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The $\bar{P}$ANDA Cluster-Jet Target – beam time results, beam dump design and other developments

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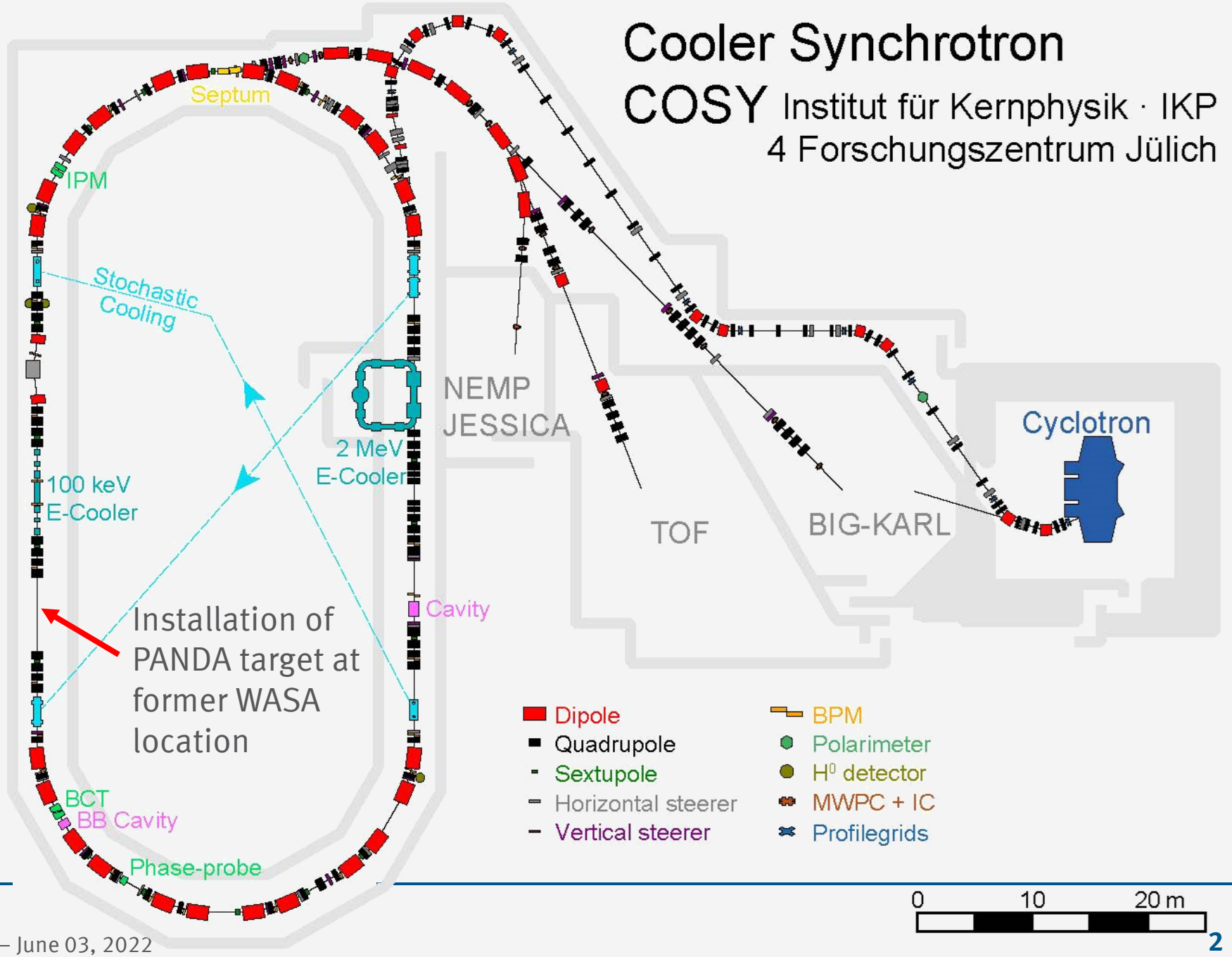
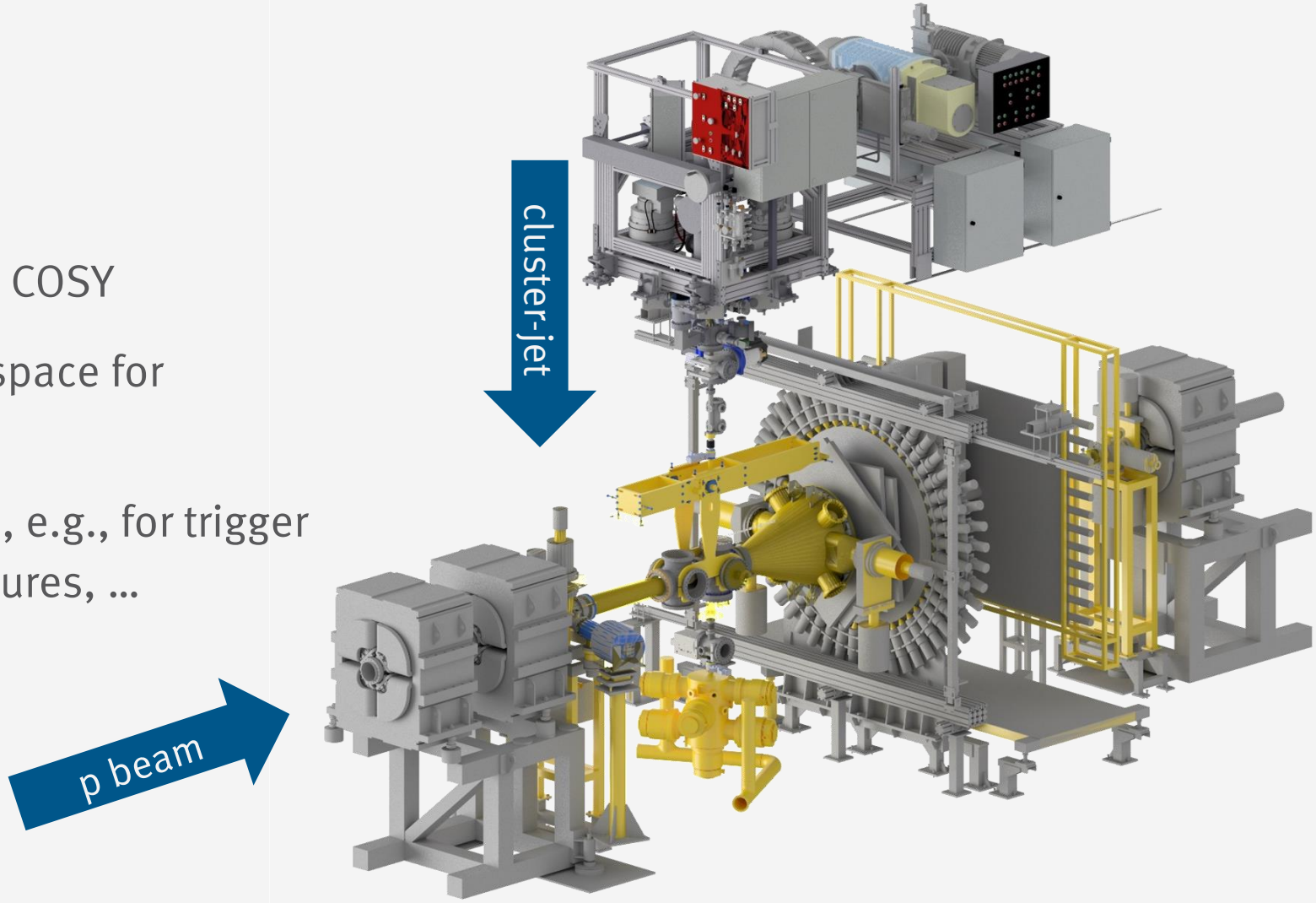
COSY

- Proton and deuteron beams
- Up to 3.5 GeV/c (overlap with PANDA)
- Stochastic and electron cooling, barrier bucket
- HESR stochastic cooling devices installed and now also HESR cavity



Integration at COSY

- PANDA cluster-jet target installed at COSY
- WASA central detector removed → space for diagnostic devices, beam dump, …
- WASA forward detector can be used, e.g., for trigger rate or investigations on time structures, …



Program at COSY

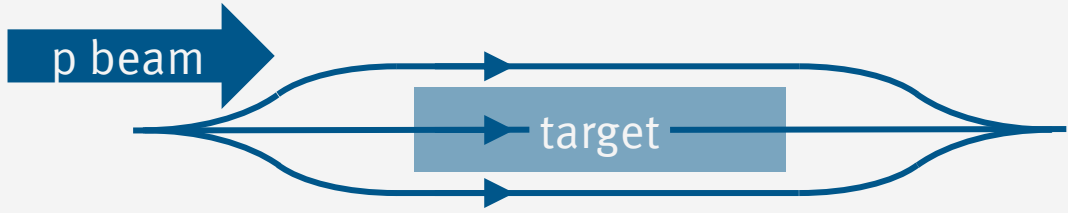
- Last beam times: 1 week in 2021 (first results will be presented) and 1 week in 2022
- Focus on beam-target interaction with stochastic cooling
  - Beam quality (e.g., momentum spread)
  - Beam lifetime

Beam quality studies

PANDA design value achieved again

Setup:

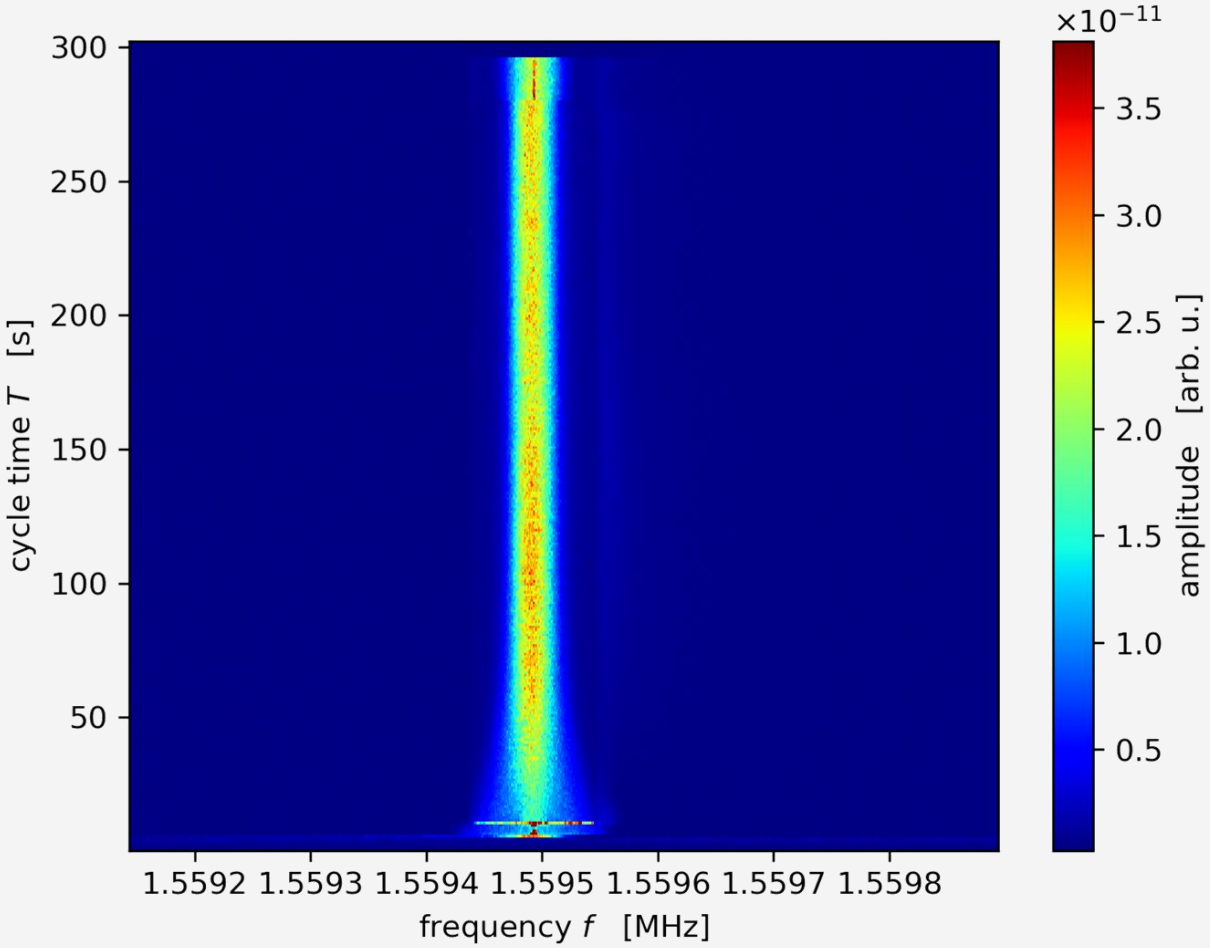
- Different combinations of target thickness ($1 \cdot 10^{13}$ to $2 \cdot 10^{15}$ atoms/cm^2) and COSY beam intensities ($1 \cdot 10^9$ to $2 \cdot 10^{10}$ stored protons)
- Beam momentum of 3.0 GeV/c
- Barrier bucket and stochastic cooling (designed for HESR)



- Measurements with COSY beam on the target and right/left of the target (residual gas contribution)
- Measured quantities: Schottky spectrum (via independent pickup), beam current, beam size, target thickness

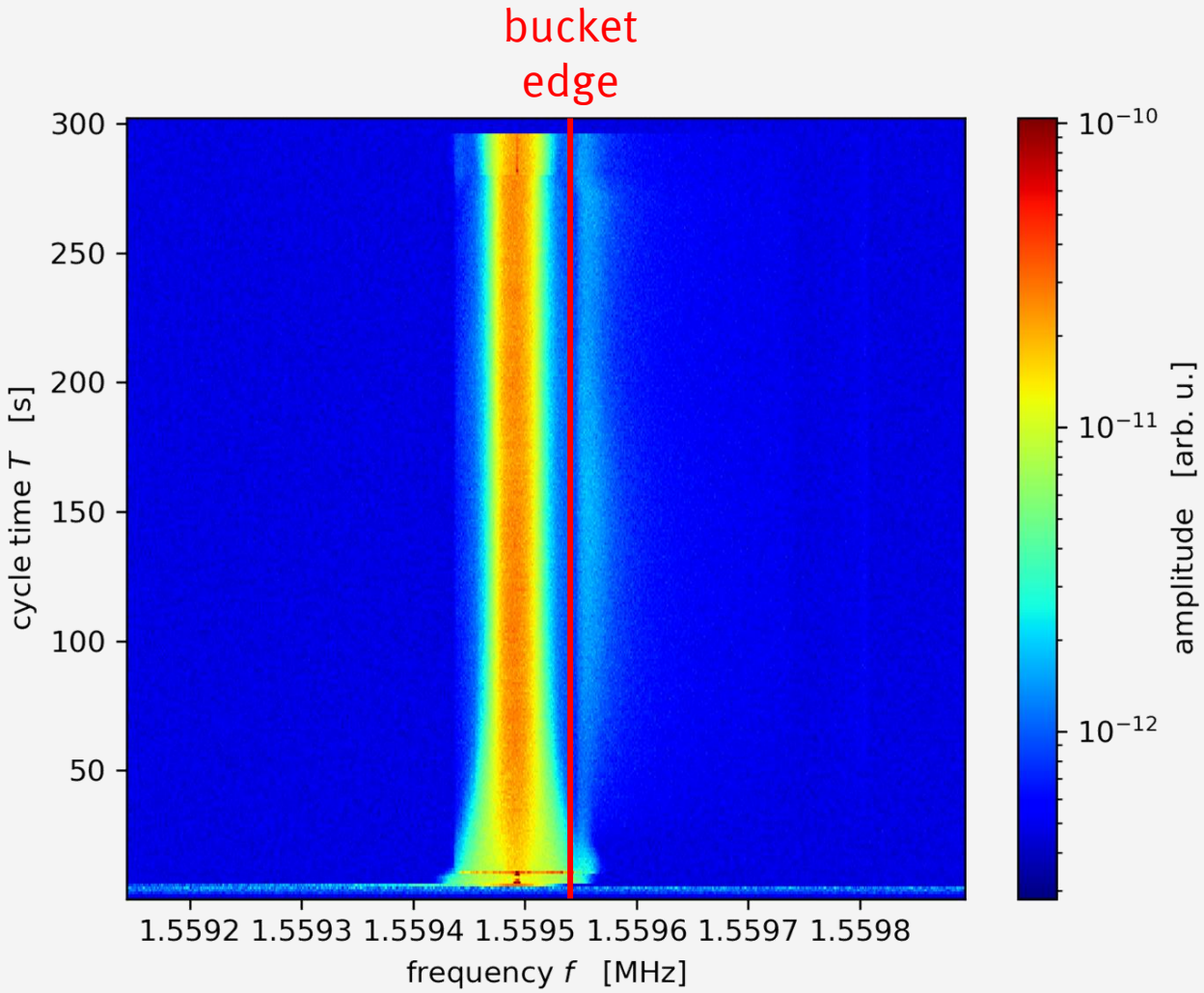
Schottky spectrum

- Schottky spectrum → spectrum of the revolution frequency (at higher harmonic)
- Without cooling and barrier bucket the spectrum would be wider and frequency will shift due to momentum loss



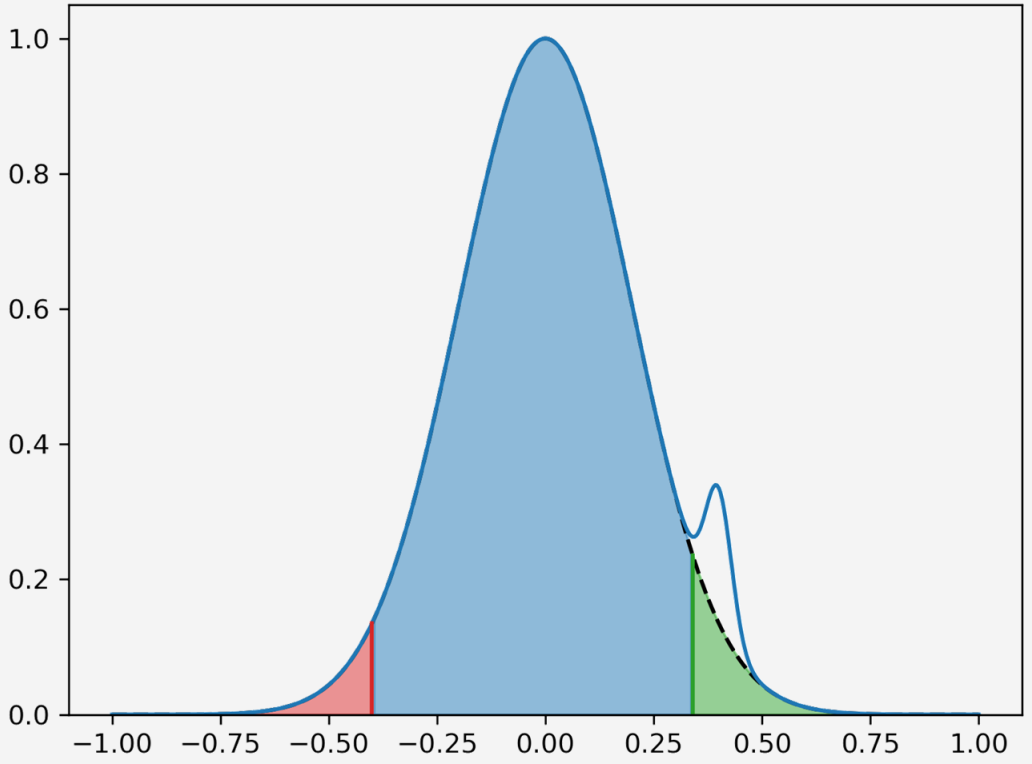
Schottky spectrum

- Schottky spectrum → spectrum of the revolution frequency (at higher harmonic)
- Without cooling and barrier bucket the spectrum would be wider and frequency will shift due to momentum loss
- Not all particles are in the barrier bucket potential → formation of a side peak
  - not expected at HESR (optimized bucket)



Schottky spectrum

- For every time step the mean frequency and the RMS are determined for the spectrum
  - Background subtracted
  - Mean and RMS are determined in region around fit maximum
  - Side peak not included
  - Signal under side peak is corrected with integral over an asymmetric Gaussian fit



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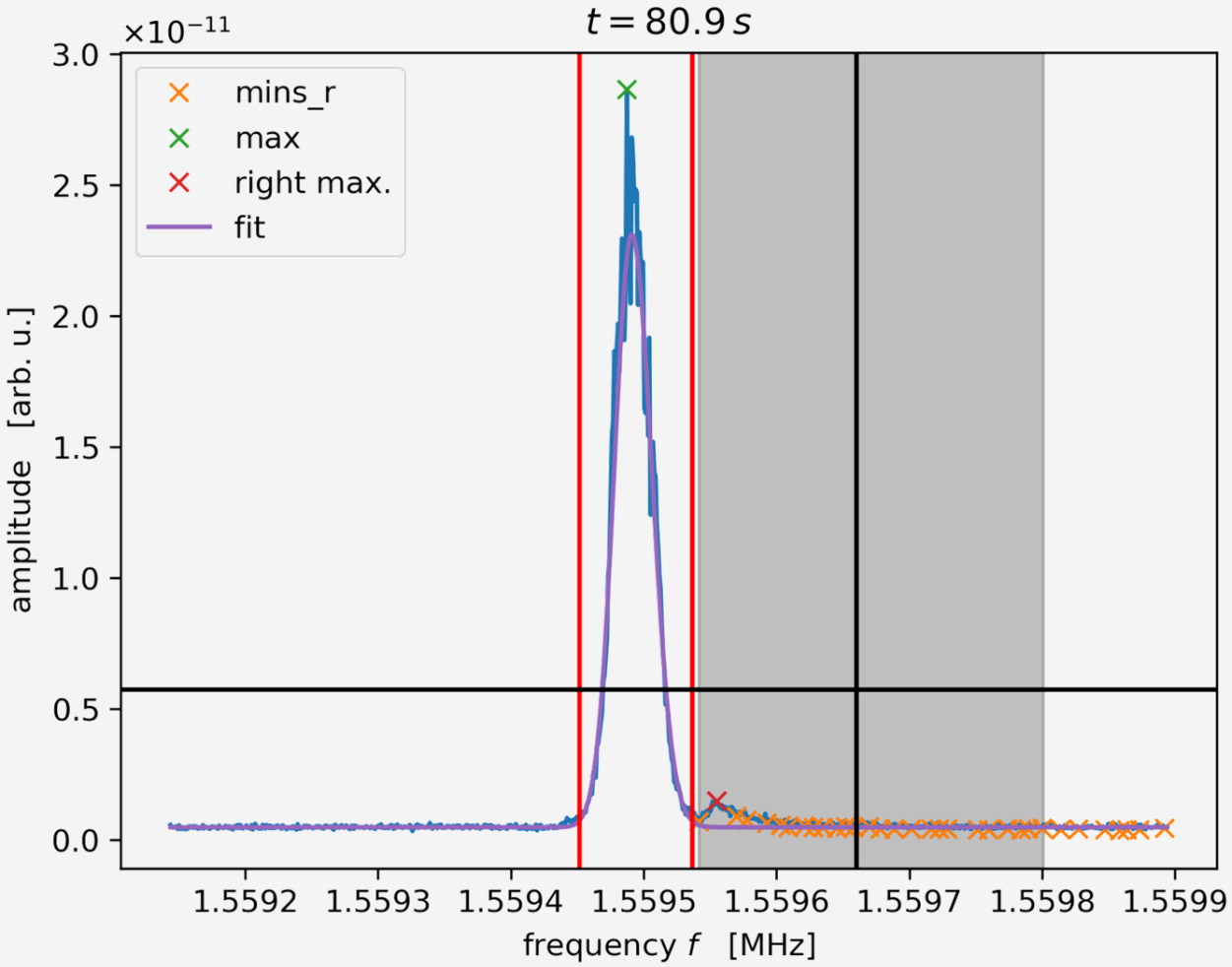
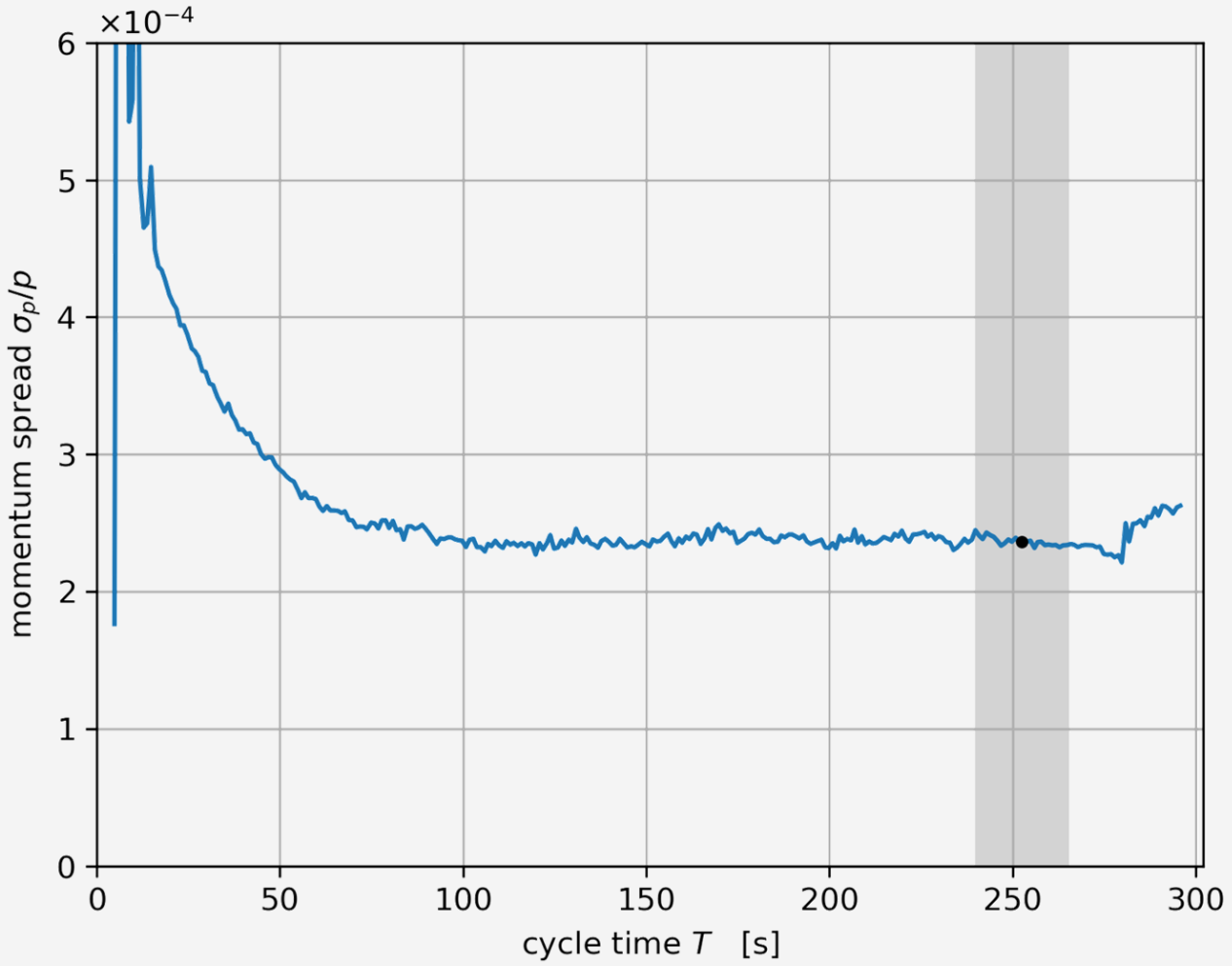


Schottky spectrum

- Frequency spread can be converted into momentum spread

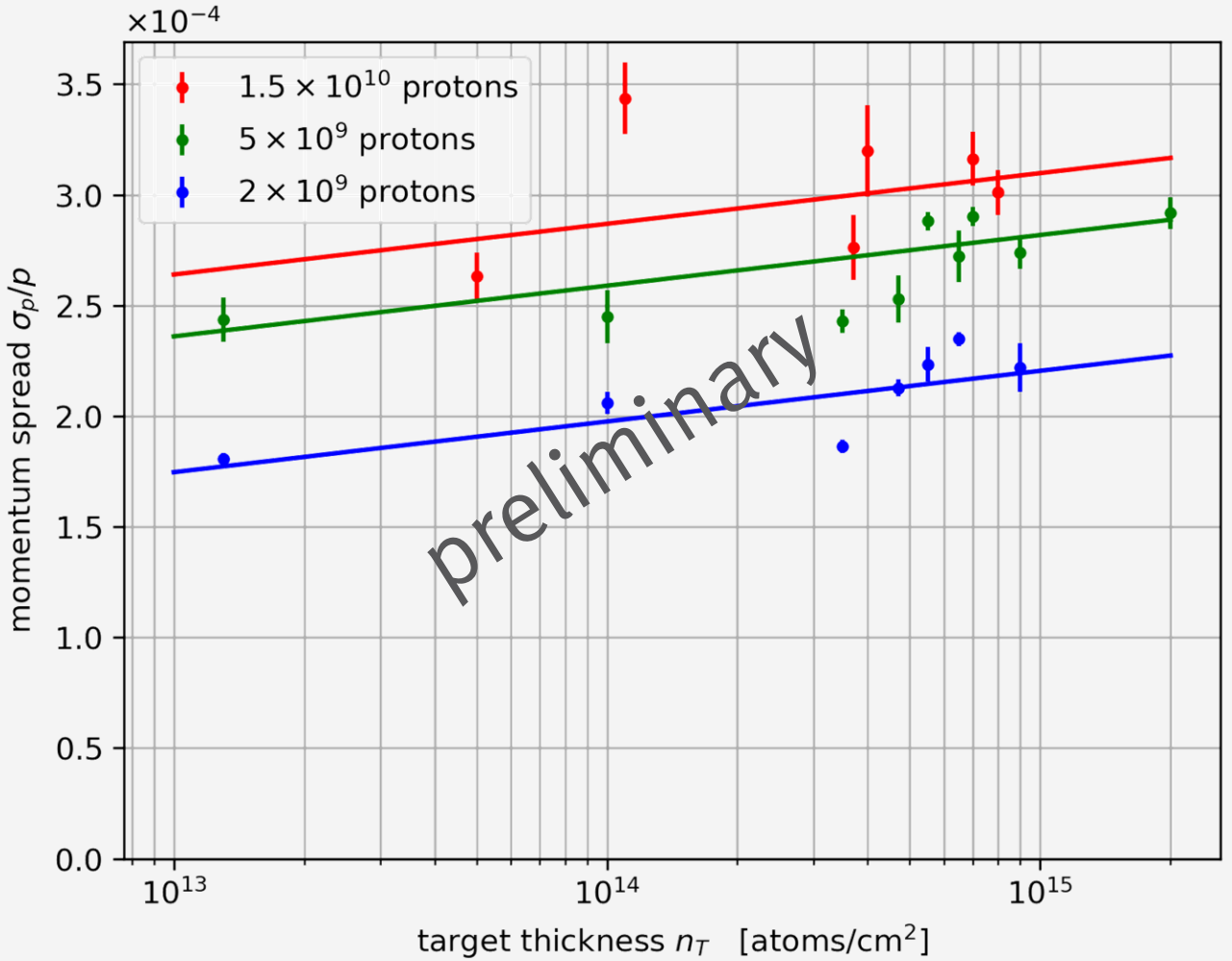
$$\frac{\Delta p}{p} = \frac{1}{\eta}\frac{\Delta f}{f}$$

- Stable conditions already after ~80 s with a thick target



Schottky spectrum

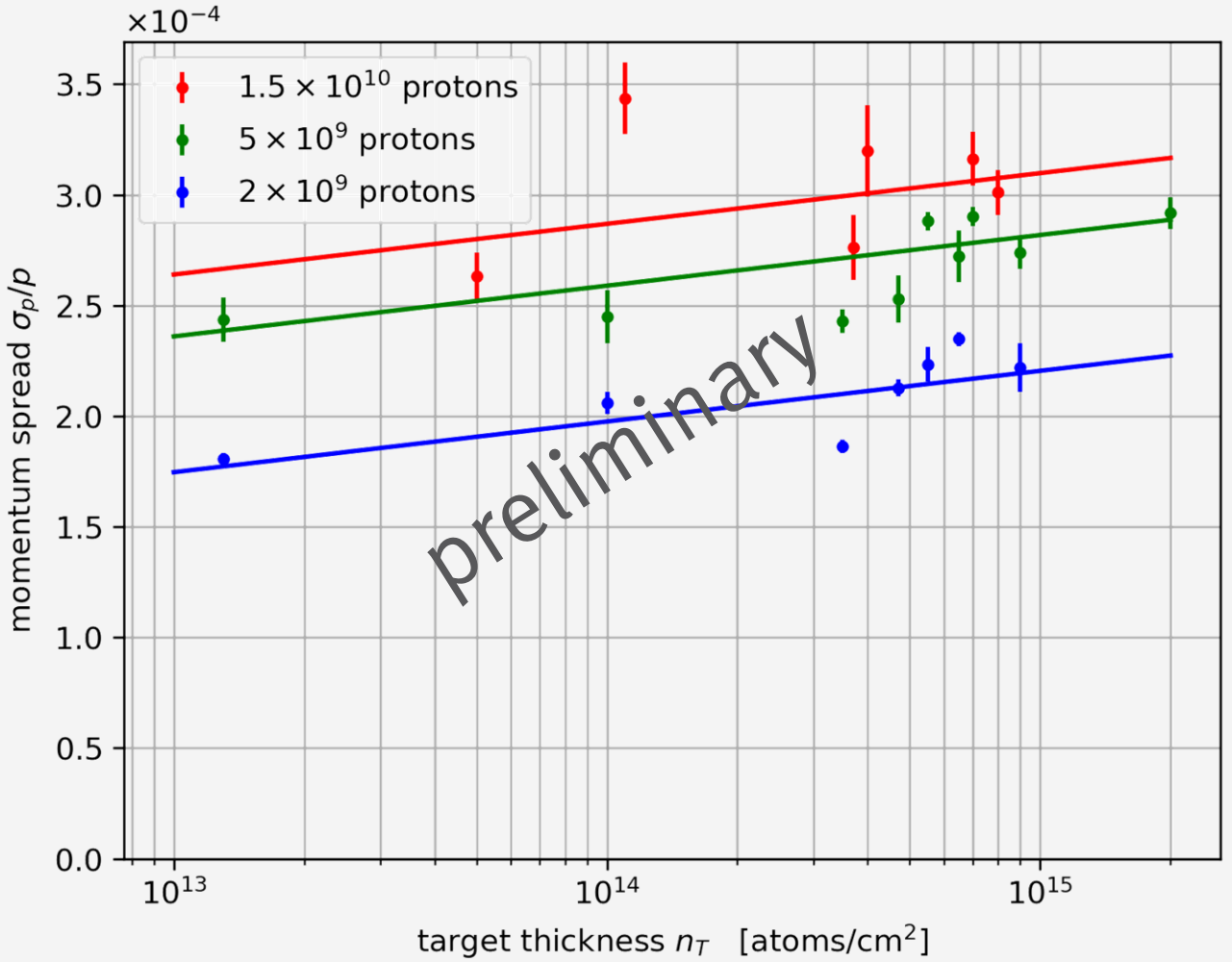
- Measured for three beam intensities and several target settings
- Small dependence on beam intensity, as expected for such a cooling device
- Very small dependence on target thickness while changing the thickness over two orders of magnitude (up to PANDA design value of $2 \cdot 10^{15}$ atoms/cm^2)



Schottky spectrum

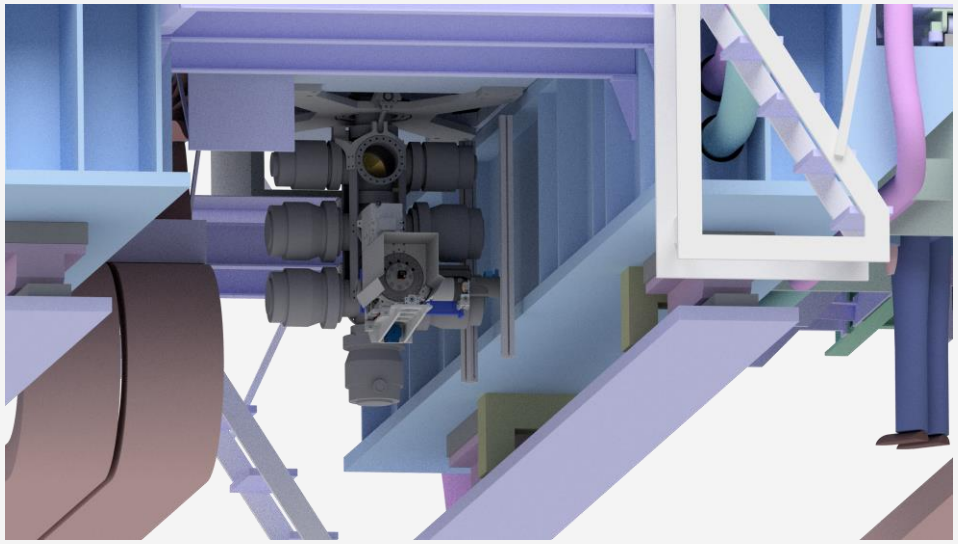
- Due to issues with COSY only a very small set of data at highest intensity could be taken in 2021
- More data points have been measured this year at highest and medium intensity

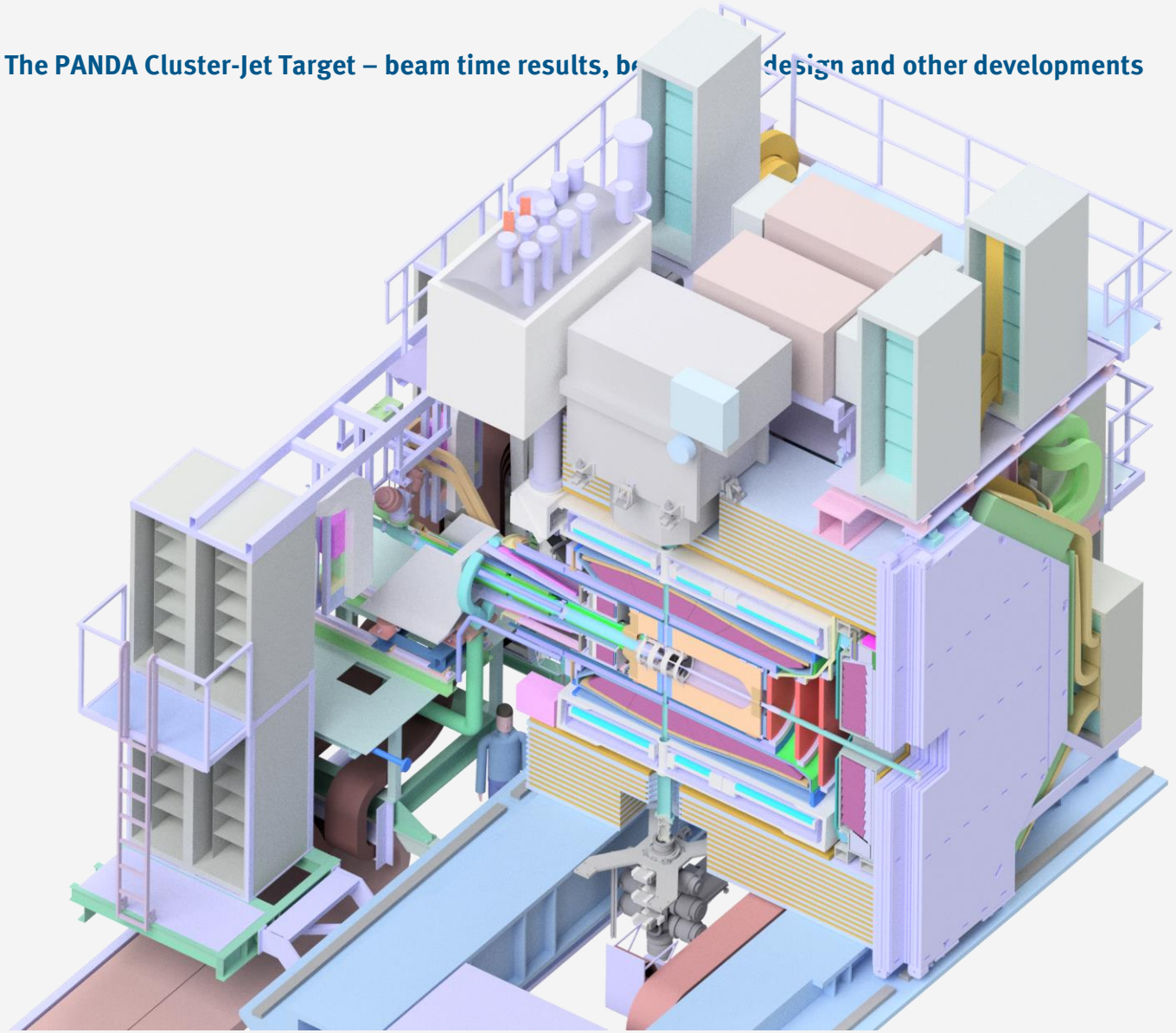
  → Due to previous maintenance (target had to be opened completely) highest thickness was not possible, but this should be solved by cleaning nozzle and collimator (not possible during beam time)



Modified target beam dump

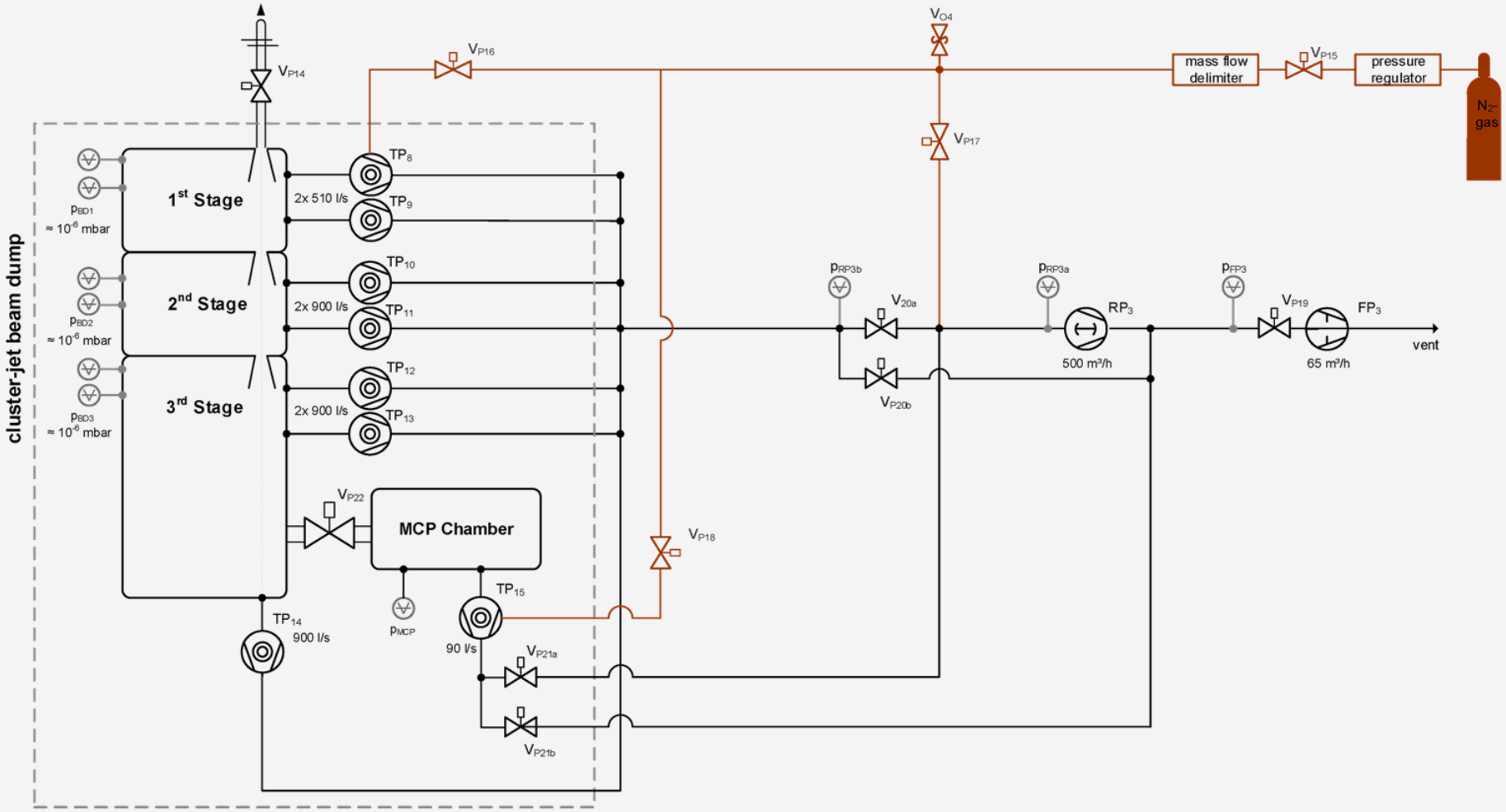
- Presented last meeting
- Accompanying pumping station in planning



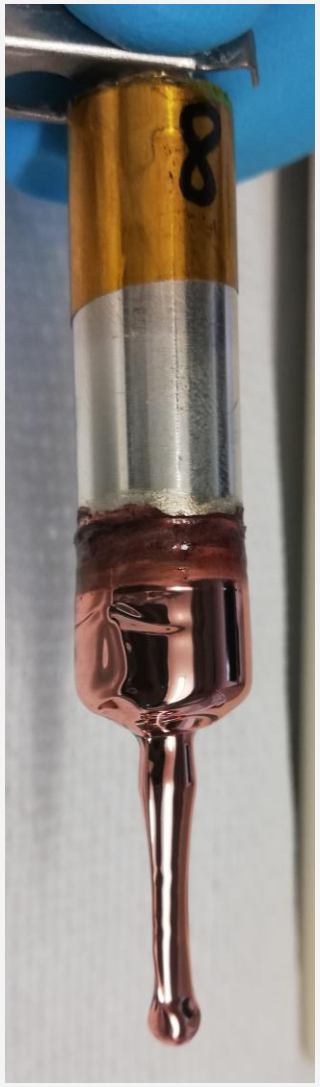


Pumping system

- Design of the beam dump pumping system started
- Located directly at the beam dump below the solenoid



Nozzle production



Nozzle production

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- This process needs very high precision to not break the drill

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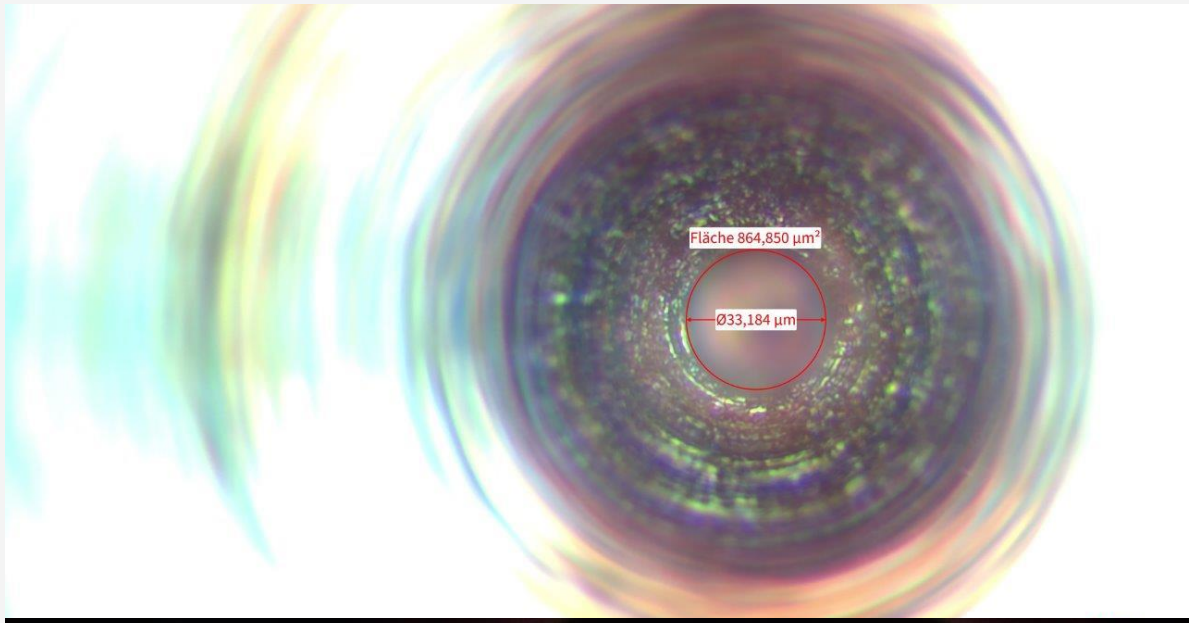
- After galvanization, the inlet and narrowest inner diameter (~30 µm) has to be drilled
- This process needs very high precision to not break the drill
- First nozzle in PANDA geometry with ~33 µm narrowest inner diameter was drilled yesterday

  → First nozzle manufactured completely in Münster
- More studies ongoing

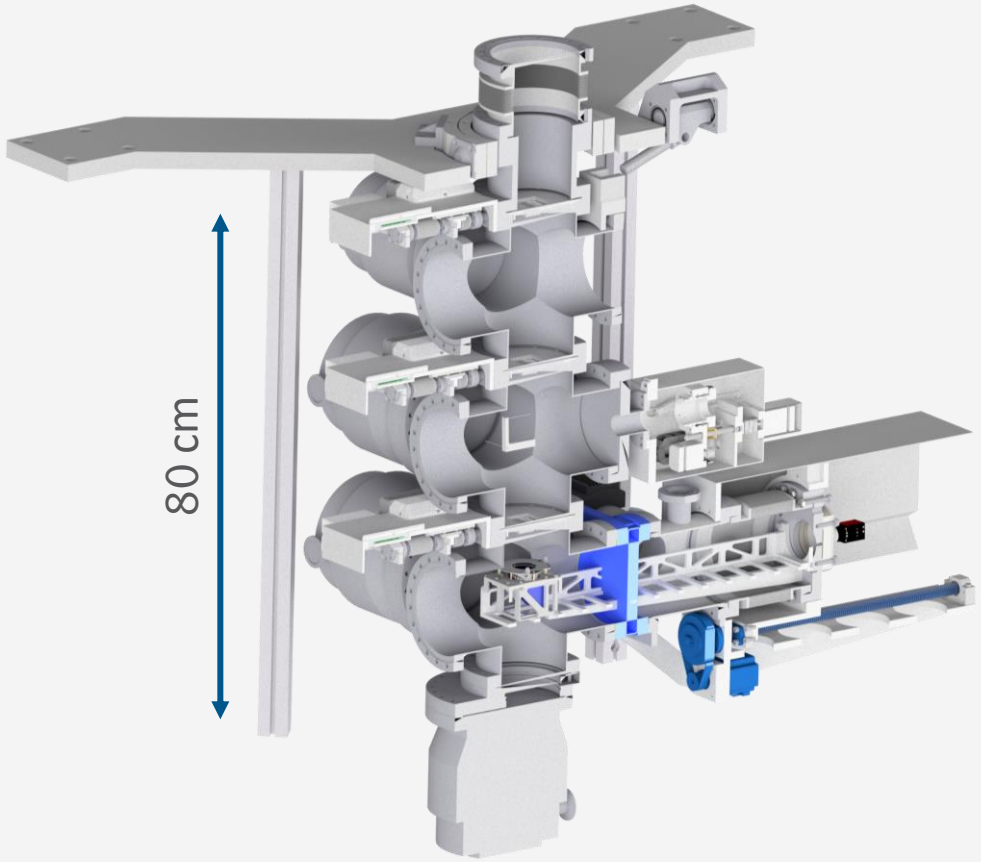


Summary and outlook

- PANDA cluster-jet target routinely in operation at COSY for studies on the beam-target interaction
- Beam quality studies has been performed with the PANDA target (thickness design value achieved), the COSY barrier bucket and a part of the HESR stochastic cooling
- Stable beam conditions already after ~80 s of cycle time reached (planned cycle time for PANDA: ~45 min), longer cycles (30 min) have been measured this year
- Momentum spread differs by less than a factor of 2 while changing the thickness by two orders of magnitude and the beam intensity by one order
- More detailed analysis (with new data sets) is ongoing

Summary and outlook

- Design of an optimized beam dump with pumping station nearly finished
- Further beam times planned with new beam dump that allows:
  - First test of the complete system
  - Additional monitoring systems for simplified adjustment and for target beam and vertex zone visualization
- Further ongoing studies: Nozzle production, performance of a new electron gun for beam dump monitor systems



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