# LIGHT – a laser-driven proton beamline

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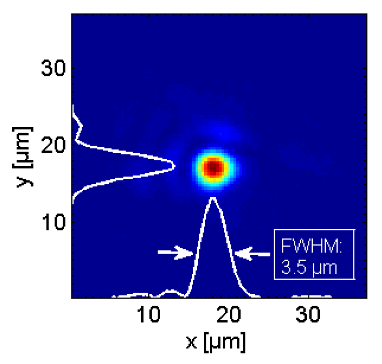
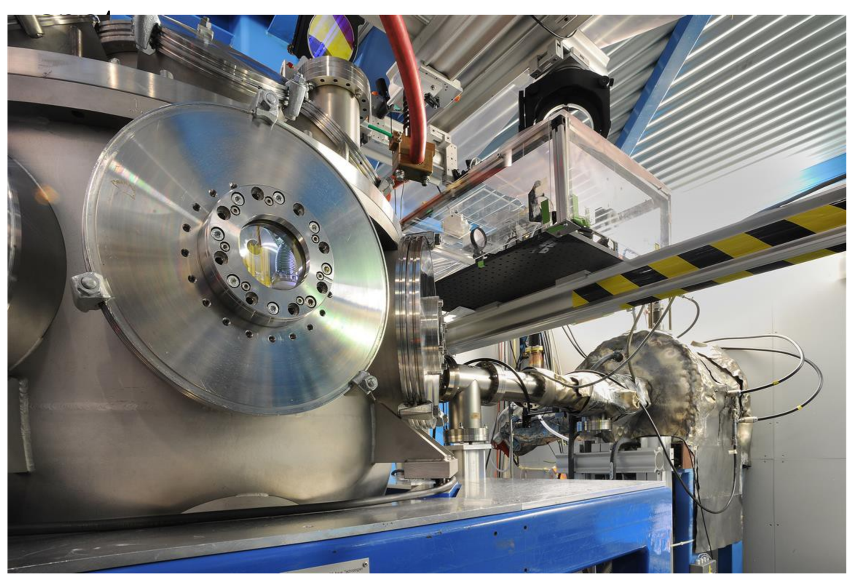
## LIGHT#

**LIGHT collaboration [1]:**
setting up a test stand for shaping laser-driven ion beams and merging these novel ion sources with conventional accelerator technology

**PHELIX 100 TW beamline at Z6:**
· on-shot laser diagnostics
· laser parameters: 15 J on target, 650 fs, 3.5 x 3.5 $\mu$m² focal

laser focal profile

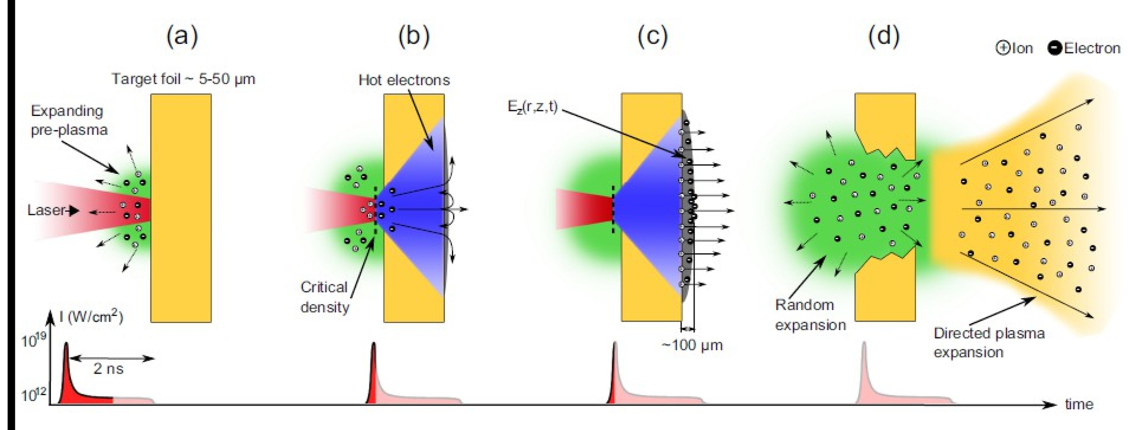


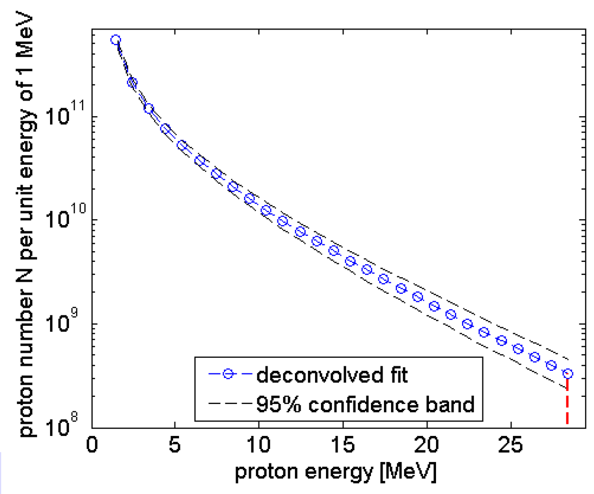



**LIGHT works on...**
· laser beam shaping [2]
· laser contrast control [3]
· target optimization
· ion capture and transport [4]
· simulations [5,6]
· post-acceleration scenarios [7]
· diagnostic development

$10^{10}$ protons in a few ns with E = 10 MeV and ΔE < 3%

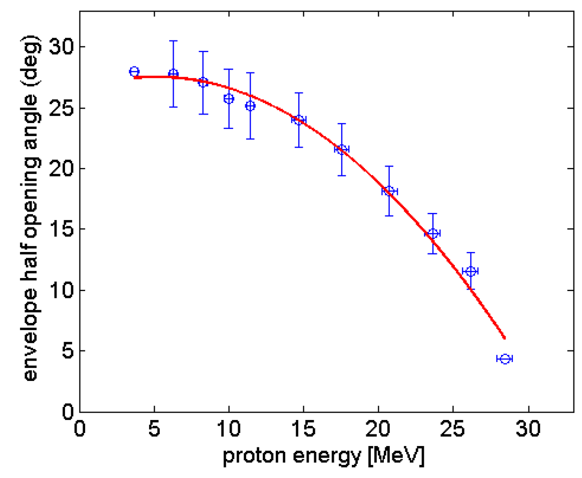
## the TNSA source

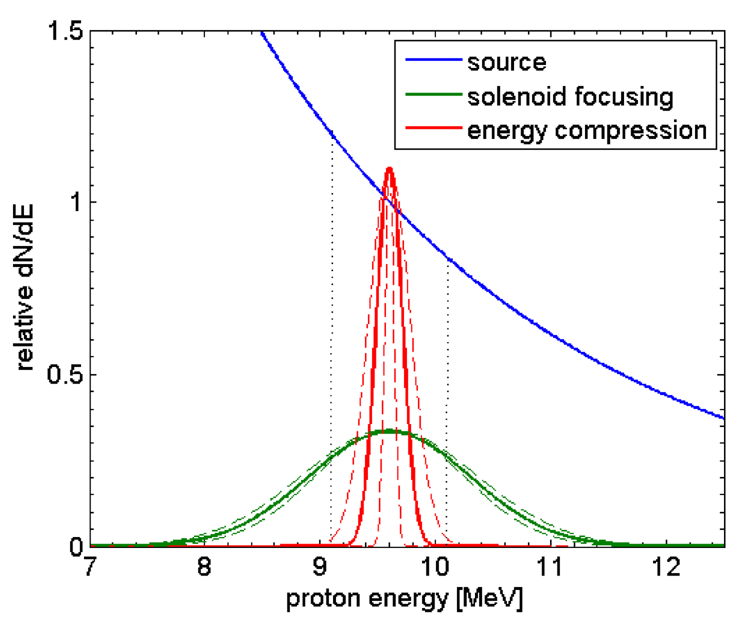



**target normal sheath acceleration (TNSA, [8]):**
· intense, low emittance [9] particle (proton) source
· continuous exponential spectrum
· large envelope divergence >25 deg half opening angle

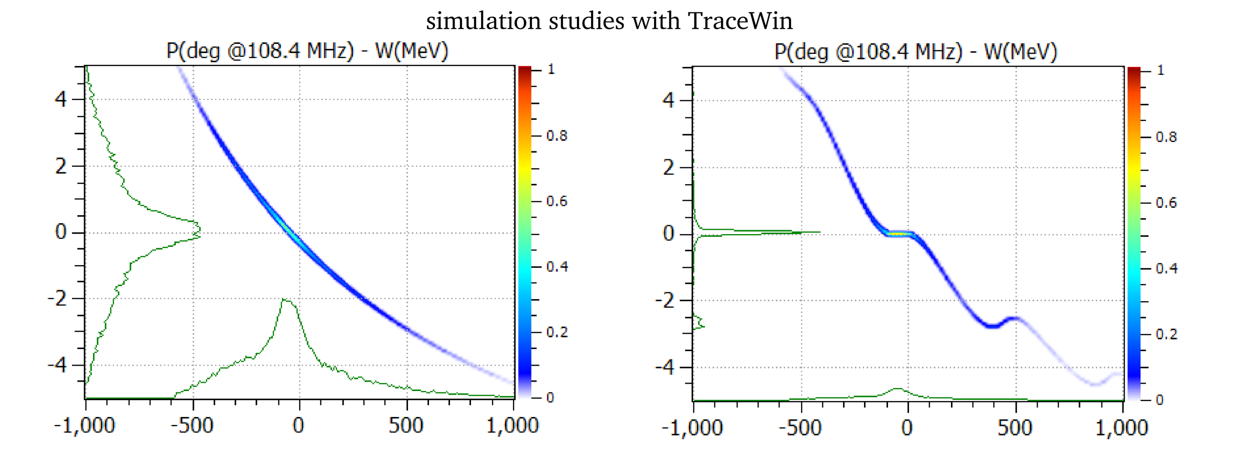
**source parameters at Z6:**
· proton cut-off energy >25 MeV
· >$10^{10}$ protons in ΔE = (10±0.5) MeV
· still large shot-to-shot fluctuations



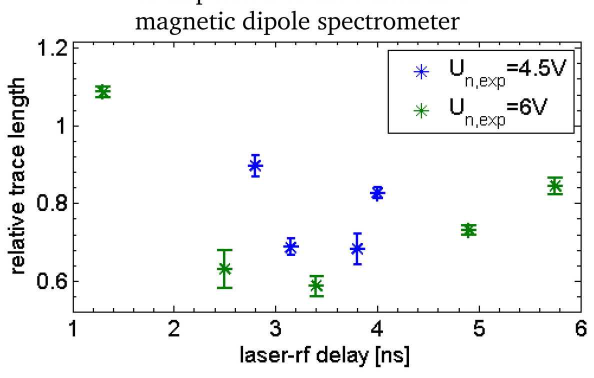




## energy compression

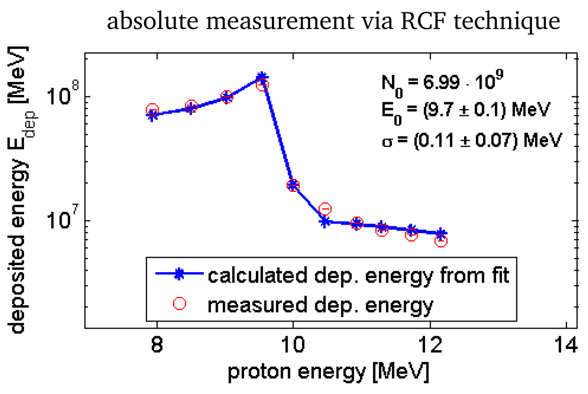
simulation studies with TraceWin

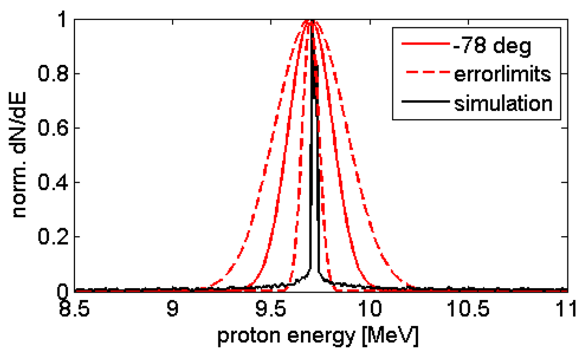



defining synch. phase $\phi_s$=-90 deg via dispersion of the bunch in a magnetic dipole spectrometer




absolute measurement via RCF technique

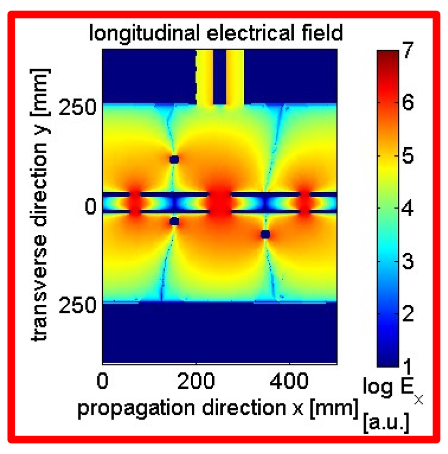


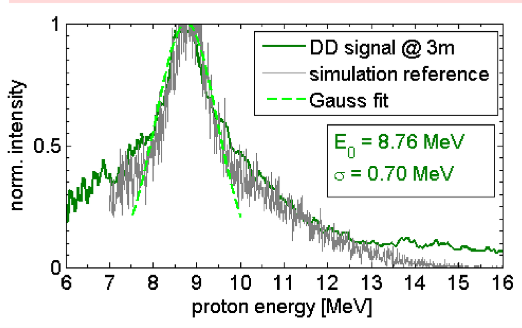

**injection at $\phi_s$=-90 deg [12]:**
· optimum energy compression
· energy spread: (2.7±1.7)%
· 1.7 x $10^9$ (±15%) protons
· (9.7±0.1) MeV energy

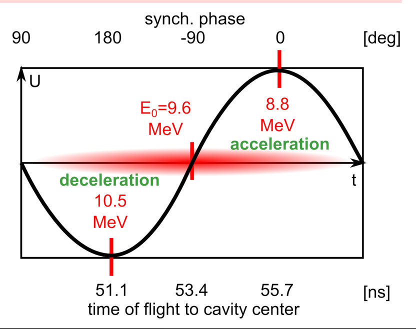
**synchronization:**
· ±0.3 ns / ±12 deg in advance
· ±0.05 ns / ±2 deg on-shot

**rf cavity:**
· 108.4 MHz, 3 gaps
· approx. 1 MV at 100 kW rf power

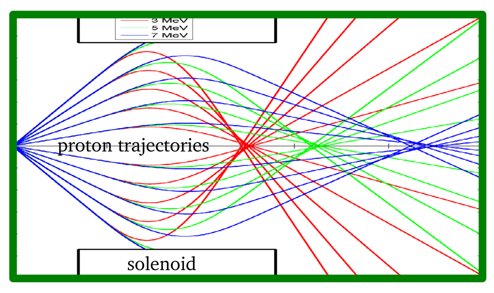



**proton bunch at 3 m to source:**
· transverse profile: 15 x 15 mm² (FWHM)
· bunch duration: 8.6 ns (FWHM)
· energy spread: (18±3)%
→ input for simulation studies (TraceWin)



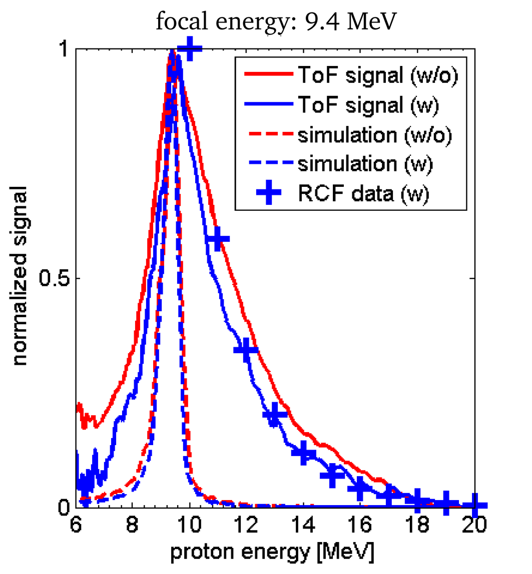



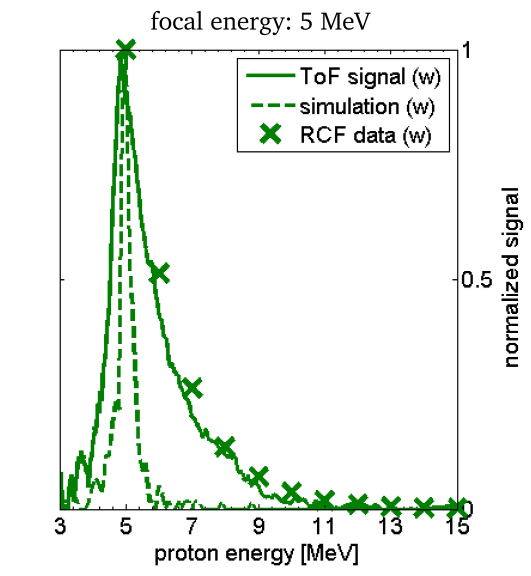

## beam capture and transport

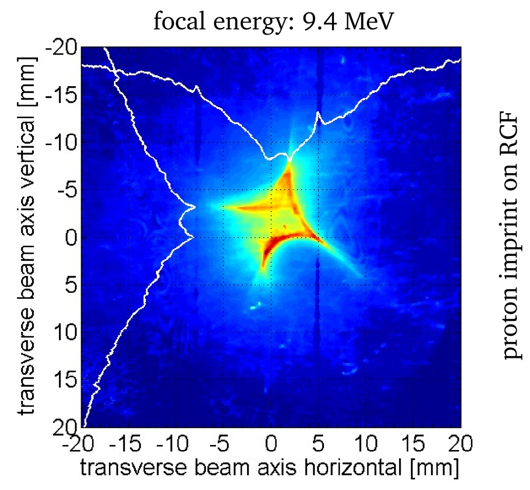


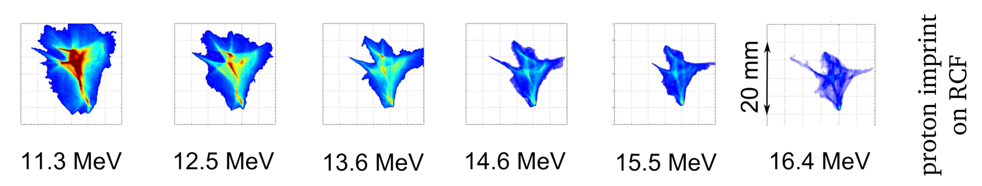

**energy selection:**
· chromatic focusing of selected energy
· capture efficiency 34%

**pulsed solenoid:**
· 40.5 mm open aperture; $B_{z,max}$ = 8.7 T



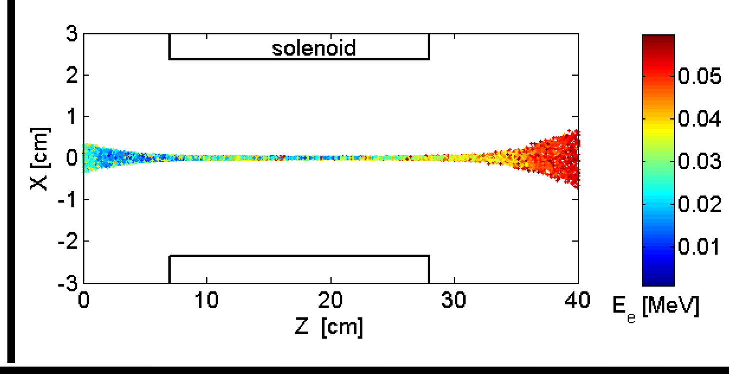



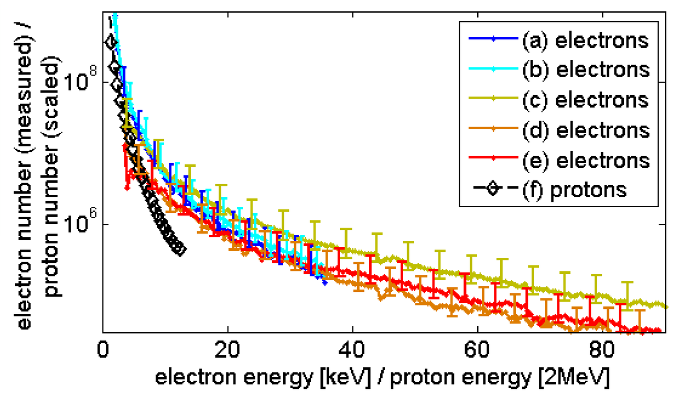




**co-moving electrons:**
· negative on-axis potential
· additional proton focusing
· bunch broadening

**proton bunch at 2.2 m to source:**
· time-of-flight (ToF) and dose (RCF, [10]) measurements
· full bunch characterization possible [11]

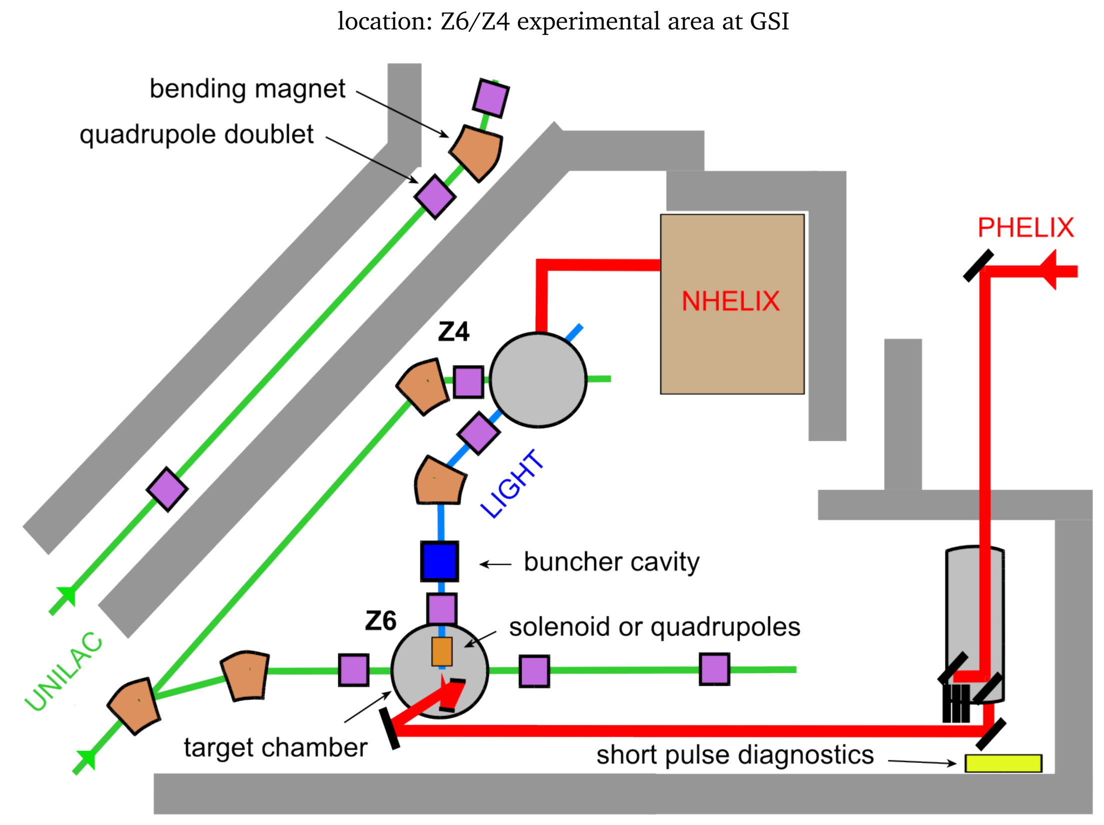



· first measurements of co-moving electrons [13]



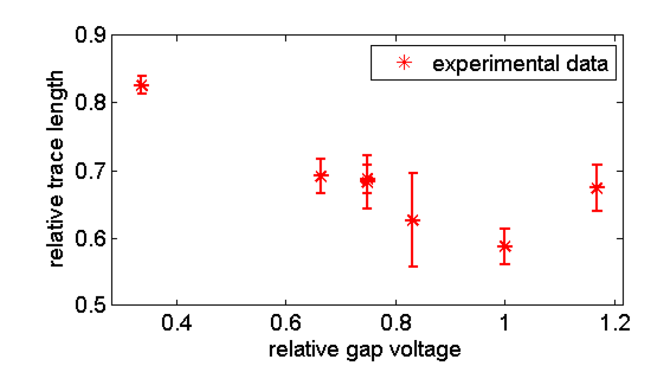

## perspectives

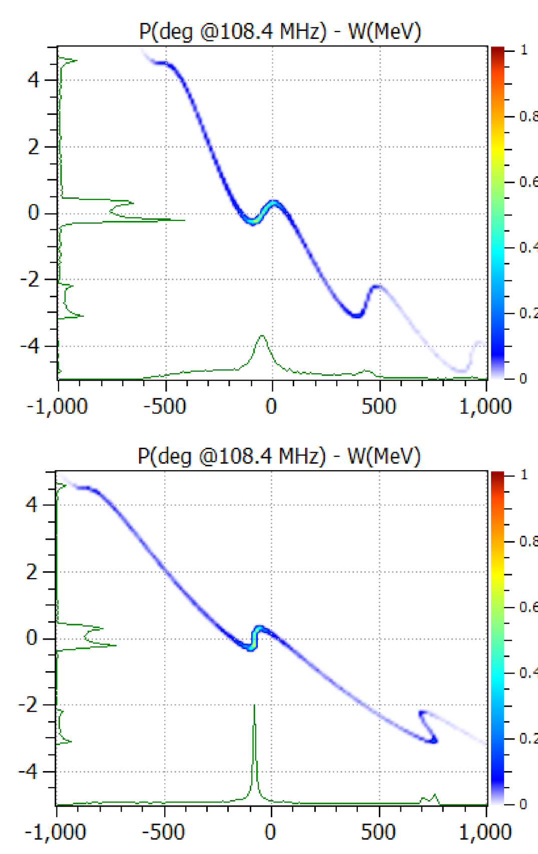
location: Z6/Z4 experimental area at GSI




**unique conditions at Z6 area, GSI:**
· additional to the PHELIX 100 TW beam: ion beamline, high-energy laser nhelix, sophisticated plasma diagnostics

**phase focusing:**
· sub-nanoseconds bunch length possible
· simulations predict: 0.1 ns




references:

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LIGHT – Laser Ion Generation, Handling and Transport

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