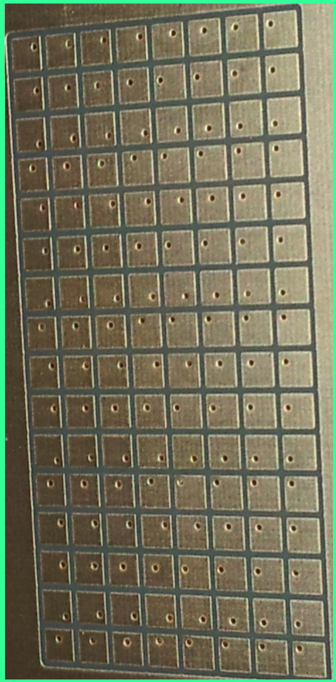
ArgonCube

pixelated modular LArTPC for DUNE ND



Fermilab, 5.03.18

Igor Kreslo
AEC/LHEP University of Bern
on behalf of ARGONCUBE collaboration

LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

UNIVERSITÄT BERN
AEC
ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

ARGONCUBE
R&D program and collaboration

2013: First idea — LHEP
LAGUNA-LBNO Glacier TPC

2017: LoI — CERN SPSC
http://cds.cern.ch/record/2268439
Two principal concepts formulated

2017: Collaboration established
R&D — full steam ahead

2018: ArgonCube → DUNE ND
R&D steered by DUNE requirements

Several dedicated grants
Switzerland, USA, Russia

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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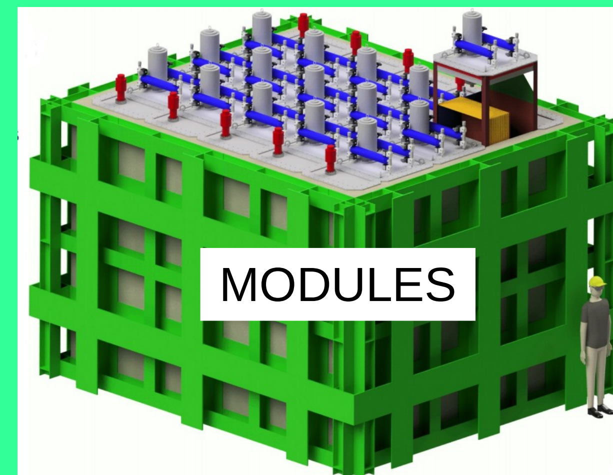
ARGONCUBE
Design motivations

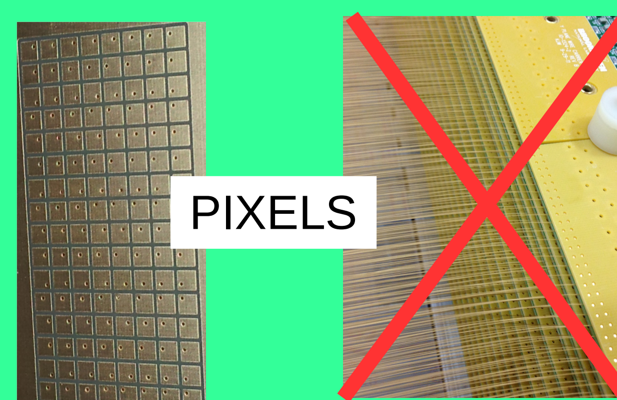
Large volume

Space charge

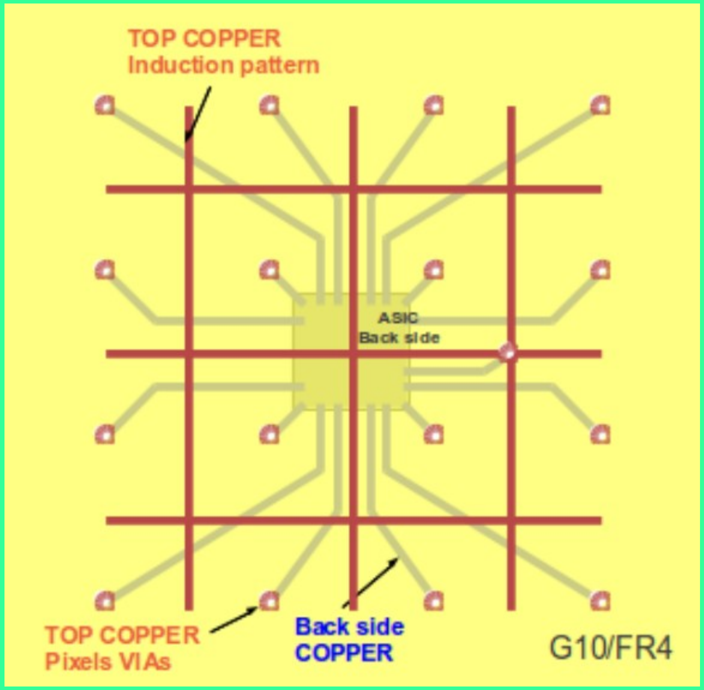
Low HV (<100 kV)



High event rate at ND (pileup)



First approach to pixels



Number of DAQ channels: nROI + nPixel

Number of physical pixels: nROI ∗ nPixel

Can use ROIs induction signal to wake up ASIC to save power.

For ND module: 2planes x 1m x 3.5m, ~5 tons of LAr per module
3x3 mm pixels → ~800000 pixels/module
If we reach 50 μW/pixel we are at 40 W/module and 8 W/ton — safe!

Need to keep heat low at very high number of channels

Requirements for pixel R/O ASIC

SNR of >10 for MIP (signal is ~15000 electrons for 3x3 pixel)

Noise ENC<1600 electrons

Heat dissipation < 50 μW/pixel

≥16 channels/ASIC

≥10 bits ADC

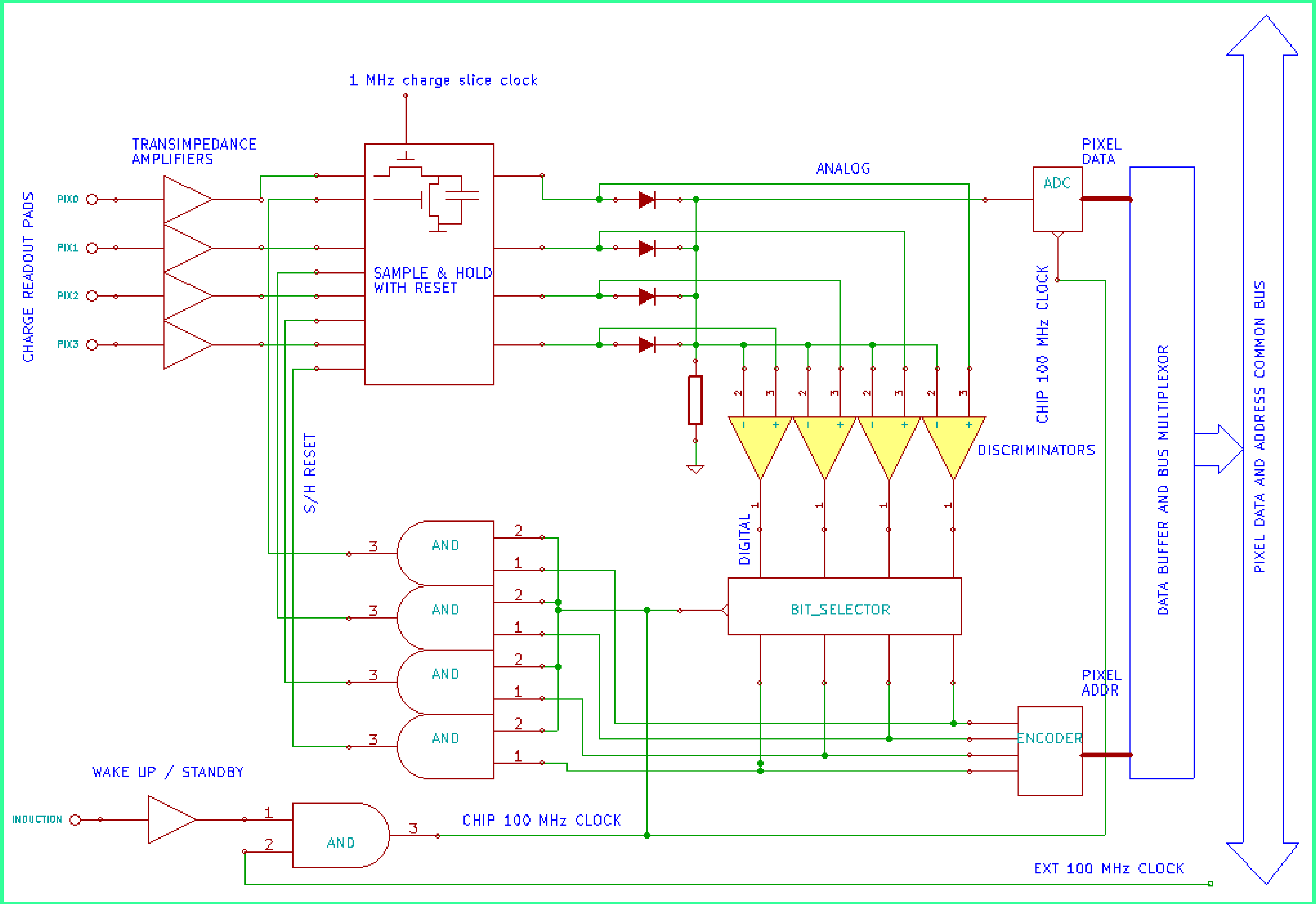
Time slice ≤ 1 us

Smart zero suppression

Multiplexing at the data output lines

Concept for pixel R/O ASIC

(proposed by I.K. in 2014, AC meeting at BNL)



First approach to pixels: LHEP 2016-2017

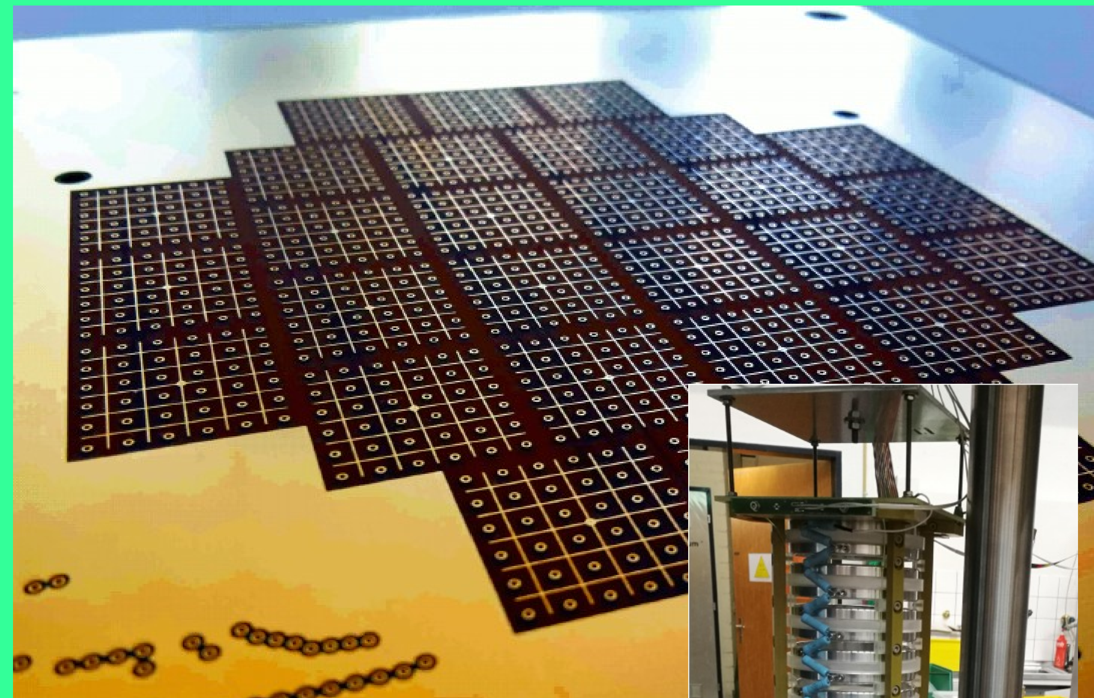
Compromise: multiplexed R/O

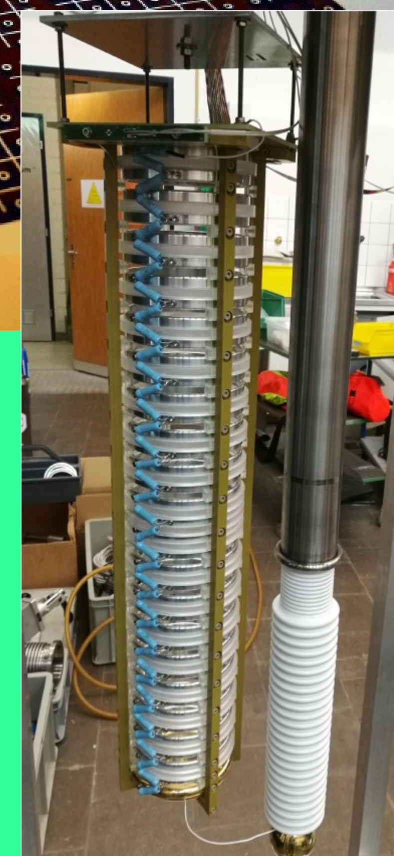
6x6 ROI with induction grid

BNL LARASIC4 as cold preamp

60 cm drift test LArTPC

2 runs: 2016 & 2017





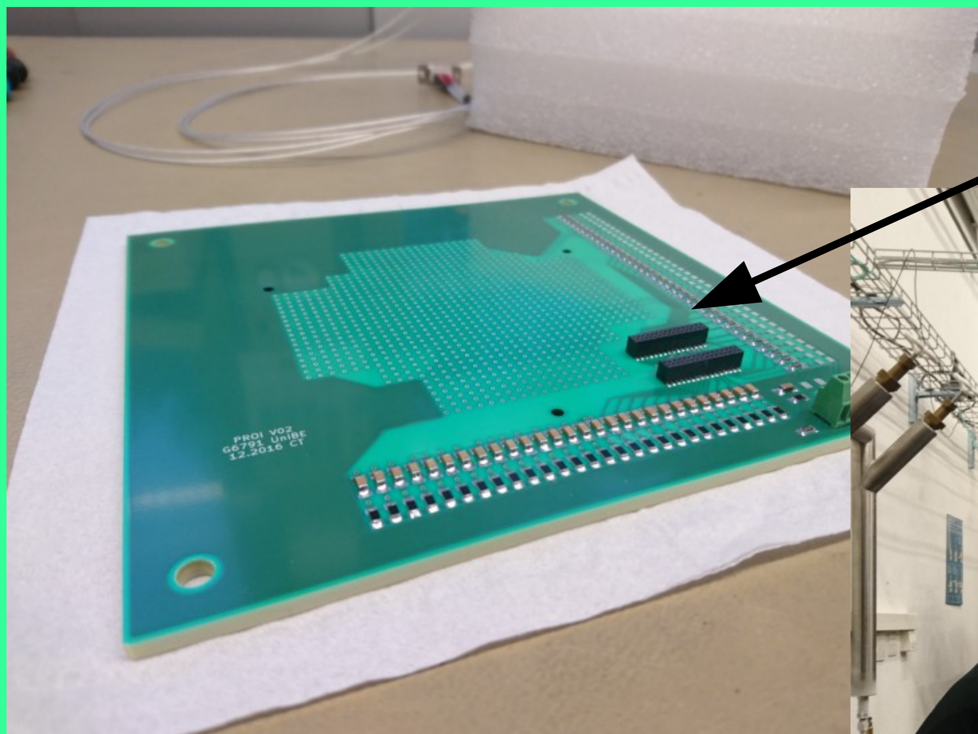
28 ROIs, each 6 × 6 pixels ⇒ **1008** pixels total @ 2.48 mm pitch

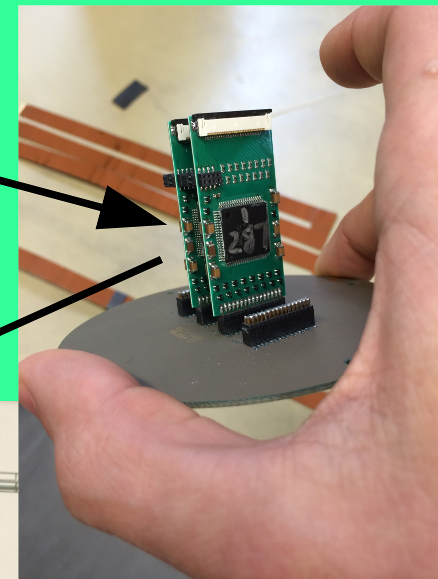
28 + 36 = **64** R/O channels

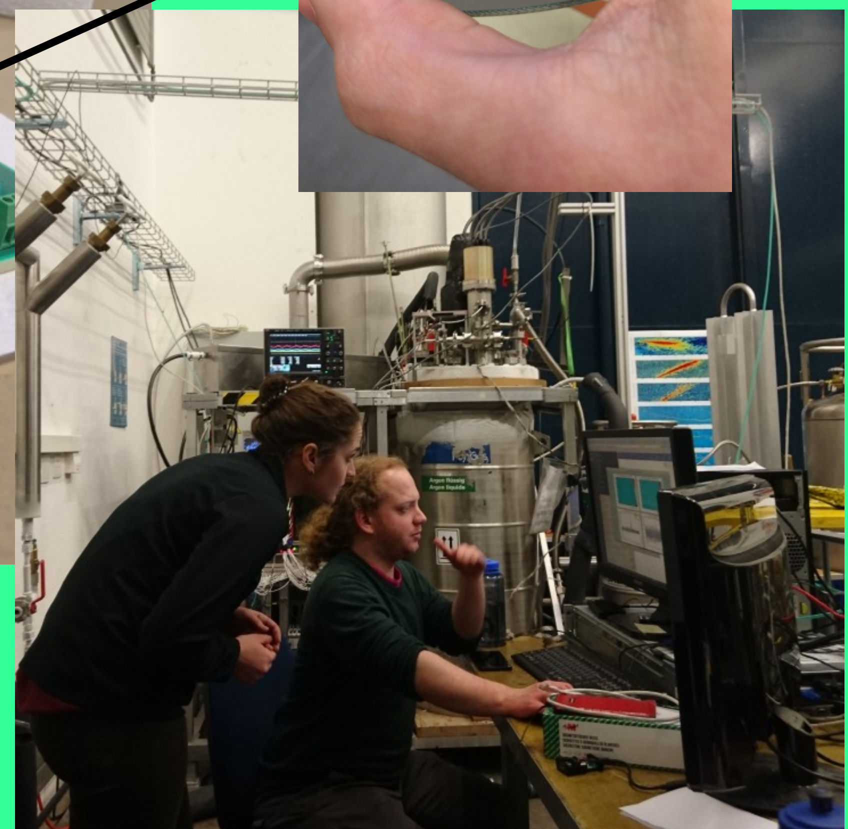
Improved ARGONTUBE R/O electronics

First approach to pixels: LHEP 2016-2017

4x LARASIC4 on very compact PCB



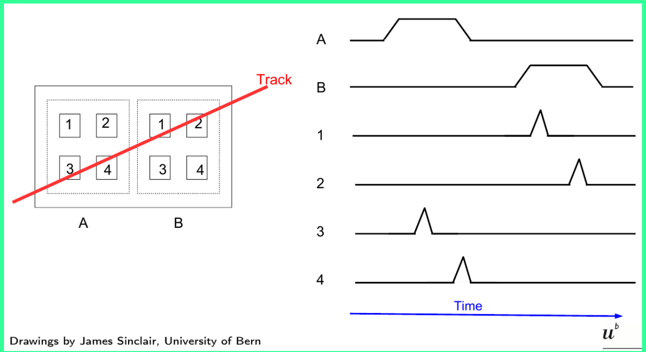


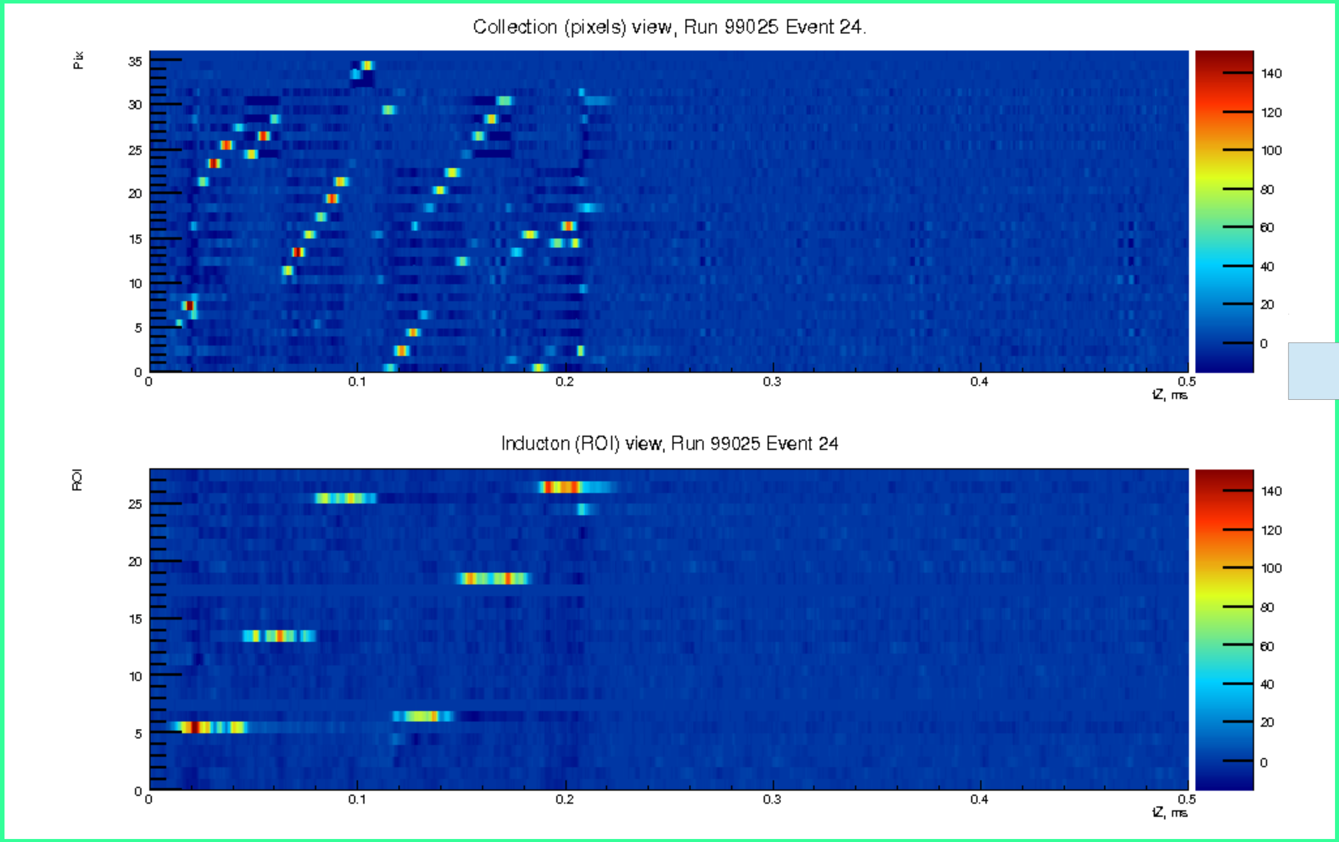


Two data taking runs conducted.

First approach to pixels: LHEP 2016-2017

Reconstruction: simple «enable» by Induction signal





SNR for MIP in worst orientation: **~15**

First approach to pixels: LHEP 2016-2017

Reconstruction: Kalman filter
on top of simple «enable»

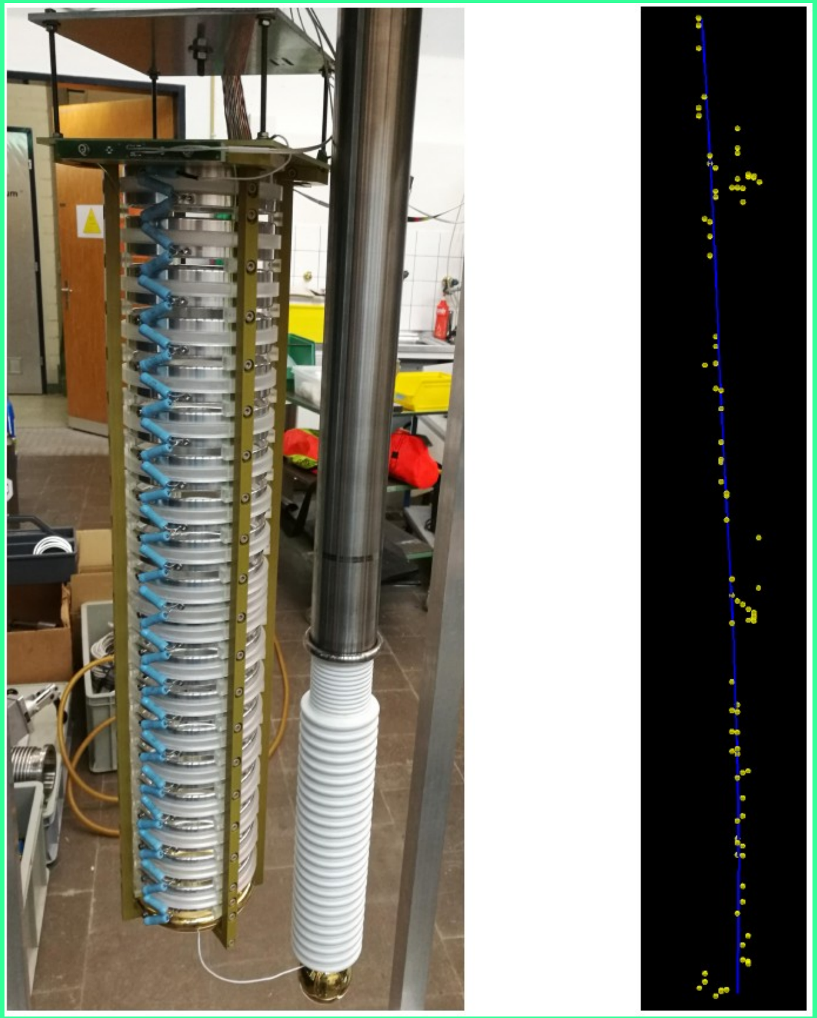
1. Noise filter
   Subtract common mode noise

2. Hit finder
   Performs threshold comparison

3. Hit matcher
   Combine pixel and ROI hits into 3D hits

4. Principal Component Analysis
   Solve multiplexing ambiguities
   Remove outliers

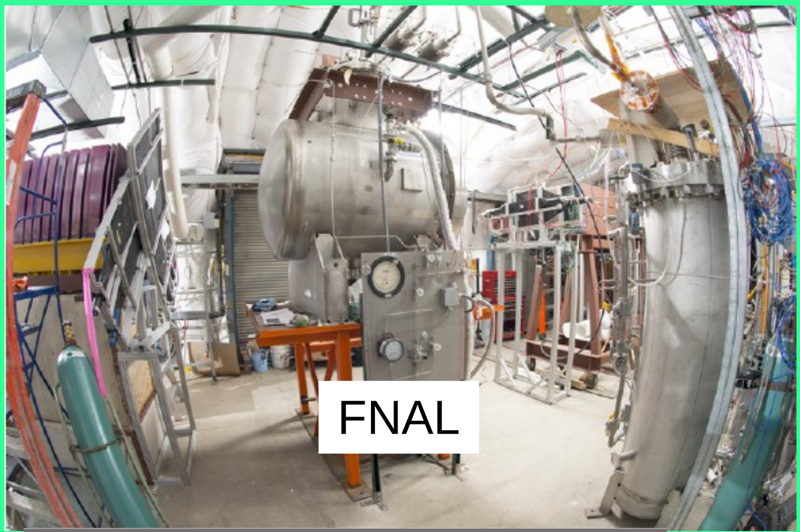
5. Kalman fitter
   Fit μ hypothesis to 3D spacepoints
   arXiv: 0911.1008, 1410.3698
   GENFIT

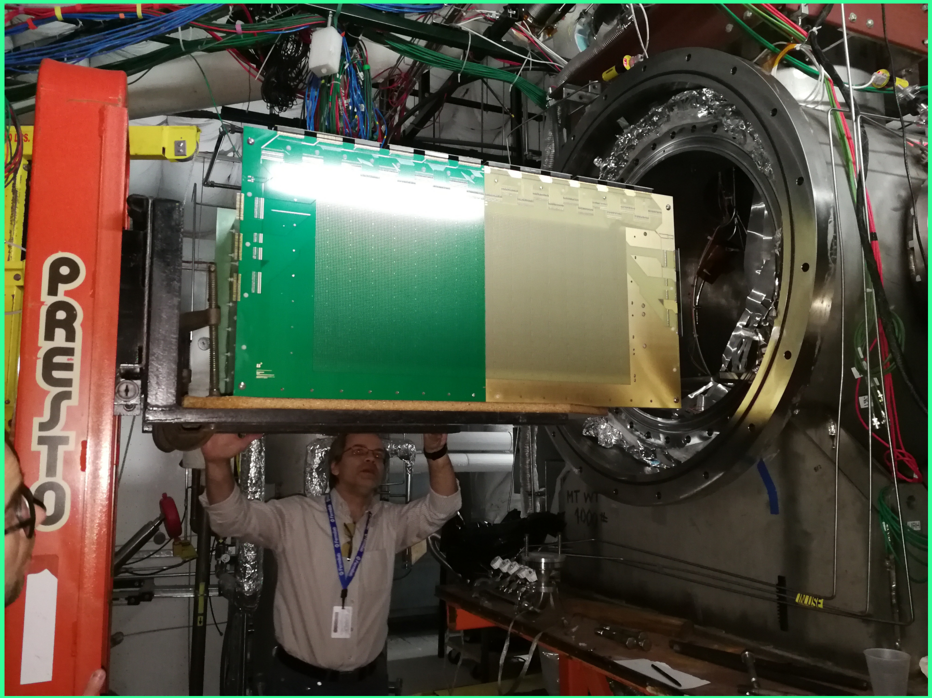


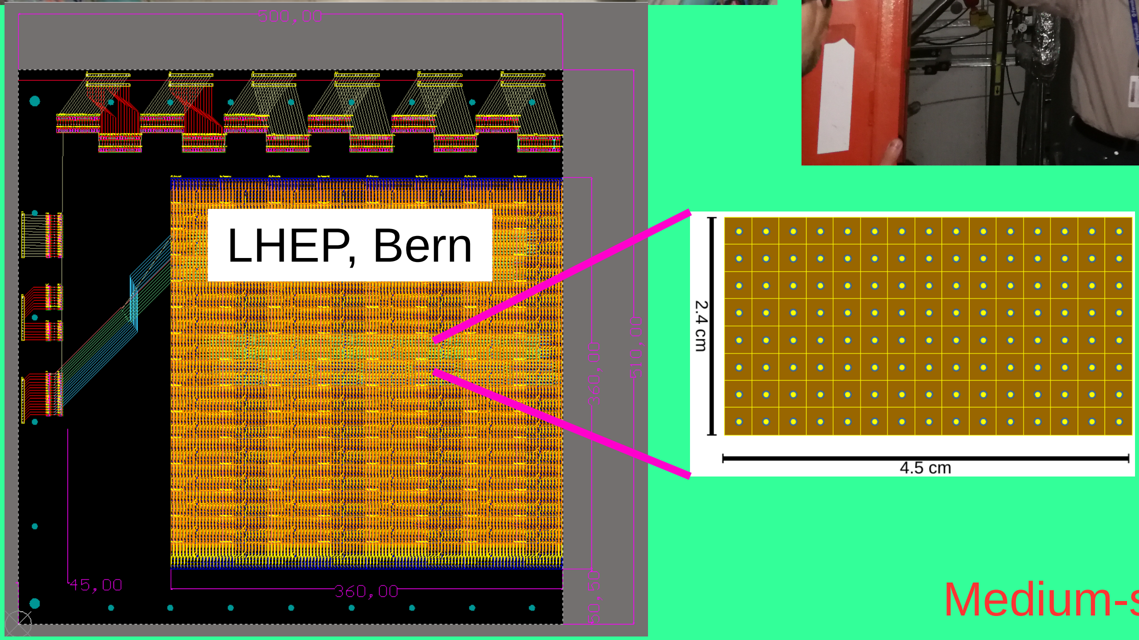
Output: tracks with PID likelihood and reconstructed momenta !

Test of our Pixel plane in LArIAT: PixLAr TPC

Run: end of 2017 — beginning of 2018





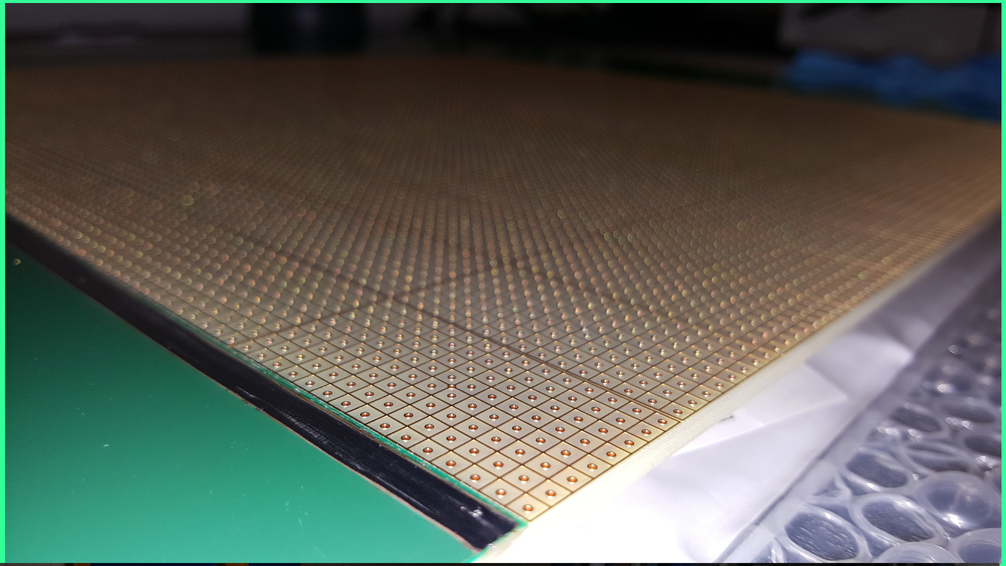


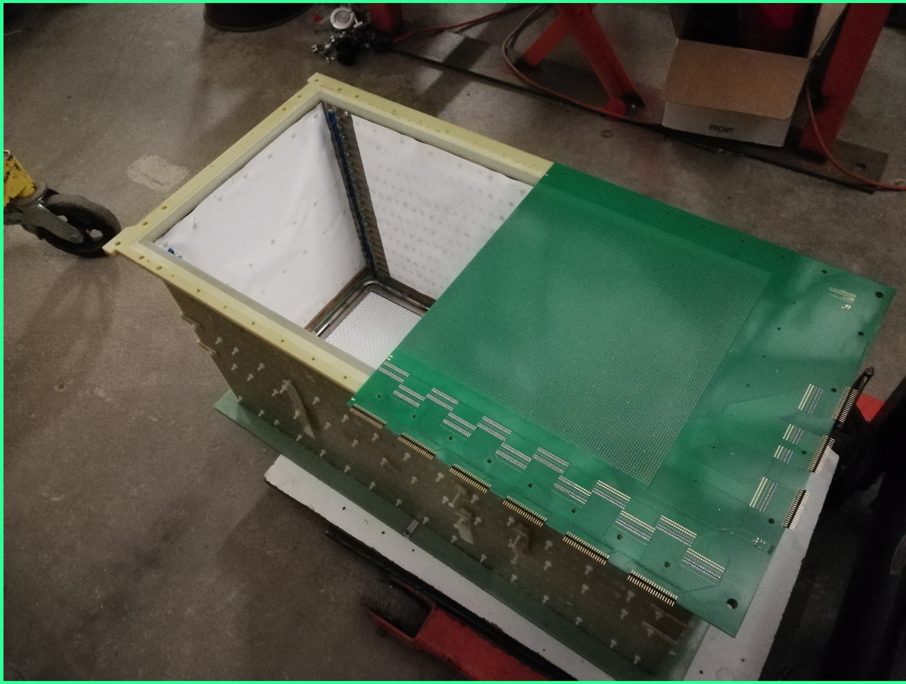
8x15=120 pix/RoI
240 RoI, 72 cm^2
28800 pixels
480 R/O channels

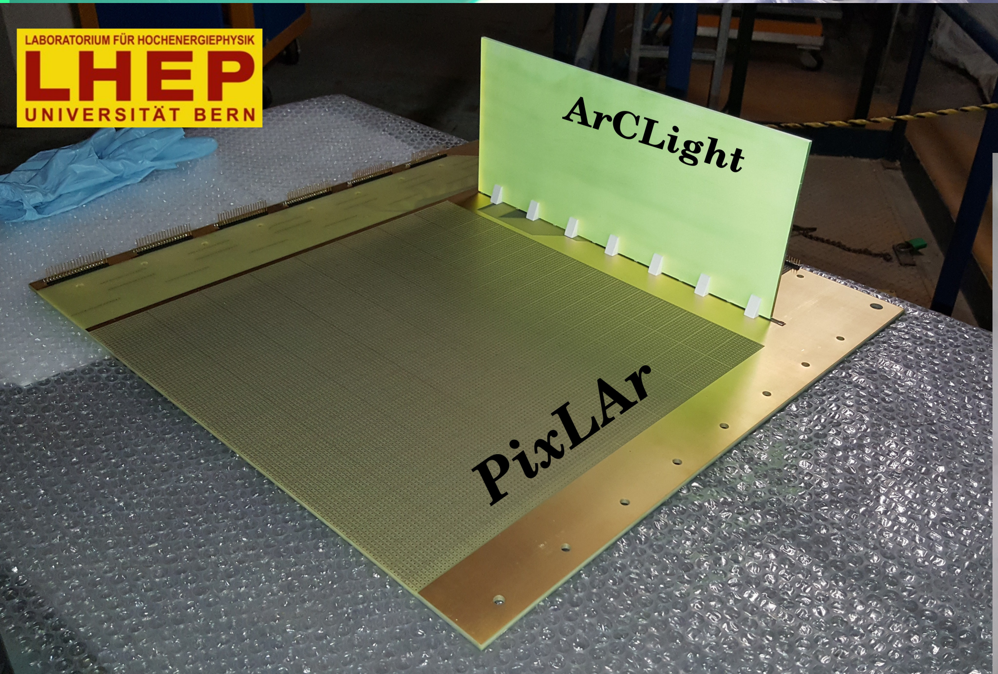
Medium-sized pixel readout test

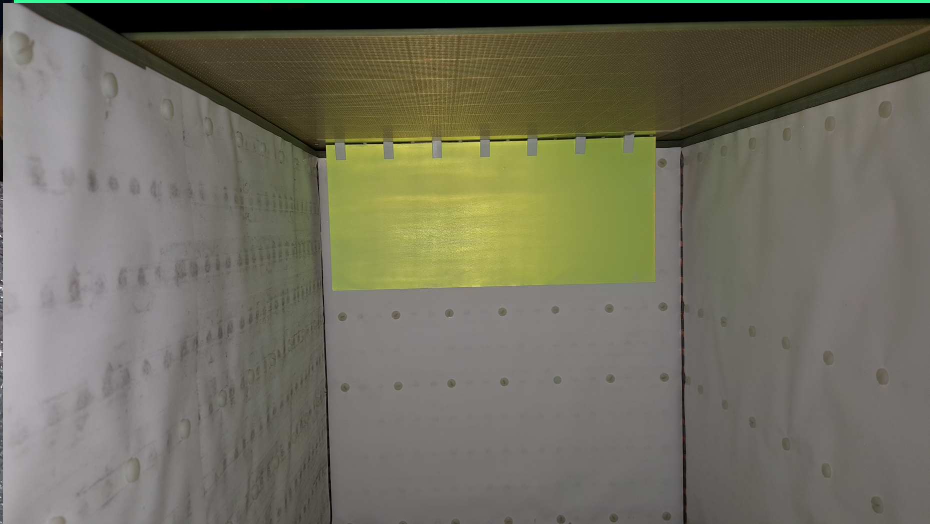
ArgonCube

Test of our Pixel plane in LArIAT: PixLAr TPC
Run: end of 2017 — beginning of 2018









Test of our Pixel plane in LArIAT: PixLAr TPC
Run: end of 2017 — beginning of 2018

11 Dec 2017 — 1 Feb 2018

426 runs are taken

Several hundred thousands events

Simple reco → 3D event display

Analysis is in progress…

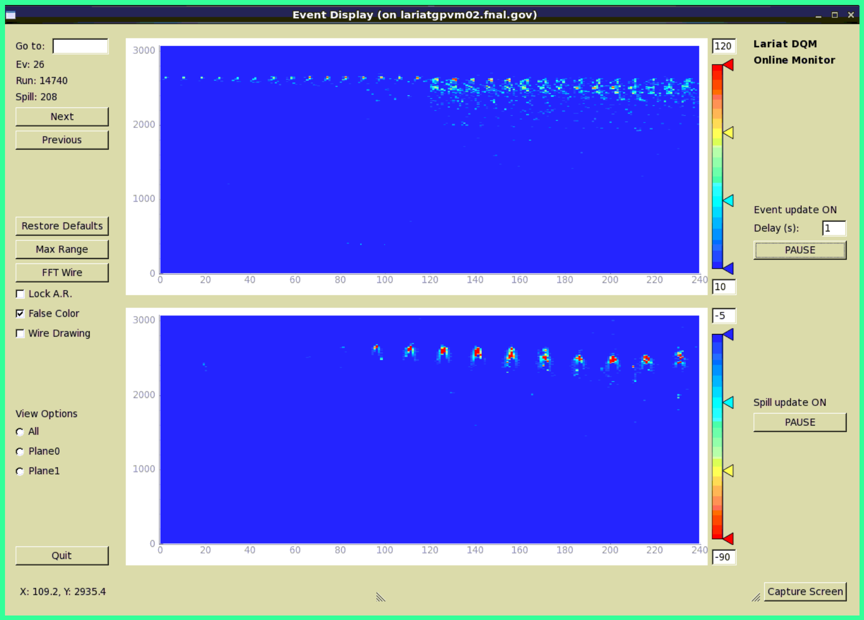
May expect:

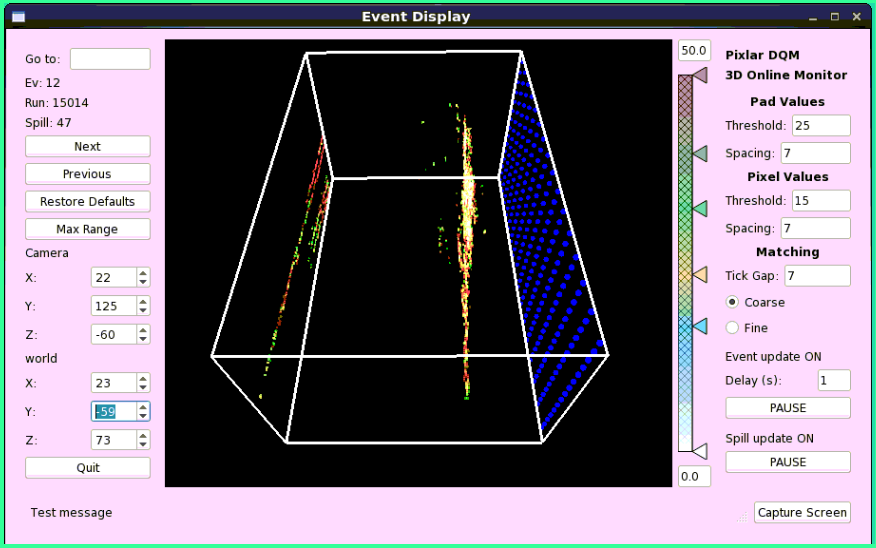
- Pion reco efficiency

- dE/dx uncertainty (vs angle)

- EM shower reco, energy uncertainty

- Pileup limit, two event separation efficiency





Pixels are good! Precious data in hands!

ARCONCUBE Module-0 non-multiplexed R/O

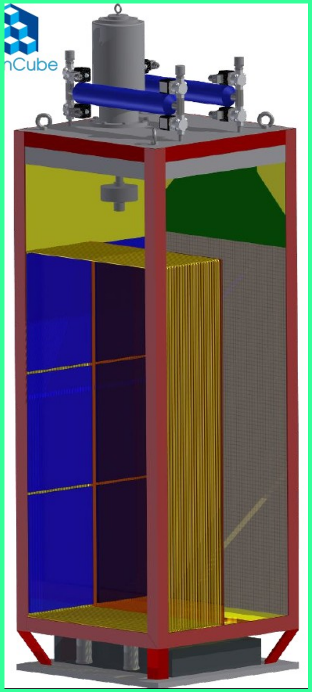
Bespoke ASIC: **LArPix**, <u>see talk by Dan Dwyer</u> !

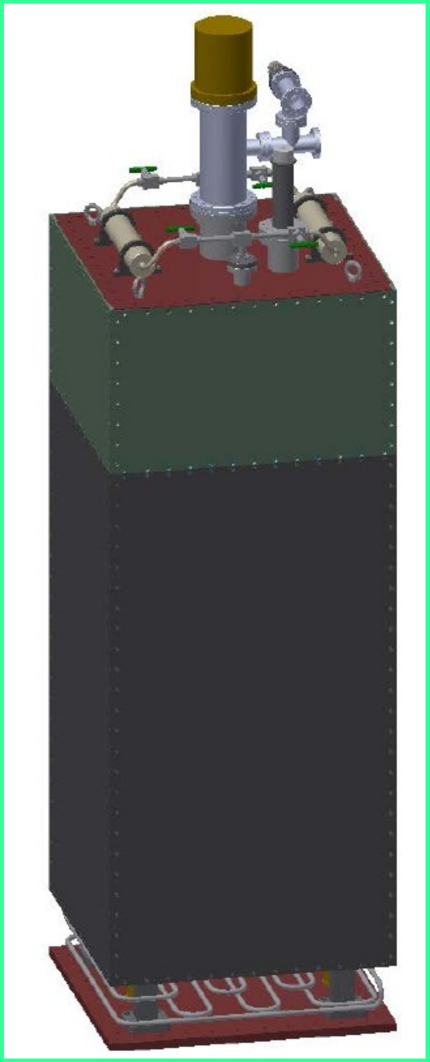
ARGONCUBE 2x2 proto in Bern:

4 modules, 0.67 x 0.67 x 1.8 m each

Run-1
small area demo

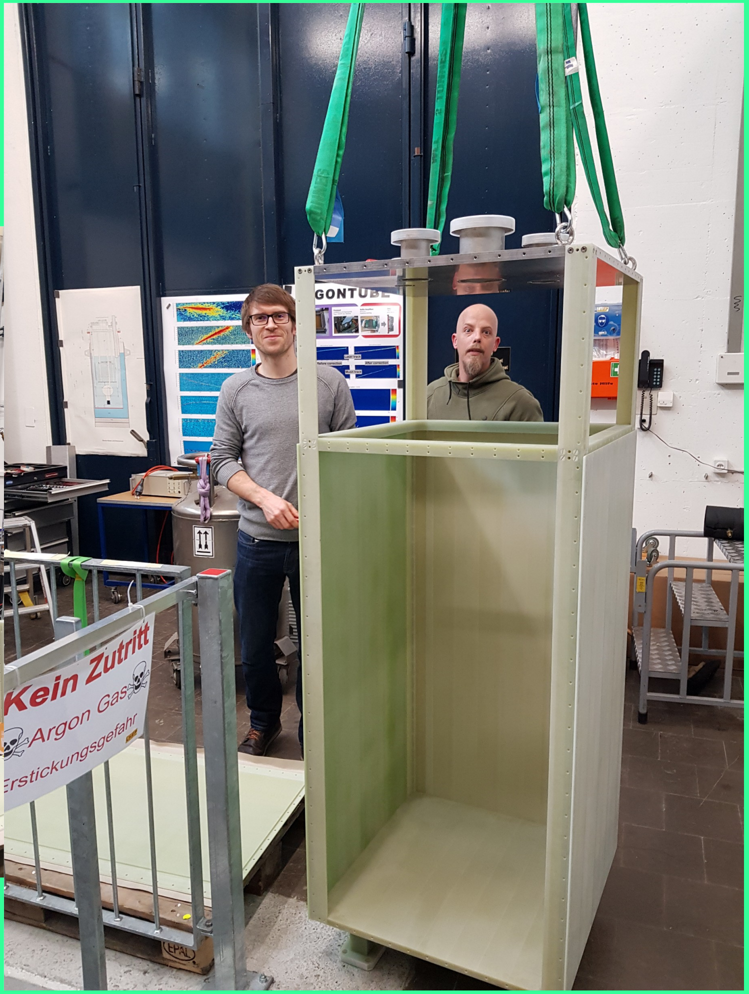
Run-2
full area anode





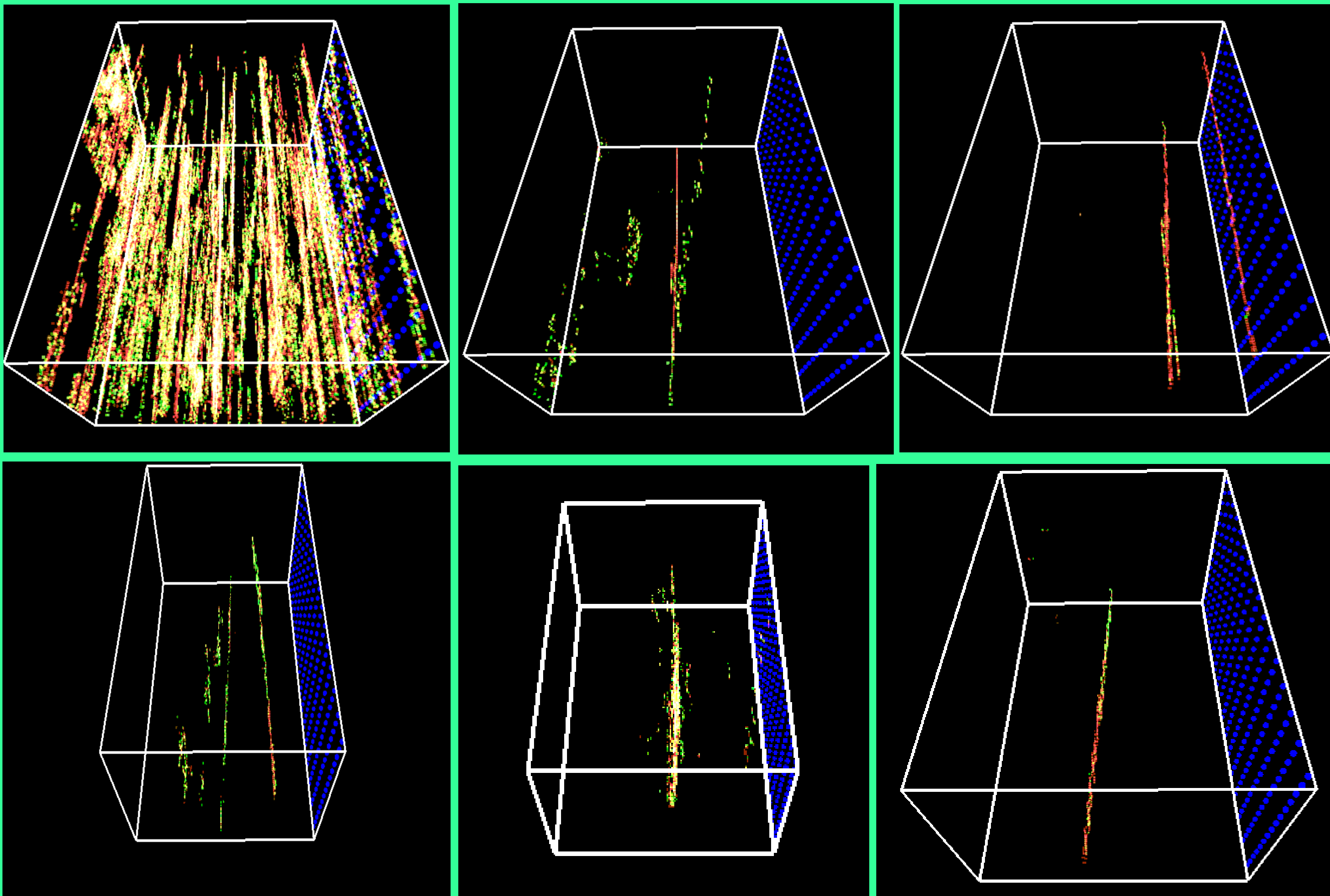
No more compromises…
Unambiguous pixelized 3D readout.

ARGONCUBE Module-0 progress



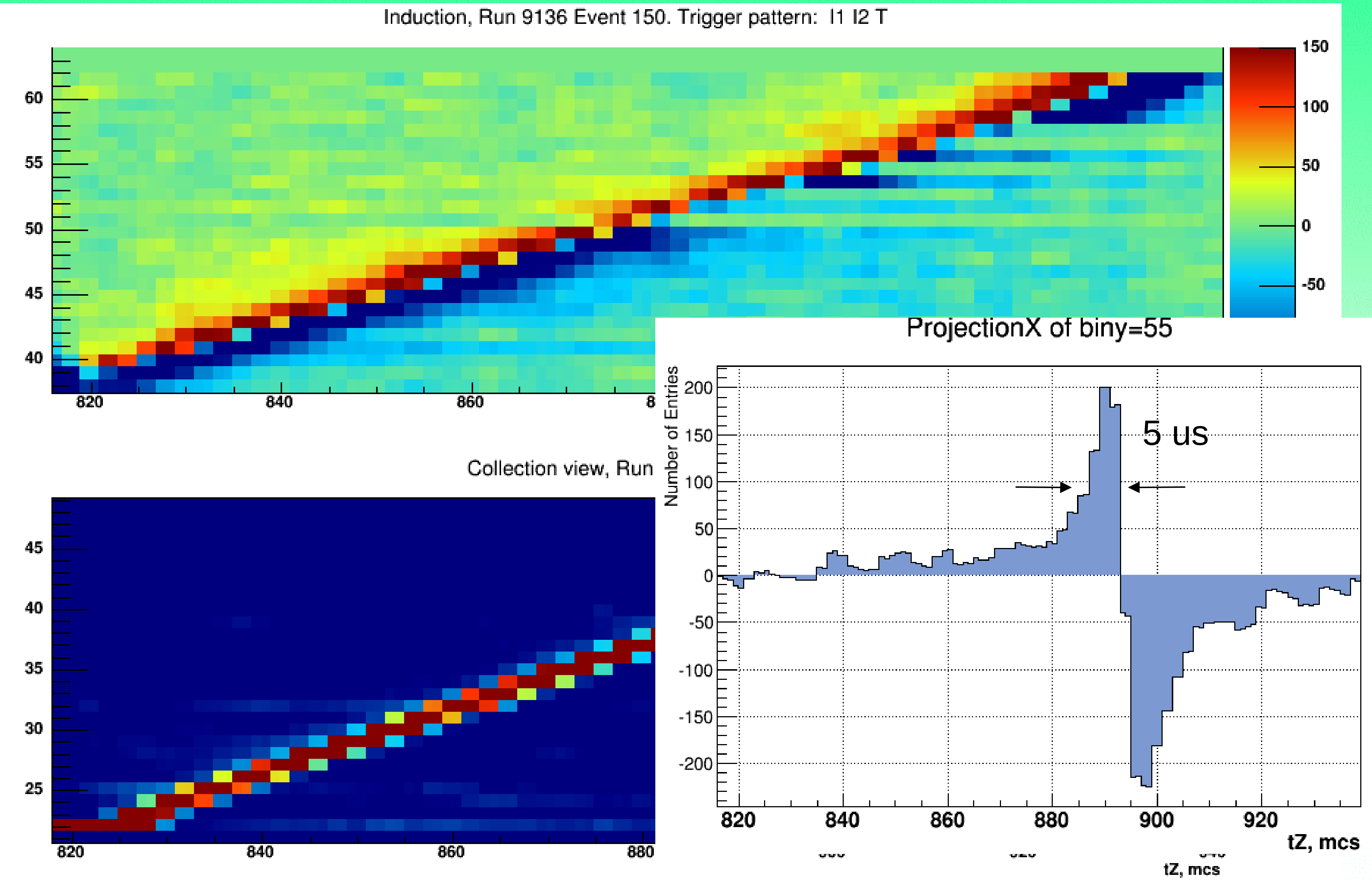
Stay tuned to our R&D program !

PixLAr Event Gallery

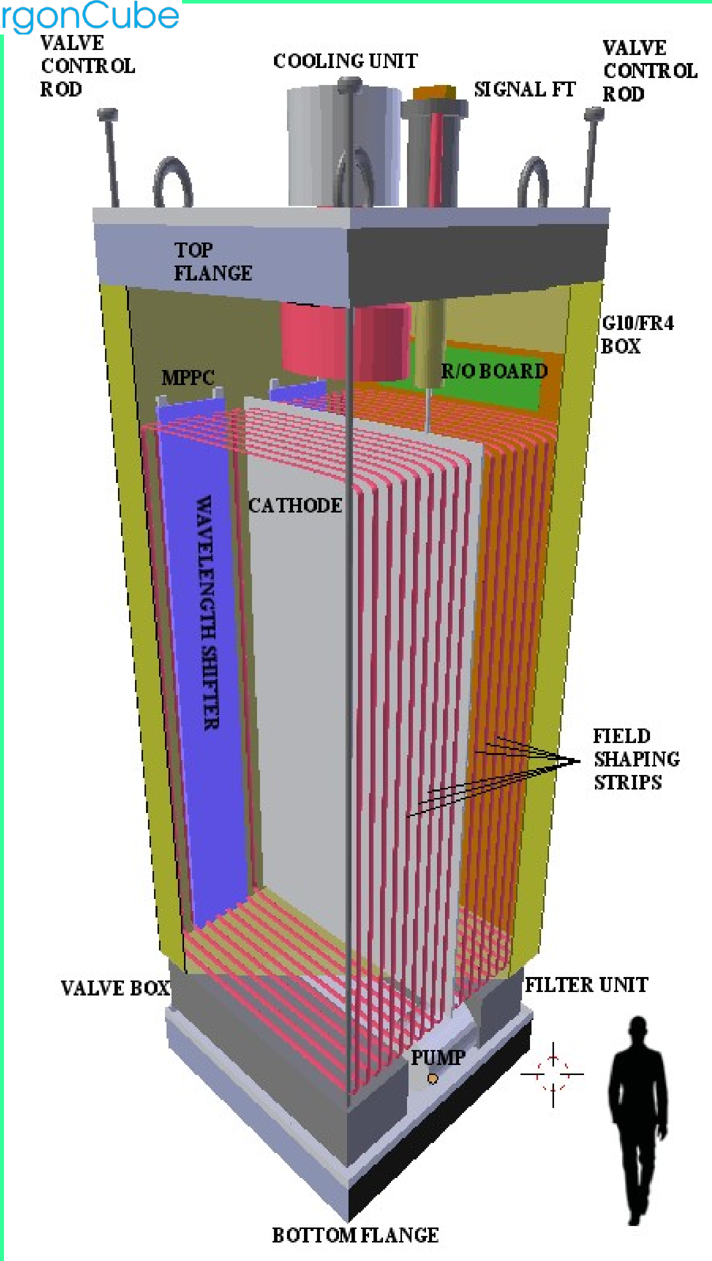


Backup Slides

Advance of induction signal → wakeup time



ONCUBE module



Module: an independent TPC

- LAr purification: recirculation through Oxygen-traps
- Temperature: individual cryo-cooler unit
(removes heat input from electronics and heat leaks)

- Cathode bias (-100 kV) supplied via HV feed-through
- Resistive divider for field shaper
- Relatively low voltage => breakdown-free setup
- Electrically transparent container => low dead volume

- PCB-technology for R/O plane manufacturing
- Pad arrays for charge readout, 3x3 mm^2 pads
- 4x8 pads ROI served by one R/O ASIC at the PCB back
- Mechanically robust production technology
- Low failure cost

- Light collection via WLS light guides
- Light readout with SiPMs in coincidence

Reliable/repairable self-contained unit