ELI-NP
Warsaw University plans and contribution
ELITPC for nuclear reactions at (not only) ELI-NP

Wojciech Dominik

Krakow ELI ERIC - ELI-Polska day

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Mgławica Kraba - HST/NASA

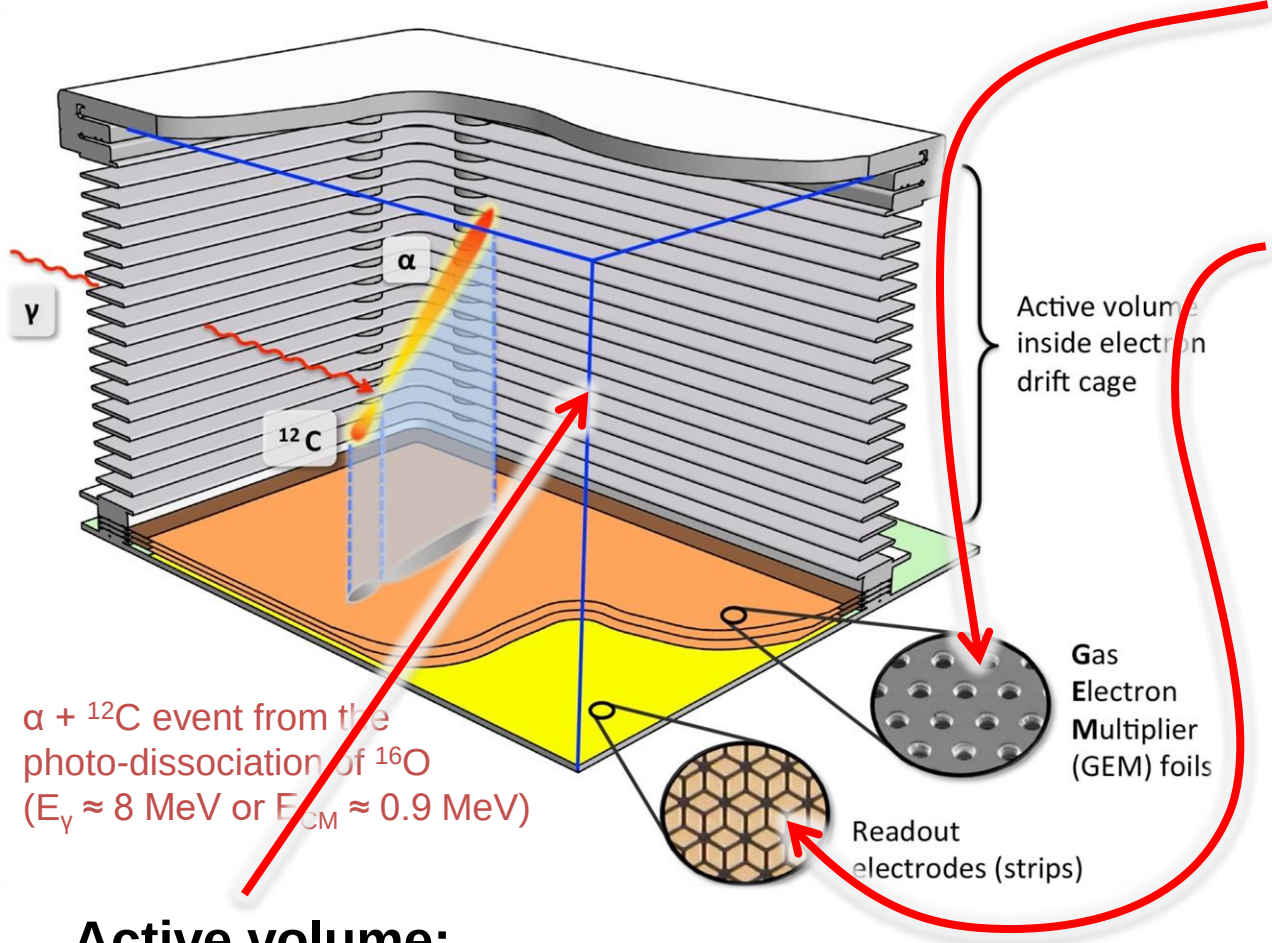
Nuclear Astrophysics studies with monochromatic γ–ray beams

- use detailed balance principle for time-reverse reactions
- measure decay products of nuclear photo-dissociation reactions

Time-reverse reaction	Detector type	Target	Astrophysical relevance
$^{16}O(\gamma,\alpha)^{12}C$	TPC	**CO_2**	**ratio C/O**
$^{19}F(\gamma,p)^{18}O$	TPC	CF_4	ratio $^{16}O/^{18}O$, CNO-cycle
$^{21}Ne(\gamma,\alpha)^{17}O$	TPC	^{21}Ne	role of ^{16}O as neutron poison
$^{22}Ne(\gamma,\alpha)^{18}O$	TPC	^{22}Ne	ratio $^{16}O/^{18}O$, CNO-cycle synthesis of ^{22}Ne (source of *n* in *s*-processes)
$^{24}Mg(\gamma,\alpha)^{20}Ne$	SSD	^{24}Mg	Si-burning
$^{96}Ru(\gamma,\alpha)^{92}Mo$	SSD	^{96}Ru	synthesis of elements with A>73 in *p*-processes

O.Tesileanu et al., Romanian Rep. in Phys. 68, Supplement (2016) S699

ELITPC : low-pressure Active-Target TPC

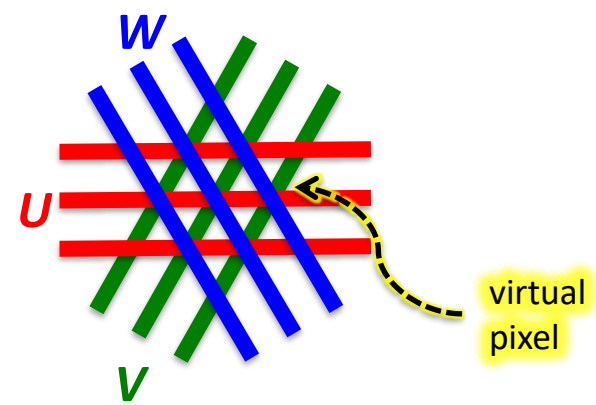


Charge amplification:

- *Gas Electron Multiplier* (GEM) structures

Readout:

- Planar, 3-coordinate, redundant strip arrays
- about 1000 channels
- *GET* electronics for signal amplification & digitization
- external trigger (100 Hz)



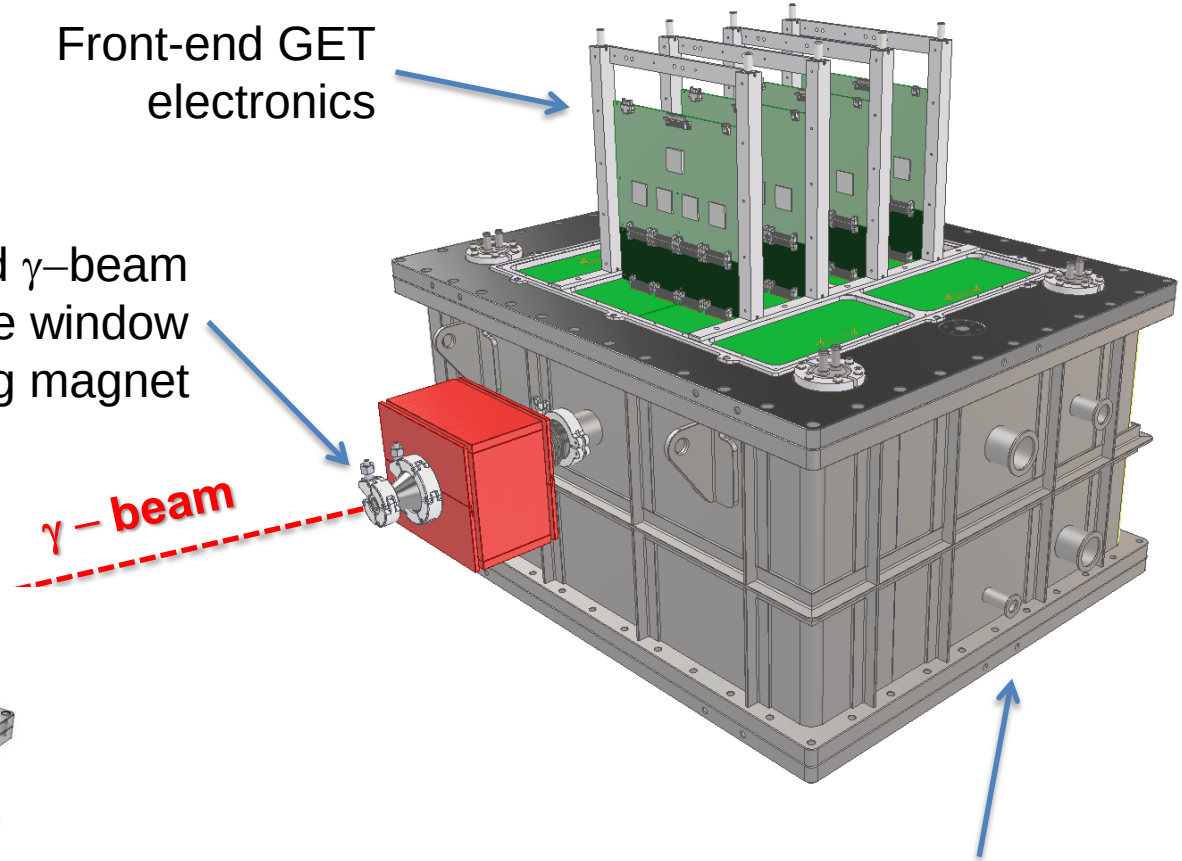
Active volume:

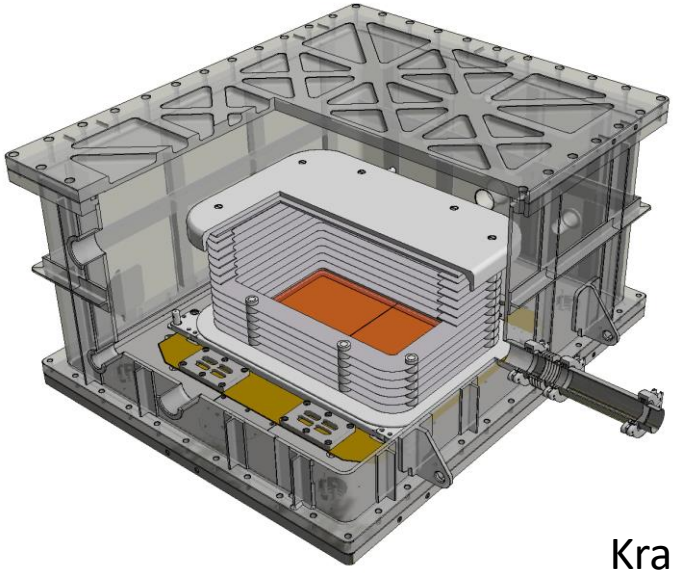
- 33 x 20 cm^2 (readout) x 20 cm (drift)
- gas pressure ~100 mbar ⇒ increase track lengths

O.Tesileanu et al., Romanian Rep. in Phys. 68, Supplement (2016) S699

ELITPC detector

ELITPC

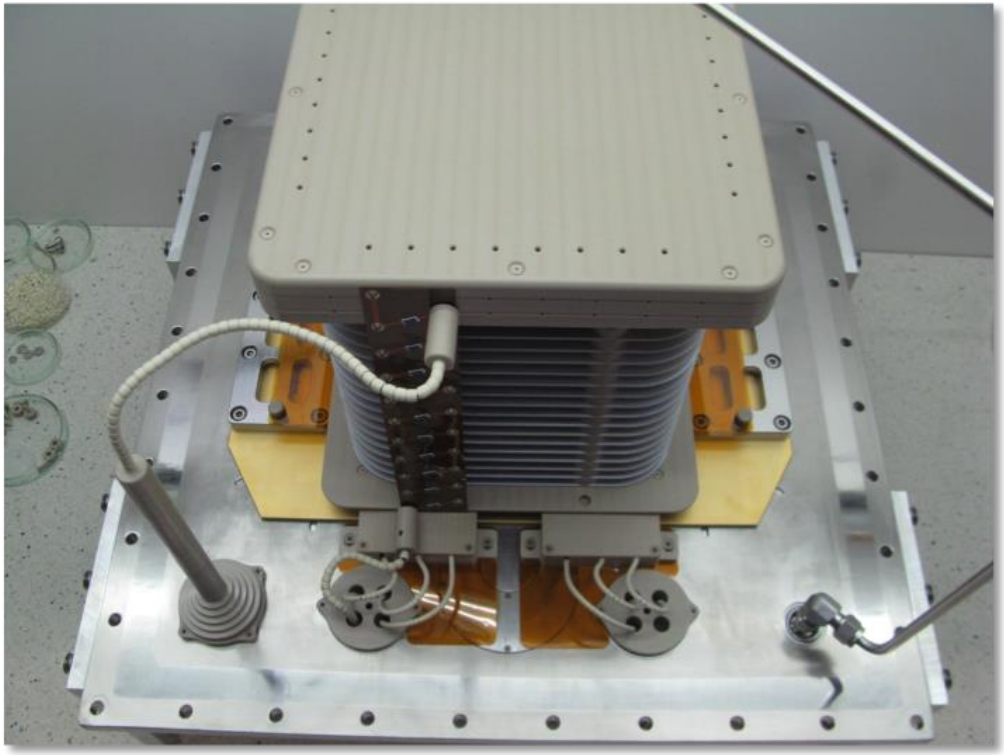


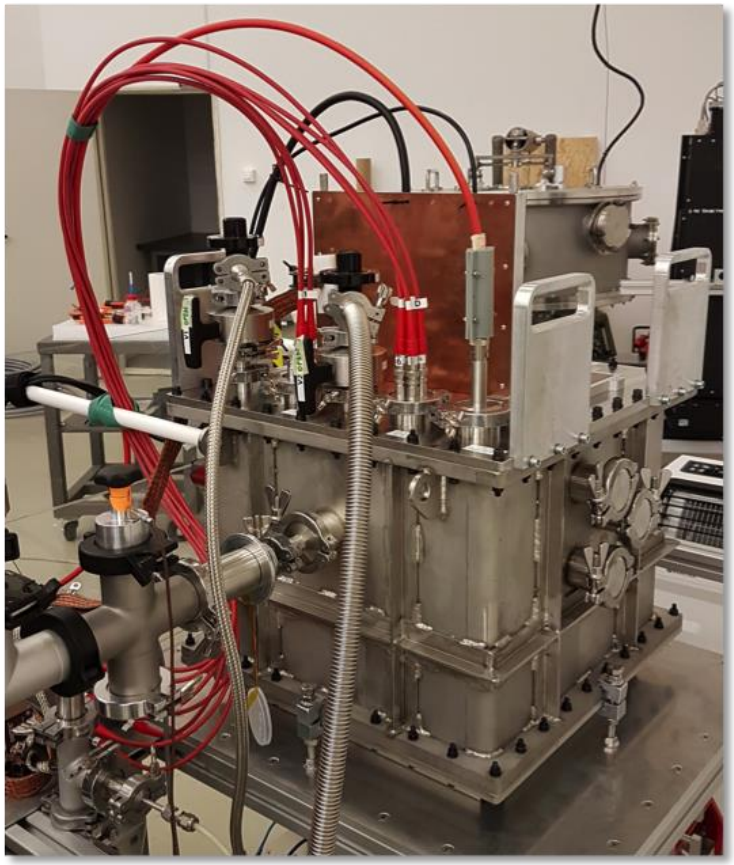


Demonstrator detector (mini-TPC)

ELITPC

- Readout area: **10 × 10 cm²**, drift length: **20 cm**
- Vacuum vessel with low-pressure gas system
- GET electronics: **256 channels** (z-CoBo)

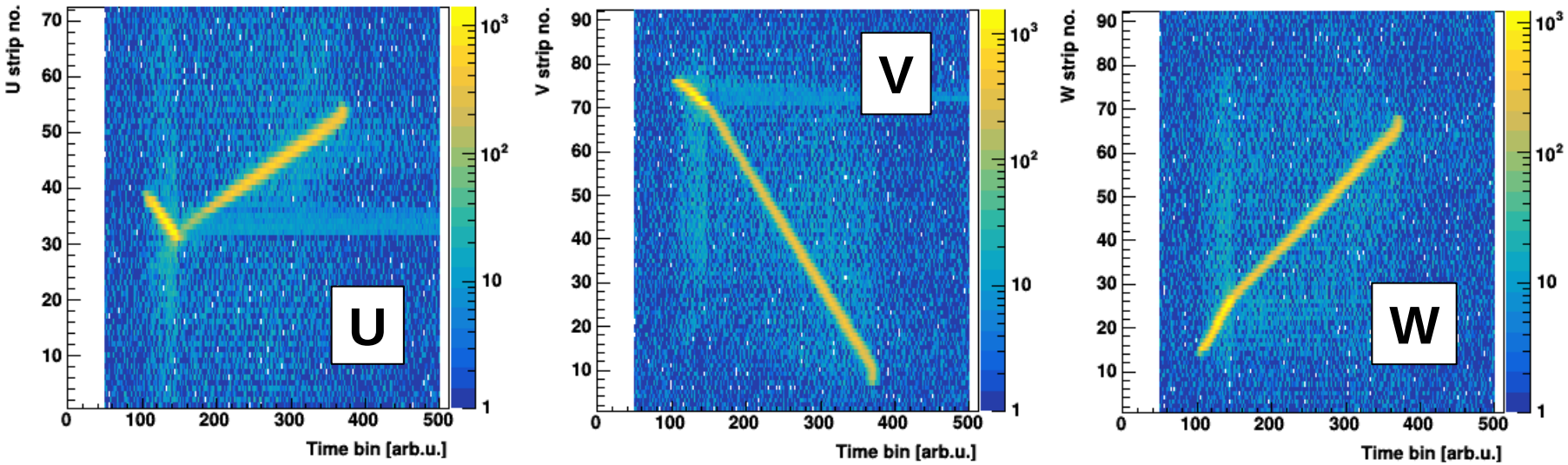


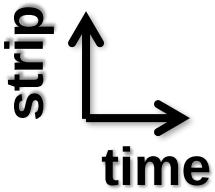


Demonstrator detector (mini-TPC)

ELITPC

- Beam test @ 3 MV Tandem, IFIN-HH, Romania – June 2018
- Neutrons produced by 6.5 MeV α-particle beam on Be target,100 mbar CO_2
- Neutrons reacting with nuclei of CO_2 gas molecules
- **Example of raw signals from U, V, W strips:**





- ZC706 readout (z-CoBo)
- Three 50-μm GEMs
- U_{GEM} = 250 V, $U_{TRANSFER}$ = 350 V, E_{DRIFT}= 100 V/cm
- 120 fC range, 25 MHz sampling, 70 ns shaping time
- about 20 Hz of external triggers (from the last GEM)

^{16}O photodisintegration experiment @ HIγS
(April-September, 2022)

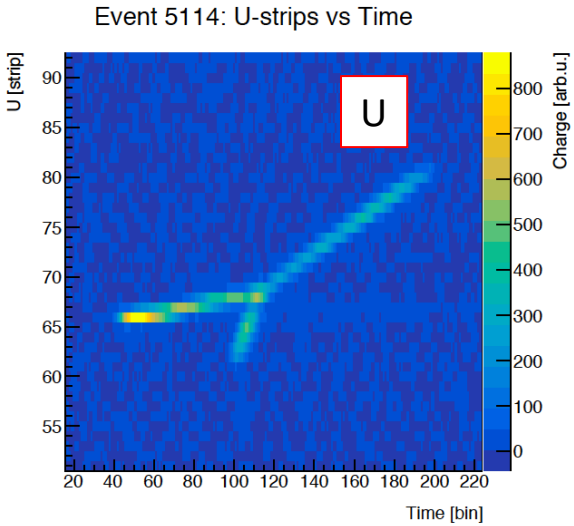
Warsaw TPC

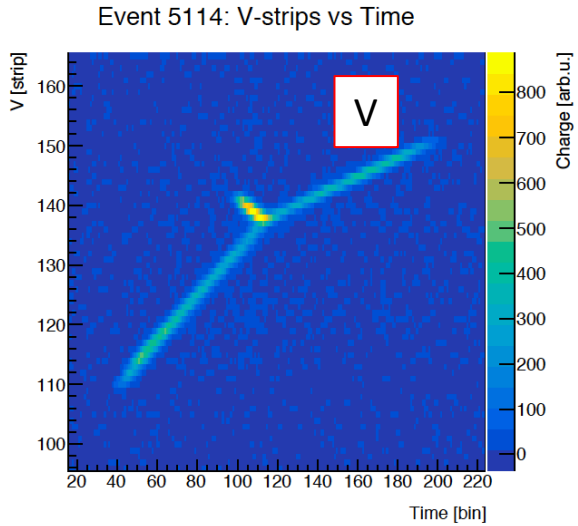
Warsaw Time Projection Chamber – full-scale prototype

^{16}O photodisintegration experiment @ HIγS
(April-September, 2022)

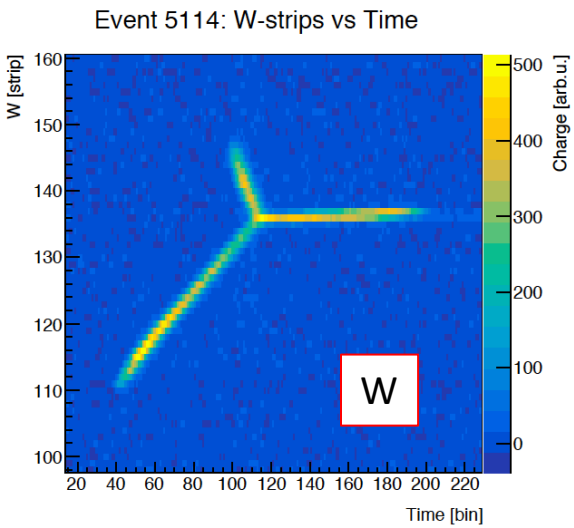
Warsaw TPC

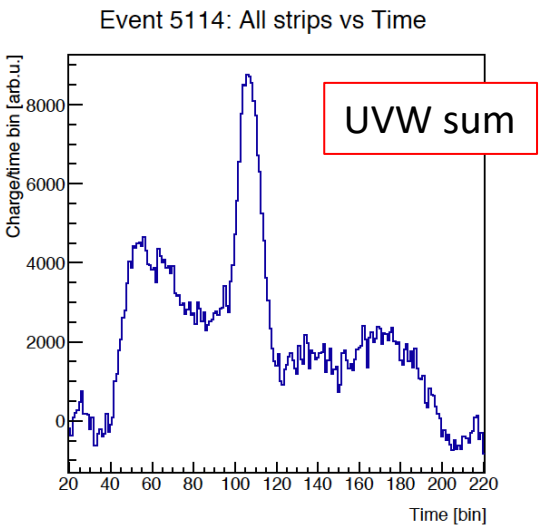
- **Example 3-particle topology:** raw data





E_γ=13.9 MeV





- Pressure: 250 mbar
- Sampling: 12.5 MHz

ELITPC - Funding of the activity

ELITPC

2013 - MoU between Warsaw University and HH-IFIN/ELI-NP.

2014-2015 - Research project contract with HH-IFIN/ELI-NP on mini-TPC at atmospheric pressure construction

2016-2019 – Collaborative R&D project with HH-IFIN/ELI-NP on: „Time Projection Chamber working at lower than atmospheric pressure with multi-channel planar electronic readout – ELITPC”

2019-2021 - Collaborative Research Contract with University of Connecticut on: „ELITPC detector – development of the DCS system, drift velocity monitoring system and the numerical tools for data analysis”

2021-2023 – Polish Ministry of Education and Science grant for construction of the final full-scale ELITPC setup at ELI-NP. Joint effort of Warsaw University and ELI-NP.

Commissioning at ELI-NP in 2024

Warsaw University – ELI-NP tasks sharing

Warsaw University

- Vacuum vessel with the Active Target Time Projection Chamber of 1024 readout channels
- HV distribution module
- ZAP interface modules for readout electronics
- Data concentrator and data processing module Z-COBO FPGA DAQ
- HV dividers with filters and interlock
- LV distribution and control module
- Firmware of the Z-COBO concentrator module
- Data Acquisition software

ELI-NP

- AsAd electronic modules for 1024 channels
- Remotely controlled HV modules
- Programmable LV modules for AsAD boards
- Automatic vacuum system (turbomolecular pumps)
- Gas filling system with the gas pressure stabilization (below atmospheric pressure)
- Detector Control Software (DCS)
- Mechanical support of the ELITPC chamber
- Computers for DAQ and DCS
- Data storage system
- Cables, materials etc

ELI-NP – ELITPC
Warsaw University plans and contribution

ELITPC

Project status:

- The core R&D on active target ELITPC and the design – done
- Ready to produce the final ELITPC system for ELI-NP
- Active Target TPC technology and GET-based DAQ maintained
- Continuation of the R&D on ELITPC monitoring, calibration, DAQ and software
- Active collaboration with GET (Saclay, CENBG, Ganil, MSU), contribution in the GET system development
- The Warsaw ELITPC team formed and working
- Plans of experiments with Active Target ELITPC-like systems at HIgS,
- Funding for the R&D continuation and experiments is not yet secured

Thank you for your attention !!!

ELITPC

The ELITPC collaboration (Feb 2023):

M. Ćwiok[1], H. Czyrkowski[1], R. Dąbrowski[1], W. Dominik[1], M. Fila[1], Z. Janas[1],
A. Kalinowski[1], K. Kierzkowski[1], M. Kuich[1], C. Mazzocchi[1], W. Okliński[1],
M. Zaremba[1],
D. Balabanski[2], C. Matei[2], A. Rotaru[2]
M. Gai[3], D. Schweitzer[3], S. Stern[3]

1) Univ. of Warsaw, Poland

2) IFIN-HH / ELI-NP, Romania

3) Univ. of Connecticut, USA

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