The ARGONCUBE proposal

ELBNF European Preparation Meeting, CERN 13 January 2015

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UNIVERSITÄT BERN

AEC ALBERT EINSTEIN CENTER FOR FUNDAMENTAL PHYSICS

LABORATORIUM FÜR HOCHENERGIEPHYSIK LHEP UNIVERSITÄT BERN

Considerations on an R&D strategy for future LAr TPCs

- Liquid argon TPCs for the LBNF: specific R&D work + SBN program as drivers for future technological/methodological choices.
- Topical R&D studies need to be performed. Achievements in Bern: long drift, cold electronics, UV laser calibration, HV studies, wireless charge readout, modularity, scalability.
- Bern graded strategy: Micro → Mini → ARGONTUBE in parallel to the SBN program (*i.e.* MicroBooNE and LAr1-ND).
- An international collaboration is growing with different experience/expertise to perform the next required R&D step towards a novel LAr TPC implementation: the ARGONCUBE.

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LHEP
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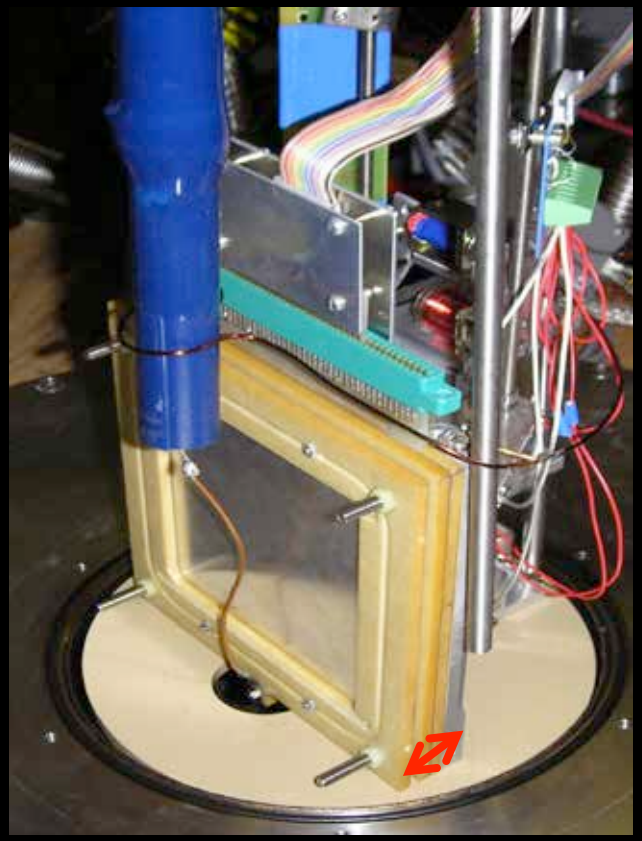
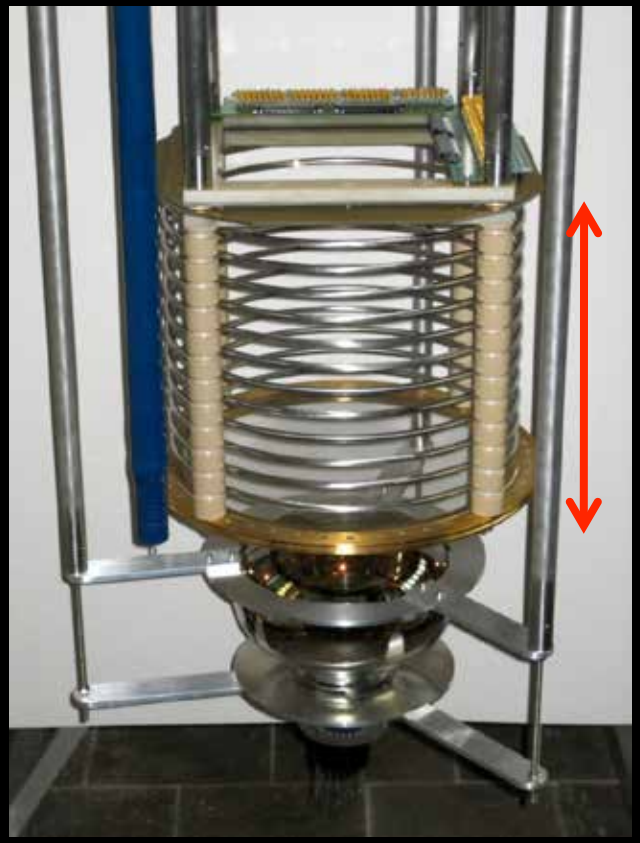
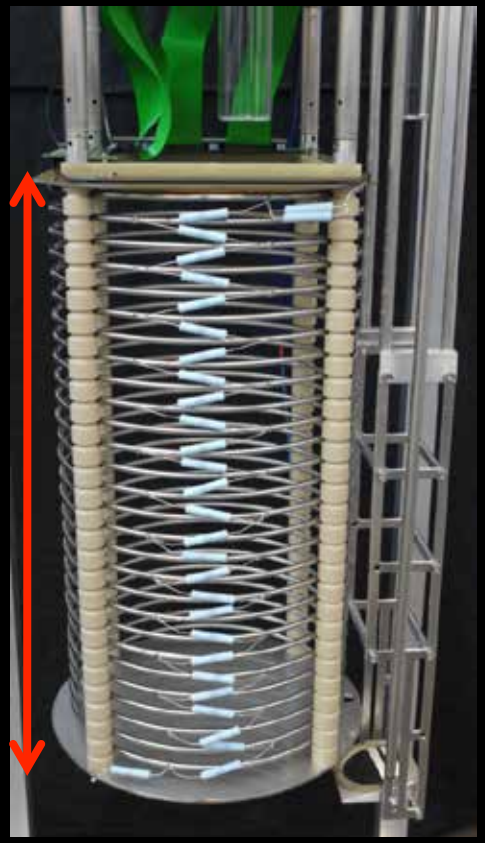
Evolution of LAr TPCs at LHEP Bern



0.5 cm



25 cm



57 cm

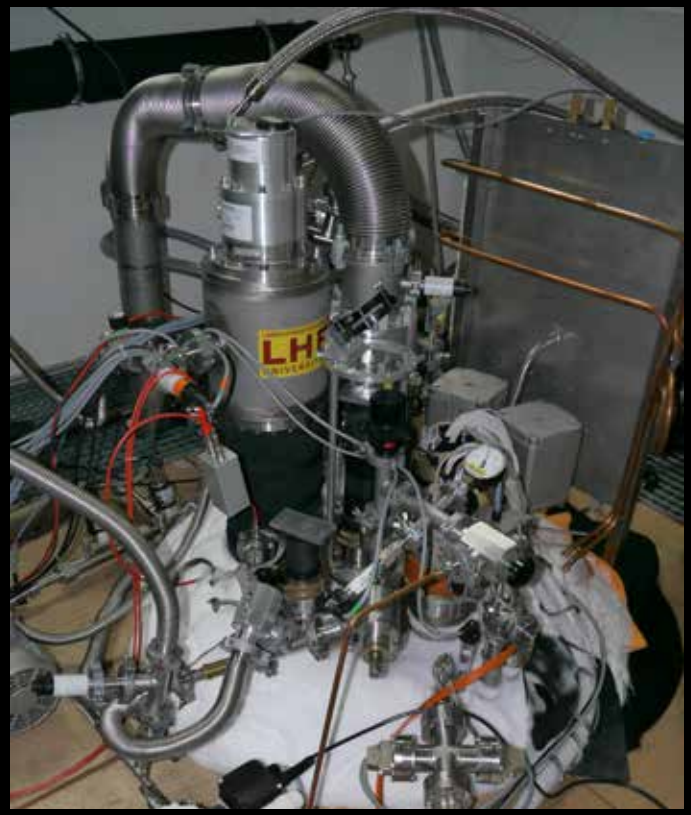
JINST 4, P07011 (2009)

New J. Phys. 12, 113024 (2010)

JINST 5, P10009 (2010)

All detectors being used for specific studies

The Bern ARGONTUBE (up to 5 m drift length)

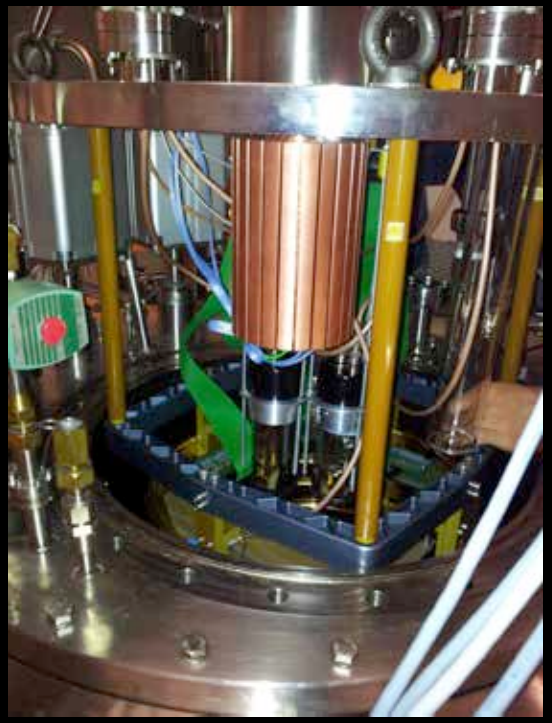


JINST 7 (2012) C02011

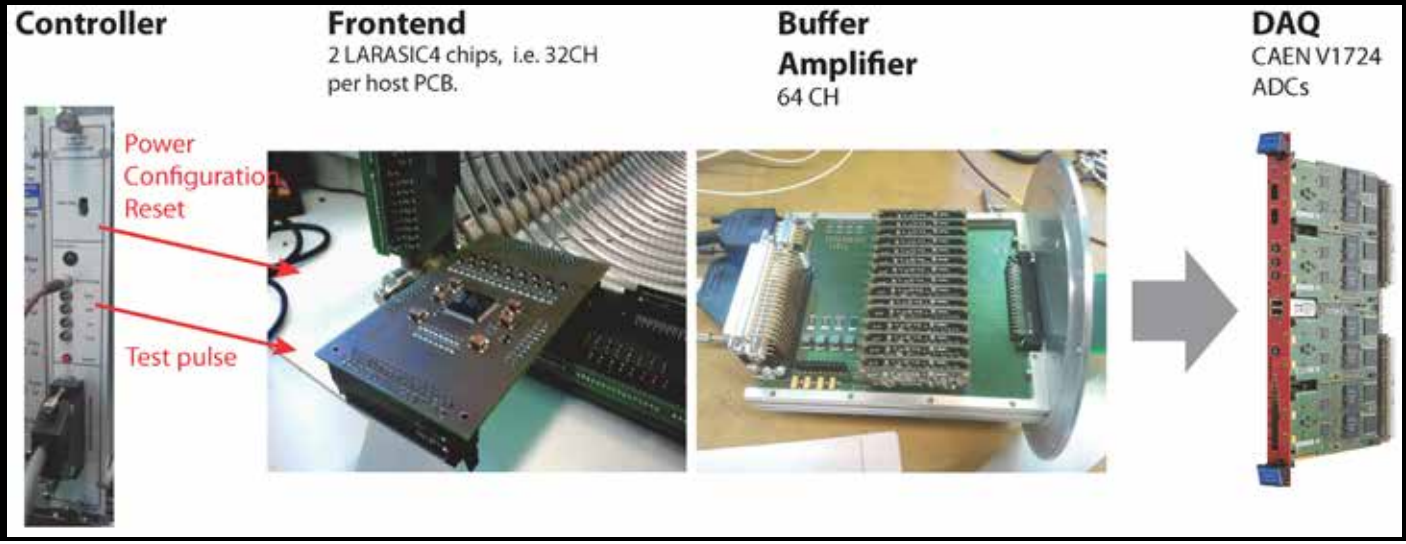
JINST 1307 (2013) P07002

Greinacher Voltage Multiplier

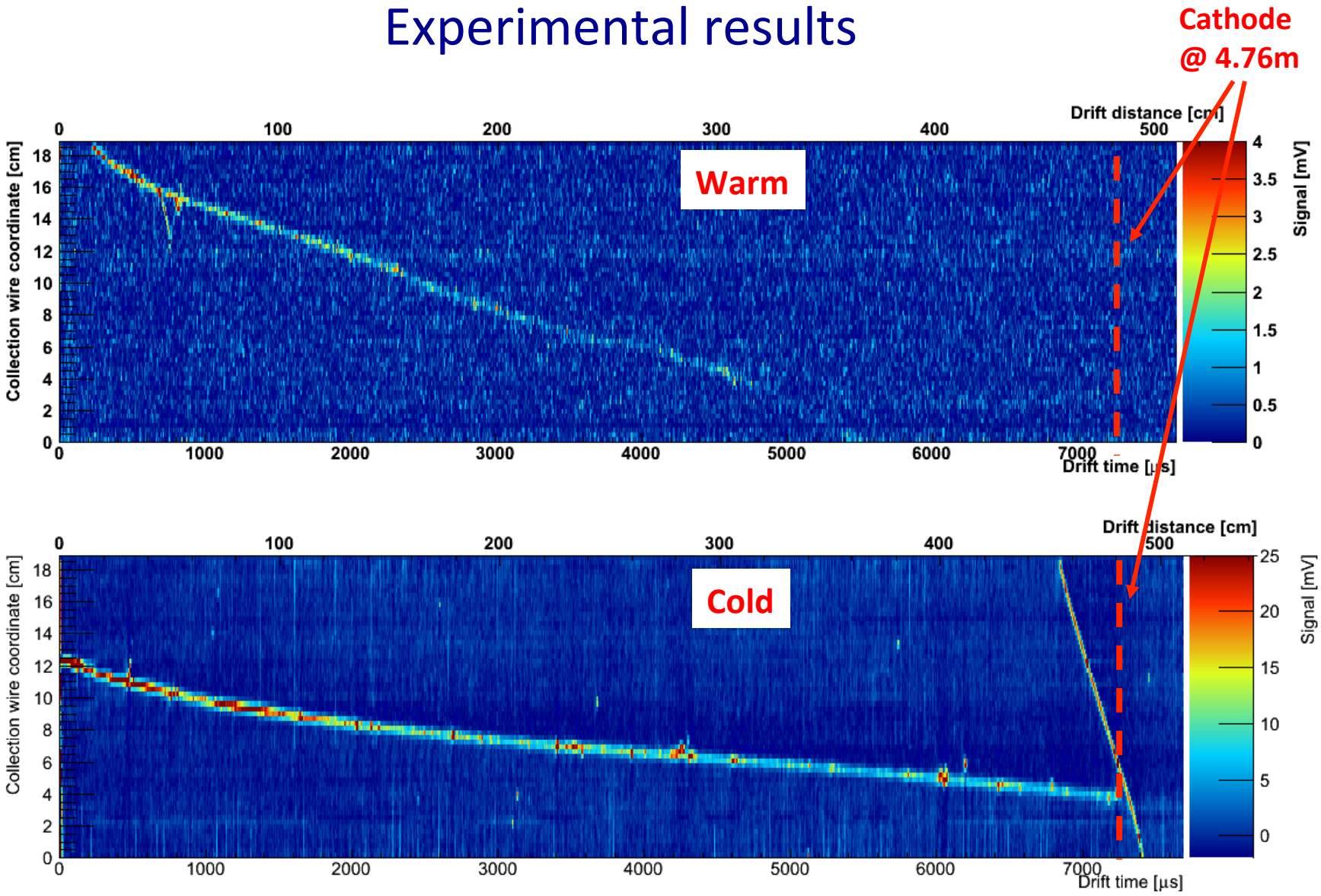
Cryo-cooler



BNL cryogenic
R/O electronics

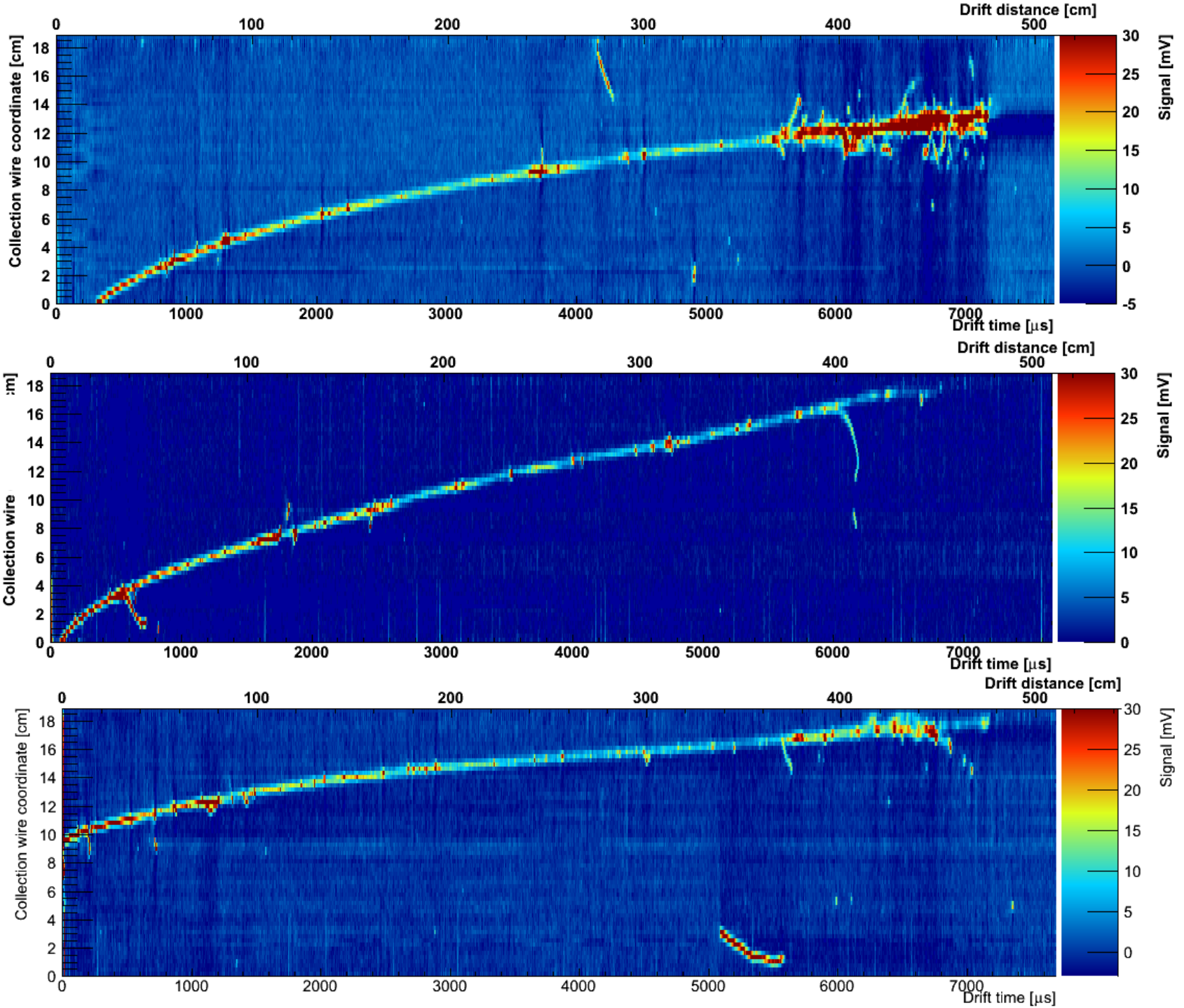


Experimental results

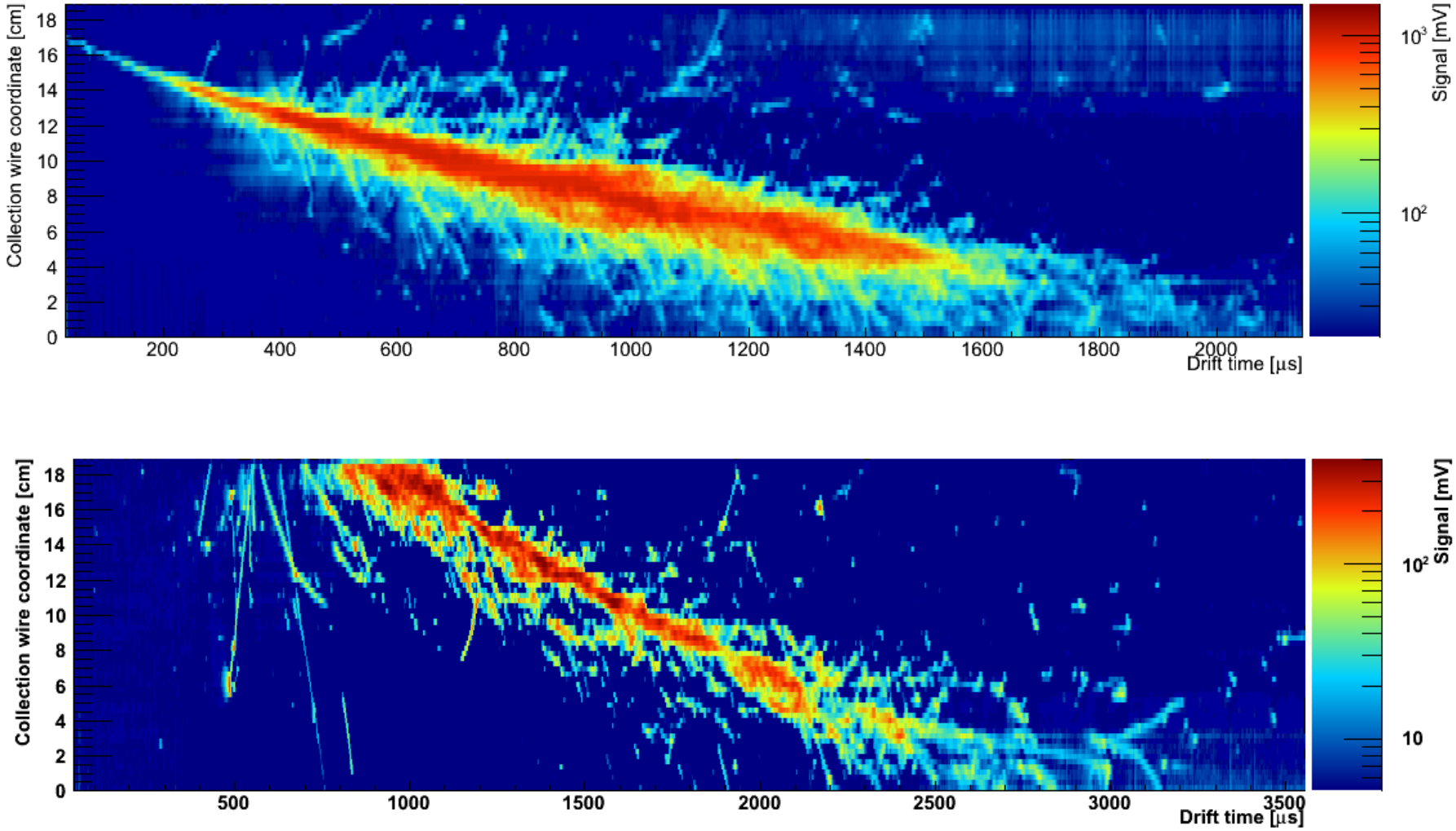


S/N (mip) = 15.7 ± 3.8

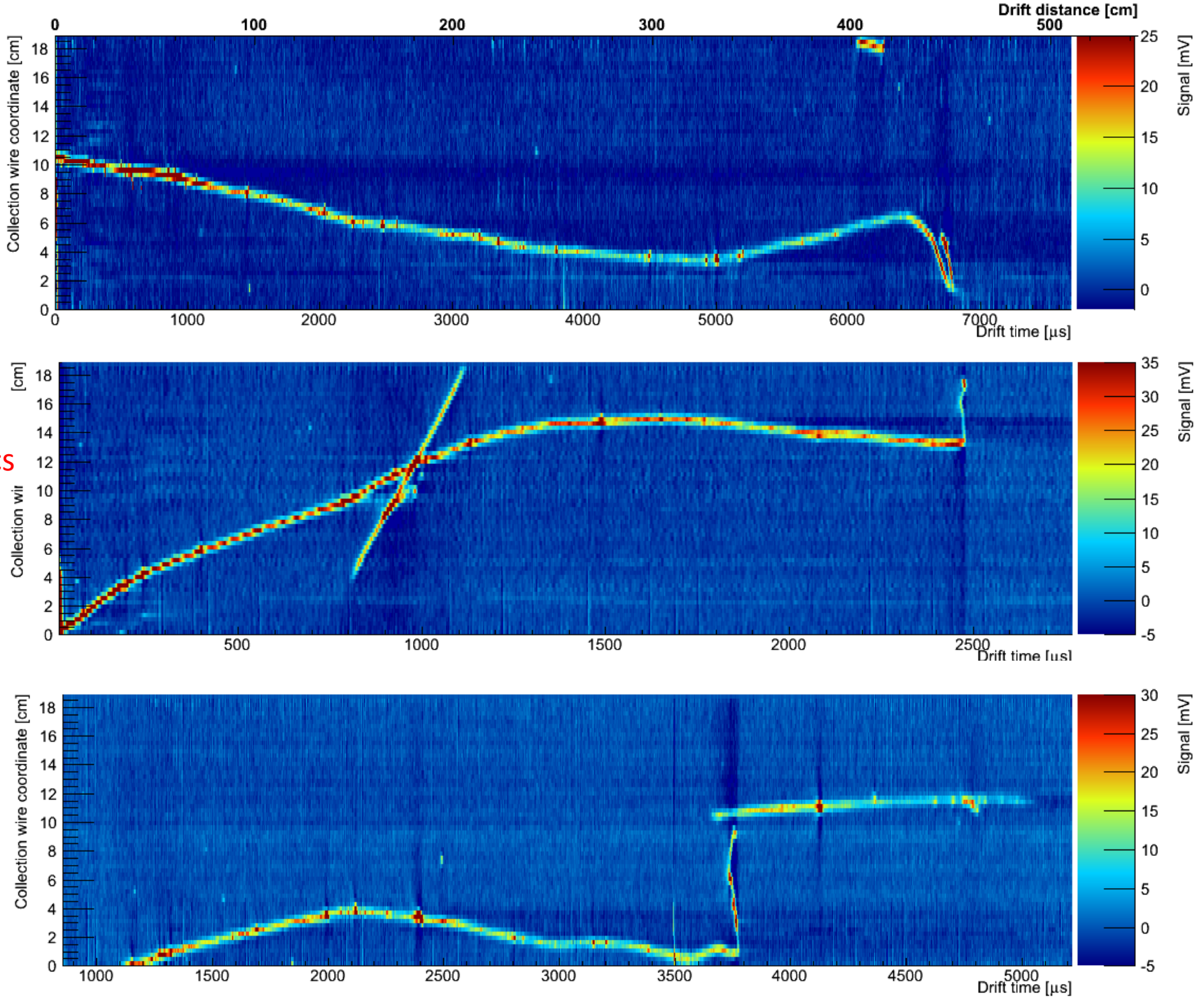
Cold electronics



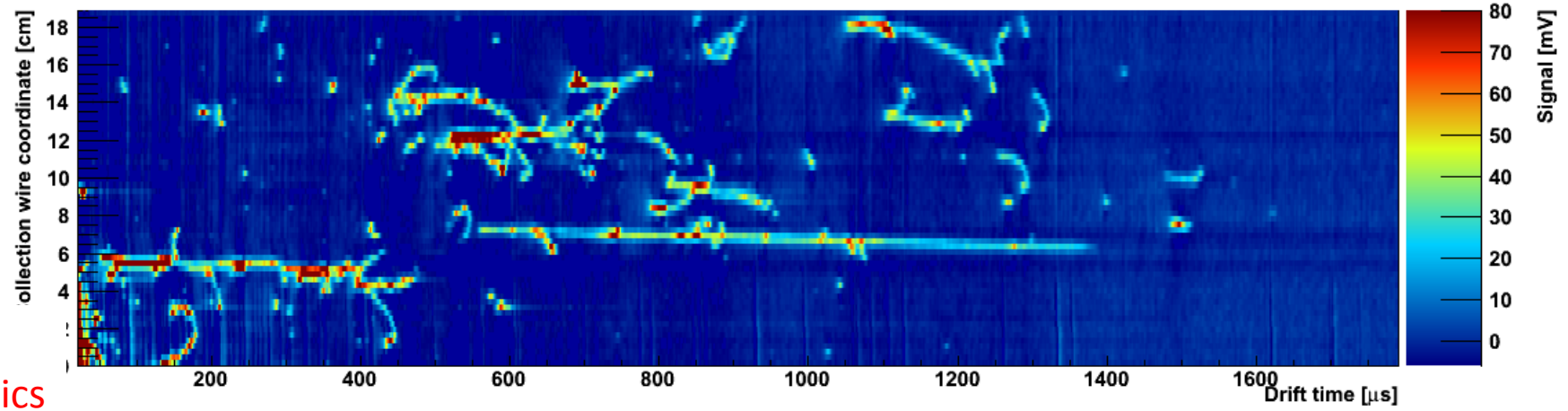
Cold electronics

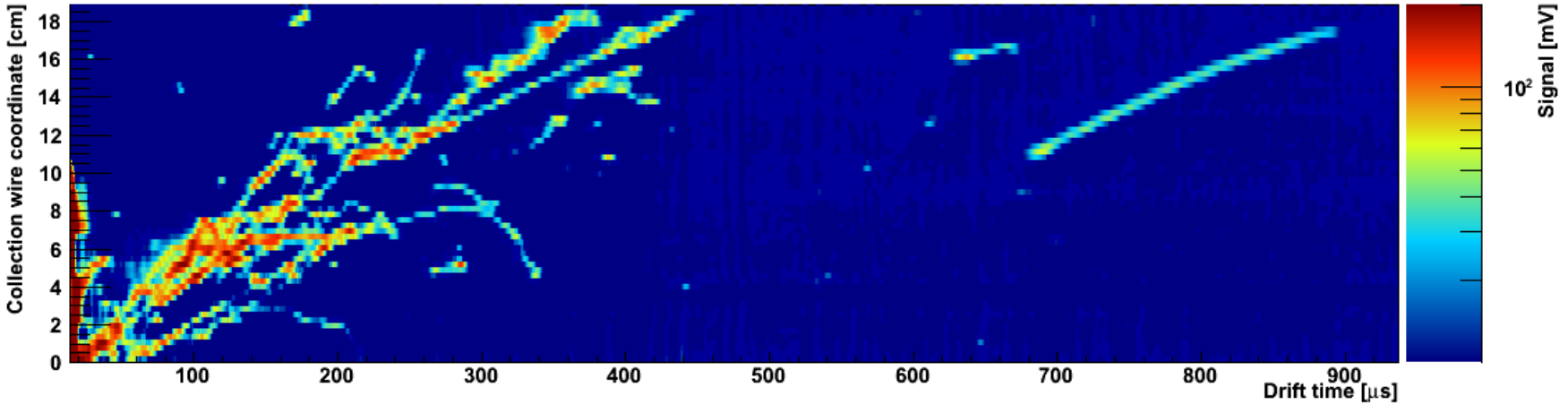


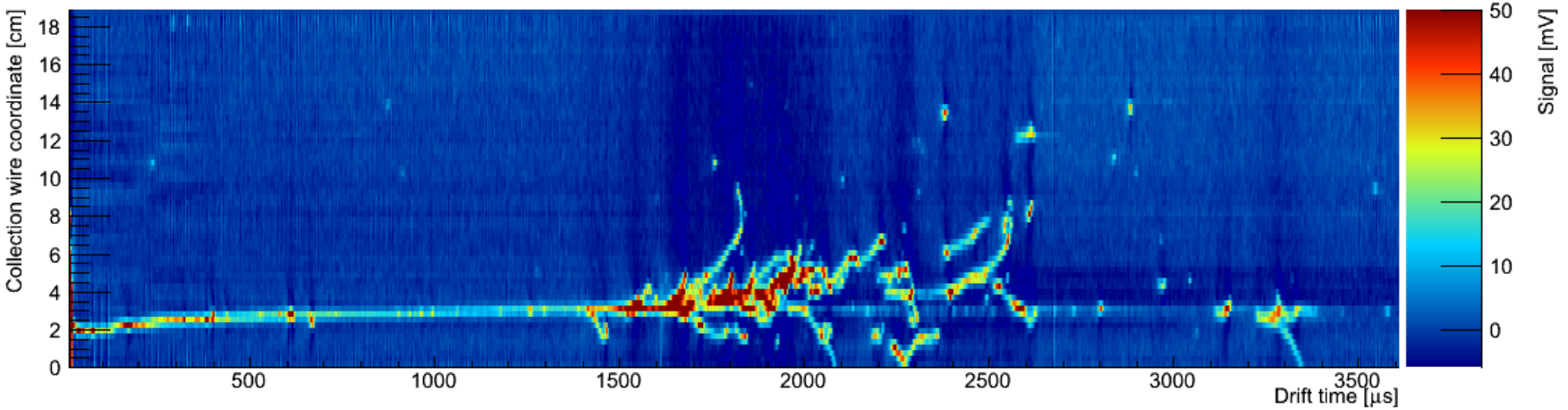
Cold electronics



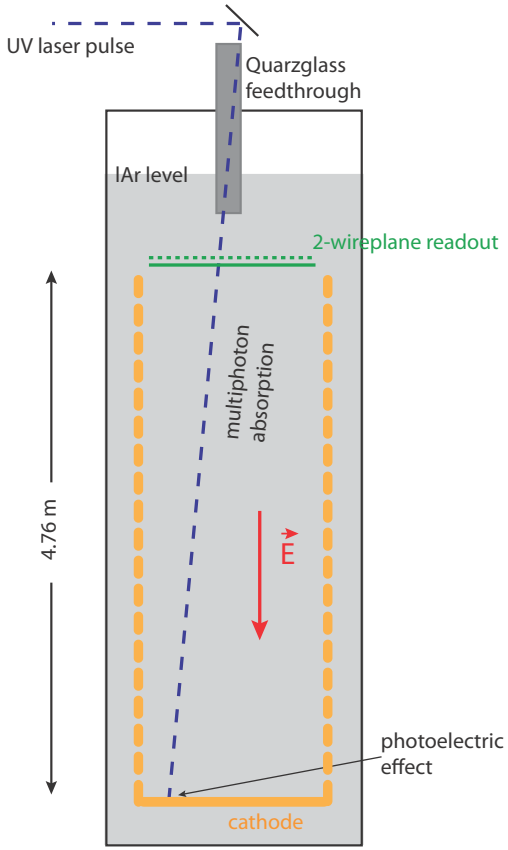
Cold electronics







UV-laser calibration

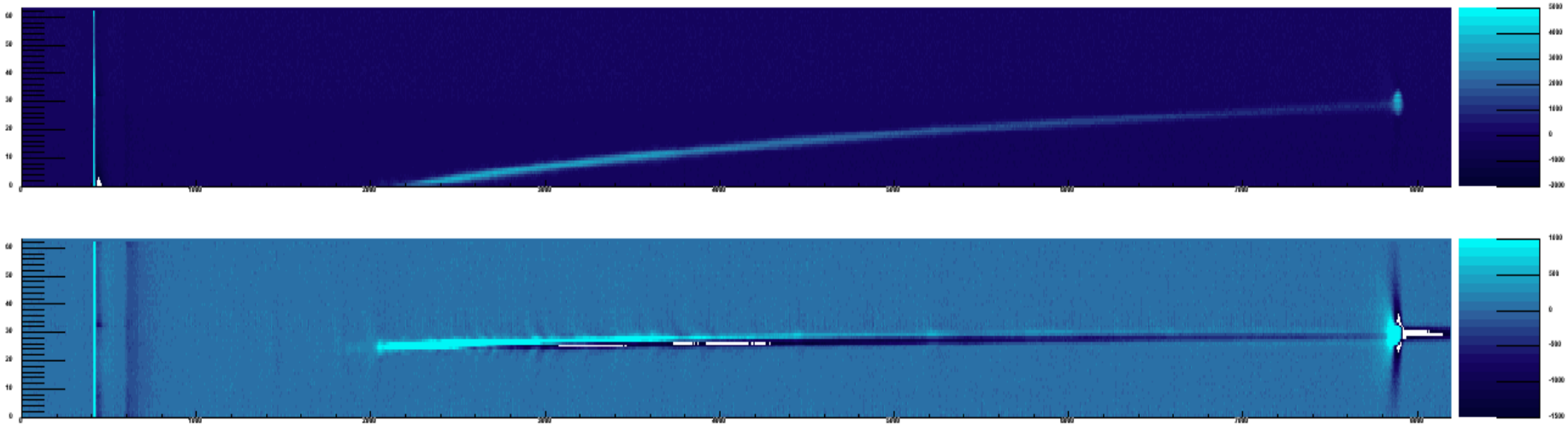


LHEP Bern pioneered the use UV laser-beams to ionize LAr by a multi-photon process

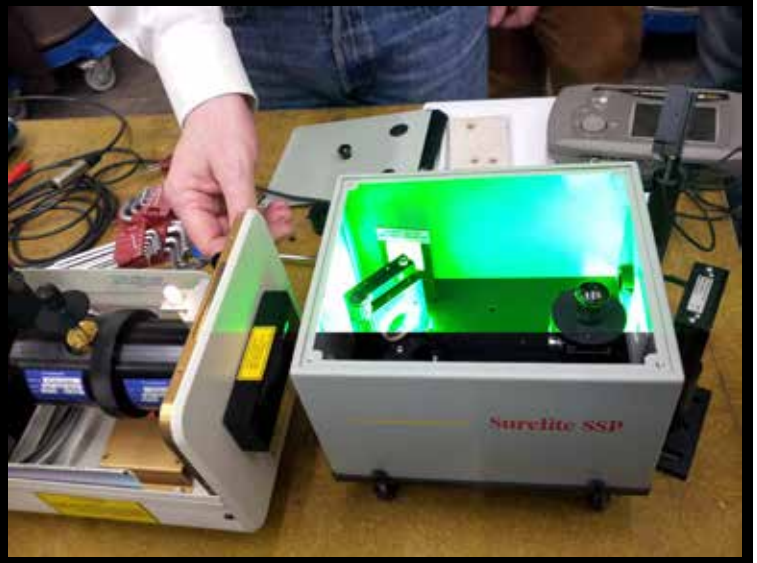
2009 JINST 4 P07011
NJP 12 (2010) 113024

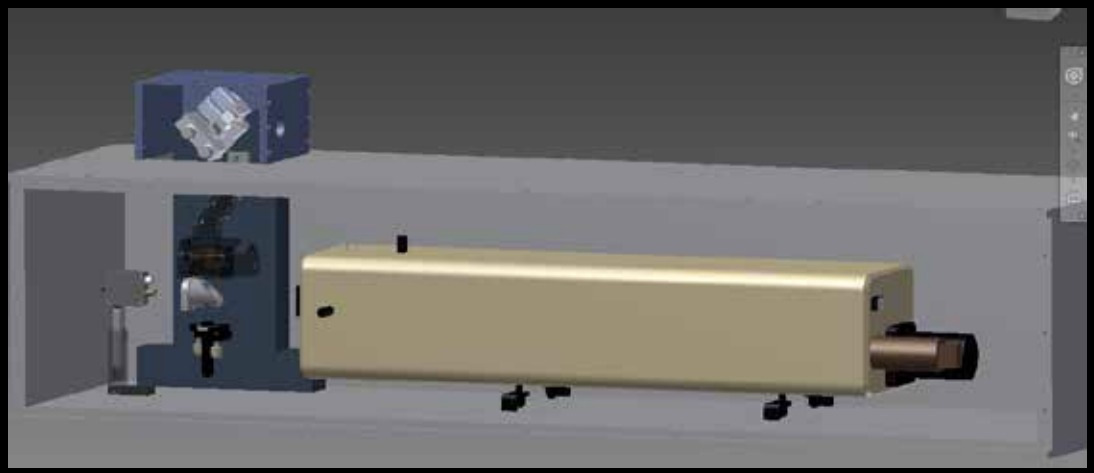
Exploit the technology to generate calibration “tracks” to correct for: space charge effects, local accumulation of ions leading to field distortions.

Applied to ARGONTUBE, MicroBooNE and LAr1-ND

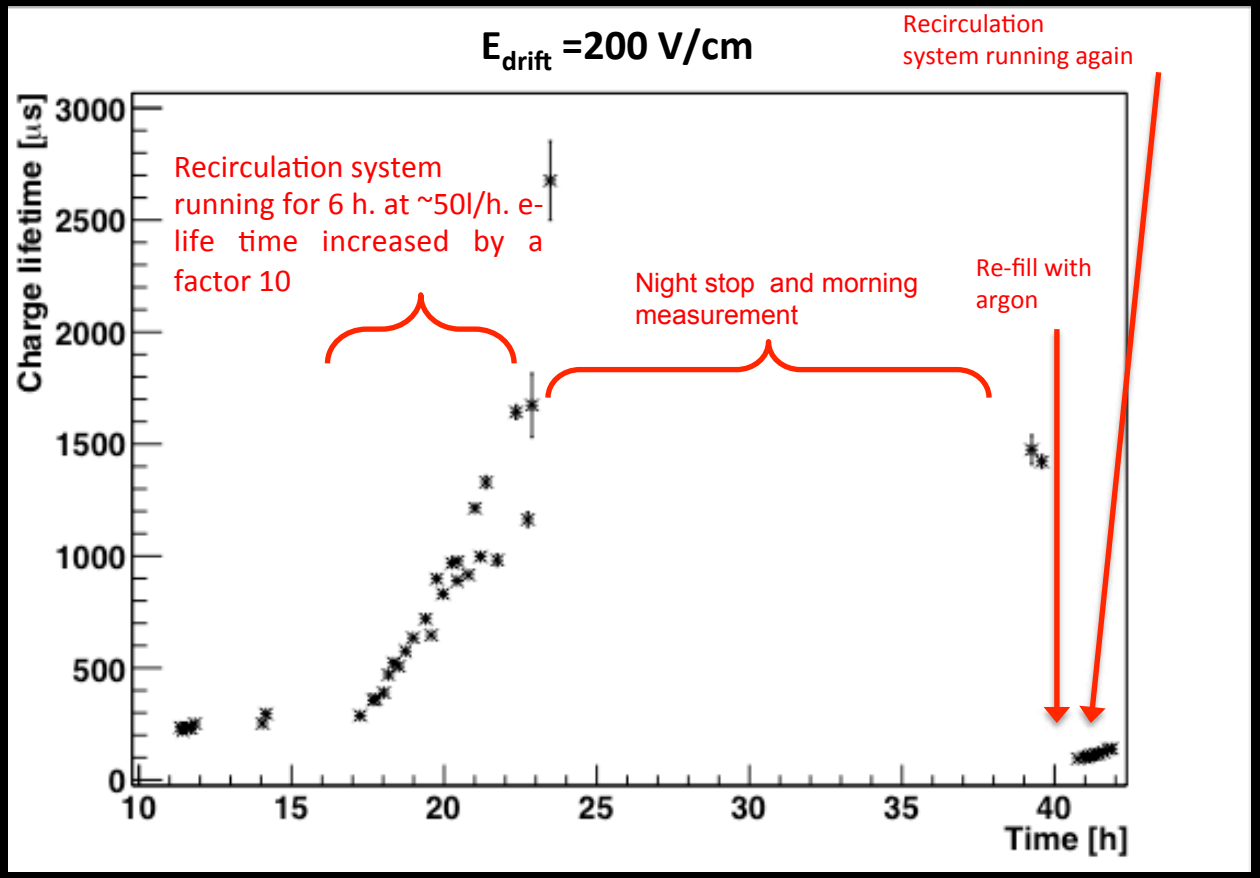


UV-laser system for MicroBooNE





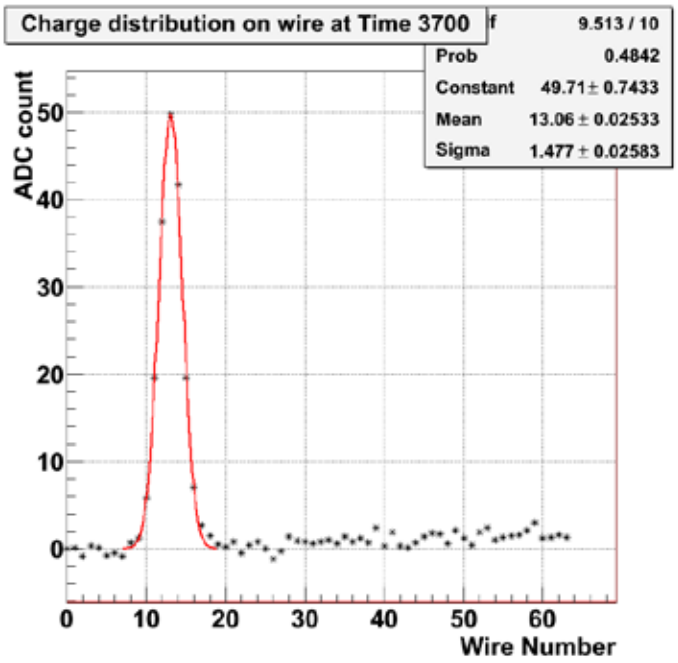
Application: measurement of purity by UV-laser tracks

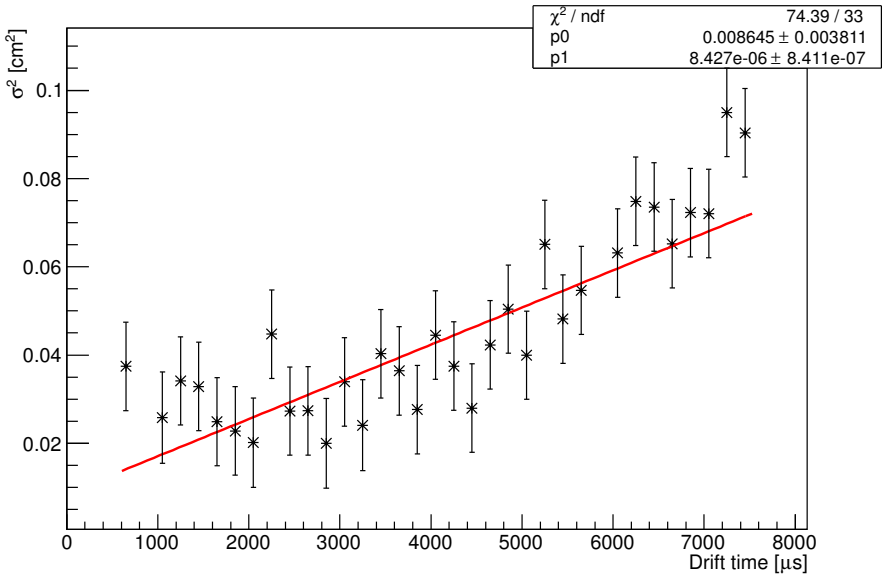


ARGONTUBE routine operation: 2.5 ms lifetime (0.12 ppb Oxygen equivalent)

Physics result from ARGONTUBE:
measurement of transverse charge diffusion (by laser beams)

$$D = \frac{\sigma^2 - \sigma_0^2}{2t}$$

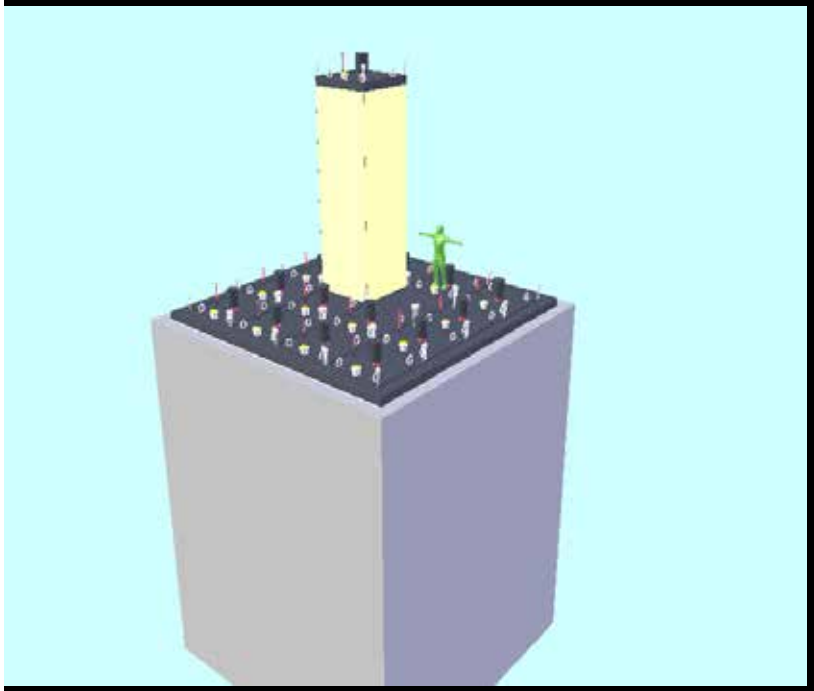




$$D = 4.21 \pm 0.42 \text{ cm}^2/\text{s}$$

From ARGONTUBE to ARGONCUBE

ARGONCUBE: a modular, scalable LAr TPC design



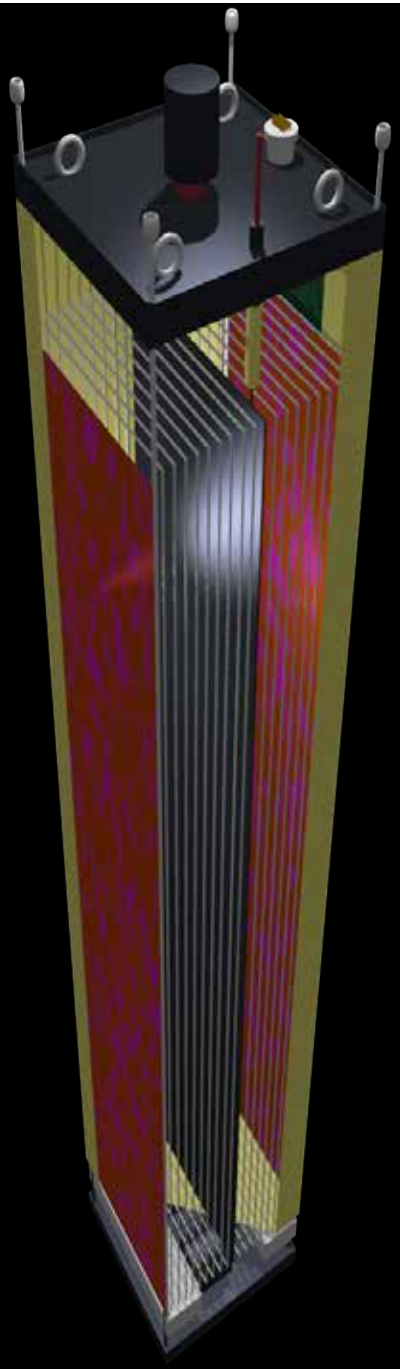
Main features:

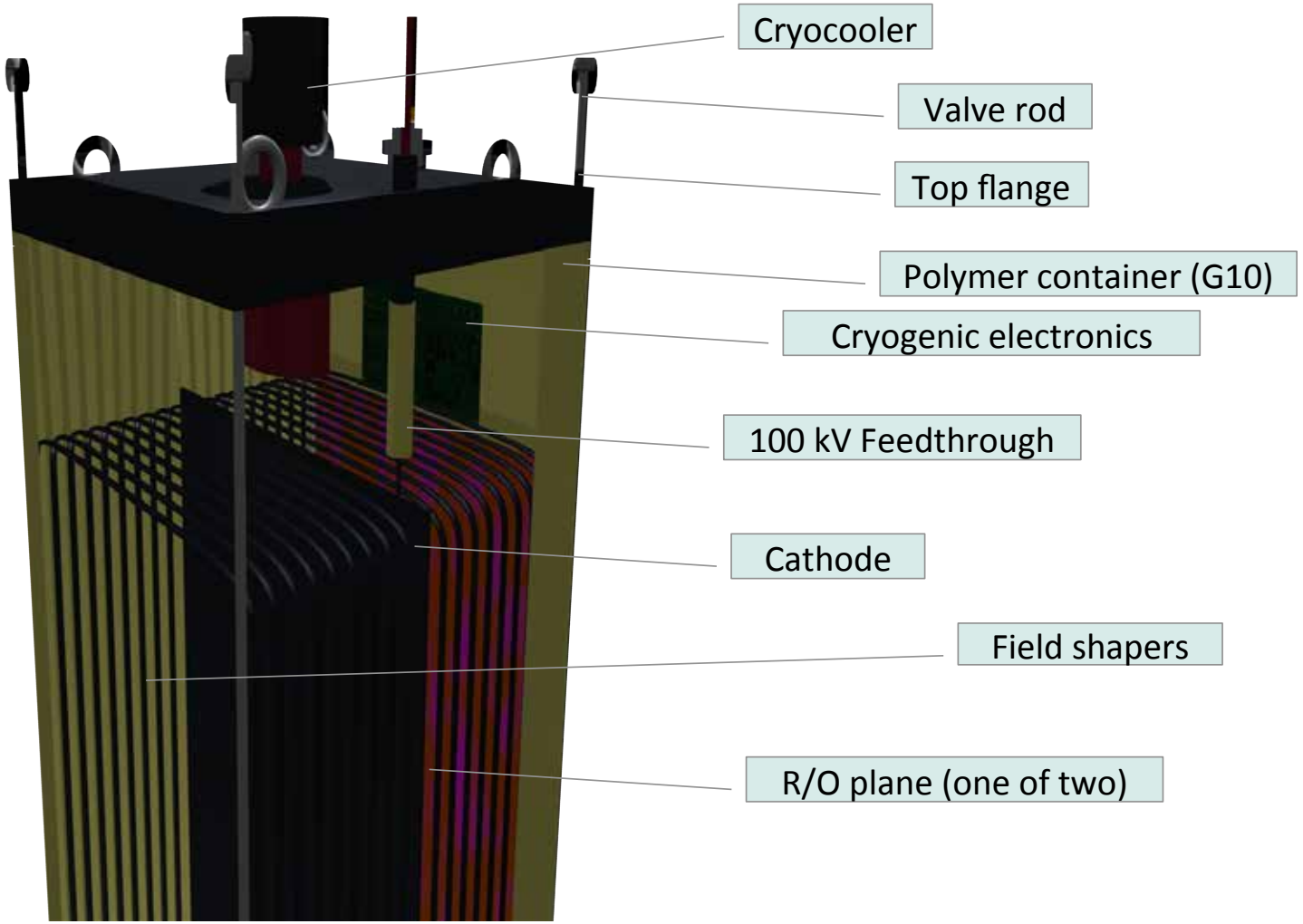
- Common bath to all independent TPC modules
- Thin walls separated modules (~2% dead mass)
- Short horizontal drift (~1-2 m), low HV
- Single phase readout
- Each module with own purification and readout systems
- Cold electronics, pick up pixels/strips, zero suppression
- Incremental detector mass

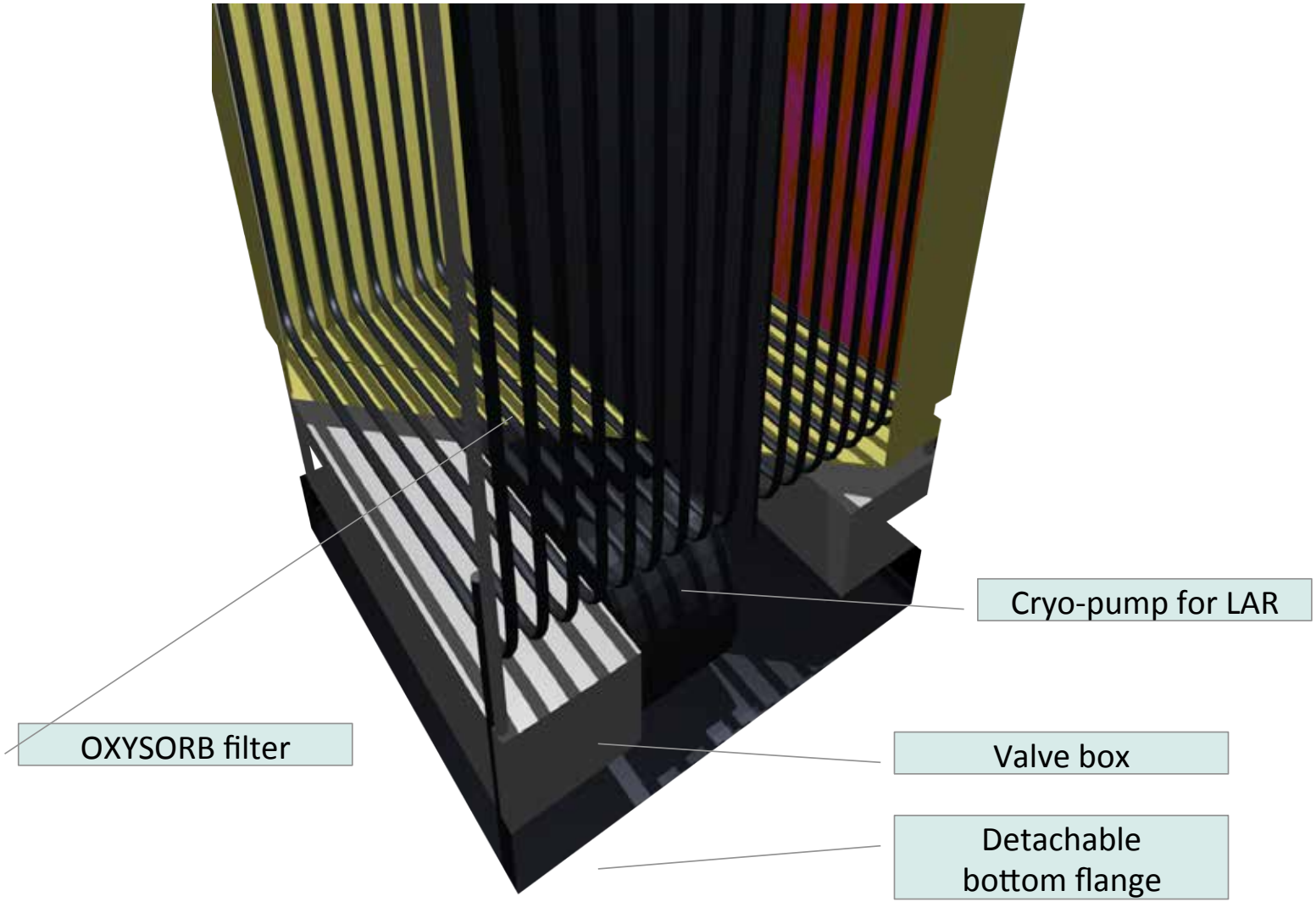
Advantages:

- "Short" drift distance, tuned to the achievable HV and purity (~1 ms drift time)
- Low space charge, low stored charge & energy compared to monolithic approaches
- Scalable with currently known and proven technology
- If pixel/strip readout viable→ simpler mechanics
- Extractable modules for staged installation and maintenance/repairs
- Modular structure allows for shared, "democratic" construction load/cost

ARGONCUBE
module design




Cryocooler
Valve rod
Top flange
Polymer container (G10)
Cryogenic electronics
100 kV Feedthrough
Cathode
Field shapers
R/O plane (one of two)

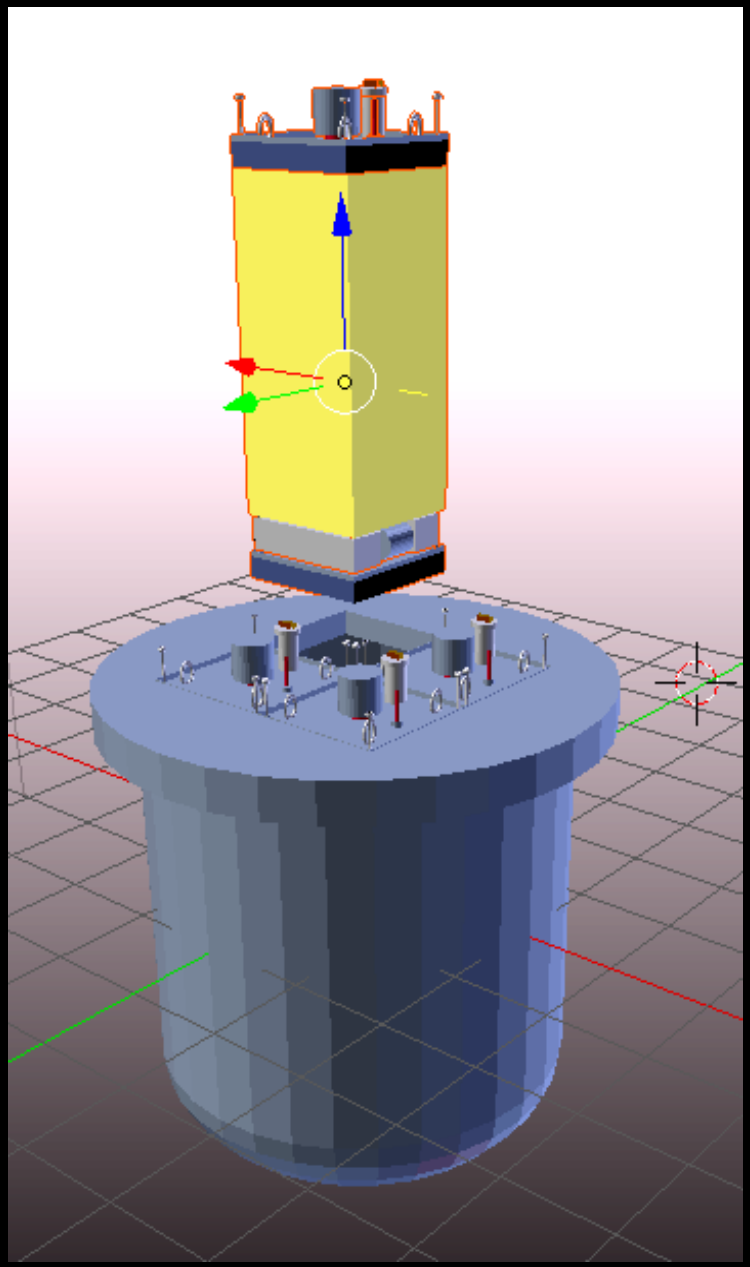

OXYSORB filter
Cryo-pump for LAR
Valve box
Detachable
bottom flange

Two ARGONCUBE R&D phases:

1) Test in Bern: 4 small-module setup for R&D studies on readout, electronics, mechanics, cryogenics, modularity, etc. Charged beam beam test in the North Area is an option.

2) Larger scale (5 modules) setup for CENF at CERN.

Cryostat for the tests in Bern



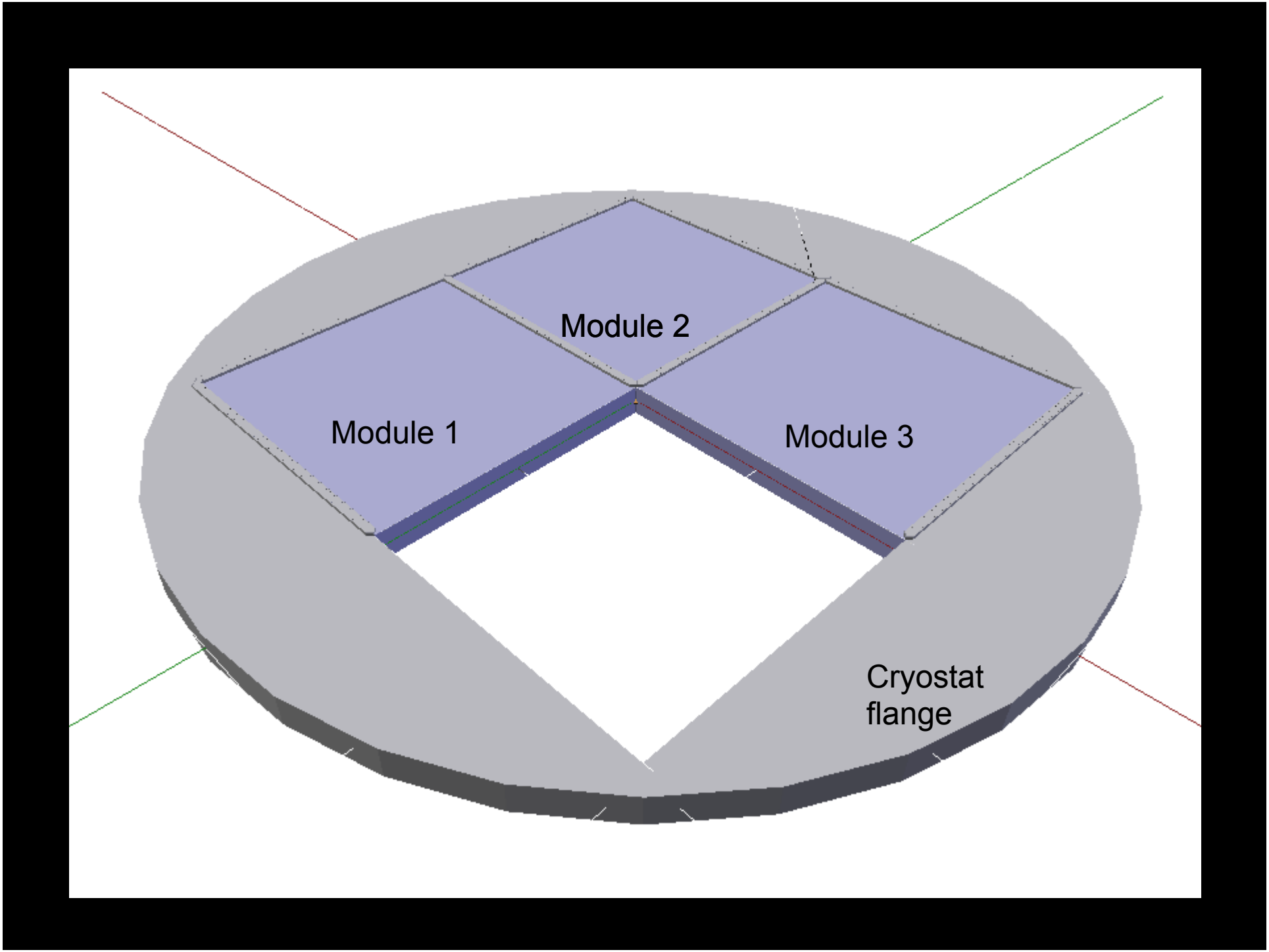
Phase 1)

4 modules (at the time in the cryostat)

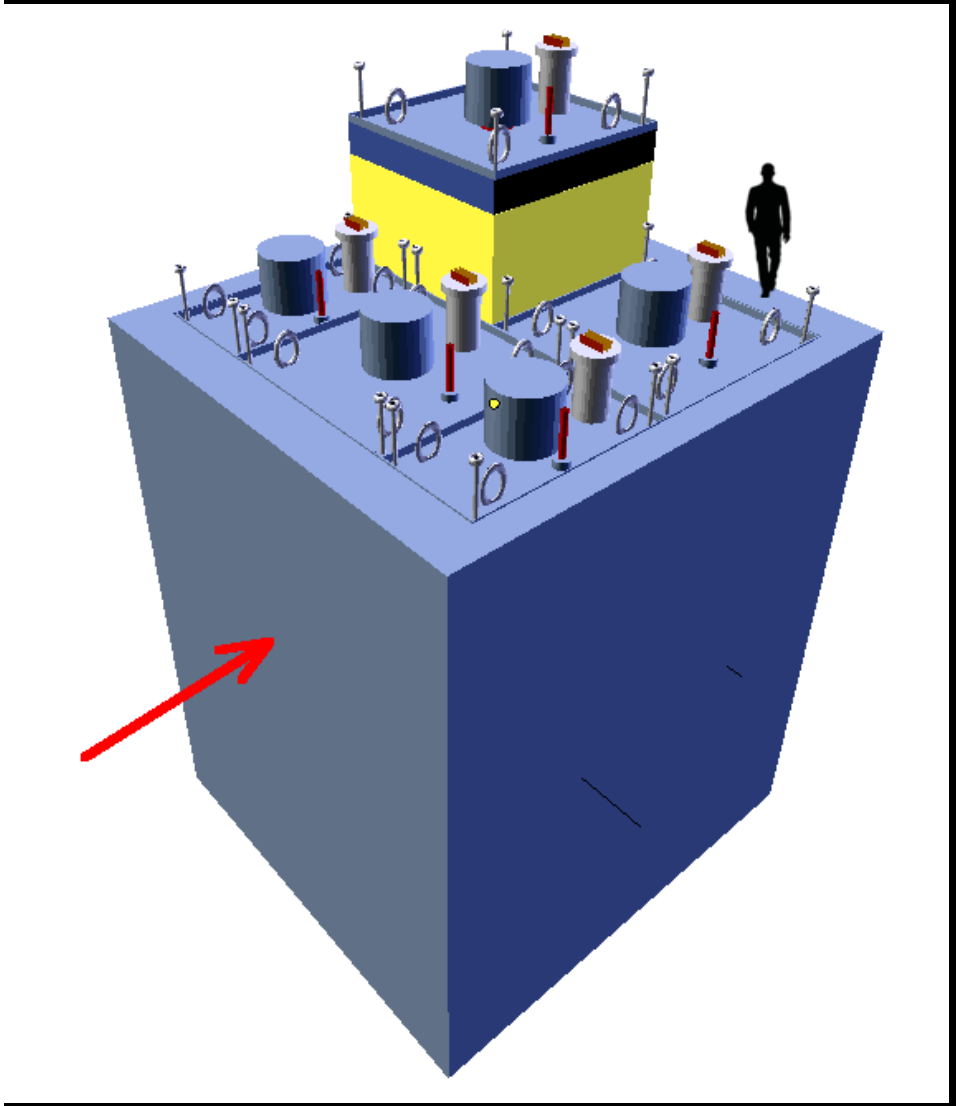
67x67 cm^2, 1.8 m high
Argon volume ~ 0.6 m^3 per module
Argon mass ~ 820 kg per module
Fiducial mass ~ 750 kg per module

Double-side drift
Max drift length: 33 cm
Field cage : copper-in-G10
Scintillation: WLS bars + MPPCs
Cryogenic preamps: LARASIC4
MicroBooNE signal feed through
ARGONTUBE HV feed through

Test different R/O and technological solutions:
No-wires option w/ pixelized readout


Module 2
Module 1
Module 3
Cryostat
flange

Phase 2)



Cryostat 5x5x5 m^3

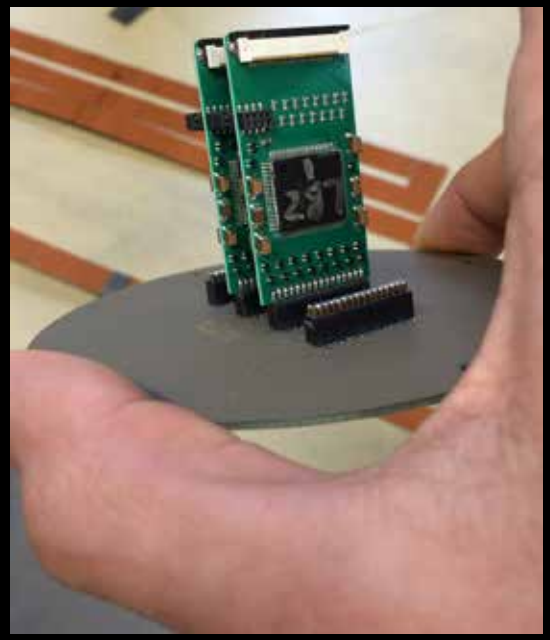
5 modules. Present design:

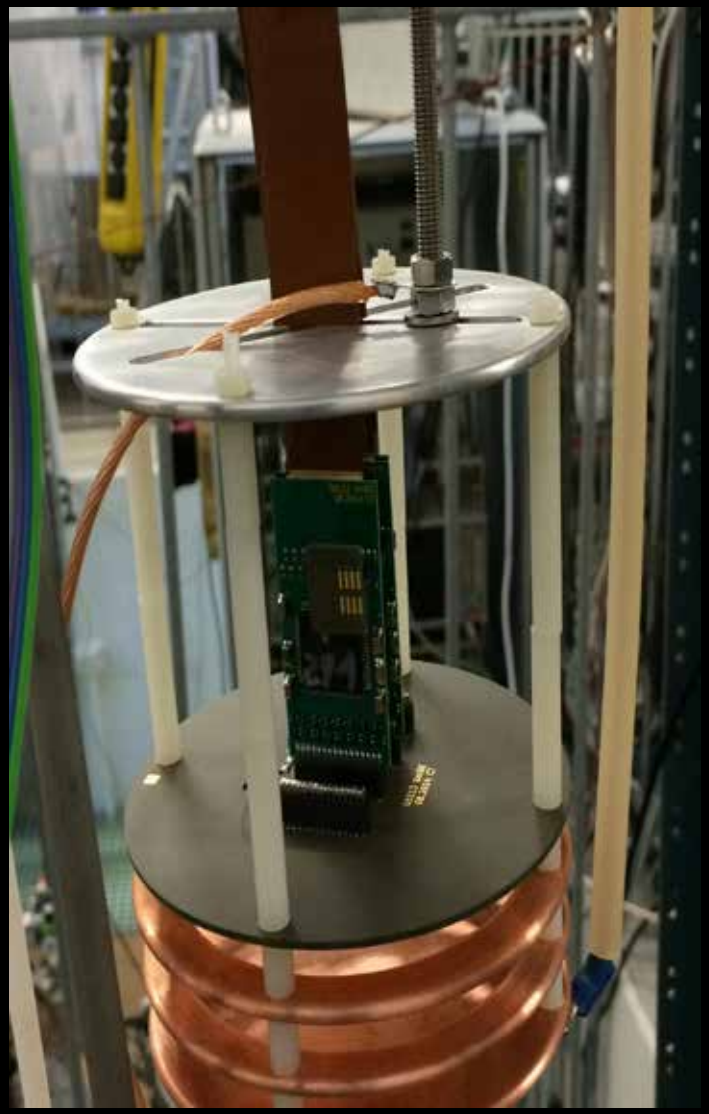
Three with 2x2 m^2 5m height
Two with 1x2 m^2 5m height

Share the cryostat with other groups?

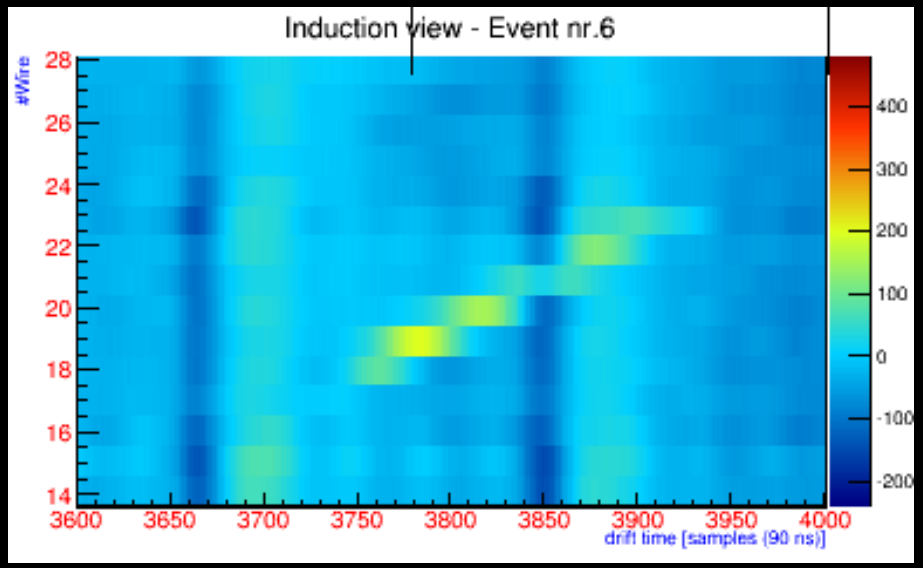
Tests with charged particle beams at CENF

Example of R&D in progress: pixel readout





Cosmic muon detection by pixel readout



LoI for the SPSC in preparation

ArgonCube: a novel, fully-modular approach for the realization of large-mass liquid argon TPC neutrino detectors

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- Two-fold challenges:
  - modular TPC structure
  - pixelized charge readout
- LBNF detectors (near and far) with the ARCONCUBE approach?

Thinking of a multi kton, scalable and modular detector…