ANEXA 1.A

Call:FAIR-RO 2024 **Project acronym: SISTINA**

FAIR Research Programme / Experiment: PANDA

Annual Summary Document[1]

Year: 2025

Months: 12

Project Title: Strong interaction studies in antiproton annihilation

Project Work Plan (according to the contract)

Stage: II. Commissioning of the 86 straw module

Activities:

- testing of HV/LV/Readout partition boards;
- gas system commissioning;
- PASTREC configuration software bug fixes and performance improvements;
- development of simulation and data analysis software.

Allocated budget: 361,700.00

Realized budget: 361,700.00

[1] Please fill in all the required items and do not alter the template

1. **Cover Page** (max 1 page)

- Group list (physicists, staff, postdocs, students):

Name	Position
Alexandru-Mario BRAGADIREANU	Research scientist (CS III) – IFIN-HH
Stefan-Alexandru GHINESCU	Research scientist (CS III) – IFIN-HH
Ovidiu-Emanuel HUTANU	Engineer - IFIN-HH
Petre-Constantin BOBOC	Research Assistant – IFIN-HH, PhD Student
Ionut IONESCU	Assistant - IFIN-HH, Student (Computing)
Neagu IONEL	Engineer –IFIN-HH
Alina MOTORGA	Accountant- IFIN-HH

- Specific scientific focus of group (state physics of subfield of focus and group's role);

Physics subfields: QCD bound states, Hypernuclear Physics.

Taking into account the expertise of our group (ATLAS, EXCHARM, FOCUS, DEAR and SIDDHARTA experiments) we expressed our interest in the measurements dedicated to charmonium and exotic states and in the Hypernuclear Physics with emphasis on Ξ^- atoms were our experience in detecting X-rays coming from transitions in Kaonic exotic atoms would be beneficial for PANDA Collaboration.

- Summary of accomplishments during the reporting period

Since PANDA experiment is now in Construction phase our short-term objectives, for 2024, were focused on research and development activities for PANDA STT sub-detector and its integration in the PANDA control system.

Accomplishments:

- commissioning of gas system; EPICS integration of gas system hardware controllers and meters; gas system logging using Grafana;

- individual straw-tube testing to tune the front-end for optimal S/N performance;

- developed custom software for sniffing and decoding the TRB3 data streams; tested three methods used for PASTREC baseline calibration; data analysis;

- integration of 86 straw prototype's geometry and defining the primary particles in PandaRoot;

2. Scientific accomplishments (max 3 pages)

Gas system with EPICS controls

We developed the gas-mixture and pressure-control system for the straw tubes using Bronkhorst pressure and mass-flow meters/controllers, which enable precise regulation and continuous monitoring of the gas parameters. With the setup shown in Figure 1, we achieved a stable and reproducible 80%–20% Ar–CO_2 mixture with no detectable O_2 contamination, while flow-parameter adjustments were supervised using a Witt Gas Analyzer (Figure 2).

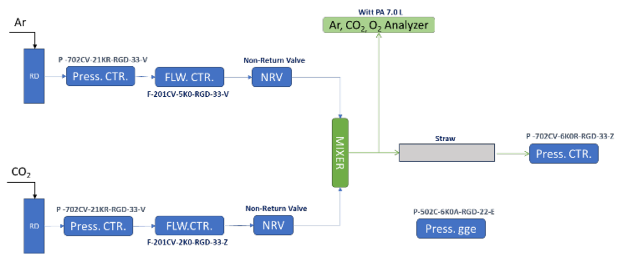

Figure. 1 Gas system schematics

Figure. 2 Witt analyser

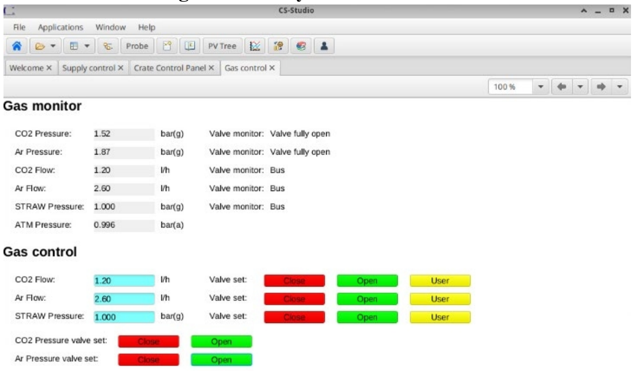

Figure.3 CS-Studio gas control interface

Figure.4 Grafana interface

The Bronkhorst devices are connected to the control infrastructure via an EPICS backend, providing robust communication and fully automated operation. Control System Studio serves as the frontend for configuration, monitoring, and diagnostics (Figure 3). All relevant process variables (PVs) are stored using the EPICS Archiver Appliance, while gas consumption, flow, and pressure can be displayed in real time or viewed historically through a Grafana dashboard.

Individual straw tubes testing

The HV bias for the straw tubes was implemented using the circuit shown in Figure 5. Several values of R2 and C2 were evaluated to reduce the parallel thermal noise originating from the bias resistor and the preamplifier input capacitance. A satisfactory signal-to-noise ratio was achieved with the component set R1 = 10 kΩ, C1 = 1 nF, R2 = 1 MΩ, and C2 = 500 pF. During testing, particular attention had to be paid to avoiding ground loops, and additional EMI filters were added to the low-voltage power supply.

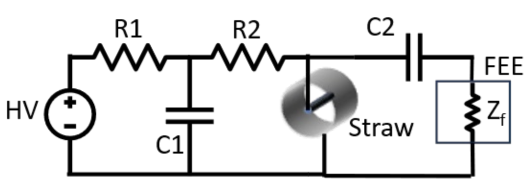

Figure 5: Straw HV bias

For completeness, we note that the high voltage was supplied using an Iseg EHS F6 30p module, operated through a Wiener MPOD system – via EPICS and CS-Studio interface.

To evaluate the spectroscopy performance of individual straws, we initially used an Fe-55 radioactive source together with an Amptek A250F preamplifier (4 mV/fC), a Cremat CR200 amplifier with a 100 ns shaper, and a DRS4 digitizer operating at 1 GHz with 14-bit resolution. A Python based software was developed in order to analyse the DRS4 data – noise filtering, peak detect and peak amplitude (or integration).

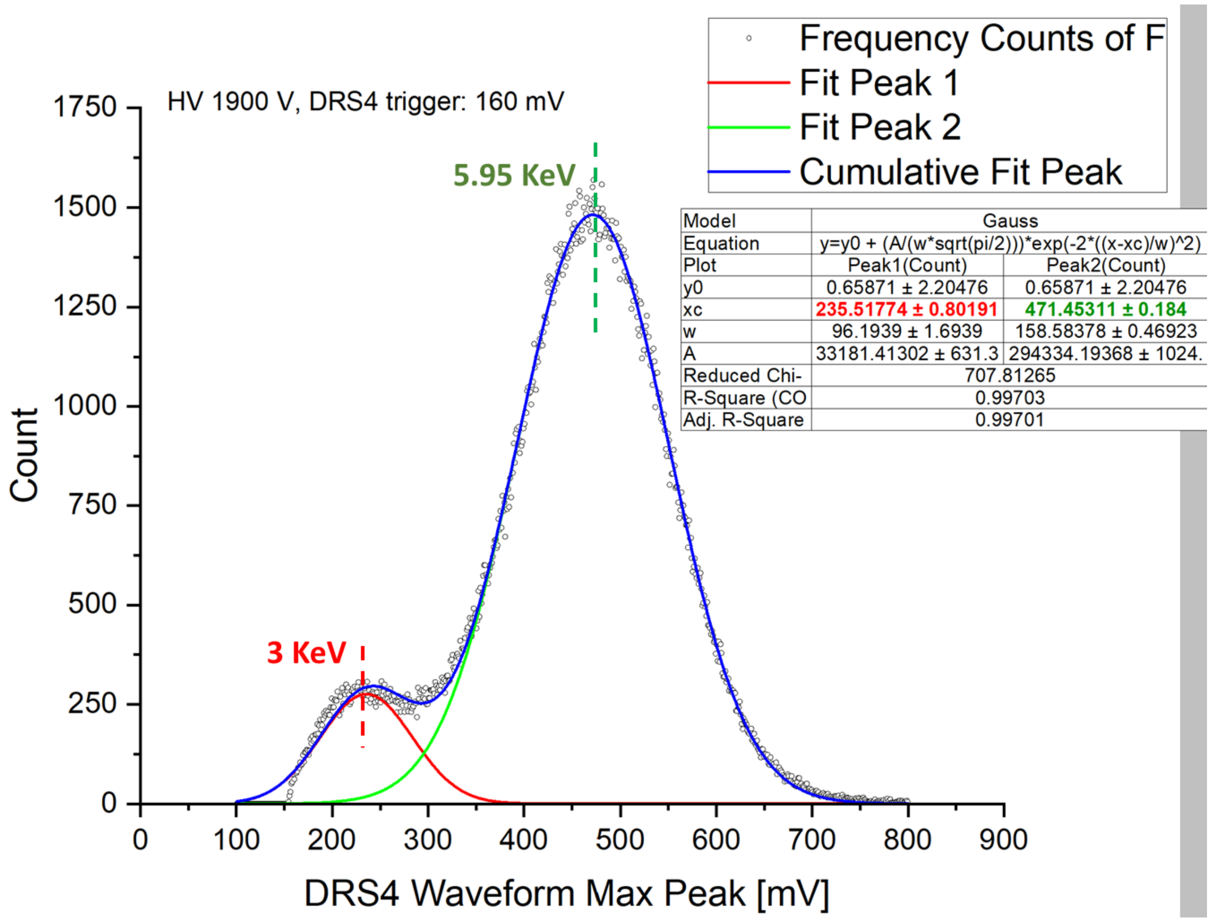

Figure 6: Fe-55 amplitude spectrum

The spectrum of an Fe-55 radioactive source, obtained with the method described above, is shown in Figure 6. Using the definition for the percent energy resolution (1) and the fit results we obtain a resolution of about 33% at 5.95 keV.

$$\% \; EEEEEEEEEEE \; RREERRRRRRRRRRRRRREE = \frac{FFFFFFFF}{PPEEPPPP \; EEEEEEEEEEE} x100 \quad (1)$$

<u>PASTREC & TRB v3 data analysis</u>

The performance of individual straws was then assessed using the PANDA STT Readout Chip (PASTTREC) [1] connected to a Trigger Read-out Board (TRB v3) [2]. Existing frameworks DABC [3] and Go4, used by HADES experiment to acquire, plot and analyse the TRB digitized data (in the case of PASTTREC straw signal rise time and fall time) provide powerful functionality, but their complexity and configuration overhead can be a barrier for rapid prototyping and routine calibration tasks. Thus, we decided to develop a much simple application able to grab TRB3 data, decode and save it in root [4] format for further analysis.

The application relies on Scapy [5] library to capture the TRB3 UDP data packets and decodes the data packets according to TRB3 user guide [6]. For debugging we used hldprint and tdc_print_code.cxx source [7], for the calculation of fine time which is not documented in [6]. After decoding the TRBv3 calibration data is subtracted for each PASTTREC input channel.

The DC baseline of each PASTTREC channel can be tuned, at the level of PASTTREC registers [8], in the interval 0-62 mV with a step of 2 mV. In order to have a common threshold value for the straw signals, a Baseline fine tuning (calibration) is necessary. Using our PASTTREC – Epics interface we implemented two methods, which can be used to perform the baseline calibration.

The first method uses the noise scanning [9] via the baseline level variation while the common discrimination threshold parameter is set to zero. For each baseline setting, the TRB scalers are read out for every channel until the maximum scaler rate is reached. Thus, a mean value for the noise can be determined for each channel. The main advantage of this method is that no calibration source or signal generator are needed to perform the baseline scan.

The second method relies on feeding at the PASTTTREC input, 8 identical analog signals (straw like), and for a fixed common threshold value and gain, perform the baseline scan with a 2mV step and, for each step and each channel record the time-over-threshold (ToT) distribution. Each ToT distribution is subsequently fitted with a Gauss distribution the mean position from fit being recorded. Having the mean ToT value for each channel at every baseline setting the alignment of channels was pursued with two procedures.

The first procedure is based on a pick and trial tuning until the mean value of ToT is achieved for all channels. However, this initial adjustment can cause slight shifts in the baseline, leading to misalignment between channels. To correct this, we perform two additional fine-tuning iterations in which the baseline of each channel is adjusted individually to minimize its deviation from the calculated mean value.

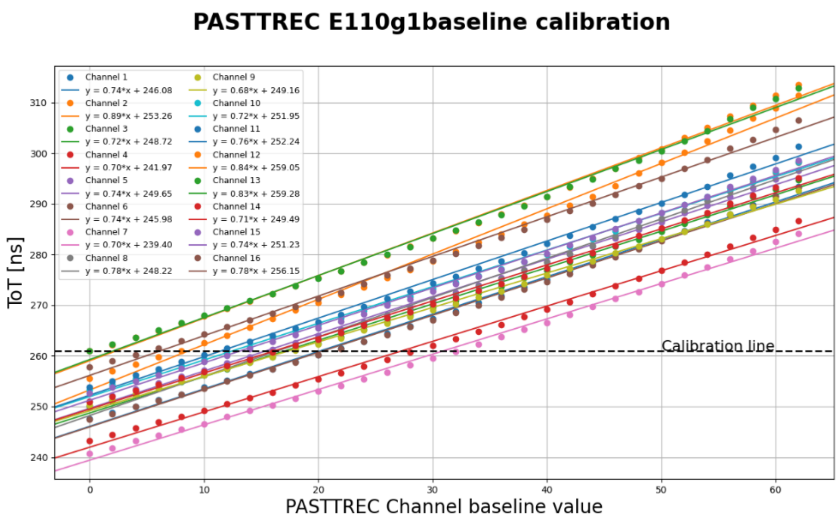

Fig. 7 Analytical baseline calibration method

The second procedure is pure analytical (see Figure 7). For each PASTTREC channel is performed a linear fit and then we determine the intersection of each channel with a line with x=0 and y = max (mean ToT). While in theory this method should provide optimal baseline tuning in reality the method fails for some PASTTREC chips when the Gain is set to 2 or 4 mV/fC due to a larger spread of mean ToT values.

What we learned up to now is that the baseline scan should be performed for each gain setting, no matter the method employed for baseline tuning. Further studies with Fe-55 radioactive source are planned for 2026.

Monte-Carlo simulations

The simulation of the full STT is integrated into the PandaRoot framework. However, to simulate our prototype using the Virtual Monte Carlo (VMC) framework within PandaRoot, we adapted the specific classes responsible for constructing the prototype's geometry and defining the primary particles. The simulation can now run with variable number of straws in a module and with charged particles with various incidence angles, reproducing to a large extent the lab conditions in Romania.

- Describe the progress in achieving the project goals

- gas system is finalized;
- individual straw-tube testing to tune the front-end for optimal S/N performance;
- configuration, readout and calibration of PASTTREC software tools developed, more tests to be done in 2026;
- integration of 86 straw prototype's in PandaRoot is ready;

3. Group members (table)

No.	Name	Role	FTE[2]	PhD/Master students
1	Petre-Constantin BOBOC	Software development	0.07	PhD student
2	Alexandru-Mario BRAGADIREANU	Controls Software development, Hardware integration	0.33	
3	Stefan-Alexandru GHINESCU	Software development	0.05	
4	Ovidiu-Emanuel HUTANU	Electronics hardware design, assembly and testing	0.27	
5	Ionut IONESCU	Software development	0.18	Student
6	Alina MOTORGA	Accounting	0.05	
7	Ionel NEAGU	Hardware integration	0.08	

4. Deliverables

- software tools for PASTTREC configuration, readout and calibration

5. Further group activities (max 1 page)

In 2023 our team joined DRD1 Collaboration – aimed for the development and application of gaseous detectors. We participated at the elaboration of the proposal for “Straw chamber technologies for hadron physics applications” work package.

6. Financial report (budged usage) for the reporting period (Annex)

[2] Total number of hours (for a certain period) = 170 average monthly hours x number of months (e.g., for a full year: 170 hours/month x 12 months = 2040 hours)

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	Type of expenditures		**2025**
1	**PERSONNEL EXPENDITURES, from which:**		**229,064.00**
	1.1. wages and similar income, according to the law		224,023.00
	1.2. contributions related to salaries and assimilated incomes		5,041.00
2	**LOGISTICS EXPENDITURES, from which:**		**15,670.47**
	2.1. capital expenditures		10,542.21
	2.2. stocks expenditures		5,128.26
	2.3. expenditure on services performed by third parties (including the contribution to FAIR)		0.00
3	**TRAVEL EXPENDITURES**		**0.00**
4	**INDIRECT EXPENDITURES – (OVERHEADS) ***		**116,965.53**
TOTAL EXPENDITURES (1+2+3+4)			**361,700.00**
Indirect Expenditures = General IFIN-HH Overheads (35% from 1+ 2.2 +3) + Particle Physics Department Overheads (14,99 % from 1 + 2.2 +3)			

7. Research plan and goals for the next year (max 1 page)

Year	**2024**		**2025**				**2026**			
Quarter	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
HV/LV/Readout partition boards for the 86 straw module										
Study mechanical and electrical coupling of tubes to board										
Prototype PCB design and production (v2 might be needed)										
Prototype PCB test (v2 might be needed)										
PANDA STT HV/LV/Readout partition boards										
Optimize the geometrical configuration of boards										
Prototype PCB design and production										
Prototype PCB test										
Gas system for the 86-straw module										
Design, construction and commissioning										
Commissioning of 86 straw module with cosmic and X rays										
Readout of tubes; parameter tuning (gas mix, pressure, HV, ASIC)										
PASTTREC configuration via EPICS										
Process variables definition and generation; IOC code										
Grafana monitoring and OPI build										
Straw Monte Carlo simulations and data analysis										
PandaROOT, Magboltz and Garfield acquaintance										
Digitization and pattern recognition algorithms development										
Simulations and experimental data analysis										

([3])

Date: 29.11.2025

[1] Mirosław Firlej et al 2023 JINST 18 P05008
[2] M Traxler et al 2011 JINST 6 C12004
[3] https://www.gsi.de/en/work/research/experiment_electronics/data_processing/data_acquisition/dabc
[4] https://root.cern/manual/
[5] https://scapy.readthedocs.io/en/latest/introduction.html
[6] Michael Bo¨hmer et al. A Users Guide to the TRB3 and FPGA-TDC Based Platforms, https://jspc29.x-matter.uni-frankfurt.de/ docu/trb3docu.pdf#subsubsection.16.1.1. 2025
[7] https://github.com/gsi-ee/dabc/tree/master/plugins/hadaq
[8] G. Korcyl et al., Readout Electronics and Data Acquisition for Gaseous Tracking Detectors, IEEE Trans. Nucl. Sci. 65 (2017) 821.
[9]https://indico.gsi.de/event/7846/contributions/34901/attachments/25356/31660/PRESENTATION_FOR_PANDA_MEETING.pdf