



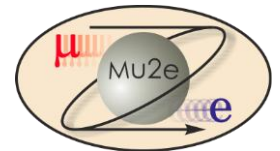
Mu2e Tracker

University Roles in Construction

Marj Corcoran

L3 manager for Straw Assemblies

October 22, 2014



Institutions and faculty/scientists

York College at CUNY—Jim Popp and Kevin Lynch

University of Minnesota—Dan Cronin-Hennessy

Rice University—Marj Corcoran

University of Houston—Ed Hungerford and Kwong Lau

Duke University—Seog Oh and Chiho Wang

Fermilab—Aseet Mukherjee, Bob Wagner, Vadim Rusu

York College at CUNY

York will

prepare all straw end pieces (50K with spares)

leak test in vacuum a few % of all straws as validation of the CO₂ leak tests

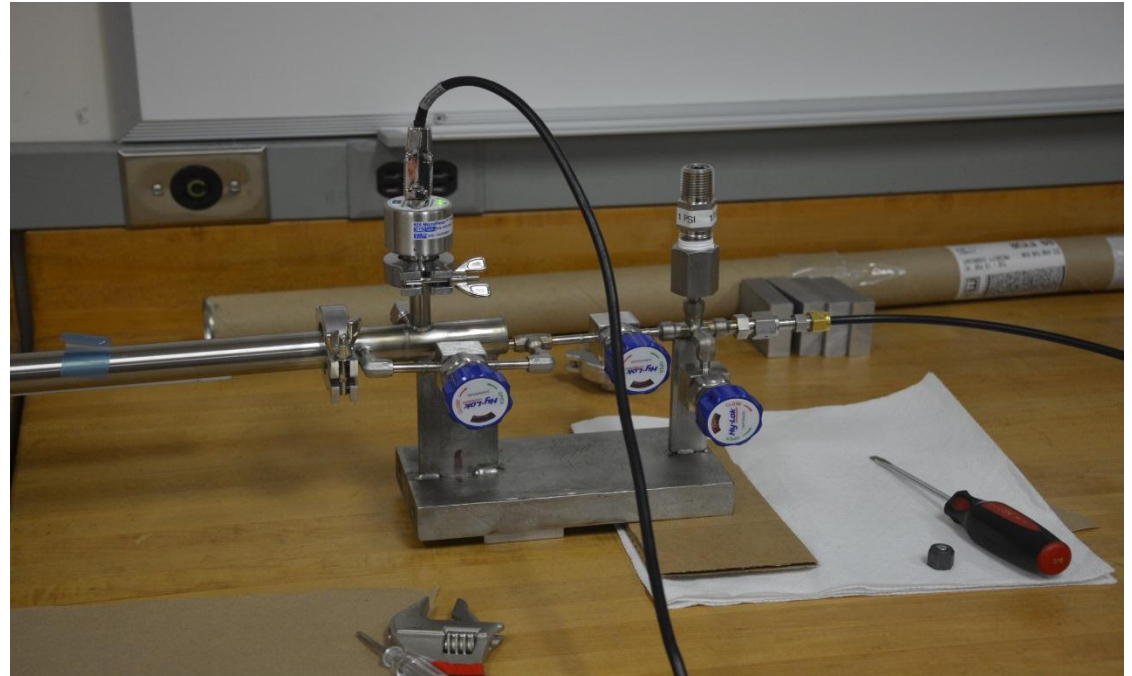
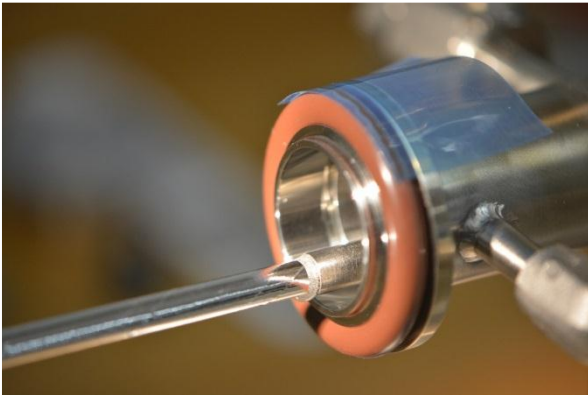
develop QA/QC database with Minnesota

design and fabricate vacuum feedthroughs



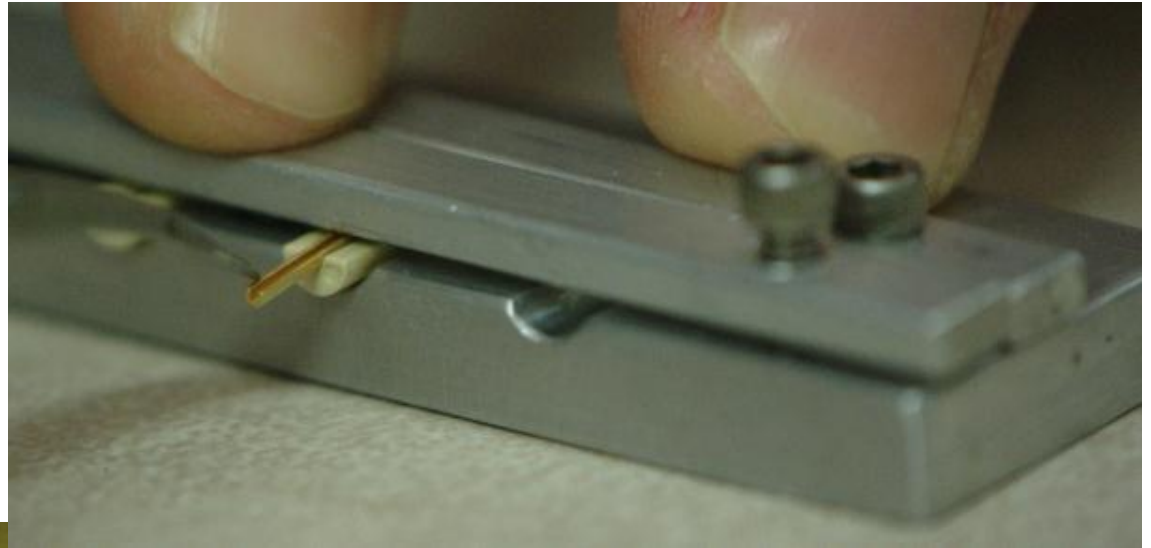
Vacuum setup and lab space at York

York vacuum setup



Straws are tested in vacuum with 1atm ArCO₂ gas. A few percent of all straws will be tested in vacuum to validate the CO₂ leak tests (discussed later).

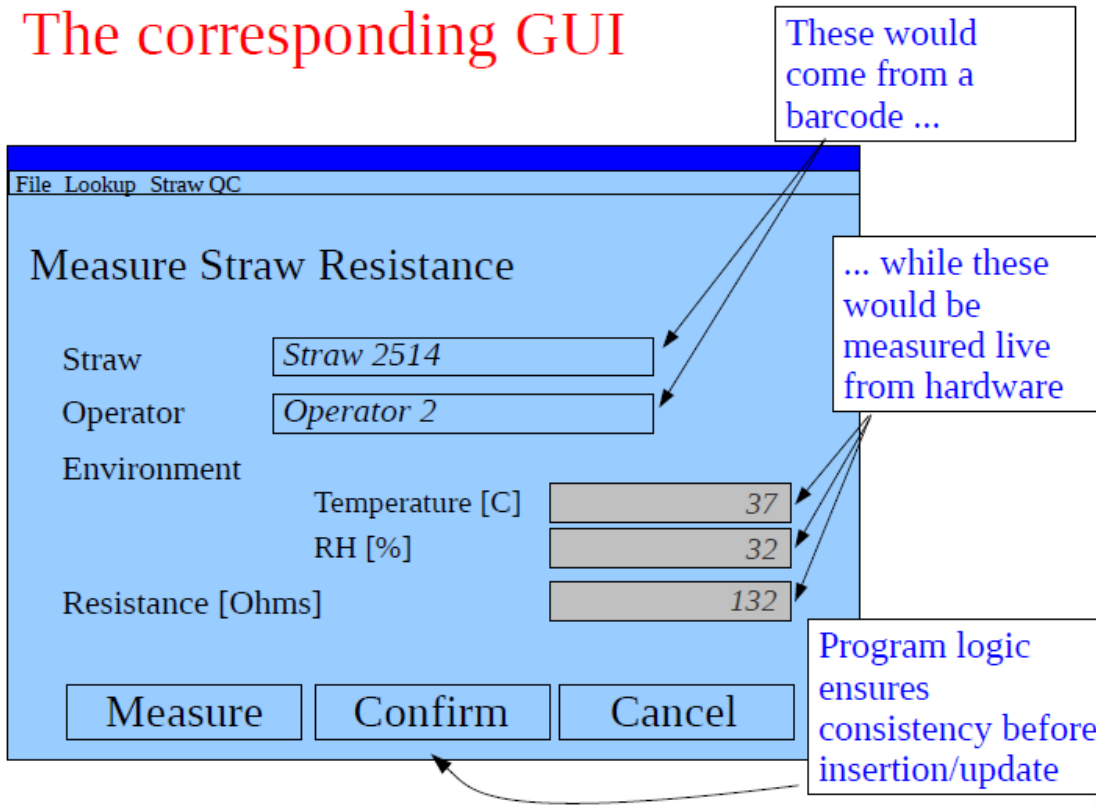
York – straw end piece assembly



York will also assemble the end straw pieces. The fixturing for this work has been developed at Fermilab.

York QA database

The corresponding GUI



The screenshot shows a GUI window titled "Measure Straw Resistance" with a menu bar containing "File", "Lookup", and "Straw QC". The main area contains several input fields and buttons:

- Straw:
- Operator:
- Environment:
 - Temperature [C]:
 - RH [%]:
- Resistance [Ohms]:
- Buttons: Measure, Confirm, Cancel

Callout boxes provide context:

- "These would come from a barcode ..." points to the Straw and Operator fields.
- "... while these would be measured live from hardware" points to the Temperature, RH, and Resistance fields.
- "Program logic ensures consistency before insertion/update" points to the Confirm button.

York is developing the QA database, drawing on the expertise at Minnesota.

University of Minnesota

Minnesota will

- Leak test all straws (25K including spares)

- Cut straws to length and insert straw terminations

- Work with York on QA database



Some of the available lab space at Minnesota

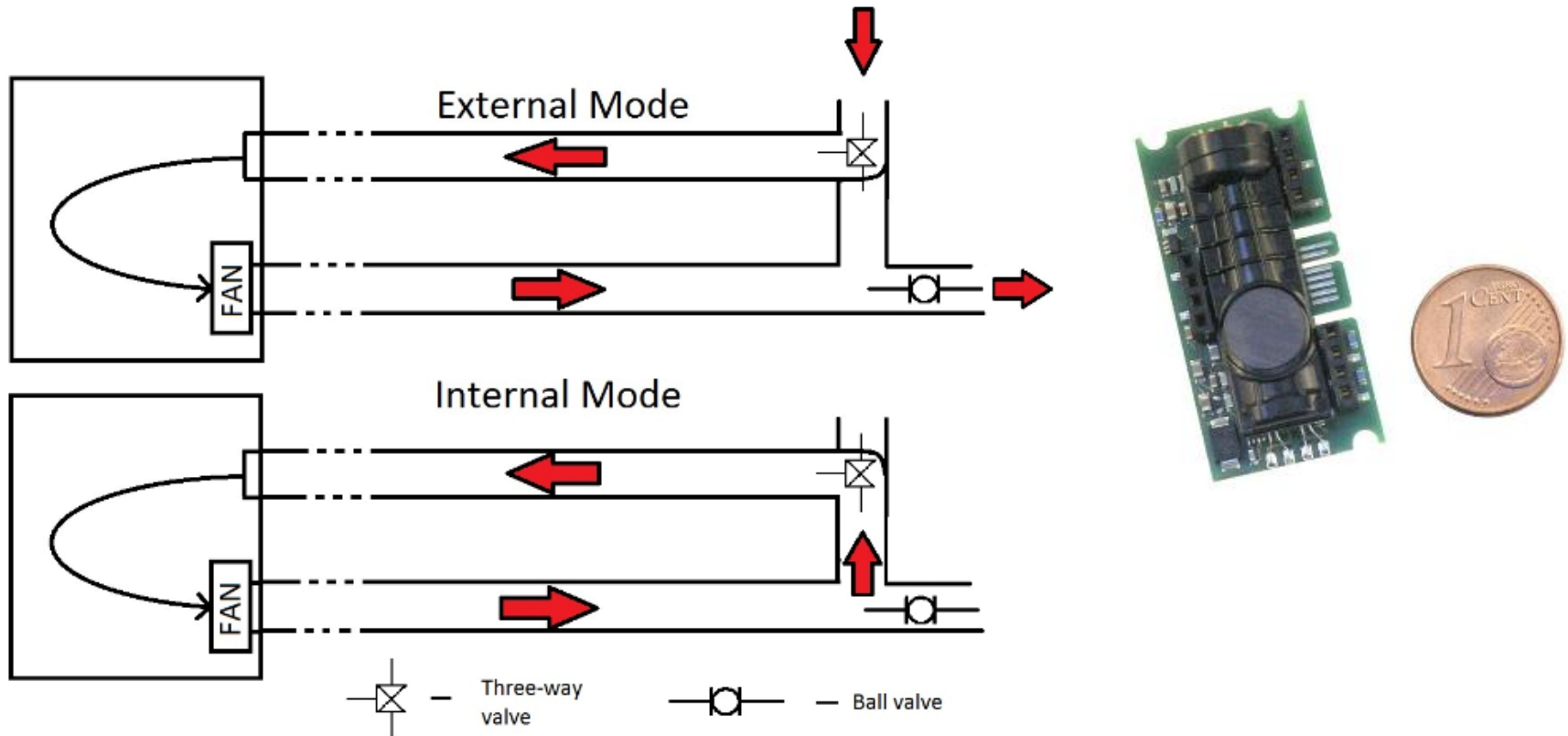
CO₂ Straw Leak Tests

Since the straws operate in vacuum, it is important to ensure that all straws have leak rates below our limit of 30×10^{-5} ccm. We will test 100% of the straws using a technique we developed using CO₂ sensors with Ar/CO₂ gas in the straws.



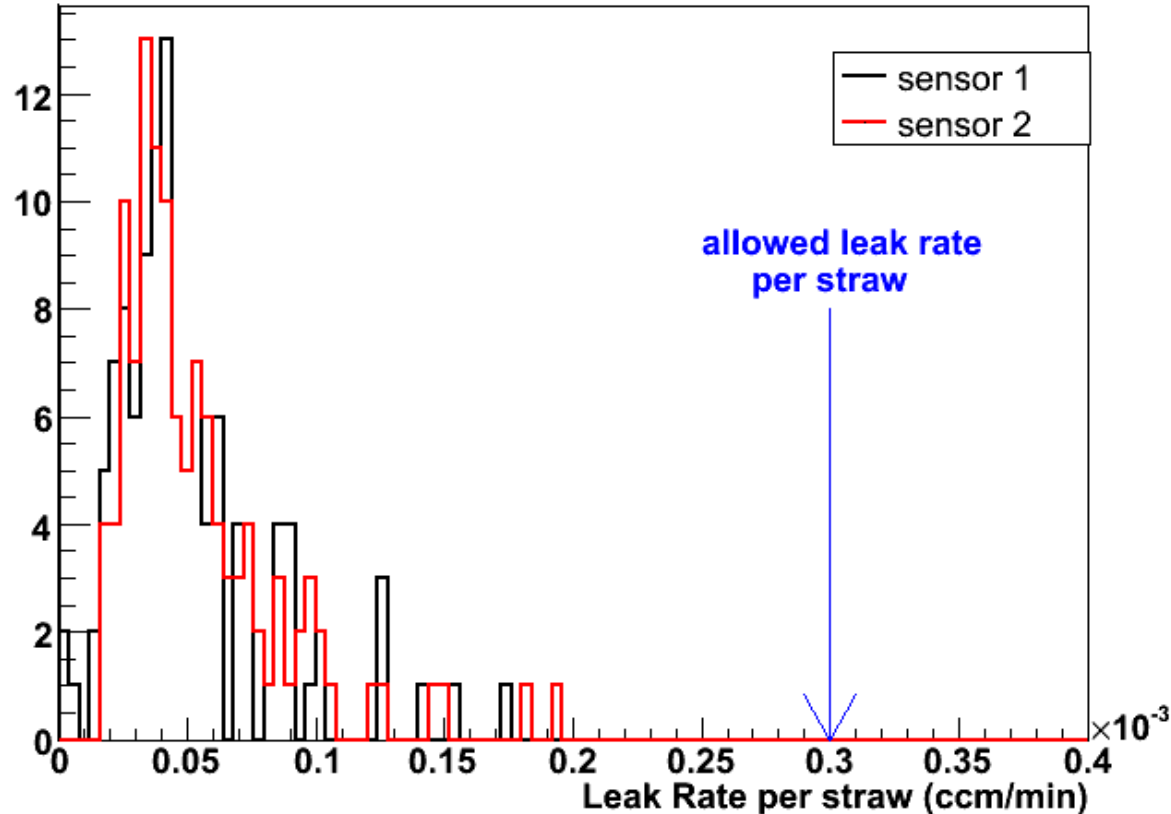
This is the CO₂ test chamber, currently at Lab 3 in the Village.

CO₂ straw leak tests



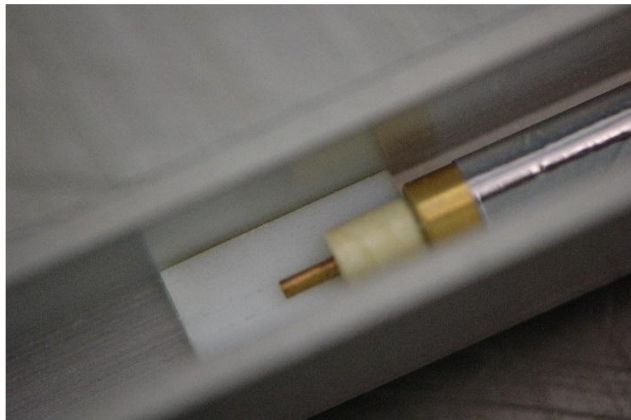
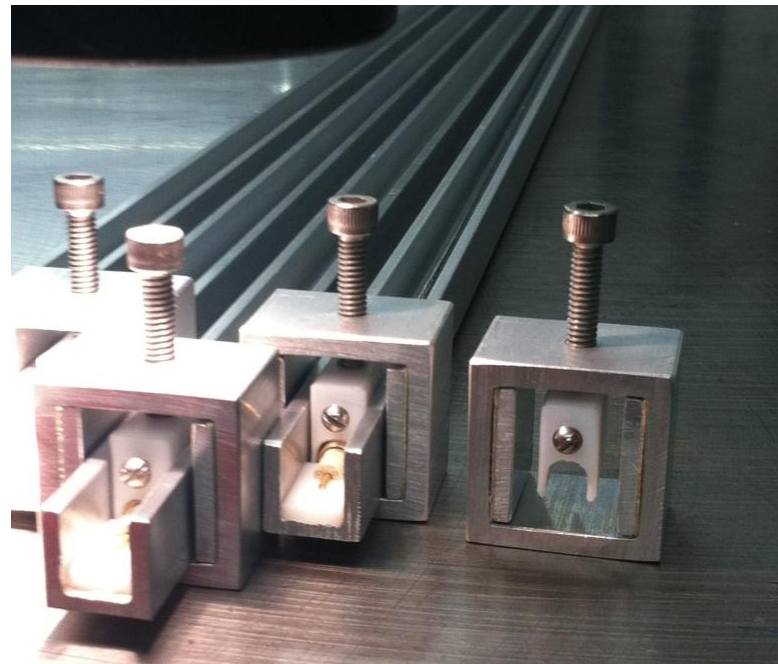
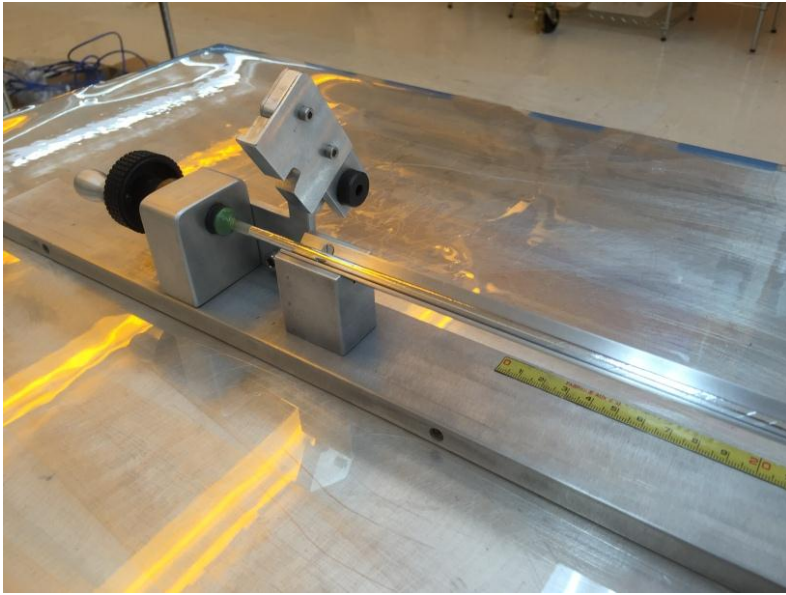
We flush the chamber with N₂, pressurize the straw with Ar/CO₂ to 1atm above ambient, insert it in the chamber, and wait about an hour. The sensor reads the CO₂ levels in ppm, providing a 10-15% measurement of the leak rate.

CO₂ leak test—first 100 straws



We tested 119 straws over this past summer, here are the measured leak rates.

Minnesota--Straw preparation



Minnesota will cut the straws to length and glue in the end pieces. Minnesota post doc Dan Ambrose already has experience with these tasks.

Rice University

Rice will

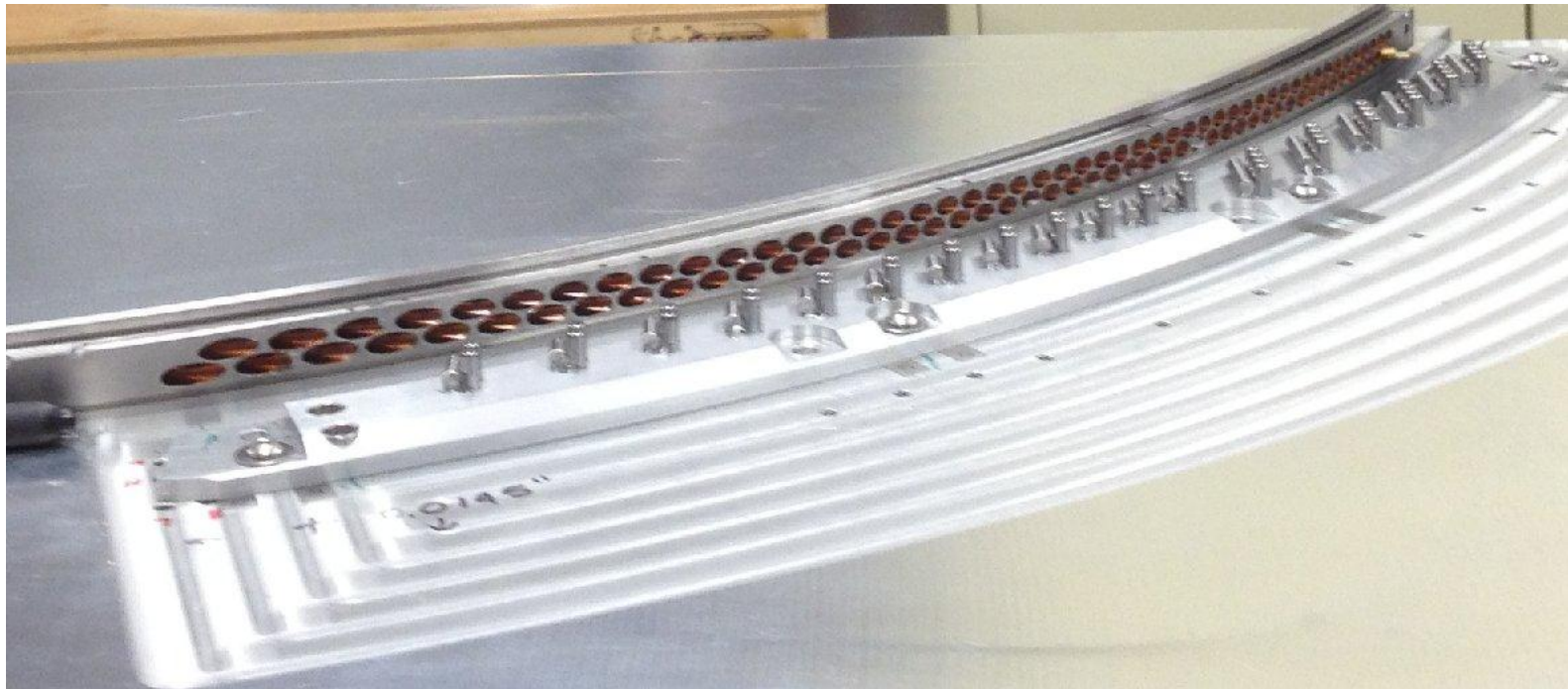
Construct 96-straw panels (220 including spares)

Run some preliminary tests



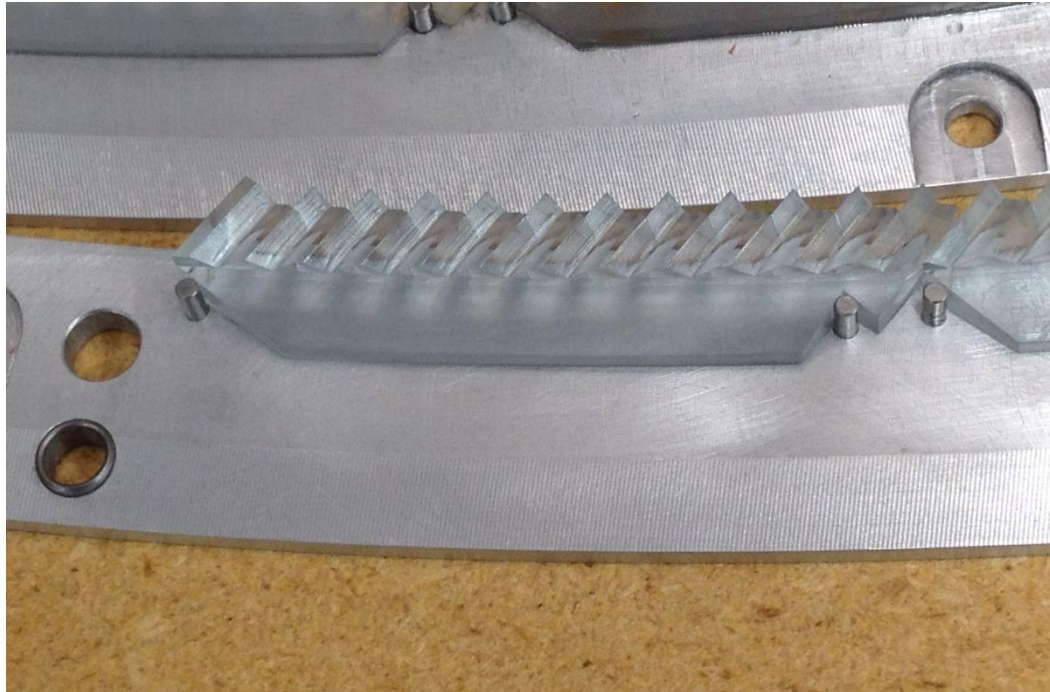
Rice clean room

Panel assembly



This is the Panel Assembly and Alignment Structure (PAAS).
This is the configuration for stringing sense wires.

Panel assembly



This is an example of the 3D printed piece that will be used to position the straws. The dowel pins in the previous picture are replaced with these pieces.

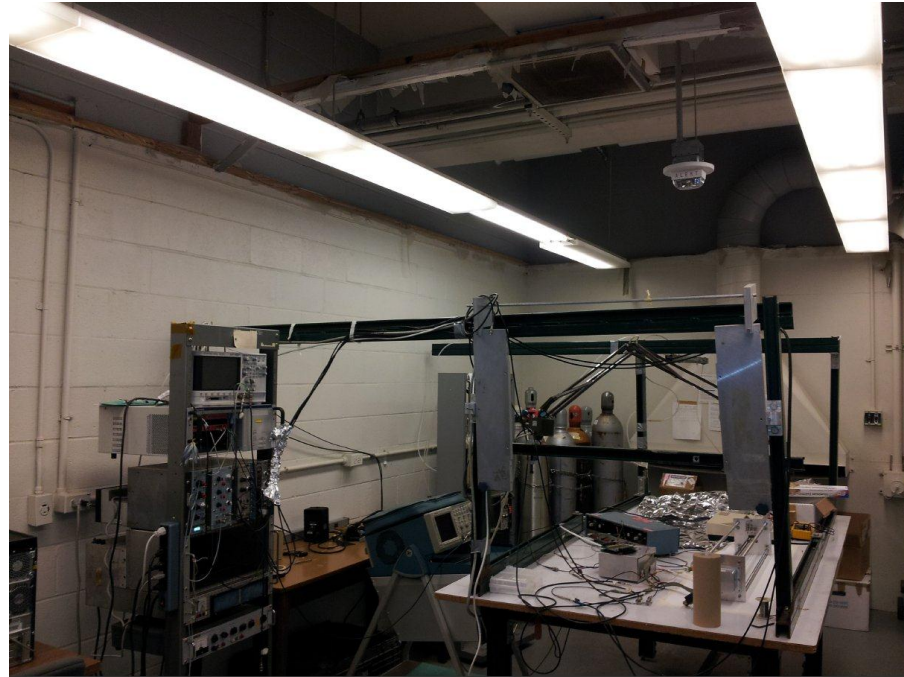
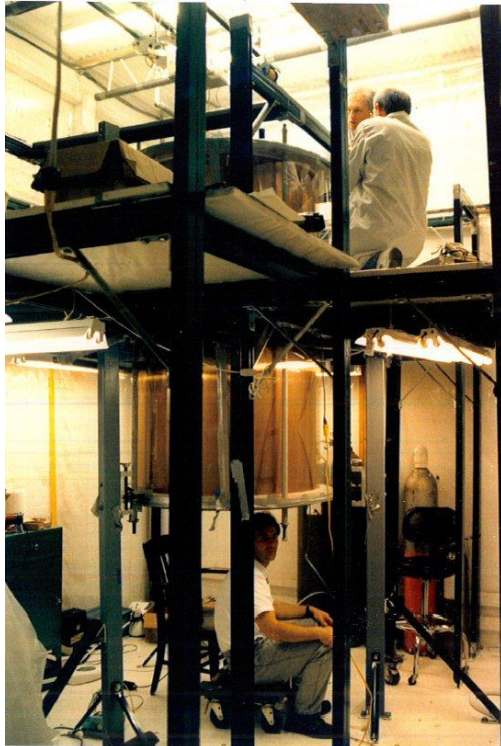
University of Houston

University of Houston will

Test all panels including HV tests, continuity, signal readout

Check all tensions in both straws and wires

UH is prepared to help with leak tests if needed



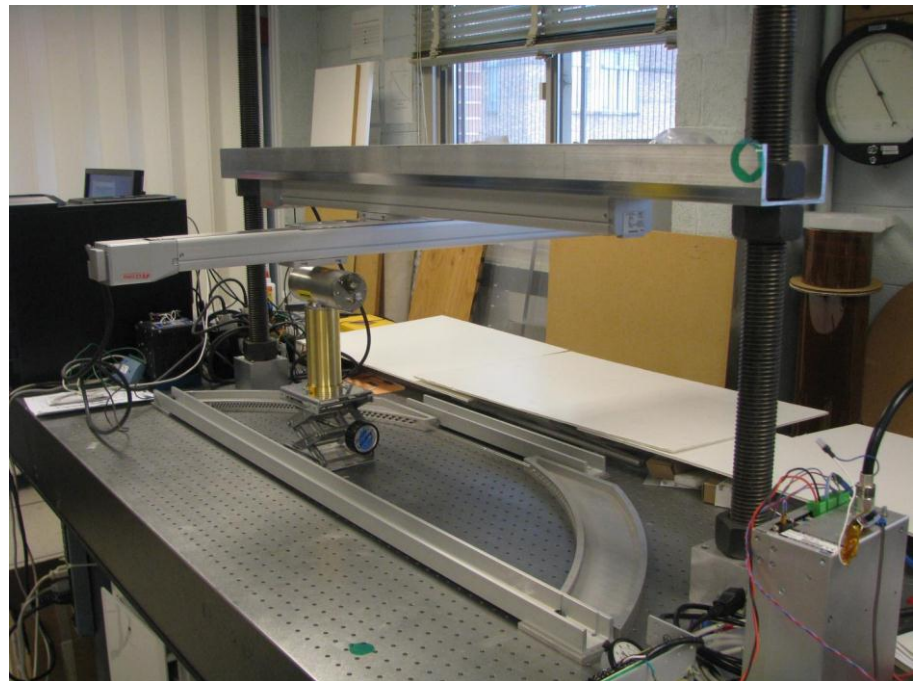
Constructing the MEGA drift chamber and some of the UH lab space.

Duke University

Duke will

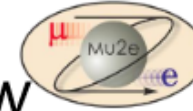
Procure the straws from PPG and perform several tests

Use X-ray machine from the Atlas TRT construction to locate each wire

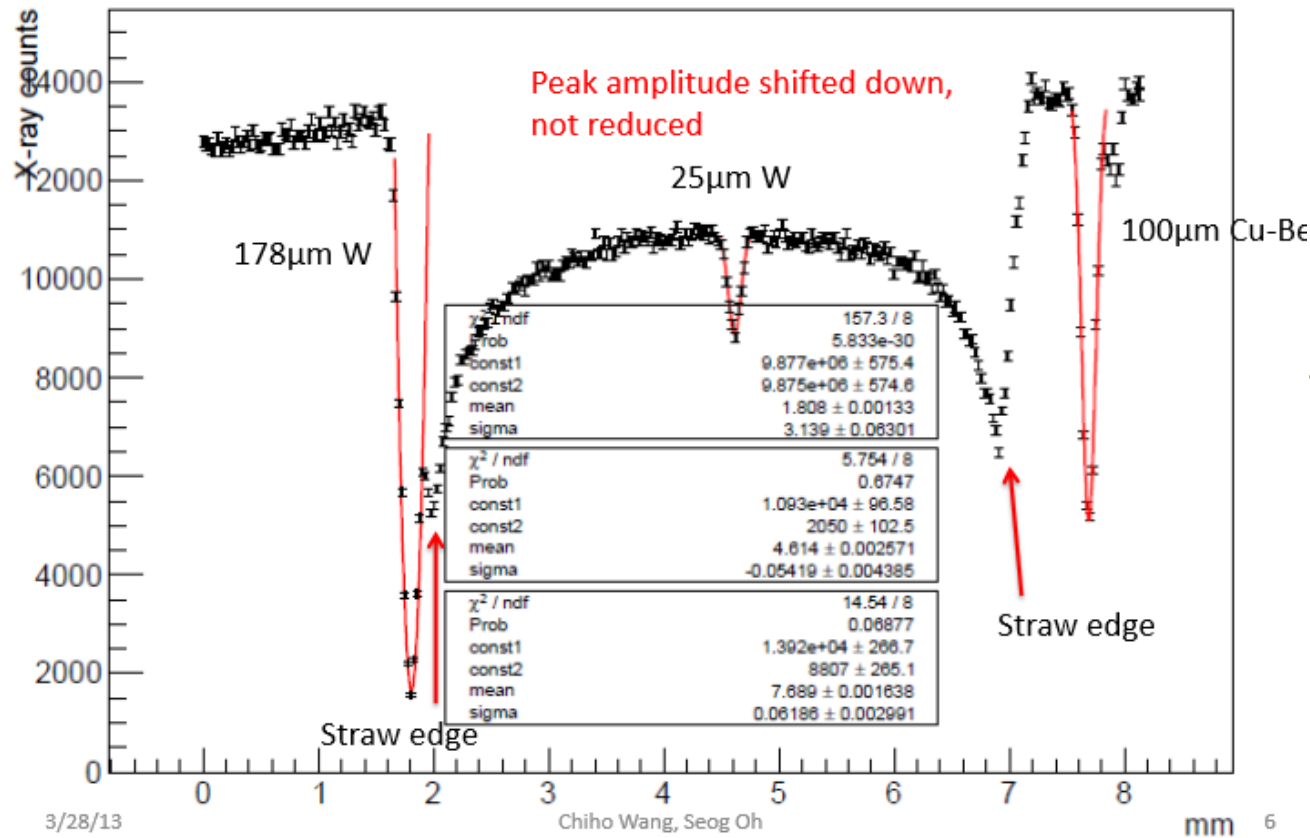


X-ray setup at Duke

Duke X-ray wire location



25 μ m wire shadowed by straw



Taken from a talk by Chiho Wang last year

Fermilab

Fermilab will

Leak test each panel in vacuum

Assemble panels into planes and construct the full tracker



Vacuum tank in Lab 3 at Fermilab

ES&H considerations

Each university has its own ES&H department, and each group will have to abide by the regulations of its university.

That said, each institution should

- Have a written safety document for the work done there

- Have a one-on-one safety discussion with each person working there

- Have periodic safety inspections.

There are not a lot of hazards:

- Compressed gas

- Soldering irons and solder

- Epoxy and other chemicals

- X-rays

Parts flow

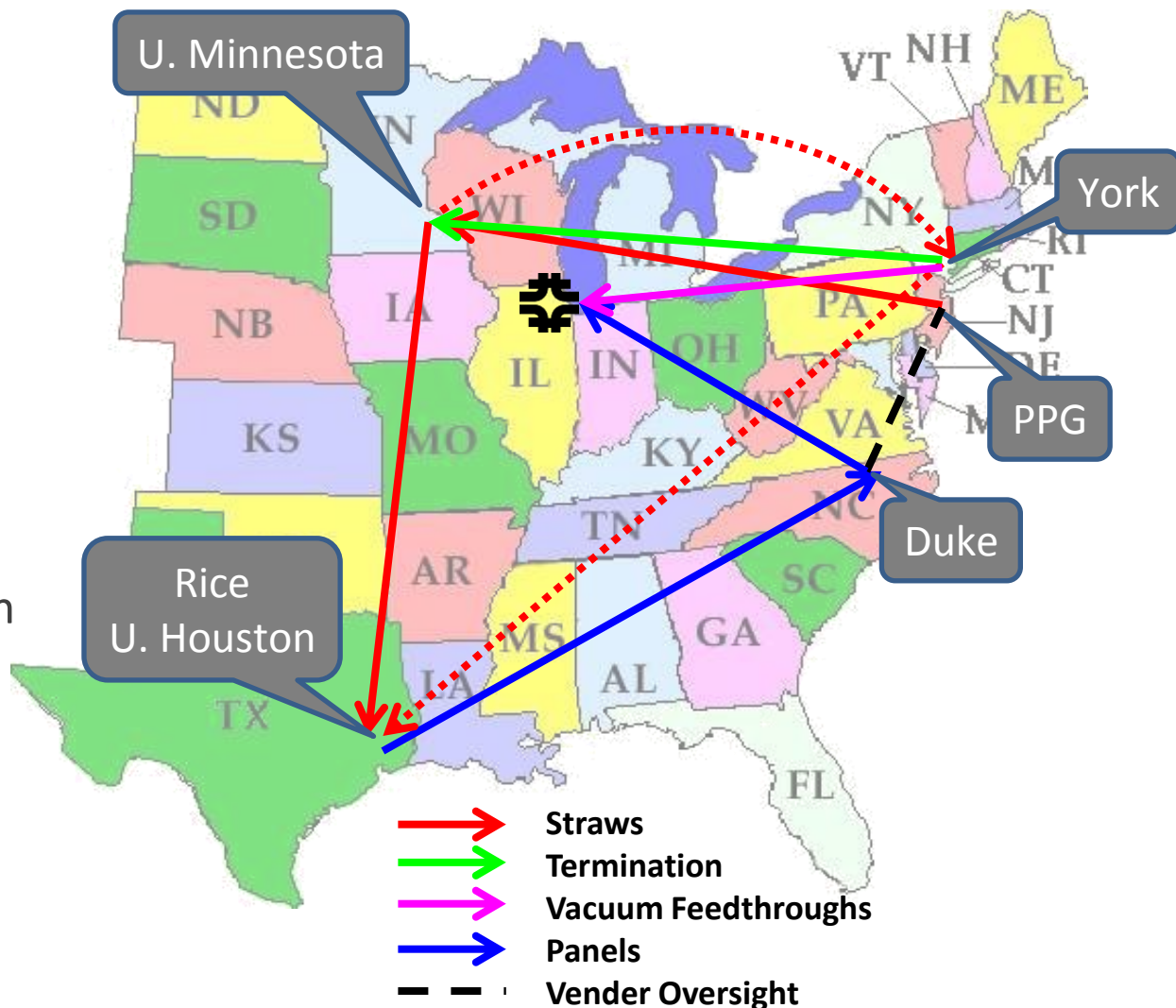
York assembles end pieces, ships to MN

MN leak tests straws, inserts end pieces, ships to Rice

Rice assembles panels, takes to UH

UH runs extensive test on all panels, ships to Duke

Duke measures wire positions, ships to Fermilab

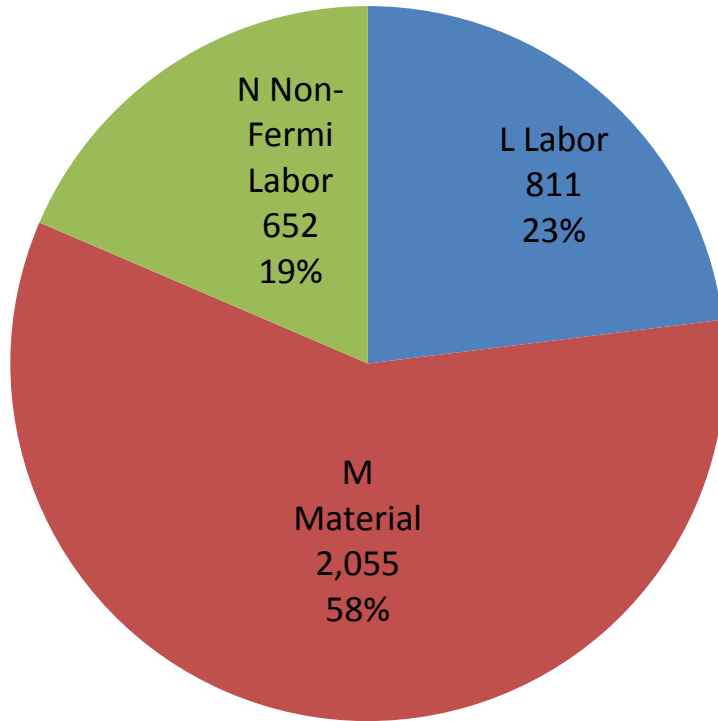


Cost Table

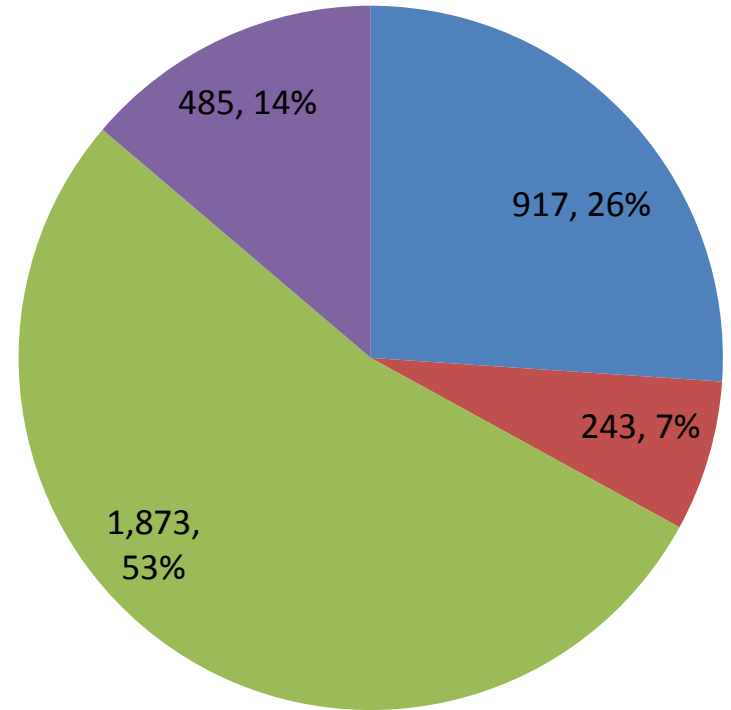
	Base Cost (AY K\$)			Estimate Uncertainty (on remaining costs)	% Contingency on ETC	Total Cost
	M&S	Labor	Total			
475.06 Tracker						
475.06.03 Straw Assemblies						
475.06.03.01 Panels	648	269	917	443	57%	1,361
475.06.03.02 Single Plane	145	98	243	67	39%	310
475.06.03.03 Gas Manifold	1,722	151	1,873	749	42%	2,623
475.06.03.04 Full Tracker Support and Assembly	193	292	485	234	51%	718
Grand Total	2,708	811	3,519	1,493	47%	5,012

Cost Breakdown

Base Cost (AY K\$)



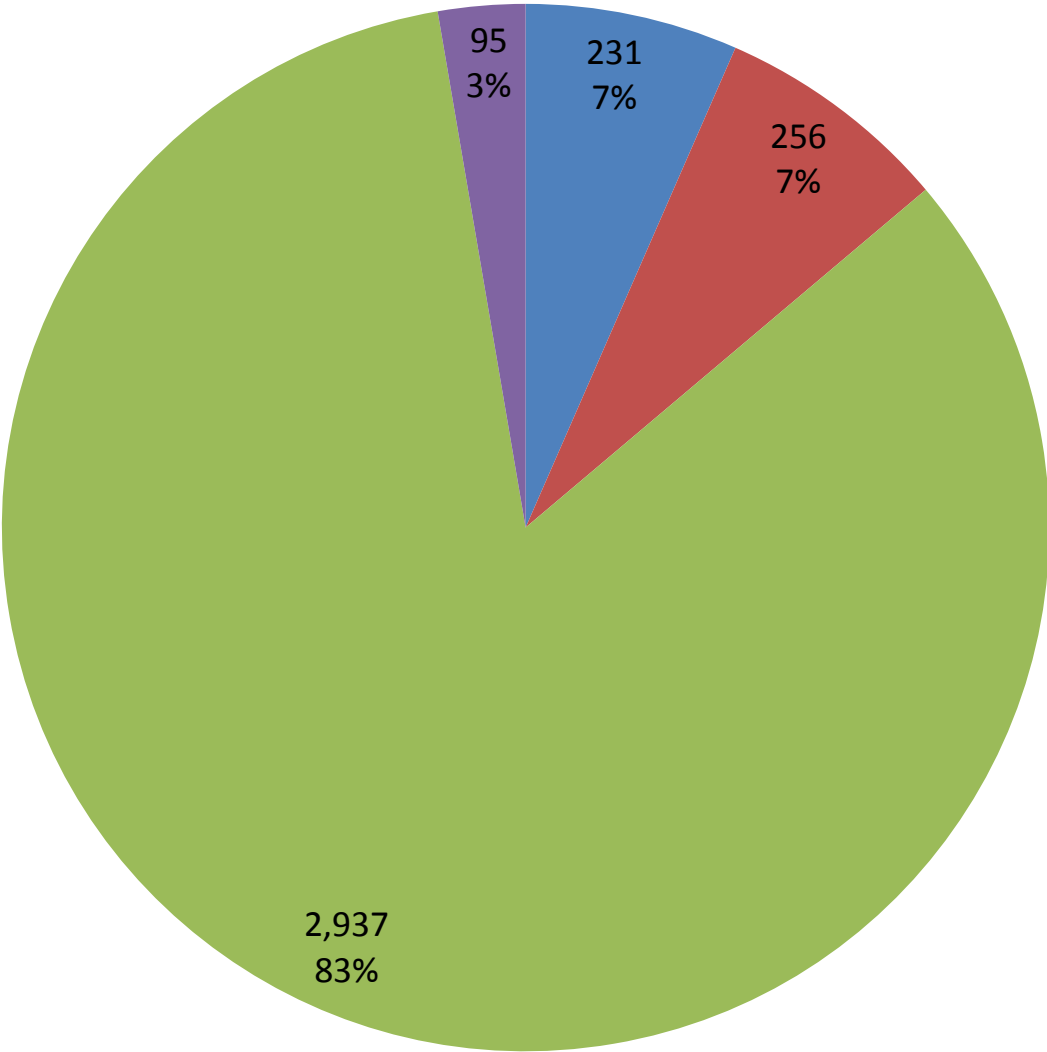
- L Labor
- M Material
- N Non-Fermi Labor



- 475.06.03.01 Panels
- 475.06.03.02 Single Plane
- 475.06.03.03 Gas Manifold
- 475.06.03.04 Full Tracker Support and Assembly

Quality of Estimate

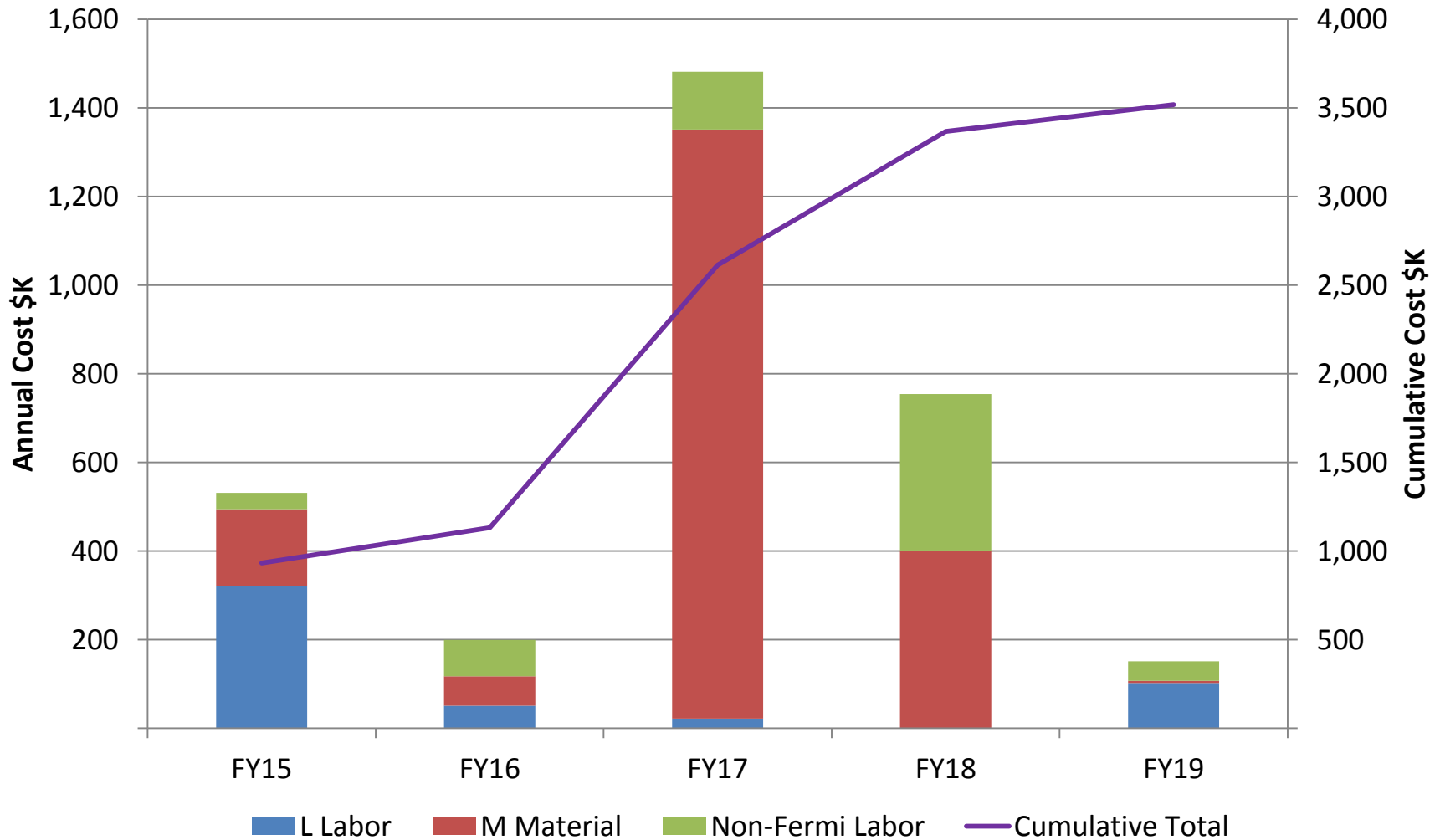
Base Cost (AY K\$)



- L1 Actual / M1 Existing P.O.
- L4 / M4 Preliminary
- L5 / M5 Conceptual
- L7 / M7 Rough Estimate Pre-Conceptual - Uncommon Work

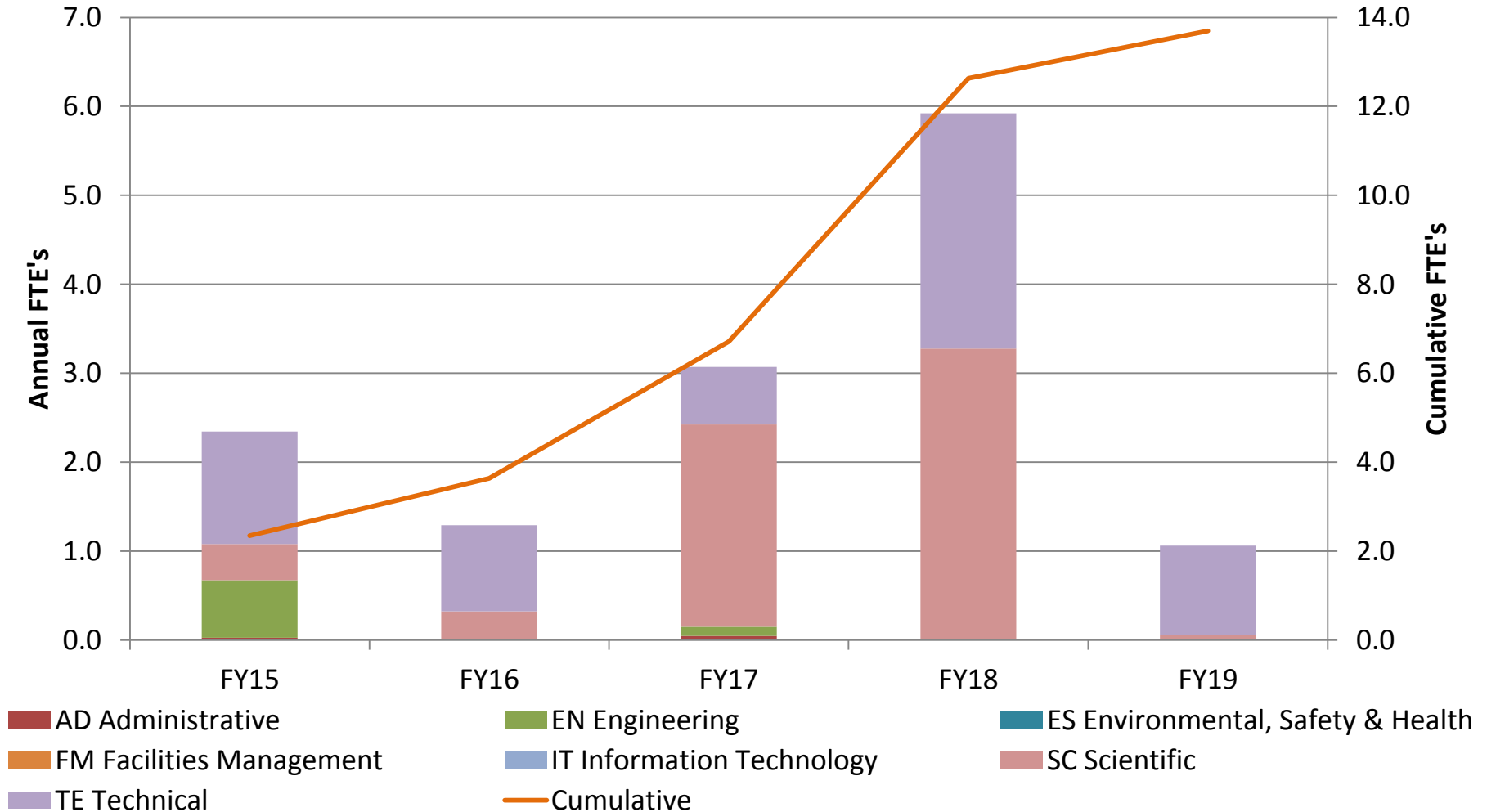
Labor & Material by FY

Base Cost (AY K\$)



Labor Resources by FY

FTEs by Discipline



Summary

All groups are on-board with this work breakdown. We can make adjustments if needed as the work progresses.

York—straw terminations, vacuum leak tests, vacuum feedthroughs, possibly help with leak tests

Minnesota—CO₂ leak tests, cut straws to length and terminate

Rice—insert straws and sense wires, complete panels

Houston—test all panels including HV tests in air and in gas, ensure that all channels see signals

Duke—procure straws, measure and document the locations of all sense wires and straws in each panel

Fermilab—leak test all panels, assemble panels into planes and planes into stations, construct full tracker

See [Docdb4635](#) for more detail on university groups' experience and facilities.