COSY Beam Time Request

For Lab. use

Exp. No.:	Session No.
E2.6	**9**

Collaboration: JEDI

Towards the EDM Polarimetry:
Commissioning of the internal polarimeter based on LYSO crystals at COSY

Spokespersons for the beam time: **Irakli Keshelashvili (Jülich)**
Bernd Lorentz (Jülich)
David Mchedlishvili (HEPI TSU)

Spokespersons for the collaboration: **Jörg Pretz (Jülich)**
Paolo Lenisa (Ferrara)

Address:
Institut für Kernphysik
Forschungszentrum Jülich
52428 Jülich
Germany

Phone: **+49 2461 615603** Fax: **+49 2461 613930** E-mail: **pretz@fz-juelich.de**
lenisa@fe.infn.it

i.keshelashvili@fz-juelich.de
b.lorentz@fz-juelich.de
d.mchedlishvili@fz-juelich.de

Total number of particles and type of beam (p,d,polarization)	Beam momentum (MeV/c)	Intensity or internal reaction rate (particles per second) minimum needed	Intensity or internal reaction rate (particles per second) maximum useful
Internal beam of polarized deuterons	**970 MeV/c**	**10^8**	**10^9**
Experimental area	Safety aspects (if any)	Earliest date of installation	Total beam time (No.of shifts)
Set-up with LYSO crystals at former ANKE area	**none**	**15th March 2019**	**2 weeks (+ MD)**

JEDI Beam Time Request for the next period

Towards EDM Polarimetry:

Commissioning of the internal polarimeter based on LYSO crystals at COSY

for the JEDI collaboration

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

December 3, 2018

Abstract

The LYSO based JEDI polarimeter has been tested 5 times using the external beam. During these beam times, the scintillating material characteristics, light sensor qualities, sampling ADC readout, power supplies, and online-offline analysis software have been tested. Also, various ΔE detector configurations have been explored. The next logical step would be to test the system under internal beam conditions and use it as a JEDI main polarimeter. We plan to install the detector system at the former ANKE target position. The whole detector assembly will first be tested for vacuum and mechanical integrity, and then installed at COSY during the spring maintenance period. For the first internal beam test **we request 1 week of machine development time and 2 weeks of measurement time to be scheduled with the designation of E002.6**.

1 Introduction

The previous proposals ([1]) describe the step-by-step development of the JEDI polarimeter. This is a dedicated polarimeter for the storage ring EDM search. The detector consists of heavy, fast, radiation-hard, novel inorganic scintillating material (LYSO [2, 3]) and modern large-area semiconductor/silicon photomultiplier (SiPM [4, 5]) arrays. Thus its stability and remarkable event selection (based on calorimetry) run without producing strong magnetic or electric fields. It is designed for medium energies and is very effective up to $T_{kin} < 350\ MeV$ for deuterons, and up to $T_{kin} < 300\ MeV$ for protons. The system utilizes the $\vec{d}C \to dC$ elastic reaction to measure asymmetries and is an extremely simple detector utilizing the modern technologies. All this has been achieved within three years of development time

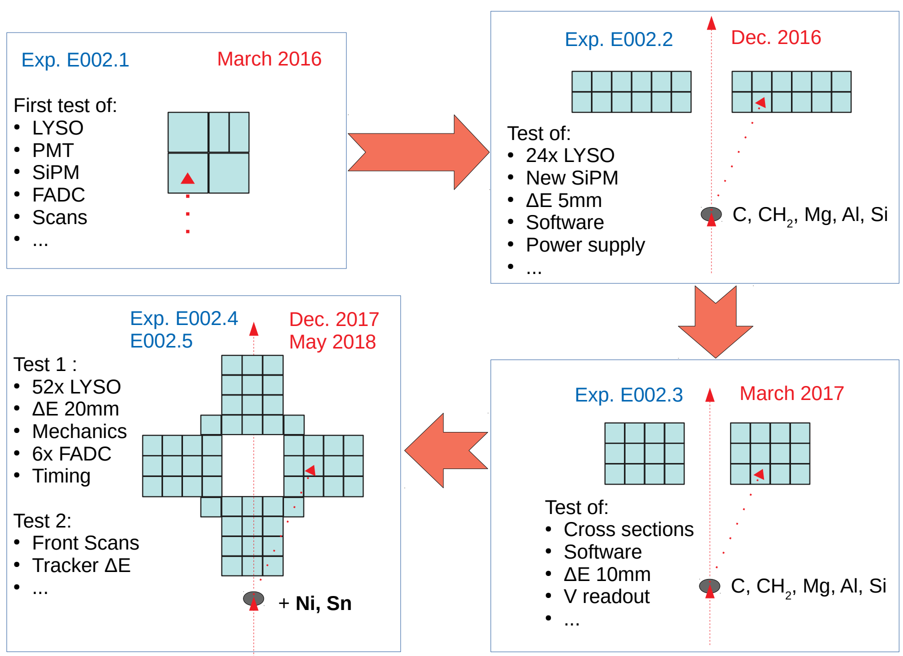

Figure 1: Timeline of the detector development stages. Altogether five beam times have been performed at the external beam experimental hall. In all these experiments, different energies and different target materials have been combined.

and five experiments (total five weeks of beam time). Figure 1 shows the steb-by-step infograph of the whole development process. During these beam times, we tested our modules using five different beam energies (polarized and unpolarized) from $100 \div 300\ MeV$ deuterons. Also, a short proton irradiation has been explored. From the first (I) test beam, we learned mainly about crystal properties and tested the SiPM readout. During the second (II) and third (III) beam times, we developed LYSO-SiPM modules (24 modules have been built). The mechanical, electrical and optical properties where optimized. In parallel with this, the analyzing powers and differential cross sections have been measured for five different target materials. The fourth (IV) and fifth (V) measurements where dedicated to a 52 module assembly with fixed mechanics for the calorimeter. The different ΔE plastic scintillators were also read by modern SiPM ([5]) and its preamplifiers have been developed. This was finalized in a combined ΔE tracking system consisting of overlaying triangular scintillating bars.

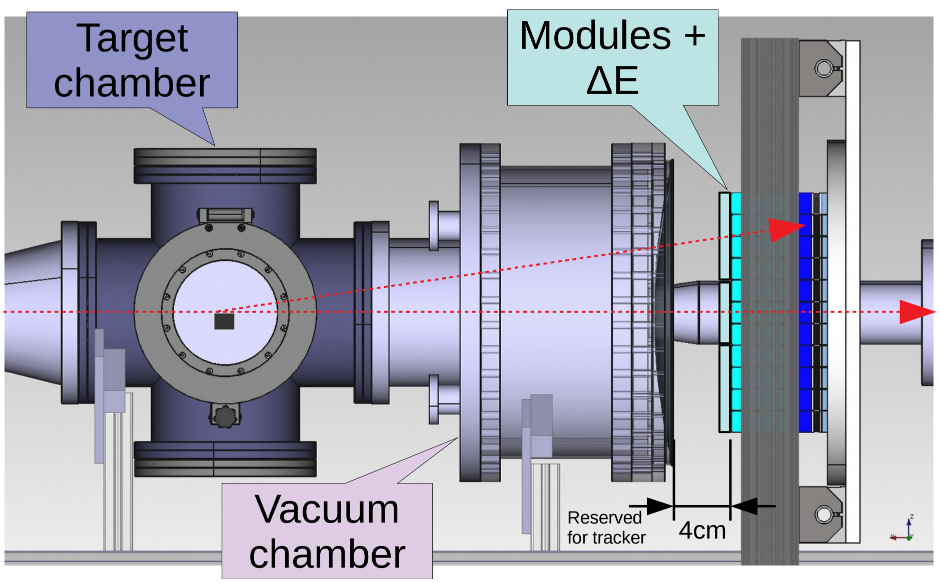

Figure 2: The JEDI polarimeter (JEPO) inserted at the former ANKE detector location. Left to right: (i) target cross flange; (ii) vacuum flight chamber (degrader is foreseen); and (iii) the polarimeter with the ΔE-detector system. The total length is 127 cm.

2 Setup

The setup at the ANKE position will consist of the existing 52 LYSO-SiPM [2, 3, 4, 5] module combined with previously used $2cm$ thick plastic ΔE scintillator bars. The target material is a graphite block, the exact copy of the target at WASA. The target support system will also be very similar to WASA. It will be inserted from the bottom side and will have more flexibilities adapted to the EDM precursor experiment. For this beam time, the vacuum chamber will be assembled without a degrader in it. But the degrader flange will already be included in the setup. The exit window is currently under construction at ZEA-1. The welding procedure is already fixed and all construction simulations are successfully completed. The exit window is hyperbolic and the material is $0.8mm$ stainless steel. Figures 3 and 4 show an assembled detector without its tracking and degrader system. The LYSO modules are mounted on openable aluminum support disk for quick maintenance.

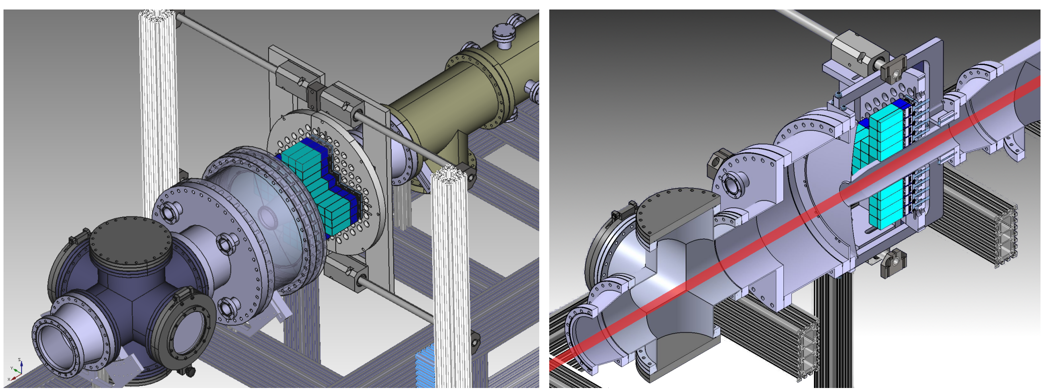

Figure 3: Left: the JEDI polarimeter mounted on the support table. The crystals can be easily installed/repaired thanks to its openable support rods. Right: Cutaway drawing of the detector without the degrader and the plastic scintillator tracker.

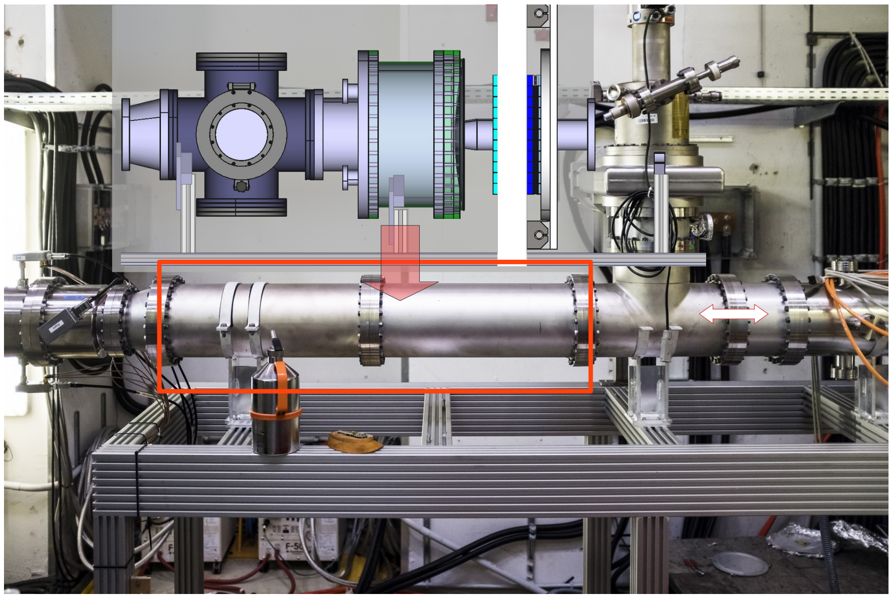

Figure 4: Actual photograph of the former ANKE cave. The insert drawing of the polarimeter shows the installation place into the beam position.

3 Data acquisiton system

In this beam time, special emphasis will be placed on the analysis software. For one redout, the combined OR signal from each arm will be generated using individual thresholds, selecting only elastic events. The output signal will be provided to the already tested EDDA / WASA time stamping readout, which can be used for the usual feedback system. In parallel with this readout (see Fig. 5), the usual polarimeter DAQ will be running. In fact, the system based on sampling readout [6] also produces time stamps for each trigger, which makes possible an even more efficient system then is available with WASA. Each elastic event can be separated using full energy deposition vs energy loss in $2cm$ plastic scintillator bars in front of LYSO crystals. This gives us excellent precision for the elastic event selection and can be used in an online analysis.

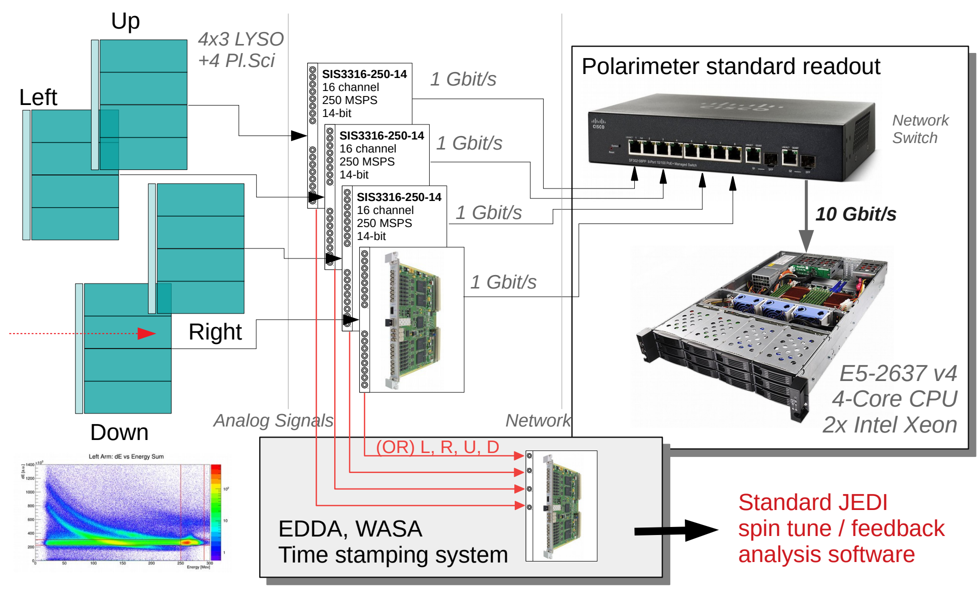

Figure 5: Schematic of the planned data acquisition system. Two parallel readouts will be used. The standard polarimeter readout and the EDDA / WASA time stamping TDC readout are fed with OR signals from each polarimeter arm.

4 Beam Time Request

In order to finalize this very successful development, we ask the CBAC committee to grant us **two weeks** of polarized deuteron beam time in the second quarter of the 2019.

References

[1] Towards EDM Polarimetry)
$http://collaborations.fz{-}juelich.de/ikp/jedi/documents/proposals.shtml$

[2] Cerium doped Lutetium PreLude420 crystal.
($http://www.crystals.saint{-}gobain.com/PreLude\_420\_Scintillator.aspx$)

[3] Sichuan Tianle Photonics Co., Ltd.
($http://tianlephotonics.com/$)

[4] SensL High Fill-Factor Arrays for Fast Timing Applications.
($http://sensl.com/products/sipmarrays/arrayj/$)

[5] OEM arrays based on KETEK WB Series silicon photomultipliers .
($https://www.ketek.net/sipm/sipm-products/oem-arrays/$)

[6] SIS3316-250-14 16 channel 250 MSPS 14-bit.
($http://www.struck.de/sis3316.html$)

[7] The Experimental Physics and Industrial Control System (EPICS)
$https://en.wikipedia.org/wiki/EPICS$