GERDA TG4 – Cryogenic Vessel

Status Report

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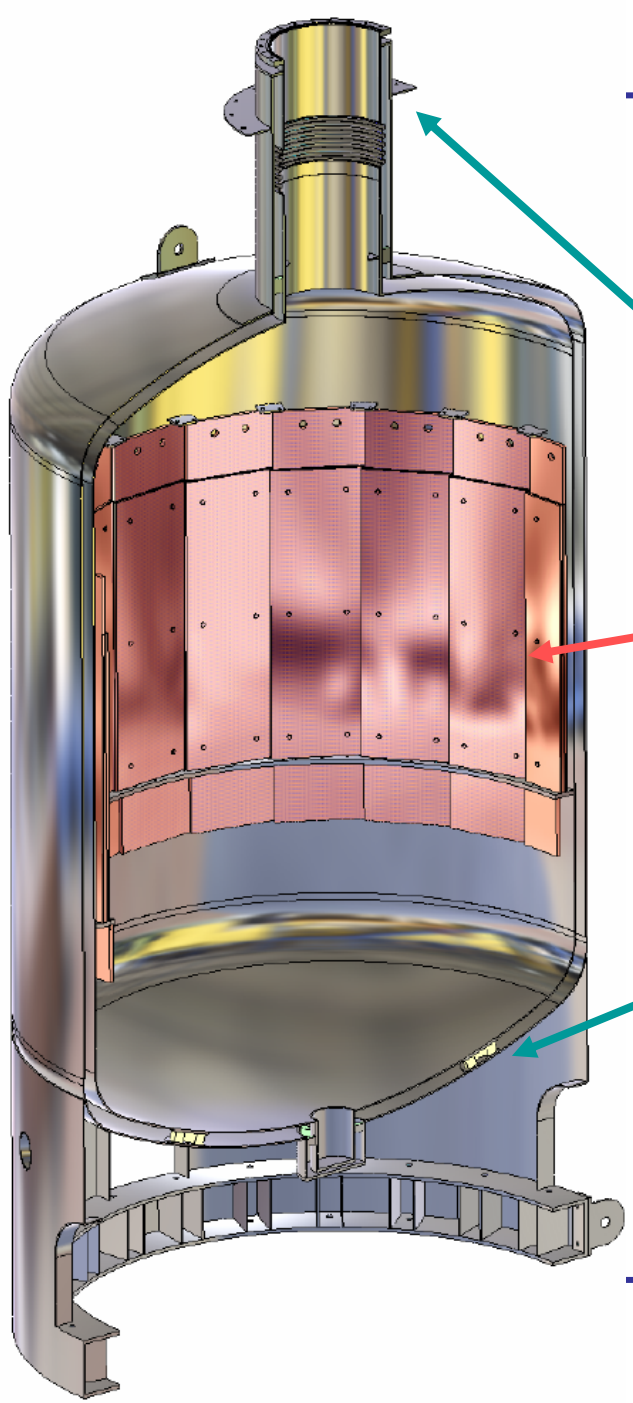
GERDA Collaboration Meeting at Ringberg
12 – 14 February 2007

Outline



Cryostat Order History & Status

Stainless steel sheets
Internal Copper shield

Safety Review

New Design Details

Schedule

Order History and Status

2006

- Aug 11 : TED publication 164333-2006 for tender of dto. **based on** Technical Specification V1.0 of August 08 (www.mpi-hd.mpg.de/GERDA/NTS-V10.pdf with drawing GC-1001-2006-5.pdf(dwg))
- Sep 29 : Deadline for quotes, 5 quotes for cryostat received, 1 for MLI
- Nov 06/11 : Contract signed by MPI / SIMIC

- Jul 25 : Order of 1.4571 sheet material for vessel heads and walls sheets, ~ 23 tons, at Nironit .
- Aug 8 : Order of vessel heads at Antonius, NL.
  - ► Production time 7 weeks after delivery of material; material delivered Nov 8 (a bit late) !
- Nov 10 : Order of 20 tons of copper at NA for internal shield

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2007

- Jan : all 1.4571 sheet material delivered to SIMIC incl. t=25mm sheets
- Feb 02 : Final amount of copper (22.2 tons) ordered at NA; rolling of t=30 mm copper plates ordered at CSN.

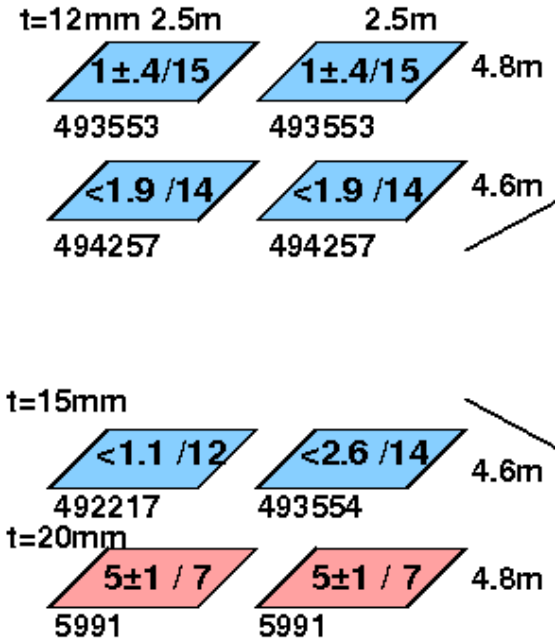
- Feb 12+x : start of vesselhead production at Antonius, delay > 2 months.

Internal Copper Shield

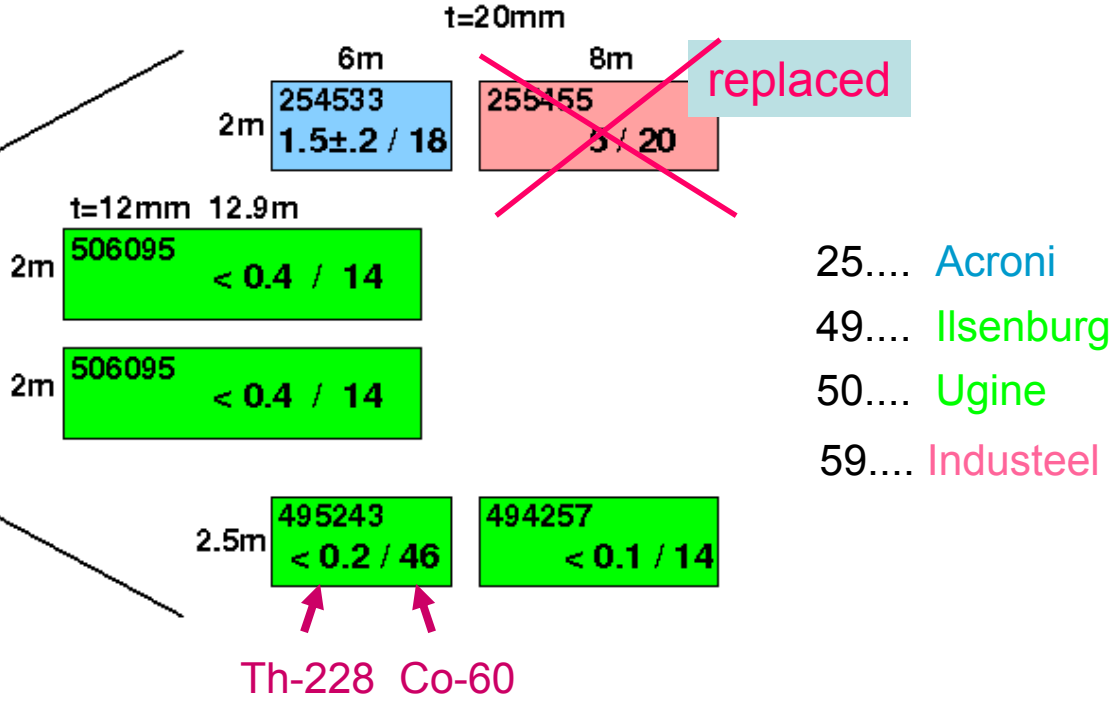
Amount of copper shield determined by radiopurity of ss sheet material:
typically 8, 23, 41 tons for 10, 3, 1 mBq(Th-228)/kg !

MEASURED ACTIVITY of SHEET MATERIAL for

vessel heads (<10 mBq/kg! – MPI HD)



cylindrical walls (<5 mBq/kg! - LNGS)



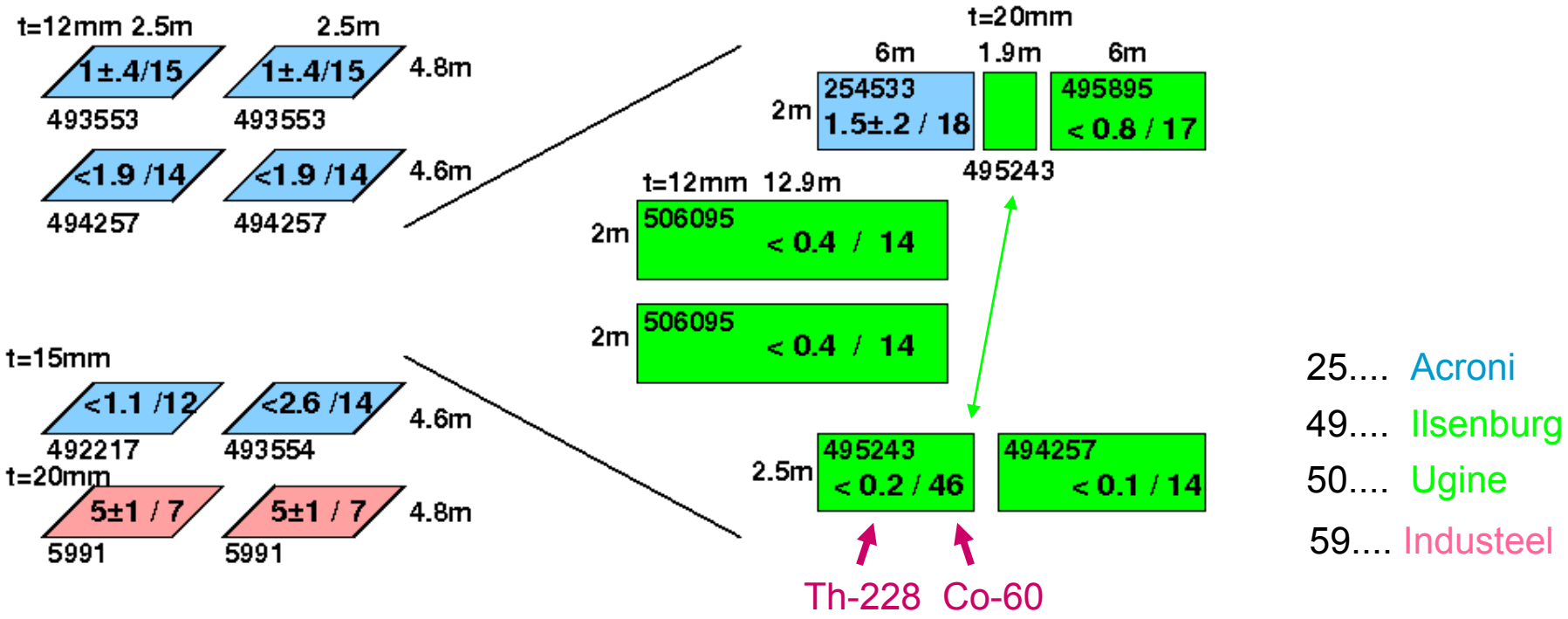
25.... Acroni
49.... Ilsenburg
50.... Ugine
59.... Industeel

Big γ counting project at LNGS and HD ► Many thanks to Matthias and MPI team!

Internal Copper Shield

MEASURED ACTIVITY of SHEET MATERIAL for

vessel heads (<10 mBq/kg! – MPI HD) cylindrical walls (<5 mBq/kg! - LNGS)



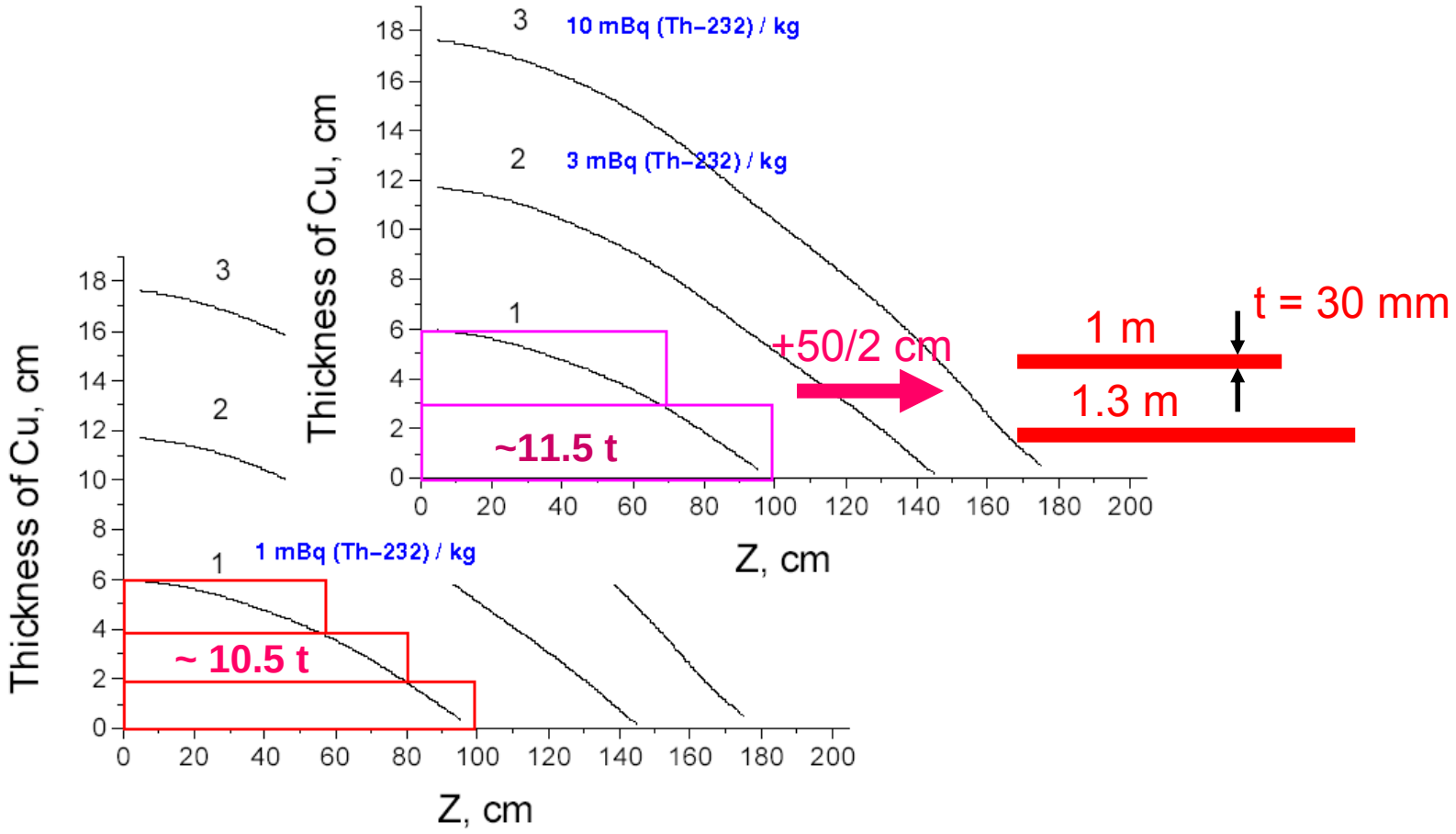
► 25 mm plate for support ring etc. also ok :

#496895 Th-228 / Co-60 : < 1 / 17

also ok: welding material

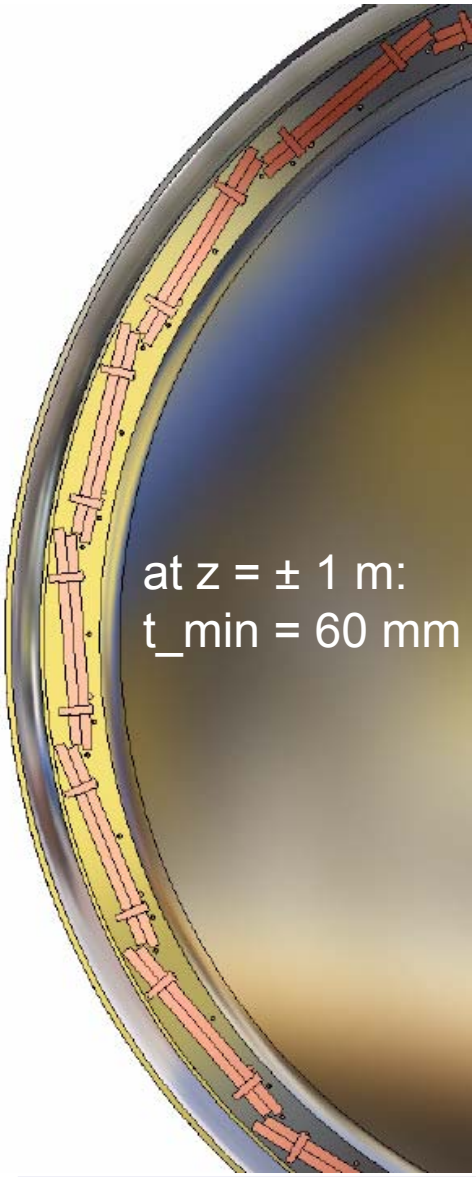
to be screened: superinsulation (Jehier), Makrolon (all samples available).

Copper Shield Profile



Profile calculations for LAr by I.Barabanov et al.

Internal Copper Shield - Realization



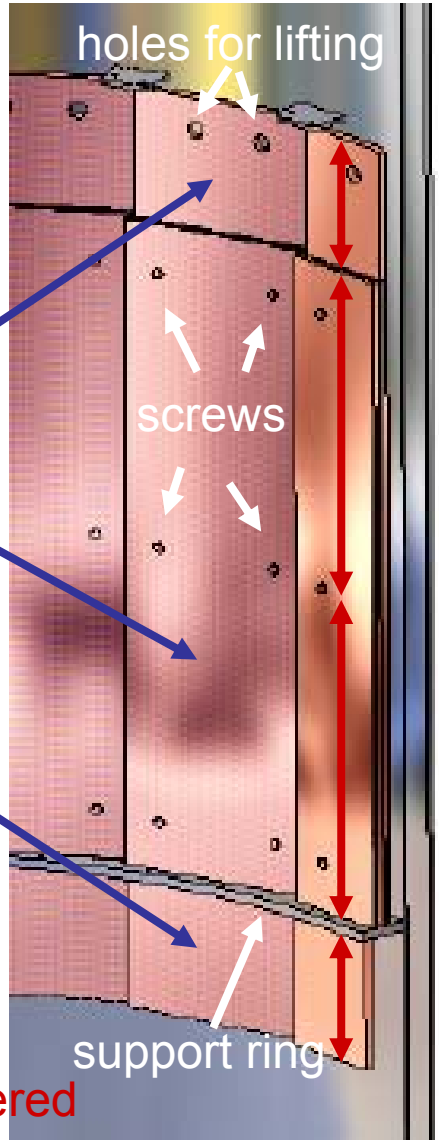
20 segments (16.14 t)

one segment (2 pieces):

1) 2400x630x30 mm (404 kg)
2) 2000x630x30 mm (336 kg)

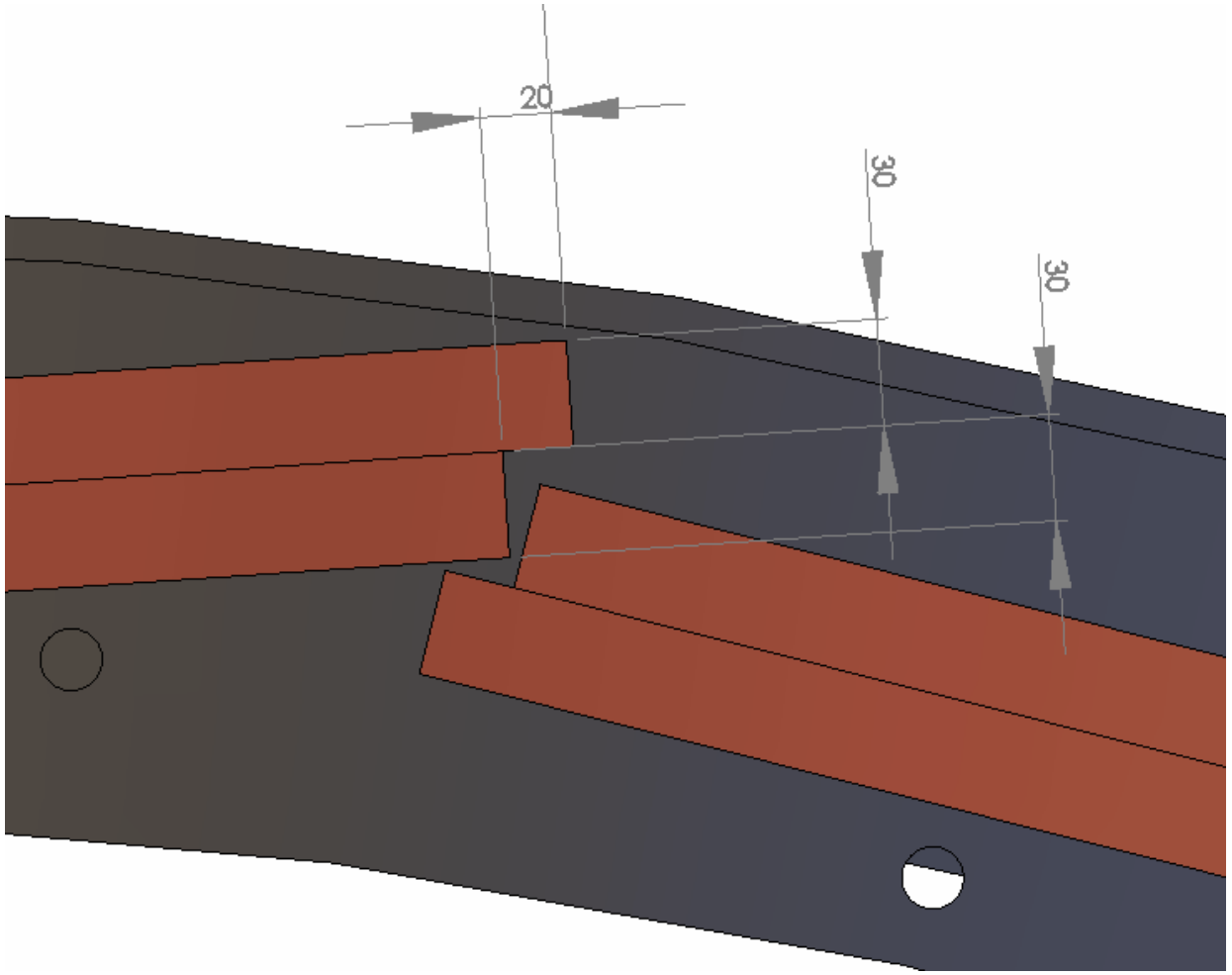
1) & 2) screwed together

3) 400x630x30 mm (67 kg)

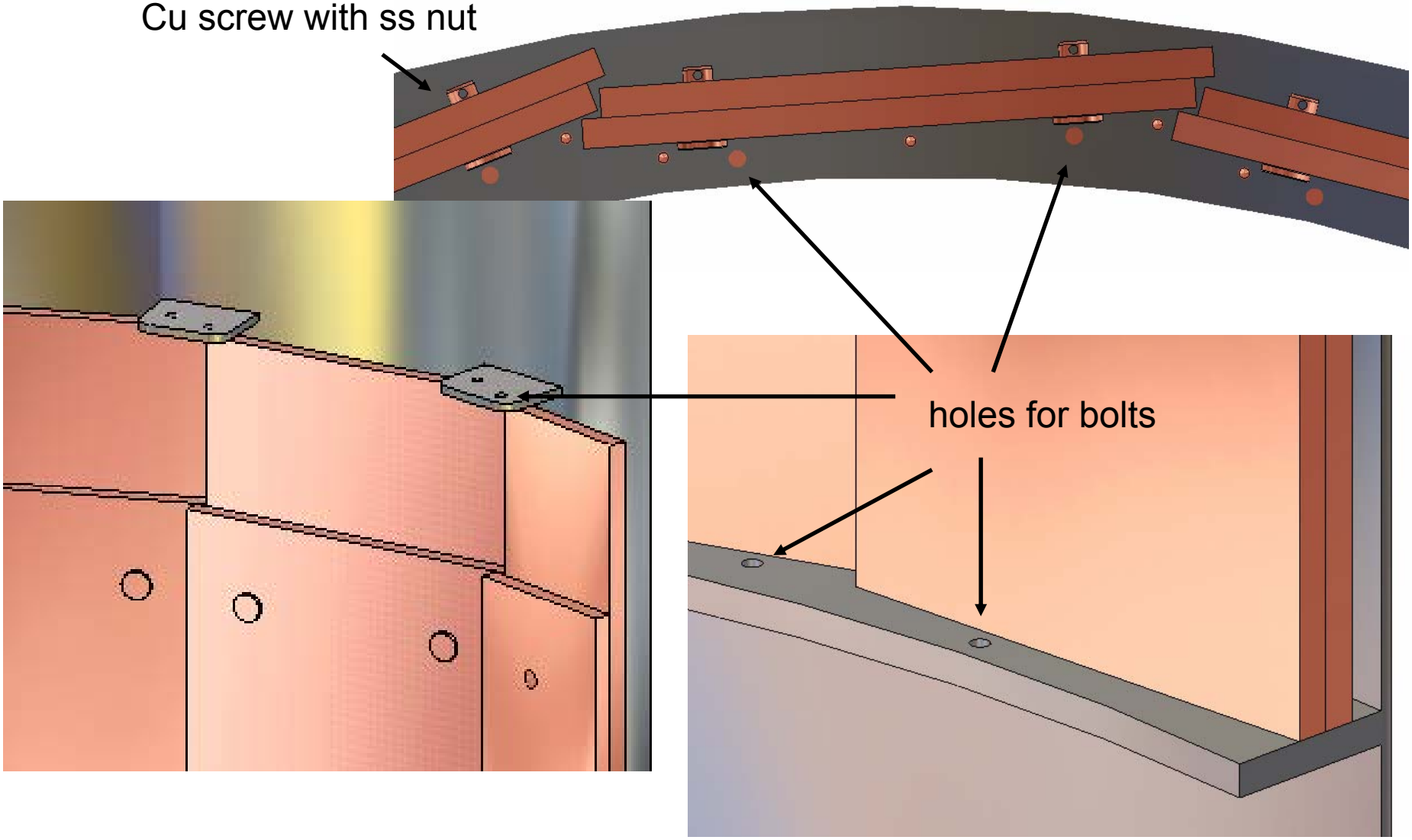


OFPR copper (NA) & rolling (CSN) ordered

Upper Segments - Overlap



Upper Segments - Fixations



New Safety Review (2006)

- May 29: A. Scaramelli outlines need for new safety review, new system!
  Proposes NIER Engineering, Bologna, which did review for many other LNGS experiments.
- Work on Version 0.2 of Technical Proposal for Safety Review in progress ► www.mpi-hd.mpg/GERDA/TPRO.html
- Jun 15: Safety meeting at LNGS, with LNGS safety experts, NIER representatives & GERDA representatives ► focus on study of top events.
- Jul 20 : Meeting with NIER at Bologna; preliminary report:
  ► 3rd wall helpful but not indispensable!
- Sep 19: Meeting at CERN, announced as final – but new information
  ► evaporation rate must be less than 10000 m³/h (by factor 3 reduced)
  ► request to provide more information on time dependence of rate
- Oct 05: Report on evaporation rate and its reduction to 10000 m³/h delivered
  ►heat transfer for LAr deduced from experiments done at MPI HD

- Nov 16: Meeting at Bologna of Carla and KTK with NIER A; final clarifications
- Dec 06: Draft of final NIER risc analysis delivered : 3 parts,
  see new GERDA safety document page
  ► www.mpi-hd.mpg/GERDA/internal/index.html -> Safety Documentation

GERDA Safety Documentation Webpage

Safety Documentation

Implemented by recommendation of GERDA Board.

Please provide your safety relevant documents to our GLIMOS, Marco Balata, or to the Technical Coordinator!

General

Technical Proposal, Version 0.2, Draft of 23 June 2006 pdf

Risc Analyses

NIER Preliminary Risc Analysis, Final Versions, December 2006
NIER: Cryogenic and Water Tank System, Risc Analysis, Technical Analysis - Phase 2, 13 Sep 06, Rev. 1 pdf
NIER: Cryogenic and Water Tank System, Risc Analysis, Technical Analysis - Phase 2, 08 Sep 06, Rev. 0 (italian) pdf
NIER: Cryogenic and Water Tank System, Preliminary Risc Analysis, Technical Analysis - Phase 1, 08 Sep 06, Rev. 3 pdf
NIER: Cryogenic and Water Tank System, Preliminary Risc Analysis, Technical Analysis - Phase 1, 07 Sep 06, Rev. 2 pdf
NIER: Annex_1, References for failure rate data pdf

TÜV Nord: GERDA cryostat & Basissicherheit, 07 Jul 2005 pdf
Air Liquide: Safety Relief Devices, Calculation Note pdf
Air Liquide: FMECA report for Cu cryostat, 01 Jul 2005 pdf
Air Liquide: HAZOP report for Cu cryostat, 01 Jul 2005 pdf
Piping and Instrumentation Diagram, 24 Jun 2005 tif

Water Tank and Auxiliary Plants

Cryostat

Details of GERDA cryogenic vessel insulations, Draft of 22 Jan 2007 pdf
Model Studies of the Gas Exhaust Rate for a Failure Scenario of the GERDA Cryostat, Draft of 05 Oc
Technical Specification - Cryogenic Liquid Nitrogen/Argon Vessel, 8 Aug 2006 pdf
Stainless Steel Cryostat Drawing GC-1001-2006-05 pdf or dwg
1.4571 data sheet pdf
welding test Antonius Vesselheads
Stainless Steel certificates pdf
Calculations for cryostat pdf

Superstructure

Safety Documents and Information from LNGS

Prevention & Protection Service includes Admittance Rules, Safety Guide, LNGS Emergency Plan,

Operational Procedures Documents

Operational Procedure OPER-GE-001 R.3 pdf

Misc

Stainless Steel Data Sheets, Deutsche Edelstahlwerke
"Applying 'Basissicherheit' to the GERDA cryostat", GERDA safety meeting at LNGS, 5 Jul 2005
RSK-Leitlininien DWR - Rahmenspezifikation Basissicherheit von ... pdf

Effect of Volumetric Ratio and Injection Pressure on Water-Liquid Nitrogen Interaction pdf

New Safety Review (2007)

- Jan 15: Safety meeting at CERN, with LNGS safety experts, NIER representatives & GERDA representatives
  - ► final meeting on NIER risc analysis, all participants satisfied
    (summary docu: Details of GERDA cryogenic vessel insulations by KTK)
  - ► new 2nd opinion and LNGS concluding document to follow

NIER Phase 3: Additional Assessment

Indice

► next page

CONSEQUENCE → FREQUENCY ↓ a) occ/year b) Ev/h	MORTAL OR IRREVERSIBLE	MAJOR	SERIOUS	MINOR	NO RELEVANT EFFECT
Frequent a) > 1 ev/anno b) $<1.1*10^{-4}$/h					
Probable a) 10^{-1} /anno - 1/anno b) $5.7*10^{-6}$ /h – $1.1*10^{-4}$/h					
Occasional a) $3*10^{-3}$ /anno - 10^{-1}/anno b) $2.8*10^{-6}$/h - $5.7*10^{-6}$ /h					
Remote a) $3*10^{-2}$ /anno - $3*10^{-3}$/anno b) $2.8*10^{-7}$/h - $2.8*10^{-6}$/h				Evento N° 1	Evento N° 2
Improbable a) $3*10^{-4}$ /anno - $3*10^{-3}$/anno b) $5.7*10^{-8}$/h - $2.8*10^{-7}$/h					Evento N° 5 Evento N°8
Not Credible a) < $3*10^{-4}$/anno b) < $5.7*10^{-8}$/h		Evento N° 6 Evento N° 3	Evento N° 10		Evento N°9

N.B. = Top 1, Events 7 and 11 are not considered in the table because of their occurrence frequencies that are lower than the category "extremely unlikely"

New Safety Review (2007)

NIER Phase 3: Additional Assessment

Indice

F Conclusions and suggestions

All the accidental conditions analysed and evaluated within a probability range of occurrence with a $10^{-4} \div 10^{-5}$ ev/year limit, appear to be suitably protected and to have acceptable consequences.

1

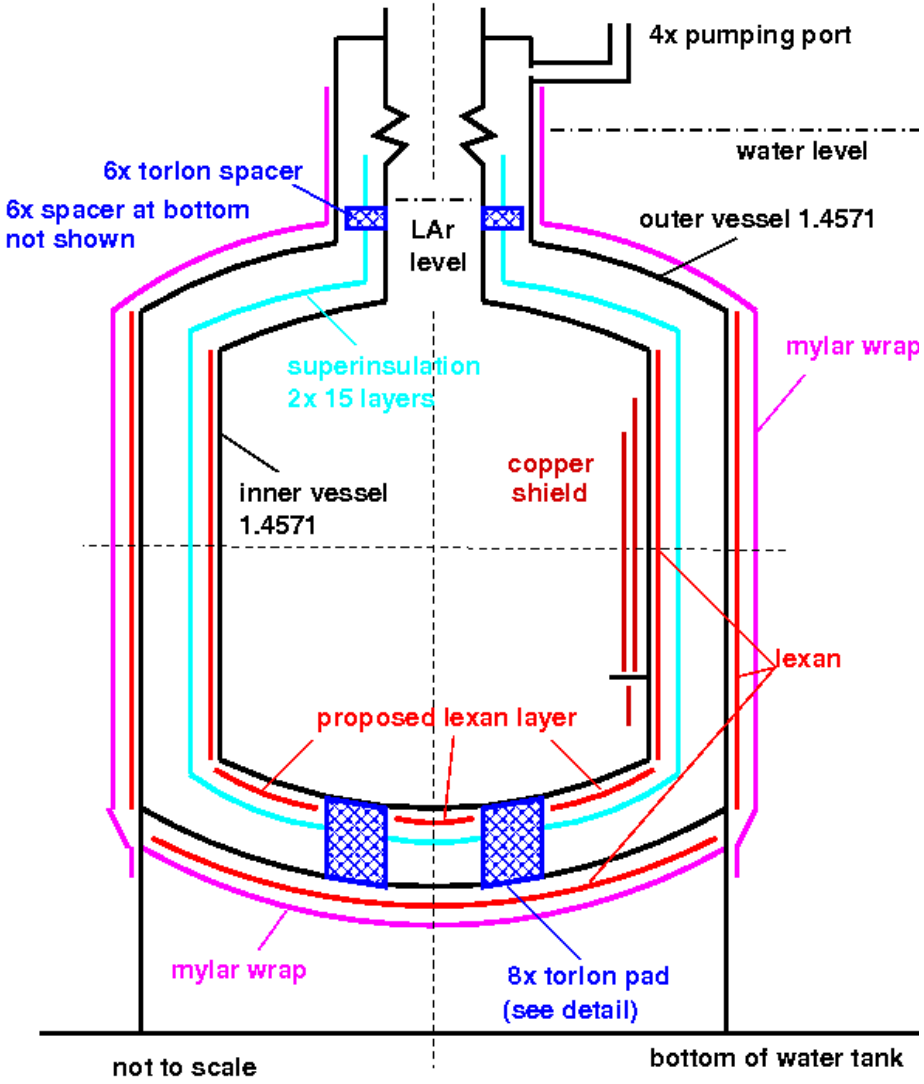
Some aspects of the Water Tank – Cryostat system require a final clarification in the right context. This means that it is necessary to specify the final characteristics, the placing and the fixing of the two layers as foreseen. To this purpose we suggest placing the two layers also in the bottom area if possible, as they appear to be useful.

2

3 Lastly, we suggest once more the differentiation of the staffs in charge of the tests and of the inspections.

Cryogenic Vessel Insulations

figure shown / discussed at CERN meeting:

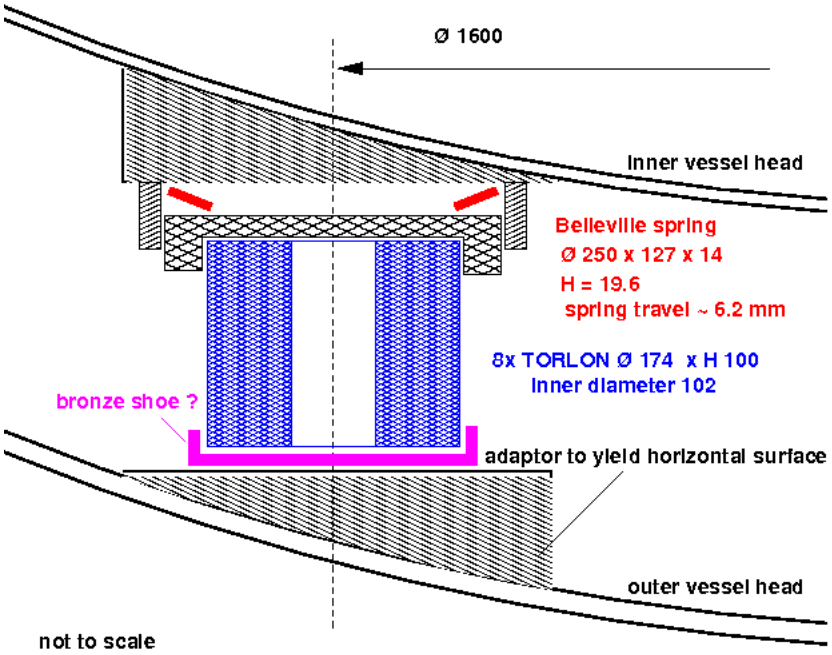


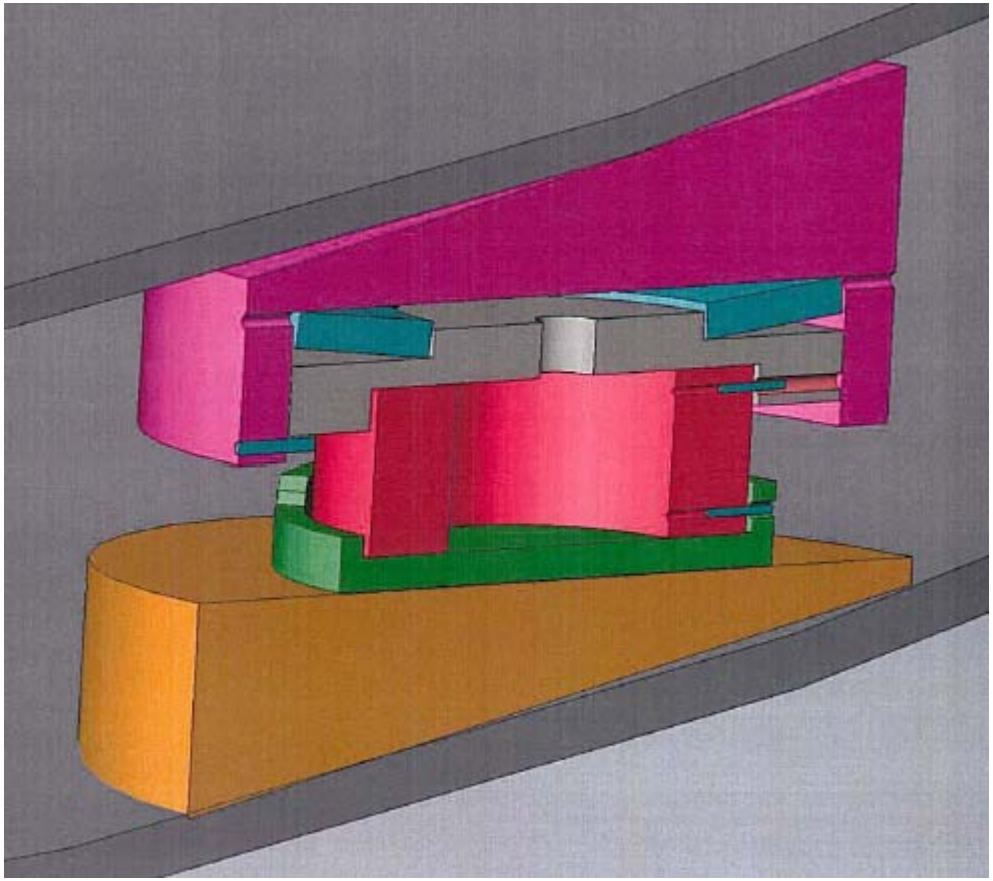
Agreement about implementation of various shields resp. barriers :

- inner vessel - horizontal shell: Makrolon thermal shield, 6mm
- outer vessel - all in contact with water : styrofoam, Makrolon 2x 3mm, mylar wrap (not finally fixed)

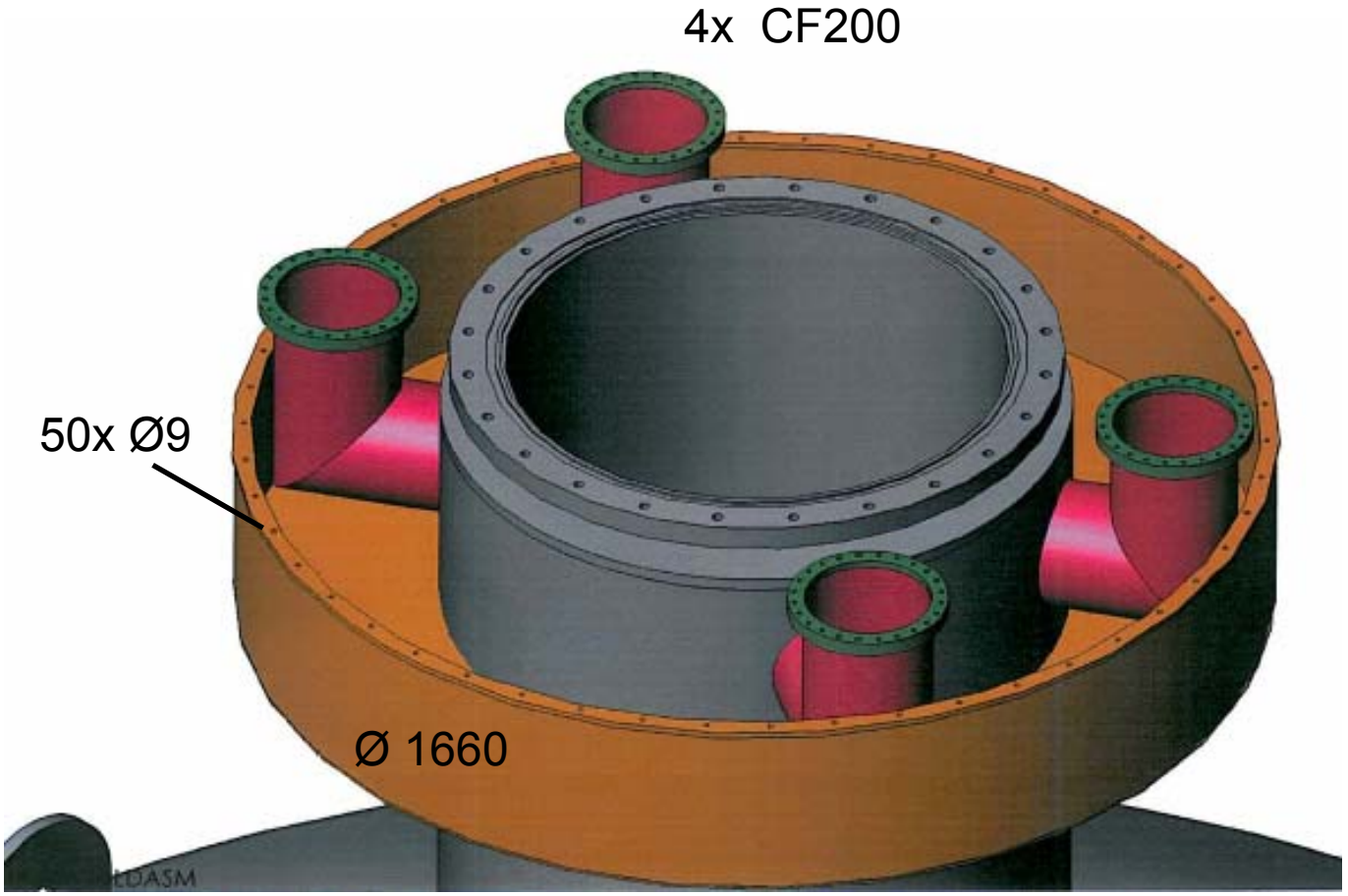
Layout of the 8 Torlon Support Pads

figure shown / discussed at CERN meeting:



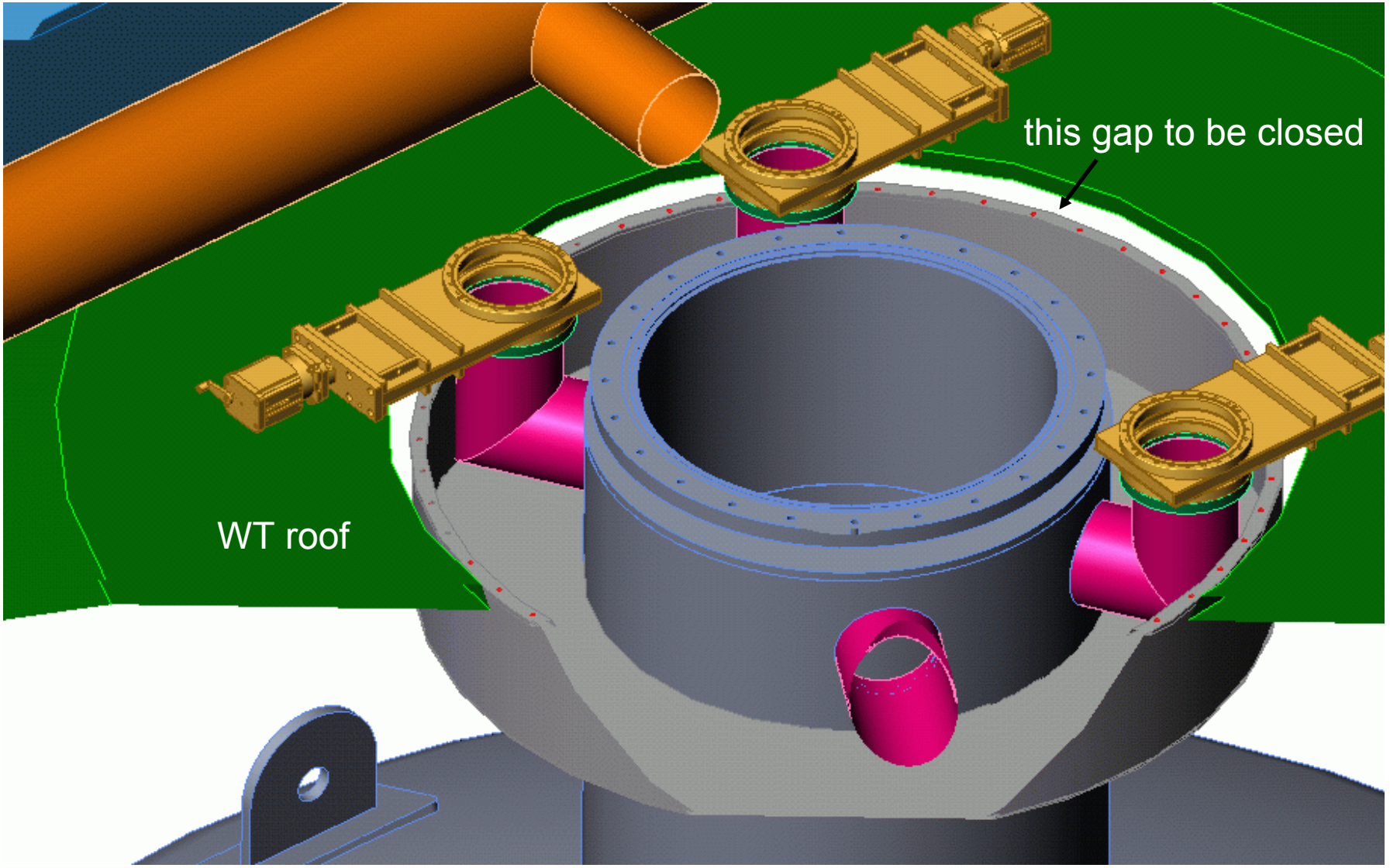


New Layout of Pumping Ports

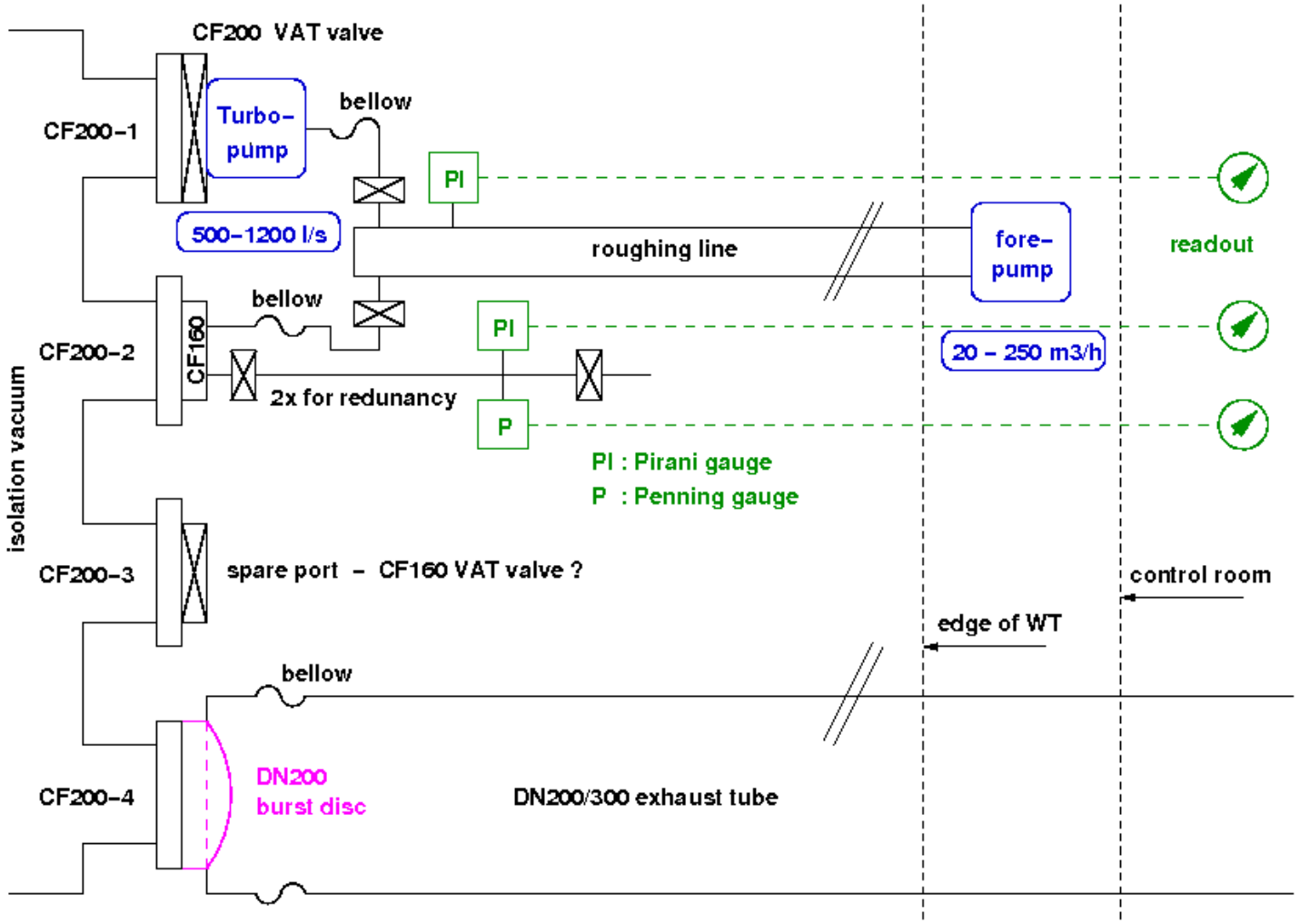


► optimum interface to WT roof

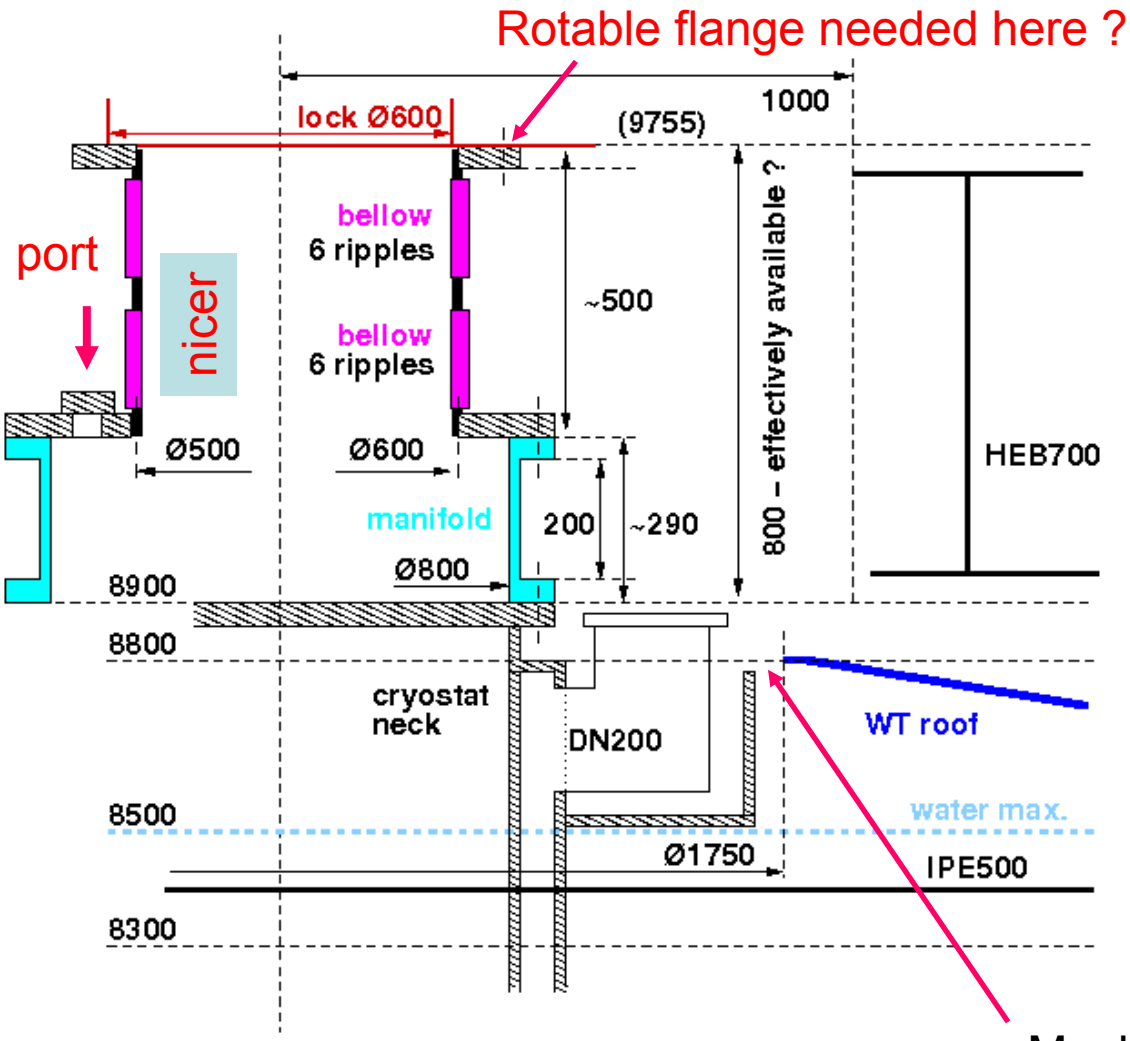
Interface WT - Cryostat



Isolation Vacuum System



Interface Cryostat – Lock – Water Tank



Critical issue: SPACE

Needed for:

1) soft bellow – implies minimum length

2) manifold & exhaust tubes

Much easier now to close this gap !

Bellow between Lock & Manifold

$t_{corrugation}$ = 0.6 mm

Material 1.4571

Ø 613 (677) mm H : 500 mm

- ► ± 80 mm axial, 73 N / mm
- ► ± 20 mm lateral, 268 N / mm (1000 cycles 2-fold safety)

or

- ► ± 25 mm lateral, 268 N / mm (150 cycles 5-fold safety)

certified for 1.5 bar overpressure and 77 K.

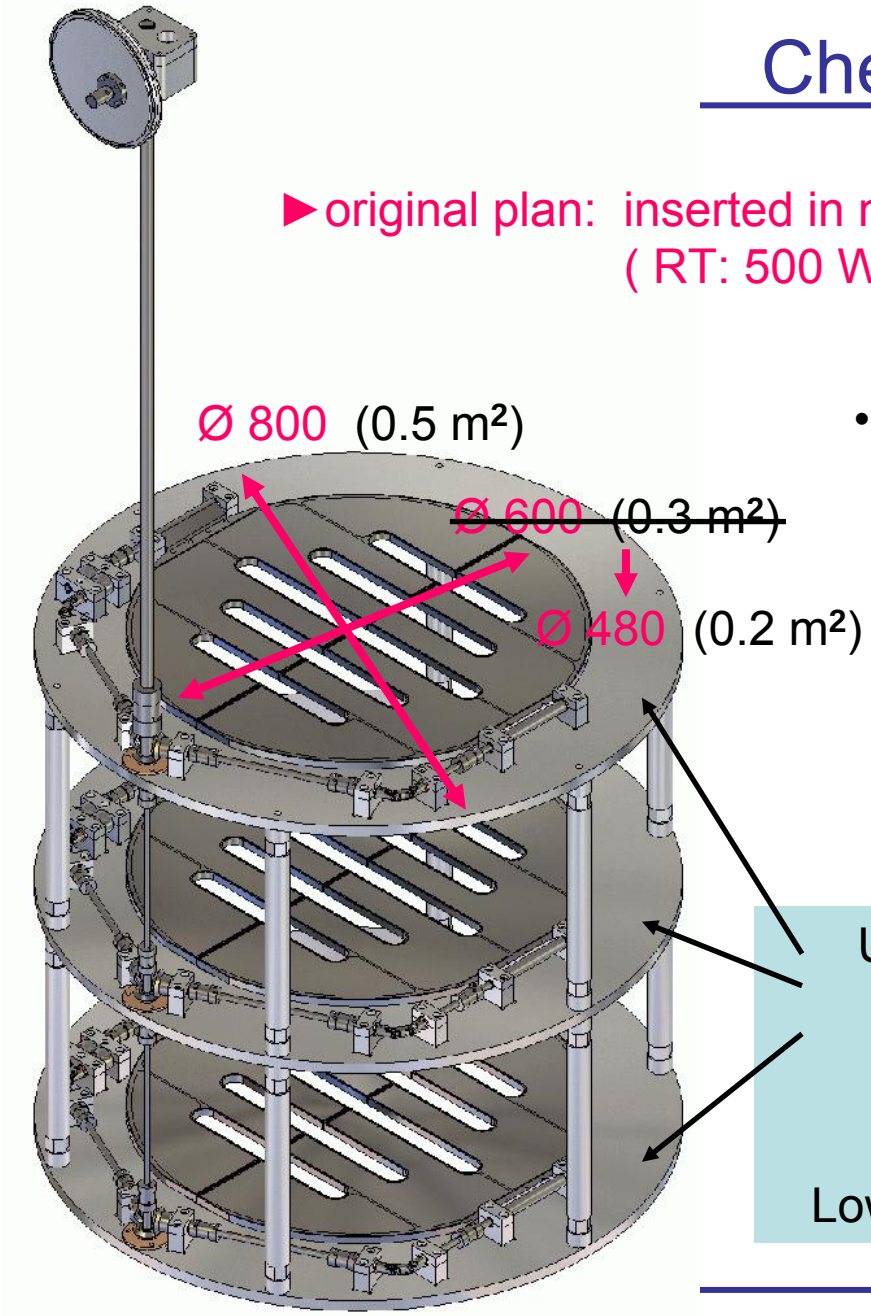
Tolerable lateral load on cryostat's neck : 160 kN

Pace seismic report:
Superstructure max. amplitude : 17 mm
Cryostat neck max. amplitude : <2 mm

Bellow satisfies all requirements
Nevertheless: looking for sample with smaller diameter, e.g Ø500 to generate more space….

Chevron(s)

►original plan: inserted in neck to shield against thermal radiation
(RT: 500 W / m² !)



- Test in prototype neck : abandonned
  ► mechanics too complex for ultra-reliable operation & access VERY difficult!

……

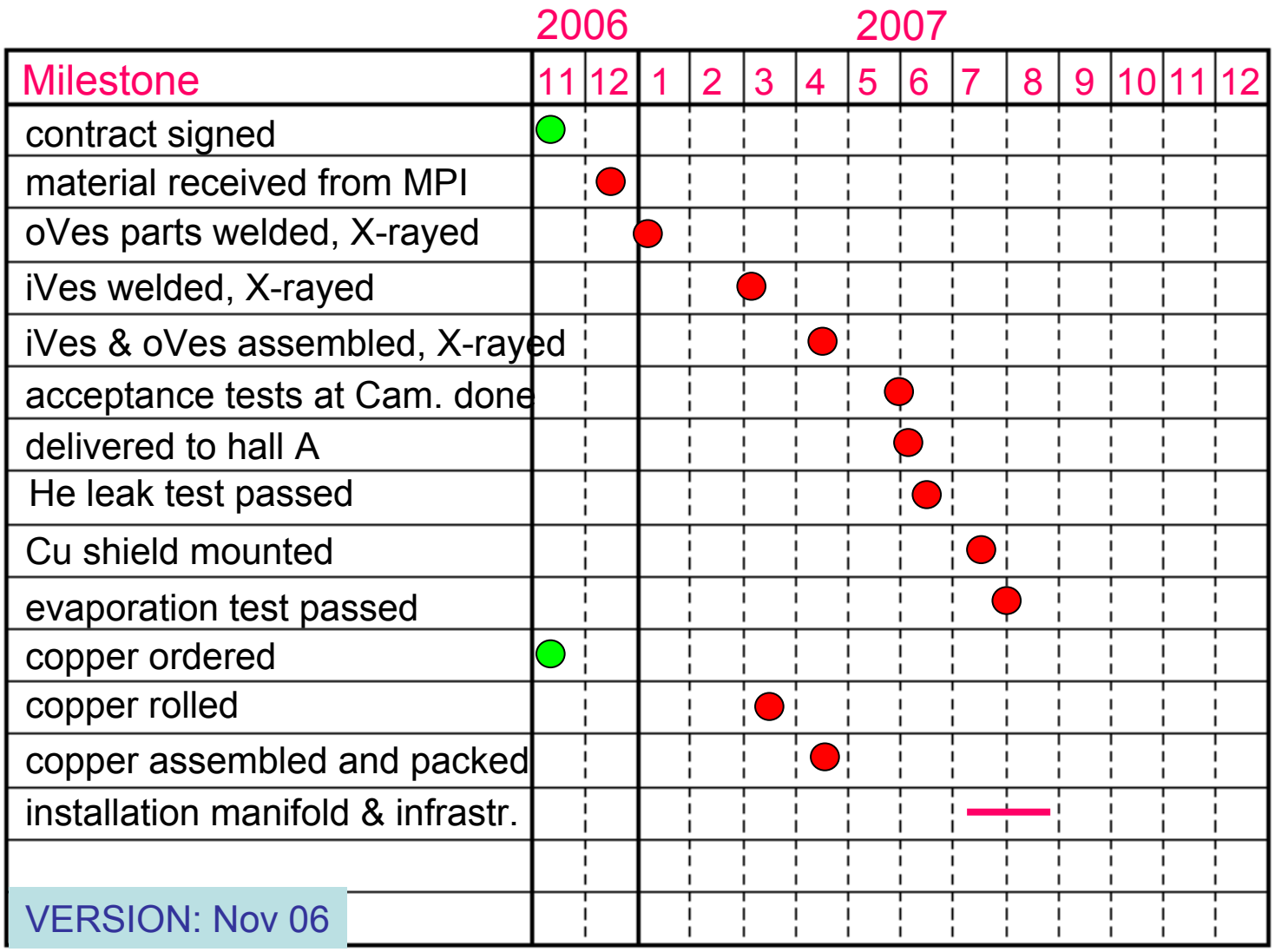
4) Other solution – reduced solid angle?

YES!

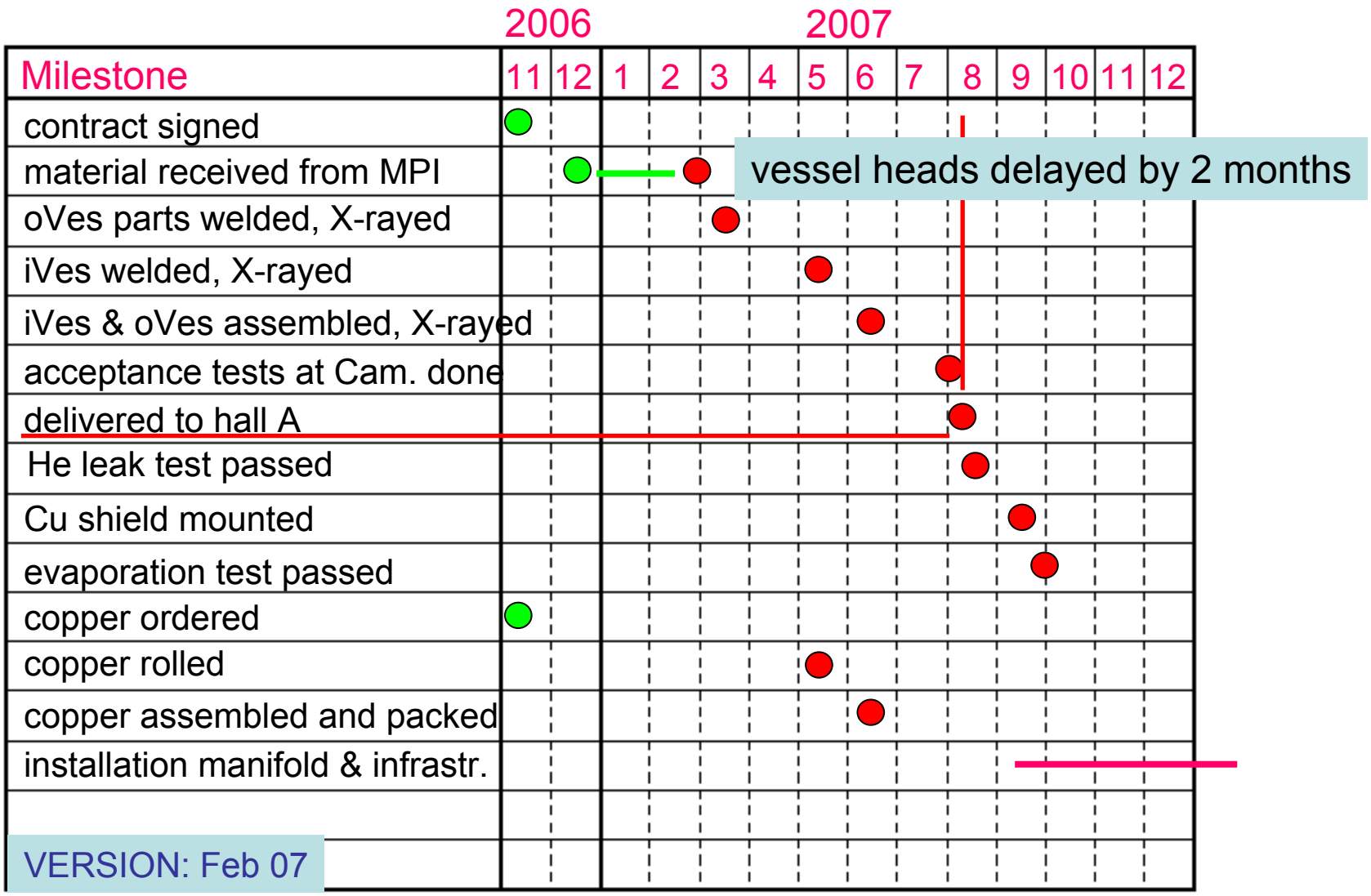
Use 3 stationary shields of $Ø_{inner}$ = 480 mm
(0.18m² , <90W)
and actively cool
(i) lowest shield & (ii) LAr in neck.

Lowest shield will also serve as Radon catcher.

Milestones for Cryostat and Copper Shield



Milestones for Cryostat and Copper Shield



Concluding Remarks

- Cryostat delayed by 2 months due to delay in vessel head production;
  - ► new date for delivery: August 2007;
  - ► most open design details - pads, copper shield – solved;
  - ► design of manifold-bellow still missing.

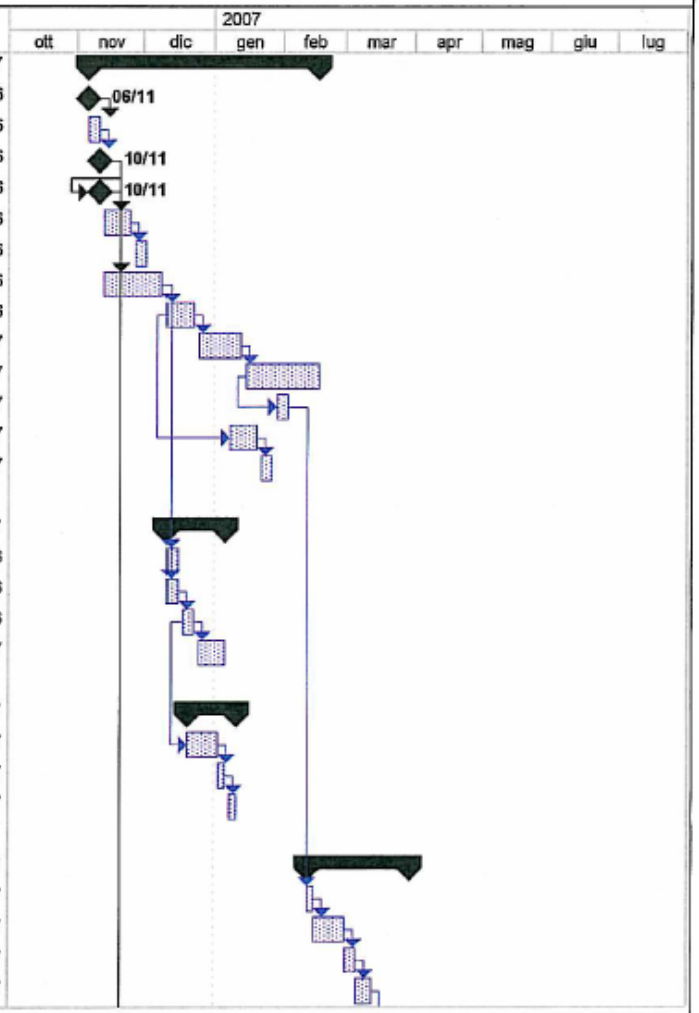
- New risk analysis by NIER completed.
  GERDA safety concept accepted by LNGS.
  - ► cryostat will have internal and external thermal barriers;
  - ► waiting for new 2nd opinion and LNGS final safety review document.

- Focus is shifting to cryogenic infrastructure and system integration.

Original Schedule by SIMIC (1)

SIMIC S.P.A. GERDA CRYOSTAT FABRICATION & COPPER PLATE INTEGRATION ON SITE pROVISIONAL GENERAL PLANNING OFFER 183-05

ID	Nome attività	Durata	Inizio	Fine
1	**Prelinary activities**	**75 g**	**lun 06/11/06**	**ven 16/02/07**
2	Order receiving	0 g	lun 06/11/06	lun 06/11/06
3	Contract review	1 s	lun 06/11/06	ven 10/11/06
4	Order acceptance	0 g	ven 10/11/06	ven 10/11/06
5	Materials by MPI availability	0 g	ven 10/11/06	ven 10/11/06
6	Quality Control Plan issue	2 s	lun 13/11/06	ven 24/11/06
7	Quality Control Plan approval by MPI	1 s	lun 27/11/06	ven 01/12/06
8	Materials by MPI delivery	4 s	lun 13/11/06	ven 08/12/06
9	Shopdrawings issue	2 s	lun 11/12/06	ven 22/12/06
10	Workshop readiness	3 s	lun 25/12/06	ven 12/01/07
11	Materials providing	5 s	lun 15/01/07	ven 16/02/07
12	Plates check by MPI	1 s	lun 29/01/07	ven 02/02/07
13	Welding procedure qualification	2 s	lun 08/01/07	ven 19/01/07
14	Welding sample cryogenic test by MPI	1 s	lun 22/01/07	ven 26/01/07
15				
16	**Fabrication and test**	**20 g**	**lun 11/12/06**	**ven 05/01/07**
17	Heads holes machining	1 s	lun 11/12/06	ven 15/12/06
18	Plates cutting	1 s	lun 11/12/06	ven 15/12/06
19	Plates bending	1 s	lun 18/12/06	ven 22/12/06
20	Outer vessell shells welding	2 s	lun 25/12/06	ven 05/01/07
21				
22	**Outer Vessel fabrication**	**16 g**	**mer 20/12/06**	**mer 10/01/07**
23	Welding of shells, skirt and bottom head	2 s	mer 20/12/06	mar 02/01/07
24	Outer Vessel X-Ray check	3 g	mer 03/01/07	ven 05/01/07
25	Outer Vessel Surface treatment	3 g	lun 08/01/07	mer 10/01/07
26				
27	**Inner Vessel fabrication**	**34 g**	**lun 12/02/07**	**gio 29/03/07**
28	Rings and stiffeners cutting	3 g	lun 12/02/07	mer 14/02/07
29	Welding of shells, rings, stiffeners, heads and compensatirs	2 s	gio 15/02/07	mer 28/02/07
30	Inner Vessel X-Ray check	3 g	gio 01/03/07	lun 05/03/07
31	Inner Vessel surface treatment	1 s	mar 06/03/07	lun 12/03/07



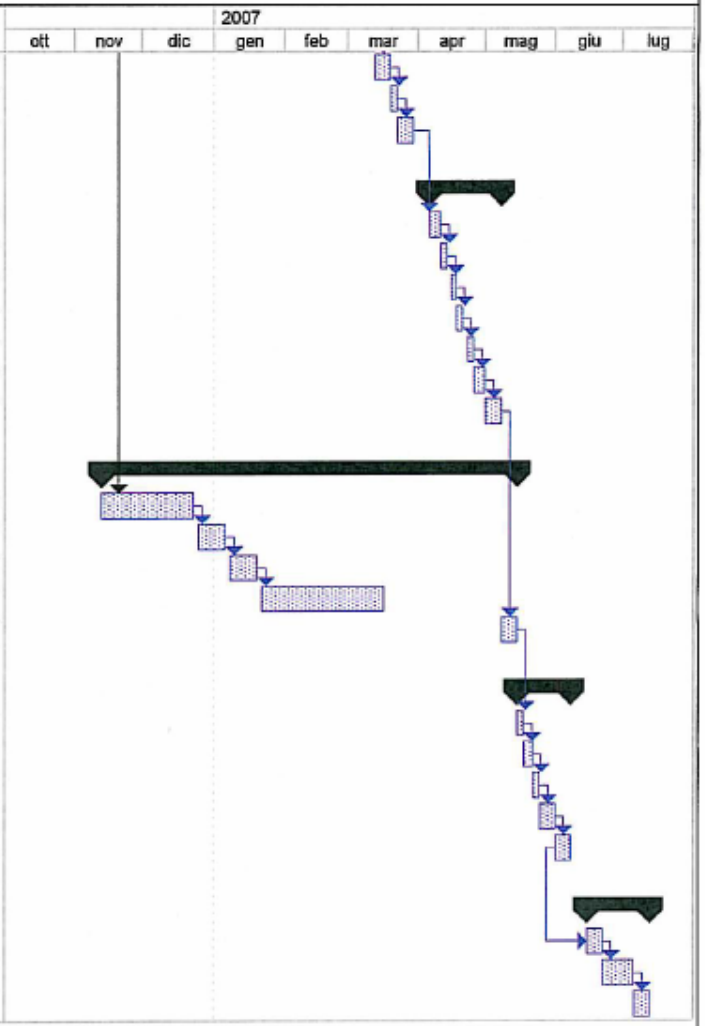
Progetto: &GERDA CRYOSTAT
Data: lun 25/09/06

Attività
Divisione
Cardine
Riepilogo
Attività esterne
Cardine esterno

Original Schedule by SIMIC (2)

SIMIC S.P.A. GERDA CRYOSTAT FABRICATION & COPPER PLATE INTEGRATION ON SITE pROVISIONAL GENERAL PLANNING OFFER 183-05

ID	Nome attività	Durata	Inizio	Fine
32	Pressure test	1 s	mar 13/03/07	lun 19/03/07
33	He leak test	3 g	mar 20/03/07	gio 22/03/07
34	Super insulation integration	1 s	ven 23/03/07	gio 29/03/07
35				
36	**Cryostat integration and tests**	**22 g**	**ven 06/04/07**	**lun 07/05/07**
37	Inner Vessel integration in the Outer Vessel	3 g	ven 06/04/07	mar 10/04/07
38	Top head welding	3 g	mer 11/04/07	ven 13/04/07
39	Top head welding US check	2 g	lun 16/04/07	mar 17/04/07
40	Cryostat sealing	3 g	mer 18/04/07	ven 20/04/07
41	Outer Vessel He leak test	3 g	lun 23/04/07	mer 25/04/07
42	Outer Vessel Nitrogen pressure test	3 g	gio 26/04/07	lun 30/04/07
43	Evaporation rate test	1 s	mar 01/05/07	lun 07/05/07
44				
45	**Tooling fabrication**	**131 g**	**lun 13/11/06**	**lun 14/05/07**
46	Tooling and top platform design	6 s	lun 13/11/06	ven 22/12/06
47	Tooling approval by MPI	2 s	lun 25/12/06	ven 05/01/07
48	Design rewieu after MPI's comments	2 s	lun 08/01/07	ven 19/01/07
49	Tooling and platform manufacturing	8 s	lun 22/01/07	ven 16/03/07
50	Copper plate integration test	1 s	mar 06/05/07	lun 14/05/07
51				
52	**Readiness for dispatch**	**18 g**	**mar 15/05/07**	**gio 07/06/07**
53	Dimensional check	3 g	mar 15/05/07	gio 17/05/07
54	Surface treatment check	2 g	ven 18/05/07	lun 21/05/07
55	Internal spaces inerting by gas	3 g	mar 22/05/07	gio 24/05/07
56	Packing	1 s	ven 25/05/07	gio 31/05/07
57	Delivery at Assergi site	1 s	ven 01/06/07	gio 07/06/07
58				
59	**On site activities**	**20 g**	**ven 15/06/07**	**gio 12/07/07**
60	Mounting tooling installation	1 s	ven 15/06/07	gio 21/06/07
61	Copper plates integration	2 s	ven 22/06/07	gio 05/07/07
62	Mounting tooling dismounting	1 s	ven 06/07/07	gio 12/07/07



Progetto: &GERDA CRYOSTAT
Data: lun 25/09/06

Attività | Divisione | Cardine | Riepilogo | Attività esterne | Cardine esterno