Quench tests analysis recap

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On behalf of the FLUKA, Collimation and Operation teams

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Collimation quench test with 6.5 TeV proton beams

B. Salvachua, A. Mereghetti, B. Auchmann, R. Bruce, P.D. Hermes, E.B. Holzer, D. Jacquet, M. Kalliokoski, D. Mirarchi, S. Redaelli, E. Skordis, G. Valentino, A. Valloni, D. Valuch, D. Wollmann, M. Zerlauth, CERN, Geneva, Switzerland

Keywords: LHC, collimation, quench, protons, MD, 6.5TeV

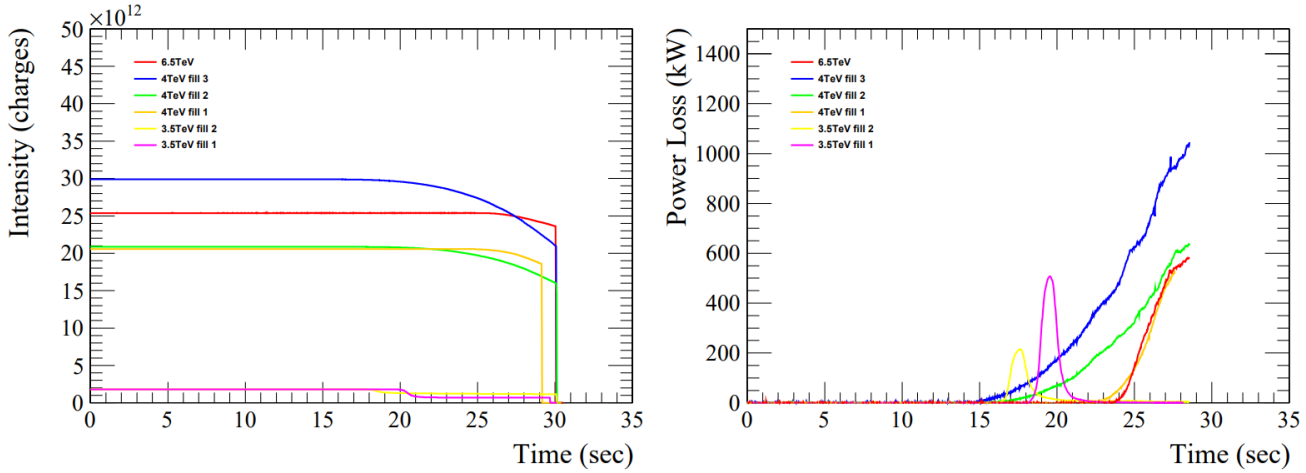


Figure 9: Left: Intensity during the proton quench tests in 2011, 2013 and 2015. Right: Power loss calculated from the BCT on the post mortem logging for the proton quench tests in 2011, 2013 and 2015.

	Power Loss in the collimation system	Beam Losses (BLM signals)	Power density in the SC coils
Can we measure it?	Yes	Yes	No
Can we simulate it?	No	Yes	Yes
	585 kW Peak. Rising over 5 sec	No magnet quenched	

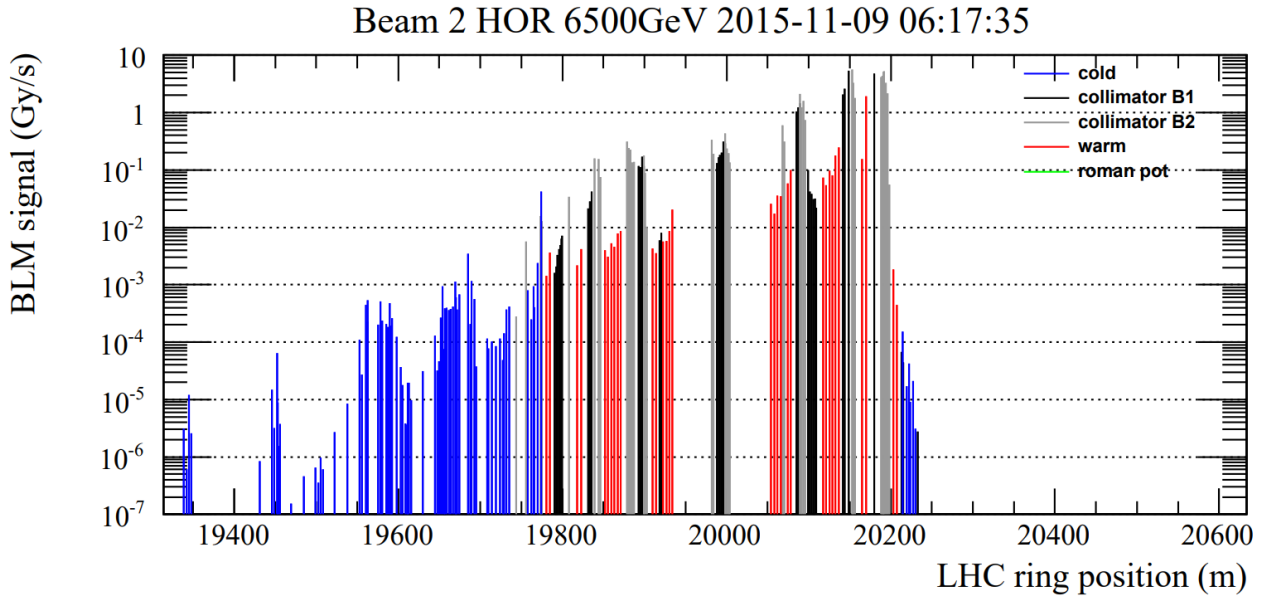


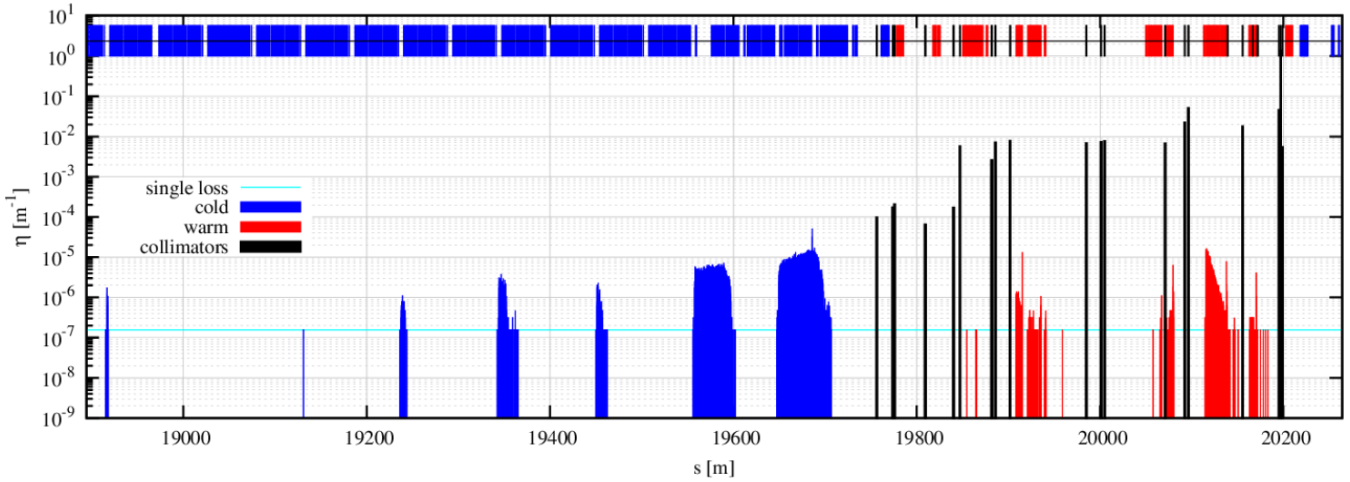
Figure 11: Beam losses in IR7 measured by the BLMs at the moment of maximum power loss.

Energy deposition simulation requirements for collimation losses

1. Creating input for further FLUKA simulations. Tracking studies

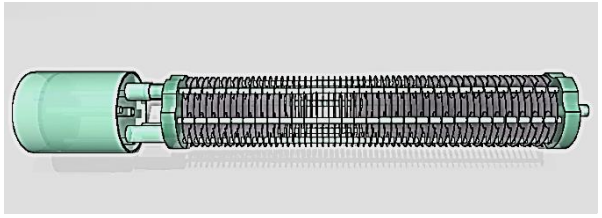
Sixtrack-FLUKA Coupling provides input

- Lossmap of proton impacts on collimator surface
- Lossmap of inelastic interaction positions



2. FLUKA simulation set up
   - Model complex geometries of all key elements of the LHC

LHC BLM



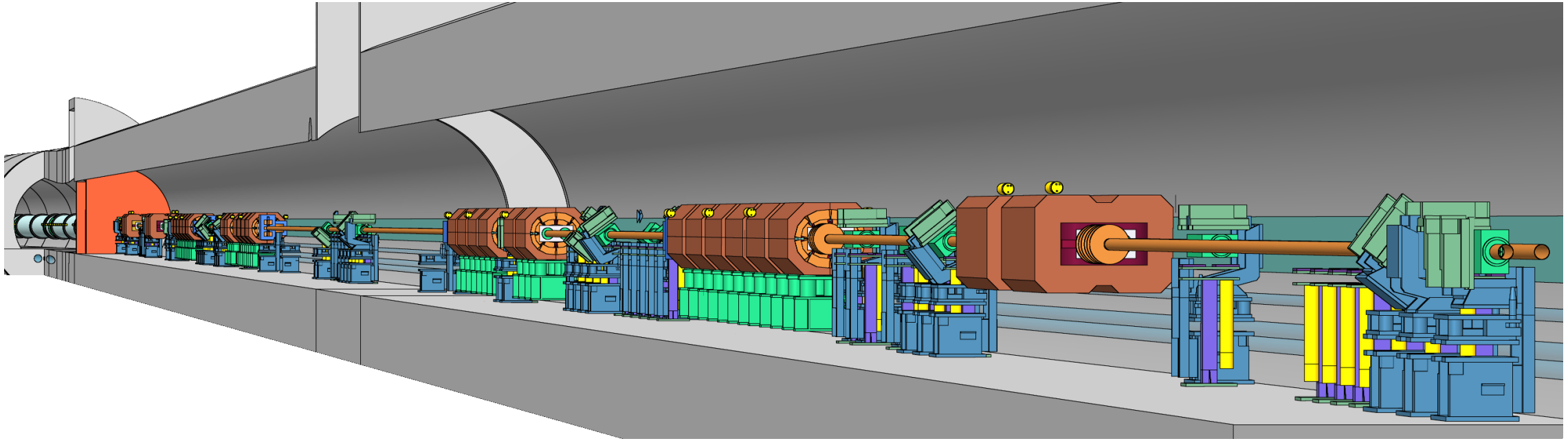
FLUKA MODEL

Picture

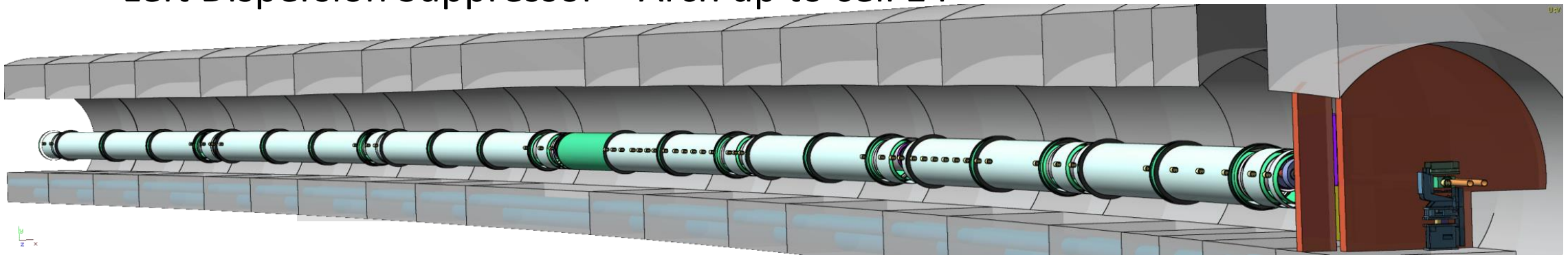
   - Set up the simulation parameters
     - Source routine
     - Magnetic fields routines
     - Physics settings
     - Scoring
     - Etc…

IR7 FLUKA geometry

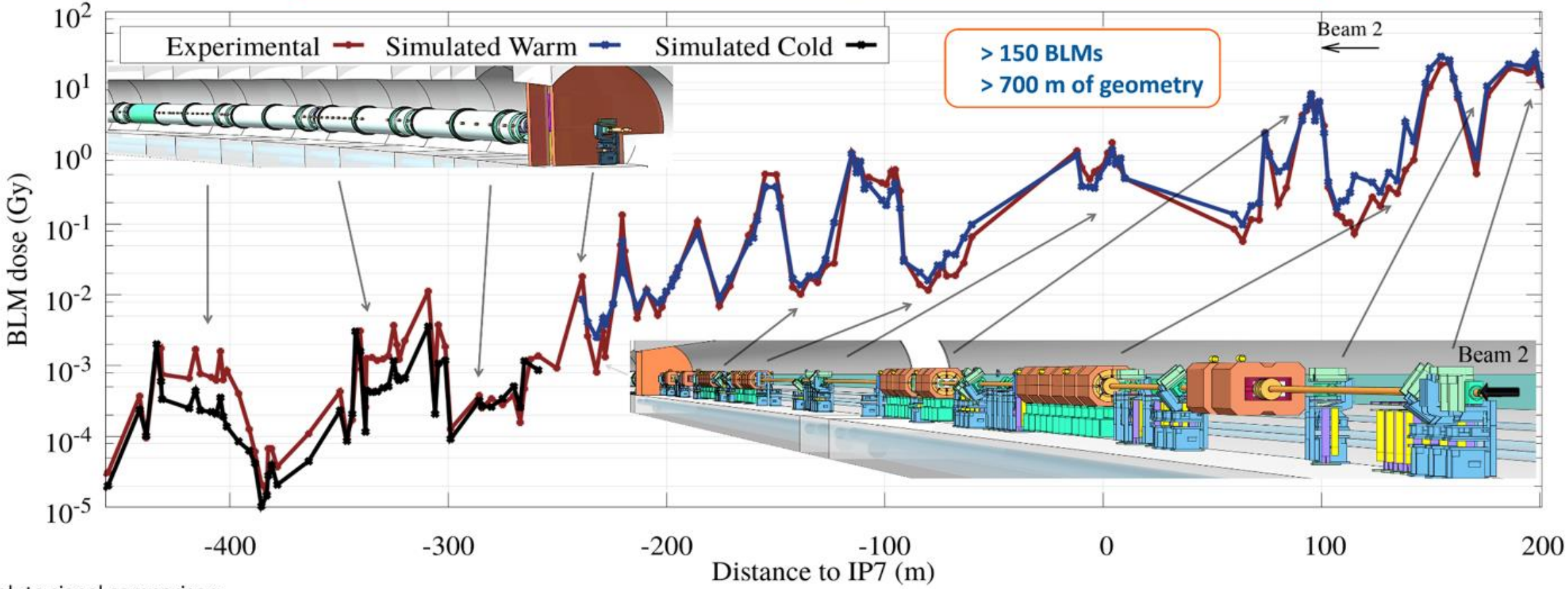
- Long Straight Section



- Left Dispersion Suppressor + Arch up to cell 14



Simulation Benchmark / BLM Signal comparison - Protons

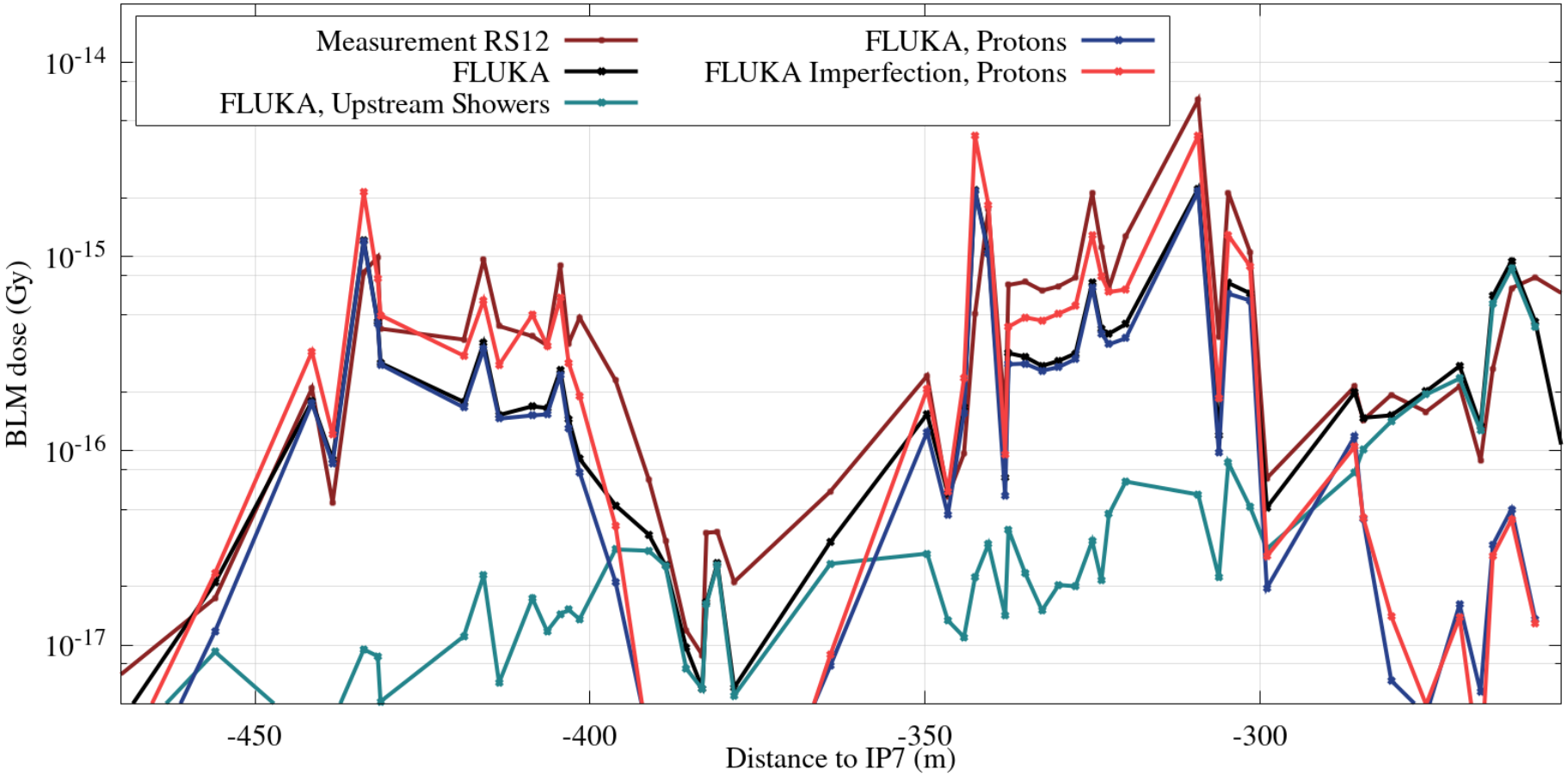


Absolute signal comparison:

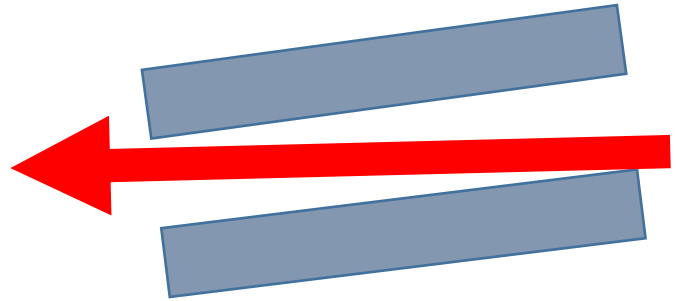
- Within a few ten percent in the Warm section
- A factor of 3 underestimation in the SC magnets → Hint at Imperfections
- Remarkable pattern reproduction over 7 orders of magnitude

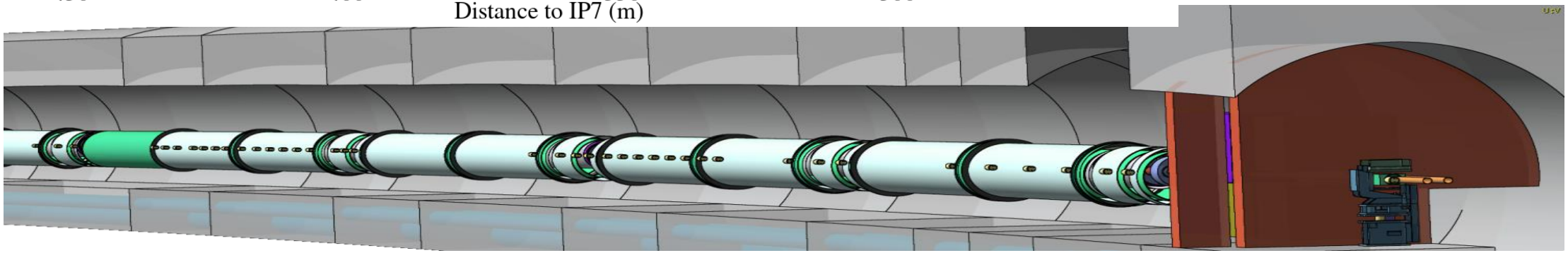
Detailed element models → Assembly with Linebuilder
Rendering of FLUKA geometry model of IR7 using Flair.

Cold section underestimation

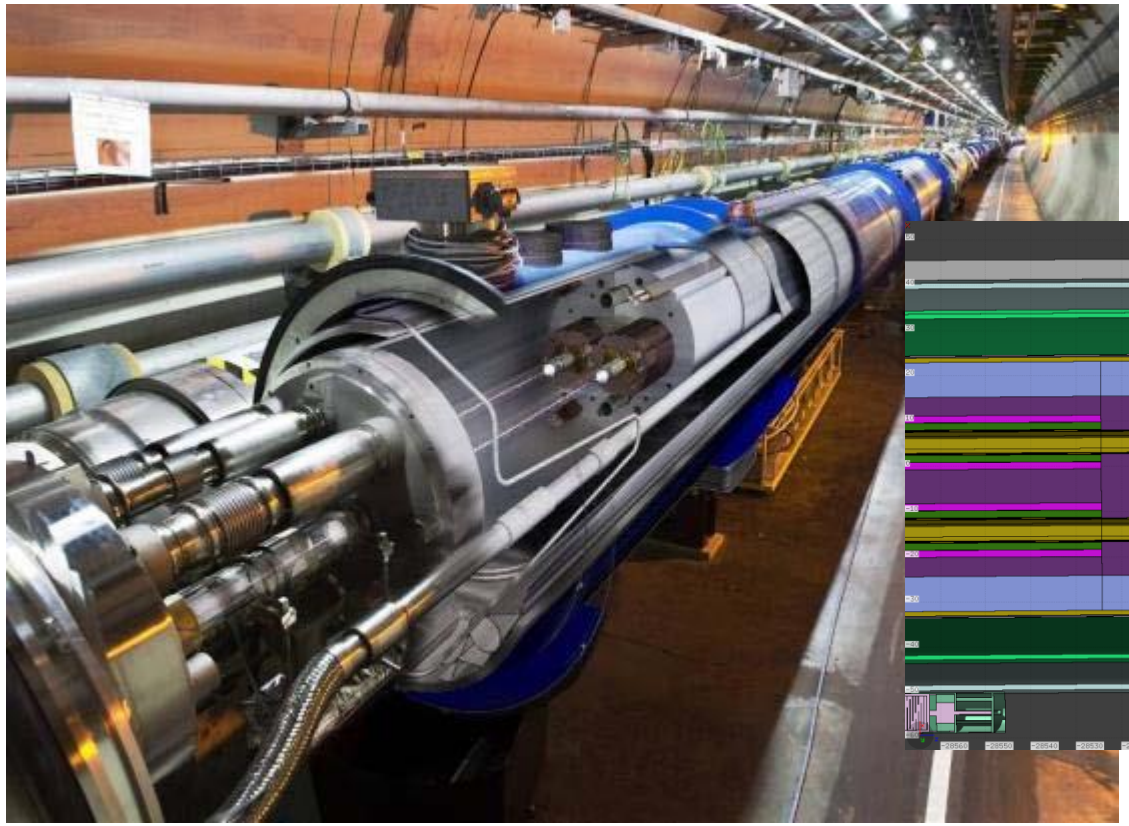


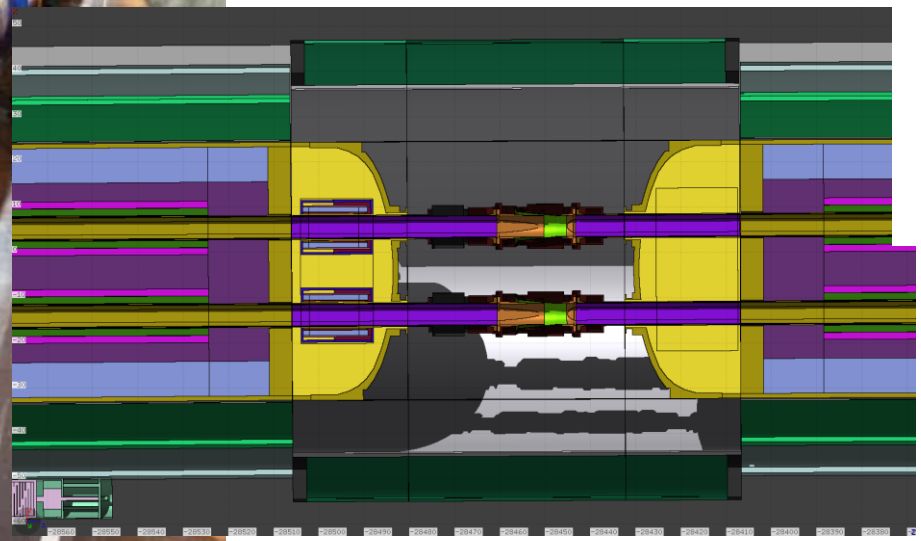
Imperfection considered:
Primary collimator Jaw misalignment

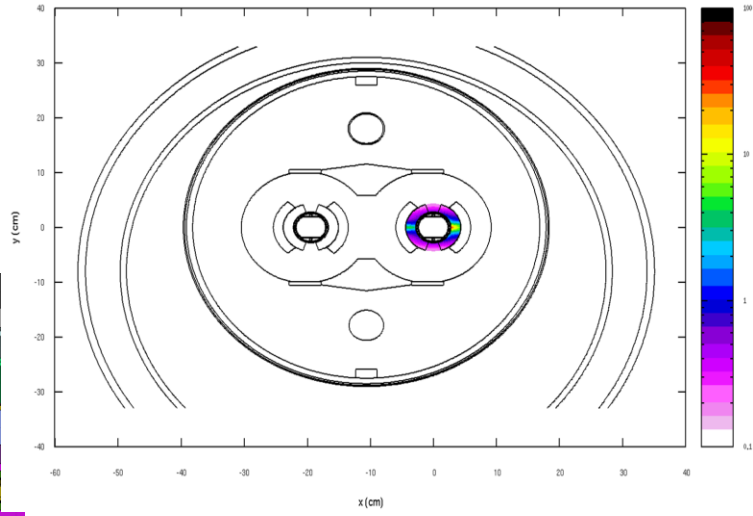


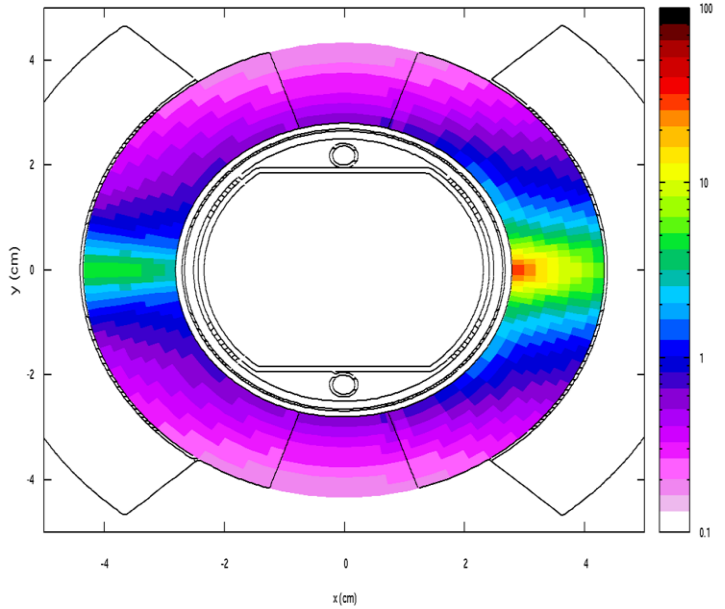


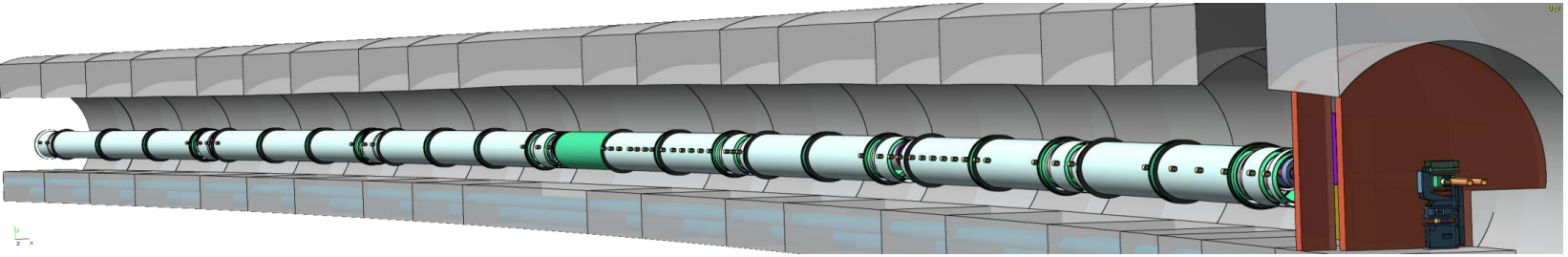
Peak power deposition in the SC coils











Cylindrical mesh

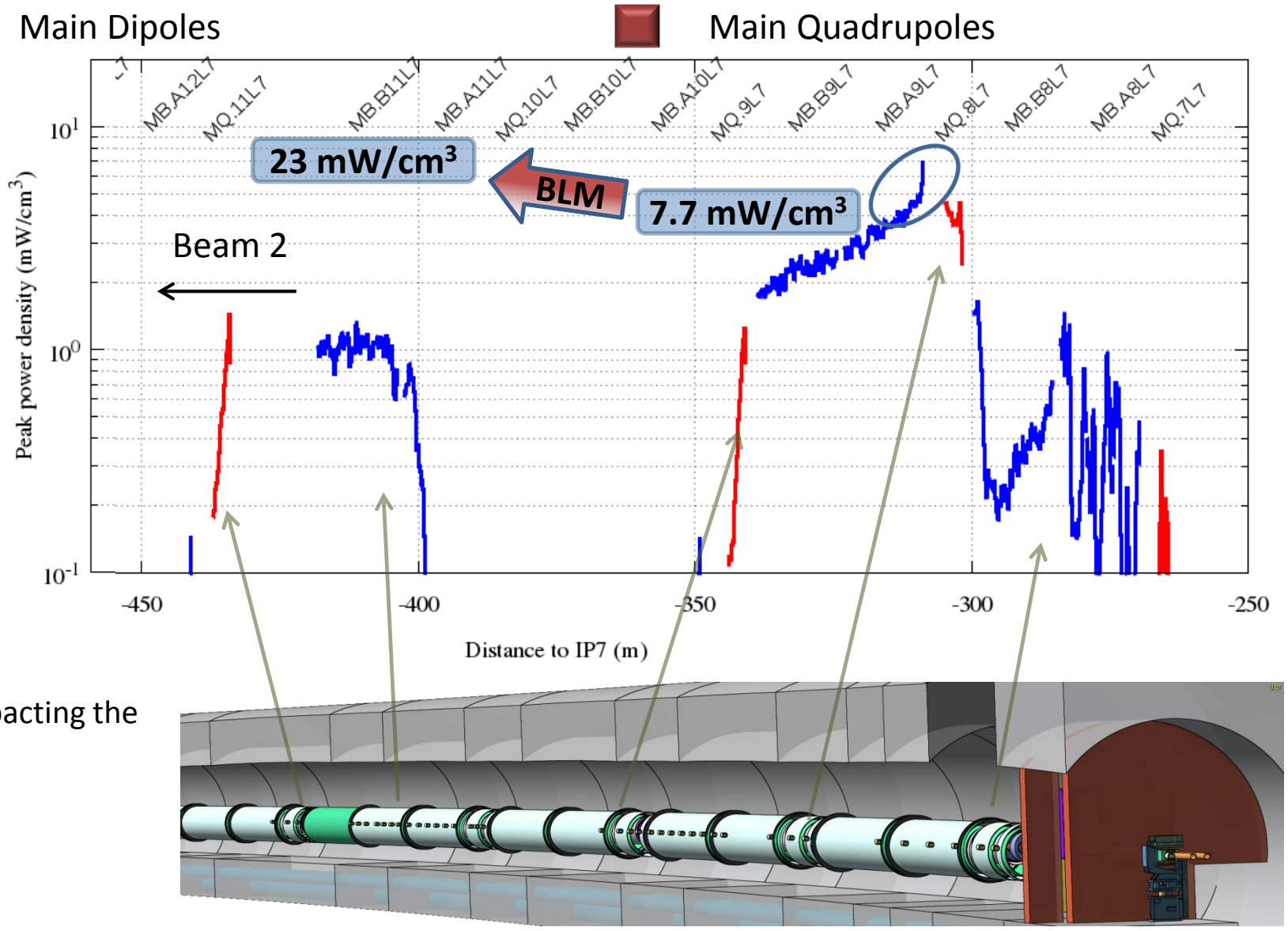
ΔR: 0.2 cm

Δ φ: 2º

Δ z: 10 cm

IR7 6.5 TeV proton QT Peak power dep. in the SC coils

	Protons Ideal Machine	Protons Imperfection
Radially averaged Peak power density (mW/cm^3) / Magnet	7.7 / MB.A9L7	15.3 / MB.A9L7
BLM ratio Measured/ simulated	3	1,5
Radially averaged Scaled peak power density (mW/cm^3)	23	23



Peak Power impacting the collimators
: 585kW
= 5.625e11 p/s

CERN-ACC-Note-2016-0031 MD

March 17, 2016
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LHC Heavy-Ion Collimation Quench Test at 6.37Z TeV

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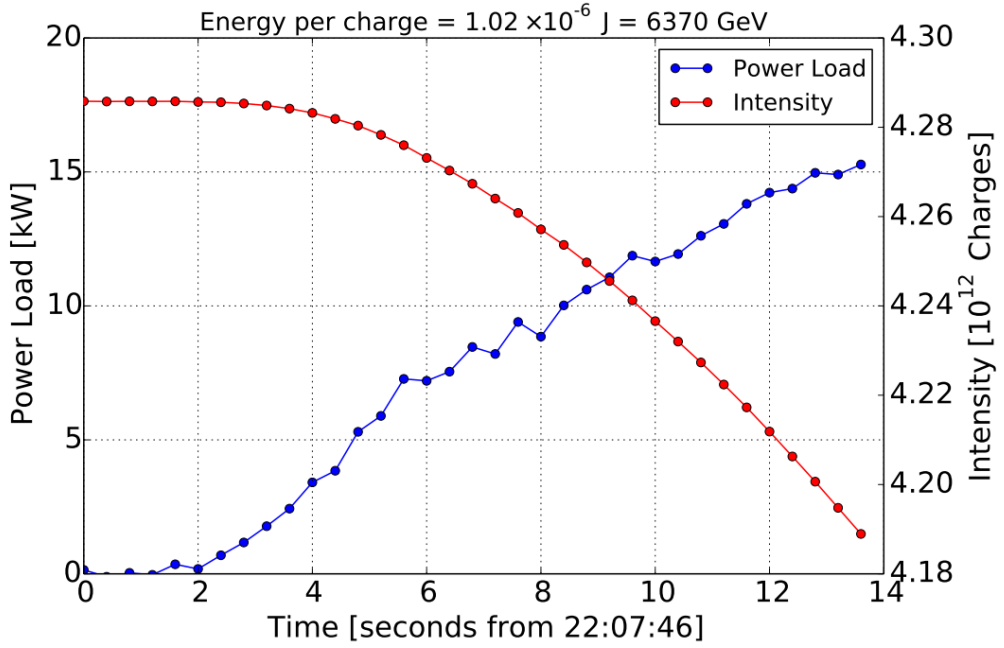
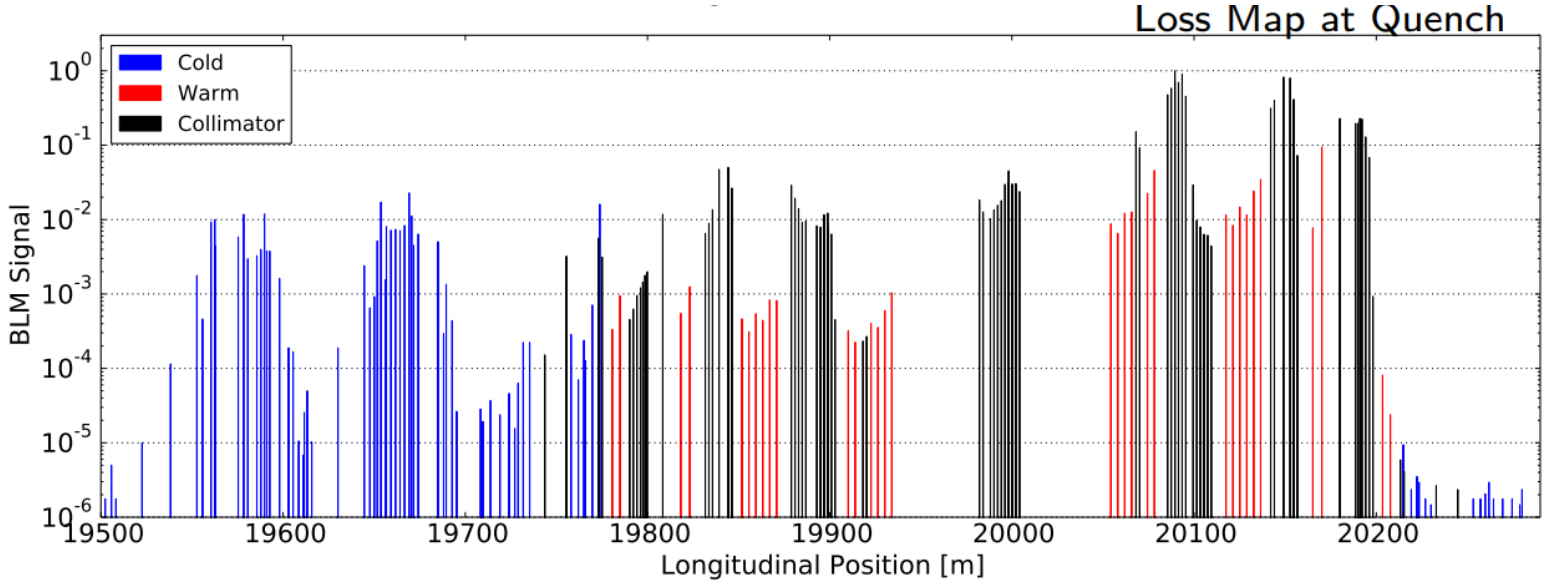
M. Kalliokoski, G. Kotzian, A. Mereghetti, D. Mirarchi, E. Quaranta,
S. Redaelli, B. Salvachua Ferrando, G. Valentino, D. Valuch, D. Wollmann,
M. Zerlauth / CERN, Geneva, Switzerland

Keywords: LHC, collimation, heavy ions, quench, MD, 6.37Z TeV

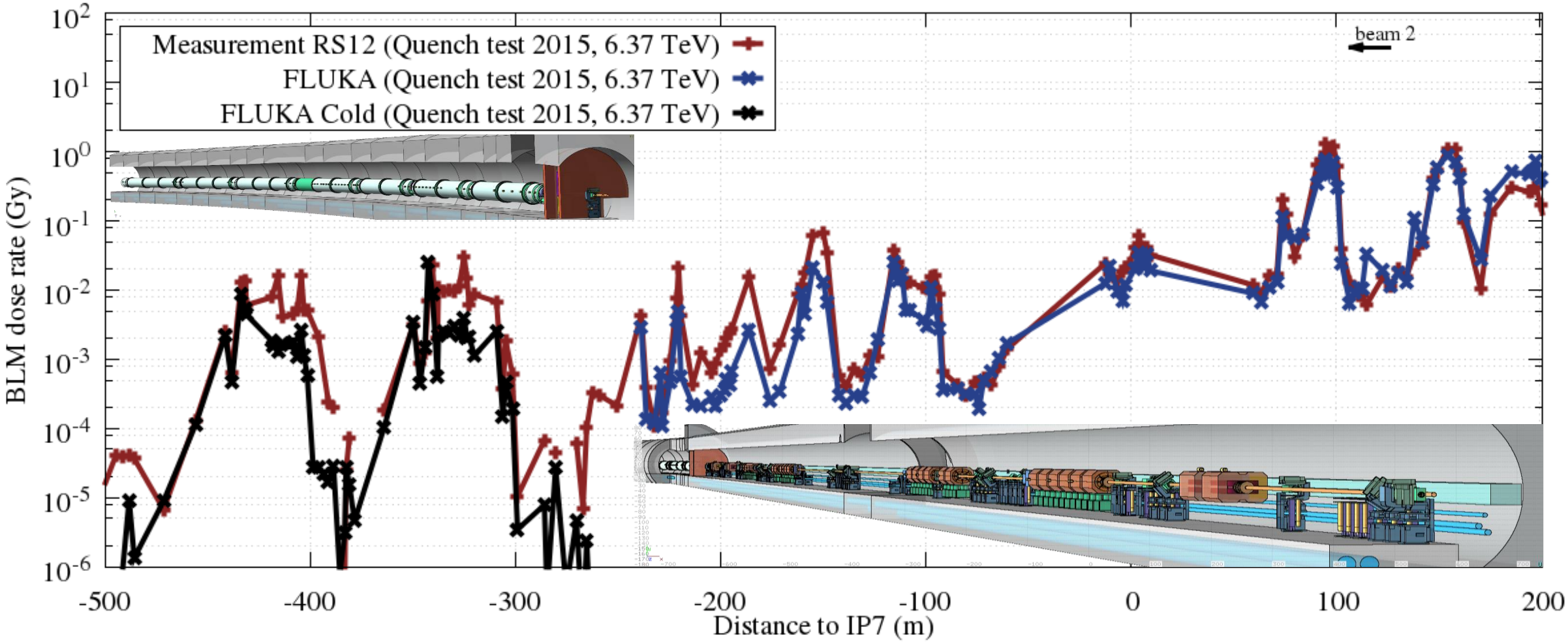


15 kW Peak.
Rising over 12 sec

Magnet Quenched!



6.37 Z TeV Ion quench test BLM comparison



Most recent Ion collimation studies with smaller impact parameter bring the underestimation to a factor of 3, similar to protons

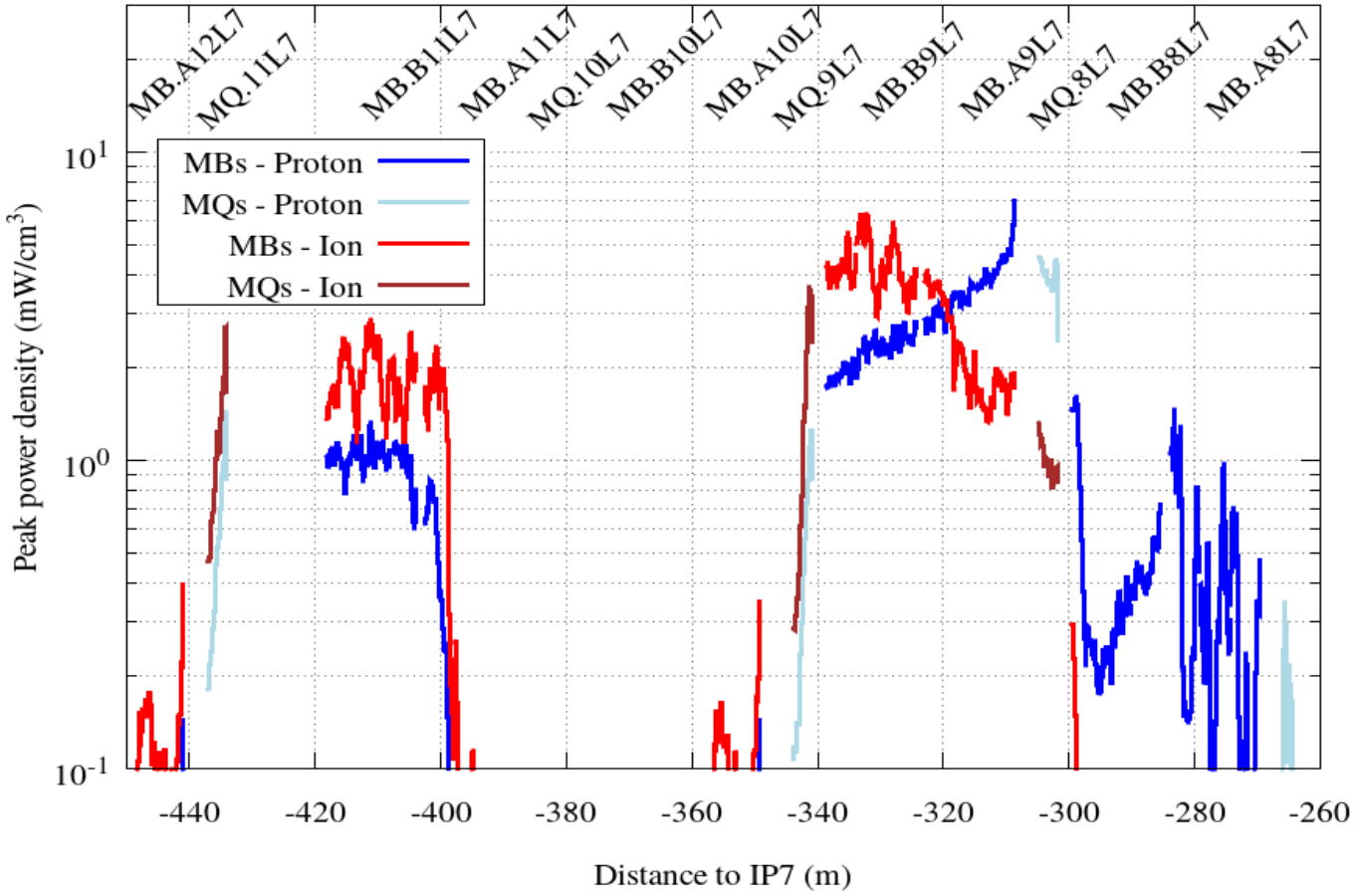
Cold section underestimation

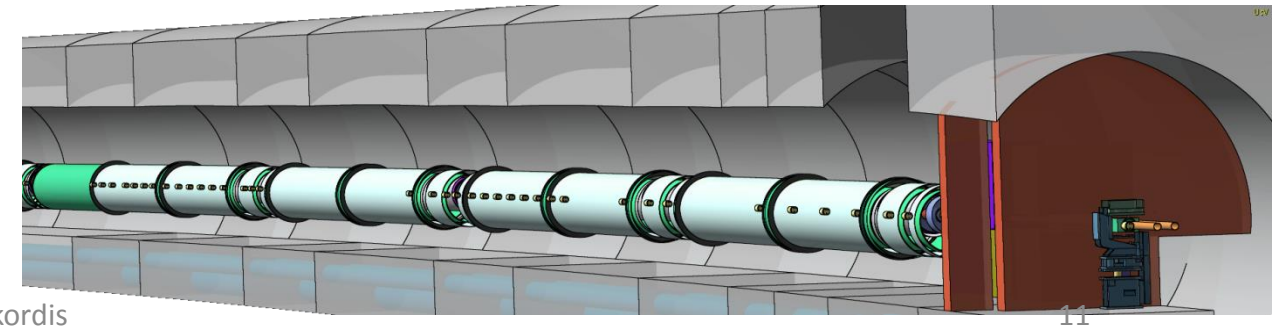
7 TeV Proton loss rate: 585 kW

6.37 Z TeV Ion loss rate: 15 kW

	Protons Ideal Machine	Protons Imperfection	Ions Ideal Machine
Radially averaged Peak power density (mW/cm^3) / Magnet	7.7 / MB.A9L7	15.3 / MB.A9L7	5-6 / MB.B9L7
BLM ratio Measured/ simulated	3	1,5	5
Radially averaged Scaled peak power density (mW/cm^3)	23	23	25-30

Peak Power density profile





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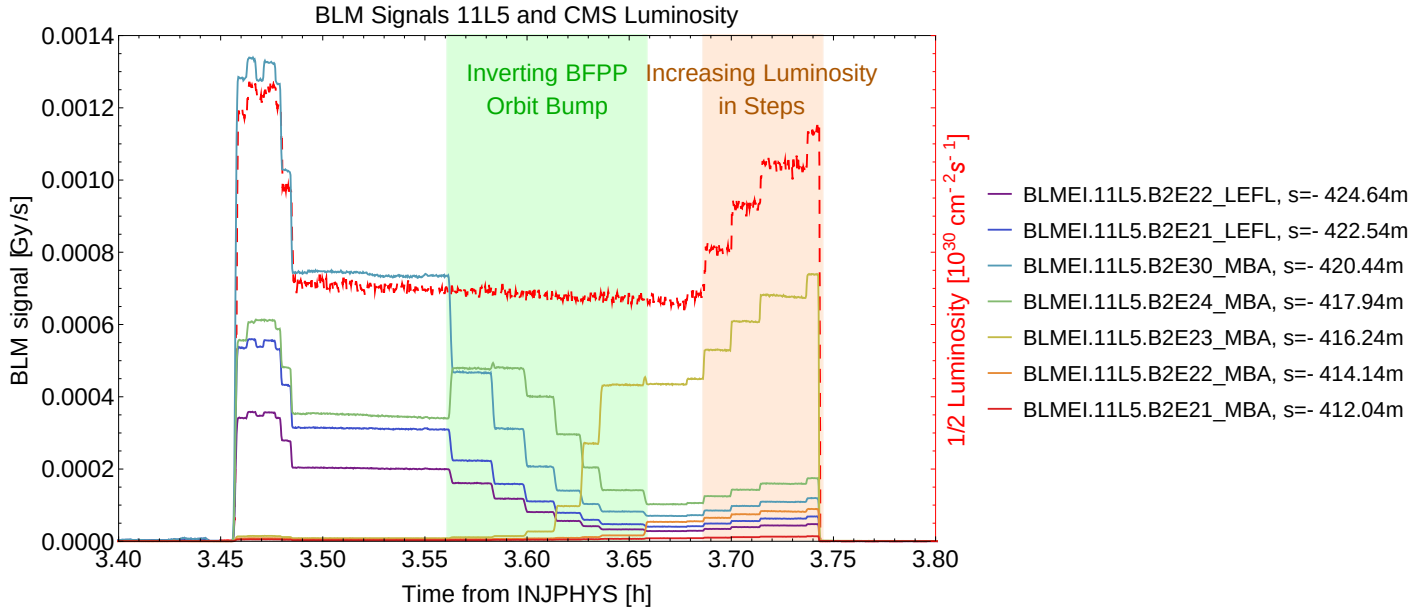
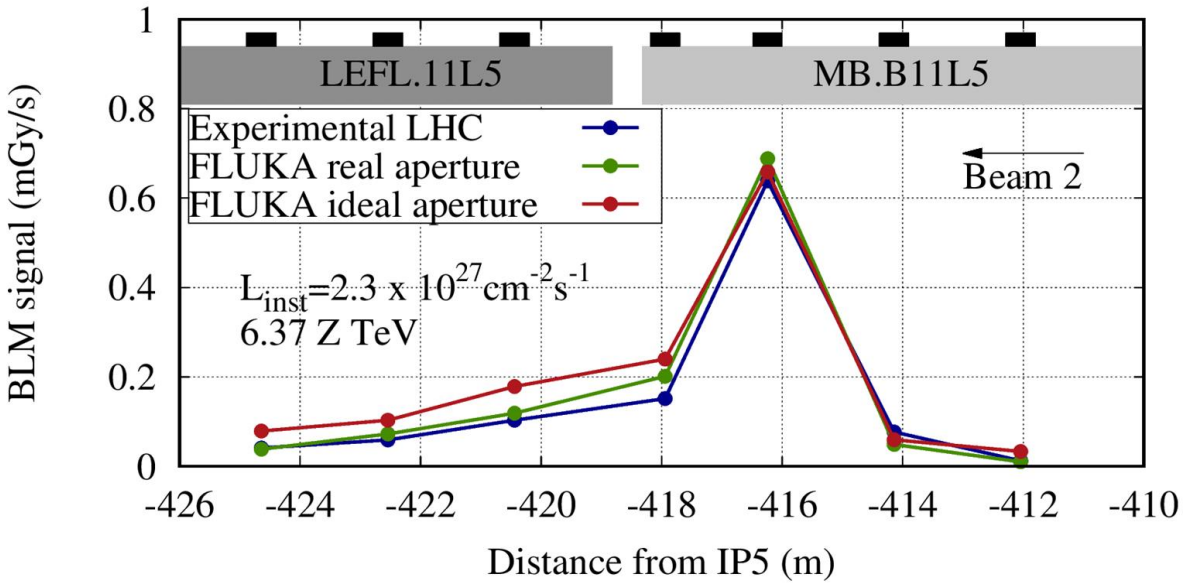
BFPP quench test

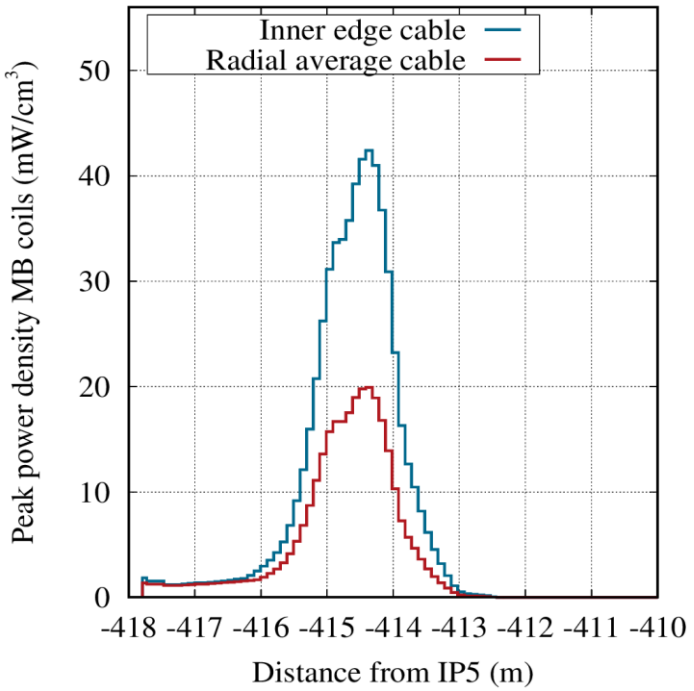
Steady losses for 20 sec

Magnet Quenched!





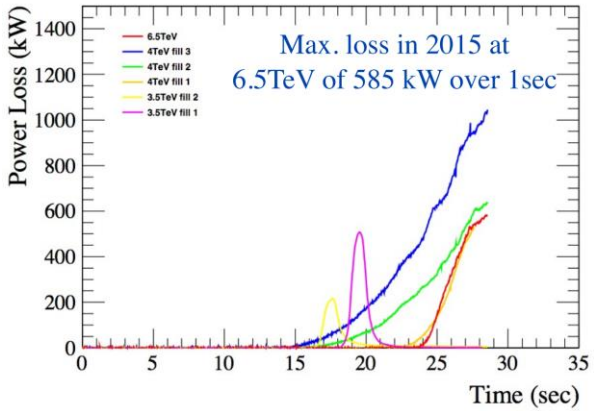
FLUKA model with **real** MB.B11L5 aperture

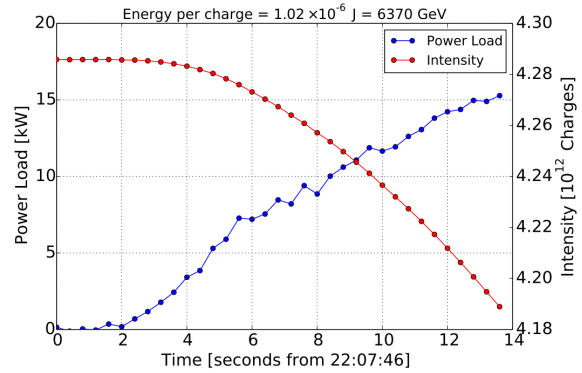


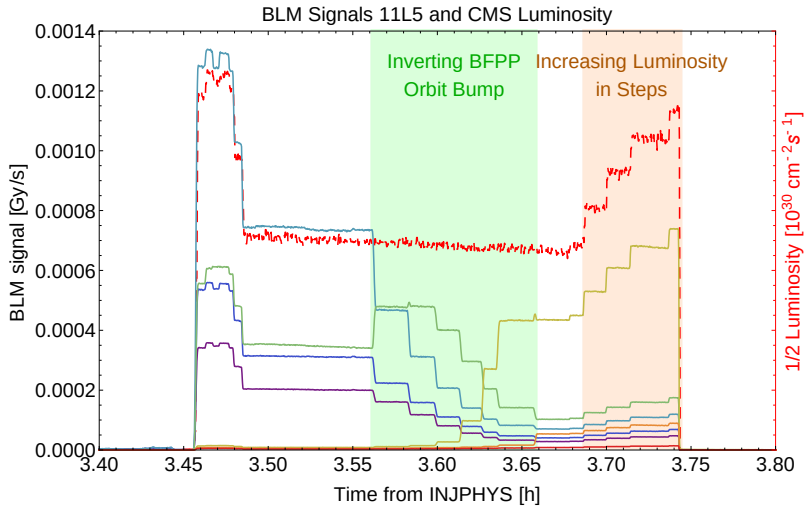
Cristina Bahamonde

Power Density summary

	Protons Ideal machine	Protons	Ions Ideal machine	Ions BFPP Imperfection
Radial averaged peak power density (mW/cm^3) / Magnet	7.7 / MB.A9L7	15.3 / MB.A9L7	5-6 / MB.B9L7	20 /
BLM ratio Measured/ simulated	3	1,5	5	<1.1
Radial averaged scaled peak power density (mW/cm^3)	23		25-30	20
Averaged peak power density in the last 5 second (mW/cm^3)	13		20-25	20
Quenched?	No		Yes	Yes



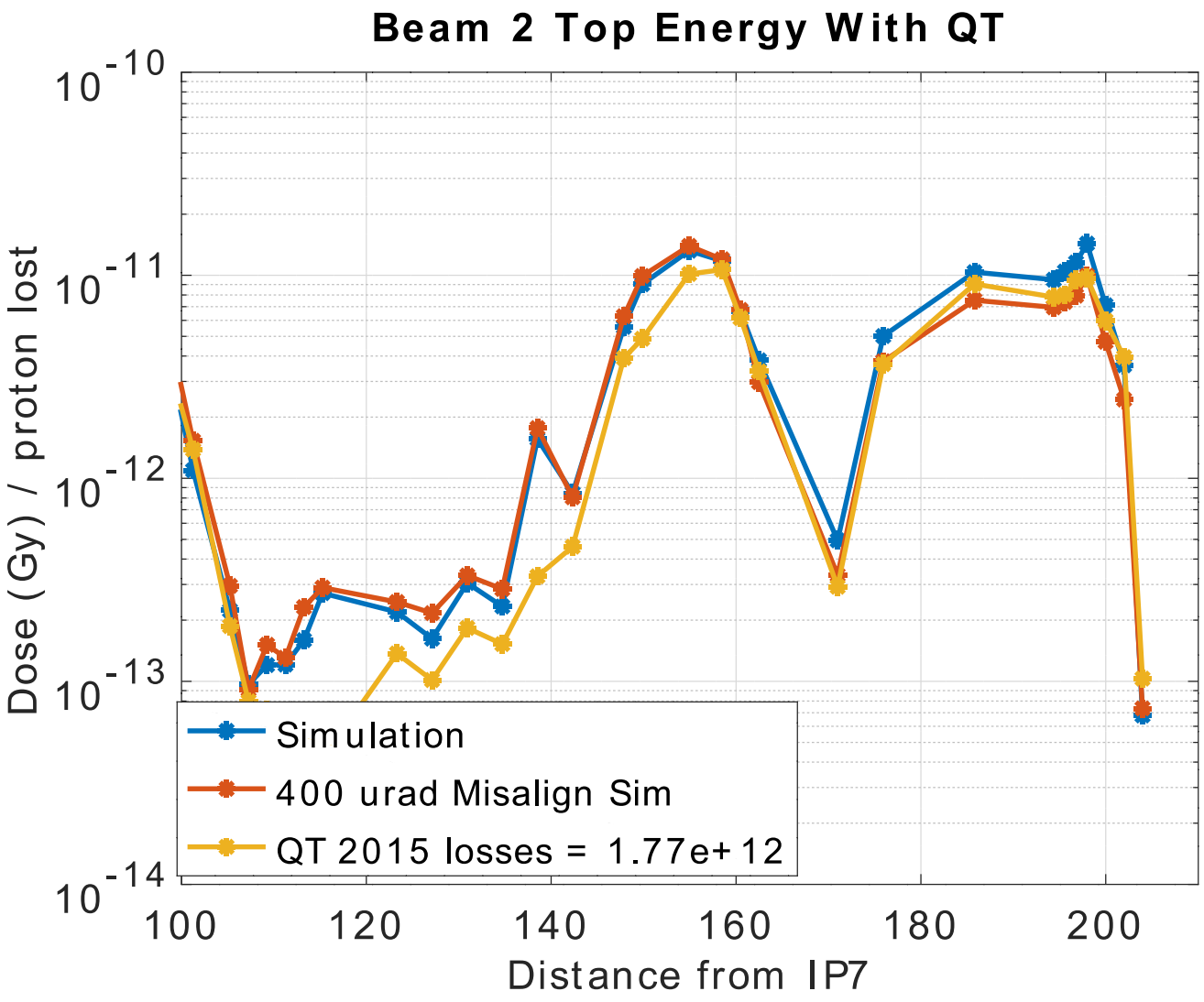


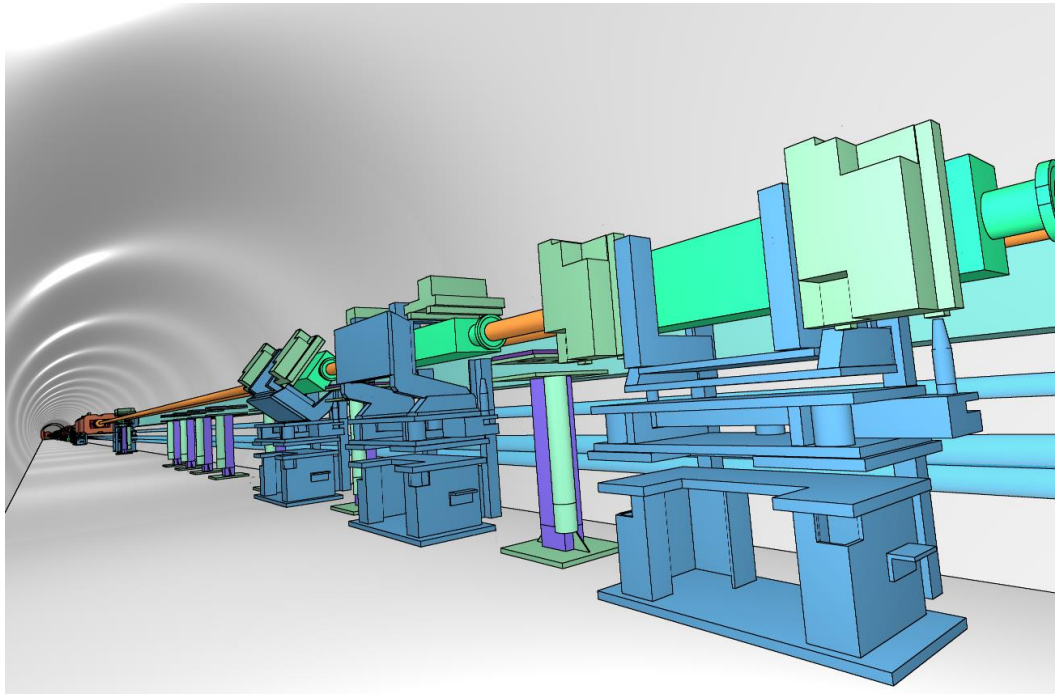


Most recent Ion collimation studies with smaller impact parameter bring the underestimation to a factor of 3, similar to protons

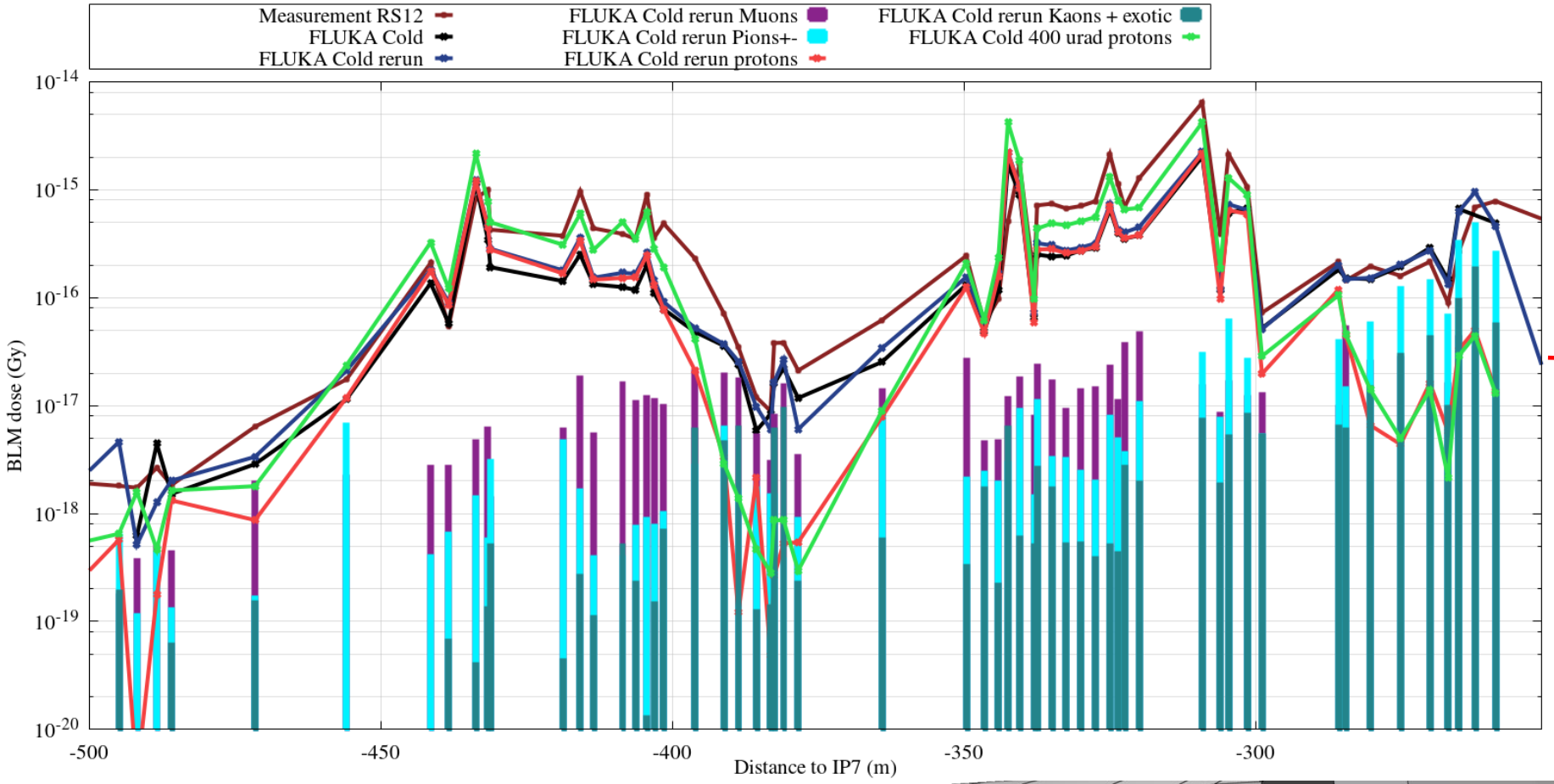
Backup

BLM comparison with 400 urad Misalignment and 2015 cumulative losses





Cold section underestimation



400 urad misalignment
Parallel jaws, Internal impact