Advanced performance measurements with microchannel-plate PMTs

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The Cherenkov photons of the PANDA DIRC detectors will be read out by 300 microchannel-plate (MCP) PMTs. Our on-going long-term measurements show that the lifetime of these devices has recently increased by more than a factor of 50 with the best PHOTONIS model reaching >15 C/cm2 integrated anode charge without any quantum efficiency (QE) loss [1]. This is safe for >10 years of operation within the PANDA high rate environment.

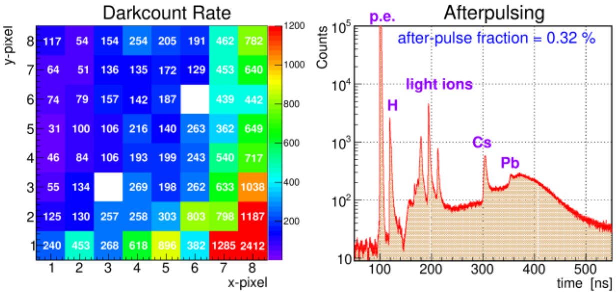
For quality assurance (QA) measurements of the MCP-PMTs we have assembled a semi-automatic setup consisting of a large copper-cladded dark box combined with a pico-second laser pulser, a 3D-stepper for accurate position scans of the active tube area, and a PADIWA/TRB DAQ system for the parallel readout of all anode pixels. It is planned to simultaneously measure with a surface scan the main performance parameters gain, time resolution, darkcount rate (DCR), crosstalk and afterpulsing for each MCP-PMT being built into the PANDA DIRC detectors. For each tube QE, surface and wavelength scans and rate capability tests will be performed, as well as for sample MCP-PMTs accelerated lifetime measurements and gain characterisations inside a strong magnetic field of >1 T.

The PADIWAs are equipped with multi-hit TDCs with adjustable thresholds that produce a time stamp and time-over-threshold for each hit anode pixel. In the TRBs this information and the number of hits are permanently written to a ring buffer and are read out in an adjustable time window around a trigger pulse that in our case is the laser trigger. The available information for this time window is the laser x- and y-position, and the hits of direct photo-electrons, darkcount, recoil electron and crosstalk events.

Among others the first scans with the new QA setup demonstrated a unique capability in terms of quantifying the DCR and the fraction of events followed by an ion afterpulse as a function of the anode pixels, and other unwanted effects like distributions of electrons recoiling from the MCP surface and crosstalk among the anode pixels induced by charge sharing and electronics.

The left plot in Fig. 1 shows the DCR of the different anode pixels for a new hiQE MCP-PMT from PHOTONIS indicating that the overall DCR is dominated by individual pixels at the corners and borders of the tube. This is a new finding and was observed also in other MCP-PMTs. The reason of this effect is currently unknown. In the right plot of Fig. 1 the afterpulsing TOF distribution of the same tube is presented suggesting that ~0.3% of the single photon events are followed by afterpulse background induced by light and heavy ions from H to Pb.

In Fig. 2 (upper-left) the xt-distribution of pixel x3-y6 of the before mentioned MCP-PMT is shown indicating the regions where charge sharing crosstalk and recoil electrons are expected. By pointing the laser to different x- and y-positions we find that the read out pixel may be also hit by events which stem from laser positions outside the pixel area (red region) and later (>100 ns) than expected for prompt laser photons. The xy-distributions of the charge sharing crosstalk and recoil electron events can be further studied and quantified. The recoil electrons reach into an area of more than twice the pixel diameter and arrive up to 5 ns later than a direct photo electron. Crosstalk mainly takes place between adjacent pixels. The width of the red strips in Fig. 2 (lower right) allows the estimation of the size of the charge cloud arriving at the anode pixel. We find about 1 mm for the tube shown here.



y-pixel \ x-pixel	1	2	3	4	5	6	7	8
8	117	54	154	254	205	191	462	782
7	64	51	136	135	172	129	453	640
6	74	79	157	142	187		439	442
5	31	100	106	216	140	263	362	649
4	46	84	106	193	199	243	540	717
3	55	134		269	198	262	633	1038
2	125	130	257	258	303	803	798	1187
1	240	453	268	618	896	382	1285	2412

Figure 1: DCR (left) as a function of the anode pixel and afterpulsing TOF distribution (right) for the hiQE MCP-PMT PHOTONIS XP85112 (9002085) with 10 µm pores.

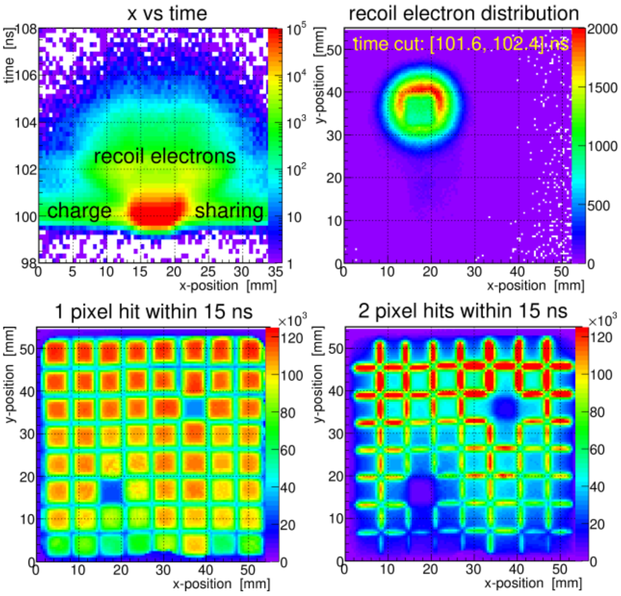


Figure 2: xy-distributions of recoil electrons (upper-right) and charge sharing crosstalk events (lower-right) for the MCP-PMT as in Fig. 1. The xt-distribution of pixel x3-y6 (upper-left) indicates the regions where events populated by recoil electrons and charge sharing are expected.

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Experiment collaboration: PANDA
PSP codes: 1.4.1.5
Grants: GSI strategic partnership (FuE): ERANTO1419, EREYRI1416

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The Barrel DIRC prototype in a beam experiment

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A beam time in August/September 2017 in the T9 beamline of the CERN PS was used to evaluate the performance of a PANDA Barrel DIRC [1] prototype in a mixed hadronic beam at several energies. Protons and pions were tagged by a time of flight system. Aspects of the PANDA Barrel DIRC (radiator bars) and of the future DIRC in the Electron-Ion-Collider (EIC) project (radiator plates) were tested.

A picture of the prototype in a configuration with a narrow bar is shown in Fig. 1. The radiator bar, made from synthetic fused silica, is coupled via a prism to an array of 12 PHOTONIS XP85012 Microchannel-Plate (MCP) PMTs. Different focusing elements were placed between the radiator bar and the prism. Figure 1 shows a cylindrical lens, designed for the EIC DIRC and made from a layer of LaK33 glass embedded between two fused silica adapter pieces.

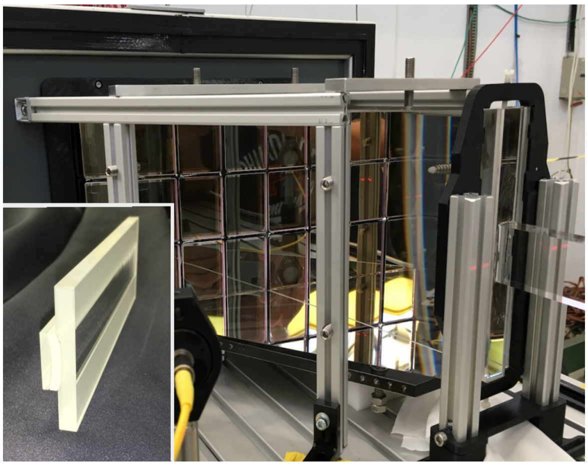

Figure 1: Photograph of the Barrel DIRC prototype at CERN. The insert shows details of the cylindrical lens.

The primary goal of this experiment was to test a compact prism with an opening angle of 33°, the cylindrical lens, and 12 new readout modules, each comprising one MCP-PMT with a high-voltage divider and four PADIWA discriminator cards, actively cooled by pressurized air. The position of the beam on the radiator bar or plate, as well as both the polar and azimuthal angle between the radiator and the beam, were adjustable to evaluate the particle identification (PID) performance of the prototype in various configurations for the entire phase space of kaons in PANDA.

Experiment beamline: CERN-T9
Experiment collaboration: PANDA
Experiment proposal: PANDA

Figure 2 shows the accumulated hit pattern for tagged pions with 7 GeV/c momentum at a polar angle of 25°. Although the spherical lens produces a sharper image than the cylindrical lens for the narrow bar, the quality of the image from the cylindrical lens agrees well with detailed Geant simulations. This is an important result for the possible use of wide plates as radiators, as one of the designs of the DIRC for the EIC detector foresees, since spherical lenses will no longer an option for wide plates and cylindrical focusing will be required.

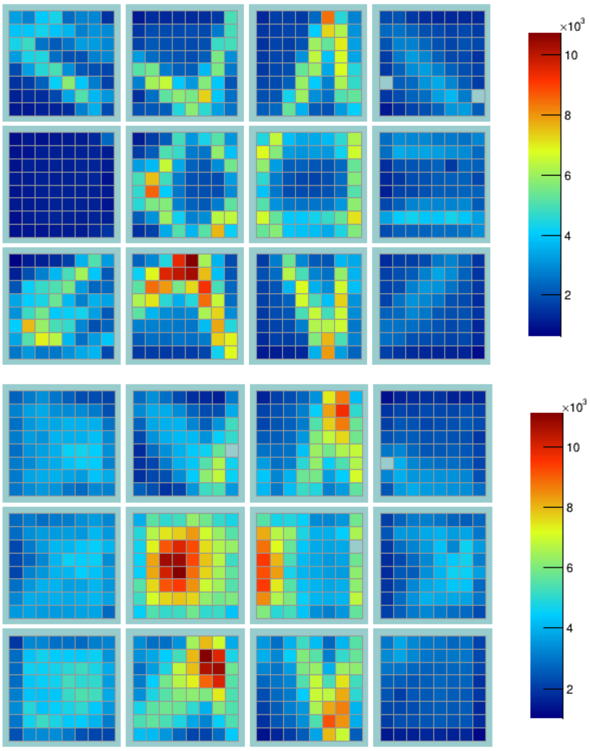

Figure 2: Cherenkov image from many events produced in a narrow bar for 7 GeV/c pions at a polar angle of 25° for a spherical lens (top) and a cylindrical lens (bottom).

References

[1] PANDA Collaboration, Technical Design Report for the PANDA Barrel DIRC detector, https://arxiv.org/pdf/1710.00684.pdf

Accelerator infrastructure: HESR
PSP codes: 1.4.1.5

Grants: ERANTO1419**, eRD14 (future Electron Ion-Collider)**
Strategic university co-operation with: Frankfurt-M / Erlangen

Optical shape measurements of the Barrel DIRC radiator bars

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The radiator bars for the PANDA Barrel DIRC are made of synthetic fused silica. Since the bars also act as light guides for the Cherenkov photons, whose angular distribution has to be conserved in many internal reflections, the bars have to meet tight specifications. The maximum deviation from a rectangular cross section must not exceed 0.25 mrad along the full length of the bar and the end faces must not differ from an ideal shape by more than 0.5 mrad. Prototype bars from different vendors have been tested to see if they fulfil those requirements.

Autocollimator Setup

The setup consists of a Nikon 6D LED autocollimator, a Nikon pentaprism and two supports to mount the bars, as shown in figure 1. The supports are wrapped with cleanroom cloth to protect the bars from scratches.

The autocollimator is a telescope-like instrument that focuses a reticle of light to infinity. It is reflected by the object surfaces back into the autocollimator, focused and observed. Reflections originating from different surfaces can be seen simultaneously as reticles through the ocular. Their distance can be measured and corresponds to the angle included by the surfaces. In order to measure the downwards-facing bar side, a pentaprism is used to deflect some autocollimator rays by 90°. The big advantage of this setup is that only relative alignment is important and that it is contact-free, so the highly polished bar surfaces are not touched.

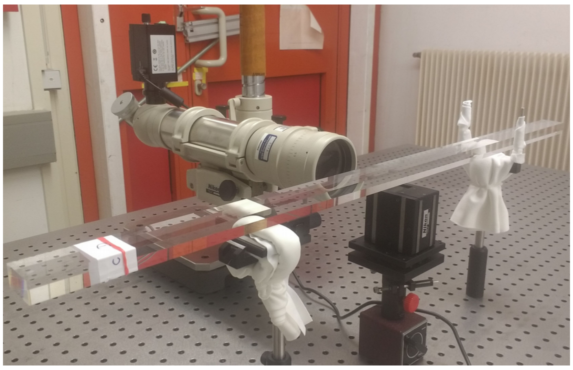

Figure 1: The measuring setup, including the autocollimator, the pentaprism, and a prototype bar mounted on two adjustable supports.

Measuring accuracy

In order to determine the optimal measuring accuracy, the positioning of the bar supports has been optimized and the precise alignment of prism and bar has been checked before each measurement. The measuring accuracy is 0.02 mrad for parallelism measurements and 0.05 mrad if the pentaprism is used [1].

Results

A comparison of results for all measured prototype bars are shown in figure 2. Due to challenges in producing single prototype bars, the quality of the end faces did not always meet the specification. This is not expected to be an issue for mass production.

The most important specification for the PANDA Barrel DIRC, the squareness and parallelism of the faces and sides, was met by two of the four vendors, InSync and Zeiss. Although a few of the parallelism measurements for the Zygo bar were marginally outside the specification, this vendor is considered validated for the mass production as well.

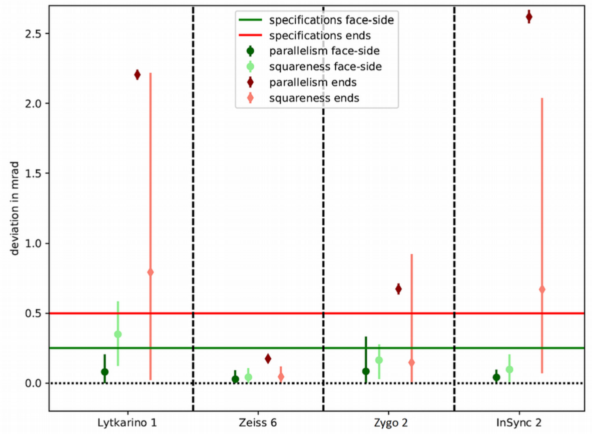

Figure 2: Comparison of the prototype bars from four different vendors, adapted from [1]. The displayed values are the mean of all measured ones, and the error bars indicate the range of the measured values. The horizontal lines show where the production specifications are.

References

[1] J.Rieger, “Optical Shape Measurements of the Radiator Bars for the PANDA Barrel DIRC”, Bachelor Thesis, TU Darmstadt, Febuary 2018

Experiment collaboration: PANDA
PSP codes: 1.4.1.5
Strategic university co-operation with: Darmstadt / Frankfurt-M
Grants: HGS-HIRe for FAIR

Surface quality of the PANDA barrel DIRC prototype radiators

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A DIRC (Detection of Internally Reflected Cherenkov light) detector will provide charged Particle Identification (PID) in the target spectrometer of the PANDA experiment. The Barrel DIRC uses rectangular bars made from synthetic fused silica as radiators. Cherenkov photons are trapped inside while they propagate through the radiator by total internal reflection until they exit towards the readout end to be measured by the photon sensors. The Cherenkov angle can be calculated from the observed hit pattern to identify the particle that traversed the radiator. Since the Cherenkov photons can undergo several hundred reflections until they reach the photon sensors, the radiators have to meet very strict optical and geometrical requirements. To ensure high transport efficiency the radiator surfaces need to be smoothly polished.

The determination of surface quality of radiators is done by using a fully automated motion-controlled laser setup, measuring critical values, such as bulk attenuation and coefficients of total internal reflection (Figure 1).

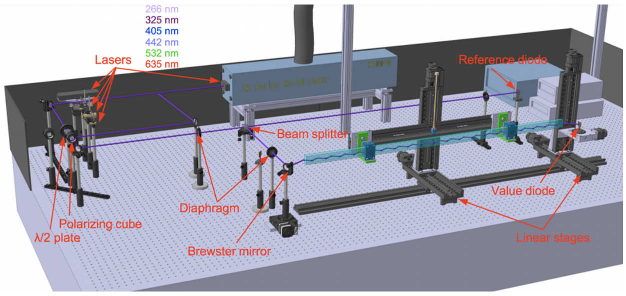

Figure 1: PANDA Barrel DIRC optics lab setup accommodating a radiator plate for an internal reflection measurement.

The attenuation length is measured by coupling the laser straight into the radiator, determining the intensity loss inside the bulk material.

For the internal reflection measurement the laser beam is coupled into the radiator at Brewster angle. Depending on the length and orientation of the radiator, the beam is internally reflected from the faces (wide sides) up to 53 times, until it exits to be measured by the (value) photodiode. An additional reference photodiode is used to correct for laser intensity fluctuations. The fraction of light lost during all internal reflections is translated into the coefficient of total internal reflection, which in turn can be related to the surface roughness via the scalar scattering theory. An extensive prototype radiator program had been started several years ago, resulting in a total of 30 prototype radiators produced by various manufacturers. Using different types of fused silica and polishing techniques, the optical quality of these prototype radiators was evaluated at GSI to qualify vendors for the mass production of DIRC bars. Upgrading the Barrel DIRC optical setup by adding a HeCd laser (325 nm and 442 nm), lead to an increase in sensitivity of measuring possible production technique related sub-surface damage inside the material. A full set of measurements for all vendors that produced prototypes is now available.

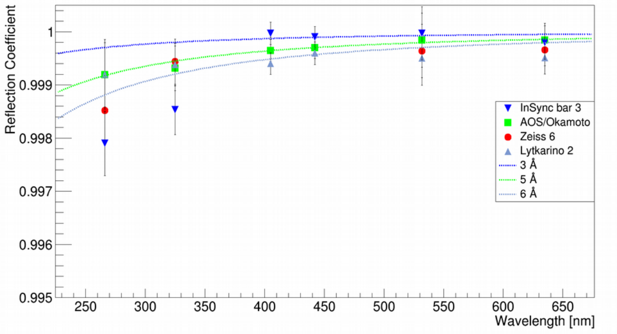

Figure 2: Reflection coefficients for four different prototype bars from AOS/Okamoto, InSync Inc., Carl Zeiss GmbH, and Lytkarino. The dashed lines show the expected reflection coefficients from theory for a given surface roughness.

Figure 2 shows results for four prototype bars. The measured reflection coefficient values are found to be in good agreement with data from the vendors.

On the basis of this data the call for tender is expected to be issued in the summer of 2018 to collect offers from manufacturers proven to be able to deliver the optical quality required for the PANDA Barrel DIRC.

The radiator production is expected to start in early 2019.

Experiment collaboration: PANDA
Experiment proposal: PANDA
Accelerator infrastructure: none
Grants: HGS-HIRe
Strategic university co-operation with:
Goethe University Frankfurt

References

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Geometrical reconstruction for the DIRC PID at GlueX

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The particle identification (PID) capability of the GlueX experiment will be enhanced by the upgrade with a Detector of Internally Reflected Cherenkov light (DIRC) [1]. It will be a compact and robust PID system utilizing optical components from the decommissioned BaBar DIRC detector [2] and a new expansion volume based on the SuperB FDIRC prototype [3]. A clean π/K separation for forward angles ($\theta < 11^{O}$) and momenta up to 4 GeV/c is expected based on the BaBar performance.

Three different reconstruction approaches are in development to evaluate the PID performance of the detector: kernel density estimation, time imaging, and geometrical reconstruction. The first two are based on probability density functions of the spatial distribution and the arrival time of the detected photons [4,5]. The 3rd method is based on look-up tables (LUTs), and was previously used for the BABAR DIRC.

The geometrical reconstruction is the first of those methods to be implemented in the current GlueX analysis framework. In this approach the direction of a detected photon is approximated by the three-dimensional vector between the centers of the bar and the hit pixel. LUTs are produced by simulating optical photons at the end of the bar, covering all possible angles, and storing direction vectors for all photons that hit a given pixel. Those direction vectors are then combined with the particle momentum vector available from the tracking system to determine the Cherenkov angle θ_C.

Figure 1 shows the reconstructed single photon Cherenkov angle distribution for 1000 pions (blue) and kaons (red) simulated by GEANT4 at 4 GeV/c and a polar angle of $\theta = 4^{O}$.

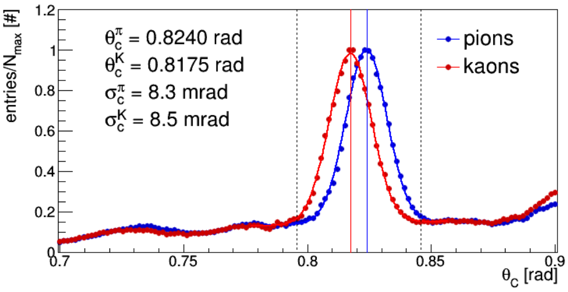

Figure 1: Reconstructed single photon Cherenkov angle distribution for 1000 pions (blue) and kaons (red). Solid vertical lines indicate the values of the expected Cherenkov angle.

A fit of a Gaussian plus a linear function gives a good description. The background is primarily caused by combinatorial reconstruction ambiguities, which are the result of the various possible photon paths inside the expansion volume. This background can be efficiently suppressed by applying selection on time difference between measured propagation time of the detected photons and the time determined from the LUT. The averaged number of the detected photons per particle after selection is 57±4.

The mean of the Gaussian fit determines the θ_C of the corresponding particle species, while the sigma of the fit gives the resolution of the reconstructed angle which is important indicator of the performance. The dashed vertical lines shows the range where an unbinned likelihood test is used to perform the PID. Figure 2 shows the resulted log-likelihood difference, giving a π/K separation power of 4.5±0.2 s.d at 4 GeV/c and 4^{O} polar angle.

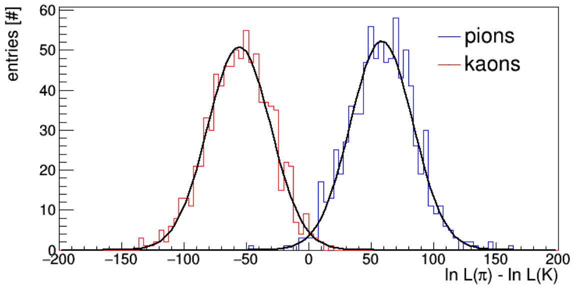

Figure 2: Pion-kaon log-likelihood difference distribution for 4 GeV/c and 4^{O} polar angle.

The reconstruction of the tracks from the full phase space of the GlueX DIRC yields photon multiplicity in a range of 30-60 photons providing π/K separation power of 3.0-4.5 s.d. at 4 GeV/c.

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Experiment beamline: none
Experiment collaboration: other: GlueX
Experiment proposal: none
Accelerator infrastructure: other: CEBAF
PSP codes: none
Grants: HGS-HIRe
Strategic university co-operation with: Frankfurt-M

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First setup for the routine tests of the APFEL-ASIC rigid flex PCBs

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Introduction

For the first slice of the PANDA-EMC-Barrel the required rigid flex PCBs with the APFEL-ASIC [1] were ordered in 2016. With the delivery of these rigid flex PCBs the developed setup for the characterisation was finalised and totally 900 PCBs are measured in functionality and analogue performance. The routine tests are done with a dedicated mainboard, developed at GSI. An external current meter is connected to the mainboard and provides the current. For the data readout the GSI 16 channel sampling ADC board FEBEX [2] and the GSI data aquisition system MBS [3] are used. Based on the MBSPEX device driver software a graphical control and operating tool (APFEL GUI) has been developed. By means of various automatic tests sequences it allows to show a positive or negative decision concerning the quality of rigid flex PCBs immediately on the GUI.

Test Procedure

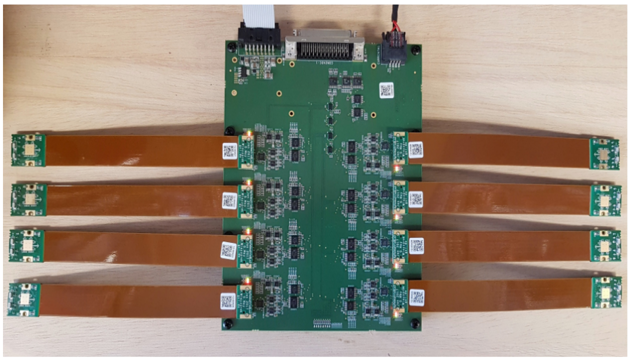
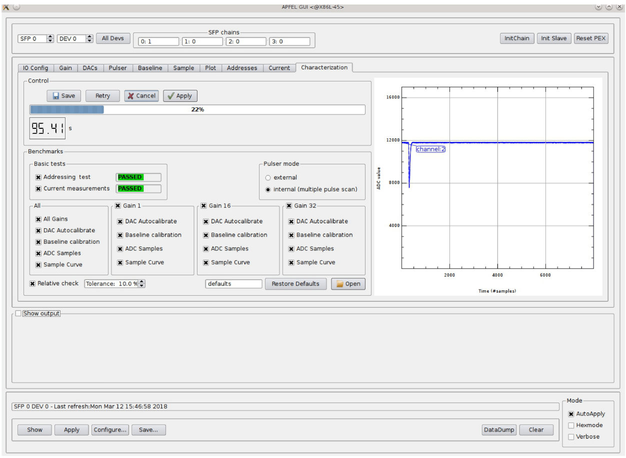


Figure 1: Mainboard overview with 8 rigid flex PCBs.

To record all dependent parameters the mainboard shown in figure 1 has been designed. Up to 8 rigid flex PCBs can be connected to the mainboard and measured successively. The test sequence is divided in a functionality test and a performance measurement. The functionality of the electronics, respectively power consumption and short connections between power, high voltage and ground potential, is specified with the current meter. Other properties like Chip ID scan or DAC access values to an on-chip register are also verified.

To define the analogue performance of the electronics the noise and the amplitude of the output signal as a function of input charge is measured. All values are saved to an ASCII file and stored into a database.



APFEL GUI <@X86L-45>

SFP 0 DEV 0

SFP chains: 0: 1 1: 0 2: 0 3: 0

22%

95.41 s

Basic tests:
☒ Addressing test PASSED
☒ Current measurements PASSED

Pulser mode:
○ external
● internal (multiple pulse scan)

All: ☒ All Gains ☒ DAC Autocalibrate ☒ Baseline calibration ☒ ADC Samples ☒ Sample Curve

☒ Gain 1: ☒ DAC Autocalibrate ☒ Baseline calibration ☒ ADC Samples ☒ Sample Curve

☒ Gain 16: ☒ DAC Autocalibrate ☒ Baseline calibration ☒ ADC Samples ☒ Sample Curve

☒ Gain 32: ☒ DAC Autocalibrate ☒ Baseline calibration ☒ ADC Samples ☒ Sample Curve

☒ Relative check Tolerance: 10.0 %

defaults

☐ Show output

SFP 0 DEV 0 - Last refresh:Mon Mar 12 15:46:58 2018

Mode: ☒ AutoApply ☐ Hexmode ☐ Verbose

Figure 2: APFEL GUI.

In figure 2 a screenshot of the APFEL GUI is shown. This tool allows to operate the routine test without technical background of the tested electronics. For the choosen characterisation in the GUI sequences are defined to be executed like gain settings, DAC programming or sending a test pulse. The online results are displayed in the GUI as well as the final overview of the test results.

Summary and Outlook

The 900 rigid flex PCBs with the APFEL-ASIC for the first slice of the PANDA-EMC-Barrel were characterised successfully. 68 of the rigid flex PCBs have failed the requirements and are sorted out. Since the ASICs and PCBs were not tested before, the yield of over 90% is an excellent result. The first beam and cosmic tests for the slice prototype are forseen for 2018.

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Measurement of Cluster Velocity Distributions for PANDA

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Cluster-jet targets are highly suited as internal targets for storage ring experiments, like the PANDA experiment at FAIR. Such targets provide by the expansion of pre-cooled gases through fine Laval nozzles a high and constant beam thickness that is additionally adjustable over several orders of magnitude. The PANDA cluster-jet target prototype, designed and built up at the University of Münster, is successfully in operation for years and achieves thicknesses of more than 2×10^{15} atoms/cm² in a distance of 2.1 m from the nozzle. The geometry of the nozzles strongly influences the production of the clusters and their characteristics. Therefore, an advanced production process of Laval nozzles was developed at the University of Münster and important investigations on the cluster beam properties are performed [1].

An essential property is the velocity distribution of the clusters, which determines directly the thickness. Therefore, detailed studies on the velocity distribution with a newly produced nozzle were realised. A spherical joint, a feature of the PANDA cluster-jet target prototype and also of the final PANDA cluster-jet target [2], offers the possibility to tilt the nozzle with angles up to ± 3.5° in horizontal and vertical direction with the narrowest diameter of the nozzle as point of rotation (see Fig. 1). The following orifice, the skimmer, only extracts a small and well defined part of the cluster beam. This allows for measurements of cluster beam characteristics from different cluster beam parts.

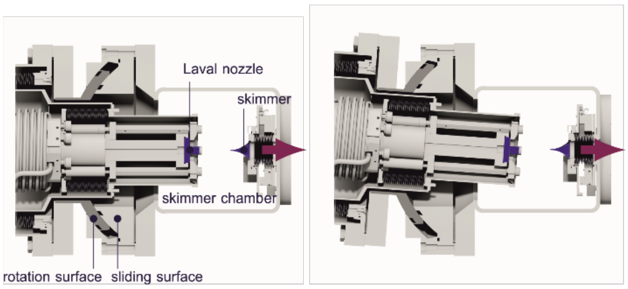

Figure 1: Spherical joint of the PANDA cluster-jet target prototype. Left: Zero position corresponds to 0°. Right: Tilting of the nozzle allows for studies of different cluster beam parts [3].

The PANDA cluster-jet target prototype offers the possibility to determine the velocity distribution of the clusters by time of flight measurements. For this purpose, a pulsed electron gun is used to ionise the clusters and to mark the start time. At the end of the beam dump and after a flight path of around 4 m, a channeltron detects the clusters and stops the measured flight time.

Studies on the velocity and thickness distribution in dependency of the tilting angle of the spherical joint show in the case of gaseous hydrogen in front of the nozzle as expected a symmetric distribution. Decreasing the temperature or increasing the pressure of the gas leads to liquid or supercritical hydrogen in front of the nozzle. As consequence, the thickness is not symmetric any more and cluster beam structures are observed (see Fig. 2). Additionally, the velocity distribution indicates the same compositions within the cluster beam. Moreover, a high thickness corresponds to a small velocity and the other way around.

To describe the velocity distributions simulations developed in the framework of the thesis of A. Täschner [4] were performed. Therein, van der Waals gas is used to characterize the velocities including a variable z parameter. This z parameter corresponds to the distance from the narrowest point of the nozzle where a decoupling of clusters from the surrounding gas is assumed. Calculations of the velocities with varied z parameter based on these results are also included in figure 2.

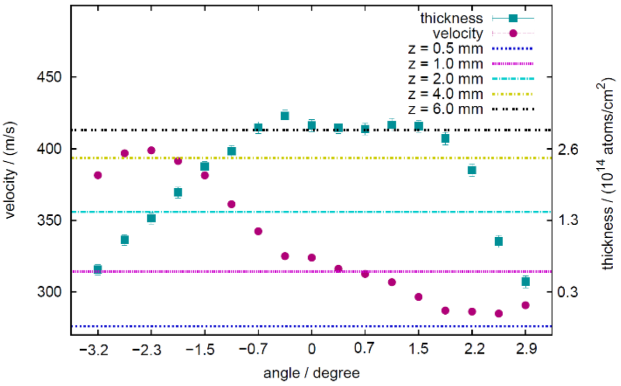

Figure 2: Thickness and velocity distribution in dependency of the spherical joint tilting angle with hydrogen at 17 bar and 22 K in front of the nozzle. The thicknesses and velocities show structures within the cluster beam. The coloured lines show the simulations with varied z parameter.

These new results expose a highly complex cluster formation process within the nozzle if a liquid or supercritical fluid is used as target material. Consequently, further studies on this topic are of highest interest to get a deeper insight into the cluster production process within the nozzle and offer the possibility to optimize the nozzle geometry towards highest thicknesses.

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Experiment collaboration: PANDA
Experiment proposal: none
Accelerator infrastructure: HESR
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Cluster-jet beam and vacuum studies at the PANDA cluster-jet target

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The internal cluster-jet target build up in close to PANDA geometry at the University of Münster will be the phase one target for the upcoming PANDA experiment at the antiproton storage ring HESR at FAIR. It is by now successfully set into operation, including the final vacuum and beam monitor systems for the PANDA experiment. Furthermore, the final PANDA cluster-jet beam dump, developed by the INFN Genova, is installed at the Münster laboratory offering the possibility to study the cluster-jet beam vacuum performance with next to PANDA conditions (cf. figure 1).

Thicknesses of more than 1.4×10^{15} atoms/cm^2 directly measured at the upcoming PANDA interaction point distance of 2.25 m away from the cluster-jet nozzle demonstrate the great performance of the PANDA cluster-jet target for a high luminosity 4π experiment. The given thickness was measured using a recently installed absolute thickness monitor system at PANDA interaction point distance. Further jet beam optimization studies are expected to yield even higher thicknesses, as already demonstrated by the PANDA cluster-jet prototype with thicknesses of more than 2.0×10^{15} atoms/cm^2 at PANDA interaction point distance [1]. Also the ongoing research of new nozzle production processes and cluster-jet beam velocity distribution studies at the PANDA cluster-jet target prototype will advance the Münster PANDA cluster-jet target performance [2].

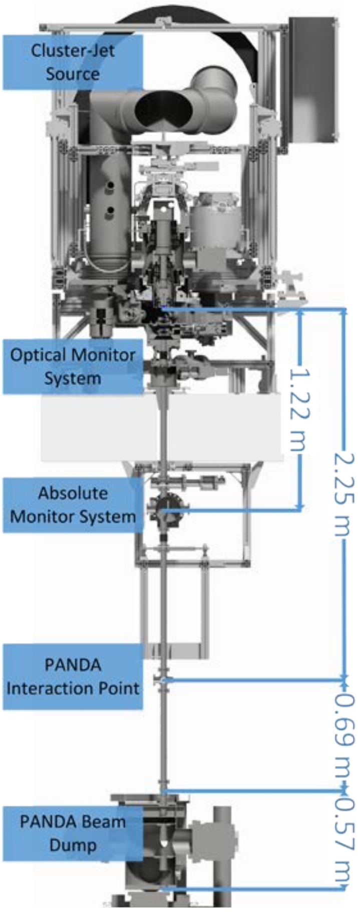

Figure 1: The PANNDA cluster-jet target setup in next to PANDA geometry at the WWU Münster.

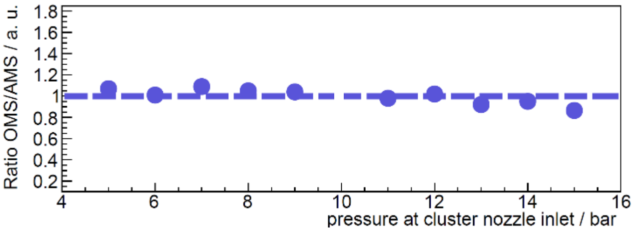

Figure 2: Scaled ratio of the relative thickness measured by the optical monitor system (OMS) and the absolute thickness monitor system (AMS) showing a proportional response.

The PANDA setup at the HESR/FAIR will be equipped with an optical monitor system due to other detector module acceptance reasons. This setup yields relative jet beam thickness information by measuring the scattered light intensity of a laser from the cluster-jet beam without influencing the jet beam itself. Recent studies showed that the response of the optical monitor system is directly proportional to the absolute measured thickness (cf. figure 2). This matching of the optical thickness to the absolute measured jet beam target thickness makes the optical monitor highly suited for the later PANDA activities at HESR/FAIR.

PANDA cluster-jet target beam and vacuum studies at the COSY accelerator

The PANDA cluster-jet target beam thickness and vacuum conditions are constantly optimized at the WWU Münster setup using specialized collimators, orifices and other means. Having reached highest thicknesses with the PANDA cluster-jet target at the WWU Münster the next step will be to perform direct accelerator beam - jet beam interaction studies.

For this reason a directly PANDA related beam time at the COSY accelerator in Jülich was approved for August 2018. Thus the PANDA cluster-jet target will be moved from the WWU Münster to Jülich and be installed at COSY in June 2018.

During the August 2018 beam time the PANDA cluster-jet target will interact with the COSY proton beam and the influence of the jet target beam on the accelerator beam quality and lifetime in conjunctions with the measurement of the accelerator vacuum conditions will be performed. Furthermore the investigation of the COSY cooling systems (2 MeV electron cooler, stochastic cooling) and its barrier bucket system is from highest interest for later PANDA experiments.

References

[1] E. Köhler, PhD Thesis, University of Münster, 2015, Germany.

[2] S. Grieser et al., Measured Velocity Distribution for Determining the Cluster Beam Thickness, GSI scientific report 2017.

Experiment beamline: none
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