

The PANDA Cluster-Jet Target Installation and Commissioning Beam Time at COSY

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GSI Darmstadt, Germany

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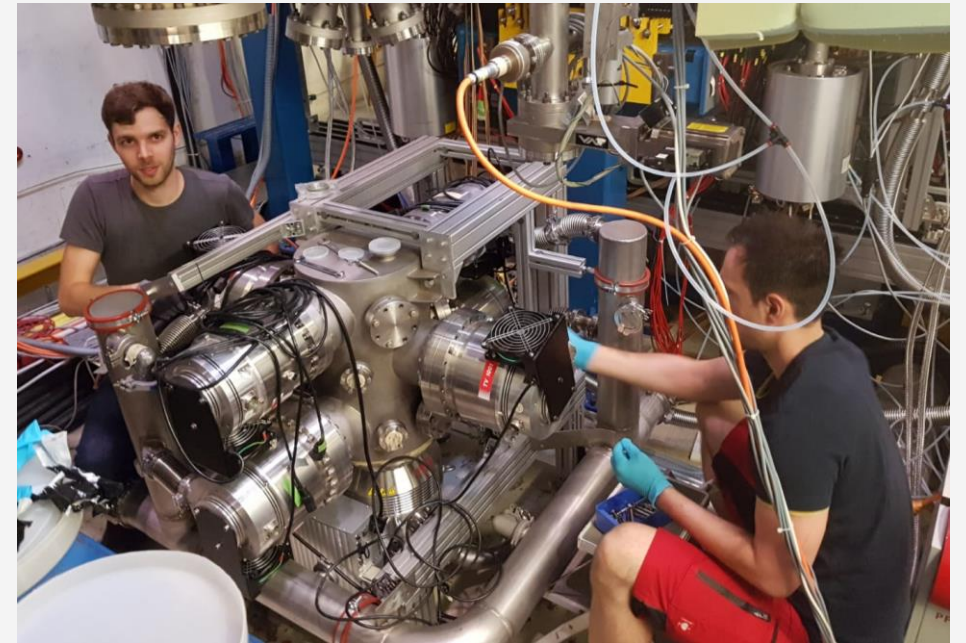
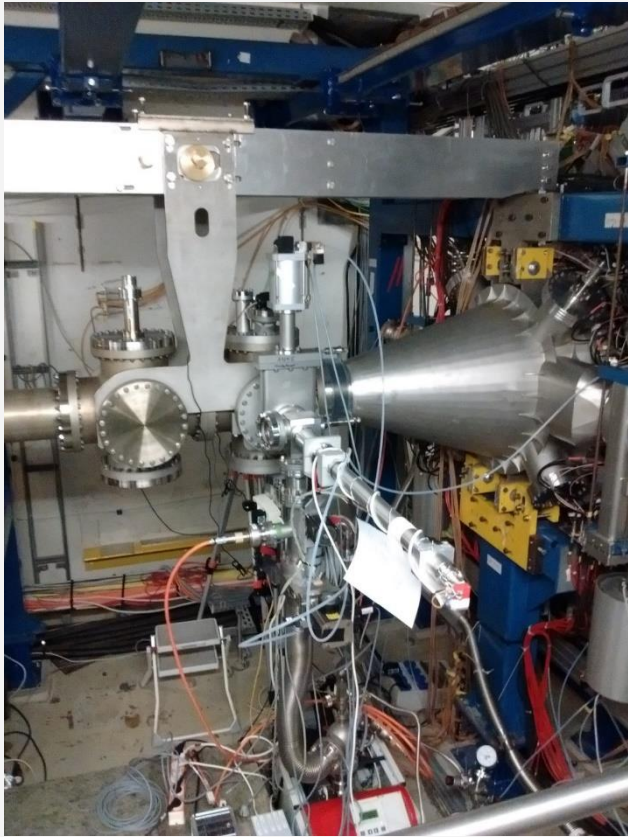
Overview

- PANDA Cluster-Jet Target installation at COSY/FZ Jülich
- Experimental programme of commissioning beam time and first results
- Beam time of stochastic cooling and 2 MeV electron cooling groups at COSY
 - HESR cooling meets PANDA cluster-jet target
- Activities at the Münster laboratories
- Upcoming PANDA CJT beam times at COSY

PANDA Target Installation at COSY

- Moving of PANDA target and beam dump from WWU Münster to COSY in June 2018
- Successful installation at former WASA pellet target location within a few weeks
 - Even though of external delays, e.g., new target platform ceiling
- End of June first cluster-jet beam passing from target source through the WASA interaction chamber, crossing COSY beamline, down to beam dump
- Many thanks to the FZ Jülich IKP and to the whole COSY crew for their support during preparation and installation time

Impression of the PANDA Cluster-Jet BD Installation at COSY



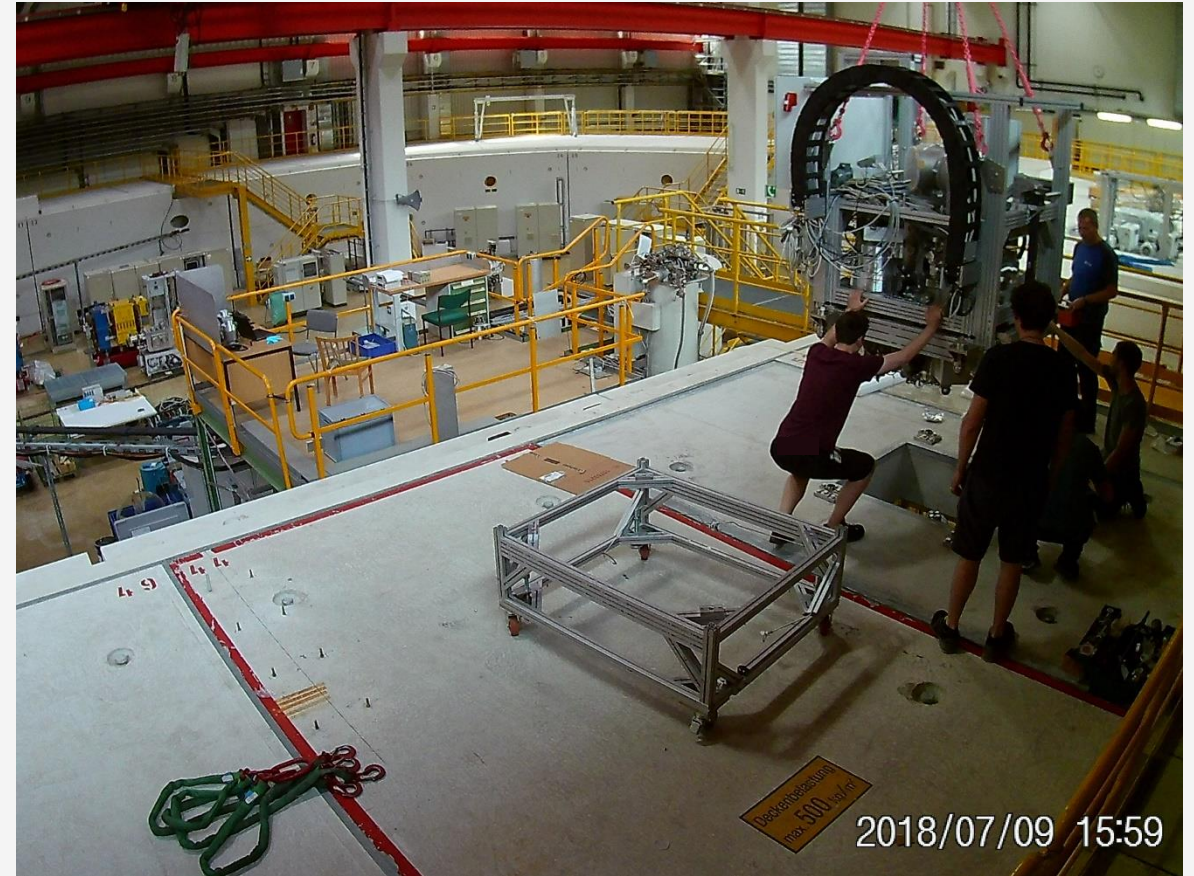
Impression of the new Platform Ceiling Installation at COSY



Impression of the PANDA Cluster-Jet Target Installation at COSY



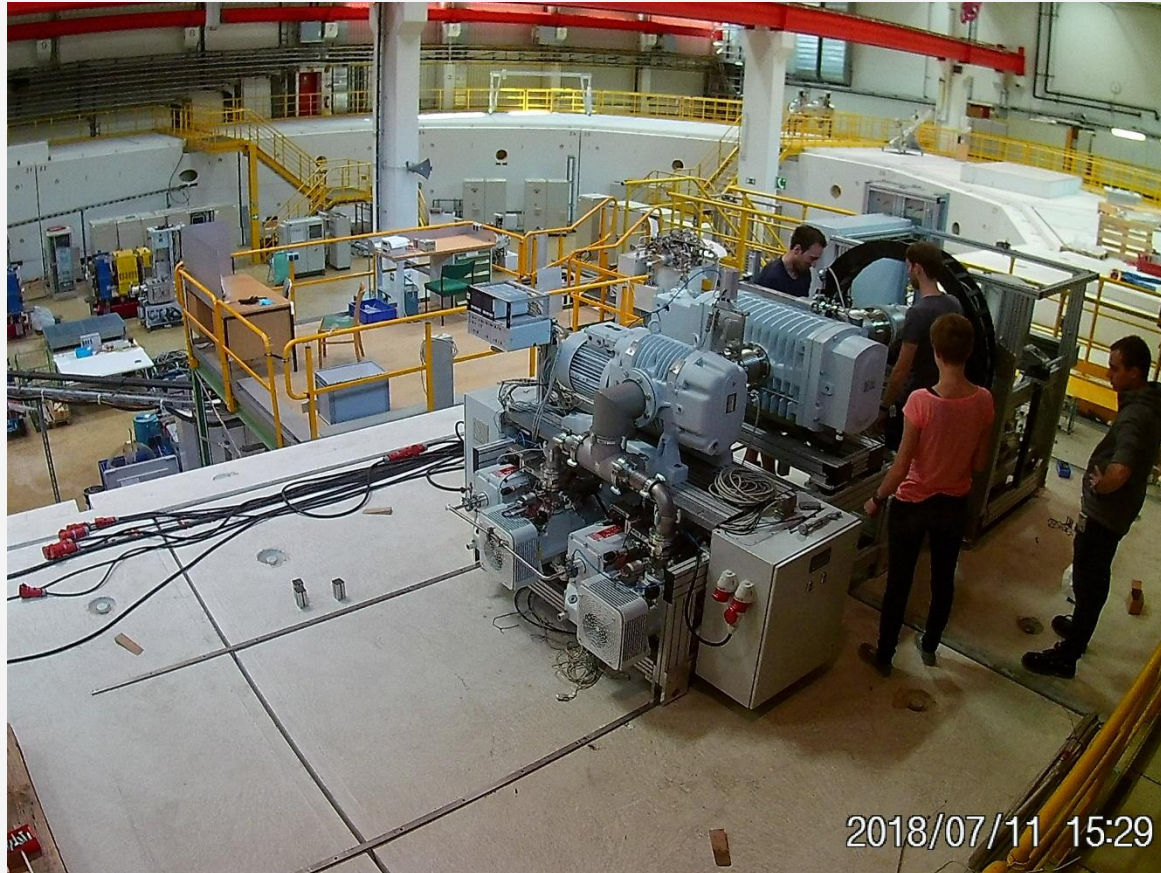
Impression of the PANDA Cluster-Jet Target Installation at COSY



Impression of the PANDA Cluster-Jet Target Installation at COSY

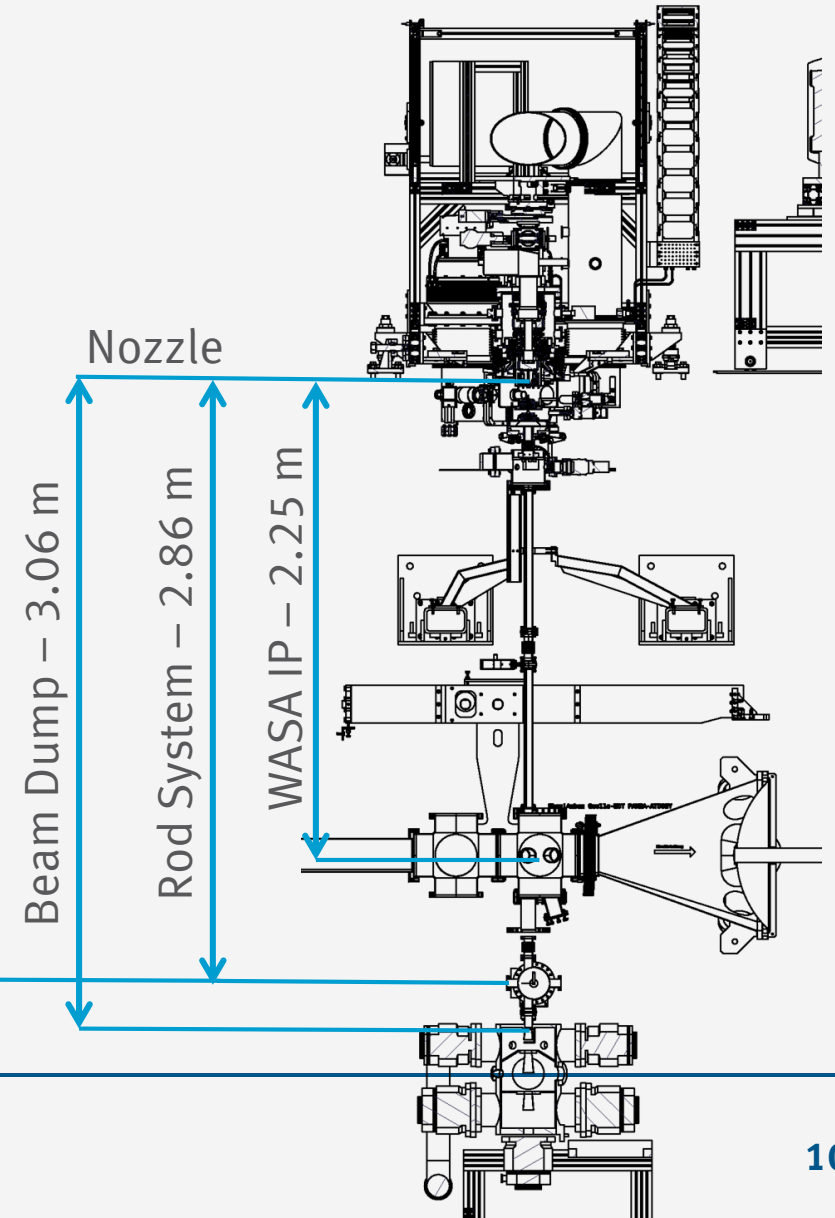
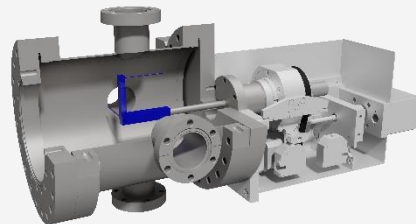


Impression of the PANDA Cluster-Jet Target Installation at COSY



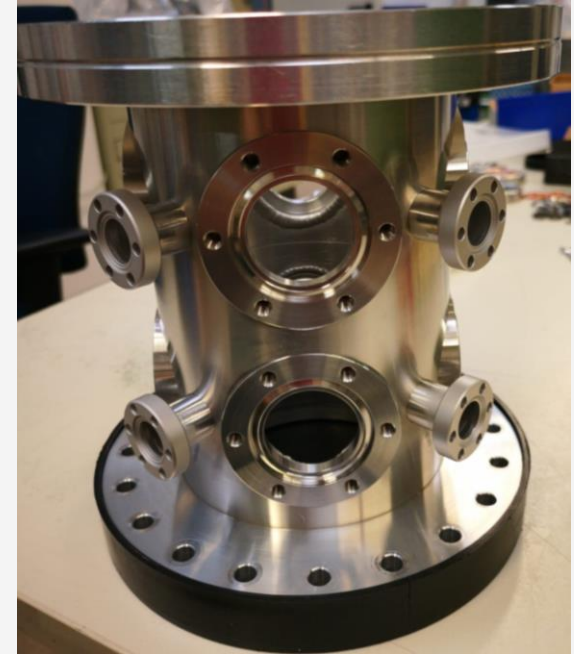
PANDA Target Setup at COSY

- Setup in next to PANDA geometry
- WASA IP = PANDA IP distance
- Rod System for jet beam thickness studies
 - Foreseen Pellet Tracking Chamber not installed
- Beam Dump distance less than at PANDA
- Worst case vacuum studies for PANDA



Pellet Tracking Chamber

- Send to Jülich for installation
- Chamber was not acid cleaned and thus not accepted by COSY vacuum crew
- Leaky after acid cleaning
- CF cutting edges got damaged by acid
- No improvement after re-welding
- Installation of Münster moving rod system for this and coming beam times

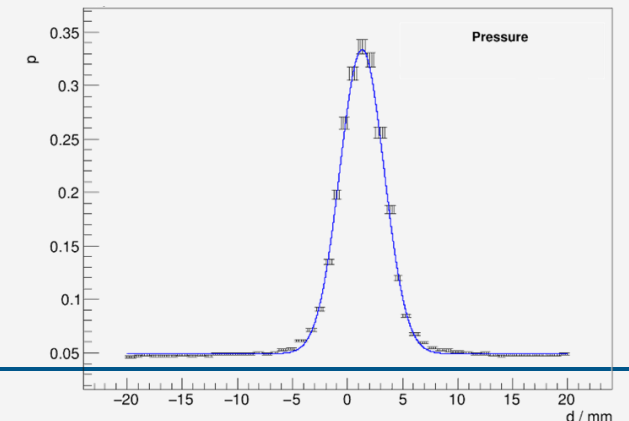
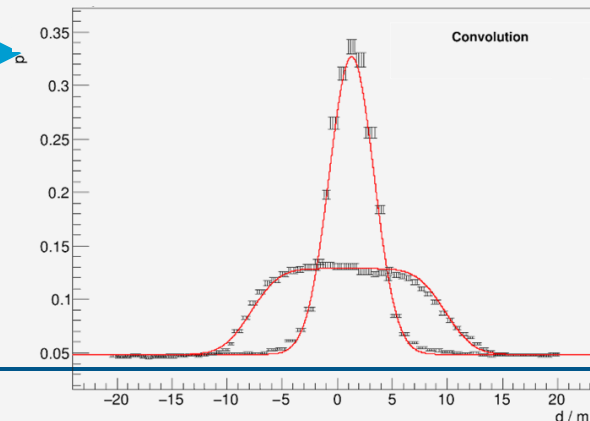
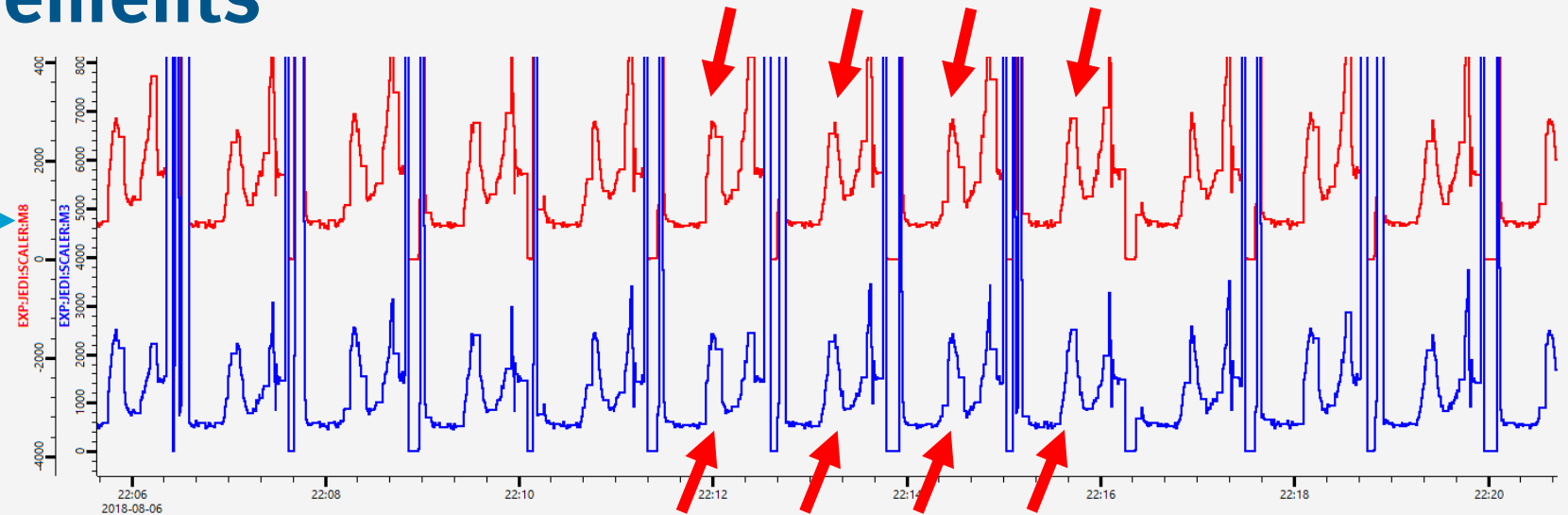


Commissioning Beam Time at COSY

- 1 Week of beam time (06.08.2018 – 12.08.2018)
- A wide variety of experimental commissioning measurements
 - Pumping speed, cluster evaporation, vacuum and beam profile measurements
 - Beam life time and energy loss studies
 - Time structure of event rate and data taking effects using the WASA detector with the PANDA CJT
 - Only one COSY beam momentum of 2.425 MeV/c
- Great first glimpse into many crucial aspects for PANDA
- Good starting point for upcoming PANDA CJT beam times at COSY

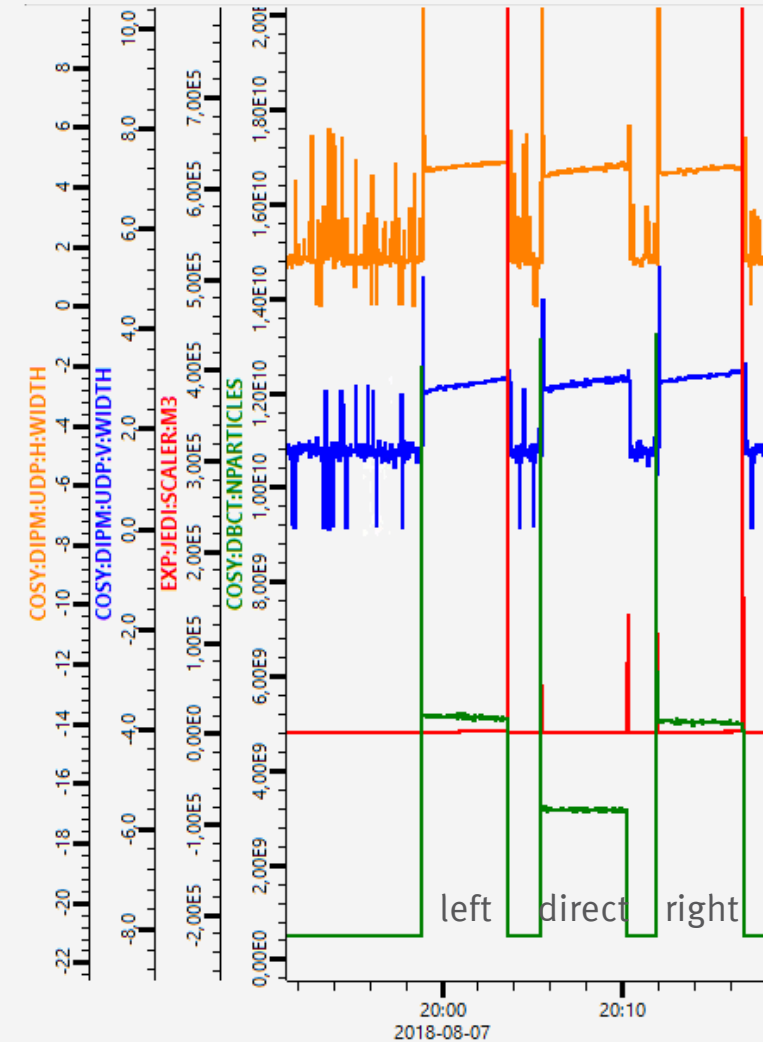
Beam Profile Measurements

- Wobbling with COSY beam to scan CJ-beam
- Slit collimator for rectangular cluster beam
- CJ-beam FWHM $\sim (4 \times 16) \text{ mm}^2$
- Using moving rod system
- Thickness: $7.4(2) \times 10^{14} \text{ atoms/cm}^2$ at PANDA distance at first try!



Influence on COSY Beam

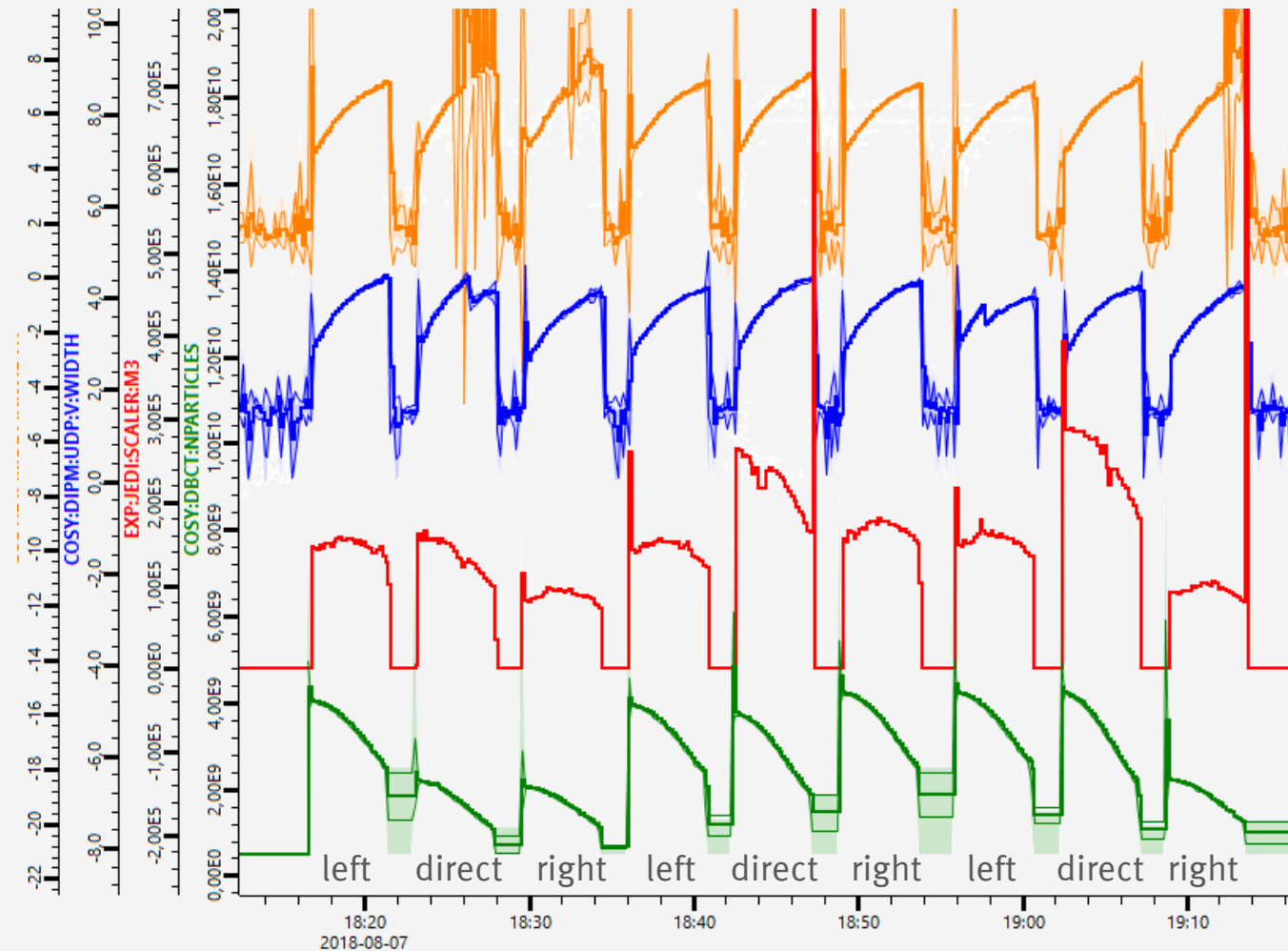
- Target off
- No HF, no Barrier Bucket
- Horizontal, vertical COSY beam size at IPM
- WASA event rate is zero
- Number of COSY particles „constant“
- Emittance growth small and similar in all cases



Influence on COSY Beam

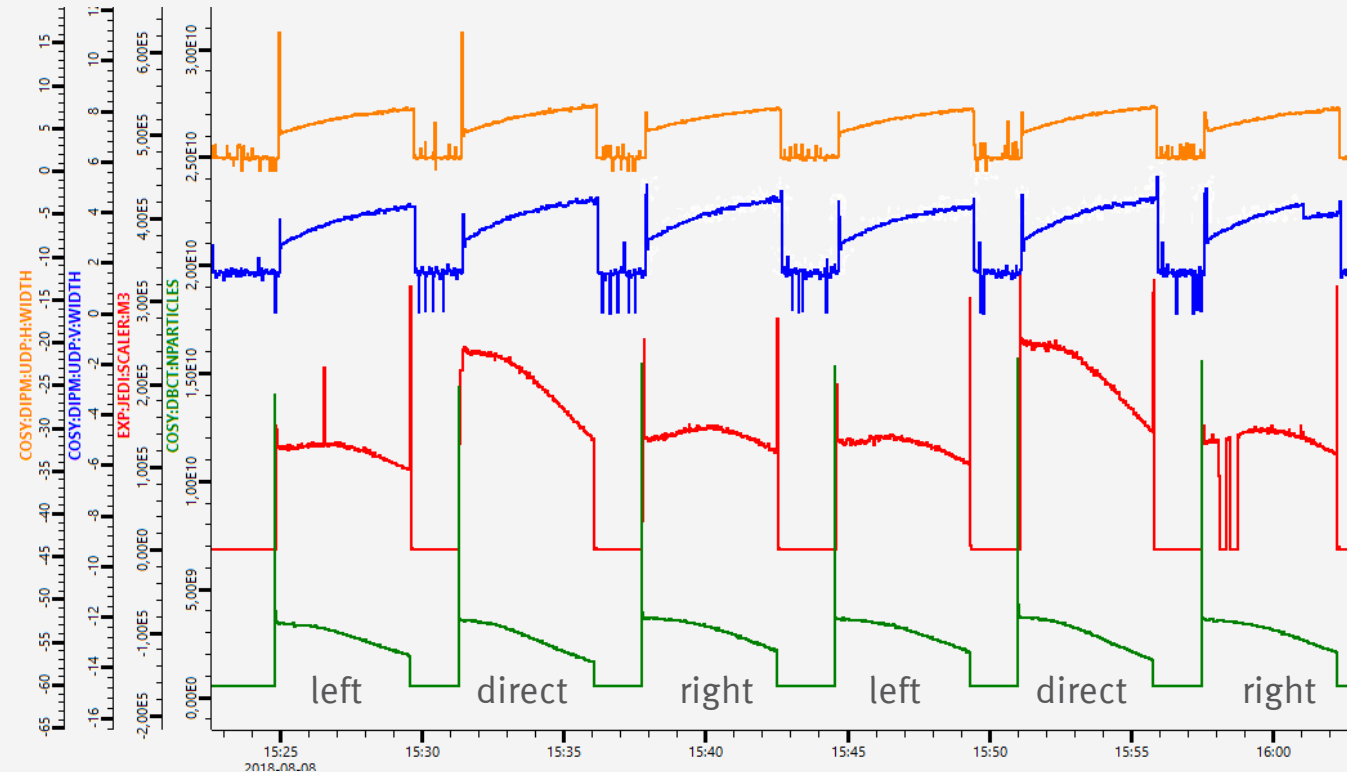
- Target on
- No HF, no Barrier Bucket
- Horizontal, vertical COSY beam size at IPM
- WASA event rate
- Number of COSY particles
- Left and right around target „constant“
WASA rate, direct on target decreasing
WASA rate
- Emittance growth similar in all cases

The PANDA Cluster-Jet Target Installation and Commissioning Beam Time at COSY



Influence on COSY Beam

- Target on
- No HF, **with** Barrier Bucket
- Horizontal, vertical COSY beam size at IPM
- WASA event rate
- Number of COSY particles
- Emittance growth similar in all cases
- Fast decrease in COSY beam life time



Schottky Frequency Measurements – Lateral Momentum

- Change in lateral momentum measured via Schottky pick up:

$$\frac{\Delta p}{p_0} = \frac{1}{\eta} \frac{\Delta f}{f_0} \quad \eta = \frac{1}{\gamma^2} - \frac{1}{\gamma_{tr}^2}$$

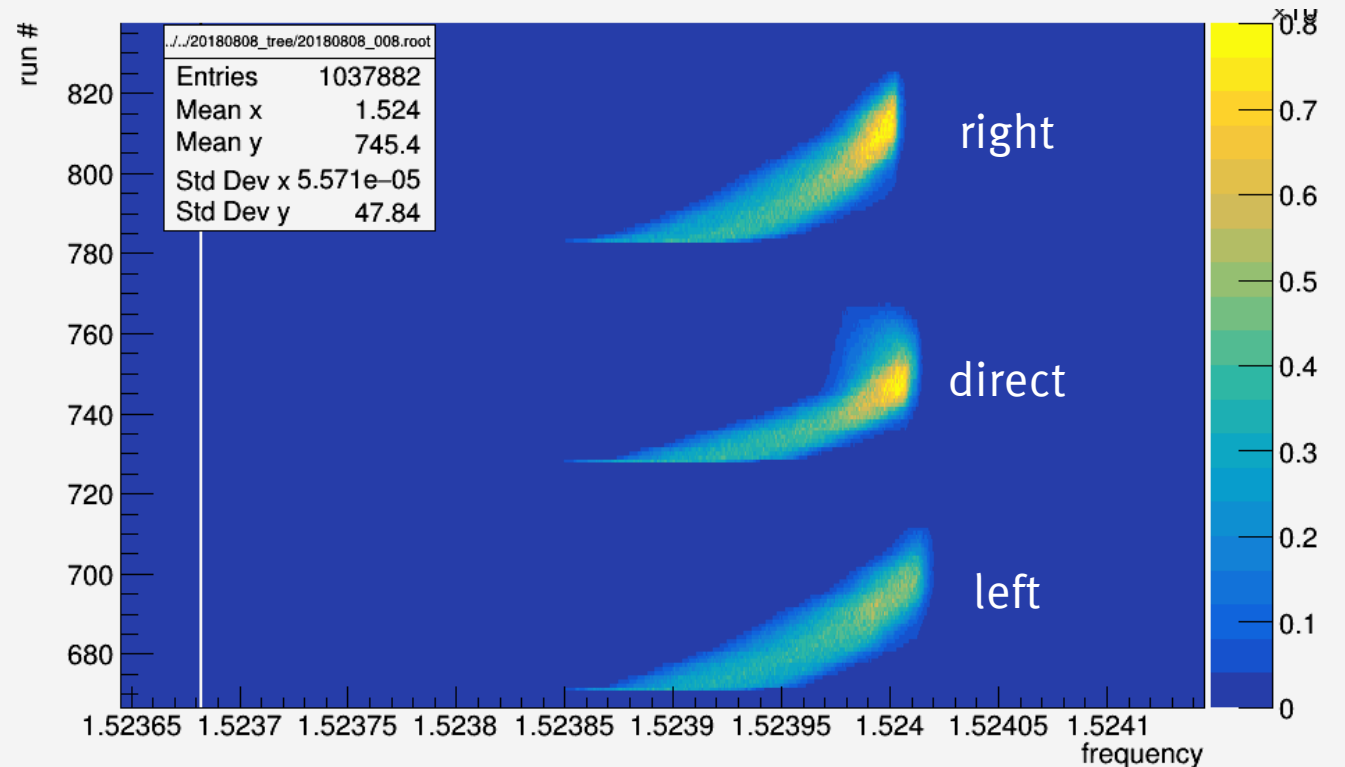
- Target thickness determination via Schottky possible:

(ref. H.J. Stein, et al: Determination of target thickness and luminosity from beam energy losses)

$$n_T = \left(\frac{1 + \gamma}{\gamma} \right) \frac{1}{\eta} \frac{1}{(dE/dx)m} \frac{T_0}{f_0^2} \frac{df}{dt}$$

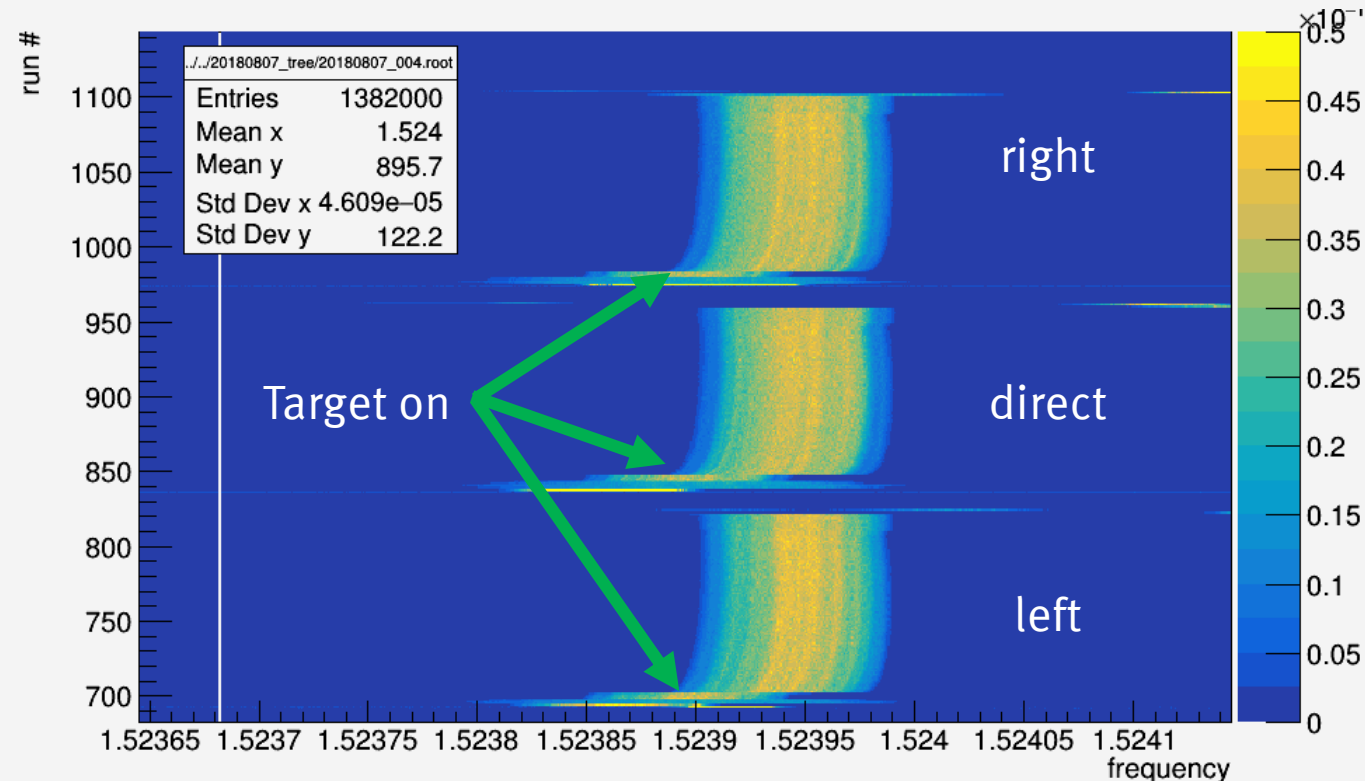
Schottky Frequency Measurements - Lateral Momentum

- Target on, **no** BB/HF
- COSY beam direct onto and around the target
- Left: $\sim 3.1 \times 10^{13}$ atoms/cm²
- Right: $\sim 6.9 \times 10^{13}$ atoms/cm²
- Direct: $\sim 8.1 \times 10^{14}$ atoms/cm²
- Possibly effect of residual gas or not perfect COSY beam bump around target
- Will be studied in detail in upcoming beam times



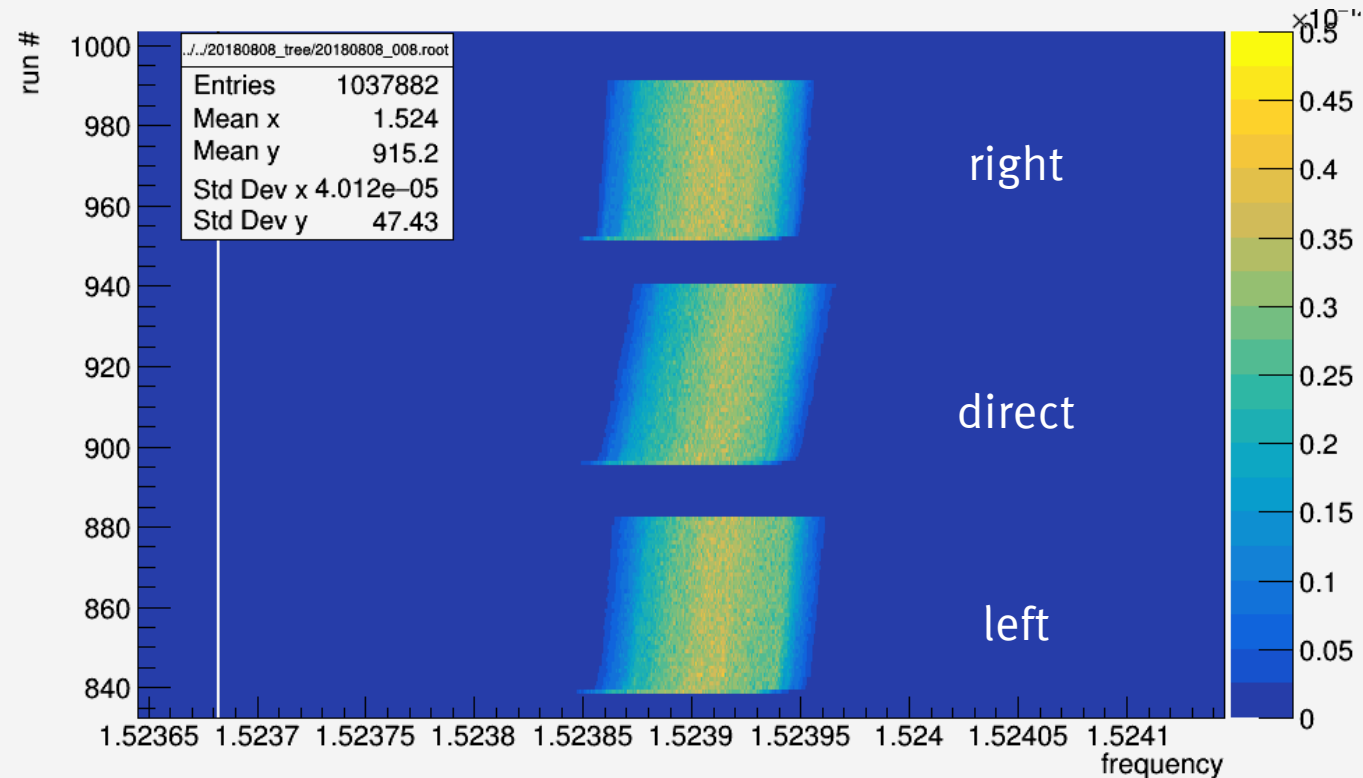
Schottky Frequency Measurements - Lateral Momentum

- Target on, **with** HF
- COSY beam direct onto and around the target
- Frequency shift after turning target on (~ 0.003%)
- Cycle length 300s
- Lateral momentum fairly stable



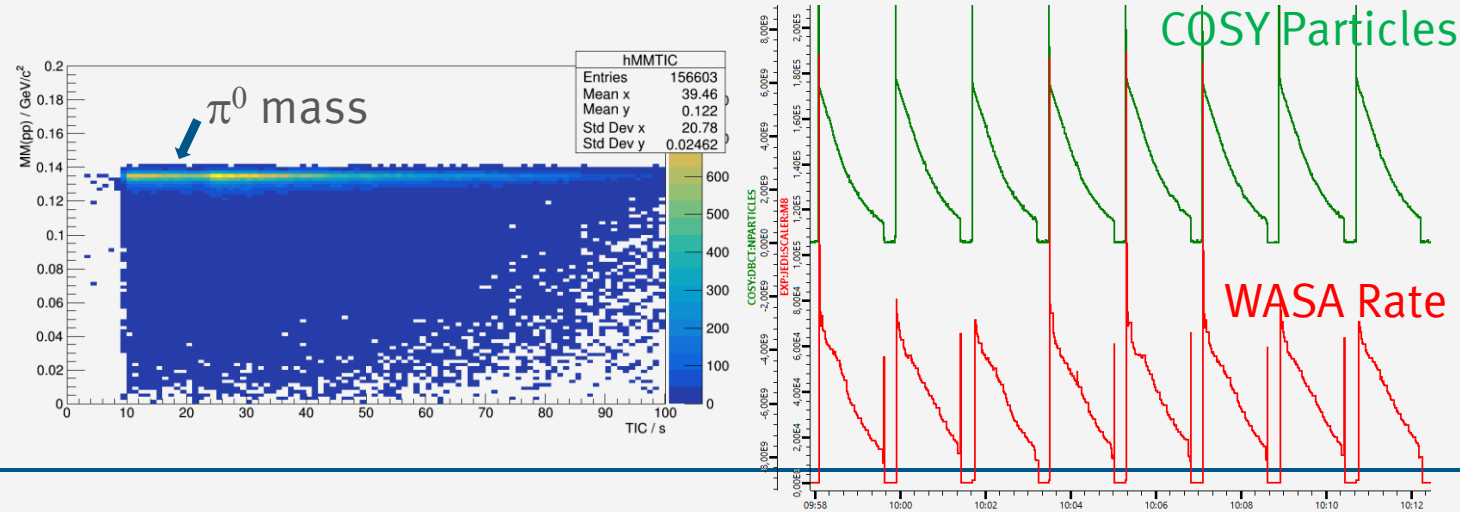
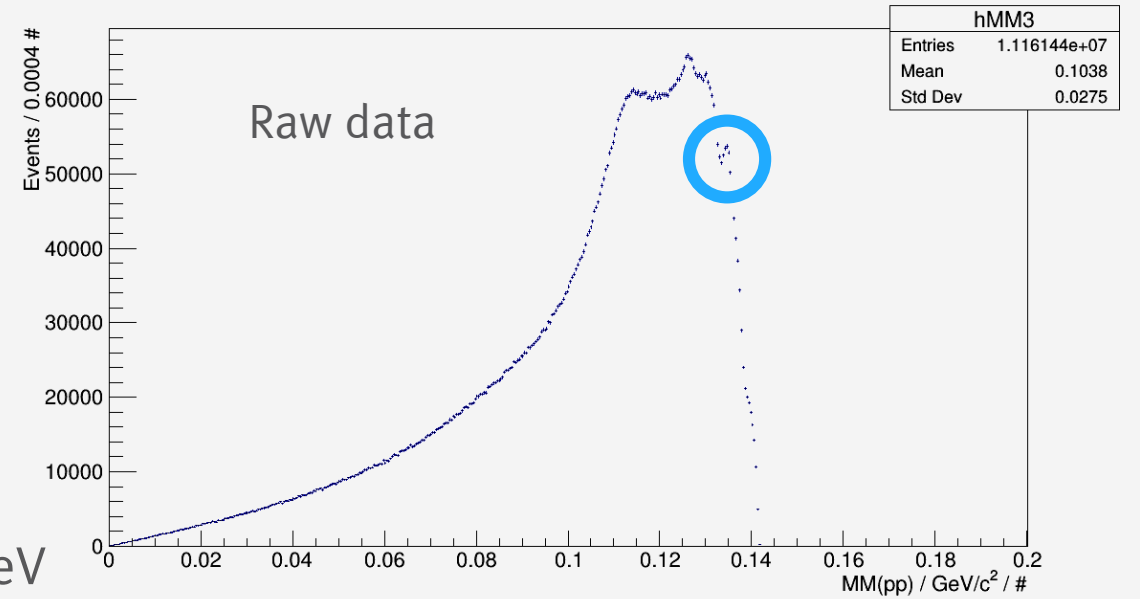
Schottky Frequency Measurements - Lateral Momentum

- Target on, **with** BB
- COSY beam direct onto and around the target
- Cycle length 300s
- Much lower shift in lateral momentum



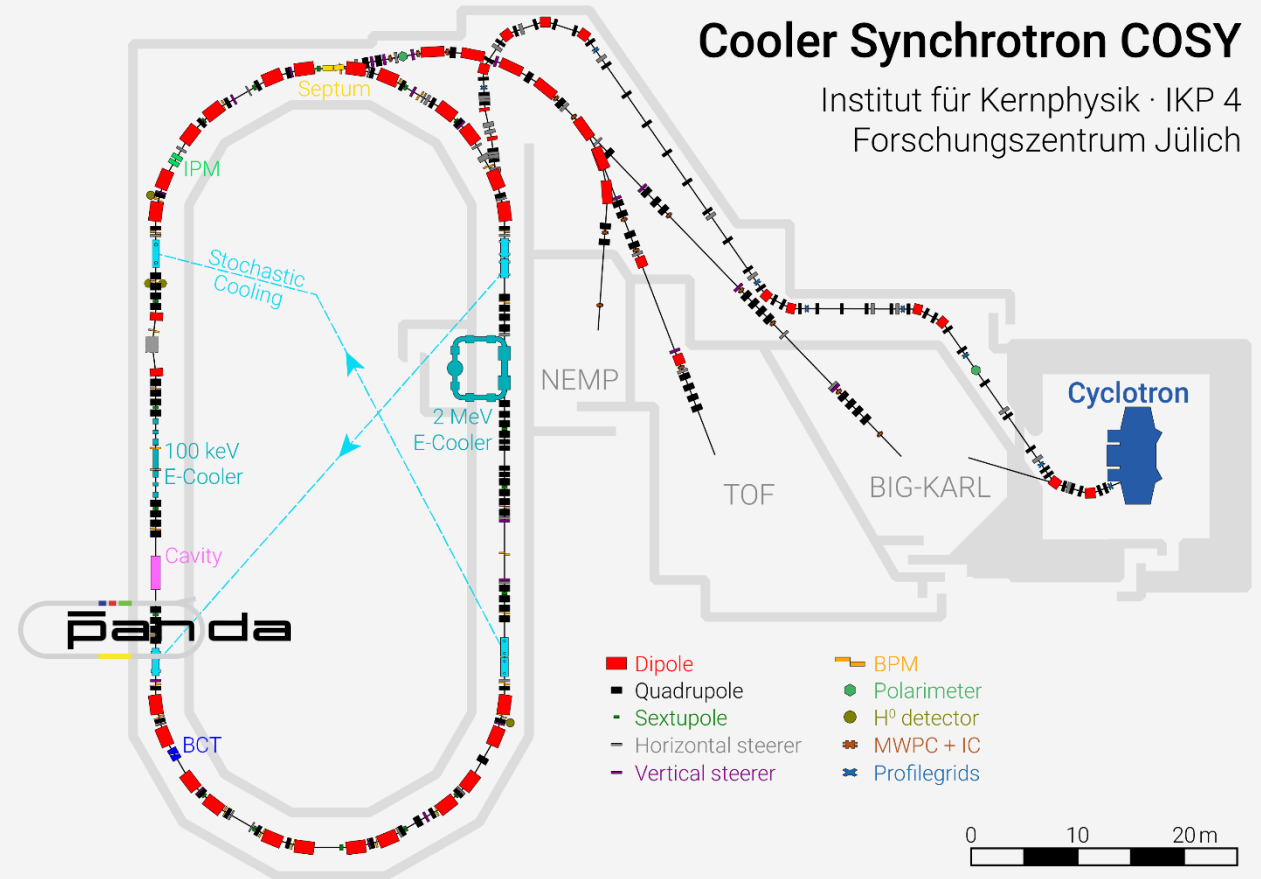
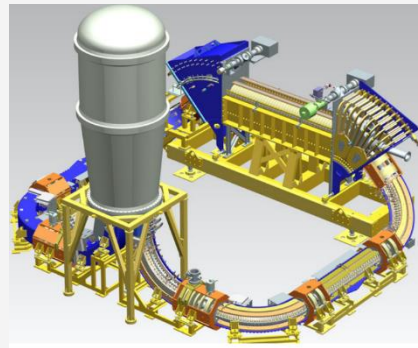
WASA Detector meets PANDA CJT

- WASA Forward Detector System used
- 800 MeV/c COSY beam, cycle time 90s
- $p p \rightarrow p p \pi^0$ ($Q = 7$ MeV)
- Background description via 760 MeV/c, $Q = -5$ MeV
- Study of signal quality and effects of BB, HF, none
- Future beam times will investigate effects of target settings on physical data taking



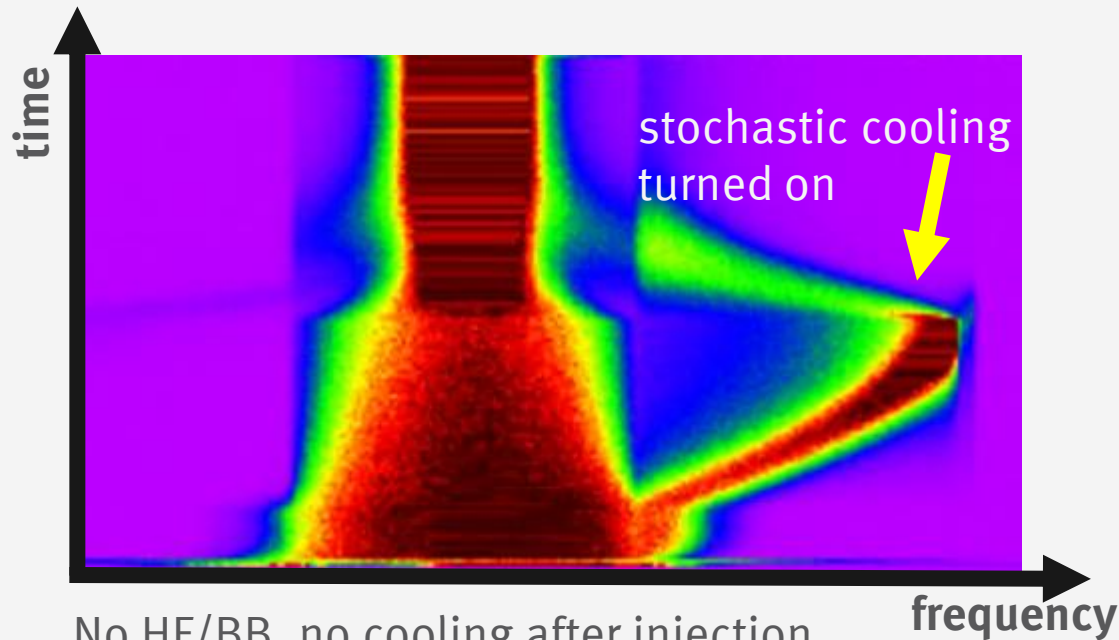
HESR Cooling Meets PANDA CJT

- 1 week stochastic cooling beam time in August 2018
- 3 weeks of combined stochastic and 2 MeV electron cooling beam time in October 2018
- Both beam times in synergy with the PANDA cluster-jet target

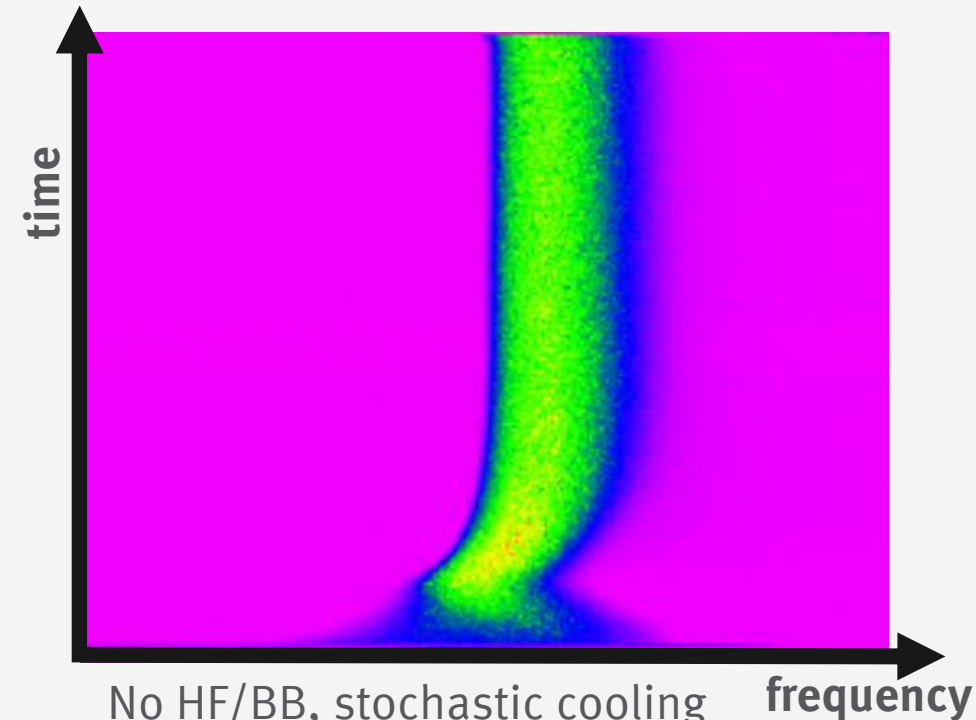


Stochastic Cooling – PANDA CJT August 2018

- Low COSY particle number: 4×10^8 COSY particles
- Only qualitative tests done in August



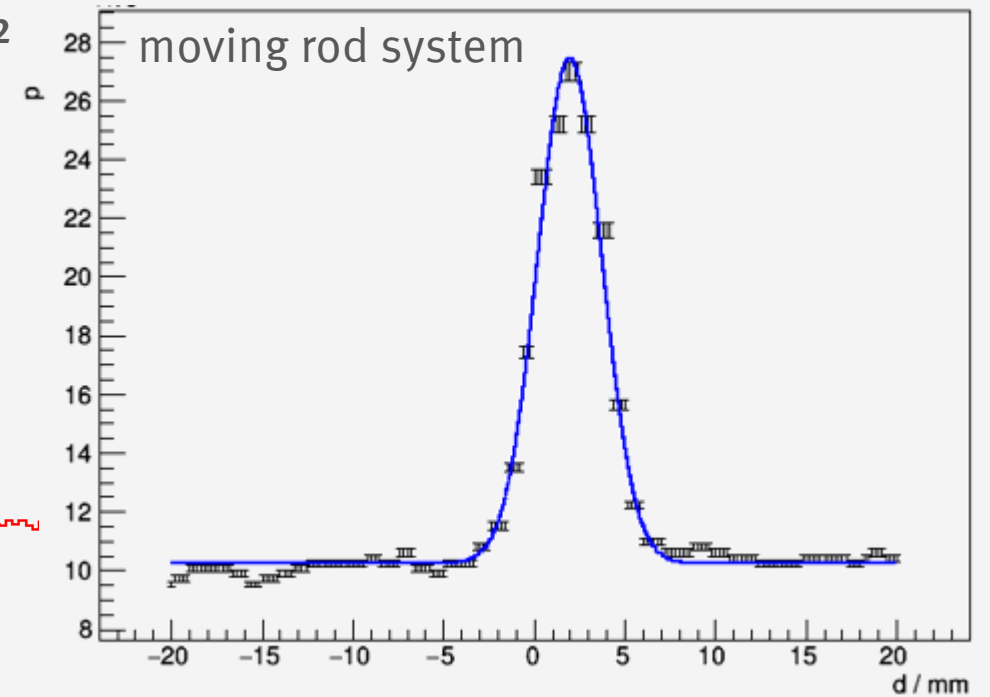
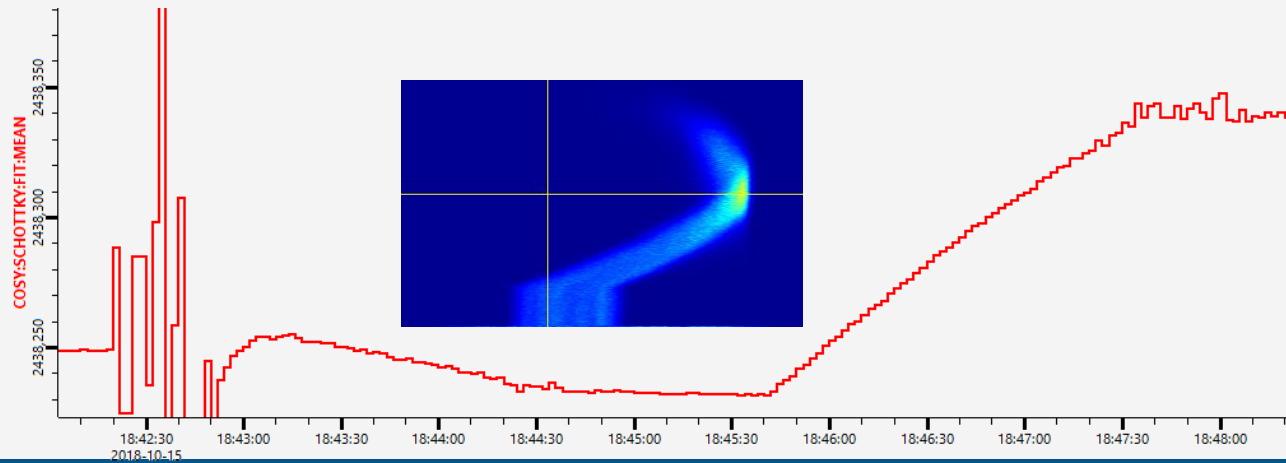
No HF/BB, no cooling after injection,
target of 3×10^{14} atoms/cm²



No HF/BB, stochastic cooling
direct after injection turned on,
target of 7×10^{14} atoms/cm²

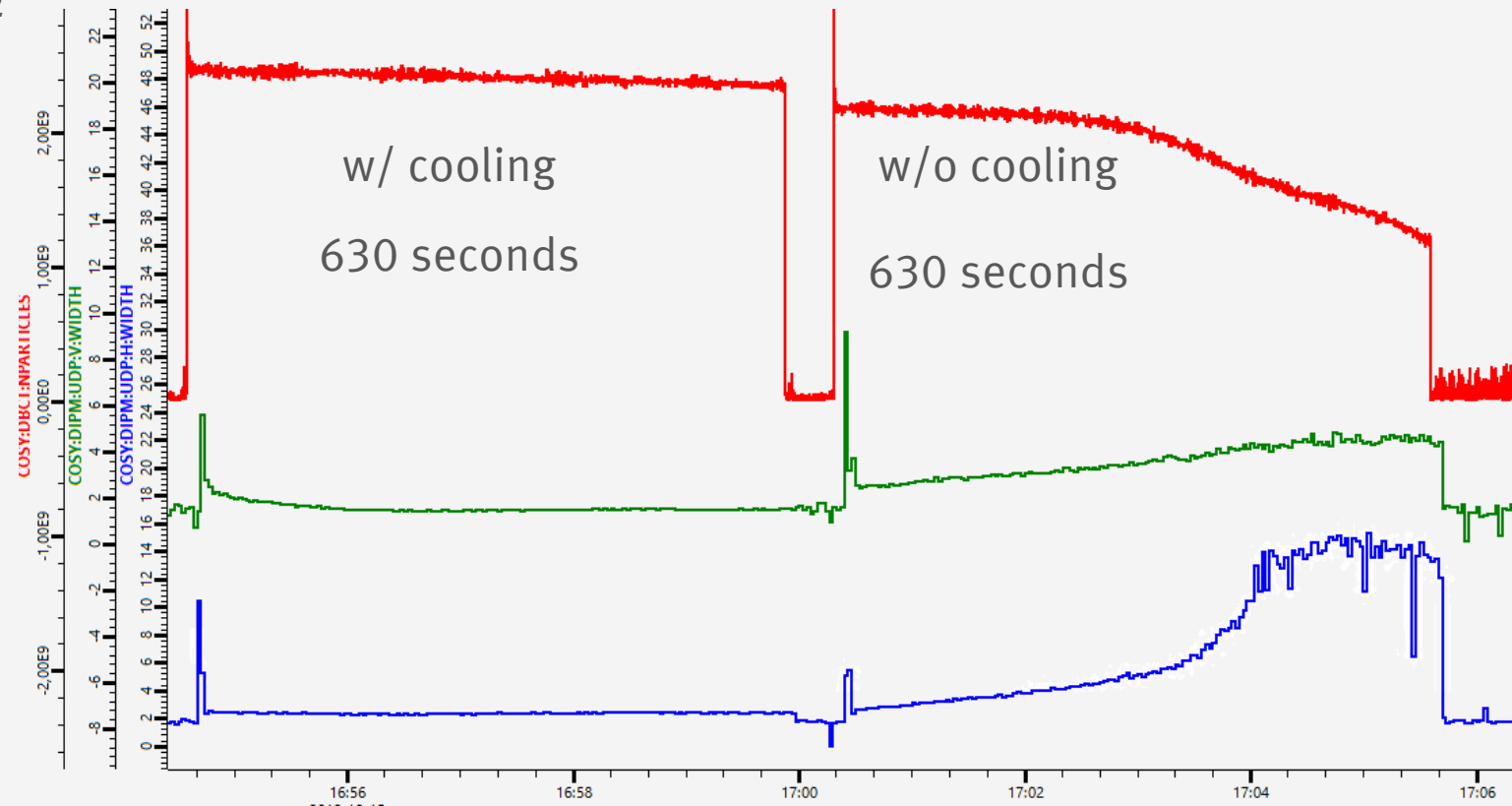
Stochastic & e-Cooling – PANDA CJT October 2018

- PANDA Target thicknesses of $1.10(2) \times 10^{15}$ atoms/cm² at PANDA IP distance, stable during beam time
- Schottky measurements second thickness with a value of $\sim 2 \times 10^{15}$ atoms/cm²



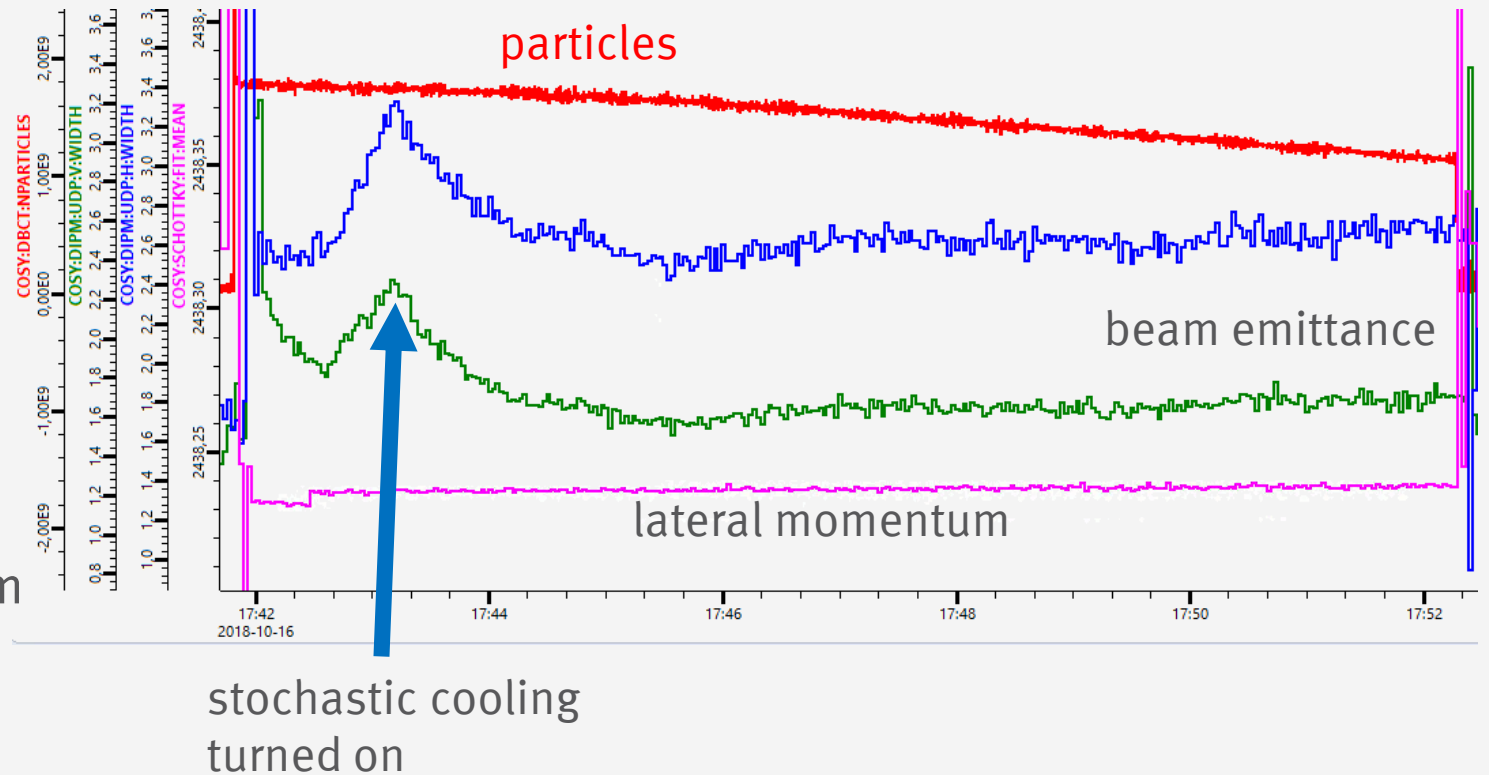
Stochastic Cooling – PANDA CJT October 2018

- Thicknesses of $>1 \times 10^{15}$ atoms/cm²
- **COSY particles** $>2 \times 10^9$
- Diameter at IPM **w/** cooling:
 - **Vertical:** <1.5 mm
 - **Horizontal:** <2.3 mm
- Diameter at IPM **w/o** cooling:
 - **Vertical:** >4 mm
 - **Horizontal:** >14 mm



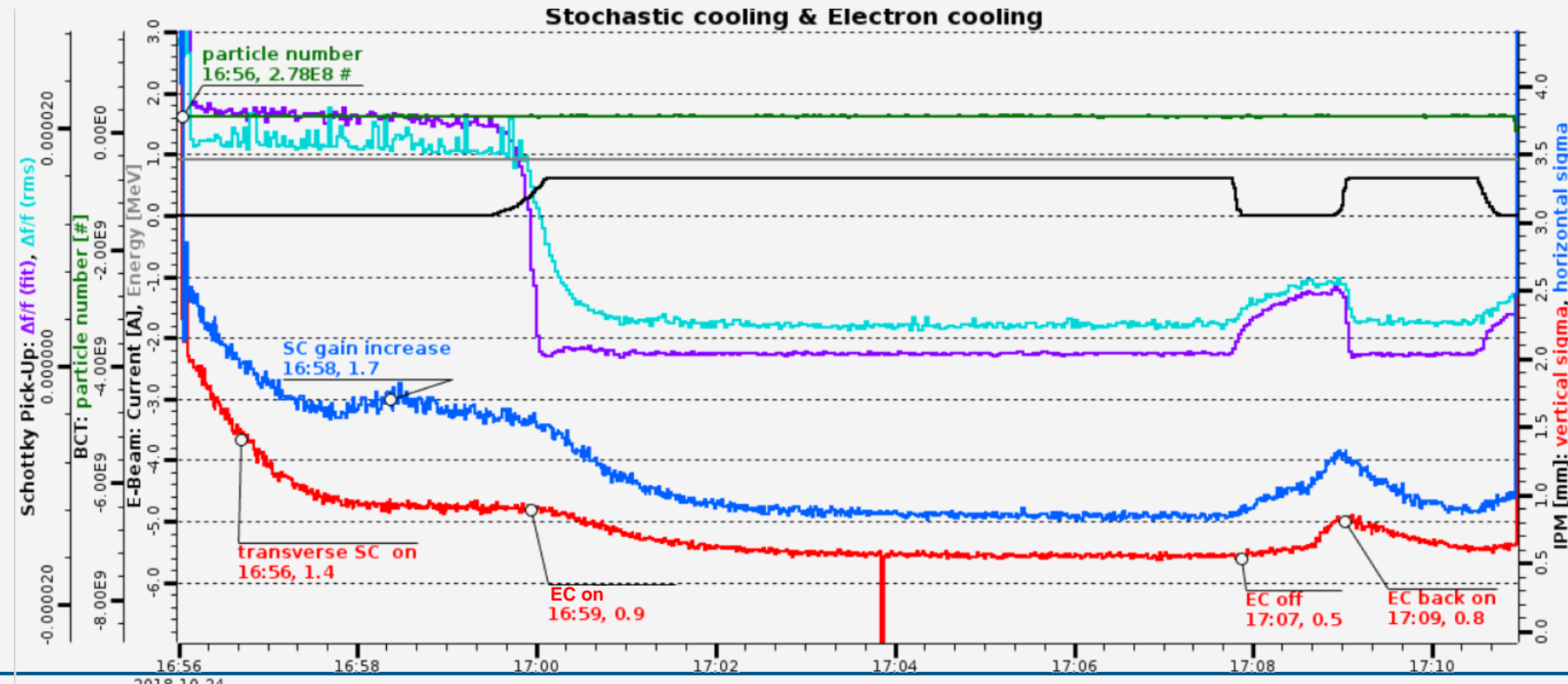
Stochastic Cooling – PANDA CJT October 2018

- Thicknesses of $>1 \times 10^{15}$ atoms/cm²
- COSY particles $>1 \times 10^9$
- With cooling:
 - Constant H/V COSY beam emittance
 - COSY beam lifetime >630 s
 - Constant mean lateral momentum
 - Constant WASA rates



Stochastic & e-Cooling – PANDA CJT October 2018

- Thicknesses of $>1 \times 10^{15}$ atoms/cm²
- COSY particles 3×10^8
- EC push for:
 - H/V emittance
 - Lateral momentum
- Constant WASA rates



Activities at the Münster Laboratories

- New hydrogen purifier arrived and being prepared for test installation at the PANDA target prototype
- Will be moved to COSY at next maintenance slot
- Will be used for March PANDA CJT target beam time



Next PANDA CJT Beam Time at COSY

- Deeper look at individual aspects tested during commissioning beam time
- Re-/better adjustment of PANDA CJT source
- Influence of different target stagnation conditions on COSY vacuum and target thickness distribution
- Different COSY beam momenta (properly at least one with higher η values)
- New online analysis tools for direct measurement adjustments if needed
- Checking off questions arised by commissioning data analysis
- Test of new hydrogen purifier performance
- And many more to come...

Conclusion

- Successful commissioning PANDA cluster-jet target beam time at COSY
 - Installation and up running in less than a month
 - Thicknesses of $>1 \times 10^{15}$ atoms/cm²
 - Test at COSY and commissioning data taken
 - Vacuum, thickness, beam life time, physical data with WASA, ...
- Tests of PANDA target in cooperation with stochastic cooling and 2 MeV e-cooling
- Status of PANDA activities in Münster
- Topics of interest for upcoming beam times at COSY