UT-BATTELLE

High Power Hg Target Conceptual Design Review

Design Requirements, Interfaces, and Schedule

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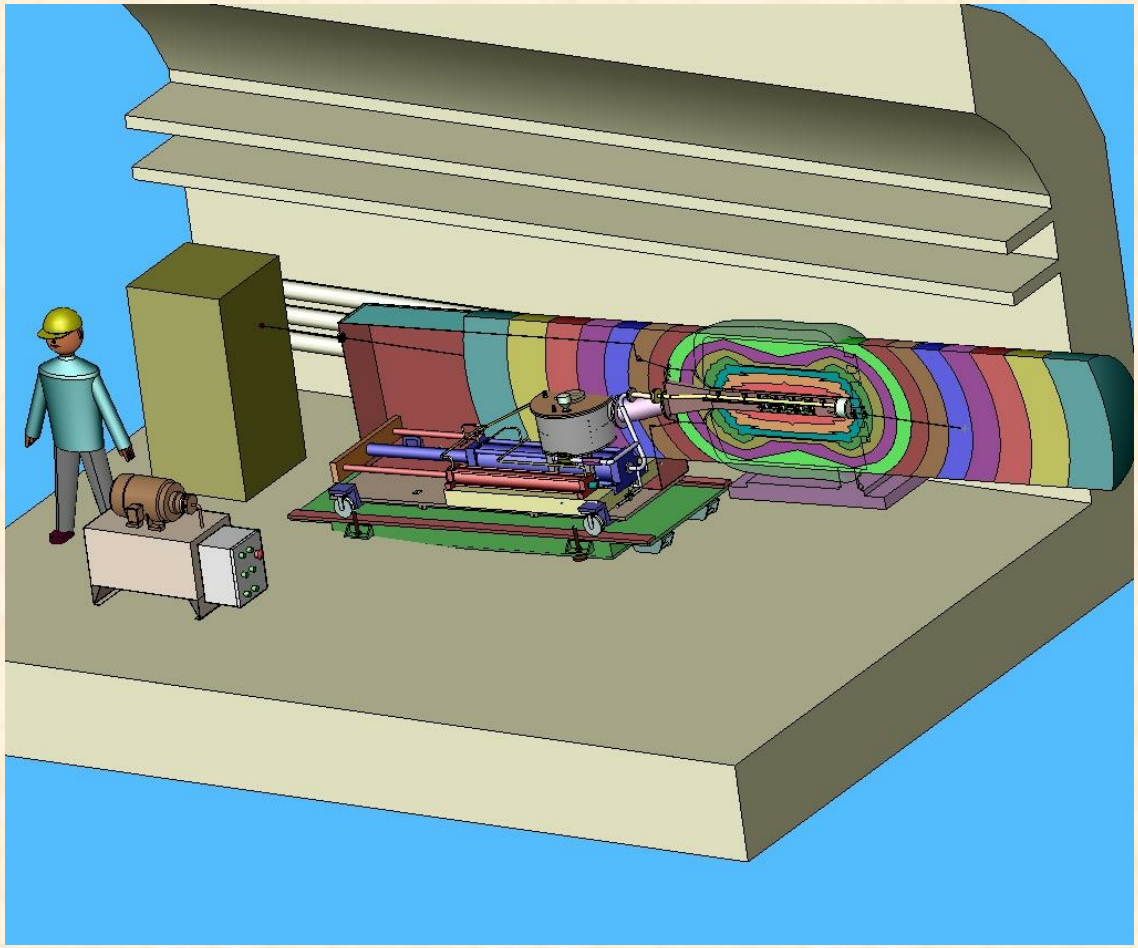
U. S. DEPARTMENT OF ENERGY

Design Requirements for the High Power Hg Free-jet Target Experiment

- **The Hg target system is part of the proof-of-principle experiment to investigate the interaction of a proton beam, high magnetic field, and a free-jet Hg target**

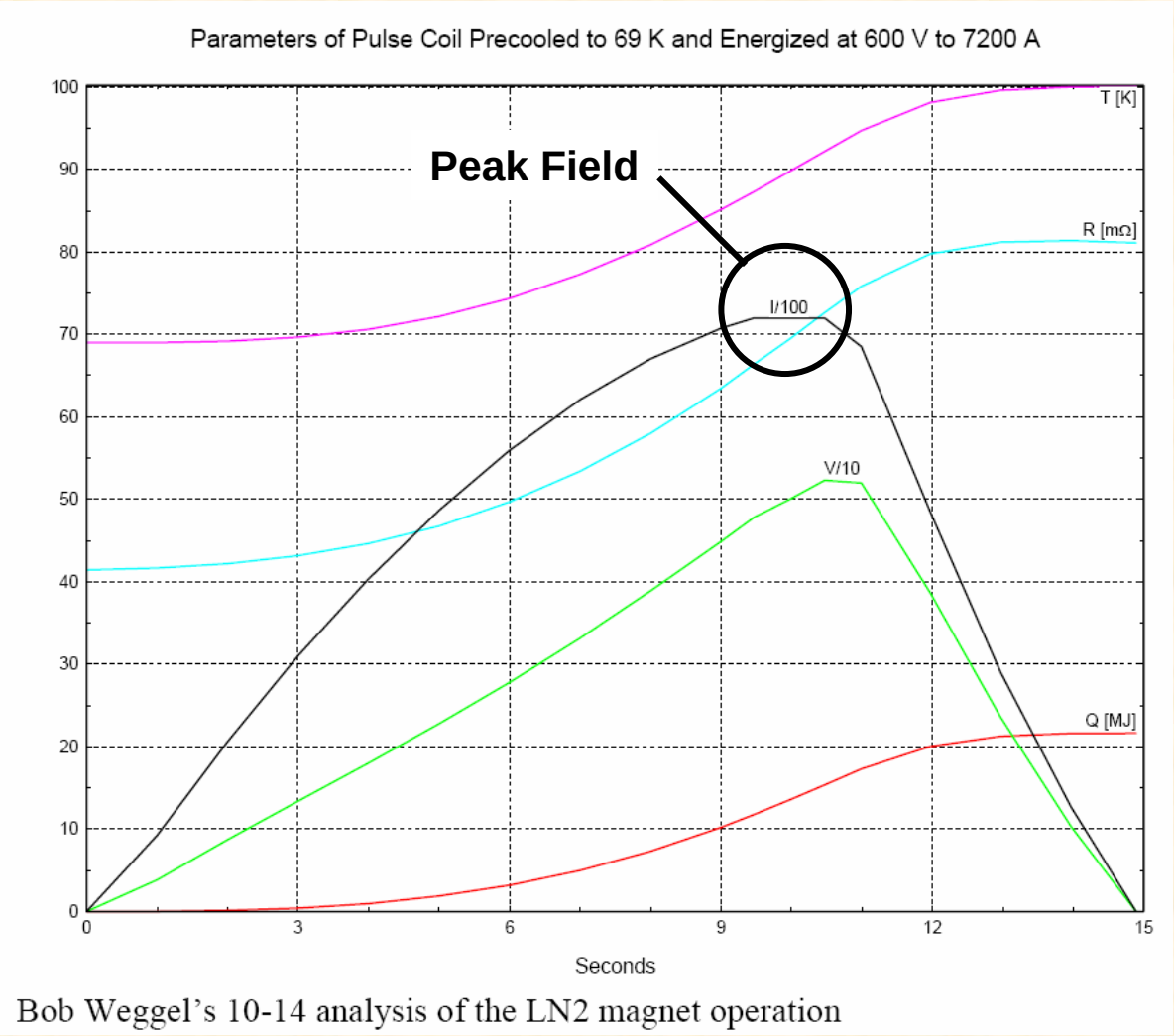


The target system delivers a free (unconstrained) jet of Hg into a 1-atmosphere environment of air

- **1-cm diameter jet, delivered every 30 minutes**
- **Full-beam interaction length is 30-cm**
- **24 GeV, 1 MW proton beam, <20x10^{12} ppp**
- **Beam line is 121-cm (47.6”) above tunnel floor**
- **Up to 100 pulses for the CERN test, 500 pulses for systems tests**
- **15 Tesla field**
- **1-sec steady state jet during the magnet peak field (unresolved)**

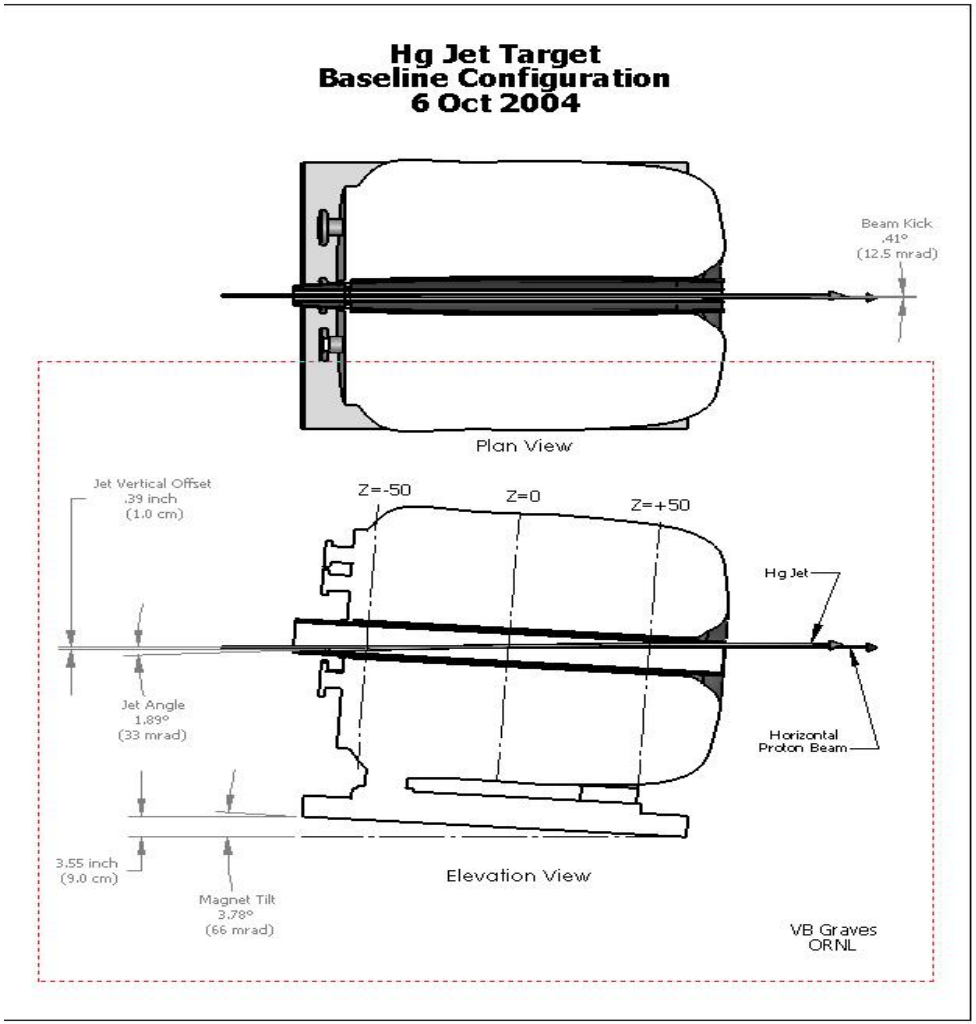
Magnetic Field Profile

- **Peak field has a 1 second flat top at t = 9.5 s**



Bob Weggel's 10-14 analysis of the LN2 magnet operation

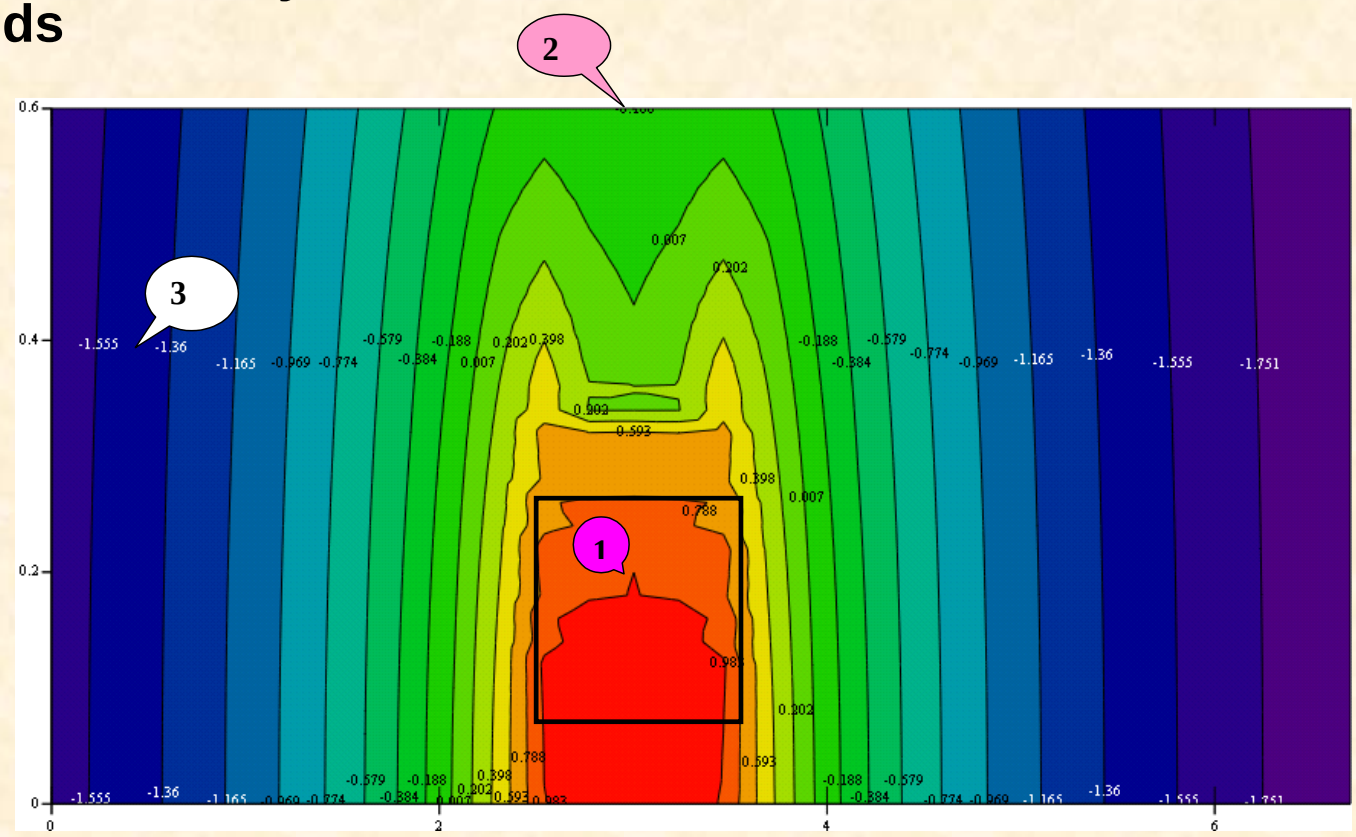
Geometry



- **Jet to beam is 33 millirad (1.89°); *jet to magnetic axis is 100 millirad (5.73°)***
- **The PB crosses the jet centerline at Z=0, which is also at 15 T in the center of the solenoid**

Stray Field Plot

- **The 15 T field is very localized but there are substantial stray fields**



$(xyz_0, xyz_1, \log(xyz_2))$

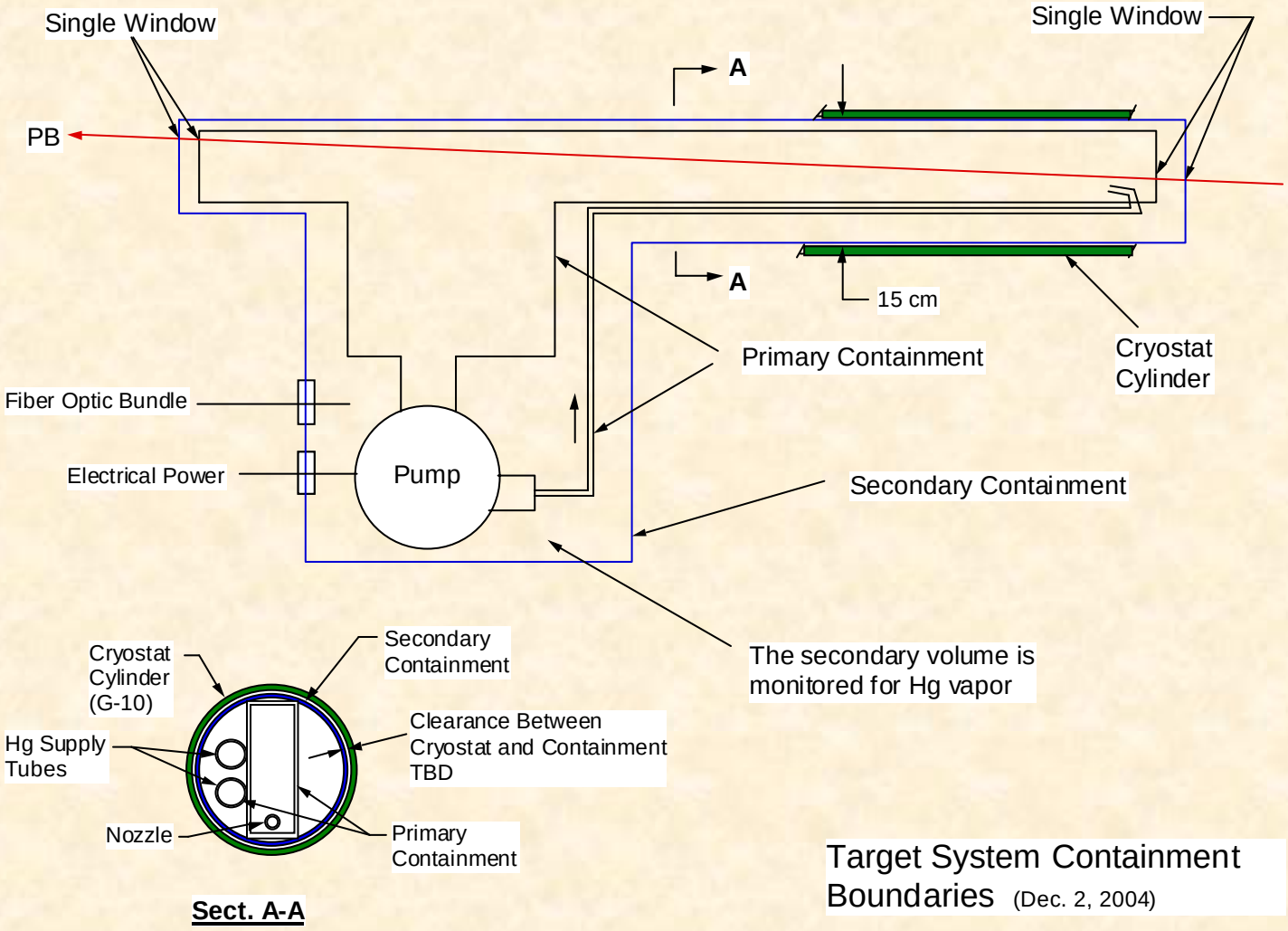
Magnetic field distribution: the axes are in meters; the rectangle is one half of the solenoid.

- **The volume within the conductor is > 9.7 T (red), > 6.1 T (orange).**
- **The field at Z=0, R=0.6 is >0.6 T, at R=1.0 (base support structure), B> ~0.1 T (1000 G).**
- **The field at Z=-2.5, R=0.4 (pump motor) is 0.03<B<0.07 T (300-700 G).**

Req'mts (cont.)

- **Environment - primary and secondary containments have air at 1 atmosphere**
  - **Air activation is not an issue since the air is not purged after each pulse and 1 hour of waiting is sufficient for decay**
  - **May require cartridge filtration like the WNR Bubble Test Loop**
- **Both containments are designed for 1 atmosphere overpressure**

Containment Schematic



Target System Containment Boundaries (Dec. 2, 2004)

Target Containment is Designed To Meet ISO 2919 (per CERN)

ISO 2919 "Classification of Sealed Source Performance" Table 2, Class 2

- **Temperature: -40º C (20 minutes), +80º C (1 hour)**
- **External Pressure: 25 kPa absolute (60 psi) to atmospheric**
- **Impact: 50 grams from 1 meter, or equivalent imparted energy**
- **Vibration: 3 times 10 minutes, 25-500 Hz at 49 m/s^2 (5 g_n, acceleration maximum amplitude)**
- **Puncture: 1 gram from 1 meter, or equivalent imparted energy**

Requirements (cont.)

- **Target system materials shall be stainless steel type 316 or 304, but …**
- **Base support structure may be fabricated from painted carbon steel or aluminum**
- **Gaskets shall be non-reactive with Hg and radiation tolerant to 10^4 rads**
- **Operating temperature of the Hg shall be from 20°C to 100°C**
- **Installation – align and insert the target probe into the solenoid bore within ±1.0 mm, and position the target/solenoid assembly to the beam line within ±0.5 mm *(fiducials are to be located on the solenoid)***

Instrumentation

- **Hg vapor sensor to monitor the secondary containment atmosphere, with remote readout**
- **Temperature sensor to monitor mercury in the sump tank, with remote readout**
- **Position sensor on syringe to monitor Hg flow rate through cylinder**
- **Viewing window(s) on the sump tank for visual observation during system tests**

Other Req'mts

- **Filling/Draining Hg – vacuum pump or peristaltic pump**

- **Maintenance/Handling - equipment is assembled hands on but maintained and operated with minimal contact by personnel**
- **Design Life – designed for 10,000 start/stop cycles**
- **Operating Cycle – up to 20 seconds of 1-cm jet every 30 minutes, up to the temperature limit of the Hg inventory**

Interfaces

- **Solenoid – the bore of the magnet positions the target cassette**
- **Proton Beam Windows – the upbeam and downbeam windows are mounted to the primary and secondary containments; Ti6Al4V alloy**
- **Optical Diagnostics – 3 windows, lenses, prisms located on the primary containment, fiber optic cables, and cable penetrations into the secondary containment**
- **Base Support Structure – base structure is shared with the solenoid**
- **Facilities – ORNL (TTF) for equipment testing, MIT (?) for integrated system tests, and CERN for the experiment**

Issues Yet To Be Addressed

- **Power supply/frequency for pump system at CERN**
- **Electrical cable … who provides ~50 m of length**
- **Labor for installation at MIT, CERN**
- **What are the safety concerns …**
  - **Ventilation**
  - **Decommissioning/disposal**
- **…**

Project Schedule

Based on performing the experiment at CERN in early FY07