HiLumi
HL-LHC PROJECT

RADIATION CHALLENGES FOR THE MACHINE

Francesco Cerutti, on behalf of the CERN EN STI FLUKA team

with contributions by L.S. Esposito, R. Garcia Alia, A. Lechner, G. Lerner, A. Tsinganis

acknowledging the input of many CERN colleagues

5th Workshop on LHCb Upgrade II zoom.us Mar 30th, 2020

OUTLINE

Collision debris figures and features

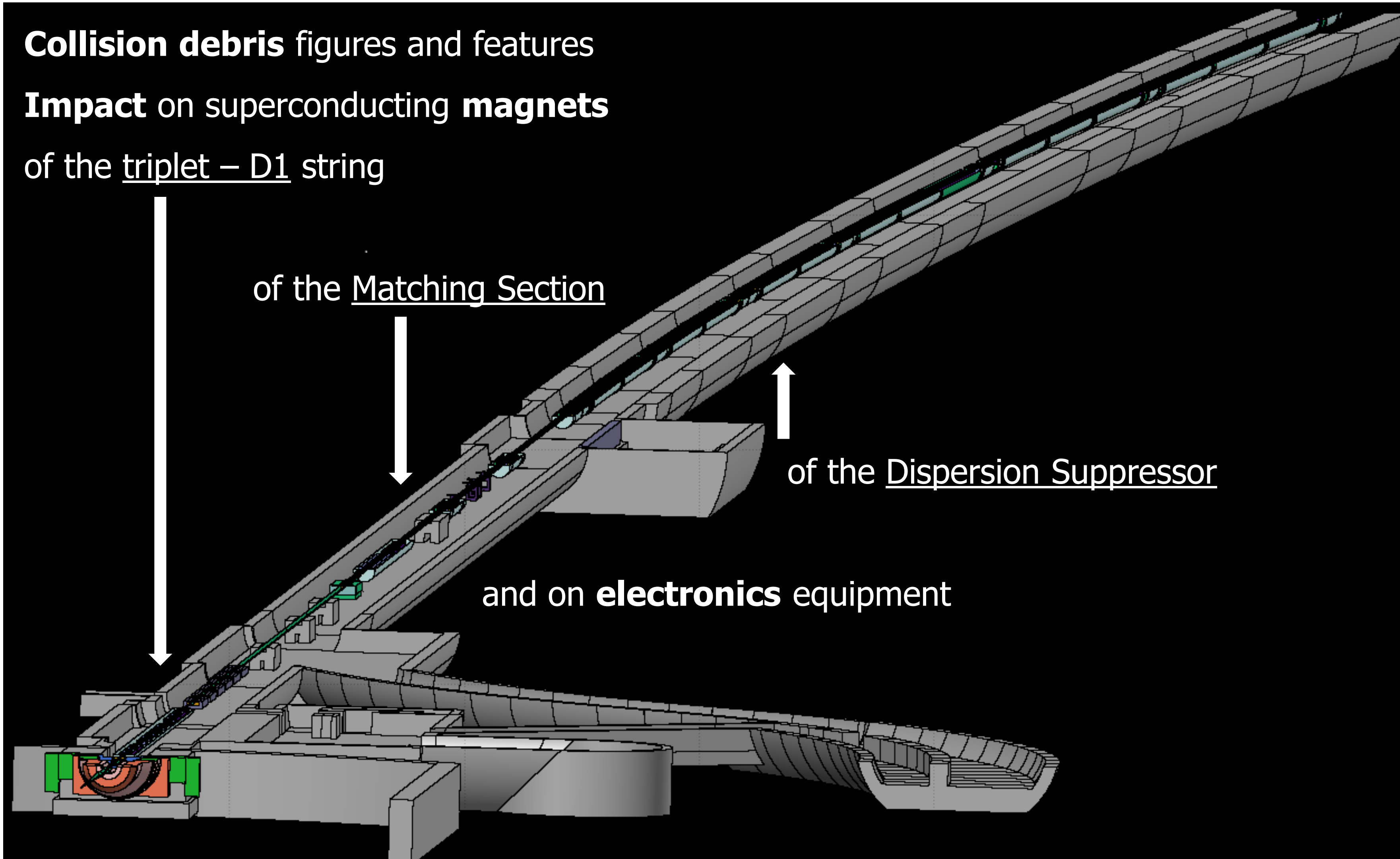
Impact on superconducting **magnets**

of the triplet – D1 string

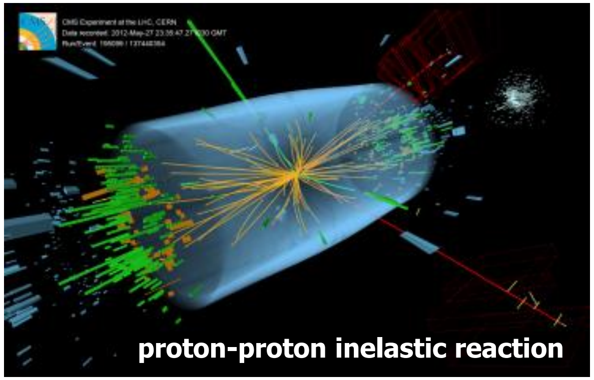
of the Matching Section

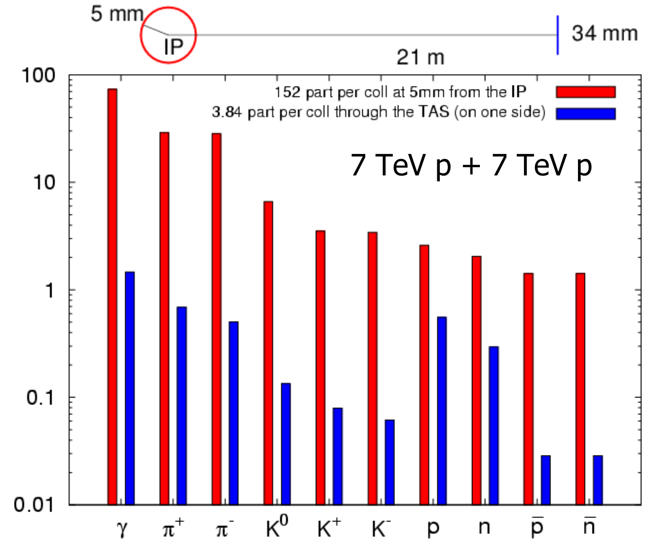
of the Dispersion Suppressor

and on **electronics** equipment



THE COLLISION DEBRIS





with 7.5 10^{-10} Higgs bosons

@ 10^{34} cm^{-2} s^{-1} , i.e. 8.5 10^{8} s^{-1} inelastic collision rate

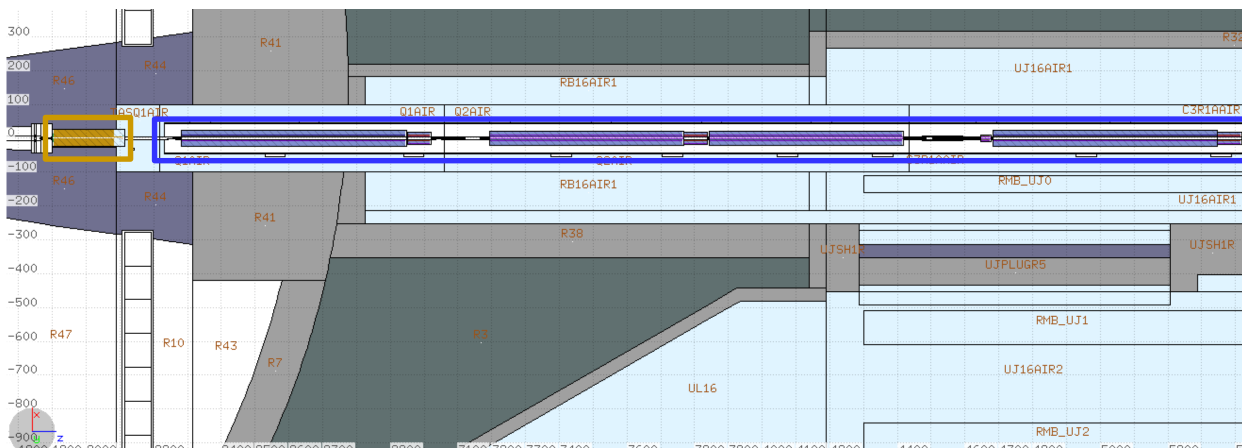
950 W towards each (L&R) side

150 W absorbed in the TAS absorber

650 W going through the TAS

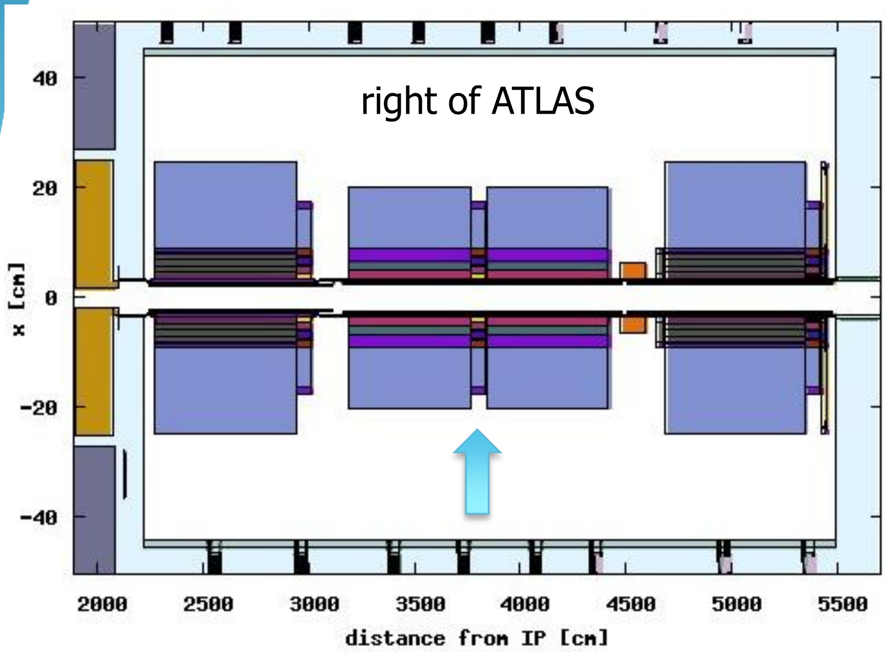
of which

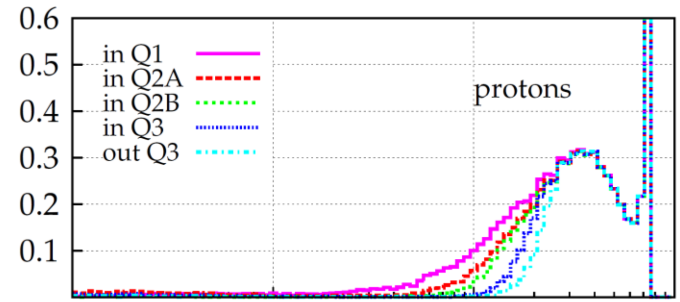
150 W absorbed in the triplet cold magnets



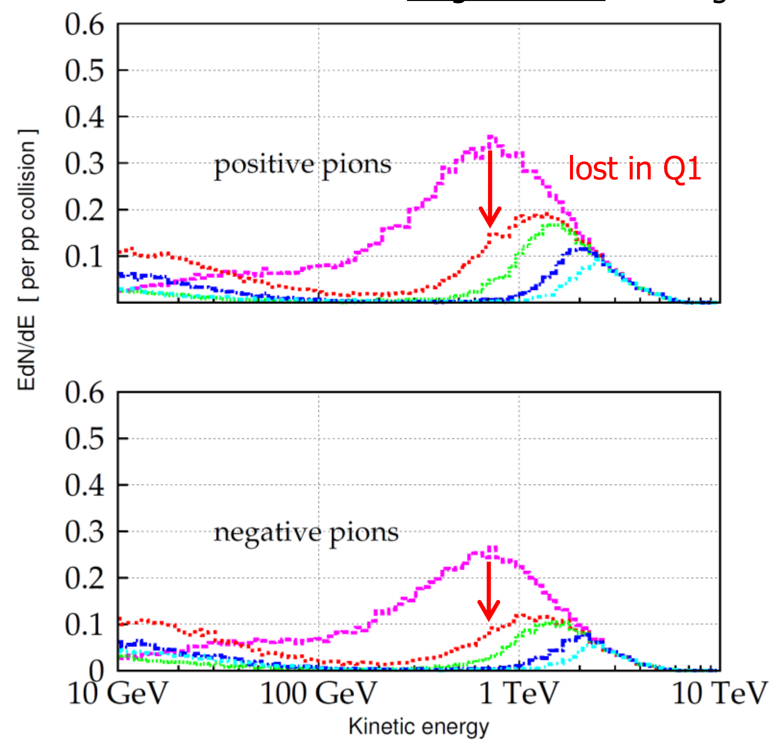
with 6.5 TeV beams (80mb) ~125 W (magnet end uncertainties) prediction at 10^{34} cm^{-2} s^{-1}
vs 115-135 W measurements (TE-CRG-OP) in the triplet cold mass

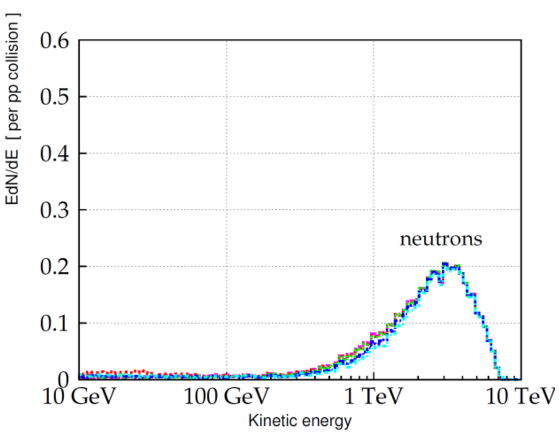
DEBRIS CAPTURE IN THE TRIPLET

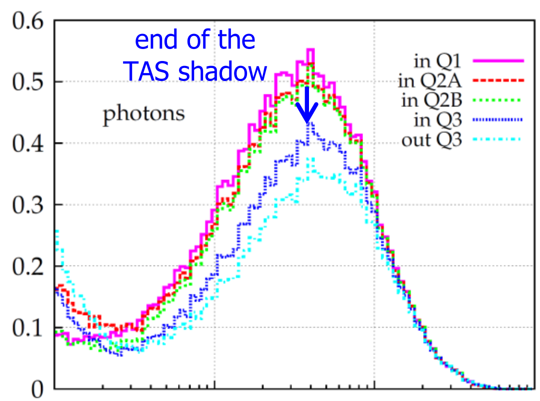




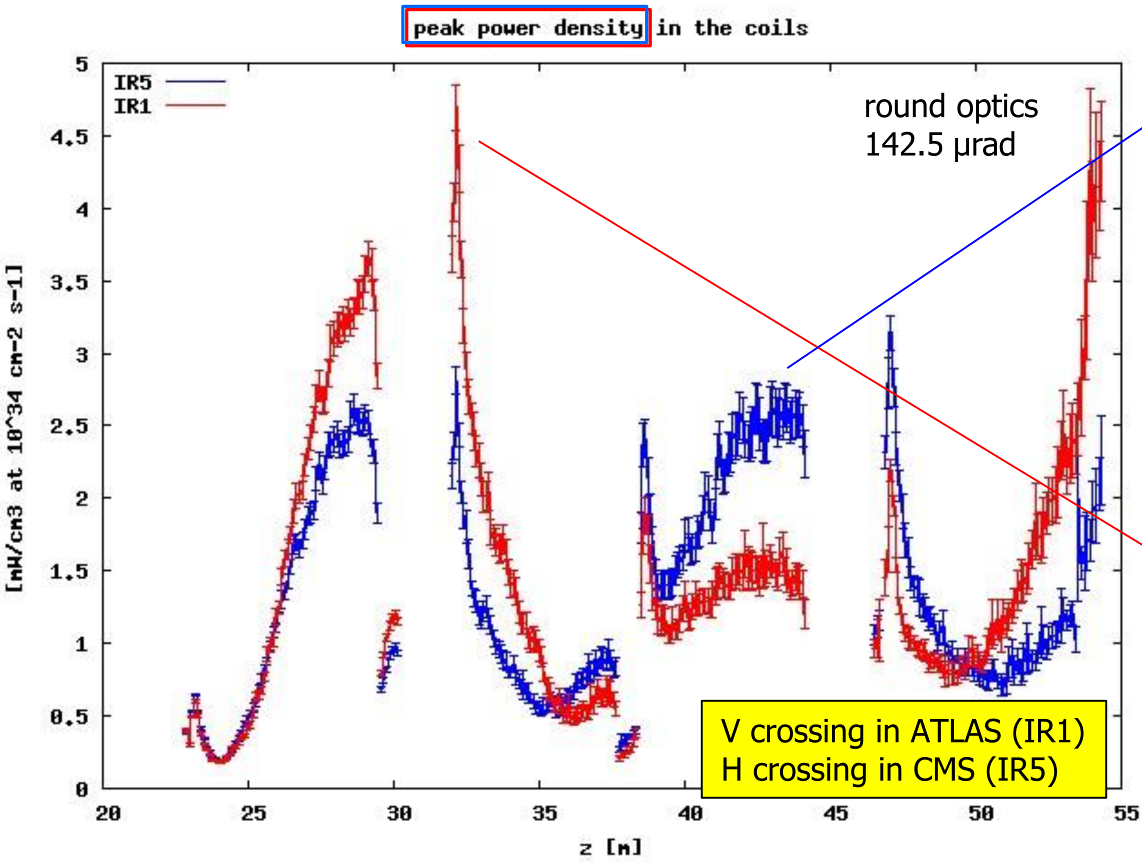
high energy spectra are depopulated by *charge particle (especially pion)* interception in the successive quadrupoles due to magnetic field bending

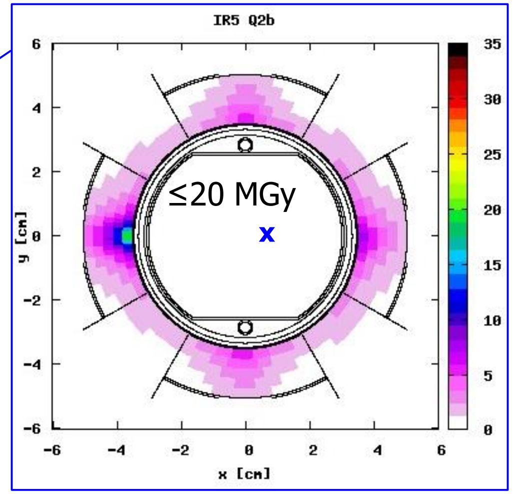




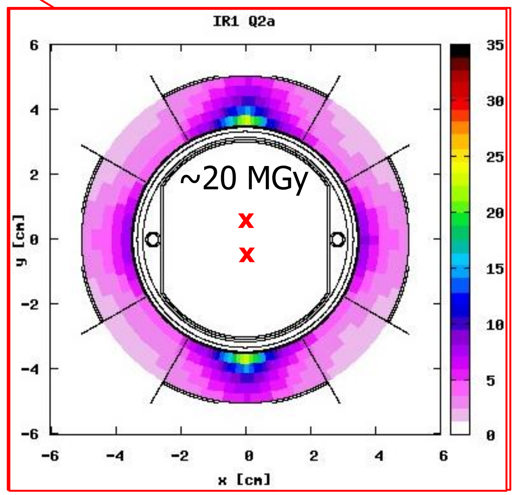


MARGIN TO QUENCH AND LIFETIME





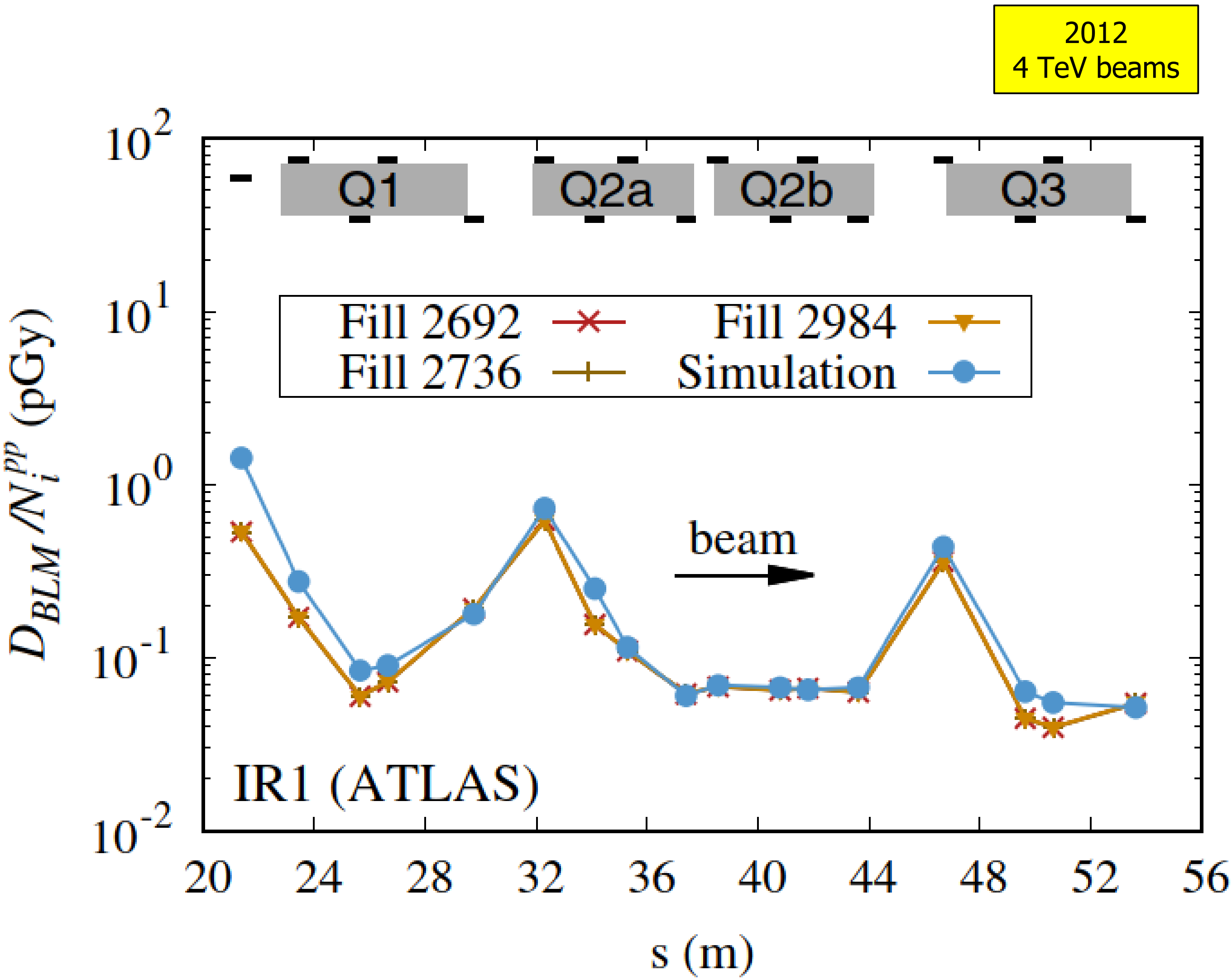
peak dose [MGy] after 300 fb^{-1}, relevant for triplet (i.e. coil insulator) lifetime



- different behavior reflecting the crossing plane variation for the same magnetic configuration of the triplet (FDF in the horizontal plane for positively charged particles coming from the IP)
- IR1 triplet (Q2a) approaches the design limit at nominal luminosity

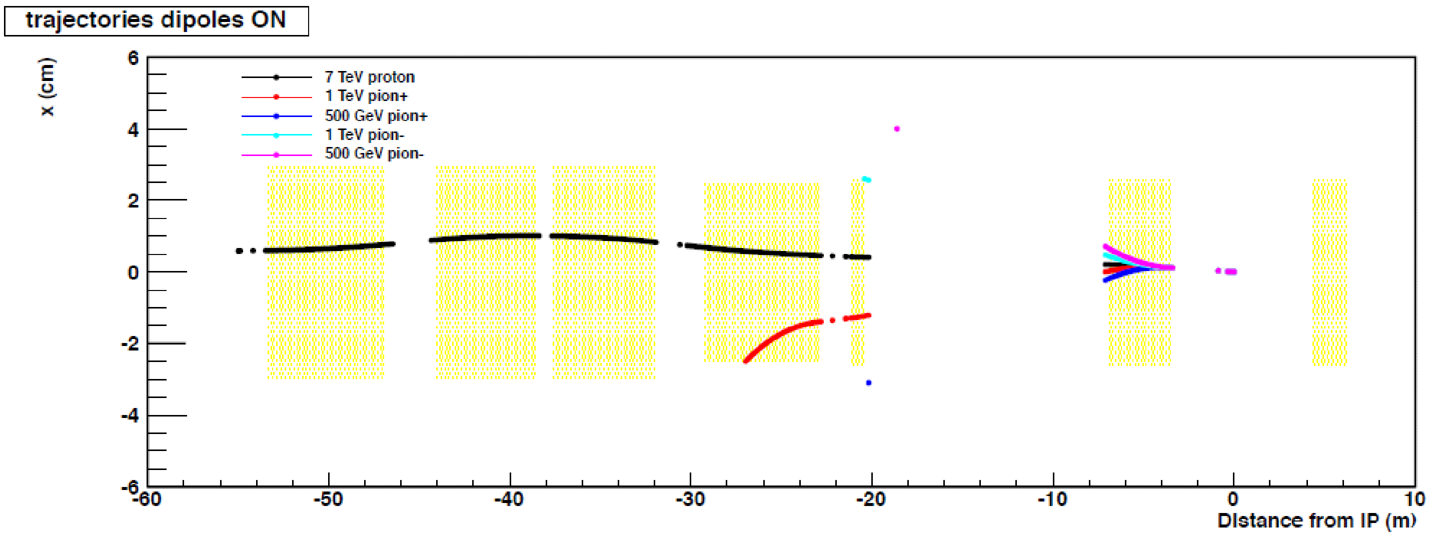
50% +V & 50% -V crossing in ATLAS (IR1)

TRIPLET: BLM BENCHMARKING

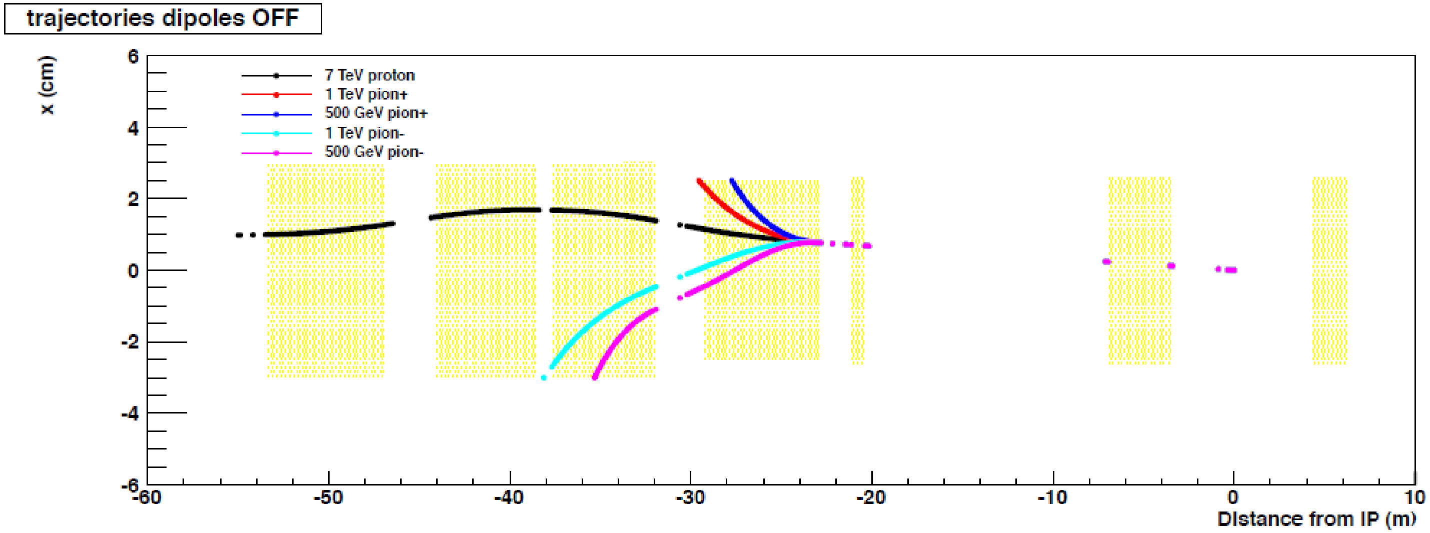


SPECTROMETER EFFECT

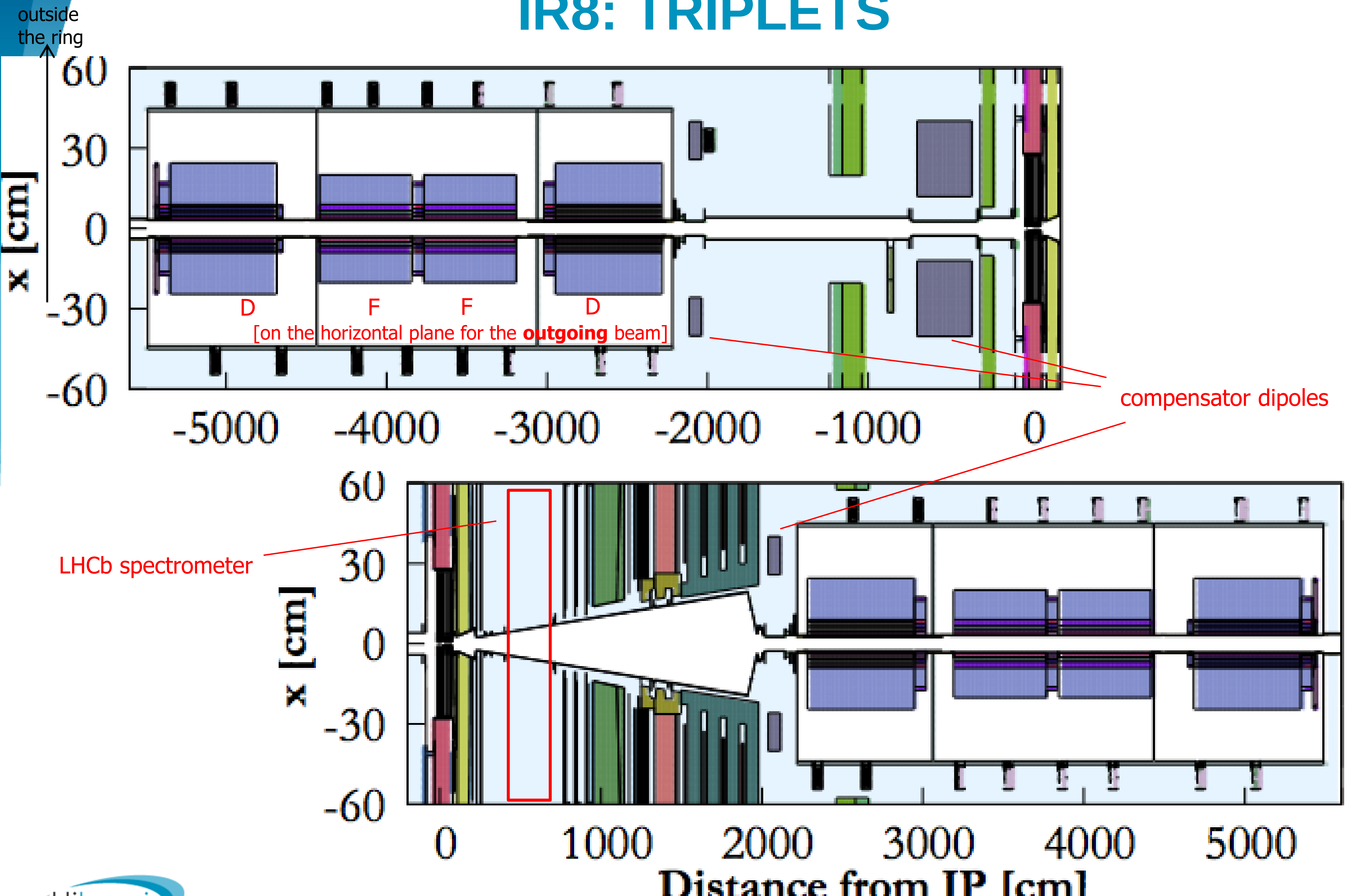
ON



OFF

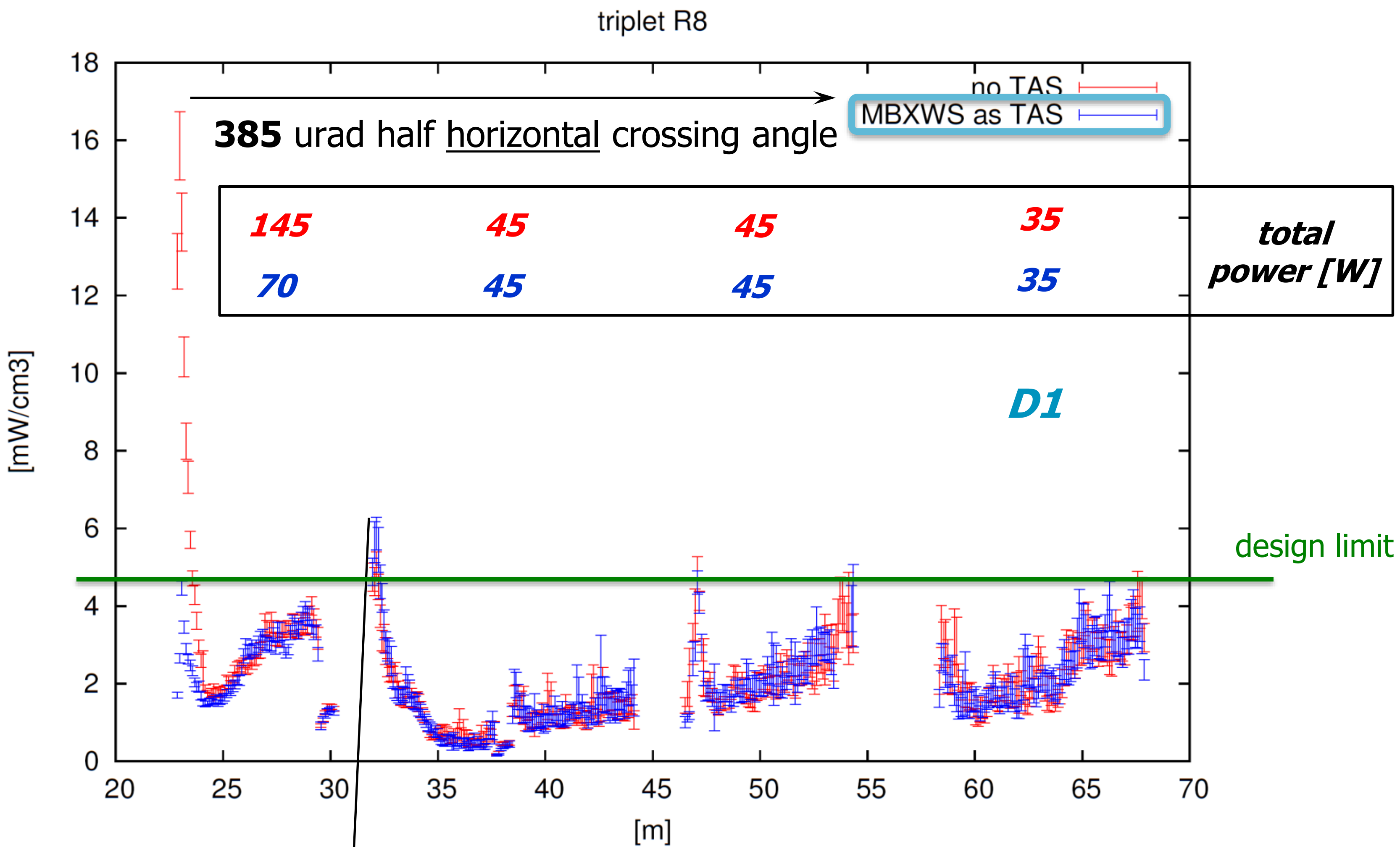


IR8: TRIPLETS



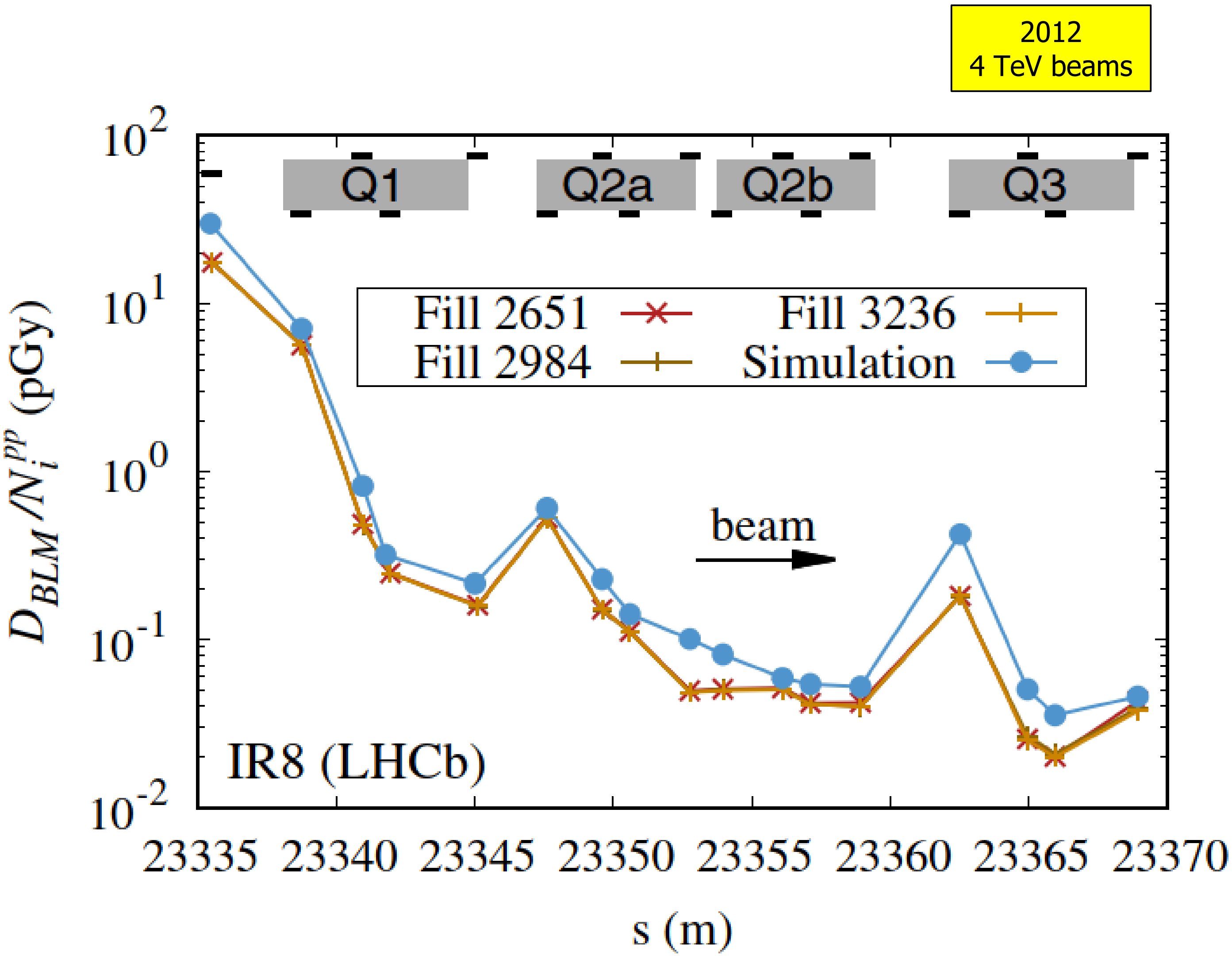
IR8: MARGIN TO QUENCH & CRYOLOAD

@ 10^{34} cm^{-2} s^{-1}

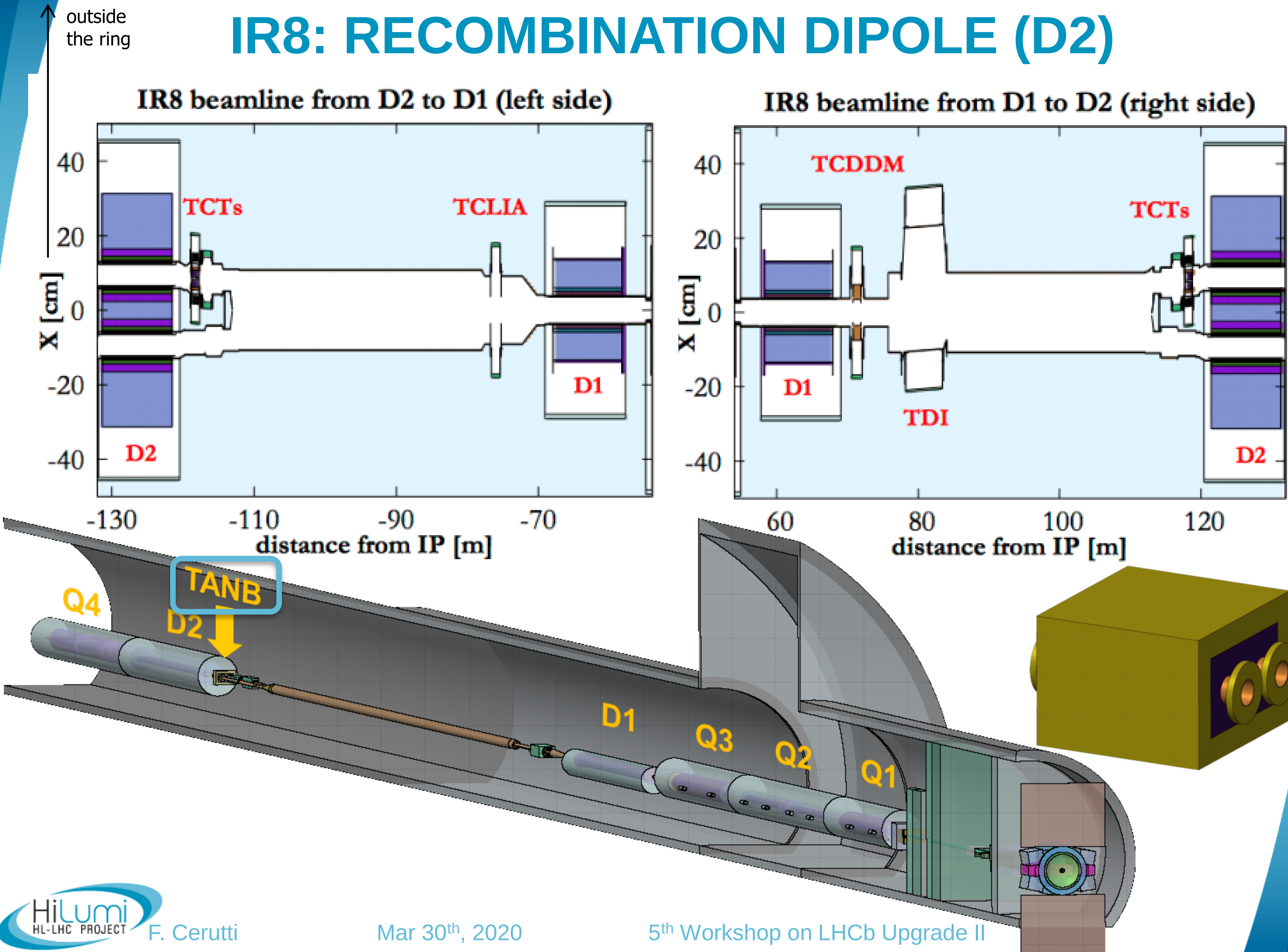


peak **dose** after 400 fb^{-1} to be evaluated vs. 30 MGy design **LIFETIME**

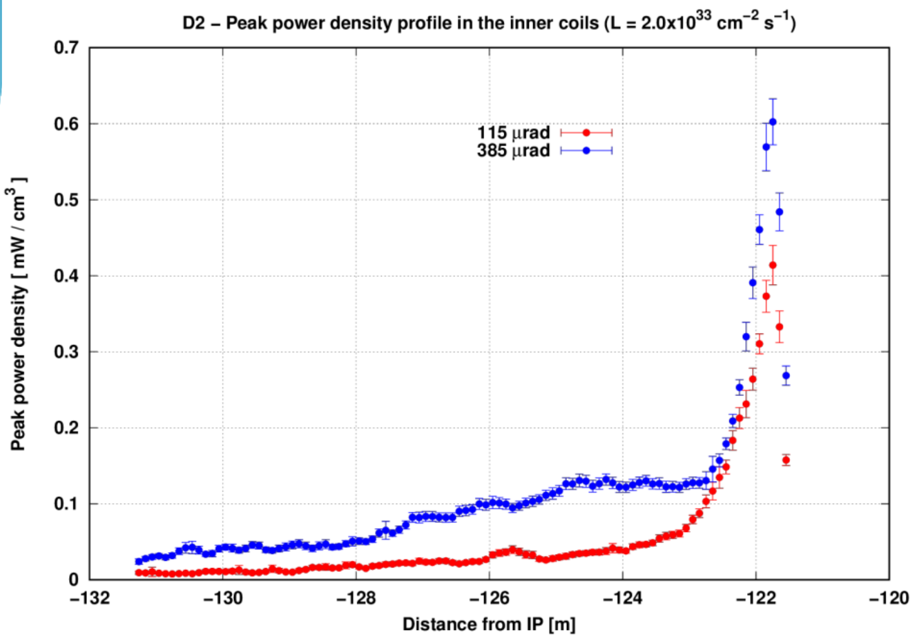
TRIPLET: BLM BENCHMARKING

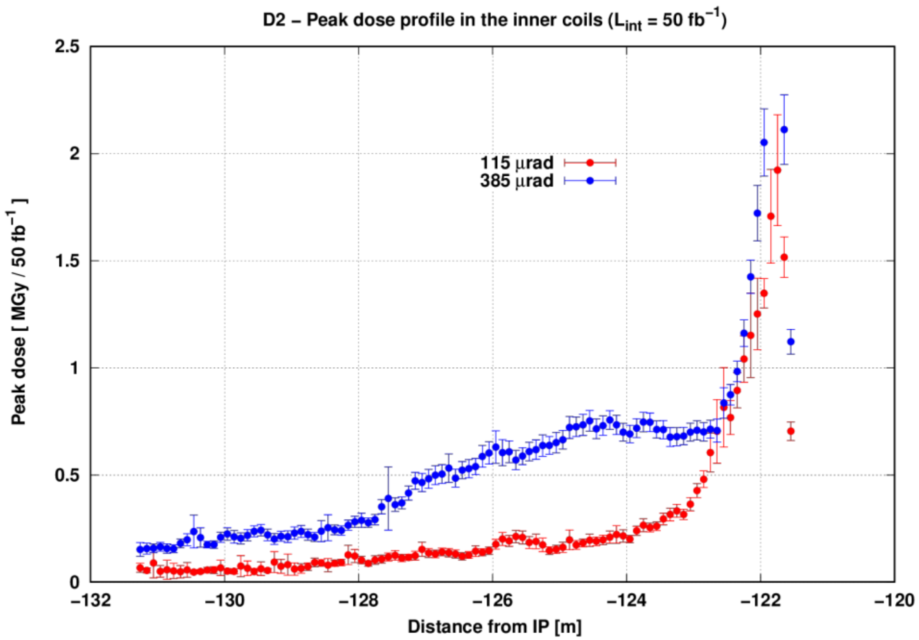


IR8: RECOMBINATION DIPOLE (D2)



D2 QUENCH MARGIN, CRYOLOAD, LIFETIME





@ 1.5 10^{34} cm^{-2} s^{-1} 5 mW/cm^3

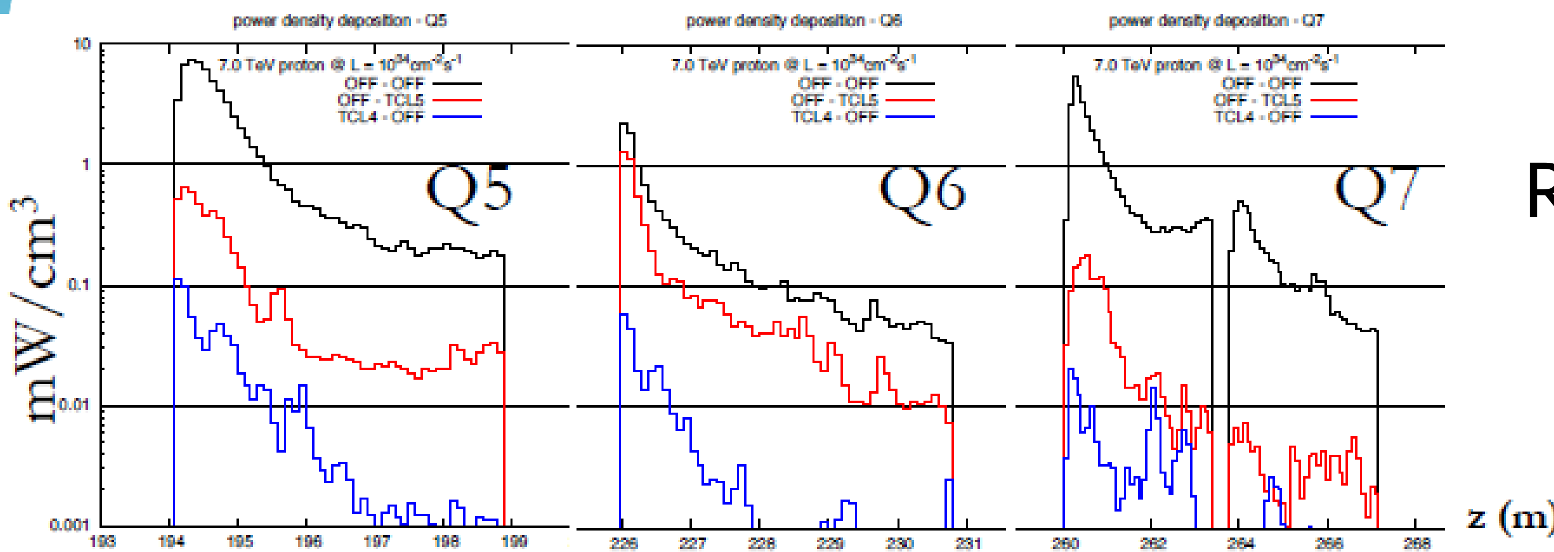
after 400 fb^{-1} ≤20 MGy

with a total load of 35 W in the cold mass

MATCHING SECTION

need for designing a collimator **(TCL)** protection system

Looking for reference at Point 1&5 @ 10^{34} cm^{-2} s^{-1}



R5 (CMS)

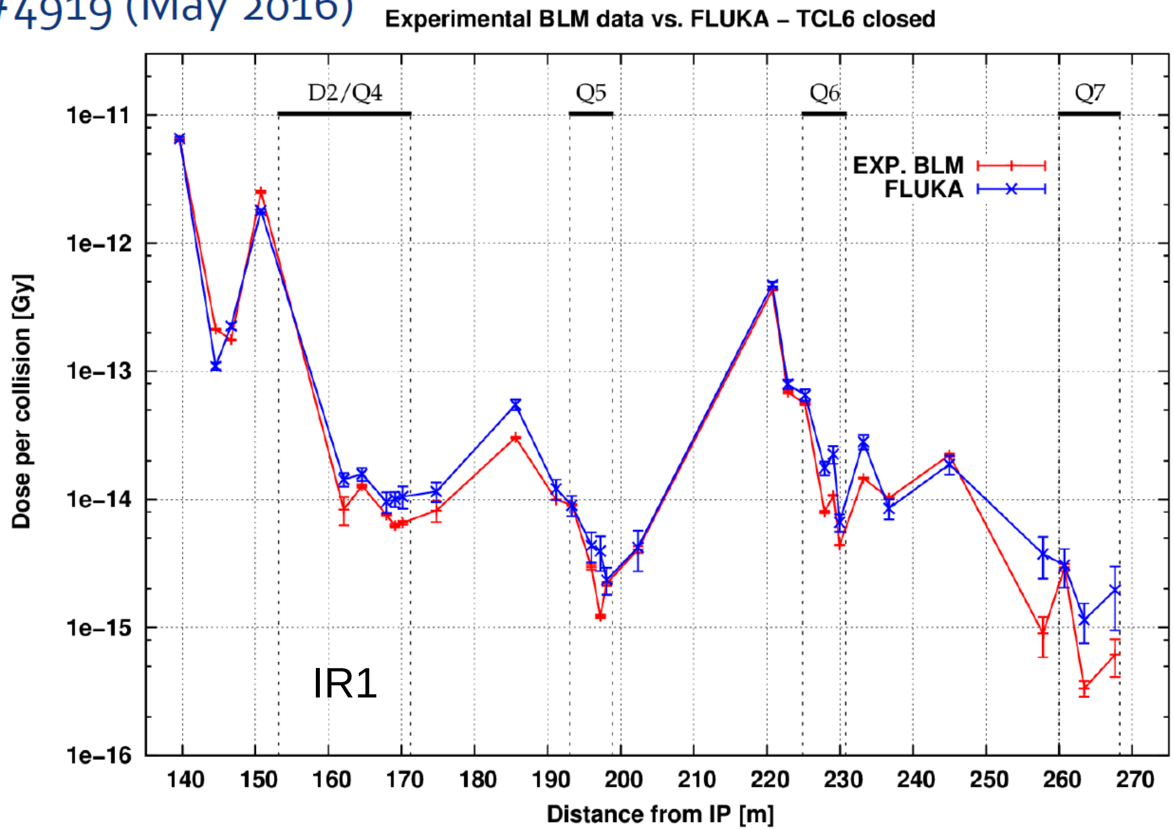
major role played by TCL4/TCL5

Point 8 specificities: different optics, different crossing angle, different TAN, injection kickers and septa around Q5*R*

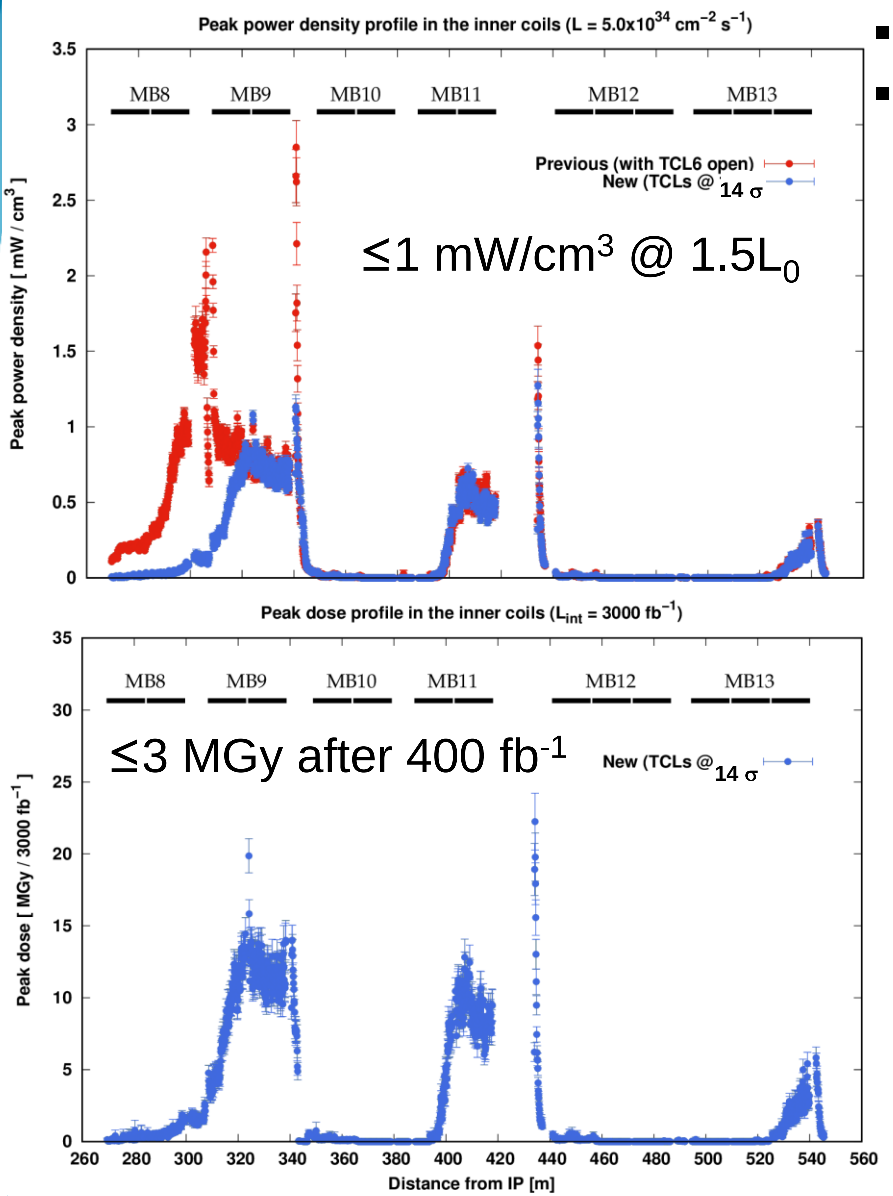
MATCHING SECTION: BLM BENCHMARKING

- Fill #4919 (May 2016)

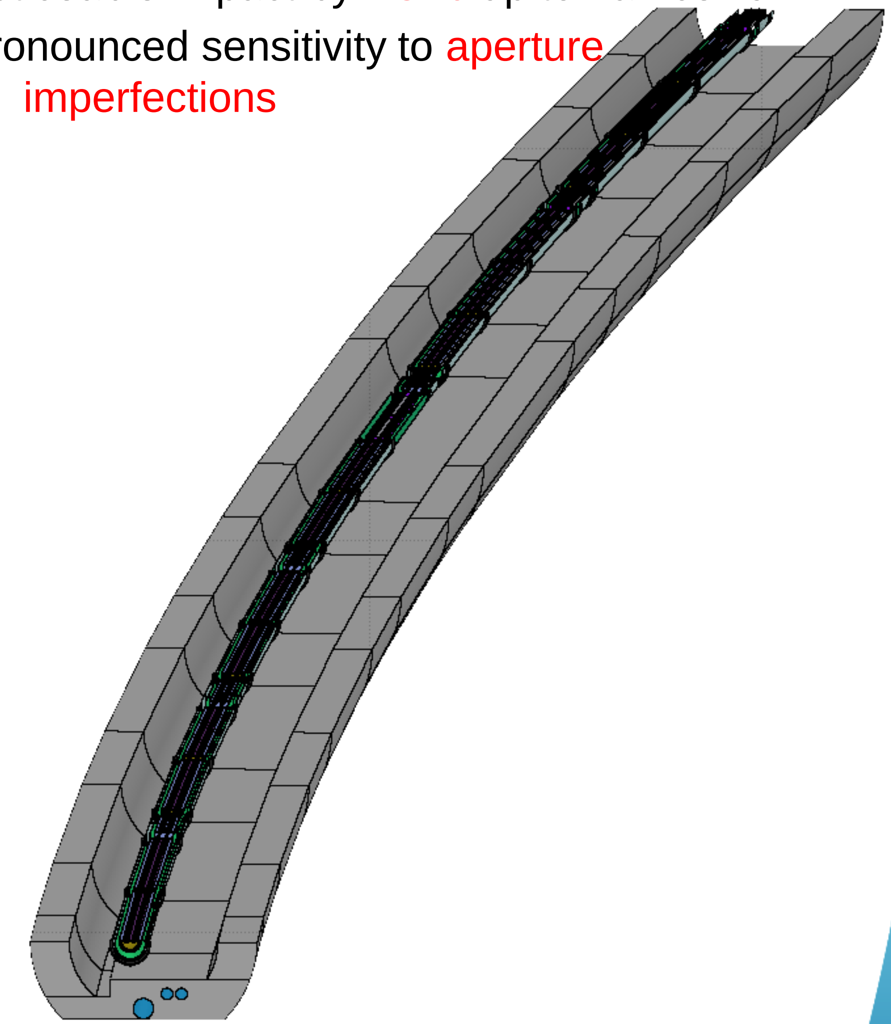
6.5 TeV beams



DISPERSION SUPPRESSOR



- noticeable impact by TCL6 up to half-cell 9
- pronounced sensitivity to aperture imperfections

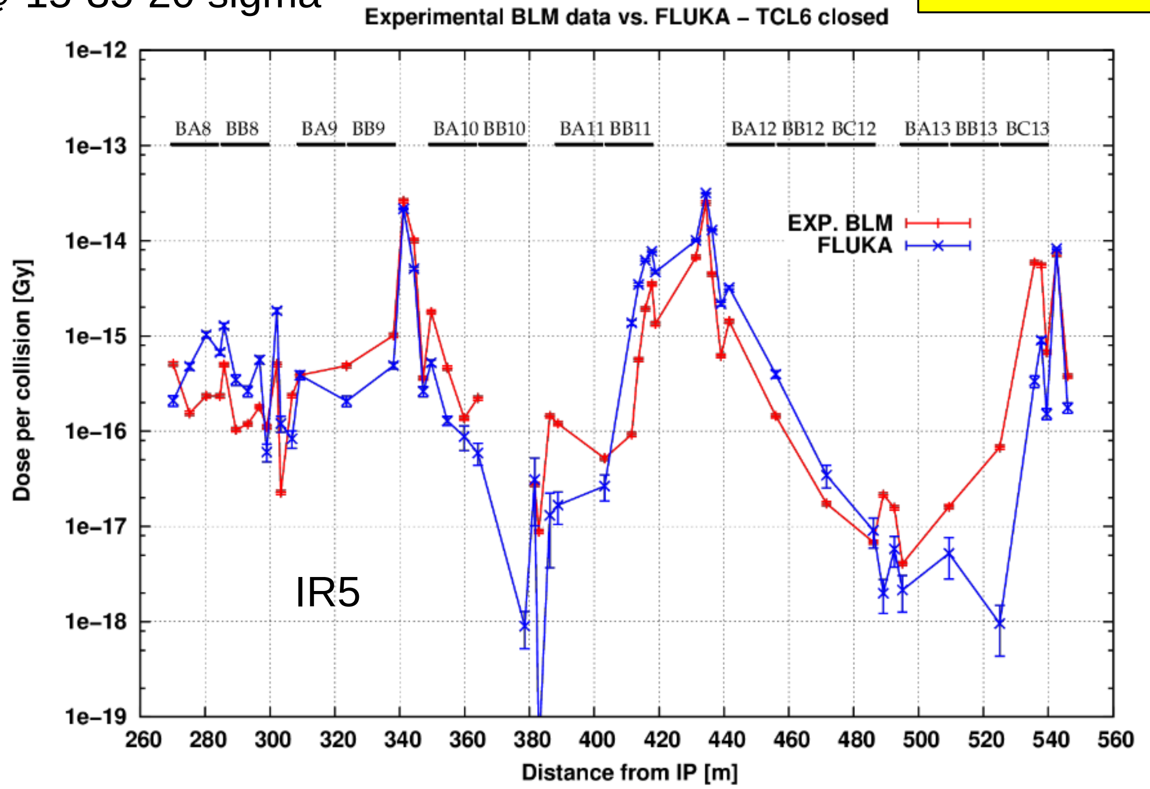


Point 8 specificities: different **dispersion** function, TCL6 lack

DISPERSION SUPPRESSOR: BLM BENCHMARKING

Fill #5401 (October 2016)
TCLs @ 15-35-20 sigma

6.5 TeV beams



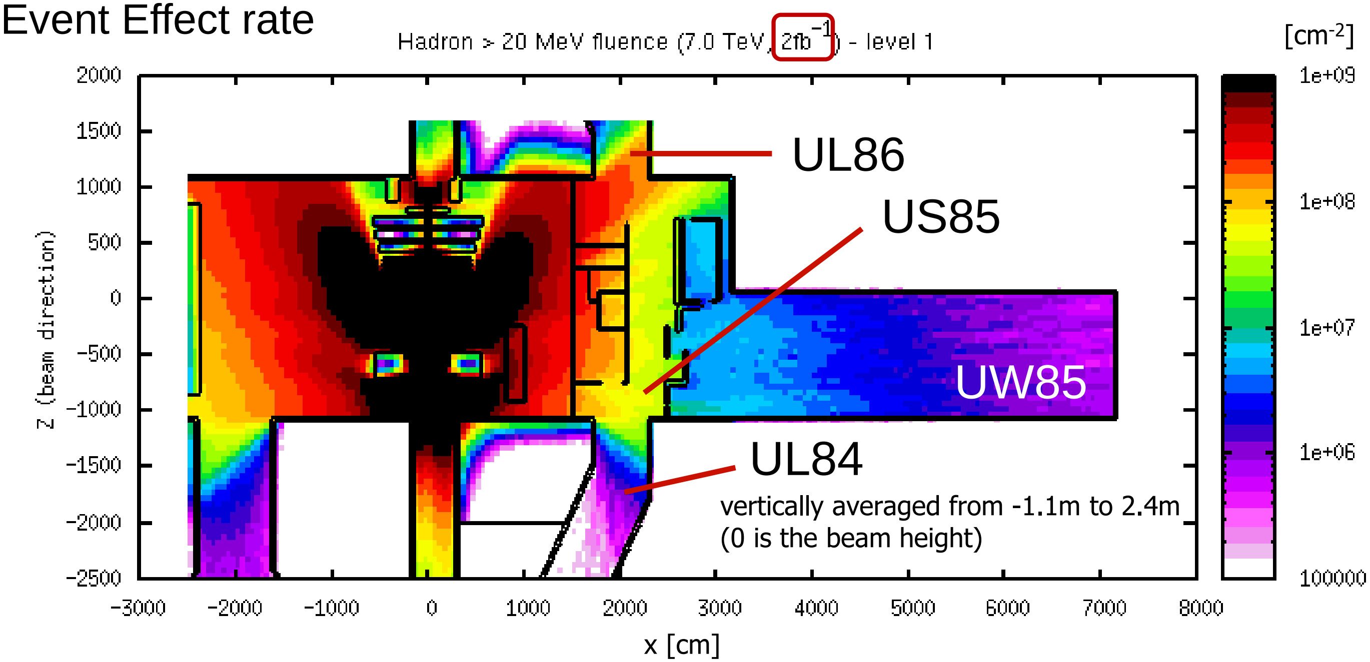
RADIATION TO ELECTRONICS

Annual High Energy Hadron fluence
determining the Single Event Effect rate

scaling up to 50 fb^{-1}/y,
i.e. 25 times more

with a reference limit
(R2E-safe) of 3 10^6 cm^{-2}/y

At higher HEH fluences
a RHA procedure is needed
for equipment qualification



- Relocations of sensitive equipment have already been foreseen (see plans for cryo racks)
- New FLUKA simulations are going to be carried on with updated geometry, aiming at an improved benchmarking against RadMon data and to study new shielding options

CONCLUSIONS

The LHCb upgrade to an instantaneous luminosity of 1.5 10^{34} cm^{-2} s^{-1} and an integrated luminosity of 400 fb^{-1} implies a TAS-like protection of Q1 and calls for the study of a physics debris collimator (TCL) system for Q5-Q7 as well as shielding solutions for the electronics equipment in the detector cavern proximity.

A systematic FLUKA study of both IP8 sides, implementing the updated detector model and crossing schemes, is being launched as the subject of a starting PhD.

An intentional triplet misalignment is known to offer on paper some potentiality, to be possibly assessed in this specific case.

The recently installed TANB, required by the Upgrade I, appears to offer an adequate D2 protection also in the long term.

The limited dose resistance of certain corrector magnets has to be reviewed in the IR8 context.