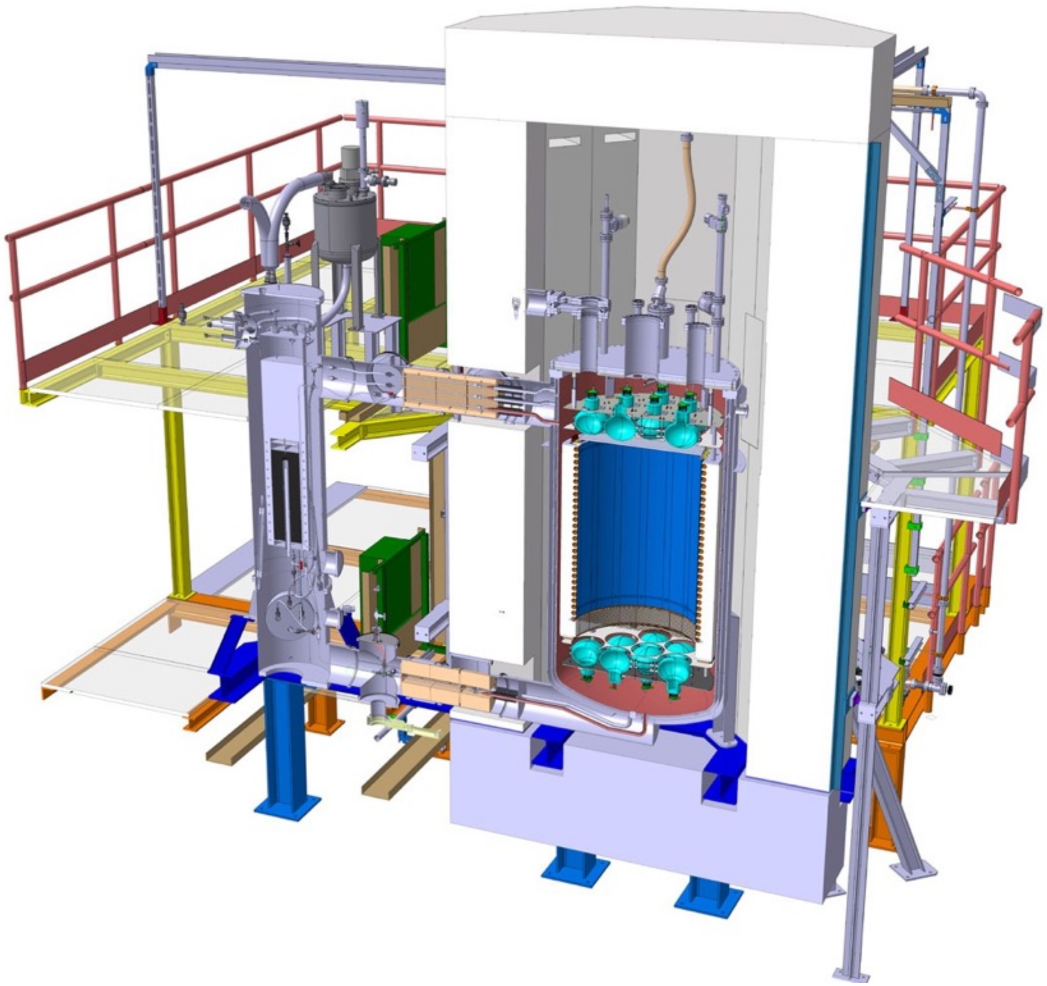
LSC EXP-08 ArDM Status Report



ETHZ led collaboration with CIEMAT, LSC, CERN and others

Christian Regenfus

ETHZ

(On behalf of the ArDM collaboration)

First ton scale LAr detector in operation

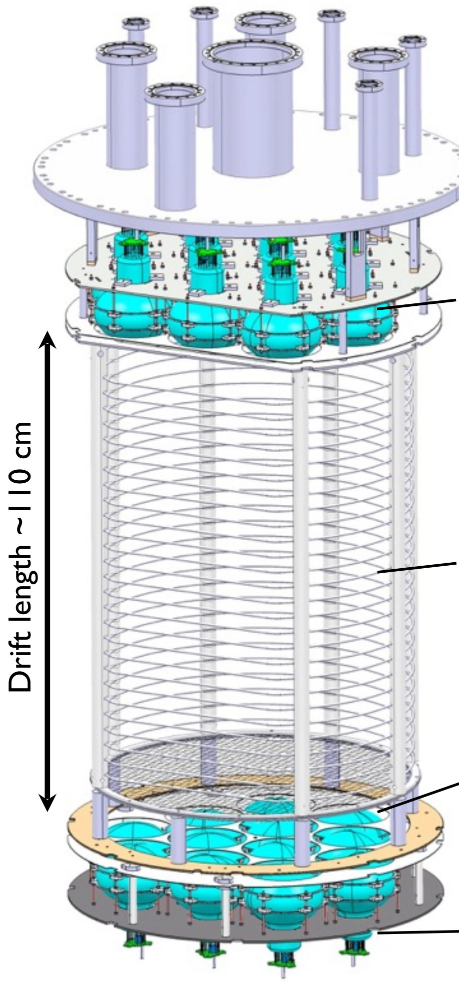
Exploring the low energy frontier of the LAr technology at the ton scale

Plan of the presentation

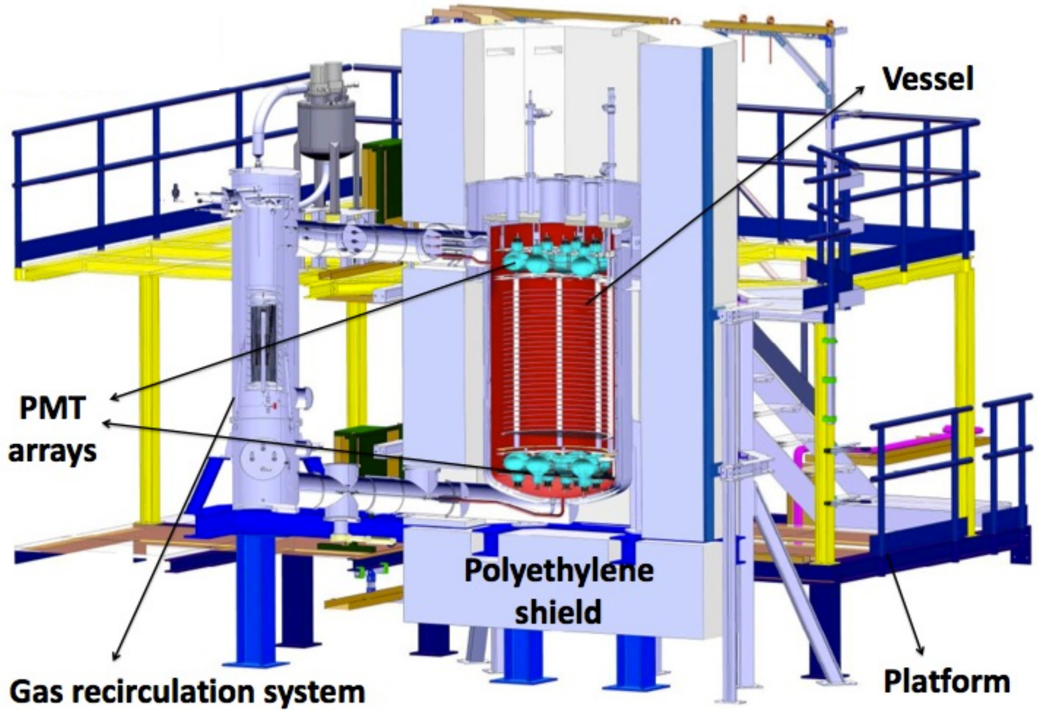
- Introduction
- Data analysis and simulation
  - High statistics analysis of Run I data
  - Assessment of α events
  - Pulse-shape discrimination analysis
  - Measurement of optical parameters
  - Evaluation of backgrounds from screening results
  - Expected sensitivity
- Hardware developments
  - New TPC drift cage, HV system
  - New radio-pure PMT bases
  - Measures to upgrade the LY
    - Replacement of TPB coated surfaces
    - Implementation of ITO coated windows
    - ICP-MS measurements
    - Design of a cold charcoal trap
- Future plans
  - Upgrade schedule and double phase runs
  - Opportunities for depleted argon
- Conclusions

ArDM in a nutshell

Total LAr mass: ~2t



Single phase setup 2015



- LAr mass: ~2t total, 850kg active, ~500kg fiducial
- Double phase, vertical TPC (0.1 – 1 kV/cm drift field)
- Cryogenic low radioactive 8” PMTs 12 + 12 (liquid and gas)
- Projected LY ~2pe / keV (@ LAr operation)
- Passive external neutron shield (~20t)
- Trigger rate / DAQ capability ~ kHz

Background recognition strategies:

- PSD and Ionization / scintillation ratio
- Localization: (fiducial volume, 3D imaging)
- Topology: (e.g. multiple elastic scatters from neutrons)

A.Rubbia J.Phys.Conf.Ser 39:129-132,2006.

Status of ArDM-1t: arXiv:1505.02443

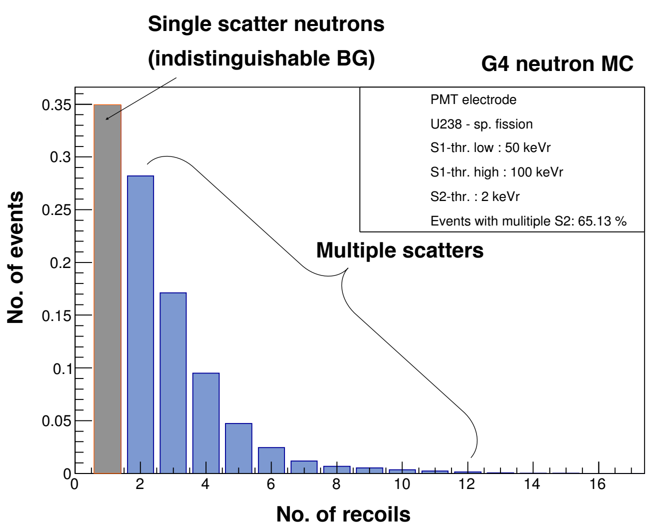
A ton scale LAr DM experiment

Expectations!

- Serious contribution to searches of higher mass WIMPs!
- Design parameters for LAr G2 and G3 future facilities!

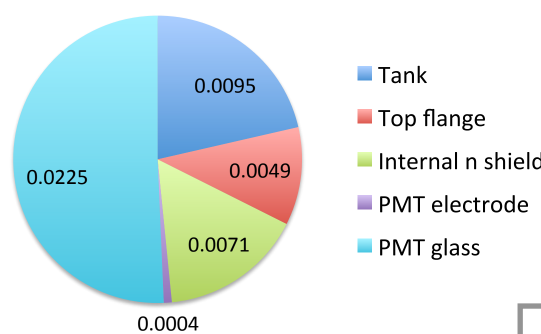
In the research focus:

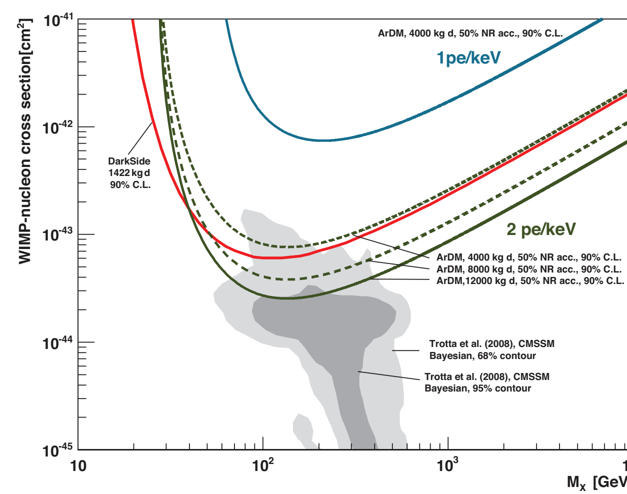
- DUV properties of large LAr targets
- Neutron interactions
- ^{39}Ar PSD studies
- Classification of depAr batches



1st task — verifying these points

Projected sensitivity for BG expectation of 0.045 n/d (MC)



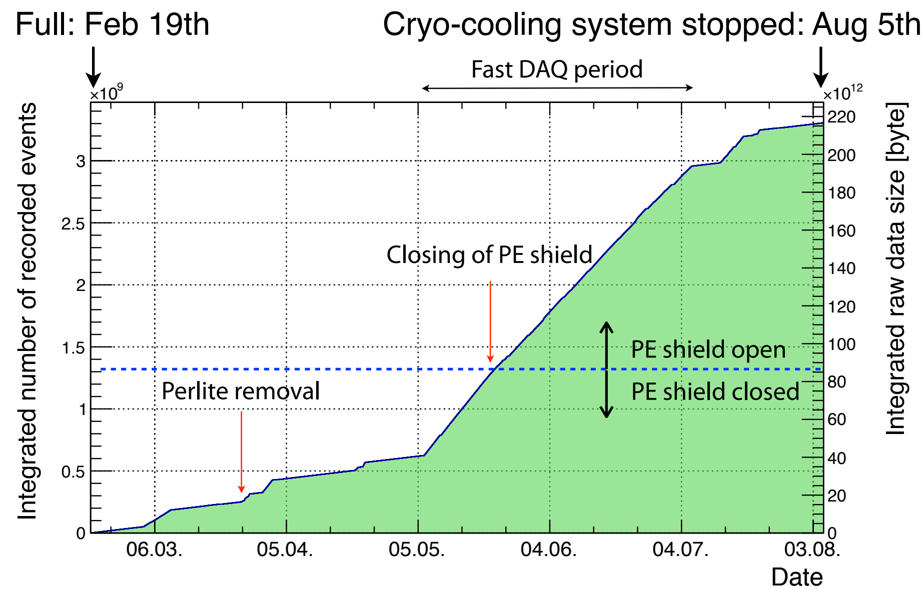


Experimental upgrades foreseen

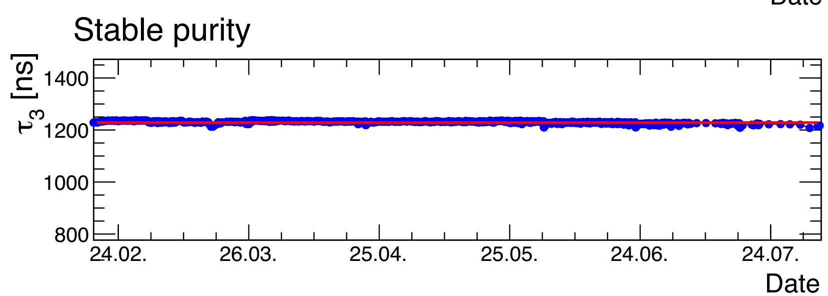
Operation of ArDM — Run I in single-phase LAr mode

Stable data taking over ~6 months — 3×10^9 triggers recorded to disk **2015**

Experiment at LSC (Canfranc / Spain)



Fully remotely controlled, e.g. from CERN



Trigger rate: 1.3–2.1 kHz , event size: 66 kB

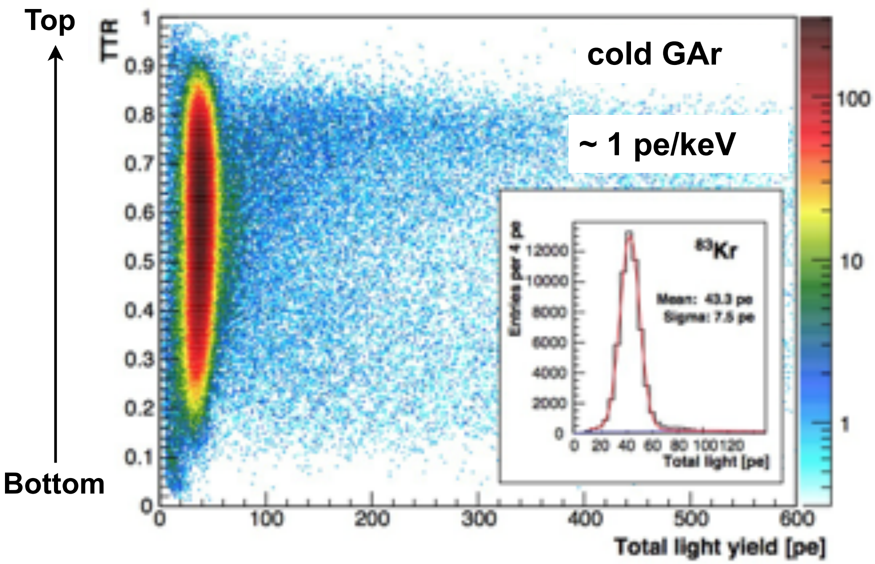
Safety: sophisticated PLC SC system

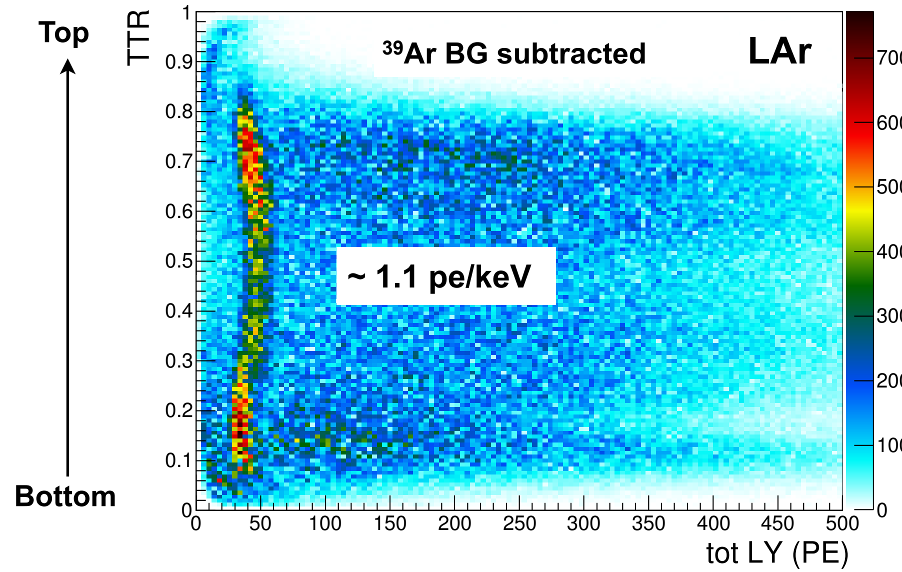
DAQ rate: 85–138 MB/s

3.3 billion triggers — 215 TB raw data

^{83}Kr signals — LY

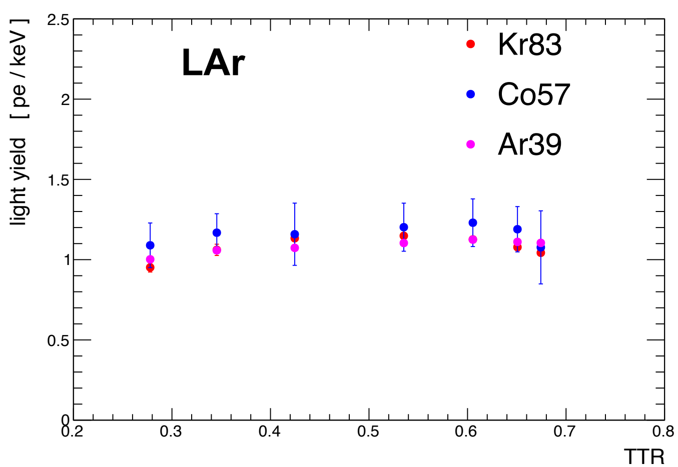
- main calibration tool
- well matched to ROI
- many features emerge





LAr: Expected 2 pe/keV

LY comparison [pe/keV]

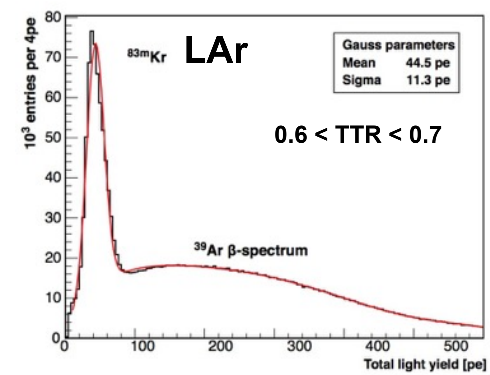


GAr

LY, width, uniformity OK

LAr :

LY lower
uniformity OK
width larger



LY and shapes: evidence for DUV absorption
ICP mass spectrometer analysis
=> conclusions for upgrade

Advances in software efforts

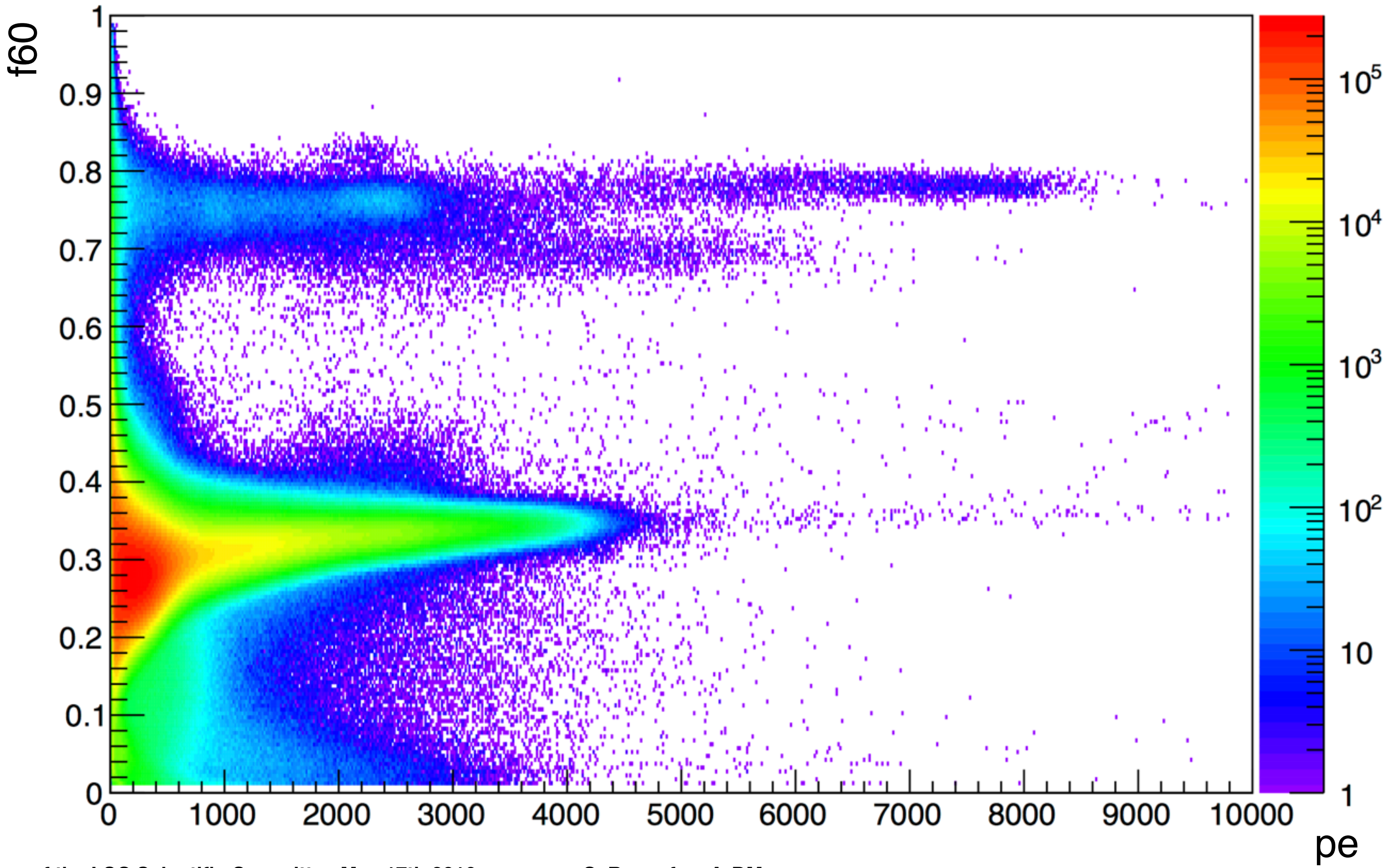
- High statistics analysis of Run I data
- Evolution of MC model
- Evaluating backgrounds from α and neutron events
- Pulse-shape discrimination analysis
- Preparation towards double phase running
- ArDM sensitivity

The full LAr target (850kg active)

Looking into one of the main features of LAr — PSD

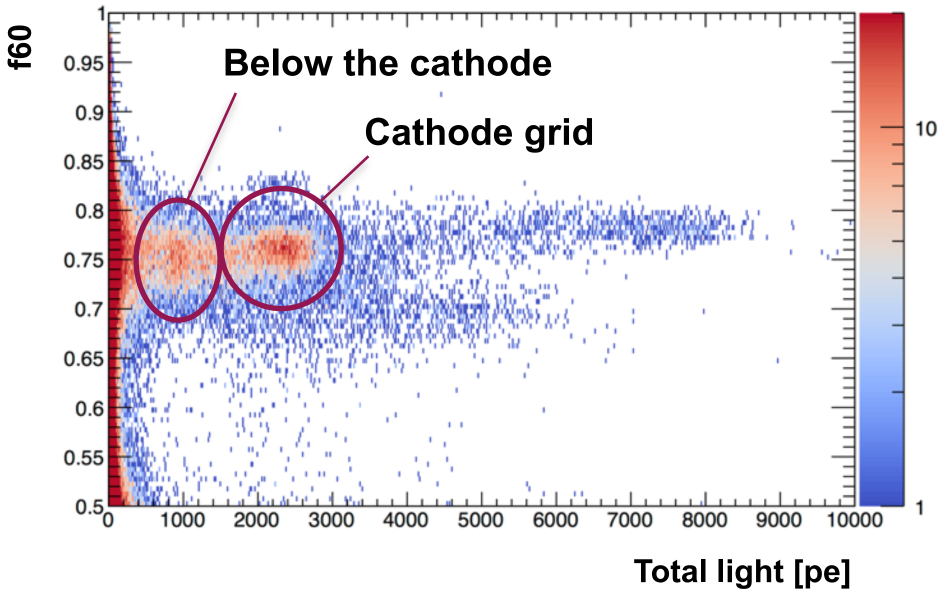
11 days data taking — 162M events plotted — no fiducial cuts

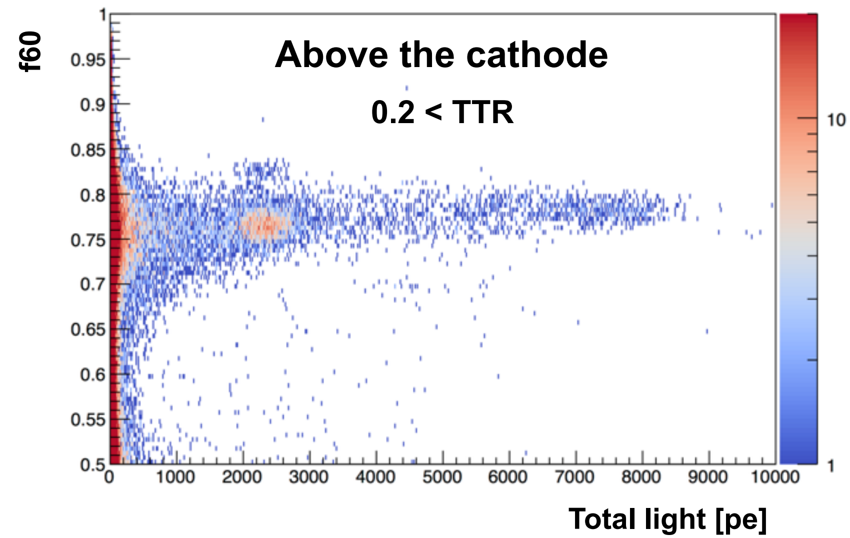
- **Basic quality cuts**
- **80% efficiency**
- **Mainly noise events**

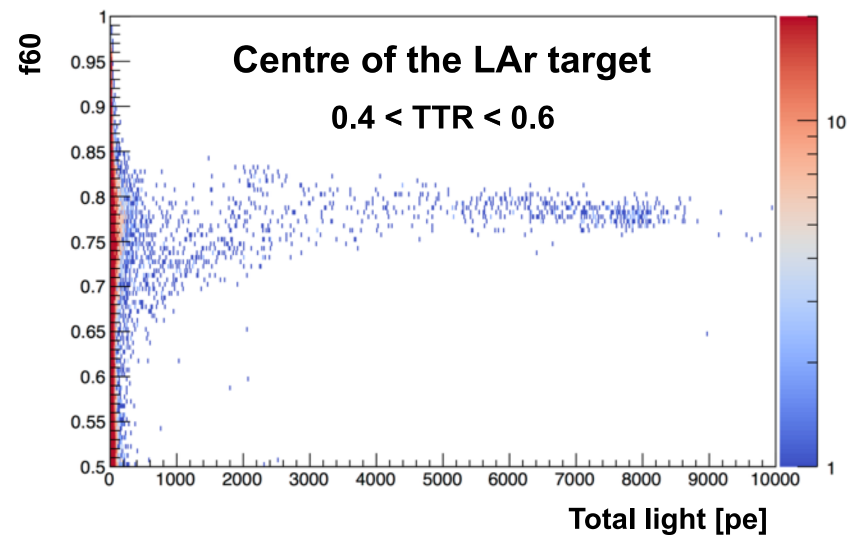


α events in more details

Emission points located far away from active volume !



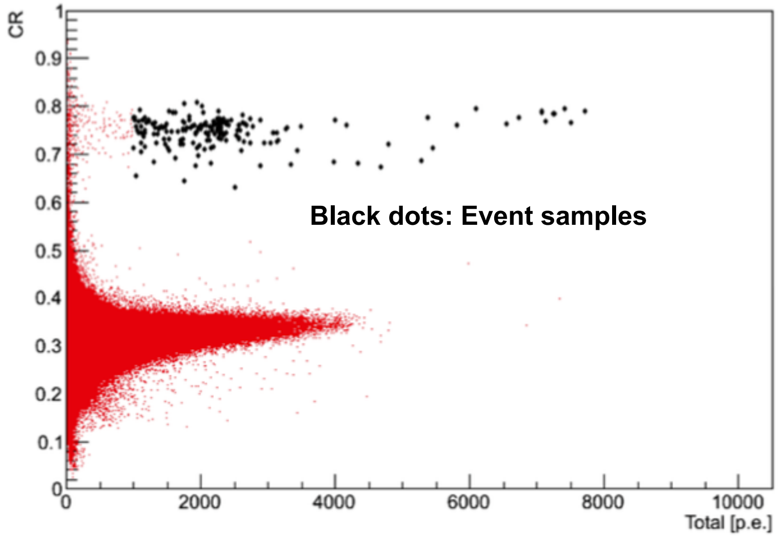


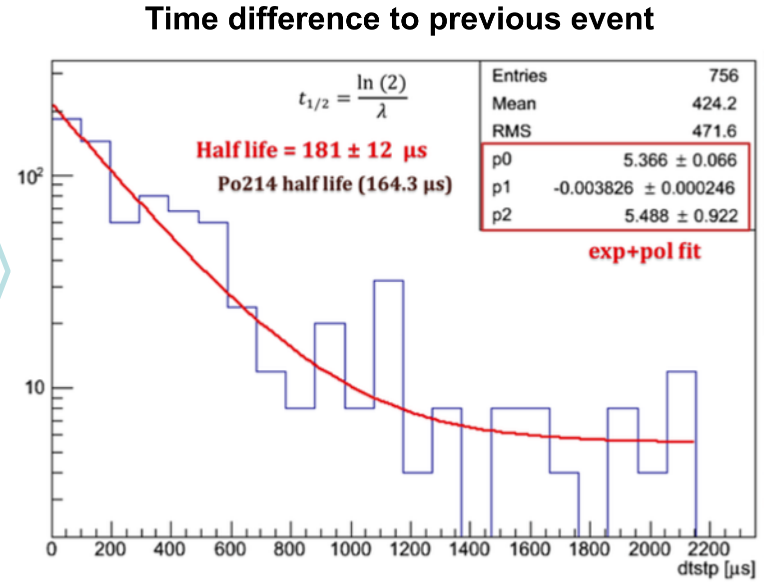


- Event rate of the order of a few Hz (entire spectrum)
- For typical energies of alphas (~5 MeV) the clusters show lower LY (<0.5 pe/keVee)
- Alphas frozen onto surfaces in corners
- Fiducialisation necessary (double phase)

Sources for α events

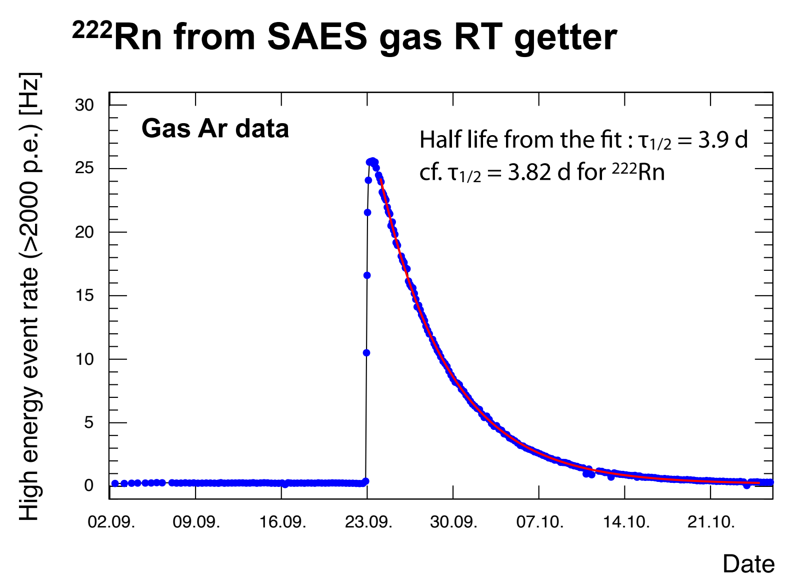
Bi-Po analysis





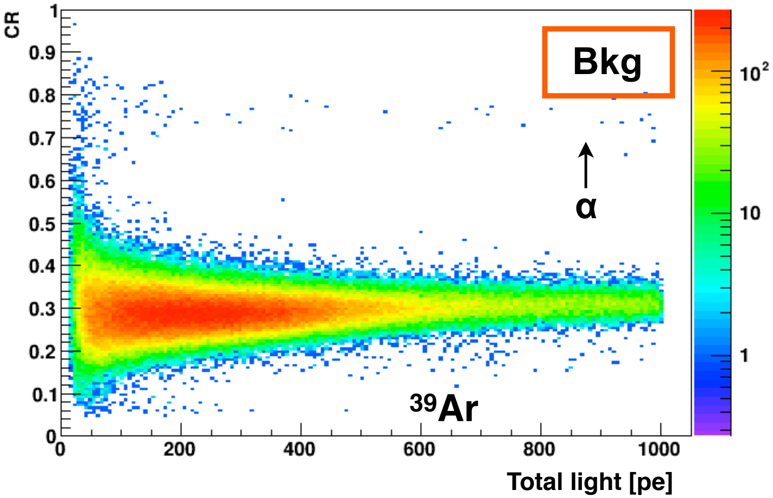
^{214}Bi	β	3.3 MeV	19.9 min
^{214}Po	α	**7.8 MeV**	**164.3 μs**

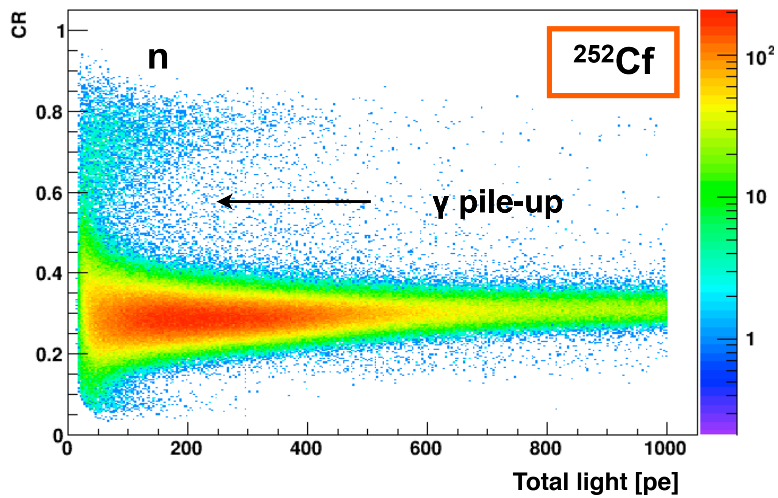
- **Evidence of ^{214}Po**
- **Low light yield (<0.5 pe/keVee)**



PSD with a ton scale target

Nuclear recoils (NR) induced by neutrons from the ^{252}Cf source detected in ArDM

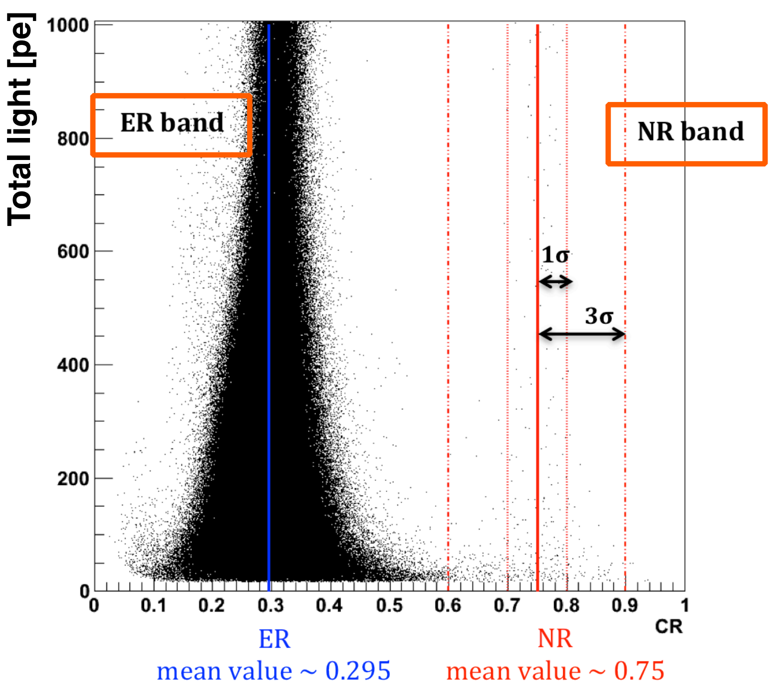


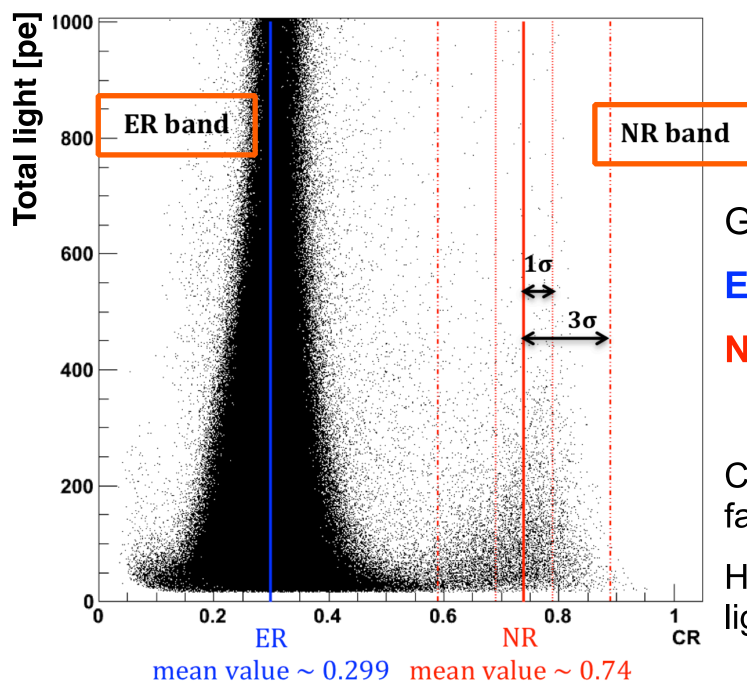


Two populations of events

NR: nuclear recoils

ER: electron recoils





Global mean of CR

ER: CR ~ 0.3

NR: CR ~ 0.7

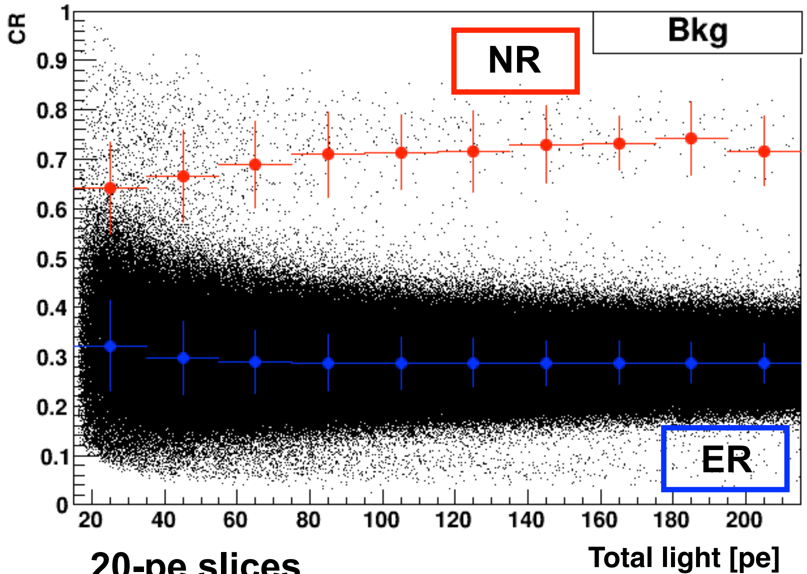
CR: component ratio (= fast light/total light)

Here CR = f90, i.e. fast light window = 90 ns

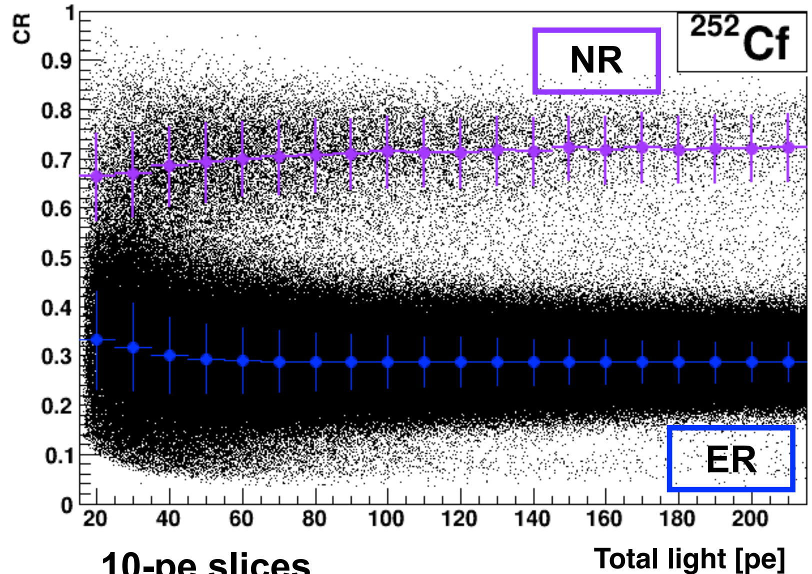
NR and ER range in light signal slices

Mean & σ (Gaussian fit) in light signal slices

in the range 0–200 pe

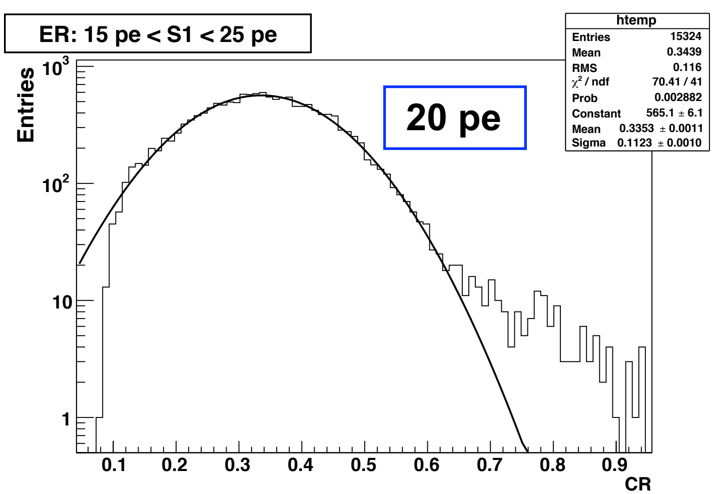


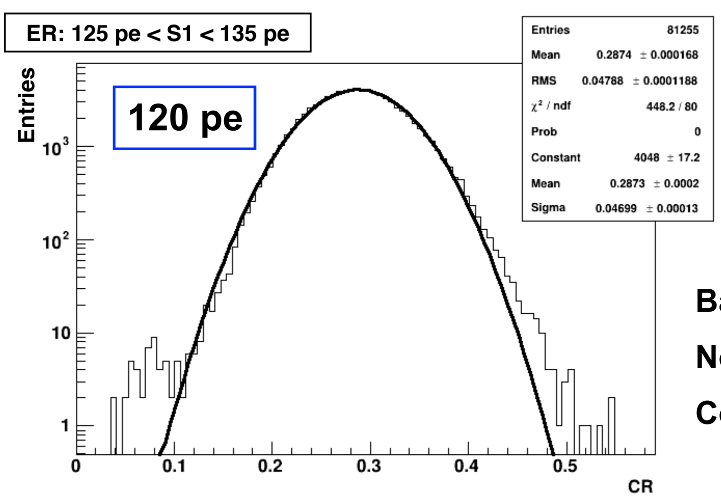
20-pe slices



10-pe slices

Gaussian fit in slices (ER band, ^{252}Cf)





Basically no cuts

No fiducialisation

Conform with gaussian PDF

ER rejection power

Band separation L_{ER}

$$L_{\mathrm{ER}} = \frac{m_{\mathrm{NR}} - N\sigma_{\mathrm{NR}} - m_{\mathrm{ER}}}{\sigma_{\mathrm{ER}}}$$

$m_{\mathrm{ER}}, m_{\mathrm{NR}}$: mean

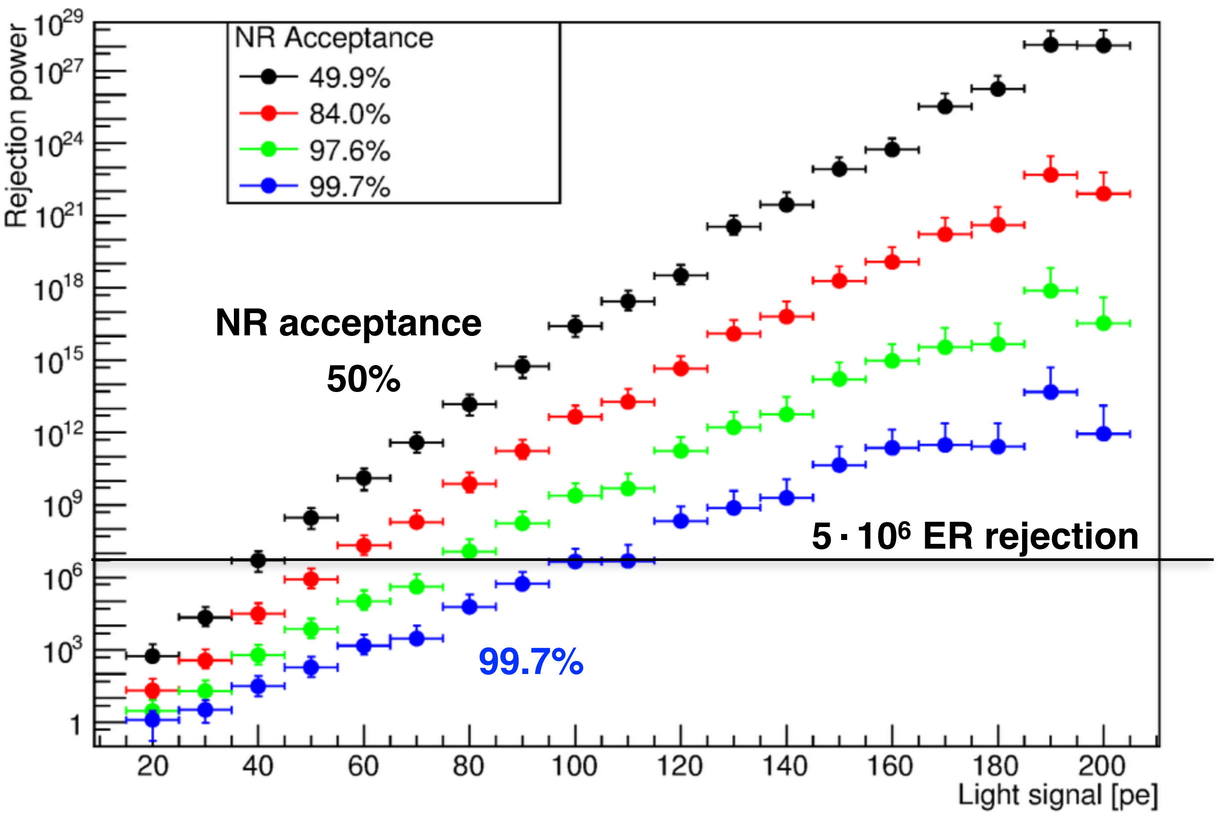
$\sigma_{\mathrm{ER}}, \sigma_{\mathrm{NR}}$: standard deviation

} Gaussian fit

NR signal region : $[m_{\mathrm{NR}} - N\sigma_{\mathrm{NR}}, m_{\mathrm{NR}} + 3\sigma_{\mathrm{NR}}],\ N = 3, 2, 1, 0$

ER leakage probability (P_{L}) **:** calculated from Gaussian

Rejection power : $1/P_{\mathrm{L}}$



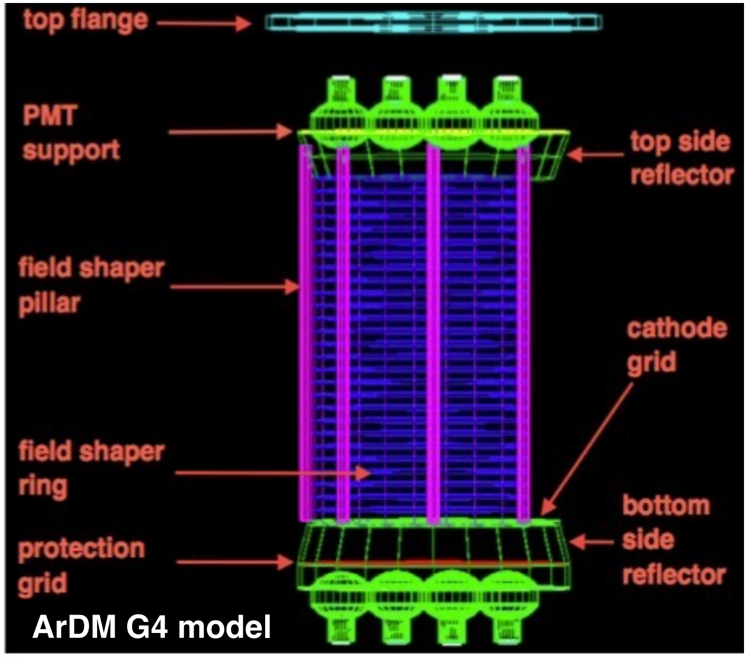
High ER rejection power if light signal is large

Strongly dependent on the light signal, also on the desired NR acceptance

First demonstration of high background rejection by PSD at a ton-scale

MC efforts

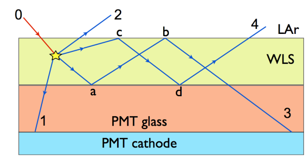
Detector simulation developed and tuned with data of Run I



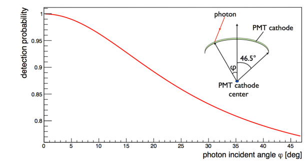
- **MC data fully digitized**
- **Same reconstruction and analysis framework**
- **MC is in a good agreement with data, typically to better 10%**
- **Main features are reproduced**

- **Full optical photon ray tracing for DUV (scintillation) and visible (wave shifted) light**

TPB surfaces



Angular effects

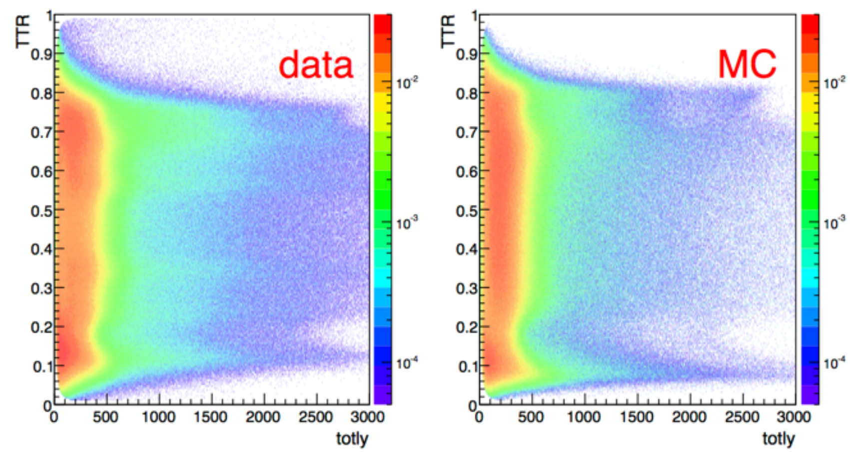


- **Optical parameters tuned to data**

  (scatt. length, absorption, refl. coefficients)

TTR vs TotLY

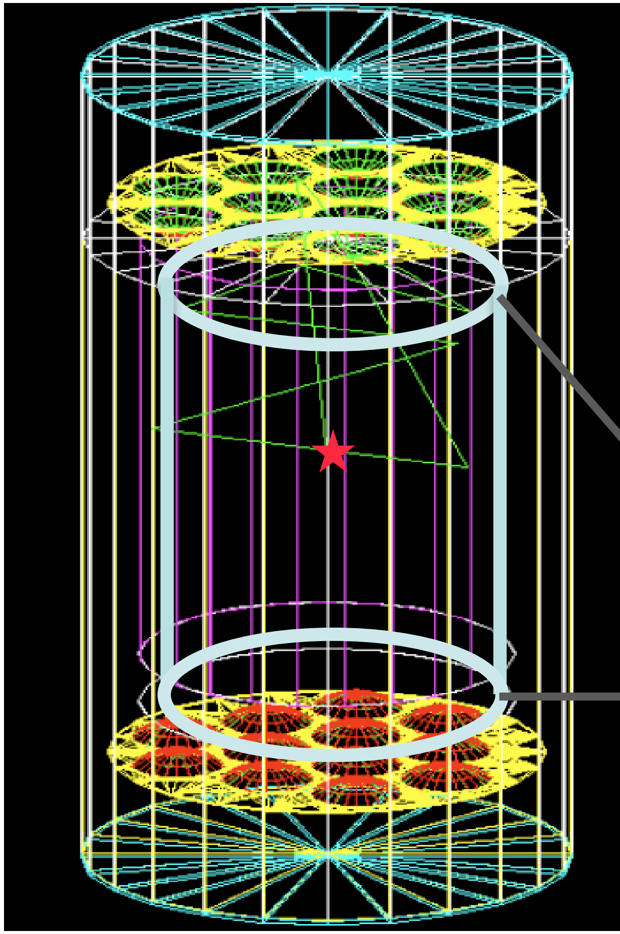
Containing all known BGs



Screening results used for e-like and n-like MC to estimate backgrounds

Description of the LY by a few parameters

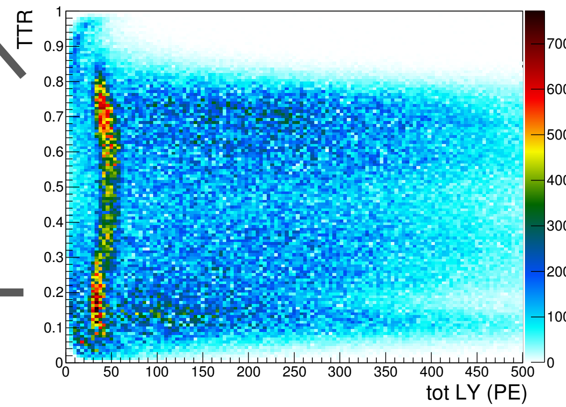
Light diffusion cell design



2 parameters most important

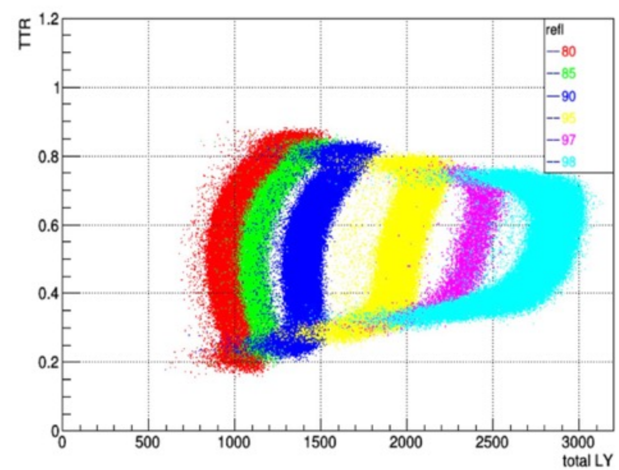
128nm   420nm

- **VUV absorption (λ_{VUVAbs}) and reflection factor ($\mathcal{R}$)**
- **Scattering (Raleigh) less important**
- **λ_{VUVAbs} and $\mathcal{R}$ anti correlated**
- **Main features are reproduced**



Gas data simulation (α)

Variation of $\mathcal{R}$



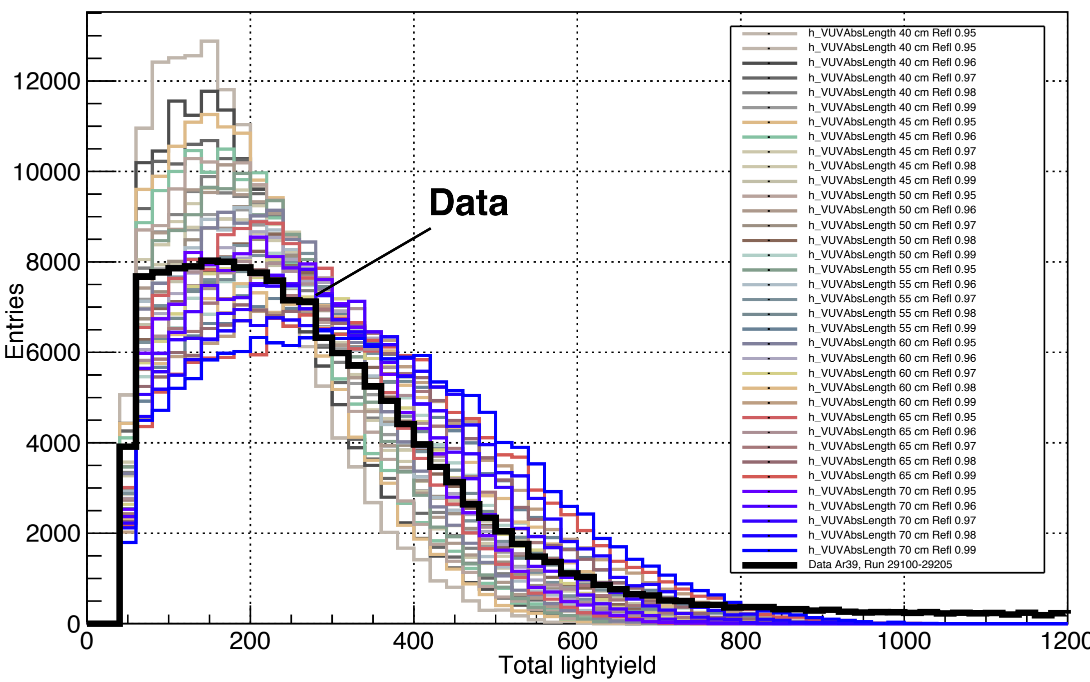
Light yield highest in the center — need large $\mathcal{R}$ => λ_{VUVAbs} must be short

More evidence from Co data (3σ) ……..

Scanning λ_{VUV} and $\mathcal{R}$

Optical parameters of the detector a priori not known

- **Most important parameters: VUV light attenuation length in LAr, reflectivity of the reflector foil**
- **Data suggested attenuation of VUV light attenuation in LAr of ~50 cm**
- **Generated Geant4 MC templates by scanning the parameters in the range**
- **VUVAbsL = [40cm,70cm], Refl = [83%, 99%]**
- **Bayesian fit was used to evaluate the best parameters matching LY to data**



Data probability function (constructed with MC):

$$P(\vec{D}|\vec{\lambda}) = \prod_i \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(y_i - f(x_i;\vec{\lambda}))^2}{2\sigma^2}}$$

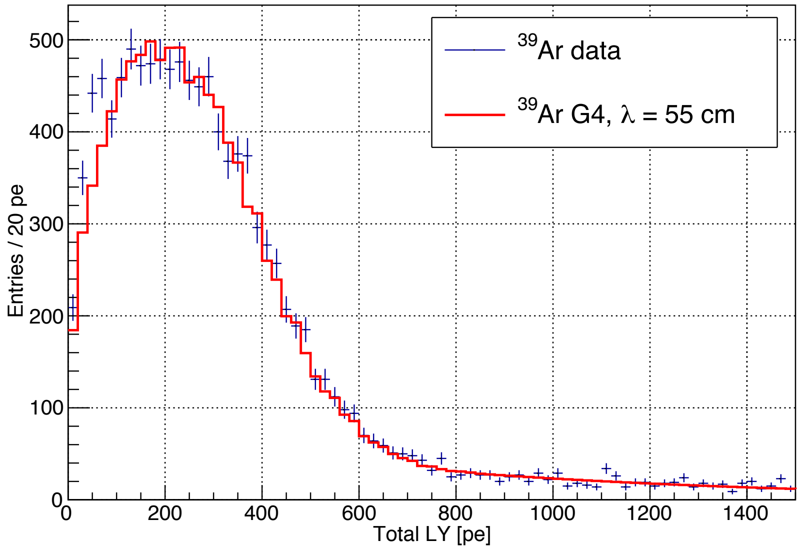
MC prediction + exponential background:

$$f(x_i;\vec{\lambda}) = A \cdot g(x_i;\lambda_{VUV}, R) + e^{(B+C\cdot x_i)}$$

Bayesian analysis

=> find $P(\vec{\lambda}|\vec{D})$ using flat priors

Bayesian analysis results



Best parameters found:

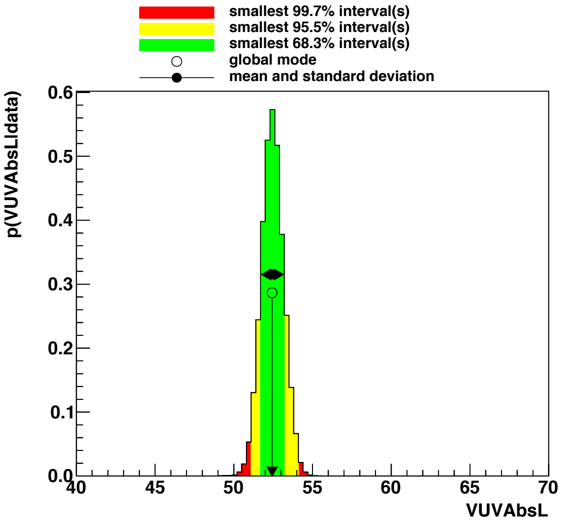
- **VUVAbsL ≈ 58 cm, Reflectivity ≈ 97%**

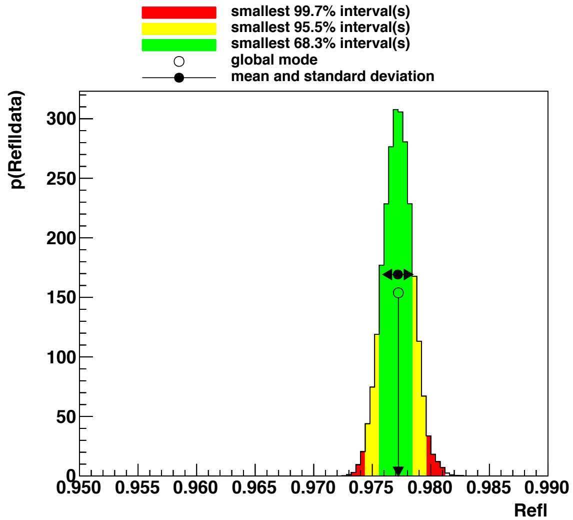
Explore systematics:

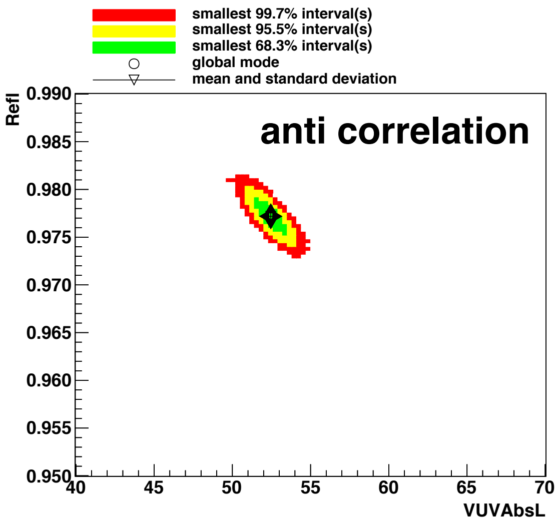
LY threshold and LY scale variation:

Parameter	Light yield threshold	Light yield scale
VUV abs. length, $\lambda_{\mathrm{VUVAbs}}$	51.7 cm - 66.8 cm	66.8 cm - 48.5 cm
Reflectivity, $\mathcal{R}$	97.5 % - 95.6 %	96.7 % - 96.5 %

Posterior probabilities after marginalizing over the other parameters







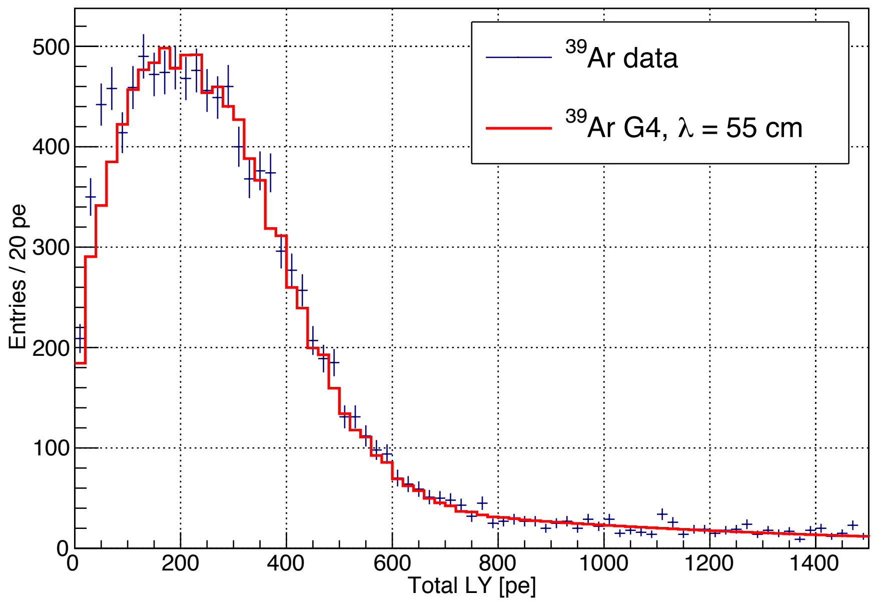
Impact of long attenuation length on LY

Most important parameters:

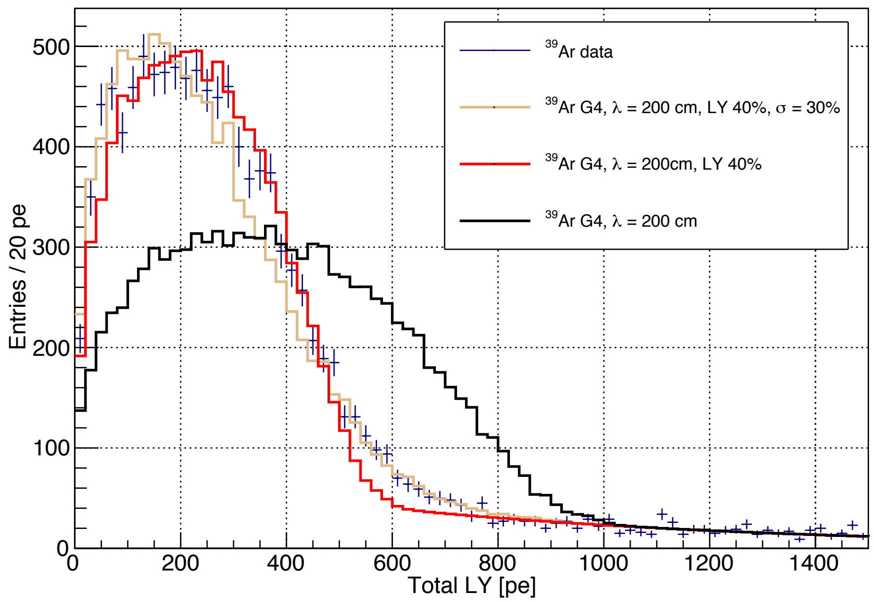
- **VUV light attenuation length in LAr (λ_{VUVAbs}), and reflectivity of the reflector foil ($\mathcal{R}$)**

- **Assuming λ_{VUVAbs} = 200 cm produces light yield a factor of 2 larger than in data**
- **Need to scale LY by 40% to reach similar light yield as in data**
- **Need additional 30% smearing to come close — <u>no match of MC and data</u>**
- **Best agreement achieved with $\lambda_{VUVAbs} \approx$ 55 cm**

Best parameters set



Set λ_{VUVAbs} to 200cm

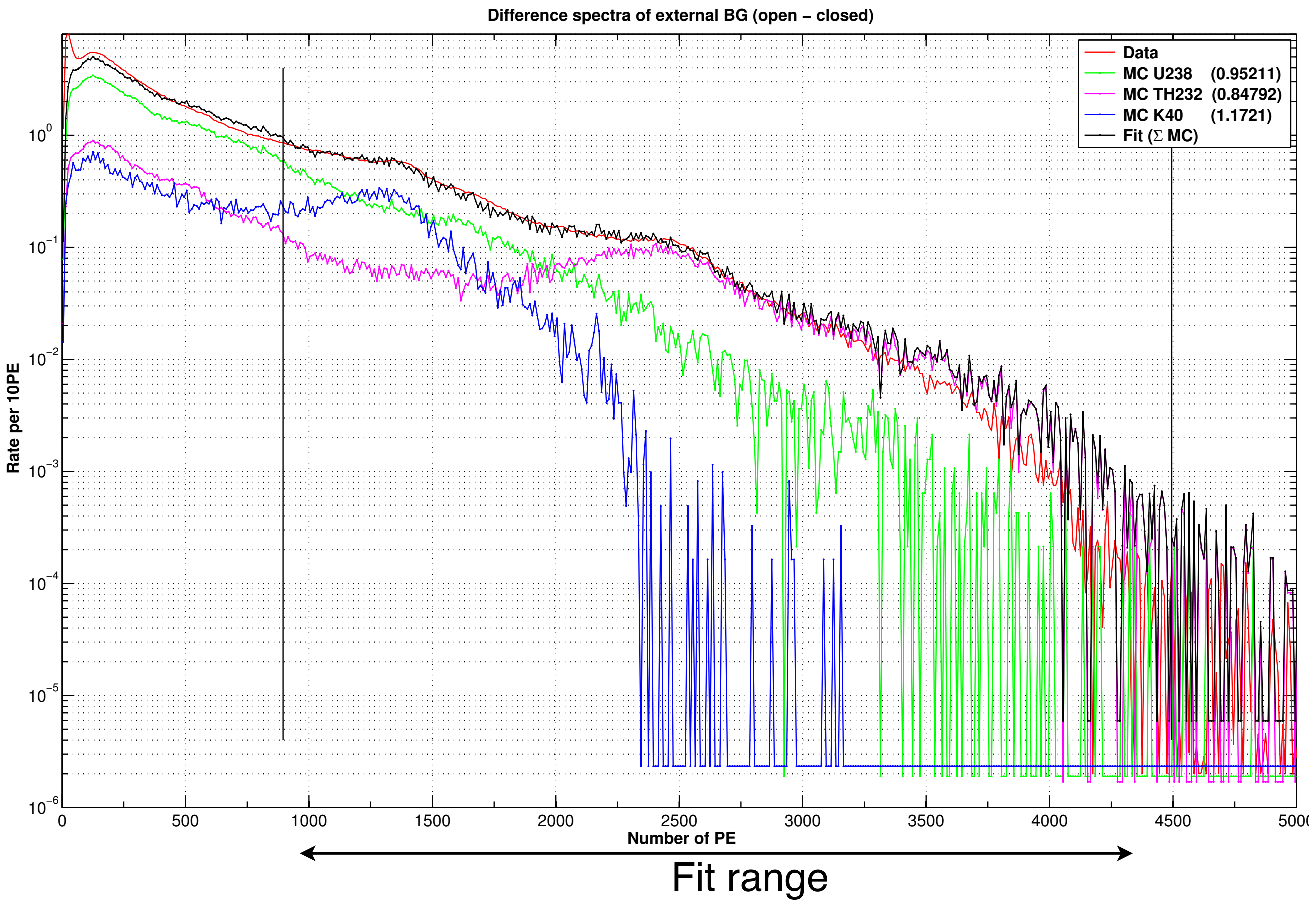


Verification of parameter scan is ongoing with Kr data

Exploring external γ backgrounds

Data from open — close top cover (difference spectrum)

Spectrum well described by ^{238}U, ^{232}Th and ^{40}K contributions



Large target feature:

Self-shielding

Spectrum extends into higher energy range

(mult. γ absorption)

Estimate comparable with LSC parameters (Ge measurement)

A. Bettini, Eur. Phys. J. Plus 127 (2012) 112.

	U-238	Th-232	K-40	Total
LSC	0.68 ± 0.17 cm^{-2} s^{-1}	0.38 ± 0.02 cm^{-2} s^{-1}	0.17 ± 0.03 cm^{-2} s^{-1}	1.23 ± 0.17 cm^{-2} s^{-1}
ArDM	0.659 cm^{-2} s^{-1}	0.146 cm^{-2} s^{-1}	0.036 cm^{-2} s^{-1}	0.806 cm^{-2} s^{-1}

Screening results

Detector components screened using HPGe at LSC

Screened components

Sample	Description	Mass [kg]	Time [d]
PMT glass	PMT – low radioactive glass (LRI)	0.7467	45
PMT metal	PMT – Internal electrodes (metal)	0.197	49
PMT base	FR-4 boards – PMT bases	0.0366	50
SS struct	Stainless steel – PMT support	2.077	62
SS clamp	Stainless steel – PMT clamps	0.2216	36
SS rod	Stainless steel – threaded rods	0.0606	62
PE clamp	HDPE - PMT clamps	0.0632	57
PE shield	External HDPE – Neutron shield	0.8378	33
HVres	Ceramic HV resistors	0.2427	21
Perlite	Perlite isolation material	0.1163	45

Results Secular equilibrium assumed for U and Th chains

Sample	^{238}U [ppb]	^{235}U [ppb]	^{232}Th [ppb]	^{40}K [ppb]	^{60}Co [kru]
PMT glass	51.7±0.3	0.70±0.02	28.3±0.5	1.7±0.07	<0.2
PMT metal	14.7±0.3	0.71±0.04	18.4±0.7	12±0.4	–
PMT base	746±1	9.0±0.1	2720±10	64±0.7	–
SS struct	0.257±0.002	<0.05	1.57±0.01	<0.04	1.24±0.01
SS clamp	<0.6	1.0±0.3	<3	<0.1	2.0±0.2
SS rod	<2	1.18±0.08	<6	0.18±0.01	0.76±0.02
PE clamp	2.85±0.05	<0.2	23.3±0.6	0.3±0.07	<0.5
PE shield	0.34±0.06	<0.03	2.41±0.03	0.06±0.01	<0.06
HVres	118±1	1.92±0.02	466±1	6.7±0.06	–
Perlite	3650±20	61±1	13000±100	3400±47	–

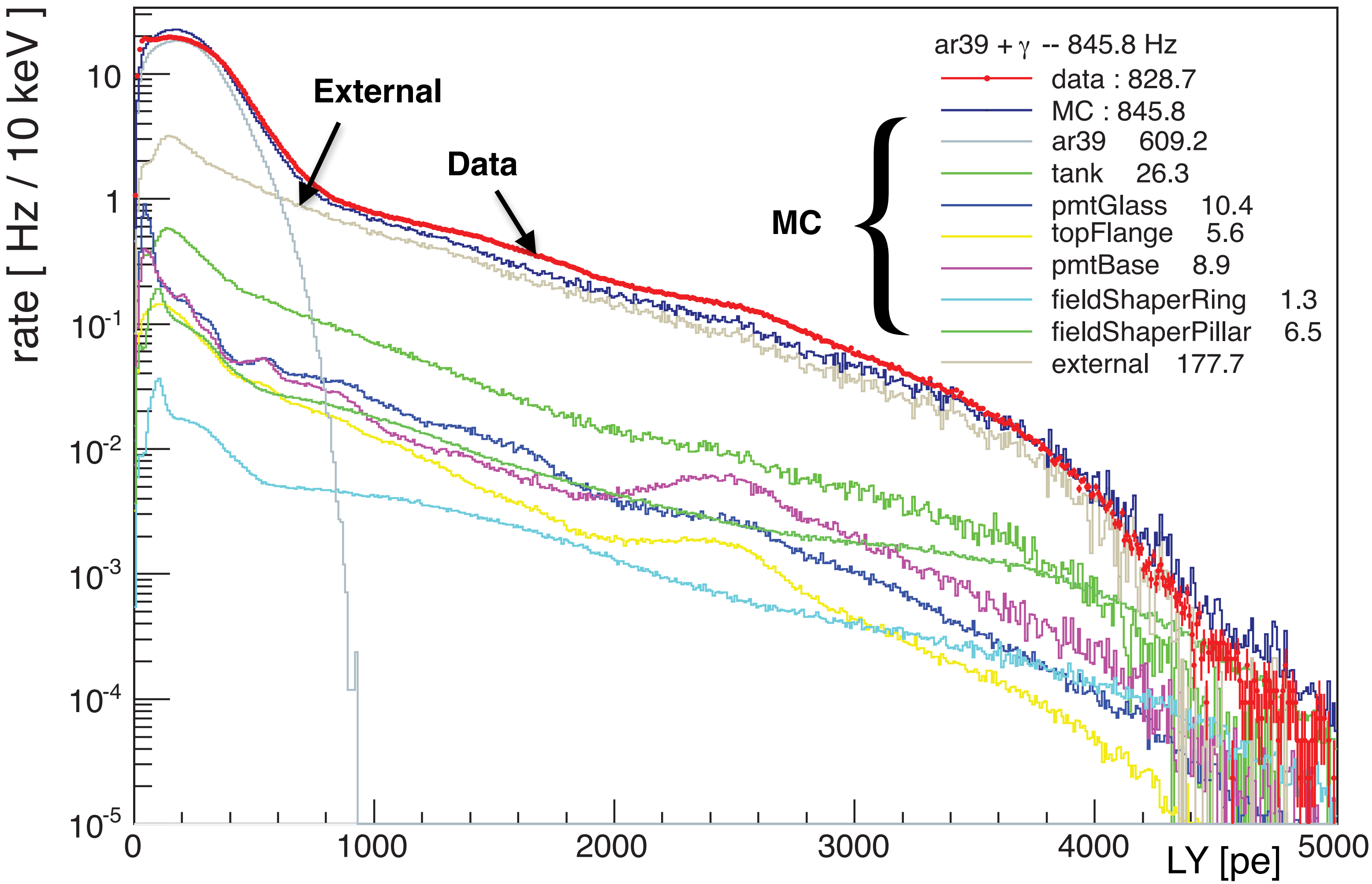
Most dirty material will be replaced for Run II

Thanks to Iulian !!

e - like spectra

Based on MC response from screening

no Fit !



850 Hz
- **73% ^{39}Ar**
- **21% external**
- **6% internal**

850 kg LAr target (~ 610L) — no fiducial cuts

Data well described by normalized MC spectra based on the material screening results + external BG

validates our low BG goals

Internal neutron background simulation

- Screening results verified
- External γ flux understood

} BG sources under control

Neutron BG simulation – in view of next runs

New detector configurations

- Internal neutron shield (Borotron)
- New PMT bases with radio pure material
- HV resistors also radio pure
- PMMA windows

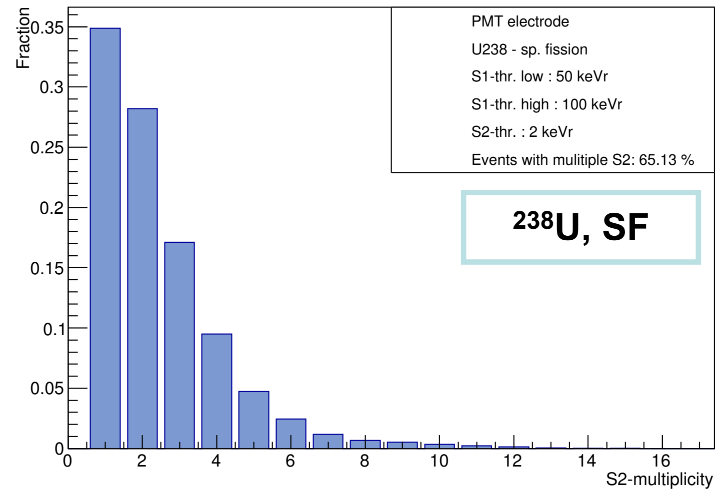
1M neutron events generated for each combination :

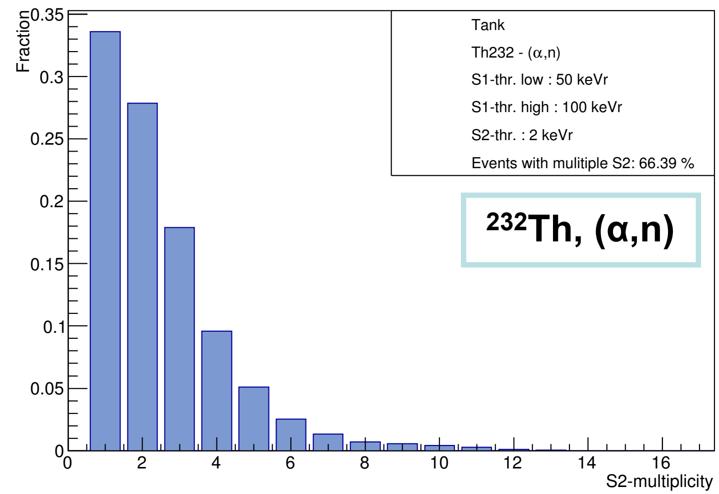
(detector component) × (isotope) × (emission type)

Four cuts applied to the generated n events

- Fiducial cut : FV with 483 kg target mass
- Inelastic scattering cut : accompanying γ's
- Energy cut : $50 < E_r < 100$ keV$_{nr}$
- S2-multiplicity cut : multiple scatter n's

n elastic scattering multiplicity





60% undergoe >1 elastic scatter in ROI

Irreducible neutron background rate

Remaining neutron events after the cuts are identified as "irreducible"

- **Irreducible rate =**

  irreducible fraction (MC) × neutron production rate from each component

Neutron production rate — **computed using SOURCES4C**

Det. comp.	cont. [ppb] ^{238}U	cont. [ppb] ^{232}Th	Volume [cm^3]	neutron rate [n/s/cm^3/ppb] ^{238}U sft	^{238}U ant	^{232}Th sft	^{232}Th ant
Tank	3.87	4.40	144566	1.1×10^{-10}	3.9×10^{-11}	9.8×10^{-16}	5.2×10^{-11}
Top flange	3.87	4.40	37947	1.1×10^{-10}	3.9×10^{-11}	9.8×10^{-16}	5.2×10^{-11}
PMT glass	51.68	28.32	8152	3.0×10^{-11}	1.5×10^{-10}	2.7×10^{-16}	6.3×10^{-11}
PMT electrode	14.70	18.36	591	1.1×10^{-10}	3.9×10^{-11}	9.8×10^{-16}	5.2×10^{-11}
Inner n shield	0.51	1.09	308473	1.4×10^{-11}	9.5×10^{-11}	1.2×10^{-16}	3.6×10^{-11}

irreducible neutrons / day
summed over all isotopes and processes

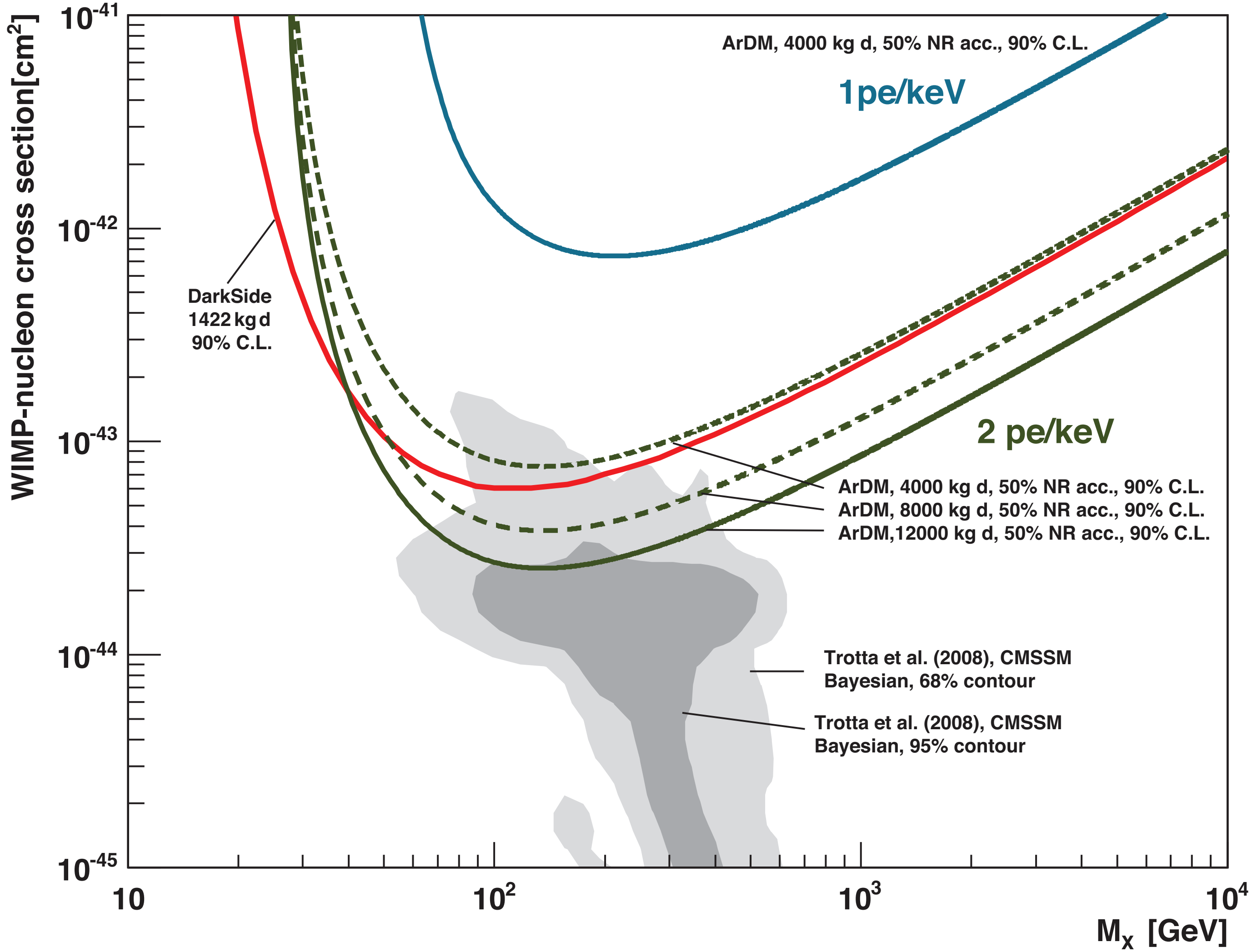
Det. comp.	emitted n/day	irr. in RoI n/day	irr. after cuts n/day
Tank	9.97	0.06	0.0095
Top flange	2.62	0.04	0.0049
PMT glass	7.65	0.14	0.0225
PMT electrode	0.16	0.00	0.0004
Inner n shield	2.52	0.03	0.0071
Total	22.92	0.27	0.0446

Irreducible rate : 0.045 n/d
(new detector configuration)

$50 < E_r < 100$ keV$_{nr}$

483 kg target mass

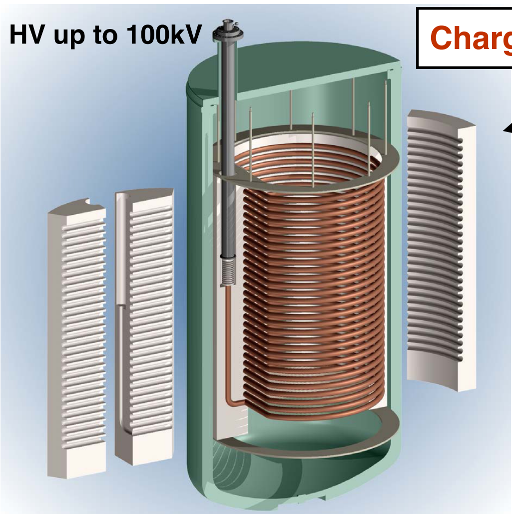
Projected ArDM sensitivity



Expect 1 neutron per 20 days (present state of hardware)
8000 kg x d corresponds to 16 life days of ArDM

Hardware upgrades and developments

Concluded from data analysis

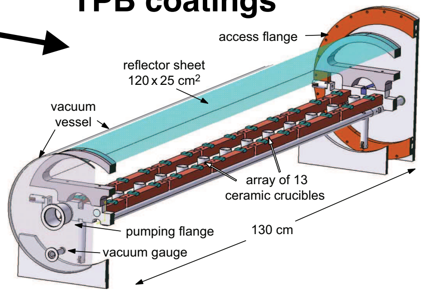


Charge signal

- New TPC drift cage, HV system
- Replace TPB coated surfaces
- Implement ITO coated windows
- Introduce cold charcoal trap
- Add cryo link (liquid storage)
- New radiopure PMT base

Light yield

TPB coatings

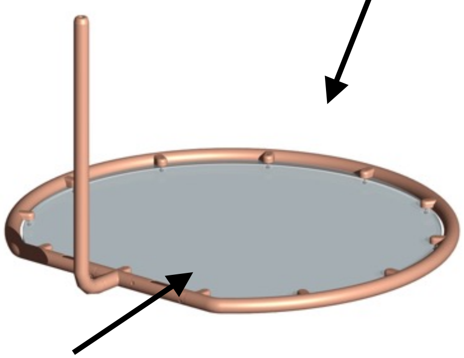


α background

Fiducialization

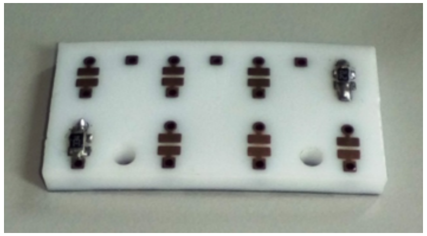
Activities ongoing at CERN and CIEMAT

Large ITO + TPB coated PMMA plates

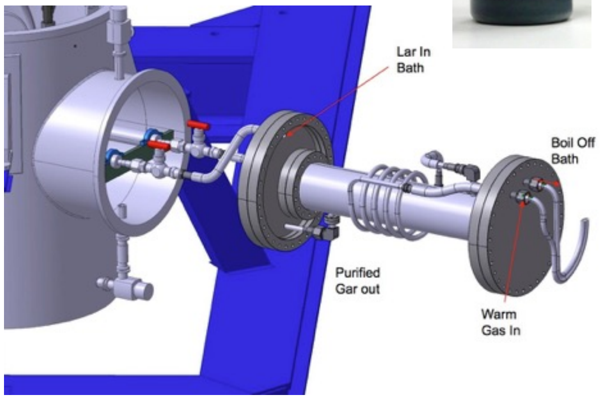


ITO layer + TPB coating

n background



Cold charcoal trap



New detector layout

Double-phase operational mode

4π VUV conversion

Neutron shield

HV feedthrough
(max. 100 kV)

Top PMT array

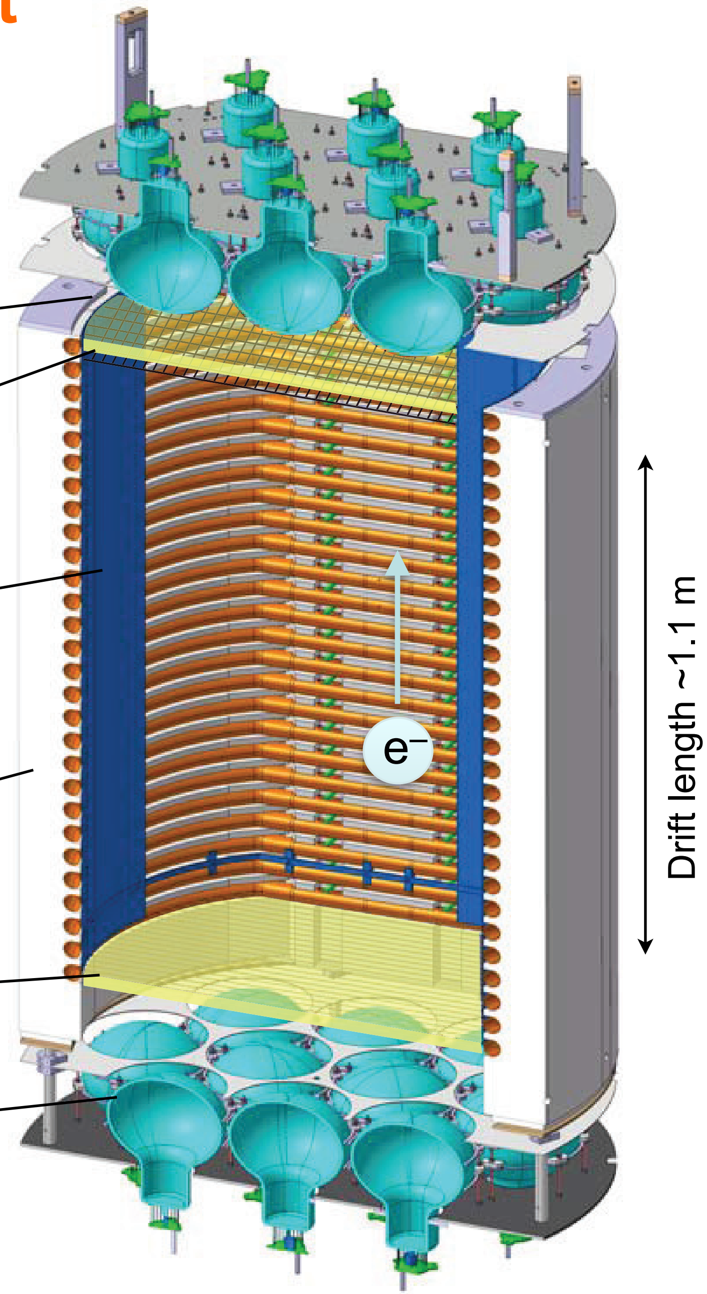
Anode window
(PMMA/ITO/TPB)
+ extraction grid
(LAr level)

Drift cage lined
with TPB coated
reflectors

Internal neutron shield
(Borotron, borated PE)

Cathode window
(PMMA/ITO/TPB)

Bottom PMT array

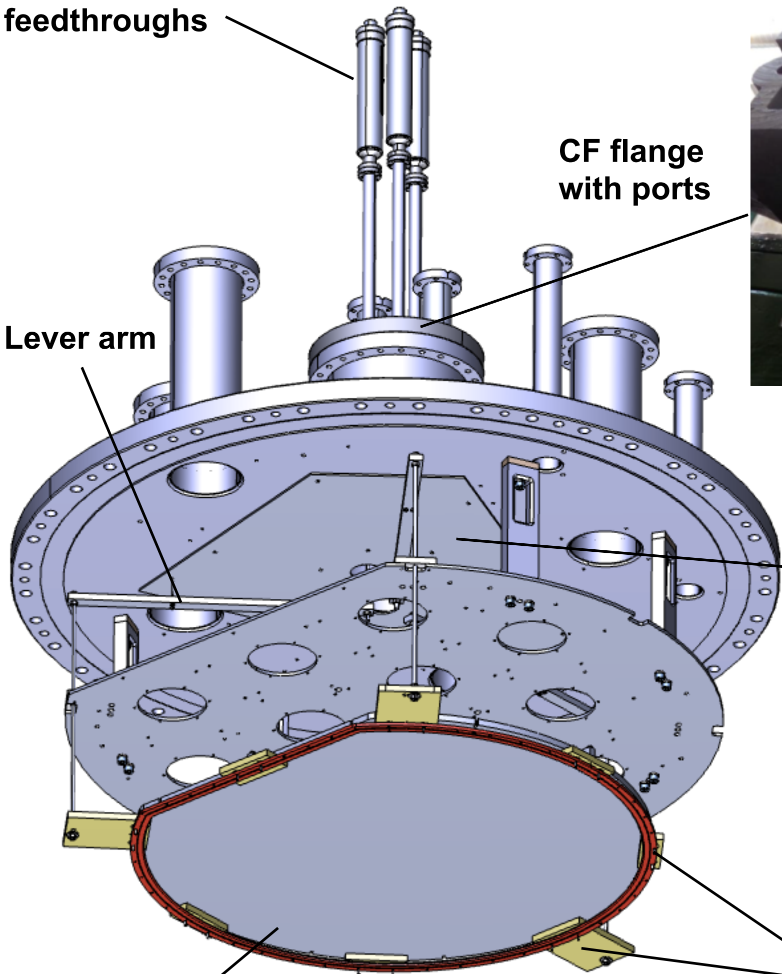


Drift E-field 250 V/cm

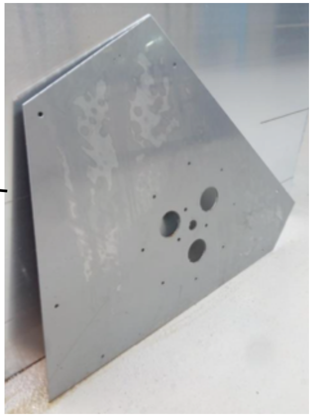
Cathode voltage ~30 kV

Extraction grid-anode window assembly

New movable hanging system



- Hanging at three points — independently movable by linear motion feedthroughs
- Position and horizontality of the extraction grid-anode assembly adjusted with respect to the LAr surface



- LAr level measured in sub-millimeter precision at three points as well

All the mechanical parts have been built at CIEMAT — ready for installation

Extraction grid ready at CERN

HV system components

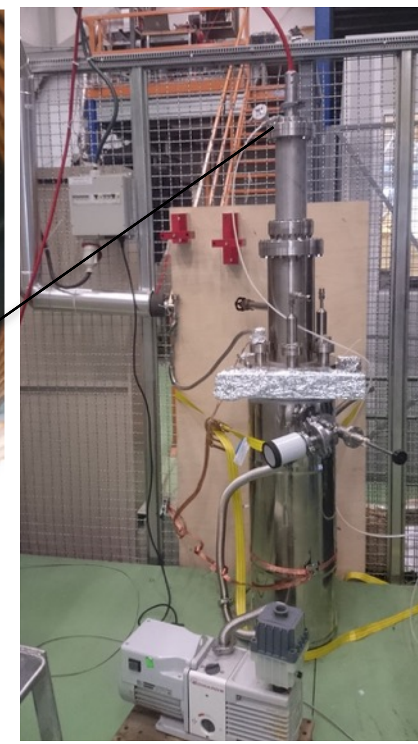
HV feedthrough

System capable of up to 100 kV is ready to be installed

- Feedthrough / Power supply / 25-m-long cable / Control software
- Tested at CERN in LAr up to 100 kV
- Control software to be integrated in the ArDM control system

100-kV power supply

Test at CERN



Feedthrough

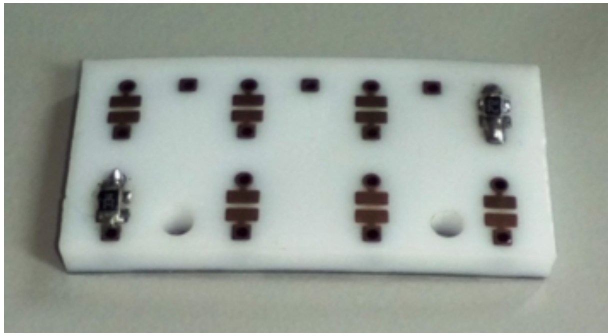
Reached 100 kV

- Nominal drift field in ArDM — 250 V/cm
  → ~28 kV at the cathode

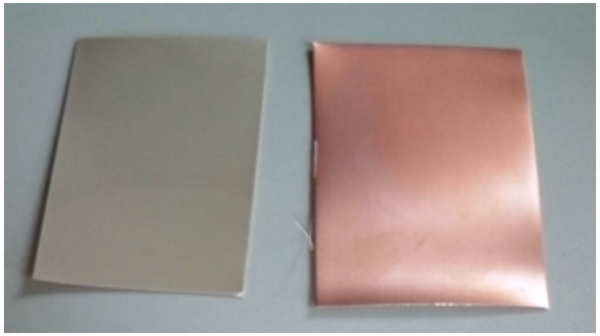
Development of new radiopure PMT bases (CIEMAT)

R&D

considered options



CUFLON (PTFE + copper)



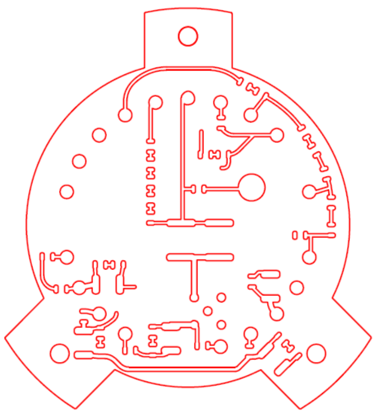
XT/duroid 8000 (PEEK + copper)

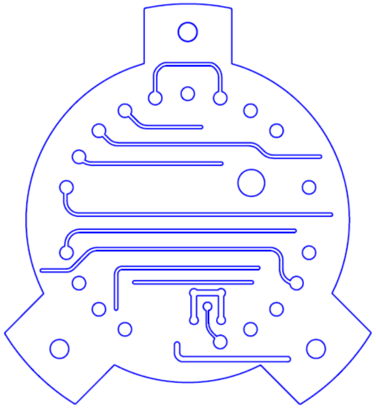
CUFLON chosen

PCBs expected to be delivered very soon

PCB layout

- **SMD COG components**
- **Improved layout — reducing inductances**





Measures to increase the light yield

- For next runs we retain the existing light-readout system based on 24 8” PMTs
- Reduction of the VUV absorption in LAr
  - ICP-MS measurement on the gaseous argon in the bottle
  - Cold charcoal trap
  - Use of argon from another supplier (CERN LAr OK)
  - Filling procedure
- Updated light collection system
  - New reflector foils freshly coated with TPB
  - ITO/TPB-coated PMMA windows — 4π coverage with a uniform TPB layer

Fabrication of new main reflectors

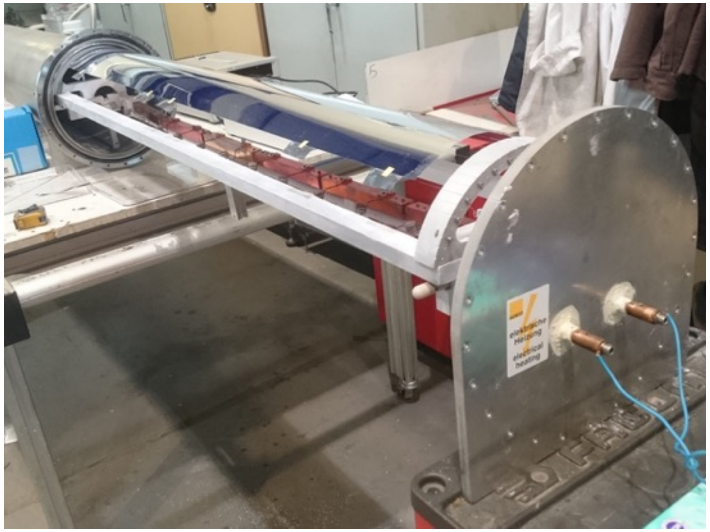
The entire TPB surface is renewed

3M Vikuiti™ Enhanced Specular Reflector Film (ESR)

- Multi-layer optical film technology
- Plastic specular reflector having high reflectivity
- 13 reflector foils + 7 spare (20 cm x 120 cm)

TPB coating at CIEMAT

- Large evaporator developed for ArDM
  - 13 crucibles in series
- Coating thickness 200 μg/cm²



Coated foil

LY improvement

Large ITO/TPB coated PMMA windows— a R&D project at CERN

Immersed in LAr

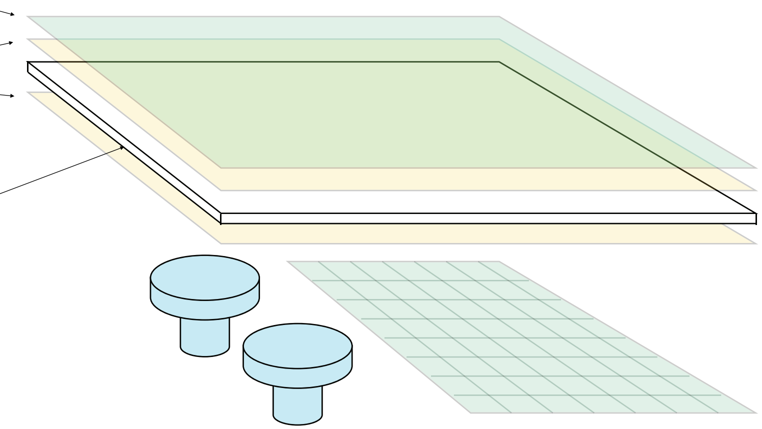
Separating volumes - <u>Defining electrical potentials</u> - HV rigidity

Spark-protection - <u>Definition of fiducial volumes</u> - Shield against bubbles

Segmented structures possible (transparent field cage)

Dielectric rigidity ~ 0.8 MV/mm

<u>Dimensions ~ m</u>



High transparency required at 420nm, the emission range of TPB

ITO coatings done:

- Sputtering facility at CERN
- Industry (Visiontek UK)

TPB: evaporator built at CERN

ITO coating is industrial standard - but limited to smaller sizes, ~0.5m

Glueing possible (ACRIFIX® 2R0190) - solvent welding - necessary?

R&D project started autumn 2015 — aiming 1x1m^2 plates (thickness $O \sim$ cm)

Industrially manufactured ITO coated plates

800 x 650 mm²

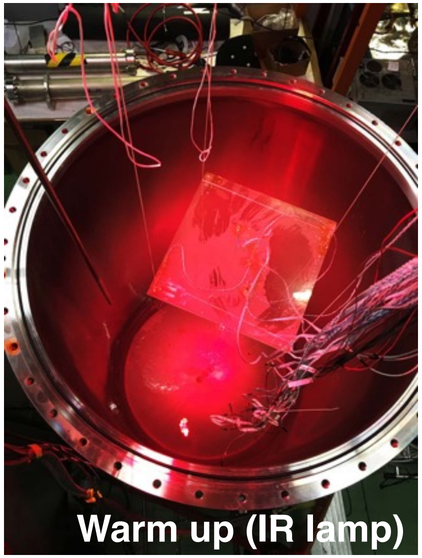
- Visiontek Systems Ltd. UK
- 10mm Acrylic plates 0.8 x 0.65 m² (largest currently available)
- Both faces coated
- Hard coated PMMA substrate used
- Optimum layer thickness for 420nm transparency

Mechanical and resistivity test

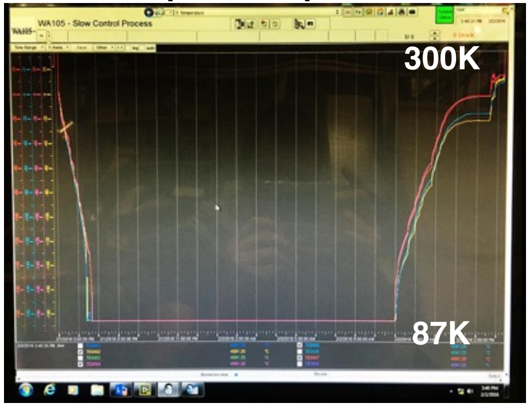
- Mechanical, electrical tests OK
- Stable conductivity
- Optical inspection after temperature cycle very satisfying

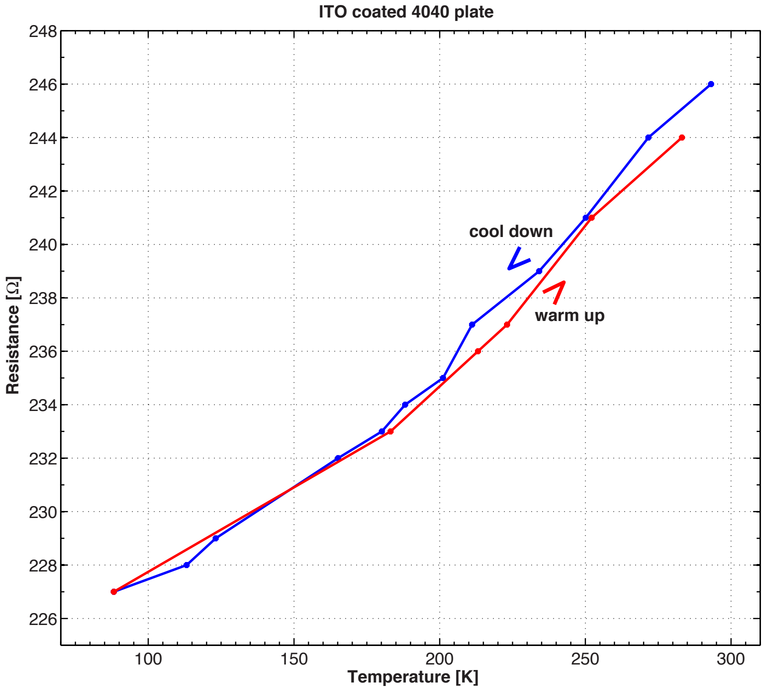
- conductivity tests done at 300K … 87K
- 4-point R measurement probing the entire surface
- ohmic behavior confirmed (I-U curves OK)

1m open cryostat @ CERN ArDM clone

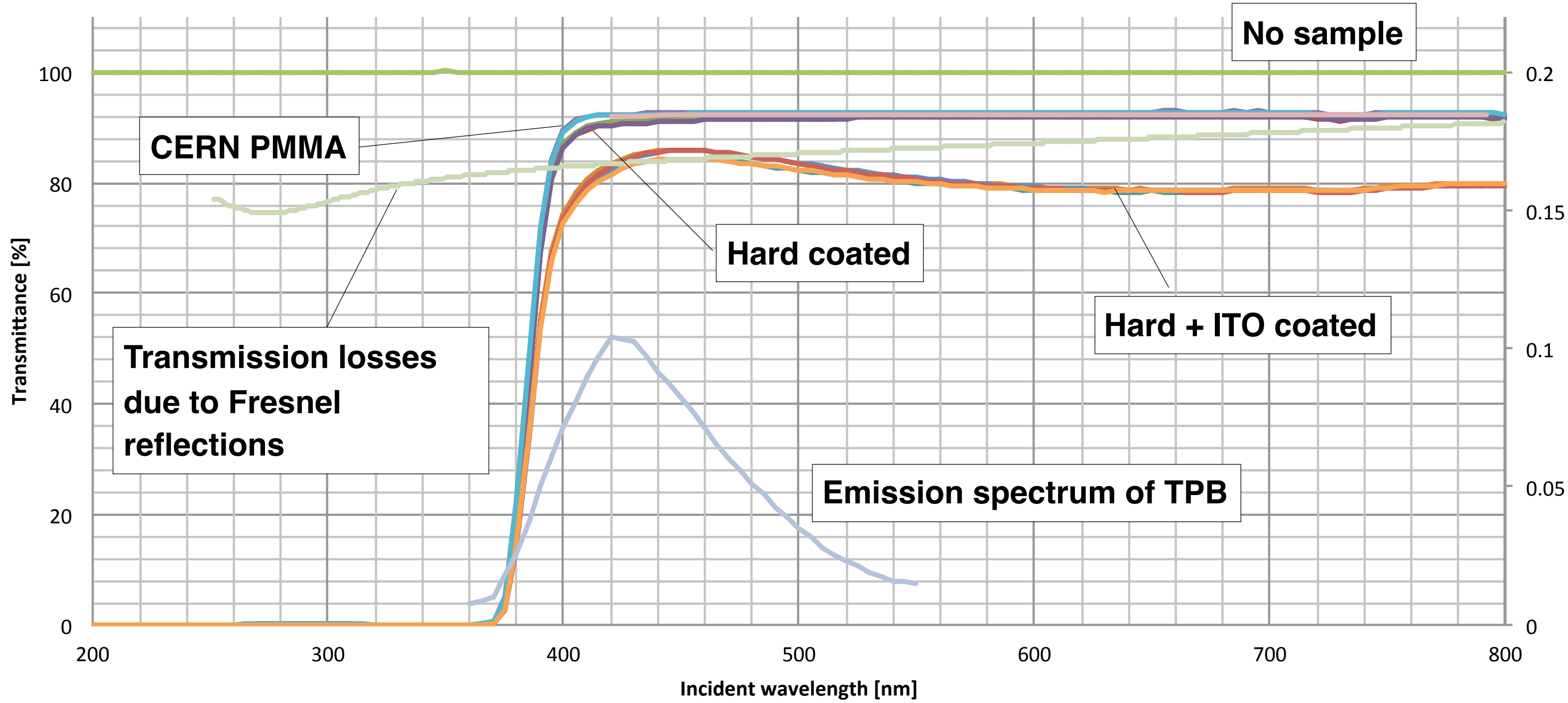


Temperature profile





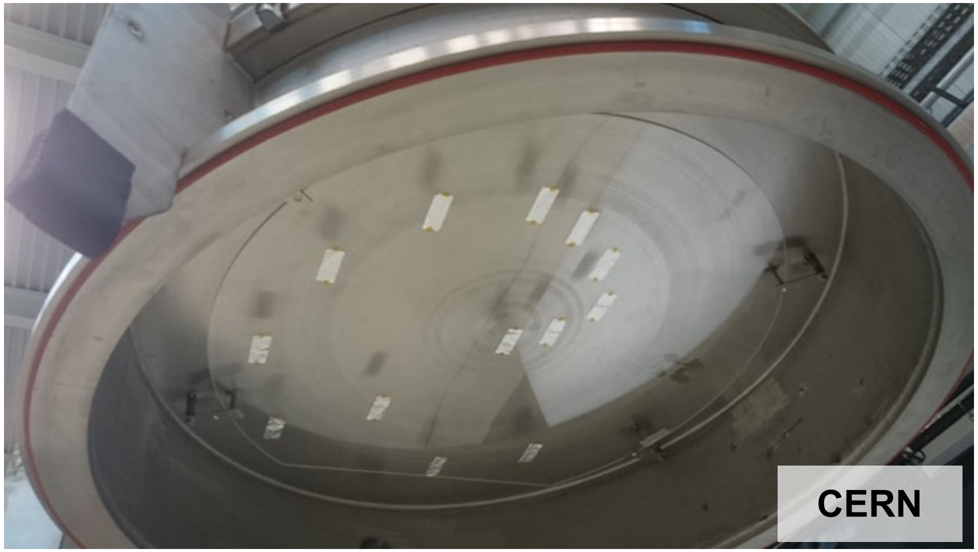
Optical tests @ 300K — different samples small fraction of absorption in the ITO layer

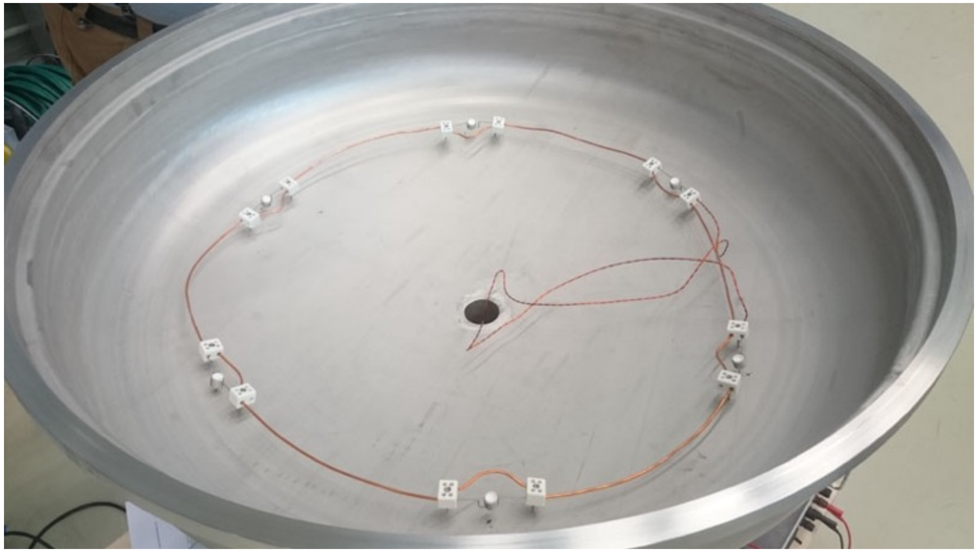


- Refractive index of ITO @ 420nm: n = 2.006
- PMMA only : T = 93.4% (transmission weighted by TPB spectrum)
- ITO coated PMMA : T = 93.2%
- Main absorption (6.6%) due to PMMA itself, marginal loss in ITO layer

TPB coating

New large size evaporator commissioned for the ArDM windows (~75 cm dia.)



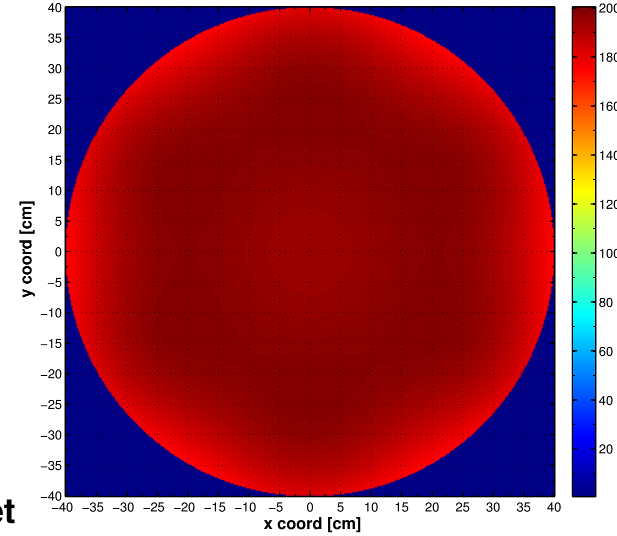


Coating parameters :

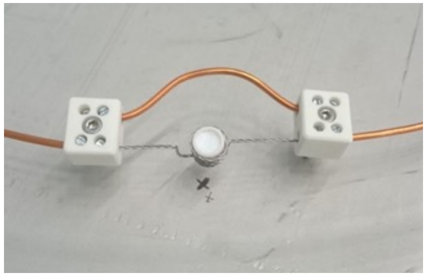
- **Circular arrangement of 6 crucibles**
- **Target : ~100 μg/cm²**
- **Efficiency : ~18% (deposited TPB/evaporated)**

Calculation of TPB thickness:

rms: ~2% over entire area

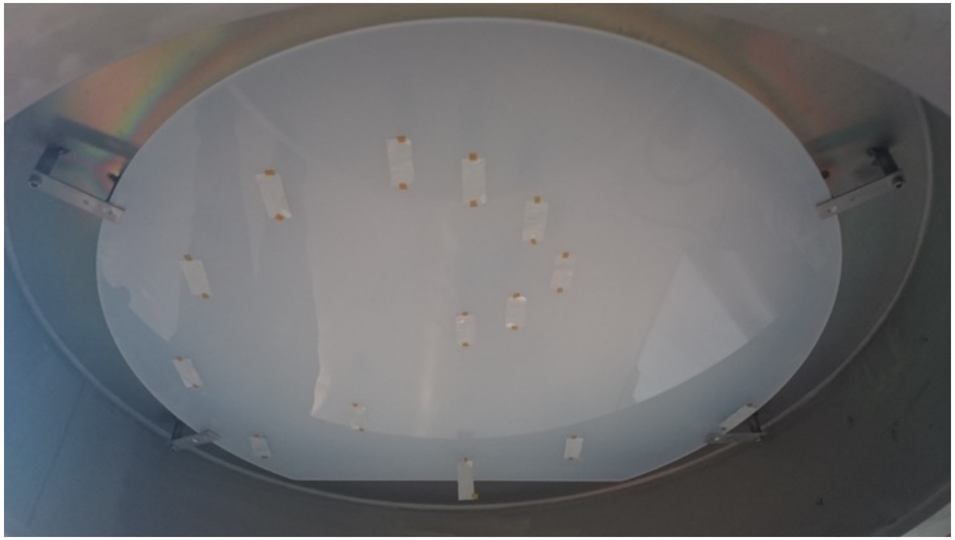


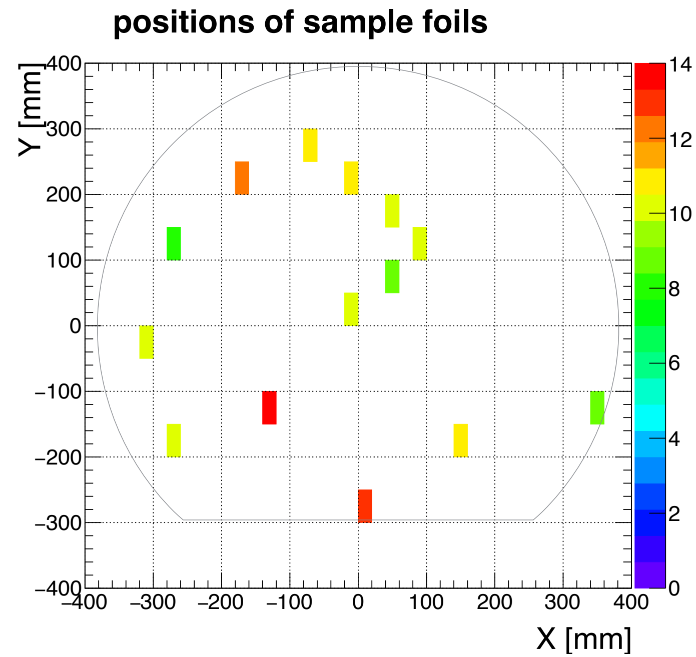
Crucible in a heater basket

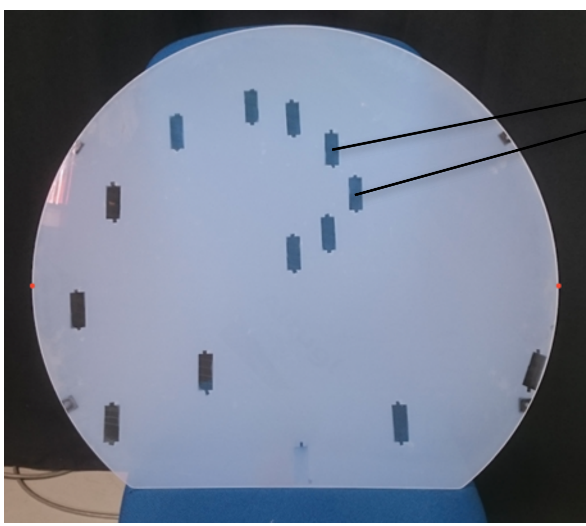


Coating result tests

PMMA test disc of the same size (without ITO) coated

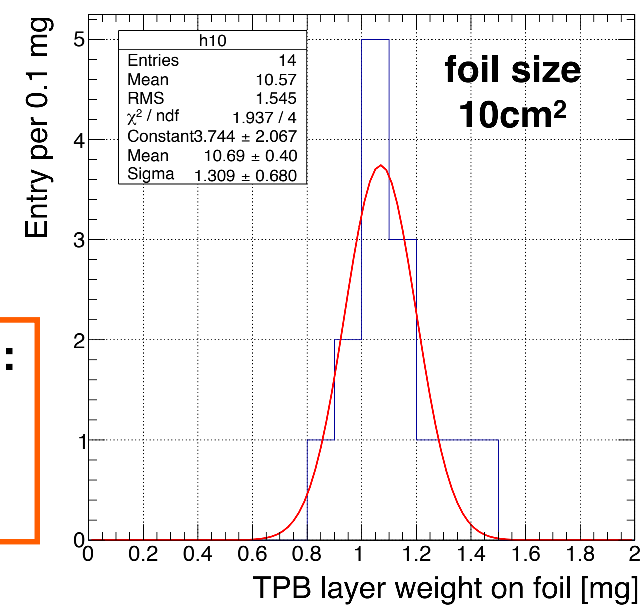




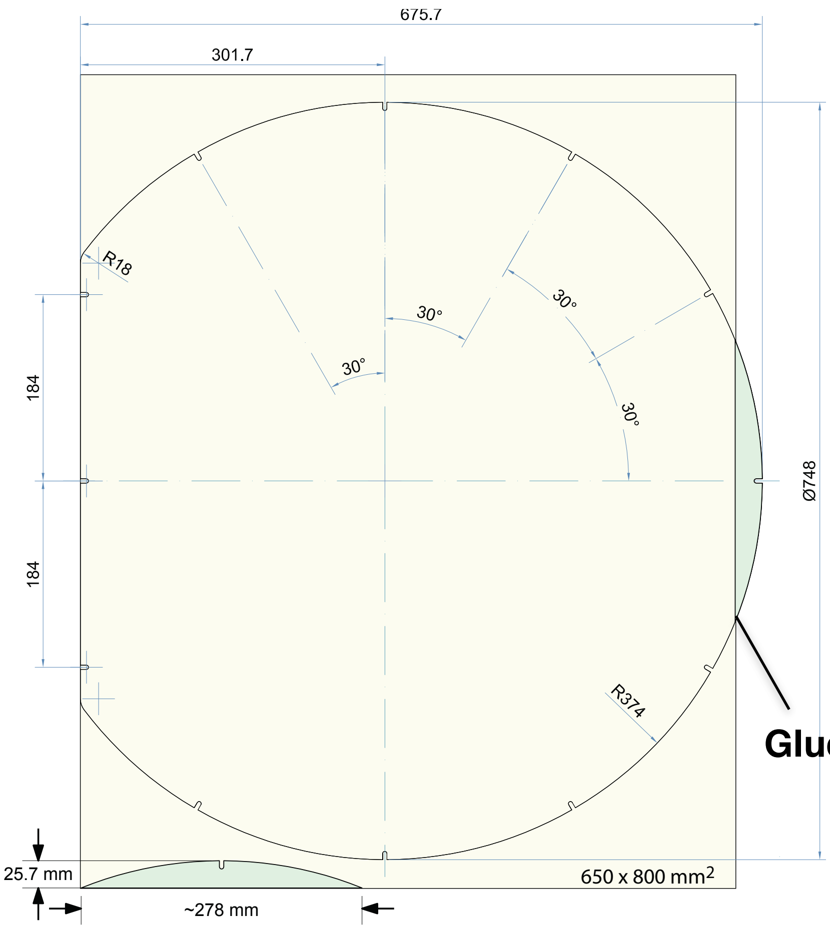


Rectangular "holes" due to the sample Al foils (for weight measurement)

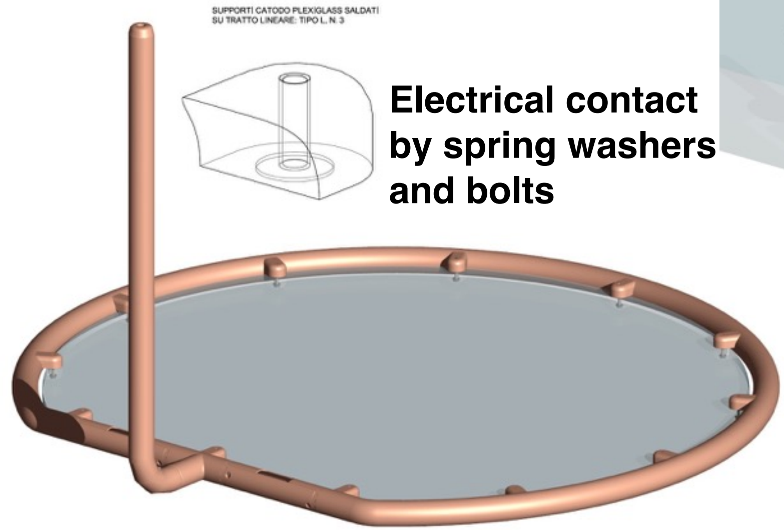
Effective TPB thickness :
107 ± 4 μg/cm²
RMS ~15%
(target ~100 μg/cm²)



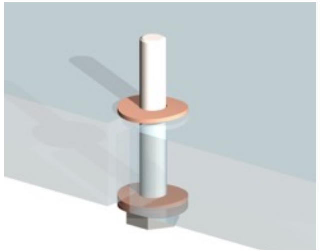
Mechanics



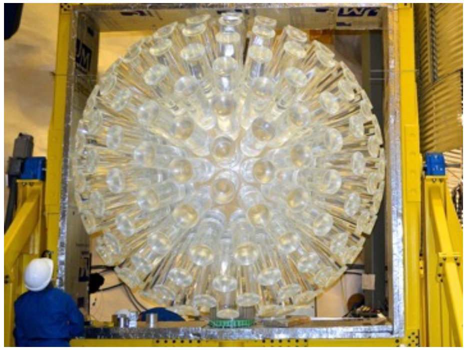
Glueing



Electrical contact by spring washers and bolts



Cathode assembly in workshop



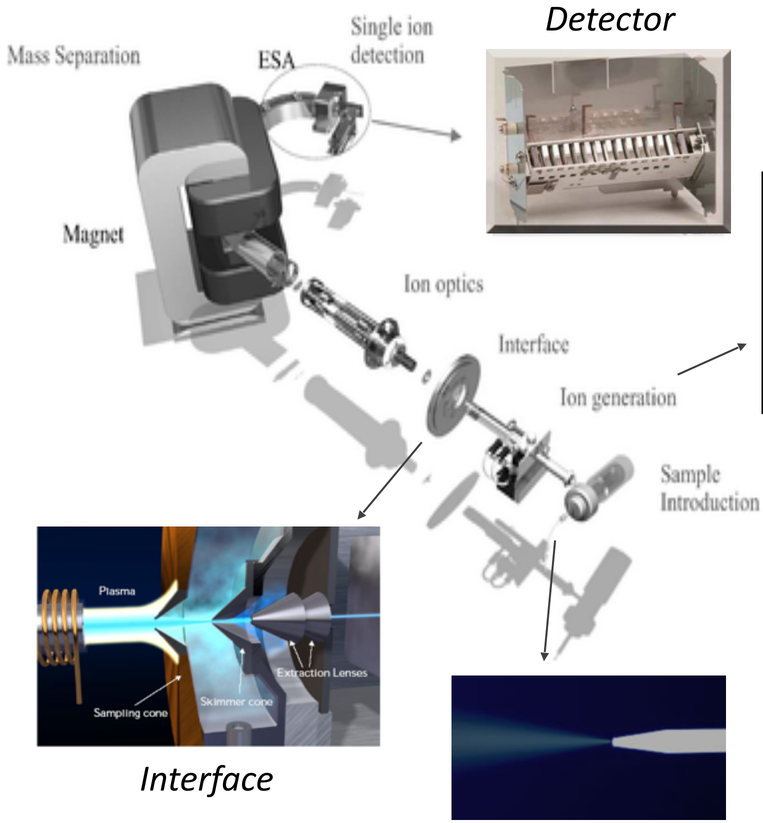
DEAP-3600 acrylic vessel

87 K — LAr temperatures

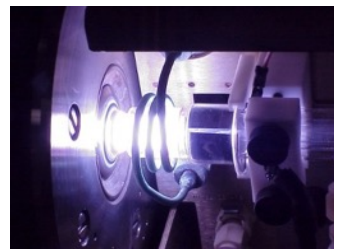
constructed with glueing

ICP-MS measurement on argon

To identify the origin of the short attenuation length



Detector



Torch

Interface

Nebulizer

at CIEMAT

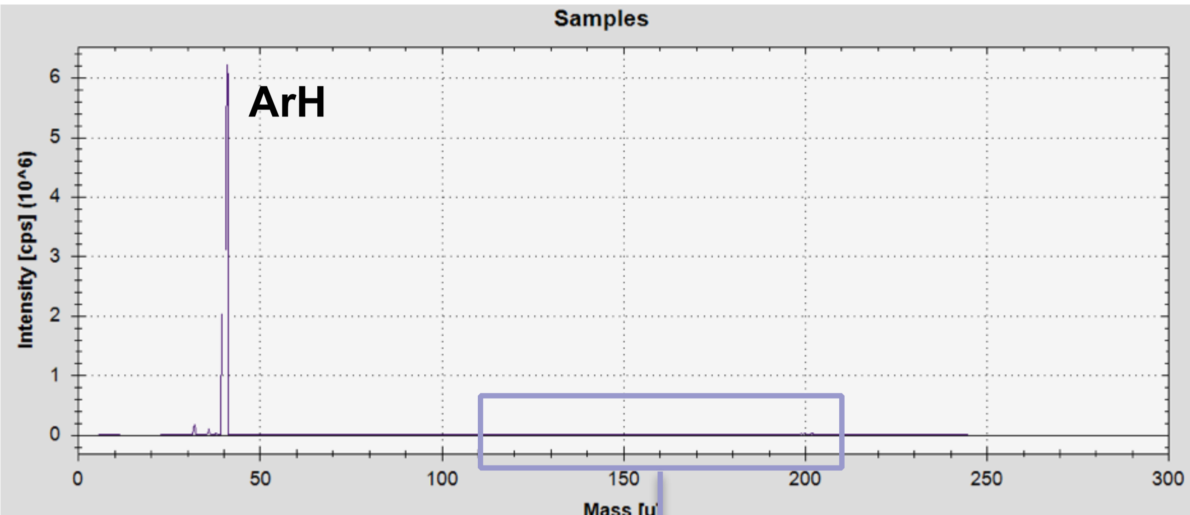
ICP-MS Element XR (Thermo Scientific)

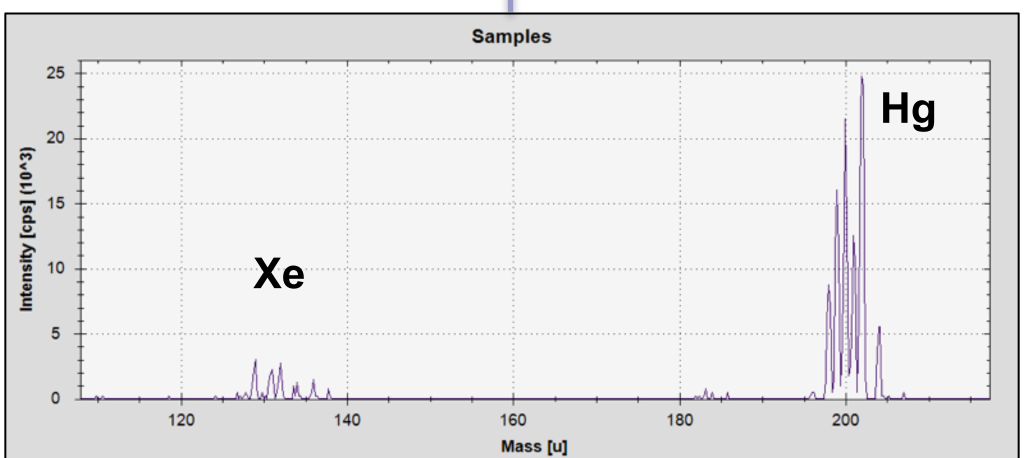
- **Most elements possible (around 80)**
- **Elemental and isotopic information given**
- **Concentration range ppq (pg/L) to mid-ppm (100s mg/L)**
- **Rapid analysis – 2–6 minutes per sample**
- **Good precision – ~2% RSDs**

Goal: measurements on the ArDM gaseous argon sample

ICP-MS measurement on argon

- Analysis of argon requires special treatment
  - Argon is used as buffer in standard analyses
- Feasibility under study — first attempt carried out (gas of similar type)





- Xe and Hg were found
- Analysis of the absolute concentration ongoing

ArDM argon sample to be sent for analysis very soon

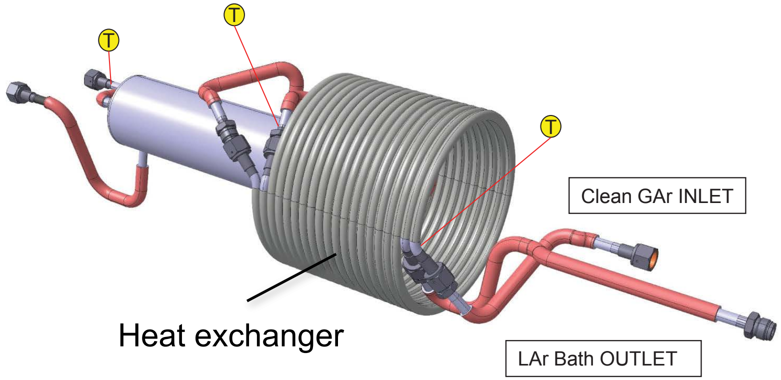
Xenon traces responsible ?

A. Neumeier et al., Attenuation of vacuum ultraviolet light in liquid argon, Eur. Phys. J., C72, 2012, 2190

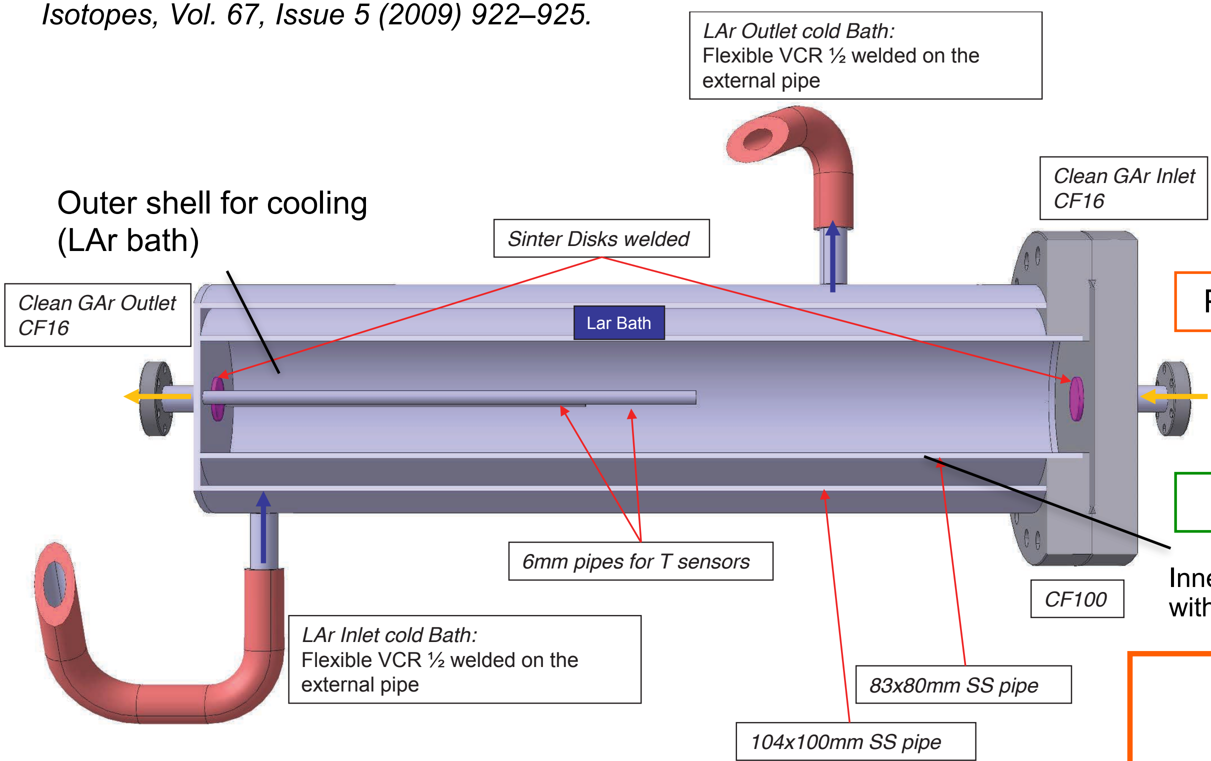
A. Neumeier et al., Attenuation measurements of vacuum ultraviolet light in liquid argon revisited,
NIM A, 800, 2015, 70

Cold charcoal trap

- **Activated carbon — CarboAct**
- **Operate in cold <100 K**
- **Removes impurities which cannot be bound chemically on getters, e.g. Rn or other noble gasses (e.g. Xe)**



H. Simgen, G. Zuzel, "Analysis of the 222Rn concentration in argon and a purification technique for gaseous and liquid argon," Applied Radiation and Isotopes, Vol. 67, Issue 5 (2009) 922–925.



Pure Ar inlet

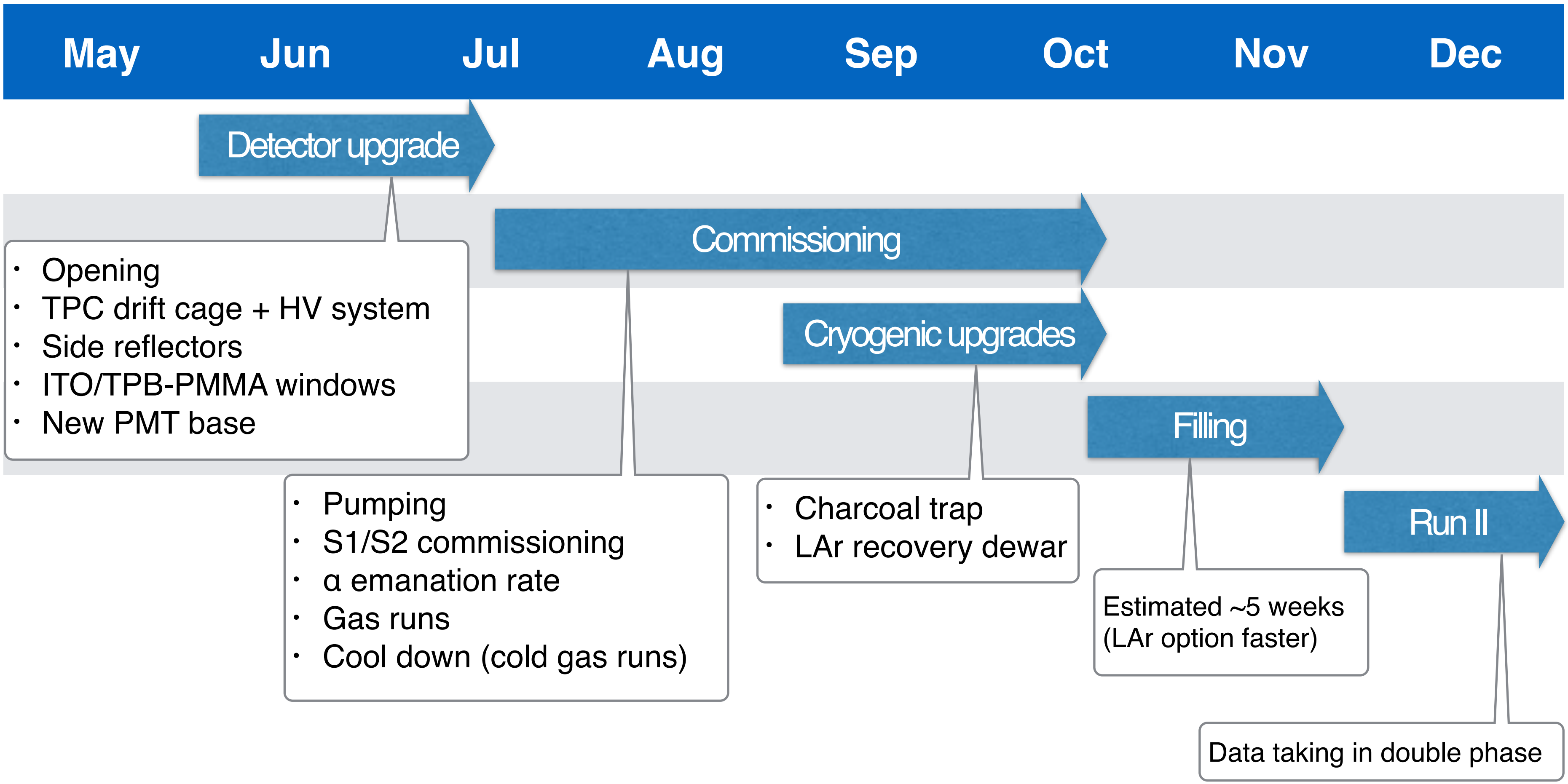
Procured

Inner volume ~2L filled with 500 g of CarboAct

Removal of heavy noble gasses
Radon, Xenon, Krypton ….

Chromatographic separation of radioactive noble gases from xenon arXiv:1605.03844v1

Plans for 2016



Opportunities with depleted argon

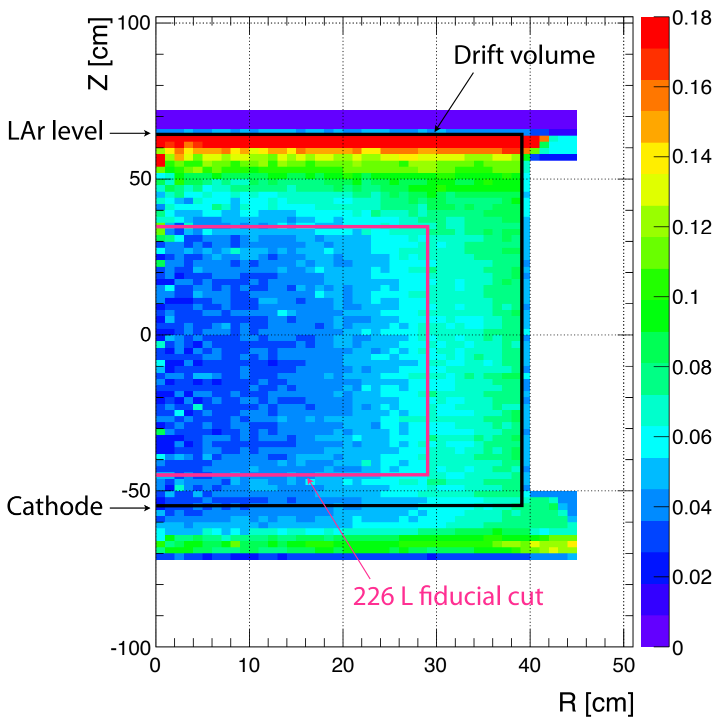
^{39}Ar depleted argon (DepAr)

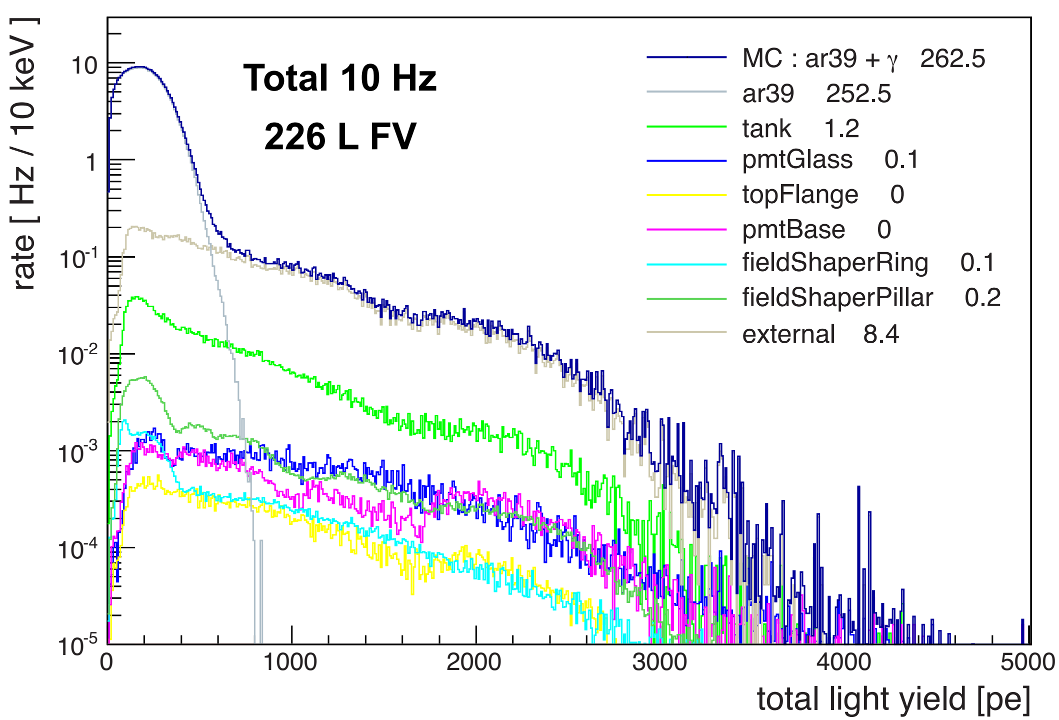
- **DarkSide collaboration is pioneering the production**
- **Presently 150 kg**
- **Recently qualified in a 50 kg LAr detector**
- **A depletion factor of 1/1400 was found with respect to atmospheric argon**

Promising for next generation LAr DM detector — have to be verified for a large quantity (~10 ton)

ArDM facility can be used

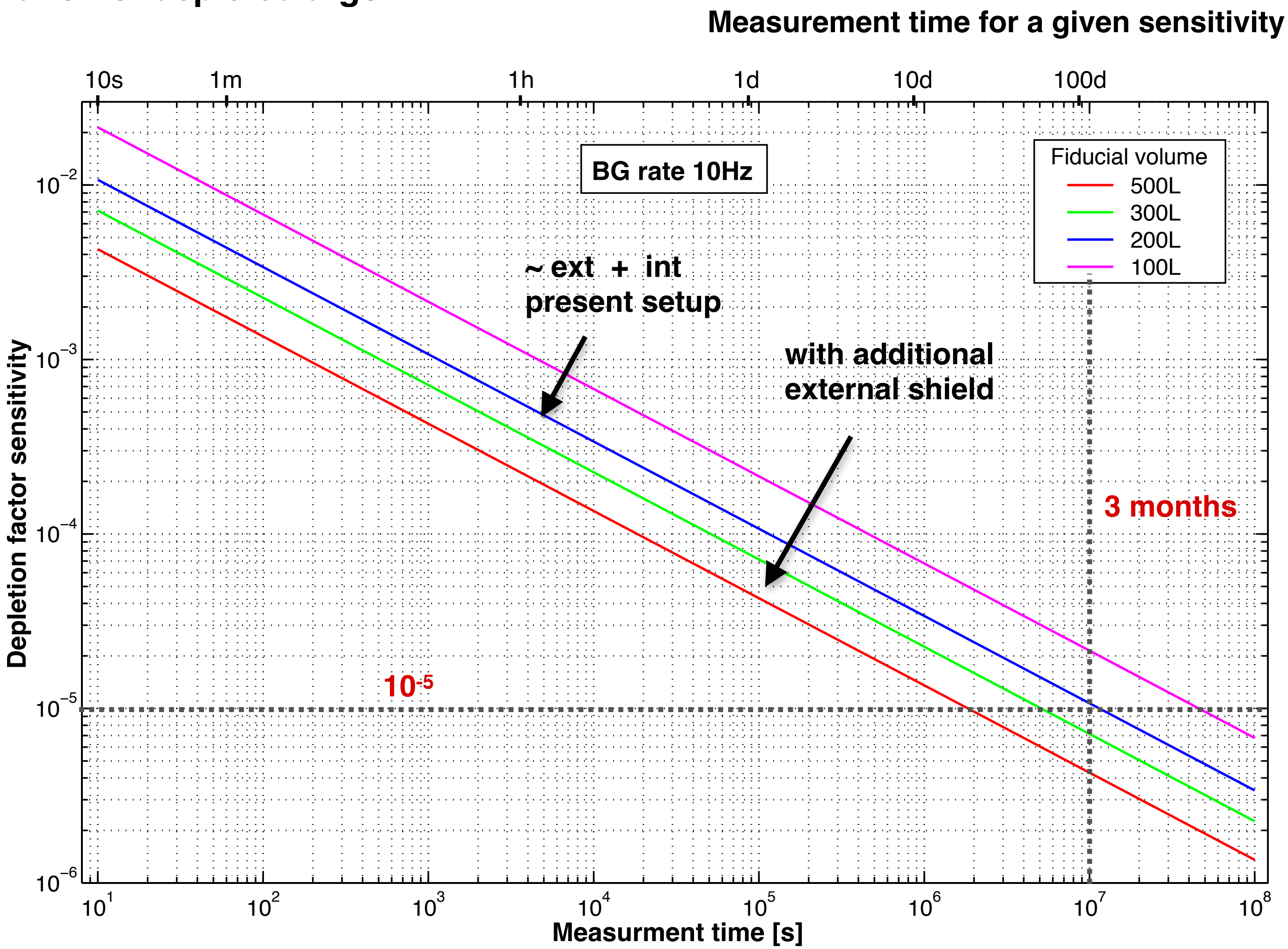
γ background MC (fiducialisation)





Projected ^{39}Ar sensitivity of ArDM for a 3σ measurement

Characterization of depleted argon



Measurement on 10^{-5} level feasible — improvements, e.g. more sophisticated analysis (spectral fit)

Conclusions and outlook

- **Analysis efforts of Run I data yield crucial information on next steps**
  - Solid frameworks for data analysis and detector simulation generated
  - The basic performance of the detector is further confirmed
  - PSD, e-like backgrounds, n-like backgrounds: OK
  - LY needs to be improved
  - 2pe/keV starts to be interesting
  - Exploration of fundamental parameters for large LAr facilities
  - Tuning of parameters indicate a relatively short DUV absorption length

- **Hardware developments and preparation towards 2 phase operation advanced**
  - Strategy of combined measures to restore LY seems very reasonable
  - Many additional improvements of inner detector parts
  - Light read out upgrade planned for later (after Run II)

- **Presently preparing double phase Run II — scheduled for 2016**
  - Clear plan of next steps of the project identified
  - Preparation, commissioning for double phase operation — this summer
  - Double phase LAr run planned for 2016

- **2017 and beyond**
  - Accumulate statistics — further hardware upgrades planned
  - Facility available for sensitive depleted argon studies (sensitivity level down to 10^{-5})
  - Full scale demonstration at the ton-scale is a necessary step towards 10-ton scale and beyond

The ArDM Collaboration thanks LSC and its staff, as well as the Scientific Committee for their continuous support.

Backup

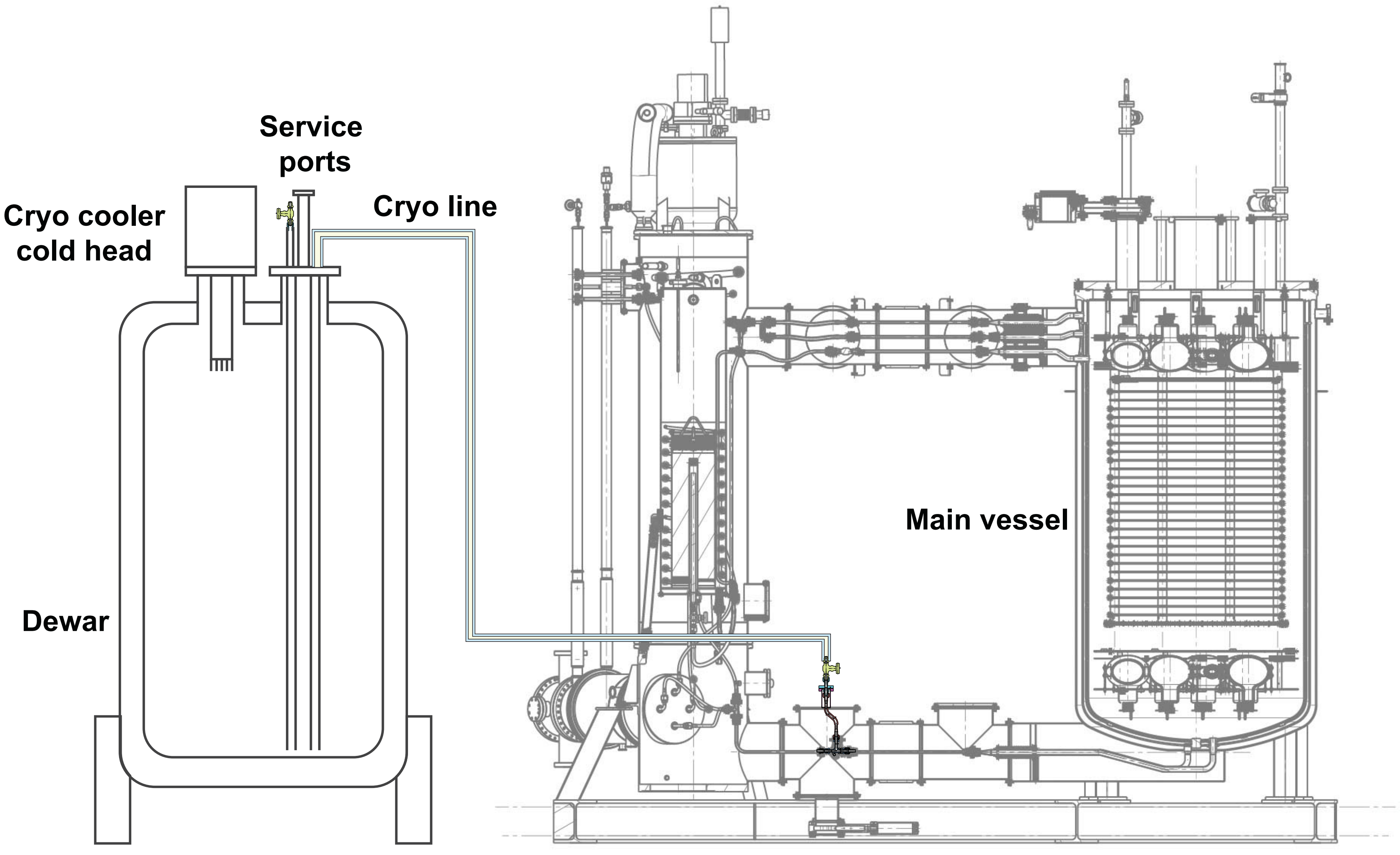
Requests to the lab

We appreciate very much the installation of a radon abatement system

Tent needed for next experimental intervention with connection to RAS

Evaluating installation of a LAr recuperation dewar into Hall A

Recuperation dewar



Cryogenic system upgrade (under evaluation)