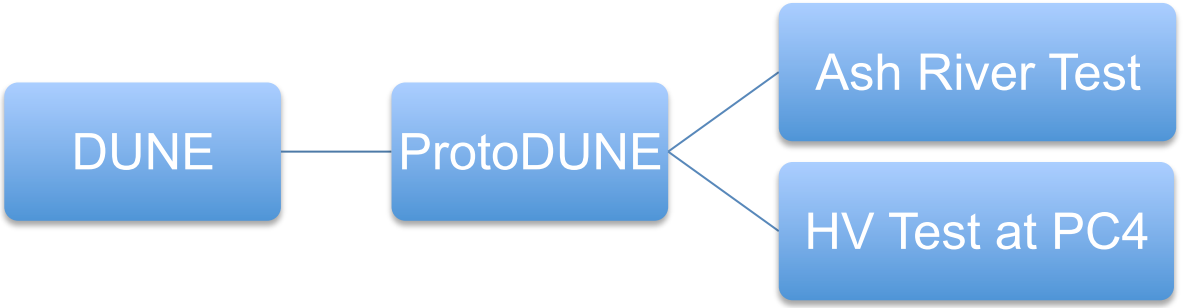
Overview and Motivation for the HV Test at PC4

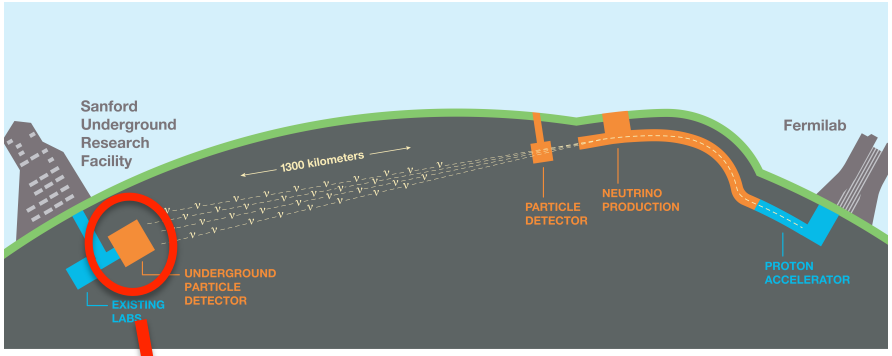
Sarah Lockwitz

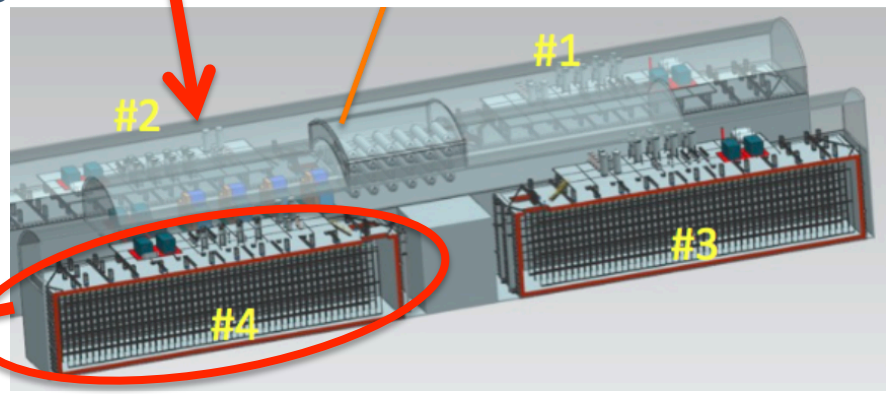
July 28, 2016

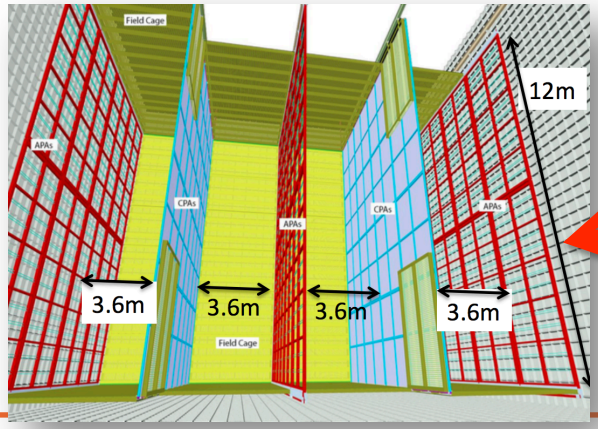
Overview



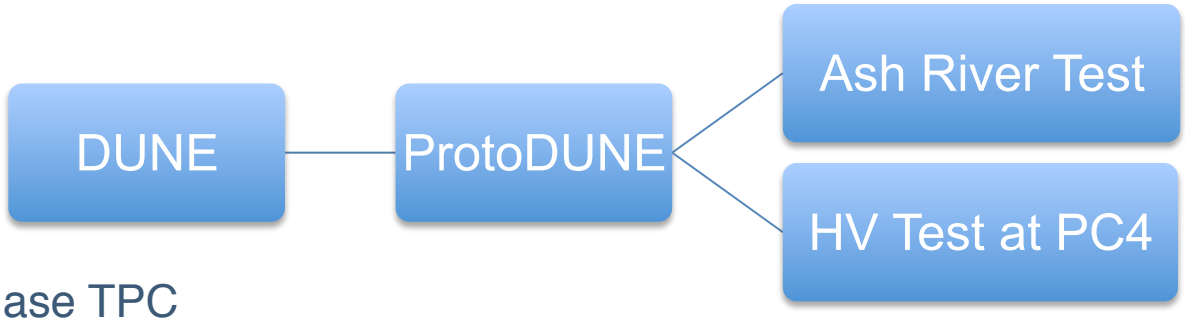
- DUNE:
  - Flagship project (first data in 2024)
  - Long baseline 40 kT liquid argon detectors (4x10 kT modules)
  - Single phase (SP) detector option
    - Each module: 12 m tall, 58 m long, (4) 3.6 m drift regions



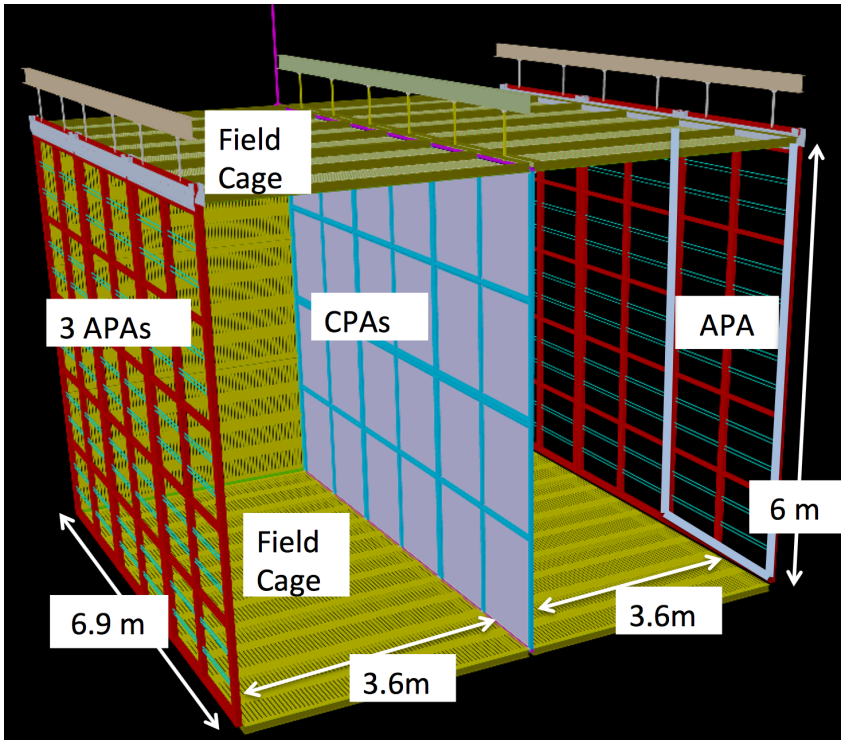




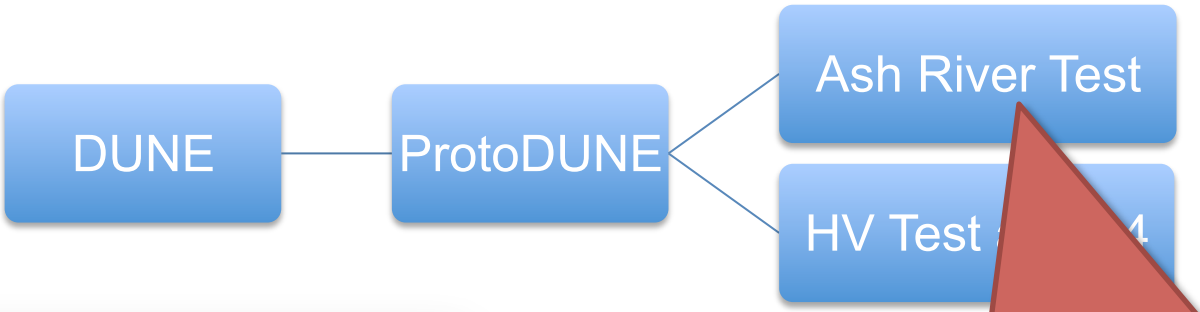
Overview

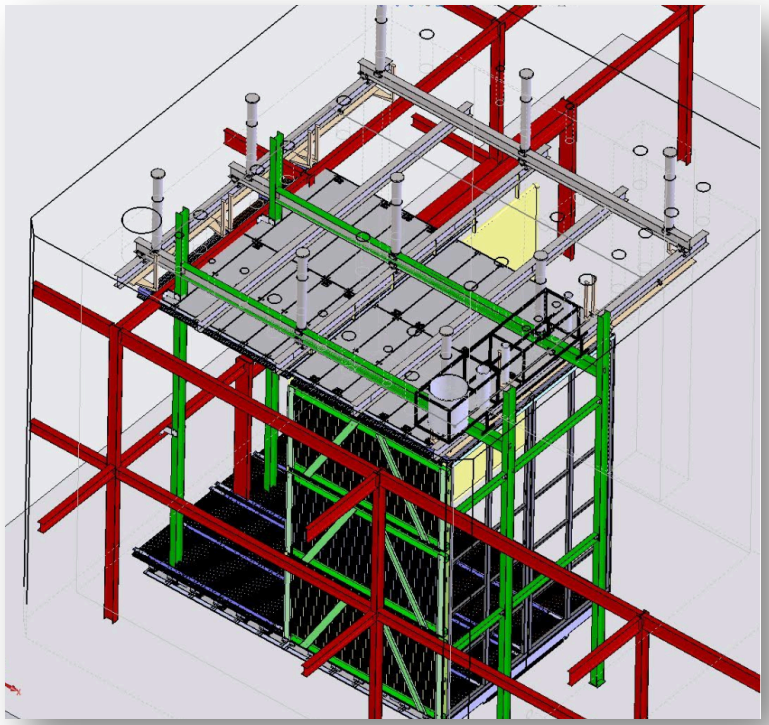


- ProtoDUNE-SP
  - Two-drift volume single phase TPC
    - 6 m tall, 6.9 m in beam direction
    - (2) 3.6 m drift lengths
      - Typically aim for 500 V/cm → -180 kV on the cathode
  - CERN test beam (sub- to several GeV particles) installation summer/fall of 2017
  - Develop fabrication & installation methods
  - Evaluate the detector performance with full scale DUNE components
  - Study particle interactions & reconstruction methods in the DUNE energy range
  - Compare single to the dual phase technology



Overview

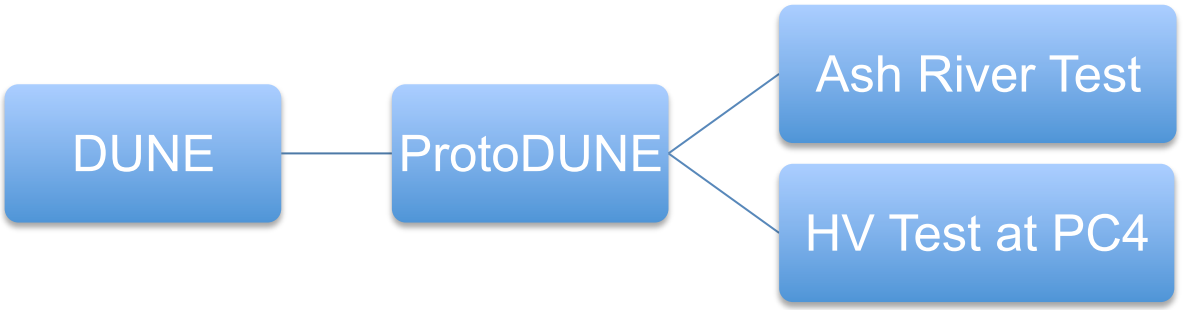




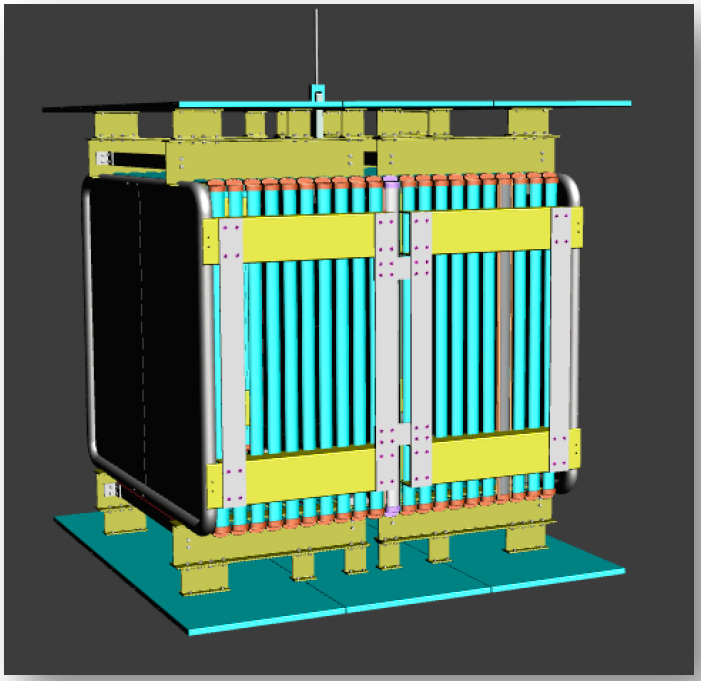
Mechanical prototype in Ash River, MN

- Full scale ProtoDUNE-SP components
- Tests interfaces and handling

Overview

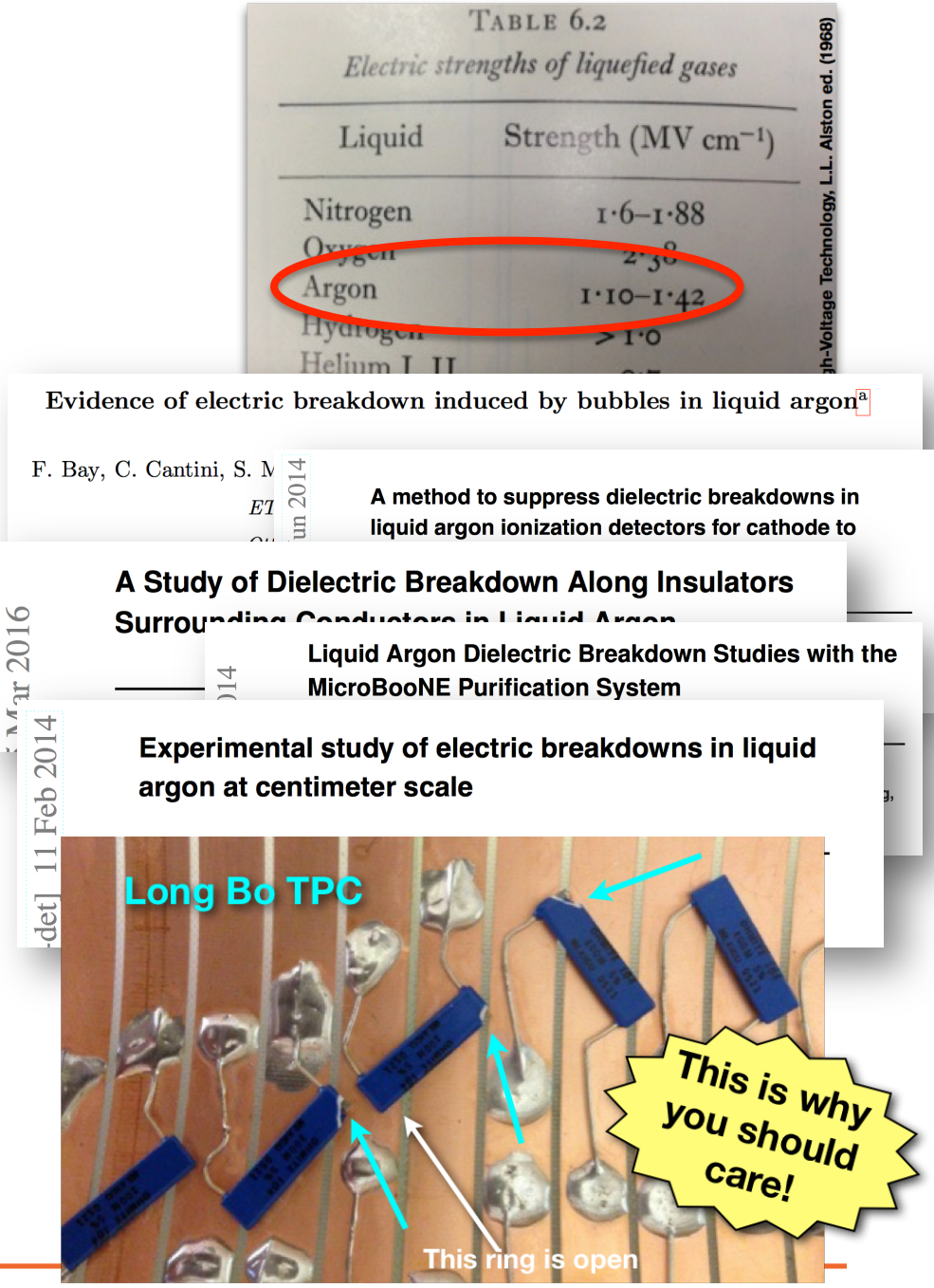


- HV Test at PC4
  - Will evaluate the design of ProtoDUNE from a high voltage perspective
    - Design verification
    - Expose any design weaknesses.
      - What voltage can be held?



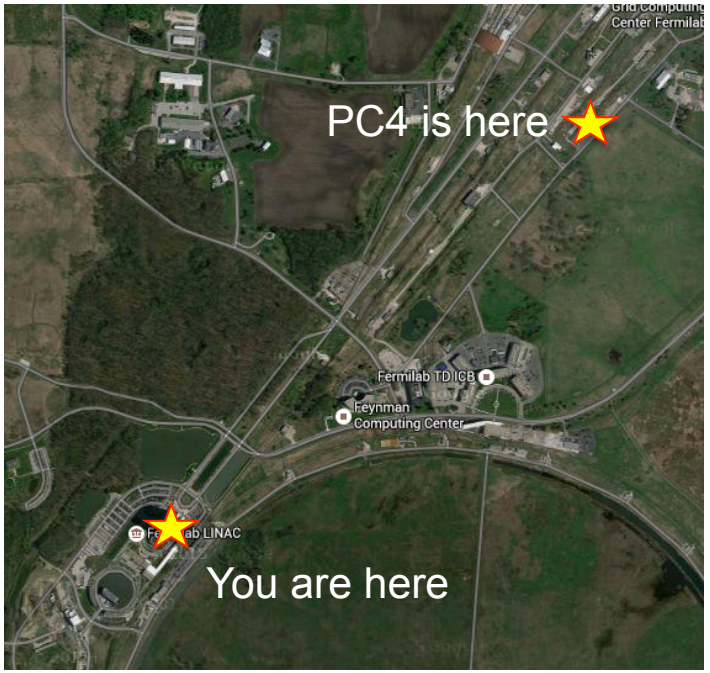
Motivation

- We need ProtoDUNE to succeed
- High voltage issues in liquid argon are not well understood
  - A breakdown will likely set the operating voltage of the experiment
  - Breakdown can damage the detector



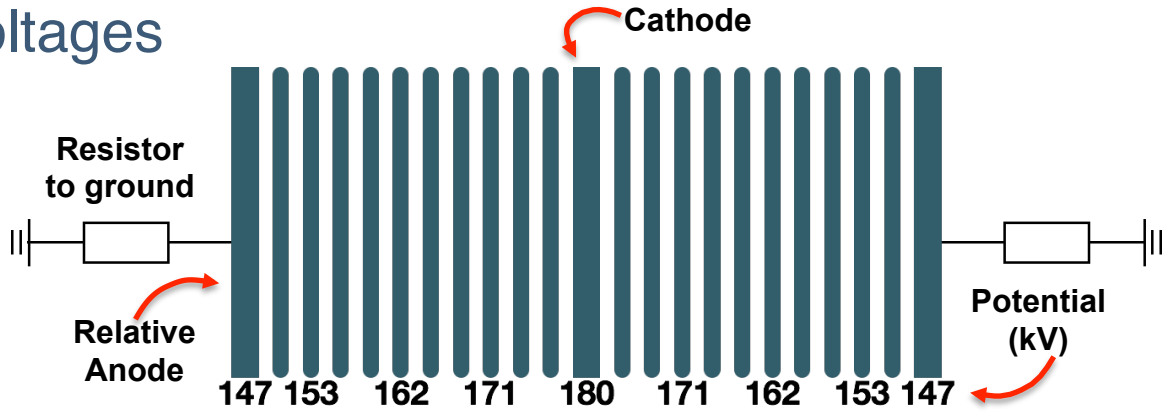
Introduction to the Test

- The test will take place in the 35 T at PC4
- We cannot fit full-sized ProtoDUNE TPC components in the cryostat
- However, this test *will be a full-field test*. The device will have the first 10 profiles of a TPC at their planned voltages



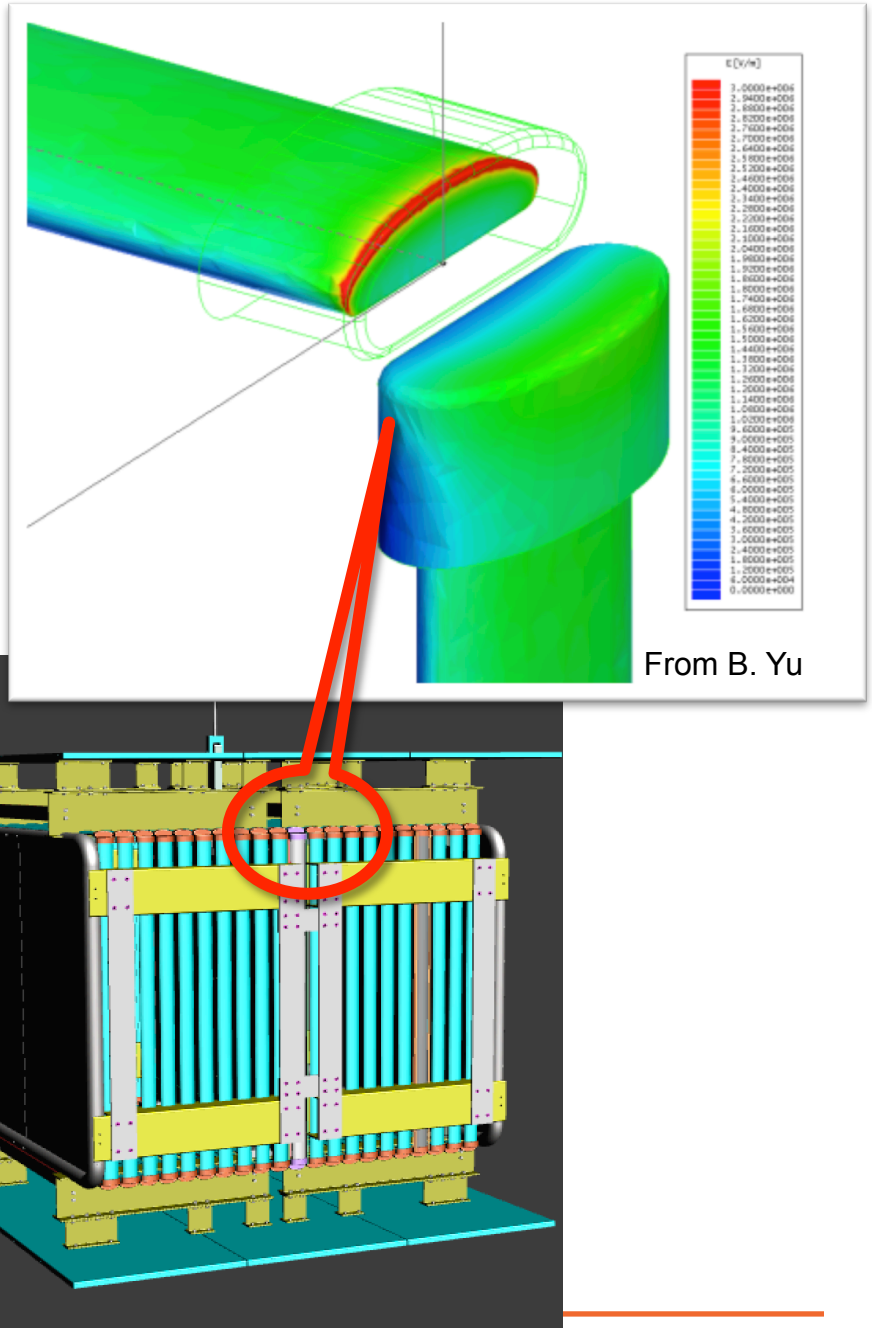
Introduction to the Test

- The test will take place in the 35 T at PC4
- We cannot fit full-sized ProtoDUNE TPC components in the cryostat
- However, this test *will be a full-field test*. The device will have the first 10 profiles of a TPC at their planned voltages



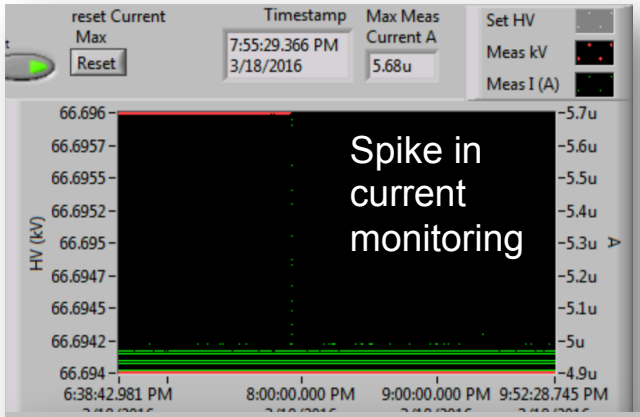
Will Evaluate

- Individual components:
  - High field areas → corners near cathode
  - New aspects of the design (profiles, resistive plate cathode, ground planes)
- *And* the integration of the pieces
  - Do the pieces of the design work together?

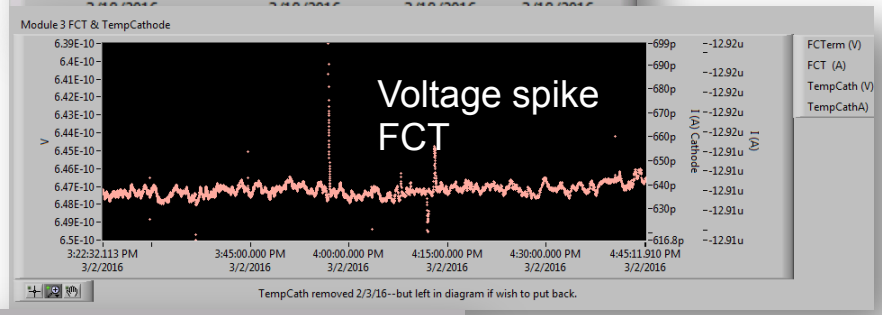


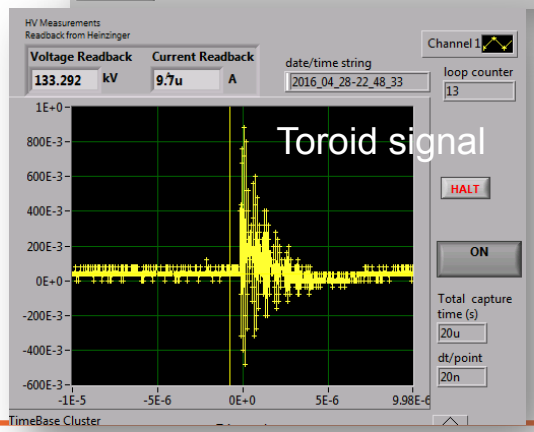
How to Evaluate: Planned Monitoring

- Current monitoring and logging
  - Monitor the current out of the power supply
- Field cage termination/Pick-off point
  - Monitor the voltage near the end of the resistor network to look for activity in the chain
- Toroid/Corona monitor
  - Sensitive to a change in current flowing through the HV cable just outside of the cryostat
- Cameras
  - William & Mary are working on installing cameras that can help diagnose potential issues.



Plots from A. Hahn of 35T Phase 2





Run Plan and Grading the Test

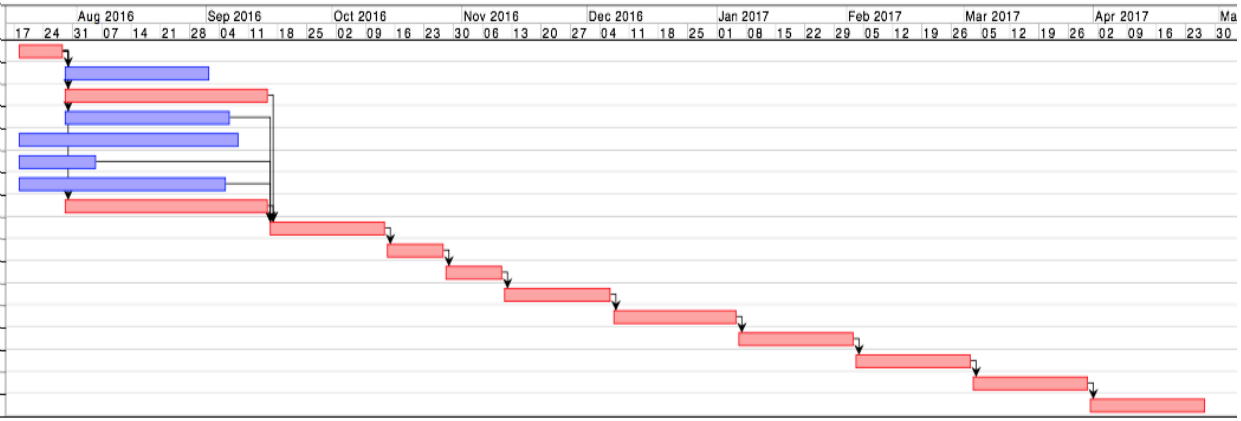
- Keep low voltage (~2 kV) on the feedthrough after the cryostat is closed up
  - Monitor the PS voltage, PS current, FCT, and toroid
  - Provides a baseline and assures of the chain's health before high voltage is applied
- Purge & fill with liquid argon
- Keep HV at 2 kV for starting the pump
- Start to purify! Previously, this has taken ~2 weeks
- Try to raise the voltage to -180 kV (rate: ~60 V/s) over the first week while purifying
- Monitor….

- What if we believe there is a breakdown?
  - Can we tell where it is?
    - → Improve the ProtoDUNE design!
  - What voltage can be held stably (> days)?
  - How long can we hold V (just below troubled voltage)?
  - Try to go as high as we can in the last week again.

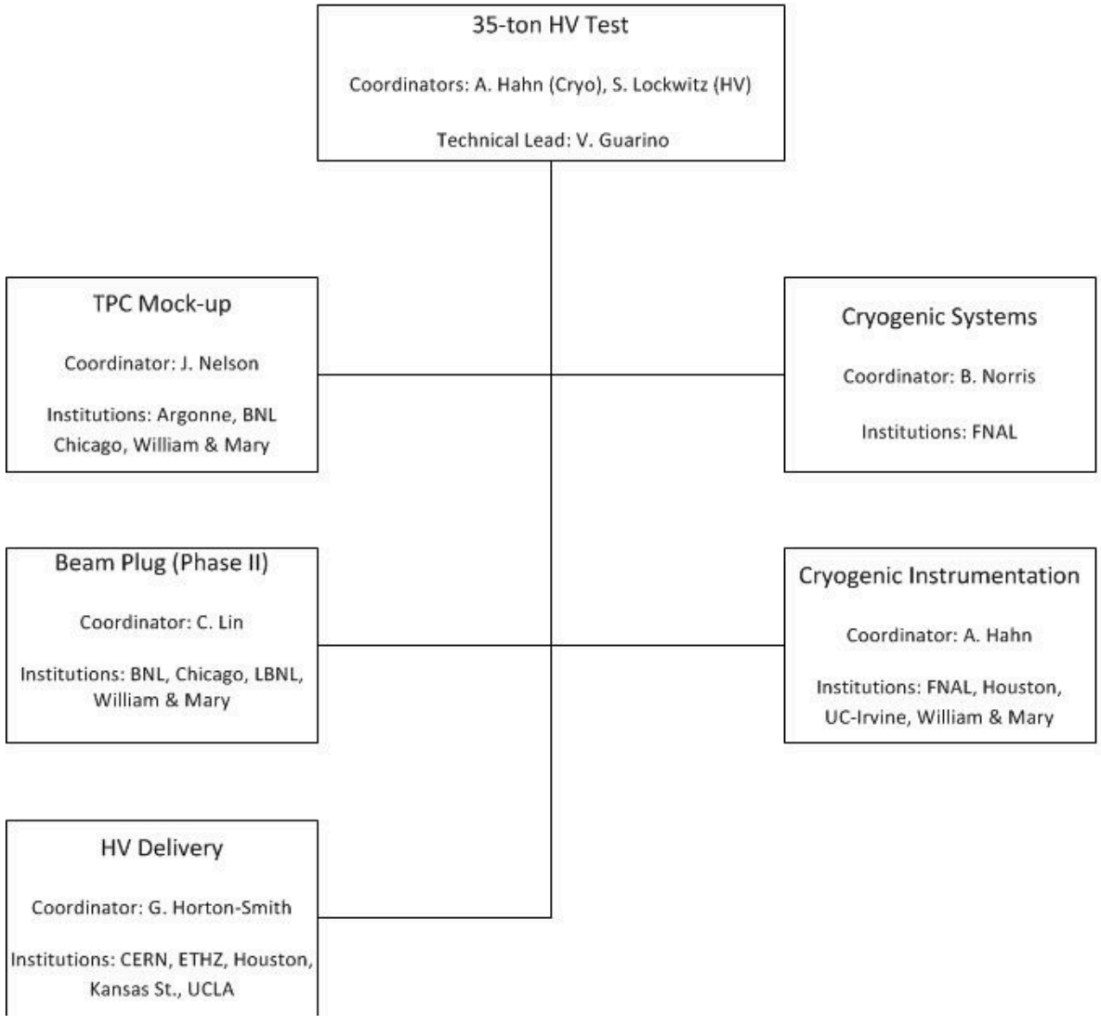
Schedule

- By 9/15/2016
  - Design, fabricate, and deliver parts to William & Mary
- 9/16/2016 - 10/13/2016
  - Clean and Preassemble parts
- 10/14/2016 - 10/27/2016
  - Parts delivered to Fermilab
- 10/28/2016 - 11/10/2016
  - Test installed in cryostat
- 11/11/2016 - 12/6/2016: Purge, cool down, fill the cryostat
- 12/7/2016 – 1/5/2017: Perform test

Name	Duration	Start	Finish
Complete fabrication drawings	9 days?	7/18/16 8:00 AM	7/28/16 5:00 PM
Deliver resistive panel for CPA	25 days?	7/29/16 8:00 AM	9/1/16 5:00 PM
Fabricate CPA	35 days?	7/29/16 8:00 AM	9/15/16 5:00 PM
Fabricate APA	28 days?	7/29/16 8:00 AM	9/6/16 5:00 PM
Procure Profiles	39 days?	7/18/16 8:00 AM	9/8/16 5:00 PM
Procure plastic caps	15 days?	7/18/16 8:00 AM	8/5/16 5:00 PM
Procure ground planes	36 days?	7/18/16 8:00 AM	9/5/16 5:00 PM
Procure material/Fabricate Field cage	35 days?	7/29/16 8:00 AM	9/15/16 5:00 PM
Clean and preassemble parts;	20 days?	9/16/16 8:00 AM	10/13/16 5:00 PM
Ship to FNAL	10 days?	10/14/16 8:00 AM	10/27/16 5:00 PM
Install in cryostat	10 days?	10/28/16 8:00 AM	11/10/16 5:00 PM
Purge, cool down, fill cryostat	18 days	11/11/16 8:00 AM	12/6/16 5:00 PM
Perform test	22 days	12/7/16 8:00 AM	1/5/17 5:00 PM
Warm up	20 days	1/6/17 8:00 AM	2/2/17 5:00 PM
Install phase II	20 days	2/3/17 8:00 AM	3/2/17 5:00 PM
Purge, cool down, fill	20 days	3/3/17 8:00 AM	3/30/17 5:00 PM
Test Phase II	20 days	3/31/17 8:00 AM	4/27/17 5:00 PM



Organizational Chart



Agenda

- Plan for ProtoDUNE-SP HV
  - Overview and background of the apparatus and device motivating the planned test
- Technical Review: Mechanical Specifications
  - Details on the time projection chamber (TPC)
- Technical Review: Electrical Specifications
  - Details on the electrical chain of the test
- Cryogenics and Plan for Instrumentation
  - Schedule and outlook of the cryogenics
- Stage II Plans
  - ProtoDUNE has a beam plug that will be tested separately