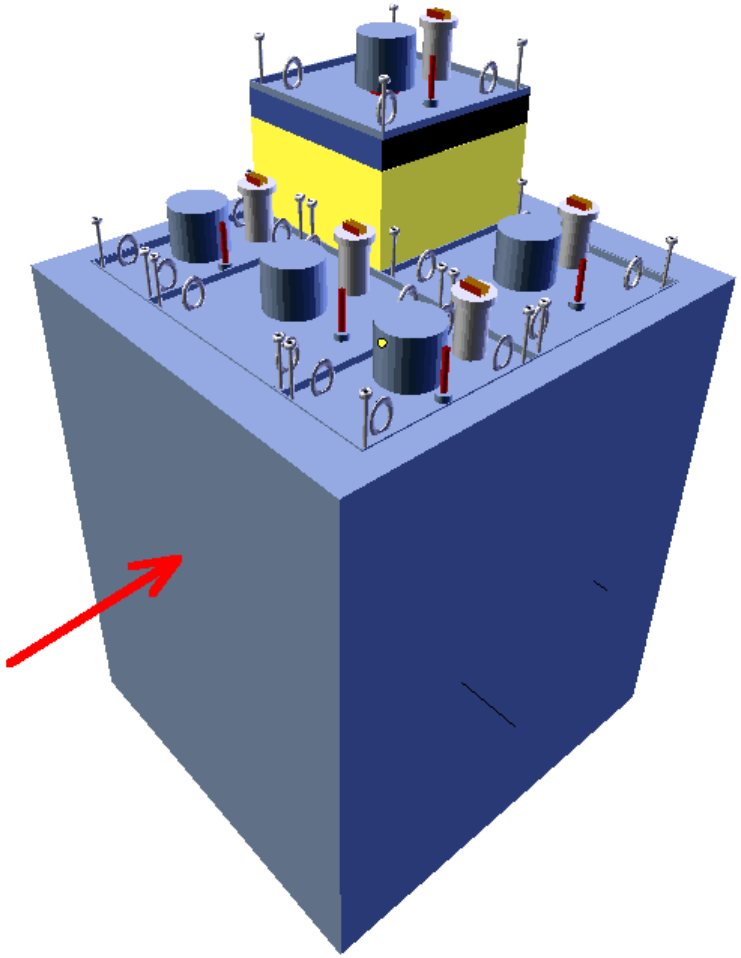
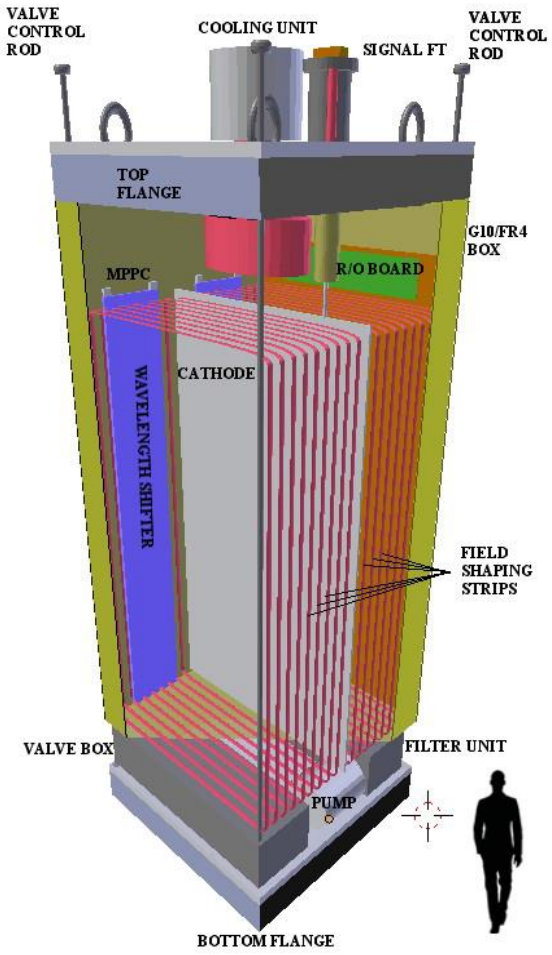
Brief summary on ArgonCube phase-1 R&D studies

Umut Kose

EP-NU Group Meeting, 28 April 2017

ArgonCube project:





- Use of a modular TPC design with pixel readout
- Detector volume segmented in to a number of self contained TPCs
- Short drift times
- Light contained within a single module
- Fully modular: upgrade and repair work without complete detector downtime
- Pixel readout
- Module construction in different institutes

R&D plans:

Phase 1: (mini ArgonCube)

- the modular detector configuration
- different readout schemes

Phase 2:

- realization of the full ArgonCube detector made of 5 full-size modules

Letter of Intent **February, 2015** ***SPSC-I-243***

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

C. Amsler, M. Auger, A. Ereditato, D. Göldi, R. Hänni, I. Kreslo, M. Lüthi, P. Lutz, Ch. Rudolph Von Rohr, Th. Strauss, M. Weber
Albert Einstein Center for Fundamental Physics (AEC) - Laboratory for High Energy Physics (LHEP), University of Bern, Bern, Switzerland

M. Bishai, H. Chen, G. De Geronimo, F. Lanni, D. Lissauer, V. Radeka, B. Yu
Brookhaven National Laboratory (BNL), Upton, NY 11973-5000, USA

J. Bremer, U. Kose, D. Mladenov, M. Nessi, F. Noto, D. Smargianaki
European Organization for Particle Physics (CERN), Geneva, Switzerland

Y. Arbelo, F. Barbato, D. Bleiner, A. Borgschulte, F. La Mattina
Swiss Federal Laboratories for Materials and Technology (EMPA), CH-8600 Dübendorf, Switzerland

A. Marchionni, O. Palamara, J. L. Raaf, G. P. Zeller
Fermi National Accelerator Laboratory (FNAL), Batavia, IL 60510 USA

M. Zeyrek
Middle East Technical University (METU), TR-06800, Ankara, Turkey

J. Asaadi, M. Soderberg
Syracuse University, Syracuse, NY 13244 USA

F. Bay, E. Cavus
The Scientific and Technological Research Council of Turkey (TUBITAK), Ankara, Turkey

B. Fleming
Yale University, New Haven, CT 06520 USA

The Committee received with interest the Letter of Intent SPSC-I-243 describing the proposed R&D to assess the feasibility of fully modular liquid argon TPCs (ArgonCube).

The SPSC encourages the ArgonCube collaboration to conduct the first stage of the proposed project at the University of Bern. The Committee expects the first stage to investigate open questions such as LAr purity, detector mechanics, charge readout options data compression and event reconstruction which should be answered before the collaboration considers submitting a proposal for future steps.

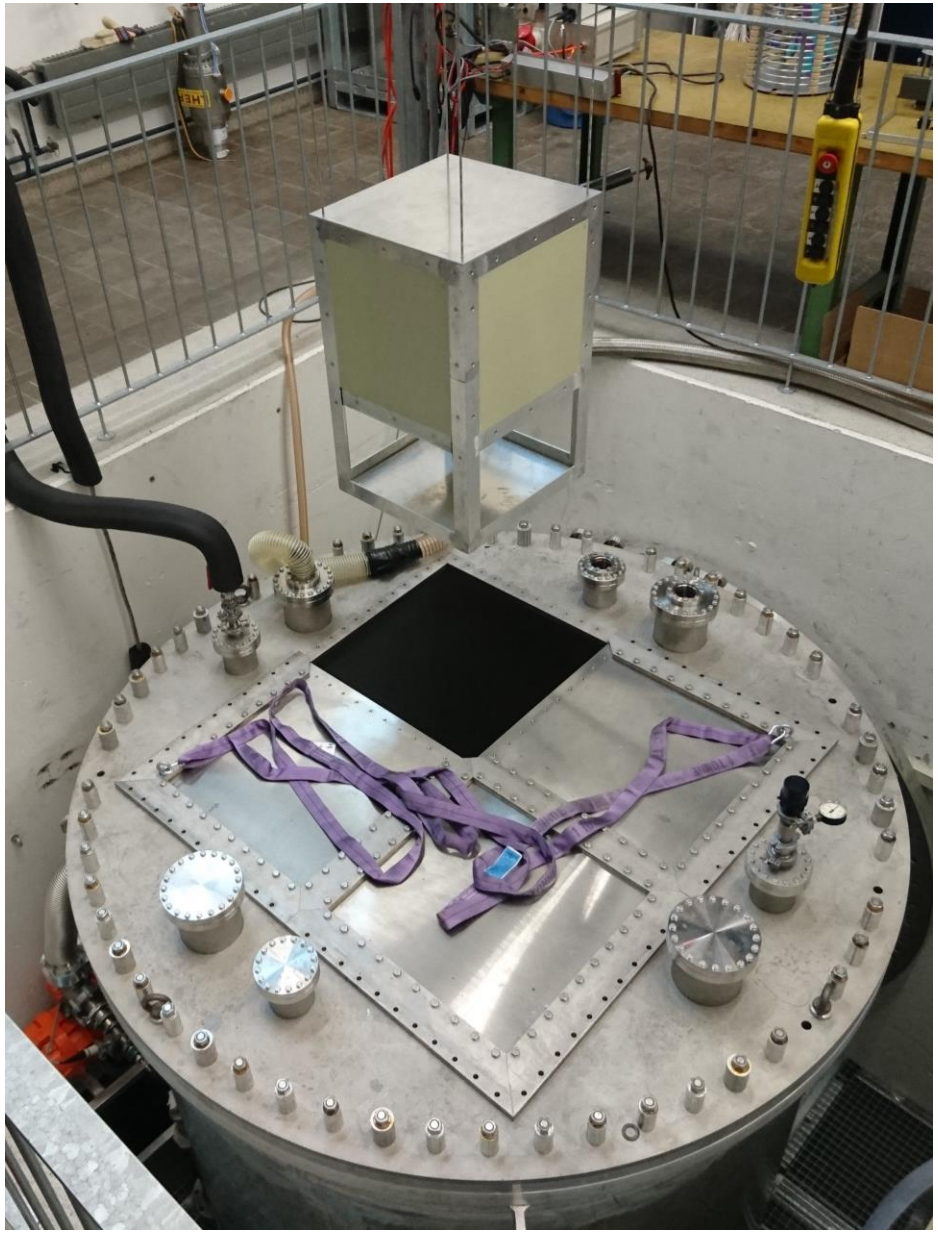
R&D studies:

- Vacuum insulated cryostat (provided by CERN) was prepared for:
  - finalizing module construction method
  - studying insertion/extraction procedures
  - to test prototype TPC modules:
    - Dimension of 67 cm x 67 cm x 1.8 m each
    - ~30 cm drift length
    - One wire-readout TPC as reference
    - Three pixel-readout TPC

- Cryostat and module material/structure test in LAr successfully completed in **October 2016** (CERN provided the materials and the construction design)

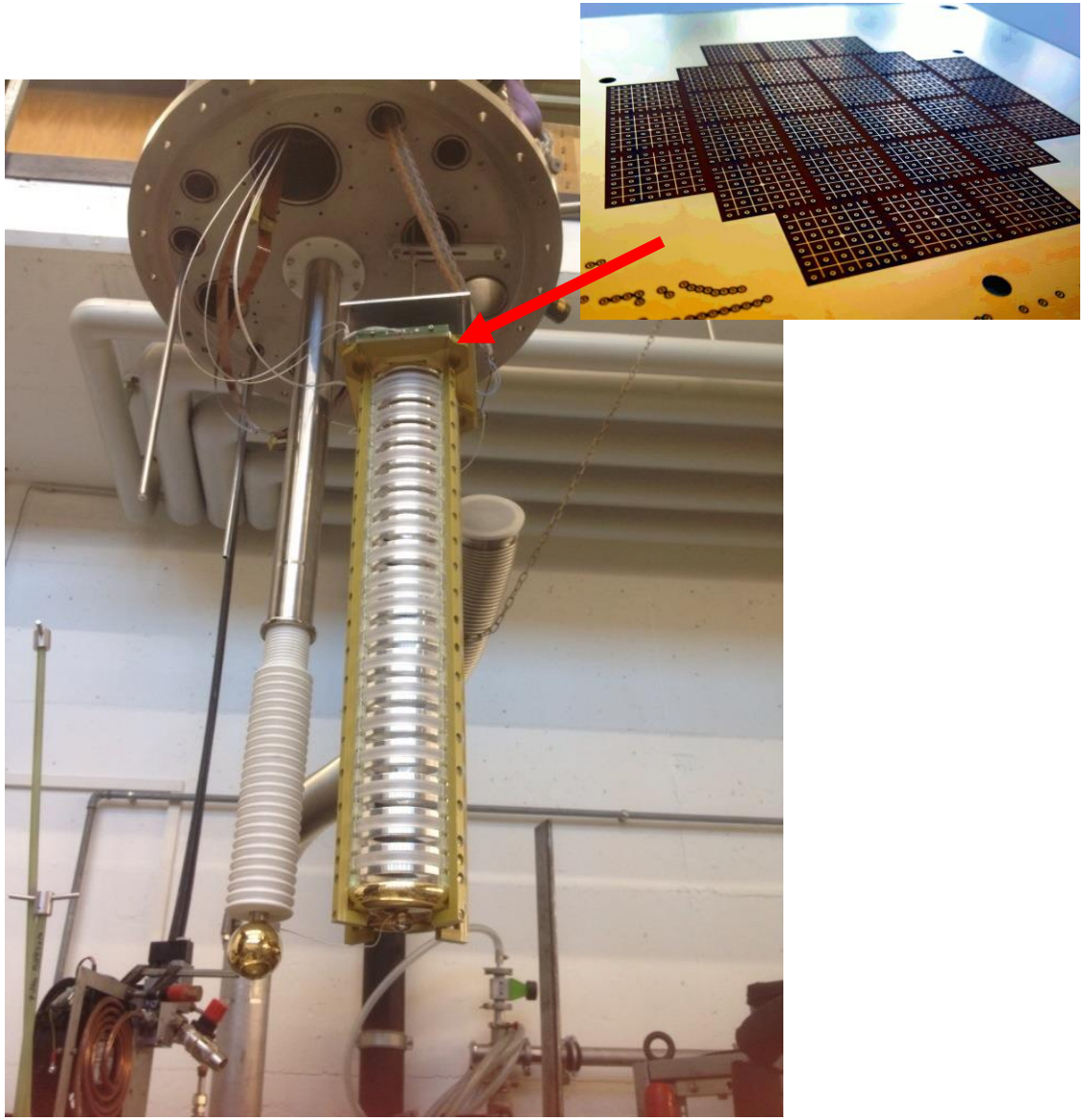
- Field cage development will start in summer 2017

- First TPC deployment will be done in **summer 2017**, pending due to some updates on the cryogenic infrastructure.
  - In **March 2017** CERN assisted with design of the cryogenic system. Installation of the system will start in **May 2017**.



The VIPER LArTPC prototype: ROI pixel readout PCB

- Cylindrical drift volume with ϕ = 100 mm and L = 600 mm
- V_{Drift} = 60 kV → E_{Drift} = 1 kV/cm
  → v_{Drift} = 2 mm/μs → t_{Drift} = 0.3 ms
- 2.86 mm pixel pitch, 6 x 6 pixel ROIs
- 28 ROIs, 36 pixels per ROI
  →64 DAQ channels, 1008 physical pixels
- Charge readout by BNL preamplifiers in LAr
- Light collection by TPB coated acrylic rings in between field shaping rings
  - Wavelength shifting fibres along drift direction
  - Silicon photomultipliers (SiPM) attached to readout plane (in LAr)

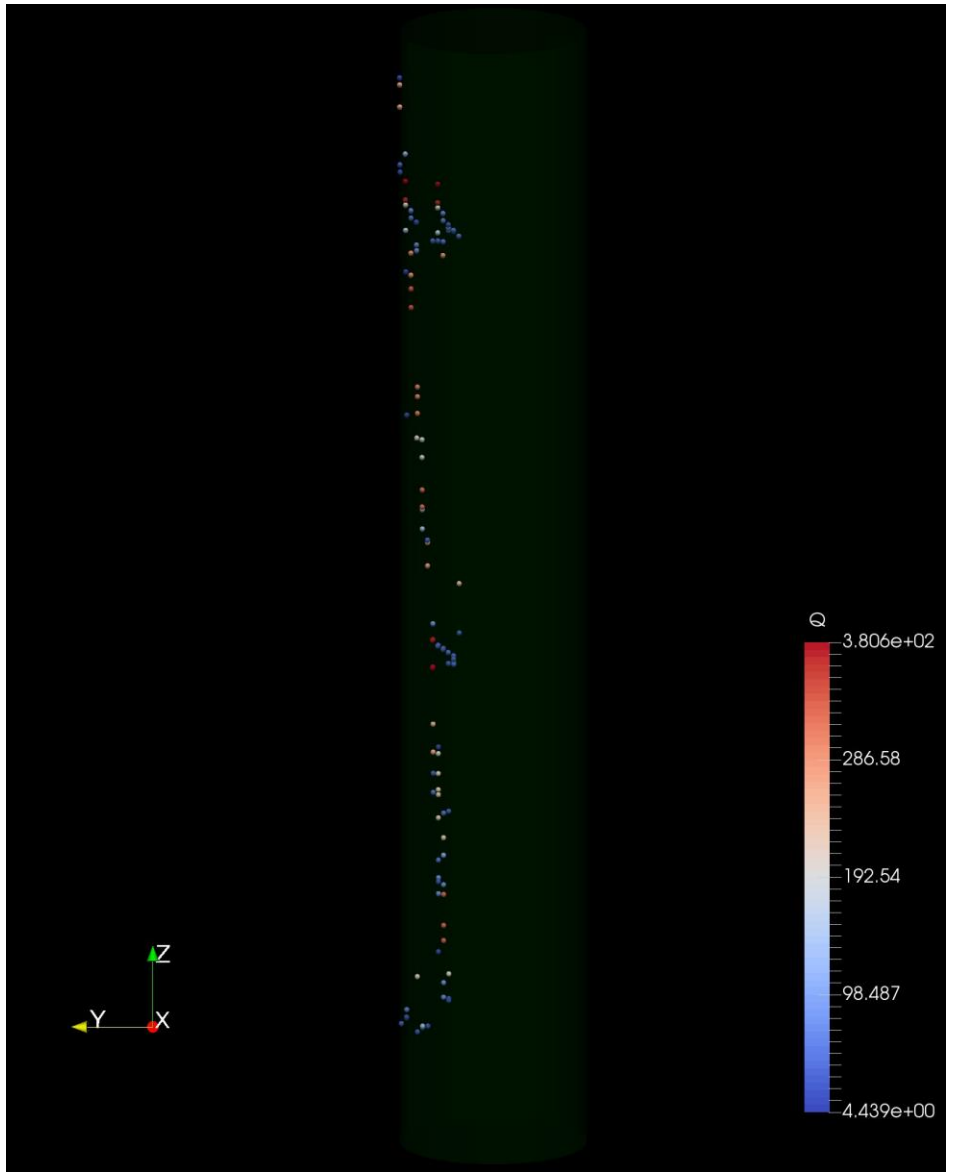


- **First phase demonstration in July 2016**
  - Noise issue (at the level of 130 mV)
    - Power supply, pixel capacitance, grounding…
  - Reconstruction ambiguities related to the multiplexing
  - Light readout system successfully used as a trigger
  - Joined partially in the data analysis

- **Second phase demonstration in February 2017**
  - Pixel PCB redesigned to minimize pixel capacitance (50 pF)
  - Amplification redesigned based on LArIAT with improved grounding
  - Noise reduced to ~30 mV
  - Multiplexing ambiguities remain (to be solved by developing new ASICS)

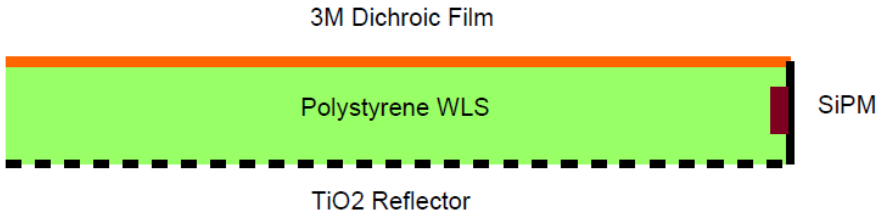
- **LBNL** joined ArgonCube in **October 2016**.
  - Experience with low noise single pixel charge readout
  - Initial ASICS design completed in **December 2016**
  - Production of first prototype in **summer 2017**
  - Testing in **fall 2017** (using identical TPC as in BERN test)

- **SLAC** expressed interest in providing a DAQ for a pixel readout system



R&D on the light readout system:

- **Dubna** joined ArgonCube in **February 2017** proposing a new light collection system a la ARAPUCA:
  - SiPMs coupled to a section of WLS plastic sheet, one side coated with a TiO2 reflective layer, the other side with 3M dichroic reflector film



- Proof of principle study completed in **March 2016**
- Studies will continue between Dubna and Bern.
- To be tested in the next R&D campaign.

Summary:

- Letter of Intent has been submitted on “ArgonCube: a novel, fully-modular approach for the realization of large mass liquid argon TPC neutrino detectors” in February 2015.

- One of the possible candidate for DUNE Near Detector

- Phase 1 R&D study: realization of a mini ArgonCube as a Technology demonstrator
  - Module design, material test etc. → October 2016
  - Pixel charge readout → July 2016, February 2017 and next in Fall 2017
  - Light readout system → started in March 2017
  - Field cage → Summer 2017

- Fully instrumented module deployment in 2018

- CERN contributions up to now:
  - Providing cryostat
  - Module design and construction steps
  - Materials of the first half module, work together on the construction and test in LAr
  - Partial contribution on phase 1 pixel readout test
  - Assistance on cryogenic
  - …