PAUL SCHERRER INSTITUT

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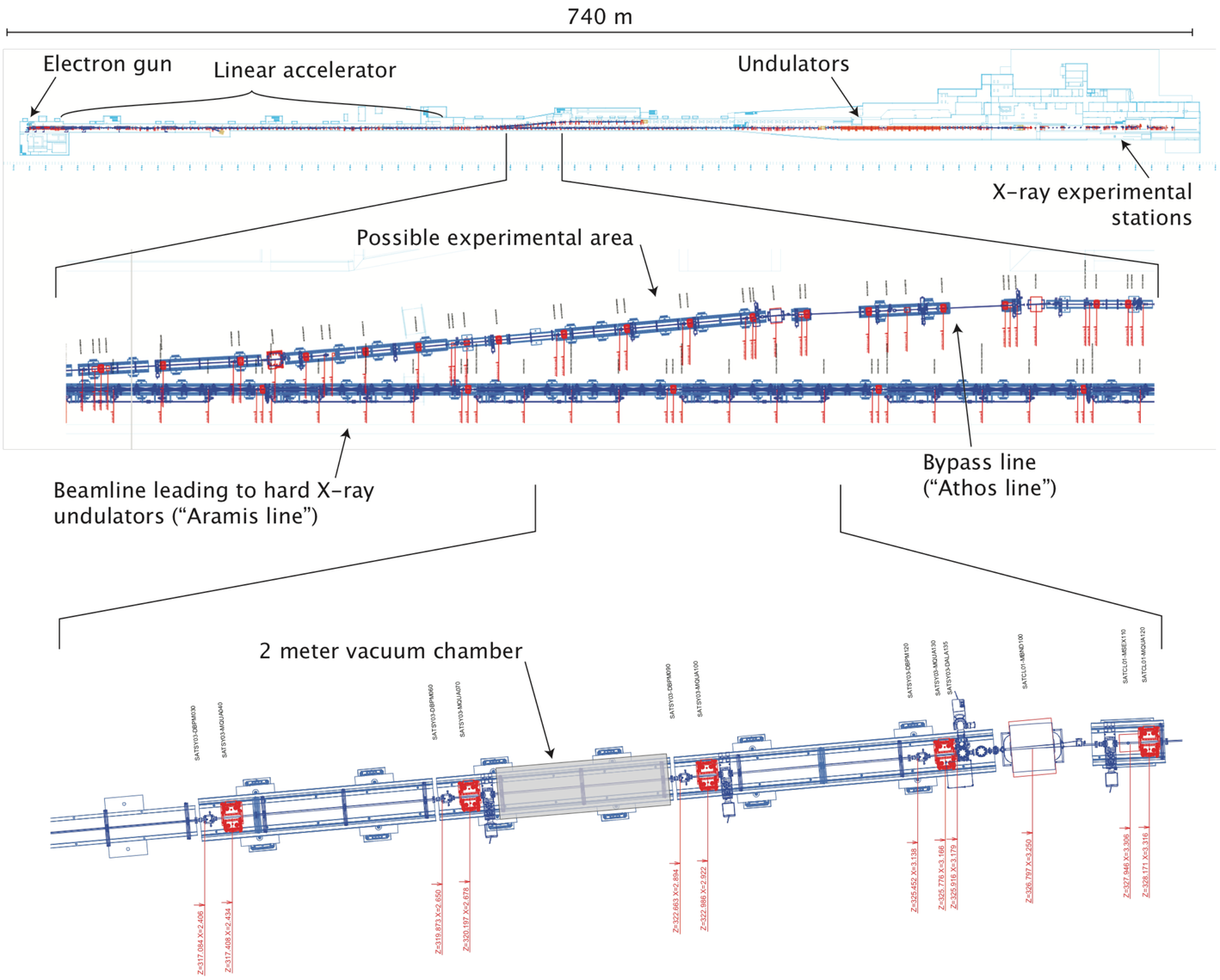
CHARACTERIZATION OF THE ELECTRON BEAM IN THE ACHIP CHAMBER IN SWISSFEL

INTERACTION CHAMBER IN SWISSFEL

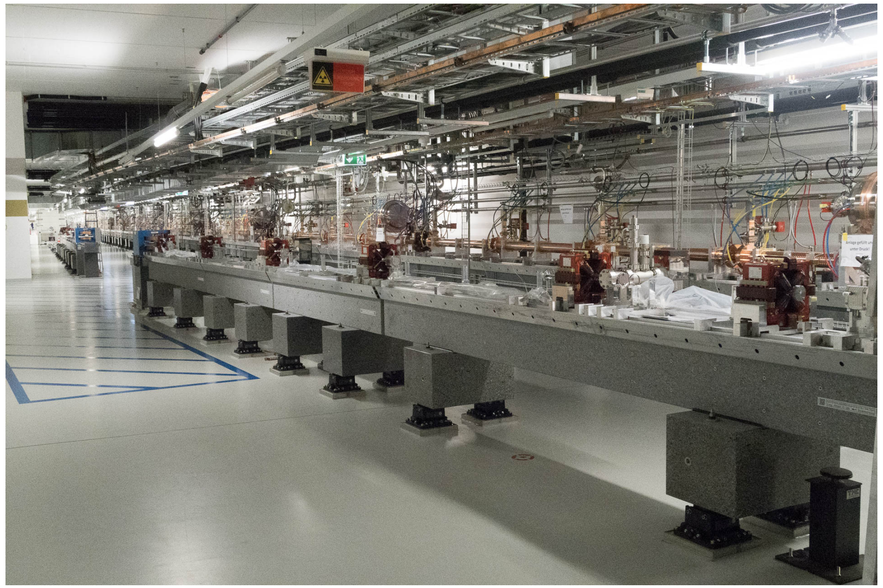
EXPERIMENTAL SETUP IN SWISSFEL

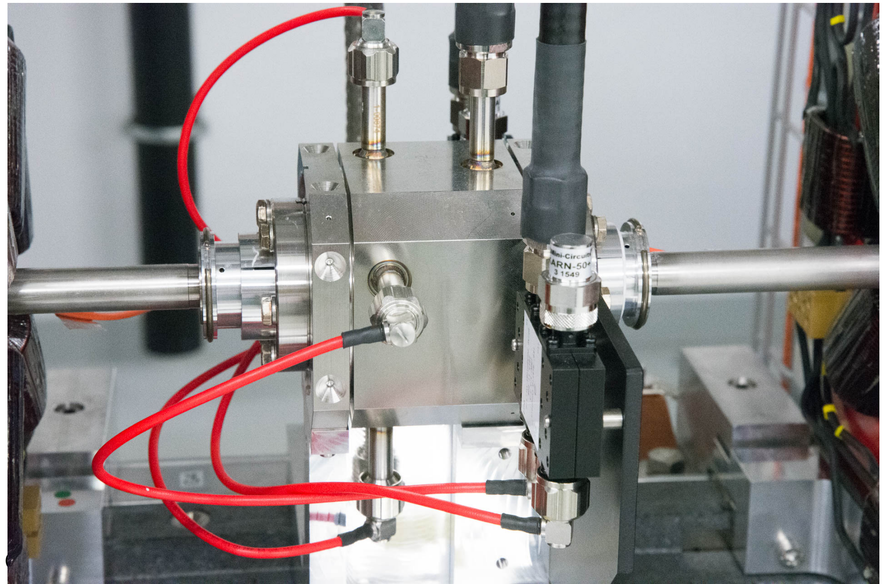
- Goals:
  - Acceleration by 1 MeV
  - Bunch shaping



ELECTRON BEAM INSTRUMENTATION

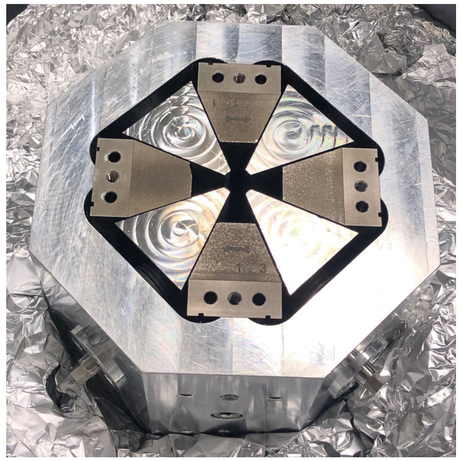
- Charge
- Profile
- Beam Losses
- Energy spectrum





QUADRUPOLES FOR BEAM FOCUSING

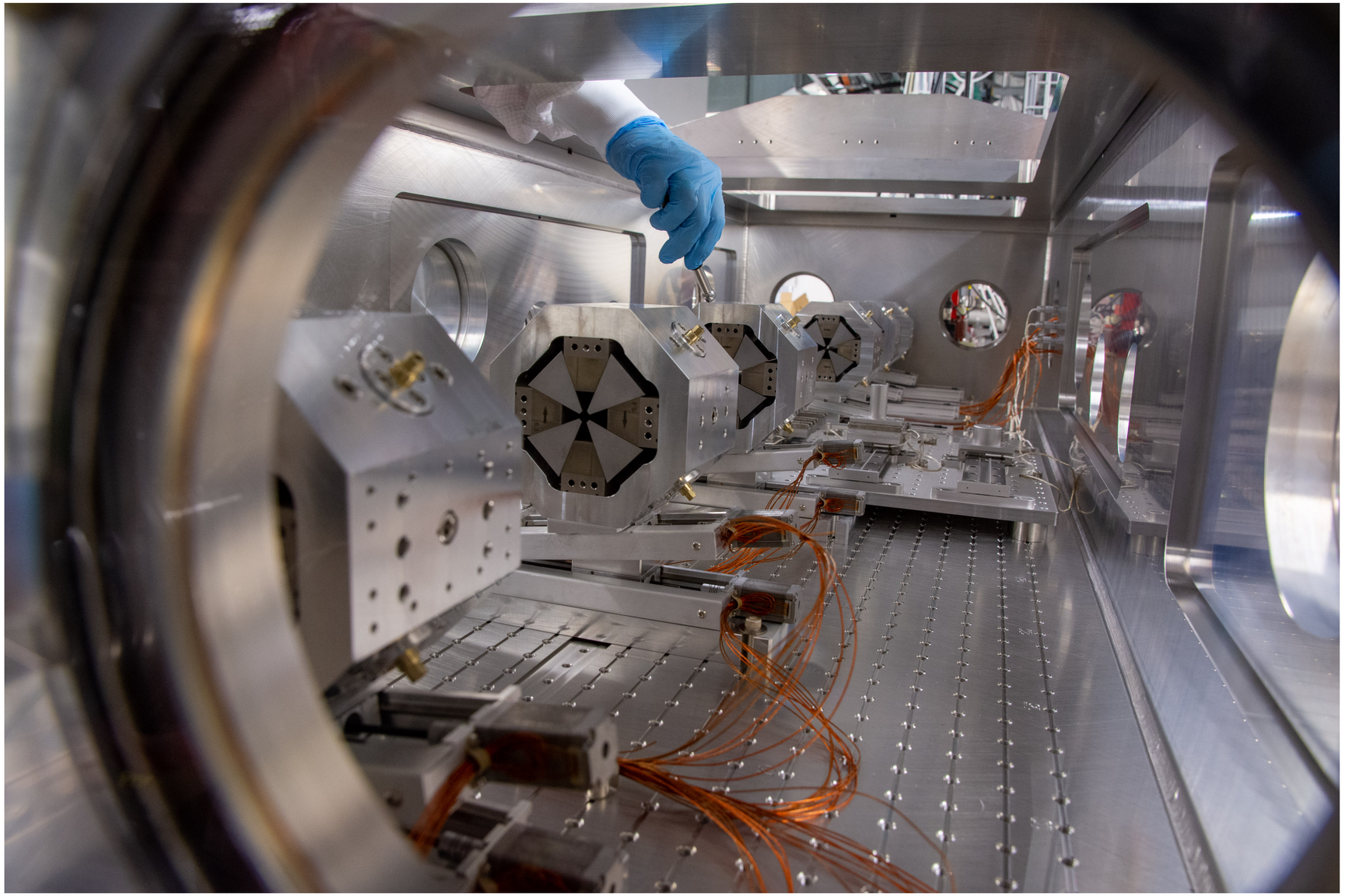
- 6 Permanent magnet quadrupoles (PMQs) calibrated (Marco Calvi)
- K-Value: 25.9 m-2, 38.8 m-2 (error < 0.2%)
- L = 0.1 m → f = 1/KL = 0.39 m, 0.26 m (at 3 GeV)



- Vacuum < 1e-7 mbar after 24 hours

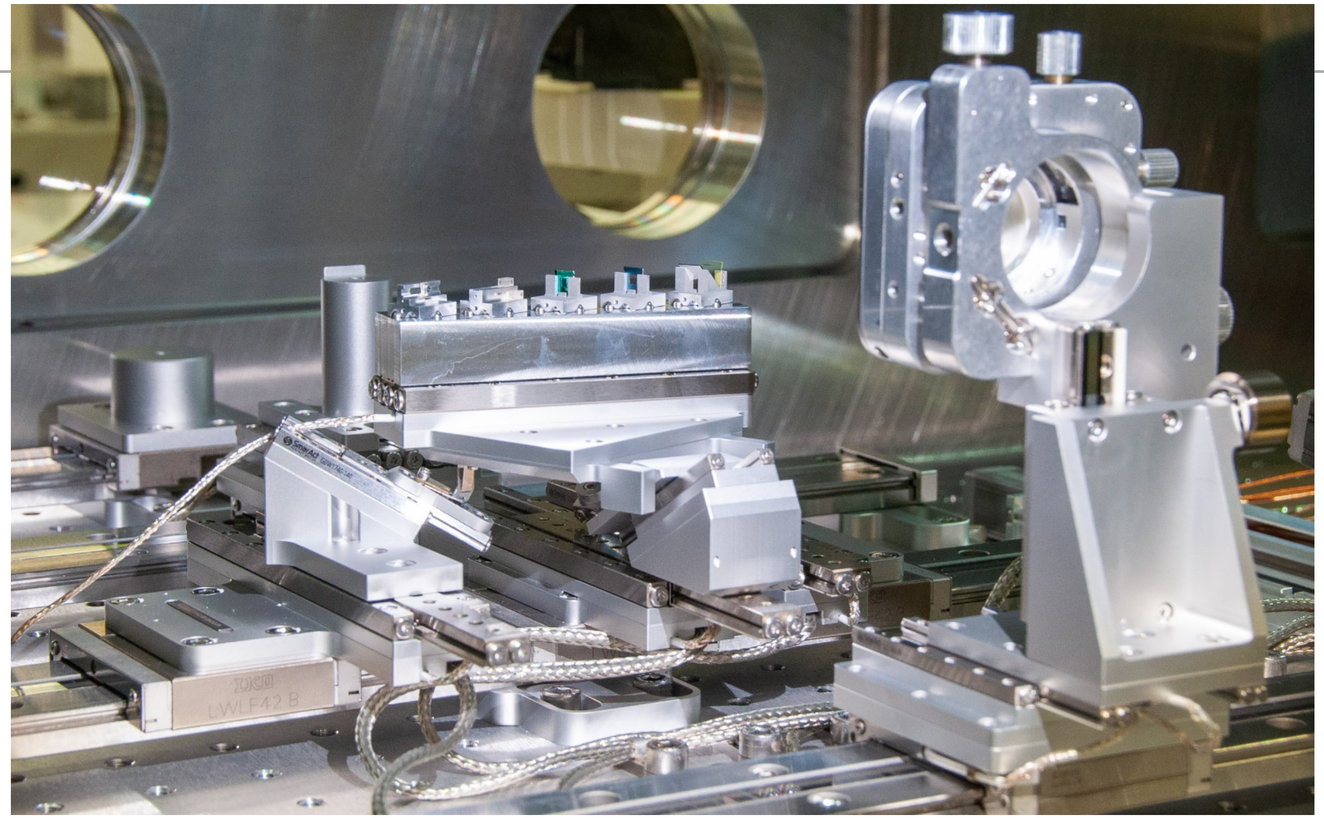
  → Chamber access for sample installation during short shutdowns (1.5 day, every month) is feasible

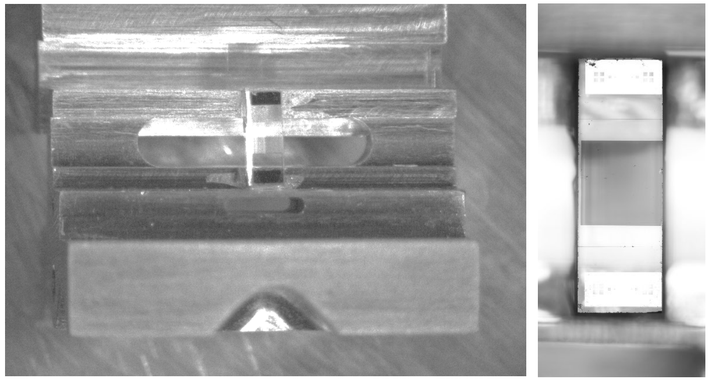
QUADRUPOLE ALIGNMENT



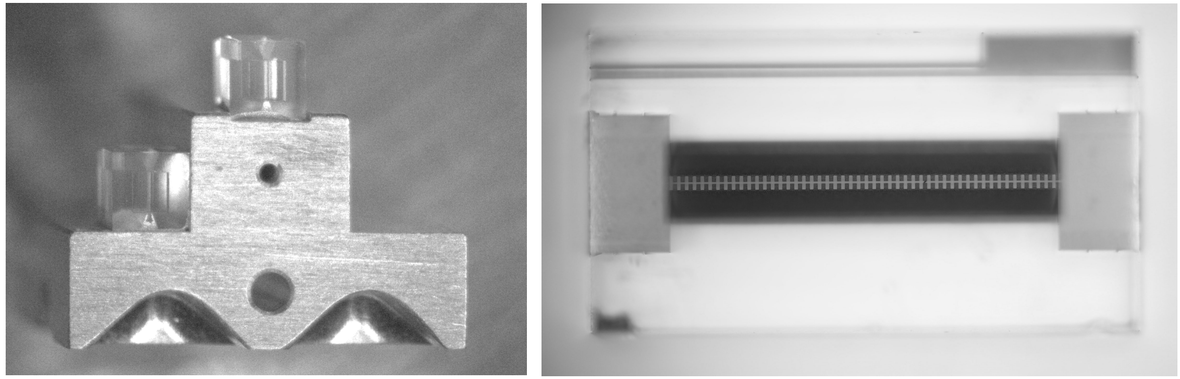
SAMPLE ALIGNMENT

- Micro Wire Scanners (2x)
- YAG Screen
- Dielectric Gratings
  - 2 µm period
  - 50 µm period





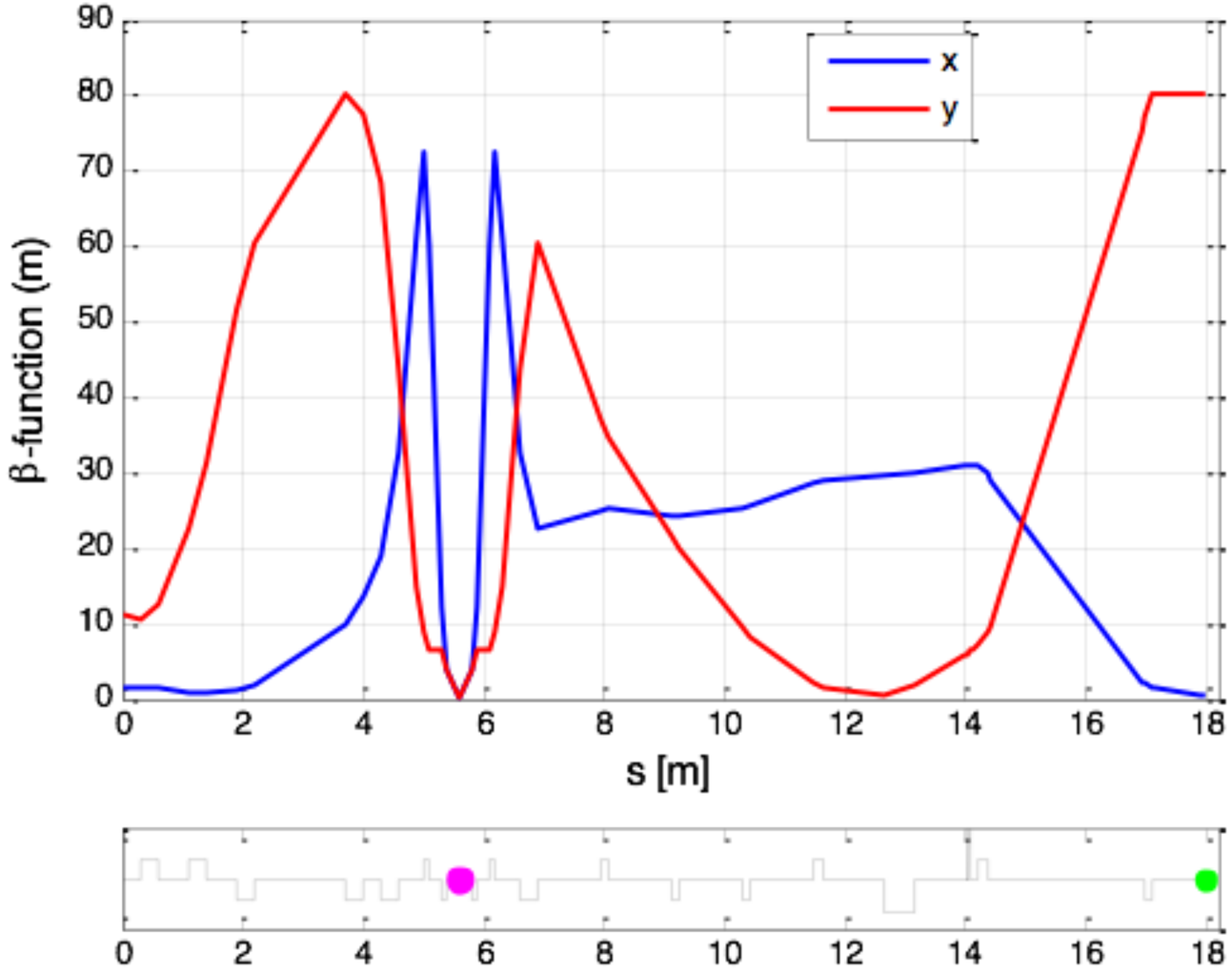
2 um dual grating, SiO2, Yu Miao, Stanford
DLA modulation experiments

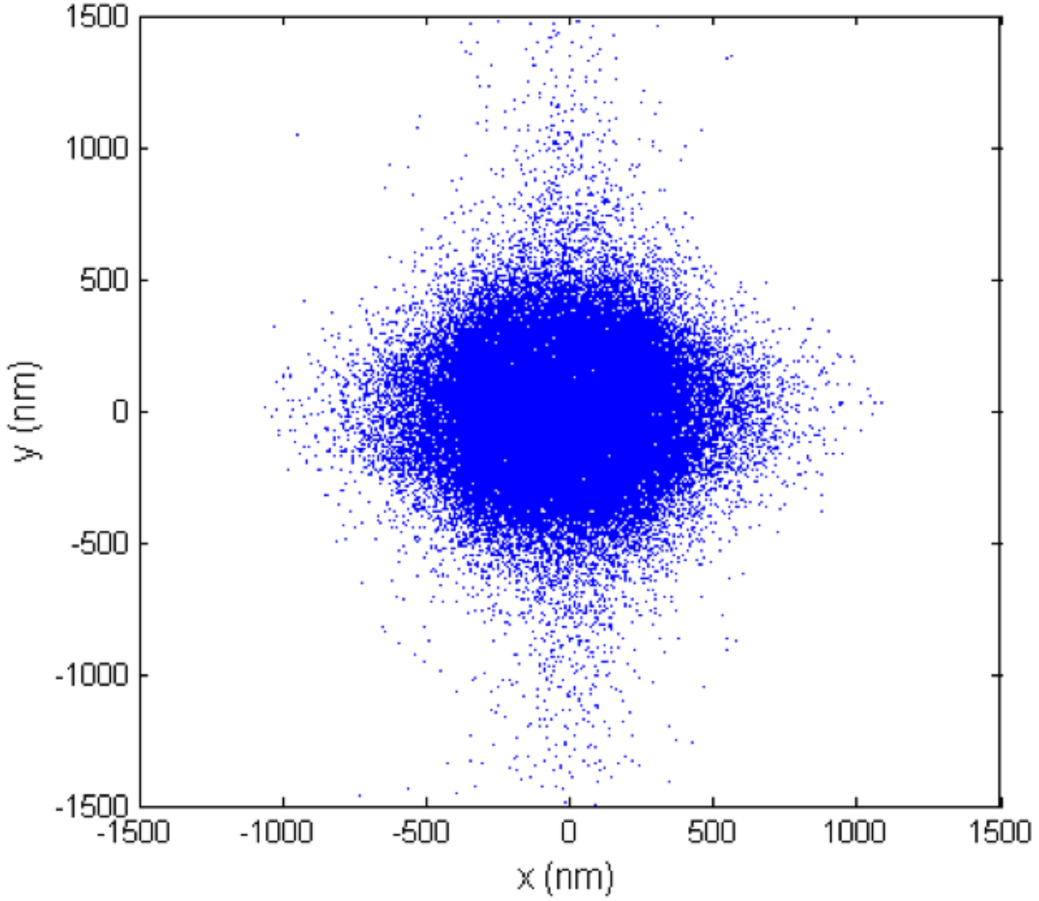


50 um dual grating, SiO2, Femtoprint,
Wake field and radiation generation

CHARACTERIZATION OF THE ELECTRON BEAM

DESIGN OPTICS

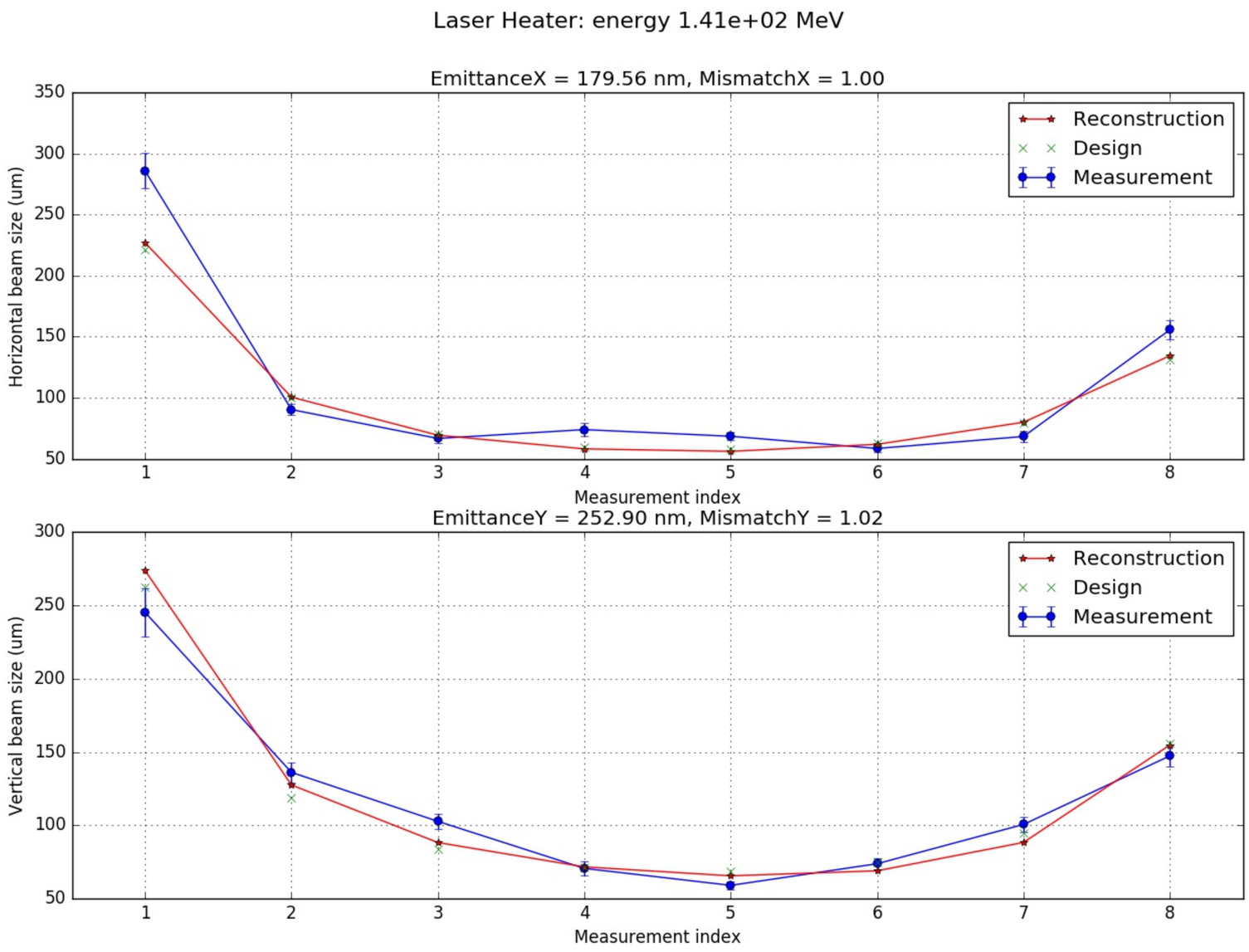




Eduard Prat

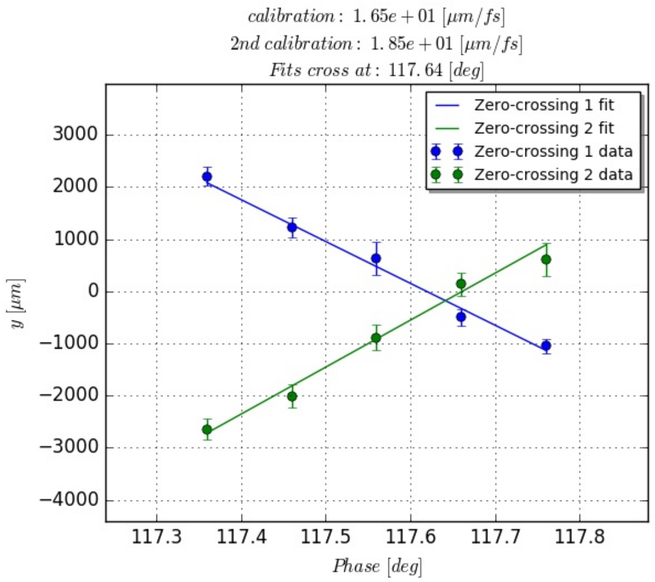
EMITTANCE MEASUREMENT

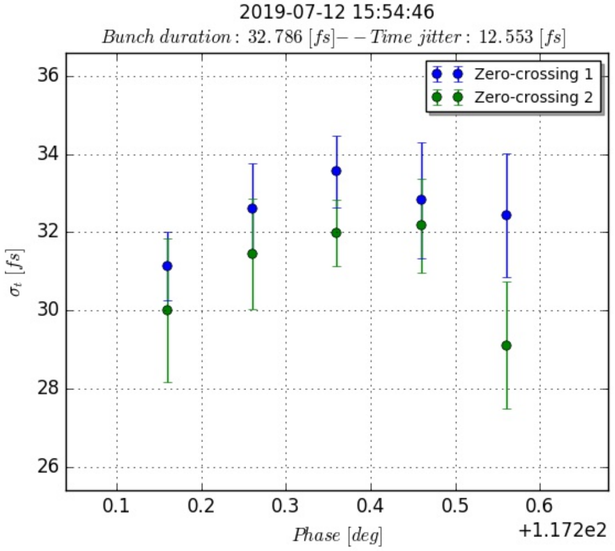
- Emittance at the Injector: 180 · 250 nm
- Beam matched to design optics

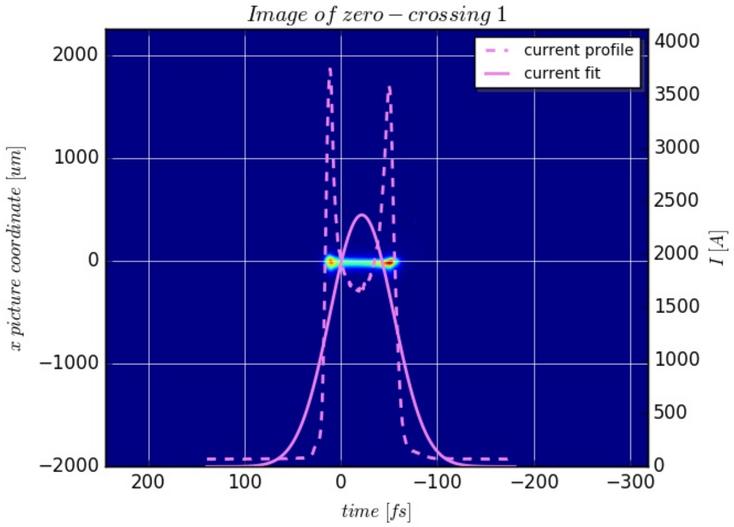


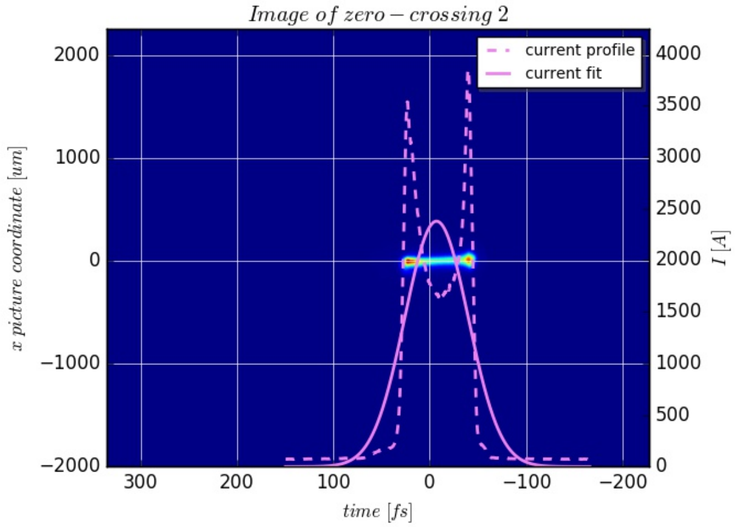
MEASUREMENT OF BUNCH LENGTH AND PEAK CURRENT

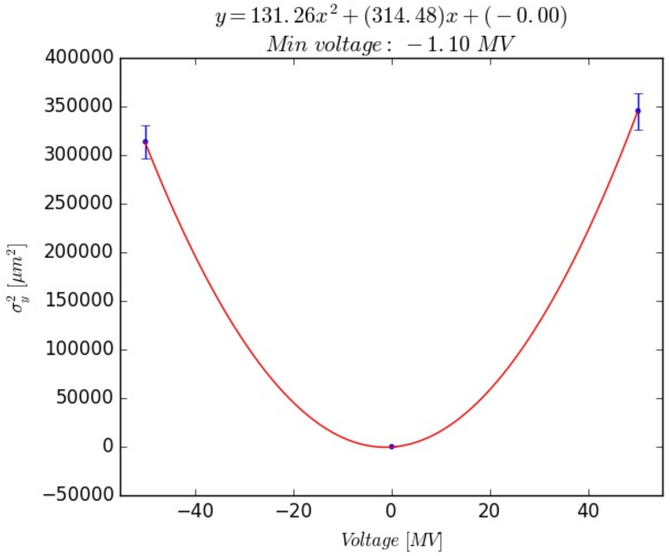
Longitudinal measurement with S30CB14 and SARCL01-DSCR170





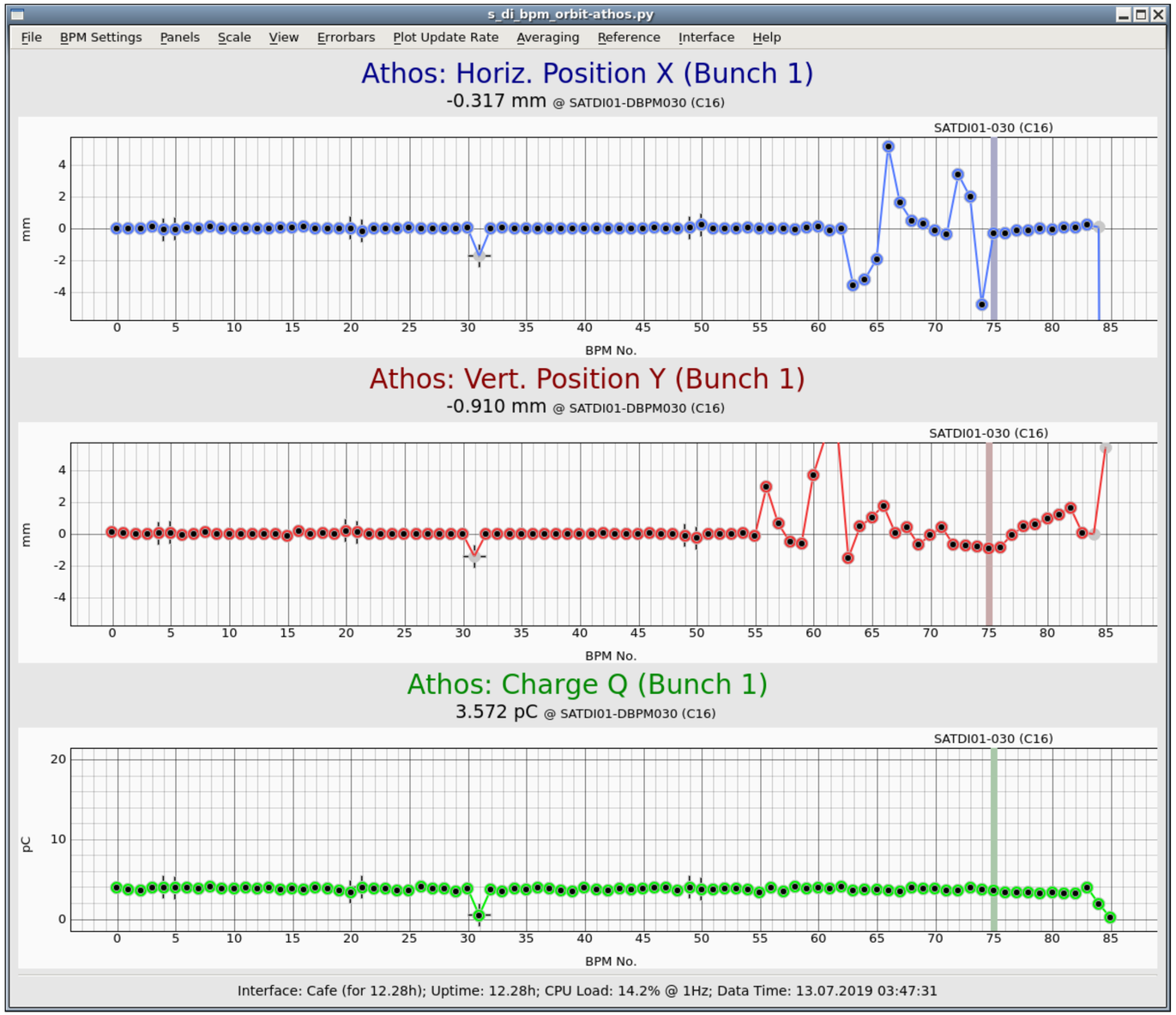






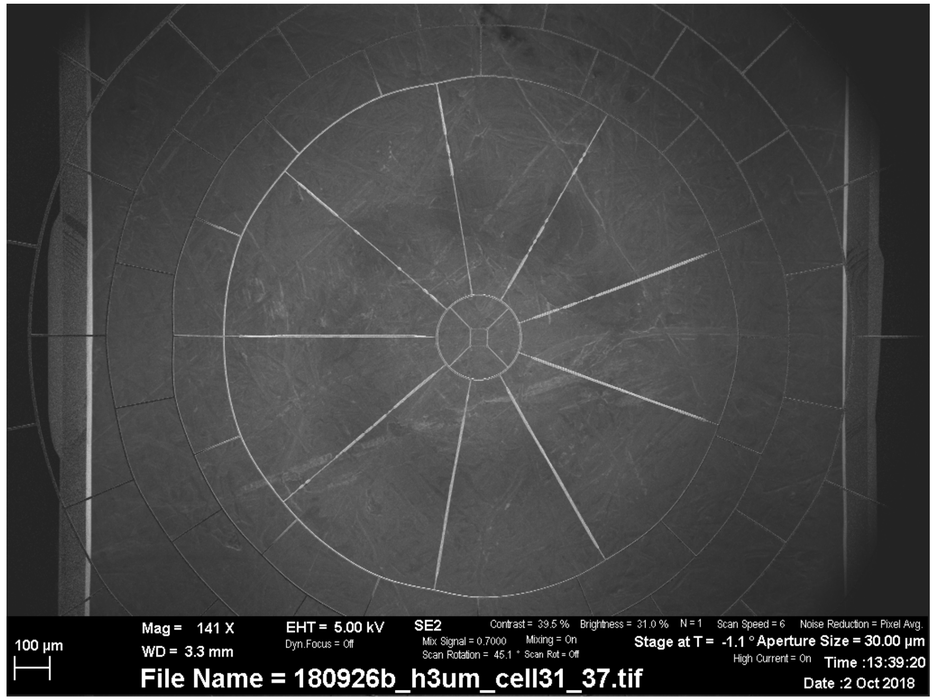
BUNCH CHARGE AND TRANSMISSION

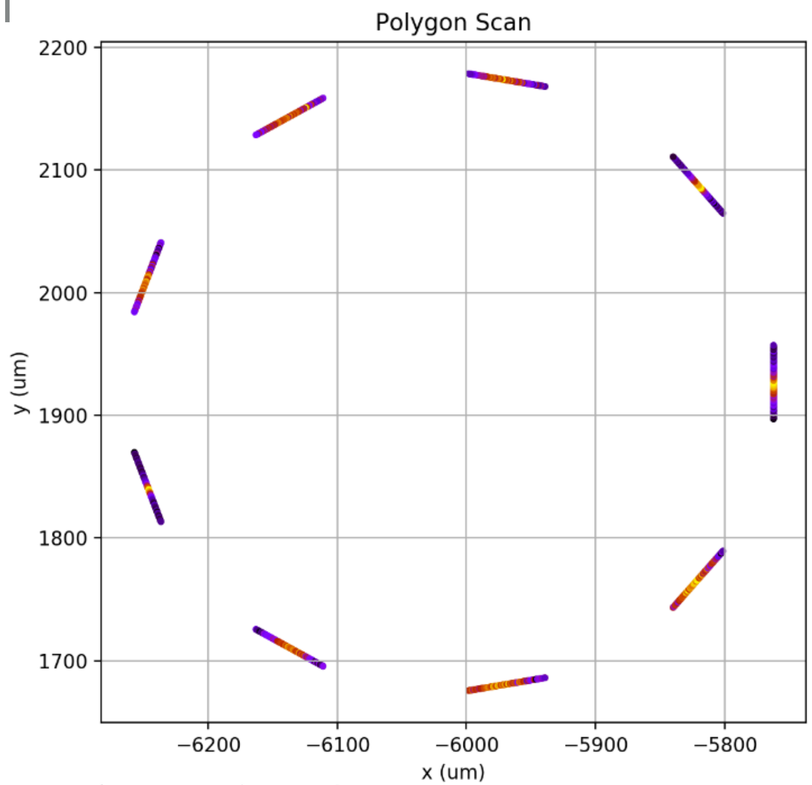
- Measured with cavity beam position monitors



V

- 2x 8h shifts for alignment and transport through chamber with quadrupoles
- Beam profile characterization started with wire scanner (wire width: ~**1 um**)
- Collect beam loss signal w.r.t. wire position

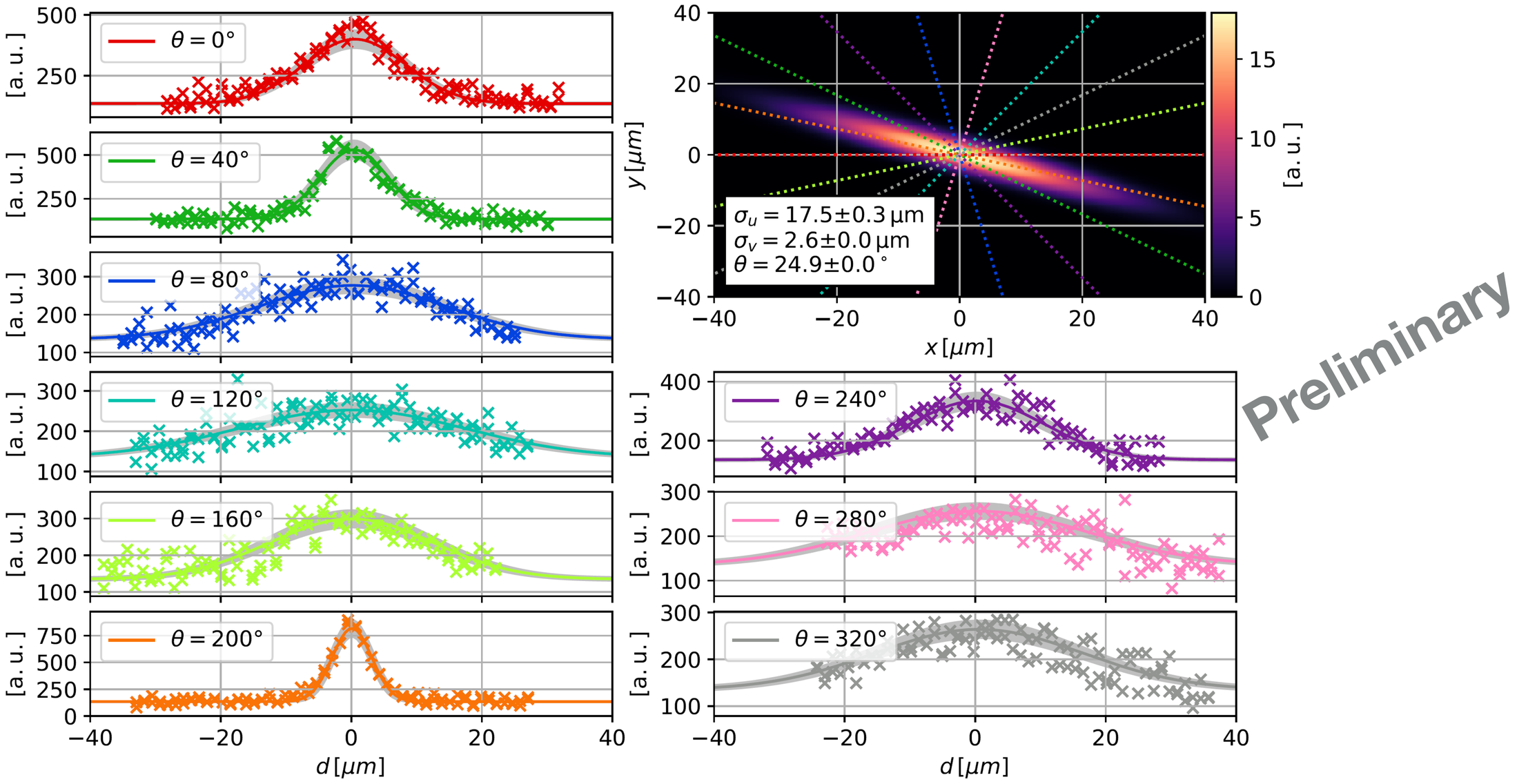




Total scan duration

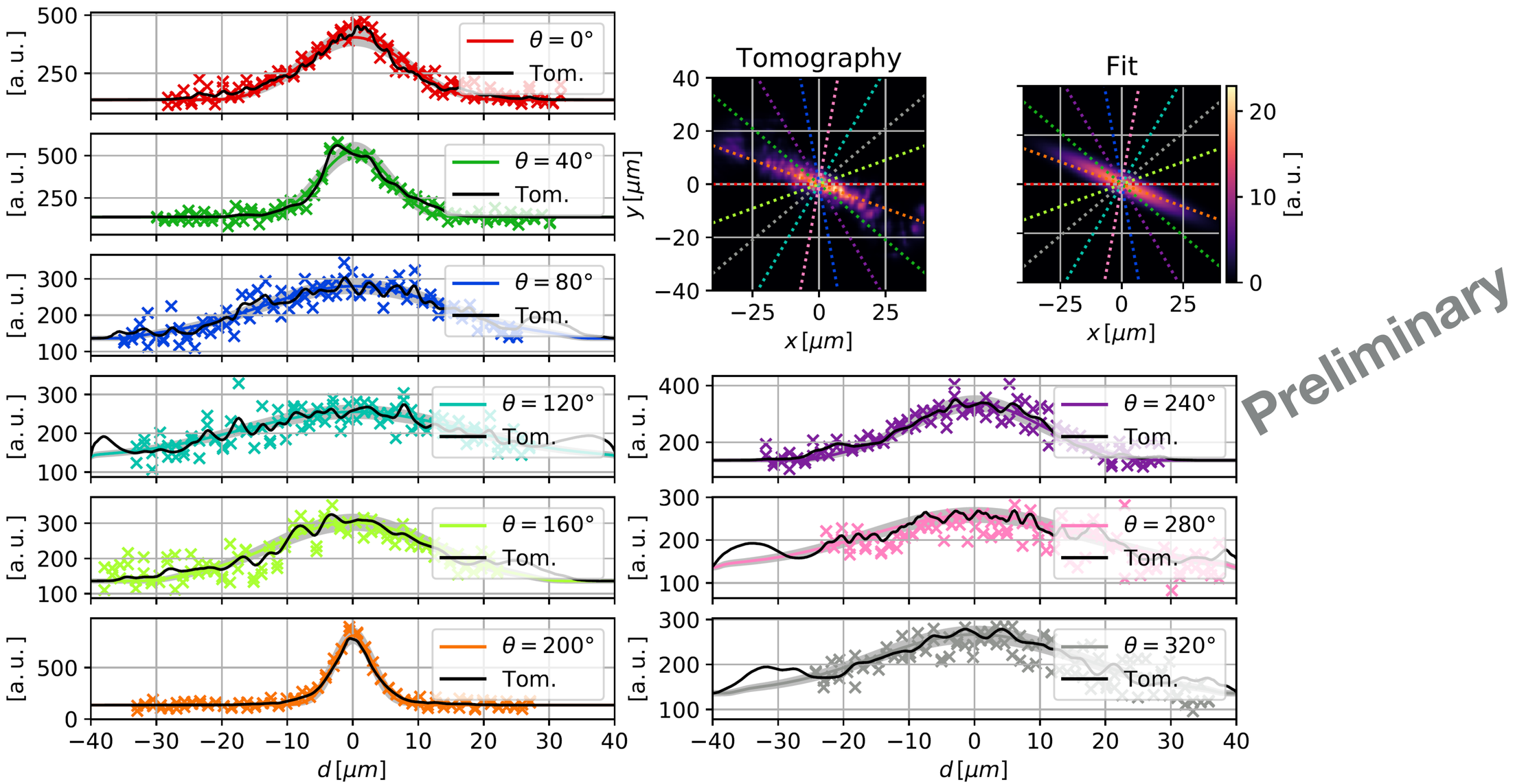
9 wires * 100 shots\wire \ 1 Hz = **15 min**

BEAM SIZE MEASUREMENT: 2D GAUSSIAN FIT

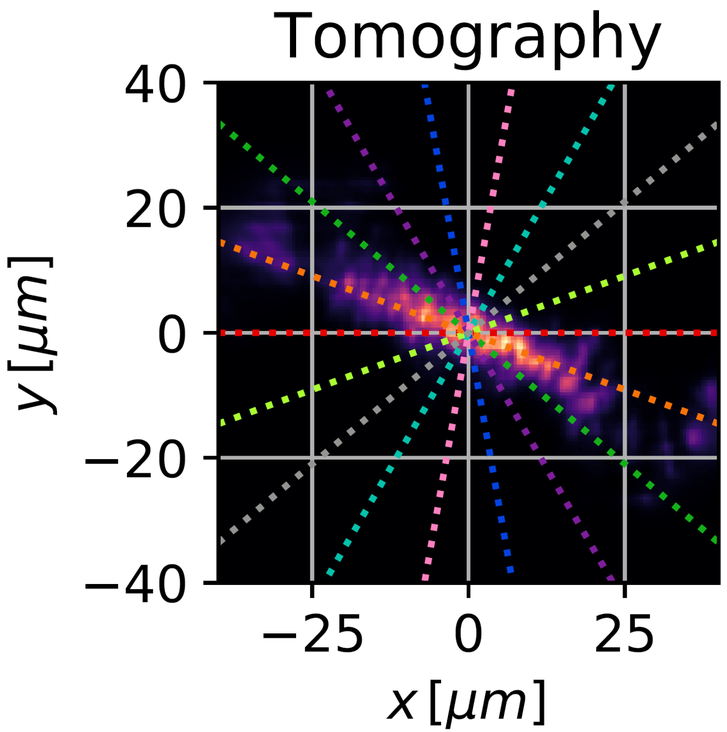


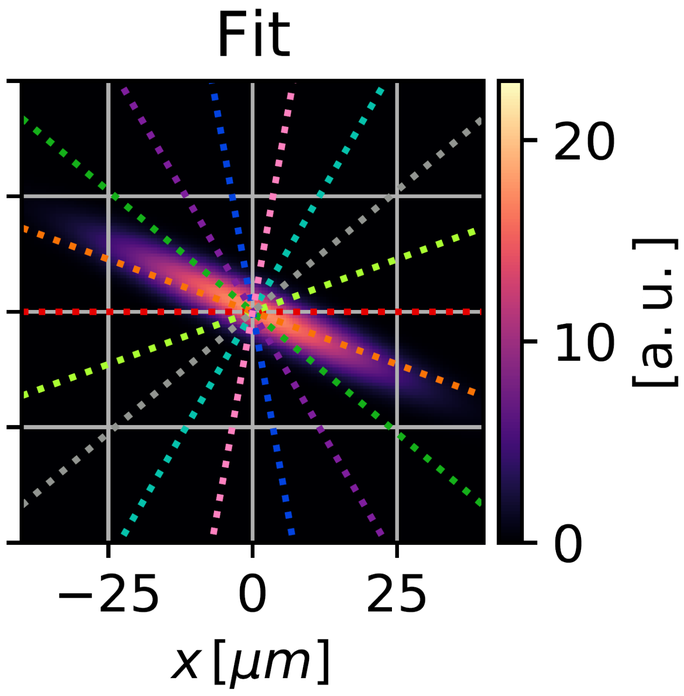
Data Analysis: Adrian Kirchner, visiting student from FAU Erlangen

BEAM SIZE MEASUREMENT: TOMOGRAPHY



BEAM SIZE ANALYSIS





Preliminary

+ No assumption on distribution
+ Feature reconstruction
– Prone to noise, smoothing kernel

– Assumption: Gaussian shape
+ Fast
+ Stable even with fewer wires and poor SNR

BEAM CHARACTERIZATION, WIRE SCAN TOMOGRAPHY

First Measurement

- $\sigma_{min} = 2.6\ \mu\text{m}\ , \sigma_{max} = 17.5\ \mu\text{m}$
- X-Y tilt: ~ 25 deg

Next steps:

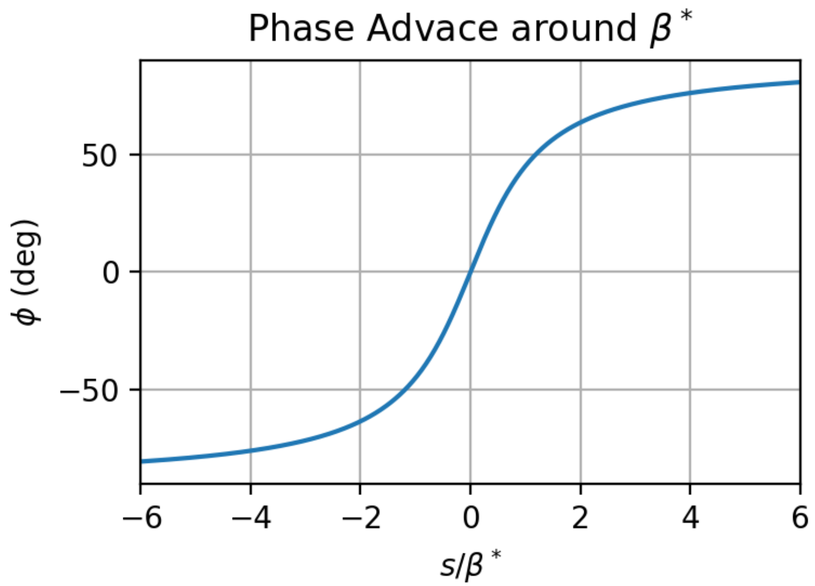
- Reduce emittance at Injector
- Improve matching
- Minimize dispersion
- Optimize alignment

} → sub-µm beam size in x and y

- Improve detector position (beam loss monitor) for better SNR

EMITTANCE MEASUREMENT WITH WIRE SCANNER

- Measure beam profile at different phase advances
- Instead of quad-scan, move hexapod along z (range: +/- 5 cm)
- At center: $\beta^* = 1$ cm
- Evolution of β around focus: $\beta(z) = \beta^* + \frac{z^2}{\beta^*}$
- Phase advance: $\phi(s) = \int_0^s \frac{dz}{\beta(z)} = \frac{1}{\beta^*} \int_0^s \frac{dz}{1 + (z/\beta^*)^2} = \arctan\left(\frac{s}{\beta^*}\right)$
- Rapid phase advance around small focus
- For +/- 5 cm: $\phi = 2 * \arctan(5) =$ 157 deg



→ 4D (x, y, x', y') Phase space tomography

The Accelerator on a Chip International Program

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