TPCs used as reaction/decay chambers

Work Package 8

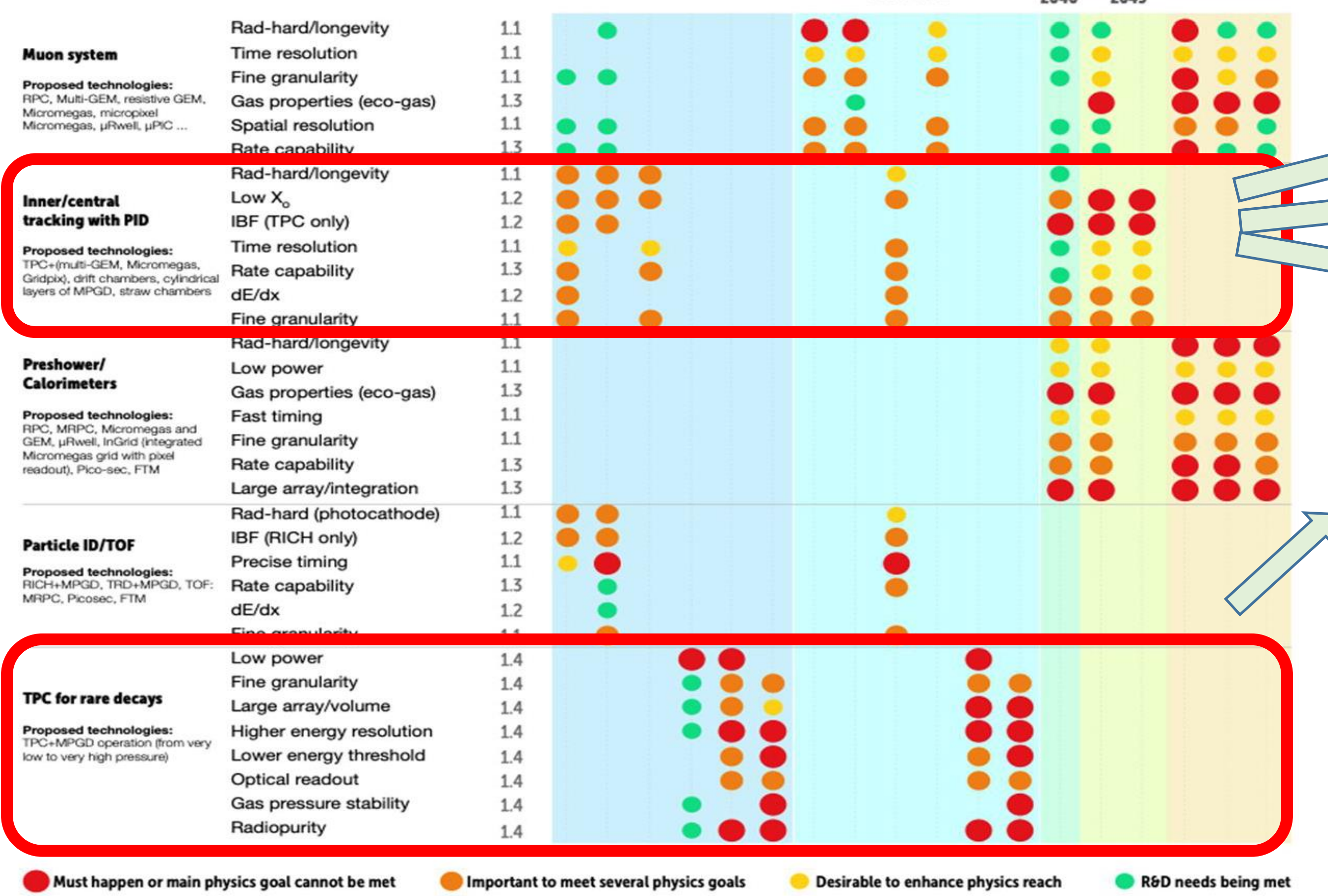
Esther Ferrer Ribas, Diego González-Díaz

DRD1 Meeting

30th January 2024

from ECFA to DRD1

ECFA



1) Large ton dual-phase (PandaX-4T, LZ, DarkSide -20k, Argo 200k, ARIADNE ...)
2) Light dark matter, solar axion, 0nbb, rare nuclei&ions and astroparticle reactions, Ba tagging)
3) R&D for 100-ton scale dual-phase DM/neutrino experiments

DRD1

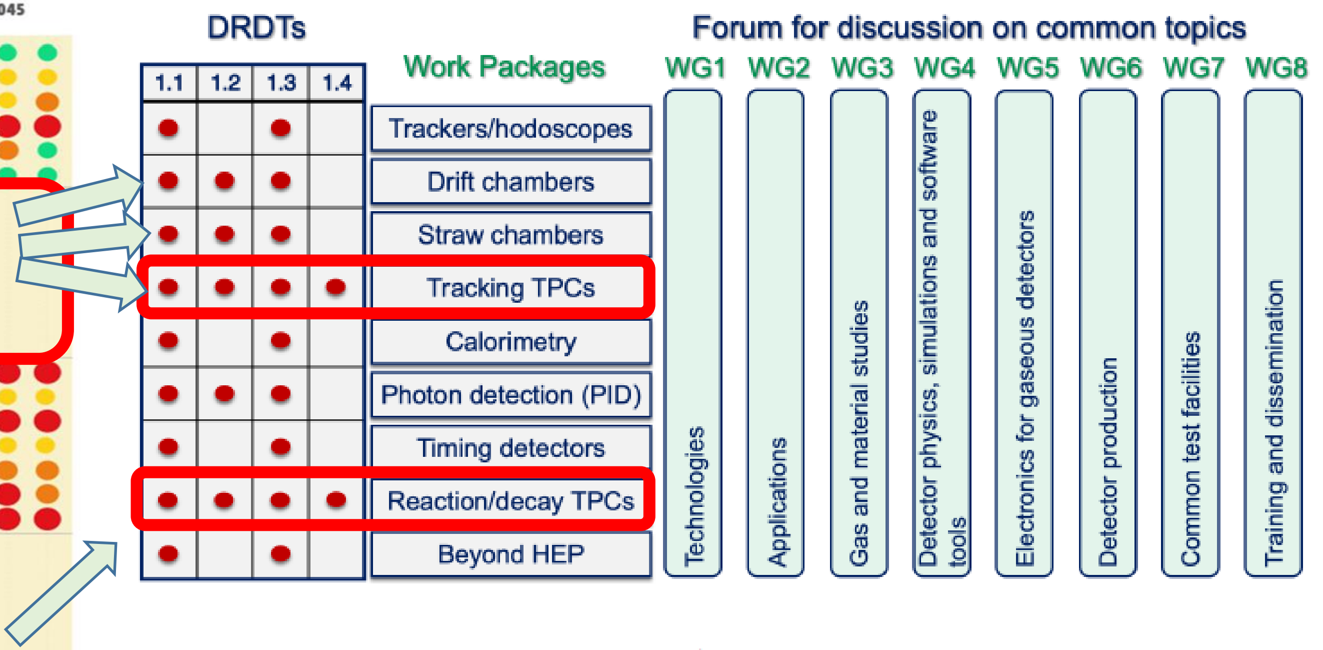
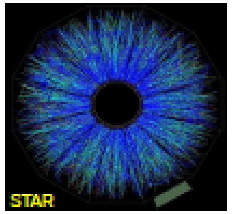
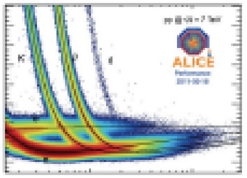


Figure 2: DRD1 Scientific Organization

- **DRDT 1.1** - Improve time and spatial resolution for gaseous detectors with long-term stability.
- **DRDT 1.2** - Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out schemes.
- **DRDT 1.3** - Develop environmentally friendly gaseous detectors for very large areas with high-rate capability.
- **DRDT 1.4** - Achieve high sensitivity in both low and high-pressure TPCs.



WP4 vs. WP8



WP4: Inner and central tracking with PID → classical HEP-TPCs at colliders
e.g. Aleph, Delphi, ALICE, STAR, etc.

WP8: TPCs as reaction and decay chambers → rare event detectors
e.g. Cygnus

But what about, if it is not that obvious? What about nuclear-physics TPCs, neutrino TPCs, etc? → Currently, we defined the following separation line:

If the TPC is only for tracking and PID of particles generated outside of the detector, the experiment belongs to WP4.

yesterday recap (long story short) →

If the TPC(-gas) is part of the active material, that is, if it is needed for the physics process under study to take place, the experiment belongs to WP8.

In case of doubt, join both 

longer version (from DRD1 extended proposal)

TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)

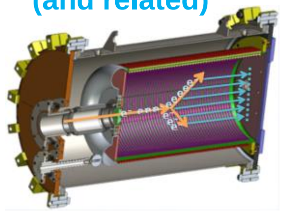
TPCs employed in the field of rare event searches, as well as those used or envisaged for neutrino physics or as active targets for nuclear reaction/decay studies, share methodological and technological characteristics. Specifically, they may not have external triggers, a condition stemming from the frequent requirement of fully containing the reaction products down to the interaction vertex, with few or no ancillary detectors. In general, this family of TPCs must deal with requirements (not all at the same time) such as full event containment, broad dynamic range, radiopurity, T_0-tagging, diffusion close to the thermal limit, dual-phase operation, optical readout, single electron, and single ion counting, Fano-level energy resolution, tens of μm spatial sampling or keV-tracking.

In case of doubt, join both

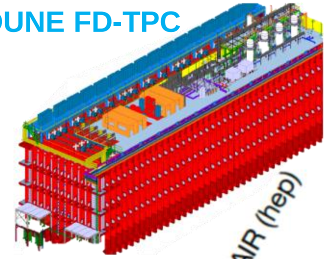
overlap with WP4

- Space charge /IBF suppresion (heavy ion facilities).
- Momentum reconstruction of uncontained tracks for neutrino physics (leptons in CC-interactions).
- Pixelated readout for recoil reconstruction (DM)

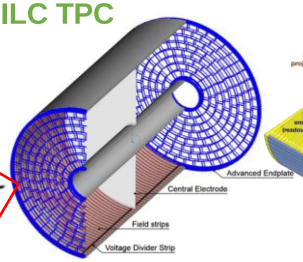
AT-TPC
(and related)



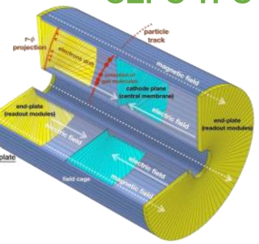
DUNE FD-TPC



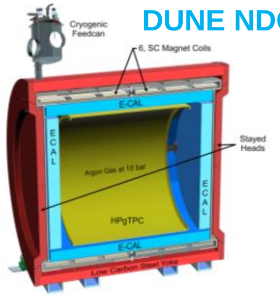
ILC TPC



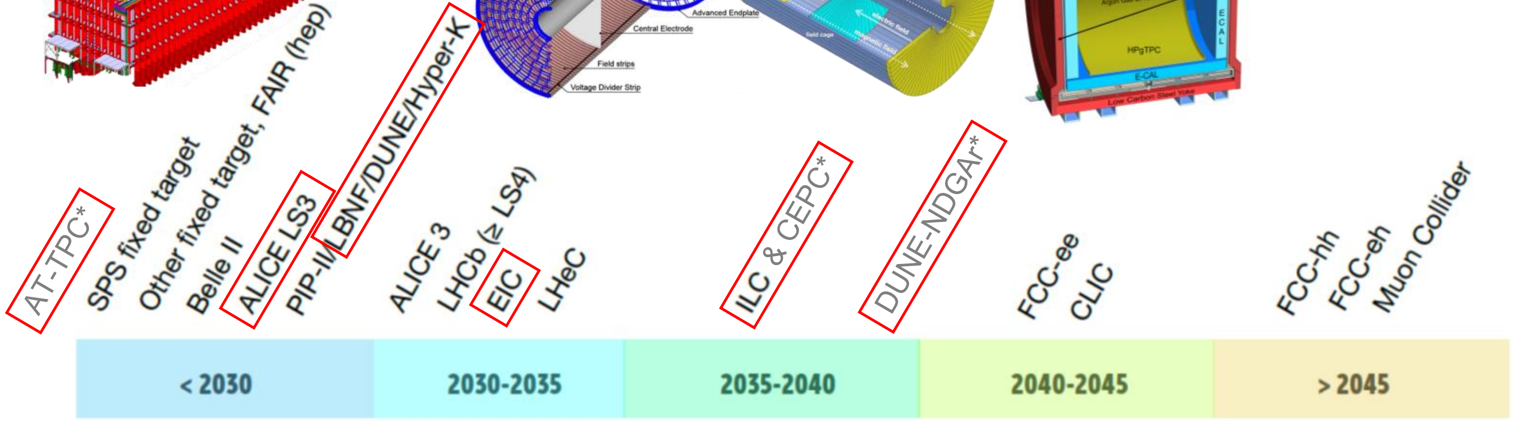
CEPC TPC



DUNE NDGAr



accelerator

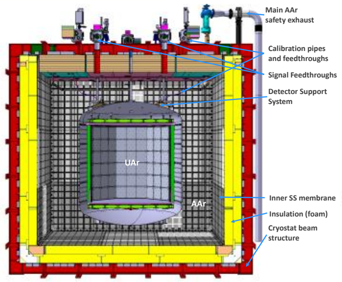


ECFA roadmap (*In grey: added)

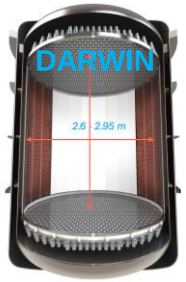
leading by example

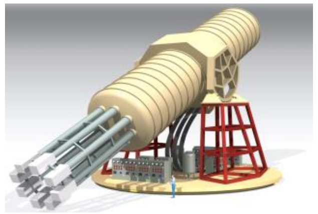
WP4

WP8



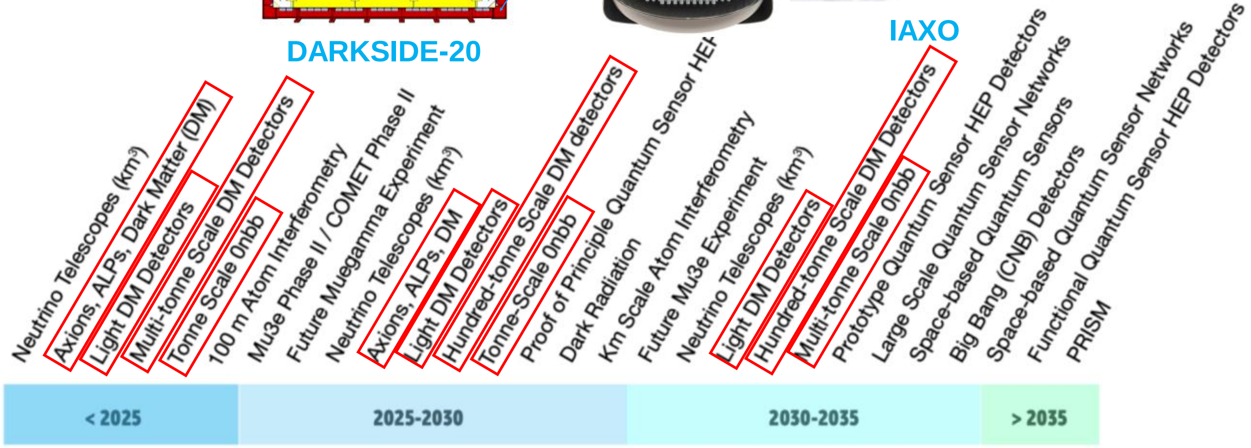
DARKSIDE-20





IAXO

non-accelerator



"Technical" Start Date of Facility
(This means, where the dates are not known, the earliest technically feasible start date is indicated - such that detector R&D readiness is not the delaying factor)

Overarching WP8 challenges (from DRD1 extended proposal)

Current challenges specific to this family of TPC technologies include:

- achieving track-reconstruction of low-energy nuclei and electrons, at granularities going from few mm down to potentially ≈tens of μm and close to the thermal diffusion limit:

  this is a driver for some of the future direct Dark Matter experiments, nuclear reactions on active targets, neutron detection, X-ray polarimetry, and more;

- operating in a broad range of pressures going from few tens of mbar to tens of bar, with energy-reconstruction performing generally down to a ≈1keV threshold if not less:

  this is essential to experiments with varied requirements going from Dark Matter to nuclear and neutrino physics, thus challenging state-of-the-art amplification structures that were developed and optimized in collider environments;

- achieving high and uniform amplification in nearly pure or weakly-doped noble gases:

  employing nearly pure gases instead of admixtures is an asset for active-target experiments as it eliminates spurious reactions. It enables, on the other hand, detection schemes aimed at near-Fano energy resolution and single-electron detection in rare event searches. However different these requirements and performance metrics might seem, experiments have long popularized pure-electroluminescence (EL) amplification on mm-scale gas gaps to achieve these. Only recently, alternative strategies based on hybrid GEM-mesh structures , FAT-GEMs or RWELL and RPWELL joined the effort;

- increasing optical throughput (primary and secondary):

  as optical imaging (based on scintillation either in the EL or avalanche-scintillation regime) extends over larger and larger areas, e.g. for low-energy WIMP detection, double-beta decay searches or neutrino physics, improvements in this direction become pressing and, related to it,

- developing more suitably scintillating and/or eco-friendly gas mixtures as well as recuperation systems;

- enhancing the radiopurity of the amplification structure and of the TPC as a whole.

WP8 projects

- Project A – High Pressure TPCs for precision studies of neutrino interactions. *(convening: DGD, Alan Bross (Fermilab))*

- Project B - TPCs for low-energy nuclear physics. *(convening: EFR, Marco Cortesi (MSU))*

- Project C - Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification. *(convening: DGD, Francesc Monrabal (DIPC))*

- Project D - Radiopure TPCs for precise track imaging and/or calorimetry with avalanche-based readouts. *(convening: EFR, Giorgio Dho (GSSI))*

WP8 main drivers and facilities

Dark matter

MIMAC, NEWAGE, DRIFT, CYGNUS, TREX-DM, NEWS-G, MIGDAL, IAXO, Darkside, ARGO, PANDA-X 4T, DARWIN

Nuclear reactions

MSCL, ELI-NP, GANIL

Neutrino Physics

NEXT, DUNE, ARIADNE

Overarching WP8 challenges + Projects → tasks

#	Task	Performance Goal
T1	Enhanced operation of optical readout across gas densities	- $\mathcal{O}$(mm)-sampling, $\mathcal{O}$(MeV)-threshold, $\mathcal{O}$(ns)-timing for ν-interactions. - Large-area amplification structures ($\gtrsim$ 50 cm $\times$ 50 cm) at optical gain $\sim 10^4$. - Tracking of low-energy nuclei (down to 10-100 keV) with good PID.
T2	Enhanced operation of charge readout across gas densities	- Large-area MPGDs ($\gtrsim$ 50 cm $\times$ 50 cm) at $\sim 10^3 - 10^4$ gain. - Large-area MPGDs ($\gtrsim$ 50 cm $\times$ 50 cm) with a large dynamic range. - $\mathcal{O}$(1 keV) threshold across pressures (100 mbar-10 bar) in $\mathcal{O}$(1000 cm^3) technology demonstrators. - IBF suppression by G*IBF=10 or better.
T3	Enhanced operation of pure or trace-amount doped noble gases	- EL operation at 2m (15bar) and 0.5m (>20bar) scale, with <10% deformation. - Single-electron thresholds on large areas for mixtures of noble gases. - MPGD concepts with enhanced EL-response (up to or above 1000 ph/e). - Improve light collection for large volumes. - Integrated, low-power and radiopure electronics for EL-based tracking.
T4	Ultra-low-energy reconstruction of highly ionizing tracks (including R&D on negative-ion readout)	- Tracking of low-energy nuclei (down to 10-100 keV) with good PID. - High dynamic range for the reconstruction of low and highly ionizing particles. - Single electron counting at $\mathcal{O}$(100 μm) in 3D, and diffusion at the thermal limit.
T5	Determination of the interaction time (T_0)	- Develop new gaseous WLS and novel gaseous scintillators, comparable or better than CF_4. - Demonstration of T_0-determination for low-energy deposits with at least $\mathcal{O}$(cm) resolution.
T6	Microscopic gas properties and gas handling	- Develop the science and technology of novel eco-friendly gases. - Derive microscopic parameters for new gases.
T7	Radiopurity	- Background levels below 10^{-6} c/keV/cm^2/s for axion research and at least $\times$10 more radiopure cameras. - New radiopure amplification structures and techniques.

Projects + community feedback → project deliverables

Project A: Neutrino Physics

‘High Pressure TPCs for precision studies of neutrino interactions’

conveners: DGD, Alan Bross (Fermilab)

- **Participating institutes:**

1. RWTH Aachen University III. Physikalisches Institut **(RWTH Aachen)**
2. Indiana University **(U Indiana)**
3. Université de Genève **(U Geneva)**
4. Institut de Fisica d’Altes Energies **(IFAE)**
5. University of Liverpool **(U Liverpool)**
6. Royal Holloway University of London **(RHUL)**
7. Imperial College **(Imperial C.)**
8. INFN Sezione di Bari **(INFN-Bari)**
9. IGFAE, Universidade de Santiago de Compostela **(IGFAE)**
10. Universidade de Vigo **(UVigo)**
11. University of Warwick **(U Warwick)**
12. Fermilab **(Fermilab)**
13. INFN-Padova **(INFN-Padova)**
14. Instituto de Física Corpuscular **(IFIC)**
15. Uludag University **(U Uludag)**

Tasks	T1: Enhanced operation of optical readout across gas densities T2: Enhanced operation of charge readout across gas densities T3: Enhanced operation of pure or trace-amount doped noble gases T5: Determination of the interaction time (T_0) T6: Microscopic gas properties and gas handling T7: Radiopurity
Deliverables	• D.1: Develop test setup(s) for electrical and optical characterization of gas mixtures of interest to neutrino physics. • D.2: Improved simulation models, in particular attending to optical properties and x-section databases of novel eco-friendly gases. • D.3: Develop complete technology demonstrators in Ar-based mixtures, including the study of basic response metrics: i) space, ii) dE/dX and ii) time resolution, iv) energy and v) tracking threshold for minimum and highly ionizing particles… • D.4: Carry the first performance studies for main TPC gases other than Ar: H_2, He, Ne, Xe… • D.5: Development of new amplification structures with optimized optical properties and/or high charge throughput for operation in large volumes and at high pressure. • D.6: Development/characterization of affordable, high-channel-density, low-noise, low-power amplification and readout electronics, compatible with pressurized operation. • D.7: Optimization of primary scintillation readout(T_0). • D.8: New TPC designs: simulation/optimization of field cage (with and without light collectors) and optimization of gas distribution.

Project A: Neutrino Physics ‘High Pressure TPCs for precision studies of neutrino interactions’

conveners: DGD, Alan Bross (Fermilab)

Institute	Deliverables							
	D.1	D.2	D.3	D.4	D.5	D.6	D.7	D.8
RWTH Aachen	X	X						
U Indiana	X		X		X			
U Geneva			X	X		X		
IFAE			X	X				
U Liverpool					X			
RHUL						X		
Imperial C.						X		
INFN-Bari			X	X				
IGFAE	X	X	X				X	X
UVigo								X
U Warwick	X		X			X		
Fermilab	X		X			X		
INFN Padova	X	X		X	X			X
IFIC	X				X		X	
U Uludag		X		X			X	X

Table A.1: Contribution to deliverables per participating institute in WP8 Project A.

Project A: Neutrino Physics ‘High Pressure TPCs for precision studies of neutrino interactions’

conveners: DGD, Alan Bross (Fermilab)

Deliverables	RWTH Aachen	U Indiana	U Geneva	IFAE	U Liverpool	RHUL	Imperial C.	INFN-Bari	IGFAE	UVigo	U Warwick	Fermilab	INFN Padova	IFIC	U Uludag
D.8									×	×			×		×
D.7									×					×	×
D.6			×			×	×				×	×			
D.5		×			×								×	×	
D.4			×	×				×					×		×
D.3		×	×	×				×	×		×	×			
D.2	×								×				×		×
D.1	×	×							×		×	×	×	×	

- Improve TPC design (field cage, gas distribution)
- T_0 detection
- Development of high-density / low-power electronics
- New/optimized amplification structures for high-pressure
- Performance studies outside argon (H_2, He, Ne, Xe)
- Technology demonstrators ($\sigma_{dE/dx}$, threshold, space and time res.)
- Simulation models (specially: eco-gases and optical properties)
- Development of small R&D setups for optical and electrical studies

Projects + community feedback → project deliverables

Project B: Nuclear Physics

‘TPCs for low-energy nuclear physics’

conveners: EFR, Marco Cortesi (MSU)

- **Participating institutes:**

1. Michigan State University **(MSU)**
2. Notre-Dame University **(ISNAP)**
3. IGFAE, Universidade de Santiago de Compostela **(IGFAE)**
4. RIKEN **(RIKEN)**
5. Saha Institute of Nuclear Physics **(SINP)**
6. IRFU, CEA, University Paris-Saclay **(IRFU/CEA)**
7. Weizmann Institute of Science **(WIS)**
8. GANIL **(GANIL)**

Tasks	T1: Enhanced operation of optical readout across gas densities T2: Enhanced operation of charge readout across gas densities T3: Enhanced operation of pure or trace-amount doped noble gases T6: Microscopic gas properties and gas handling
Deliverables	• D.1: Development of novel MPGD structures for enhanced performance of charge readout for different gas densities in terms of gain stability and low IBF. • D.2: Development of novel MPGD structures for enhanced performance of charge readout for operation in pure elemental gas at different pressures. • D.3: Construction of technology demonstrators to assess novel concepts regarding high-rate operation, 3D optical imaging and charge readout. • D.4: Development of a gas cell for rare or hazardous gases. • D.5: Optimization of the readout to deal simultaneously with protons and high-Z charged particles. • D.6: Model detector response and specifically ion-feedback.

Project B: Nuclear Physics ‘TPCs for low-energy nuclear physics’

conveners: EFR, Marco Cortesi (MSU)

Institute	Deliverables					
	D.1	D.2	D.3	D.4	D.5	D.6
MSU	X	X	X		X	X
ISNAP	X	X				X
IGFAE	X		X	X		
RIKEN			X		X	X
SINP						X
IRFU/CEA					X	X
WIS	X	X	X		X	X
GANIL	X	X	X	X	X	

Table B.1: Contribution to deliverables per participating institute in WP8 Project B.

Project B: Nuclear Physics ‘TPCs for low-energy nuclear physics’

conveners: EFR, Marco Cortesi (MSU)

Deliverables	MSU	ISNAP	IGFAE	RIKEN	SINP	IRFU/CEA	WIS	GANIL	
D.6	×	×		×	×	×	×		Detector modelling (specifically ion feedback)
D.5	×			×		×	×	×	Readout optimization to deal with high and low Z simultaneously
D.4			×					×	Development of a gas cell for hazardous gases
D.3	×		×	×			×	×	Technology demonstrators (high rate, 3D optical imaging)
D.2	×	×					×	×	New/optimized amplification structures for ≃ 0-1bar in pure gas and high gain
D.1	×	×	×				×	×	New/optimized amplification structures for ≃ 0-1bar at low-IBF

Institute

Projects + community feedback ⇨ project deliverables

Project C: electroluminescence and related

'Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification '

conveners: EFR, Francec Monrabal (DIPC)

- **Participating institutes:**

1. Donostia International Physics Center **(DIPC)**
2. Instituto de Física Corpuscular **(IFIC)**
3. Universitat Politècnica de València **(UPV)**
4. Laboratório de Instrumentação e Física Experimental de Partículas **(LIP-Coimbra)**
5. Universidade de Santiago de Compostela **(IGFAE)**
6. University of Coimbra **(U Coimbra)**
7. University of Aveiro **(U Aveiro)**
8. Astrocent **(Astrocent)**
9. Weizmann Institute of Science **(WIS)**

Tasks	• T3: Enhanced operation of pure or trace-amount doped noble gases. • T5: Determination of the interaction time (T_0). • T6: Microscopic gas properties and gas handling. • T7: Radiopurity.
Deliverables	• D.1: Optimize electronic and scintillation properties of electroluminescent gas mixtures from 1bar up to pressures around 50bar experimentally and in simulation. • D.2: Development of large-area EL-structures. • D.3: Development of radiopure MPGD structures with enhanced electroluminescent response (higher dielectric strength, wavelength-shifting, operation at the liquid-gas interface…). • D.4: Development of radiopure MPGD structures with enhanced response for cryogenic operation (resistive protection through layers or plates, new geometries…). • D.5: Develop new light-collection techniques for large TPC volumes. • D6: Develop compact, low-power, electronics for EL-based tracking planes. • D7: Development of technology-demonstrators for novel gas mixtures and improved light collection schemes.

Project C: electroluminescence and related

conveners: DGD, Francec Monrabal (DIPC)

'Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification '

Institute	**Deliverables**						
	D.1	D.2	D.3	D.4	D.5	D.6	D.7
DIPC	X	X			X	X	X
IFIC	X				X	X	X
UPV						X	
LIP-Coimbra				X			
IGFAE	X		X	X	X		
U Coimbra	X	X	X	X	X		
U Aveiro	X		X	X			X
Astrocent			X	X	X		
WIS	X	X		X	X		X

Table C.1: Contribution to deliverables per participating institute in WP8 Project C.

Project C: electroluminescence and related

conveners: DGD, Francec Monrabal (DIPC)

'Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification '

Deliverables	DIPC	IFIC	UPV	LIP-Coimbra	IGFAE	U Coimbra	U Aveiro	Astrocent	WIS
D.7	×	×					×		×
D.6	×	×	×						
D.5	×	×			×	×		×	×
D.4				×	×	×	×	×	×
D.3					×	×	×	×	
D.2	×					×			×
D.1	×	×			×	×	×		×

Institute

- D.7 ⇨ Technology demonstrators for new gas mixtures and light collection schemes
- D.6 ⇨ Compact electronics for EL-based tracking.
- D.5 ⇨ Improve light collection
- D.4 ⇨ New amplification concepts in cryogenics (RWELL, RPWELL…)
- D.3 ⇨ New EL concepts (wavelength-shifting, floating…)
- D.2 ⇨ Develop large-area EL structures
- D.1 ⇨ Optimize EL structures from 1-50bar (exp. and sim.)

Projects + community feedback ⇨ project deliverables

Project D: Dark Matter and related

'Radiopure TPCs for precise track imaging and/or calorimetry with avalanche-based readouts'

conveners: EFR, G. Dho (GSSI)

- **Participating institutes:**

1. Gran Sasso Science Institute (GSSI),
2. IRFU, CEA, University Paris-Saclay (IRFU/CEA) ,
3. INFN Sezione di Roma (INFN-Roma1),
4. STFC Rutherford Appleton Laboratory (RAL),
5. Helsinki Institute of Physics (HIP),
6. University of Hawai at Manoa (UH Manoa),
7. University of New Mexico (New Mexico),
8. European Organisation for Nuclear Research (CERN),
9. CAPA & Universidad de Zaragoza (CAPA/UNIZAR),
10. Laboratório de Instrumentação e Física Experimental de Partículas (LIP-Coimbra),
11. Australian National University (ANU),
12. LPSC-Grenoble (IN2P3/UGA),
13. Institute of Experimental Physics, Hamburg University (U Hamburg),
14. Kobe University (U Kobe),
15. University of Bonn (U Bonn)

Tasks	• T1: Enhanced operation of optical readout across gas densities. • T2: Enhanced operation of charge readout across gas densities. • T3: Enhanced operation of pure or trace-amount doped noble gases. • T4: Ultra-low-energy reconstruction of highly ionizing tracks (including R&D on negative-ion readout). • T5: Determination of the interaction time (T_0). • T6: Microscopic gas properties and gas handling. • T7: Radiopurity.
Deliverables	• D.1: Development of technology-demonstrators operated in the range 0.1bar-1bar (in electron or negative-ion mode, with optical or charge readout), over areas of at least 10cm x 10cm, with high pixelization and close to the diffusion limit. • D.2: Characterization, modelling and optimization of the properties of CF_4, NG-CF_4 and NG-CF_4-SF_6 mixtures (optical, and negative-ion response), as well as those of similar or equivalent mixtures if found.*(NG==Noble Gas) • D.3: Develop algorithms for reliable T_0 determination based on charge diffusion or (negative-ion) minority carriers. • D.4: Develop suitable amplification structures (including solid wavelength-shifters), radiopure photosensors and radiopure construction techniques for charge and optical imaging. • D.5: Optimization of gas distribution, material selection and purification strategies. • D.6: Introduce new H-rich mixtures for increased sensitivity to light dark matter. • D.7: Develop a detection strategy capable of imaging 5.9keV X-rays and fast-neutron interactions in the gas, simultaneously. • D.8: Build a chamber for R&D on electron counting.

Project D: Dark Matter and related ‘Radiopure TPCs for precise track imaging and/or calorimetry with avalanche-based readouts’

conveners: EFR, G. Dho (GSSI)

Institute	Deliverables							
	D.1	D.2	D.3	D.4	D.5	D.6	D.7	D.8
GSSI	X	X	X				X	
IRFU/CEA				X				
INFN-Roma1		X		X	X	X		
RAL	X			X			X	
HIP	X			X				
UH Manoa	X	X		X				X
New Mexico	X	X		X				X
CERN	X	X		X				
CAPA/UNIZAR				X				
LIP-Coimbra		X	X					
ANU	X	X		X		X		
IN2P3/UGA						X	X	
U Hamburg	X	X		X	X	X	X	
U Kobe	X			X				
U Bonn	X	X		X			X	

Table D.1: Contribution to deliverables per participating institute in WP8 Project D.

Project D: Dark Matter and related

conveners: EFR, G. Dho (GSSI)

‘Radiopure TPCs for precise track imaging and/or calorimetry with avalanche-based readouts’

Deliverables	GSSI	IRFU/CEA	INFN-Roma1	RAL	HIP	UH Manoa	New Mexico	CERN	CAPA/UNIZAR	LIP-Coimbra	ANU	IN2P3/UGA	U Hamburg	U Kobe	U Bonn	
D.8						×	×									Build a chamber for R&D on electron counting
D.7	×			×								×	×		×	Simultaneous reconstruction of electron and nuclear recoils
D.6			×								×	×	×			Study H-rich mixtures
D.5			×										×			Optimization of gas distribution, material selection and purification
D.4		×	×	×	×	×	×	×	×		×		×	×	×	Develop radiopure structures for optical and electrical imaging
D.3	×									×						T_0-reconstruction through diffusion or minority carriers
D.2	×		×			×	×	×		×	×		×		×	Characterization/modelling/optimization of CF_4, NG/CF_4, $NG/CF_4/SF_6$
D.1	×			×	×	×	×	×			×		×	×	×	Technology demonstrators on ~10cm x 10cm with high pixelization and close to the thermal limit.

Institute

Executive milestones and deliverables

Milestones/Deliverable		
12M	24M	36M
M1.1 **Review and design**: review of TPC technologies for reaction/decay studies: status and perspectives; design/construction of small R&D chambers. **[T1-T7]** **M1.2** **Development and tuning of simulation tools**: design, development and/or tuning of modelling and simulation tools (IBF, ionization, optical response, Geant4). **[T1-T7]**	**M2.1** **Construction of prototypes**: start construction of technology demonstrators for large area coverage. **[T1-T7]** **M2.2** **Characterization of key technologies**: characterize electronics, amplification structures and overall TPC behaviour in small R&D chambers, comparison with simulations. **[T1-T7]**	**D1** **TPC commissioning and proof of principle demonstration**: characterization of mid-size technology demonstrators for reaction/decay studies, focusing on energy and tracking thresholds, energy resolution, dynamic range and IBF. **[T1-T7]** **D2** **Analysis and definition of next steps**: establish guidelines for future developments based on requirements from future facilities and the achieved/achievable performances. **[T1-T7]**

Resources

available

WP	Description	Material [kCHF] (2024)	Material [kCHF] (2025)	Material [kCHF] (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers/Hodoscopes	651	516	501	47.45	50.9	50.7
WP2	Inner and Central Tracking with PID Capability, Drift Chambers	394	163	167	19.45	21.45	23.45
WP3	Inner and Central Tracking with PID Capability, Straw and Drift Tube Chambers	163.5	70	65	32	37.3	40.3
WP4	Inner and Central Tracking with PID Capability, Time Projection Chambers	268	268	253	15	15	14.5
WP5	Calorimetry	150	150	150	12.75	12.75	12.75
WP6	Photo-Detectors	275	325	315	11.9	11.4	11.4
WP7	Timing Detectors	420	311	311	24.1	21.7	20.7
WP8	TPCs as Reaction and Decay Chambers	495	505	405	78.35	73.05	72.55
WP9	Beyond HEP	803	783	694	40.5	37.5	35.2
	SUM	**3456**	**3091**	**2861**	**281.5**	**281.05**	**281.55**

Table 10: DRD1 Workpackages, cumulative resources (Material [kCHF] and FTE) available in existing funding lines covering the ECFA strategic R&D for the years 2024, 2025, 2026.

requested

WP	Description	Material [kCHF] (2024)	Material [kCHF] (2025)	Material [kCHF] (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers/Hodoscopes	716	1040	670	21.8	23.55	23.55
WP2	Inner and Central Tracking with PID Capability, Drift Chambers	79	89	93	3.15	8.4	9.15
WP3	Inner and Central Tracking with PID Capability, Straw and Drift Tube Chambers	525	325	330	11.7	12.9	12.9
WP4	Inner and Central Tracking with PID Capability, Time Projection Chambers	238	238	238	11.3	11.3	11.3
WP5	Calorimetry	50	50	50	1	1	1
WP6	Photo-Detectors	180	270	250	4.6	5.1	5.6
WP7	Timing Detectors	257	307	346	3	5.5	6.9
WP8	TPCs as Reaction and Decay Chambers	516.5	471.5	436.5	35.1	40	40
WP9	Beyond HEP	140	225	275	15.9	20.4	23.9
	SUM	**2701.5**	**3015.5**	**2688.5**	**107.55**	**128.15**	**134.3**

Table 11: DRD1 Workpackages, additional (not existing) funding request to cover the ECFA strategic R&D for the years 2024, 2025, 2026.

Next steps

- WP4/WP8 coordinators:

D. Gonzalez Diaz, E. Ferrer Ribas, F. I. Garcia Fuentes, P. Gasik, J. Kaminski

- Email list:

DRD1-WP8-contact@cern.ch

-> one per project perhaps?

- Kick-off meeting

Essentially ready, but needs clarification regarding WP-structure. WP8 organization based on project-conveners and WP-coordinators seems satisfactory.

-> Cand this be maintained as we move forward?

Concern (shared by DGD and EFR) that dealing with WP8 without 1 additional person per project is not viable.