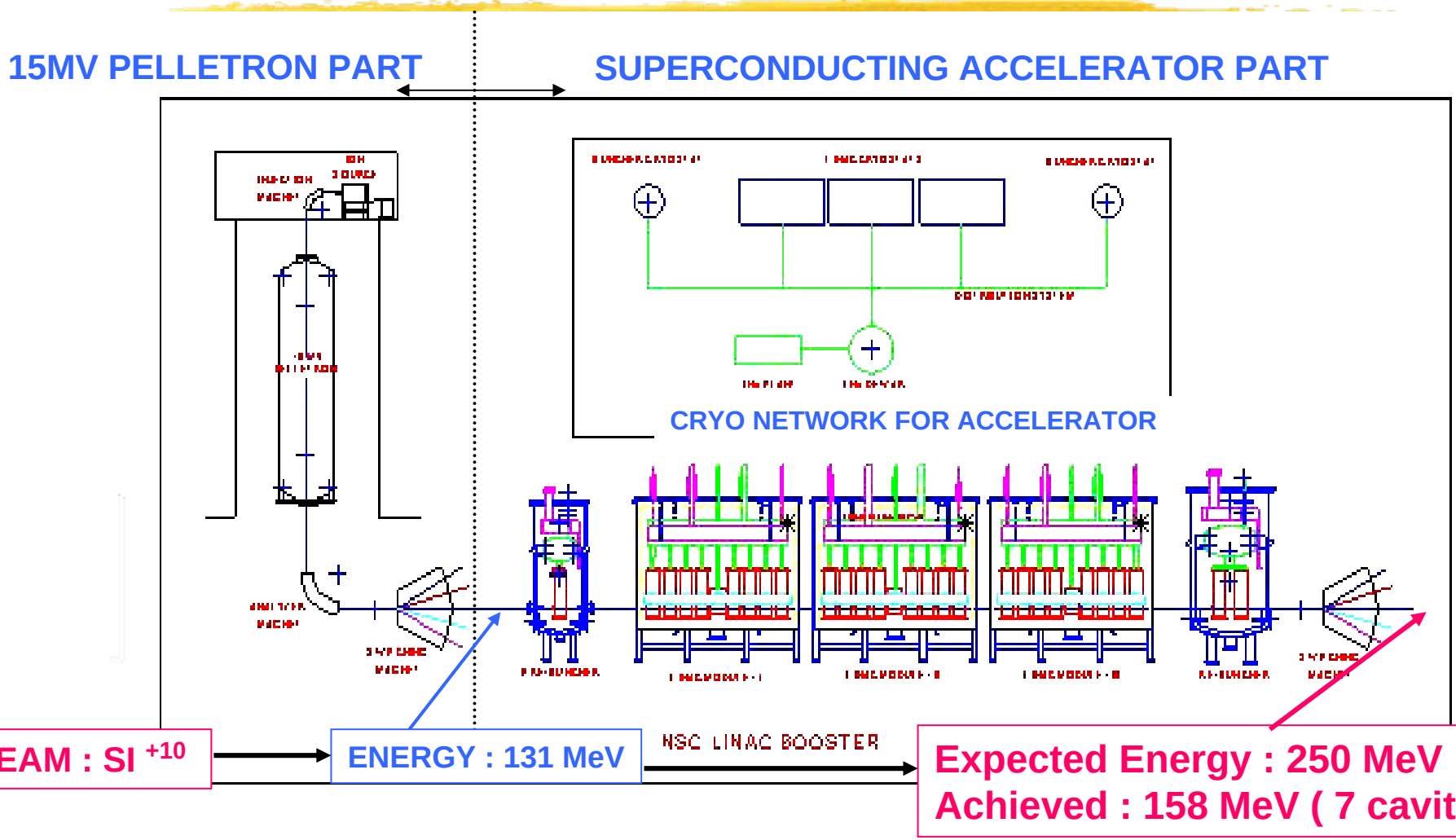
# CRYO MODULES & CRYO DISTRIBUTION SYSTEM DEVELOPED AT IUAC

T S DATTA

Inter- University Accelerator Centre

New Delhi

# Schematic of Tandem and Superconducting Linear Accelerator of IUAC, DELHI

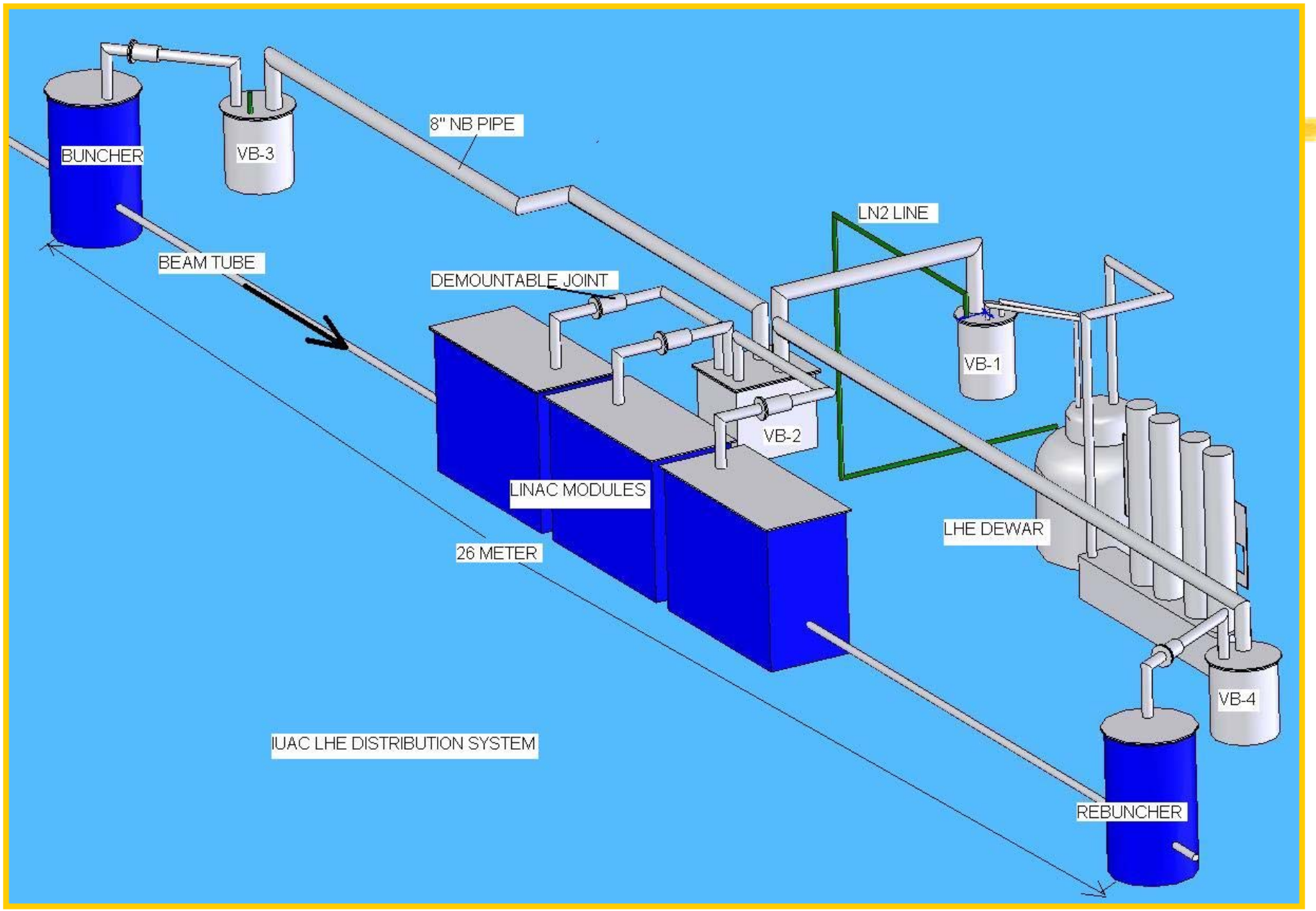


# A. SC LINEAR ACCELERATOR PROJECT

( Executed by Cryo Group and under operation)

- **DESIGN & DEVELOPMENT DIFFERENT TYPE OF CRYOMODULES**
- **IN - HOUSE DEVELOPMENT OF LIQUID HELIUM & NITROGEN LINES WITH DISTRIBUTION BOX**
- **CRYOGENICS DATA ACQUISITION & CONTROL ROOM**
- **HELIUM PURIFIER**
- **CRYO FACILITY ( Helium/ Nitrogen Refrigerator )**

# SCHEMATIC VIEW OF HELIUM CRYO NETWORK



# CRYO DISTRIBUTIONLINE

- **Designed to a Total flow rate of 800 litres/hr liquid helium in parallel mode to all 5 cryomodules**
- **Option** ( Considering length is only 50- 60 m)
  - Only MLI , No LN2 shield : Higher load , Easy fabrication
  - **With LN2shield : Low Load, Fab difficulty √**

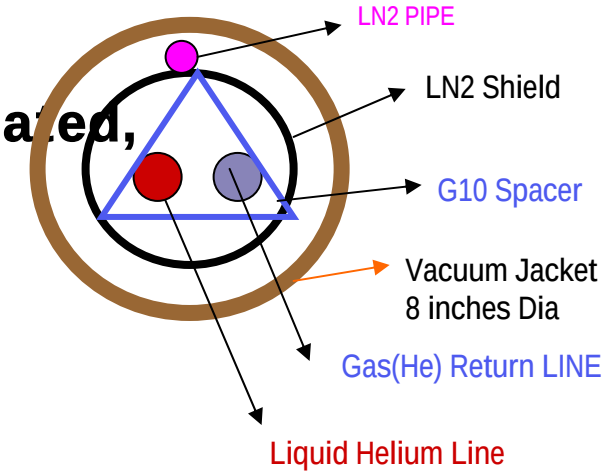
## Execution

**Option 1** : T**o third party as a complete Project with required input parameters**: **Higher Cost, Import of Segment line**

**Option 2** : IUAC take the responsibility on development & testing And fabrication by third party : **Expertise Dev, Cost, willingness of Third party from India √**

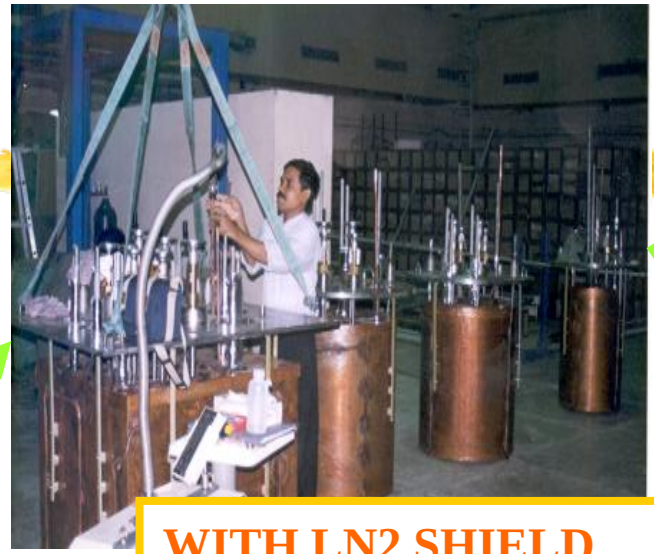
# Specification of Lhe Distribution Network

- **Four Valve boxes** : **Weka valves, Vacuum break, Instrumentation, Rectangular & Circular shape, LN2 Shielded**




- **CRYO LINE : Vacuum jacketed, MLI insulated, LN2 shielded Line, 50 meters length.**
- **Demountable Joints to isolate line from Cryostats**
- **MEASURED LOAD**
- **: 21 W in 23 meters length**
- **Actual Load in Line : 0.51 W/ m**

# FEW PICTURES DURING FABRICATION OF CRYO LINE AND VALVE BOXES



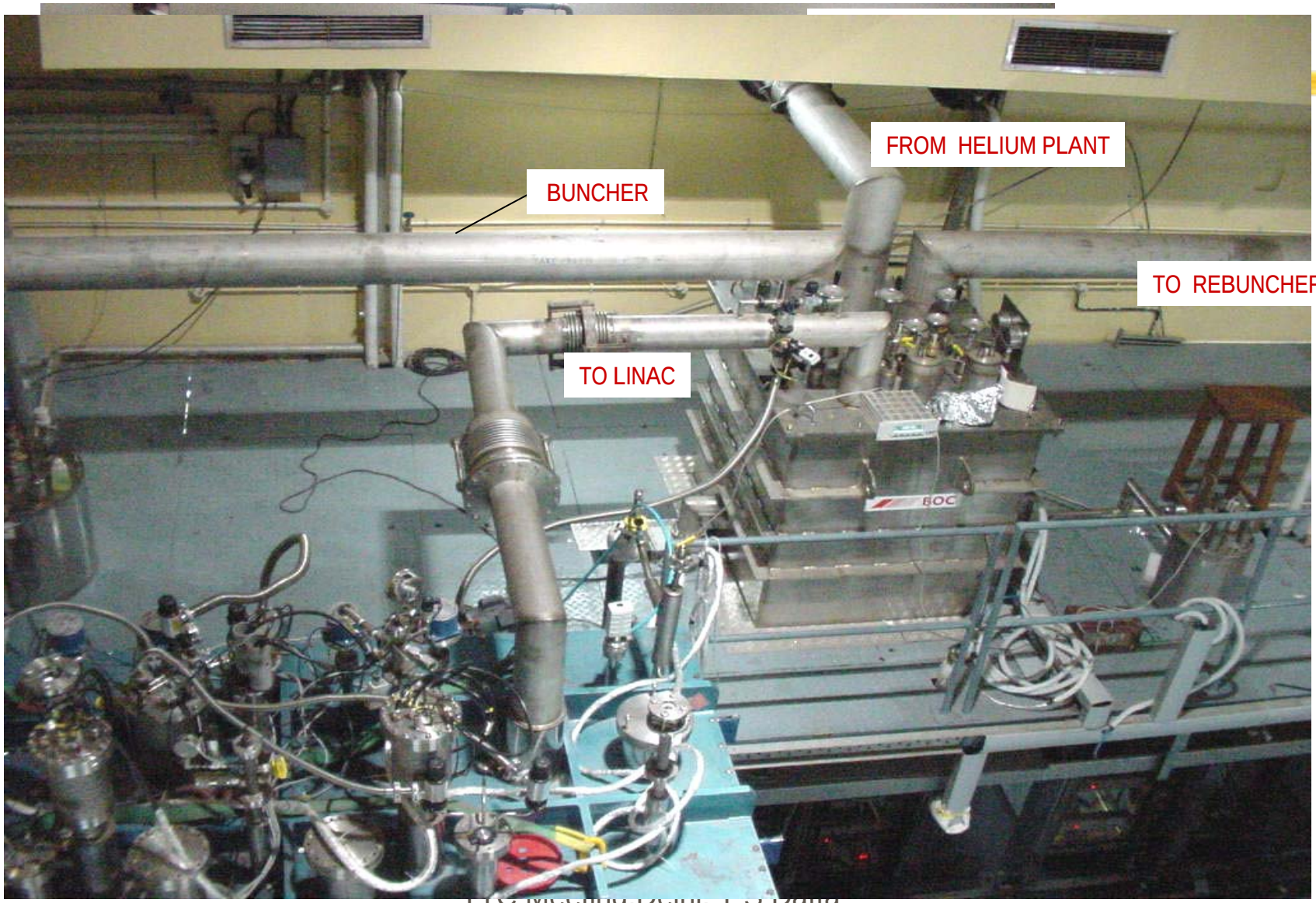
WITH LN2 SHIELD

WITH MLI & VACUUM JACKET

VALVE BOX AFTER ALL WELDING, THEMAL SHOCKING, AND LEAK TESTING

SEGMENT OF CRYO LINES

# LIQUID HELIUM DISTRIBUTION LINE
## ( Operational Since 2002)



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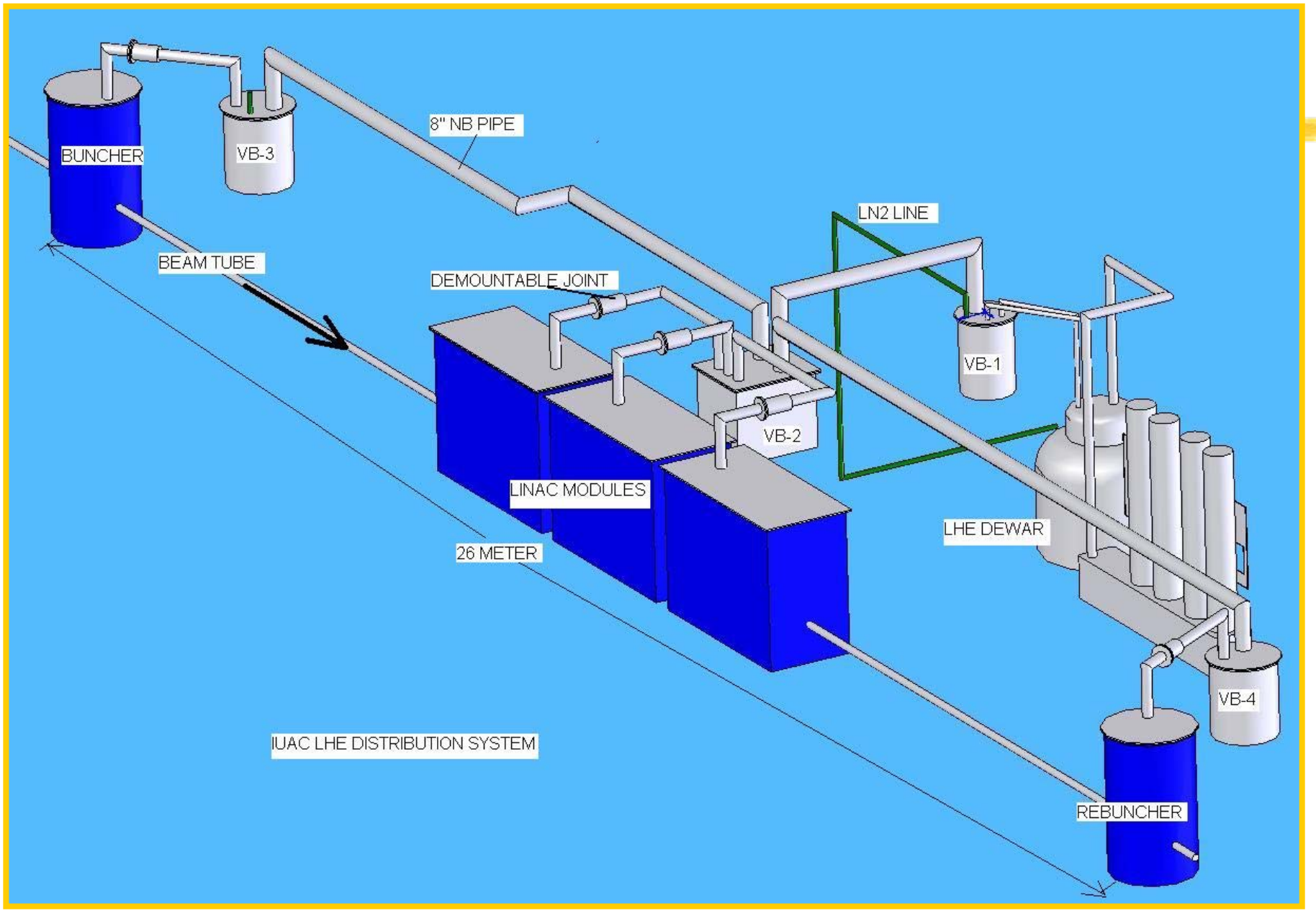


# CRYOMODULES TYPES

## A. BUNCHER & REBUNCHER : Cylindrical Shape , one/ two cavities only

**This was our first beam line Cryostat, had a tough time to locate cold leak: Delayed**

**IUAC & INDUSTRY were exposed with respective weak link**

**Corrected for the Next Main**

B. LINAC Module

**Smooth Ride : Confident for 2nd/ 3rd module**


**BUNCHER WITH VALVE BOX**

# CRITICAL SPECIFICATION FOR SINGLE LINAC CRYOMODULE

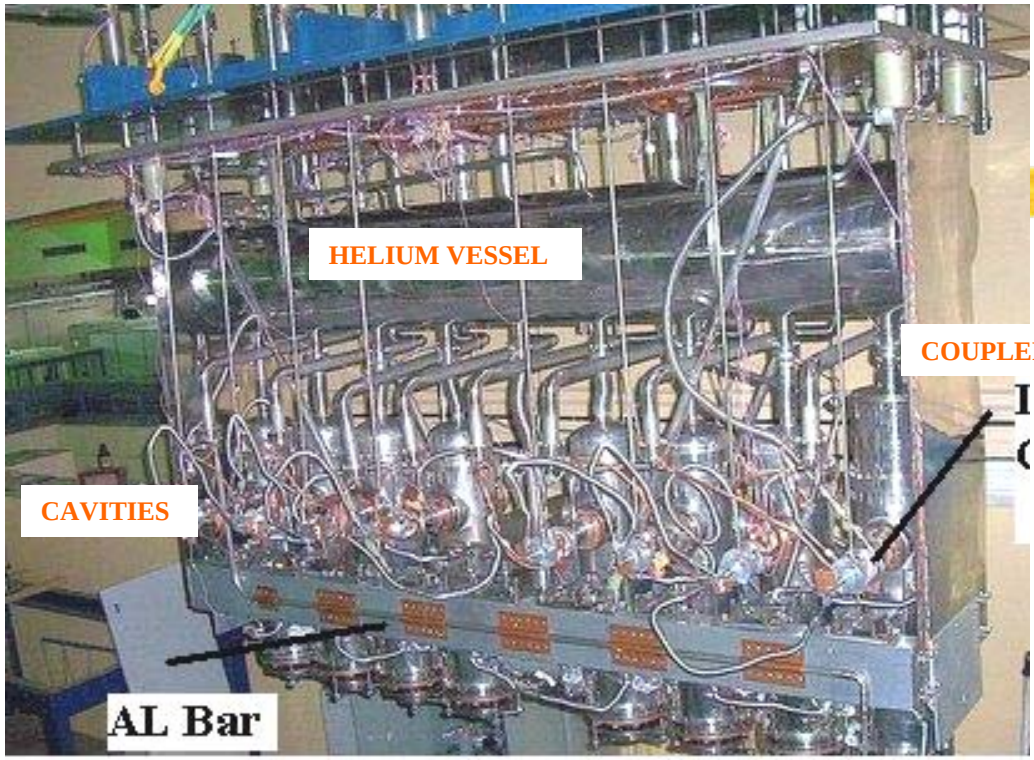
- **COLD MASS at 4.2 K : 600 Kg ( with 8 Cavities)**
- **Dimension : 2900 x 1300x 1900 mm**
- **Common Beam line and Cryostat Vacuum ( 10-8 torr)**
- **NO MLI ( Clean environment) : Thermal Copper Shield**
- **Critical Alignment Mechanism**
- **Total load : 80 W ( 30 W) LHe Flow 115 litres / Hr**
- **Demountable Joint Between Cryostat and distribution line**

**DESIGN/ Development/Testing/ Commissioning : IUAC,**

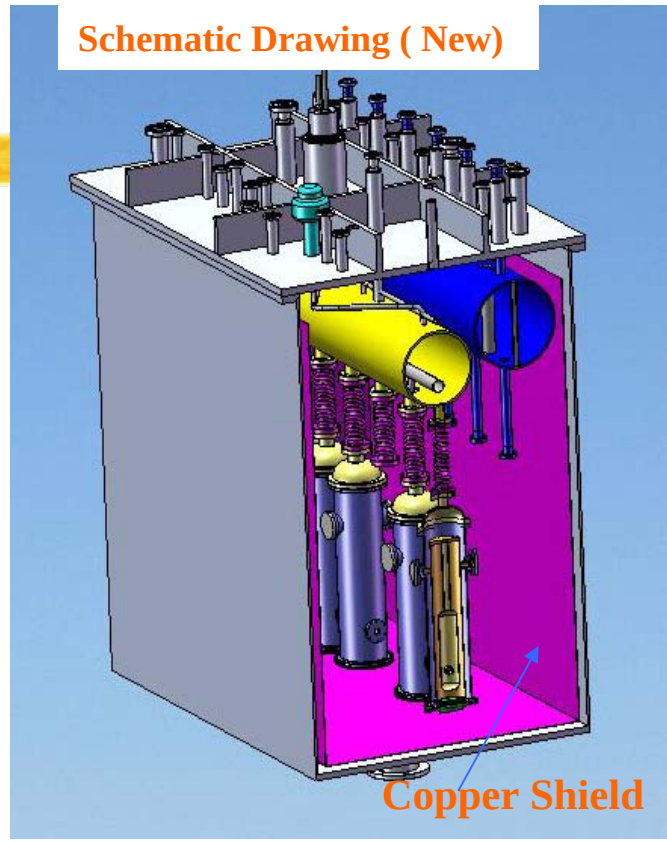
**Fabrication : DON BOSCO**

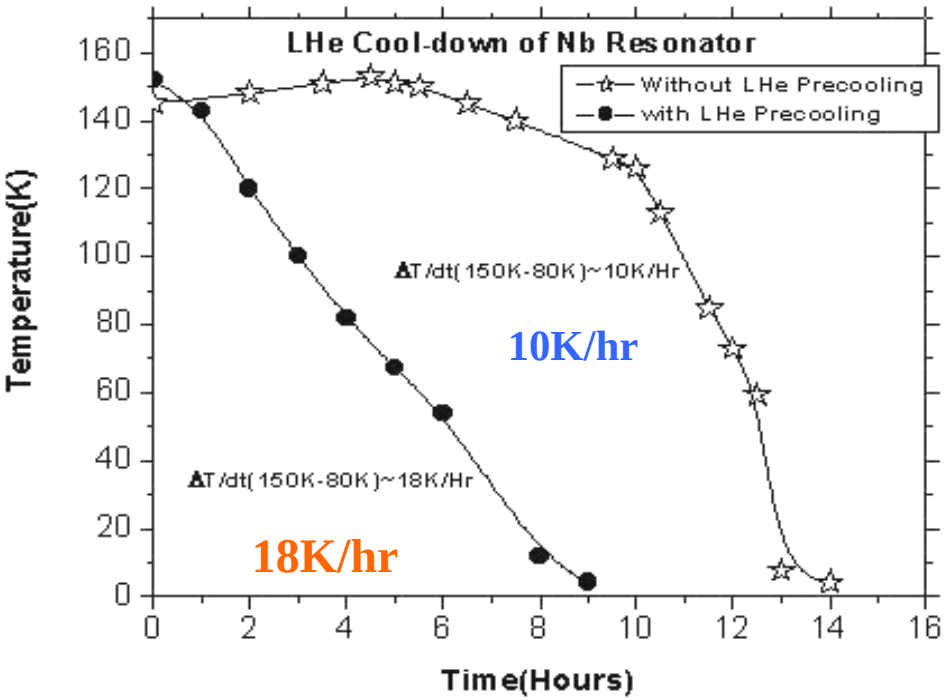
First one Completed in 2002, 2nd & 3rd are under fabrication

# LINAC CRYOMODULE COMPONENTS




Cavities with Acessories inside cryomodule



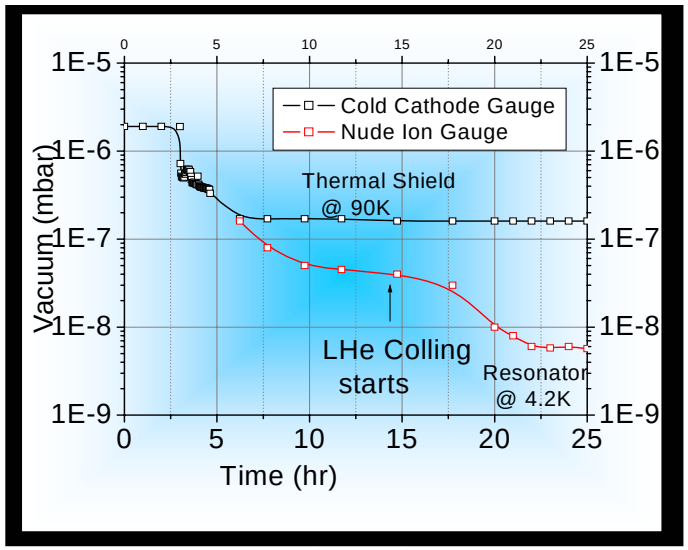




## Shortfall:

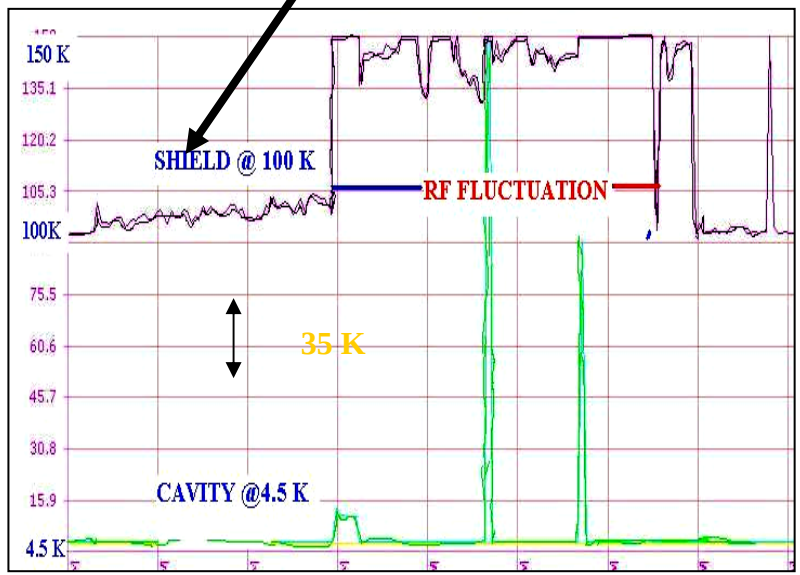
1. Slower Cool Down rate
2. Higher Static load, 3. Vacuum ?

Indirect :

4. Lower Eacc
5. Higher Multipactoring Time : 60 Hrs ( 16 )
6. Temperature Reading Fluctuation with RF




Vacuum Profile of LINAC



# Improvement ( Modification ) on Current Cryomodules

**Faster Cool Down rate > 20 K/hr**

**Liquid Helium Dropping up to the bottom of cavity through manifold in the Helium Vessel**

**Alignment of whole assembly at Vacuum**

## Analysis of Total Static Load at 4.2 K in Linac Cryo Module

| Component | Design Load | Measured Lo |
|---|---|---|
| 1. Conduction | 4.99 | < 5W ( Anchoring |
| 2. Radiation | 2.67 W | 5.6 ( Av Sh. T 105 K |
| 3. Al bar/SS sheet | 2W | 12 W |
| 4. Drive Coupler | ---- | 5 W |
| 5 Slow tuner/ Temp Sensor leads | 2 W | 2 W |
| Total | 11.66 W | 29.5 W |

**Optimized Static load for Each module : 15 W ( 30 W Present )**

**1. Effective Shield Temperature < 85K : 100 K**

**2. Static load from Support Structure : Al bar replaced with I channel ( Low mass and specific heat), Effective pre-cooling**

**5. Shorter Length of RF Cable**

# ASSOCIATED INDIAN INDUSTRY

- M/S DON BOSCO Technical Institute, New Delhi
  - **Cryomodules, Cavity Fabrication**
- M/S BOC India Ltd , Kolkata
  - **: Cryo Distribution line**
- M/S Vacuum Technique, Bangalore : Cryostat
- M/S INOX India Ltd. : LN2 line & Storage Vessel
  : Potential Candidate on He line
- M/S Fillunger, Pune : Can Deliver

# Cost and Schedule of Sub Project

- **Cost of LINAC MODULE ( 1999)** Fabrication : 10.00 lakhs, Material : 8 Lakhs, Total : **20.00 lakhs**
- **Cost of a Complete Linac Module ( 2008) : 50 lakhs**
- **$ 1,00,000**

**Both the Systems are in use for last 7 years and performance is satisfactory**

## *DISTRIBUTION LINE*

**50 meters LHe line with four valve boxes**

**Cost in 2000 : 20 lakhs** **(Ex Valves, MLI, G-10 Spacer & Q/A)**

**Expected Cost of Similar He line with Valve Boxes may be RS. 1.00 crore ~ $ 2,00,000**

# CONCLUSION

**IUAC with Limited Man power was able to Deliver the Specialized Products in Time from the Scratch**

With the guidance from Nodal agency and International Experts, quality on developed product in India can be improved/ Cost can be reduced .

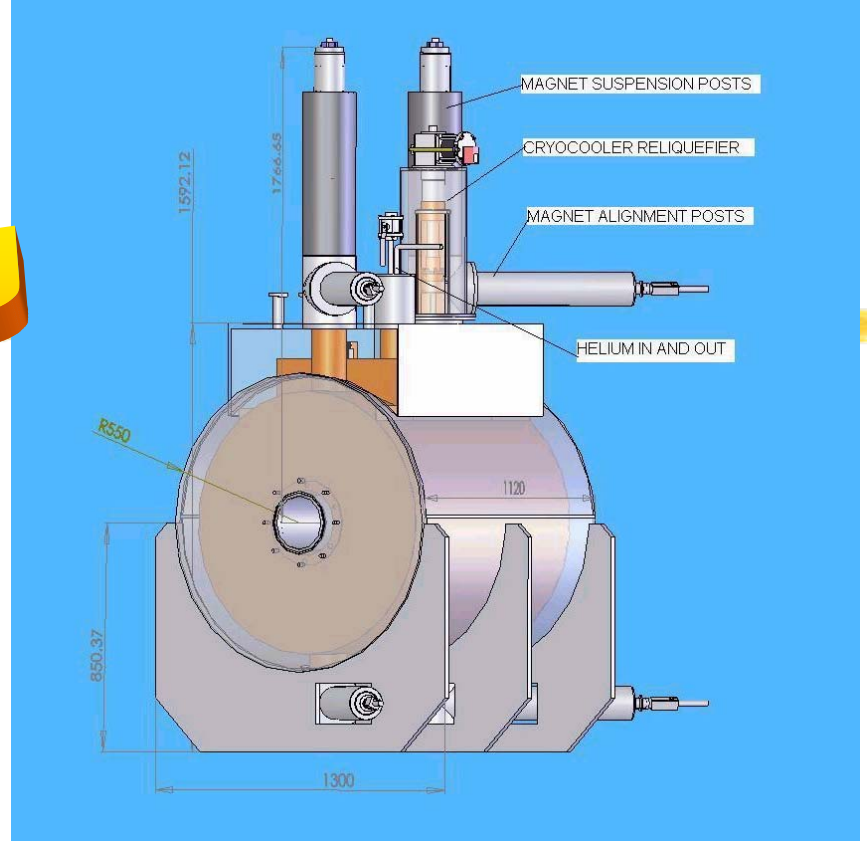
**Technically IUAC is capable to take up any assignment on Cryomodules/ Cryo Distribution Line Subject to**

**Requirement by Nodal Agency/ Any Labs**

**Supported By IUAC Higher Authority**

# THANK YOU


CRYO CONTROL ROOM




**SC Quadrupole Magnet Cryostat**
**Under development at IUAC**

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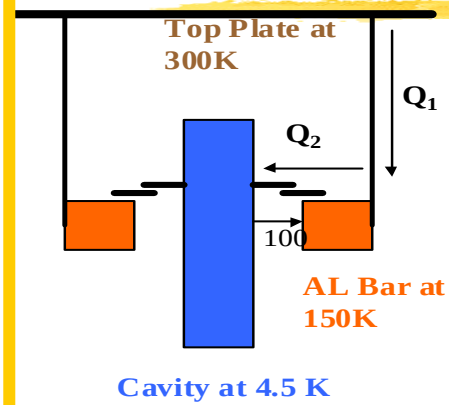
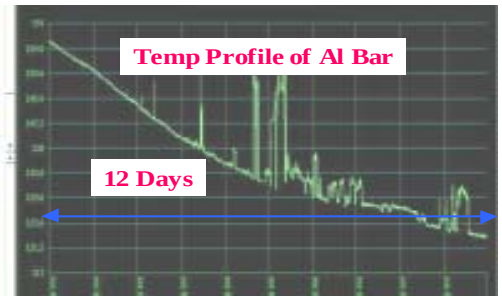
| **Total** | **11.66 W** | **29.5 W** |

## Contribution by Aluminum Support Structure

With 8 Cavities , dT/ dt = 8- 9 K in 25 hr, $m_{Al}$= 160 Kg, **Calculated Q2 = 12 W**




**Heat Balance to the aluminum Bar**

$Q_1 - Q_2 = M_{AL}\, c_p\, dT/dt$, Q1 ~ 0

The Contact resistance plays key role