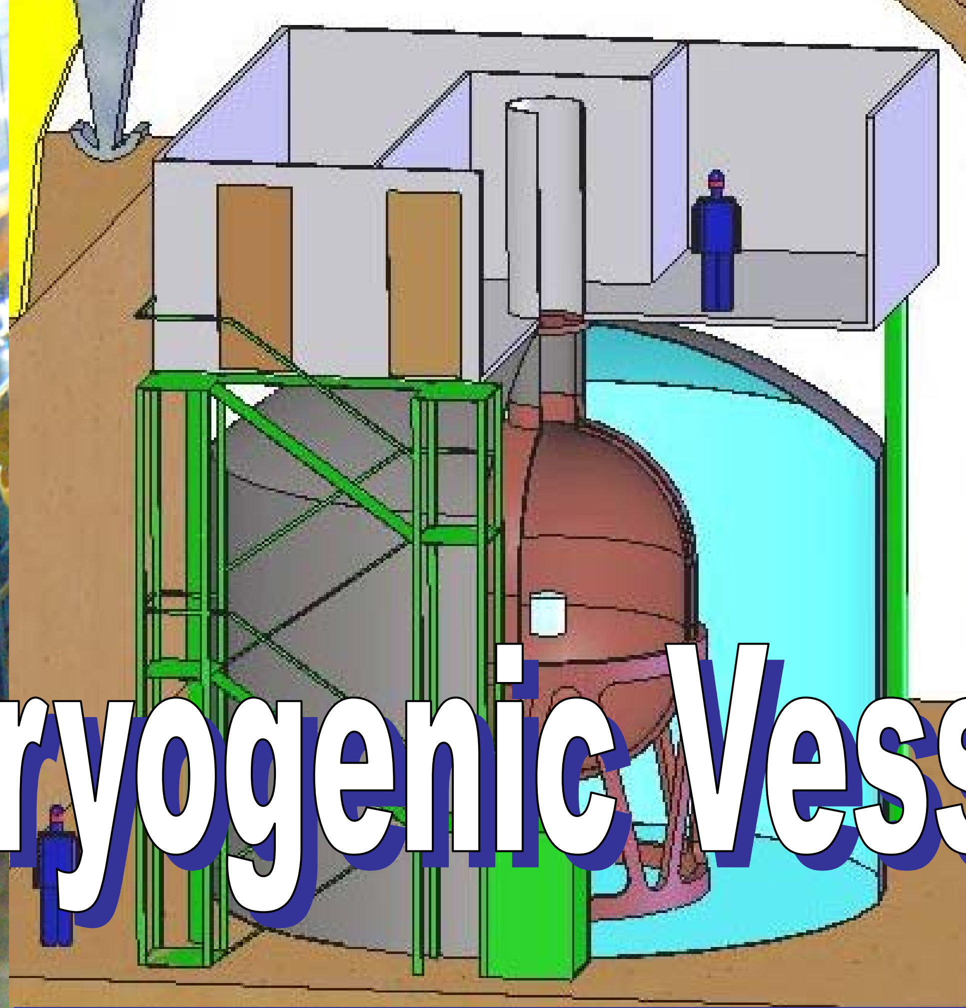

# Cryogenic Vessel

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GERDA collaboration meetingLNGS, February 2005

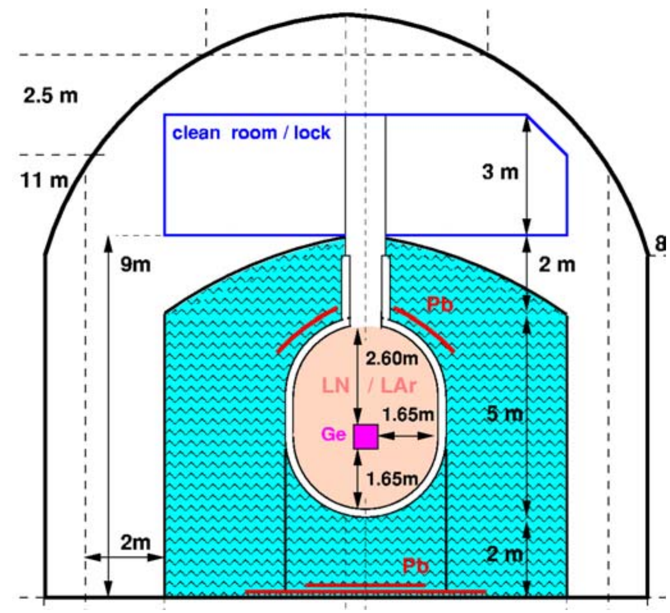
# Intro - MC Results

**Detailed MC for external gamma background: 2 kg diode in Cu cryostat inside water vessel**

**Results for background index:**

**Contribution (in $10^{-4}$ / (keV•kg•y)): from**

| | |
|---|---|
| Cu | 1.2 |
| steel | 0.2 |
| | |
| cylindrical | 0.066 |
| upper | 1.1 |
| bottom | 2 |
| open neck | 110 |
| neck + 10cm Pb | 1.1 |
| neck + 15cm Pb | 0.11 |




Cu : 25 μBq / kg of Th-232
Fe : 20 mBq / kg of Th-232
ext. : 0.0625 / ($cm^2$•s) 2.6 MeV γ

► more details in Igor Barabanov's talk

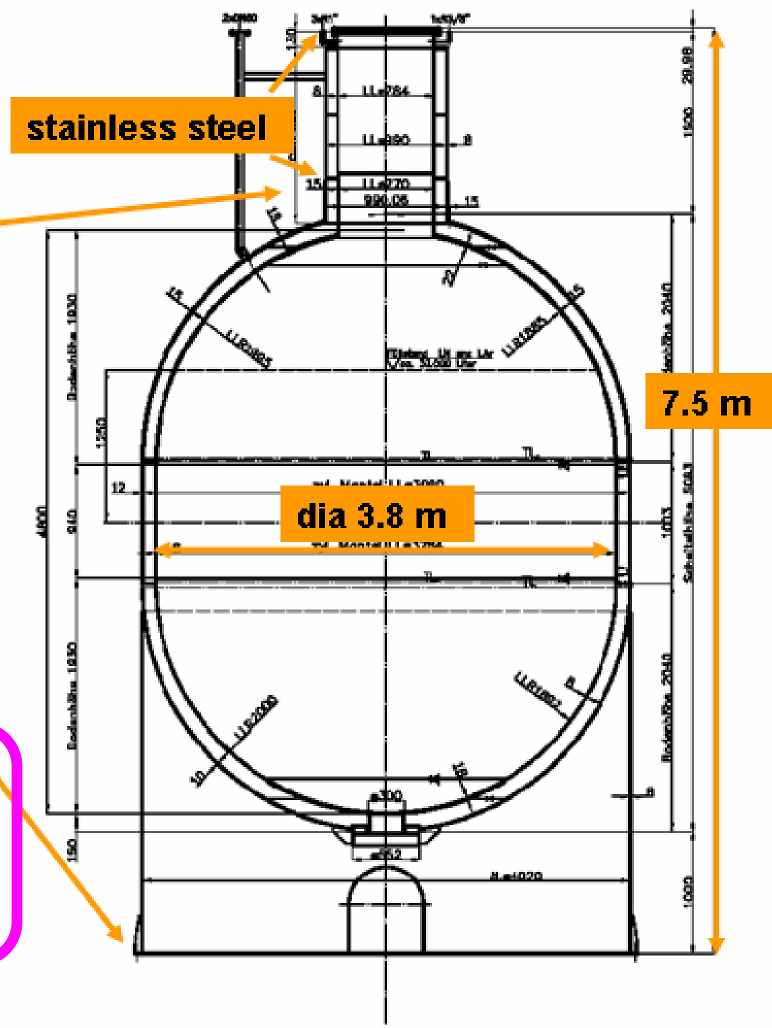
# Reminder : so far, two cryostat options considered

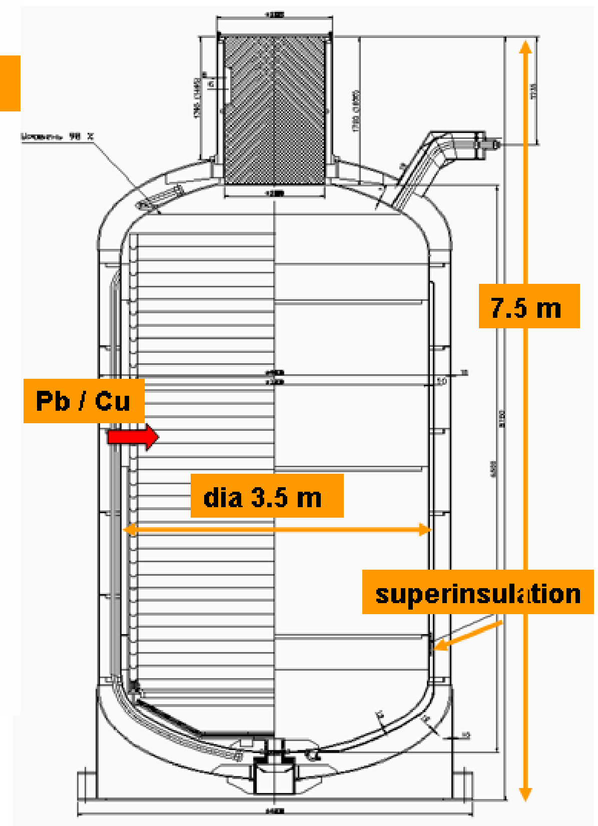
## baseline #1

custom design

- all copper except part of neck
- superinsulation
- earthquake tolerance
  v: 0.5 g / h: 0.6 g
- fabrication by EB welding

to be still optimized:
- thermal losses through neck !
- earthquake tolerance ?
- radiopurity of DIN copper



# .... and 'Stainless Steel' Option

#2

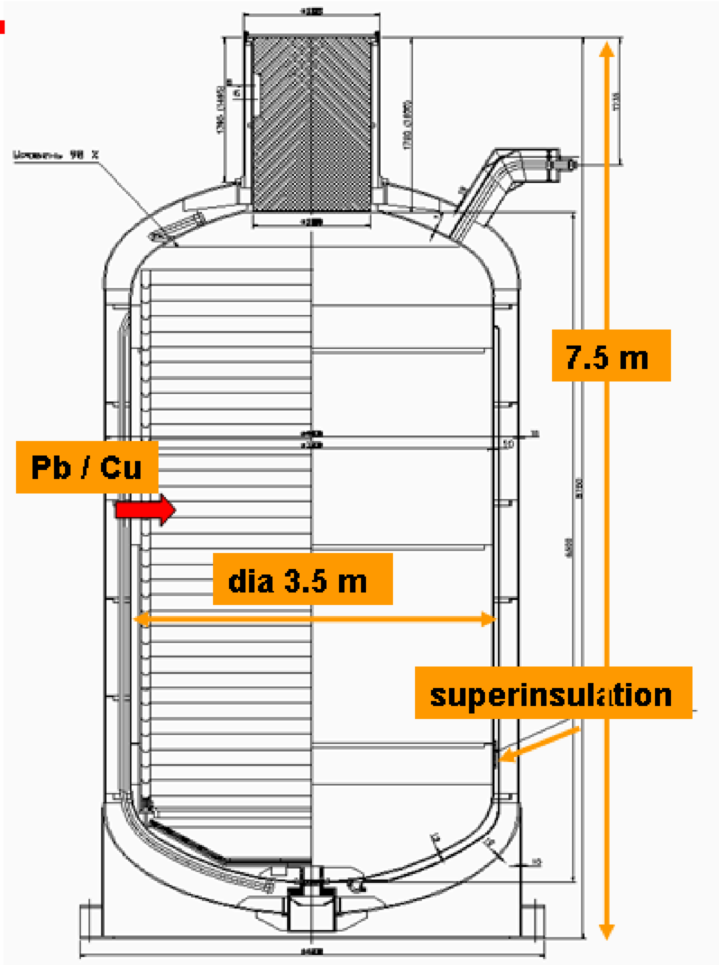
## alternative

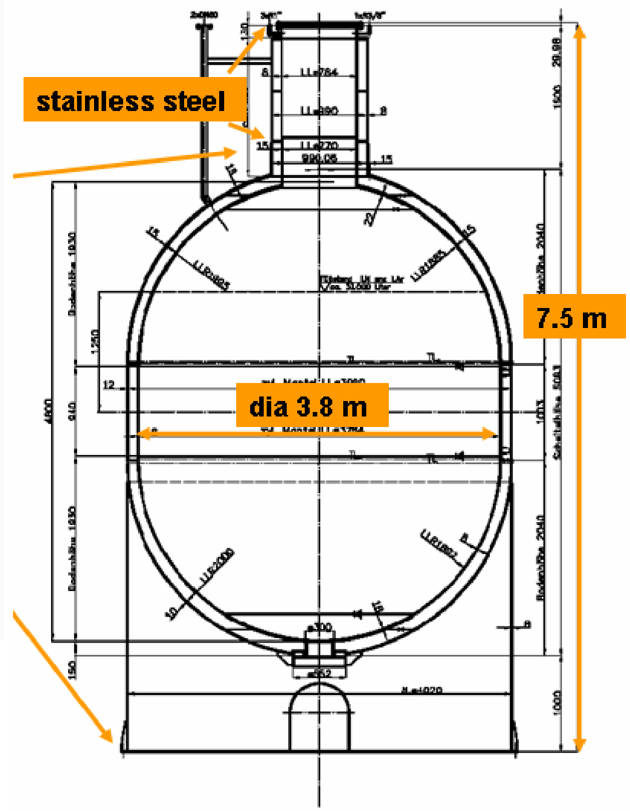
**design by CRYOGENMASH**

**deduced from standard cryostat line**

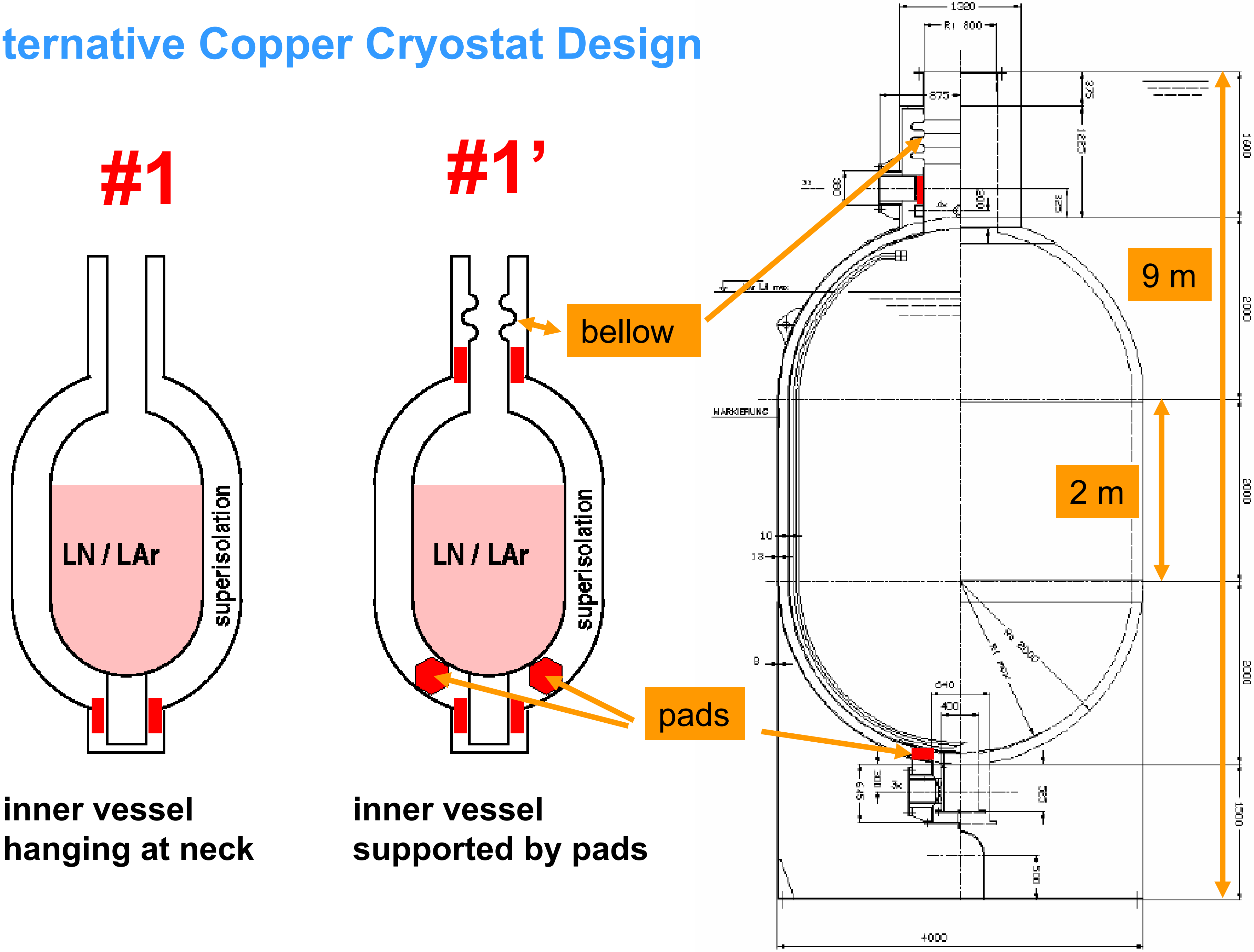
- **stainless steel**
- **superinsulation**
- **Pb load up to 50 tons**
- **mature design**
- **ready to be bought**

copper plates vs lead bricks



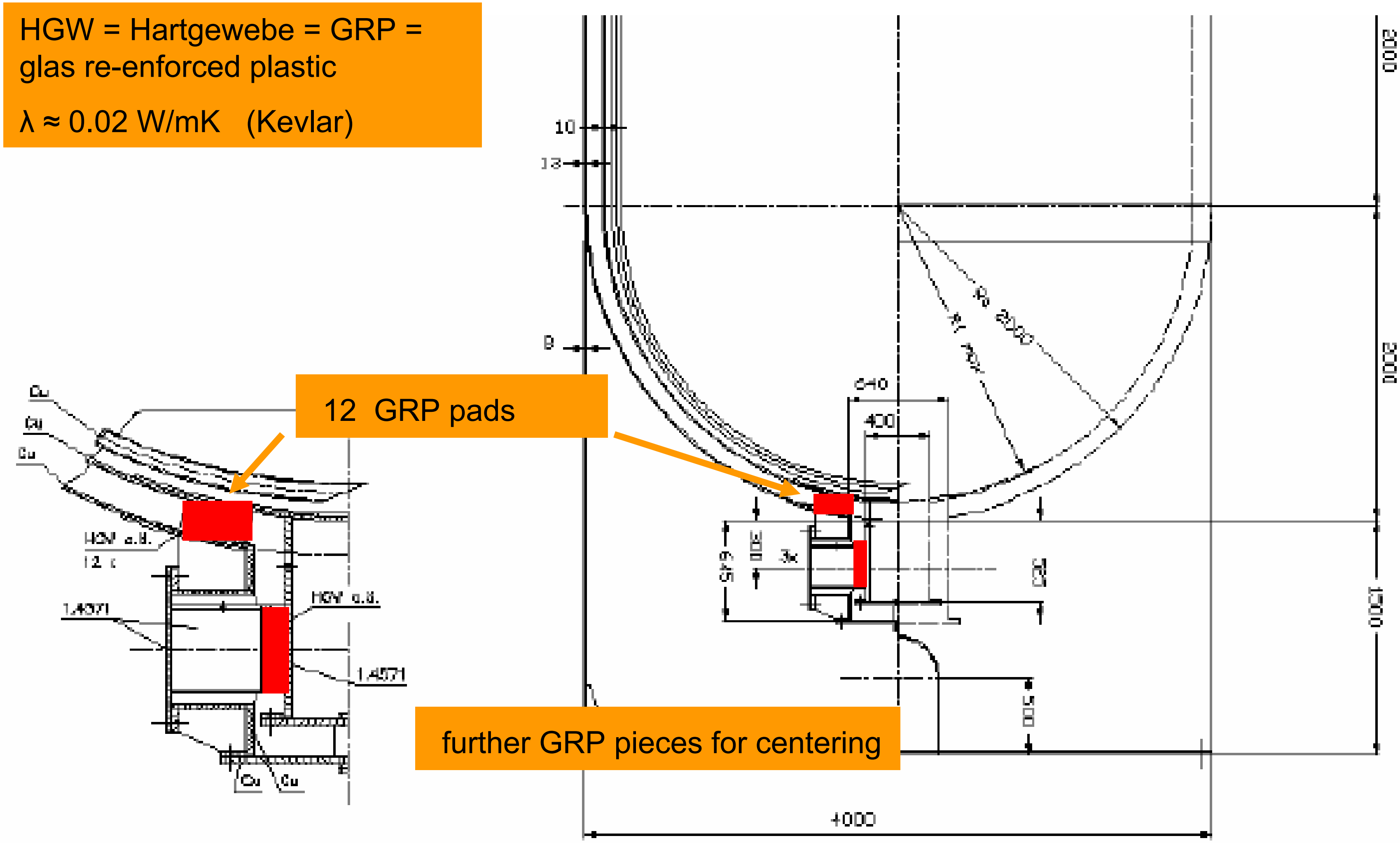
# Alternative Copper Cryostat Design



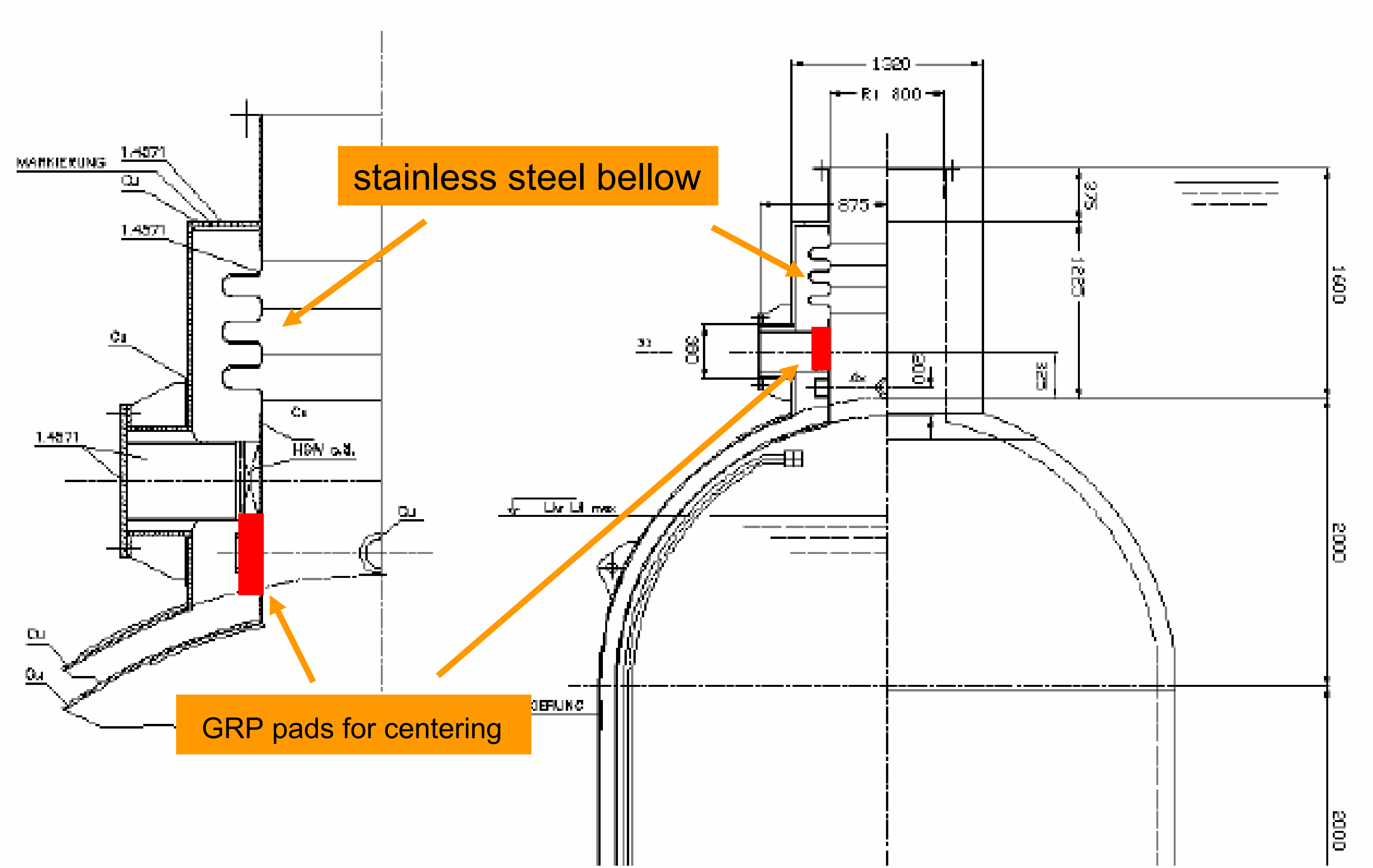
# Details Bottom

HGW = Hartgewebe = GRP = glas re-enforced plastic

λ ≈ 0.02 W/mK (Kevlar)

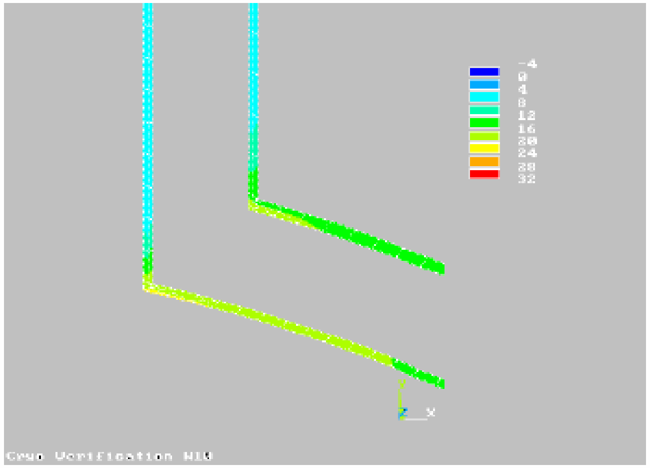


# Details Top

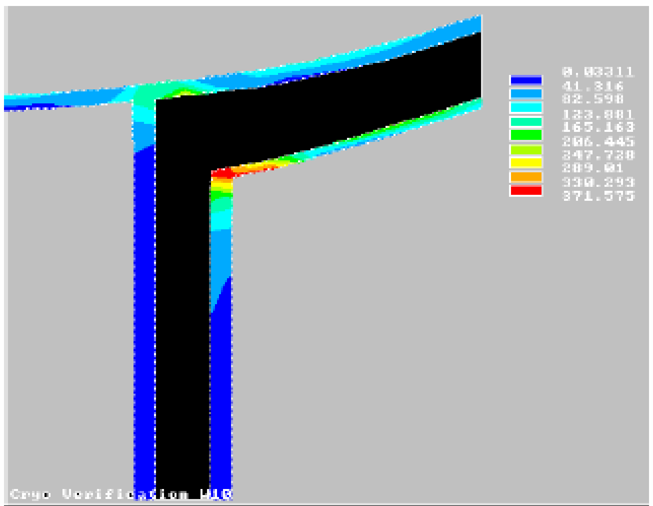


stainless steel bellow
GRP pads for centering
MARKIERUNG
1.4571
Cu
1.4571
Cu
1.4571
Cu
HGW ...
Cu
Cu
Cu
1320
Ri 800
875
375
1225
1600
2000
2000
325
800

# More Characteristics of Option #1'



Spannungen an den oberen Ausschnitten



Spannungen an den unteren Ausschnitten

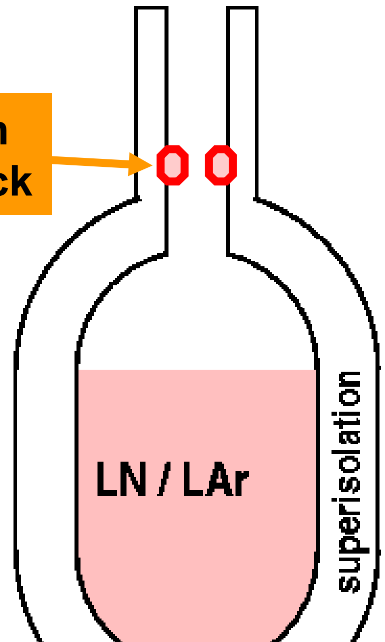
**Thermal losses:**

- **surface 103 W = 0.11% / day**
- **neck 49 W = 0.05% / day**
- **pads 19 W = 0.02% / day**

**► total 171 W = 0.19% / day**

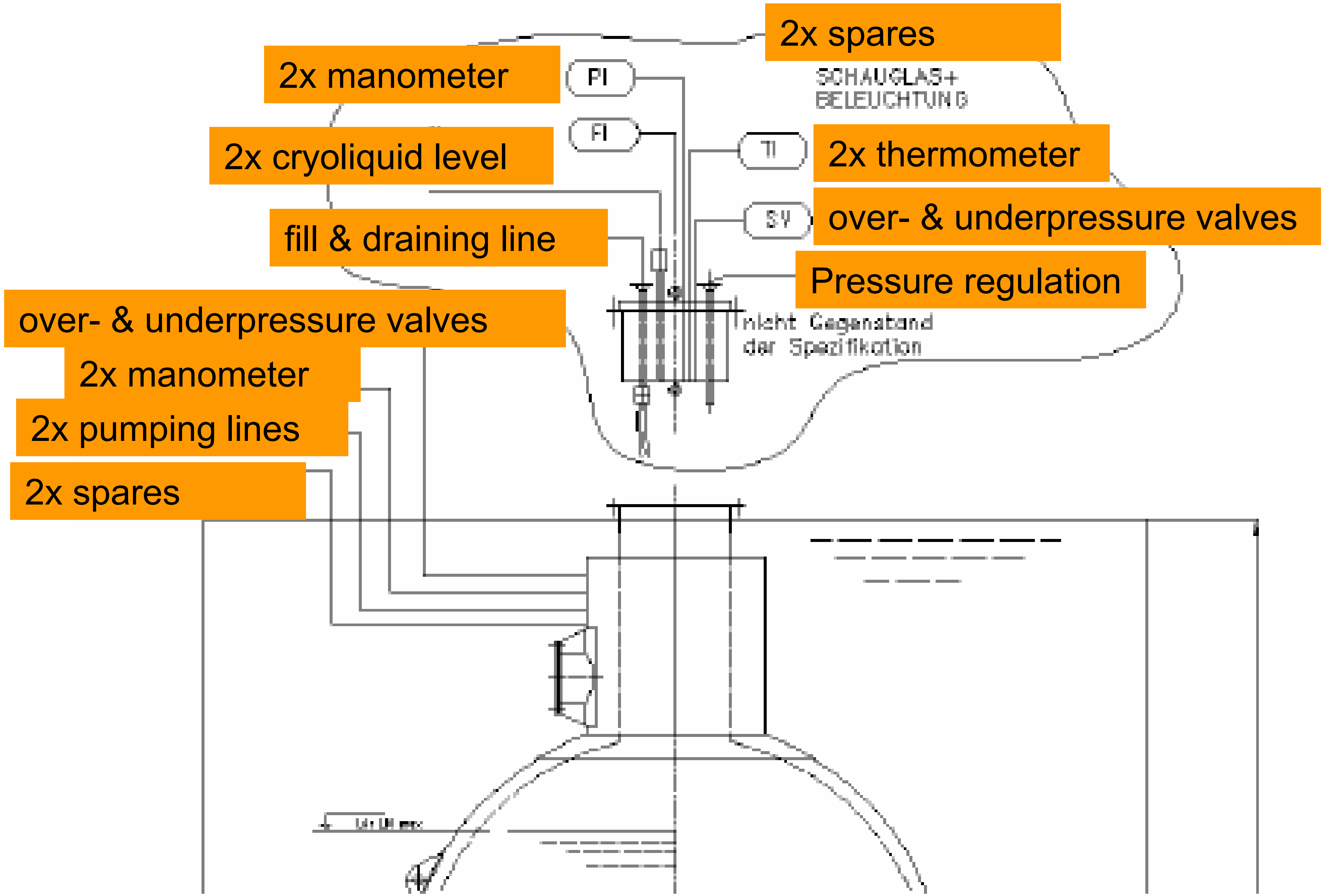
**Design fulfils requirement for thermal loss to be <0.2% / day.**

**even less for #1 with heat shield in ss neck**




**Finite element analysis proves earth quake tolerance of 0.6g vertical & horizontal.**

# Redundant Instrumentation



# Infrastructure Designed by Cryogenmash

| Item | D mm | Name |
|---|---|---|
| 1 | | Cryostat |
| 2 | | Water tank |
| 3 | | Tank V=10 m3 |
| 4 | | LN2 Evaporator |
| 5 | | Cryosorption pump |
| 6 | | Vacuum pump P=0.05 MPa |
| 7 | | Vacuum pump two-rotor P=1.10-3 torr |
| 8, 9 | | Heat exchanger |
| 10 | | Passive shielding (Cu) |
| 11 | | Detector |
| 01, 02 | | Nozzle (d=1mm |
| EH1 | | Heater N=15 kV |
| PR1 | | Pressure regulator |

| Item | D mm | Name |
|---|---|---|
| PR2 | | Pressure regulator P=0.1-0.2 MPa |
| S1, S2, S3, S4 | 30 | Safety valve |
| [illegible] | 65 | Hand drive valve |
| [illegible] | 25 | Hand drive valve |
| V5 | 30 | Hand drive valve |
| VU, VE0 | 25 | Three-way valve |
| VE1 | 6 | Hand drive valve |
| [illegible] | 10 | Instrument valve |
| VE3 | 6 | Electromagnetic valve |
| VE5 | 25 | Electromagnetic valve |
| VC1 | 10 | Overflow valve |
| [illegible] | 30 | Vacuum valve |
| RD1 | | Membrane unit |

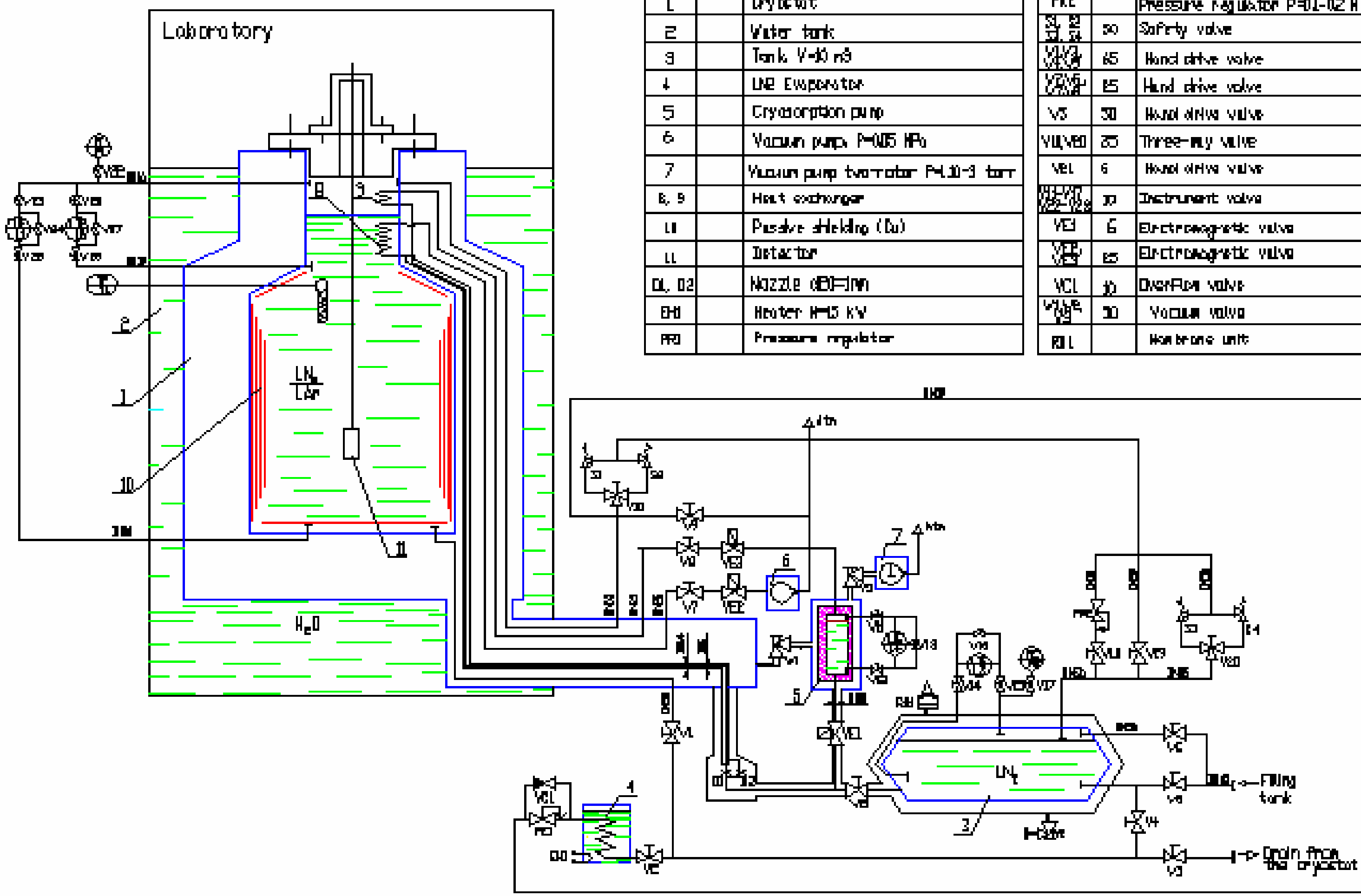
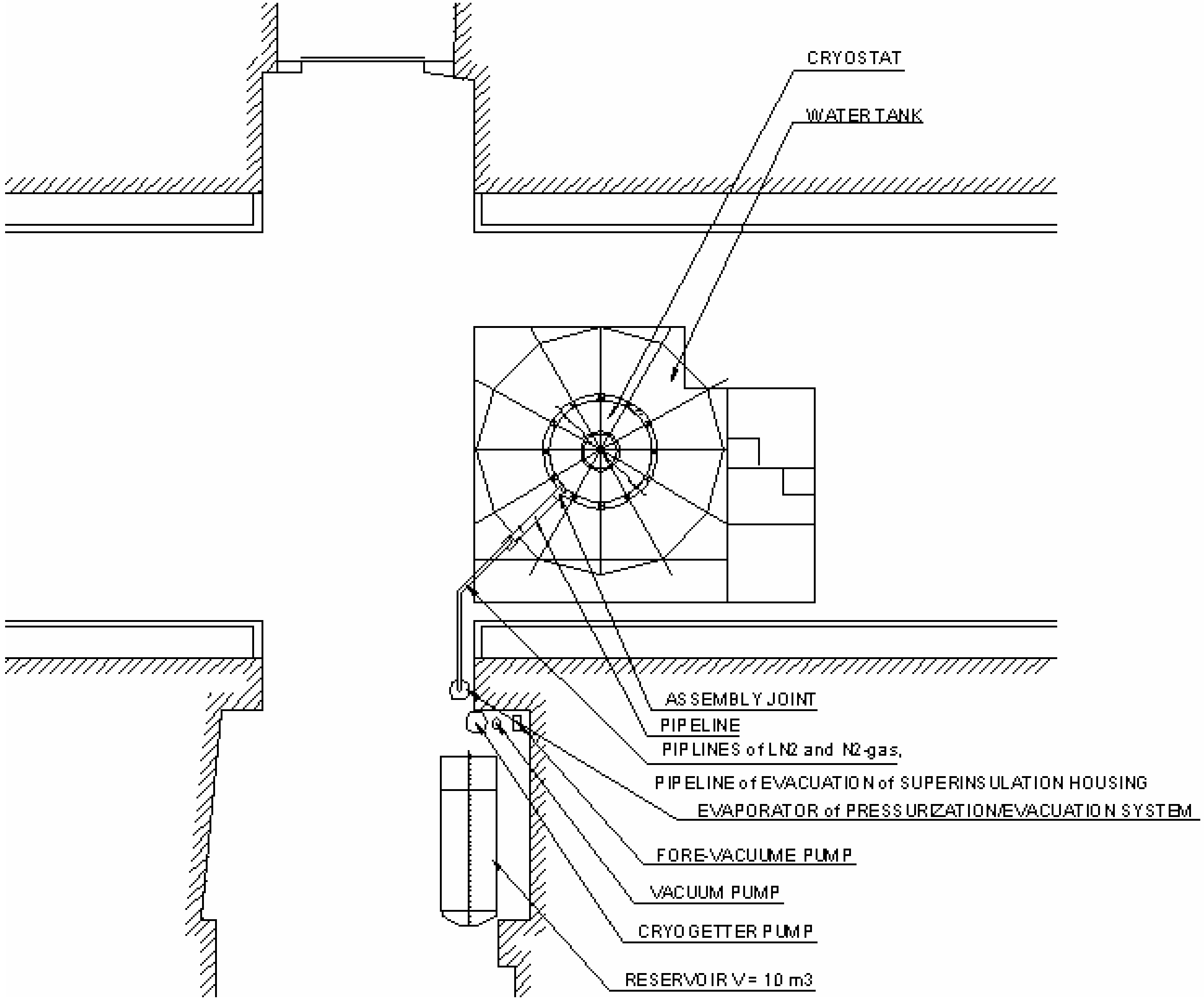



Fig. 1 – General scheme of LN2 supply of cryostat

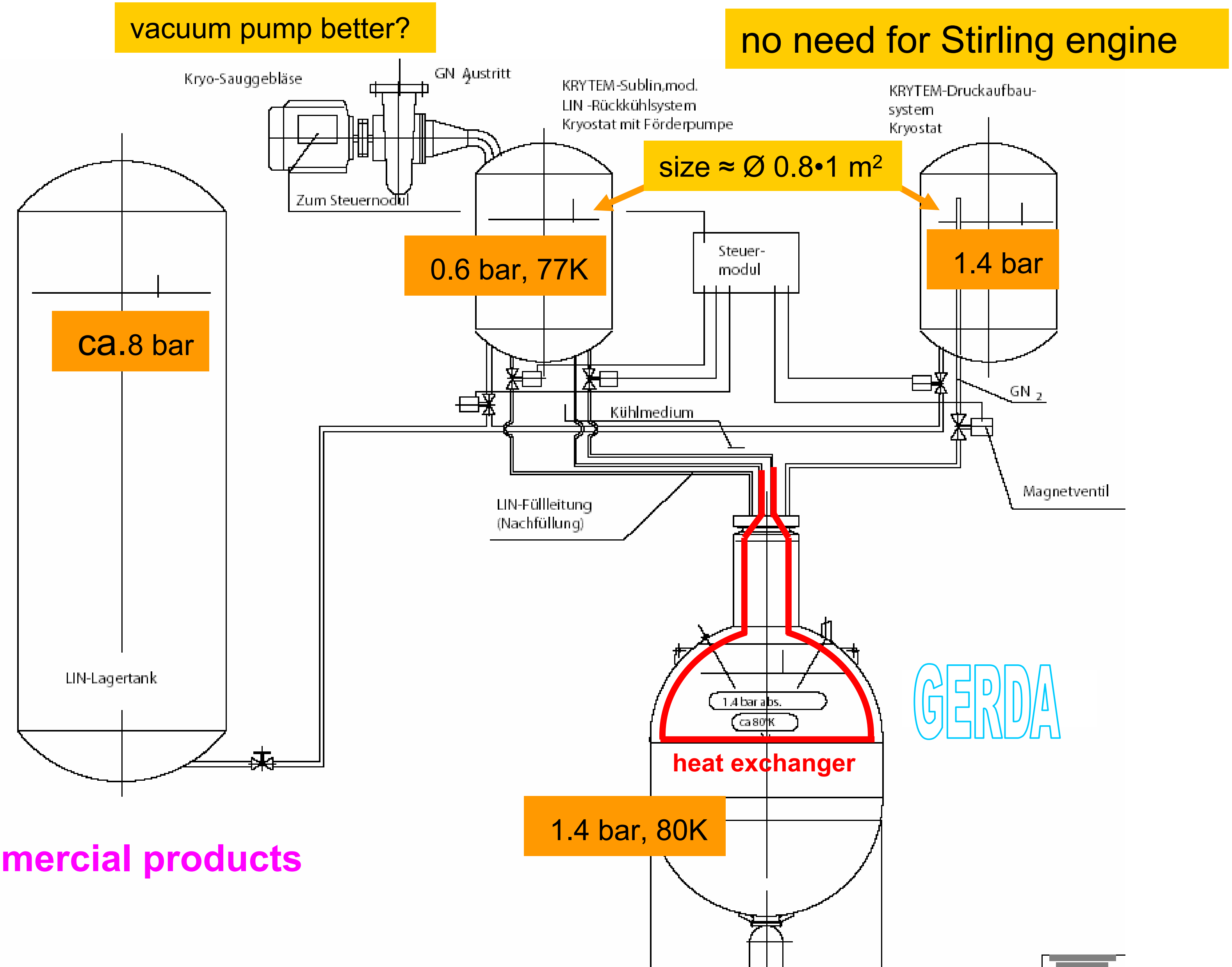
► more details in Vasily Kornoukhovs's talk

# Arrangement of Cryogenmash Infrastructure in Hall A



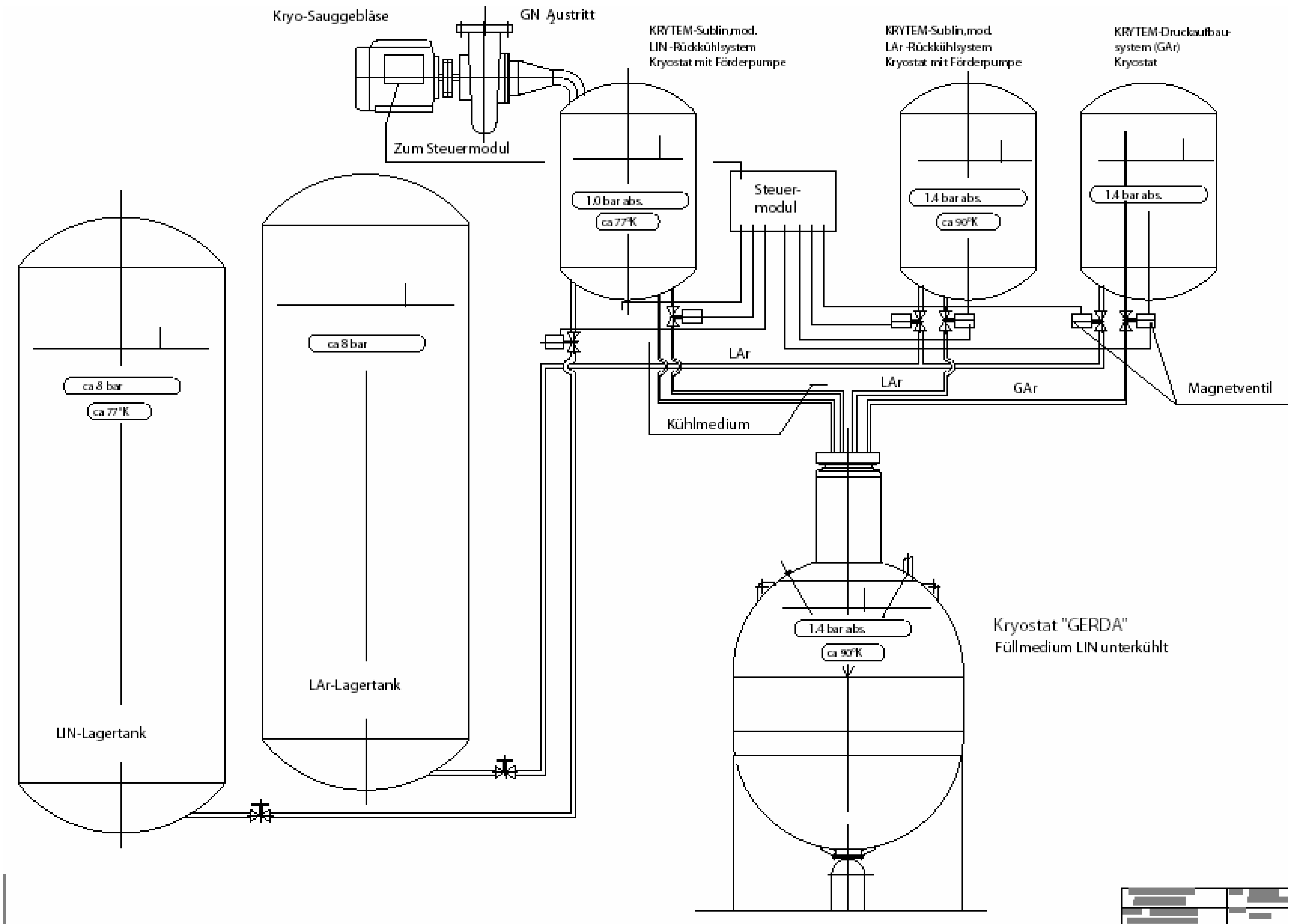

► more details in Vasily Kornoukhovs's talk

# Infrastructure: Re-fill and Cooling System for LN




all commercial products

# Infrastructure: Re-fill & Cooling System for LAr



# Material Screening

- superisolation foil

  two samples – scheduled for measurements

- HGW = GFP (glass fiber enforced plastic) for pads

  γ-counting with Ge-diode in progress

- CuP granulate – needed for production of DHP copper

  Baksan : in progress
  HD done : < 3 mBq/kg (preliminary)

  Oxygen-free DHP copper is produced by adding 150 to 400g of phosphorus (P) per ton Cu. - CuP granulate has 10(weight)% P.

  If 2g of CuP are added to 1 kg Cu and A(CuP) = 5 mBq/kg
  ► DHP copper activity is increased by 10 μBq / kg.

  ► DHP copper fulfils radiopurity requirement for cryostat!

# Remarks on Safety

# Risks of Cryostat in Water Vessel

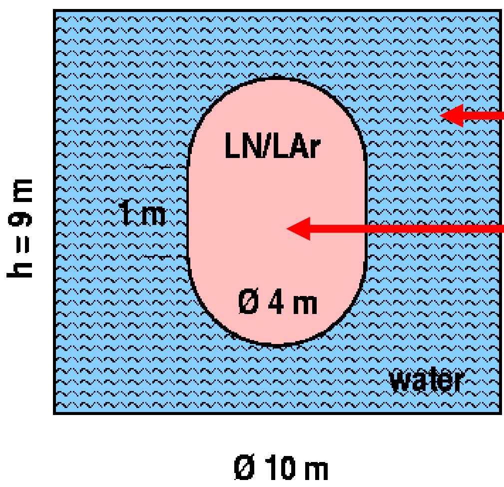
**Possible Failures:**

- **loss of vacuum for superisolation**
- **leak in outer vessel**
- **leak in inner vessel**
- **leak in both vessels**

**Consequences ?**

**Possible reactions:**

- **drain of cryoliquid ?**
- **drain of water ?**




**A few characteristic numbers:**

**660 m$^3$ $H_2O$**

**46 m$^3$ LN / LAr = 37 / 64 tons LN / LAr**
**= 32.000 / 39.000 m$^3$ $N_2$ / Ar gas**

**LNGS ventilation : 40.000 m$^3$ / h**

# Loss of Vacuum for Superisolation

apparent λ between 77 & 300 K
( mW / m•K)

- $N_2$ gas 17
- vacuum 5
- evac. perlite 1-2
- fiberglass 2
- superisolation (1.7 – 4)•$10^{-2}$

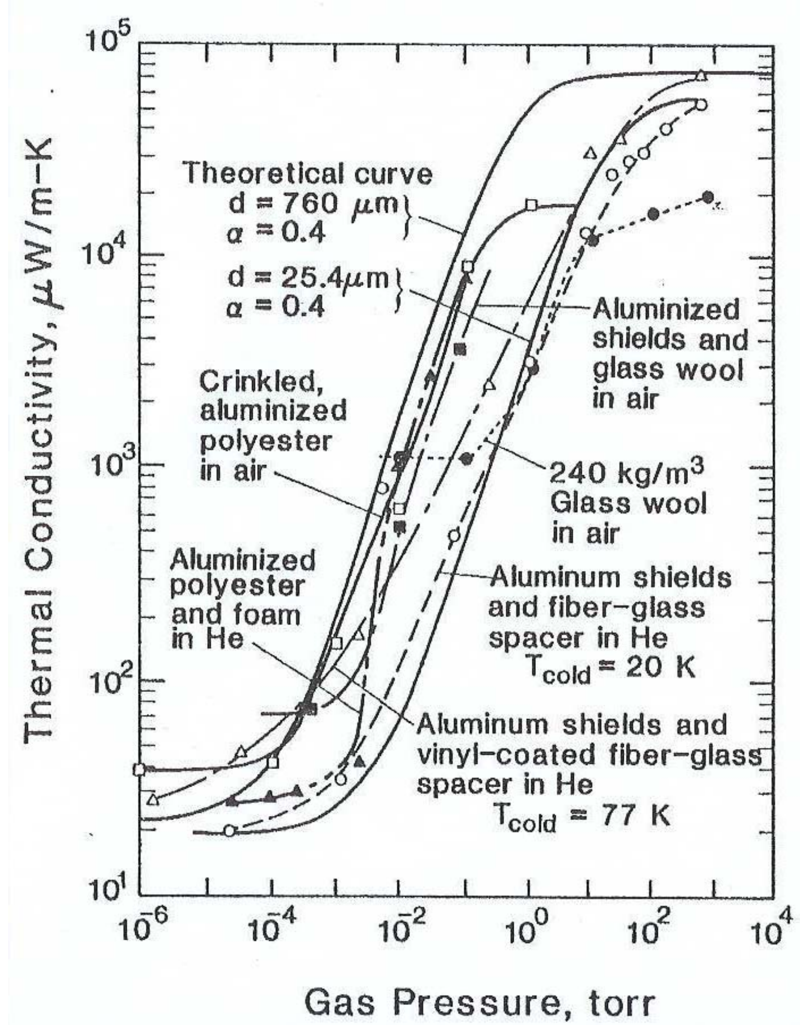
**assume loss factor of 700 !**

- **nominal loss 0.2% / day ≈ $10^{-4}$ / h**

**► loss of vacuum: 7% / h**
**► vessel will be empty after ≈14 hrs**

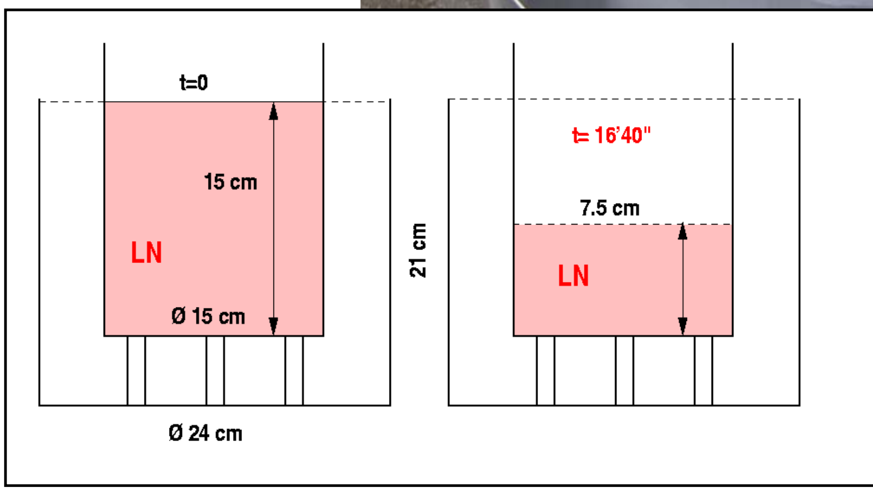
**► maximum gas load : ≈ 2800 $m^3$ / h**

**► ok for ventilation of 40.000 $m^3$ / h !**




Effect of gas pressure on thermal conductivity of superisolation
(Timmermans & Flynn, p.389)

# Test 1



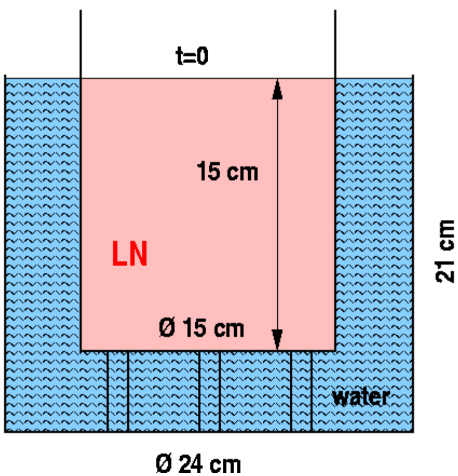
**scaling factor GERDA / test : 24.4**

**► 24.4•2•16,7' = 13.6 hrs  (agrees too well)**

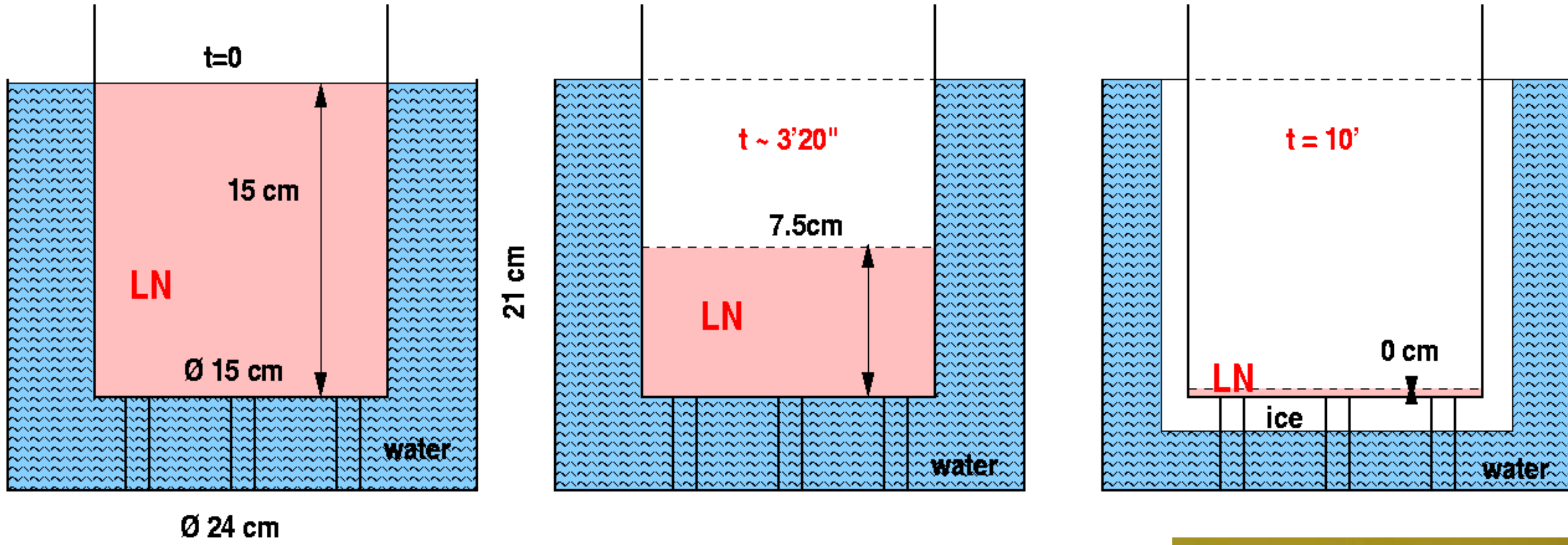
# Test 2 - Leak in Outer Vessel







# Leak in Outer Vessel




same scaling factor GERDA / test : 24.4

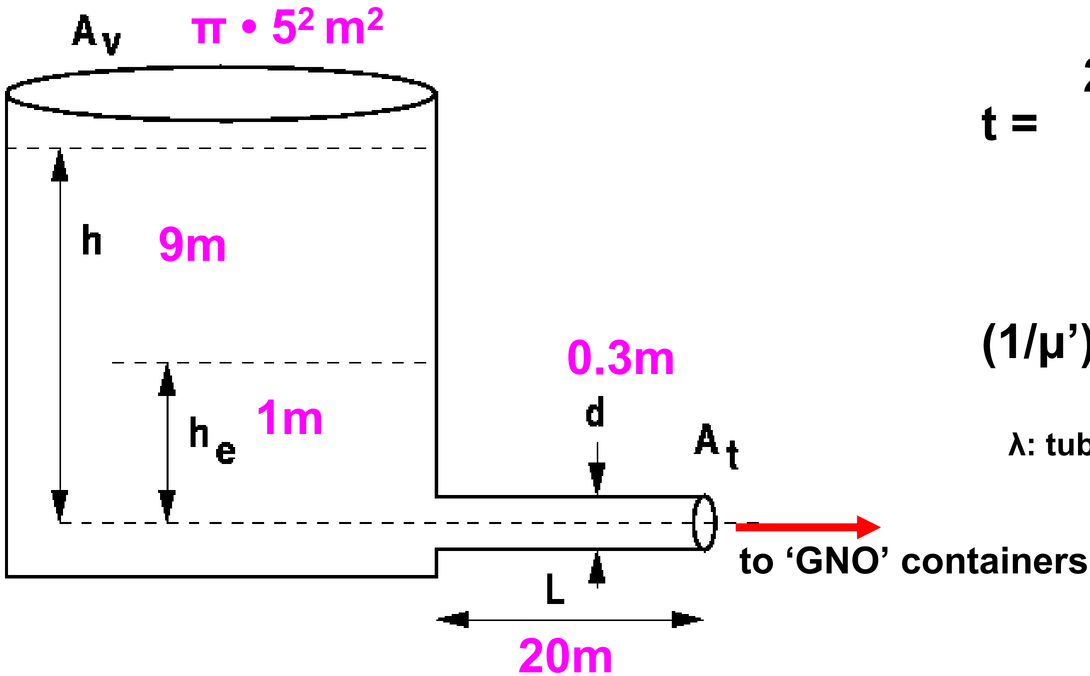
• half of vessel emptied after 1.4 h

▶ 11.000 $m^3$ / h gas load – peak load higher!

• vessel completely emptied after 4 hrs
(isolating ice)

▶ fast – <0.5 hrs - emptying of water vessel desirable

# How to Empty the Water Wessel Really Fast?




$$t = \frac{2 \cdot A_v \cdot (\sqrt{h} - \sqrt{h_e})}{\mu' \cdot A_t \cdot \sqrt{(2g)}}$$

$$(1/\mu') = \sqrt{1 + \lambda \cdot (L/d)}$$

$\lambda$: tube roughness : assume 0.02!

W.Bohl: Technische Strömungslehre

t ( 9m – 1m) ≈ 25’

**Fast emptying of water vessel seems possible.**

**► Optimize tube(s) and water volume!**

# Time Schedule & ....

**Proposal:** 2005 Mar: system design finalized

May: safety reviewed, materials screened, **cryostat ordered**

2006 Jan: cryostat installed

**Actually:**

- Copper cryostat seems feasible, 2 designs available
- Material screening in progress, DHP copper acceptable
- Design of infrastructure in progress, various options emerging

- Prior information notice about contract for cryostat and infrastructure published in SIMAP
- Start of award procedure at March 15.

**SIMAP-MPI-K 31 Jan'05 10:25 - ID:2005-002331**

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Publication of Supplement to the Official Journal of the European Communities
2, rue Mercier, L-2985 Luxembourg
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## PRIOR INFORMATION NOTICE

Works ☐
Supplies ☑
Services ☐

Reserved for the Publication Office
Date of receipt of the notice ______________
Identifier ___________________________

**Is this contract covered by the Government Procurement Agreement (GPA)?** NO ☐ YES ☑

## SECTION I:CONTRACTING AUTHORITY

....etc...................

## SECTION II: OBJECT OF THE CONTRACT

SUPPLIES ☑
SERVICES ☐

**II.1) TITLE ATTRIBUTED TO THE CONTRACT BY THE CONTRACTING AUTHORITY ***

Superinsulated copper cryostat for liquid nitrogen and/or argon including auxiliary equipment

**II.2) NOMENCLATURE**

**II.2.1) Common Procurement Vocabulary (CPV) ***

| | Main vocabulary | Supplementary vocabulary *(when applicable)* |
|---|---|---|
| Main object | **28212200** | -- |
| Additional objects | **28212000** | -- |

....etc...................

# .... & Next Steps (incomplete To-Do-List )

- **Get OK for GERDA installation!**

  ► 1st step: Technical Proposal
  ► 2nd step: Safety Report
  ► ... steps: iterate

- Prepare technical specifications for tenders
- Start welding tests, Cu-Cu, ss-Cu - pro-beam facility at Burg now in operation
- Evaluate quotes of interested companies
- Decide on cryostat design and infrastructure wanted
- Order DHP copper for cryostat
- Decide on vessel cleaning procedure
- Verify Ø 4m for vessel transportation
- ......

# Conclusions

- Further obstacles for copper cryostat removed

  ✓ radiopurity of DHP copper <25 µBq / kg Th-232
  ✓ earthquake tolerance 0.6g horizontal & vertical
  ✓ thermal loss < 0.2% / day

- 'Prior Information Notice' for purchase published
  ► SIMAP-MPI-K 31 Jan'05 ID:2005-002331

- Definition of cryogenic infrastructure in progress
  ► space requests to be clarified asap!

- URGENT: Technical Proposal for Safety Review/Report!