Energy deposition studies for TCLs in IR1/5

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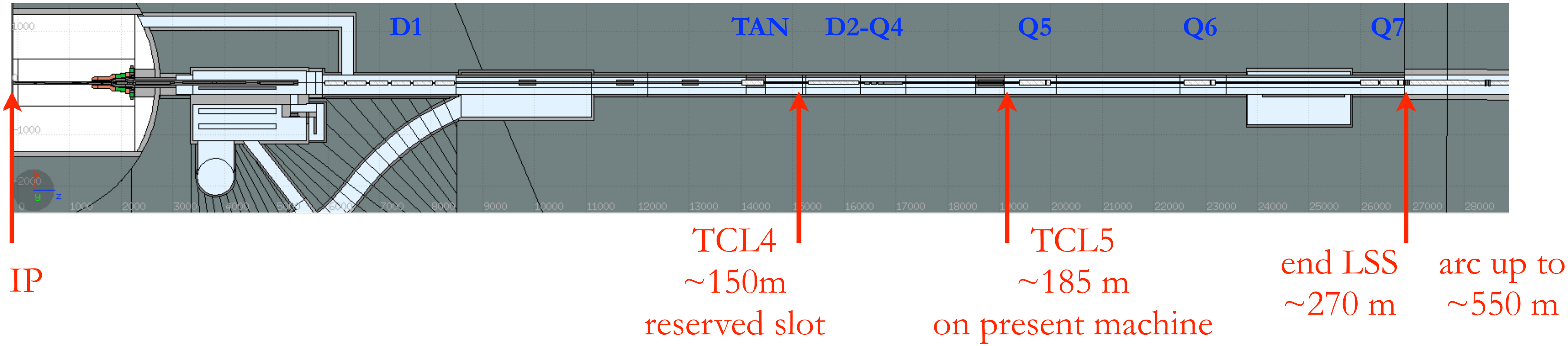
on behalf of the FLUKA team

Outline

- Following past studies† justifying the introduction of TCLs in the high luminosity interaction points of LHC, we review their role
  - in view of related layout choices during LS1 (possibly considering forward physics detector request¶)
  - in view of possible DS upgrade in LS2
- Different scenarios have been simulated with FLUKA to investigate the effects of TCL4 and TCL5 on collision debris
  - shower-induced peak power in the Matching Section
  - proton loss map and shower-induced peak power in the Dispersion Suppressor

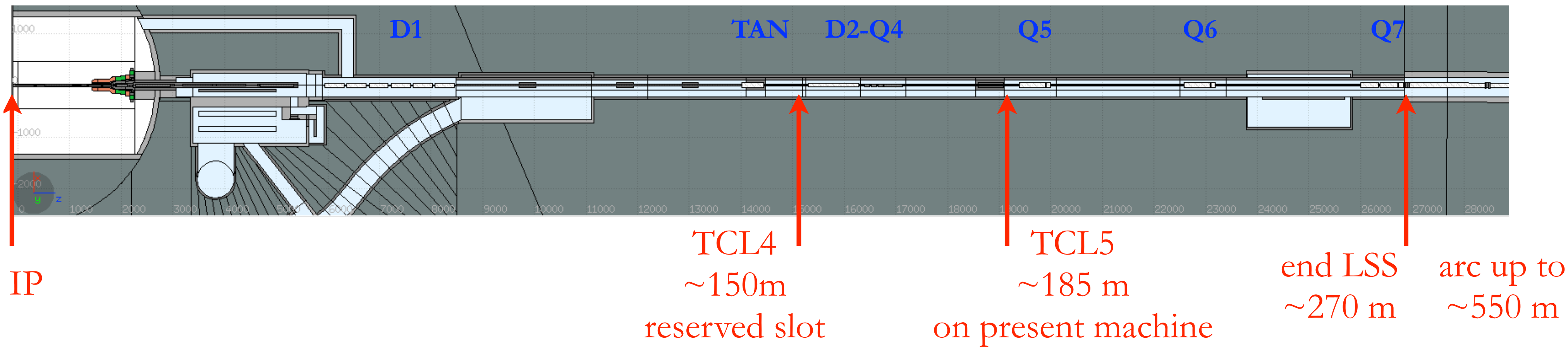


† LHC Project Note 398 (2000) and LHC Project Note 633 (2003)
¶ sLHC Project Note 0029 (2011)

FLUKA model

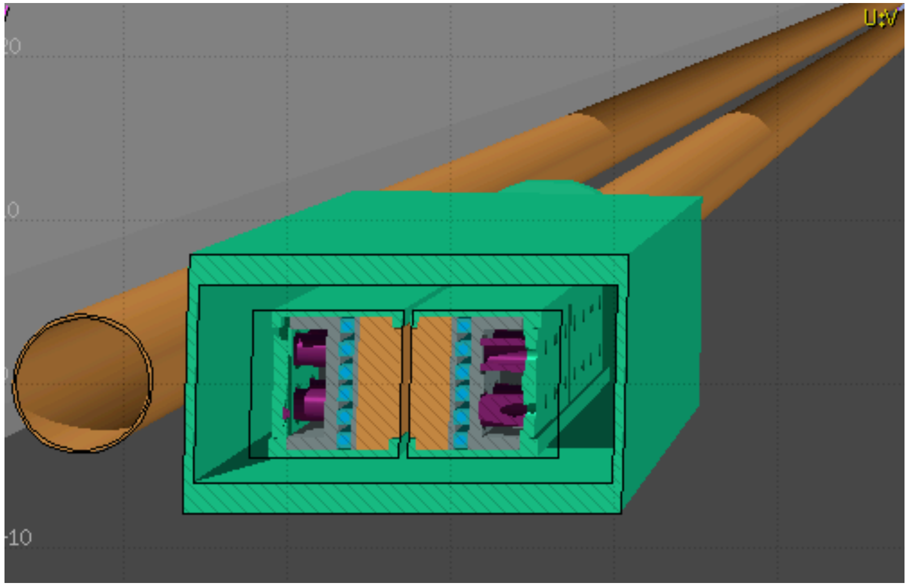
- 7+7 TeV proton collisions at IR5 (IR1)
- DPMJET as event generator
- 85 mb proton-proton inelastic cross section, including diffractive
- Results normalized to 10^{34} cm^{-2} s^{-1}

- LHC optics with 142.5 μrad half-crossing angle

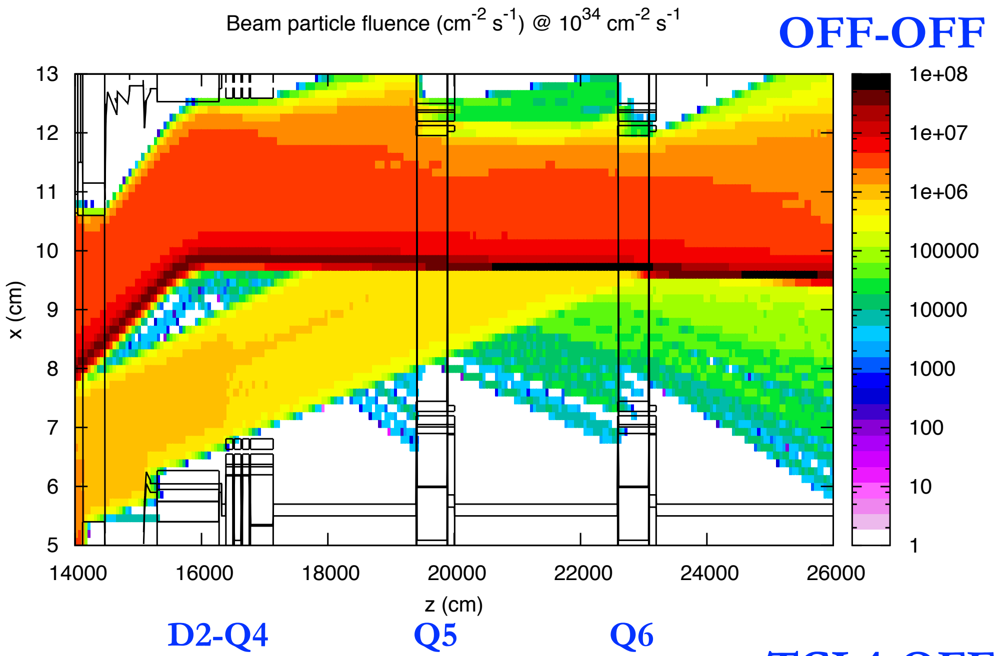


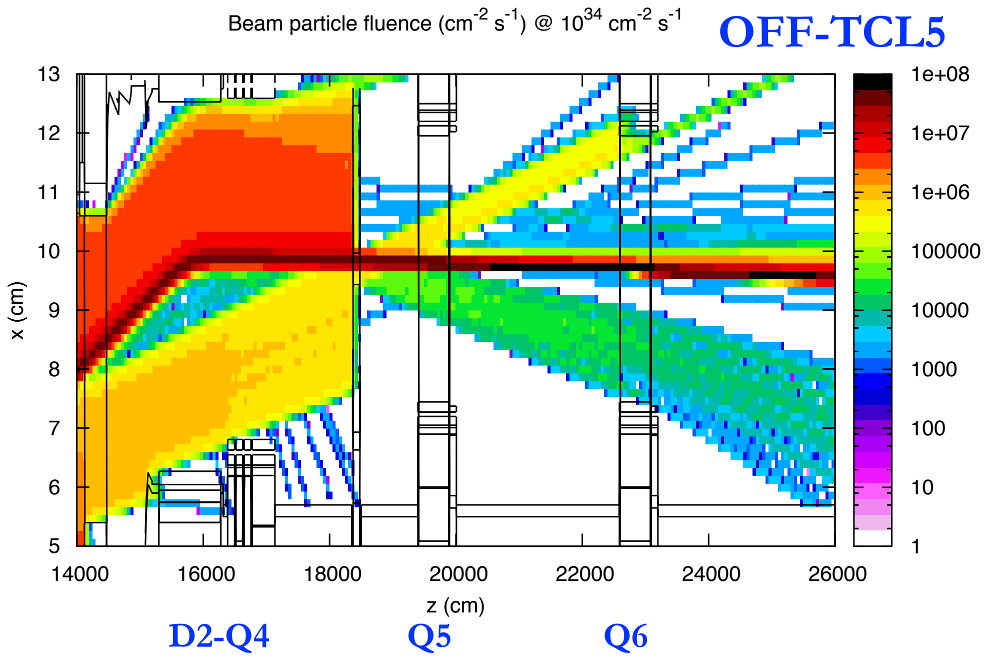
TCL4 and TCL5

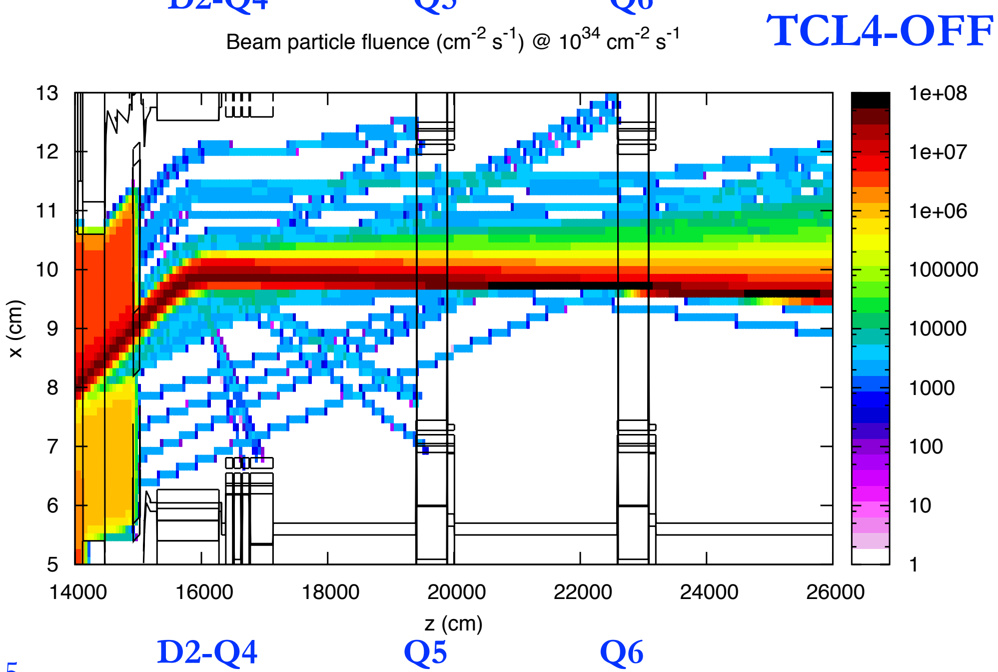
- Collimators to absorb Physics debris coming from interaction point
- B1 (B2) elements right (left) side IP
- Copper jaws
- Half-gap set to 10 horizontal sigmas ($\varepsilon^* = 3.75$ μm rad):
  - 0.528 cm for TCL4
  - 0.266 cm for TCL5
- Roman Pots in cell 4 removed



IR5: primary collision product fluence



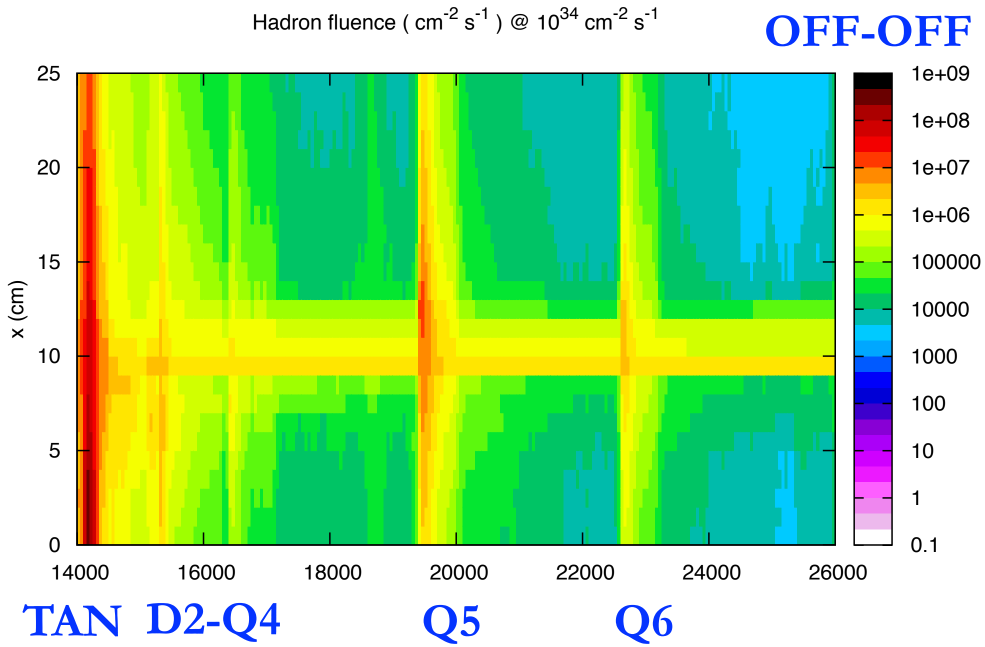


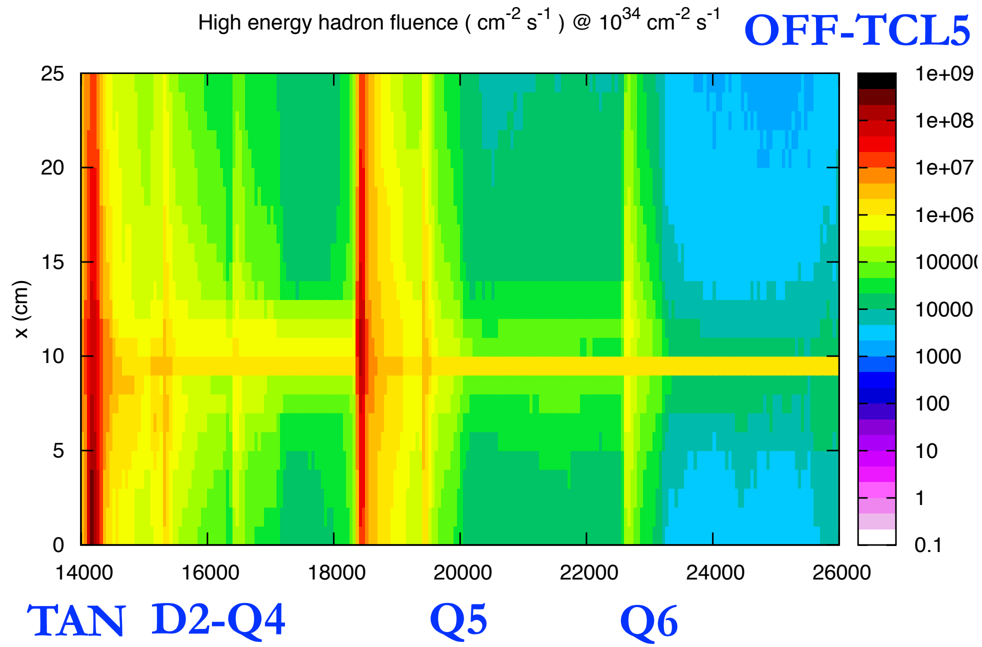


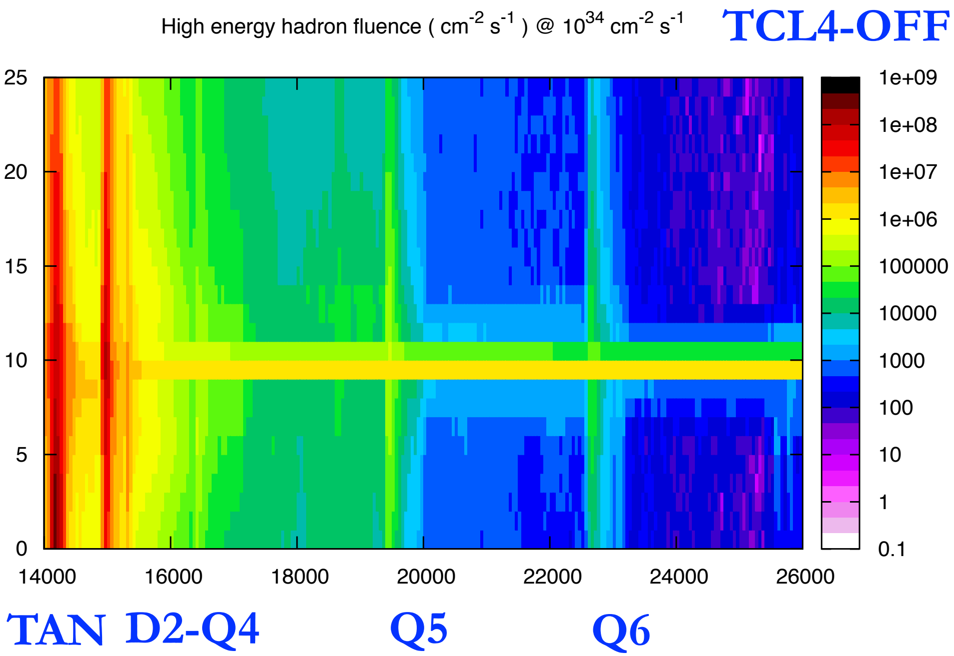
vertical average over 6 cm at beam height

TCL4 provides a better cleaning of collision debris in the MS

Shower: high energy hadron fluence



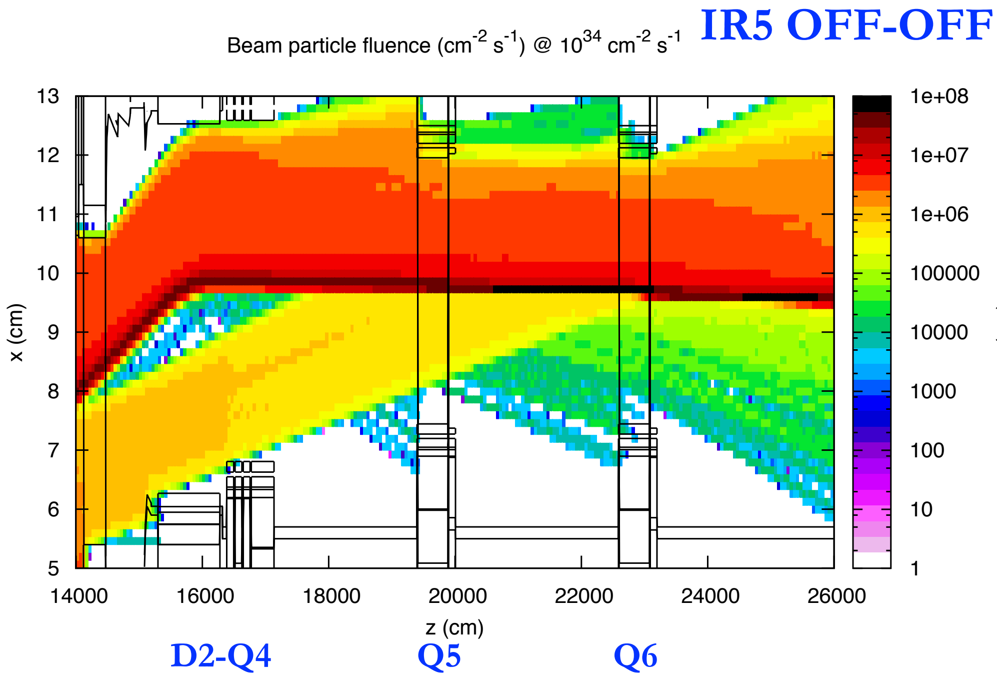


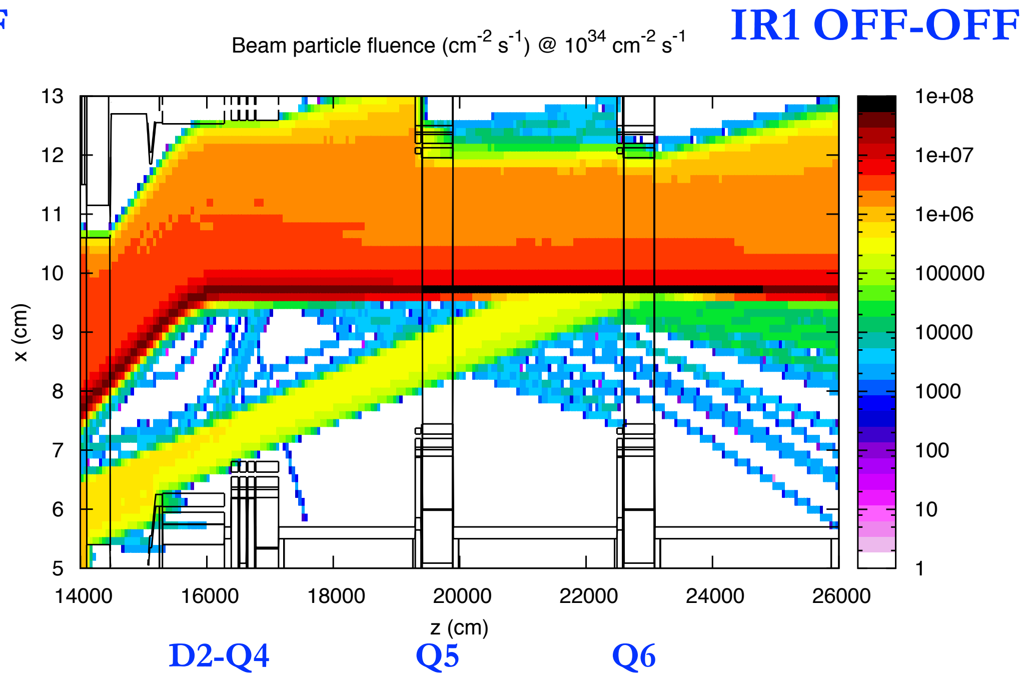


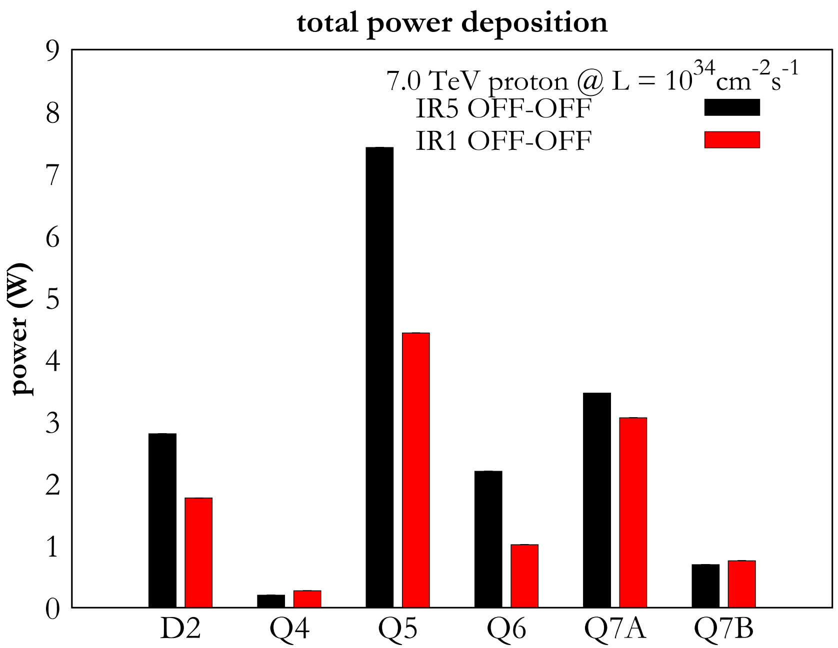
- vertical average over 50 cm at beam height
- multiply by 10^7 to get fluence (cm^{-2}) per 100 fb^{-1}

better shower cleaning by TCL4

A look at IR1



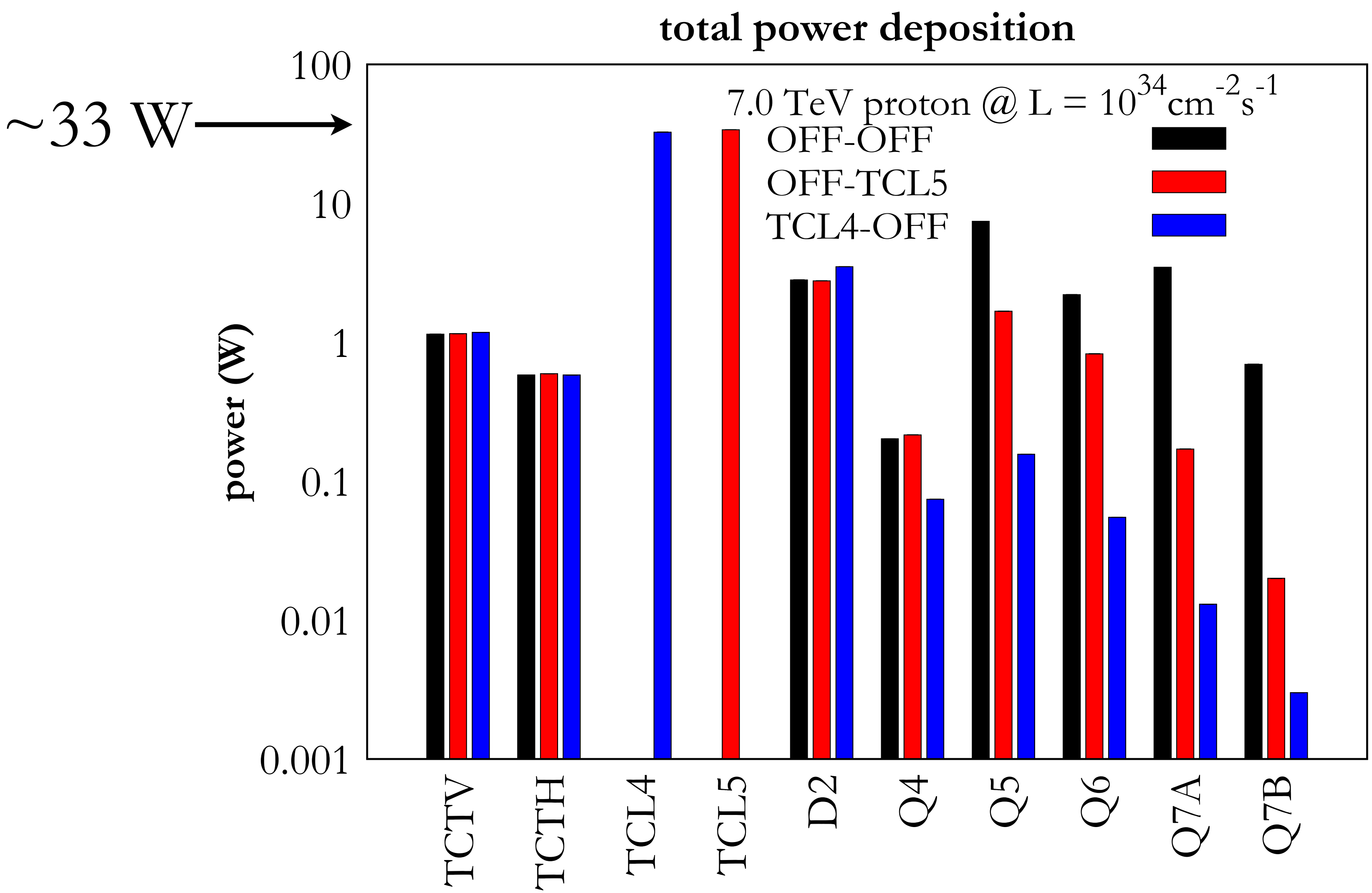




vertical average over 6 cm at beam height

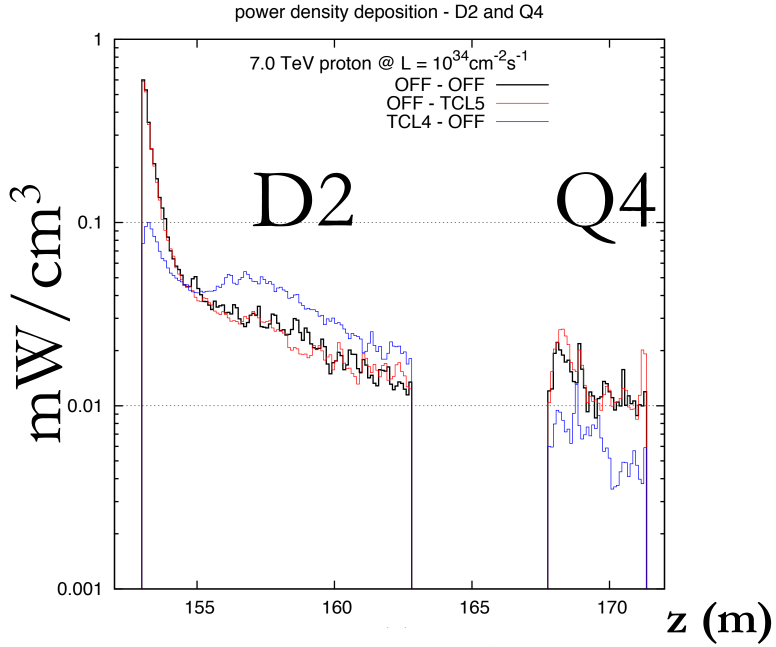
higher load on Q5 in IR5 because of the crossing angle

IR5: total power



TCL 4 provides a better local protection in the Matching Section

IR5: peak power in the MS

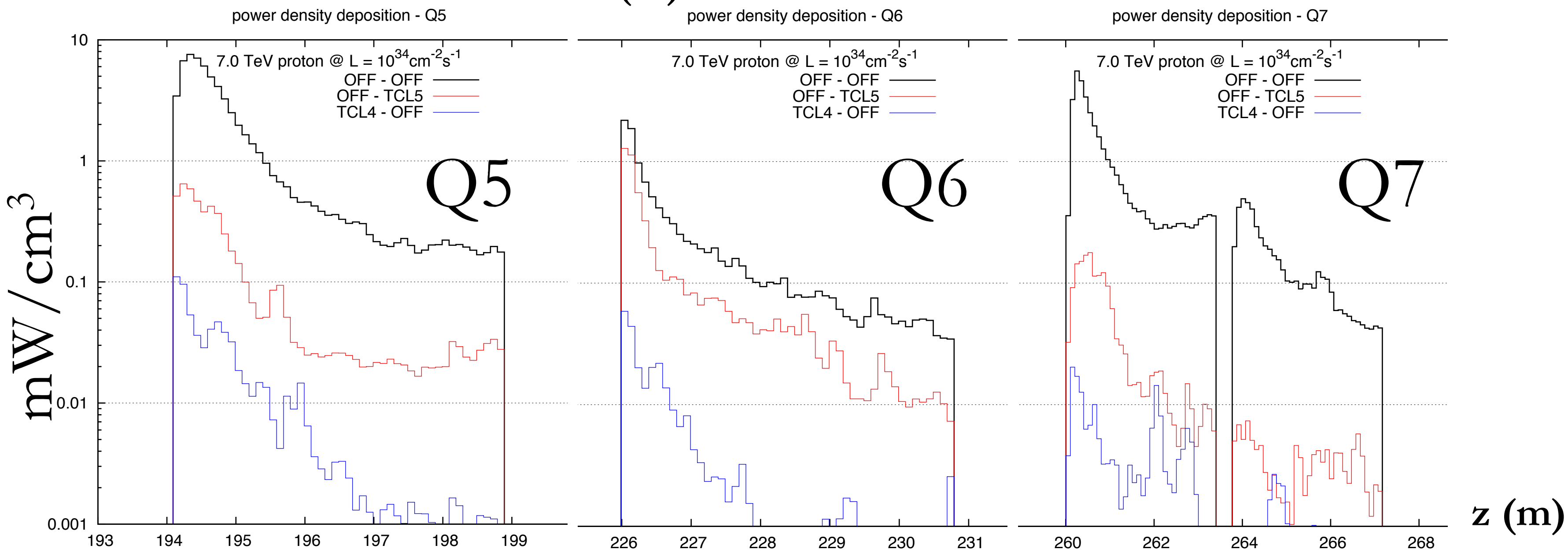


- Binning scoring: $\Delta z = 10$ cm, $\Delta\phi = 2$ deg averaged radially on the entire coil
- Calculations done with optics v6.500. Using v6.503, Q5 peak value raises about 2 mW/cm^3 in case of TCL5

As per previous studies†:

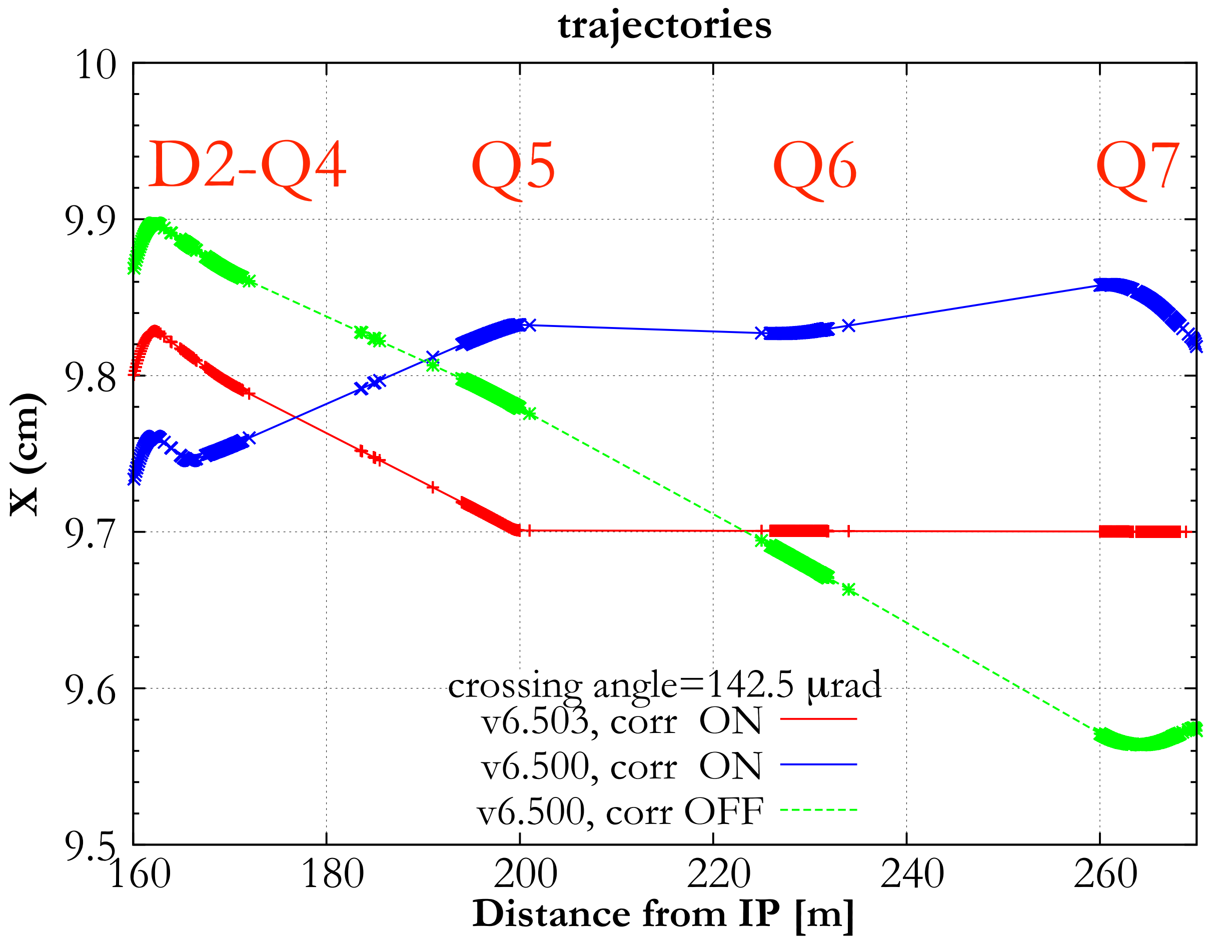
- D2 not an issue (thanks to TAN)
- Q5 and Q7 protection advisable
- power peaks of about same order in IR1

TCL4 more efficient in protecting MS



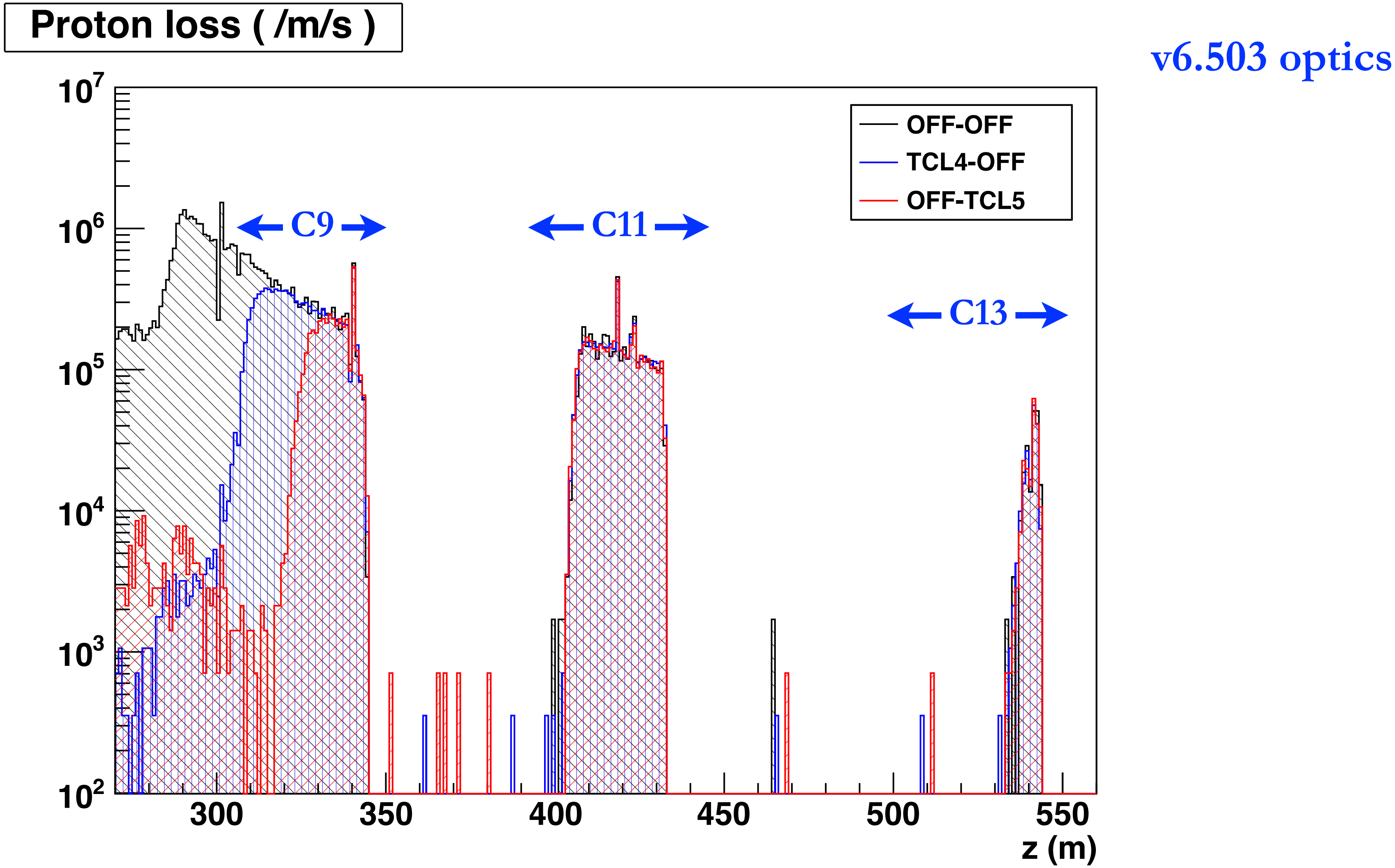
9 † LHC Project Note 398 (2000) and LHC Project Note 633 (2003)

Trajectory accuracy



Crossing angle is closed after Q5 corrector:
v6.500 optics (the one on CERN optics web page) does not guarantee the correct trajectory
After some fixes, we can achieve 1 µm accuracy up to the arc (Cell 13)

IR5: proton losses in the arc

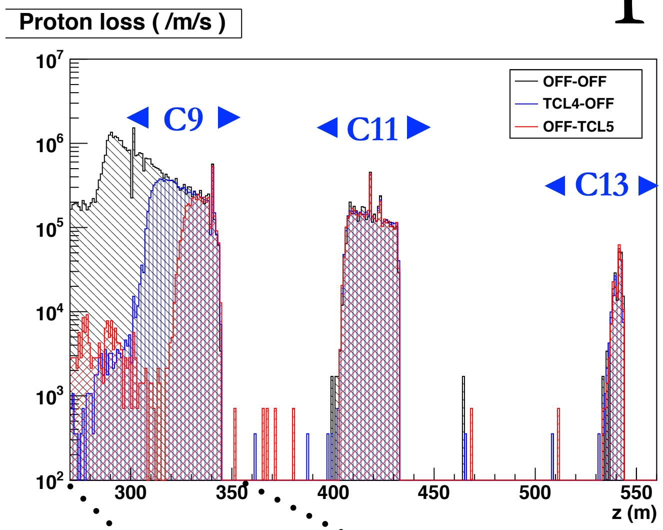


Losses induced by collision debris are localized in C9 and C11

TLC4 provides less protection in the dispersion suppressor than TCL5, anyhow limited to C9

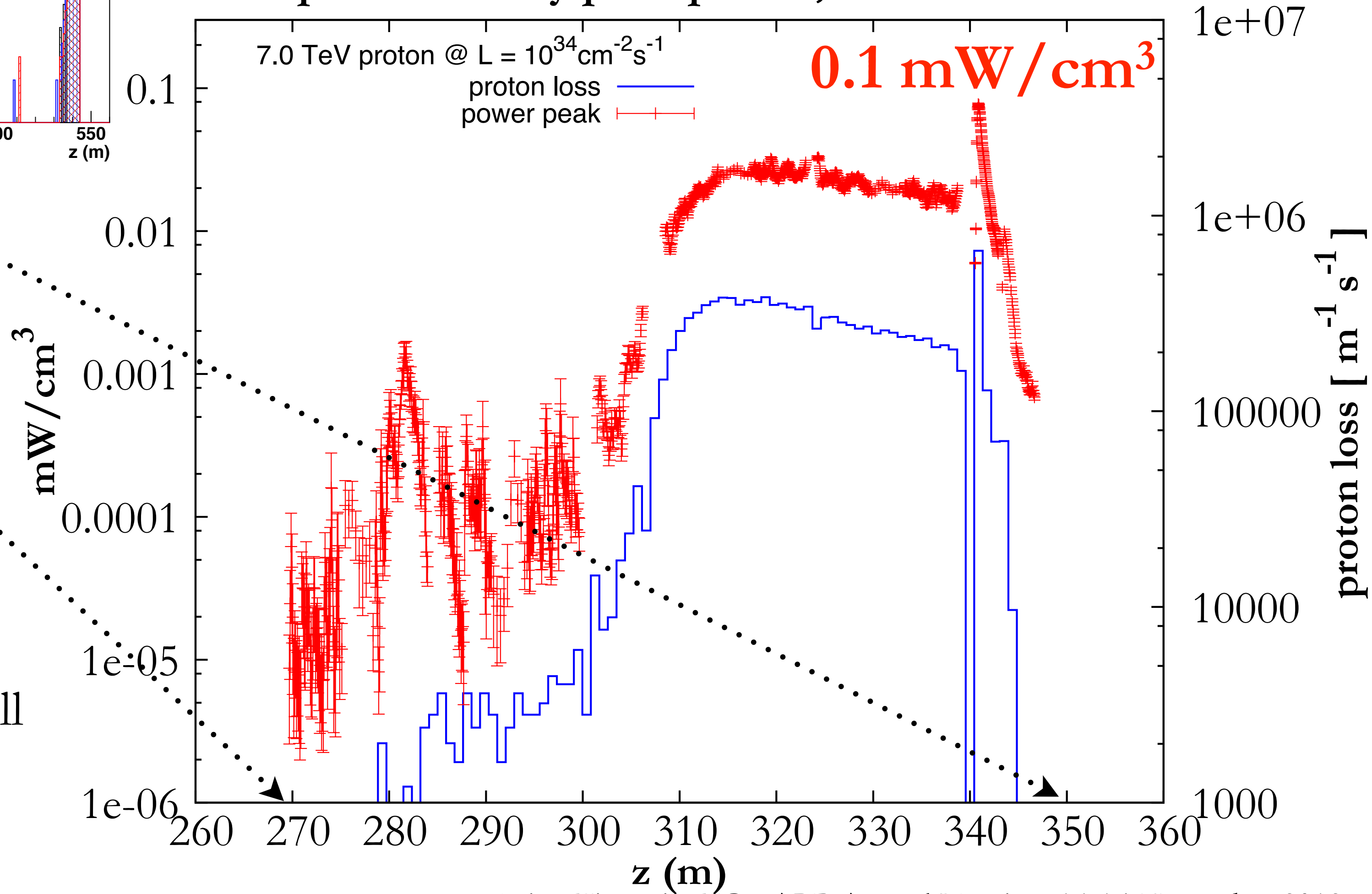
Shower effects are evaluated starting from these proton loss maps

IR5: peak power in the arc



Contributions from upstream showering not evaluated for C8

power density peak profile, TCL4-OFF



In C9 peak power well below 1 mW/cm^3

Conclusions

- Advisable to protect Q5 and Q7 (same outcome for both IR1/5), as per previous studies†
- TCL4 provides a better protection, but limited to Matching Section
- Peak power on DS elements is well below 1 mW/cm^3 at 10^{34} cm^{-2} s^{-1} instantaneous luminosity
- TCL6 role should be investigated, also with respect to R2E

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