ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ETH Institute for Particle Physics

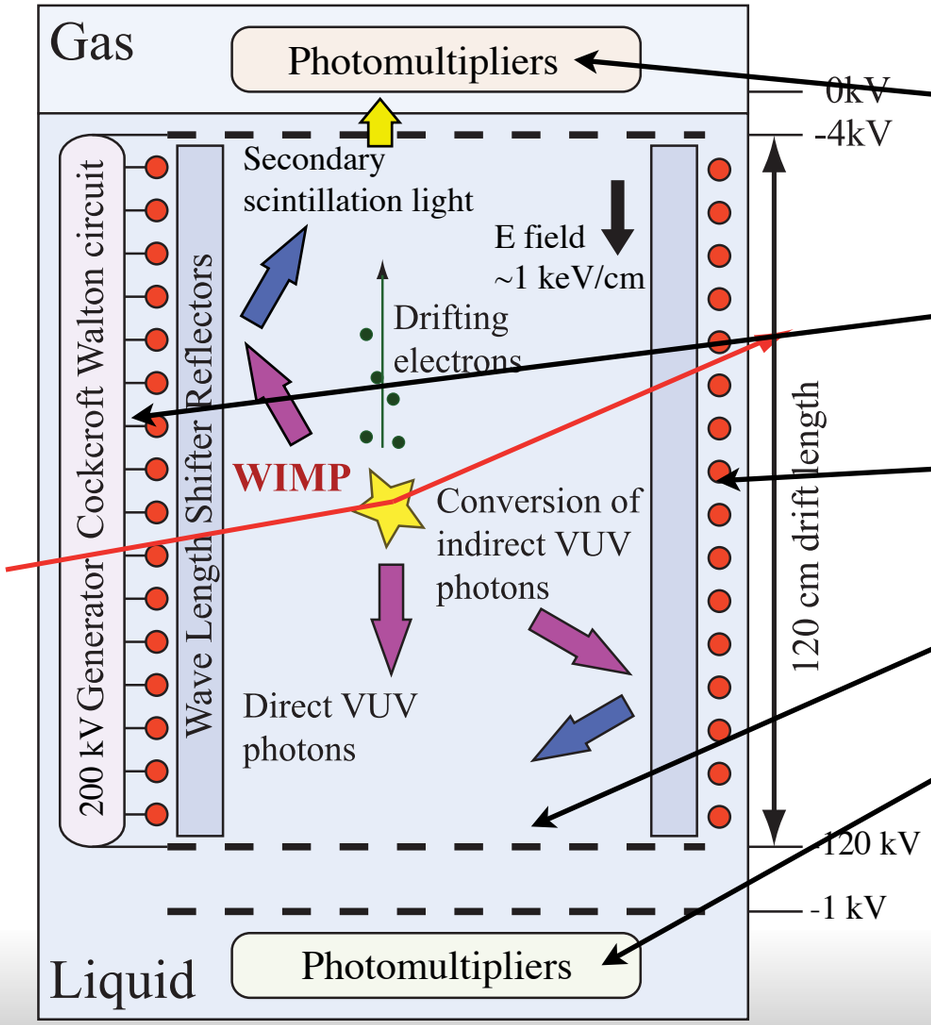
The ArDM experiment

Status report

Lukas Epprecht on behalf of the ArDM Collaboration

CHIPP-Plenary Meeting, Karthause Ittingen, September 14 2012

ArDM: Design Parameters



Top flange with services

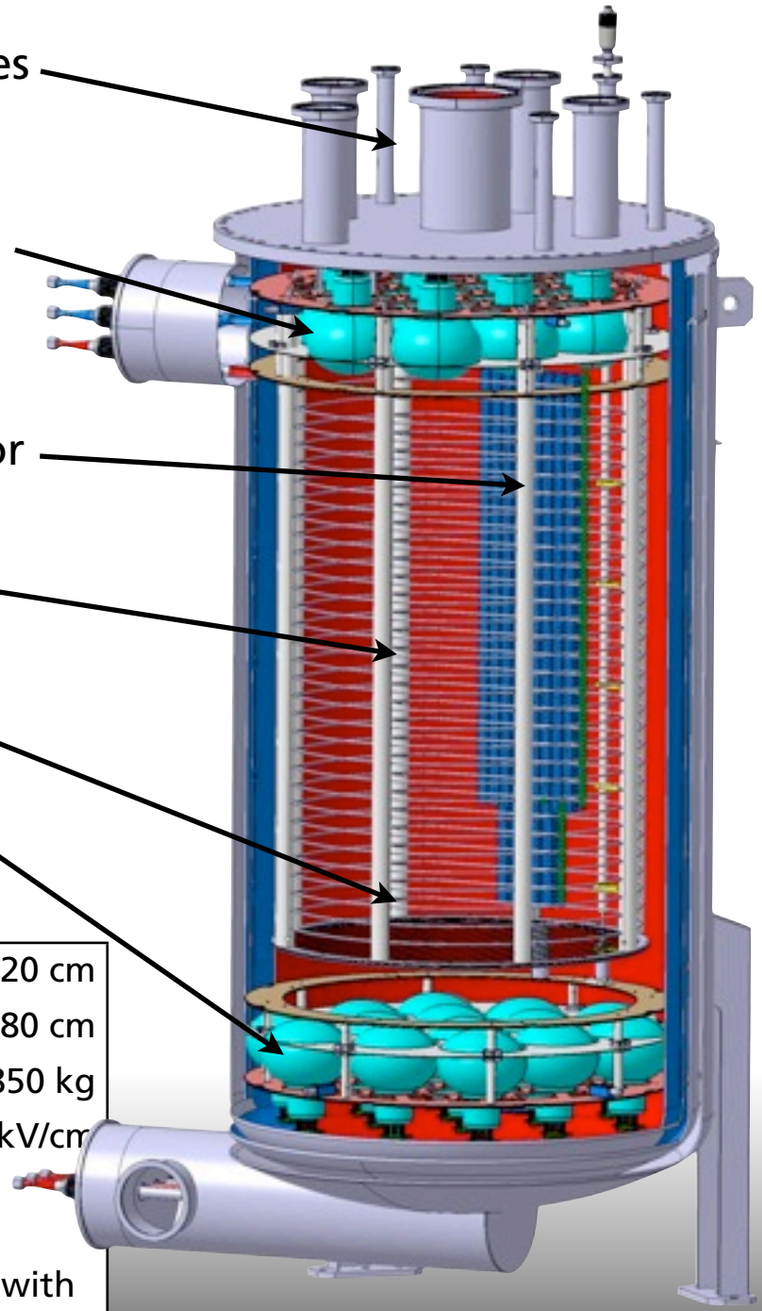
Low background photomultiplier

High voltage generator

Field shaper

Cathode

Low background photomultiplier



Total drift length:	120 cm
Diameter:	80 cm
Target:	850 kg
Drift field:	up to 1 kV/cm

Shielding with 150 mm LAr & 600 mm of polyethylene

Temperature control of detector with LAr cooling jacket

Expected Signal in ArDM

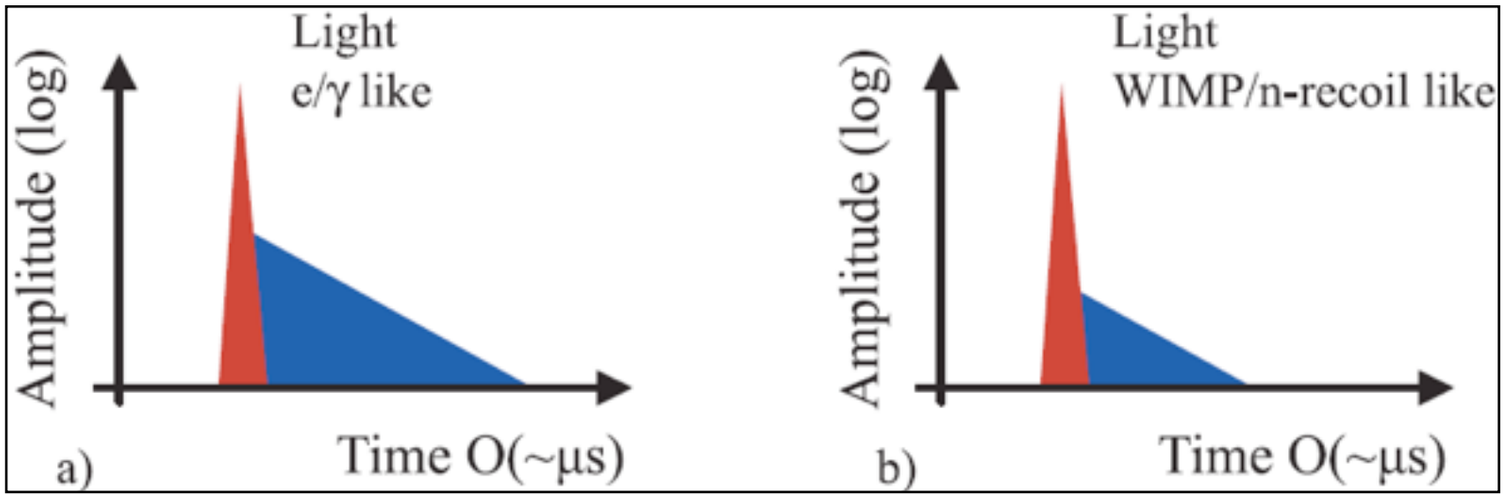
We assume:

- 500 kg active mass after fiducialization.
- Background rejection: 10^7 (10^4 from PSD and 10^3 from S1/S2) for beta/gamma background
- Signal efficiency: 50%
- Neutrons from materials included and neutron shield in place
- WIMP mass 100 GeV and xsec 10^{-44} cm^2
- Region of interest 30-100 keV

^{39}Ar [evt / day]	gamma [evt / day]	neutrons [evt / day]	background [evt / day]	WIMP rate [evt / day]
$1.5*10^6$	47'500	0.07	0.22	0.25

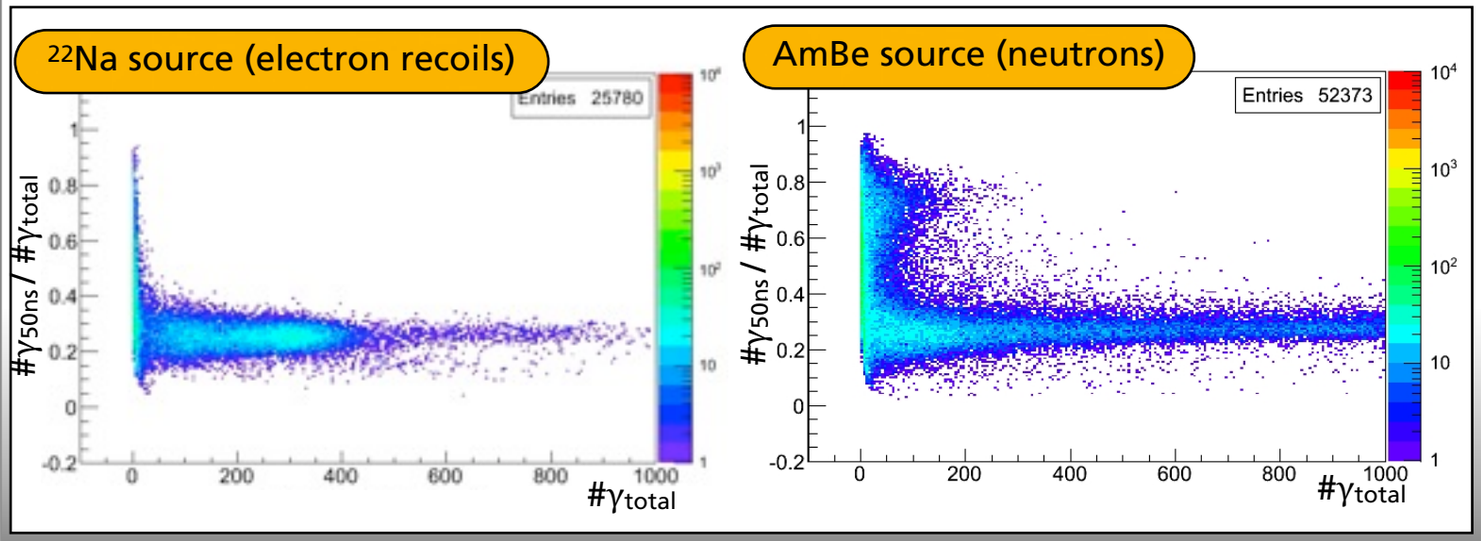
Particle discrimination

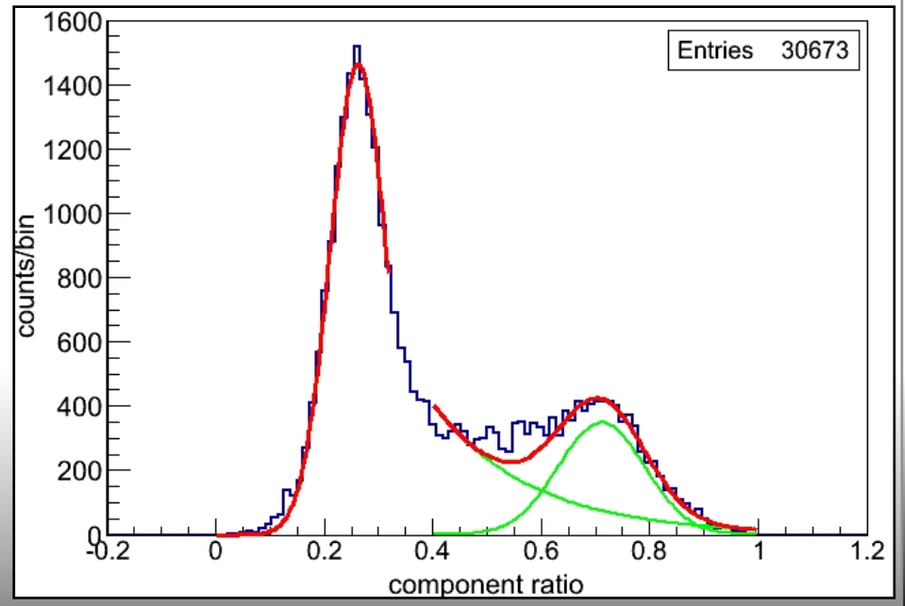
Pulse shape discrimination



- The amount of light coming from fast and slow decay of excited Ar molecules (~ 5 ns vs. ~1.6 μs) varies for the type of interaction.
- Taking the ratio between the light coming in the first few nano seconds and the total amount of light gives a clear signature of the type of interaction

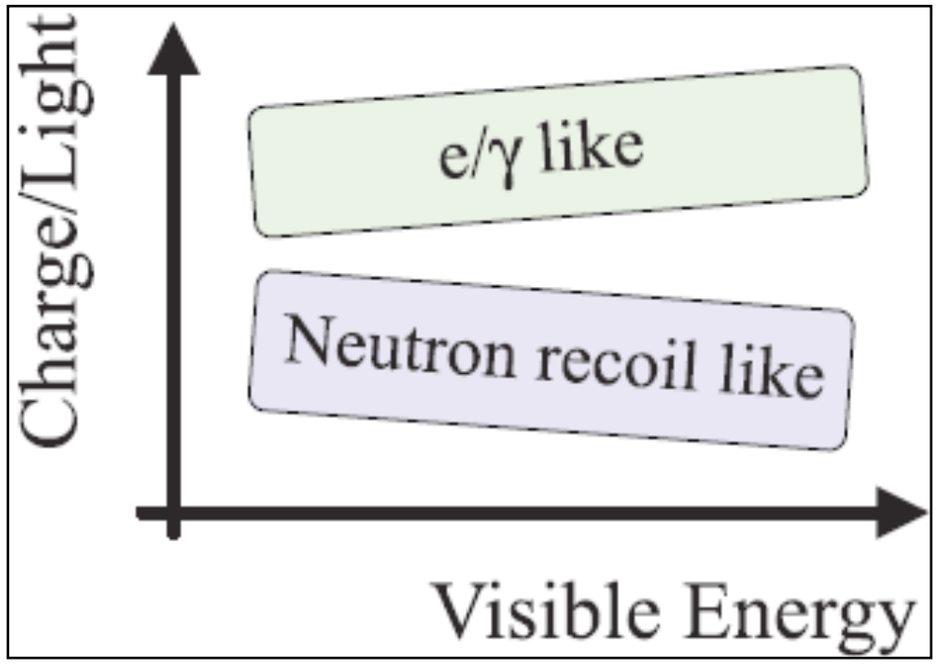
Actual measurement with ArDM on surface

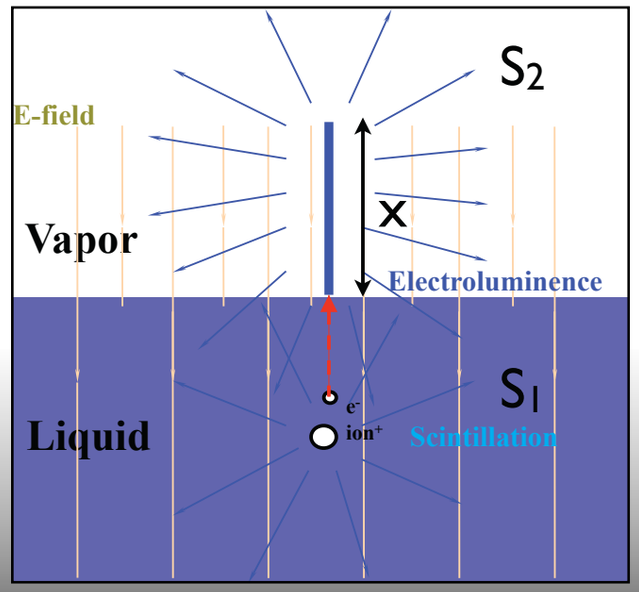


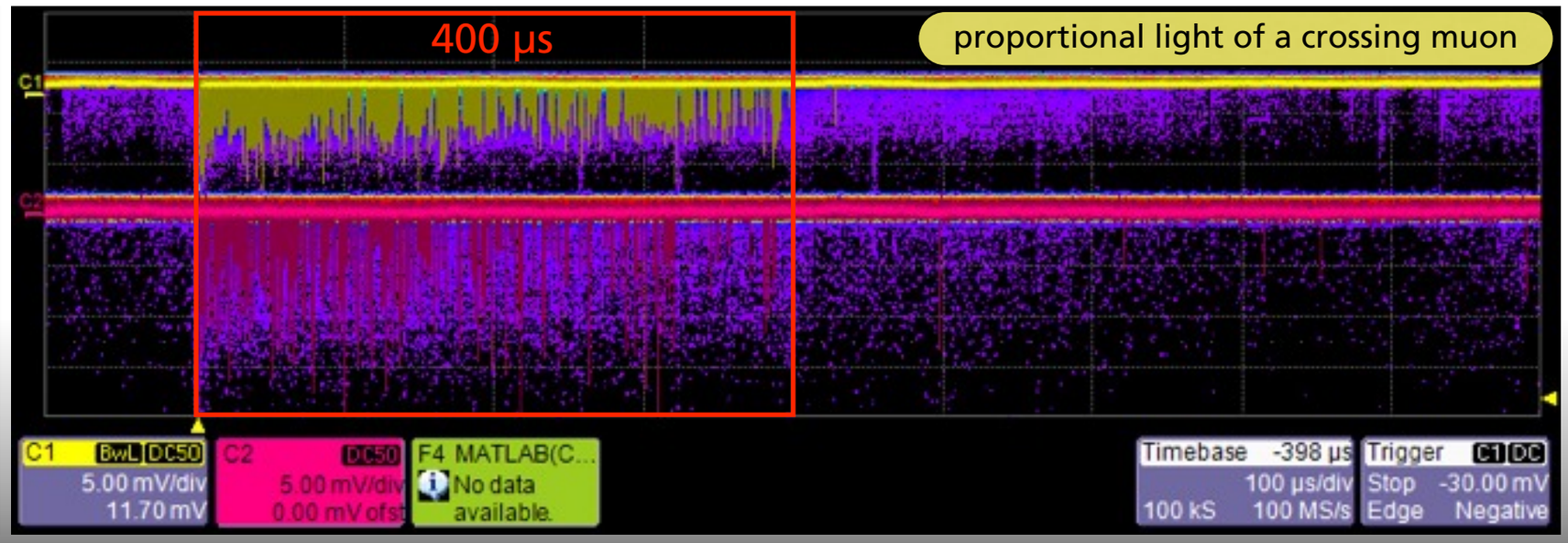


Light / Charge ratio

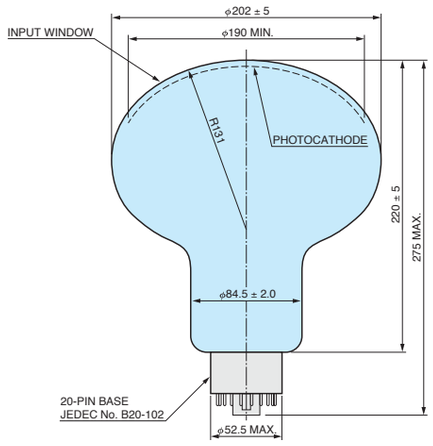
- Charge accelerated in argon gas creates electro luminescent light
- Amount of light at a given E-field is proportional to the amount of charge released by the interaction
  - It is a good way to measure the total energy loss of a particle interacting with the liquid argon
- Ratio between light (S1) and charge (S2) depends on drift field and type of interaction
  - Electron and nuclear recoil can be distinguished
- Delay of S2 gives z-component for particle identification



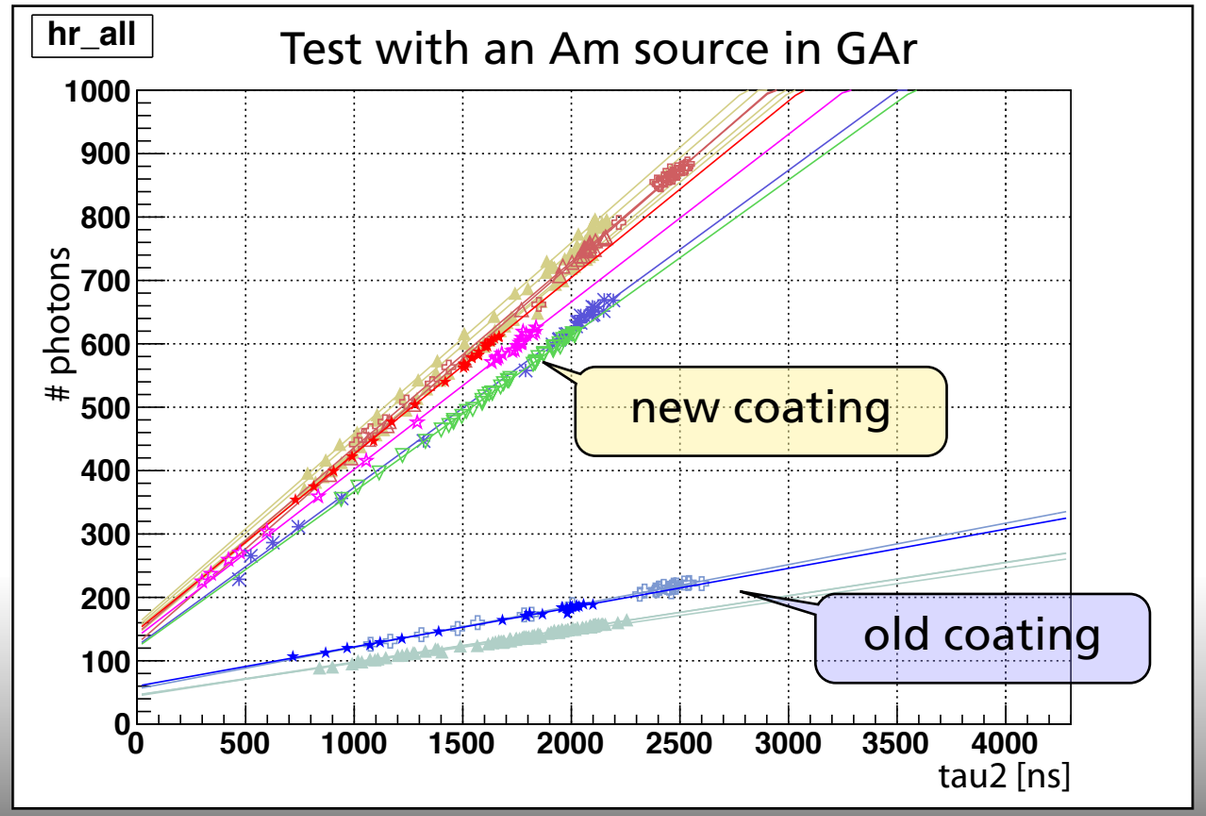




Wavelength Shifter Coating on PMTs

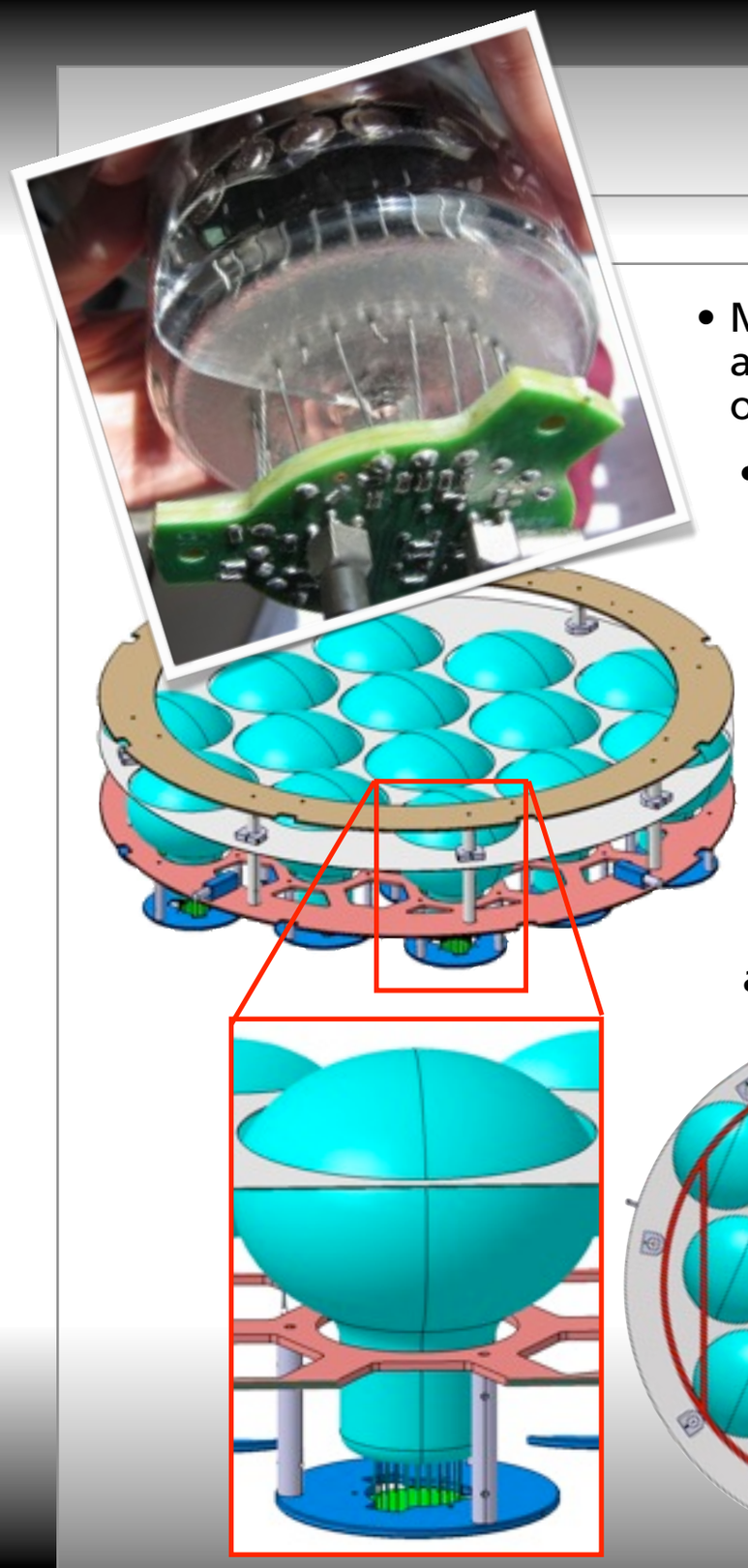


- 12 x 8 inch cryogenic low radioactivity PMT from Hamamatsu are located each at the top and bottom of the detector
- Glass is not transparent for VUV scintillation light of 128 nm
  - Scintillation light has to be shifted

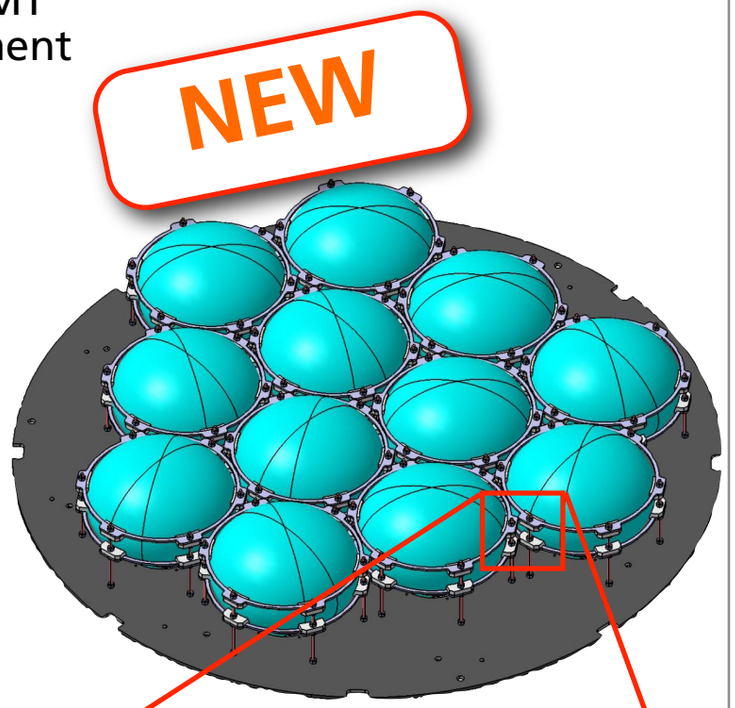


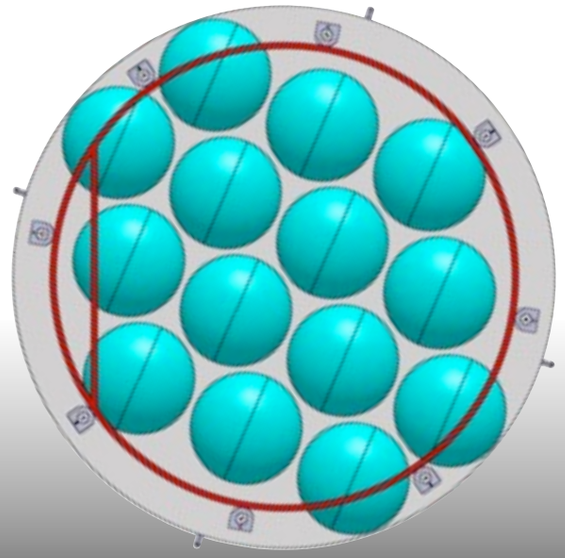
- An unexpectedly poor efficiency has been found by the previously coated PMTs compared to the fresh coating of the second 12 PMTs
  - Comparison between the two coatings shows a 5x increased light collection efficiency for the newly coated PMTs
- All PMTs have to be recoated
  - Currently the first bunch of 12 pcs. are getting coated in the CERN coating workshop

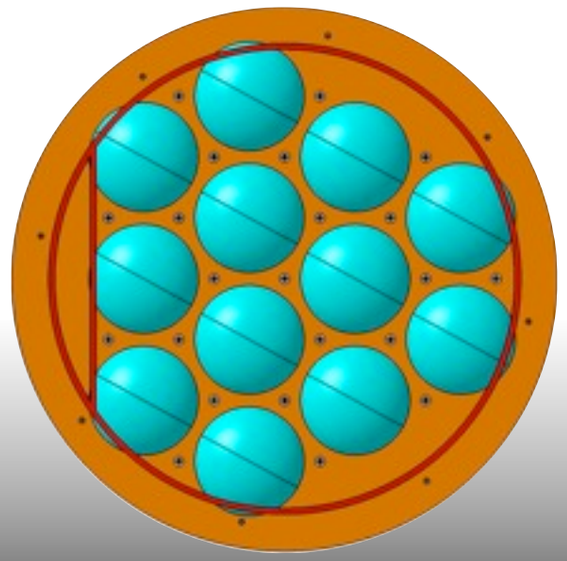
Light readout: ArDM 1st phase

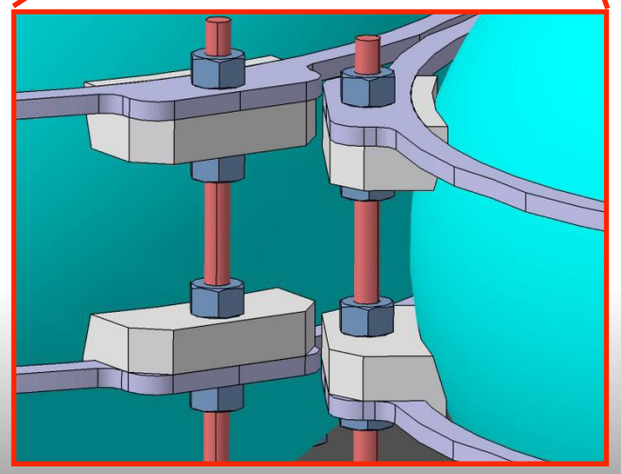


- Maximum amount of photons by the use of 2 PMT arrays, on top and bottom for precise measurement of ^{39}Ar background
  - 12 PMTs on each array
  - <u>Unexpected delay:</u>
    - 2 broken PMTs after last test run caused by thermal stress (crack starts on interface metal-glass)
  - Redesign of the PMT holder
    - New fixation
    - Improved geometry
  - New voltage divider (spark resistant in gas argon)





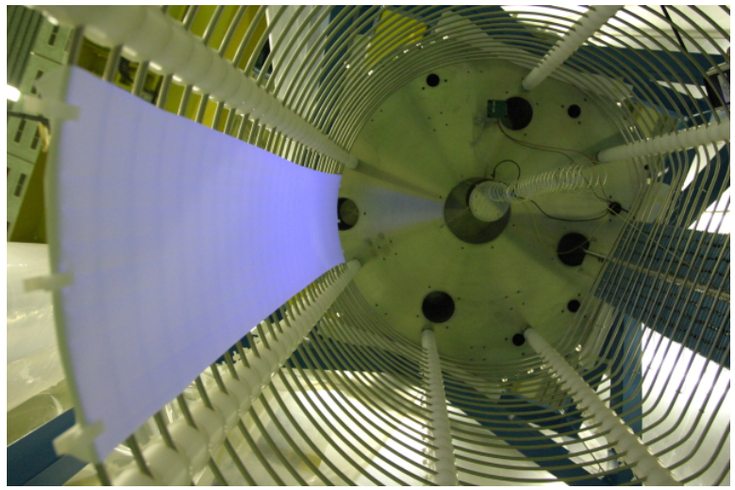




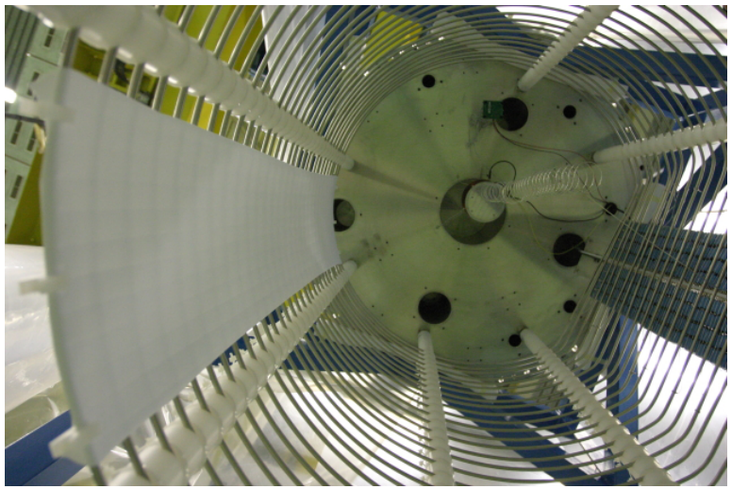
Reflectors

The ArDM Collaboration *et al* 2009 *JINST* **4** P06001

Reflector foils mounted on field cage

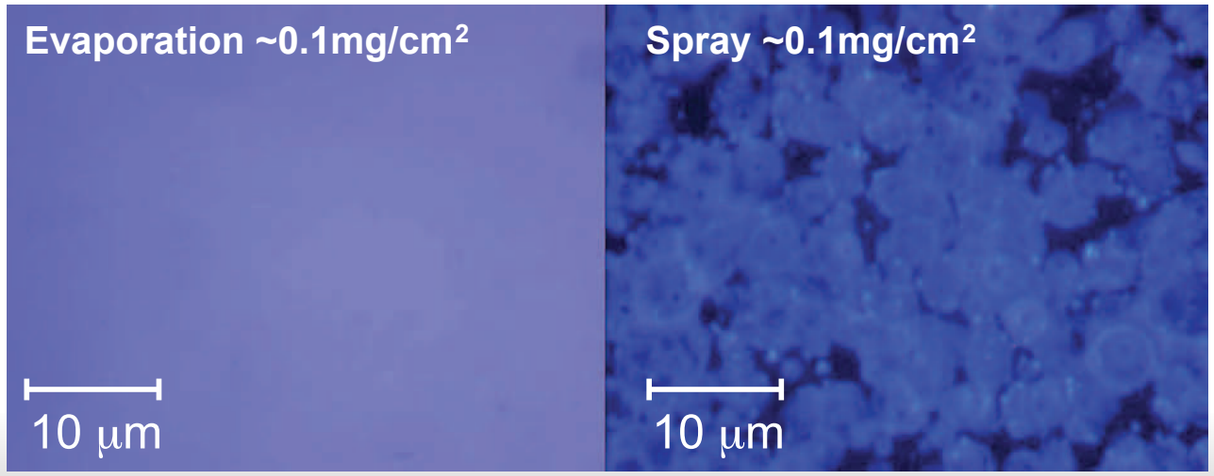


UV-illuminated reflector

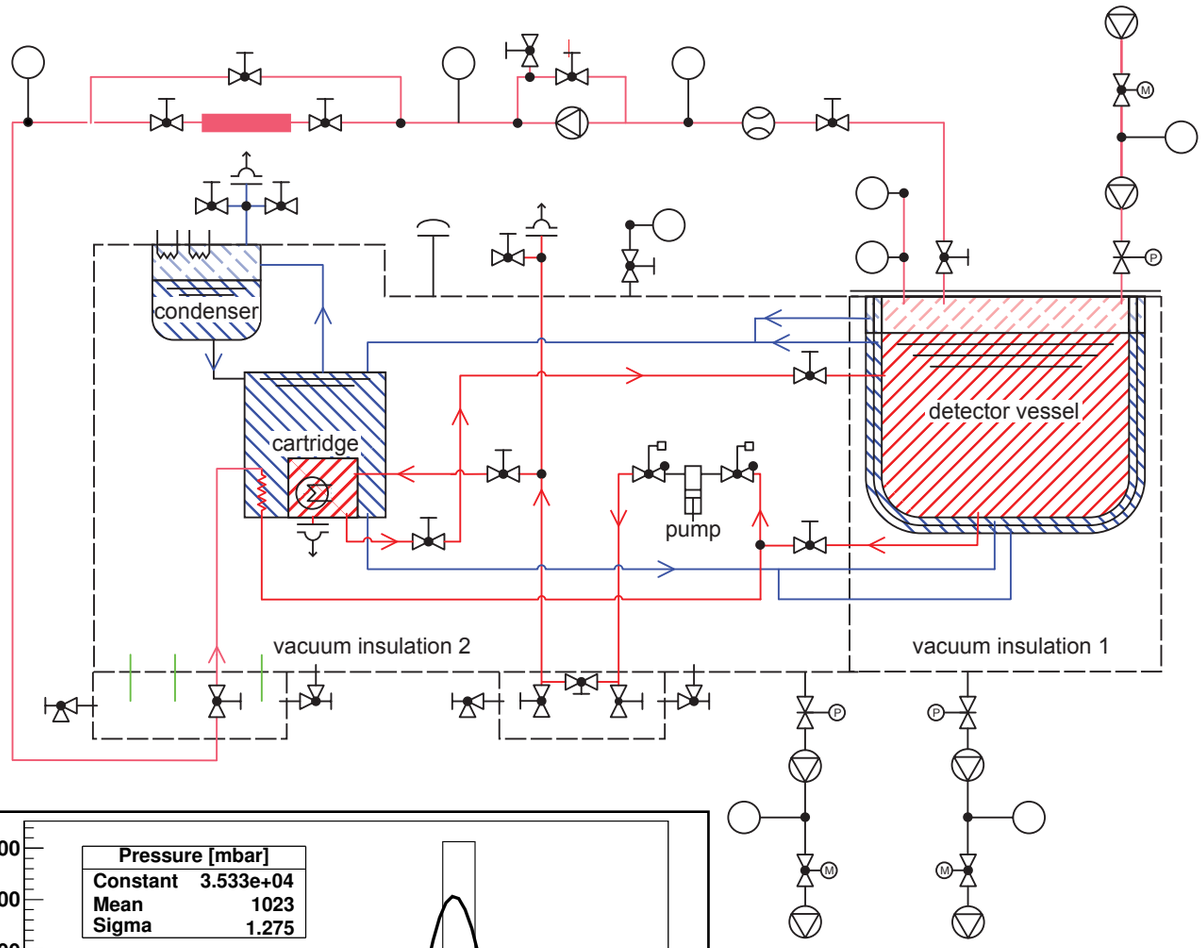


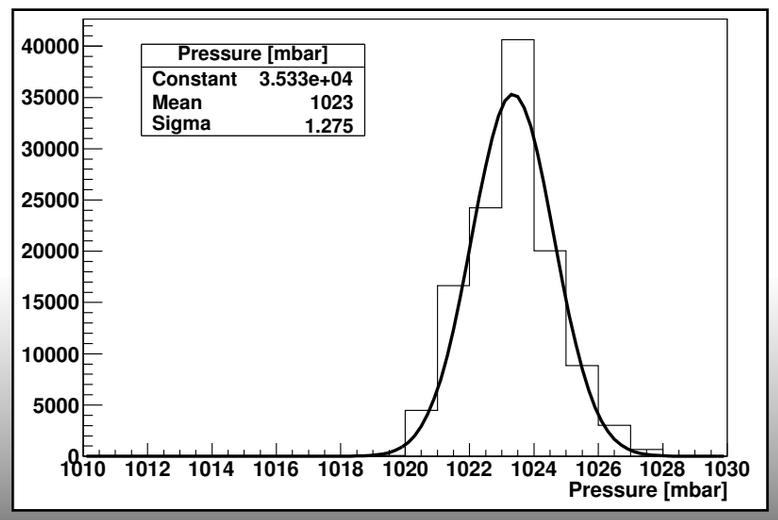
non-illuminated reflector

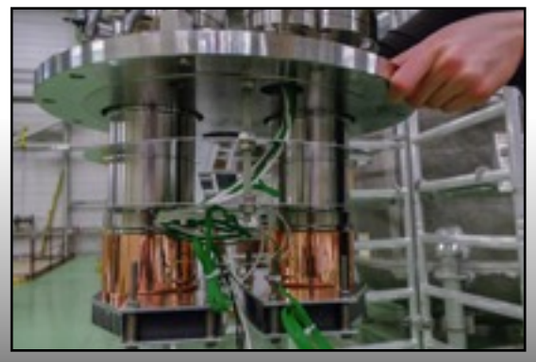
- 12 foils of 1200x200 mm^2 confine the fiducial volume
- VUV light must be converted on reflectors
  - TPB has to be deposited on them
  - deposition done with vacuum evaporation
- Reflectors not only have to reflect light inside fiducial volume but also block background from outside



Cryogenic System





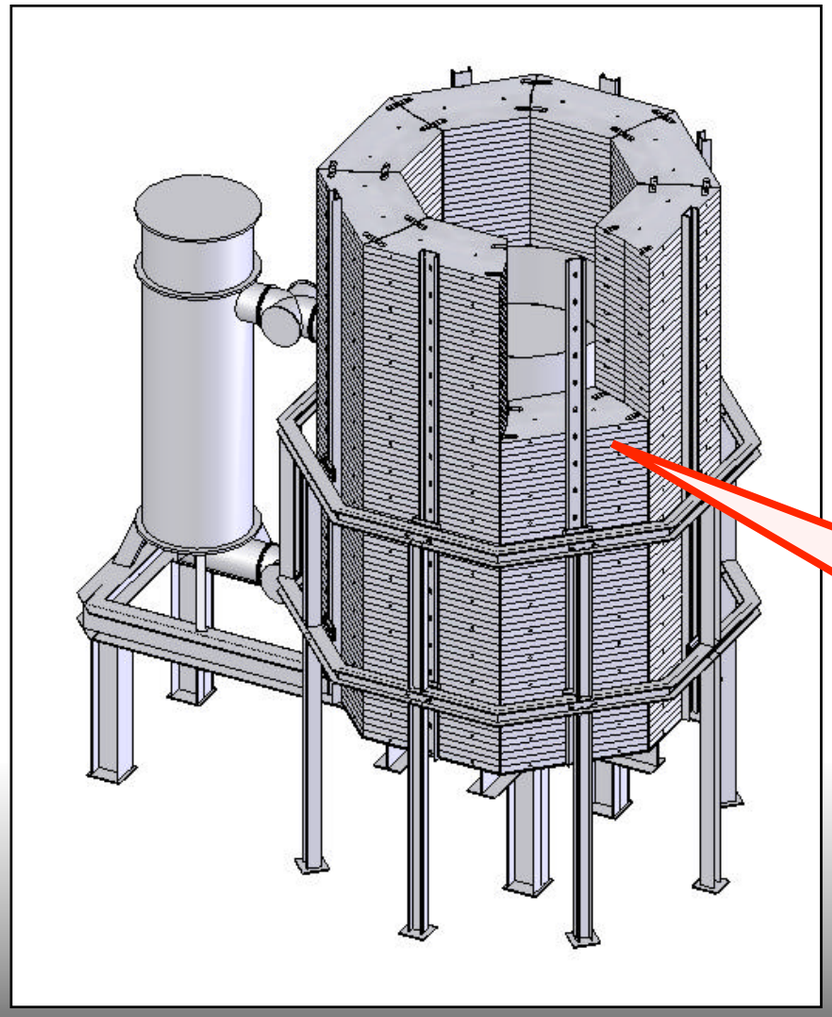


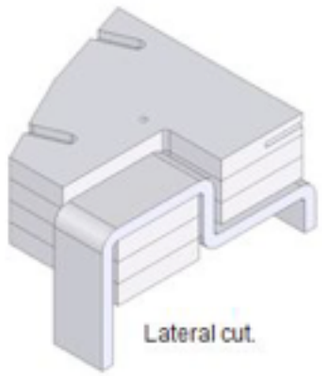
- Two independent, completely sealed argon circuits
- Detection medium (red): highly purified and totally sealed against atmosphere
- Cooling medium (blue): sub-cooled argon re-condensed with 2 cryocooler of totally 600 W of cooling power
- Cooling power is regulated with a PID controller to keep a constant temperature
- Pressure variations in the detector are less than 5 mbar over weeks
- Successful operation in 2 test runs of more than 1 month each

Neutron Shield

Under responsibility of CIEMAT group (Madrid)

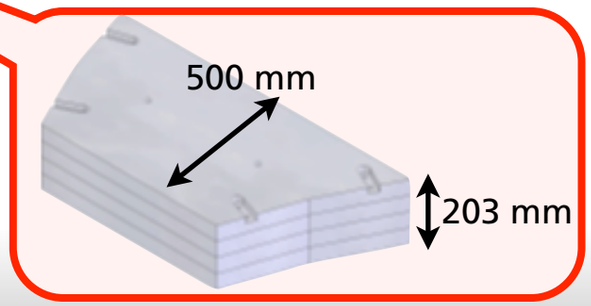
- Material: polyethylene
- Radial thickness: 50 cm
- Total 600 slabls
- Blocks of ~ 20 cm height, clued together out of 4 slabs
- Total weight: ~17 tons (incl. cup and floor)

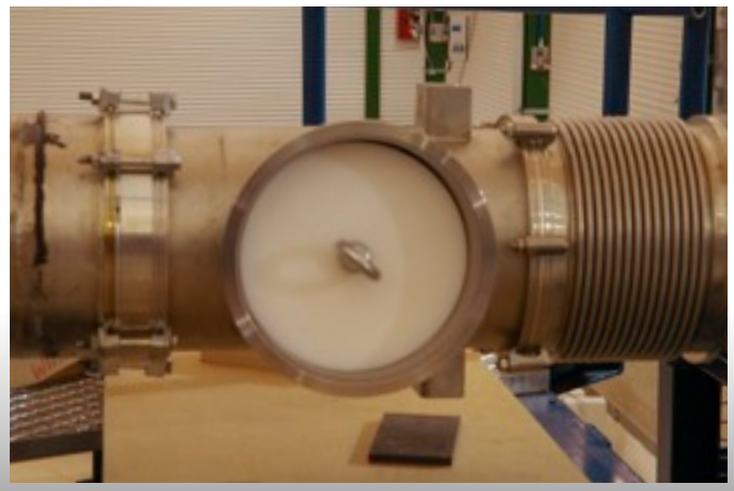




Cable feed through

Ring of one slab height





Shielding inside vacuum insulated tubes

LSC (Laboratorio Subterráneo de Canfranc)

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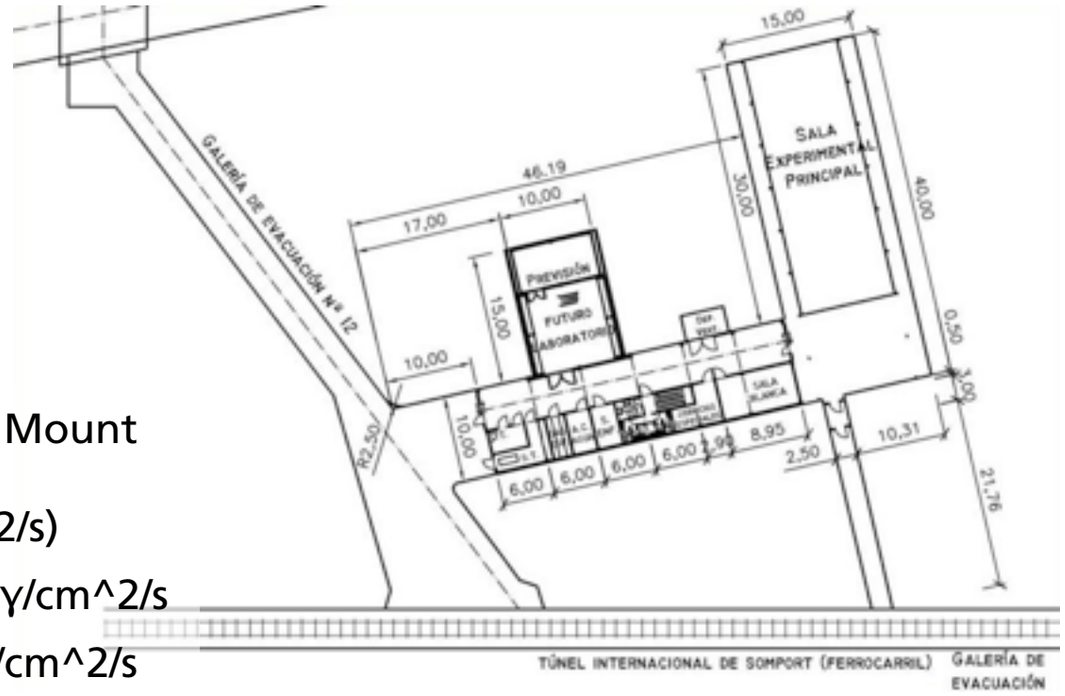
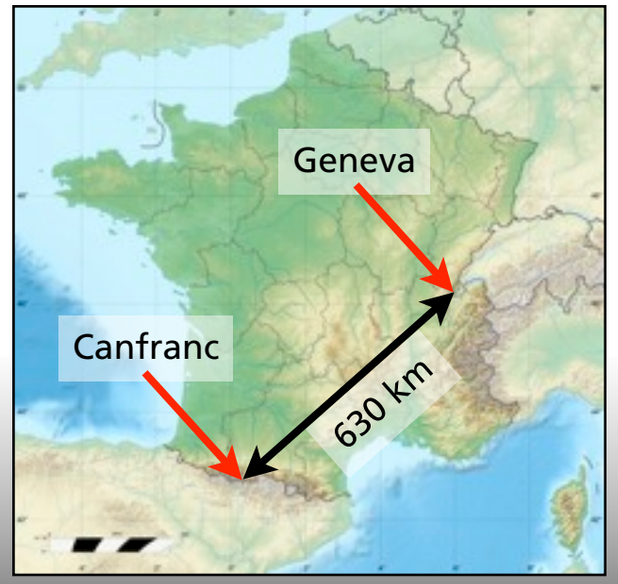
- Location: Somport tunnel between France and Spain
- Size of main hall: 40 × 15 × 10.5 m

- 850 m deep under the Mount Tobazo (~ 2500 m.w.e; μ flux ≈ 2x10–7 μ/cm^2/s)
- Gamma flux ≈ 2x10–2 γ/cm^2/s
- Neutron flux ≈ 10–6 n/cm^2/s
- Radon ≈ 50-100 Bq/m^3





Transport CERN --> LSC

Preparation in Geneva at CERN

All parts professionally packed and boxed

Truck arriving in the Spanish pyrenees

Transshipping from the big truck on smaller lorry to enter lab

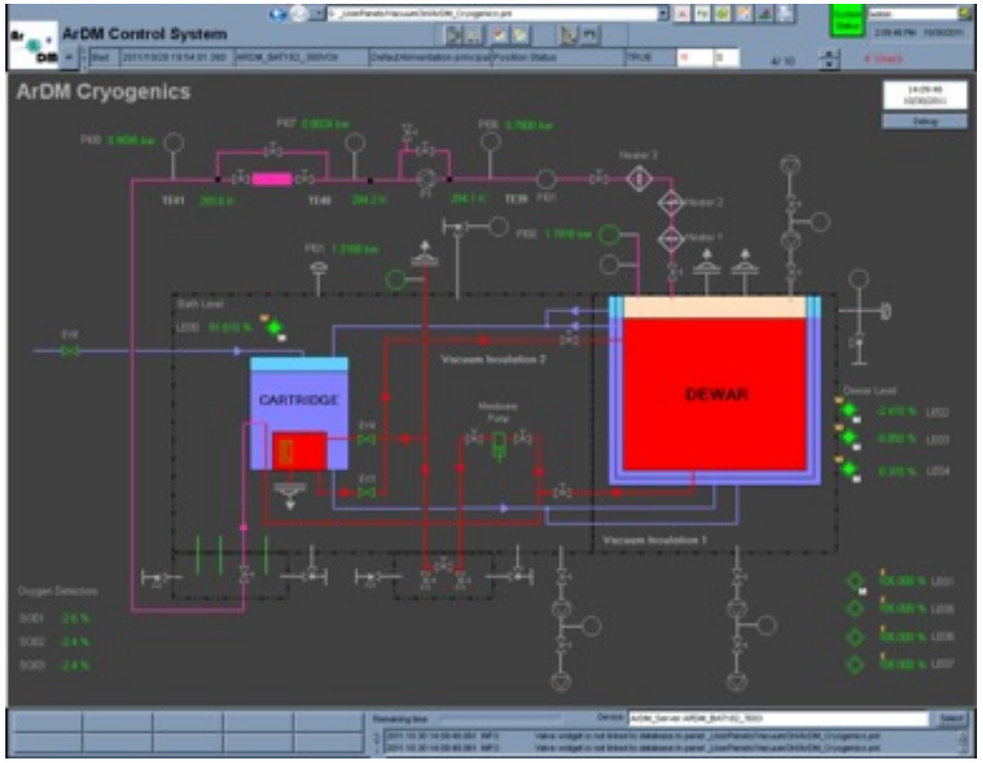
Arrival in the cavern

All boxes stored in the pool

Installation

- 10 days of hard work ...
- Main vessel and cryogenic hardware installed
- Commissioning of electronics and hardware ongoing

ArDM Control and Safety System

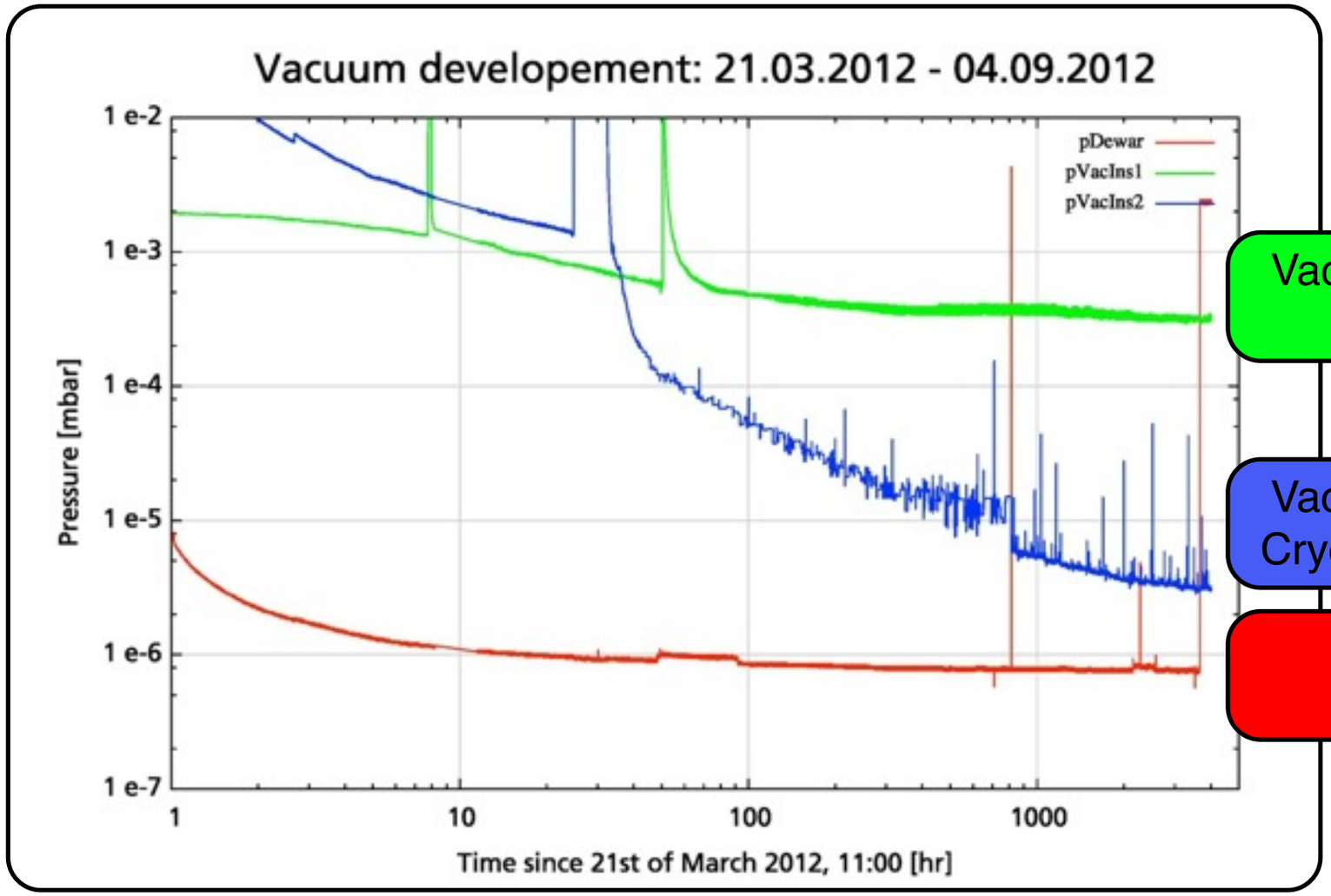


Remote desktop connection

Homepage (read only)

- Experiment is controlled by a Schneider PLC and PVSS software (industrial standard)
- The PLC monitors more than 100 sensors and controls more than 50 actuators
- Safe operation ensured by automatic regulation of the vacuum and cryogenic system
- There is the possibility to actively control the different parameters via remote desktop connection
- Automatic SMS and email alarms are sent in case of irregularities

Vacuum



Vacuum Insulation Cryostat

Vacuum Insulation Cryogenic Services

Cryostat

- Pumps are running since middle of March
- Vacuum is still improving
- No internal leaks detected
- Remote control / shift over the internet

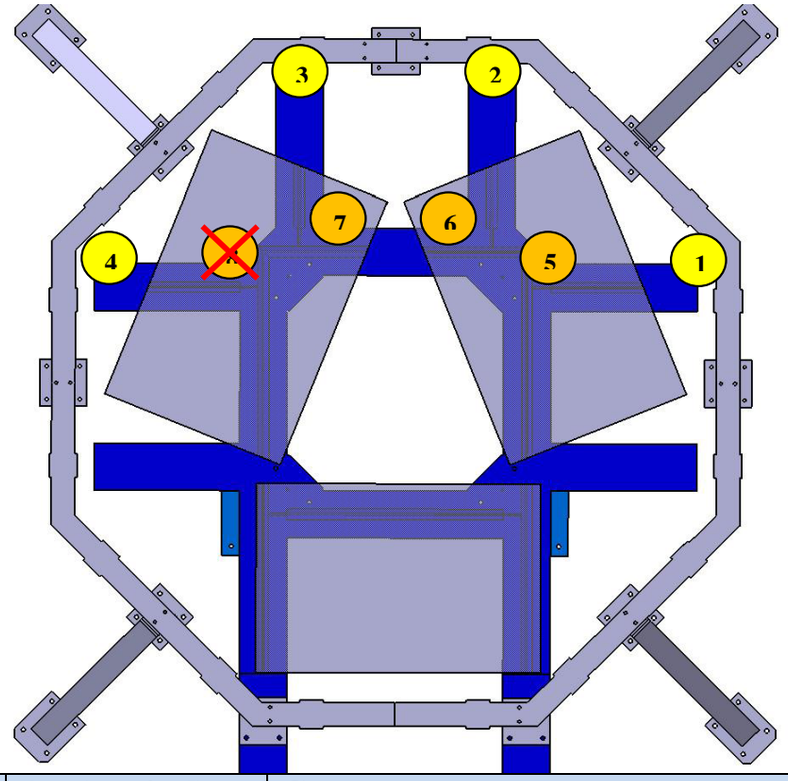
Conclusion

- Commissioning of the cryogenic setup finished by end of 2011 at CERN
- ArDM project played a fundamental role in developing and maintaining leadership of the group in the liquid argon detector technology
- Transfer and installation in the Canfranc underground lab finished in March 2012
- Commissioning at LSC ongoing (partly remote from CERN)
- New detector components are under construction and are to be tested at CERN
  - PMT coating is ongoing
  - Design of new PMT arrays finalized
  - Possibility of a new high voltage feedthrough under investigation
- Underground operation to be started as soon as possible (2013)


Thank you!

Backup:

Load test



Before mounting the detector, a load test has been done

~32 tons of led were mounted on platform

Main deformation comes from rubber soles between concrete ground and platform

Point Number	Δ x (vertical)	Comment
1	1.5 mm	1)Weight was not well centered, shifted in the direction of points (4) and (8) already noticed before measuring. 2) As shown in the picture pillars where we took measure are more stressed than the other two
2	2.03 mm	
3	3.06 mm	
4	3.0 mm	
5	1.1 mm	1) The deformation at the pillars is much smaller. 2) Considering the weight of the Shield and the Detector, the displacement at the pillars will be **less than 1 mm**
6	1.3 mm	
7	1.4 mm	
8	lost	

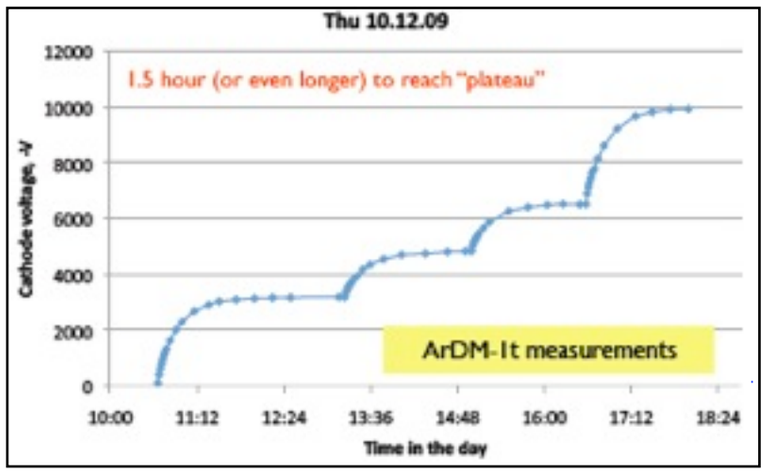
Precision of the survey: **+- 0.15 mm at the points (2), (3), (6) and (7)**
+- 0.2 mm for the point (1), (4), (5) and (8)

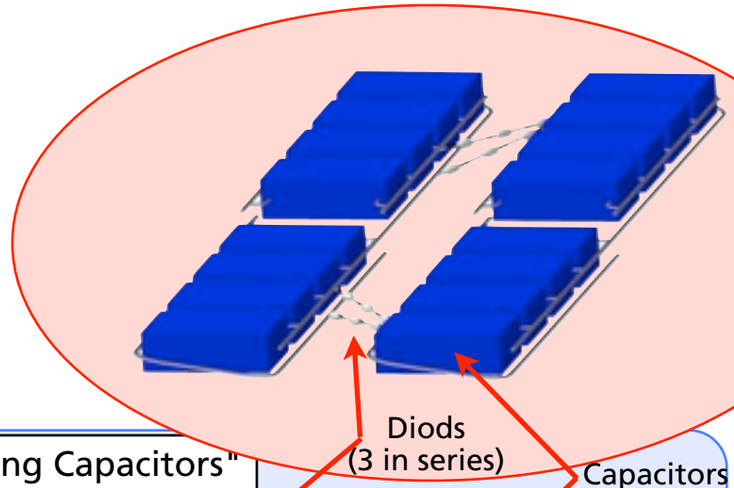
High voltage

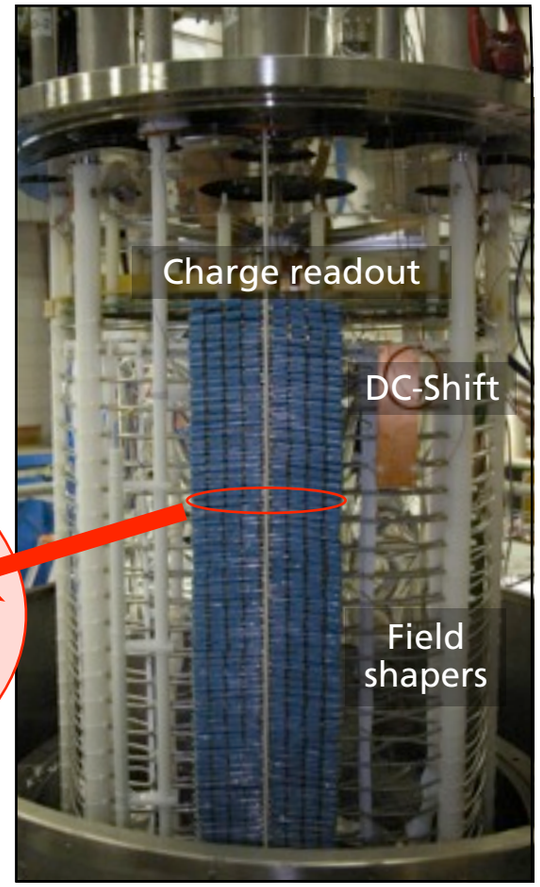
S. Horikawa et al., arXiv:1009.4908

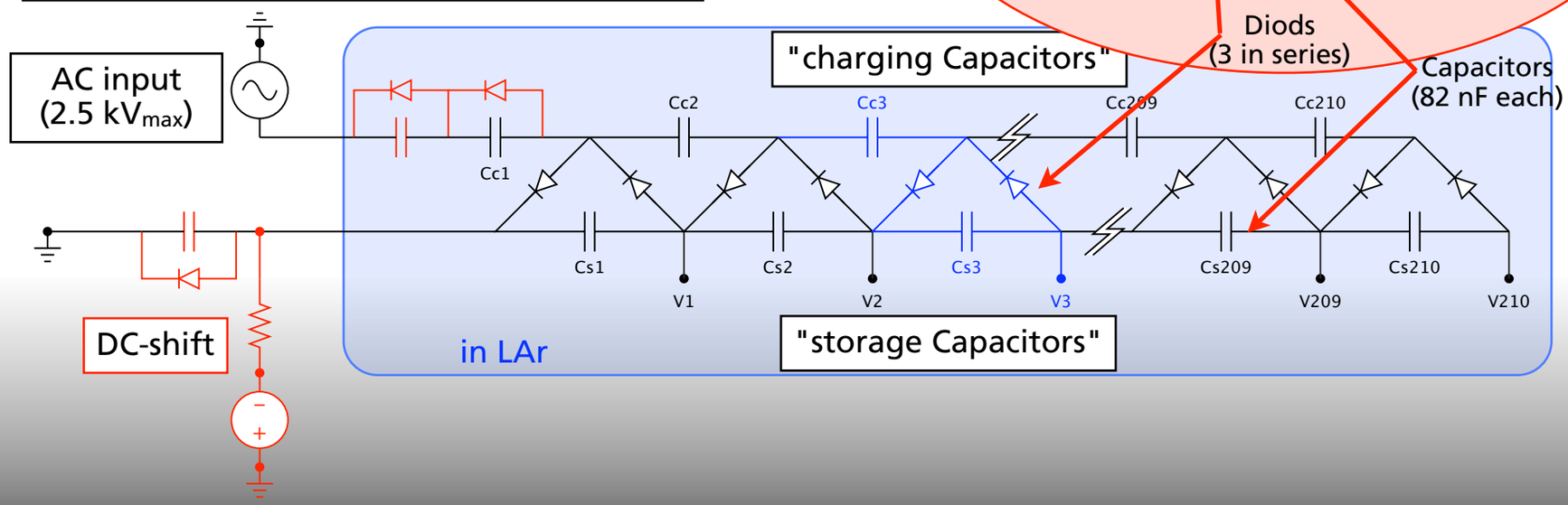
- Greinacher- / Cockcroft-Walton HV multiplier immersed in liquid argon (good insulator)
- 210 stages (1520 HV capacitors & 1260 avalanche diods)
- Low alternating input current (50 Hz; maximum $V_{pp(in)}$ ~ 2.5 kV)
- Ideally: $V_{out}(n)=n \times V_{in}$
- Starting voltage has to be negative
  - DC shift up to -8 kV possible

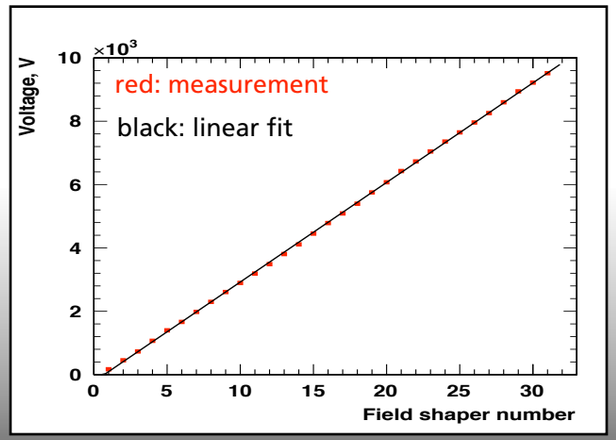
Tested up to 70 kV (600 V/cm)



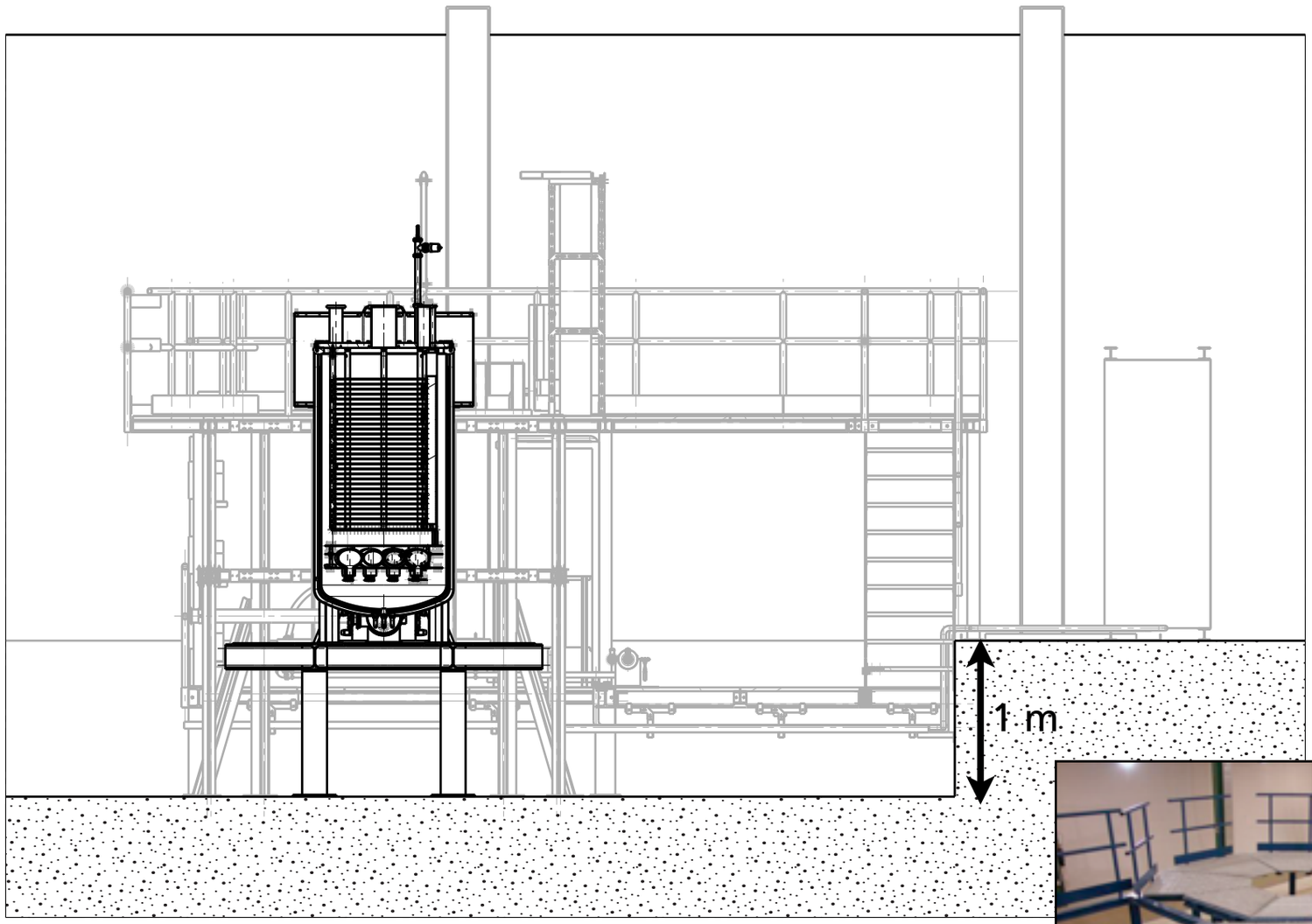








Platform



- For safety, ArDM is mounted on platform in "piscina"
- In case of spill, liquid argon is confined
- Floors of platform made with tramex grids
  - heavy argon gas "falls" in confinement pool
- Total volume of basin ~ 300 m^3
- Gas detection system to be installed

A self supporting structure has been built to host the experiment.

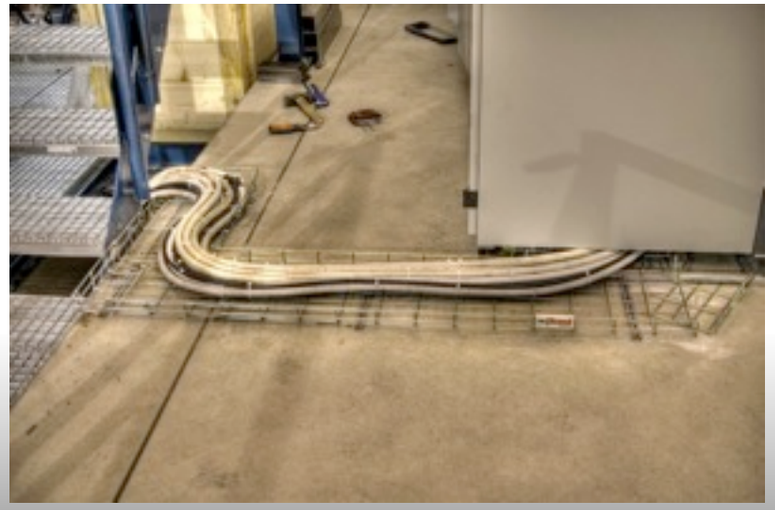
It provides space for all the services and also for a small workshop to assemble parts

The Slow Control System

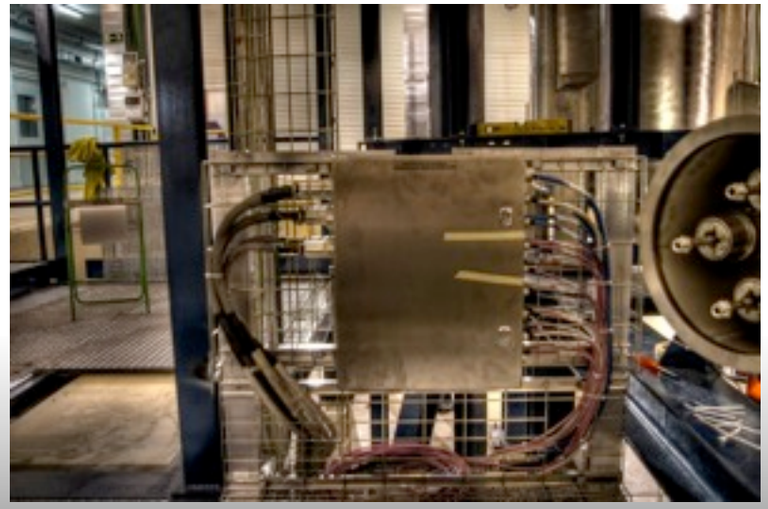
PLC Slow Control System

- The experiment is controlled by a PLC (Programmable Logic Controller) system using 5 standard racks
- 2 additional racks for DAQ and high voltage
- Everything assembled and debugged on surface at CERN
- Shipment in one piece to Spain
- Power- and signal distribution from PLC with a minimum amount of cables to 2 distribution boxes.
- Distribution to the sensors, pumps, ... from box beside the detector.

Each sensor, pump, ... connected



Connection of PLC - experiment with minimum amount of cabling



Signal cables are distributed through 2 boxes close to the detector