Novel optical amplification structures for Dark Matter searches

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Dark Matter Coffee. AI generated image

European Union
AstroCeNT
NICOLAUS COPERNICUS ASTRONOMICAL CENTER OF THE POLISH ACADEMY OF SCIENCES
NATIONAL SCIENCE CENTRE POLAND
European Funds Smart Growth
Republic of Poland
FNP Foundation for Polish Science
European Union European Regional Development Fund

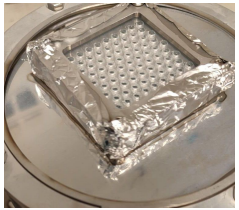
Developing novel optical amplification structures - WLS FAT-GEM

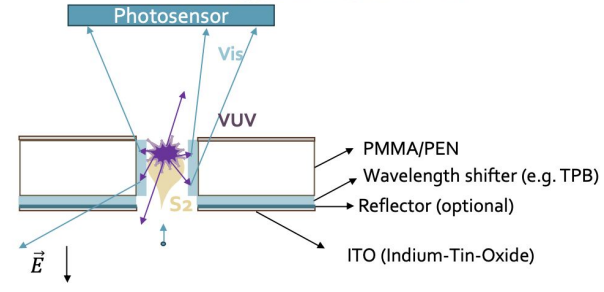
R&D on novel amplification structures

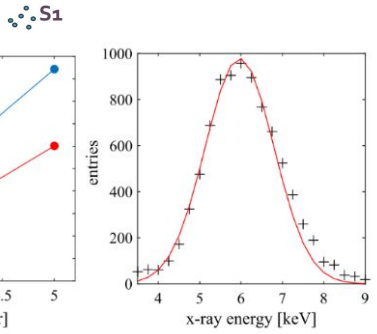
Wavelength-Shifting Field-Assisted Gas Electroluminescence Multiplier (WLS FAT-GEM)

New structure developed at ASTROCENT and IGFAE (Instituto Galego de Física de Altas Enerxías)

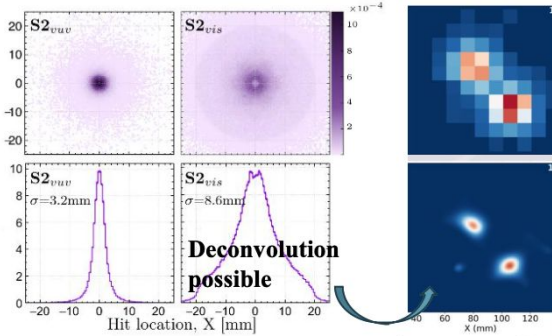
- Scalable solution (tileable)
- Increase both EL yield and light collection efficiency
- Wavelength-Shift VUV to Vis (S1 and S2)



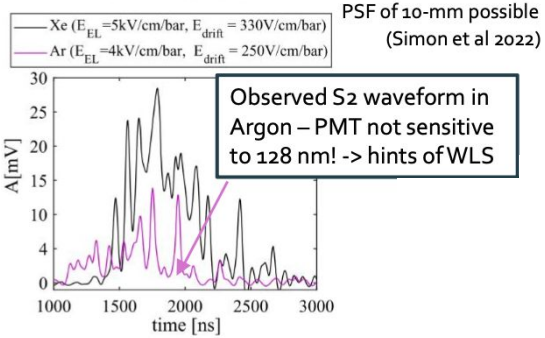




Simulation:



PSF of 10-mm possible (Simon et al 2022)



Preliminary results:

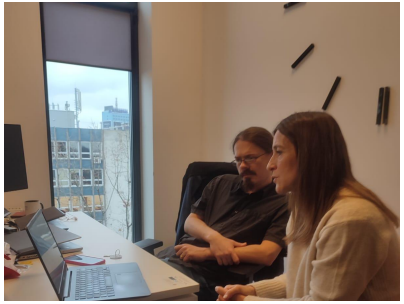
Comparison with a TPC supplied with wire mesh electrodes, shows:
-Similar S1 light collection yield (up to 75%);
-Up to 2-3 times higher S2;

Current Activities

AstroCeNT facilities

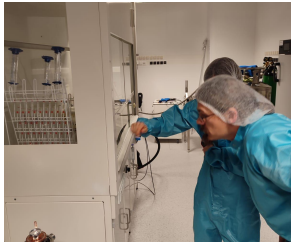
AstroCeNT

Office space plus electronics and workshop.



CEZAMAT

Lab space - production and testing of new materials and structures.

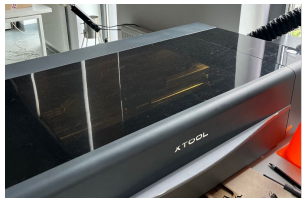
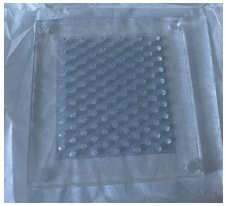


Current Activities

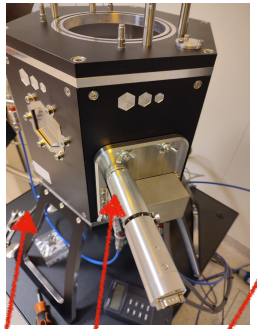
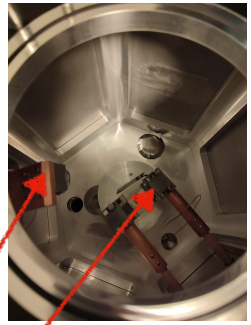
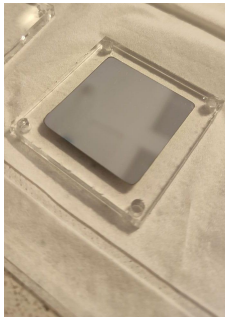
Production at AstroCeNT

Important Milestones:
- Production of the first batch at AstroCeNT;
- Innovative technique to produce using laser cutting techniques;

Laser cutting

Evaporation

View port

Movement feedthrough

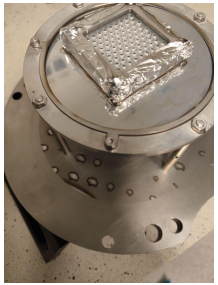
Thin film thickness monitor

Evaporation boat

Spray coating

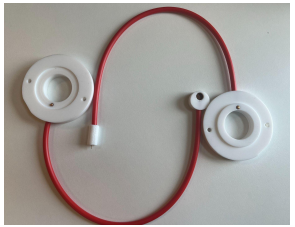

Thermal curing and annealing

WLS Evaporation



Testing

- Electrical insulation
- Operation stability



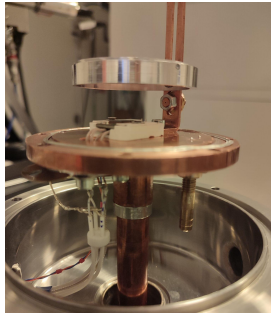

Current Activities

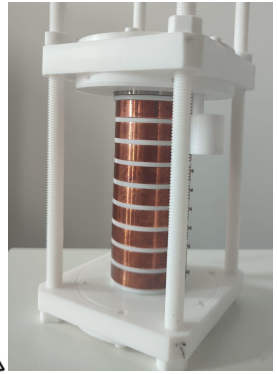
Development of Infrastructures to Study WLS and WLS Structures at Astrocent

ArGSet

- Modular structure (for both WLS materials or WLS FAT-GEMs);
- Charge and light readout;
- Independent biasing;
- Pressure and temperature studies;

Config. 1 WLS Material testing

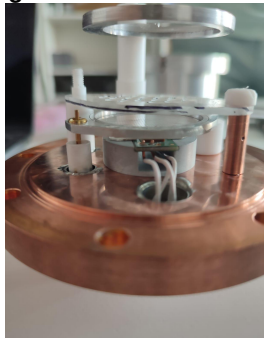


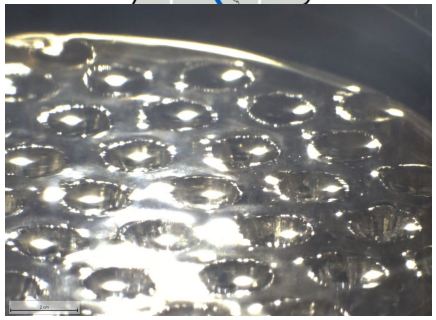


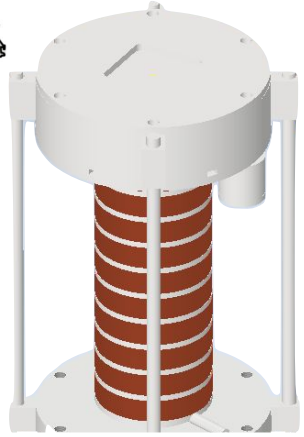
Dual-Phase TPC under construction at Astrocent (SONATA BIS)

- Modular structure
- Allows to easily compare mesh and WLS FAT-GEMs
- Optical readout

Config. 2 WLS Structures testing

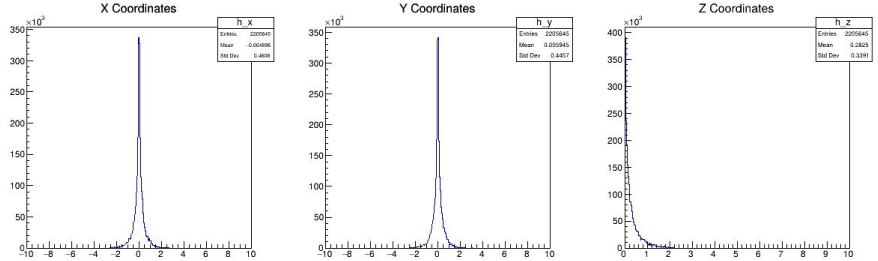




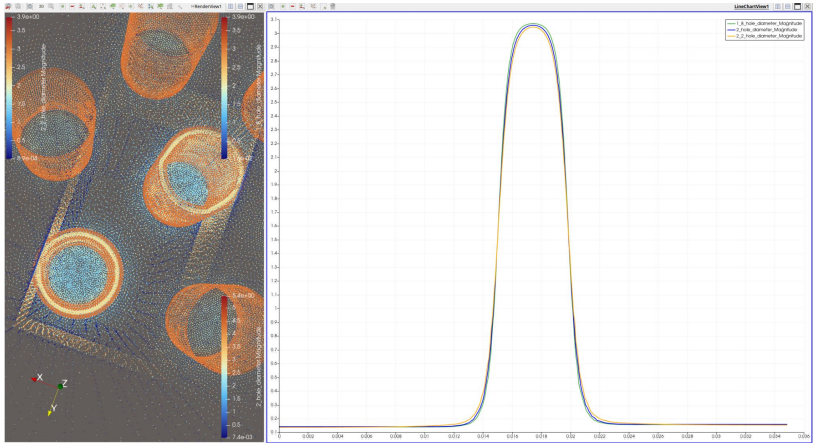


Simulation

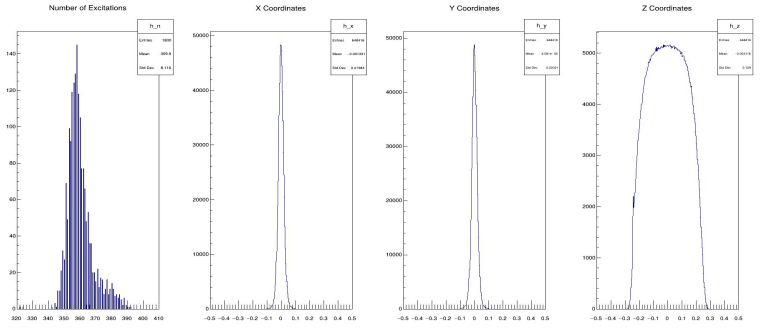
Primary electron distribution 5.9 keV X-rays in Argon @4bar

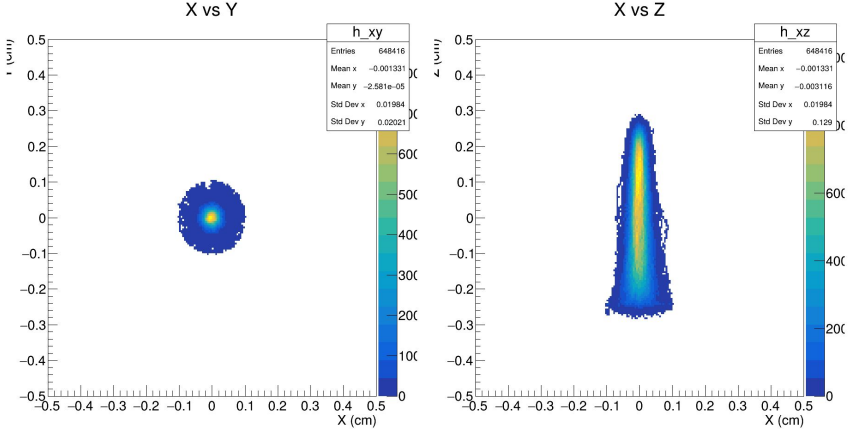


FAT-GEM electric field profile



VUV photon emission distribution (one hole)





Strengthening Synergies within AstroCeNT

Towards establishing an independent research line

Team:

André Cortez (Leader)

Pedro Costa e Silva (Postdoc) - from October 2025

Kristian Haverson (Postdoc) - from March/April 2026

Diego Rodas Rodriguez (PhD student)

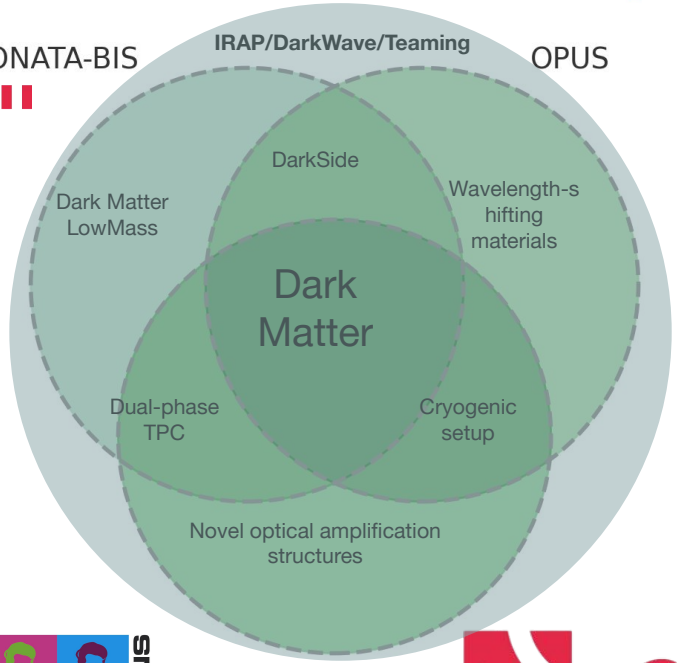
Aheesh Chandrakant Hegde (PhD student)

[co-supervision with Marcin Kuźniak]

Aleksander Gnat (Technician)

Advisors:

Marcin Kuźniak and Masayuki Wada



SONATA-19

MSCA Postdoctoral Fellowship

NATIONAL SCIENCE CENTRE POLAND

Funded by the European Union

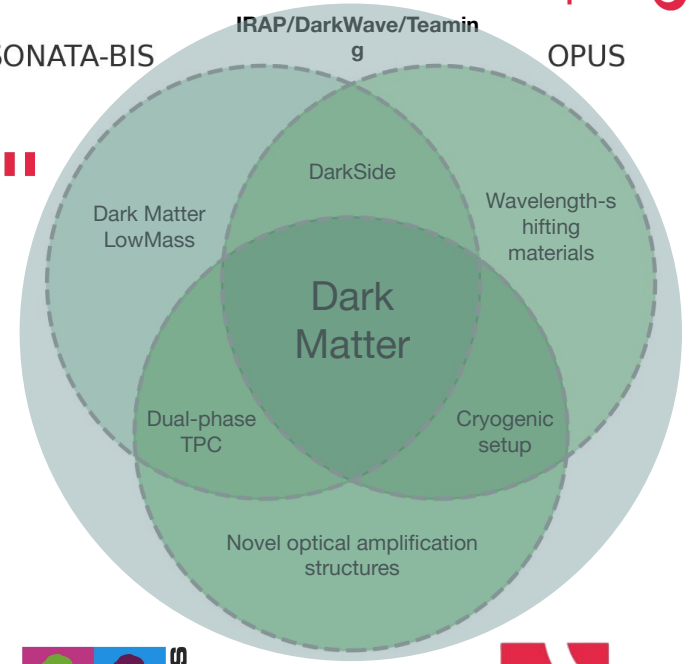
Dissemination and funding

Papers - 5

-"Impact of extreme ultraviolet radiatio...", Agnes, P.; Berger, Q.; Bomben, M. ..., 2025, PhRvD, 111, 102001
- "New candidate polymeric wavelength shi...", Kuźniak, M.; Choudhary, S.; Pawłowski, S. ..., 2025, JInst, 20, C05006
-"Production, quality assurance and qual...", DarkSide-20k Collaboration; Acerbi, F.; Adhikari, P. ..., 2025, EPJC, 85, 1334
-"New candidate polymeric wave...", Kuźniak, M.; Choudhary, S.; Pawłowski, S. ..., LIDINE 2024, 2025;
-"X-ray Single-Pixel Imaging…", 2025, JINST
Matilde Simões, Pedro Vaz, A. F. V. Cortez.

Presentations

Oral - 3 IBER/Seminar/DRD1
Poster - 3 DRD1/LIDINE (best poster)



Funding

MSCA Postdoctoral Fellowship 2023	600k PLN (about 150k euro)
NCN SONATA-19	1.2M PLN (about 300k euro)
Wektory Nauki	204 k PLN 50% -> MNiSW

MSCA Postdoctoral Fellowship

NATIONAL SCIENCE CENTRE POLAND

Funded by the European Union

Strengthening Synergies

Astroparticle Frontiers - Seminar Series

- March 27 Miroslav Macko IEAP Czech Republic SuperNemo
- April 24 Paulo Brás LIP Portugal LZ
- May 15 Giorgio Dho INFN LNF Italy CYGNO
- September 25 Ricardo Peres Imperial College of London UK XENON
- October 16 Samuele Torelli Donostia International Physics Center Spain NEXT
- November 6 Yue-Lin Sming Tsai Purple Mountain Observatory China Theory
- November 13 Kazuki Sakurai University of Warsaw Poland Theory
- November 27 Ayuki Kamada University of Warsaw Poland Theory

Strengthening Synergies

- Signed MoU with DRD1.
  - André - team leader. Pedro Silva - deputy team leader
- DRD1 - common fund - 2nd place - resubmission (Pedro Silva)
- MARIE Skłodowska-CURIE ACTIONS -Doctoral Networks (DN) - submitted
- MARIE Skłodowska-CURIE ACTIONS -Staff exchange (SE) - 68% (resubmission)
- Sonatina 10 - Pedro Silva

6th DRD1 Collaboration Meeting

Building an international network

Working towards establishing an international network

- WLS FAT-GEM collaboration (**leading effort**);
- DRD1/CERN collaboration;
- DarkSide (since November 2024)
- Steering/Cooperation Committee NÜRDAM/Bolu University (Turkey) - Since 2023

Developing some new ideas..

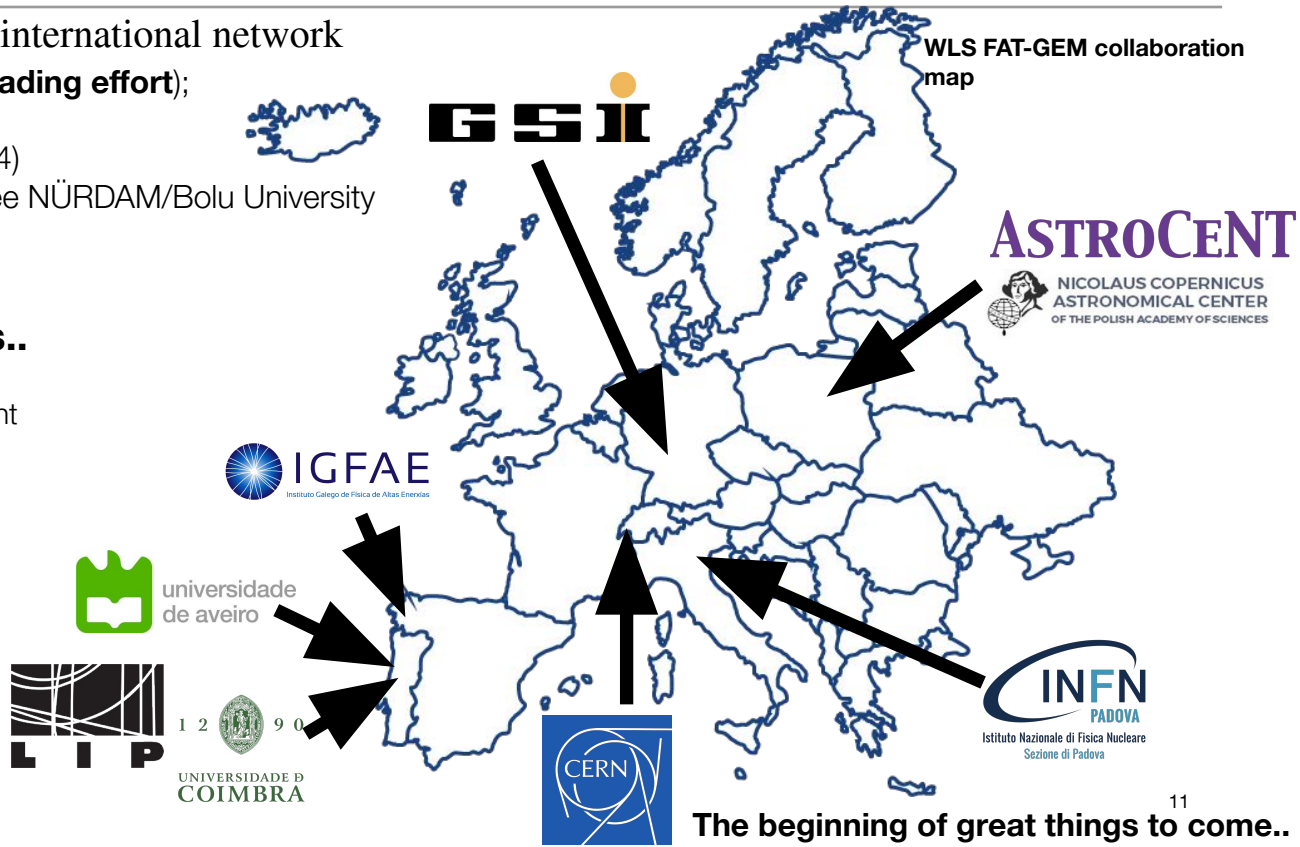
Radon trapping system using WLS FAT-GEMs of potential interest to rare event experiments;

Electrostatic Focusing for large area operation. (Sonatina 10)

Interested partners:

IEAP/CTU Prague (Czech Republic)

Institute of Physics Jagiellonian University (Poland)



The beginning of great things to come..

Thank you!

Dark Matter Coffee. AI generated image

This work was supported by the National Science Centre (NCN) **SONATA-19 Project** No. 2023/51/D/ST2/02297 and from the European Union's research and innovation programme Horizon Europe under the **Marie Skłodowska-Curie grant** agreement No 101154972

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