PARTICLE FLUENCES ON LHC MAGNETS

Francesco Cerutti

Anton Lechner and Alessio Mereghetti

with contributions from

Markus Brugger

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A WORD OF CAUTION

This presentation is intended to characterize the HL-LHC radiation environment for the cables (superconductor and insulator) of the most exposed magnets, i.e. the quadrupoles of the final focus triplet, mostly subject to the collision debris, for a target integrated luminosity of 3000 fb^{-1} at 14 TeV center-of-mass energy

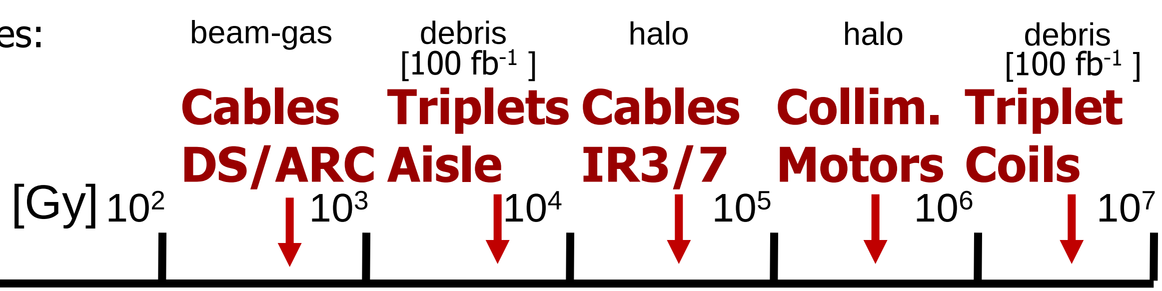
However, the definition of the HL-LHC layout is going to start now, so the one adopted here is just a tentative and quite simplified approximation. In particular, no shielding is implemented in the magnet design. Therefore, absolute numbers should be taken as providing orders of magnitude.

Machine monitors, due to their location, provide run-time values which are quite far from the values experienced by the magnet coils. Simulations play an essential role for estimating the latter ones, while being benchmarked against the first ones.

Large radial (!) and longitudinal gradients in the machine

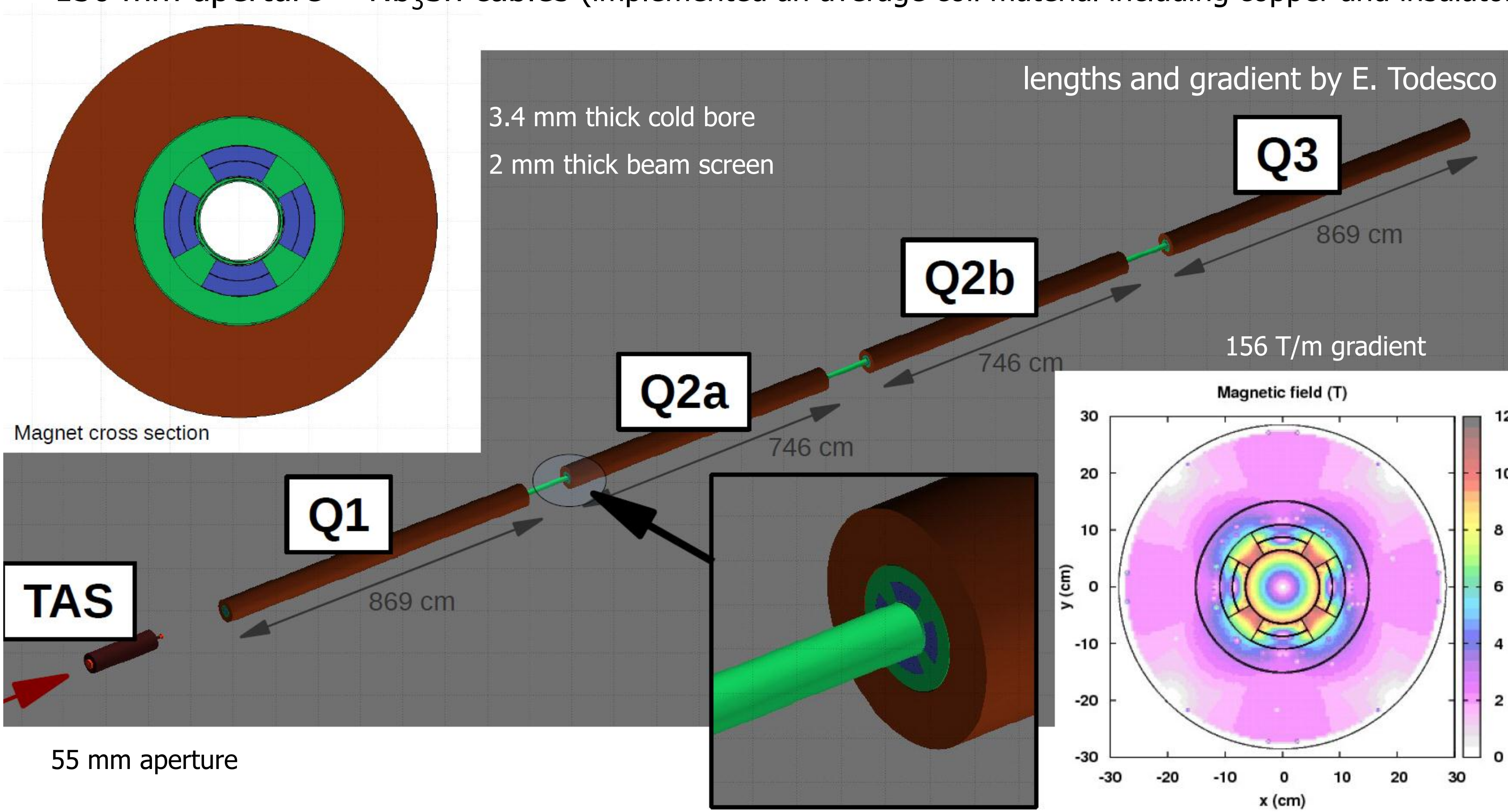
and different loss sources:

per <u>nominal</u> LHC year
"HotSpots"



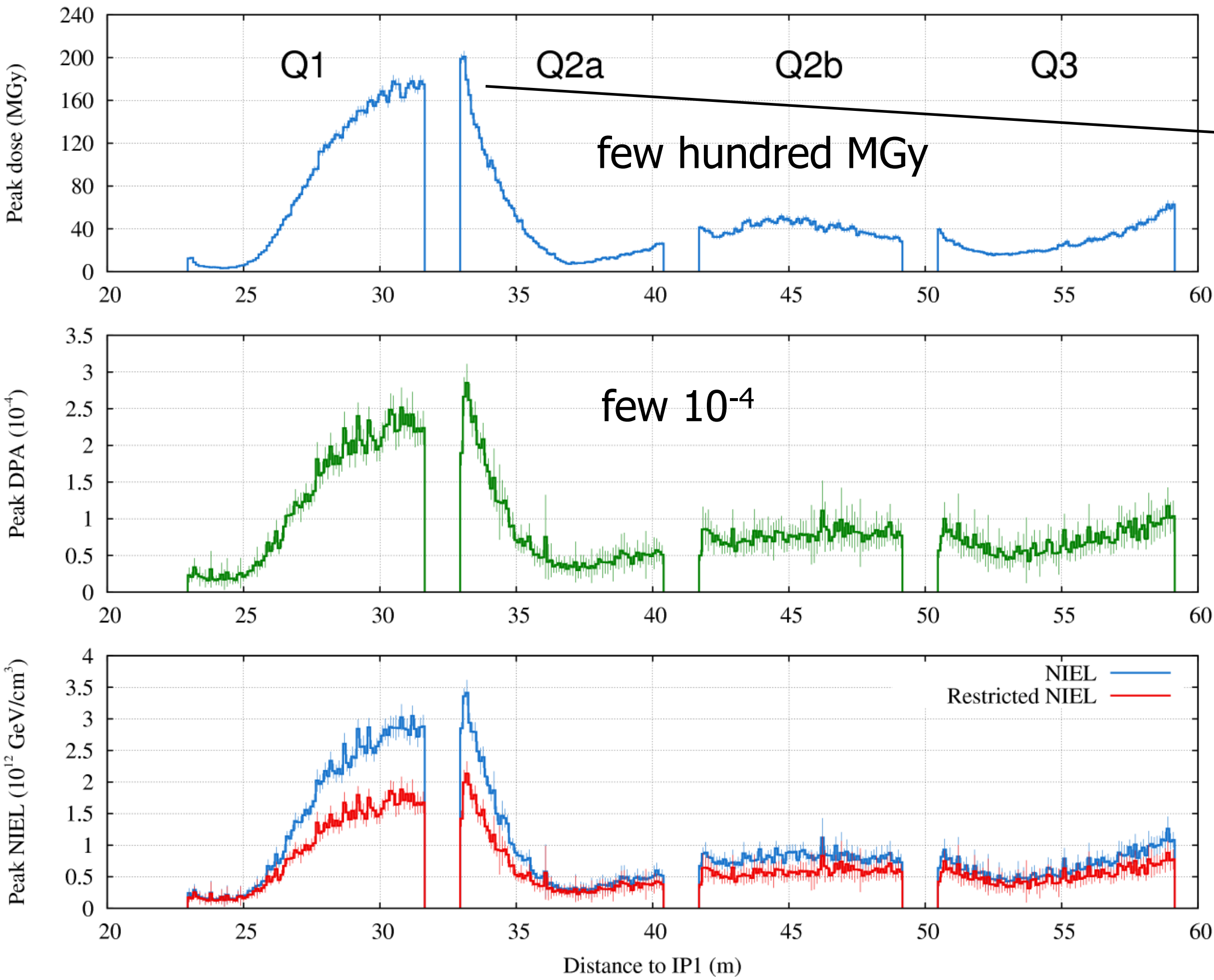
THE MODEL

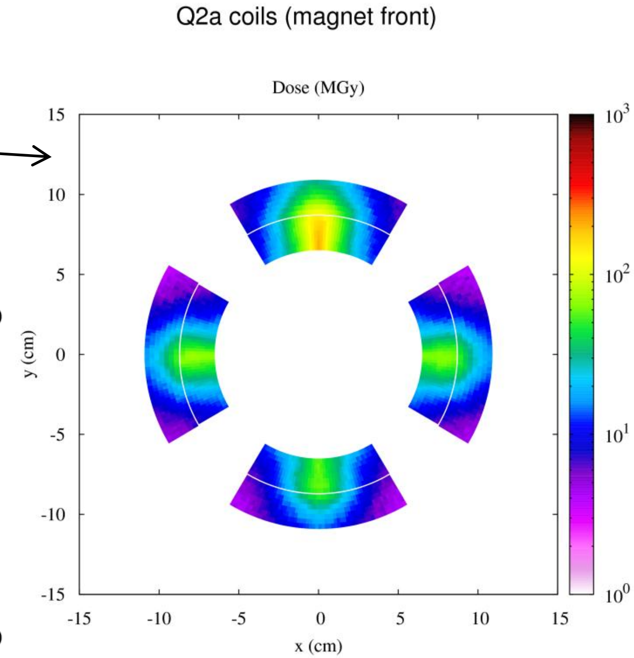
130 mm aperture Nb_3Sn cables (implemented an average coil material including copper and insulator)



PEAK DOSE, DPA AND NIEL IN THE COILS

referred to the *innermost 3 mm* over **3000 fb^{-1}** for 7 TeV proton beams, vertical crossing (205 μrad half angle)





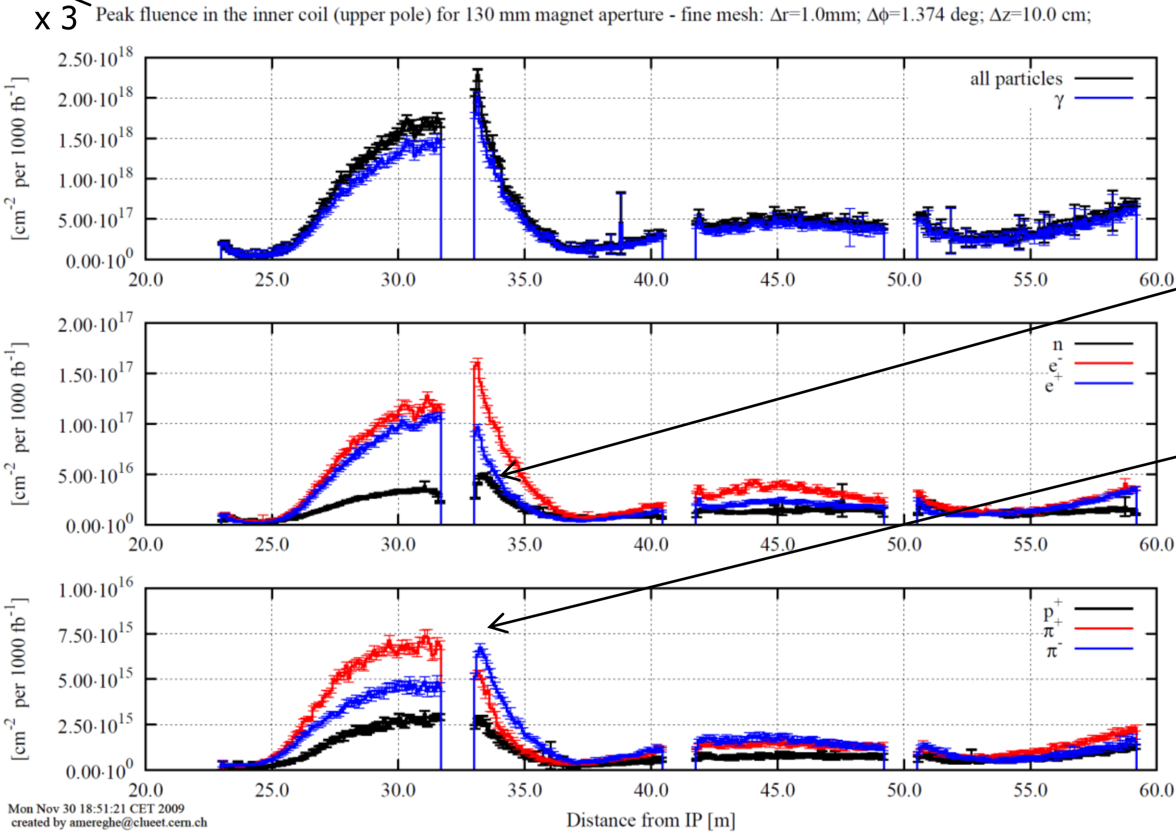
DPA and restricted NIEL threshold 40 eV

PEAK FLUENCE IN THE COILS

in the inner cable

[cm^{-2} per **1000 fb^{-1}**]

x 3



peak of

(1.5) 10^{17}

neutrons $cm^{-2}/3000\ fb^{-1}$

and

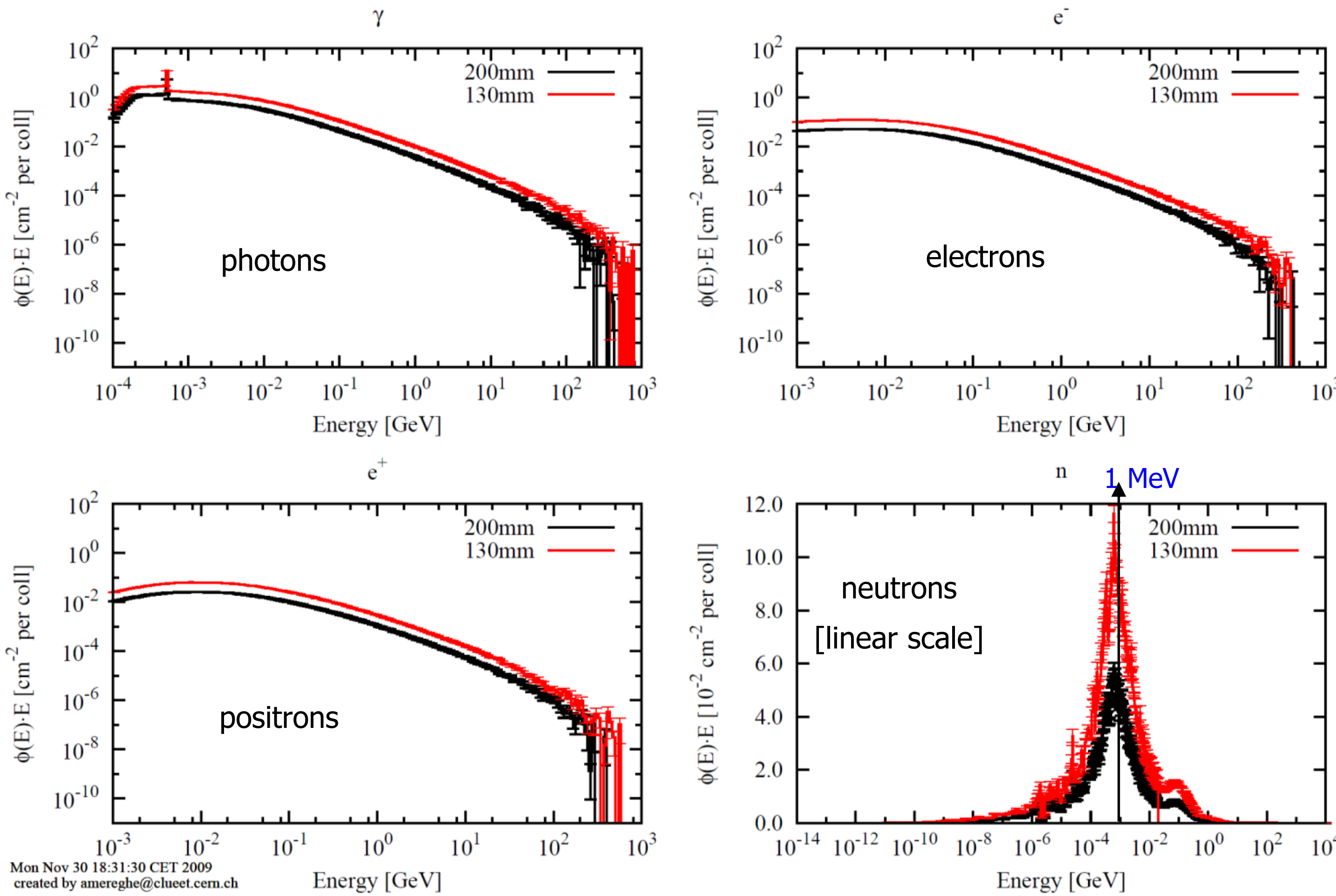
a few 10^{16}

pions $cm^{-2}/3000\ fb^{-1}$

tracklength fraction [%]	
photons	88
electrons/positrons	7
neutrons	4
pions	0.45
protons	0.15

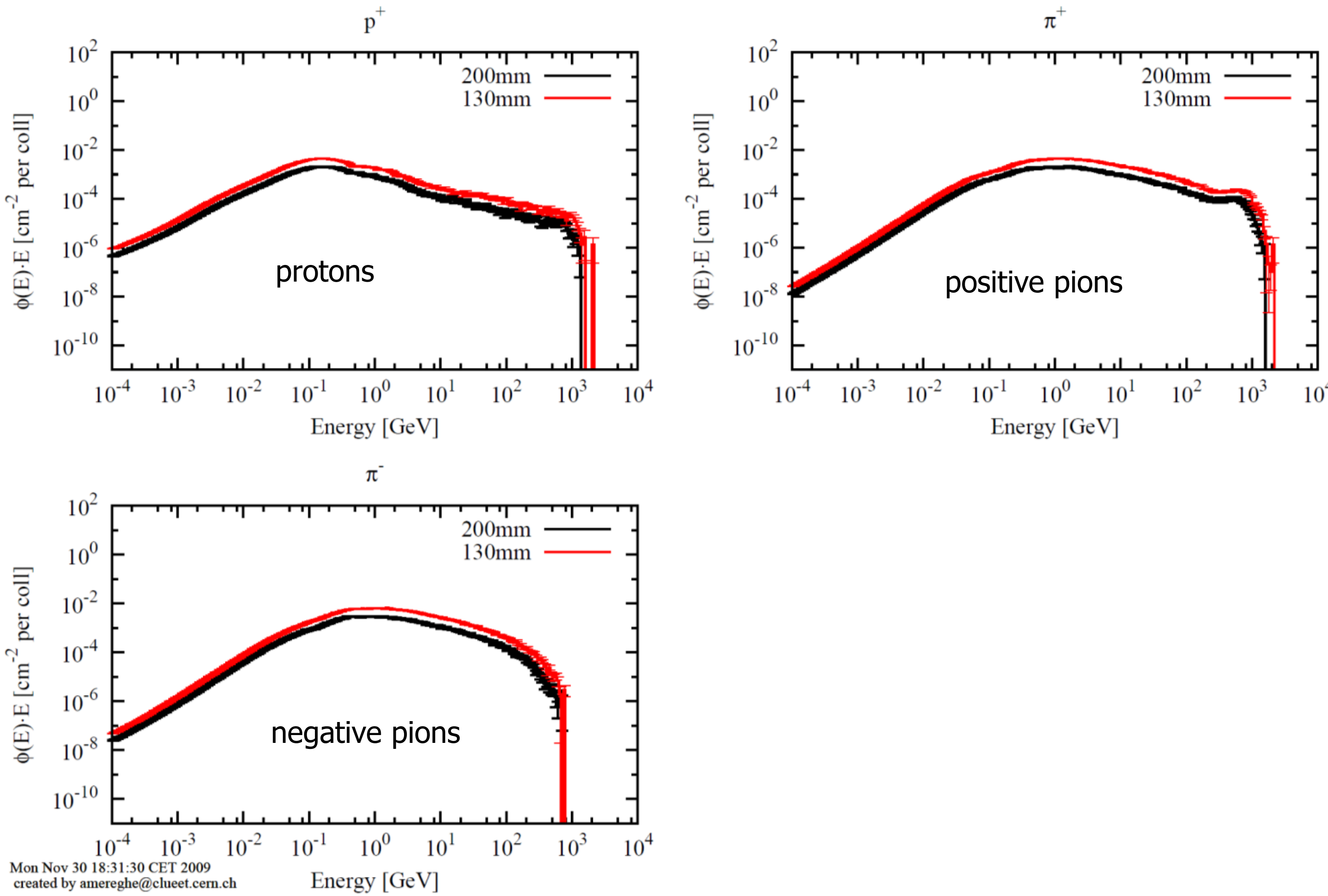
PARTICLE SPECTRA IN THE COILS [I]

Particle spectra in the inner coil (upper coil) in Q2a (at peak location, i.e. 15 cm from magnet beginning)

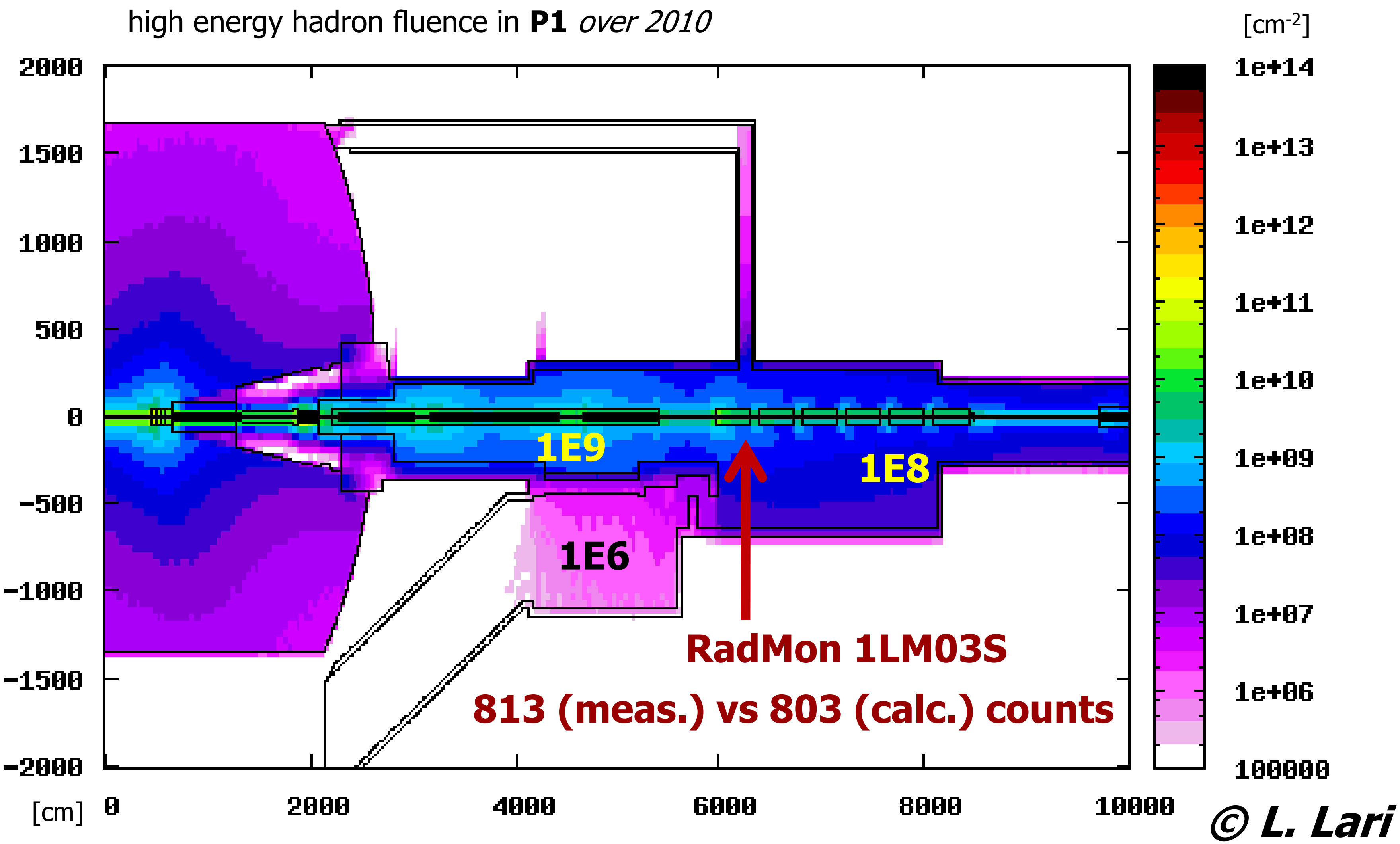


PARTICLE SPECTRA IN THE COILS [II]

Particle spectra in the inner coil (upper coil) in Q2a (at peak location, i.e. 15 cm from magnet beginning)



BENCHMARKING VS FIRST LHC EXPERIENCE [I]

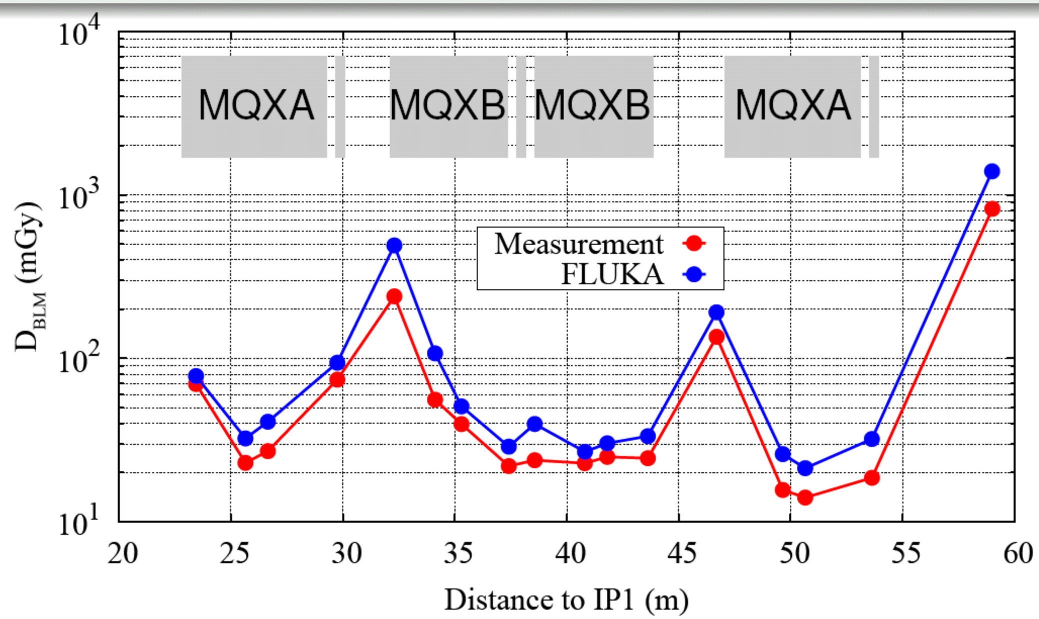


BENCHMARKING VS FIRST LHC EXPERIENCE [II]

stable collisions in **P1** at 7 TeV center-of-mass *on 2010 Oct 28*

Time-integrated dose in BLMs

Measurement vs FLUKA (for an integrated luminosity of 6255.71 nb^{-1}):



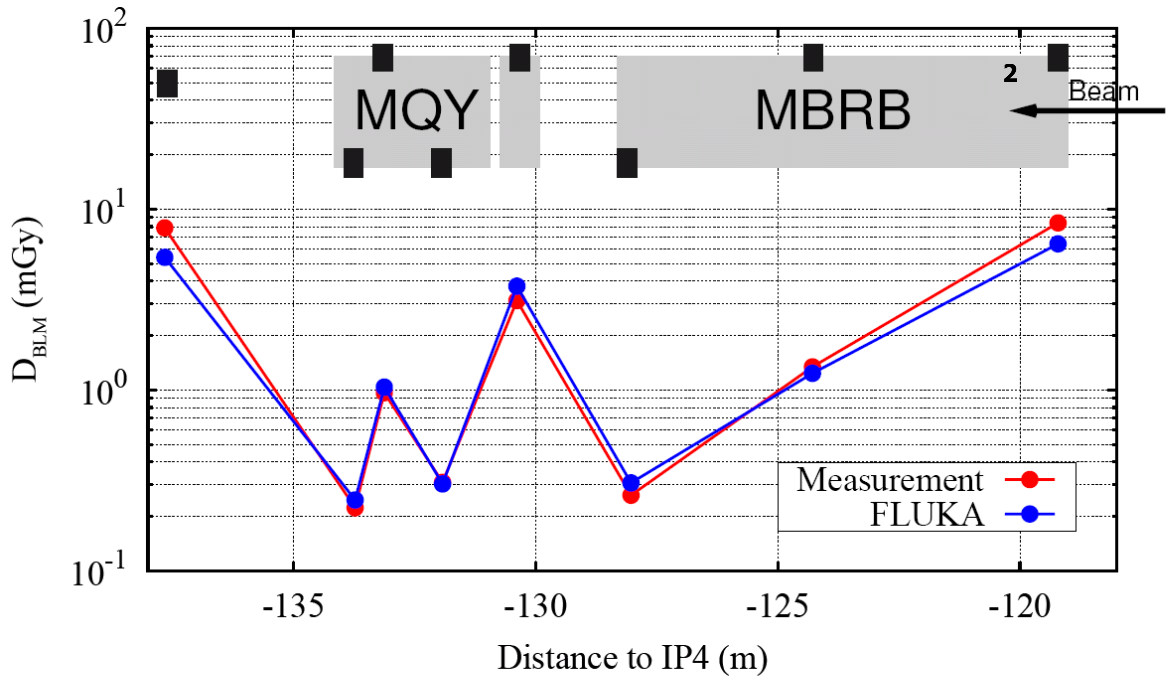
- Relative pattern well reproduced, some discrepancies can be ascribed to missing geometry details (lessons learned from wire scanner simulations)
- **Systematic offset to be understood**, possible source of differences could be normalization (luminosity, total cross section), ...

BENCHMARKING VS FIRST LHC EXPERIENCE [III]

quench test induced by the wire scanner *on 2010 Nov 1* on the left of **P4** at 3.5TeV

Time-integrated dose in BLMs

Experiment vs FLUKA (v_w=25 cm/sec):



Absolute comparison!

geometry details are critical for the accuracy of the prediction of the BLM responses

CONCLUSIONS

Preliminary (without cold shielding!) calculations indicate that over the HL-LHC target integrated luminosity (3000 fb^{-1}) triplet quadrupole cables and insulators will undergo radiation peak values of the order of

hundred MGy (dose)

10^{-4} (dpa)

$10^{17(16)}$ neutrons(pions)/cm^2 (fluence)

Particle fluence spectra on the coils have been calculated

More accurate evaluations have to refer to the final layout/design