Energy deposition in the Triplet-D1 region (V1.2)

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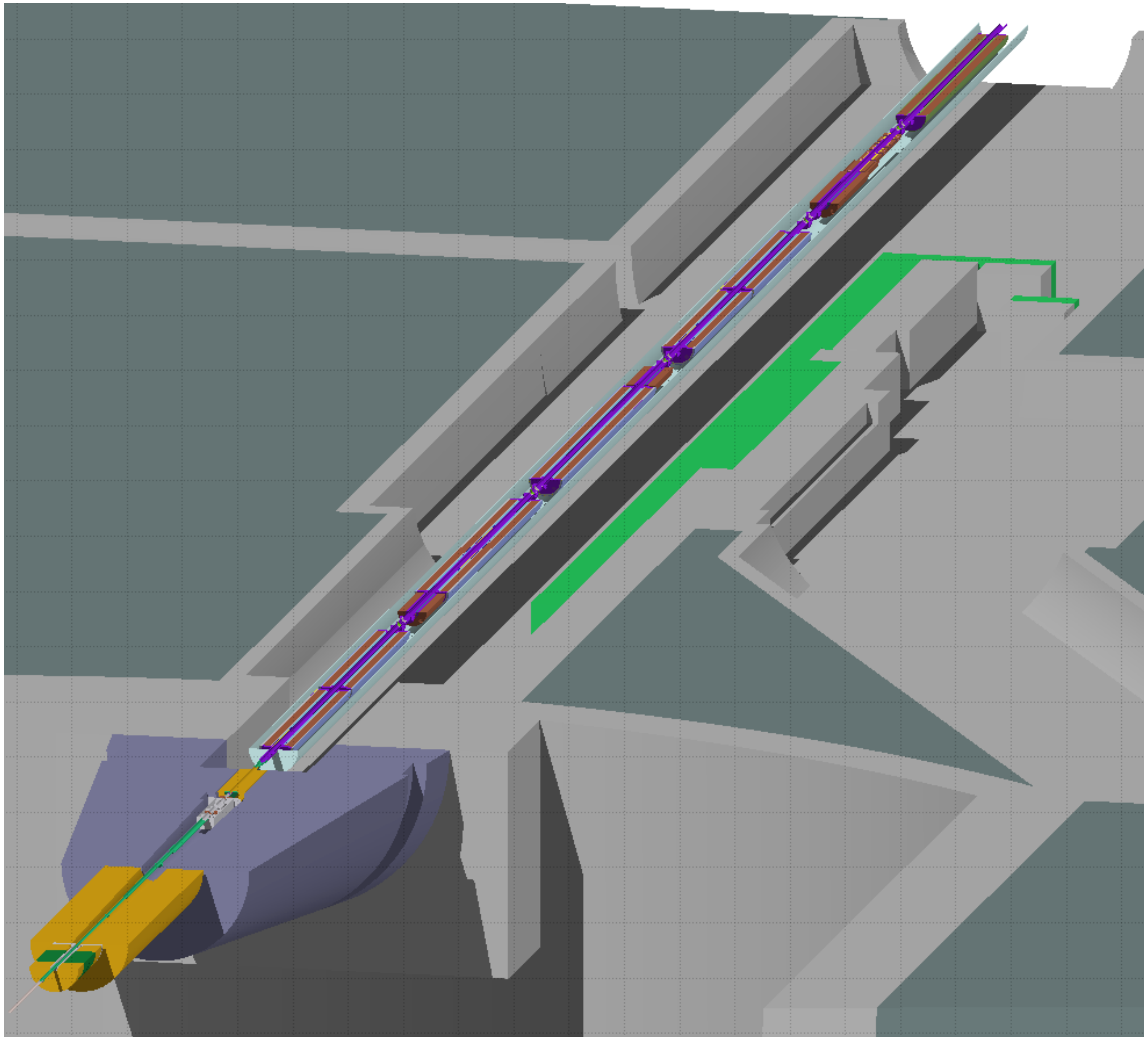
Outline

- Simulation setup
  - Layout and optics
  - Geometry
- Results for round optics (V/H)
  - Total power
  - Peak power/dose
- Other optics
- Dose minimisation with alternative optics & crossing combinations
- Dose map in the tunnel
- Summary & further studies

Simulation setup

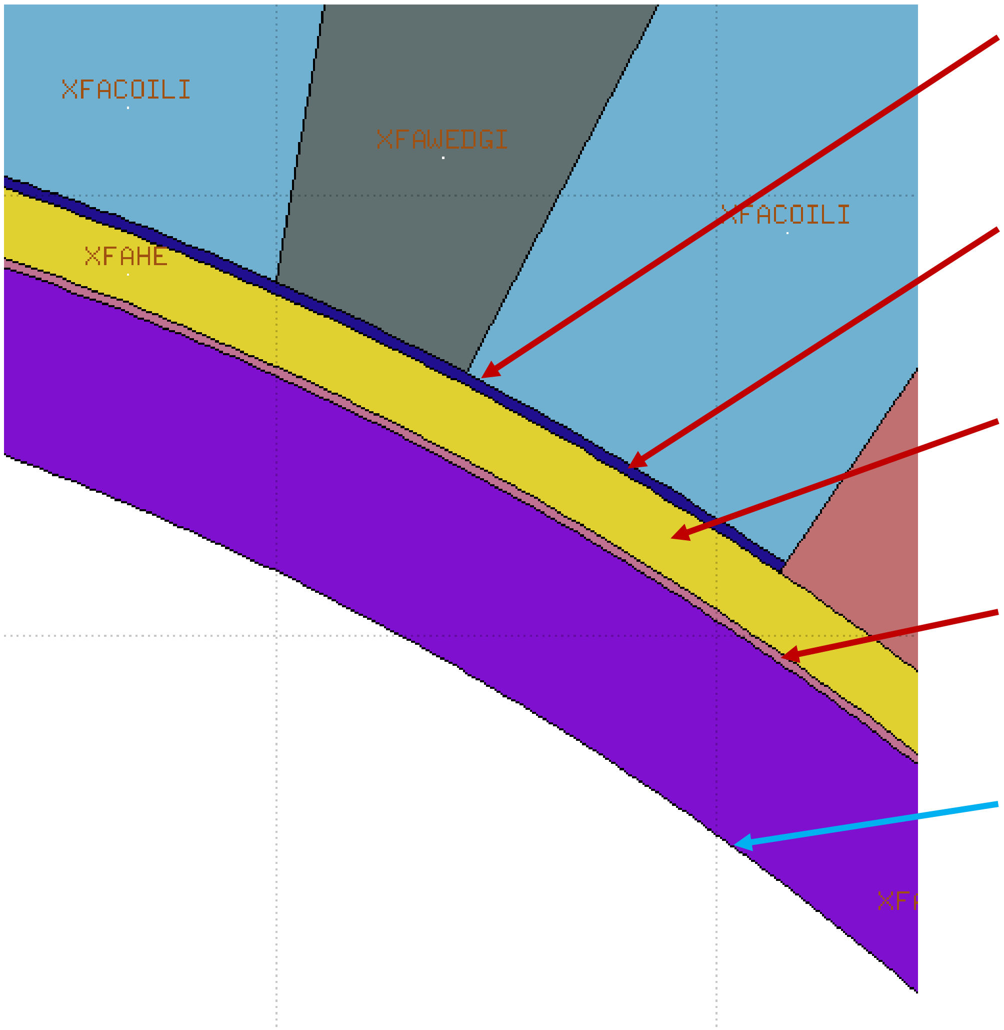
Layout and optics



- Element lengths and positions extracted from V1.2 TWISS file
  - Exception: TAS kept at V1.1 position
  - TAS aperture = 60mm
- New magnetic field map for D1, normalised to the TWISS value (as for all magnetic elements)
- Two main scenarios studied:
  - Round optics, β*=15cm, crossing 295μrad
    - 1. Vertical crossing (IP1)
    - 2. Horizontal crossing (IP5)

Geometry upgrades & updates

- **1. Update of various layer thicknesses**

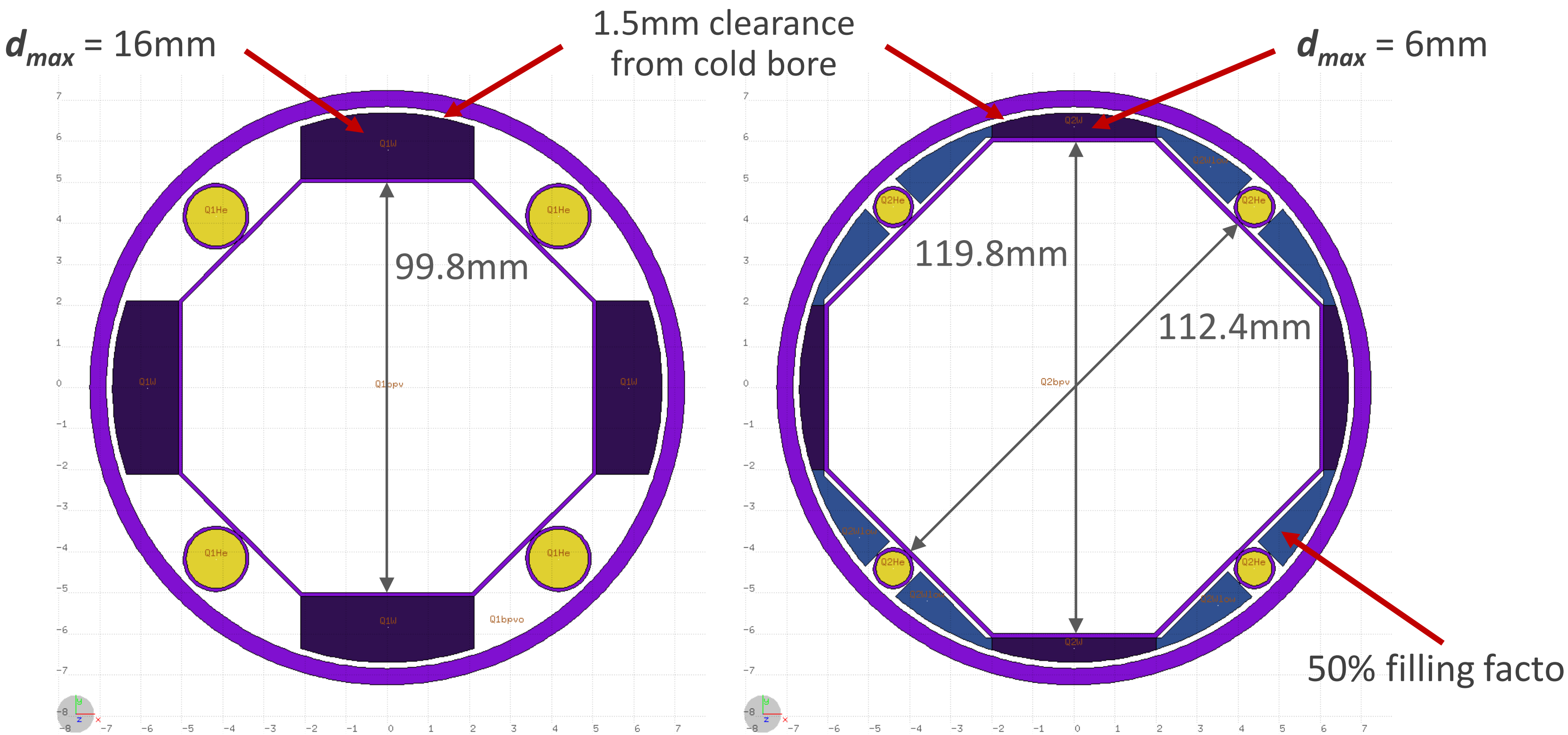


- Coil aperture (cold): ***R* = 7.435cm**
- 250µm insulation
- 1.5mm liquid He
- 200µm insulation
- 4mm cold bore (R_{in} = 6.84cm)

Geometry upgrades & updates

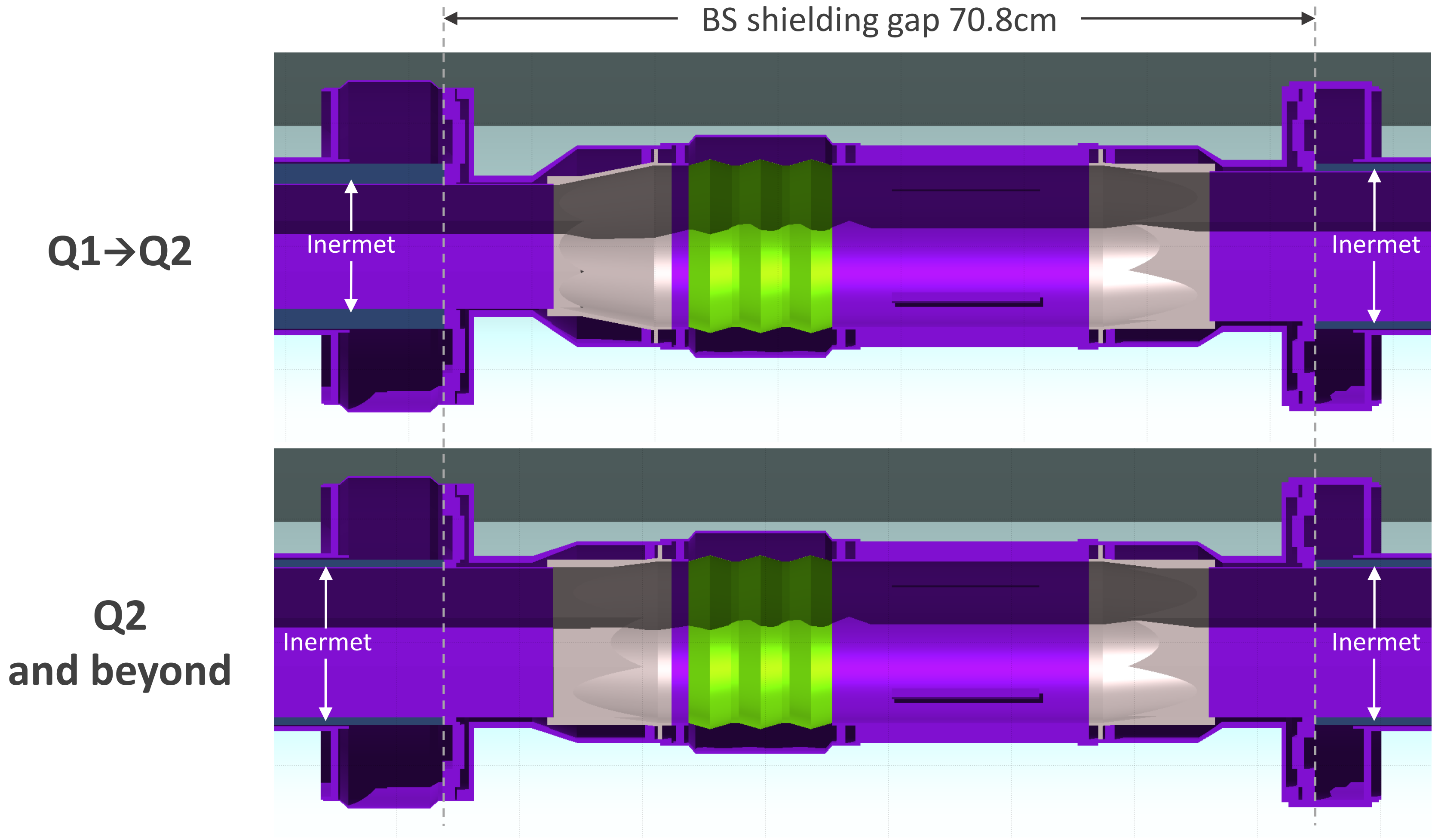
- **2. Beam screen design**
  - Inermet shielding extended towards the poles in “thin” BS (50% filling factor)
  - Adjustment (1.1mm radial reduction) of dimensions to adapt to change in the defined coil aperture and other layers (insulation etc.) (previous slide)

Q1 **Q2 and beyond**



Geometry upgrades & updates

- **3. New FLUKA models of interconnect with circular BPM**



Design provided by R. Fernandez-Gomez, T. Lefevre

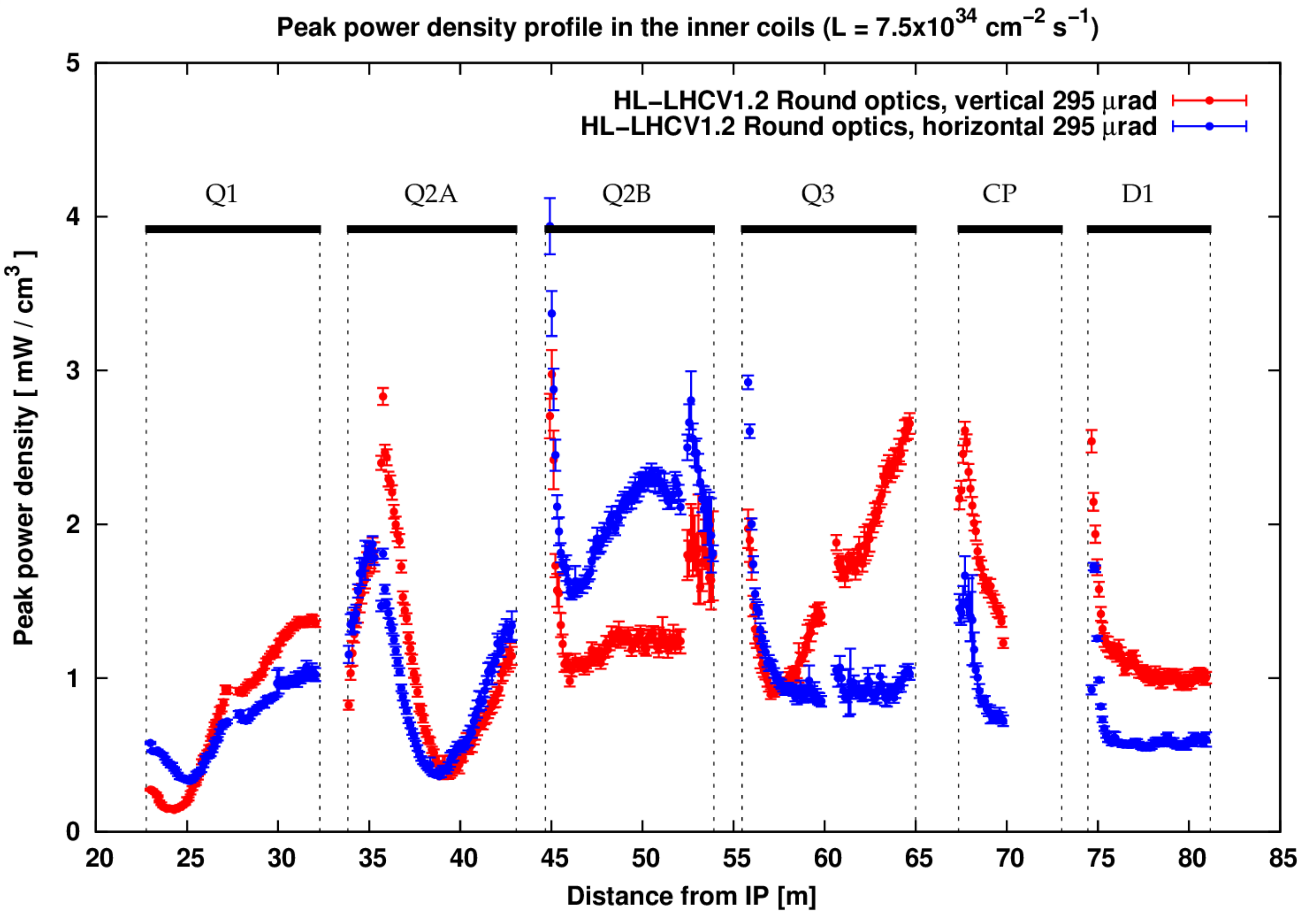
Results

Total power for $L=7.5L_0$

	Round vertical		Round horizontal		Round vertical V1.1	
	Magnet cold mass	Beam screen	Magnet cold mass	Beam screen	Magnet cold mass	Beam screen
	Power [W]					
Q1A + Q1B	167	251	176	257	140	210
Q2A + corr.	139	115	127	101	150	90
Q2B + corr.	170	147	178	153	165	100
Q3A + Q3B	186	153	160	125	220	105
CP	85	106	58	73	105	90
D1	113	107	92	84	135	80
TOTAL	**860**	**879**	**791**	**793**	**915**	**675**

- Extension of BS shielding towards poles (with a 50% filling factor!) re-balances loads between CM and BS
- Loads in horizontal crossing ~10% lower with respect to vertical crossing

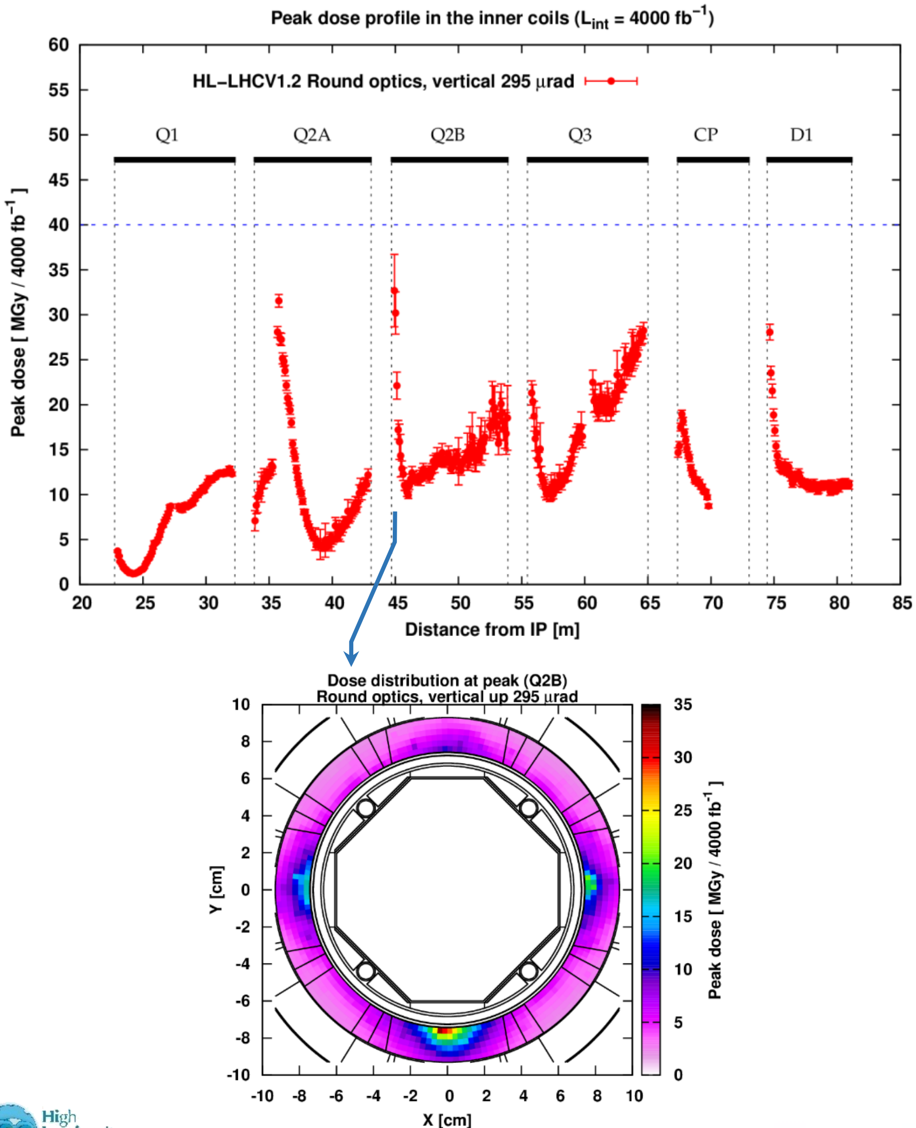
Peak power density (L=7.5L_0)



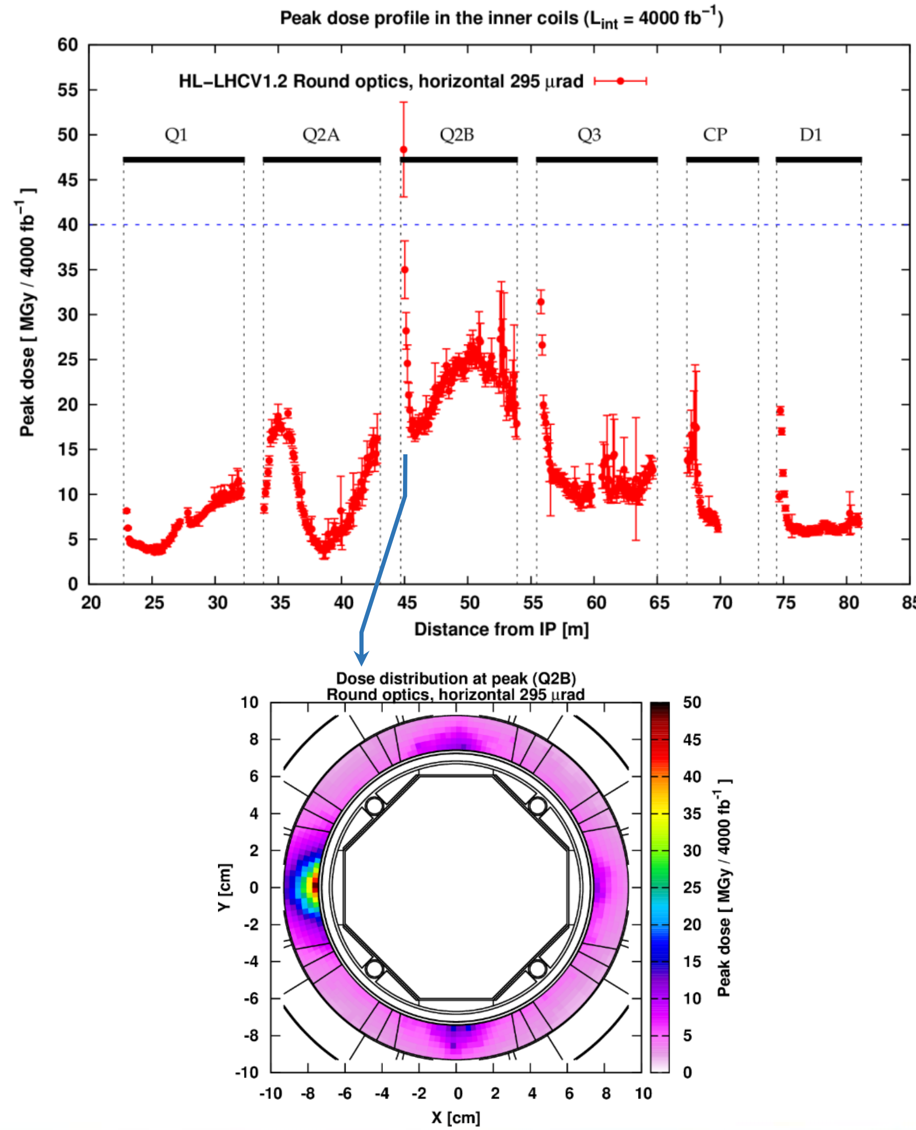
- Peak power density well below design values overall
- There is an important effect in the IP-faces due to shielding gap in the interconnect, especially in horizontal crossing

Peak dose (L_{int} = 4000fb^{-1})

Vertical crossing

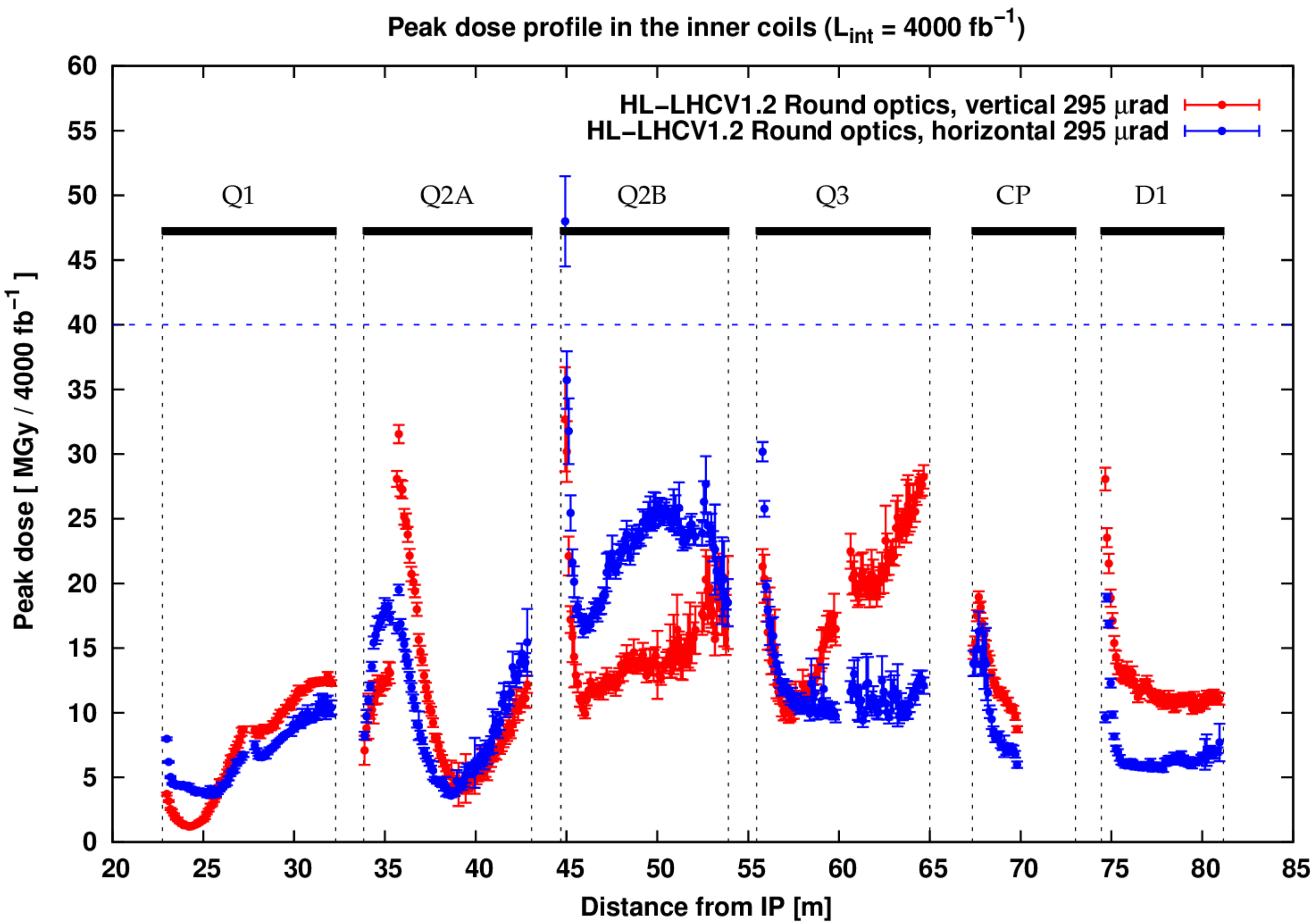


Horizontal crossing



Peak dose (L_{int} = 4000fb^{-1})

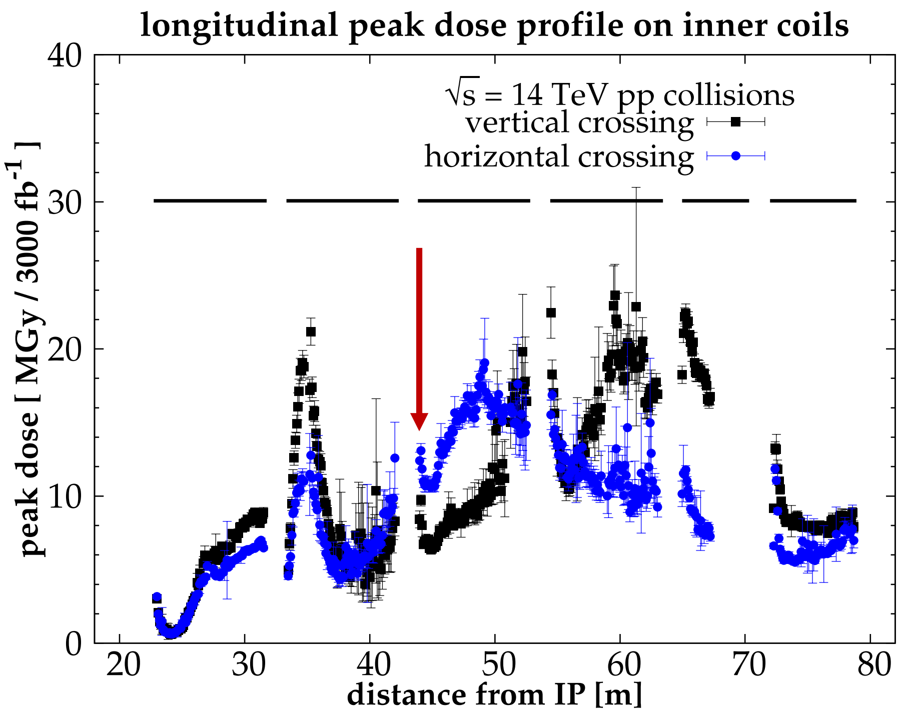
- The horizontal case is worse
  - Shielding gap in the interconnect creates a localised problem

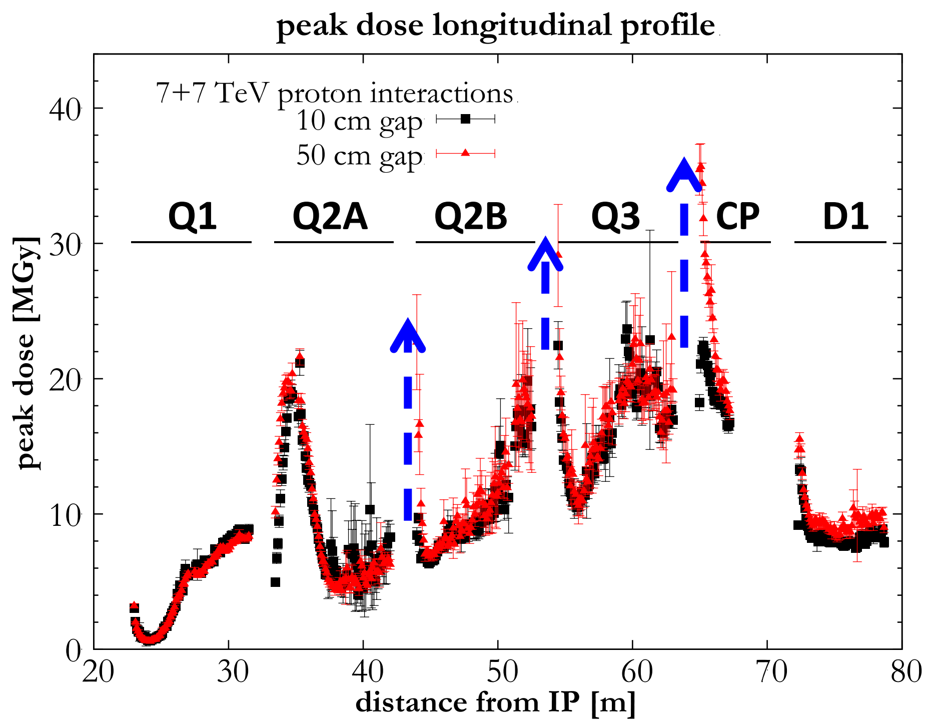


Is this consistent with previous results?

- YES
  - An increase in the peak dose in Q2B is expected going from vertical to horizontal crossing
  - A longer gap (from 10 to 50cm) in the BS shielding was shown to lead to significantly higher peak dose values in the IP-faces (especially in Q2B)
    - *REMINDER: Gap is now ~71cm*

L_{int} = 3000fb^{-1}



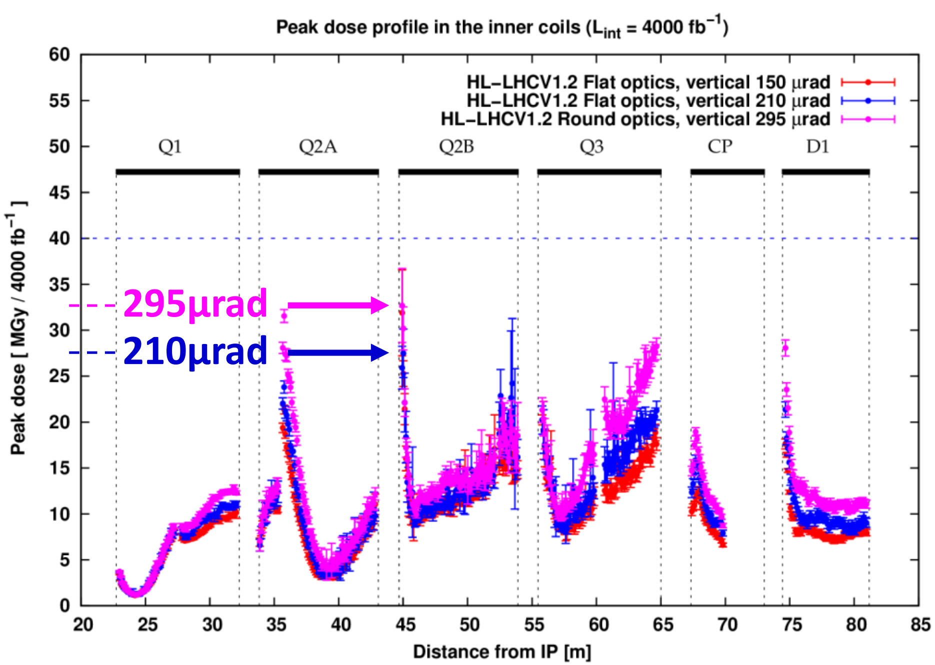


See F. Cerutti, 5th PLC Meeting, July 2, 2013

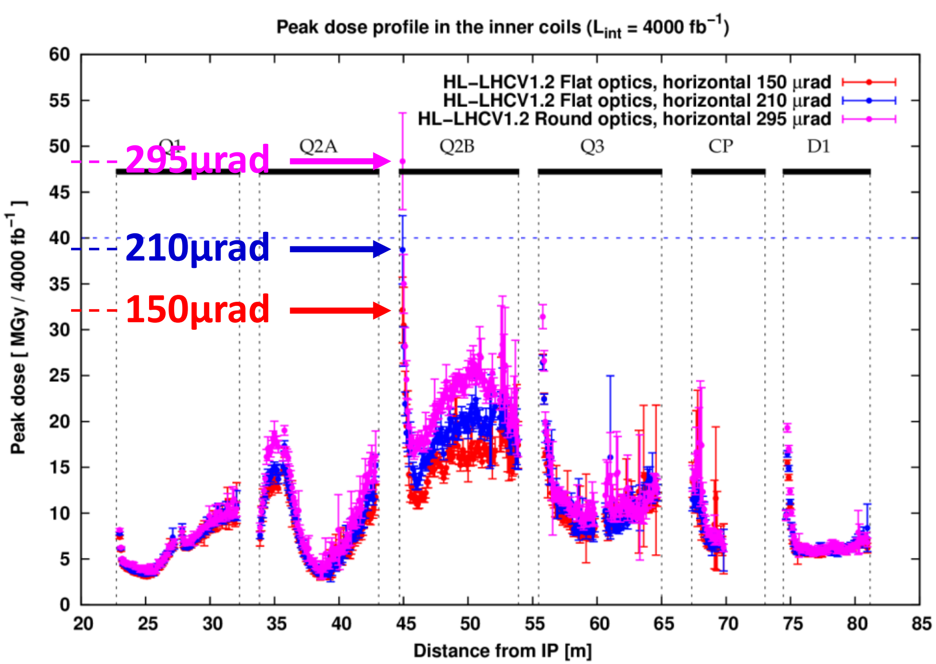
Further studies: flat optics

- Two flat optics scenarios were also studied for both vertical and horizontal crossing
  - 150µrad half-crossing angle, β^*_x / β^*_y = 40 / 10 cm
  - 210µrad half-crossing angle, β^*_x / β^*_y = 40 / 10 cm
- Sensitivity of results to changes in bunch length and beam divergence is limited
- On the contrary, the crossing angle plays an important role
  - Lower dose for lower crossing angle

Vertical crossing



Horizontal crossing



Peak dose minimisation with alternative optics & crossing combinations

In collaboration with S. Fartoukh (BE/ABP)

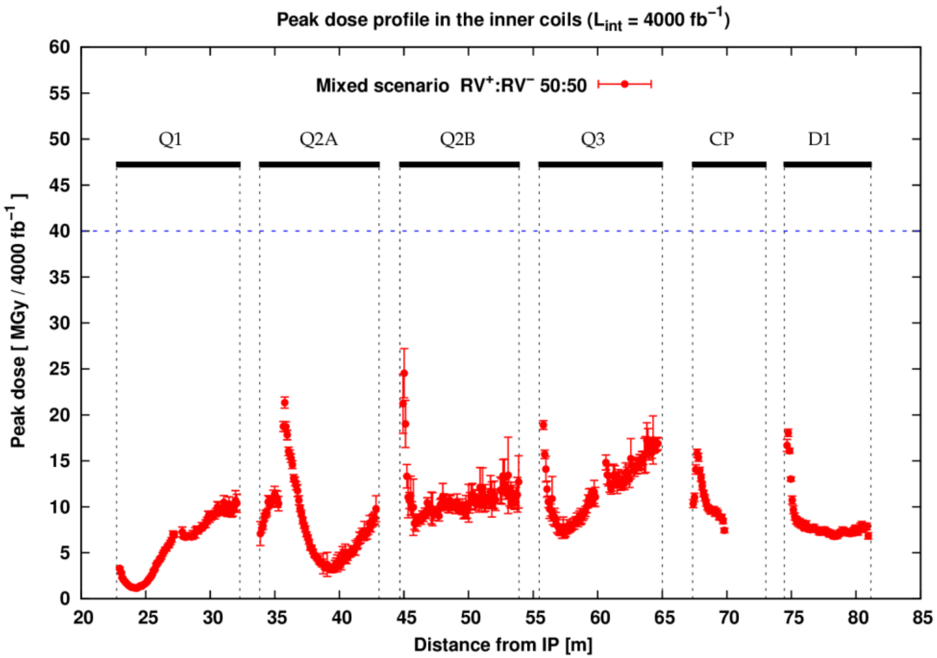
Peak dose minimisation scenarios

- Different combinations of optics and crossing can reduce peak dose values
- The flexibility of such combinations depends on various constraints e.g.:
  - Possibility of exchange of crossing planes between IP1 and IP5 (HV→VH)
  - Possibility of running with the same crossing plane in IP1 and IP5 (HH or VV)
- Four scenarios considered, with decreasing constraints:
  - 1. Baseline scenario: 50% vertical up (V^+) / 50% vertical down (V^-) in IP1, 100% horizontal (H) in IP5 with round optics
  - 2. Crossing plane exchange between the two IPs: 50% H, 25% V^+, 25% V^- with round optics
  - 3. Crossing plane exchange between the two IPs: 50% H, 25% V^+, 25% V^- with flat optics (150μrad)
  - 4. No constraints: 50% V^+ / 50% V^- with flat optics (150μrad) in both IPs, which is better than 100% H

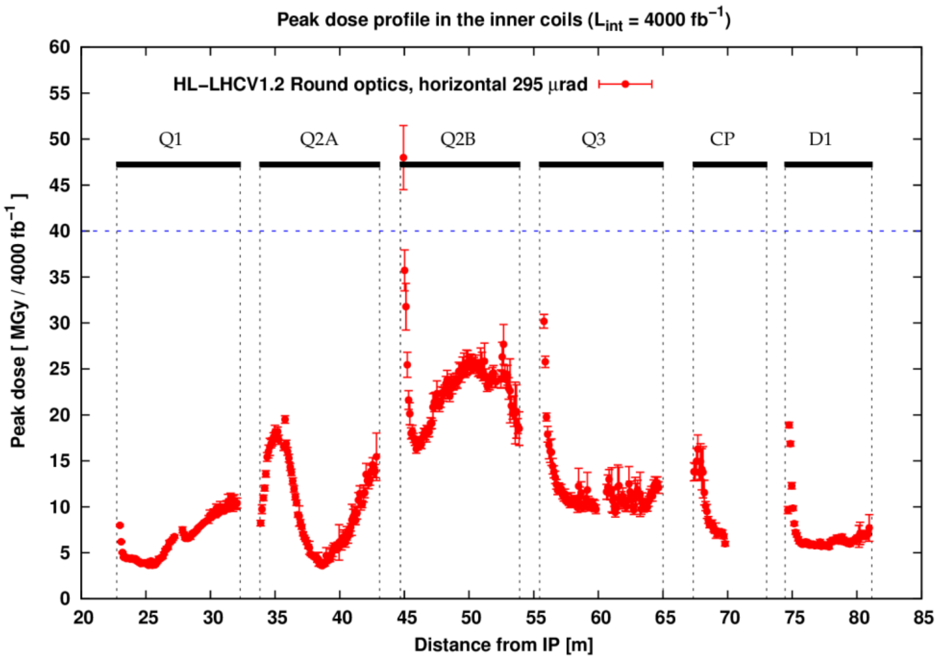
Peak dose minimisation scenarios

- 1. Baseline scenario:
  - 50% vertical up (V^+) / 50% vertical down (V^-) in IP1
  - 100% horizontal (H) in IP5 with round optics
- Important reduction in IP1 (from 35 to 25MGy)
- **BUT**, we remain exposed to the high peak value in IP5
  - If the local problem is cured, peak values would be below 30MGy.

IP1

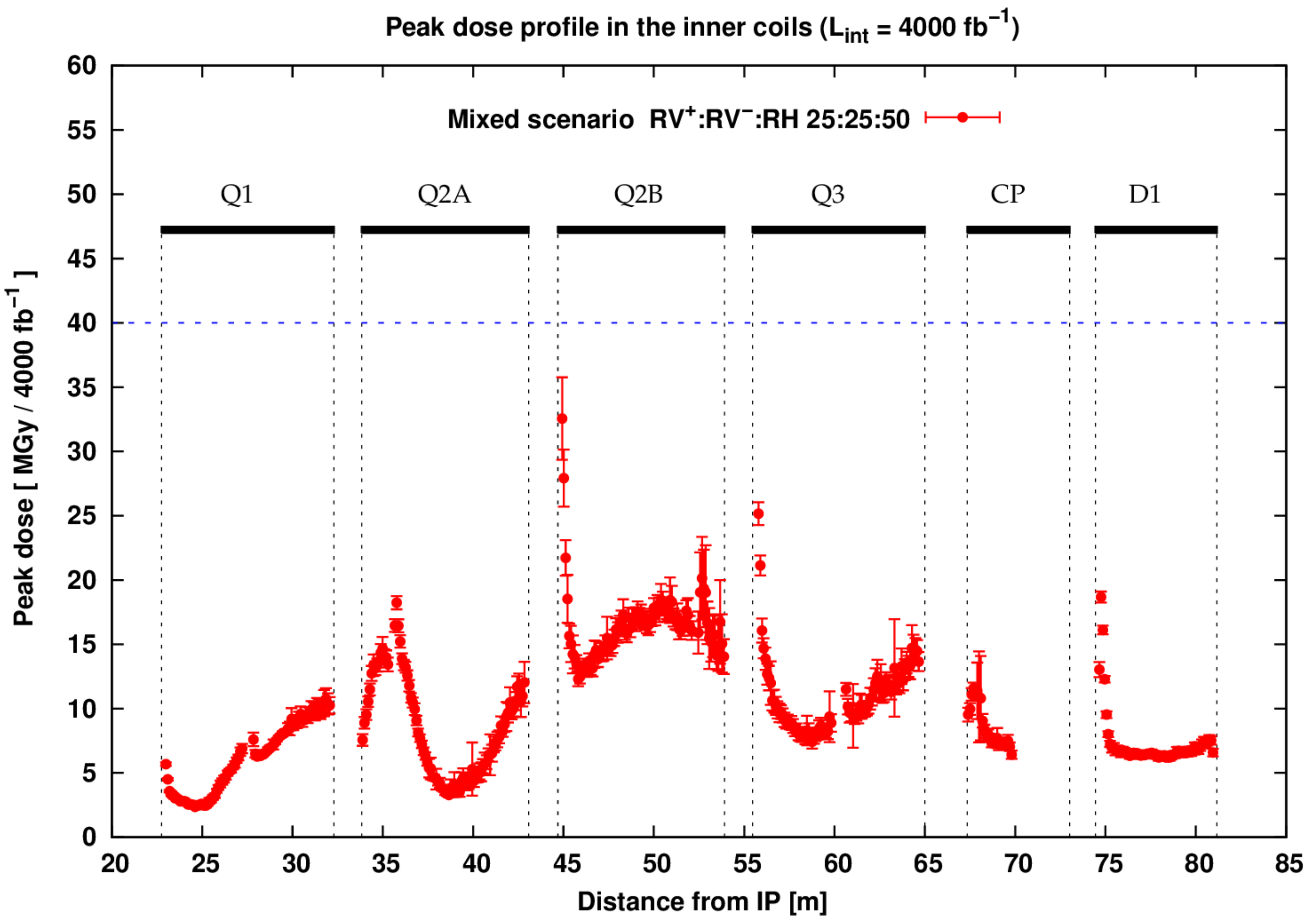


IP5



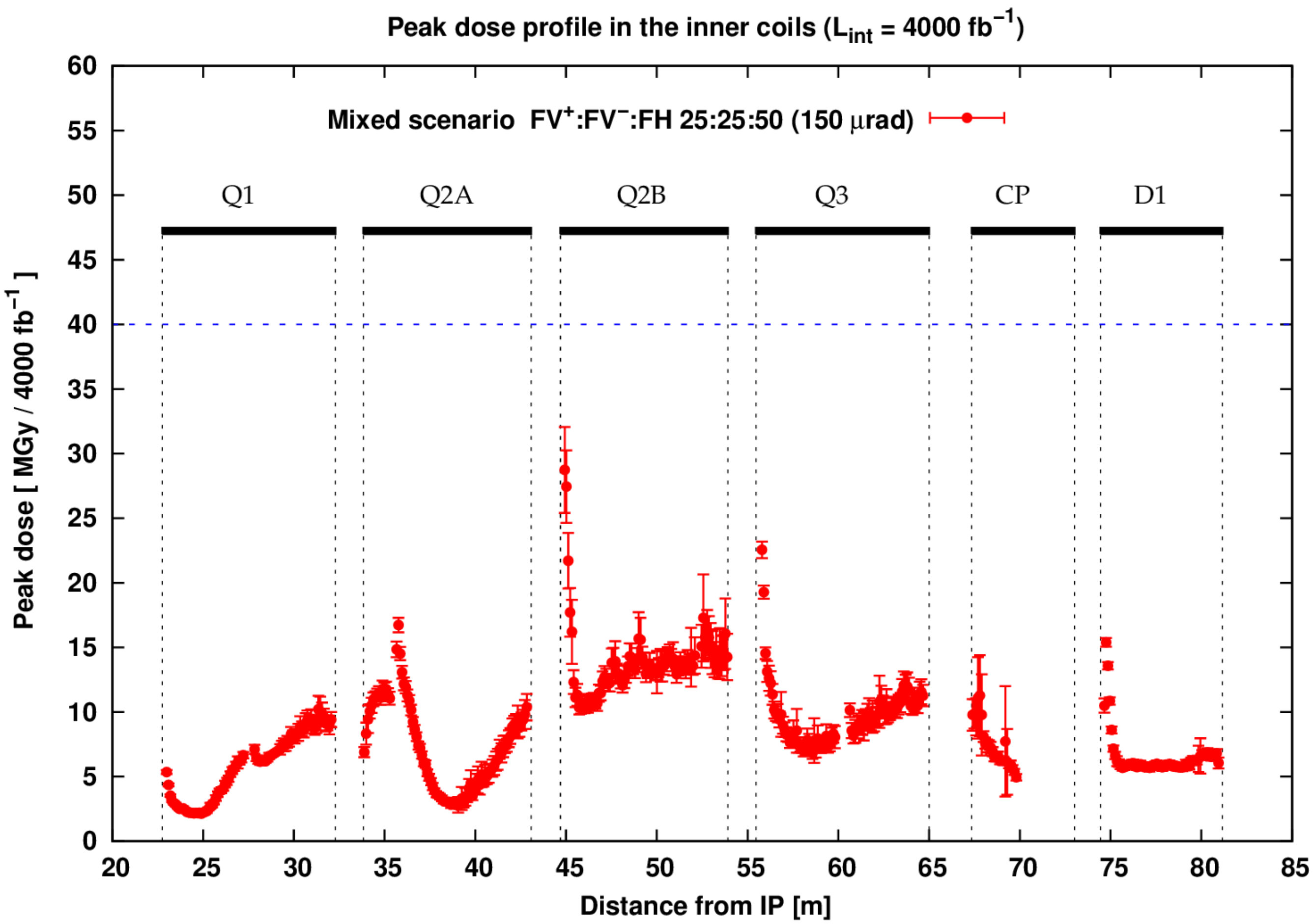
Peak dose minimisation scenarios

- 2. Crossing plane exchange between the two IPs
  - 50% H, 25% V^+, 25% V^- with round optics in both IPs



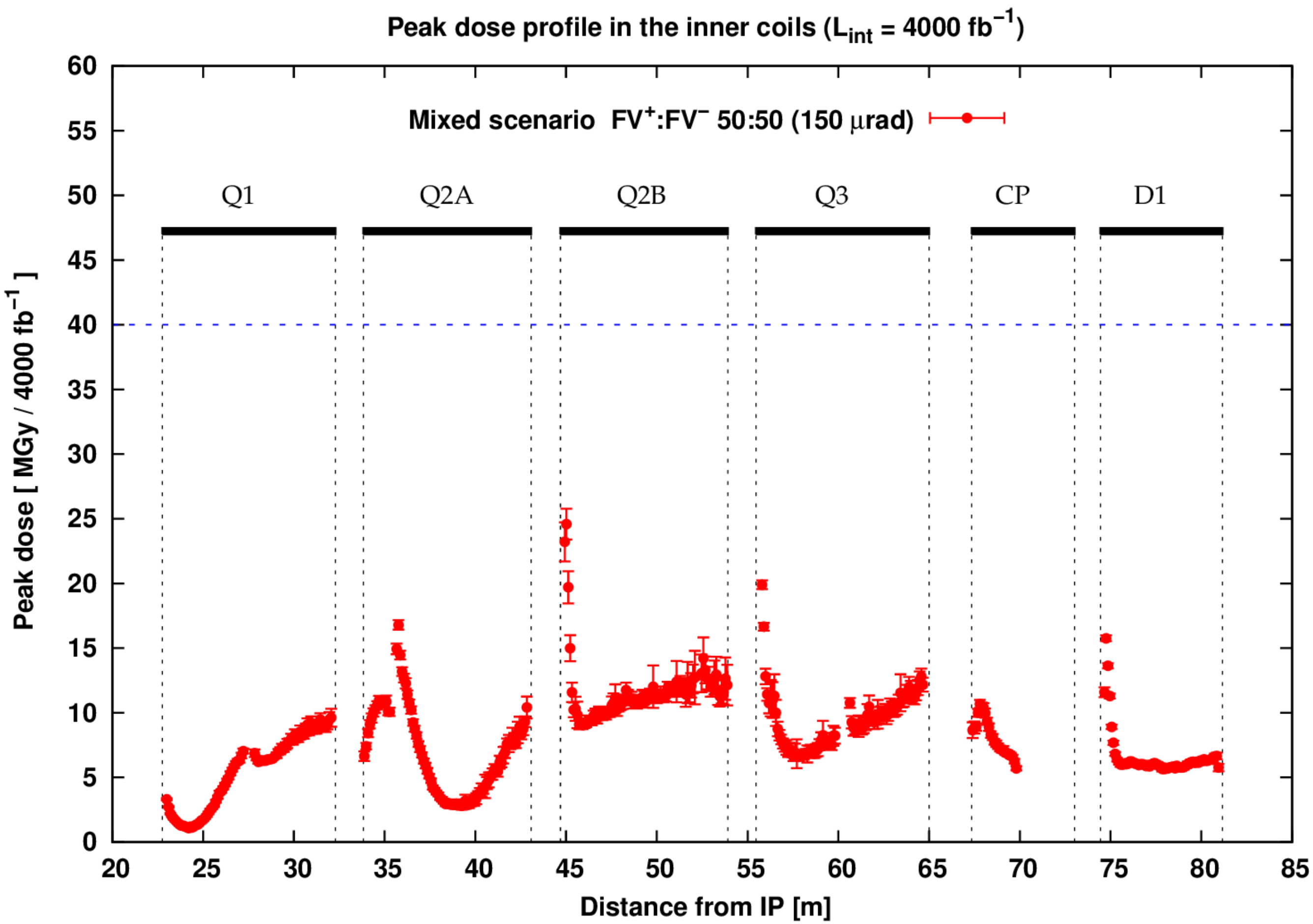
Peak dose minimisation scenarios

- 3. Crossing plane exchange between the two IPs
  - 50% H, 25% V^+, 25% V^- with flat optics (150μrad)



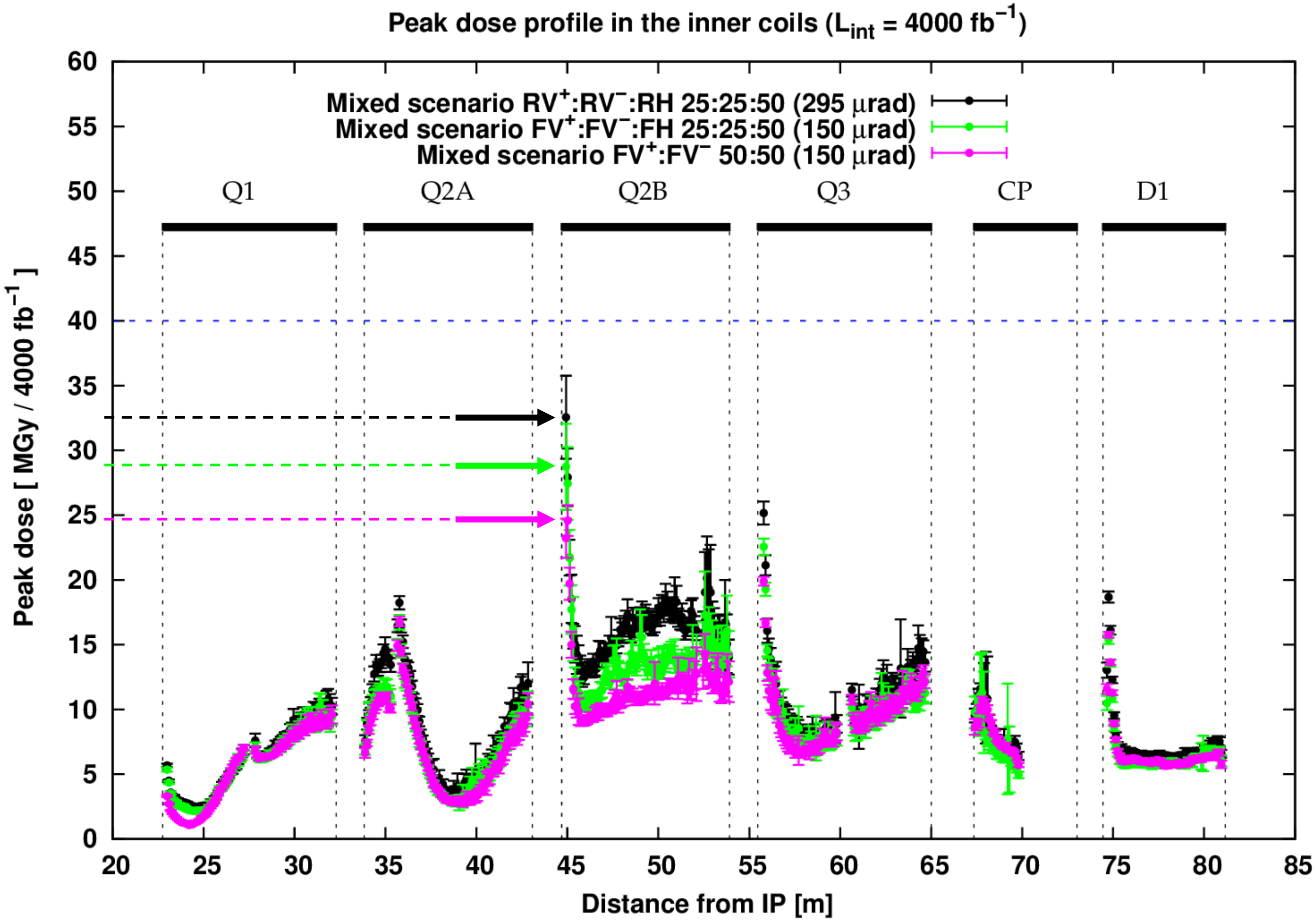
Peak dose minimisation scenarios

- 4. No constraints
  - 50% V^+ / 50% V^- with flat optics (150μrad) in both IPs



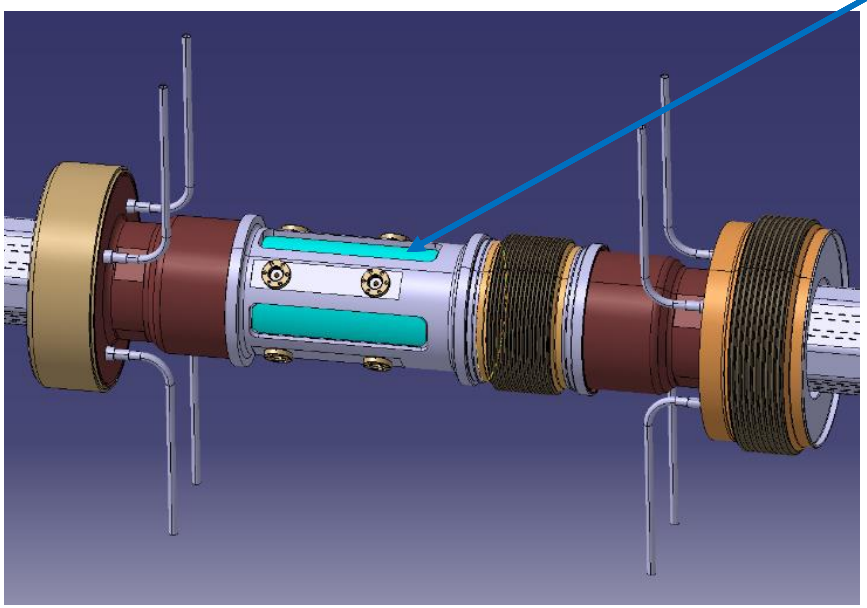
Peak dose minimisation scenarios

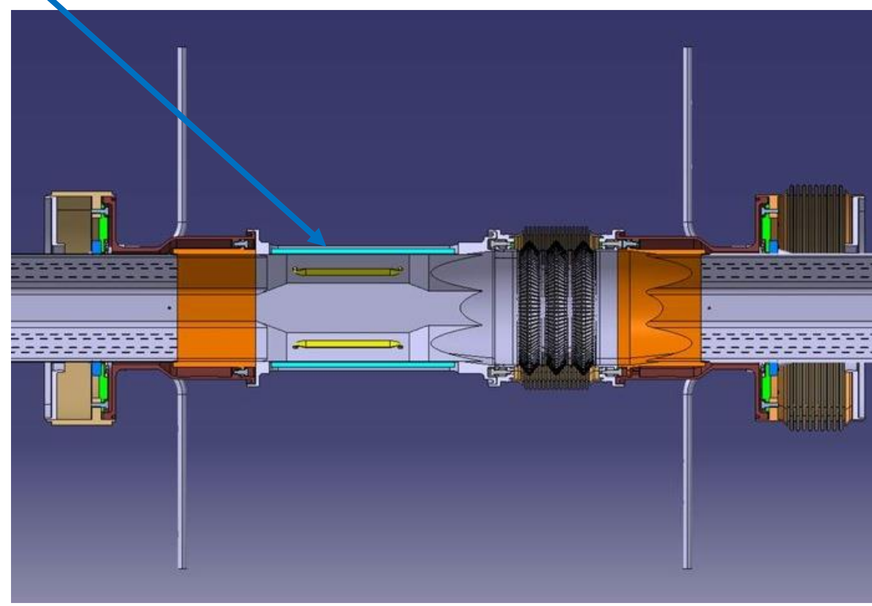
- Comparison of three mixed scenarios:



Alternative designs

- Circular BPM in Inermet
  - Peak dose reduction up to 10%
- Octagonal BPM with inner Inermet absorbers
  - Shielding gap reduction to ~57cm (instead of 71cm with circular BPM)
  - The shorter gap would surely lead to a reduction of peak dose values
  - **BUT** the gap is still quite long (more than the 50cm studied in the past)
  - This solution is not expected to cure the problem





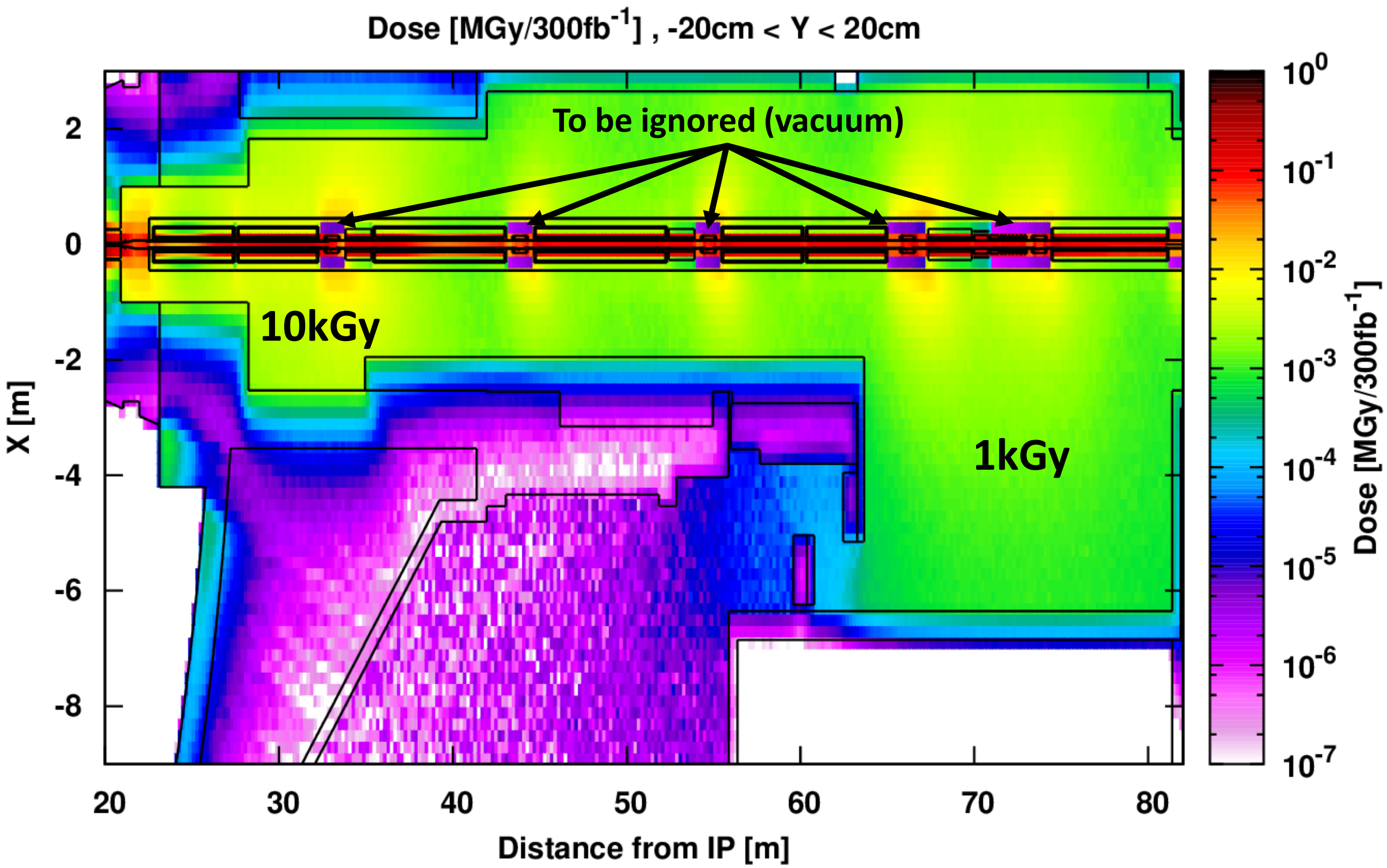
Courtesy: T. Lefevre

- Is it possible to further extend the shielding?

Dose map in the tunnel

Dose per year of operation (L_{int} = 300fb^{-1})

- Relevant for vacuum and survey equipment, cabling etc.



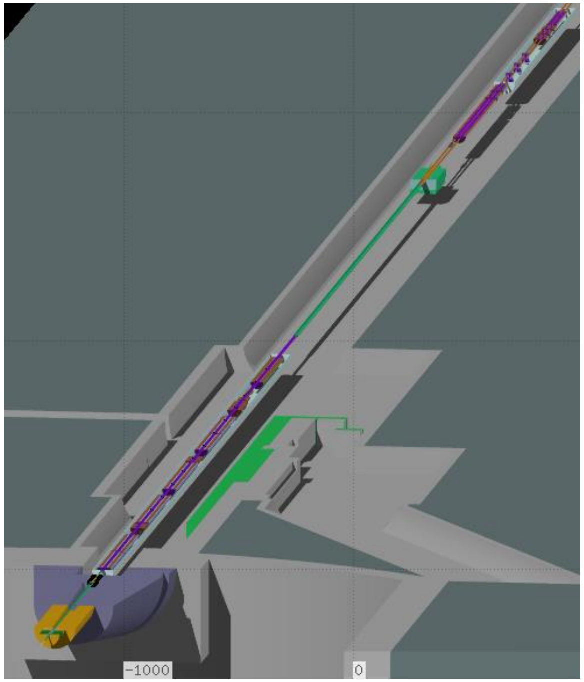
- Averaged over ±20cm from the beam level
- Dose ~1kGy in the tunnel, except in the TAS-Q1 region
- A few tens of kGy at the interconnects

Summary

- Simulation parameters updated to V1.2
- Various geometry updates (magnet aperture, BS designs)
- New models added: interconnects with circular BPM
- Peak dose estimates show challenging localised problem in IP-face of Q2B, especially for horizontal crossing
- Flat optics scenarios show improvements attributable to the lower crossing angle
- Different optics and crossing combinations (depending on hardware options) could significantly reduce peak dose values
- Dose of ~1kGy per year in the tunnel

Looking further…

- Study will be extended to the **matching section**



Current reference for the D2-Q4 region:

L. Esposito's talk at the 2014 Annual Meeting at KEK

http://indico.cern.ch/event/326148/session/17/contribution/43

- Most significant changes with respect to V1.1
  - TAXN twin bores from 80mm to 85mm
  - D2-Q4 corrector aperture: from 100mm (previously guessed) to 105mm (as the D2)
- Both crossing planes need to be studied

- …and further:
  - Debris losses in the **Dispersion Suppressor**

High Luminosity LHC

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