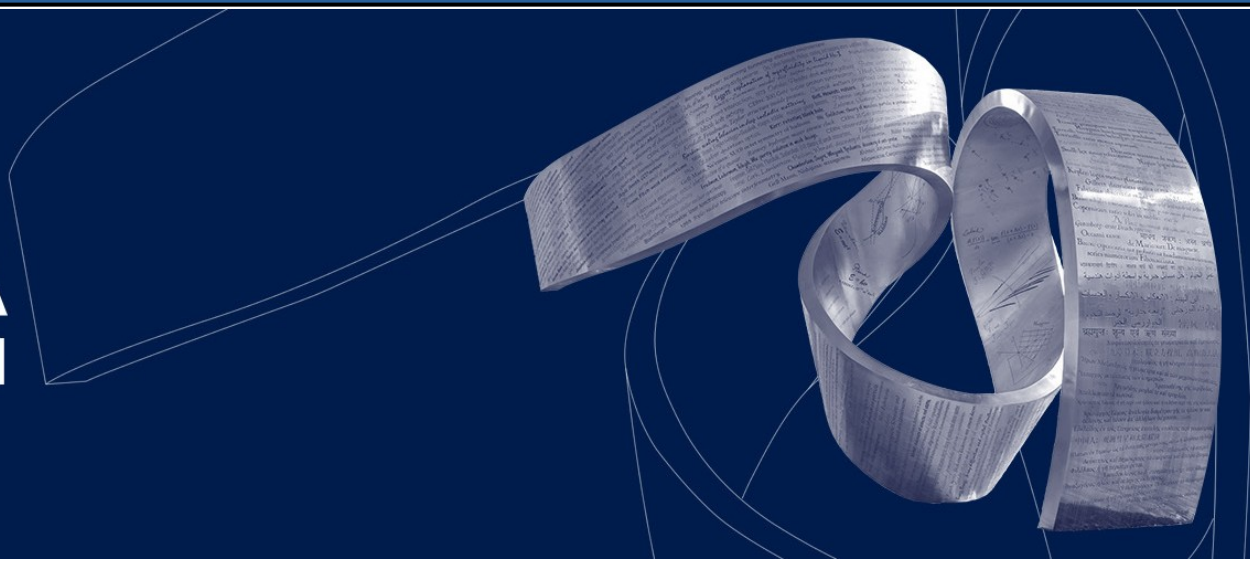


RECFA

visit to Portugal



Detectors R&D

Alberto Blanco

Auxiliary research at LIP

On behalf of the Portuguese detector R&D community



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de aveiro



Who we are. People.

Only PhD holders



Joaquim Santos



José Matias



António Bento



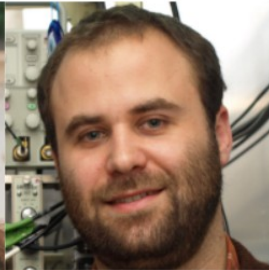
Luís Fernandes



Cristina Monteiro



Carlos Henriques



Alberto Blanco



Paulo Fonte



Luís Margato



Andrey
Morozov



Vitaly Chepel



Vladimir
Solovov



Francisco
Neves



Filipa Borges



Filomena
Santos



José Escada



Alexandre
Fonseca
Trindade

LibPhys-UC	University of Coimbra
I3N-UA	University of Aveiro
RPC	Resistive Plate Chambers R&D group
nDet	Neutron detectors group
LiXe	Liquid Xenon group
GasD	Gaseous detectors group
LOMAC	Laboratory of optics and scintillating materials

SNO/DUNE	Neutrino Physics group
CMS/ATLAS	LHC groups
LUX and LZ	Dark matter group

Performing basic research not necessarily linked to an experiment

LIP groups



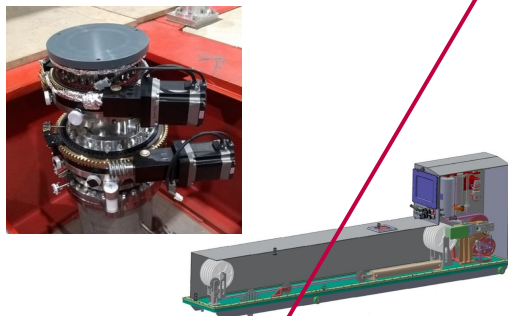
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Already included by others presentations (not covered in the rest of the document)

R&D on detector calibration

Calorimetry, timing detectors, DCS, ...



Reflectivity measurements, DCS

SNO/DUNE	Neutrino Physics group
CMS/ATLAS	LHC groups
LUX and LZ	Dark matter group

Medical Physics

Other works performed within groups ...

Who we are in numbers.

	FTE	Trainees	MSc	PhD	Senior	Senior Permanent	Technicians /Engineers	Men	Women	External Partners
LibPhys-UC	6			4	4	2	0	4	4	CERN (RD51), CYGNO, NEXT, WIS
I3N-UA	6,5	6	3	6	5	3	0	6	8	CERN (RD51, COMPASS/AMBER), NEXT
RPC	5,1	2	1	2	7	5	0	7	2	CERN (RD51, SHiP, SND), GSI/FAIR (HADES/R3B), USC, Hidronav
nDet	1,7	3	1	0	5	4	0	6	0	TUM - FRMII, ESS, ILL and ISIS
LiXe	1,2	0	0	1	3	3	0	7	0	CERN (RD51), WIS
GasD	4,4	3	2	1	5	4	0	7	3	CERN (RD51), NEXT
LOMAC	1,5	1		2	5	1	1	5	3	CERN (ATLAS, FCC), NEXT
Total	26,4	15	7	16	34	21	1	42	20	

FTE without undergraduate students and trainees or technicians

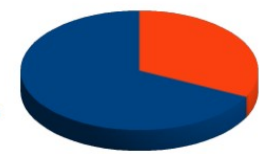


LIP has a well equipped **Detector Lab and Precision Mechanical workshops**, with 3 technicians and 5 Engineers

13 non permanent seniors!!



■ MSc 12%
■ PhD 28%
■ Senior 60%



■ Men 68%
■ Women 32%

Who we are. International collaborations.

International collaborations linked to experiments

CERN https://www.home.cern/	RD51	https://rd51-public.web.cern.ch/
	SHiP	http://ship.web.cern.ch/
	SND@LHC	https://snd-lhc.web.cern.ch/collaboration
	COMPASS	http://wwwcompass.cern.ch/compass/
	AMBER	https://amber.web.cern.ch/
GSI/FAIR https://www.gsi.de/	HADES	https://hades.gsi.de/
	R ³ B	https://www.r3b-nustar.de/
LSC https://lsc-canfranc.es/	NEXT	https://next.ific.uv.es/next/
LNGS https://www.lngs.infn.it/	CYGNUS	https://web.infn.it/cygnus/cygnus/
	ICARUS	https://icarus.sites.lngs.infn.it/

International collaborations where the groups has responsibilities or collaborates

Other international collaborations not linked to experiments

Weizmann Institute of Science (WIS)	https://www.weizmann.ac.il/pages/
Institut Laue-Langevin (ILL)	https://www.ill.eu/
Technical University of Munich (TUM)	https://www.frm2.tum.de/en/frm2/home/
ISIS Neutron and Muon Source	https://www.isis.stfc.ac.uk/Pages/home.aspx
The European Spallation Source (ESS)	https://europeanspallationsource.se/
University of Santiago de Compostela (USC)	https://www-fp.usc.es/
Companies : Hidronav, RI-TE	http://hidronav.com/page2.html https://www.ri-te.pt/






- R&D on **absolute primary and secondary scintillation yield of Xe** and **Xe** with sub-percent **CH₄, CF₄, CO₂ additives** and of **Xe-He mixtures (NEXT)**.
- R&D on absolute primary and secondary **scintillation yield of Kr.**
- R&D on absolute primary **scintillation yield of Ar.**
- R&D on neutral **Bremsstrahlung emission in Xe (NEXT)** and **Ar**;
- R&D on absolute **scintillation yield in GEM avalanches** for **He-CF₄ mixtures** and with the addition of few percent isobutane or methane (**CYGNO**);
- **GEM-125** and **COBRA-125** (125 micron thick).
- Application of COBRA-125 to the **CYGNO** TPC
- R&D on the **PISA photon-multiplier**;
- R&D on neutron detection with gas detectors based on Nanoparticle-aerosol.

Gas emission properties

New gas amplification structures

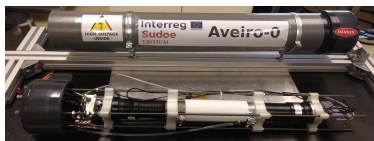
Particle Physics and instrumentation

High Energy Physics Experiments

- RD51 collaboration
- COMPASS collaboration 
- AMBER collaboration 
 - Emergence of hadron mass
 - π and K structures through DY and J/ψ
- NEXt experiment 
 - Search for $0\nu\beta\beta$ decay

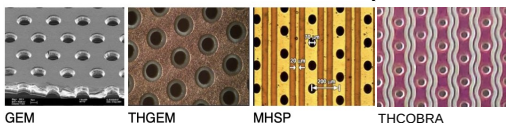
Environmental radiation surveillance

- Tritium and Radon monitors

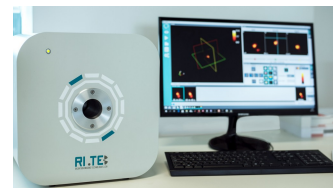


Micropatterned gaseous detectors

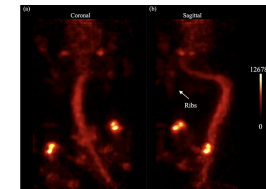
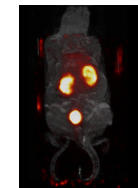
- Simulation and development



Innovative PET systems: Education, Preclinical and Clinical

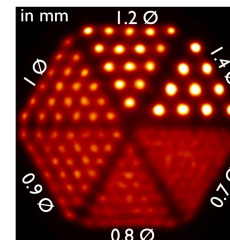


^{64}Cu imaging of RANKL-ME-180 xenografts (0.8 MBq/ μg)
Dewulf et al., *Pharmaceutics* 2022, 14(5), 939

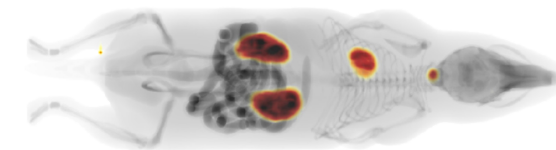


^{18}F -NaF
easyPET.3D scan of healthy mouse (17g) (16 MBq)

Simulations iPET



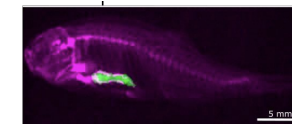
Derenzo phantom filled with 500 μCi (18,5 MBq) of ^{18}F FDG



MOBY phantom emulating a 34 g mice injected with a total activity of 11.1 MBq of ^{18}F FDG: kidneys, heart, and thyroid

X-ray fluorescence imaging

- Elemental mapping of biological samples



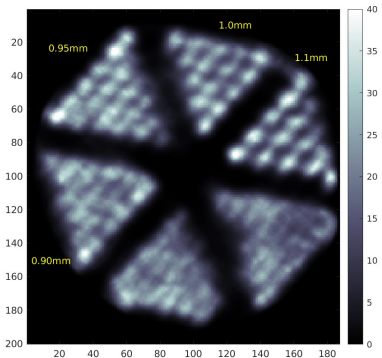
- Spectral CT imaging based on gaseous detectors

RPC-PET

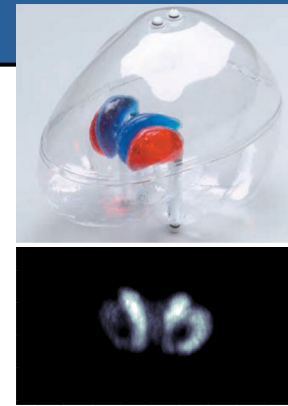
RPC-PET for small animals

HiRezBrainPET, state of the art resolution < 1 mm FWHM

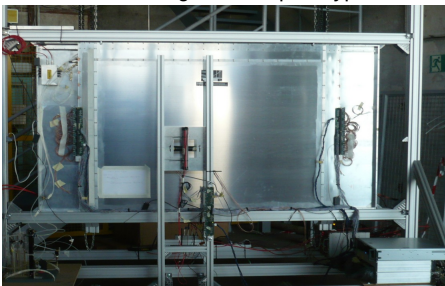
NIMA 1051 (2023) 168236



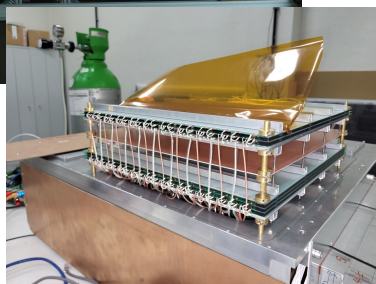
Brain RPC-PET



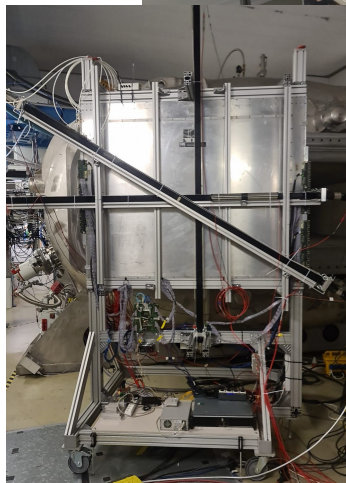
SHiP timing detector prototype



HADES FD-RPC TOF



TOF-Tracker prototype



R³B proton TOF



Timing RPCs (tRPCs) and PS-tRPCs

RPC-TOF-FD for the HADES NIMA 1045 (2023) 16765

TOF for R³B and SHiP NIMA 1055 (2023) 168445

0.1 m² RPC TOF-Tracker prototype



AUGER RPCs



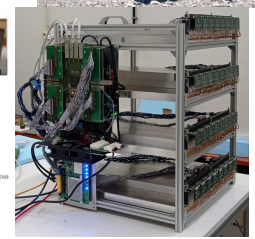
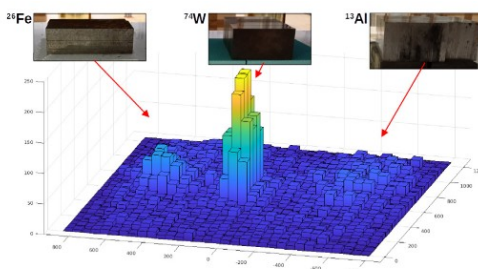
Scatter tomograph for Industry

Autonomous RPCs

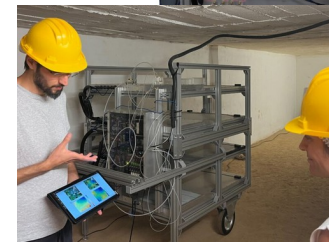
Outdoor RPC NIMA 1054 (2023) 168446

Muon tomography NIMA 1046 (2023) 167744

Sealed RPCs



Sealed RPC telescope



Mine tomograph



Development of a novel neutron detection technology based on RPCs

Neutron scattering science (NSS) such as, e.g., Neutron Diffraction, Neutron Reflectometry and Neutron Spin Echo:

Detection efficiency $> 50\%$

High spatial resolution (< 0.25 mm)

High timing resolution (ns)

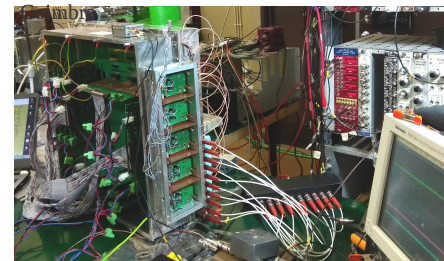
ToF capability.

NIMA 1052 (2023) 168267

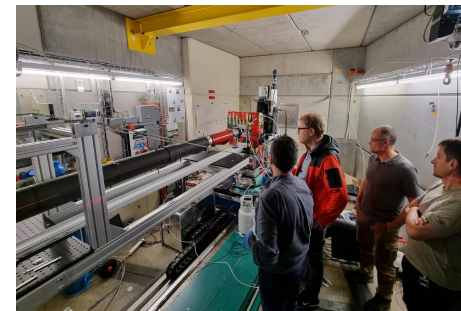
JINST 17 P02016

JINT 16 P07009

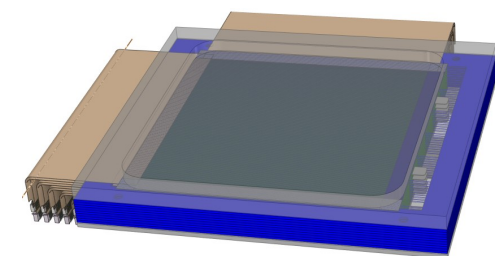
Proof-of-concept nRPC-4D demonstrator developed at LIP,



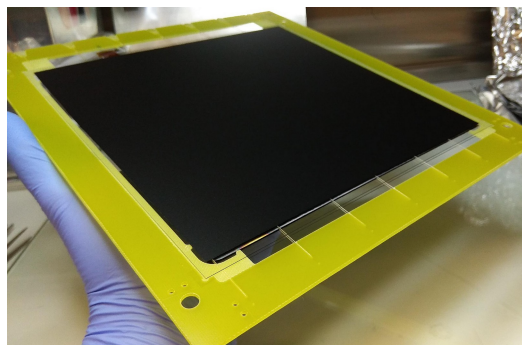
Testing of the nRPC-4D demonstrator on a neutron beamline at PSI



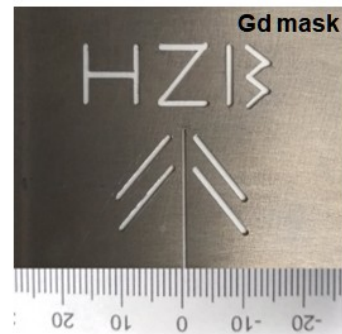
Detectors for fast neutrons for nuclear physics, e.g., for beta-delayed neutron emission experiments



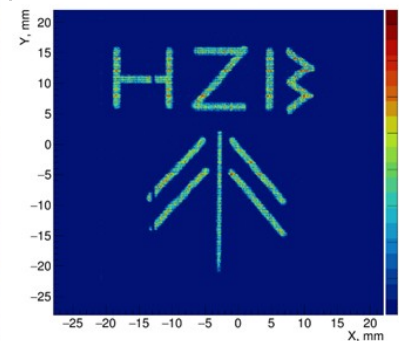
nRPC-4D CAD



10B double RPC

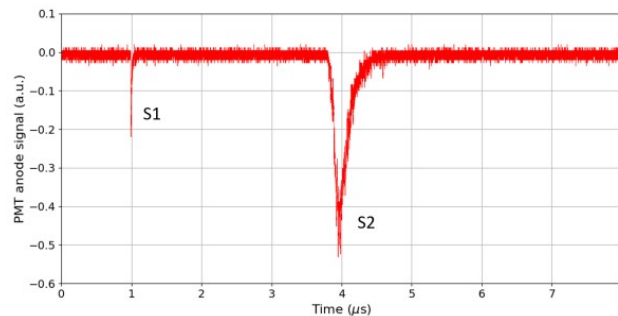
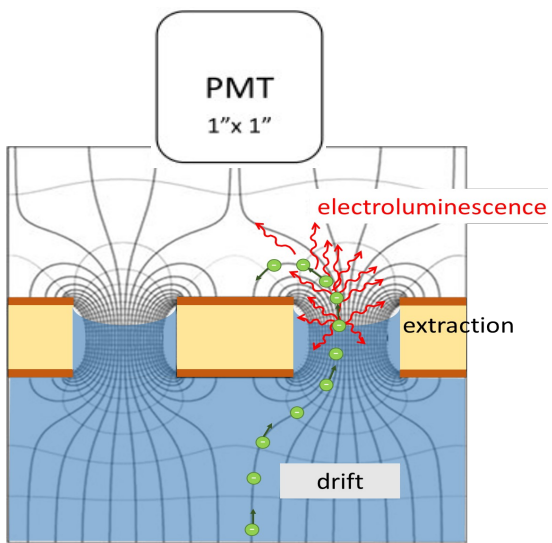


Gd mask



Neutron image

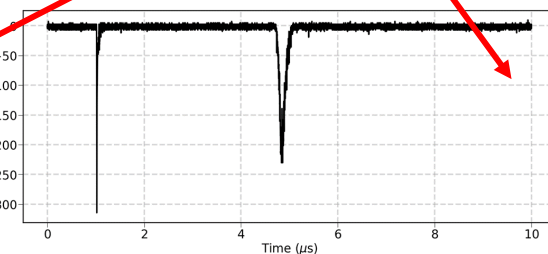
Development of a **novel concept** of double-phase LXe/LAr detector with a **Floating Hole Multiplier (FHM)** (e.g., a THGEM freely floating on the surface of liquid xenon)



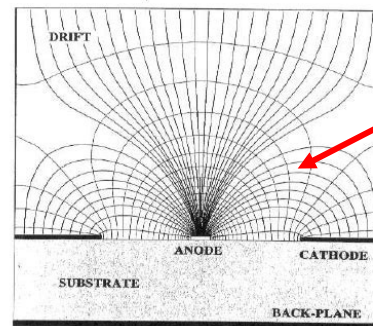
Chepel_JINST(2023)18_P05013



LXe in the THGEM holes
Electroluminescence in LXe



Development of a **novel concept** in single phase LXe detectors with electroluminescence on thin strips



Study of gas mixtures:

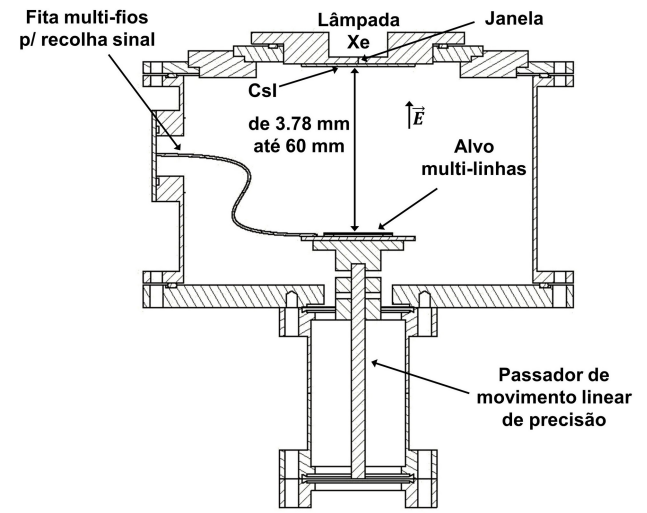
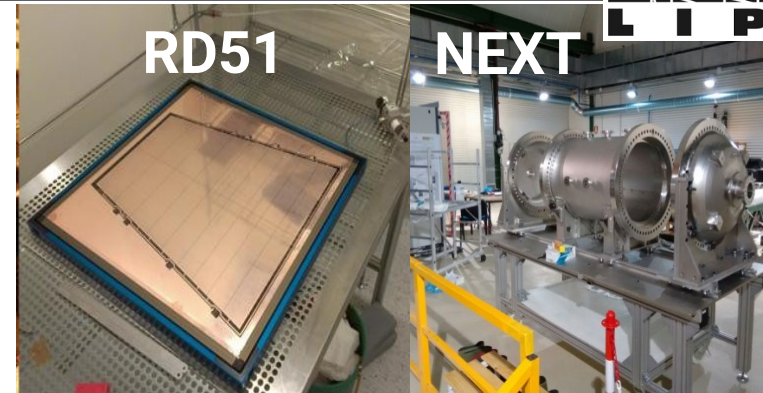
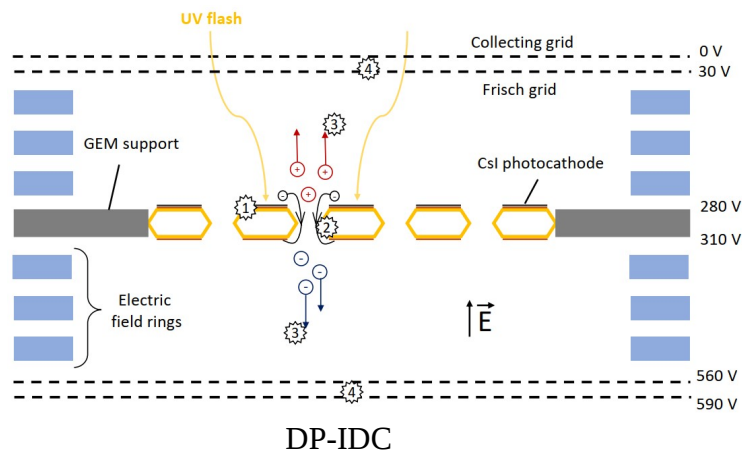
Optimize electron **diffusion**, **stopping power**, **energy resolution** – without compromising other interesting properties of the mixtures.

IEEENS 70 (2023), 3 NIM A 1045 167603 (2023) NIM A 1049 168038 (2023)

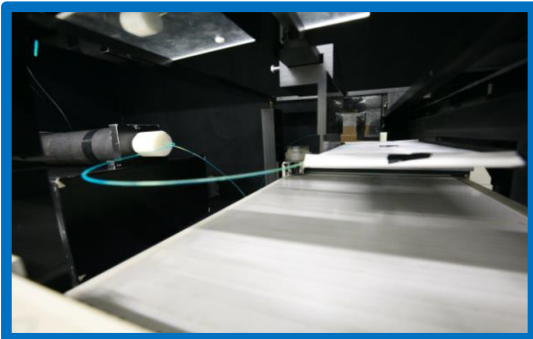
Study of drift of electrons and ions in gases.

NIM A 1045 167575 (2023) NIM A 1029 166416 (2022)

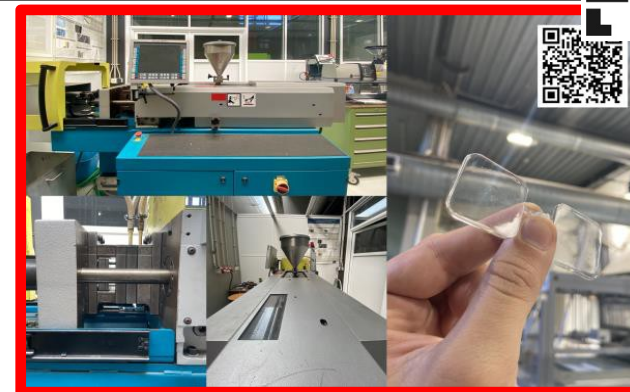
Monte Carlo simulation to explain experimental results.



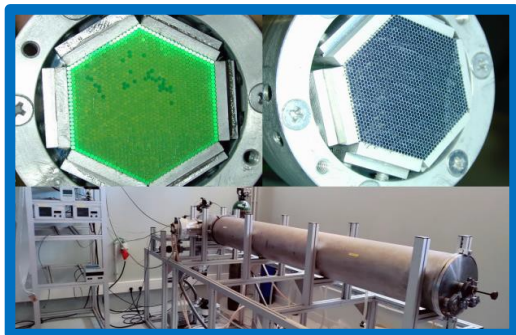
Electron Diffusion Measurement Chamber



Scintillator characterisation with LED or 90Sr source
(ex. studies for FCC calorimeters)



Production of PET and PEN scintillators for FCC detectors
Collaboration with Institute for Polymers and Composites Uni. Minho



Magnetron Sputtering machine
(ex. polish and mirror of scintillating and WLS fibres for NEXT or Microdosimetry)



WLS/scintillating Optical fibre characterisation with LED



Exploratory R&D on new plastic scintillator materials
Calorimetry for future collider experiments

Scientific Output and responsibilities 2017-2023

	Direct author	Indirect author	International Conferences	MSc defences	PHD defences	Responsibilities
LibPhys-UC	17	51	25		10	-RD51 founders. -Leading the working group on experimental absolute Scintillation yield measurements in Xe (NEXT) -and in He-CF4 mixtures (CYGNO)
I3N-UA	31	78	90	14	2	-RD51 founders and member 2 mandates as CB chair -Members of COMPASS, AMBER and NEXT -AMBER Drell-Yan physics group co-coordinator -COMPASS/AMBER W45 detectors responsible person
RPC	27	78	17			- HADES RPC-TOF and FD-RPC-TOF coordinator, -Member of HADES CB and TB, member of SHiP CB and TB -Small animal PET operation coordinator
nDet	9	0	7		1	
LiXe	3	0	4			- RD51 founders and member - Leadership of 1 common RD51 projects
GasD	21	29	15	5	2	- RD51 member - Leadership of 1 common RD51 projects
LOMAC	1	0	2	3		- R&D and construction of optical fibres for NEXT
Total	109	236	160	22	15	

Quite respectable number!!!

From the international collaborations where groups participate: HADES, SHiP, NEXT, ...

Relatively small number ... work is in progress.

Scientific Output and responsibilities 2017-2023

	RD51	COMPASS / AMBER	SHiP	HADES	Next	CYGNO	Xenon	DRD1, 2,6	Responsibilities
LibPhys-UC	Founder Member				Member 1x Leading Working Group	Member 1x Leading Working Group	Member DCS Run Coordinators	Founder Member	-RD51 founders. -NEXT: Leading the working group on experimental absolute Scintillation yield measurements in Xe and in He-CF4 mixtures => CYGNO. - XENON DCS analysis, R&D - DARWIN R&D
I3N-UA	Founders Member 2x CB chair	Member 2x Leading Group						Founder Member	-RD51 founders and member 2 mandates as CB chair -Members of COMPASS, AMBER and NEXT -AMBER Drell-Yan physics group co-coordinator -COMPASS/AMBER W45 detectors responsible person
RPC	Old Member		Member CB TB 1x system	Member CB TB 2x full System				Founder Member	- HADES RPC-TOF and FD-RPC-TOF coordinator, -Member of HADES, SHiP CB and TB -Small animal PET operation coordinator
nDet								Founder Member	
LiXe	Founder Member 1x Project Leadership							Founder Member	- RD51 founders and member - Leadership of two common RD51 projects
GasD	Member 1x Project Leadership				Member Gas mix Studies			Founder Member	- RD51 member
LOMAC					Optical Fibers			Founder Member	- R&D and construction of optical fibres for NEXT



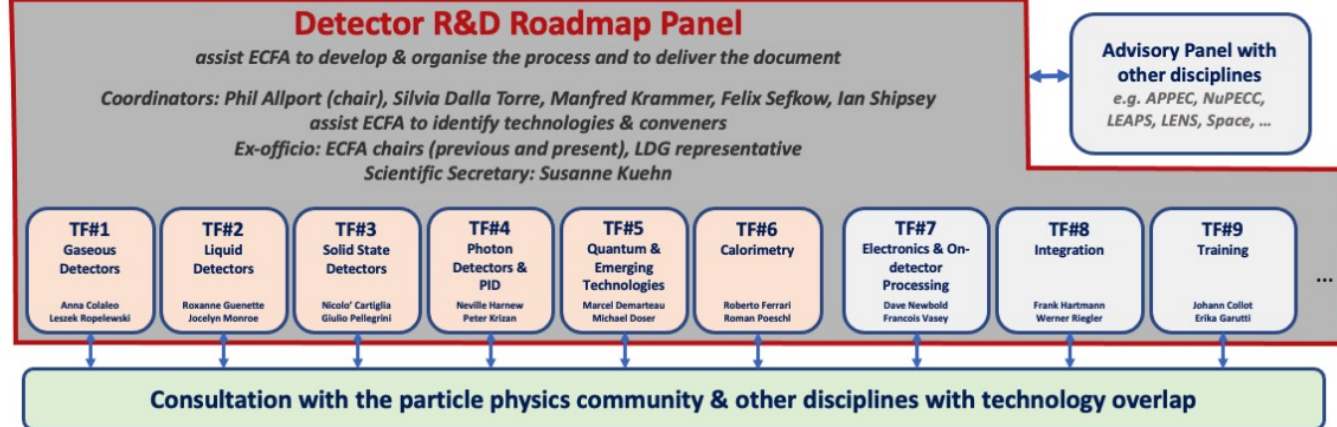
Mostly all groups are/were within RD51 and will be in DRD1,2,6 applying to national fund together



	European	National	Total	Excluding medical physics and tomography
LibPhys-UC		292	292	PTDC/FIS-NUC/2525/2014, PTDC/FIS-NUC/3933/2021 CERN/FIS-INS/0025/2017, CERN/FIS-INS/0026/2019 CERN/FIS-INS/0013/2021, CERN/FIS-TEC/0038/2021
I3N-UA	380	640	1020	
RPC	65	210	275	AIDA-2020, 101004761 AIDAinnova CERN-FIS-INS-0009-2019, CERN/FIS-INS/0006/2021, CERN/FIS-PAR/0030/2017
nDet	162	50	212	654000 SINE2020, EXPL/FIS-NUC/0538/2021
LiXe	0	140	140	CERN/FIS-INS/0025/2017, CERN/FIS-INS/0026/2019, CERN/FIS-INS/0013/2021
GasD	0	123	123	PTDC/FIS-NUC/2525/2014, PTDC/FIS-NUC/3933/2021
LOMAC	0	50	50	EXPL/EME-NUC/1311/2021
Total	607	1505	2112	



National funding FCT



All groups will join DRDX

Collaborations are still in a development stage but for the moment we are present in:

DRD1 – Gaseous detectors

- WG2. Applications. WP7 Timing detectors (2x groups).
WPD Radiopure TPCs for precise track imaging and/or calorimetry
- WG6 and WG8. Detector production and training and dissemination.
- WG9. BHEP. WP1 Muon tomography.

DRD2 – Liquids detectors

- WG1 and 2. Charge and light readout.
- WG3. Targets Properties. Purification

DRD3 - Solid state detectors

- WP2, WP9

DRD6 - Calorimetry

No specific financial support for these activities is foreseen or expected support for MoU

1. **A lot of quality and original work.** The groups propose original ideas and do not limit themselves to following trends.
2. This is why **groups are often wanted for large experiments.**
3. The **R&D performed serves as a basis** for the construction of instruments in experiments.
4. Strong **international involvement** of all groups.

1. **Short term and unstable funding** resulting in uncertain continuity of the line of research and making participation in long term projects (including international) complicated or even impossible.
2. Some of the activities have **lost financial support on MoUs (renovation not signed by FCT): e.g., HADES and AMBER**
Even worse **some experiments** (responsibilities: HADES 2x full detectors & XENON slow control + analysis) **running without financial support!!!!**
3. **Lack of permanent positions**, which creates professional instabilities and seriously harms scientific creativity.
4. **Obsolete equipment** resulting from the lack of investment programs and respective funding.
5. Lack of diversity of funding opportunities at the national level.

A stable/foreseeable funding (even it is not big) + extra funding depending on projects will be very welcome.