GlueX Central Drift Chamber

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for the GlueX Collaboration.

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Straw Tracker R&D Mini-Workshop

University of Michigan

October 14, 2024

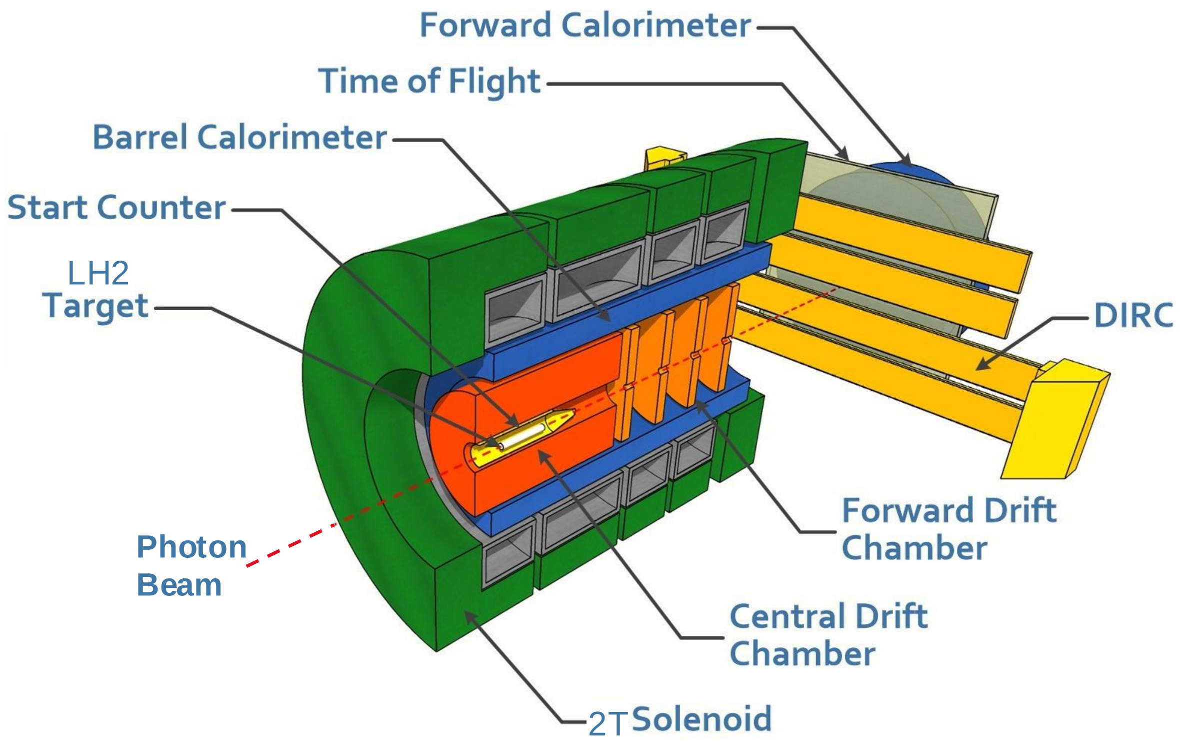
GlueX Experiment, exploring light meson spectrum with photoproduction at Jefferson Lab

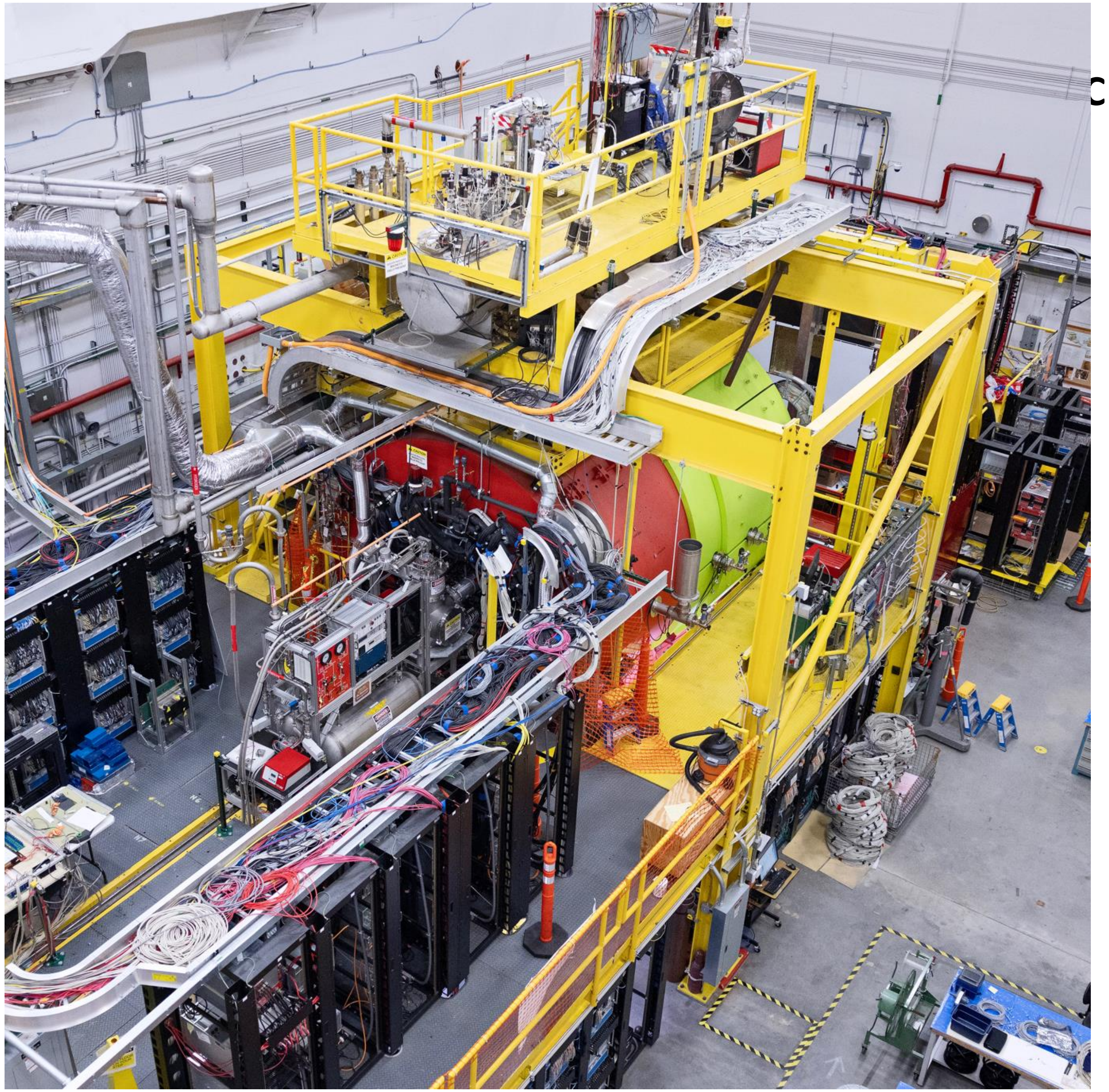
- Goal: search for and study spin-exotic hybrid mesons
- 12 GeV electron beam from CEBAF
  Continuous Electron Beam Accelerator Facility
- Polarized photon beam created in Tagger Hall
- GlueX spectrometer located in Hall D

GlueX spectrometer

The GlueX Beamline and Detector NIM A 987 (2021) 164807

Large acceptance, optimized for light meson spectroscopy
Cerenkov detectors added in 2019





Acceptance θ = 1–120°
Charged $\sigma_p/p \sim$ 1-5%
Neutral $\sigma_E/E = 6\% / \sqrt{E} \oplus 2\%$

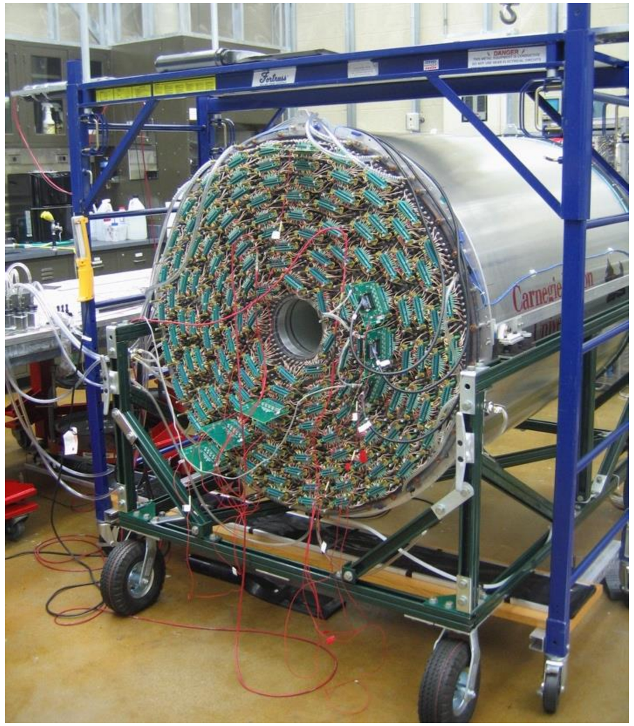
Hall D

Central Drift Chamber (CDC) – charged particle tracking and identification

- 1.5m long x 1.2m diameter cylinder
- 3522 straw tubes, 1.6cm diameter, in 28 layers, 16 stereo (+/- 6 degrees)
- 50/50 Ar/CO2 gas mix, approx. 30 Pa above atmospheric pressure
- Straw tube wall thickness 109 µm : 4 layers of mylar, 100nm Al on inside
- Straw electrical resistance 75 to 100 Ω

Table 1: The geometry of the CDC.

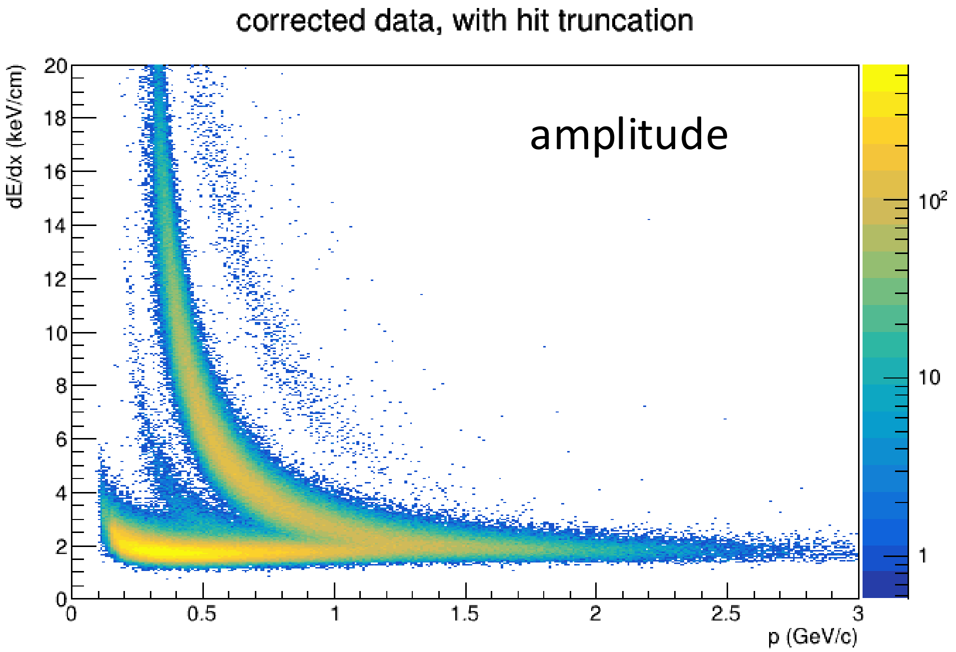
Active volume inner radius	99.2 mm
Active volume outer radius	555.4 mm
Active length	1500.0 mm
Chamber assembly inner radius	87.5 mm
Chamber assembly outer radius	597.4 mm
Upstream gas plenum length	31.8 mm
Downstream gas plenum length	25.4 mm
Thickness of 28 straws, mylar	2.22 % Rad.Length
Thickness of 28 straws, gas	0.34 % Rad.Length
Thickness of downstream endplate	2.14 % Rad.Length

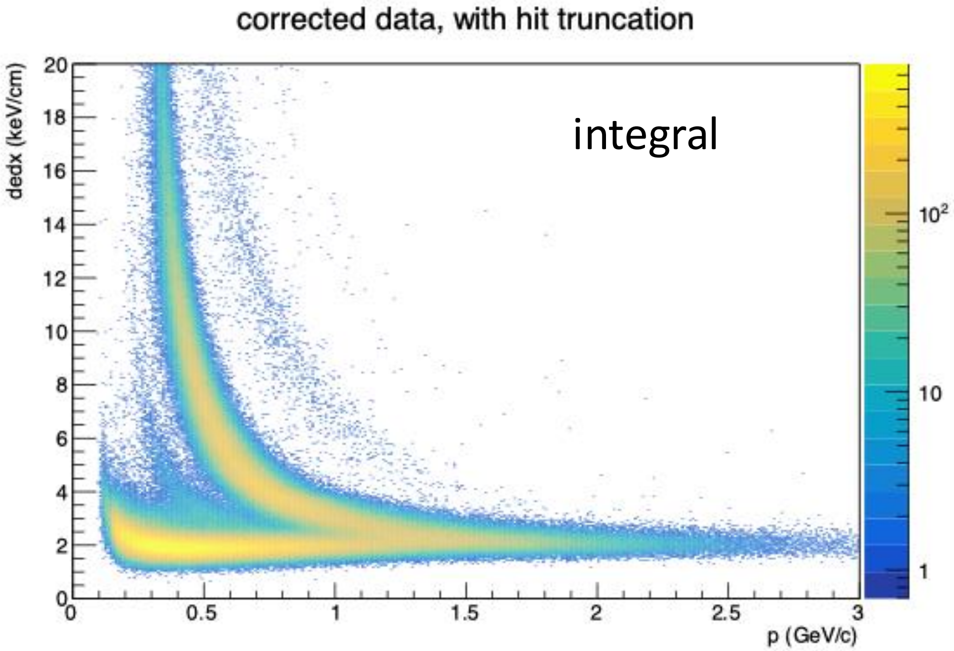


dE/dx

We use the height of the first pulse for dE/dx, as it gives better resolution than the pulse integral.
A space-charge correction is applied.
The 20% of the hits with highest pulse amplitude are discarded, to remove the tail of the dE/dx distribution.

Tracks with 16 + hits in the CDC, no reaction selection or kinematic fit





Operational Reliability 2014 to 2024 and into the future

Wires	3522 in total. 2 broke and were disconnected in 2015. +4 to 6 problem channels since 2016, most likely faulty HVB or preamps.
Gas volume	Leak in 2015 along outer shell joint Chamber was extracted, patched with tape and epoxy. No further problems.
Performance	Stable with time, repeated HV scans from 2018 to 2021 show 2125V as the optimum HV. The chamber gain is consistent between 2017 and 2020. The CDC holds its operating HV with no trouble. The performance of the CDC has not deteriorated noticeably with time.
Gas supply	The orifice of the mass flow controller in the Hall clogged (corrosion?) in 2018. That MFC was replaced with a rotameter. There have been no problems since then.
Overall	No problems (or signs of problems developing) since 2018. The outlook is good.
Electronics	Supplies of replacement HVBs, preamps, fadcs are limited.
People	How many of us will be still around in 2032?! Calibration scripts are documented.

Lessons learned

Place a very strict tolerance on C fiber endplate hole diameter.

Request that the manufacturer should use a supportive honeycomb structure when packaging straws for shipping.

Monitor the resistance of the straw-tubes' inner conductive layer closely.

To avoid straw sag, use perfect straws, install straws before stringing, consider adding additional mechanical support.

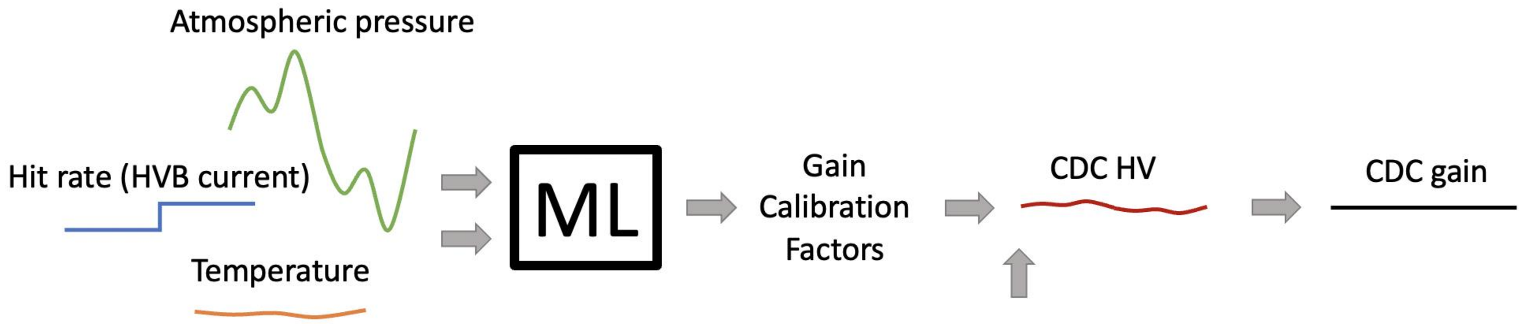
To seal the cylindrical parts of the outer shell together (separated to avoid magnet quench causing eddy currents), best use epoxy with Kapton or mylar.

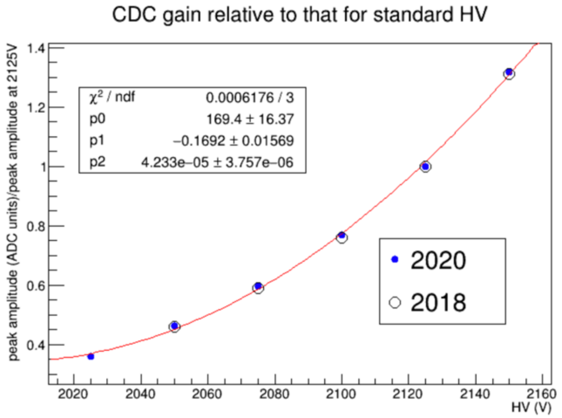
Consider the effect of the chosen gas on its supply equipment, mass flow controllers, etc.

HV power supplies can be a source of noise and might require filtering.

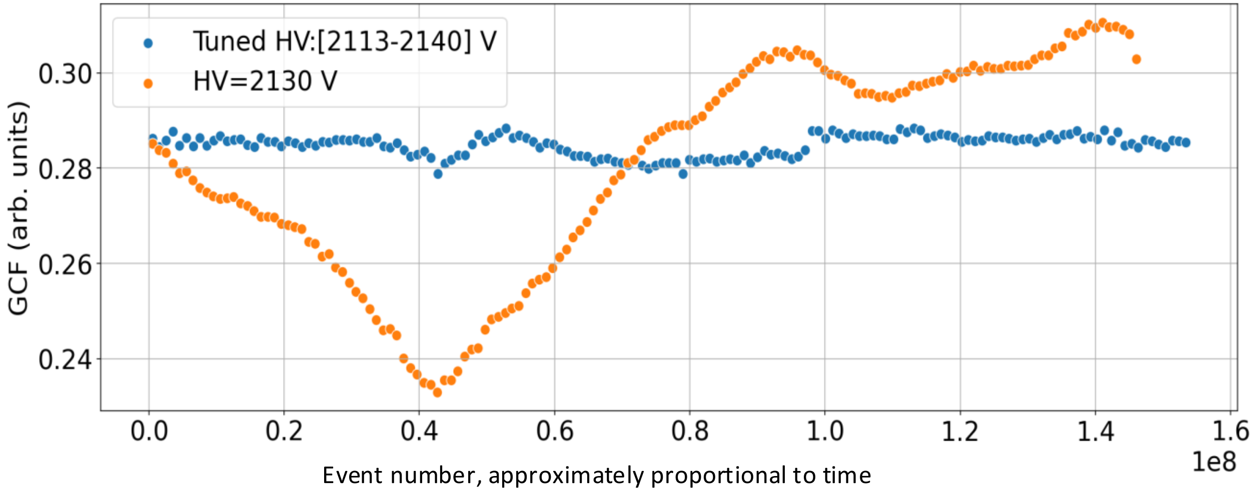
RoboCDC - autonomous gain stabilization

David Lawrence, Naomi Jarvis (CMU),
Thomas Britton, Torri Jeske,
Diana McSpadden, Nikhil Kalra





Gain correction factor vs time, ML-tuned and constant HV



ML: Gaussian Process Regression
Trained to predict GCF from EPICS (temp & pressure)

CHEP 2023 ACAT 2021

Publications and acknowledgements

CDC construction Jarvis et al, NIM **A962** (2020) 163727
Prototype and simulations Van Haarlem et al, NIM **A622** (2010) 142
GlueX Technical Construction Report

RoboCDC Britton et al EPJ Web of Conferences **295** (2024) 02003
RoboCDC Jeske et al J. Phys.: Conf. Ser. **2438** (2023) 012132

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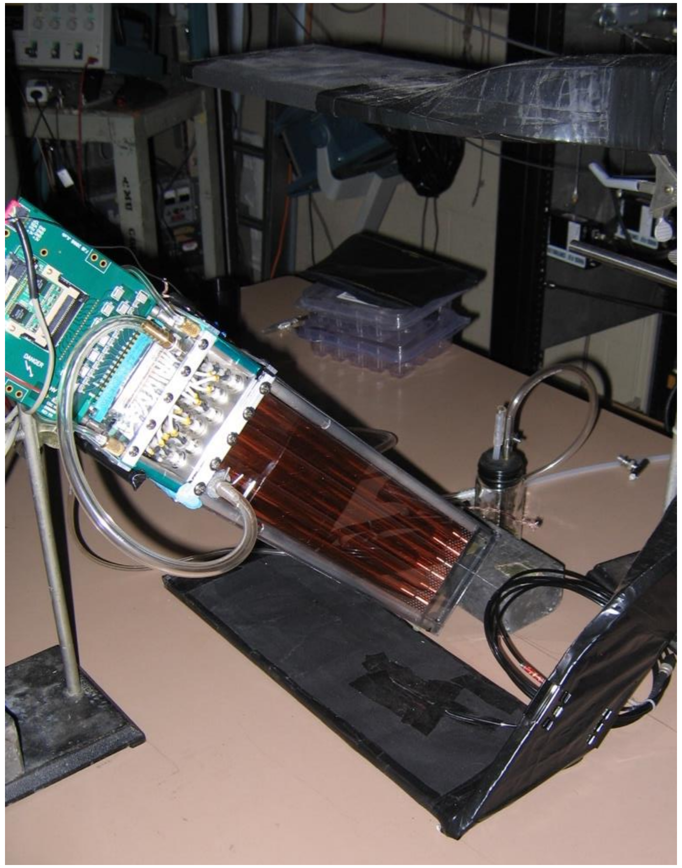
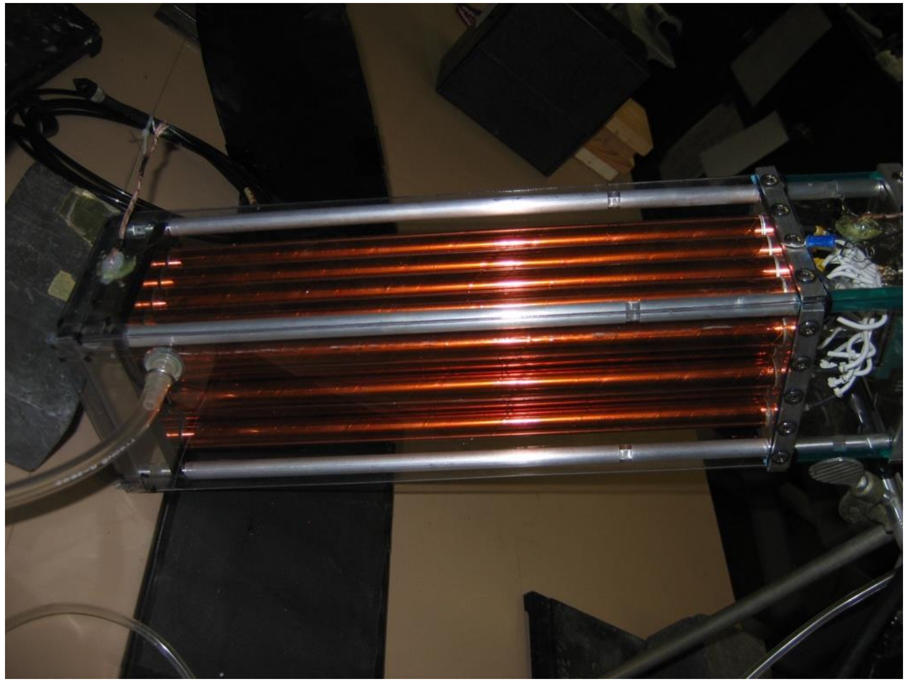
RoboCDC development work was supported by DOE grant LAB-20-2261.

Prototype studies





Construction Timeline

Phase 1: Mounting and Alignment of Endplates

Completed Sept 2010

Phase 2: Installation of Straws (gas lines + outer shell)

Completed Oct 2011

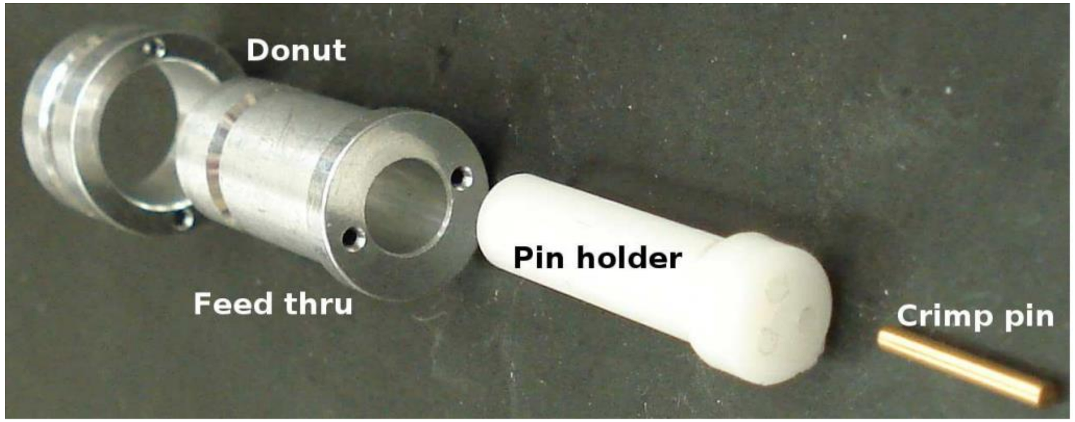
Phase 3: Wire Stringing

Completed Feb 2012.
5 broken wires and 2 rows with low tension replaced.

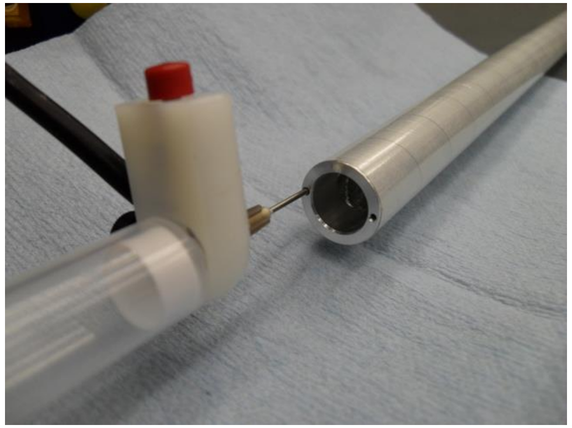
Phase 4: Electronics and plenums

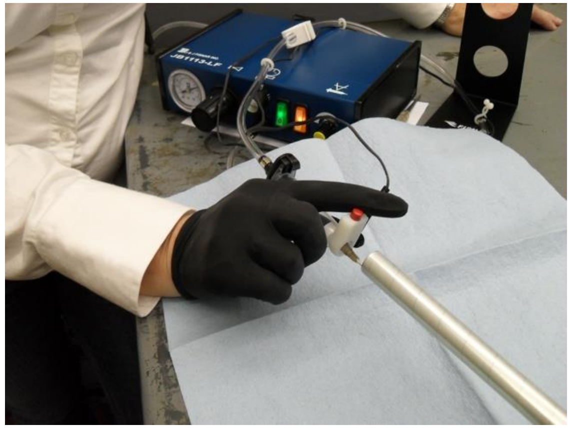
Completed Feb 2013

Gluing components into straws

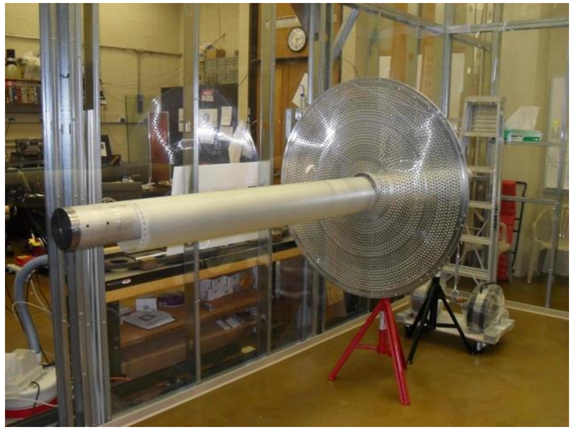
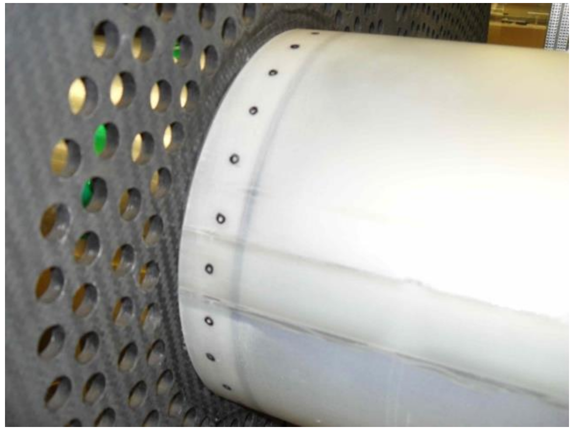


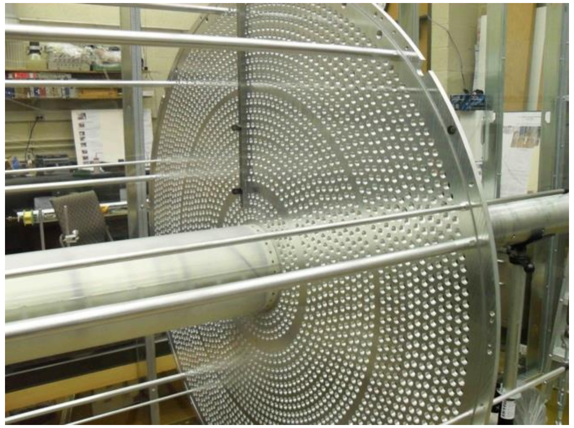
Al donut and feedthru upstream
Noryl downstream





Frame construction and alignment

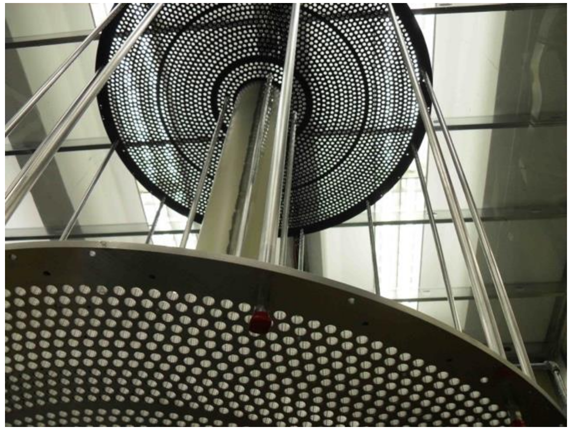






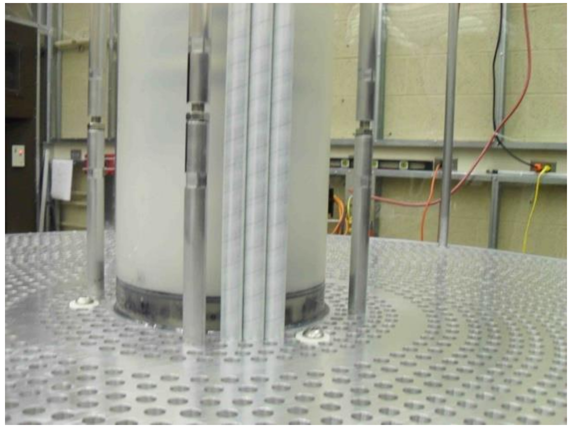

Frame reorientation

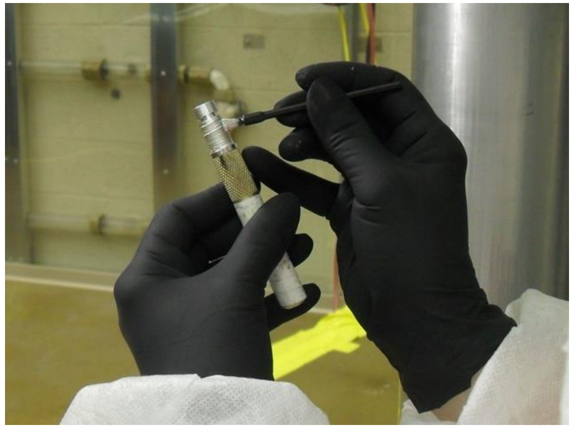
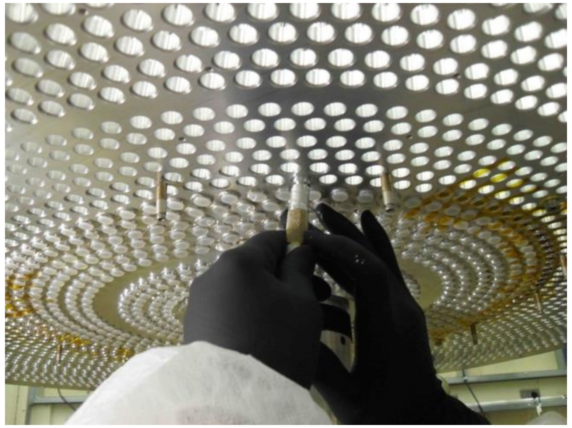
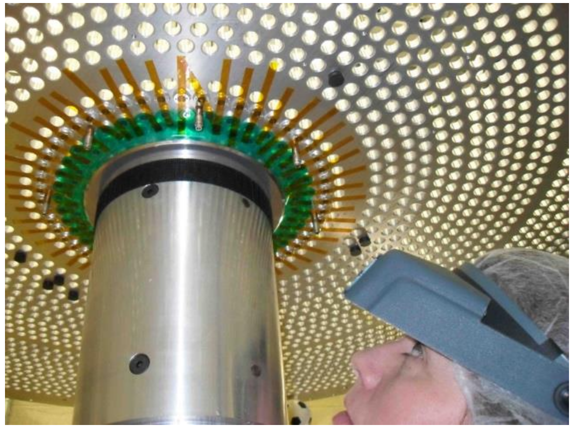




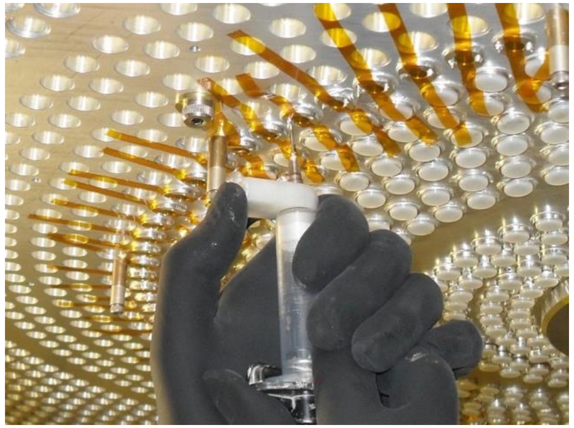



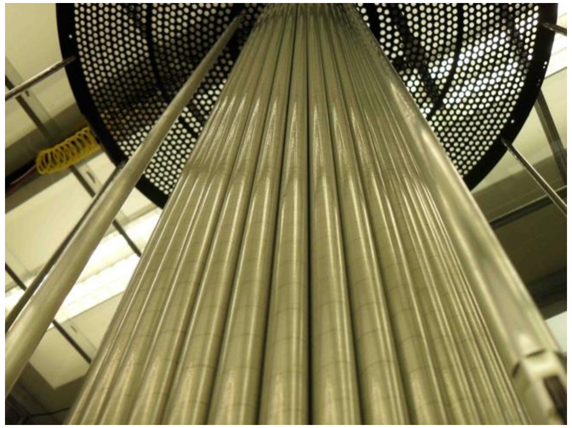
Straw installation

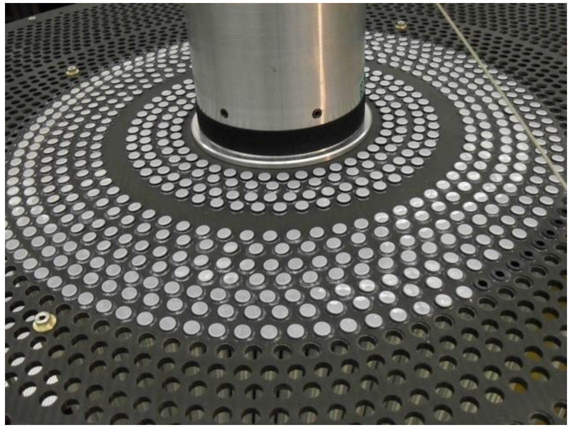


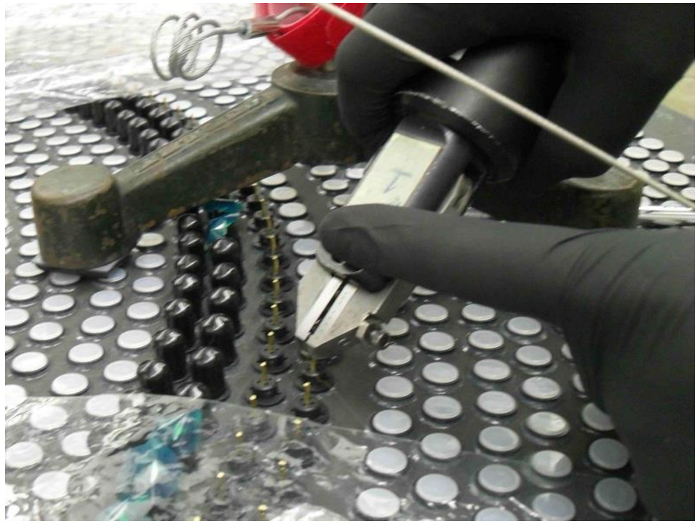

Straw installation

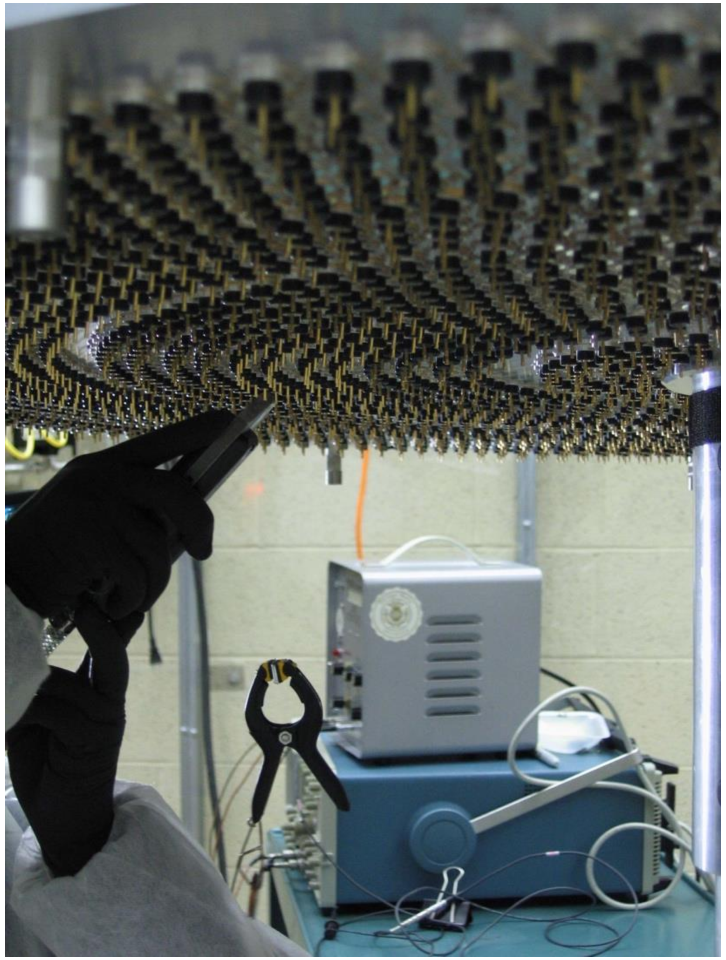




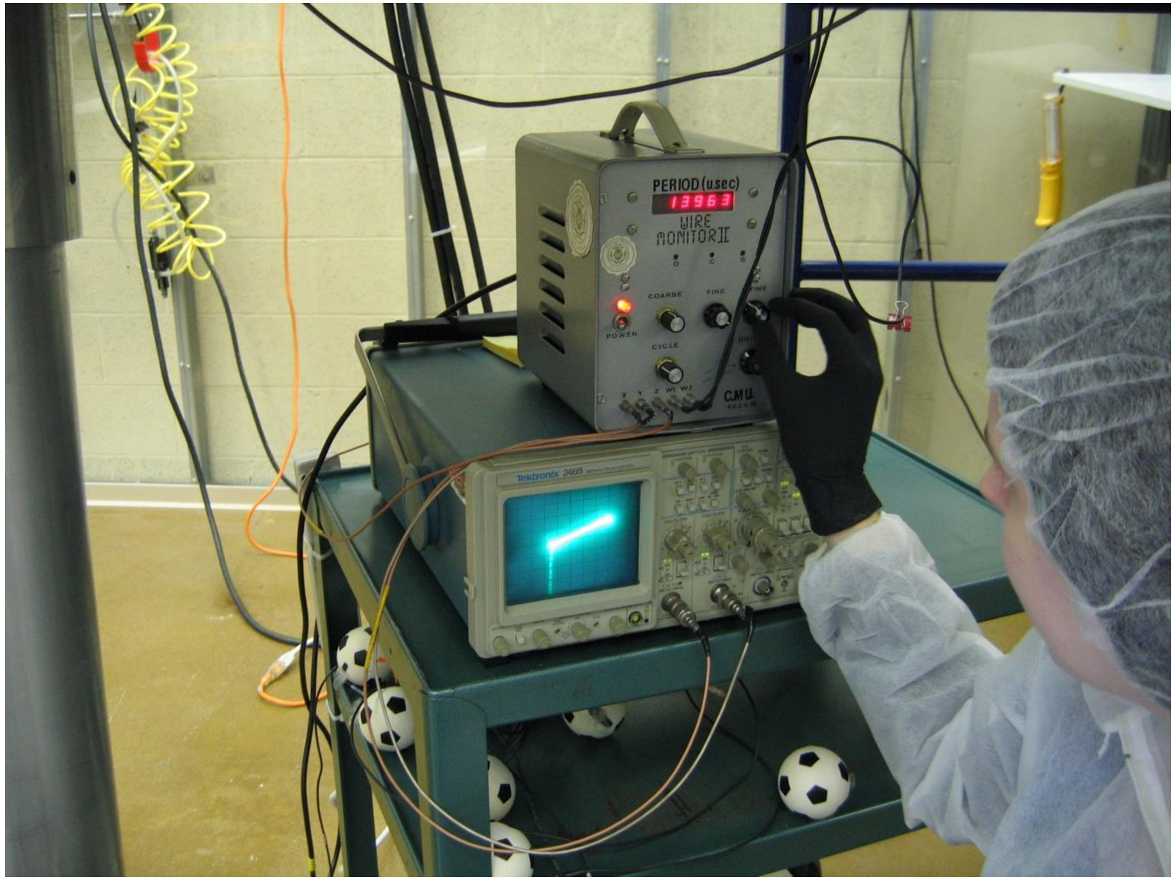
Stringing



Stringing

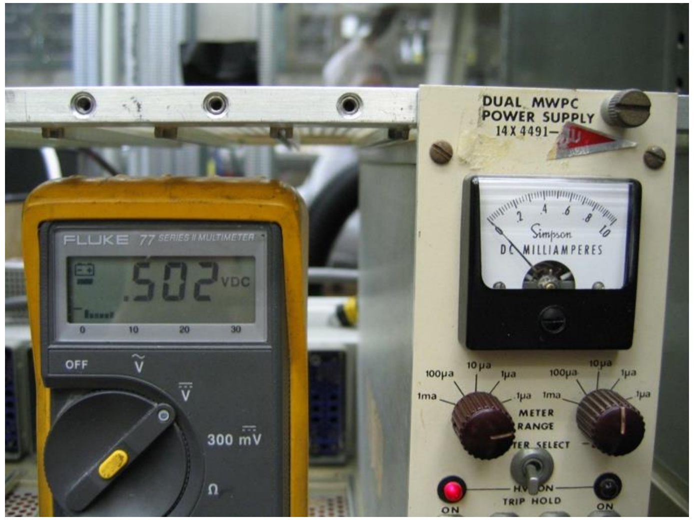


Wire tension measurements



$F = 4L^2f^2\mu/g$ Roth & Schumacher NIM A 369(1996)215

More tests after stringing

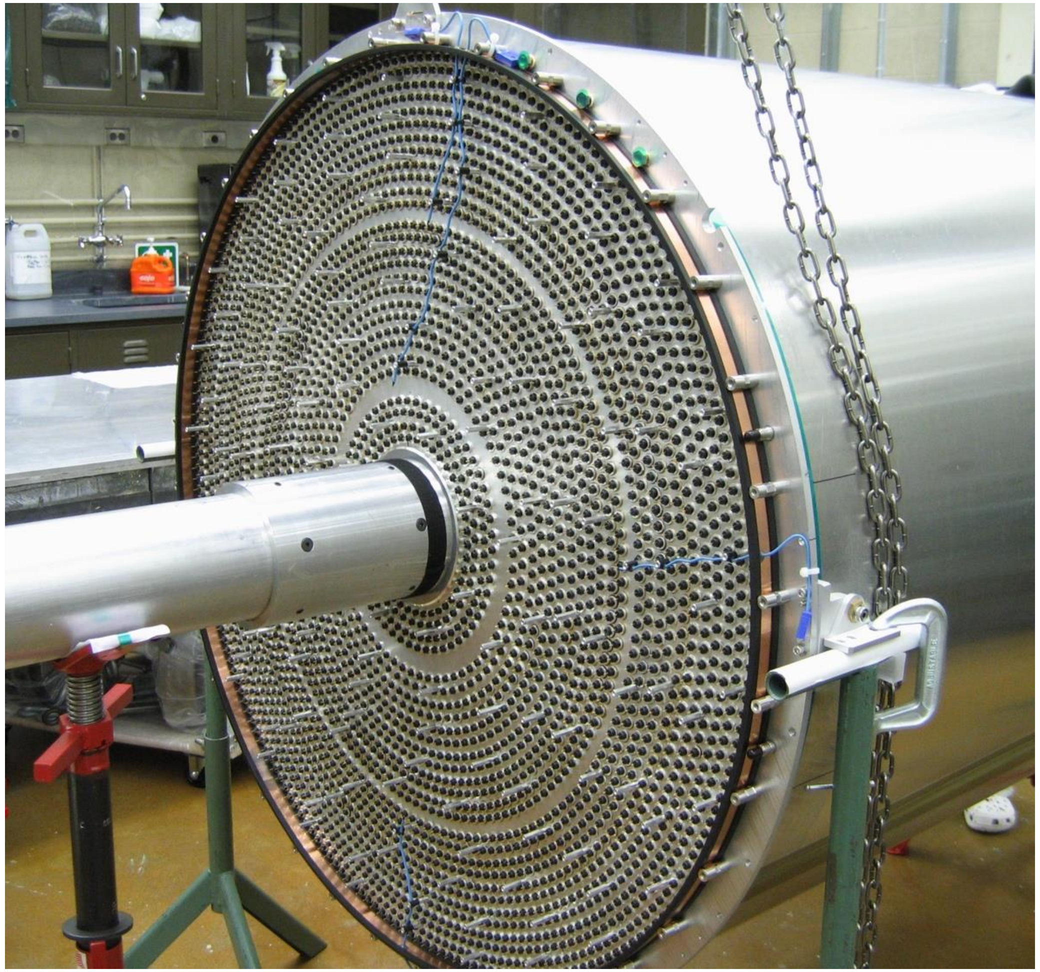


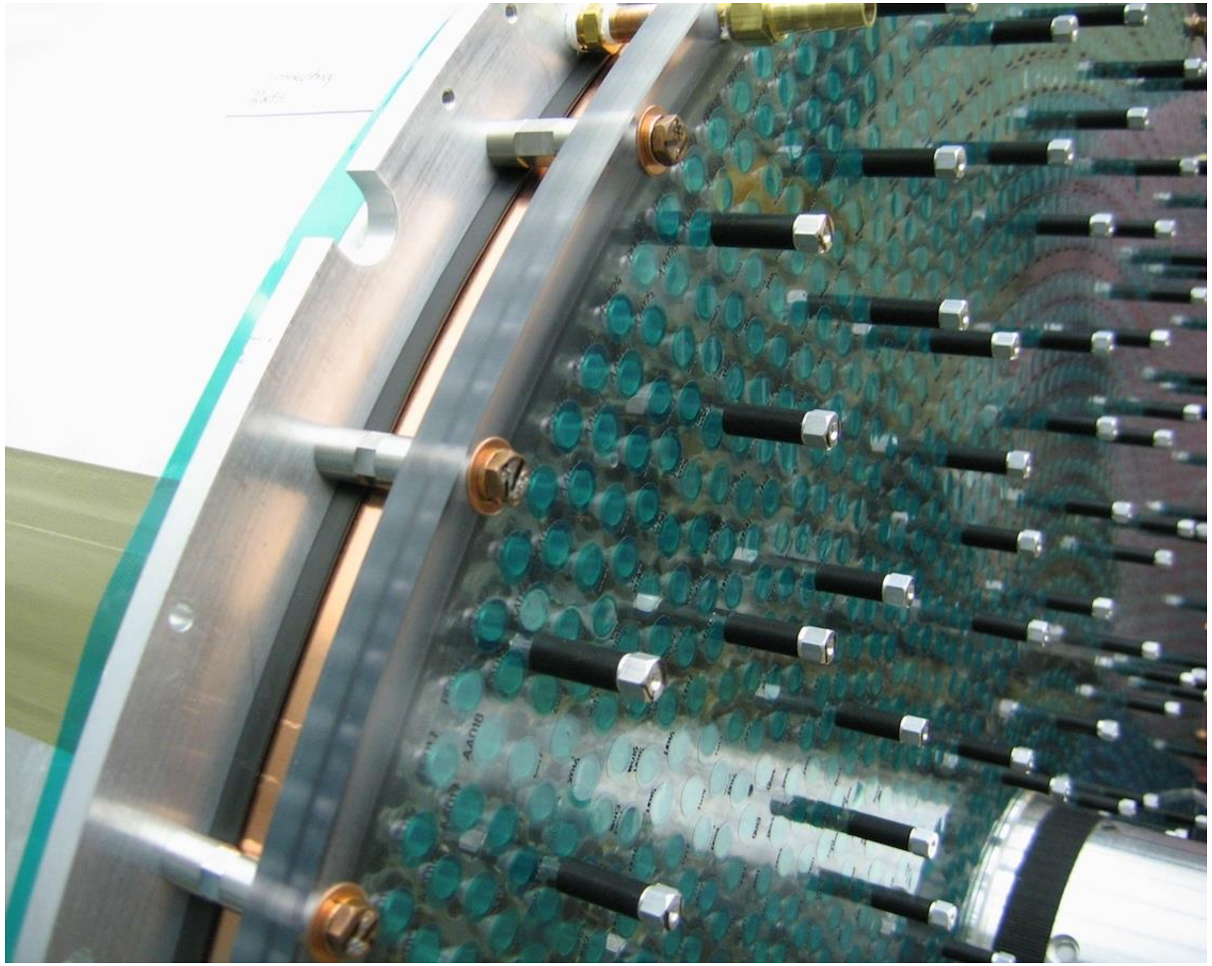
500V applied to each wire

Resistance of each wire measured

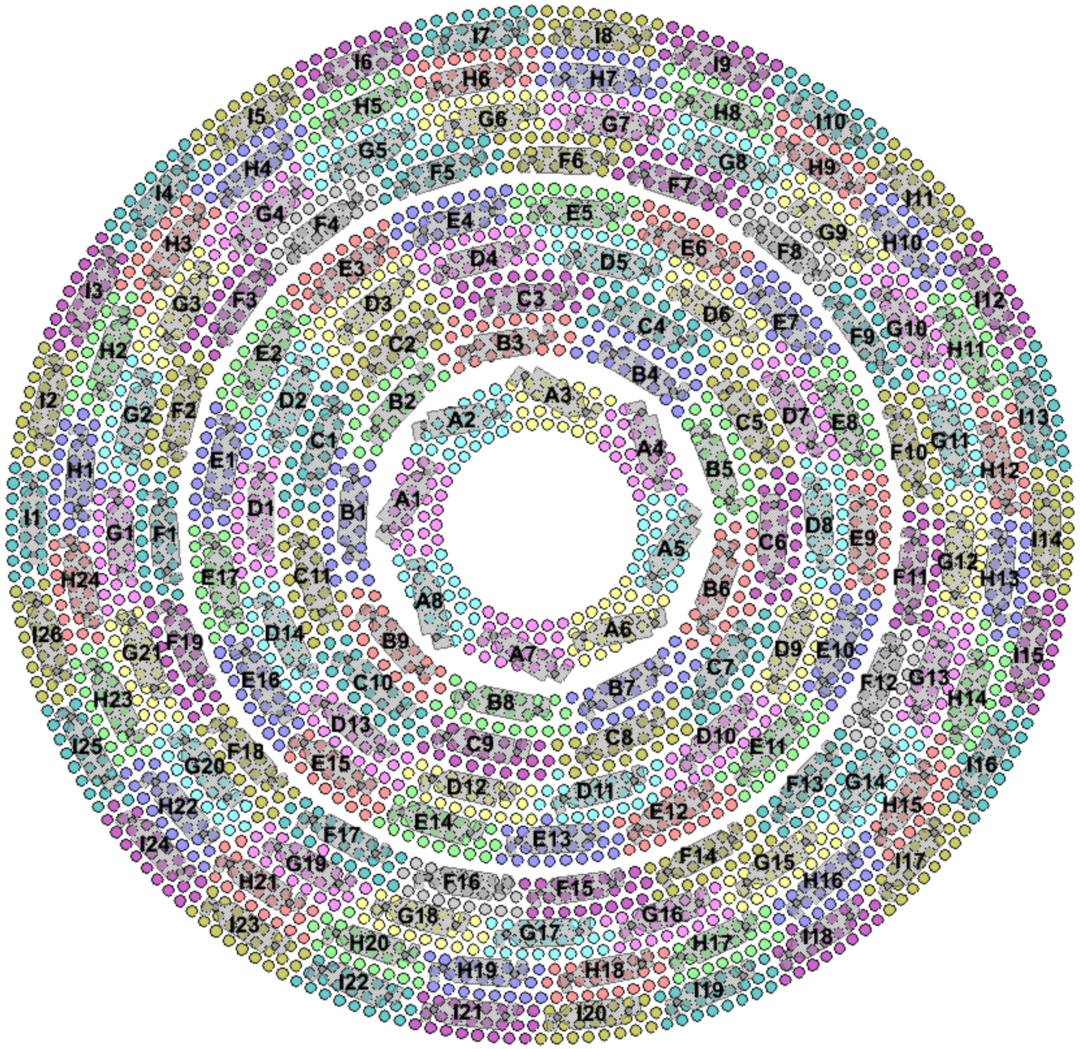
Reorientation to horizontal

Upstream plenum and thermocouples





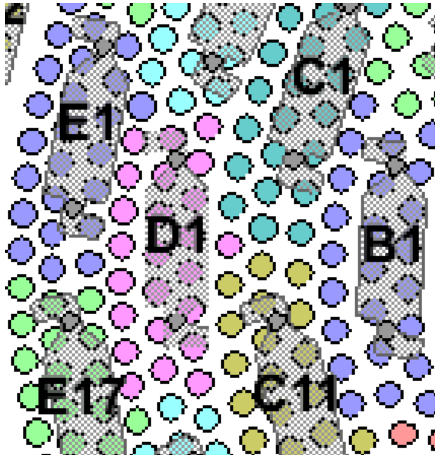
Wiring plan – allocating pins to transition boards



149 transition boards
3522 wires

Estimated wire lengths
40% 3.75 in
30% 4.0 in
30% 4.5 in
Mean length 4.0 in

Wiring details



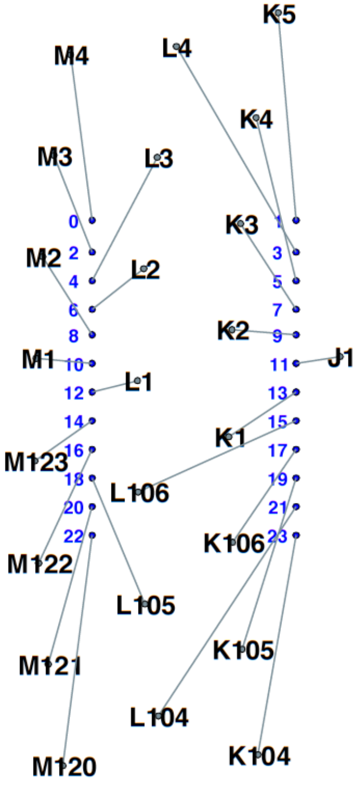
D1

Pad	Straw	Estimated	Used
0	M4	4.00 in	
2	M3	3.75 in	
4	L3	4.00 in	
6	L2	3.75 in	
8	M2	3.75 in	
10	M1	3.75 in	
12	L1	3.75 in	
14	M123	3.75 in	
16	M122	3.75 in	
18	L105	4.00 in	
20	M121	4.00 in	
22	M120	4.50 in	

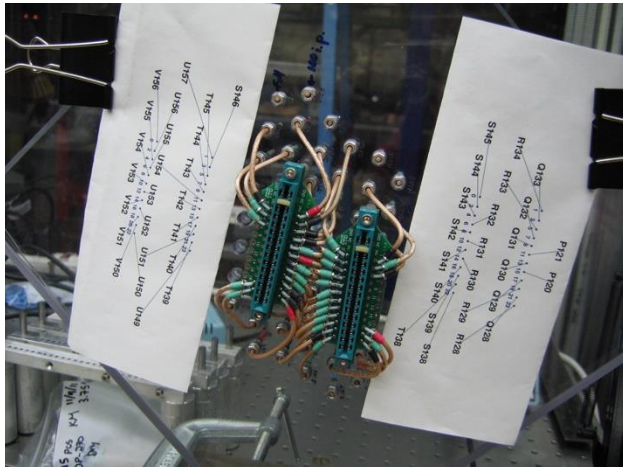
Pad	Straw	Estimated	Used
1	K5	4.00 in	
3	L4	4.50 in	
5	K4	4.00 in	
7	K3	3.75 in	
9	K2	3.75 in	
11	J1	3.75 in	
13	K1	3.75 in	
15	L106	4.50 in	
17	K106	4.00 in	
19	K105	4.00 in	
21	L104	4.50 in	
23	K104	4.50 in	

Shopping list and log

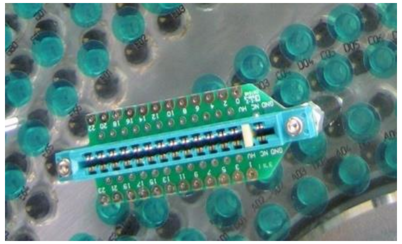
11	3.75 in wires
8	4.0 in wires
5	4.5 in wires
0	longer



Map, board D1

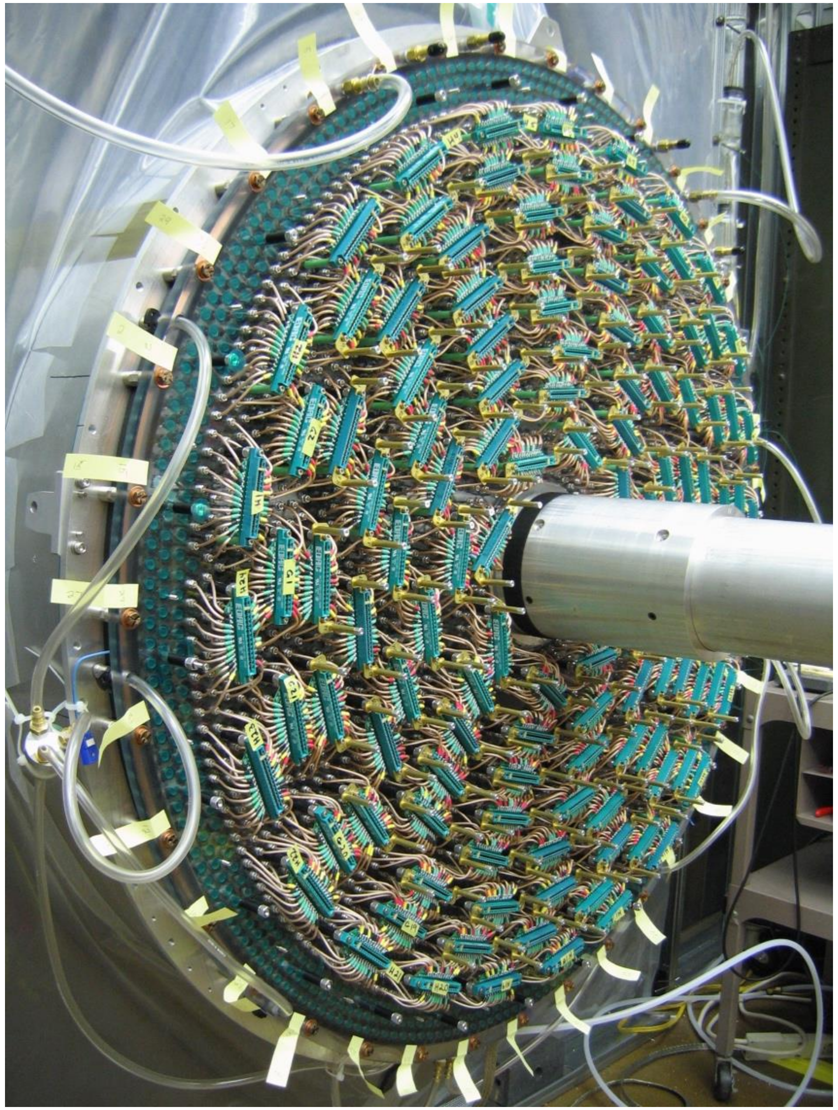


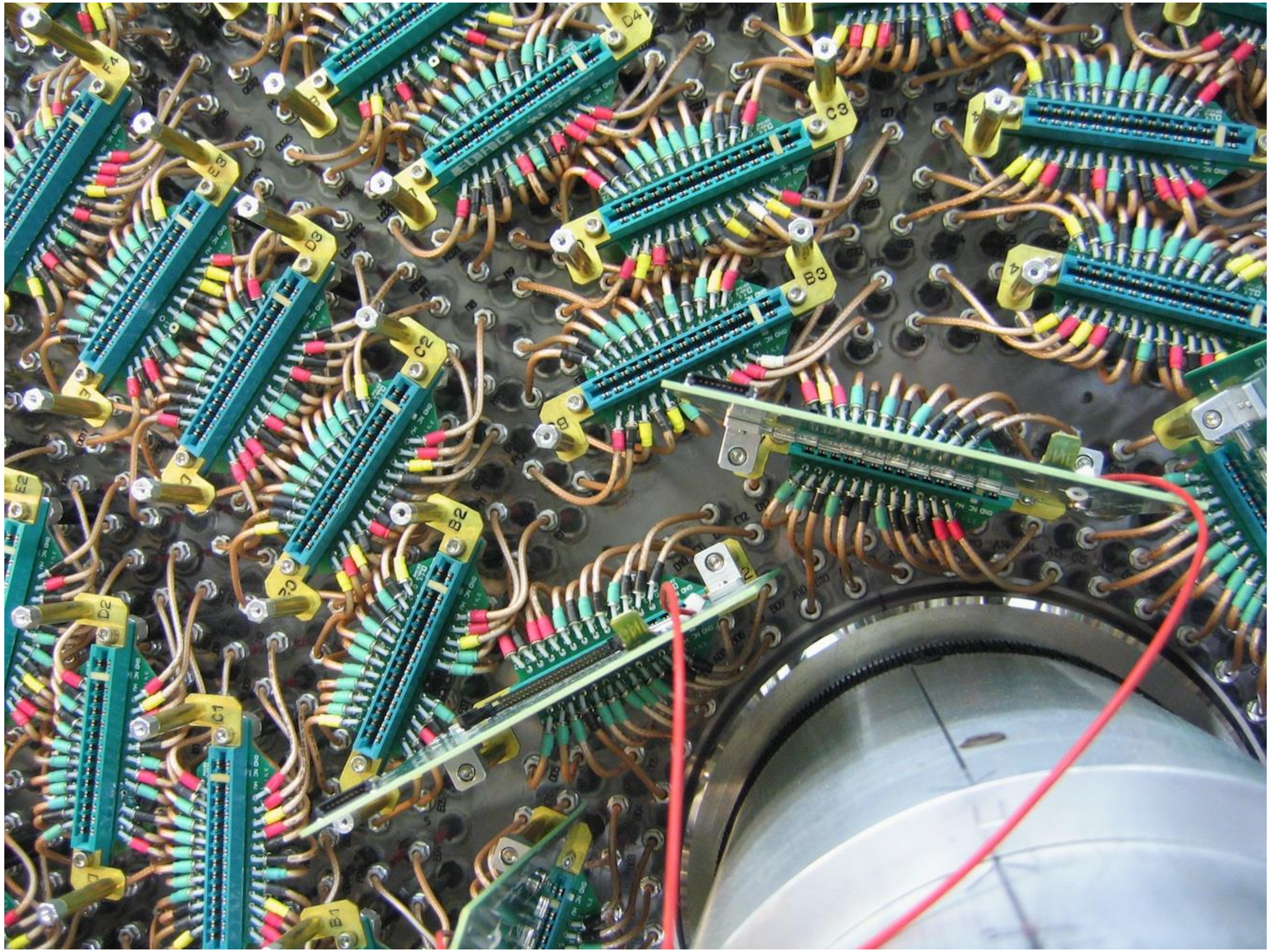
Practice jig



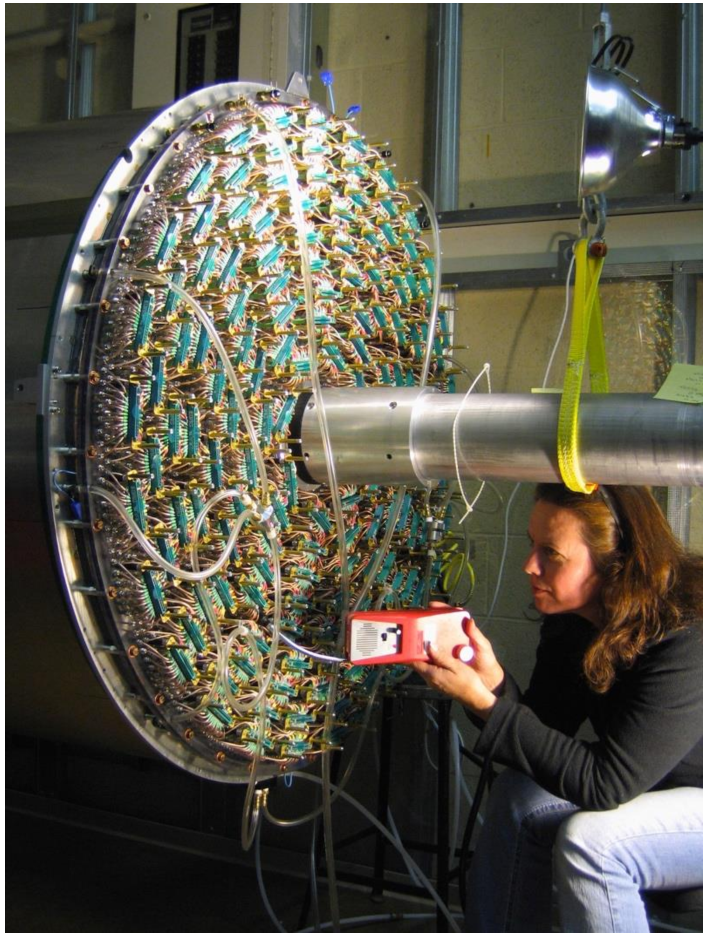
Real thing

Connection of transition boards completed





Checking for leaks



Wiring completed Oct 2012

CDC moved back into cleanroom

90% argon 10% ethane

Leaks found in wiring
and in temporary downstream plenum

Sealed leaks and retested

Moved onto cart, removed temporary plenum

Checked all electrical connections

Transport cart

Front upper brace removable

Vibration damping mounts
for support brackets

Pneumatic tires

4” thick dual density foam

Boat cleats

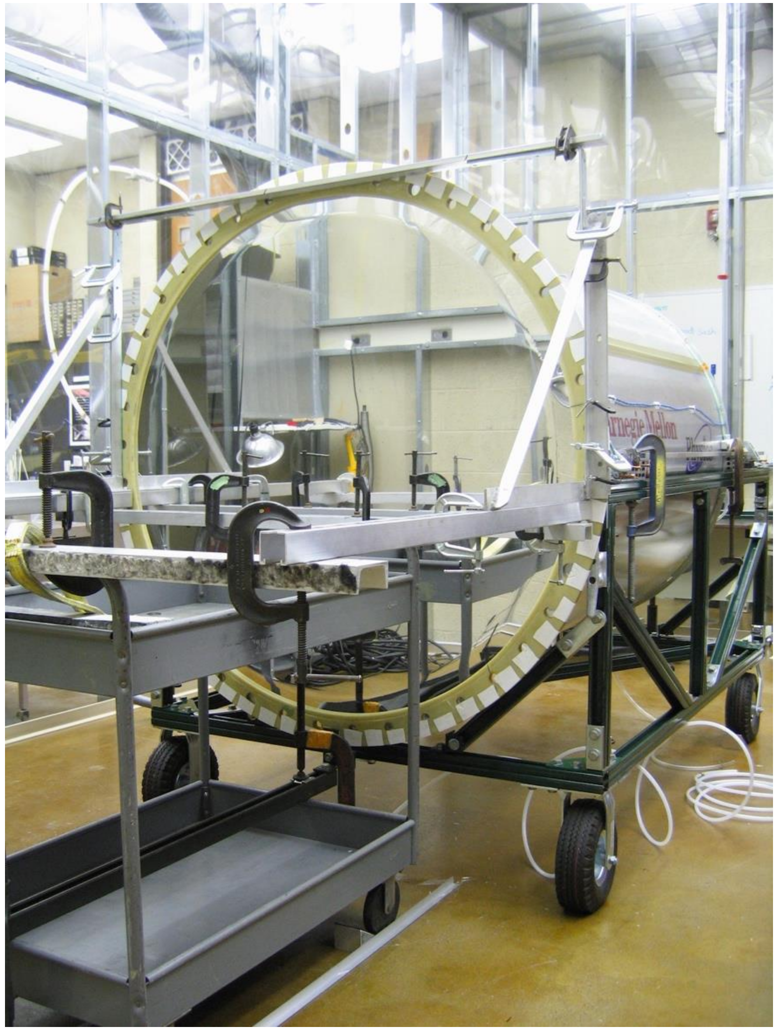
Marine mooring snubbers

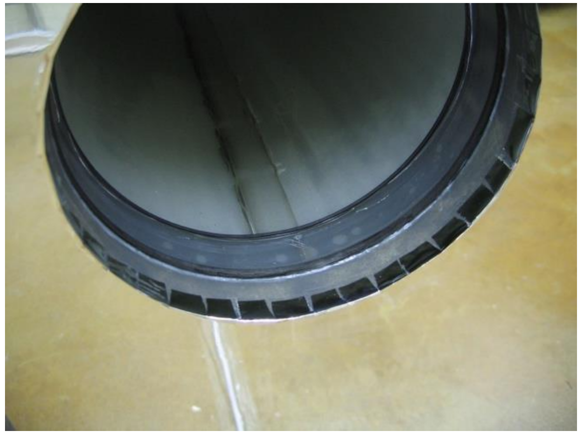
Downstream plenum and thermocouples

Thermocouples installed before removing hubs and mandrel

Rohacell standoffs keep thermocouples and plenum endwall in place

Downstream plenum wall





Double sided 0.002” Aluminized mylar
Stretched and taped onto transfer ring
Glued to CDC rohacell
Clamped whilst curing

Mylar tabs folded over the rohacell edges and epoxied

Ground braid from both sides of mylar glued to shell with conductive epoxy

Ready for delivery

CDC construction team at CMU

Project Leader: Curtis Meyer

Project Scientist: Naomi Jarvis

Construction Manager: Gary Wilkin

Technicians: Amy Woodhall, Kaitlin Mueller

Students: Maddi Brumbaugh, Rahul Kurl,
Tom Charley, Brent Driscoll, Devin McGuire,
Ariana Golden, Mason Blaschak,
Liz Keller, Aleksandar Popstefanija