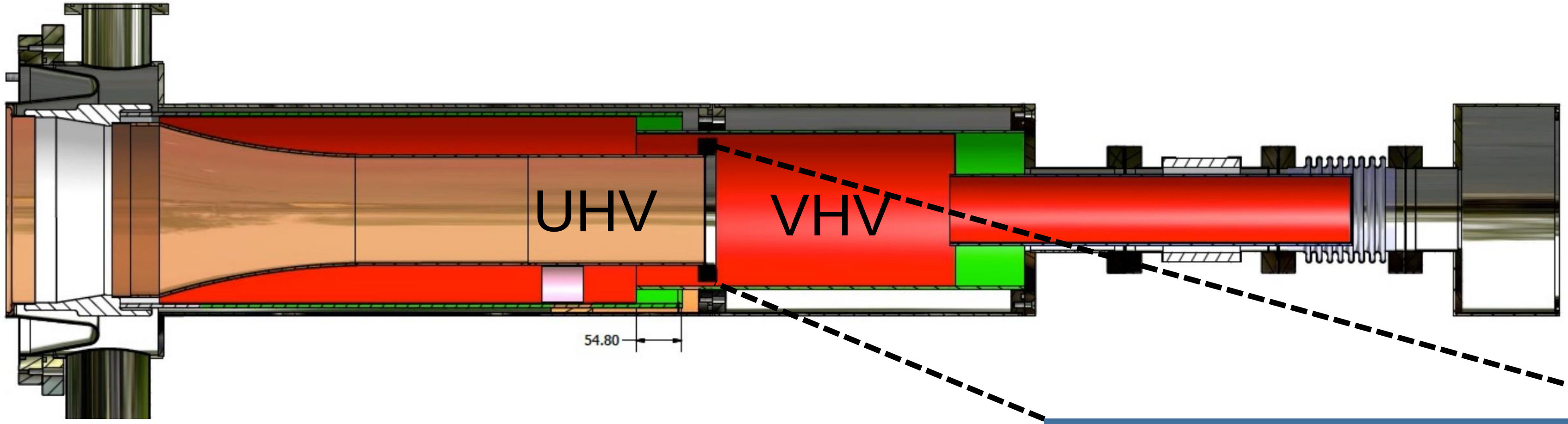
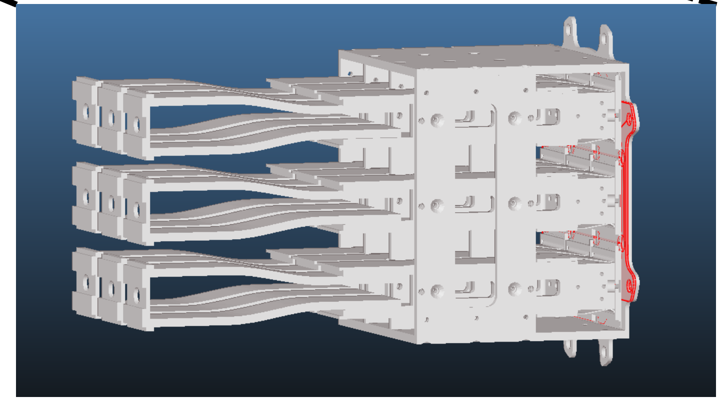
Vacuum Investigations

Phase-1 vacuum conductance simulations

Importance of vacuum compatibility

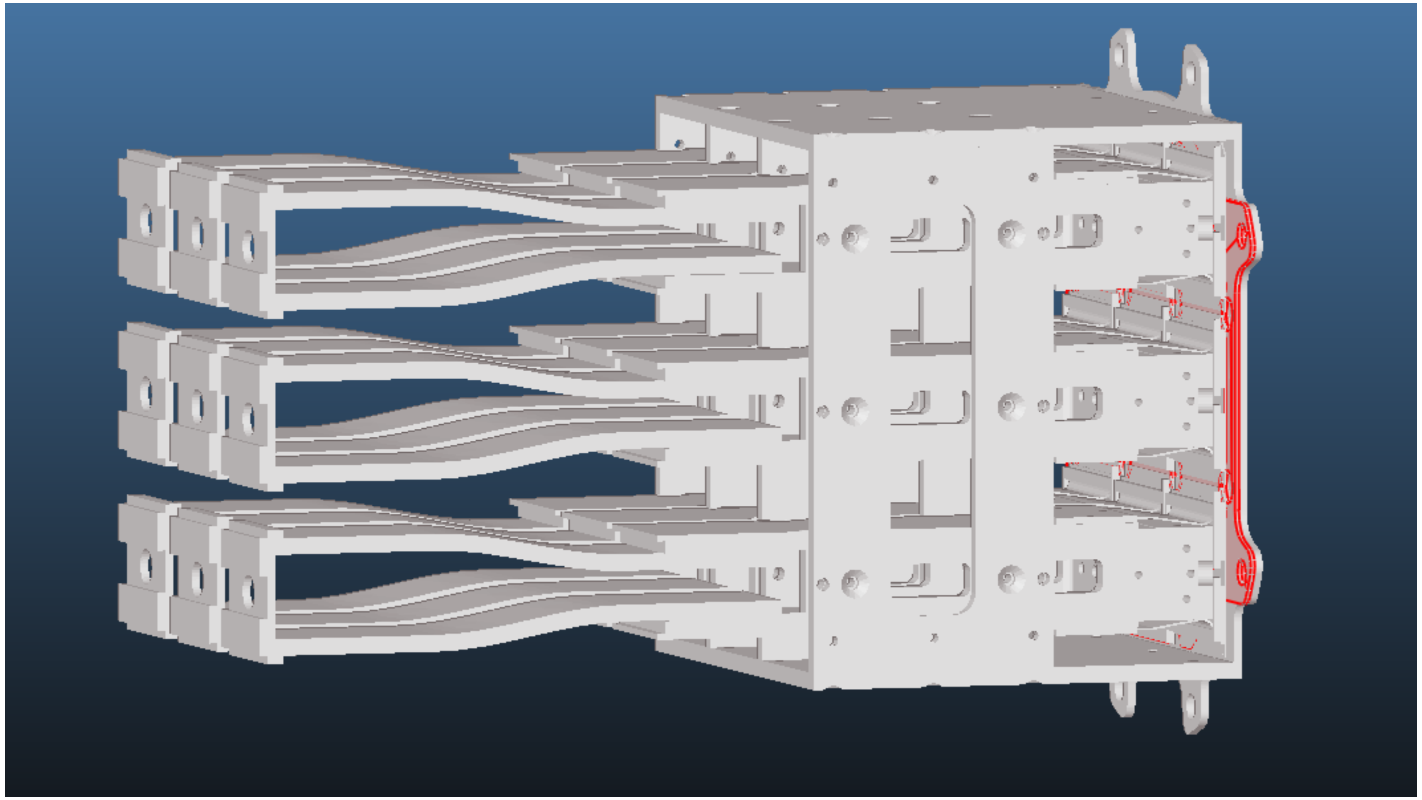




- No tight separation of UHV spectrometer side from VHV electronics side
  → Increased scattering
  → Possible depositions

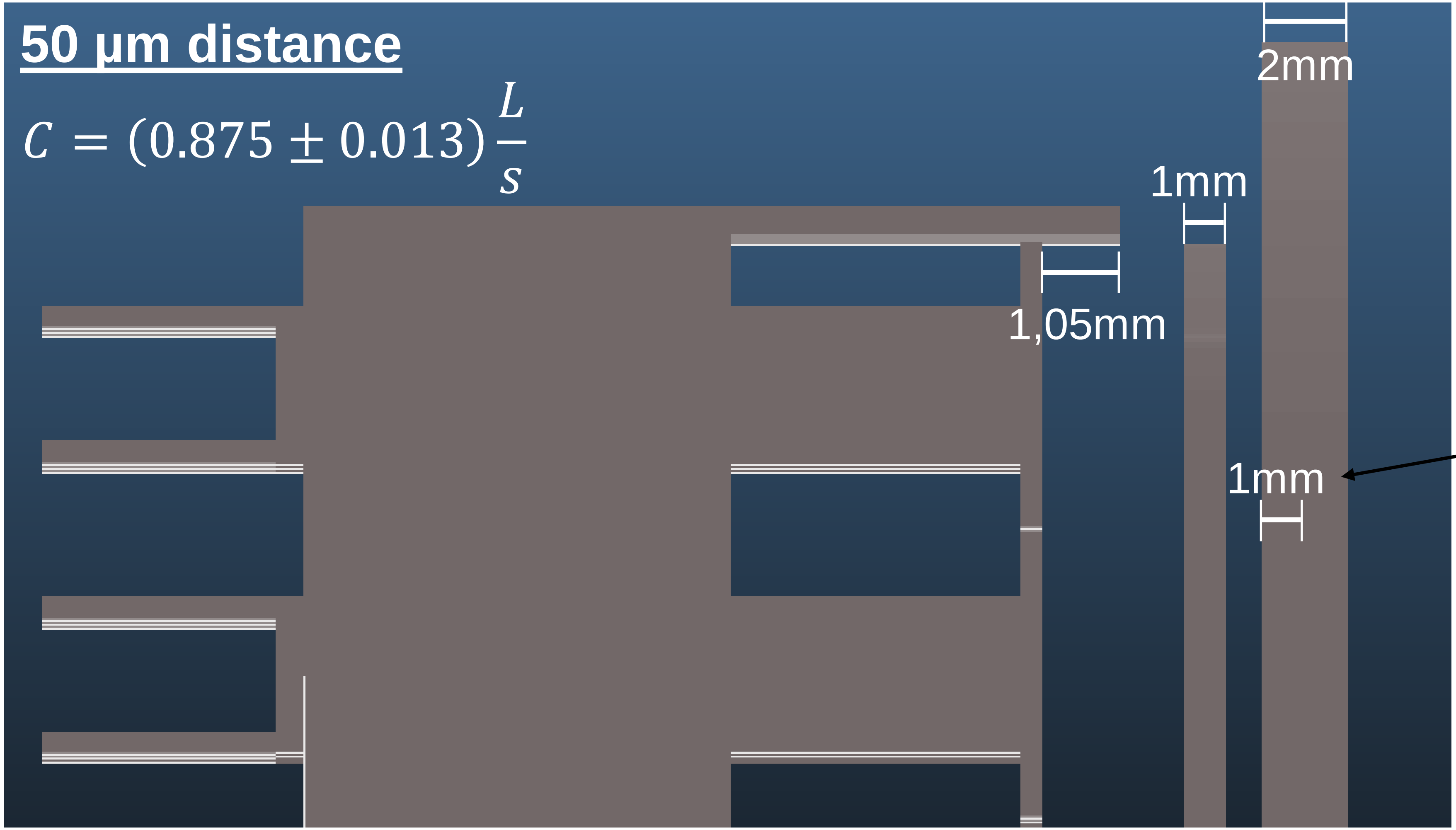
Vacuum shield design

- Shielding split in two parts
  - →part of detector mounting
  - →thickness partly adjustable
  - →Adjustable material selection (stainless steel,kapton, combination)



- Design distance aim d=50µm

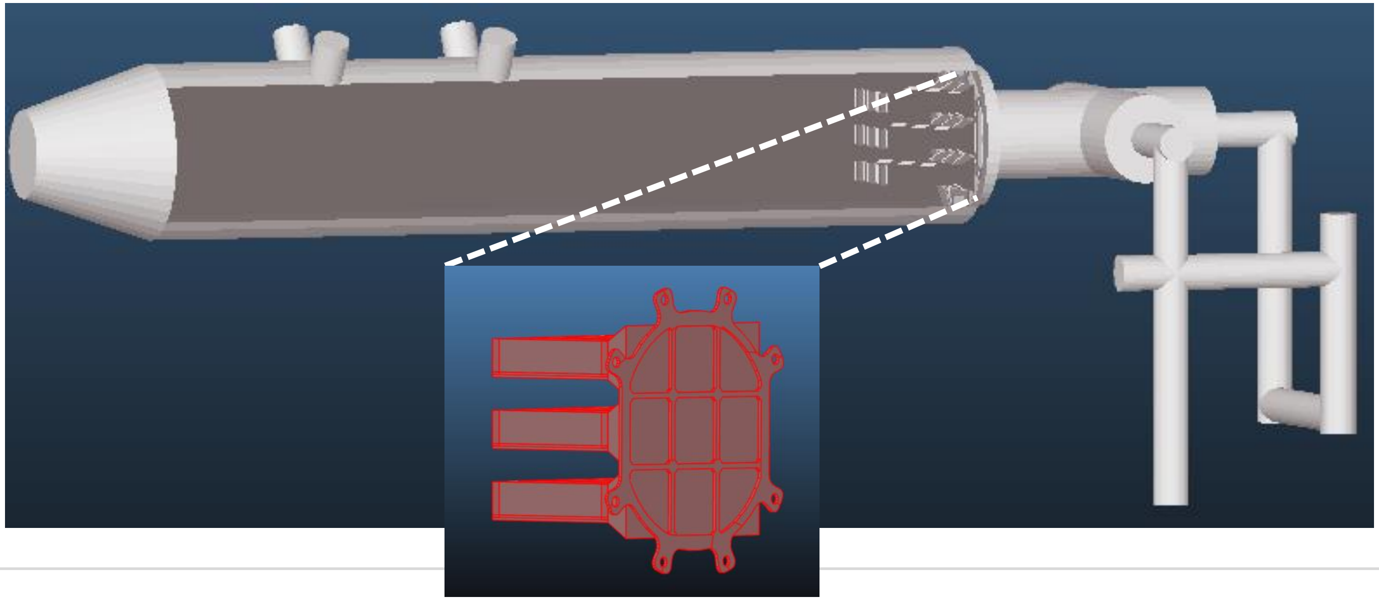
Vacuum shield design



Cavities (optional)

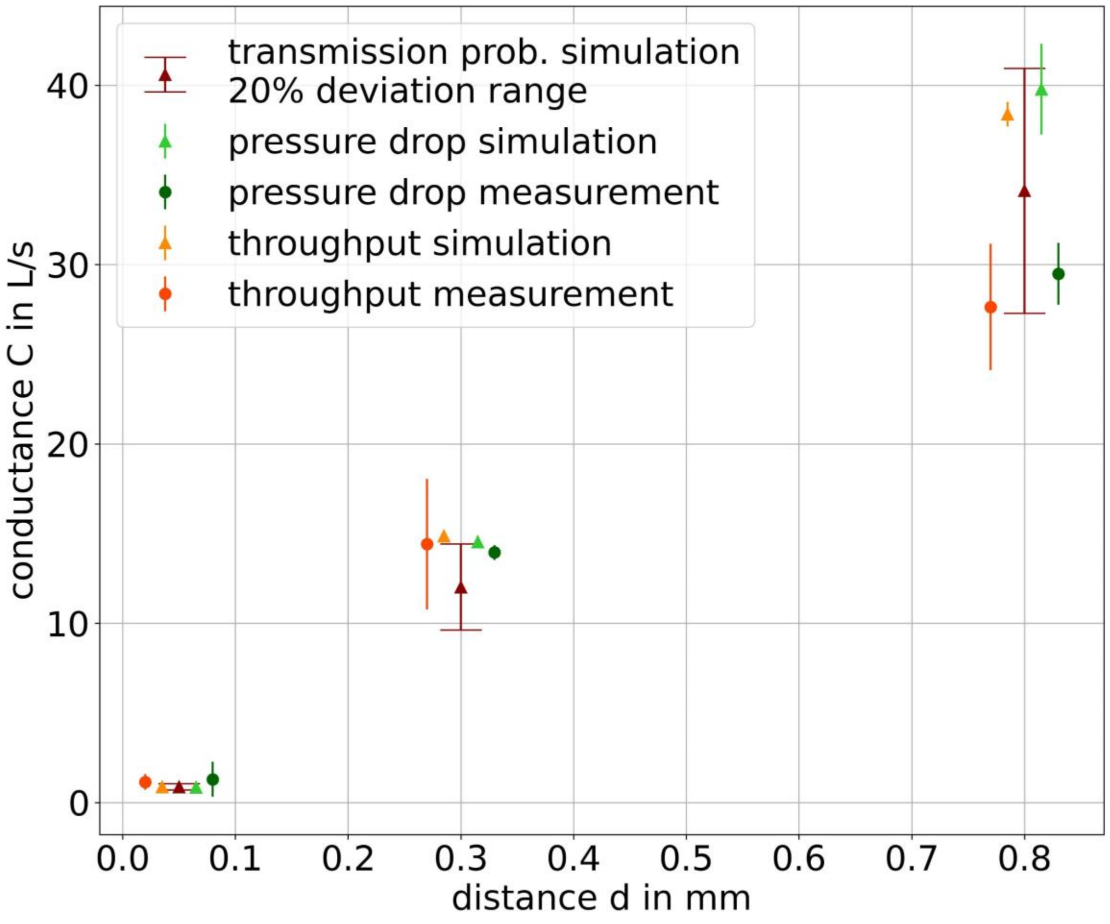
Measurement setup

- Dedicated setup to determine detector conductance
- 2 independent measurement methods
  - +1 simulation method



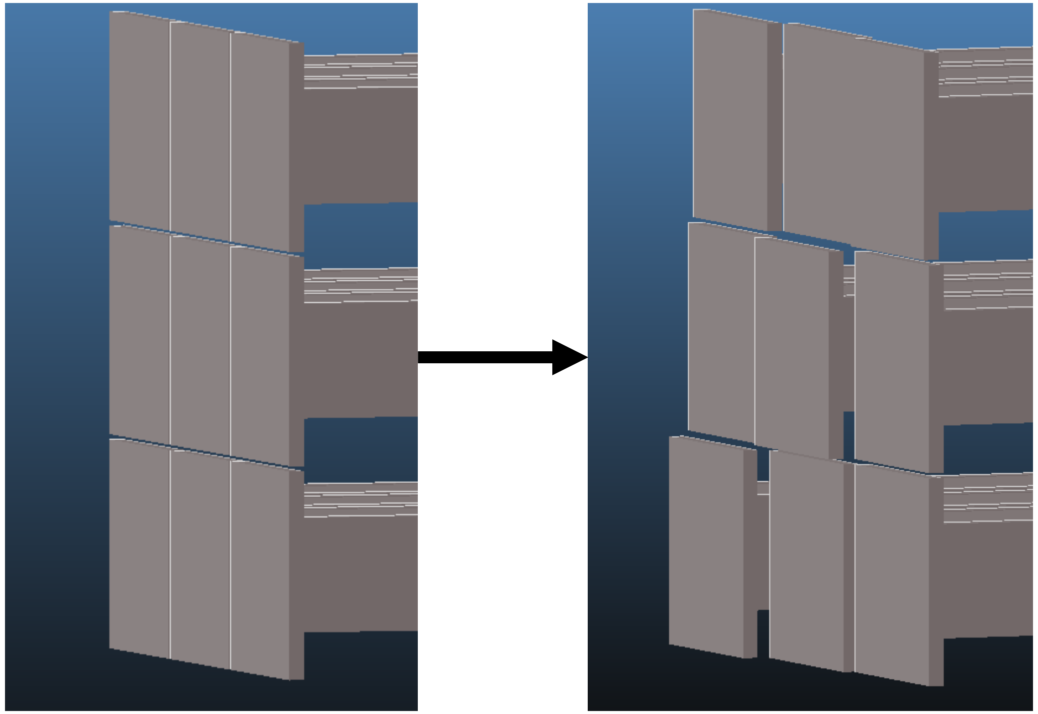
Conductance measurements

- Simulations in agreement with meaurements
- Design distance of 0.05 mm in desired range of ~1 L/s
- Strong dependency on distance



Gluing induced distance deviations

- Investigation of module positioning



-50µm
design distance

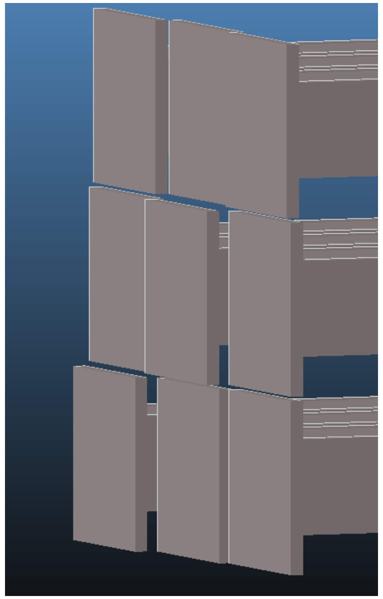
±50µm
random deviations

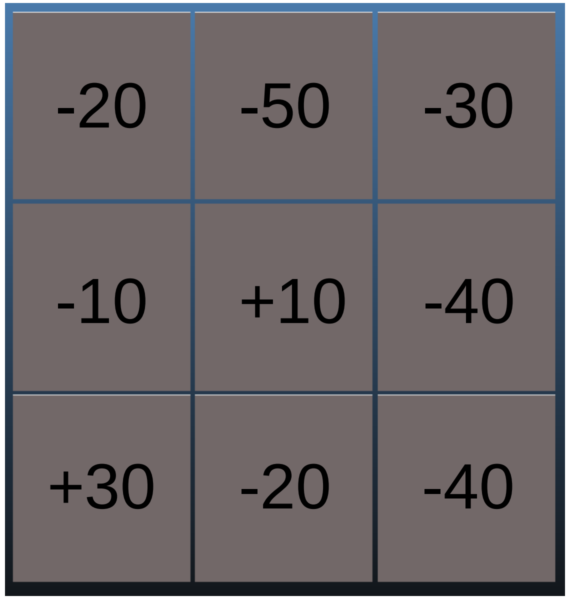
Gluing induced distance deviations

- Investigation of module positioning

- determine conductance for

    1) Random offset

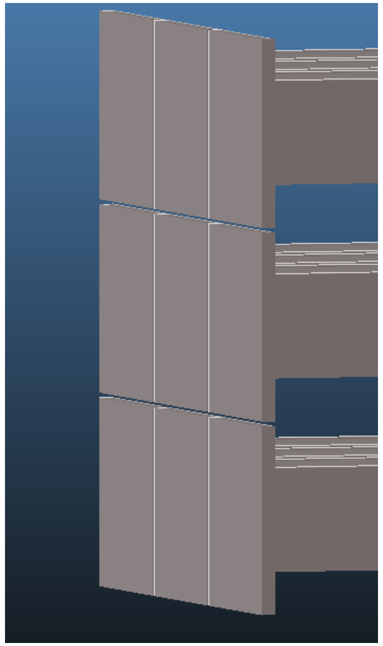




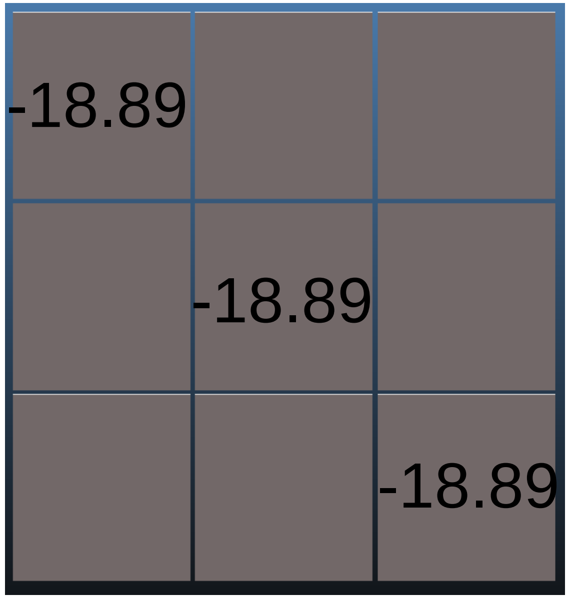
Added to -50µm design distance

Gluing induced distance deviations

- Investigation of module positioning
- determine conductance for
    1) Random offset
    2) Mean added distance



Mean: 68.89 µm



Added to -50µm design distance

Gluing induced distance deviations

- Investigation of module positioning

- determine conductance for

  1) Random offset
  2) Mean added distance
  3) High distance module @ each position

-90	-10	-10
-10	-10	-10
-10	-10	-10

Added to -50µm design distance

Gluing induced distance deviations

- Investigation of module positioning

- determine conductance for

  1) random offset
  2) mean added distance
  3) high distance module @ each position
  4) optimized positioning according to 3)

-40	-20	-40
+10	-20	+30
-30	-10	-50

Added to -50µm design distance

Comparison to mean distance

Karlsruher Institut für Technologie

- Conductance compared to mean distance @68µm $C_{mean} = 1.43\frac{L}{s}$

$$\Delta C = \frac{C - C_{mean}}{C_{mean}}$$

1) Random: $\Delta C = 0.071 \quad (C = 1.53\frac{L}{s})$
2) Mean: $\Delta C = 0.000$
3) High distance module →
4) Optimized $\Delta C = -0.012 \quad (C = 1.42\frac{L}{s})$

-0.005	0.085	0.002
0.094	0.076	0.094
0.003	0.090	-0.008

- Improvement of ~8% (0.1 L/s) for optimized layout

Relative or absolute effect

- How large is $\Delta C = \frac{C - C_{mean}}{C_{mean}}$ for overall increased distance

Mean

-18.89		
	-18.89	
		-18.89

Random

-20	-50	-30
-10	+10	-40
+30	-20	-40

Optimized

-40	-20	-40
+10	-20	+30
-30	-10	-50

Added to -150µm distance

	Mean	Random	Optimized
C in L/s:	5.26	5.31	5.15
ΔC :	-	0.01	-0.02

Relative or absolute effect

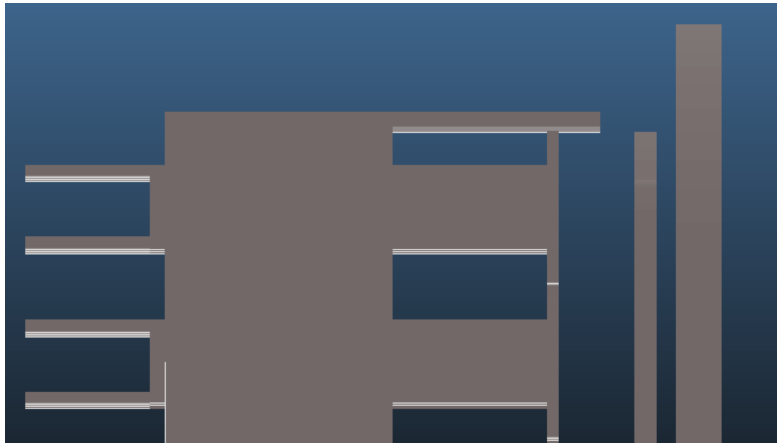
- Positioning of modules is not critical
  - Improvement on absolute scale of 0.1-0.2 L/s

- Fluctuations in gluing thickness greatly impact conductance
  - $C(50\mu m) = 0.88\ \frac{L}{s} \longrightarrow C(68\mu m) = 1.43\ \frac{L}{s}$

- Difference in module length still valuable for detector conductance
  - Variable shield thickness can compensate some deviation

-40	-20	-40
+10	-20	+30
-30	-10	-50

Relative or absolute effect



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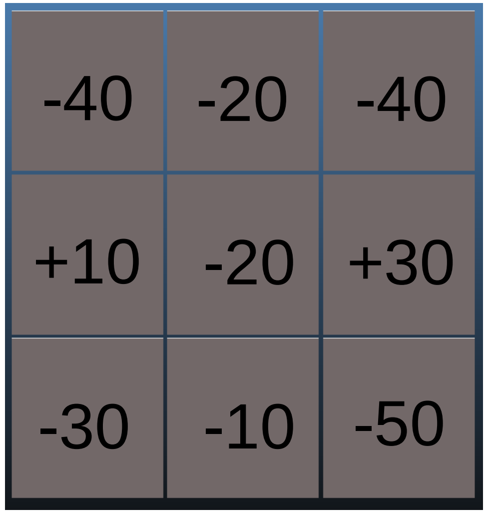
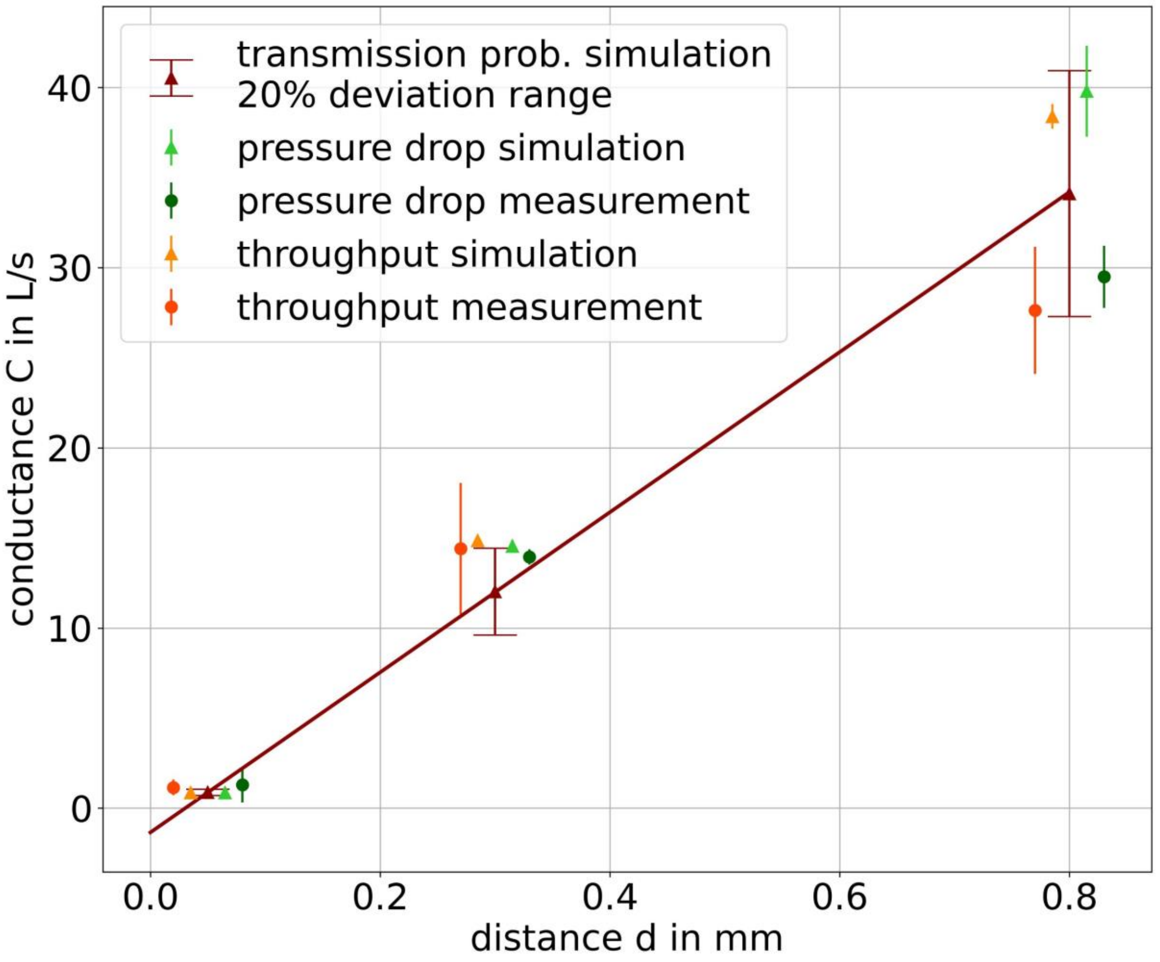


Conductance simulations

- Design distance of 0.05 mm in desired range of ~1 L/s

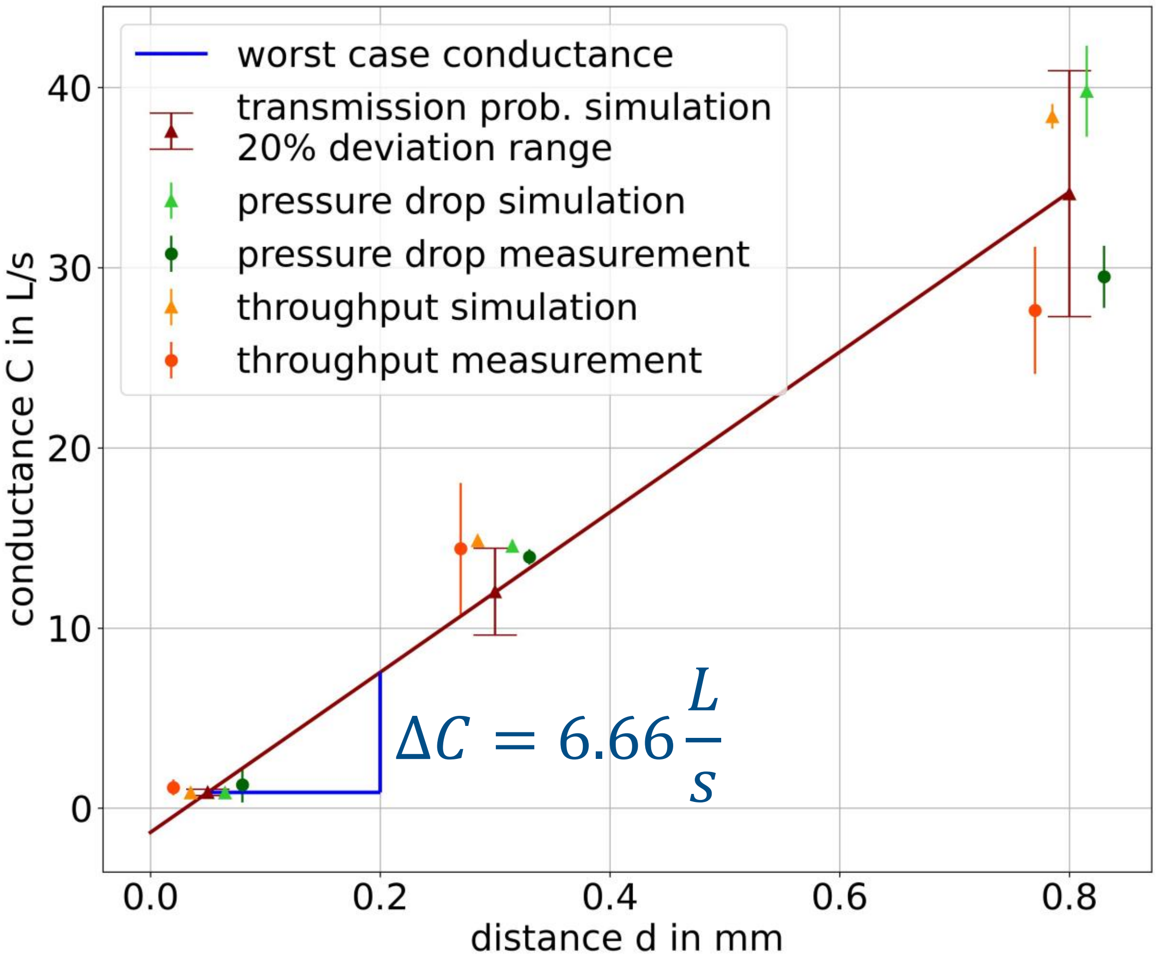
- Strong distance dependence: 4.4 L/s per 0.1 mm



Conductance simulations

- Design distance of 0.05 mm in desired range of ~1 L/s
- Strong distance dependence: 4.4 L/s per 0.1 mm
- Worst case feasibility estimation:
  - Production accuracy limits: 0.1 mm
  - Additional gluing layer difference: 0.05 mm

deviations of ~1 order of magnitude possible

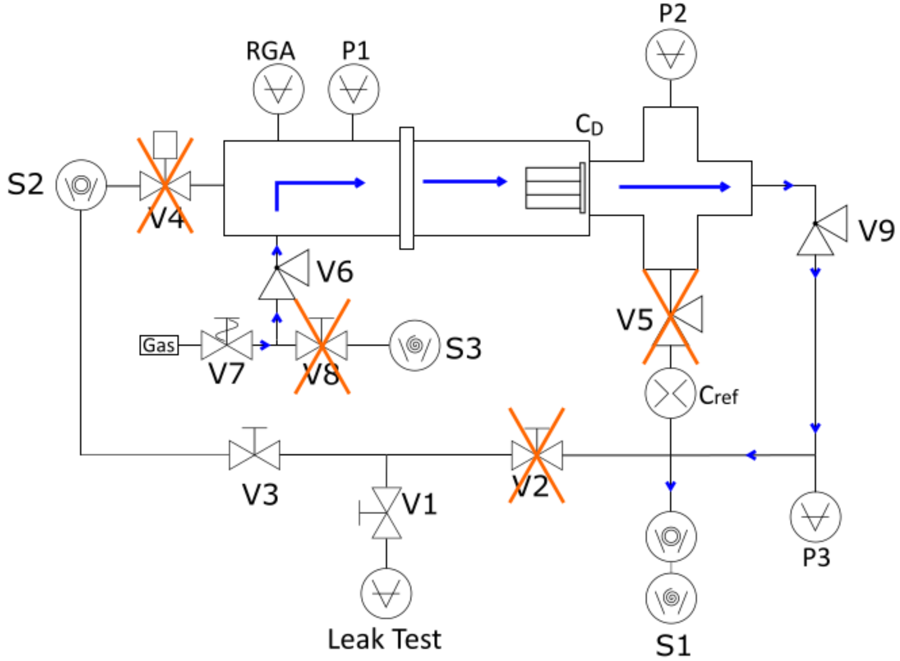


Conclusion/Outlook

- Conductance at design distance in desired range ~1 L/s
  - Module positioning is not critical
  - But exact module length is still benefical
  - Very sensitive to distance changes (4.4 L/s per 0.1 mm)
- Outgassing measurements planned at KIT
- Simulation of final pressure in Main Spectrometer is being set up
- Sensitivity study for deteriorated vacuum conditions in main spectrometer

Measurement methods

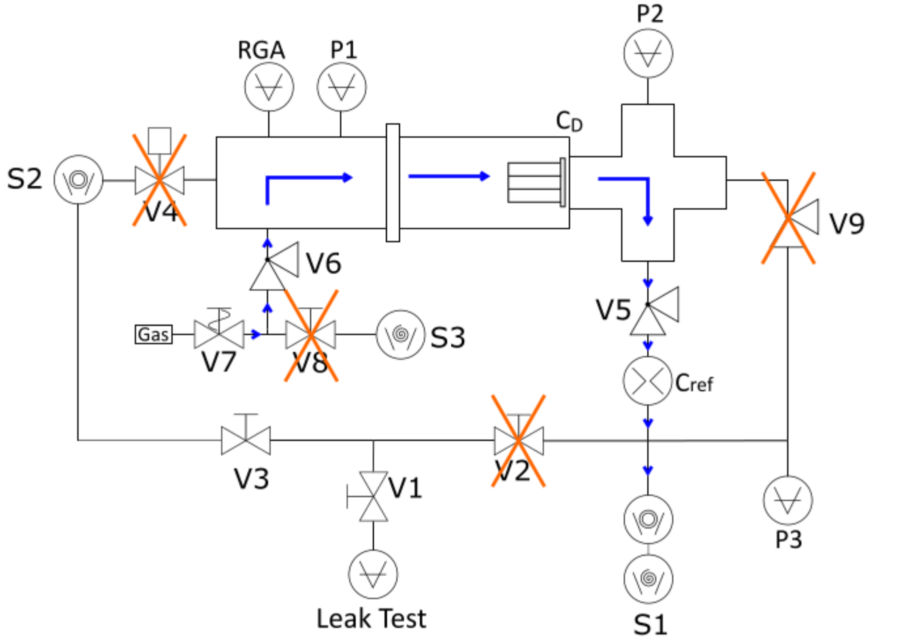
Pressure drop



Determination of conductance via exponential pressure drop:

$$P(t) = P(0) \cdot e^{-\frac{t}{\tau}} \quad \text{with} \quad \tau = \frac{V}{S_{eff}} \approx \frac{V}{S + C_D}$$

Throughput



Determination of conductance via pressure difference at equilibrium:

$$C_D = \frac{Q}{P_1 - P_2} \quad \text{and} \quad C_{ref} = \frac{Q}{P_2 - P_3}$$

Measurement principle

Transmission probability

- $C_{hole} = \frac{1}{4} \cdot A_1 \cdot \bar{c} \rightarrow C = C_{hole} \cdot \alpha$

with $\alpha = \frac{Absorption(A_2)}{Desorption(A_1)}$

and $\bar{c} = \sqrt{\frac{8 \cdot R \cdot T}{\pi \cdot M_{gas}}}$