A Multi-Leaf Faraday Cup especially for proton therapy of ocular tumors

C. Kunert*, S. Seidel, J. Bundesmann, T. Damerow, A. Weber, A. Denker

*finished his PhD in Februrary 2015

Helmholtz-Zentrum Berlin, protons for therapy

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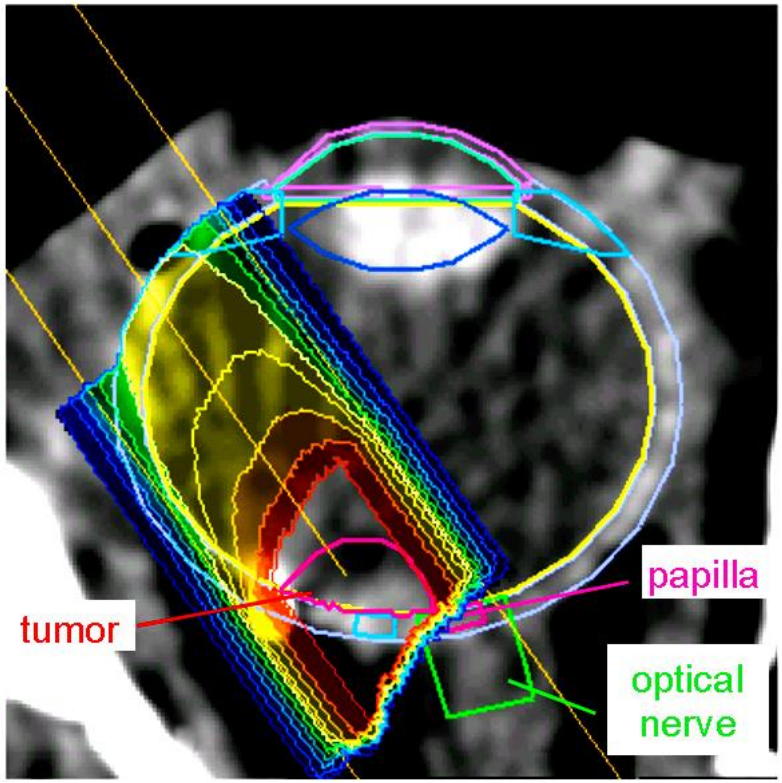
OVERVIEW

- Motivation
- Methods and Material
- Results
- Application
- Conclusion

MOTIVATION

- corporation between HZB and Charité Berlin
- treatment of uveal melanoma
- since 1998 over 2800 patients
- 96% tumor control after 5 years

- human eye: diameter of about 24 mm
- → very small and complex organ with several critical structures
- finite range needed

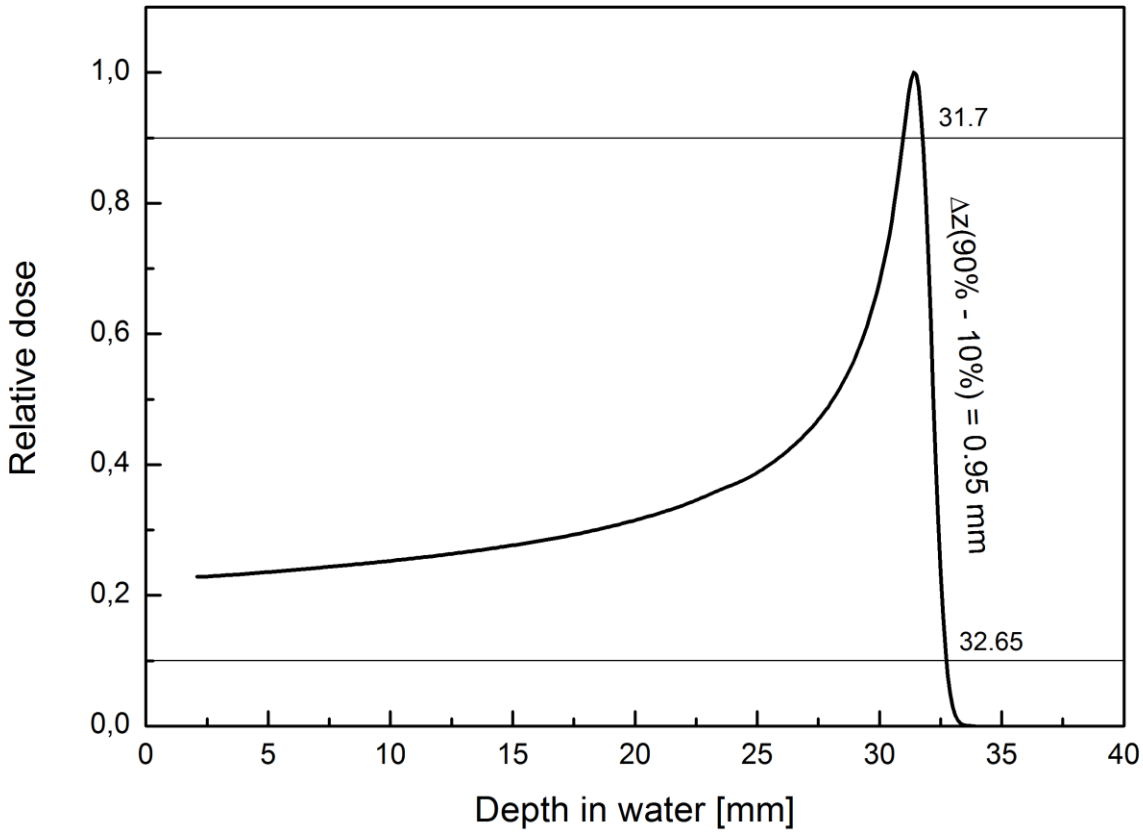


MOTIVATION

Protons for therapy

- finite range
- energy deposition at the end of Bragg Peak
- water as reference
- our Beam: 68 MeV, distal fall off (90/10)

< 1 mm in water



METHODS AND MATERIAL

- measurement in air
- measurement of full radiation field

- range measurement with resolution of 0.1 mm water or better

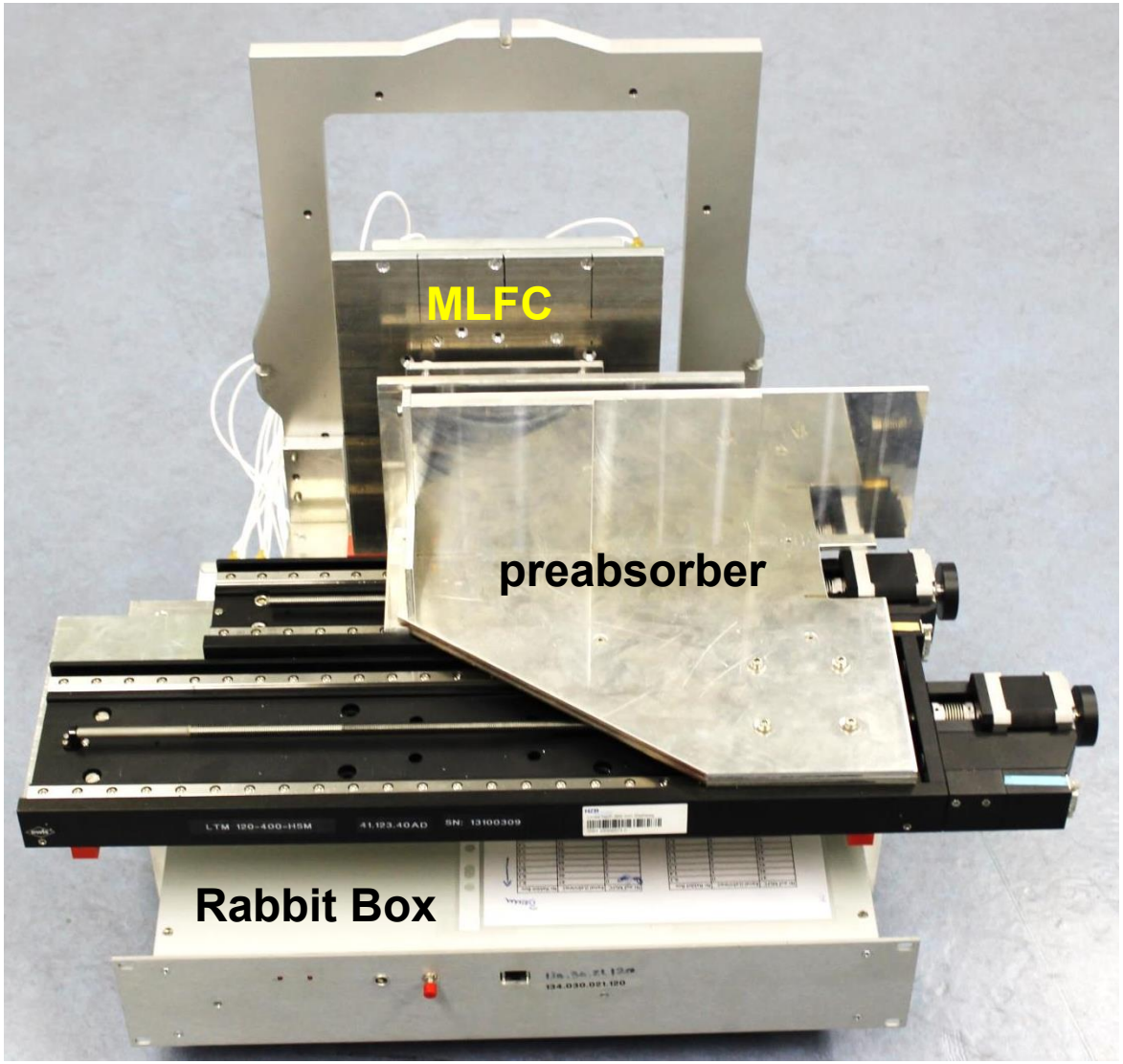
→ **10 µm** Copper foil corresponds to approx. **50 µm** water

→ **25 µm** Kapton foil corresponds to approx. **32 µm** water

- 6.75 mm copper = 675 foils needed to dump full beam
- our MLFC: 47 copper foils

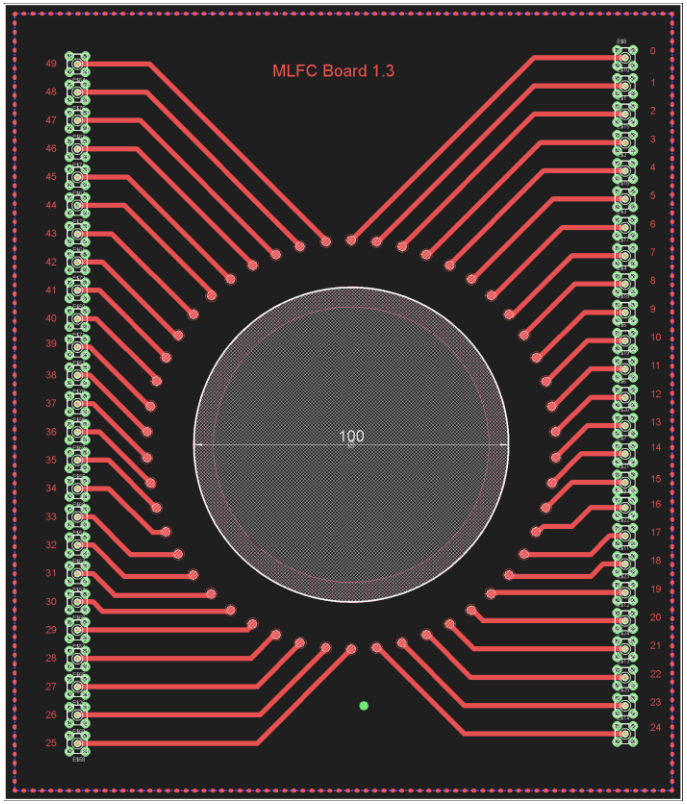
METHODS AND MATERIAL

- **MLFC**



METHODS AND MATERIAL

- copper foils with diameter of 10 cm to cover whole radiation field
- connection via 50 Ω impedance to a SMA connector
- connection to Rabbit Box with special double shielded low noise cables

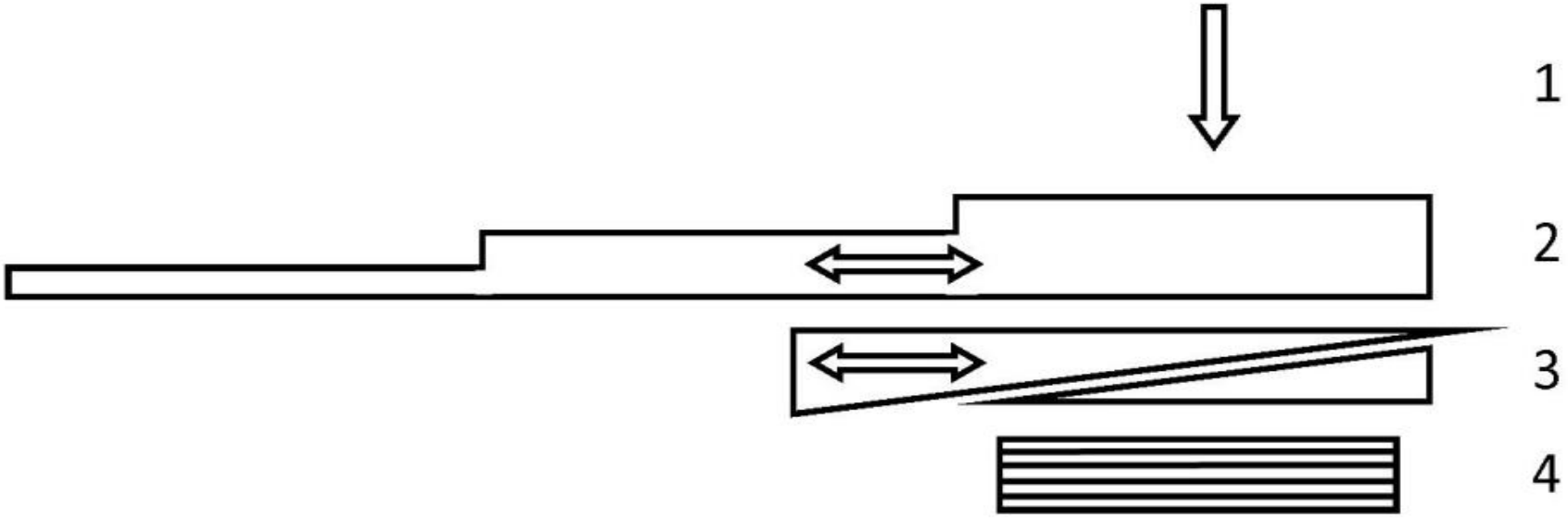


Thanks to iThemba Labs!

NRF National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

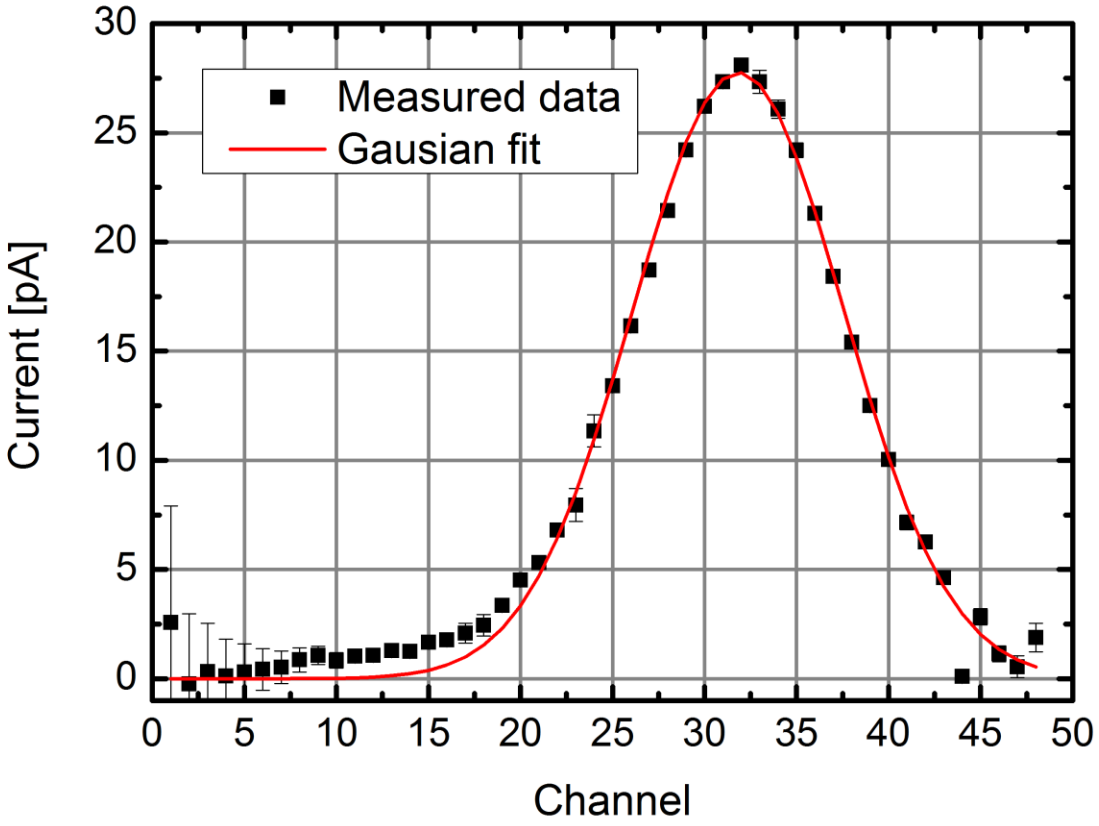
METHODS AND MATERIAL

- preabsorber to degrade the beam
- energy range between 30 MeV and 70 MeV
- combination of stair and double wedge
- stair with 4 steps (0 – 12 mm aluminium)
- double wedge for fine adjustment (3 – 6 mm aluminium)
- program to automatically find the right position



RESULTS

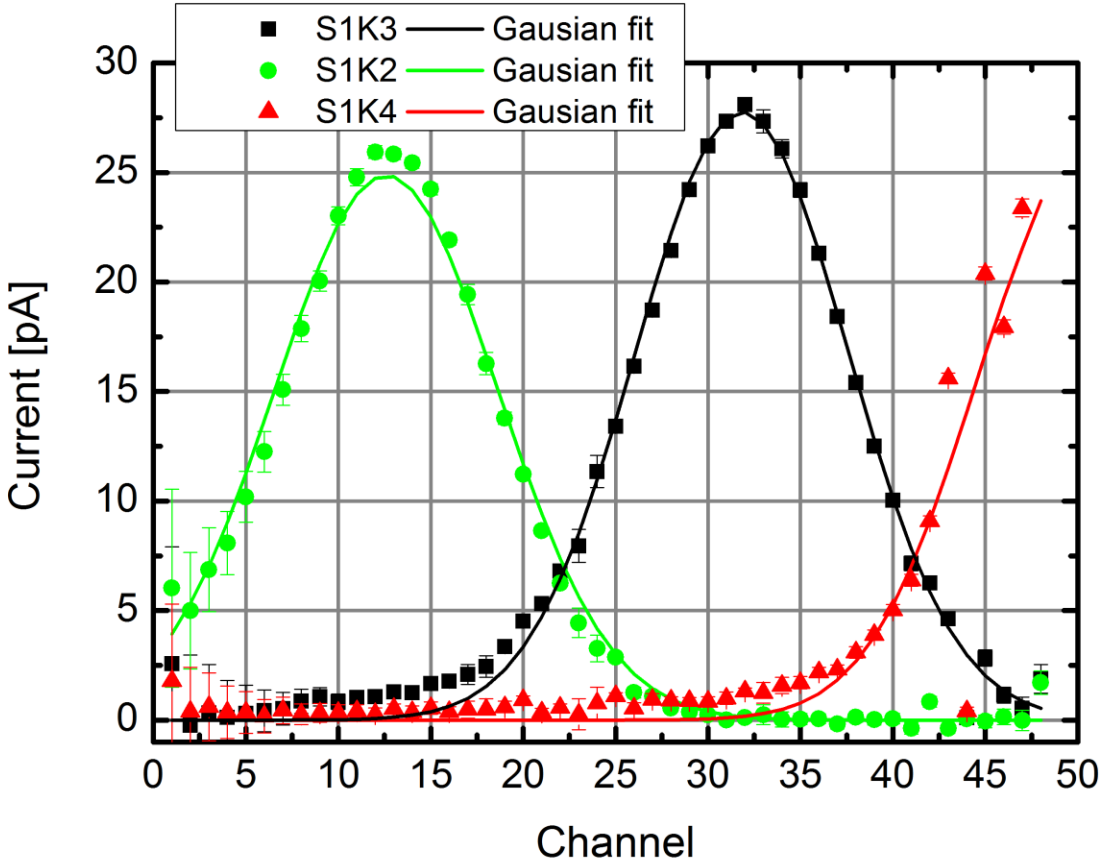
- typical measurement
- preabsorber 16.68 mm aluminium
- current 500 pA
- almost Gaussian shaped curve
- Gaussian fit to determine center and sigma
- energy of 67.6 MeV



Results of Gausian fit	
Center	31,8 ± 0,3 Channels
Sigma	5,8 ± 0,3 Channels

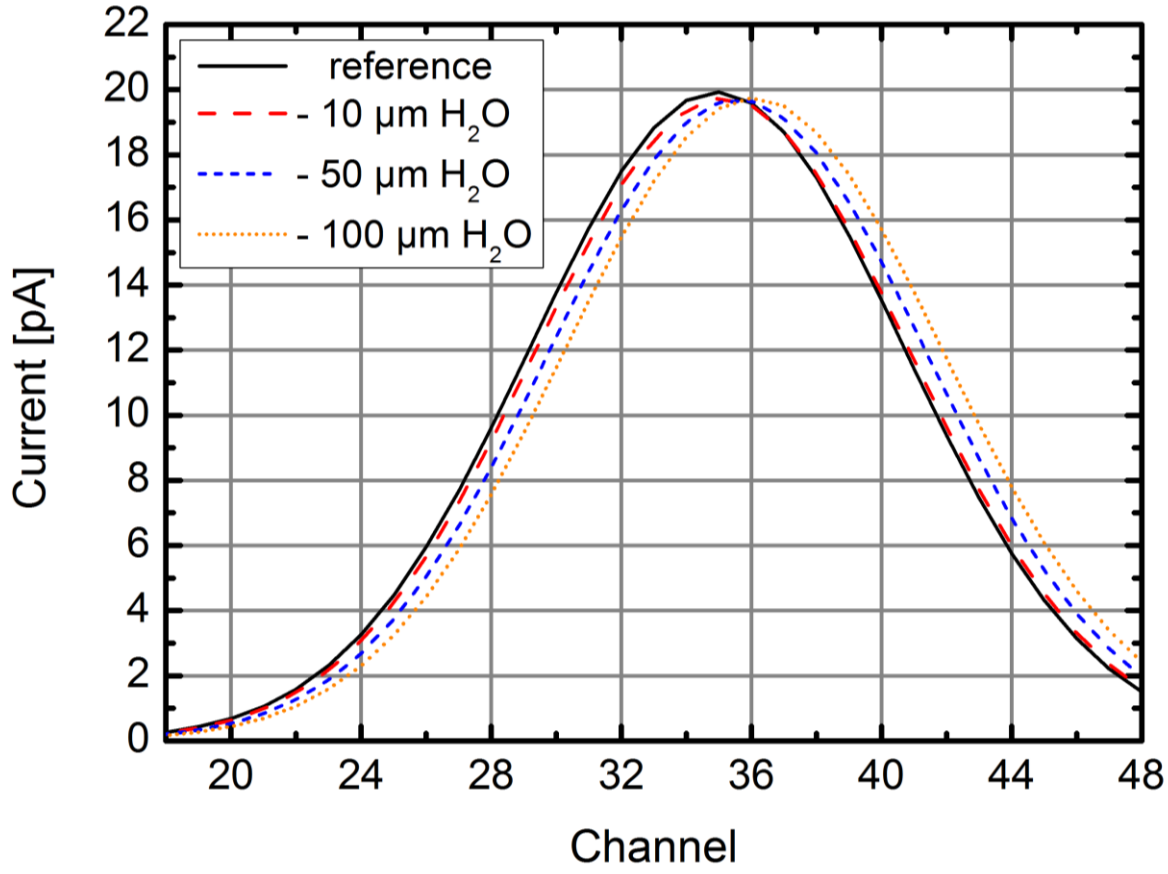
RESULTS

- measurement with different preabsorber positions
- same initial energy



RESULTS

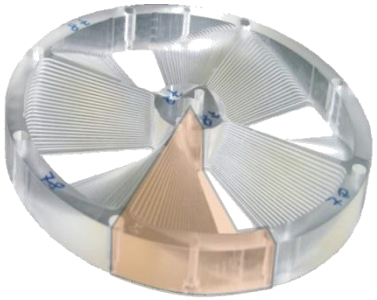
- range shift of 10 µm water equivalent possbile
- difference above 50 µm clearly visible
- resolution with 50 µm twice as good as required

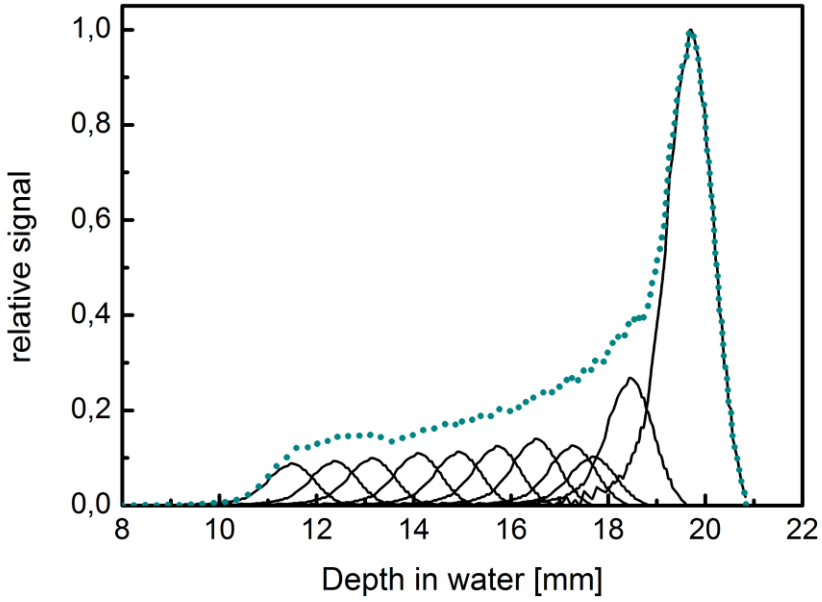


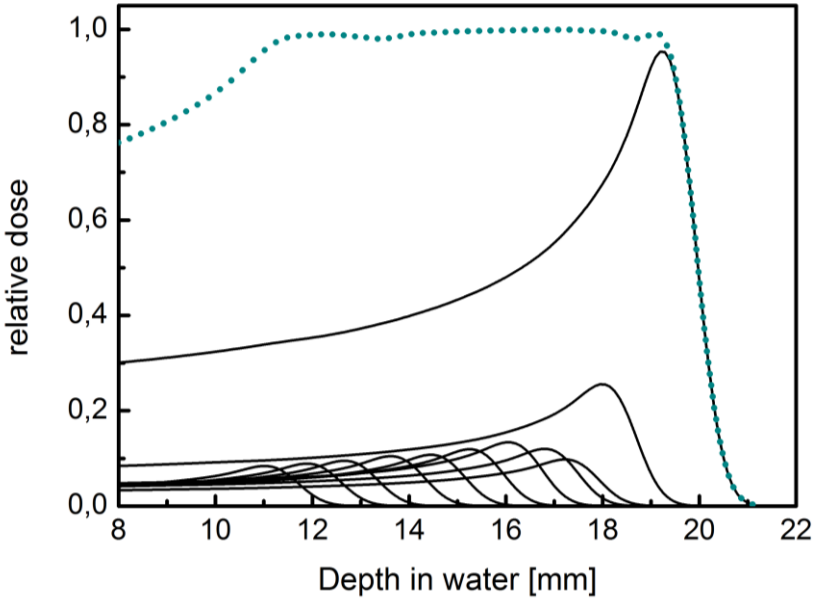
APPLICATION

Measurement of Spread Out Bragg Peak (SOBP)

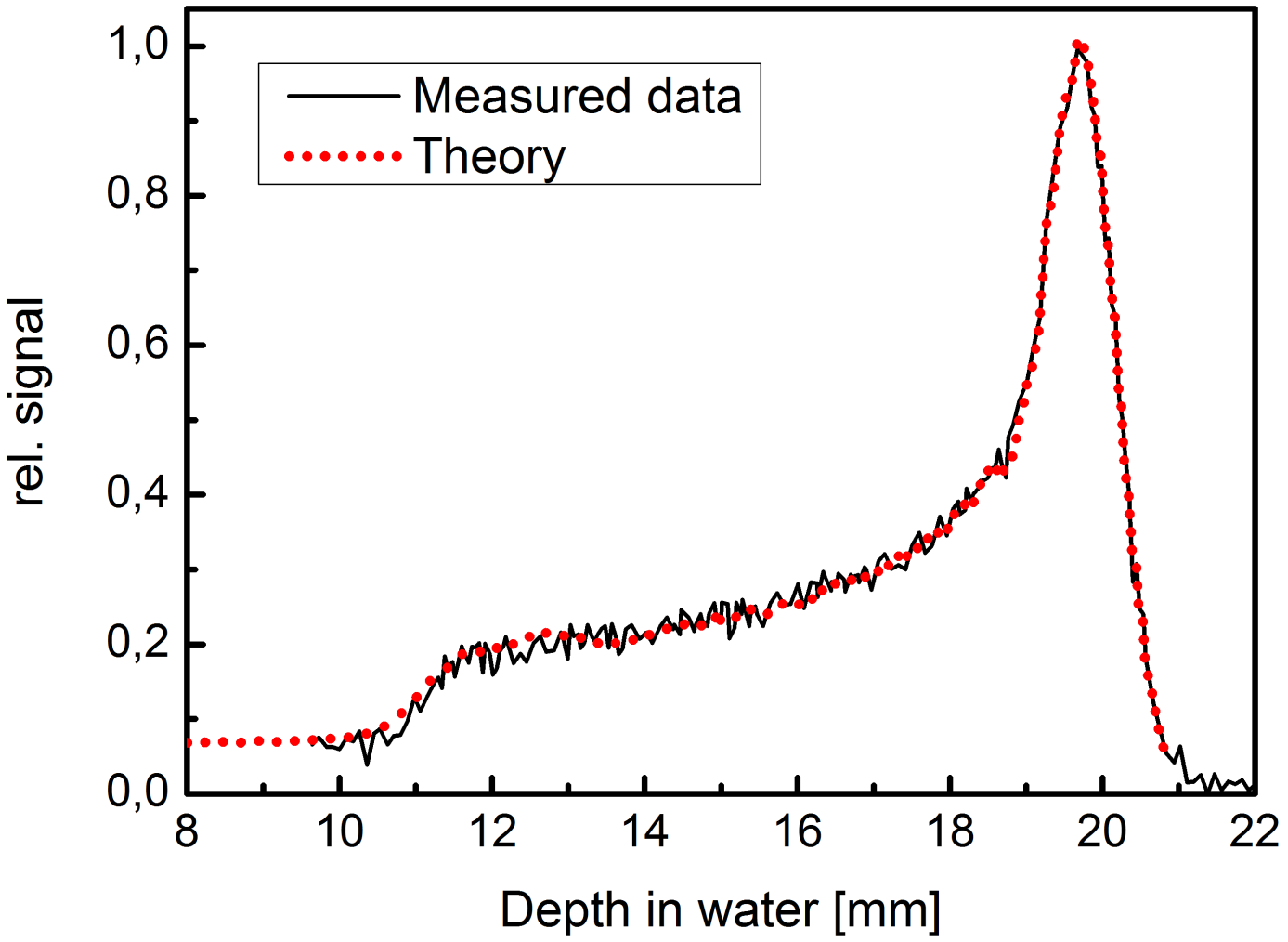
- SOBP typical for proton therapy
- use of modulation wheel
- superposition of single Bragg Peaks with different ranges





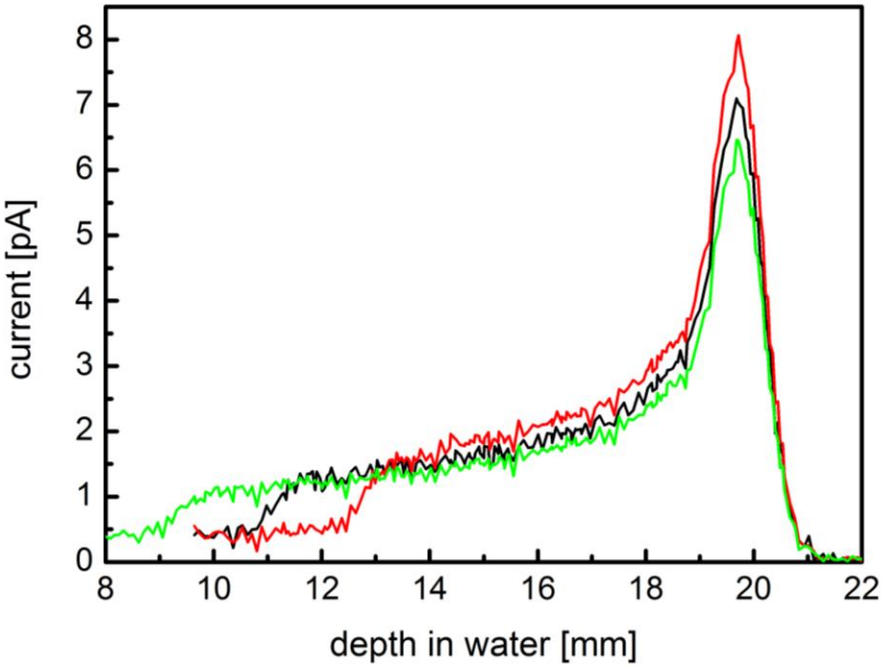


APPLICATION

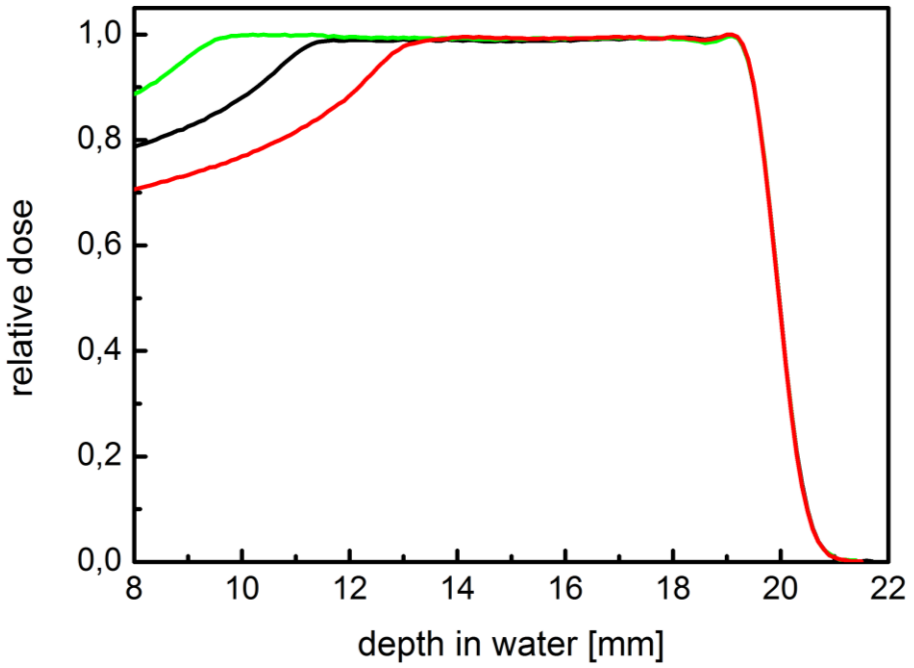


APPLICATION

different modulation



measurement with MLFC
(less than 3 minutes)

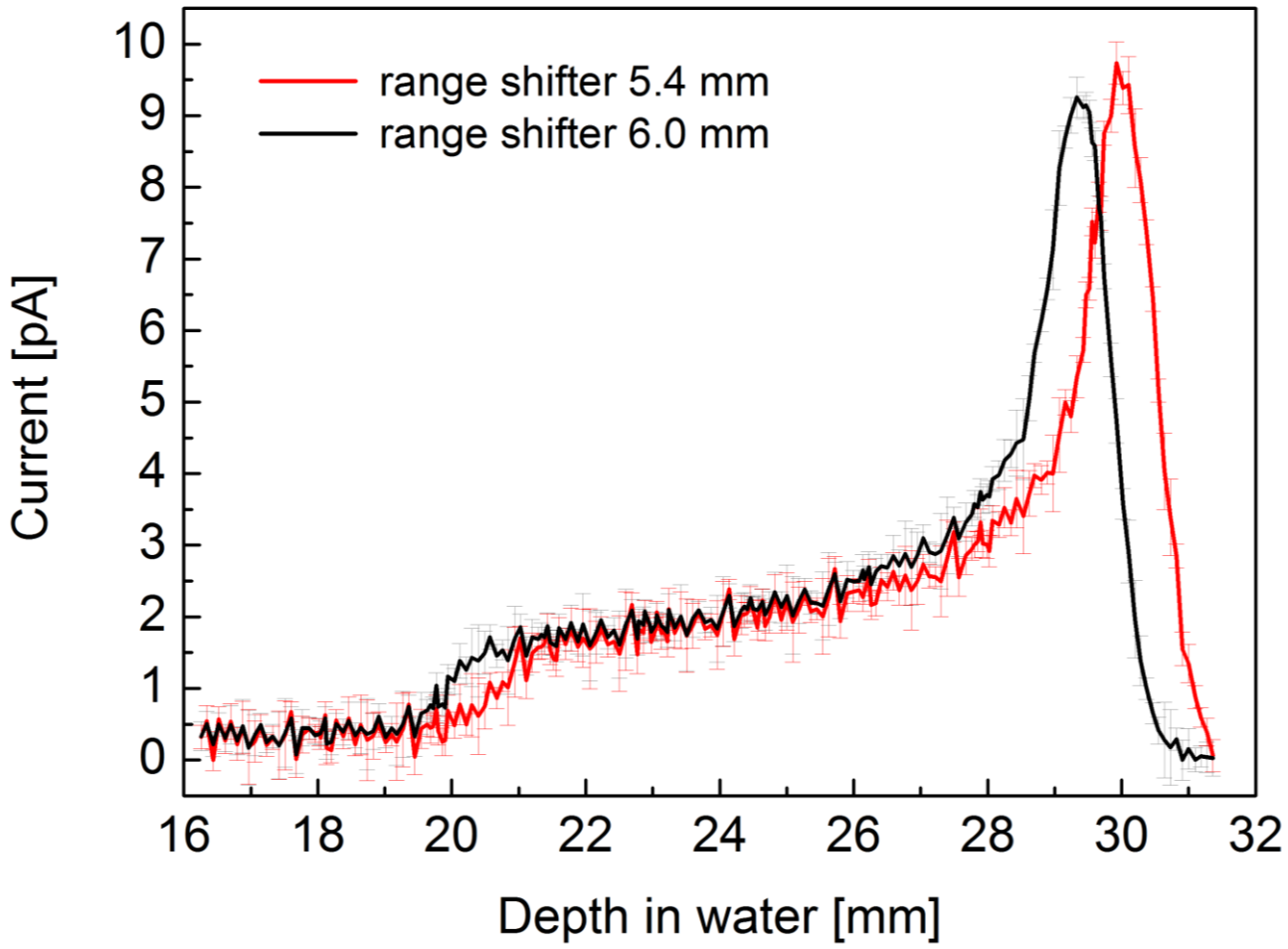


measurement with water phantom
(15 minutes)

APPLICATION

different range

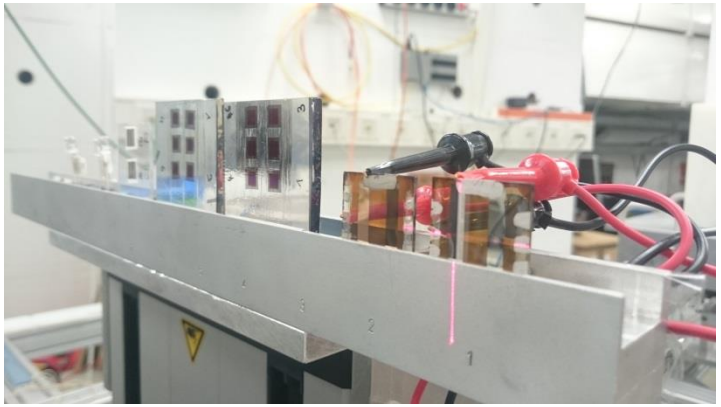
- verification of proton range for patient treatment



APPLICATION

Energy verification for radiation hardness tests

- different energies are needed
  → degradation with different thicknesses of aluminium as preabsorber
- thickness calculated with SRIM
- verification of calculation with MLFC



requested energy	energy with SRIM*	energy with lookup**	measured energy
30 MeV	30,7 MeV	30,9 MeV	31,0 MeV
50 MeV	49,3 MeV	49,3 MeV	49,3 MeV
68 MeV	67,7 MeV	67,7 MeV	67,6 MeV

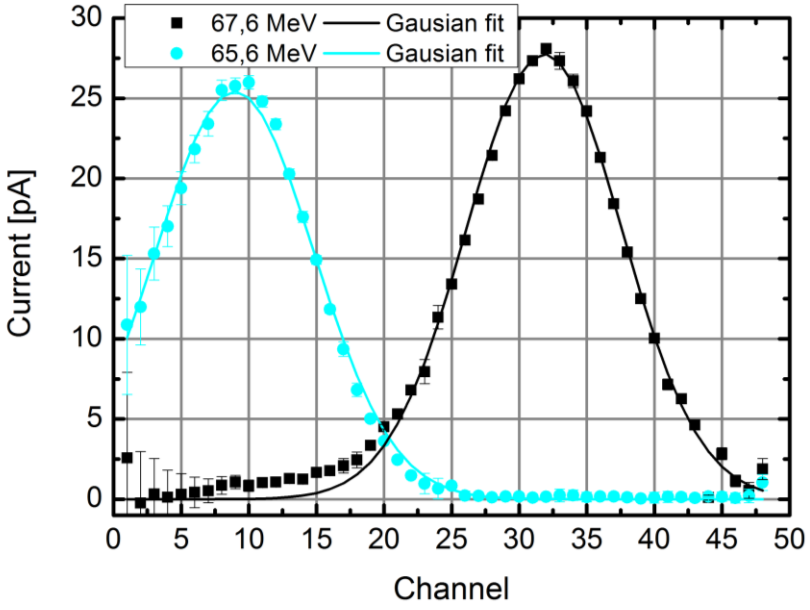
CONCLUSION

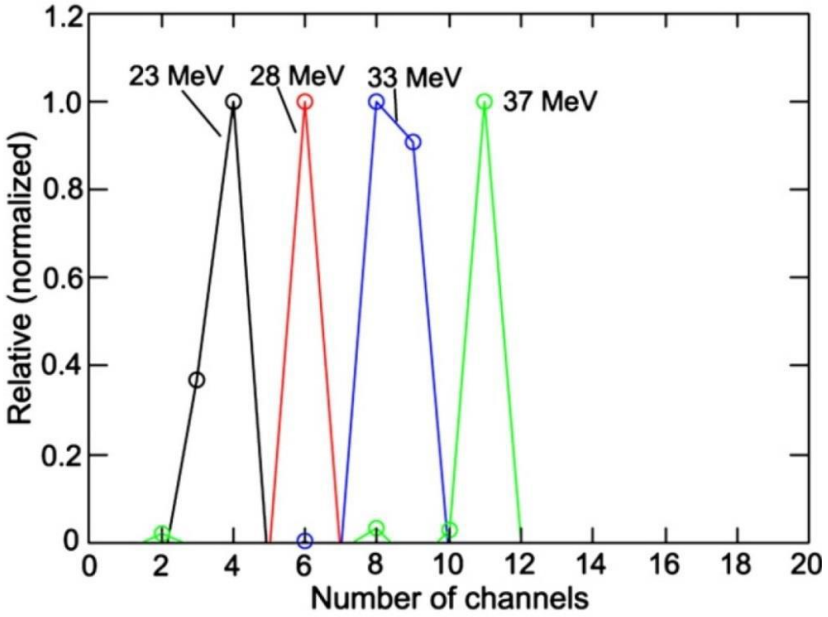
- measurement of energy (in the range of 30 MeV – 70 MeV) at the target position without changing the beam line
- resolution of 0.1 mm range in water
- energy resolution of 0.1 MeV
- relative range resolution of 0.05 mm in water
- verification of range and modulation in tumor therapy possible
- verification of requested energies for radiation hardness tests possible

THANK YOU FOR YOUR ATTENTION !!

RESULTS

- Comparison to the MLFC of the National Cancer Center in Corea (treatment of deep-seated tumors)



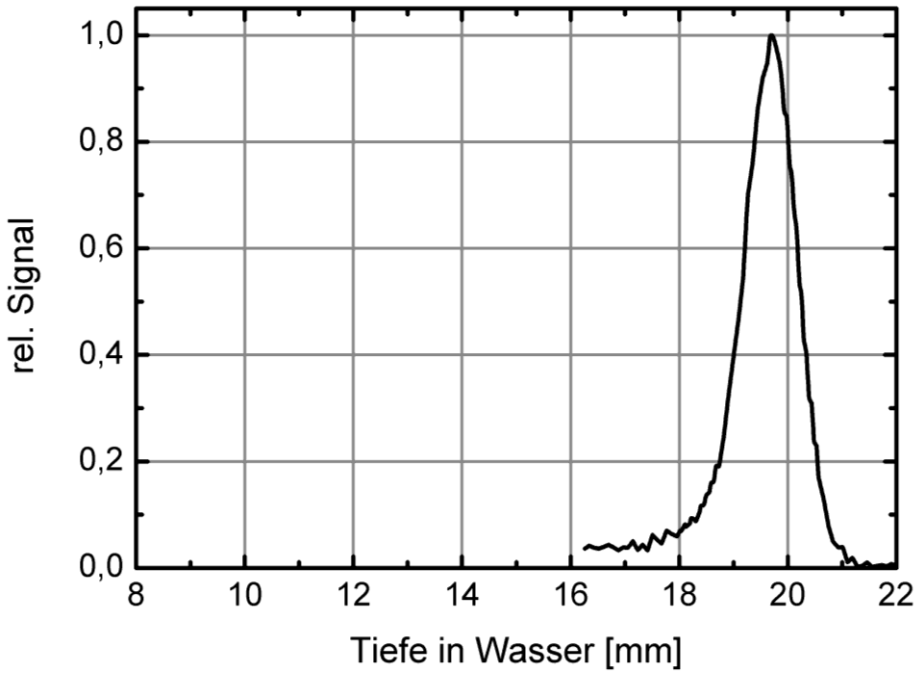


- 47 copper foils
- thickness of 10 µm
- energy resolution of 0.1 MeV
- range resoultion below 0.1 mm in water

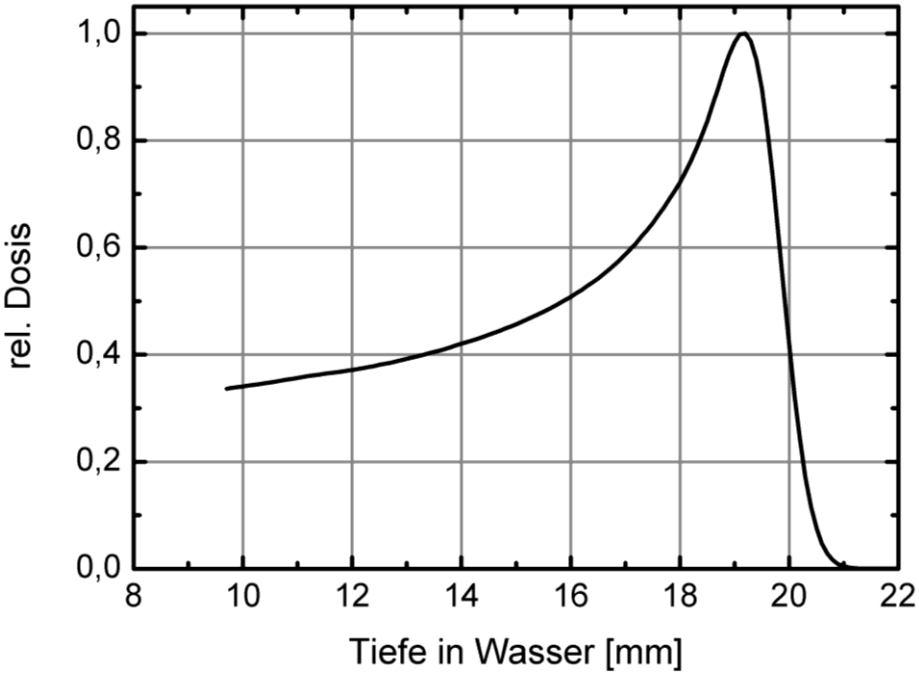
- 30 aluminium disks
- thickness of 0.5 mm
- energy resolution of 2.5 MeV
- range resoultion of approx. 0.8 mm in water

APPLICATION

Monoenergetic proton beam



MLFC



water phantom

MLFC

Software

- **programed in LabVIEW**
- **Controling the preabsorber system and finding the correct position**
- **Presentation and saving of the data including subtraction of underground**
- **Aquiring and processing of data in terms of channel number, energy or range (water or silicium)**