

Dose-dependent biological damage of tumour cells by laser-accelerated proton beams

*status proton acceleration
first cell irradiation
(online) diagnostics*

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S. Kraft, K. Zeil, J. Metzkes, T. Richter,
C. Richter, et al.

A. Irman, A. Jochmann, et al.
+ P. Michel, U. Lehnert & ELBE team

M. Bussmann, A. Debus, T. Kluge, et al.

M. Siebold, S. Bock, U. Helbig, F. Kroll, F.
Röser, M. Löser, et al.

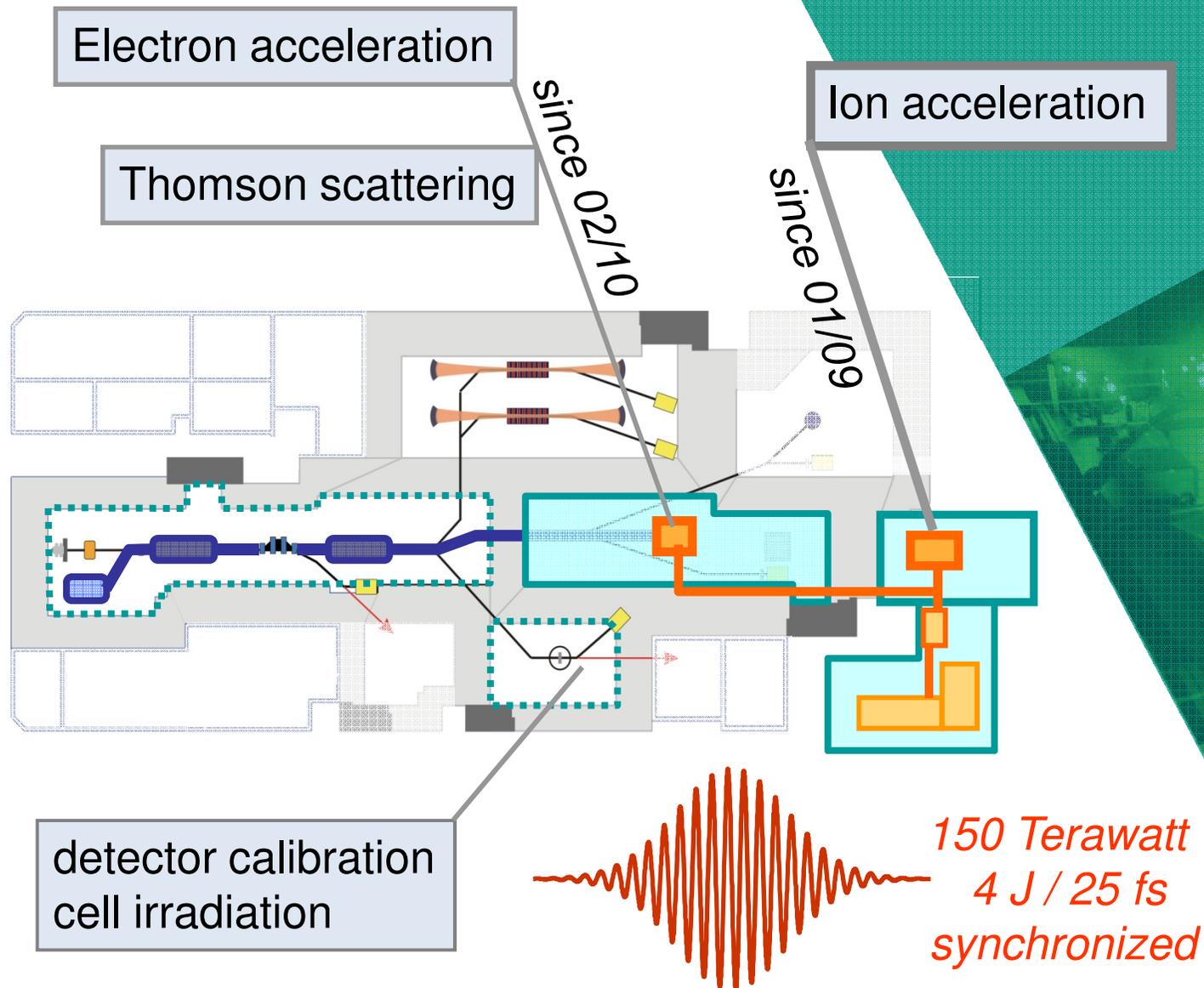
T. Cowan, R. Sauerbrey



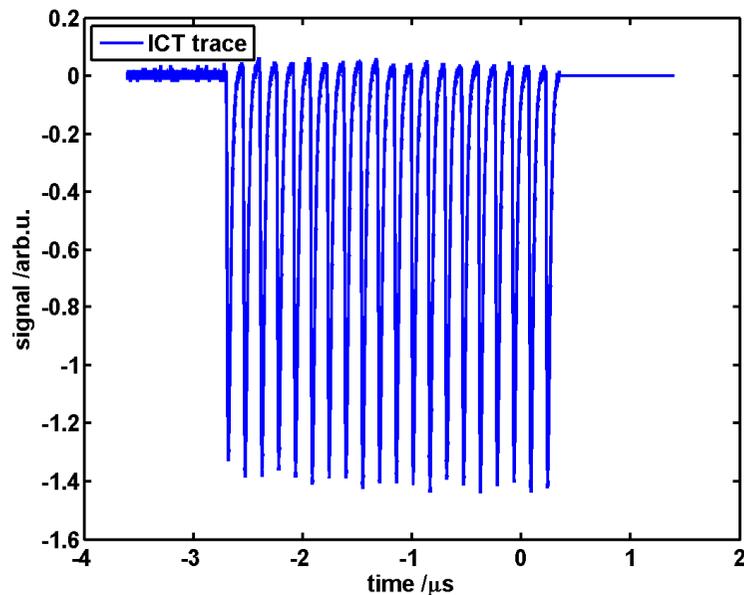
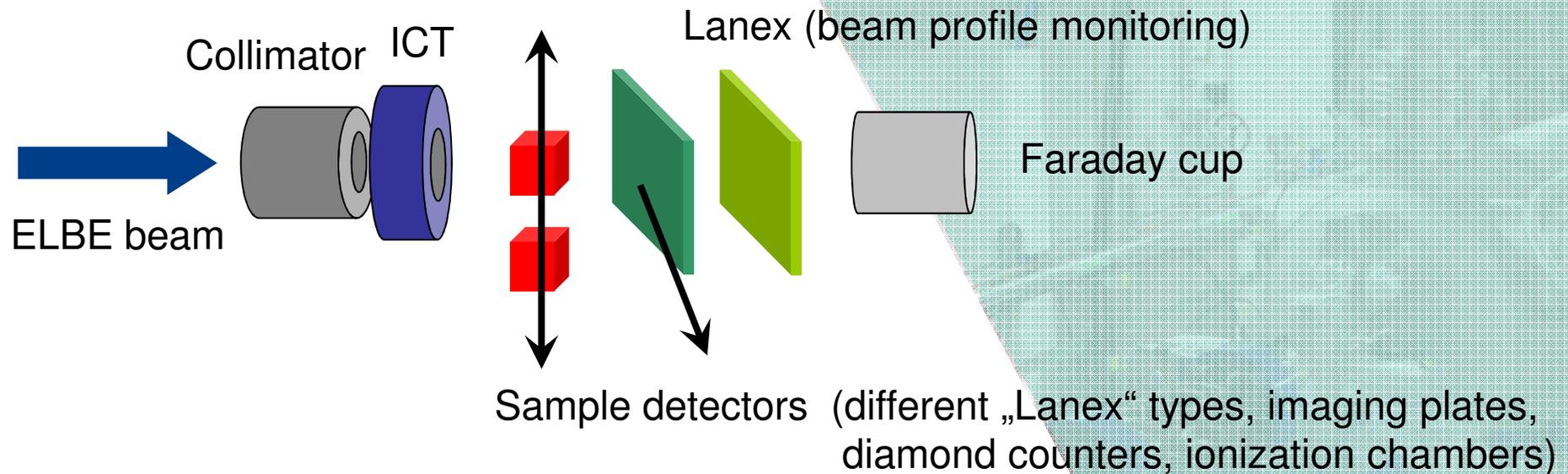
J. Pawelke, L. Karsch,
W. Enghardt, et al.



The present 150 TW laser labs @ ELBE

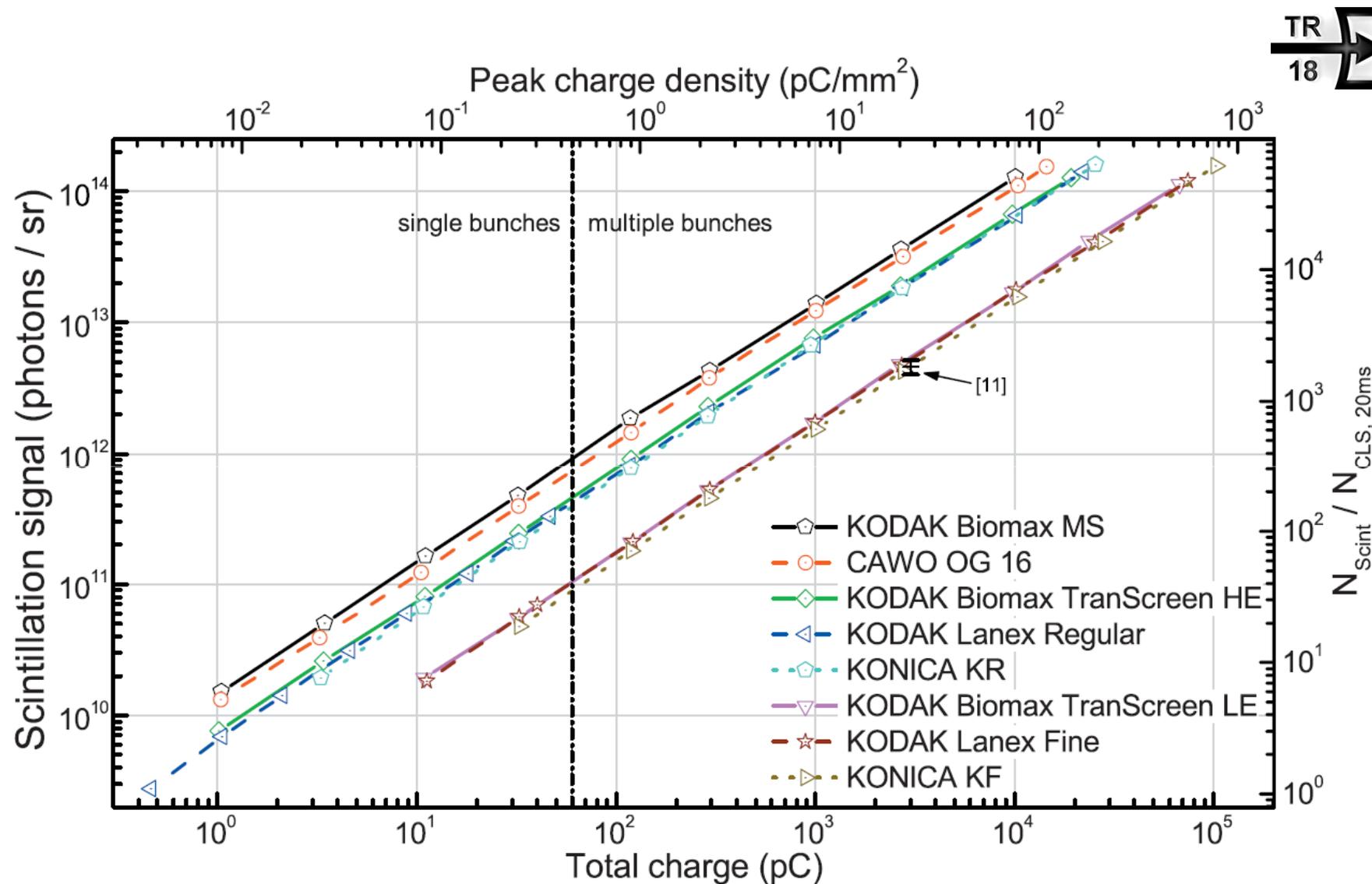


Detector calibration

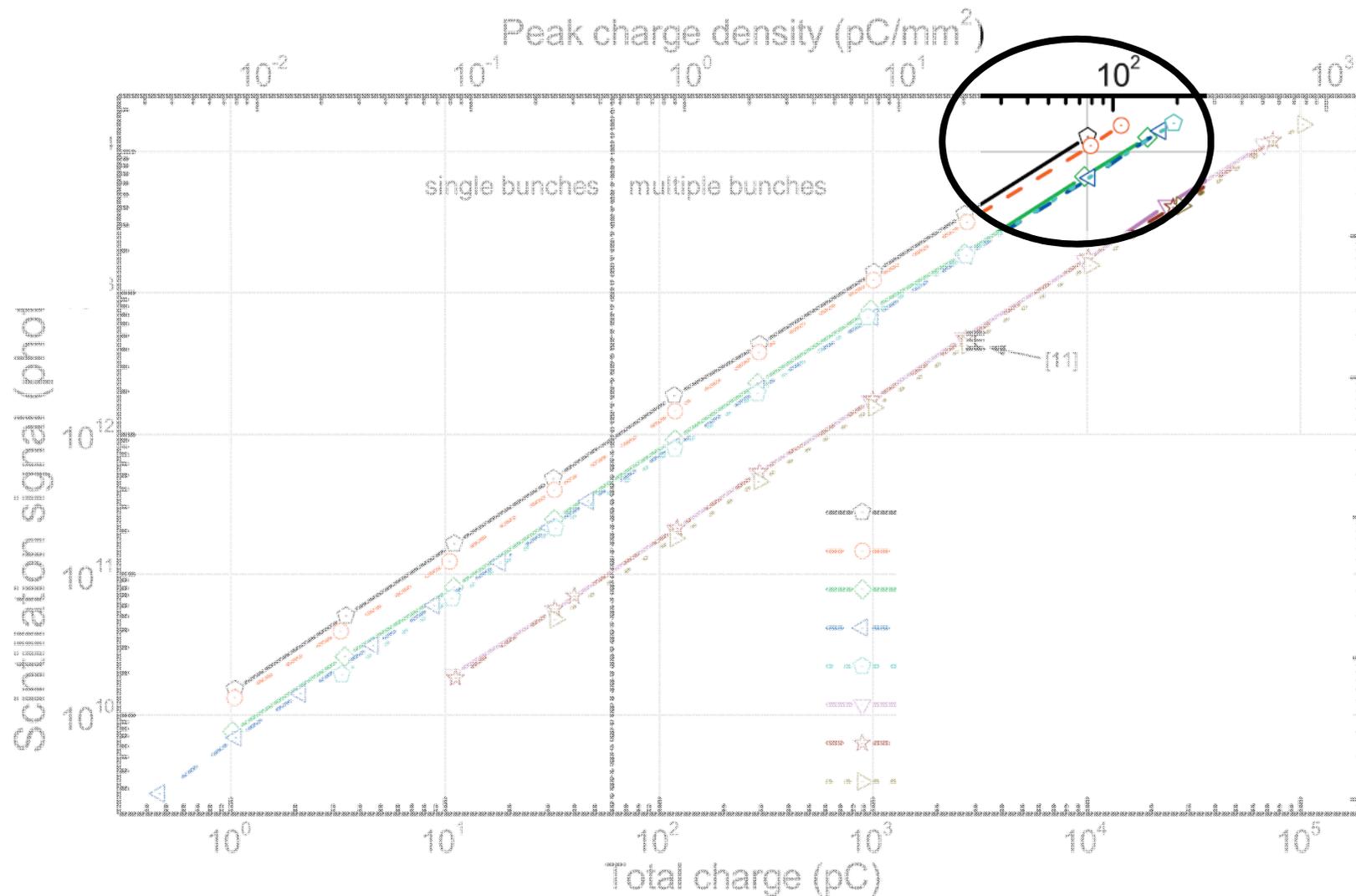


- up to 70 pC (at present) in ps pulses
- pulse trains (13 MHz) or single pulses
- external 200 keV X-ray reference

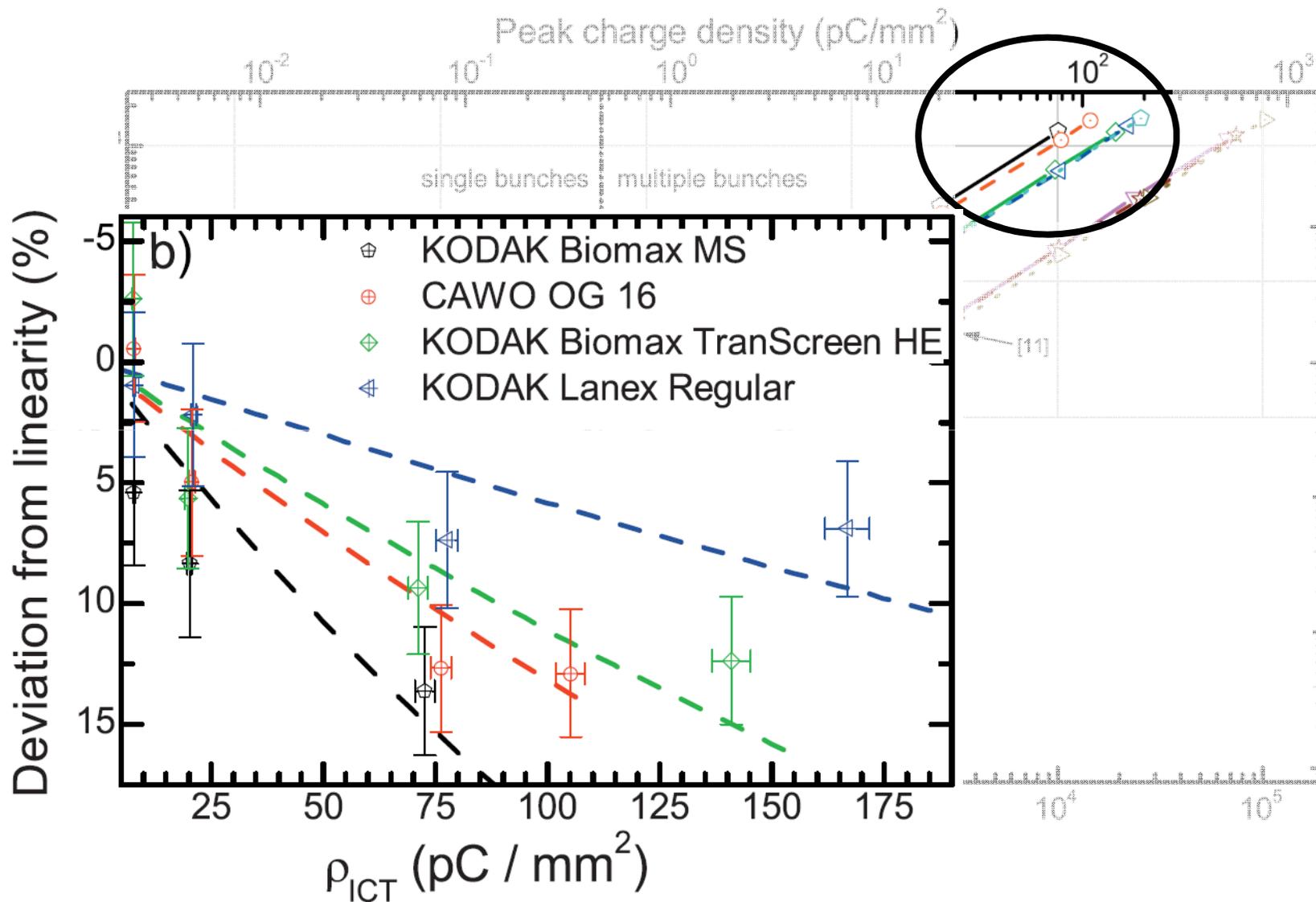
„Lanex“ and IP calibration (with independent reference)



Lanex: A. Buck, et al., *Rev. Sci. Instr.* 81, 033301 (2010) **IPs:** K. Zeil, et al., *ibid.* 013307 (2010)

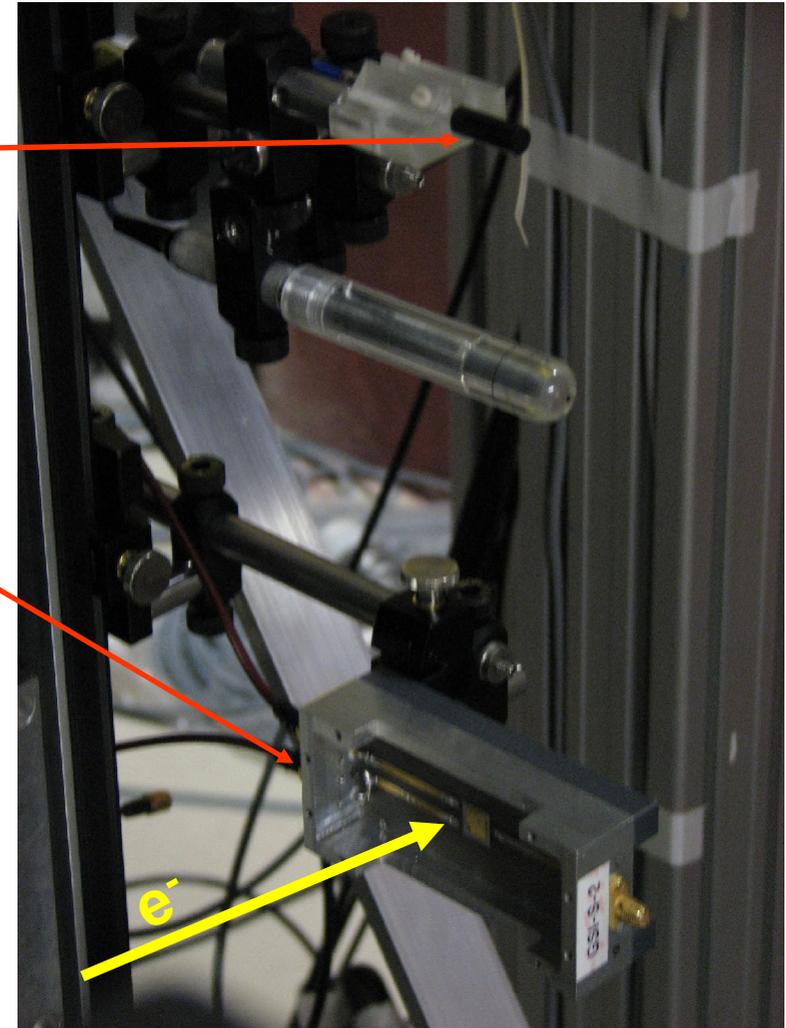
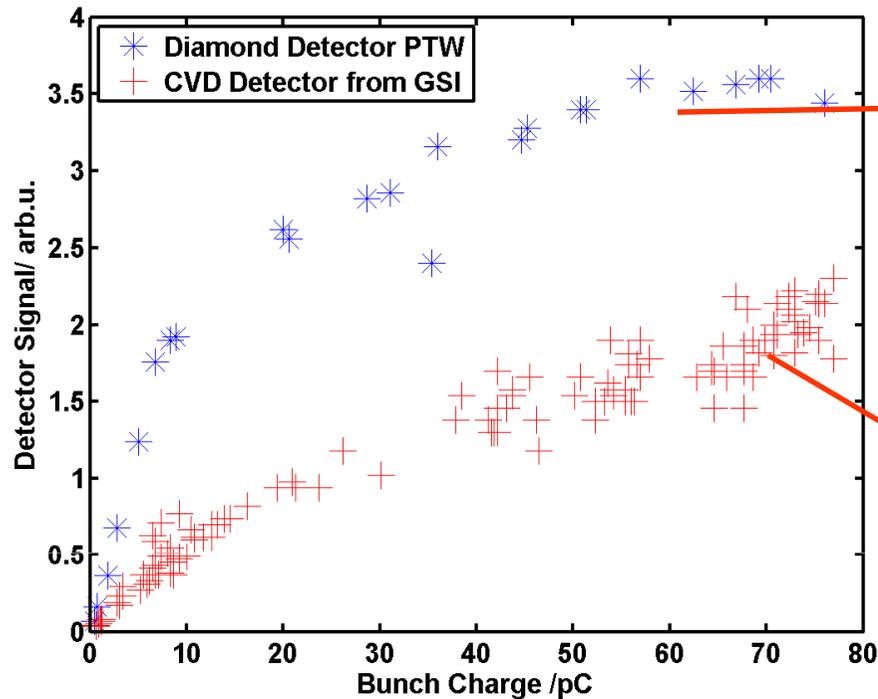


Lanex: A. Buck, et al., *Rev. Sci. Instr.* 81, 033301 (2010) **IPs:** K. Zeil, et al., *ibid.* 013307 (2010)



Lanex: A. Buck, et al., *Rev. Sci. Instr.* 81, 033301 (2010) **IPs:** K. Zeil, et al., *ibid.* 013307 (2010)

Diamond detectors



PTW-Diamond (natural) [specs]:

80 keV ... 20 MV photons

(4 ... 20) MeV electrons

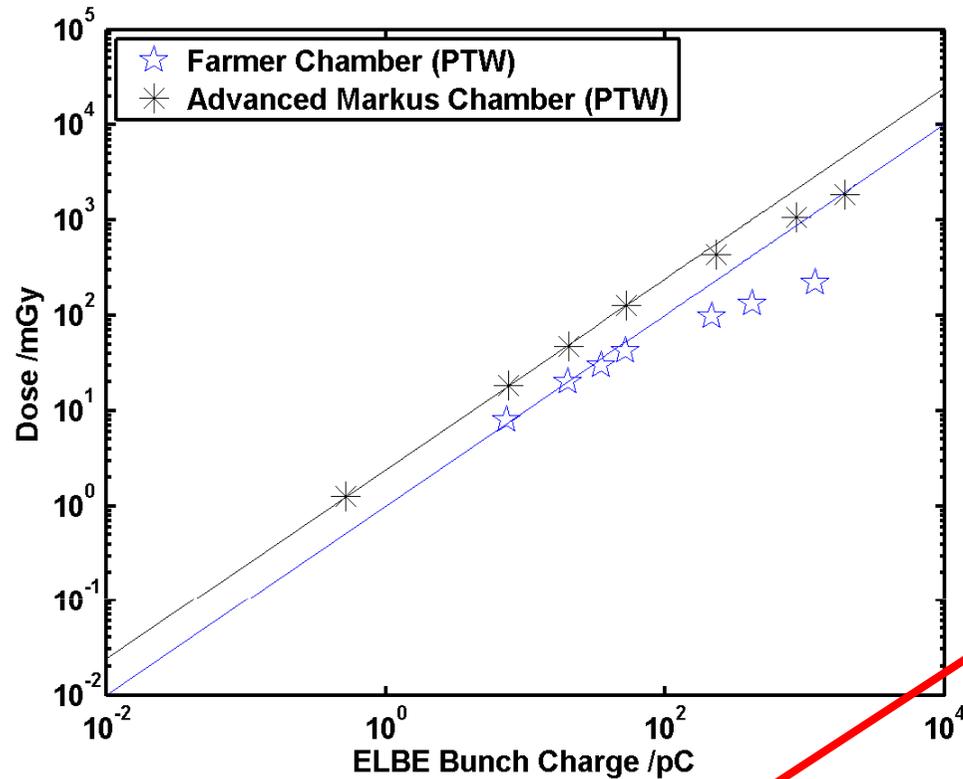
Sensitive volume (3 ... 15) mm² x (0.1 ... 0.4) mm

Chemical Vapor Deposition by GSI

Sensitive volume 100 mm² x 100 μ m

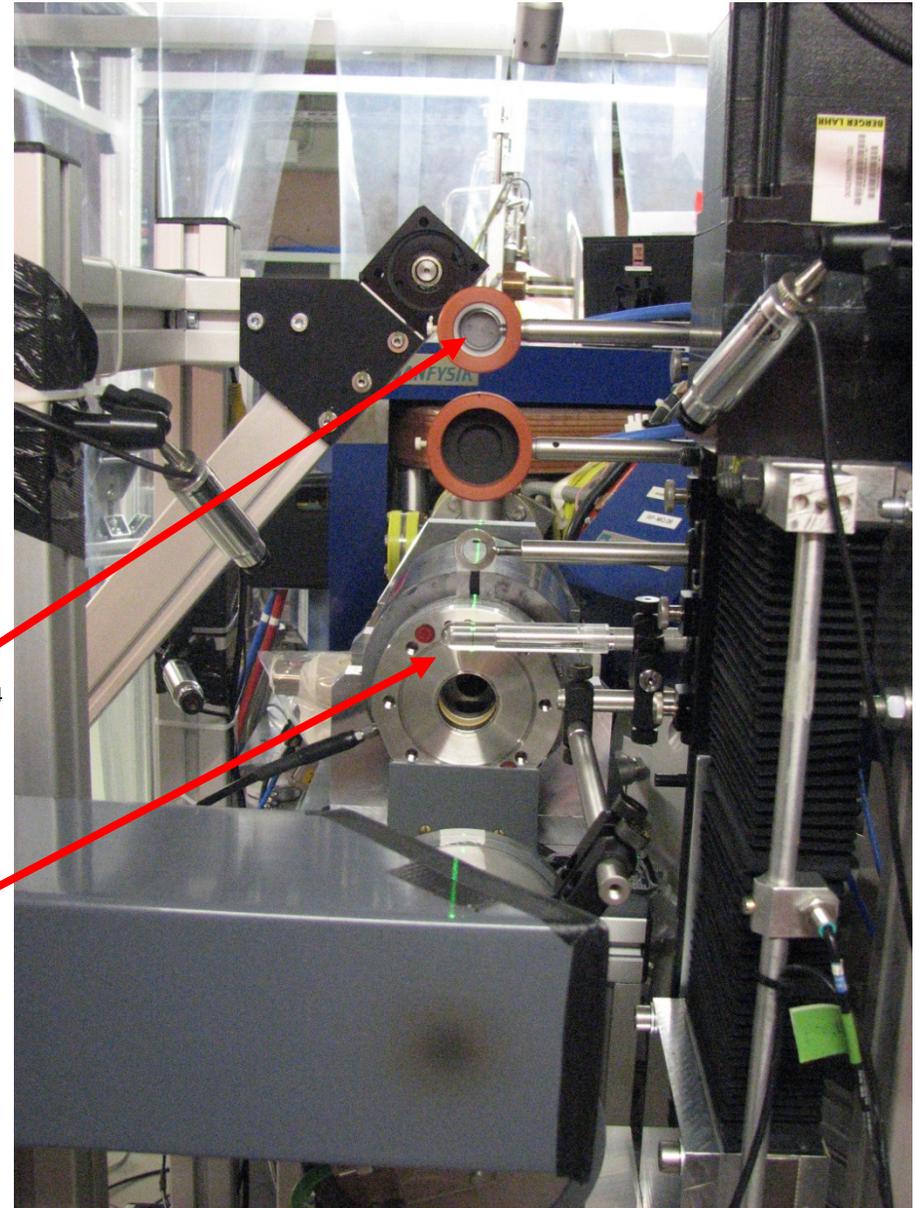
- No amplifiers needed
- Fast response \rightarrow TOF for low energetic ions
- High sensitivity/dynamic range

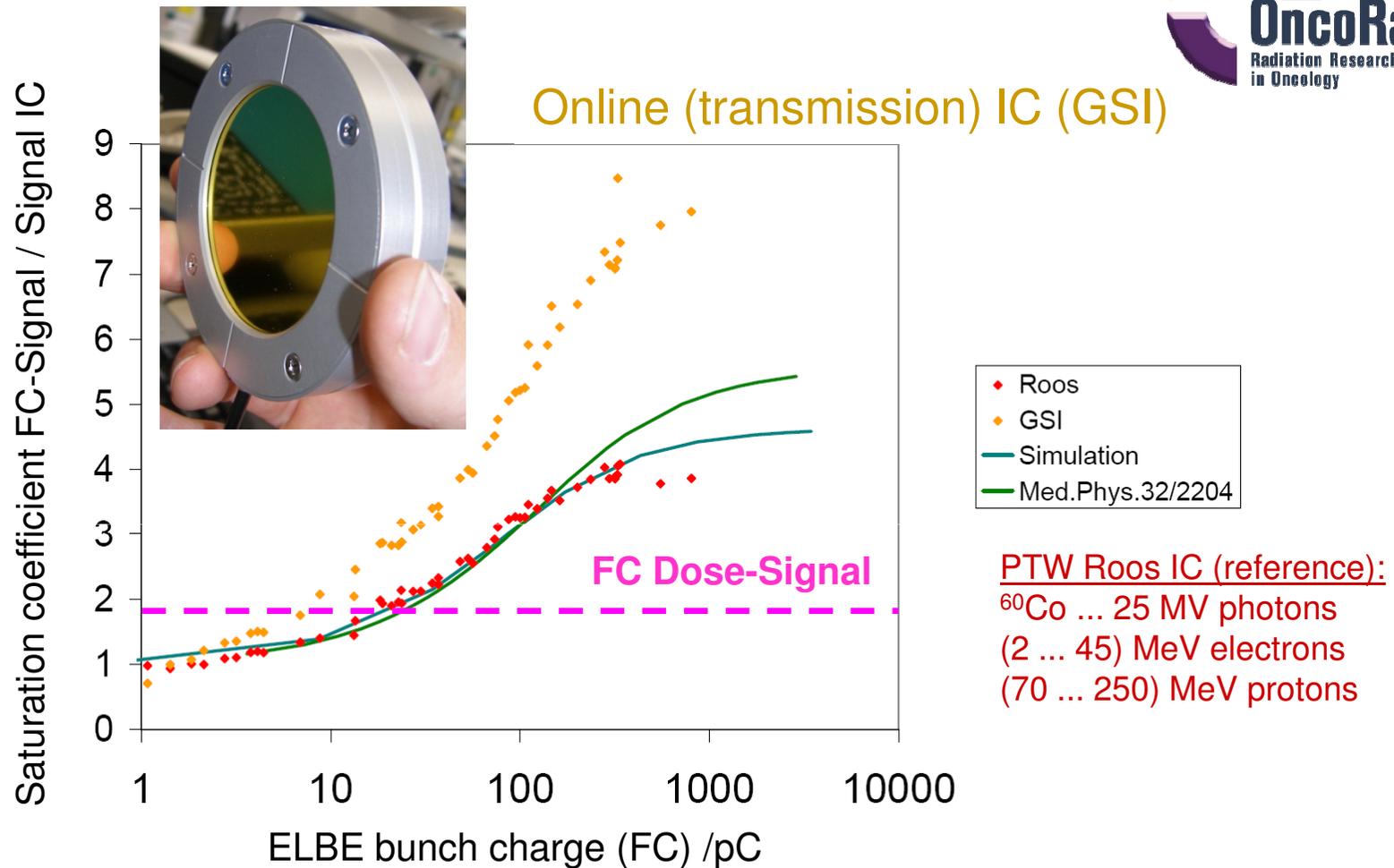
Ionization chambers



Advanced Markus IC:
(2 ... 45) MeV electrons

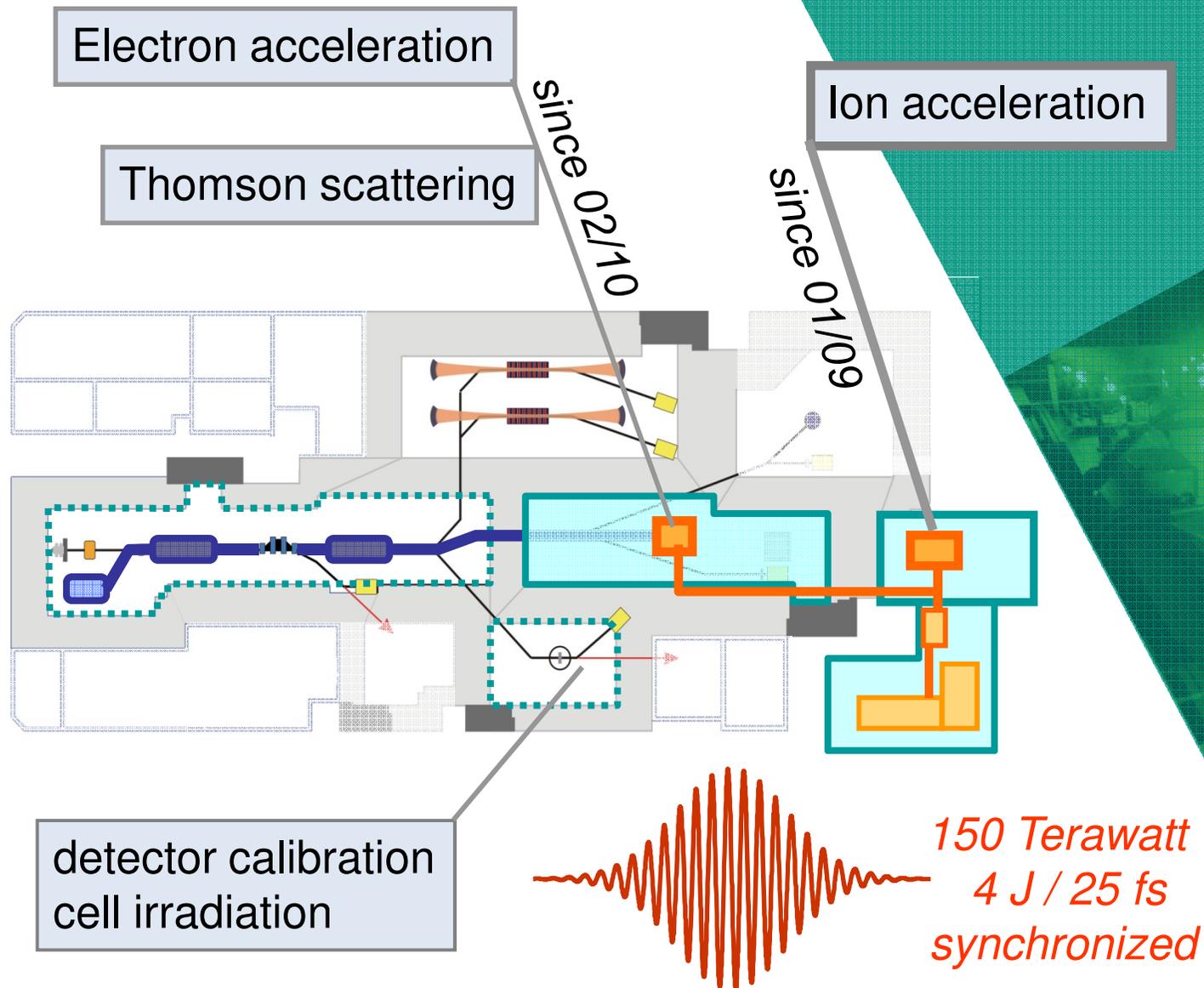
Farmer IC:
30 keV ... 50 MV photons
(10 ... 45) MeV electrons
(50 ... 104) MeV protons





→ No significant influence of the higher peak current (ps pulses) as compared to conventional calibration sources (μs pulses)

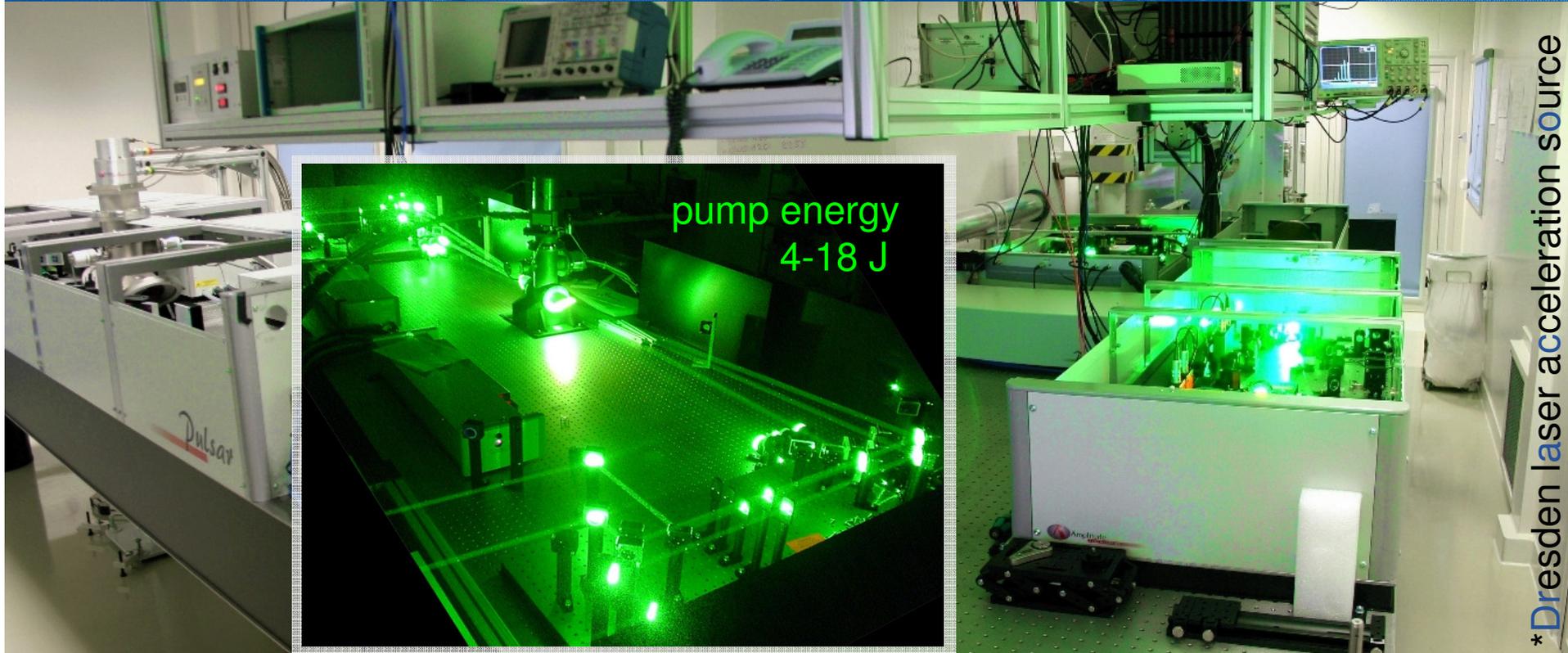
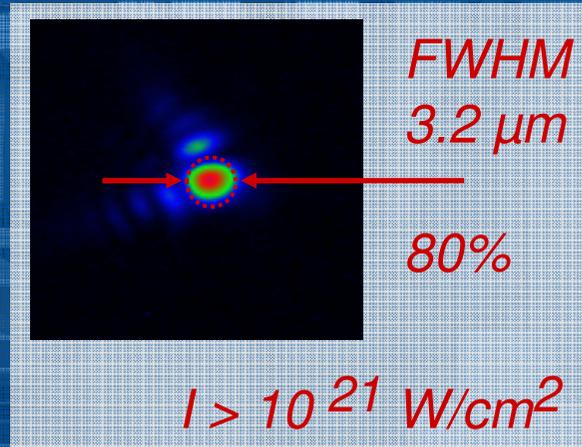
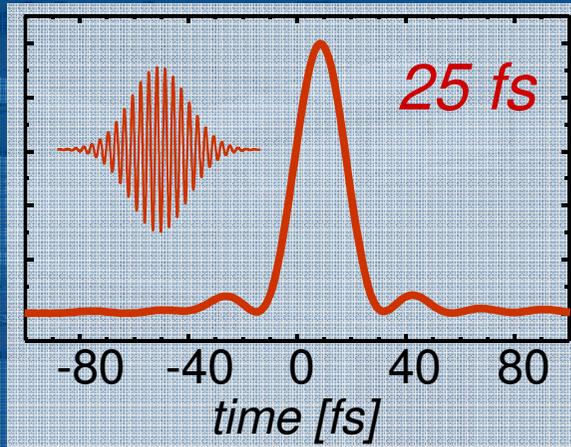
The present 150 TW laser labs @ ELBE



150 TW laser DRACO* @ FZD

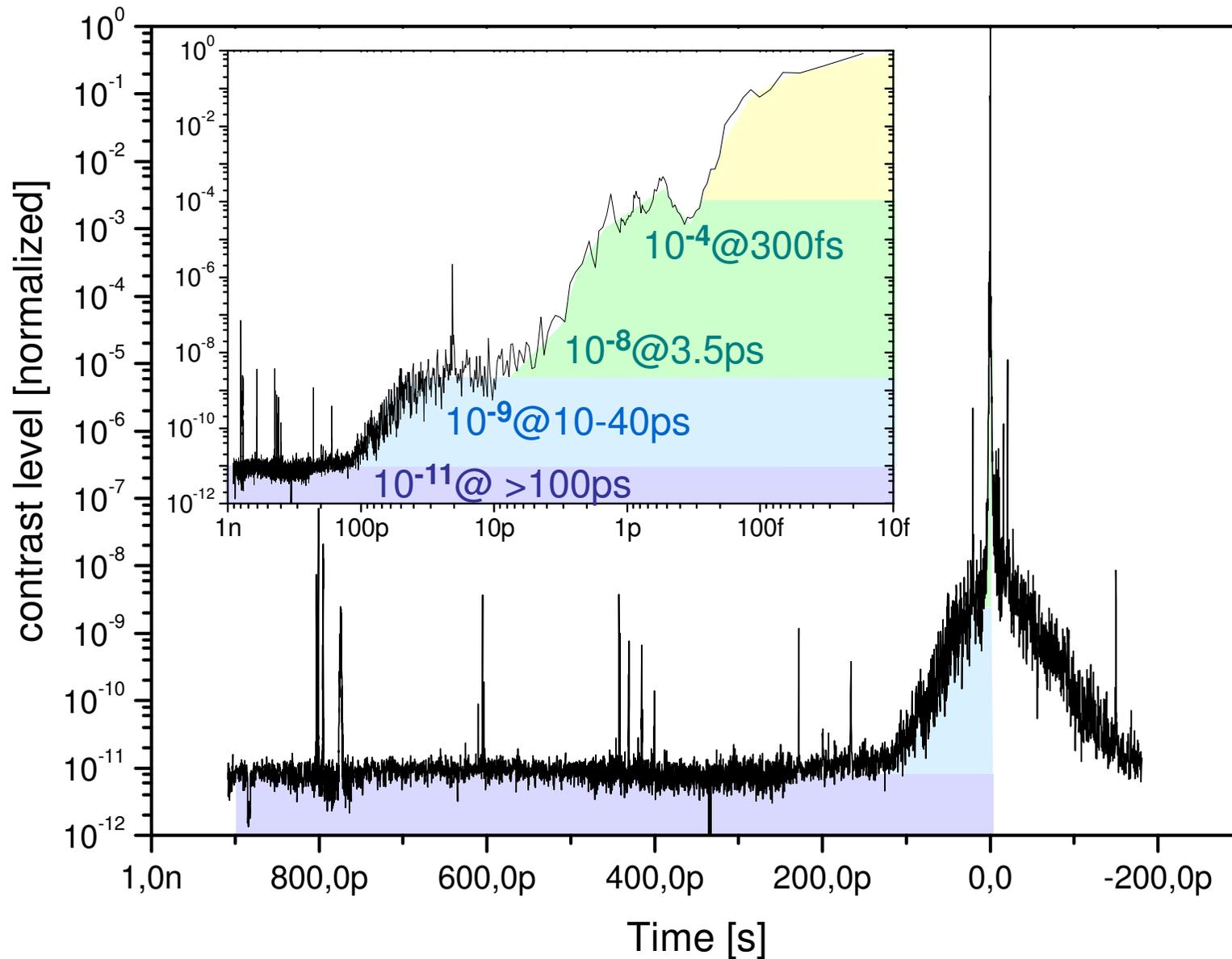


**Ti:Sapphire
CPA laser
>4 J (on target)
10 Hz**

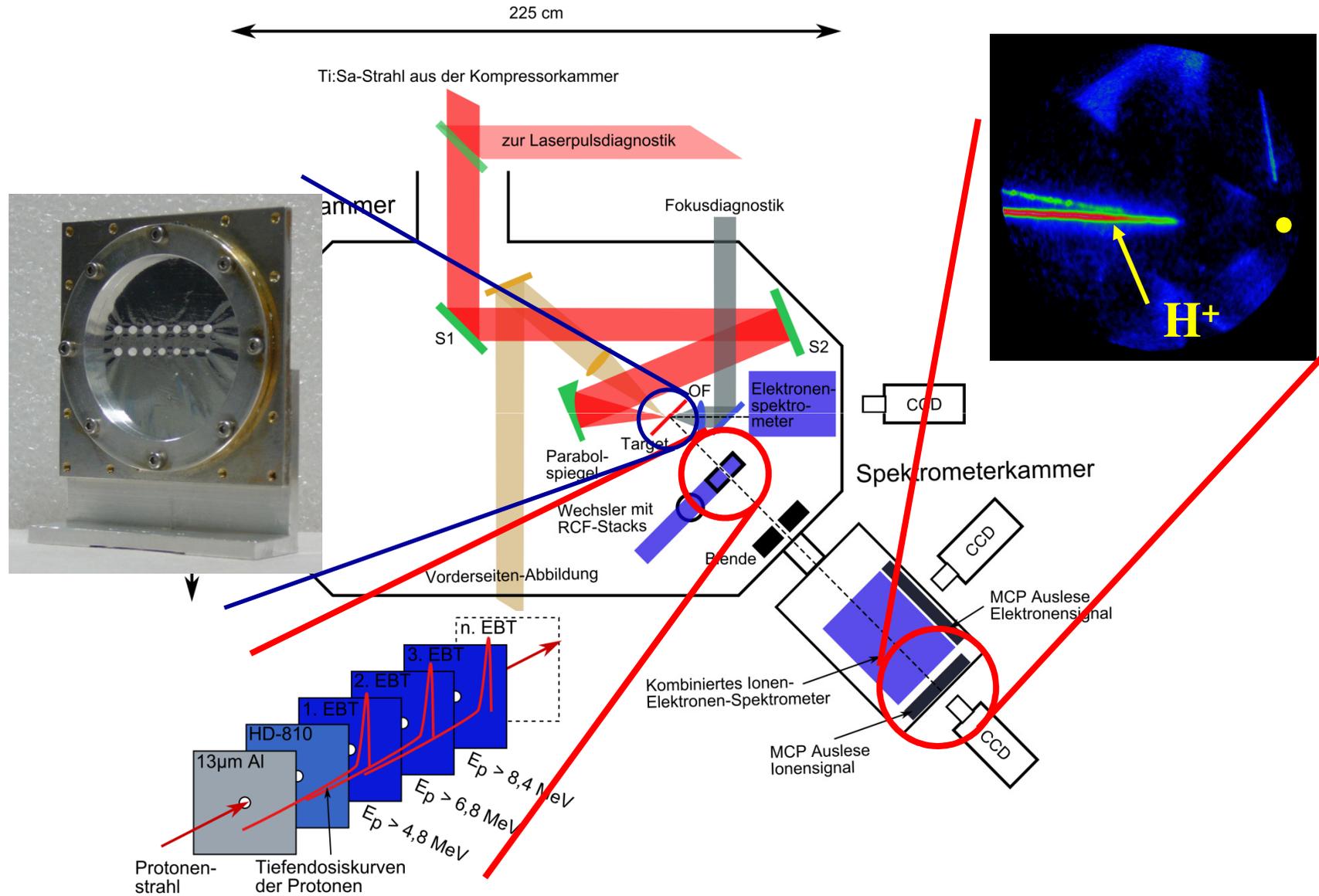


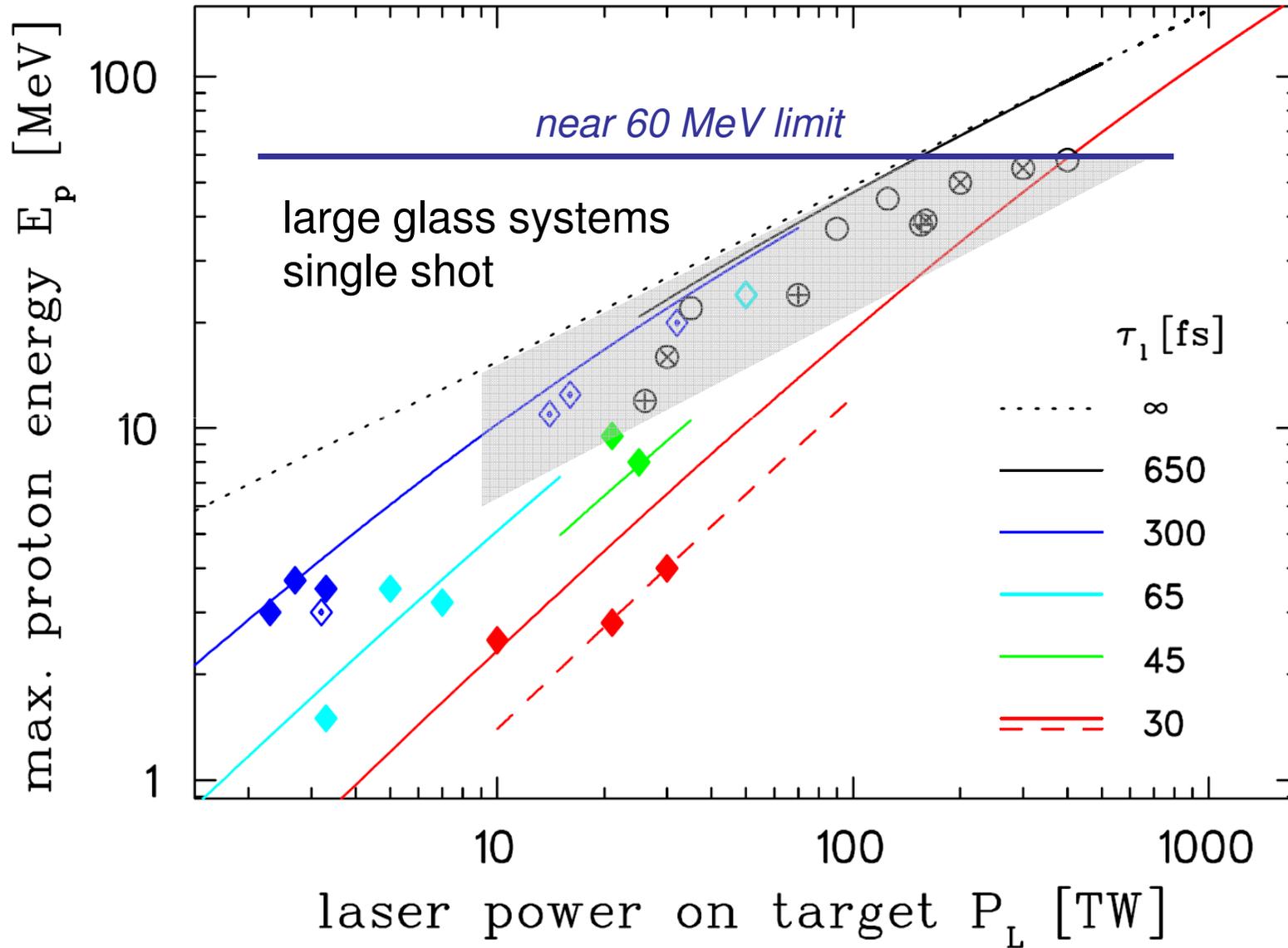
*Dresden laser acceleration source

Pulse contrast (full chain, no plasma mirror)

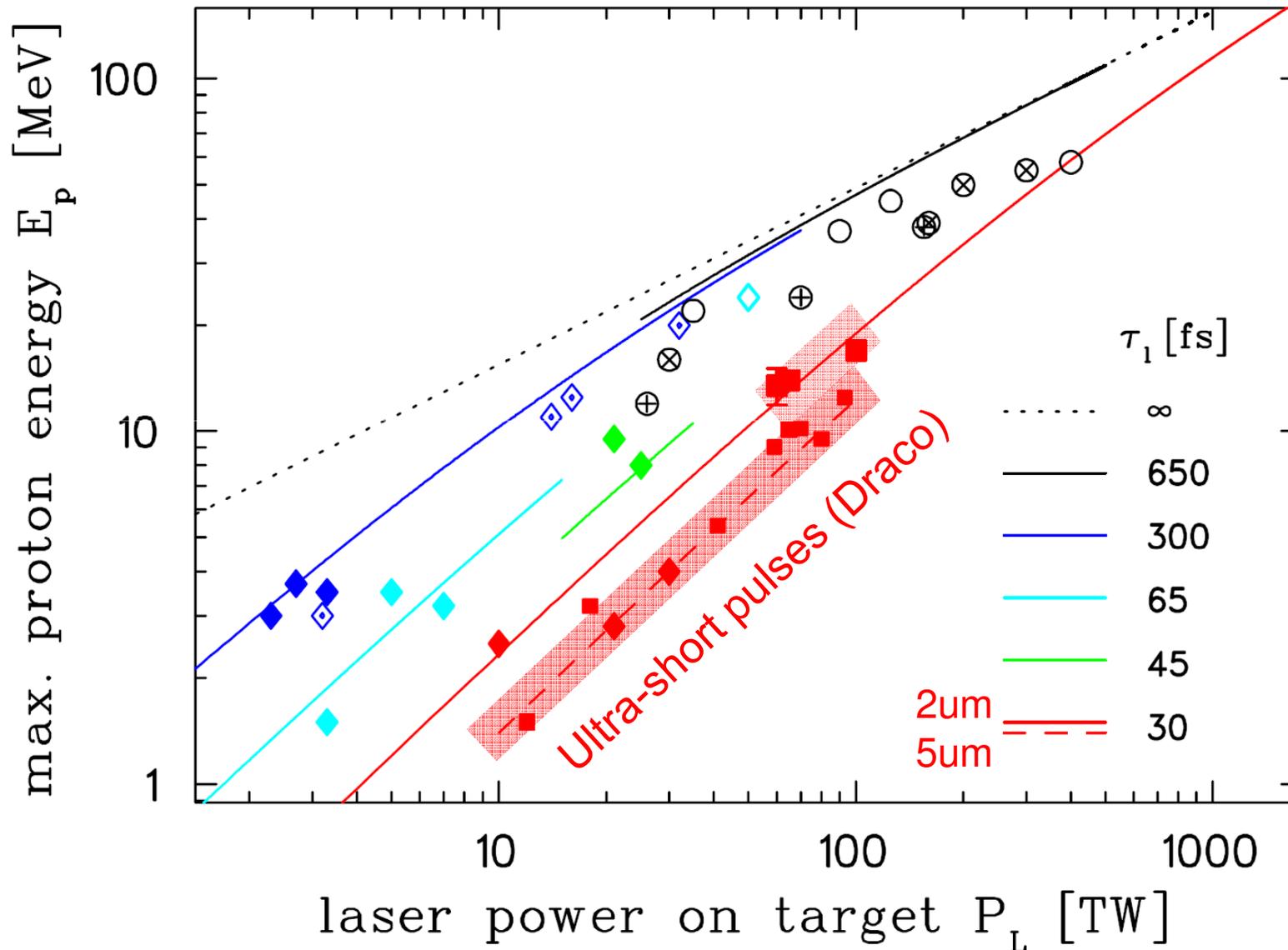


Laser ion acceleration - setup

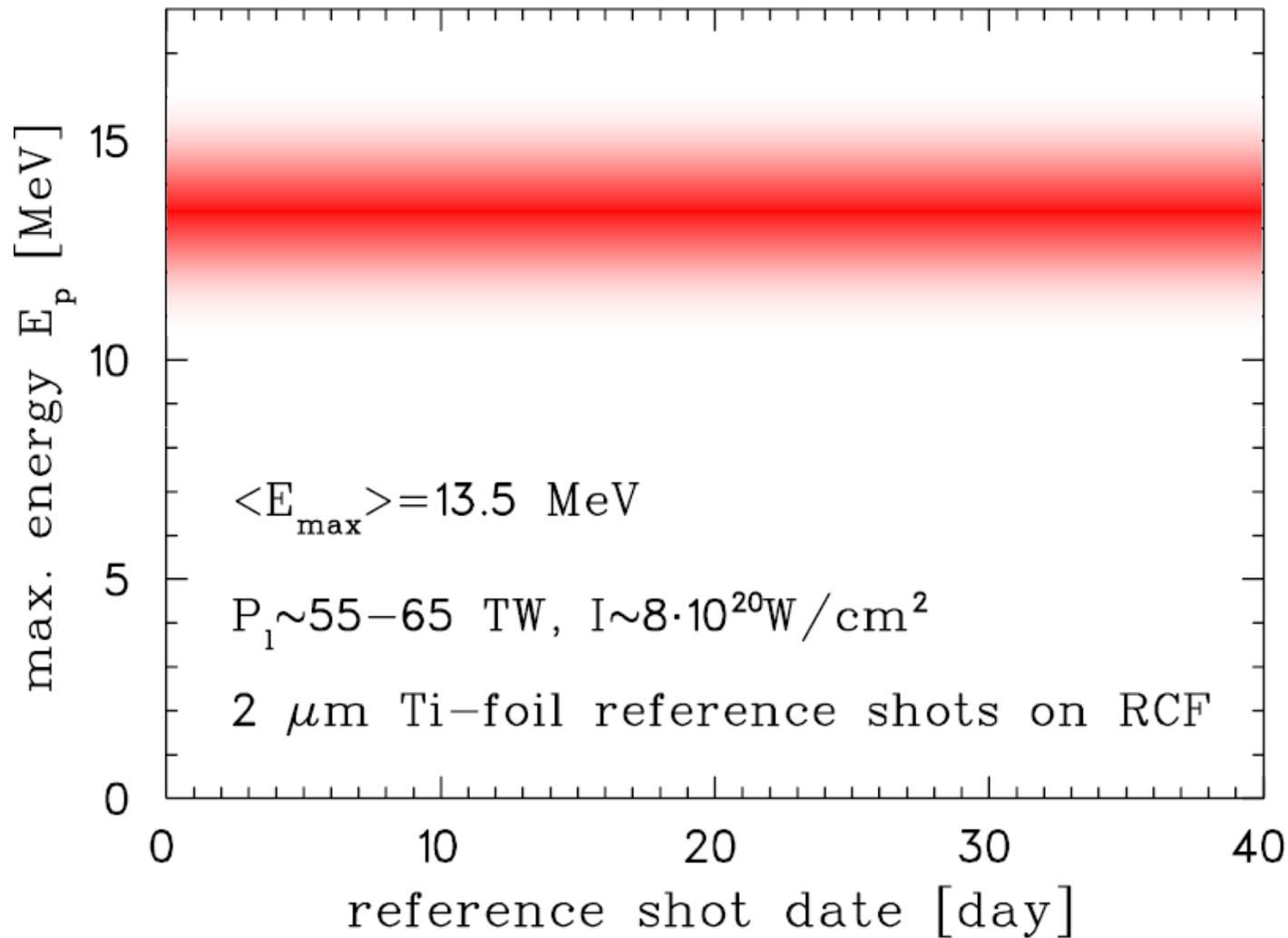


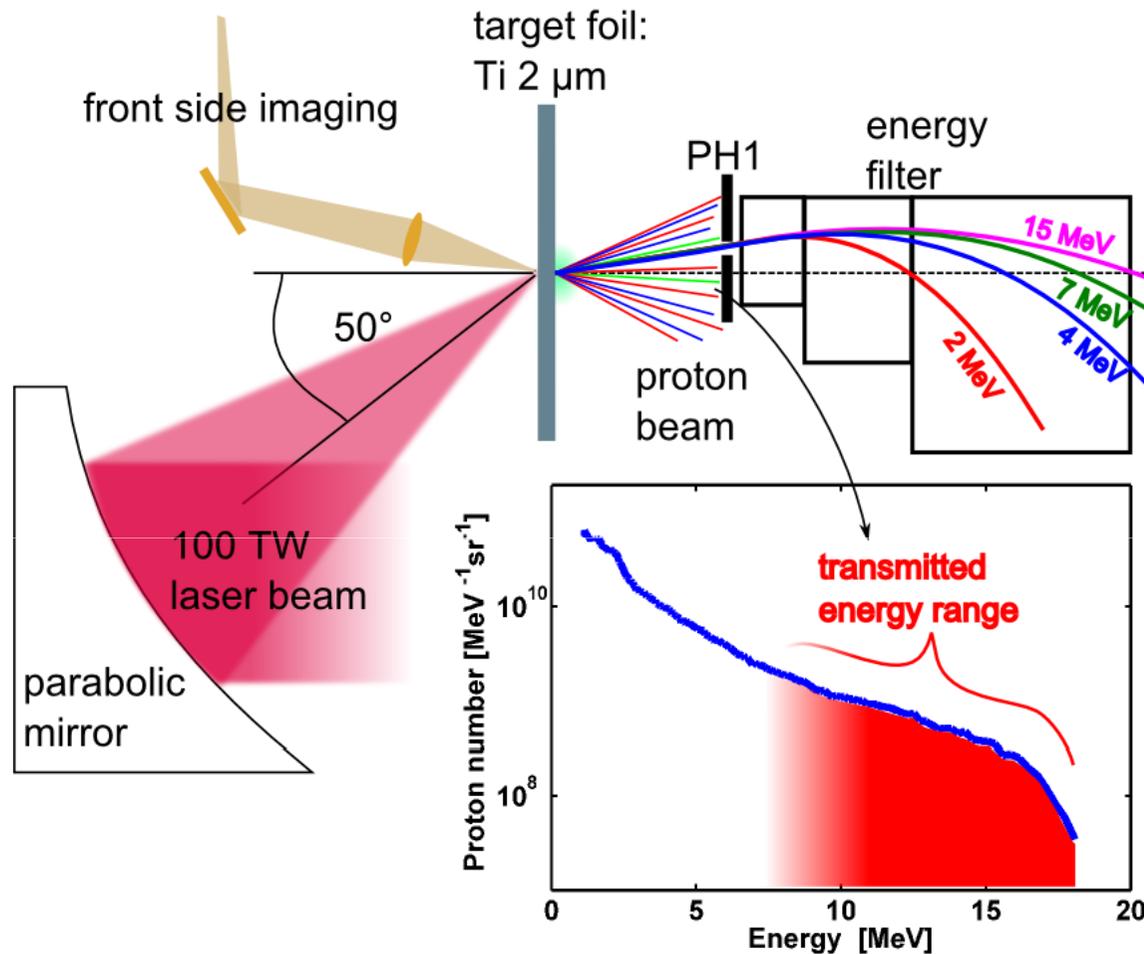


scaling following J. Schreiber, et al., PRL 97, 045005, 2006



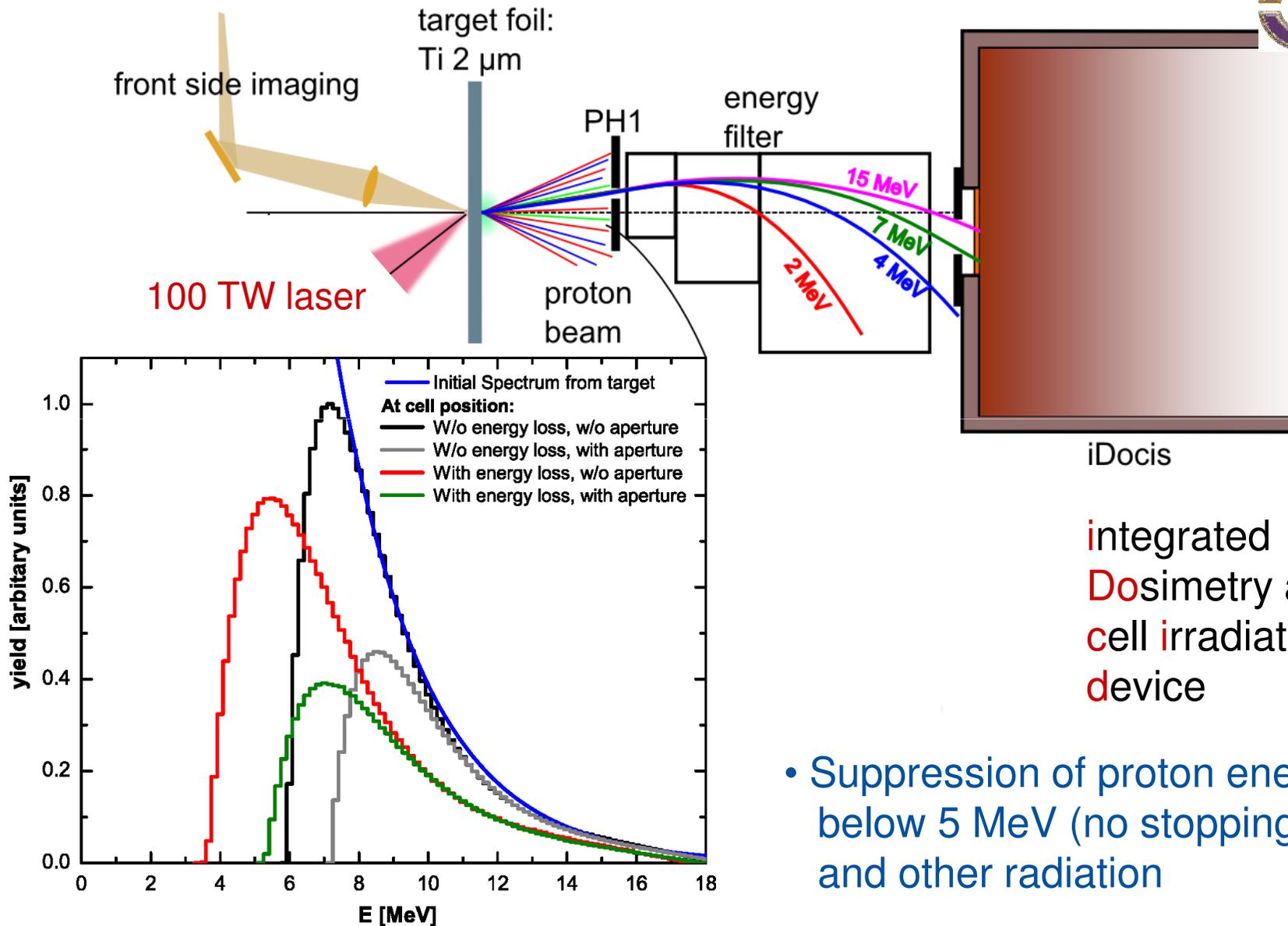
K. Zeil, et al., *New Journal of Physics* 12, 045015 (2010)





- Provision of sufficiently energetic proton pulses for filtering
- Establishment of dosimetry protocol, online and absolute dosimetry

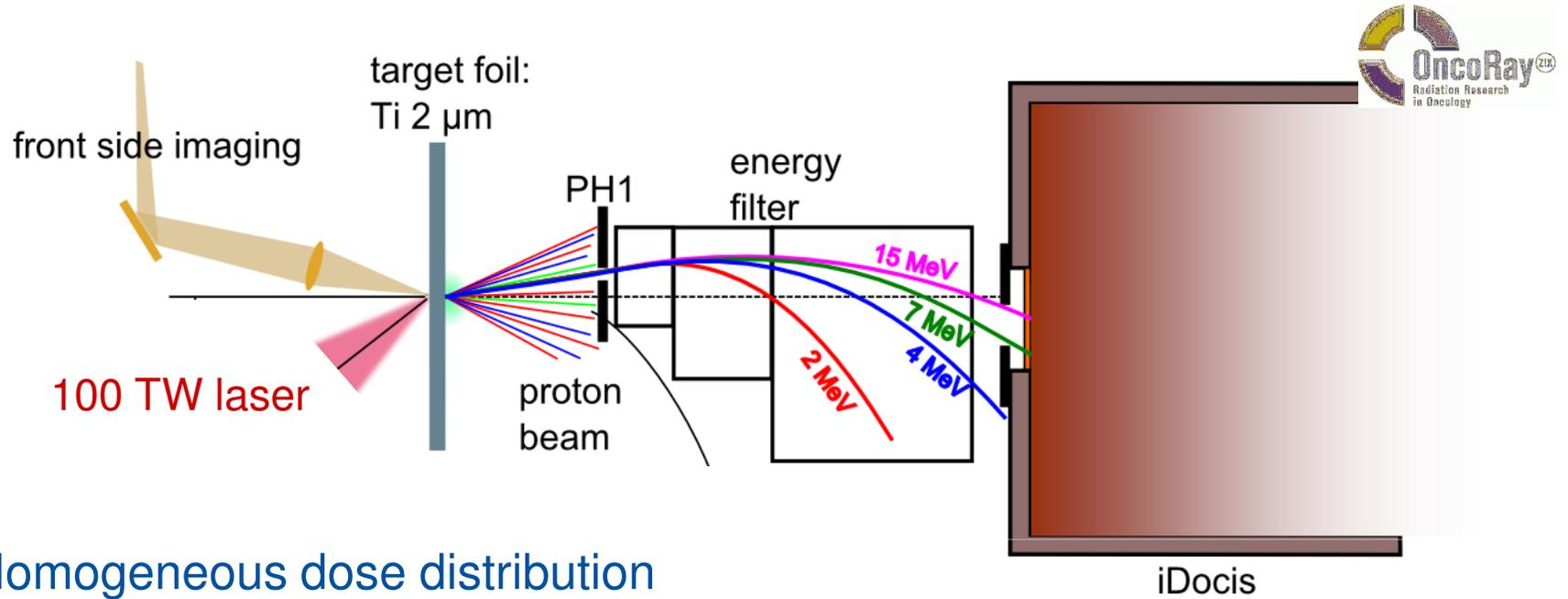
Dose dependent cell irradiation



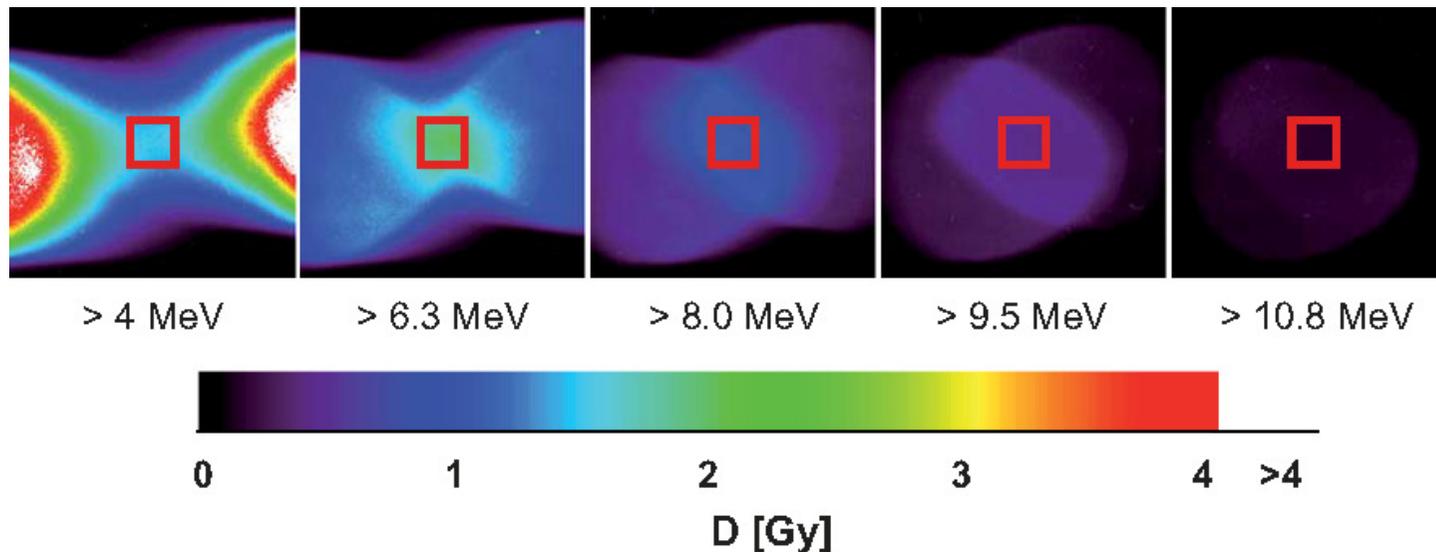
integrated
Do simetry and
cell irradiation
device

- Suppression of proton energies below 5 MeV (no stopping) and other radiation

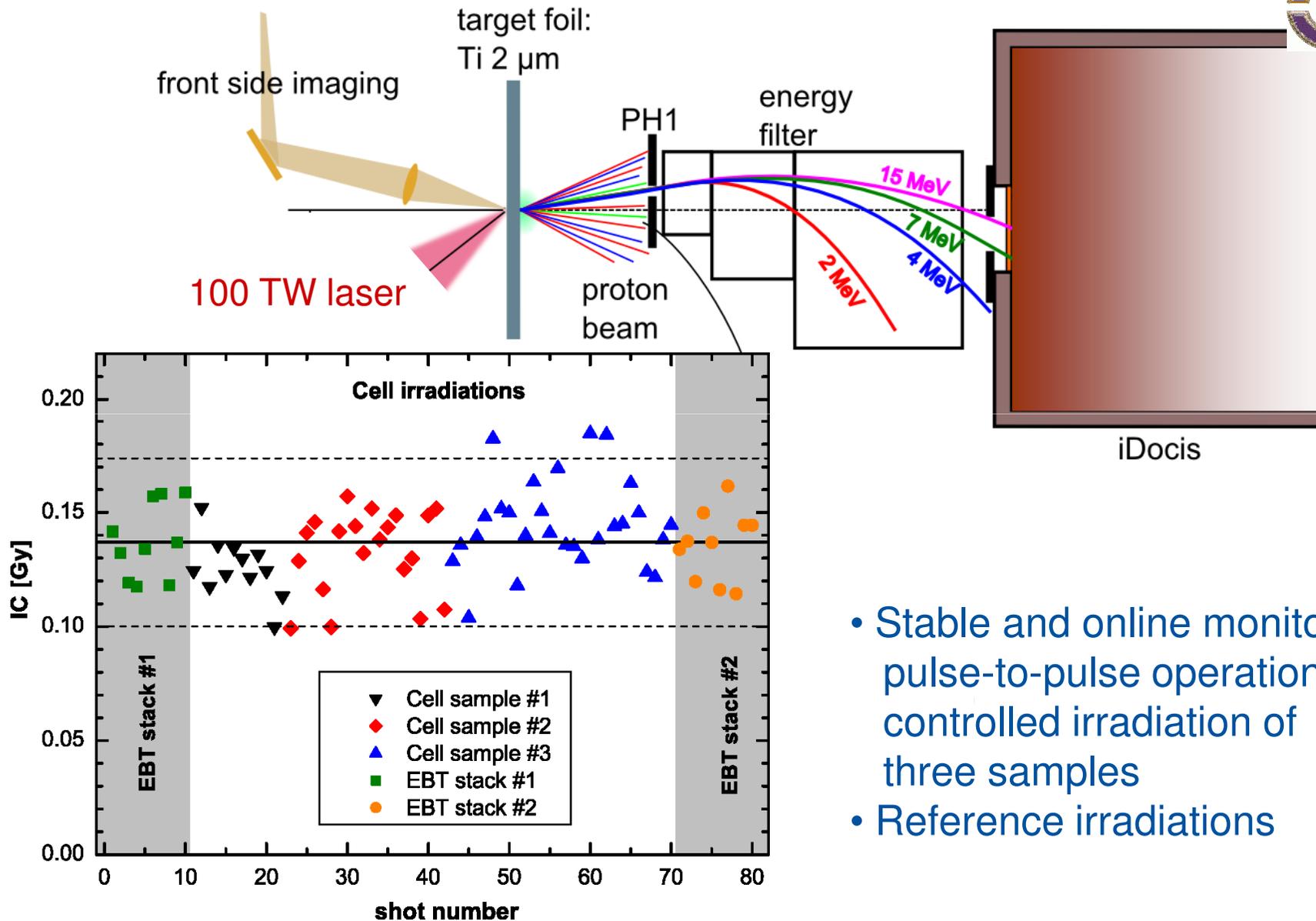
Dose dependent cell irradiation



- Homogeneous dose distribution

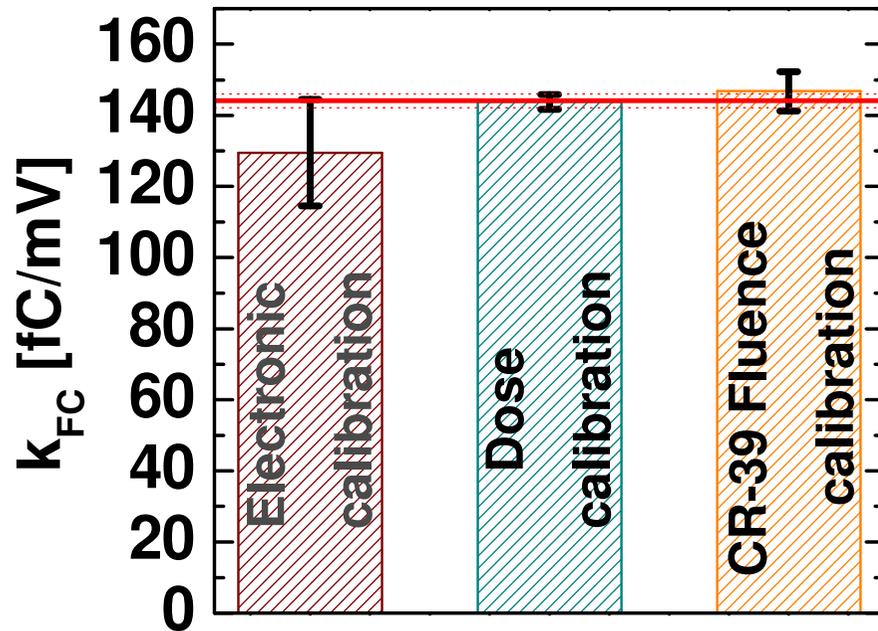


Dose dependent cell irradiation

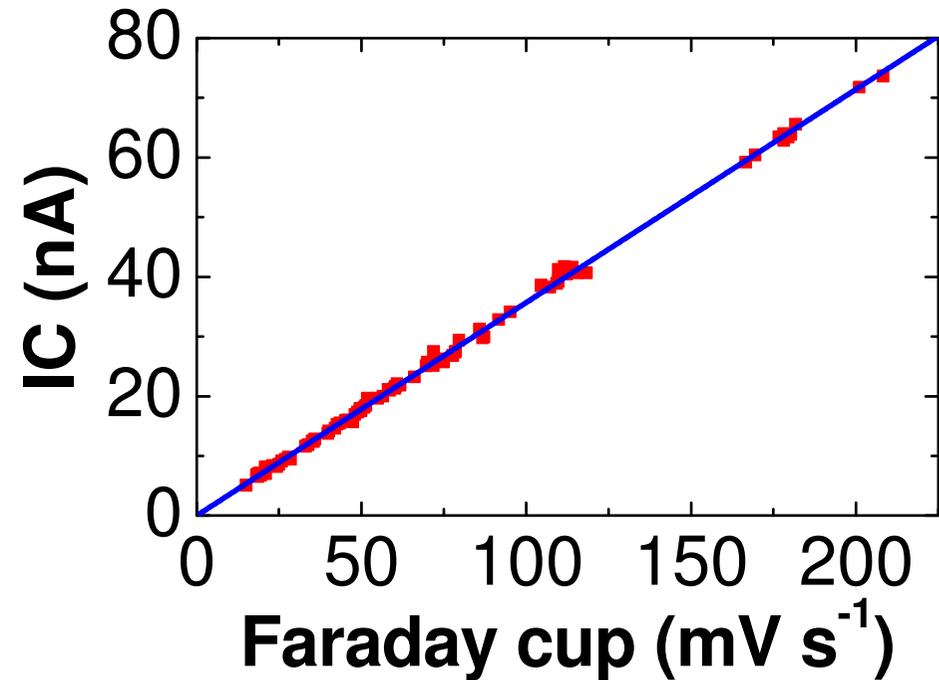


- Stable and online monitored pulse-to-pulse operation for controlled irradiation of three samples
- Reference irradiations

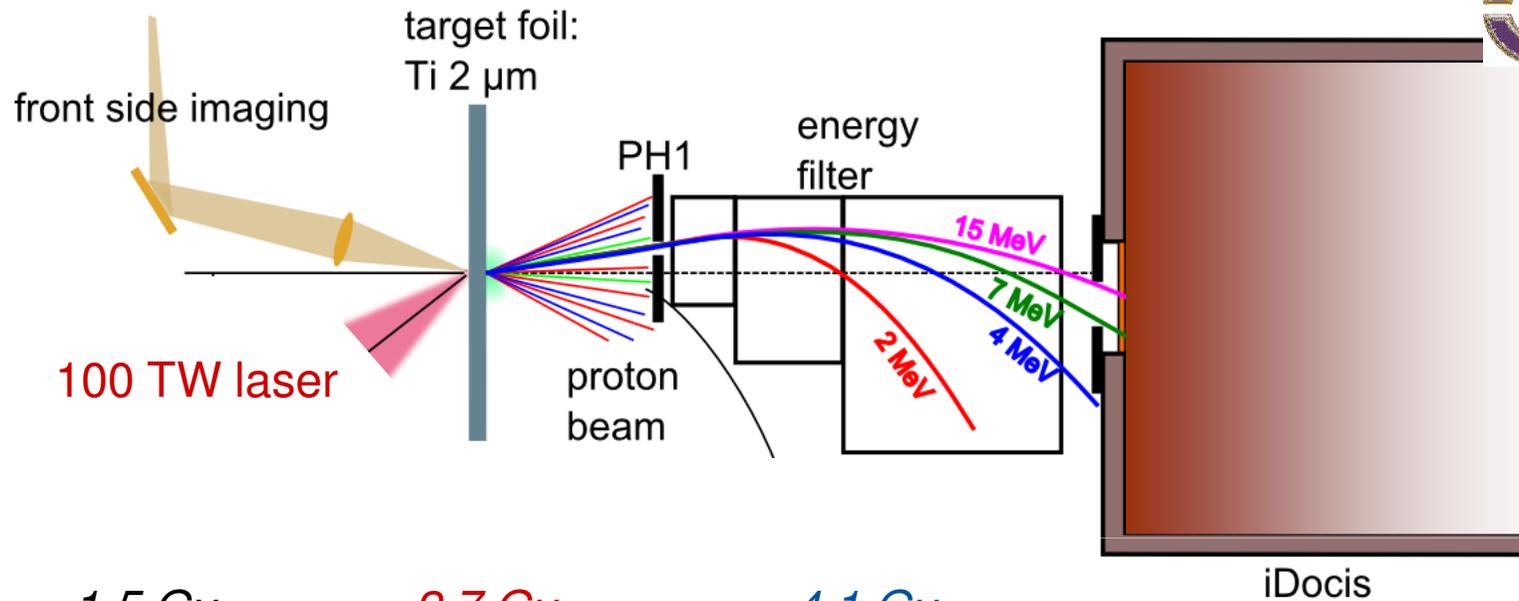
absolute calibration
Faraday cup



Correlation between
online (IC) and absolute
(FC) dosimeter



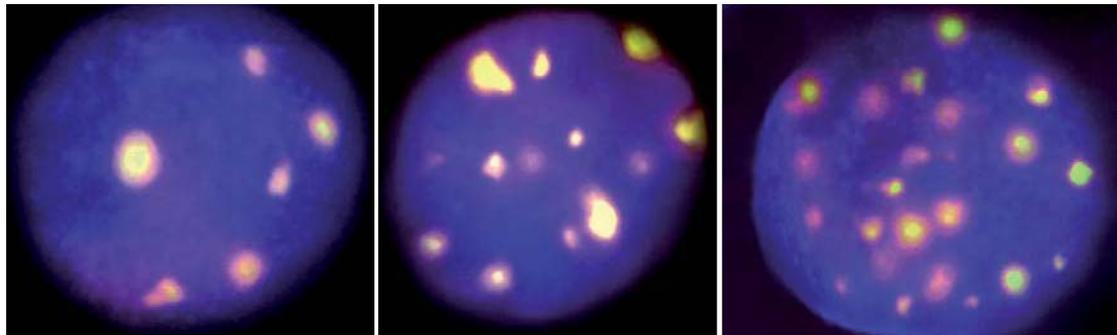
Dose dependent cell irradiation



1.5 Gy

2.7 Gy

4.1 Gy

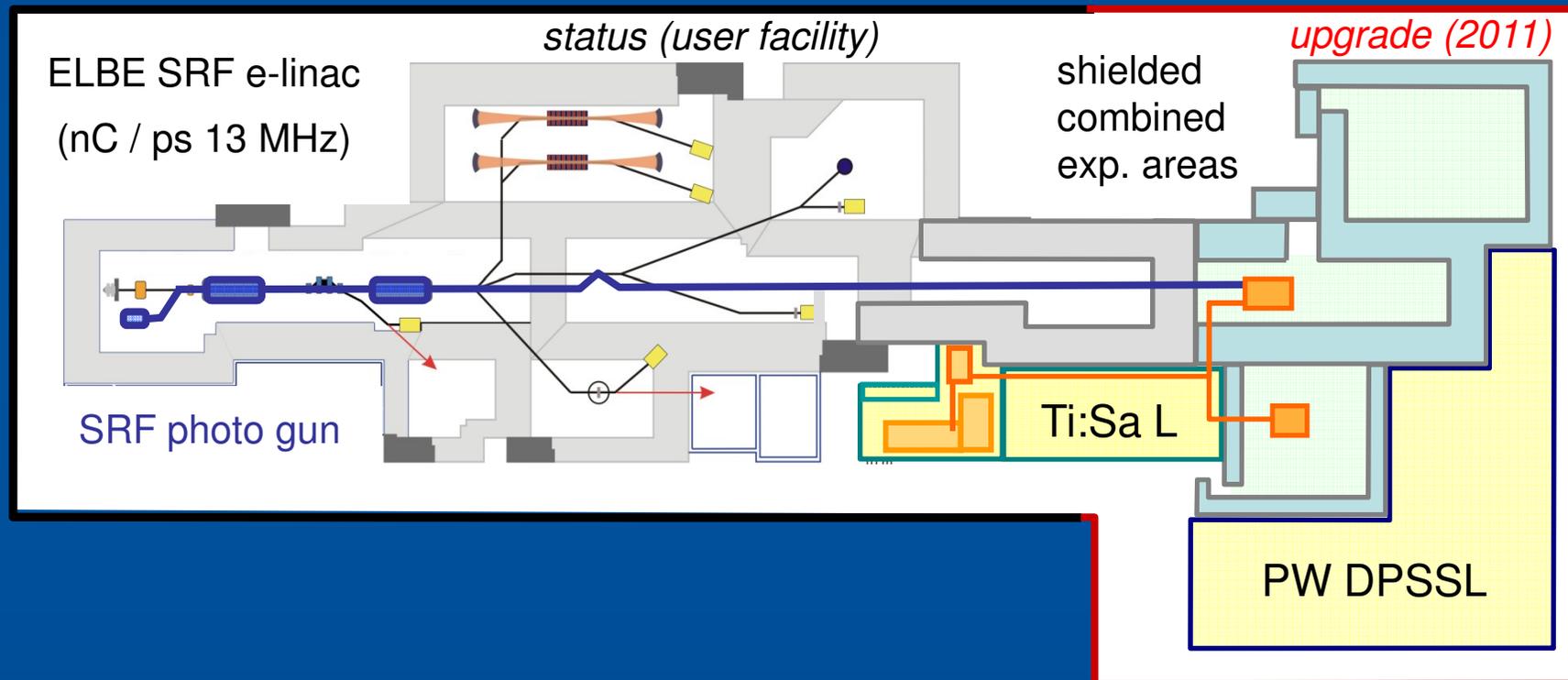


(stained cell nucleus)

- dose dependent cell damage (double-strand break repair activity)
- full-scale radiobiological experiment soon

S. Kraft, et al., *New Journal of Physics* 12 (2010)

- New space for
- PW DPSSL development
 - Ti:Sapphire upgrade
 - Combined exp. areas with ELBE (compressed)



dual approach: **Ti:Sapphire PW class laser** (~30J in 30fs, now 4J in 30fs)
Diode pumped solid state PW laser (~150J in 150 fs, few Hz)



Start of laser plasma activities ~2007



2010



**Forschungszentrum
Dresden Rossendorf**

(multiple filamentation of freely propagating 100 TW beam in air)



... thanks for your attention