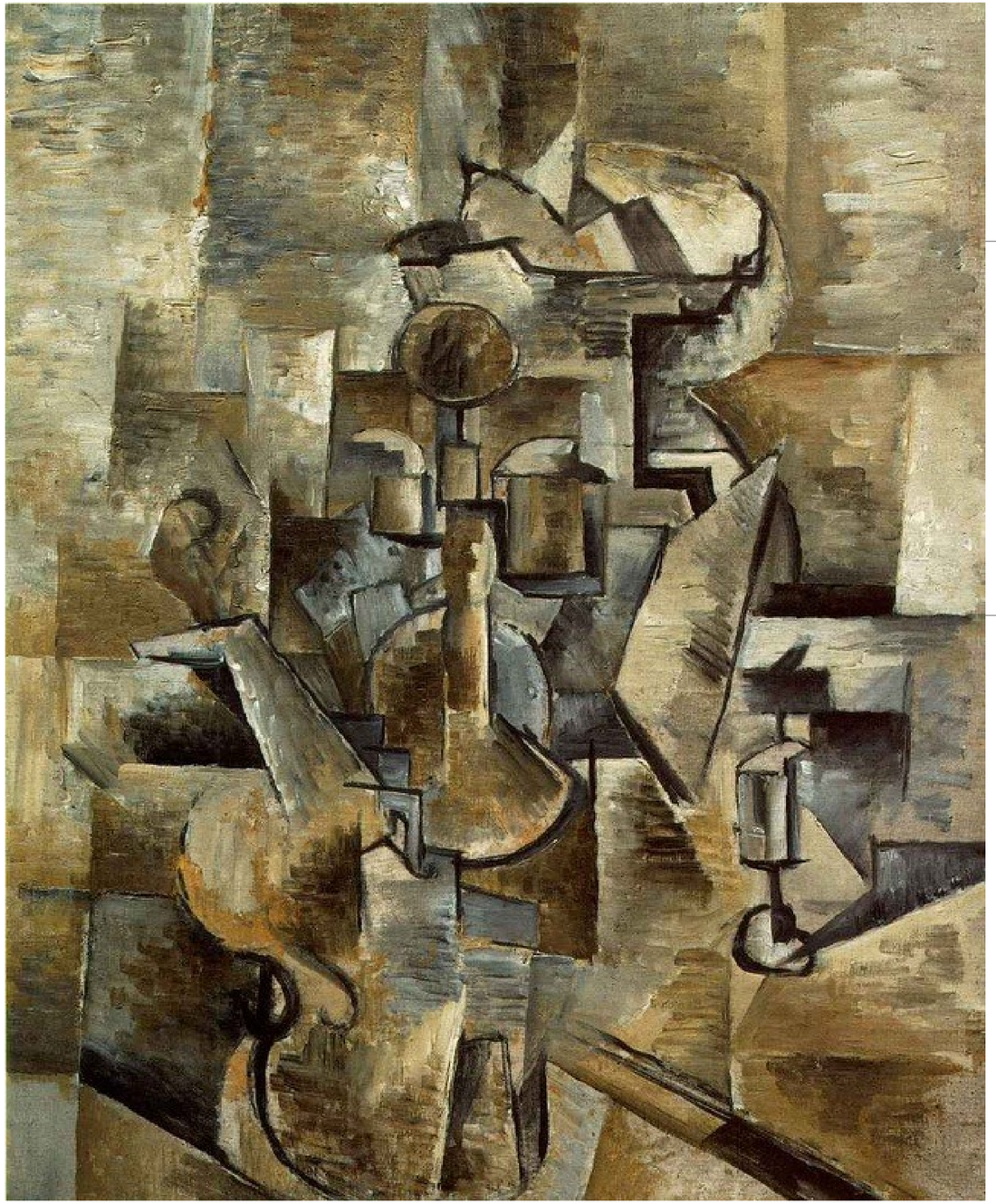


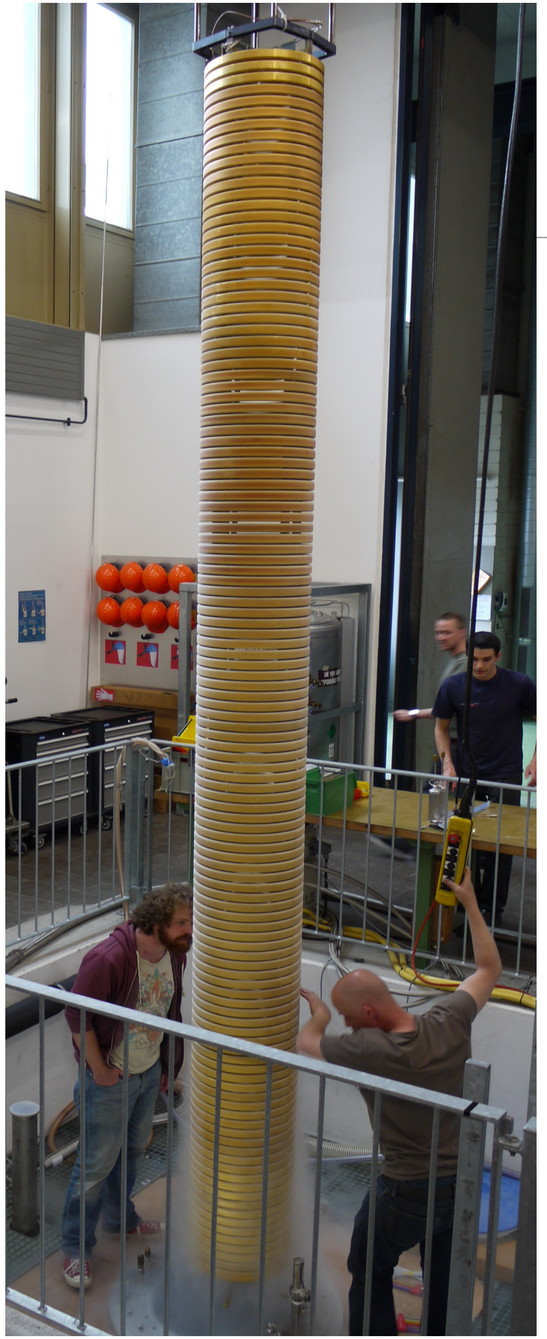
Braque’s Violin and Candle Stick, Paris 1910

LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

UNIVERSITÄT BERN
AEC
ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

The R&D Landscape of ArgonCube (From Tube to Cube)

James Sinclair LHEP Bern October 2017

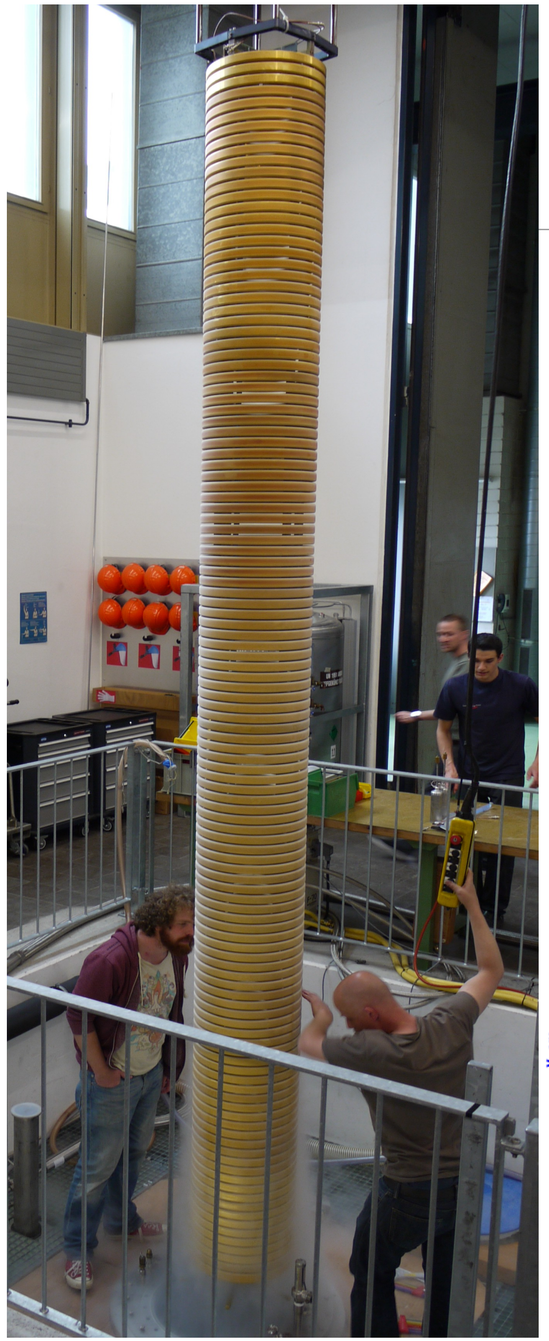


ArgonTube

Primary goal was to investigate achievable drift distances.

5 m drift TPC, 1 kV/cm, 500 kV at cathode

- Diffusion
- Charge lifetime
- HV
- Unknown Unknowns



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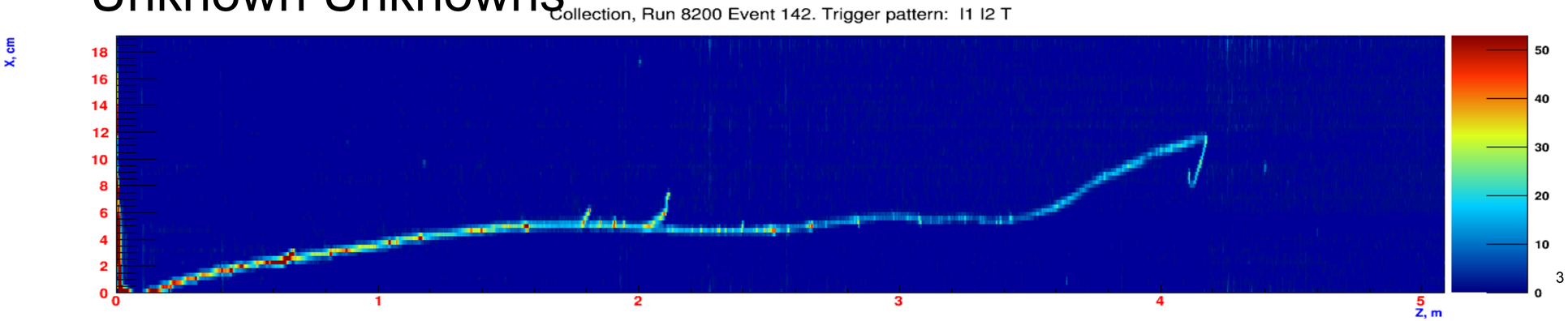

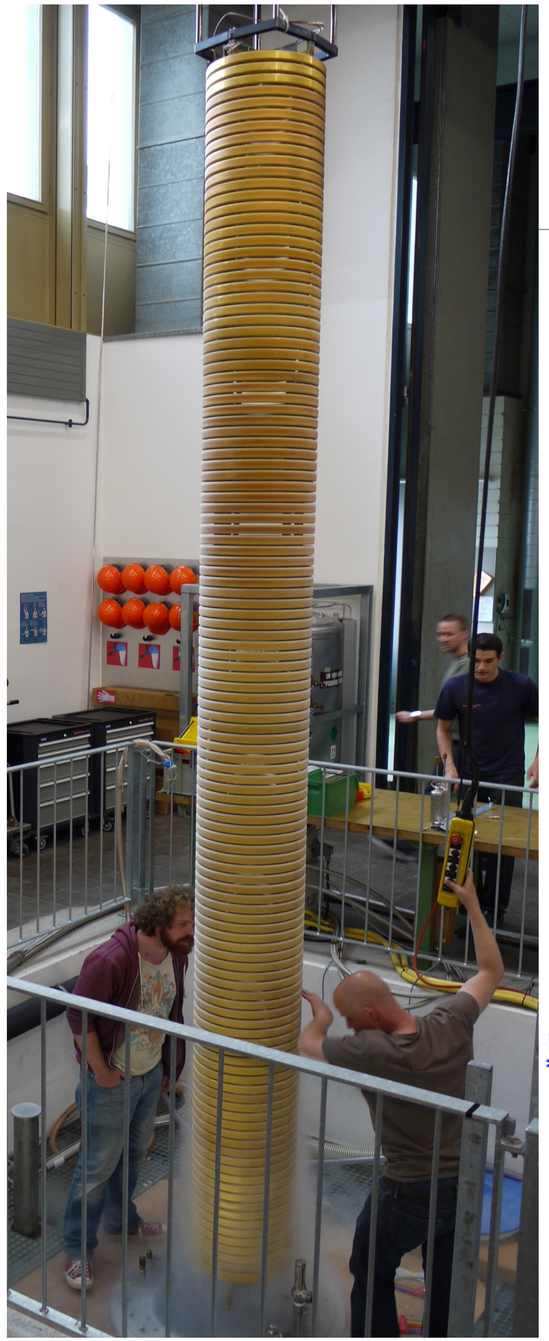

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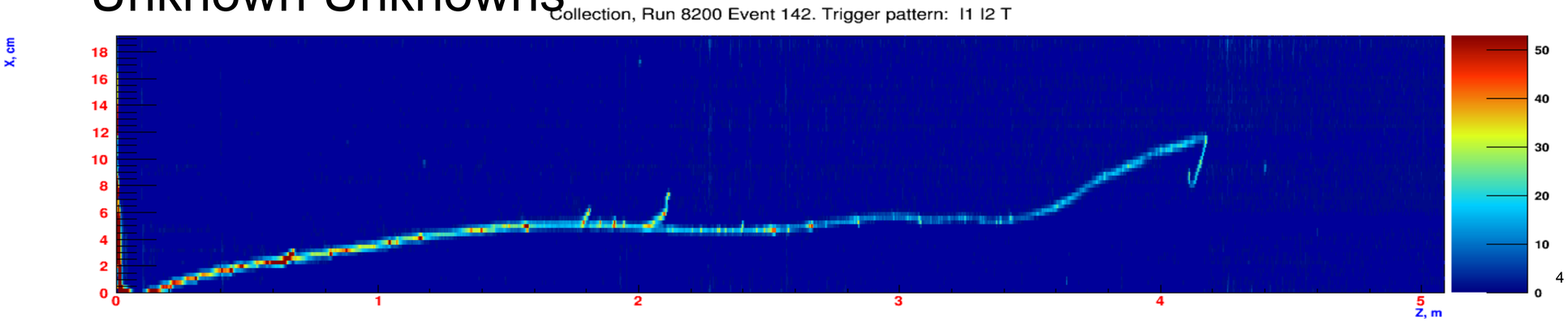
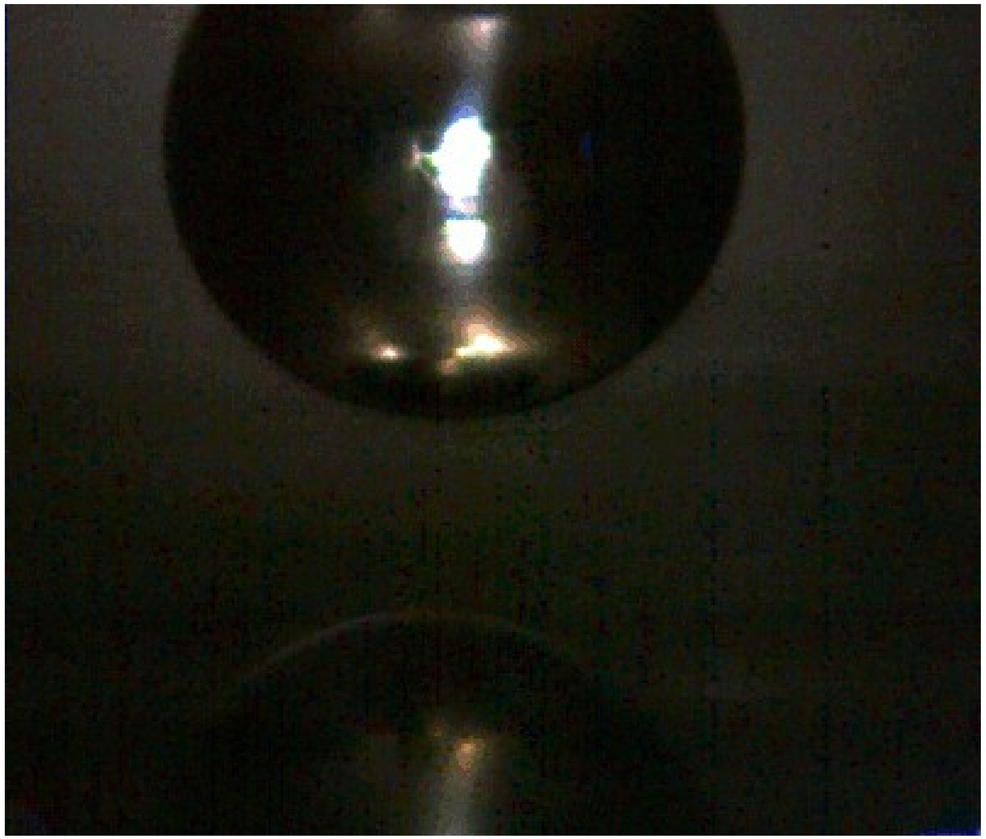
See Damian's prototypes talk



HV Breakdown Studies

The 1960’s values of LAr dielectric strength (1.4MV/cm) measure of O (100 microns).

Bern studies showed that at larger distances breakdowns observed at 40 kV/cm.



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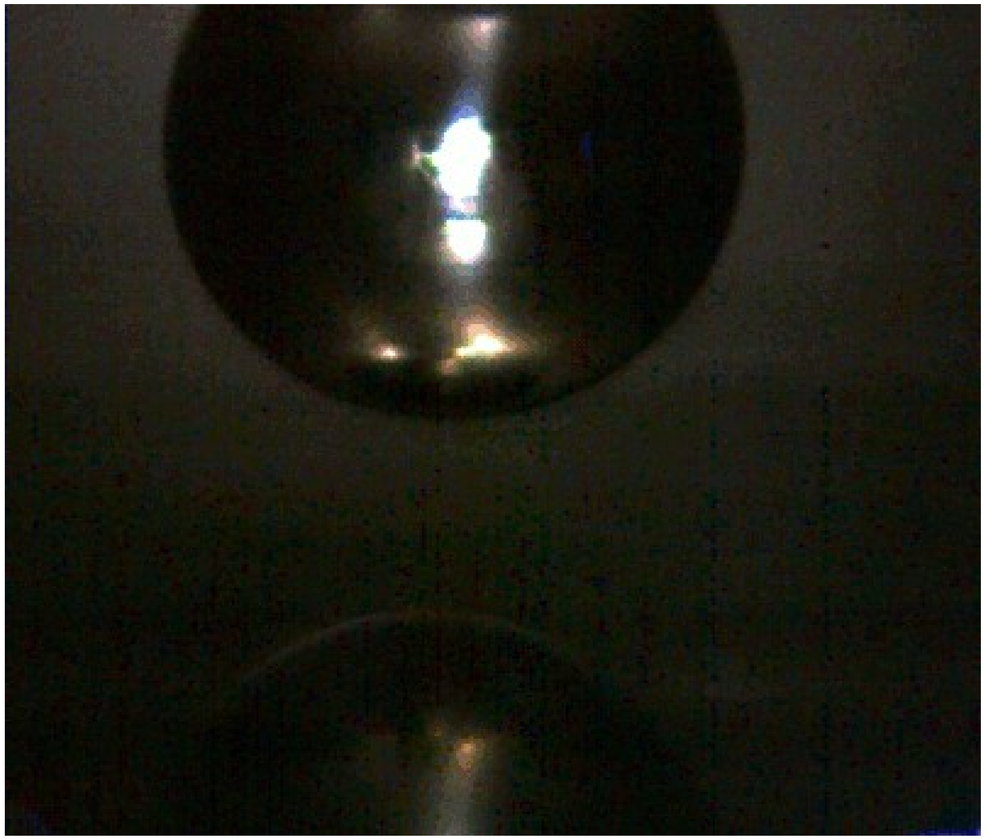


To ArgonCube

How to achieve a large mass LArTPC without HV?

Segment the detector volume in to a number of self-contained TPCs sharing a common cryostat:

- Lower voltage & less stored energy
- Shorter drift-times
- Less stringent purity

Additional benefits:

- Less pileup
- Contained scintillation light
- Run constantly (upgrade/repair sans detector downtime)
- Split construction

...might just make LAr work in high multiplicity environments

To ArgonCube

What is needed to segment the detector volume in to a number of self-contained TPCs, and work in high multiplicity environments?

Charge readout:

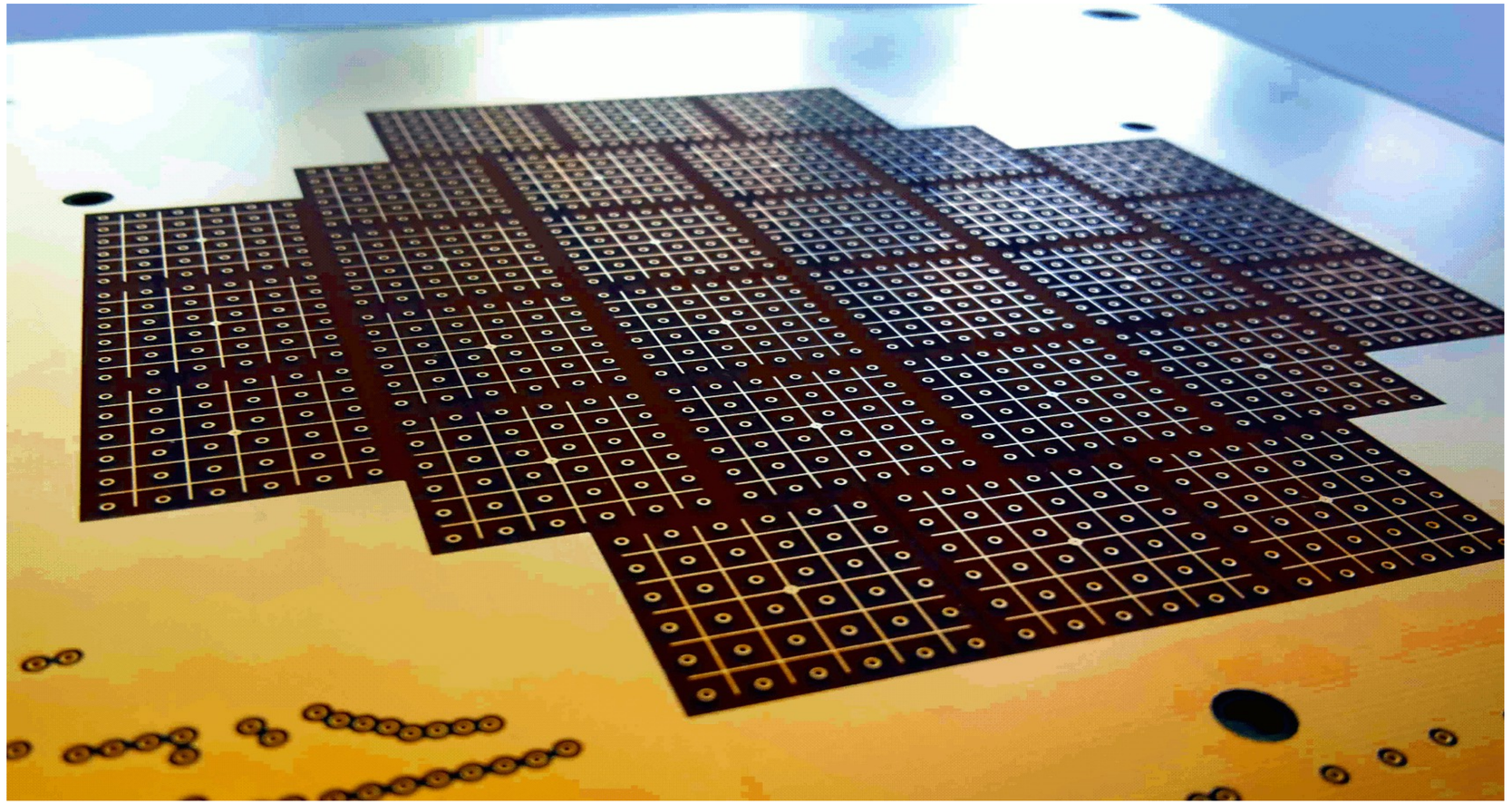
– Compact, robust and unambiguous.

Light readout:

– Compact and robust with large area coverage

...and box to put it all in

Pixelated Charge Readout



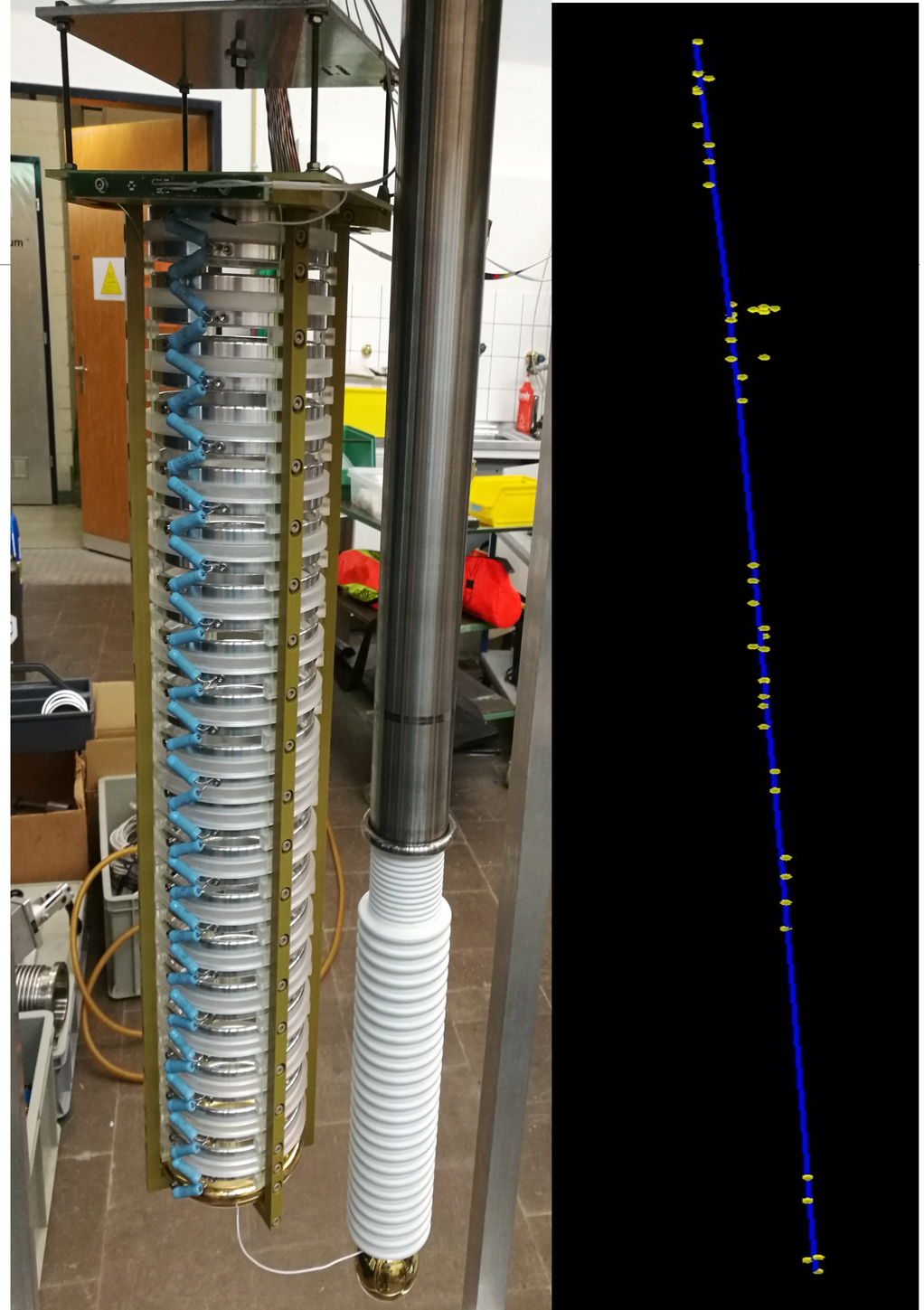
Pixels are mechanically stable and enable the full 3D tracking capabilities of LArTPCs

Pixel Demonstration TPC

Pixelated charge readout was successfully demonstrated in Bern in summer 2016.

Cold SiPMs were also shown to be viable for light readout.

These test lead to international interest.



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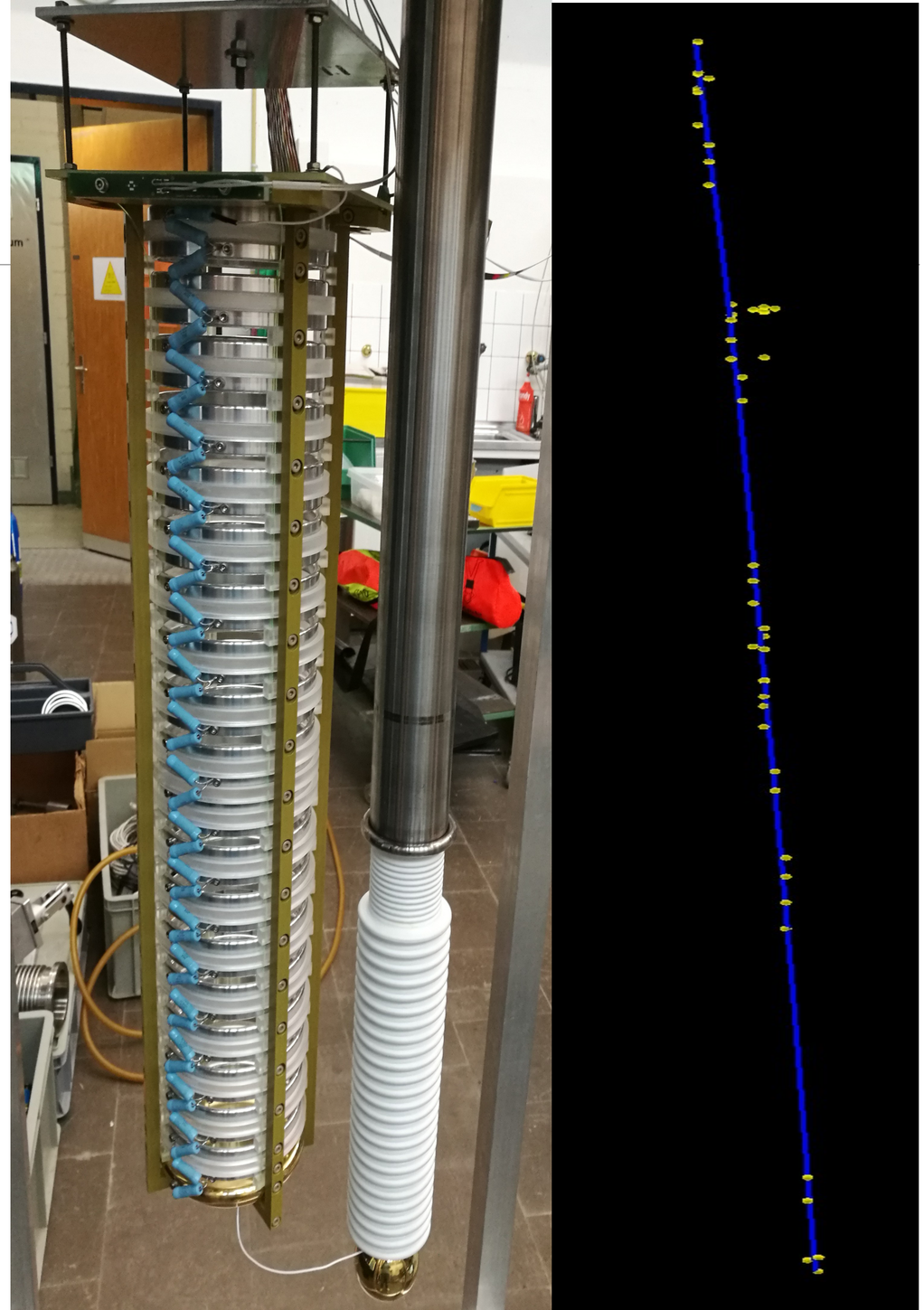
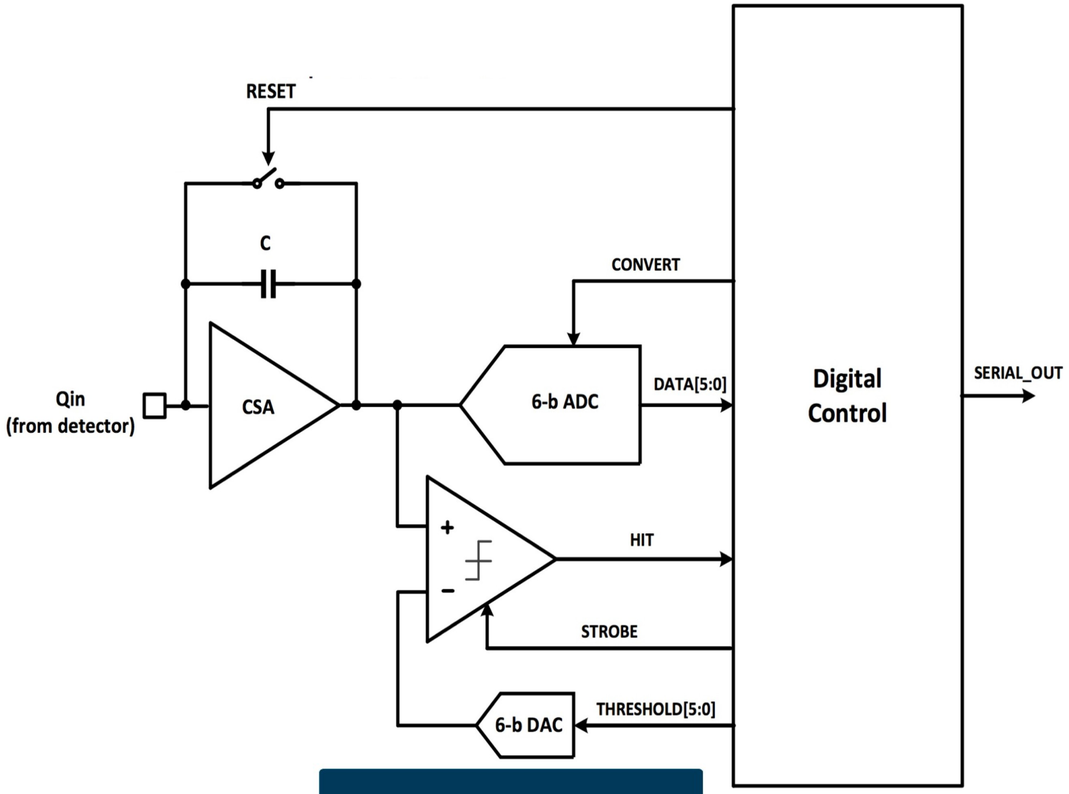
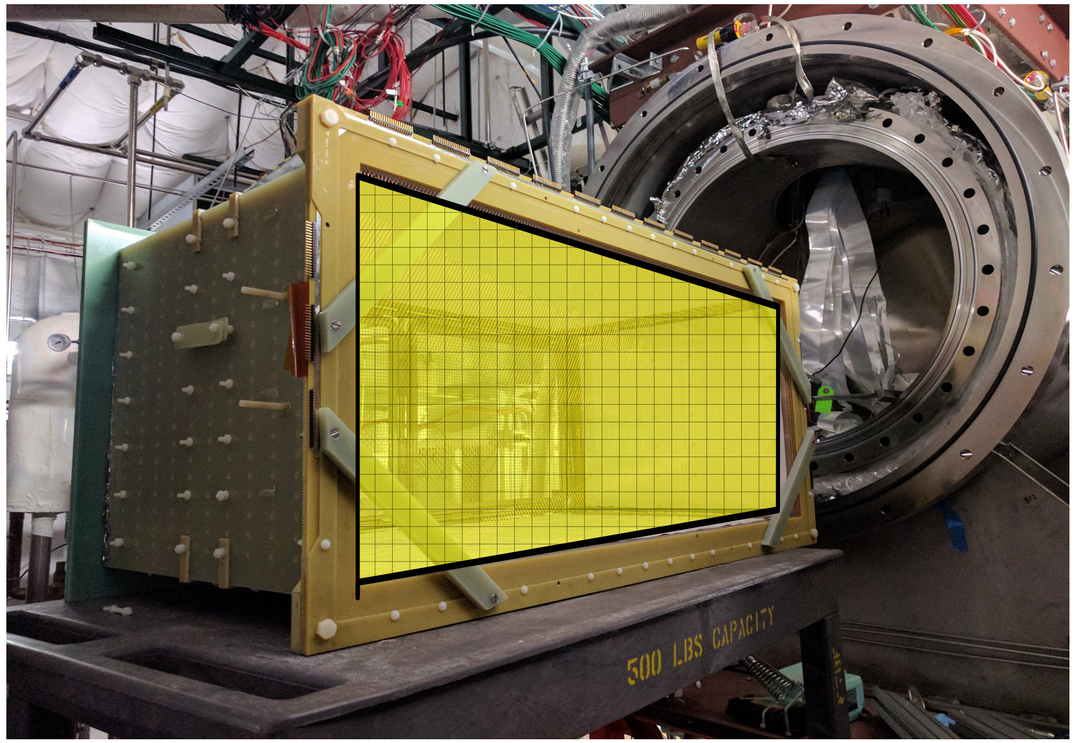


What's Next for Pixels – LArPix & PixLAr

LArPix: Bespoke pixel ASICs



PixLAr: Pixels in a LArTPC in a test beam



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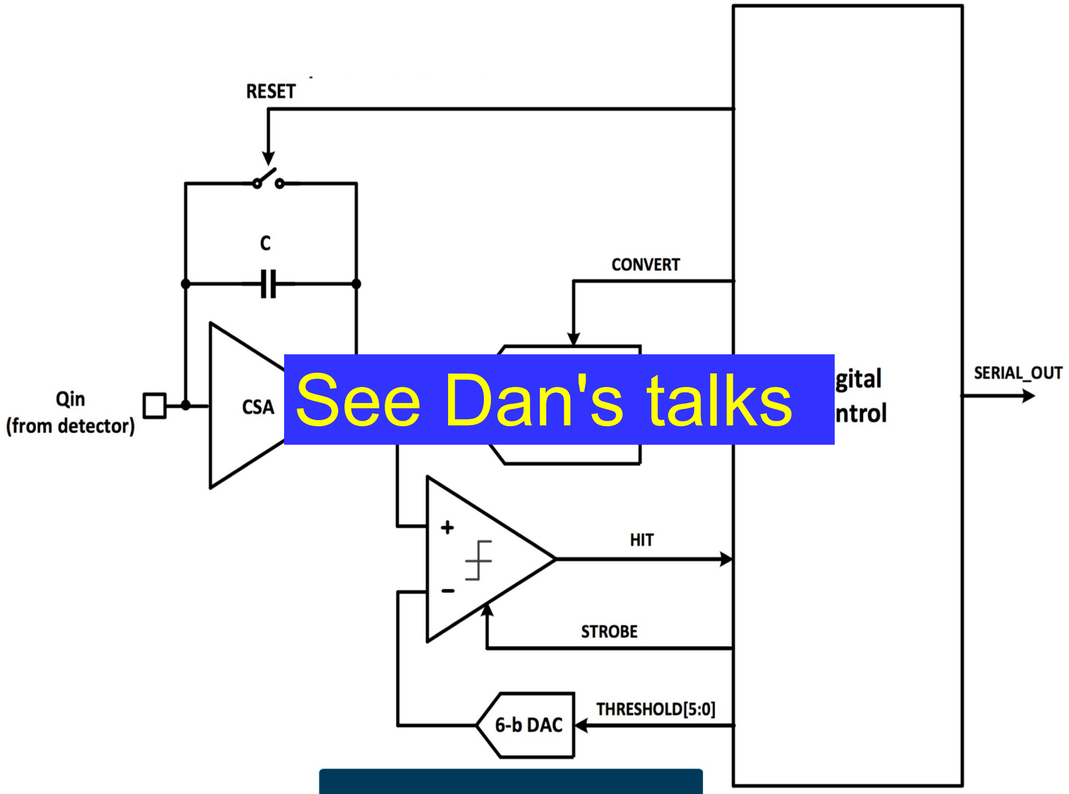
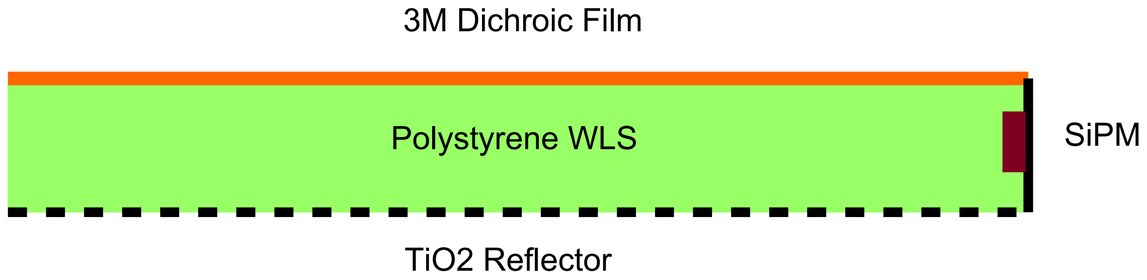
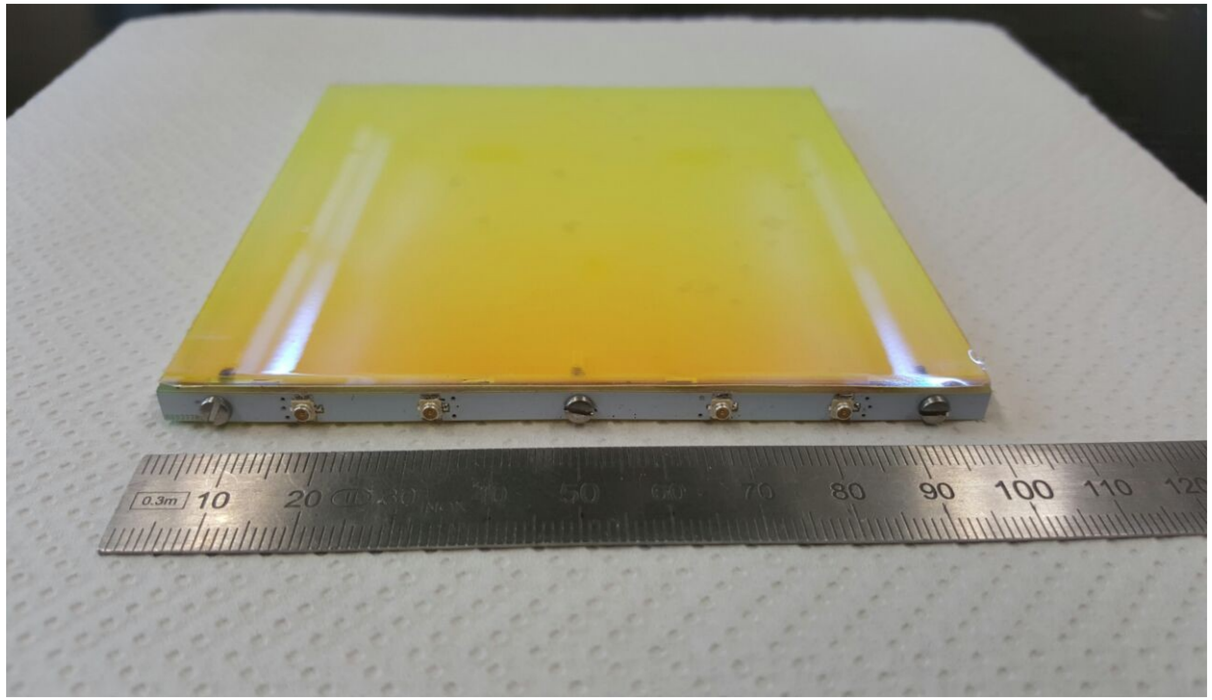


PixLAr: Pixels in a LArTPC in a test beam

Light Readout

Inspired by ARAPUCA, the ArgonCube Light readout (ArCLight) was developed in Spring 2017.





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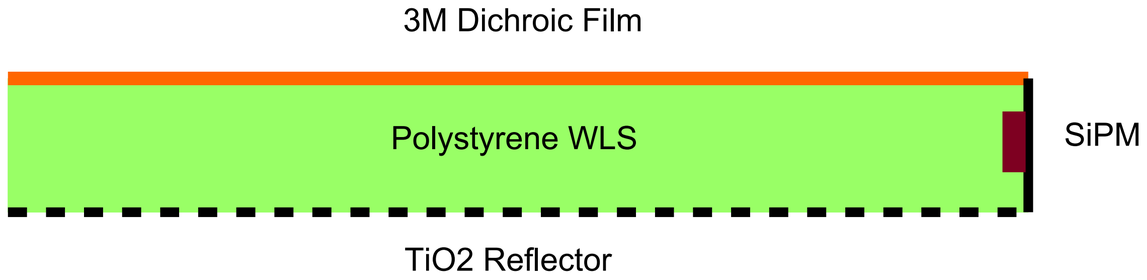
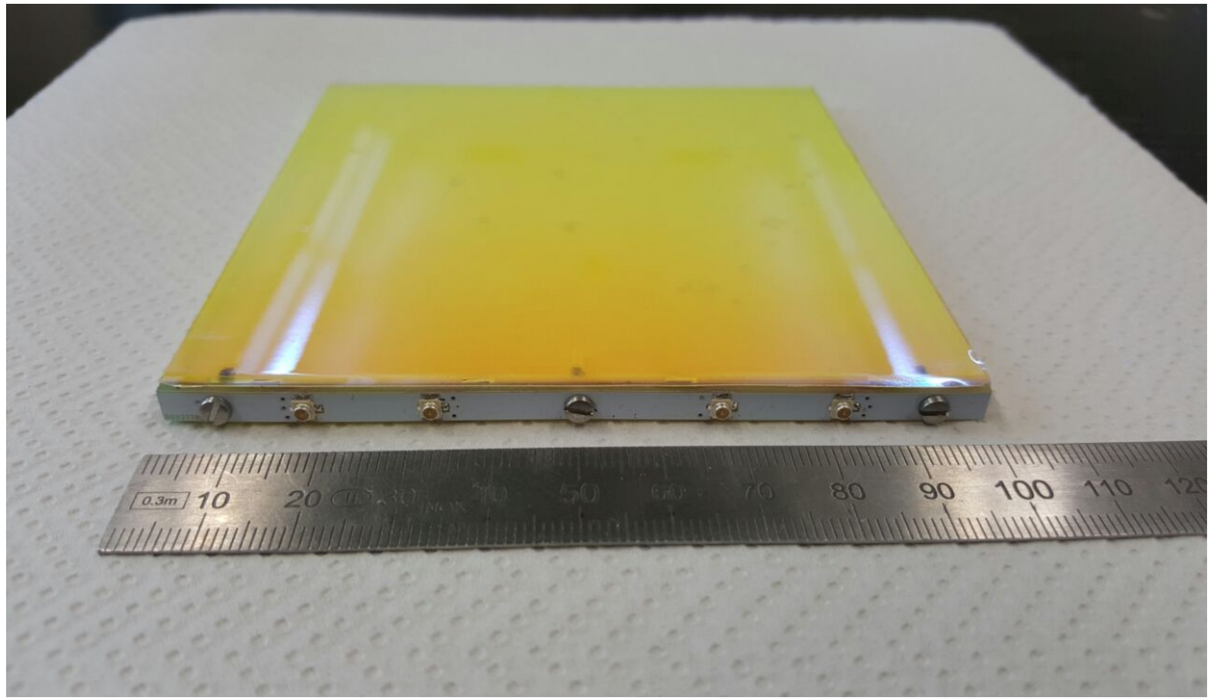
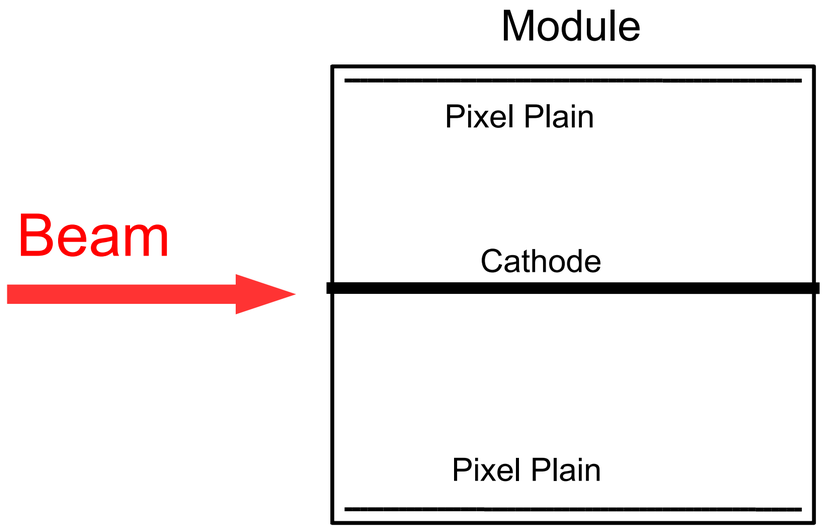




See Igor's talks

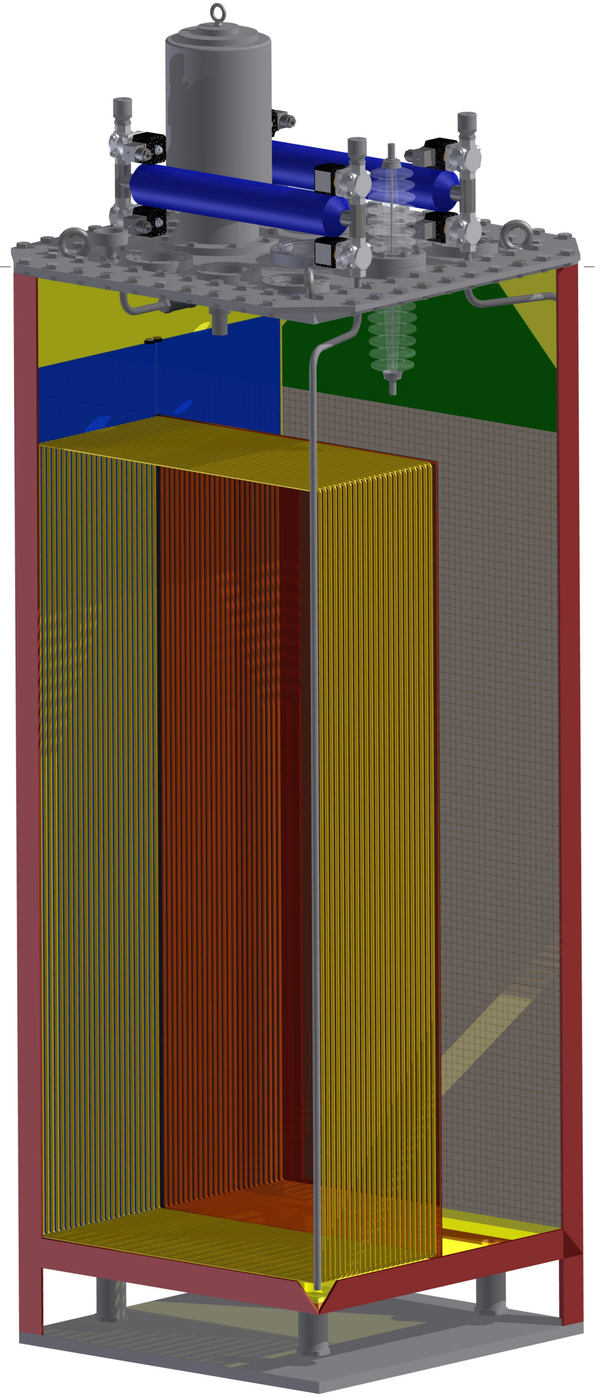
A Box to Put it All in

ArgonCube modules contain 2 independent TPCs.



Each module is submerged in, filled from, and cooled by a common LAr bath.

Once filled, the inner volume is isolated from the bath, recirculated and filtered.



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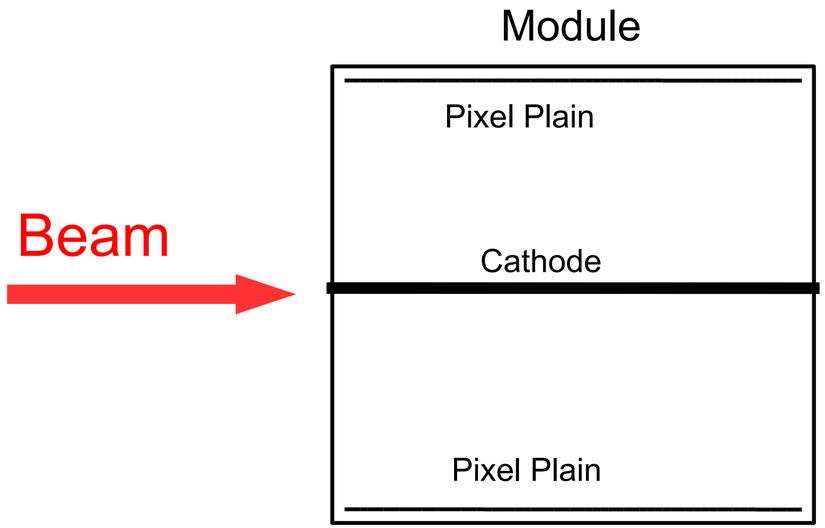

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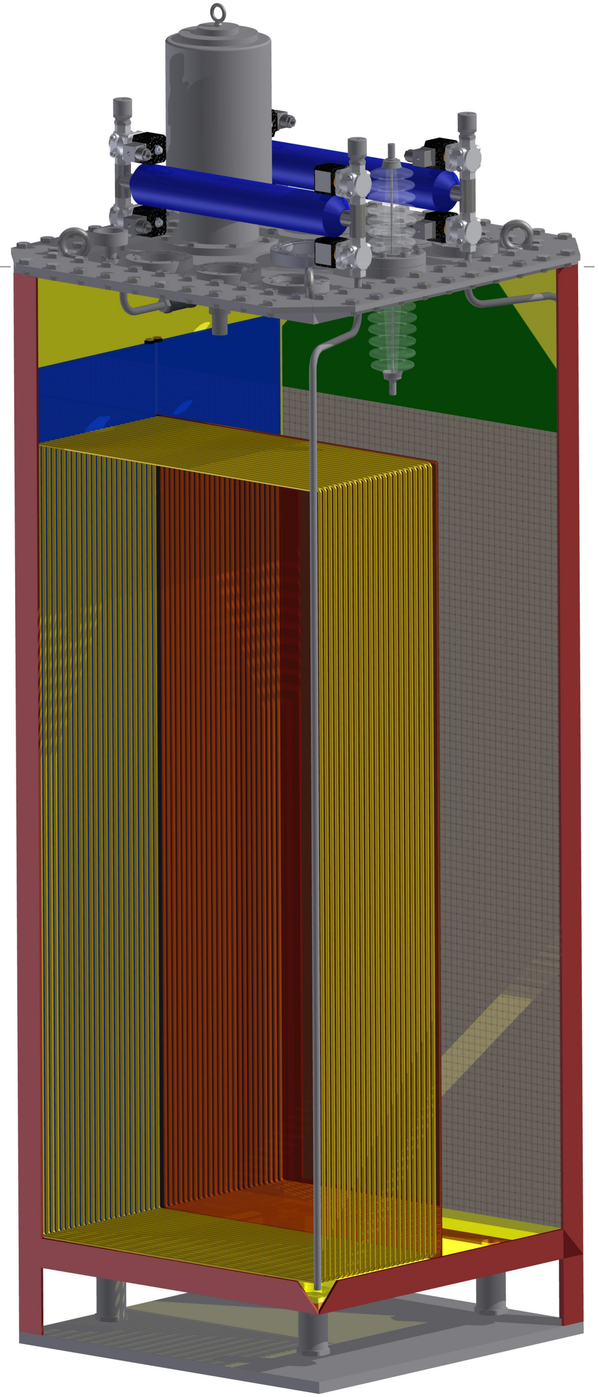

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ArgonCube 2 x 2

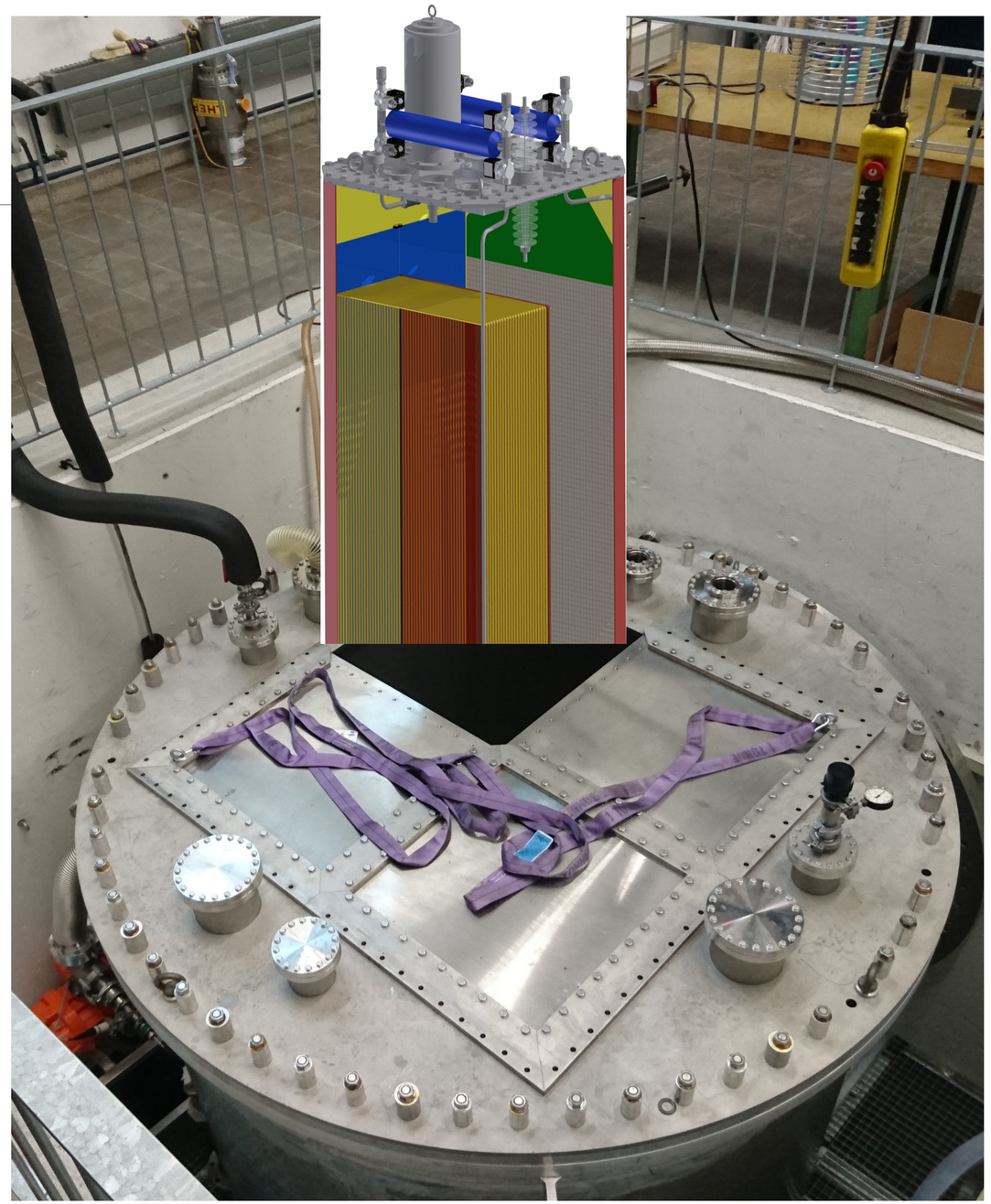
The 2 x 2 prototype uses a 2 m tall, 2 m wide cylindrical cryostat in Bern.

Each module 0.67 x 0.67 x 1.8 m^3
(33 cm drift).

Initial test will reuse the pixel demonstration TPC as a purity monitor (December 2017).

Followed by 3 fully instrumented pixel modules, and 1 reference wire module.

Eventual test beam deployment.



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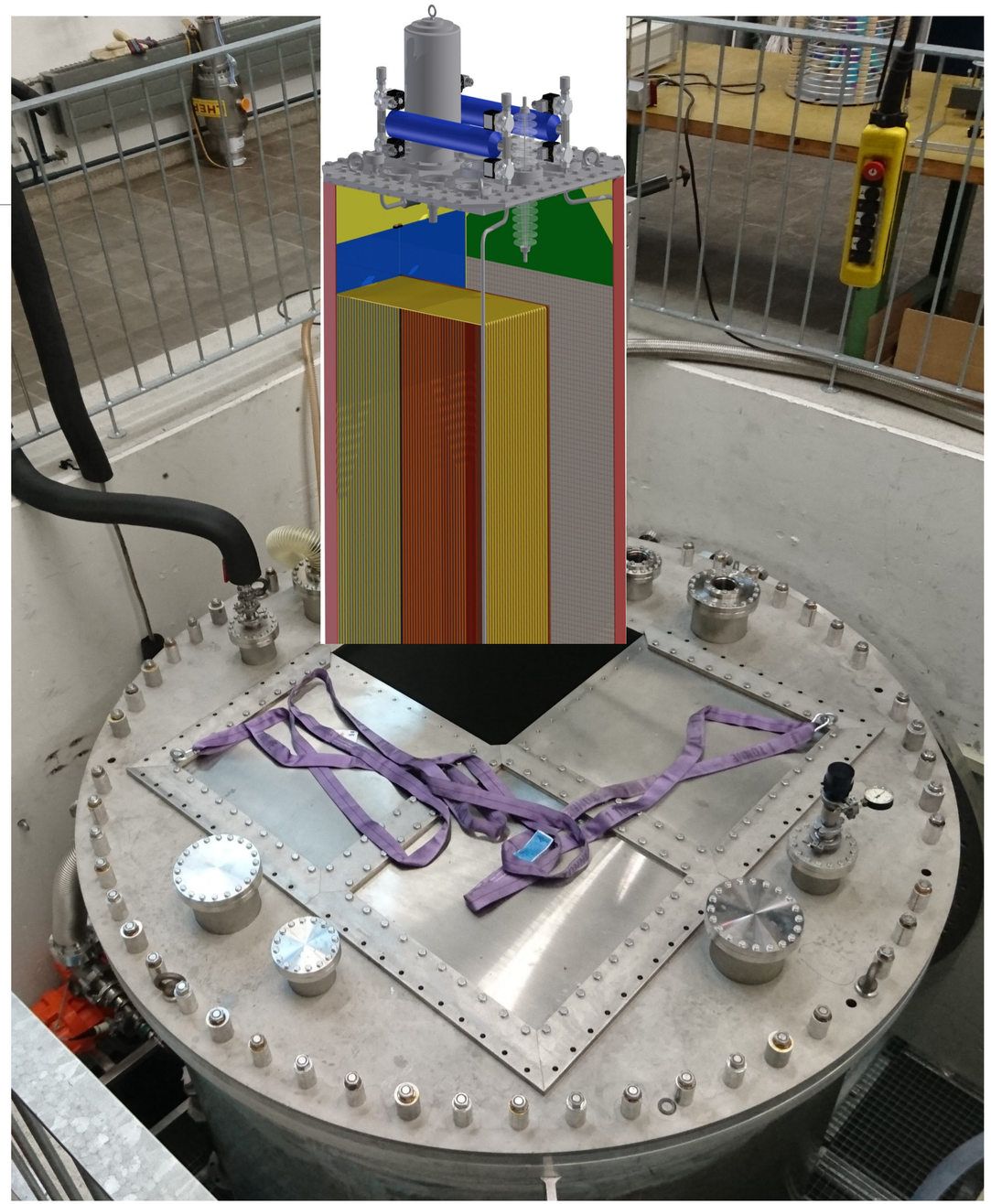
See Roger's talks

See Neil's talks



ArgonCube to CERN

Move the 2 x 2 ArgonCube prototype to CERN for test beam studies as a ProtoDUNE ND.

Submitted LoI to CERN SPSC in June 2017.
http://cds.cern.ch/record/2268439

Feedback (unofficial):
- Positive for pixels
- Must demonstrate purity
- Show synergy with ProtoDUNEs

Further review as part of SPSC Experimentation at the Neutrino platform Meeting (Oct).

CERN-SPSC-2017-025 / SPSC-I-246
13/06/2017

Letter of Intent

ArgonCube: a Modular Approach for Liquid Argon TPC Neutrino Detectors for Near Detector Environments

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ArgonCube in DUNE

In September ArgonCube received the strong support of DUNE as the LAr component of its ND Complex.

DEEP UNDERGROUND NEUTRINO EXPERIMENT

16th September 2017

Dear Professor Ereditato,

As Co-Spokespersons of the DUNE experiment, we would like to express our support for the ongoing R&D for the ArgonCube concept for a modular Liquid Argon Time Projection Chamber (LAr-TPC).

The DUNE collaboration has not yet defined the concept for the Near Detector, but the scientific case for a hybrid system comprising a LAr-TPC and fine-grained tracker system is widely accepted; it will almost certainly form the basis for the concept taken forward to a conceptual design report.

ArgonCube provides an attractive solution that combines 3D readout with relatively short drift distances, both necessary requirements to operate in the high-multiplicity environment of the DUNE near detector.

For the above reasons, we are writing on behalf of the DUNE collaboration to express strong support for the development activities proposed by the institutions working on ArgonCube.

Yours sincerely,

Professor Edward C. Blucher

Professor Mark A. Thomson

The Final Goal - ArgonCube In the DUNE ND

Based on current dimensions of ND hall (8.5 m tall)

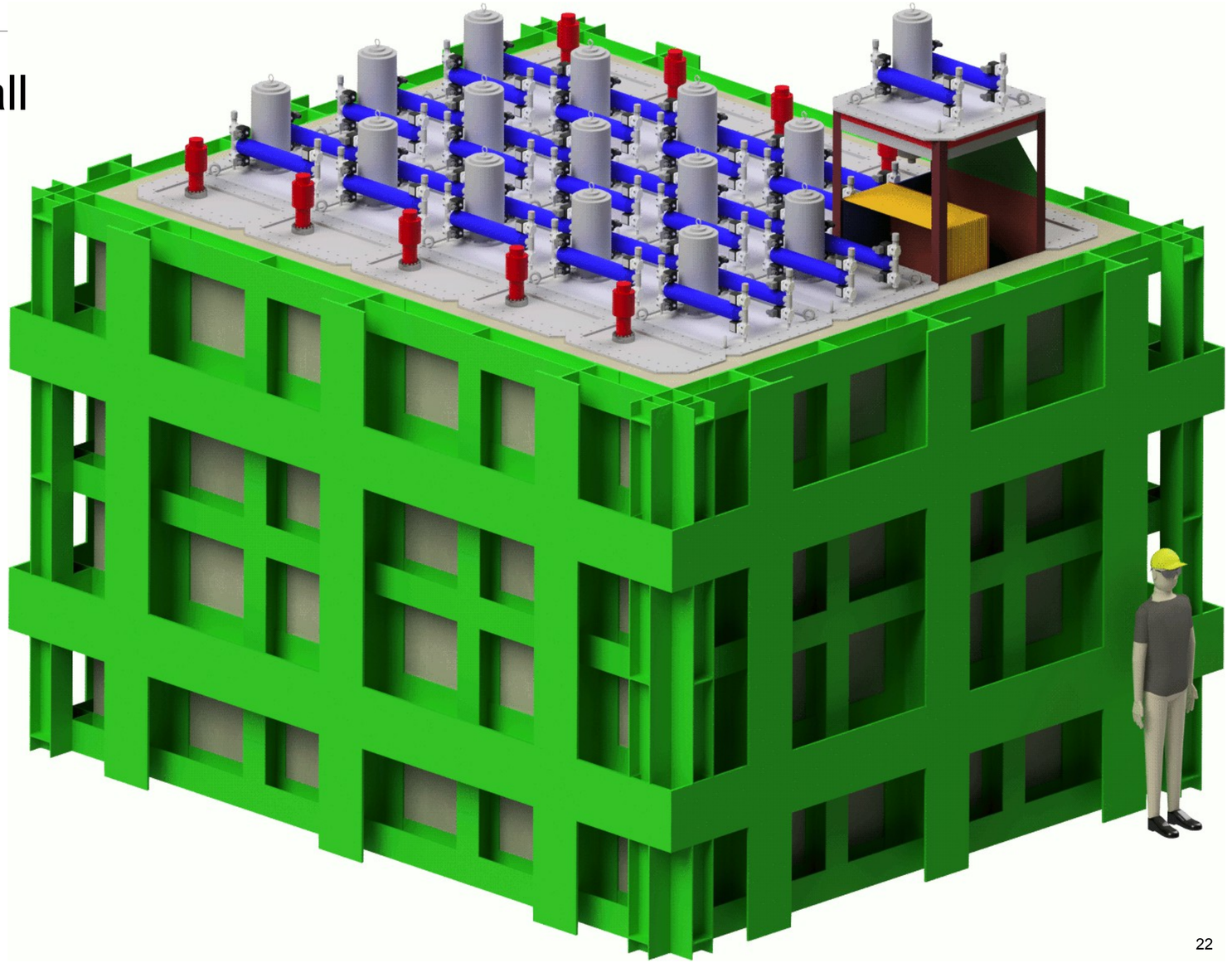
LBNL studies suggest 30 t LAr TPC is sufficient

Proposed geometry is 3 x 5 modules (longest in beam)

Each module: 1 x 1 x 2.5 m^3 (50 cm drift, 50 kV)

Total detector: 7 x 5 x 4.5 m^3 (inc. cryostat & ancillaries)

Active volume: ~ 5 x 3 x 2 m^3



Summary

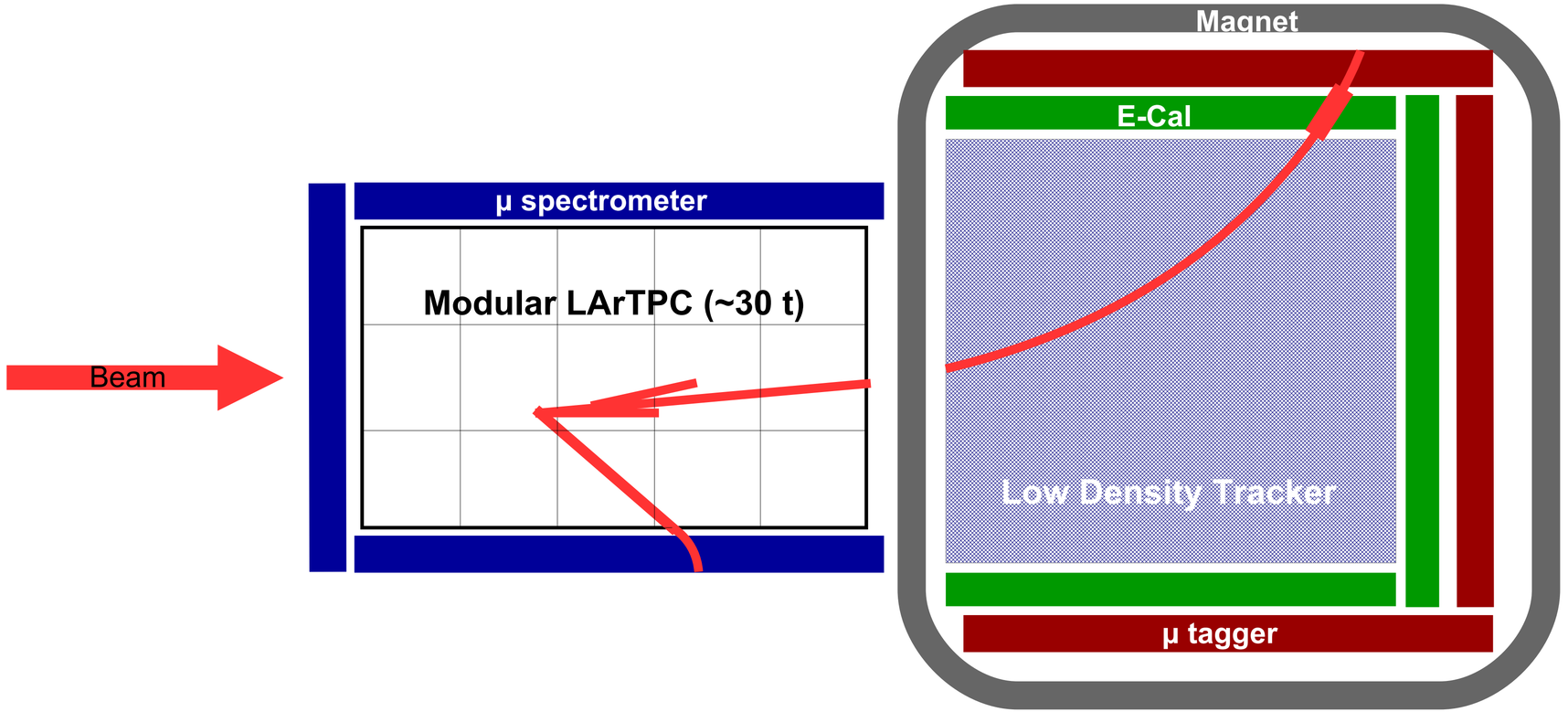
The ArgonCube concept is based on considerable experience with LAr. Its modular TPC and pixelated charge readout alleviate some issues faced by monolithic detectors.

Success of technology demonstrators has brought further collaboration, enabling scaled up test beam studies of both charge and light readouts. As well as the development of bespoke readout electronics.

The near-term goal is the deployment of instrumented modules in the 2x2 prototype in Bern. Followed by test beam studies of the detector at CERN. With the ultimate goal of developing a LarTPC for the DUNE ND complex

Backup - The DUNE Near Detector

The current collaboration concept design is a ‘hybrid’ LArTPC + tracking detector.



Modular LAr-TPC: high statistics -Ar interactions, assessment of LArTPC response.

Low Density Tracker: precision characterization of ν-nucleus interactions, complementary signal vs. BG discrimination. Possibly FGT or GArTPC.