The Booster Neutrino Beamline

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April 17, 2014

Accelerator Physics and Technology Seminar

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- Has been for the past 12 years.

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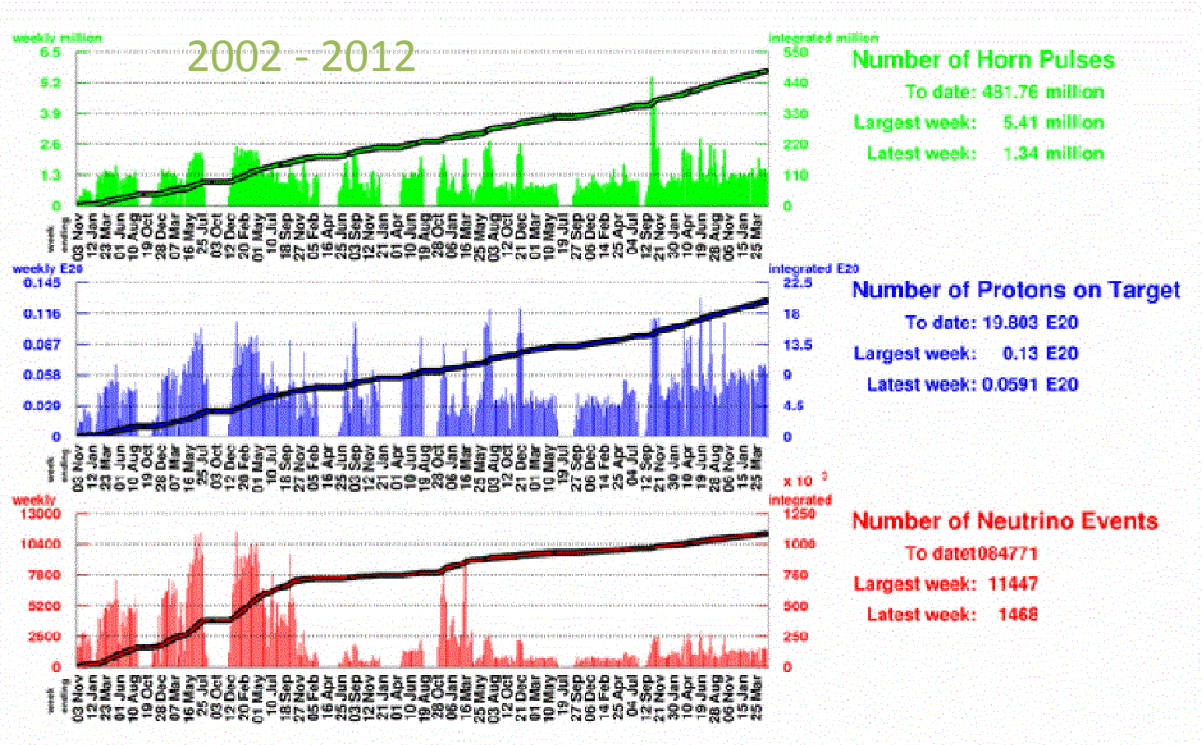
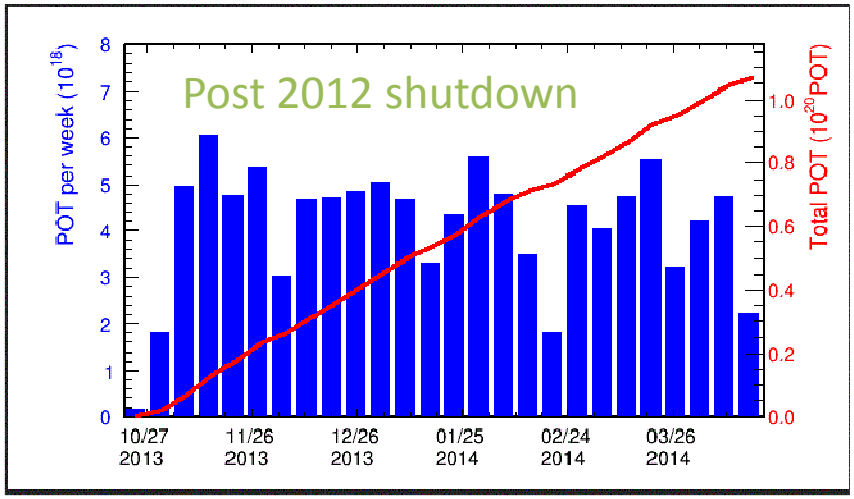
Thank you

Backup Slides

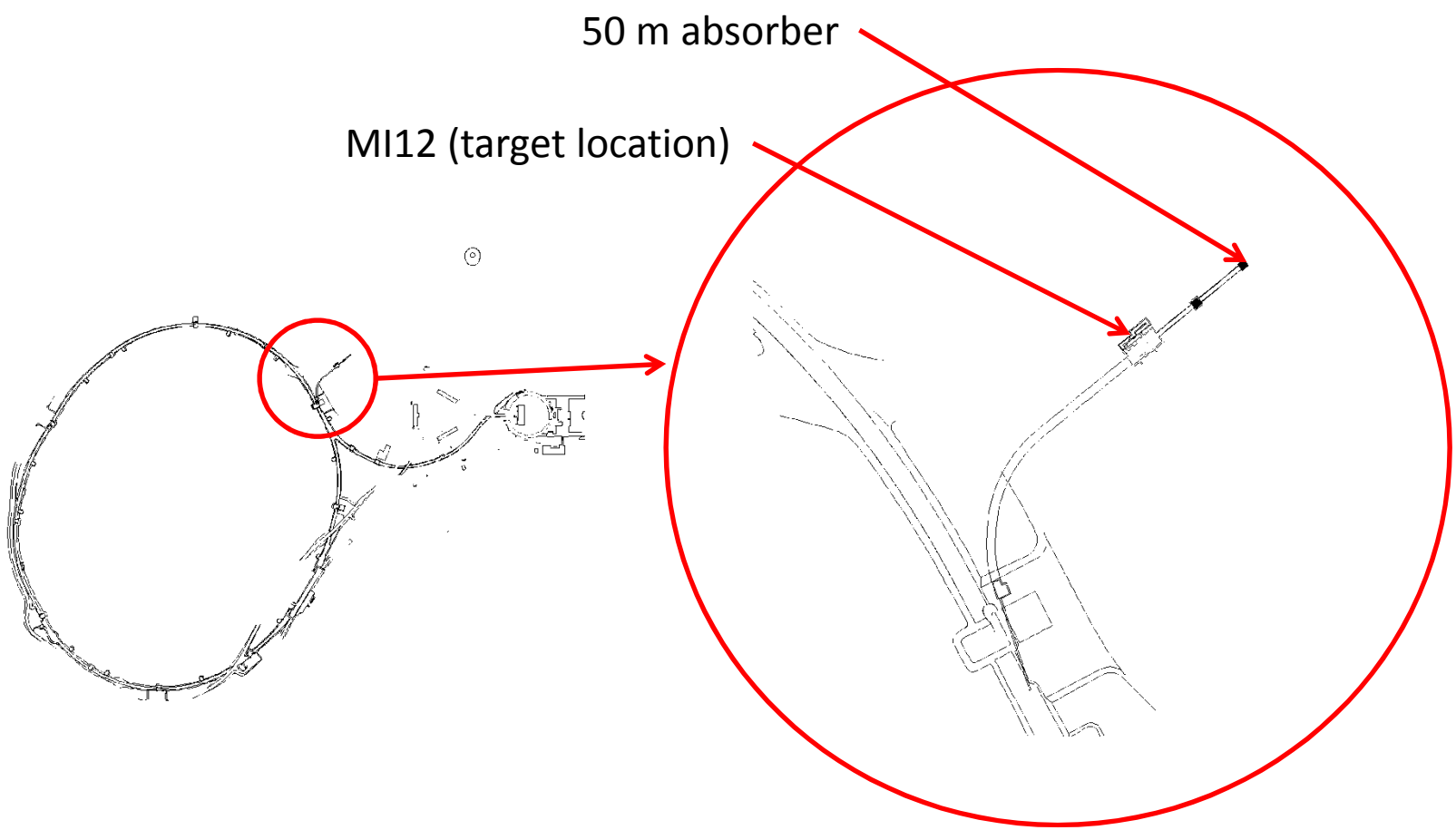




Since turning on, BNB has transported 2.1E21 protons.

The horn has pulsed half-a-billion times.

Location



Location

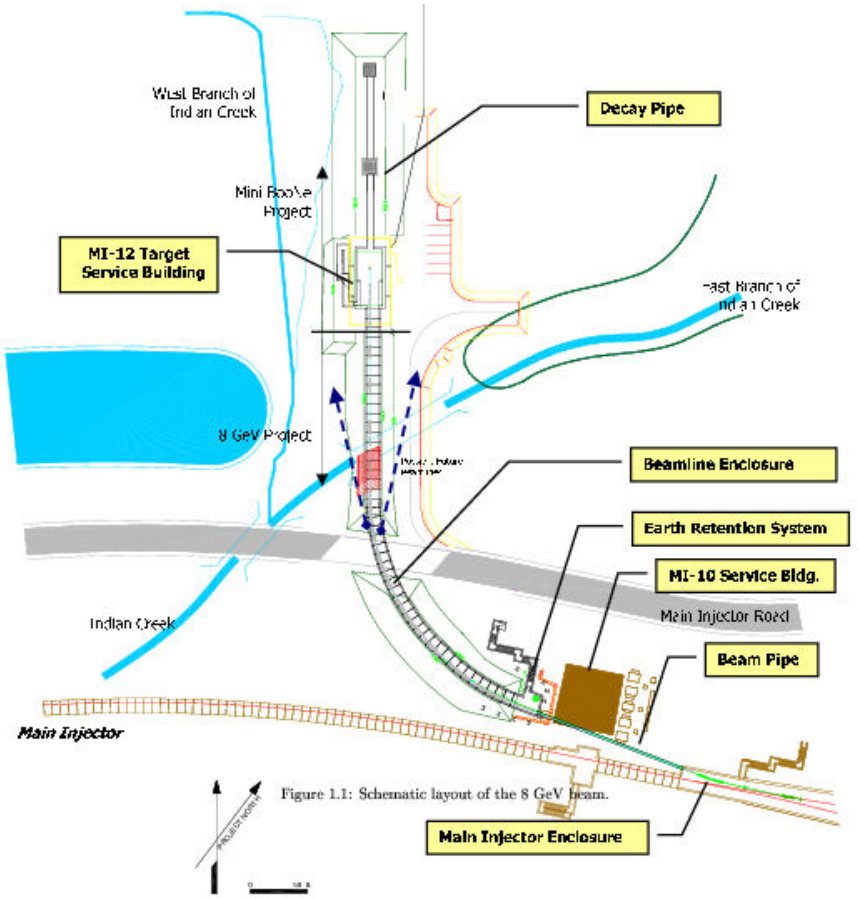
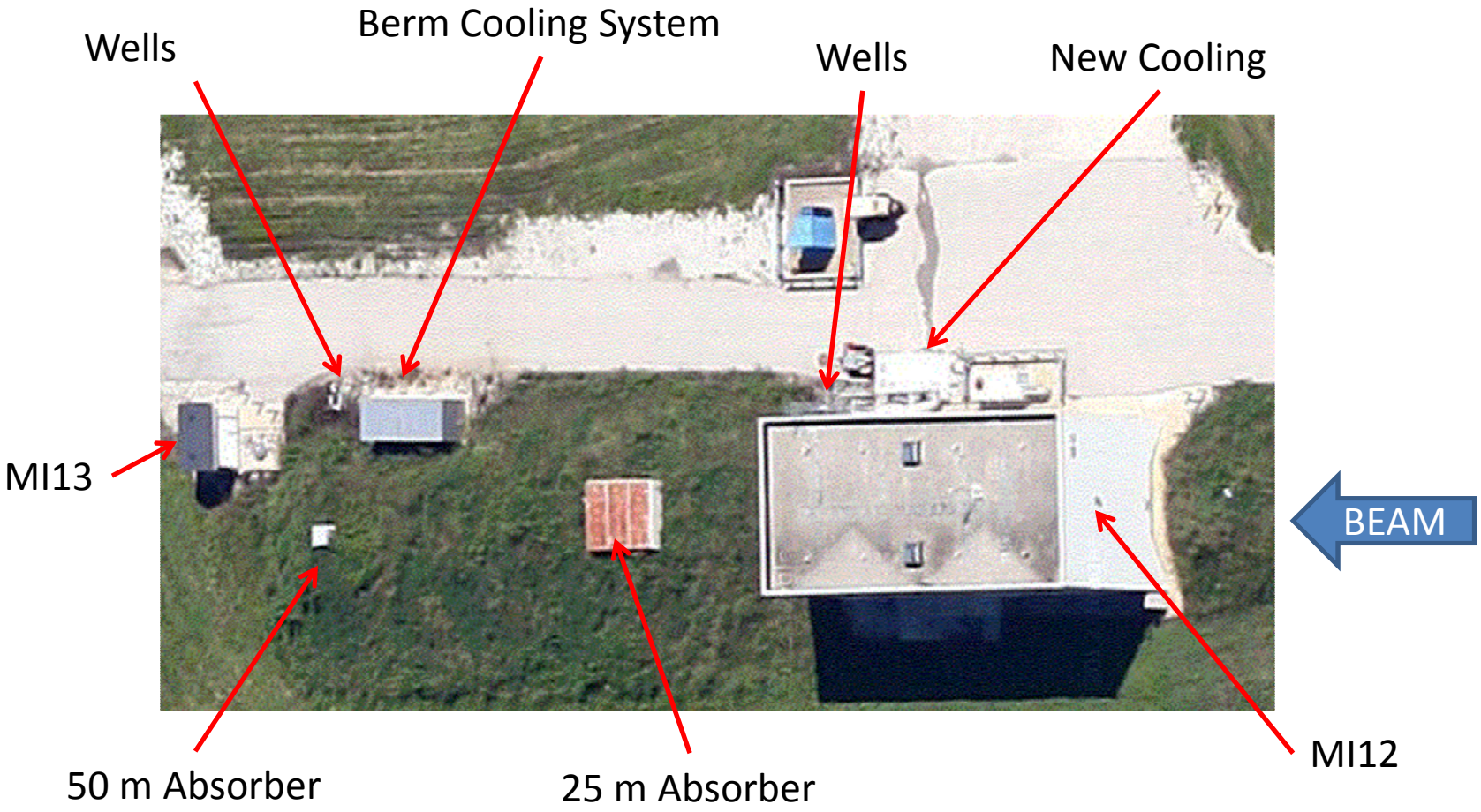
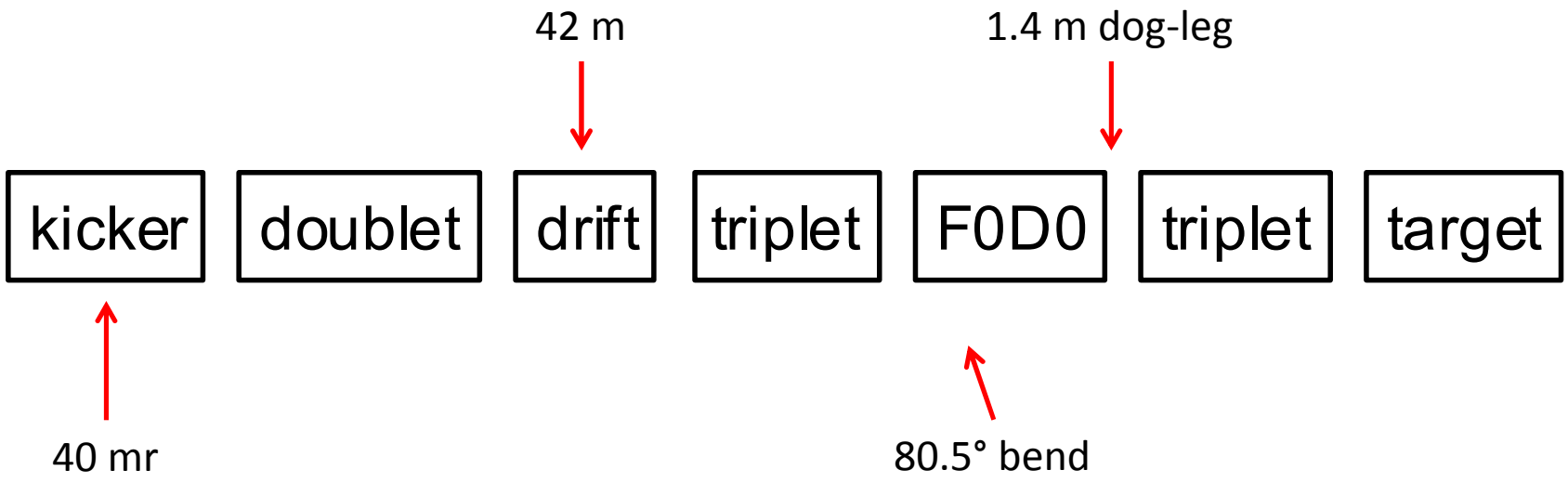


Figure 1.1: Schematic layout of the 8 GeV beam.

Location


Wells
Berm Cooling System
Wells
New Cooling
MI13
BEAM
50 m Absorber
25 m Absorber
MI12

Beamline – Block Diagram



The Booster Neutrino Beamline was designed by Al Russel

Beamline -- Schematic

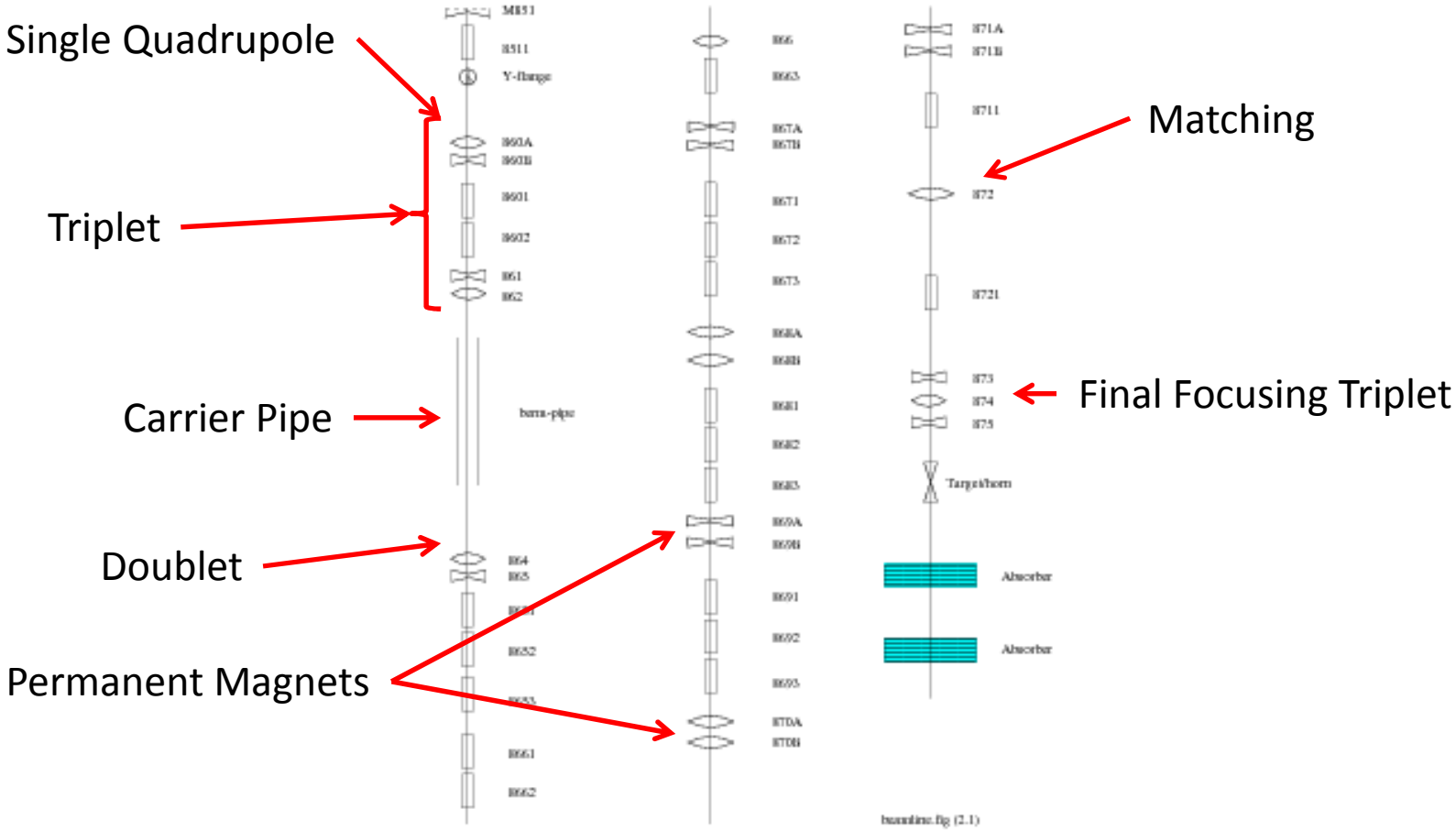
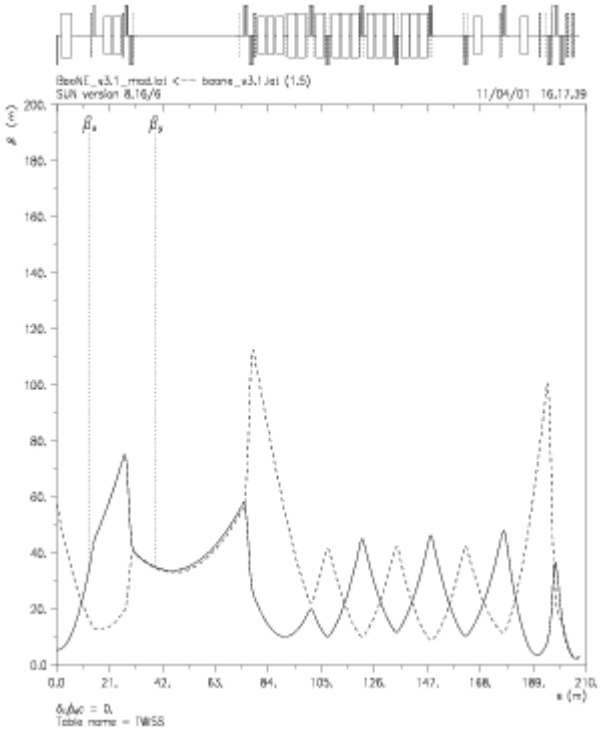


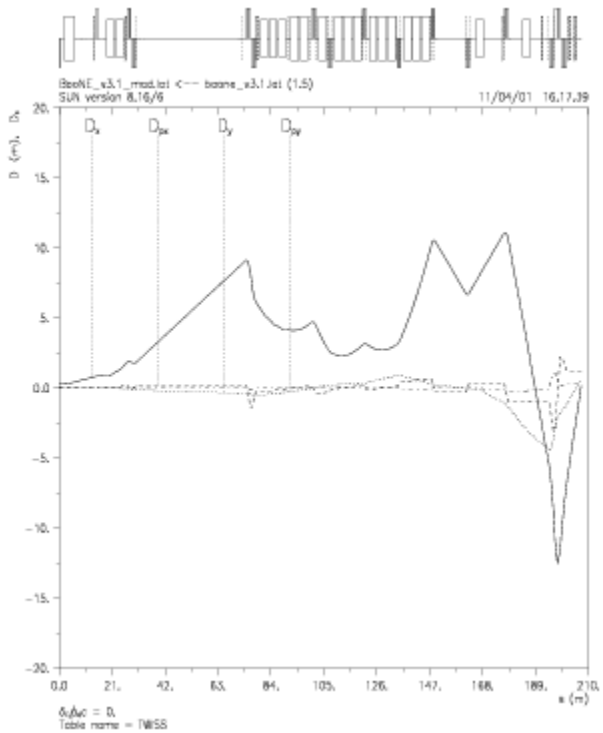
Figure 2.1: Beamline schematic and function. Elements are listed in Table 2.1.

Optics



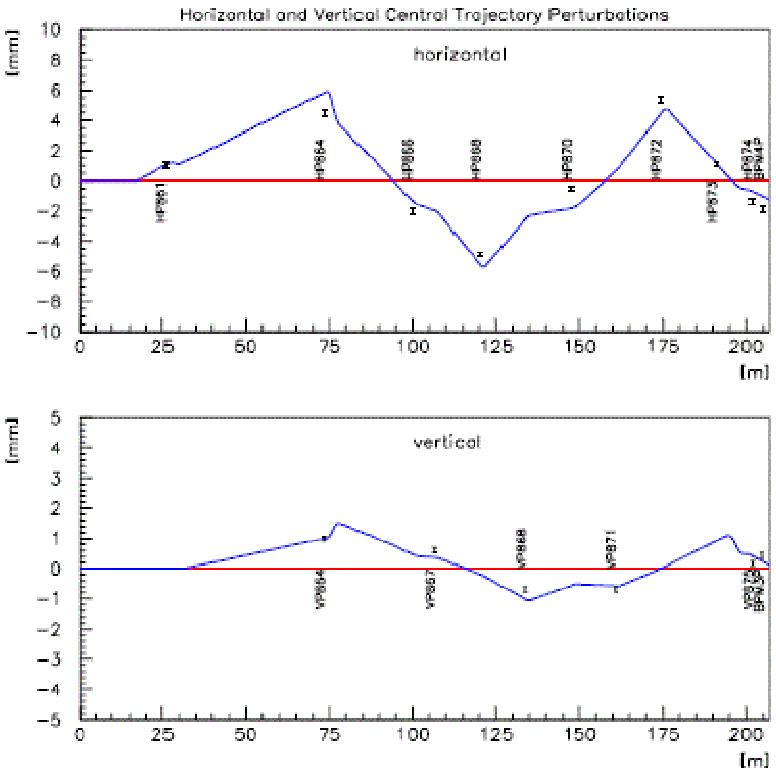
8 GeV.
Designed to deliver 5E12 protons per pulse at 5 Hz average.
~40 degree phase advance per cell.

Optics



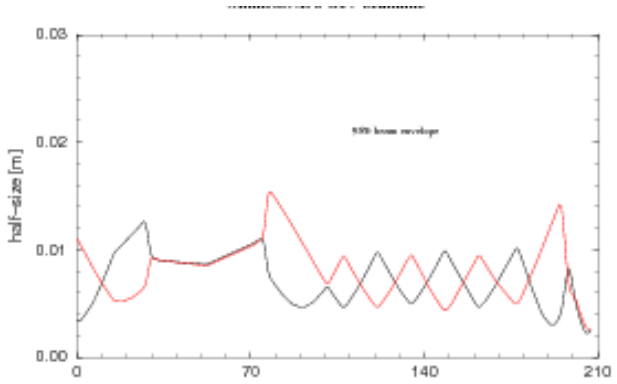
Up to 12 m horizontal and 5 m vertical dispersion.
Use large aperture (6-3-120) dipoles.
Zero dispersion at target.

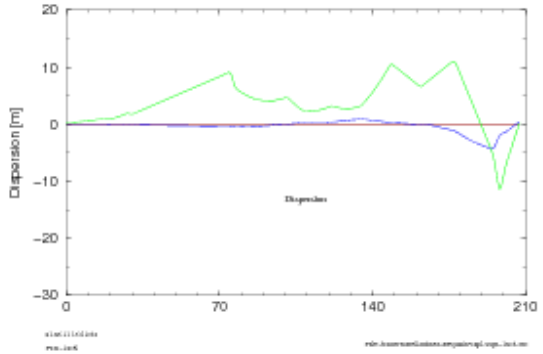
Optics



- 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:

$$\Delta i_1 \rightarrow \Delta p_1, \Delta p_2, \Delta p_3$$
$$\Delta i_2 \rightarrow \Delta p_2, \Delta p_3$$

- Leads to a linear equation:

$$\Delta\vec{p} = \begin{pmatrix} \frac{\Delta p_1}{\Delta i_1} & \cdots & \frac{\Delta p_n}{\Delta i_n} \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \Delta p_n / \Delta i_n \end{pmatrix} \Delta\vec{\imath}$$

or

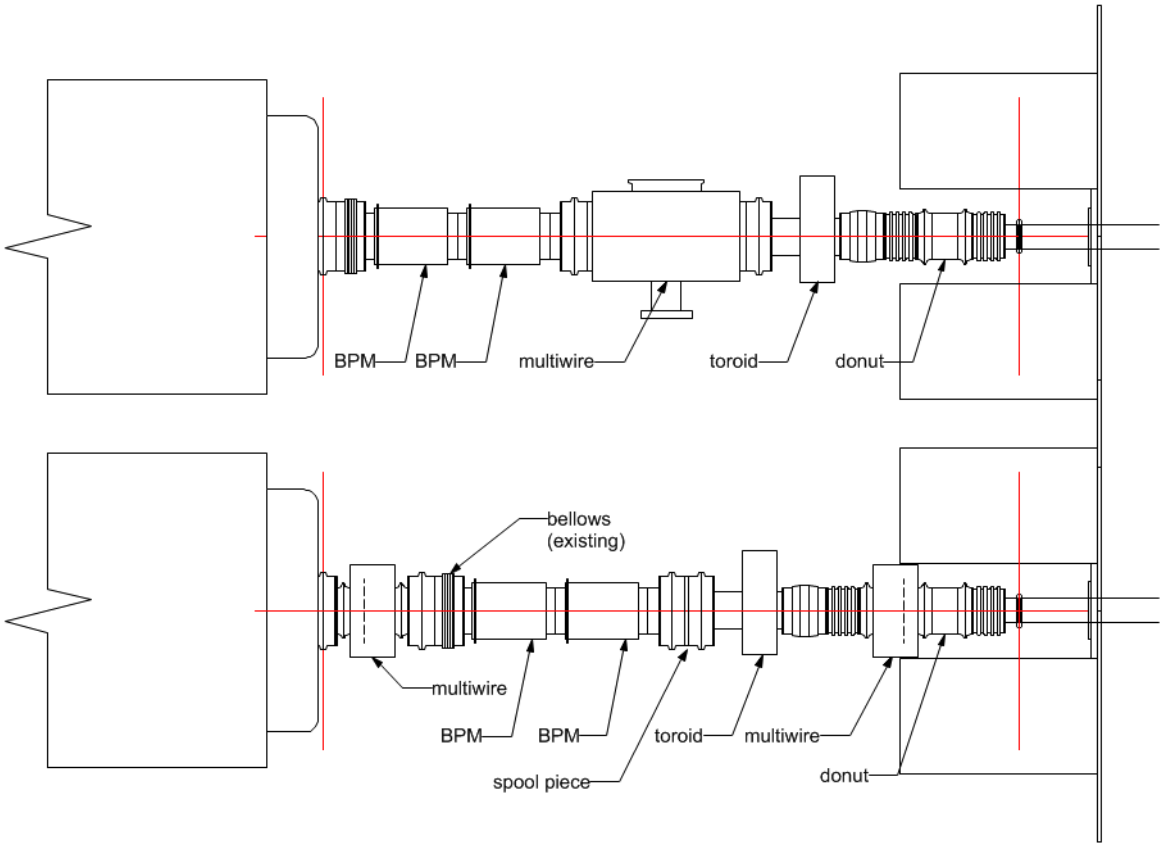
$$\Delta\vec{p} = \boldsymbol{M}\Delta\vec{\imath}$$

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

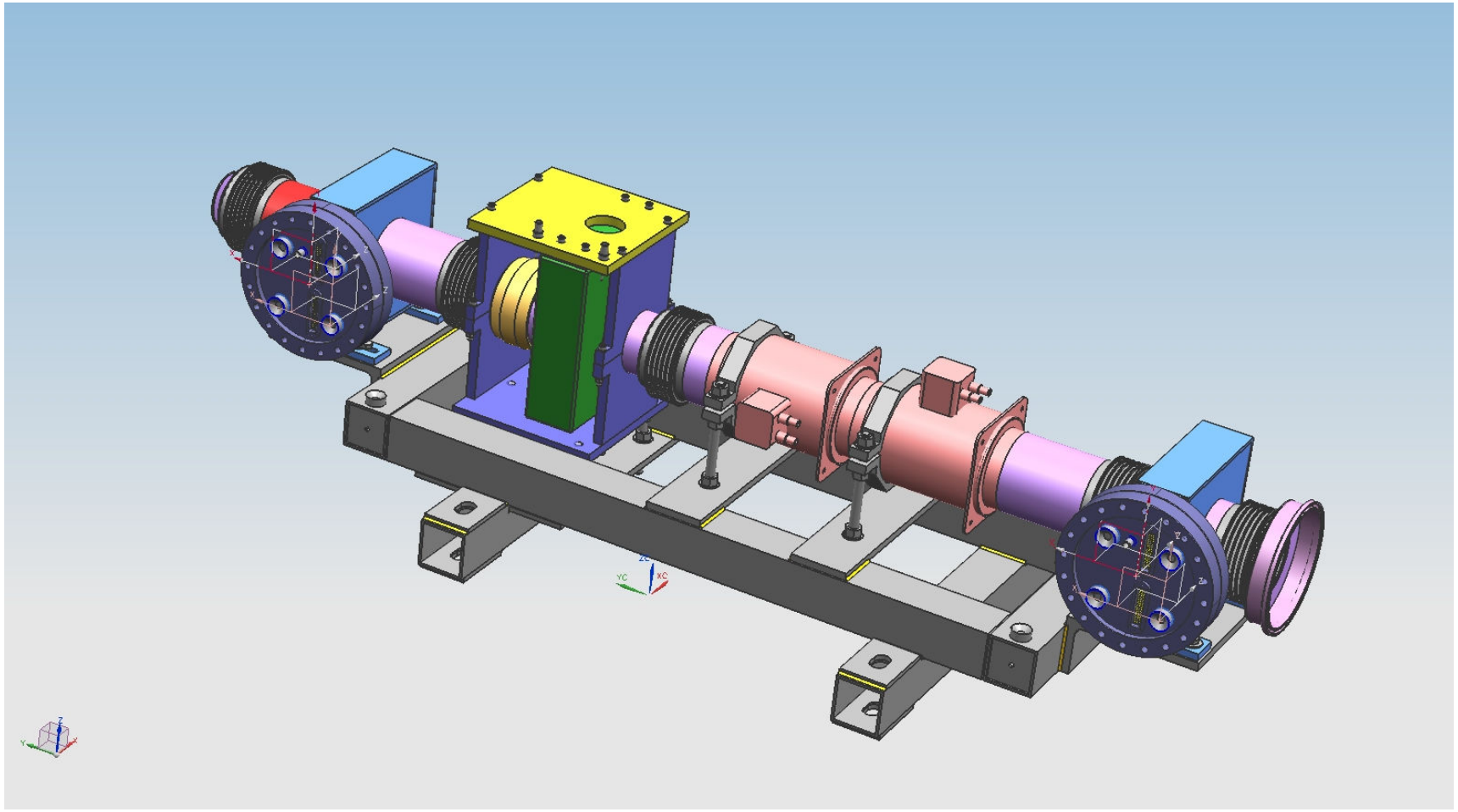
$$\Delta\vec{\imath} = M^{-1}\Delta\vec{p}$$

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

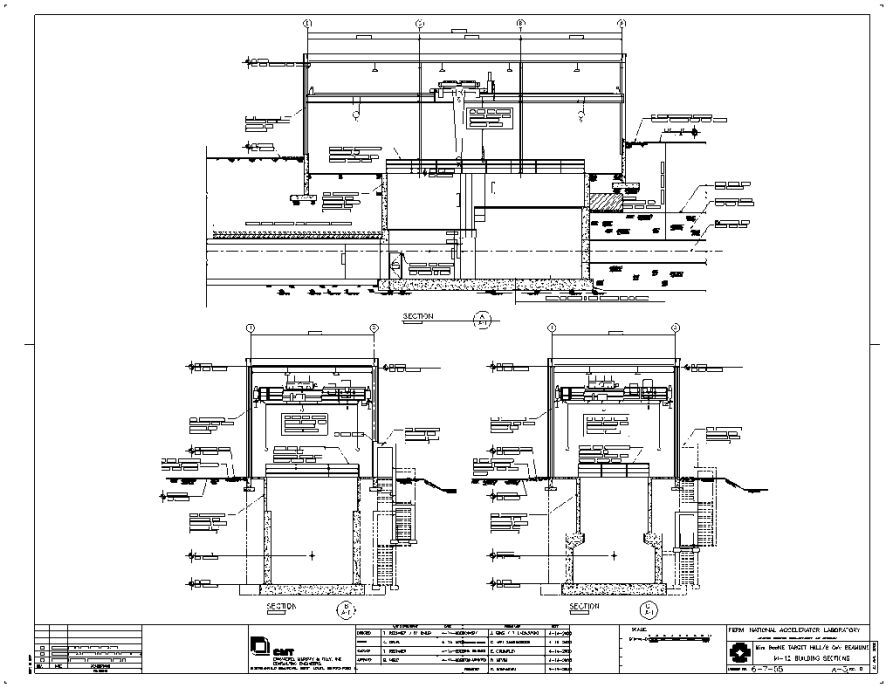
New Pre-Target Instrumentation



Version Two



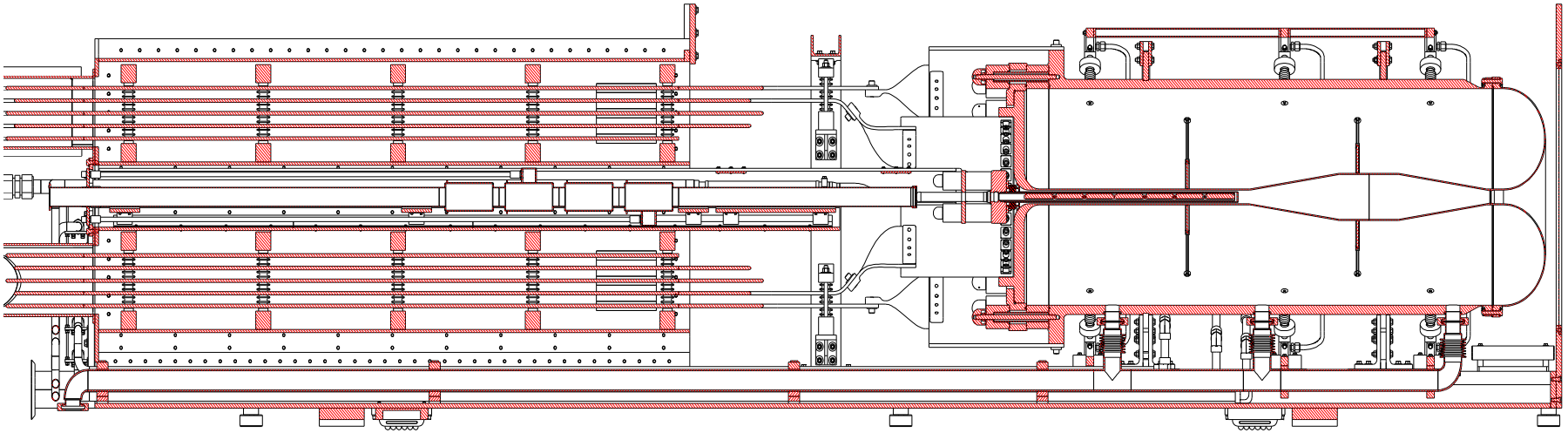
MI12 – Access to Target/Horn



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

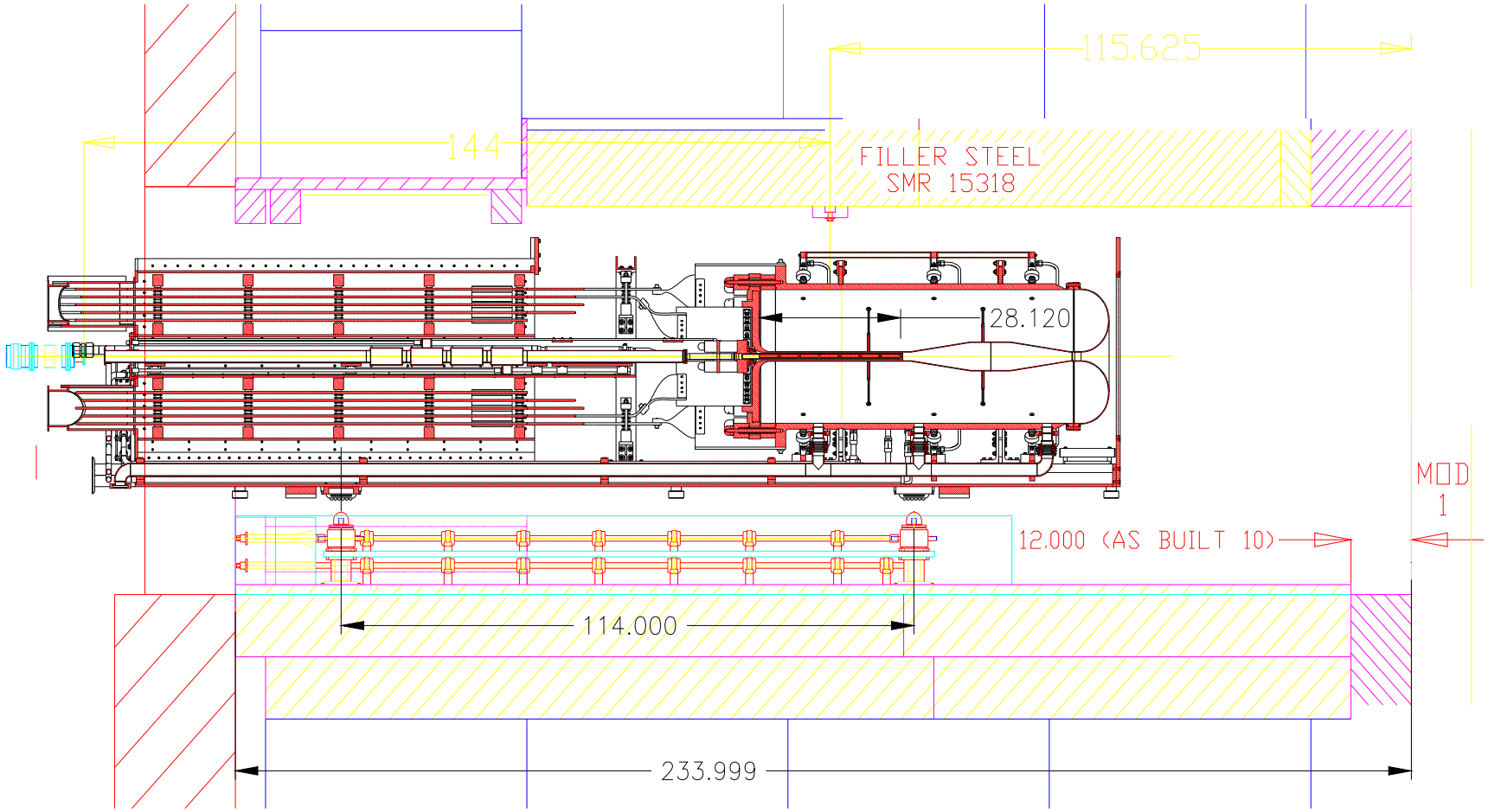
Target and Horn

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

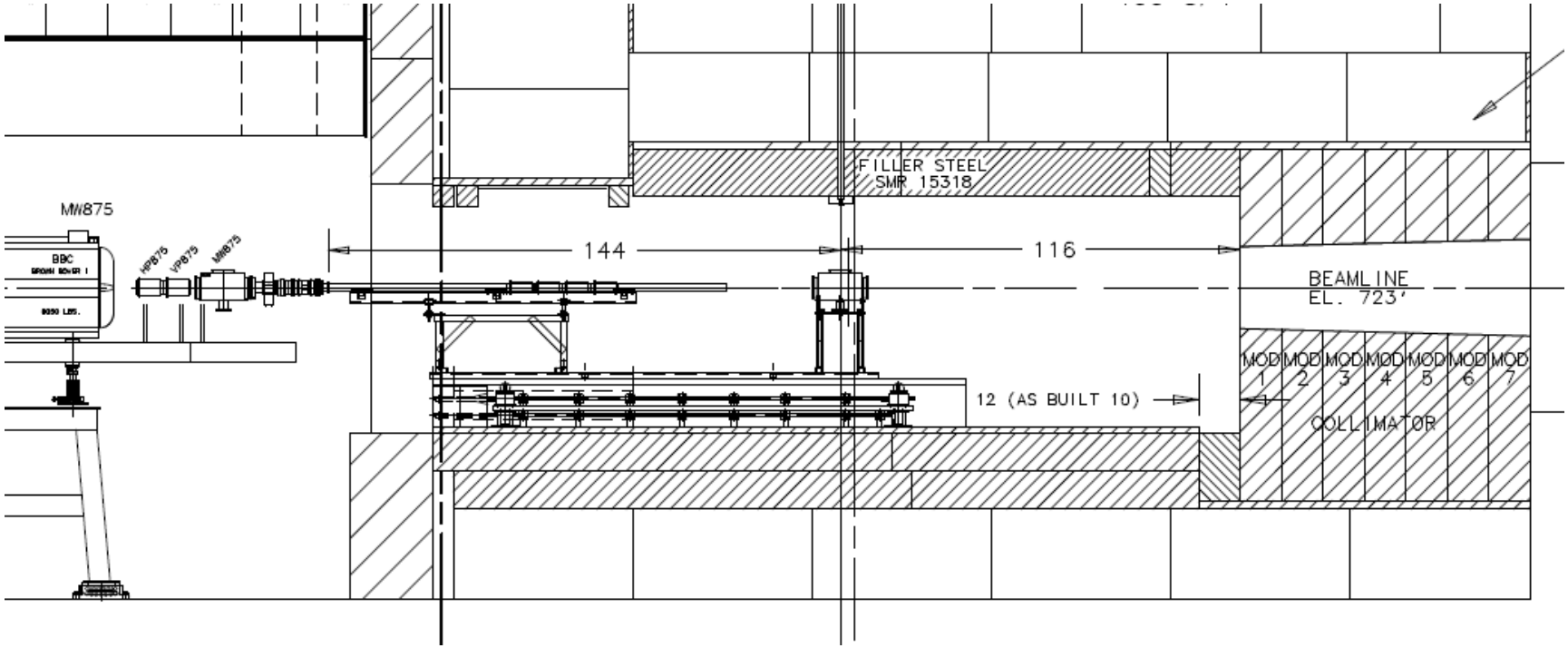


Target and horn are built and installed as a single unit, although it is possible to change only the target.

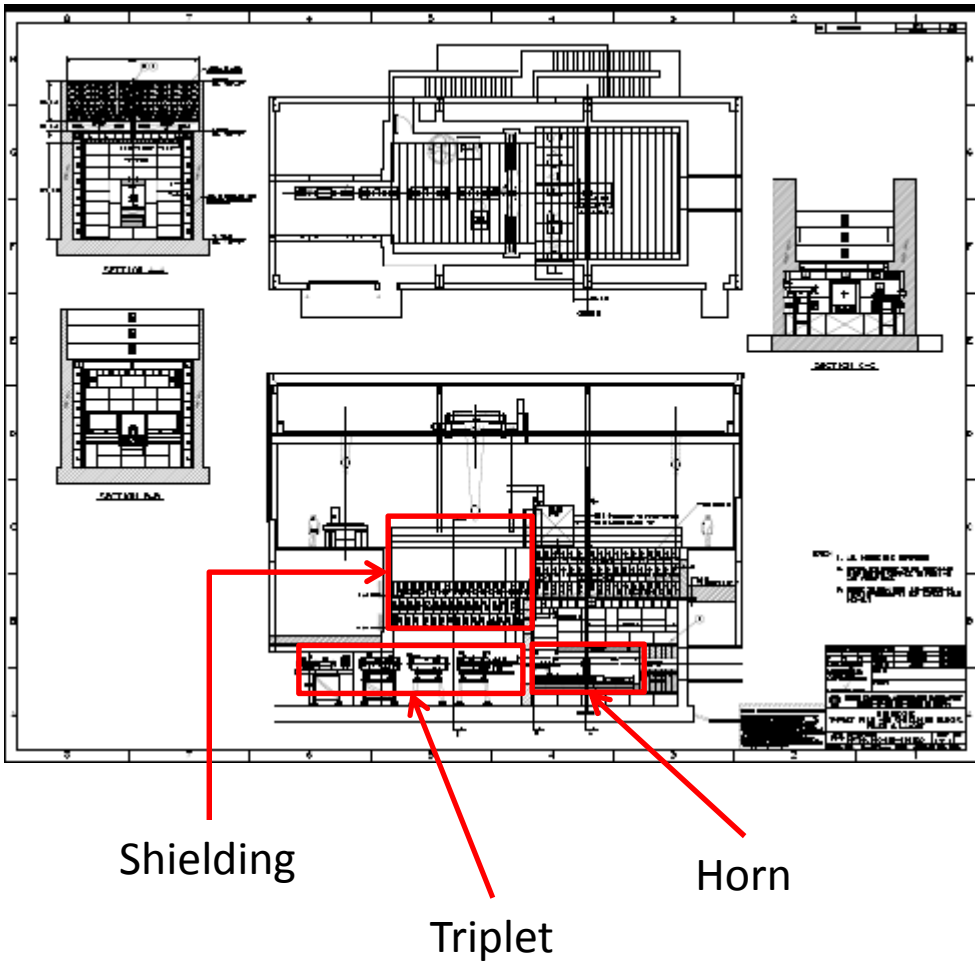
Target/Horn in Target Pile



Target Pile


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

MI12 – Target/Horn Change



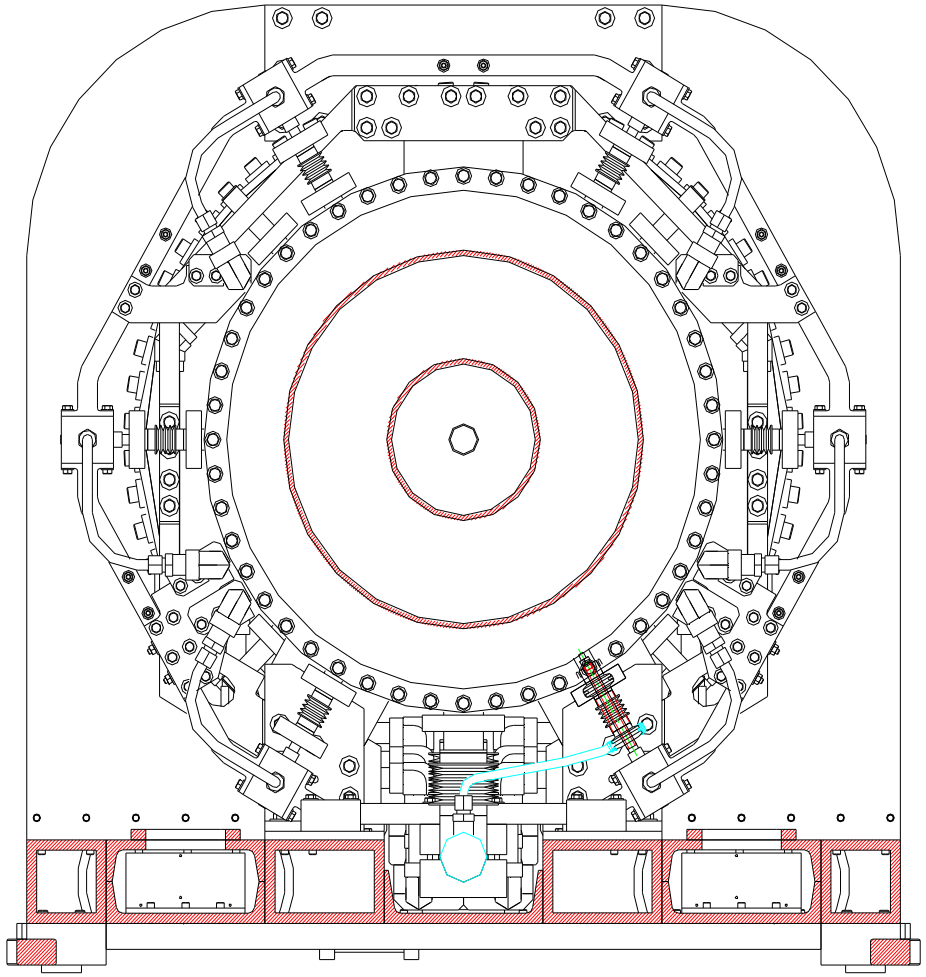
- Target/Horn is buried in a shielding.
- Unstack 6x15 shielding blocks. Blocks needed to be wrapped
- Remove final focus triplet.
- Lower coffin.
- Remove horn.
- Reverse procedure.

Total time: 12 weeks.

First Horn – MBH1

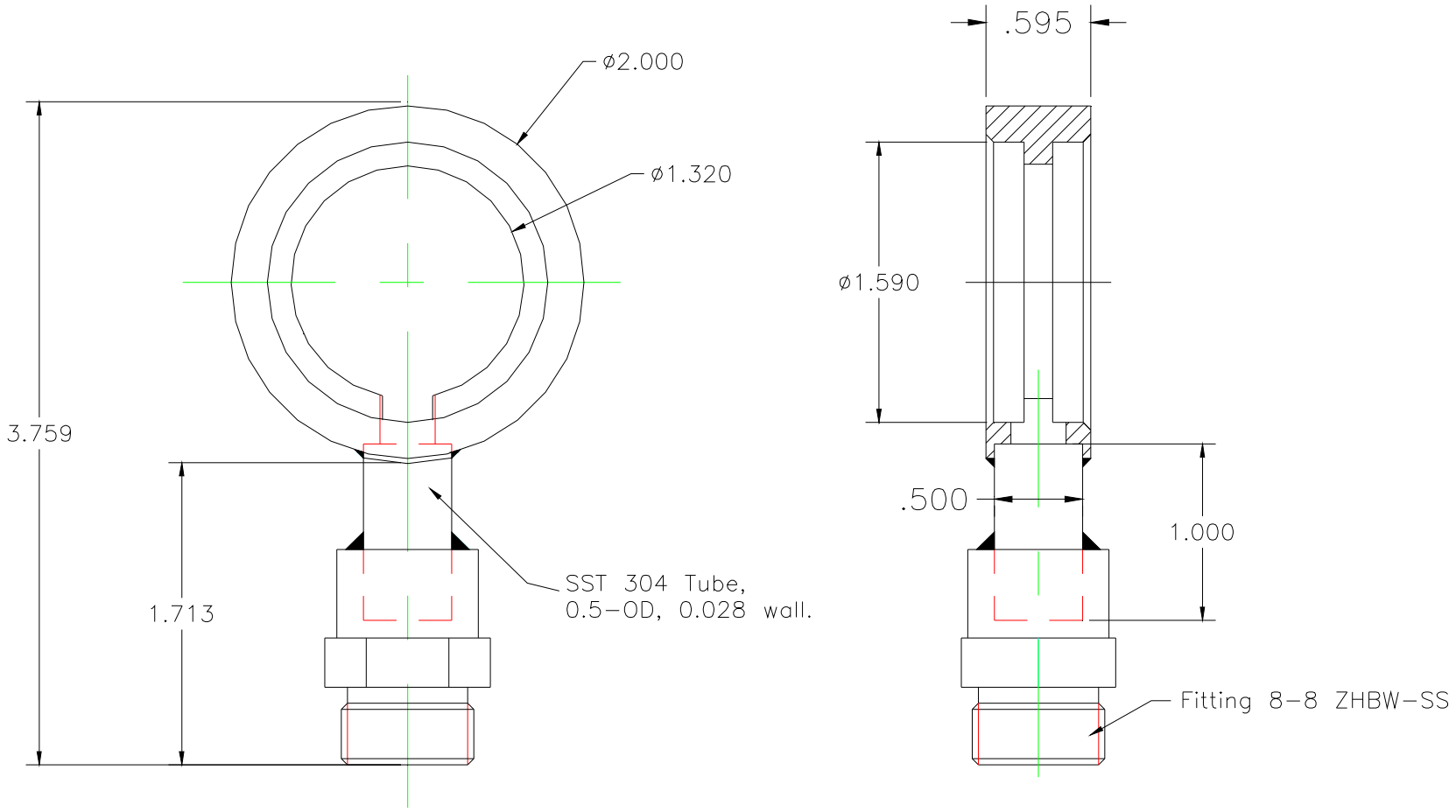
- April 28, 2002 to July 28, 2004
- 97 million pulses
- Both horn and target were replaced
- Suspected cause of failure was stagnant water in return line bellows.

Modification



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

Modification

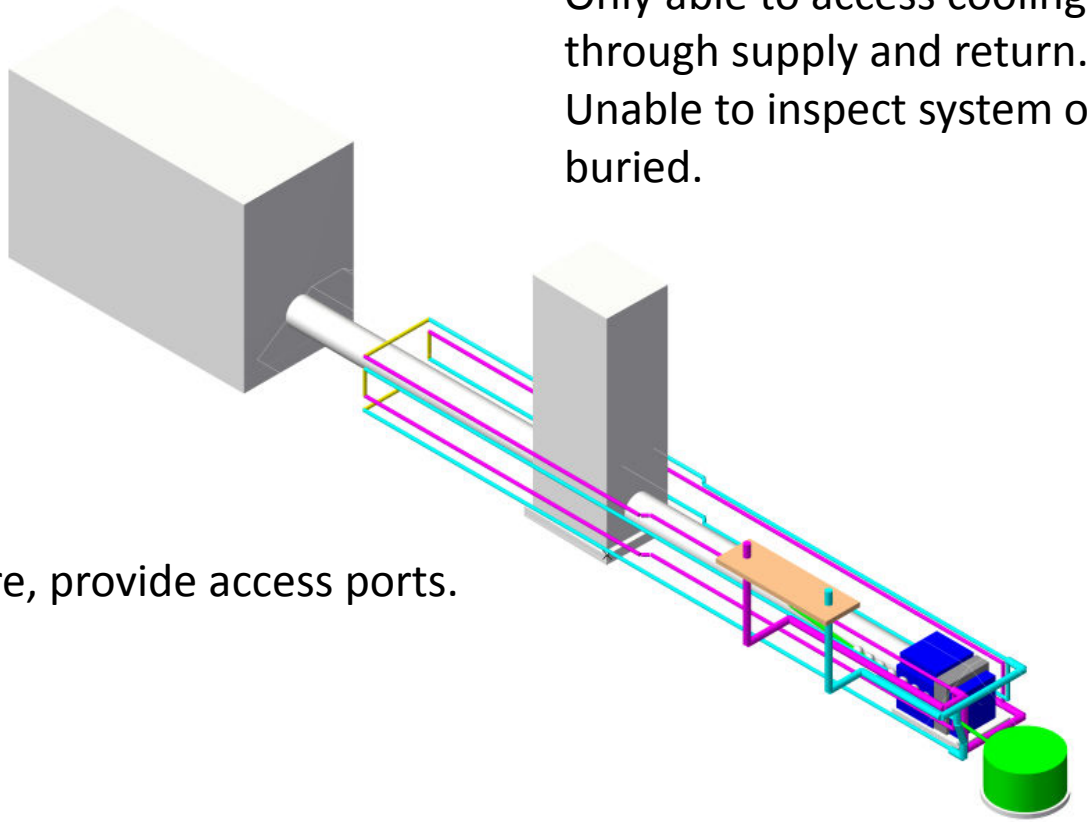


MBH2

- 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.
- Has provided new data regarding fatigue of aluminum.
- Have kept water circulating during all shutdowns.

Berm Cooling System

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

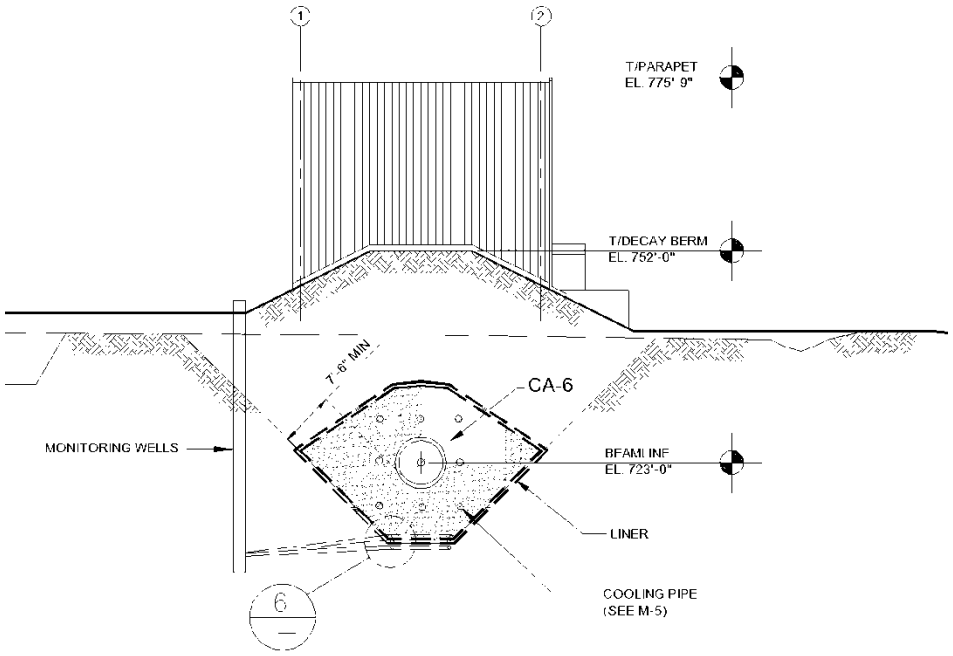


In the future, provide access ports.

Tritium Mitigation

- Minimize tritium contact with groundwater.
- Bury decay pipe in dry aggregate instead of moist soil.
- Use an impermeable barrier – prevent any tritium from leaving the zone.
- Add “de-watering wells” as a backup to impermeable barrier.

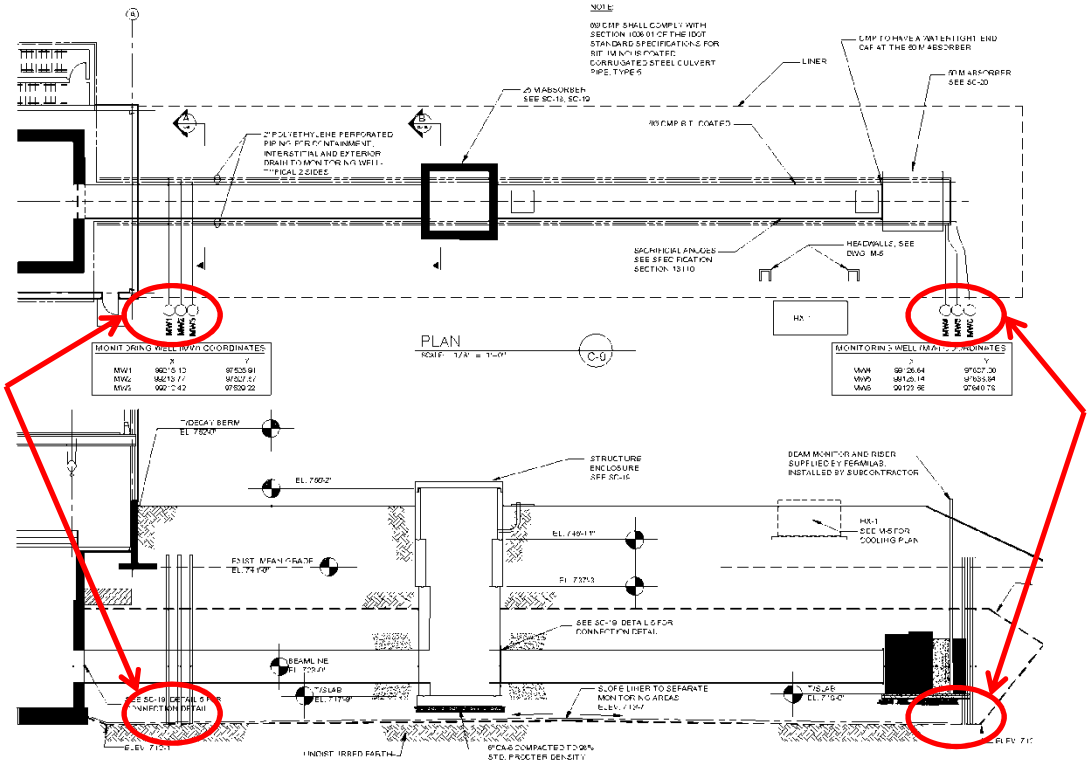
Barrier and De-Watering



- Decay pipe buried in 12 to 15 feet of aggregate.
- Aggregate is surrounded by two impermeable liners.
- Three drainage systems located:
  - Inside aggregate, next to inner liner.
  - Between inner and outer liners.
  - Immediately outside outer liner
- Each drain connects to two monitoring wells, one upstream and one downstream.

Wells

Three upstream wells



Three downstream wells

Well Pump

De-Watering System

Pros

- Impermeable barrier prevents water from infiltrating the aggregate.
- Wells are inexpensive.
- Use standard transducer to monitor water level.

Cons

- Impermeable barriers tear and are no longer impermeable.
- Wells are inaccessible – when pump fails, one needs a crane to pull the entire pipe.
- Hard water clogs transducer.

Ending Comments

- The Booster Neutrino Beamline continues to operate.
- MicroBooNE is slated to use the facility.
- MBH3 has been built and tested.