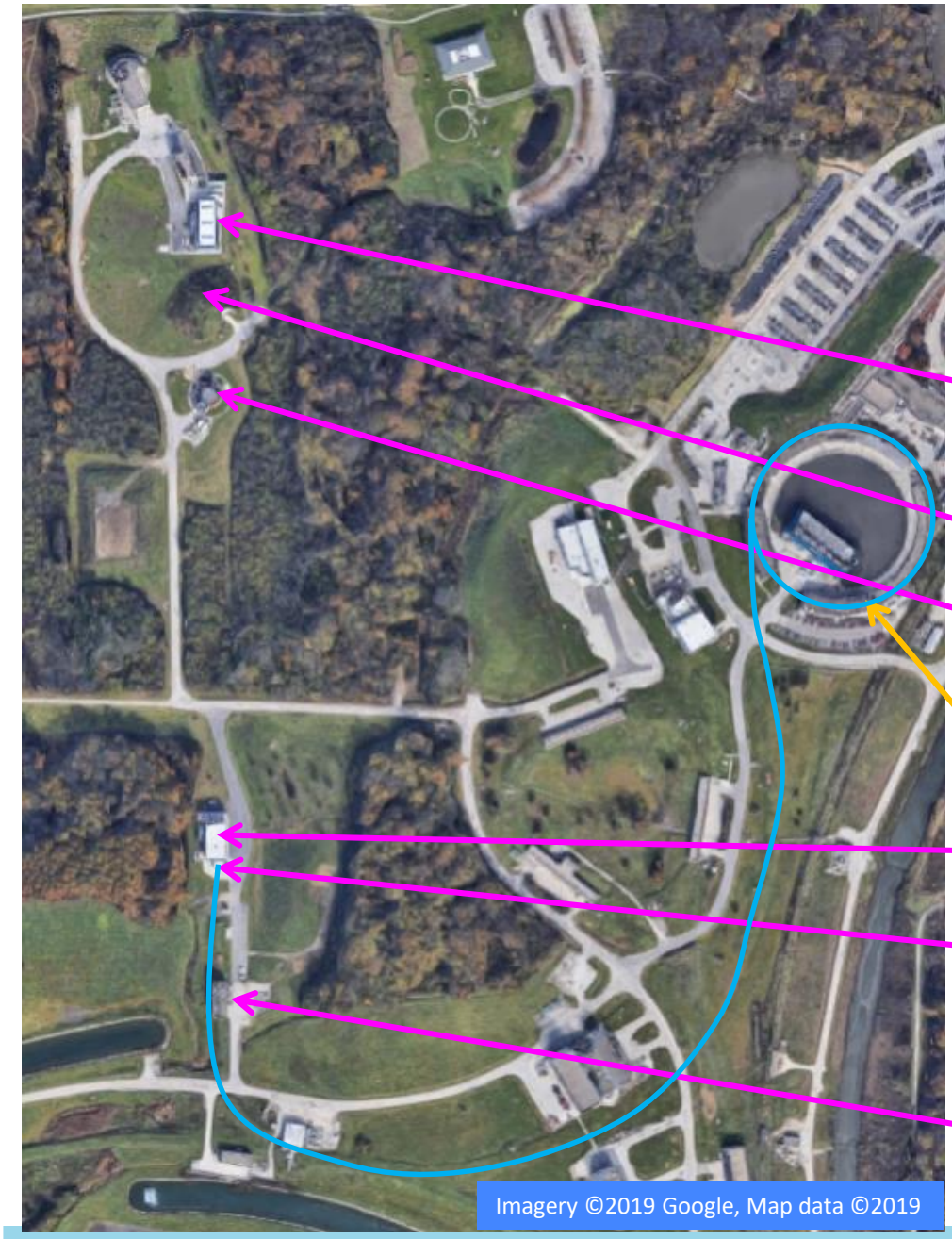
Booster Neutrino Beamline Status

Thomas R. Kobilarcik

Neutrino Beams and Instrumentation, 2019

22 October 2019

Booster Neutrino Beamline and Detectors



ICARUS (new)

MiniBooNE (off)

MicroBooNE (new)

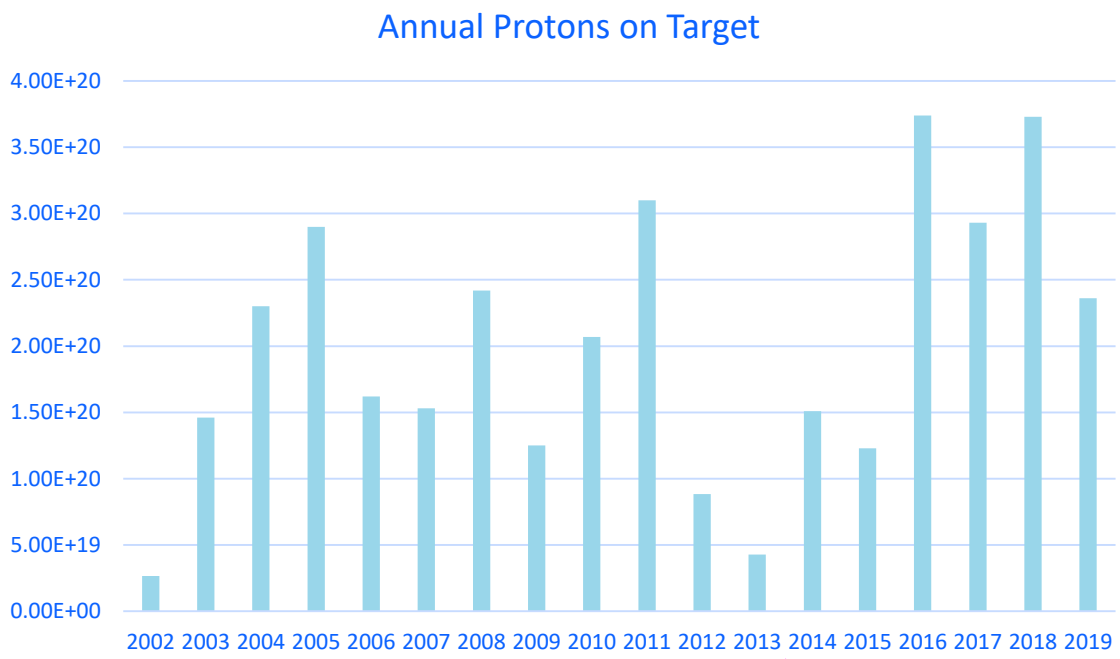
Booster

SB-ND (new)

ANNIE (new-ish)

Booster Neutrino Beamline Target Hall

Fermilab



Since turning on, BNB has transported 3.6E21 protons

The horns have pulsed ~3/4 of a billion times

BNB is assessed for 5×10^{12} protons per pulse at 5 Hz average

Off-target running (limited intensity)

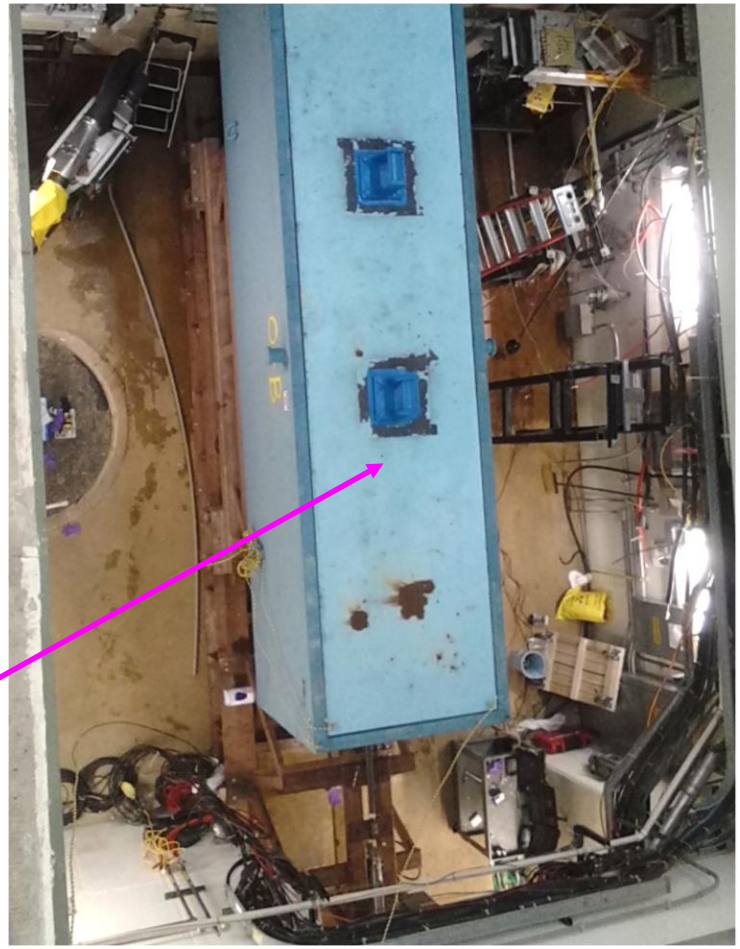
- The “big news” – Horn #2 failed
  - Alignment module also failed and had to be redesigned
  - Took advantage of time to inspect decay pipe
- Then Horn #3 developed a problem (fixed in place)
  - Upgraded target hall profile monitors
- Prior to Horn #2 failure:
  - Ran in “off target mode” for dark matter search
  - Installed temporary profile monitors at 25 m absorber (to measure beam trajectory)
- Since Horn #3 installation:
  - Installed rapid trim to facilitate off-target running if requested
  - Measured bunch length before and after bunch rotation
  - Upgraded accelerator signal distribution system to better serve broadened Short Baseline program

Horn #2 Failed

Horn is buried in target pile

Part of beamline is removed to allow for working space.

Horn is transferred directly into coffin, reducing exposure



Second Horn Trivia

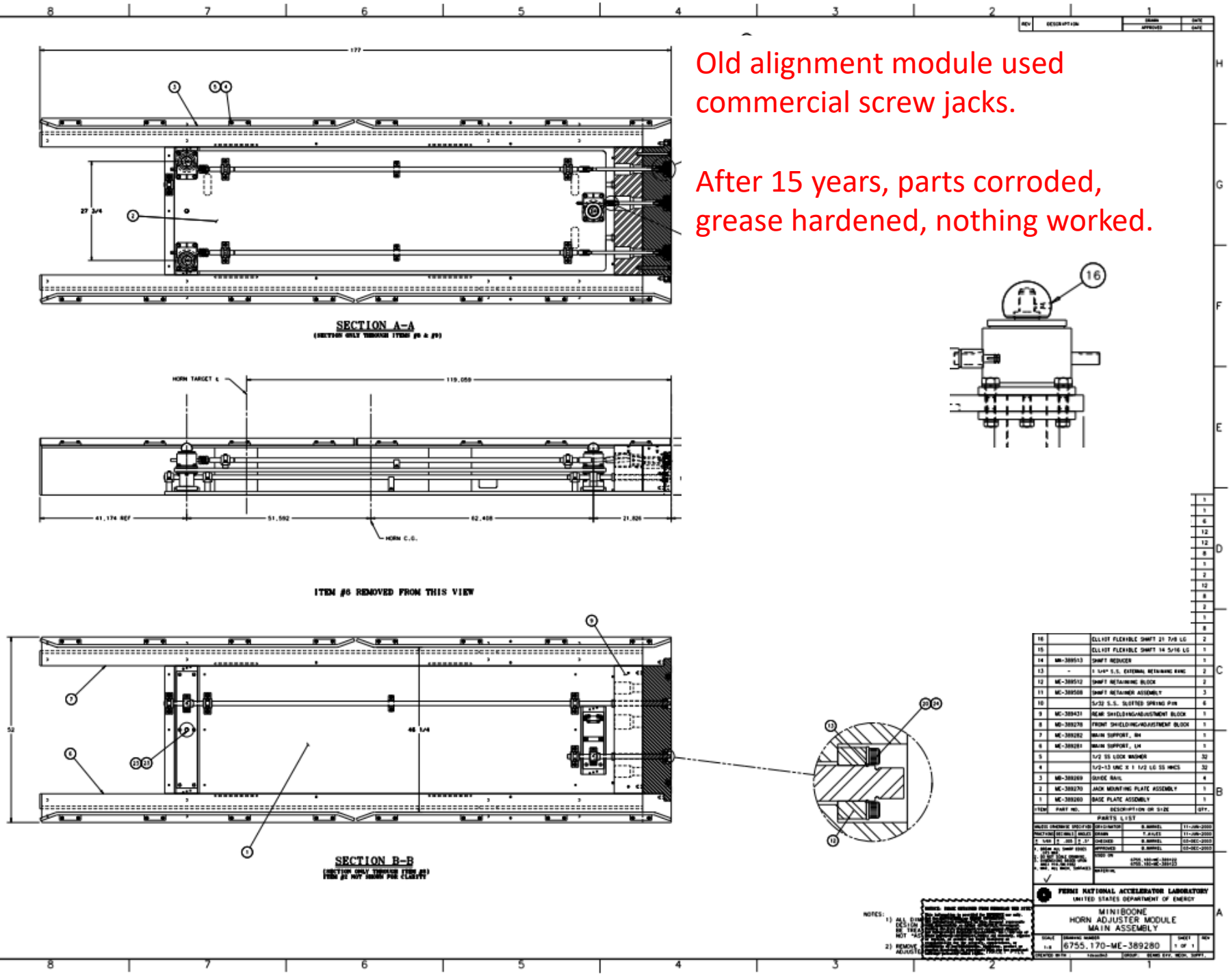
- December 2004 to 2015.
- 1/2 billion pulses.
- Two of the six water lines had been valved out due to leakage, but still had adequate cooling.
- Provided new data regarding fatigue of aluminum.
- Water is continually circulated, even during shutdowns and off-target running, to avoid stagnation.

Target and Horn Assembly

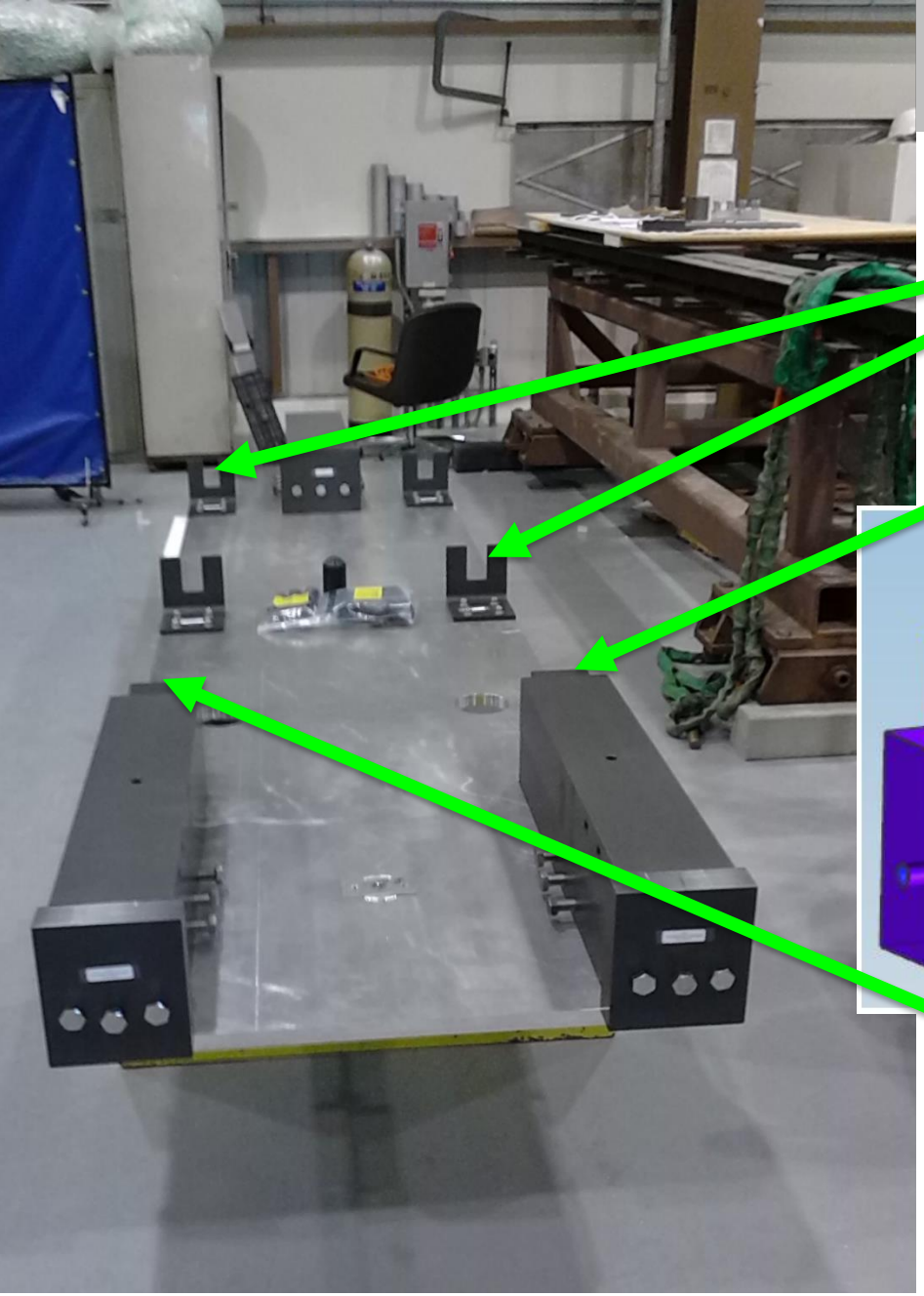
Target/Horn Assembly sits on an alignment module in the target pile
When we attempted to remove horn, found that alignment module no longer worked – needed a new alignment module

Old alignment module used commercial screw jacks.

After 15 years, parts corroded, grease hardened, nothing worked.

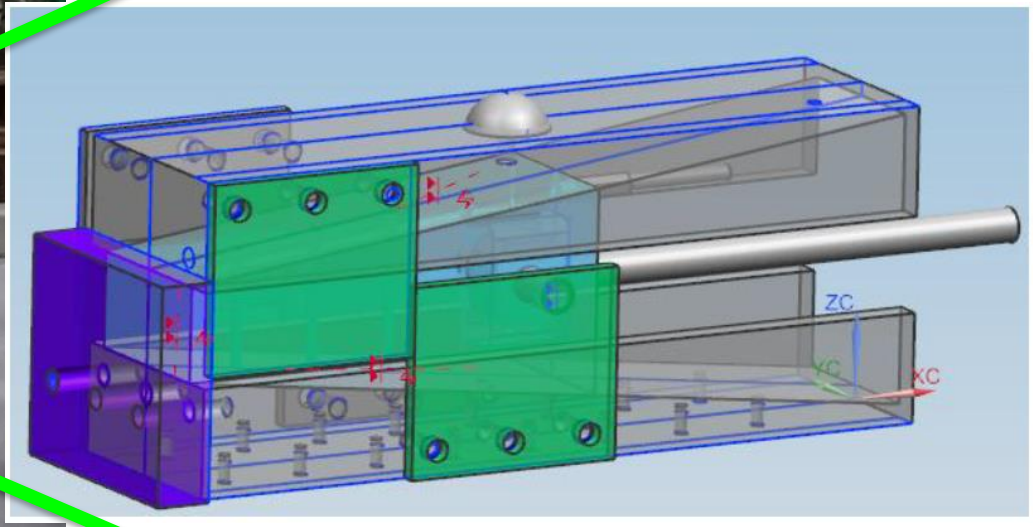


New Alignment Module



Brackets to hold push rod

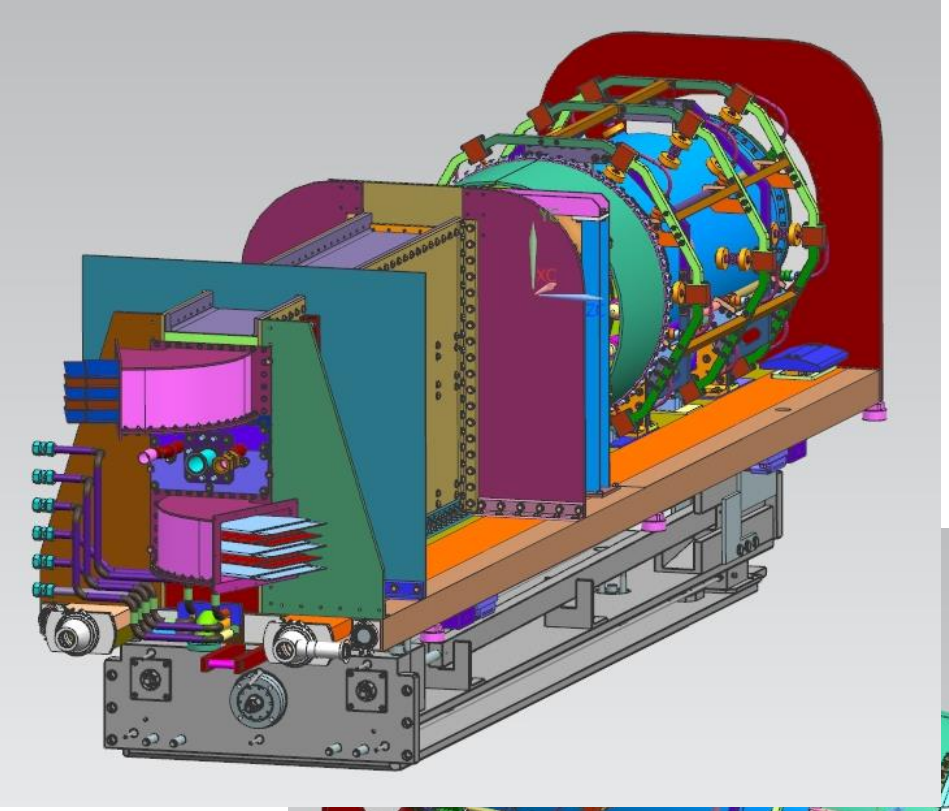
Moving parts are anodized and have provision for air bearing

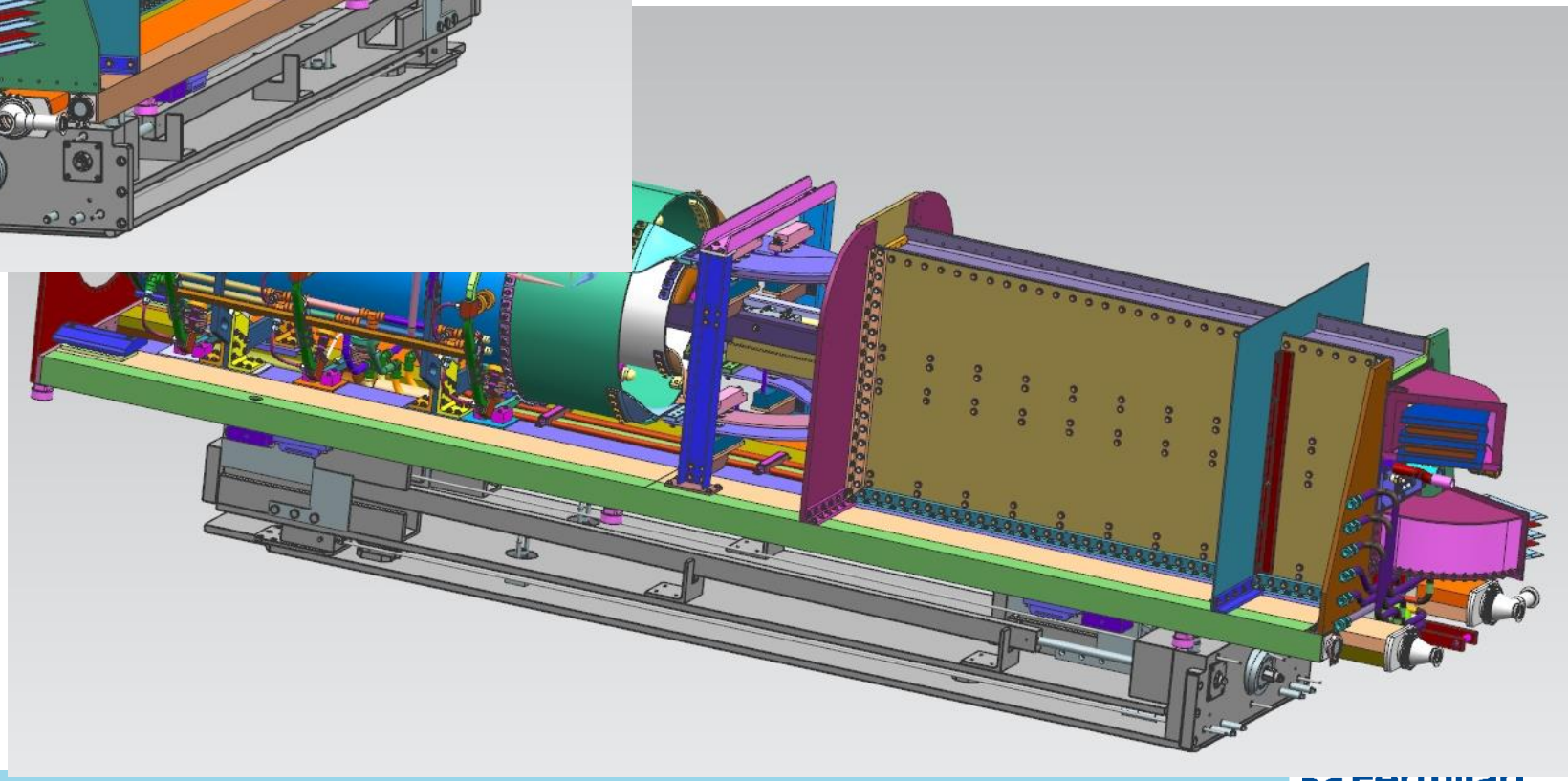


Lifting Wedge

Design by D. Pushka, AD/Target Systems

Fermilab



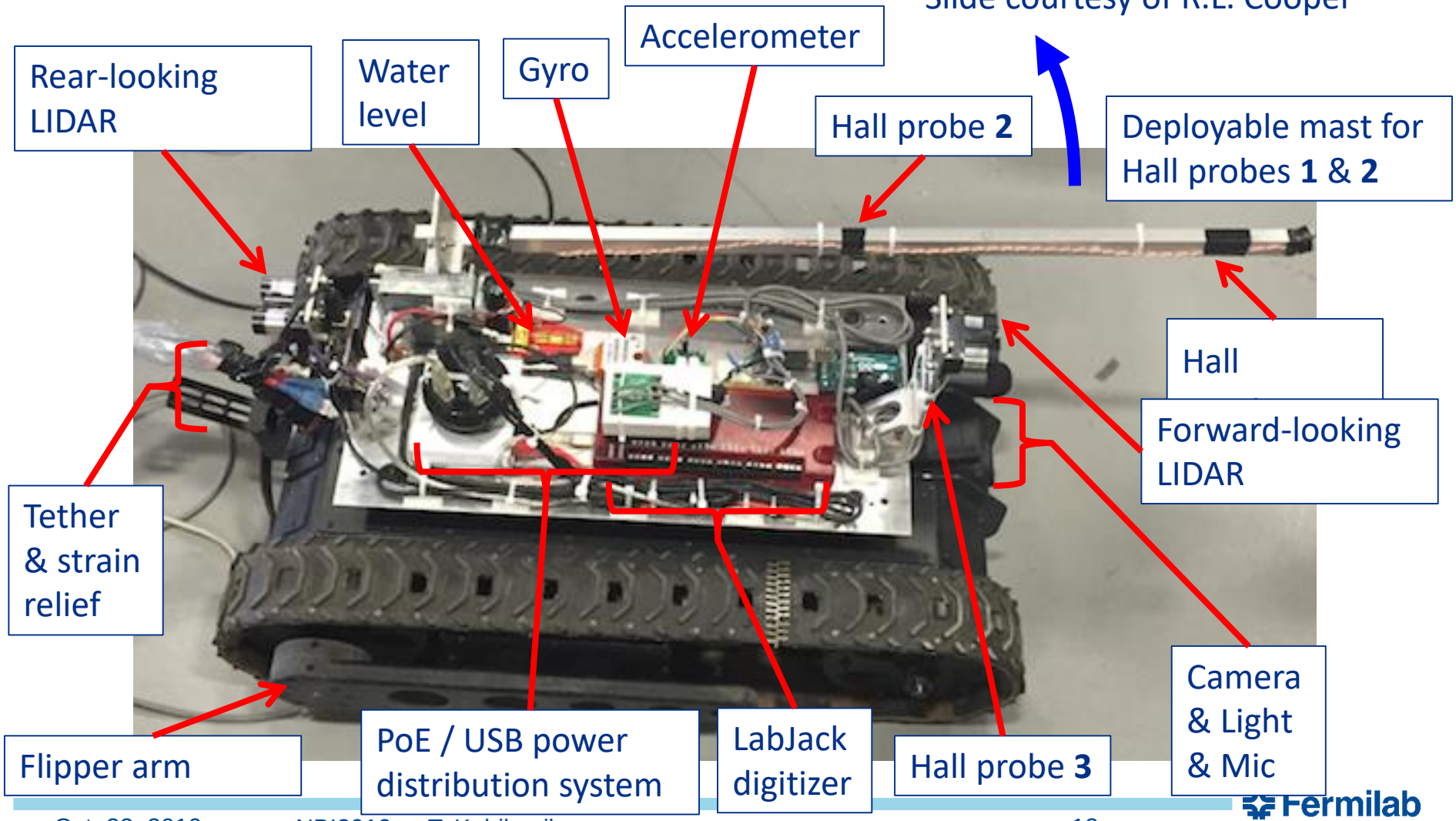


While the new alignment module was being designed …

FRED*: Instrumentation Package

*Finding Radiation Evidence in the Decay pipe

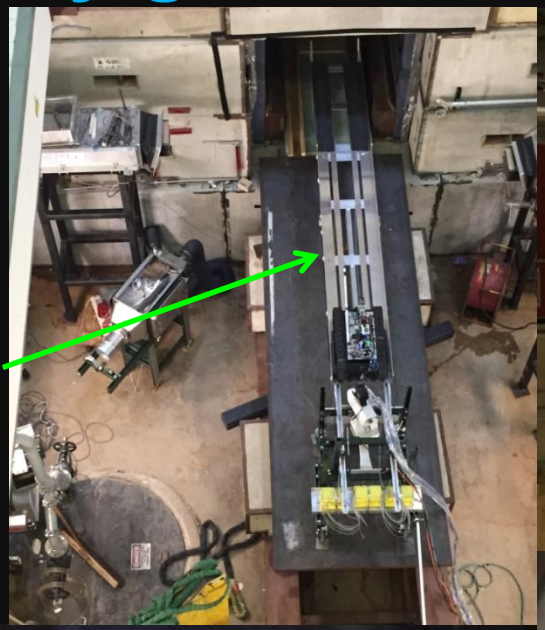
Slide courtesy of R.L. Cooper



Fermilab

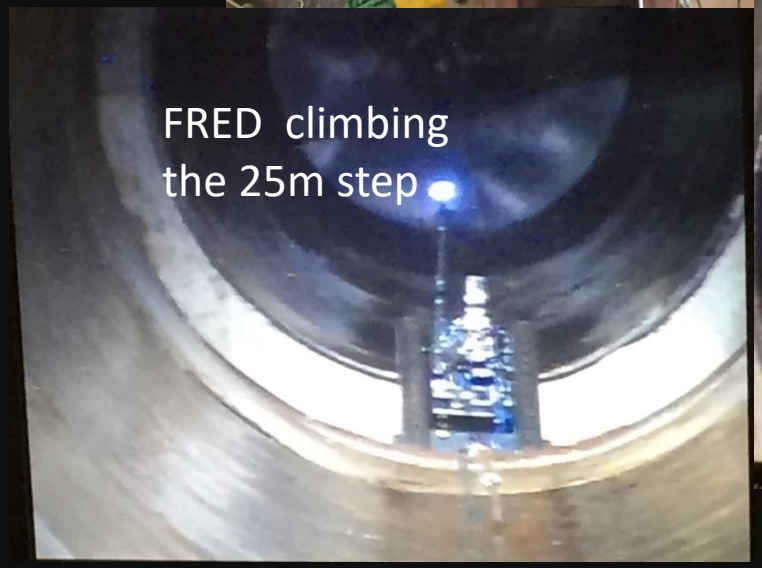
Boldly go where no one has gone…

FRED ready to go into the horn chase



Deployment Ladder

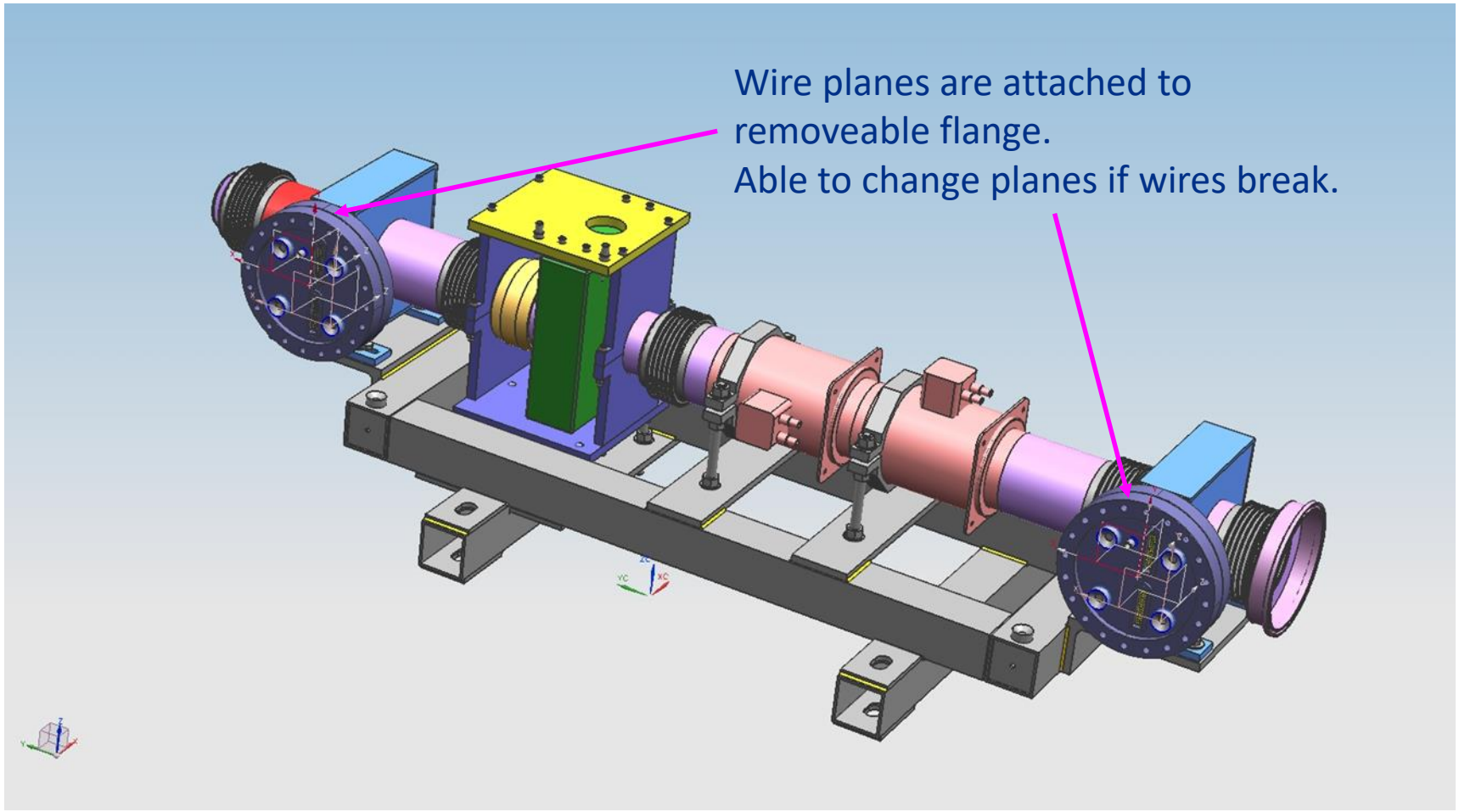
FRED in the collimator



FRED climbing the 25m step

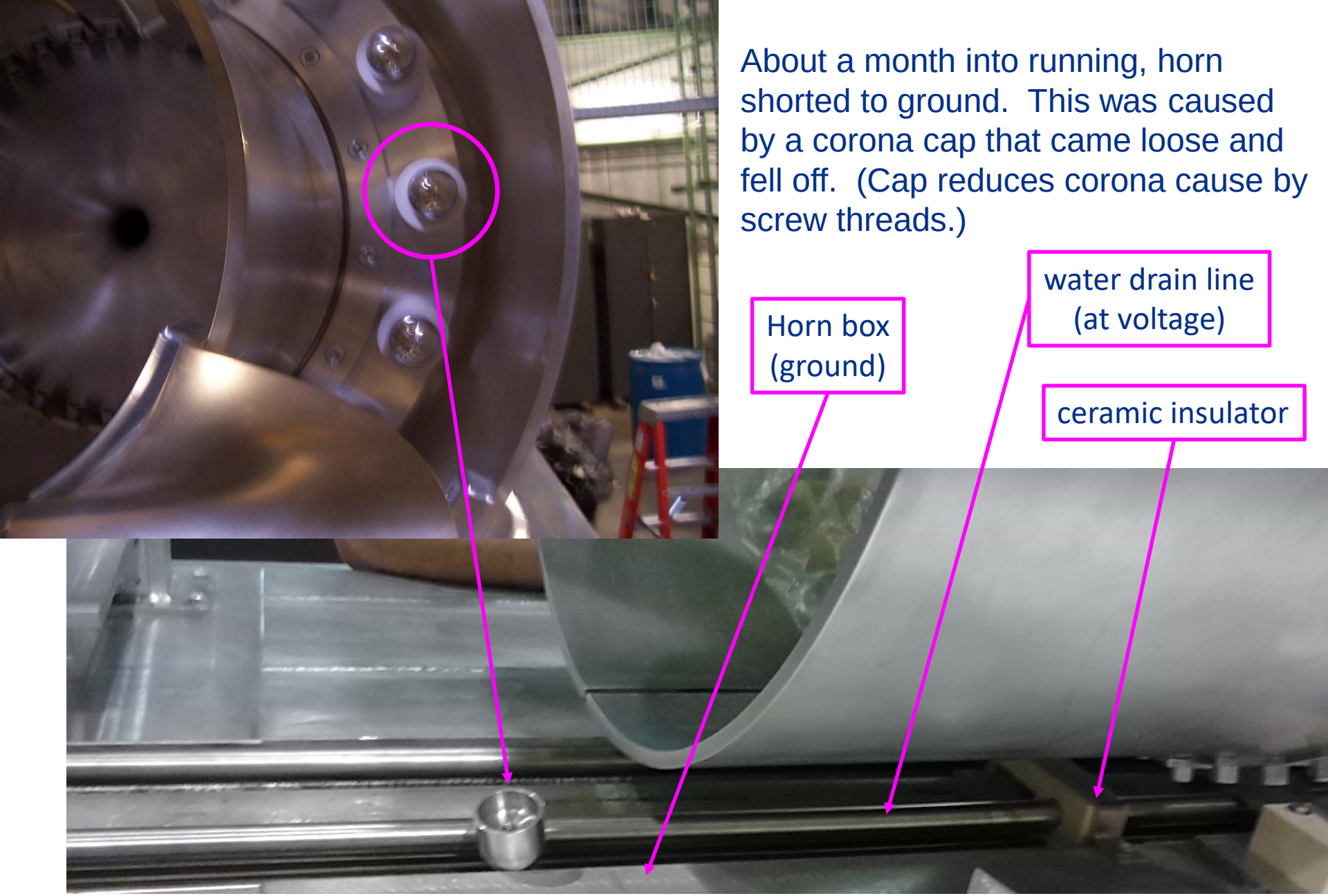
FRED at the 50m absorber, what the heck is that…

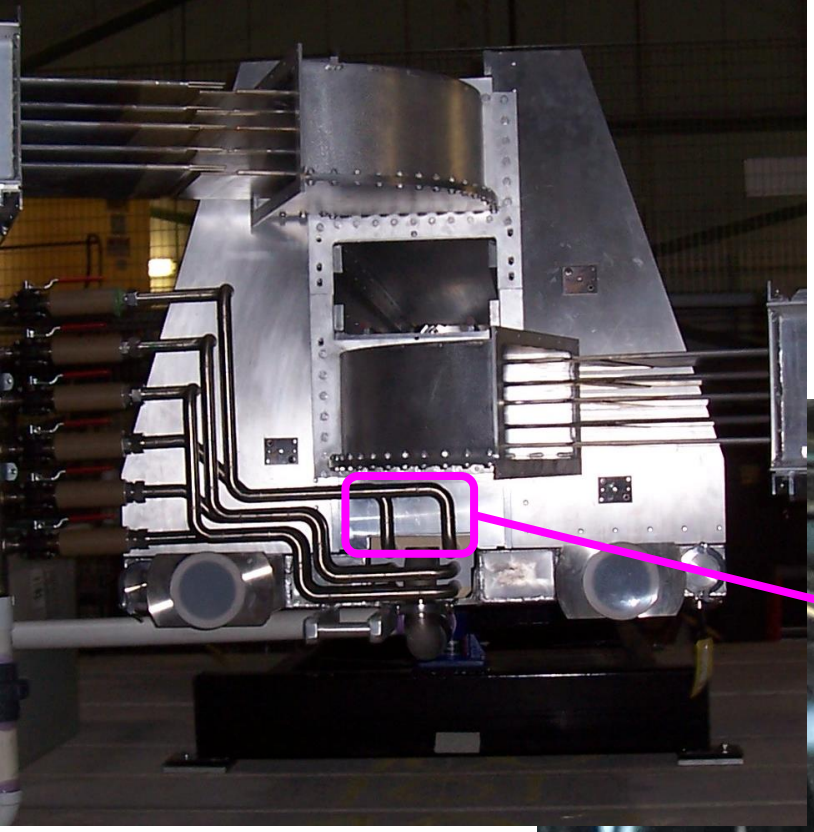
Fermilab



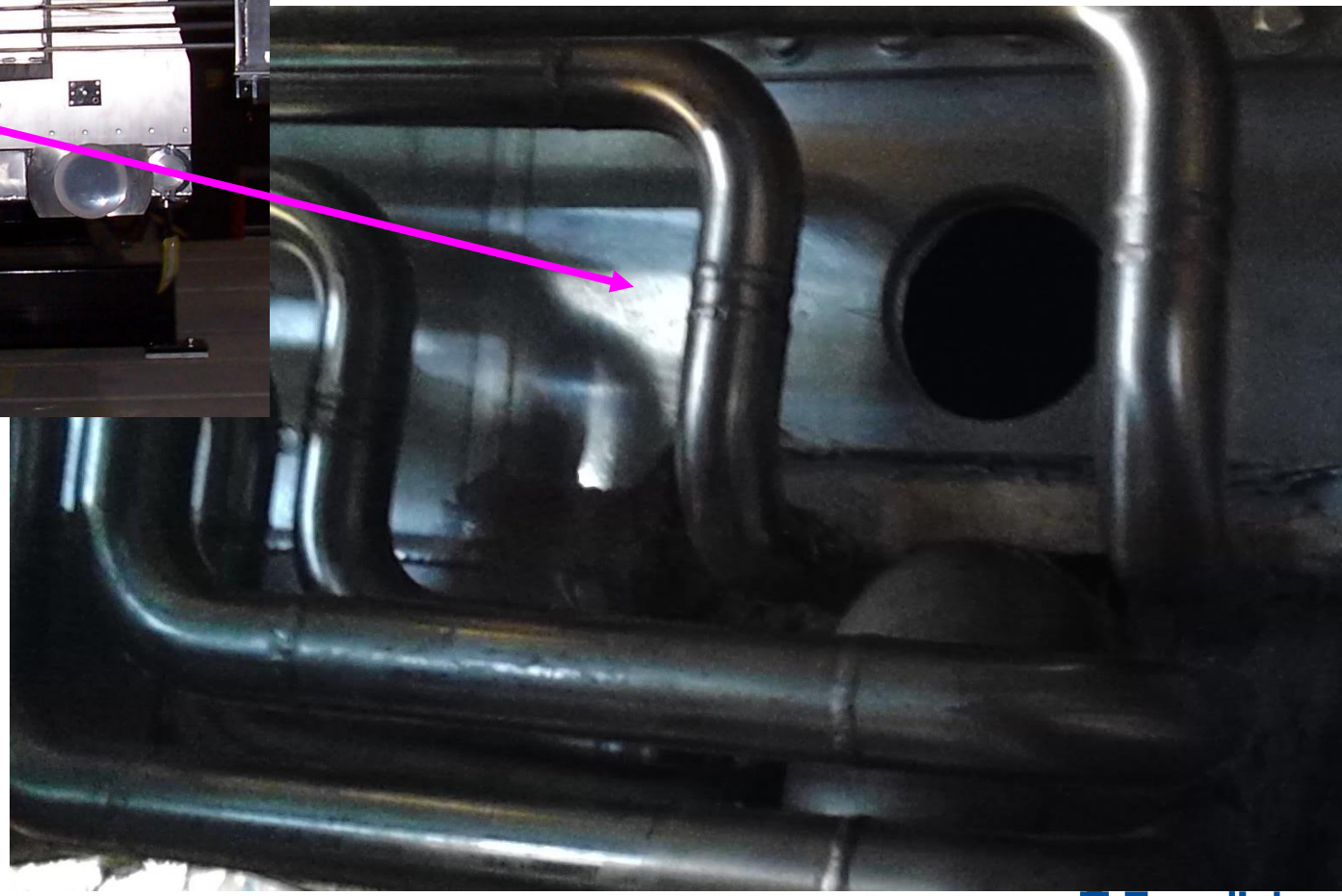
Second generation low-mass multiwires. Welded joints, easy access to wire plane, more robust mechanical design. Separation between planes remains at 110 cm and planes retain 0.5 mm pitch. New instrumentation package was installed during Spring, 2015, horn change.

About a month into running, horn shorted to ground. This was caused by a corona cap that came loose and fell off. (Cap reduces corona cause by screw threads.)





Hole in horn box through which the corona cap was removed.

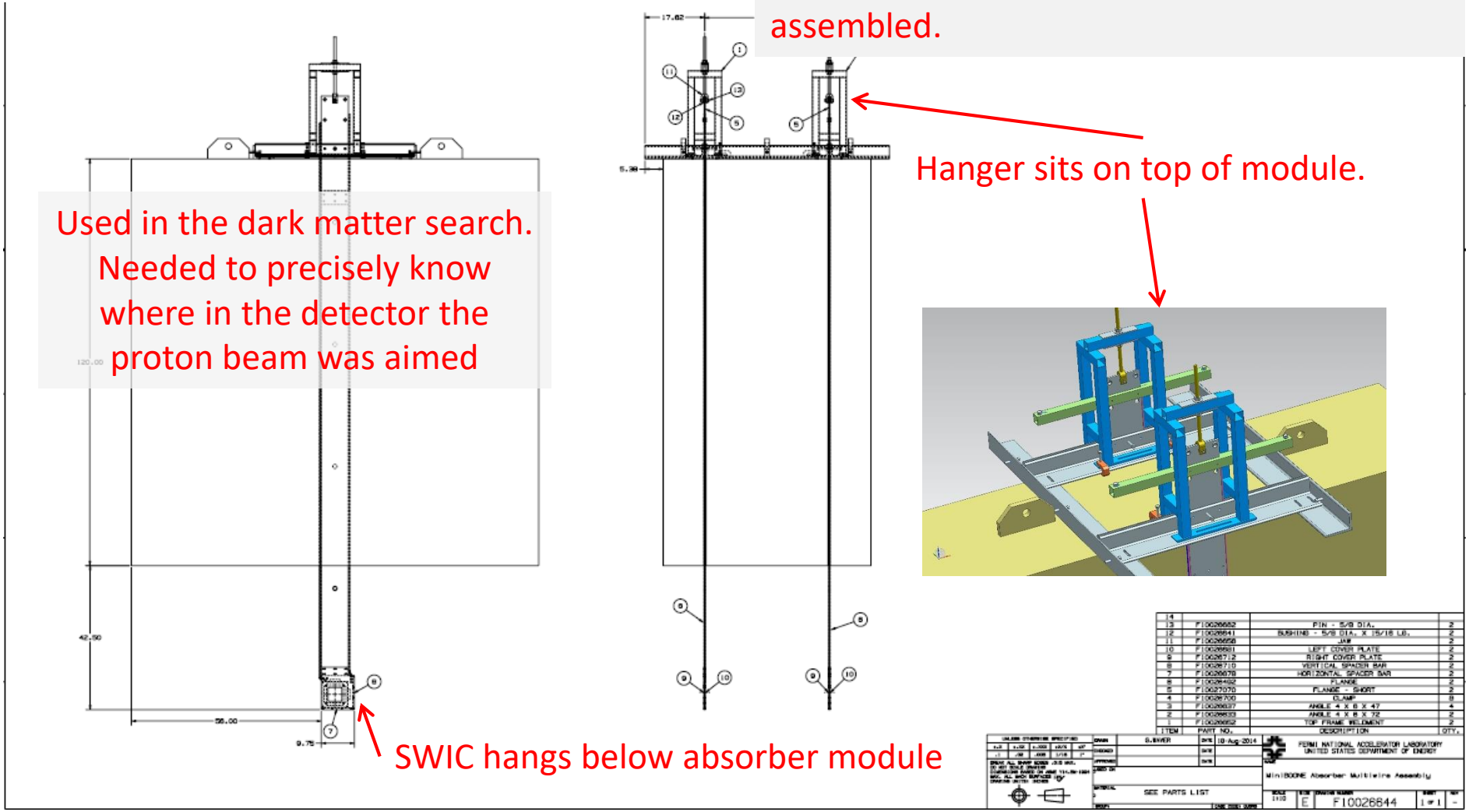


Access port is now a feature of BNB horns

Rewind to before Horn #2 failure

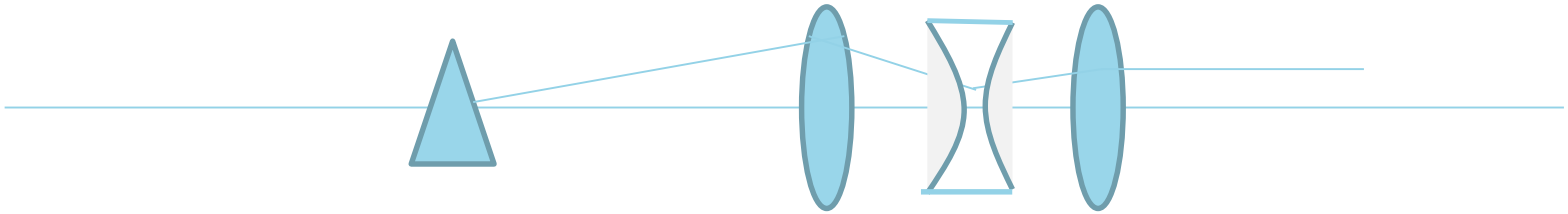
Temporary Profile Monitors at 25 m Absorber

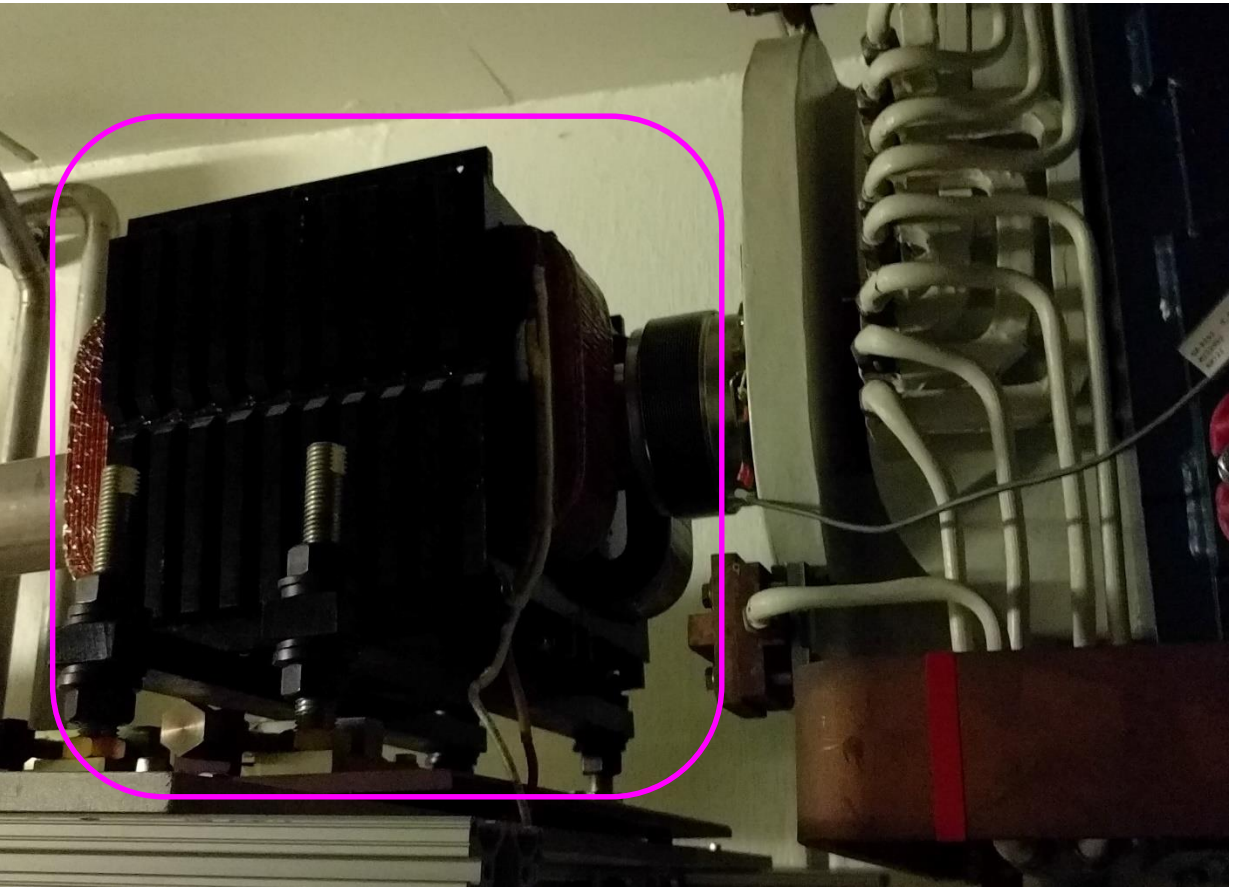
Profile monitor wires are referenced to fiducials on top of hanger. Referencing can be done in the shop with entire hanger assembled.



Forward to Horn #3 running

Rapid Trim Magnet for Off-Target Running





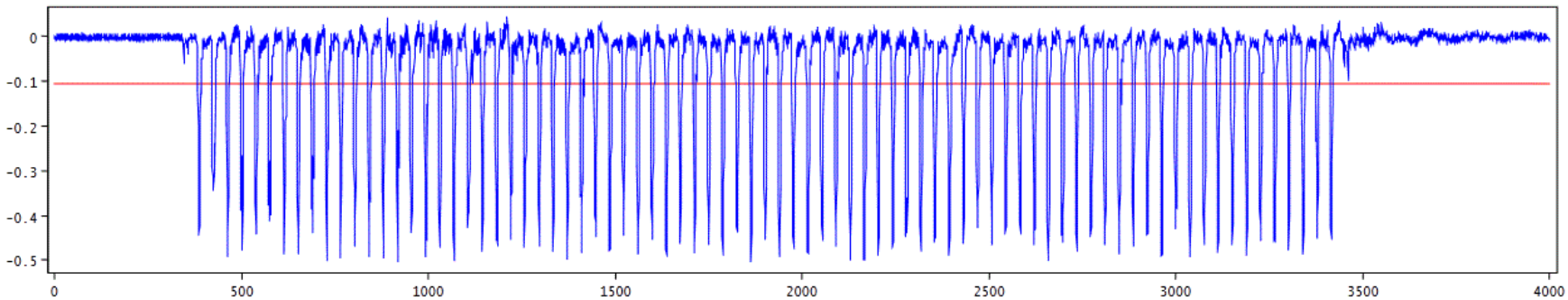
Installed at upstream focal point of final focusing triplet.

(Converts an angular kick to a parallel offset)

Able to ramp up and down in <1/30 of a second (half a Booster cycle).

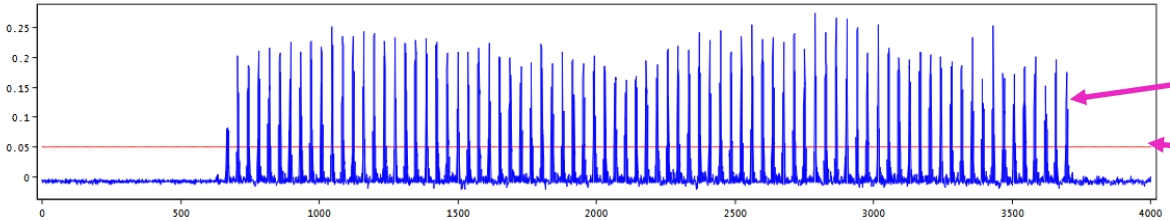
Can be triggered independently of horn – not rate limited by horn.

Resistive Wall Monitor Put to Use



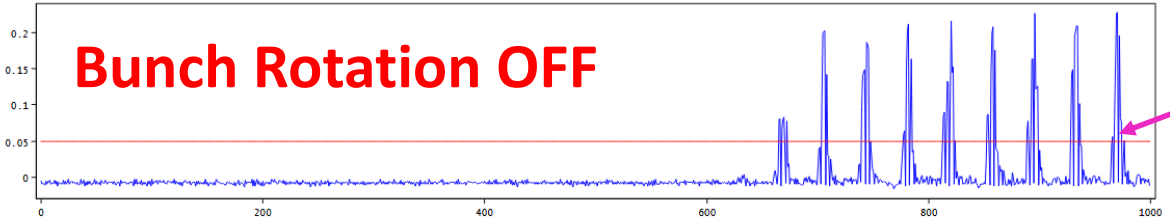
2 GHz sample rate over entire spill.

Data is recorded every pulse, and is available through the Intensity Frontier Beam Database.



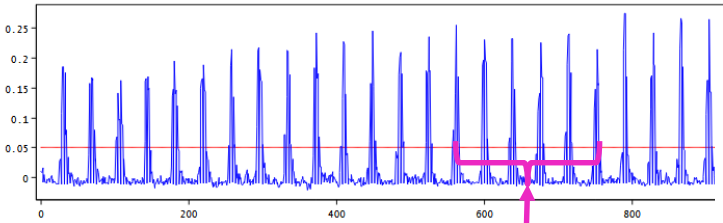
Individual bunches

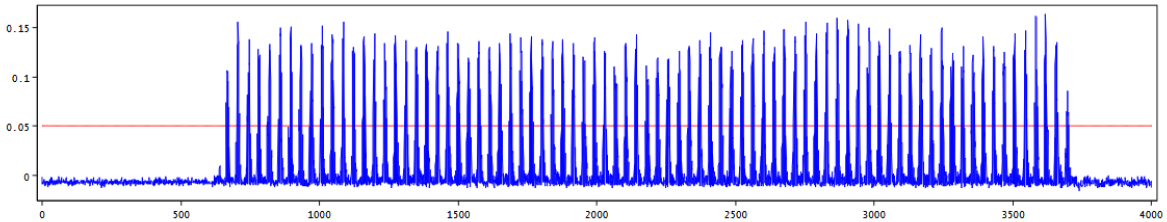
Trigger threshold



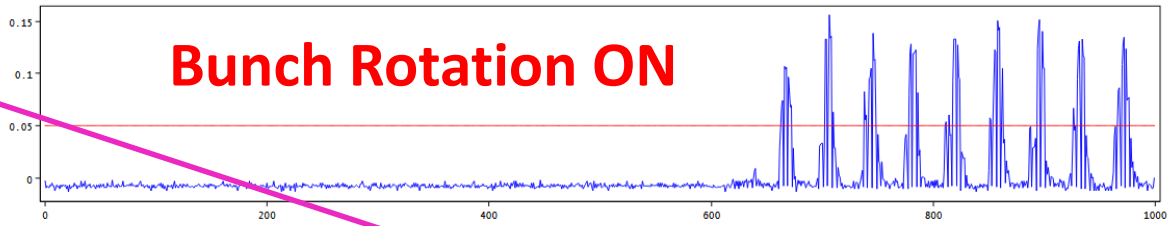
Problem with digitizer – drops every fourth record

Digitizer measures voltage induced by



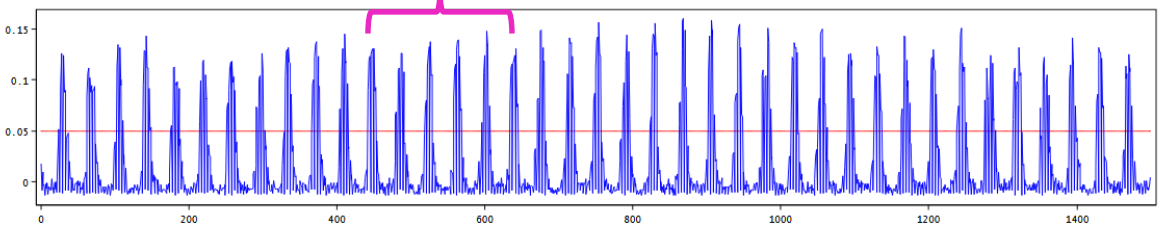


Spacing between bunches remains the same



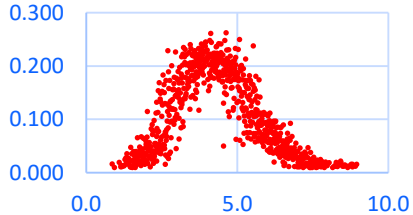
Beam looks “broader”

How much?



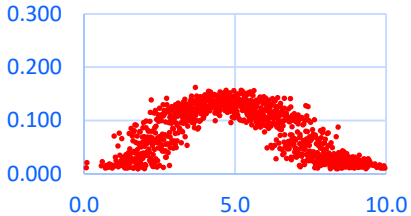
Bunch Rotation

Bunch Rotation OFF



(horizontal units: ns)

Bunch Rotation ON



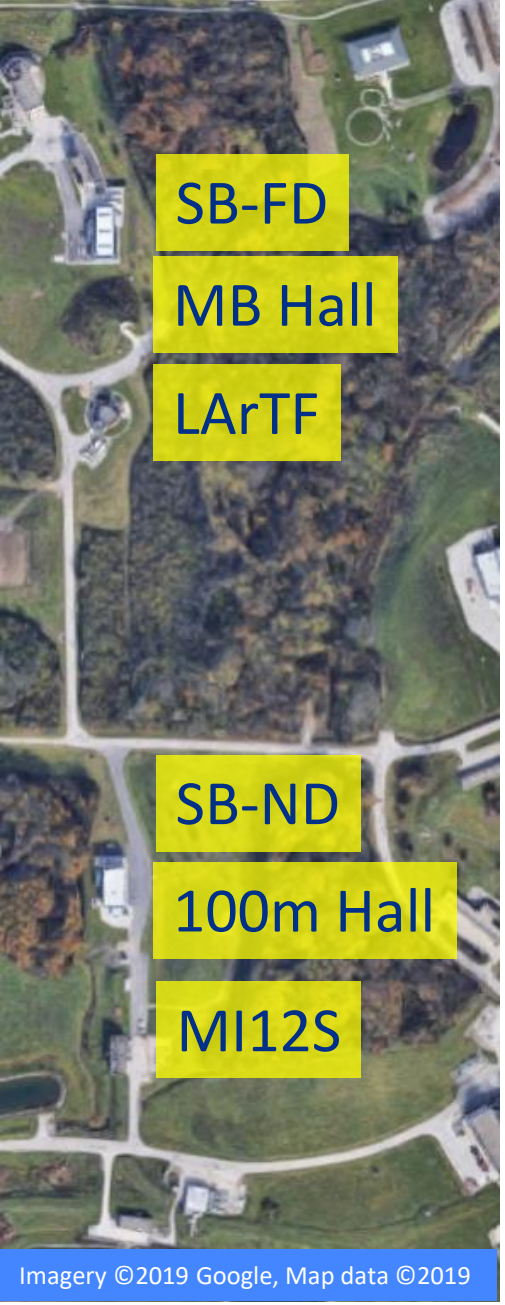
(horizontal units: ns)

Based on 10 measurements each with bunch rotation on and off, bunch rotating the beam increases the 1-sigma time-spread at the resistive wall monitor from 1.48±0.03 ns to 2.15±0.13 ns.

Increase time spread, but decrease momentum spread.

Beam is smaller in high-dispersion regions → lower losses.

Under good conditions, the hourly rate could increase by ~7%.



Accelerator Signals

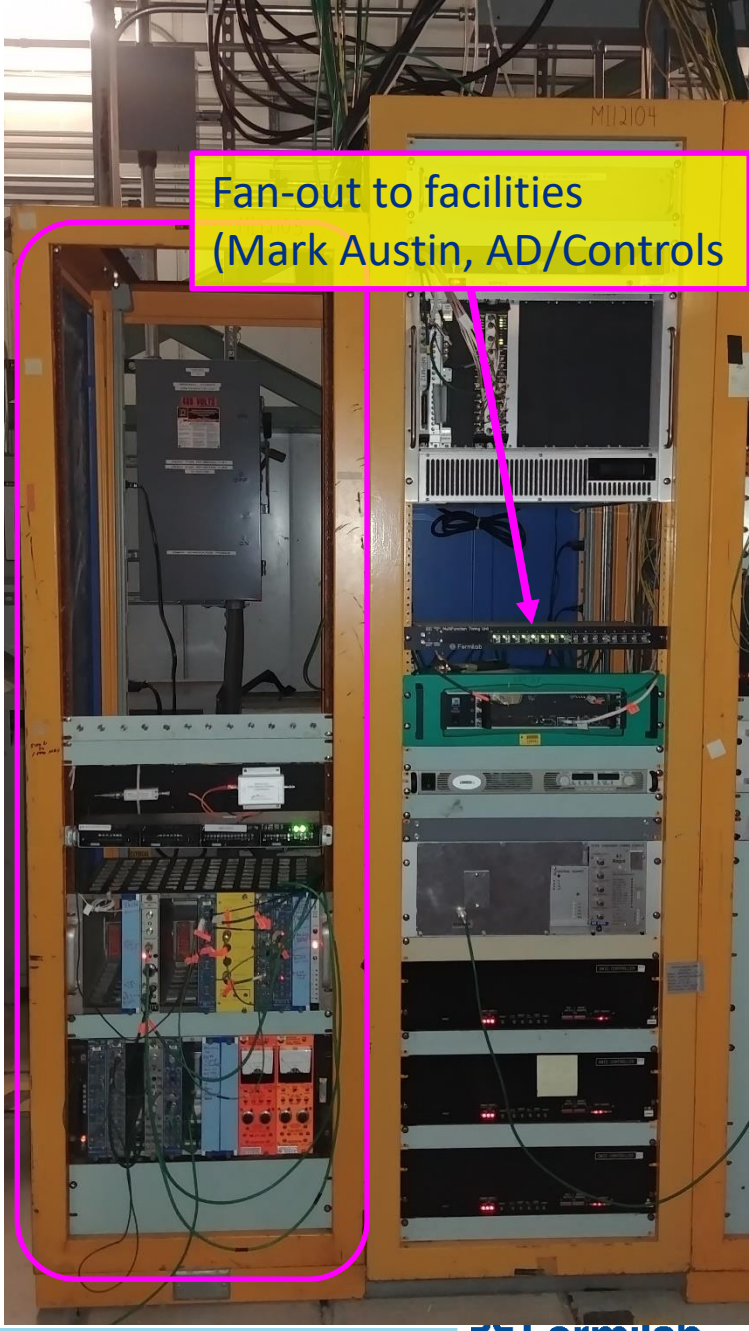
Many useful signals (Booster extraction, beam crossing RWM) are available in MI12S

Had been treating them as one-offs when sent to individual experiments

Coordinating with Neutrino Division to send standard signals to each facility. From that point, experiment can use as needed.

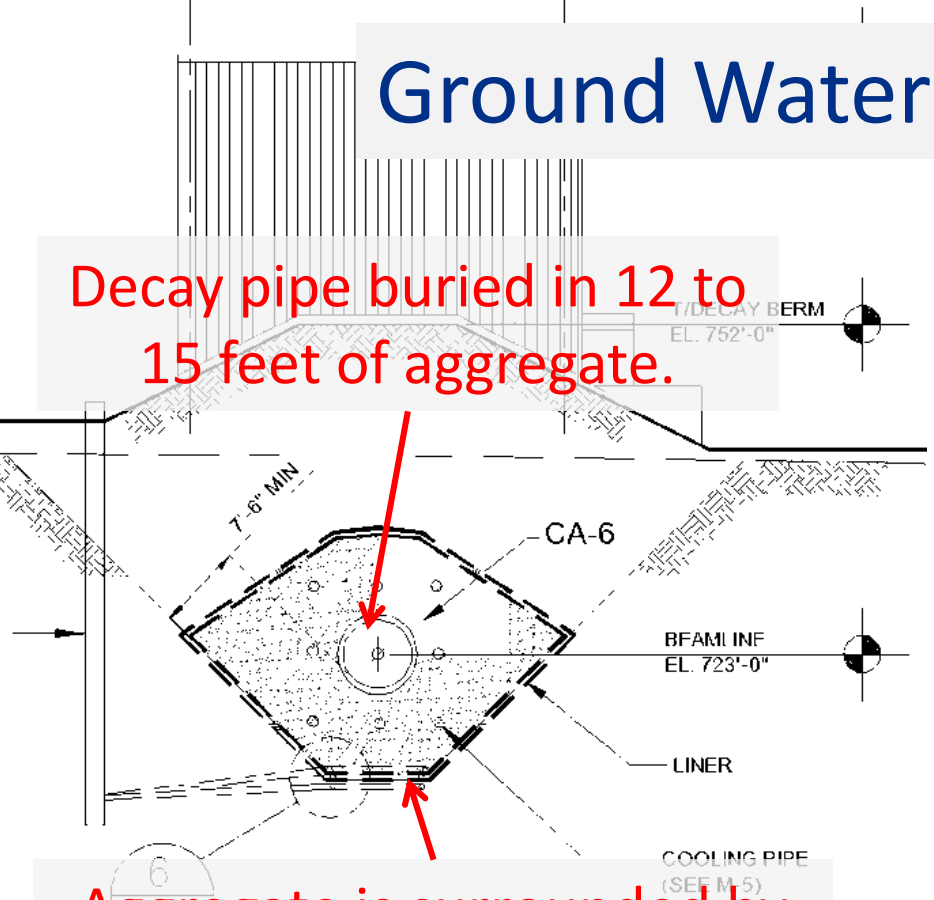
Dedicated rack in MI12S for experiments to use. Provides clean separation between AD and EXP hardware.

Effort lead by Alyssa Miller, AD/External Beams



Ground Water Problems

Decay pipe buried in 12 to 15 feet of aggregate.



Aggregate is surrounded by two impermeable liners.

Early on we found a leak in the impermeable liners

Install high-density polyethylene cover to keep water away from liner.

This did not work, either

Project lead by Cons Gattuso
AD/Engineering Support

Backup Slides


M112104
M112105
480 VOLTS


M112105

Beamline -- Schematic

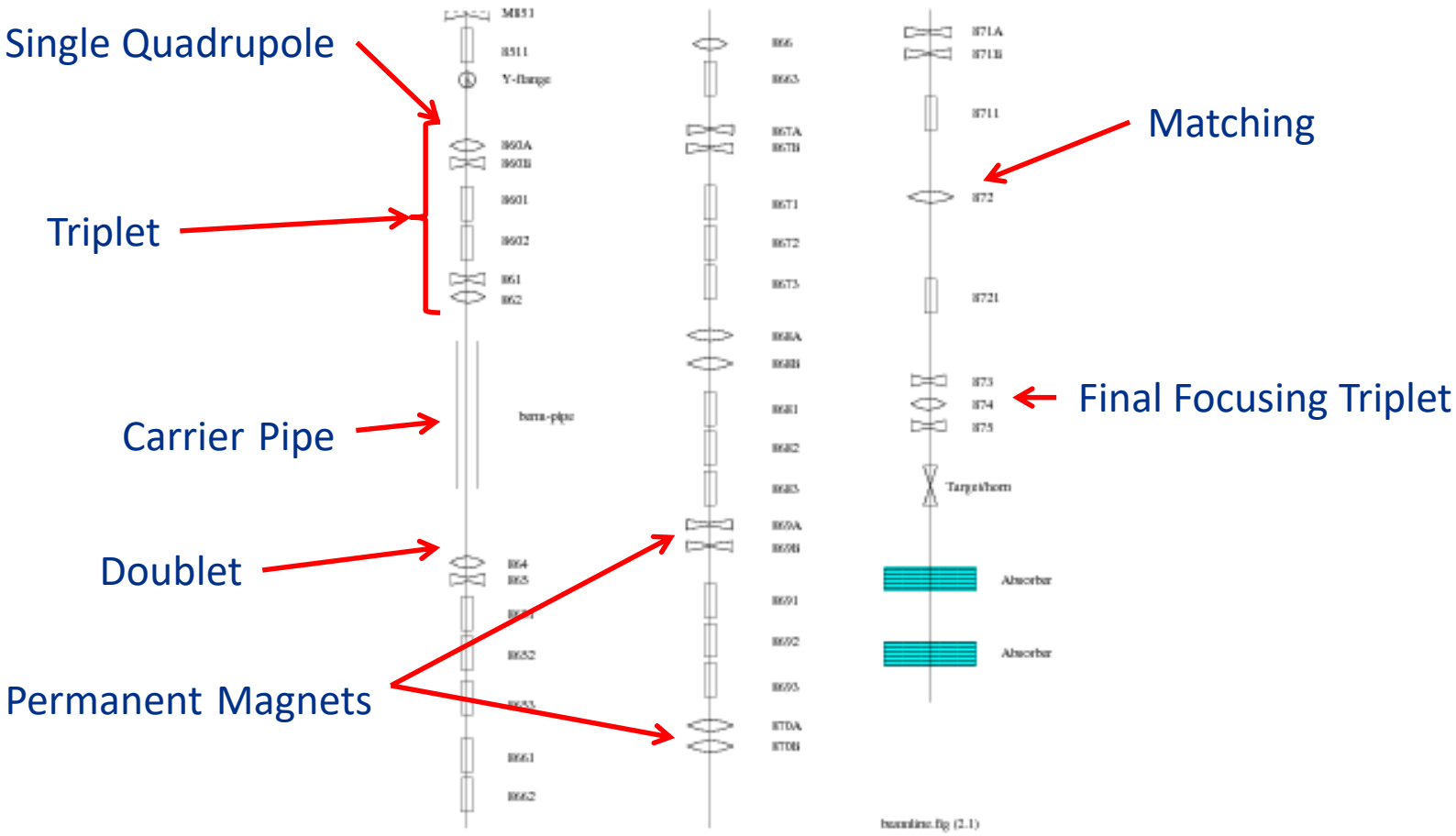


Figure 2.1: Beamline schematic and function. Elements are listed in Table 2.1.