

# GERDA TG4 - Cryogenic Vessel

## Status Report

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GERDA Collaboration Meeting at Tübingen  
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# Outline

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Safety Review

Impact on / Update of Cryostat Design

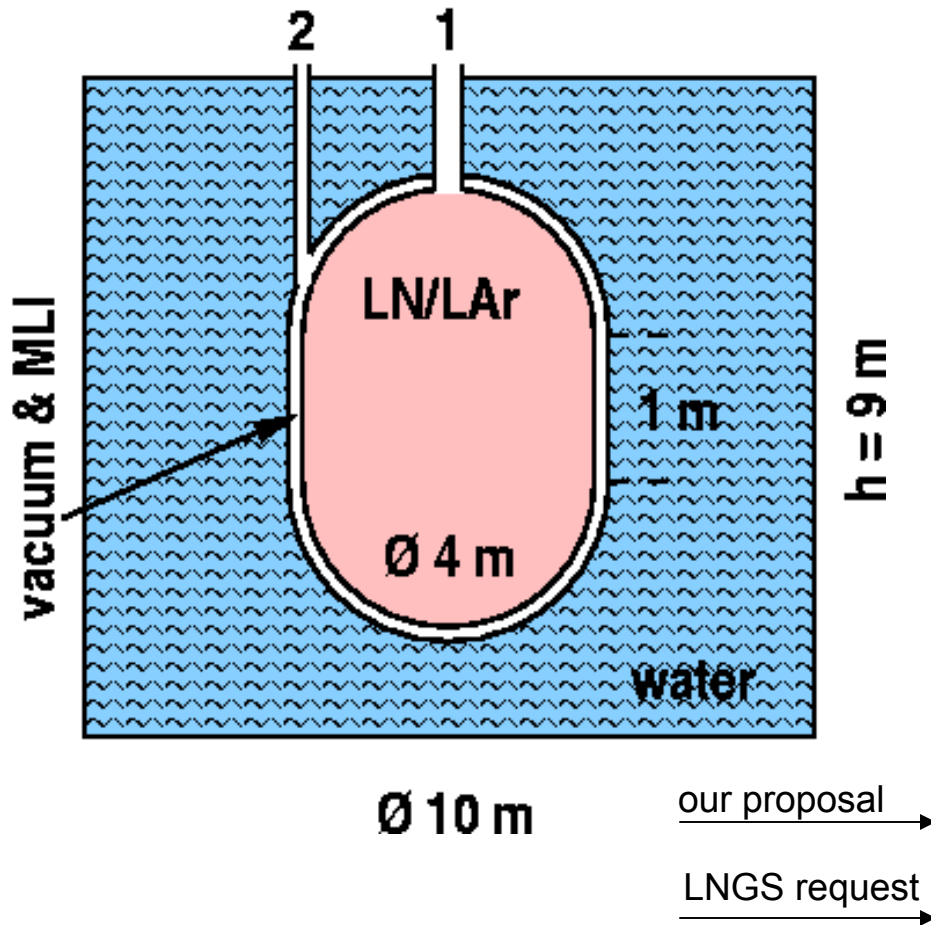
Preparations for Cryostat Fabrication

Next Steps

Conclusions

# Safety Review – The Issue

50 m<sup>3</sup> cryostat in 660 m<sup>3</sup> water vessel



Although FMECA & HAZOP analysis conclude cryostat system to be safe if constructed 'correctly', nevertheless concerns due to **severe consequences in LNGS underground lab** from

- single shell rupture
  - ▶ huge exhaust of cold N<sub>2</sub>/Ar gas
- double shell rupture
  - ▶ possibility of explosion-like N<sub>2</sub>/Ar evaporation

Possible countermeasures:

- replace water by PE, Pb,..., + container
- replace water by ice (see Lev's talk)
- lower probability for single shell rupture to  $<10^{-7}$  per year applying the Basissicherheitskonzept (BSK)
- build 3rd wall (several options)

# Safety Review – The History

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**INPUT : cryostat drawings and Technical Proposal**

Apr 21 : Preparatory meeting (LNGS, MPI-HD) in Milano

Apr 25 : Order for FMECA, HAZOP & PID awarded to Air Liquide (AL)

Apr 28 : Kick-off meeting in Sassenage (AL, MPI-HD)

May07 : Intermediate meeting at CERN (AL, LNGS, MPI-HD)

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**INPUT : FMECA, HAZOP, PID, and TÜV Nord report:**

**GERDA cryostat & Basissicherheitskonzept (BSK)** (▶ see TG4 webpage)

Jul 05 : 'Final' meeting at LNGS (AL, LNGS, MPI-HD)

▶ LNGS will ask for 2<sup>nd</sup> opinion on GERDA risk assessment

← summer vacations!

**INPUT : 2<sup>nd</sup> opinion paper**

Sep 05: Meeting in Milano (LNGS, MPI-HD)

▶ Request for 3<sup>rd</sup> wall

Sep 08 / 09 : GERDA management meeting in Munich / letter to LNGS directorate

**INPUT : GERDA specs for 3<sup>rd</sup> wall; paper by consultant**

Sep 22: 3<sup>rd</sup> wall meeting at CERN (LNGS, MPI-HD, consultants)

Sep 28: 3<sup>rd</sup> wall meeting at LNGS (LNGS, consultant, phone conference)

**Oct 13 : GERDA safety concept approved by LNGS if 3<sup>rd</sup> wall is installed**

FMECA = Failure Mode, Effects and Criticality Analysis , HAZOP = Hazard and Operability analysis , PID = Piping and Instrumentation Diagram

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# Safety Review – 2nd opinion details

- Conclusions of TÜV report on BSK for GERDA are not accepted.
- Statement – independent of cryostat's material:  
'low-probability events with catastrophic consequences need additional passive or "absolute" barriers.'

- 'Copper material for cryostat acceptable'.

- 'Consequences of mixing of water & cryoliquid are so catastrophic ...  
.... that additional, passive countermeasures are needed.'
- According to Seveso directive, events with very low frequency ( $10^{-6}/y$  to  $10^{-8}/y$ ) are only tolerable if ALARP\* is fulfilled.
- 'Cryostat is single containment structure from structural point of view.'

## Recommendations:

- ▶ implementation of 'additional, separated shell'
- ▶ preparation of evacuation plan

\* **ALARP** principle : residual risk shall be **As Low As >Reasonably< Practicable**

# Safety Review – GERDA Letter ...

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... stating that

.... in the hope of minimizing the delay of GERDA, we will consider the implementation of an additional wall as recommended in [2<sup>nd</sup>op] provided that such a wall

- does not affect the physics performance of the experiment, and
- is within the financial capabilities of the collaboration.

and asking to confirm that

- water is accepted as shielding material;
- copper is accepted as structural material for cryostat & additional wall;
- with the adoption of an additional wall satisfying the above constraints, GERDA's safety concept is acceptable to LNGS;
- LNGS will provide the evacuation plan recommended in [2<sup>nd</sup>op];
- LNGS will provide the simulations of the LN and LAr evaporation rates.

# Impact on / Update of Cryostat

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## **Delays despite of real fast LNGS action**

AD2000 → BSK → AD2000 detour  
All orders stopped until obvious that GERDA  
safety concept will be approved.  
Impact of 3<sup>rd</sup> wall not yet fully understood.

**Improved design** due to intensified interactions  
between  
MPI, TÜV Nord, designers and manufacturers.

'Resting on pads' cryostat version (with compensating bellow in neck) selected  
in order to reduce stress in copper-stainless steel welds.





# Cryostat Update - Improvements

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- Use of OFE ('OFPR') copper instead of DHP copper
  - ▶ higher radiopurity
- Use of Korbbogen head instead of hemispherical heads
  - ▶ much easier fabrication, can be pressed, cheaper, more reliable
  - :-( cryogenic surface & volume increased
  - :-( material thickness increased
- Use of BSK design rules
  - ▶ stress minimized
- 'Ausgehalste' transitions at neck and bottom
  - ▶ welds now at positions of reduced stress

# Cryostat Update

## Fabrication of steel vessel head from segments



# Cryostat Update

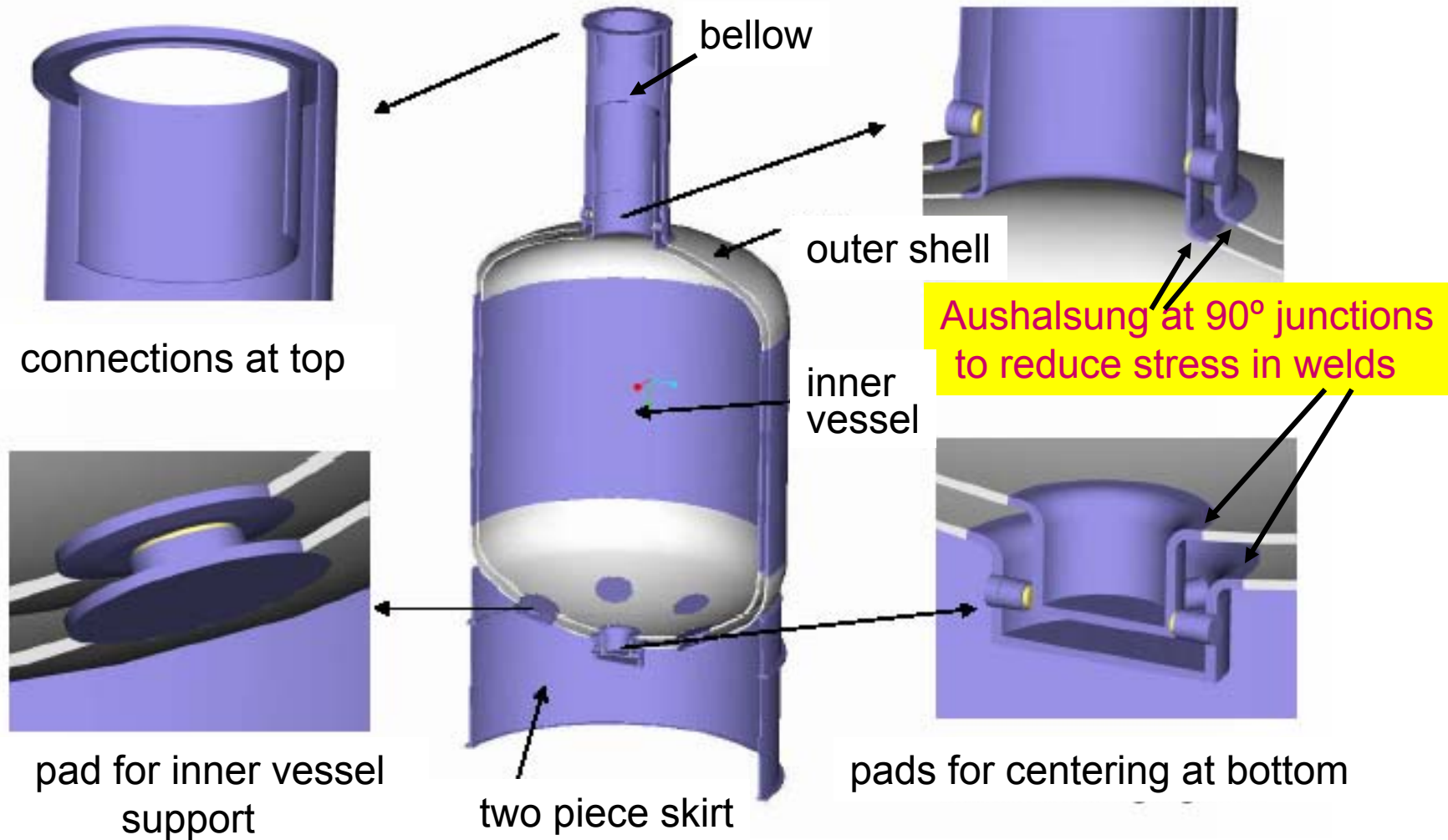
Plungers for pressing vessel heads



GERDA Korbbogen heads will be pressed from one single OFE copper sheet which is produced by joining 2 or 3 flat OFE copper sheets by e-beam welding.

# Cryostat Update

## improved design - details





# Preps for Cryostat Fabrication (I)

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Aug 25 : coordination meeting at TÜV Nord, Hamburg, with [almost] all parties involved in fabrication and certification of cryostat:

TÜV Nord, experts for materials, welding, pressure equipment,....  
IGN, engineering company  
Norddeutsche Affinerie, OFE copper producer  
Walzwerk Schreiber, rolling plant  
Antonius, manufacturer of vessel heads  
pro-beam Burg, e-beam welding company  
[still lacking: cryogenic expert input]

# Preps for Cryostat Fabrication (II)

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Result: plan for test and certification of material & e-beam welding

Sep : list of pieces / welds for certification process

: phone conference on construction details

Sep 20: order of 1+ ton of OFE copper incl. rolling

Oct 12: delivery of 8 mm thick 1.4404 ss plates

Oct 17: delivery of rolled 5, 12, 20 mm thick OFE copper plates

Oct 21: material cut and milled at MPI HD, shipped to pro-beam

KW45 : e-beam welding of Cu-Cu, Cu-1.4404, 1.4404-1.4404 for  
'Verfahrensprüfung' and materials test;

Production of test pieces for pressing by Antonius

dto+2: results of material and weld test available

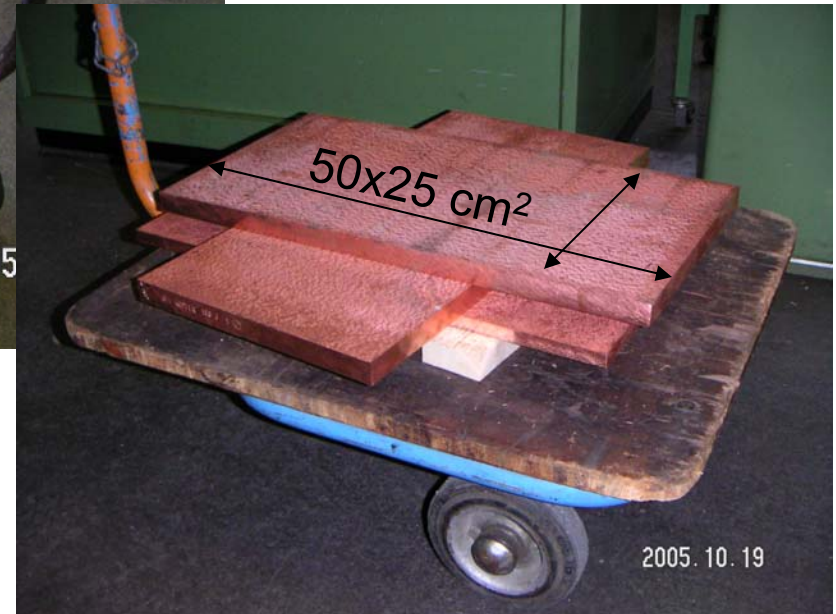
dto+>2: tests by Antonius done

Dec ??: certification process finished

# Materials for E-Beam Welding Certification



5, 12, and 20 mm thick OFE copper plates  
8 mm thick 1.4404 plates



# Next Steps

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## IF welding test milestone passed :

- determination of cryostat's wall thickness
- certification of design by TÜV Nord
- cryogenic review of cryostat design (quote available)
- 'order' of cryostat
- tender / order of installation of superinsulation
- tender / order of cryogenic infrastructure

## Open issues, e.g.:

- selection of superinsulation (teflon sample not yet delivered)
- cleaning of copper surface / cryostat
- layout of clean infrastructure at e-beam welding facility
- time schedule for cryostat production, installation
- procedure for installation, implications of 3<sup>rd</sup> wall



# Conclusions

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- Safety concept of GERDA is approved if 3<sup>rd</sup> wall is installed.
- 3<sup>rd</sup> wall is not a component of the cryostat – but cryostat support will provide the interface for the 3<sup>rd</sup> wall.
- Cryostat will be built according to AD2000 pressure code.
- Improved cryostat design available.
- Certification of e-beam welding, 'Verfahrensprüfung', is in progress.
- Certification procedure is used to run through all production steps from copper production, rolling, to final welded product.
- Delivery date for cryostat to be determined after certification in collaboration of all parties involved.
- Still numerous issues open

NB: a) GERDA construction site available in June 2006  
b) LNGS ventilation system upgrade in progress, will be completed with the installation of 2<sup>nd</sup> duct.