Booster Neutrino Beamline Facility Operations Update Present & Future

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September 23, 2014

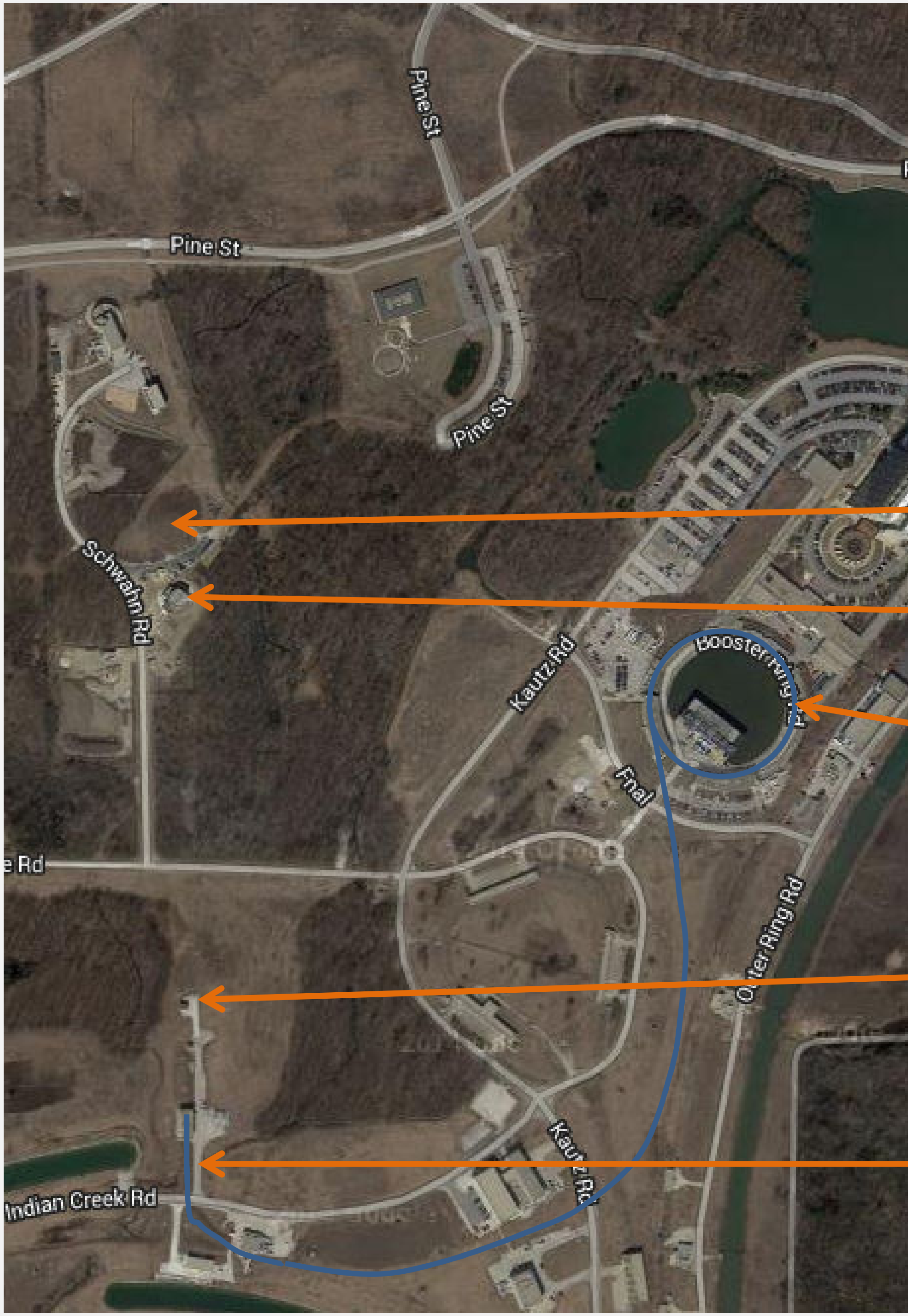
Neutrino Beams and Instrumentation, 2014

SEPTEMBER

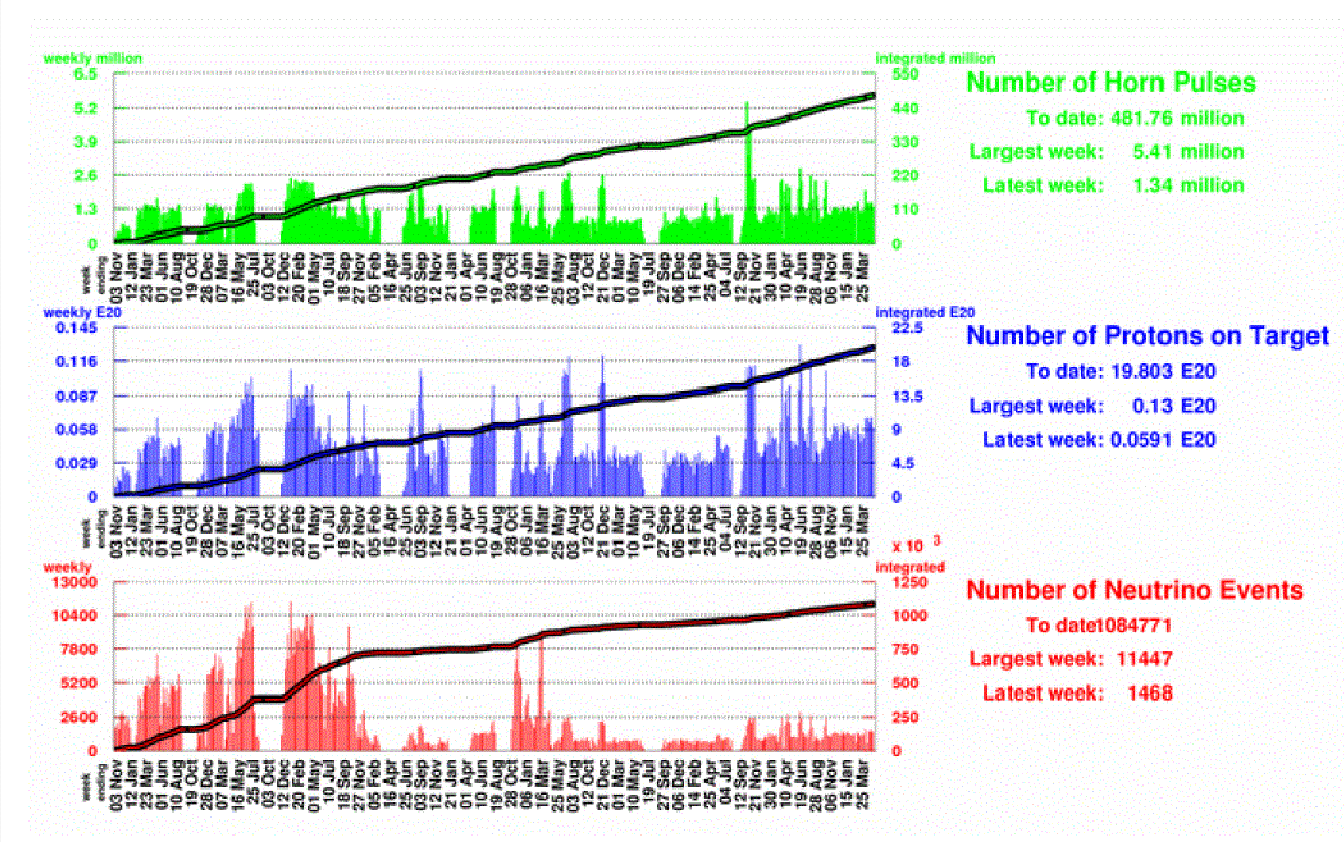
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

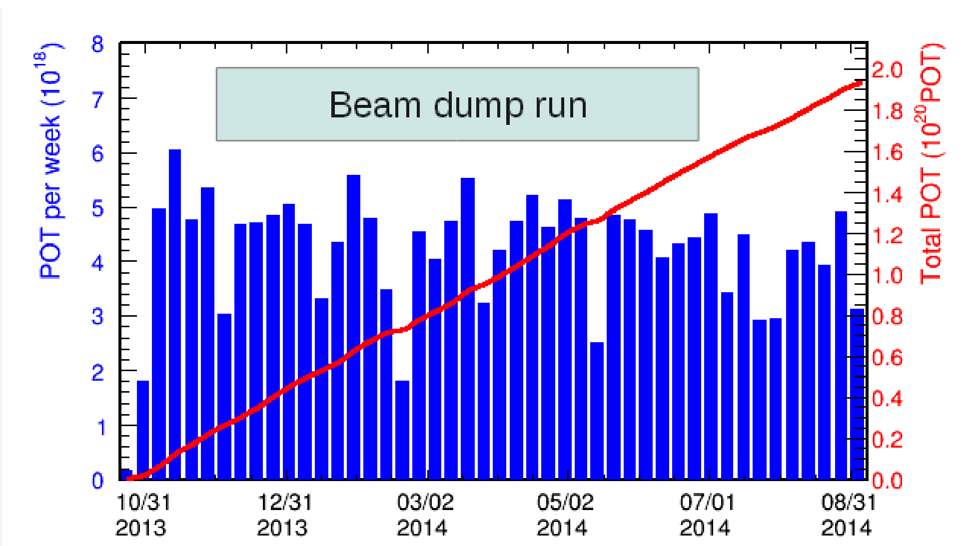
PRESENT

Booster Neutrino Beamline and Detectors




Primary
Beamline

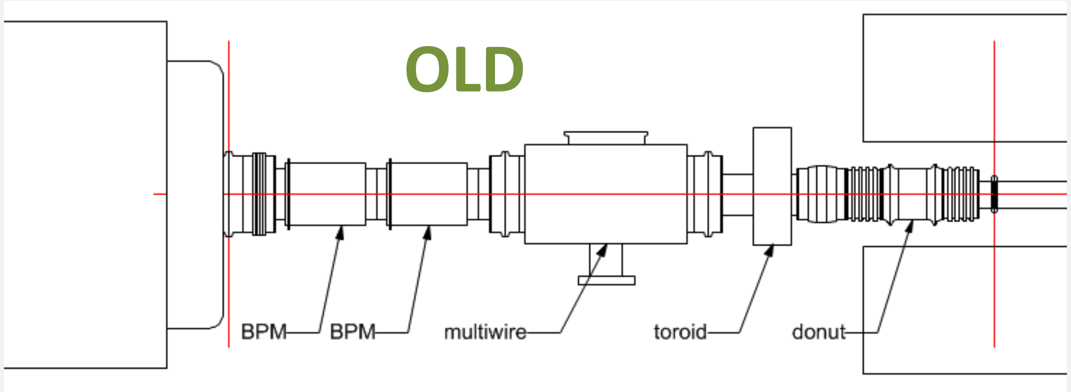




Since turning on, BNB has transported 2.1E21 protons.

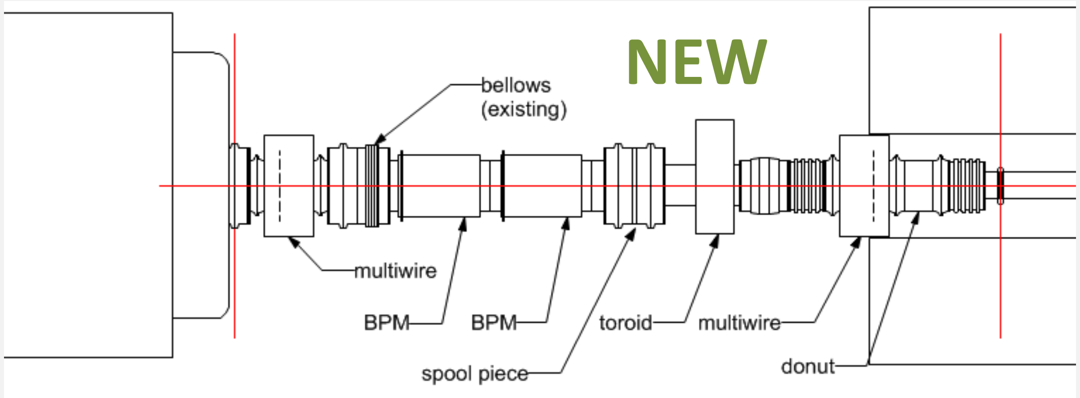
The horns have pulsed half-a-billion times.

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

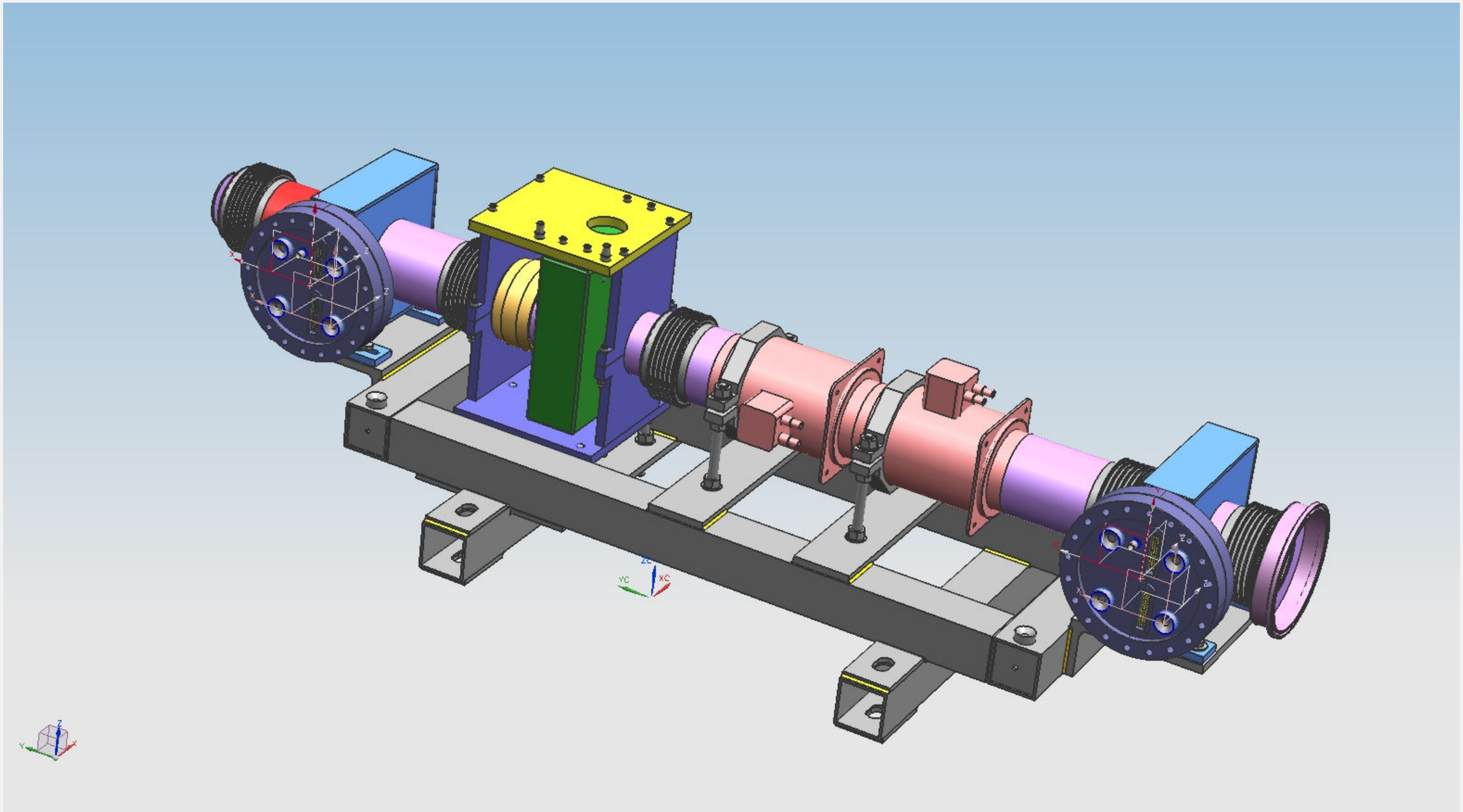


Old instrumentation was able to keep beam on target, measure intensity, and measure beam width when needed.

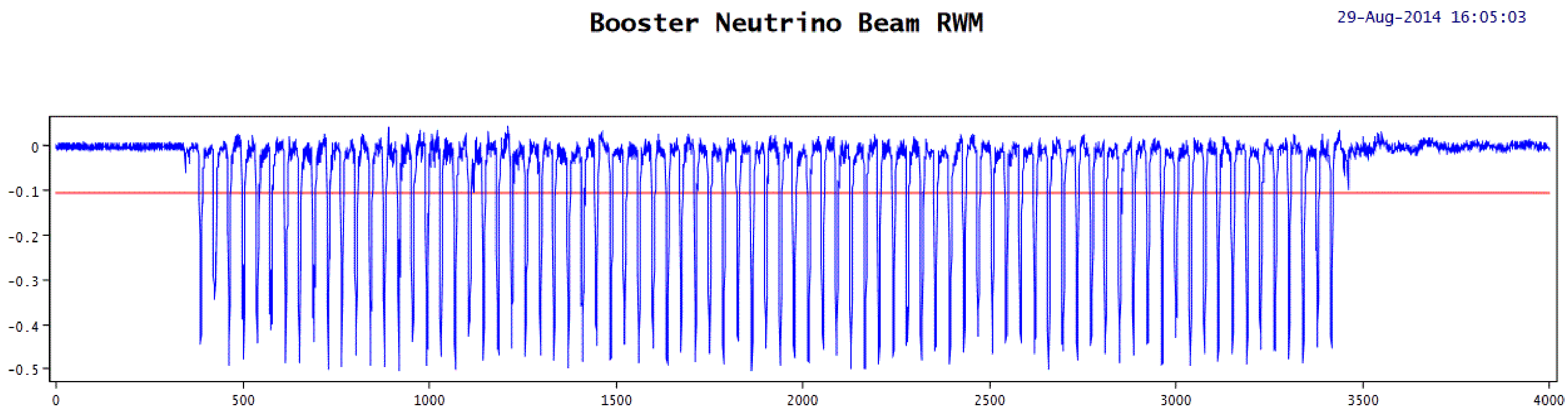
New instrumentation employs low-mass multiwires, allowing continual monitoring of beam shape.



Additionally, we are able to reference multiwires to external coordinate system, allowing us to locate beam position and trajectory in site coordinate system.



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 will be installed when horn is changed.



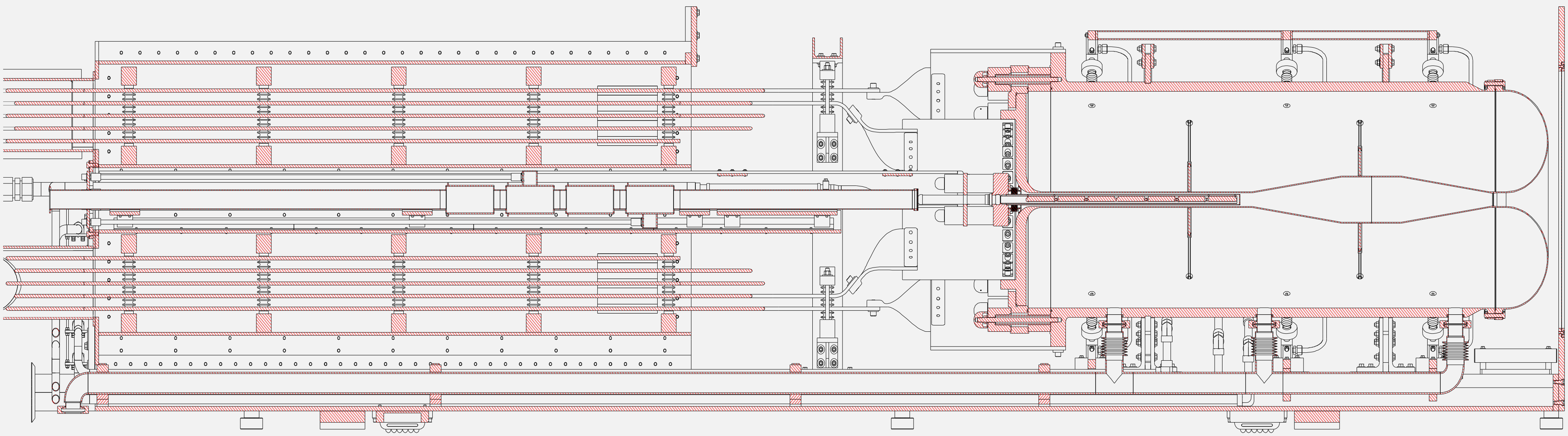
2 GHz sample rate over entire spill.

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

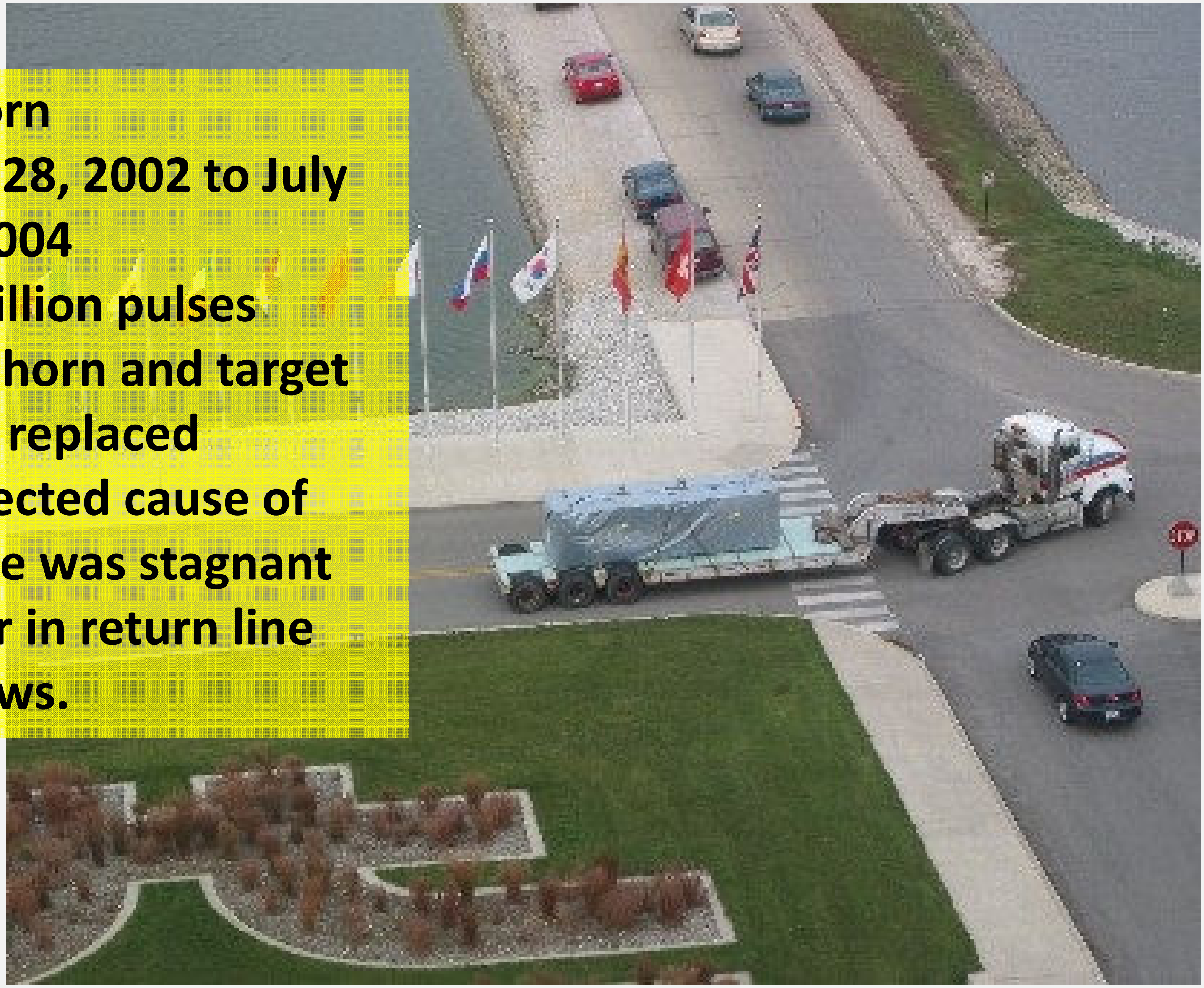
Secondary Beamline and Associated Systems

Target and Horn Assembley

Designed by Larry Bartoszek
Built by AD Mechanical Support Target Group
Present engineer is Vladimir Sidorov

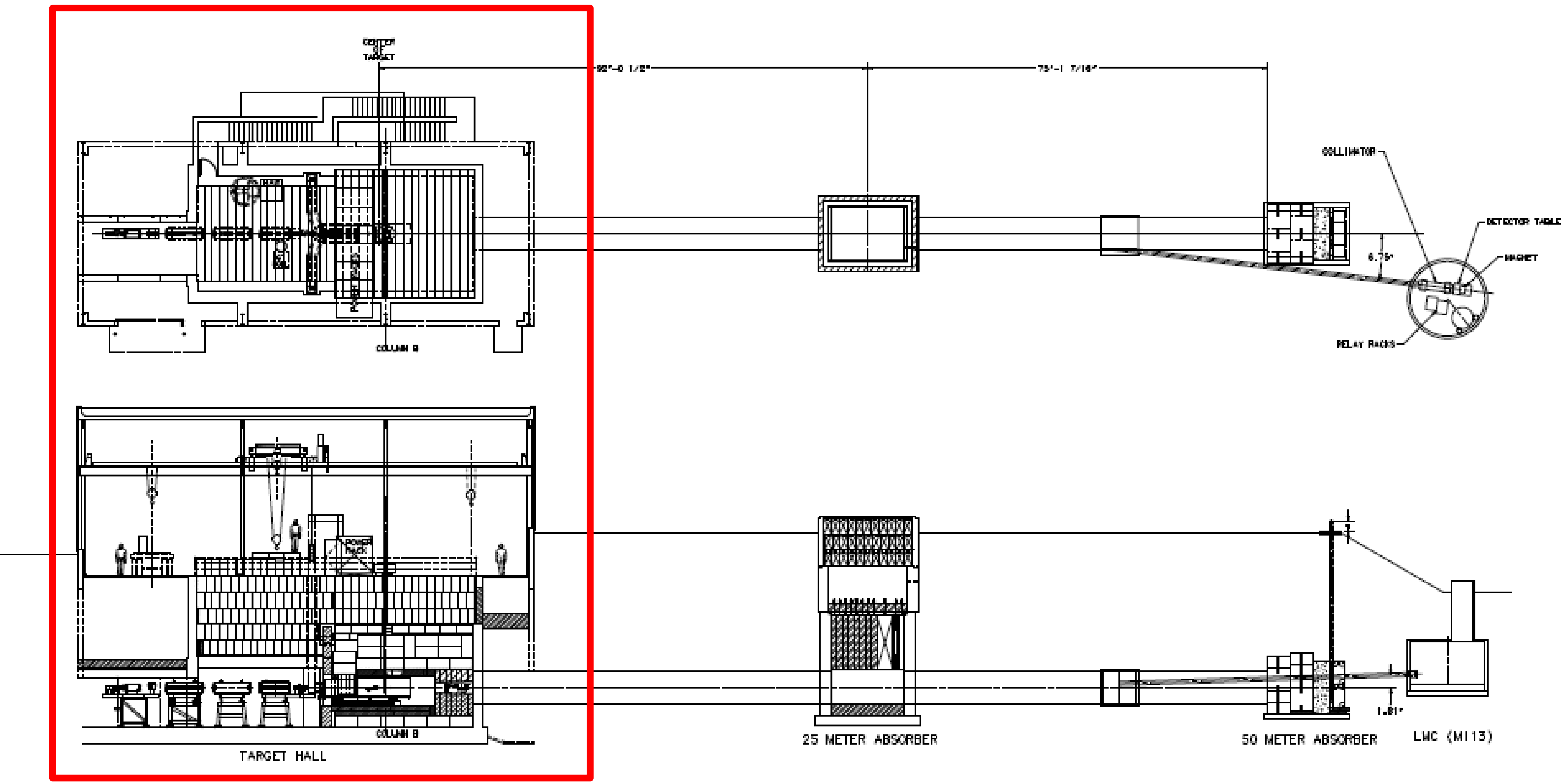


Target and horn are built and installed as a single unit, although it is possible to change only the target.

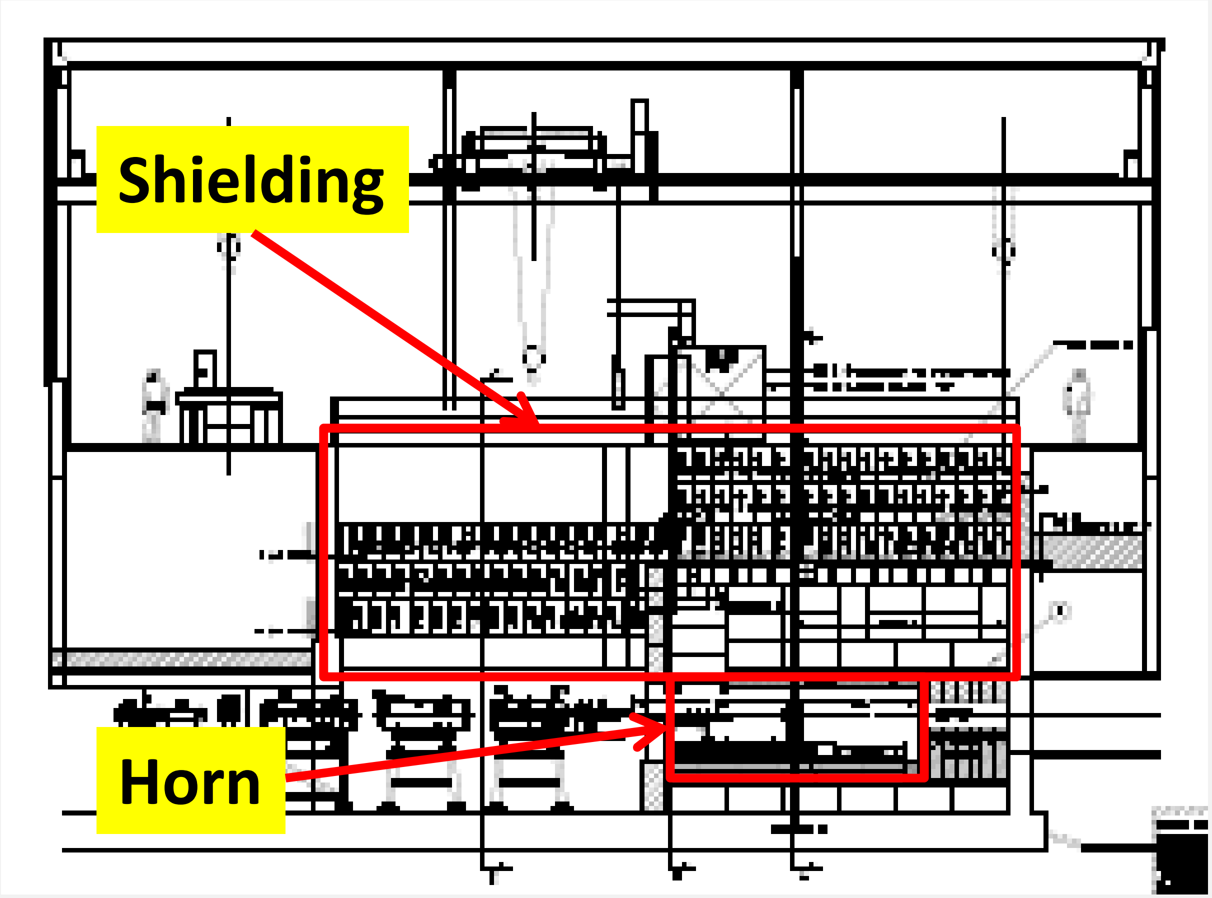


First Horn

- April 28, 2002 to July 28, 2004
- 97 million pulses
- Both horn and target were replaced
- Suspected cause of failure was stagnant water in return line bellows.

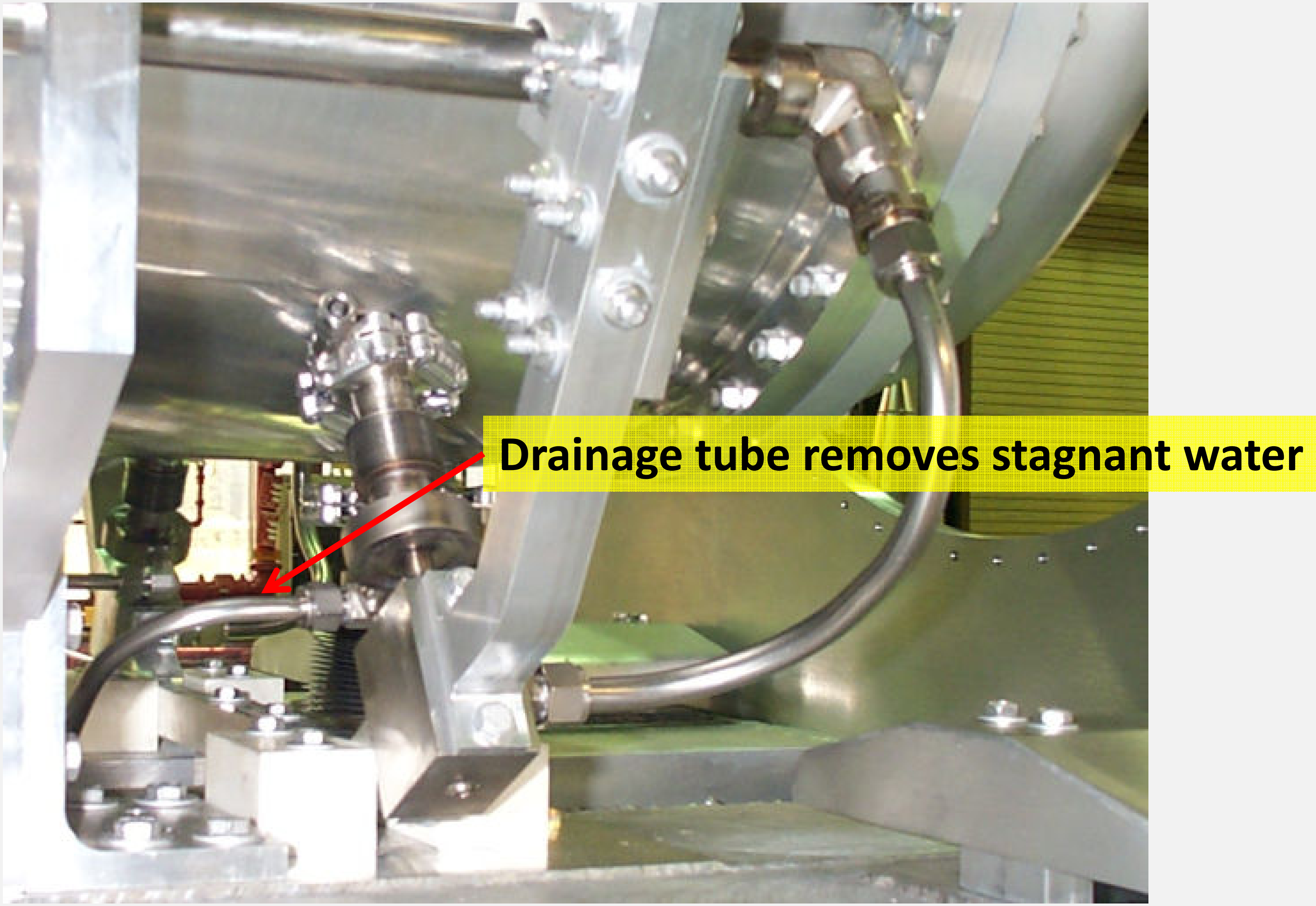


CENTER OF TARGET
92'-0 1/2"
75'-1 7/16"
COLLIMATOR
DETECTOR TABLE
MAGNET
6.75"
RELAY RACKS
COLUMN B
COLUMN B
TARGET HALL
25 METER ABSORBER
1.81"
50 METER ABSORBER
LMC (M113)



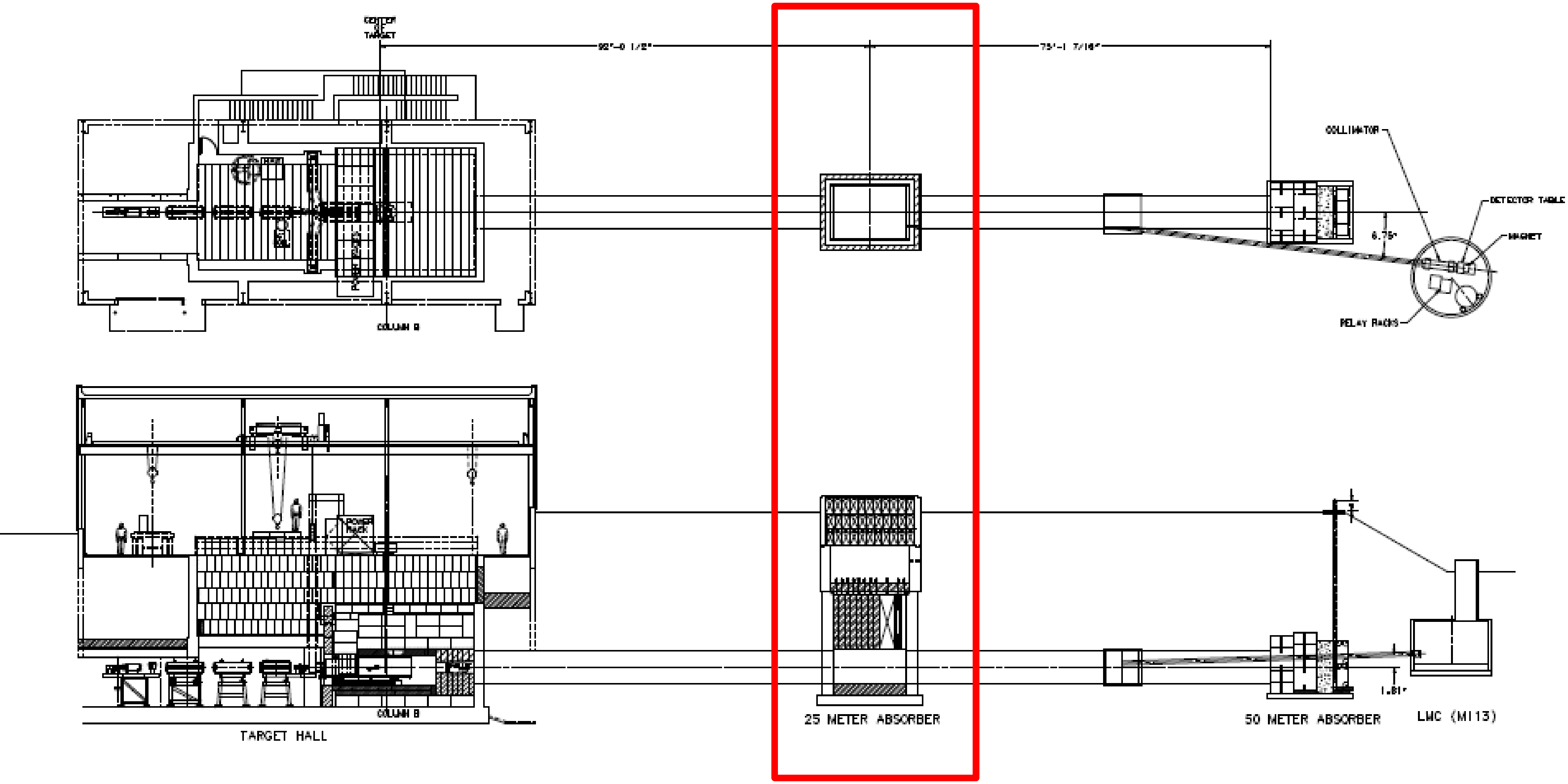
- Unstack 6x15 shielding blocks. Blocks needed to be wrapped.
- Remove final focus triplet.
- Lower coffin.
- Remove horn.
- Reverse procedure.

Target and Horn are buried in shielding.
Approximately 12 weeks to change horn, most of which is removing shielding infrastructure.
Target can be changed independently of horn.


Drainage tube removes stagnant water

Second Horn Trivia

- December 2004 to present.
- 1/3 of a billion pulses.
- Two of the six water lines have been valved out due to leakage, but still have adequate cooling.
- Provides new data regarding fatigue of aluminum.
- Water is continually circulated, even during shutdowns and off-target running, to avoid stagnation.



CENTER OF TARGET
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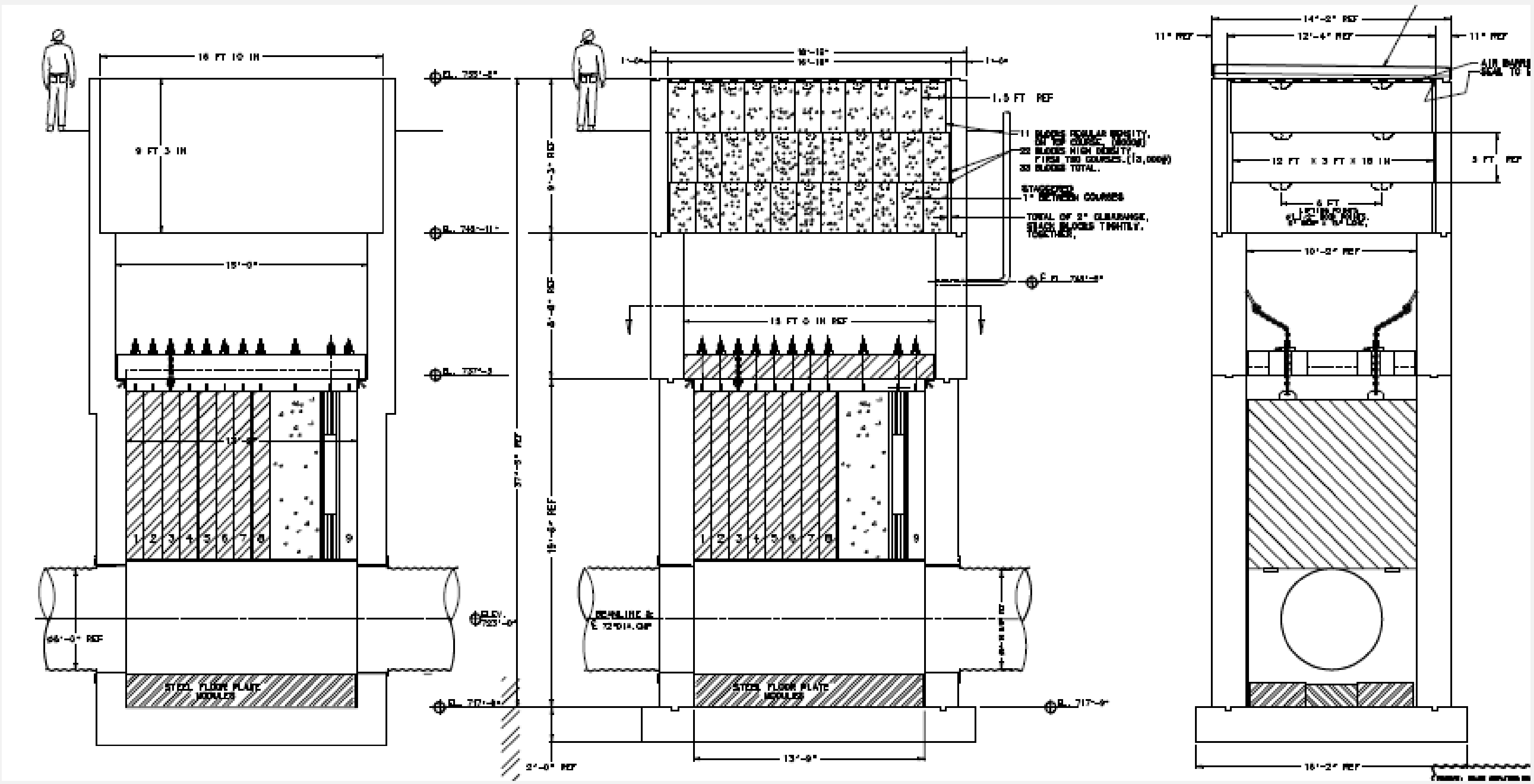
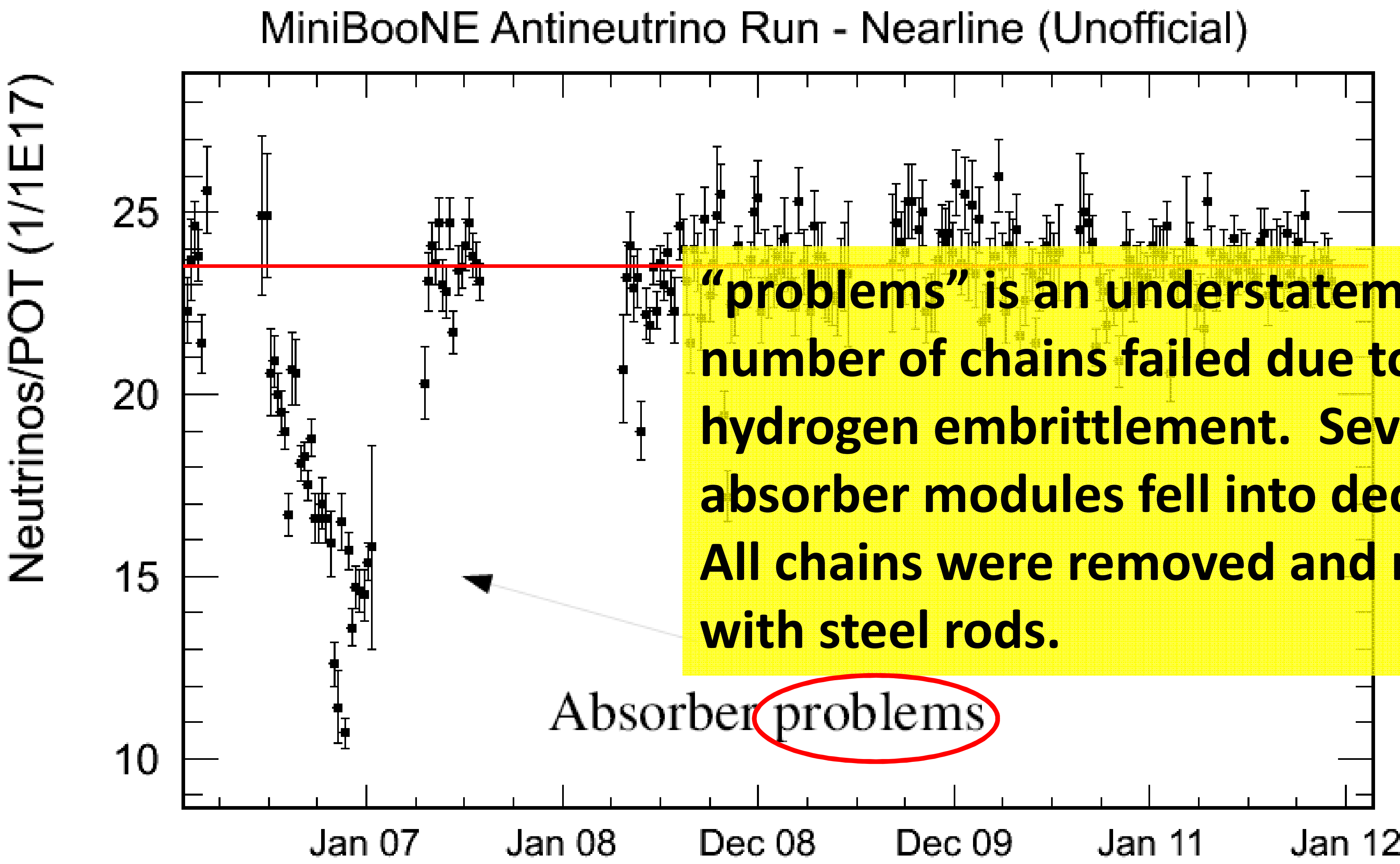
25 METER ABSORBER
50 METER ABSORBER
LMC (MI13)

Deployable absorber located 25 m from target.
Absorber consists of nine one foot thick steel plates, one three foot thick concrete block, and one foot thick instrumented panel.
Each module is ten feet wide and ten feet tall.
Originally suspended with high-strength steel chains



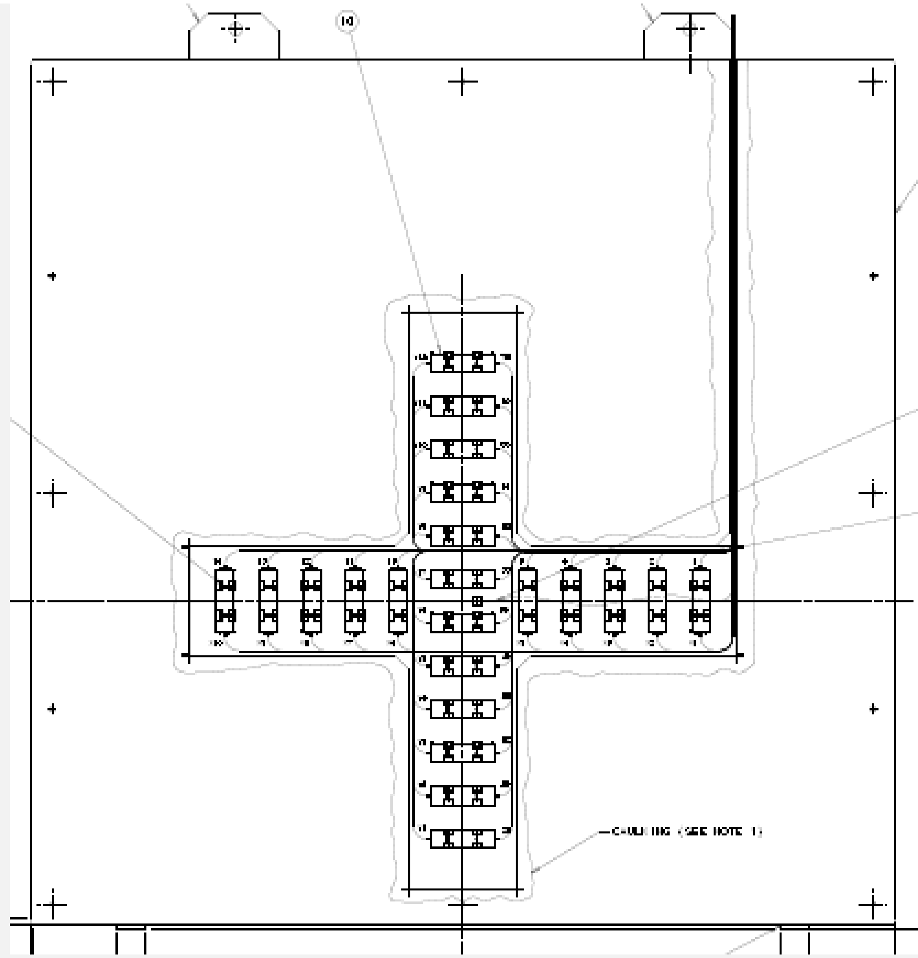
AntiNeutrinos/POT unofficial



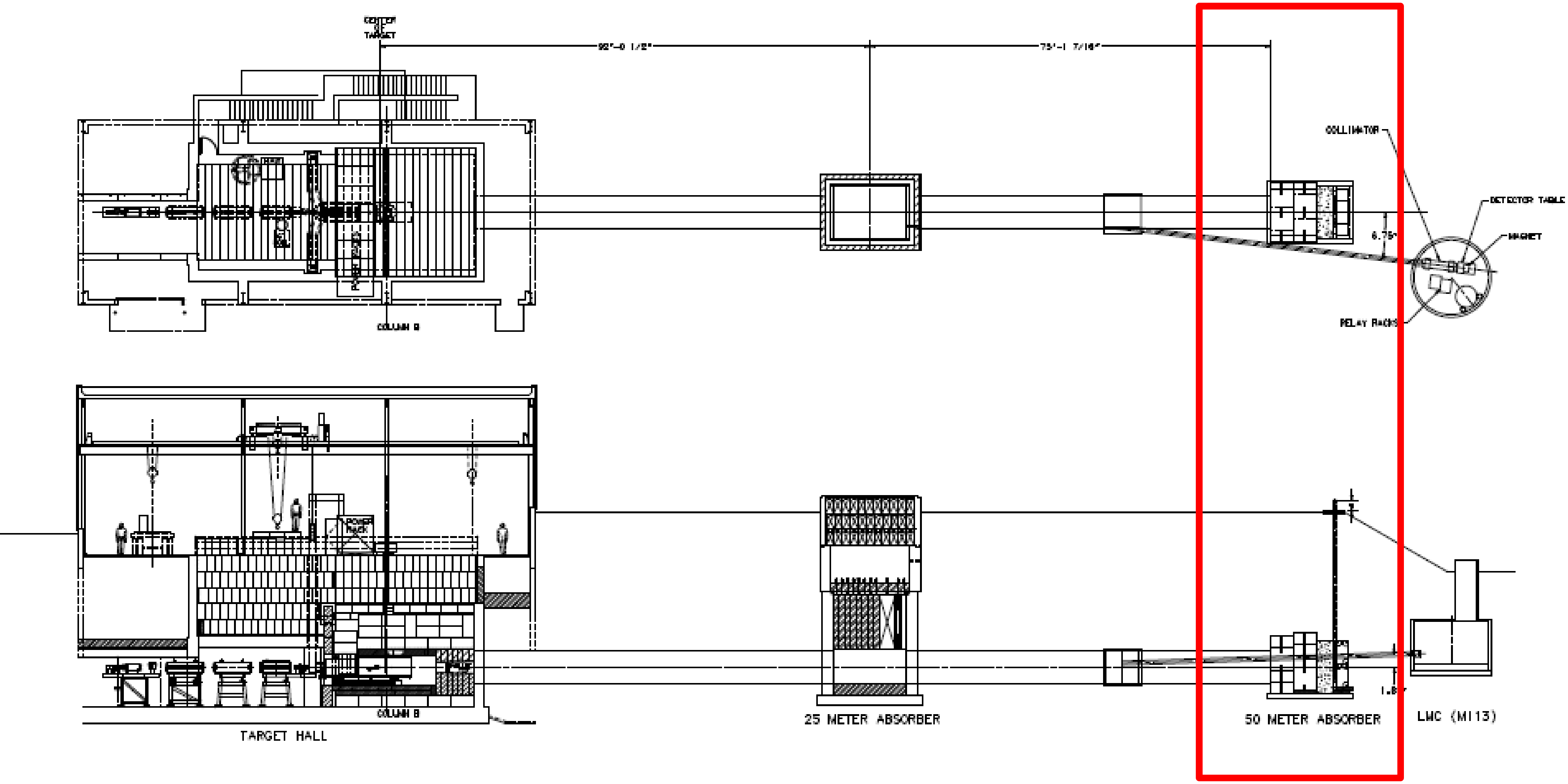
"problems" is an understatement. A number of chains failed due to hydrogen embrittlement. Several absorber modules fell into decay pipe. All chains were removed and replaced with steel rods.

One absorber module is instrumented with loss monitors.

Unfortunately, this is one of the modules that fell, and it is not known if the loss monitors still work.



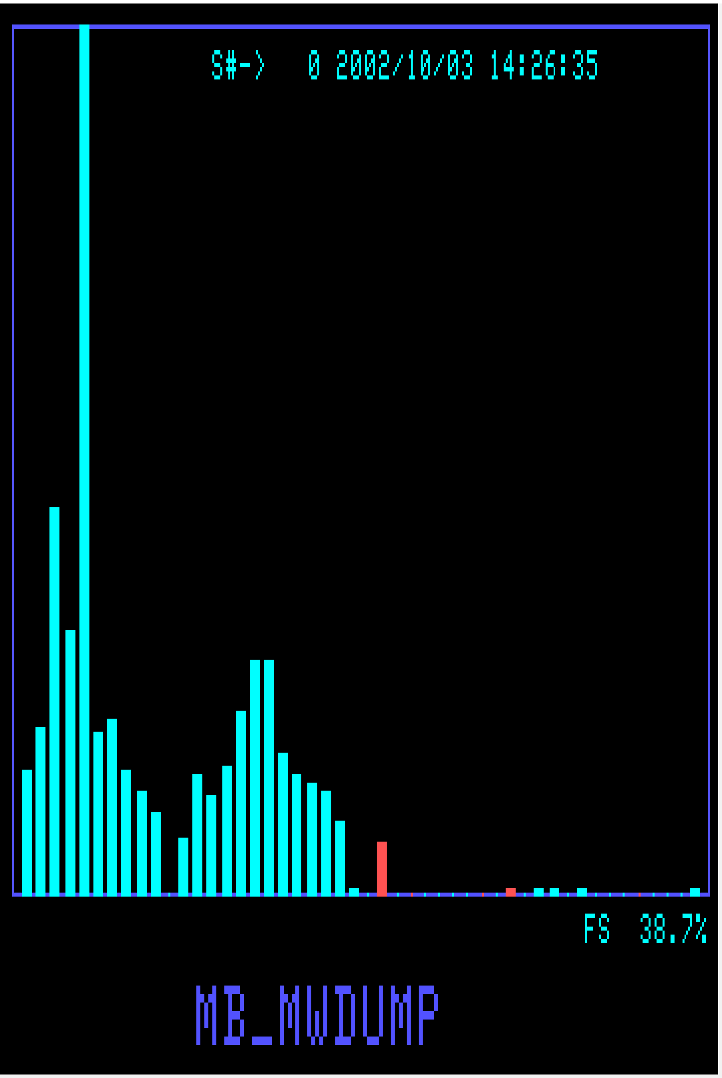
Each module consist of six two inch thick steel plates. The plates are welded together.
The module is instrumented by cutting a cross is two of the plates (the second and third plates from the front). A slot to run the cables is also cut in the plates.



COLLIMATOR
DETECTOR TABLE
MAGNET
RELAY RACKS
25 METER ABSORBER
50 METER ABSORBER
LMC (MI13)
TARGET HALL

The 50 m absorber has the same instrumentation as the 25 m absorber

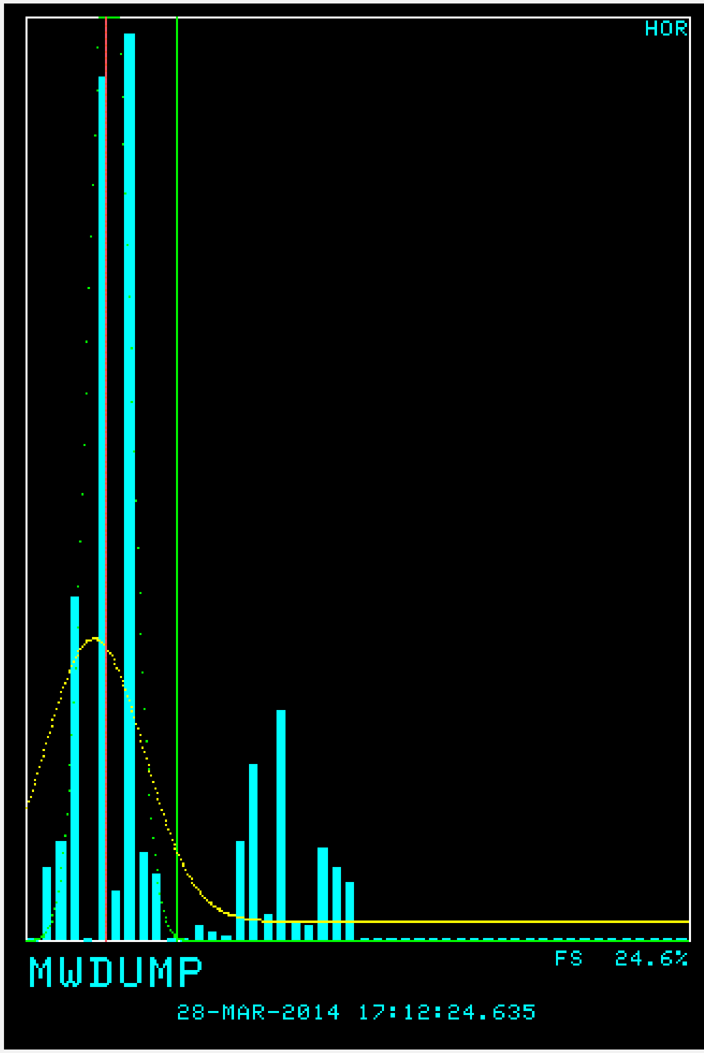
8’ 8” of steel “blue blocks”, three feet of concrete (10’ by 10’), one instrumentation panel, and 26” of steel (more “blue blocks”).



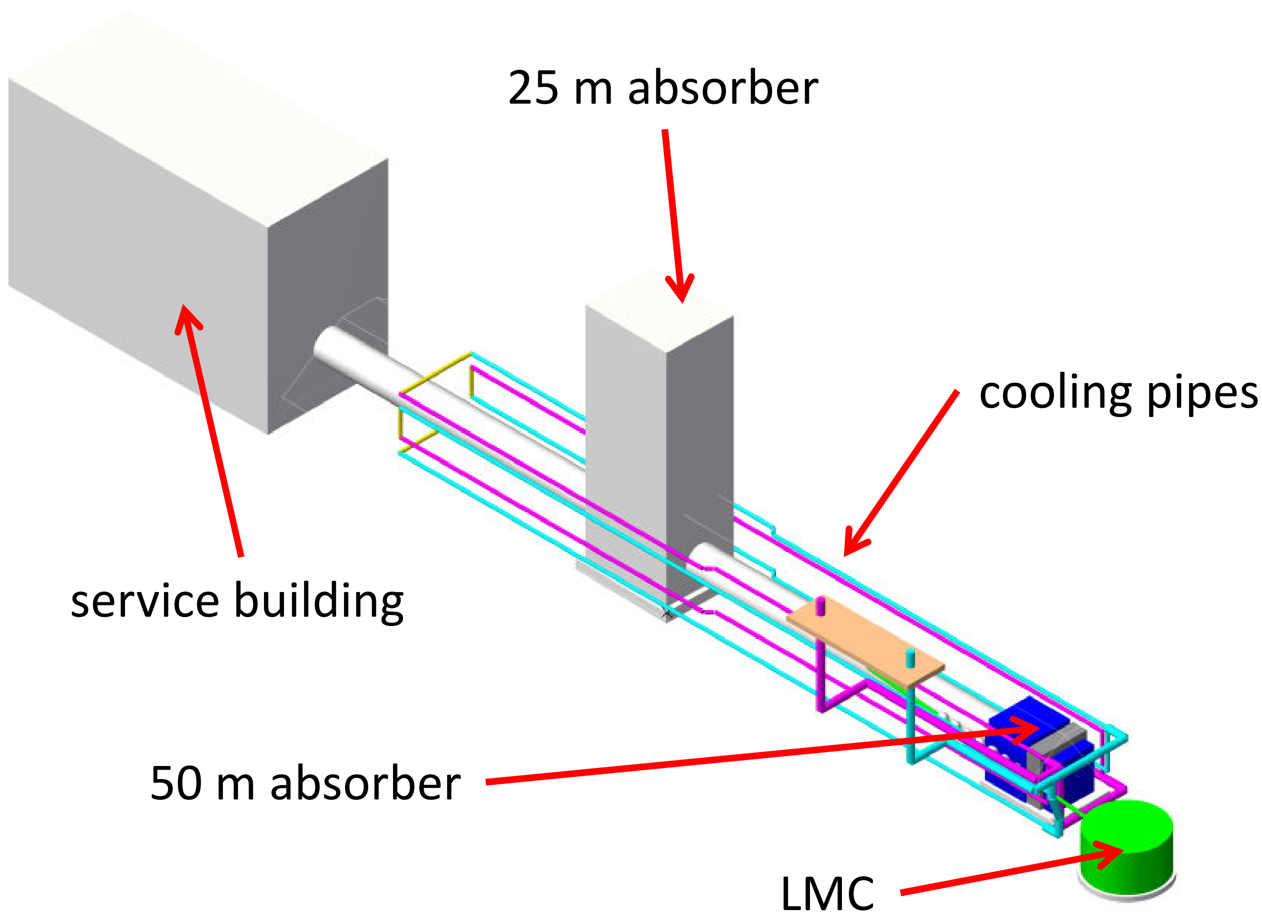
The array of loss monitors is read back using the same electronics as we use for the profile monitors.

Over time the signals have degraded. Because the system is buried, there is no access to it.

Profile data is recorded in IF Beams database.



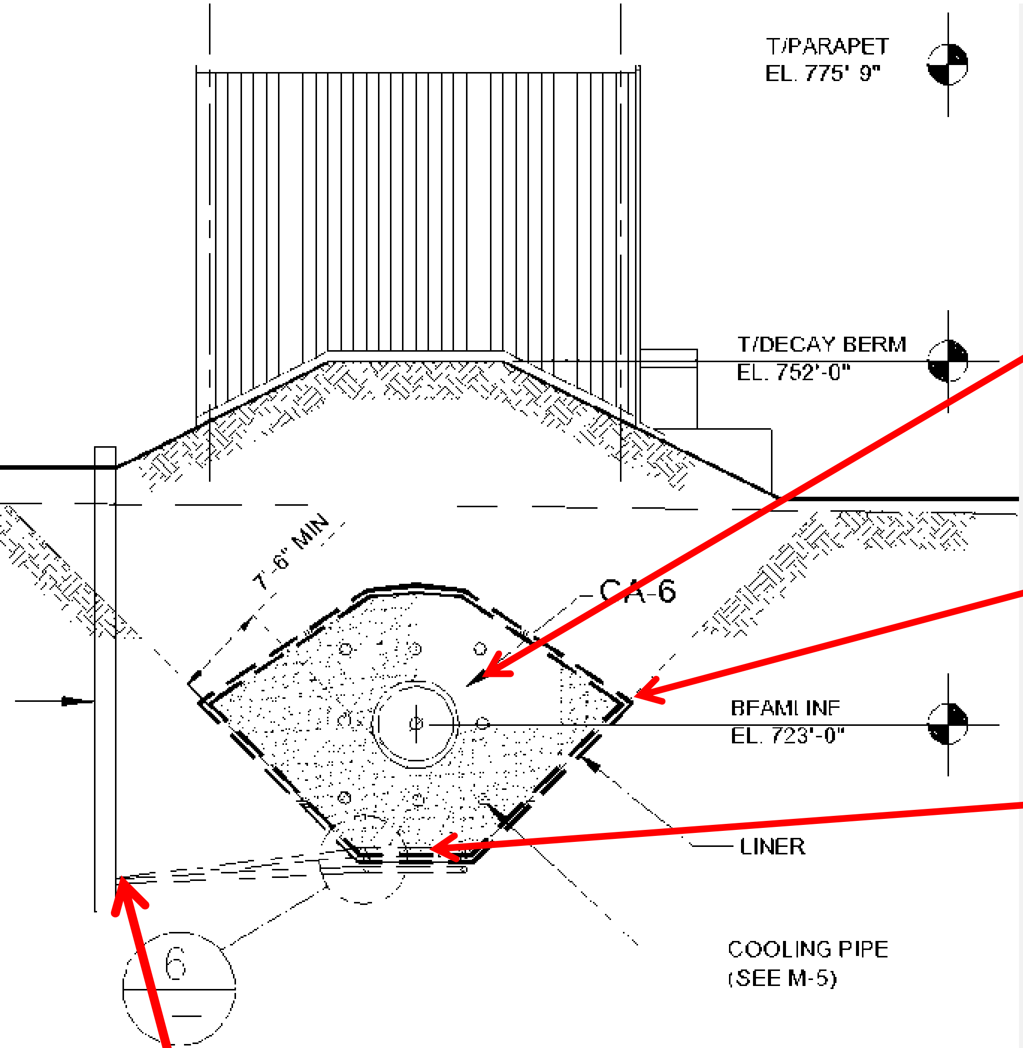
Berm Cooling System



Closed loop air system. Air is circulated through large HDPE pipes in order to remove heat from berm.

Only able to access cooling pipes through supply and return. Unable to inspect system once buried.

System was first used in 2013 for off-target running. Temperature probes were inserted through LMC pipe near absorber.



Decay pipe buried in 12 to 15 feet of aggregate.

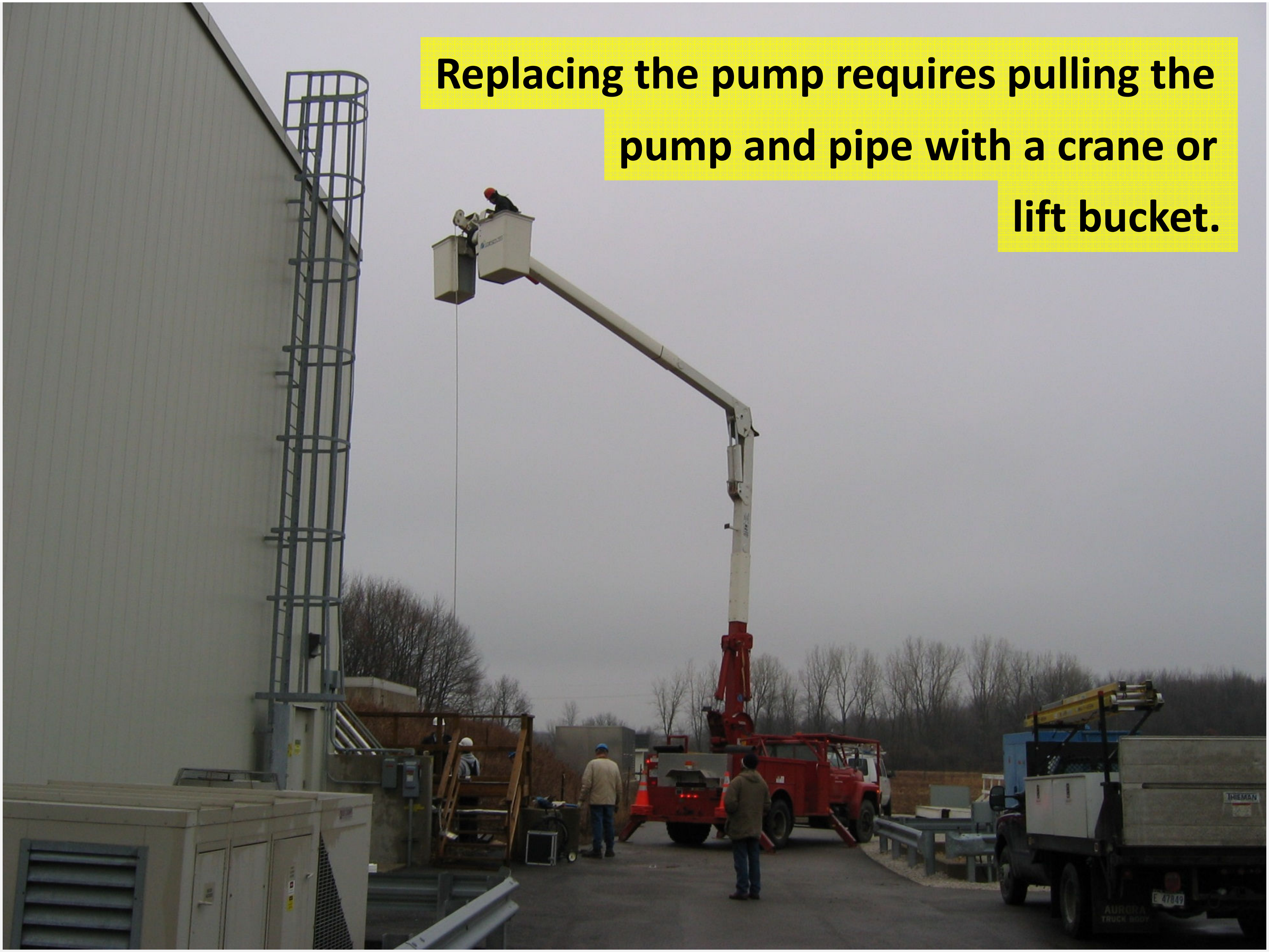
Aggregate is surrounded by two impermeable liners.

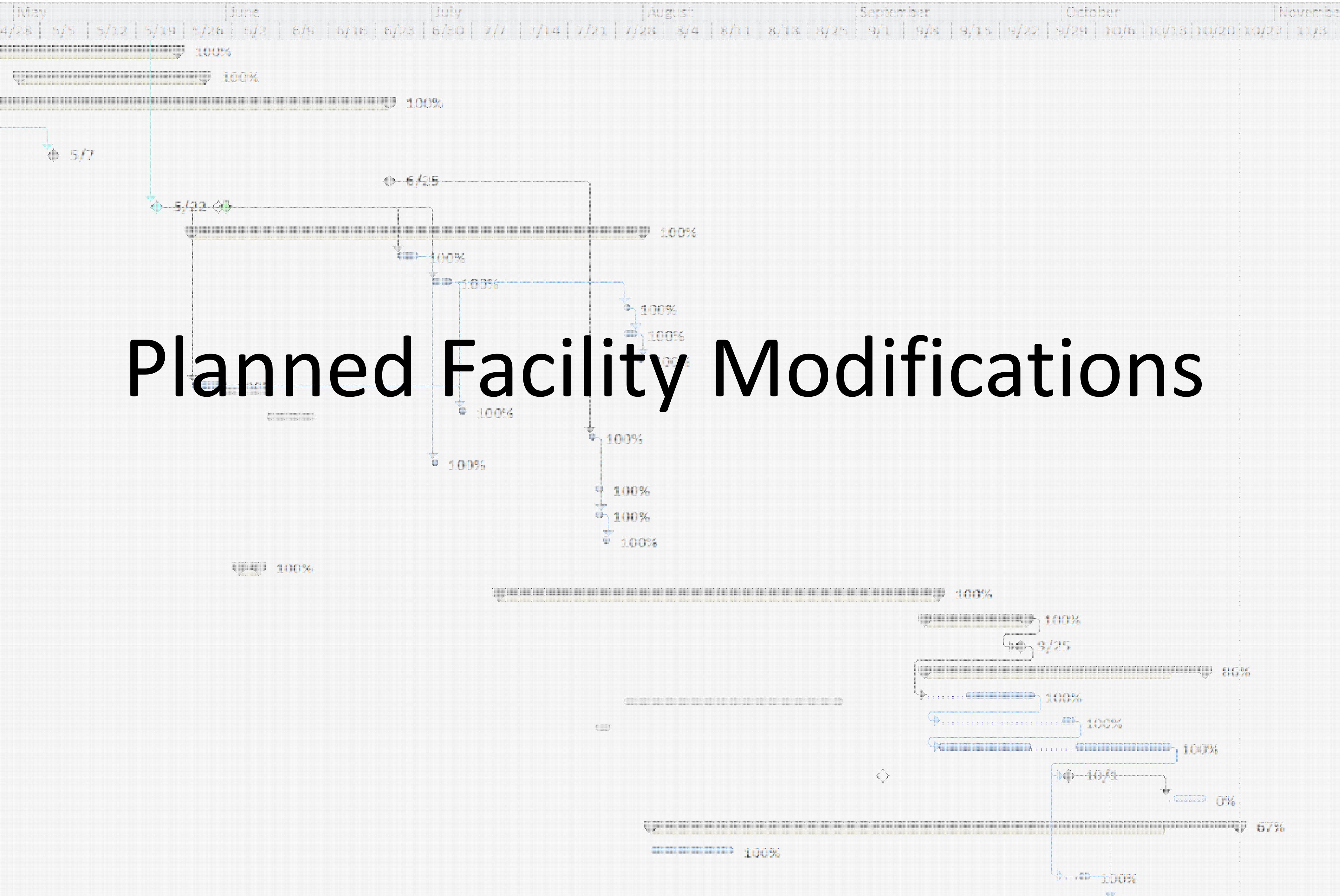
Three drainage systems.

Expect water in exterior drain tile, but inner and interstitial drains should remain dry. Early on we found they did not, implying there is a leak in the liner

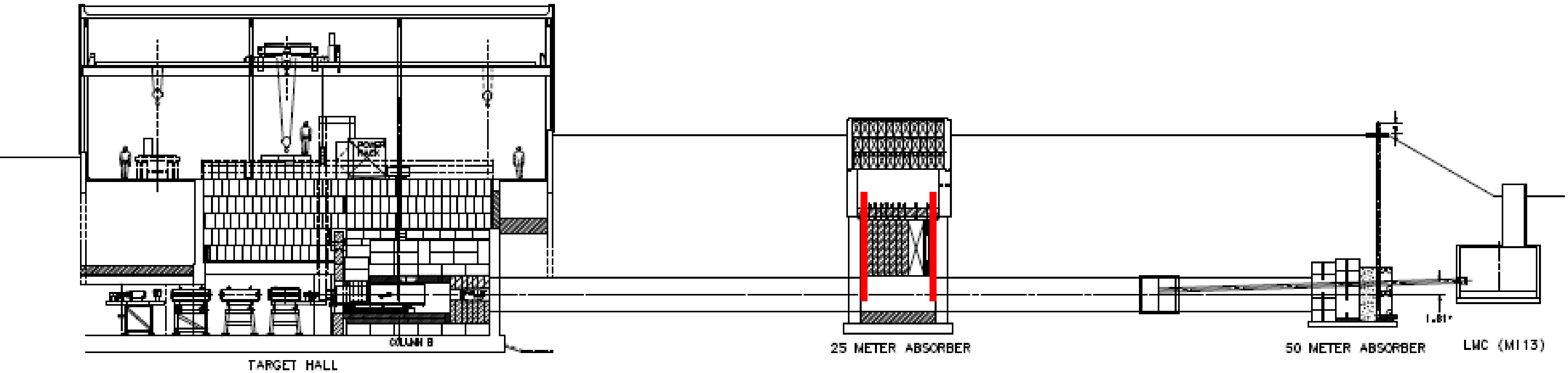
Each drain connects to two monitoring wells, one upstream and one downstream.

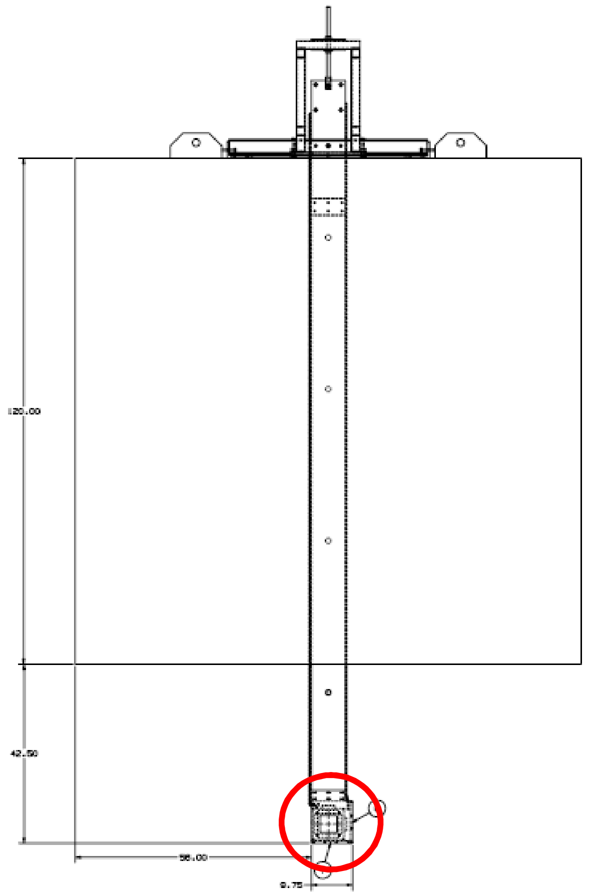

service building
liner
upstream wells
downstream wells


Replacing the pump requires pulling the pump and pipe with a crane or lift bucket.



Planned Facility Modifications





Run beam off target.
Hang two SWICs (Segmented Wire Ionization Chamber) upstream and downstream of 25 m absorber.
This will allow one to tie the primary beam trajectory to the site coordinate system.
This is a one-time measurement.

Planned for this year, after the shutdown.

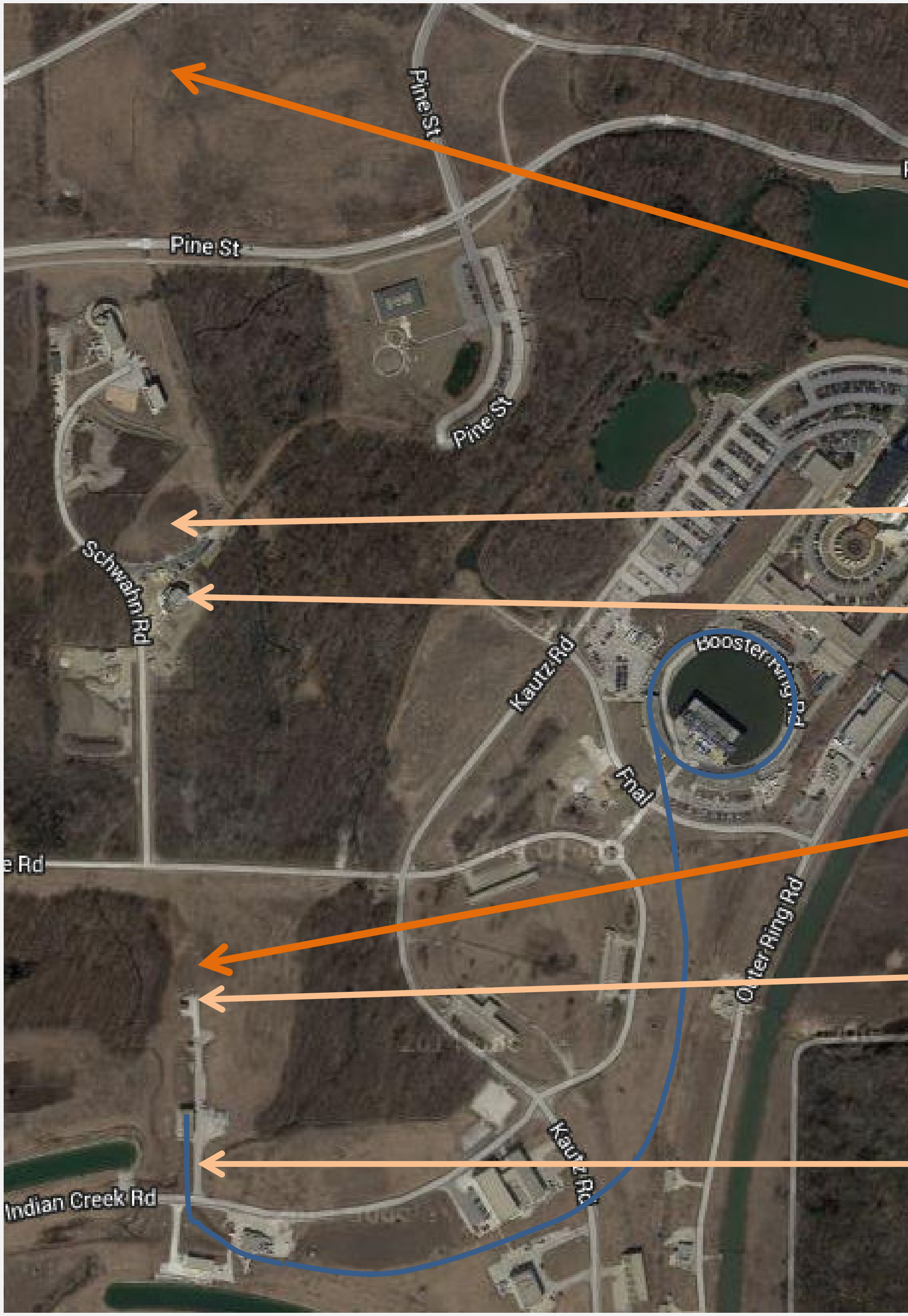
Install impermeable barrier to keep water away from liner.

Over the past year a temporary tarp was placed over the berm and adjoining area. This worked well in keeping water out of the tear.

New barrier is permanent. About one foot of dirt will be remove, the barrier will be installed, and the dirt will be replaced. Drain tile will be installed around the toe of the berm.

Work starts this week

Possibilities …



Room for More Detectors

New Far Detector ?

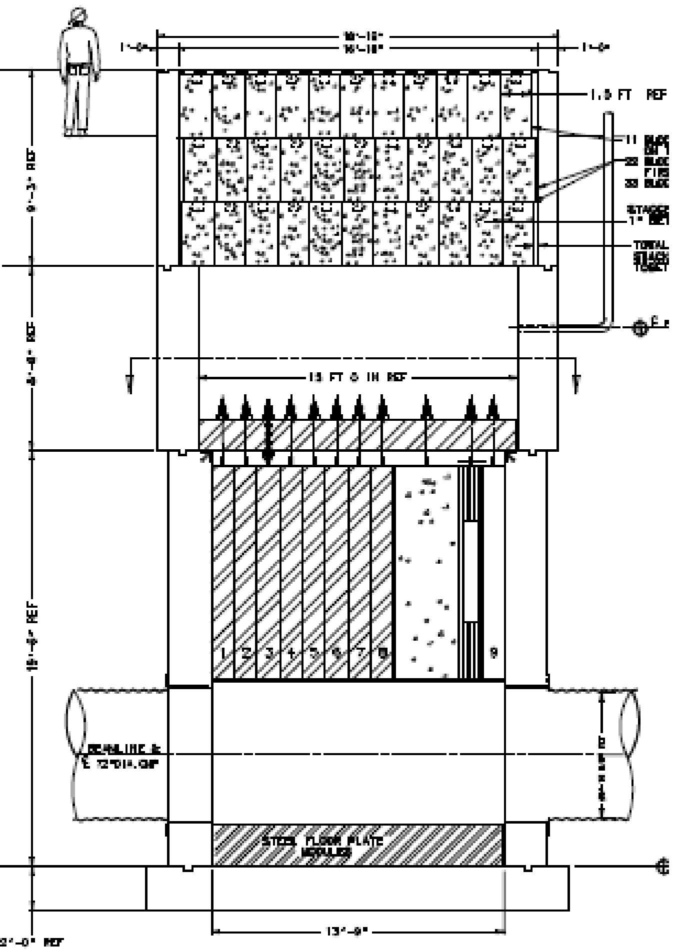
MiniBooNE

MicroBooNE

New Near Detector ?

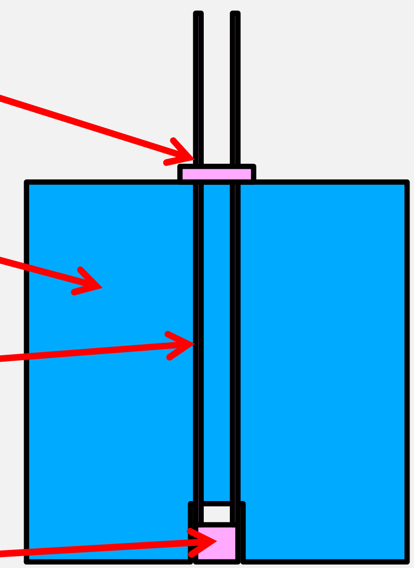
SciBooNE

Booster Neutrino Beamline



Modify first and last modules to contain retractable wire chambers.

Due to how the absorber system is build, one would need to lower all the absorbers, pull out the first and last modules, replace them with modified modules, then lift all back in place.



Alignment would be challenging.

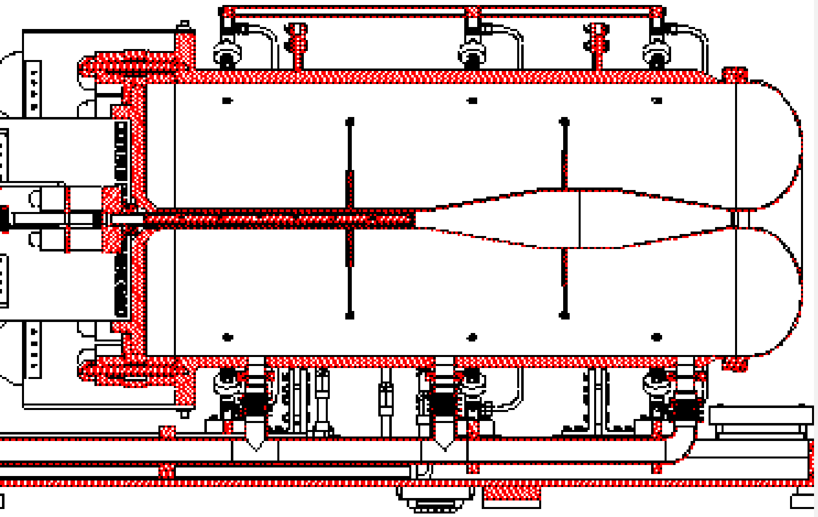
Dig up and rebuild the 50 m absorber.

Replace blue blocks with steel plates in order to eliminate cracks.

Install a hadron monitor, similar to that in the NuMI beamline.

Build a structure to allow access.

This would be challenging. The liner would have to be opened and then resealed. The aggregate surrounding the absorber is radioactive. The blue blocks are radioactive. However, this option would allow one to know accurately the direction of the primary beam.

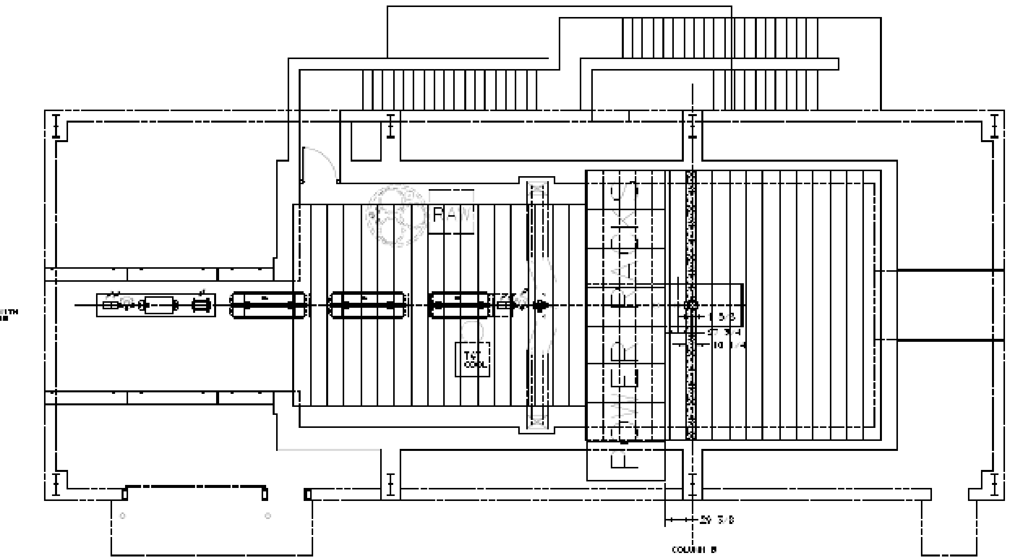


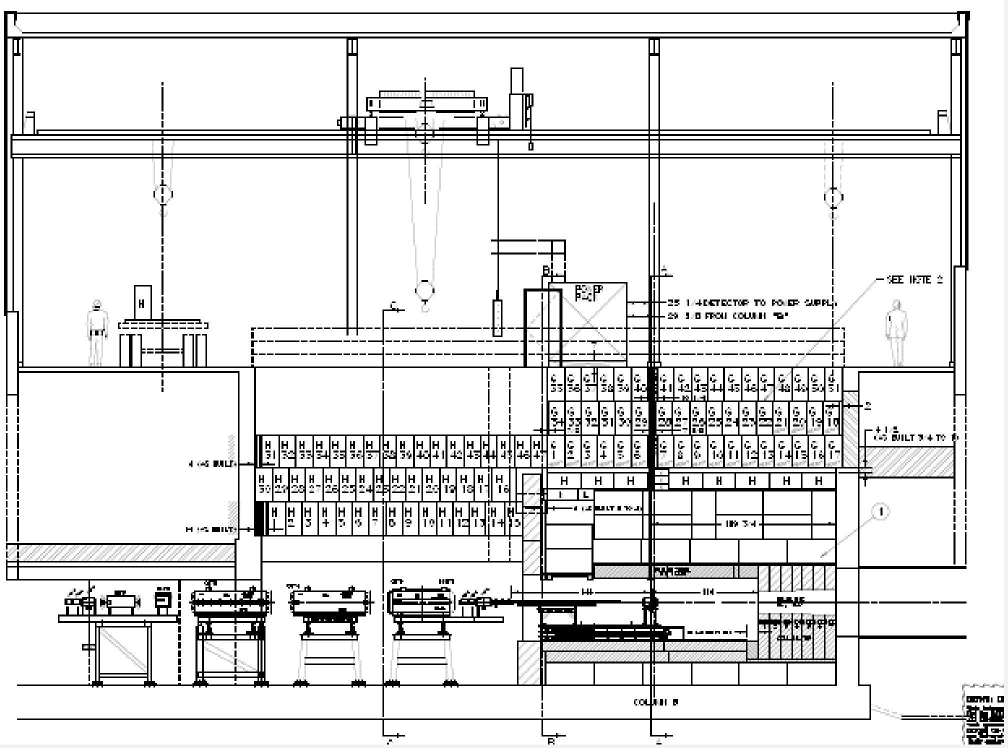
Re-optimize horn.

Change target material.

Change shape of inner conductor.

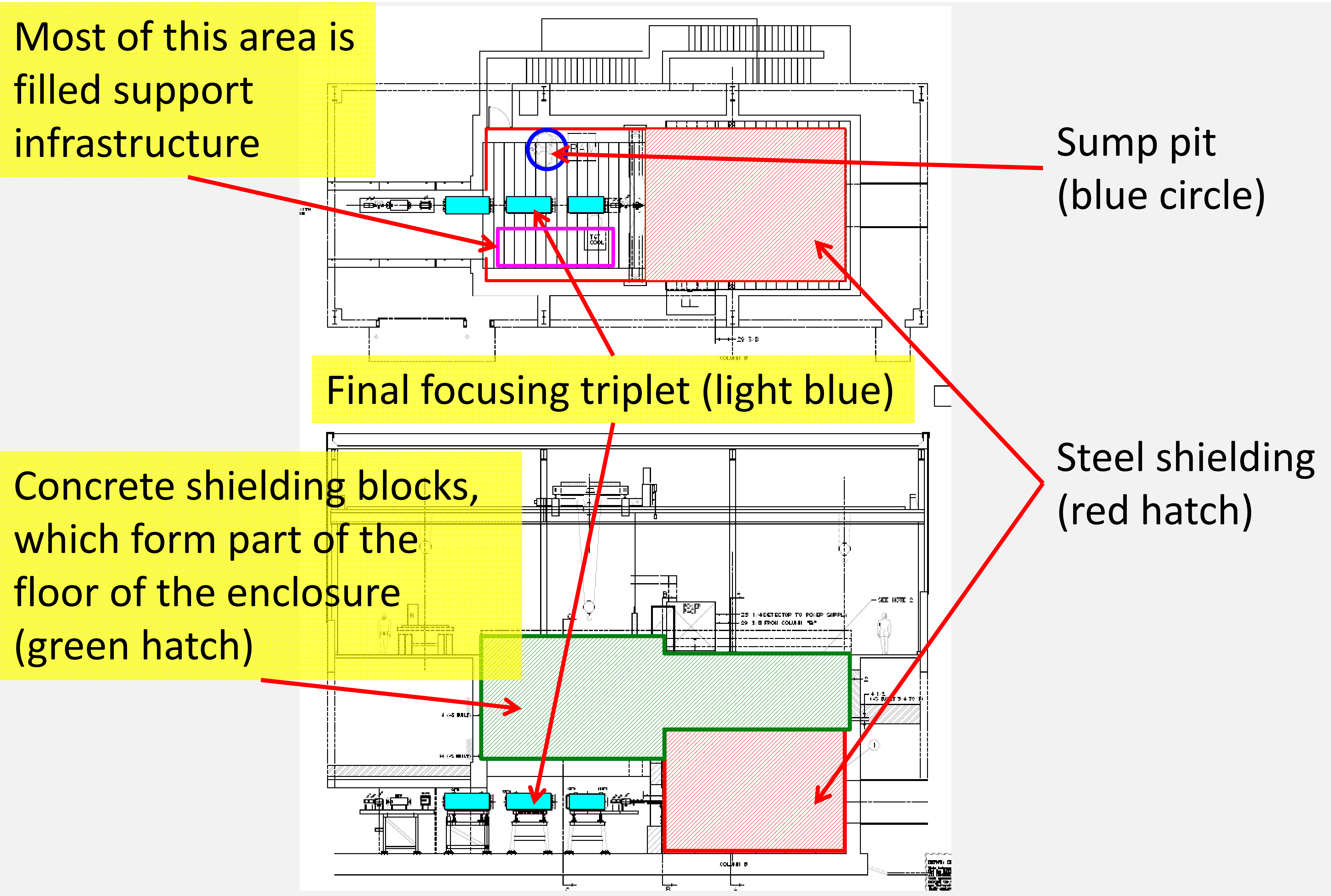
The present target and horn system is optimized for MiniBooNE. The target size and material can be changed to suit the need of future experiment. The shape of the inner conductor can also be changed.



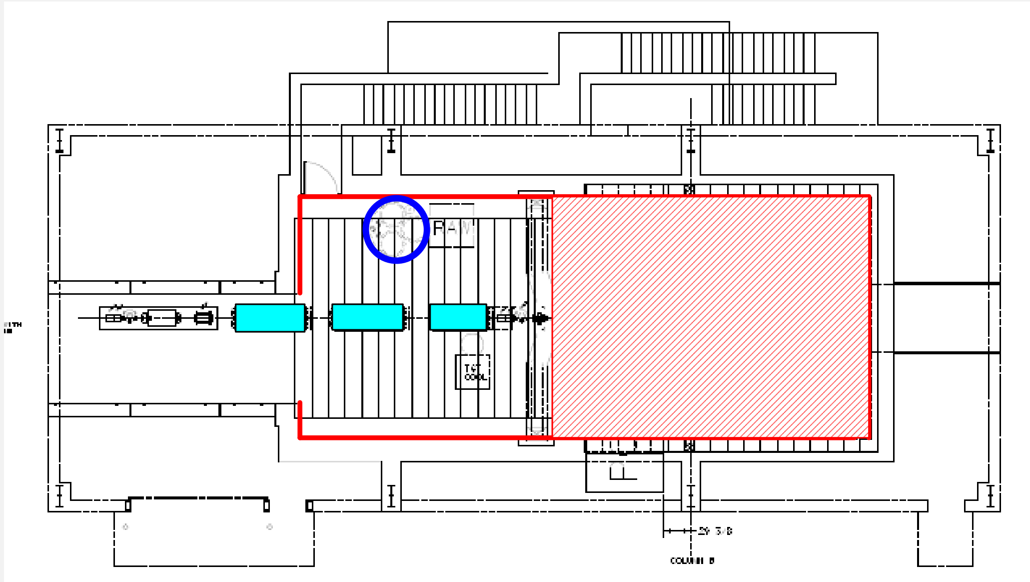


Add a second horn. But…

Where do you put it?



Most of this area is filled support infrastructure
Sump pit (blue circle)
Final focusing triplet (light blue)
Steel shielding (red hatch)
Concrete shielding blocks, which form part of the floor of the enclosure (green hatch)



Use smaller magnets for triplet, which allows one to push beamline upstream?

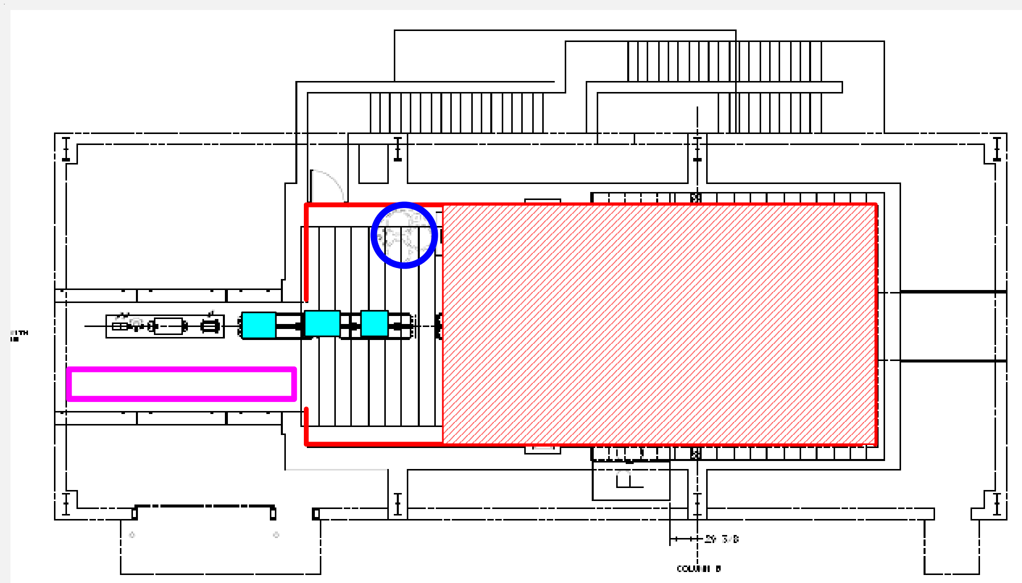
Fill free space in target hall with steel shielding?

Move infrastructure into tunnel?

How does one route the striplines for the second horn?

Does one need to re-route striplines for the first horn?

Where does one put the power supply for the second horn?



Build a new beamline.

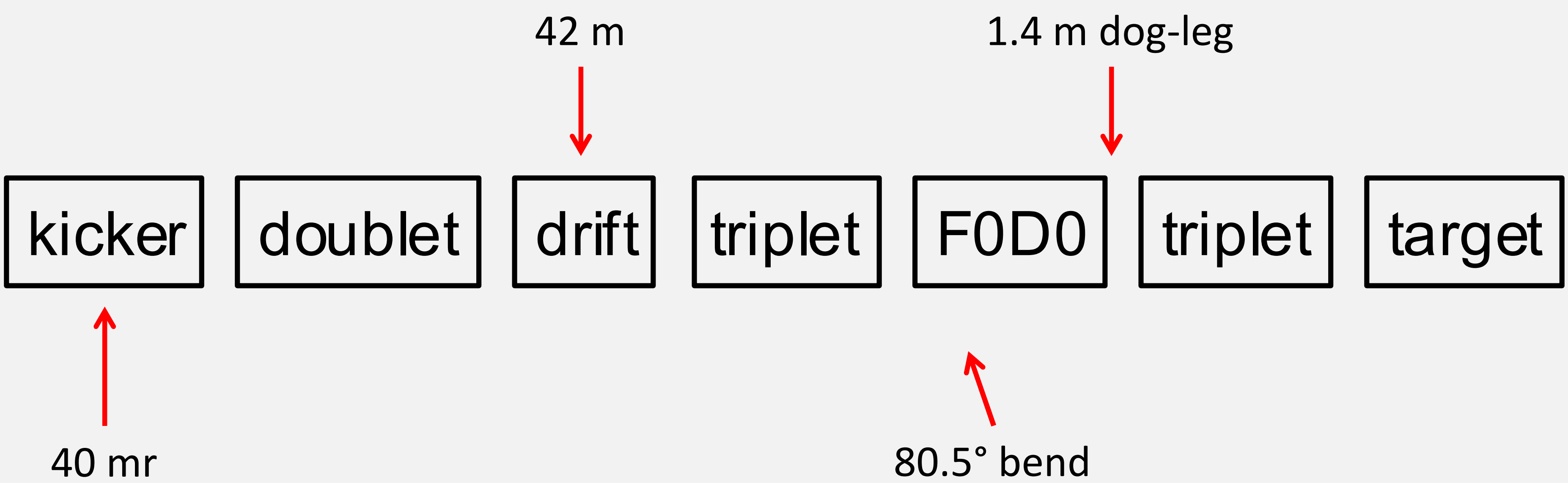
Ending Comments

- The Booster Neutrino Beamline has run successfully for the past 12 years.
- BNB will run to support MicroBooNE.
- Thought should be given as to what upgrades are desirable for an expanded short baseline neutrino program.

Backup Slides

Location

Beamline – Block Diagram



The Booster Neutrino Beamline was designed by Al Russel

Beamline -- Schematic

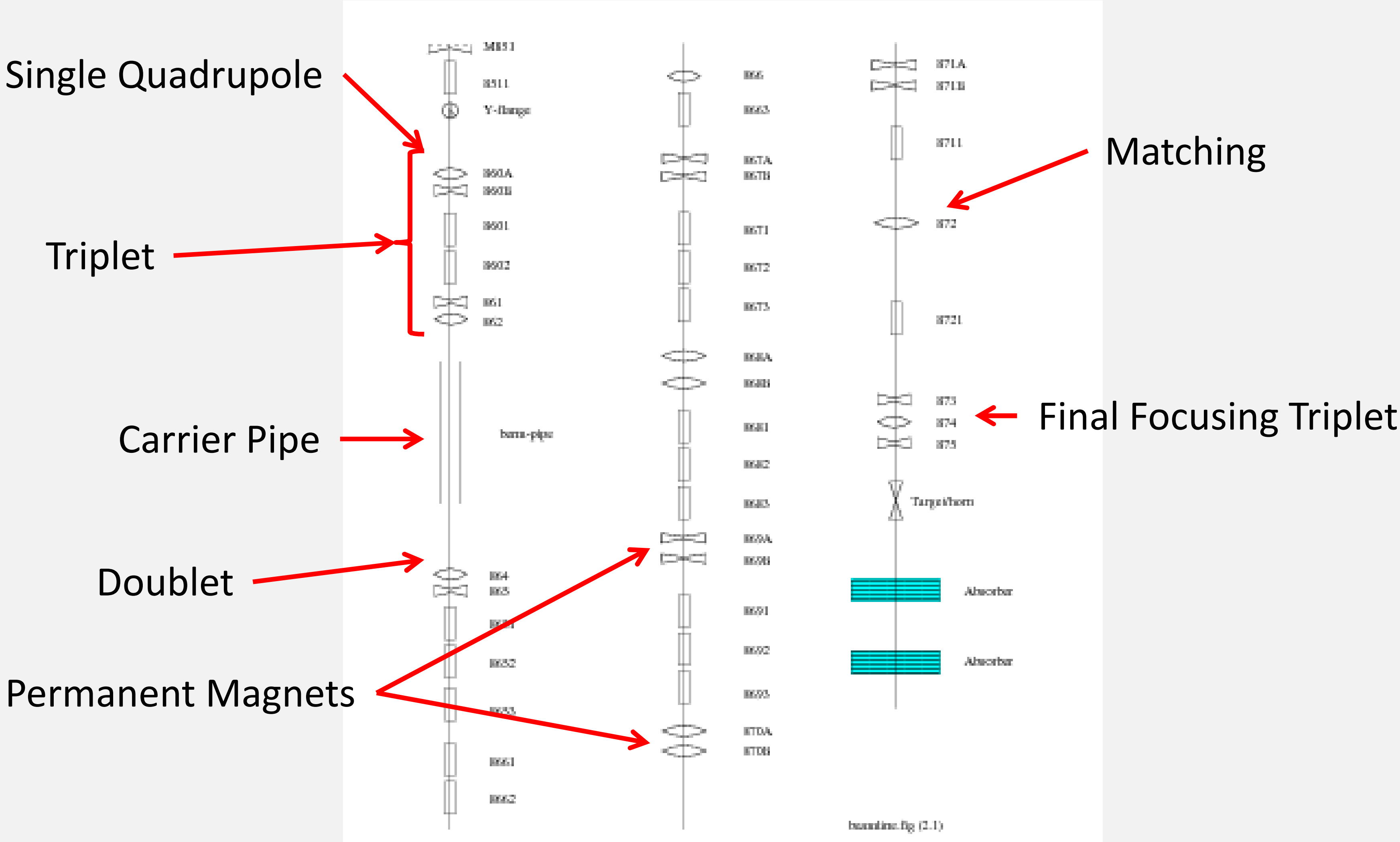
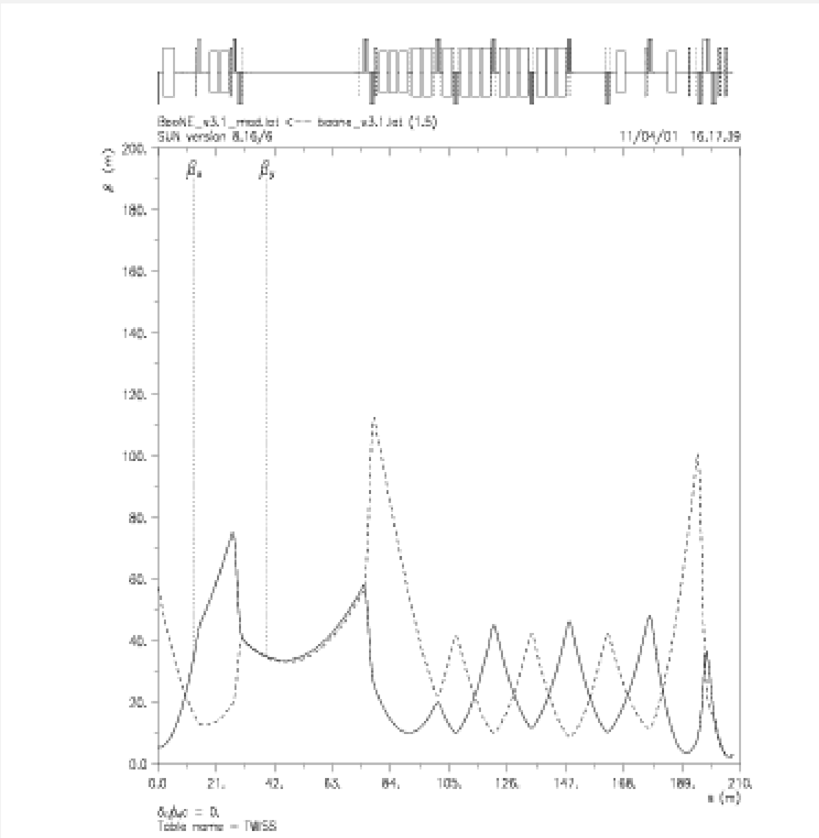


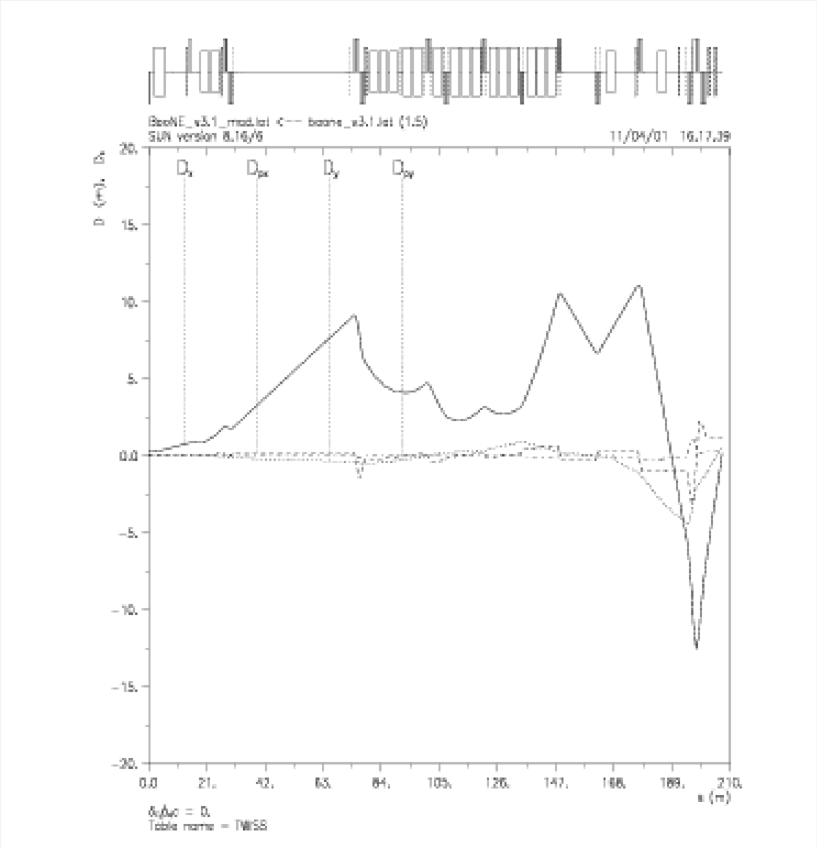
Figure 2.1: Beamline schematic and function. Elements are listed in Table 2.1.

Optics



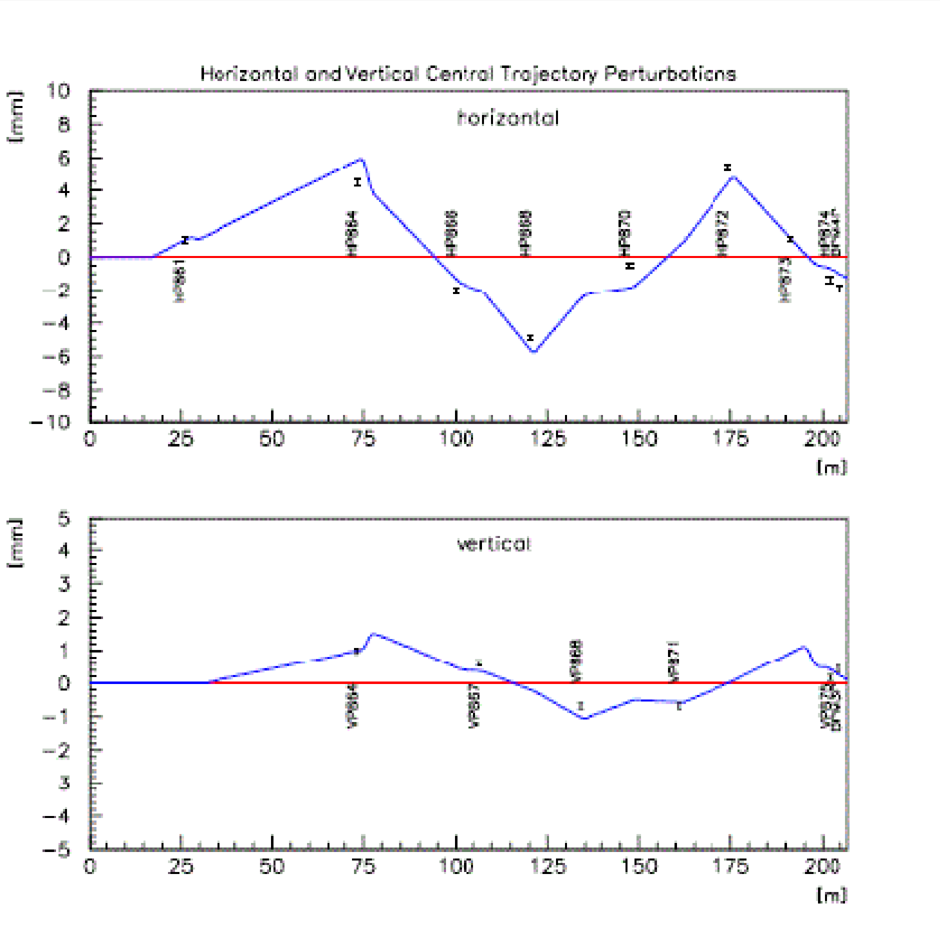
8 GeV.
Designed to deliver 5E12 protons per pulse at 5 Hz average.
~40 degree phase advance per cell.

Optics



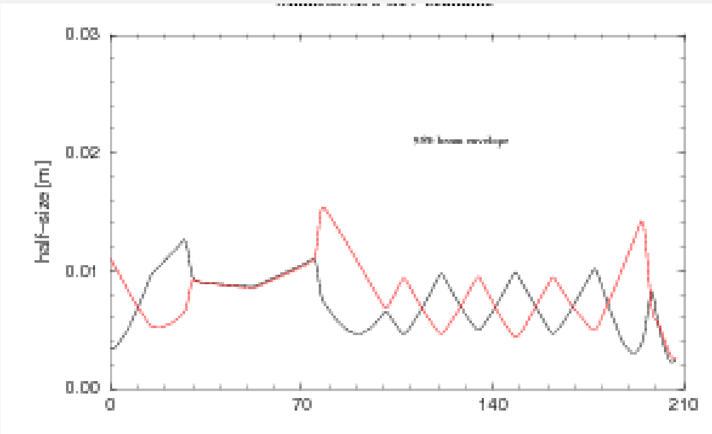
Up to 12 m horizontal and 5 m vertical dispersion.
Use large aperture (6-3-120) dipoles.
Zero dispersion at target.

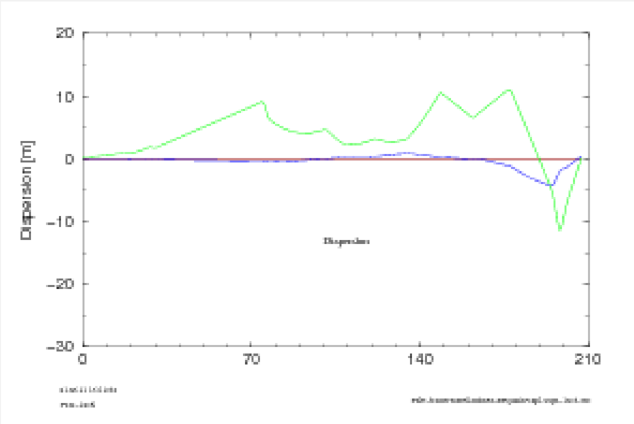
Optics



- Beam was bumped upstream, both vertically and horizontally.
- Quadruple transfer functions were adjusted to match data.

Optics





- Known lattice functions at 851 are propagated down beamline.
- Good match between prediction and measurement.

Changed momentum by inserting a piece of copper. Able to accurately predict perturbed trajectory.

Keeping Beam on Target -- AutoTune

- Change the current on a trim magnet and measure the movement on downstream BPMs:

$$\Delta i_1 \rightarrow \Delta x_1, \Delta x_2, \Delta x_3$$
$$\Delta i_2 \rightarrow \Delta x_2, \Delta x_3$$

- Leads to a linear equation:

$$\Delta\vec{x} = \begin{pmatrix} \frac{\Delta x_1}{\Delta i_1} & \cdots & \frac{\Delta x_1}{\Delta i_n} \\ \vdots & \ddots & \vdots \\ 0 & \cdots & {}^{\Delta x_n}/_{\Delta i_n} \end{pmatrix} \Delta\vec{i}$$

or

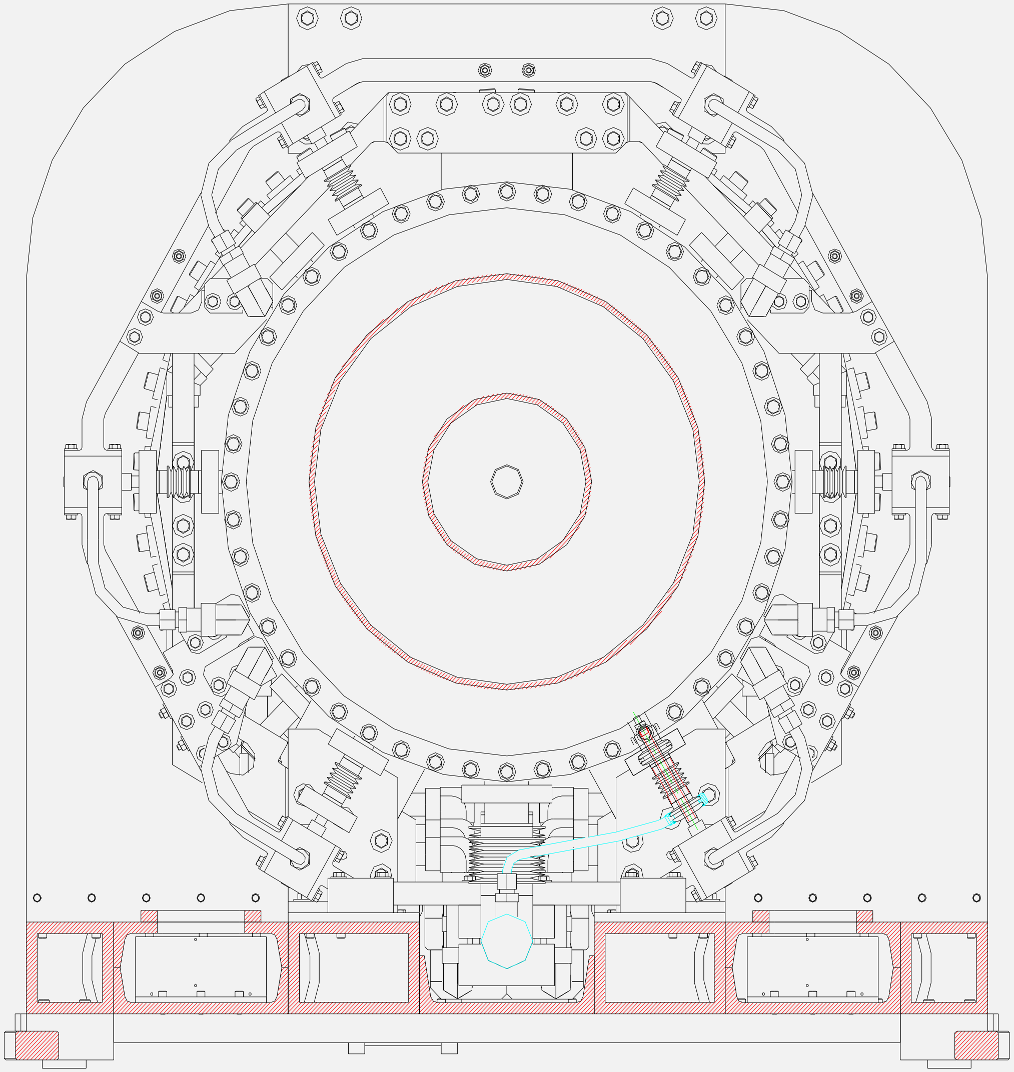
$$\Delta\vec{x} = \boldsymbol{M}\Delta\vec{i}$$

- Choose correctors and BPMs so that “M” is invertible.
- Can now solve for change in current given needed correction to positions:

$$\Delta\vec{i} = M^{-1}\Delta\vec{x}$$

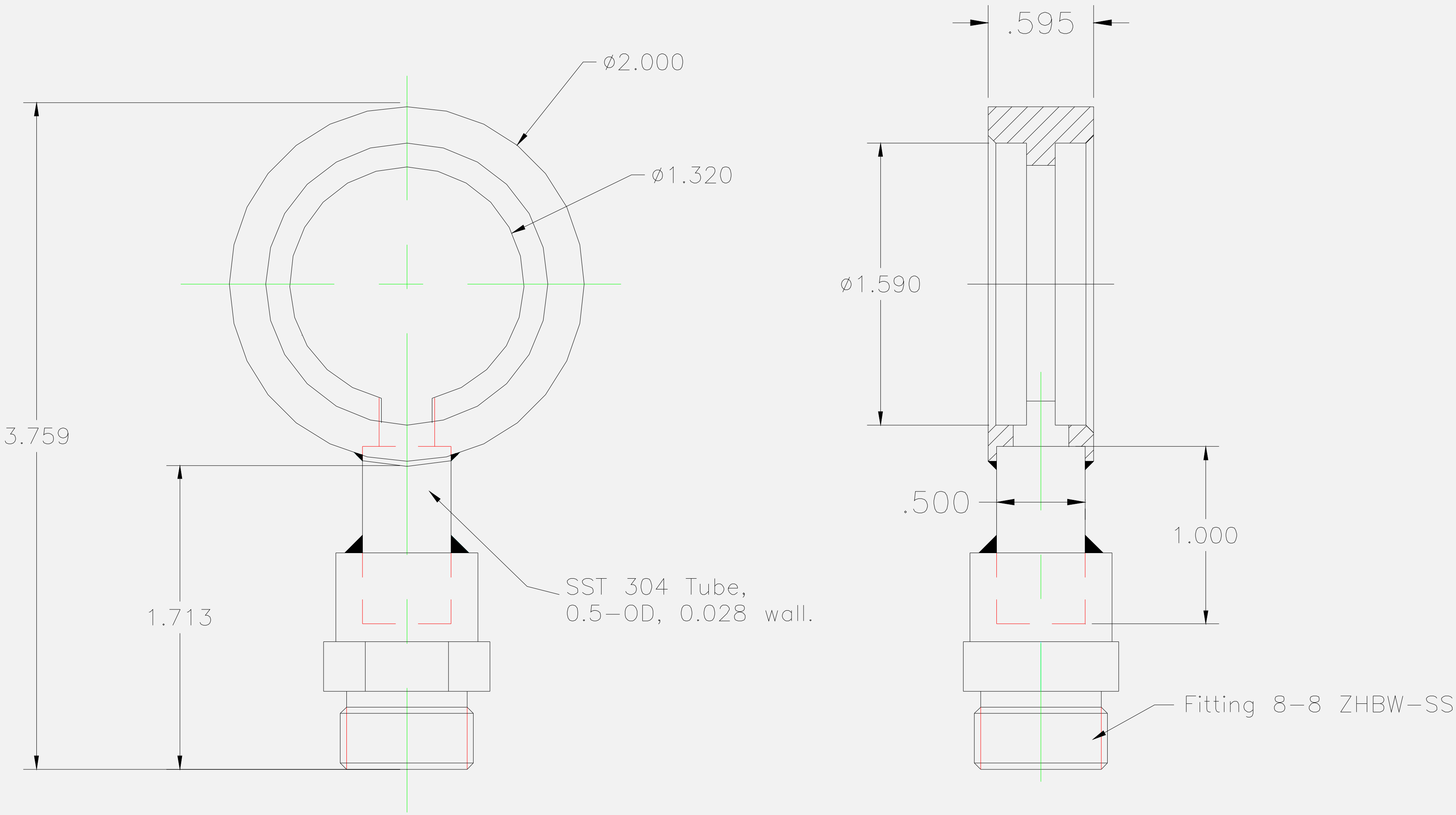
- To insure convergence:
  - Add tolerance to ideal position.
  - Make a fraction of the full correction.

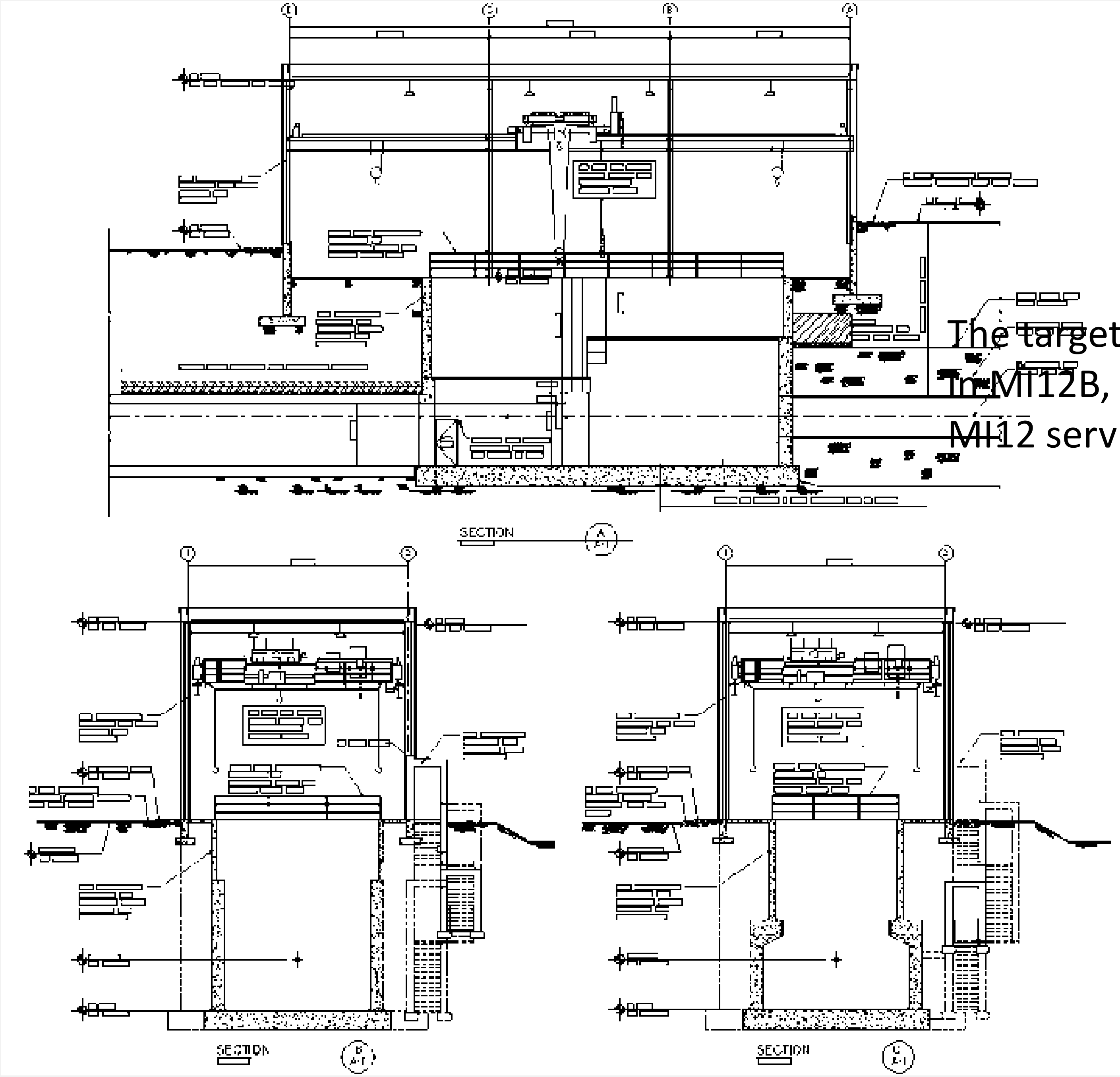
Modification



- Added drainage tube to return lines at five o’clock and seven o’clock position.
- Minimizes stagnant water.

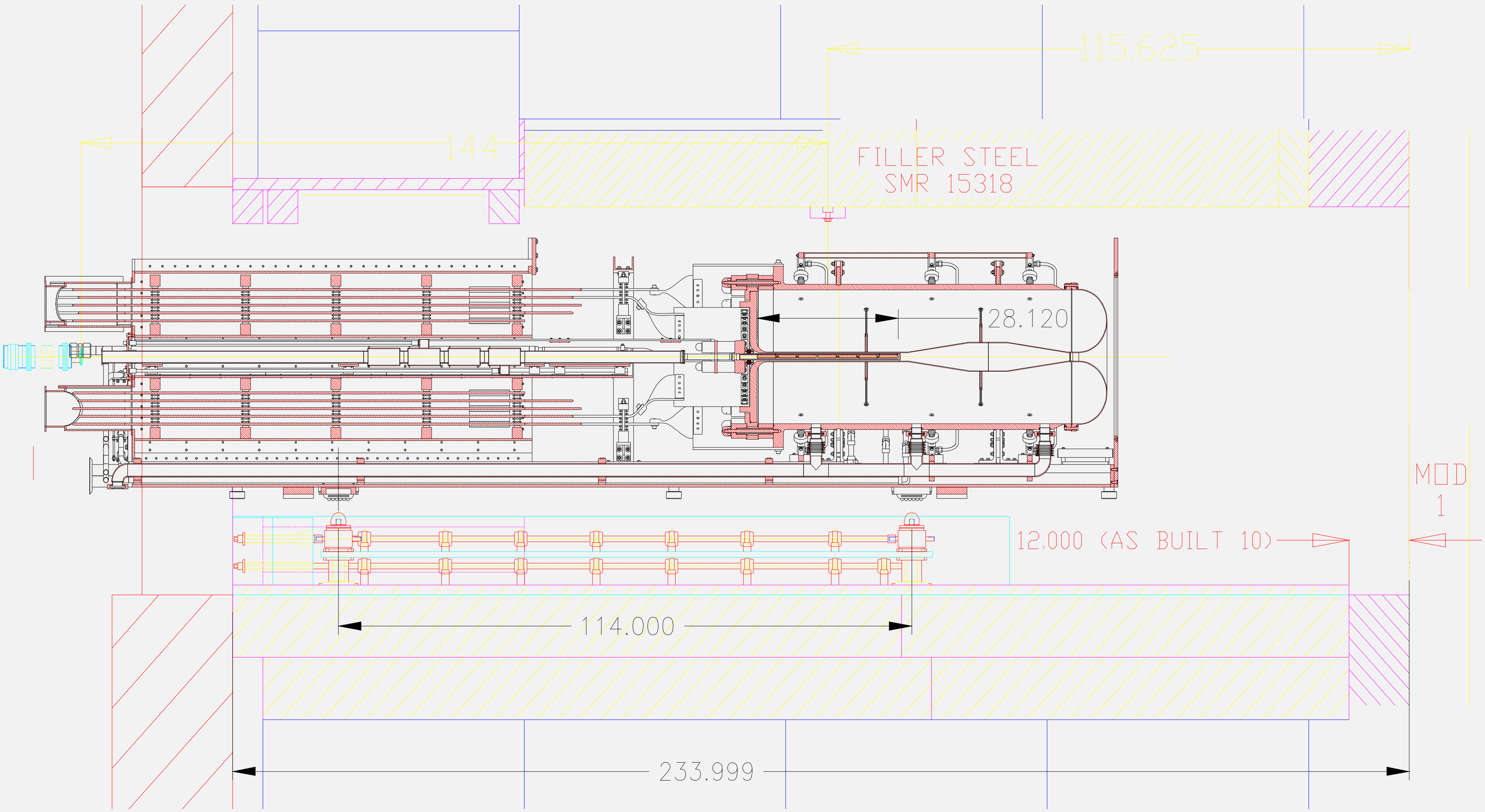
Modification



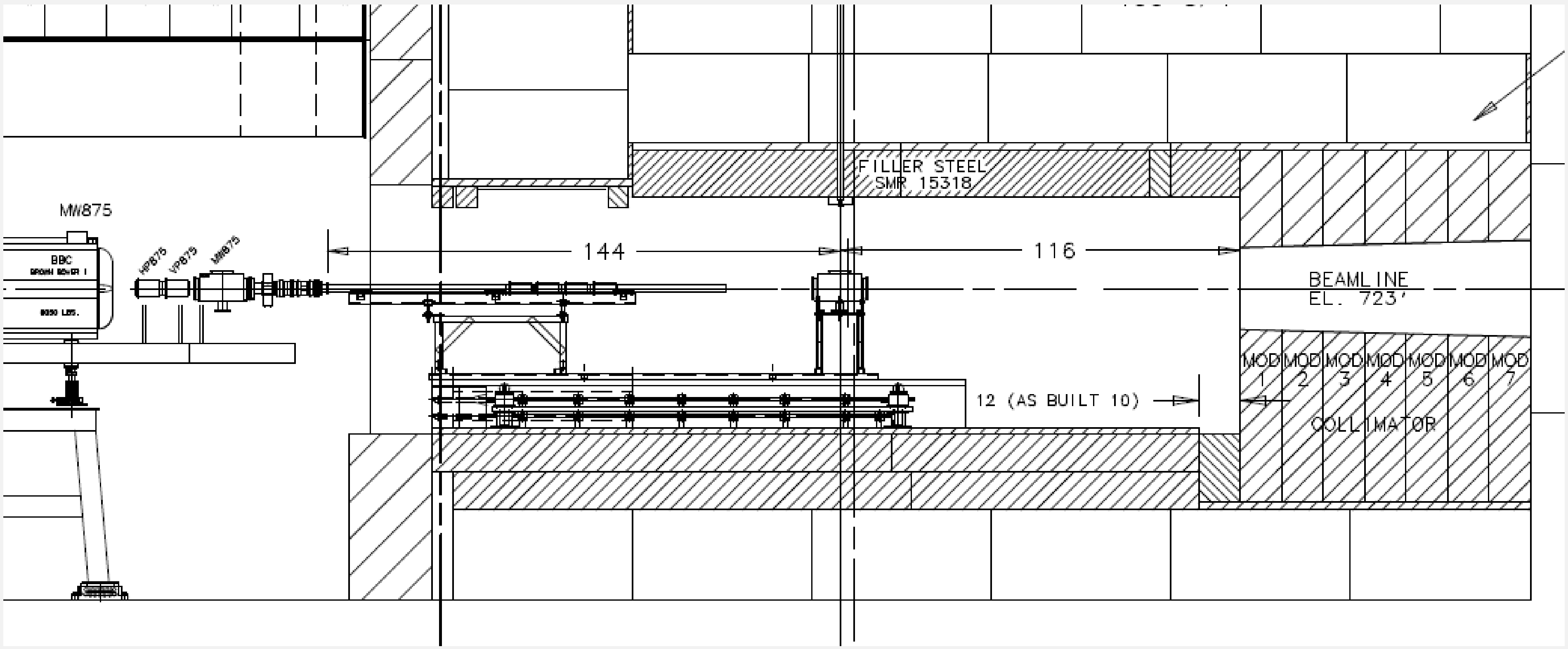


The target and horn are located in MI12B, accessed through the MI12 service building.

Target/Horn in Target Pile



Target Pile

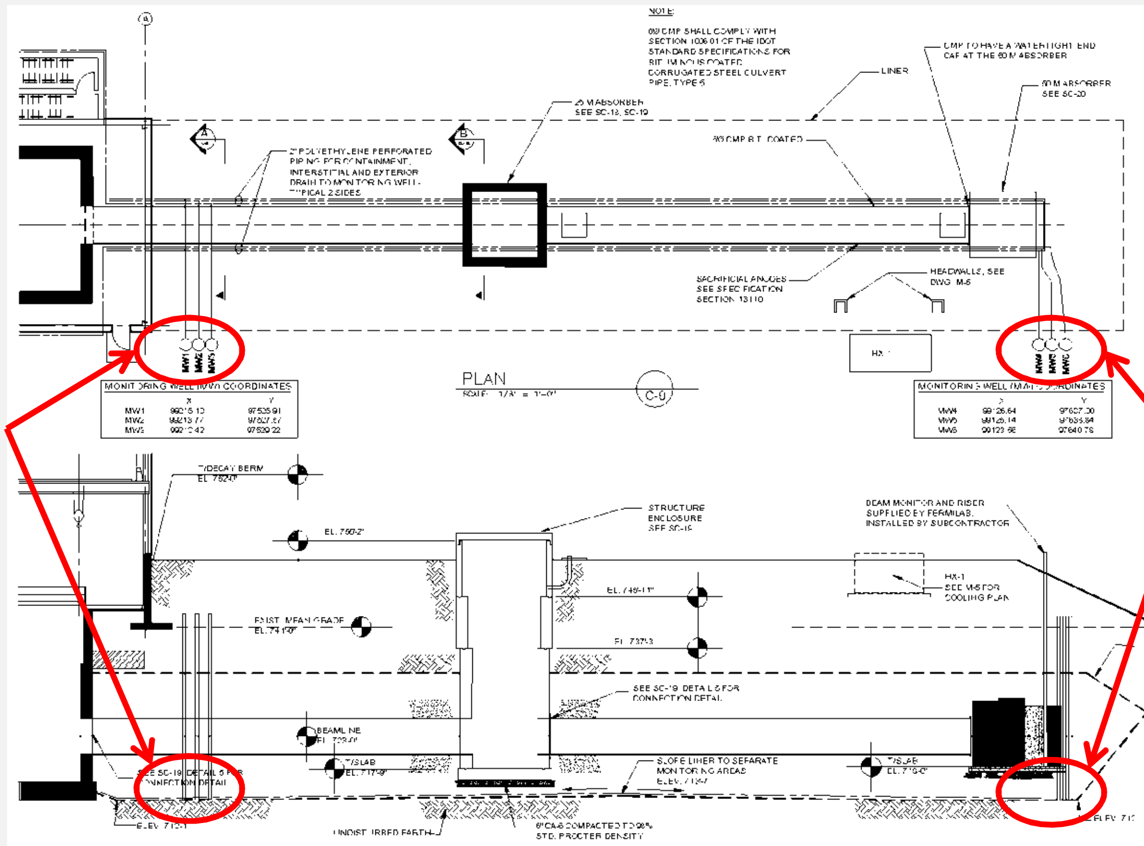


MW875
BBC
HP875
VP875
MW875
144
116
FILLER STEEL
SMR 15318
BEAMLINE
EL. 723'
MOD 1
MOD 2
MOD 3
MOD 4
MOD 5
MOD 6
MOD 7
12 (AS BUILT 10)
COLLIMATOR

Well Pump

Transducer

Three upstream wells



Three downstream wells