ArgonCube Prototypes

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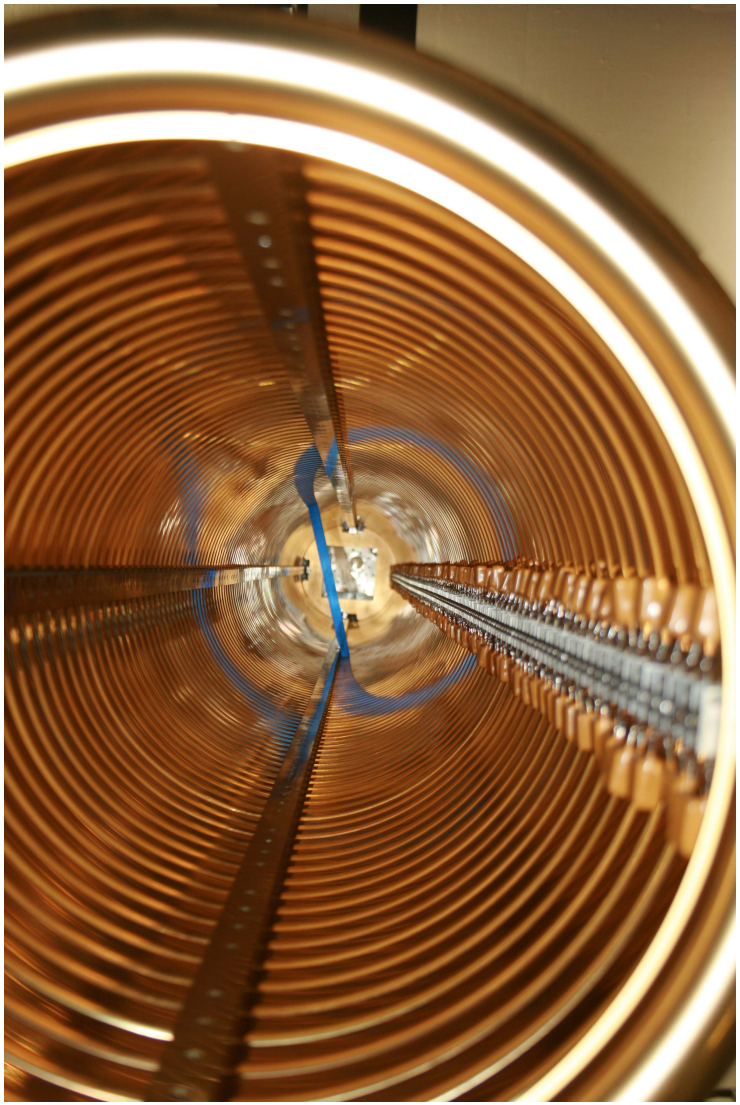
ArgonCube Collaboration Meeting 2017

ArgonTube

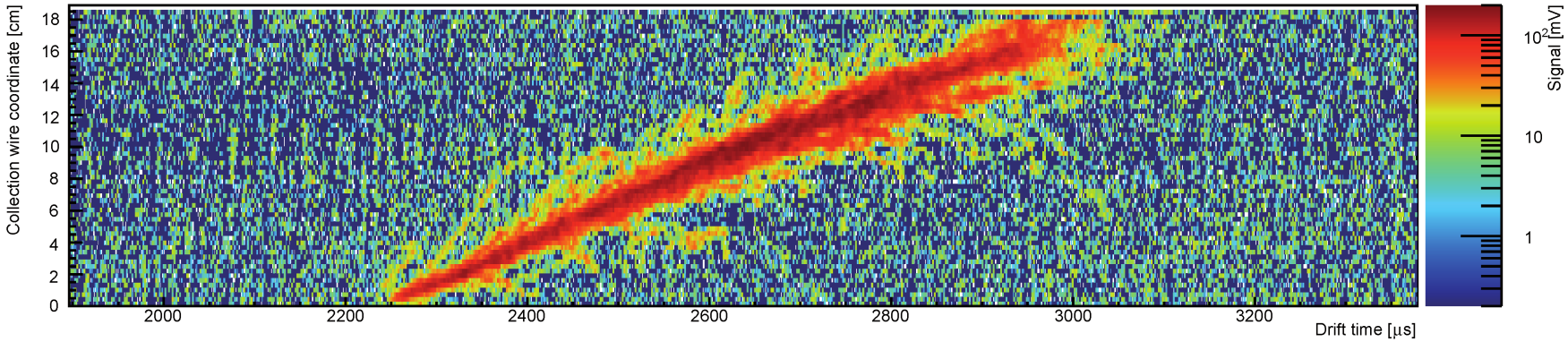
The predecessor of ArgonCube arXiv:1304.6961, 1408.6635



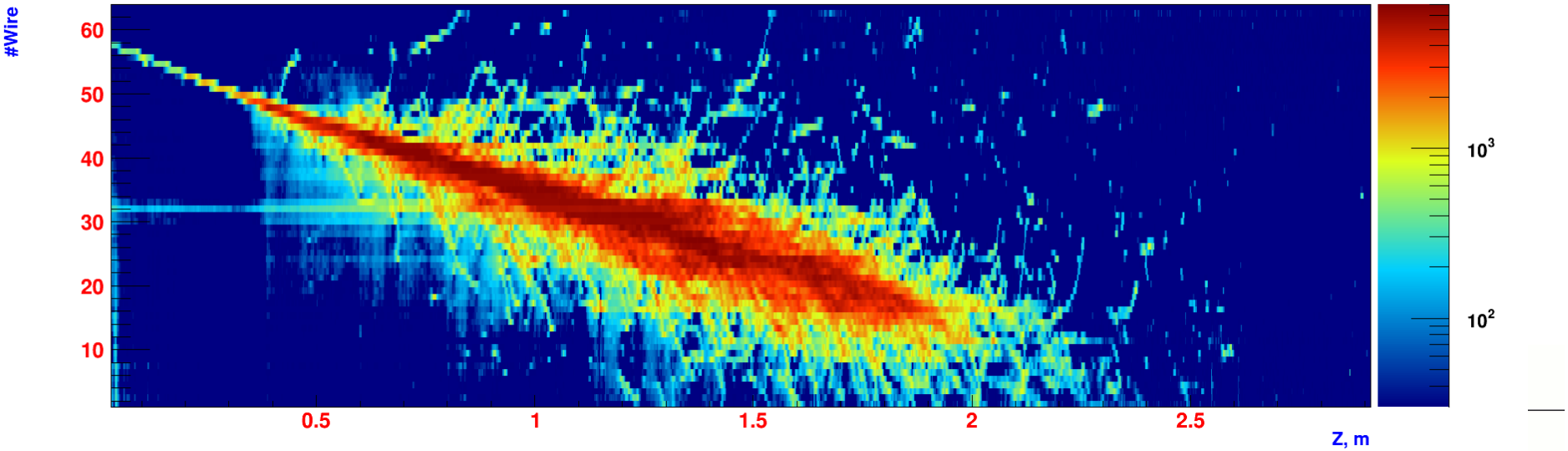
- Cosmic ray data
- 5 m drift length
- 2 ms charge lifetime
- Test of UV laser calibration
- V_{Drift} up to 500 kV from cold Greinacher voltage multiplier

Cold charge readout electronics

warm vs cold arXiv:1408.7046

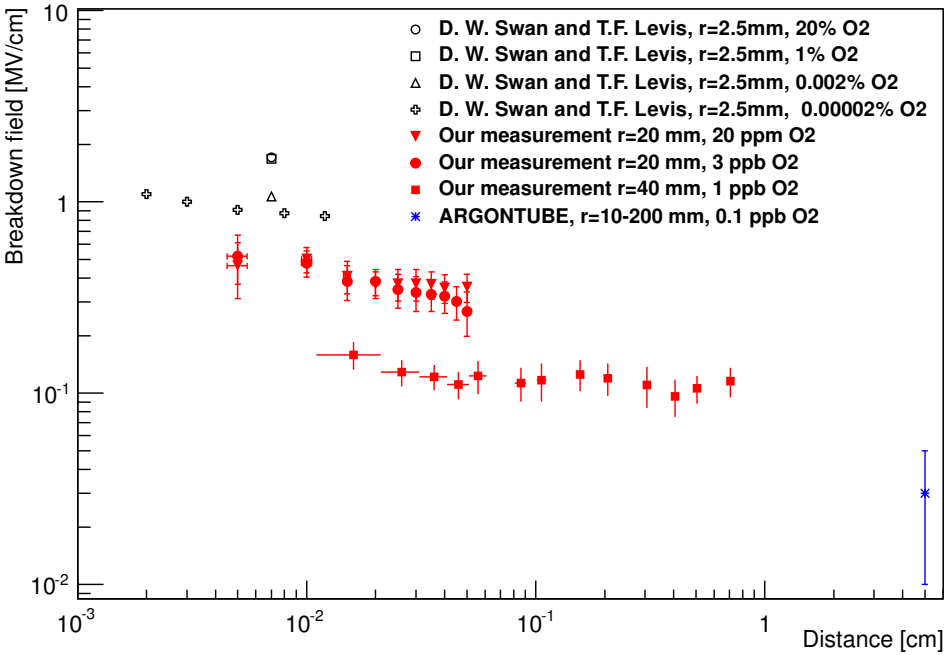


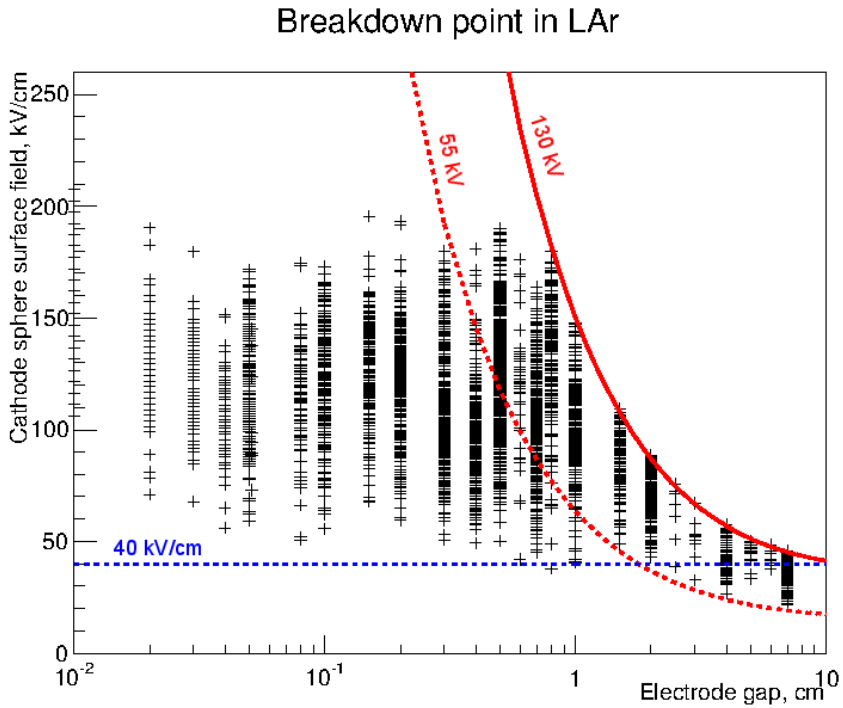
Induction view, Run 8135 Event 74. Trigger pattern: I1 I2 S



Dielectric strength of liquid argon

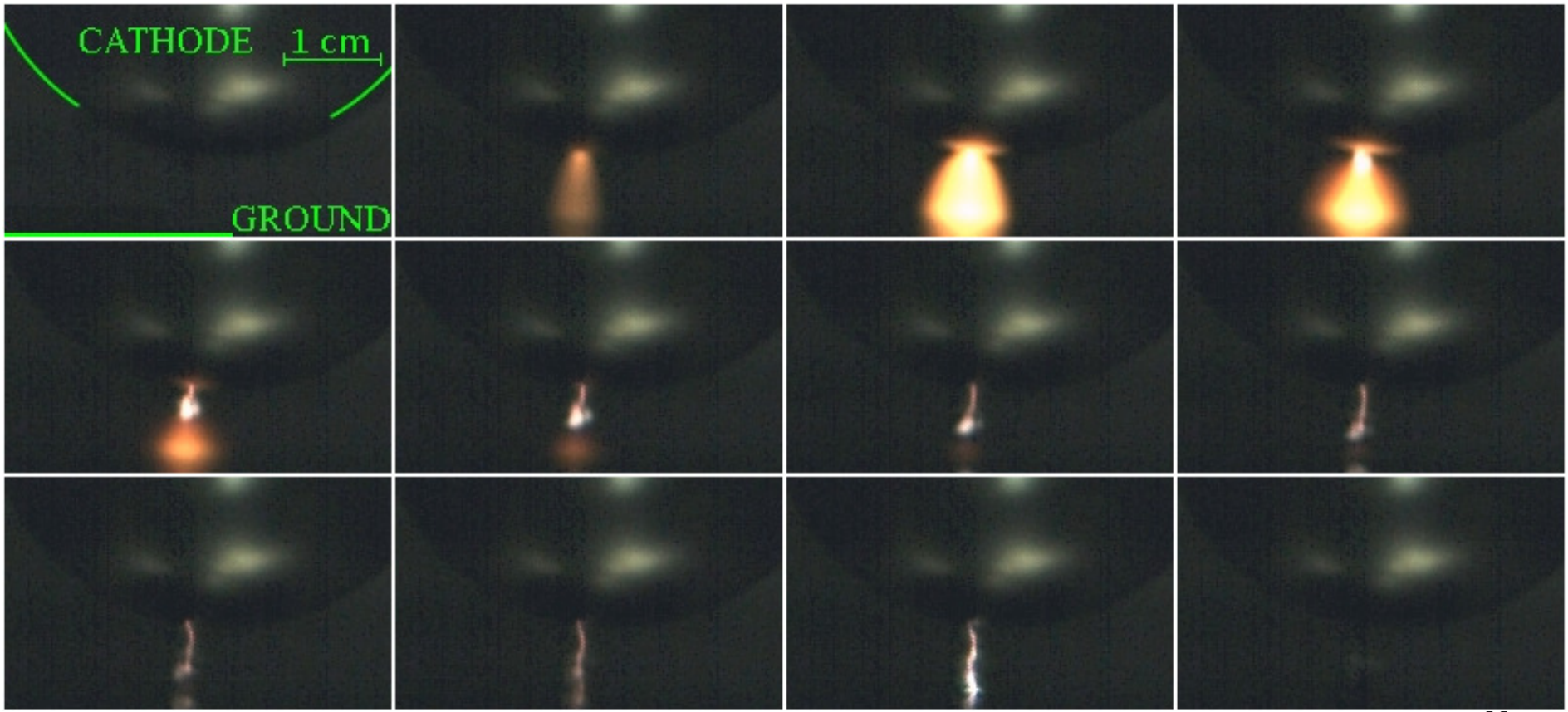
Failed to reach design voltage arXiv:1401.6693





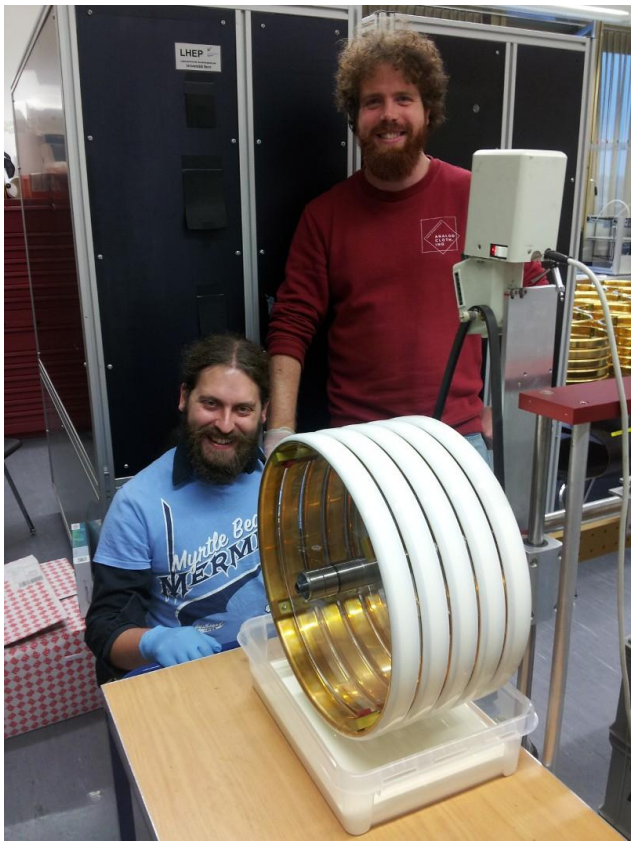
Footage of a typical breakdown

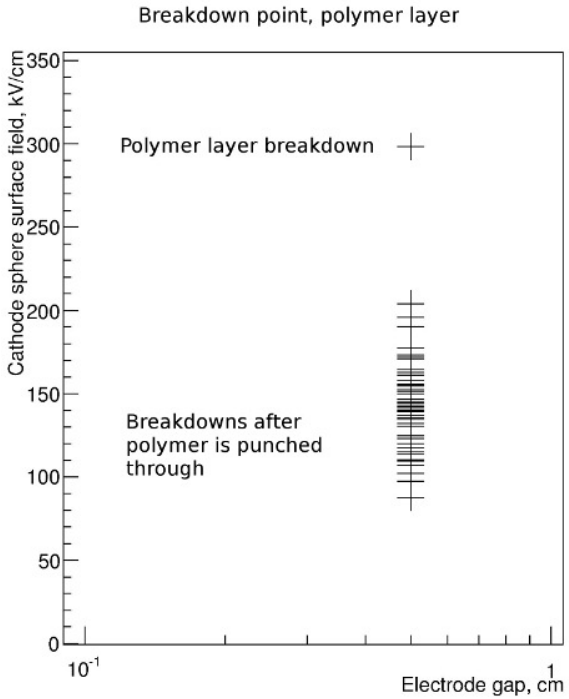
arXiv:1512.05968

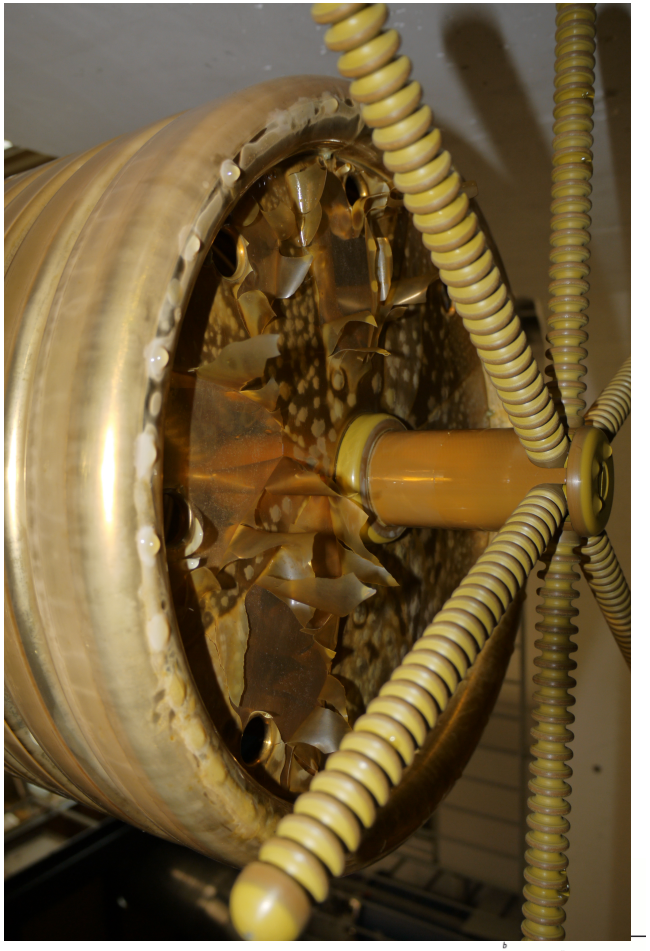


Preventing breakdowns

with a polymer coating arXiv:1406.3929







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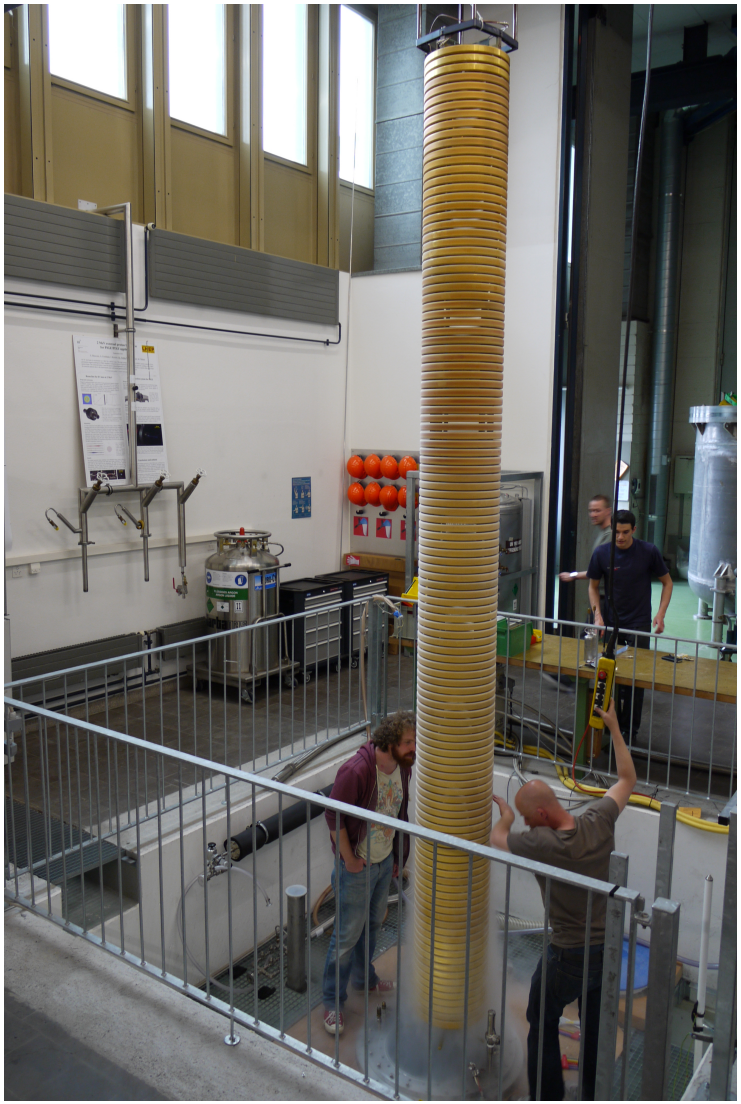
Lessons learned



- Field distortion due to space charge

$\Rightarrow$ Need laser calibration

- Dielectric strength much lower than anticipated

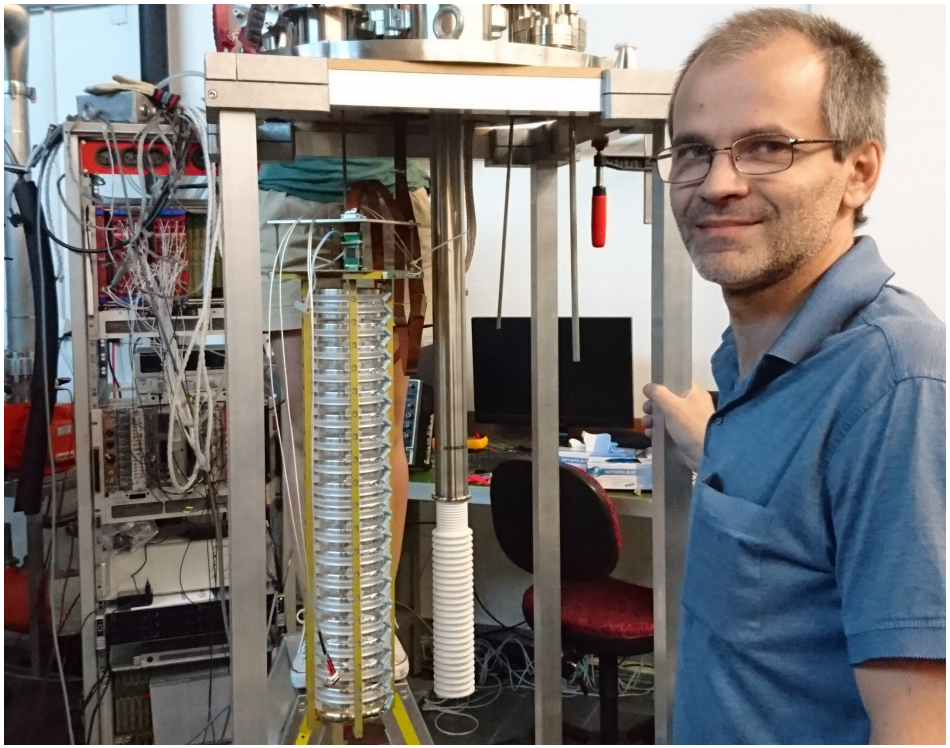
$\Rightarrow$ Increase dead volume or decrease drift voltage

$\Rightarrow$ Less charge and longer drift time

$\Rightarrow$ Increased purity requirements

Large monolithic LArTPCs are not easy!

Pixel prototype TPC



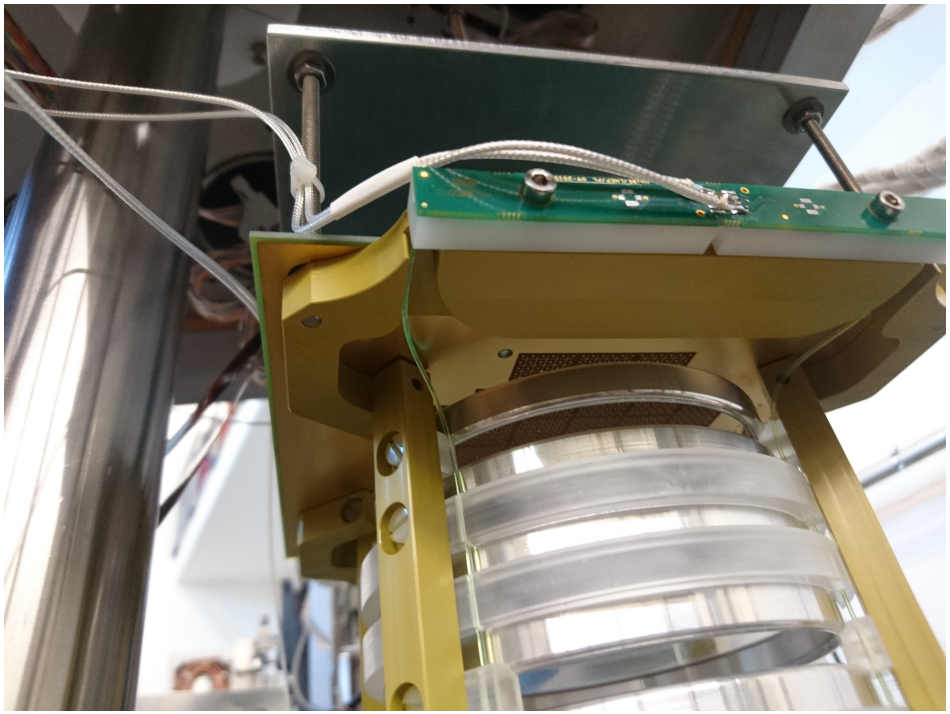
- 200 l bath cryostat,
  $\varnothing = 500\,\text{mm}$, $h = 1100\,\text{mm}$
- 130 kV HV feedthrough
- Cylindrical drift volume
- $\varnothing = 100\,\text{mm}$
- $L = 600\,\text{mm}$
- $V_{\text{Drift}} = 60\,\text{kV}$

$\Rightarrow$ $E_{\text{Drift}} = 0.1\,\text{kV}\,\text{mm}^{-1}$

$\Rightarrow$ $v_{\text{Drift}} = 2\,\text{mm}\,\mu\text{s}^{-1}$

$\Rightarrow$ $t_{\text{Drift}} = 300\,\mu\text{s}$

Pixel prototype readout



- 64 DAQ channels for 1008 physical pixels
- Charge readout by BNL LARASIC4* preamplifiers in LAr

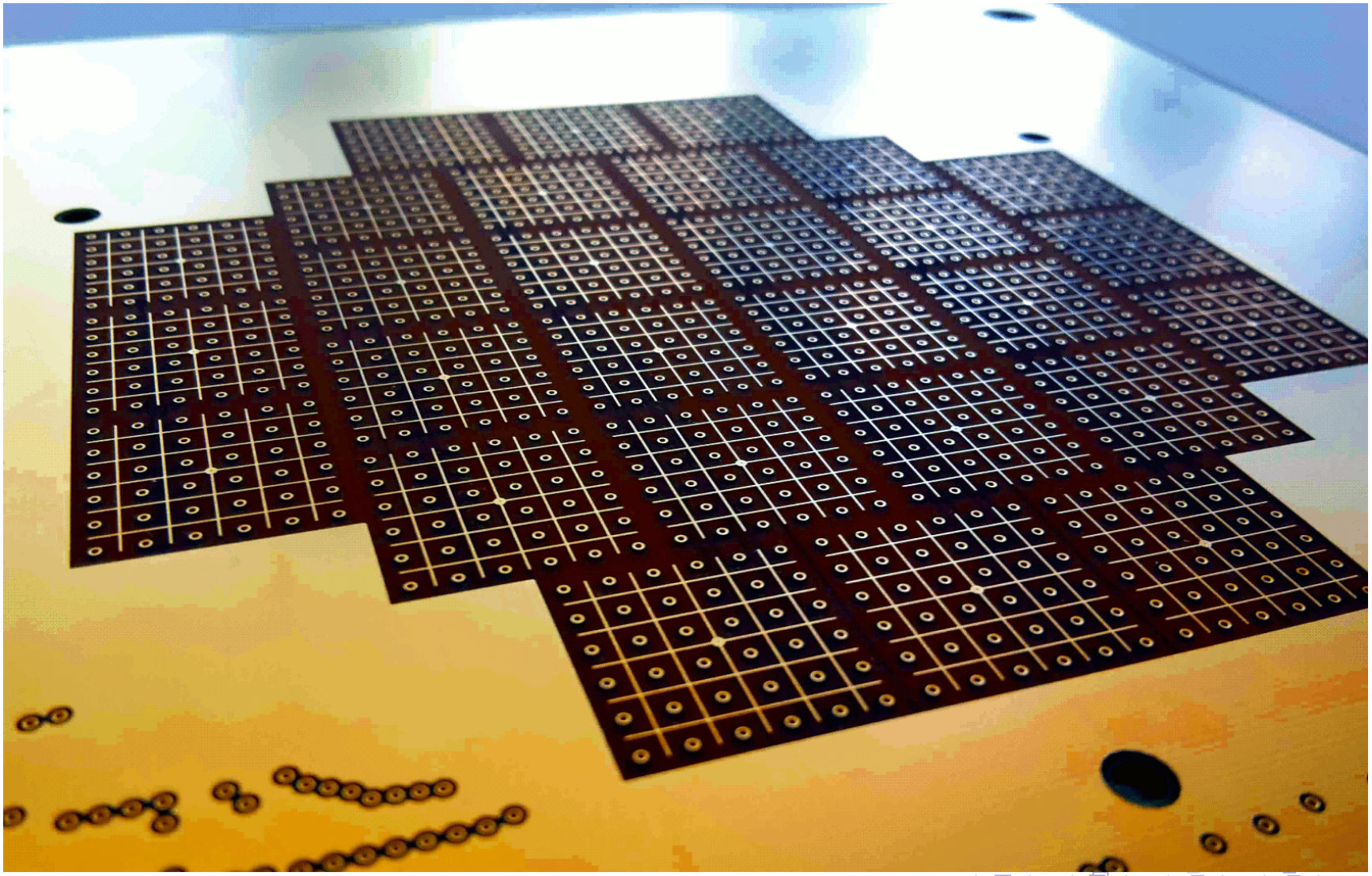
↪ CAEN ADCs at room temperature

- Light readout by TPB coated acrylic field cage spacers

↪ Hamamatsu S12825-050P SiPMs

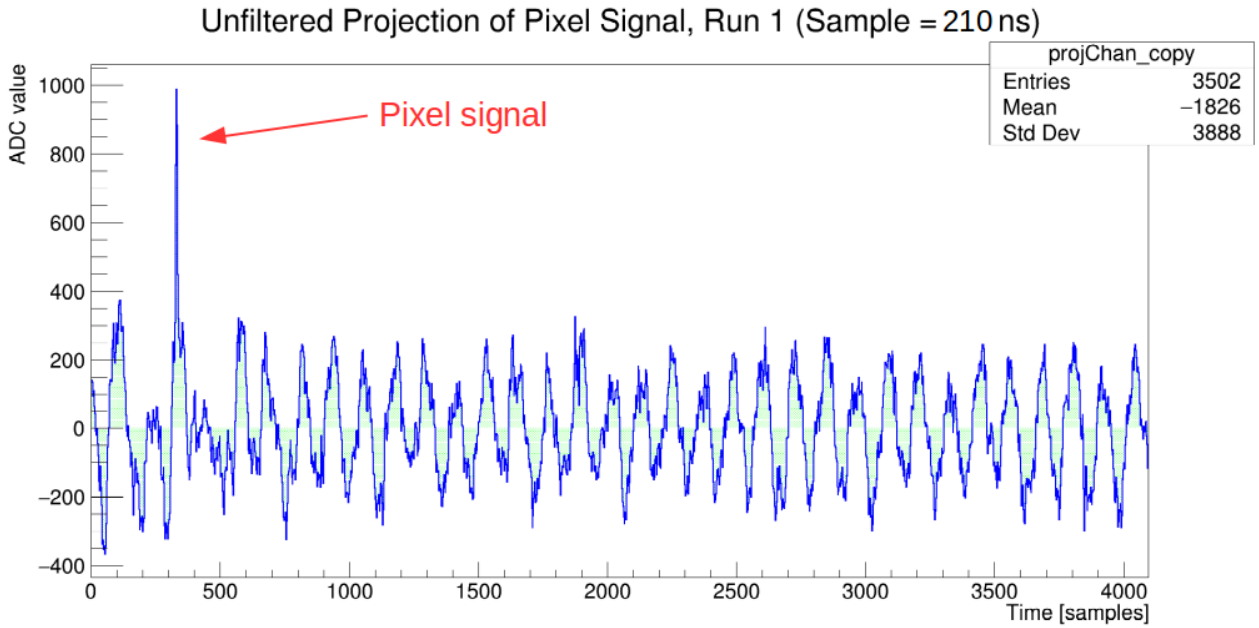
Pixelated charge readout prototype PCB

1008 pixels @ 2.48 mm pitch, see my pixel talk



Pixel run 1

High noise levels



- MIP $\frac{\mathrm{d}E}{\mathrm{d}x} = 2.1\,\mathrm{MeV\,cm^{-1}}$
- $W_\mathrm{i} = 23.6\,\mathrm{eV}$
- $E_\mathrm{Drift} = 1\,\mathrm{kV\,cm^{-1}}$
- $R_\mathrm{c} = 0.7$
- $\sigma_\mathrm{Noise} = 8079\,e$
- $\mathrm{SNR} = 1.9$

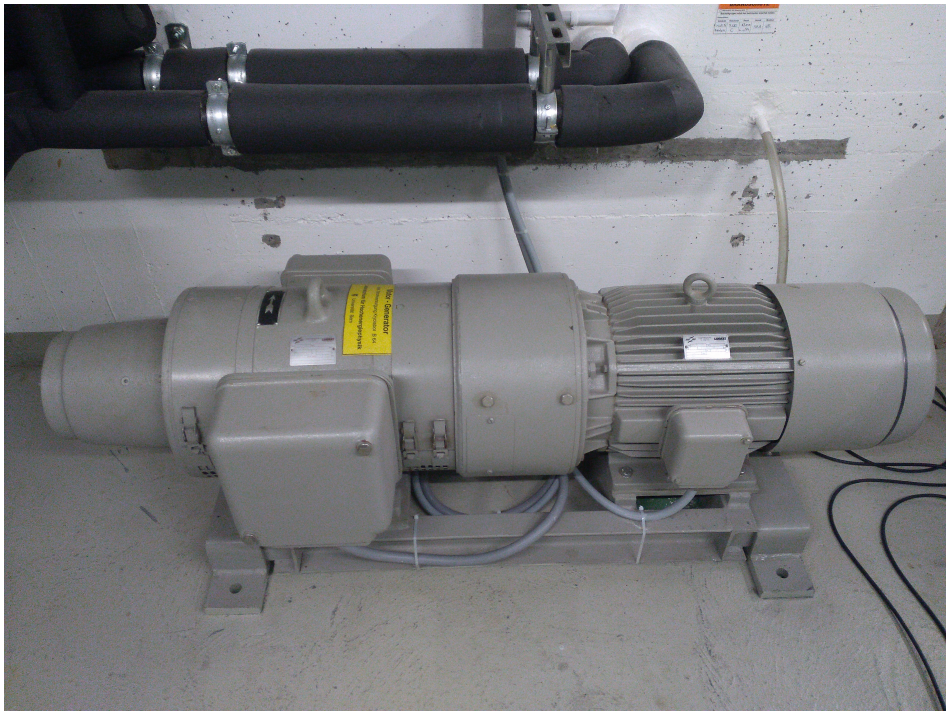
Noise mitigation

Move away from the noise source

- Noise becomes a lot better after 18:00
- Aircon switches off at this time
- Found an armada of fan motor controllers
- Very noisy and right behind experiment

Noise mitigation

Clean power supply



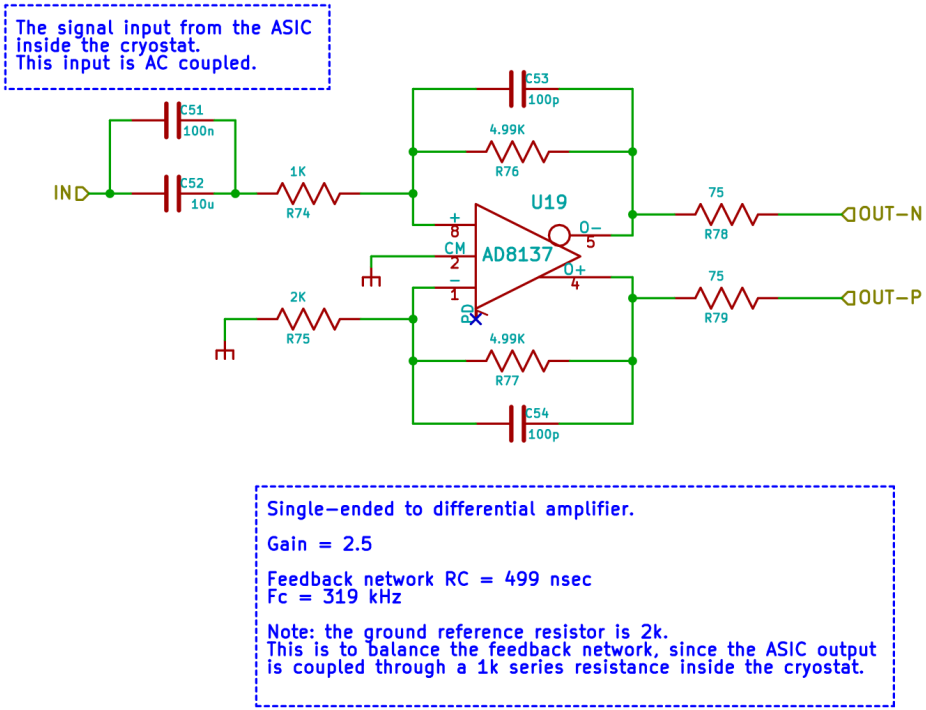
- 10 kV A motor-generator (M-G set)
- Mechanically decoupled electrical grid
- No noise from current-carrying wires
- Protective earth conductor can be disconnected if needed

↪ Remove ground loops

- Not suitable for three-phase pumps due to circuit layout

Noise mitigation

Differential signal routing



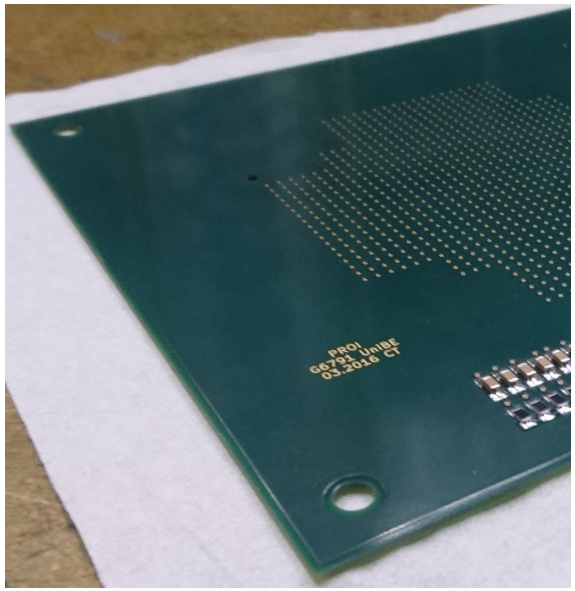
- From cryostat feedthrough to ADCs
- LArIAT design (Dean Shooltz)
- High resistance to common-mode pick-up noise
- No ground connection

↪ Remove ground loops

- Signal routing inside cryostat single-ended

Noise mitigation

Reduce PCB capacitance



1.75 mm thick

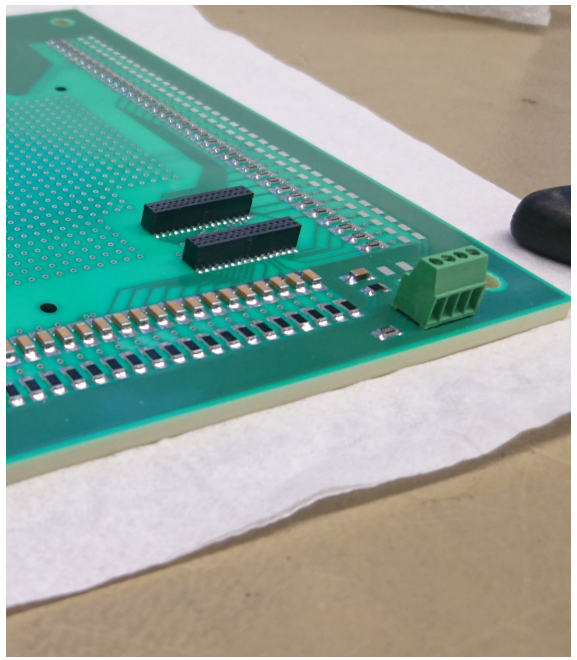
- 28 pixels per DAQ channel due to multiplexing

↪ High capacitance due to many long PCB tracks

- Several ground planes for shielding

⇒ High Johnson noise plus high capacitive coupling to ground

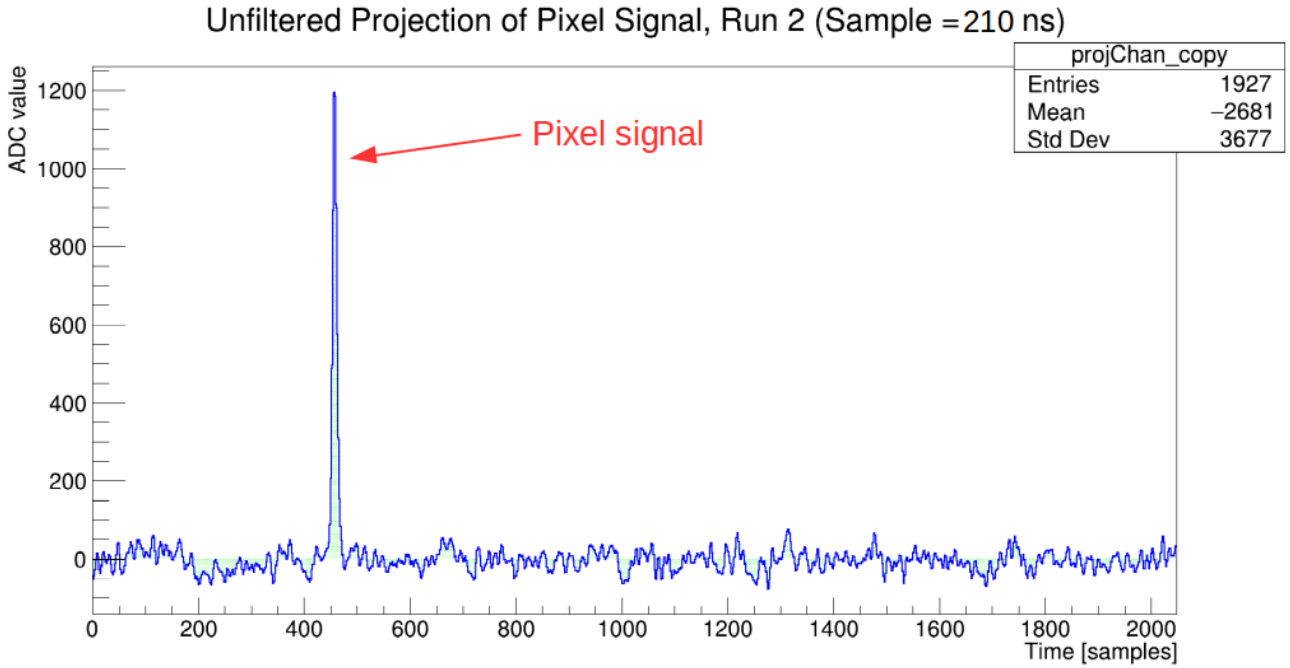
- Solution: Remove ground planes and increase PCB thickness



3.5 mm thick

Pixel run 2

Much better noise levels



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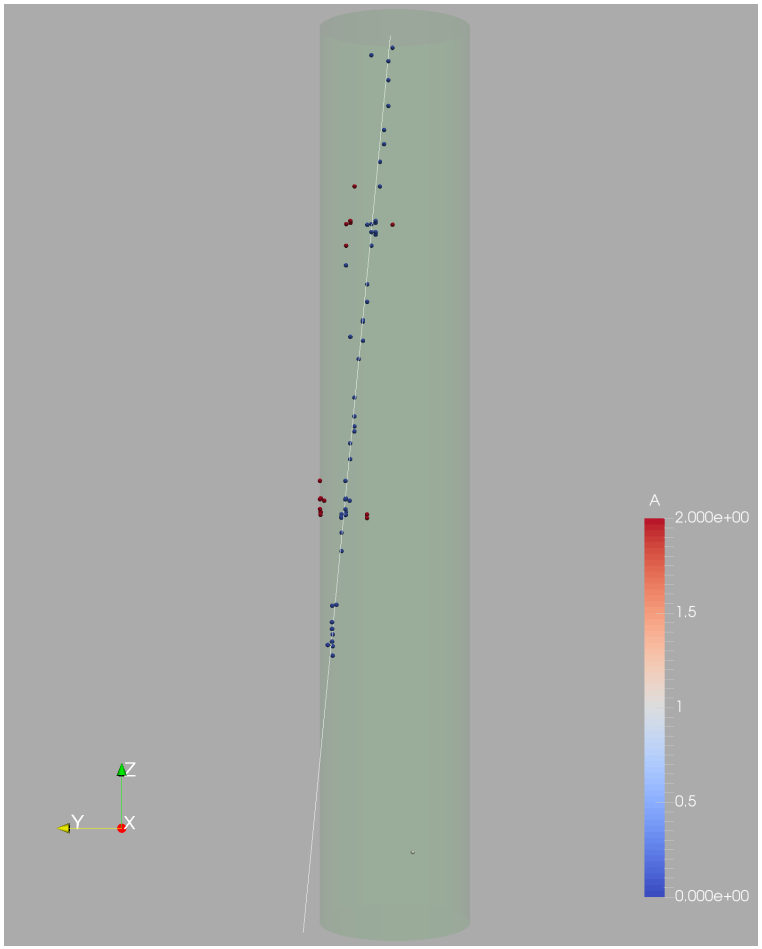
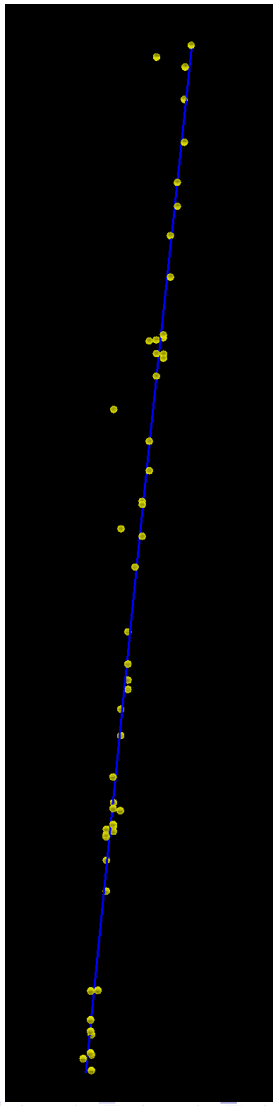
- $W_\mathrm{i} = 23.6\,\mathrm{eV}$
- $E_\mathrm{Drift} = 1\,\mathrm{kV\,cm^{-1}}$
- $R_\mathrm{c} = 0.7$
- $\sigma_\mathrm{Noise} = 1208\,e$
- $\mathrm{SNR} = 12.8$

Pixel prototype 3D event

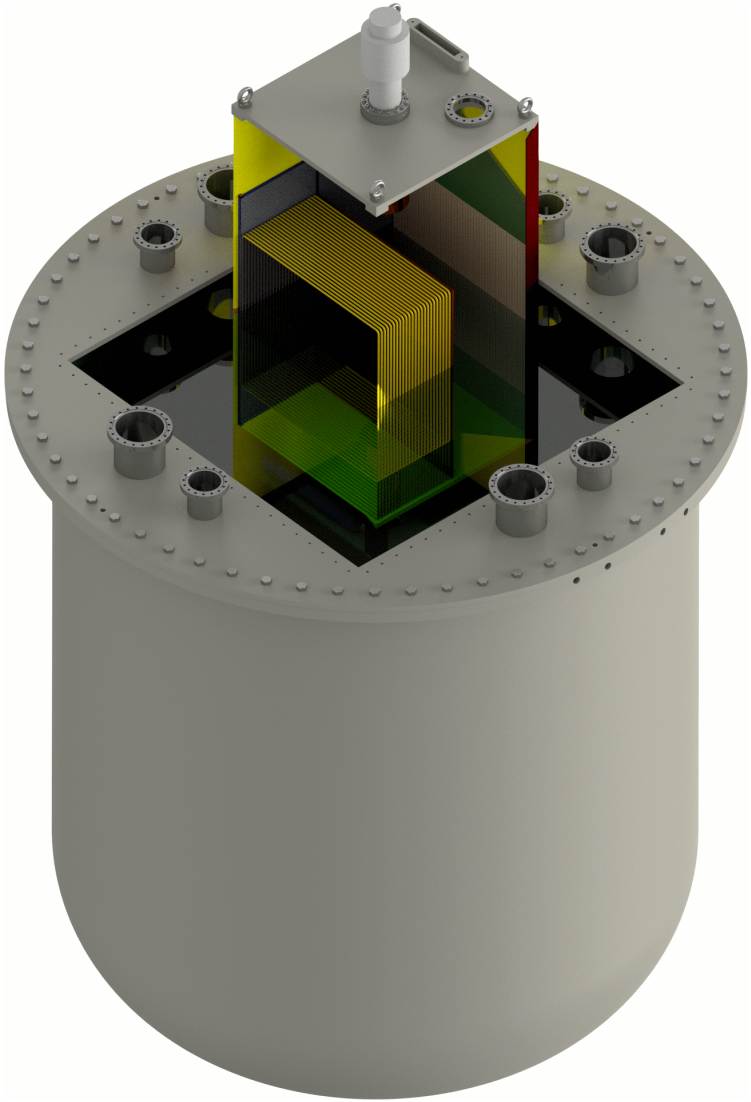
See my pixel talk





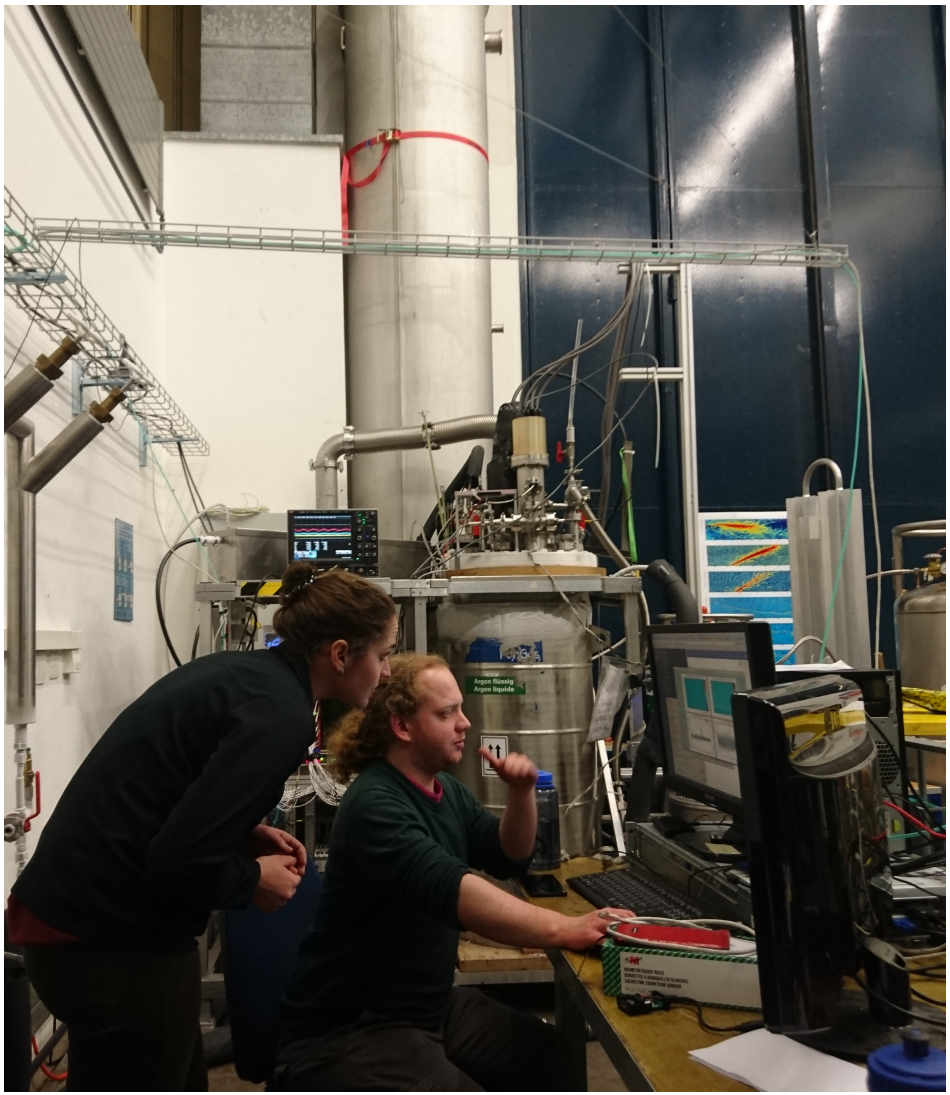
Outlook

2×2 demonstrator in Bern, see talks of Martin and Roger



- First test with pixel prototype TPC
- Demonstrate cryogenics
- Test insertion/extraction
- Check purity afterwards

Summary



- ArgonTube was a very successful R&D project
- Influenced several current and future physics experiments
- Pixel technology for ArgonCube successfully demonstrated
- Still a lot of R&D ahead
- Lots of opportunities for collaboration

Thank you