

AIDA II kick-off meeting, CERN 3/6/2015

Cryogenic Detectors WP8

D.Autiero (IPNL Lyon) and S.Murphy (ETHZ)

Organisation news:

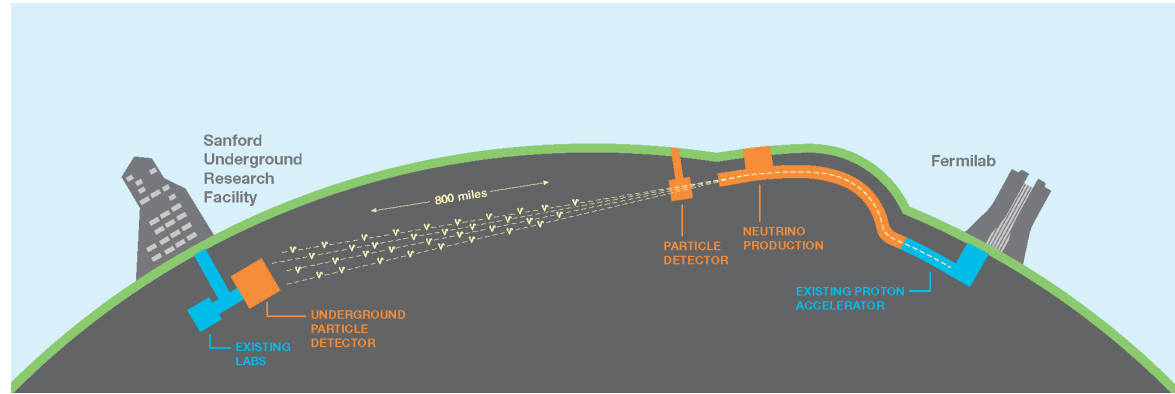
- ✓ The WP8 activity is related to WA105 which in the context of the Neutrino Platform at CERN is providing the hardware infrastructure as a test-bed of the Networking Activities of WP8. WA105 activities are in an advanced state (see next slides) and the NA activity of the AIDA II groups has de facto already started
- ✓ A large effort in the last year was also devoted in developing a common strategy with the USA for **long-baseline neutrino experiment with liquid argon detector**. This has brought to the ELBNF LOI (December 2014), the formation of the DUNE collaboration (April 2015) and the writing of the DUNE Conceptual Design Report (May 2015). **The WP8 neutrino community of AIDA II is deeply involved in this effort** (A. Rubbia: DUNE co-spokesperson, D. Autiero: member of the DUNE executive committee). **This is also the occasion to extend the networking activities of WP8 including also a technological review of the developments in the USA.**

- ✓ D. Autiero the WP8 coordinator is at Fermilab for the DOE review. S. Murphy (ETHZ) has been appointed since June 1st 2015 co-coordinator of WP8 and is giving this report
- ✓ Due to the clash of the DOE CD1 review of the DUNE long-baseline neutrino project which is involving many people of WP8, the first meeting of WP8 is postponed to June 17th at 10:00 (the meeting will be held at CERN and a video remote connection will be available as well, more details will be available in a mail sent to the WP8 mailing list)

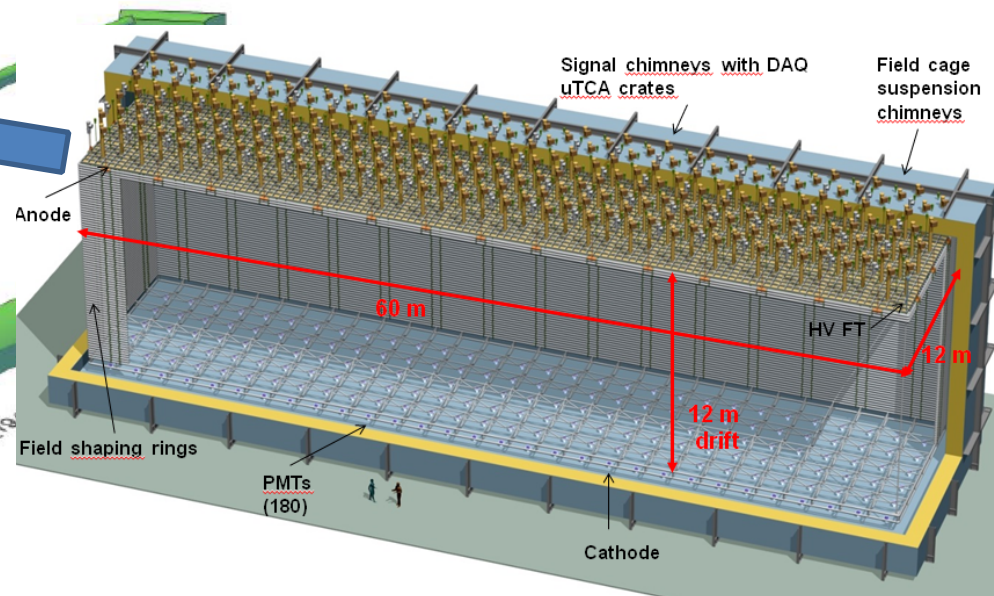
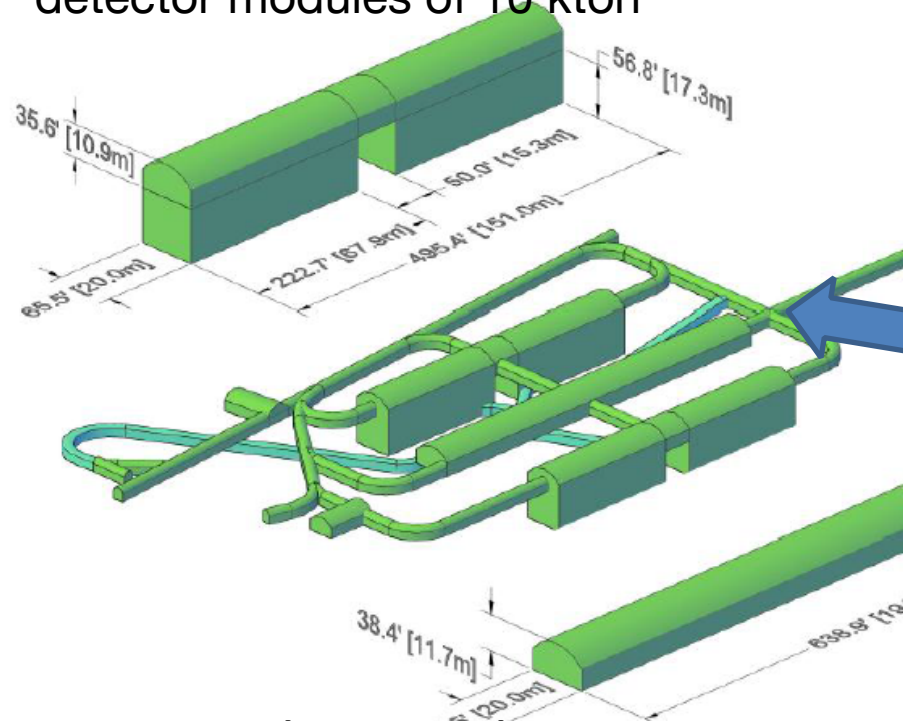
LBNF-DUNE project:

1.2 MW neutrino beam from FNAL to SURF underground laboratory with 40 kton Liquid Argon detector.

4 underground caverns with detector modules of 10 kton



Example of a double-phase design module. Active volume 12x12x60 m³

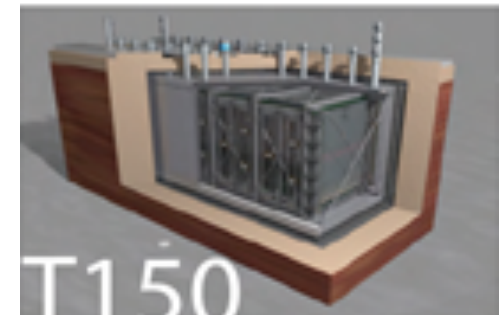
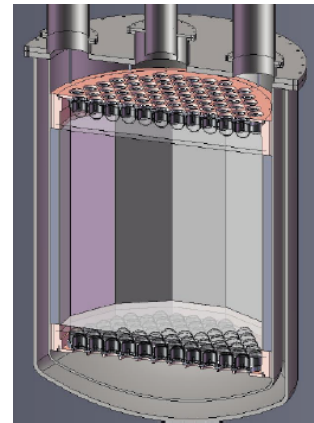
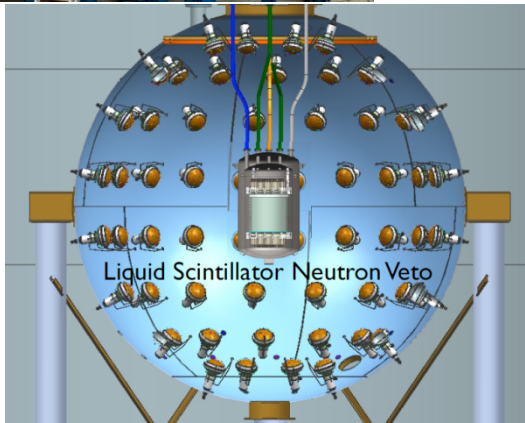
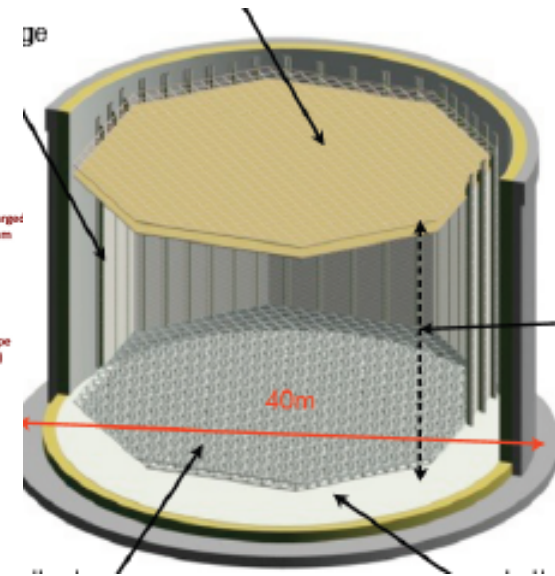
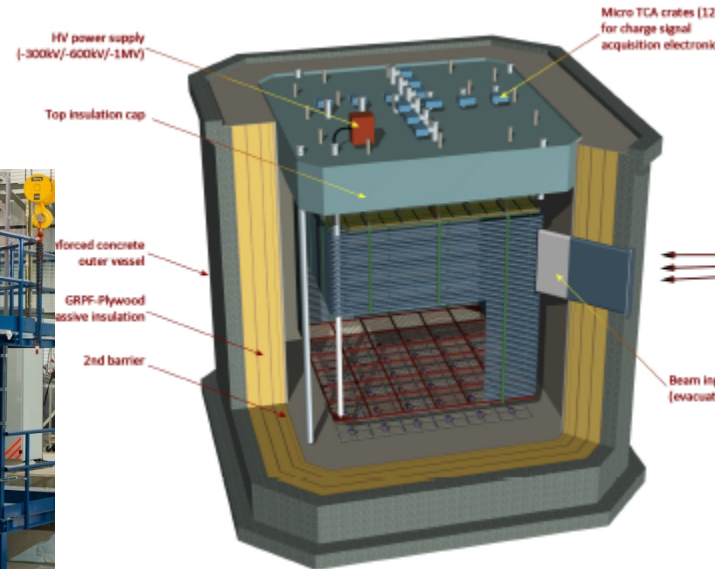


DUNE CDR (4 volumes) completed

Interests:

Large cryogenics detectors based on liquefied noble gases for:

- Neutrino physics
- Astro-particle physics
- Dark matter searches

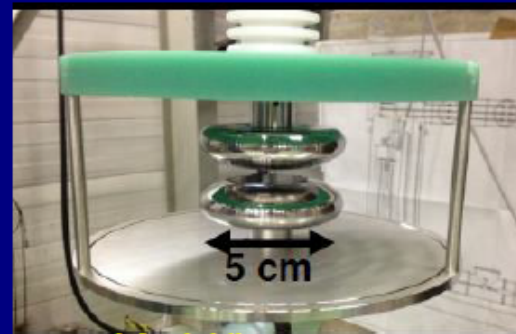


A decade of tests in laboratories

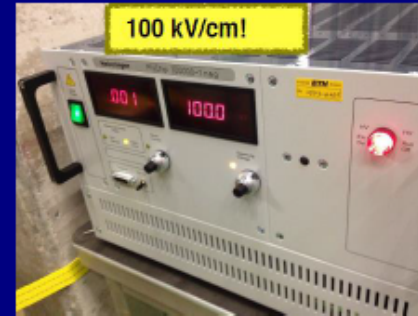
Parallel ongoing technical R&D activities:



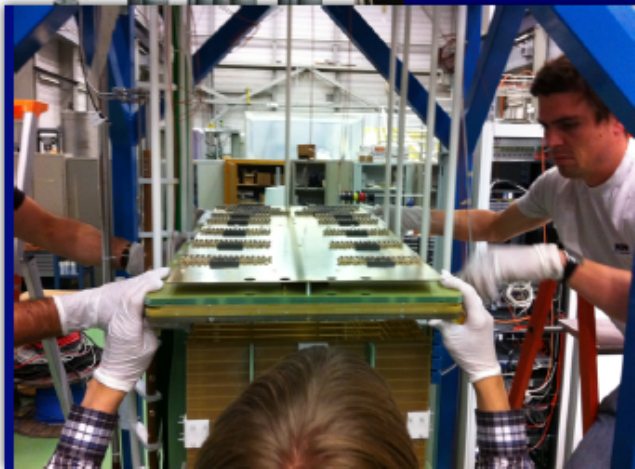
10x10x20 cm
LEM-anode fast test setup



LAr rigidity test setup



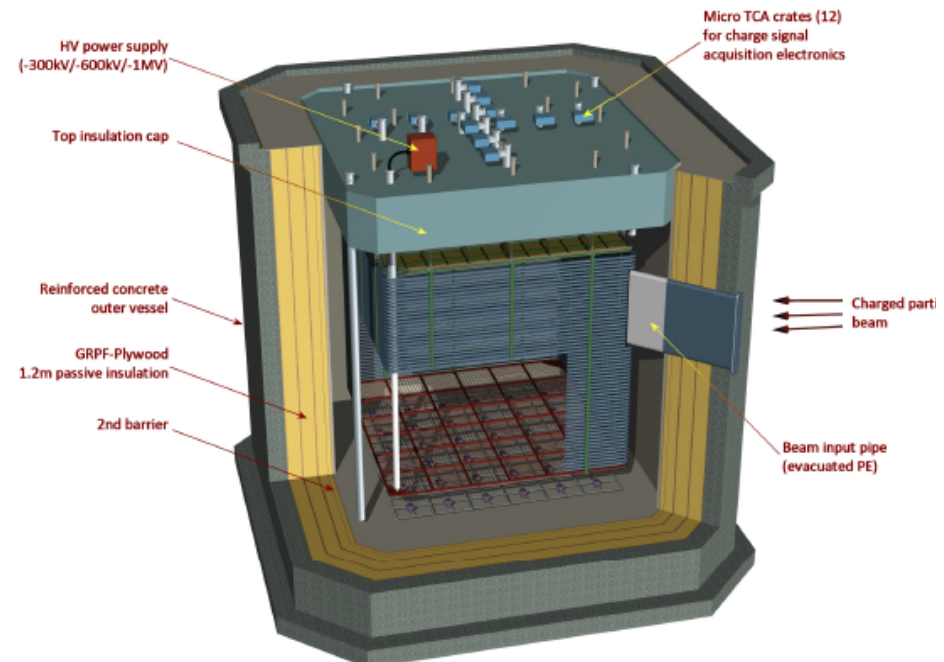
Readout test setup in Lyon



The WA105 infrastructure at CERN

DLAr 6x6x6m³ design

- Membrane GTT® tank with passive insulation
- Top deck with chimneys and insulation
- **6x6m² anode large readout area, 6m long drift length** (3ms max drift time @ 1kV/cm)
- Charged particle beam window
- 300 ton LAr instrumented: 7680 charge readout channels, 36 PMTs (baseline layout)



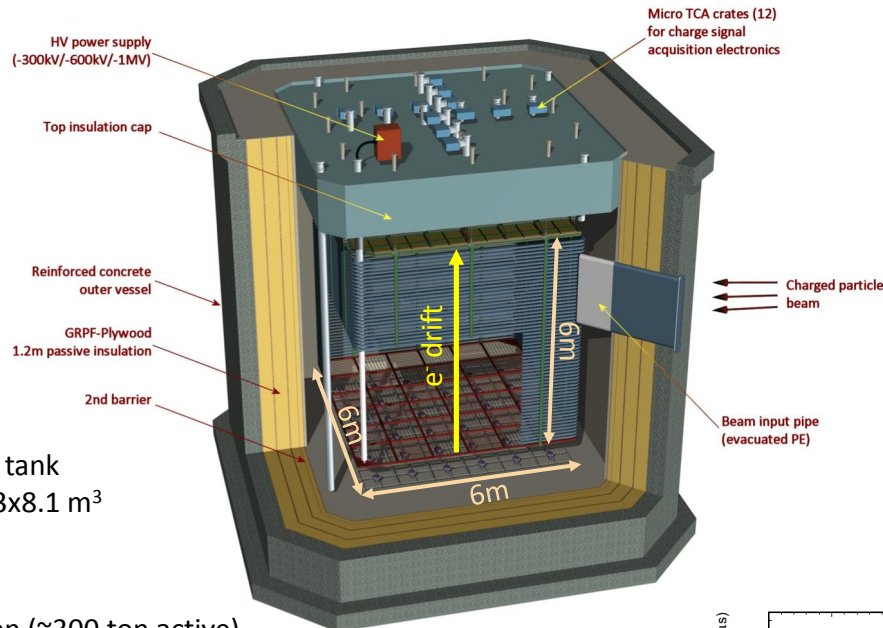
Liquid argon density	T/m ³	1.38
Liquid argon volume height	m	7.6
Active liquid argon height	m	5.99
Hydrostatic pressure at the bottom	bar	1.03
Inner vessel size (WxLxH)	m ³	8.3 × 8.3 × 8.1
Inner vessel base surface	m ²	67.6
Total liquid argon volume	m ³	509.6
Total liquid argon mass	t	705
Active LAr area	m ²	36
Charge readout module (0.5 x0.5 m ²)		36
N of signal feedthrough		12
N of readout channels		7680
N of PMT		36

Data taking in 2017

The WA105 infrastructure at CERN

WA105

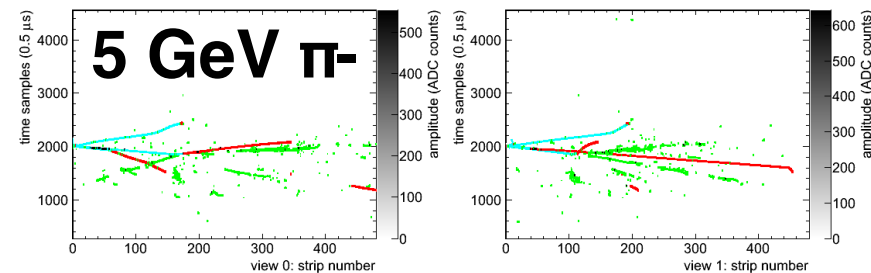
Build and operate a large scale prototype to demonstrate the feasibility of Double phase LAr TPC design for O(10kt) detectors



Some detector parameters:

- Insulated membrane tank
→ inner volume 8.3x8.3x8.1 m³
- Active area 36 m²
- Drift length 6 m
- Total LAr mass 705 ton (~300 ton active)
- Hanging field cage & readout plane
- # of signal channels: 7680 in 12 signal FT
- # of PMTs: 36

- Membrane GTT® tank with passive insulation
- Top deck with chimneys and insulation
- **6x6m² anode large readout area, 6m long drift length** (3ms max drift time @ 1kV/cm)
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6x6x6m³ DLAr R&D goals: summary

Double phase LAr TPC validation:

1. Longest drift in LAr (up to 6m)
2. Ionisation e- transverse and longitudinal diffusion
3. e- attenuation and its compensation by charge multiplication with LEM operating in gas phase (LEM gain uniformity/stability/calibration)
4. HV operation in the range 300kV-600kV (or 0.5-1 kV/cm over 6m)
5. Validation of the corrugated membrane cryostat with passive insulation
6. ≤ 100 ppt O₂-equivalent impurities in LAr in such a tank
7. Low-noise accessible ionisation charge signal readout electronics operating at low temperature (~ 110 K)
8. Reachable and optimisation of S/N ratio
9. Verification of possible effects of positive ions (surface! - n/a underground)
10. Robust light readout (UV aging resistant), immersed electronics
11. First calibration of a LAr TPC with beam e-/ μ /hadrons

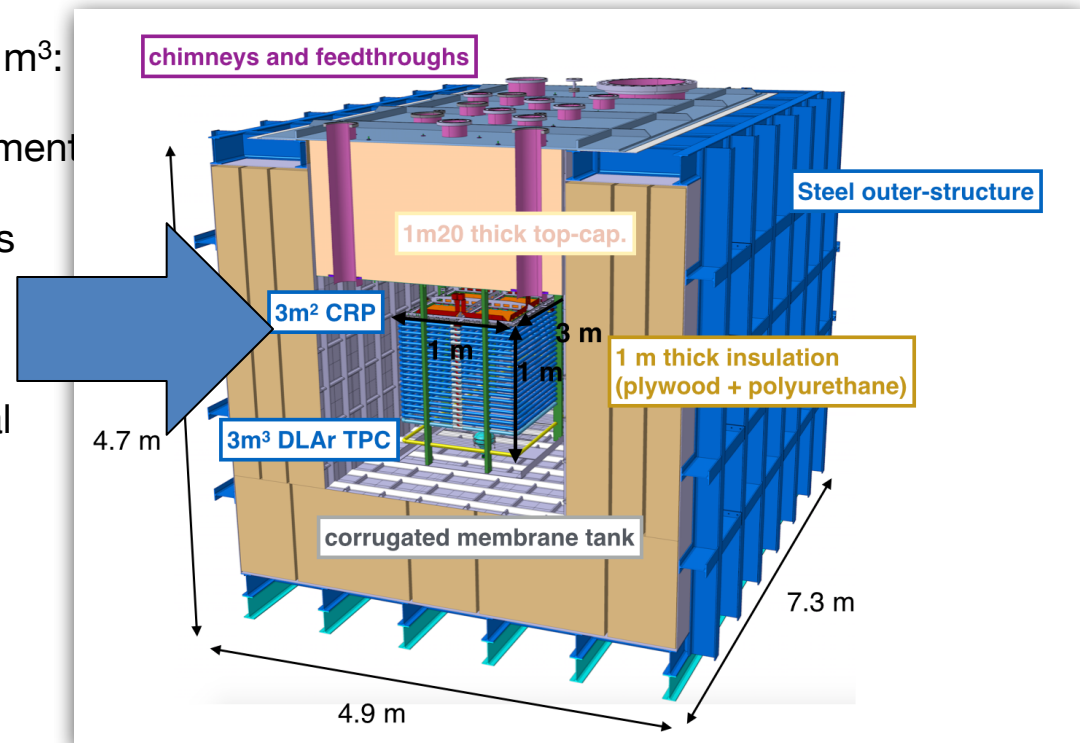
Progress on WA105 DLAr detector 6x6x6 m³:

- Membrane vessel design and procurement
- Cryogenics
- Charge Readout Plane (CRP) detectors
- CRP structure and hanging system
- Feedthroughs
- HV and field cage
- Charge readout FE electronics + digital electronics
- Light readout system + electronics
- DAQ and online processing
- Slow Control

3x1x1 m³ prototype LAr-proto

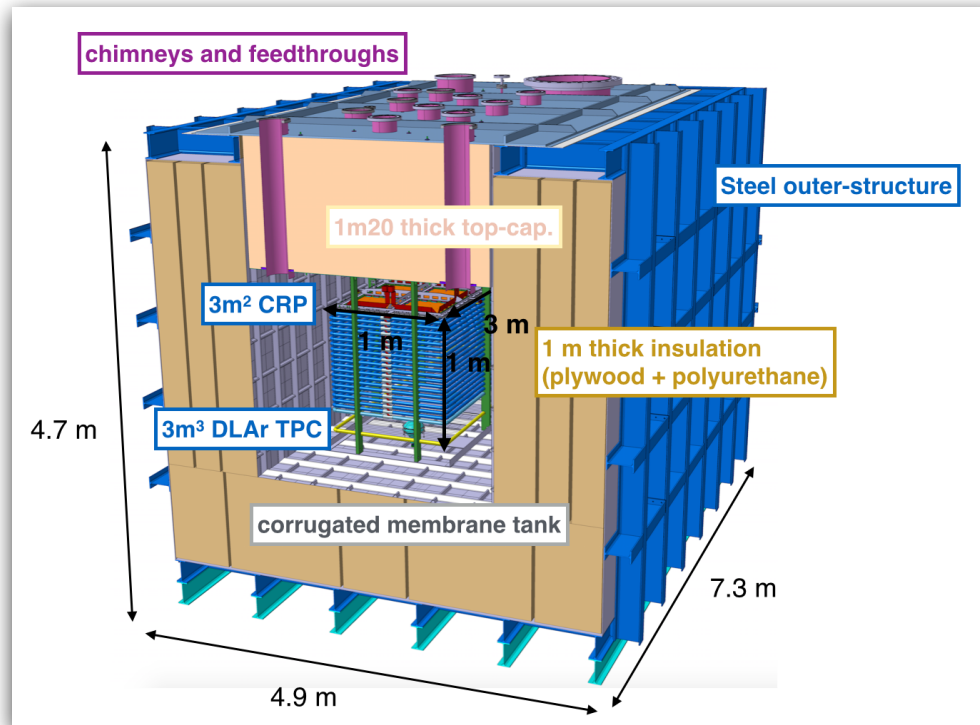
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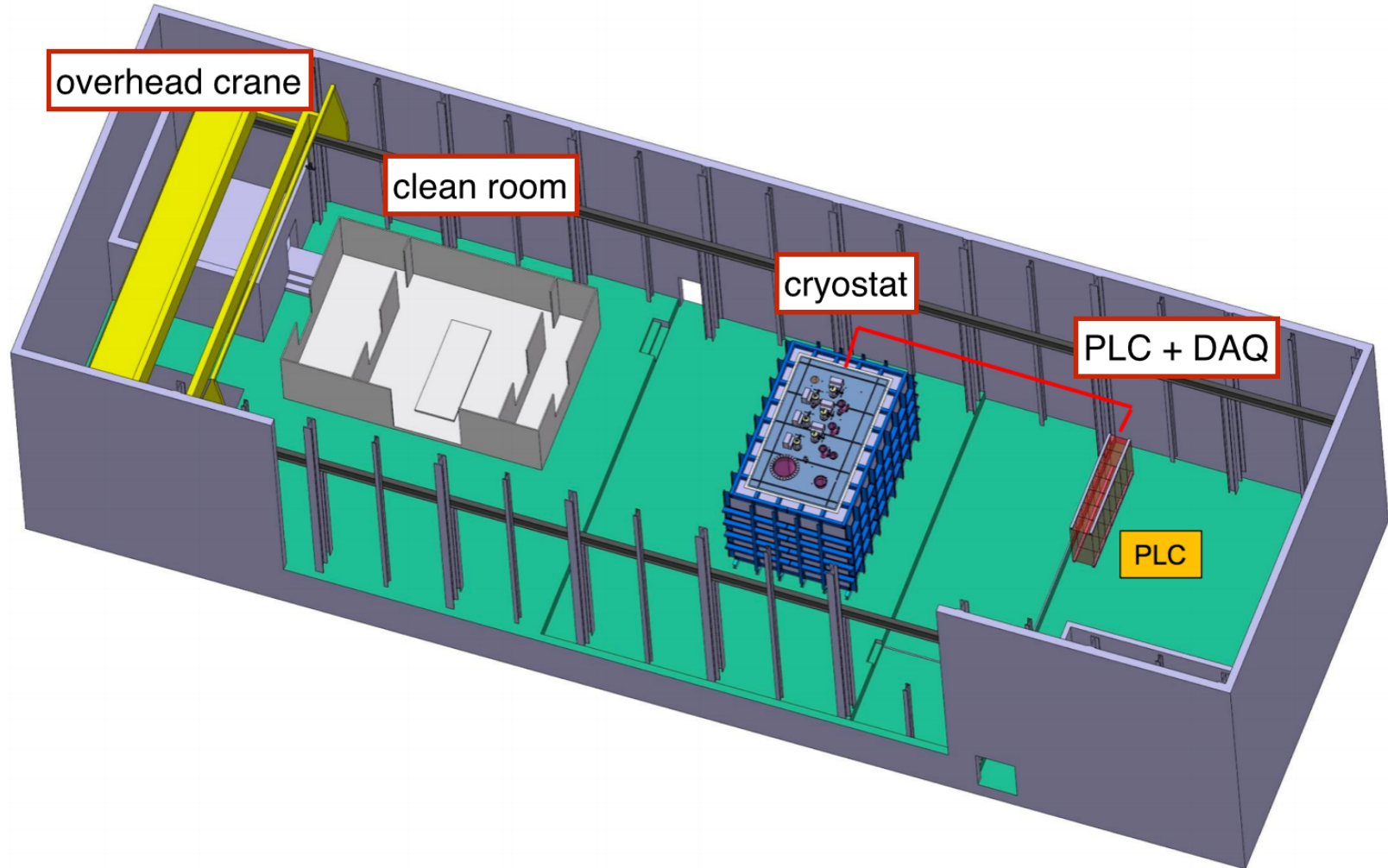


Advanced state of design, prototyping and production preparation

For many items huge benefit from immediate application of a smaller 3x1x1 m³ prototype LAr-proto (minimal size of RO unit in 6x6x6)



- ✓ **Fully engineered versions of many detector components** with pre-production and direct implementation (installation details and ancillary services)
- ✓ **First overview of the complete system integration:** set up full chains for Quality Assessment, construction, installation and commissioning
- ✓ **Anticipate legal and practical aspects** related to procurement, costs and schedule verification
- ✓ Dedicated weekly meeting to follow up construction progress



overhead crane

clean room

cryostat

PLC + DAQ



Cryogenic detectors Networking Activity:

Basic concept and modus operandi:

- ❖ Benefit of the R&D infrastructure at CERN for WA105 and of other infrastructures available in different laboratories (piggy-back)
- ❖ Integrate the hardware available in these infrastructures in a networking activity with dedicated personnel (→ main requests to AIDA II in terms of manpower: postdocs contracts)
- ❖ Matching funds from other personnel involved in the activities and existing equipment

Goals:

- **Networking and exchange** among the existing EU expert groups involved in the development of the most innovative experimental techniques
- **Reviewing and reporting** on some crucial development aspects for large cryogenic detectors.
- **Sharing of information and tools (dissemination)** in the community and creation of a state of the art common knowledge of the field broadly applicable in future projects

AIDA II support:

- 5 Postdoc contracts of 2 years each for the 5 sub-tasks of WP8 (profiting of ongoing developments on WA105 and R&D on small prototypes present in collaborating laboratories, help in organizing the networking and exchange among the groups and in producing a reporting on some crucial development aspects for the cryogenic detectors).
- Travel money for meetings of the NA

Outcome:

- ✓ Networking exchange and creation of common knowledge
- ✓ Common assessment and demonstration of techniques
- ✓ Reviewing and reporting on the techniques

Dynamic outcome during the project and communication: common WEB repository

Final outcome: written deliverables on the techniques investigated
Demonstrate state of the art of the various techniques, develop tools and technical knowledge of common utility shared in the community **(Added value to projects like WA105 which without AIDA II would focalise on itself, knowledge transfer for larger impact with R&D tools and techniques made available to the community)**

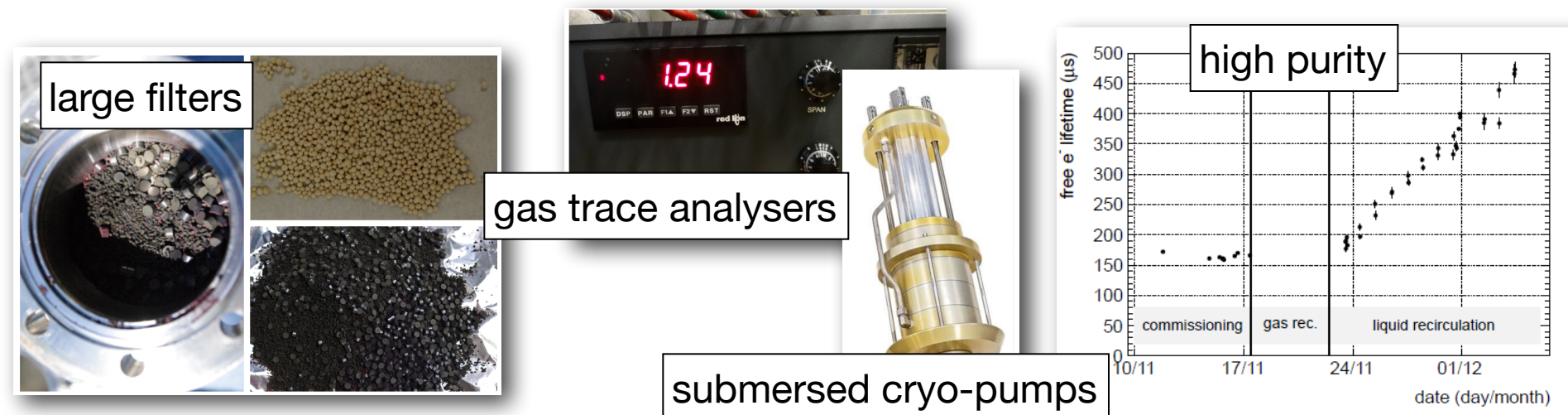
- **Topics and corresponding deliverables: (detector technologies)**
 - ➔ **Purification and monitoring**
 - ➔ **Charge readout and double-phase**
 - ➔ **Light readout**
 - ➔ **Very high voltage**
 - ➔ **Magnetisation**
- These 5 topics are identically structured in terms of goals and deliverables, following the guidelines presented above. They corresponds to frontier developments in the field.
- Collaborating institutes: CIEMAT, CEA, ETHZ, Genève, Glasgow, IN2P3 (IPNL, APC, LPNHE, LAPP), UCL

Purification and Monitoring (Task leader UCL)

As explained before, like the deliverables for the other topics, this deliverable will include

Networking, Reviewing and Sharing of infos and tools (NRS) the following points:

- ✓ Scaling of purification systems for massive cryogenic detectors (purification and recirculation of noble liquids and gases)
- ✓ Assessment of common measurement techniques for purity monitoring
- ✓ Techniques for levels control and measurement of thermodynamic conditions

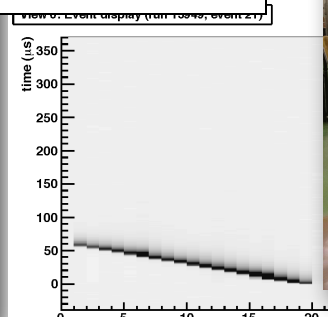
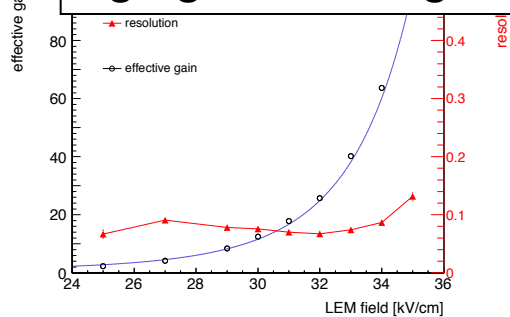


Charge readout and double phase (Task leader IPNL)

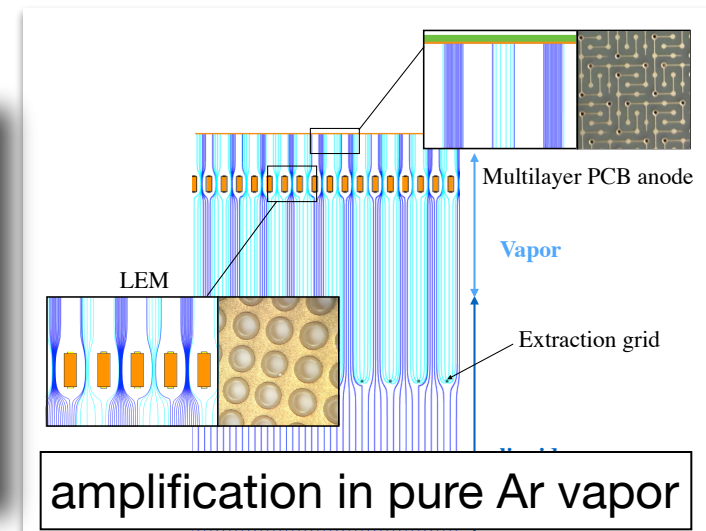
Networking, Reviewing and Sharing of infos and tools (NRS) on the following points:

- ✓ Ionisation charge readout techniques in liquefied noble gases
- ✓ Double-phase techniques for charge amplification with electrons extraction from the liquid phase and amplification with micro-pattern gas detectors in absence of quenching
- ✓ Charge readout front-end cryogenic electronics and large scale digitization systems
- ✓ Definition of a basic setup detector+electronics for sharing in the community

high gains on large area ThGEMs



prototyping



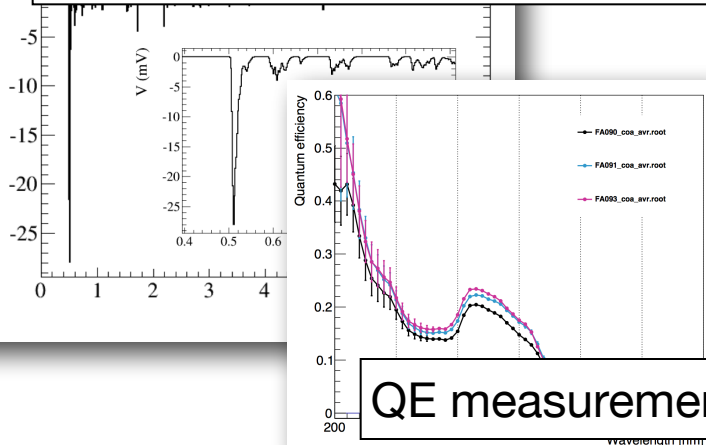
amplification in pure Ar vapor

Light readout (Task leader CIEMAT)

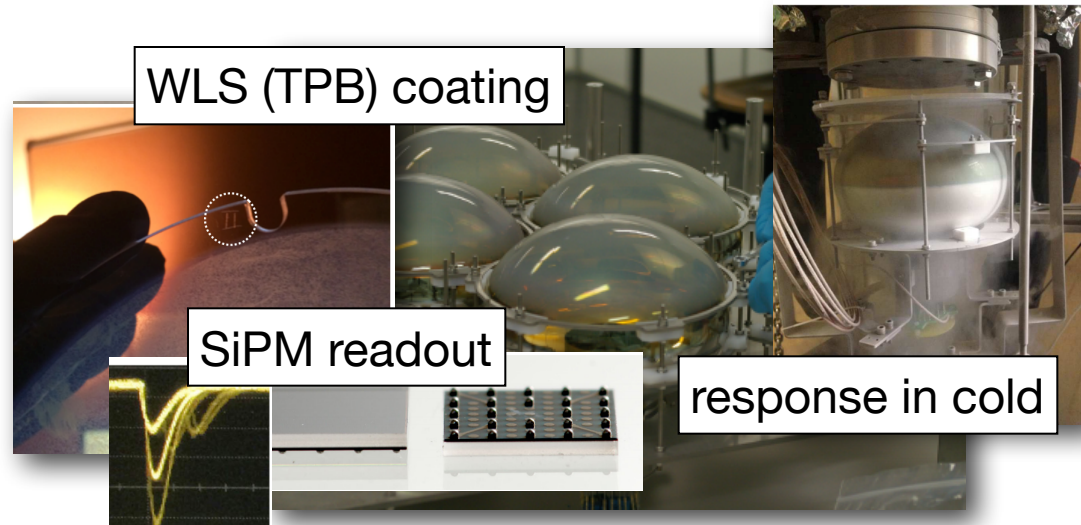
Networking, Reviewing and Sharing of infos and tools (NRS) on the following points:

- ✓ Large photo-detectors (PMT, SiPM) for the readout of scintillation light in liquefied noble gases
- ✓ Wavelength-shifting techniques for large area readout in cryogenic detectors
- ✓ Digitisation techniques of the scintillation signals in liquefied noble gases and definition of a basic setup (PD+electronics)

light simulation in double phase



WLS (TPB) coating



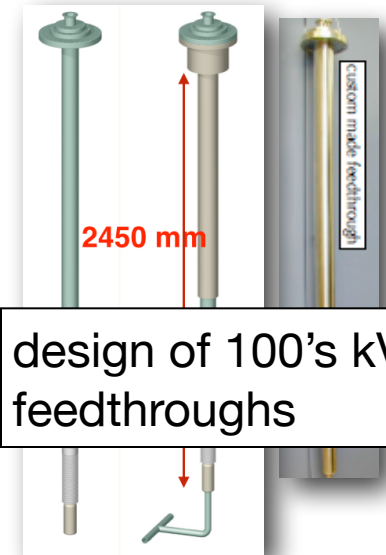
Very High Voltage (Task Leader ETHZ)

Connected to high fields, long drift paths -> V up to ~MV

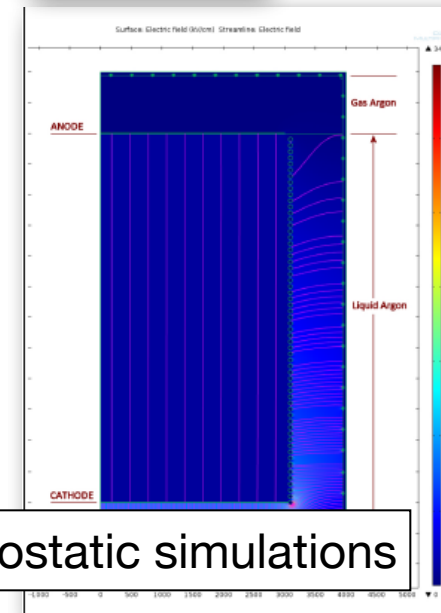
Networking, Reviewing and Sharing of infos and tools (NRS)
on the following points:

- ✓ Reviewing of VHV generation
- ✓ VHV transport: connection to VHV generators and feedthrough
- ✓ Study of phenomena related to high fields in nobles gases and liquids
- ✓ Study of cathodes and drift field cages design

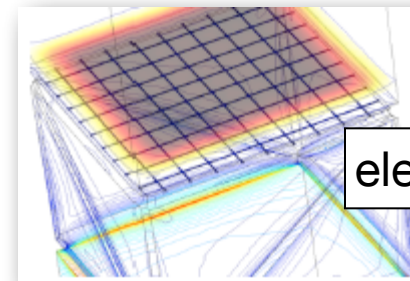
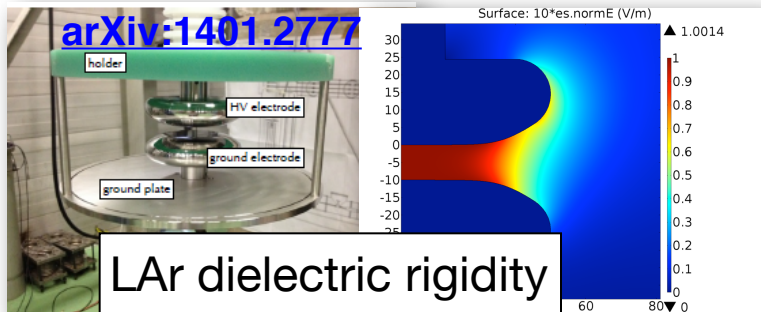
Example of NA in the field: « High voltage in noble liquids »
<https://indico.fnal.gov/conferenceDisplay.py?confId=7394>



design of 100's kV feedthroughs



electrostatic simulations

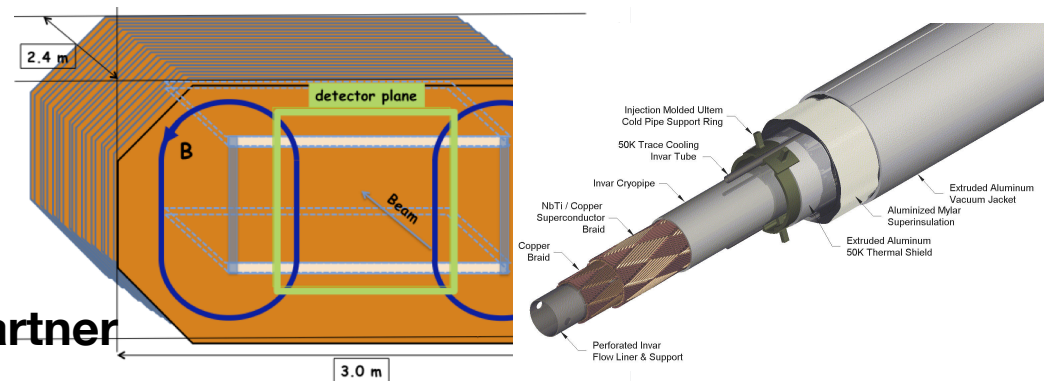


Magnetisation (Task Leader Glasgow)

Magnetisation of large volumes in cryogenic detectors based on testing novel superconductive magnetisation schemes: originally proposed for MIND detectors of LBNO, Neutrino Factory, nuSTORM. having great potential for other detectors based on liquefied noble gases

Networking, Reviewing and Sharing of infos and tools (NRS) on the following points:

- ✓ Study of magnetisation based in Superconducting Transmission Line (STL)
- ✓ Study of magnetisation based on High Temperature Superconducting (HTS) line
- ✓ First tests on iron: MIND50 hardware from AIDA available at CERN



Fermilab also interested in being a partner

Conclusion

- The activities of **WP8 are already in an advanced state** thanks to the infrastructure provided by WA105 and the enlargement to the USA community with the involvement in DUNE.
- WP8 is the occasion for a **strong Networking Activity** and technological review on 5 strategic aspects of cryogenic detectors:
 - Purification and monitoring
 - Charge readout and double-phase
 - Light readout
 - Very high voltage
 - Magnetisation
- This allows for common assessment and sharing of information and tools in the EU cryogenic detectors community => creation of a state of the art common knowledge of the field broadly applicable in future projects

Conclusion (2)

- The first meeting of WP8 has been postponed to June 17th due to the involvement of several people in the DUNE CD1 review. At the meeting there will be an assessment of the work planning and the hiring of the postdocs.
- We are planning to start soon the WEB site for the collection of the information related to WP8 activity. It can be made independent, using the resources in the contributing labs or integrated in the AIDAII web server (if already foreseen).