WP6.4 – Updates on Dose and Dpa studies on SC Links at P1

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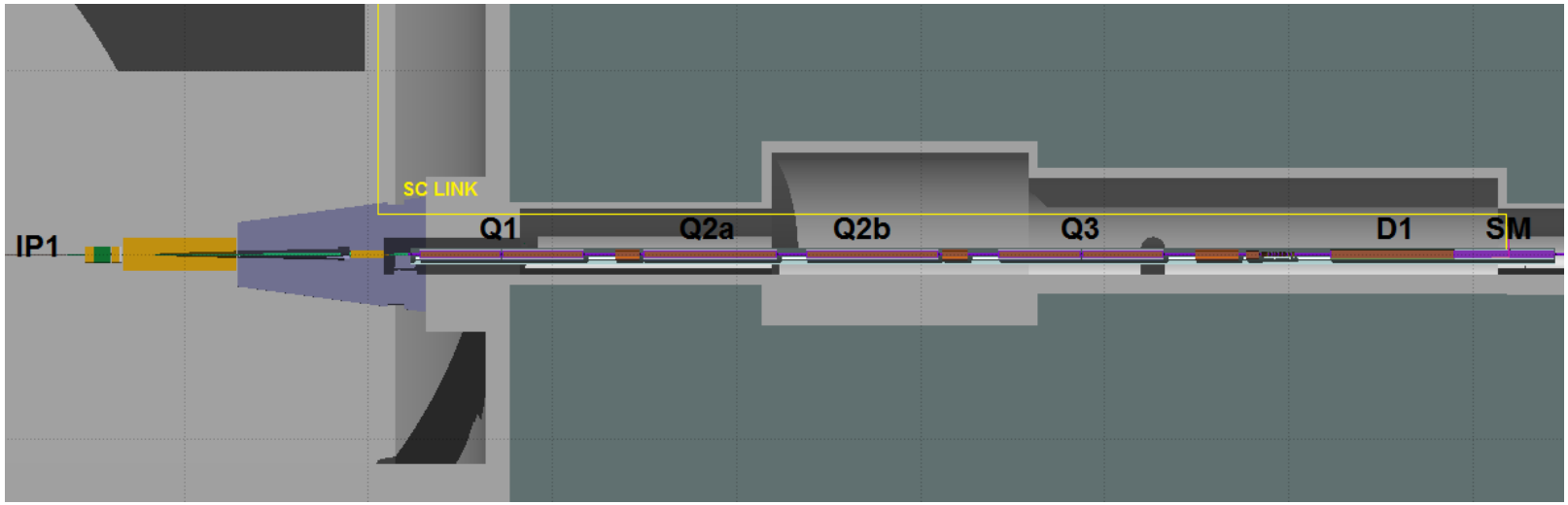
Outlines

- SC Link in P1 layout
- SC Link: real structure and simulated layout
- Critical points
- First quadrupole region: results and analysis
- Shuffling Module region: results and analysis
- Conclusions

P1



Possible disposition of the SC link in the FLUKA simulation of P1 geometry

The link will start its run from the surface and will enter in ATLAS cave between the interaction point and the Q1. Than it will run parallel to the beam line at about one meter from the quadrupoles . At the end it will enter in the shuffling module (located at about 80 m from the IP1).

SC Link Structure

Sub-unit of 18 MgB_2 (green) wires around a Cu (red) bulk
Φ = 6.5 mm

20 kA cable
6 sub-unit around a steel (grey) tube
Φ = 19.5 mm

Concentric 2×3 kA cable
(Kapton in orange)
Φ = 8.4 mm

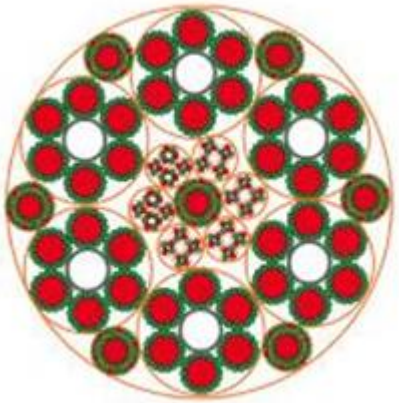
0.4 kA cable
Φ = 3 mm

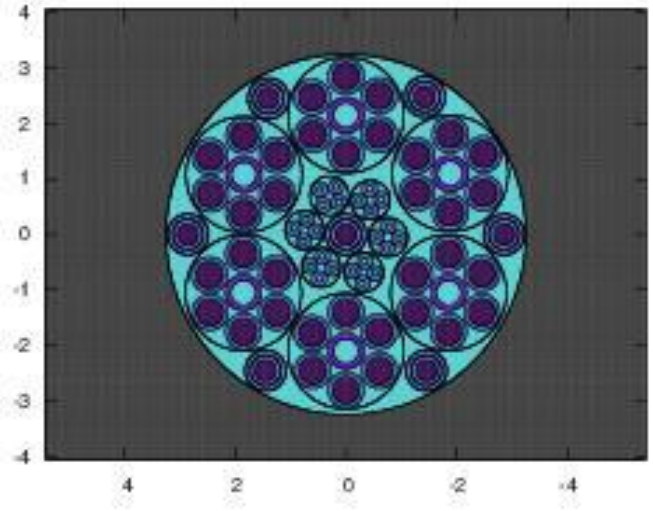
0.12 kA cable
Φ = 3 mm

165 kA cable assembly
(6×20 kA, 7×2×3 kA, 4×0.4 kA, 18×0.12 kA)
Φ = 65 mm
(white regions are flled with 20 K Helium)

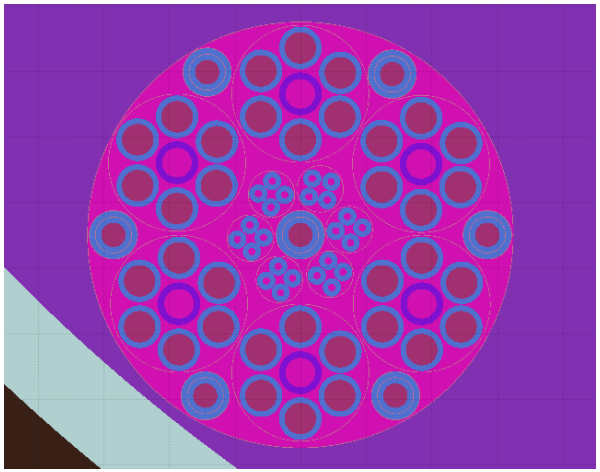
SC Link in FLUKA

Real SC Link





Simulated SC Link

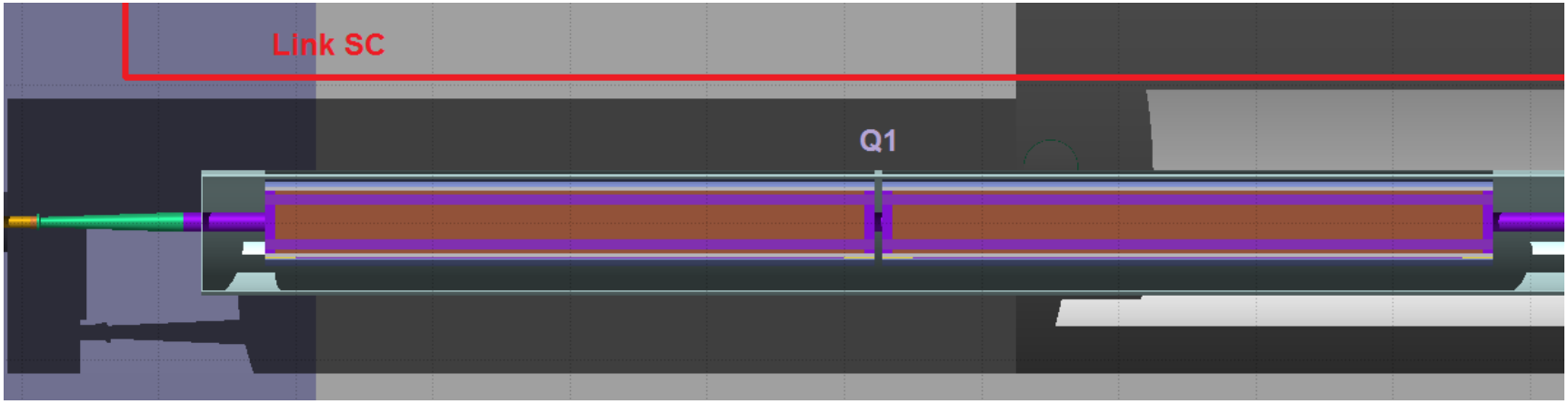


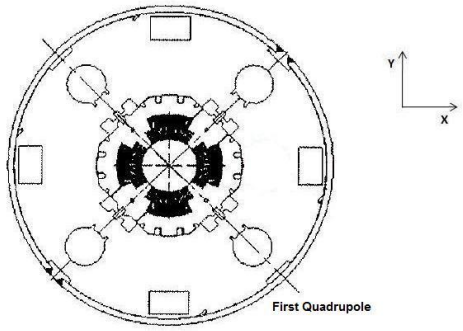
Real Link simulated in FLUKA.
We used this configuration for the P1 simulations.

Critical Points

- **First Quadrupole**: this is the quadrupole closest to the interaction point and here there will be the highest debris.
- **Shuffling Module**: in this region the SC link will pass very close (about 20 cm) to the beam pipe.

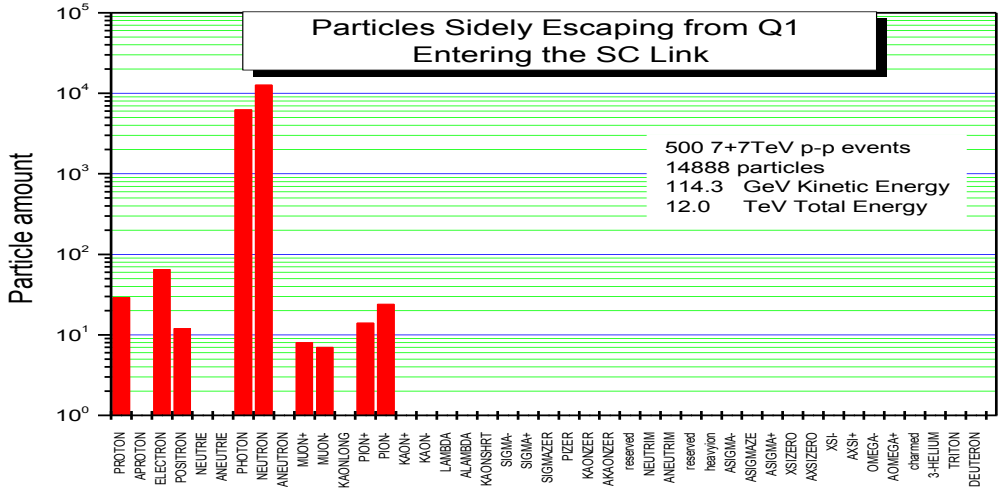
First Quadrupole Region





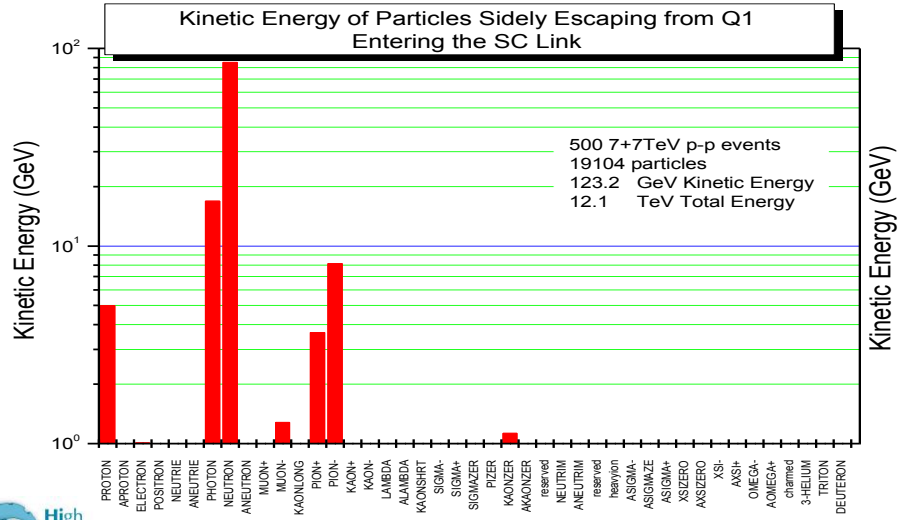
The SC Link will run parallel to the first quadrupole at about 1 m distance.

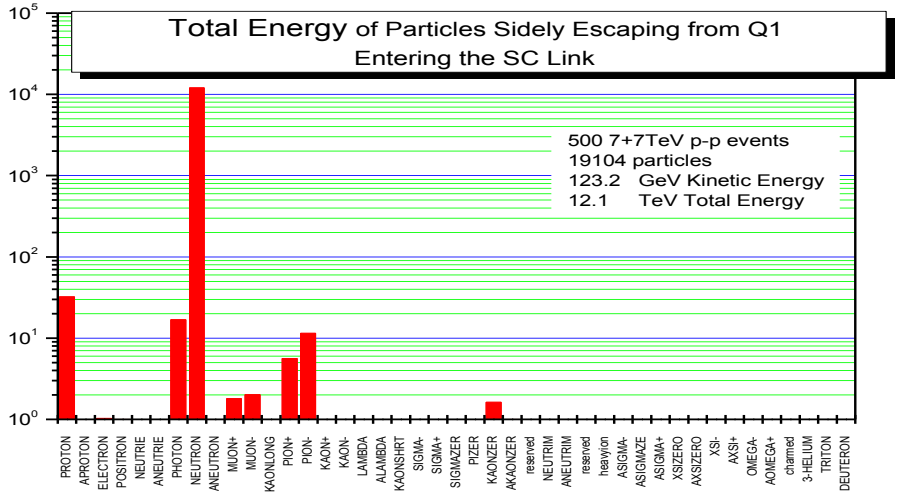
Particles Entering SC Link (10 m) Q1



$7.6 \cdot 10^{18}$ particles/3000 fb^{-1}

High number of neutrons

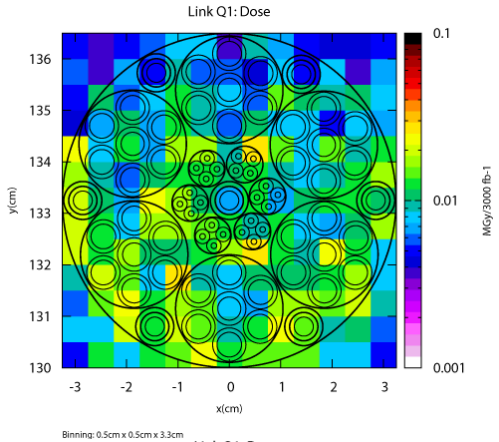


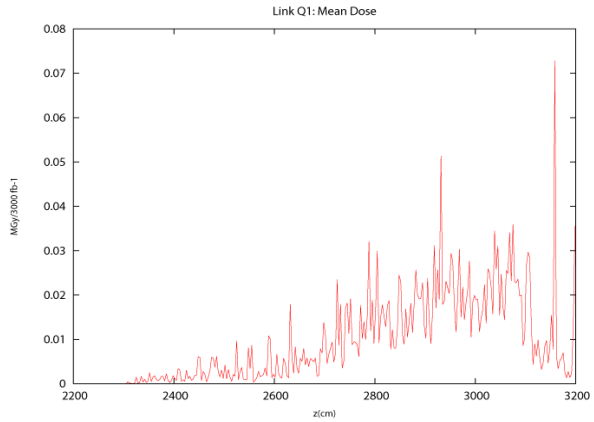


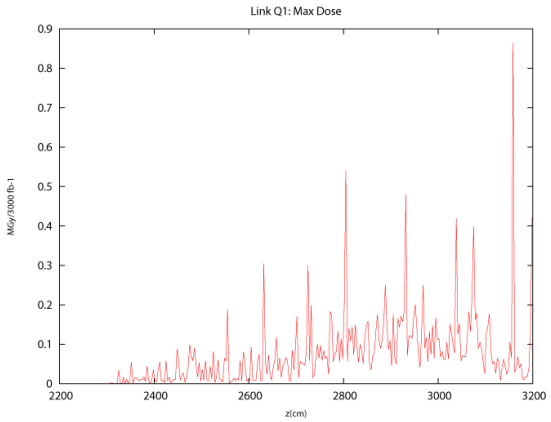
High Luminosity LHC

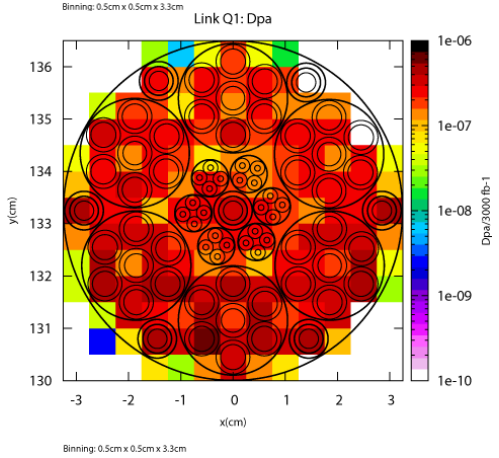
Q1 Dose & Dpa

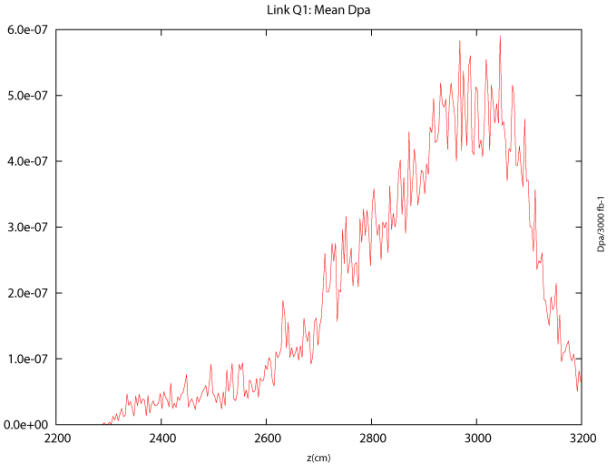
Peaked dose trends: the link is 10 meters long so there will not be an uniform deposition along the length of the cable

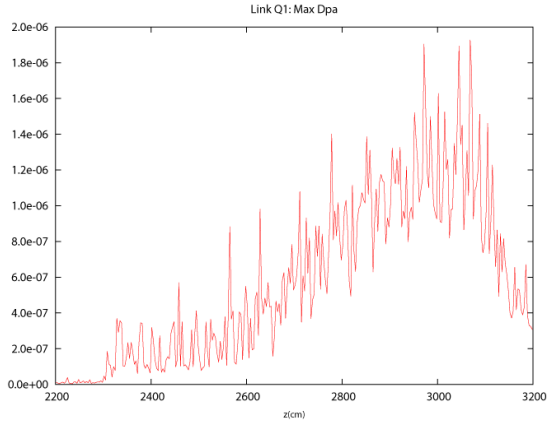






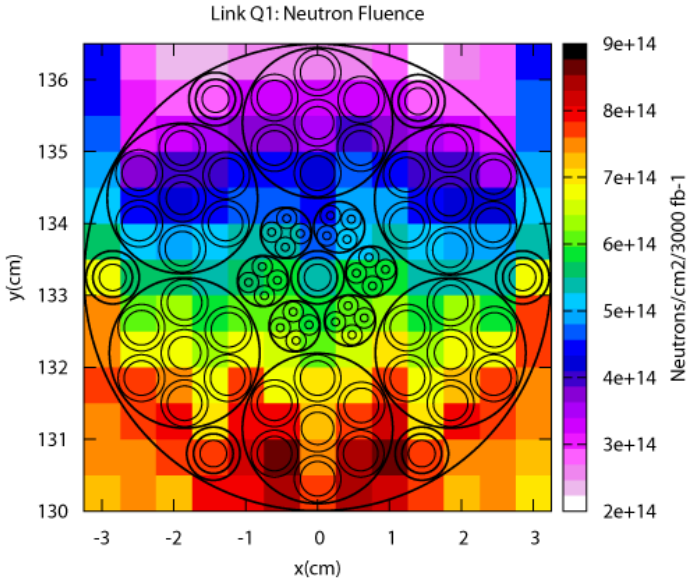






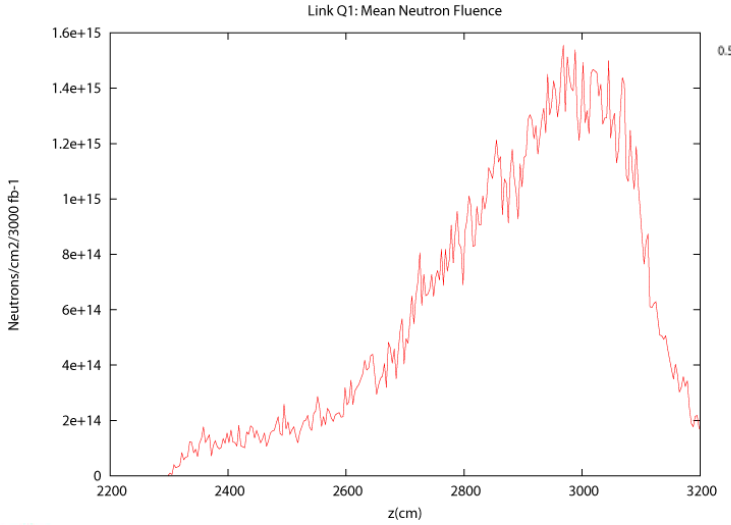
Dpa trends are more regular thank to the high number of neutrons impinging on the link

Q1 Neutron Fluence

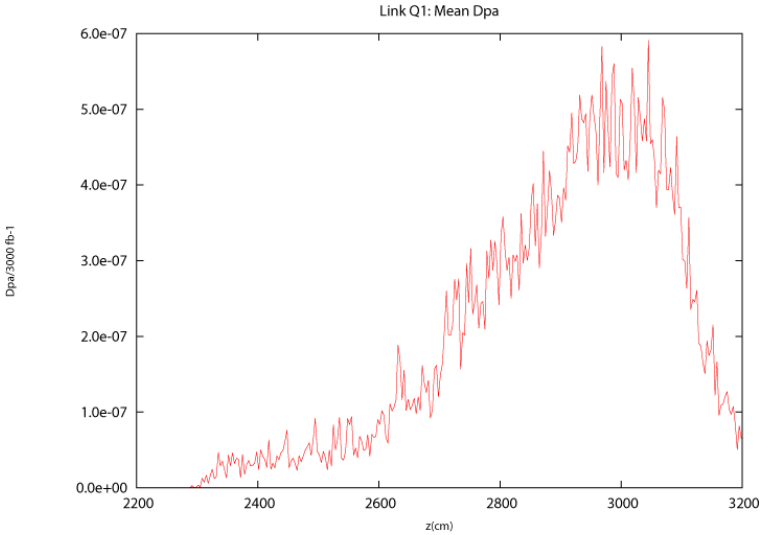


Neutron Fluence

Dpa



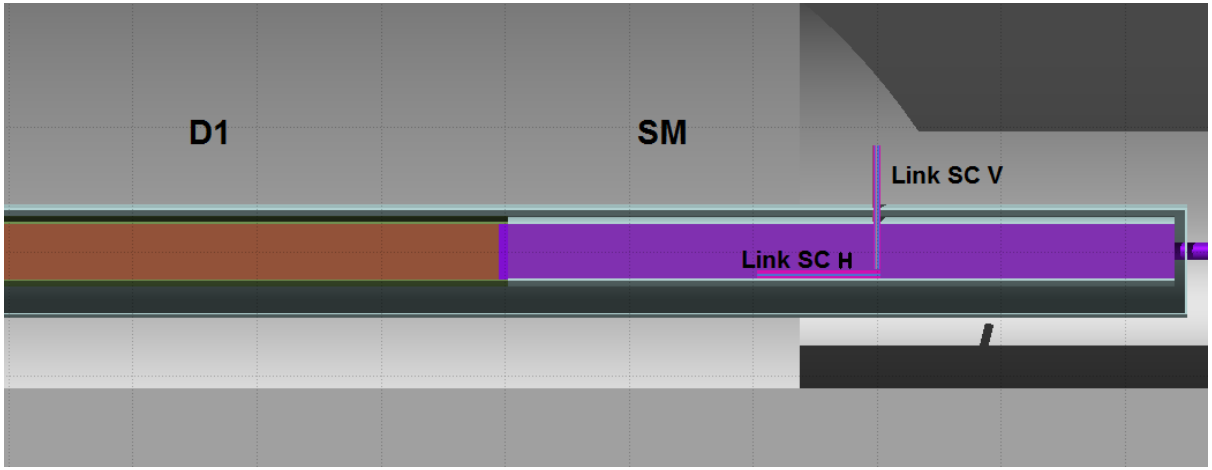
Very similar trends

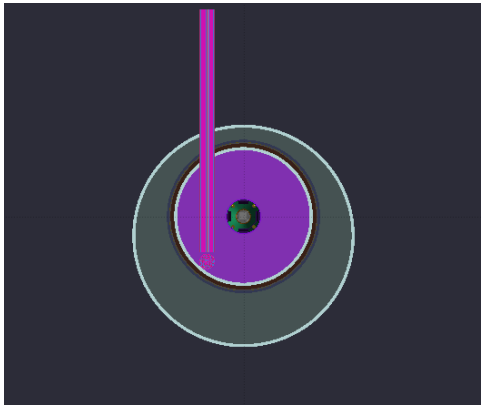


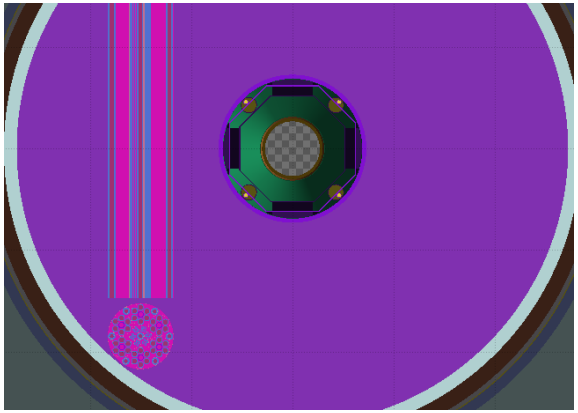
Q1 Analysis

- The region presents a not optimal statistic due to the low number of particles impinging. The particles are not uniformly distributed along the length of the link (except for neutrons which are enough to produce a good fluence trend and so a good dpa trend).
- The **maximum dose and maximum dpa values are low** and the statistical error is under 20%.

Shuffling Module Region

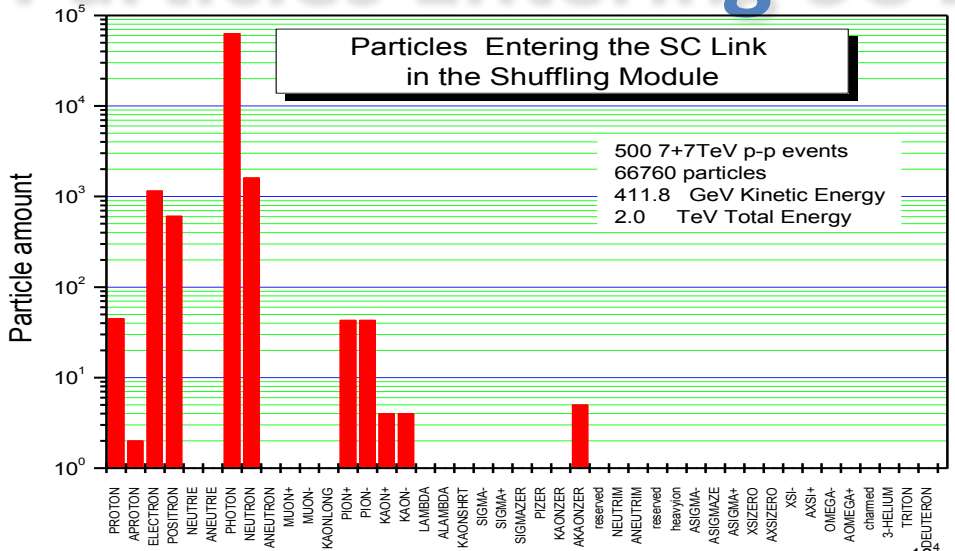






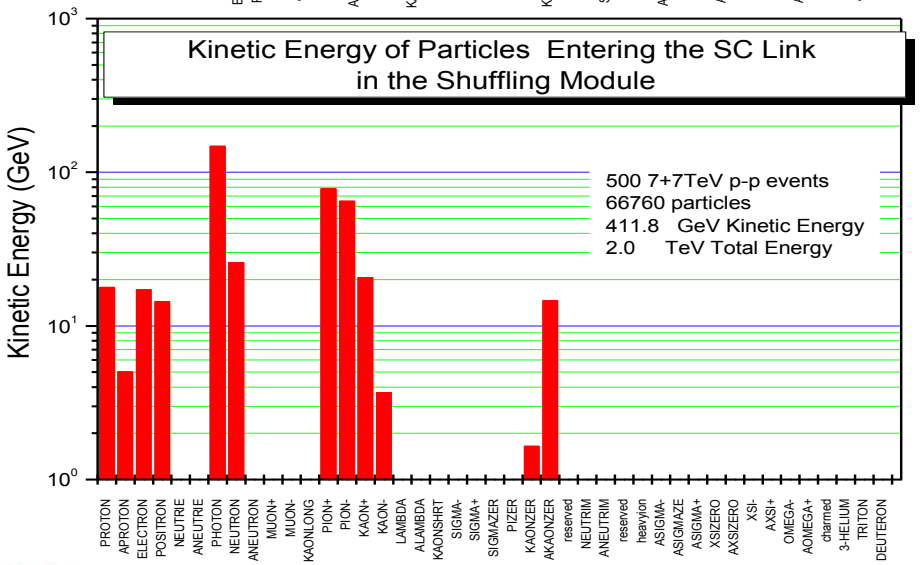
The SC link will enter in the shuffling module from above (vertical cable) and than will lay on the bottom (horizontal cable) before been separated in his components and connected to the loads.

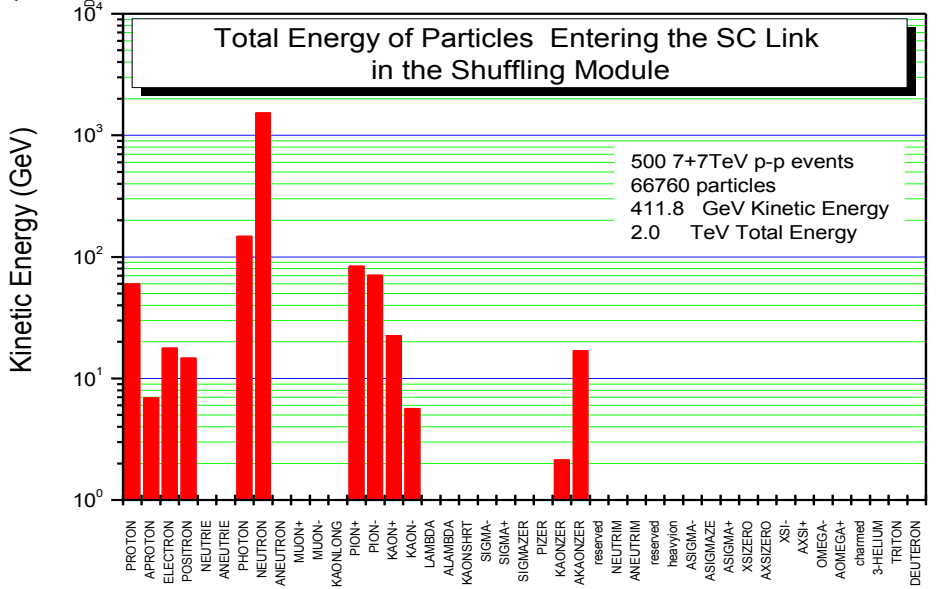
Particles Entering SC Links (2x1m) SM



$3.4 \cdot 10^{19}$ particles/3000 fb^{-1}

High number of photons

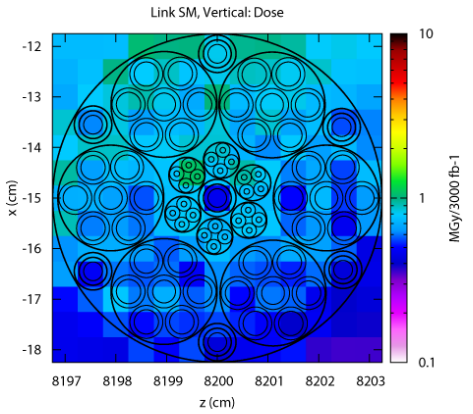


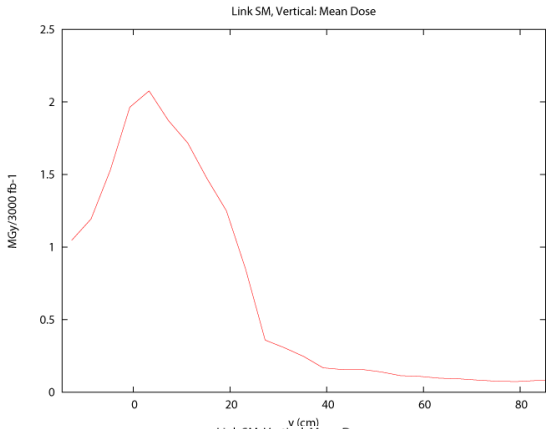


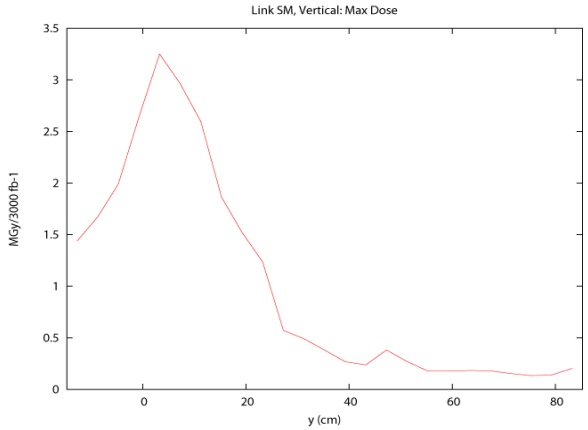
High Luminosity LHC

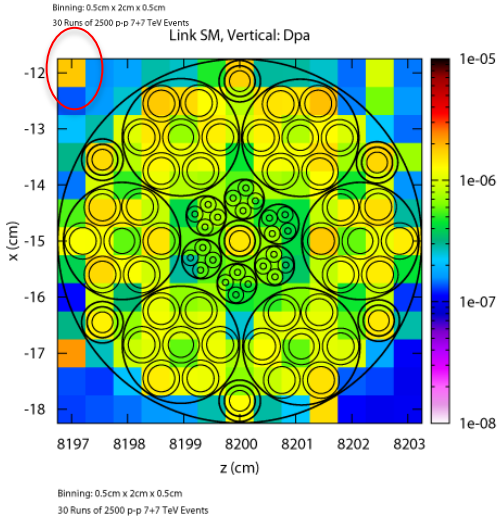
SM Vertical Cable Dose & Dpa

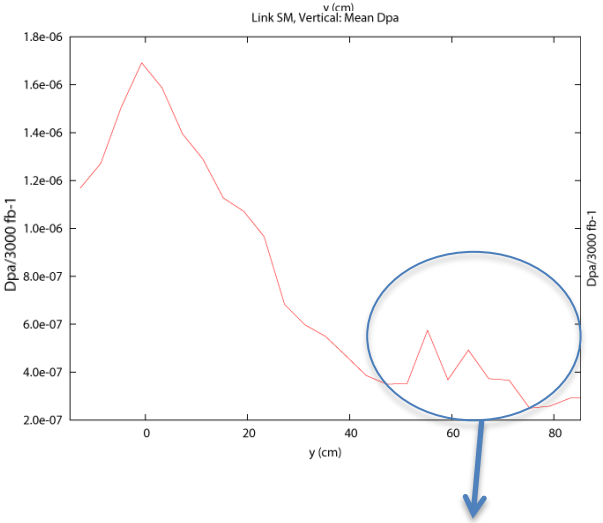
Good trends: the high number of particles impinging on the same bins gives an excellent statistic

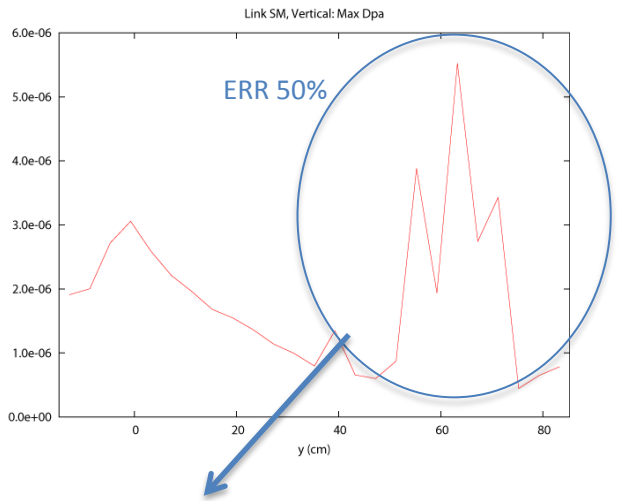






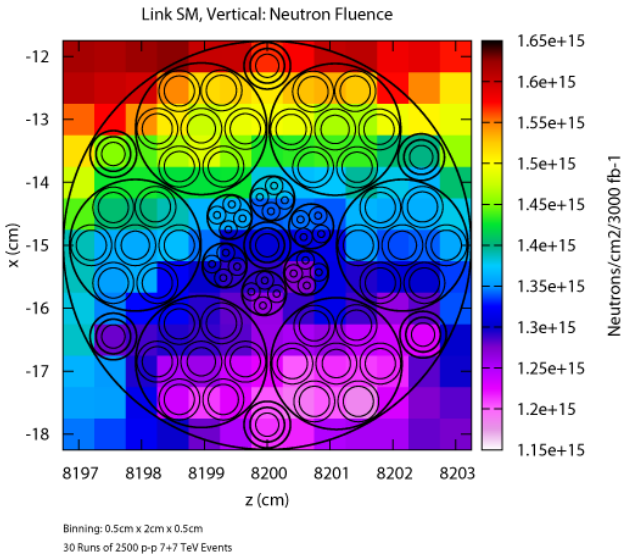


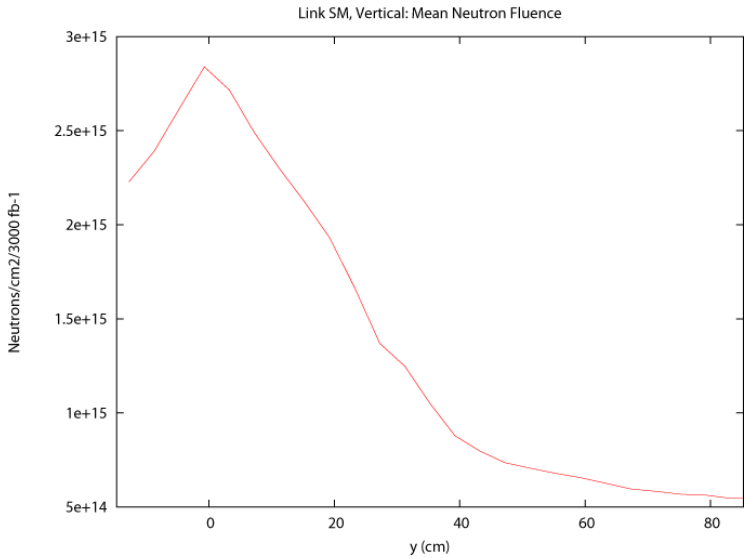


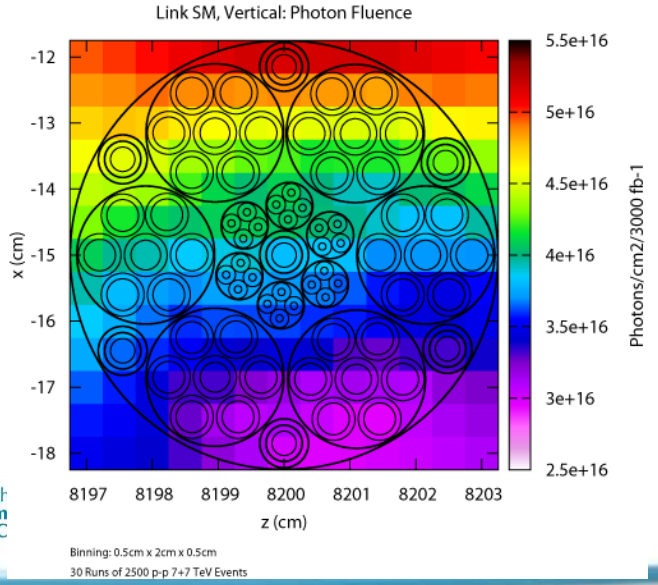


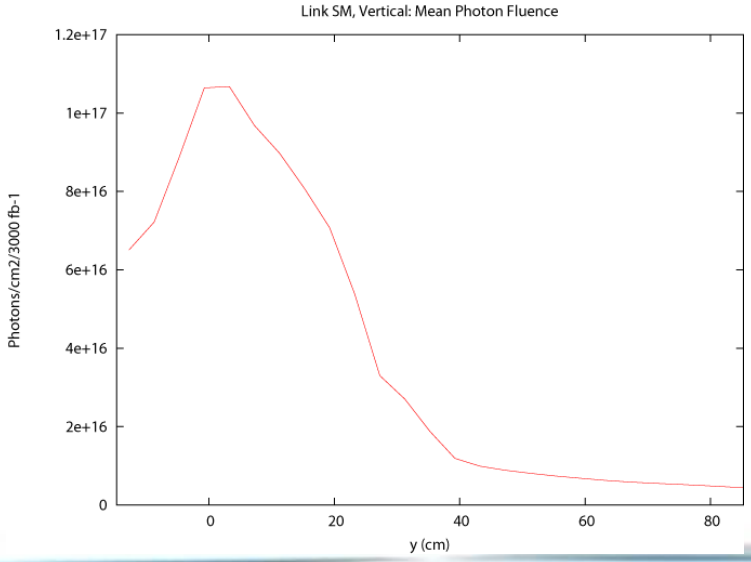
Peaks due to the dpa in air: they must be ignored

SM Vertical Cable Fluences

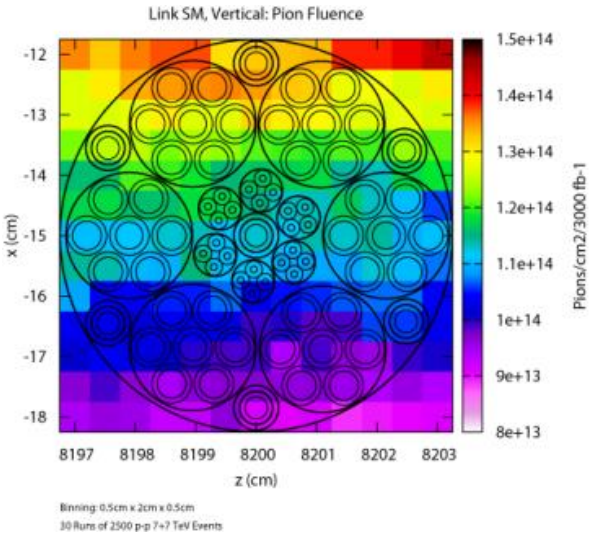


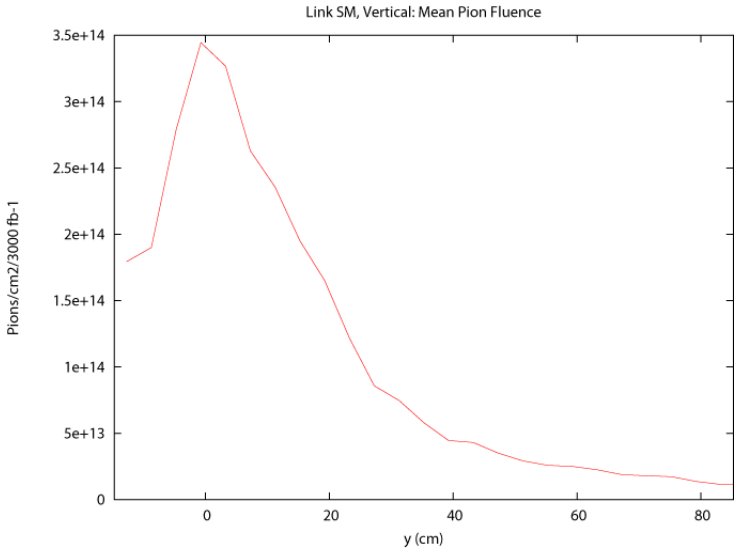


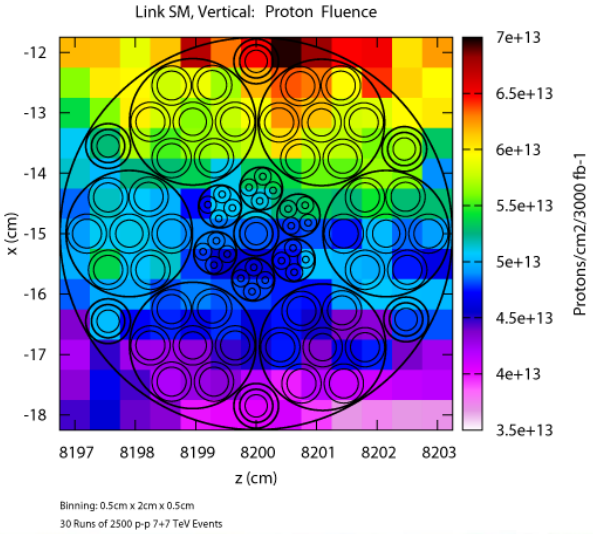


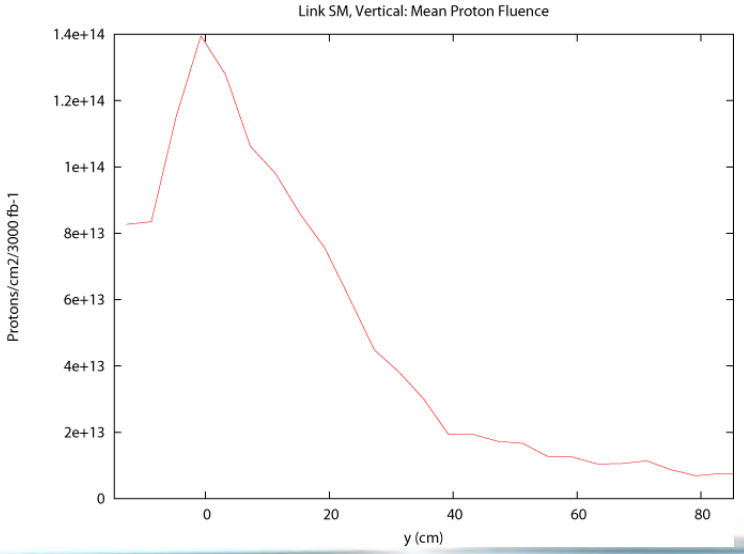


SM Vertical Cable Fluences



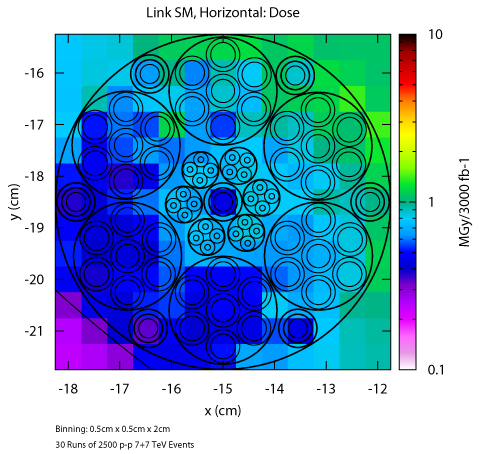


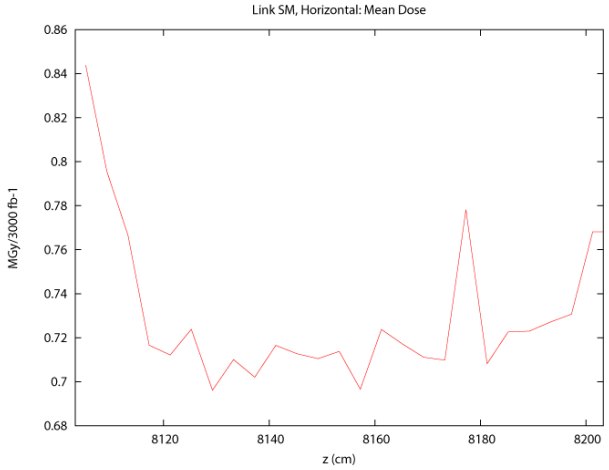


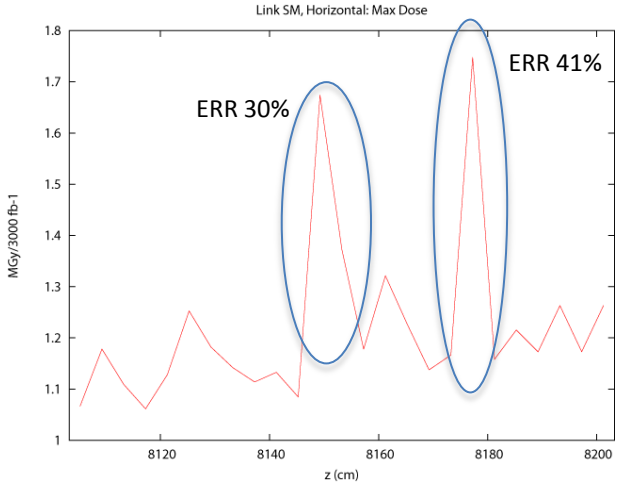


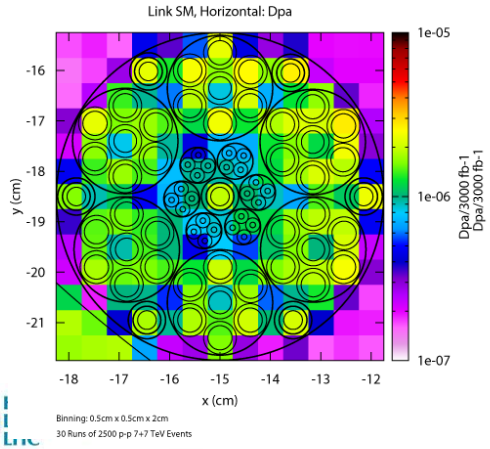
SM Horizontal Cable Dose & Dpa

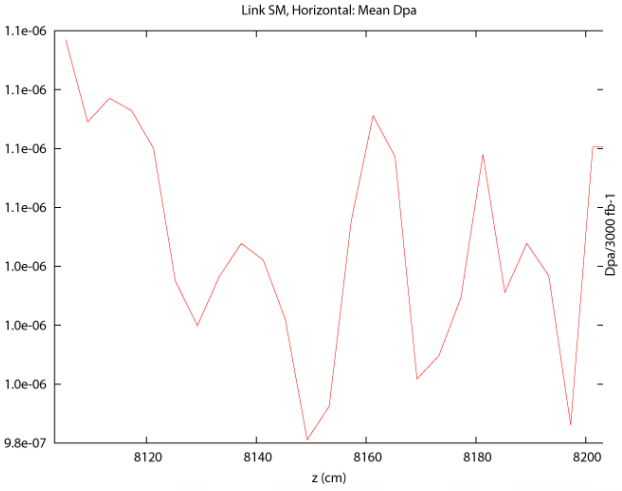
The circled peaks are due to very energetic Single Events which don't permit a good statistical convergence of the results: they can be neglected

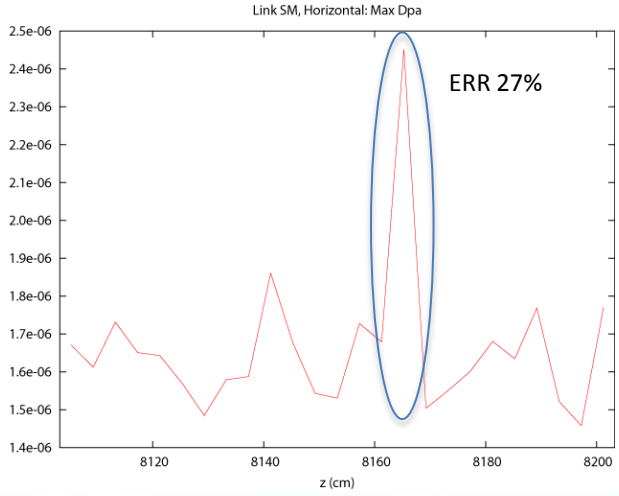




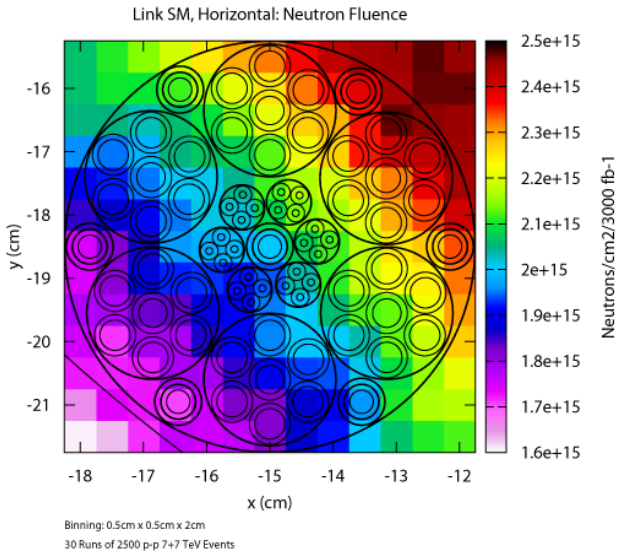


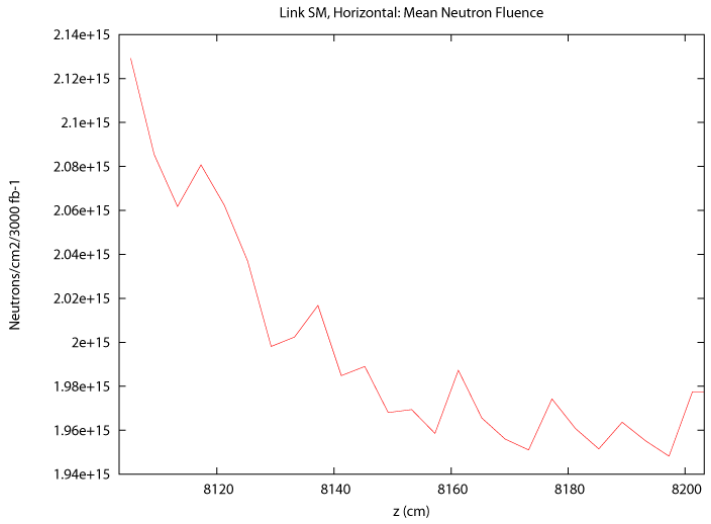


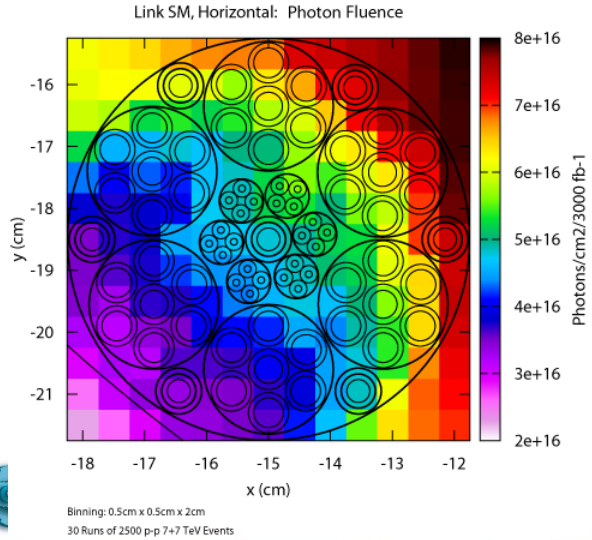


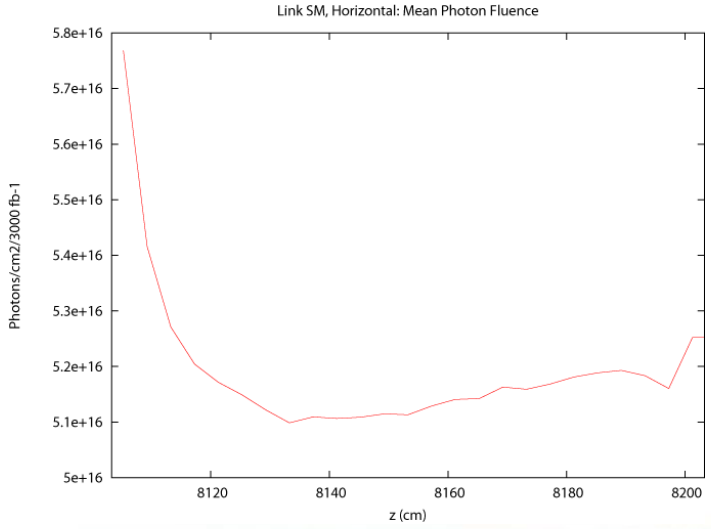


SM Horizontal Cable Fluences



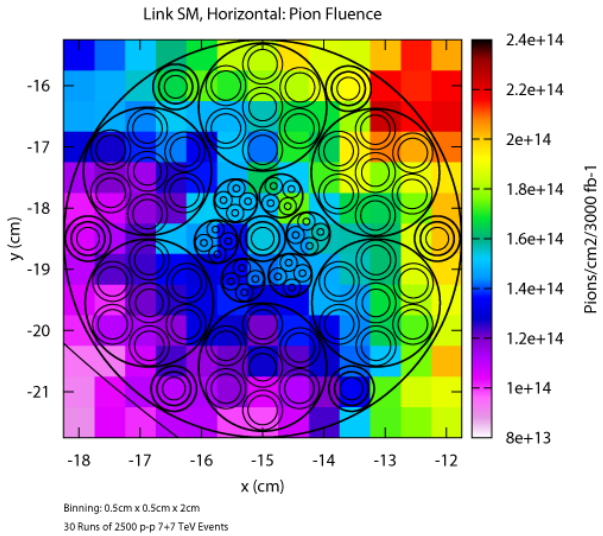


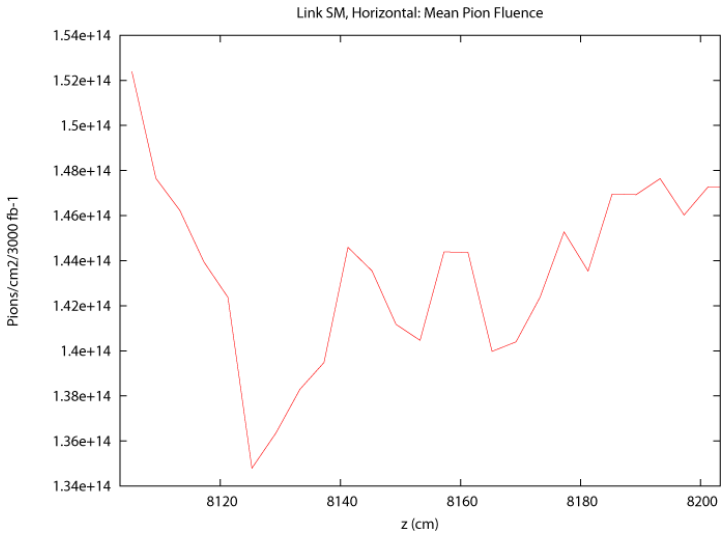


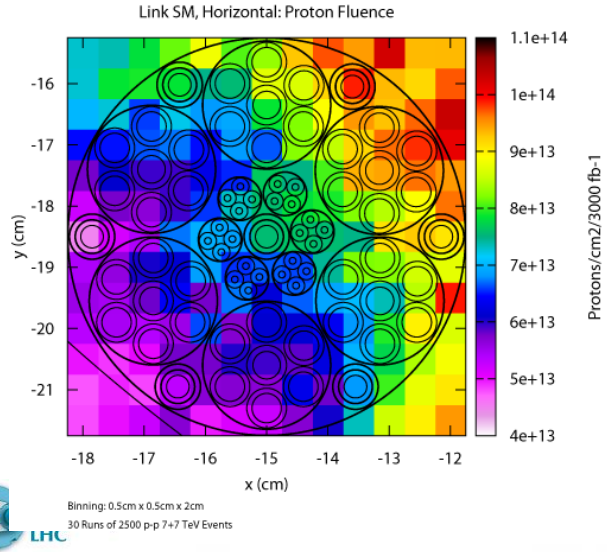


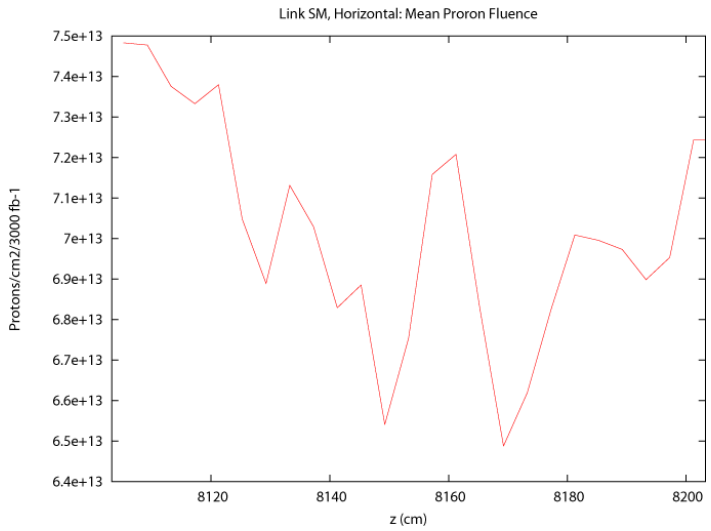
The number of neutrons and photons impinging on the SC Link are enough to generate good trends along the length of the cable

SM Horizontal Cable Fluences









The little number of pions and protons impinging on the SC Link causes irregular trends

SM Analysis

- In the vertical cable the trends are regular and the errors are very low.
- In the horizontal cable there are some Single Events that cause anomalous peaks with high error (greater than 20%) that can be neglected for an integrated analysis.
- Being the maximum dose and maximum dpa in the vertical section of the SC link **we will focus on the vertical cable for the Shuffling Module region.**

Conclusions

Region	Max Dpa [dpa]	Err%	Max Dose [MGy]	Err%
First Quadrupole	$1.97 \cdot 10^{-6}$	17.6	0.86	15.7
Shuffling Module	**$3.11 \cdot 10^{-6}$**	7.0	**3.30**	5.8

The maximum values in both the critical regions are very low:

- the dose shows a peak of 3.3 MGy when the design limit for the SC Link (precisely for the kapton) is 50 MGy
- the dpa maximum is of the order of magnitude of 10^{-6} that will be probably under the safety threshold (not yet defined)

The SC links in the P1 will live until the dead of HL-LHC

Acknowledgment

感謝

- A. Ballarino
- F. Cerutti , L. S. Esposito

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