Dose to beam screen and dose from beam screen

F. Cerutti, L.S. Esposito
EN-STI/EET

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Outline

- Inner Triplet—CP—D1 beam screen:
  - **radiation on the beam screen**
  - effect on the coil energy deposition due to its **different executive design**
  - **updated total heat load**

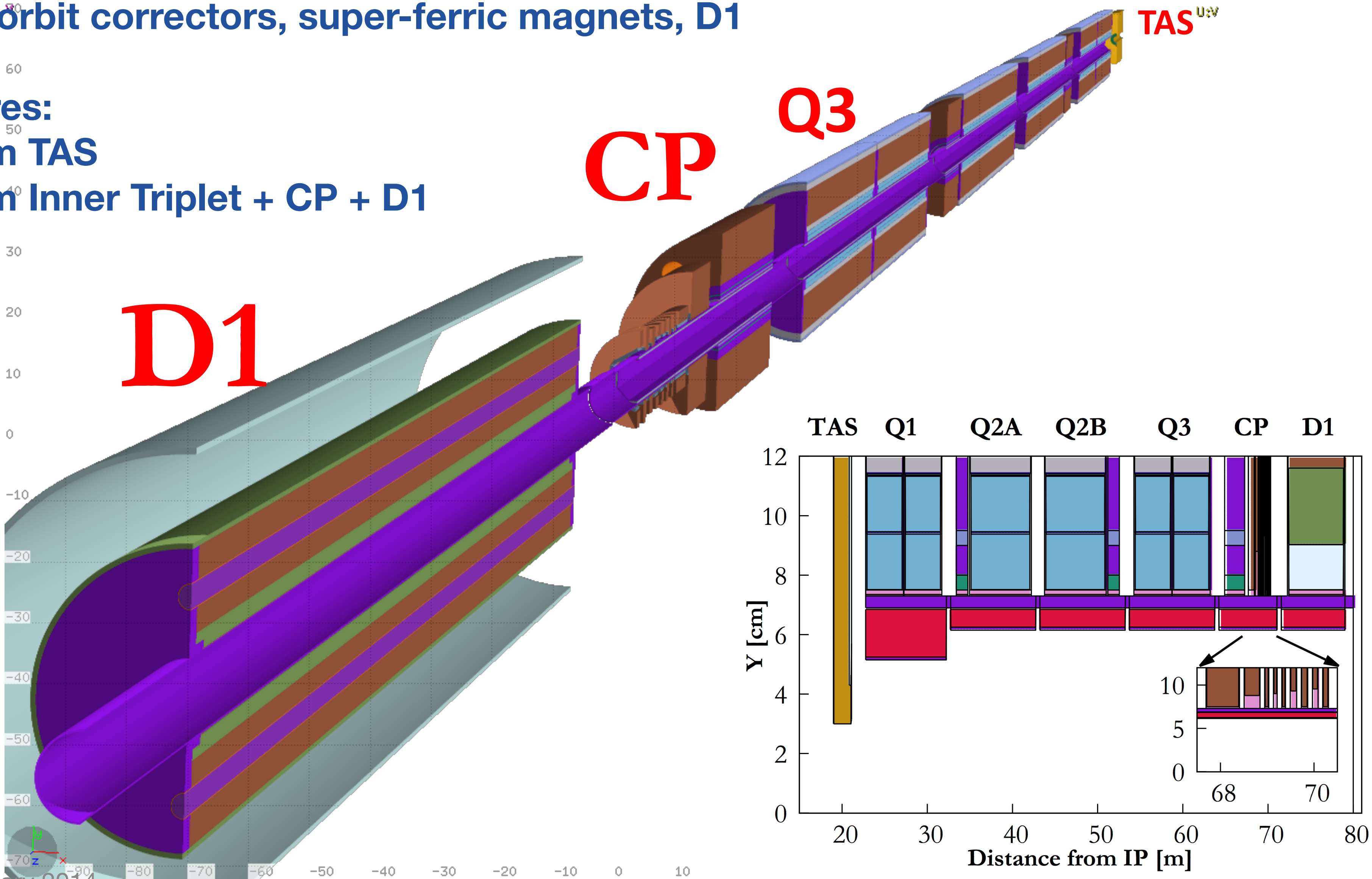
- Protection elements in the Matching Section:
  - TAN, collimators, **masks**
  - present energy deposition estimations

Inner Triplet—CP—D1

FLUKA geometry model for IT—CP—D1

Coils:
Nb3Sn: IT quadrupoles
Nb-Ti: orbit correctors, super-ferric magnets, D1

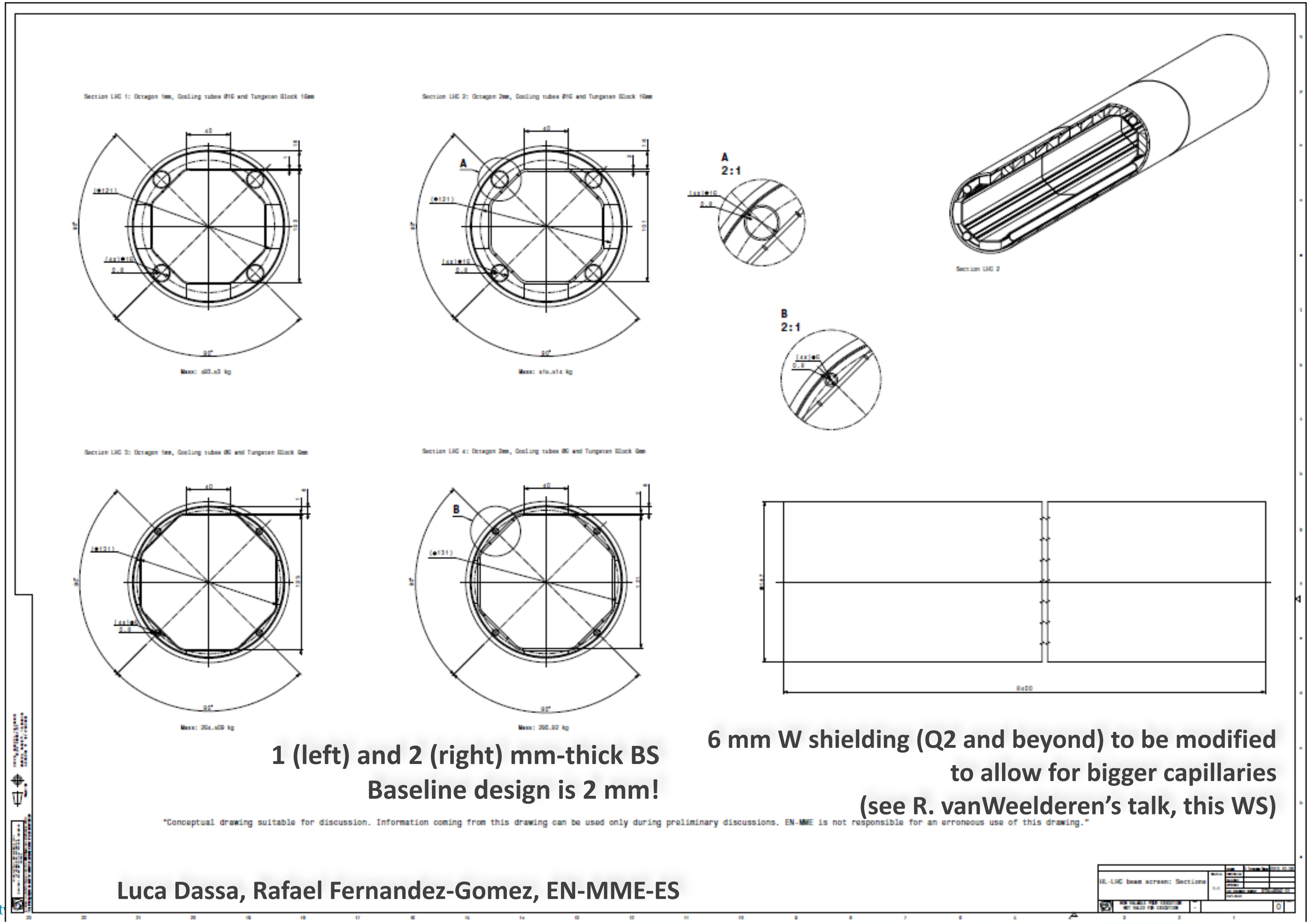
Apertures:
60 mm TAS
150 mm Inner Triplet + CP + D1



28 February 2014

Conceptual design of the beam screen (BS) for the Q1 and Q2-Q3-CP-D1 areas.

Reference: R. Kersevan, WP3 meeting, 28 January 2014



1 (left) and 2 (right) mm-thick BS
Baseline design is 2 mm!

6 mm W shielding (Q2 and beyond) to be modified to allow for bigger capillaries (see R. vanWeelderen's talk, this WS)

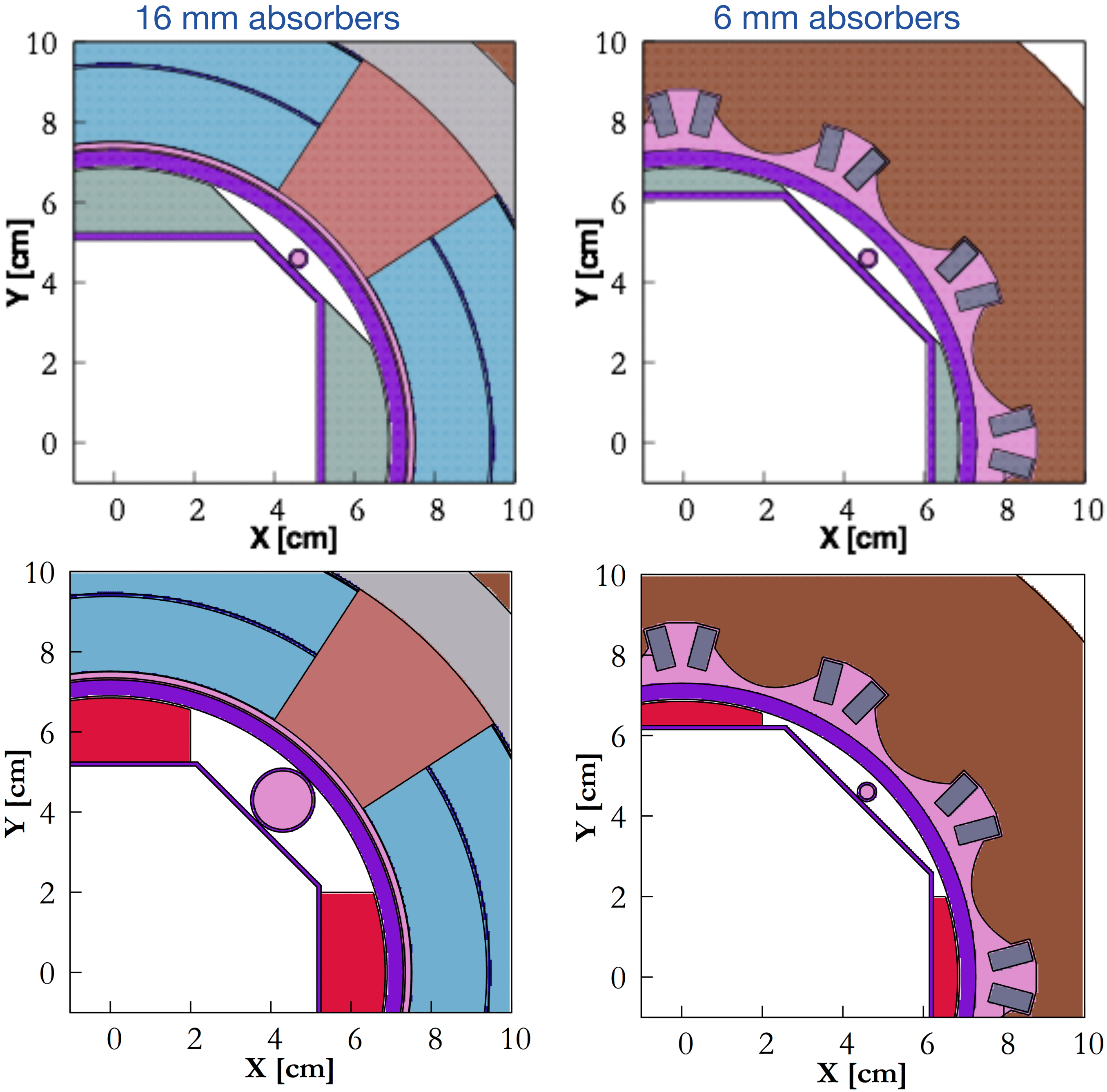
Luca Dassa, Rafael Fernandez-Gomez, EN-MME-ES

High Luminosity LHC

Spot the differences between beam screens

old version

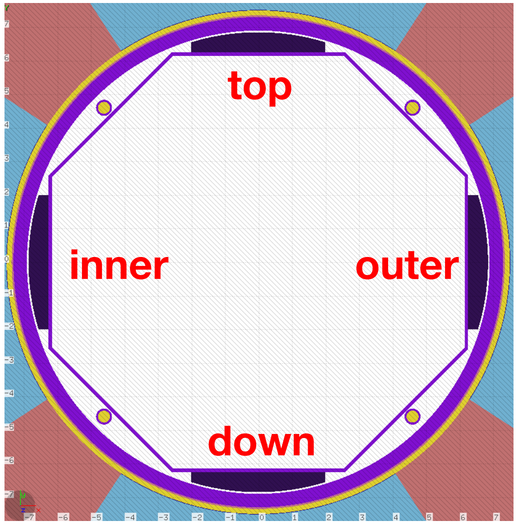
new version

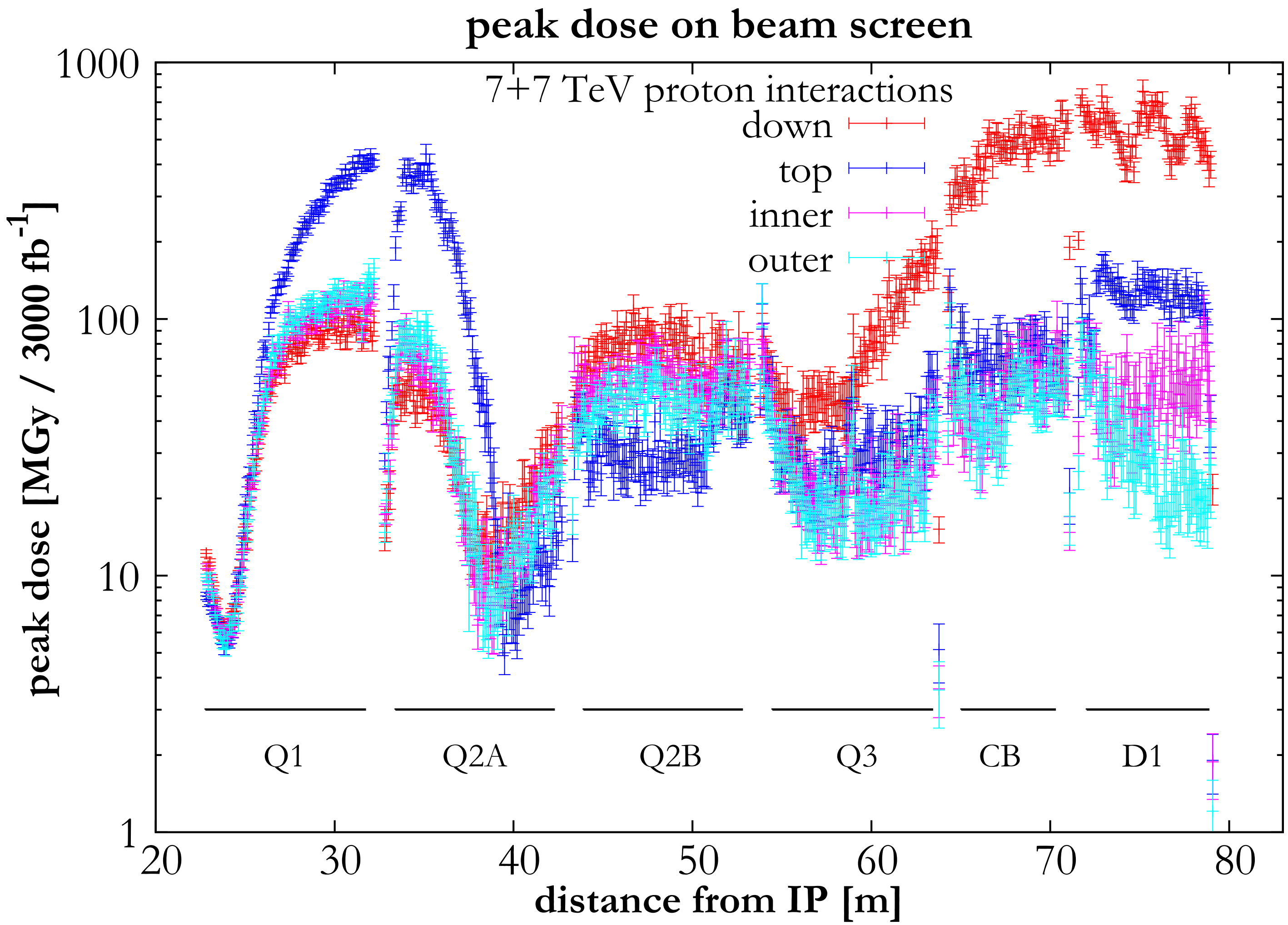


1. cooling capillary (tube) size
2. absorber shape
3. INNERMET 180
4. beam screen thickness (2⇒1 mm)

thus bringing
Q1 aperture to 113 mm
elsewhere to 123 mm

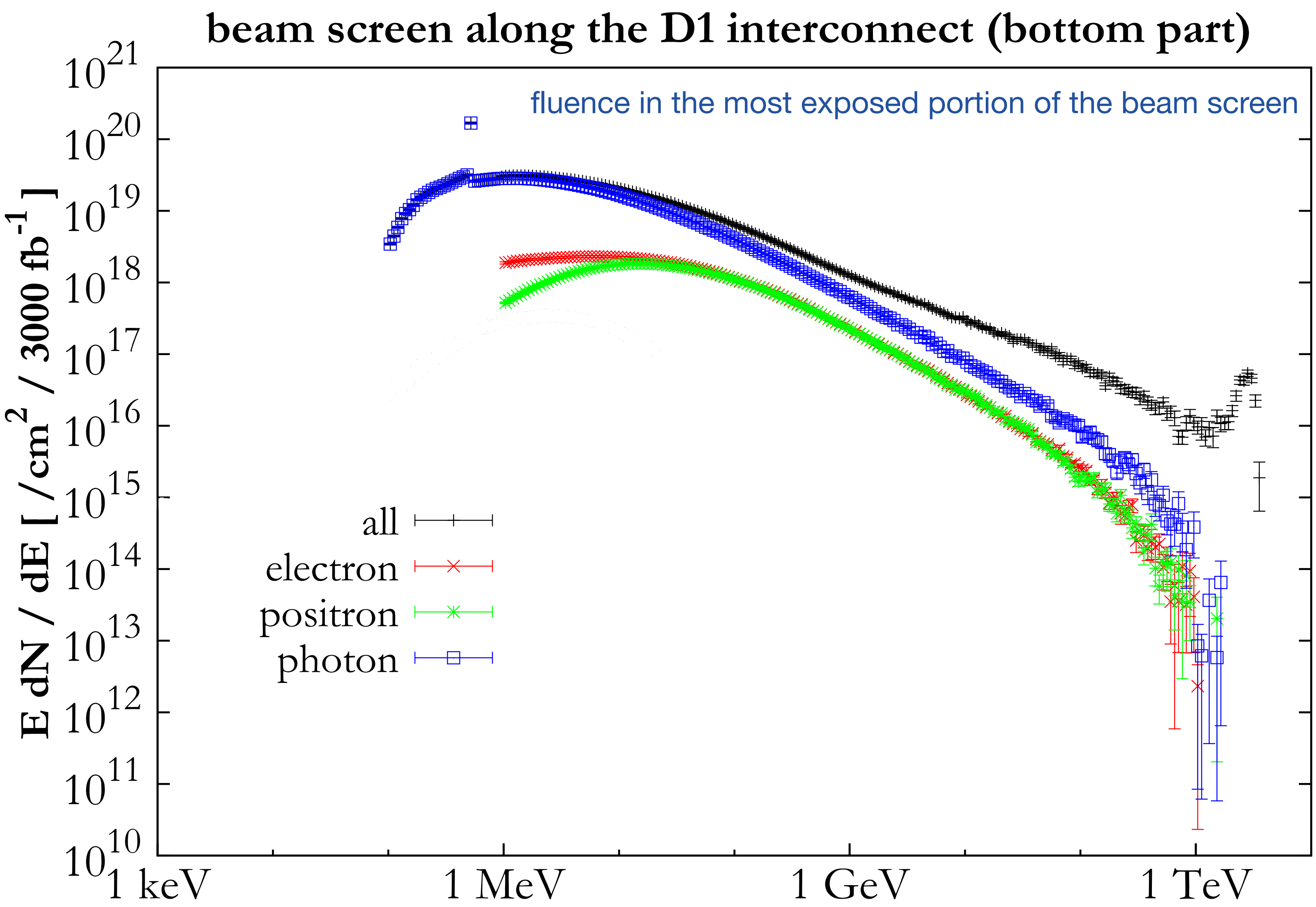
Peak dose deposited on the beam screen





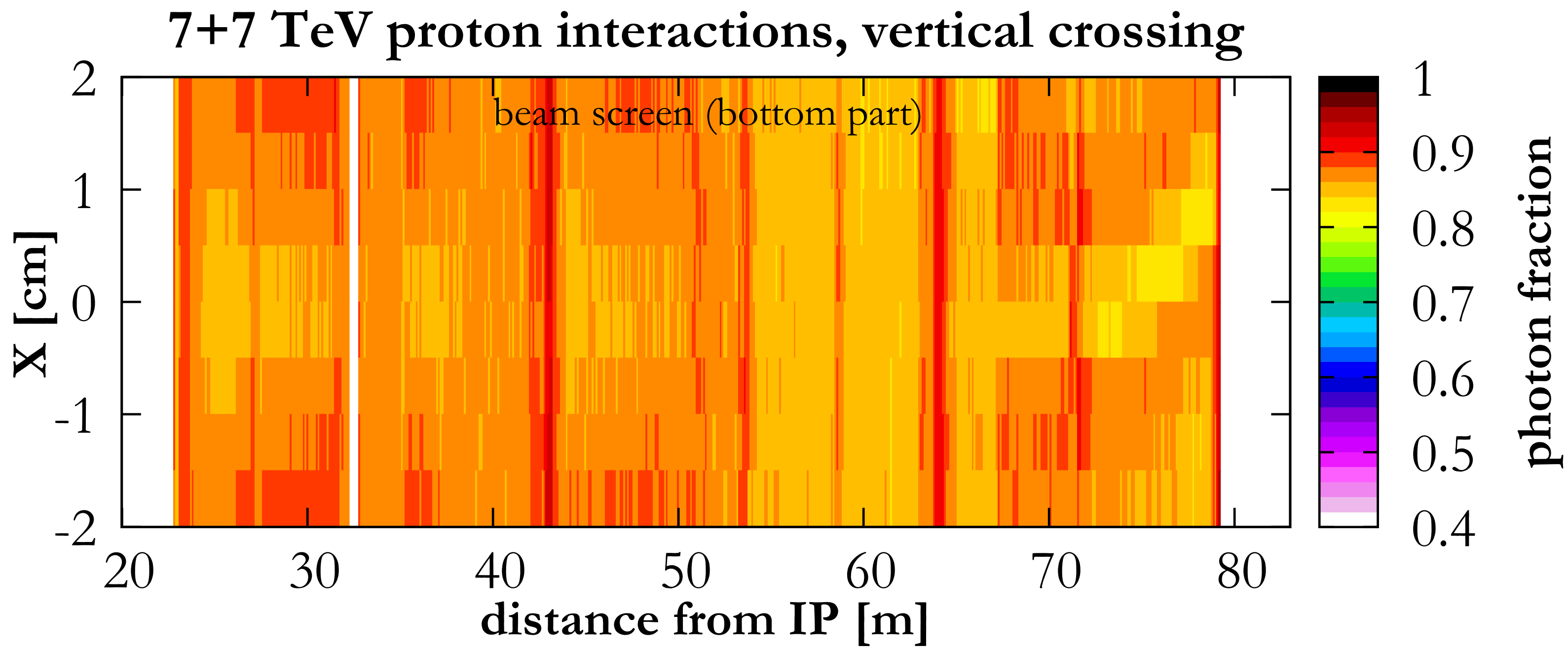
Relevant for the carbon coating used to mitigate electron cloud heating, follow-up of a discussion with M. Taborelli

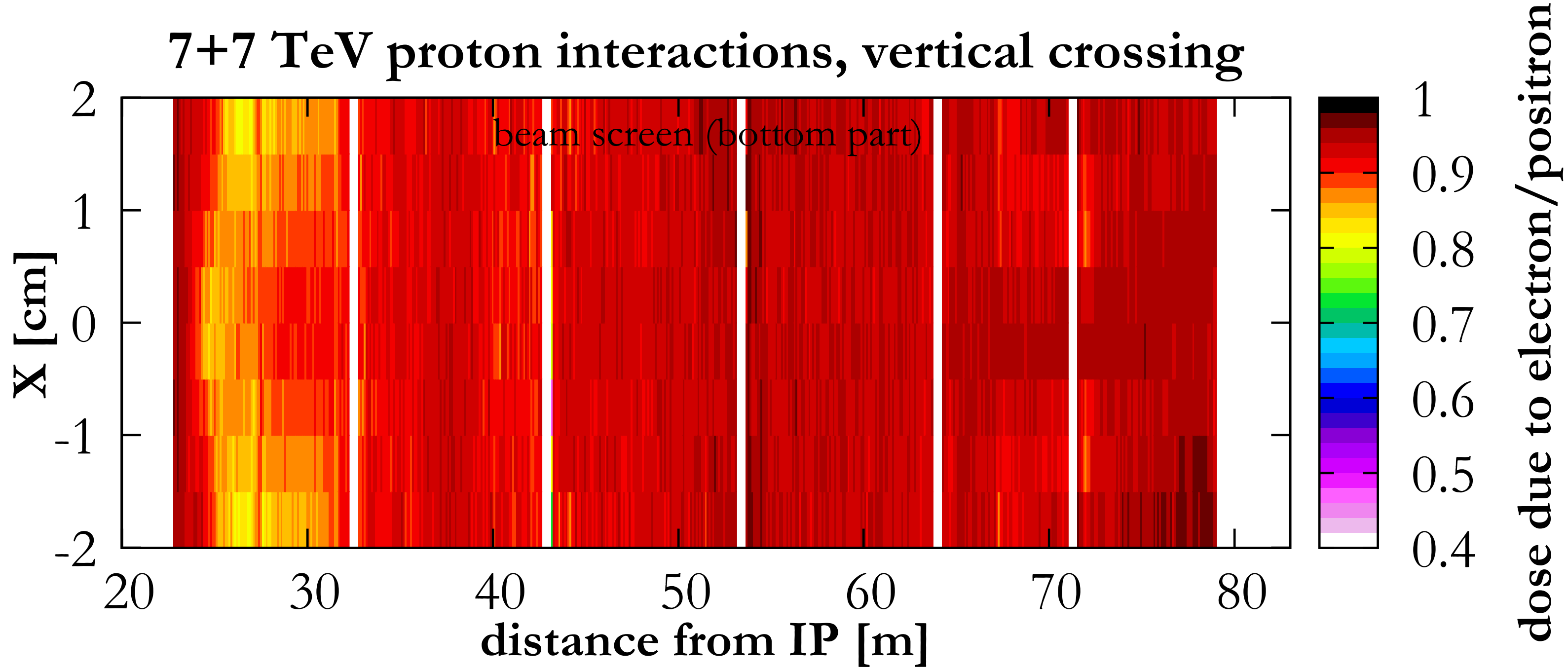
Particle species that contribute to the dose



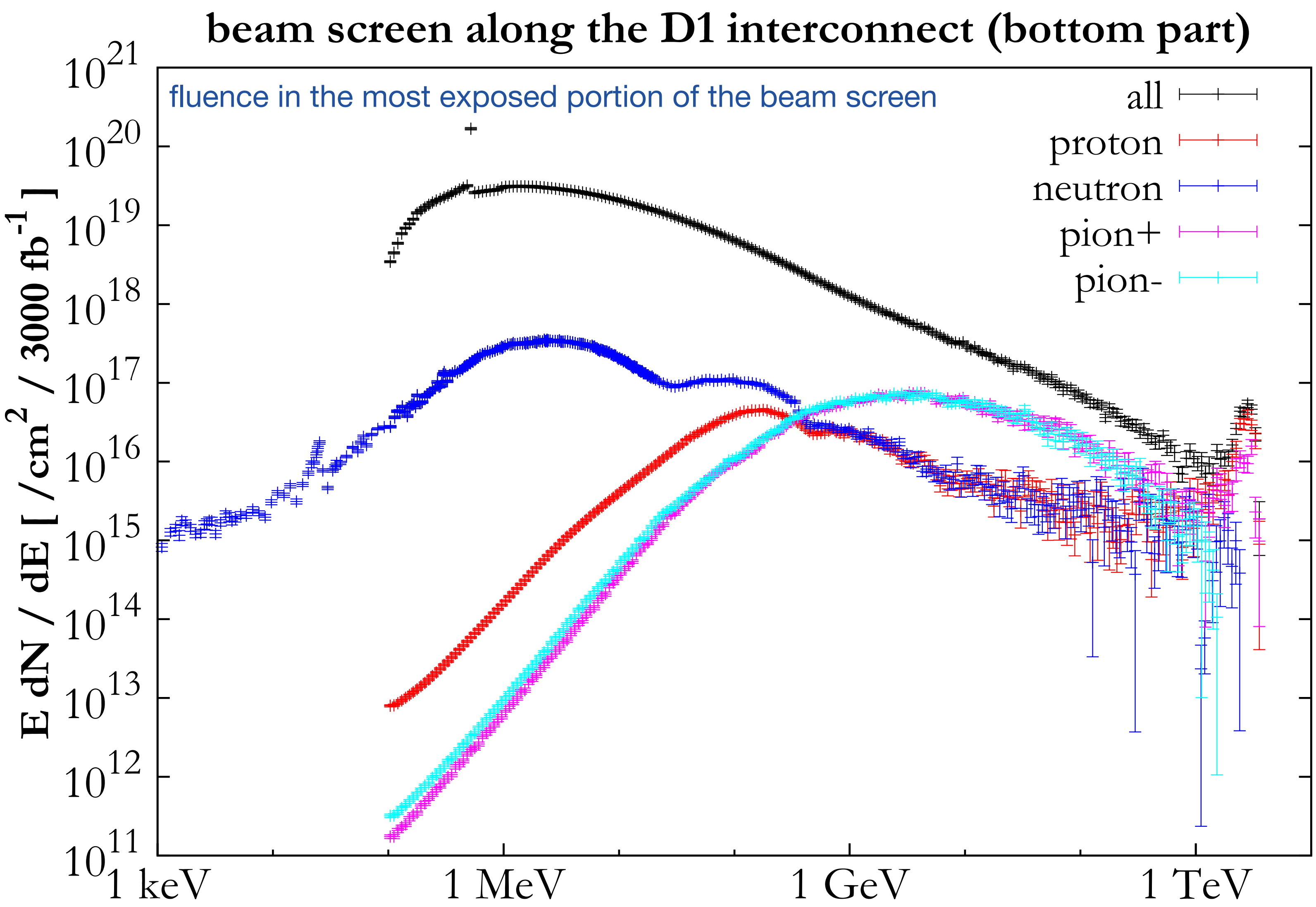
Deposited dose is mainly due to electrons/positrons, whereas the fluence is dominated by few MeV photons

Main contributors to the fluence and dose



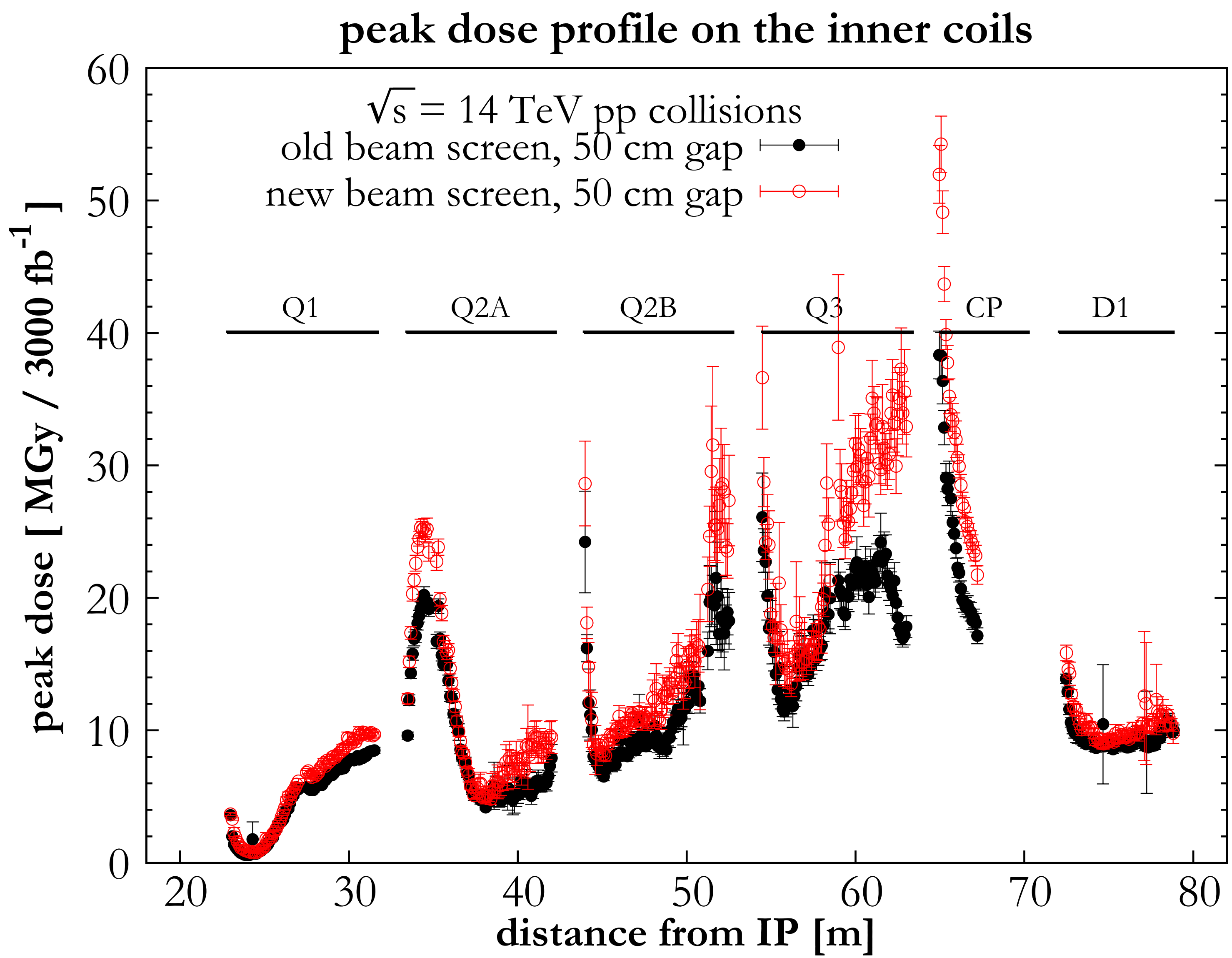


High energy spectrum



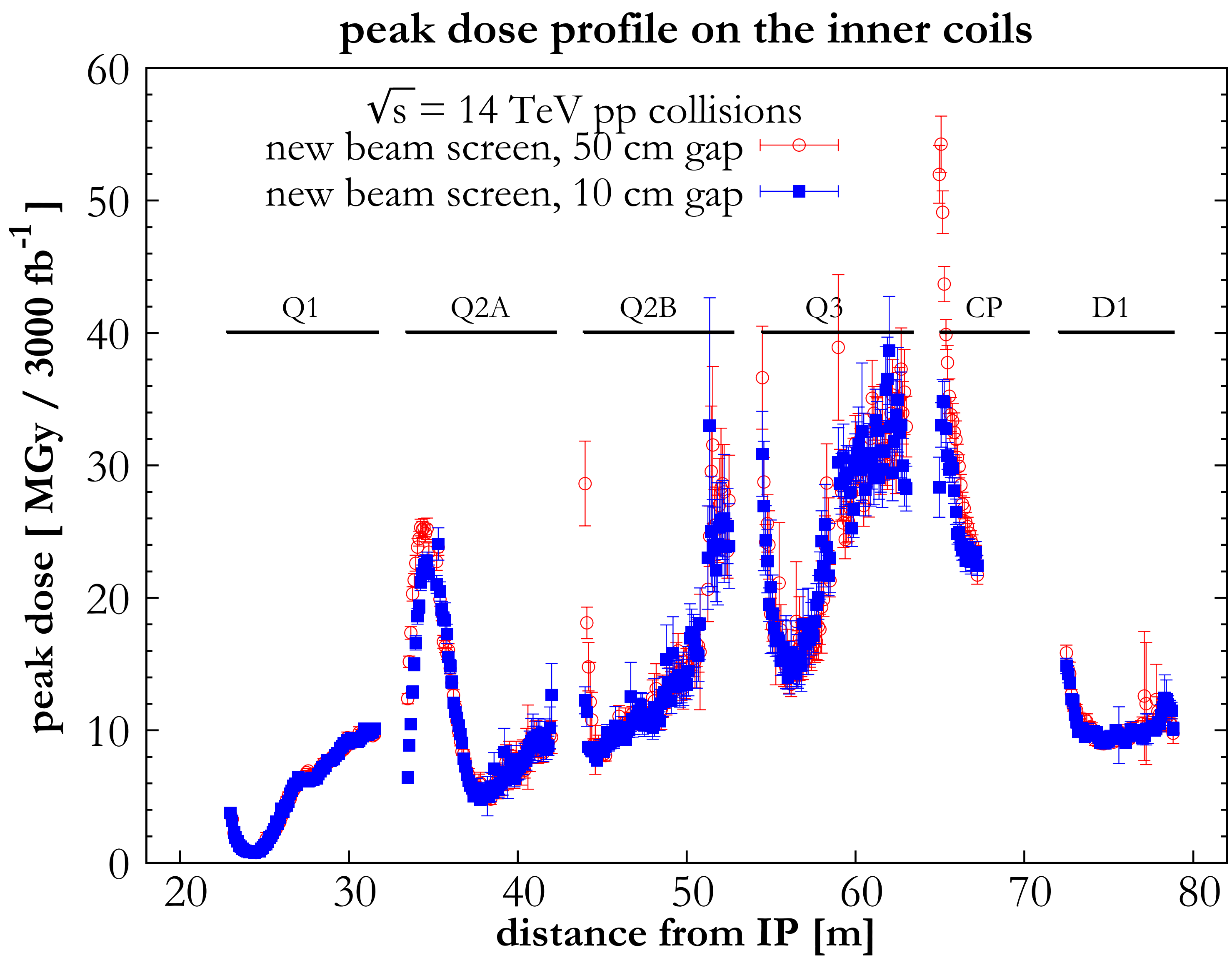
For energy > 10 GeV the spectrum is dominated by hadrons
with a fluence ~ 10^{17} particles / cm^2

Effect on peak dose due to BS design changes



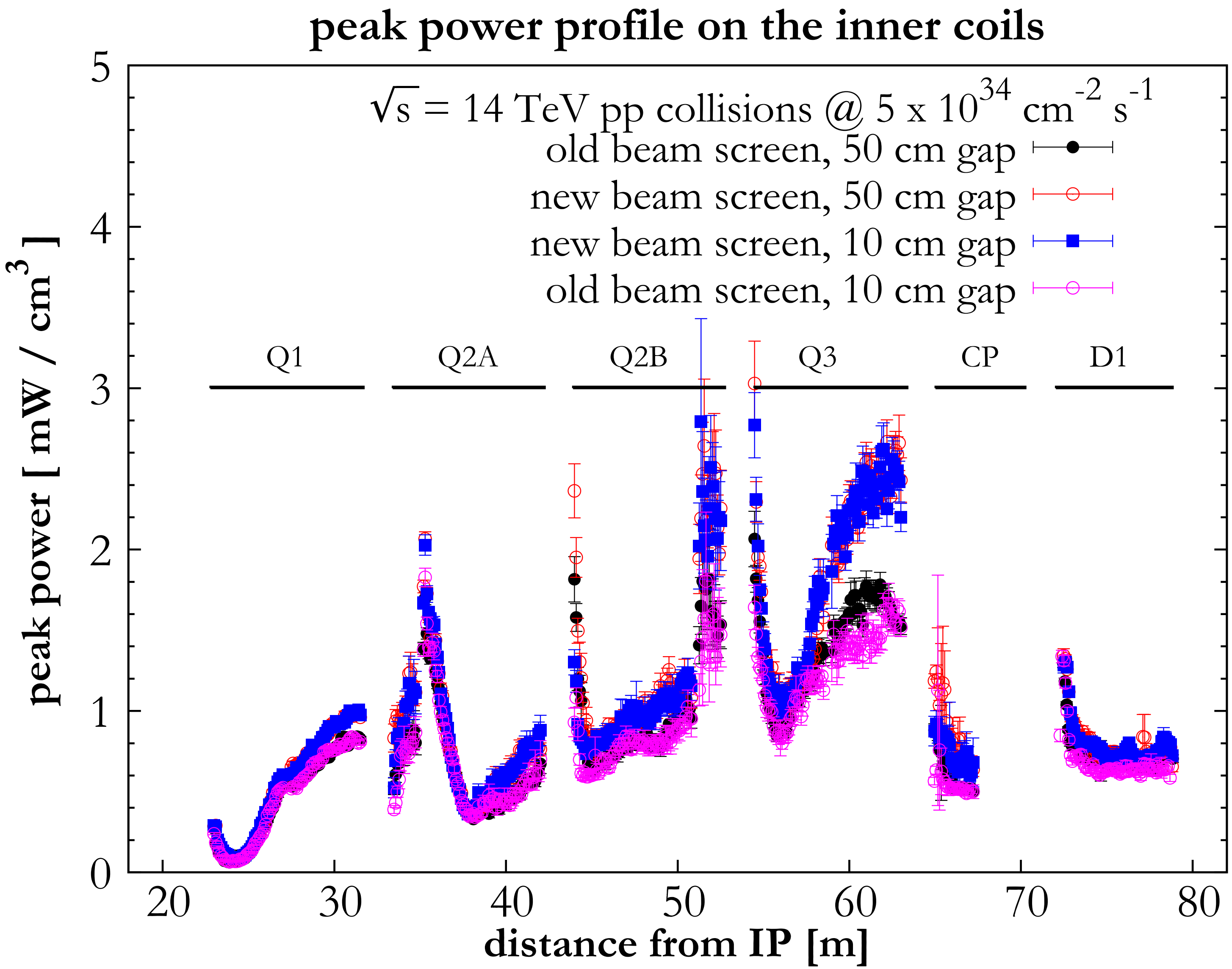
Possible mitigation (to be investigated): move the orbit corrector at the end of the CP (effect on beam performance?), or see next slide

BPM with tungsten absorbers



Beneficial especially for the interconnect Q3—CP

Peak power profile



Machine operation is guarantee with a factor 10 from quench value

Total heat load UPDATED (vertical crossing)

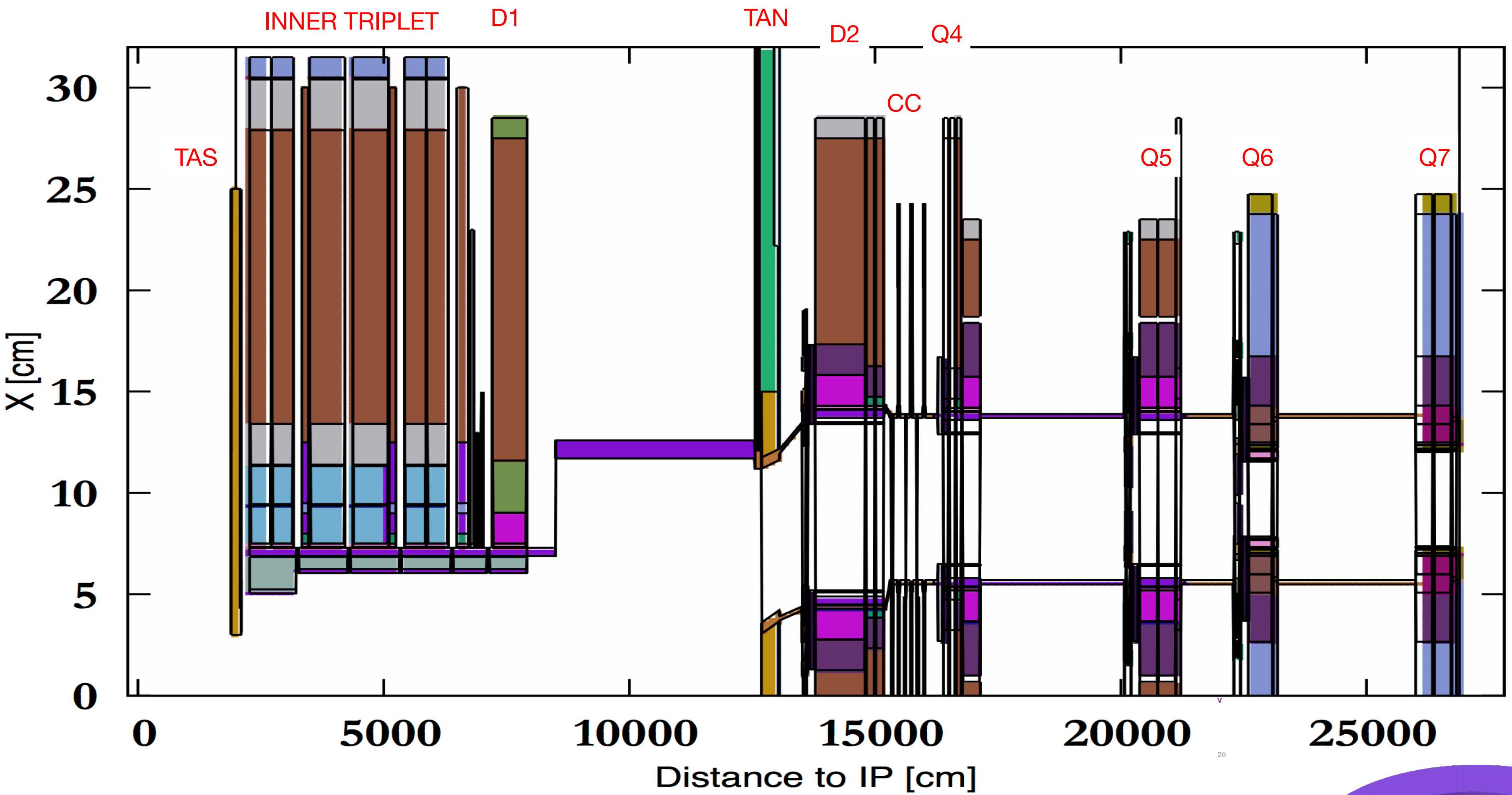
	50 cm gap in ICs		10 cm gap in ICs	
Power [W]	**Magnet**	**Beam**	**Magnet**	**Beam**
Q1A + Q1B	110	150	110	150
Q2A + corr	105	50	105	50
Q2B + corr	130	70	130	65
Q3A + Q3B	160	60	160	60
CP	70	45	65	45
D1	100	50	95	50
Interconnects	25	85	25	95
Total	**700**	**510**	**690**	**515**
Previous estimation	630	615	615	630

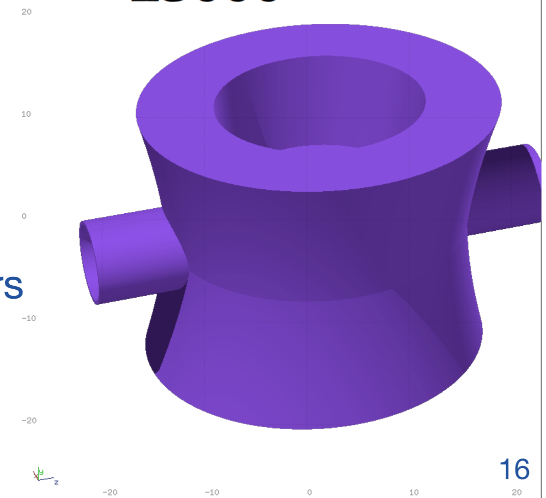
Figures reported refer to a luminosity of 5×10^{34} cm^{-2} s^{-1}

Total values for horizontal crossing are about 10% lower

Matching Section

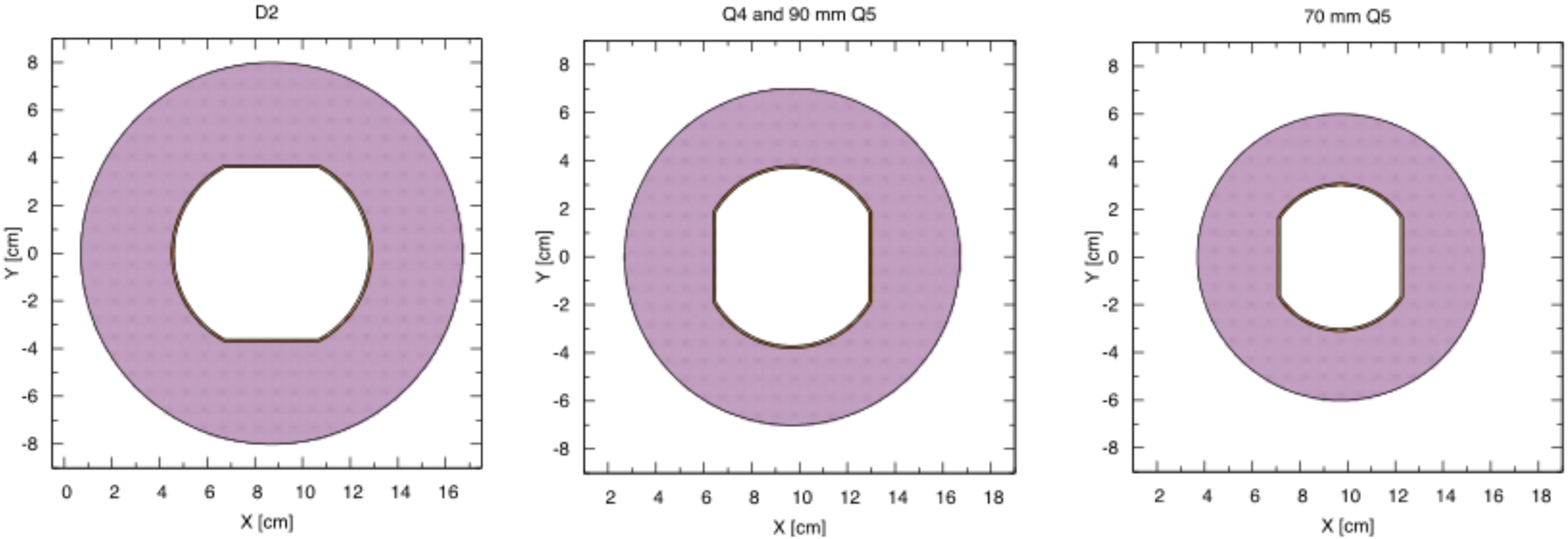
Matching Section beam-line





- D2, Q4 and their associated correctors are new magnets
- Q5 is present MQY (70 mm) module
- Q6 and Q7 are present magnets
- Crab cavities
- Protection issues have been addresses by means of TAN redesign and, collimators and masks
- First iteration completed taking into account of optics, magnet and integration constraints

Inventory of Matching Section protecting devices



- Masks:
  - INNERMET 180 as bulk material on 1 mm copper beam screen-shaped support (i.e. aperture is dimensioned to match the beam screen of the protected magnet)
  - 50 cm long placed at 1.5 m from magnetic length
  - mask–beam screen gap set to 75 cm
  - distance between active parts of TLC–mask set to 75 cm

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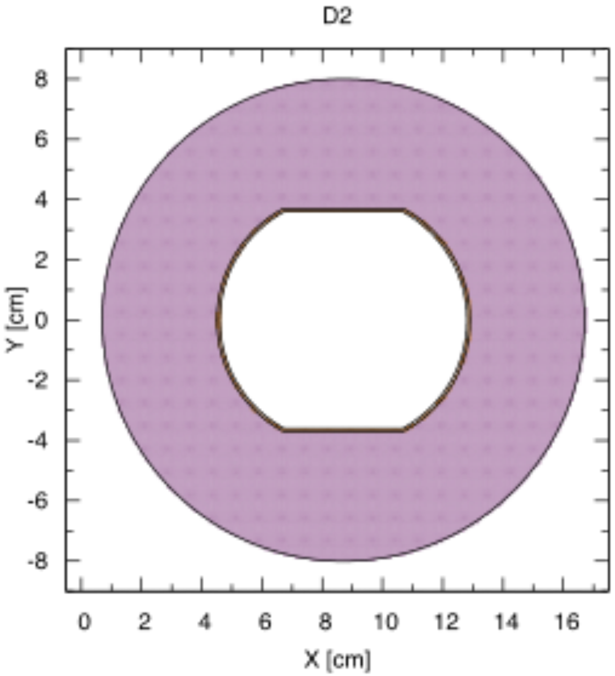

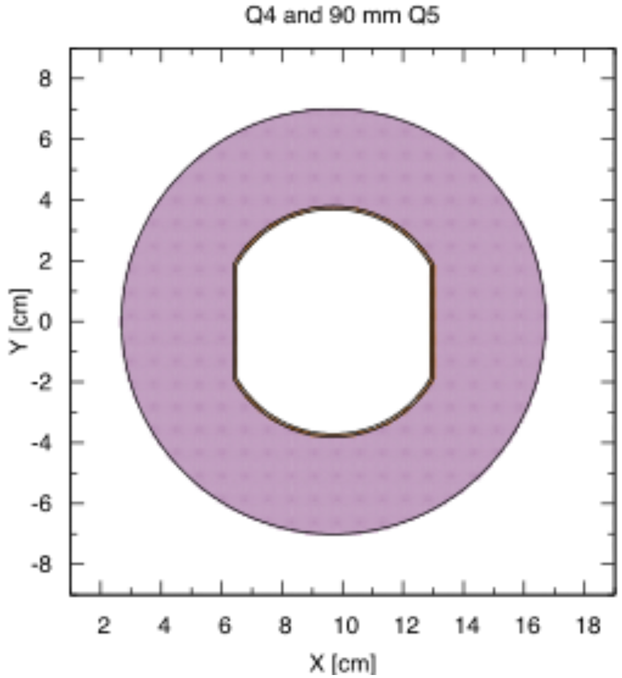

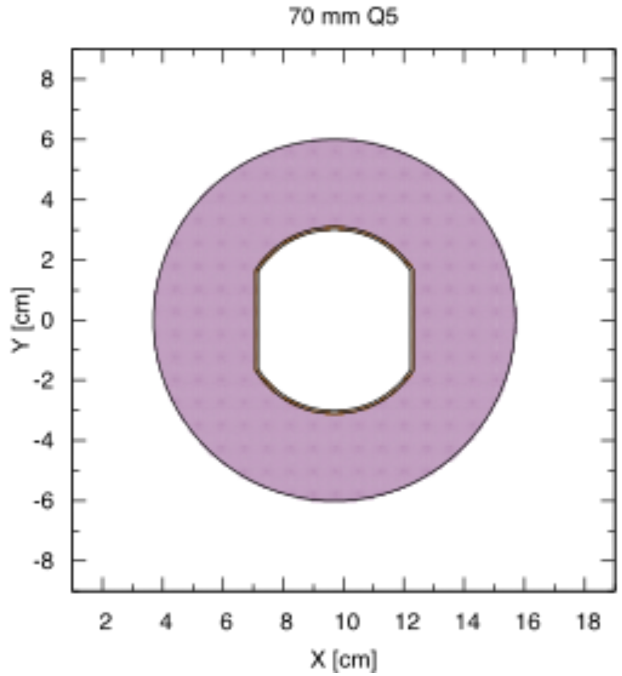

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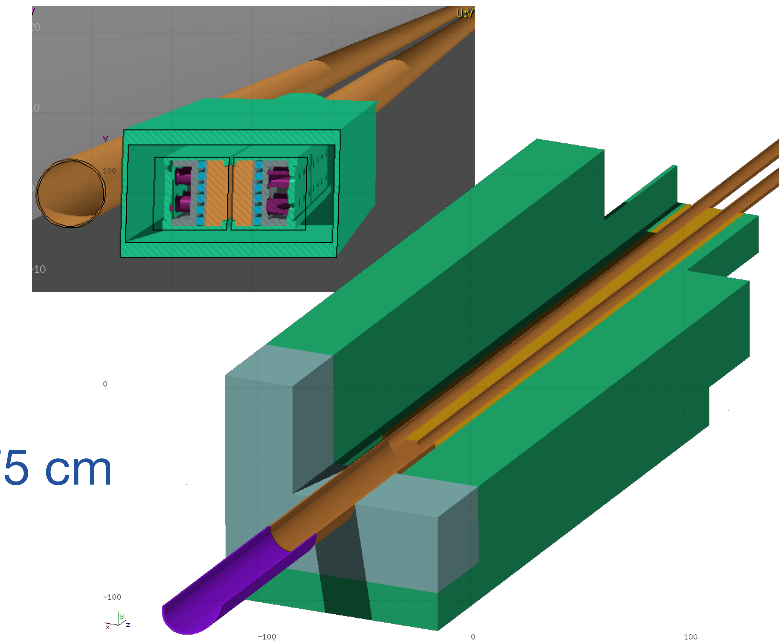
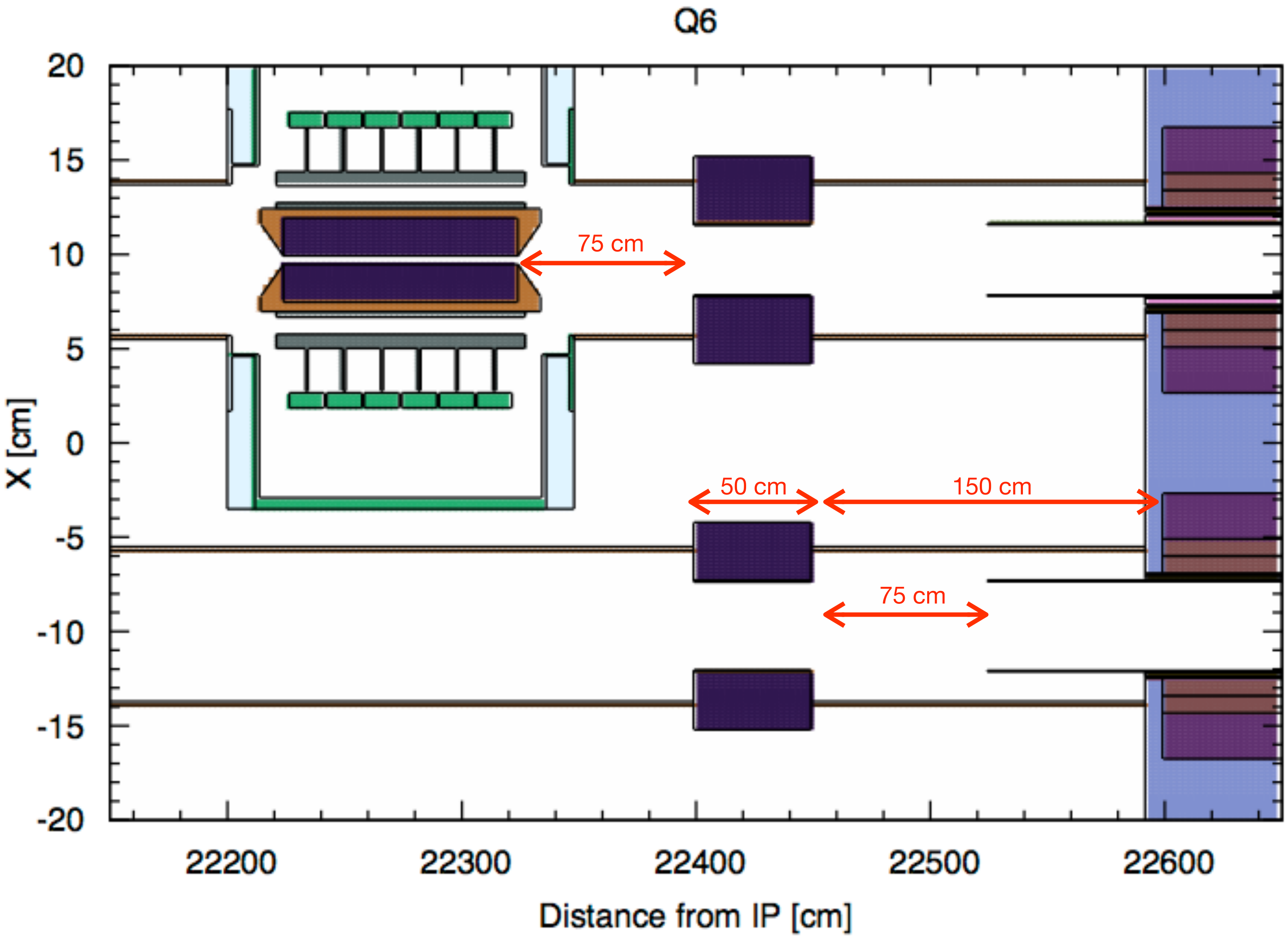
  - distance between active parts of TLC–mask set to 75 cm
- Of course plus TAN, and TCLs (in front of D2, Q5, Q6)



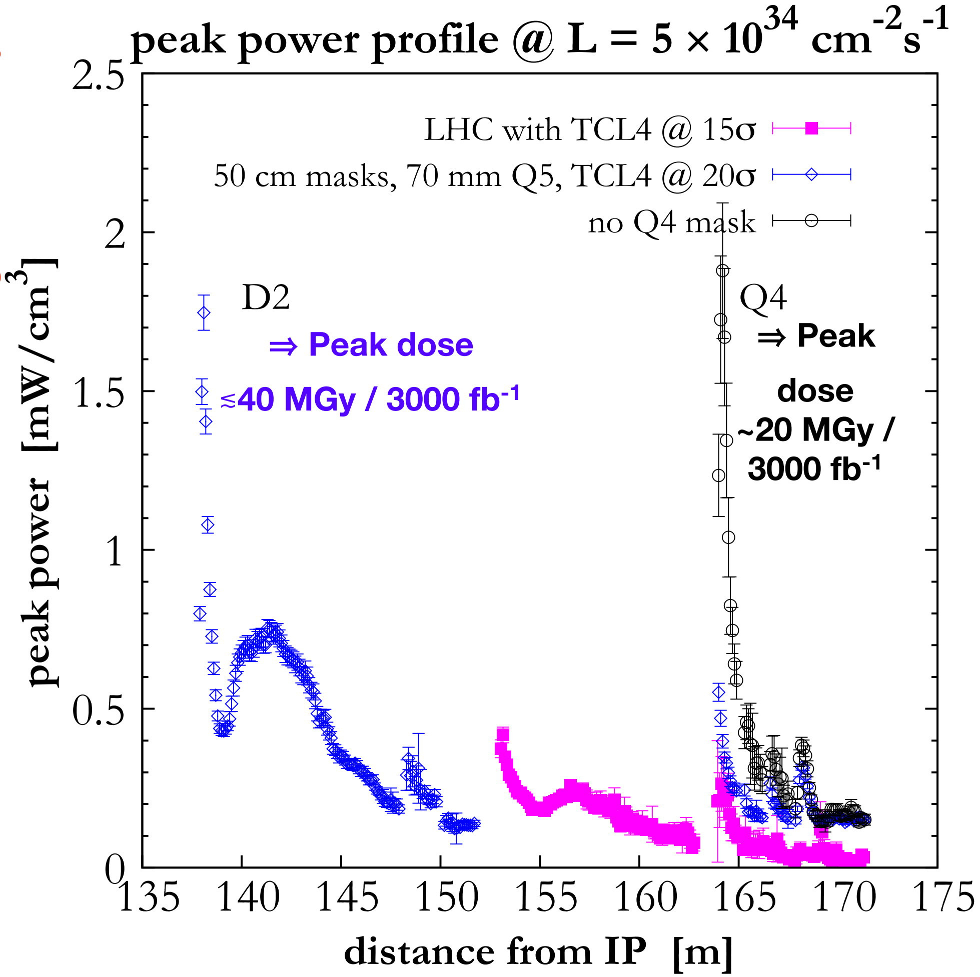
Layout example: Q6 IP-side

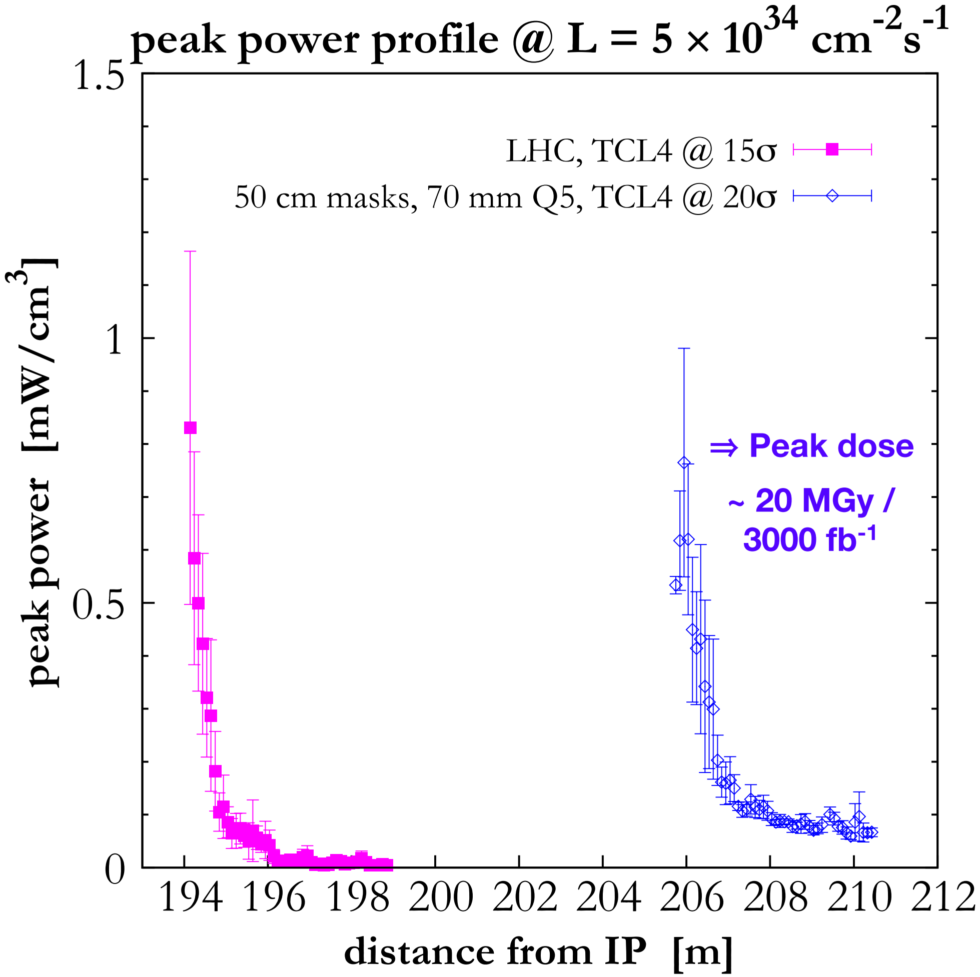


TCL4 opening set at 10 σ [~8.5 mm] (trajectory offset ~3 mm taken into account)
TCL5 opening set at 10 σ [~6.0 mm]
TCL6 opening set at 10 σ [~2.3 mm]

Peak power profile: HL vs LHC

Reference: 23rd HiLumi WP2 Task Leader Meeting, 31 January 2014





As reference heat load on D2 ~ 50 W, of which ≲ 2 W on the beam screen

Proviso: other optics should be checked, from previous calculation without masks

- flat optics ⇒ D2 peak power ×10
- sround optics ⇒ Q4 peak power ×3

Summary

- IT—CP—D1 beam screen is exposed to ~ **1 Gy after 3000 fb^{-1}** mainly of **electromagnetic nature**

- Impact of the executive beam screen design has been evaluated
  - The most important mitigation measure seems to be **shielded Q3—CP interconnect**

- Updated total heat load figures on the IT—CP—D1 string
  - the **cold mass (beam screen)** is expected to absorb **700 (515) W** from collision debris at **$5 \times 10^{34} cm^{-2} s^{-1}$**

- The protection of the Matching Section relies on the **synergy between TAN, collimators and masks**
  - A first iteration taking into account inputs from optics, magnet, energy deposition and integration has been concluded
  - **Hot points** individuated:
    - **D2** (TCL4@20σ) where 2 mW/cm^3 can be reached (40 MGy/3000 fb^{-1})
    - **Q4** corrector (w/o mask) 2 mW/cm^3 can be reached (20 MGy/3000 fb^{-1})