BFPP Losses during 2015 Heavy Ion Operation

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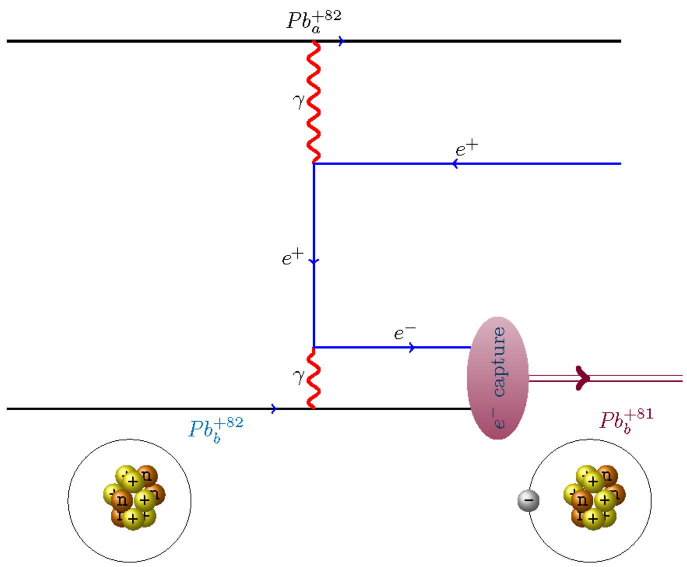
Outline

- Introduction
- Losses around the ring (2015 vs. 2011)
- Bumps and losses observed in each IP
  - IP1
  - IP5 – incl. test of increased amplitude 11L5
  - IP2
  - IP8

Secondary Beams Produced in Pb-Pb Collisions

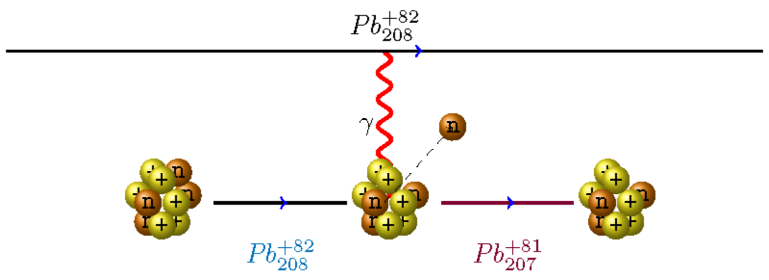
Bound-free pair production (BFPP)

$$^{208}\mathrm{Pb}^{82+} + ^{208}\mathrm{Pb}^{82+} \longrightarrow ^{208}\mathrm{Pb}^{82+} + ^{208}\mathrm{Pb}^{81+} + \mathrm{e}^{+}$$



and **electromagnetic dissociation (EMD)**

$$^{208}\mathrm{Pb}^{82+} + ^{208}\mathrm{Pb}^{82+} \longrightarrow ^{208}\mathrm{Pb}^{82+} + ^{207}\mathrm{Pb}^{82+} + \mathrm{n}$$



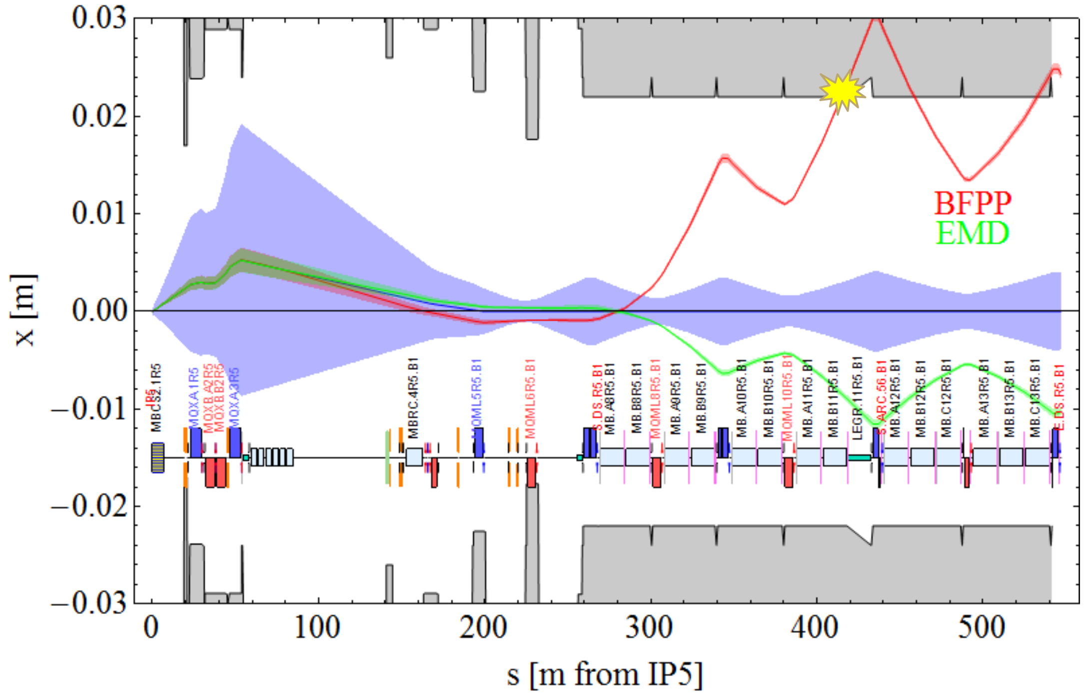
have large interaction cross-sections in Pb-Pb collisions and are the main contribution to fast Pb-Pb burn-off (hadronic cross-section is 8b):

$$\sigma_{\mathrm{c,tot}}(3.5Z\ \mathrm{TeV}) = \sigma_{c,\mathrm{BFPP}} + \sigma_{c,\mathrm{EMD}} + \sigma_{c,\mathrm{hadron}}$$
$$\approx \boxed{253.6\ \mathrm{b}} + \boxed{195.6\ \mathrm{b}}$$

Secondary Beams Produced in Pb-Pb Collisions

These reactions **change the charge-to-mass ratio of the ions**, which **changes bending** in (main) dipoles: $B\rho = p/q$

Secondary Beam Paths right of IP5



Main: **208-Pb-82+**

BFPP: **208-Pb-81+**

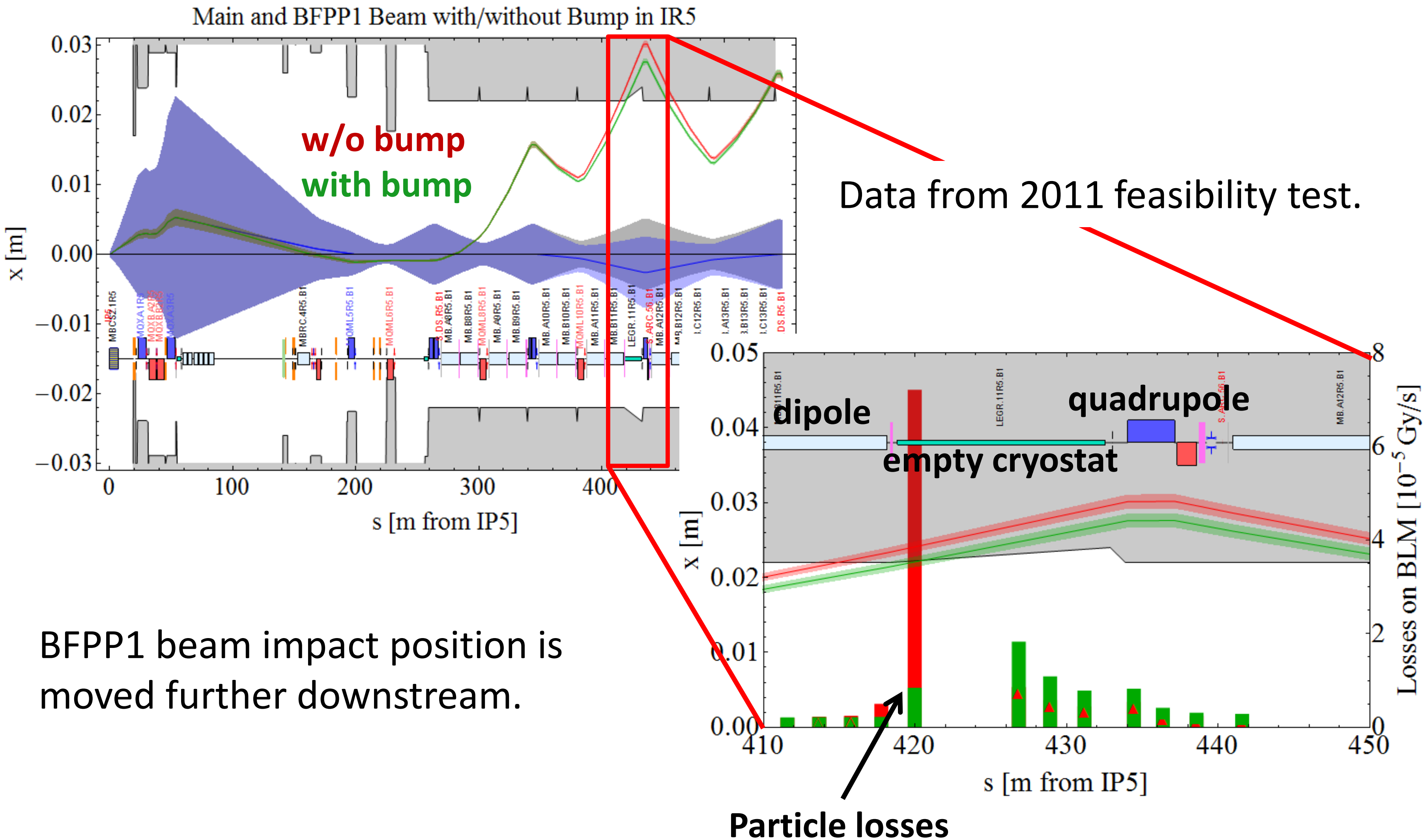
EMD: **207-Pb-82+**

Intense secondary beams are produced that impact in a superconducting magnet downstream from the IP.

⇒ <u>Luminosity limit</u>, if deposited power exceeds quench limit.

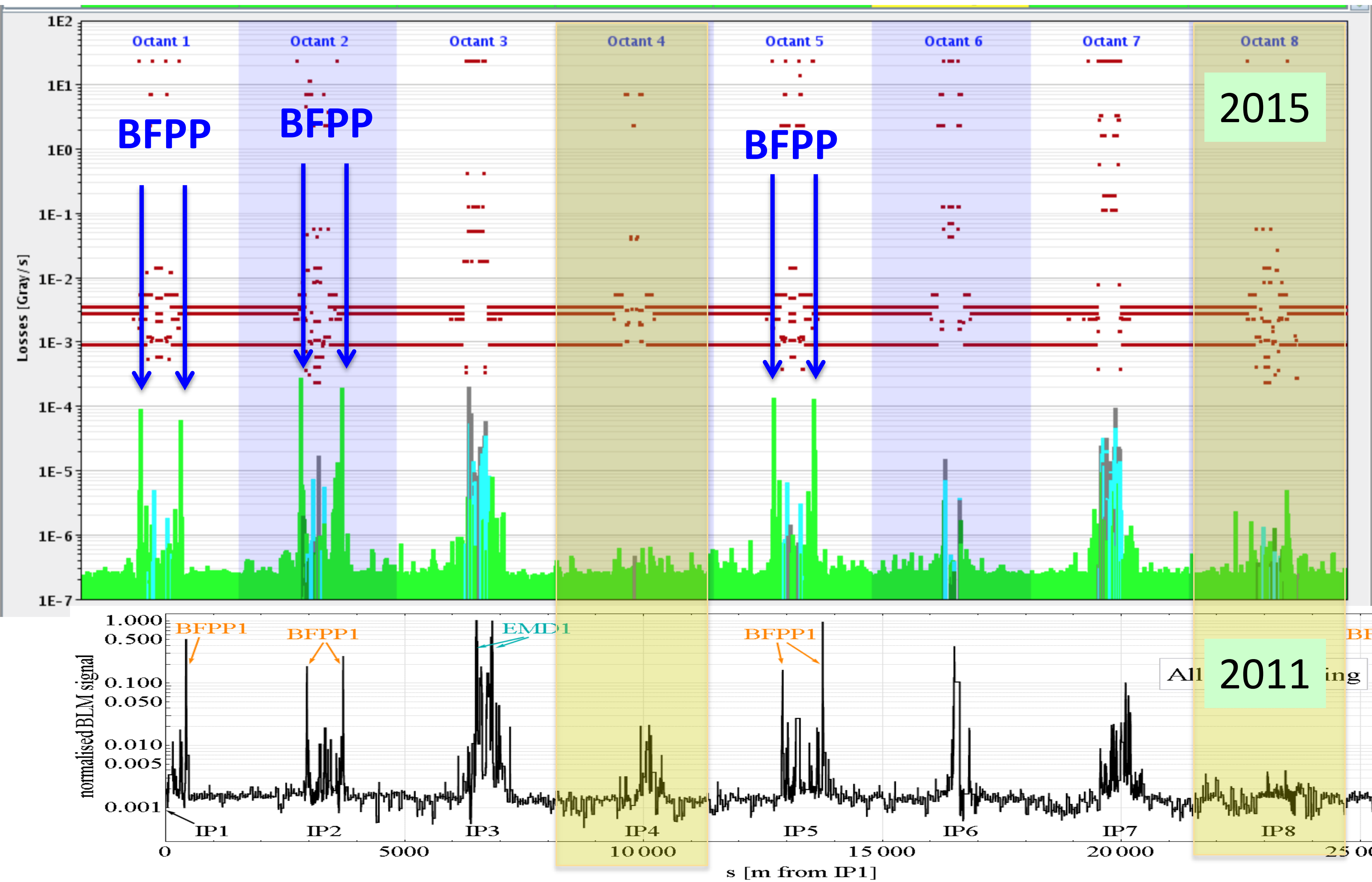
Risk Mitigation with Orbit Bumps – Test 2011

Orbit bumps are now used to move the secondary beam losses into the empty cryostats around IP1 and 5 in order to reduce risk of quench.



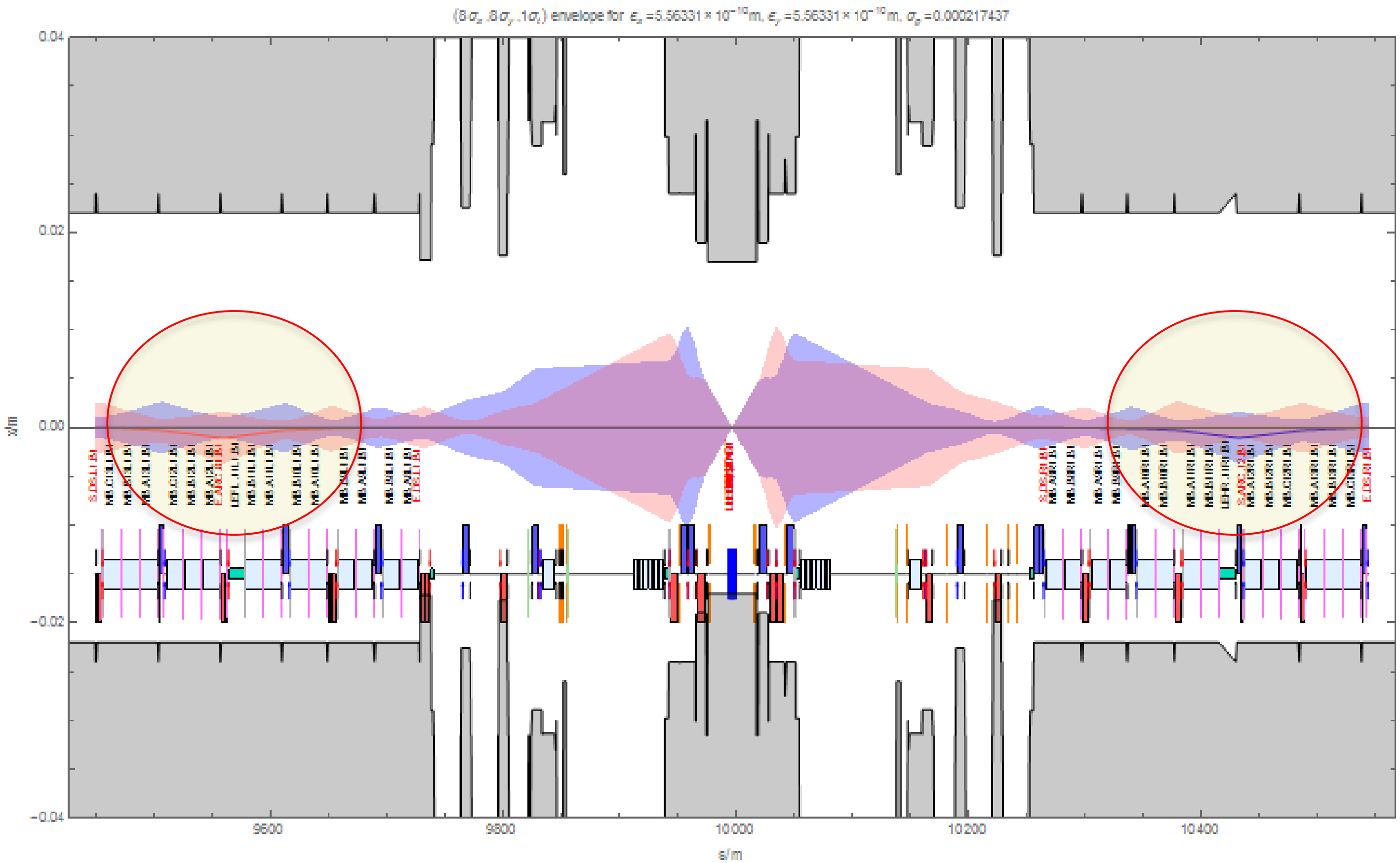
BFPP1 beam impact position is moved further downstream.

Loss Pattern around the Ring, 4 (3) colliding IPs



IP1

IP 1/5 unit bumps



Correctors used for bumps

7_ 9_ 13

ACBCH7.R1B1, ACBH9.R1B1, ACBH13.R1B1

ACBCH7.L1B2, ACBH9.L1B2, ACBH13.L1B2

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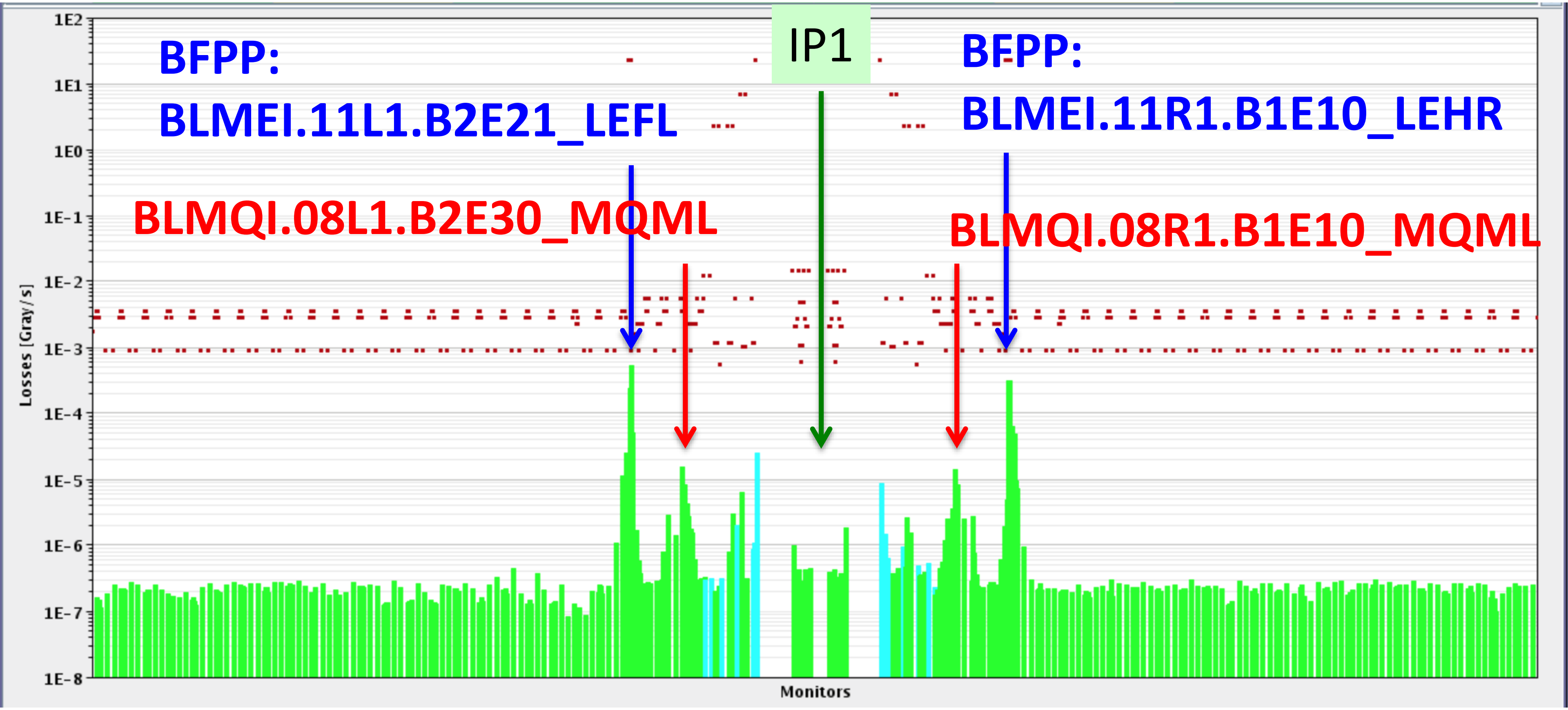
BFPP Losses around IP1

Bump Correctors: **7-9-13**

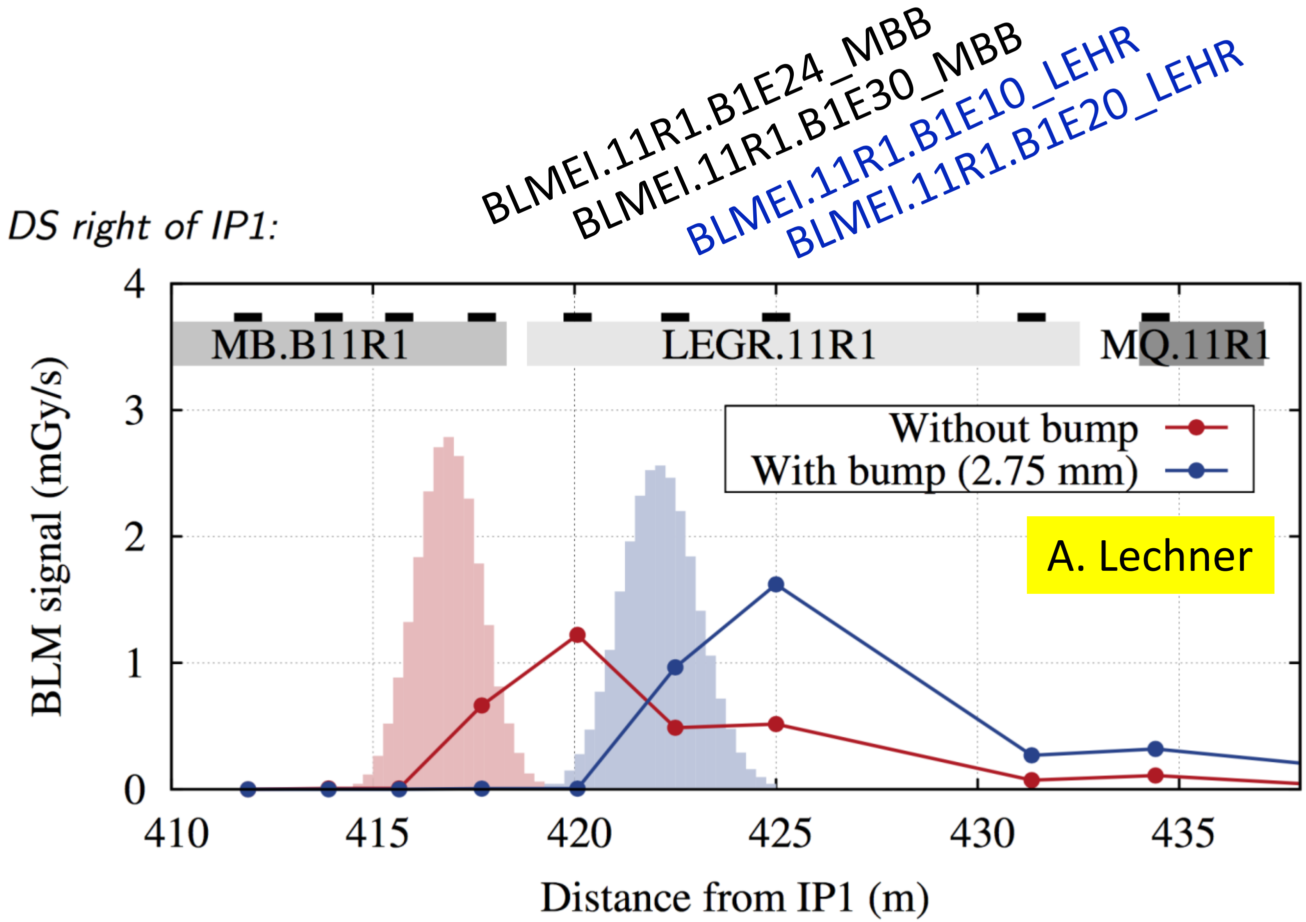
Bump Amplitude: **-3.2mm (L) / -2.75mm (R)**

The BFPP bumps move the losses deep into the empty cryostat

➔ Losses in last BLM on MB are at least a few 10 times smaller



FLUKA Simulations of BLM Signals



The BLM signals suggest that the situation **on both sides** is similar to the blue simulation.

IR1/5: shifting the BFPP loss location to the connection cryostat

Run 2 optics (assuming β^* =80 cm):

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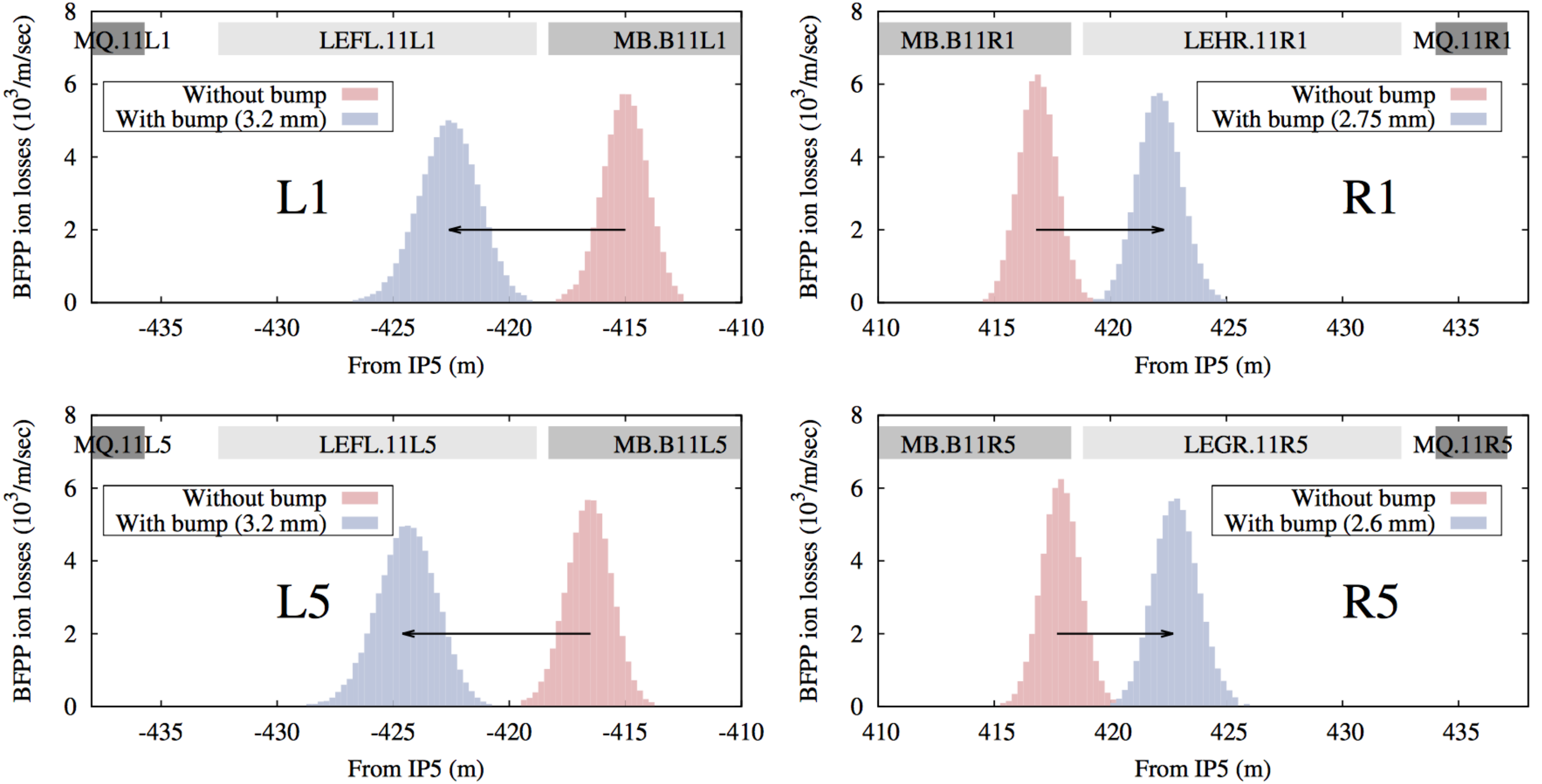


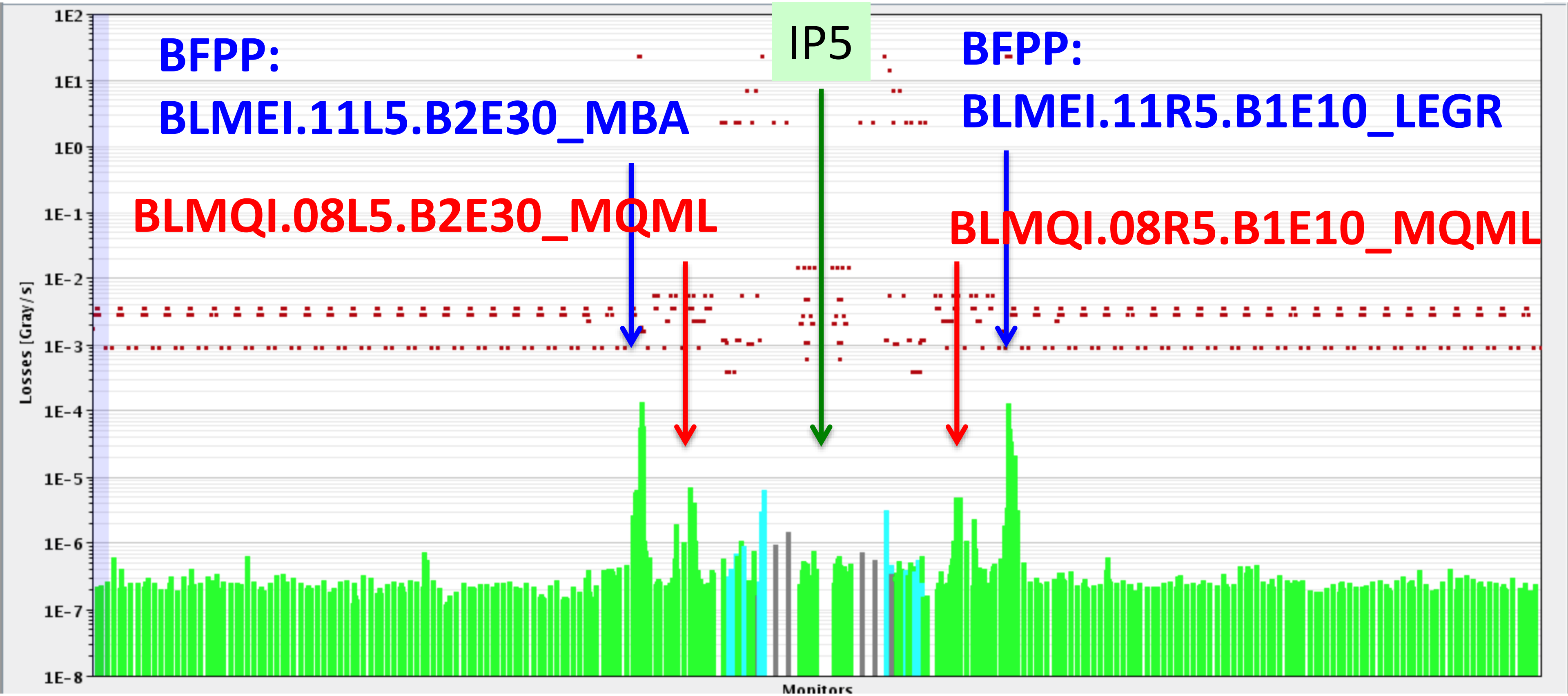
Some uncertainty on the position (~1-2 m) due to beam screen tolerances etc.

IP5

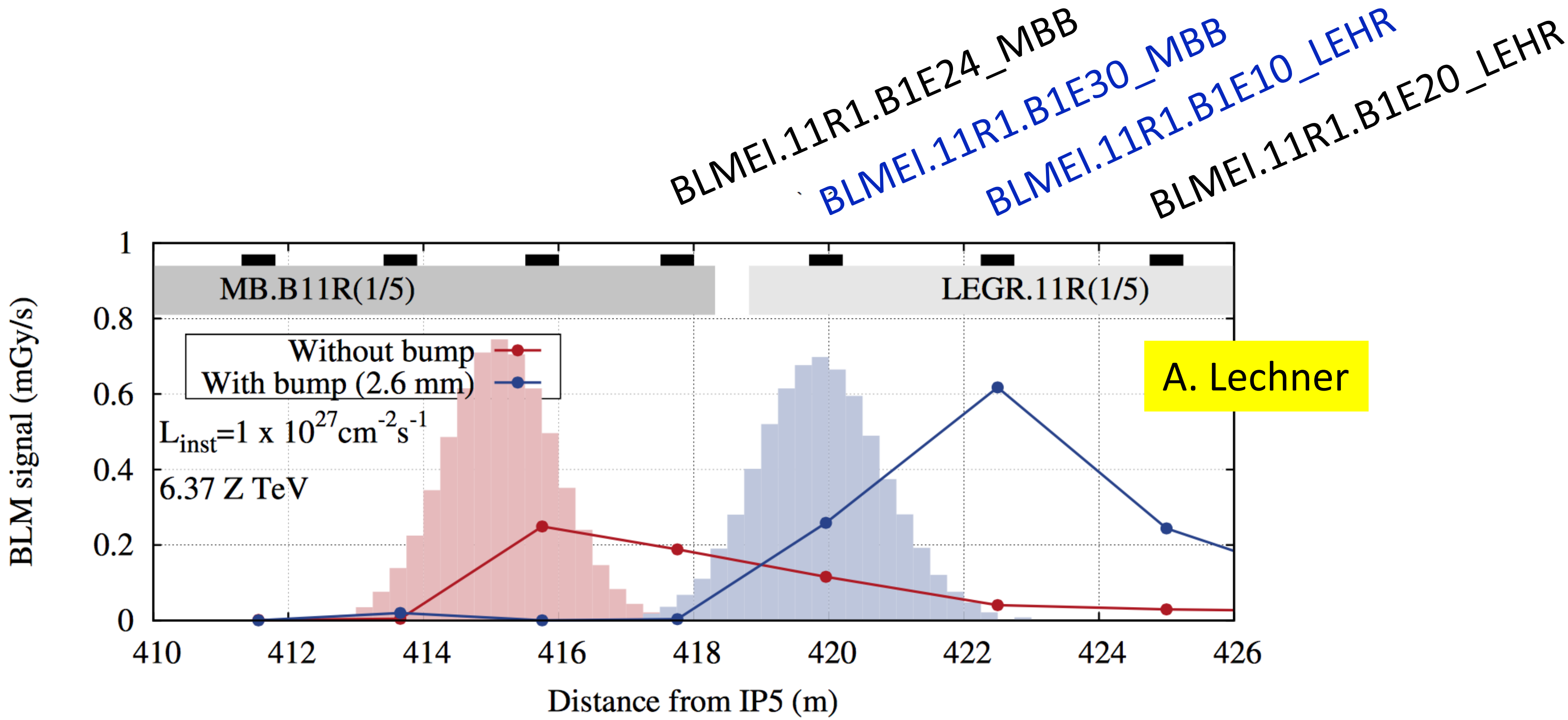
BFPP Losses around IP5

Bump Correctors: **7-9-13**
Bump Amplitude: **-3.0mm (L) / -2.6mm (R)**

The right BFPP bump moves the losses into the empty cryostat.
Losses are still in MB on the left side.



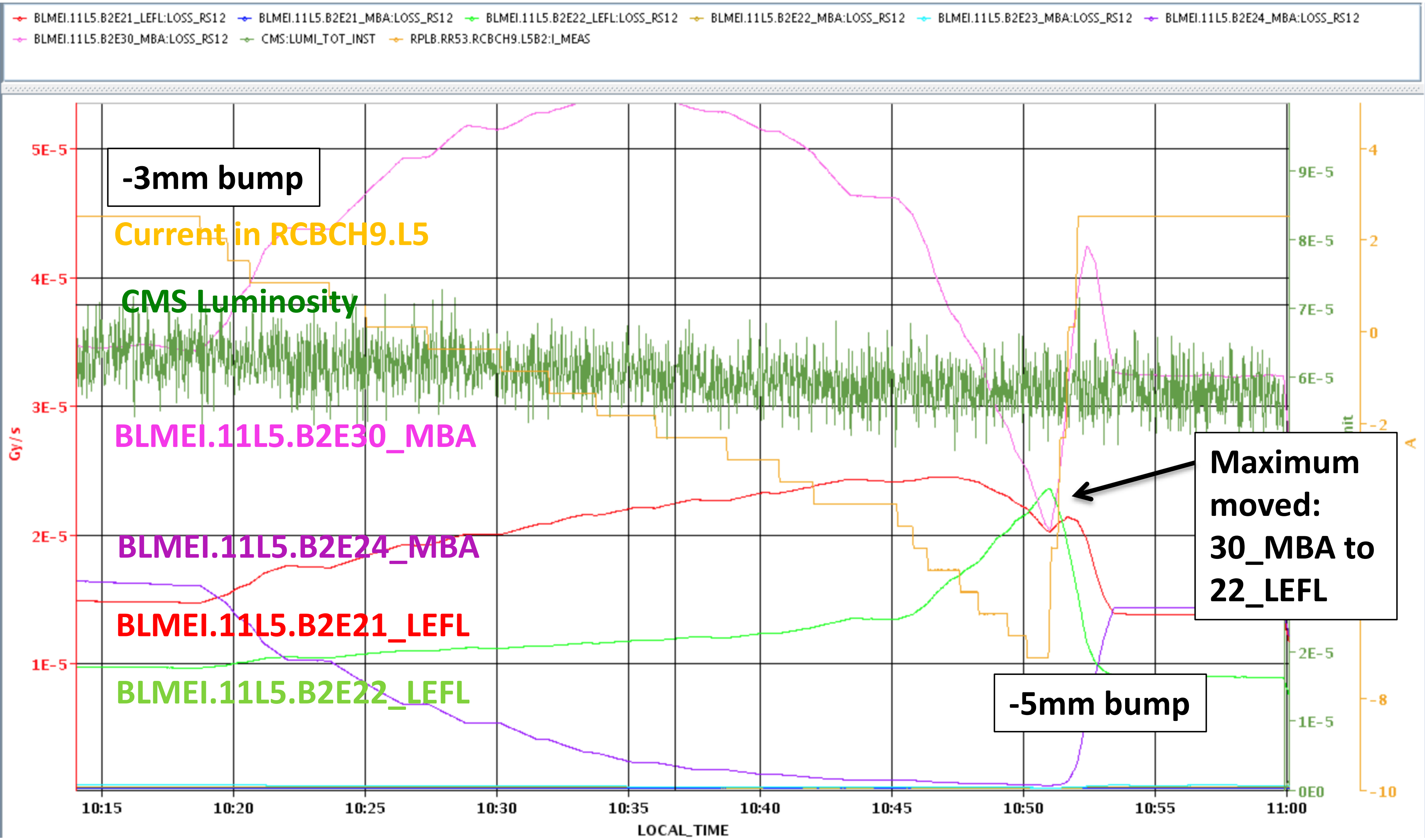
FLUKA Simulations of BLM Signals



The BLM signals suggest that

- **right of IP5** the beam impacts as shown in blue simulation.
- **left of IP5** the impact seems to be more similar to the red simulation, but one BLM further downstream.

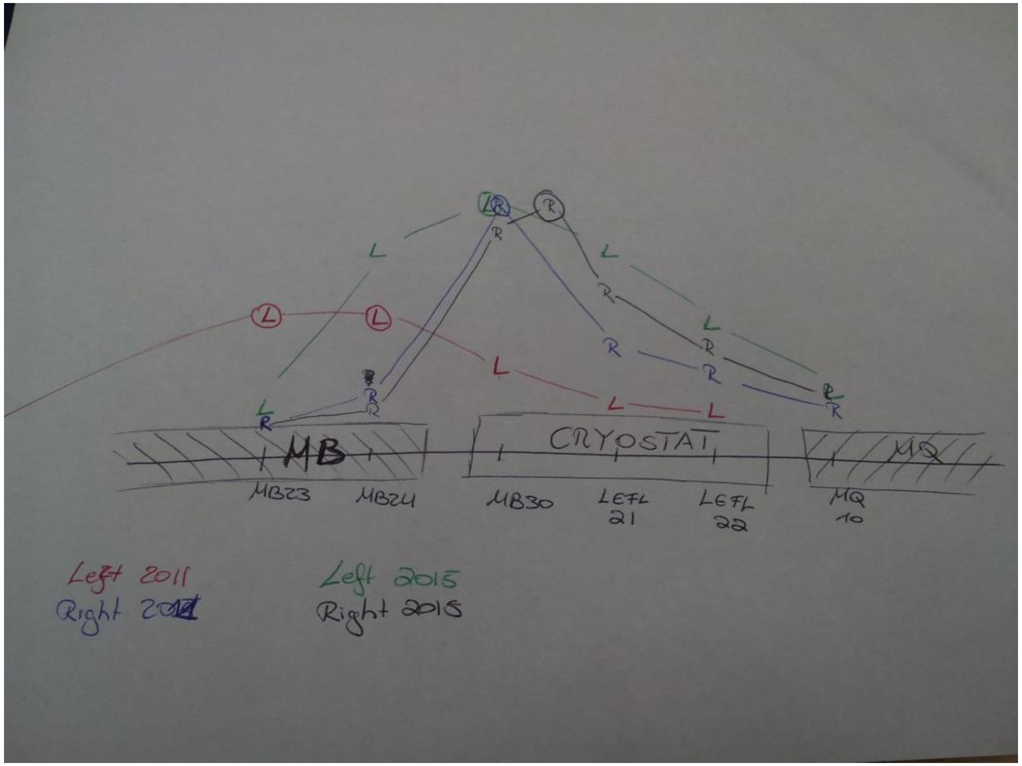
Increase Bump 11L5 to move loss peak into cryostat



Left-Right Asymmetry: Bump 11R5 has -2.6mm amplitude for similar loss pattern

Left-Right Asymmetry in IP5

Comparison of approximated BLM signals in 2011 and 2015

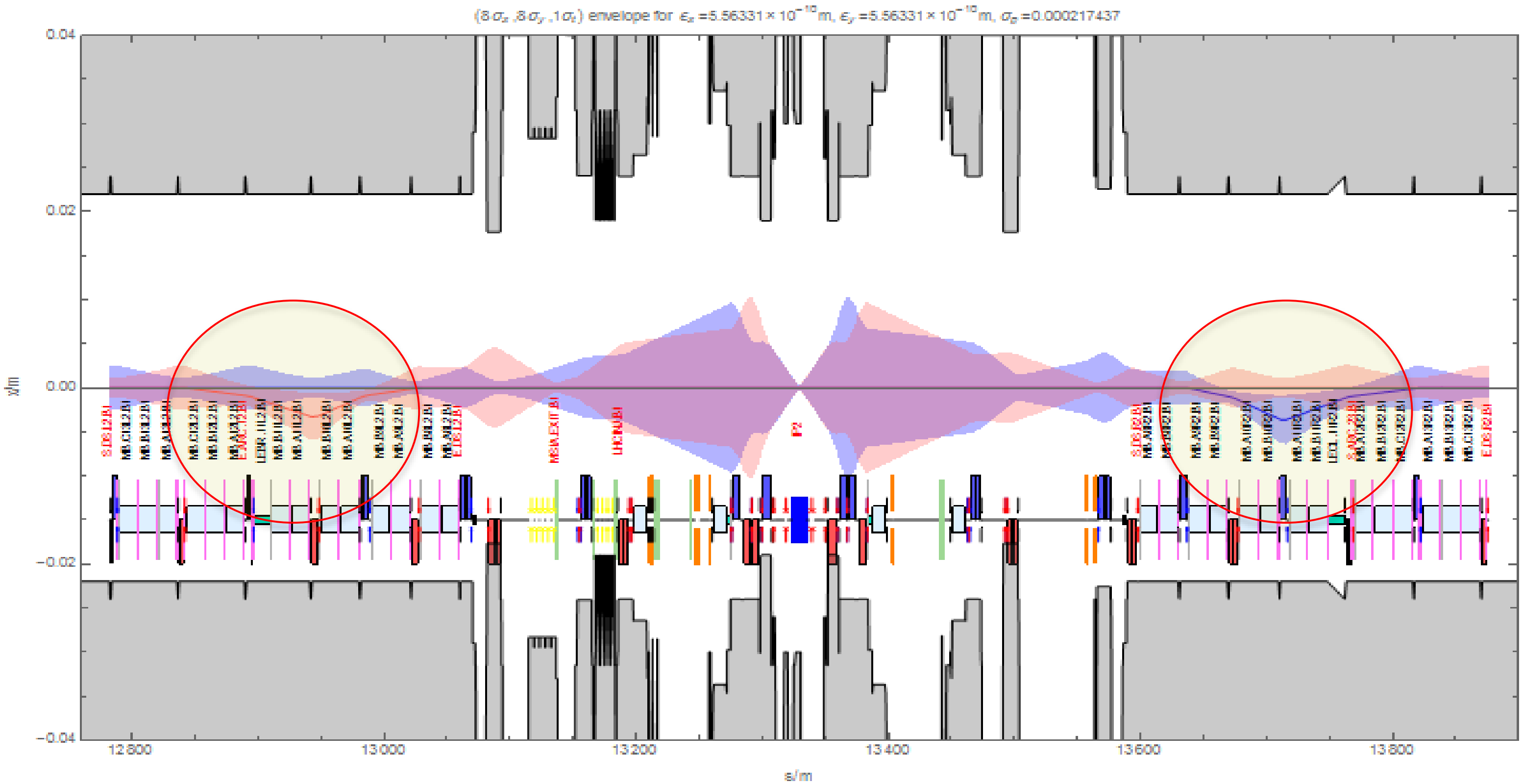


The asymmetry seems to have been there already in 2011

➔ displaced beam-pipe?

IP2

IP 2 bumps



Correctors used for bumps

8_ 10_ 12

ACBCH8.R2B1, ACBCH10.R2B1, ACBH12.R2B1

ACBCH8.L2B2, ACBCH10.L2B2, ACBH12.L2B2

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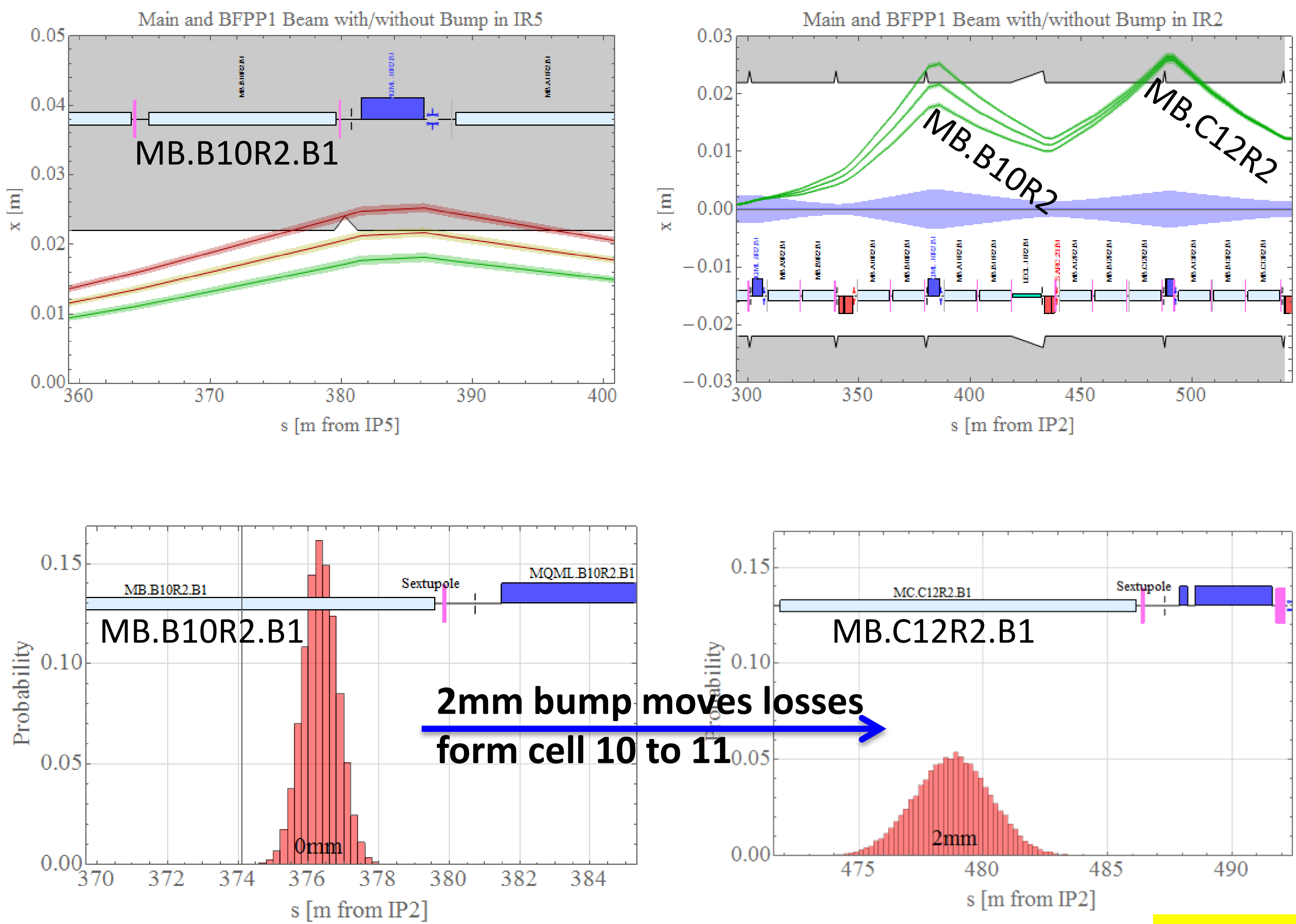
IP2 : Spreading losses over 2 cells



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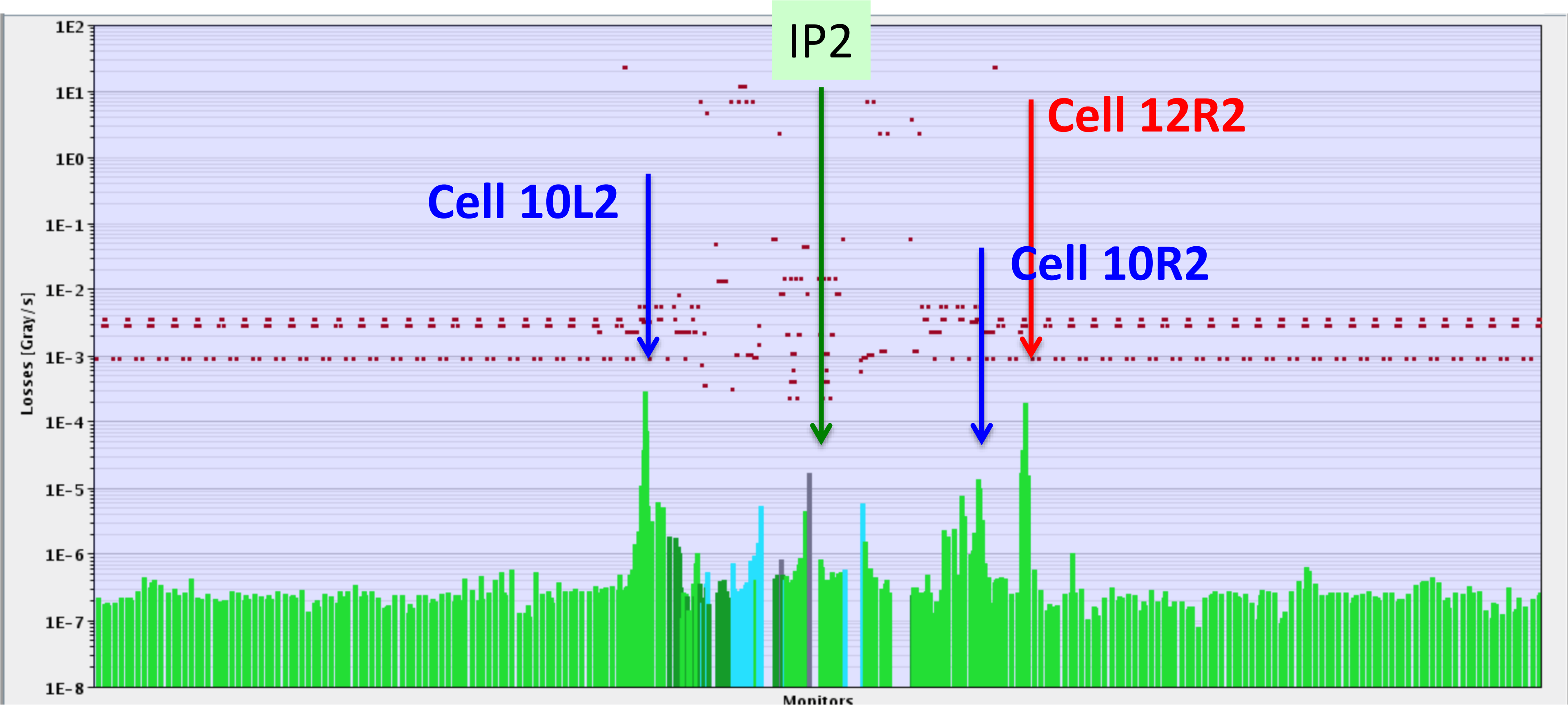
IP2 : Spreading losses over 2 cells

Bump Correctors: **8-10-12**
Bump Amplitude: **-3mm**

The left bump is not large enough to move losses to cell 12.

Initial loss location 10R2 was partially moved to 12R2.

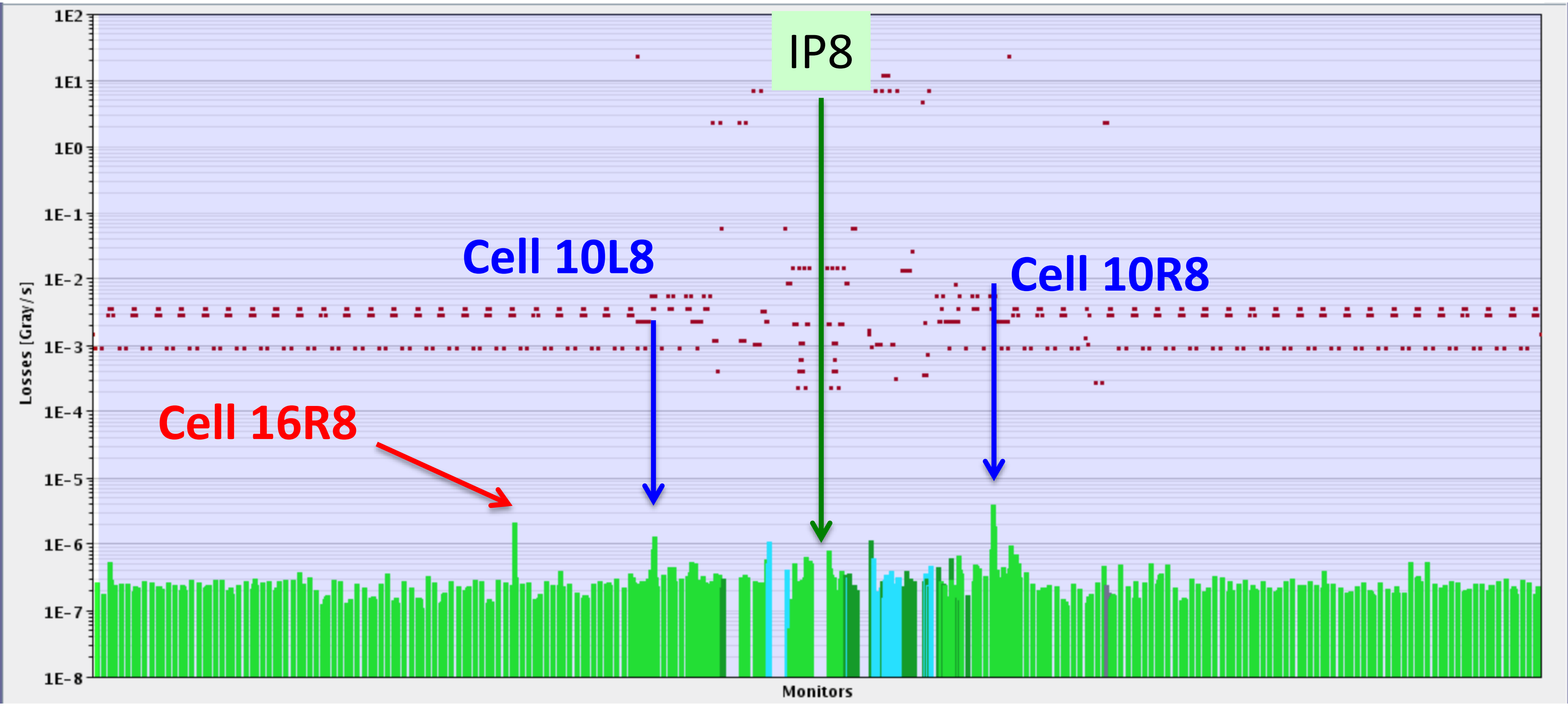


IP8

BFPP Losses around IP8

No BFPP Bumps

Small loss peaks appear as well around IP8 in similar locations as in IP2.



Conclusion

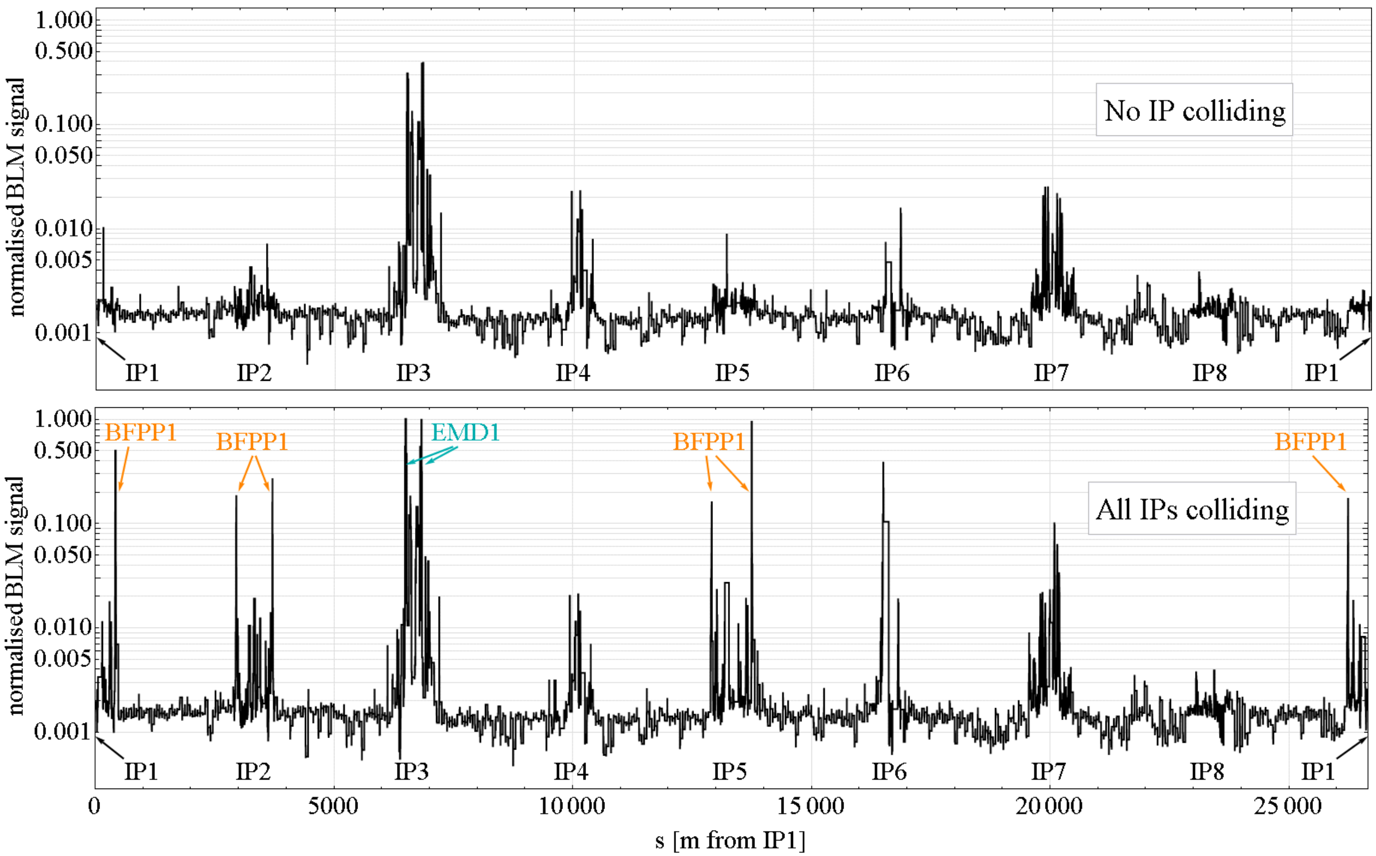
- BFPP bumps are efficient on both sides of IP1, right of IP5 and right of IP2.
- With the currently validated maximum amplitude, the loss location lies still inside MB.11L5.
  - An amplitude of -5mm (currently -3mm) is necessary to move the losses into the empty cryostat left of IP5.
  - This left-right asymmetry is as well observed in the 2011 data.
- Losses to the right side of IP1/5 are already well predicted by simulations.
- Impact positions on left side seem to be systematically different than calculated.

THANK YOU
FOR YOUR ATTENTION

Backup

Particle Losses around the Ring

Data from 2011

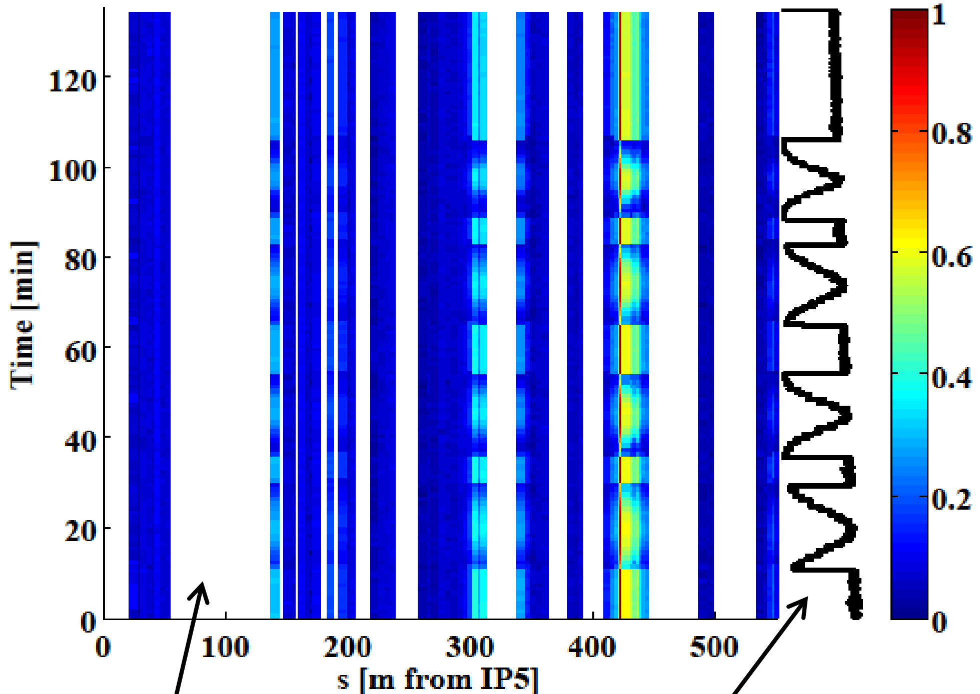


Before collisions

IP1, IP2, IP5 colliding

BLM Losses close to the IP5

BLM signals during *van der Meer (VdM) Scans* in IP5 in 2011



White spaces are not covered by BLMs

Luminosity Evolution