FLUKA Usage in Radiation Field Study at AREAL"

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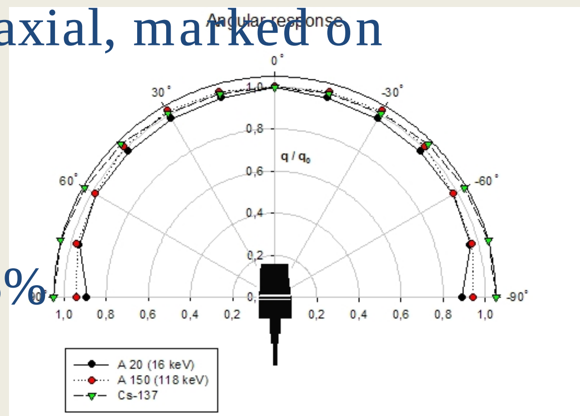
Introduction

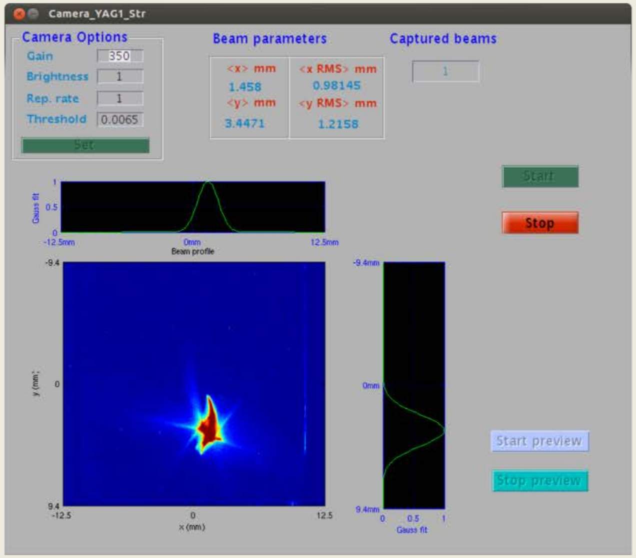
- Beam and dose measurements.
- Using SimpleGEO for modeling the geometry of AREAL building.
- The usage of Monte Carlo code FLUKA to model the radiation fields.
- FLUKA simulation results:
  - ✓ The distribution of electron beam energy for different areas, depending on the energy spread of the electrons;
  - ✓ The equivalent dose distribution in the building, depending on the energy spread of the electrons.
- SimpleGeo was applied to show:
  - The equivalent dose 2D distribution in the tunnel , control-room, laser room and RF hall;
  - A profile of the dose distribution, depending on the changes in the electrons initial energy spread.

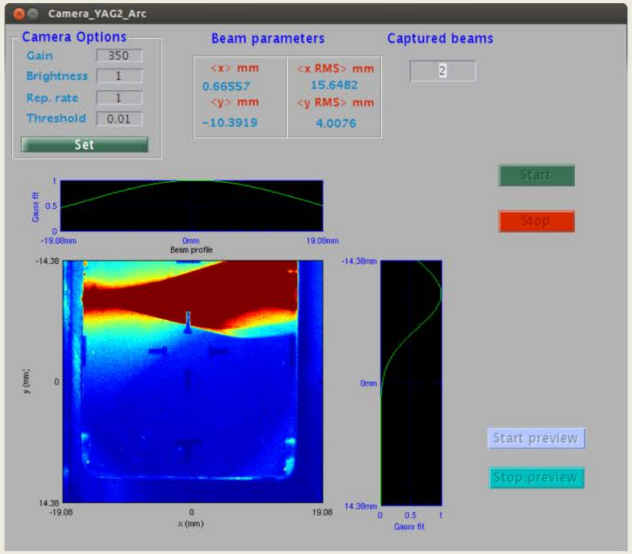
Technical Specification OD-01

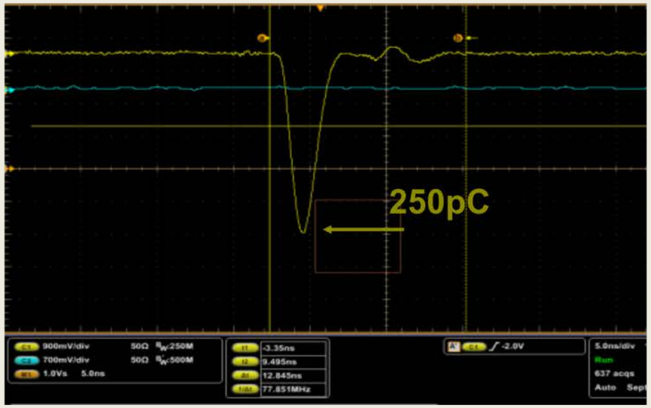
- Display ranges
  - Dose rate: $0 \cdots 2000\ \mu SV/h$
  - Dose: $0 \cdots 2000 \frac{\mu SV}{h}$
- Energy ranges:
  - Photon radiation: 6 keV to 15 MeV
  - Beta-radiation: 60 keV to 3 MeV
- Radiation probe: Air opened ionization chamber
  - Volume: 600 cm^3
  - Preferred beam direction; point of reference: axial, marked on detector
- Measurement uncertainties:
  - Fine measurement range 20: $< 15\%$
  - Fine measurement ranges 200 and 2000: $< 5\%$

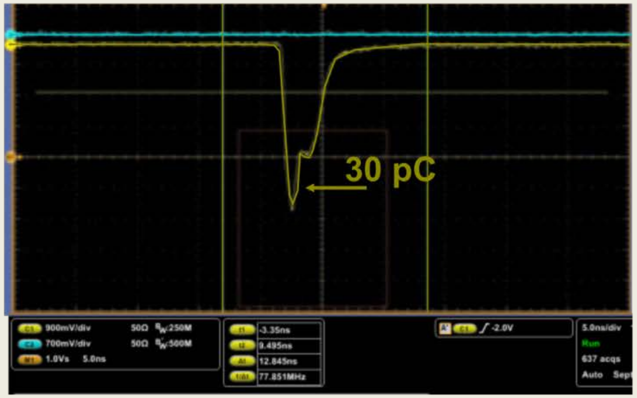


Beam Parameters

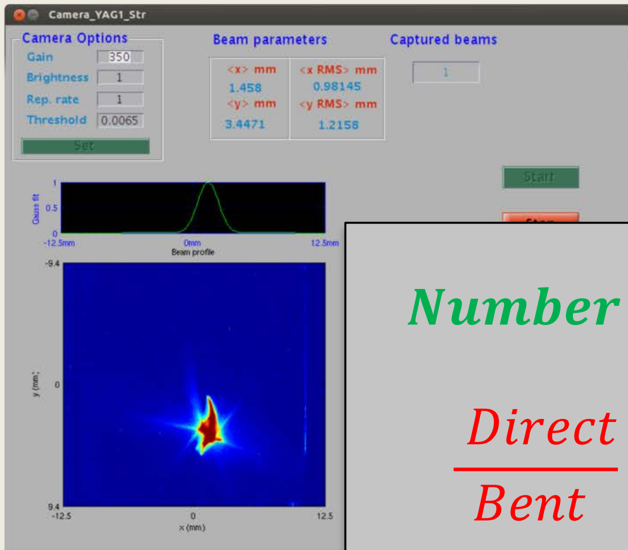


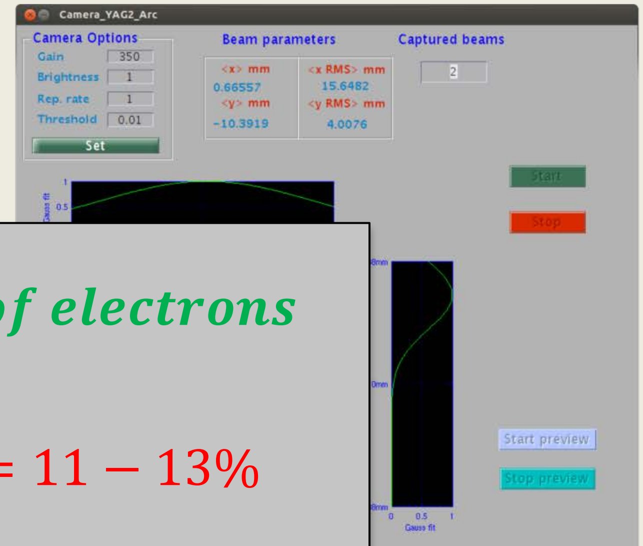






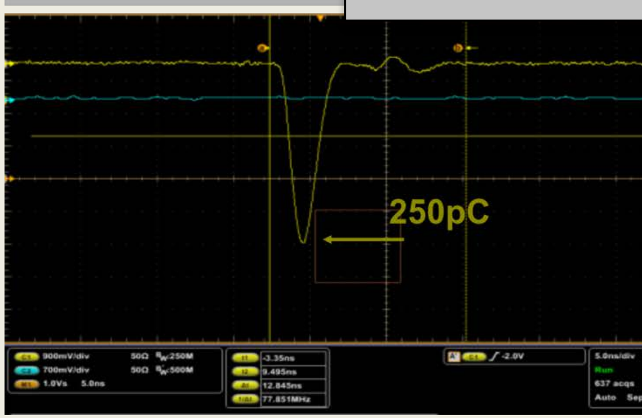
Beam Parameters



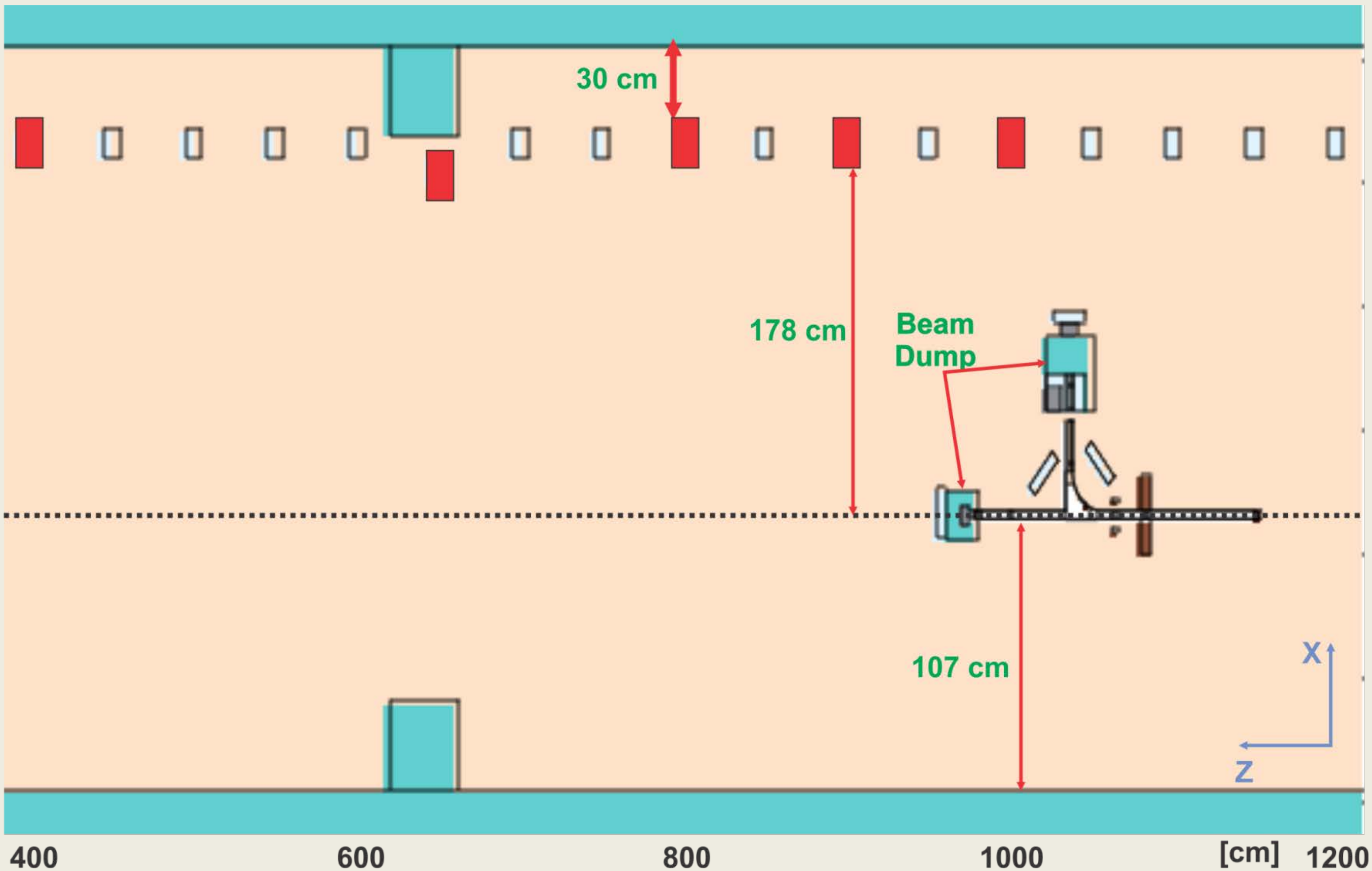


Number of electrons

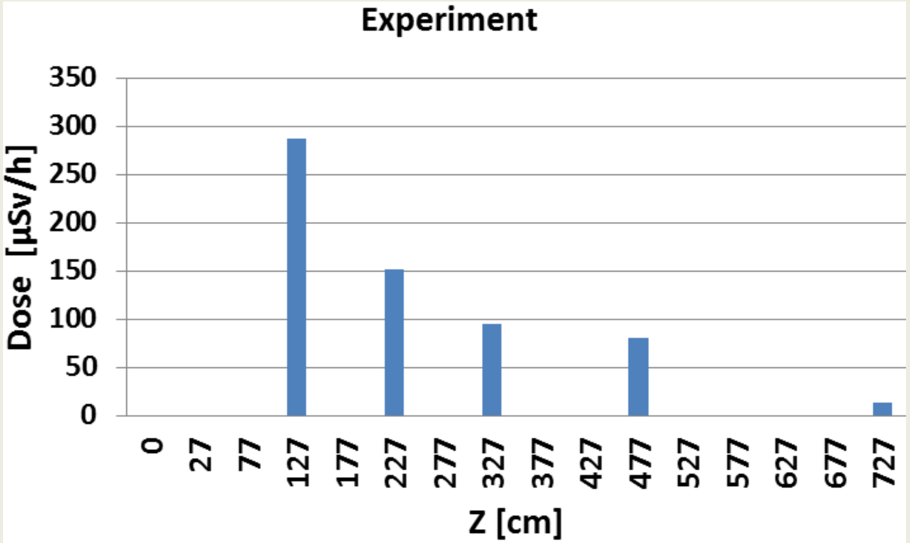
$$\frac{Direct}{Bent} = 11 - 13\%$$



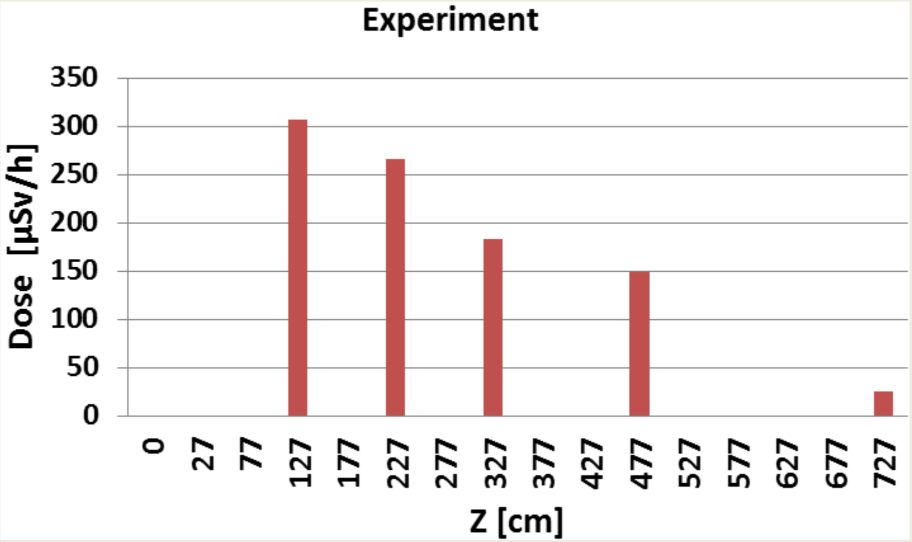
Measurements Position in Tunnel



Measurement Results



Equivalent Dose in the Tunnel For the Direct Beam.



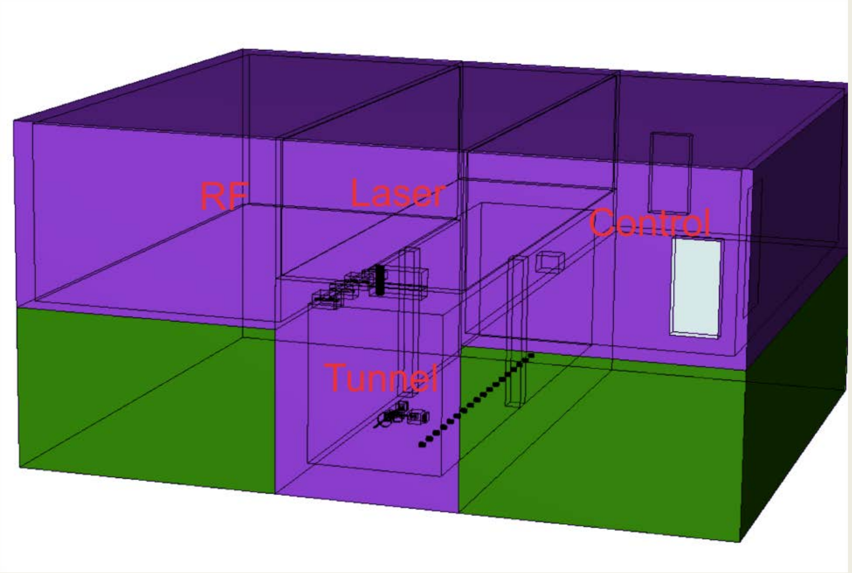
Equivalent Dose in the Tunnel For the Bent Beam.

Geometry & drawings

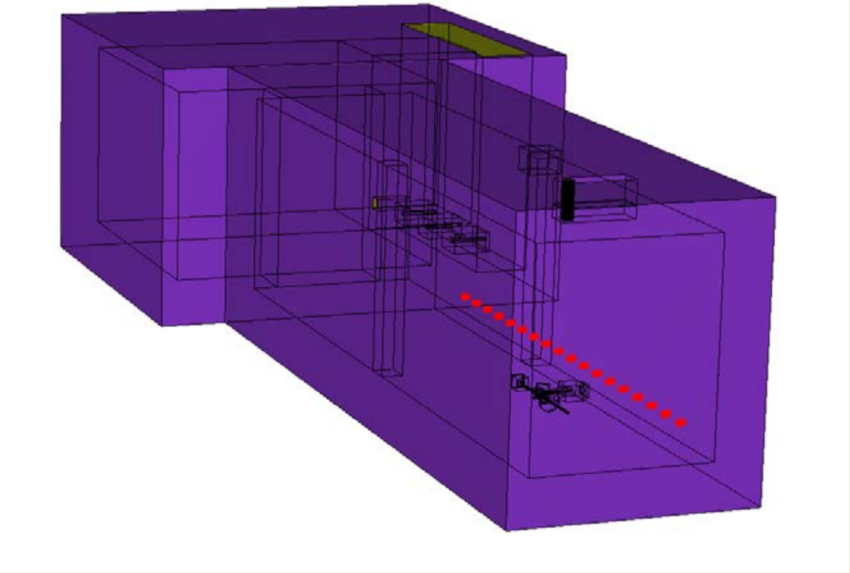
- The most challenging part was the implementation of the real buildings and machine geometry using FLUKA's combinatorial geometry.

- It is not always possible to model all the details of the actual geometry using only simple shapes.

AREAL Geometry Modeling

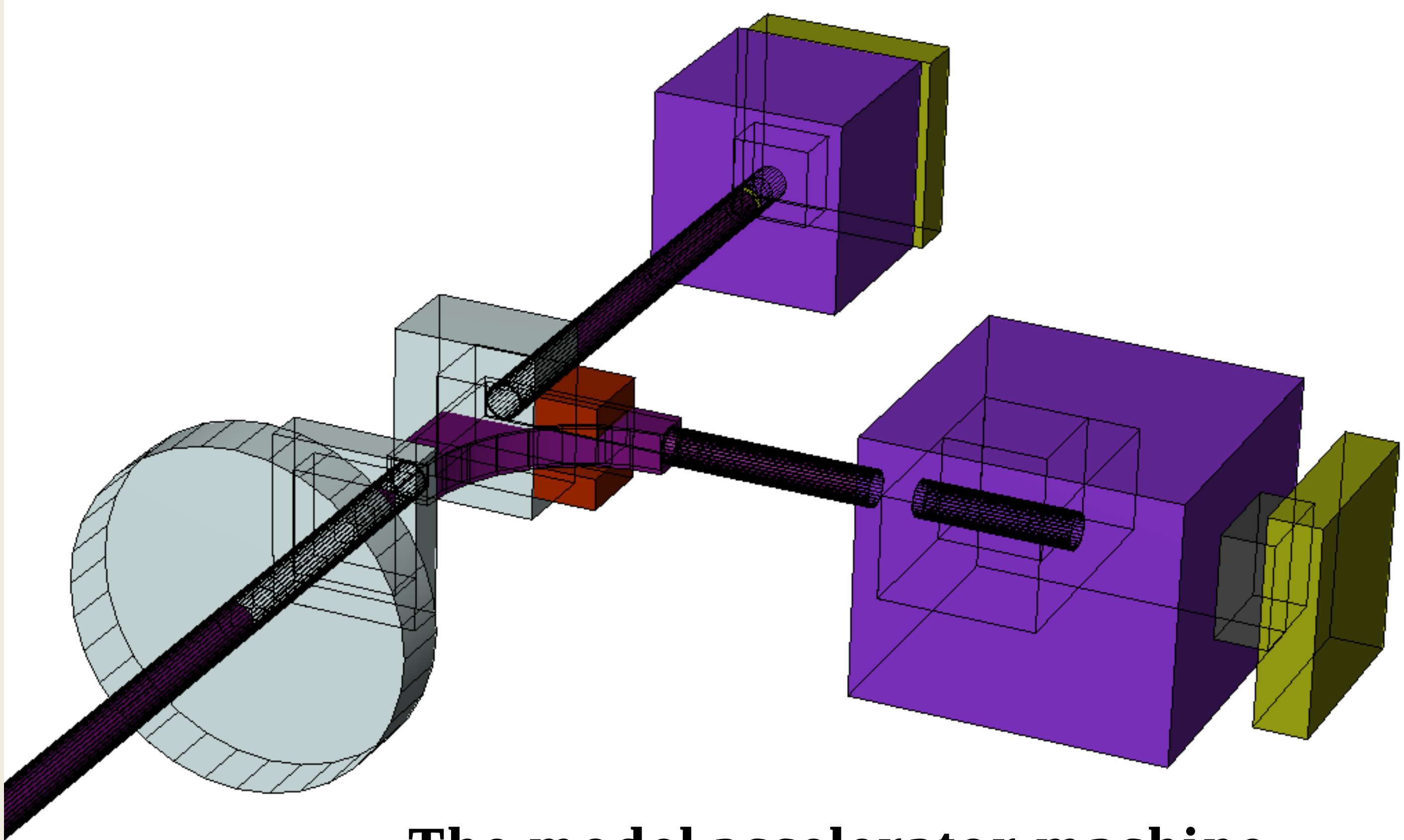


The Model of AREAL halls (SimpleGeo)



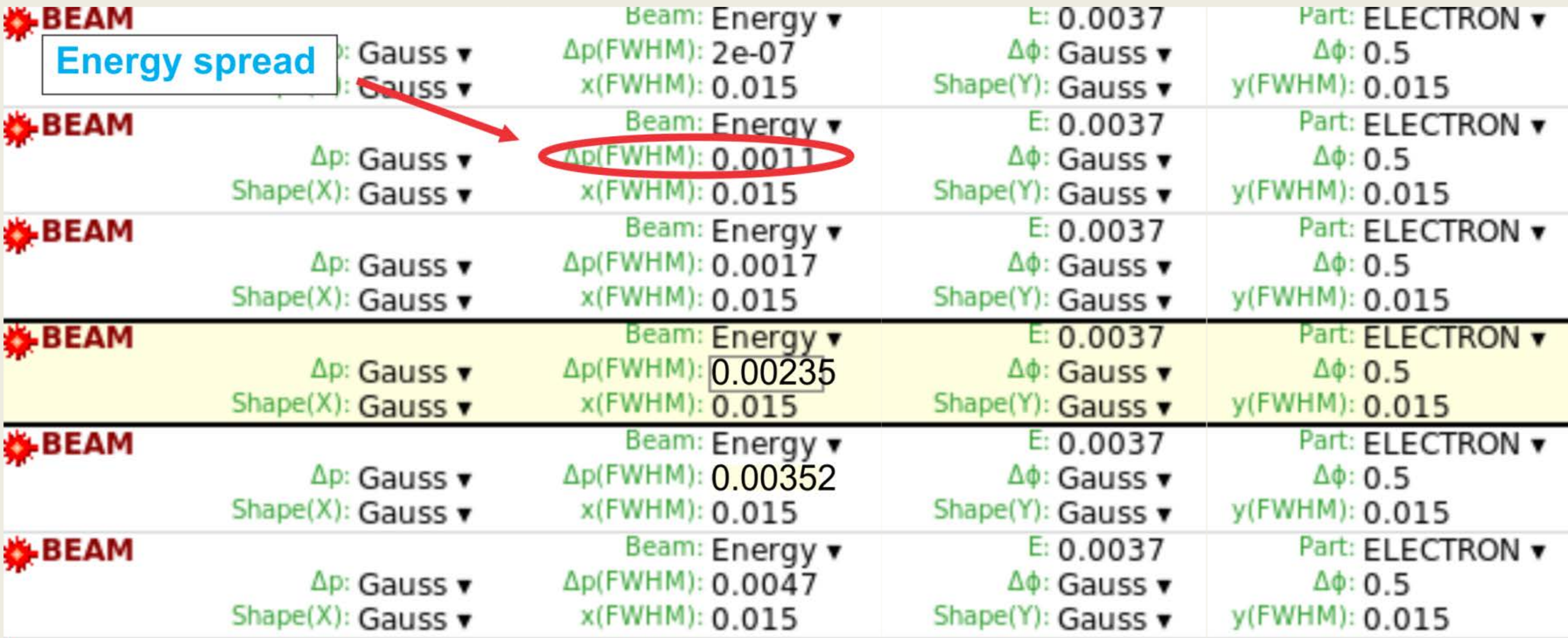
The Model of machine hall (SimpleGeo)

Diagram of AREAL Accelerators



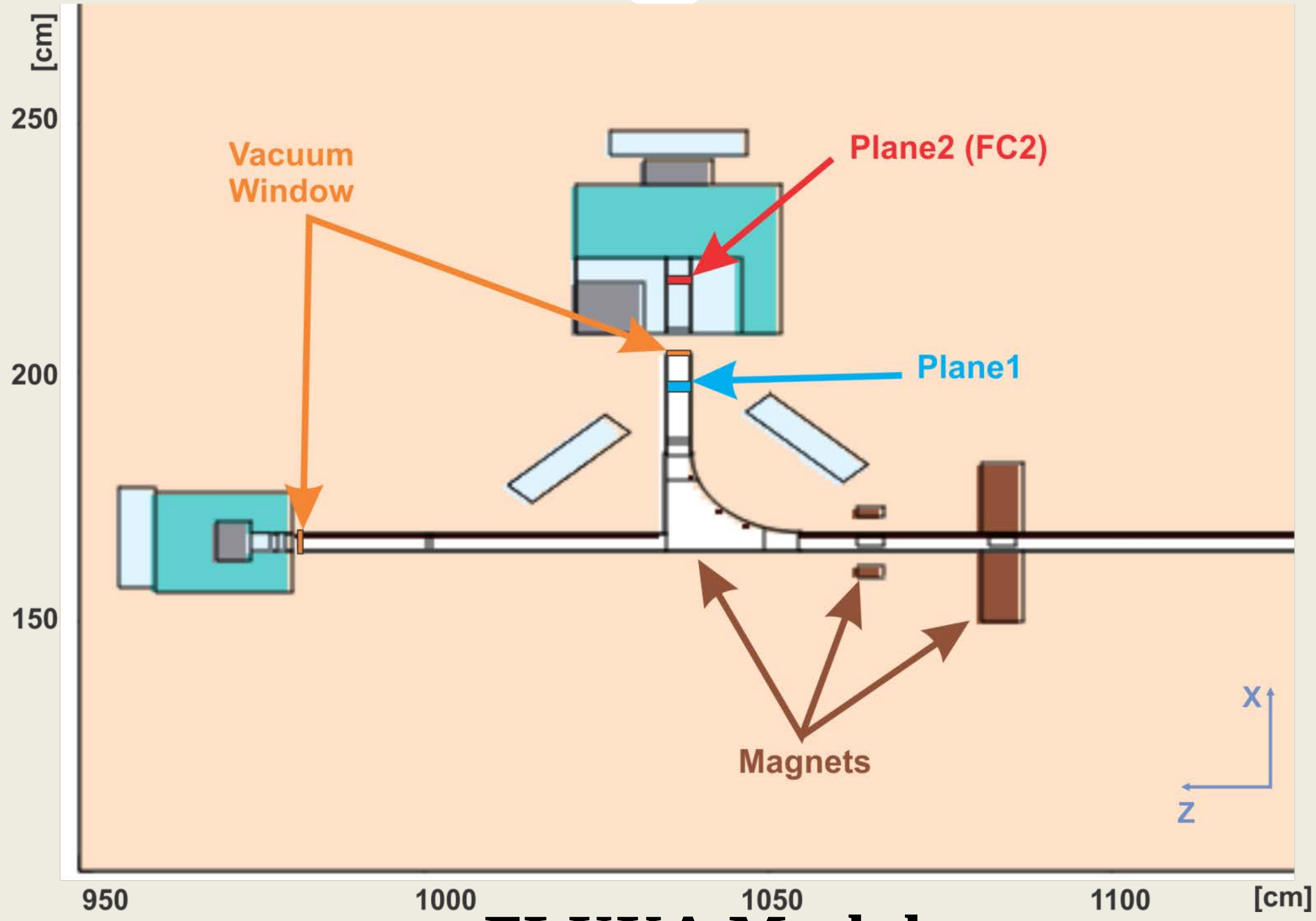
The model accelerator machine
(SimpleGEO)

FLUKA Simulation



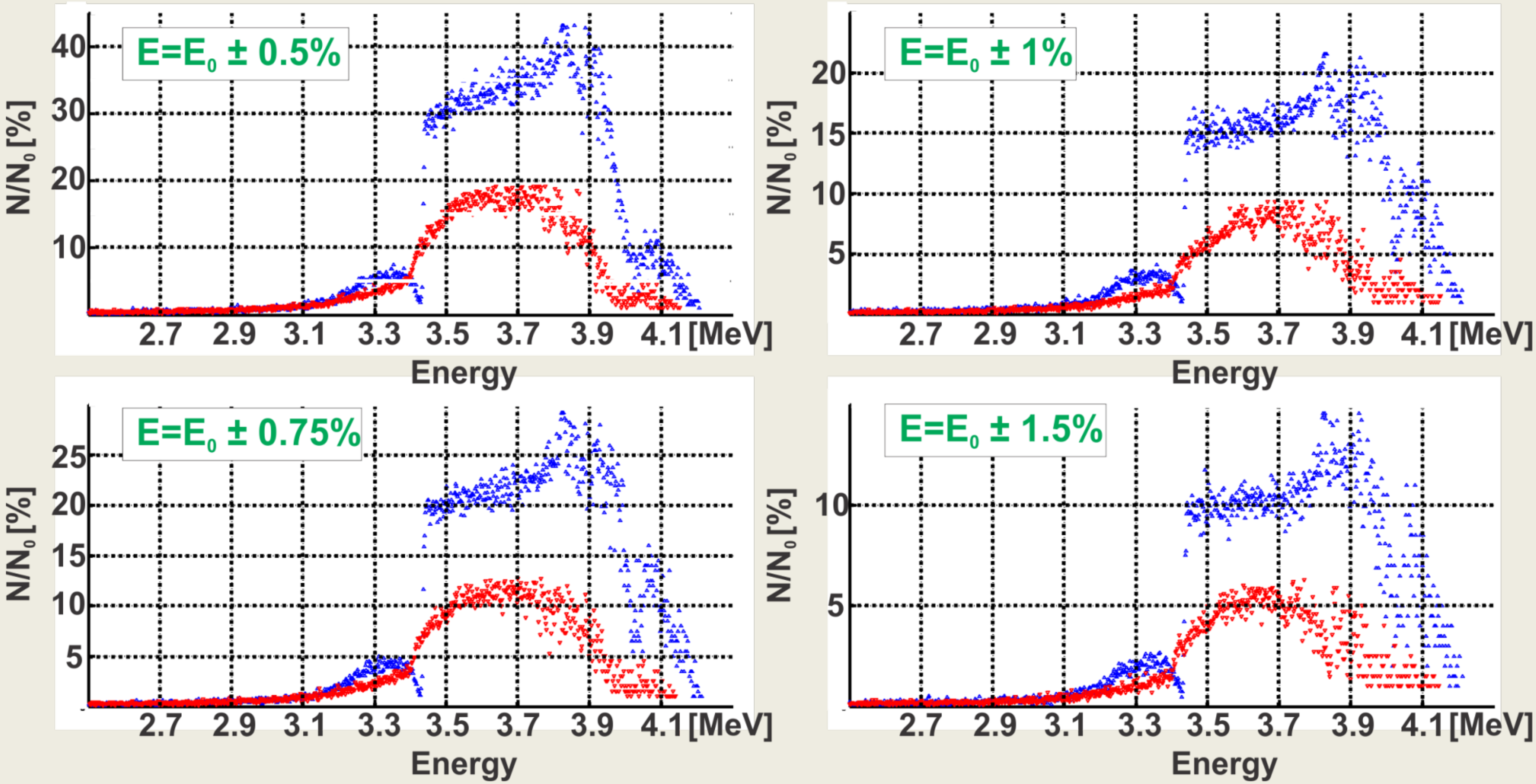
Electron Beam Initial Parameters

Diagram of AREAL Accelerators

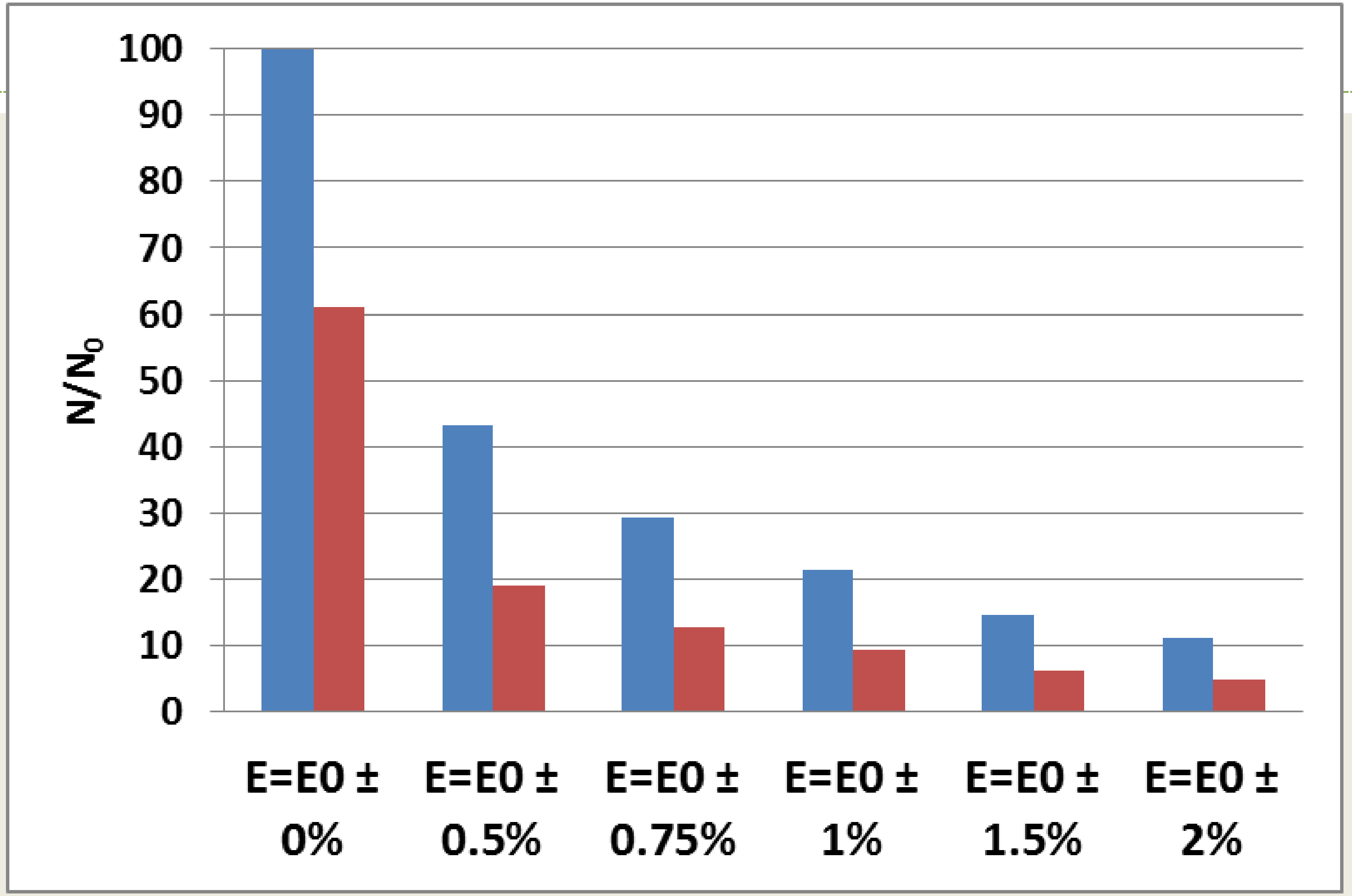


FLUKA Model

Energy Distribution

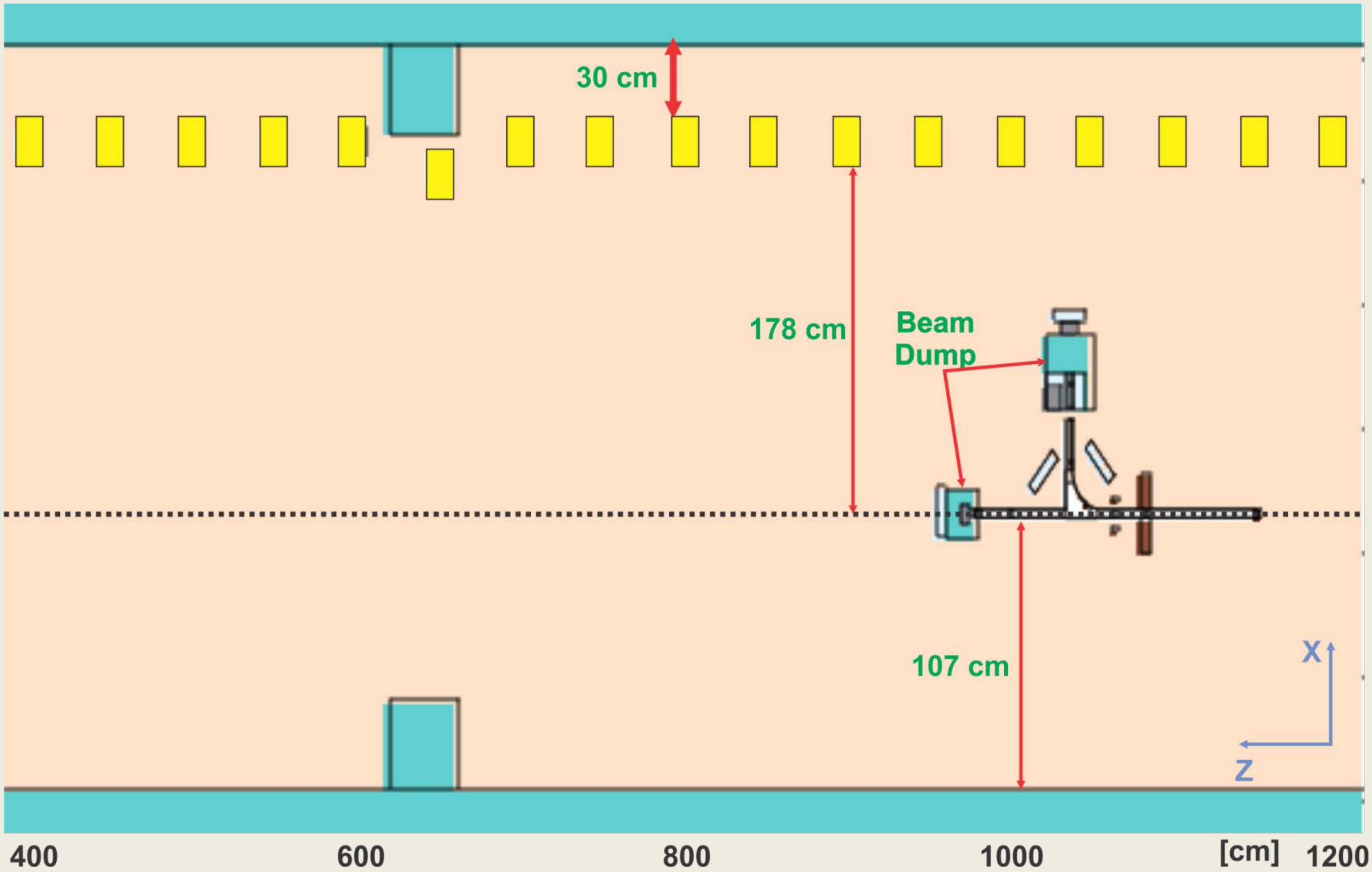


Energy spectrum of electron at vacuum window (blue) and at final FC (red) for various values of energy spread.

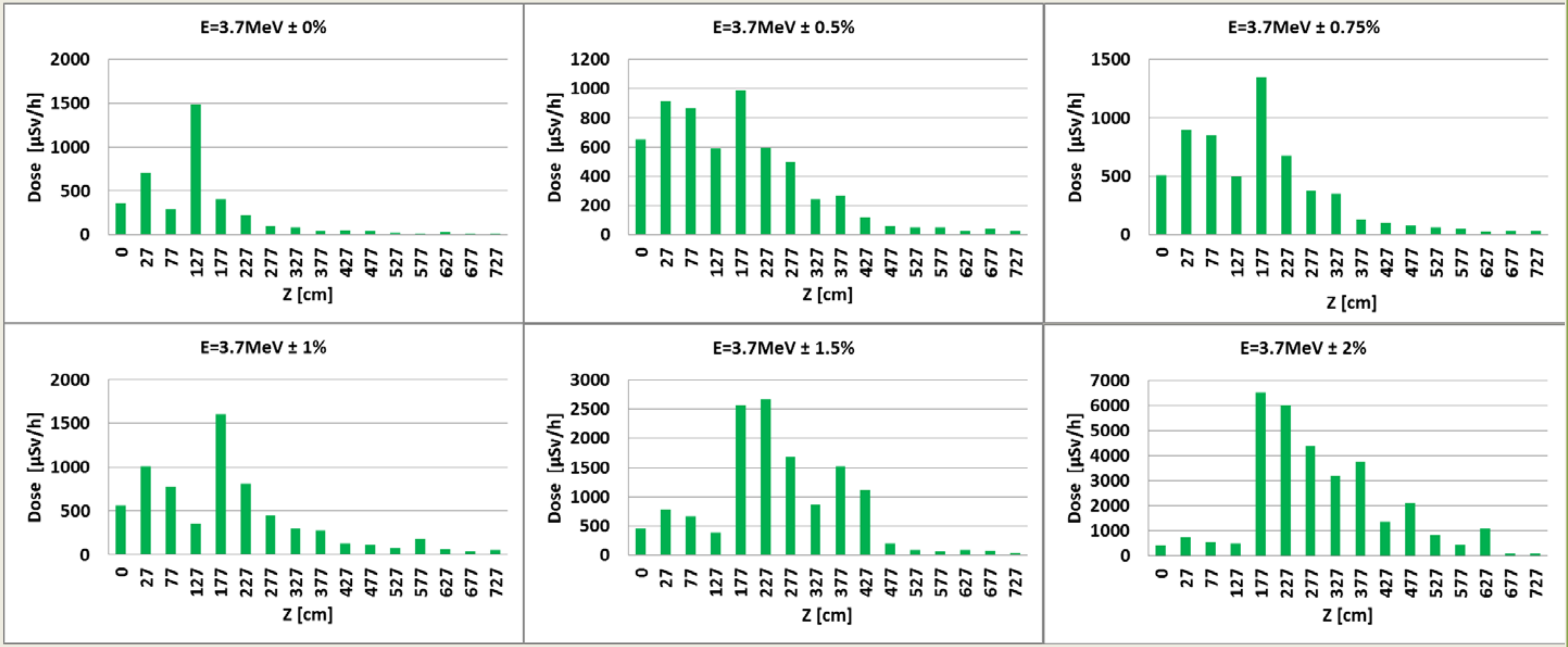


The percentage of electrons reaching the vacuum window (blue) and FC (red).

Measurements Position in Tunnel

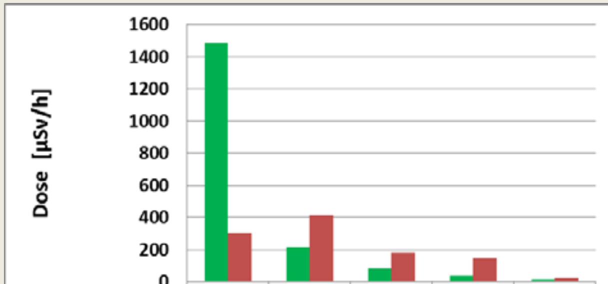


FLUKA Results for Bent Beam

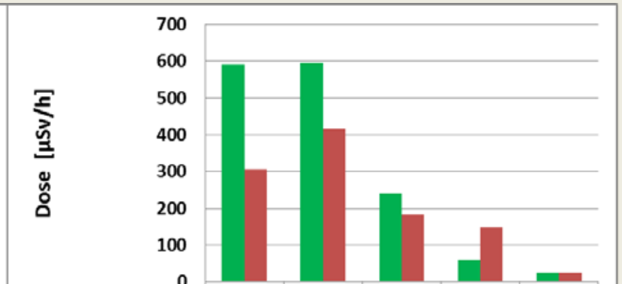


Simulation values of the integral dose within the dosimeter volume for different positions and energy spreads in the machine hall.

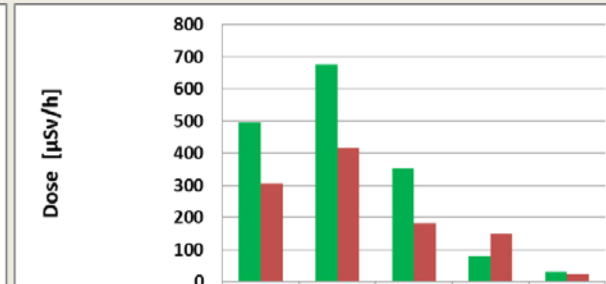
FLUKA Results for Bent Beam



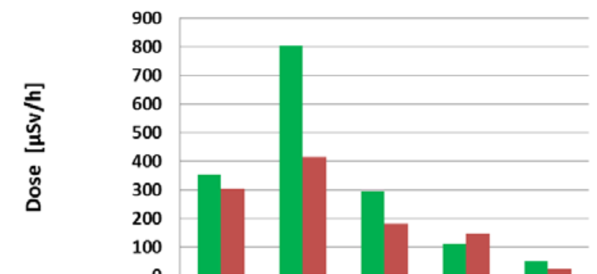
	127	227	327	477	727
E=3.7MeV ± 0%	1485	218.25	80.4375	40.71938	13.75875
Experiment	306.2	416	182.5	149.3	25



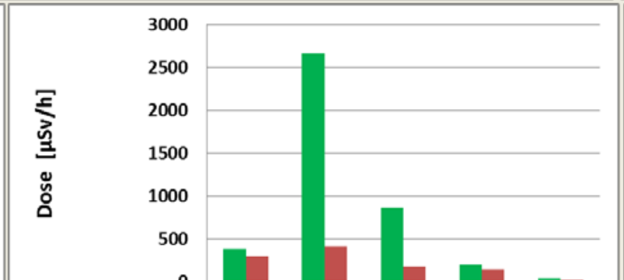
	127	227	327	477	727
E=3.7MeV ± 0.5%	590.625	596.25	242.4375	59.625	24.4125
Experiment	306.2	416	182.5	149.3	25



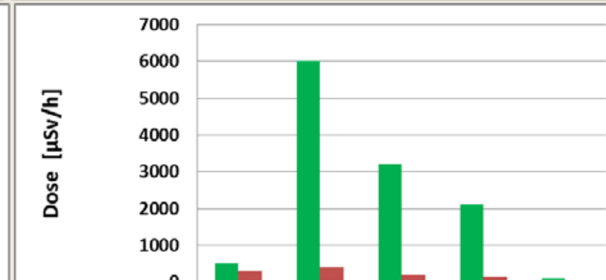
	127	227	327	477	727
E=3.7MeV ± 0.75%	494.4375	675	352.125	81.5625	30.76875
Experiment	306.2	416	182.5	149.3	25



	127	227	327	477	727
E=3.7MeV ± 1%	356.0625	804.375	296.4375	114.1875	52.425
Experiment	306.2	416	182.5	149.3	25



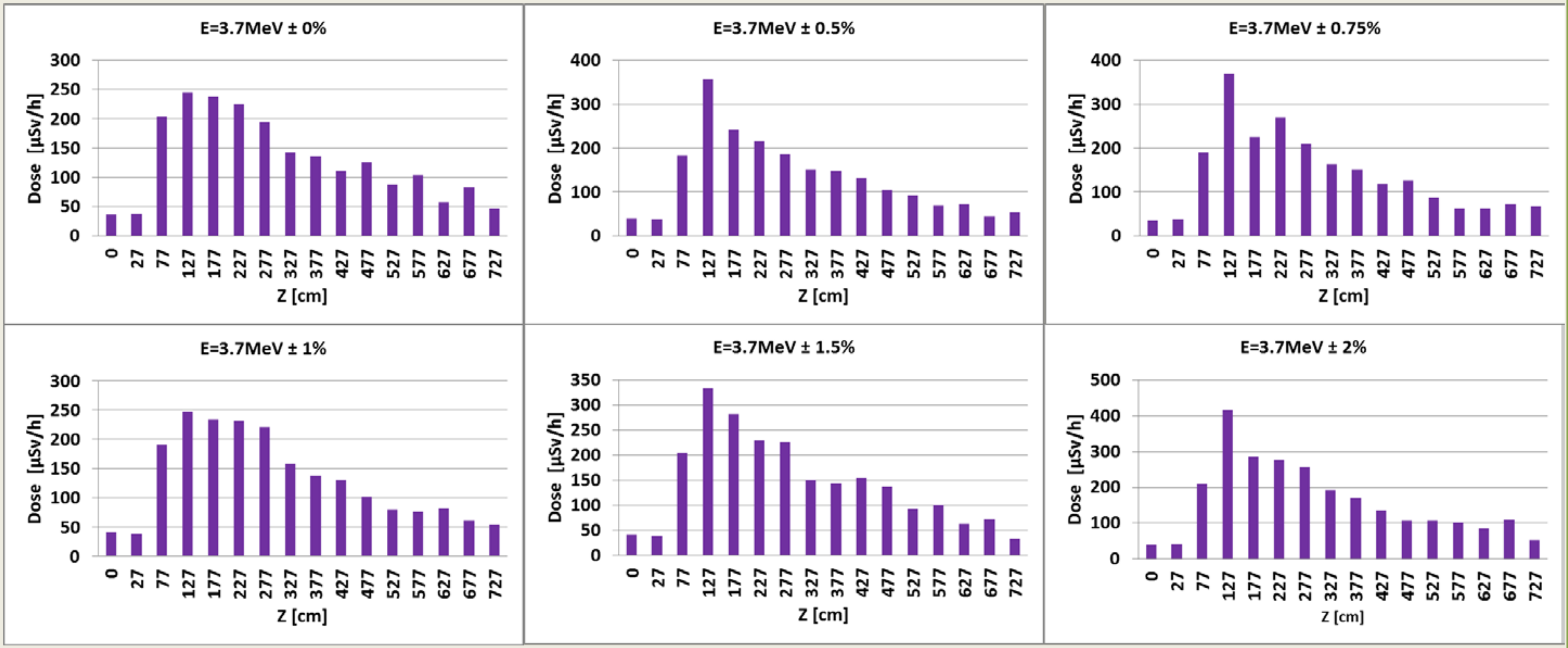
	127	227	327	477	727
E=3.7MeV ± 1.5%	384.75	2666.25	866.25	201.9375	40.78125
Experiment	306.2	416	182.5	149.3	25



	127	227	327	477	727
E=3.7MeV ± 2%	510.1875	6018.75	3211.875	2115	104.625
Experiment	306.2	416	182.5	149.3	25

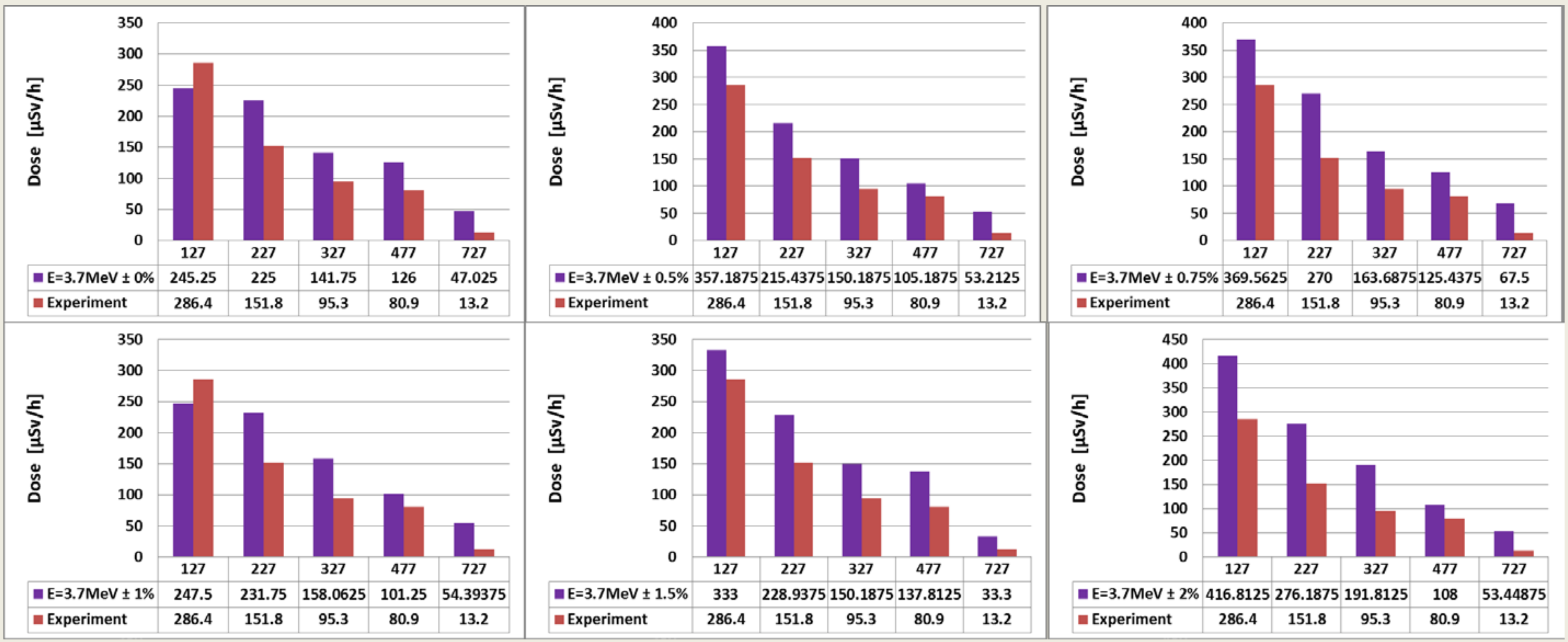
Measured and simulated integral dose values for a certain position in the machine hall

FLUKA Results for Direct Beam



Simulation values of the integral dose within dosimeter volume for different positions and energy spreads in the machine hall.

FLUKA Results for Direct Beam



	127	227	327	477	727
E=3.7MeV ± 0%	245.25	225	141.75	126	47.025
Experiment	286.4	151.8	95.3	80.9	13.2

	127	227	327	477	727
E=3.7MeV ± 0.5%	357.1875	215.4375	150.1875	105.1875	53.2125
Experiment	286.4	151.8	95.3	80.9	13.2

	127	227	327	477	727
E=3.7MeV ± 0.75%	369.5625	270	163.6875	125.4375	67.5
Experiment	286.4	151.8	95.3	80.9	13.2

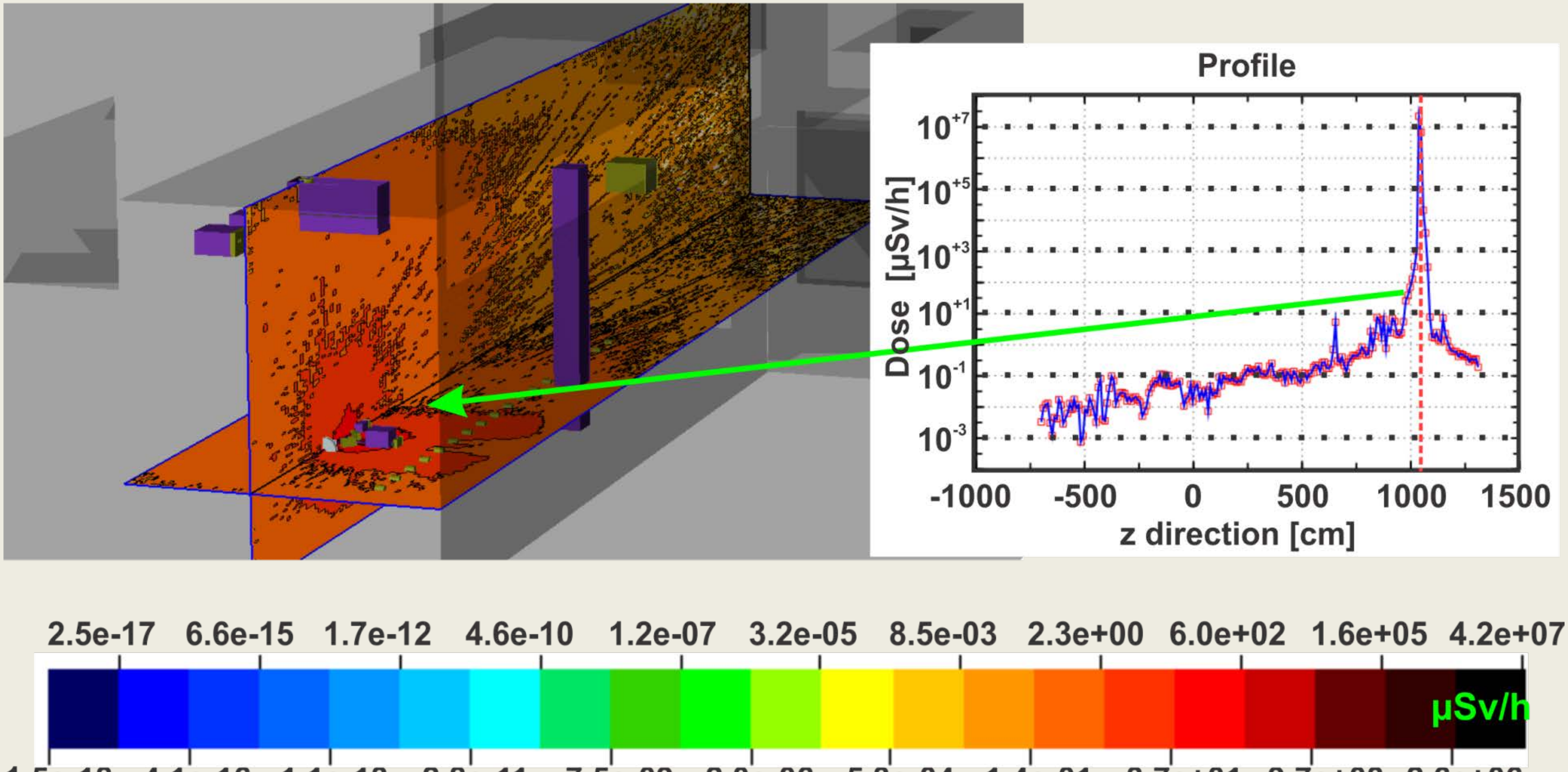
	127	227	327	477	727
E=3.7MeV ± 1%	247.5	231.75	158.0625	101.25	54.39375
Experiment	286.4	151.8	95.3	80.9	13.2

	127	227	327	477	727
E=3.7MeV ± 1.5%	333	228.9375	150.1875	137.8125	33.3
Experiment	286.4	151.8	95.3	80.9	13.2

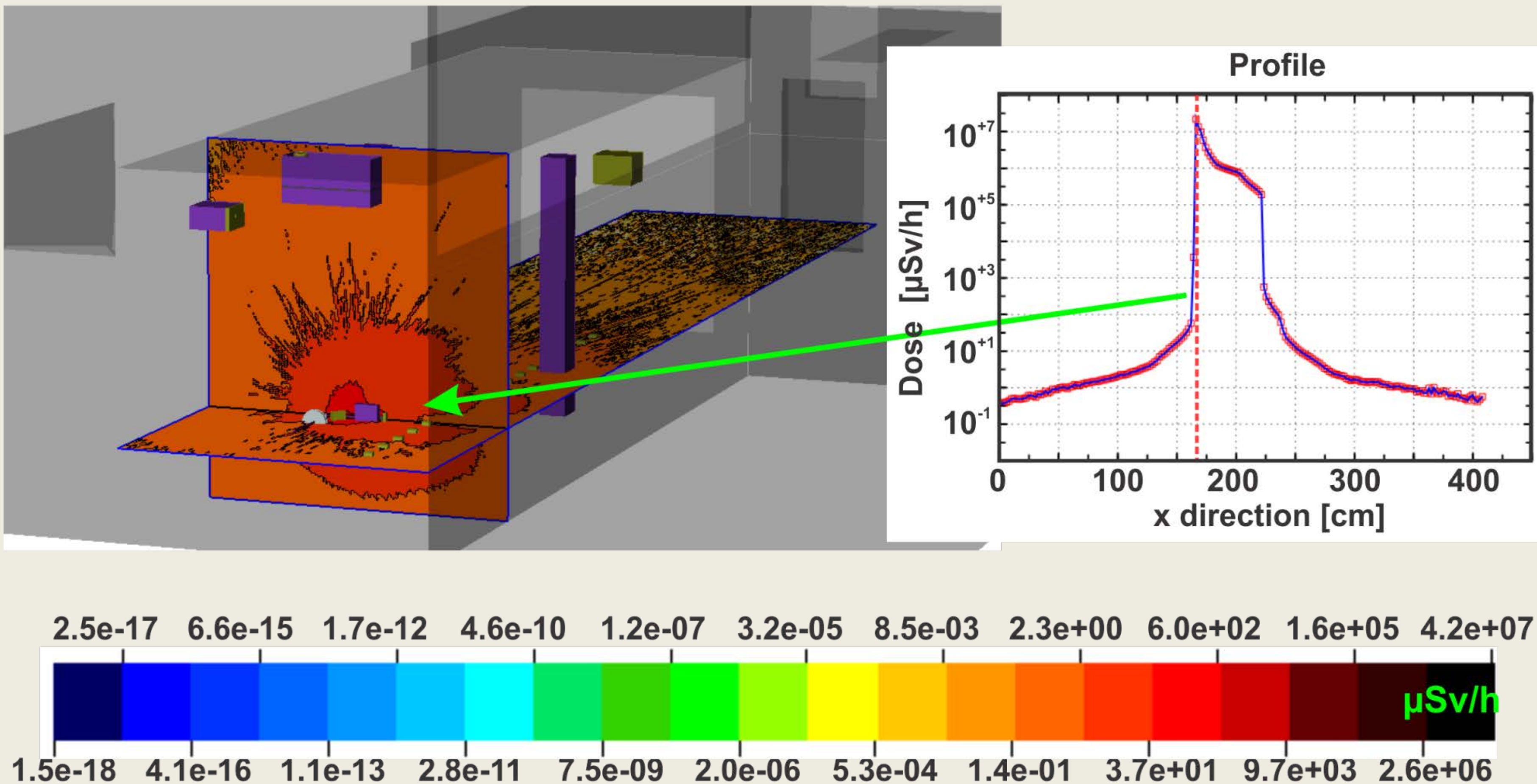
	127	227	327	477	727
E=3.7MeV ± 2%	416.8125	276.1875	191.8125	108	53.44875
Experiment	286.4	151.8	95.3	80.9	13.2

Measured and simulated integral dose values for a certain position in the machine hall

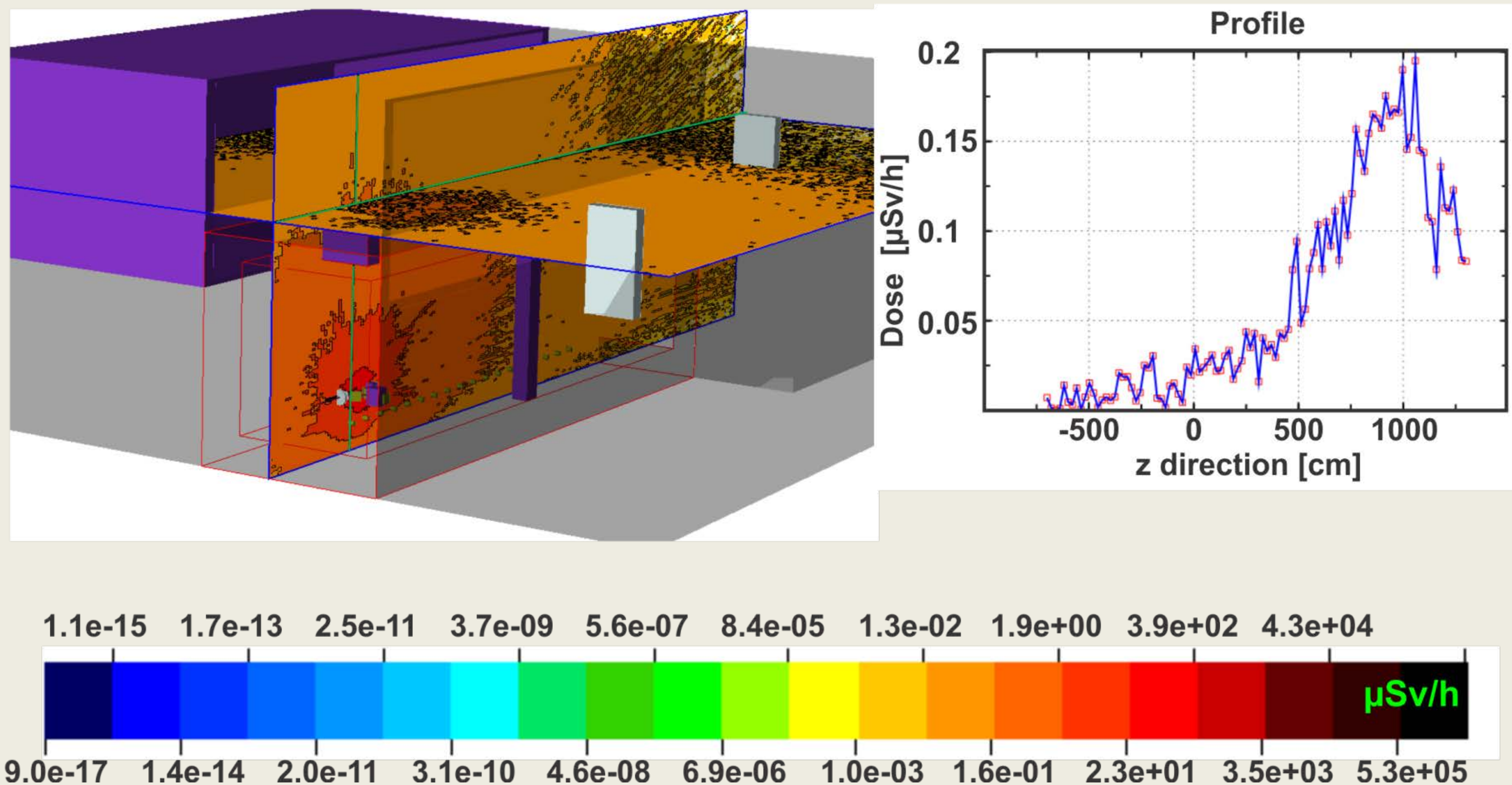
2D Dose Distribution In Tunnel



2D Dose Distribution In Tunnel



2D Dose Distribution In Laser Room



Next Steps

- To measure the integral dose in Laser and RF rooms by dosimeter usage.
- To improve simulation results using FLUKA custom routines.
- Using FLUKA code for modeling AREAL radiation field at 20 MeV.

Thank You for Attention !