PIP-II 650 MHz Cryomodules Transportation Plan

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on behalf of the 650 MHz team

TESLA Technology Collaboration Meeting

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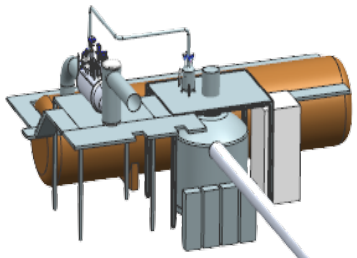
A Partnership of:
- US/DOE
- India/DAE
- Italy/INFN
- UK/UKRI-STFC
- France/CEA, CNRS/IN2P3
- Poland/WUST

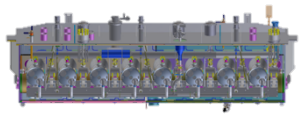
PIP-II Linac



Cryoplant

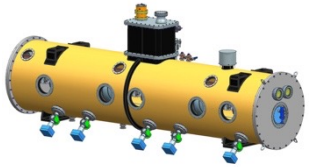
CDS

HWR
8 Cavities
162.5 MHz



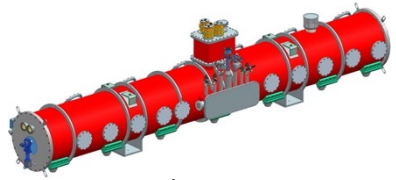
Single Spoke
SSR1 X 2
16 Cavities
325 MHz

Single Spoke
SSR2 X 7
35 Cavities
325 MHz

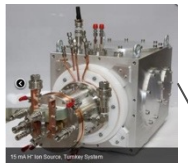


Elliptical
LB650 X 9
36 Cavities
650 MHz

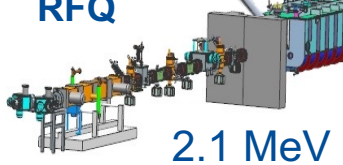
Elliptical
HB650 X 4
24 Cavities
650 MHz



H- Ion source



RFQ



2.1 MeV

10 MeV

32 MeV

177 MeV

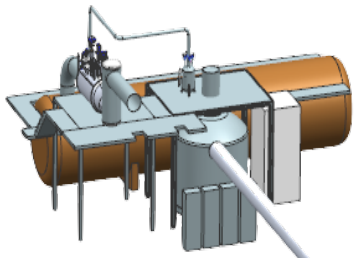
516 MeV

833 MeV

Superconducting

Room Temperature

PIP-II Linac – CM Transatlantic Shipment



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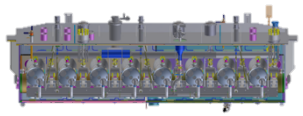

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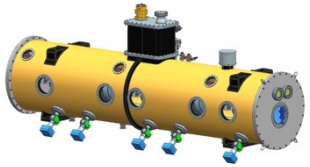

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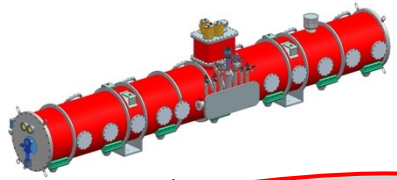

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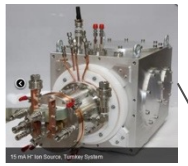

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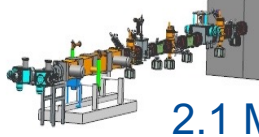

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Superconducting

Room Temperature

CM	Transatlantic Shipment
HWR	-
SSR1 & 2	-
LB650	1 + 9
HB650	1 + 3

Need for Transportation

- Majority of Production 650 MHz CMs to be assembled in UK & France
- These CMs are to undergo transatlantic shipment by road & air
- Prototypes used to validate designs of CMs, transport frames, and logistics

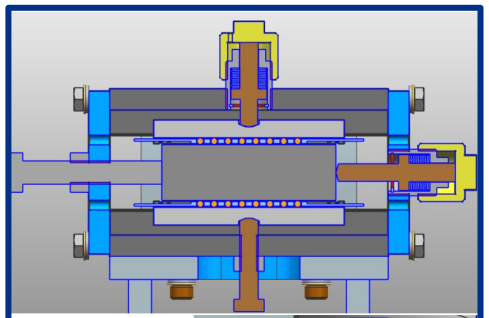
	Assembly	Pre-Transport Cold Test	Transport from	Transport to	Post-transport Cold Test
Proto. HB650	FNAL	✓	USA	UK	–
		–	UK	USA	✓
Proto. LB650	CEA	✓	France	USA	✓
Prod. HB650	UKRI (3)	–	UK	USA	✓
	FNAL (1)	–	–	–	–
Prod. LB650	CEA	✓	France	USA	✓

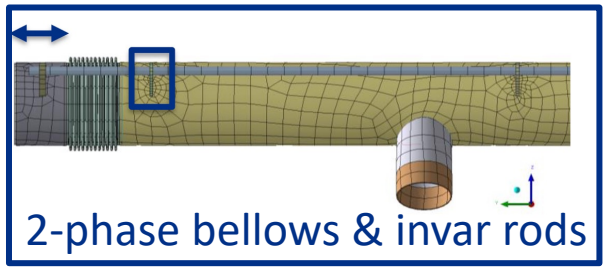
PIP-II Team's CM Transport Experience

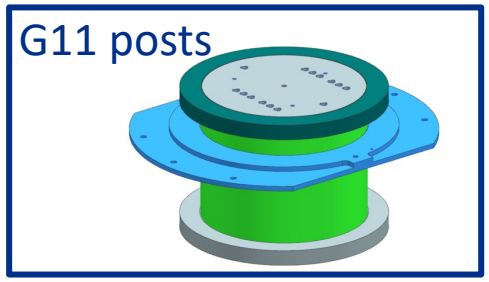
- LCLS-II
  - 1.3GHz & 3.9GHz
  - Shipping CM's to SLAC
  - Partnership with JLab
  - Onsite transport
- PIP-II
  - SSR1
    - Onsite Transport
  - HWR
    - Transport from Argonne National Lab
    - Onsite transport
- 650 MHz CM & Transport specifications defined based on these experiences & ESS

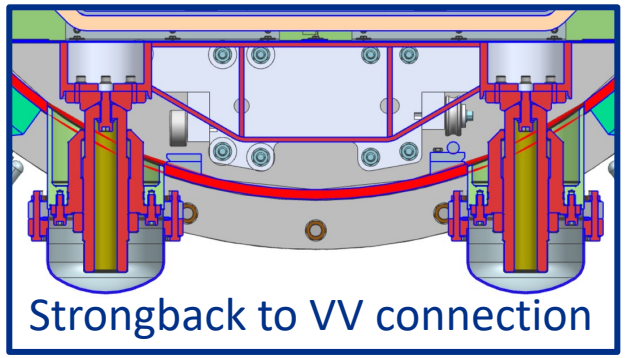
HB650 CM Design for Transport

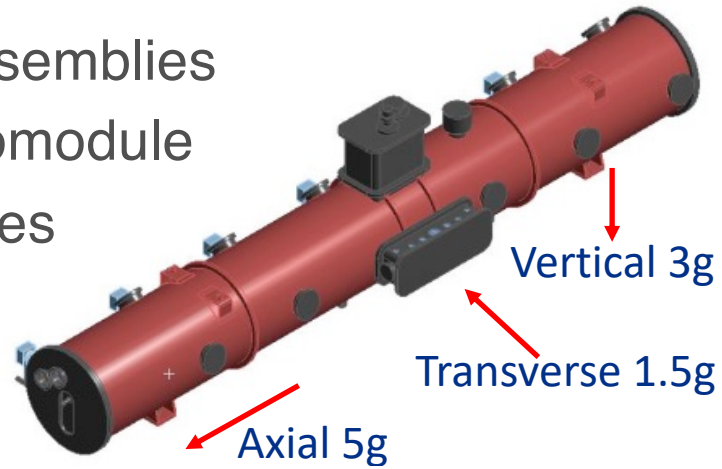
- Overseas transportation requirement applied to components & assemblies
- Extensive analyses done, with model built to represent whole cryomodule
- Several components' design optimized as a result of these analyses

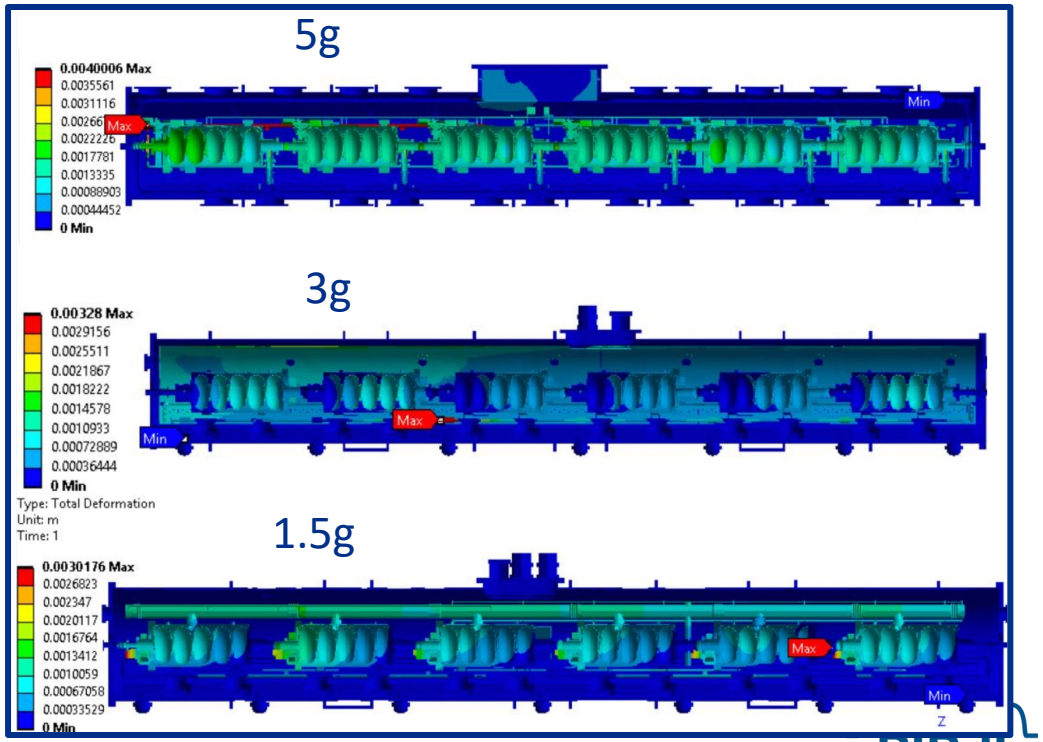






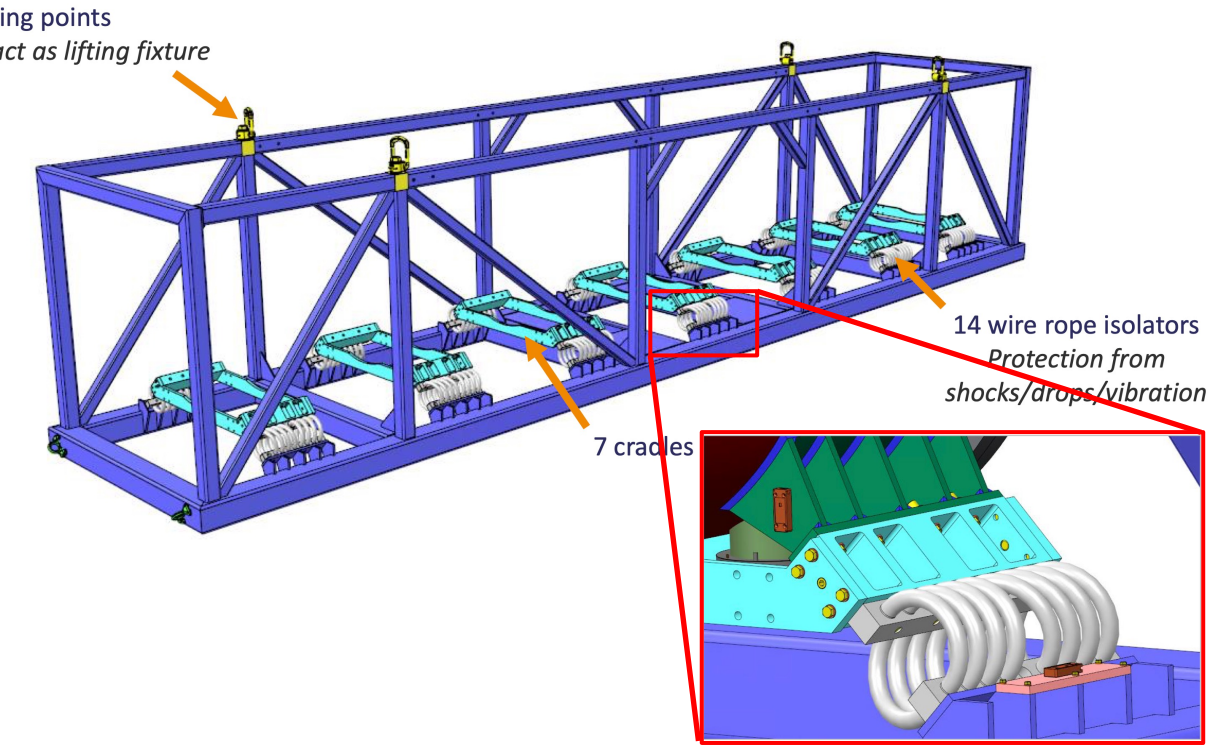






HB650 CM Transport frame

- Designed by STFC-UKRI, & first frame procured by Fermilab
  - MIL-STD-810H air & road; ISO 13355:2016 road; ASTM D4169 – 16 road
- Frame shock input defined by MIL-STD-810H worst case on-road transport shock



Shock direction	CM design	Frame spec.	Frame design output	
Vertical	3.5g	2.5g	0.8g	✓
Transverse	1.5g	1.5g	1.0g	✓
Longitudinal	5.0g	3.5g	0.7g	✓

HB650 Transportation Validation Plan

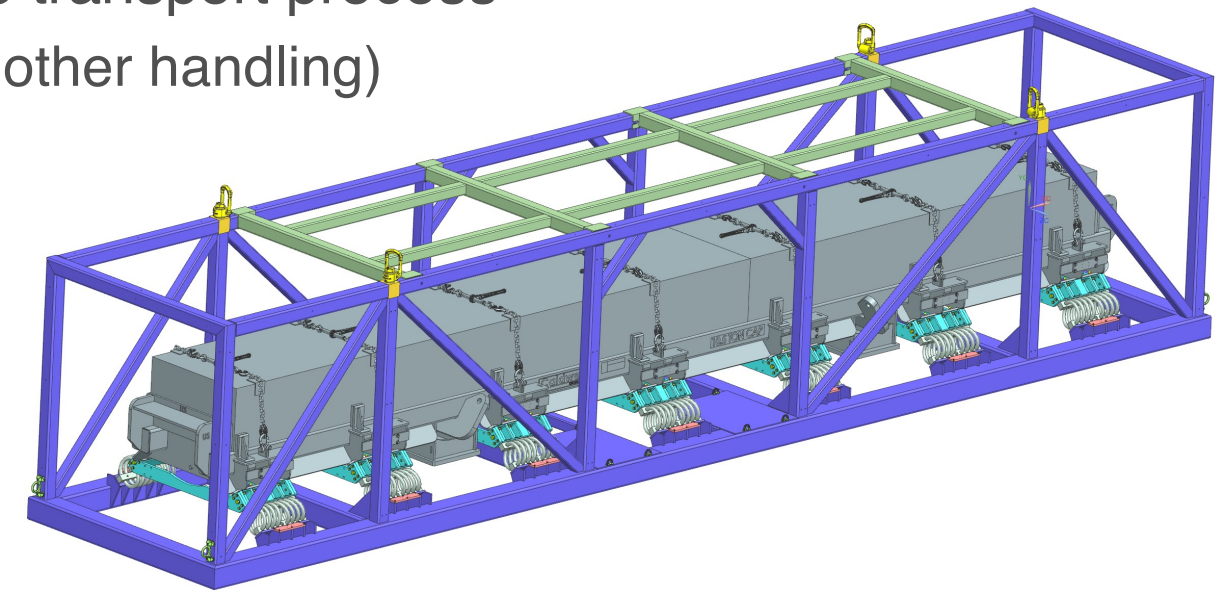
Using Dummy Load

✓ Transportation frame for prototype HB650 CM has been procured

- ‘Dummy load’ representative of the CM interfaces & weight being procured

- Transportation frame with dummy load will be shipped in Q1/Q2 CY22 from Fermilab to STFC-UKRI & back, validating the complete transport process
  - Logistics (customs, oversight, loading, and other handling)
  - Mechanical design of the frame
  - Instrumentation

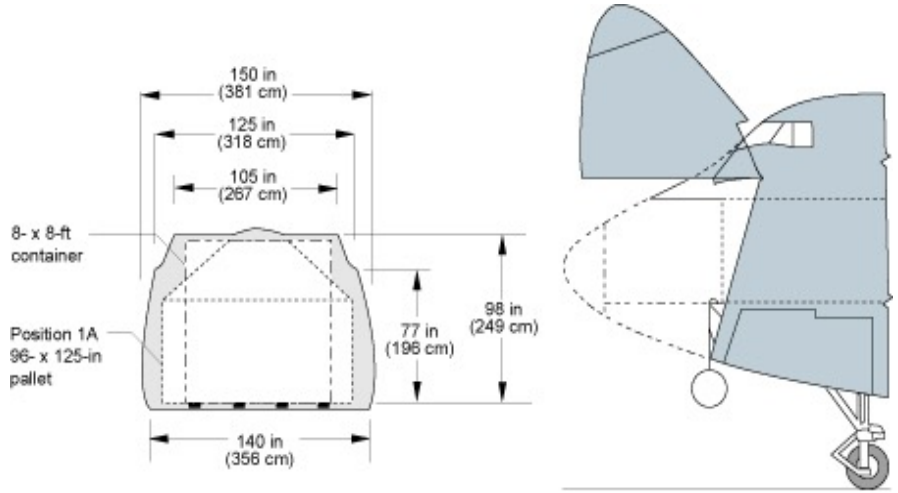
- Valuable experience at STFC-UKRI:
  - Experience with loading/unloading
  - Drop testing to MIL-Standard (tentative)

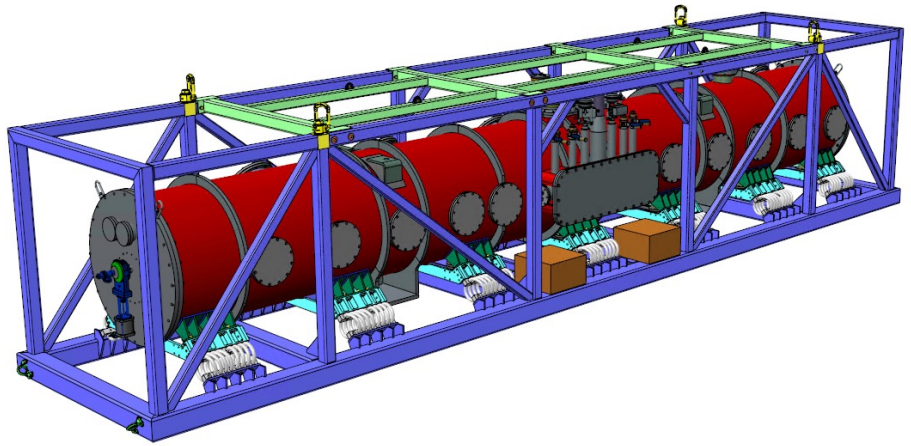


HB650 Transportation Validation Plan

Using Proto-CM

- Local Road Testing to validate system in Q3 CY22
  - Using demonstrated frame and CM internal sensors
  - Escalating road tests to full speed
- Shipment to and from UK is final demonstration of full system in Q3/Q4 CY22
  - Overseas shipping logistics
  - Custom-made covers for module/frame
  - Instrumentation systems validation
- Validation of Acceptance Testing
  - Fermilab and STFC-UKRI both do incoming & outgoing inspections





Design Optimization & Feedback

- Prototype HB650 CM and Transportation System validation to feed into:
  - Production HB650 CM,
  - Second HB650 transport frame,
  - LB650 CM, &
  - LB650 transport frame design.

- LB650 CM & transport frame validation to include
  - Road test at CEA using frame & prototype LB650 CM
  - Shipment of prototype LB650 CM in frame from CEA to Fermilab
  - Cold-testing before and after transportation at CEA and Fermilab, respectively

Summary

- Majority of PIP-II 650 MHz CMs to undergo transatlantic shipment after assembly
- Dedicated, custom transport frames to be used for transporting CMs
- Transport frame design to be validated using dummy load
  - Shipment from Fermilab to STFC-UKRI & back
- Prototype CMs to be used to validate design & transportation system
  - HB650: Shipment from Fermilab to STFC-UKRI & back
  - LB650: Shipment from CEA to Fermilab
- Prototype HB CM transport system validation is to be done in CY22, & is to feed into LB CM & frame design

Thank you!