Simulation studies of the mixed radiation field in TCC2 area

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Outline

- Introductory remarks
- Simulation of TCC2 area
- Radiation maps (fluxes and dose rates)
- Dosimetry
- Conclusions

Introductory remarks

We are interested in:

Radiation Tolerance of Components and Systems

→ Total energy deposition and particle fluence suffered by our devices before they fail

Energy deposition in material = DOSE (Gy)

$$1\,\text{Gray} = 1\,\frac{\text{Joule}}{\text{kg}}$$

material dependence

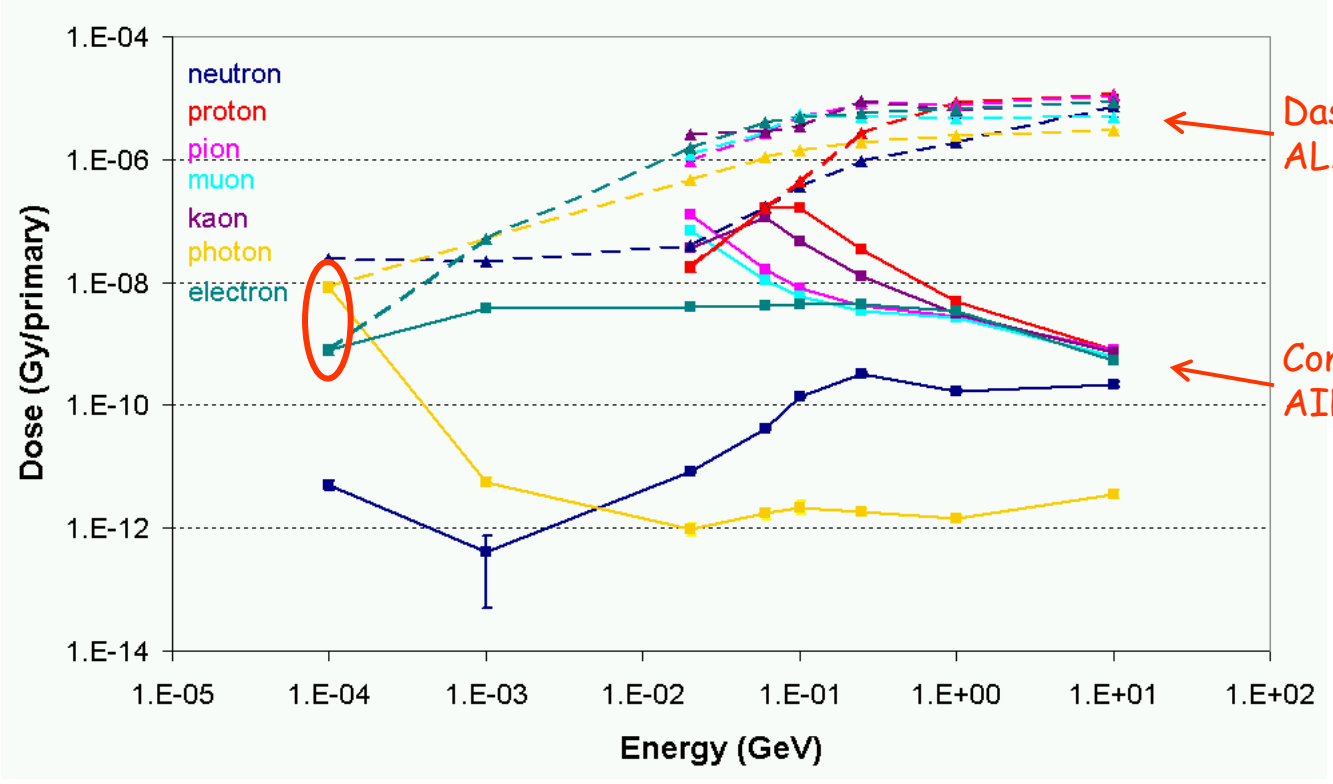
Introductory remarks

Some of our dosimeters:

- Radio-Photo-Luminescence and Thermo-Luminescence Dosimeters (RPL and TLD)
  - Glass / photons and electrons (0.1 - 50 MeV)
    [ISO/ASTM 51956, 2002]
- Polymer-Alanine Dosimeter (PAD)
  - Alanine / photons and electrons (0.1 - 28 MeV)
    [ISO/ASTM Standard 51607, 2002]
- Ionization Chambers (PMI)
  - Air / Charged particles (?)
- Simulation
  - Air / All particles (all energies)

Introductory remarks

Simulation studies using a cylinder of Alanine ($C_3H_7NO_2$) or Air (N+O) and various particles at various energies



Dashed / Triangles: ALANINE

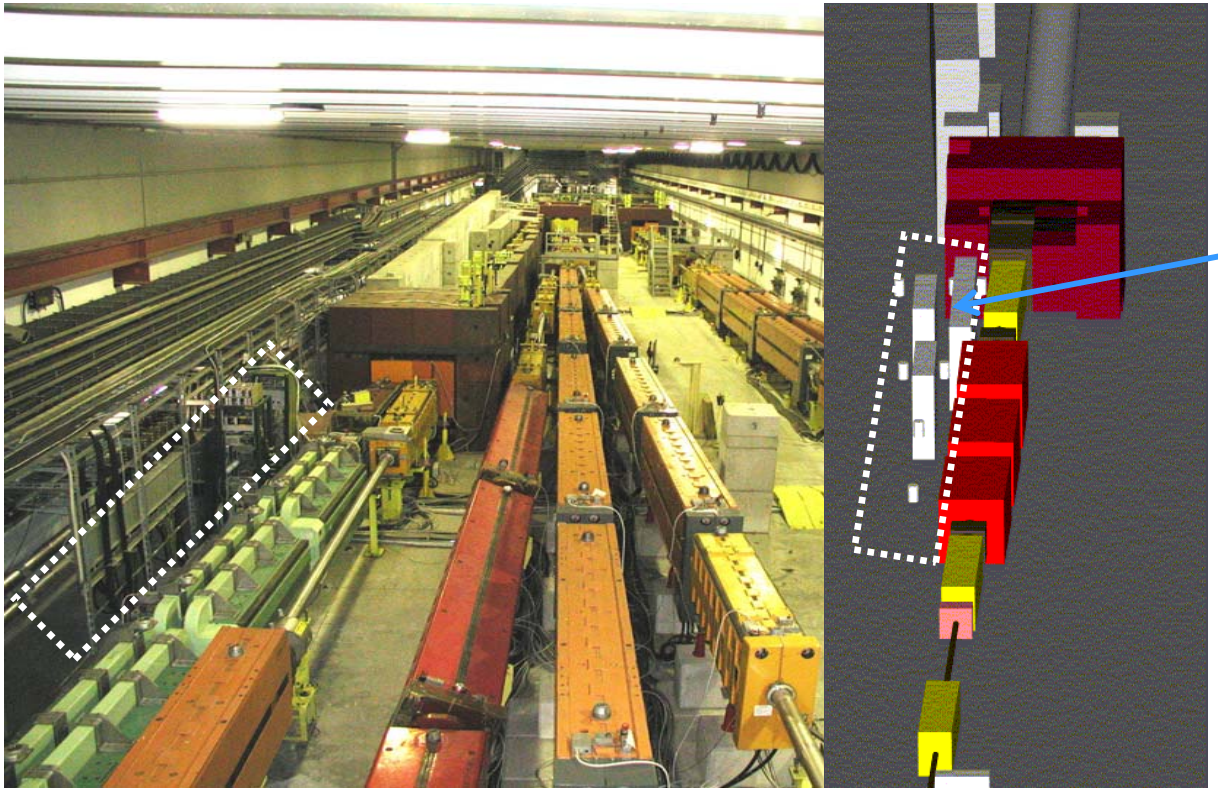
Continuous / Squares: AIR

Important remarks !

Our "axioms":

- Energy Deposition in AIR should be the reference (same for LHC tunnel).
- PMI is the dosimeter of interest.
- PMI measurements in Gy !
  Sv refers only to photons during beam off.
  In TCC2 this is not the usual case …

Simulation of TCC2 area



[www.fluka.org]

... using FLUKA

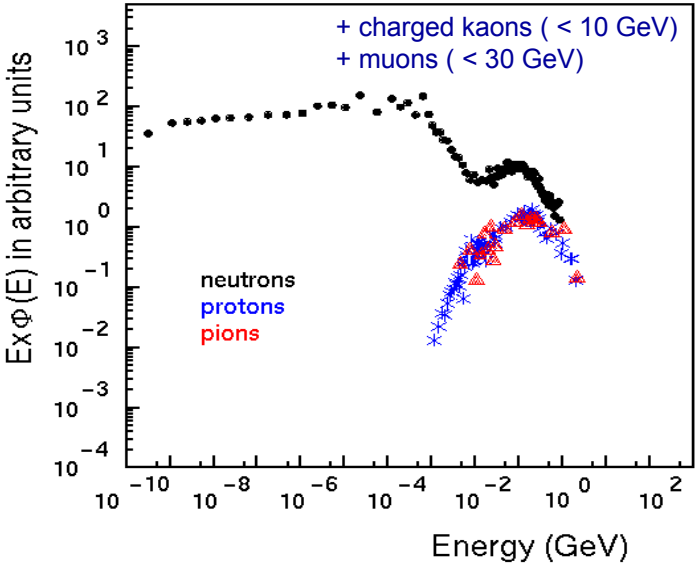
→ Transport and Interaction

electromagnetic (< 1000 TeV)
hadronic particles (< 20 TeV)

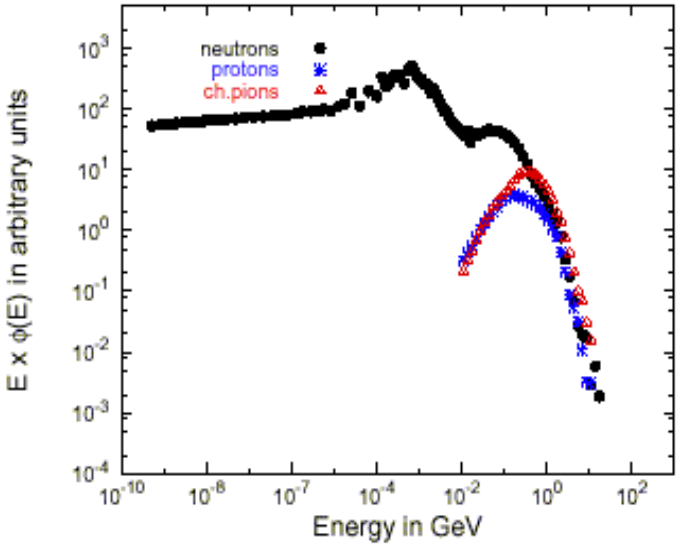
Particle Spectra

The fluences in TCC2 area

(at rack position, 1 - 1.5 m from beam)



The fluences in the LHC tunnel



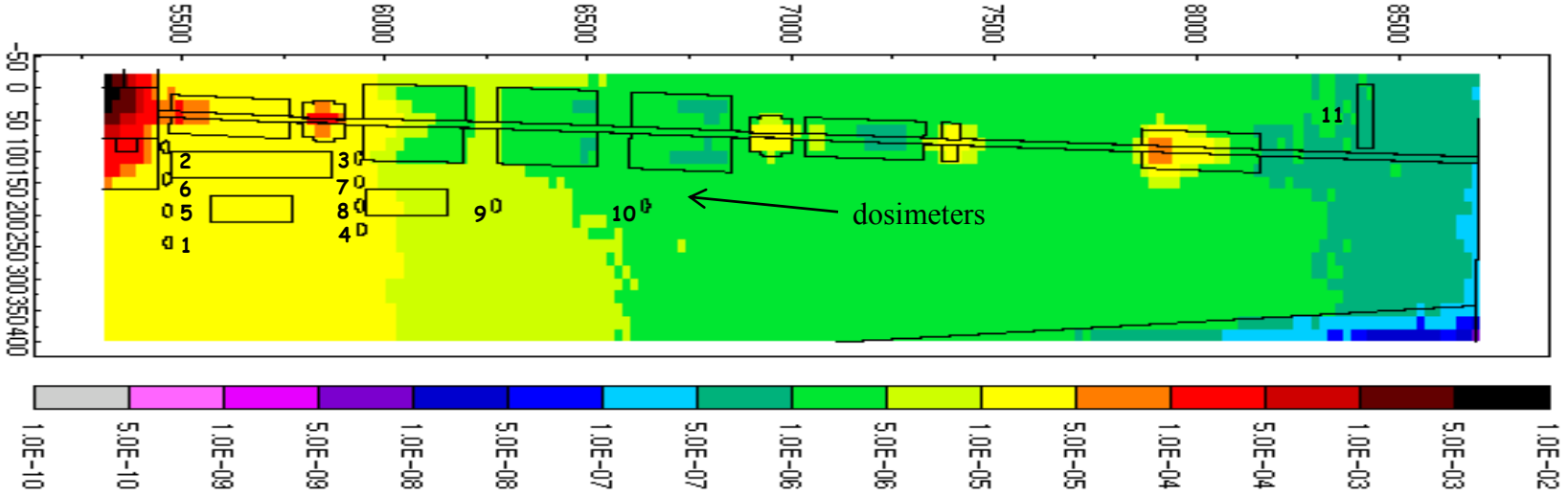
[C. Fynbo, G. Stevenson, CERN, 2001]

Similar spectra (typical of concrete / iron environment)

Almost similar energy ranges…

Fluence map – Total Hadrons

Total hadron fluence in cm^{-2}/proton hitting on the T6 target.



On average we have ~ $3 \cdot 10^{16}$ protons on T6 / day *(see SPS logfile)*

Near TAX:

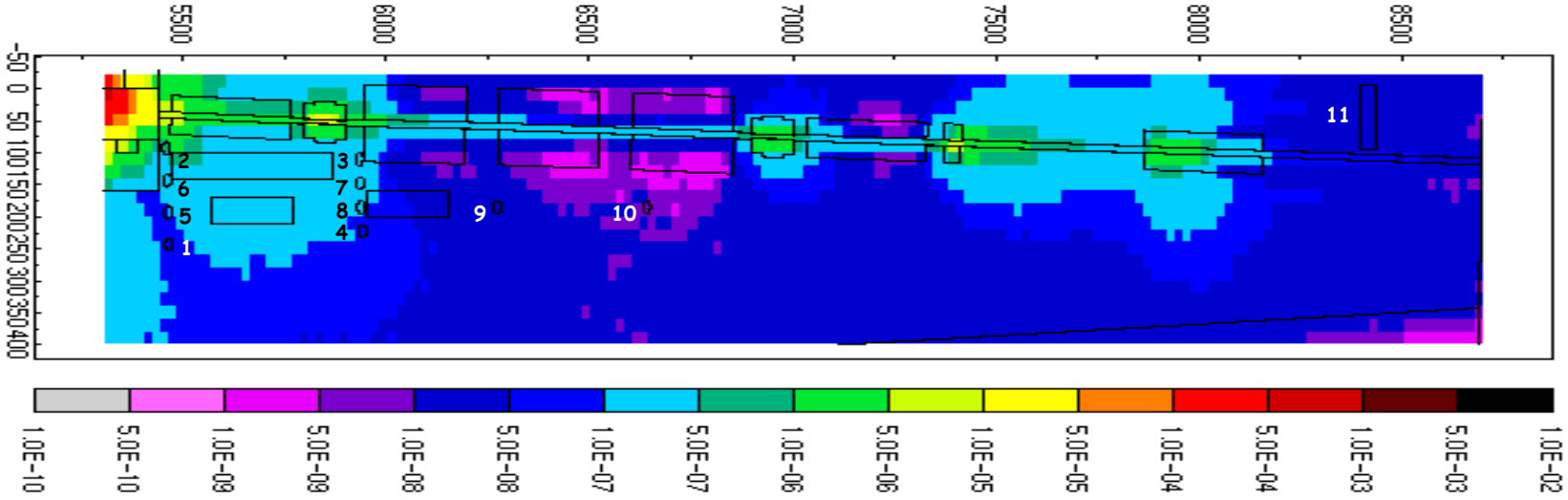
$1 - 5 \cdot 10^{-5}$ cm^{-2}/proton $\times$ $3 \cdot 10^{16}$ protons = $0.3 - 1.5 \cdot 10^{12}$ cm^{-2}/day

In LHC:

~ 10^{12} cm^{-2}/ year *[C. Fynbo, G. Stevenson, CERN, 2001]*

Fluence map – Hadrons > 20 MeV

Hadrons > 20MeV fluence in cm^{-2}/proton hitting on the T6 target.



Near TAX:

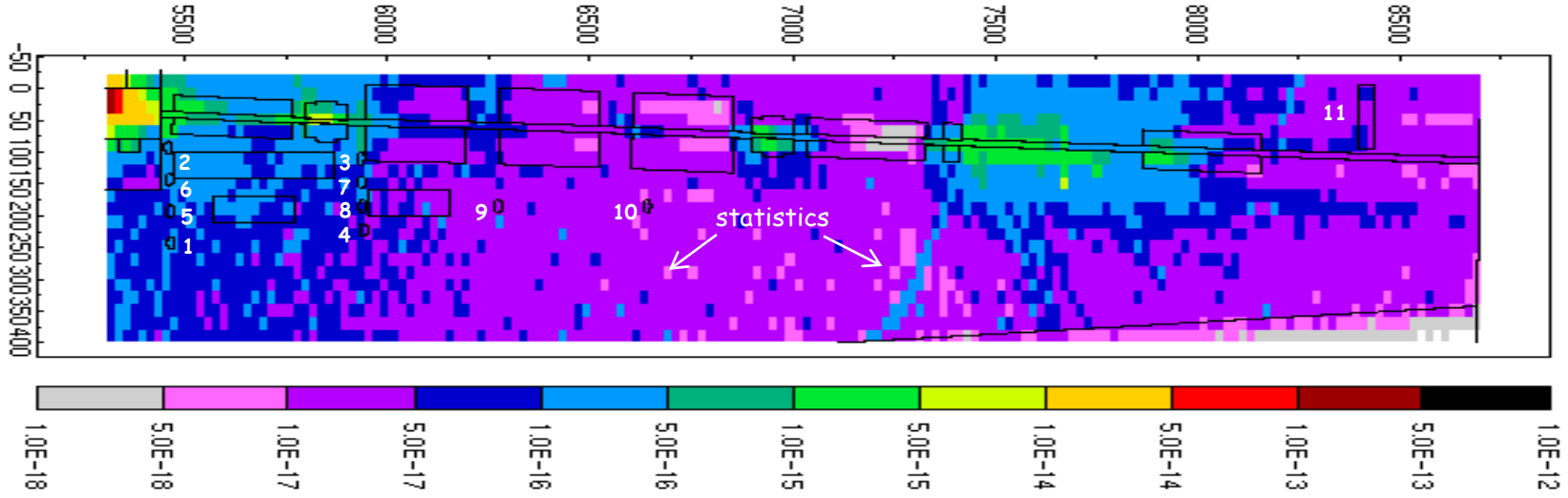
$1 - 5 \cdot 10^{-7}$ cm^{-2}/proton $\times$ $3 \cdot 10^{16}$ protons = $0.5 - 1.5 \cdot 10^{10}$ cm^{-2}/day

In LHC:

~ 10^{10} cm^{-2}/ year *[C. Fynbo, G. Stevenson, CERN, 2001]*

Dose map

Dose in Gy/proton hitting on the T6 target.



Near TAX:

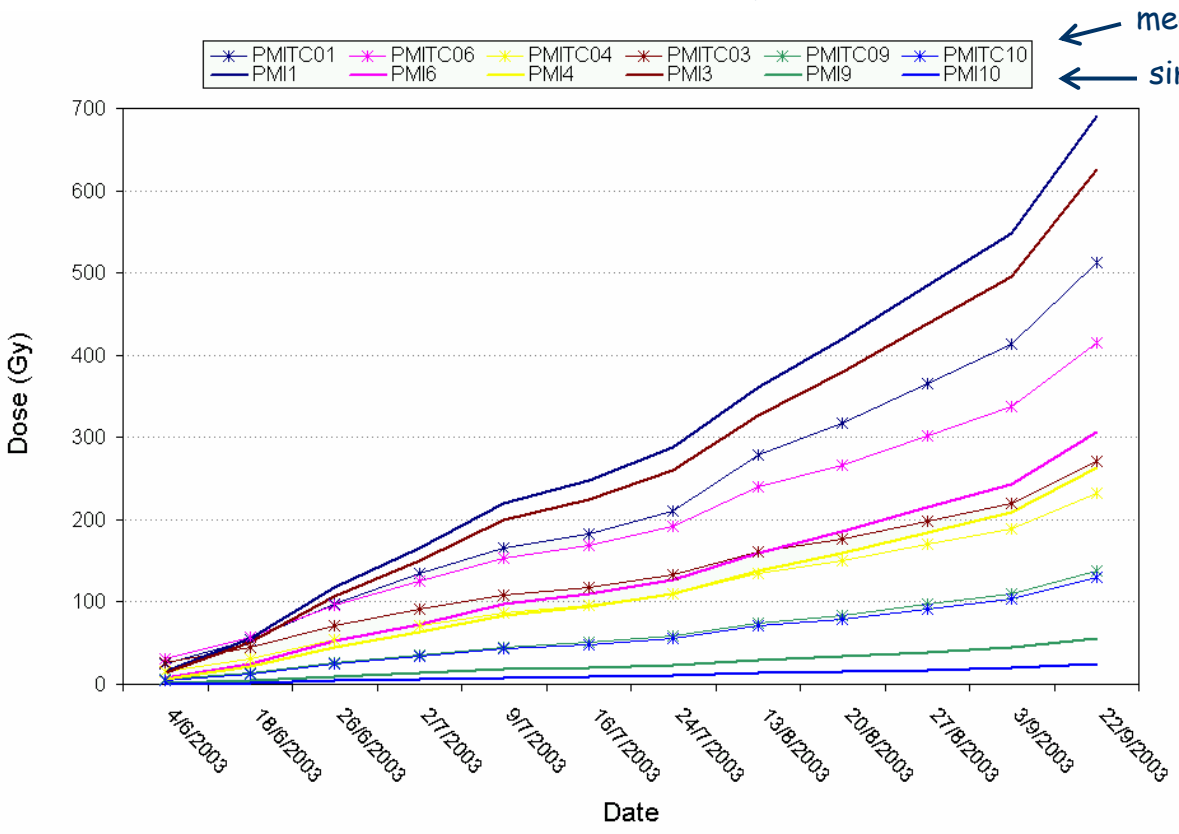
~ $1 \cdot 10^{-16}$ Gy / proton $\times$ $3 \cdot 10^{16}$ protons = ~ 3 Gy / day

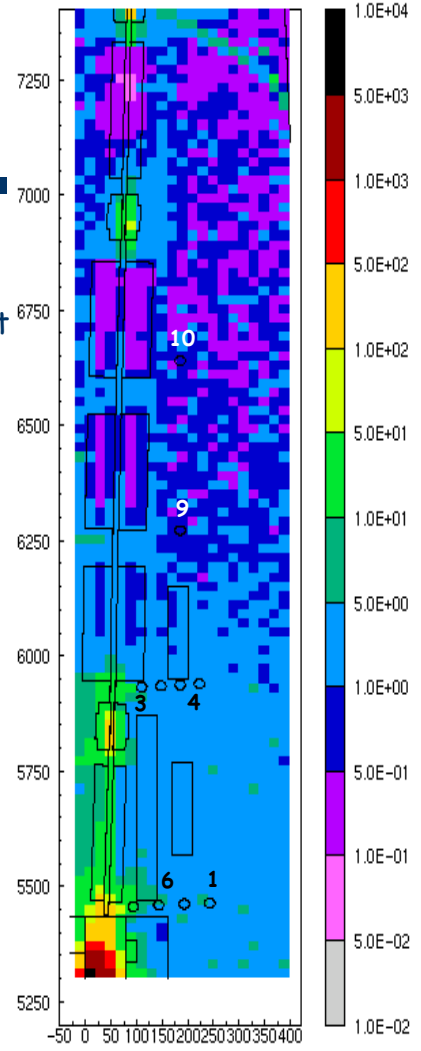
In LHC:

5 – 10 Gy / year *[C. Fynbo, G. Stevenson, CERN, 2001]*

Dosimetry

Cumulative graphs



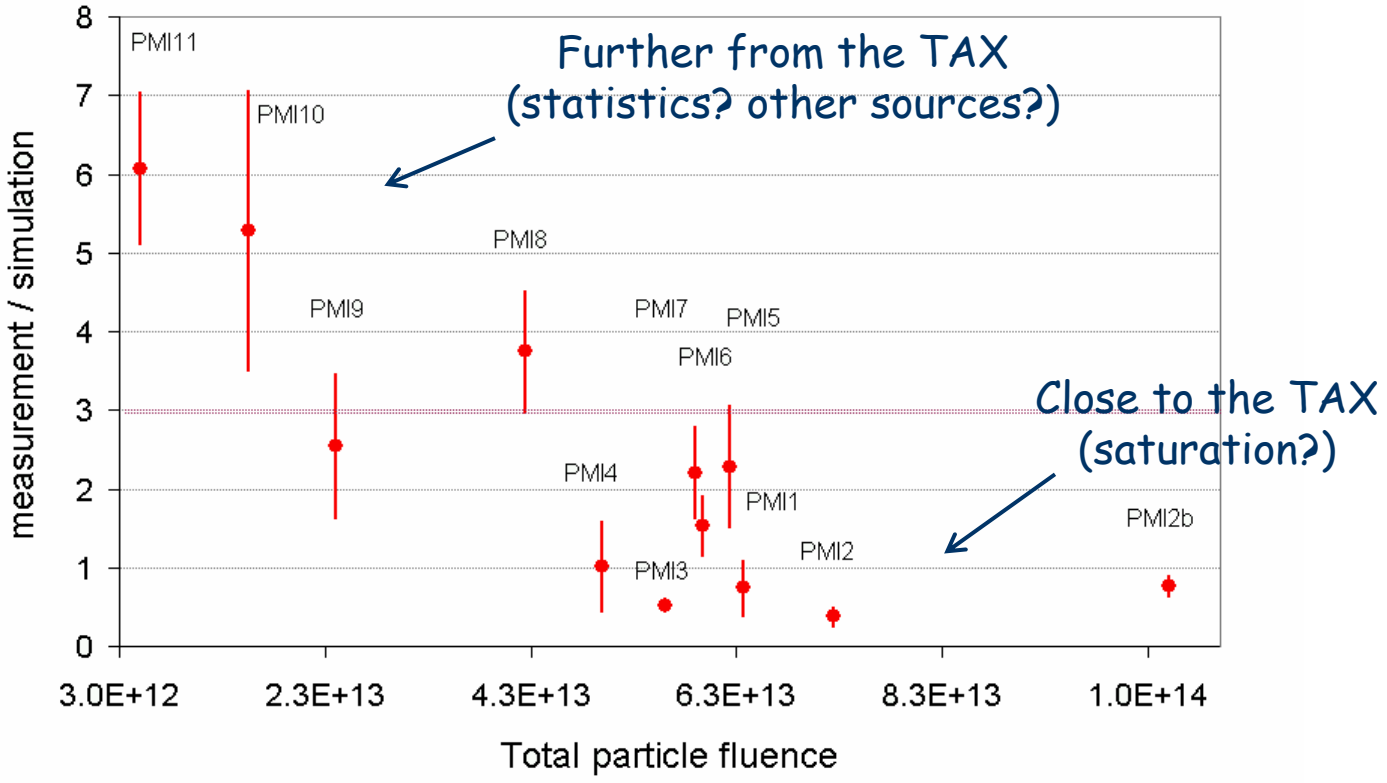


Dose (Gy/day)
[for $3 \cdot 10^{16}$ p on T6]

More graphs under http://lhc-radwg.web.cern.ch/LHC-radwg/

Dosimetry – Ratios

Most of the PMIs agree within a factor of 3…
(mean values of 8 independent runs)



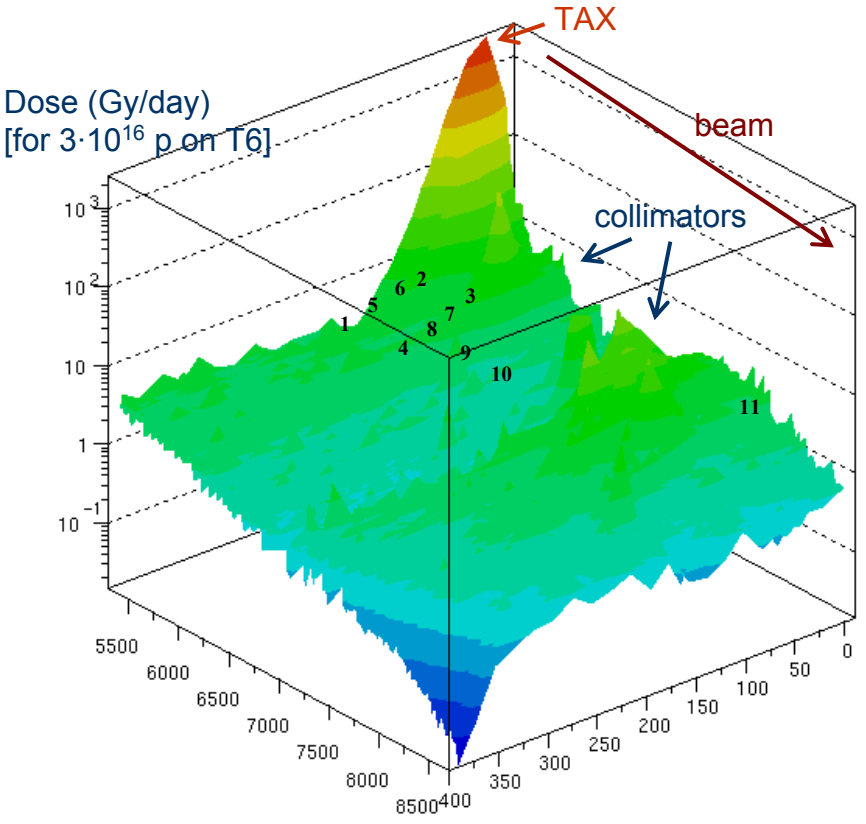
Dosimetry – Discussion

- For the positions away from the TAX there is a large difference between measurement and simulation.

In TCC2 area there is a very steep field gradient. Doses decrease rapidly away from the TAX (point source).

During the simulation, statistics is less leading to larger errors.

Other sources (not included in the current study) may become important away from the TAX …



Conclusions

- Use TCC2 for final tests:

  1 day in TCC2 ≈ 1 year in LHC

- For the positions 1 – 8 simulation values are better to use, but prefer PMI values for the positions 9 – 11.

- Particle fluences are very important for the radiation tolerance studies and are well defined by the simulation maps.

- Use the "per proton on T6" maps and calculate the values you need by looking up the SPS logfile for the period of interest.
  [cern.ch\Divisions\SL\DIV_SL\STAT\SPSSTAT\PROTONS\Current\Tab\SPROTONS.XLS]