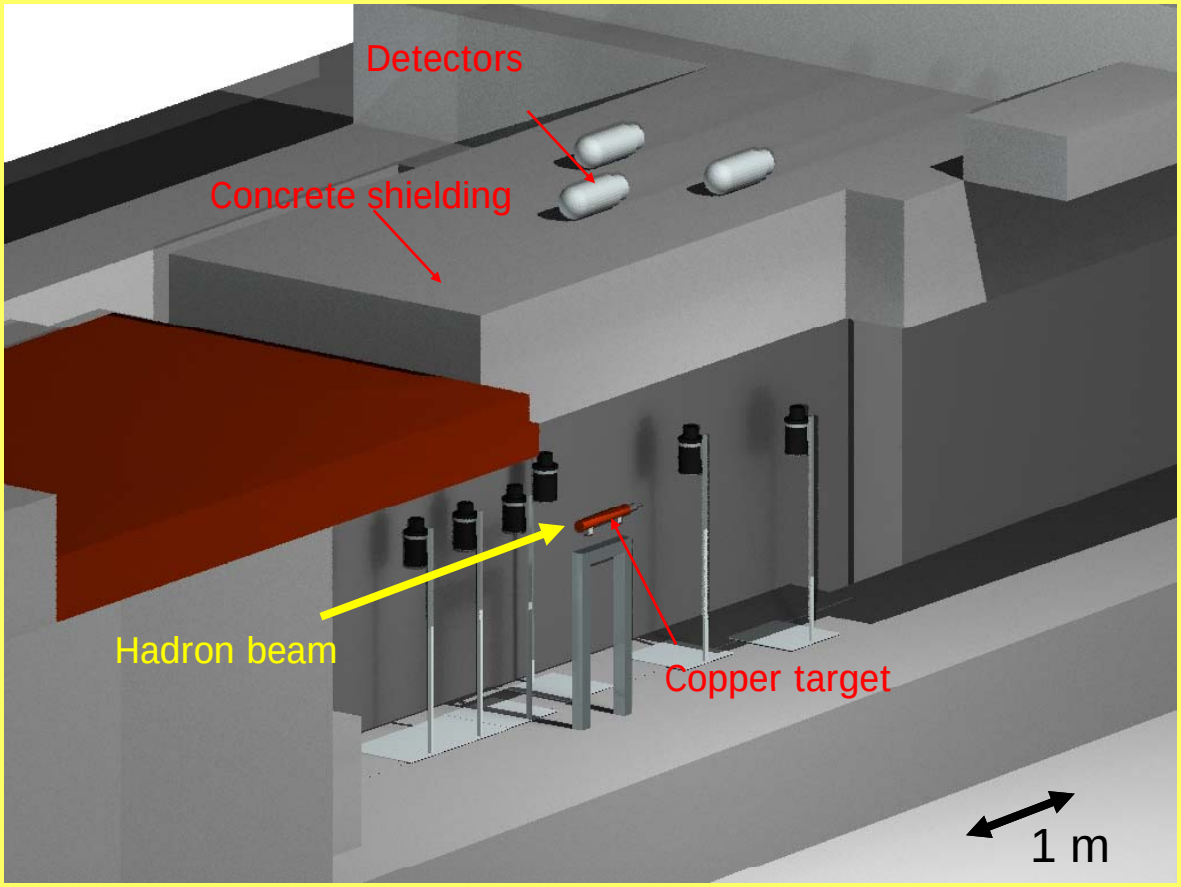
Irradiation Facilities at the SPS North Experimental Area

Helmut Vincke on behalf of RP

Content

- CERF
- TCC2 irradiation facility
- CERF++

CERN-EU high-energy Reference Field (CERF) facility



CERF exists since 1992

CERF is an irradiation facility providing high-energy mixed radiation fields

How? ➔ A mixed hadron beam is intercepted by a copper target ➔ high-energy mixed radiation field produced by EM and hadronic cascades

Secondary SPS beam line (H6) is used to irradiate copper target.

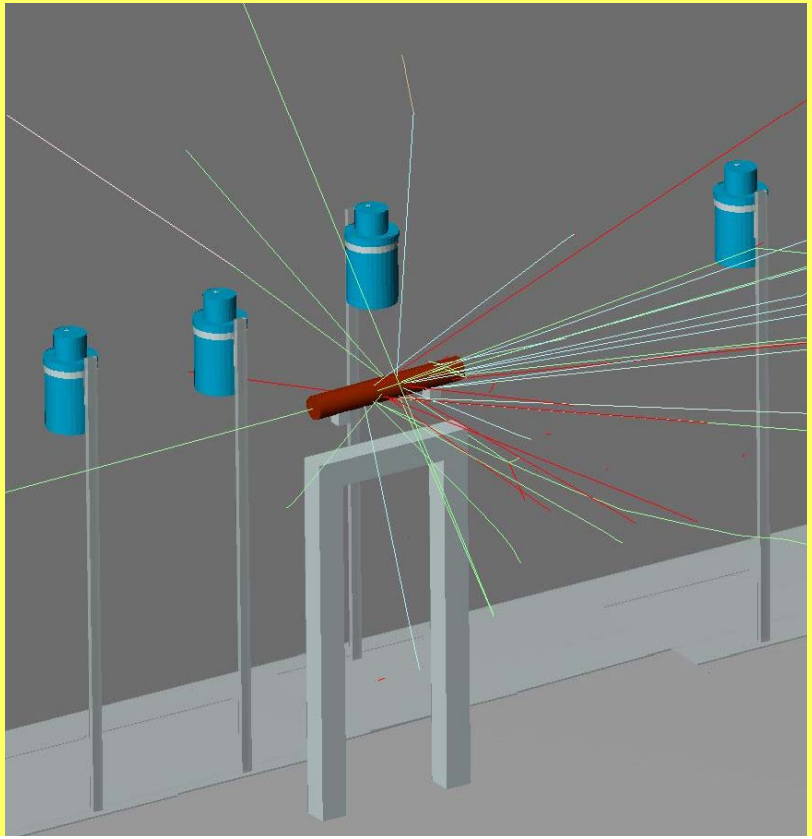
Parameters of the H6 beam

Momentum: between 20 GeV/c (even 5 GeV/c) and 205 GeV/c

Typical CERF momentum: 120 GeV/c

Intensity: up to 10^8 particles per SPS cycle (16.8 s)

Particle composition: 60.7% π^+, 34.8 % protons and 4.5 % K^+

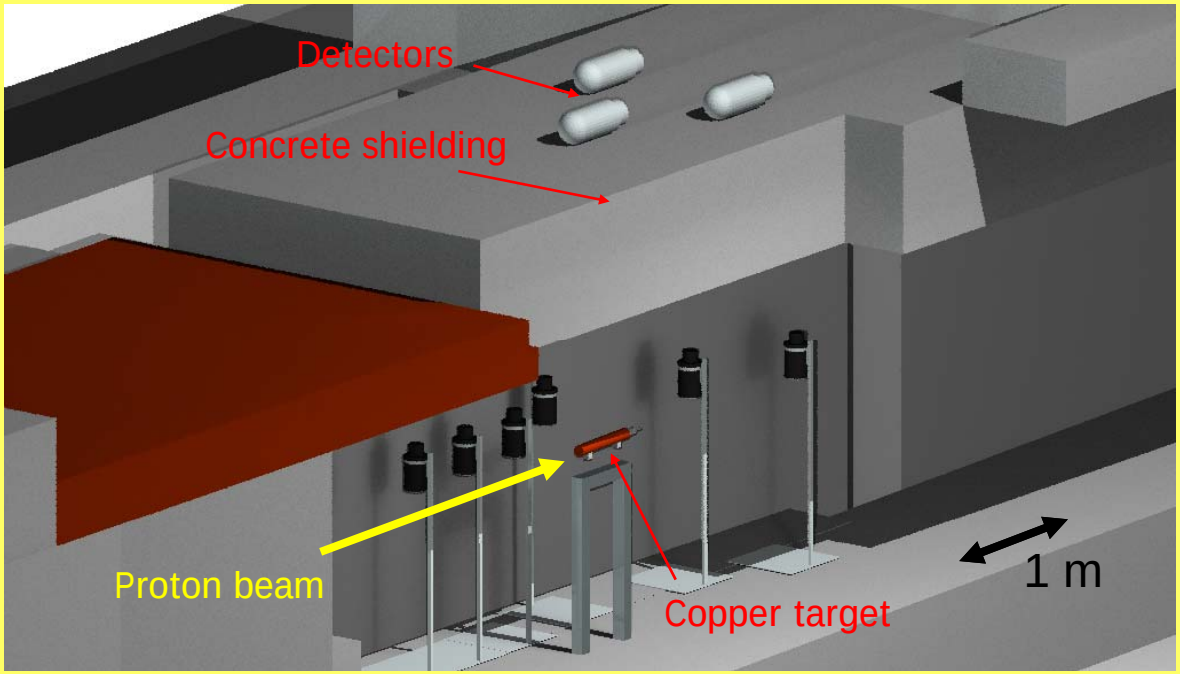


Parameter of Target

Material: copper (λ= 15 cm)

Length: 50 cm

Diameter: 7 cm



Video 1

Video 2

Shielding parameter

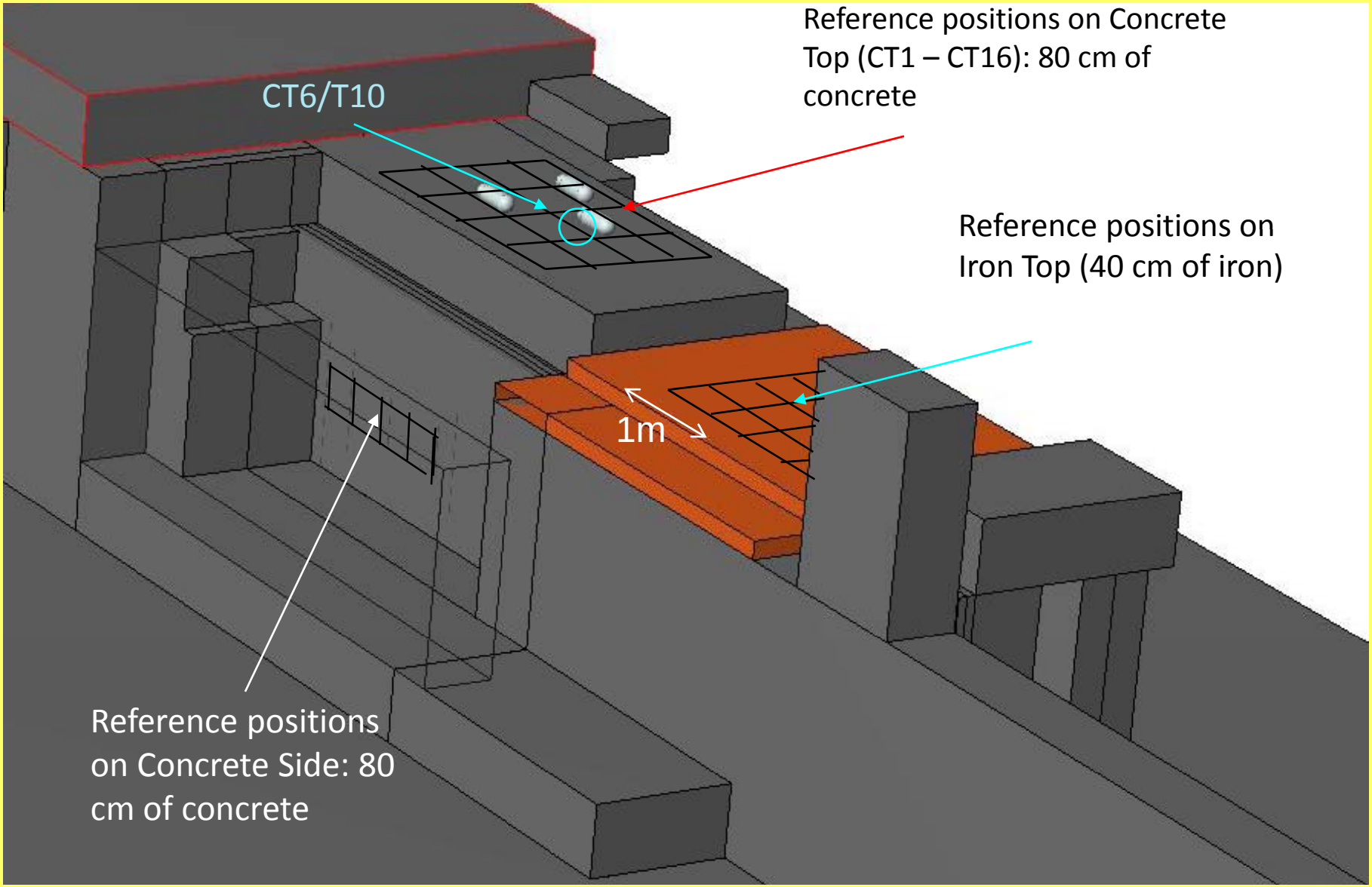
No shielding (inside): radiation field close to target

Tests of Beam Loss Monitors, calibration of High-Level dosimeters, activation studies: benchmark of FLUKA calculations

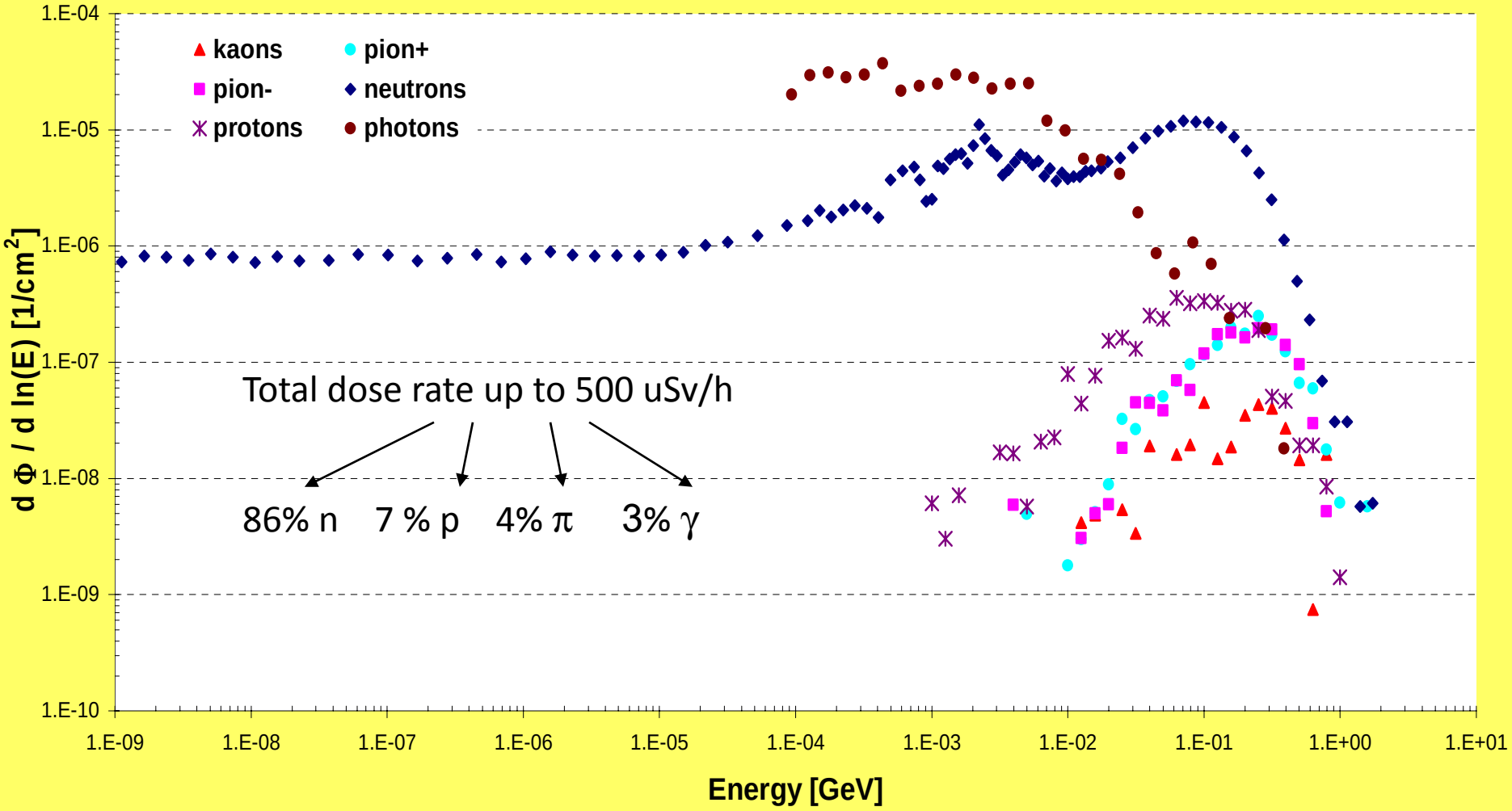
80 cm of concrete or 40 cm of iron: attenuated radiation field

Calibration of radiation protection instruments used in accelerator behind thick shielding facilities and for cosmic radiation at high altitude …

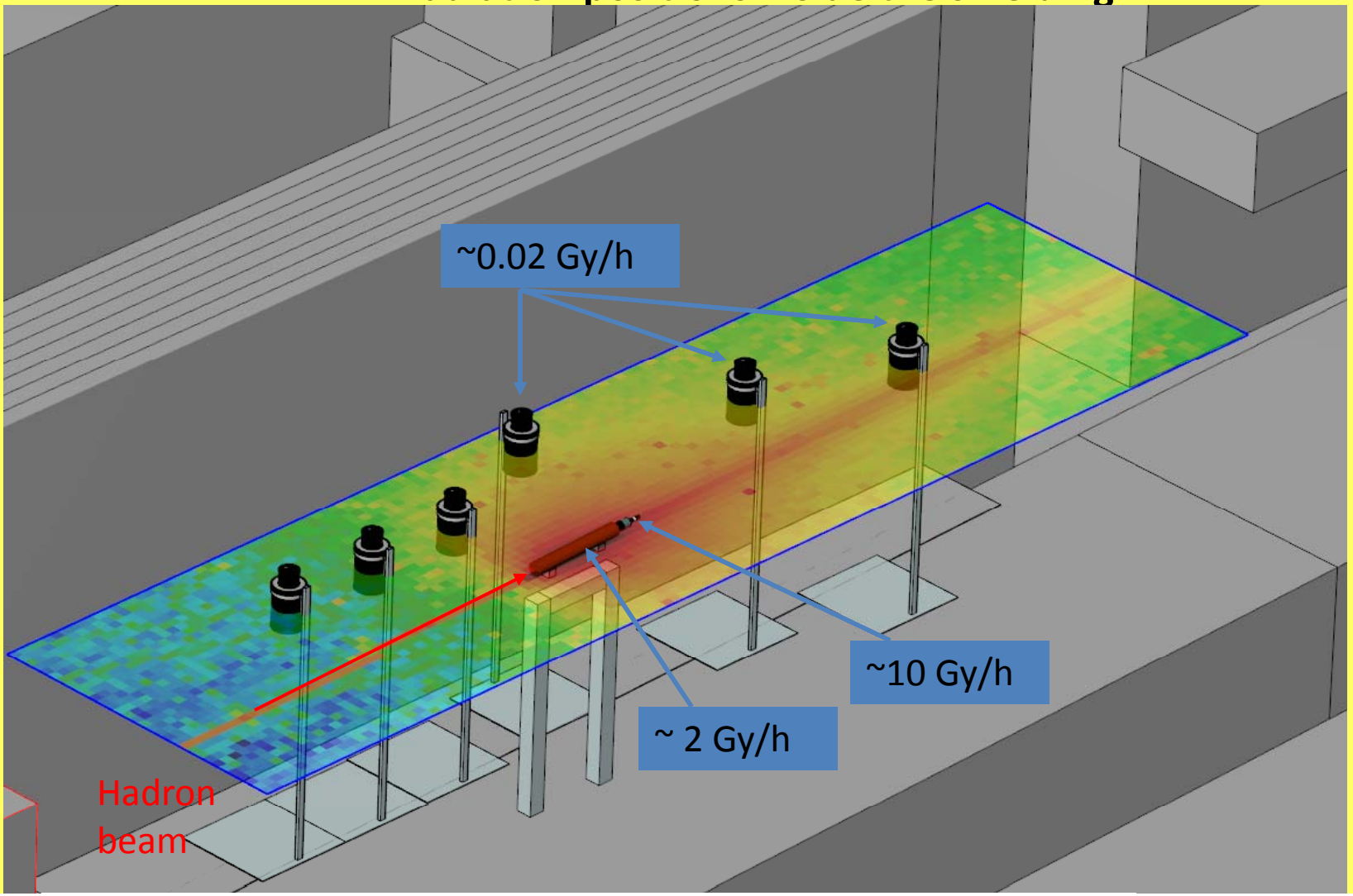
Irradiation positions outside the shielding

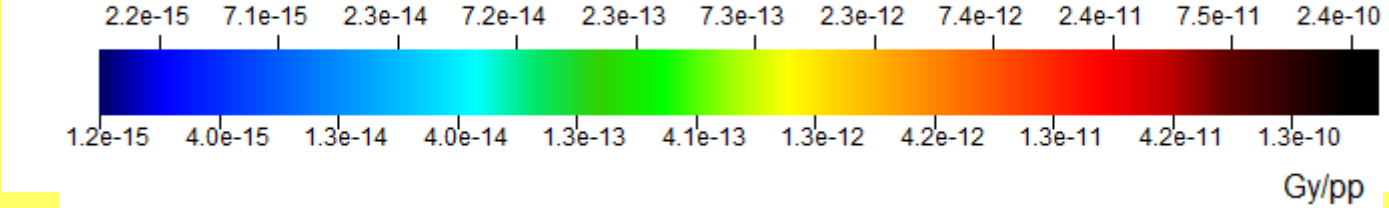


Particle fluence spectra at reference position CT6/T10



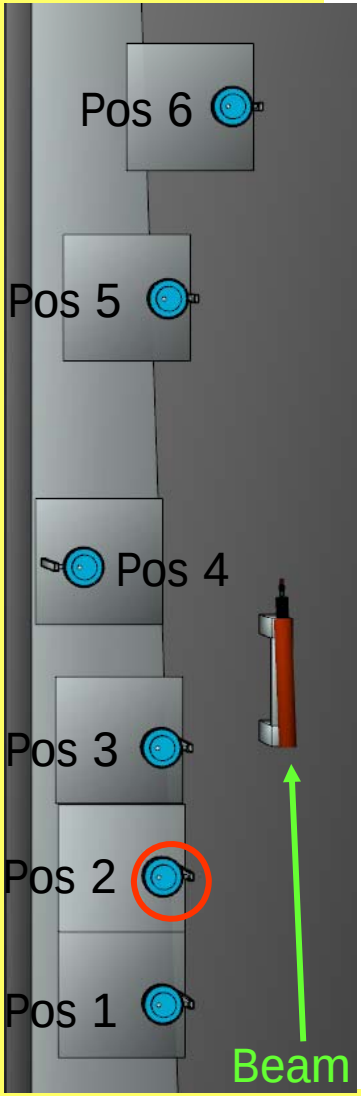
Irradiation positions inside the shielding

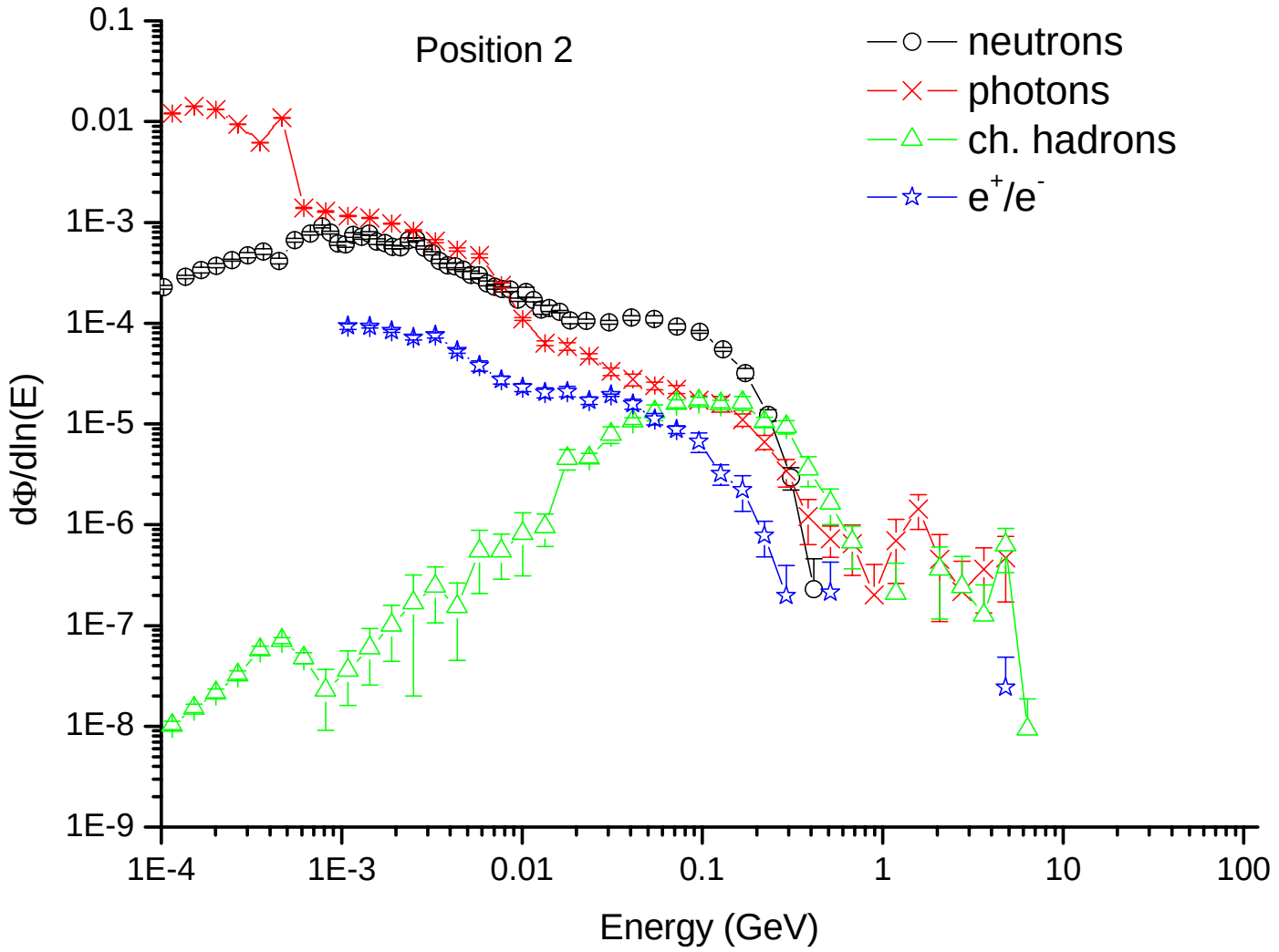




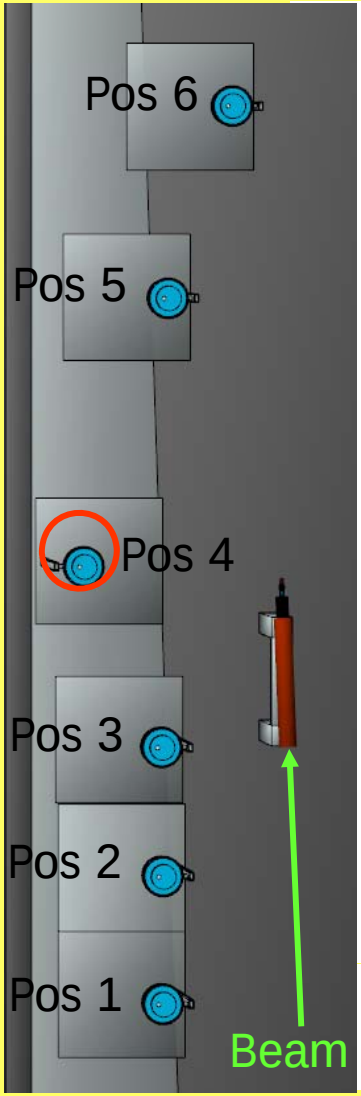
Dose rate at 1E8 protons/spill

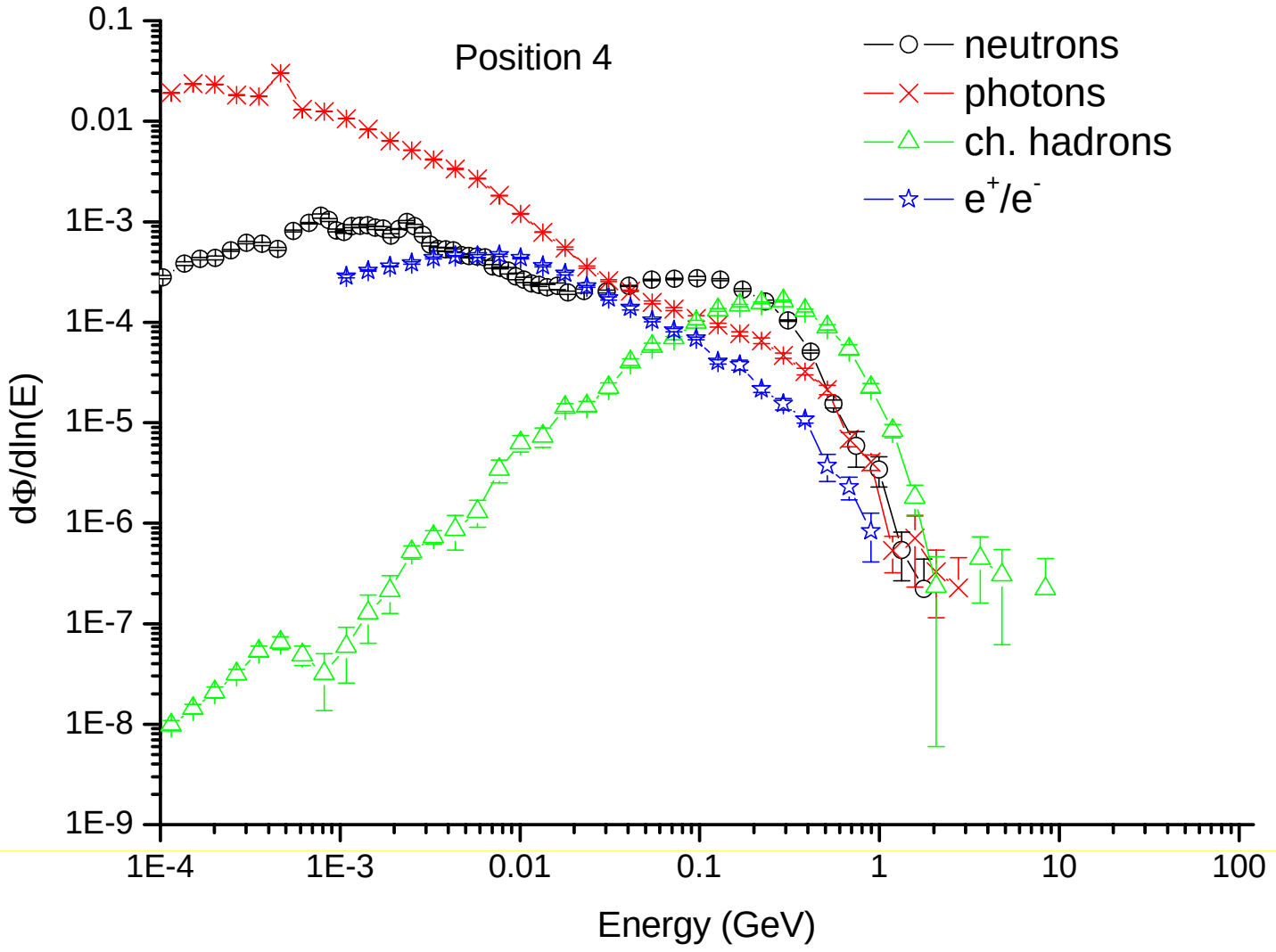
Fluence at different detector positions



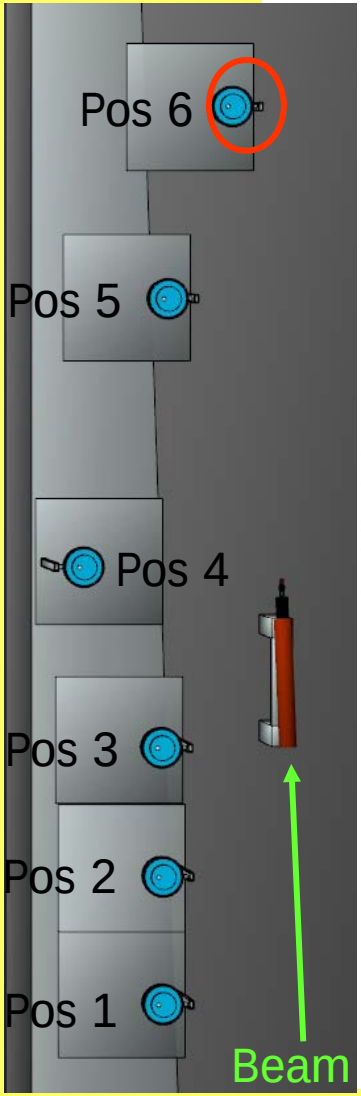


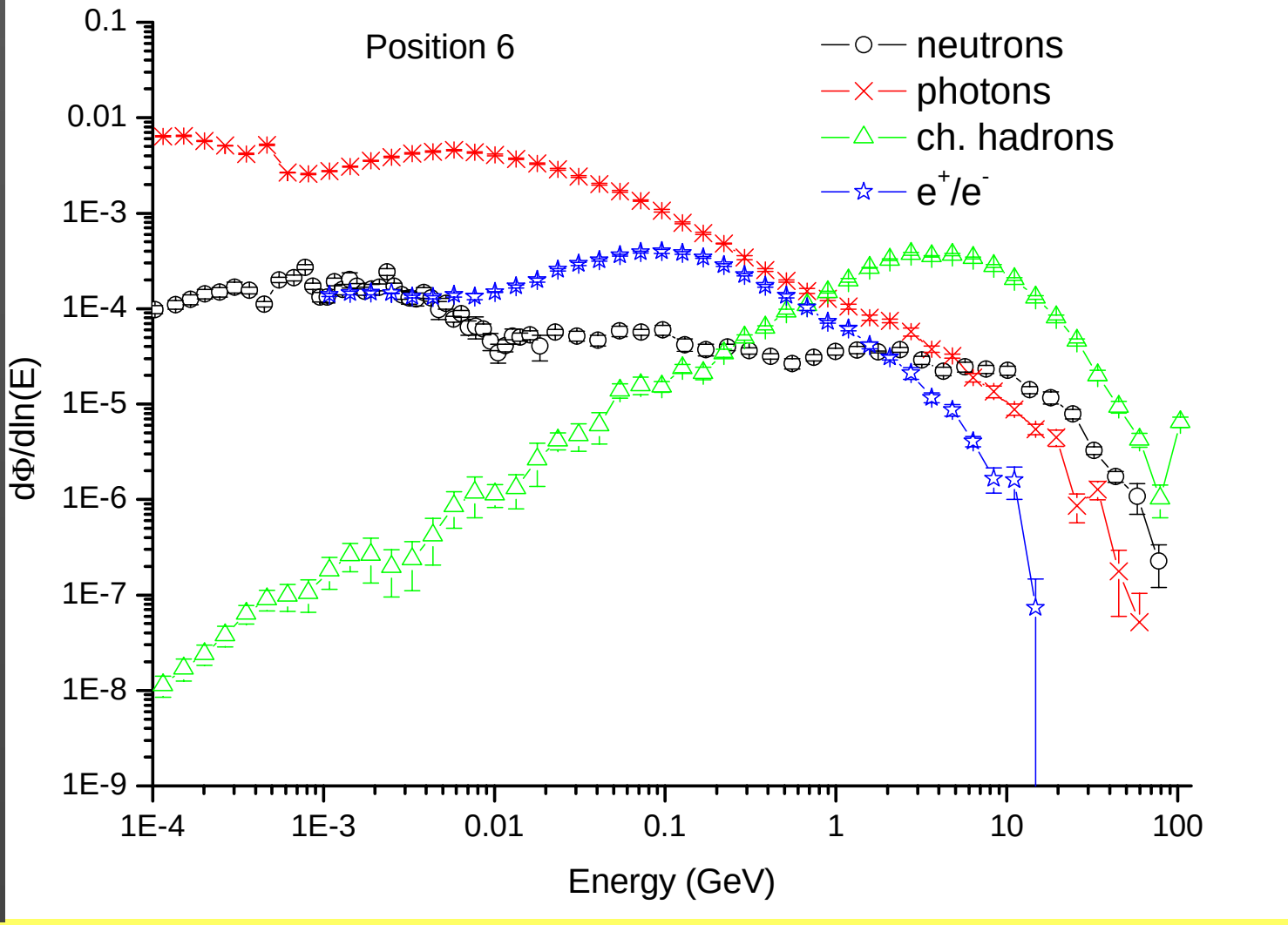
Fluence at different detector positions





Fluence at different detector positions





Annual availability of CERF

During the last years the annual availability was between 1 and 2 weeks.

Present applications

- **Radiation Protection**
  - LHC radiation monitor studies
  - Space and aircraft dosimetry
  - High and low level dosimetry
- **FLUKA benchmarks**
  - Material activation studies
  - Instrumentation studies
- **LHC beam loss monitor studies**

Achievements of the last 10 years

• Facility used by more than 70 scientists from 50 external institutes (~20 different countries) and various CERN groups (RP, AB, TS,…)

• ~ 85 international publications

• ~ 60 internal CERN notes

Cons of CERF

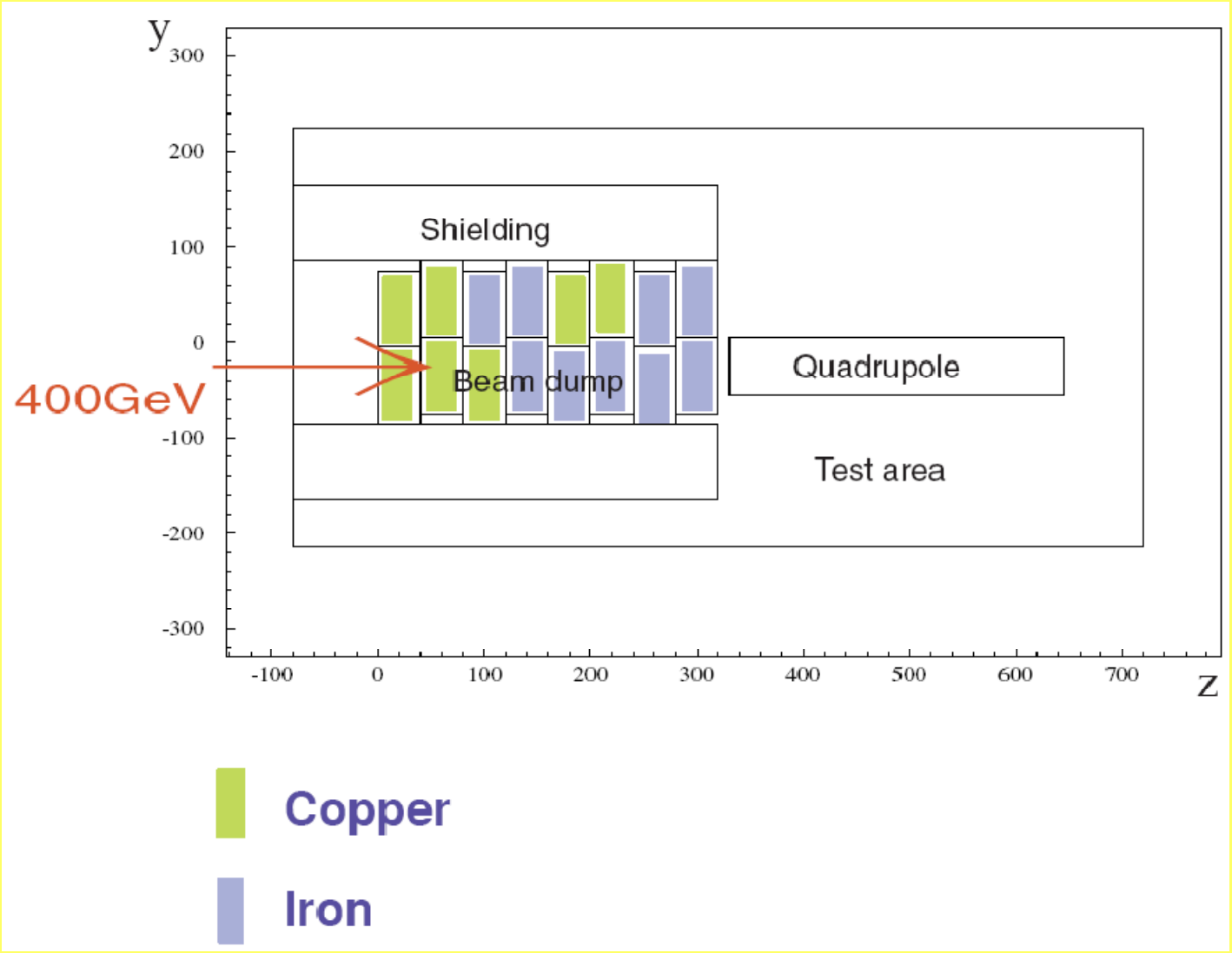
- Muon background on Top positions of the shielding (for outside position)
- Hadron background from neighboring beam lines (for outside position)
- Limited dose rate (at reasonable measurement positions)

Pros of CERF

- Well defined radiation field at all positions
- Well controllable irradiation conditions due to beam control by users
- Several kinds of radiation fields (inside cave vs. shielding)

TCC2 irradiation facility

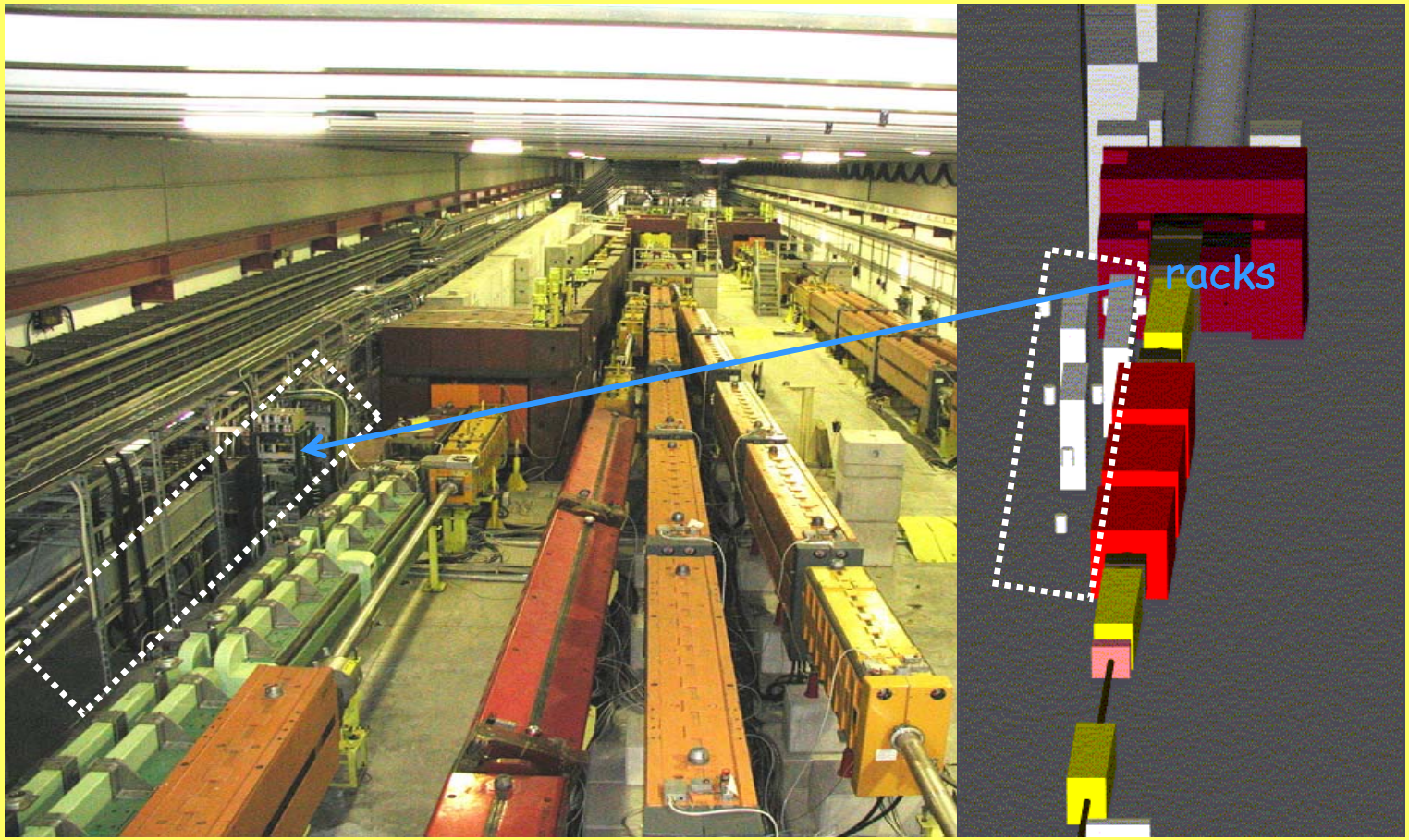
(information about facility provided by Thijs Wijnands and taken from a talk given by Katherina Tsoulou at the RADMON Day 2004)



Facility was used first time in 1992

Simulation of TCC2 area

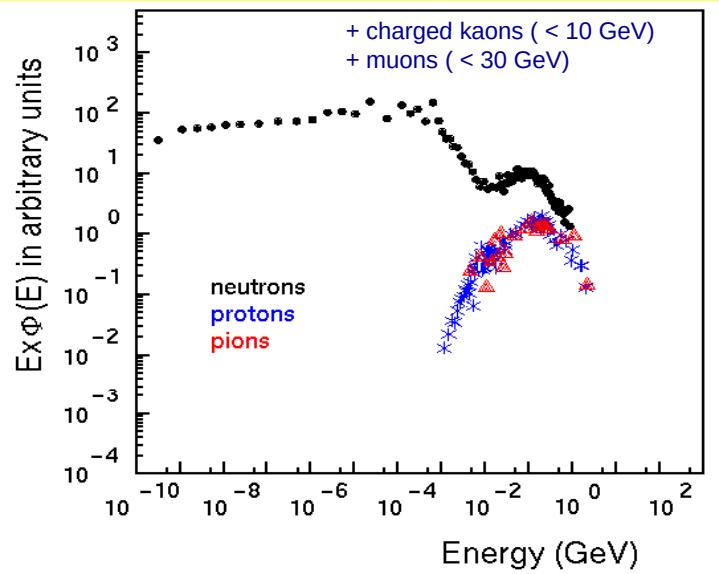
Detailed reconstruction of the test area …



Particle Spectra

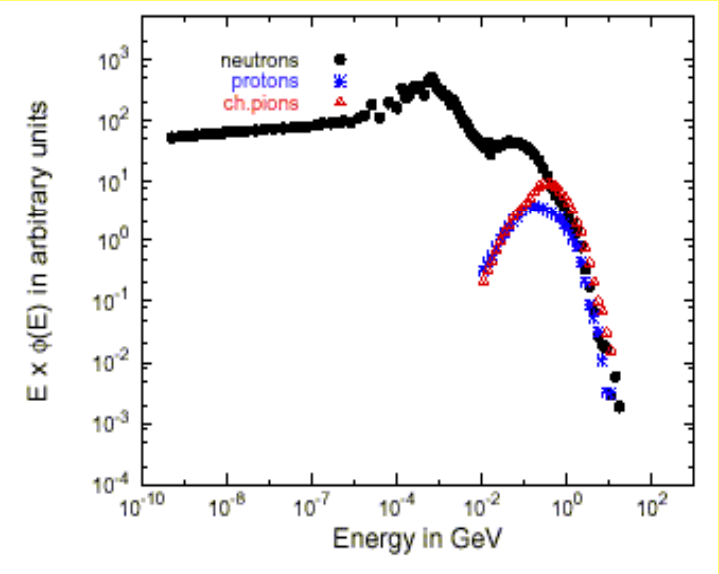
The fluences in TCC2 area

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



[K. Tsoulou, CERN, 2004]

The fluences in the LHC tunnel



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

Similarities between spectra (typical of concrete / iron environment)

Irradiation conditions at the TCC2 facility

	LHC arcs	*Near TAX in TCC2*
Total hadron fluence	~ 10^{12} cm^{-2}/ year	0.3 – 1.5 · 10^{12} cm^{-2}/day
Hadron fluence > 20 MeV	~ 10^{10} cm^{-2}/ year	0.5 – 1.5 · 10^{10} cm^{-2}/day
Dose	5 – 10 Gy / year	~ 3 Gy / day

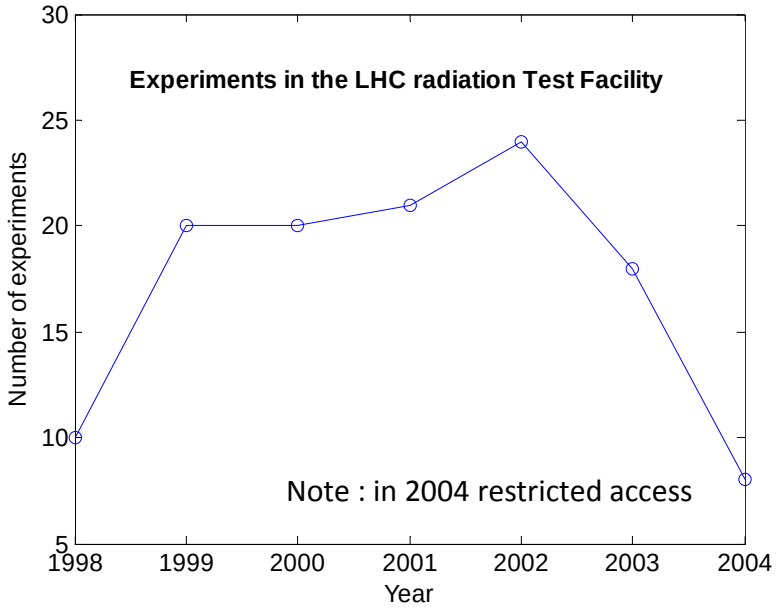
[LHC data taken from C. Fynbo, G. Stevenson, CERN]

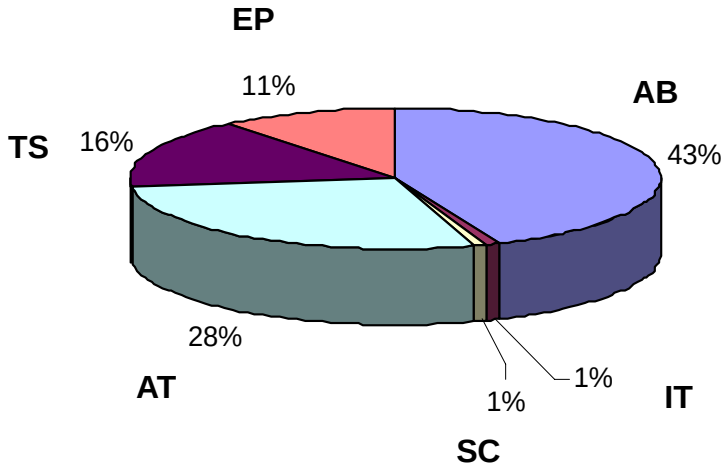
Usage : irradiation of single components and complete systems

Pros:
- High doses within reasonable time
- Sufficient space to test complete systems

Cons:
- parasitic experiment ➔ no control over beam and radiation conditions
- access to the area is problematic due to very high residual dose rate

TCC2 test facility – statistics



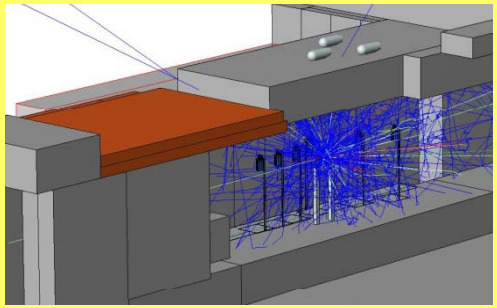


Facility closed in 2005 – no beam in SPS

Not reopened in 2006

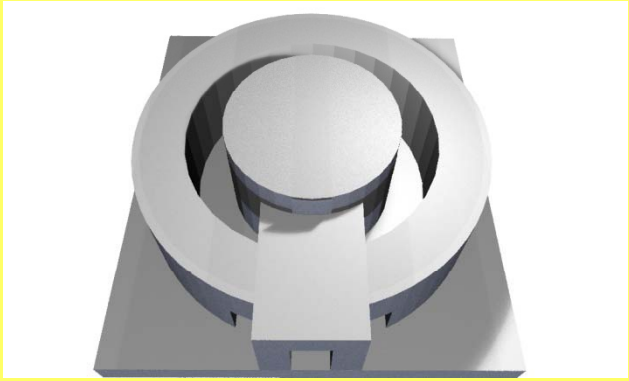
First ideas for a new irradiation facility

CERF



TCC2

CERF ++

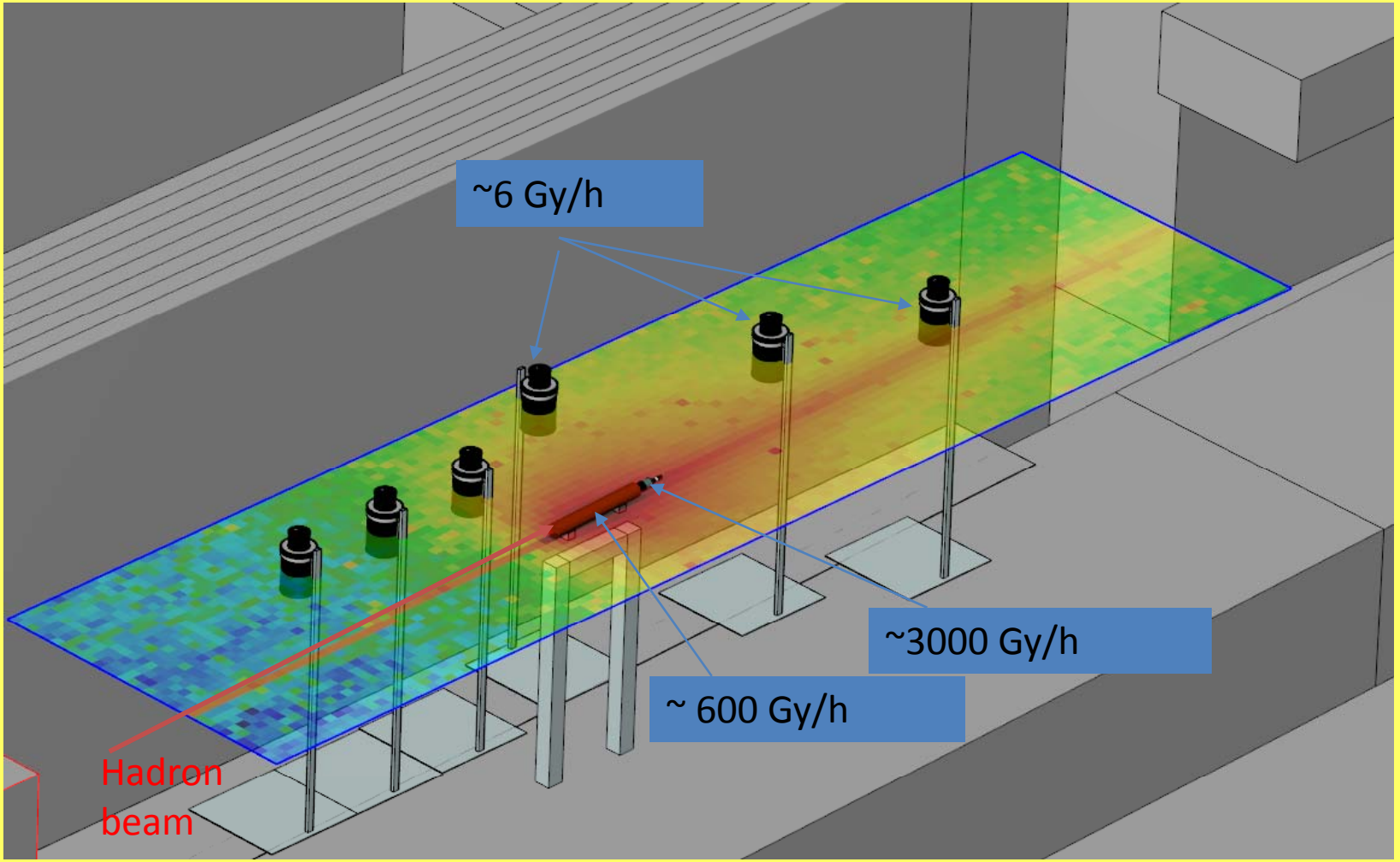


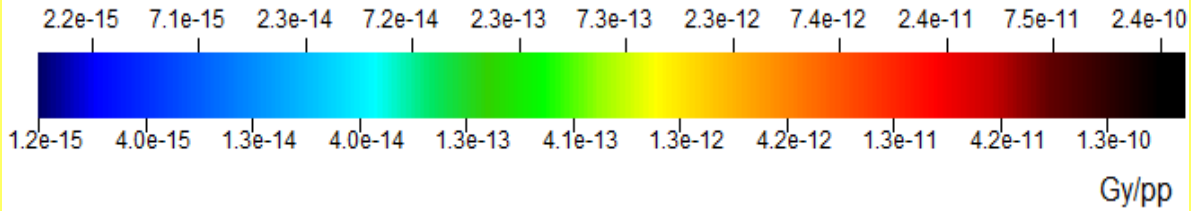
CERF++

- Typical target shielding configuration ➔ low and high dose areas
- Increased beam intensity: up to 10^{10} hadrons per spill (factor 100 higher than CERF)
- Primary particle energies up to 400 GeV
- Different shielding materials ➔ bias of particle field composition
- Exchangeable targets
- Slow extraction of SPS (no pile up effect for measurement devices)
- Low undesired background

- Increase of dose rate by about a factor 300 (compared to CERF)
- Well defined low and high-dose irradiation location at one facility
- Variable radiation field compositions (by varying the angle between detector and target)

Irradiation locations inside the shielding
(CERF results scaled to CERF++ parameters)





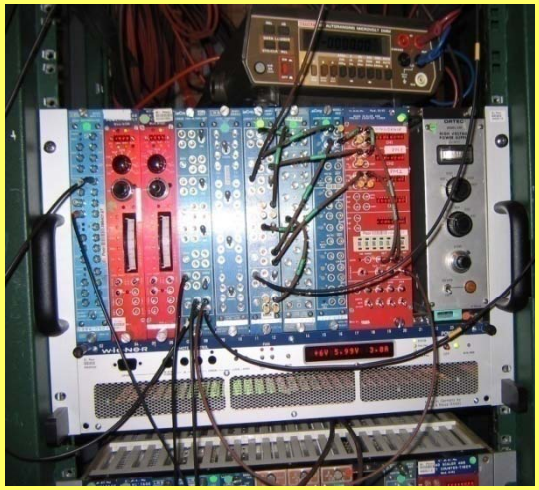
Dose rate at 1E10 protons/spill (400GeV)

Possible application fields for the proposed facility

Radiation Protection Instrumentation (µGy – Gy)

µGy - Gy

Radiation Tolerance Tests for Electronics (> 10 Gy)



> 10 Gy

High Level Dosimetry (0.1 Gy – MGy)

> 100 Gy

New facility

CERF (presently)

Possible client communities for this facility

Outside shielding (low dose) applications

- All CERF user:

Radiation Protection

- Radiation monitor studies
- Space and Aircraft dosimetry

FLUKA benchmarks

- Shielding studies
- Instrumentation studies

Inside shielding (high dose) applications

Radiation Protection

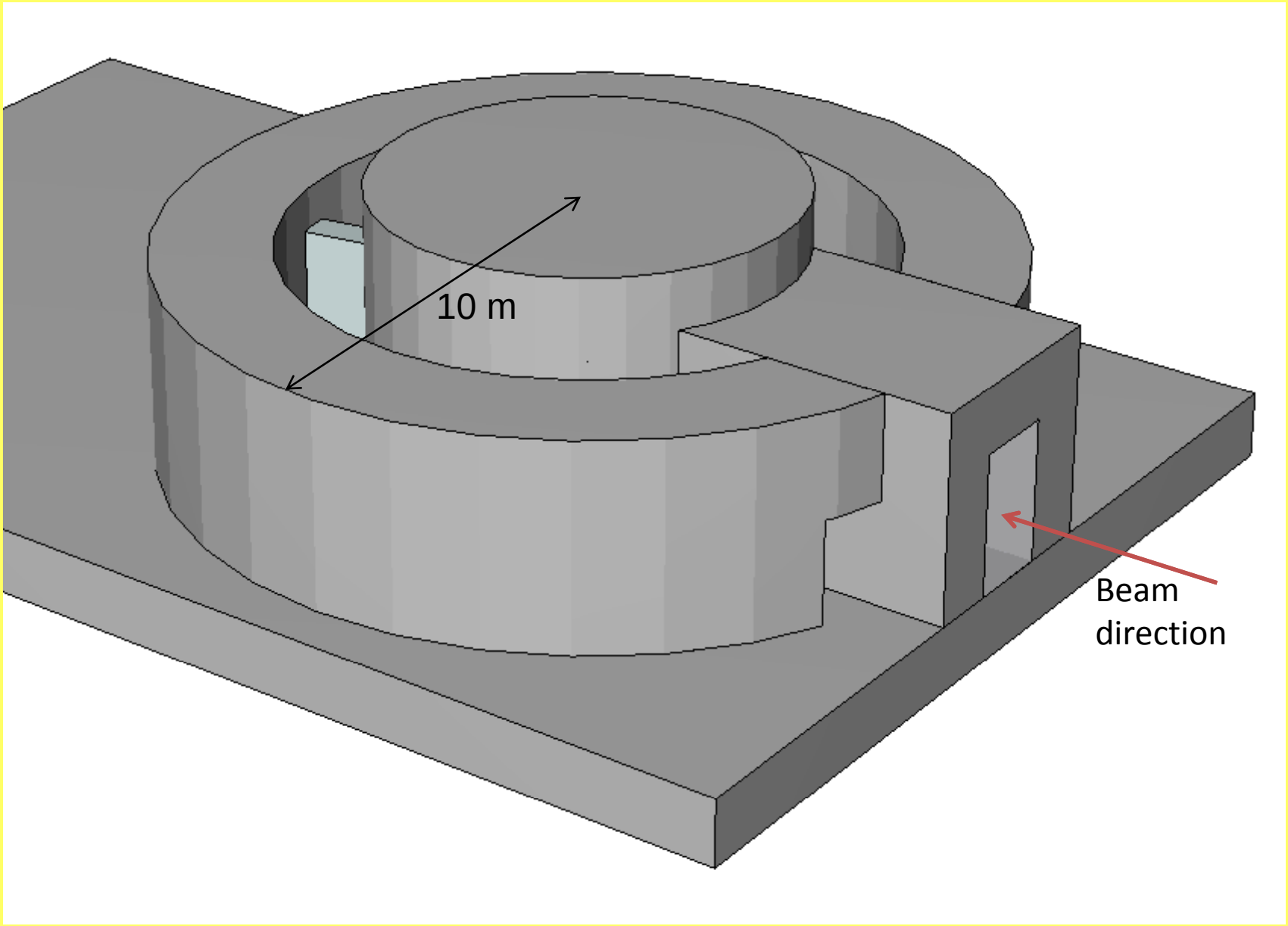
- Radiation monitor studies

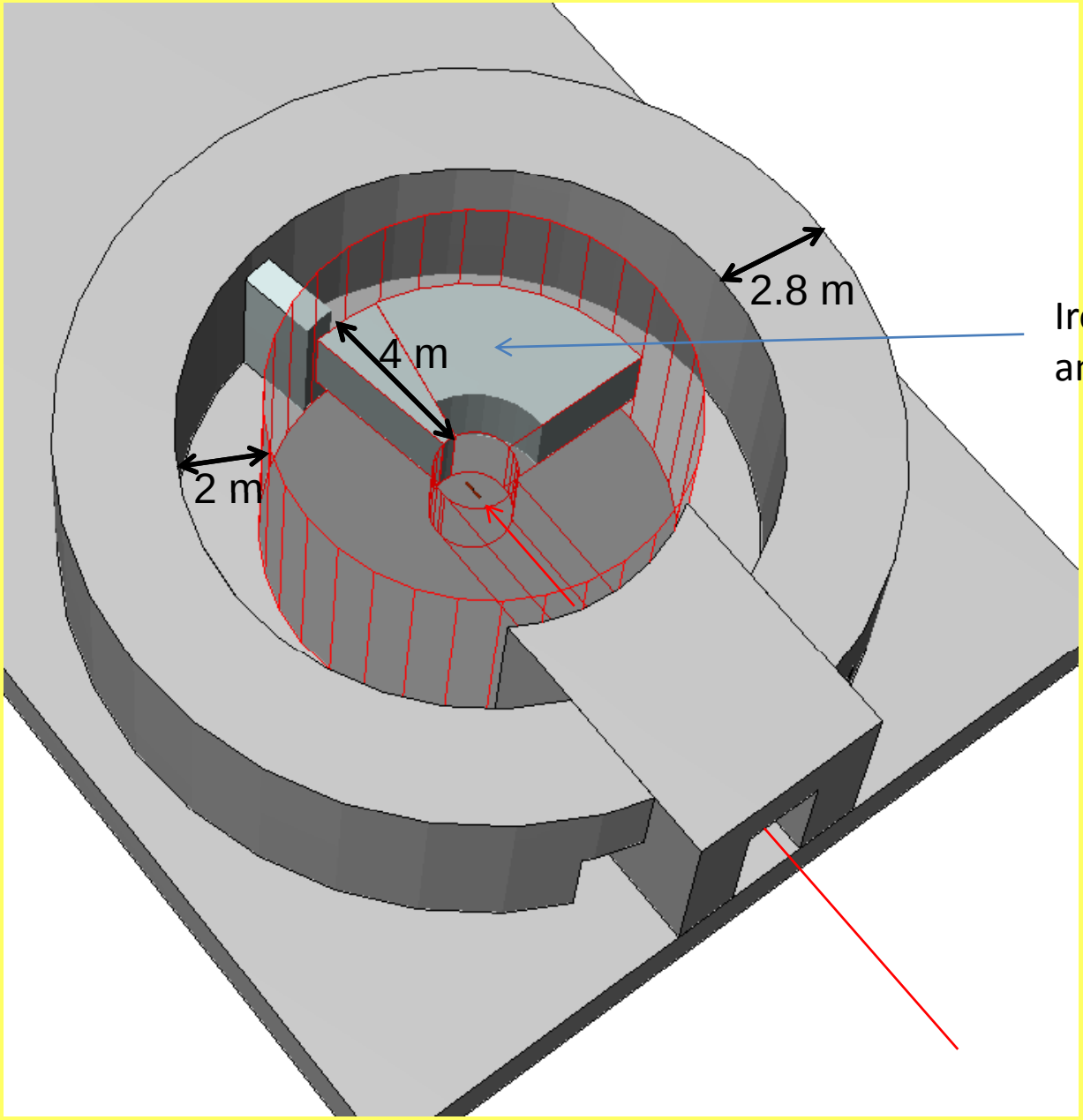
FLUKA benchmarks

- Material activation
- Instrumentation studies

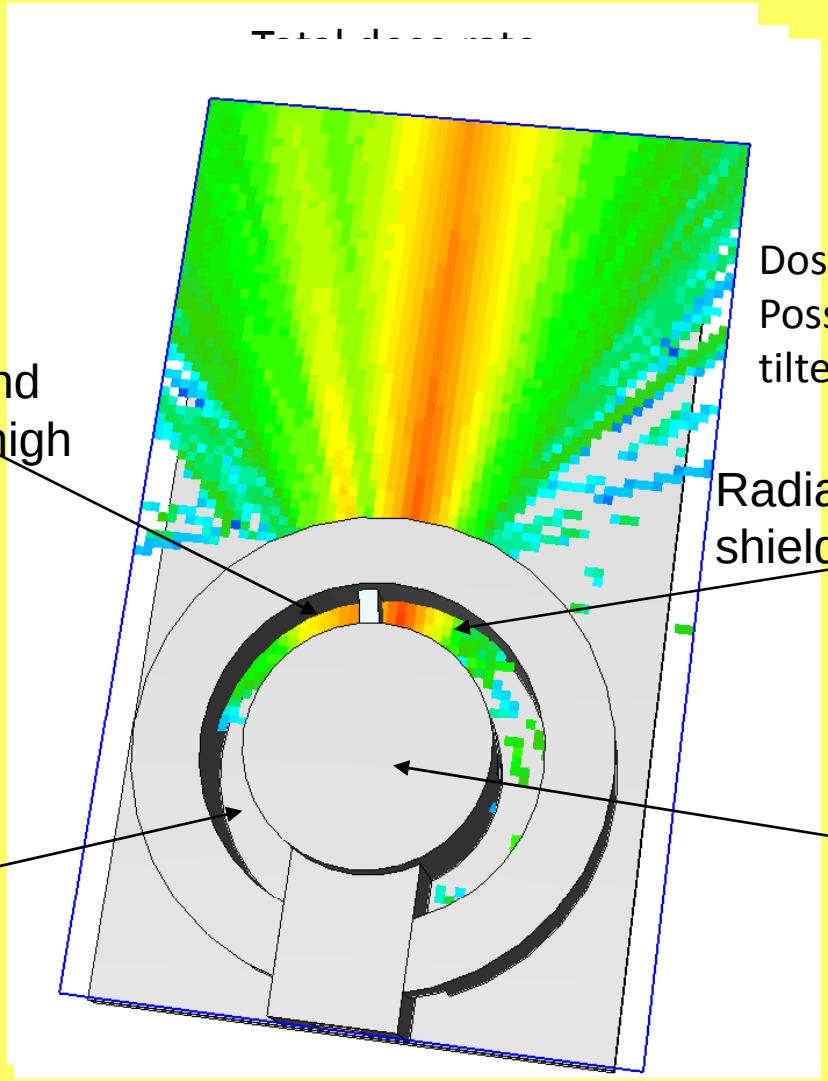
LHC beam loss monitor studies
High Level Dosimetry studies
Material tests
Electronics hardness tests

Proposed design of CERF++ facility




2.8 m
4 m
2 m
Iron shielding
and dump

Dose rate during operation with 1E10 protons (400 GeV) per 16.8s



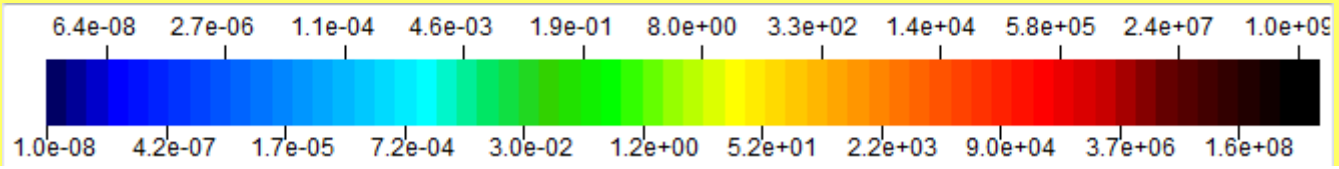
Dose rate caused by muons
Possible solution: downward tilted beam direction

Radiation field behind concrete shielding (high energies)

Radiation field behind iron shielding (high energies)

High dose area (field composition depends on angle to target)

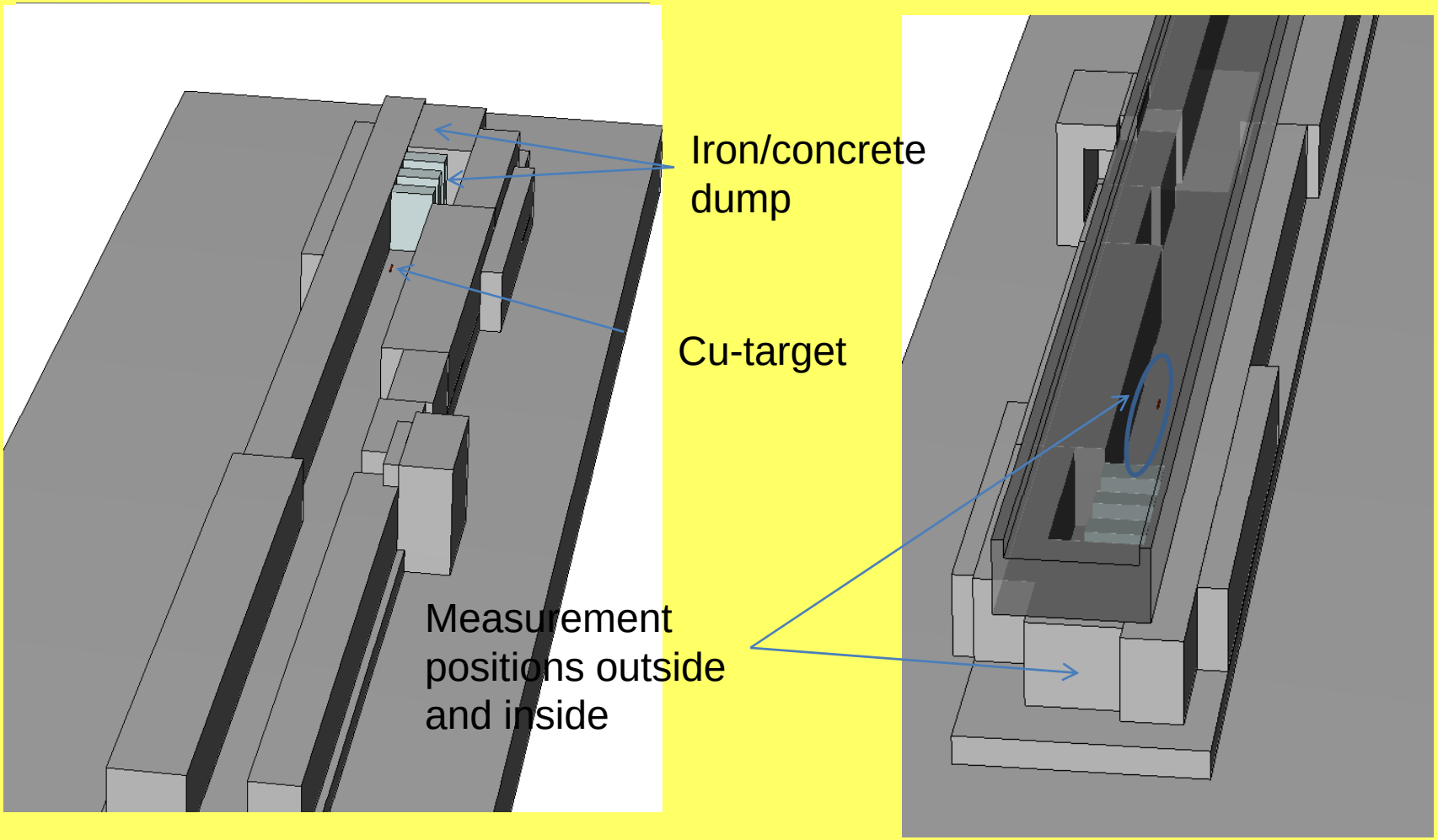
Radiation field behind concrete shielding (low energies)



uSv/h

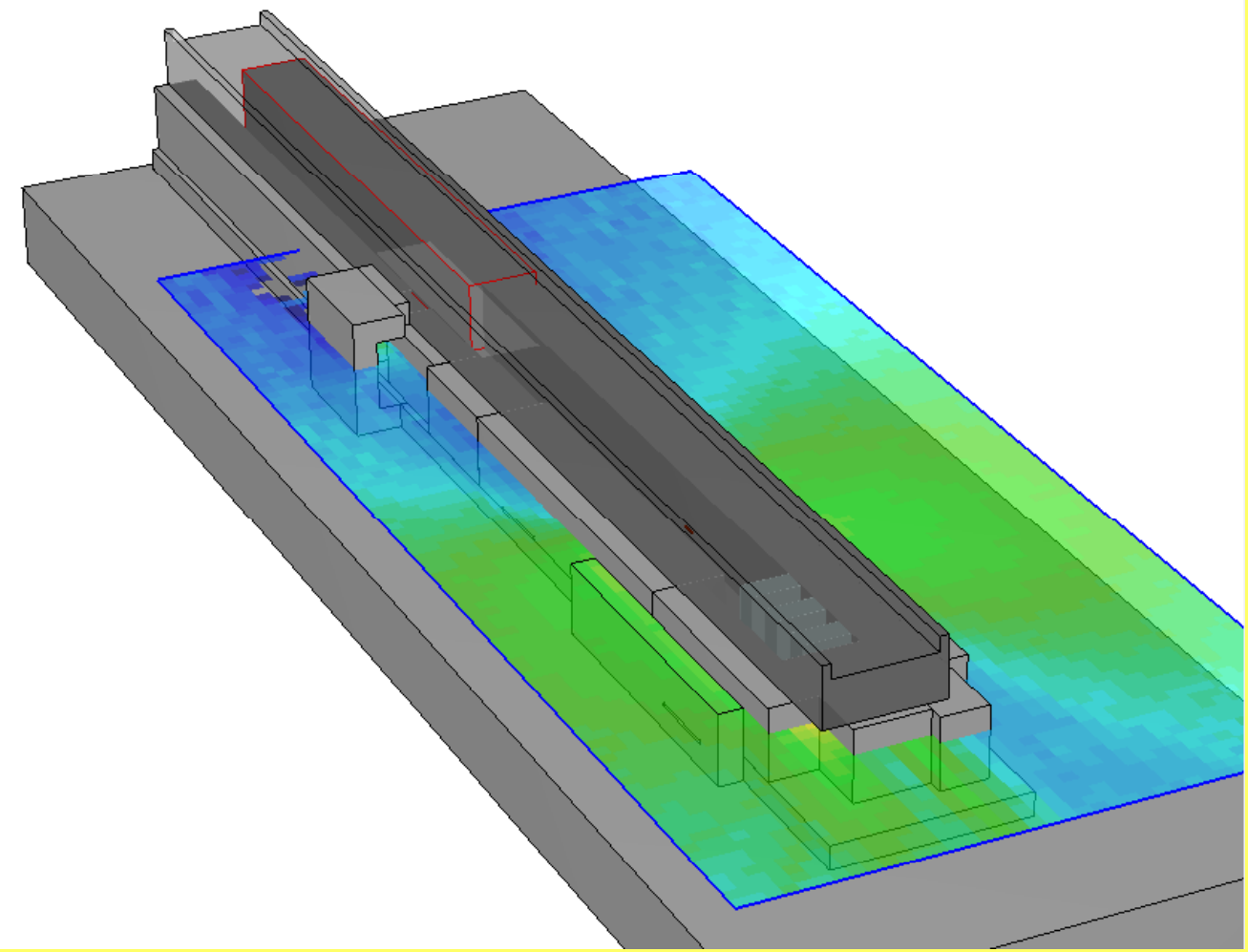
Preliminary low intensity CERF++ test facility at H4 beam line

Main goal of this test: verifying calculated muon contribution behind dump
Beside RP test, also AB was already using the high dose part of the facility for tests



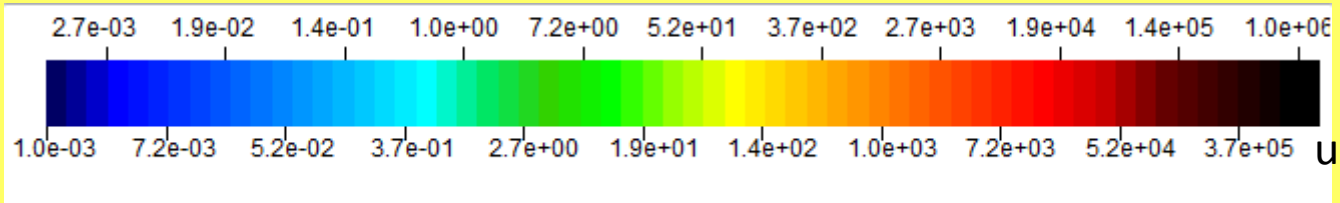
Operation conditions: 1E8 protons (@300 GeV) per SPS extraction

Preliminary analysis of dose rate during operation with 1E8 protons (300 GeV) per SPS extraction



Accurate analysis is under way

Radiation levels in accordance with Supervised Area restrictions, confirmed by measurements



Points to be studied and discussed for CERF++

- Which target material ➔ heating study of target required
- Optimization of the experimental location (H4? SPS?)
- Optimization of facility layout
- Radiation safety aspects
    - Muon dose downstream the installation (bending magnets before target)
    - Radiation levels at accessible areas (study under way)
    - Activation of the targets (remote handling?)
    - Activation of area around target ➔ marble layer inside cage
- Manpower required to install the facility
- Manpower required to operate such a facility
- Costs of installations

Outlook

• Further feasibility studies will be performed. Eduard Feldbaumer (PhD student, who has done all CERF++ calculations) is currently working on this subject.

• A location for such a facility has to be found and problems have to be studied and sorted out (First ideas exist already).

• In the mean time we continue in 2008 with studies at CERF (H6 beam line) and our CERF++ test facility (H4 beam line).

Acknowledgement

We are very grateful for the help of AB/ATB, in particular of Ilias Efthymiopoulos, Bruno Chauchaix, Sylvain Girod and their team for setting up the H4 beam line.

END