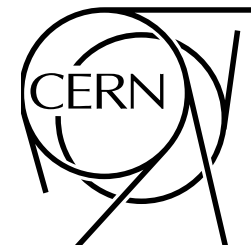


# Cryostat project introduction, scope, milestones, strategy

Author M.Nessi, CERN

LBNF Cryostat, final design review

SURF, 21-22 August 2017



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## Who Am I and Where Have I Been?

Leader of the CERN Neutrino Platform.

Liaison between CERN and Fermilab/DOE on Neutrino projects.

Member of the LBNF/DUNE Collaborations.

Technical Coordinator of the ATLAS LHC project at CERN during construction and Run1 operation, up to the Higgs discovery.

Experience includes 27 years as a project manager and technical leader of a few very large international projects. Large experience on detectors and complex systems.

Education as Particle Physicist (PhD). Physics Professor at the University of Geneva. At CERN, senior staff Research Physicist. JINST director.

## Our history

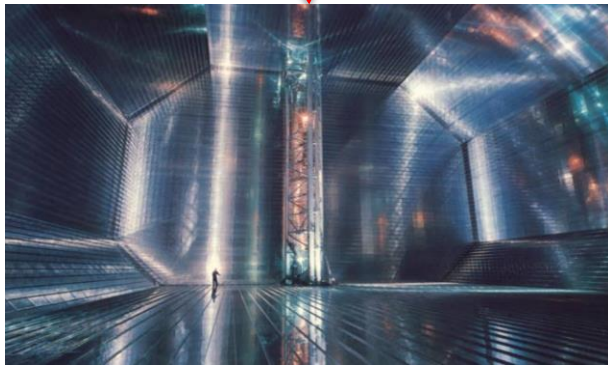
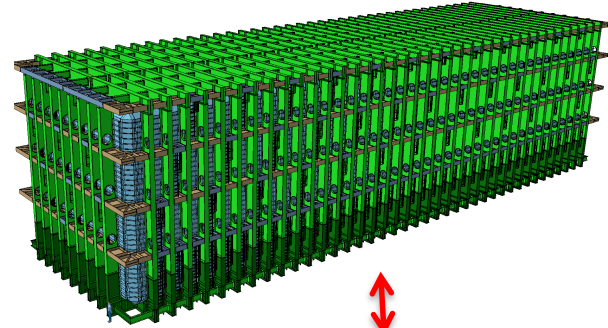
- 2014 : first plans of the concept of a warm structure, steel based, standalone which will support the LNG-GTT type membrane cold cryostats
- 2015 : first LBNF design review : <https://edms.cern.ch/document/1510834>
- 2015 CERN signs a cooperation agreement with the Paris LNG firm GTT
- Our concept presented to the DOE-CD3 review, well received
- Prototypes process to start to learn about the LNG technology and the warm structure integration (WA105 demonstrator, protoDUNES, ICARUS, SBND)
- 2016 start of the protoDUNES construction
- 2016-Now : preparation at CERN of the design to be presented to this review

# Strategy

**LNG**



**LBNF**



**GTT**



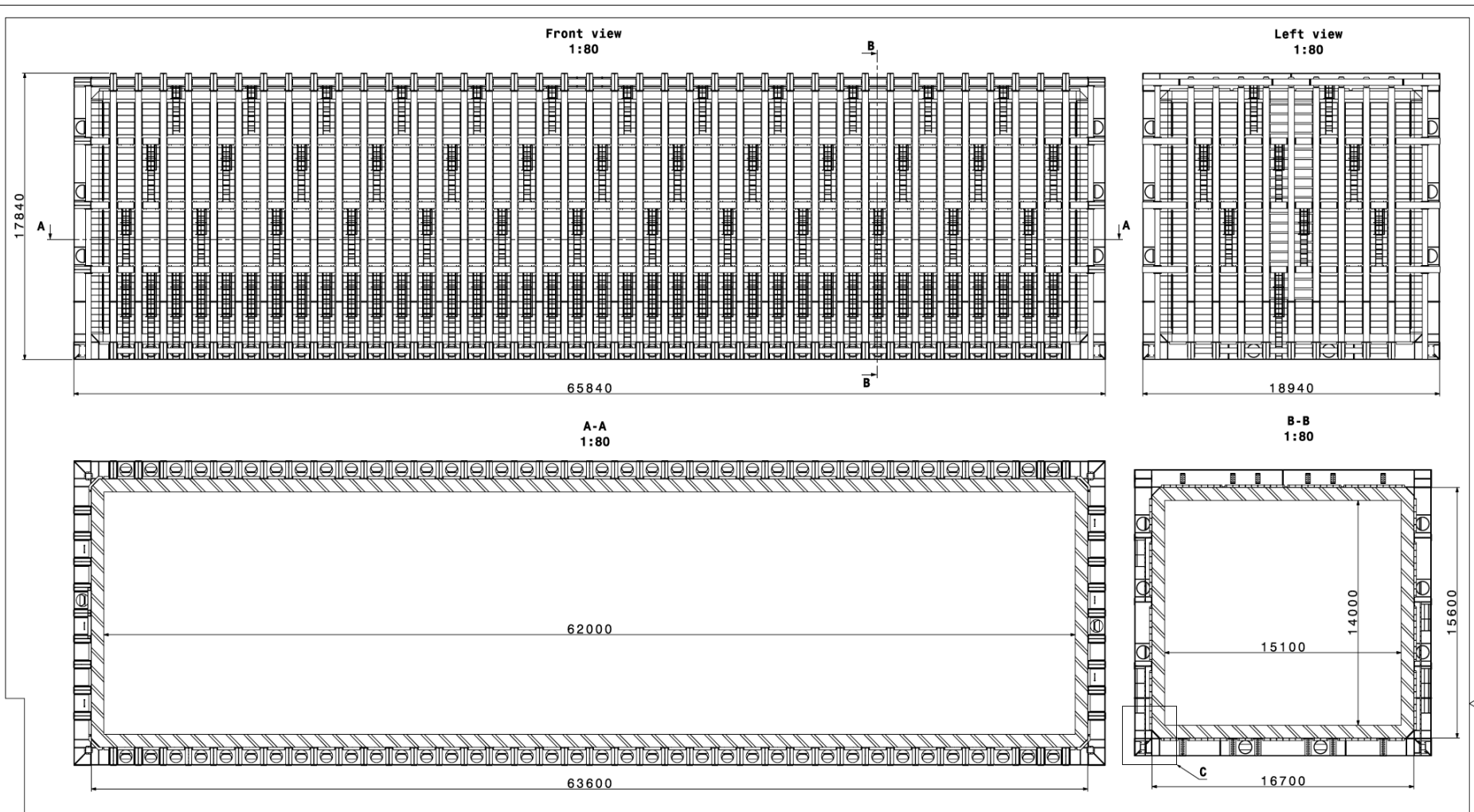
GTT proprietary technology

# Strategy

- Warm structure design and structural analysis done at CERN, by CERN qualified personnel (engineers, designers,...) (see A.Catinaccio presentation)  
<https://edms.cern.ch/project/CERN-0000173554>
- Consulting contracts active at CERN for various cross checks and tests
- R&D supported by an ambitious prototypes program at CERN (see D.Mladenov presentation)
- Design and tests rules agreed between CERN and FNAL in a signed document (see O.Beltramello presentation)
- This final design review as a phase transition towards construction
- This final design review layout and models as basis for the next engineering project : GTT cold cryostat design (2018). Deliverables:
  - Membrane cryostat detailed list of components
  - Membrane cryostat detailed assembly procedure
  - List of GTT qualified firms for the material and assembly tendering
- 2019 start of the procurement and contractual phase
- 2021 ready for starting the installation work at SURF

# Warm structure requirements : <https://edms.cern.ch/document/1834010>

- Dimensions: <https://edms.cern.ch/document/1834156>



## Warm structure requirements : <https://edms.cern.ch/document/1834010>

- **Structure and Material**

### ***Structure***

- HL1100 M profiles for the main structural beams

### ***Material***

- *The material is:*
- S460ML for the main beams
- S460ML for all bolting connections
- S460ML for the 12mm outer steel plates



## Warm structure requirements : <https://edms.cern.ch/document/1834010>

- **Main load conditions**

Self-weight of the members: main beams: HL1100M- 433 kg/m

Insulation weight (thickness 800mm) including the primary membrane: 115 kg/m<sup>2</sup>.

The 12 mm steel plates: 7850 kg/m<sup>3</sup>, not including ribs

Detector wet-weight and service: to be defined, today expected to be at the level of ~106 metric tons for the entire detector inside and 50 metric tons for the services on top of the cryostat. Weight to be handled in first estimation in a uniform way over the entire surface and volume. To play safe we use 200 metric tons in all calculations.

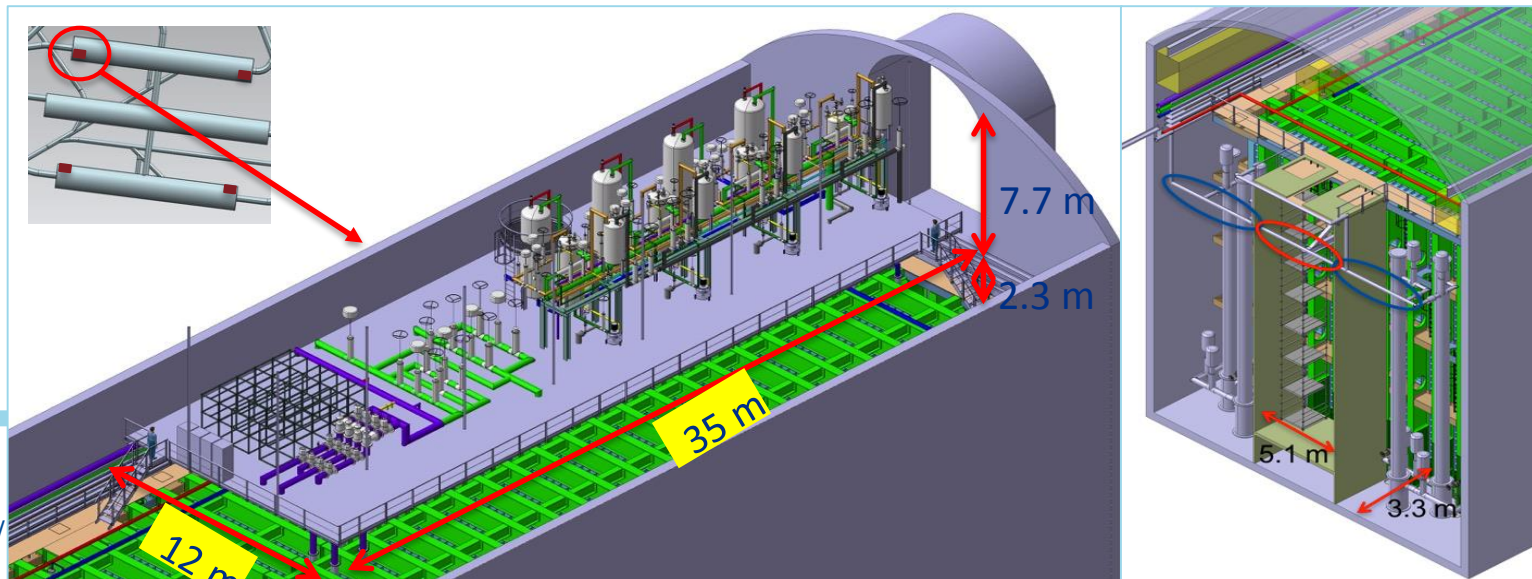
Hydrostatic pressure of the LAr (96%) filling with liquid, rest gas:  
The density of the LAr: 1395 kg/m<sup>3</sup>

Gas volume overpressure:  
Nominal Operation Scenario: 130 mBar  
Accidental Loading: 350 mBar

# Warm structure requirements : <https://edms.cern.ch/document/1834010>

## • Additional conditions

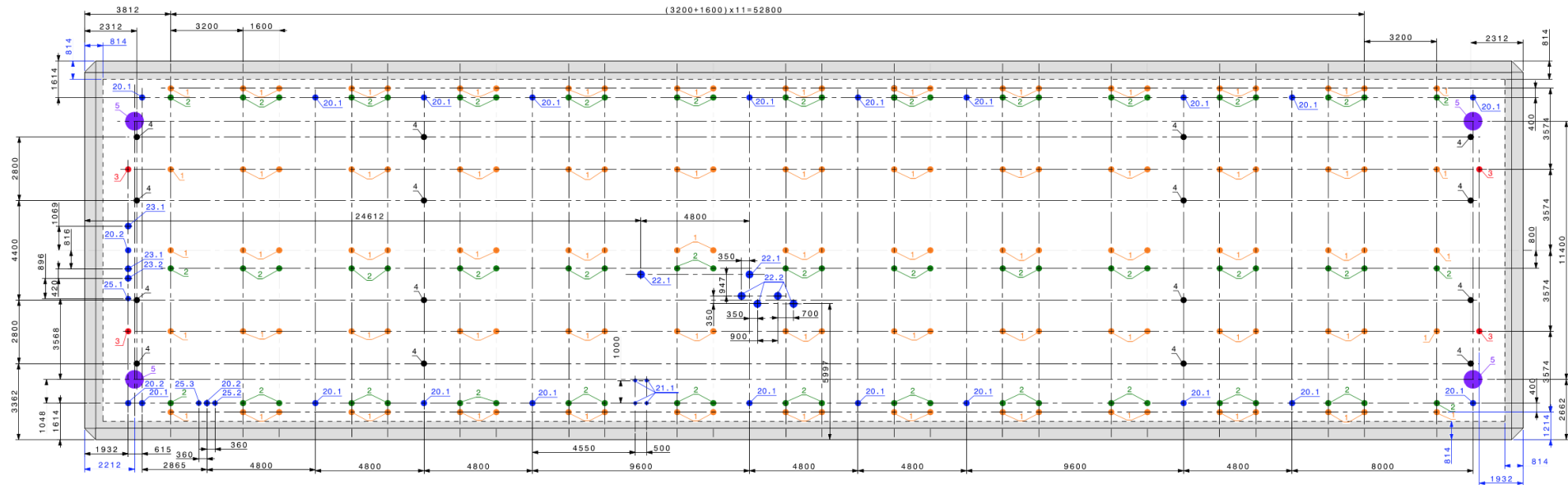
- Warm structure posed free on the concrete floor, no structural connection to the cavern floor and walls
- LAr proximity cryogenics on a mezzanine structure, placed ~2.3 m above the top of the cryostat, supported directly on the roof of the cavern. No load requirements on the cryostat
- Top of the cryostat at the same level as the floors of the drifts. Input to excavation!
- Complex penetration layout (top, still to be agreed with DUNE)
- LAr extraction using 4 pumps placed on the lower part of one of the small walls (protoDUNE experience)



# Warm structure requirements : <https://edms.cern.ch/document/1834010>

- Top penetrations : <https://edms.cern.ch/document/1834561>

Top view  
1:70



Pos.	Diameter [mm]	Quantity	Description
1	Ø250	120	Support
2	Ø250	72	Cable
3	Ø250	4	High voltage
4	Ø250	16	Instrumentation
5	Ø800	4	Manholes

Pos.	Diameter [mm]	Quantity	Description
20.1	Ø250	20	L+G Ar cool down
20.2		3	Spare
21.1	Ø152	4	G Ar Controlled vent
22.1	Ø324	2	G Ar Boil off
22.2		4	G Ar Relief/Safety
23.1	Ø273	2	L Ar Return
23.2		1	L Ar Emergency return
24.1	Ø350	4	L Ar Pump
25.1	Ø219	1	G Ar Purge
25.2		1	G Ar Make up
25.3		1	G Ar Momentum

## Warm structure requirements : <https://edms.cern.ch/document/1834010>

- **Additional conditions**

### Access

- All components have to be lowered through the existing shafts and drifts. Needs tools and a realistic scenario
- Structure (external) must be accessible through all phases of the project, in particular during cooling down and filling
- The possibility should be study to allow forced air circulation on the lower part of the structure

# Work Organization

- Design work done at CERN with CERN engineers (large effort). Structural analysis and production drawings.
- Some calculation cross checks subcontracted to engineering firms
- Structural tests subcontracted to the University of Coimbra mechanical labs
- Tests structures subcontracted to specialized firms (beams, bolts, construction). In this process the welding procedures, the QC and all construction norms will be defined and will be the basis for the final production
- The mezzanine is being defined and engineered. CERN has provided manpower for the first design, integration and requirements definition for the proximity LAr cryogenics
- CERN effort to define the penetration layout, as a basis for the future
- This review as a phase transition towards construction
- Next step contract with GTT for the final design of the membrane cold cryostat
- In parallel we plan a verification with an engineering effort with a S.Dakota licensed engineer or engineering firm for the warm structure

## This review

- Project definition and requirements
- ProtoDUNE lesson learned
- Design and test rules
- List of components and CAD models
- Logistics and lowering of material
- Design engineering and structural analysis
- Mechanical structural tests
- Access requirements
- Installation requirements, sequence and tools
- LAr proximity cryogenics mezzanine
- Remaining activities, open issues

# Milestones

- August 2017 : this review
- September 2017 : CERN Finance committee for GTT engineering contract
- November 2017 : sign engineering contract with GTT
- 2018 GTT engineering
- September 2018 : CERN FC for Material procurement (warm and cold)
- Spring 2019 : sign contracts for materials procurement and delivery to SURF
- 2019 and 2020 : Material construction and shipping. First warm structure
- September 2019 : CERN FC for assembly contracts (warm and cold)
- Spring 2020 sign assembly contracts
  
- **Ready to start assembly in 2021**

# WWW pages, EDMS repository <https://twiki.cern.ch/twiki/bin/view/CENF/LBNFProjectCryostats>

Welcome to the LBNF Project - Cryostats TWiki Home page

## General

- [EDMS link](#)
- [Membrane Cryostats design and tests requirements](#)

## Reviews

- [first design review 2015](#)
- [final design review 21-08-2017](#)

## Status presentations

- [EDMS link](#)

## WARM VESSELS (final design August 2017)

- [Requirements: Design, layout and dimensions](#)
- [Structural analysis and models, hystory](#)
- [all relevant final documents in public access mode](#)
  
- [Schedule](#)

## details: CAD files: 3d models and drawings

- [layout drawings](#)
- [3D models](#)
- [Production drawings](#)
- [Penetrations layout](#)
- [Mezzanne models and drawings](#)
- [CF models \(cavern and infrastructure\)](#)

## details: production: project details

- [mechanical qualification tests](#)
- [material Procurements](#)
- [warm vessel installation](#)
- [Pictures](#)



## Documents and references

- Warm structure requirements :  
EDMS : <https://edms.cern.ch/document/1834010>
- WWW link covering this review material  
<https://twiki.cern.ch/twiki/bin/view/CENF/LBNFProjectCryostats>
- WWW link to all structural analysis details  
<https://edms.cern.ch/project/CERN-0000173554>

# Summary

- We are presenting our view on the design and construction of the warm cryostat vessel
- All documents related to it should be available on EDMS and WWW documents
- We consider this review as a phase transition toward the next steps in the project
- We think we have cumulated enough information to be able to proceed further with the remaining engineering studies (cold vessel, S.Dakota engineering validation,...)
- From now on we expect that all changes to this design will be handled as formal change requests, according to the LBNF/DUNE procedure