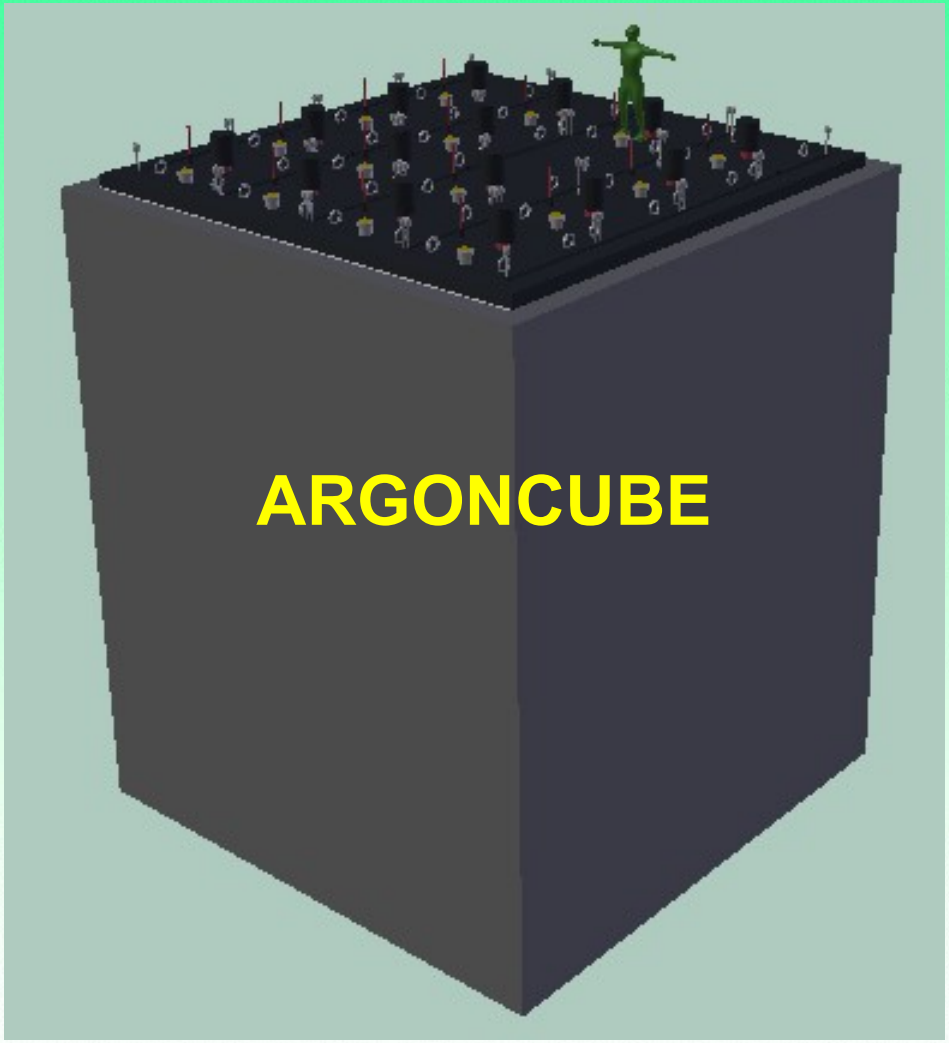
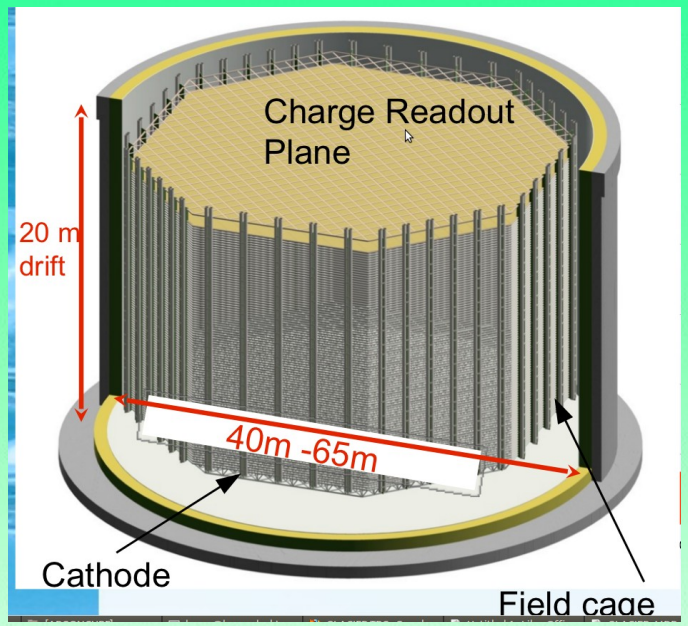
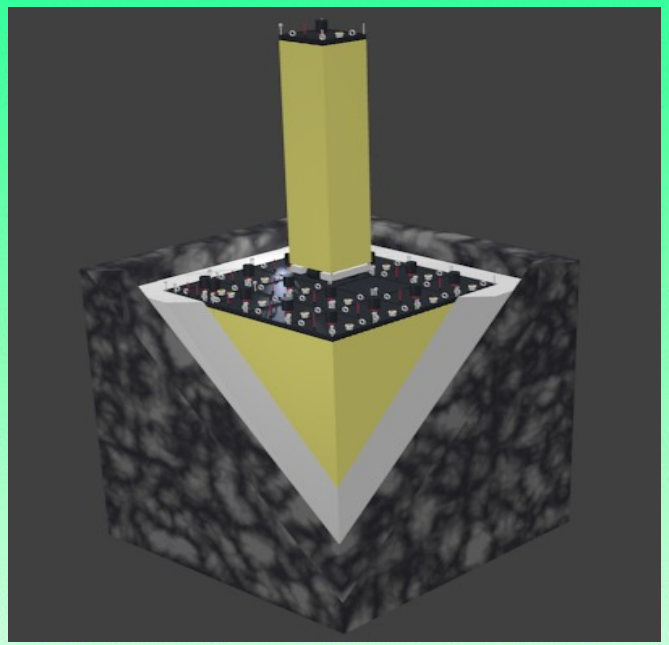
Modular scalable TPC for neutrino observatories



Reference data

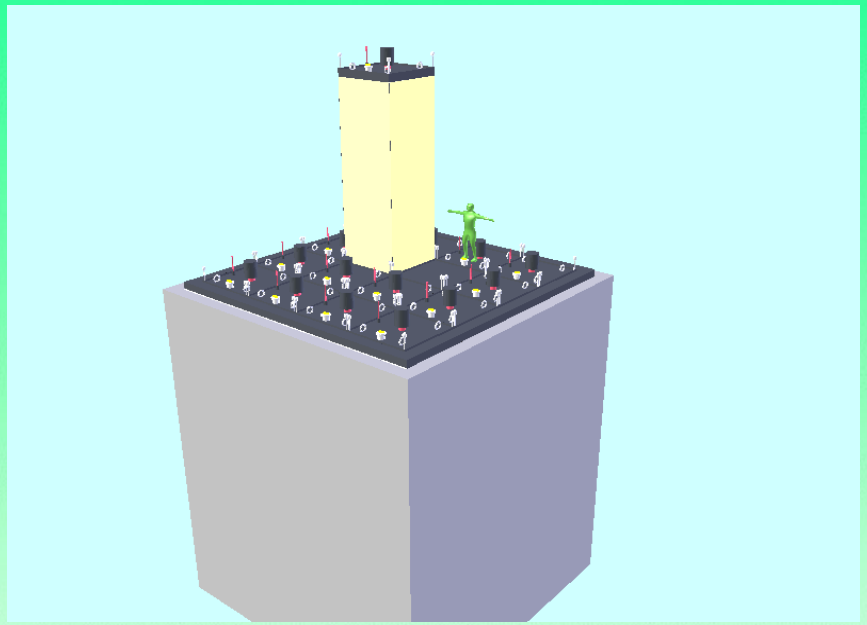




GLACIER highlights (for reference)
- Single 30 kton argon volume
- 20 kton active (70%)
- Vertical electron drift
- Double-phase charge amplification
- Single drift readout ~ 10-20 ms
- Cathode potential ~1-2 MV

ARGONCUBE (design goals)
- Total 30 kton argon volume, split by ~50 ton modules
- 29 kton active (97%)
- Horizontal electron drift
- Charge amplification by cryogenic electronics
- Cathode potential ~100 kV

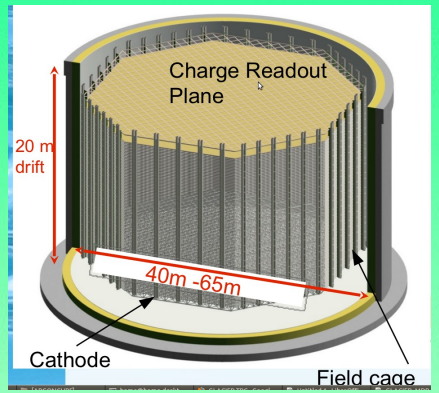
Highlights of modular approach

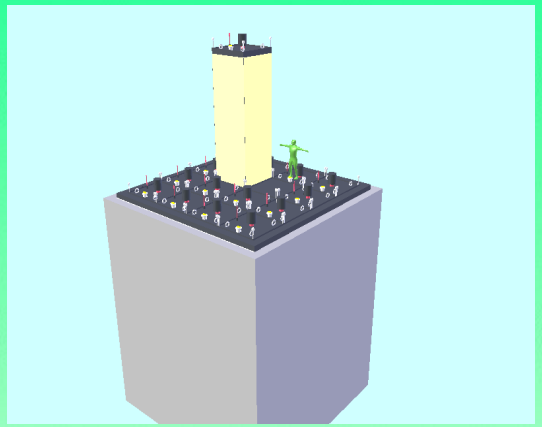


ARGONCUBE

- Transportable modules
- Unified modules → high redundancy
- Step-by-step commissioning
- Extract module → Repair → Re-insert
- Scalable and extendable (same tech. for ND and FD)
- Iterative upgrade with new technologies
- **Cathode potential O(100 kV)**
- **2% dead mass**
- **Drift time O(1 ms)**

Cathode potential





GLACIER

1-2 MV:
- Feedthrough is a challenge

- Drift time > 10 ms

ARGONCUBE

100 kV
- Feedthrough made at LHEP
- Wide choice of PS units
- Drift time ~ 1ms

Charge attenuation → calorimetry constant term

LAR Purity ~ 0.01 ppb

Purity ~0.1 ppb (reached in ARGONTUBE)

Accumulation of volume charge

Low distortions (~3%, in MicroBooNE 10%)

Risk of breakdowns (arcing)

Stored charge ~ 1nF x 1 MV = 1 mC
Stored energy 1 mC x 1 MV = **1 kJ**

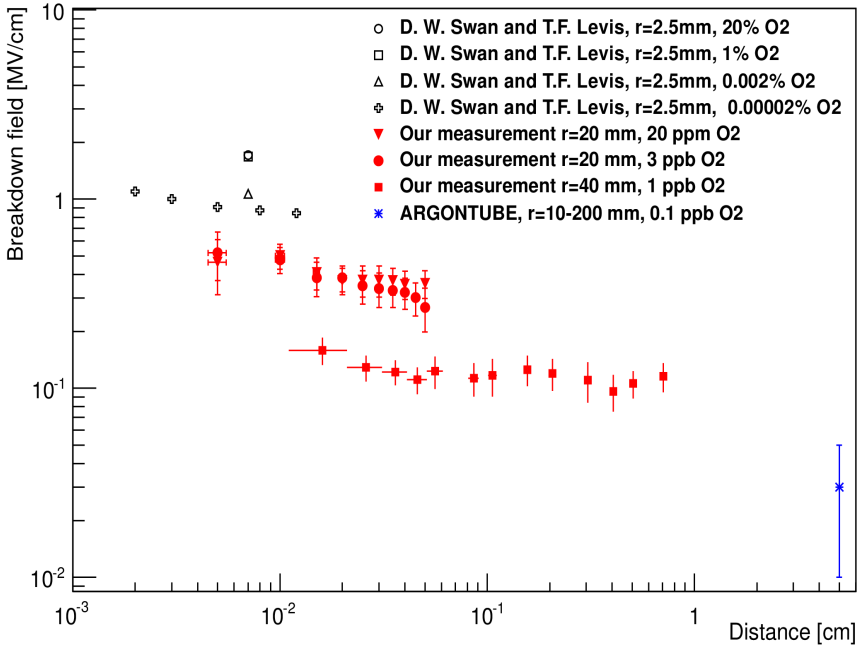
~ 1nF x 100 kV = 0.1 mC / module
0.1 mC x 100 kV = **10 J / module**

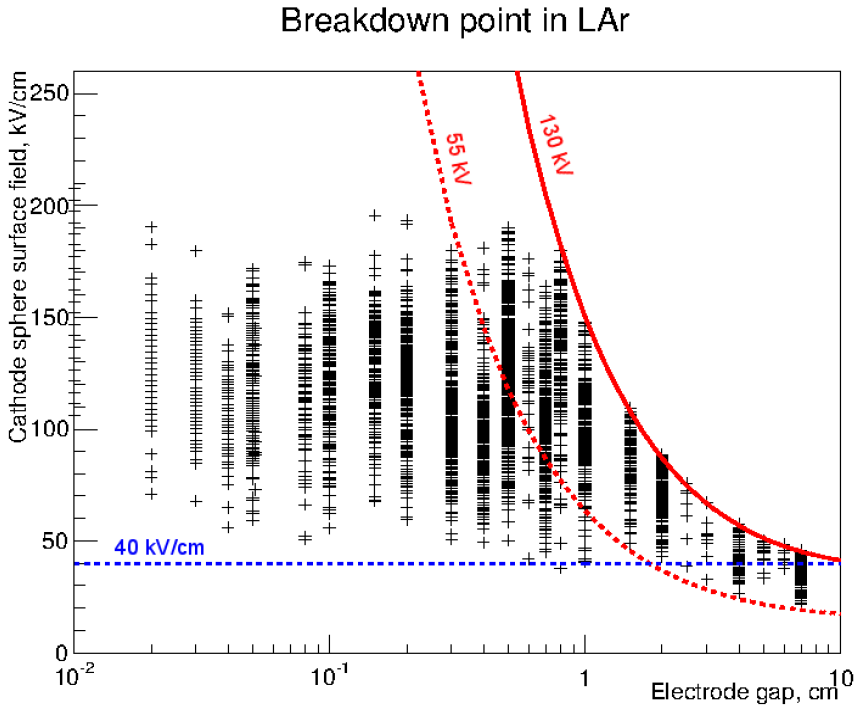
Risk of breakdowns (arcs)

"Experimental study of electric breakdowns in liquid argon at centimeter scale"
A. Blatter, A. Ereditato, C. -C. Hsu, S. Janos, I. Kreslo, M. Luethi, C. Rudolf von Rohr, M. Schenk, T. Strauss, M.S. Weber (U. Bern, AEC) et al.. Jan 26, 2014. 13 pp.
e-Print: arXiv:1401.6693 [physics.ins-det]

At scales of > 1 cm LAR is not so good dielectric,
arcing happens already at 40 kV/cm of applied field

ARGONCUBE : safely below 30 kV/cm





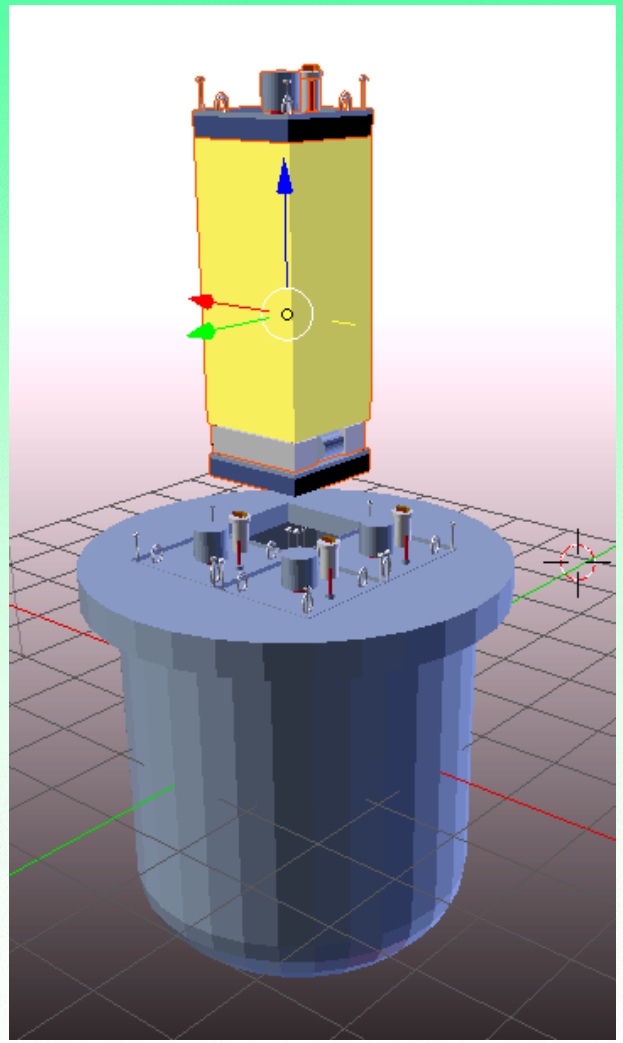
ARGONCUBE
Small size prototype

10.10.14 Cryostat is delivered to Bern

Vacuum isolated

Inner volume:
197 cm diameter
180 cm height of cylindrical part

ARGONCUBE
Small size prototype



4 modules

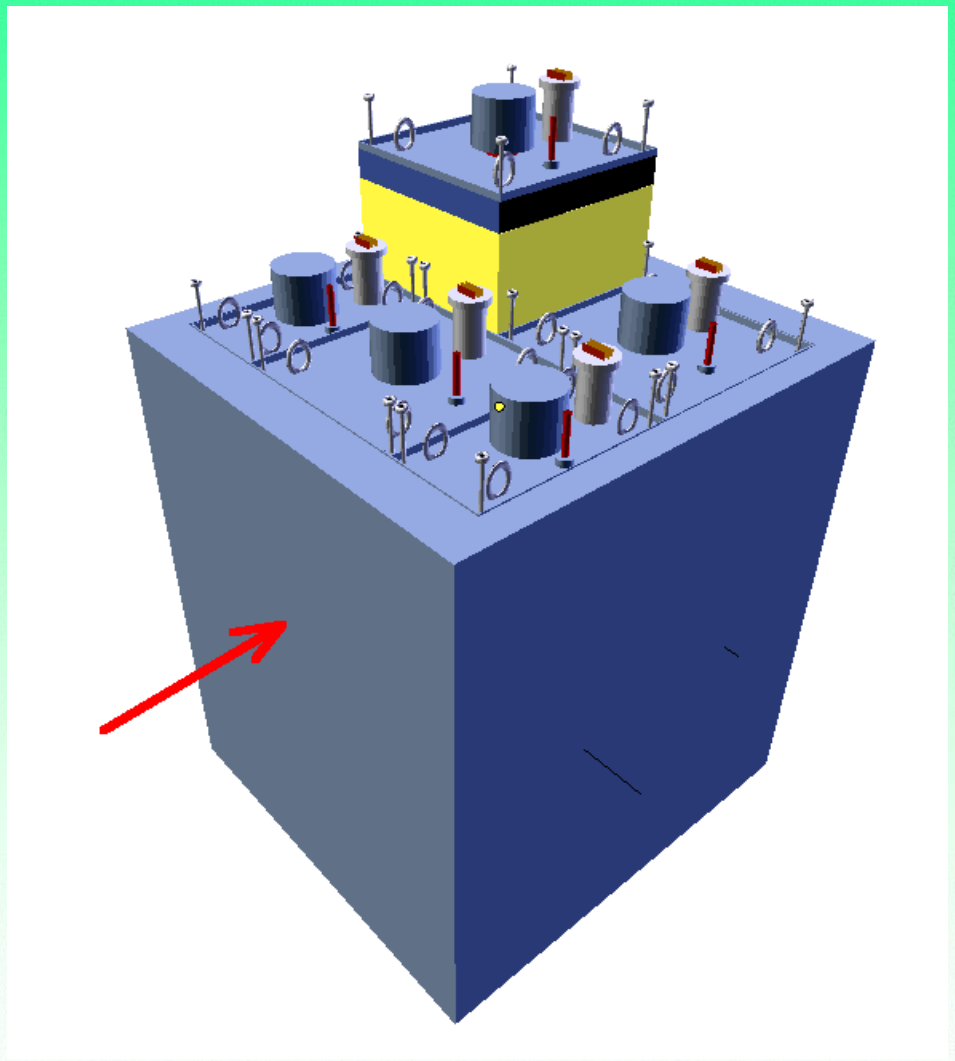
67x67 cm, 1.8m high

Argon volume ~ 0.6 m^3 per module

Argon mass ~ 820 kg per module

Fiducial mass ~ 750 kg per module

ARGONCUBE
Phase2 prototype

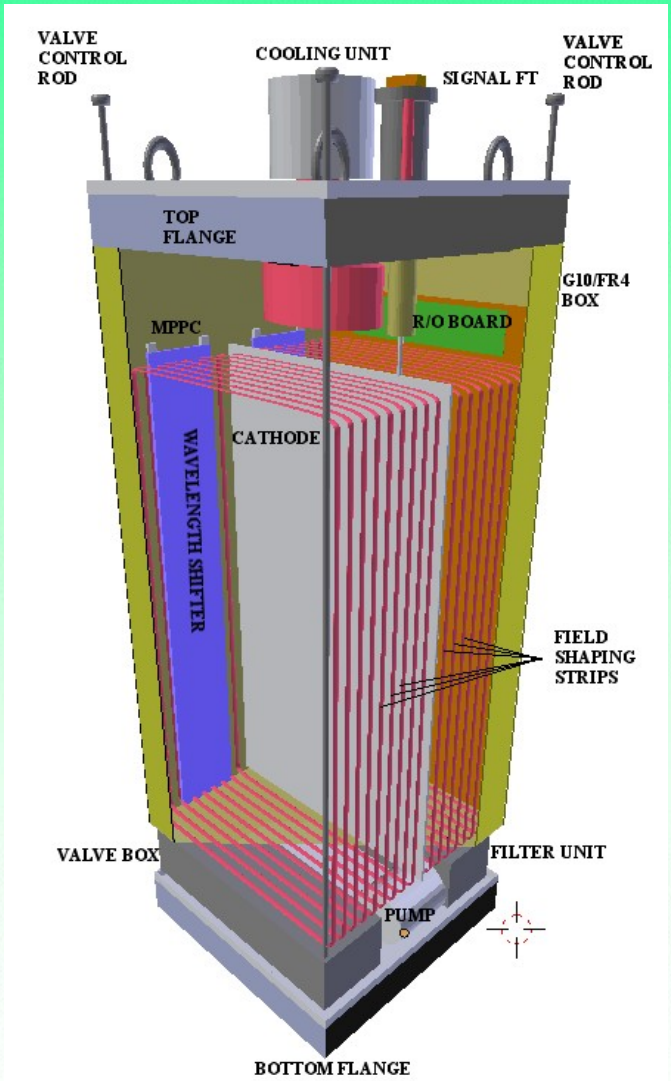


Cryostat 5x5x5 cub.m

5 modules

2x2m (1x2m), 5m high

ARGONCUBE
Small size prototype

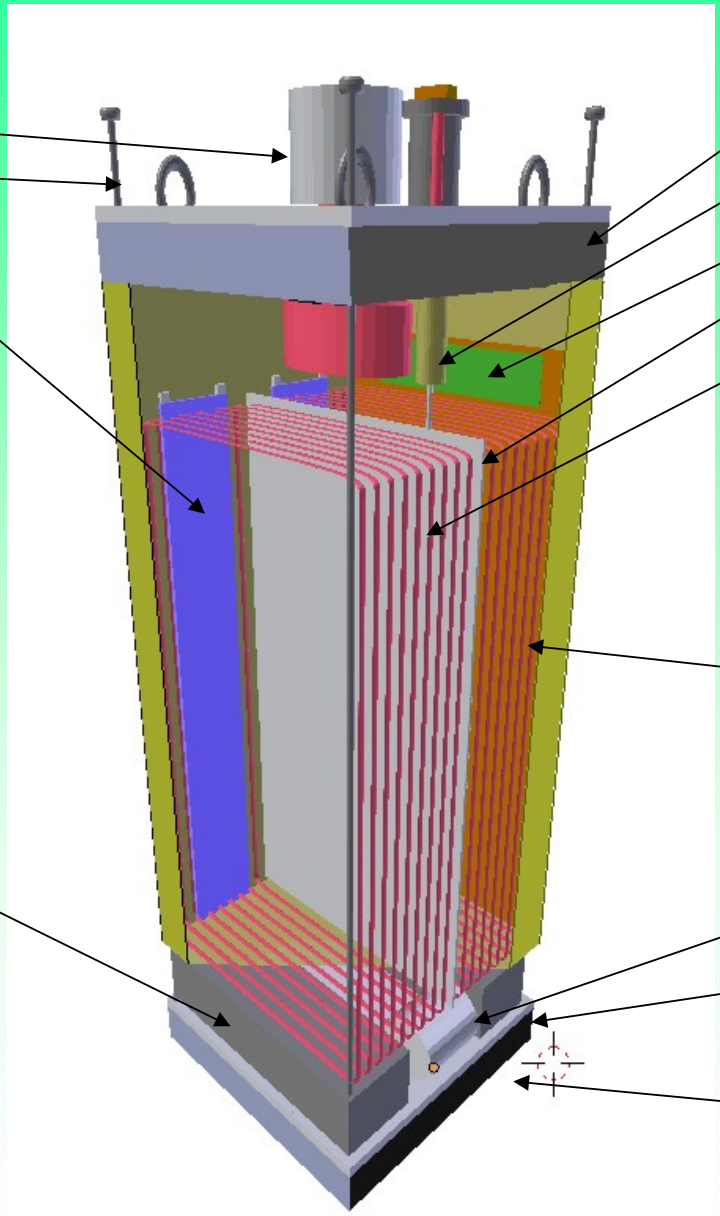


TPC module

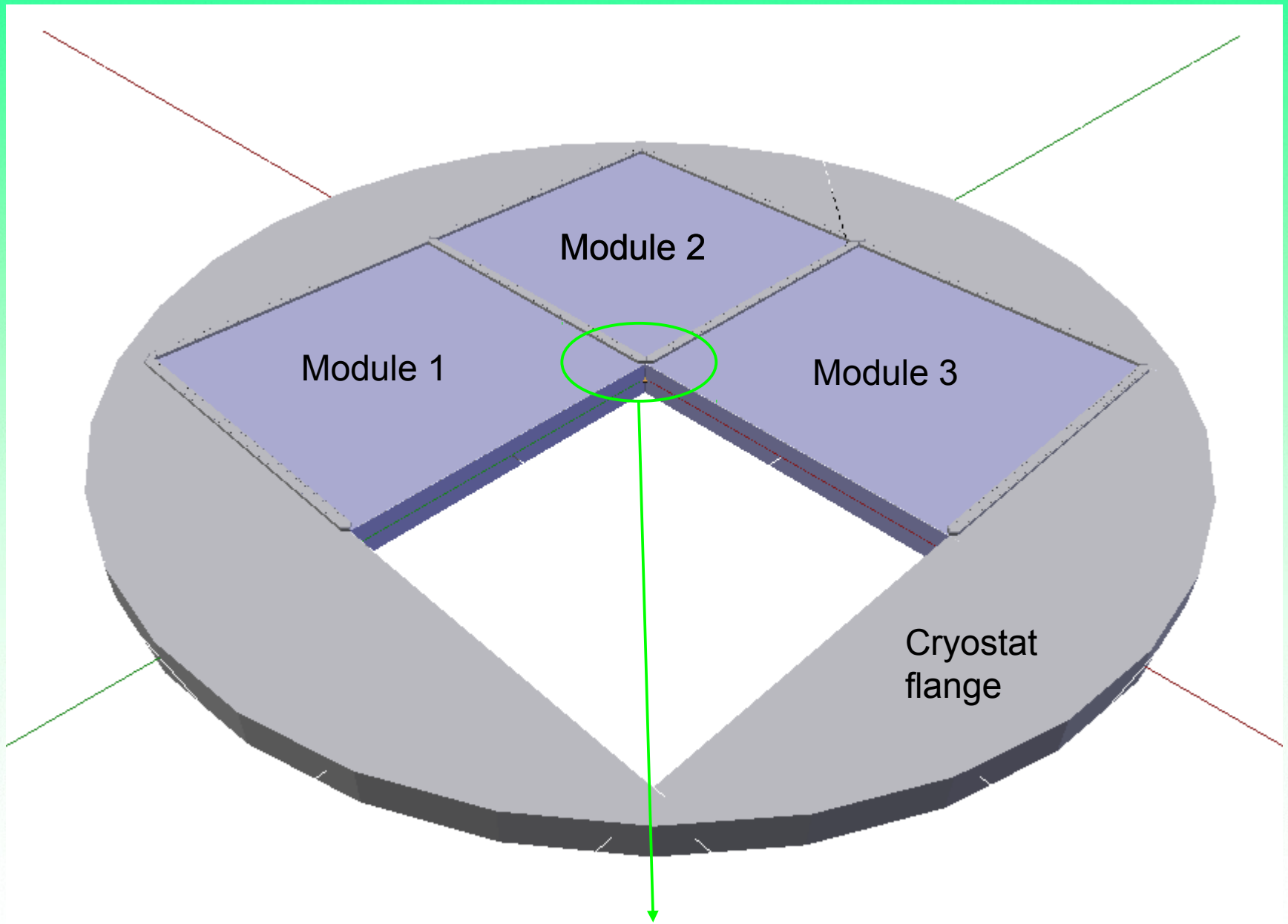
67x67 cm, 1.8m high

Double-drift scheme
Drift length: 33 cm
Field cage : copper-in-G10
Scintillation: WLS bar + MPPCs
Cryogenic preamps: LARASIC4

ARGONCUBE
Module design

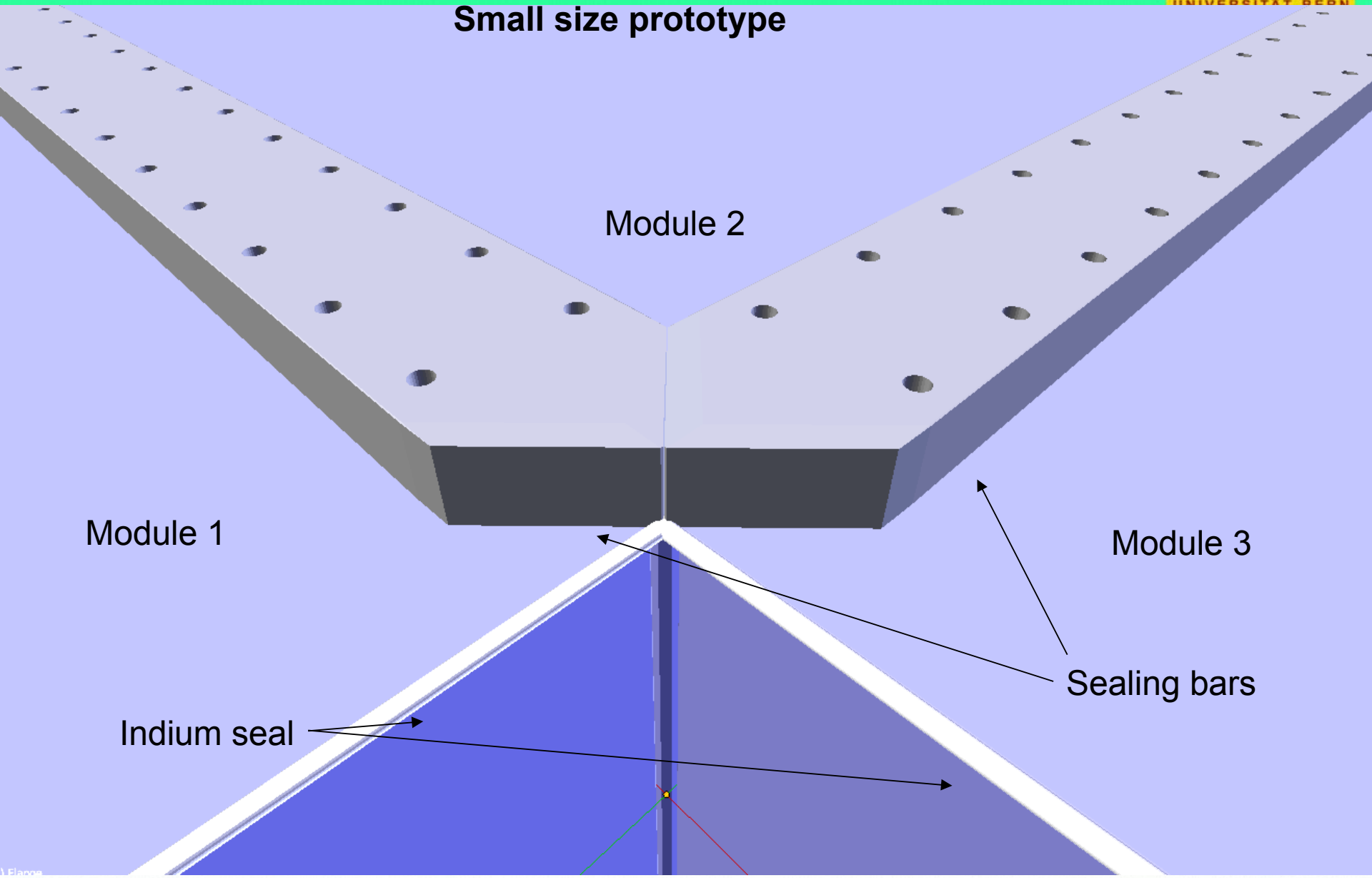


ARGONCUBE
Small size prototype

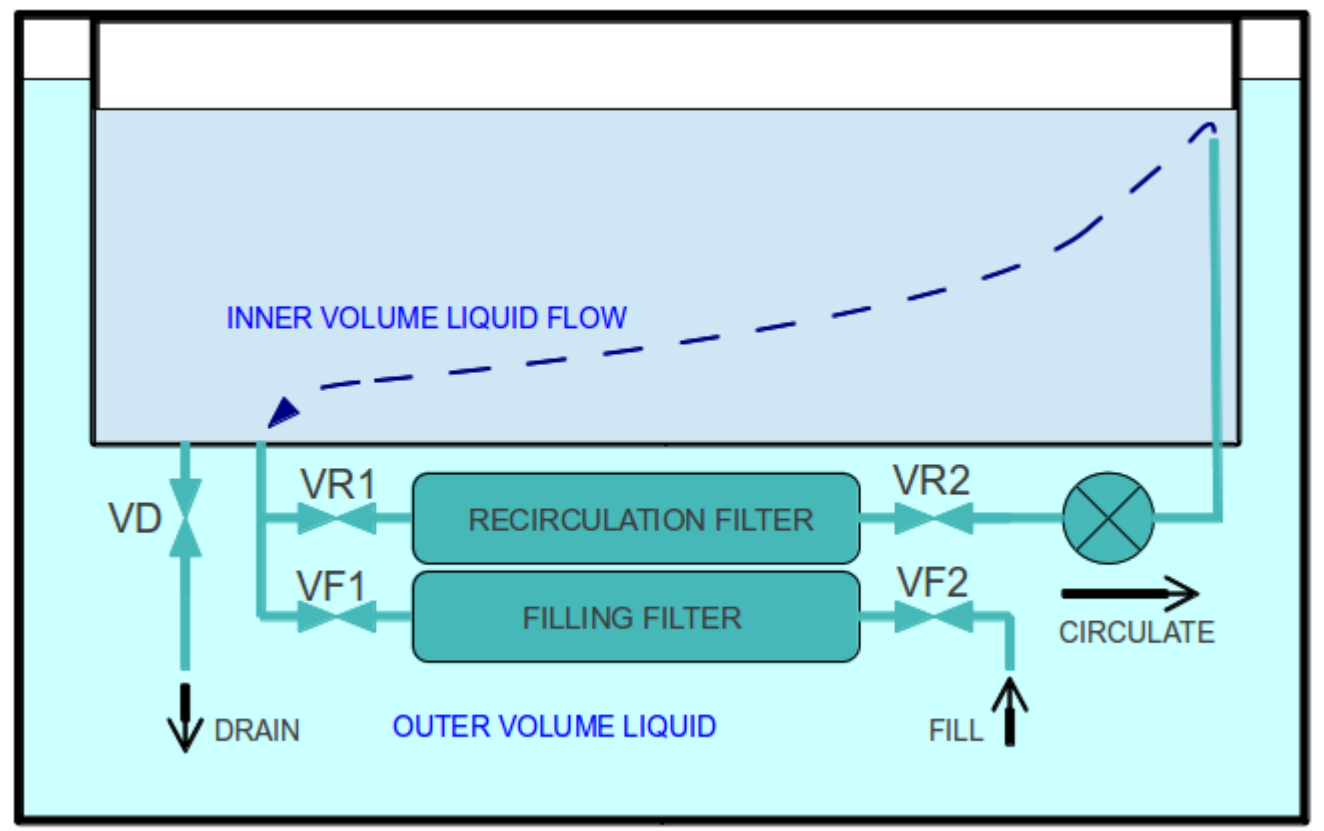


ARGONCUBE

Small size prototype



ARGONCUBE
Liquid argon flow diagram



Module insertion/extraction

1. Top flange seal removed
2. Top flange unfixed from neighbors
3. Module lifted until bottom matches top
4. Fix “bottom” flange to neighbors
5. Detach support rods
6. Seal the flange
7. Remove the module

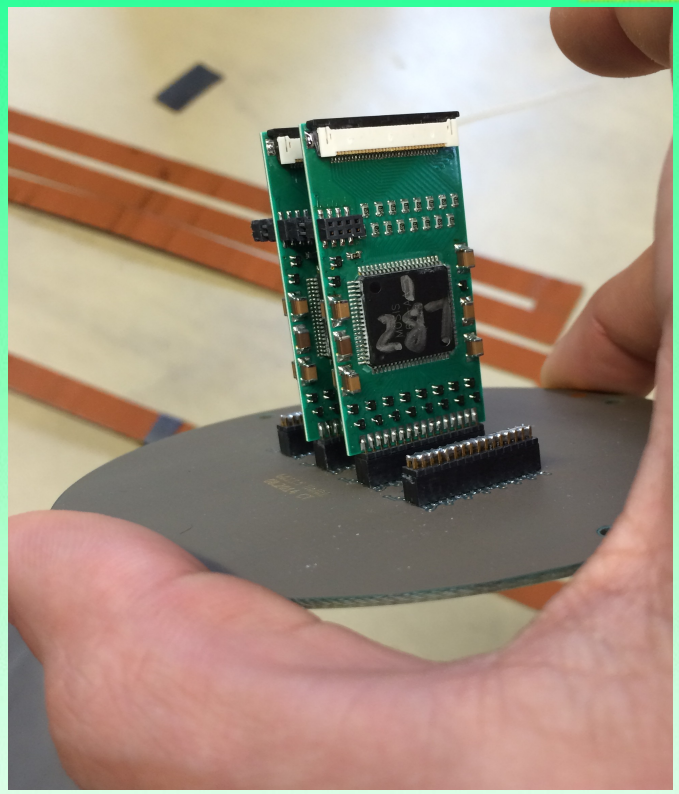
Module lifting : the valves are
configured to drain LAr to outer volume

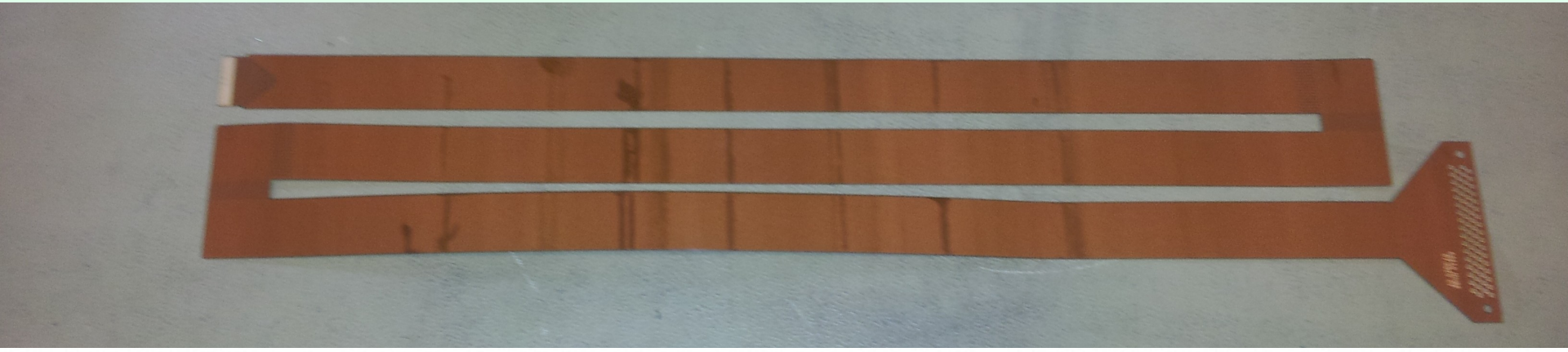
Module insertion : LAr passes
from outer volume via filter into module

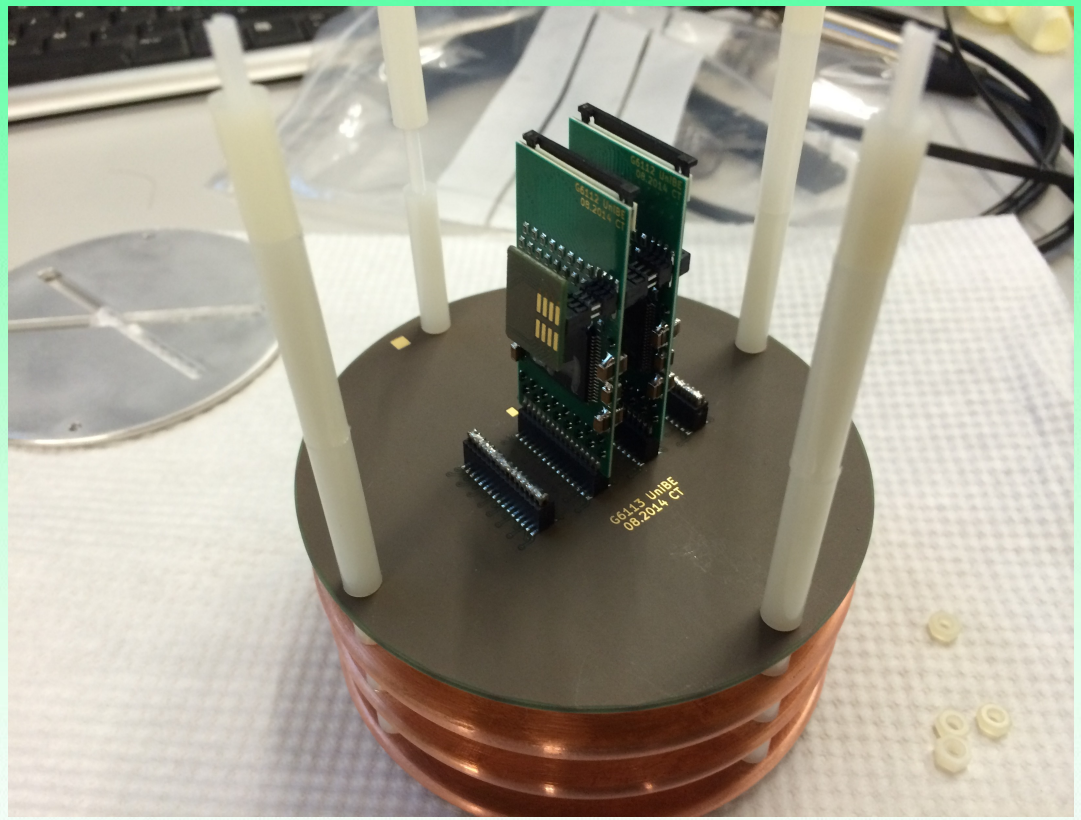
Operation : LAr is recirculated through
the same filter by cryo-pump
(turbo, Barber-Nichols)

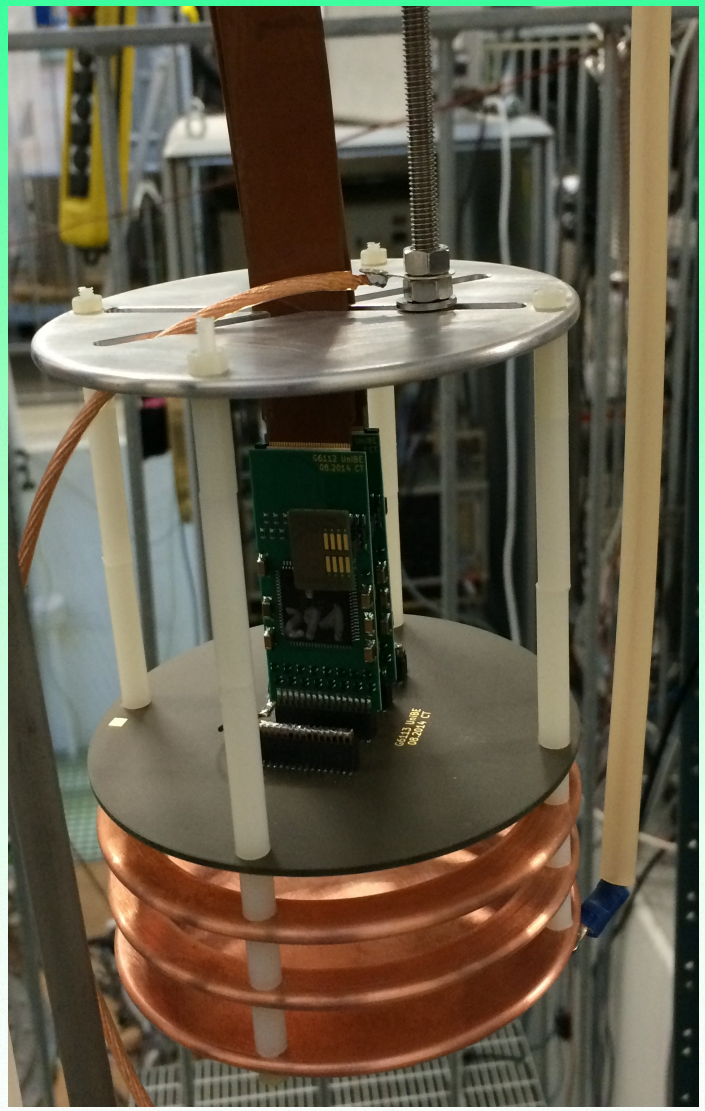
R&D on pixel charge readout

LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

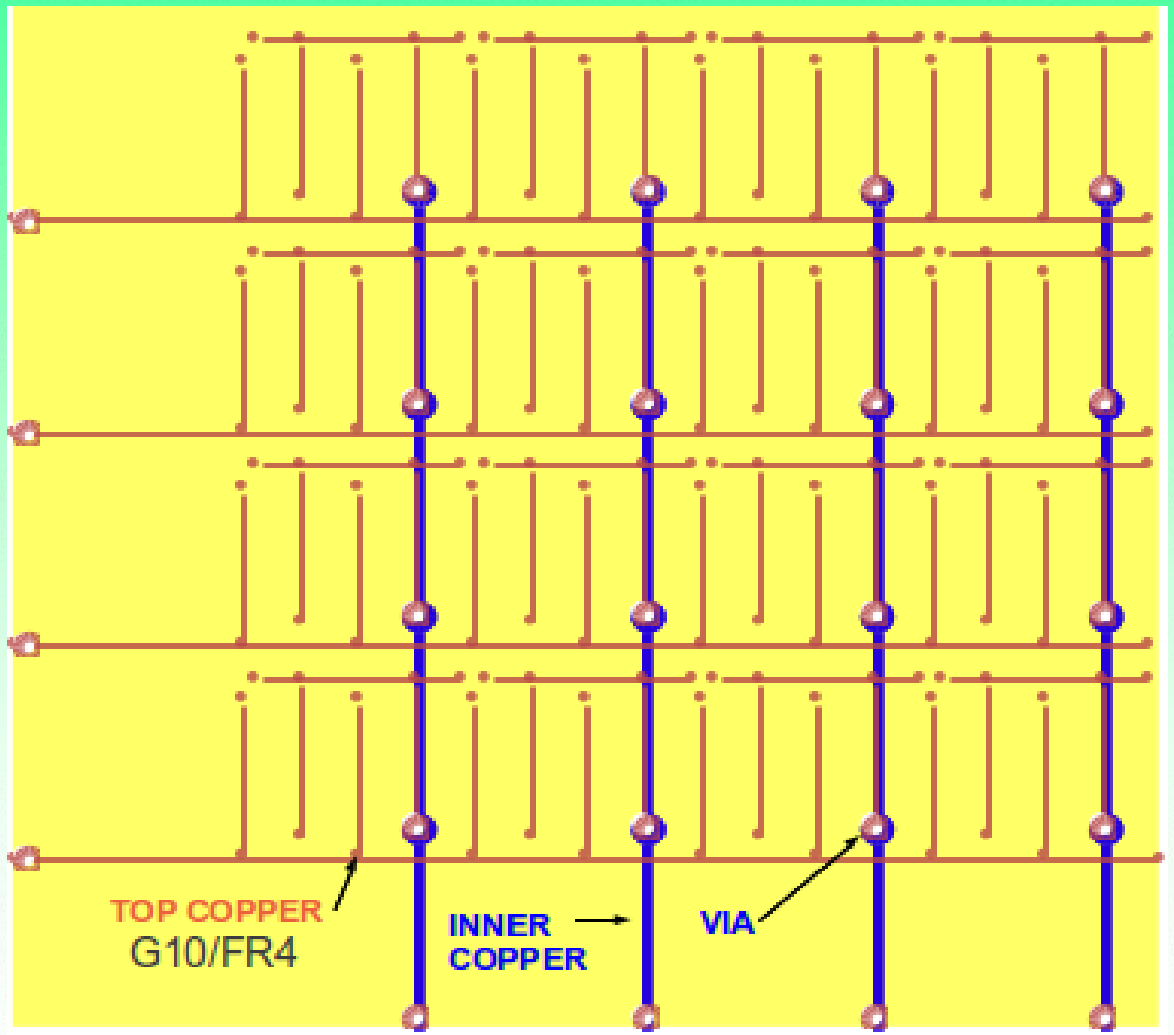




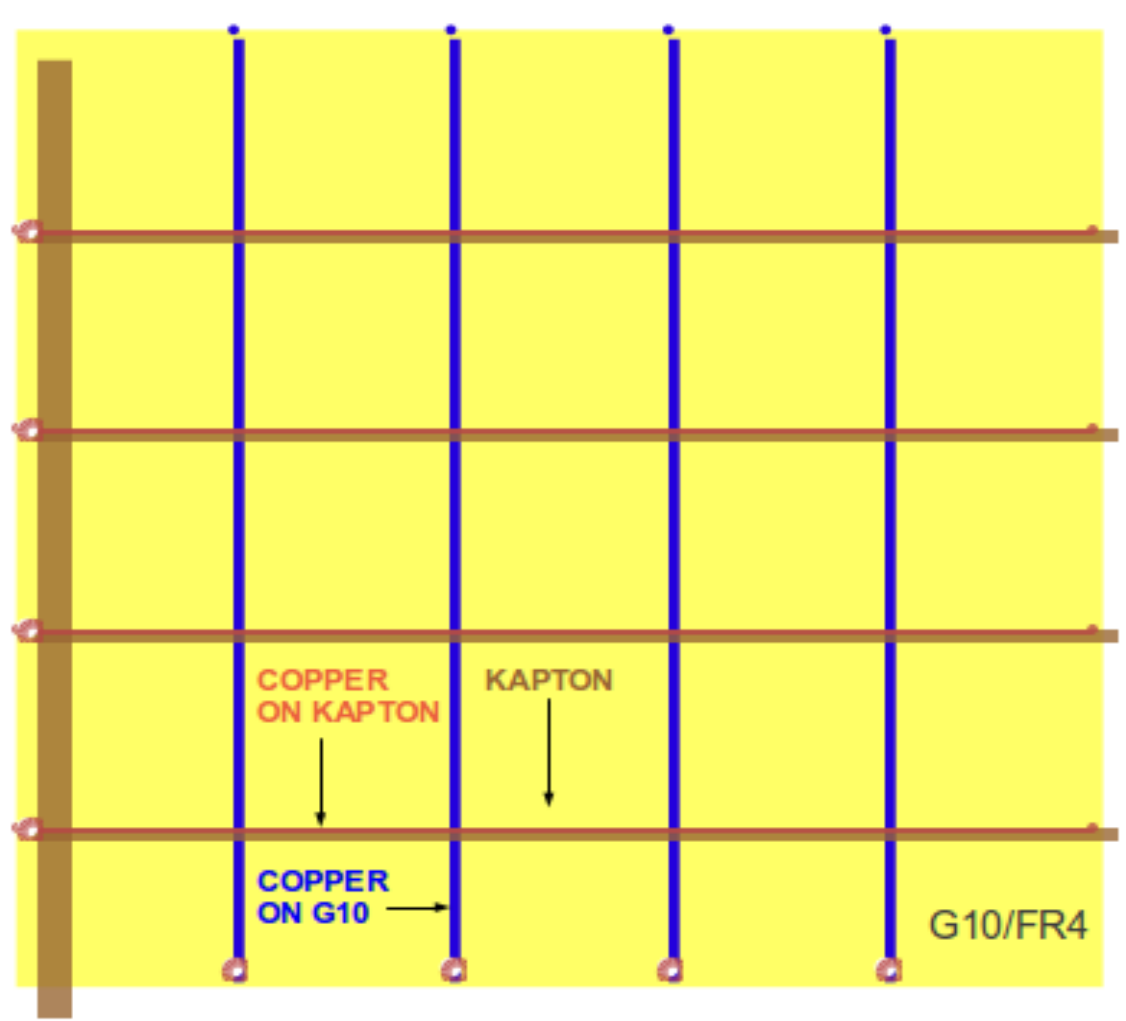

G6113 UniBE
08.2014 CT


G6113 UniBE
08.2014 CT

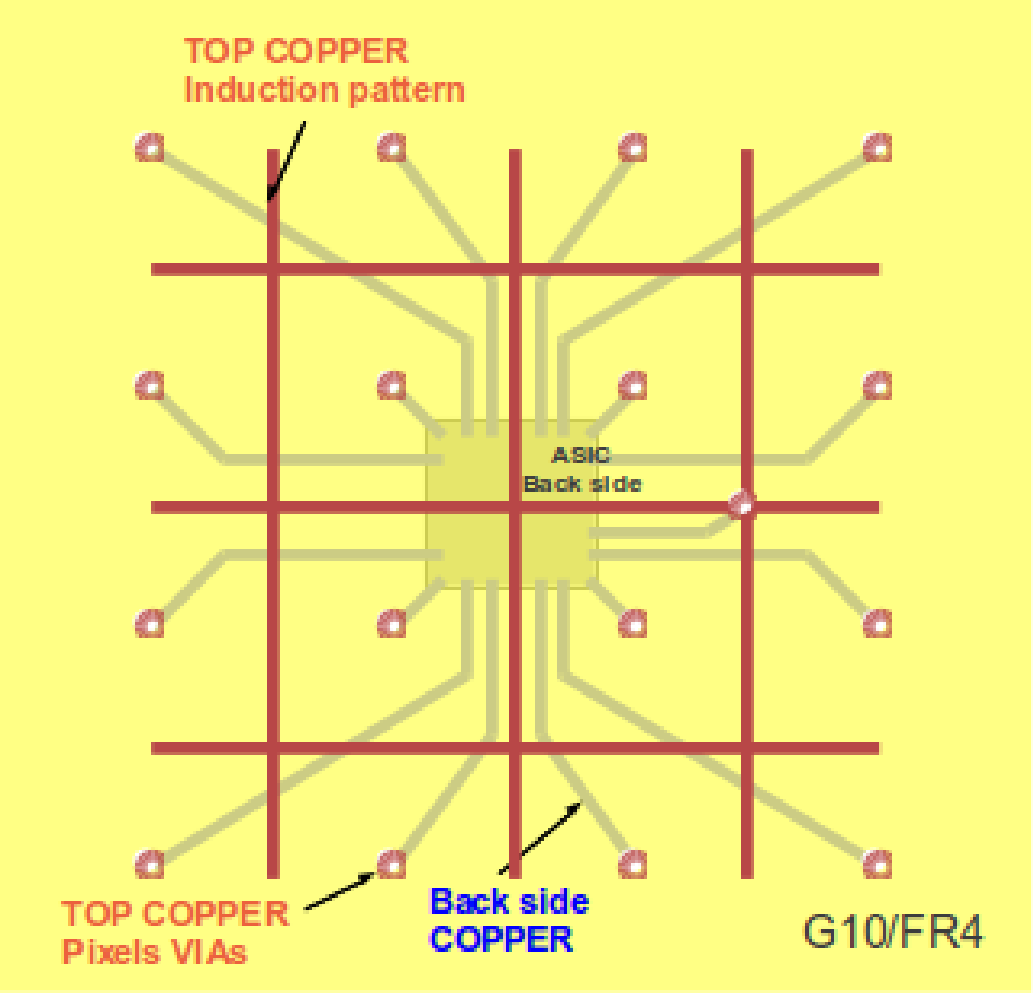
R&D on pixel charge readout
Pattern 1: X-Y shared charge collection



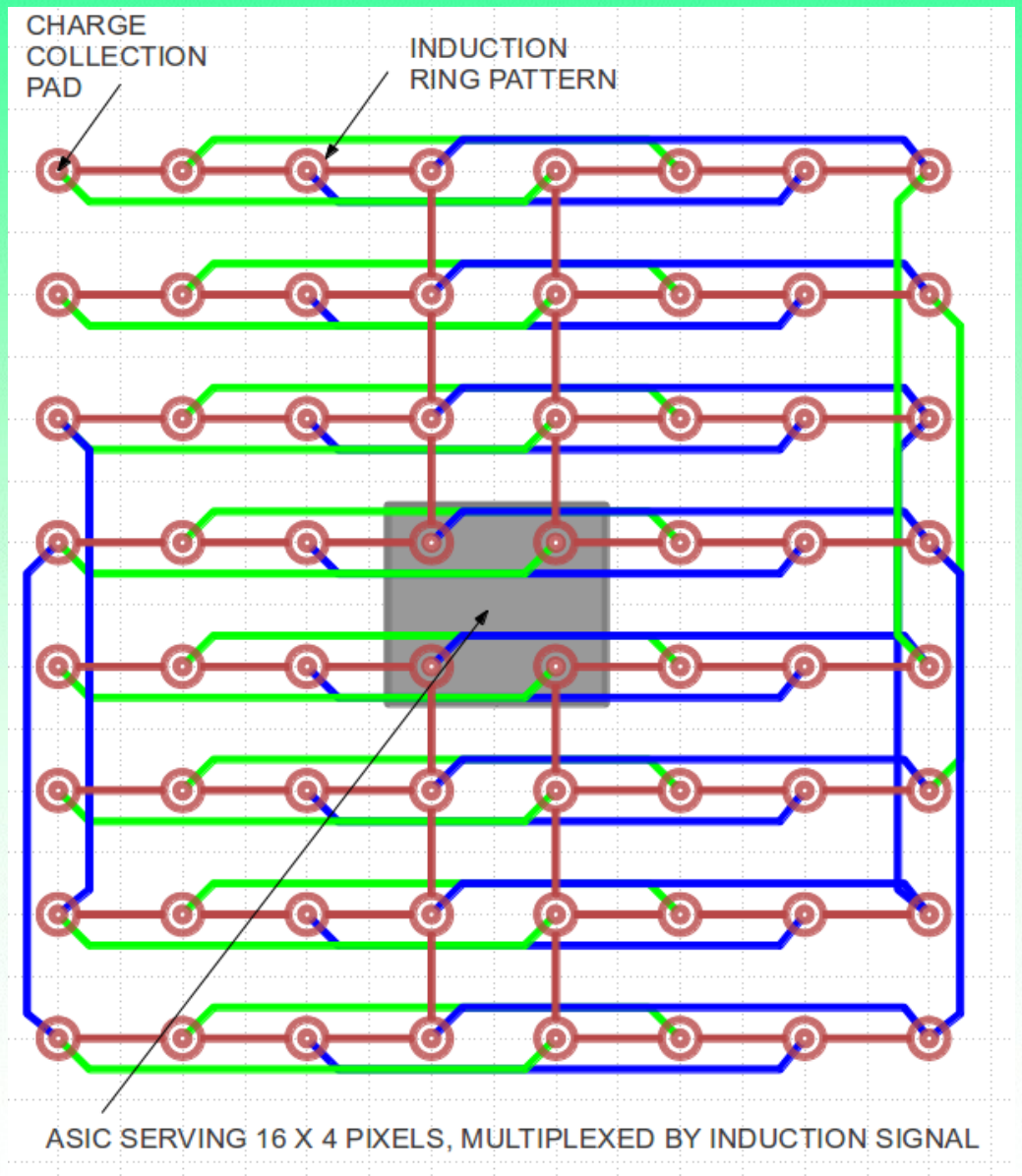
R&D on pixel charge readout
Pattern 2: X-Y shared charge collection



R&D on pixel charge readout
Pattern 3: Pixel charge collection with induction ROI



R&D on pixel charge readout
Pattern 4: Pixel charge collection with Improved induction ROI



R&D on pixel charge readout
Smart token zero suppression