Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

FRPT
FLASH RADIOTHERAPY & PARTICLE THERAPY 2021

Multi-leaf Faraday cup for quality assurance in radiation therapy with electron and ion beams at conventional and ultra-high dose rate

UHDpulse

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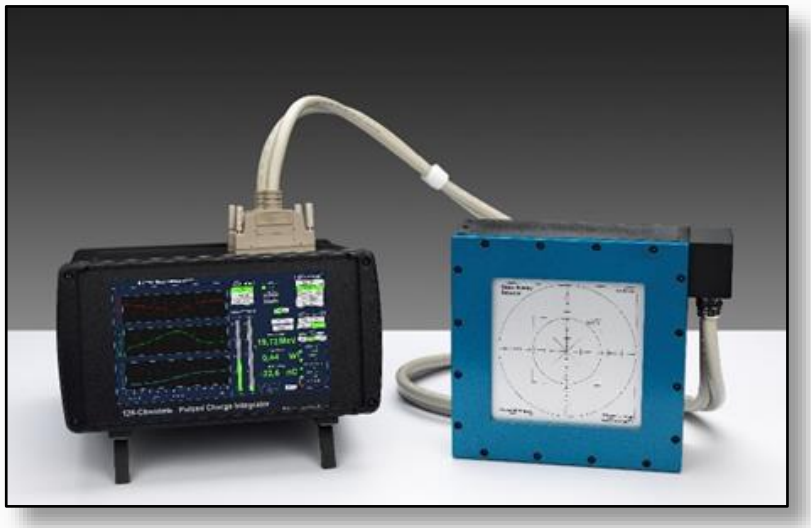
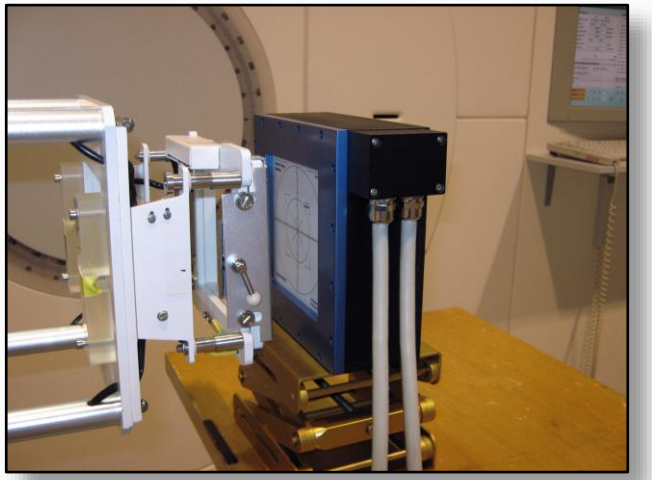
CONFLICT OF INTEREST DISCLOSURE: nothing to disclose

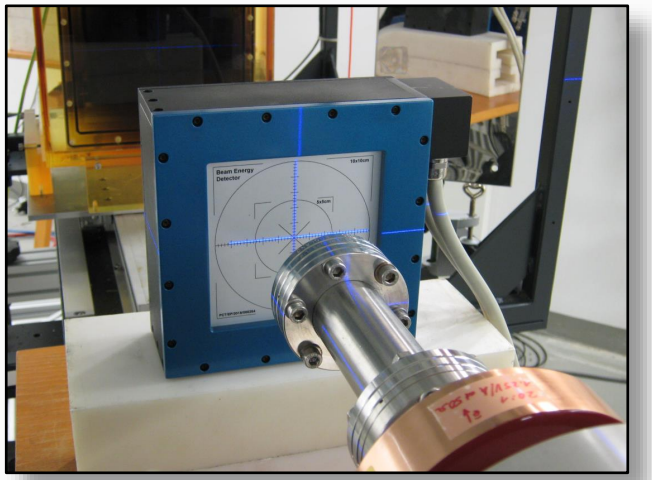
portable Multi-leaf Faraday cup

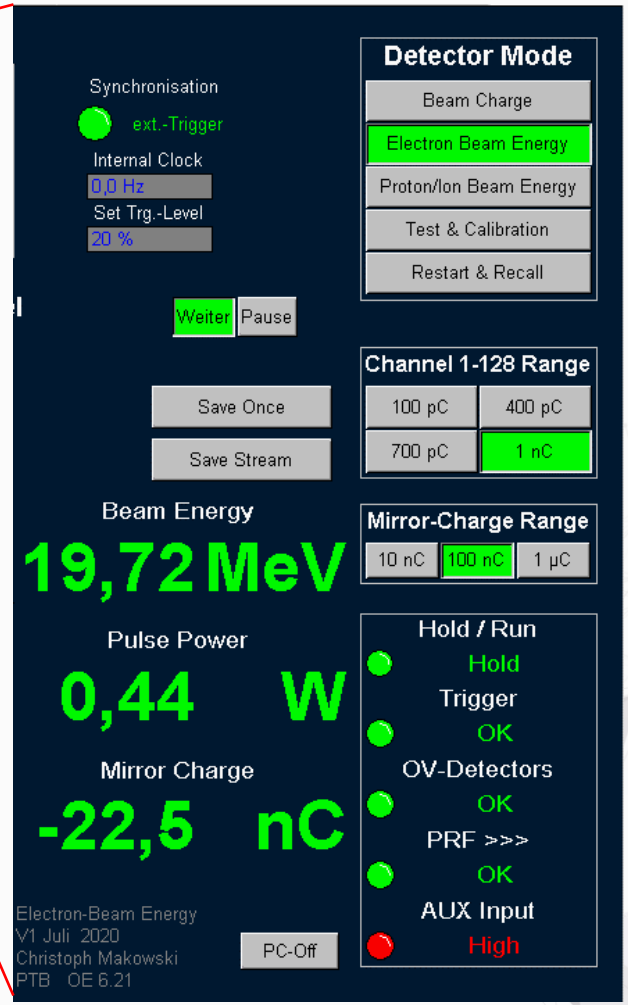


PTB developed a portable Multi-leaf Faraday Cup (MLFC) for energy determination of charged particle beams

portable Multi-leaf Faraday cup





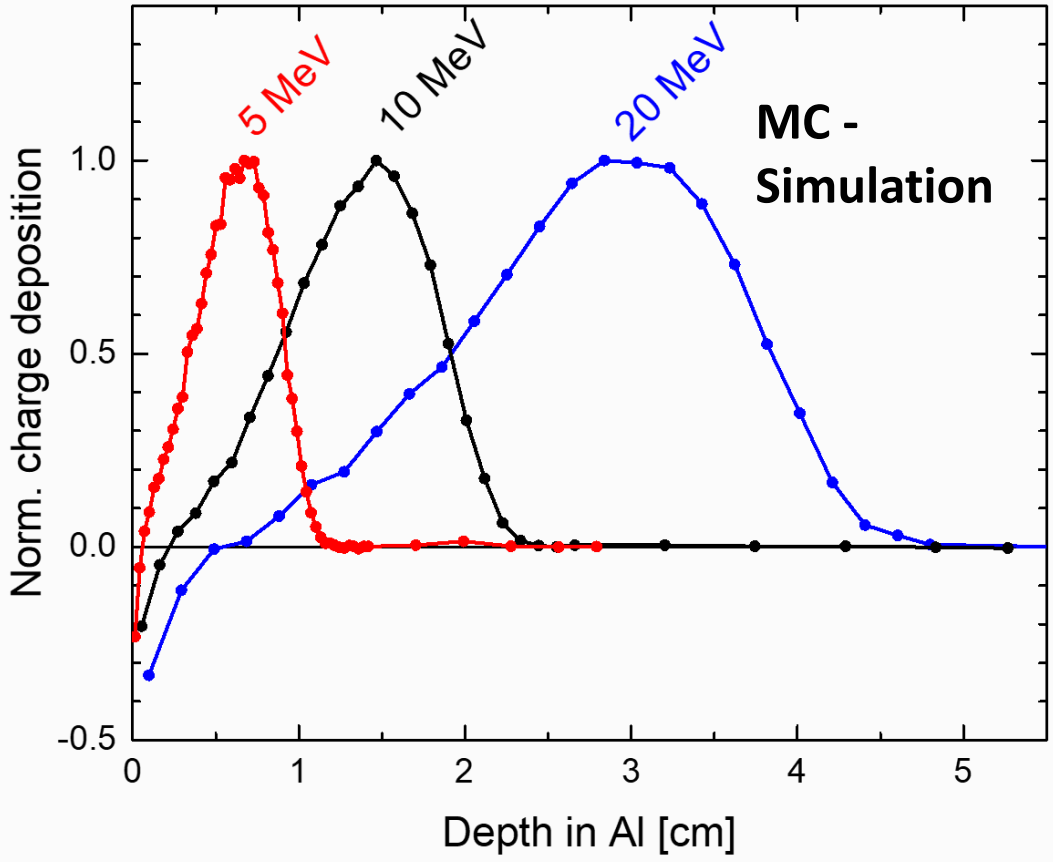


- real-time display of the beam energy and charge per pulse
- pulse resolved up to PRF 10 Hz
- works also in continuous beams

principle of measurement

Electrons:

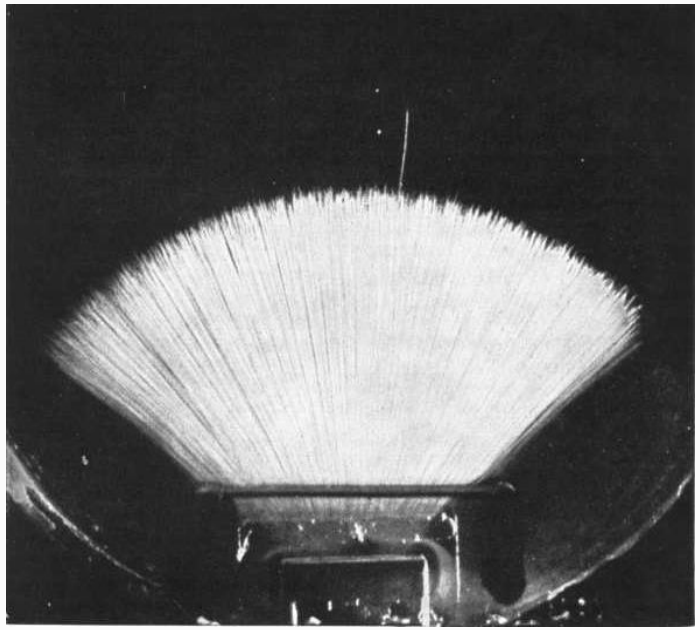
range distribution depends on energy.



P. Andreo et al., RIAST-UOP-TR 1, Tables of Charge- and Energy-Deposition

Ions:

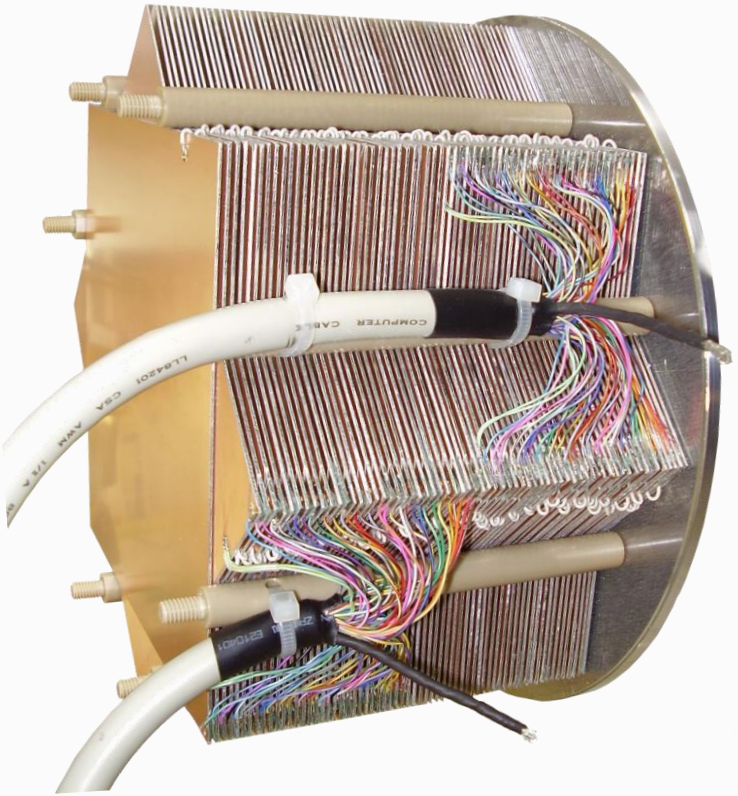
range is a function of energy.



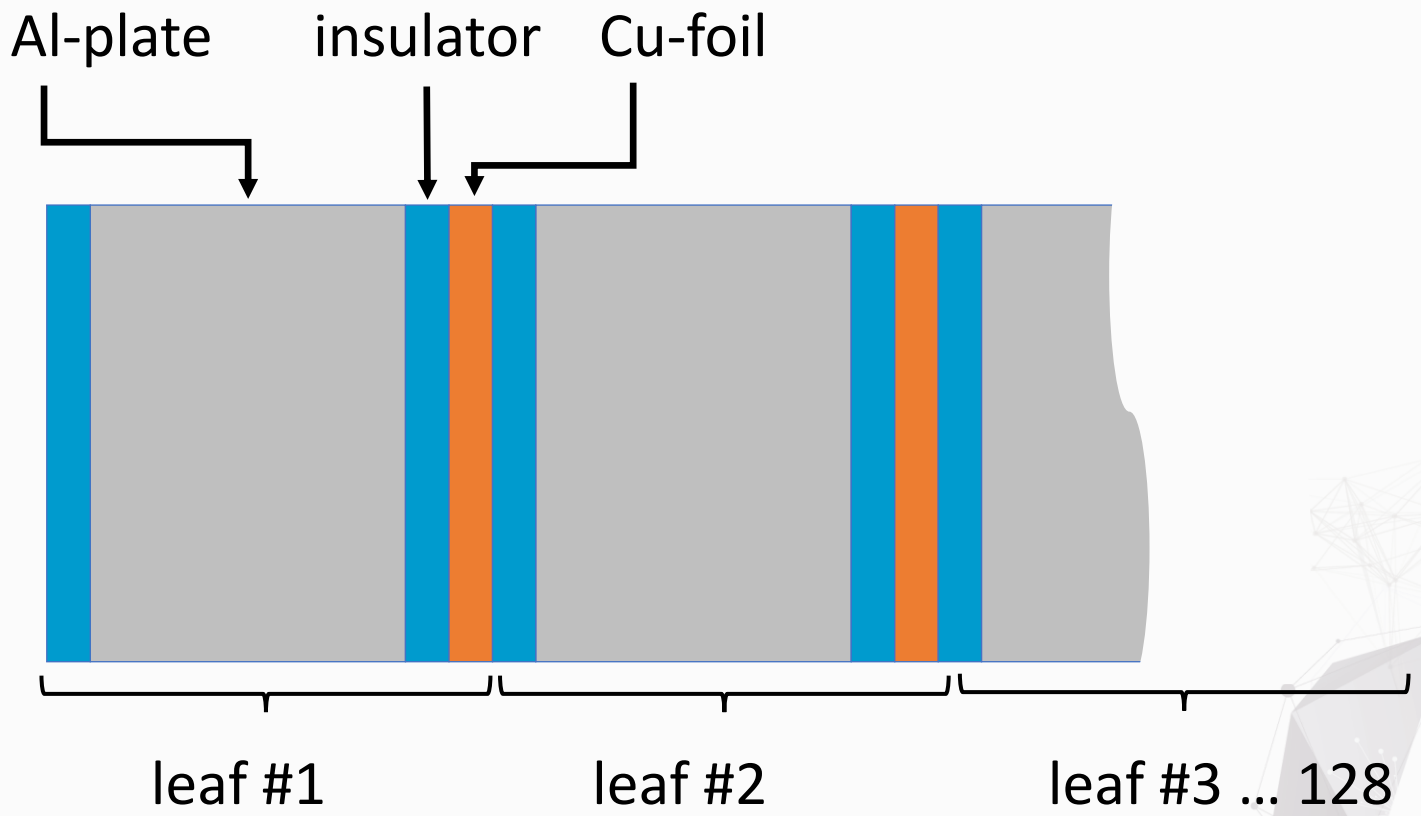
Bothe, Gentner & Maier-Leibnitz, An Atlas of Typical Expansion Chamber Photographs

equal ion energy -> sharply defined range

MLFC design

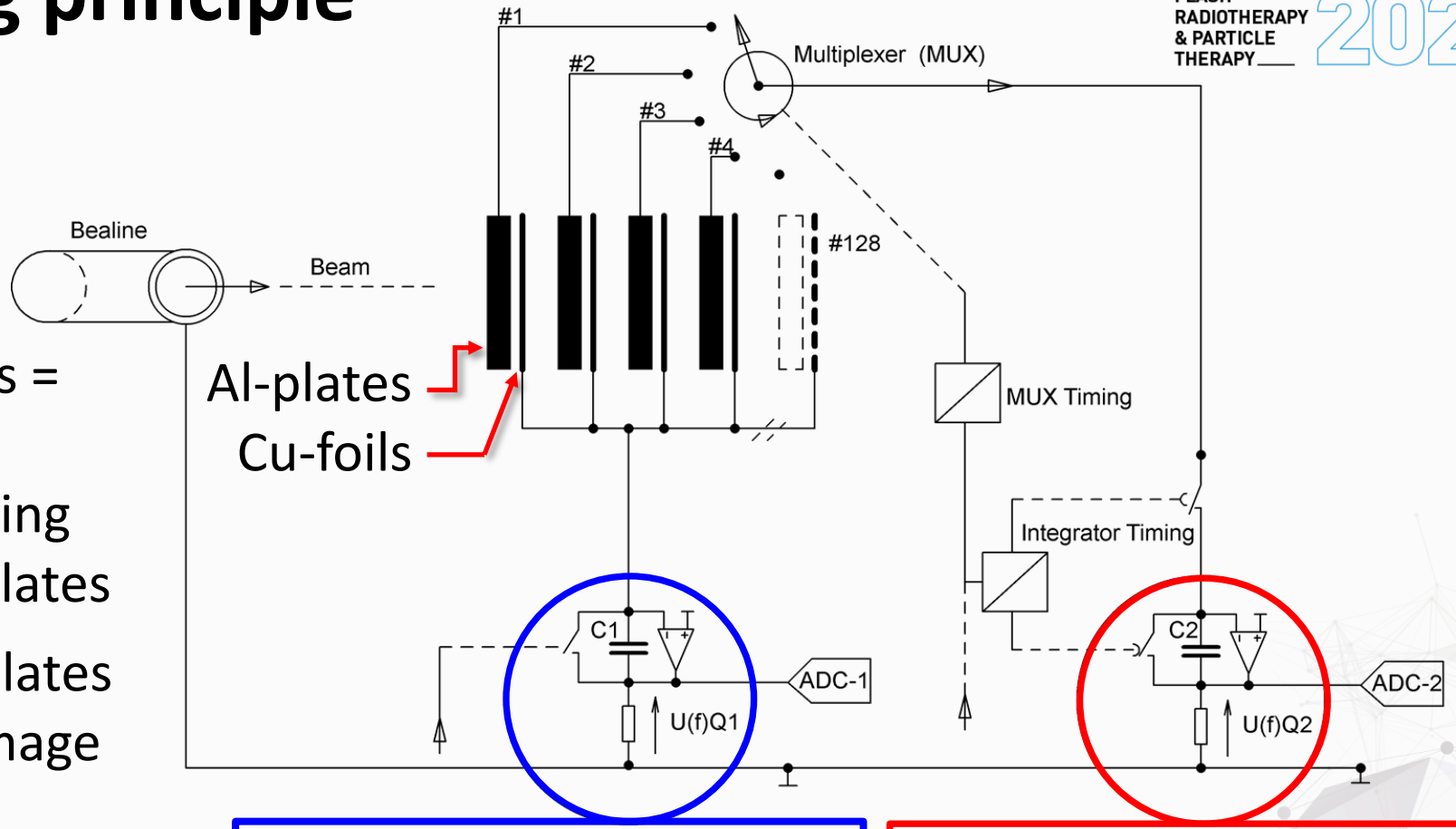


stack of 128 leafs



MLFC operating principle

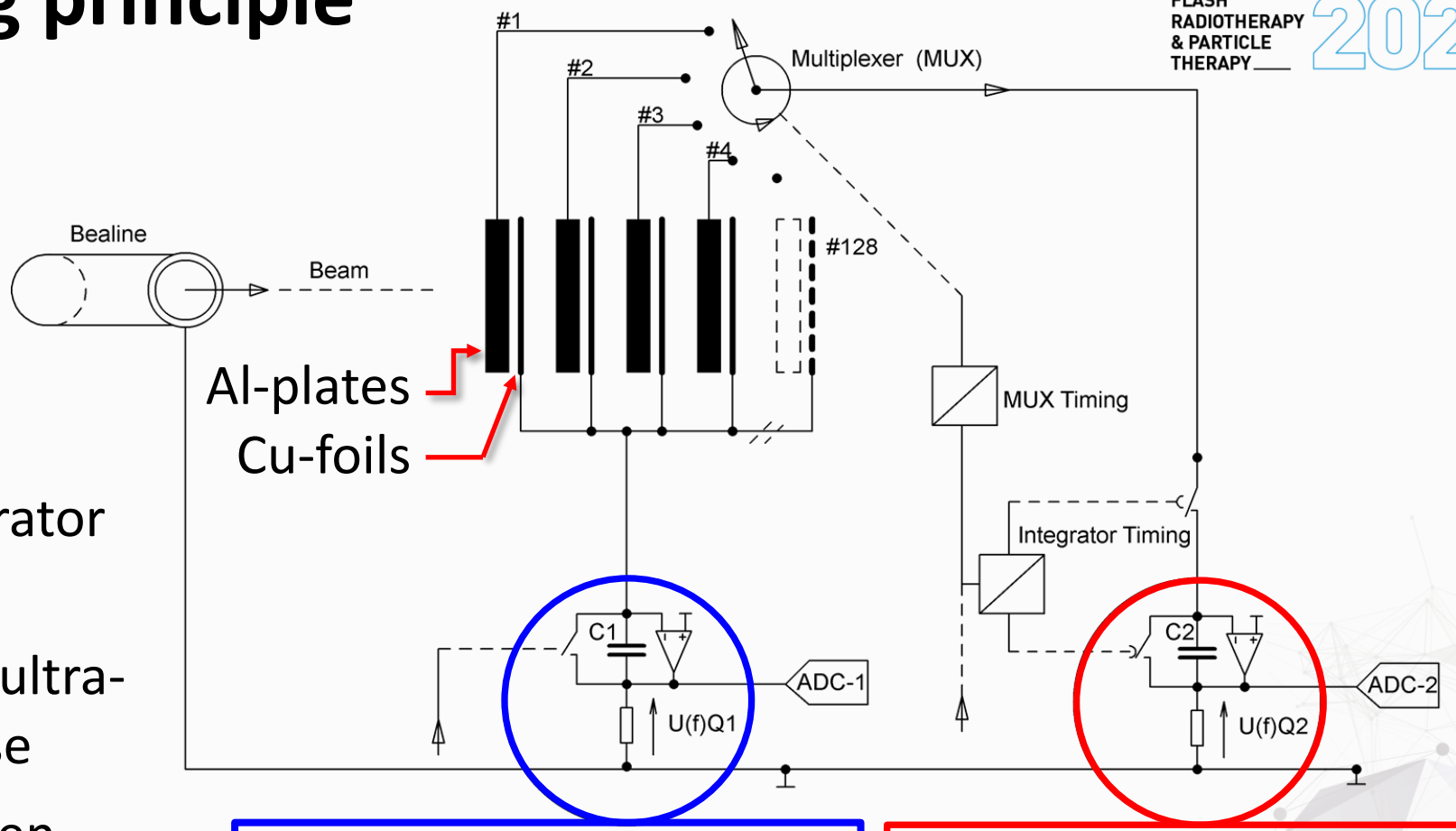
- beam charges Al-plates
- image charge on all Cu-foils = total collected charge monitored without disturbing charge distribution on Al-plates
- sequential read out of Al-plates after threshold value for image charge reached
- -> similar S/N ratio for ultra-high and conventional dose rates



Charge-Integrator #1: monitoring of the total image charge on Cu-foils

Charge-Integrator #2: sequential readout of the 128 Al-plates

MLFC operating principle



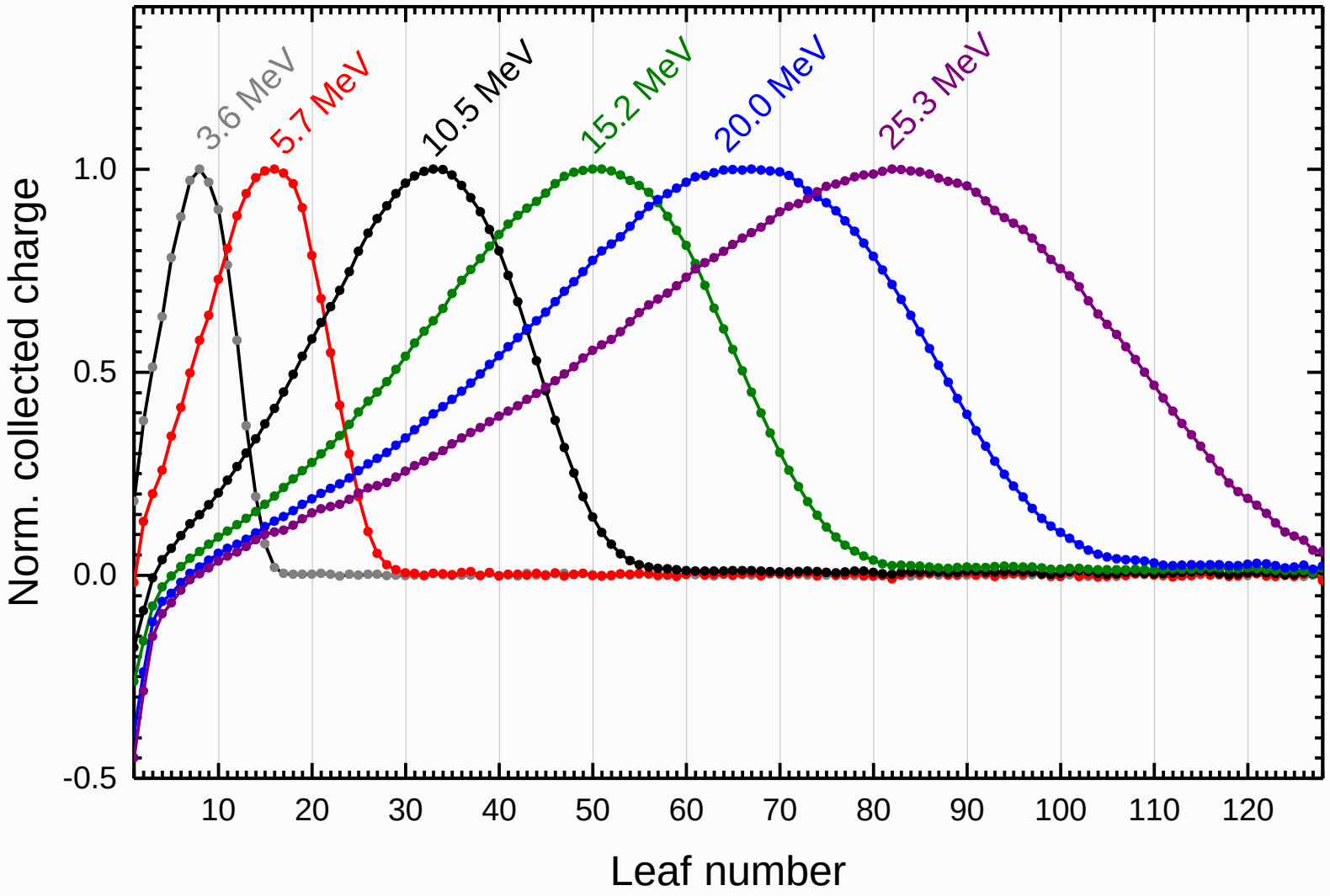
Pulse resolved mode:

- range of the Current-Integrator can be adjusted
- -> works pulse resolved at ultra-high and low dose per pulse
- the readout is done between the beam pulses (PRF < 10 Hz)

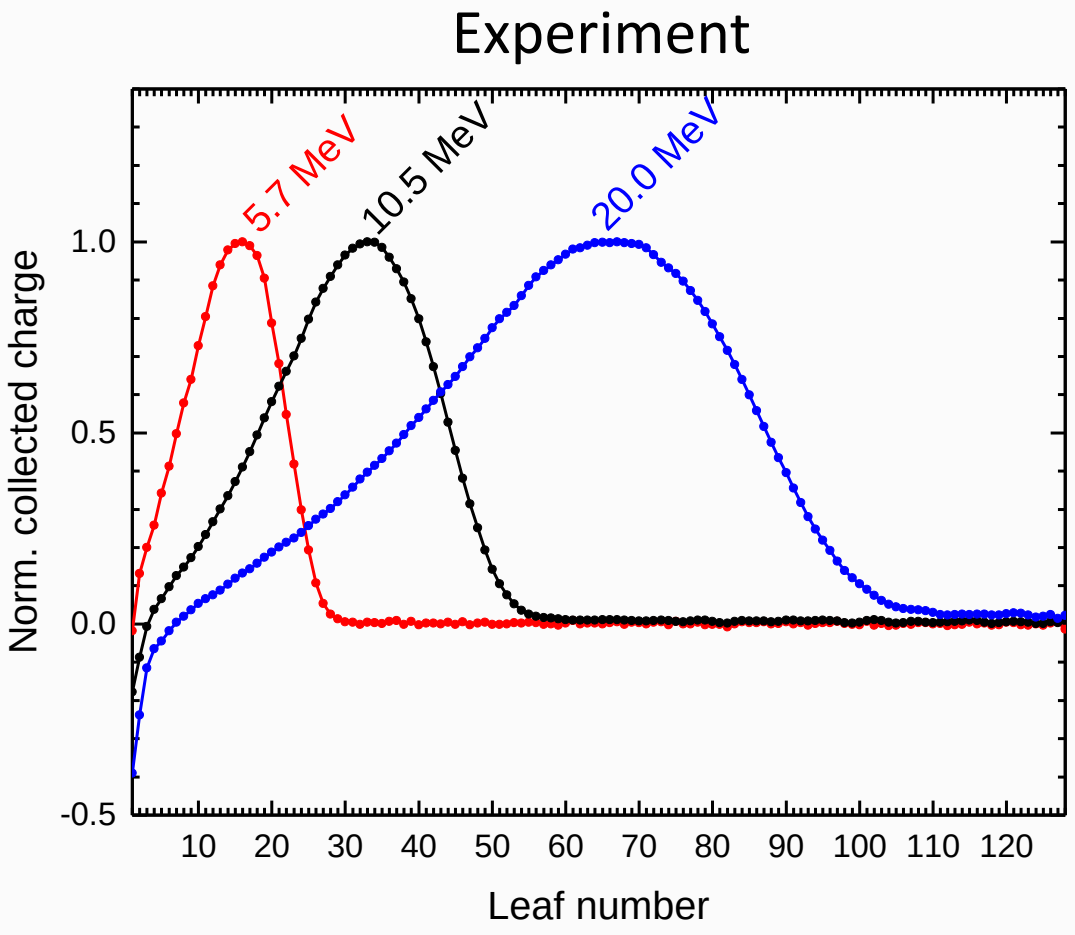
Current-Integrator #1: monitoring of the total image charge on Cu-foils

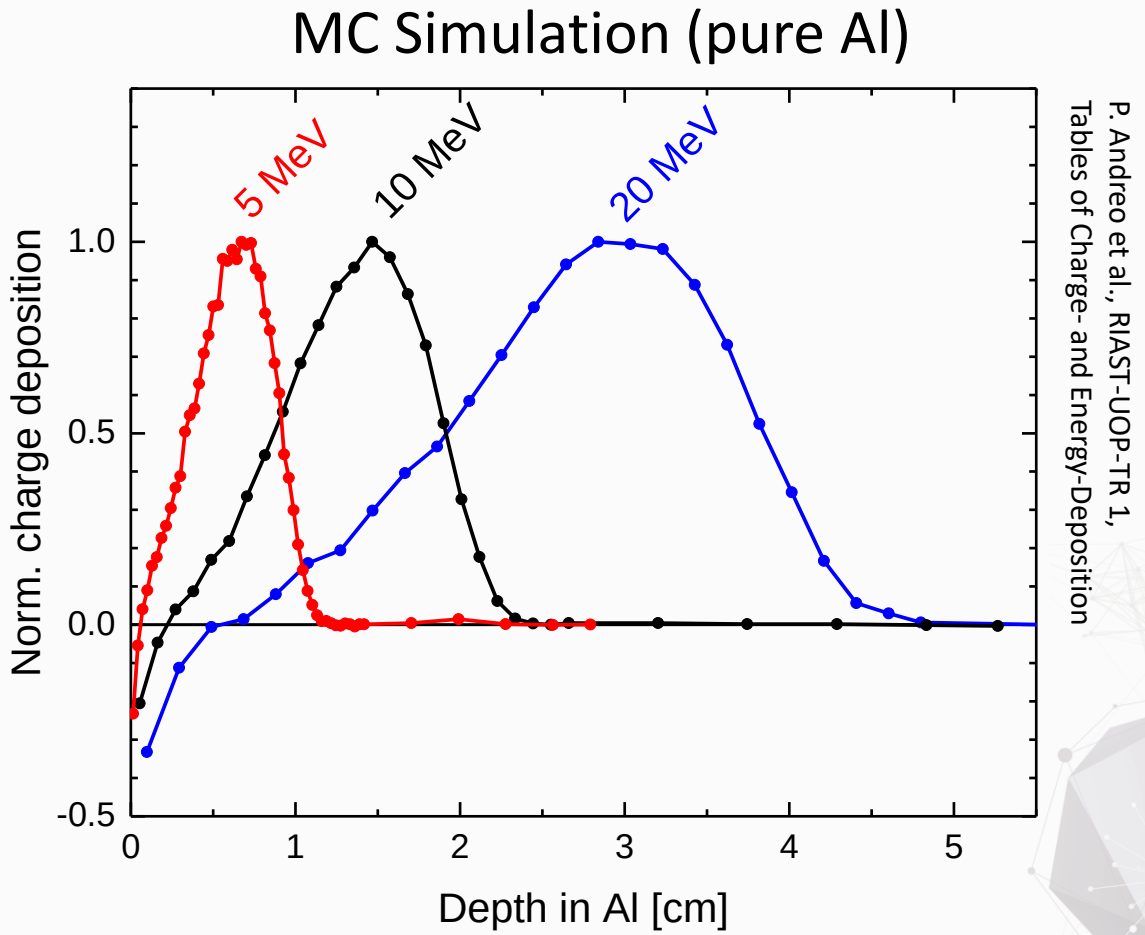
Current-Integrator #2: sequential readout of the 128 Al-plates

MLFC raw data for electron beams



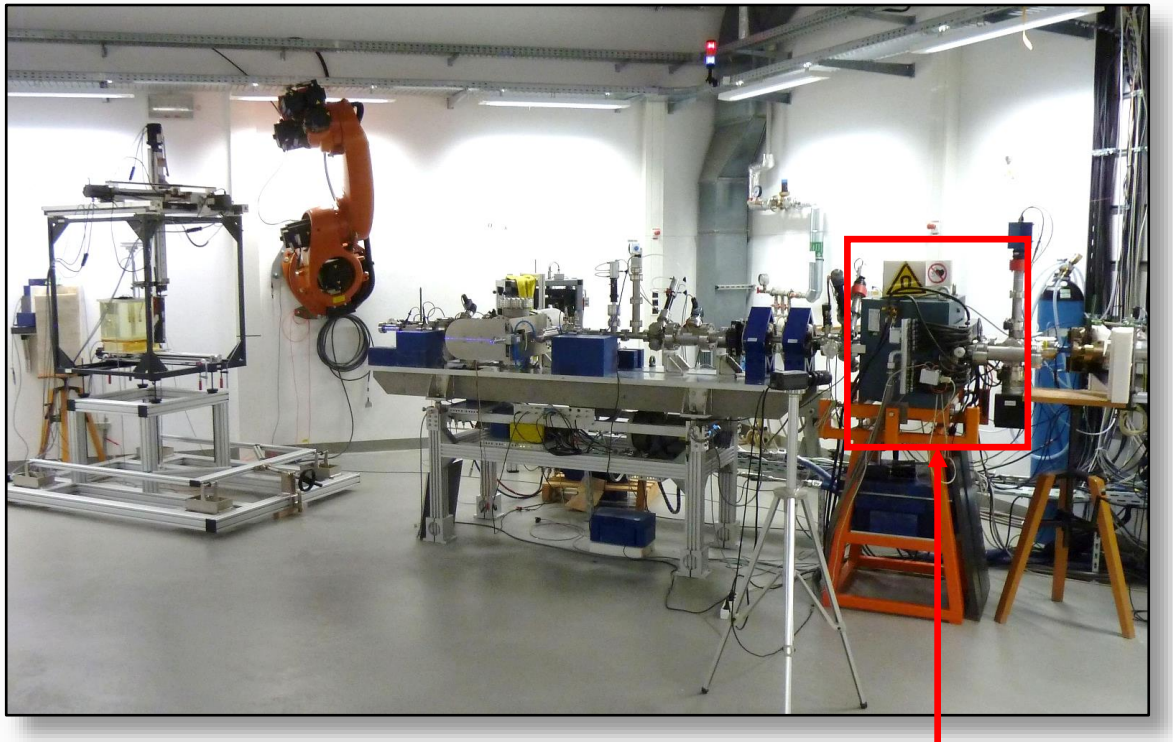
MLFC raw data for electron beams



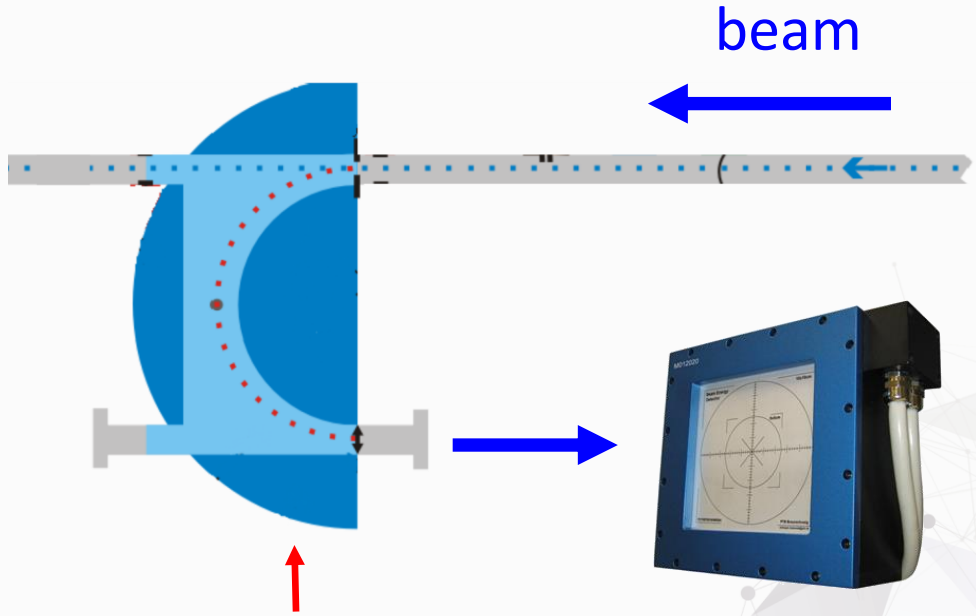


P. Andreo et al., RIAST-UOP-TR 1, Tables of Charge- and Energy-Deposition

Calibration in monoenergetic electron beams

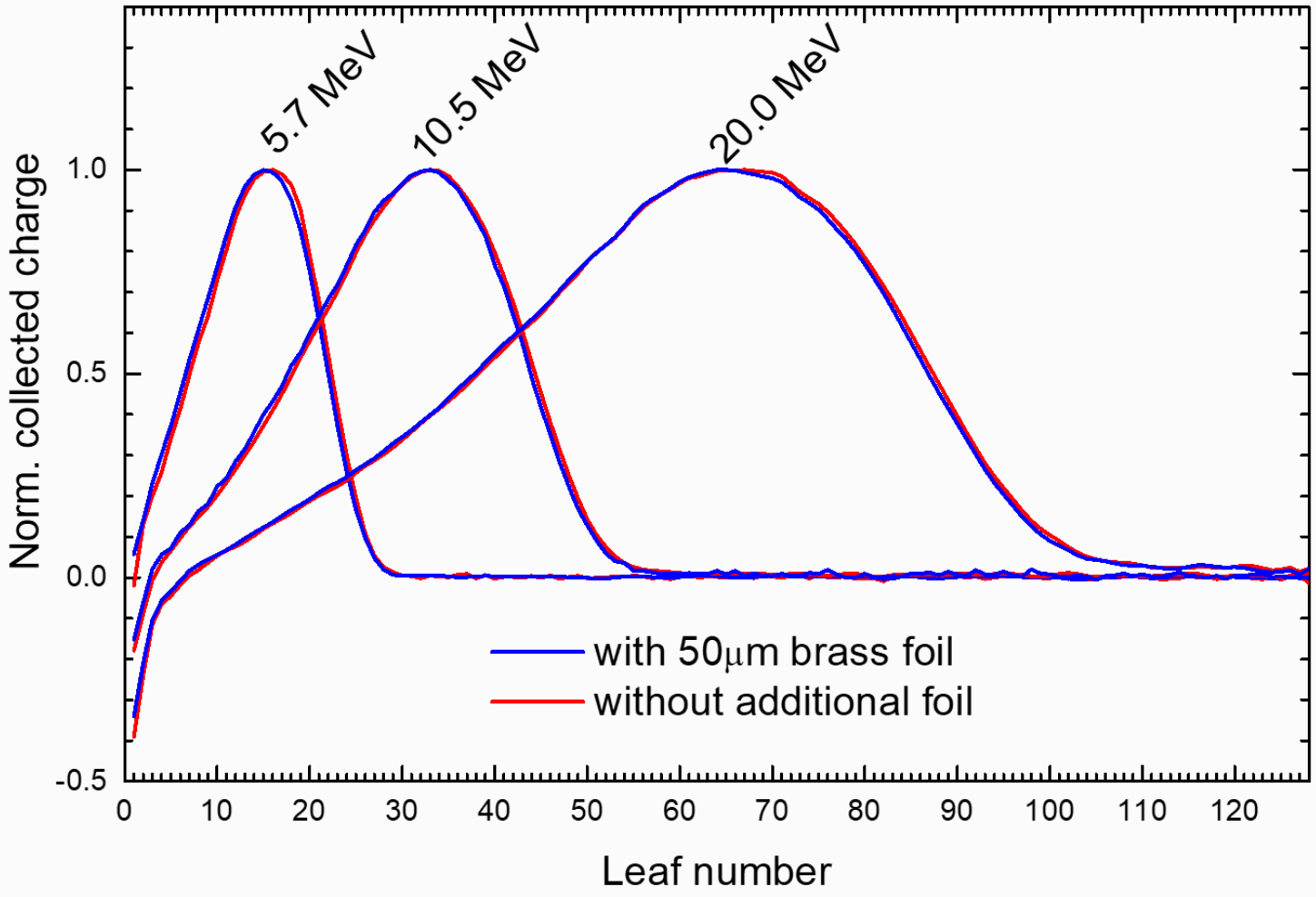


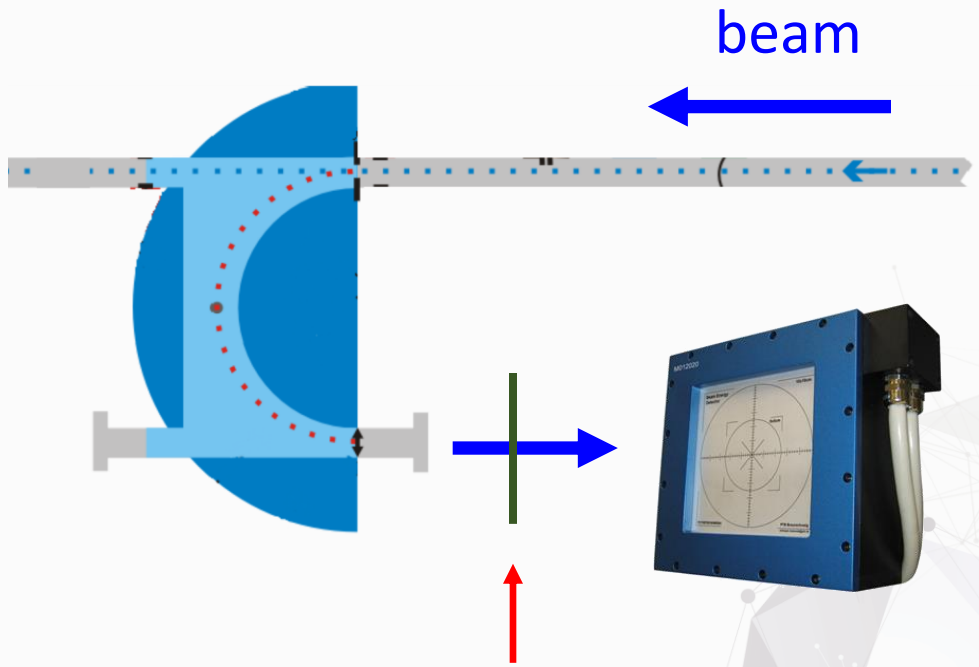
Beamline of PTB's research electron accelerator



180° magnetic spectrometer

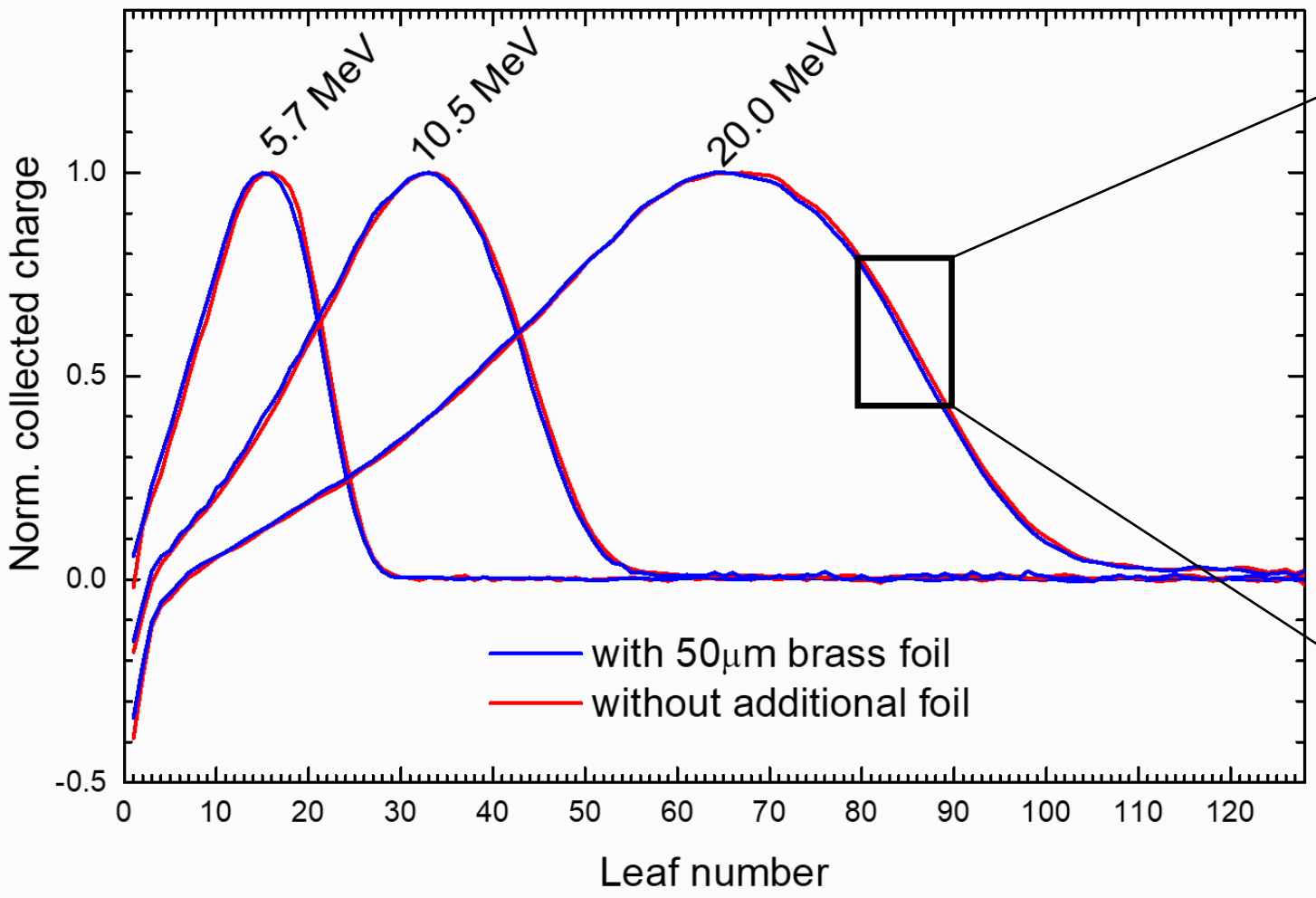
Energy resolution at electron beams

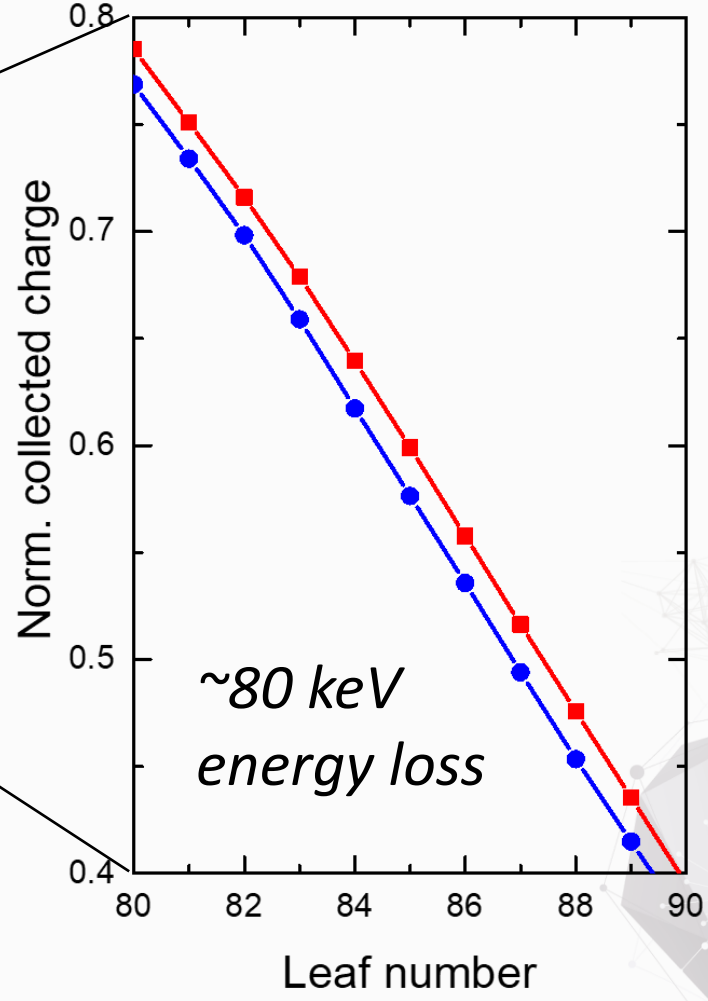




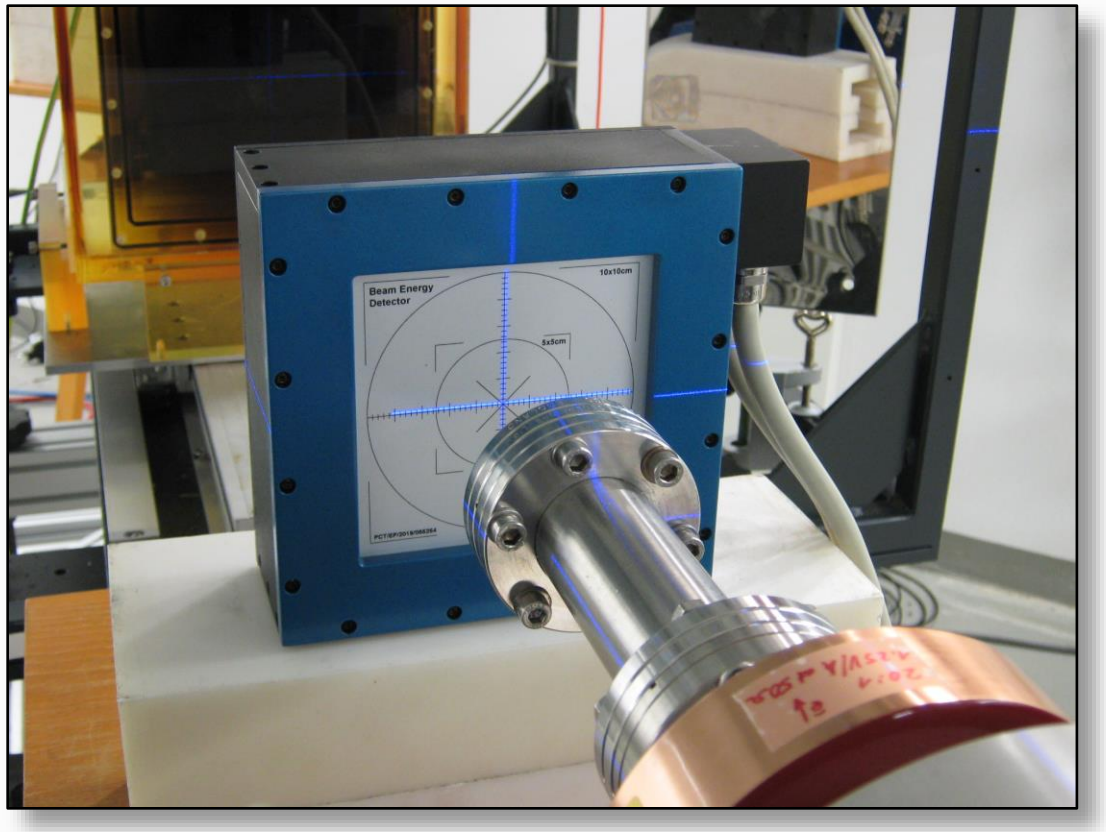
50 um brass foil ->
~80 keV energy loss

Energy resolution at electron beams

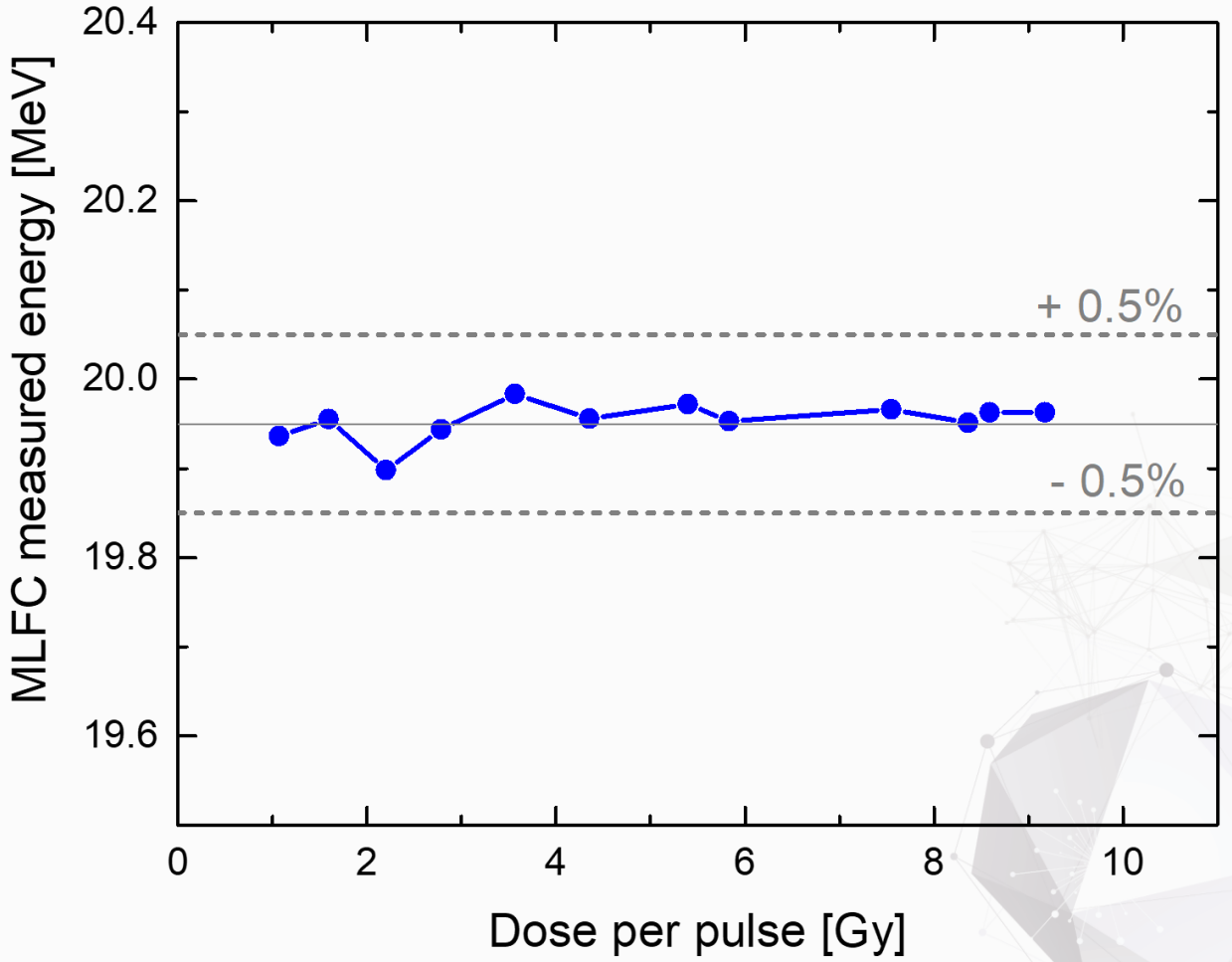




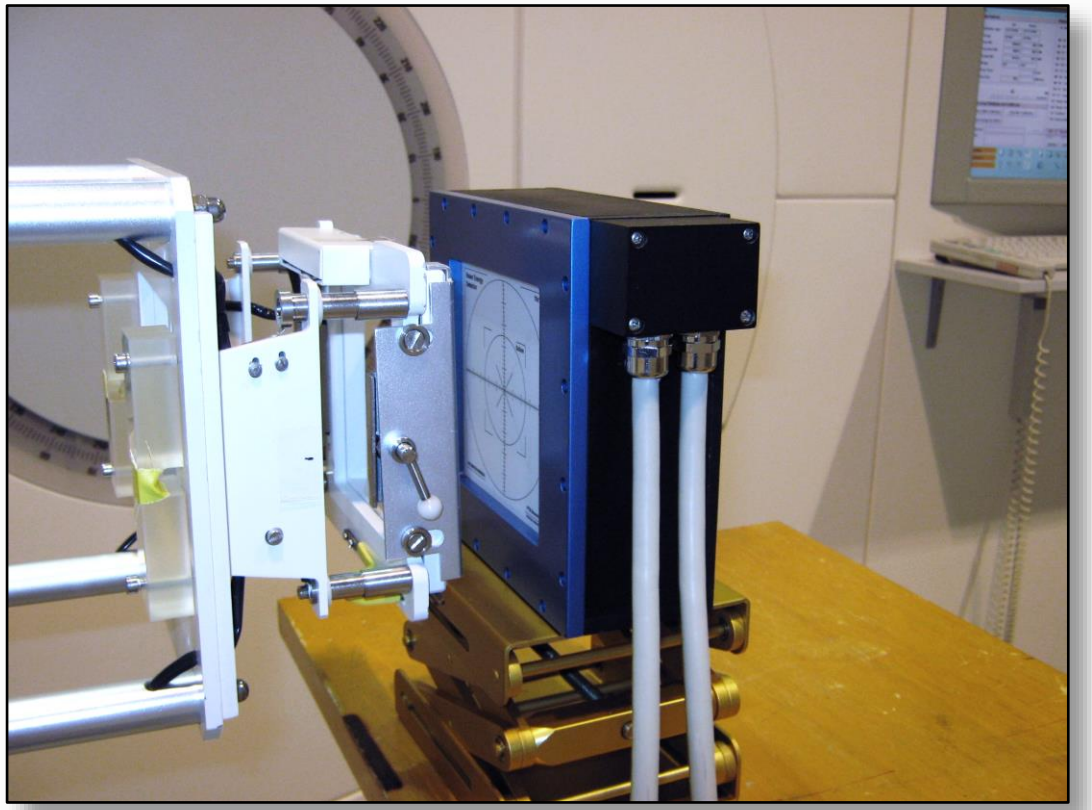
Electron energy at ultra-high dose rates



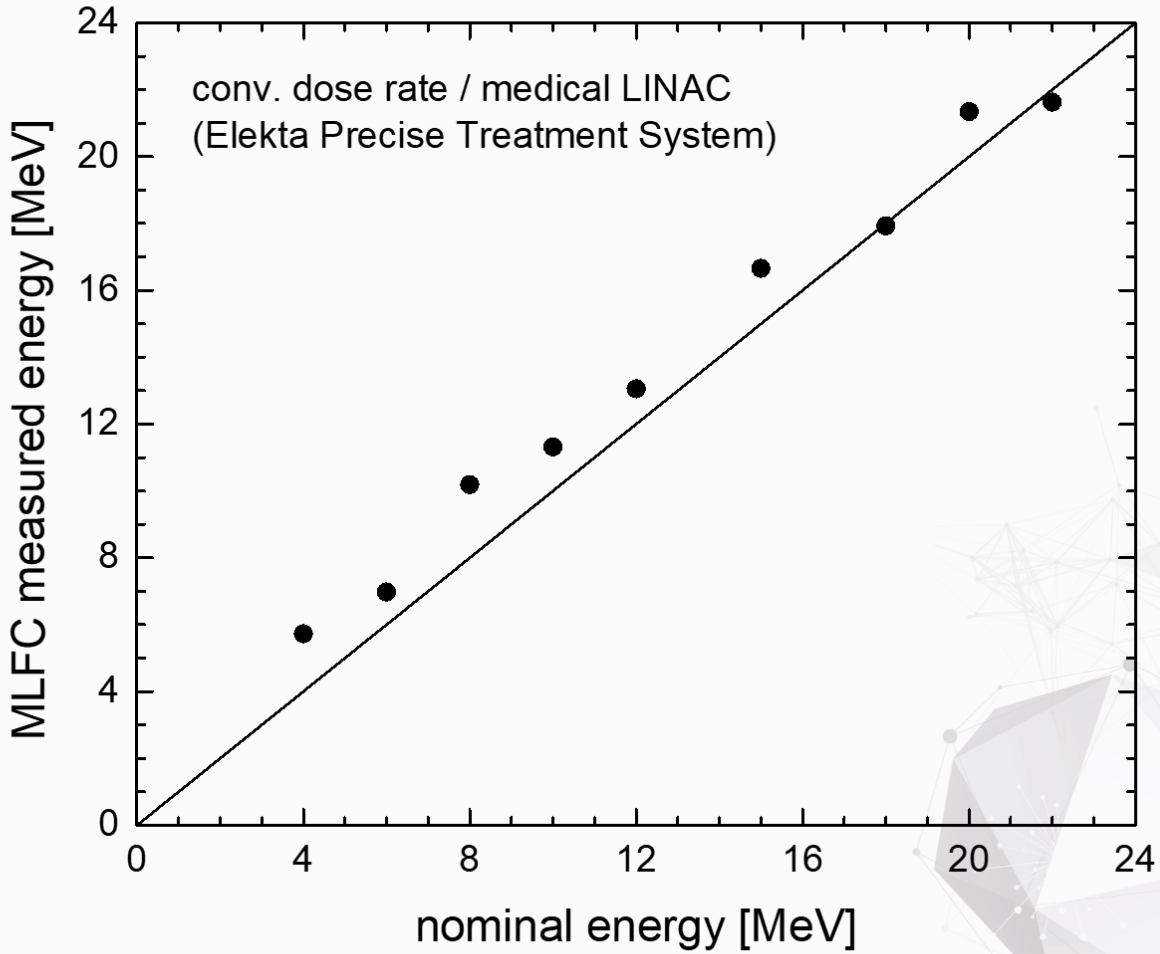
MLFC in front of PTB's research electron accelerator



Electron energy at conventional dose rates



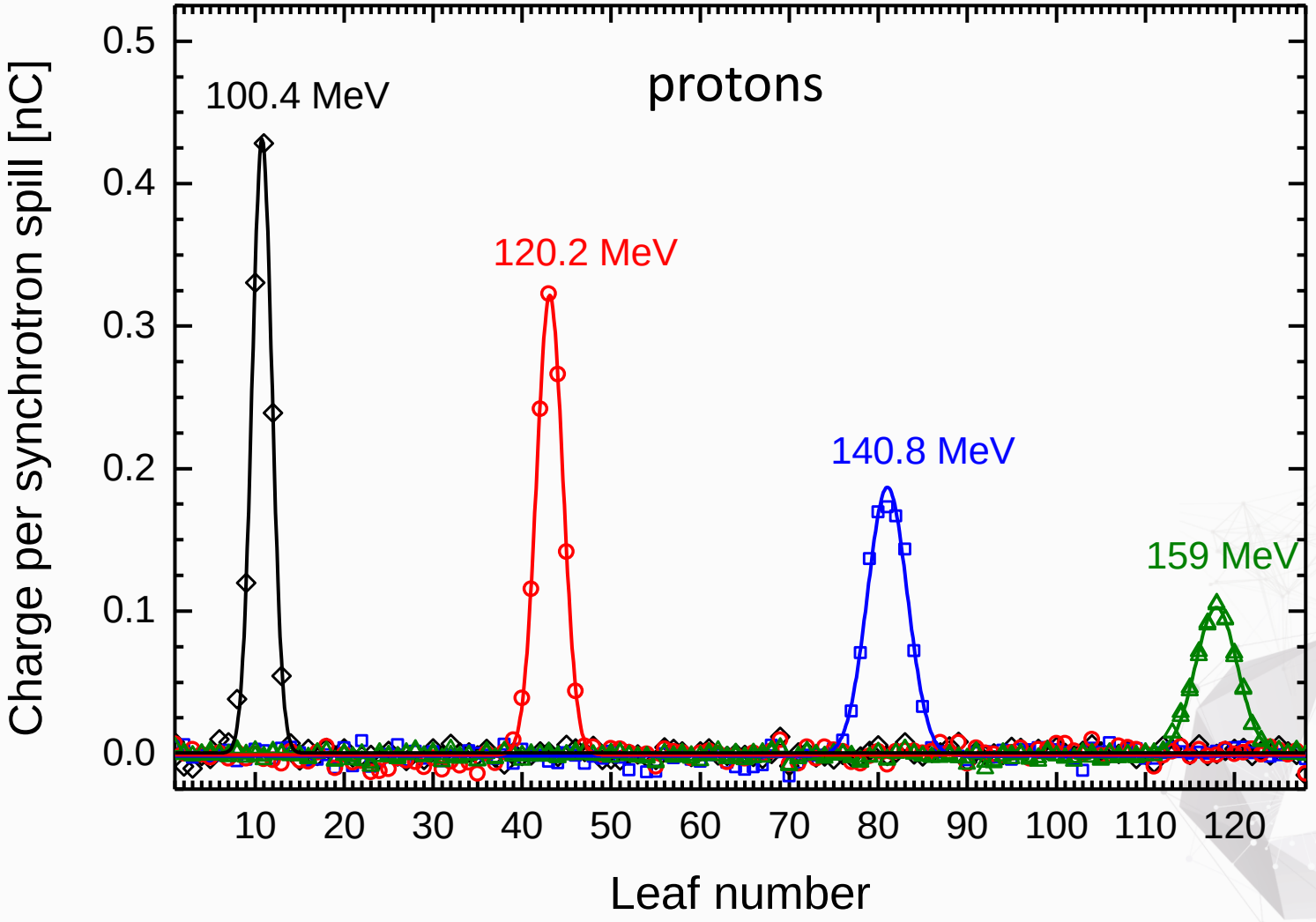
MLFC in front of medical LINAC



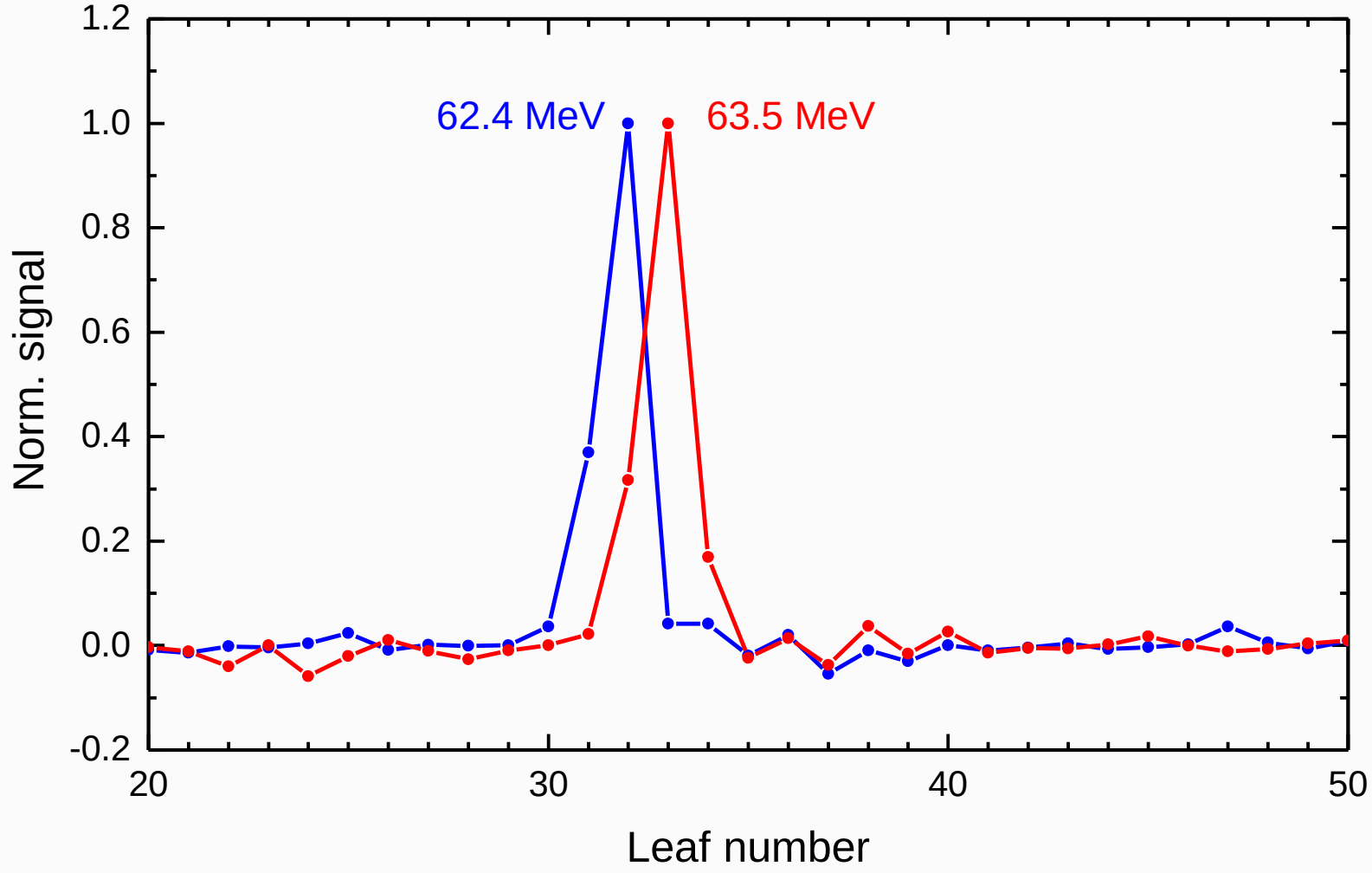
MLFC raw data for proton beams

proton beam

range shifter:
3 cm Al-disk



Energy resolution for protons



Conclusion

- PTB's portable MLFC can detect electron energy differences of 80 keV.
- For proton beams the detectable energy differences are estimated to 60 keV.
- MLFC works independent of the dose rate
- it could be used for quality assurance of charged particle beams with conventional as well as ultra-high dose rate
- Energy and charge can be measured quick and precise.

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

This project (18HLT04) has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

http://uhdpulse-empir.eu/