Isola del Gran Sasso 15 June 2009

Summary of the discussions concerning the shroud

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Reminder:

- radon emanation of cryostat ~ 30 mBq

- LAr cooling above the center of the cryostat & heating at the walls (= source of Rn)
  → convection will transport Rn to the Ge array, convection time ~ few days,
  → background index of 1E-3 cnts/(keV kg y) unless Rn sticks to the walls

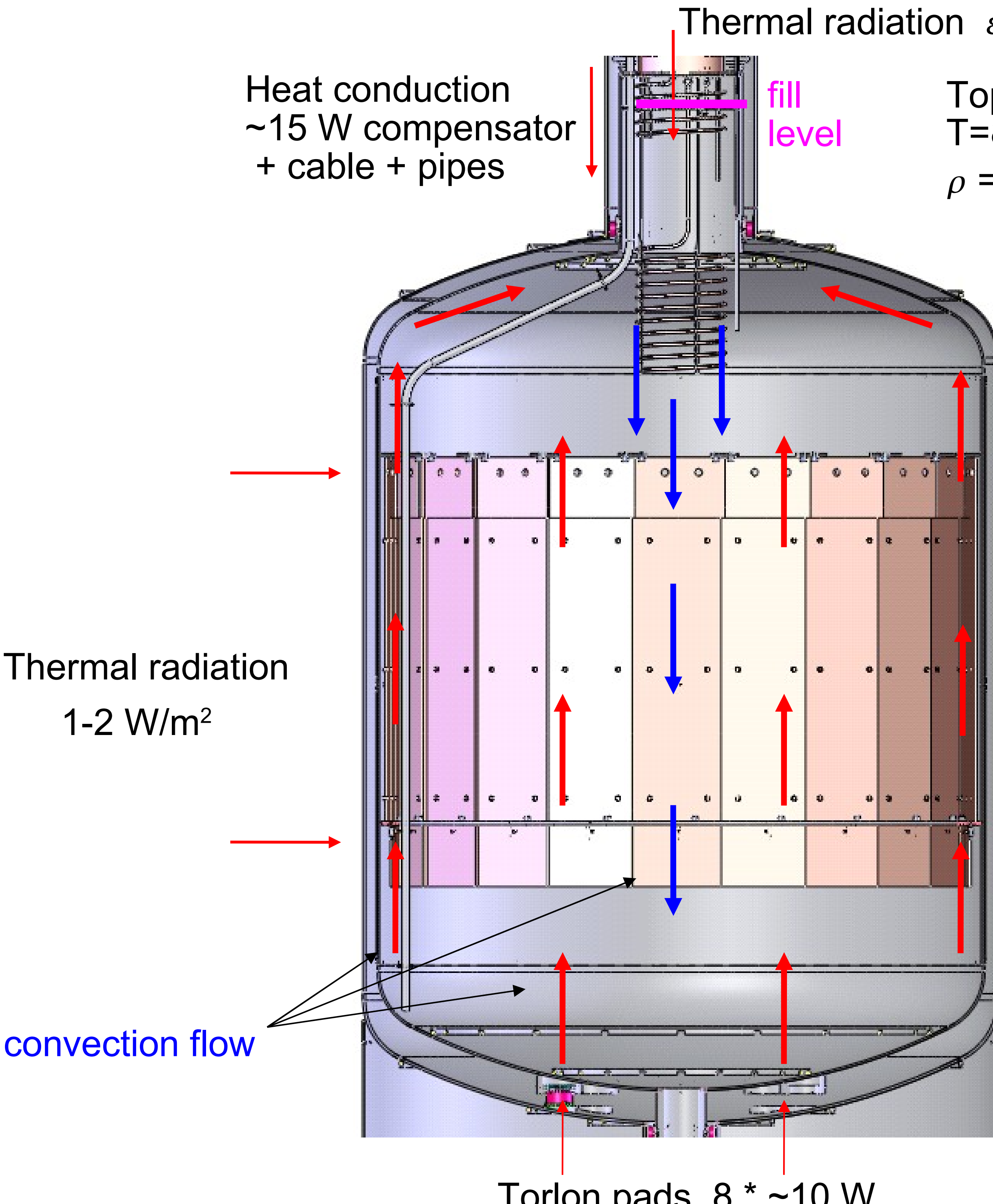
- proposal: build a shroud around Ge array
  → index a factor of 10 lower (see GSTR-09-001)

provided the shroud does not contribute itself !!!

- radon emanation measurement in HD < 70 μBq
- ICPMS measurement at LNGS:
  < 0.2 ppb (= 0.9 mBq/kg) ^{232}Th
  < 0.2 ppb (= 2.6 mBq/kg) ^{238}U

note:

20 μBq/kg ^{232}Th → 0.17E-4 cnts/(keV kg y



Top heat exchanger:
T=88K, p=1.2 bar T_{boil}=88.9K
ρ = 1.39 kg/l

Bottom heat exchanger:
T=86K p=1.34 bar T_{boil}=90.0K
ρ = 1.40 kg/l

Goal:
- subcooled LAr in neck and cryostat
- density of LAr in neck lower than in cryostat
- no mixing of LAr between neck and cryostat

But:
convection will transport Rn from source=wall to crystals
→ uniform Rn concentration too optimistic (circulation time ~ $T_{1/2}$)

Feedback from Bela: major objections against any shroud

- a simple design comes more and more complicated to cure problems introduced by each step (steel cryostat → add copper shield → add shroud to reduce Rn bkg)
  Worry: additional unpredictable complications
  reply: even without the copper shield we need a shroud unless Rn sticks to the walls
  (Rn emanation was not discussed for a copper cryostat in GERDA proposal)

- additional material in vicinity of detectors, question of radiopurity
  reply: Rn emanation ok, unfortunately even ICPMS is not sensitive enough for bulk activity, copper is OFHC copper from the standard supplier (Norddeutsche Affinerie)

- additional mounting steps & further contaminations of the vessel during mounting
  reply: test mounting in HD, no large addition risk of further contaminations during mounting

- unknown convection behavior with the shroud
  - are all heat inputs known?
    reply: except for thermal radiation input from top, I am confident
  - temperature gradient inside shroud: cold LAr on top and warm at bottom → mixing
    reply: only heat input inside shroud from electronics of ~ 0.05 W / channel
    → small or no gradient and only above the Ge array
  - LAr from neck enters shroud
    reply: only if LAr in neck has lower temperature → adjust heat exchanger cooling power
    (3 temperature sensors in neck, 4 in upper part of cryostat)
  - LAr from cryostat enters shroud
    reply: proposal to close the shroud at the bottom to avoid (large) flows of LAr through shroud

- movement of shroud inside LAr → contact with detectors
  reply: no known lateral force except earth quake, entire shroud has “large” shear stiffness,
  LAr dampens movements, no LAr movements since cryostat completely filled

Feedback from Allen: no general objection against shroud itself but

- how to isolate the LAr volume with the detectors best, e.g. extend the shroud to the top?
  reply: then the performance of the neck heat exchanger is questionable,
  how to cool thermal radiation heat input inside shroud?
  LAr temperature gradient neck (88 K) to cryostat (86 K) should avoid mixing

- can we add a bottom piece to the shroud to prevent convective flow?
  reply: this can be done (fixation points added),
  need large enough holes for filling
  → holes will allow convection since volume flow rate of convection is smaller

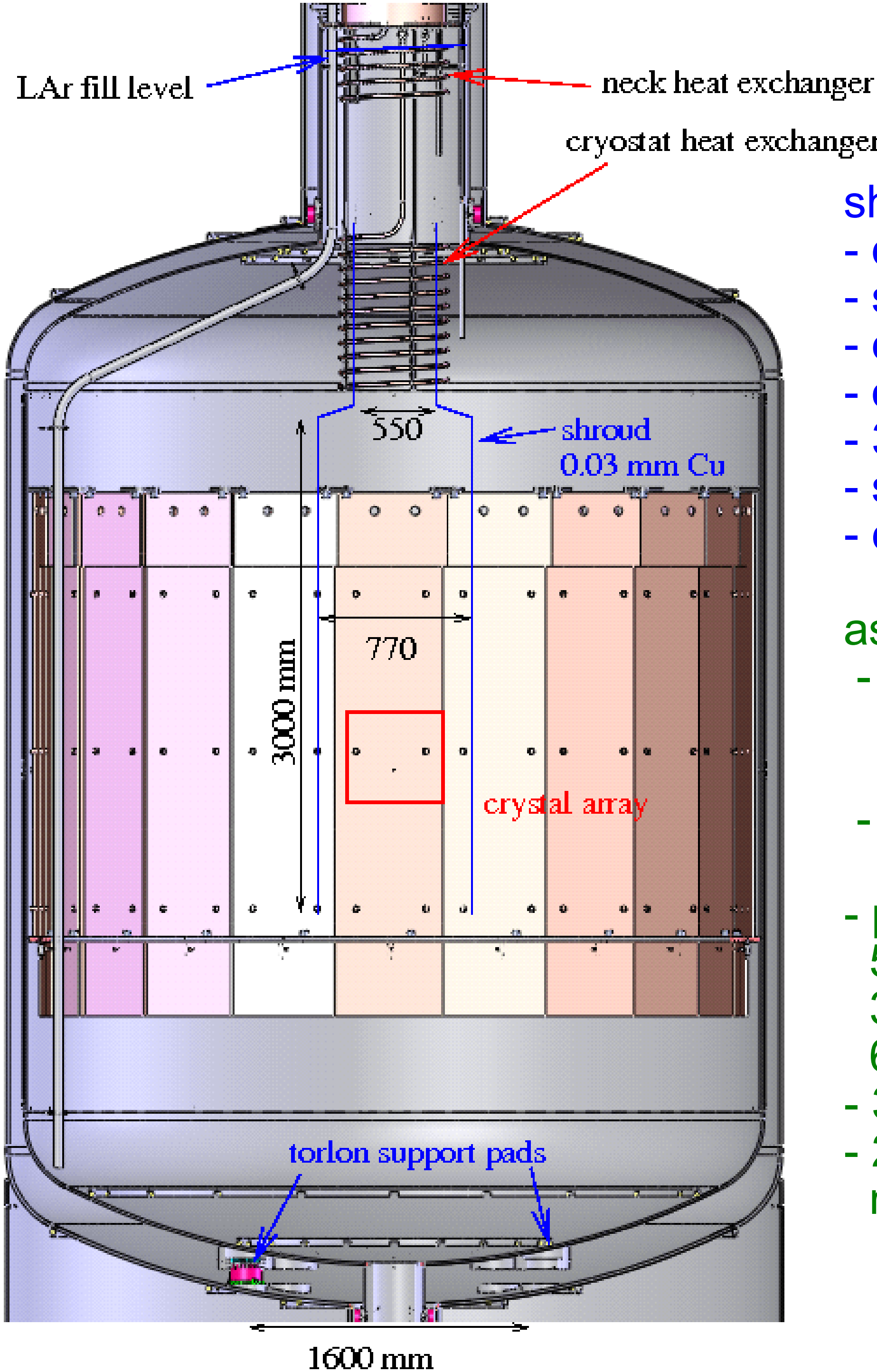
- can we install the shroud later?
  reply: this is a big effort: drain all LAr & unmount all piping inside/outside cryostat,
  it is easier to remove the shroud later by cutting the copper foil

Other input from phone conference end of April:

- How to measure Rn concentration of different “LAr volumes”? Need to evaporate ~ 100 liters
  LAr extraction points at
  1) bottom of cryostat,
  2) cryostat heat exchanger
  3) inside the neck ~10 cm below fill level
  4) inside shroud by mounting a pipe through the calibration source flange

- shroud electrically isolated such that HV can be applied (in preparation)

Proposed shroud design



shroud design:
- diameter 770 mm
- starts 10 cm "above cryostat"
- ends 1 m below crystal array
- open on top and bottom
- 30 micron copper foil, 3 m high
- stainless steel fixation at top
- copper ring at bottom

assumptions for simulation:
- all Rn in
  10 cm thick layer at wall and
  20 cm thick layer around shroud
- homogeneous Rn concentration in this volume of 13.3 m^3
- phase I array:
  5 Heidelberg-Moscow +
  3 IGEX +
  6 GeniusTF detectors
- 30 mBq emanation
- 2 separate LAr volumes (no mixing): neck and cryostat

Personal summary:

- we need shroud unless Rn sticks to the walls
- biggest worry is limited sensitivity of ICPMS
- shroud has to be installed at the beginning
- unclear whether a bottom is useful

Have to decide now!