Latest Progress from FREIA

Rocío Santiago Kern

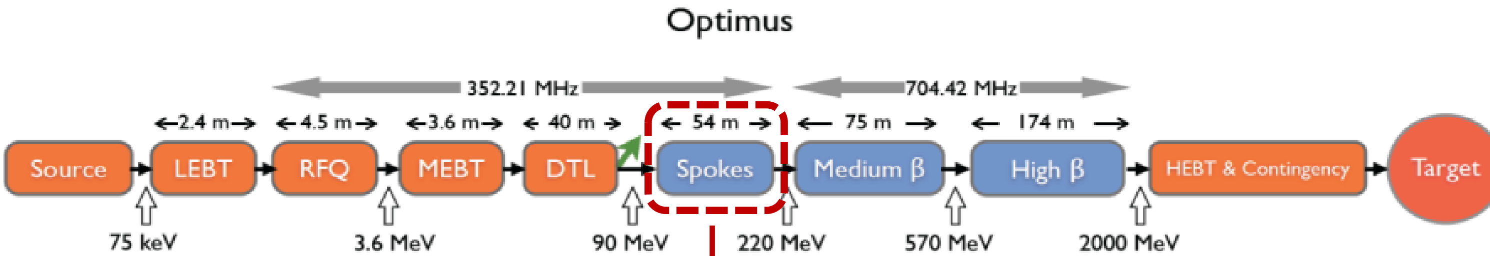
FREIA Laboratory, Uppsala University

15th of May 2014

Contents

- Work for the ESS Accelerator
- Spoke Cavity Testing
- Bunker
- RF Power Station
- Helium Liquefier
- Horizontal Cryostat
- Vacuum System

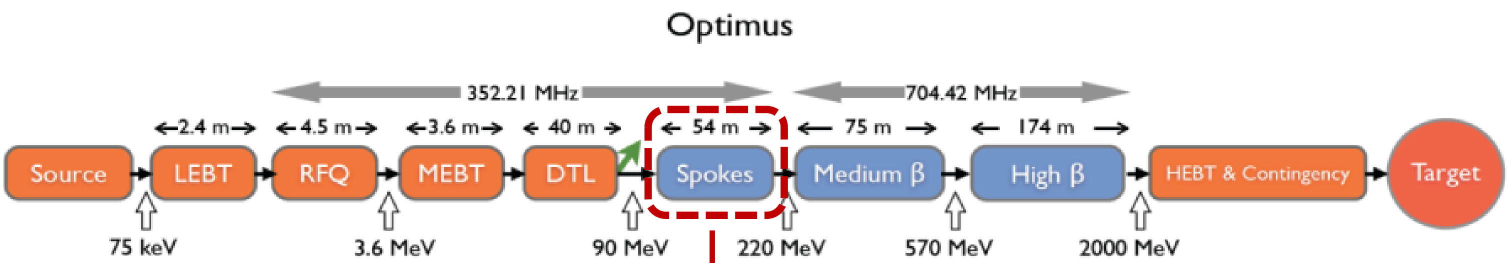
Work for the ESS Accelerator (1/2)



Frequency [MHz]	Total # of cavities	Total # of cryomodules
352.21	26	13

1 spoke prototype

Work for the ESS Accelerator (1/2)



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1 spoke prototype

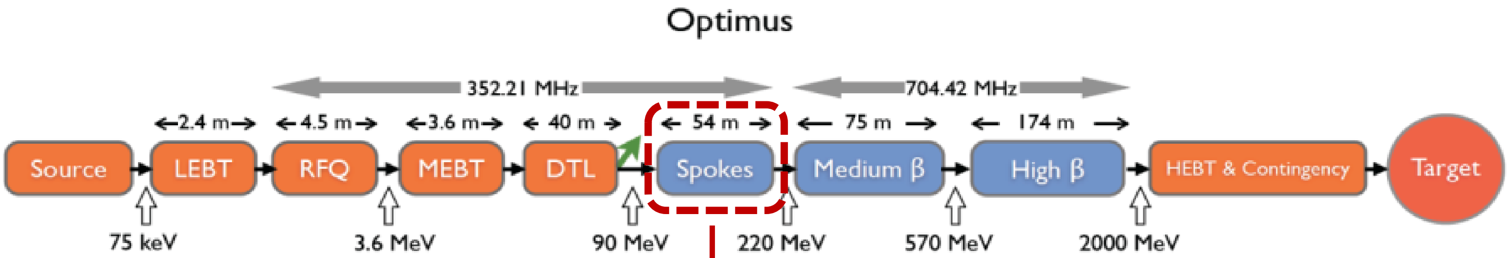
High-power Spoke Linac Testing

UU-ESS-IPNO-CERN Collaboration

- High power soak testing of power source, controls, amplitude and phase stability with accelerating cavity
- Test cavity tuning system, dynamic load, electron emission and multipacting
- Test of mechanical susceptibility of cavity

Work for the ESS Accelerator (1/2)

EUROPEAN SPALLATION SOURCE



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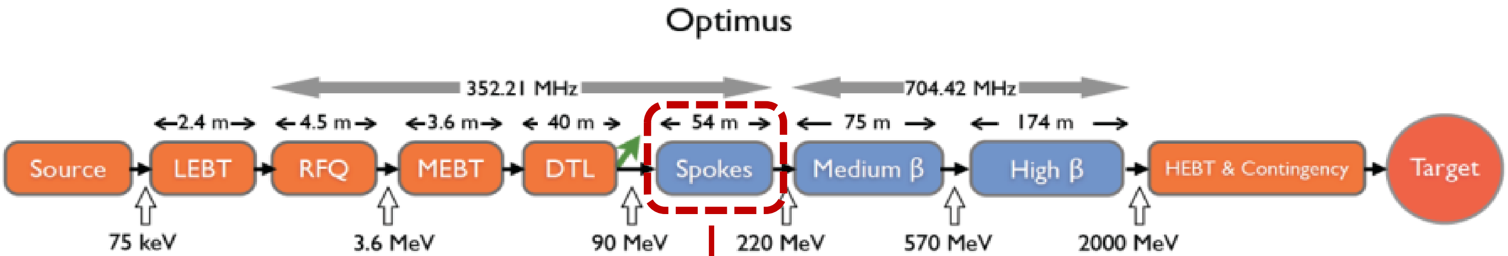
RF Source Development

UU-Industry Collaboration

- vacuum tube amplifier (Thales, Electrosys)
- solid-state amplifier (Siemens)
- SSA module & combiner optimization (NXP, ESRF, CERN)

Work for the ESS Accelerator (2/2)



Frequency [MHz]	Total # of cavities	Total # of cryomodules
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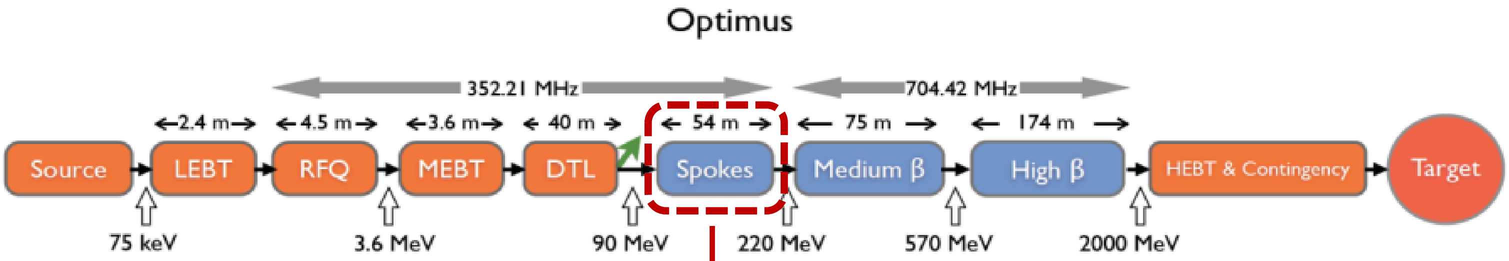
Same as with spoke cavity ← **1 prototype cryomodule**

Work for the ESS Accelerator (2/2)



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Same as with spoke cavity ← **1 prototype cryomodule**

Future

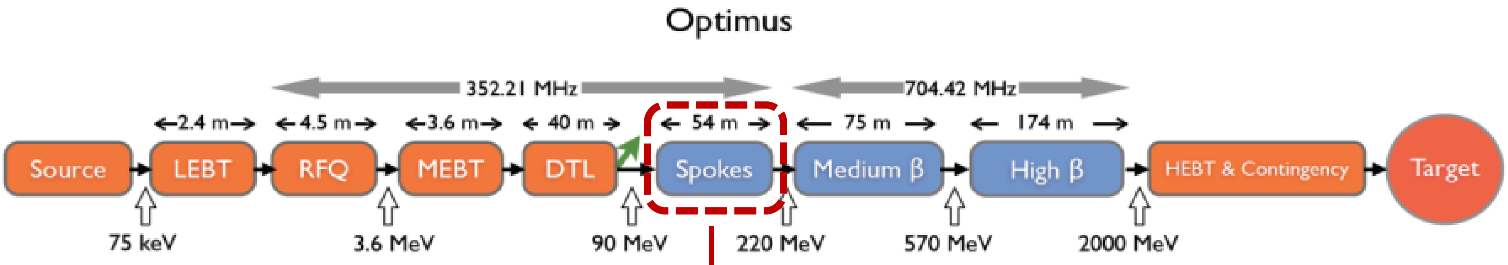
Spoke Linac Cryomodules (13#)

UU-ESS-IPNO Collaboration

- Continue prototype testing (2016)
- Acceptance testing of spoke linac cryostat with 2 cavities each
- Requires high throughput and planning (7-8 weeks per cryomodule)

?

Work for the ESS Accelerator (2/2)



Frequency [MHz]	Total # of cavities	Total # of cryomodules
352.21	26	13

Same as with spoke cavity ← **1 prototype cryomodule**

Future

Spoke Linac Cryomodules (13#)

UU-ESS-IPNO Collaboration

- Continue prototype testing (2016)
- Acceptance testing of spoke linac cryostat with 2 cavities each
- Requires high throughput and planning (6 weeks per cryomodule)

Valve Boxes (13#)

UU-ESS-Industry Collaboration

- Development and acceptance tests of the spoke crymodules valve boxes

?

Spoke Cavity Testing

- To test the spoke cavity, three main subsystems are needed

Spoke Cavity
(superconducting)

Drawing taken from P. Duthil's presentation at the Vacuum Standardization Meeting, Lund Feb 2014

Spoke Cavity Testing

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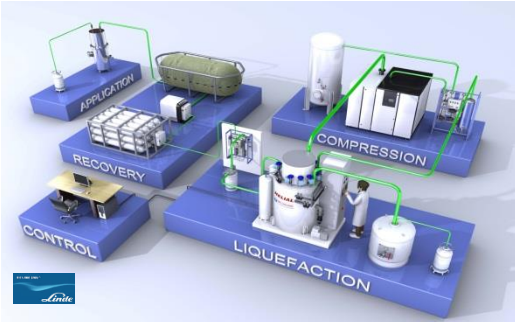

Cryogens

Courtesy of P. Duthil

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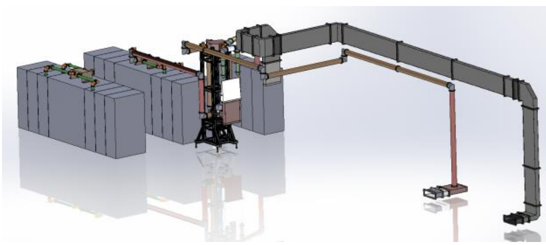
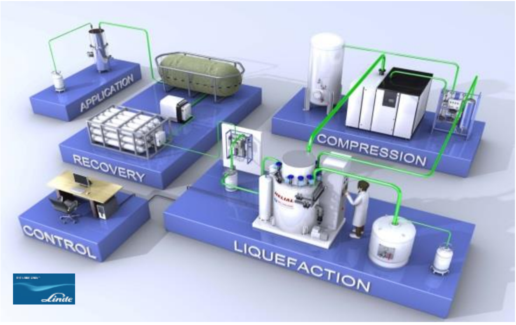


RF power



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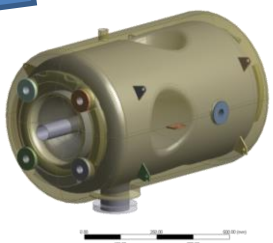

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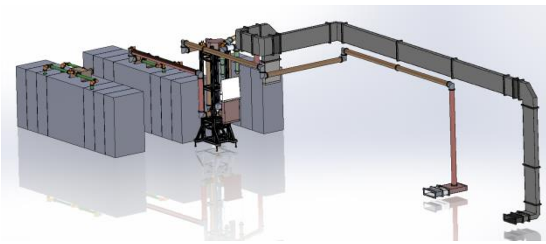

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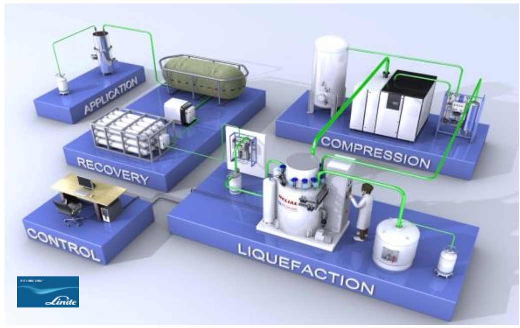

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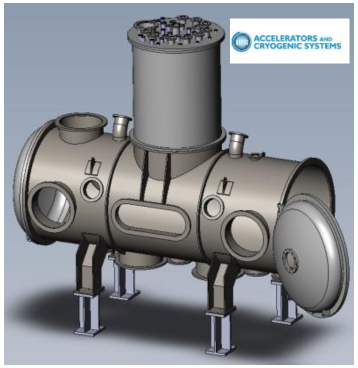

Horizontal Cryostat

Spoke Cavity Testing

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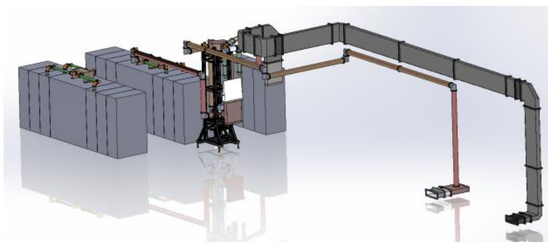

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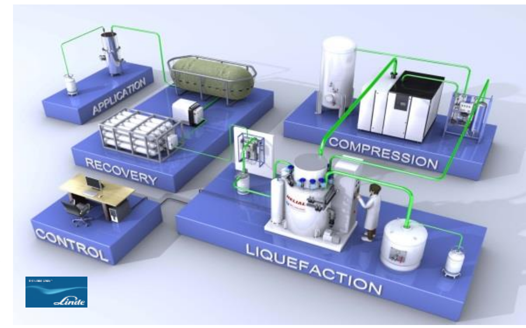

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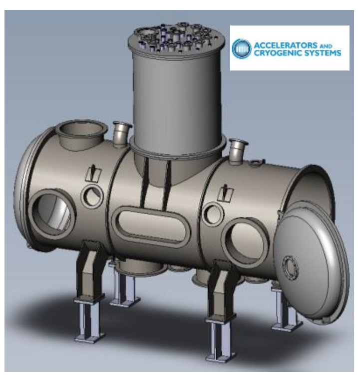
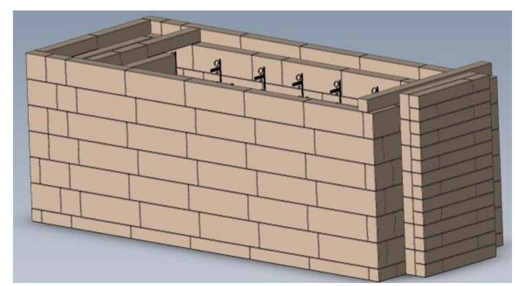


Horizontal Cryostat

To avoid radiation in public areas:



Bunker

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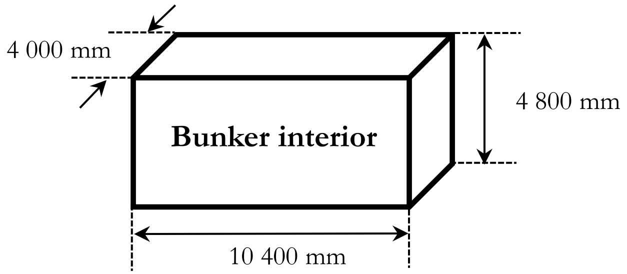
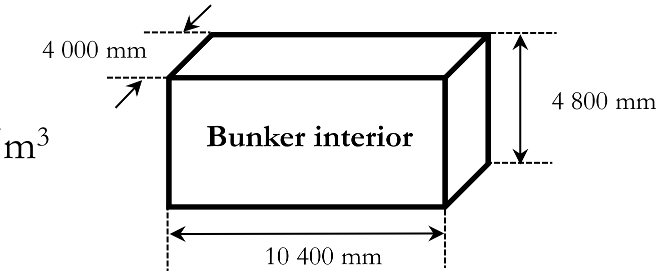


Bunker

Conrete blocks:

- Magnetite
- Density of 3.9 t/m^3
- 517 blocks
- 16 different sizes



Bunker

Chicane:

- Waveguides
- Return GHe lines

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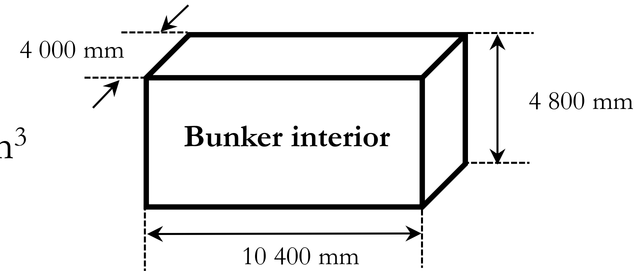

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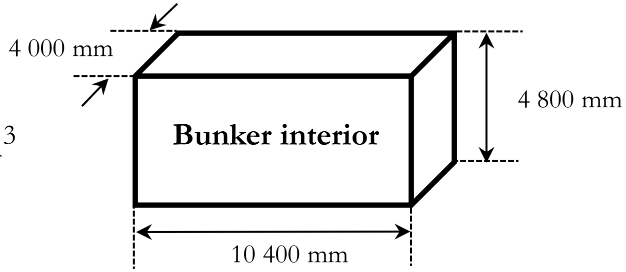


Chicane:

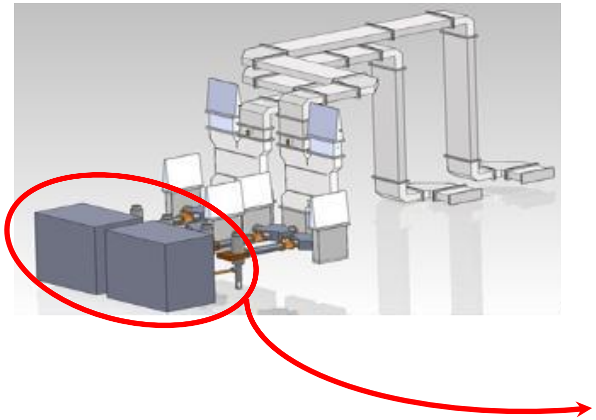
- Waveguides
- Return GHe lines

RF Power Station

2 independent systems to power the cavity

ESS pre-series #1

- 352 MHz, 400 kW pulsed
  - Tetrode technology
  - FREIA 2pc
  - ESS linac 26pc
- FREIA design based on TH595 (most competitive solution)



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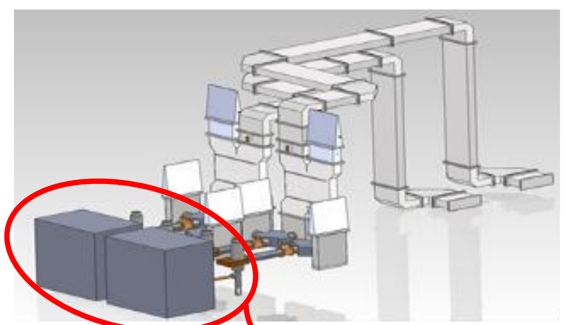
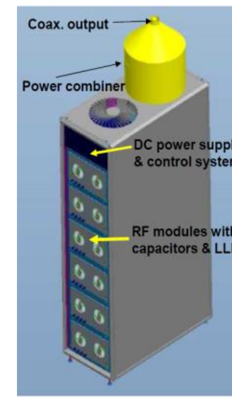


Solid-state R&D station

- 352 MHz, 400 kW pulsed
  - FREIA 1pc
- Commercial design
  - 1 kW transistors
  - 8 kW modules
  - coaxial combiner



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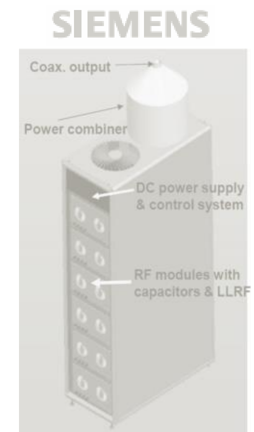

By mid July 2014

By mid November 2014

Helium Liquefier (1/2)

- Manufactured by Linde Kryotechnik AG
- **Over 140 l/h** at 4.5K
- 2000 l LHe dewar

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- 100 m^3 gasbag + recovery system

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- Manufactured by Linde Kryotechnik AG
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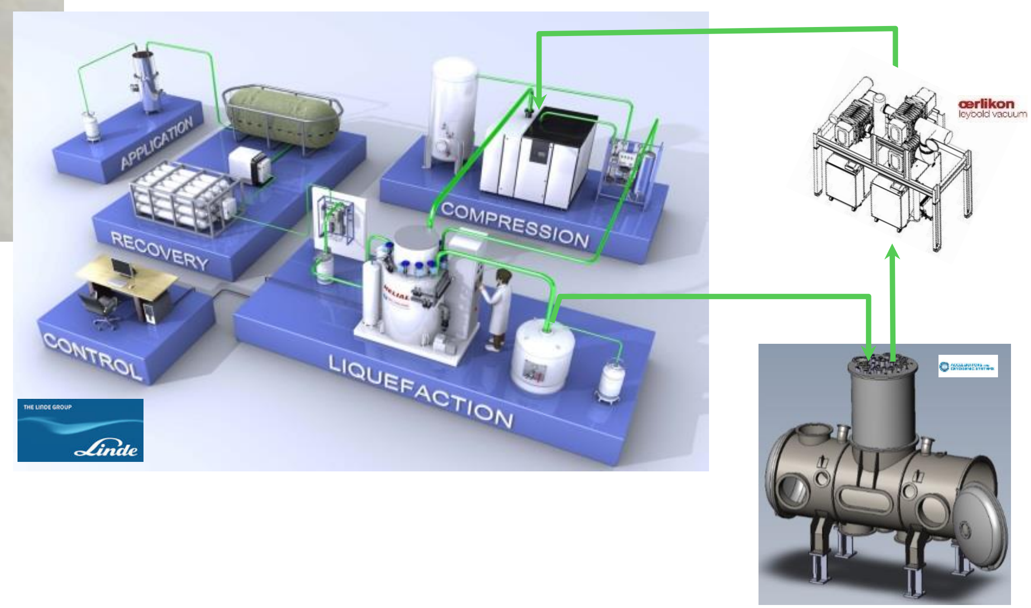
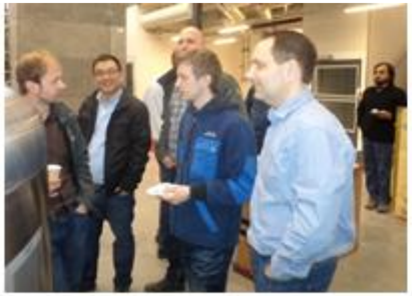
- 2000 l LHe dewar
- 100 m^3 gasbag + recovery system
- HNOSS connected in **closed loop**



Helium Liquefier (2/2)



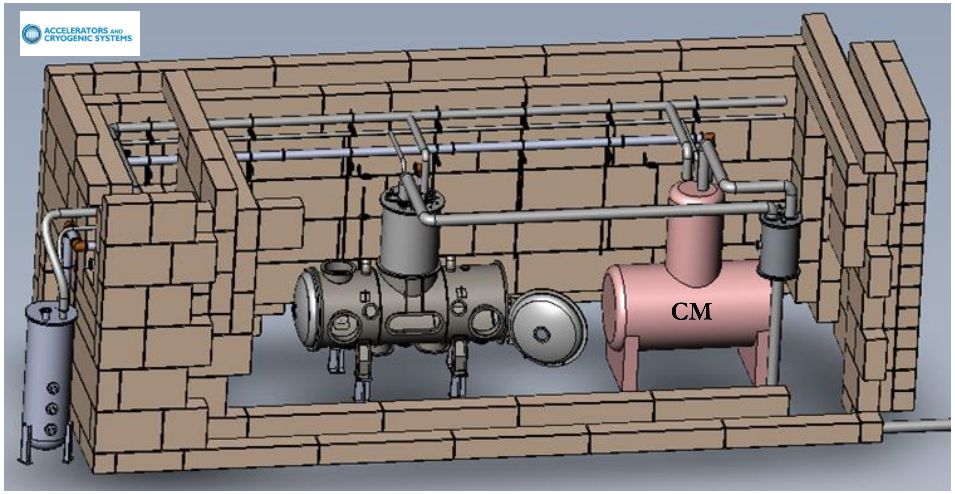
Succesful acceptance tests on 19th March 2014

↓

Over 150 l/h

- **with LN2 pre-cooling,**
- **at LHe dewar rising level**

Horizontal Cryostat (1/2)



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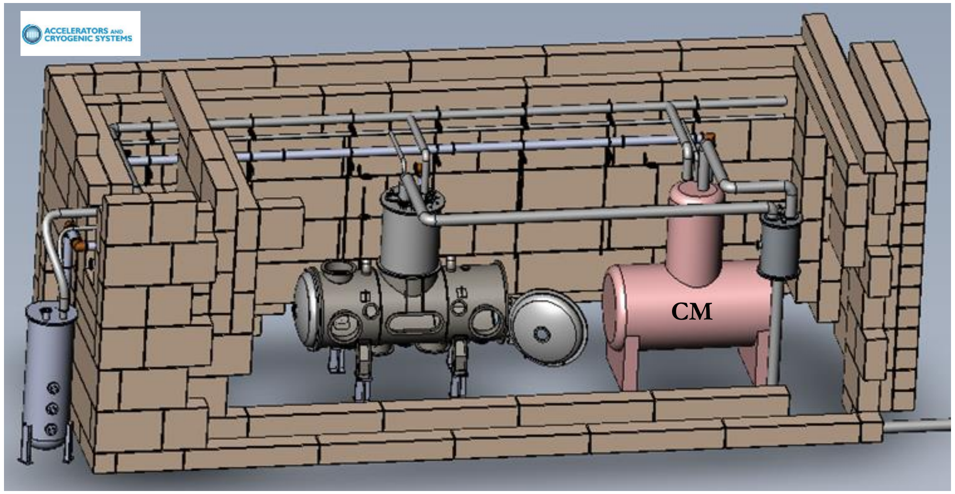

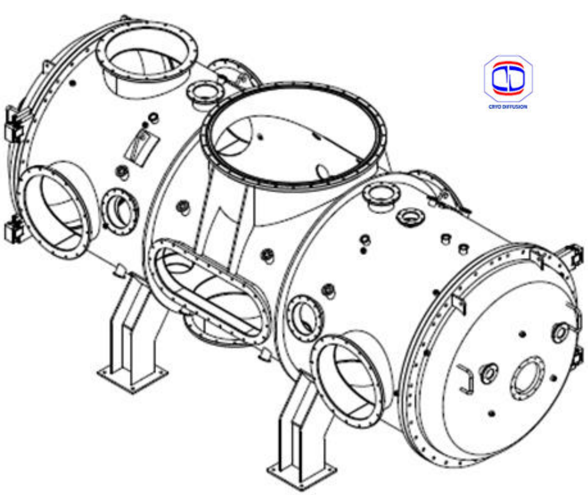

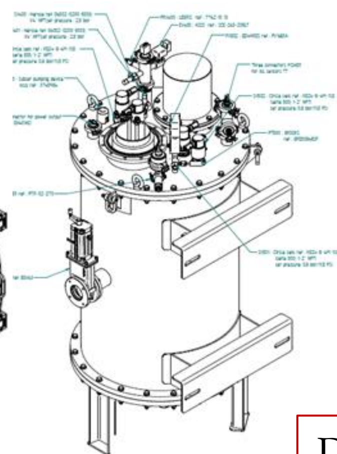

Designed by *Accelerator and Cryogenic Systems*, France
Manufactured by *Cryo Diffusion*, France

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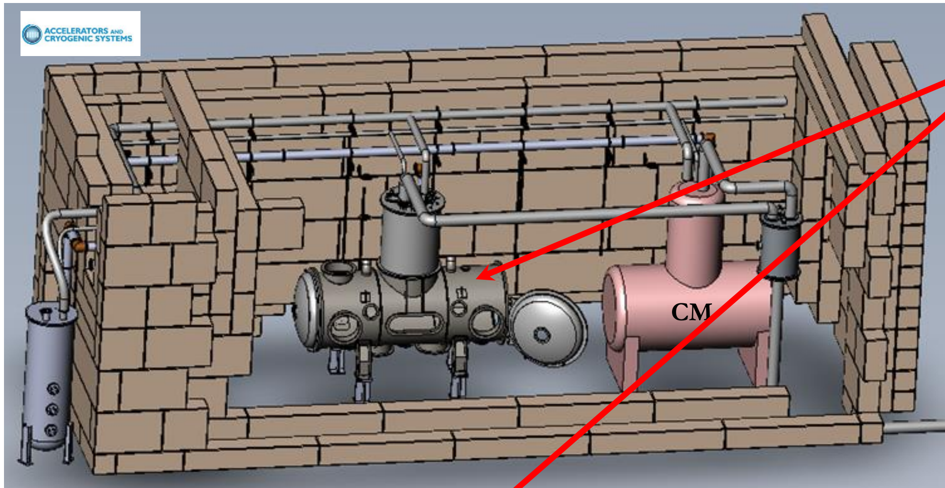
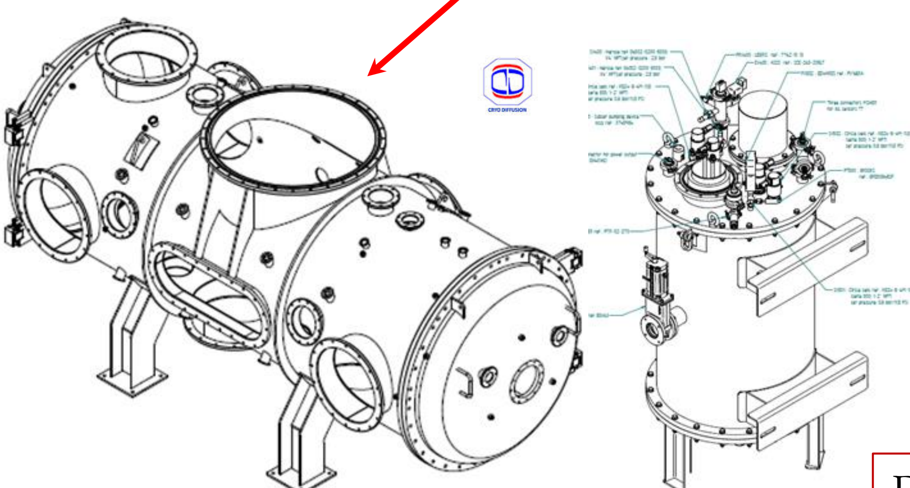


- **HNOSS**: *Horizontal Nugget for Operation of Superconducting Systems*
  Houses the cavities
  - Main Vacuum Vessel
  - Valvebox



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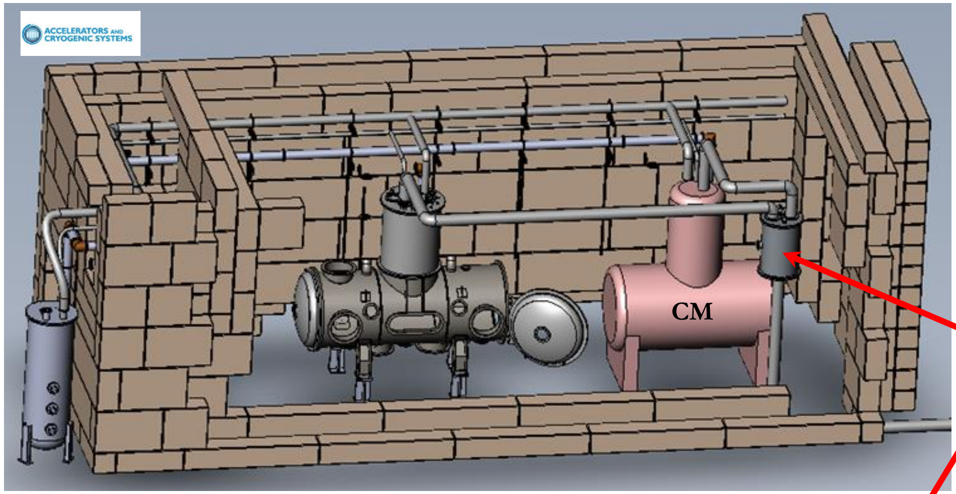

- **HNOSS**: *Horizontal Nugget for Operation of Superconducting Systems*
  Houses the cavities
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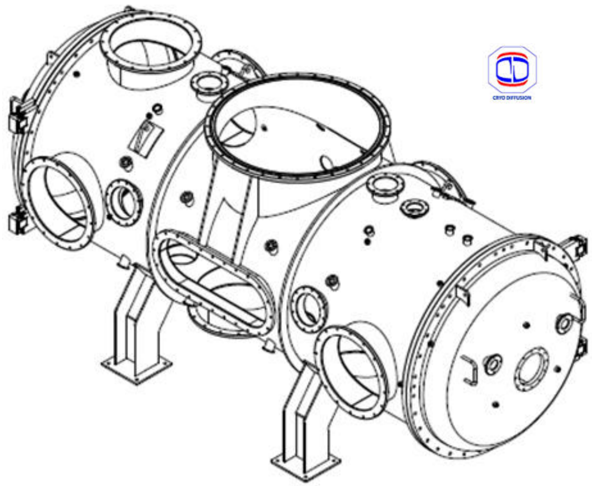
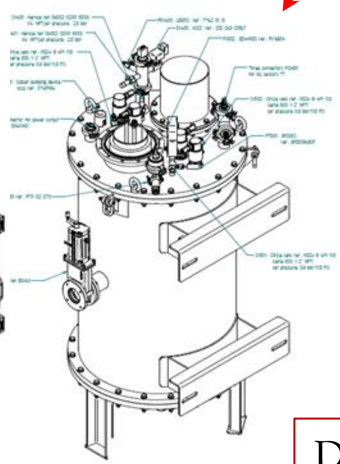
- Interconnection box (**ICB**):
  Distributes cryogens to HNOSS and CM





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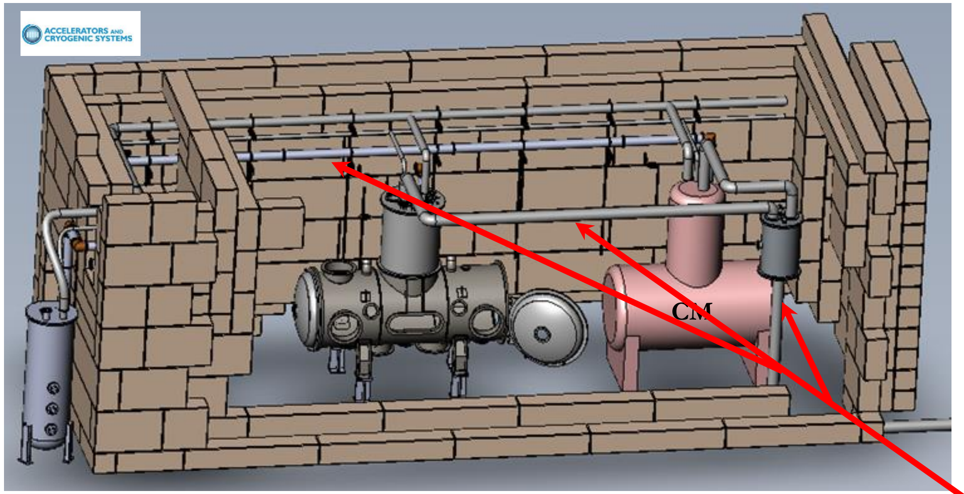

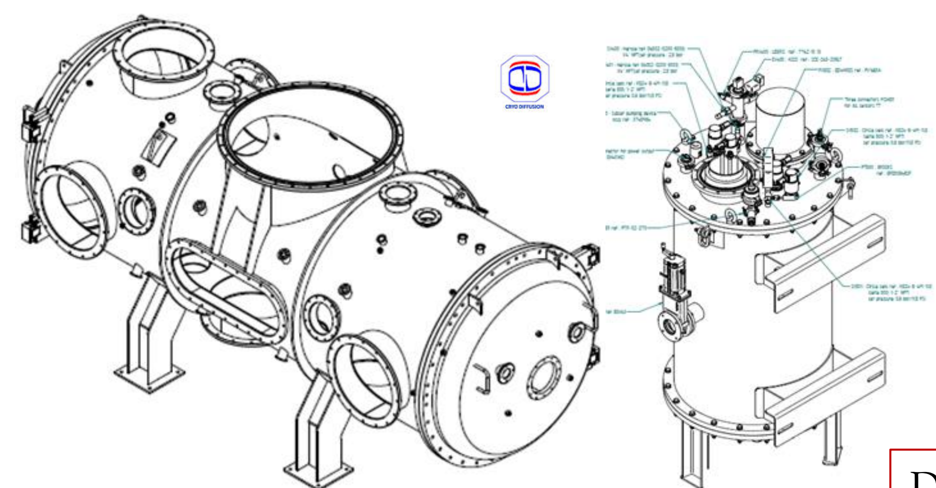

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- Cryogenic **transfer lines** (inlet and outlet)
  LN_2 and LHe

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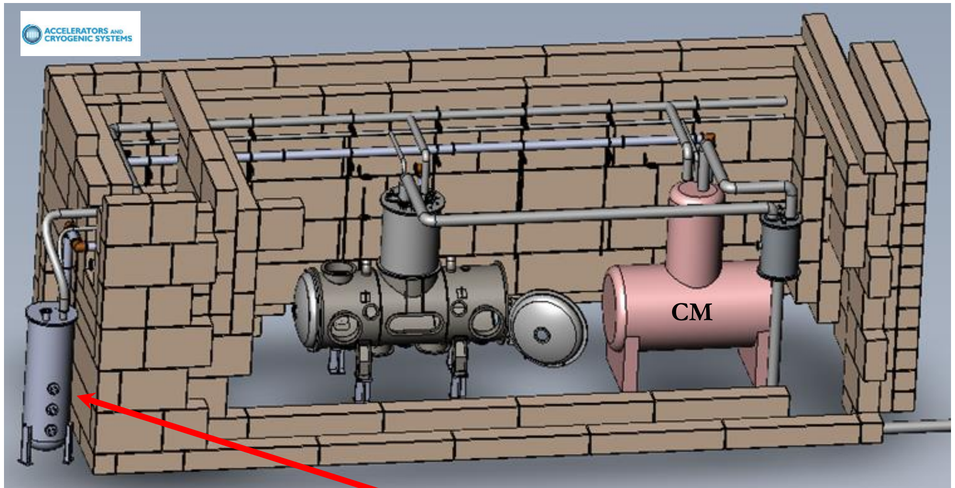
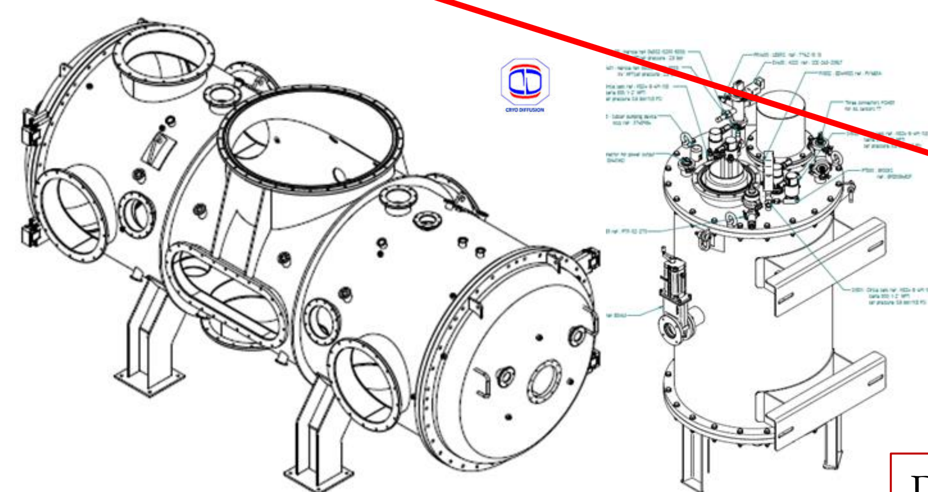
Horizontal Cryostat (1/2)





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  Houses the cavities
  - Main Vacuum Vessel
  - Valvebox
- Interconnection box (**ICB**):
  Distributes cryogens to HNOSS and CM
- Cryogenic **transfer lines**
  LN_2 and LHe
- **Gas heater** for return GHe
  From 5K-7K to 300K

Designed by *Accelerator and Cryogenic Systems*, France
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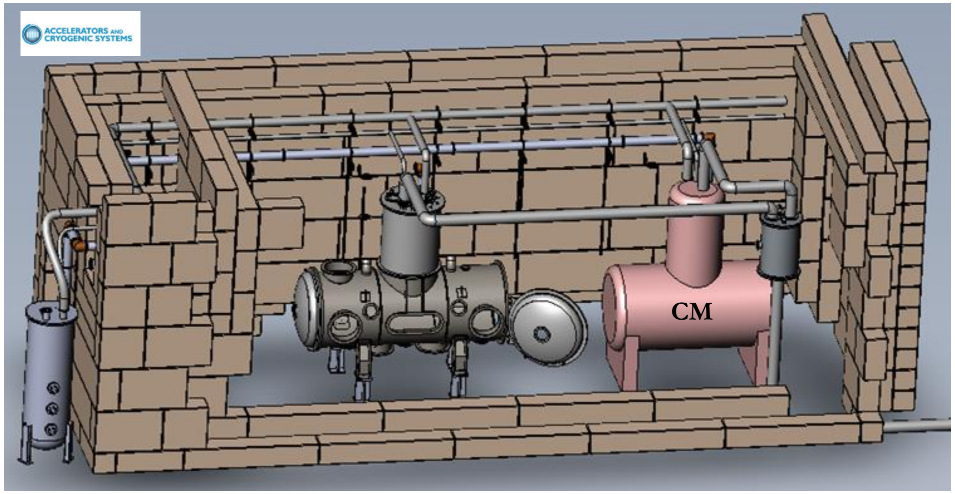
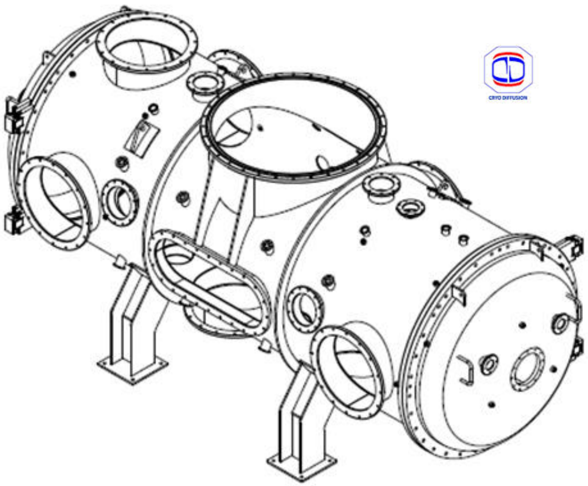
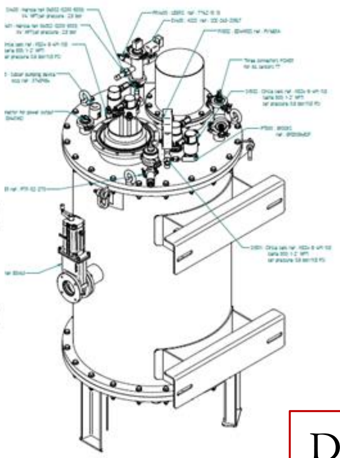
Horizontal Cryostat (1/2)







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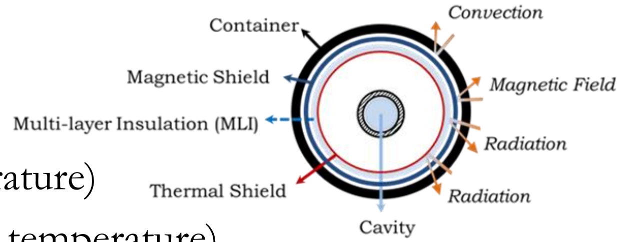
- Cryogenic **transfer lines**
  LN_2 and LHe
- **Gas heater** for return GHe
  From 5K-7K to 300K
- **Control system**

Designed by *Accelerator and Cryogenic Systems*, France
Manufactured by *Cryo Diffusion*, France

Horizontal Cryostat (2/2)

- **Shields**
  - Vacuum (room temperature)
  - Magnetic shield (room temperature)
  - Thermal shield (70K)



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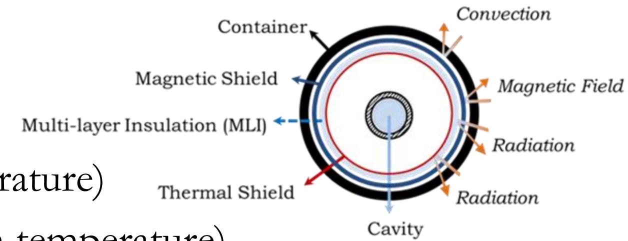
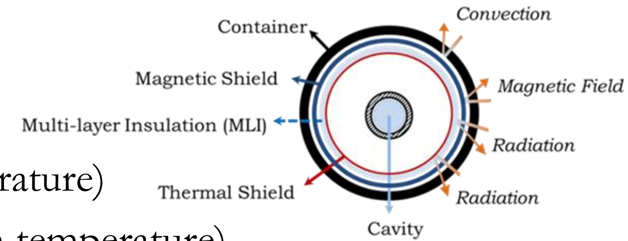


- **Shields**
  - Vacuum (room temperature)
  - Magnetic shield (room temperature)
  - Thermal shield (70K)
- **Distributes** cryogens
  - LN_2: thermal shield, table, Tesla power couplers
  - LHe: cavities

Horizontal Cryostat (2/2)



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- Supercritical Helium path for cooling of spoke power coupler

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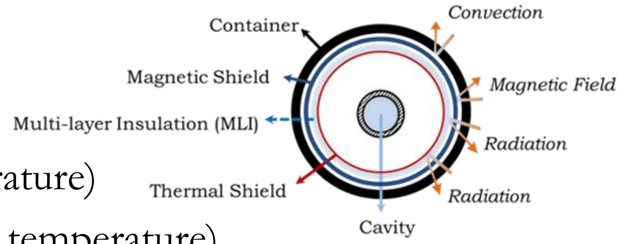
- Contains piping and valves to produce and store **4K** and **2K** LHe



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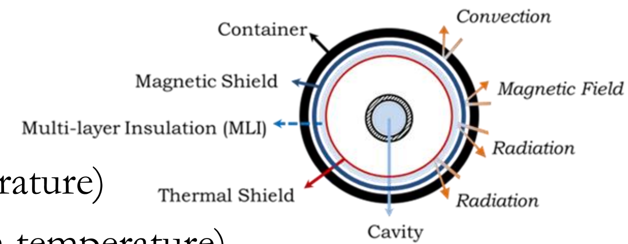

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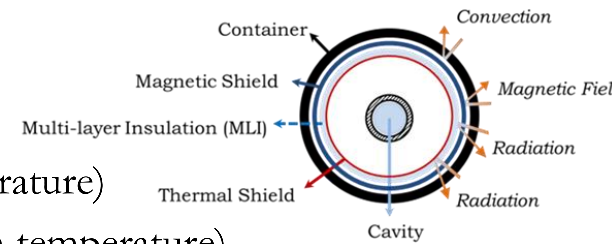
  - LHe: cavities
- Supercritical Helium path for cooling of spoke power coupler
- Contains piping and valves to produce and store **4K** and **2K** LHe
- HNOSS mechanical characteristics:
  - **Inner length 3240 mm**
  - **Inner diameter 1300 mm**
  - Beam axis at 1.6 m

Horizontal Cryostat (2/2)



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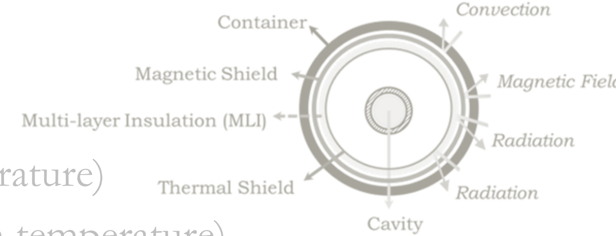
  - LHe: cavities
- Supercritical Helium path for cooling of spoke power coupler
- Contains piping and valves to produce and store **4K** and **2K** LHe
- HNOSS mechanical characteristics:
  - **Inner length 3240 mm**
  - **Inner diameter 1300 mm**
  - Beam axis at 1.6 m

+ Mock-up Cavity for acceptance tests

Horizontal Cryostat (2/2)



- **Shields**
  - Vacuum (room temperature)
  - Magnetic shield (room temperature)
  - Thermal shield (70K)
- **Distributes** cryogens
  - LN_2: thermal shield, table, Tesla power couplers
  - LHe: cavities
- Supercritical Helium path for cooling of spoke power coupler
- Contains piping and valves to produce and store **4K** and **2K** LHe
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Vacuum System (1/2)

Insulation Vacuum

High degassing rates (MLI)

⇩

Insulation Vacuum: 10^{-4}-10^{-5} mbar
(with cryopumping 10^{-6} mbar) → *Turbomolecular pump*

Vacuum System (1/2)

Insulation Vacuum

High degassing rates (MLI)

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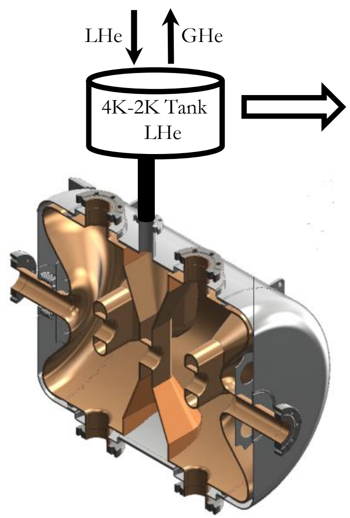
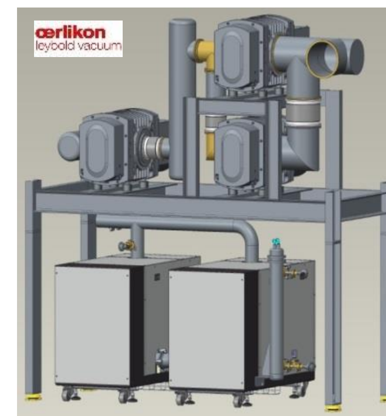


Temperature variation: 4K-2K

- Dry system
- 90 W at 1.8 K
- Mass flow capacities
  - 3.2 g/s at 10 mbar
  - 4 g/s at 15 mbar
  - 10 g/s at P ≥ 200 mbar



Vacuum System (1/2)

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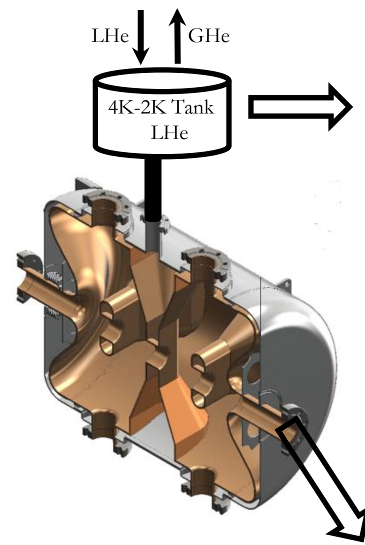

Temperature variation: 4K-2K

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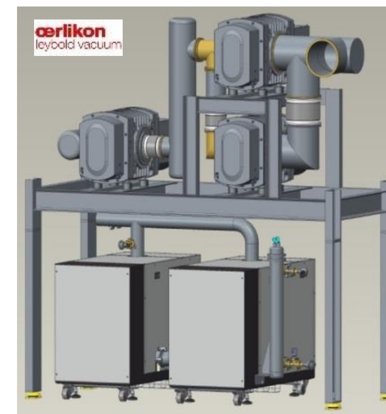


Beam Vacuum: 10^{-10}-10^{-11} mbar → *Ion/Getter pump*

Vacuum System (2/2)

Insulation Vacuum

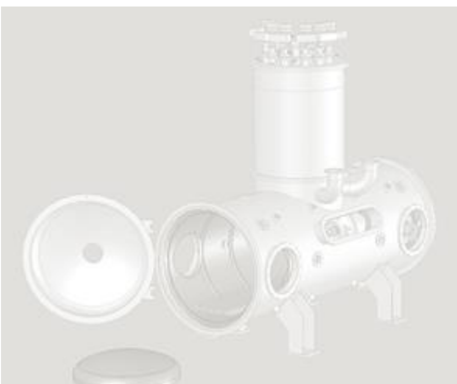
High degassing rates (MLI)

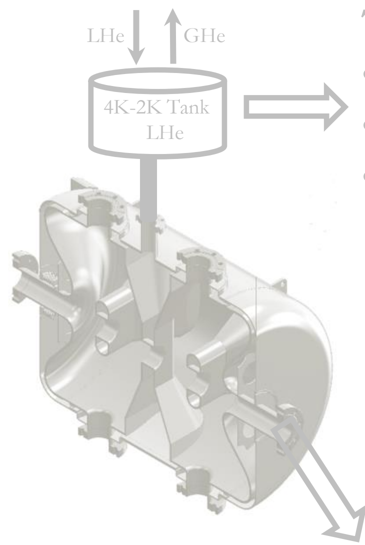
⇩

Insulation Vacuum: 10^{-4}-10^{-5} mbar
(with cryopumping 10^{-6} mbar)

Turbomolecular pump

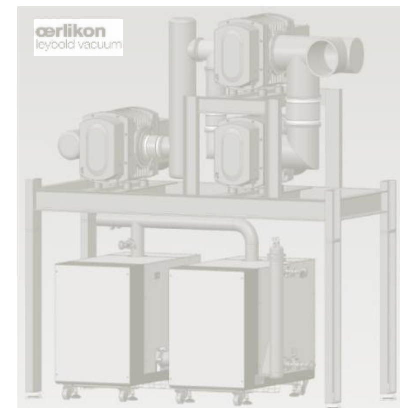
By begining of August 2014



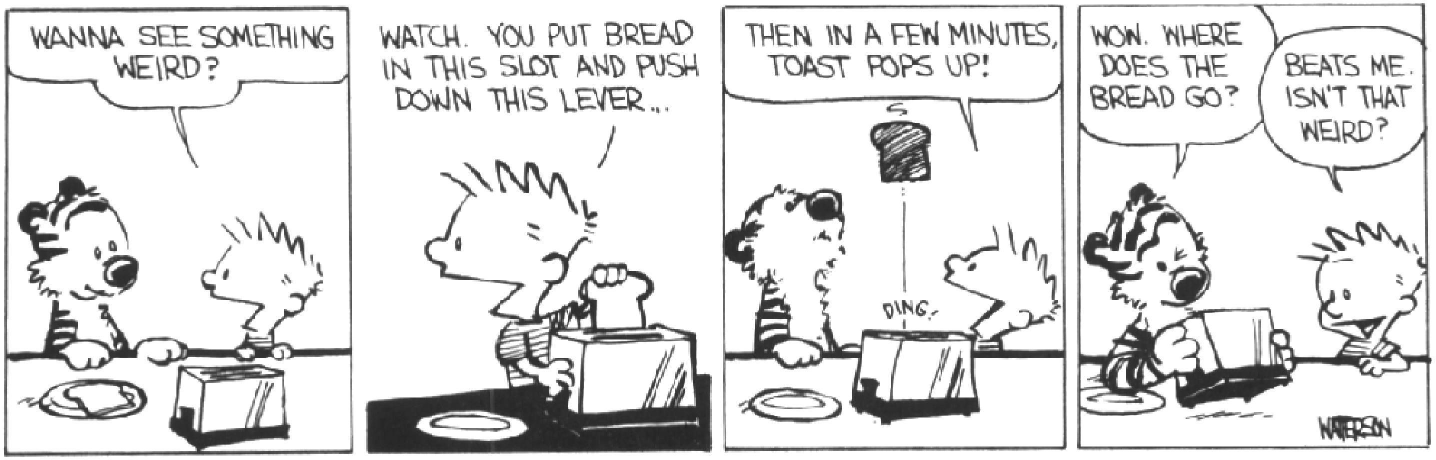


Temperature variation: 4K-2K

- **Dry system**
- 90 W at 1.8 K
- Mass flow capacities
  - 3.2 g/s at 10 mbar
  - 4 g/s at 15 mbar
  - 10 g/s at P ≥ 200 mbar



Beam Vacuum: 10^{-10}-10^{-11} mbar → *Ion/Getter pump*

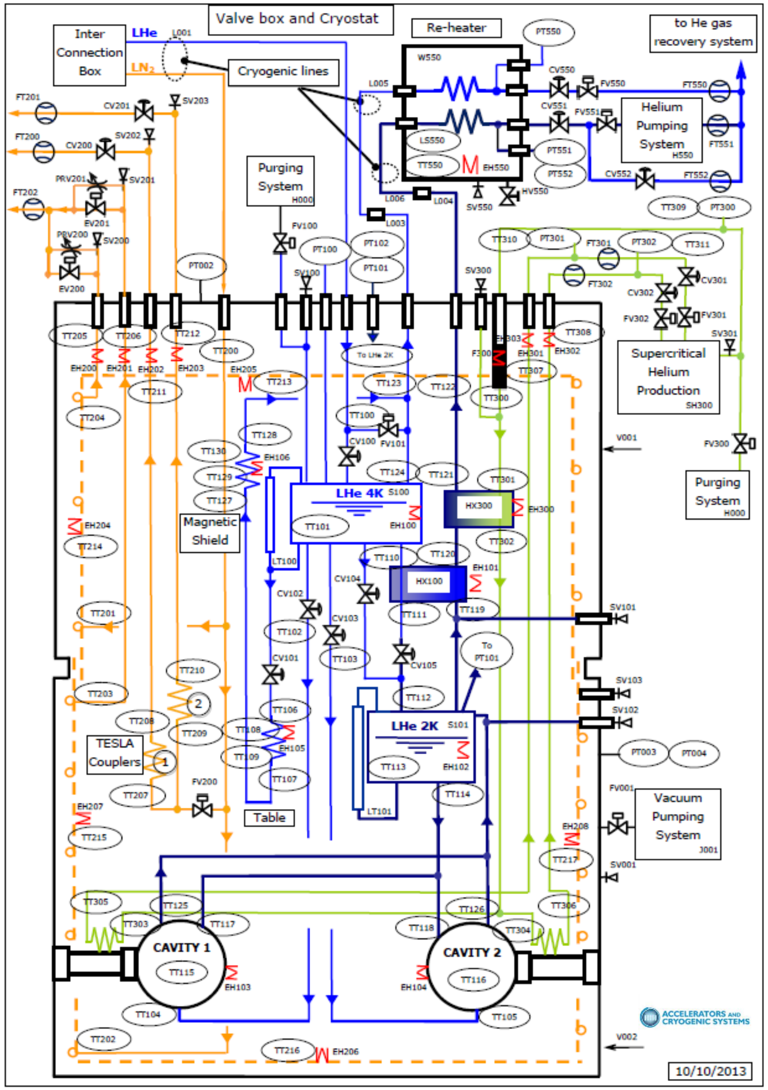


Thank you for your attention!

Doubts?

Questions?

Pleads?


Valve box and Cryostat
Inter Connection Box
LHe
LN₂
Cryogenic lines
Re-heater
to He gas recovery system
Helium Pumping System
Purging System
Supercritical Helium Production
Purging System
LHe 4K
Magnetic Shield
HX300
HX100
LHe 2K
TESLA Couplers
Table
Vacuum Pumping System
CAVITY 1
CAVITY 2
ACCELERATORS AND CRYOGENIC SYSTEMS
10/10/2013