EPOS – an intense positron beam project at the Research Center Rossendorf

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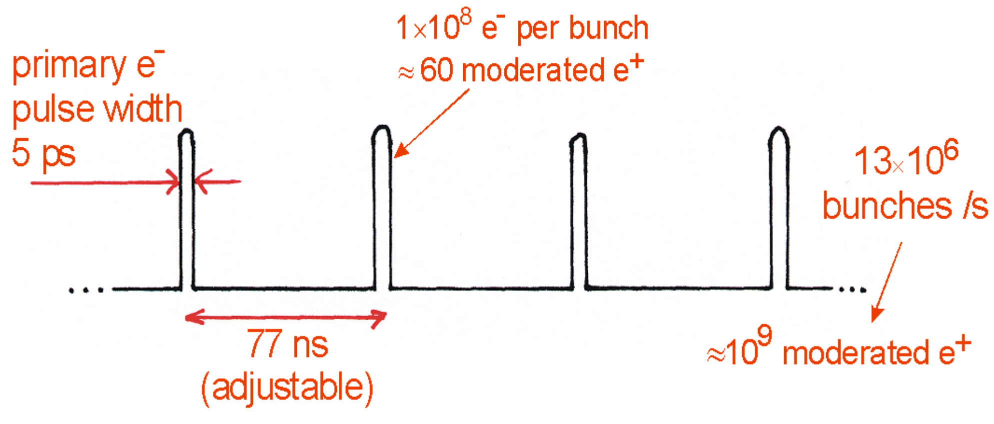
The EPOS positron source at Research Center Rossendorf

- Main experiment in Rossendorf: Radiation source ELBE = **E**lectron **L**inac with high **B**rilliance and low **E**mittance
- Primary electron beam (40 MeV x 1 mA = 40 kW)
- Main goal: IR Free-electron Laser
- Very interesting time structure: cw-mode of short bunches

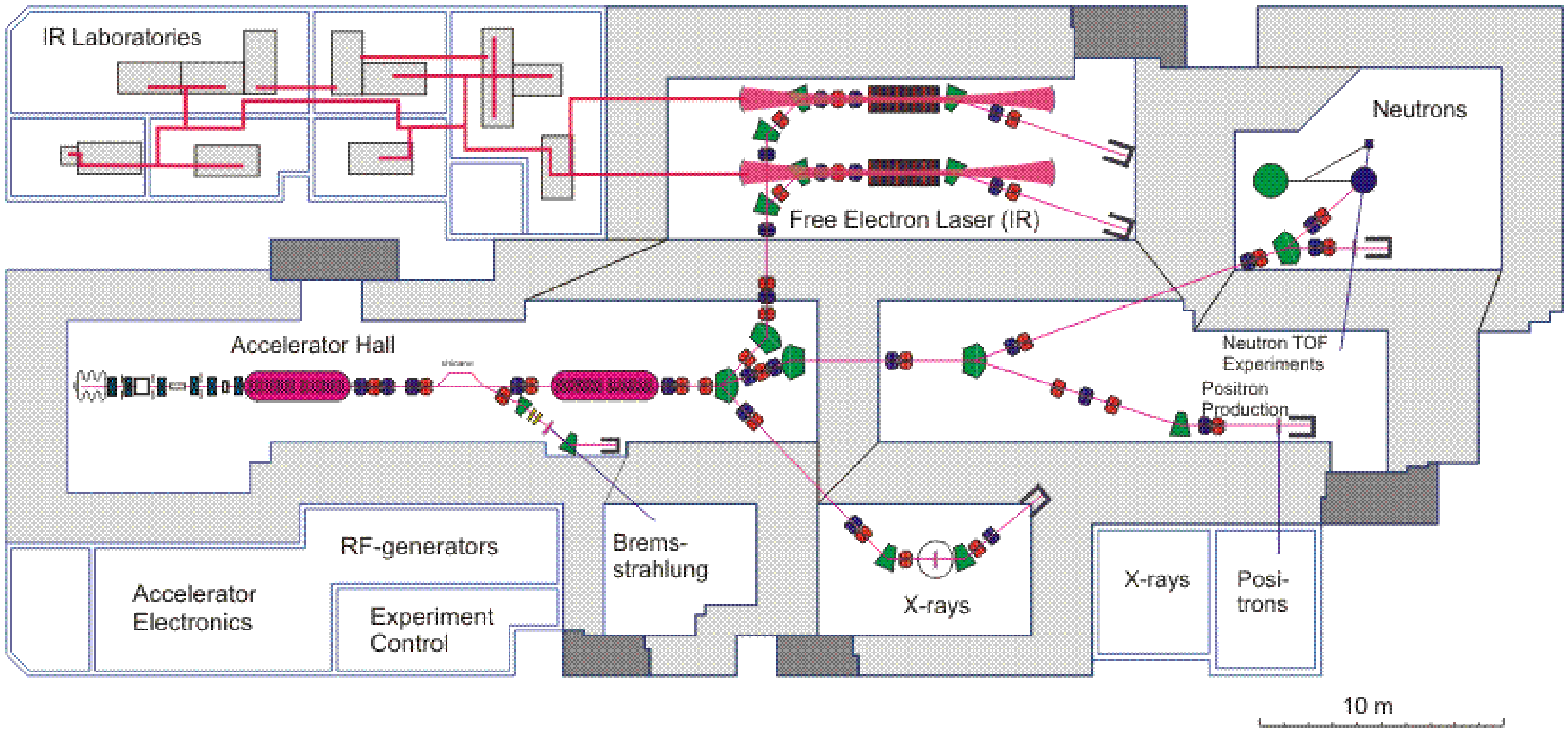


electron bunches

EPOS = ELBE Positron Source

- Intense beam of slow (monoenergetic) positrons
- All relevant positron techniques for materials research (positron lifetime, Coincidence Doppler broadening, AMOC)
- EPOS is external facility of Martin-Luther-University Halle at Research center Rossendorf
- User-dedicated facility
- Remote controlled via internet
- Financing by University Halle, Land Sachsen-Anhalt and European Community

Ground plan of the ELBE hall



Positron Lab

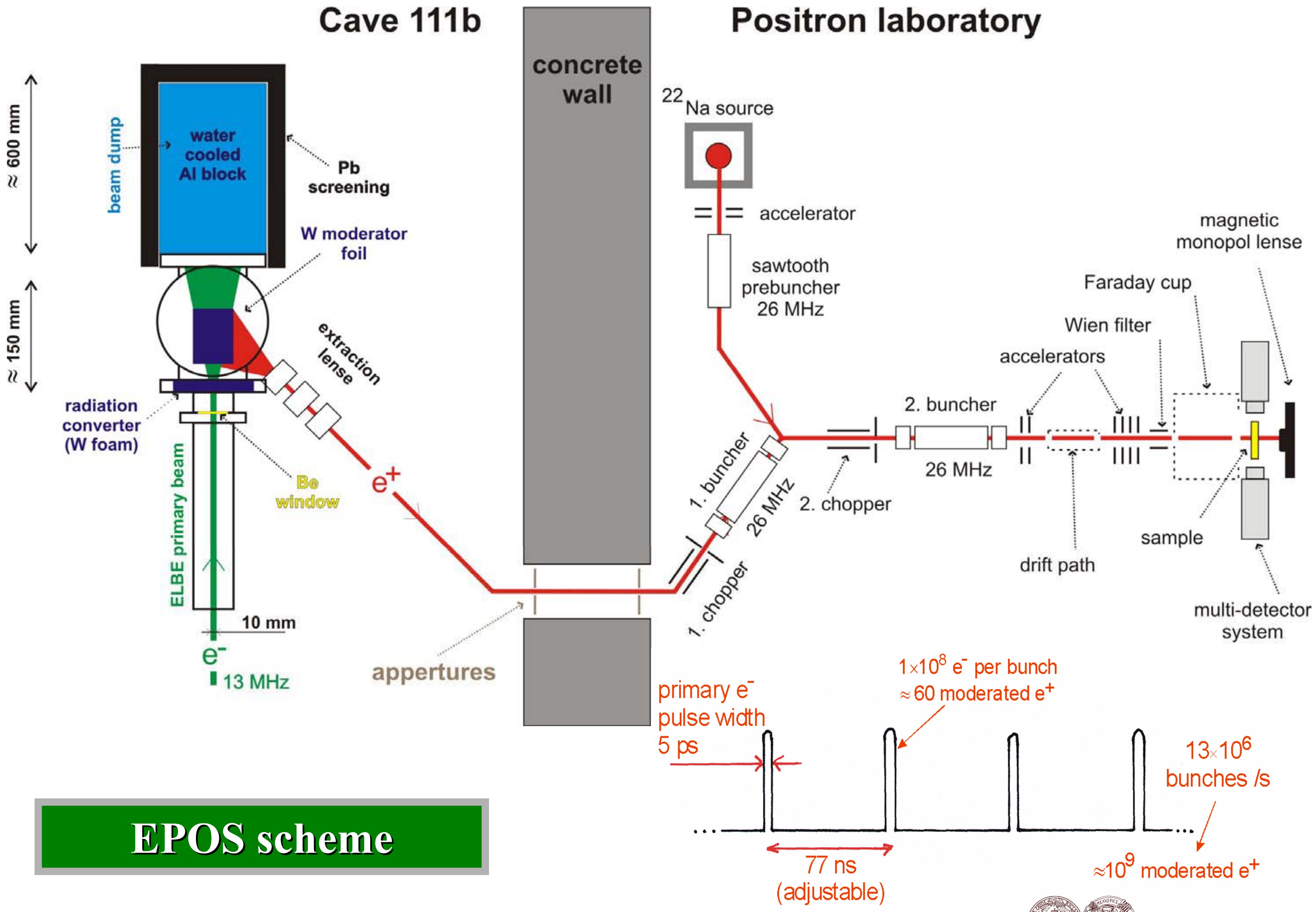
- positron lab in ELBE hall already available

X-ray Lab

Positron Lab

concrete screening of Cave 111b (location of e^+ converter)

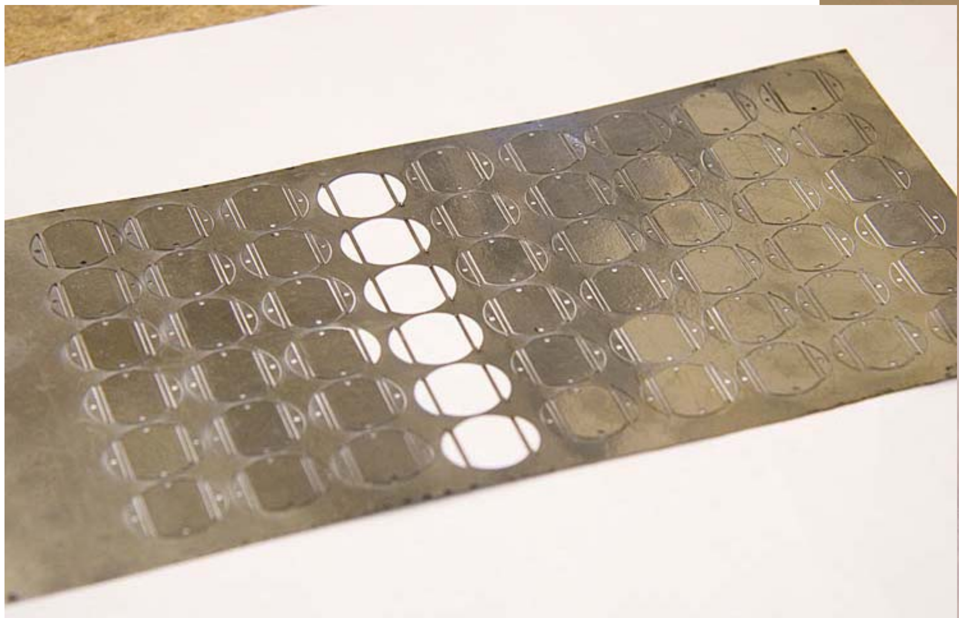

3,2 m concrete screening
of Cave 111b
cable tunnel to be used for e+
beamline
photo taken in November 2003

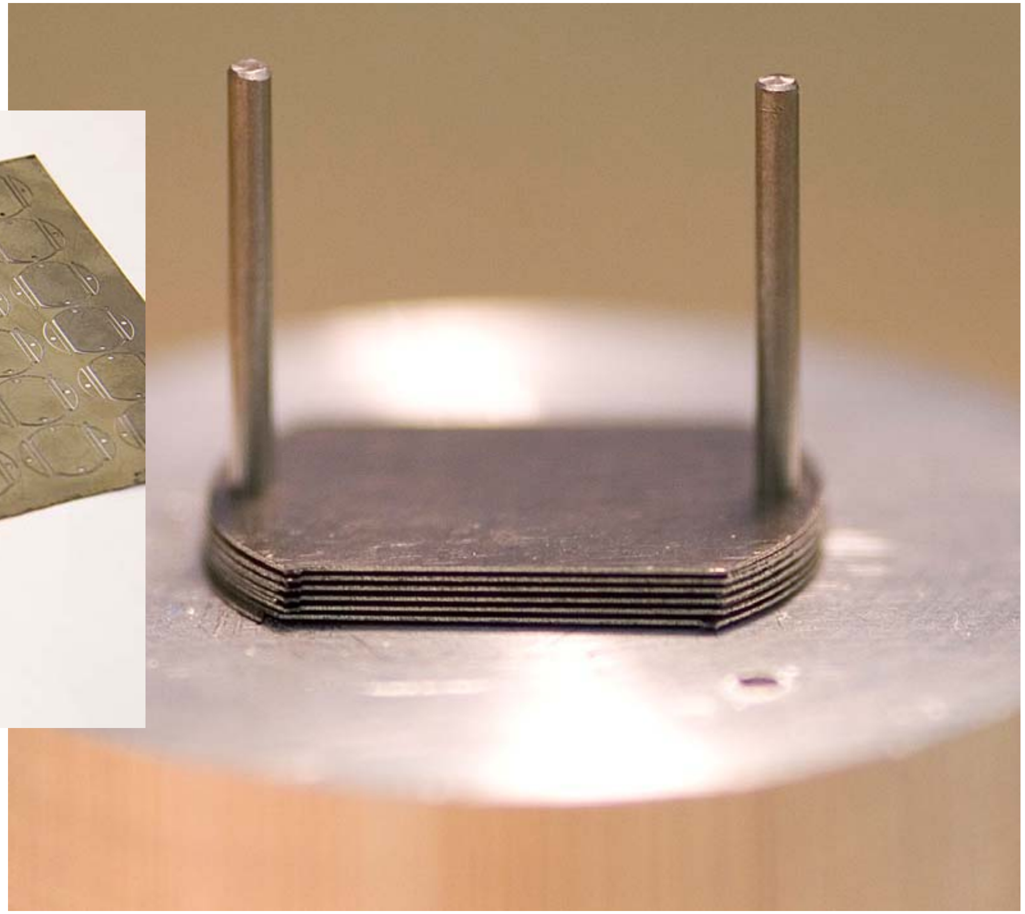

Cave 111b
concrete wall
Positron laboratory
≈ 600 mm
≈ 150 mm
beam dump
water cooled Al block
Pb screening
W moderator foil
extraction lense
radiation converter (W foam)
Be window
ELBE primary beam
10 mm
e-
13 MHz
e+
appertures
22Na source
accelerator
sawtooth prebuncher 26 MHz
1. buncher
26 MHz
1. chopper
2. chopper
2. buncher
26 MHz
accelerators
drift path
Wien filter
Faraday cup
magnetic monopol lense
sample
multi-detector system
primary e- pulse width 5 ps
1×10^8 e- per bunch
≈ 60 moderated e+
13×10^6 bunches /s
≈10^9 moderated e+
77 ns (adjustable)

EPOS scheme

Directly water-cooled Electron-Positron Converter

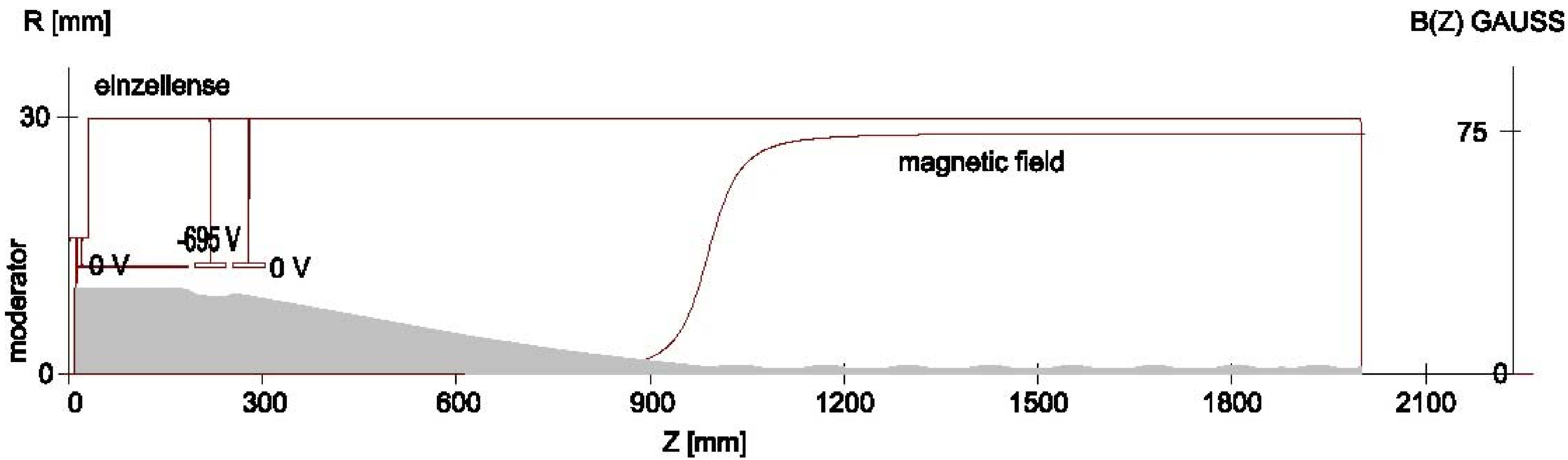
- first attempt: porous W (30 % porosity) -> too low water flux at 10 bar
- stack of 50 pieces W-foils 0,1 mm separated by 0,1 mm -> 13,5 l water at 1,5 bar
- foils cut by IR-laser in our workshop



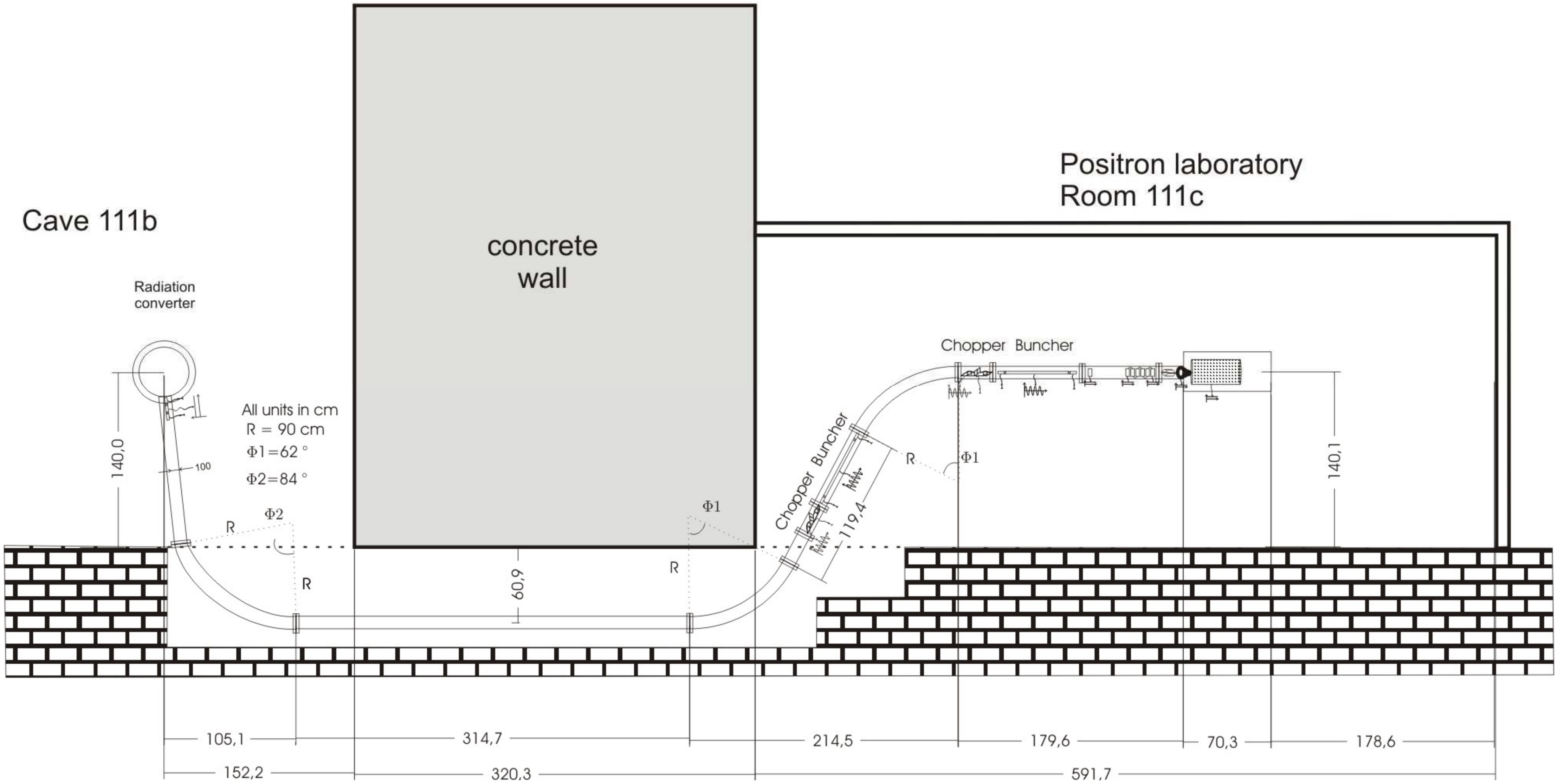


Simulation of positron extraction

- simulation done by EGUN
- area of 20 mm diameter at moderator is used and squeezed to about 2 mm



EPOS scheme



Cave 111b
Positron laboratory
Room 111c
concrete
wall
Radiation
converter
All units in cm
R = 90 cm
Φ1=62 °
Φ2=84 °
Chopper Buncher
Chopper Buncher
Φ1
Φ2
R
140,0
140,1
119,4
60,9
100
105,1
314,7
214,5
179,6
70,3
178,6
152,2
320,3
591,7

Magnetic Beam Guidance

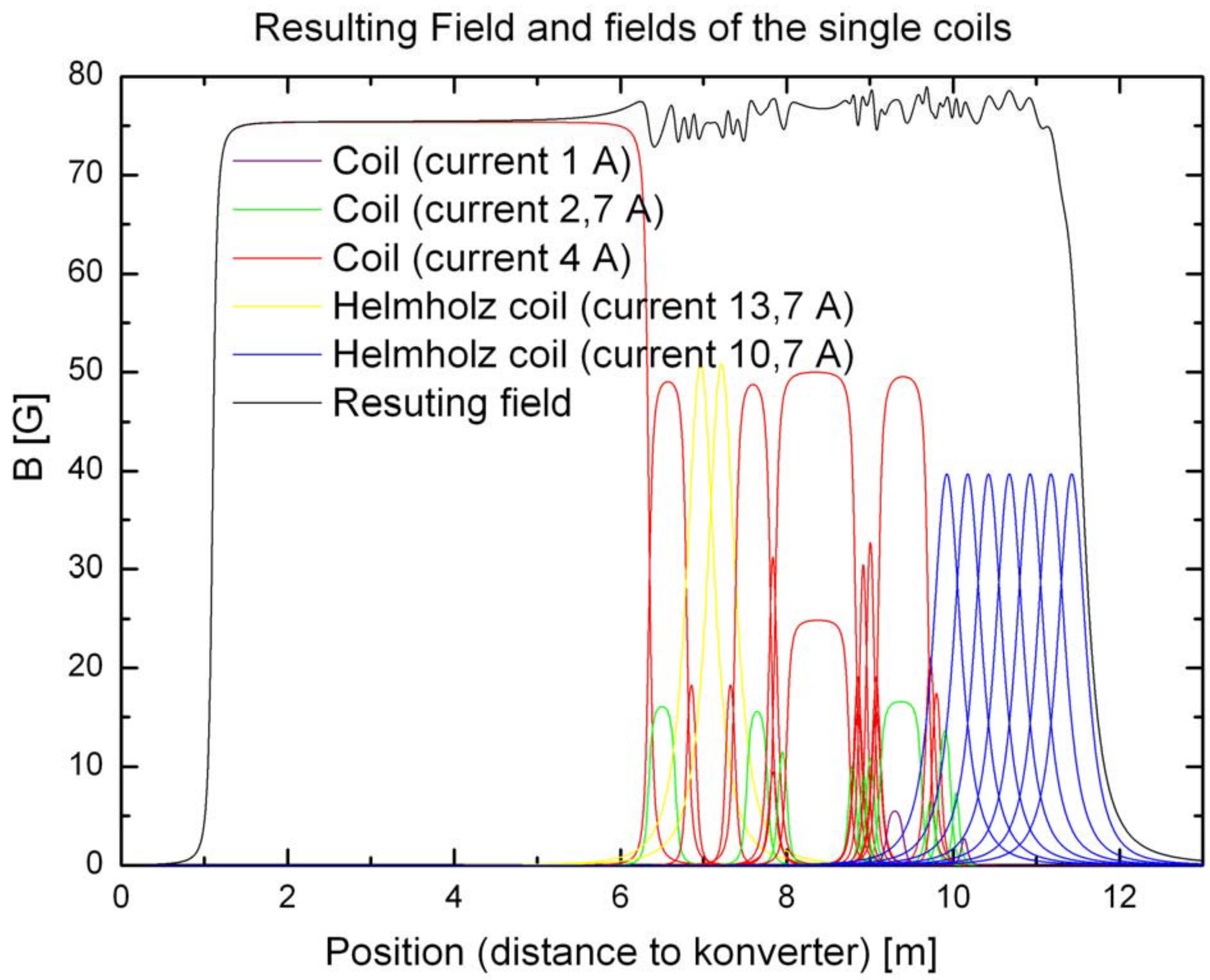
Magnetic field of 75 Gauss

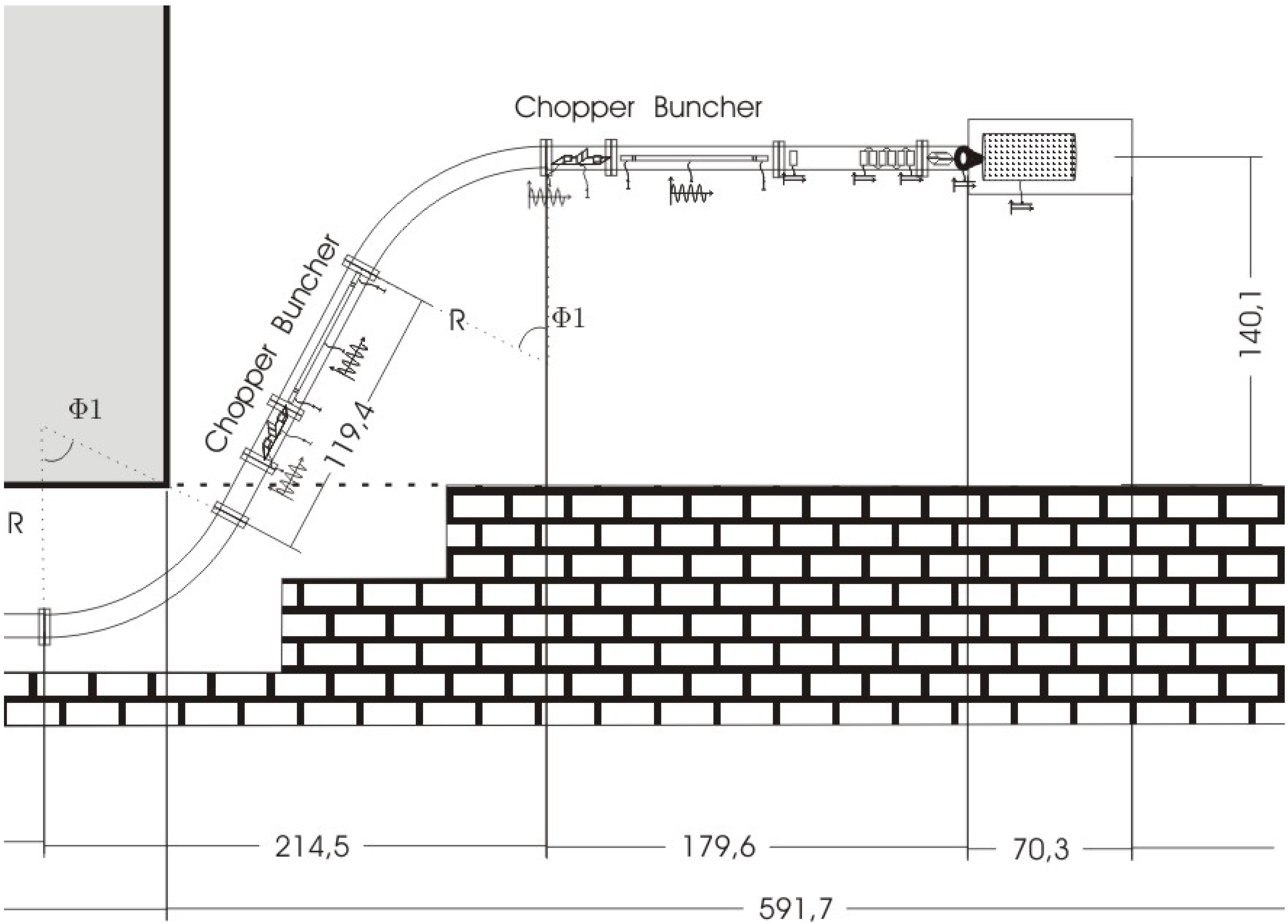
45 coils but only
5 different currents
5 Power supplies

➔maximum change 6 G
➔Gradient < 0,11 G/mm

Steering coils

30 coils with different
(computer-driven) currents

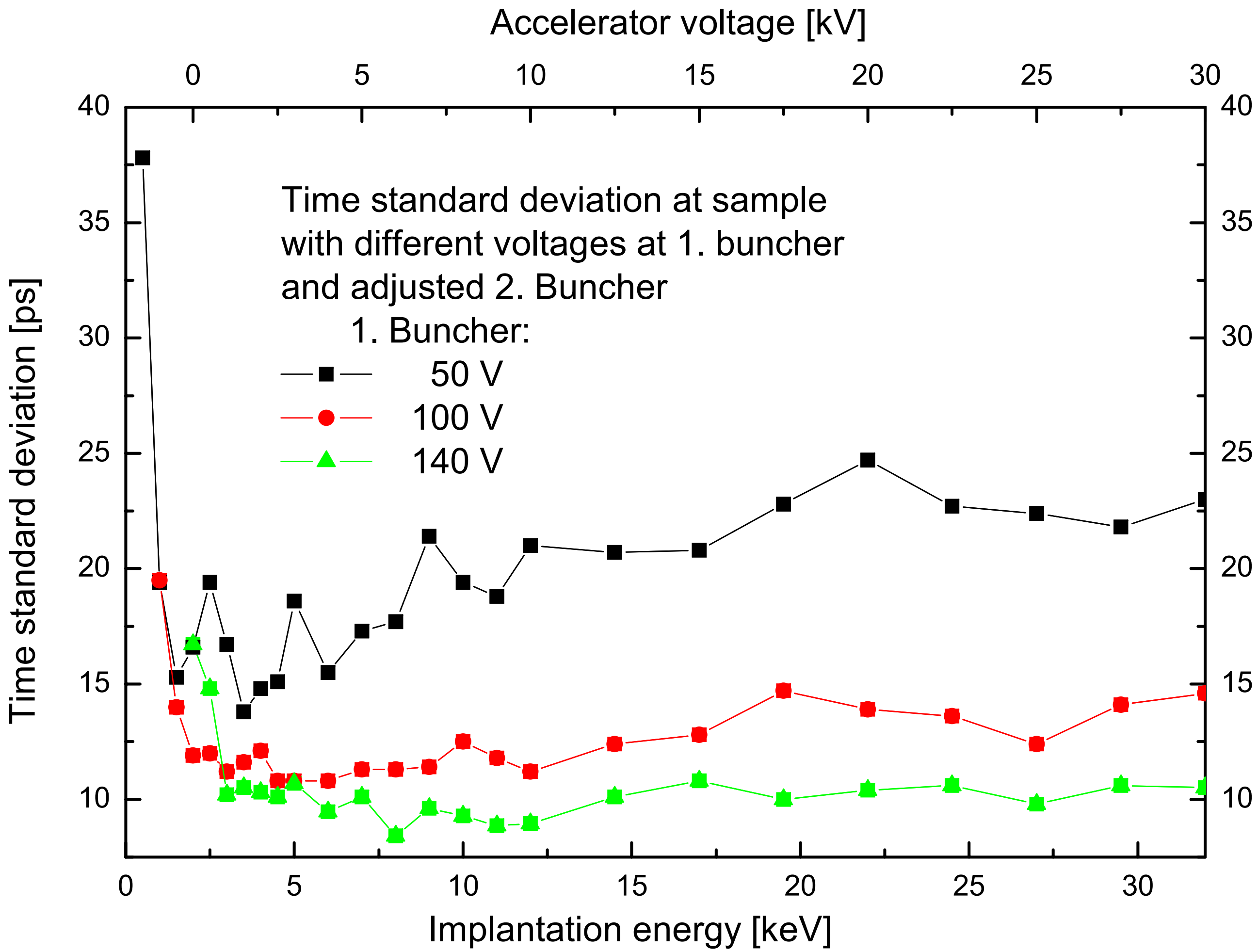



Chopper Buncher
Chopper Buncher
R
Φ1
Φ1
R
119,4
140,1
214,5
179,6
70,3
591,7

- Simulation of bunching by POSBUNCH
- C++ author: V. Bondarenko
- source code available on request

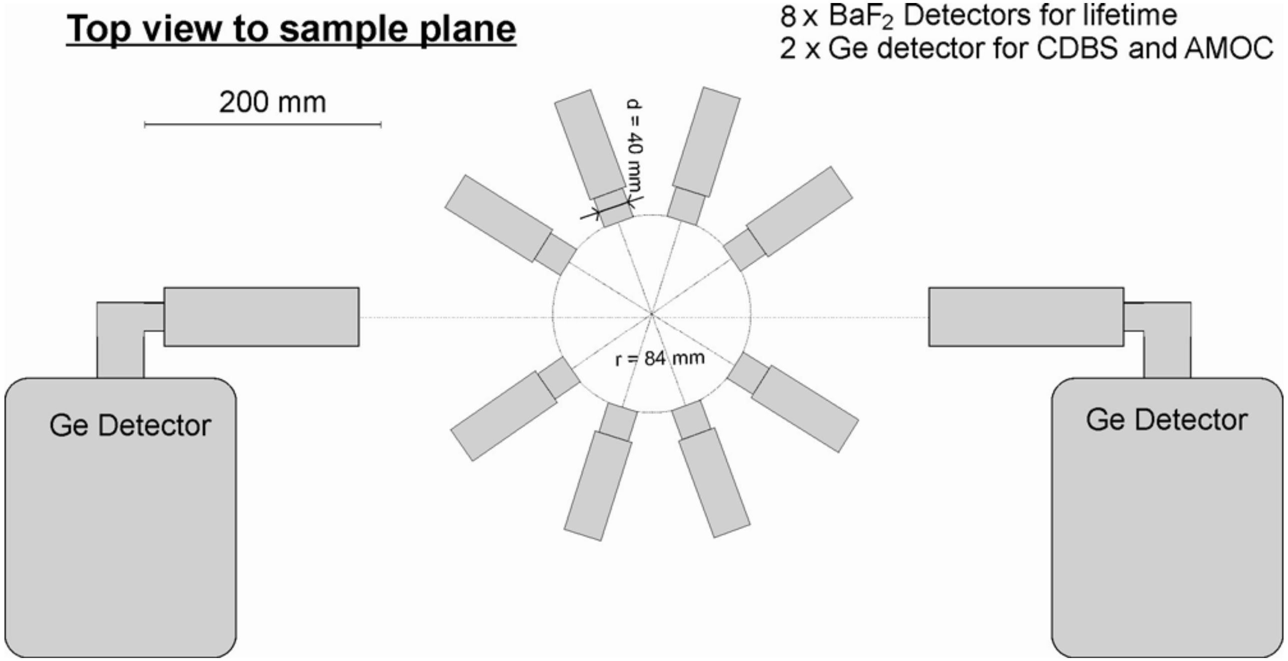
Simulation of Buncher Voltages

Both buncher RF-voltage amplitudes and the drift path energy must be adjusted for each beam energy for optimum time resolution

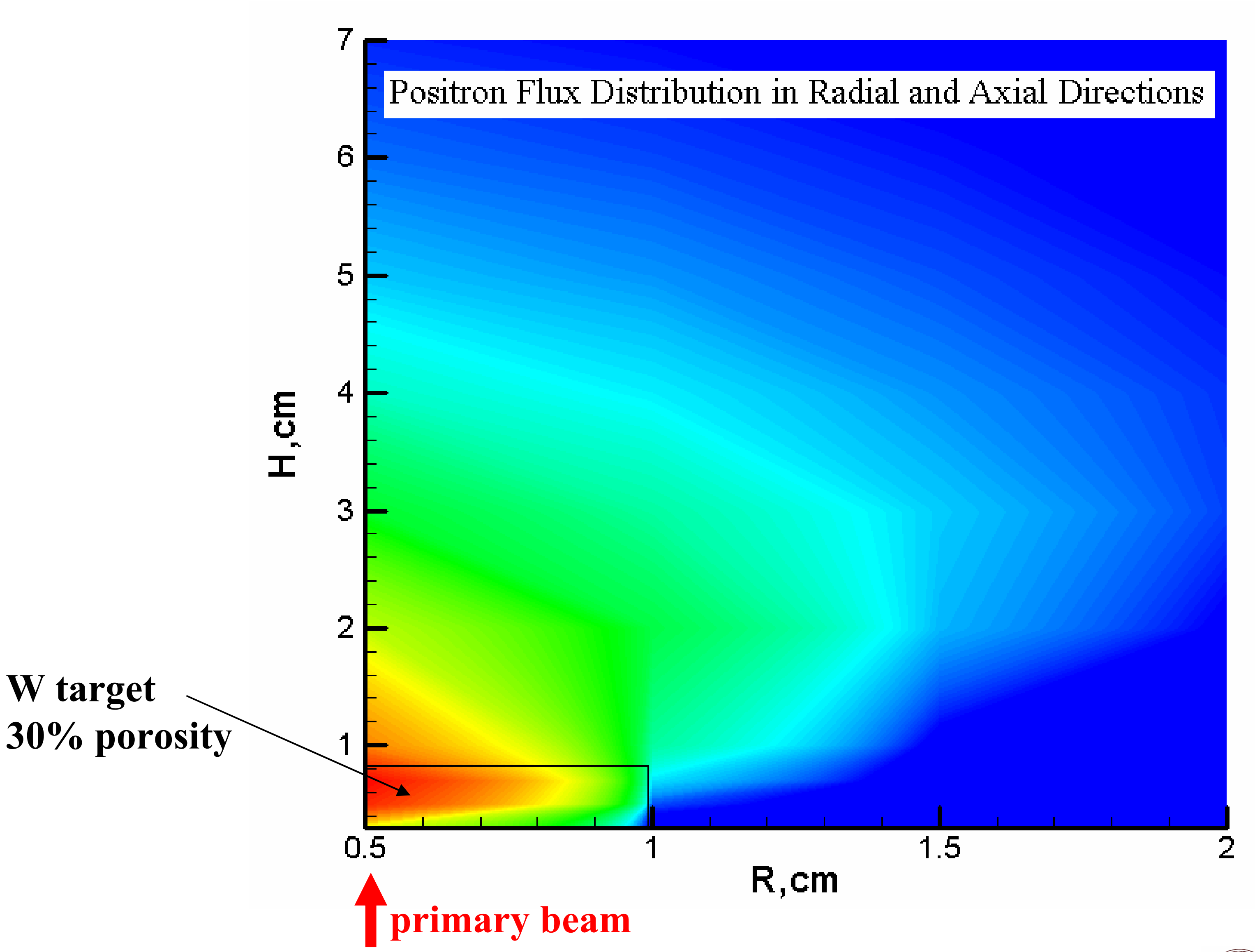


Detector system

- **3 experiments**: lifetime spectroscopy (8 BaF_2 detectors); Doppler coincidence (2 Ge detectors), and AMOC (1 Ge and 1 BaF_2 detector)
- **digital detection system**:
  - lifetime: almost nothing to adjust; time scale exactly the same for all detectors; easy realization of coincidence
  - Doppler: better energy resolution and pile-up rejection expected
  - pulse-shape discrimination improves spectra quality

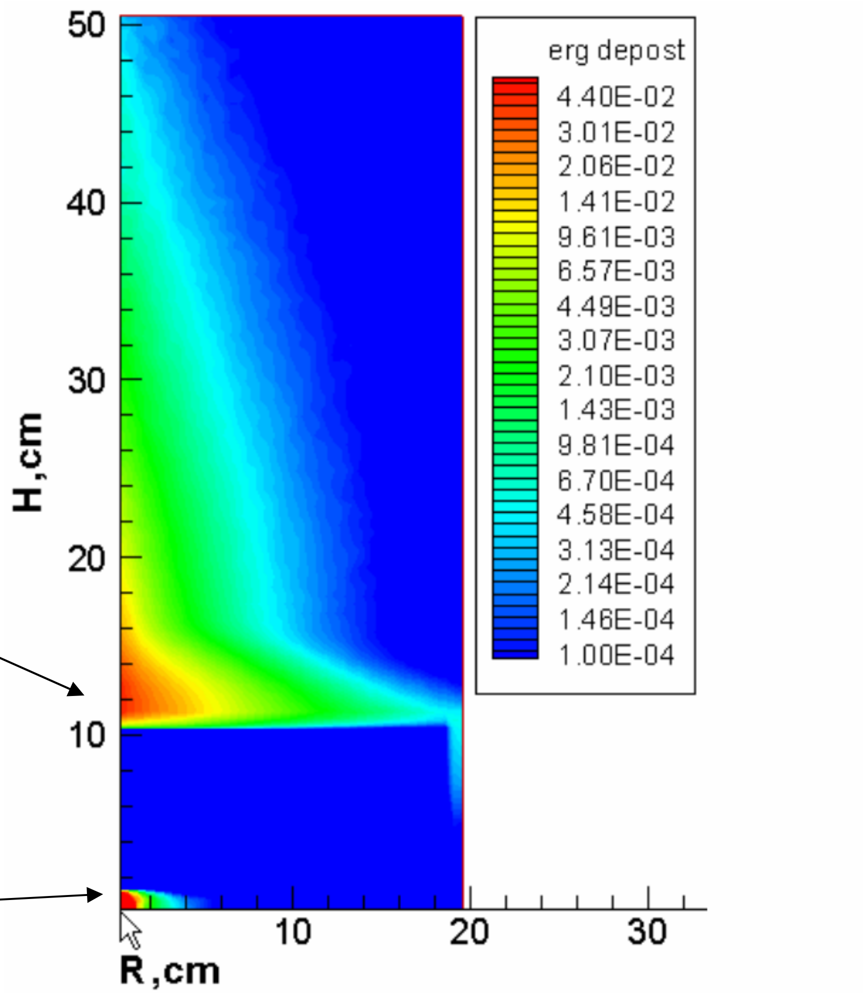


Simulation of Positron distribution



Simulation of Energy deposition

Al beam dump **21 kW**
(made of 5N-purity)



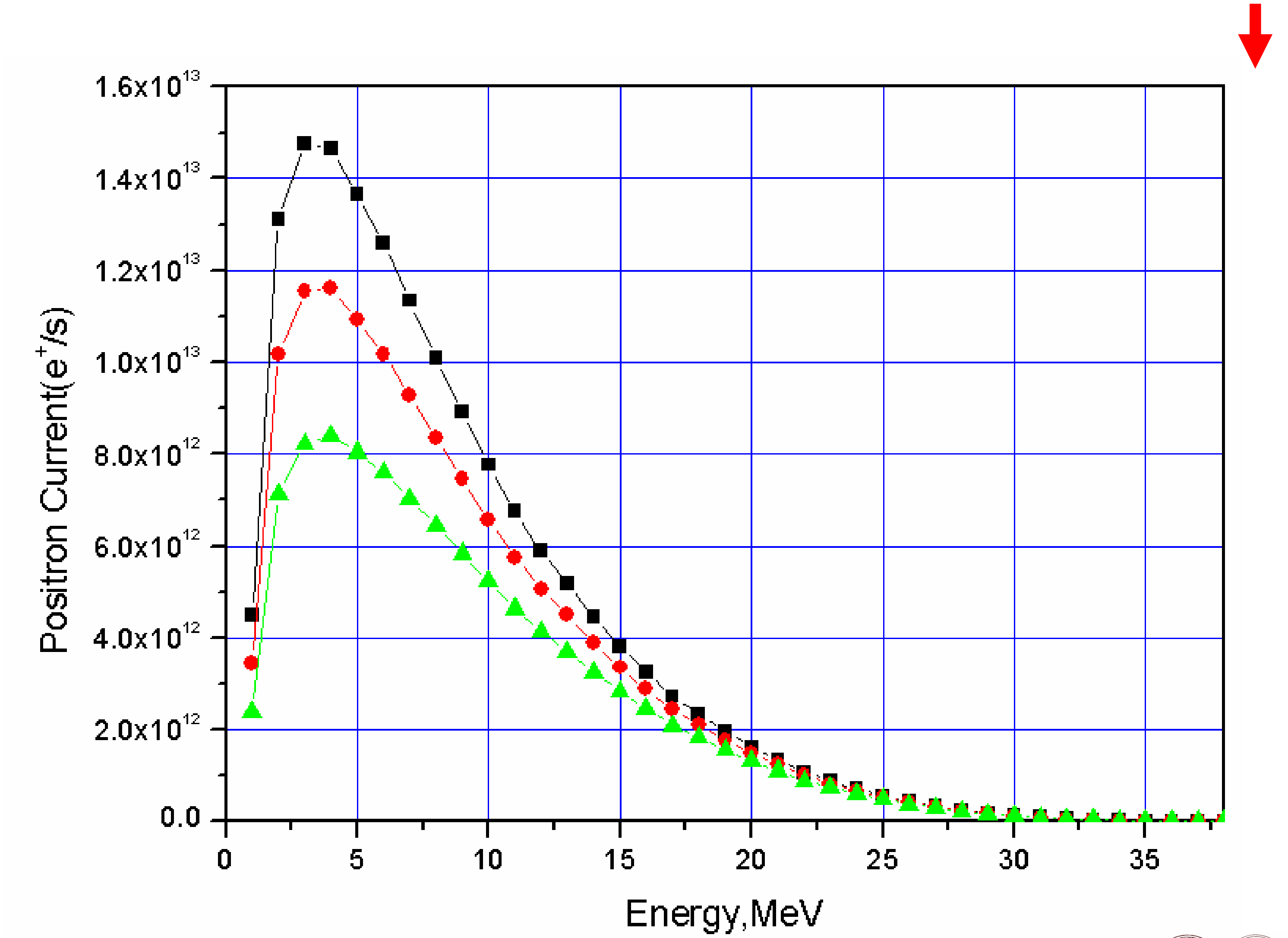
W target
14 kW

EPOS Density Energy Deposition (in MeV/cm^3) for Distance = 10cm

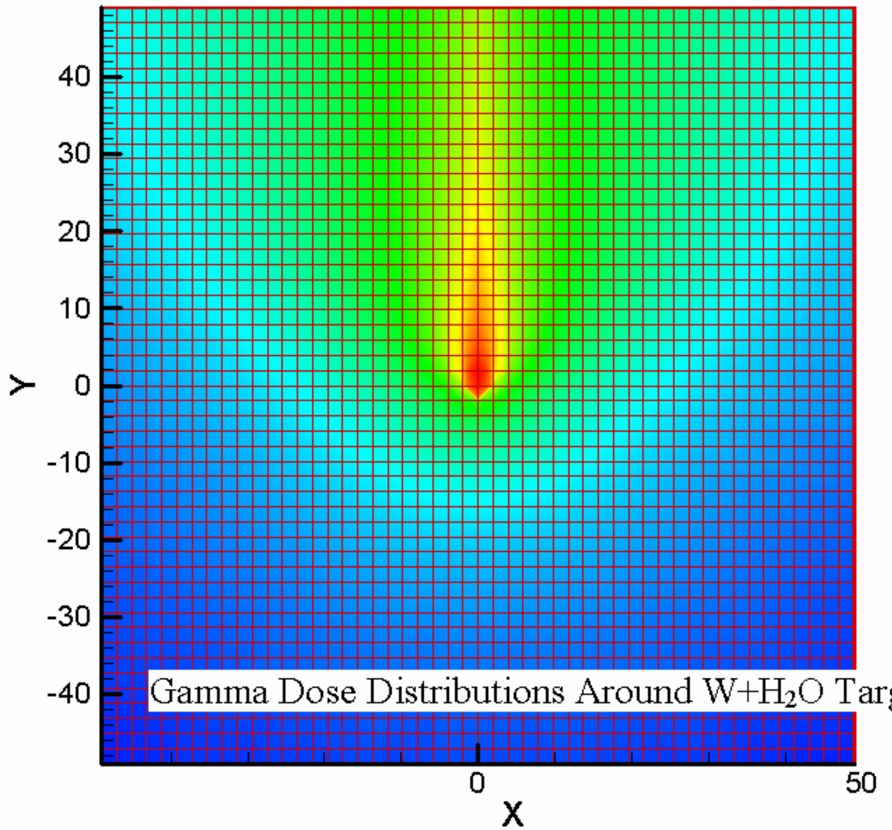
primary beam

Simulation of Positron Energy Distribution

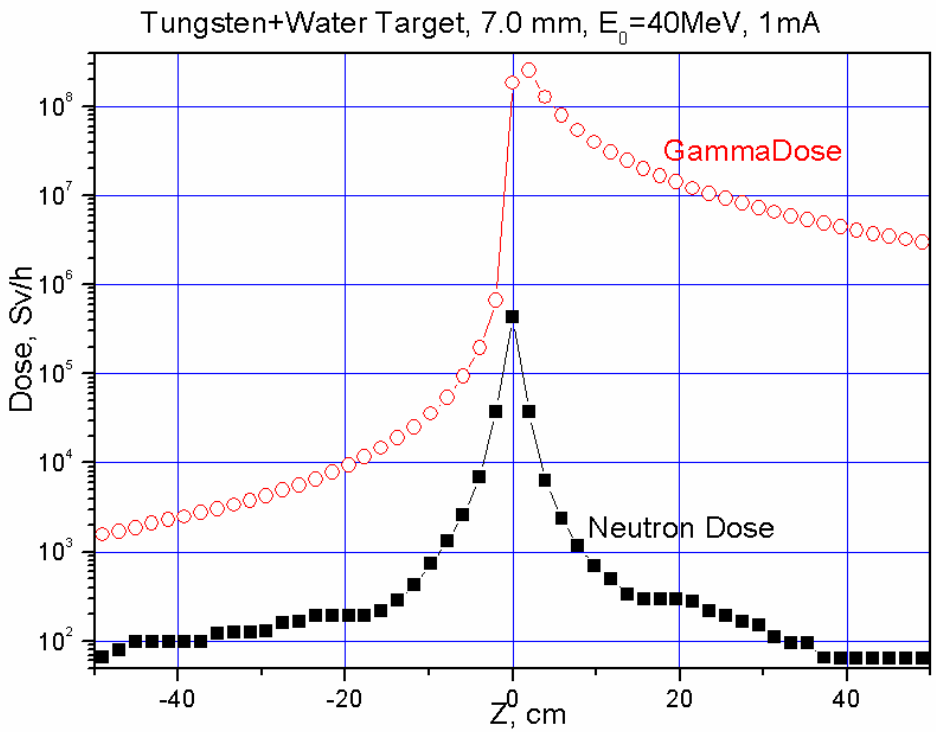
primary electron beam 40 MeV



Simulation of expected γ and n dose



Gamma Dose Distributions Around $W+H_2O$ Target



Neutron and Gamma Dose Distributions Around $W+H_2O$ Target in Axial Direction

Screening by lead blocks, Polyethylene bricks and heavy concrete

Time Schedule

	1. Year	2. Year	3. Year
Laboratory			
Simulation e^+ converter			
Simulation beam			
Converter chamber and vacuum system in tunnel			
Screening of converter chamber			
First chopper / buncher			
Test converter / beam transport			
Vacuum system completion			
Conventional source chamber			
2. Chopper / buncher			
Sample chamber			
Completion of beam electronics			
Test transport system			
Detector system and software			
Automation			
Software lifetime / Doppler spectra			
Optimization of time resolution			