COSY Beam Time Request

For Lab. use	
Exp. No.: **E2.5**	Session No. **7**

Collaboration: JEDI

Towards the EDM Polarimetry

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Total number of particles and type of beam (p,d,polarization)	Kinetic energy (MeV)	Intensity or internal reaction rate (particles per second)	
		minimum needed	maximum useful
Extracted beam of polarized deuterons	**100, 200, 270, 300 MeV**	**10^3**	**10^7**
Experimental area	Safety aspects (if any)	Earliest date of installation	Total beam time (No.of shifts)
LYSO crystals at external BIG KARL area	**none**	**1st April 2018**	**2 weeks (+ MD)**

JEDI Beam Time Request for the next period

Towards the EDM Polarimetry (Progress report)

for the JEDI collaboration

http://collaborations.fz-juelich.de/ikp/jedi

November 14, 2017

Abstract

This report is based on a previous proposal [1], where the introduction and the motivation for coming measurements are described. This time we are building the final version of the hadron calorimeter comprising 52 LYSO-SiPM modules. While most of the LYSO modules were bought from Saint Gobain, four modules will be assembled with crystals from a Chinese LYSO vendor as a test. Also, a new model of SiPM arrays with much smaller pixels (larger pixel numbers thus improved dynamic range) will be tested. Further modifications of readout system and the use of a new powerful data server must improve our measurement capabilities. Modified online analysis and a slow control system are also expected to provide better functionality. All in all, we would like to extend and improve the coming measurement with additional beam time as soon as possible.

For the planned measurements using the polarized deuteron beam, we request **two weeks** of COSY beam time preceded by one week of machine development (MD). Four beam energies between 100 and 300 MeV will be with six different target materials at the BIG KARL experimental area.

1 Introduction

Since the last CBAC meeting (June 2017), the primary emphasis is set on further development of the final polarimeter design for the use with the internal COSY beam. The design requirements and restrictions are now matched to the former ANKE target section. The length of the whole polarimeter fits into the space between (1.3 m) a superconducting solenoid and the COSY beam position monitors (BPM) (see Fig. 1). The detector is meant to be

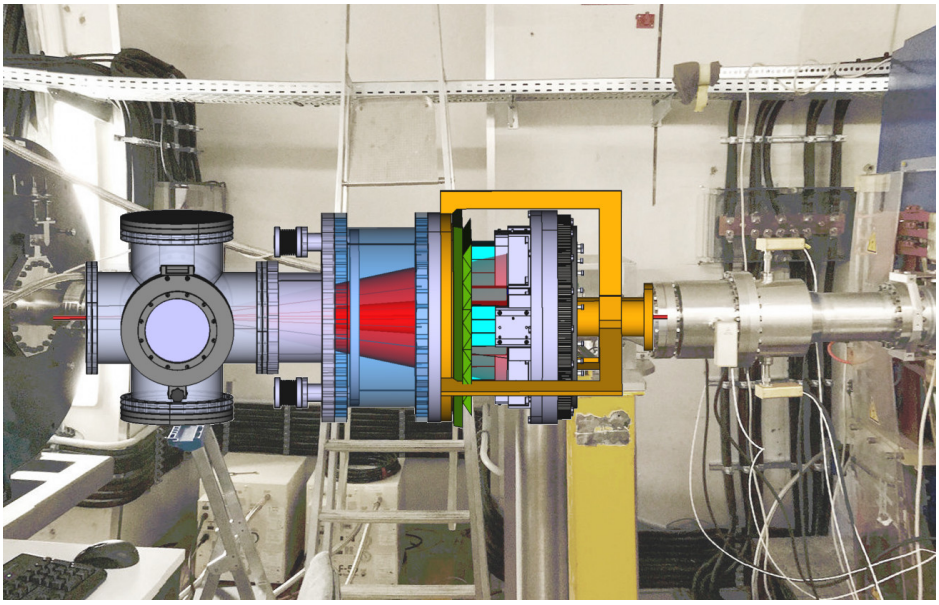

Figure 1: The JEDI polarimeter inserted at former ANKE detector location. Left to right: (i) target cross flange; (ii) vacuum flight chamber with degrader in a closed position; and (iii) the polarimeter with the tracking system.

very precisely rotatable to perform small angle calibrations respective to the polarization vector. One can also precisely adjust to polarization vector at the particular place in a storage ring. It also will be capable of quickly (less then 2 sec.) rotating 90 degrees if needed (in case of polarization flip in a horizontal plane) for the asymmetric distribution of the crystals (Butterfly mode shown in Fig. 2). In this case, most crystals will be installed in one plane to maximise polarimeter performance for a non-fully-populated detector. The new revised concept will consists of three main components: (i) The target chamber, (ii) the vacuum flight chamber with degrader, and (iii)

the polarimeter itself. (see Fig.: 3) The LYSO-SiPM module construction is

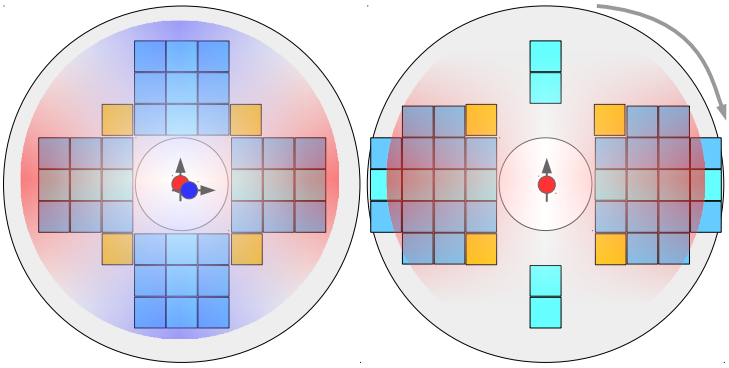

Figure 2: Left: cross configuration for the static polarimeter setup; Right: "Butterfly" configuration for the better performance. In this case, rotations is needed to adjust polarimeter for the in plane (horizontal) polarization.

very slightly modified for an improvement in the detector performance. In contrast to last measurements, now we can more than double our geometrical acceptance and so increase the detector performance. A new dedicated, computationally very powerful server computer will also be employed for the direct data taking and for the online analysis.

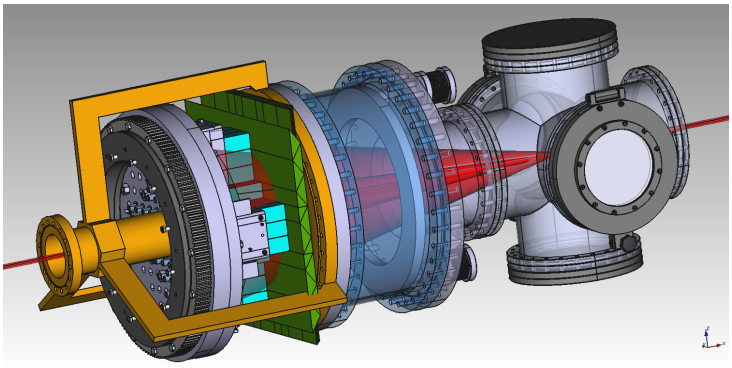

Figure 3: Current concept of JEDI polarimeter at internal experiment.

2 Current Status

The preparation of the coming experiment (due to different constrains) is behind schedule. The full establishment of all goals from the last request will be impossible. This is mostly due to delayed delivery of the new components. The figure 4 shows the current construction of the test setup for the external experimental hole. This is almost one-third of the final polarimeter. Using this setup, the performance and development of the detector part will be finalized. Next year (2018) we would like to equip this setup with all components and be ready for an internal experiment for the end of 2018 / beginning of the 2019. Below we will itemize the current status of the setup:

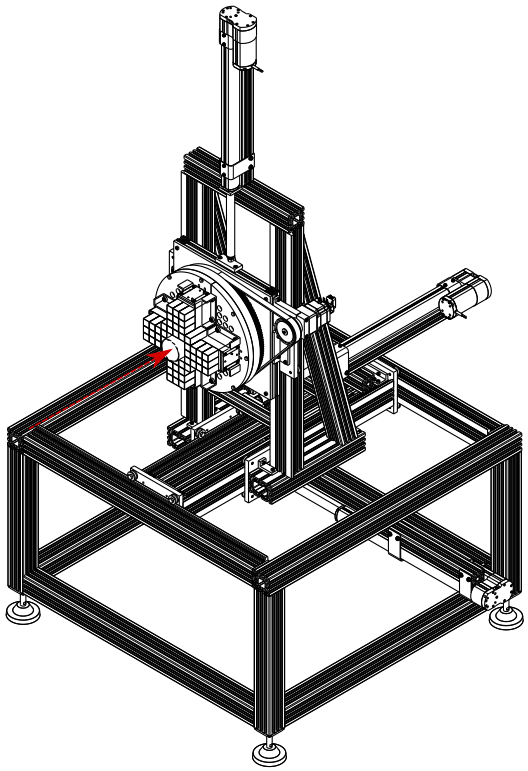

Figure 4: New dedicated setup for the Big Karl experimental hall.

- All new 24 LYSO crystals from Saint Gobain [2] were delivered in time at end of summer. From previous delivery, 18 crystals out of 24 were

also produced with the wrong chamfer edges. All of those 18 crystals are newly refurbished. In fact, one of them was broken, but we got its replacement in time.

Four LYSO crystals from another new vendor [3] were bought at almost half cost. This will be tested during the next beam time. Unfortunately, they were not cut accurately. They promise to deliver them for the December beam time. Practically this means we must completely test them during the next beam time.

- All SiPM arrays from SensL [4] for all 52 modules are selected out of 54. Their readout PCBs are still under production and are expected to be delivered soon. Finally, new arrays (26 new sensors) will be tested in a black box and made ready for the module assembly.

  Also, we learned about a new development from another high-quality SiPM producer company [5] with the same geometry: 8x8 array, each 3x3 mm SiPM with 25 and 15-micrometer pixels. In particular 15-micrometer sensors are very demanding since they have almost 2.7 times more pixel density that of the current version. This will almost triple our dynamic range. Modules with Ketek arrays are now in the design (readout PCB needs to be adopted) and construction process.

- The new setup is currently under construction made with Rose+Krieger GmbH standardized aluminum frames, shown in Fig.: 4. The construction needs to be a little bit modified due to unexpected problems and will be tested during the December beam time. The setup as it was targeted in the last proposal [1] is automated. It can move in X-Y-Z direction and rotate around the beam axis. This will give us a possibility to put each module onto the external beam line and calibrate carefully. Also, a small rotation will also test our capabilities for how precisely we can find the polarization vector direction (which is expected to be vertical).

- In addition to past target materials (C, Mg, Al, Si, CH_2), we also add two new elements Nickel Ni and Tin Sn. This will shift our scope to a different mass region for the analyzing power measurements. So, the useful statistics and good special resolution will be needed. In total, now we have six different isotopes to measure for vector analyzing power and differential cross section.

- Tracking threeangular plastic scintillator bars, which were described in the last proposal [1], are unfortunately impossible to produce in our mechanical workshop. The external companies were not sure to be on time, and we decided to delay this task for coming beam times. For the December beam time, the two additional (other two were already used during two last measurements) 2 cm thick plastic ΔE scintillators with 8 SiPM readouts will be used. This will limit our special resolution to crystal geometry but will guarantee high energy resolution for the measurements.

- With more than double the number of LYSO-SiPM modules, plus multiple scintillation triangular bars, the number of channels will reach almost 100. This needs very sophisticated hardware and software performance for the online analysis. Until now we have demonstrated that it was possible to have more computing power than online analysis needs. Now the challenge is tripled, but with our estime, we can overcome this problem, too.

- The GEM detector for the December tests is operational and will be delivered soon to Juelich. The performance and its optimisation will be performed during the next beam time. If possible, we will measure the beam profile for the total cross section measurements described in the previews proposal [1]. In any case, this detector will provide very high special resolution and will be used during all incoming external experiments.

  Additionally, we are building a thin plastic scintillator scanner to install downstream to the beam. This will be high count rate X-Y scanner.

2.1 Beam Time Request

As it was mentioned above, the currently requested beam time will be an extension of the already scheduled December beam time (calender week 50). This is in part to fulfill goals for precise tracking and in part to include new components of the final construction. Also, we request several energies, six different target materials and analyzing power with cross-section measurements, which makes a very high demand for extended measurement time. During the previous beam times, we measured one energy per day or two,

including hardware tests and data taking for different conditions. Asymmetry measurements were normally performed with the maximum count rate COSY could provide for the polarized extracted beam. But for the cross-section measurements, the minimum deuteron flux was used since all incoming deuterons needed to be tagged before hitting the target.

All the details will be presented during the CBAC session.

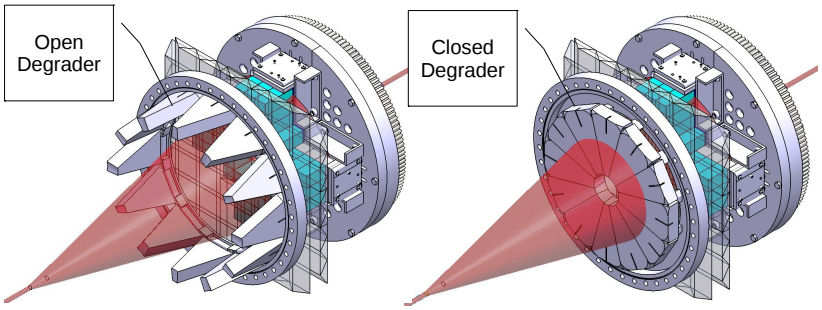

Figure 5: A degrader system for proton measurements.

In order to continue this very successful development, we ask the CBAC committee to grant us two weeks of polarized deuteron beam time (in the Q2 or Q3 quarter of the 2018) with several beam energies up to 300 MeV.

References

[1] Towards the EDM Polarimetry, May 18, 2017
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(*http* : *//sensl.com/products/sipmarrays/arrayj/*)

[5] OEM arrays based on KETEK WB Series silicon photomultipliers .
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[6] RK Rose+Krieger GmbH
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