

16.07.2010

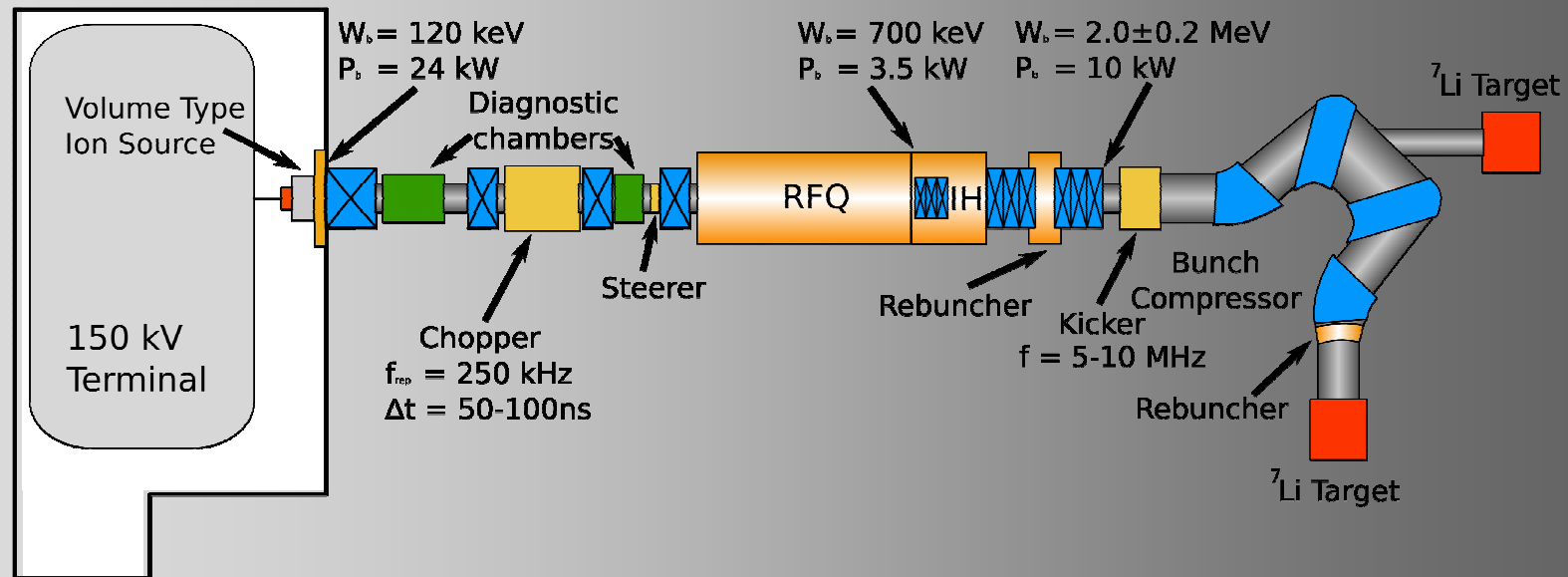
Frankfurter Neutronenquelle

Status und Perspektive

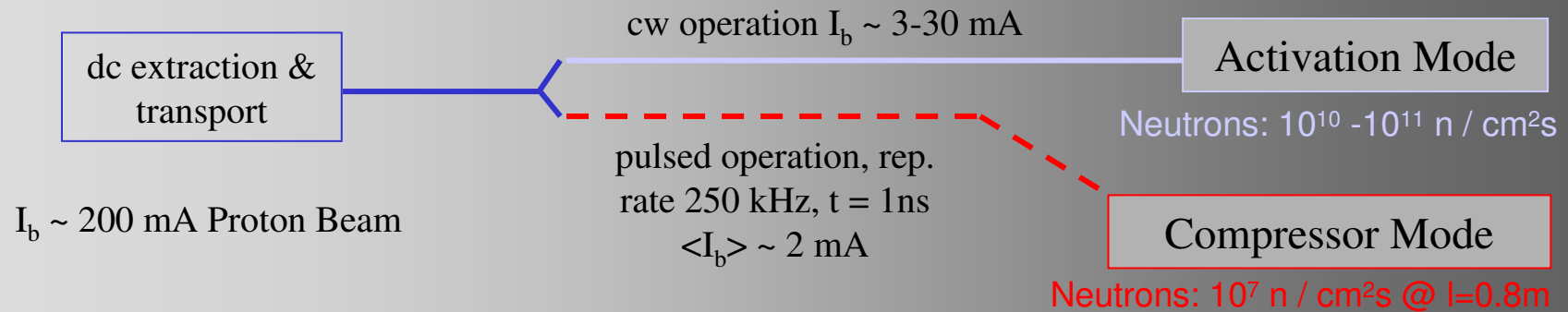
on behalf of the FRANZ community

Oliver Meusel

Overview



Overview

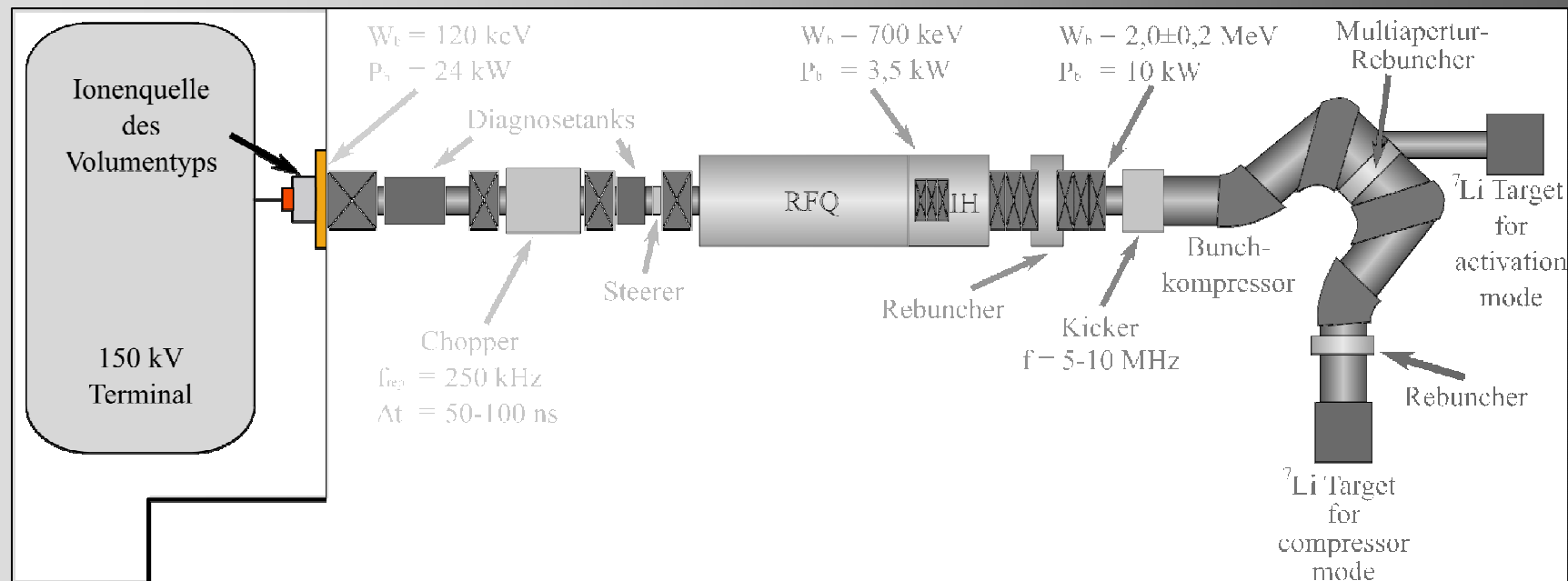


Accelerator Physics

Target Development

Neutron Physics

Ion Source

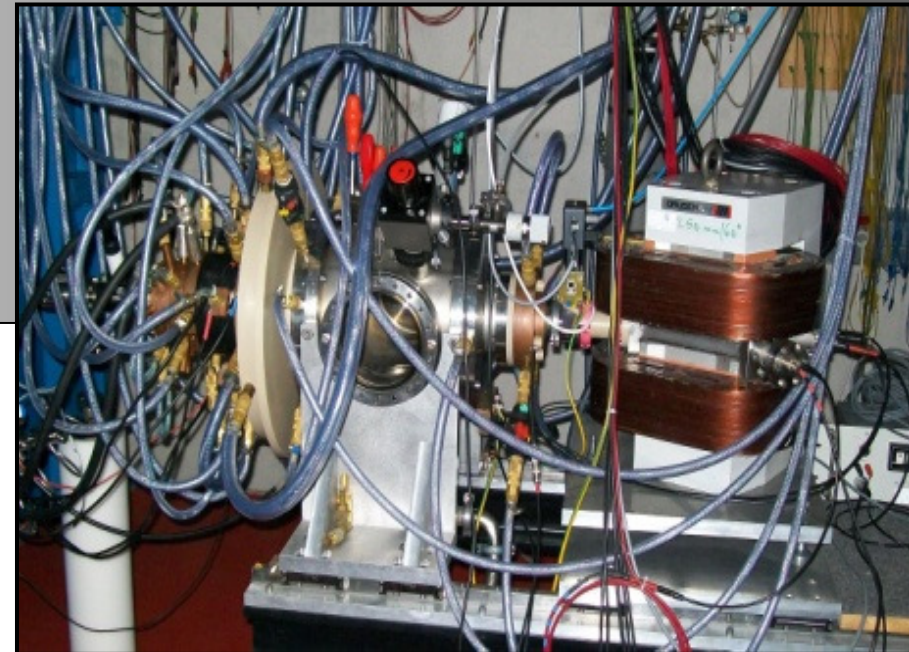
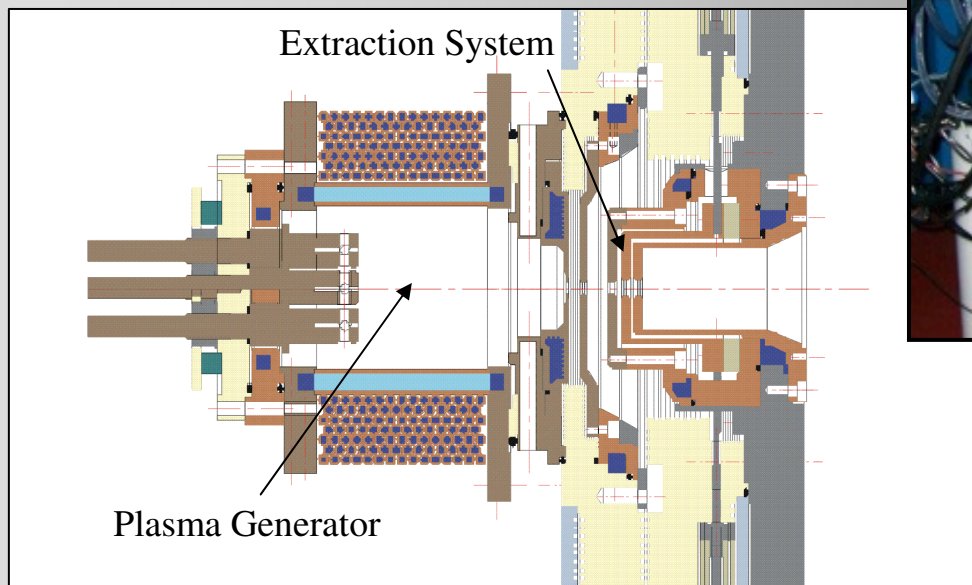


Ion Source Development & Design

$$I_p = 200 \text{ mA} \quad \epsilon_{\text{rms, norm}} = 0.07 \pi \text{ mm mrad}$$

$$W = 120 \text{ keV} \quad \text{dc-operation}$$

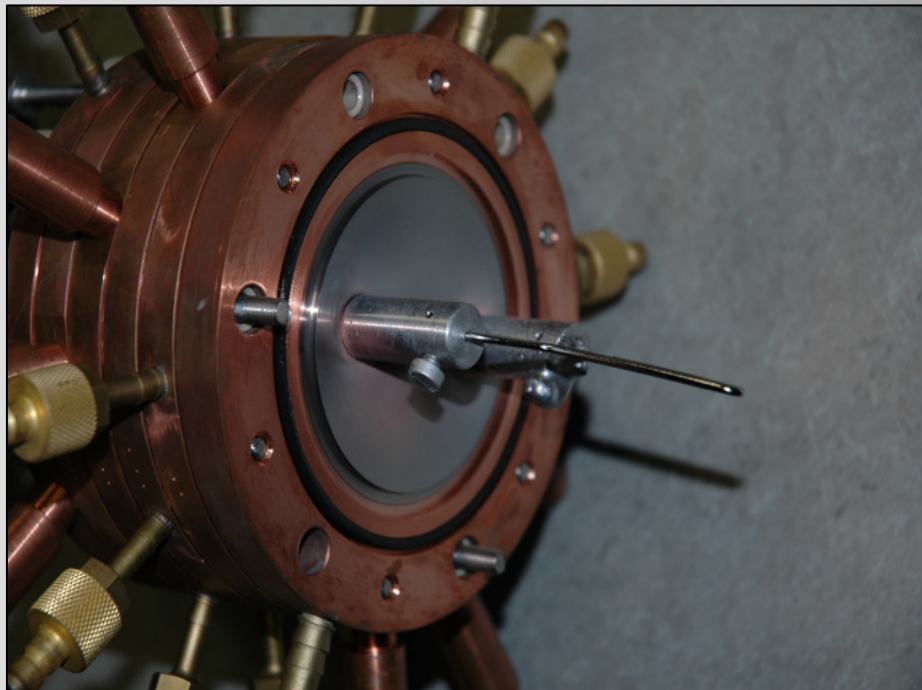
$$P = 24 \text{ kW}$$



mechanical design of the proton source

K. Volk, W. Schweizer, R. Nörenberg

Plasma Generator & Extraction System

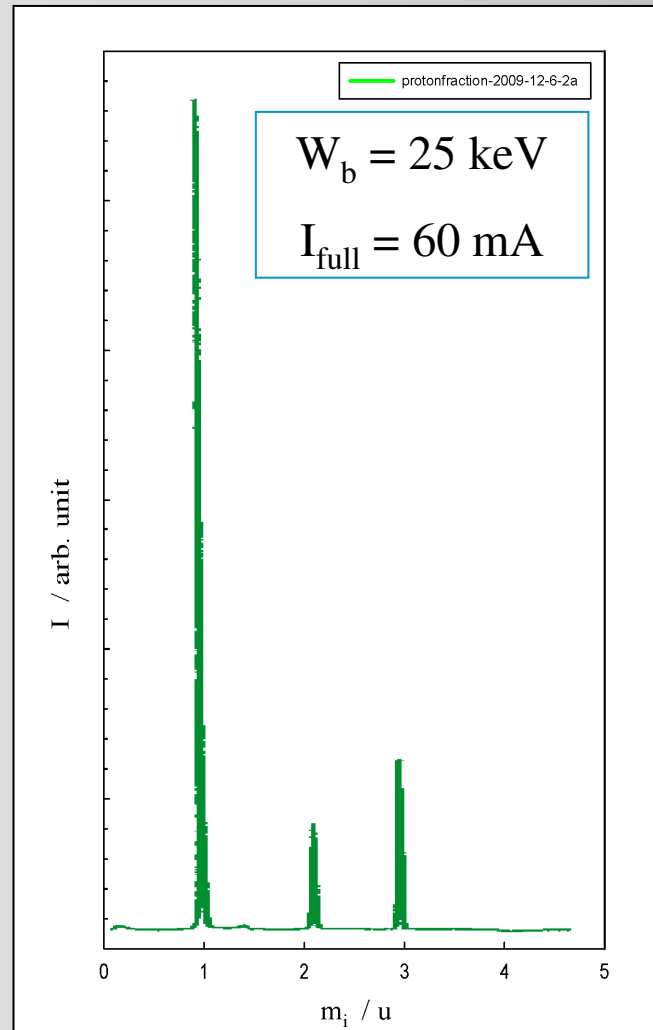


hot filament driven gas discharge

Experiments

- lifetime of the filament
- reliability of the source
- sparking
- power deposition in the extractor
- plasma vs. beam properties

Impact of Plasma Properties



$$I_p = 200 \text{ mA} \quad N = 1,2 \cdot 10^{18} \text{ s}^{-1}$$

steady state assumption

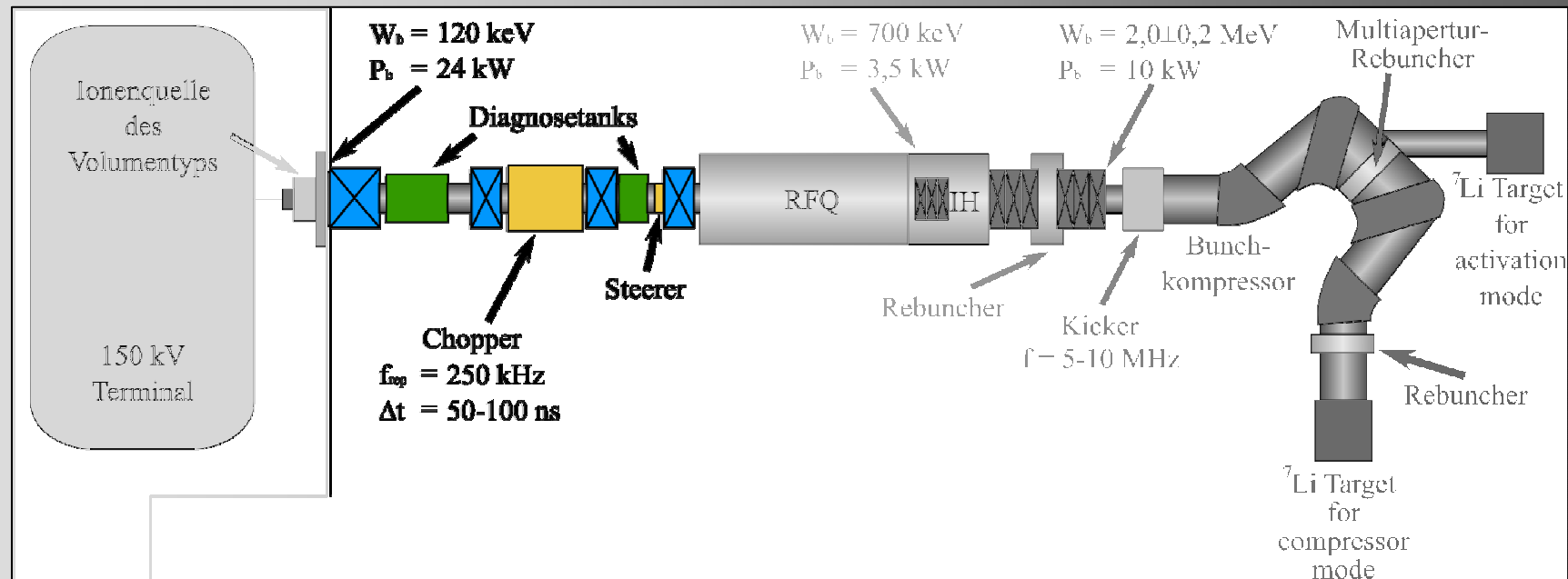
$$\overbrace{\sum_1^p n_p \cdot \sigma_p}^{\text{Erzeugung}} \xleftrightarrow{\text{Gleichgewicht}} \overbrace{\sum_1^v n_v \cdot \sigma_v}^{\text{Vernichtung}} + \overbrace{[\text{Extraktion}]}^{\text{Störung}}$$

cold plasma: $T_i \sim 0,5 \text{ eV}$ & $T_e \sim 5 \text{ eV}$

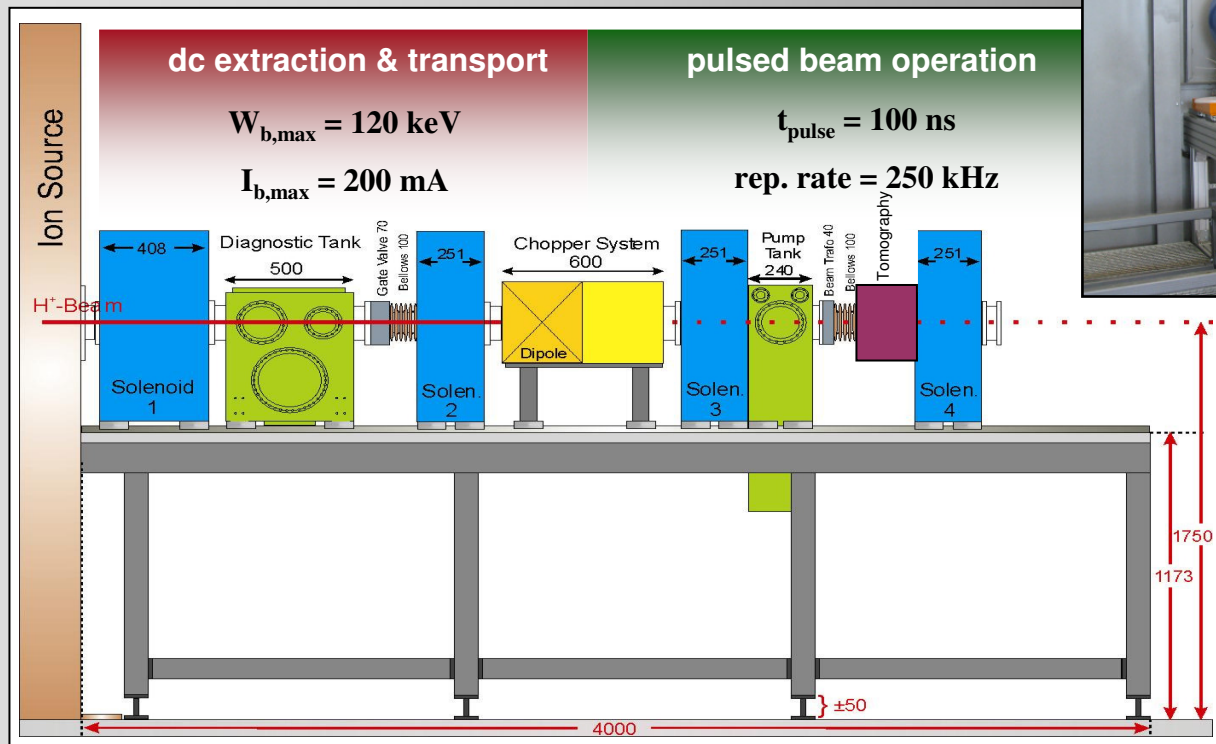


- small rms-Emittance
- production of protons via secondary reaction $\text{H}_2^* + e \rightarrow \text{p} + \text{H} + 2e$

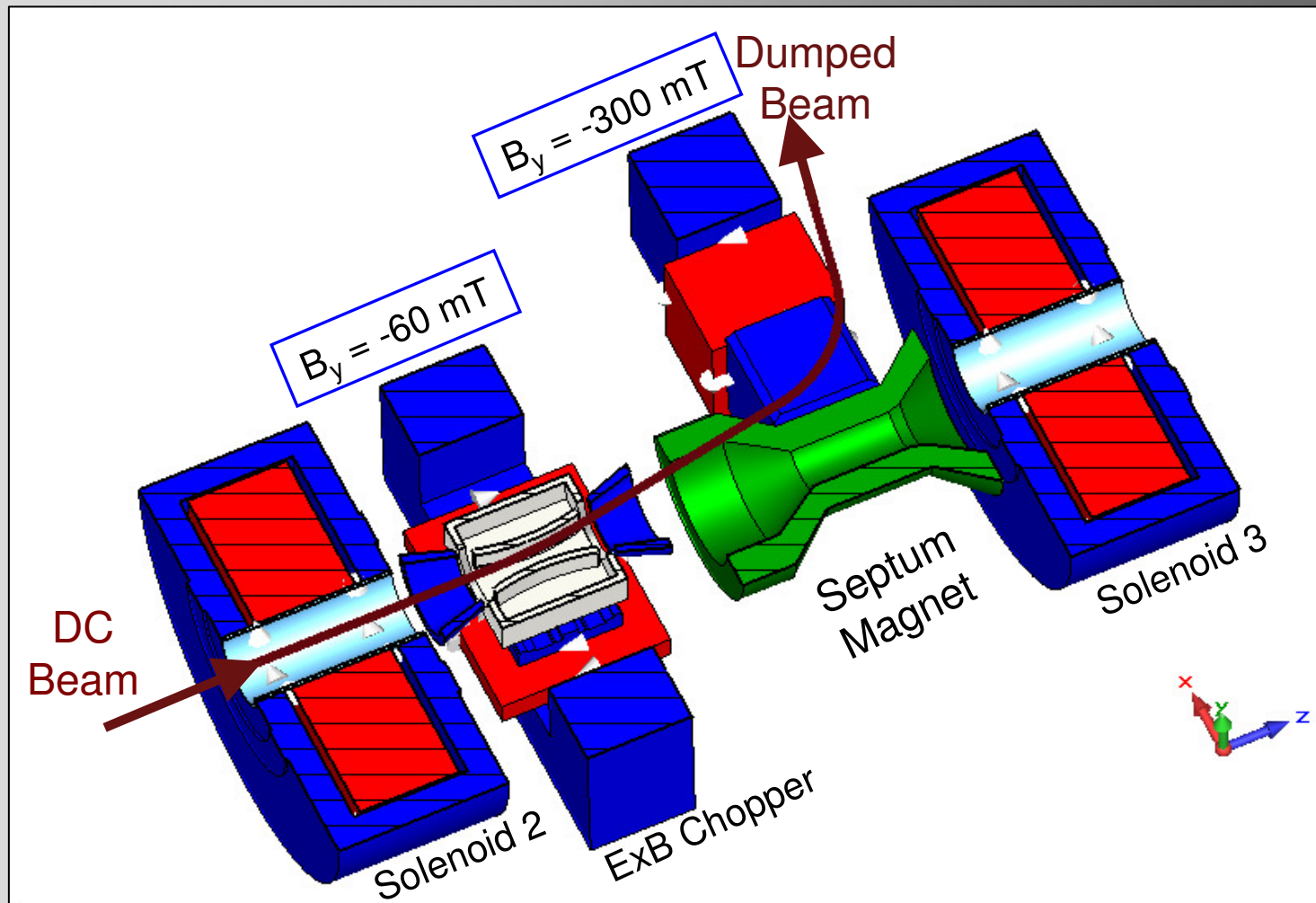
Low Energy Beam Transport



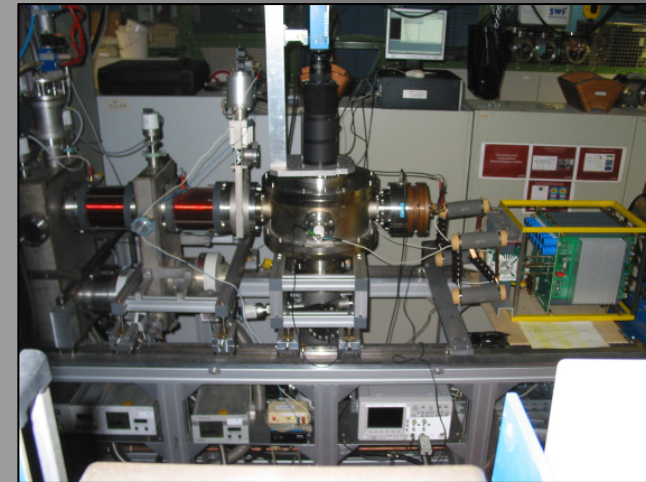
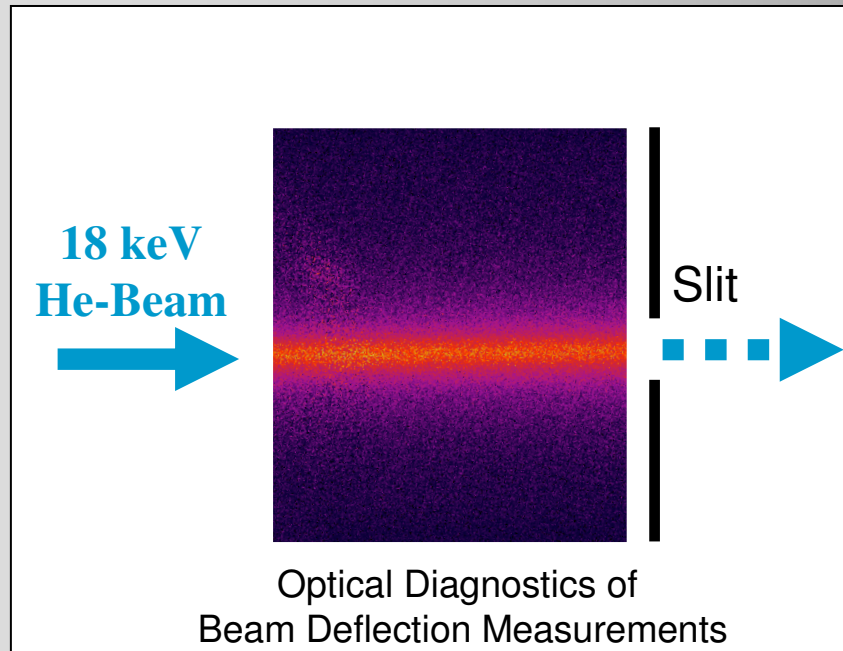
LEBT - 3 Sections - 4 Lenses



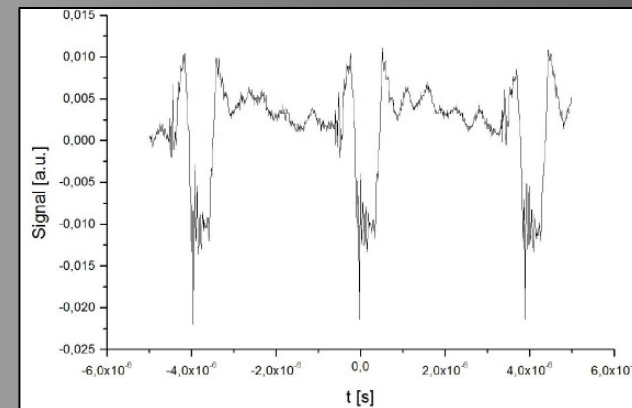
E x B - Chopper



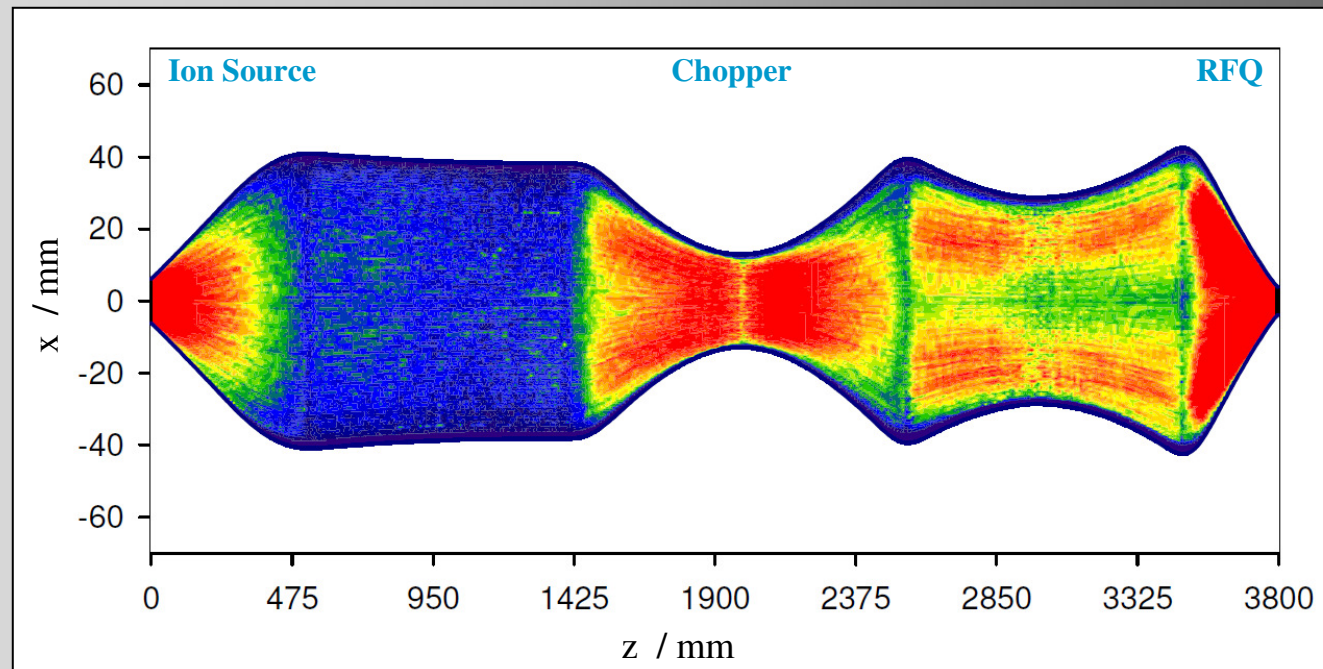
Pulser and Electric Deflector



$t_{\text{pulse}} = 100 \text{ ns}$ rep. rate = 250 kHz



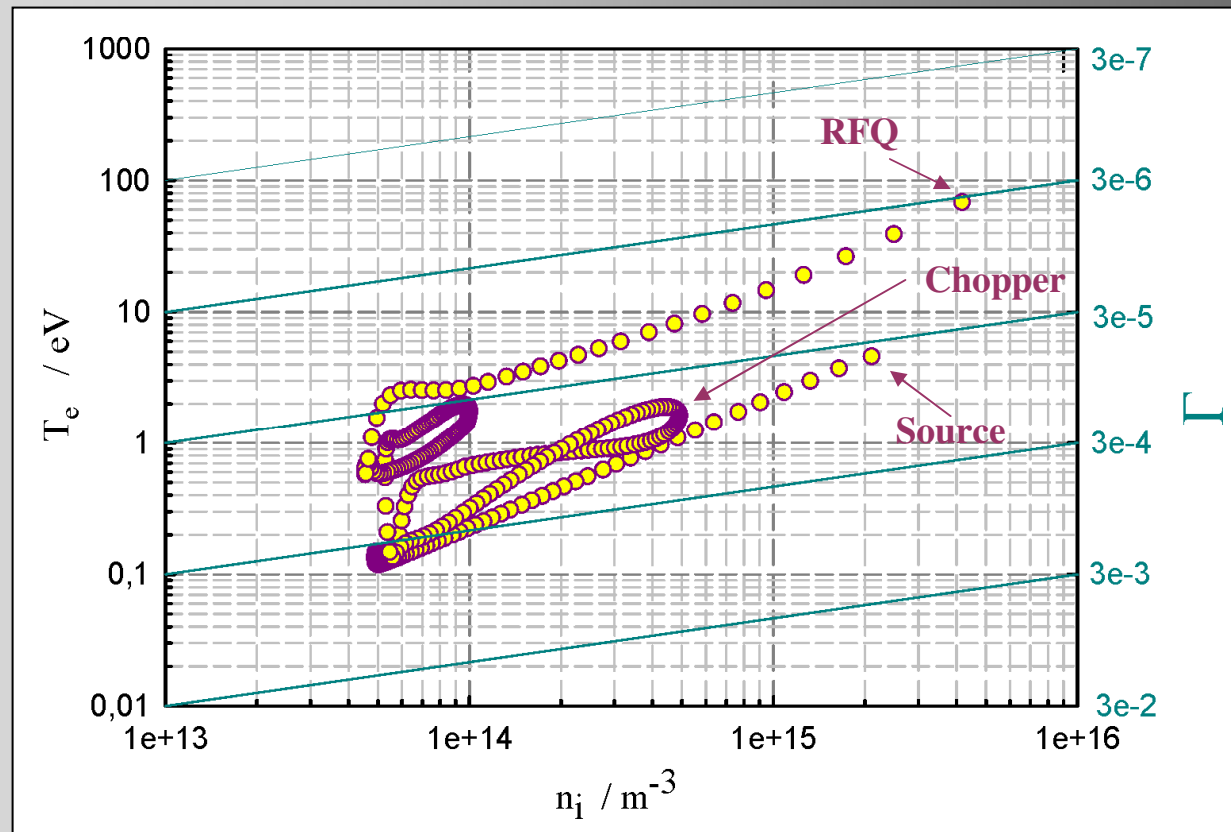
Emittance Growth due to Lens Abberations



density distribution of transverse momentum $v_{t,px}$

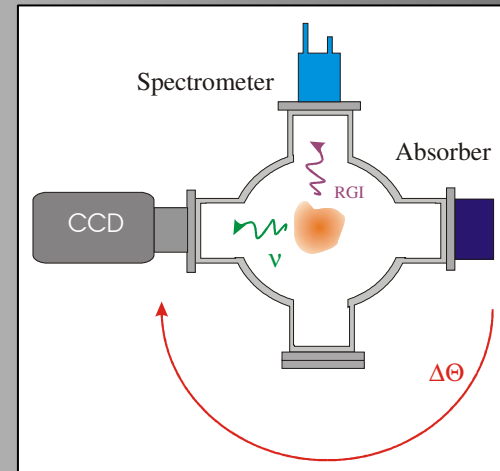
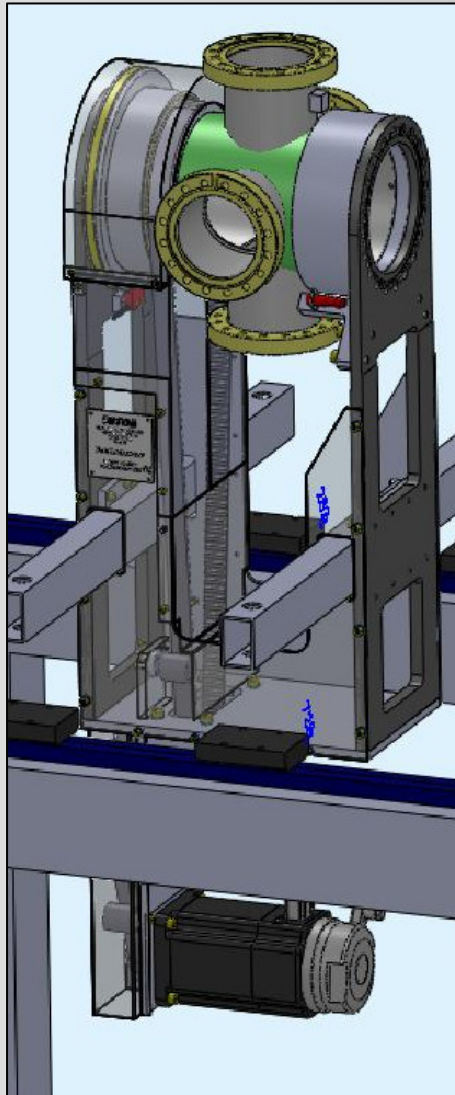
$$v_{t,px} = \int_{-y}^{+y} n_i \cdot \epsilon_{rms,x} dy$$

Emittance Growth due to Collective Processes

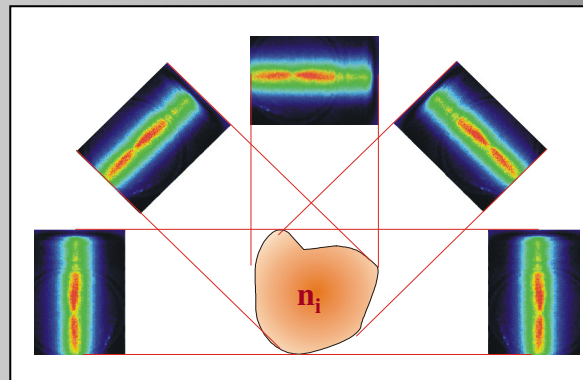


phase diagram of the proton beam during the transport through LEBT section

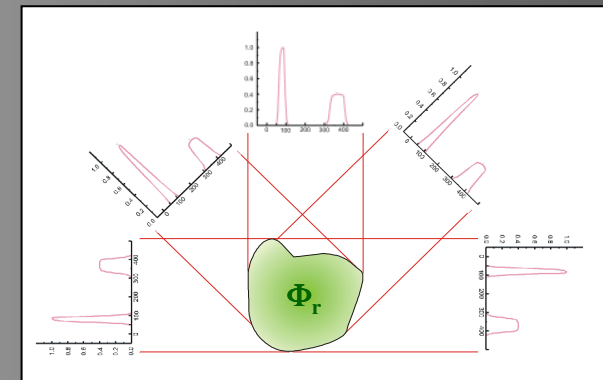
Beam Diagnostics



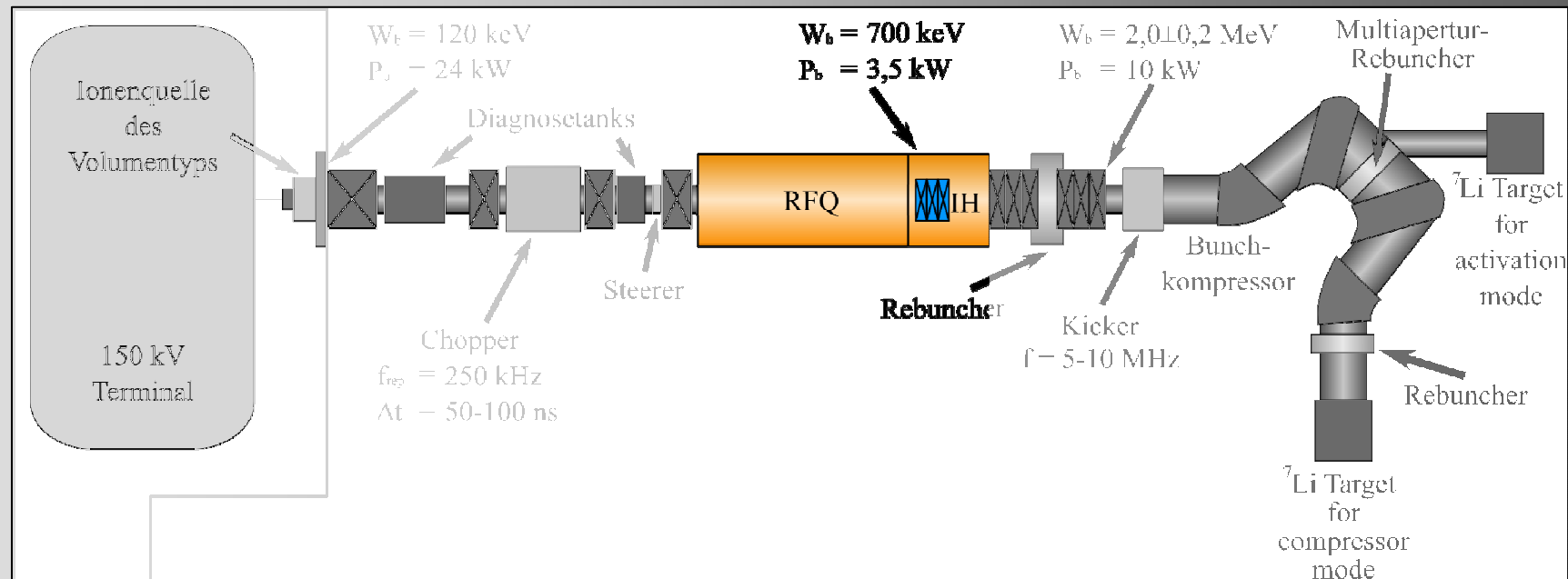
optical profiles



potential distribution

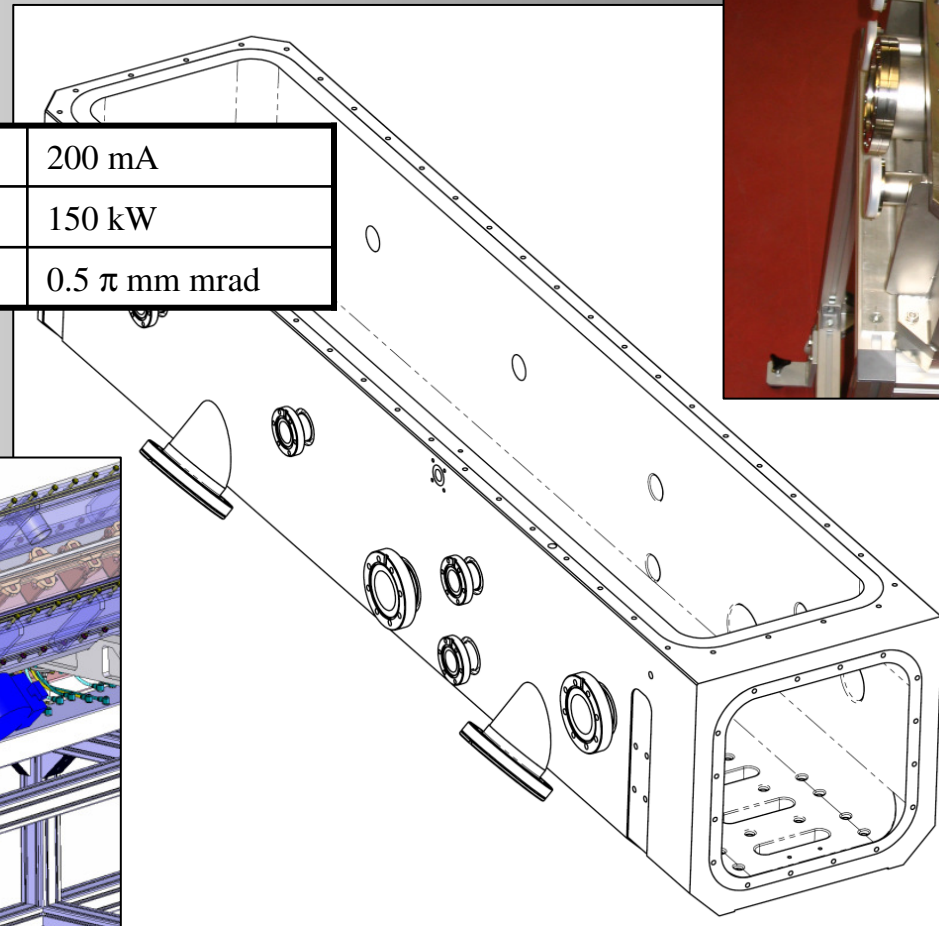
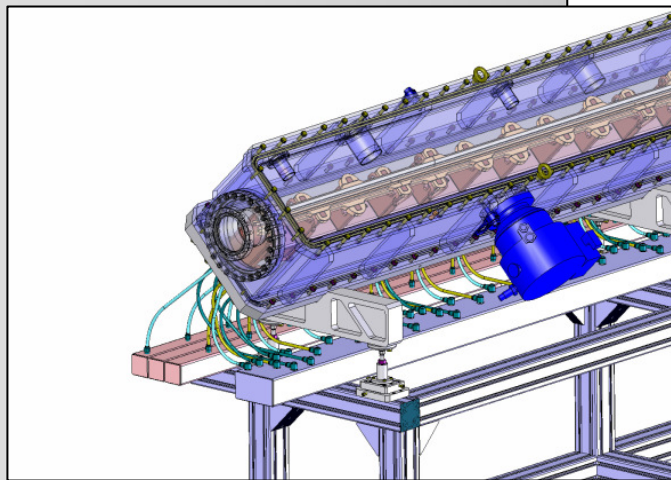
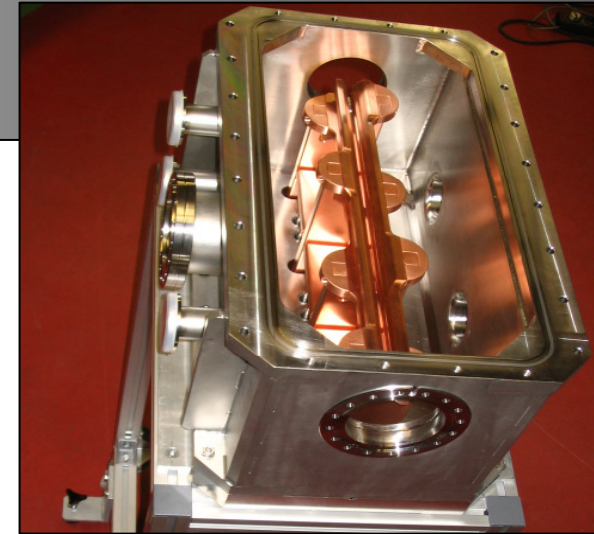


Accelerator Stage

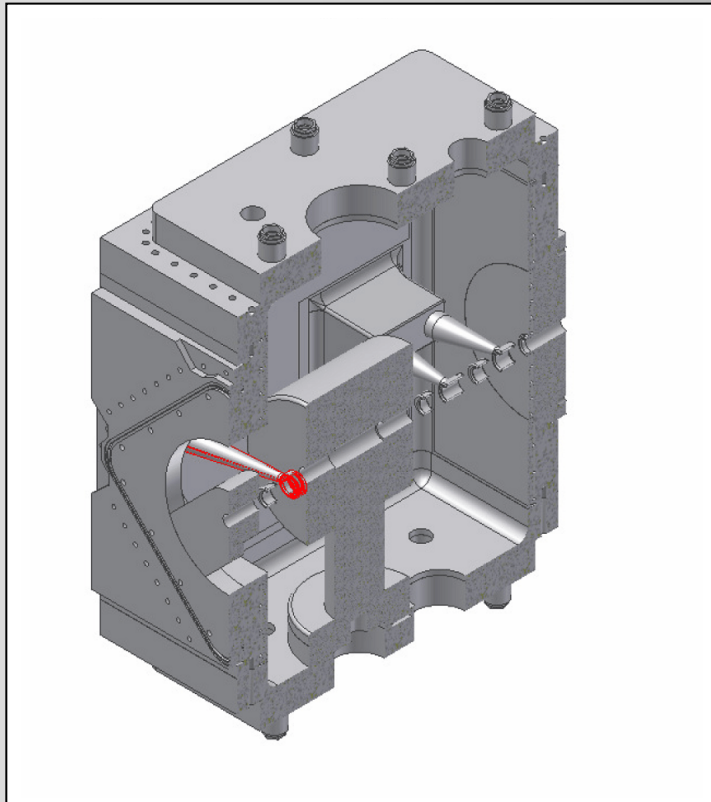


Radio Frequency Quadrupole - RFQ

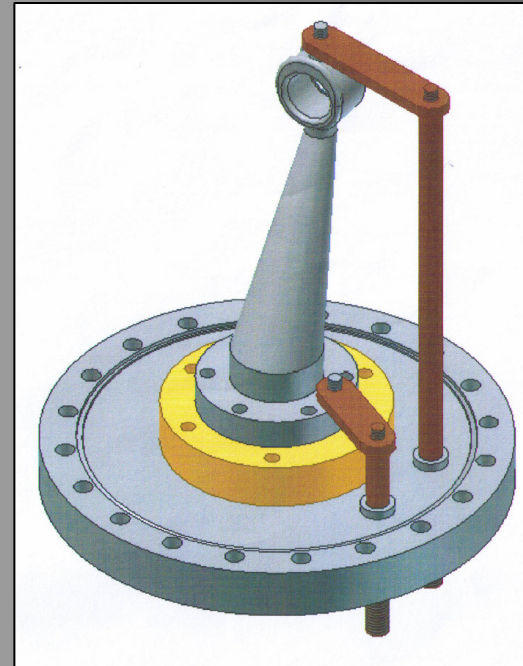
Max. Proton Current	200 mA
Exp. Power Consumption RFQ	150 kW
RFQ Acceptance (norm. rms)	0.5π mm mrad



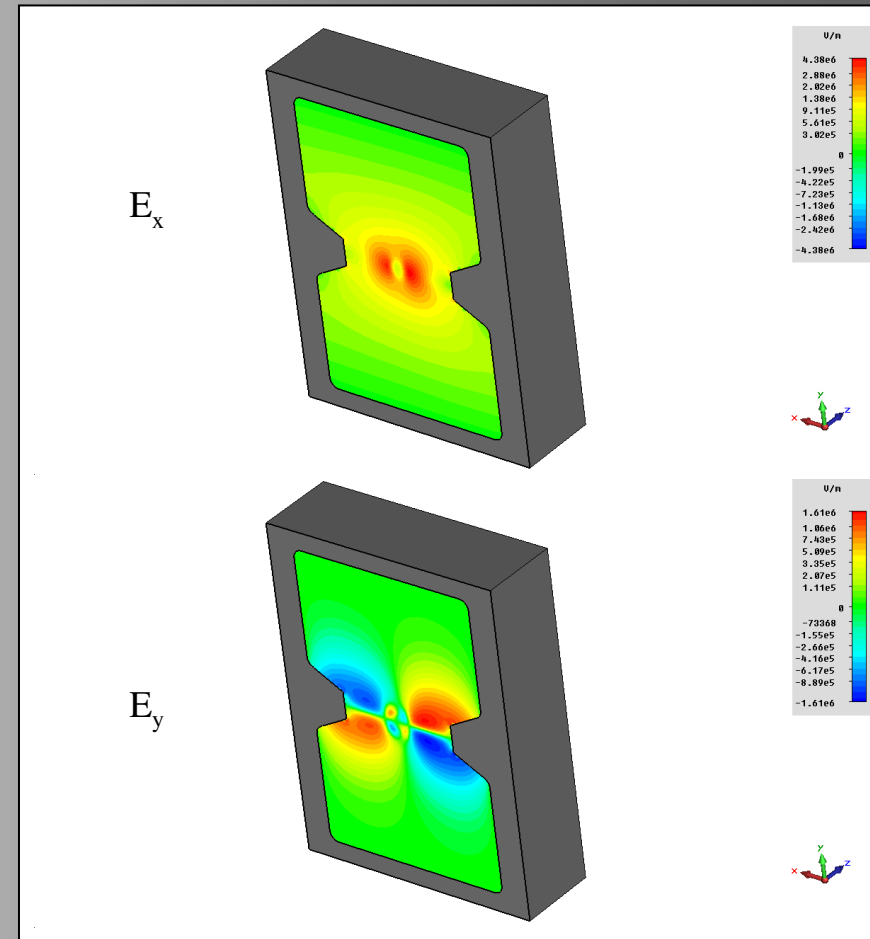
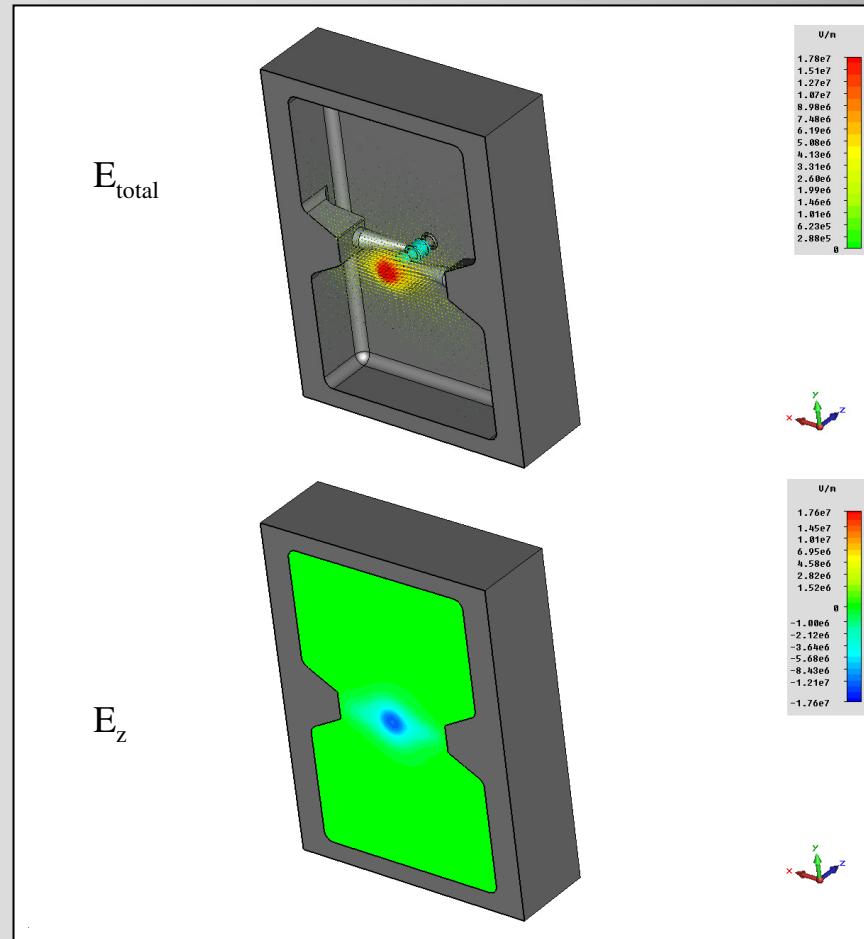
IH - Cavity



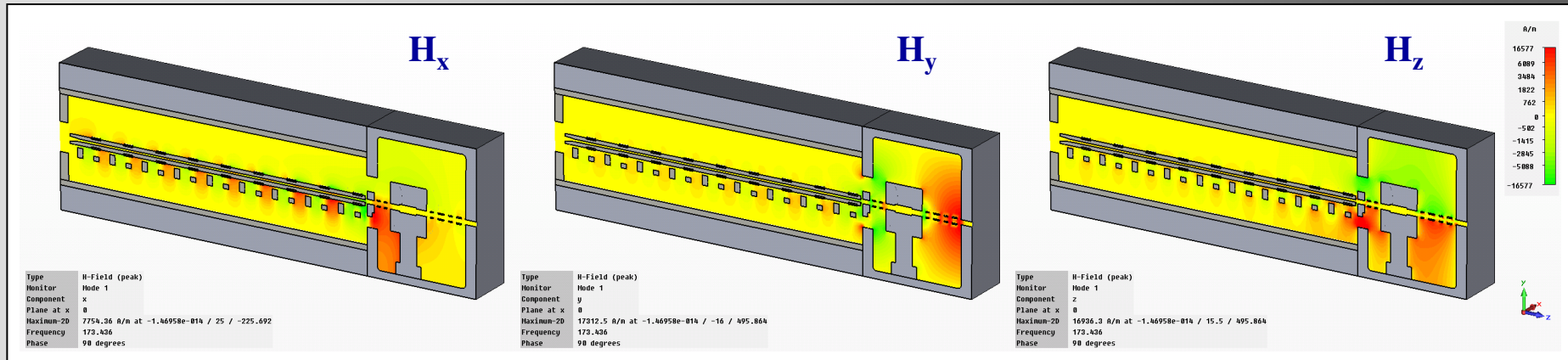
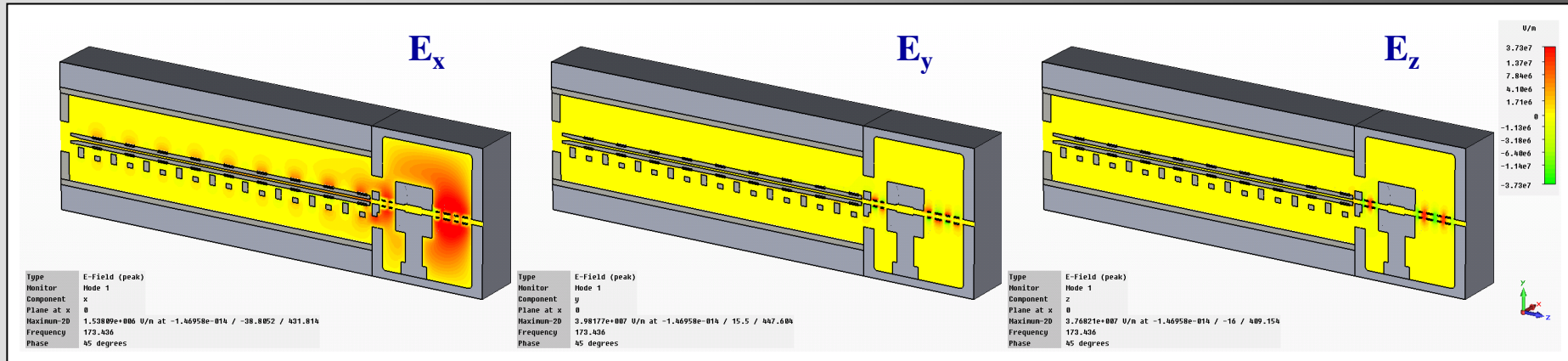
Max. Proton Current	200 mA
Exp. Power Consumption IH	54 kW
IH ϵ (out, norm. rms)	0.95π mm mrad



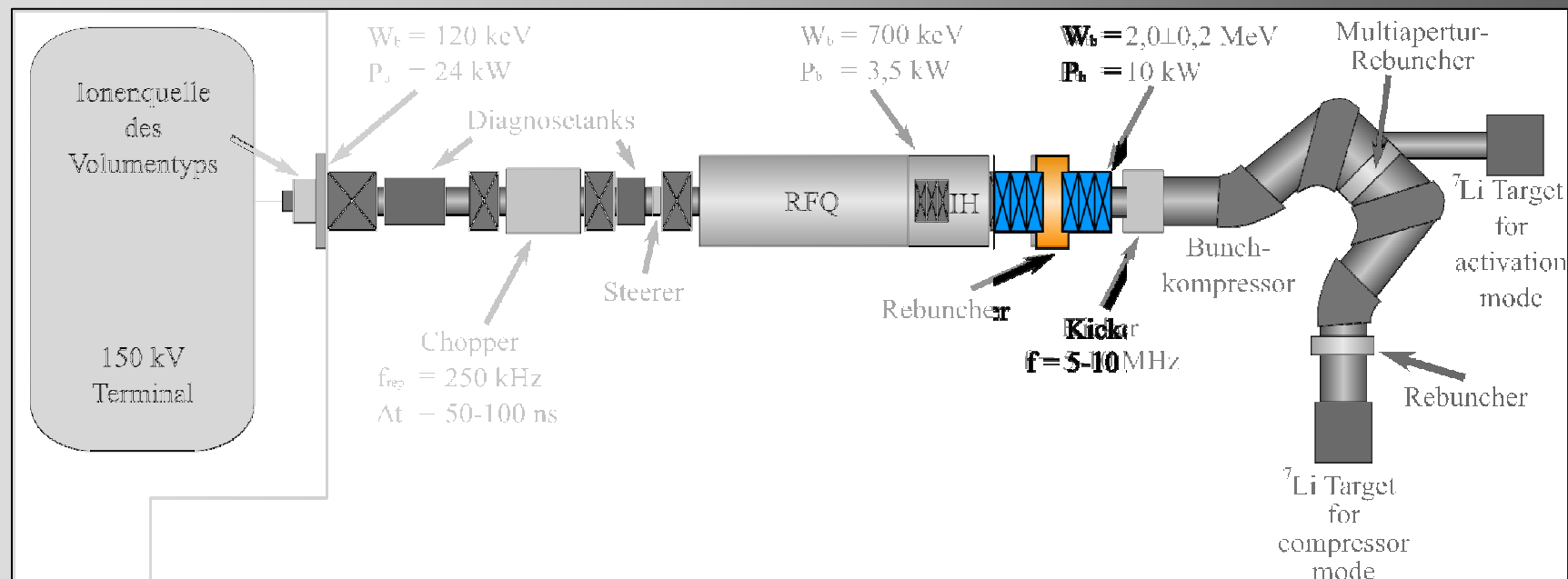
IH - Cavity E-Field Distribution



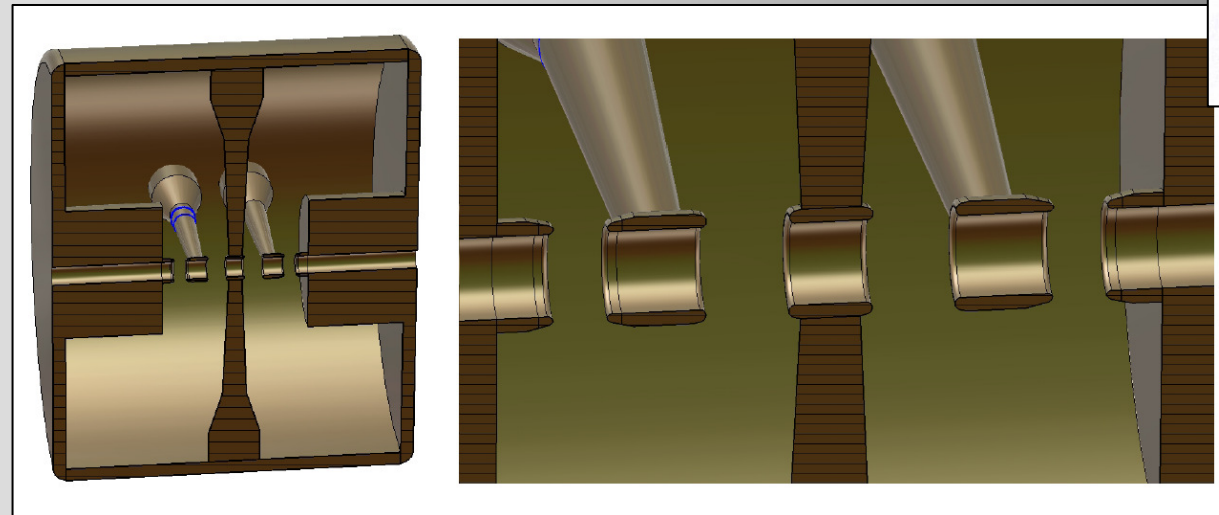
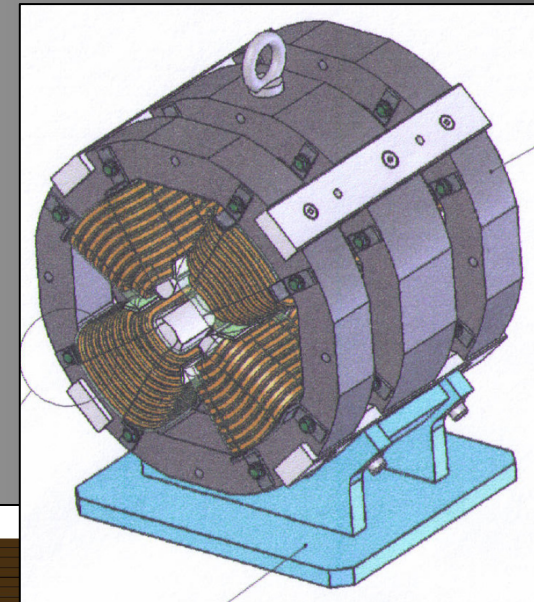
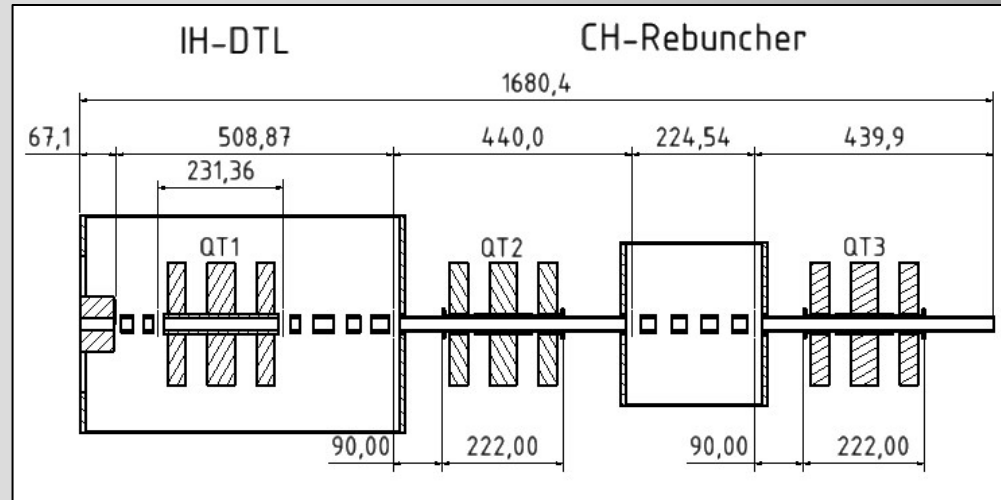
Coupled RFQ-IH Cavities



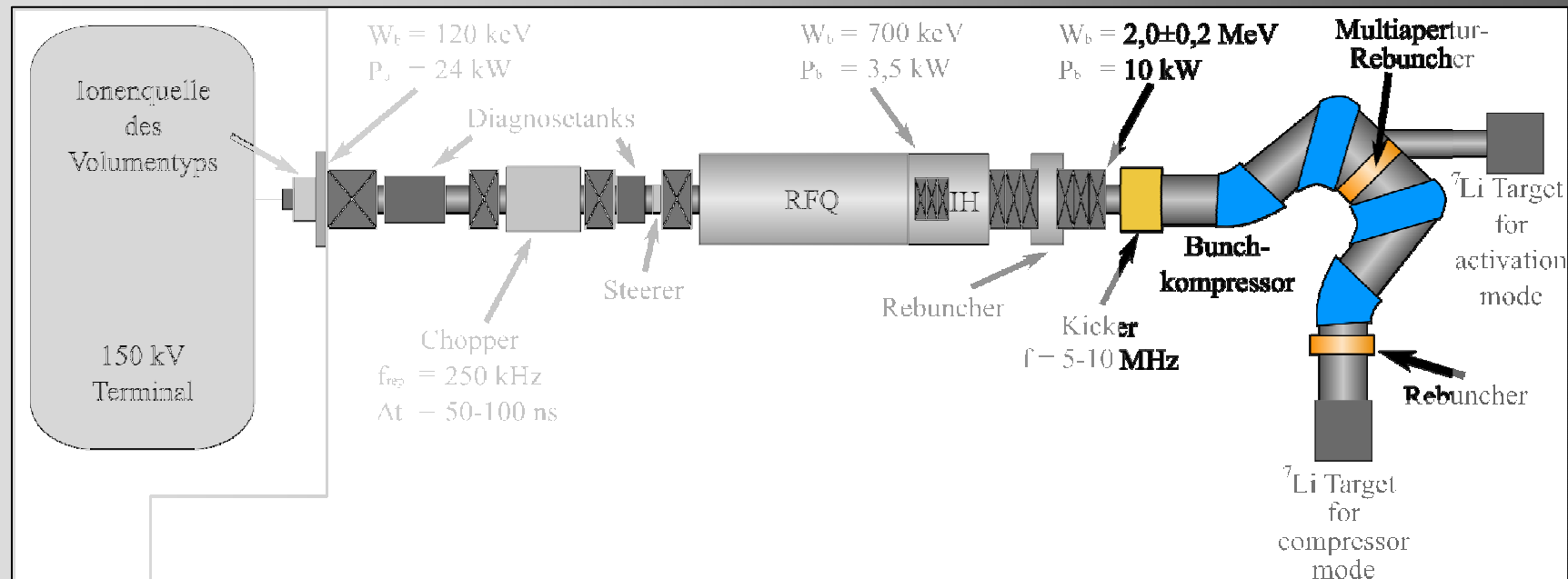
Medium Energy Beam Transport



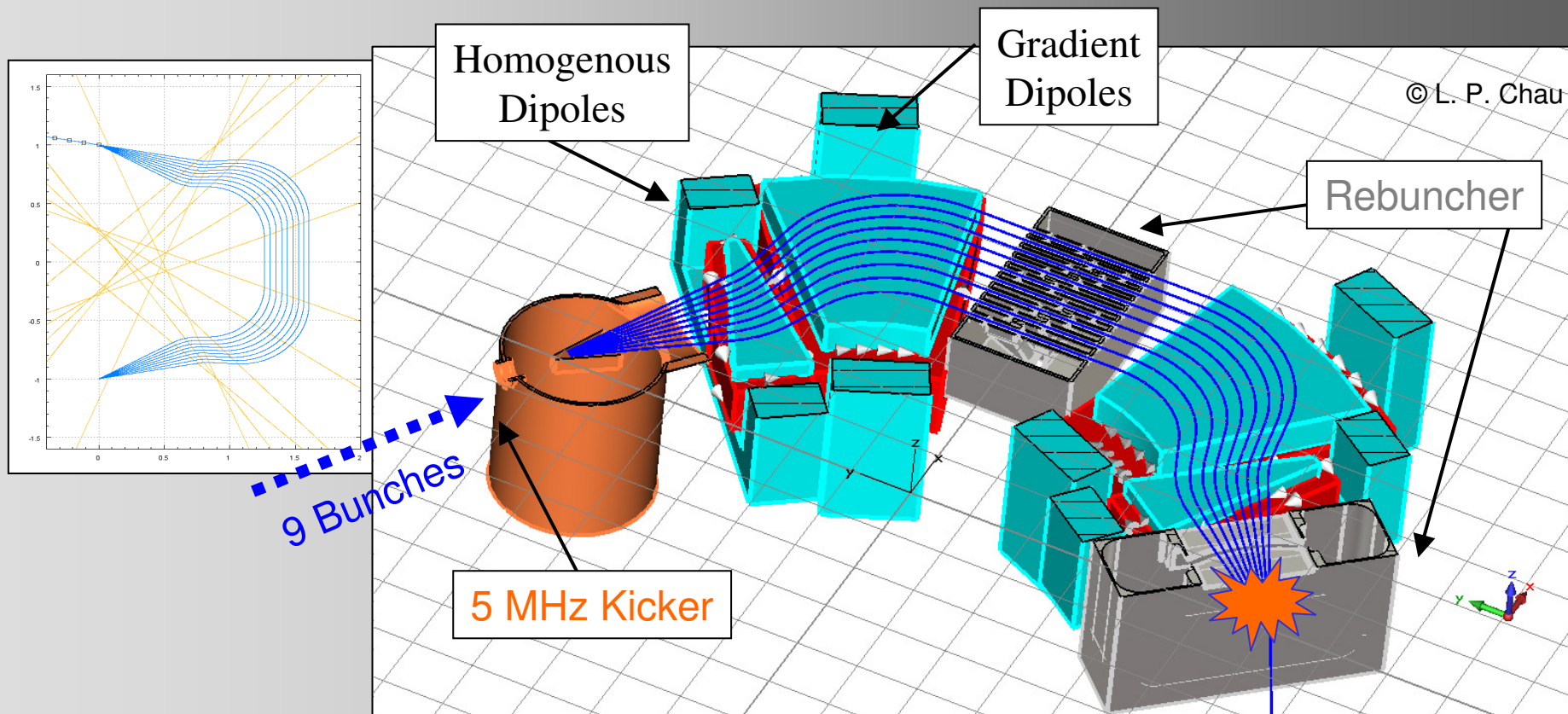
CH - Rebuncher Cavity



Bunch Compressor



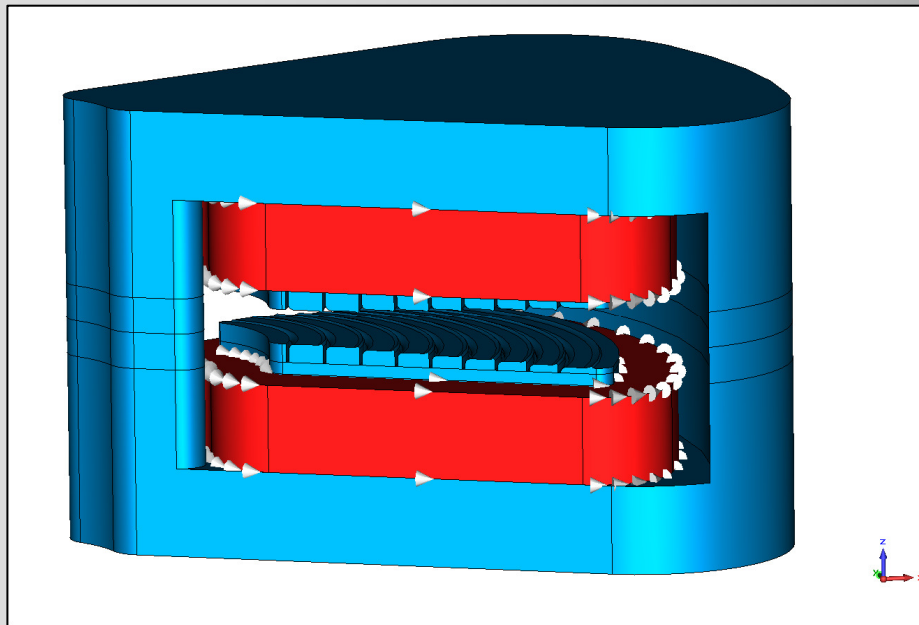
Towards Compression Ratio of $\eta = 48$



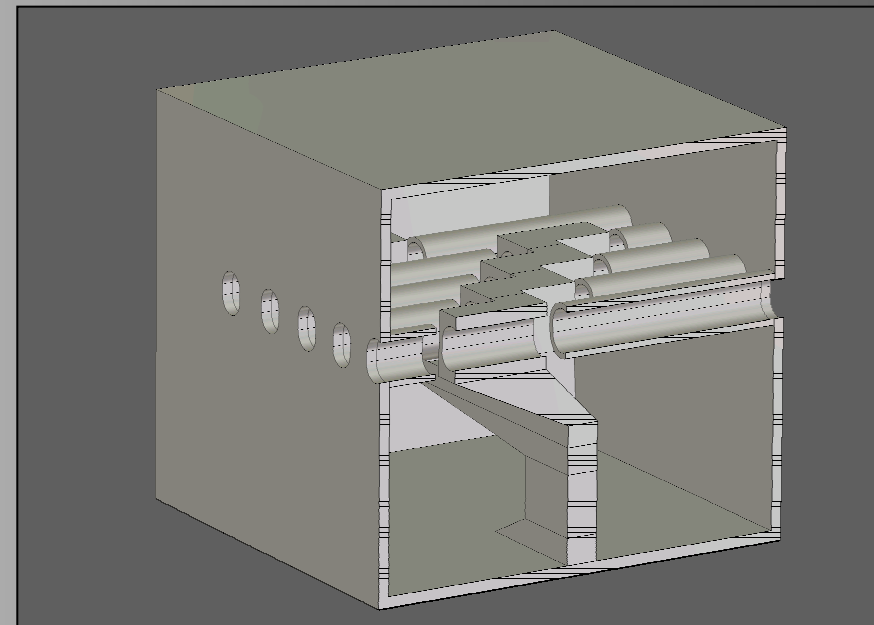
Single 1 ns Pulse
at Li-Target

Design Study of Multi Track Devices

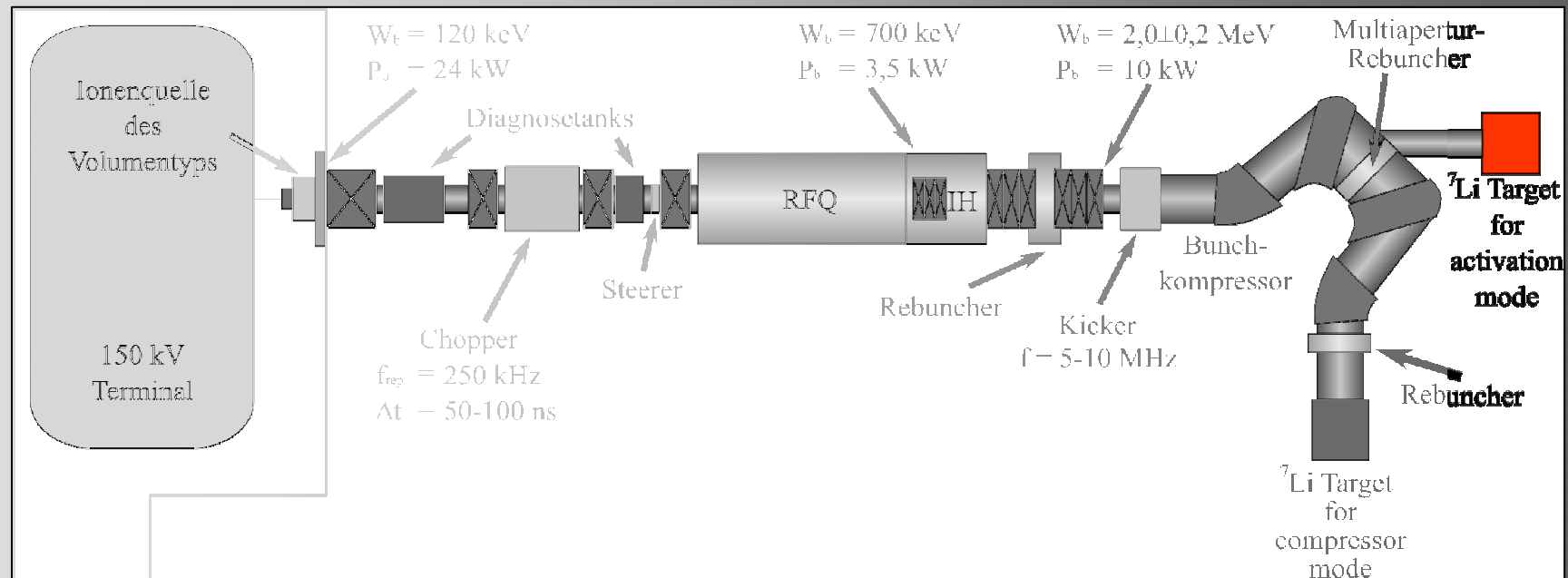
Duplex Gradient Dipole



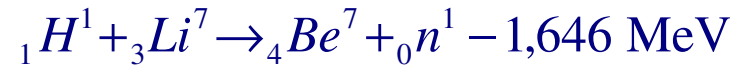
Syrinx Rebuncher



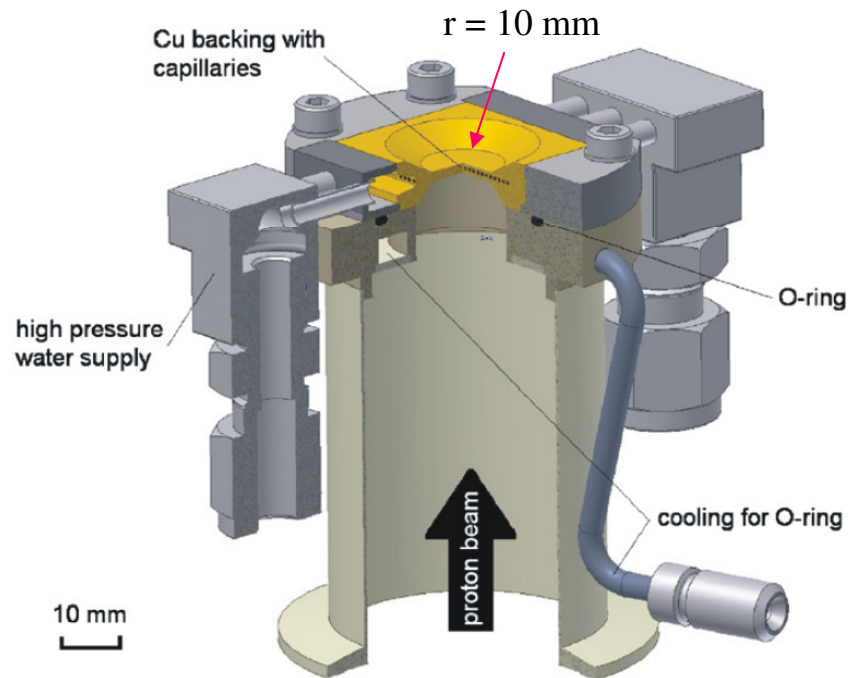
Activation Branch



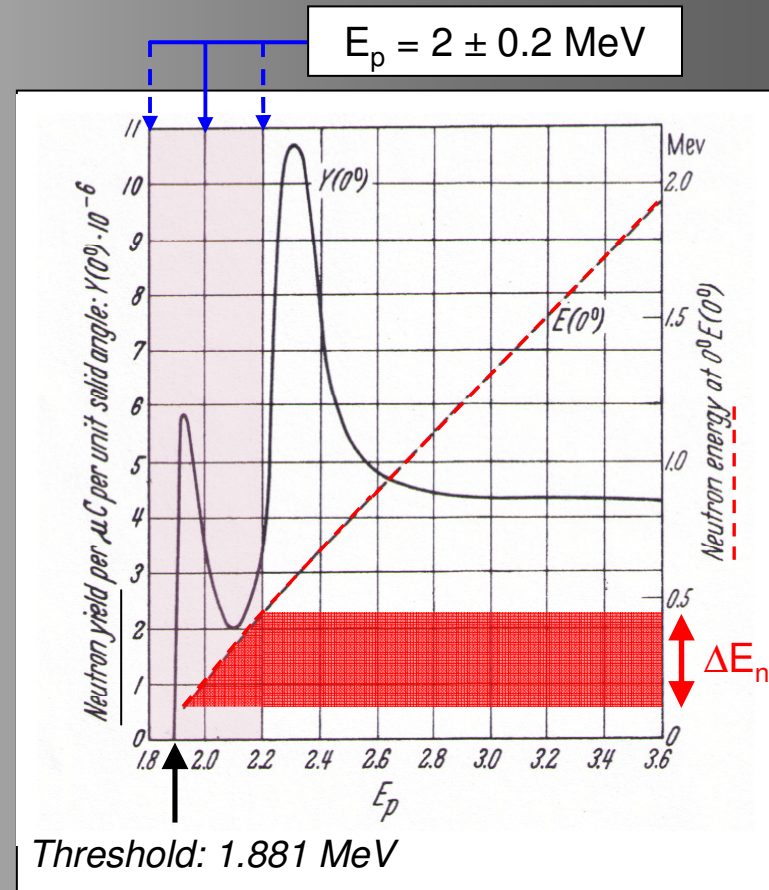
High Power Target



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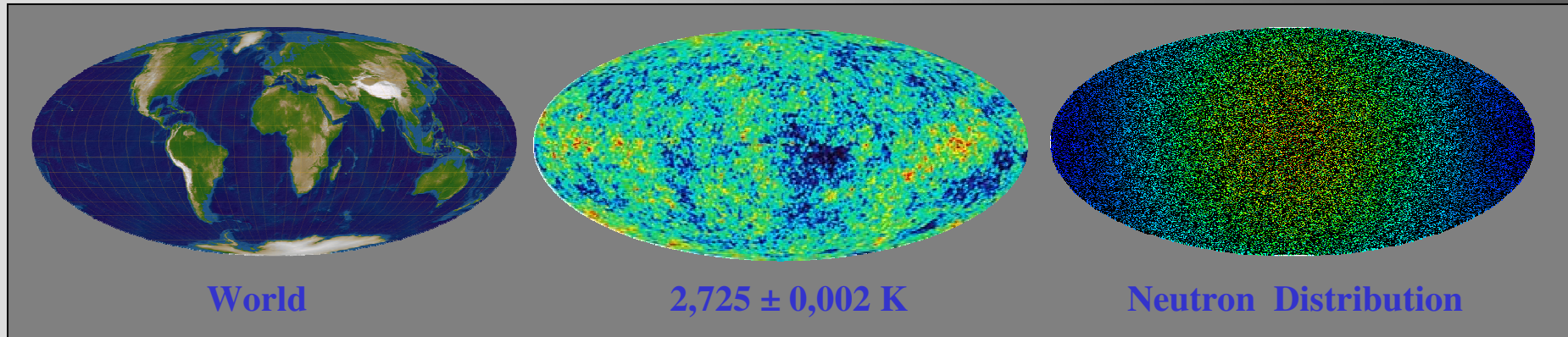
Target prototype development at Karlsruhe for beam power up to 6 kW.



Neutron yield and maximum neutron energy in forward direction (0°).

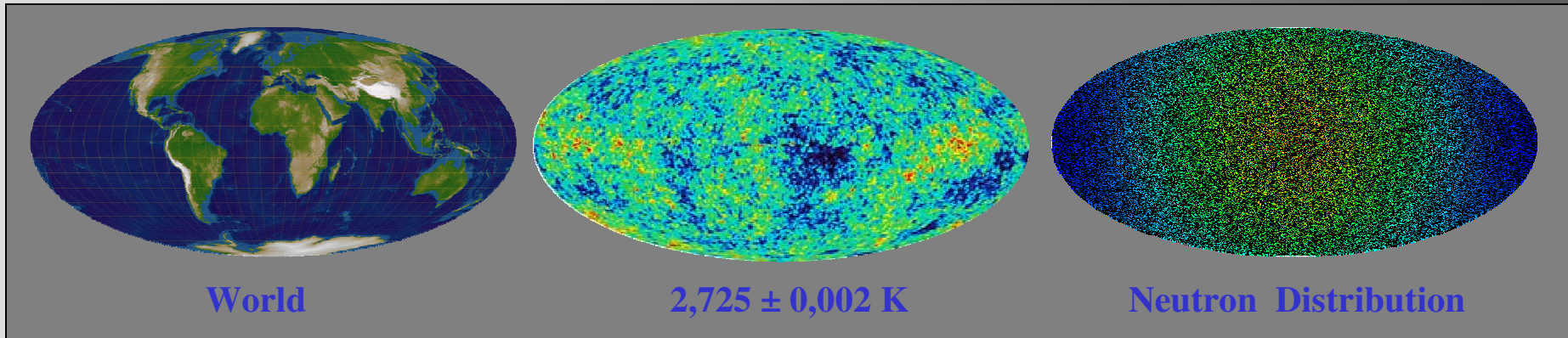
Neutron Dynamics

examples for Mollweide projection

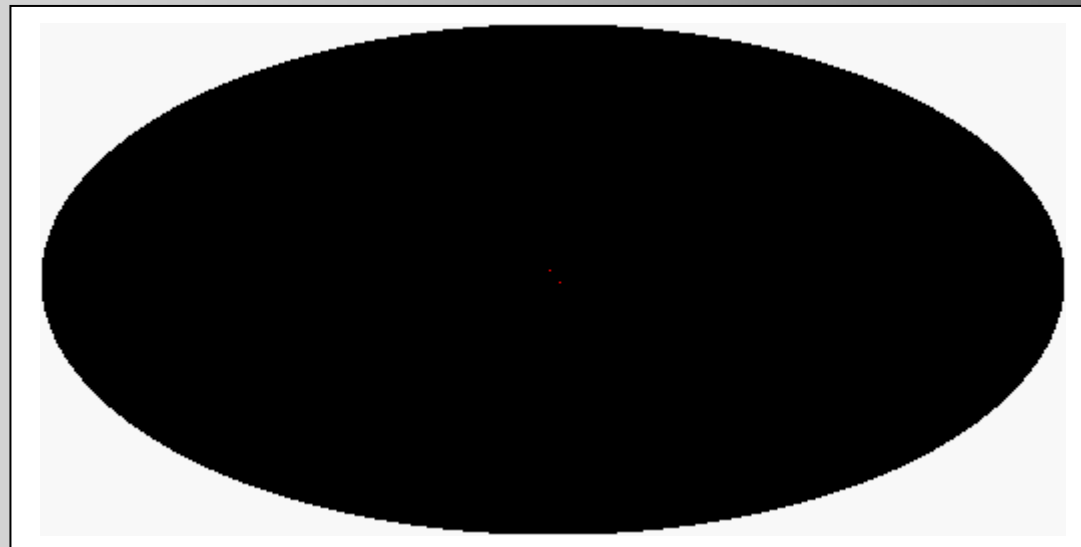


Neutron Dynamics

examples for Mollweide projection

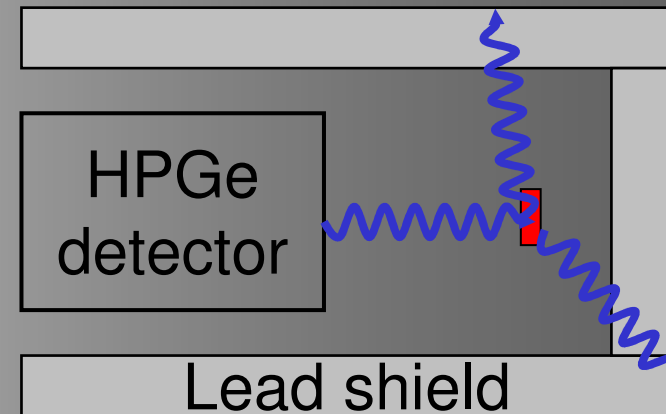
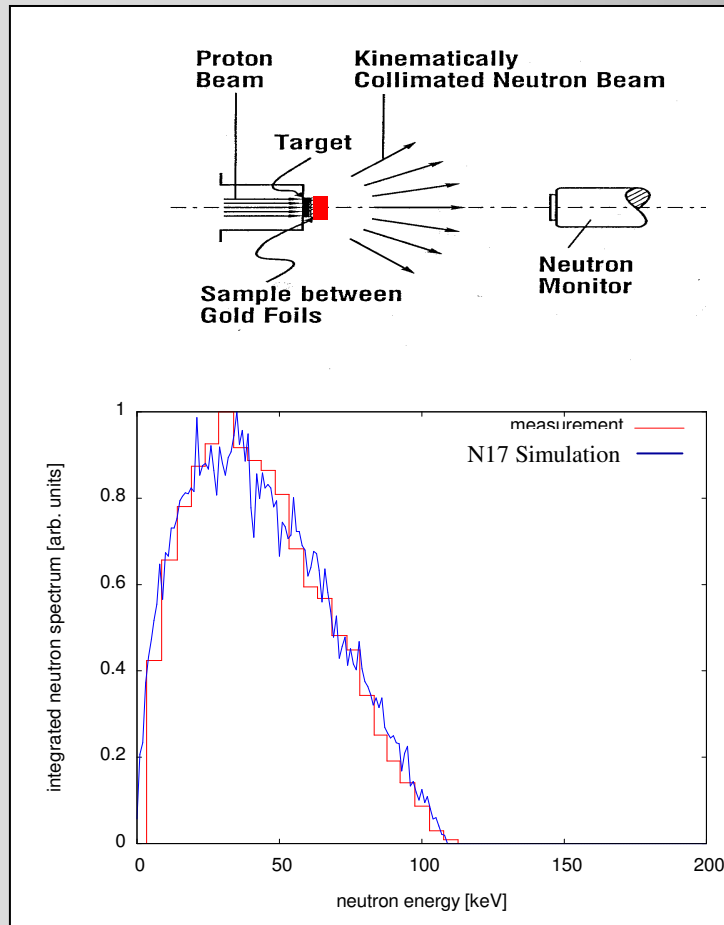


Neutron energy
distribution as a
function of E_p



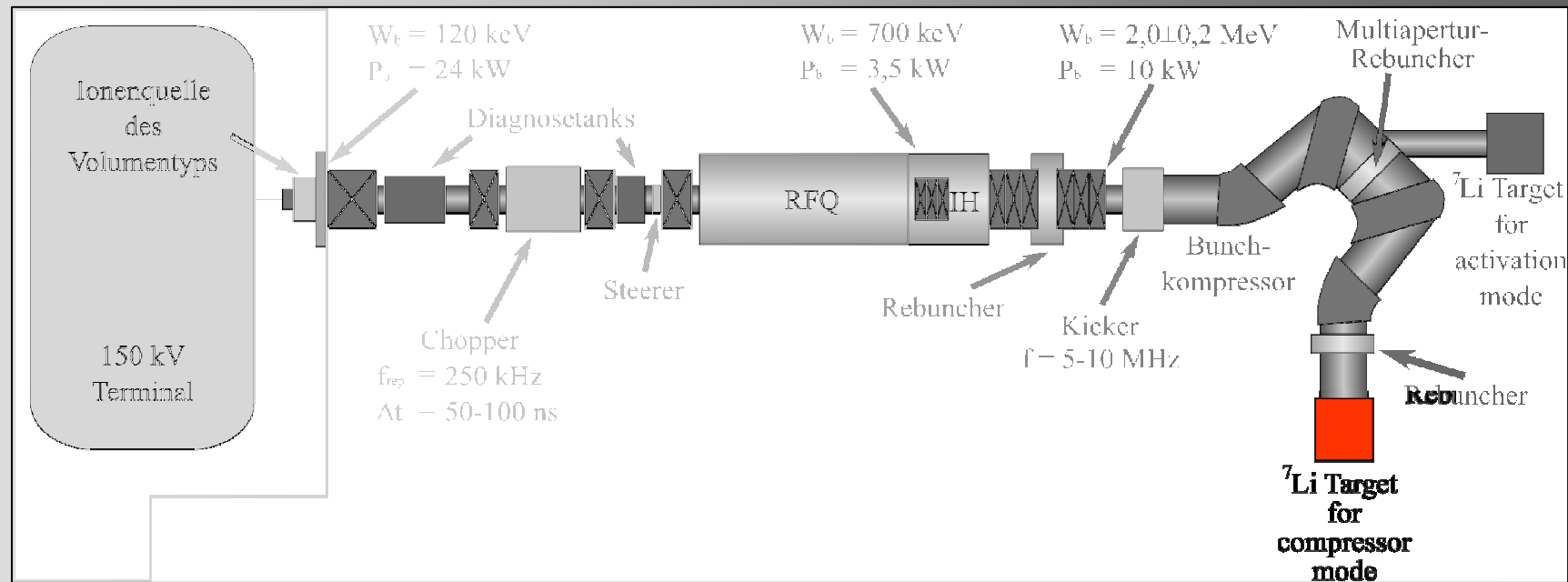
Experiments

neutron capture reaction



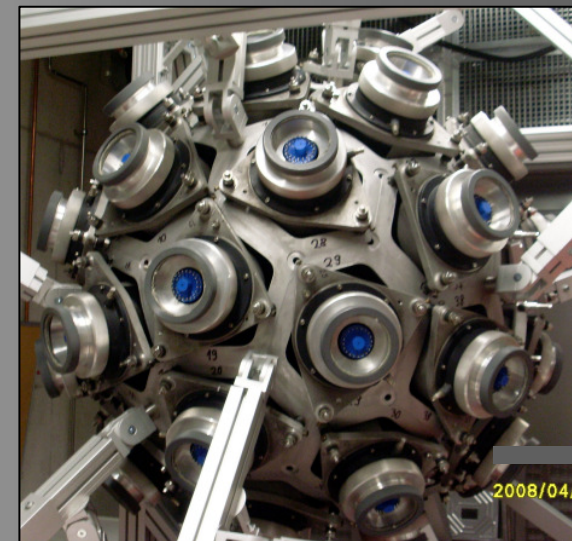
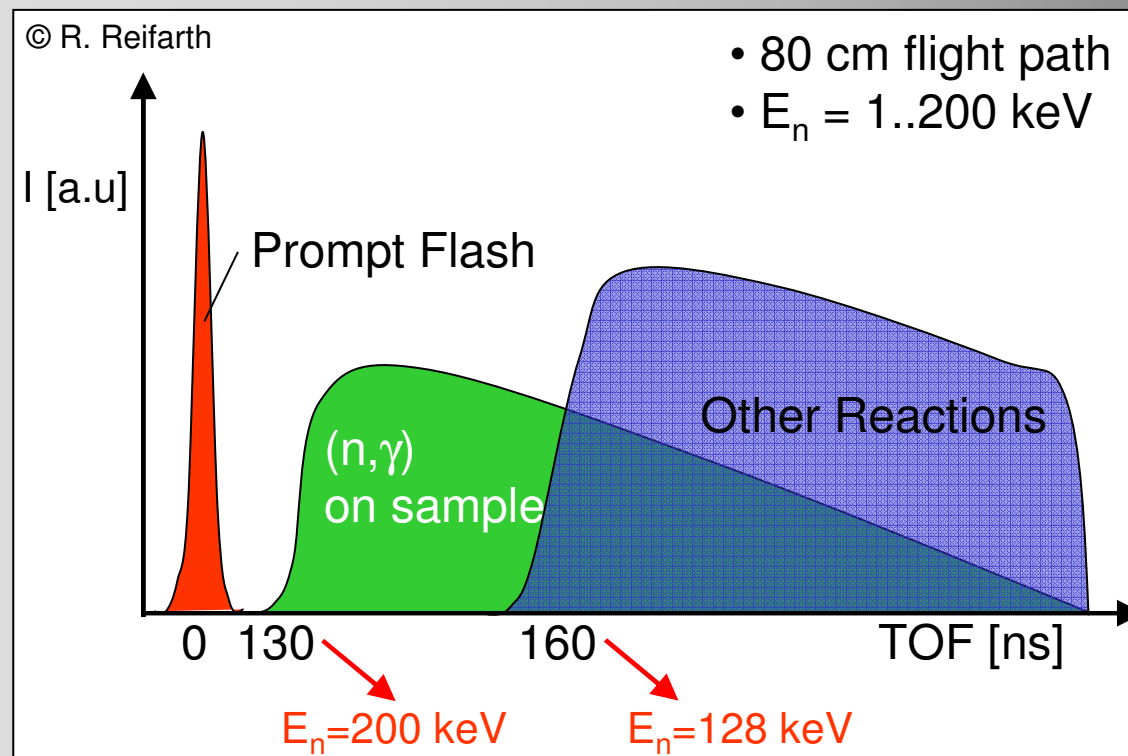
measurement of neutron
induced activity

Compressor Branch



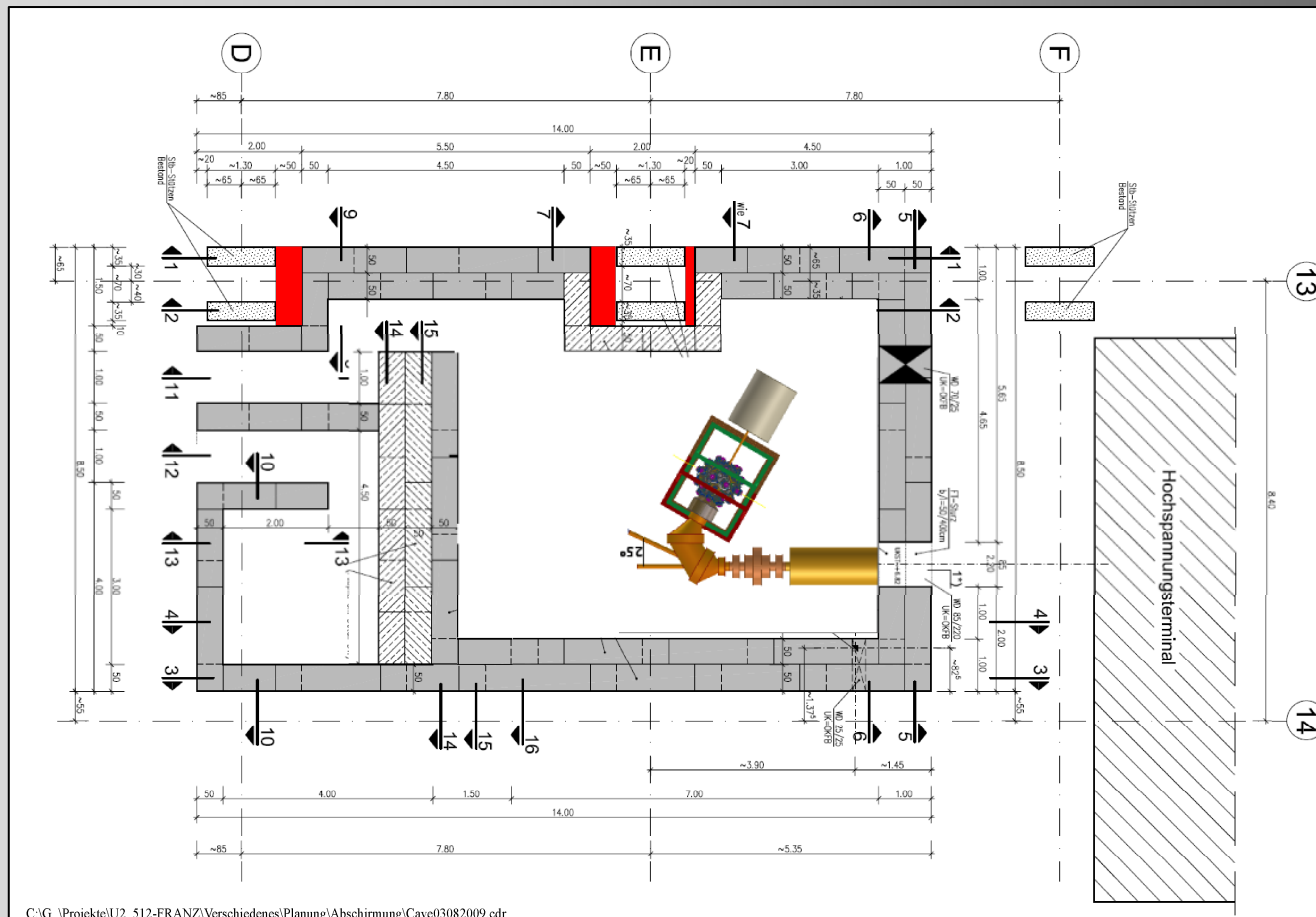
Compressor Mode

- Measurement of differential cross sections of small amounts of (radioactive) samples (advanced fuel cycle, astrophysics)
- Determination of properties of resonances (spins and parities)
- Study of γ -decay - photon strength functions



4π BaF₂- detector after transfer from Karlsruhe to Frankfurt.

Shielding



floor plan of FRANZ within the concrete shielding

Thank You!

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K. Stiebing, J. Stroth / *IKF, Goethe Universität Frankfurt*

F. Käppler, D. Petrich / *IKF, FZ Karlsruhe*

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