

WP 30: JRA12 – Spin for FAIR

Andrea Pesce – IKP-2 (FZJ)

STRONG2020 Annual Meeting – October 14th-15th 2020



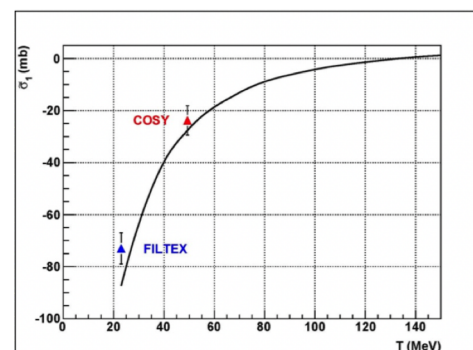
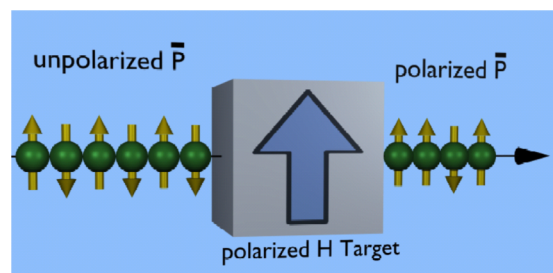
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

JRA12 – Spin for FAIR: Motivation

- Development of an efficient method for polarizing antiproton beams at FAIR

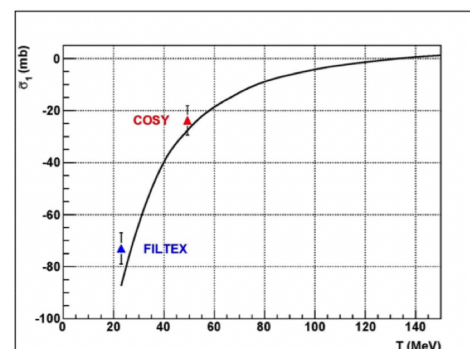
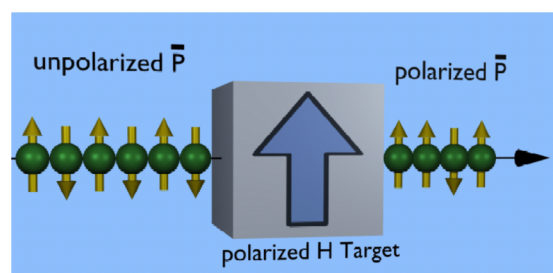
JRA12 – Spin for FAIR: Motivation

- Development of an efficient method for polarizing antiproton beams at FAIR
 - ✓ Spin filtering of protons with transverse polarization performed at COSY



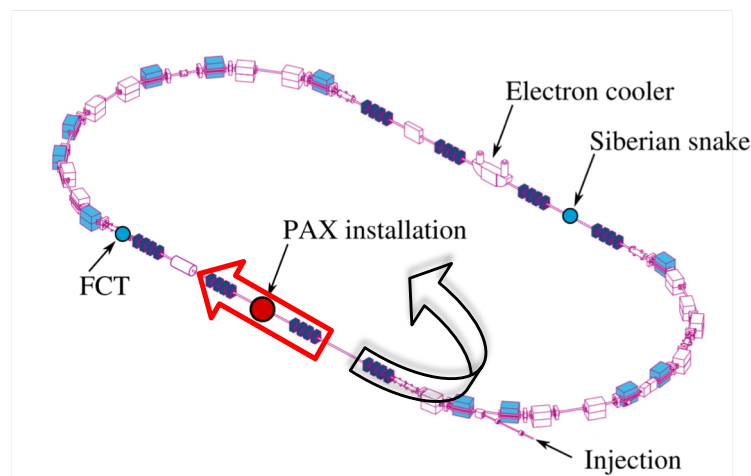
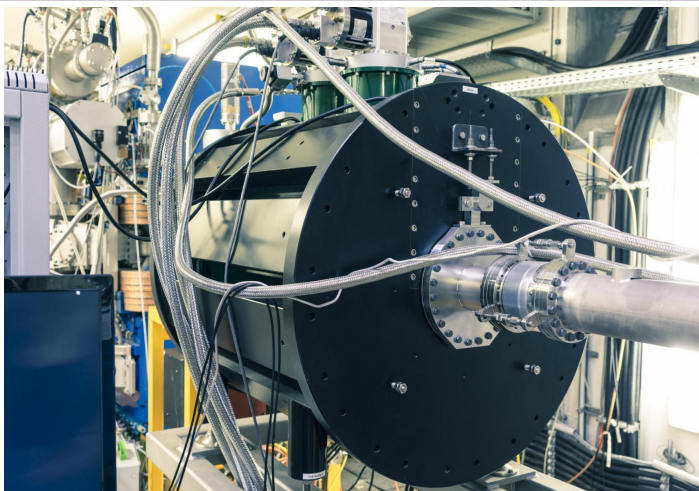
JRA12 – Spin for FAIR: Motivation

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- Test with longitudinal polarization needed to complete the measurement
 - Full determination of the $p_{\text{bar}}-p$ cross section
 - Experimental Storage Ring at FAIR

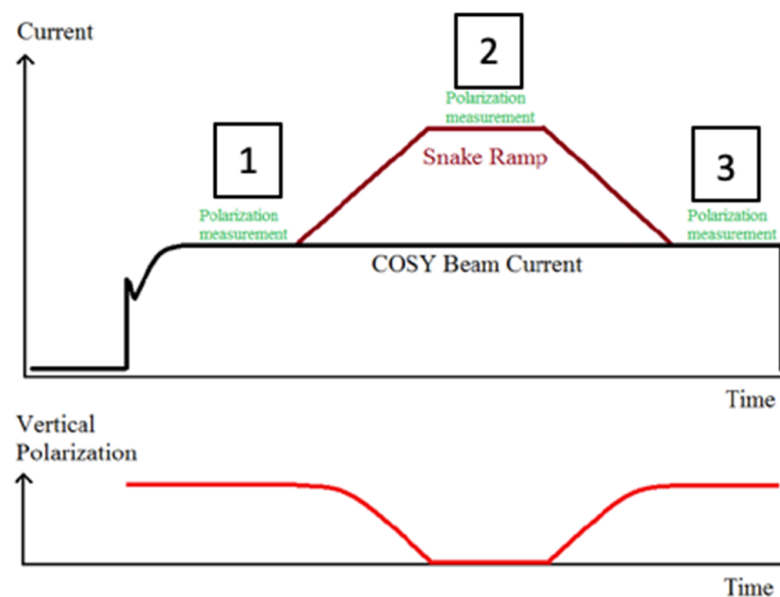
T1: Siberian Snake Commissioning



- Installed in COSY @ ANKE place
- First commissioning beam time in March 2020
- Will provide longitudinal polarization at PAX section

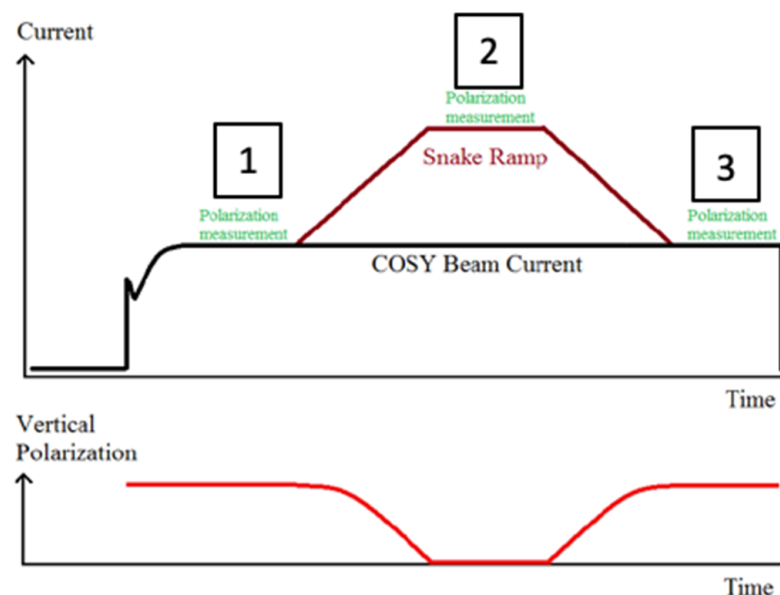
T1: Siberian Snake Commissioning

- Injection of a polarized p-beam
- Acceleration@135 MeV (521 MeV/c)
- E-cooling
- Snake ramp up (goal is 2.7 T)
- Tune shift compensation through quadrupole jumps



T1: Siberian Snake Commissioning

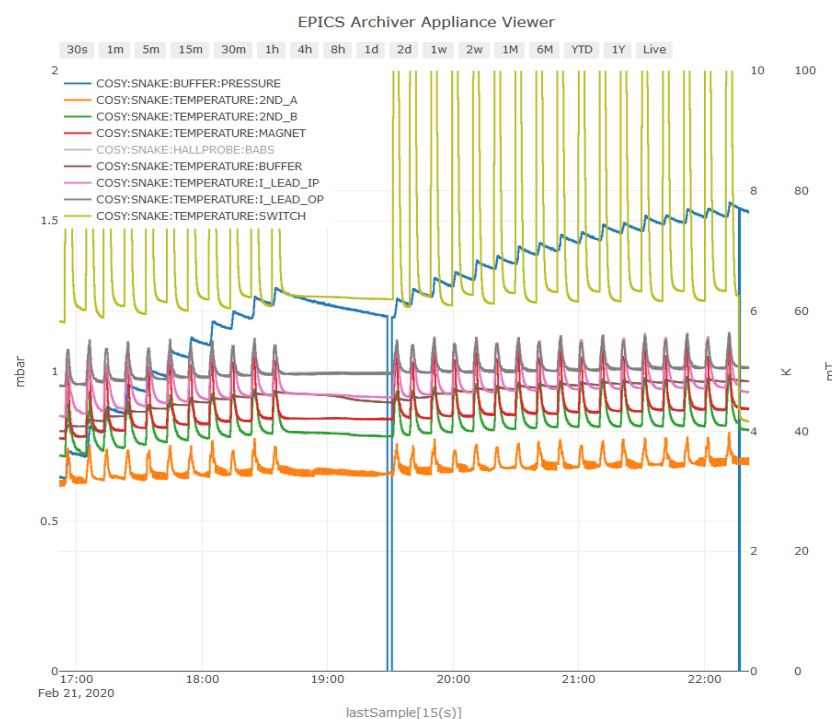
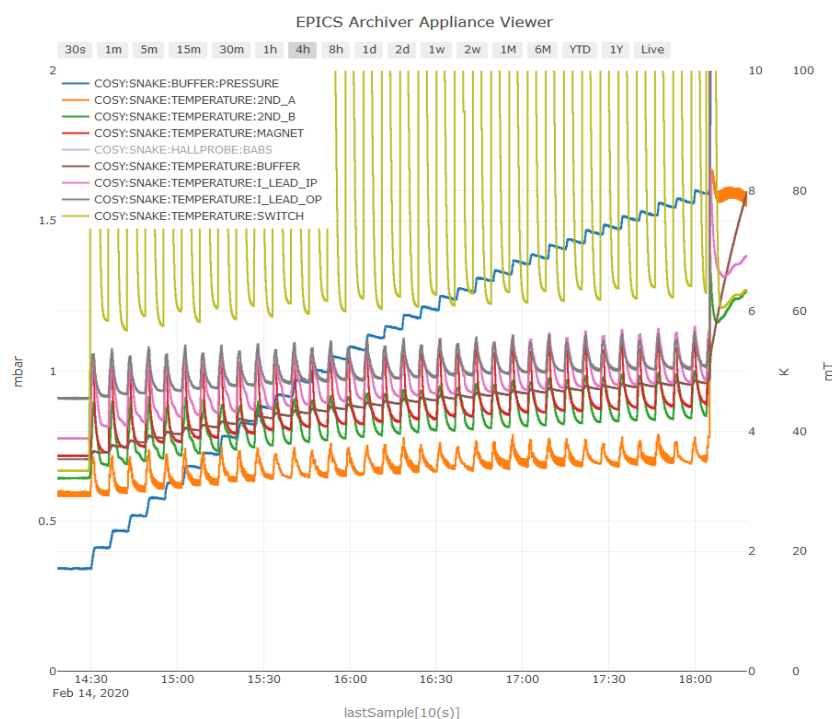
- Injection of a polarized p-beam
- Acceleration@135 MeV (521 MeV/c)
- E-cooling
- Snake ramp up (goal is 2.7 T)
- Tune shift compensation through quadrupole jumps
- Detect polarization rotation into the horizontal plane via monitoring the beam vertical polarization with JePo polarimeter



T1: Siberian Snake Commissioning Quenching Issue

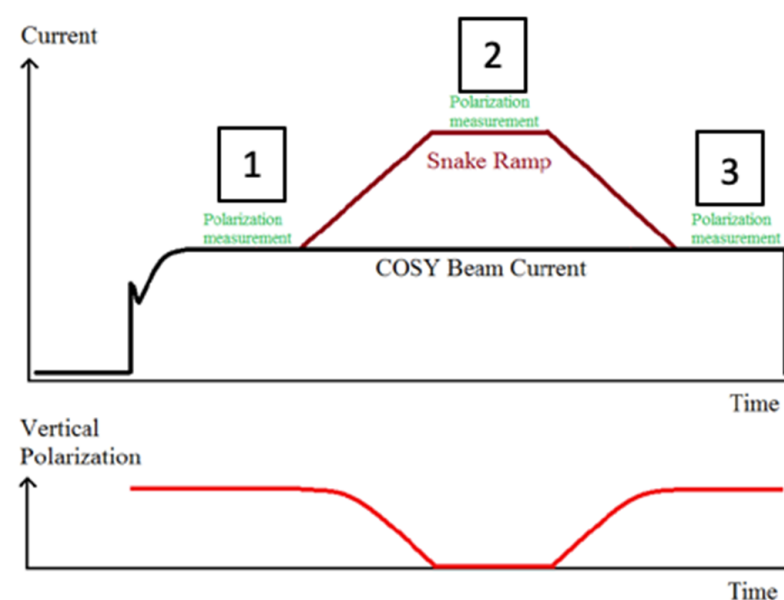
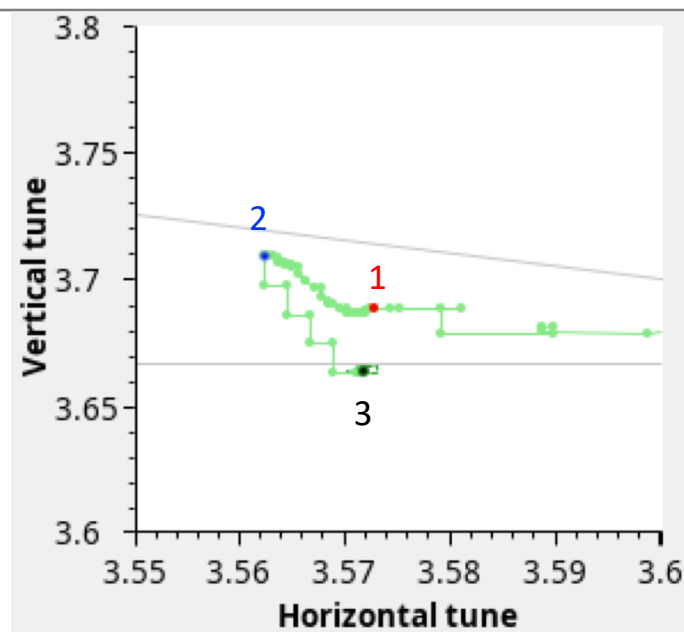
2.7 T with 1.56 A/s
300 s dwell time

2.7 T with 1.17 A/s
500 s dwell time



T1: Siberian Snake Commissioning Tune Shift

- Tune shift observed during Snake ramp



$(3.573; 3.688) \longrightarrow (3.562; 3.709) \longrightarrow (3.572; 3.664)$

T1: Siberian Snake Commissioning Tune Shift

- Tune shift observed during Snake ramp
- Compensation through **step wise** snake ramp + slow quadrupole jump



Necessary because:

- $f_{Sol}^{-1} \propto B_{Sol}^2$
- $f_{Quad}^{-1} \propto k \propto \frac{\partial B_{Quad}}{\partial x}$

T1: Siberian Snake Commissioning Tune Shift

- Tune shift observed during Snake ramp
- Compensation through **step wise** snake ramp + slow quadrupole jump



Necessary because:

- $f_{Sol}^{-1} \propto B_{Sol}^2$
- $f_{Quad}^{-1} \propto k \propto \frac{\partial B_{Quad}}{\partial x}$
- The MAD-X model of COSY was used to 'predict' the Snake action. The Snake solenoid and the e-cooler magnets were implemented during the beam time

T1: Siberian Snake Commissioning Phase Space Coupling

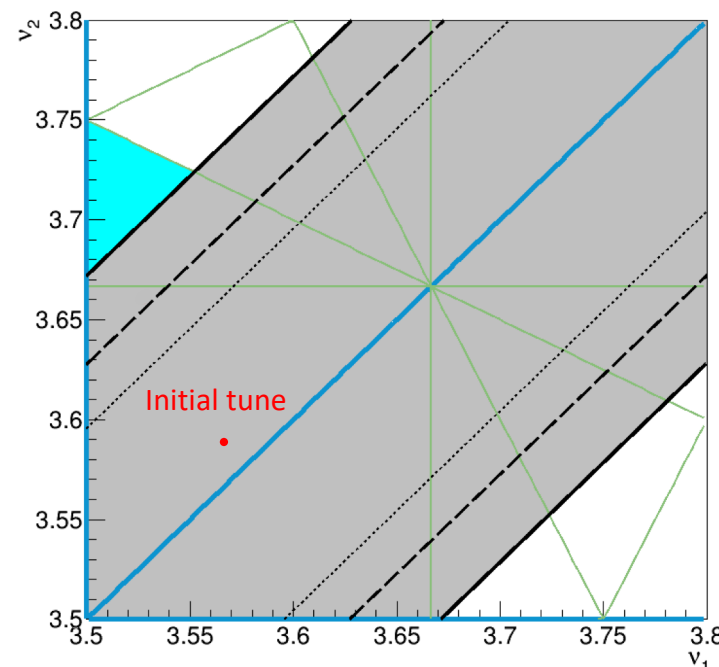
The snake high field introduces a phase space coupling

- Tune split appears

$$\Delta\nu_{min} = \frac{gB_{sol}L}{4\pi|B\rho|}$$

- Tunes near the resonance
 $\nu_x - \nu_y = 0$ cannot be reached
while the solenoid is on

.... 1.5T
---- 2 T
— 2.7 T $\Delta\nu_{min} = 0.167$ (0.172 model)



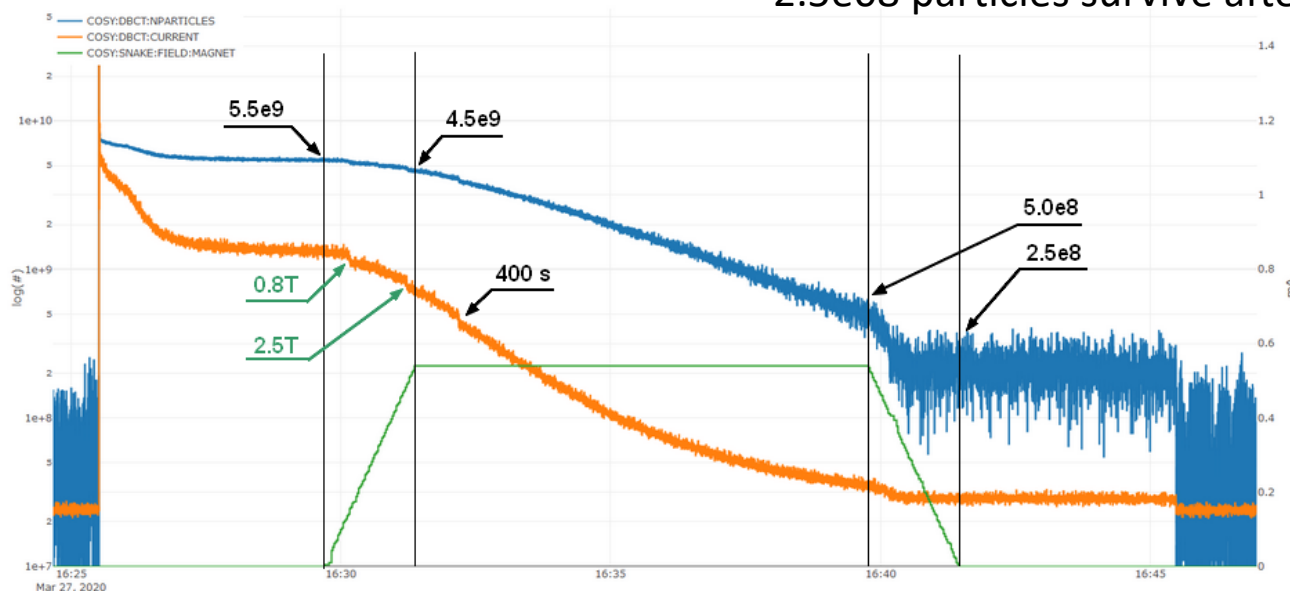
T1: Siberian Snake Commissioning Results

Initial Tunes: $\nu_x = 3.572$; $\nu_y = 3.688$

Flatop @ 2.7 T

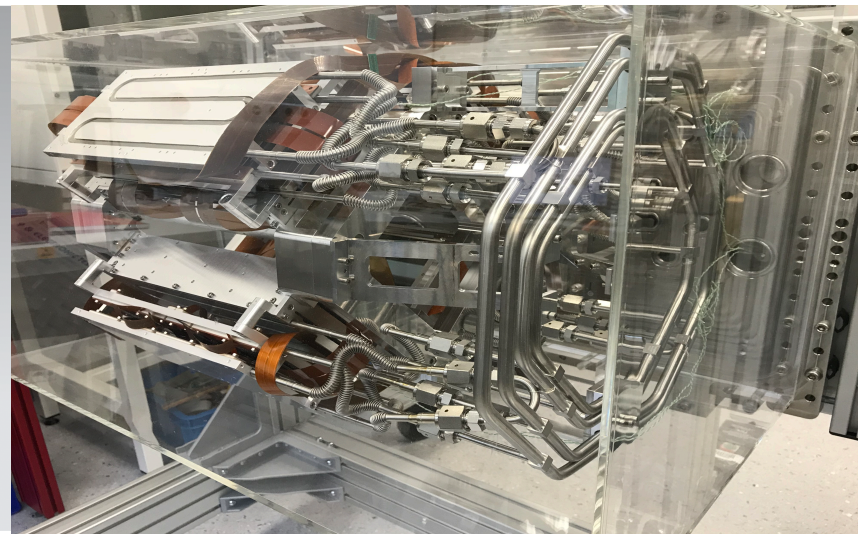
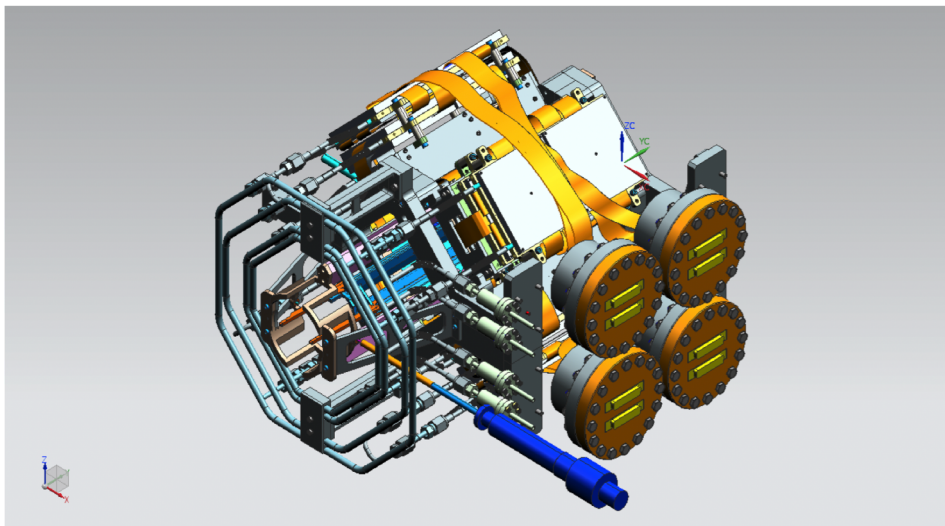
MQU1/MQU5 and MQU2/MQU6 used to compensate the tune shift

$\sim 2.5 \times 10^8$ particles survive after ramp-down



Jump	B _{Sol}	MQU 1,5	MQU 2,6	MQU 4
I	0.0 T	123%	-23%	185%
II	0.0 T – 1.5 T	-23%	-8.5	0.0%
III	1.5 T – 2.4 T	-90%	11%	0.0%
IV	2.4 T – 2.7 T	-15%	0.0%	0.0%

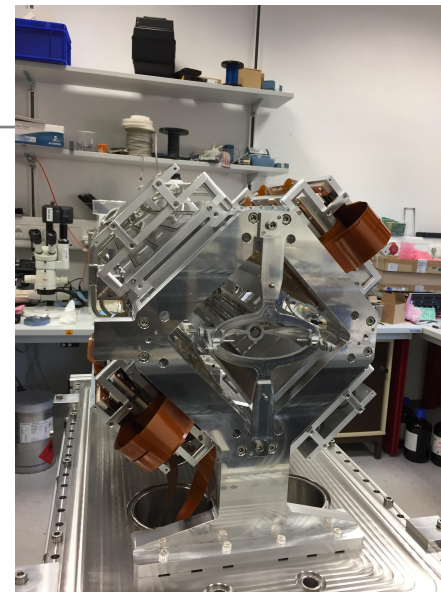
T2: PAX Detector Commissioning



- Multi-purpose silicon vertex detector installed around the storage cell for:
 - p-p (p_{bar} -p) elastic
 - p-d elastic
 - Deuteron breakup
- Energy 30-200 MeV

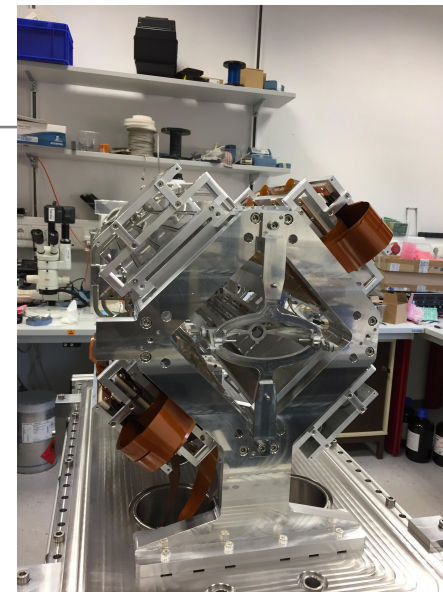
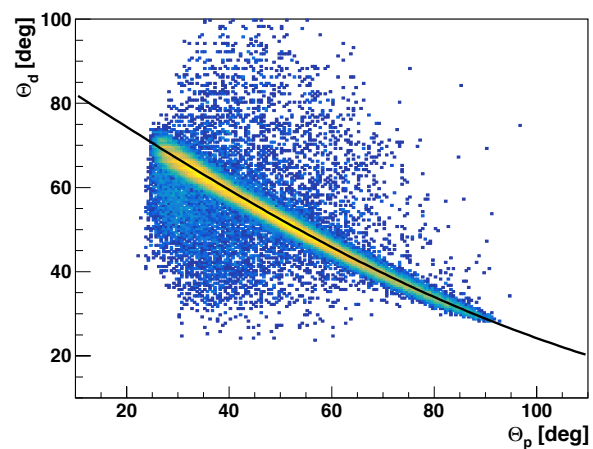
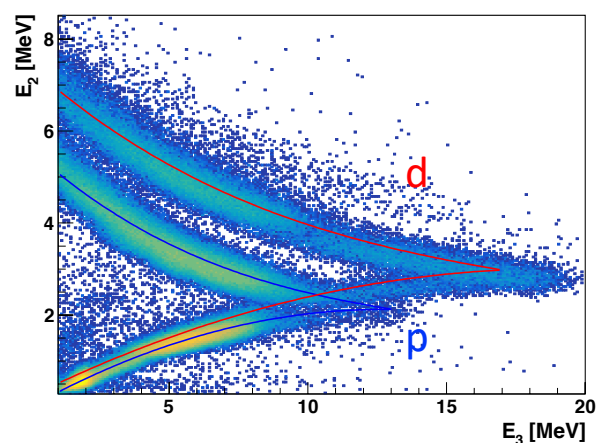
T2: PAX Detector Commissioning

- Installed at PAX section for commissioning with 2 quadrants
- Unpolarized p beam vs. polarized d target



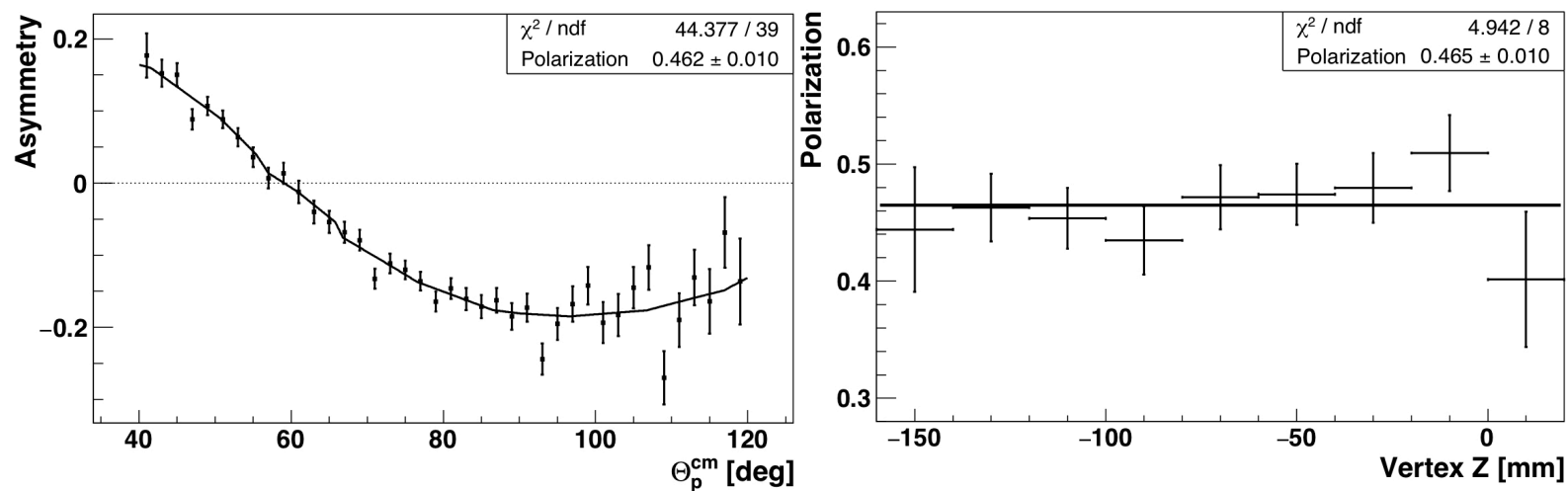
T2: PAX Detector Commissioning

- Installed at PAX section for commissioning with 2 quadrants
- Unpolarized p beam vs. polarized d target
- Identification of p-d elastic events



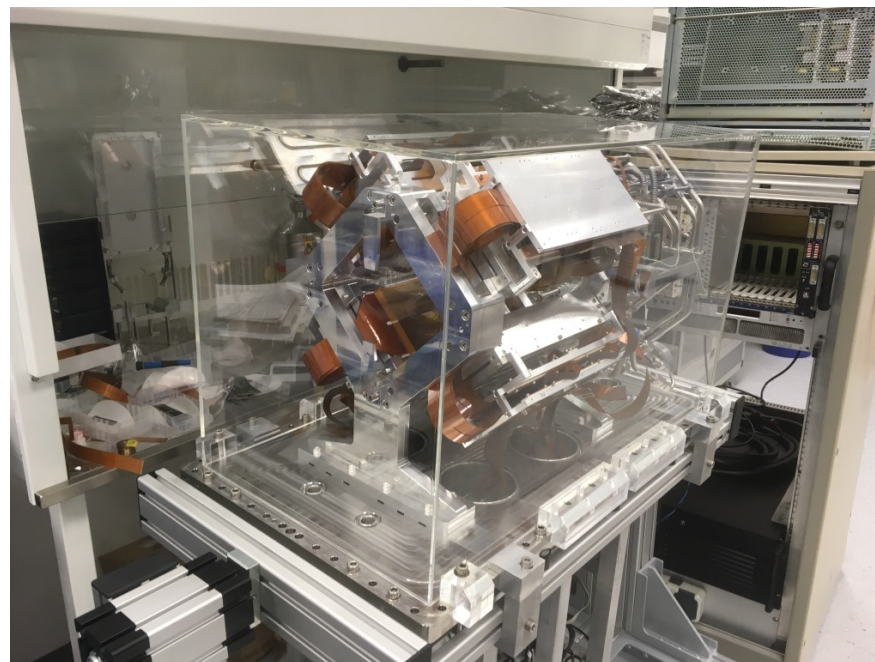
T2: PAX Detector Commissioning Results

Determination of target polarization



T2: PAX Detector Commissioning

- 4 quadrants assembled!
- Test bench for data acquisition from cosmics was set up before CoVid-19 crisis started
- Full commissioning foreseen at COSY, according with the coordinated management of the PAX interaction point



Deliverables and Milestones

- ✓ D30.1 'Report on snake and detector commissioning delivered in May 2020.

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D30.1	Report on snake and detector commissioning	30 - INFN	Report	Public	12

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- MS70: Detector commissioning
 - ✓ Commissioned in COSY with 2 assembled quadrants
 - ✓ First measurement of target polarization
 - ✓ 4 quadrants completed and assembled
 - Full commissioning foreseen at PAX place

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- MS70: Detector commissioning
 - ✓ Commissioned in COSY with 2 assembled quadrants
 - ✓ First measurement of target polarization
 - ✓ 4 quadrants completed and assembled
 - Full commissioning foreseen at PAX place
- MS71: Snake commissioning
 - ✓ First commissioning beam time performed in March
 - ✓ Compensation of the tune shift induced by the solenoid
 - Second beam time requested

What's next...?

- The COSY model used to determine how to change the quadrupole strengths during snake ramp needs to be further developed and benchmarked
- Compensation of the tune variation through the implementation of a tune feedback → **beam time requested** (end of 2021)
- Compensation of the phase-space coupling via the introduction of skew quadrupoles in the beam line
- Resuming PAX detector acquisition on test bench
- Full commissioning of PAX detector foreseen at COSY, according to the availability of the PAX interaction point
- **Longitudinal spin filtering experiment foreseen at COSY**

Thank you for your attention!