Simulation comparisons to BLM data

E.Skordis

On behalf of the FLUKA team

Collimation losses
BLM signals vs simulation overview

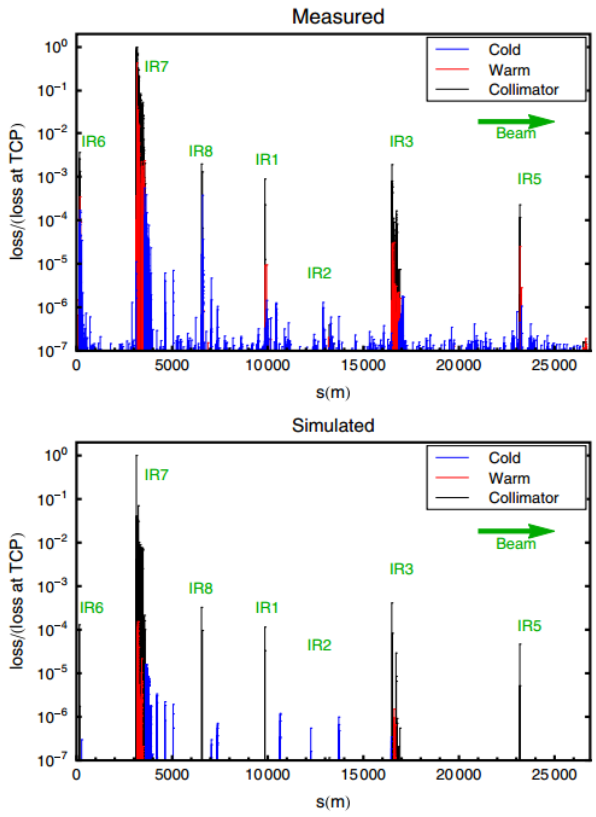


FIG. 6. Beam loss distributions around the LHC as measured by BLMs during a qualification loss map on April 12, 2011 (top) and from a SixTrack simulation (bottom), with the results binned in 1 m intervals. Both simulation and measurement assume a beam energy of 3.5 TeV and $\beta^* = 1.5$ m. They are both normalized to the highest loss, and the initial losses occur in the horizontal plane in B1.

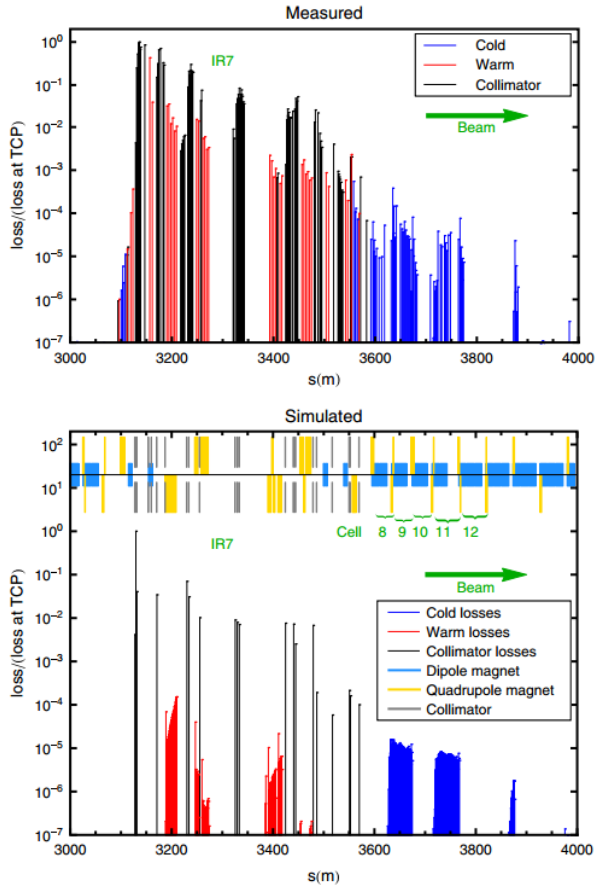


FIG. 7. Loss locations in IR7 (zoom of Fig. 6) from measurement (top) and SixTrack (bottom). The layout of the main magnetic elements (quadrupoles and dipoles) as well as the collimators is also shown, together with the LHC cell numbers at the cold loss locations.

BLM Signal = Gy/s

≠

Collimator losses = #protons inelastically interacting (lost)

BLM and Beam losses

- Do BLMs actually detect Beam losses?

Yes! . . . Partially…

- Partially?

BLMs detect only a tiny part of the particle shower and converts it to signal (dose).

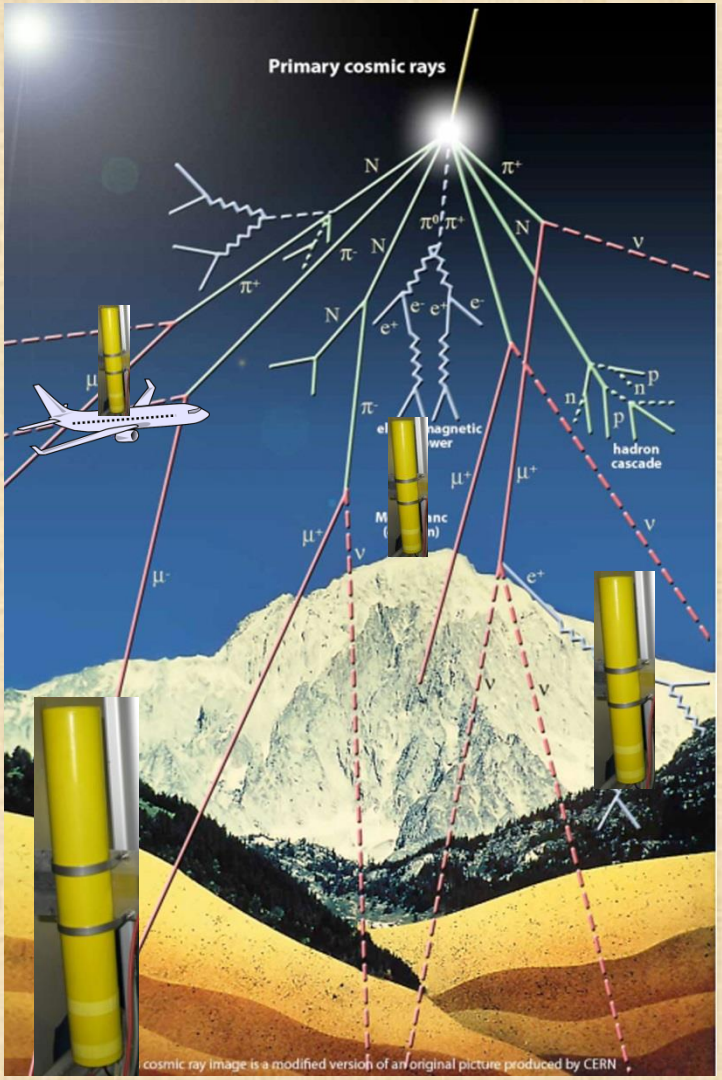
- Which part and how much?

Depends… on 3 main factors:

- ➢ Position of the BLM relative to shower
- ➢ Proton energy (450… 4000… 7000… GeV)
- ➢ Beam loss scenario (Regular cleaning, accidental scenario etc.)

- What happens to the other part?

Absorbed by the LHC elements and the tunnel walls



Energy deposition simulation requirements for collimation losses

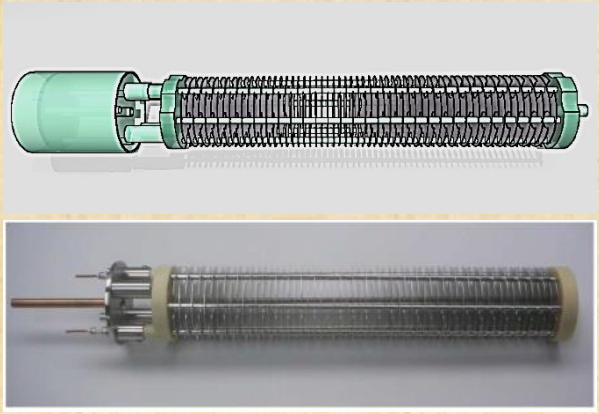
1. Creating input for further FLUKA simulations

Old method: Sixtrack simulations produce lossmap of proton inelastic interactions in the collimators

New method: Sixtrack-FLUKA Coupling provides input (lossmap of inelastic interactions or proton impacts on collimator surface)

2. FLUKA simulation set up
   - Model complex geometries of all key elements of the LHC
   - Set up the simulation parameters
     - Source routine
     - Magnetic fields routines
     - Physics settings
     - Scoring
     - Etc…

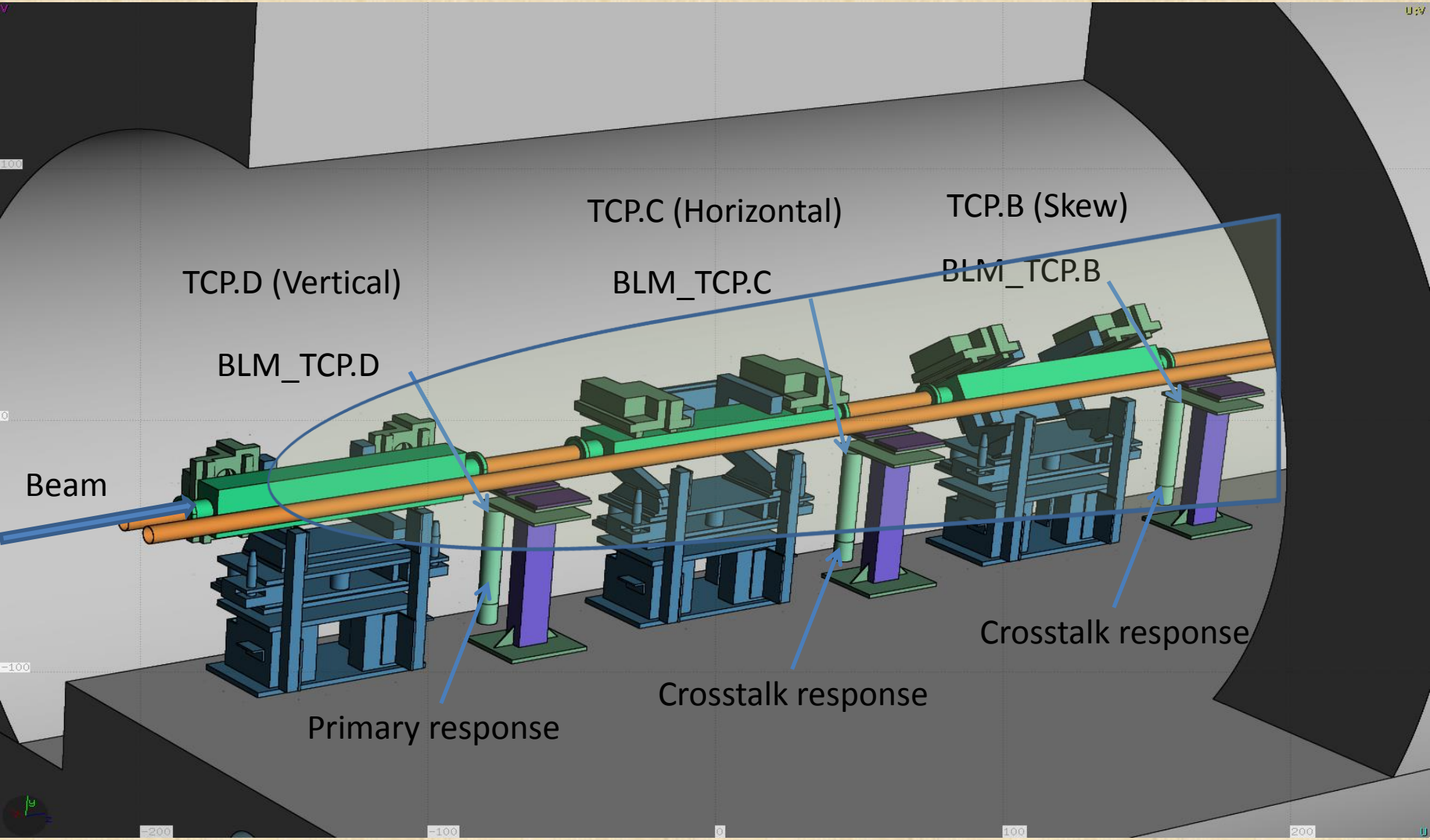
LHC BLM



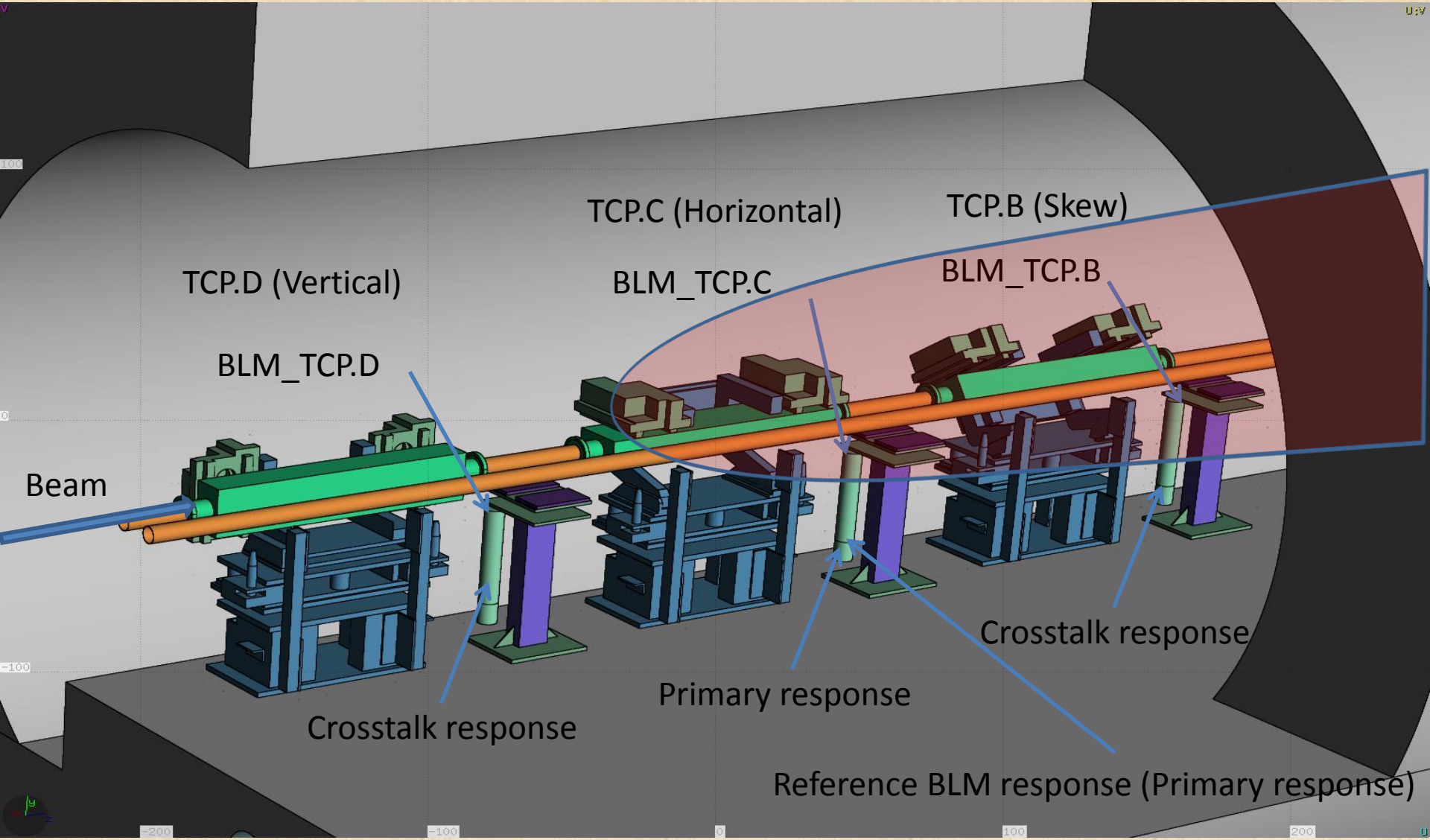
FLUKA MODEL

Picture

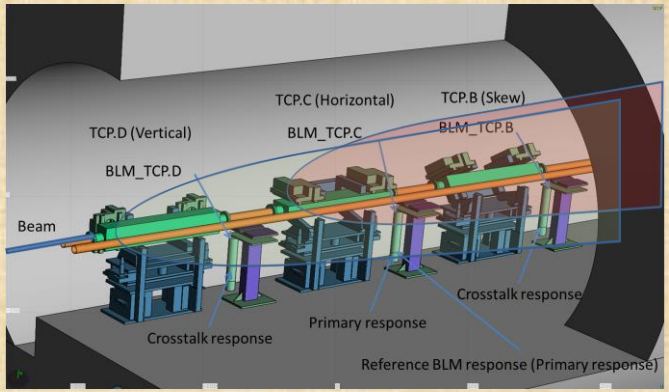
TCP simulated Geometry



TCP simulated Geometry



BLM Responses Beam1
IR7 TCPs



Initial energy of protons = 3.5 TeV

Values are normalised to the reference:
TCP.C (BLM_TCP.C) Primary response = **4.58 10^{-12} Gy/p**

IR7 beam 1 TCPs
(Values are normalised to the **TCP.C(BLM_TCP.C)** response)

Simulated Collimator \ BLM response	BLM_TCP.D	BLM_TCP.C	BLM_TCP.B
TCP.C (Horizontal)	0.01	**1**	2.53
TCP.D (Vertical)	**0.58**	1.80	2.13

A factor of 2 lower than the Horizontal Primary BLM signal

BLM final **signal** calculations **must** take into consideration the Crosstalk

Primary response appears with **BOLD**

BLM Responses for TCTs and "Correction"

Primary response appears with **BOLD**

(Values are normalised to the **TCP.C(BLM_TCP.C) primary** response) for 3.5 TeV case

IR1 TCTs (Beam energy 3.5TeV)		
BLM response / Simulated Collimator	BLM_H1	BLM_V1
TCT_H1	**7.21**	1.14
TCT_V1	0.40	**3.25**

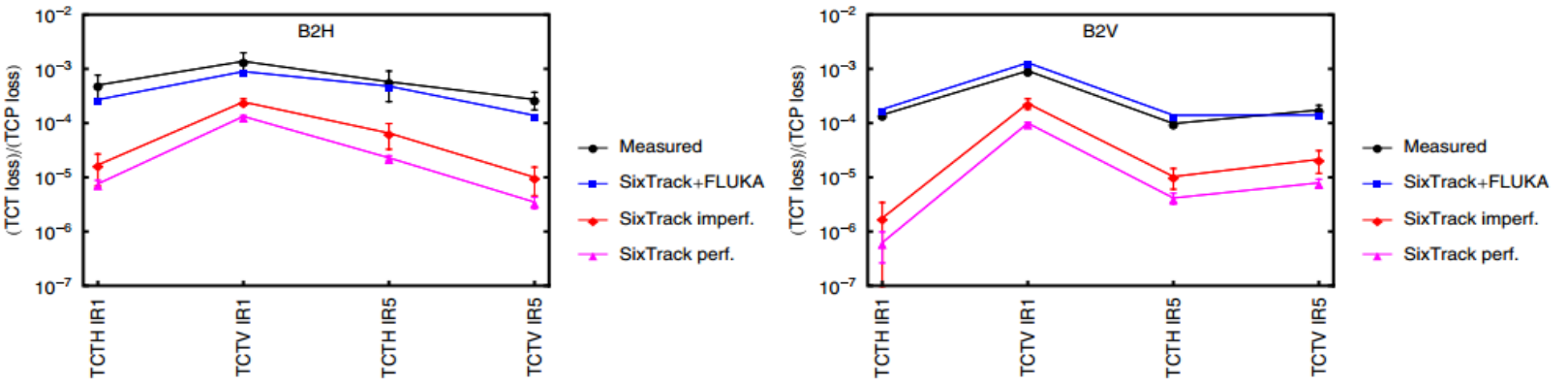


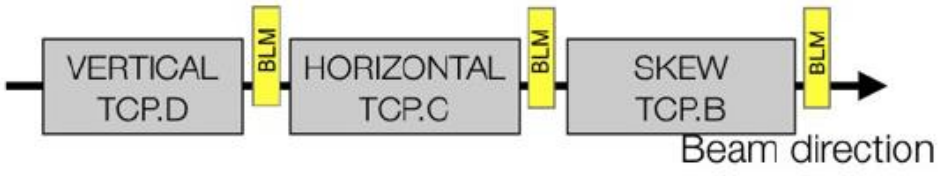
FIG. 15. The ratio of BLM signal, or particles lost, on horizontal and vertical TCTs to the TCPs in simulations and measurements in the 2011 machine. Simulation results are shown both from counting primary losses in SixTrack, as well as with a two-step simulation where FLUKA simulates the shower to the BLMs, starting from the SixTrack impacts in the simulations including imperfections. The errors on the SixTrack simulations indicate the standard deviation over different random seeds with imperfections.

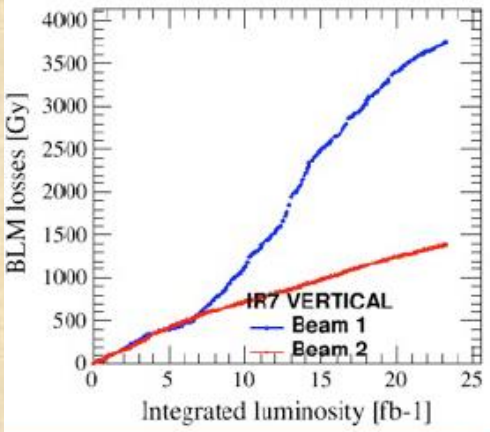
After TS2 Vertical losses in Beam 1 seem to strongly increase.

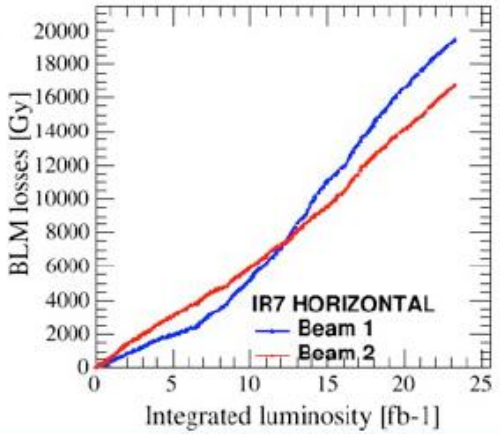
We try to unfold the contribution from vertical and horizontal losses.

Correction factors from simulation can be applied to each BLM signal to get primary losses at each collimator subtracting the Crosstalk of upstream collimator losses

LMC – 1st October 2014
B. Salvachua







BLM Responses Beam1
IR7 TCPs

Initial energy of protons = 3.5 GeV

Values are normalised to the reference TCP.C (BLM_TCP.C) Primary response = **0.5307e-4 GeV/p**

IR7 beam 1 TCPs

(Values are normalised to the TCP.C(BLM_TCP.C) response)

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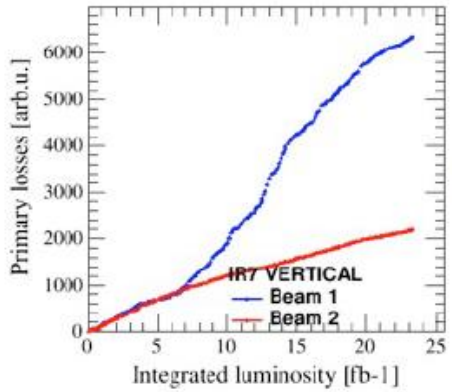
Primary response appears with **BOLD**

Coll.WG, 6th May 2013



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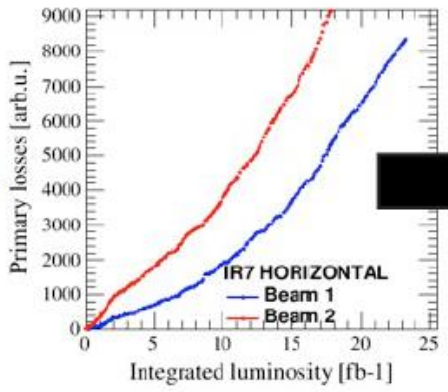

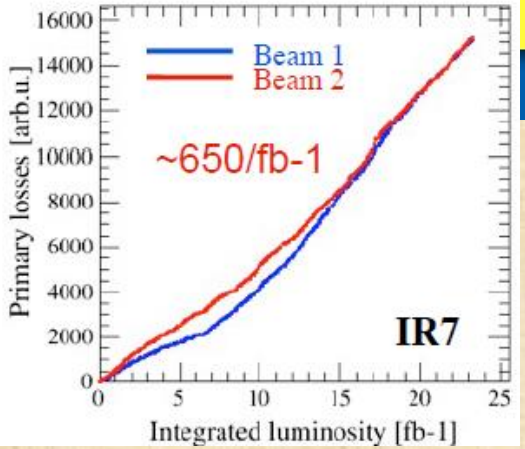

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The response matrices can be used also *online* in order to disentangle losses in each collimator!

At the moment, a universal BLM threshold for protecting the primary collimators is set for all three BLMs *not* accounting for the crosstalk resulting into overprotection and possible limitation of the device

LMC – 1st October 2014
B. Salvachua

BLM Responses Beam1
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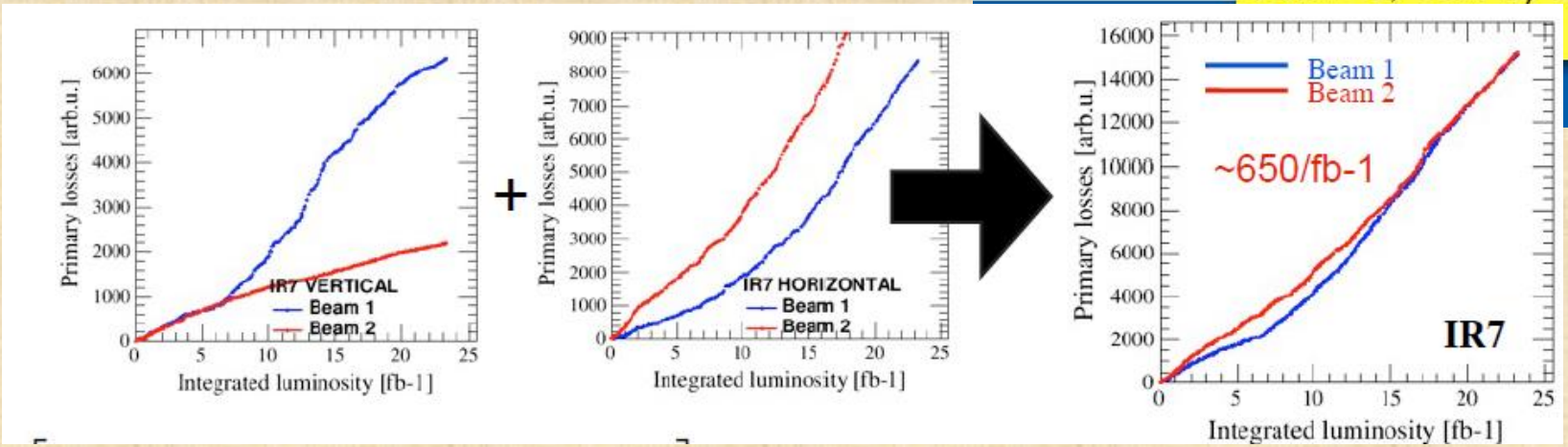
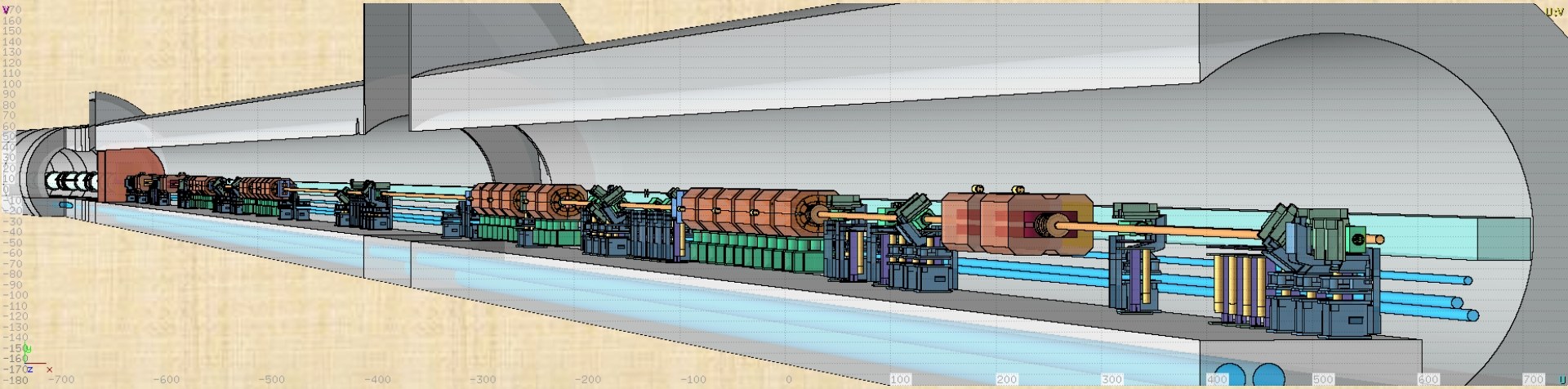
Coll.WG, 6th May 2013

12

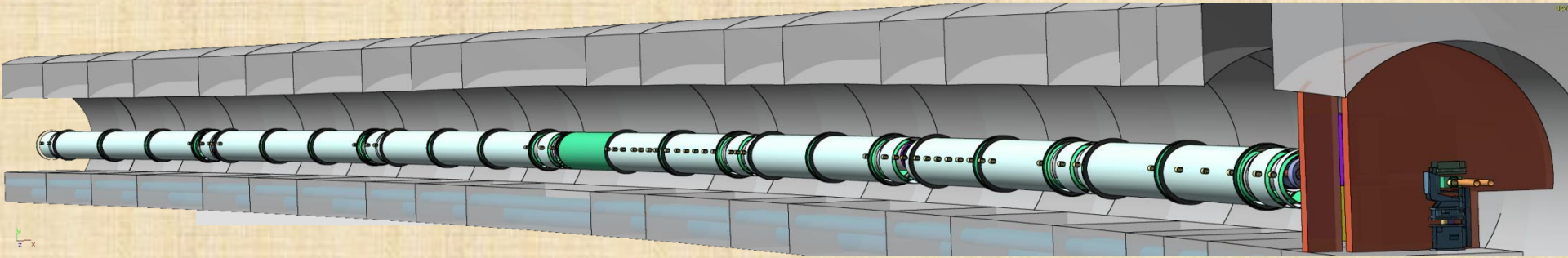


IR7 FLUKA geometry

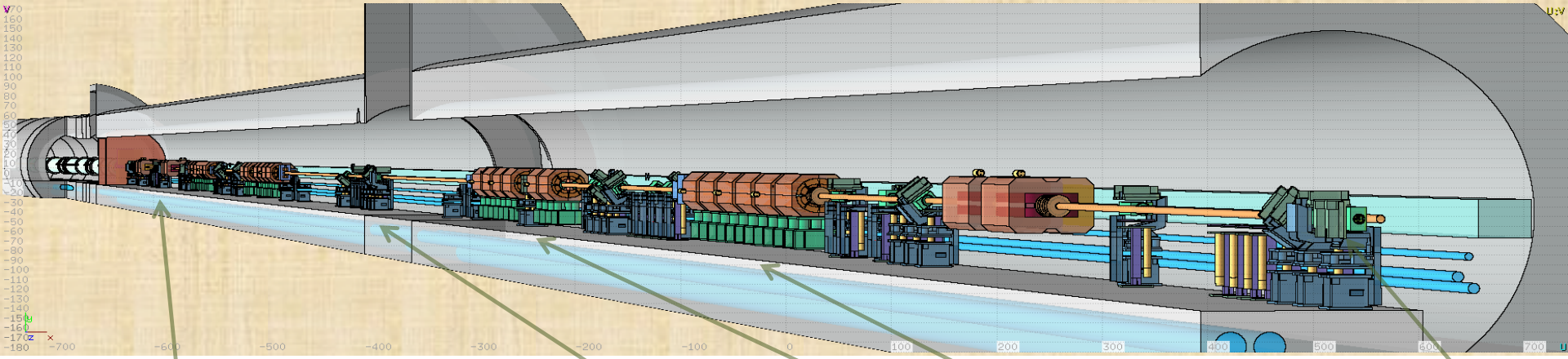
- Long Straight Section

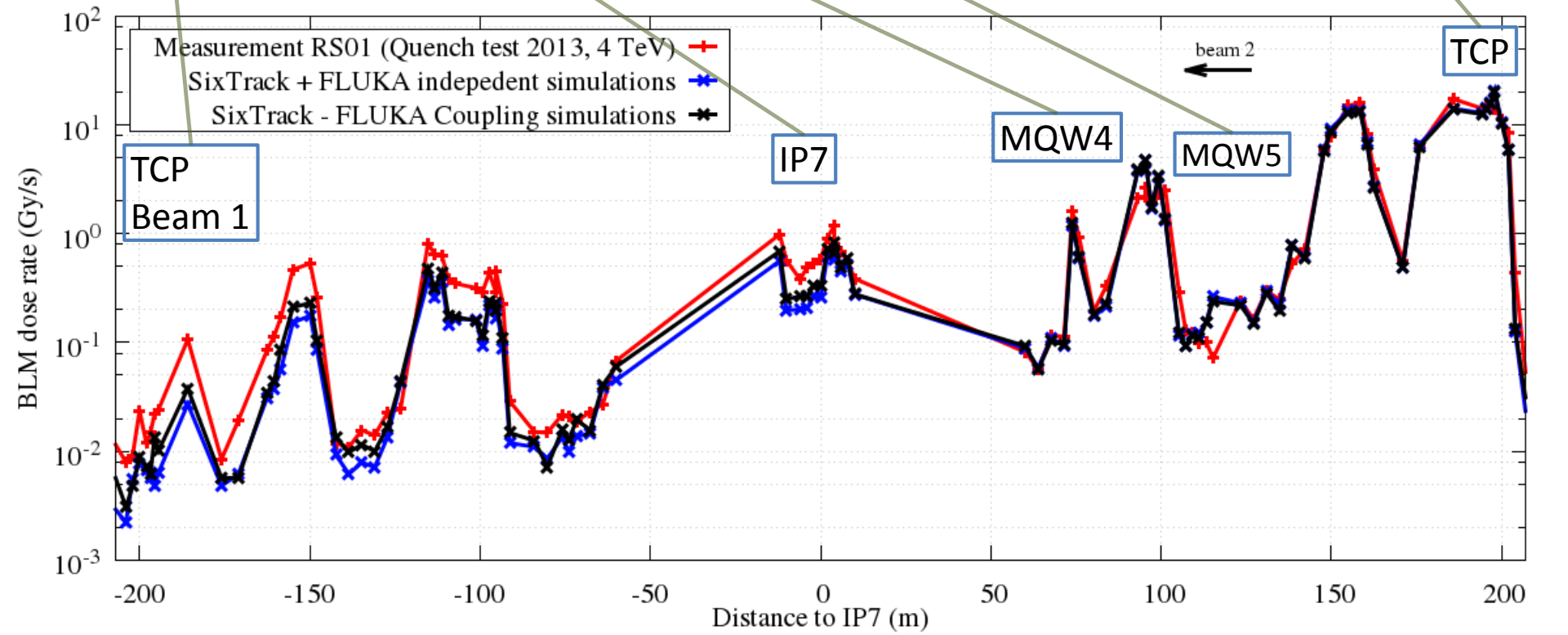


- Left Dispersion Suppressor + Arch up to cell 14

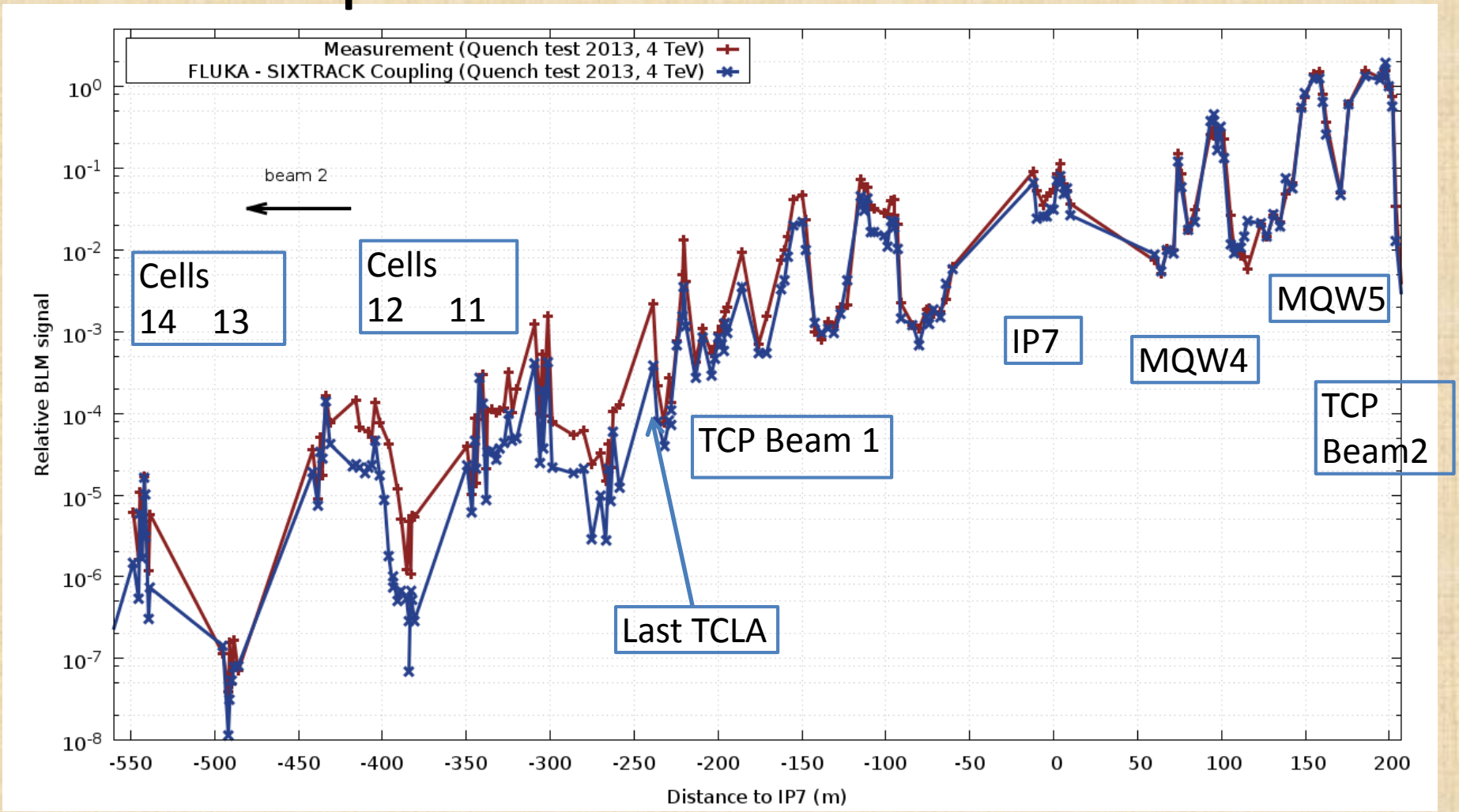


IR7 2013 Collimation Quench Test
FLUKA – Sixtrack Simulations



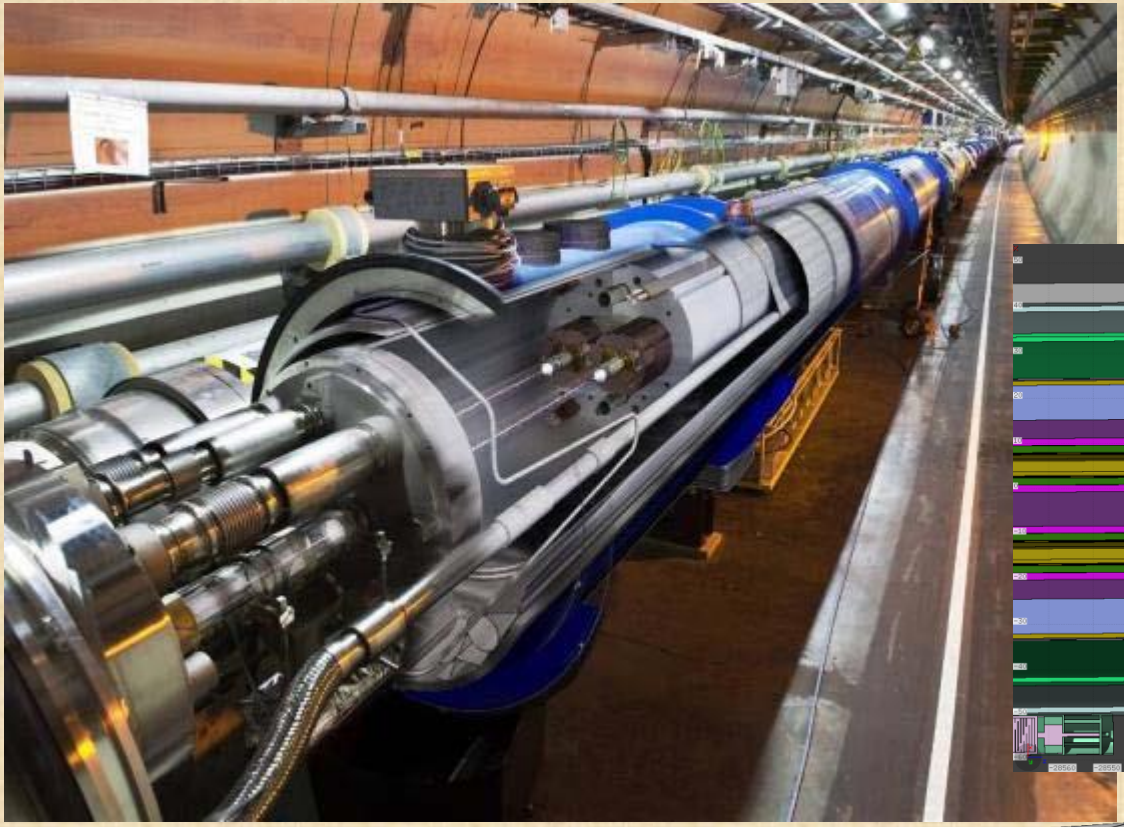


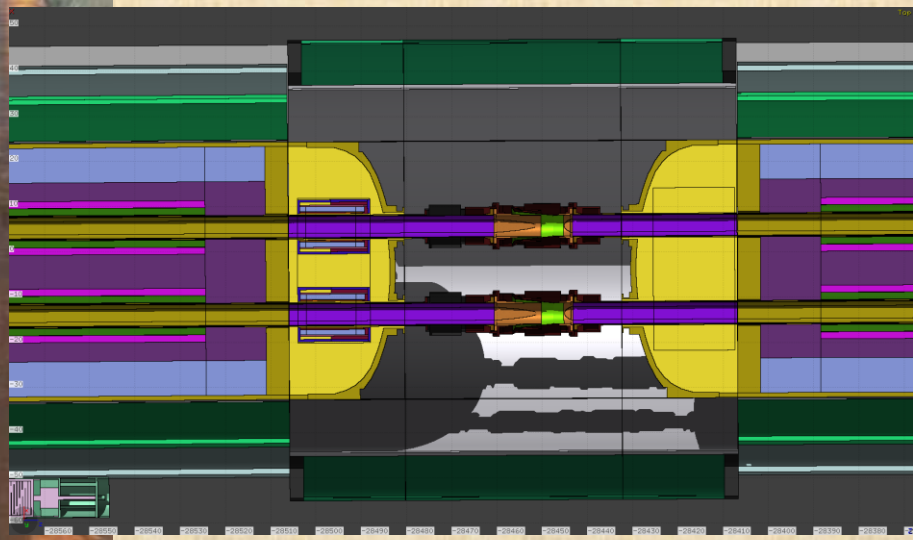
IR7 extended BLM signal comparison Experimental vs Simulation

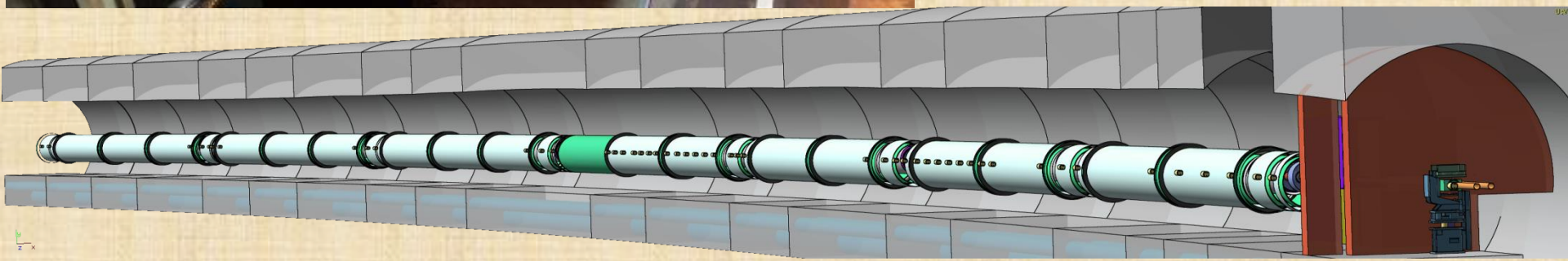


Values are normalised to the signal of the BLM at TCP.B(Skew) due better statistics and very good absolute agreement.

IR7 DS Peak power deposition in the SC coils

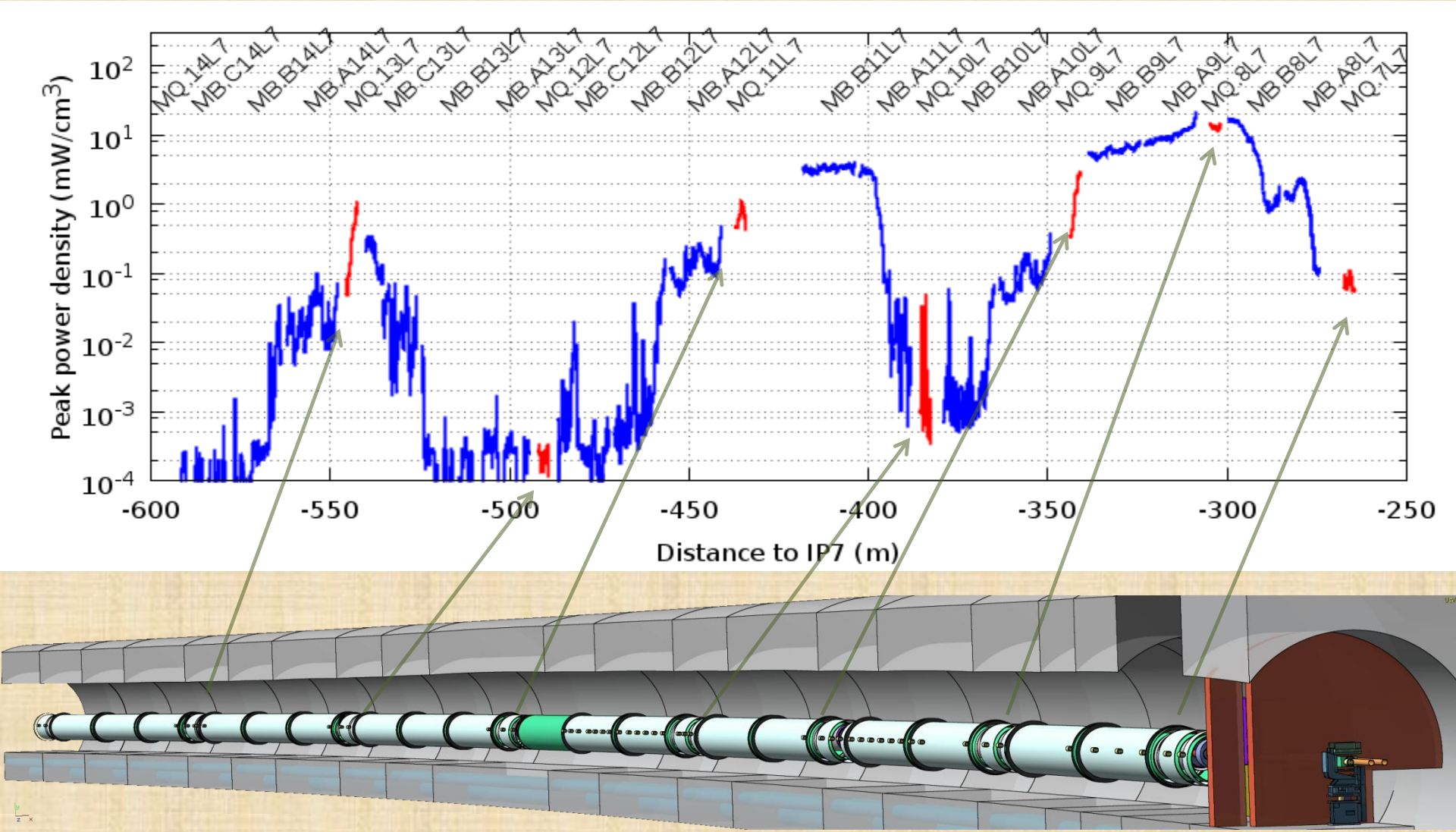






IR7 DS Peak power deposition in the SC coils

Main Dipoles Main Quadrupoles



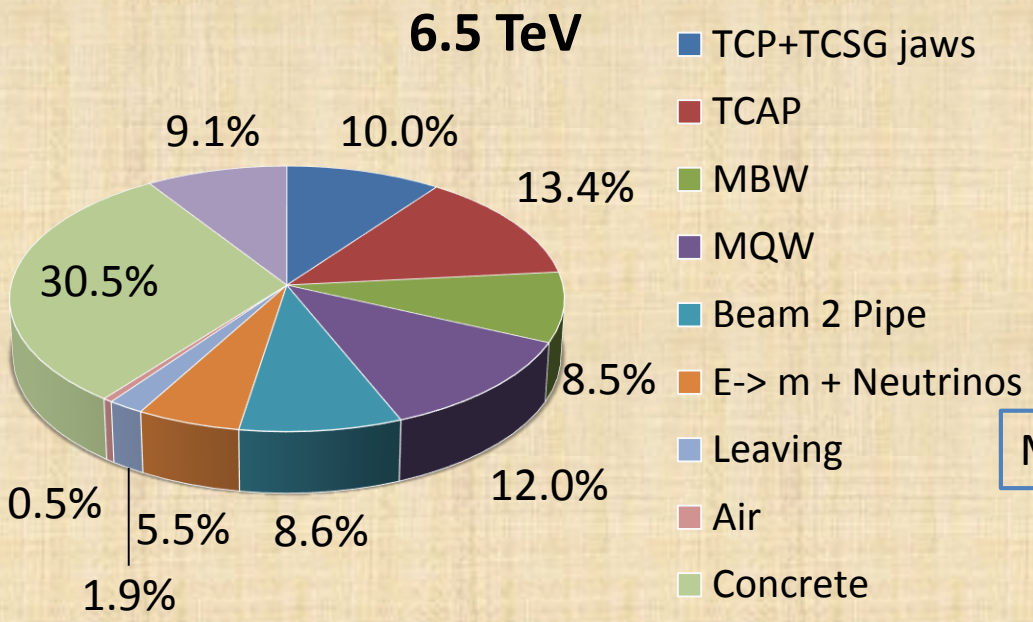
Conclusions

- Both Sixtrack and Sixtrack-FLUKA coupling benchmarked successfully
- Good understanding of the collimation losses through the Sixtrack-FLUKA modelization (Excellent BLM pattern reproduction)
- Assessment of BLM responses to collimation losses -> disentangle the amount of losses that each collimator gets
- New BLM comparison is planned for the upcoming 6.5 TeV proton and ion collimation quench test -> identify the origin of discrepancies

Thank you!

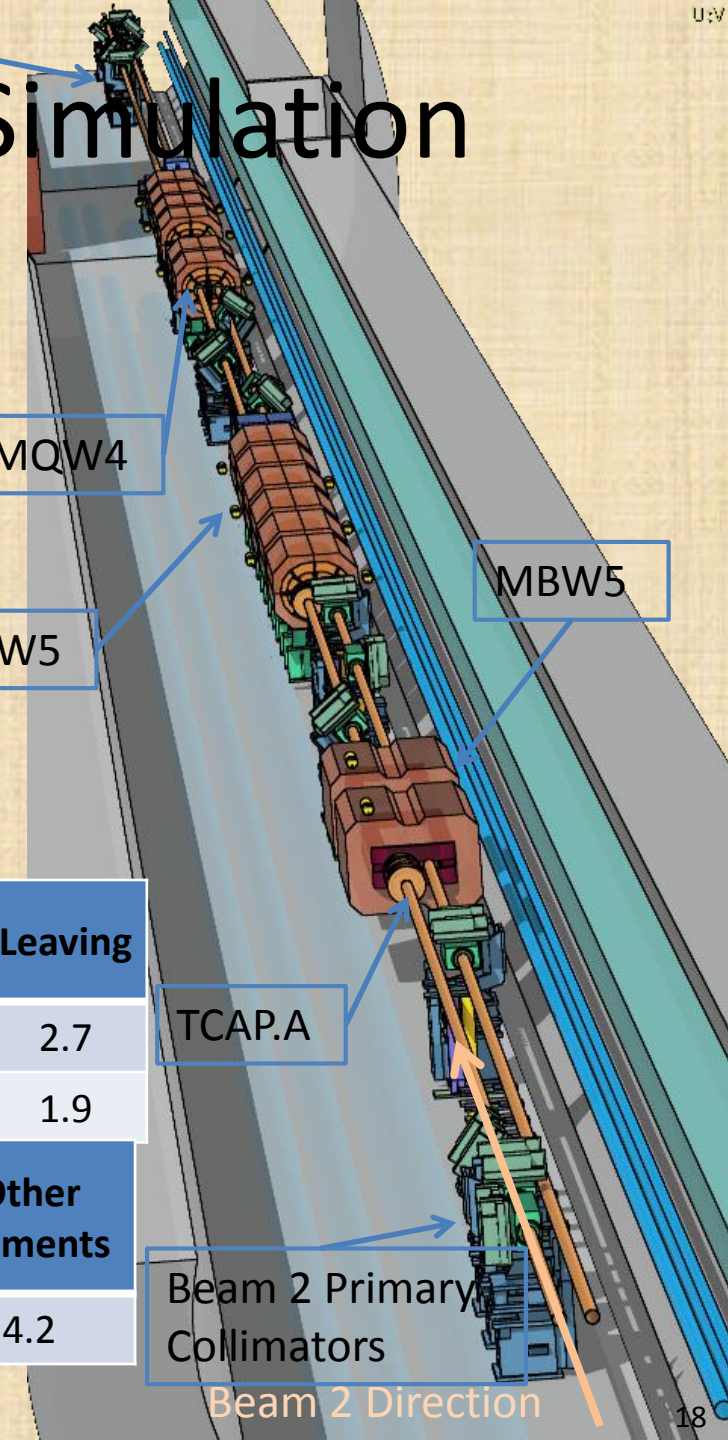
BACK UP SLIDES

IR7 FLUKA - Sixtrack Simulation

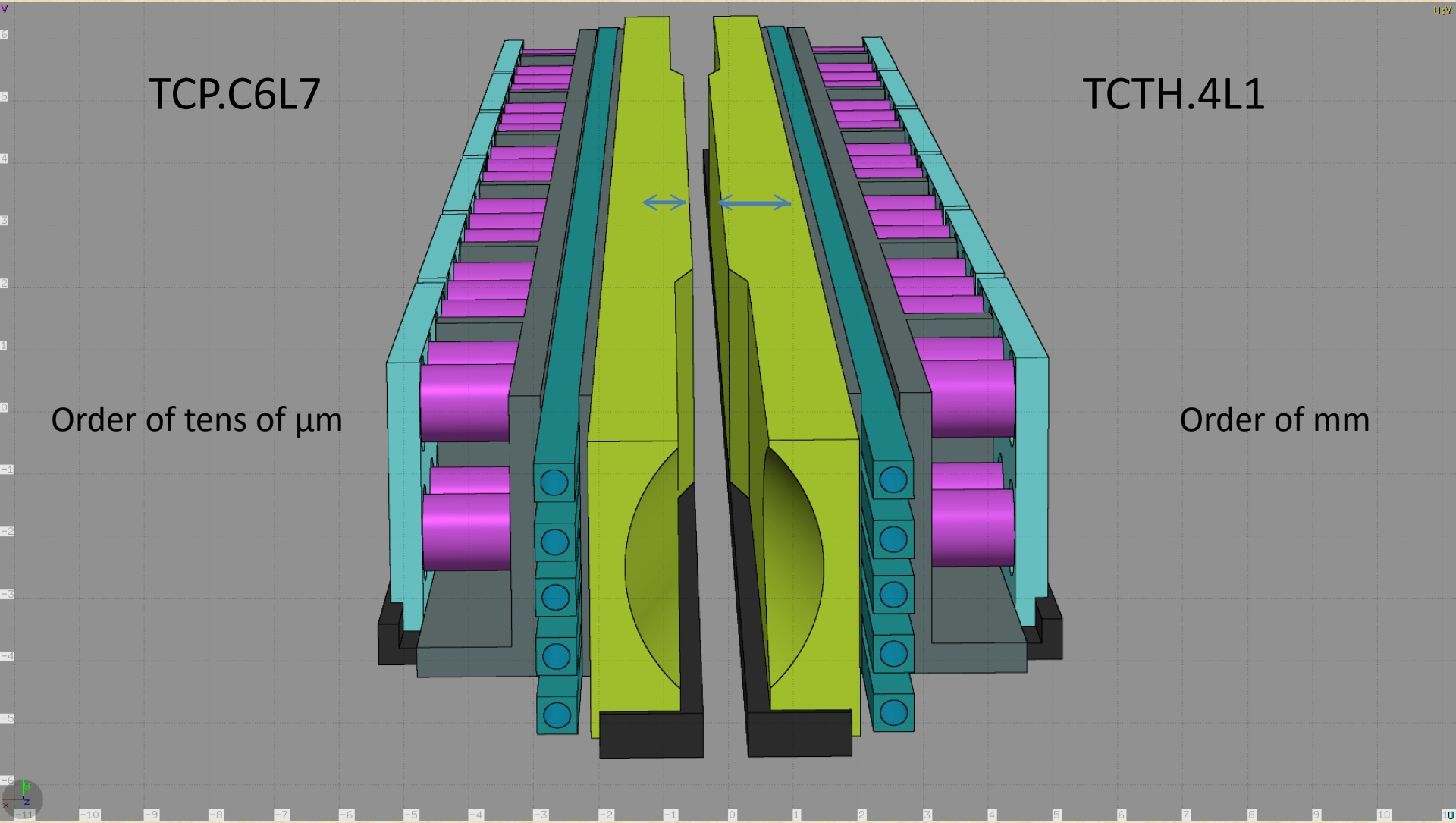


TeV \ %	TCP+TCSG Jaws	TCAP	MBW	MQW	Beam 2 Pipe	Environment	E -> m + Neutrinos	Leaving
4	10	12.9	8.5	9.5	8.6	41.6	6.2	2.7
6.5	10	13.4	8.5	12	8.6	40.1	5.5	1.9

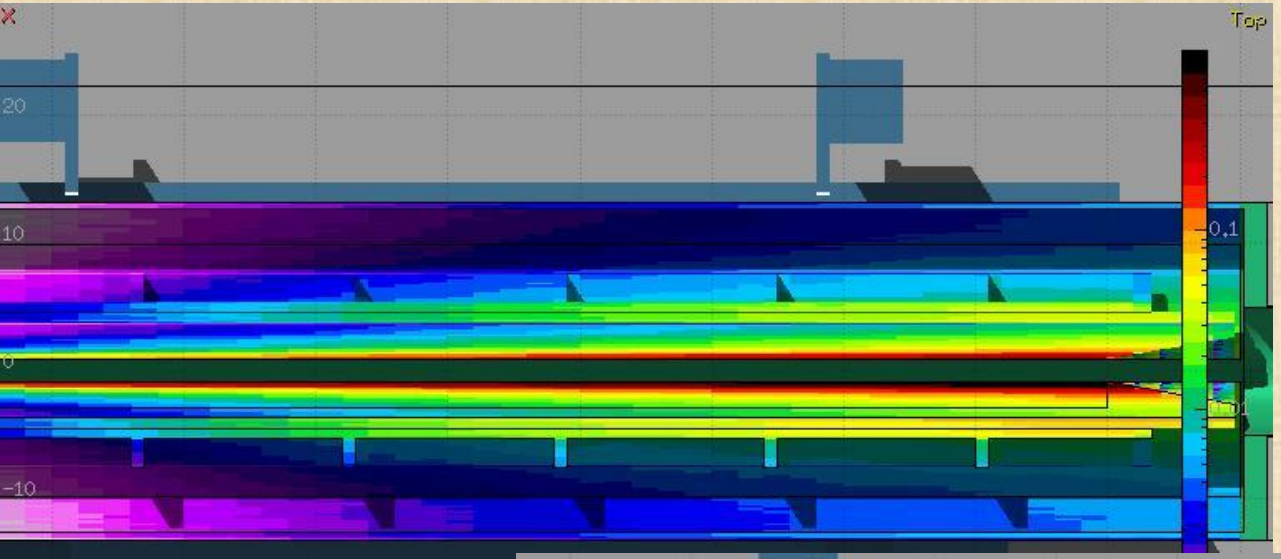
Enviroment	Air	Concrete Tunnel	Tunnel Cables	Collimator Support + Tank	Beam Pipe supports	Other Elements
40.1 +=	0.5	30.5	0.9	3	1	4.2



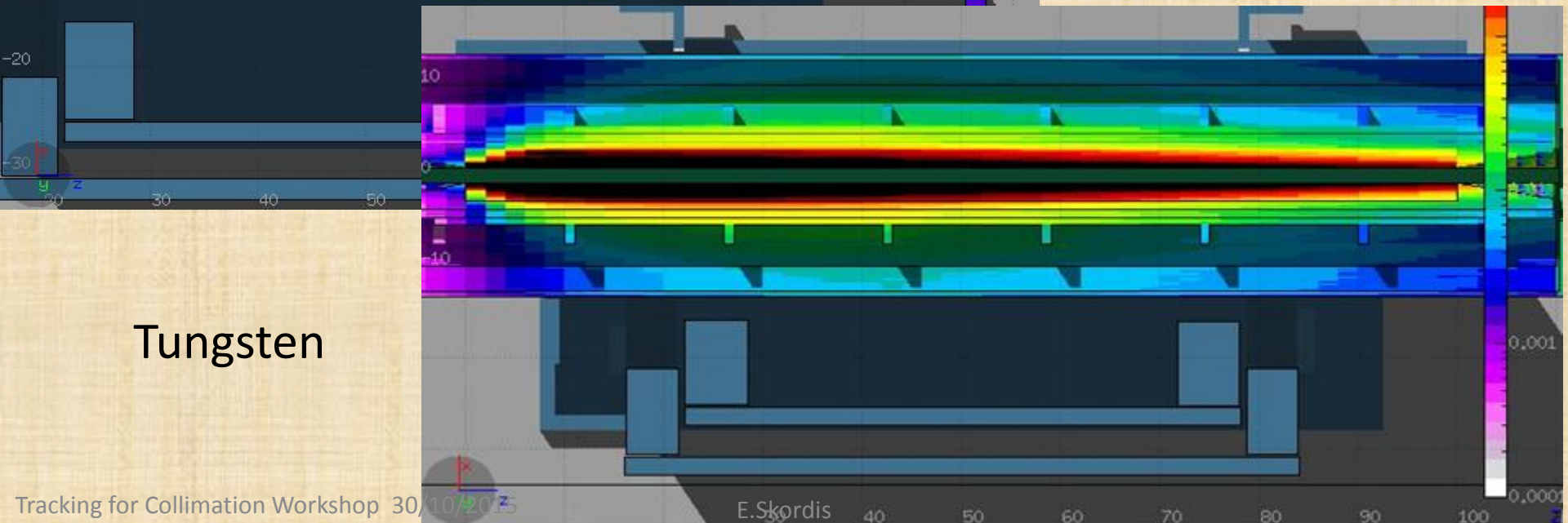
Different average ***transverse depth*** of interactions (Impact Parameter)



Different *shower development*



Graphite



Tungsten

TCTH+VA pictures

TCT_VA BLM is further away in comparison with the TCT_H BLM