First 4K Test Cryostat

Status and Plans

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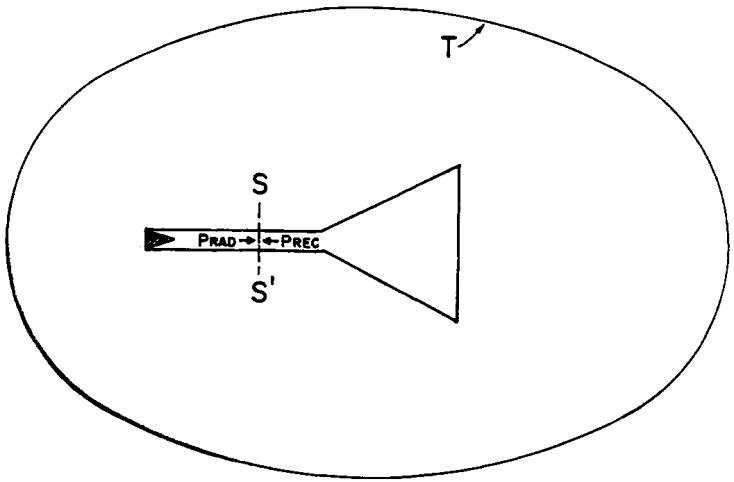
for the MADMAX working group

Reminder: Blackbody Radiation

- blackbody radiation:
  (per area dA, solid angle $d\Omega$, bandwidth $d\nu$)

$$p_{\mathrm{BB}} = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{k_B T}} - 1} \overset{\nu \ll h/k_B T}{\approx} \frac{2\nu^2}{c^2} k_B T \quad \text{(Rayleigh-Jeans)}$$



- for any antenna $A_{\mathrm{A,eff}}\Omega_{\mathrm{A}} = \lambda^2$.
- an ideal antenna surrounded by it sees in $\Delta\nu$

$$P_{\mathrm{A}} = p_{GB} A_{\mathrm{A,eff}} \Omega_{\mathrm{A}} \Delta\nu \approx k_B T \, \Delta\nu.$$

System Noise Temperature

- sample signal $\Delta\nu\,\Delta t \gtrsim 1$.
- total measurement time $\tau = N\Delta t$.
- for a measurement of time Δt noise fluctuates

$$\Delta P \sim P = k_B T_{\mathrm{sys}} \Delta\nu$$

- then for large N:

$$\Delta P_N = P/\sqrt{N} = P/\sqrt{\Delta\nu\,\tau}$$

$$= k_B T_{\mathrm{sys}} \sqrt{\frac{\Delta\nu}{\tau}} \quad \text{(Dicke)}$$

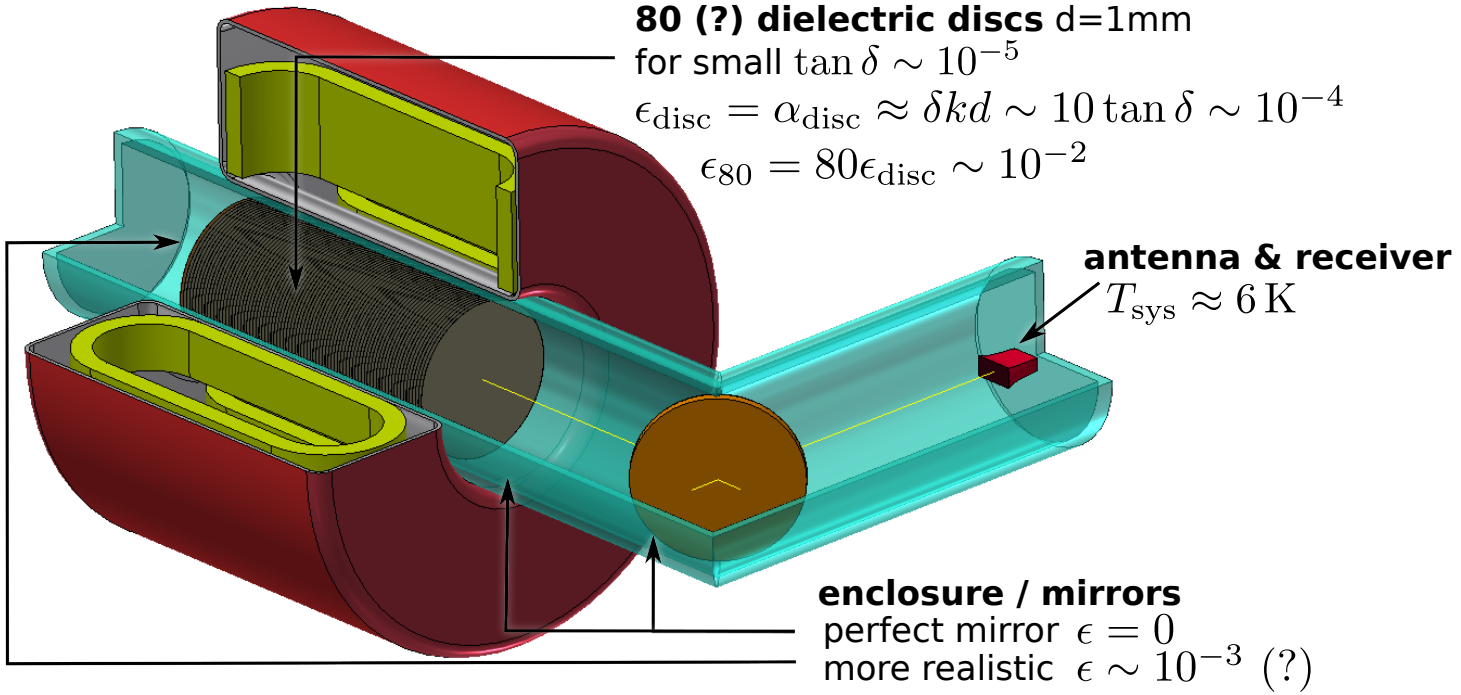
for rigorous statistical derivation, cf. e.g.

B.M. Oliver Proceedings of the IEEE, Volume 53, Issue 5, page 436-454 (1965)

System Noise in MADMAX

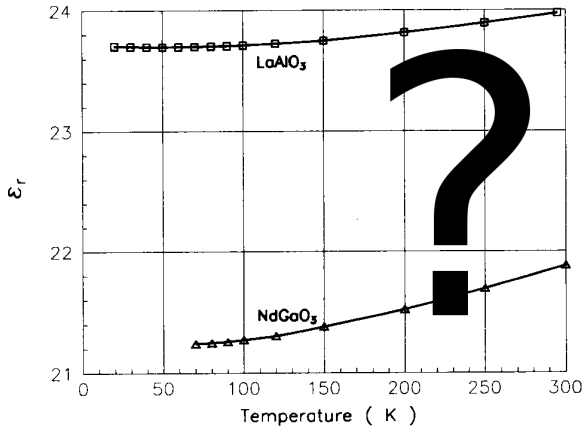
- gray body with emissivity ϵ_ν emits:
  $p_{\mathrm{GB}} = \epsilon_\nu p_{\mathrm{BB}} \approx k_B\, \epsilon_\nu T\, \Delta\nu$
- $\alpha_\nu + t_\nu + r_\nu = 1$ and $\epsilon_\nu = \alpha_\nu$ (Kirchhoff)

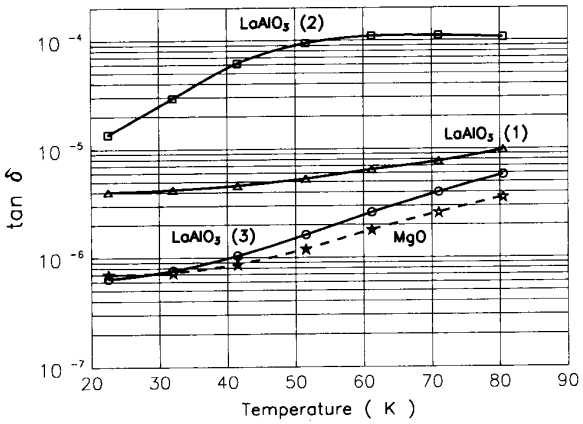
  (α_ν: absorbtivity, t_ν: transmissivity and r_ν: reflectivity)



Need: Understand Noise $T_{\mathrm{sys}} = T_{\mathrm{sys,receiver}} + T_{\mathrm{sys,booster}}$

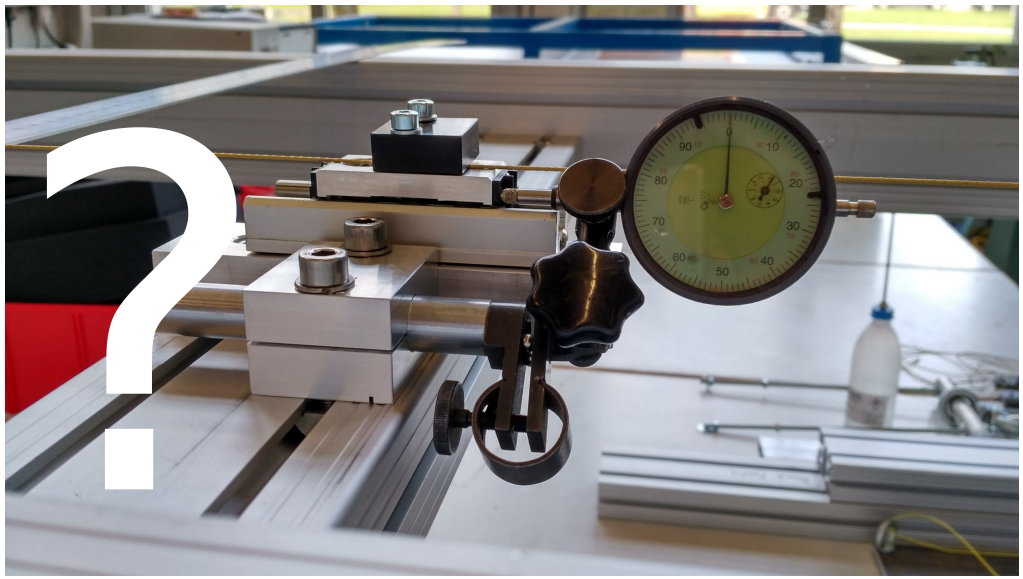
Other Questions



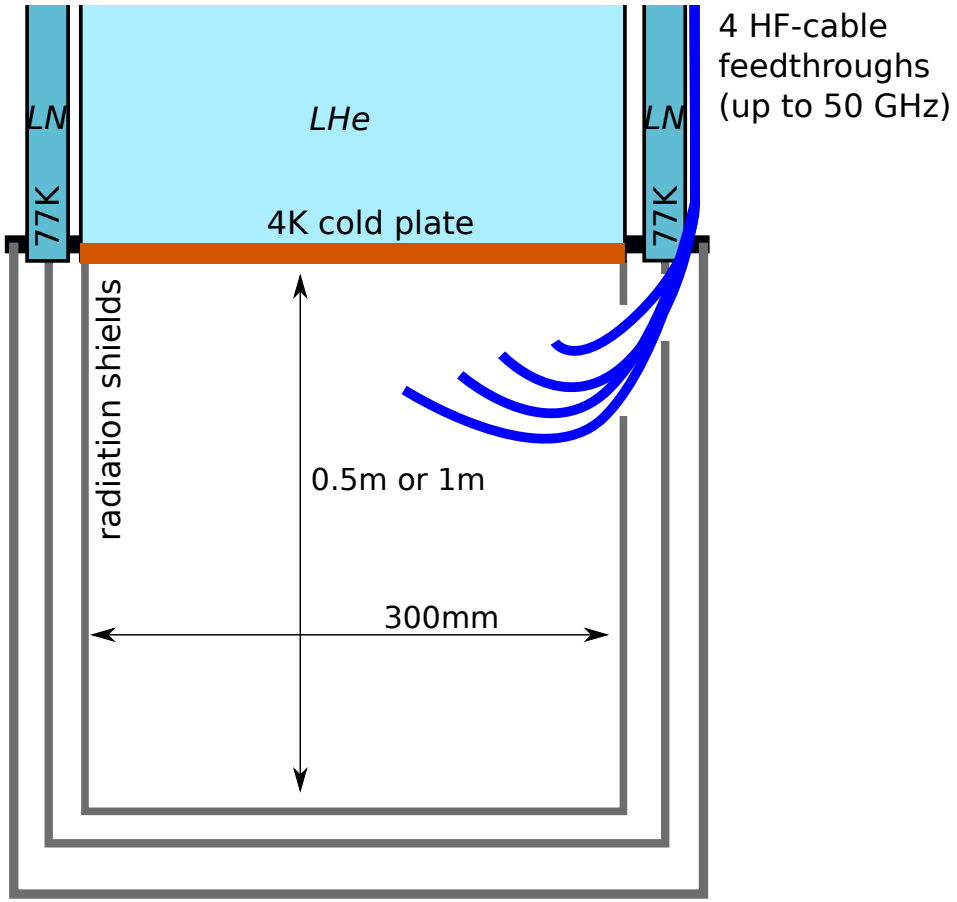


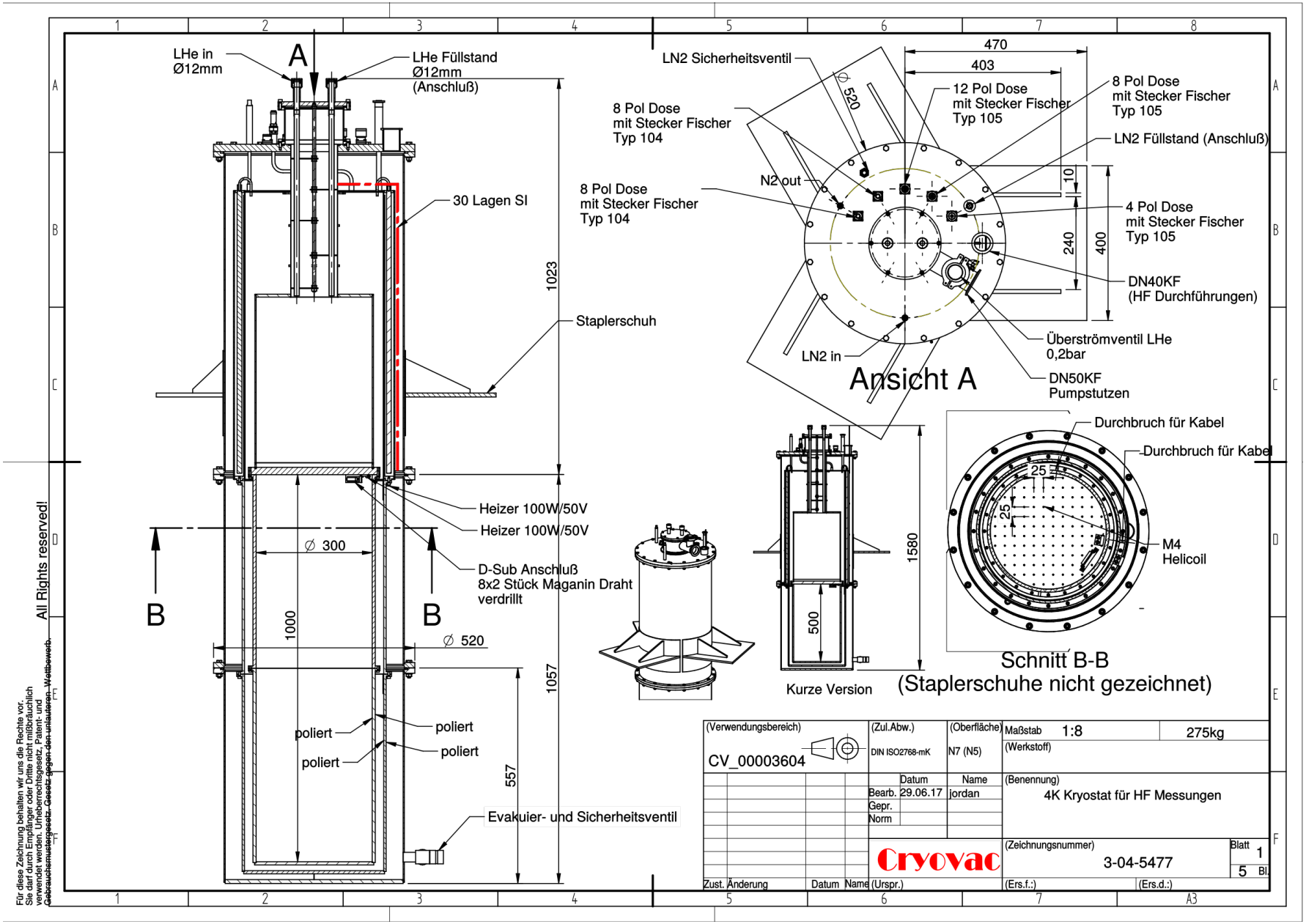
Material Properties
@ cryogenic Temperatures

Booster Mechanics
@ cryogenic Temperatures



A 4K Kryostat




LHe in
Ø12mm
A
LHe Füllstand
Ø12mm
(Anschluß)
30 Lagen SI
1023
Staplerschuh
Heizer 100W/50V
Heizer 100W/50V
D-Sub Anschluß
8x2 Stück Maganin Draht
verdrillt
∅ 300
B
B
1000
∅ 520
1057
557
poliert
poliert
poliert
poliert
Evakuier- und Sicherheitsventil
LN2 Sicherheitsventil
470
403
∅ 520
12 Pol Dose
mit Stecker Fischer
Typ 105
8 Pol Dose
mit Stecker Fischer
Typ 105
LN2 Füllstand (Anschluß)
8 Pol Dose
mit Stecker Fischer
Typ 104
N2 out
8 Pol Dose
mit Stecker Fischer
Typ 104
10
240
400
4 Pol Dose
mit Stecker Fischer
Typ 105
DN40KF
(HF Durchführungen)
LN2 in
Überströmventil LHe
0,2bar
DN50KF
Pumpstutzen
Ansicht A
1580
500
Kurze Version
Durchbruch für Kabel
Durchbruch für Kabel
25
25
M4
Helicoil
Schnitt B-B
(Staplerschuhe nicht gezeichnet)
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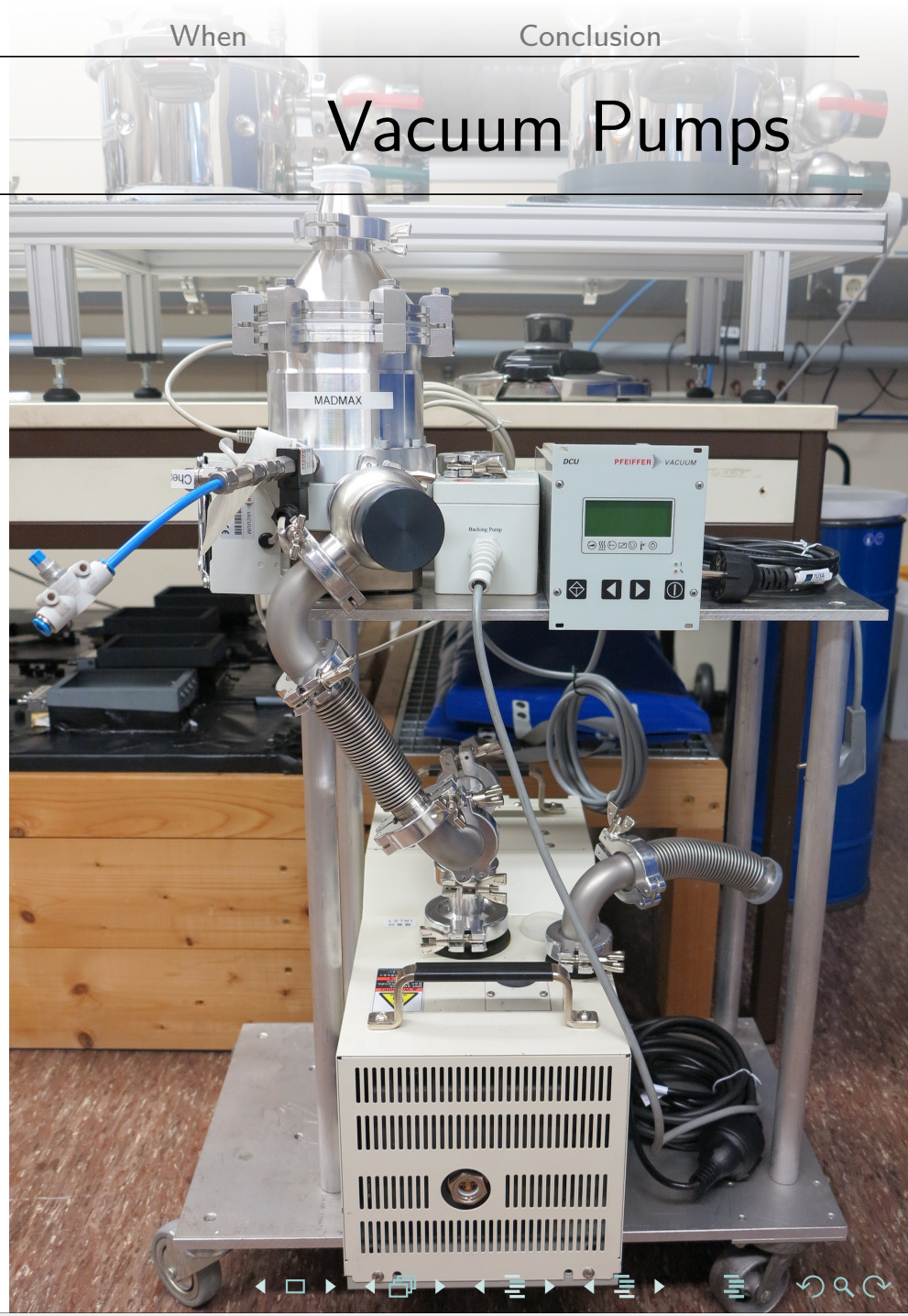
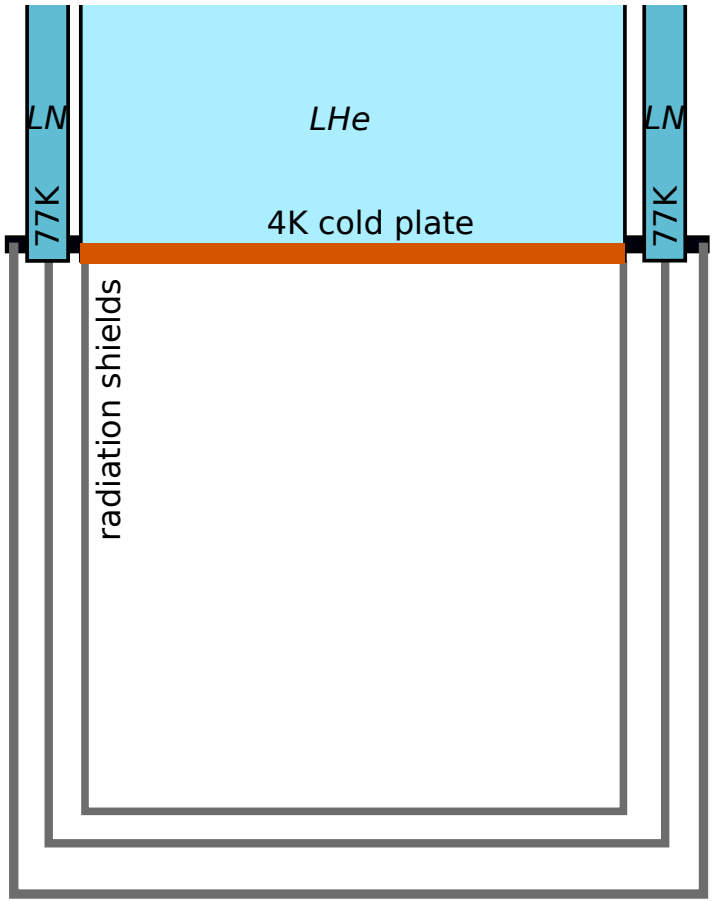
Gebrauchsmustergesetz, Gesetz gegen den unlauteren Wettbewerb.
(Verwendungsbereich)
CV_00003604
(Zul.Abw.)
DIN ISO2768-mK
(Oberfläche)
N7 (N5)
Maßstab 1:8
275kg
(Werkstoff)
Datum
Name
Bearb. 29.06.17 jordan
Gepr.
Norm
(Benennung)
4K Kryostat für HF Messungen
Cryovac
(Zeichnungsnummer)
3-04-5477
Blatt 1
5 Bl.
Zust. Änderung
Datum
Name
(Urspr.)
(Ers.f.:)
(Ers.d.:)
A3

Holding Structure

Vacuum Pumps

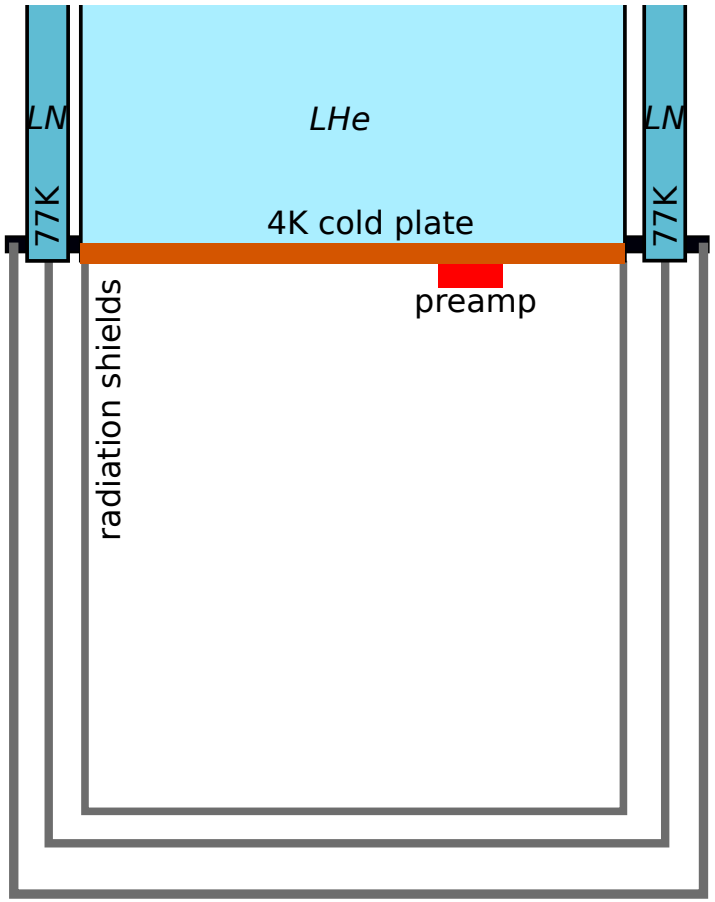


Measuring Noise



schematic, not to scale
cables and other details not shown

Measuring Noise



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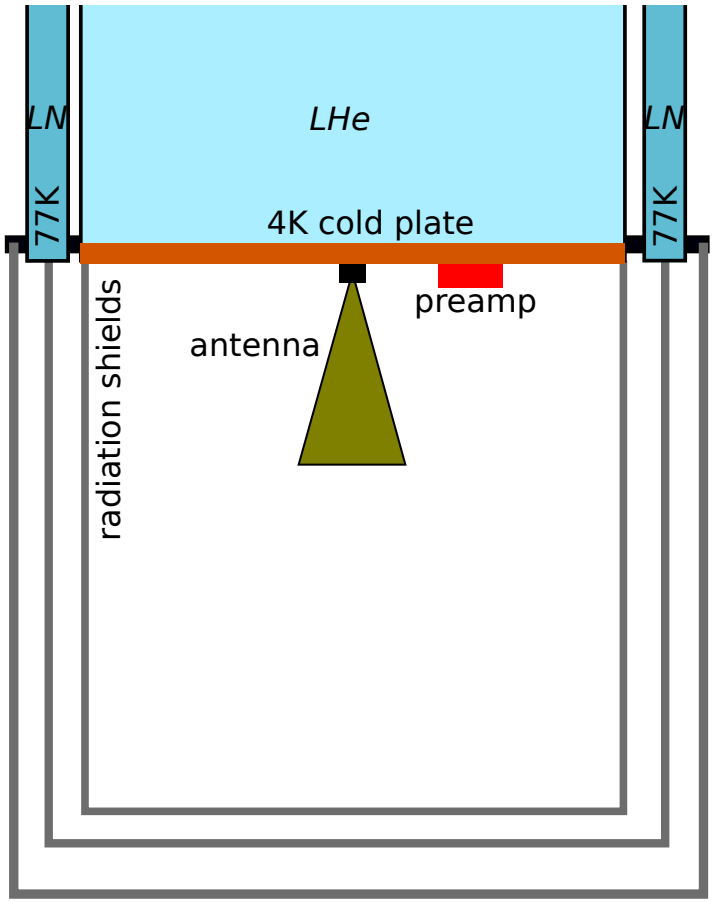
Measuring Noise



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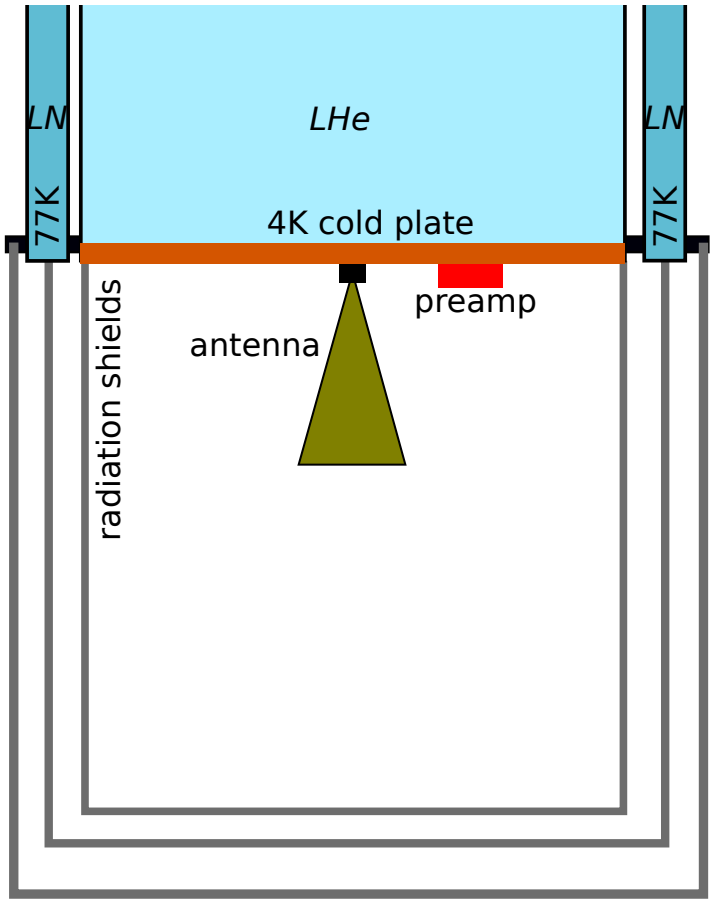
Measuring Noise



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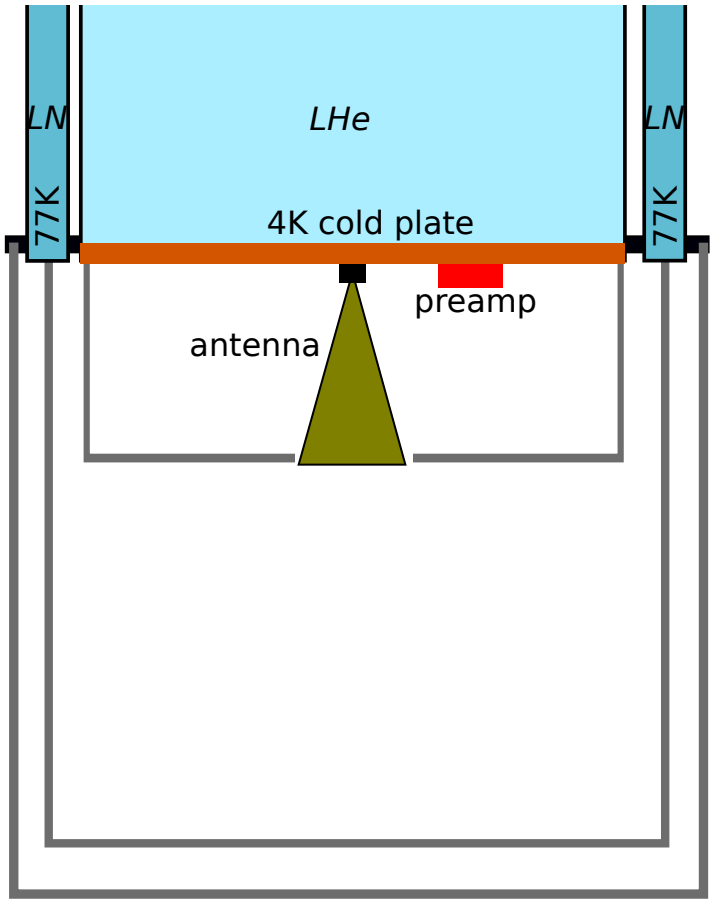

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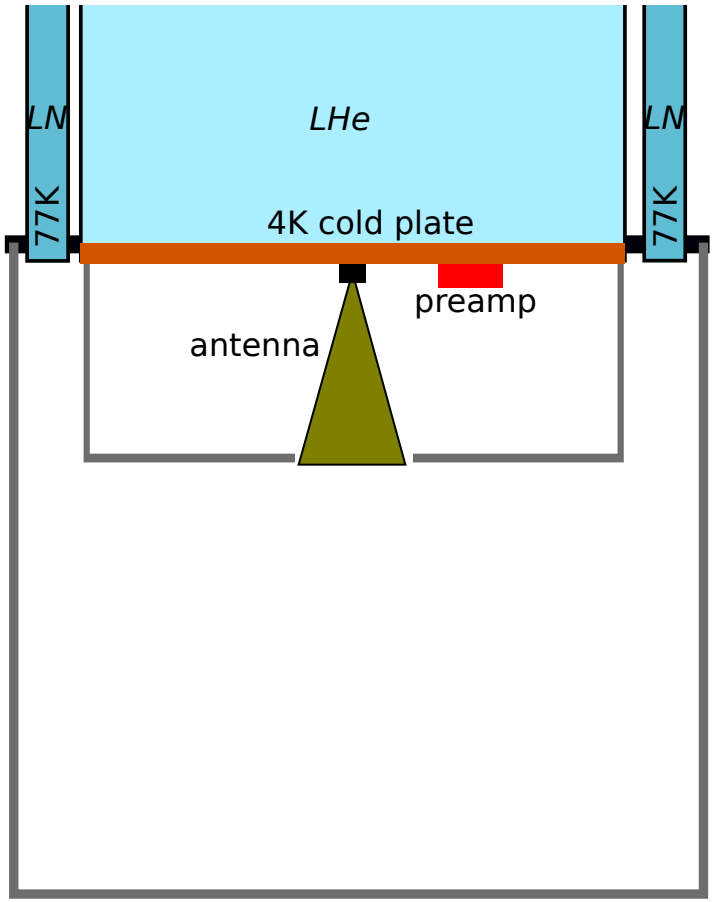

schematic, not to scale
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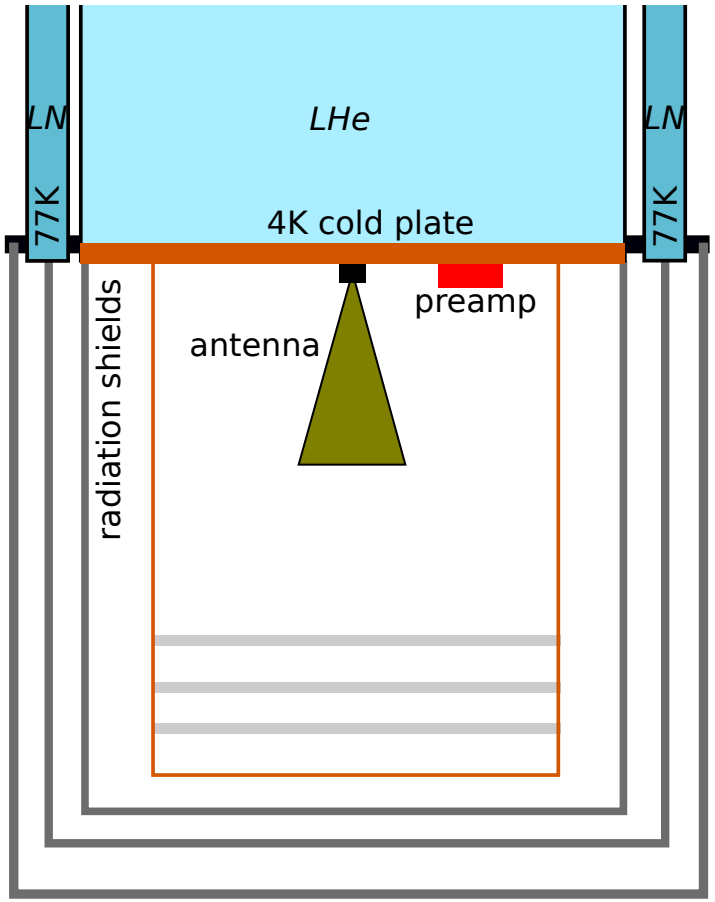
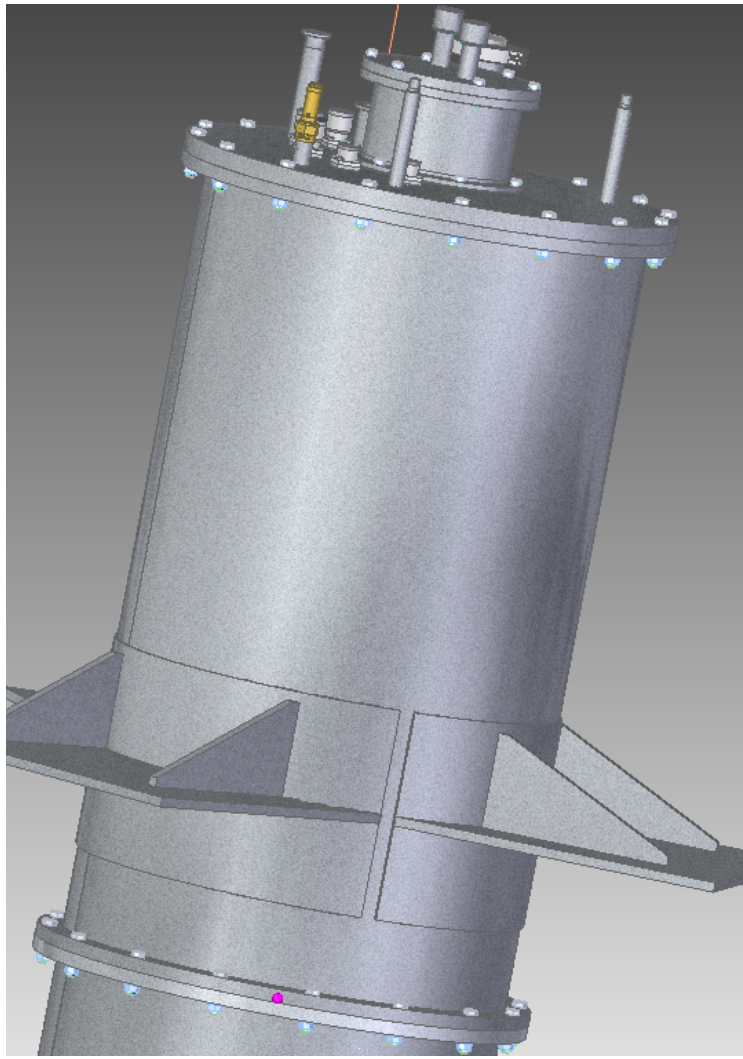
Measuring Noise



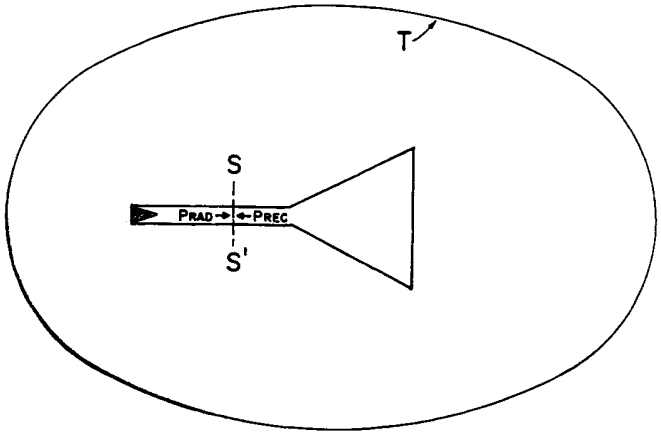
schematic, not to scale
cables and other details not shown

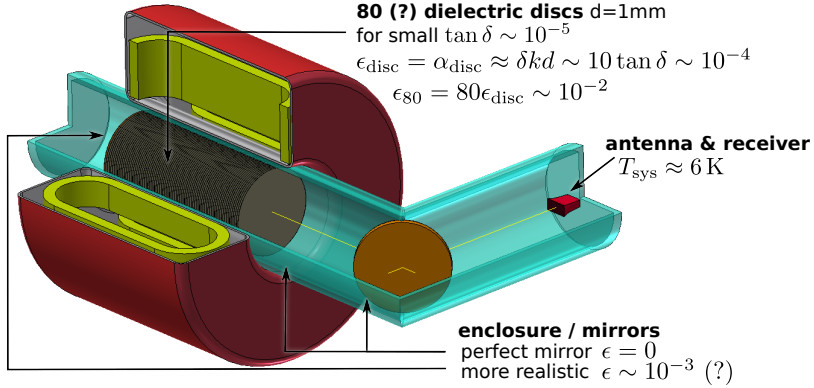
Timeline

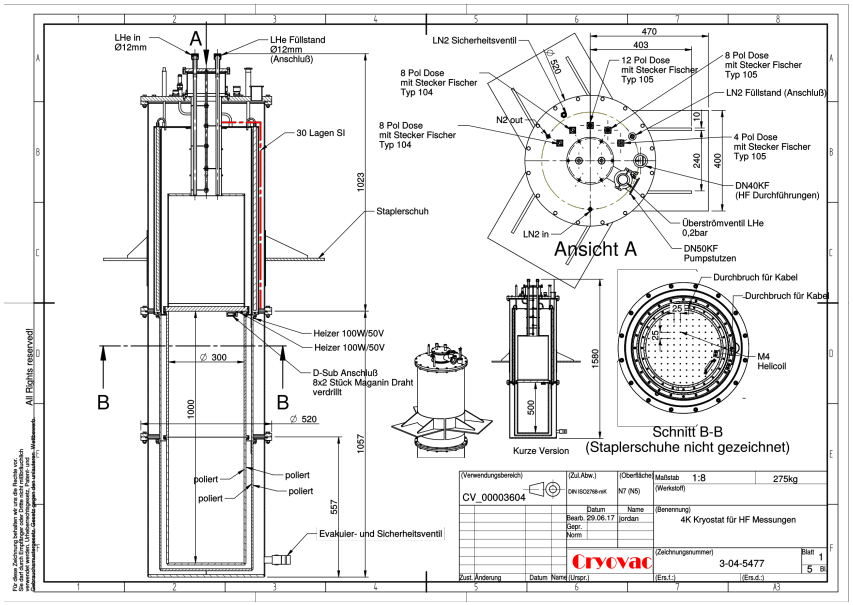
- November
  delivery
- end 2017
  setup, commissioning,
  first cool down
- 2018
  first receiver measurements
  waveguide noise measurements
  material measurements
  other purposes tbd

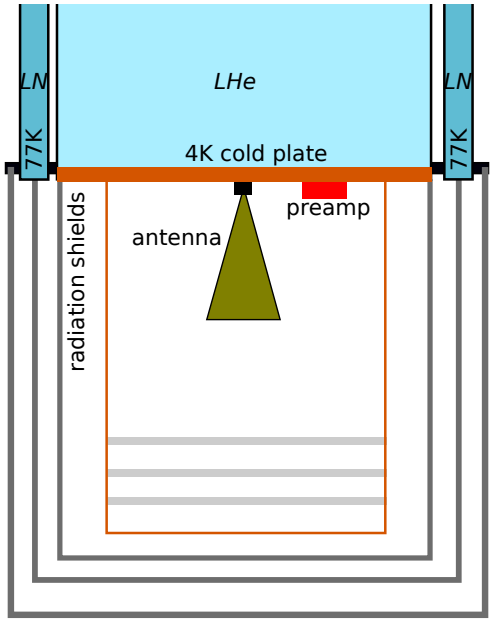


Conclusions









schematic, not to scale
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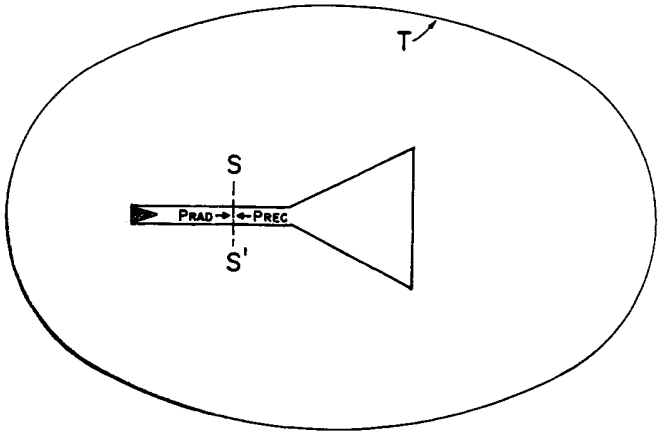
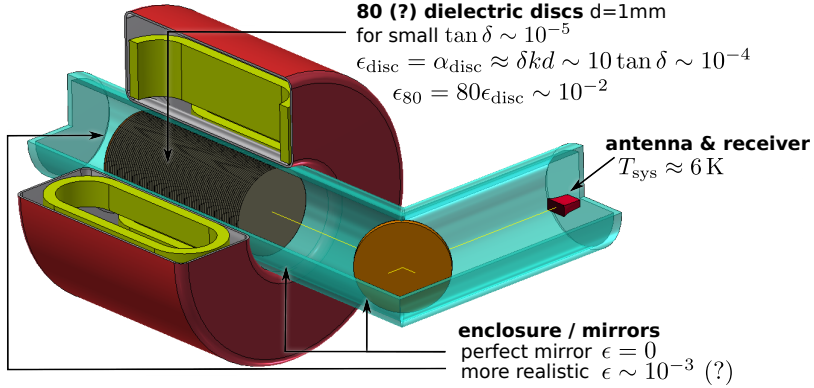
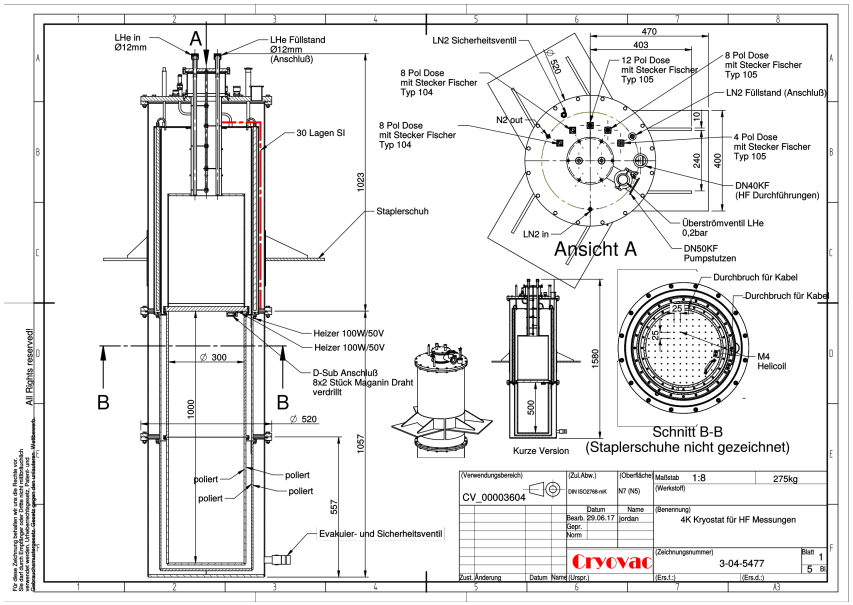
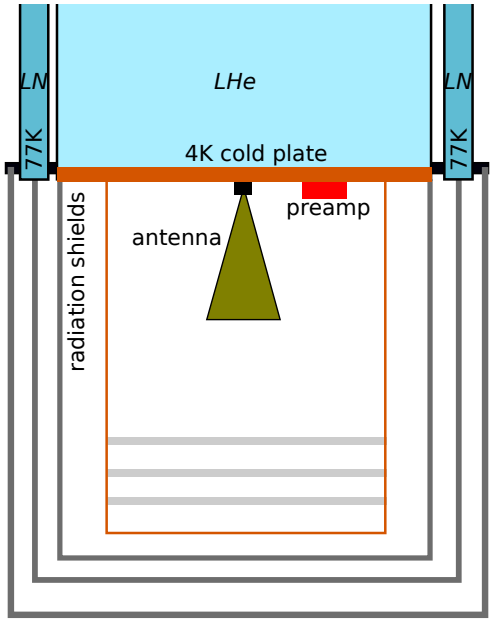
Thank You very much









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