R&D activities on NaI/NaI(Tl) detectors at CAPA, UNIZAR

PID2019-104374GB-I00 (IPS: M.L. SARSA/M. MARTÍNEZ)

Instrumentation for the future of particle, nuclear and astroparticle physics and medical applications
6-7 March 2023
Barcelona

CAPA
Centro de Astropartículas y Física de Altas Energías
Universidad Zaragoza

OUTLINE

- Past DRD activities carried out, expertise gained by the group, leadership
- Future DRD plans: scientific challenges, infrastructure available, synergies/collaborations with other groups, funding plans and needs
- Number of FTEs involved in the DRD activities including researchers, engineers and technical staff
- Interest in participation in the DRD collaborations

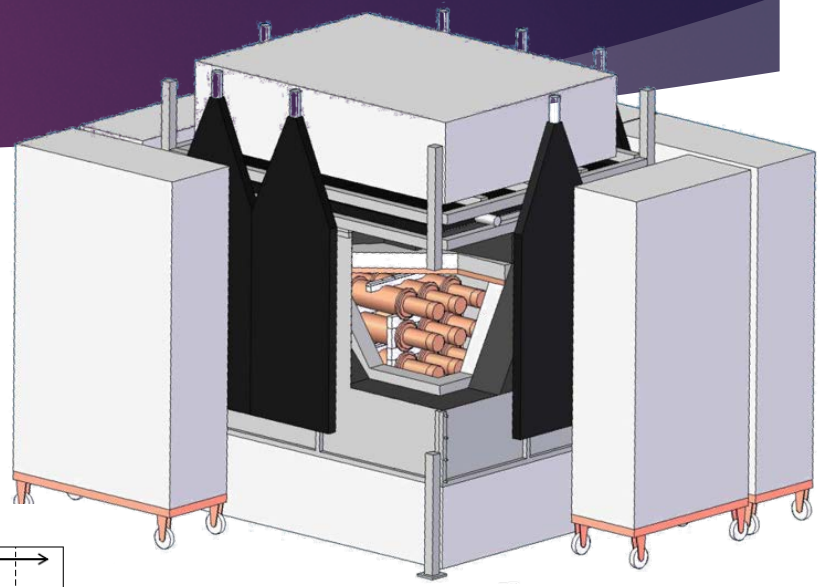
Past DRD activities carried out, expertise gained by the group, leadership

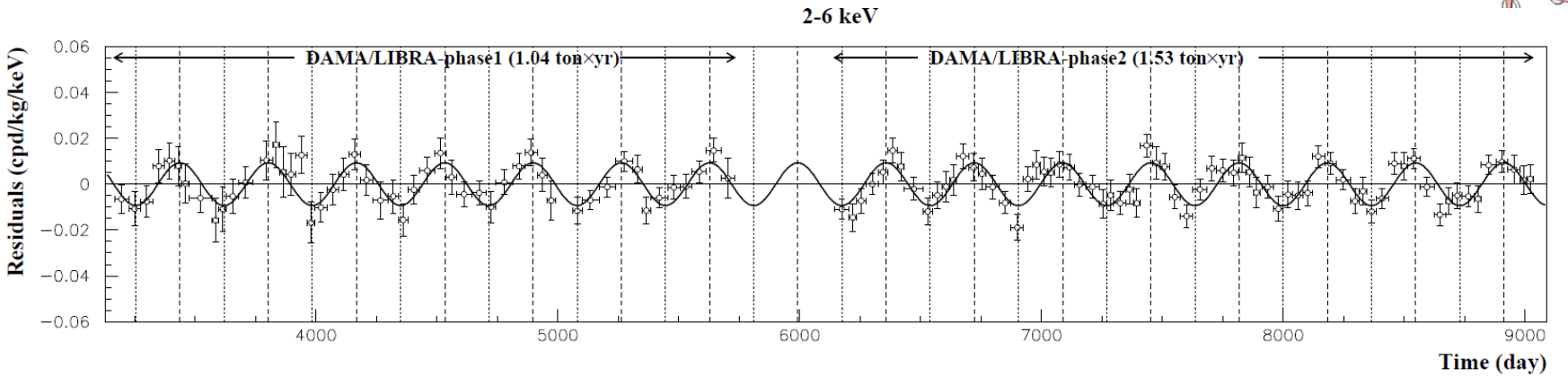
- DR&D expertise for application in direct dark matter and double beta decay searches - **RARE EVENT SEARCHES / UNDERGROUND PHYSICS**
- Expertise accumulated since the 90's
- **Different detection techniques:**
  - **Ionization chambers (KRYPTON)**
  - Germanium detectors (COSME, IGEX)
  - Scintillators (DM32, ANAIS)
  - Bolometers (ROSEBUD, EURECA)
  - Scintillating bolometers (ROSEBUD)

Present activities

ANAIS-112 – Goal

Testing the puzling DAMA/LIBRA signal by searching an annual modulation in 1-6 keV (2-6 keV) region using NaI(Tl) scintillators to avoid model-dependencies on the interpretation in terms of DM





Present activities

ANAIS-112 – DRD

NaI(Tl) detectors used in ANAIS have been developed in collaboration with Alpha Spectra Company: outstanding light collection

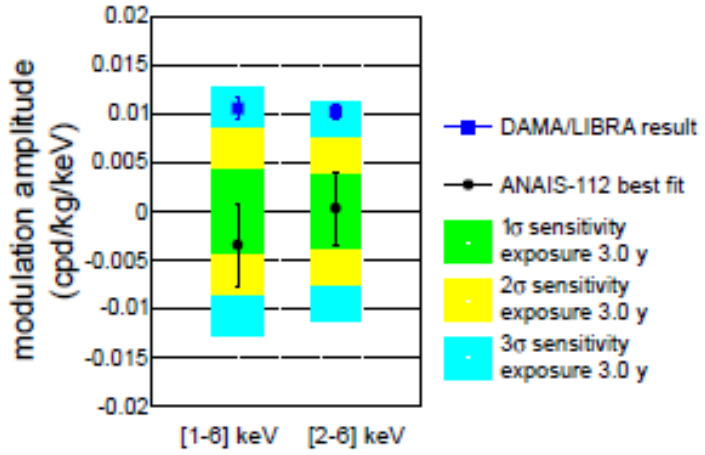
Coupled to HQE PMTs in the LSC clean room

Commercial electronic modules used for the readout using specifically developed DAQ software and data analysis protocols – at present using Machine Learning techniques

Present activities

ANAIS-112 – Status and prospects

In data taking phase



PHYSICAL REVIEW D **103,** 102005 (2021)

Editors' Suggestion Featured in Physics

Annual modulation results from three-year exposure of ANAIS-112

J. Amaré,[1,2] S. Cebrián,[1,2] D. Cintas,[1,2] I. Coarasa,[1,2] E. García,[1,2] M. Martínez,[1,2,3,*] M. A. Oliván,[1,2,4] Y. Ortigoza,[1,2] A. Ortiz de Solórzano,[1,2] J. Puimedón,[1,2] A. Salinas,[1,2] M. L. Sarsa,[1,2] and P. Villar[1]

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PHYSICAL REVIEW LETTERS **123,** 031301 (2019)

First Results on Dark Matter Annual Modulation from the ANAIS-112 Experiment

J. Amaré,[1,2] S. Cebrián,[1,2] I. Coarasa,[1,2] C. Cuesta,[1,‡] E. García,[1,2] M. Martínez,[1,2,3] M. A. Oliván,[1,§] Y. Ortigoza,[1,2] A. Ortiz de Solórzano,[1,2] J. Puimedón,[1,2] A. Salinas,[1,2] M. L. Sarsa,[1,2,†] P. Villar,[1,2] and J. A. Villar[1,2,*]

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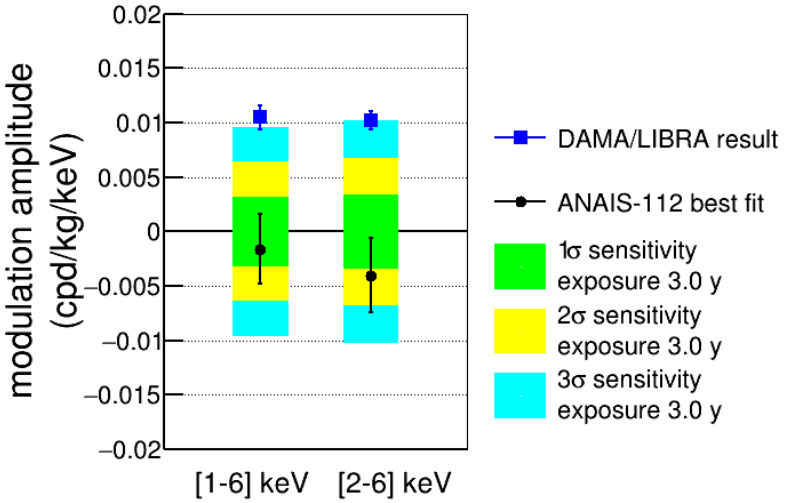
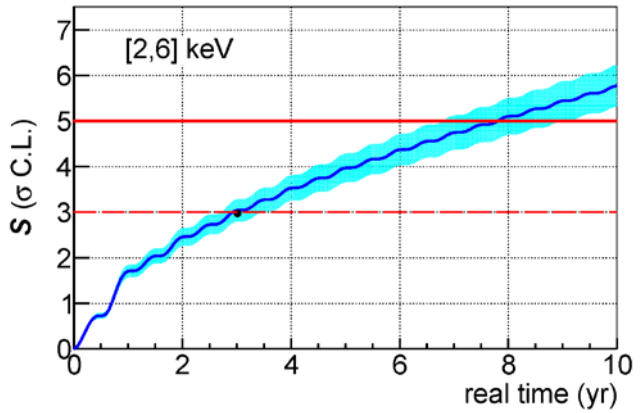
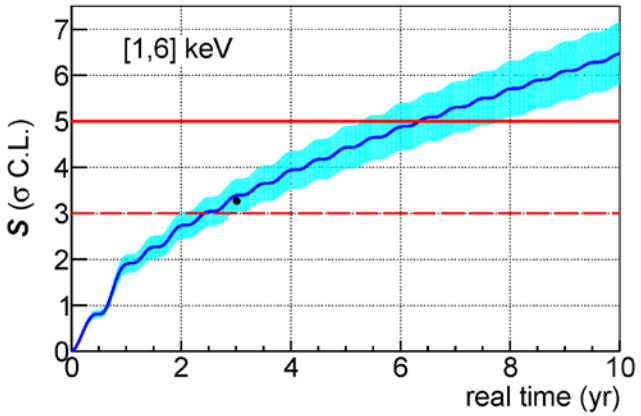
Present activities

ANAIS-112 – Status and prospects







Journal of Cosmology and Astroparticle Physics
An IOP and SISSA journal

Improving ANAIS-112 sensitivity to DAMA/LIBRA signal with machine learning techniques

I. Coarasa,[a,b] J. Apilluelo,[a] J. Amaré,[a,b] S. Cebrián,[a,b] D. Cintas,[a,b] E. García,[a,b] M. Martínez,[a,b,c] M.A. Oliván,[a,b,d] Y. Ortigoza,[a,b,e] A. Ortiz de Solórzano,[a,b] T. Pardo,[a,b] J. Puimedón,[a,b] A. Salinas,[a,b] M.L. Sarsa[a,b] and P. Villar[a]

Present activities, leadership

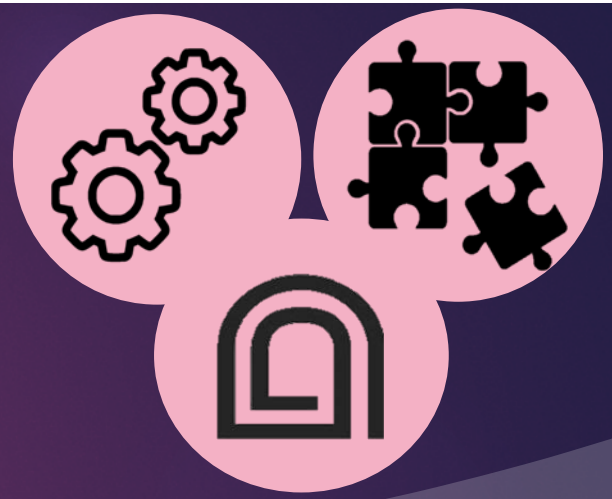
- ANAIS-112 leads the International effort to test the DAMA/LIBRA result
  - Effort in transparent protocols and open data politics



- DAMA/LIBRA puzles the field for more than twenty years -> Strong international repercussion

- Recognition of this expertise in the operation of scintillator detectors is resulting in invitations to join other projects

Present and next future activities



C. Palomares' talk

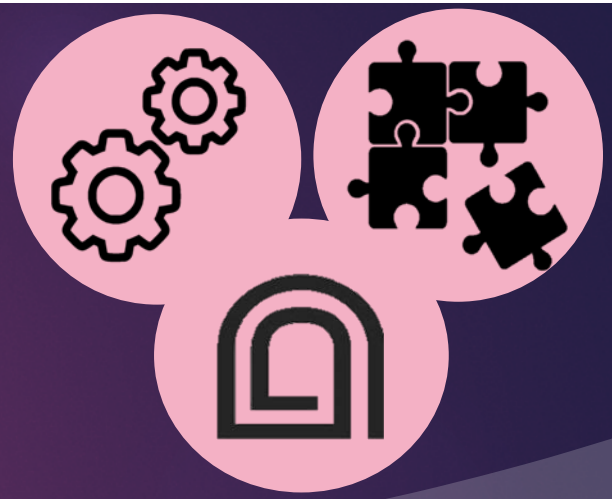
ANAIS-112

ANAIS+

DArT/DarkSide

R. Santorelli's talk

Present and next future activities



- **ANAIS-112** will take data to get a sensitivity at 5 sigma C.L. on DAMA/LIBRA result, **by the end of 2024** -> This task is not implying a real DRD, although we are trying to improve the DAQ for this last period of measurement and developing new analysis tools based on ML.

- **ANAIS+ is our main DRD activity at present and along next years**: we want to improve the performance of NaI detectors and evaluate the sensitivity in the application of the detection of light dark matter.

- We are collaborating in **DArT experiment** at LSC and **DarkSide experiment** (see R. Santorelli's talk) and introducing in **LiquidO collaboration** (see C. Palomares's talk)

FTE involved in DRD activities

	TOTAL	ANAIS-112	ANAIS+	otros
Permanent Scientific Staff	4,5	1,75	2	0,75
Permanent Technical Staff	0.5	0,1	0,2	0,2
PIF	3+1	1,5	1+0,5	0,5 +0,5
Researchers paid by project	1	0,5	0,5	0
Technicians paid by project	0.5	0,5	0	0

Present and next future activities: funding

- The starting of ANAIS+ activities was included in our presently active FPN-project: **PID2019-104374GB-I00**
- ANAIS+ has funding from the complementary plans (MRR) for the next 3 years
- ANAIS+ is one of the main goals of our project proposal for 2023-2026, **PID2022** call, pending of evaluation

MINISTERIO DE CIENCIA E INNOVACIÓN

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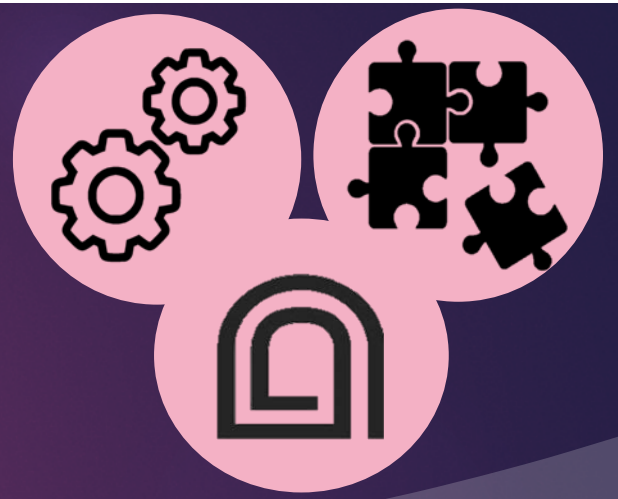
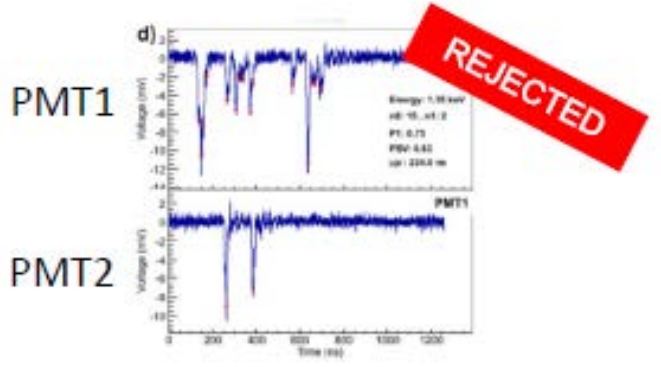
Plan de Recuperación, Transformación y Resiliencia

ANAIS+



- Expertise acquired in the operation of ANAIS-112 opens the door to improve the performance of NaI detectors
- Sensitivity at present limited by crystal radiopurity and PMT-origin spurious light events

- Replacing the PMTs with SiPMs
- Working at low temperature
- Growing radiopure crystals underground at LSC

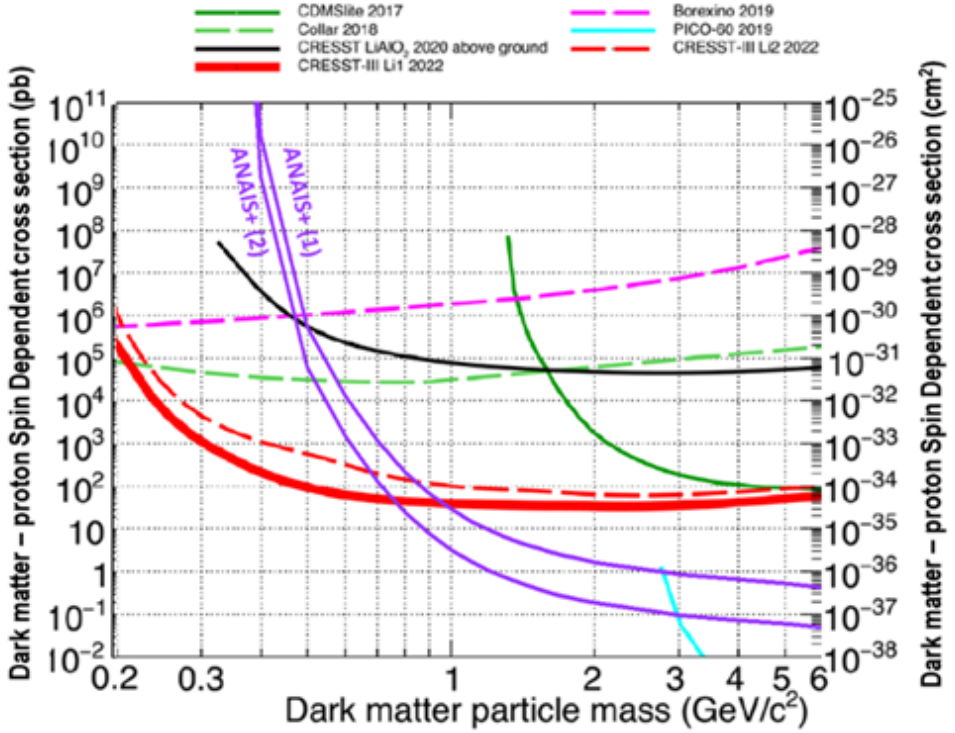


Energy threshold reduction down to 100eV / Background reduction

ANAIS+

Experimental driver: demonstrating the sensitivity of this technique for light dark matter particles searches (Spin-Dependent interacting) and neutrino coherent scattering.

DRD challenges: using SiPMs for single photon detection, aiming at sub-keV energy range -> DRD 4



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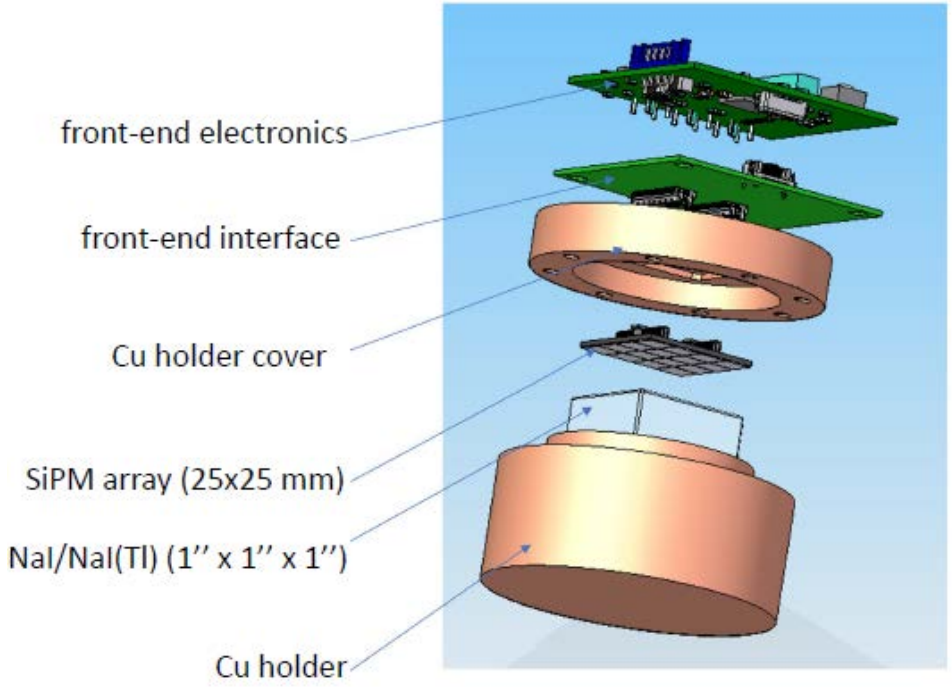
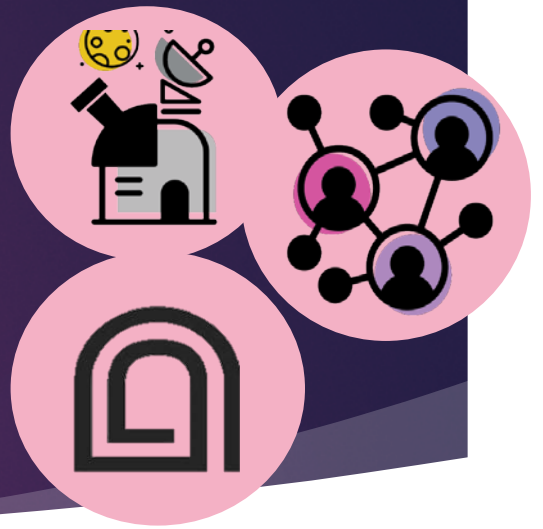
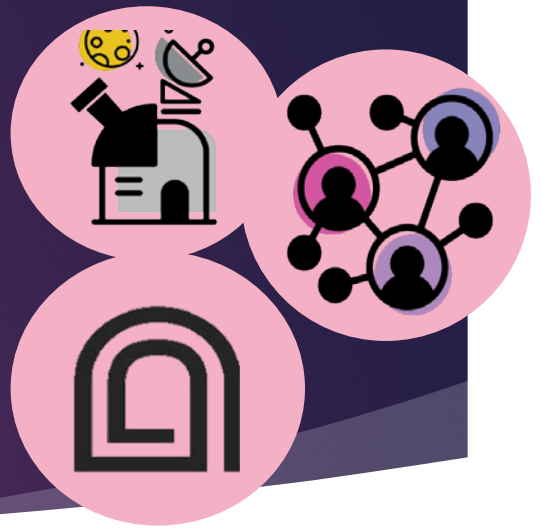


ANAIS+: synergies with other groups and infrastructures



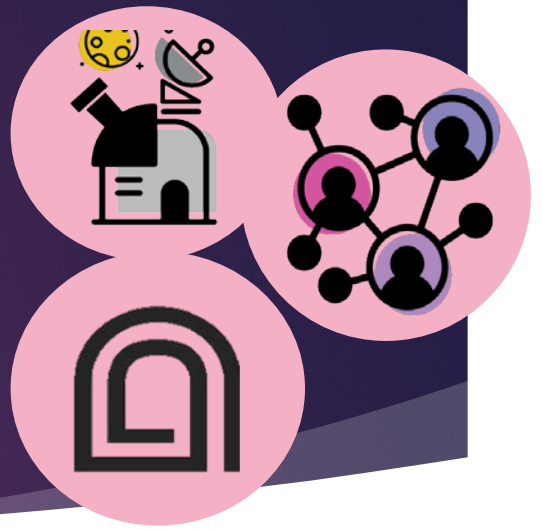
- ANAIS+ is one of the main goals of our project proposal for 2023-2026, PID2022 call, pending of evaluation, a coordinated project with the CIEMAT-DM group and supported by the LSC
- CIEMAT brings for the operation of the LAr infrastructure at LSC: 1 FTE researcher, 1 PhD student and 1 FTE technical engineer / Access to FBK SiPMs built for DarkSide
- Collaboration with LSC for the installation of an underground crystal growing facility, property, unique in the world
- Interest in collaborating for SiPM readout – MUSIC board testing at present ->integrated front-end for the future

Interest in participation in the DRD collaborations: summary



- **R&D on INORGANIC SCINTILLATORS WITH OPTICAL READOUT using SiPMs**, one of the KEY technologies for photon detection according to the ECFA Roadmap – DRD4.
- **The experimental driver** is achieving an improvement on the sensitivity of direct dark matter searches for low mass WIMP candidates with Spin-Dependent coupling, but if successful, other applications as the detection of coherent neutrino scattering could be considered. Moreover, there are strong synergies with R&D in other detection technologies using SiPMs, which will provide opportunities for innovation.
- **Detector challenges** being addressed:
  - improve light collection in inorganic scintillators and then, both energy threshold and resolution at low energy
  - improve noise conditions and then, energy threshold (Front-end integrated readout will be very interesting)
  - improve radiopurity of the crystals by growing underground and screening at LSC of all the other detector components

Interest in participation in the DRD collaborations: summary



- We have **expertise** in different detection techniques applied to rare events searches
  - Scintillation is our present focus as detection strategy and SiPM as light detectors
  - Efforts in analysis techniques, background modelling and evaluation and machine-learning techniques
- We have access to **specific infrastructure**
  - at the LSC for radiopurity assay, crystal growing, measurements in low radiation environment, etc.
  - We are commissioning a cryogenic test-bench for SiPM testing and prototypes