The High-power Target Experiment at CERN

International Scoping Study

CERN

September 22, 2005

Harold G. Kirk
Brookhaven National Laboratory

The Goal: Intense Secondary Beams

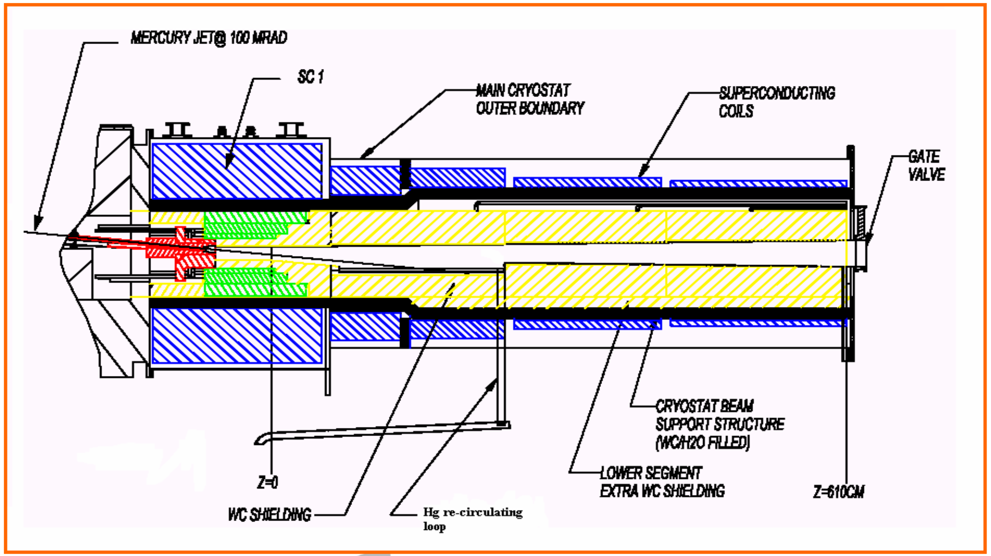
World-wide interest in exploring new physics opportunities via intense new beams

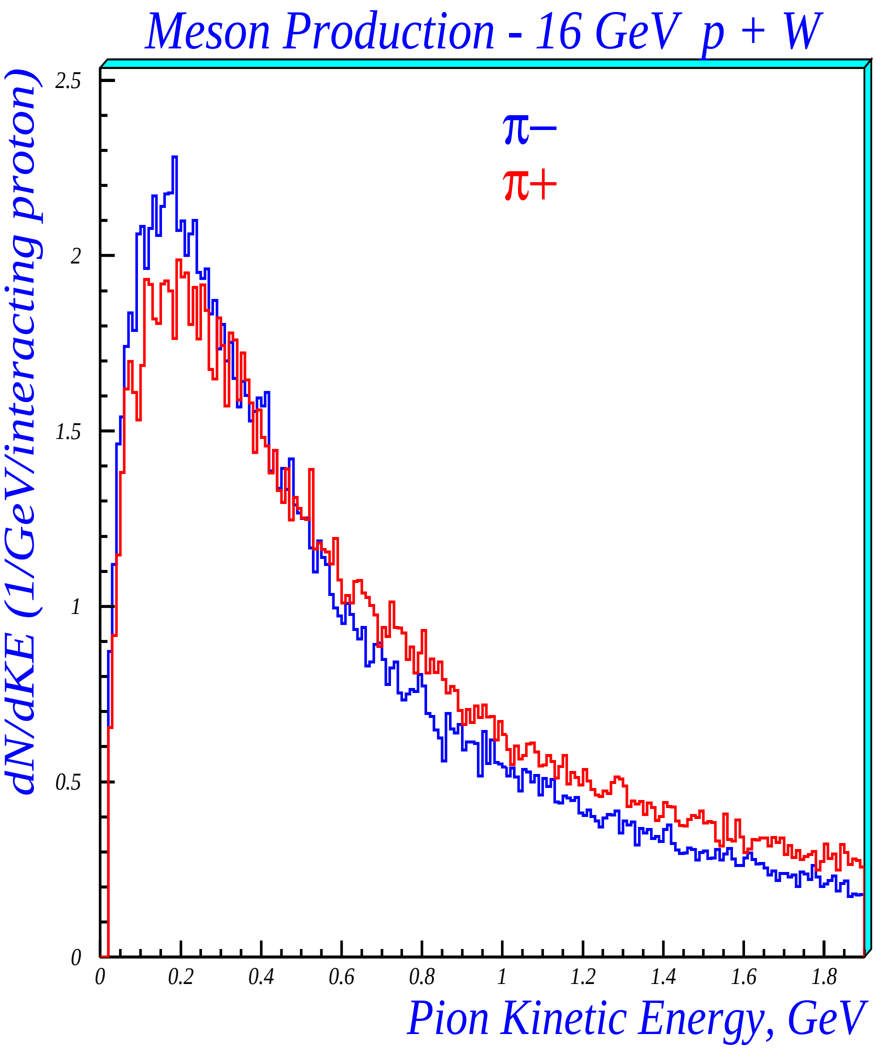
- Kaons
  - Kopio—BNL
  - CKM—FNAL
  - LOI's 4,5,16,19,28 – JPARC
- Neutrons
  - SNS
  - JAERI/JPARC
- Neutrinos
  - Numi—FNAL
  - BNL to Homestake
  - T2K – JPARC
  - CNGS—CERN
- Muons
  - g-2 – BNL
  - Meco – BNL
  - Sindrum--PSI
  - Prism- JPARC
  - Neutrino Factory/Muon Collider

Achieving Intense Muon Beams

Maximize Pion/Muon Production

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





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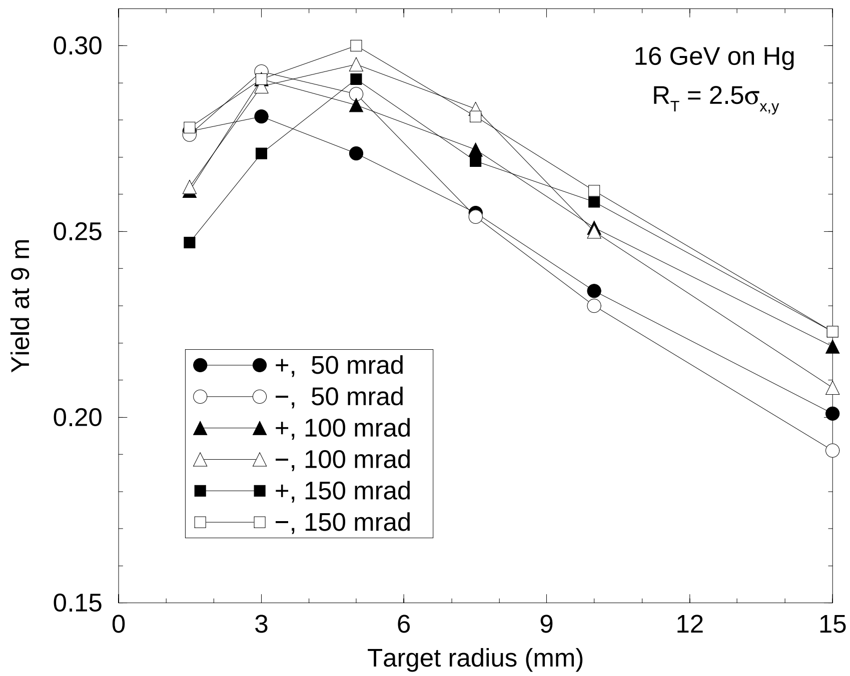
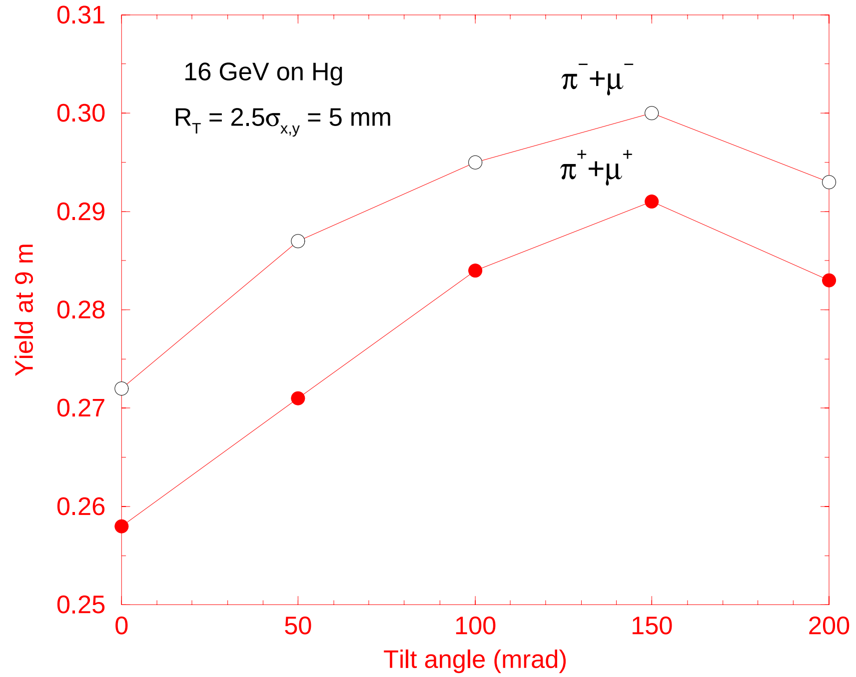
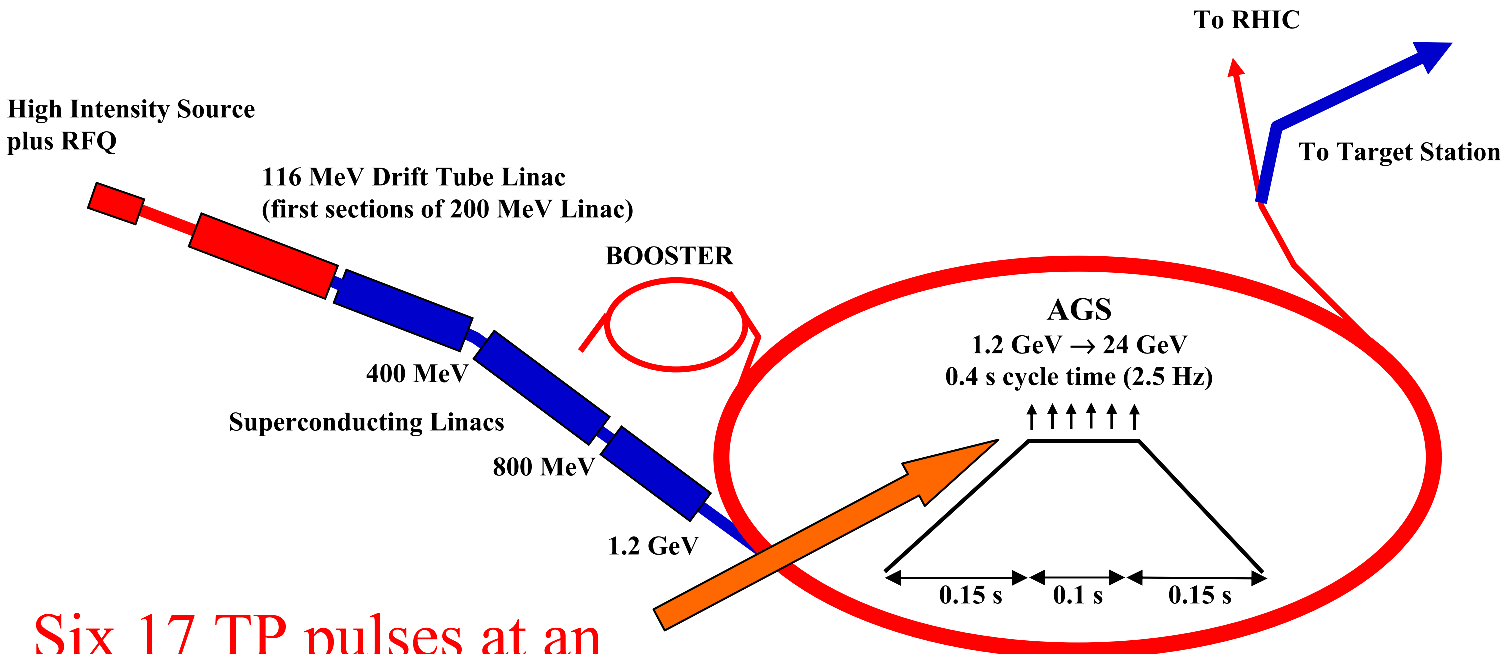
Optimizing Soft-pion Production





AGS Proton Driver 1 MW Scenario



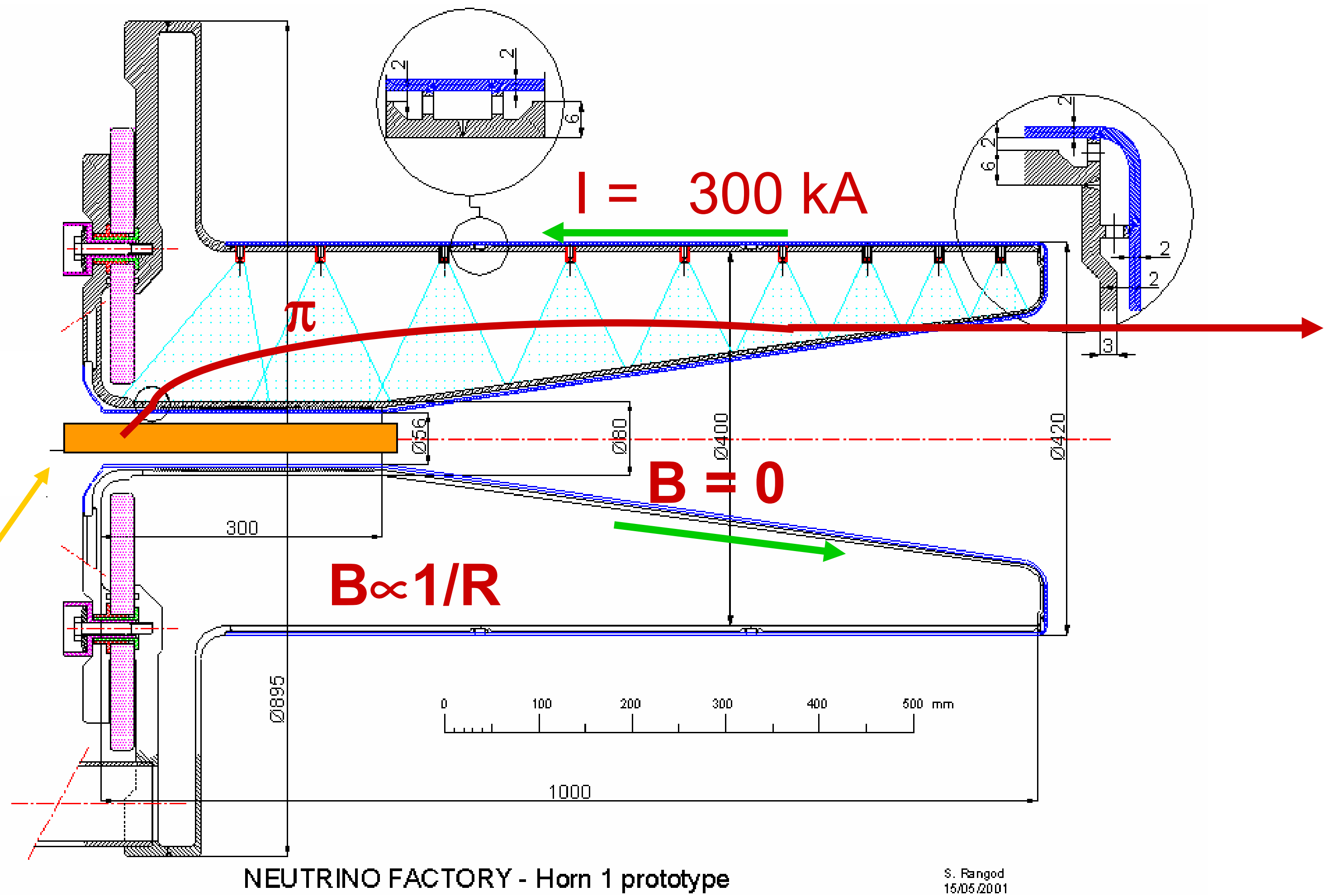
Six 17 TP pulses at an effective 50 Hz rate

The SPL Neutrino Horn

2.2 GeV
at 4MW
50 Hz
operation

Protons

Hg Jet



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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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T. Robert Edgecock[1], Tony A. Gabriel[3], John R. Haines[3], Helmut Haseroth[2],
Yoshinari Hayato[4], Steven J. Kahn[5], Jacques Lettry[2], Changguo Lu[6], Hans Ludewig[5],
Harold G. Kirk[5], Kirk T. McDonald[6], Robert B. Palmer[5], Yarema Prykarpatskyy[5],
Nicholas Simos[5], Roman V. Samulyak[5], Peter H. Thieberger[5], Koji Yoshimura[4]

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

Participating Institutions

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

Proposal submitted April 26, 2004

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Approval --- April 4, 2005

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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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Our reference: CSO-2005-037/O

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Professor K.T. McDonald
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Princeton University
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U.S.A.

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

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
- Partial/multiple extraction possible at 14 GeV
- Beam on target April 2007

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

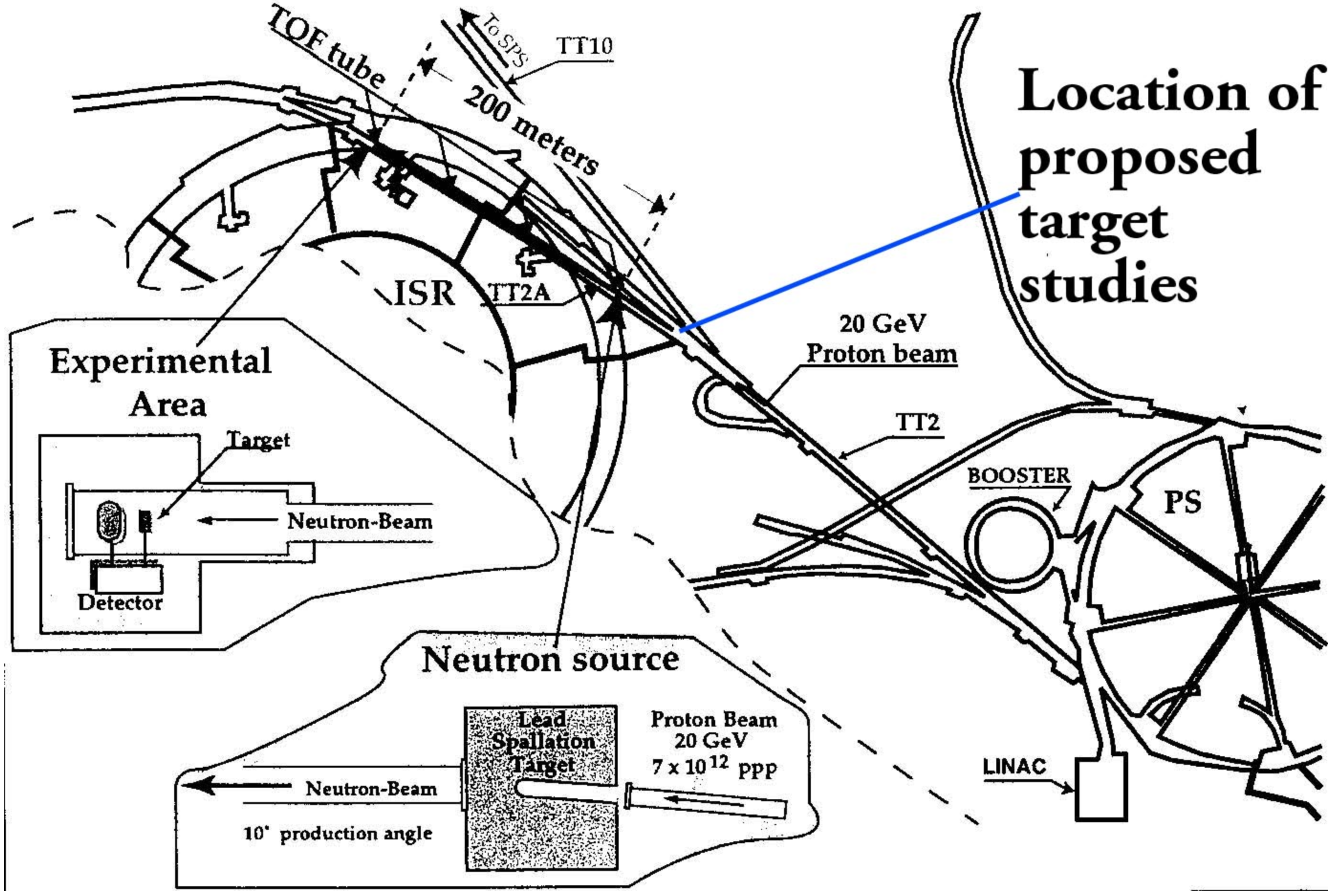
1.2mm x 1.2 mm rms beam spot 180 J/g

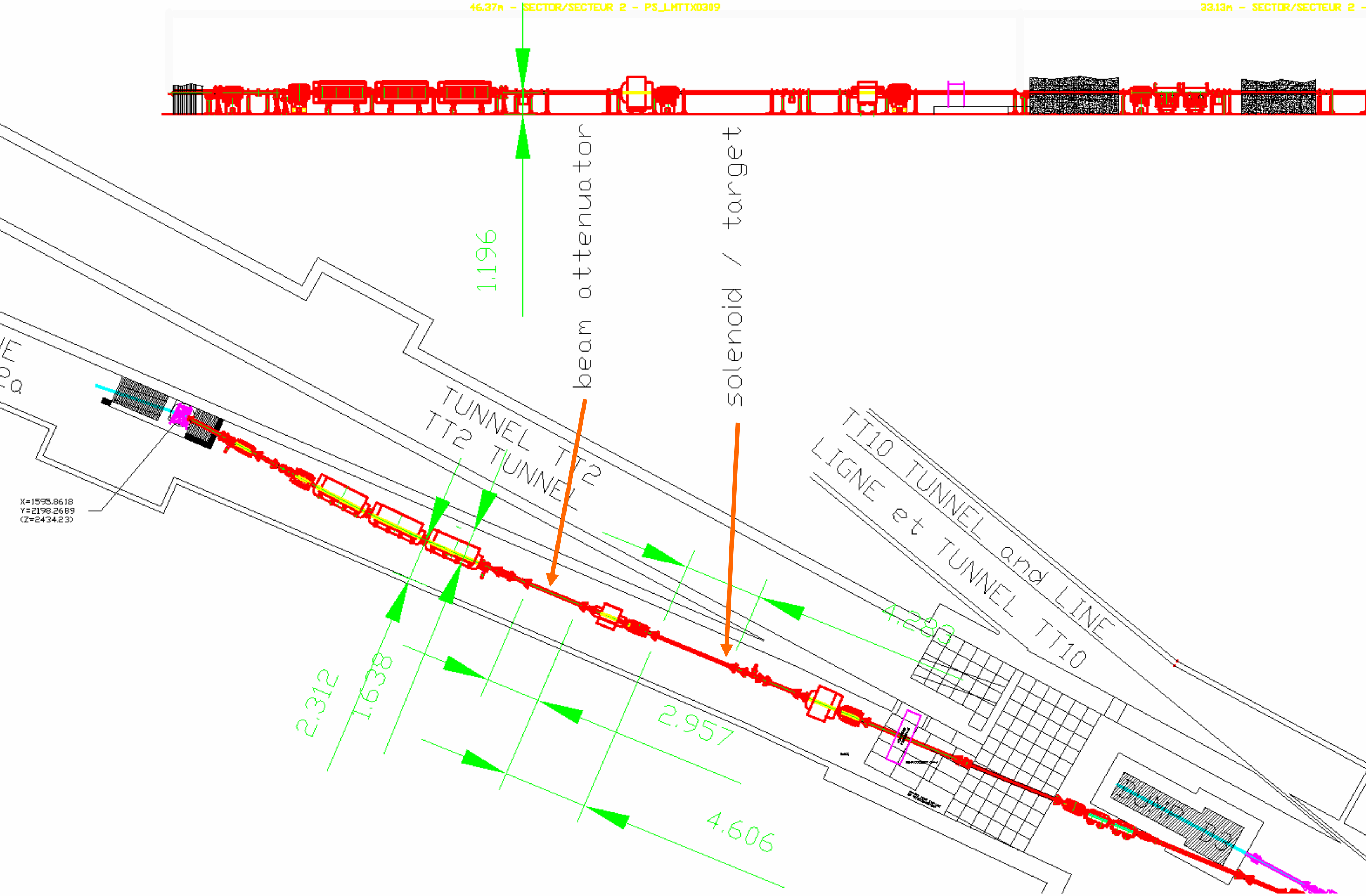
Run plan for PS beam spills

The PS Beam Profile allows for:

- Varying beam charge intensity from 5 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.

Target Test Site at CERN





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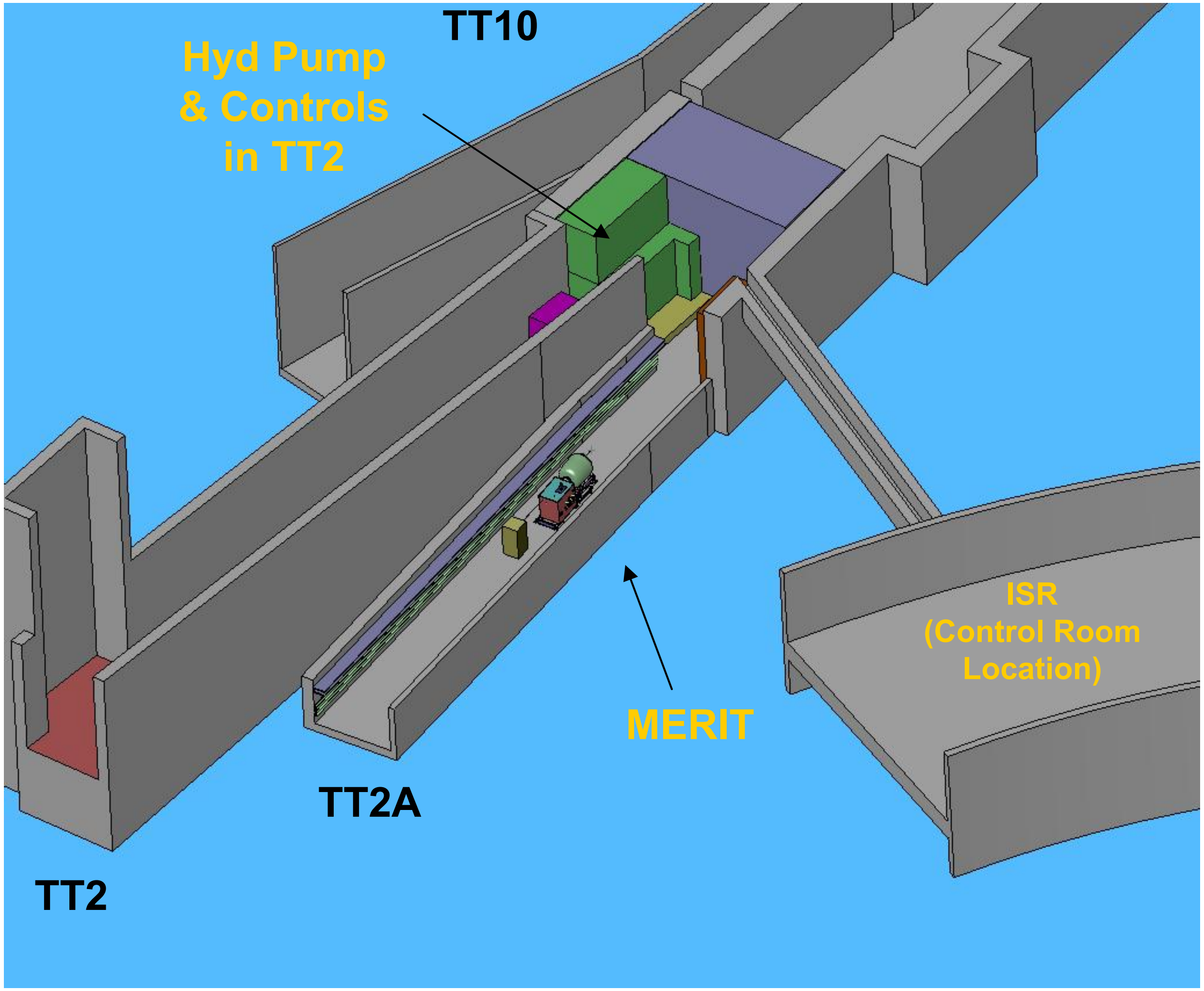
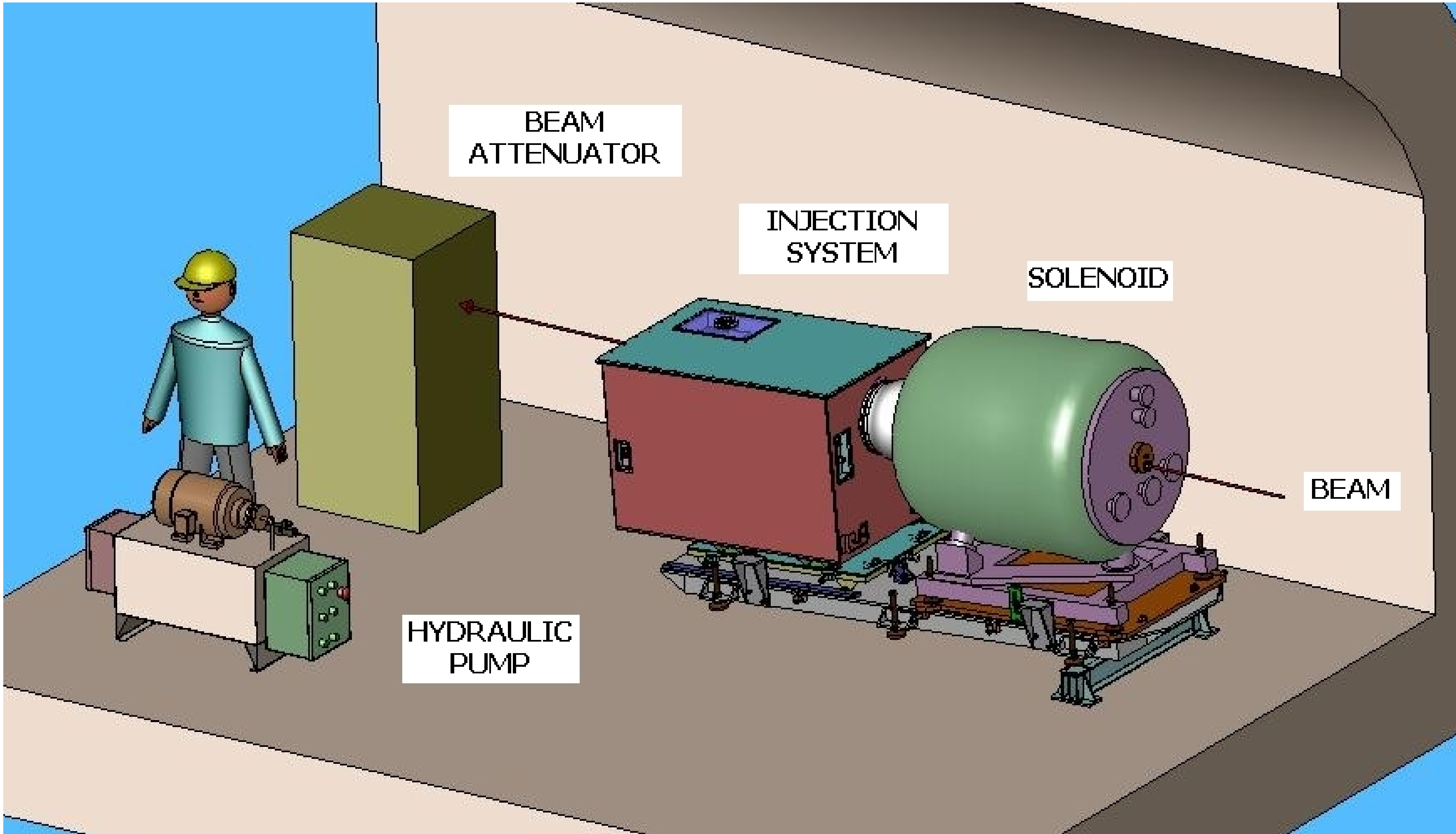
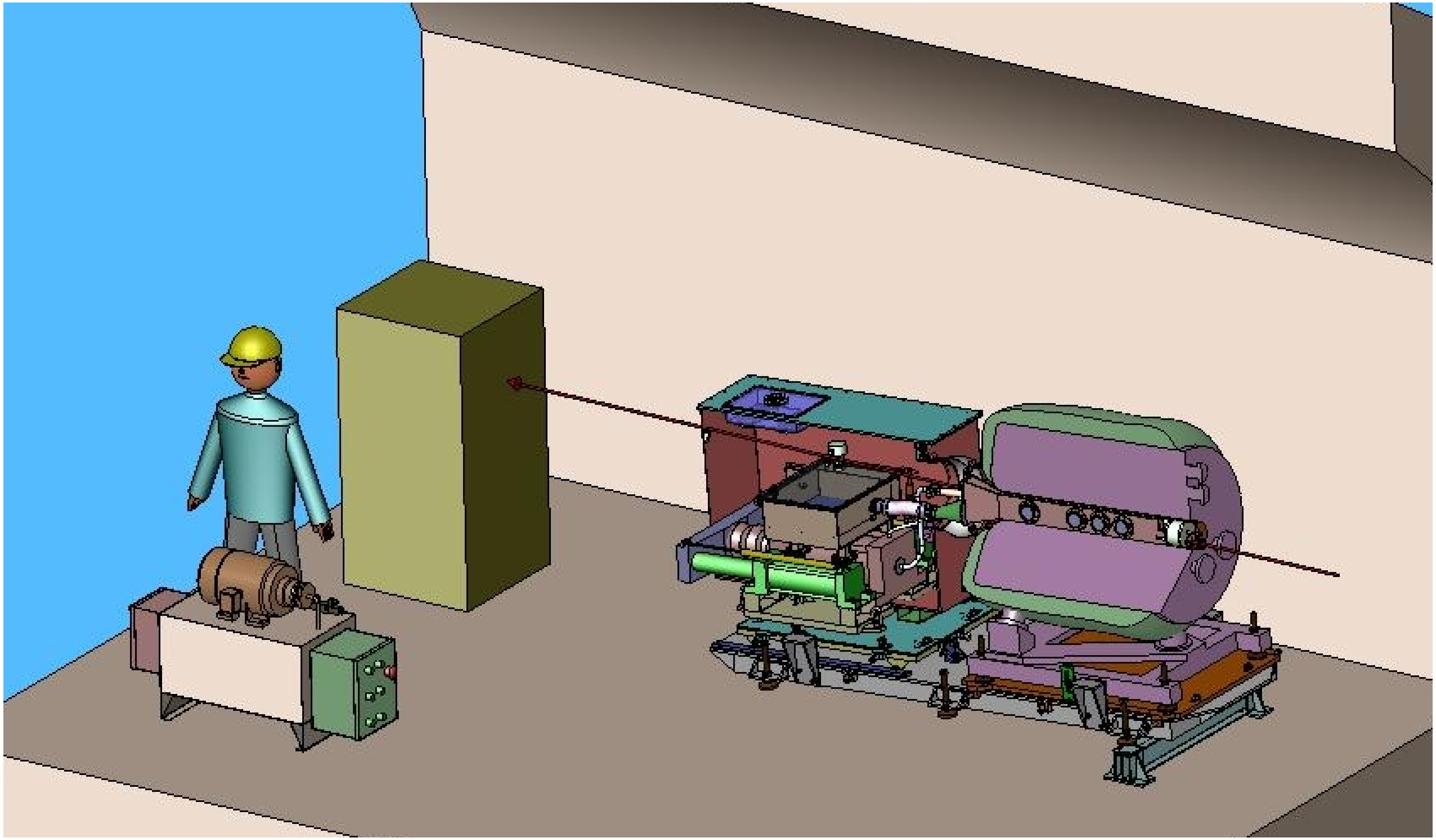
The Tunnel Complex



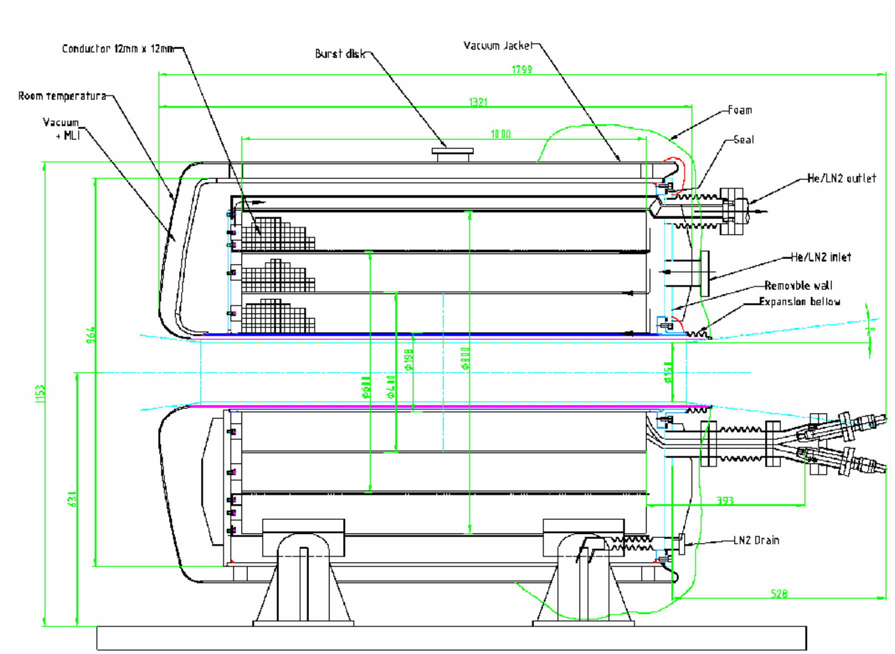
The Footprint of the Experiment

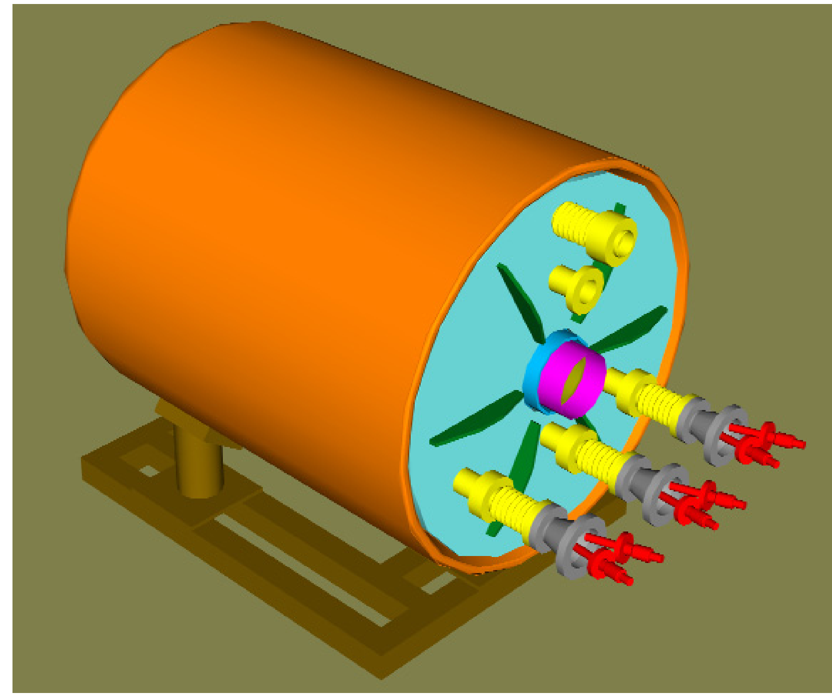


Hg Jet System Layout



High Field Pulsed Solenoid





- 80º K 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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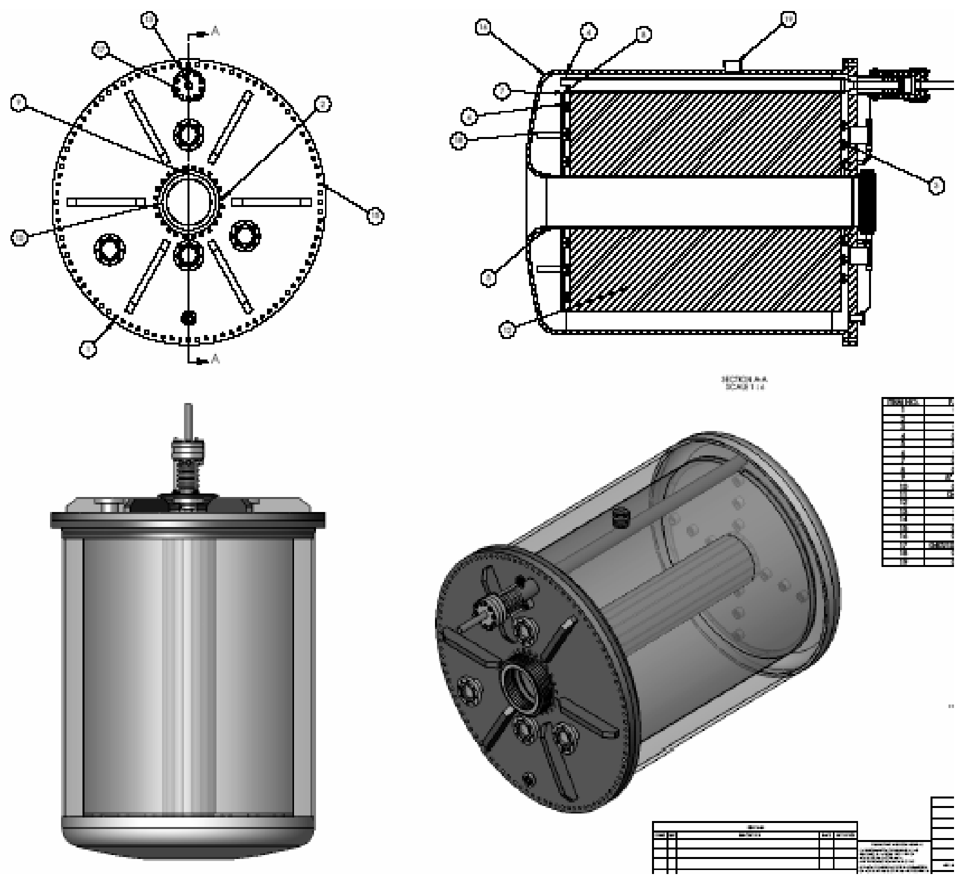
Fabrication of the Cryostat

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

Coils Installation

The 3 Coils Nested
August, 2005

Coils inserted into pressure vessel
September, 2005

Cryosytem Layout

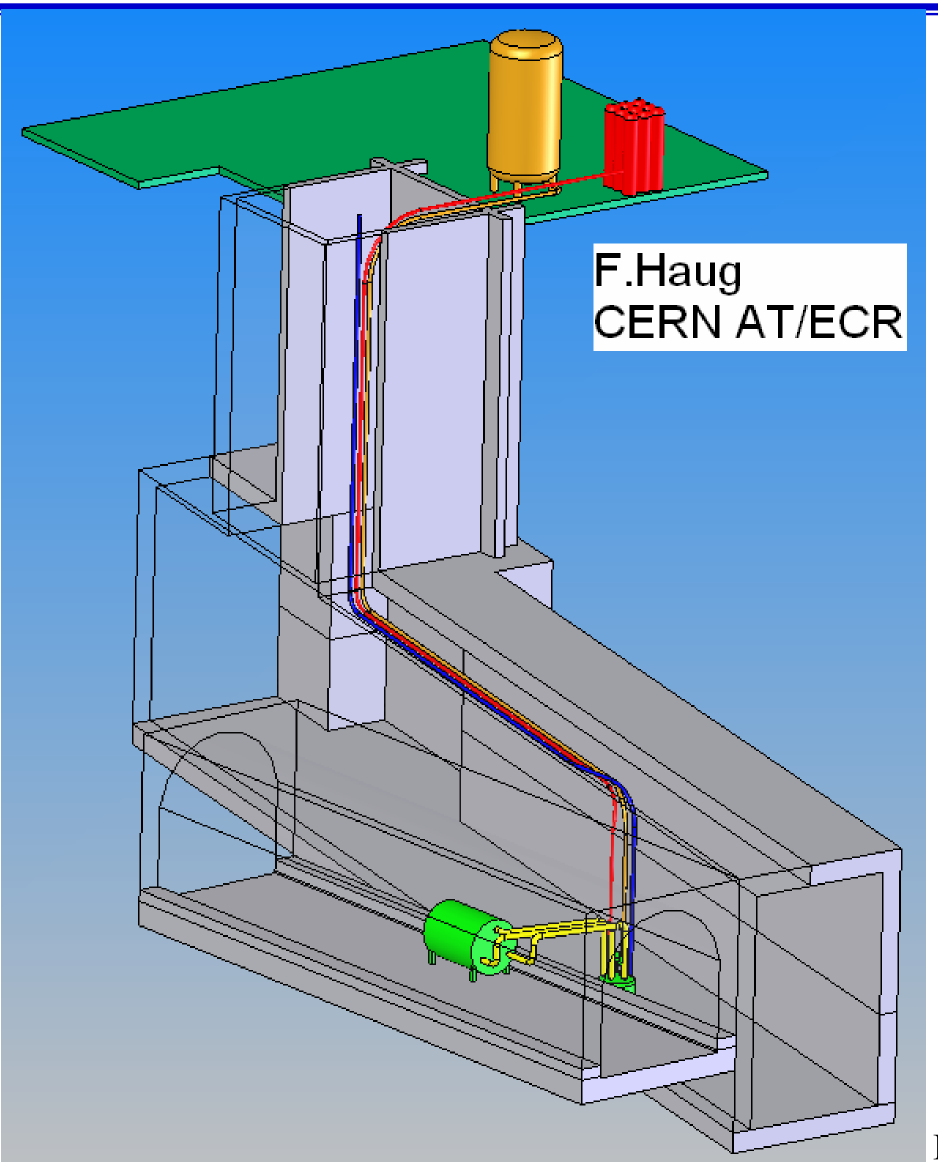
LN_2 and N_2 gas stored on the surface.

Cold valve box in the TT2 tunnel.

Exhaust gas vented into TT10 tunnel through filtration system.

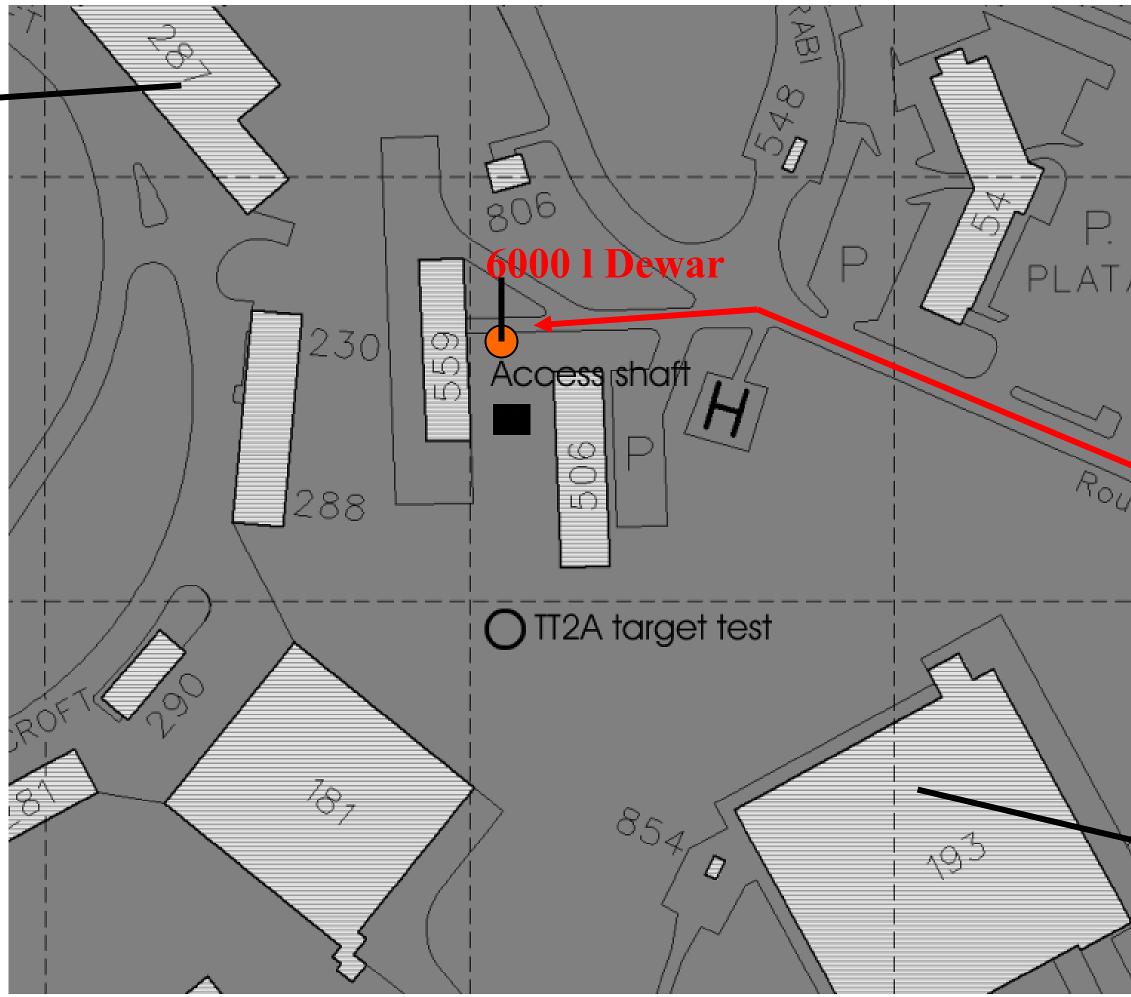
~ 150 liters of LN_2 per Magnet pulse.

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



Surface above the ISR

Two 18kV sub-stations



Access Route

One 18kV Sub-station

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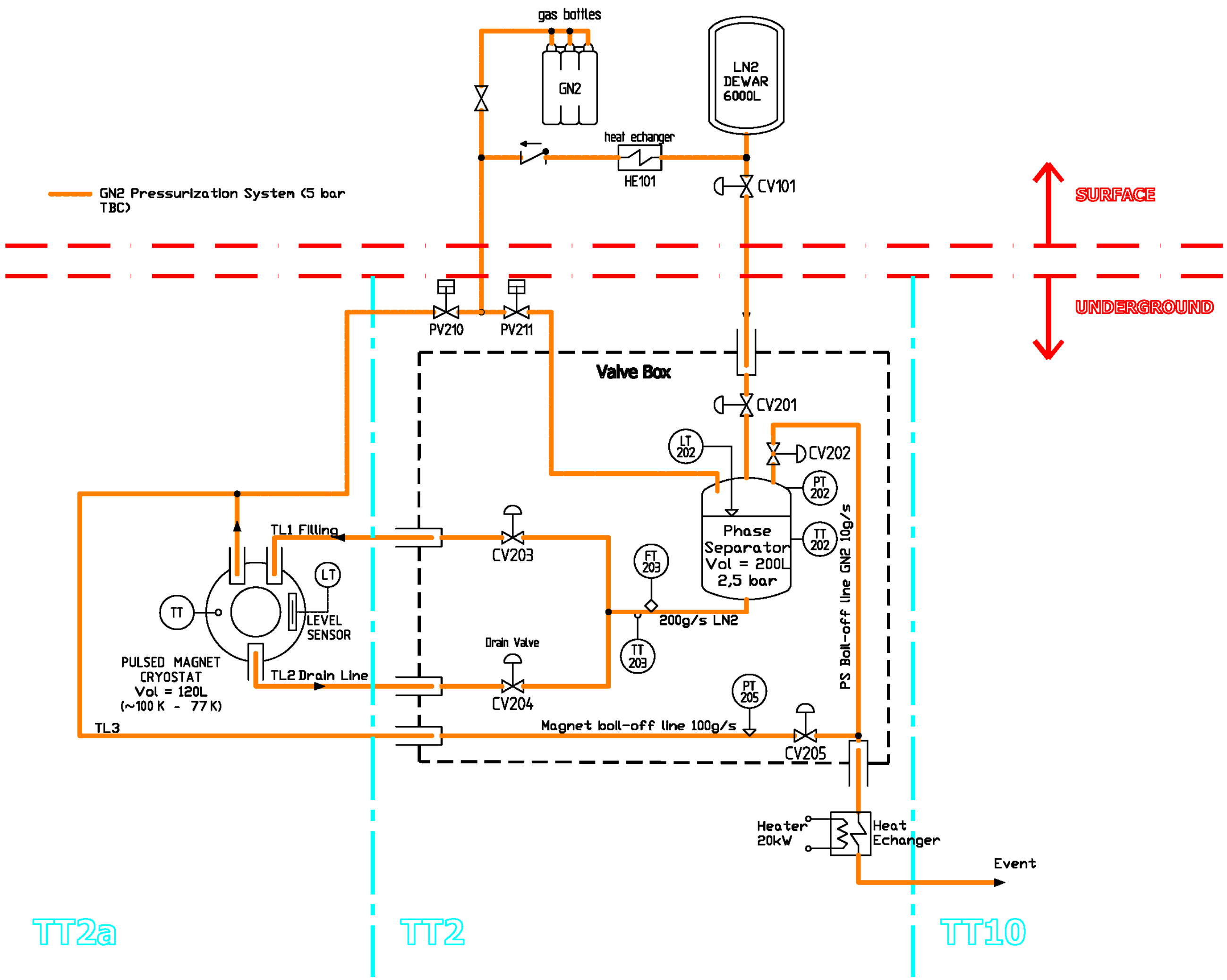
The Cryogenic System

Key Features

- 30 minutes rep-rate
- LN_2 purge before shot
- Liquid purge to buffer storage
- Gas purge to TT10



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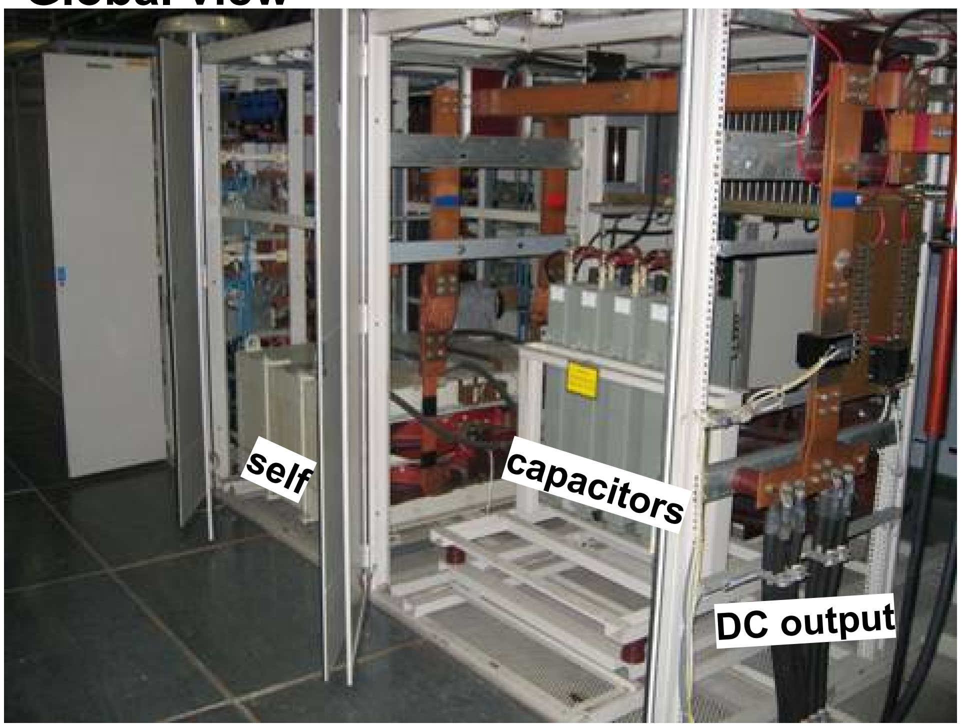
Power Converter (From SPPS Transfer Line)

8000 Adc, 1000 Vdc

Strategy:

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

Global view

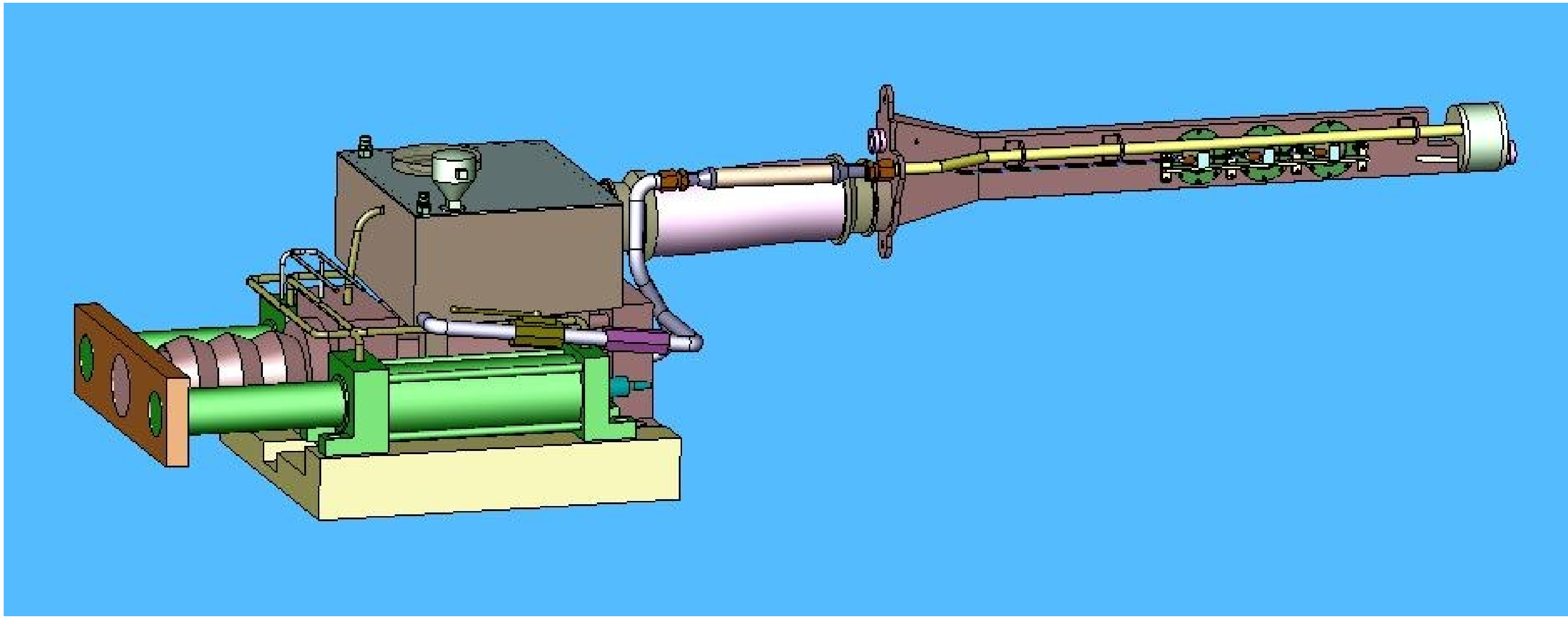


Rectifier bridges

Passive filter

Passive filter capacitors

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

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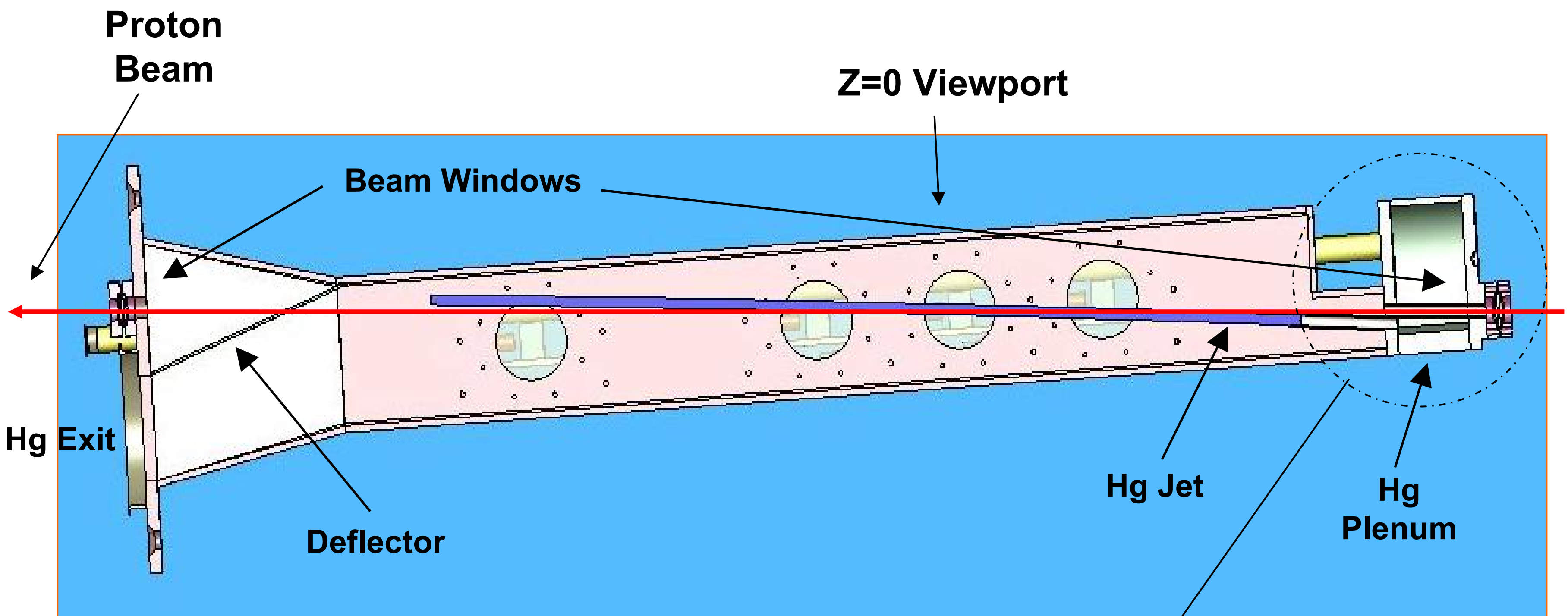
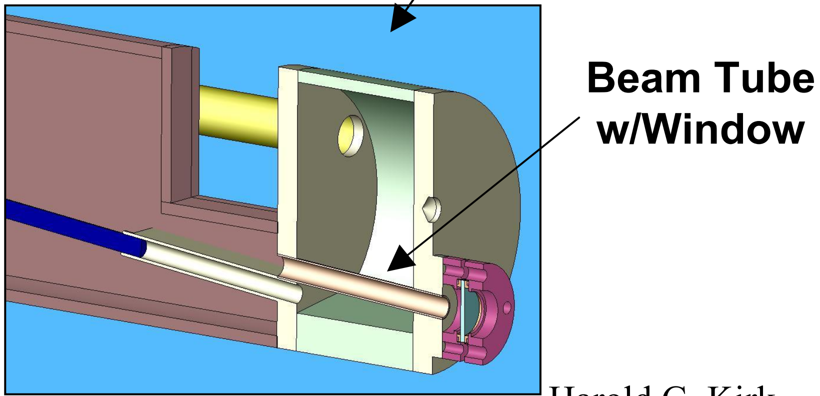
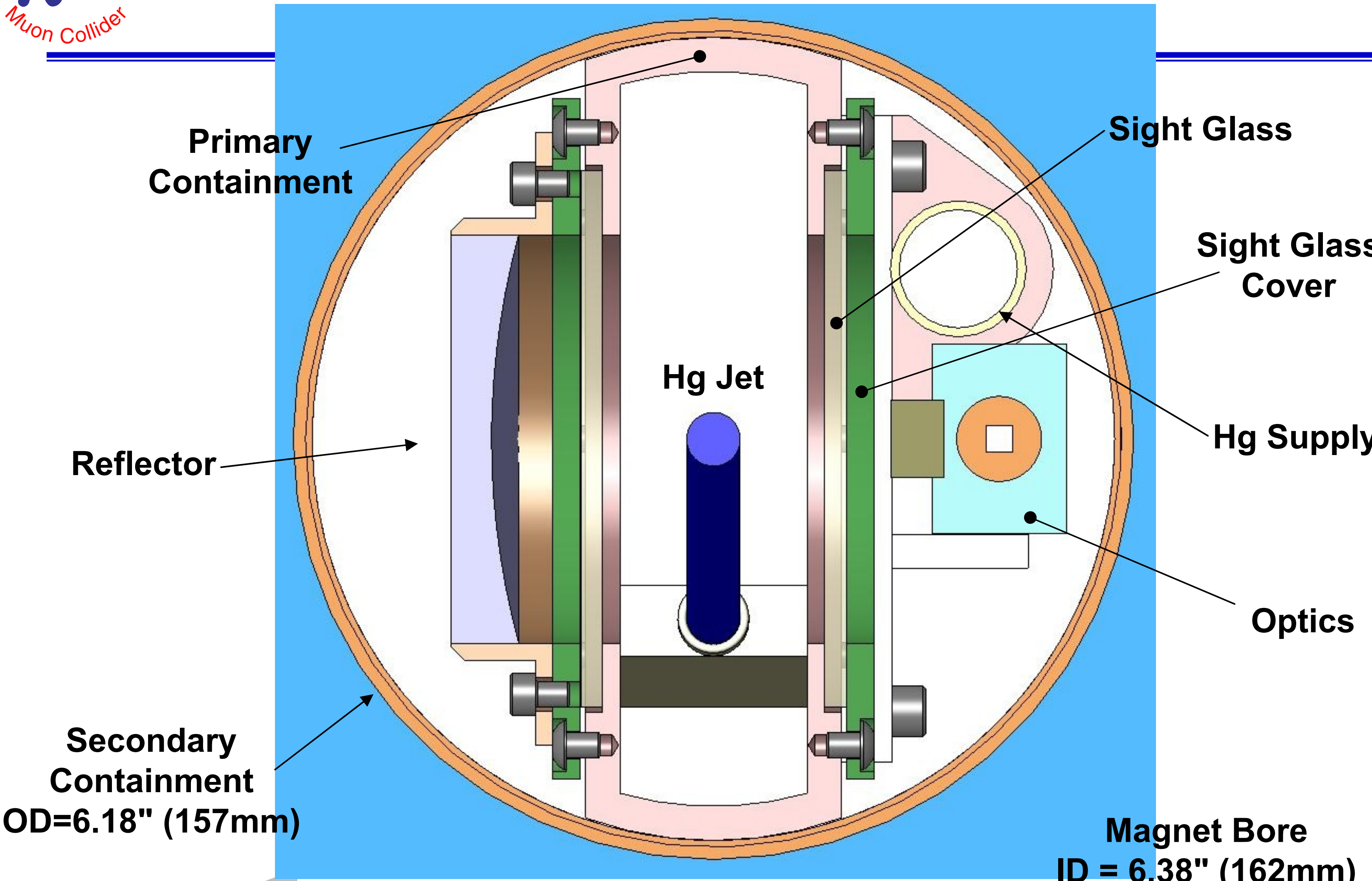
Primary Containment – Side View

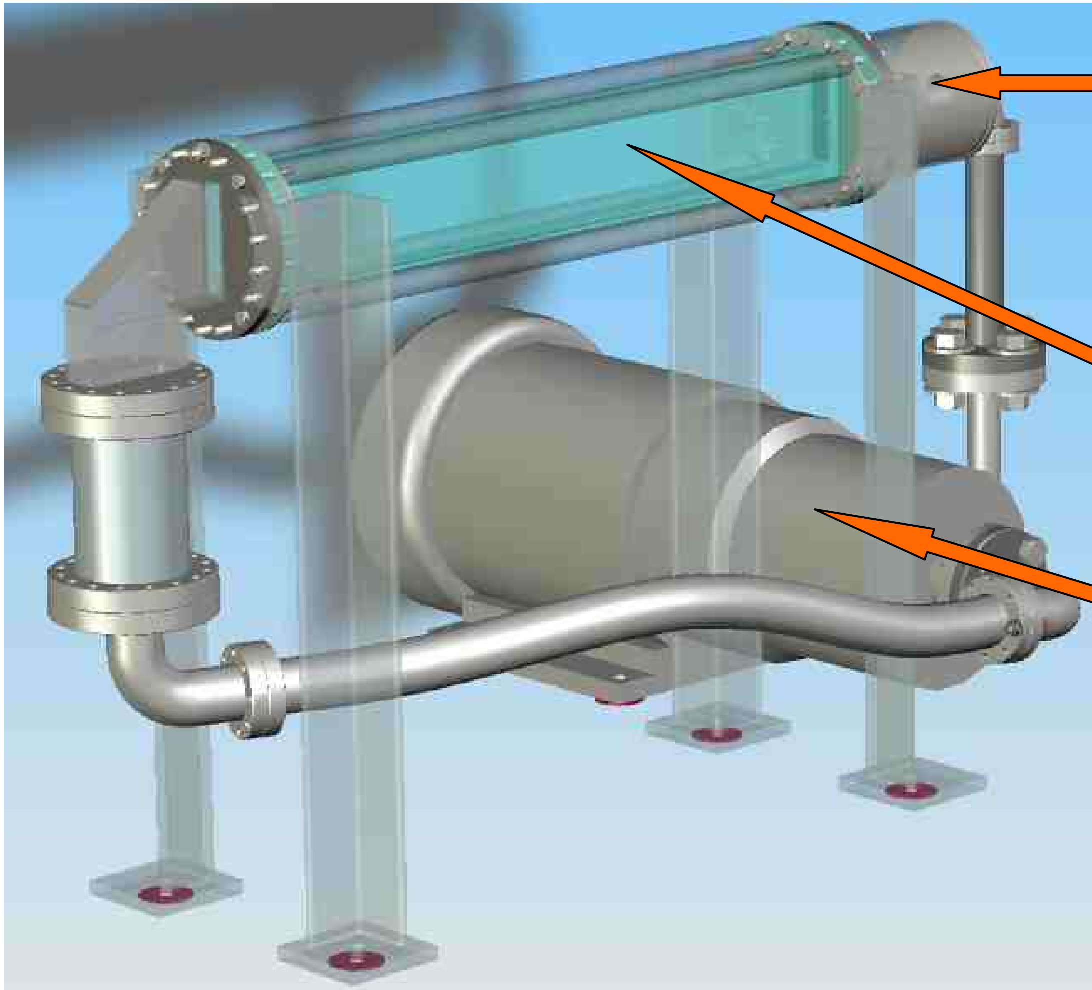




Primary Containment Cross Section



Princeton Nozzle R&D

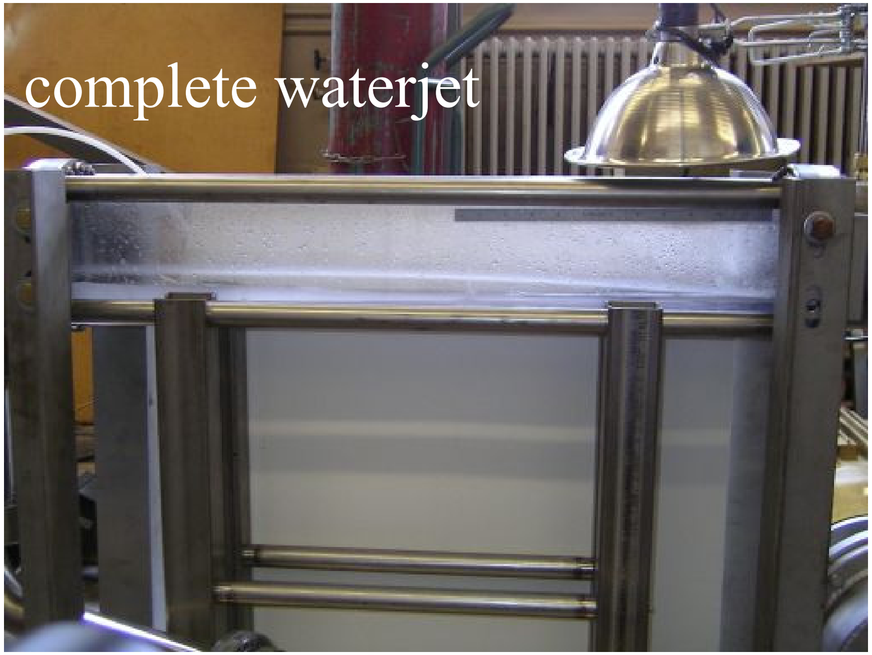


Replaceable Nozzle Head

Lexan Viewing Channel

20 HP Pump

Fast camera capture of waterjet September 16, 2005 @ Princeton



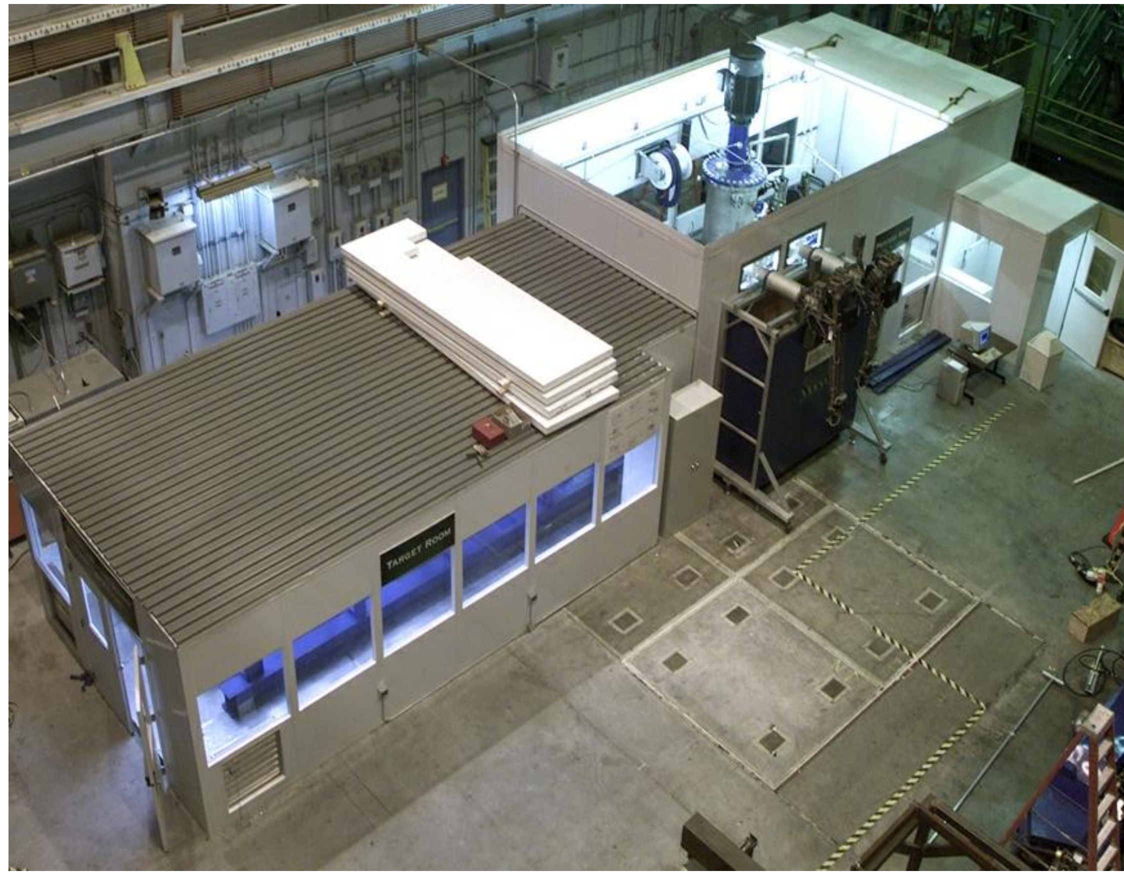
Measured Waterjet Velocity 12 m/s

nozzle: diameter ~8 mm, length 6-inch

Camera: FastVision 13 capability
1280x1024 pixels, 500 frames/sec, 0.5 sec video
or …

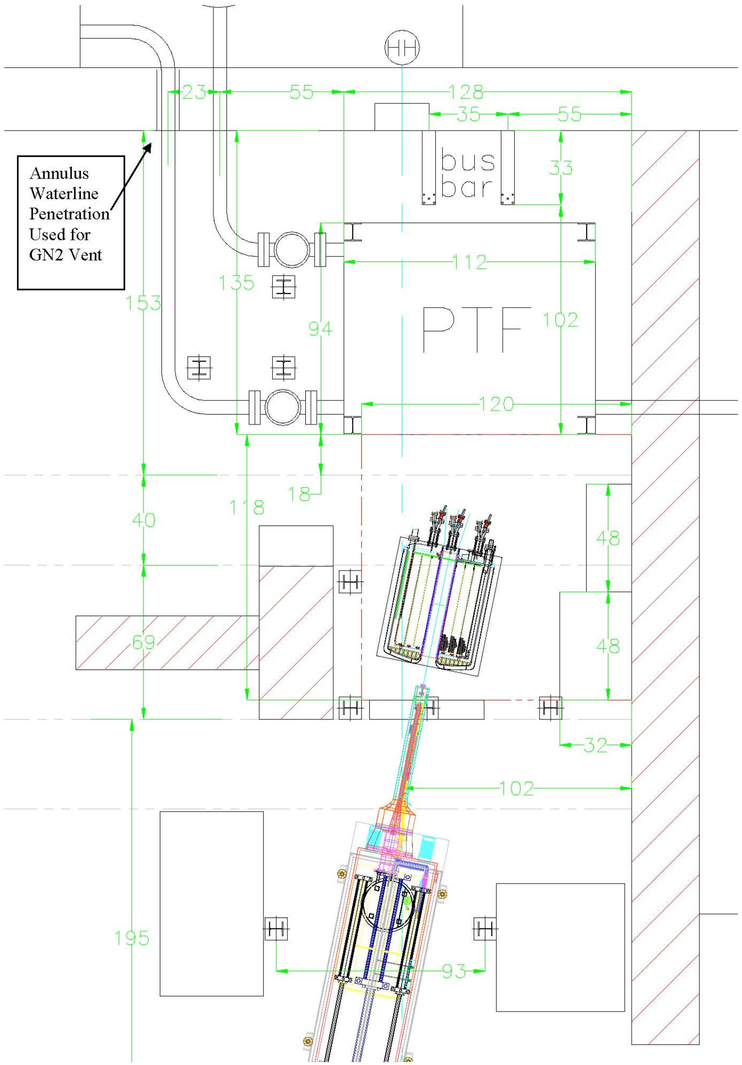
The Target Test Facility (TTF) - Basis For ORNL's Hg Handling Experience

- 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



System Commissioning

- Ship Pulsed Solenoid to MIT October 2005
- Test Solenoid to 15 T peak field November 2005
- Integration of Solenoid/Hg Jet system Summer 2006



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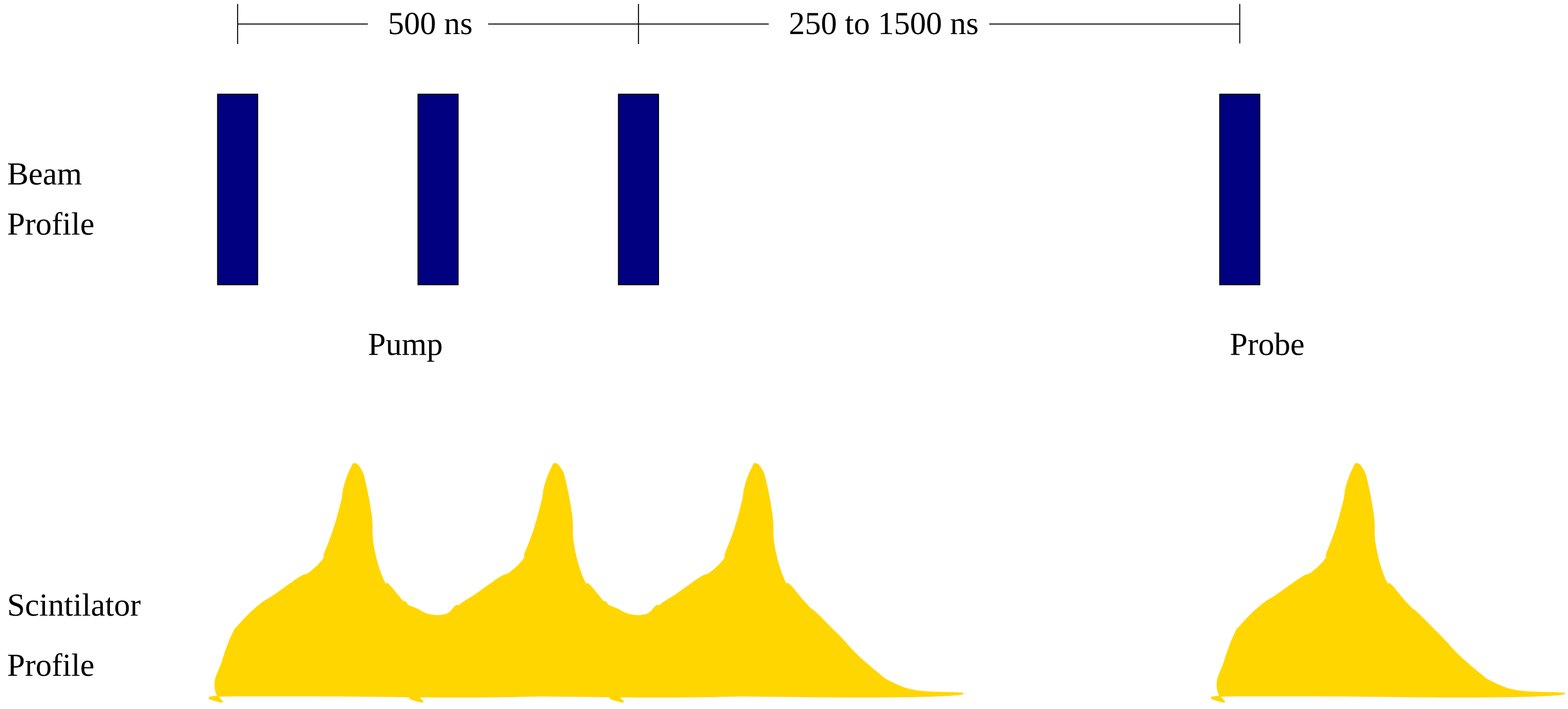
PS Extracted Beam Profile



Target Experiment Milestones

Pulsed Solenoid Delivery	October, 2005
Pulsed Solenoid at 15T	November, 2005
Hg Jet Commisioning	Spring, 2006
Solenoid/Hg Jet Integration	Summer, 2006
Cryo System test	Summer, 2006
The Power Supply Commissioning	Fall, 2006
Target Delivery to CERN	Fall, 2006
Experiment Commissioning	Winter, 2006/2007
Beam on Target	April, 2007

Summary

The nTOF11 (MERIT) Experiment

- Study single beam pulses with intensity up to 28TP
- Study influence of solenoid field strength on Hg jet dispersal (B_o from 0 to 15T)
- Study 50 Hz operations scenario
- Study cavitation effects in the Hg jet by varying PS spill structure—Pump/Probe
- First beam expected April 2007
- Confirm Neutrino Factory targetry concept

Backup Slides

The Experimental Installation Point

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

The TT2 Tunnel Complex