With LIGHT to highest ion beam intensities and shortest ion beam pulses

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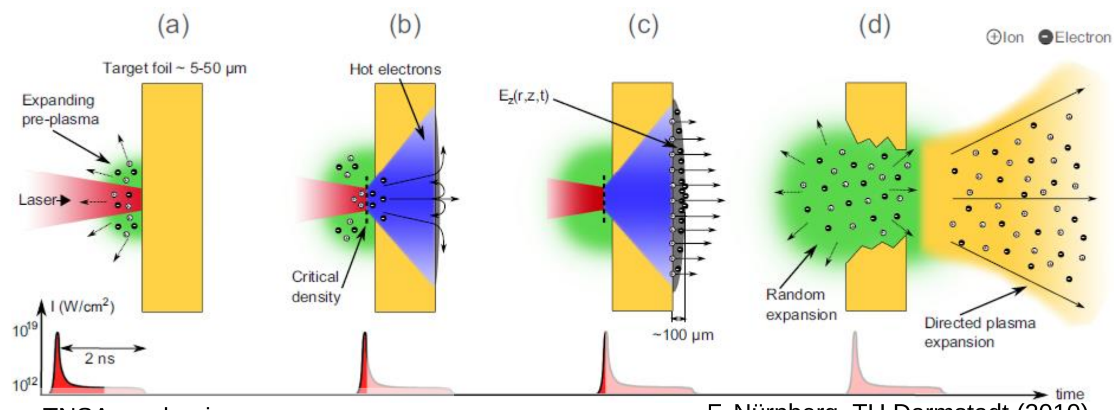
LIGHT

About the project [1,2,3]:

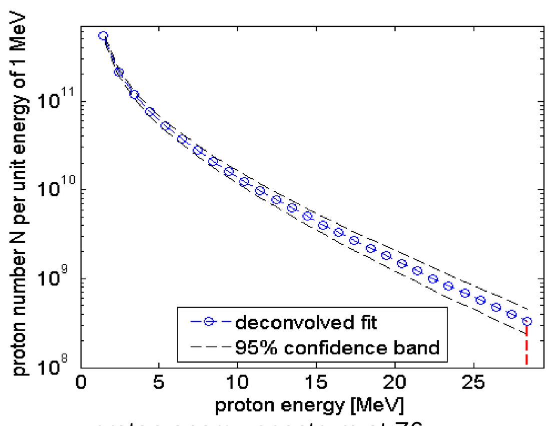
LIGHT stands for Laser Ion Generation, Handling and Transport;
collaboration of TUDa, GSI, Uni Frankfurt, HI Jena, HZDR
proton/ion acceleration driven by the GSI PHELIX laser
beam shaping via conventional accelerator technology

Target Normal Sheath Acceleration (TNSA):

intense ion source: $10^{11} – 10^{13}$ protons in ~ 1 ps
low emittance: < 0.01 mm mrad transversal, 10^{-4} eV s longitudinal [4,5]
huge accelerating field gradients: MV/μm

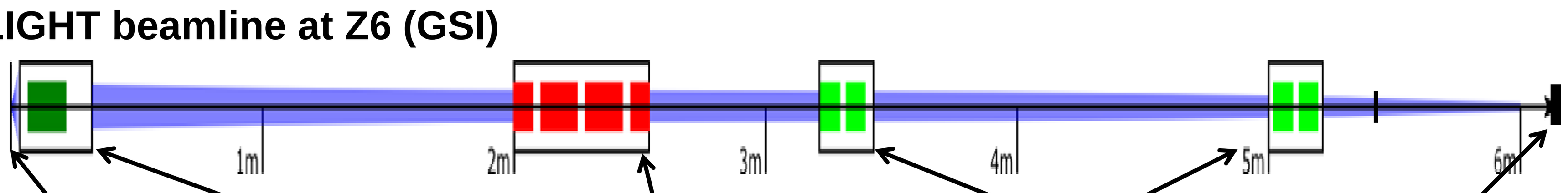


TNSA mechanism
F. Nürnberg, TU Darmstadt (2010)



proton energy spectrum at Z6
S. Busold, TU Darmstadt (2014)

LIGHT beamline at Z6 (GSI)



thin foil: proton acceleration (e.g. 10 μm gold)

solenoid: energy selection via chromatic focusing

rf cavity: rotation in longitudinal phase space

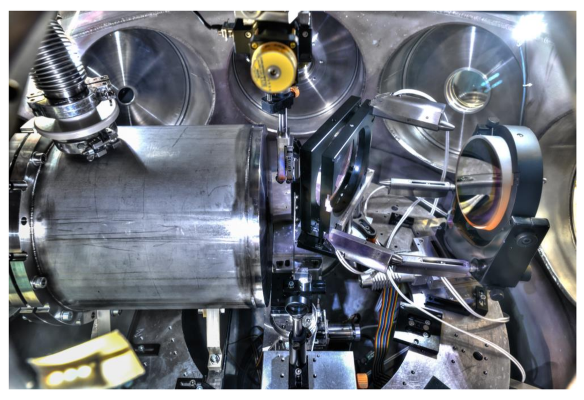
quadrupole doublets: transport

beam diagnostics

energy capture with a pulsed solenoid

pulsed solenoid

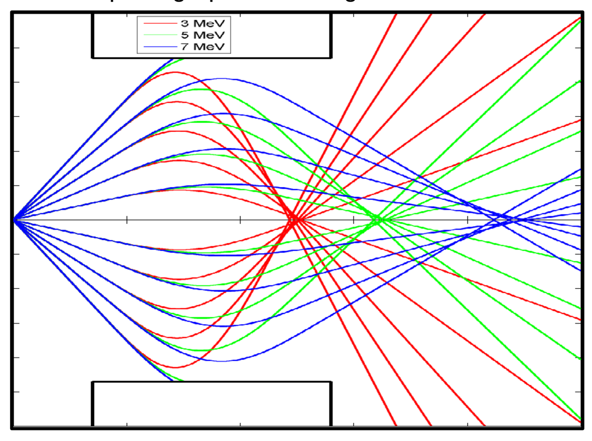
- 40.5 mm clear aperture
- $B_{z,max}$ = 8.7 T
- field characterized and simulated
- discharge time 0.2 ms



photograph of the target chamber

chromatic focusing

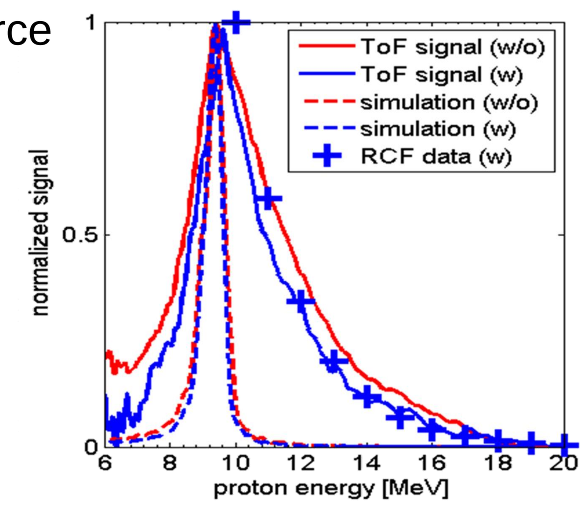
- energy selection by aperture
- B = 7.35 T
- focus at 2.2 m at 9.4 MeV
- $n_p > 10^9$ (9.4 ± 0.5) MeV
- capture efficiency 34%



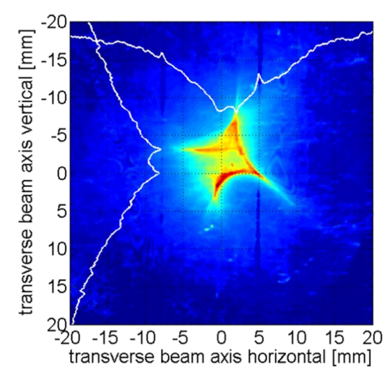
particle trajectories inside the solenoid

experimental results

- proton bunch at 2.2 m to source
- ToF and dose measurement
- full bunch characterization



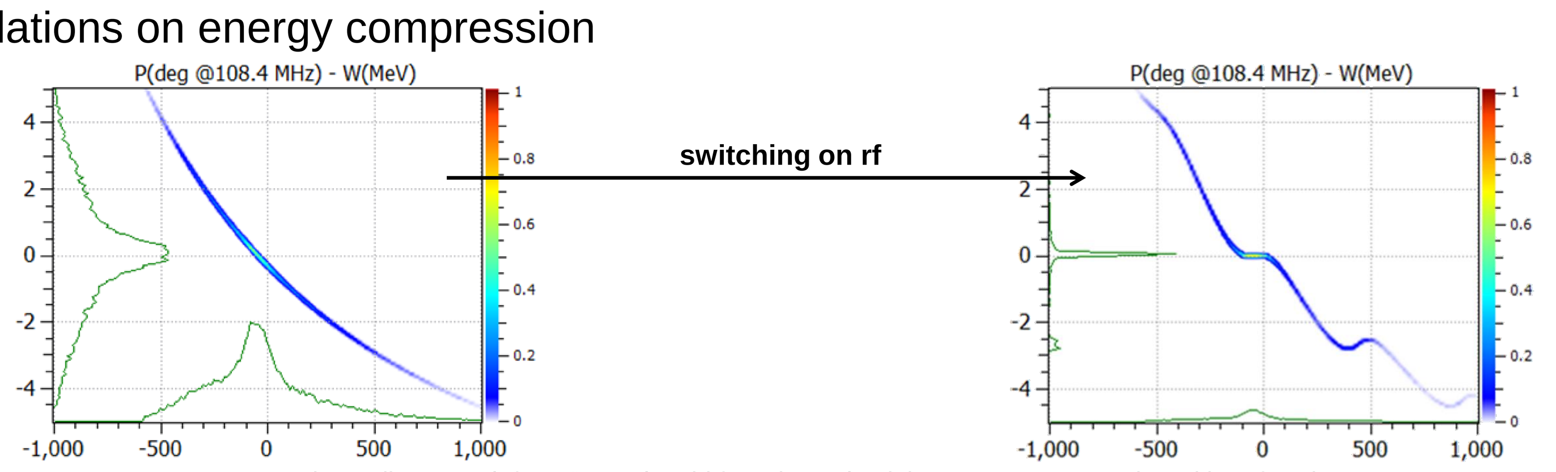
proton bunch at 2.2 m to source



transverse beam profile

energy compression with a rf cavity

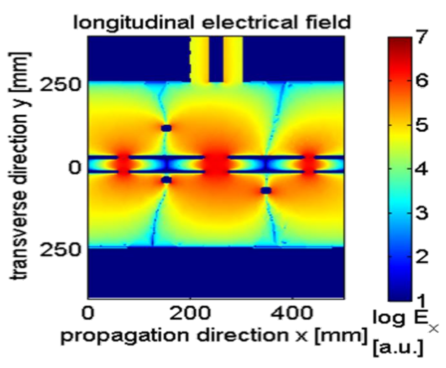
simulations on energy compression



energy phase diagrams: left: at 3 m solenoid focusing only; right: energy compression with a rf cavity.
S. Busold, TU Darmstadt (2014)

double spiral resonator:

- rf power > 200 kV
- 3 gaps
- acceleration voltage ± 1 MV
- 108.4 MHz
- injection into rf at -90° synchronous phase

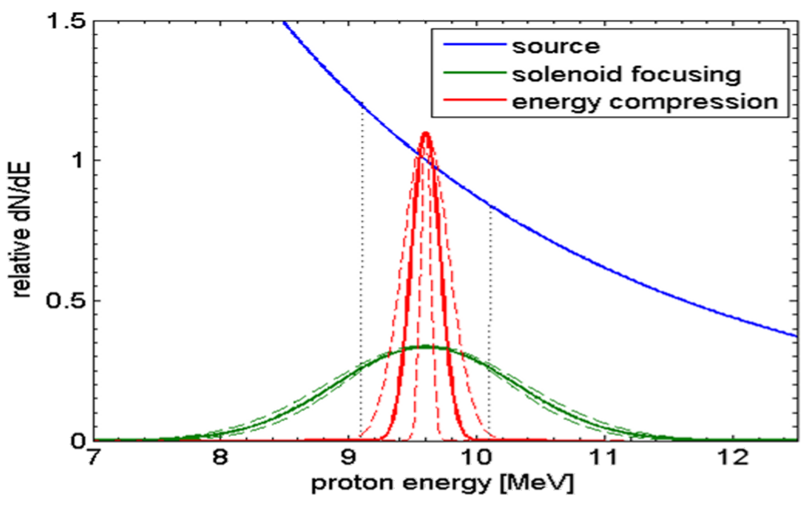


electric field of rf cavity

photograph of rf cavity

experimental results

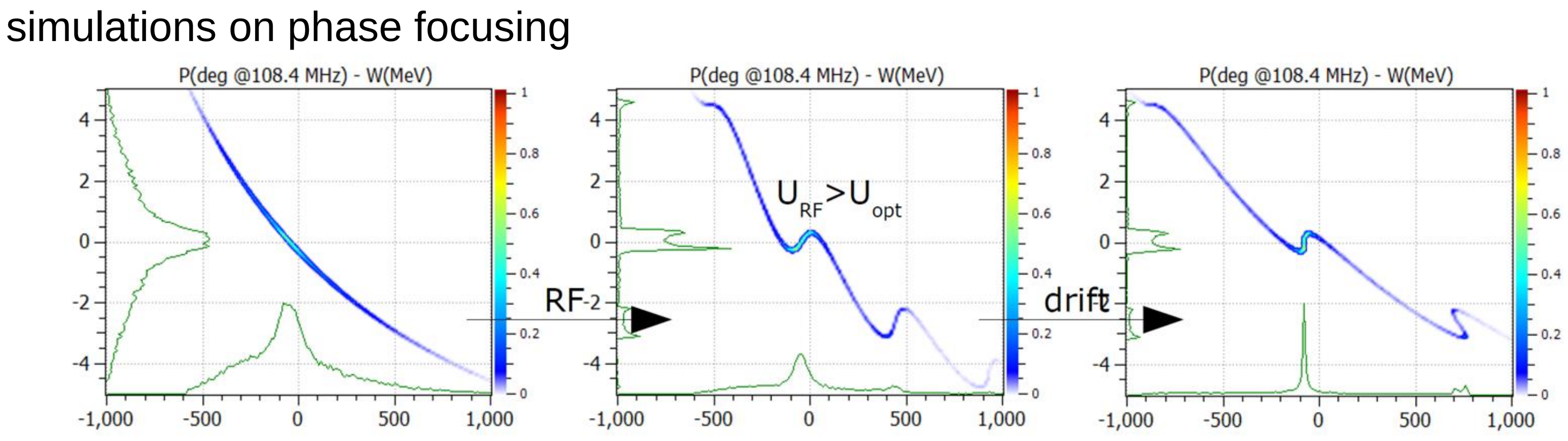
- measurement with RCF and spectrometer
- $\Delta E/E_0$ = 2.7% ± 1.7%
- $n_p = 1.7 \times 10^9$ ± 15%



energy compression at 3 m

phase focusing with the rf cavity

simulations on phase focusing

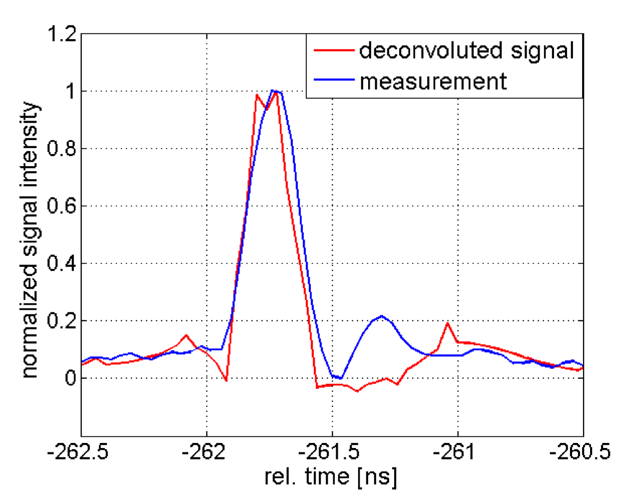


energy phase diagrams: left: at 3 m solenoid focusing only; middle: at 3 m cavity turned on; right: at 6m short ion bunch.
S. Busold, TU Darmstadt (2014)

Detector for short proton pulses:

pcCVD diamond detector (13 μm thick, 1 mm radial area, impedance matching for fast readout)

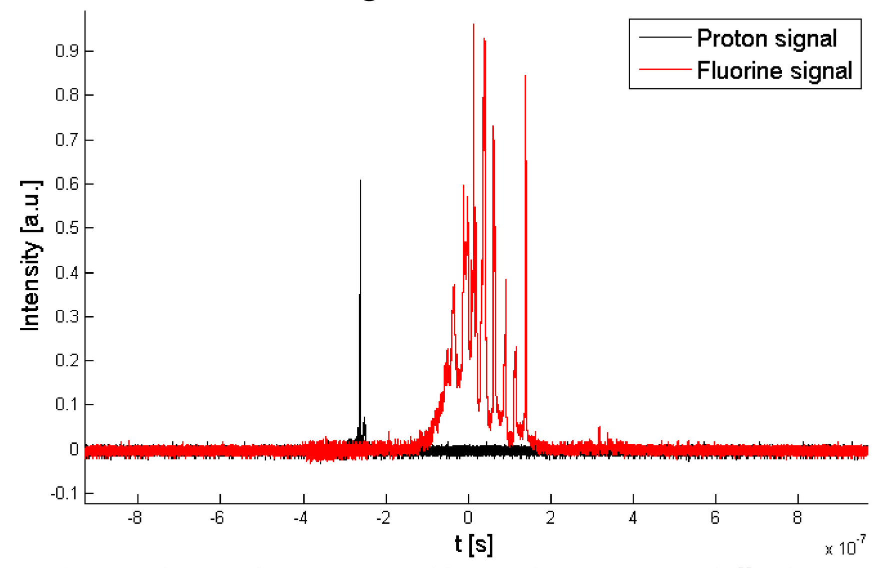
Phase focussing of 8 MeV/u Protons



Real pulse length at 6 m:

- convolution of a Gaussian pulse profile with detector response function
- np = 5×10^8 in a pulse length of **209±18 ps**
- I = 1×10^9 1/ns ≈ 160 mA

Phase focussing of 0.95 MeV/u F^{7+}



Generation and Transport of heavy Ions successfully demonstrated!

- formation of multitude of peaks due to bunching in cavity
- energy/u and particle numbers lower as for protons because of overall lower generation efficiency

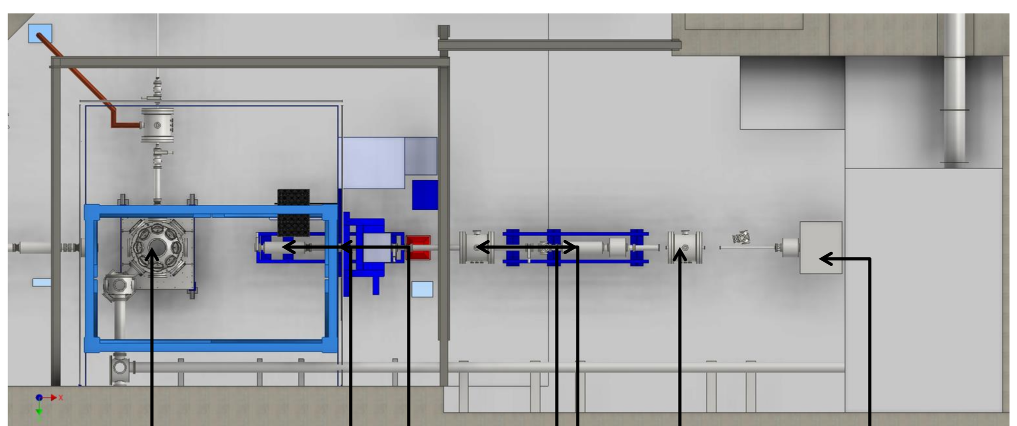
outlook

2017

Further improvement of heavy ion beam
mproving on homogenity of proton beam (high energy feature)

2018

Reconstruction of the LIGHT experimental area



References:

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[2] S. Busold et al., *Focusing and transport of high-intensity multi-MeV proton bunches from a compact laser-driven source*, PR-STAB **16**, 101302 (2013)

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