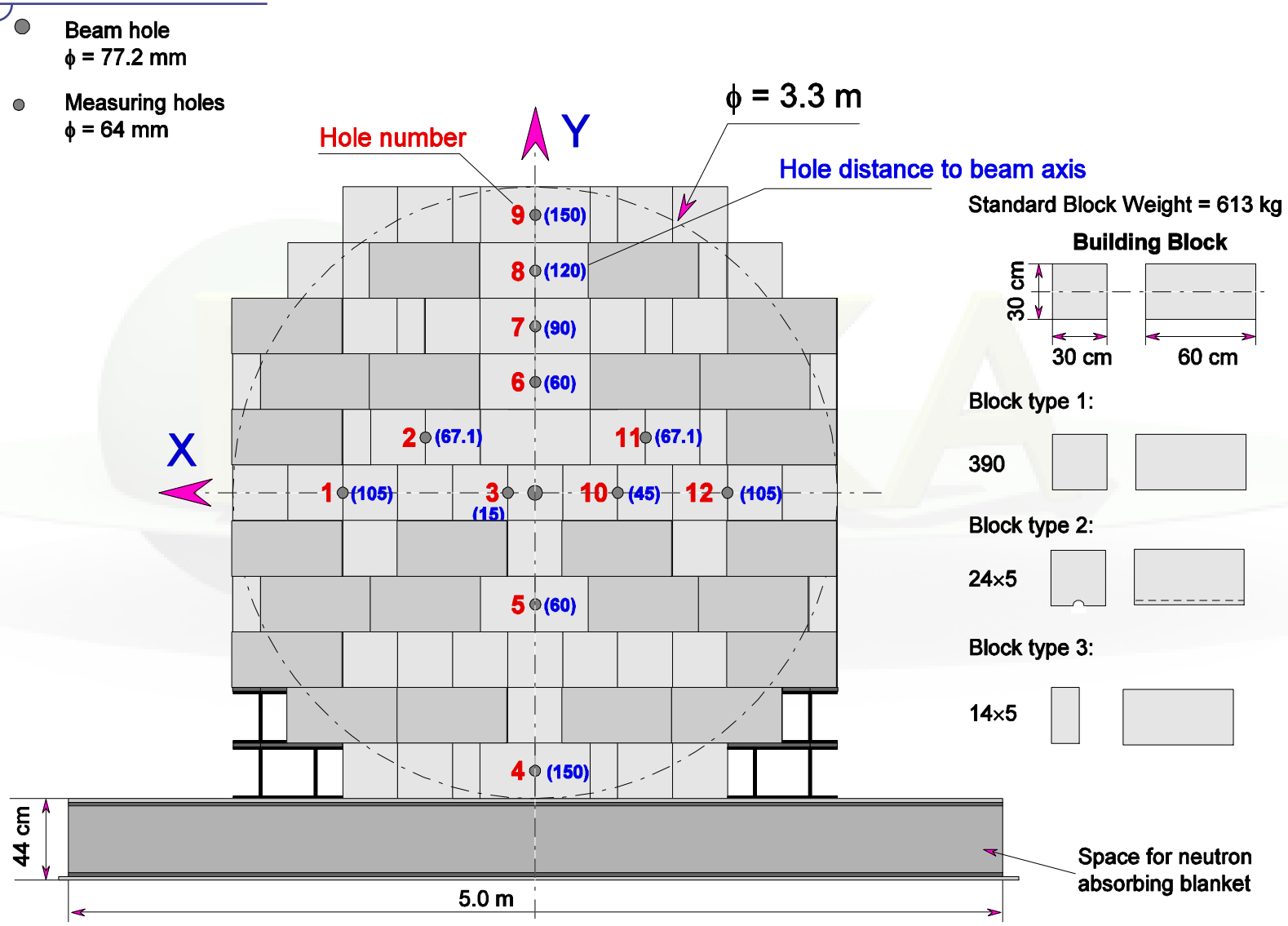
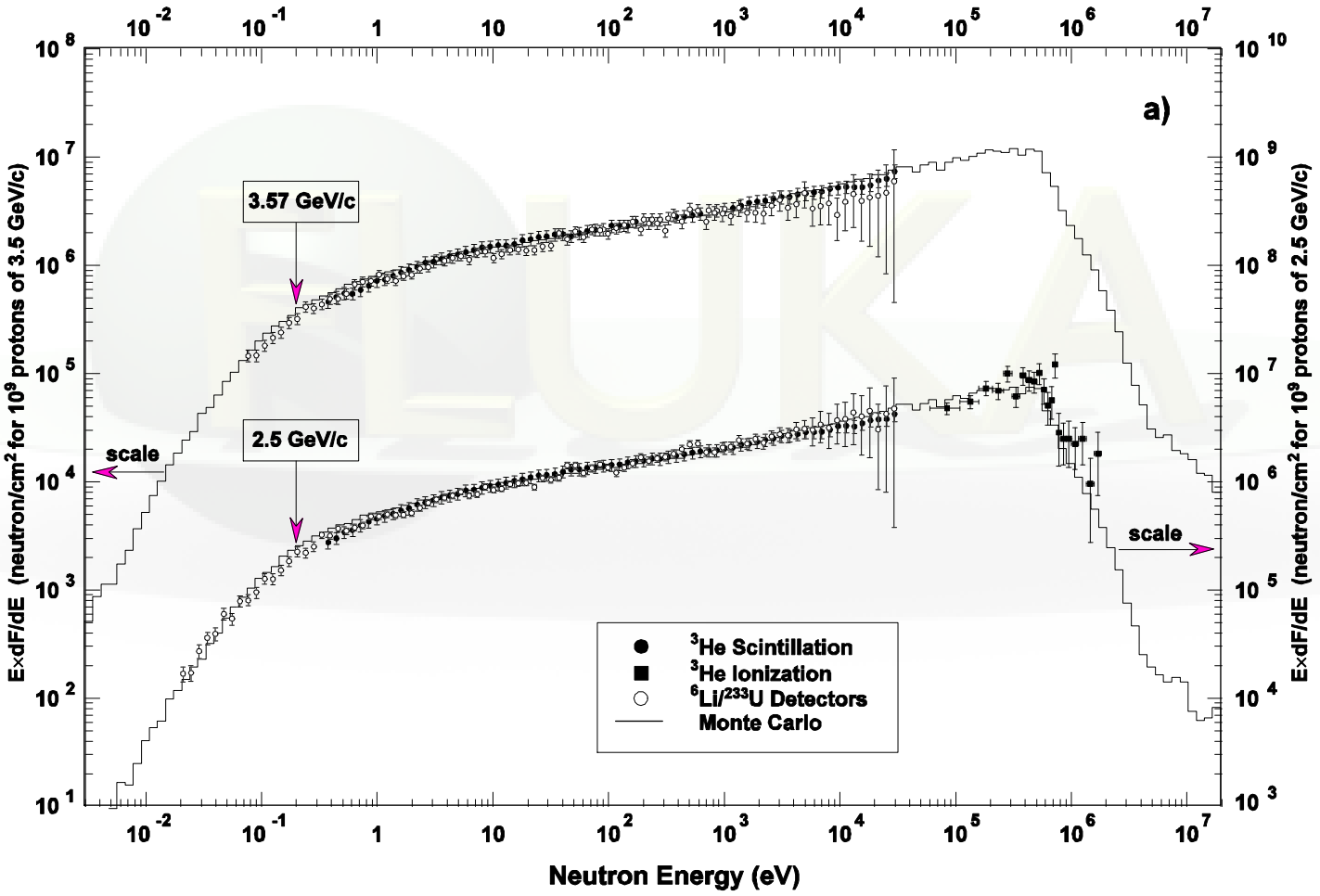
Examples of FLUKA Applications

The TARC experiment at CERN:



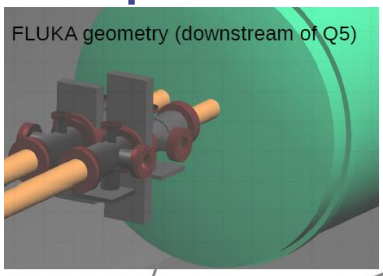
The TARC experiment: neutron spectra

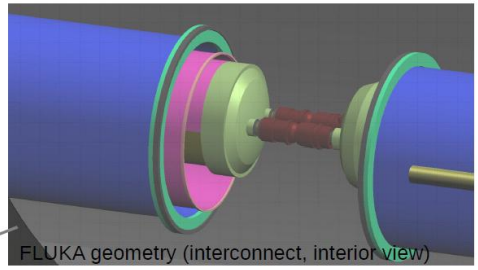
FLUKA + EA-MC (C.Rubbia et al.)

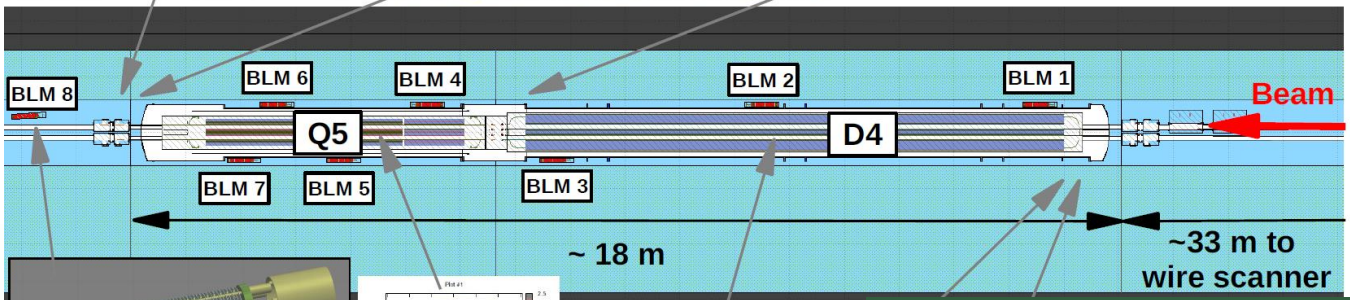


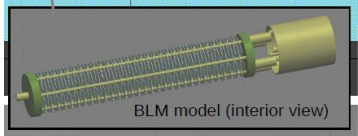
Application & Benchmarking – *LHC operation*

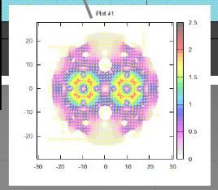
Test quench induced by the wire scanner *on 2010 Nov 1* on the left of P4 at 3.5TeV

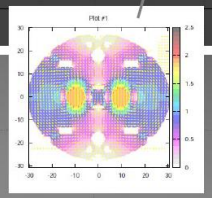






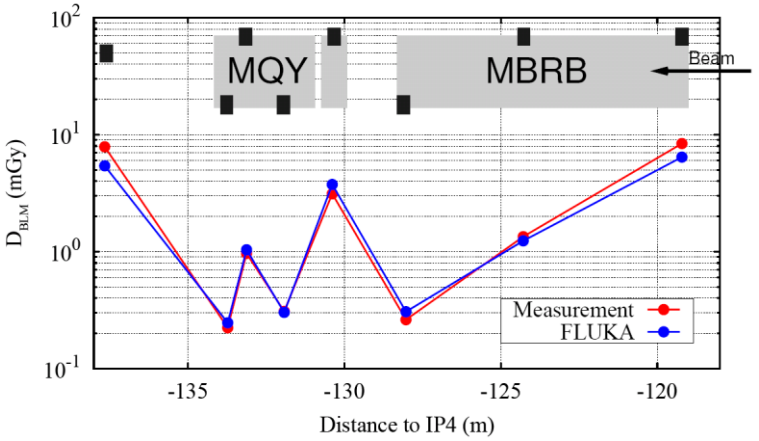






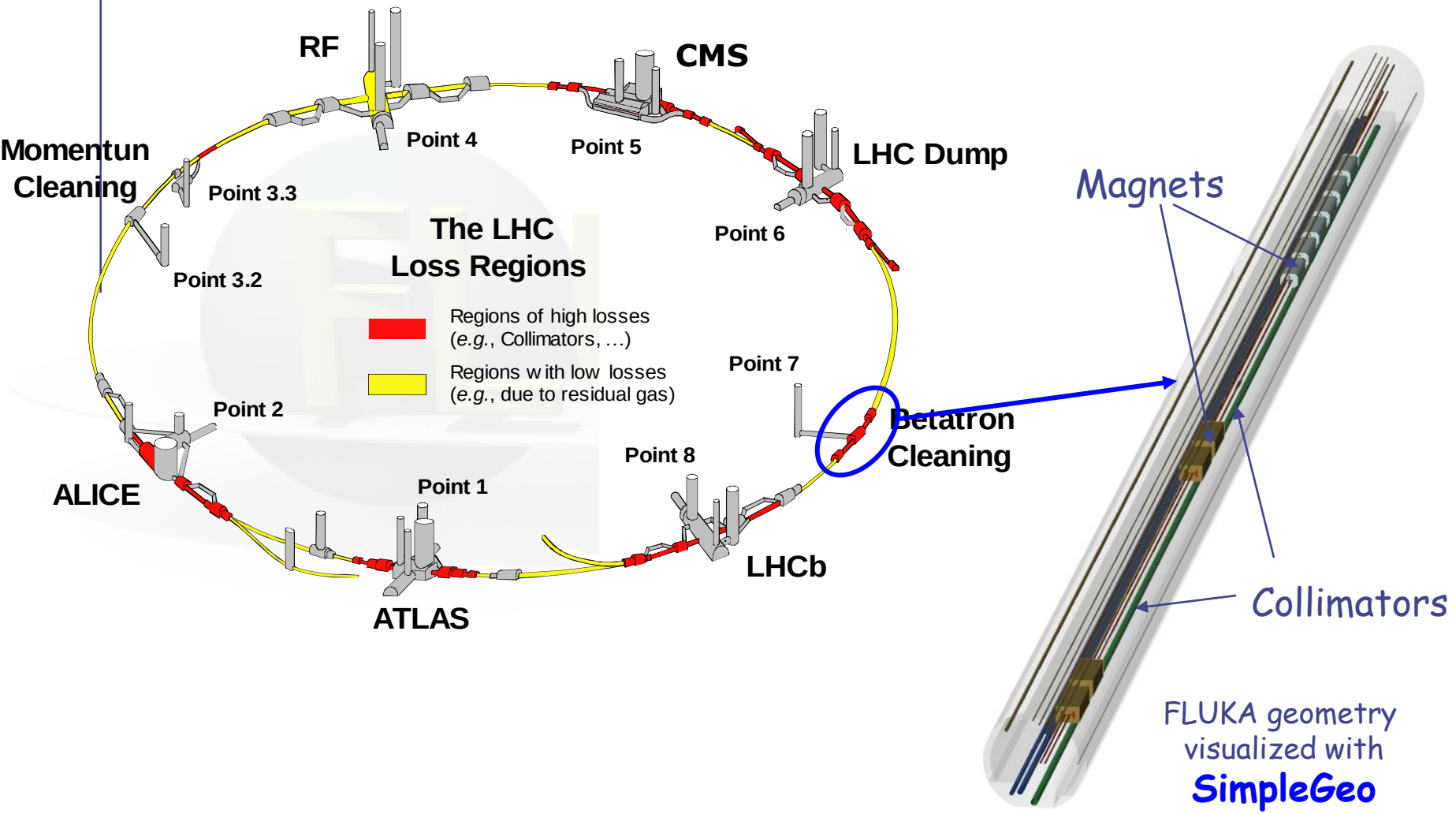
Time-integrated dose in BLMs

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

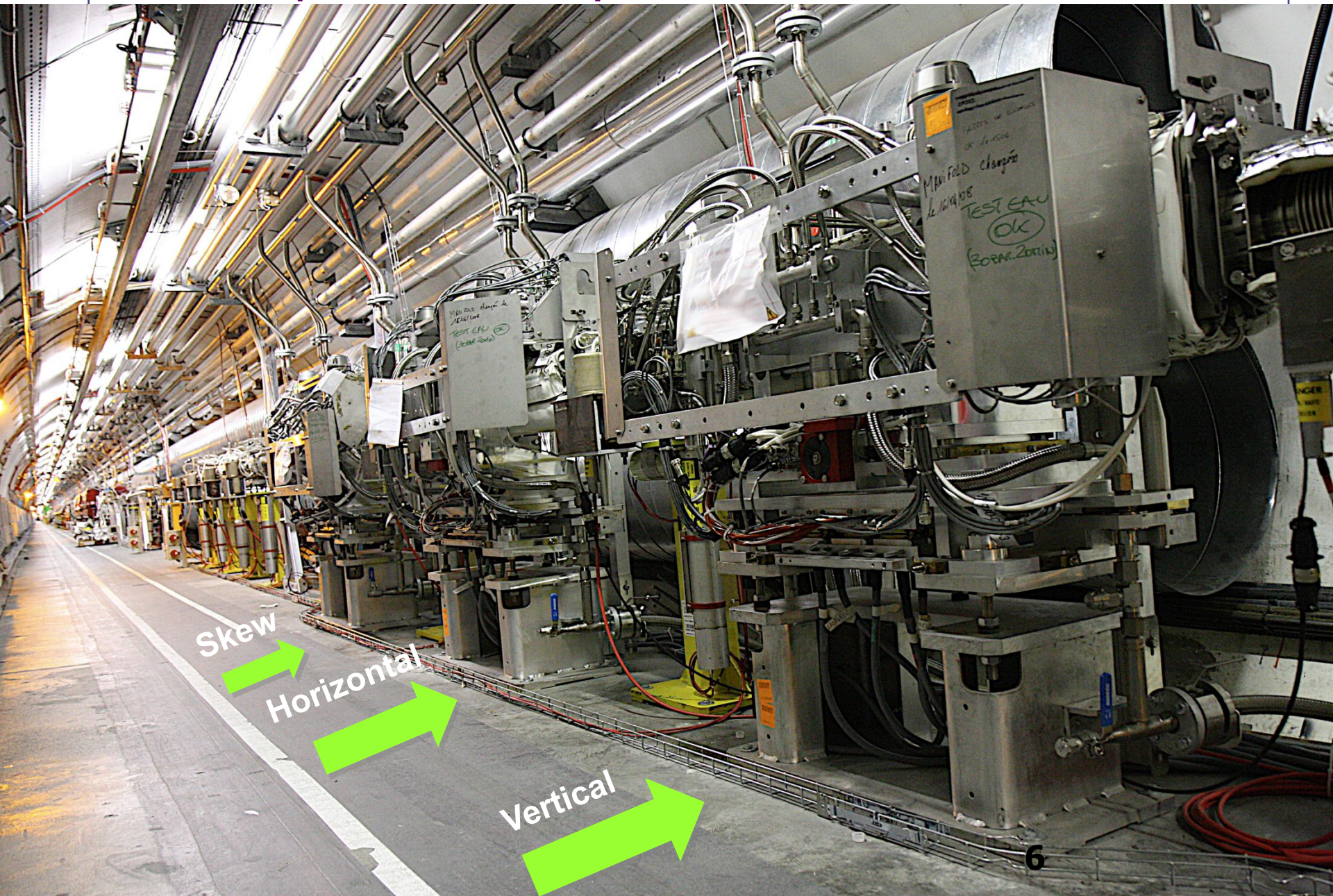


Absolute comparison!

Applications – *LHC collimation region*



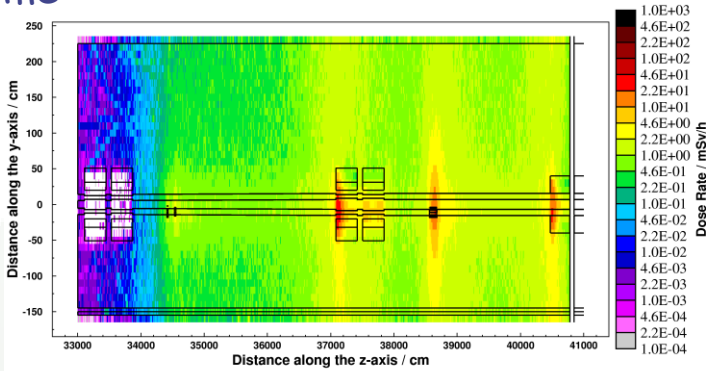
Example: 3 Primary Collimators IR7



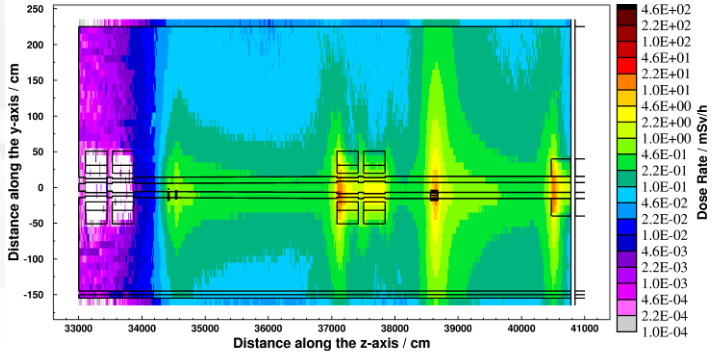
Applications – *LHC collimation region*

Cooling time

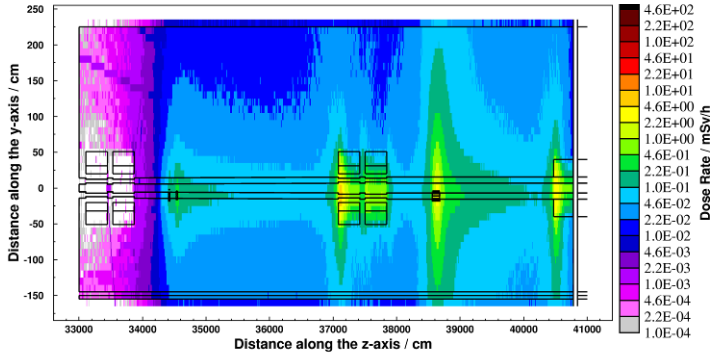
8 hours



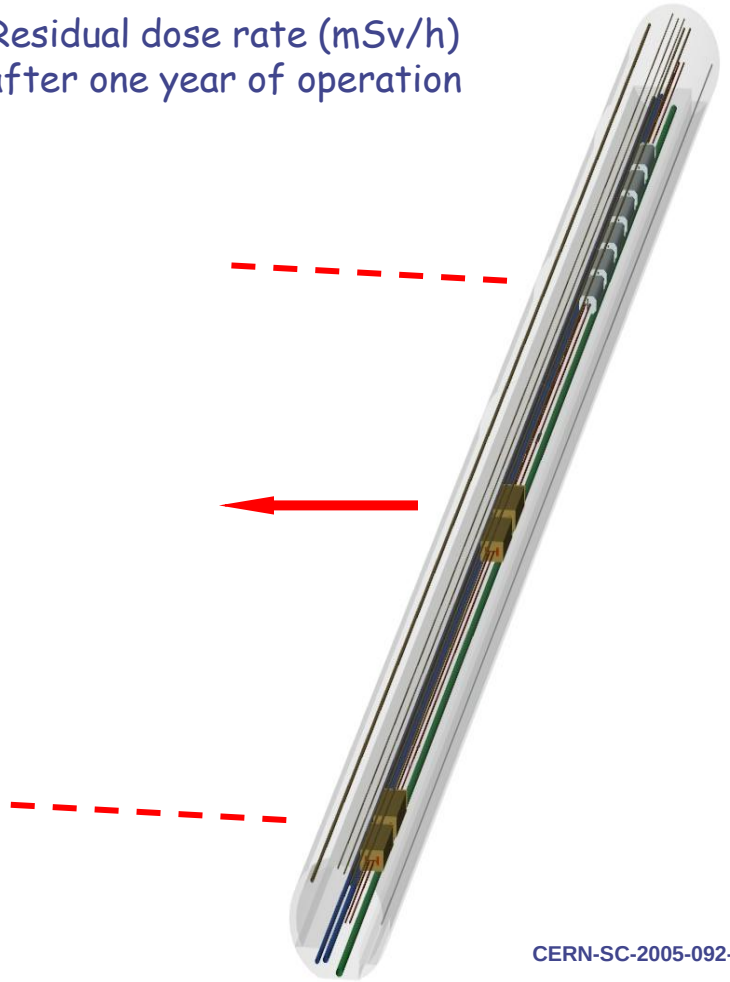
1 week



4 months



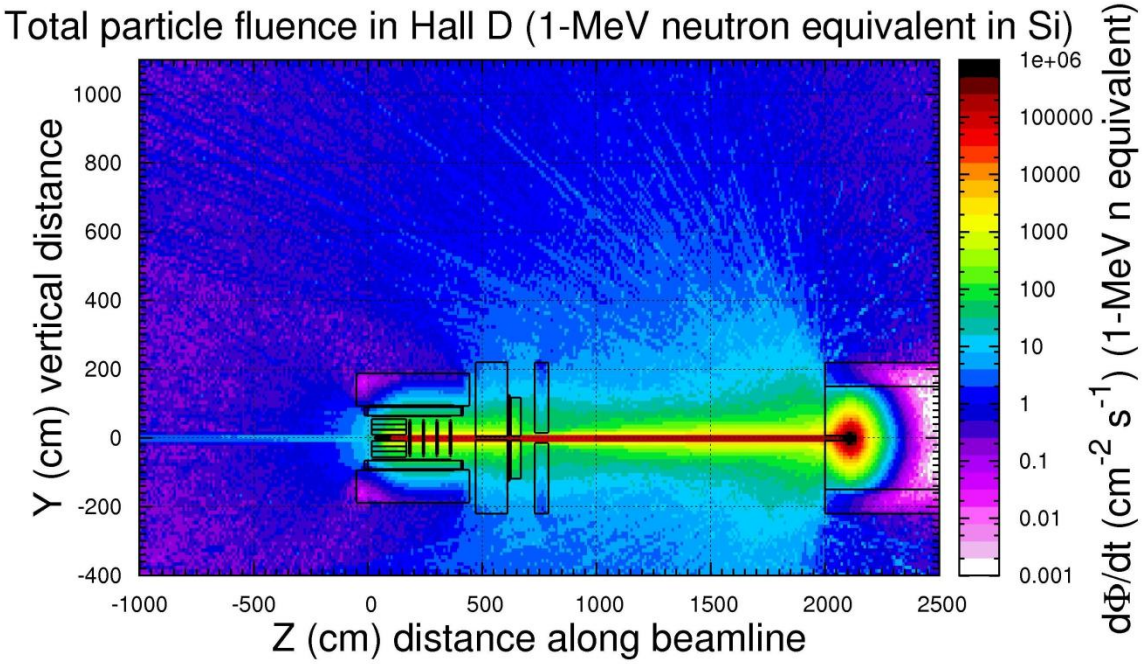
Residual dose rate (mSv/h)
after one year of operation



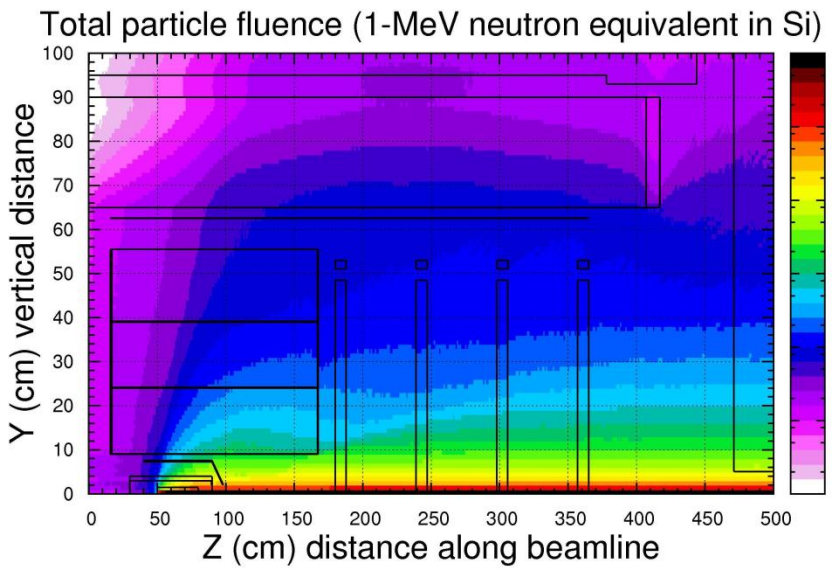
CERN-SC-2005-092-RP-TN

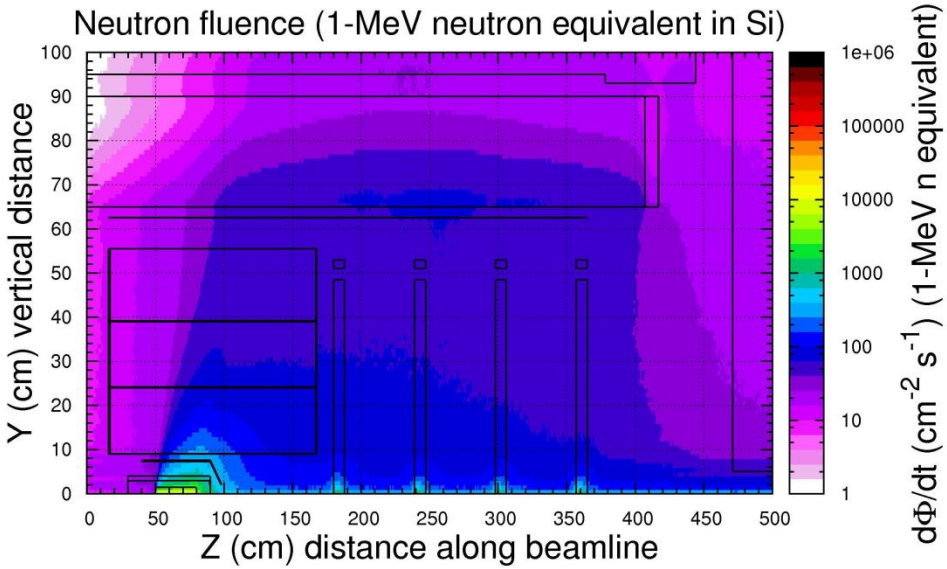
REMANENT DOSE RATE MAPS
OF THE LHC BETATRON CLEANING INSERTION (IR7)

M. Brugger, D. Forkel-Wirth, S. Roesler

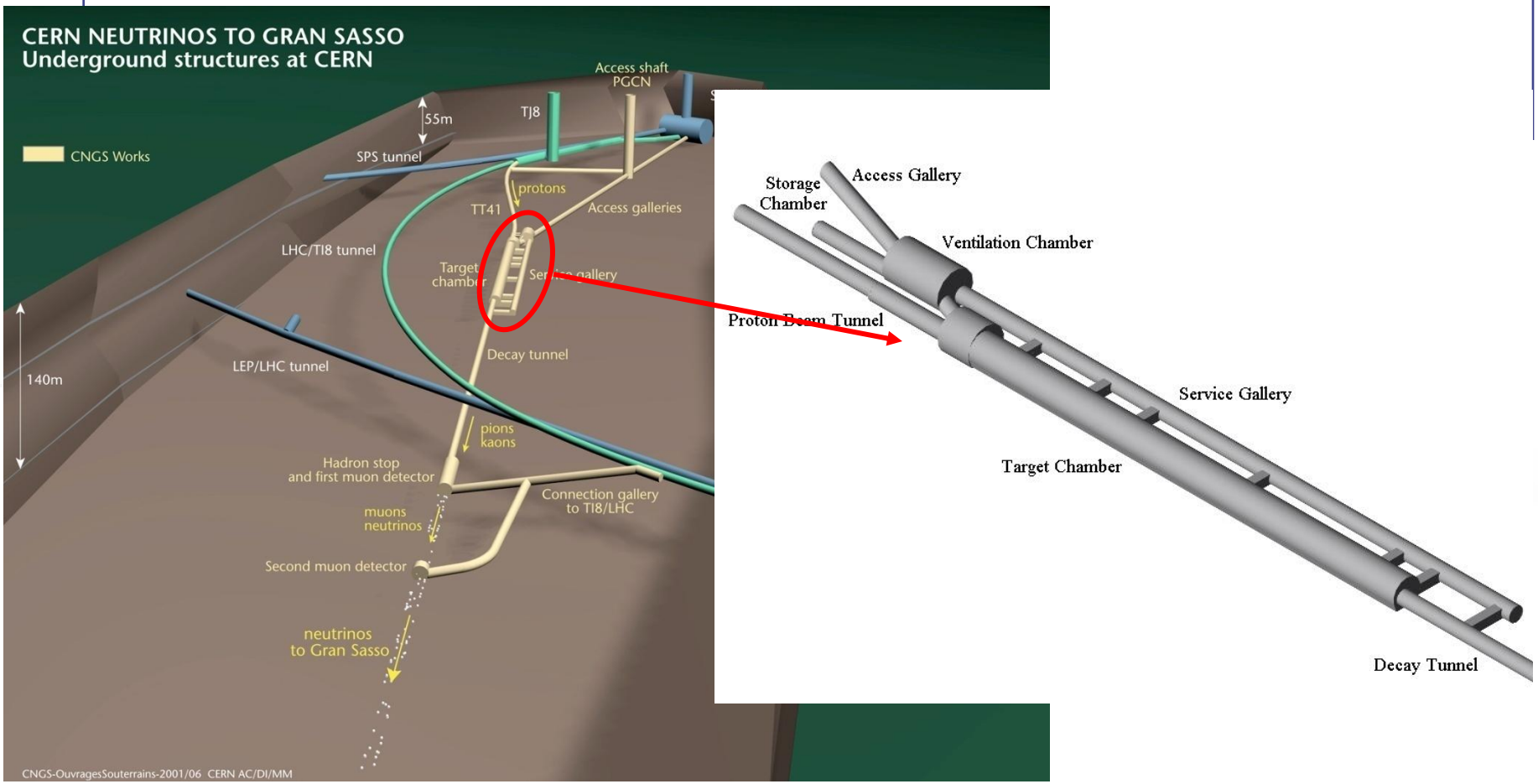


Calculated 1-MeV neutron equivalent fluence rate in Si (GlueX experiment at Jlab)

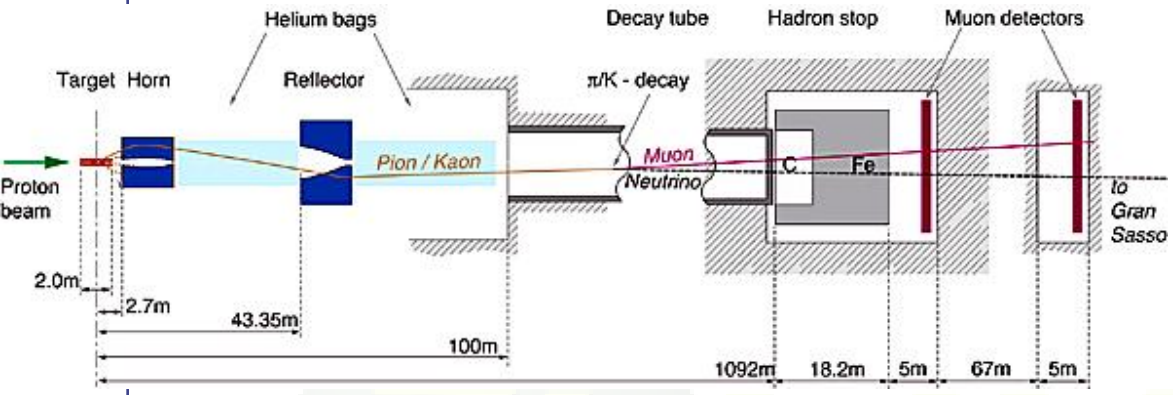


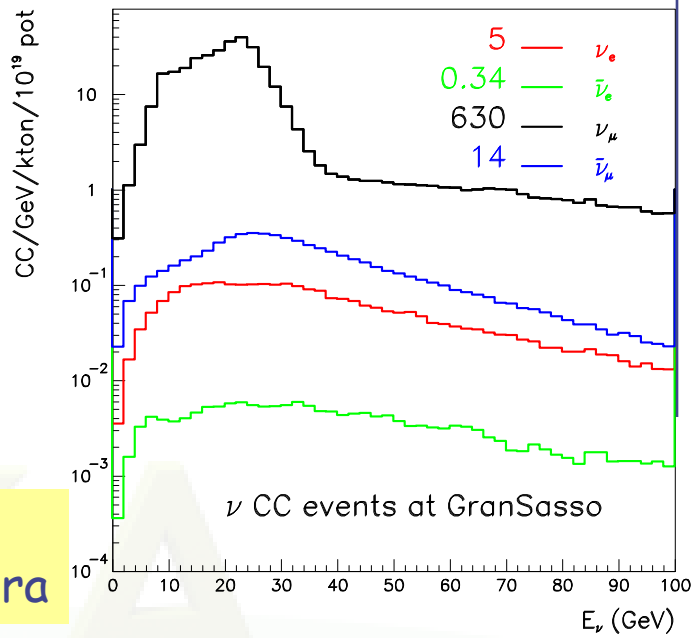


Applications – *CNGS*

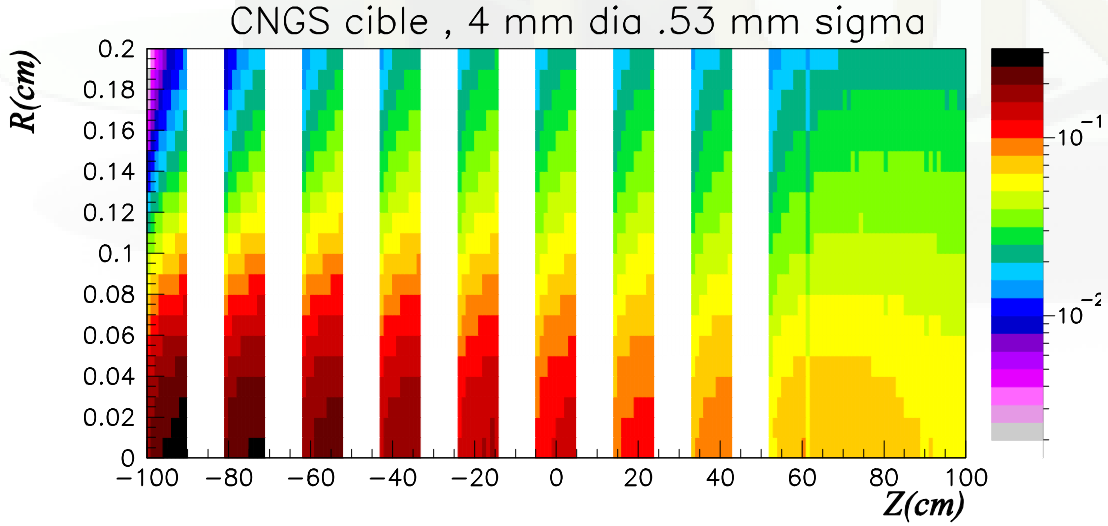


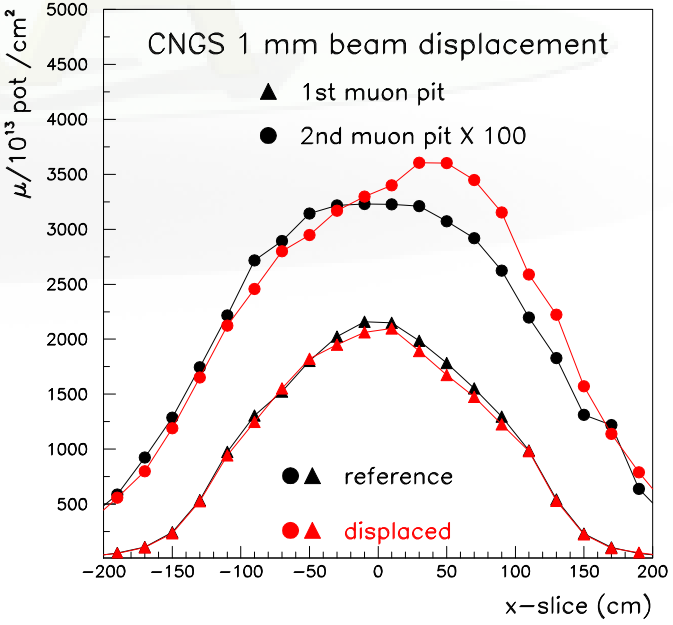
Cern Neutrino to Gran Sasso





Engineering and physics: target heating, shielding, activation, beam monitors, neutrino spectra

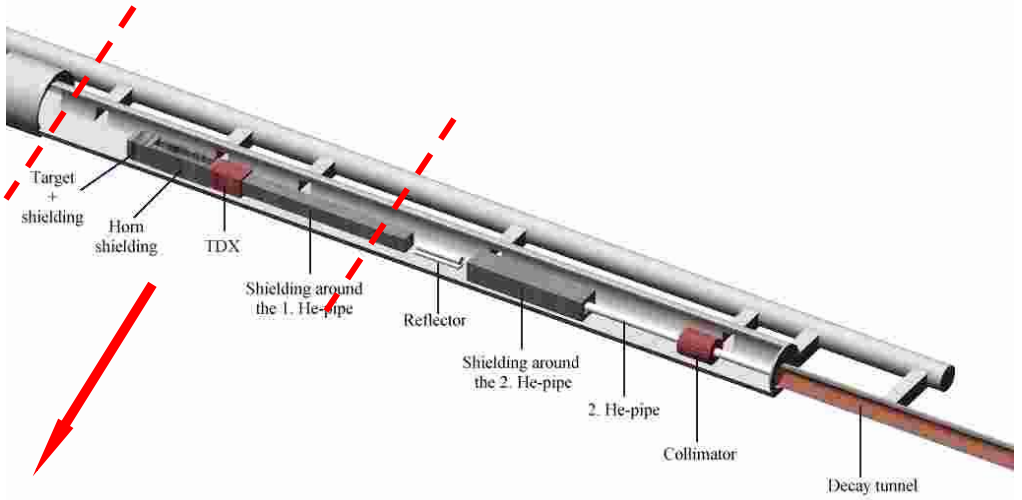




Muons in muon pits: horiz. distribution for beam alignment

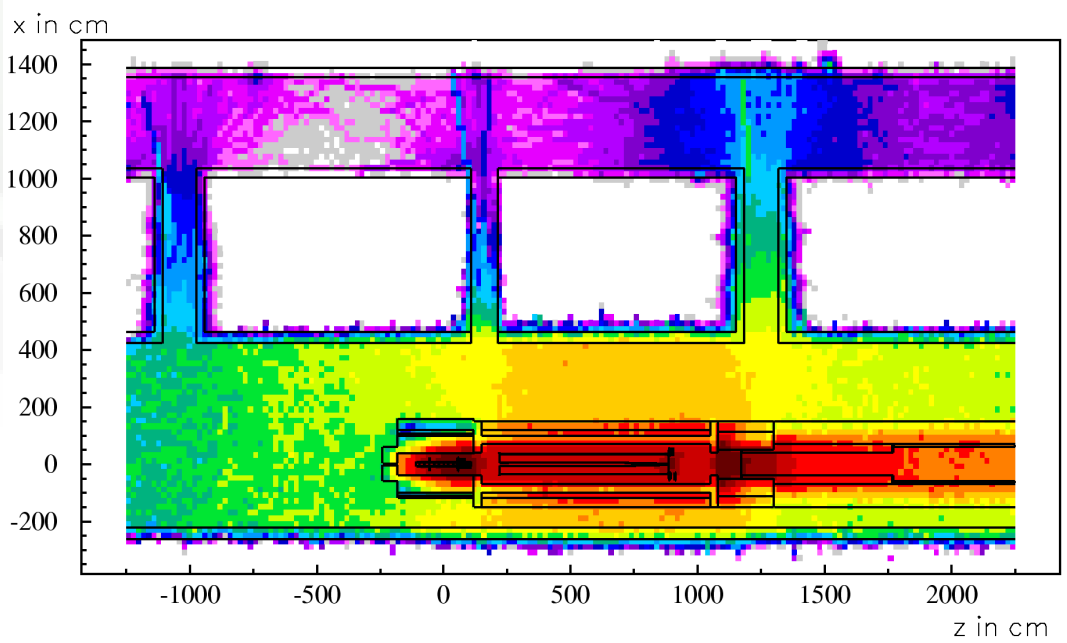
Energy deposition in CNGS target rods, GeV/cm³/pot

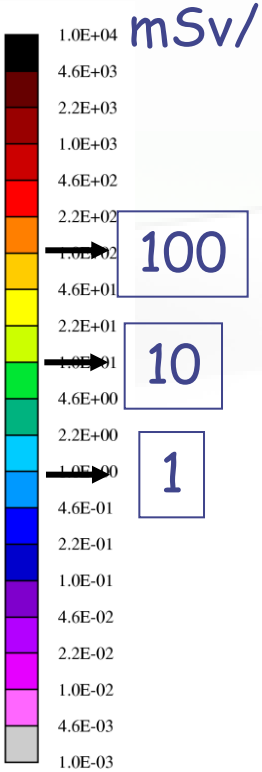
Applications – *CNGS*



Example:

t_{cool} = 1 day





Residual Dose Equivalent Rate (mSv/h)

200 days irradiation, 1 day cooling

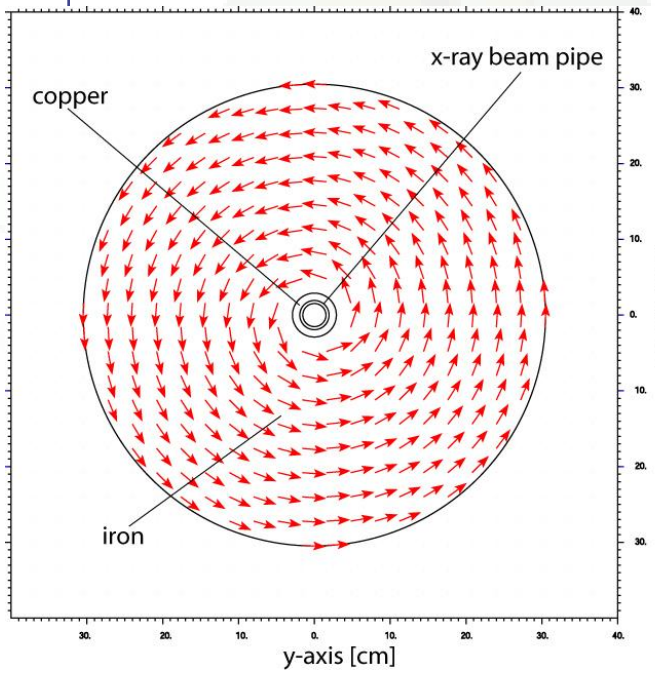
8×10^{12} protons/s

Effect of a magnetic muon spoiler in the LCLS tunnel

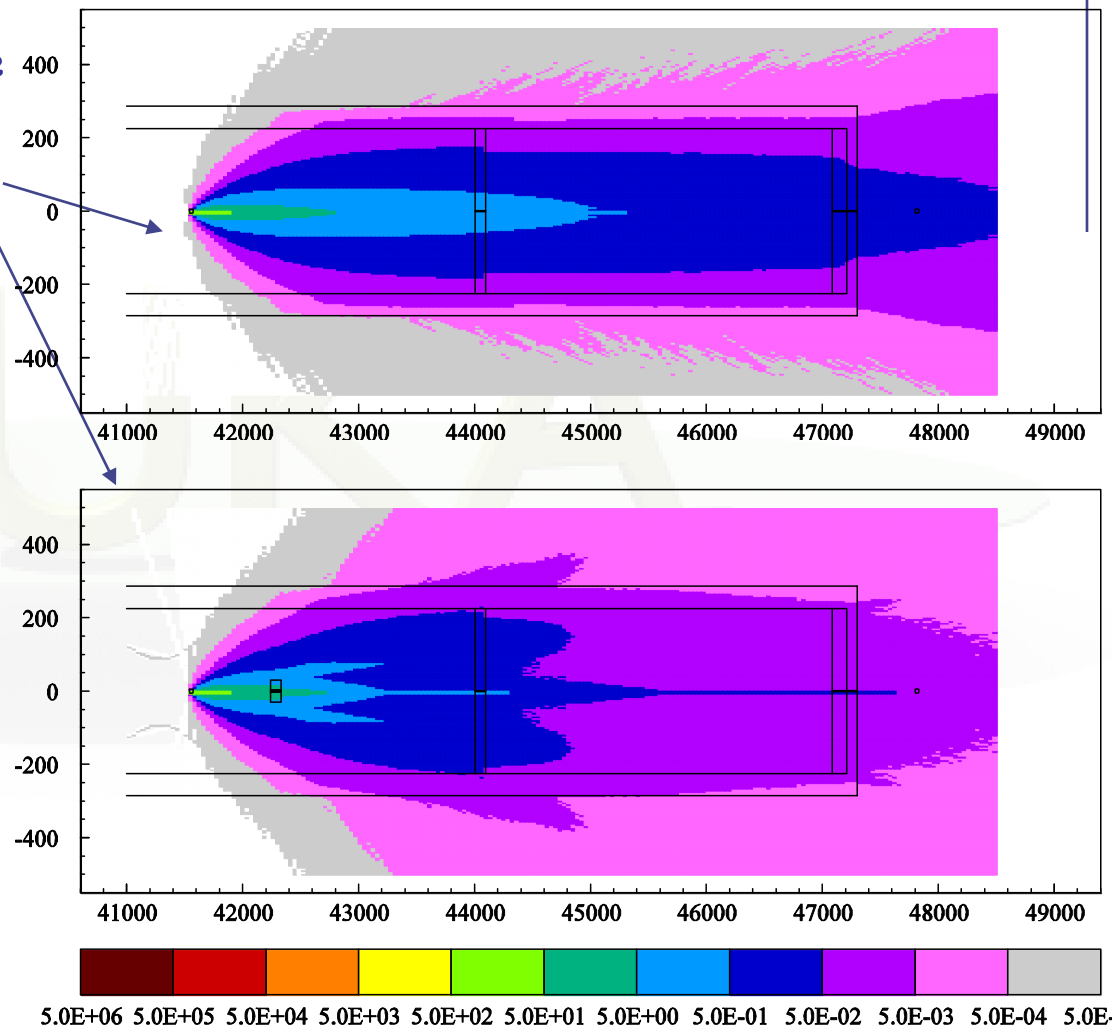
The spoiler allows to reduce the shielding thickness in the forward direction.

dose rate map without spoiler

the same with spoiler



Magnetic field map used by FLUKA



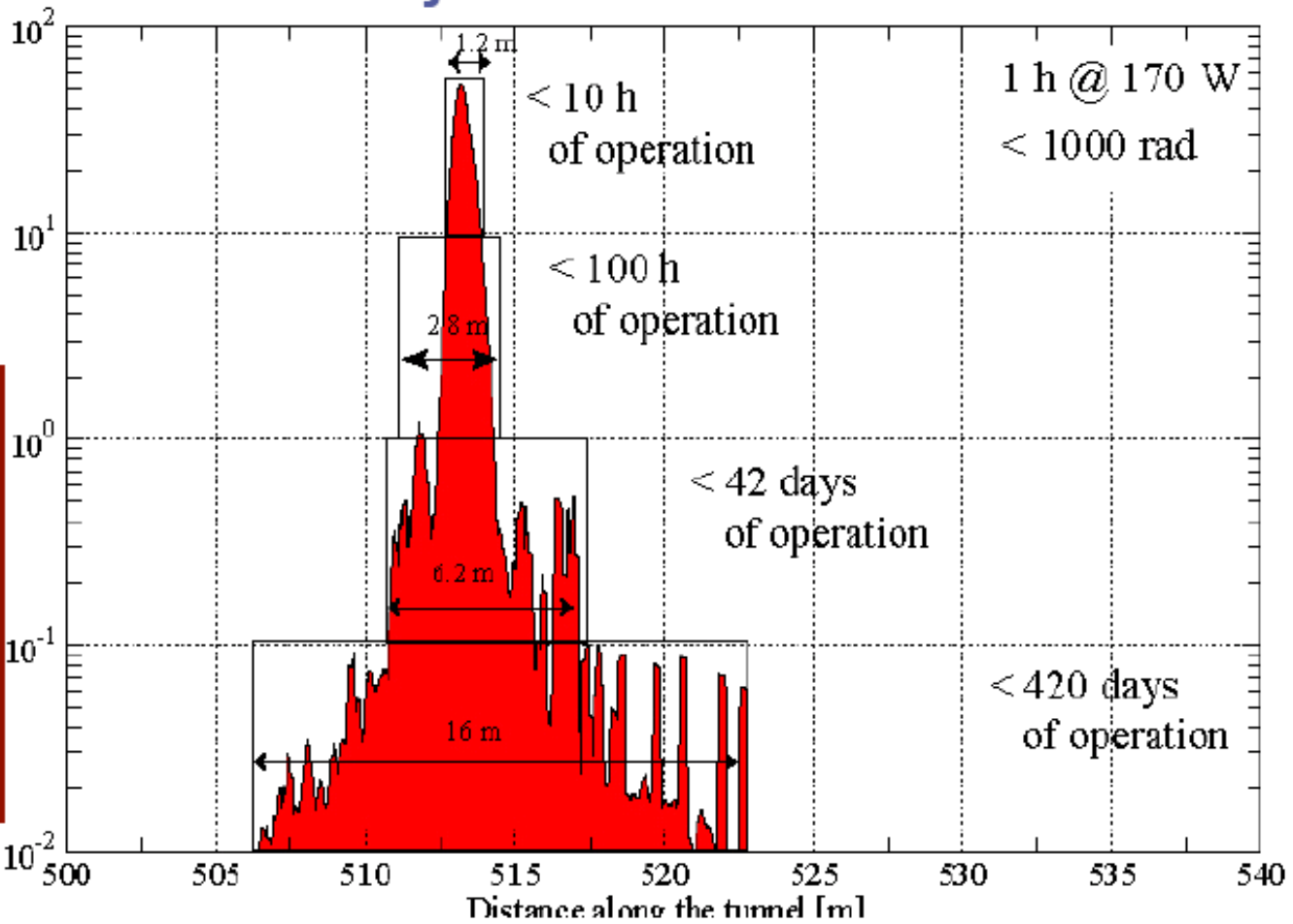
Damage to electronics

SLAC: Damage to electronics near the dumps at the LCLS (Linear Coherent Light Source)

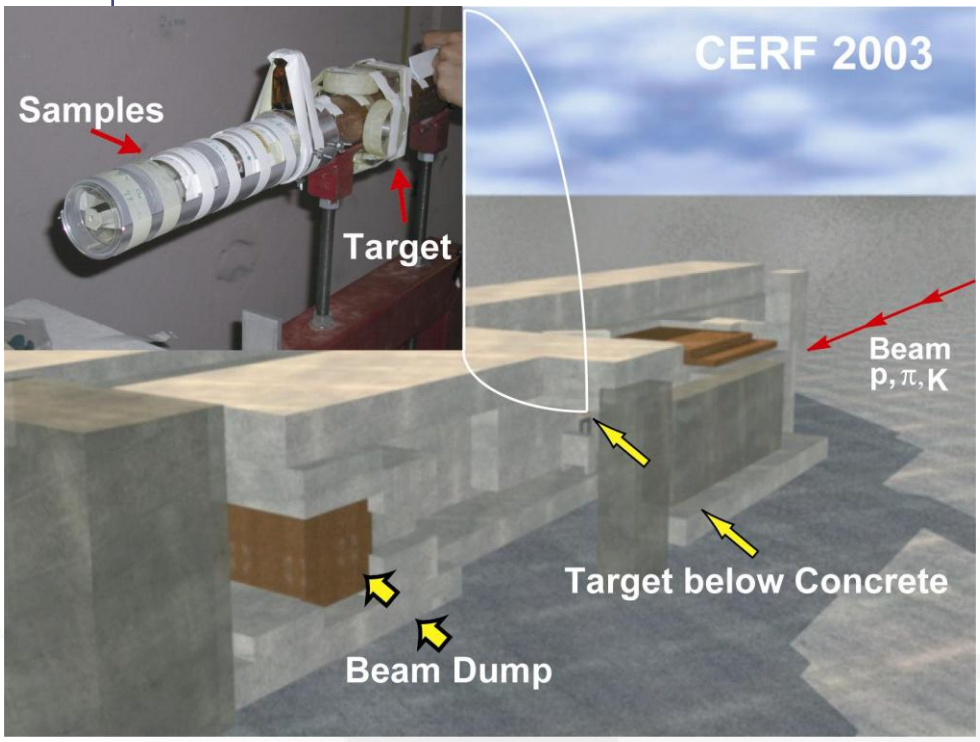
The lifetime of electronic components can be estimated as a function of the distance to major sources of radiation

1-MeV neutron equivalent fluence

Calculation of lifetime of electronics equipment as a function of the distance to TDUND



CERN-EU High-Energy Reference Field facility (CERF)

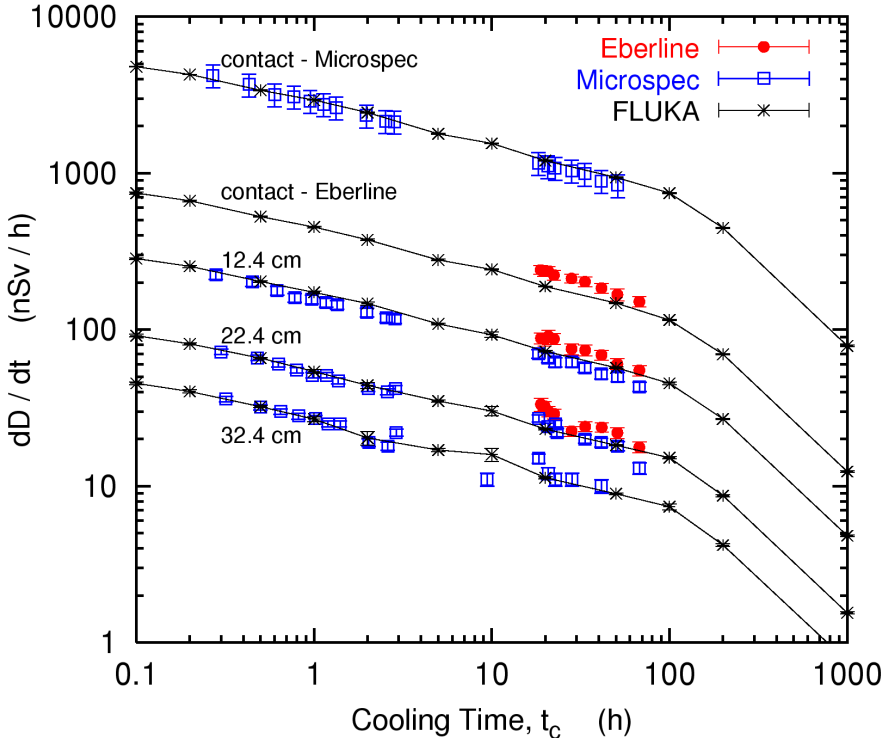


samples in contact with a 50 cm long, 7 cm diameter copper target, centred on the beam axis

Microspec

Thermo-Eberline dose-meter FHZ 672

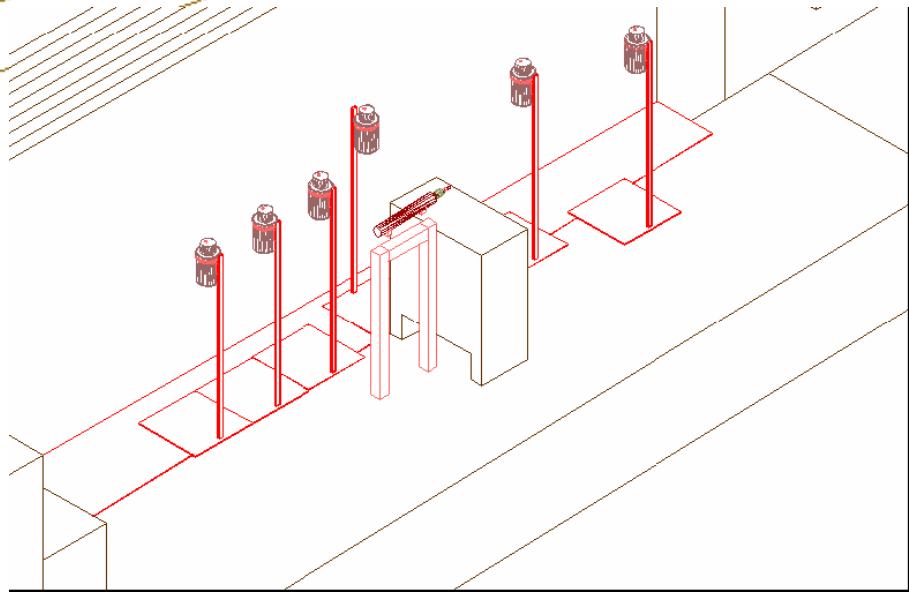
Iron



Test of instrumentation : Beam Loss Monitors at CERF

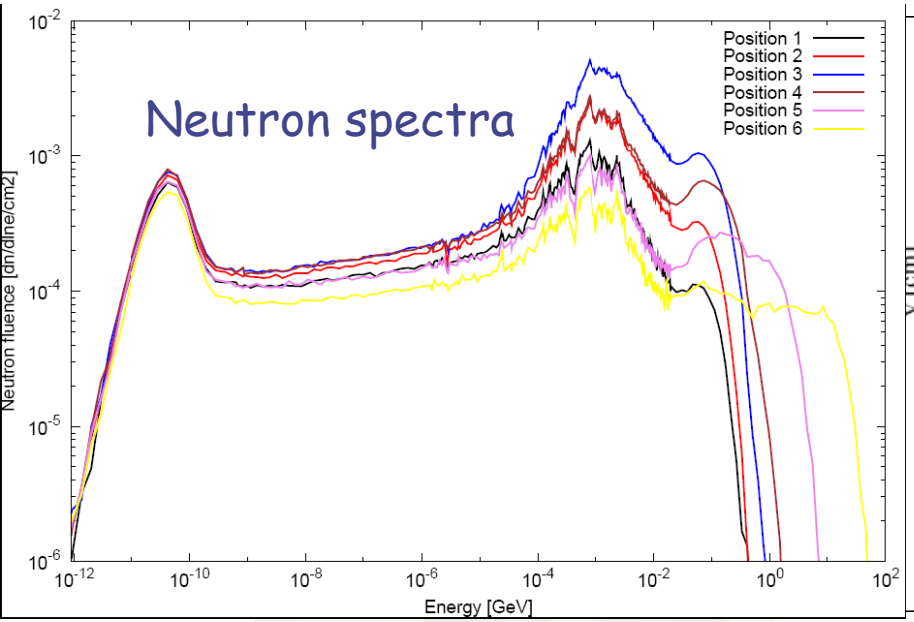
CERN-EN-NOTE-2010-002-STI

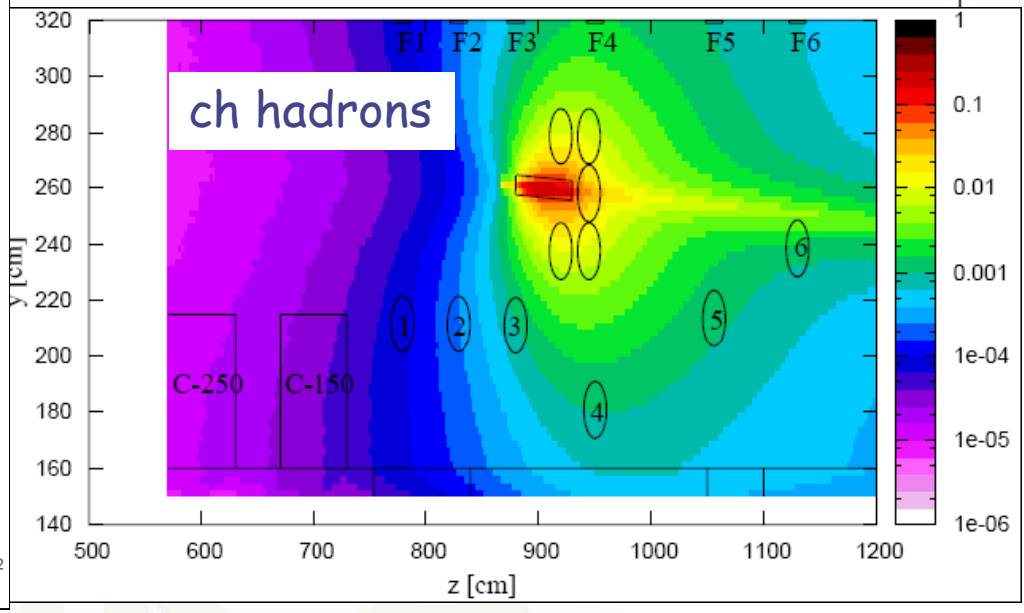
CERF setup

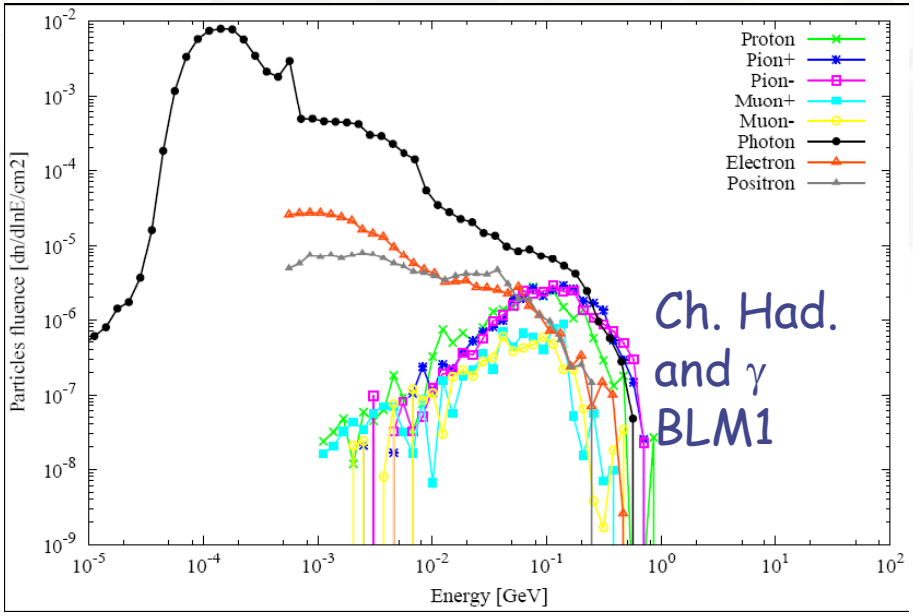


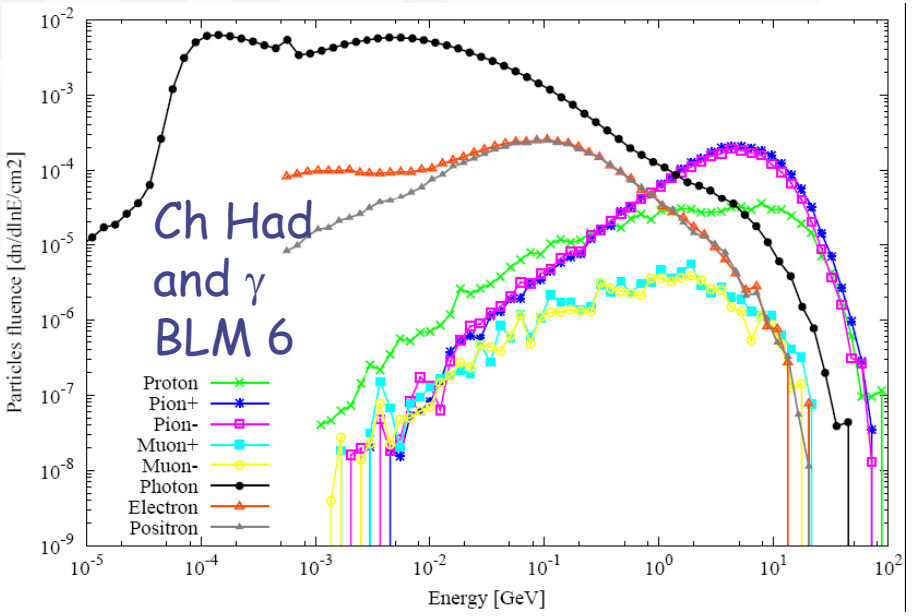
BLM's positions

CERF particle spectra





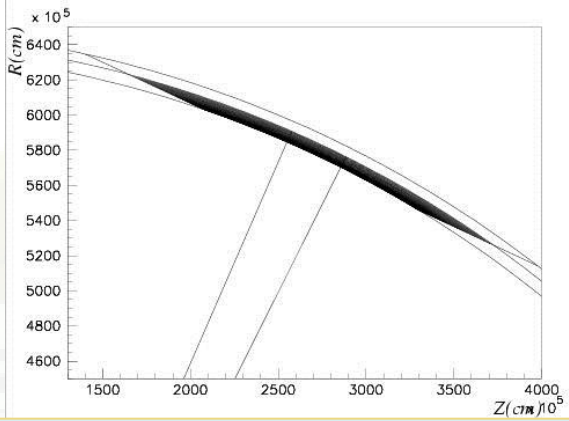


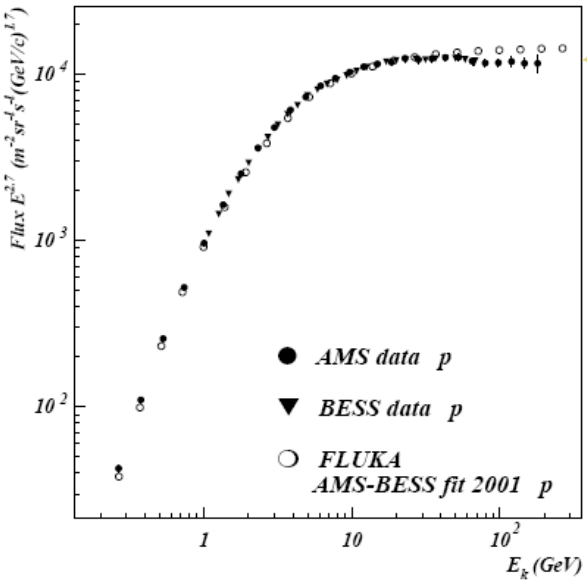


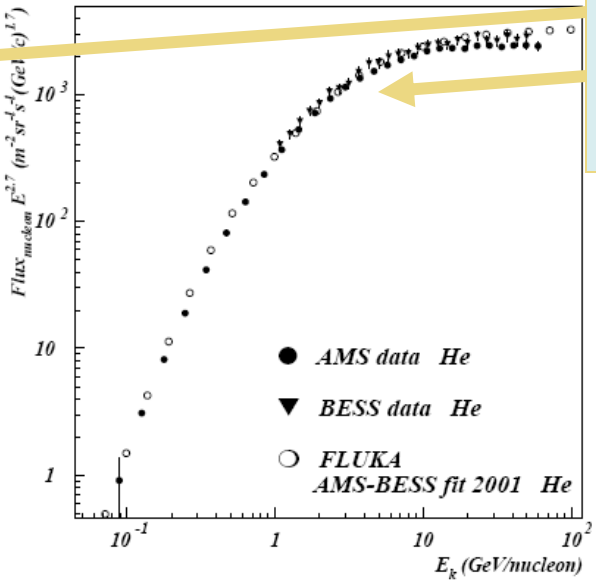
The FLUKA C.R. library

Dedicated FLUKA library + additional off-line packages including:

- Primary spectra from Z = 1 to Z = 28 (derived from NASA and updated to most recent measurements). Other primary flux choices can be added by the user (Agrawal-Stanev-Gaisser-Lipari flux. All nucleon spectrum).
- Solar Modulation model (correlated to neutron monitors)
- Atmospheric model (MSIS Mass-Spectrometer-Incoherent-Scatter)
- 3D geometry of Earth + atmosphere
- Geomagnetic model



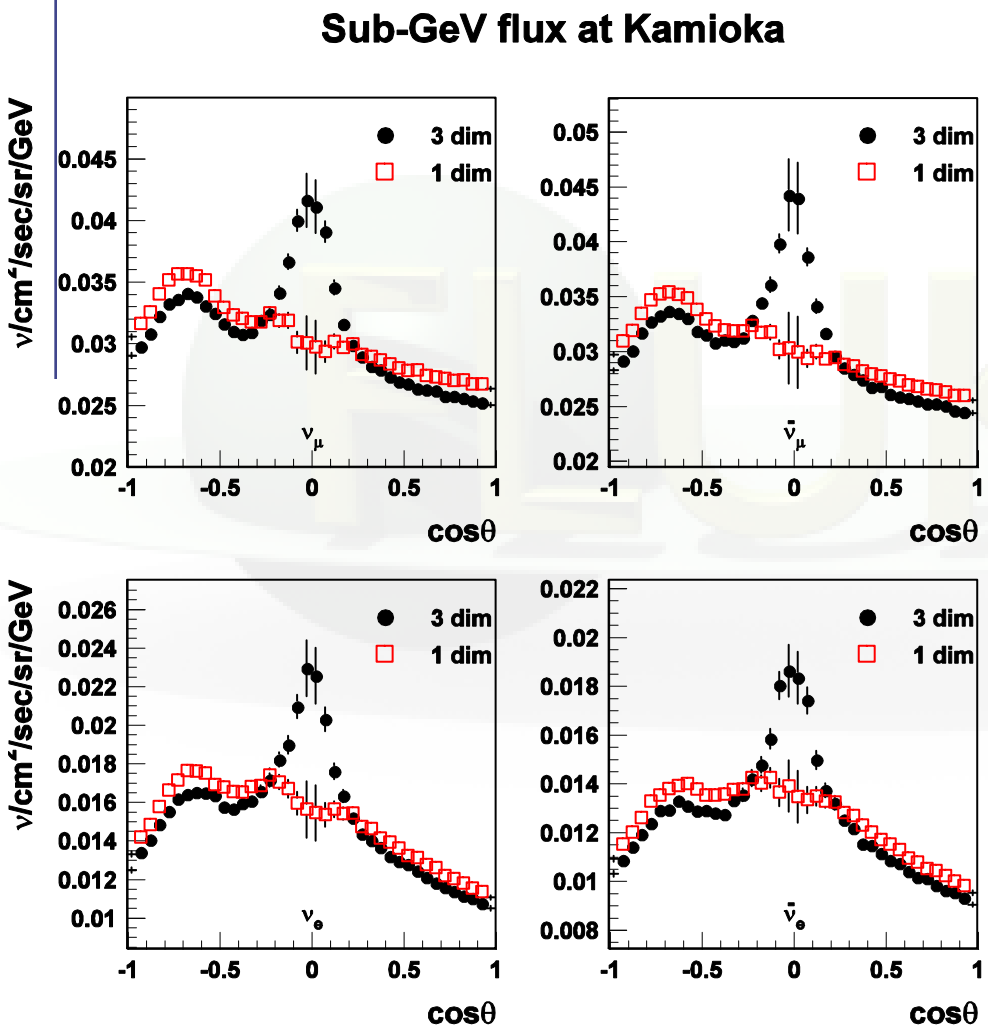




modulated for a given date, location according to geomag. model, solar modulation

FLUKA: superposition model → nucleon-Air interaction
FLUKA+DPMJET: full N-Air interactions

(3D) Calculation of Atmospheric ν Flux



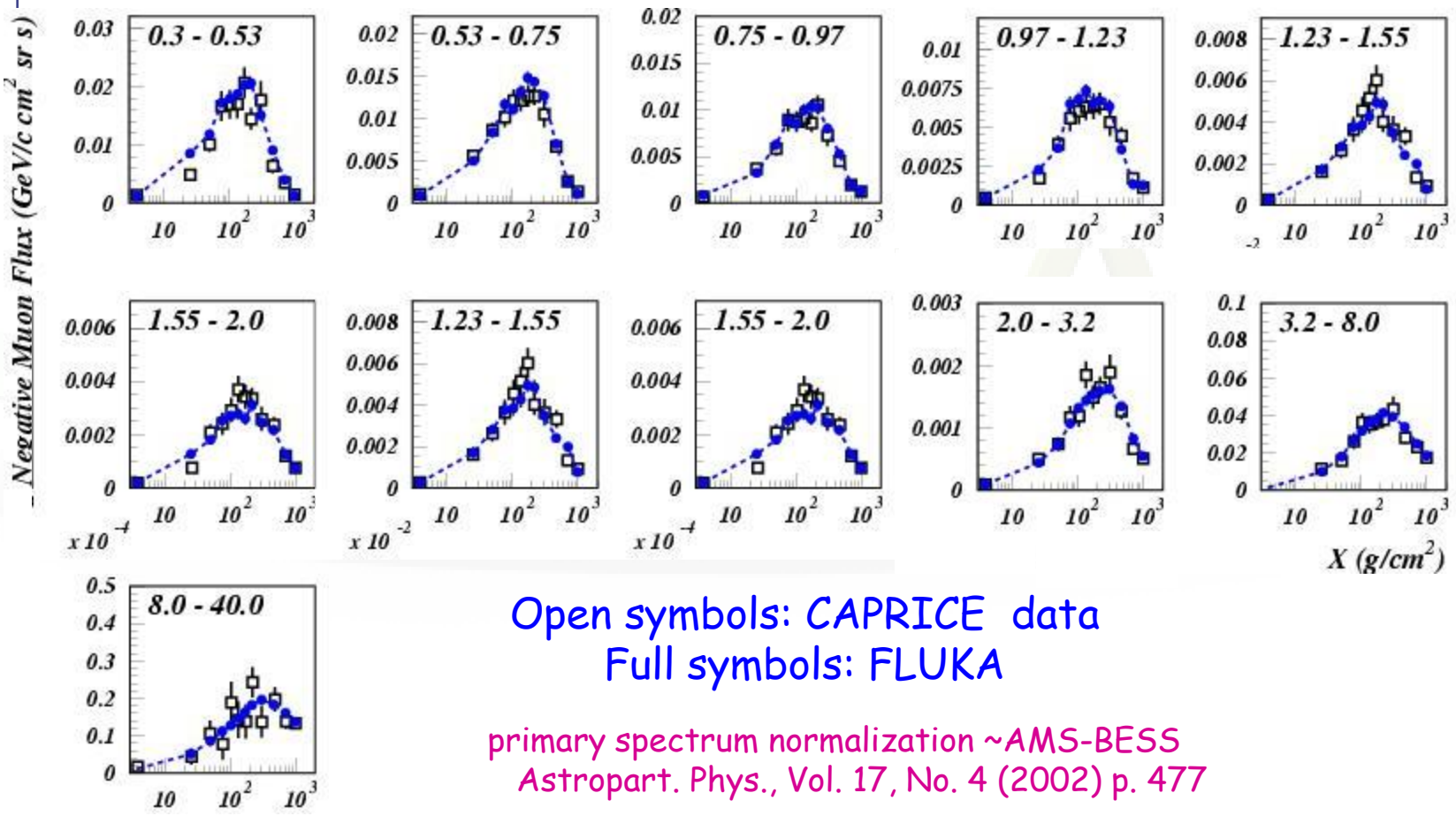
The first 3-D calculation of atmospheric neutrinos was done with FLUKA.

The enhancement in the horizontal direction, which cannot be predicted by a 1-D calculation, was fully unexpected, but is now generally acknowledged.

In the figure: angular distribution of ν_μ, $\bar{\nu}_\mu$, ν_e, $\bar{\nu}_e$

In red: 1-D calculation

Negative muons at floating altitudes: CAPRICE94

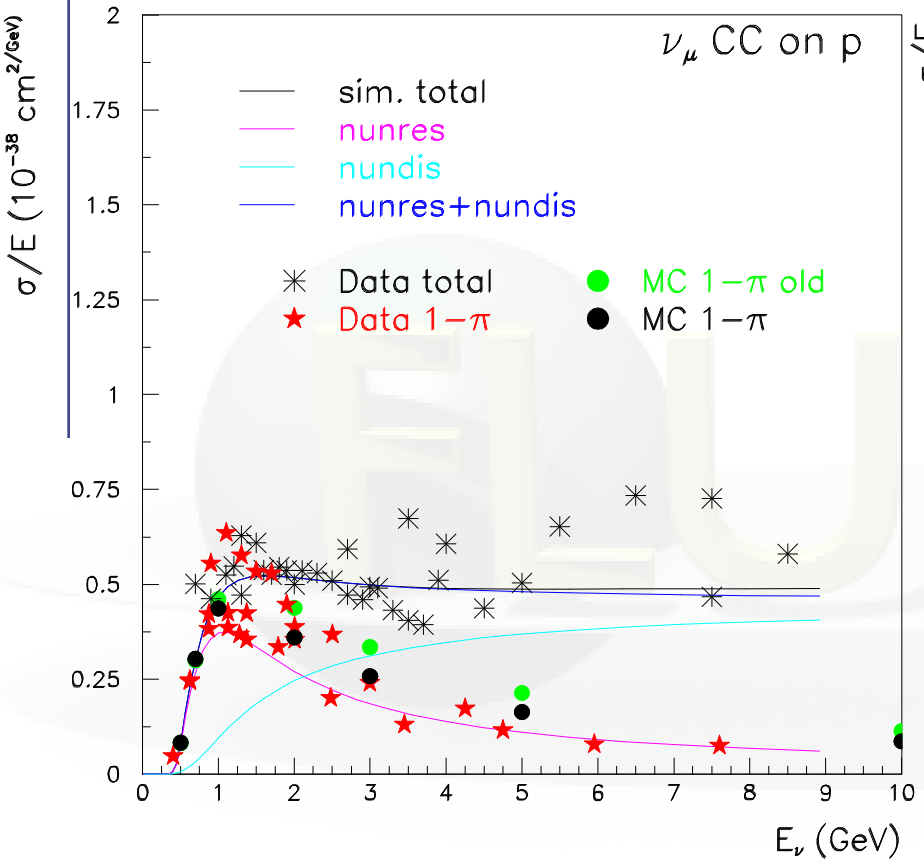


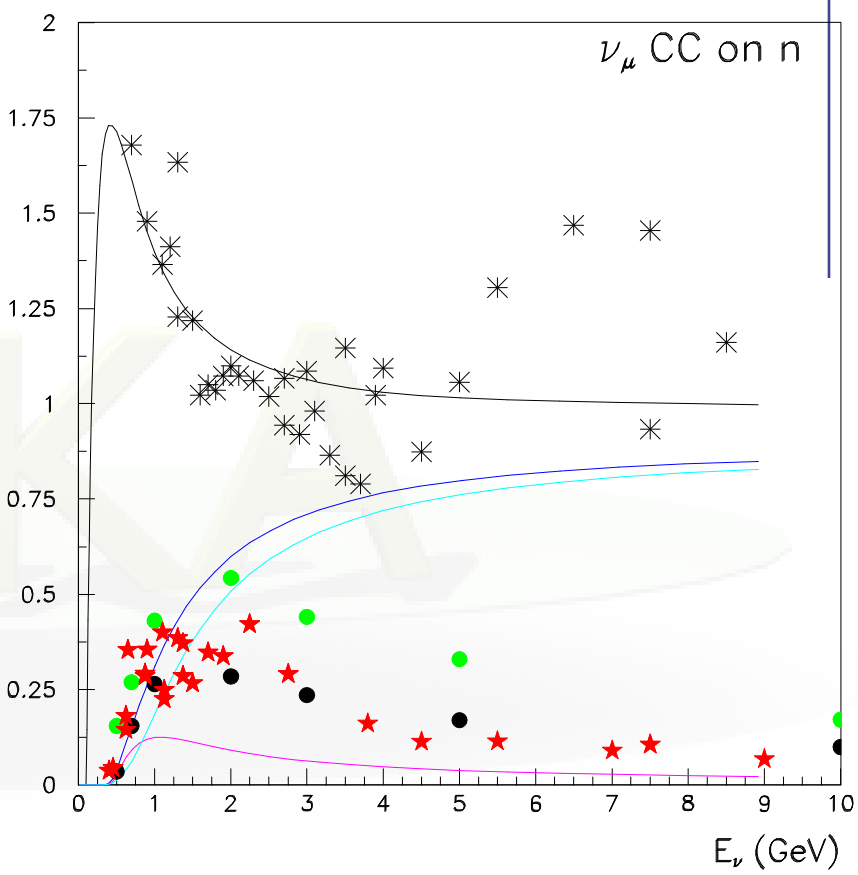
Open symbols: CAPRICE data
Full symbols: FLUKA

primary spectrum normalization ~AMS-BESS
Astropart. Phys., Vol. 17, No. 4 (2002) p. 477


FLUKA

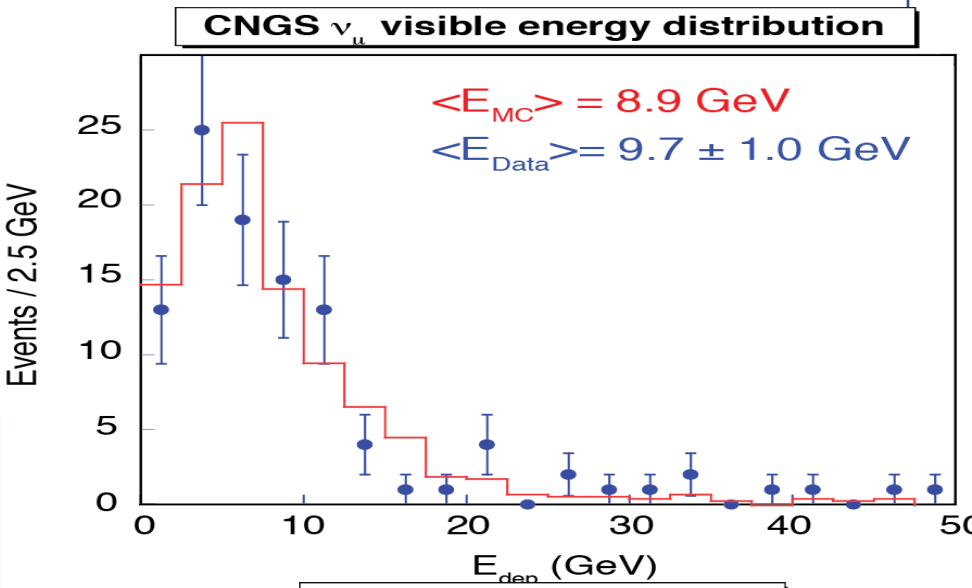
Neutrino interactions:

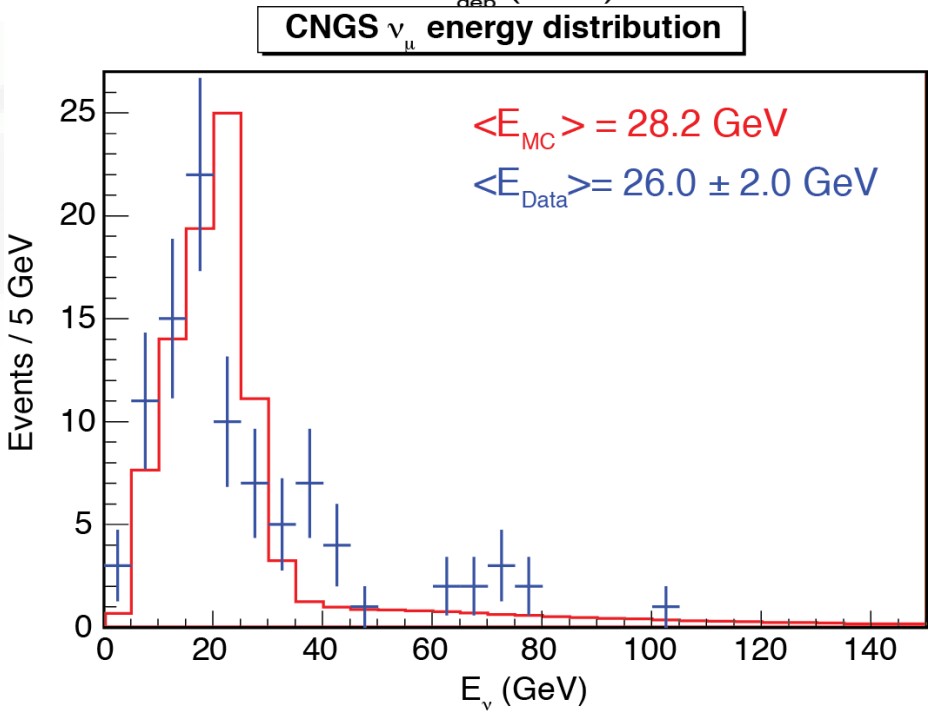




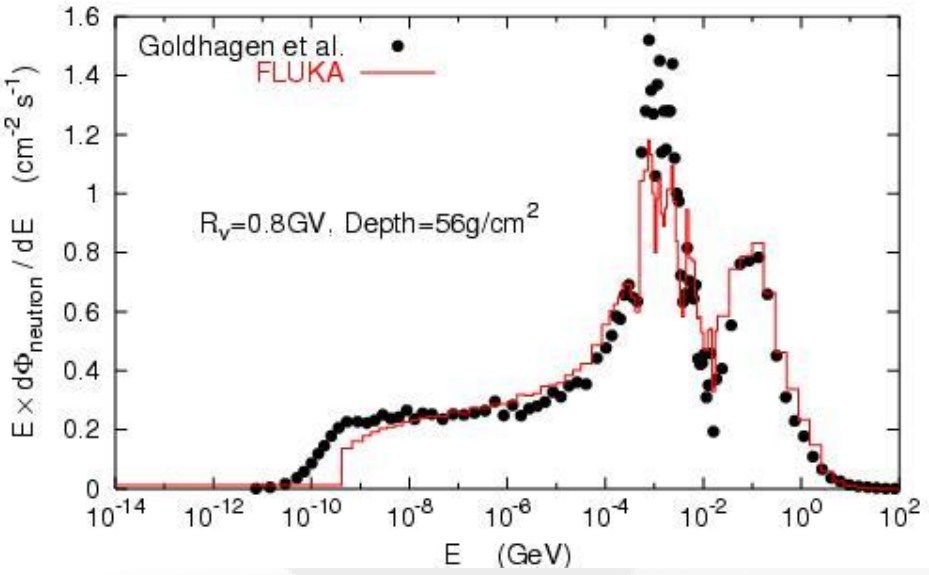
Simulation of ICARUS exp. @ LNGS

- **Calorimetric reconstruction:**
  - **"raw" deposited energy compared with MC for CNGS CC interactions (2010 data)**
- **Total measured energy of 2010 ν_μ CC:**
  - **Lepton and hadronic jet reconstructed separately**
  - **μ momentum via multiple scattering**
  - **hadron energy from calorimetric measurement**





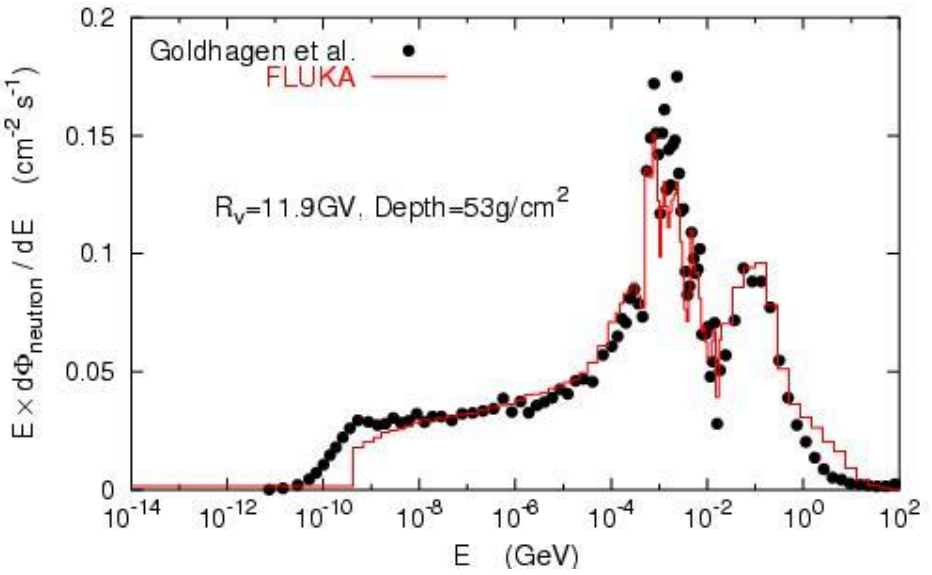
Neutrons on the ER-2 plane at 21 km altitude



Measurements:

Goldhagen et al., NIM A476, 42 (2002)

Note one order of magnitude difference depending on latitude

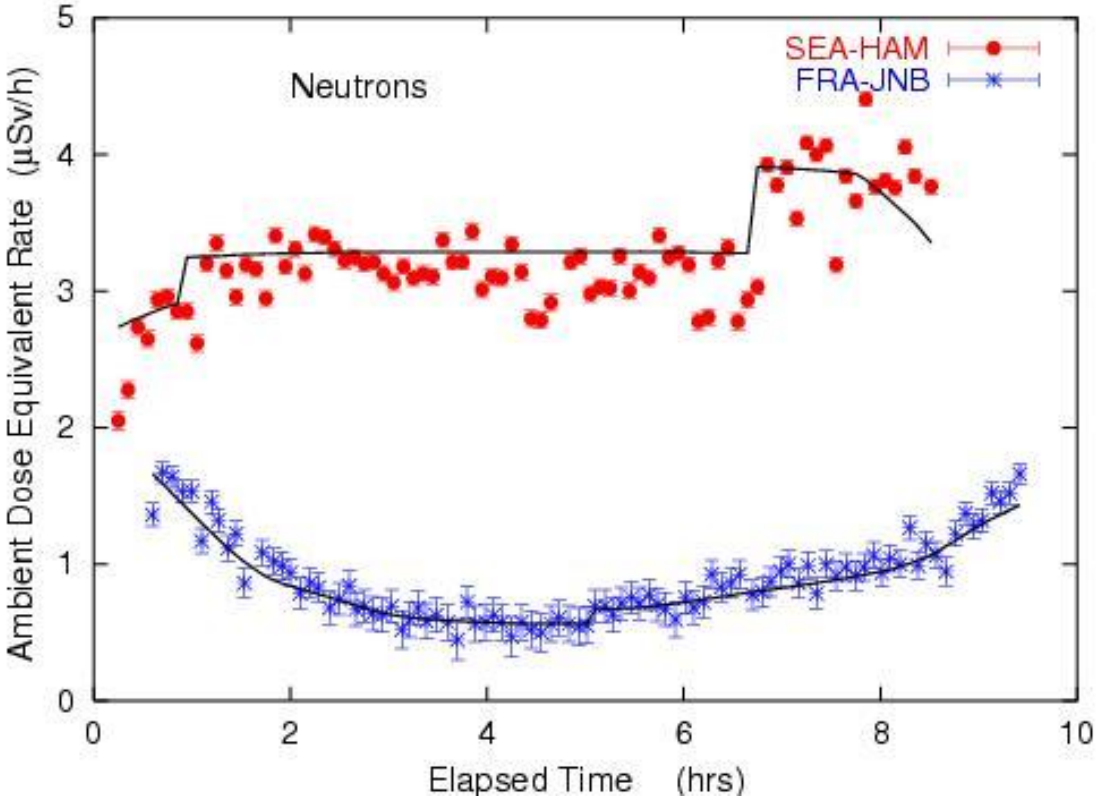


FLUKA calculations:

Roesler et al., Rad. Prot. Dosim. 98, 367 (2002)

Dosimetry Applications

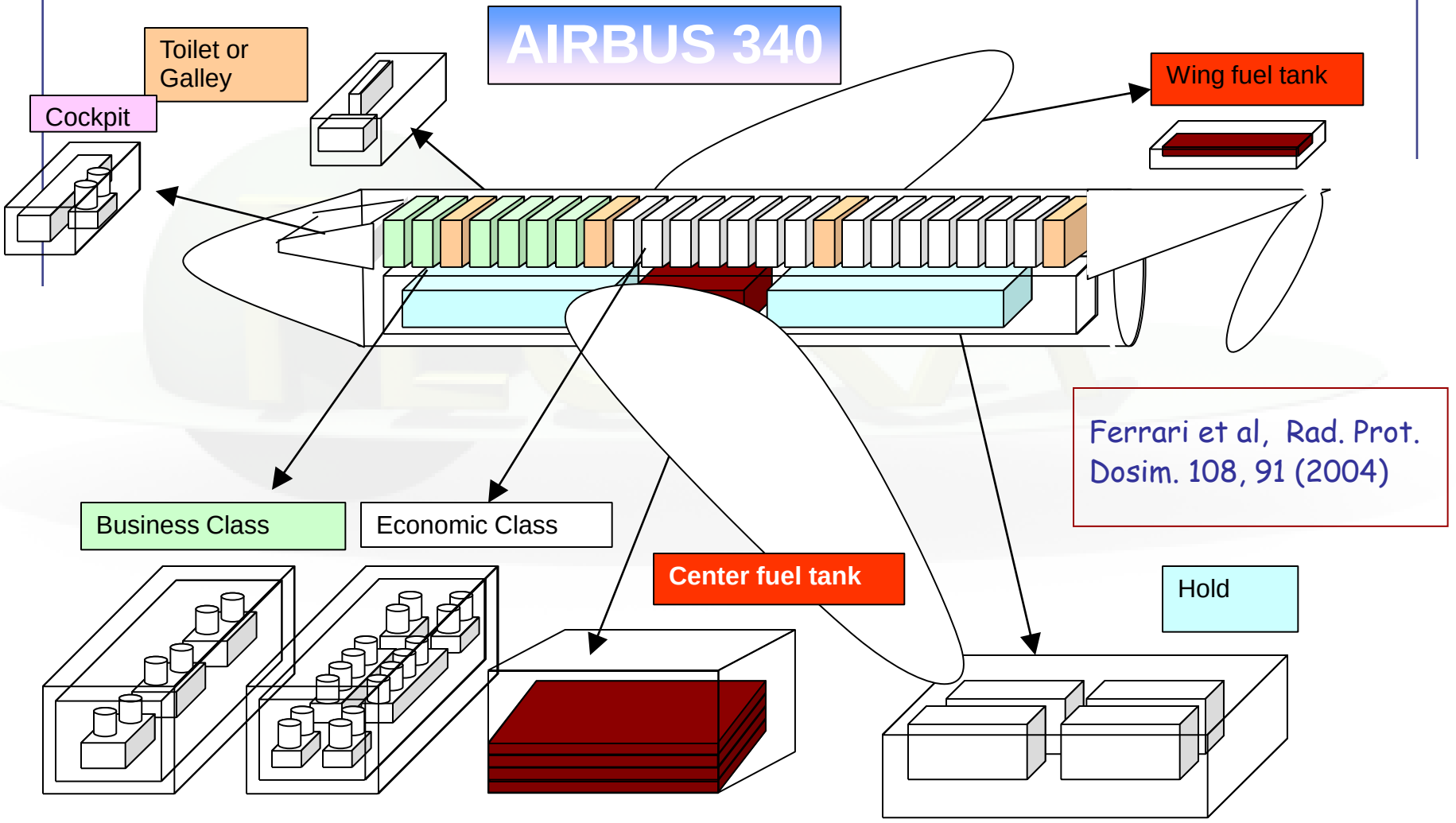
Roesler et al.,
Rad. Prot. Dosim.
98, 367 (2002)



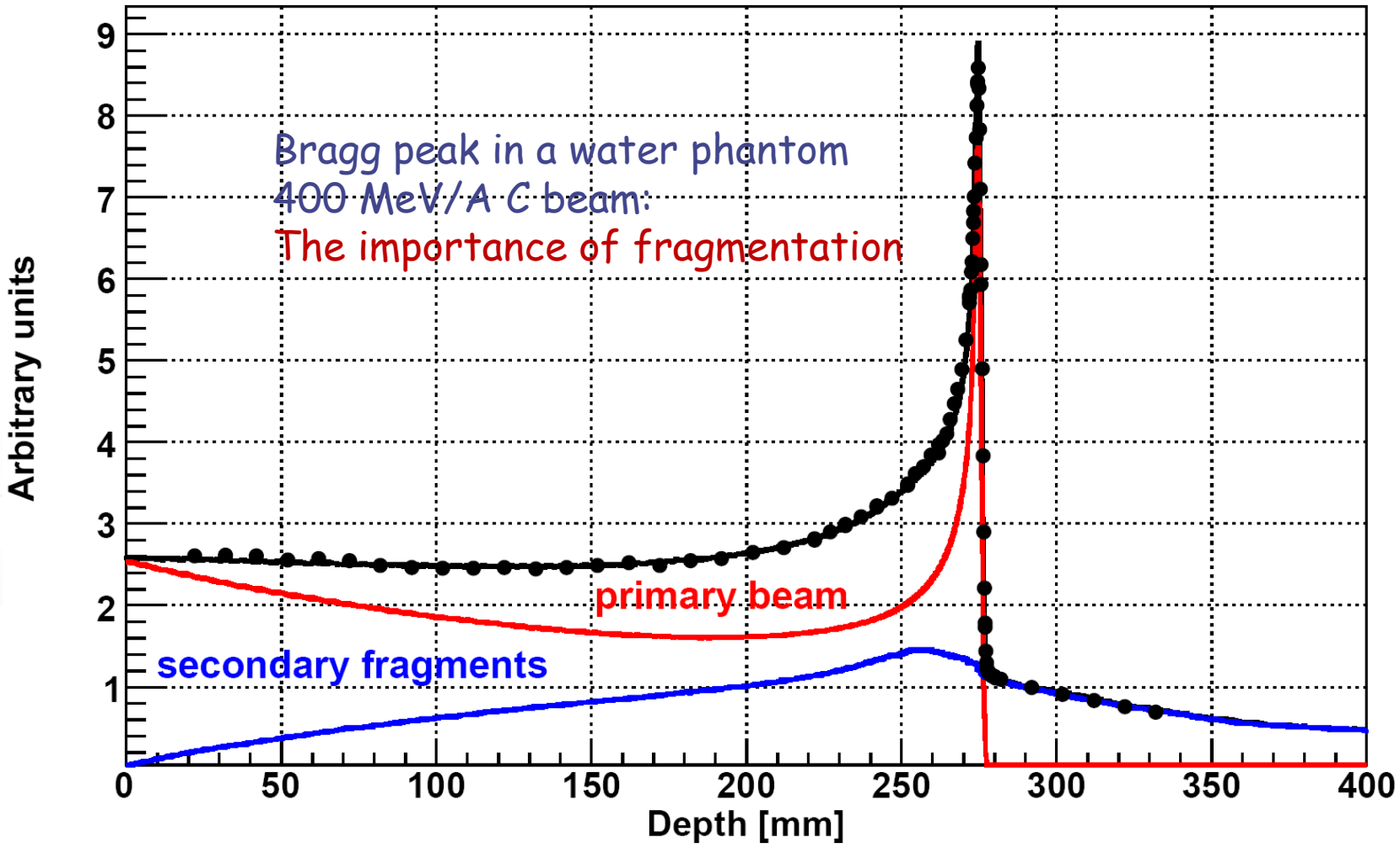
Ambient dose equivalent from neutrons at solar maximum on commercial flights from Seattle to Hamburg and from Frankfurt to Johannesburg.

Solid lines: FLUKA simulation

Dosimetry applications: doses to aircrew and passengers



Carbon Ion Therapy



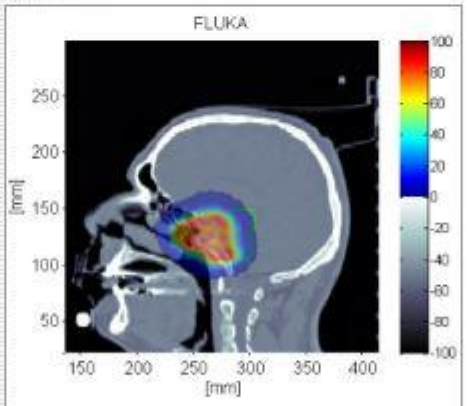
Exp. Data (points) from Haettner et al, Rad. Prot. Dos. 2006
Simulation: A. Mairani PhD Thesis, 2007, Nuovo Cimento C, 31, 2008

http://cdsweb.cern.ch/journal/CERNBulletin/2012/20/News%20Articles/1447488?ln=en

The Bulletin
Issue No. 20-21/2012 - Monday 14 May 2012
Printable version

A Monte Carlo code for ion beam therapy

Initially developed for applications in detector and accelerator physics, the modern Fluka Monte Carlo code is now used in many different areas of nuclear science. Over the last 25 years, the code has evolved to include new features, such as ion beam simulations. Given the growing use of these beams in cancer treatment, Fluka simulations are being used to design treatment plans in several hadron-therapy centres in Europe.



Fluka calculates the dose distribution for a patient treated at CNAO with proton beams. The colour-bar displays the normalized dose values.

Fluka is a Monte Carlo code that very accurately simulates electromagnetic and nuclear interactions in matter. In the 1990s, in collaboration with NASA, the code was developed to predict potential radiation hazards received by space crews during possible future trips to Mars. Over the years, it has become the standard tool to investigate beam-machine interactions, radiation damage and radioprotection issues in the CERN accelerator complex.

Recently, the medical community has shown great interest in Fluka for a different type of application: ion beam therapy for cancer treatment. As this type of intervention uses particle beams to target tumour cells, it is very

http://www.isgtw.org/spotlight/physics-software-used-fight-cancer

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Physics software used to fight cancer

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In the past, we've reported on how computing and physics tools are used to advance and administer new cancer treatments. Now researchers at CERN and INFN are once again repurposing a physics tool for use in the battle against cancer: a simulation code called Fluka.

Fluka was originally designed for accelerator and detector physics. Physicists use it to accurately predict electromagnetic and nuclear interactions in matter.

For example, CERN has used it to study beam-machine interactions and radiation damage, and NASA has used it to forecast radiation exposure in astronauts.