WBS 1.1.3 *Power Supply System*

Level 3 Manager

Nancy Grossman

FNAL

February 26, 2002

Outline

- **Overview & Specifications** **(N. Grossman, 15')**
  - → General Layout & Overall Specifications
  - → Transmission Line (TL) Shielding Blocks
  - → Prototype Horn 1 Flexible Joint, Horn 2 Non-flex Joint
  - → Remote Clamp
  - → TL through the Shield Block & Beyond
- **Response to Recommendations** **(N. Grossman, 5')**

- **TL Block Design/Status** **(B. Boettinger, 20')**
- **Prototype Flex Joint & Single Strip Test Plans/Status** **(B. Boettinger, 30')**
- **Break**
- **Clamp design/status** **(B. Boettinger, 30')**
- **TL through Block & Beyond Design/Status** **(B. Boettinger, 20')**
- **Testing at MI8** **(J. Hylen, 20')**

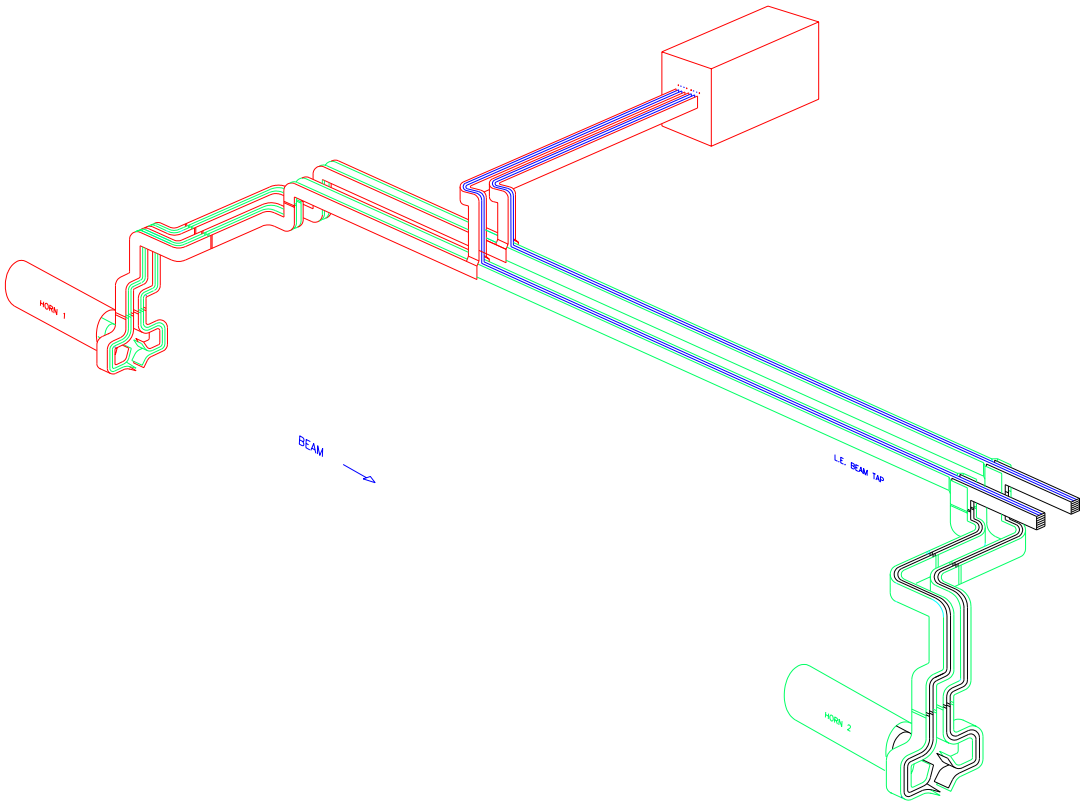
- **Summary, Schedule, Concerns** **(N. Grossman, 10')**

Engineering

- **MI8 Transmission Lines, Dummy Load**
  - → Dave Tinsley (ME)
- **Transmission Line Shielding Blocks:**
  - → Bill Boettinger (ME)
- **Prototype Horn 1 Flexible Joint**
  - → Ingrid Fang (ME, 95% of design), Zhijing Tang (ME, ANSYS)
  - → Bill Boettinger (ME, finalize design)
- **Horn 2 Fixed Joint & MI8 Setup for Flex Joint/Clamp Testing**
  - → Dave Tinsley (ME, 90% of design)
  - → Zhijing Tang (ME, ANSYS)
  - → Bill Boettinger (ME, finalize design)
- **Remote Clamp**
  - → Tom Cygan (ME, 95% of design)
  - → Bill Boettinger (ME, finalize design)
- **TL through the Shield Block and Beyond**
  - → Bill Boettinger (ME)
- **Electrical Aspects: Ken Bourkland (EE)**

General Layout: Target Hall Transmission

- Material: Aluminum, Dimensions: 12 inches wide by 3/8 inch thick
- Width: Stripline nominal width is 12 inches, reduce to 8” from below clamp to horns.
- Gap: Stripline nominal spacing between bars is 3/8 inch, can increase in flex region.



PICTORIAL REPRESENTATION OF HORNS AND STRIPLINE

General Layout: Horn 1 Region

General Layout: Horn 1 Region

General Layout: Testing at MI8

Production Horn PS and Test Stand Transmission line are Installed and Running in MI8.

>> 2.7 msec pulses, 200KA and 1.9 second repetition rate

>> Pulses to date: 3.5 million

5.5 million total to the prototype horn 1.

Target Hall pulse ~1.9 msec, 1.9 second repetition rate.

Overall Specifications/Concerns

1. Horn 1 expected movement: ~5mm

- → 2 mm rotation
- → 3 mm translation
- → Frequency: 1-2 scans at commissioning, 5 movements per scan, center and one to each side, top and bottom
- → Resultant force on horn: ~ 400 lb.

2. Horn 2 does not move (except due to expansion from heating)

3. Radiation Environment such that ceramics must be used near the beam, but not necessary above the module/T-blocks.

4. Vibration, keep to a minimum everywhere.

Biggest horn vibration is from stripline (MI8 measurements)

Not near horn natural frequencies (200 Hz)

Overall Specifications/Concerns

5. Cooling

- → Target chase cooled by 10,000 to 30,000 cfm flowing in the beam direction in the horn region and back in the opposite direction between the top of the T-blocks and the concrete cap.
- → Beam heating: ~183 KW/m^3 (transmission line near the beam)
- → TL Electrical heating: ~27 KW/m^3 (flex joint number)
- → Assume air cooling from target chase is sufficient (will need to check)
- → Air flow through TL shield block from top of module to horn should not be obstructed (this air flow cools stripline)
- → Air dam is needed at the H-block cover between the module and the stripline along the target hall wall (intended to contain air-borne radiation).

6. TL Routing must not block:

- → Survey holes in T-blocks just off module ends, need direct vertical line of sight.
- → Must clear carriage cross beam and T-blocks crossing over it.
- → Module cross pieces where connections are made.

Overall Specifications/Concerns

7. Need to be able to remove section of stripline from top of module to beyond module sides so that the module can be lifted out.

Disconnects at:

- → Remote clamp at bottom of module
- → Top of module
- → Beyond edge of T-blocks

8. TL above shielding needs stands to keep it secure and to keep it from vibrating and a cover (sloped) to keep things from falling on it or people putting things on it.

9. Lifetime:

- → Part of stripline connected to horn will be replaced each time a horn is replaced, ~ once per year.
- → Part of stripline within stripline block (includes clamp) does not have to be replaced every time a horn is replaced, but we will most likely have a spare just in case.
- → Lifetime of NuMI ~ 10 years

Overview/Specifications: TL Shielding Blocks

TL Shielding Blocks:

- Material: Steel, boltable design for ease of access to TL if problems are encountered.
- Gap Dimension: 3/8” minimum air gap from TL to conducting material.
- Dimensions: design modeled and iterated in MARS to keep residual dose rates below ~10 mrem/hr .
- Weight limitations due to crane

Horn 1 Flexible Joint

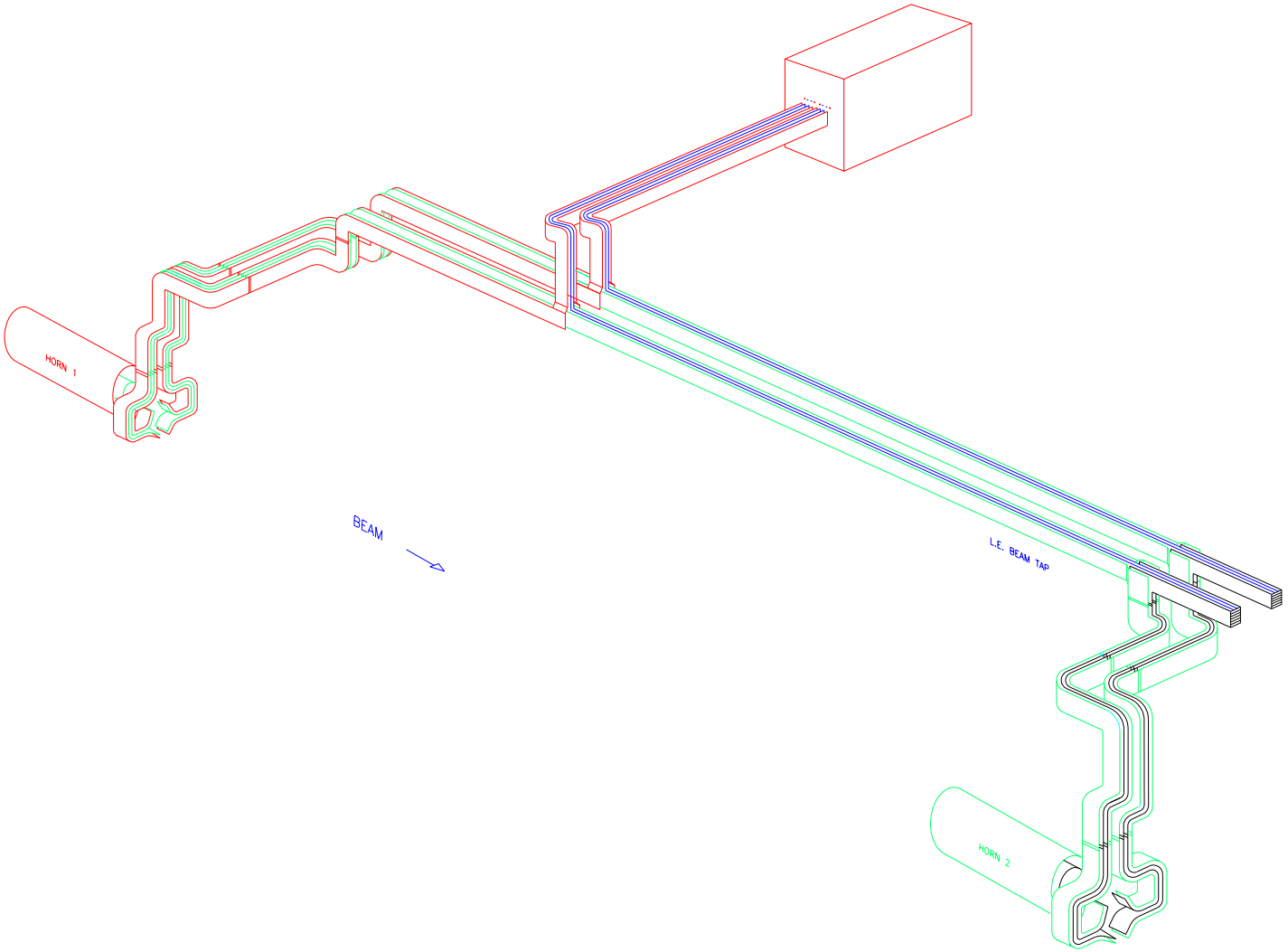
Horn 2 Non-Flex Joint

- Same design as Horn 1 flex joint, scaled up to Horn 2 size and without EDM (slits).
- ANSYS results show that the forces on the horn from the TL due to the expansion of the horn from heating are reasonable.

Remote Clamp

- Highly radioactive once run, must work remotely, make & break connection in the hot cell.
- Minimize scratching of silver plating.
- Concerns about TL fingers welding together.
- 1400 psi min. clamping force needed, 3200 psi design.
- Links to bottom of shield block “floats” clamp so fingers will self-align to each other.
- Lead-in dagger pins to help aligning.
- Push-off/pull-on draw bars.

Transmission Line through the Block and Beyond



PICTORIAL REPRESENTATION OF HORNS AND STRIPLINE

Response to Recommendations: Flex Joint Review (July 2001)

- Other design options were considered, rejected due to additional welds needed, difficulty of transitioning from flex joint to rest of transmission line, etc.
- Eliminate welding near slits – not necessary. Have a sample piece with a slit.
- 3 wire EDM vendors have seen the drawings for the slits, say they can do it and are bidding.
- Replaced rocking clamps with fixed clamps (20% increase in force on horn, now 422 lbs, ANSYS analysis.)
- Extend slits so all are the same length, this decreased the stress on the slit hole to 14 ksi (was 30 ksi with fixed clamps and shorter slit)
- Clamps are offset by 3.5” to reduce local electrical “hot spots” – insignificant change to load on horn (ANSYS).
- Inner and outer flag length shortened less than ½” in order to allow more clearance in the chase.

Response to Recommendations: Flex Joint Review (July 2001)

- Ceramics have all been re-designed to make assembly easier, better electrical isolation (now use a ceramic sleeve through the bolt hole), sheer force of ceramic estimated at 1500 psi-OK.
- Welding specifications are based on what worked for Miniboone.
- Fatigue analysis completed for maximum offset resulted in a safety factor of 8 for 10 million pulses. A static magnetic load and thermal load analysis was also completed.
- Test piece is being made and will be force tested (force vs. displacement) in the village. Check for quality, etc.
- Prototype flex joint and remote clamp will be installed and pulsed in MI8 in both the centered and off-set position for several months (~ 1 million pulses/month)
- Expect to make spares of the remote clamp, flex joint and TL shield block.

Response to Recommendations: Horn PS/TL Review (August 2001)

- Consider using a dynamic type fastener (e.g., spiralock nut) in the clamp joints and stripline support brackets.
- Consider measuring bolt preload in critical connections by measuring bolt stretch as opposed to bolt torque.
- Consider longitudinal damping along the TL section along the Target Hall wall to damp out possible undamped vibrations from electrical pulsing.
- Clamp will be tested at MI8 along with the prototype flexible joint.
- One ME is working on the flex joint, remote clamp and TL block, thus minimizing interfacing problems, but perhaps overloading Bill at times.
- Converting drawings to IDEAS8 still a problem, although slowly diminishing.
- Worry about scratching the silver-plating off the TL “fingers” when clamping/unclamping. A lot of thought has gone into the present design in this area. We will test the design by lowering the top TL section and clamp into the lower section out at MI8. There is time and money for changes if necessary.

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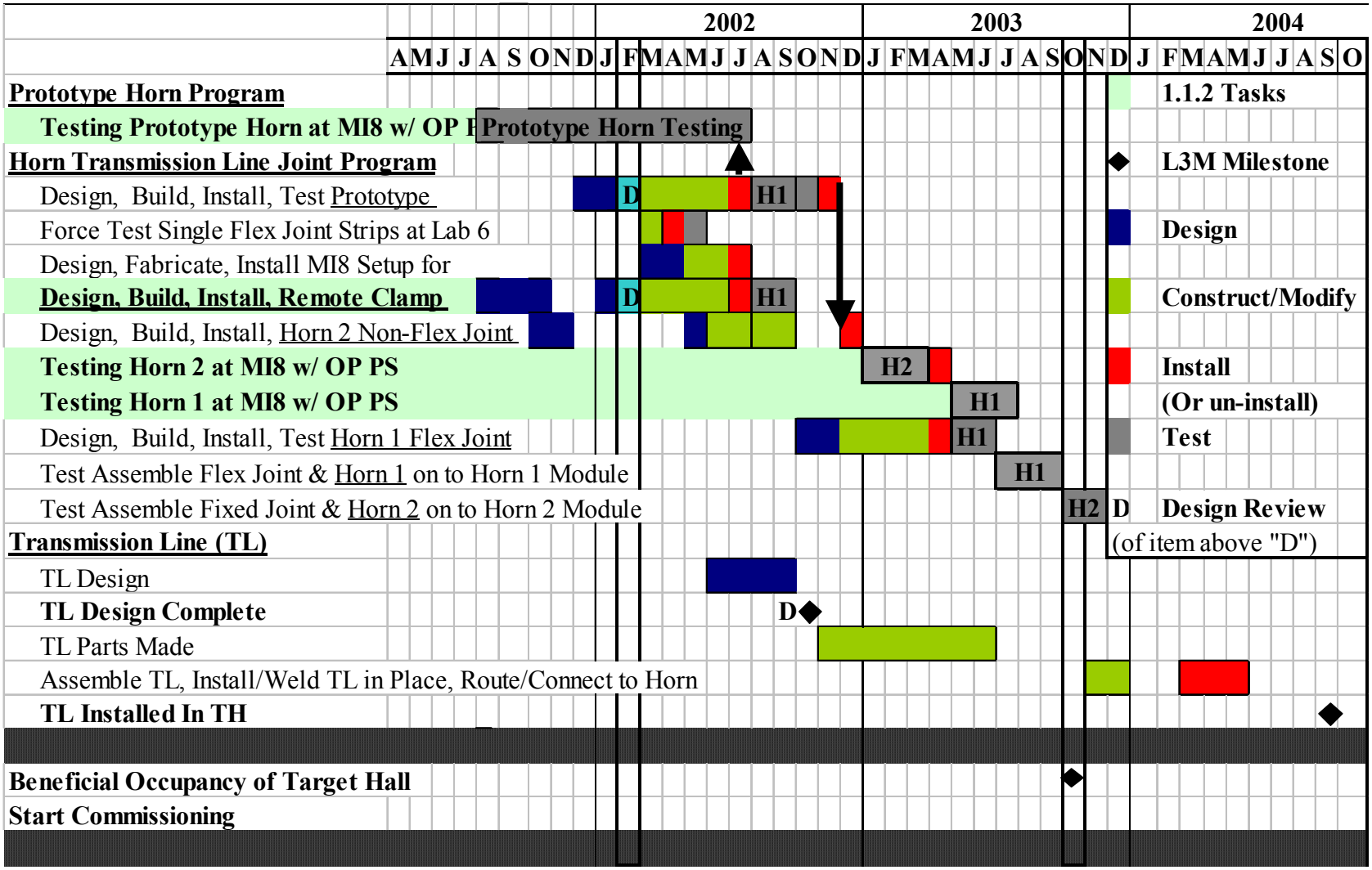
Summary/Schedule/Concerns



Schedule, Summary,Concerns

Summary:

- **Production horn PS pulsing on horn and prototype TL at MI8.**
  - → 5.5 million pulses on horn (3.5 million with production PS)
- **Shield block design well along and quite robust.**
- **Prototype flex joint looks good.**
  - → Cutting 12" to 8", forming, wire EDM-ing and ceramic PO's are all out the door.
  - → Testing Aug-Oct, should give plenty of time to work out problems.
  - → Costed for a full horn 1 flexible joint, hopefully will only need part of that cost for upgrading the prototype flexible joint/clamp.
- **Horn 2 non-flex design is a scaled flex joint design without the slits.**
- **Clamp drawings done in 1 week, ceramics already ordered.**
- **Test setup at MI8 is relatively flexible for horn2 and horn1 testing. Need to finalize the details.**

Concerns:

- **Ceramics/fabrication issues/vibration/installation of clamp/joint – learn with prototype single flex pieces and setup/testing at MI8.**
- **Schedule is a bit tight.**