CLIO cryostat design

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Design policy

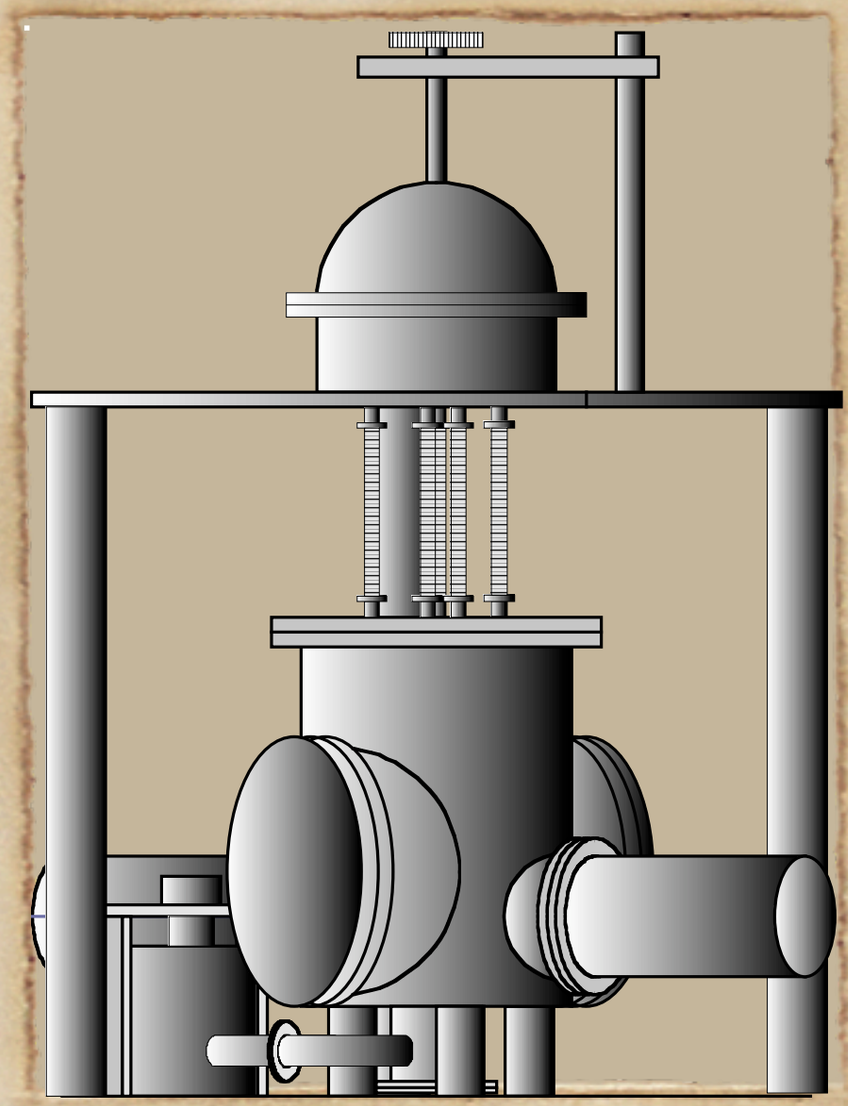
- Succession to CLIK
  - use of refrigerators
  - surface area
- Improve of CLIK
  - initial cooling
  - vibration isolation
- Easy handling
  - one person operation
  - access

Contents

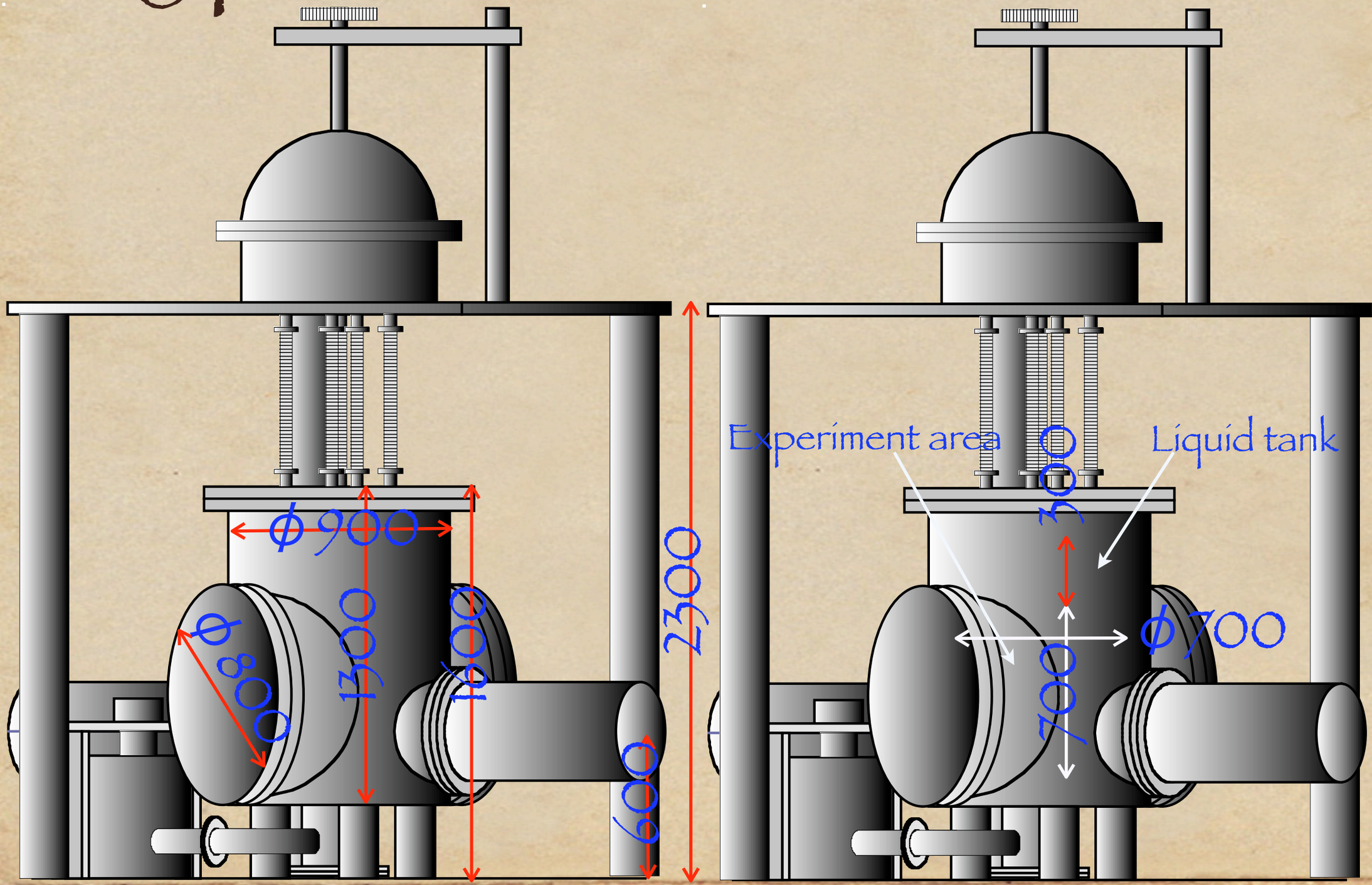
- Design policy
- Overview of new cryostat.
- Initial cooling strategy.
- Vibration isolation strategy.
- Access inside.
- etc.
- Experiment plan.

Overview of new cryostat

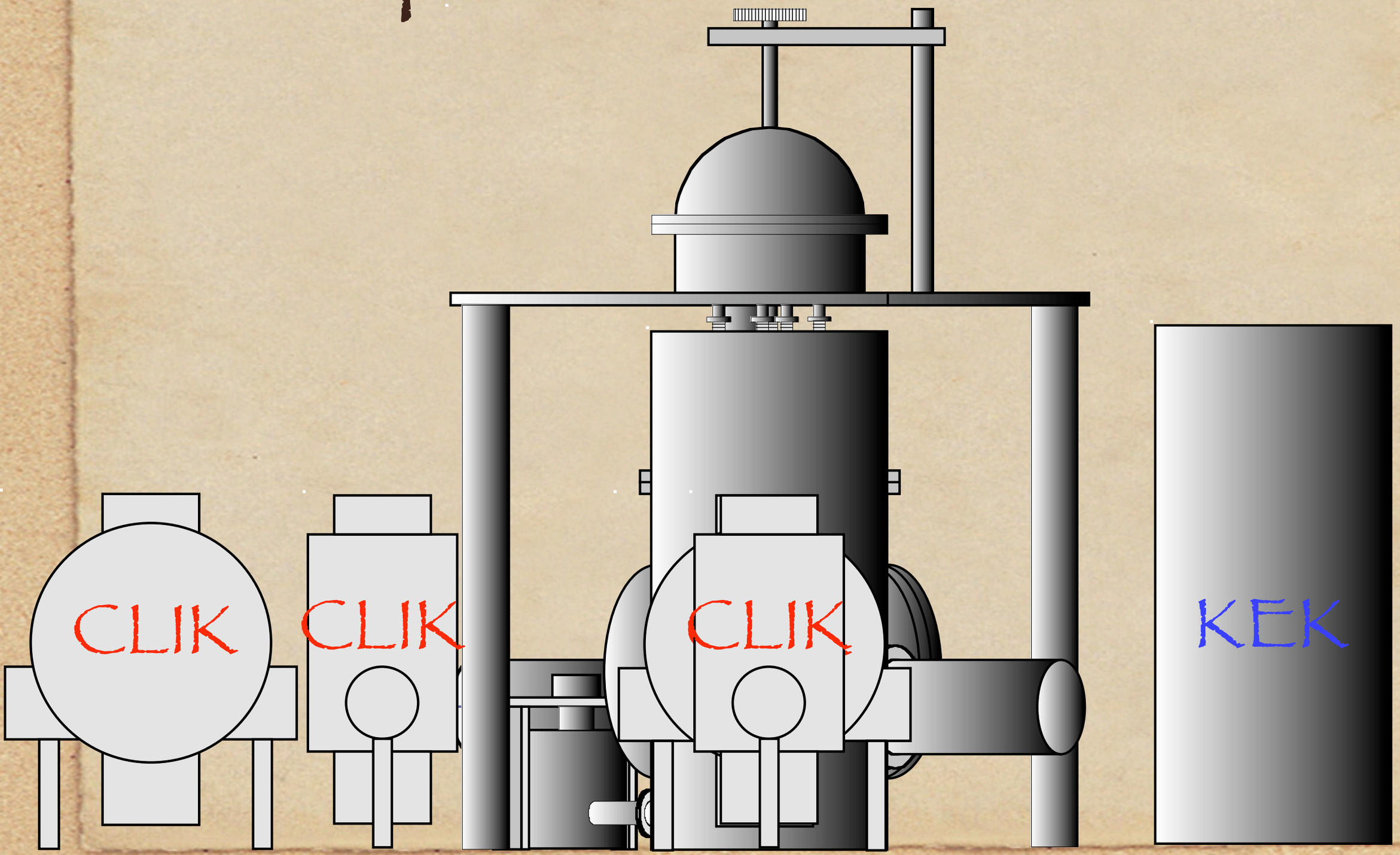
- Cylindrical mirror tank
  - ϕ900 × 1300
  - height; 1600
  - beam height; 600
- 40K S. A = 5m^2
  - same as CLIK
- 4K volume;
  - ϕ700 × 700 =270L
  - 200L (CLIK)
- 100L liquid tank



Typical dimensions

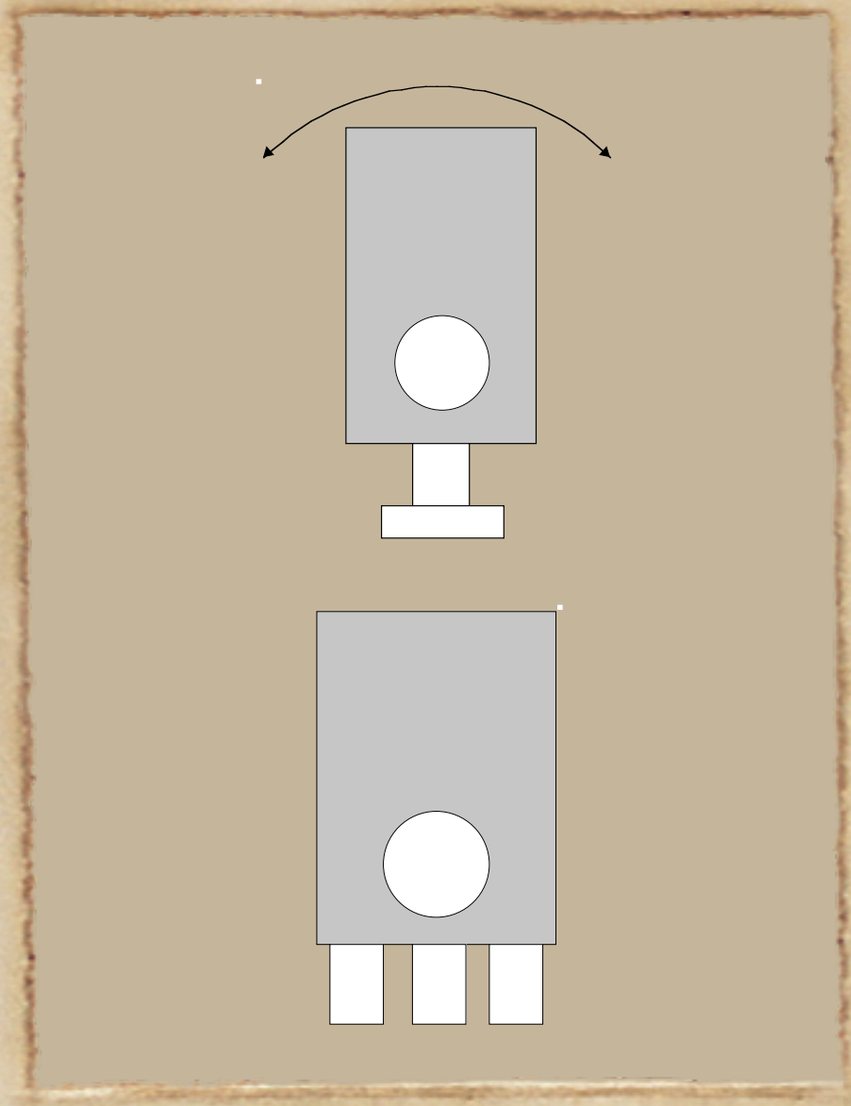


Compare with others



Cylindrical body

- CLIK
  - unstable set up
  - one leg, small area of the base
- Improvements
  - three legs
  - larger base area
- Access inside?



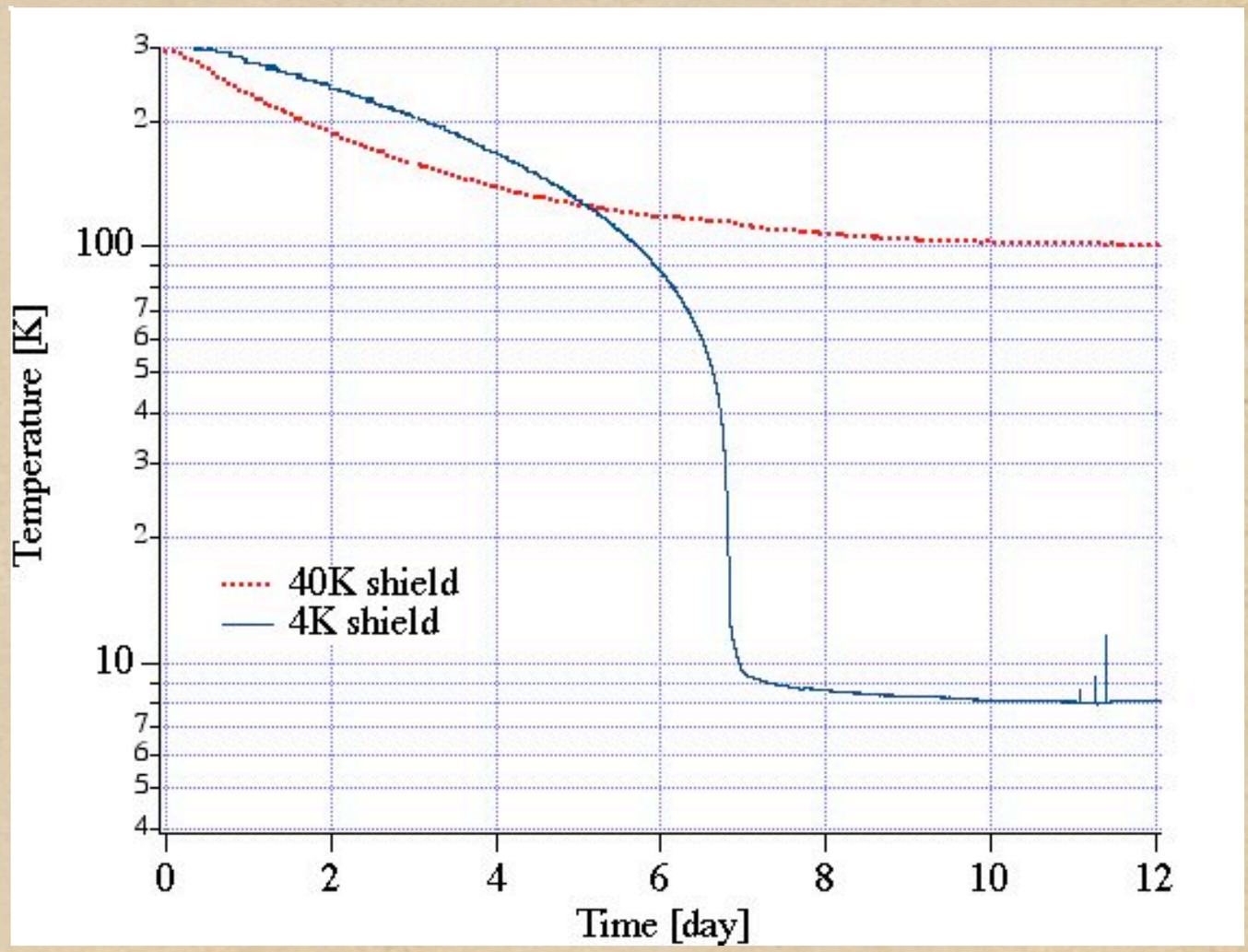
Liquid tank

- Refrigerator free operation
  - 100L= 270h = 11 days (20W heat)
    - 2 - 3 days operation may be possible.
- Initial cooling
  - 50L of liquid N2.
- ϕ700 × 300 = 115L

Initial cooling strategy

- 6 days for 90K.
- 1 day for 8K.

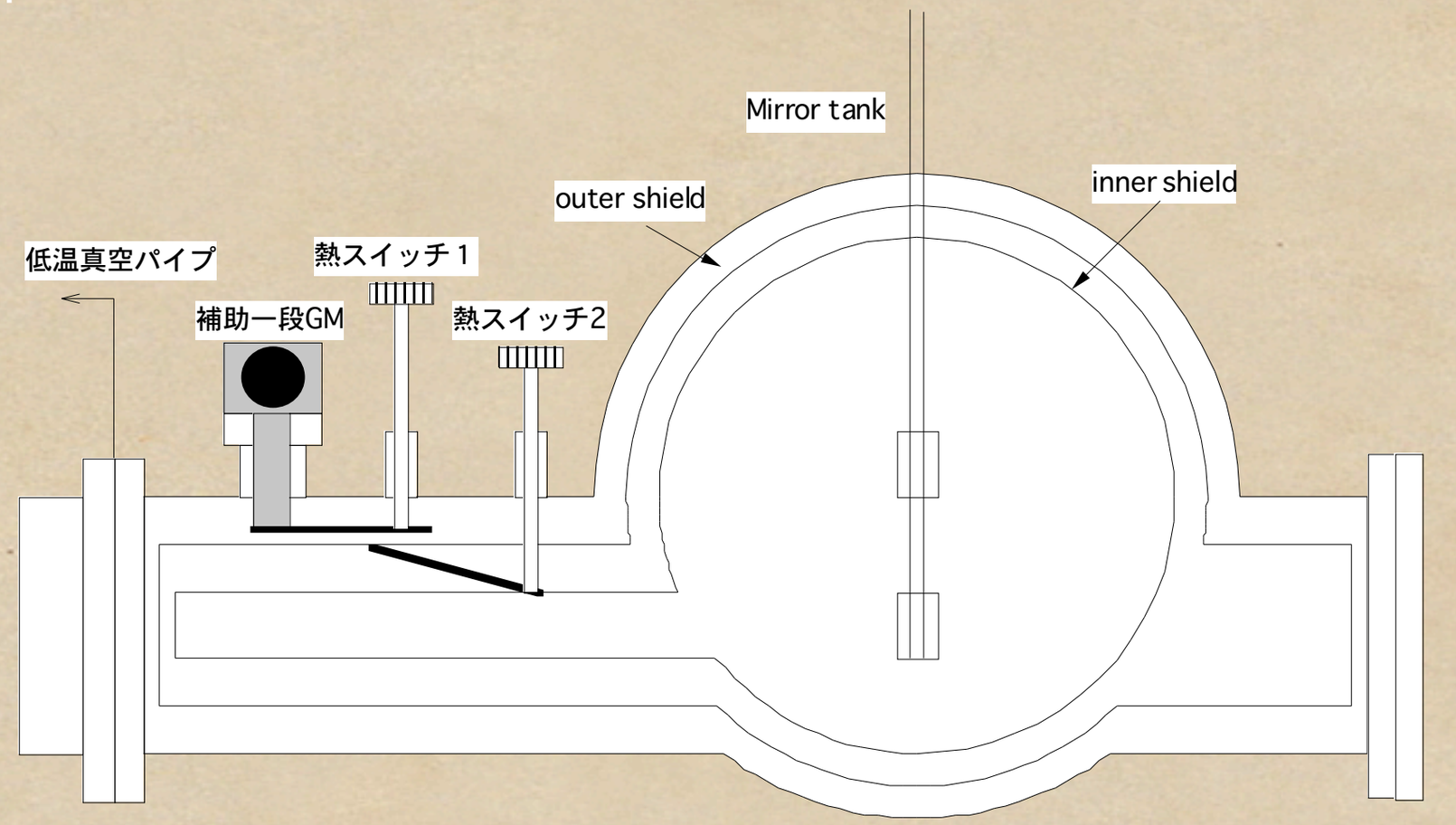
- Thermal switch
- N2 evaporation



Initial cooling strategy - thermal switch

- Support GM refrigerator
- Two thermal switch
  - 300K-outer shield
  - outer-inner shield
- No liquid
- 2/3 cooling time(2 days - 4 days)

Initial cooling strategy
~ thermal switch 2



Initial cooling strategy -N2 evaporation method

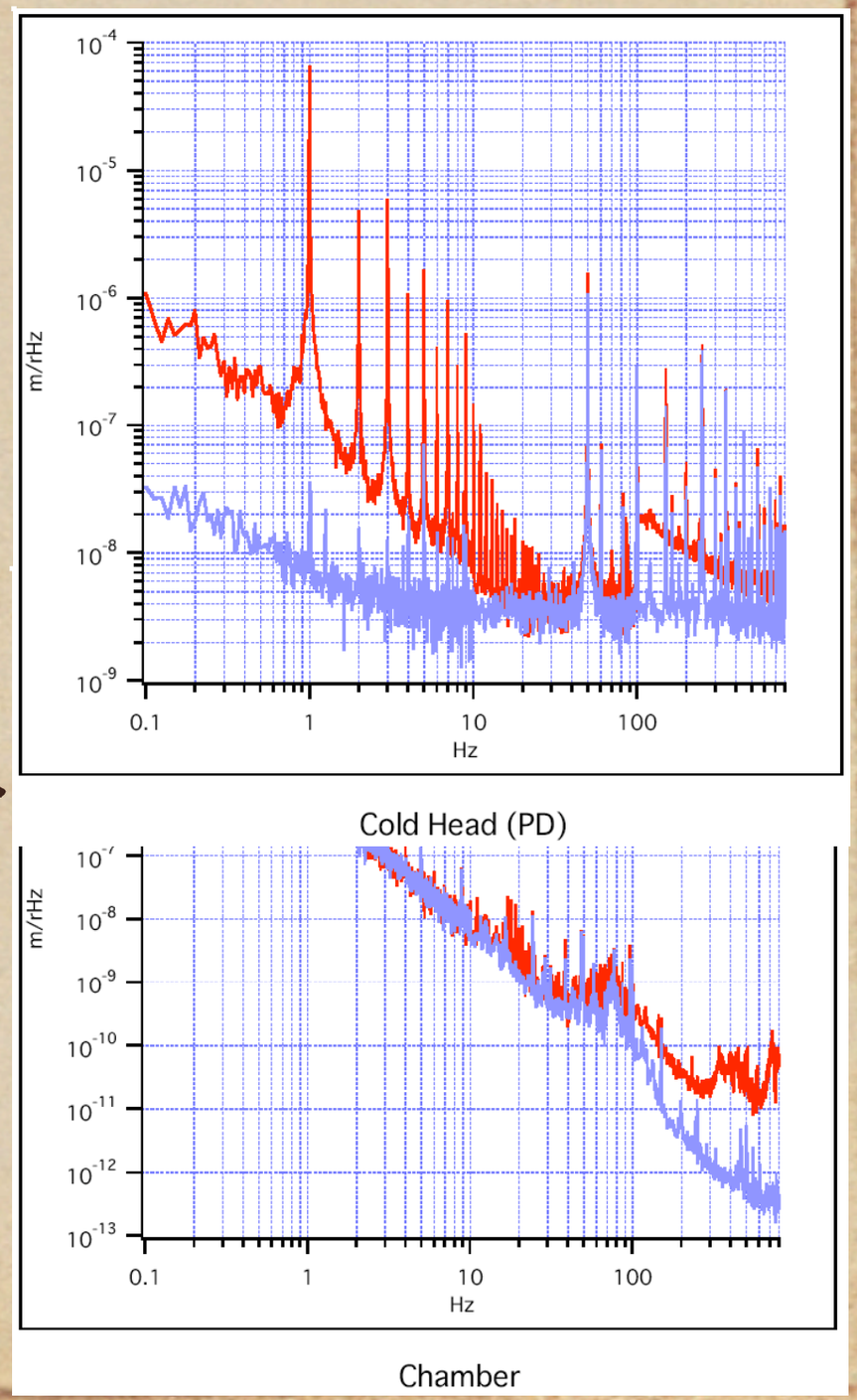
- Use liquid N2
  - N2 evaporation - cool inner shield
  - N2 gas enthalpy - cool outer shield
- Already tested in KEK cryostat
  - less than 20 hours for 90K

Initial cooling strategy - conclusion

- Both method applied?
- Thermal switch - initial cooling
- Liquid tank - refrigerator free operation

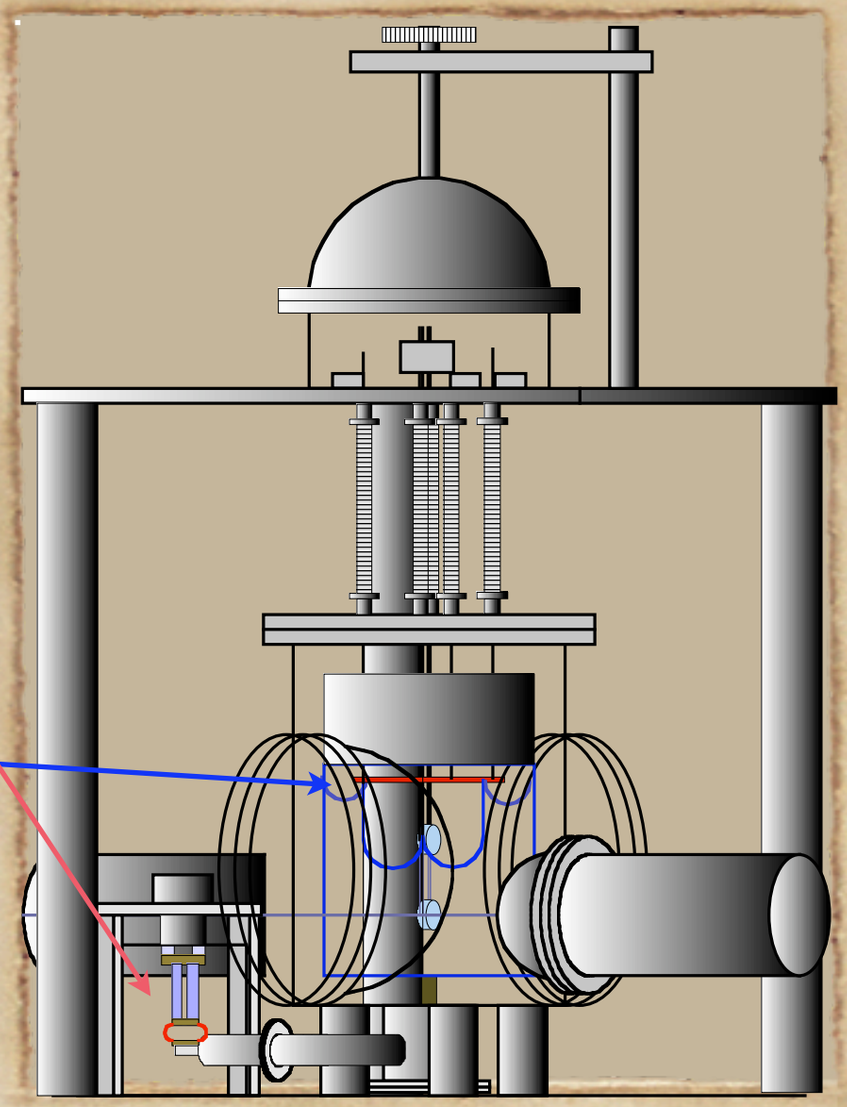
Vibration noise of refrigerator

- Two kinds noise source.
- 1Hz cold stage vibration.
  - 10^{-4}m/rtHz
  - 10^{-9}m/rtHz @ Kamioka
  - -100dB
- Around 100Hz surface wave.
  - 10^{-10}m/rtHz
  - 10^{-12}m/rtHz @ Kamioka
  - -40dB

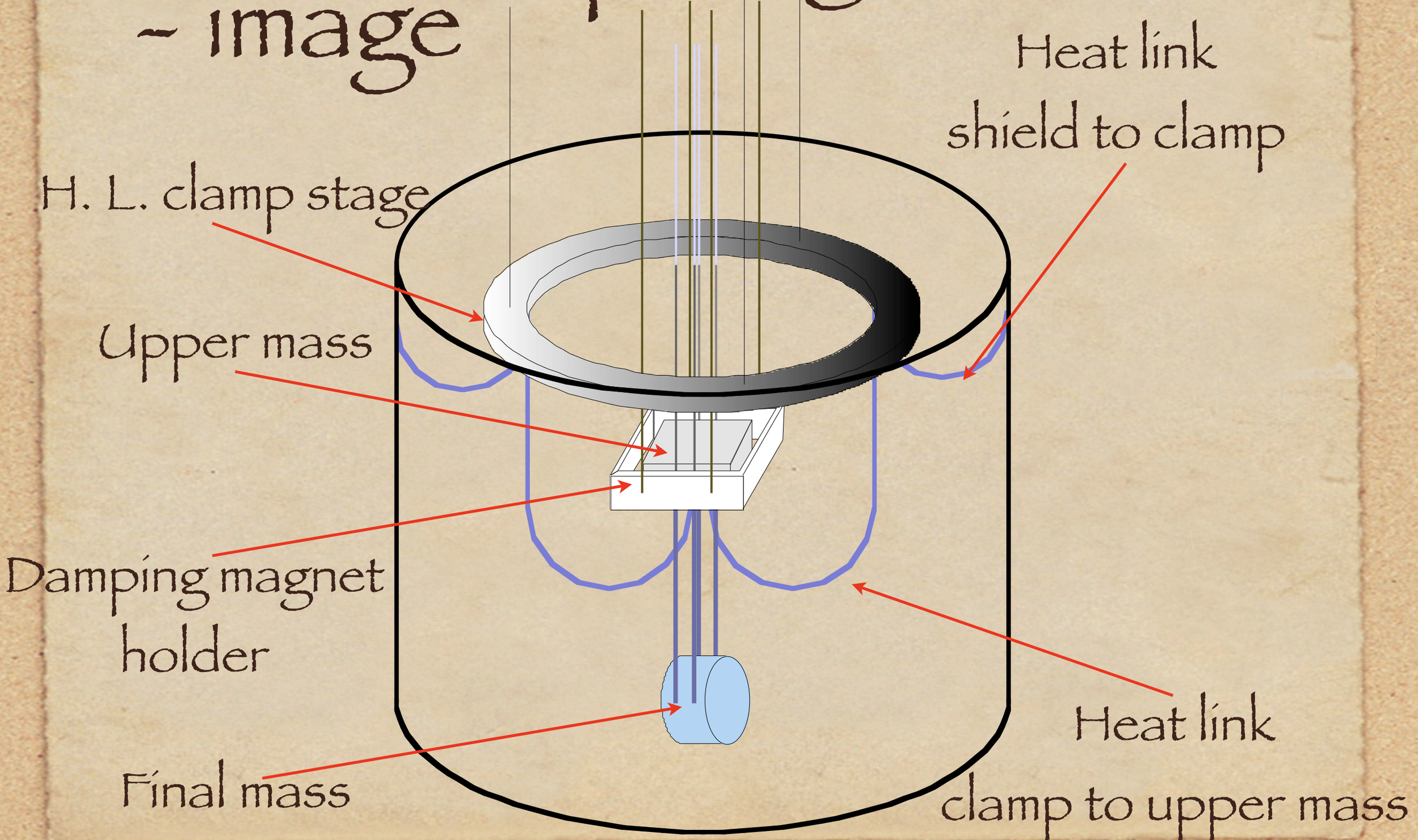


Vibration isolation strategy

- Two stages vibration isolation
- Cold head isolator
  - SUMITOMO
  - -40dB for 1Hz
- Suspended H. L clamp stage
  - -40dB for 1Hz
  - more than -40dB isolation at 100Hz.



H. L. clamp stage - image



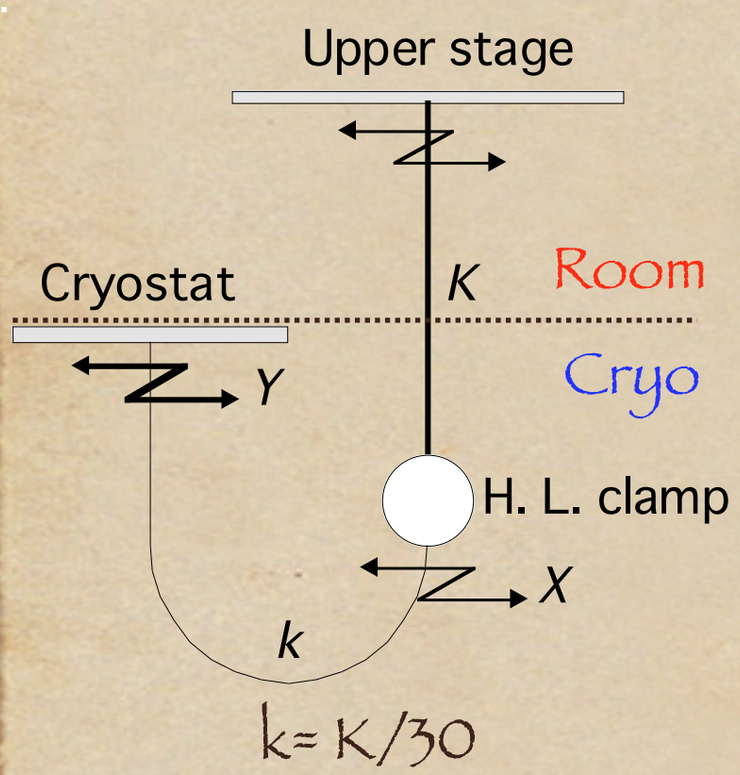
H. L. clamp stage - concept

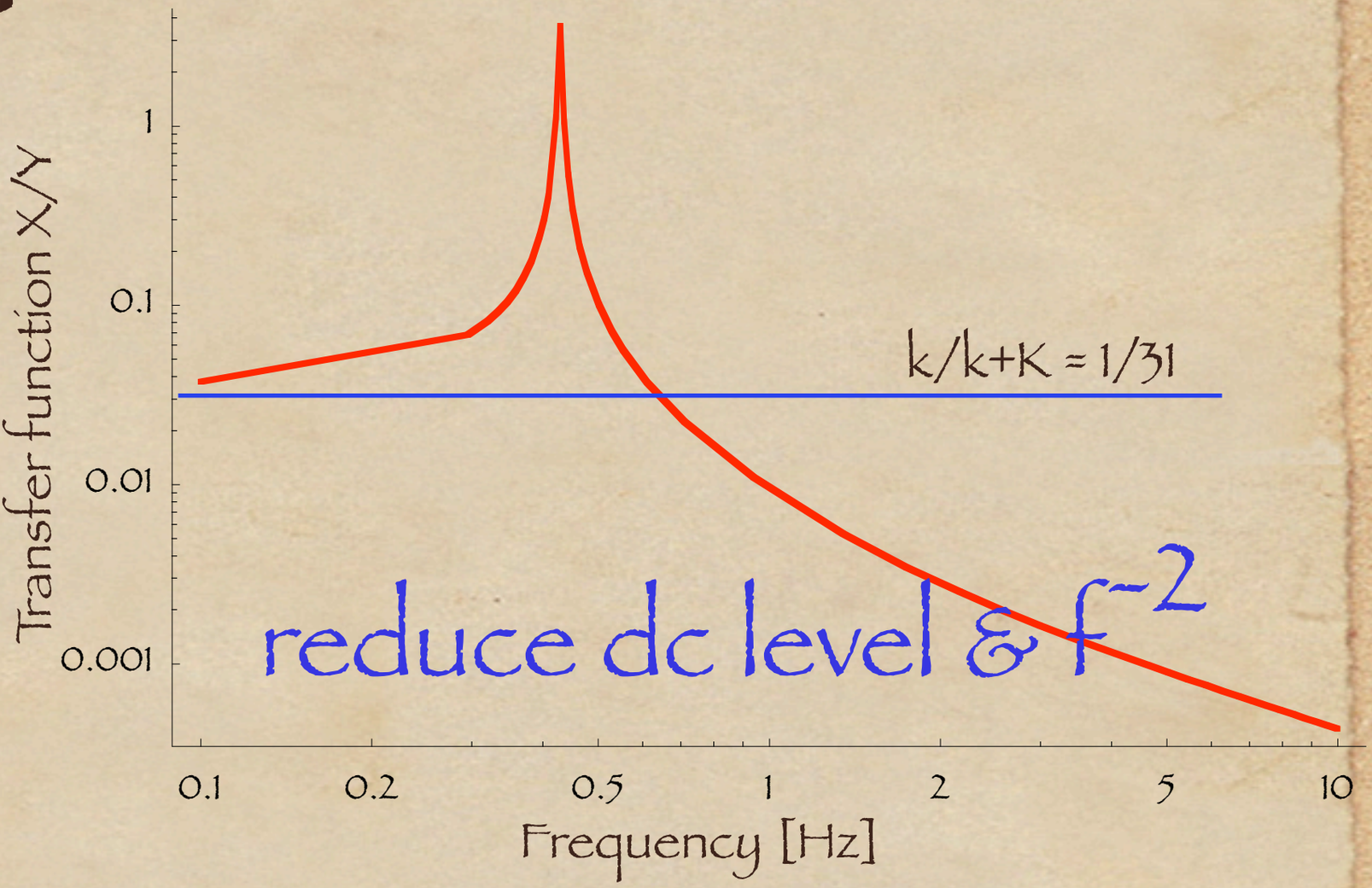
- Vibration isolation concept
  - Fix to the ground.
  - Radiation shields are hard to be fixed.
- We need...
  - not quiet shields,
  - quiet heat link clamp.
- To make quiet heat link clamp...
  - suspend from quiet place.
    - upper stage.
    - on the ground.

H. L. clamp stage - features

- Features
  - Suspended from the chamber on the upper stage.
    - free from the cryostat vibration.
    - maintenance available.
  - 1.4m pendulum.
    - 420mHz = 2.4sec
  - Kasahara Aluminum heat link.
    - mechanically weak connection.
  - All passive.

H. L. clamp stage - model

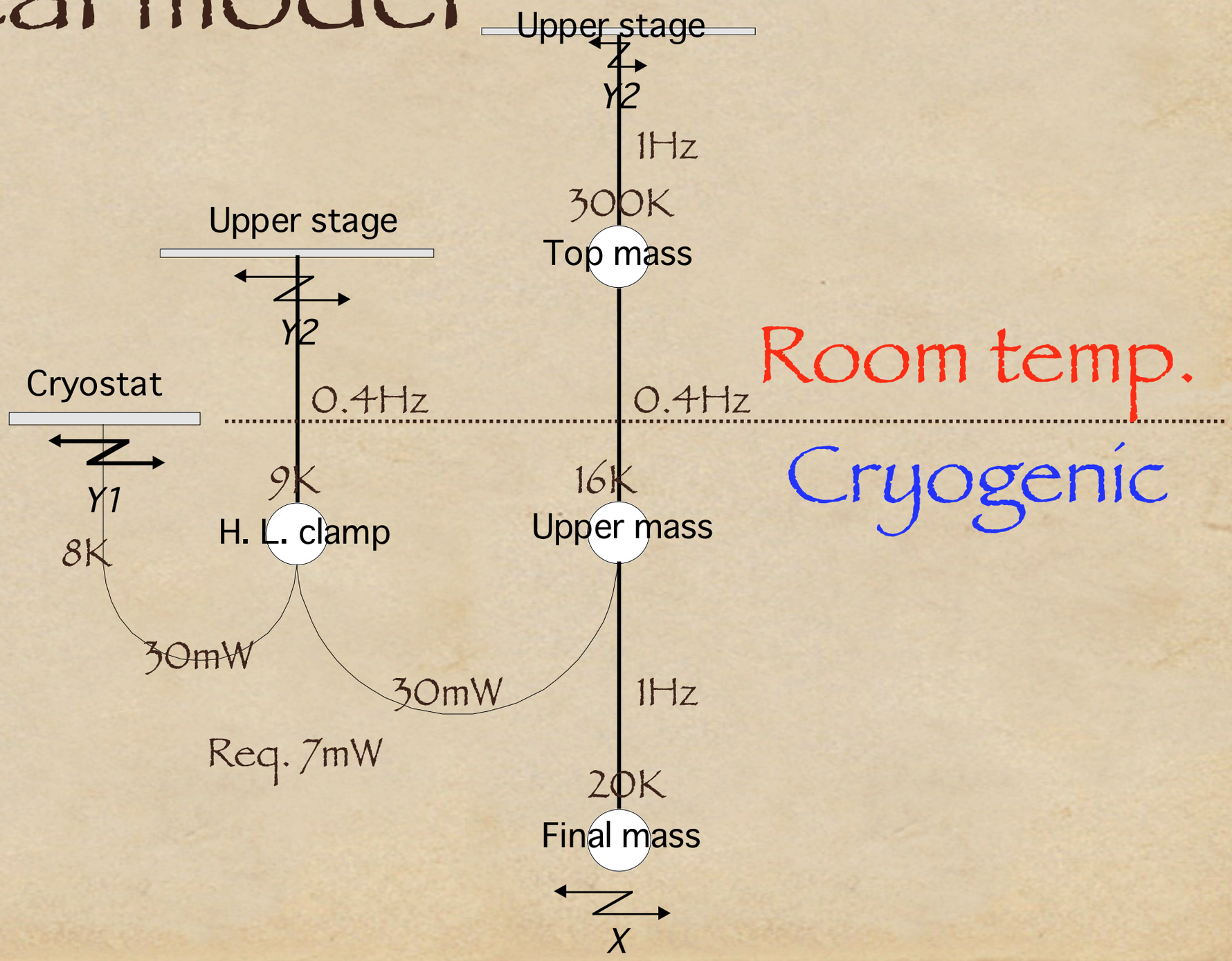




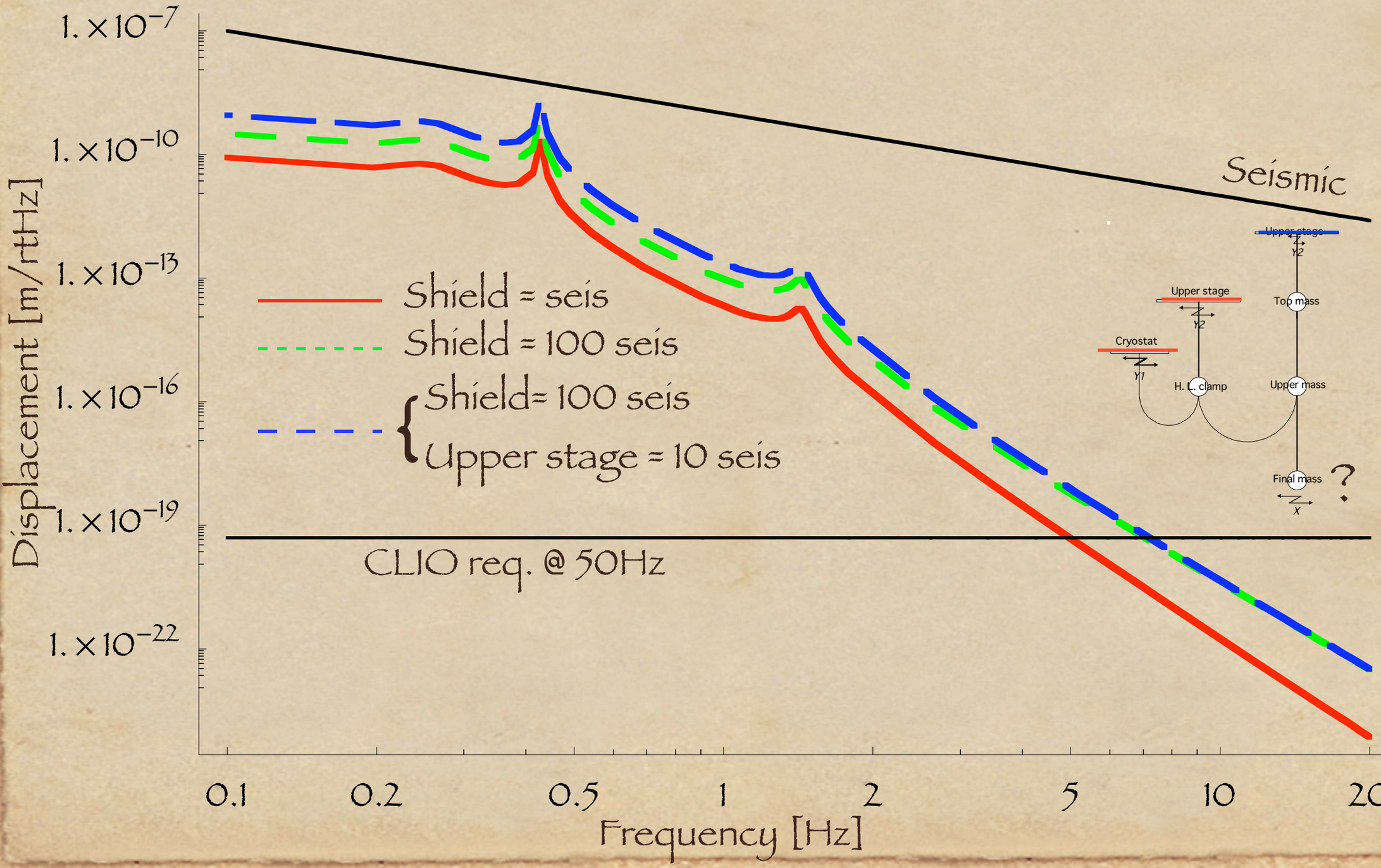
-40dB for 1Hz & 100Hz are possible.

1/30 × 1/4 = 1/120

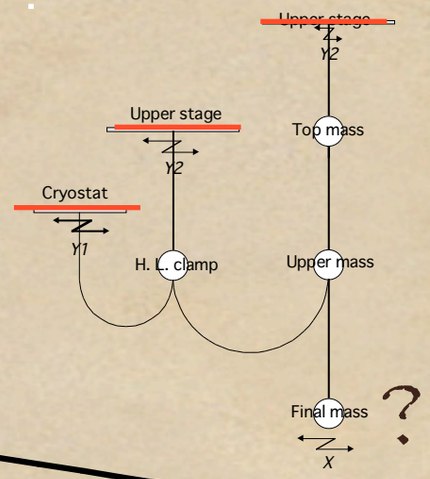
H. L. clamp stage - total model



Displace noise by H. L.



Total noise



Displacement [m/rtHz]

$1.\times10^{-10}$

$1.\times10^{-15}$

$1.\times10^{-20}$

$1.\times10^{-25}$

Seismic

CLIO req. @ 50Hz

Shield = seis

Shield = 100 seis

Shield= 100 seis

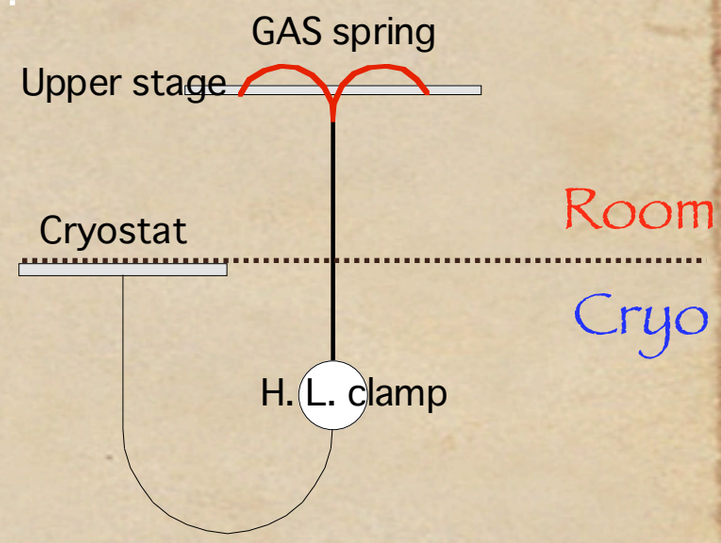
Upper stage = 10 seis

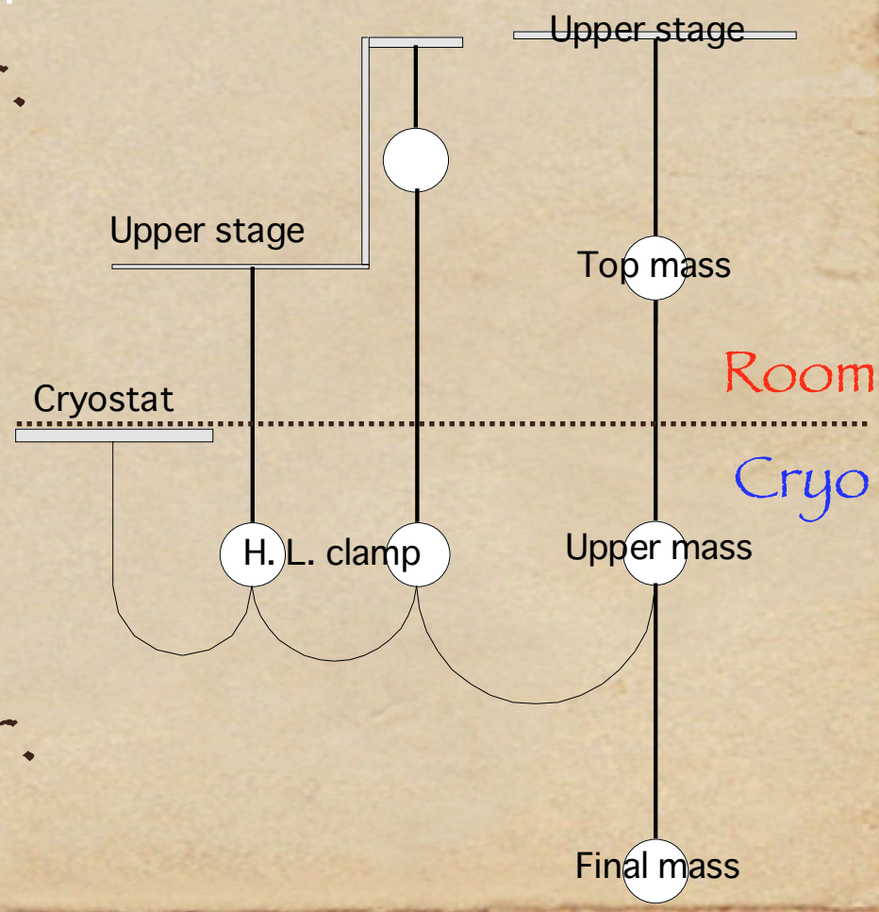
0.1 0.5 1 5 10 50 100

Frequency [Hz]

H. L. clamp stage - for LCGT

- Vertical vibration is the most serious.
- Suspend H. L. clamp stage by low frequency vertical isolator.
  - L. F. vertical isolator is in room temp.
  - stable operation.
- Multi stages is available.
- Heat link design may be easier.



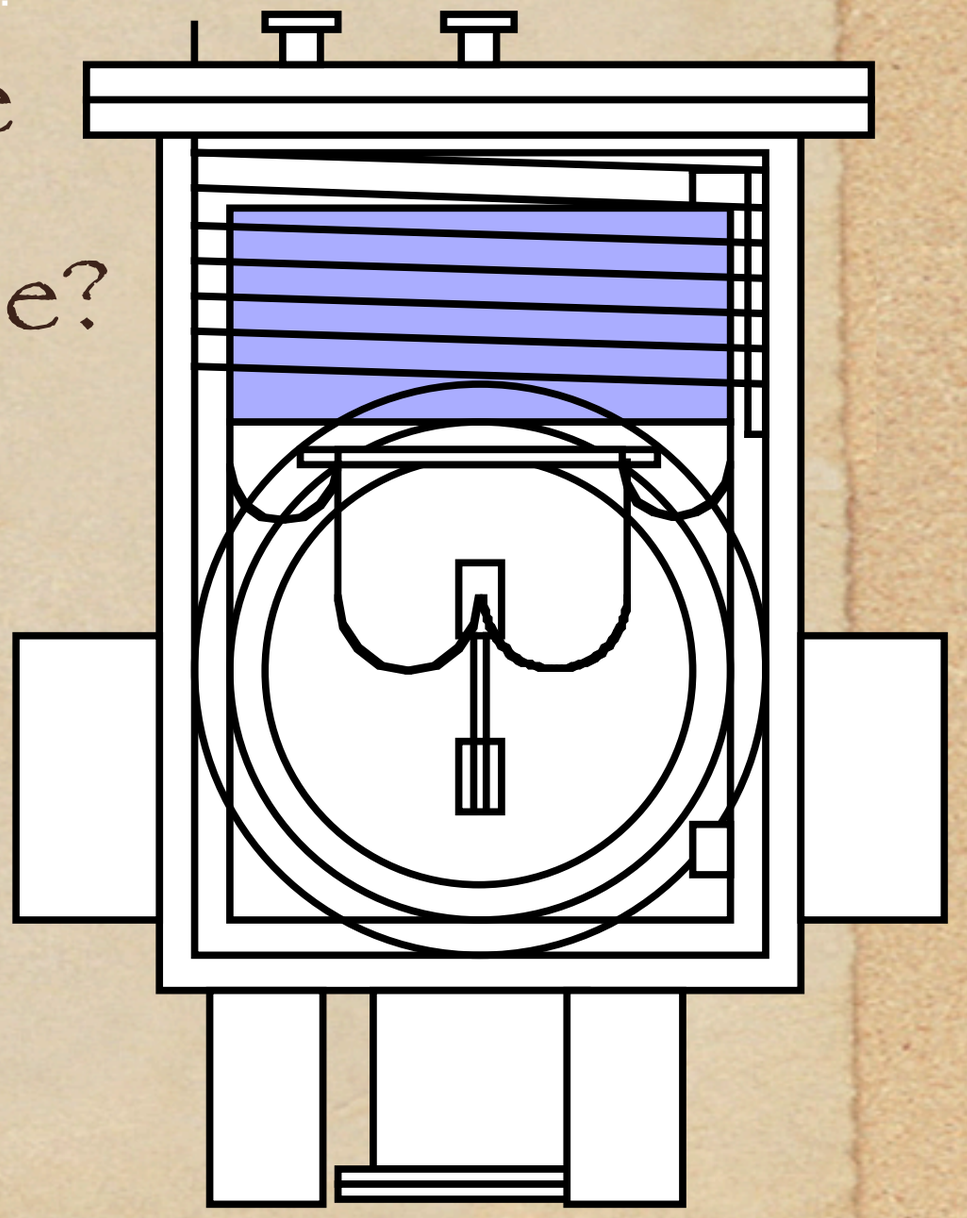


Summary of suspended H. L. clamp stage.

- Simple solution for vibration of the cryostat.
- High maintenance availability.
- Several options are available.
- Requirement of the cryostat can be reduced.
  - Simplify structure of the cryostat.

Access inside

- Mirror tank; ϕ800 flange
  - door like or detachable?
- Outer shield; ϕ700 hole
  - detachable
- Inner shield; ϕ600 hole
  - detachable



etc.

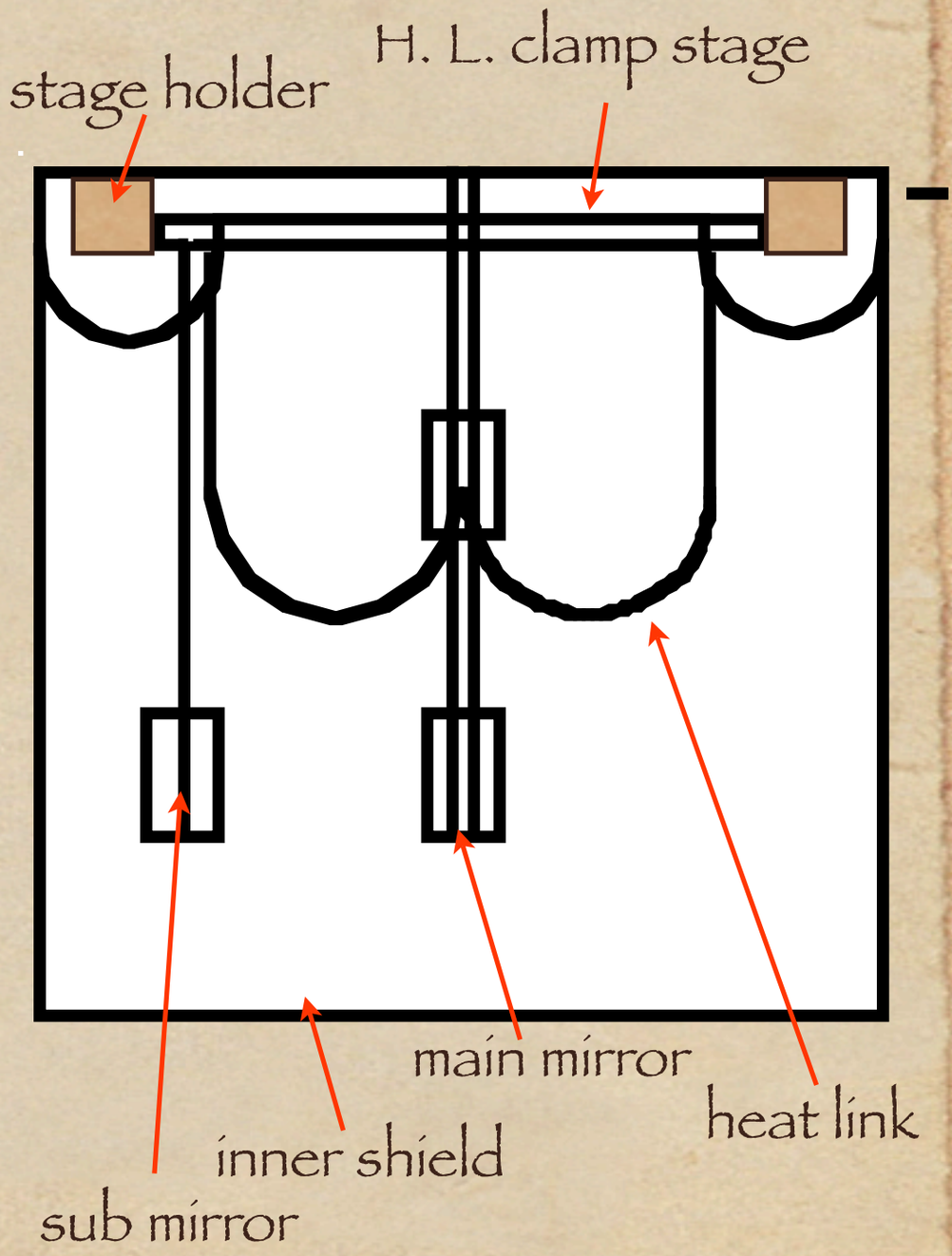
- Signal feed through
  - 18 coaxial & 2 sets 48 pins connector.
- Thermometers.
  - PtCo & CERNOX.
- Vacuum pomp.
  - TMP & Rotary.

Experiment plan

- in Toshiba
  - vacuum & cooling test
  - initial cooling test
  - cooling test by liquid He
  - vibration measurement
- in Kamioka mine
  - vacuum & cooling test
  - vibration measurement
  - development of H. L. clamp stage
  - development of CLIO suspension
  - vibration isolation measurement

Vibration isolation measurement

- 1st; hold to the mirror tank.
  - measure the vibration of M. Tank.
- 2nd; release H. L. clamp stage.
  - measure the vibration of H. L. clamp stage.
- 3rd; connect H. L. clamp stage to the suspension.
  - observe effect of the heat link.



Summary for the mirror tank

- Cylindrical mirror tank.
- Thermal switch & liquid N2 methods for initial cooling.
- Suspended heat link clamp stage.
- Experiment plan for H. L. clamp stage.

Refrigerator unit & connection pipe

- Connection pipe
  - similar to CLIK
- Refrigerator unit
  - adjust for Sumitomo refrigerator
  - no liquid tank

Cryogenic vacuum pipe

- 5m × ϕ400 vacuum pipe.
- 5m × ϕ300 radiation shield.
  - Alminum 3mm thickness.
- 80K one stage pulse tube refrigerator.

	at refrigerator	req. of isolation	ref unit	clamp stage
1Hz vibration	10^-4 [m/rtHz]	-100dB	-80dB	-40dB
surface wave 100Hz	10^-10 [m/rtHz]	-40dB	Nothing	-40dB