Cryogenics for Test Facilities

Jay Theilacker

Goals for SRF Infrastructure

Fermilab

- **To perfect U.S. fabrication & processing of SRF cavities and modules and to demonstrate performance with a full range of testing (including beam)**
  - Deploy ILC design / processing / assembly techniques
  - Establish process controls to reliably achieve high gradient cavity operation and module performance
  - **Test cavities and modules at the component level and in a systems test to demonstrate yield, reproducibility and beam performance**
- To facilitate commercial production of SRF components and modules
  - Train and transfer SRF technology to the US industry
  - Allow industrial participation and input to the process
    - Similar to SC cable and magnet technology transfer
- To participate in SRF Research and Development
  - Develop expertise in SRF technology and provide training base for construction and operation of future accelerators
  - Our attempt to fit into the world's SRF community

All of this work will be carried out with US/international collaboration

US Laboratories Capacity

Fermilab

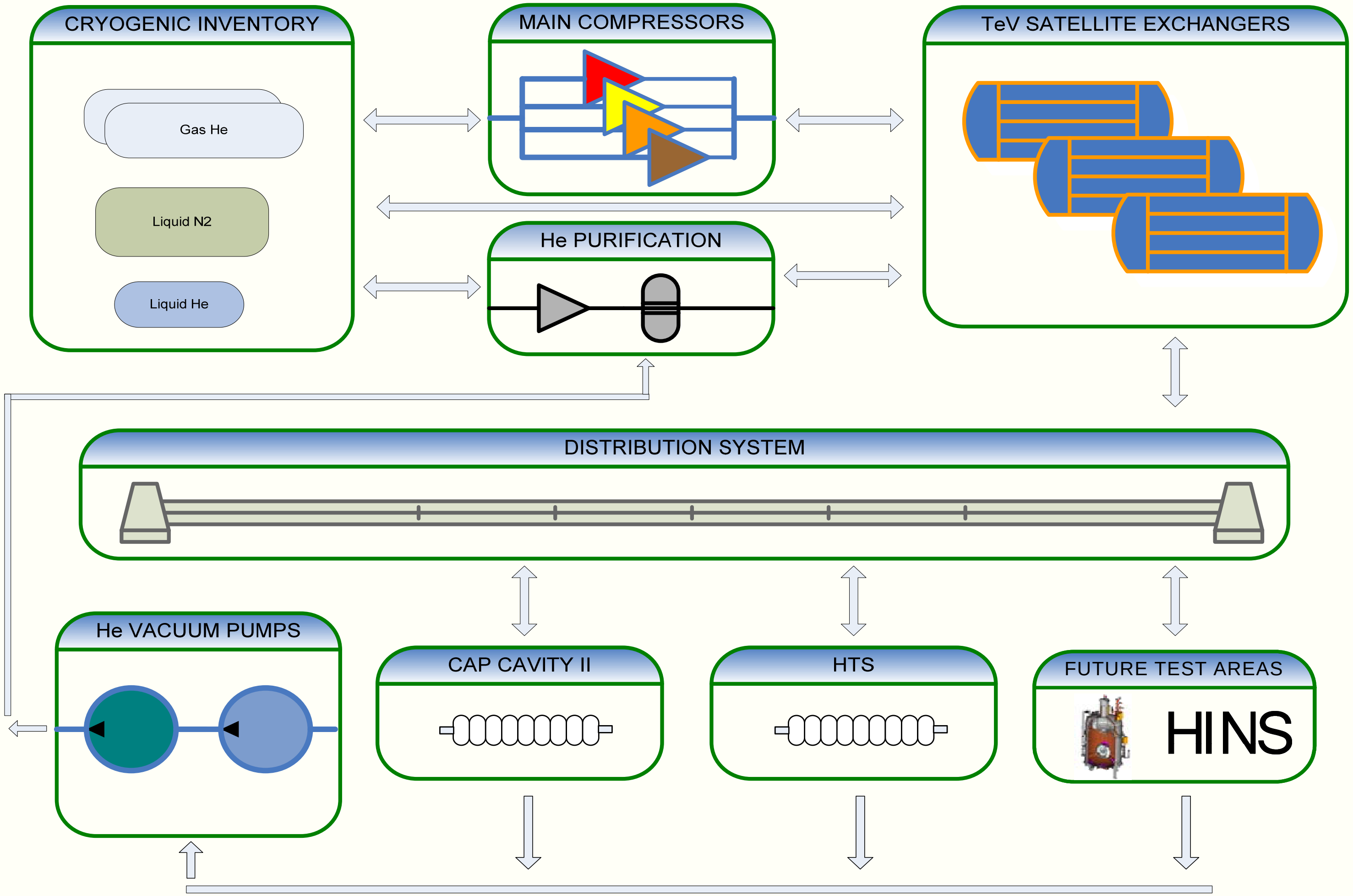
Program	FY07	FY08	FY09	FY10	Capacity Needed/yr by FY10
Cavity Processing (EP, HPR, Bake)	Jlab-30 Cornell-10	Jlab-40 Cornell-10 ANL-40	Jlab-40 Cornell-10 ANL-40 Fermilab-20	Jlab-40 Cornell-10 ANL-40 Fermilab-100	200
Vertical Testing	Jlab-30 Cornell-10 Fermilab-20	Jlab-40 Cornell-10 Fermilab-75	Jlab-40 Cornell-10 Fermilab-75	Jlab-40 Cornell-10 Fermilab-200	200
Horizontal Testing	**Fermilab-6**	**Fermilab-24**	**Fermilab-24**	**Fermilab-72**	**72**
Cryomodule Assembly	Fermilab-1	Fermilab-4	Fermilab-12	Fermilab-12	12
Cryomodule Test	**Fermilab: ILCTA_NML**	**Fermilab: ILCTA_NML**	**Fermilab: ILCTA_NML**	**Fermilab: ILCTA_NML CMTS**	**12**

Outline

Fermilab

- **MDB Cryogenics**
  - Limited scope, low cost
  - Built using mostly existing components ($5M value)
  - Not optimized
- **NM Cryogenics**
  - Dynamic scope
  - Requires new cryogenic plant
  - Warrants cost optimization
- **Fermilab Cryogenics Assets**
  - What cryogenic infrastructure is available past 2009?
  - What does it take to make it usable for SCRF R&D?

MDB Cryogenics



NM Cryogenics

Fermilab

- **LONG TERM SCOPE :** ***PROVIDE RELIABLE CRYOGENIC SERVICE TO PHOTOINJECTOR (PI) WITH ILC RF UNIT OPERATING AT ILC PARAMETERS WITH A MINIMAL TOTAL (CAPITAL AND OPERATING) COST***

- **ILC CM operating parameters**

Beam	**Cryogenics**
E_{acc} = 31.5 MV/m	T_{cavity} = 2.0 K
Q = $1E^{10}$	T_{shield} = 5 to 8 K
Rep rate = 5 Hz	T_{shield} = 40 to 80 K

- **CHALLENGES OF THE LONG TERM SCOPE**
  - **CAPACITY**
  - **RELIABILITY**
  - **OPERATING TEMPERATURES**

NM Cryogenics (cont.)

Fermilab

- Multi phase approach is planned to fulfill the long term scope
- Cryogenic loads
  - 1st phase: PI and a single Type III plus CM
  - 2nd phase : PI and two Type III plus CM
  - 3rd phase : PI and RF Unit
- Cryogenic plants
  - 1st phase : Single TeV satellite refrigerator $$
    - 4 g/s LHe or 625 W @ 4.5 K, 80 K LN_2 for shields
  - 2nd phase : Two TeV satellite refrigerators $
    - 8 g/s LHe or 1,250 W @ 4.5 K, 80 K LN_2 for shields
  - 3rd phase : New hybrid cryogenic plant $$$
    - 300 W @ 2 K, 300 W @ 5 to 8 K, 4 kW @ 40 to 80 K

NM Cryogenics (cont.)

- At the end of the 2nd phase
  - Maximum Rep Rate

NM Phase		# of Tev Satellite refrigerators	
		1	2
1	PI + Single ILC cryomodule	< 1 Hz	5 Hz
2	PI + Two ILC cryomodules	n/a	5 Hz
3	PI + Single RF Unit	n/a	< 2 Hz

  - Thermal shields won't match ILC specification

- 3rd phase requires a new refrigerator
  - A significant investment
  - Long lead item
  - We have examined surplus systems (SSC plant, etc.)
  - We have conducted industrial cost study
  - Requires overall SCRF scope definition

Required Funding

Fermilab

Infrastructure	M&S	SWF	Total with Indirect
Cavity Fabrication Infrastructure	$ 3,000	$ 675	$ 4,380
Cavity Processing Facilities	$ 11,100	$ 4,590	$ 18,945
Vertical Test Stand (VTS 2 & 3)	$ 2,625	$ 1,845	$ 5,475
Horizontal Test Stand (HTS 2)	$ 1,220	$ 1,057	$ 2,805
Cavity/Cryomodule Assembly Facilties (CAF_MP9 & ICB)	$ 690	$ 270	$ 1,158
NML Facility (ILCTA_NML)	$ 18,270	$ 23,220	$ 51,700
Cryogenics for Test Facilities	**$ 10,690**	**$ 950**	**$ 13,692**
Cryomodule Test Stand	$ 5,400	$ 2,970	$ 10,180
Material R&D	$ 870	$ 722	$ 1,960
Illinois Accelerator Research Center	$ 20,000	$ 4,050	$ 28,605
Grand Total ($k)	**$ 73,865**	**$ 40,349**	**$ 138,900**

Most infrastructure is in place

$2,397 M&S
24.7 SWF

New Hybrid Cryogenic Plant

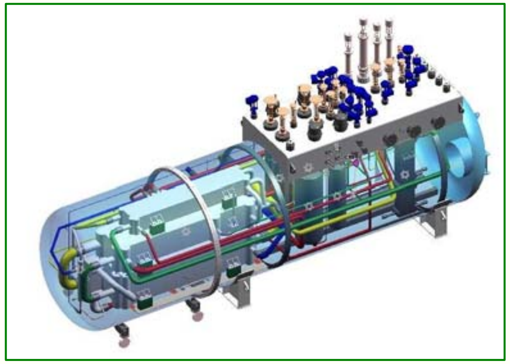
- **An industrial budgetary study estimated for a**

  300 W at 2 K

  300 W at 5-8 K

  4,100 W at 40-80 K

  plant to be:



  $5.6M cold box and compressors

  $1.2M installation and startup

  $3.9M distribution, controls and auxiliary

- **Long lead item: ~24 month delivery**

Fermilab cryogenics assets

Fermilab

- **Fermilab has a significant amount of cryogenic assets, equipment and expertise, which with investment can be made usable for SCRF activities when Tevatron shuts off**

- **Most of the equipment, particularly Central Helium Liquefier (CHL), can not be used "AS IS" for SCRF activities**
  - **4.5 K Helium liquefier**
  - **Requires 2K satellite for superfluid and shields production**
  - **Need to be automated to reduce operating cost**

- **Cryogenic asset value depends on SCRF test area location and a cost of conversion for SCRF specific cryogenic needs**

- **Work is being conducted to identify additional investment required to make use of Tevatron cryogenics for superfluid SCRF**

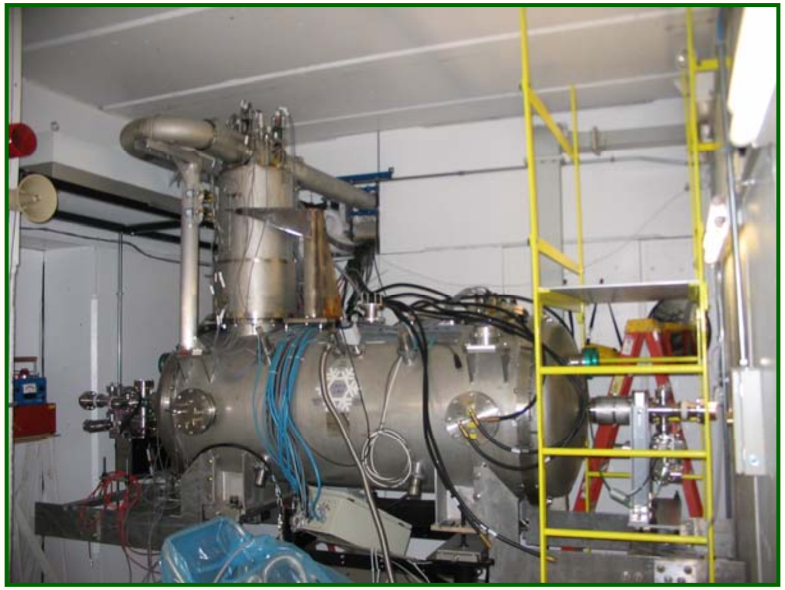
Fermilab

CTF Refrigerators

- Three TeV Satellite Refrigerators
- Capacity (each):
  - 625 W @ 4.5 K or 4 g/s LHe
- Located 500 m South from MDB

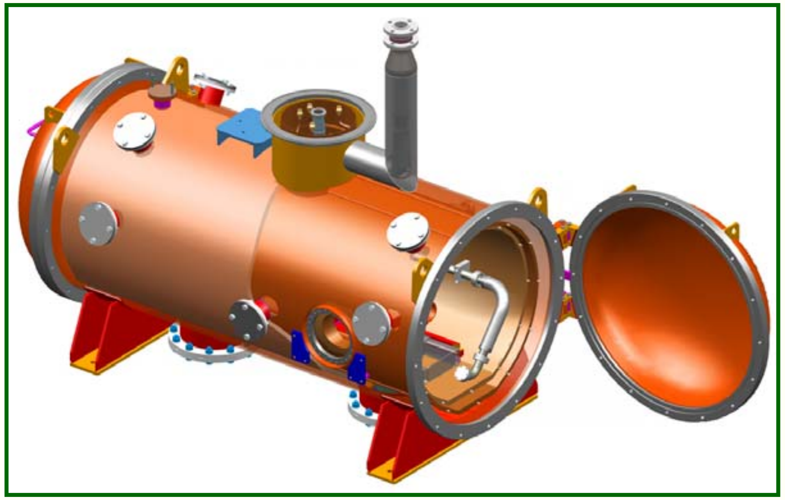
- Reciprocating expanders
- Distributed control system
- Pressure piping and cryogenic transfer lines.

MDB Test areas



* Capture Cavity II from DESY
* Feed Box with modified J-T heat exchanger
* Cryogenic instrumentation, controls, ODH system, etc

* Horizontal test cryostat
* Cryogenic interface similar to the Capture Cavity II



Cryogenic inventory

10,000 gal Liquid Nitrogen Dewar
50 psig MAWP

Two 30,000 gal GHe Tanks
250 psig MAWP

1,000 gal Liquid Helium Dewar
40 psig MAWP

Helium purification

Full flow helium purifier
300 psig MAWP

Purifier compressor:
- **Mycom helium screw compressor**
- **30 g/s capacity**

He Vacuum pumps

* Kinney/TUTHILL
  2,100 KLRC Liquid ring
  10,000 KMDB Roots Blower
* JLab skids refurbished at FNAL
* Capacity:
  10 g/s He @ 12 torr

* Reworked for helium service
  Helium guarded dynamic seals
  Sub-atmospheric components
* Variable speed drive
* Upgraded controls

Distribution system

MDB bayonet can designed at SLAC and built at Fermilab

CTF Bayonet cans with LHe and LN_2 subcooler

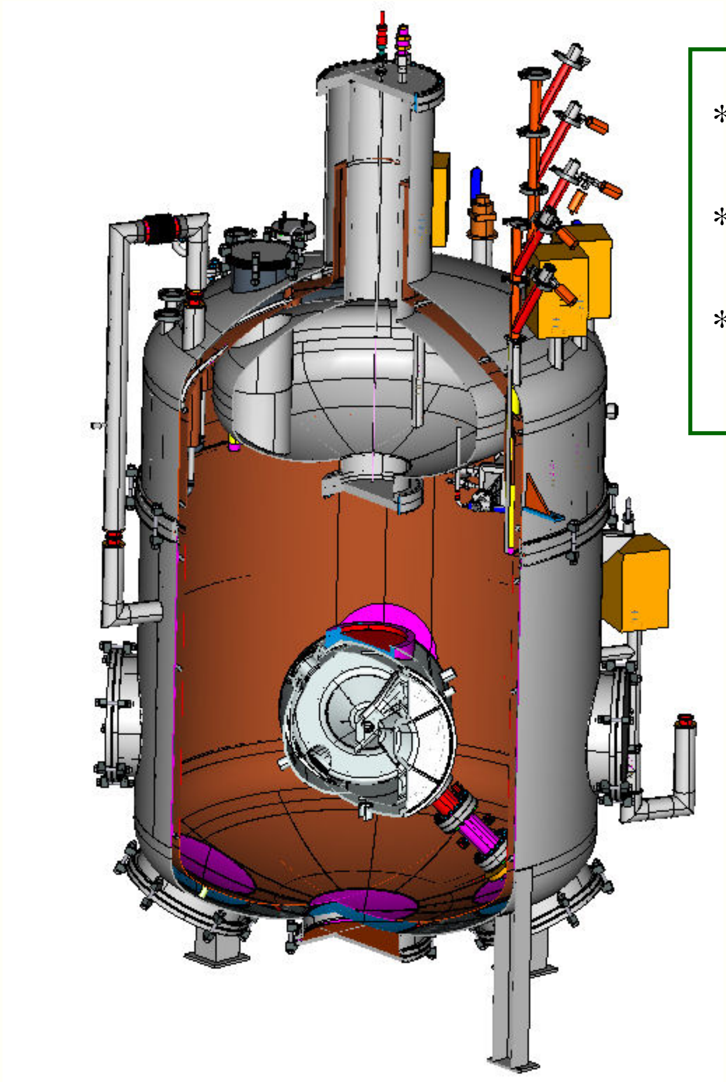
Expansion box from muon bend beam line

Main helium compressors

Fermilab

* Four oil-flooded screw compressors
* Manufactured by Mycom
* Capacity 60 g/s each
* Pressure
  Discharge ~300 psig
  Suction ~ 1.2 psig
* Power
  ~400 hp each

HINS



- Vertical test cryostat for spoke resonators testing
- Warm RF section solenoids
- Spoke cryomodules with solenoids