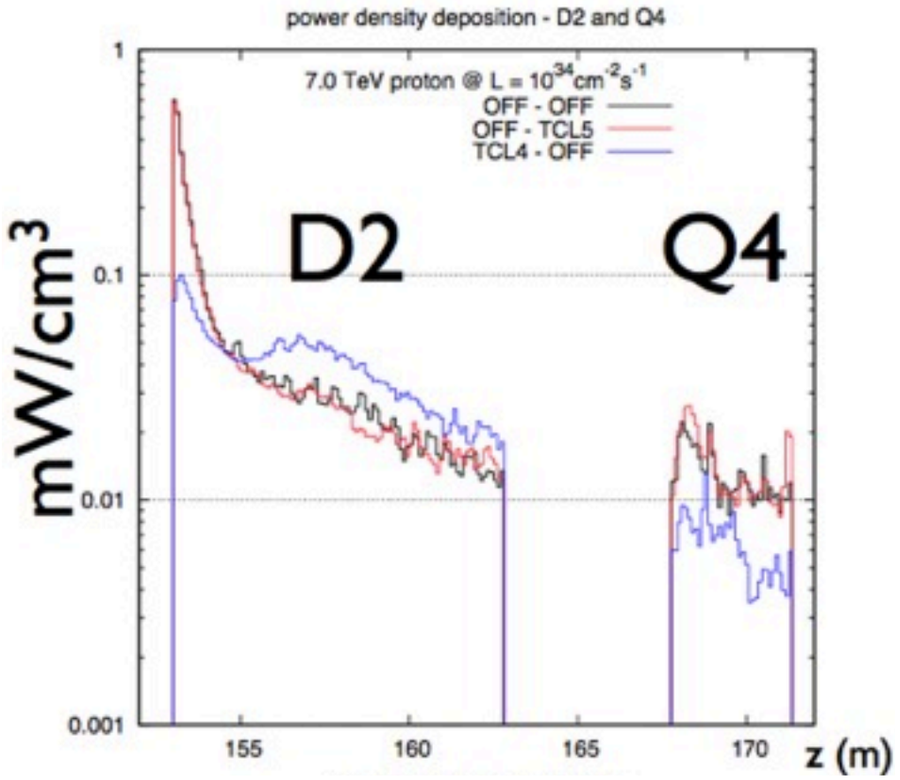


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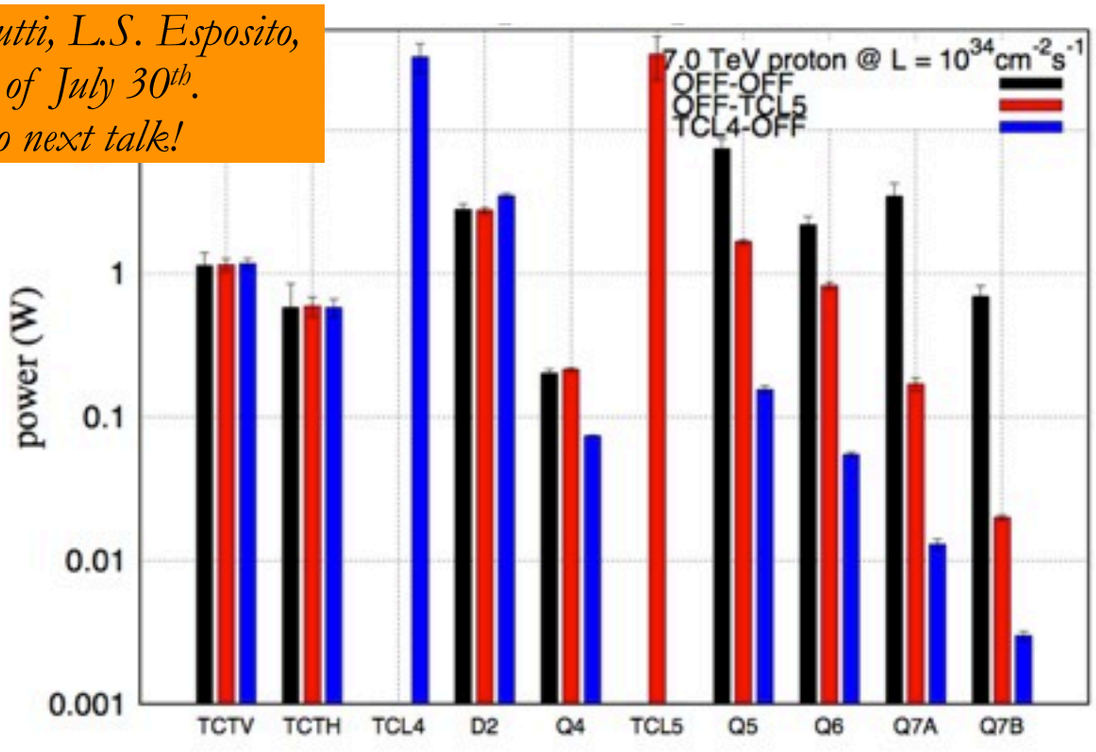


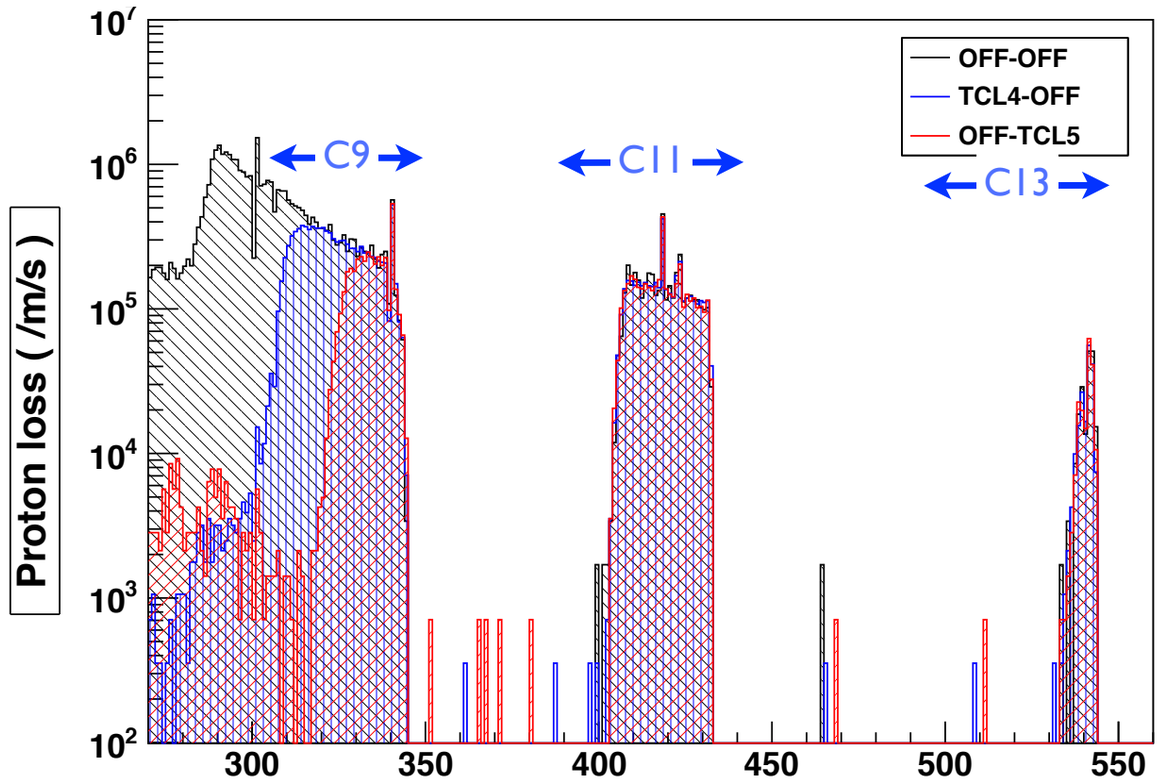


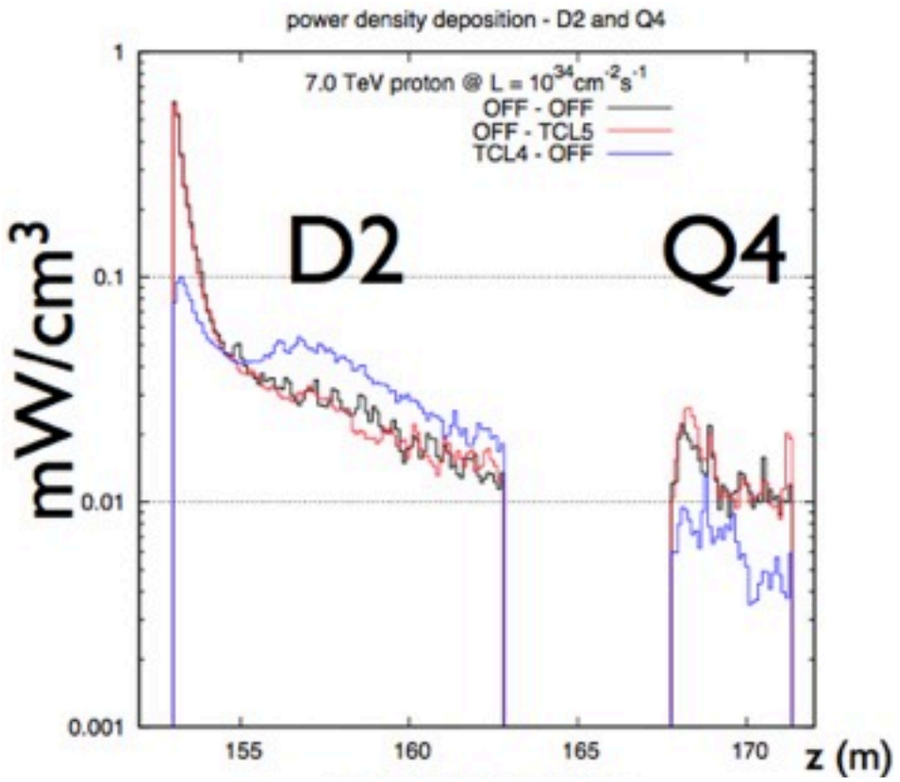


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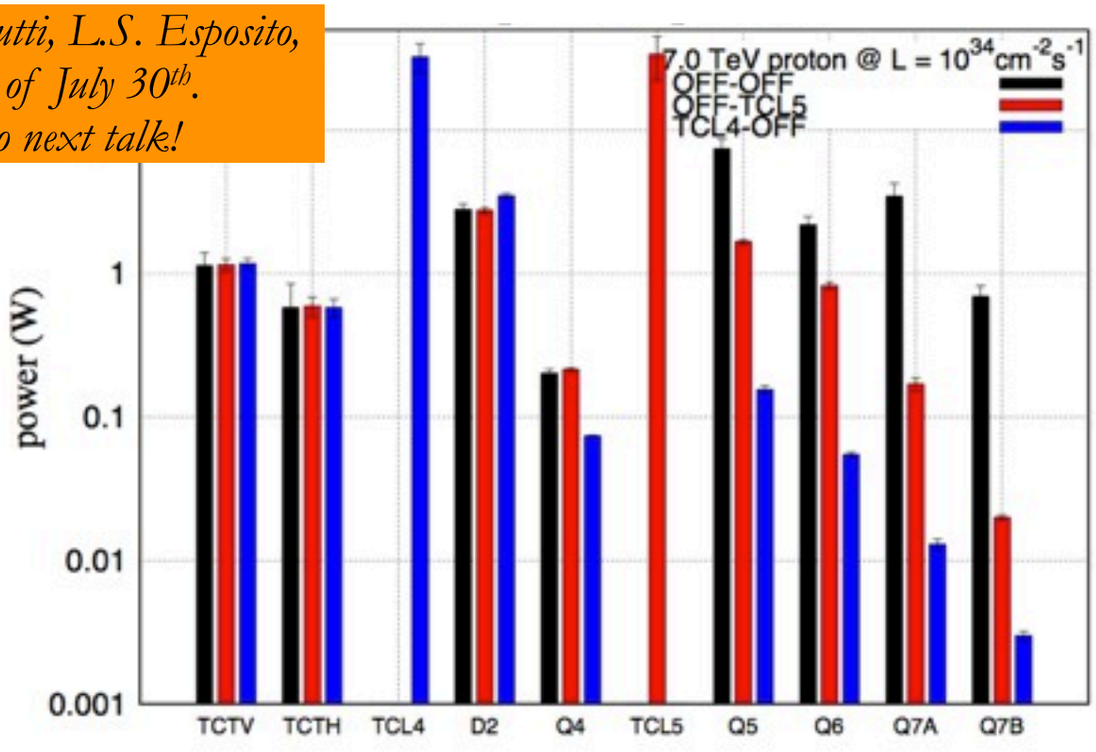


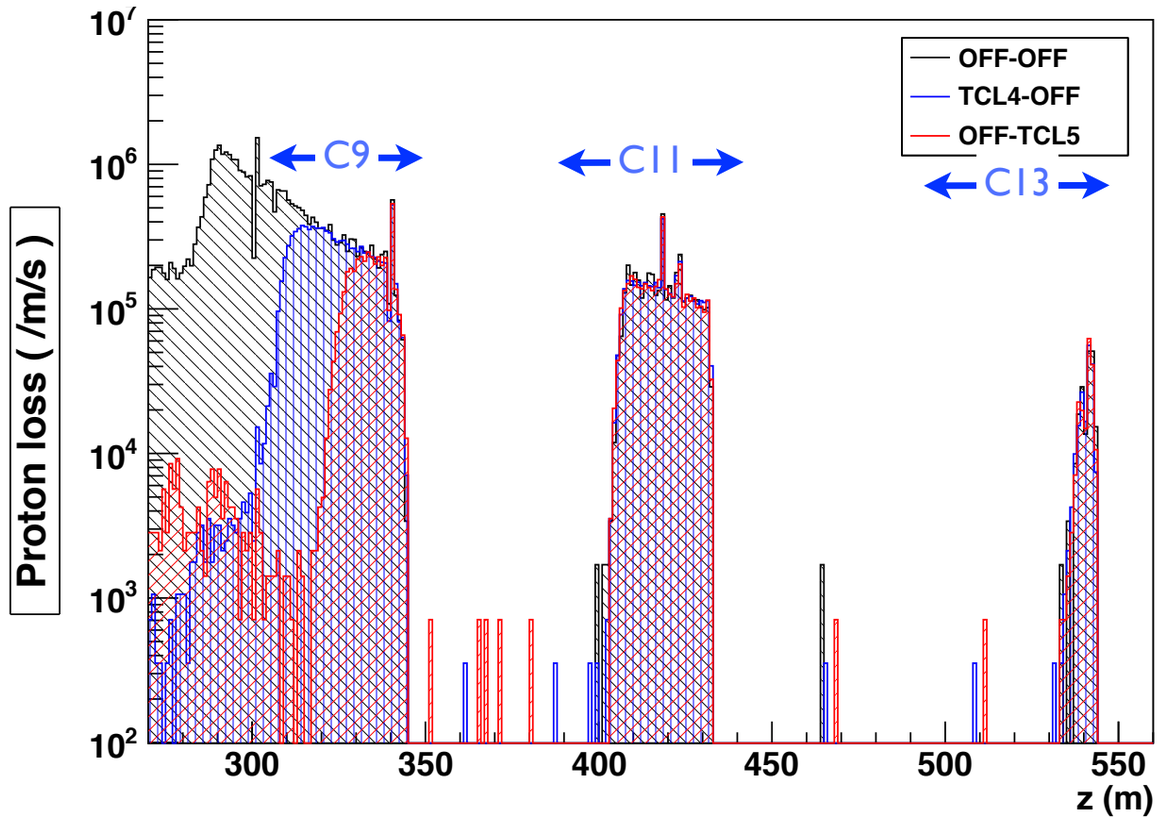


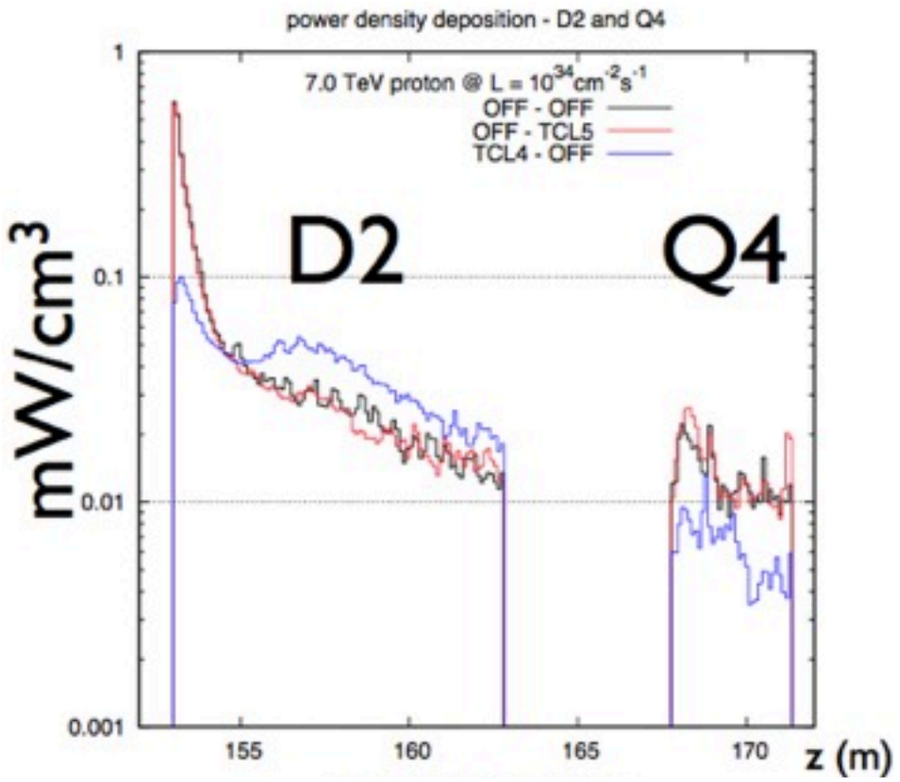


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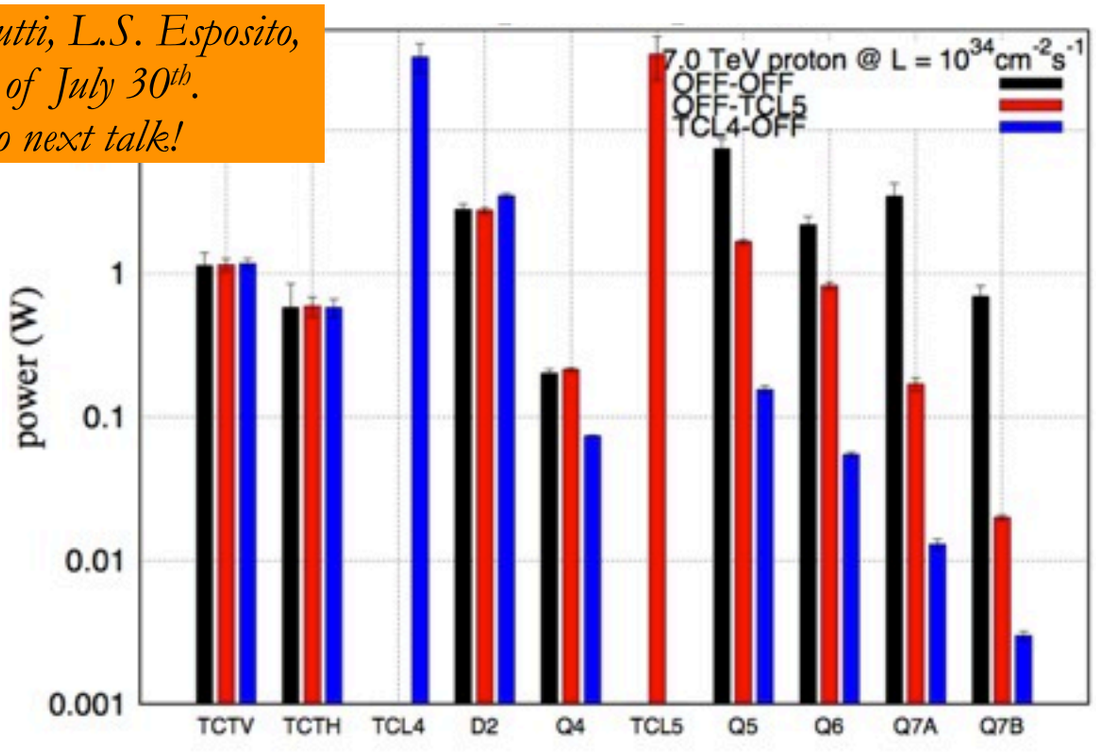


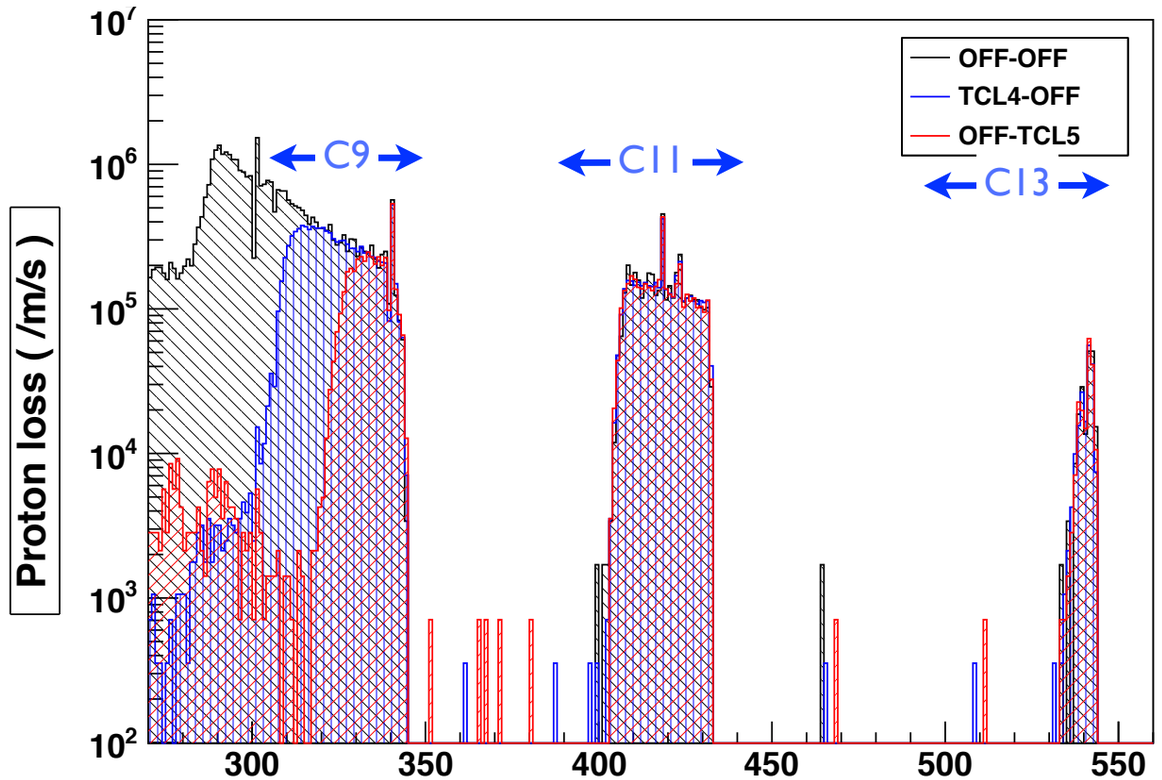


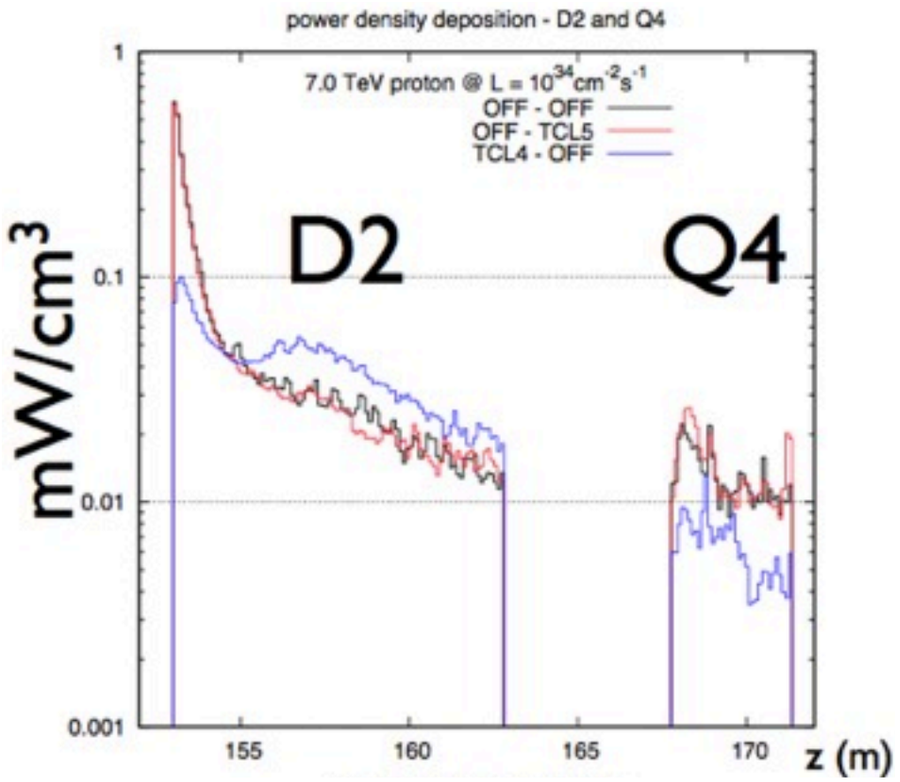


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- The assessment of the need for a TCL-6 requires more simulations. Cannot guarantee now that we can take data (AFP/TOTEM) without them!

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*(discussed with ATLAS, CMS, TOTEM)*

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**Proposal approved by the LMC. Detailed implication on LS1 works being evaluated (ECR's in preparation).**

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- Roman pot insertion to physics settings on 13/10/2011 (3.5 TeV, β*=1.0m)
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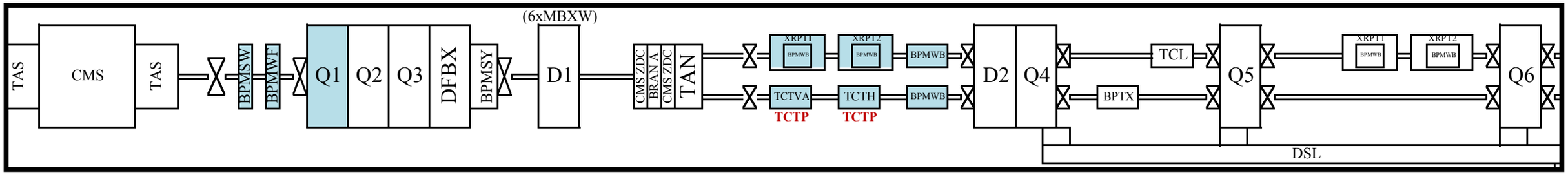
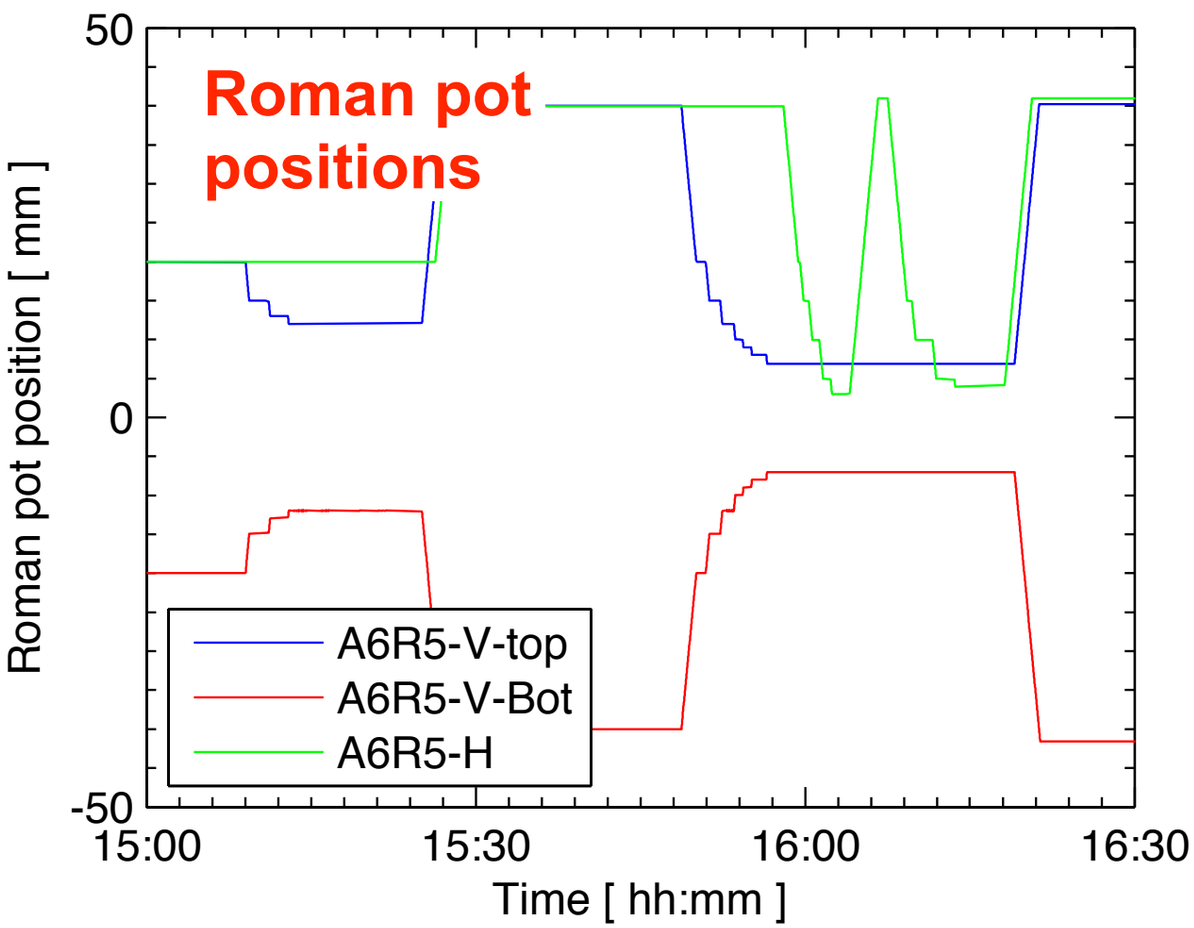
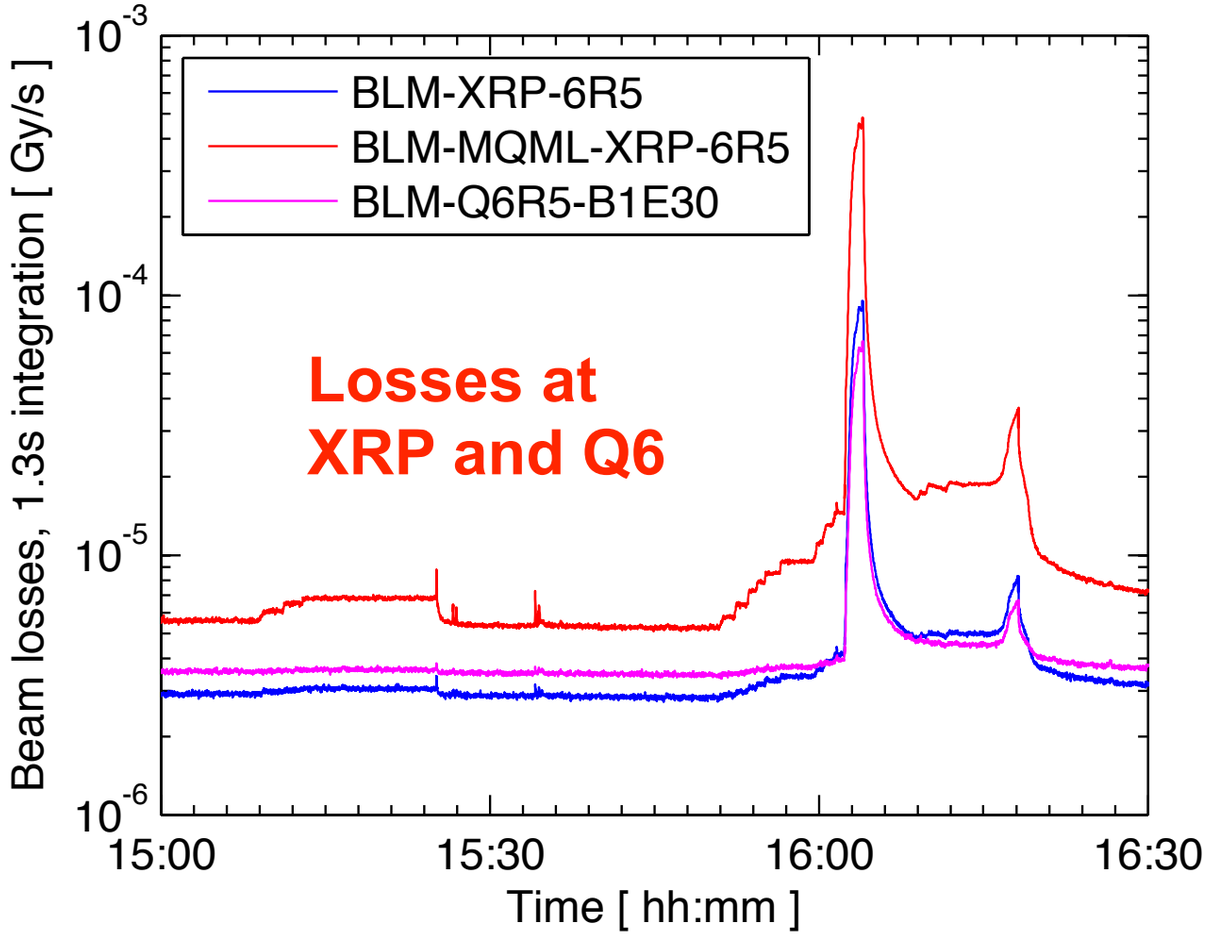
  *(Need to quantify this with detailed simulations)*



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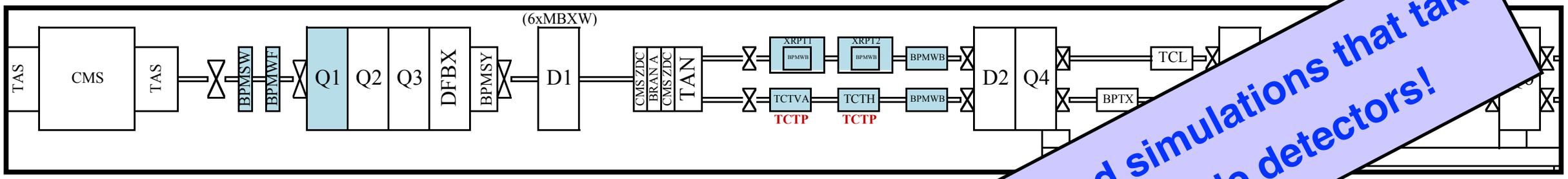
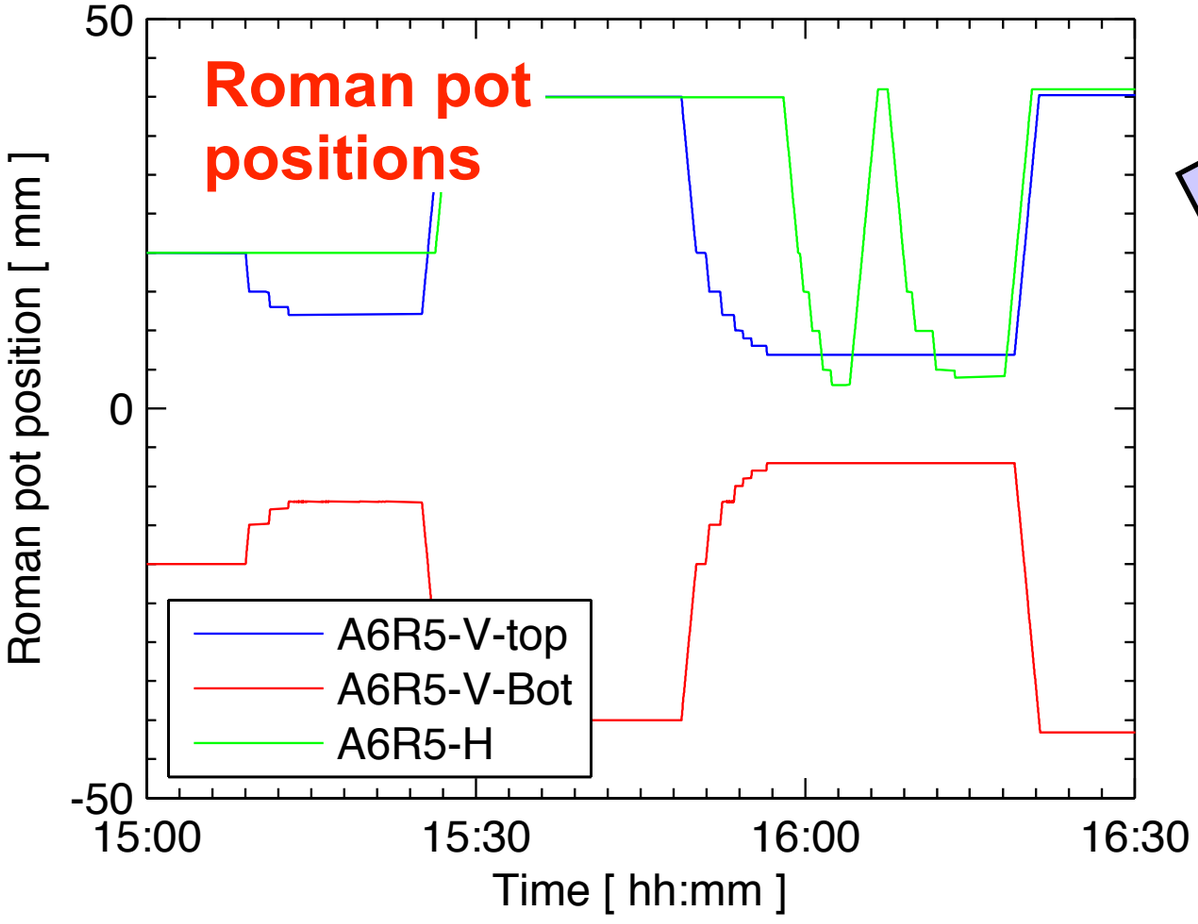
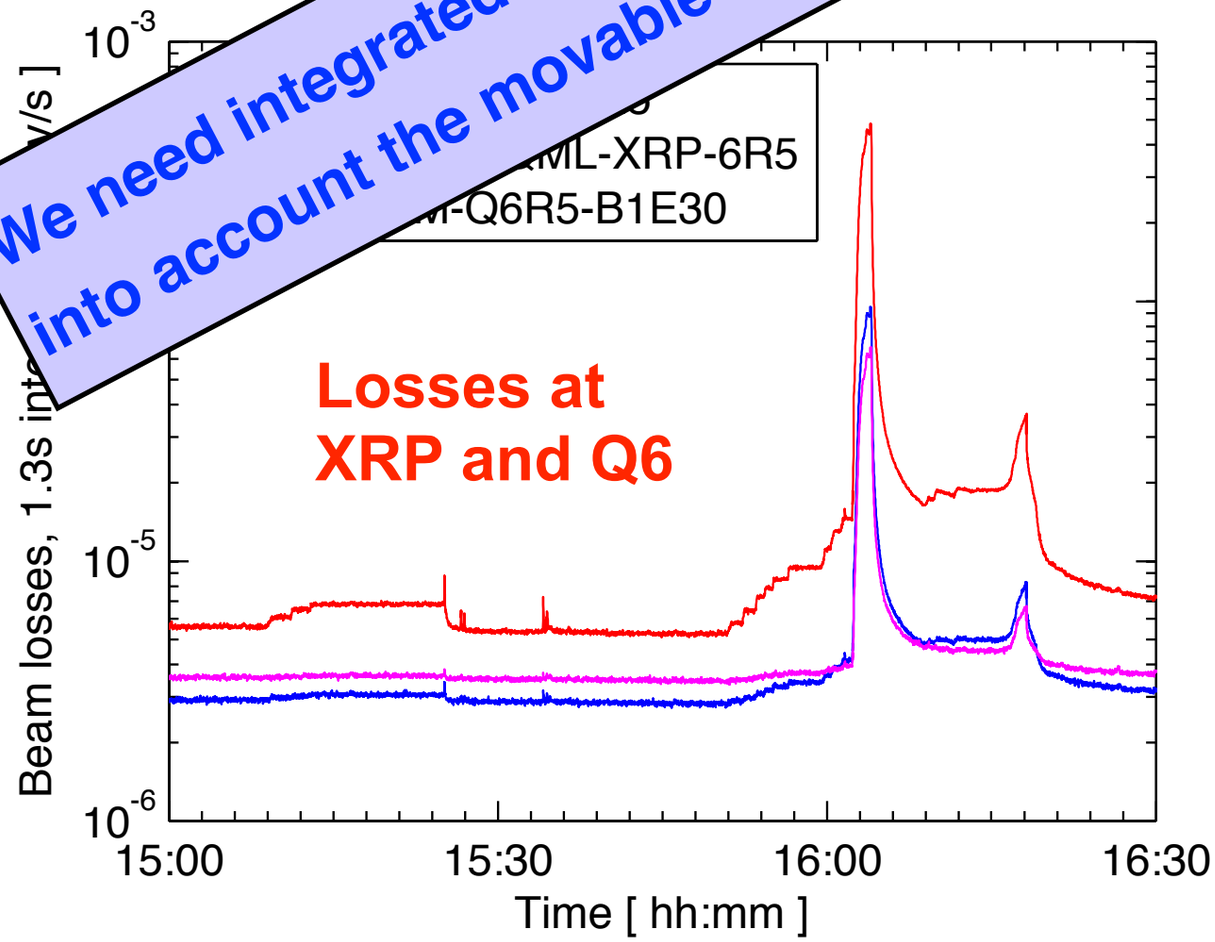



We need integrated simulations that take into account the movable detectors!



# Outline

- ☑ Introduction
- ☑ Present designs
- ☑ IR collimation after LS1
- ☑ **Considerations for HL-LHC**
- ☑ Conclusions

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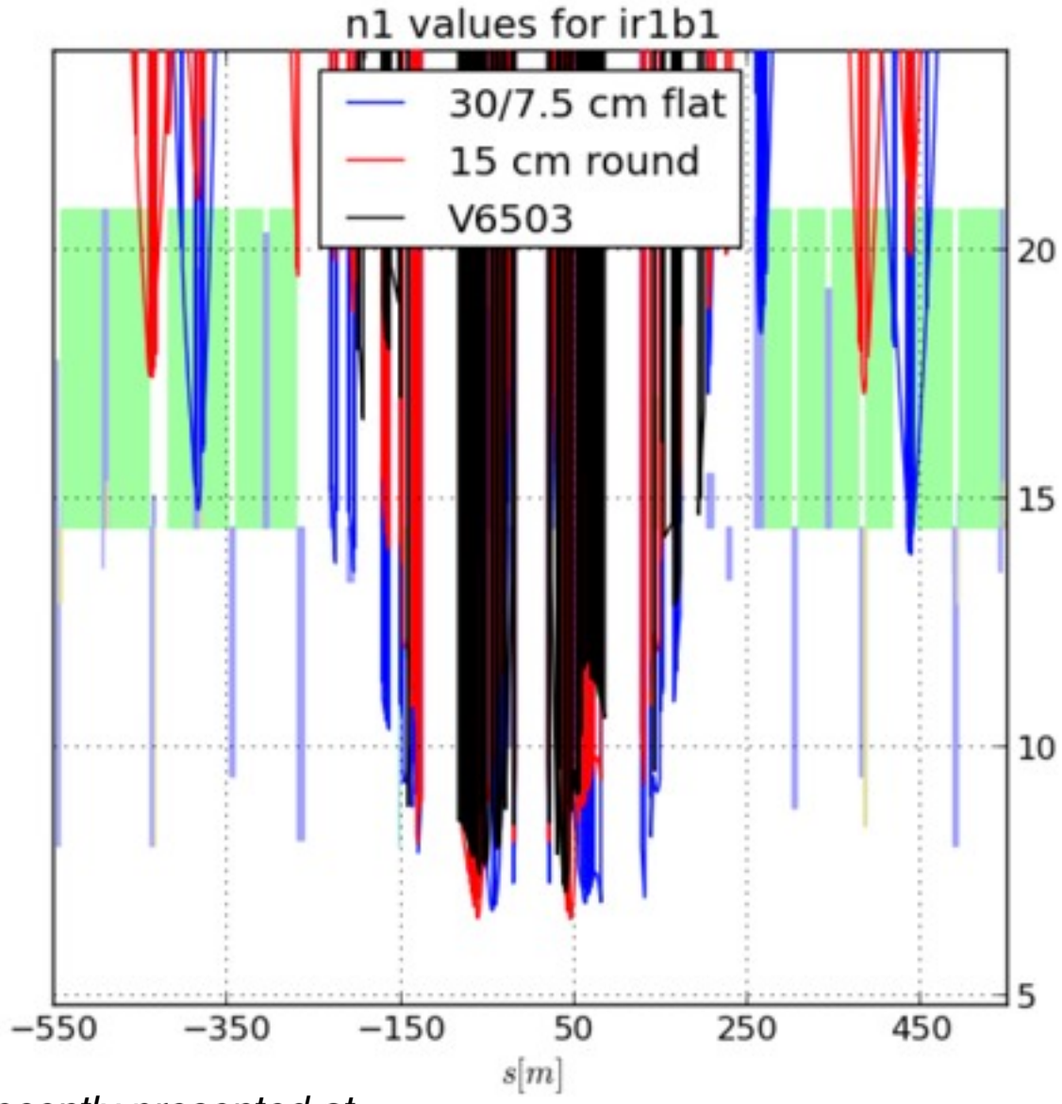
**Clearly, expect similar needs for IR collimat… incoming and outgoing beam!**

**The design of IR collimation is now taken into account as integral part of the IR layout definition!**

# Example: IR aperture for HL-LHC

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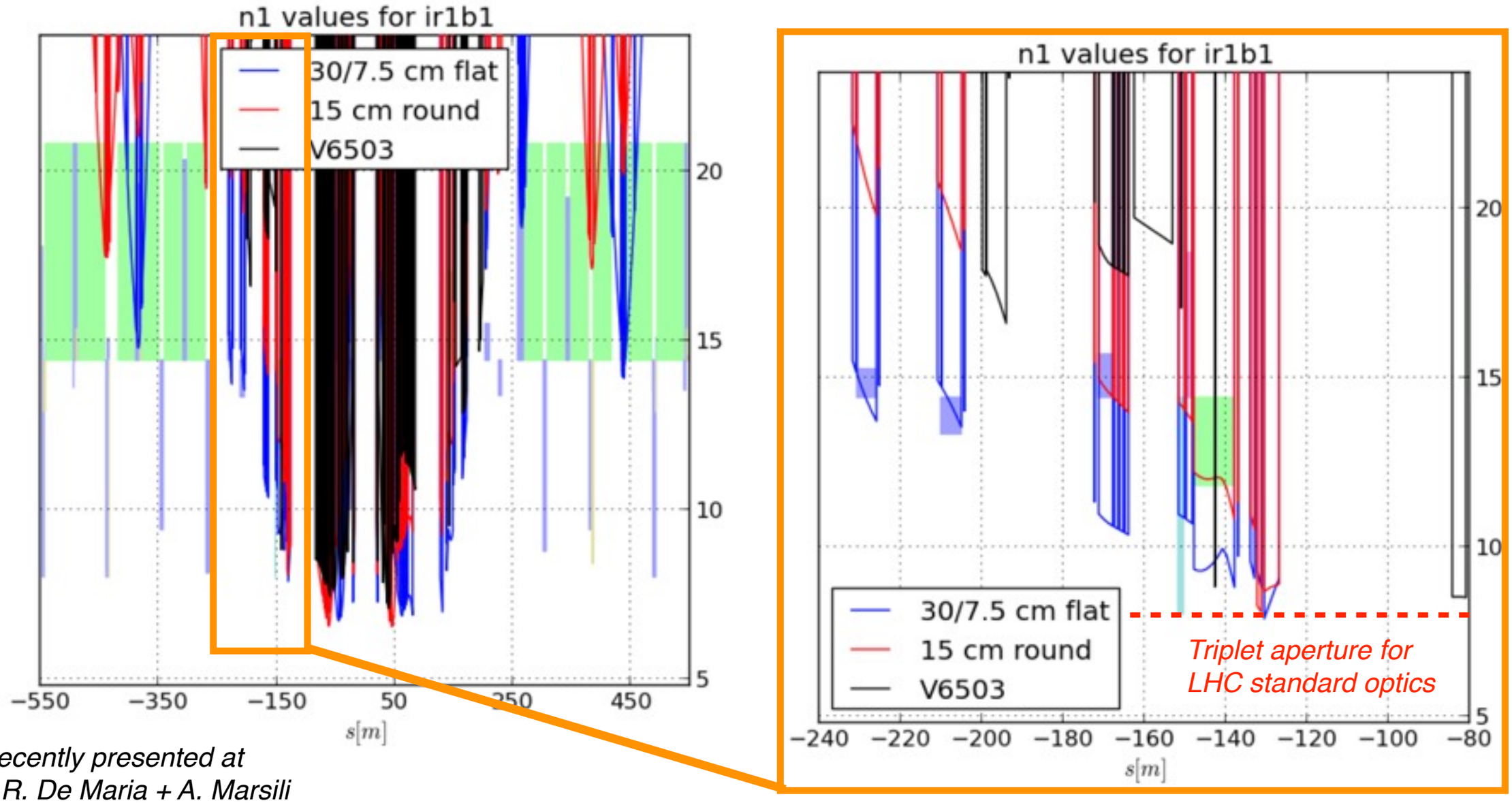


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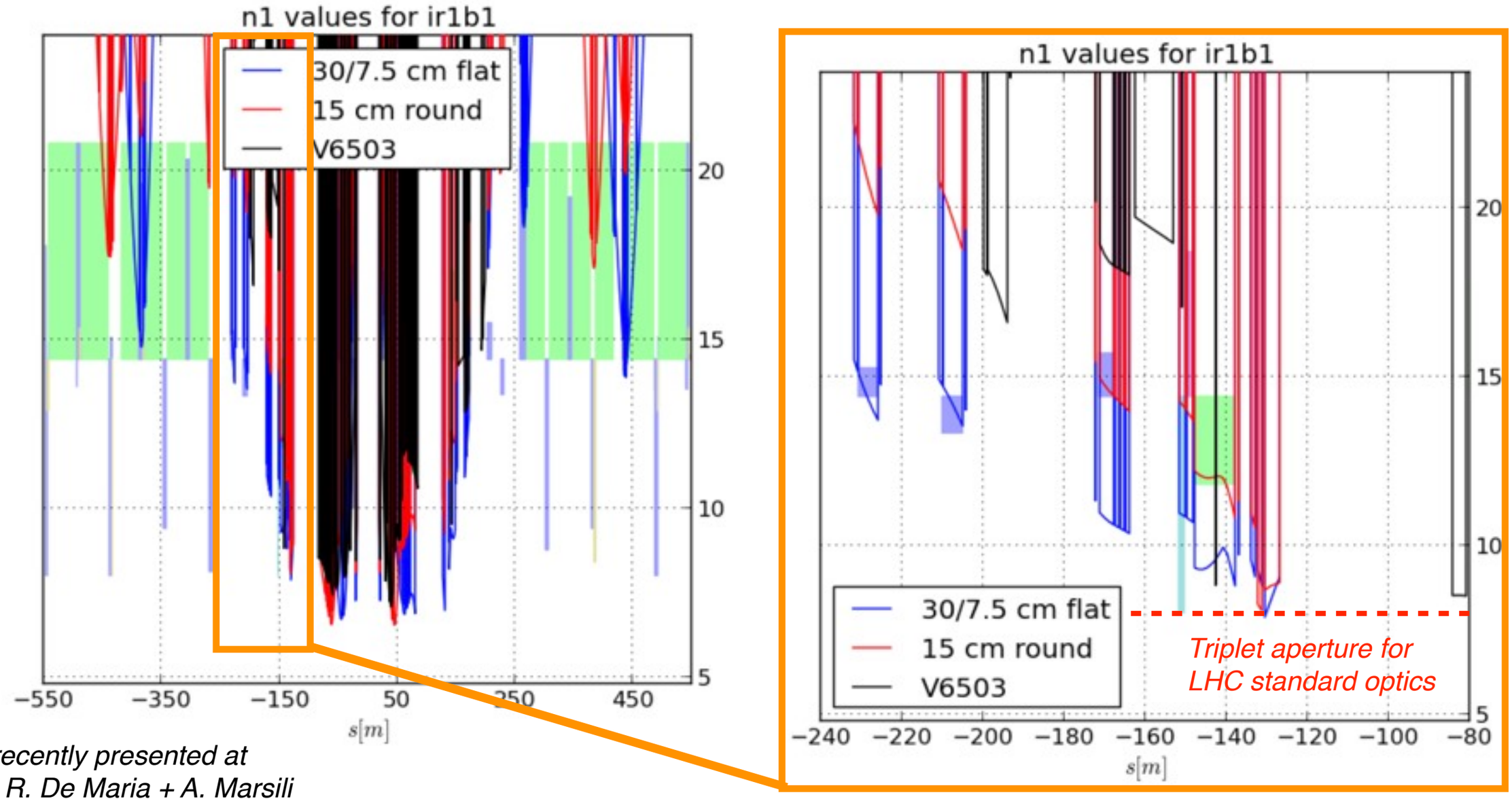


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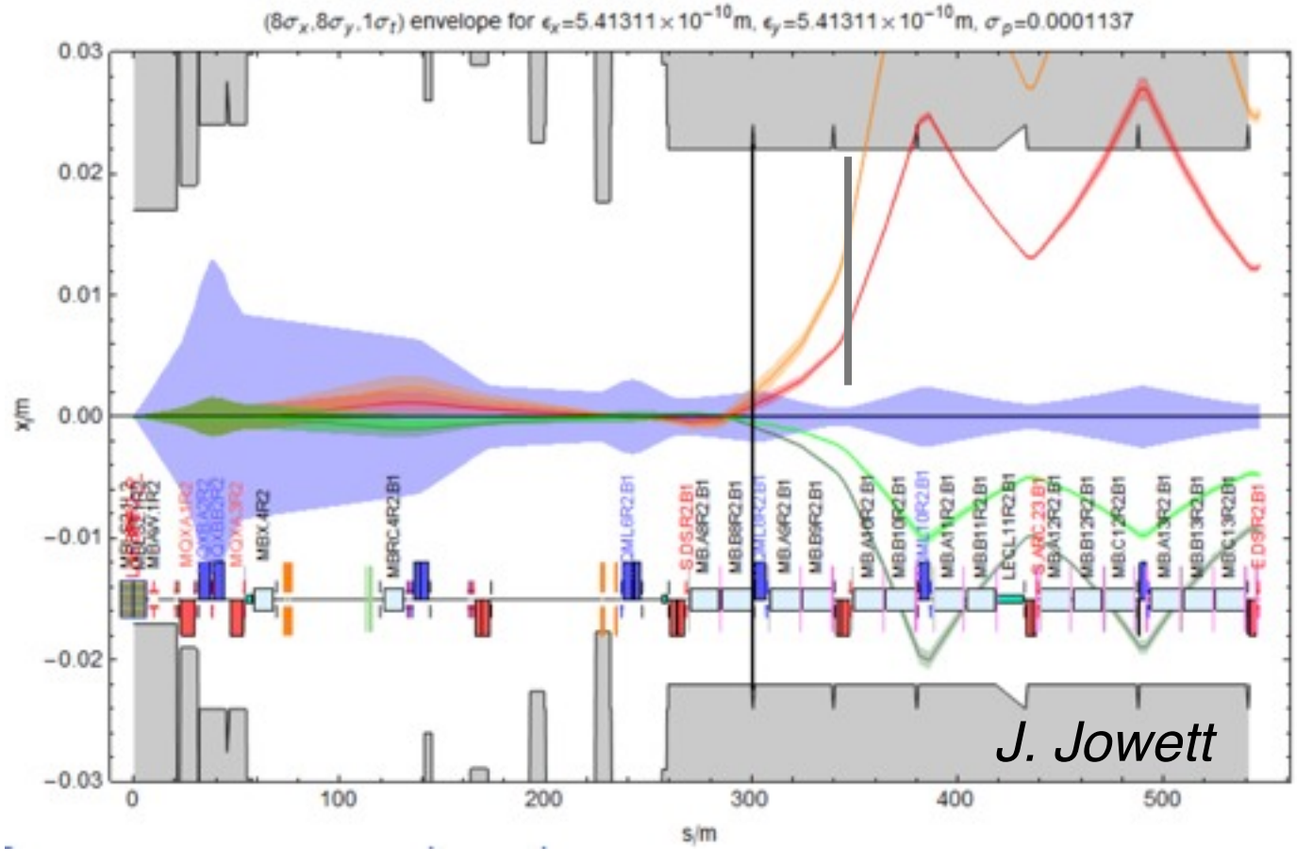
**Ongoing studies (HiLumi-WP5 in collaboration with WP2):**

- Assessing the needs to add additional protection for the incoming beam *à la* TCT.
- Studying the phase advances for optimized cleaning of the outgoing beam.
- Clearly, need an integrated study of the layout to fulfill all requirements!

# Collimator for forward physics?

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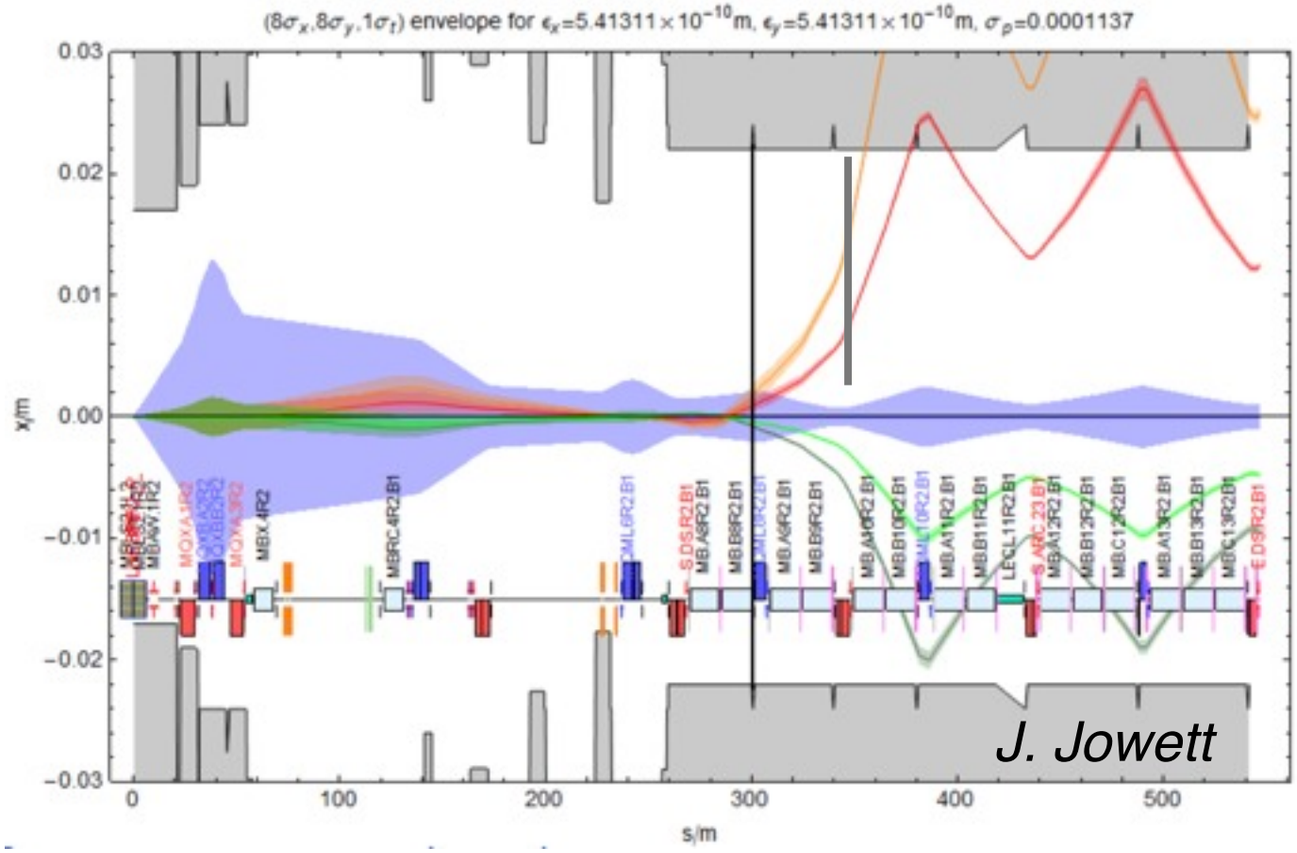


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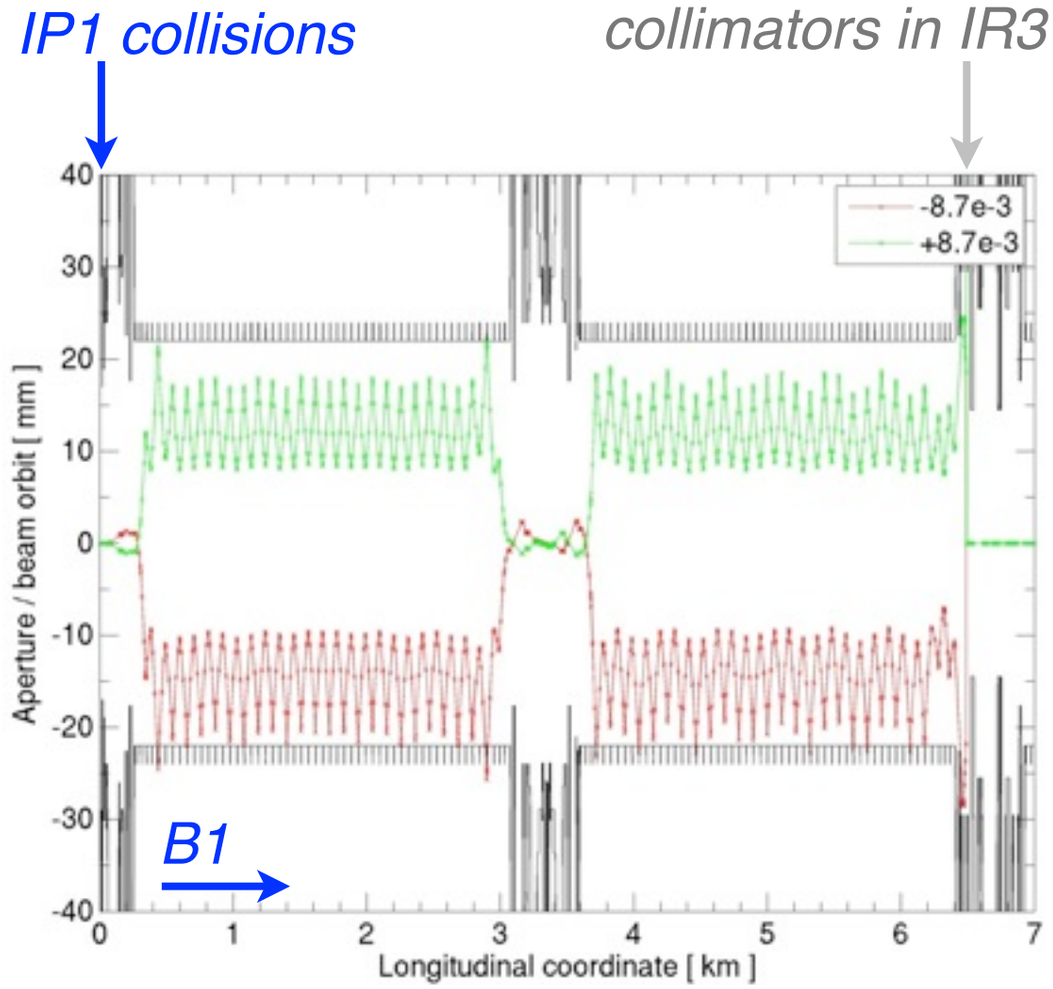
IR3 represent the momentum bottleneck of the machine.

Can catch particles with momentum errors in the range **1 - 8 x $10^{-3}$**!

Preliminary discussions with TOTEM.



# Conclusions

- **Reviewed the baseline collimation upgrade in the IRs for LS1**
  - *Will replace 18 collimators in IR1/2/5/6/8: improved machine availability and β*!*
  - *Proposed an improved TCL layout baseline: TCL-4, -5 and -6.*
  - *Other important changes not discussed here.*
- **A project review in spring 2013 will address the needs for LS2**
  - *Present layout might be compatible with proton operation until LS3.*
  - *Ion operation might be closer to limits, in particular for physics debris in IR2.*
  - *Working on different fronts (collimation, magnets, ...) to prepare the DS collimators!*
- **The HL-LHC will pose many new challenges for IR collimation that we being addressed with high priority**
  - *New collimators for incoming beams?*
  - *Appropriate layouts for physics debris cleaning with new optics solutions.*
- **We supported strongly the forward physics community and will continue to do so!**
  - *LS1 works compatible with presently known requirements.*
  - *Open to new ideas for the future!*

# Reserve slides

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  *The TCL-5's were installed. Used in physics since the beginning of 2012.*

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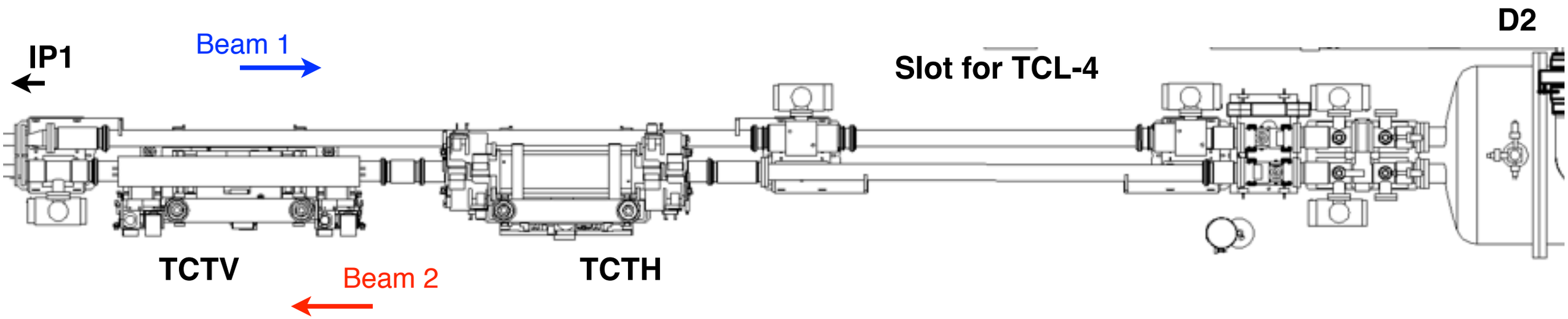
- In spring this year we triggered a re-evaluation of the **present TCL layout**:

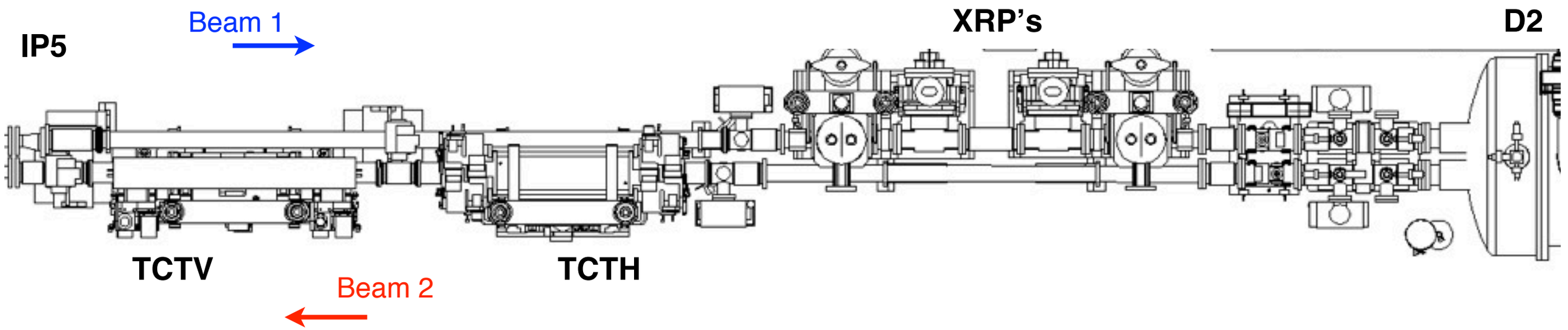
  *Do we need to change the present layout during LS1?*

  *Does the operational experience and updated simulation confirms old results?*

  *What are the new requirements of the **forward physics community**?*

# Layout of cells 4 in IR1 and IR5




TCL-4 installation in IR5 was postponed due to conflicts with TOTEM Roman pots.

It was decided to adopt the same layout in IR1.

This layout were reviewed taking into account new requirements of the forward physics community! Comparative assessment of TCL-4/TCL-5 +