The High-Power Target Experiment at CERN

Report to MUTAC

LBNL

April 25, 2005

Harold G. Kirk
Brookhaven National Laboratory

The Goal: Intense Secondary Beams

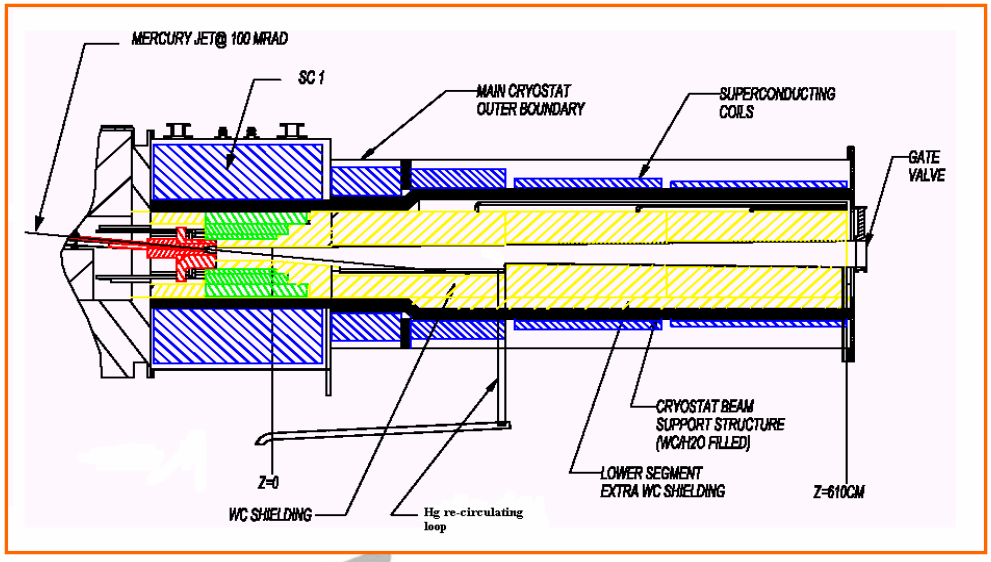
World-wide interest in exploring new physics opportunities via intense new beams

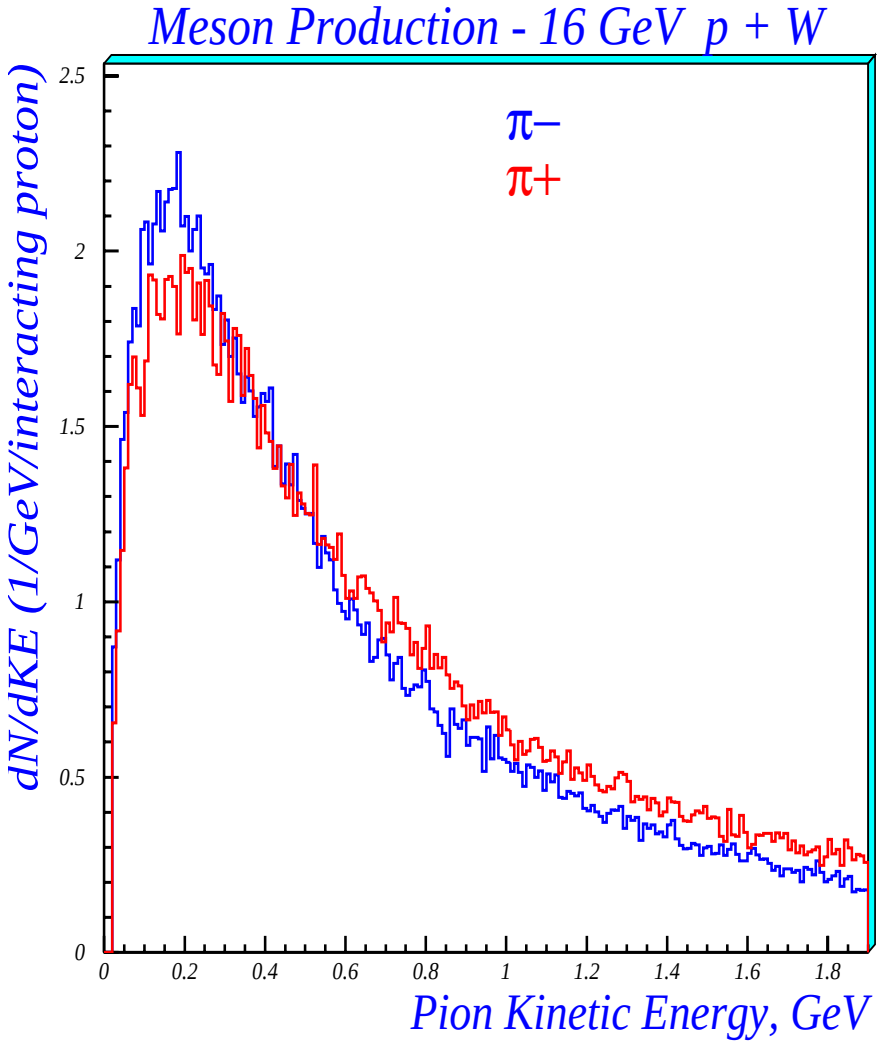
- Kaons
  - Kopio—BNL
  - CKM—FNAL
  - LOI's 4,5,16,19,28 – JPARC
- Neutrons
  - SNS
  - JAERI/JPARC
- Neutrinos
    - Numi—FNAL
    - BNL to Homestake
    - T2K -- JPARC
- Muons
  - g-2 – BNL
  - Meco – BNL
  - Sindrum--PSI
  - Prism- JPARC
  - Neutrino Factory/Muon Collider

Achieving Intense Muon Beams

Maximize Pion/Muon Production

- Soft-pion Production
- High Z materials
- High Magnetic Field





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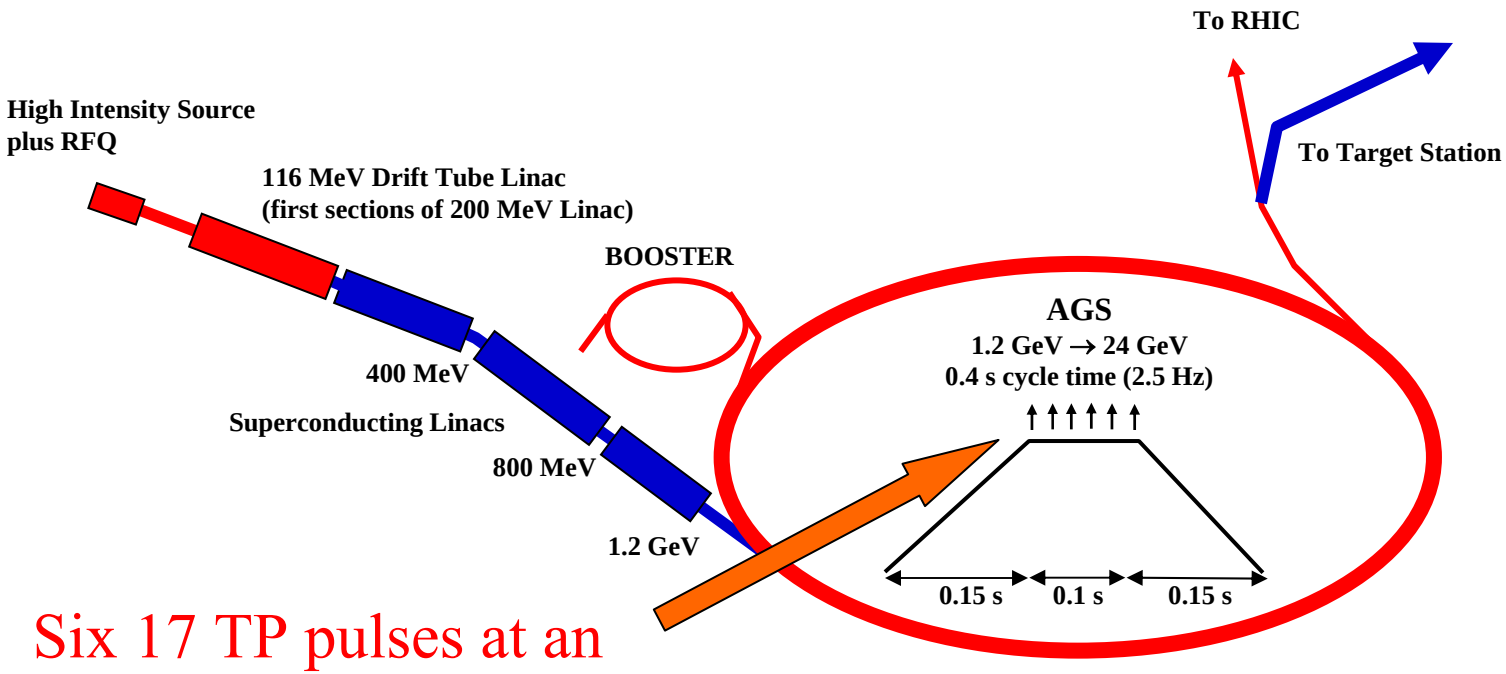
Neutrino Factory Feasibility Study 2

AGS Proton Driver 1 MW Scenario



Six 17 TP pulses at an effective 50 Hz rate

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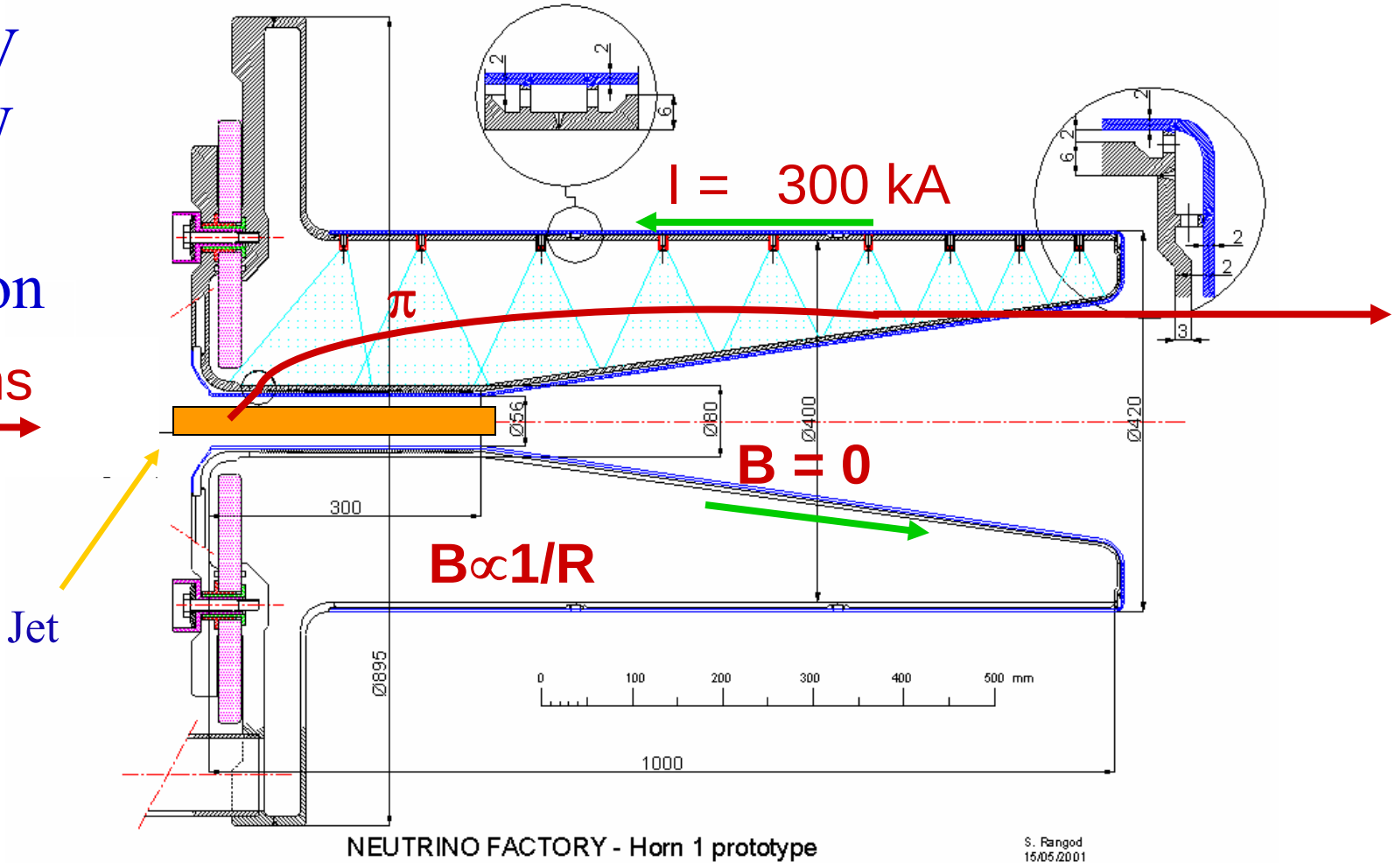
The SPL Neutrino Horn

2.2 GeV
at 4MW
50 Hz
operation

Protons



Muon Collaboration

Proposal to Isolde and nToF Committee

CERN-INTC-2003-033
INTC-I-049
26 April 2004

A Proposal to
the ISOLDE and Neutron Time-of-Flight Experiments
Committee

Studies of a Target System for a 4-MW, 24-GeV Proton Beam

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Spokespersons: H.G. Kirk, K.T. McDonald
Local Contact: H. Haseroth

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Participating Institutions

1) RAL
2) CERN
3) KEK
4) BNL
5) ORNL
6) Princeton University

Proposal submitted April 26, 2004

Harold G. Kirk

Approval --- April 5, 2005

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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Geneva, 4th April 2005

Dear Professor Kirk and Professor McDonald,

Concerning your proposal P186 to the INTC (Studies of a Target System for a 4-MW, 24-Gev Proton Beam), I am happy to inform you that following consideration at the meetings of 2 December 2004 and 3 March 2005, the experiment has been approved by the CERN Research Board. It will be known as nTOF11.

Yours sincerely,

J. Engelen

Harold G. Kirk

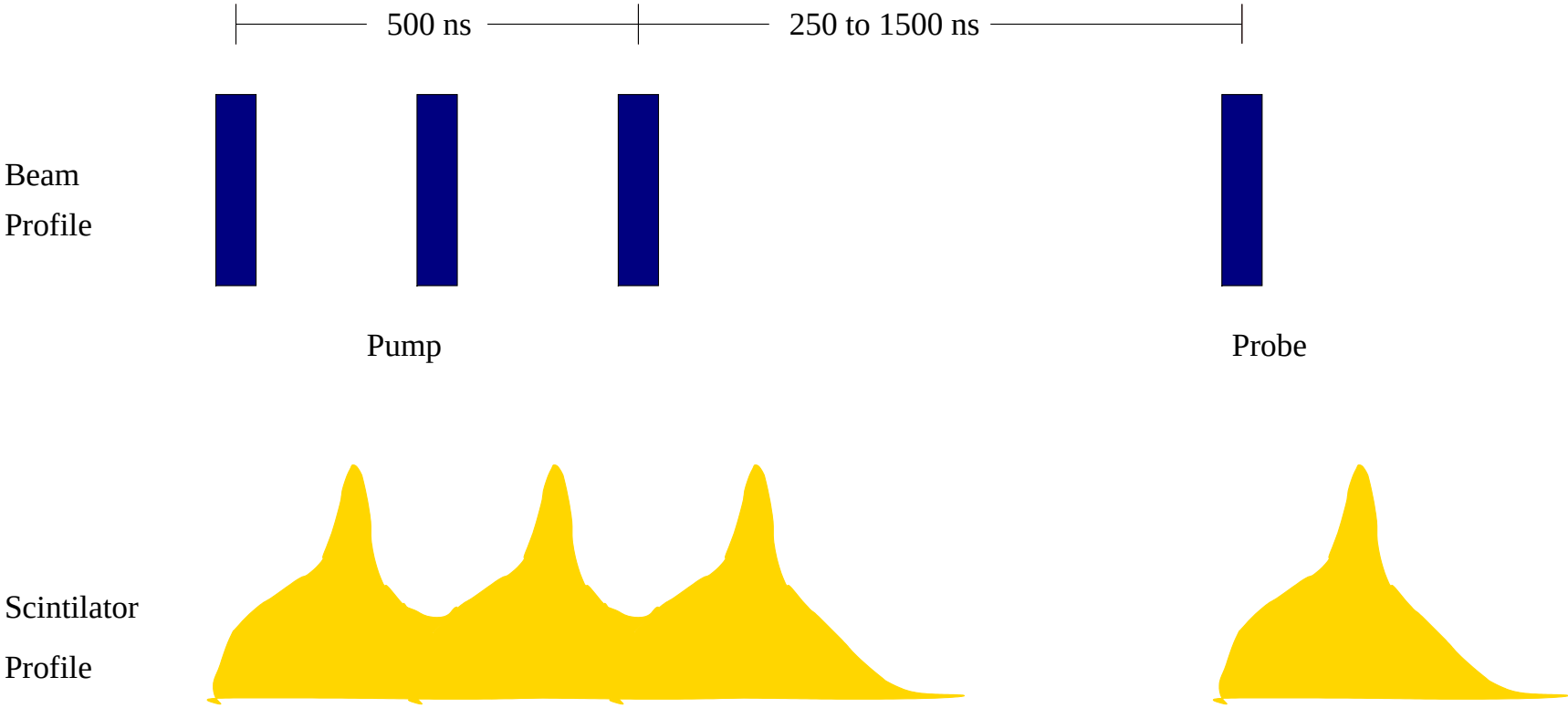
Profile of the Experiment

- 24 GeV Proton beam
- Up to 28 x 10^{12} Protons (TP) per 2μs spill
- Proton beam spot with r ≤ 1.5 mm rms
- 1cm diameter Hg Jet
- Hg Jet/Proton beam off solenoid axis
  - Hg Jet 100 mrad
  - Proton beam 67 mrad
- Test 50 Hz operations
  - 20 m/s Hg Jet
  - 2 spills separated by 20 ms

PS Beam Characteristics

- PS will run in a harmonic 8 mode
- We can fill any of the 8 rf buckets with 4 bunches at our discretion.
- Each microbunch can contain up to 7 TP.
- Fast extraction can accommodate entire 2μs PS fill.
- Fast kicker capacitor bank recharges in 11 ms
- Extraction at 24 GeV
- Beam on target April 2007

PS Extracted Beam Profile



Peak Energy Deposition

Neutrino Factories

Hg target; 1 MW 24 GeV proton beam; 15 Hz

1cm diameter Hg jet ; 1.5mm x 1.5mm beam spot 100 J/g

Hg target; 4 MW 2.2 GeV proton beam; 50 Hz

2cm diameter Hg jet; 3mm x 3mm beam spot 180 J/g

E951

Hg target; 4 TP 24 GeV proton beam;

σ_y=0.3mm x σ_x=0.9mm rms beam spot 80 J/g

CERN PS (projected)

Hg target; 28 TP 24 GeV proton beam

1.2mm x 1.2 mm rms beam spot 180 J/g

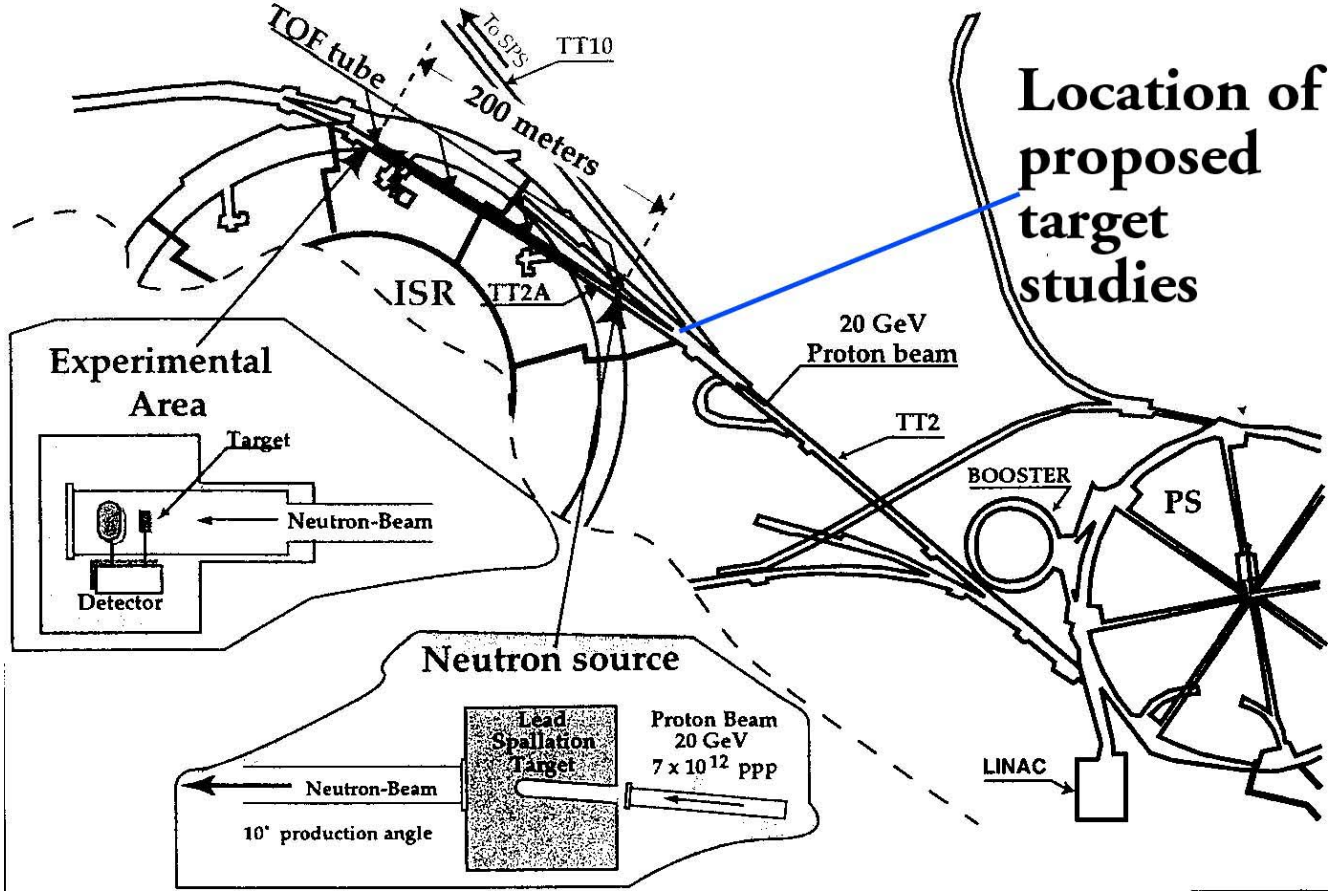
Run plan for PS beam spills

The PS Beam Profile allows for:

- Varying beam charge intensity from 7 TP to 28 TP.
- Studying influence of solenoid field strength on beam dispersal (vary B_o from 0 to 15T).
- Study possible cavitation effects by varying PS spill structure (Pump/Probe)
- Study 50 Hz operation.

Muon Collaboration

Target Test Site at CERN



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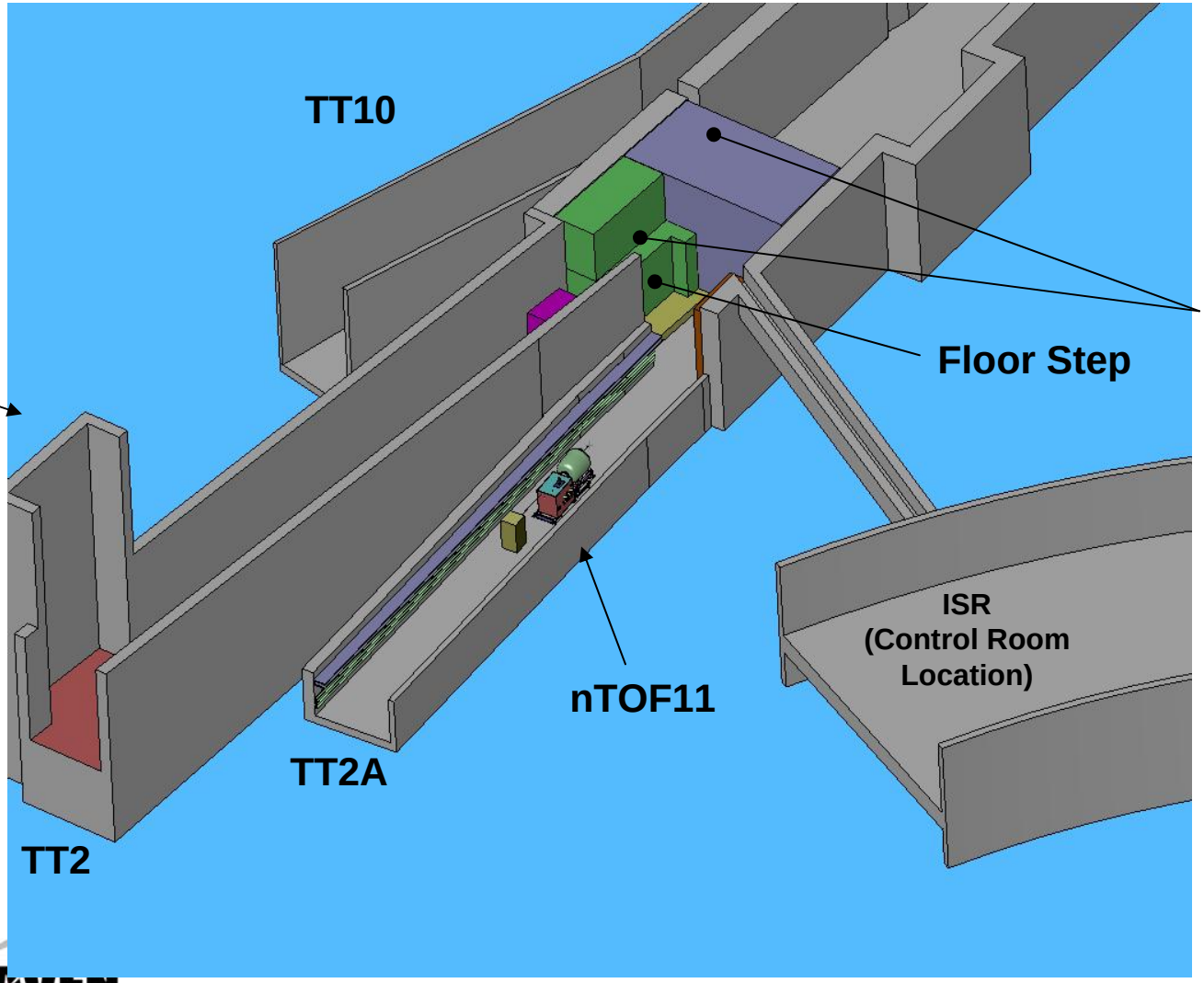
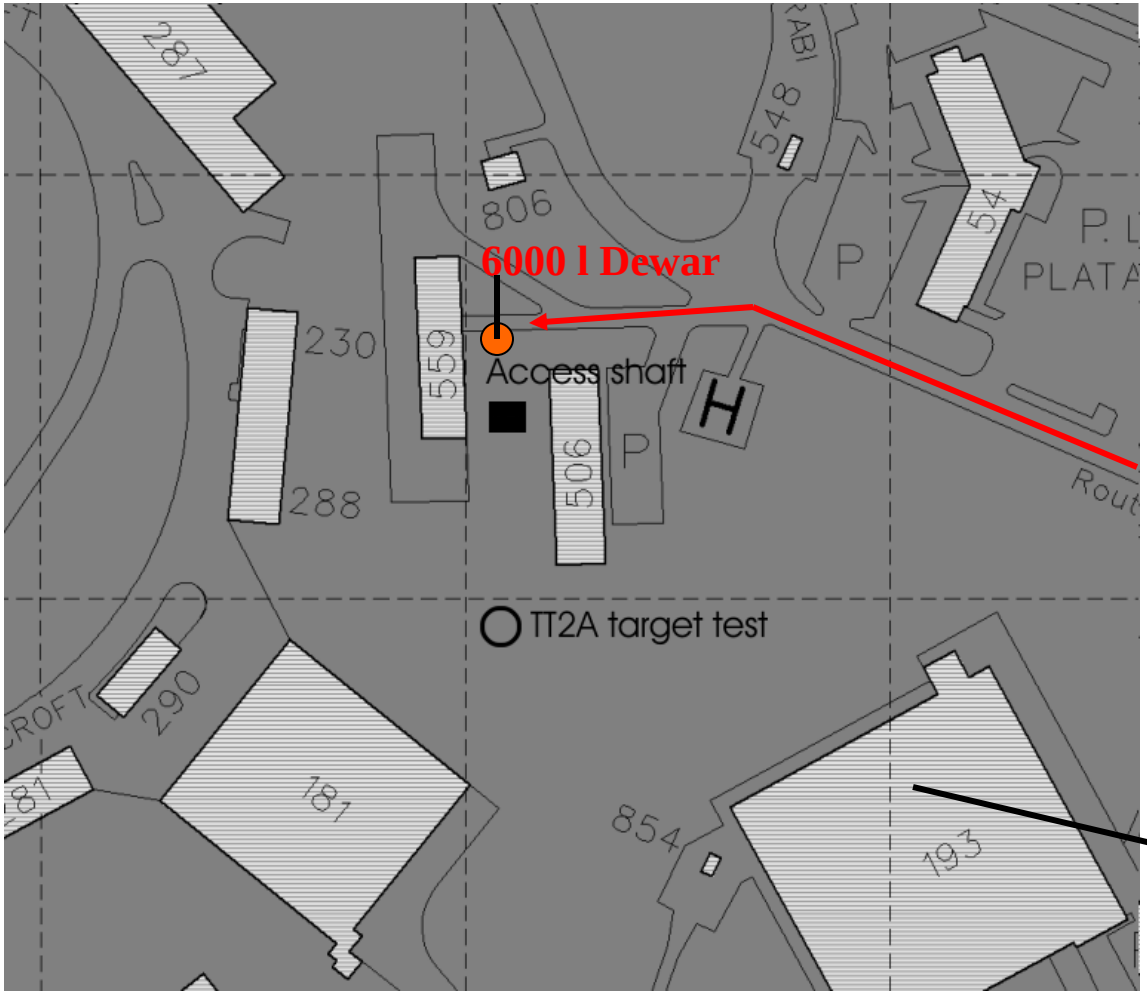
Location of the nTOF11 Experiment



Surface above the ISR



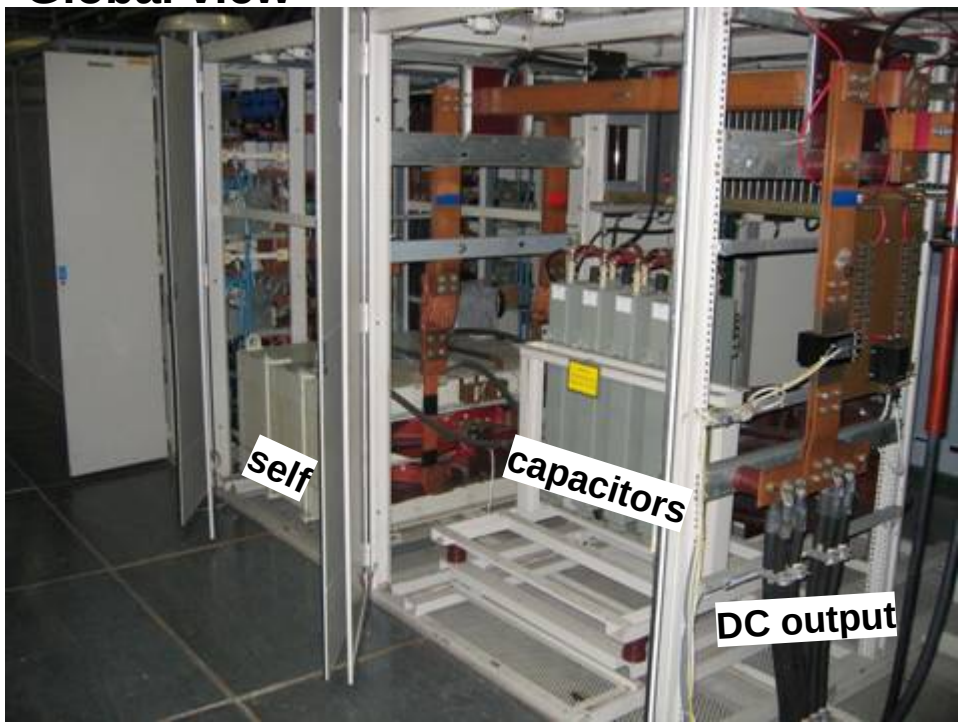
Power Converter (From SPPS Transfer Line)

8000 Adc, 1000 Vdc

Strategy:

- ***Refurbishment of the West Area Power Converter, making it compatible with the project requirements***

Global view



Rectifier bridges

Passive filter

Passive filter capacitors

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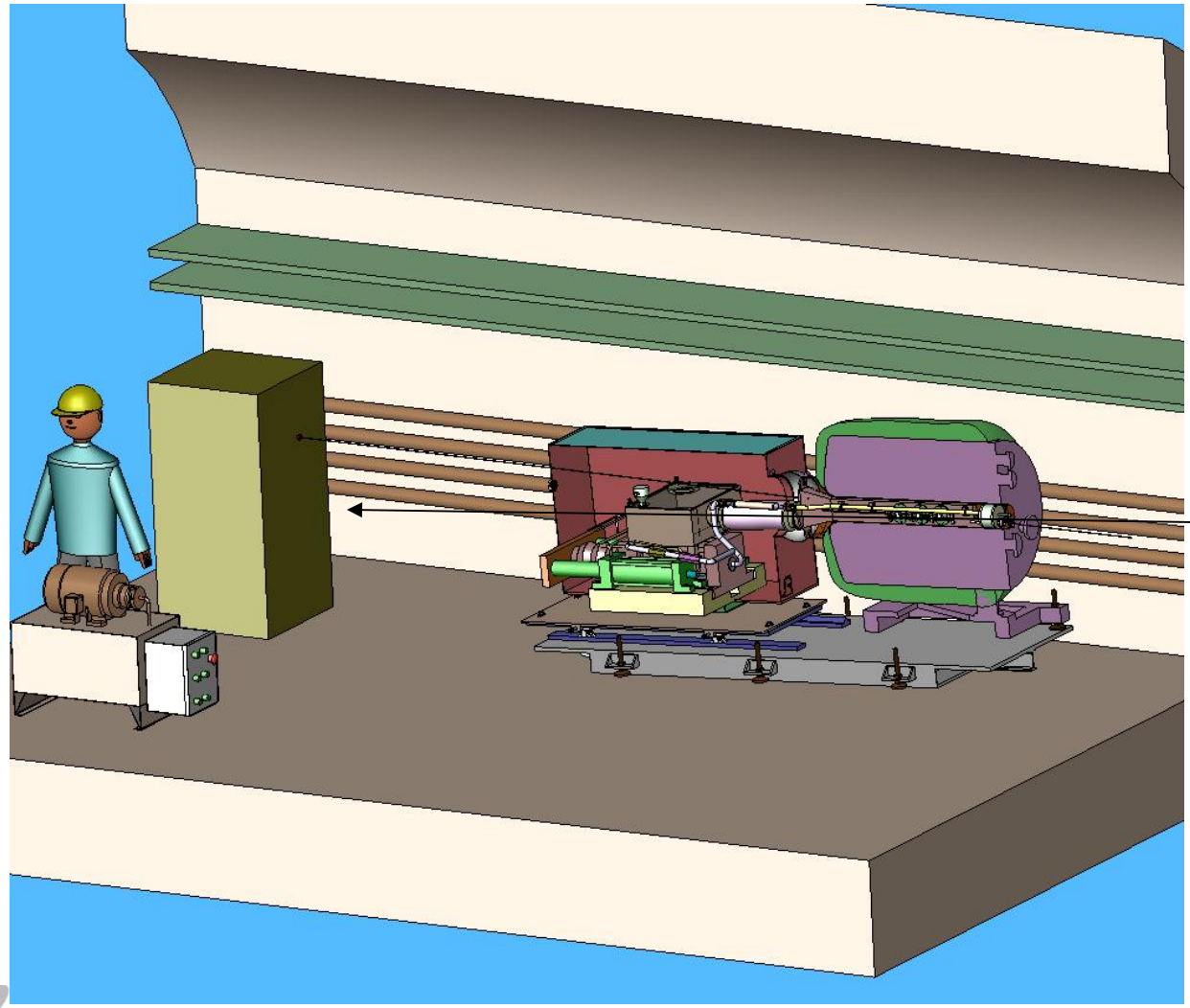
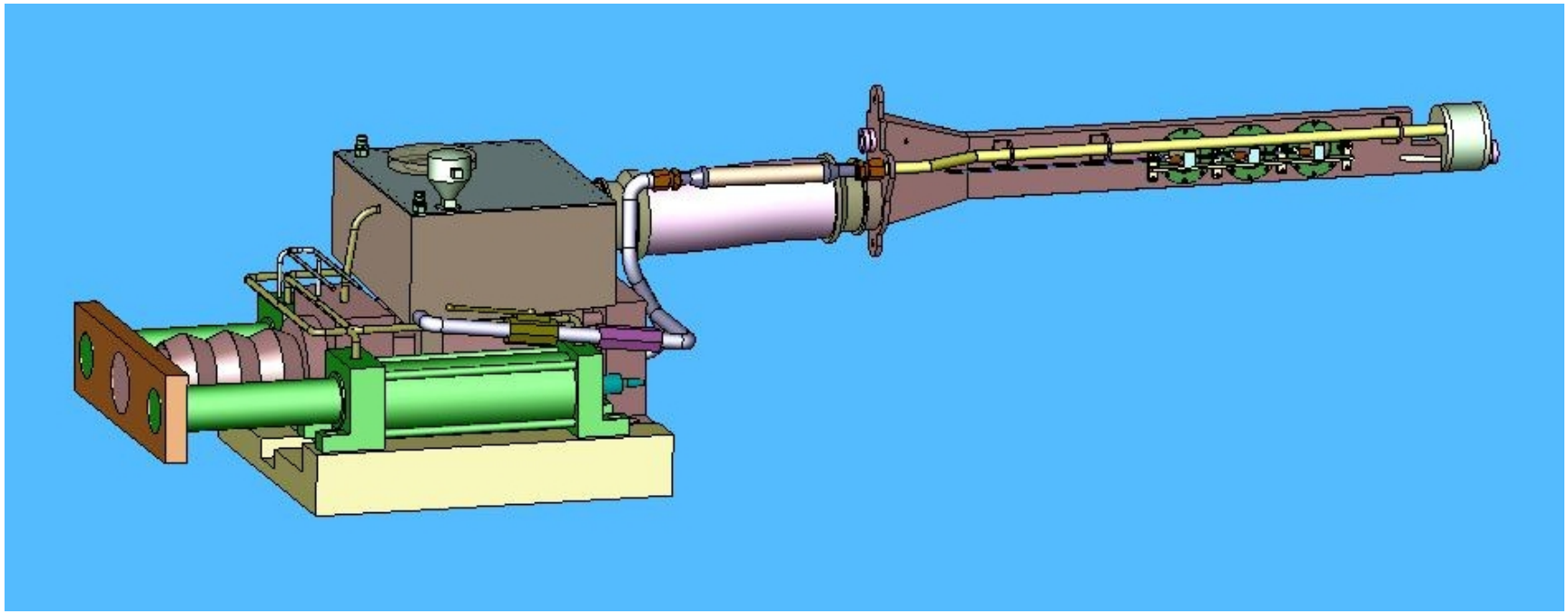
The Experimental Installation Point

The Experimental Footprint



The Hg Jet System

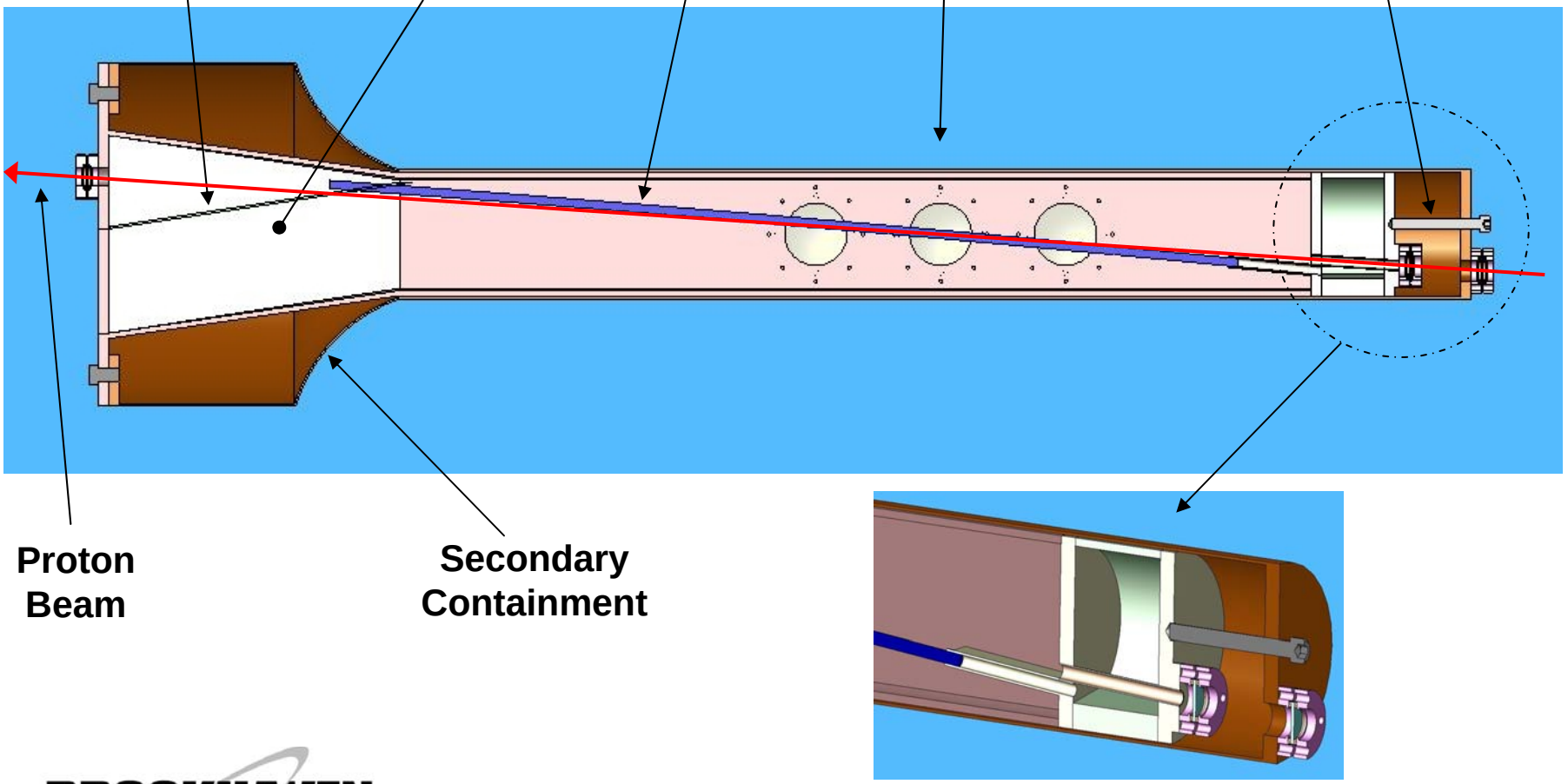


Double Containment System, with snout inserted into magnet.

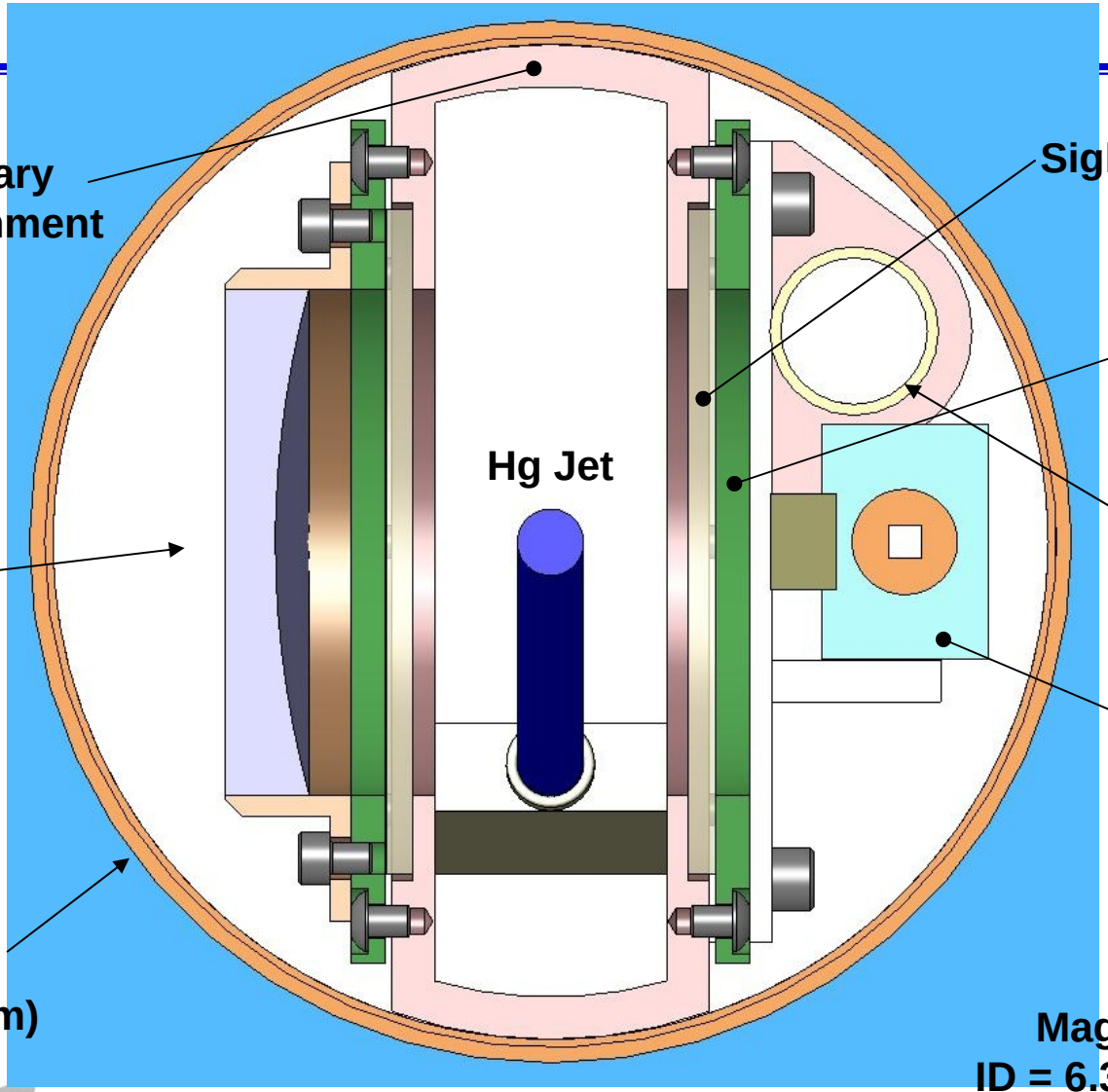
Mercury inventory ~ 20 liters.

Hydraulic system can deliver up to 1000 psi, to propel mercury at > 20 m/s

Primary Containment – Side View

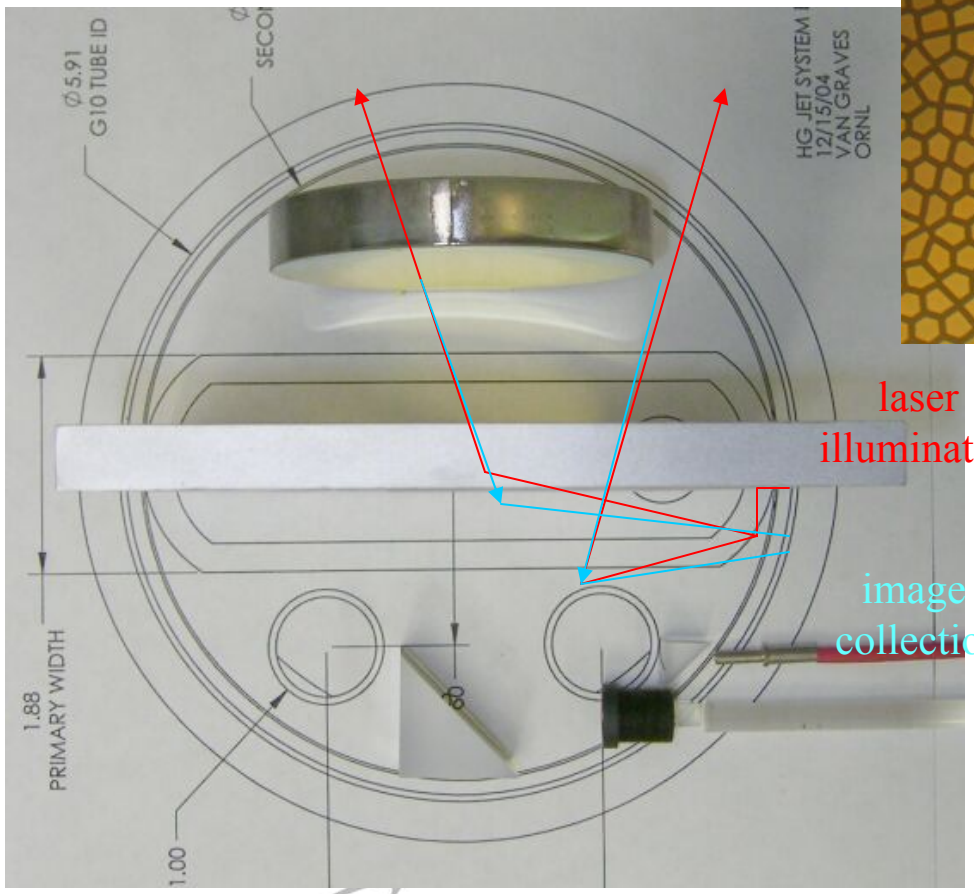


Primary Containment Cross Section



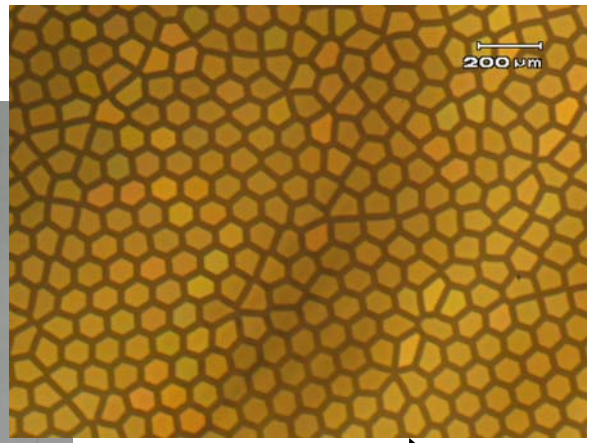
Optical Diagnostics:
Retroreflected Illumination

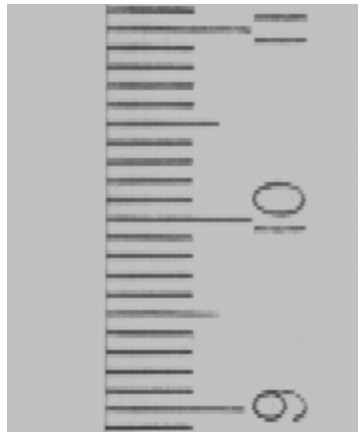
Spherical mirror

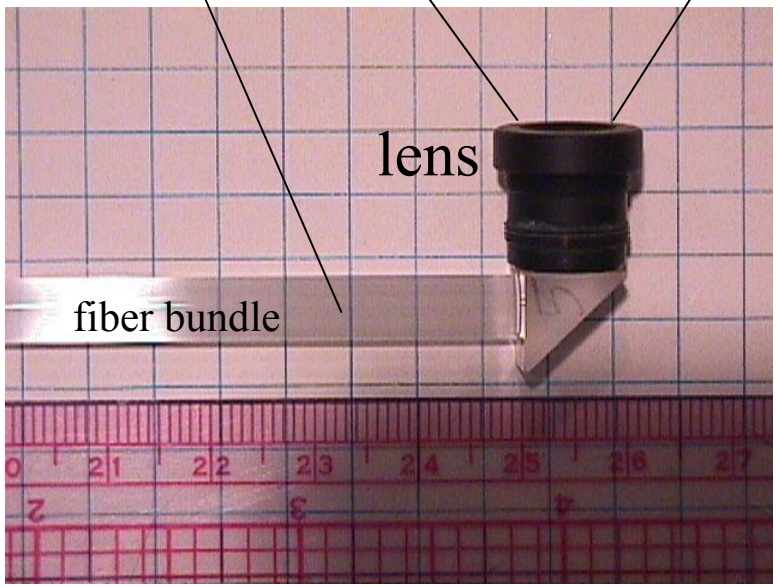


laser illumination

image collection







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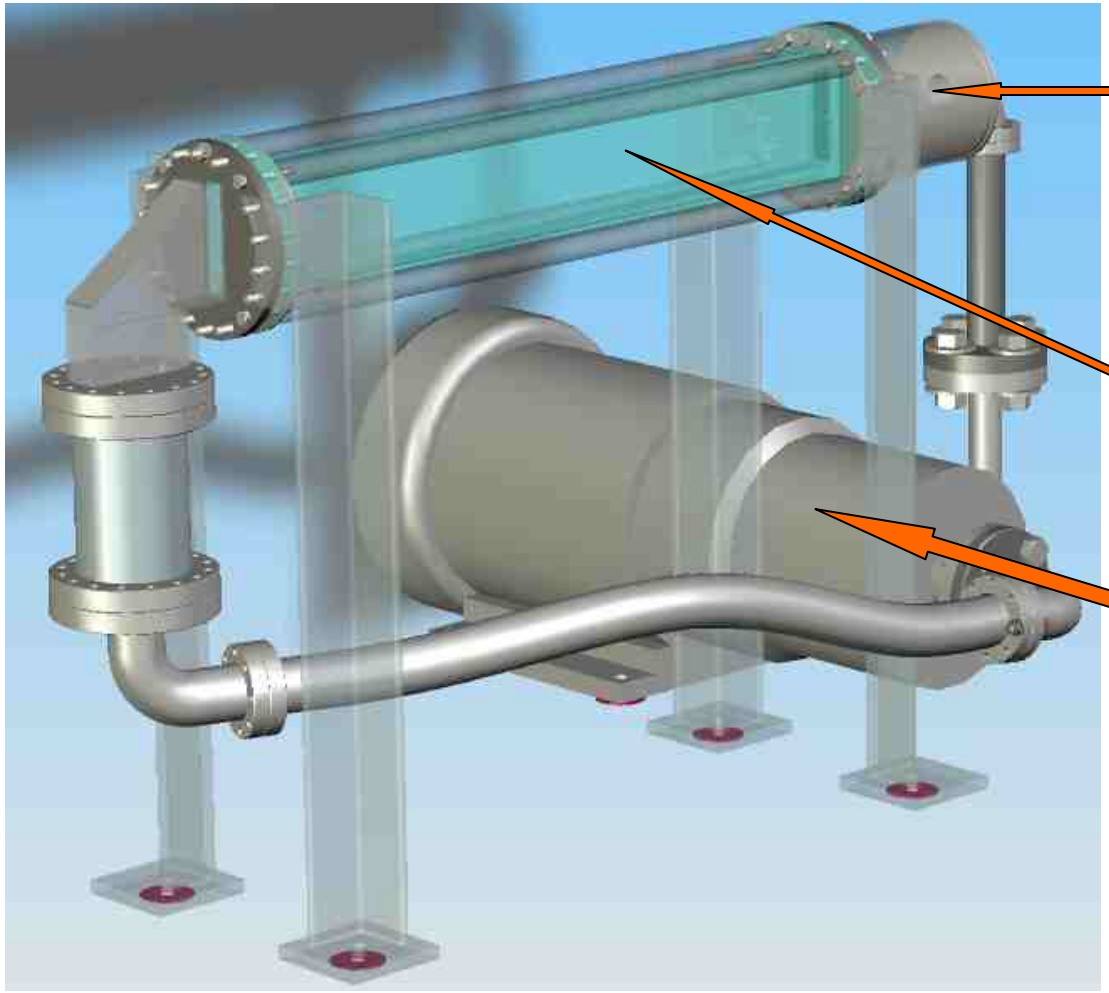
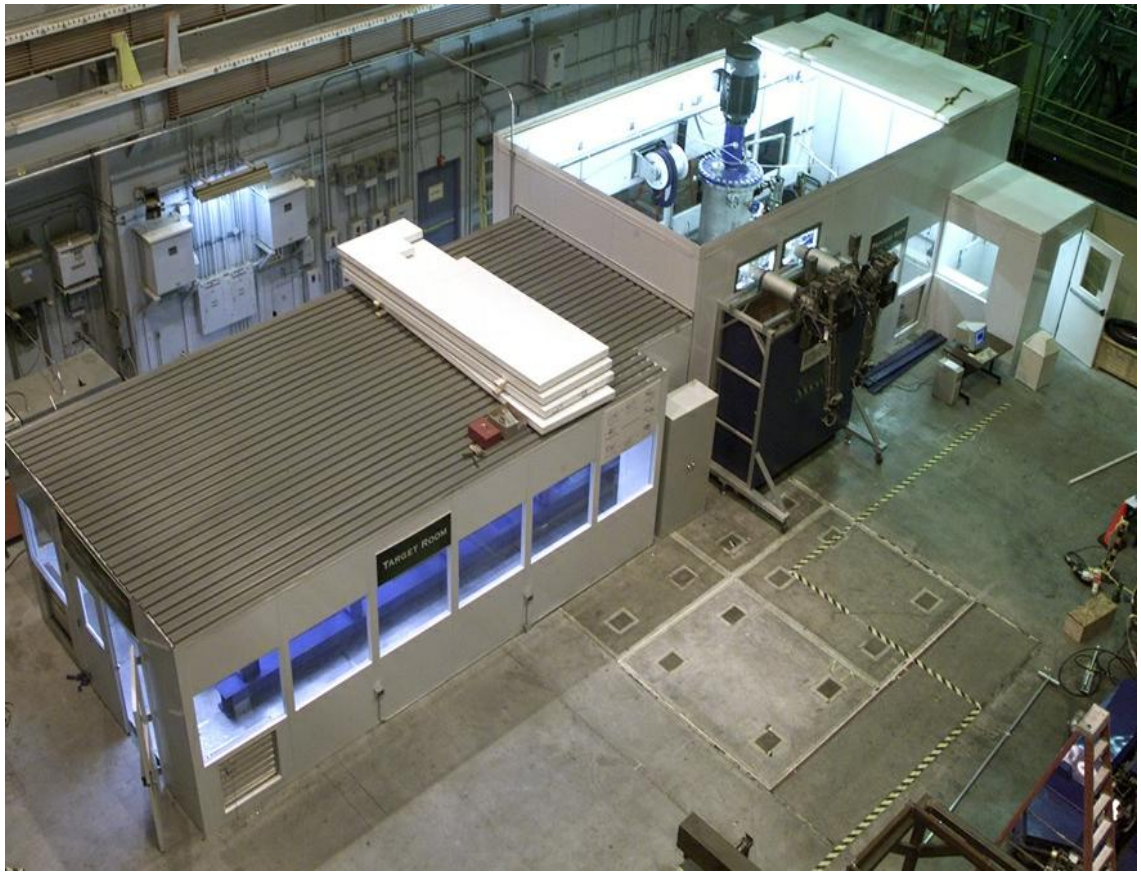
Princeton Nozzle R&D



The Target Test Facility (TTF) - Basis For ORNL's Hg Handling Experience

- Full scale, prototype of SNS Hg flow loop
- 1400 liters of Hg
- Used to determine flow characteristics
- Develop hands on operating experience
- Assess key remote handling design issues



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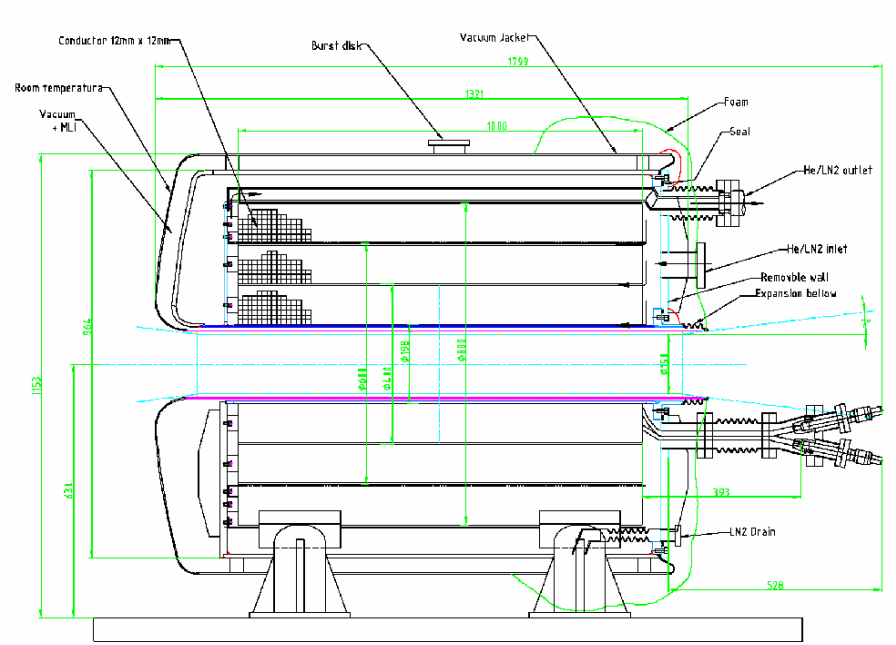
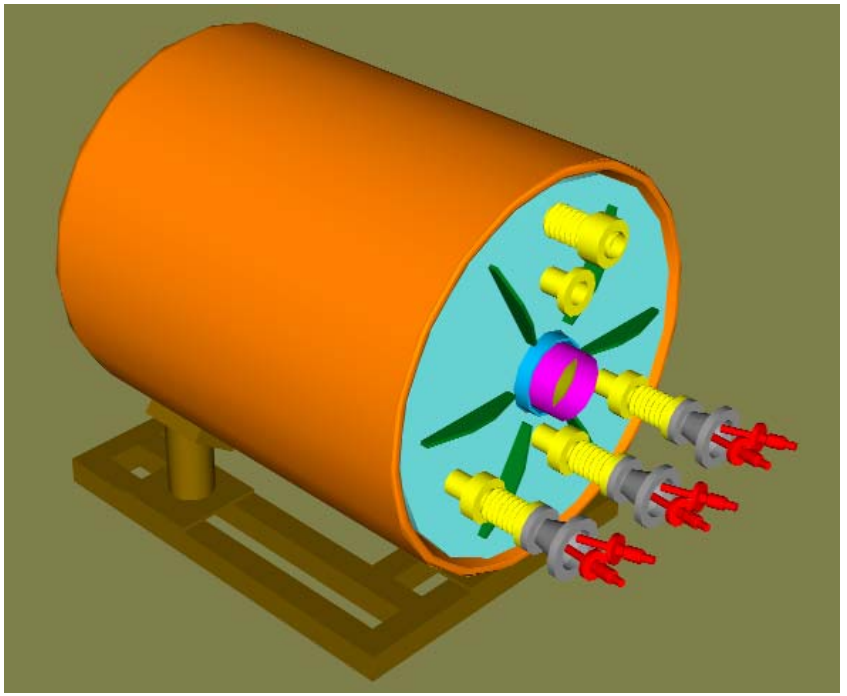
High-field Pulsed Solenoid





- LN_2 Operation
- 15 T with 5.5 MW Pulsed Power
- 15 cm warm bore
- 1 m long beam pipe

Peter Titus, MIT

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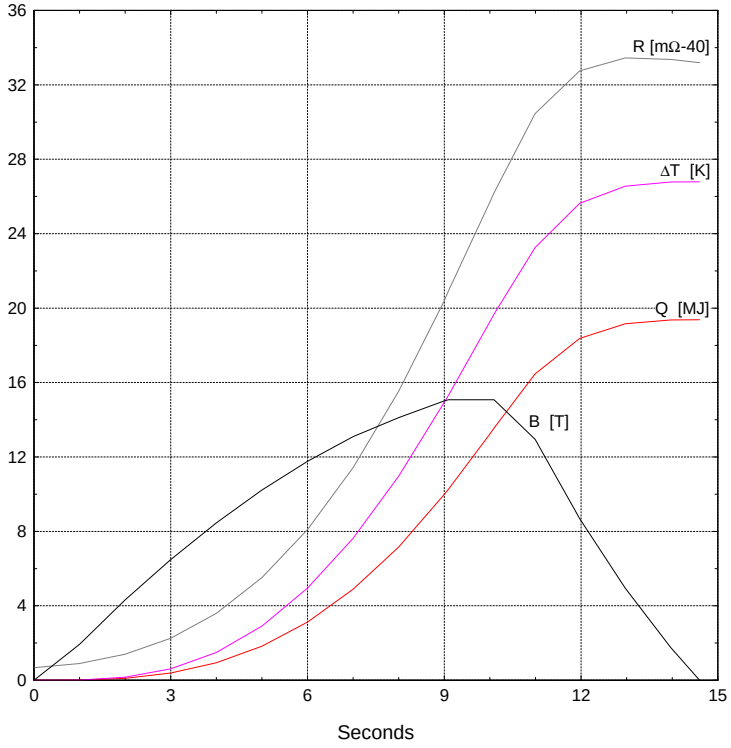
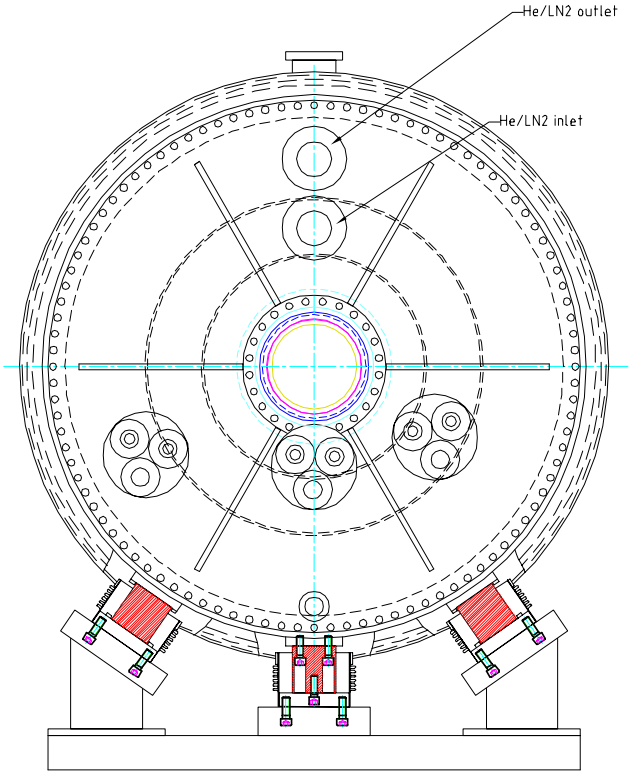
Pulsed Solenoid Performance

Pulse Coil Cooled to 70 K and Charged to 7200 A at 600 V, then -600 V





15T Peak Field with 5 MVA PS at 80^{O} K

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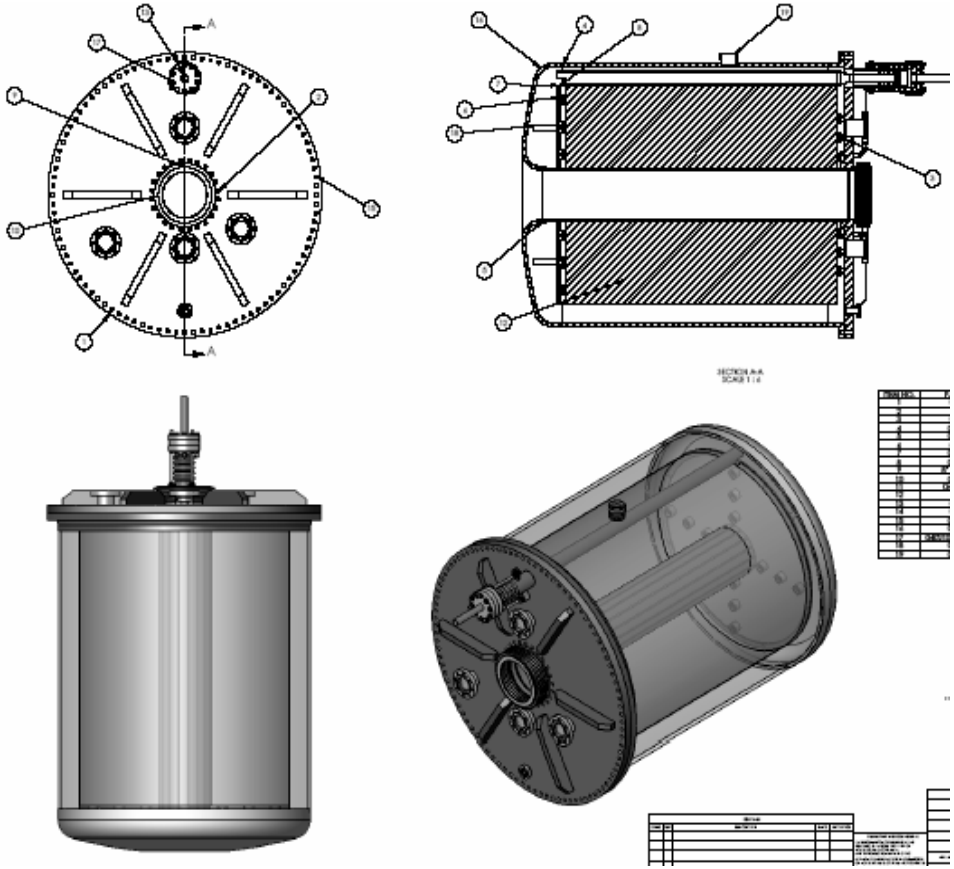
Fabrication of the Cryostat

CVIP has been awarded the contract.



The Cryostat pressure vessel
Photo taken April 12, 2005

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Coil Fabrication

Everson Tesla, Inc has been sub-contracted to fabricate the coils

The three coil sets

Photo taken April 12, 2005

Cryosytem Layout

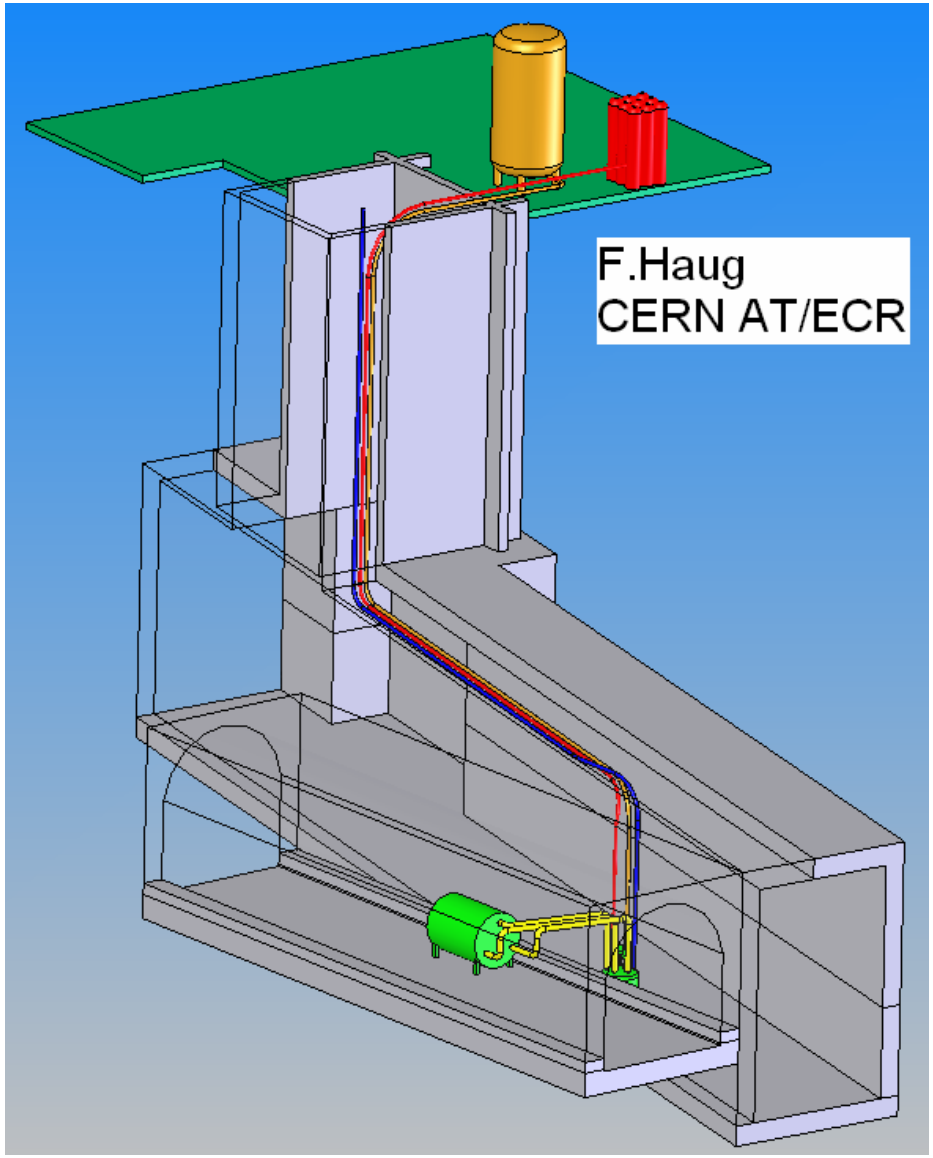
LN_2 and He gas stored on the surface.

Cold valve box in the TT2 tunnel.

Exhaust gas vented to surface through filtration system.

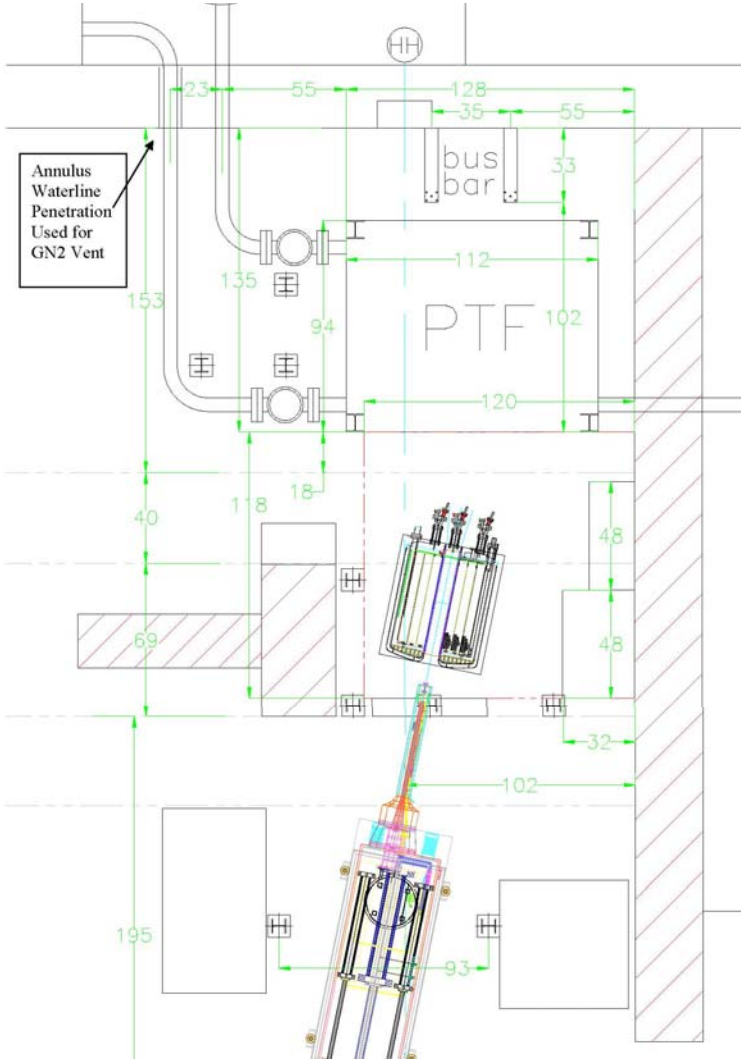
~ 150 liters of LN_2 per Magnet pulse.

Magnet flushed with He prior to each pulse, to minimize activation of N_2.



System Commissioning

- Ship Pulsed Solenoid to MIT
July 2005
- Test Solenoid to 15 T peak field
August 2005
- Test Cryogenic valve box
September 2005
- Integration of Solenoid/Hg Jet system
Summer 2006



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High-Power Target Experiment

Budget agreed to by the Collaboration Technical Board on Sept. 22, 2004.

Subject to continued flat funding from US DOE.

	FY05	FY06	FY07	Total
Magnet Systems				
Solenoid Testing	100		100	200
Cryogenics	25	325	200	550
Power Supply	340			340
PS Installation			50	50
Decommission			30	30
Hg Jet				
System Integration	85	75	50	210
Nozzle R&D	25	25		50
Optics		25		25
Fabrication		40		40
Decommission			30	30
Project Management	53	75	40	168
Simulations	50	50	50	150
Experiment Operations			50	50
Total	678	615	600	1893

Muon Collaboration

Summary

The CERN nTOF11 experiment is now approved to demonstrate a mercury jet target in a 15-T solenoid plus an intense 24-GeV pulsed proton beam.

An international collaboration has completed the design of all major components:

- **Mercury delivery system (ORNL, Princeton)**
- **Optical diagnostics (BNL)**
- **15-T, LN2-cooled pulsed solenoid magnet (MIT)**
- **5-8 MVA power supply (BNL,CERN)**
- **LN2 cryogenic system (CERN, RAL)**

The budget is in place to complete fabrication, commissioning and operation of the experiment over the next 2 years.

Completion of this experiment in 2007 will bring a successful close to a major phase of R&D for a Neutrino Factory based on a muon storage ring.