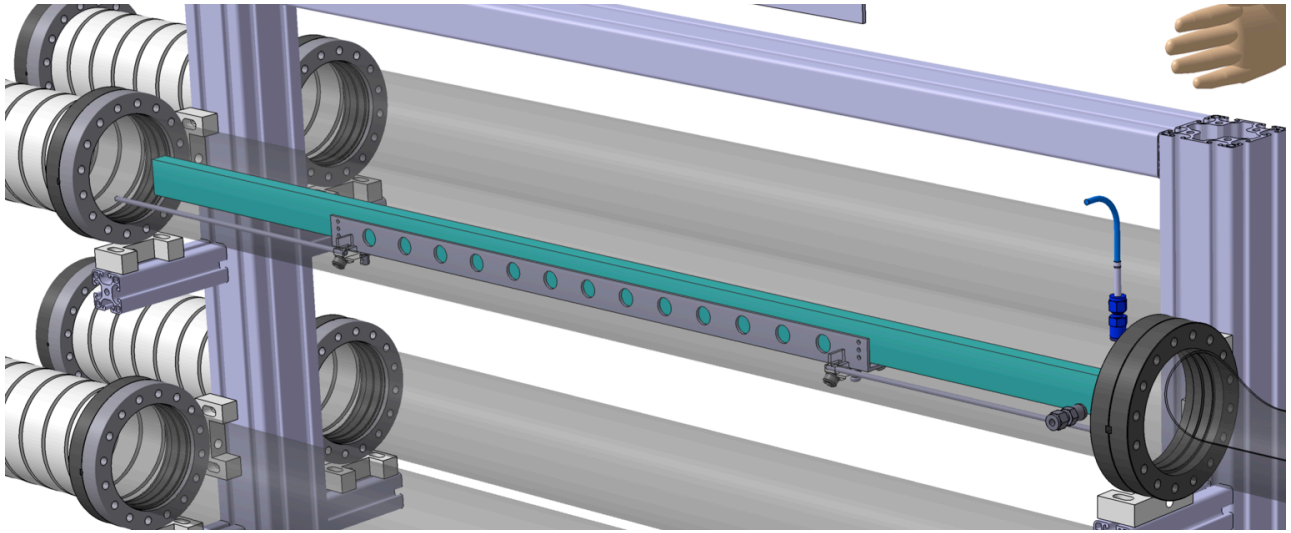
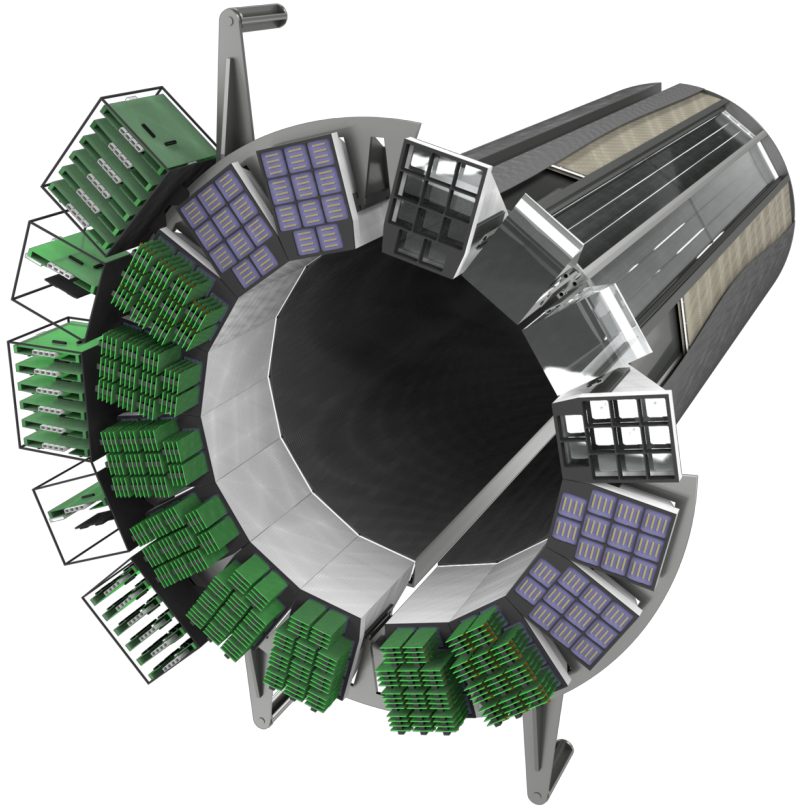
Status of the Pollution Measurement Setup at GSI





Georg Schepers

GSI Damstadt

on behalf of the

PANDA Cherenkov Group

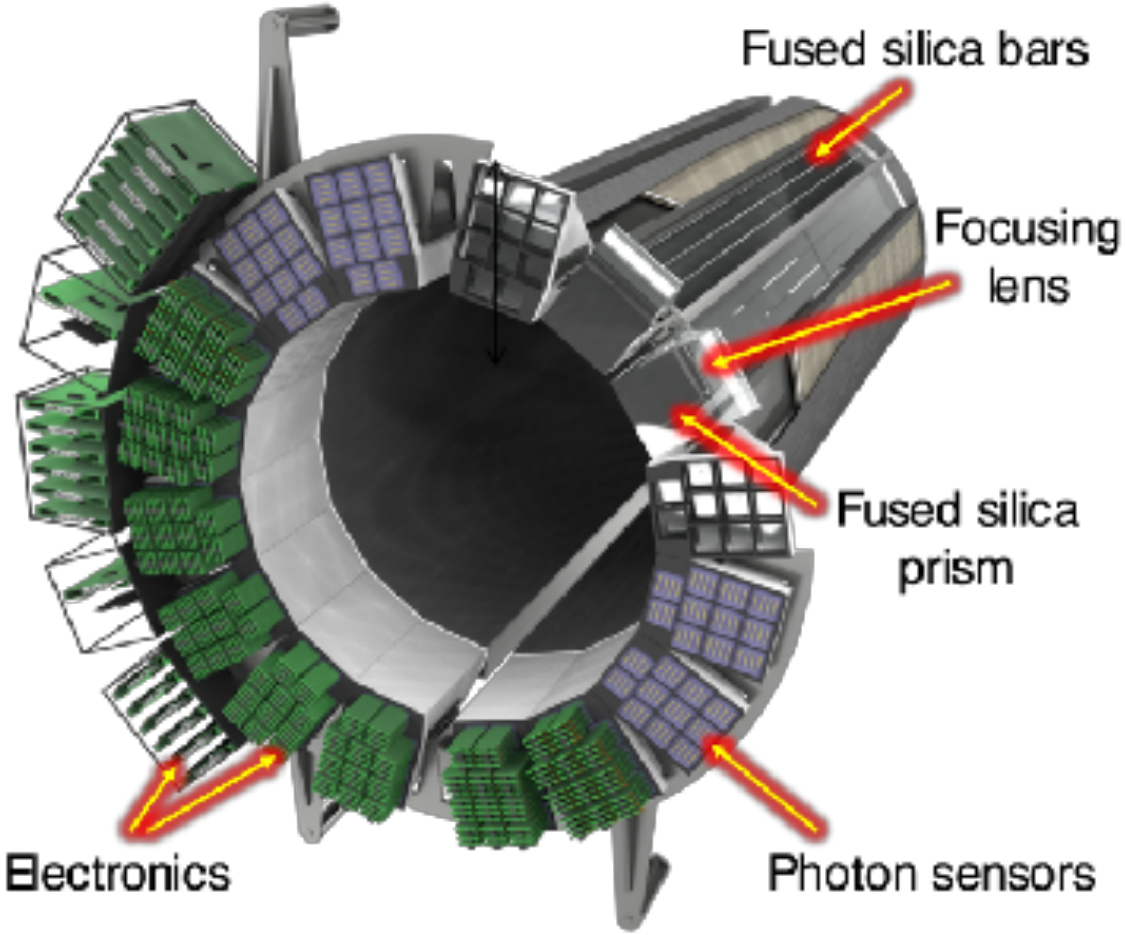
PANDA week, GSI Darmstadt

25.06.2019

Design

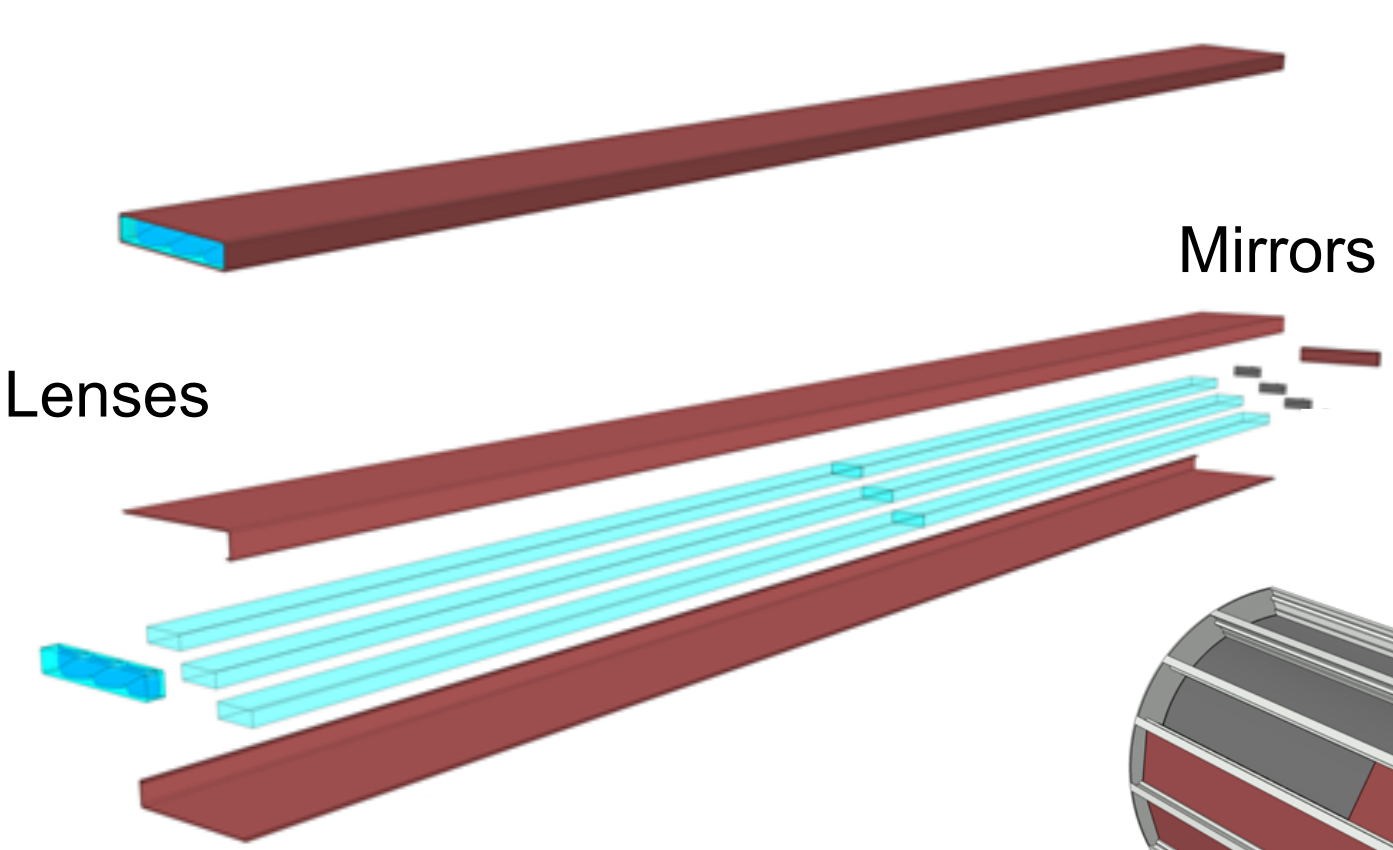
Compact fused silica prisms, 3 bars per bar box, 3-layer spherical lenses.

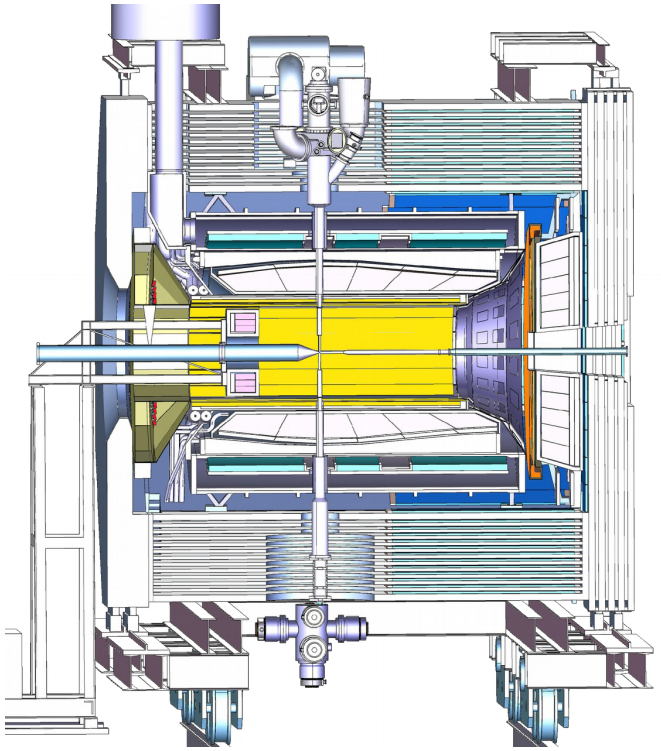
- 48 radiator bars (16 sectors), synthetic fused silica,
  17mm (T), 53mm (W), 2400mm (L).
- Focusing optics: 3-layer spherical lens
- Compact expansion volume:
  30cm-deep solid fused silica prisms
  ~11,000 channels of lifetime-enhanced MCP-PMTs
- Fast FPGA-based photon detection.
  ~100ps per photon timing resolution
- Expected performance (simulation and particle beams):
  better than 3 s.d. π/K separation for entire acceptance.

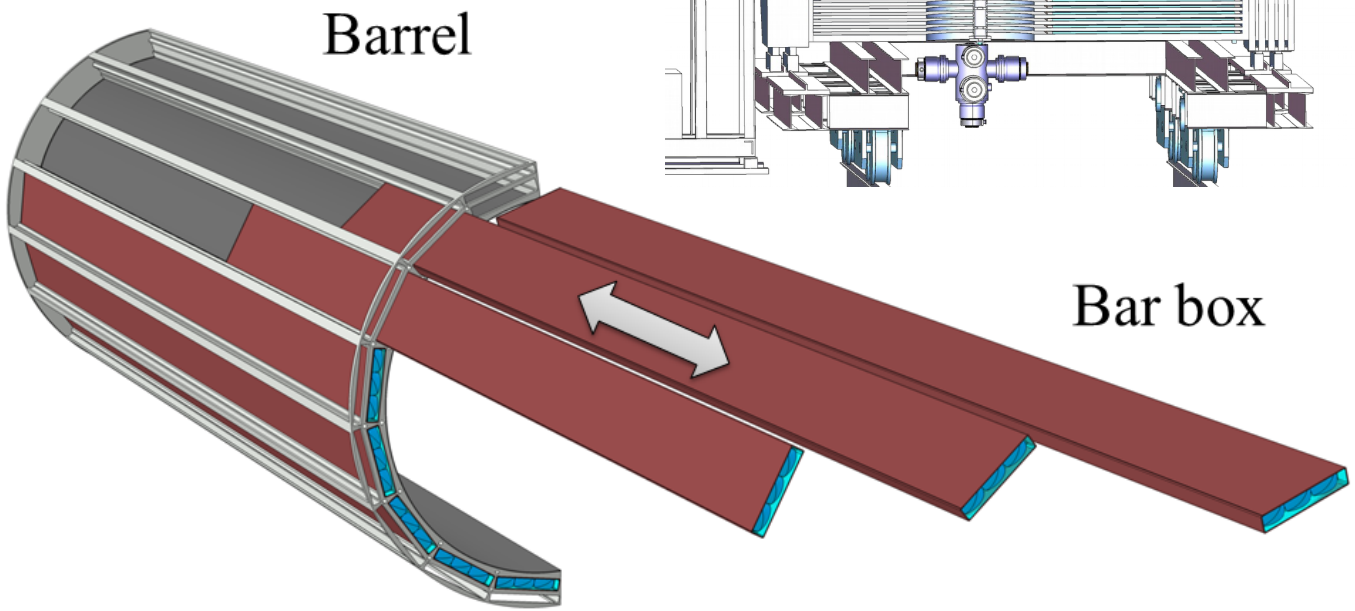


PANDA Barrel DIRC TDR, arXiv:1710.00684

Bar box





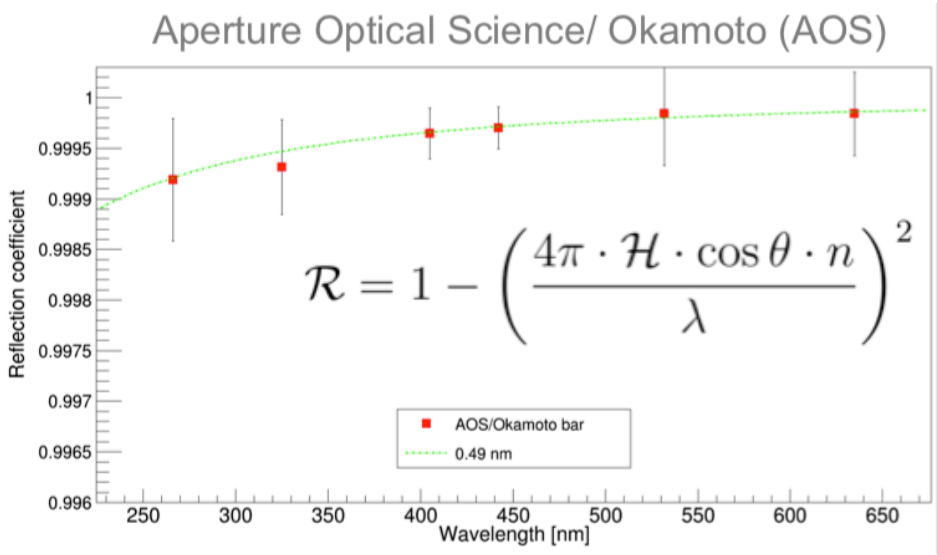


Goal

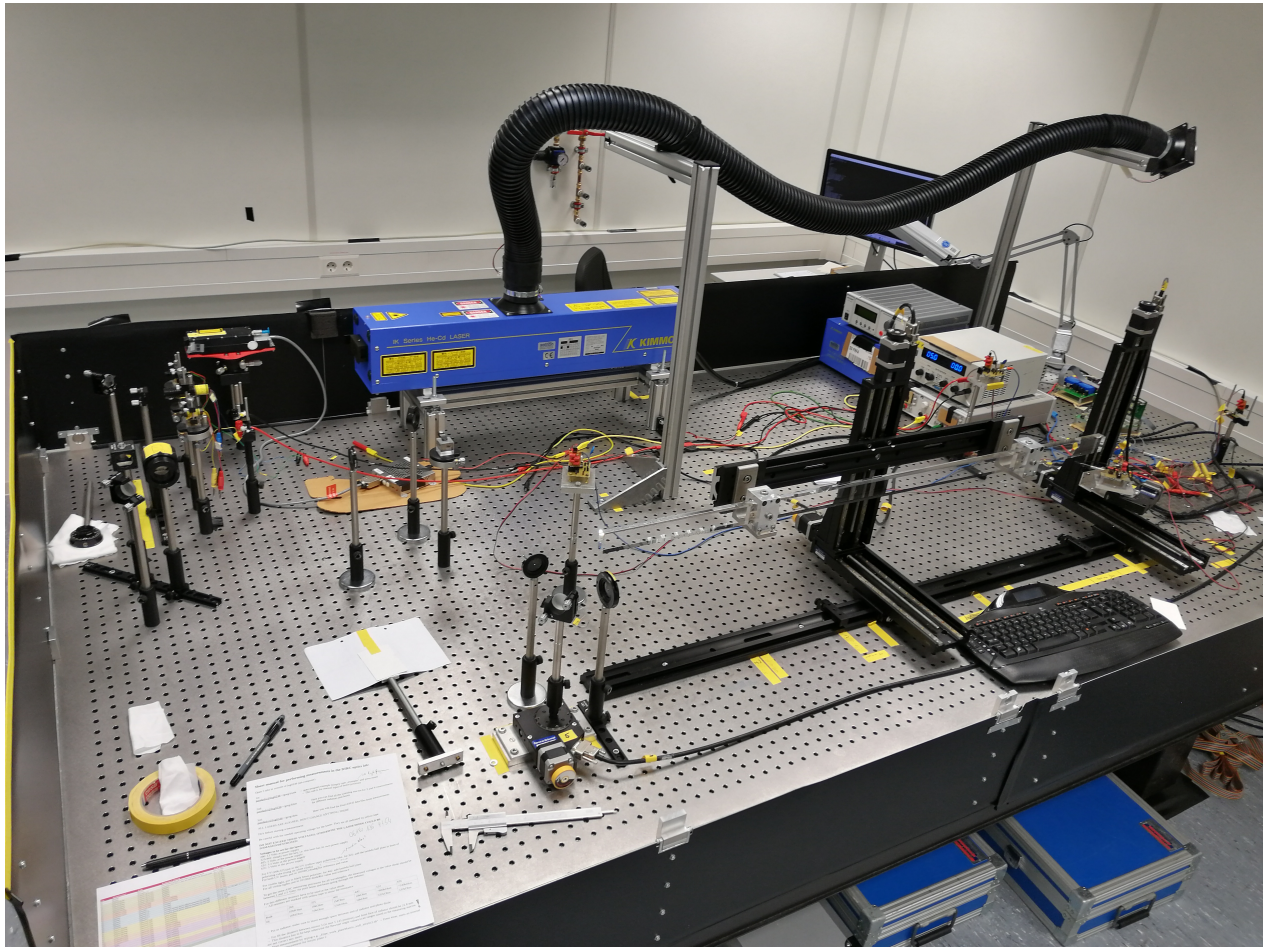
Necessary: Long term Study of the Internal Reflection Coefficient of the DIRC bars as a Function of Quartz Surface Pollution

- Method and its accuracy
- Possible Pollutants
  - Glue for bar connections (Epotek 301-2)
  - PEEK-screws/buttoms
  - Carbon fiber laminate
  - Material for the cookies

Laser setup optical lab

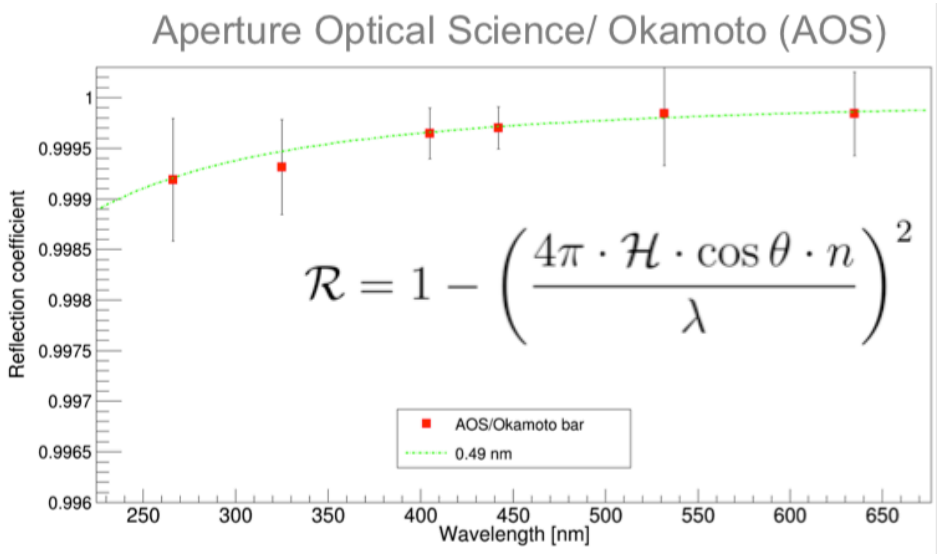


Marvin Krebs DPG, 2018

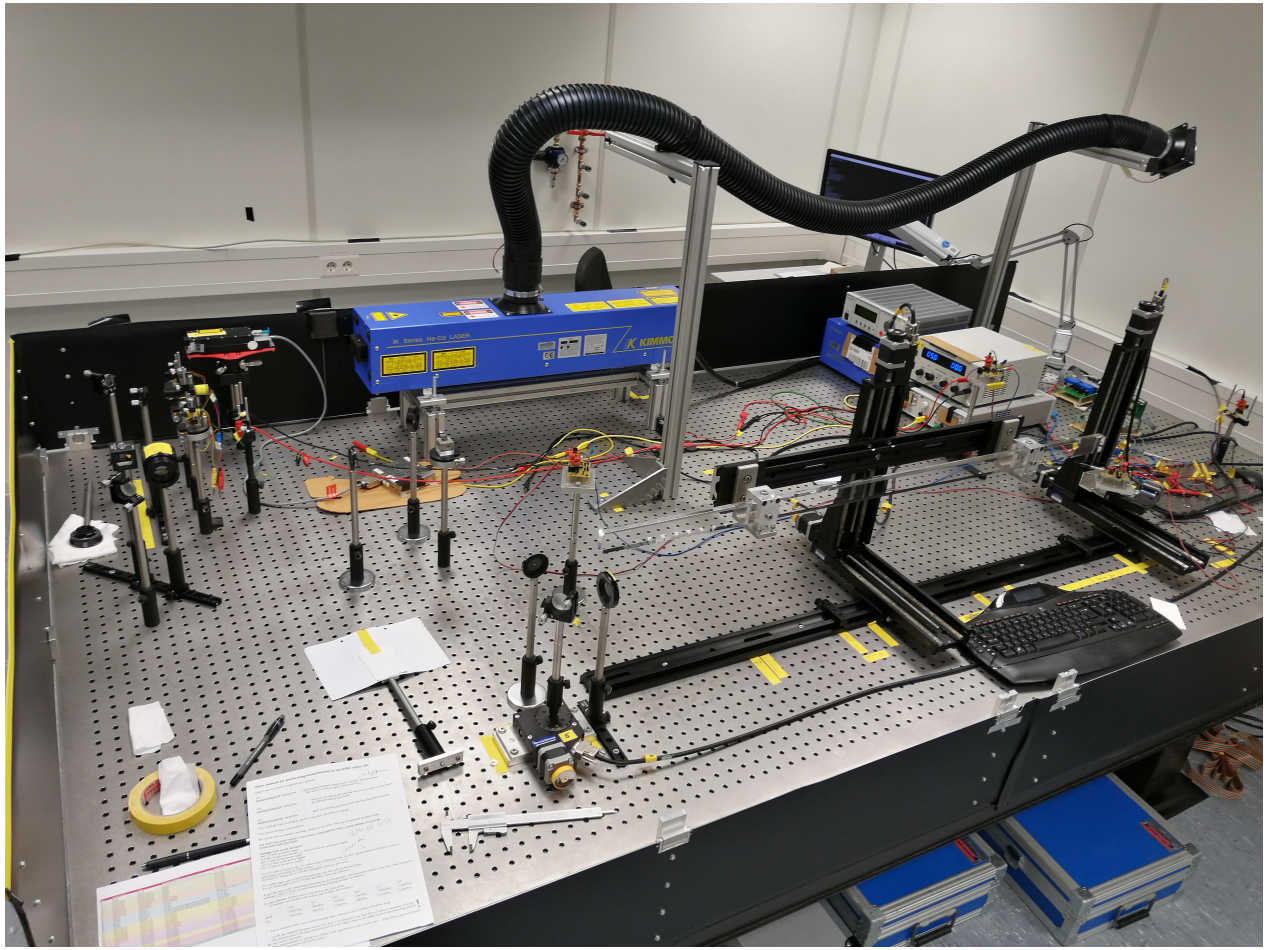


Conclusion Marvin Krebs, 2019:
“Setup delivers reproducible results with a precision better than 1‰ (internal reflection)”

Laser setup optical lab



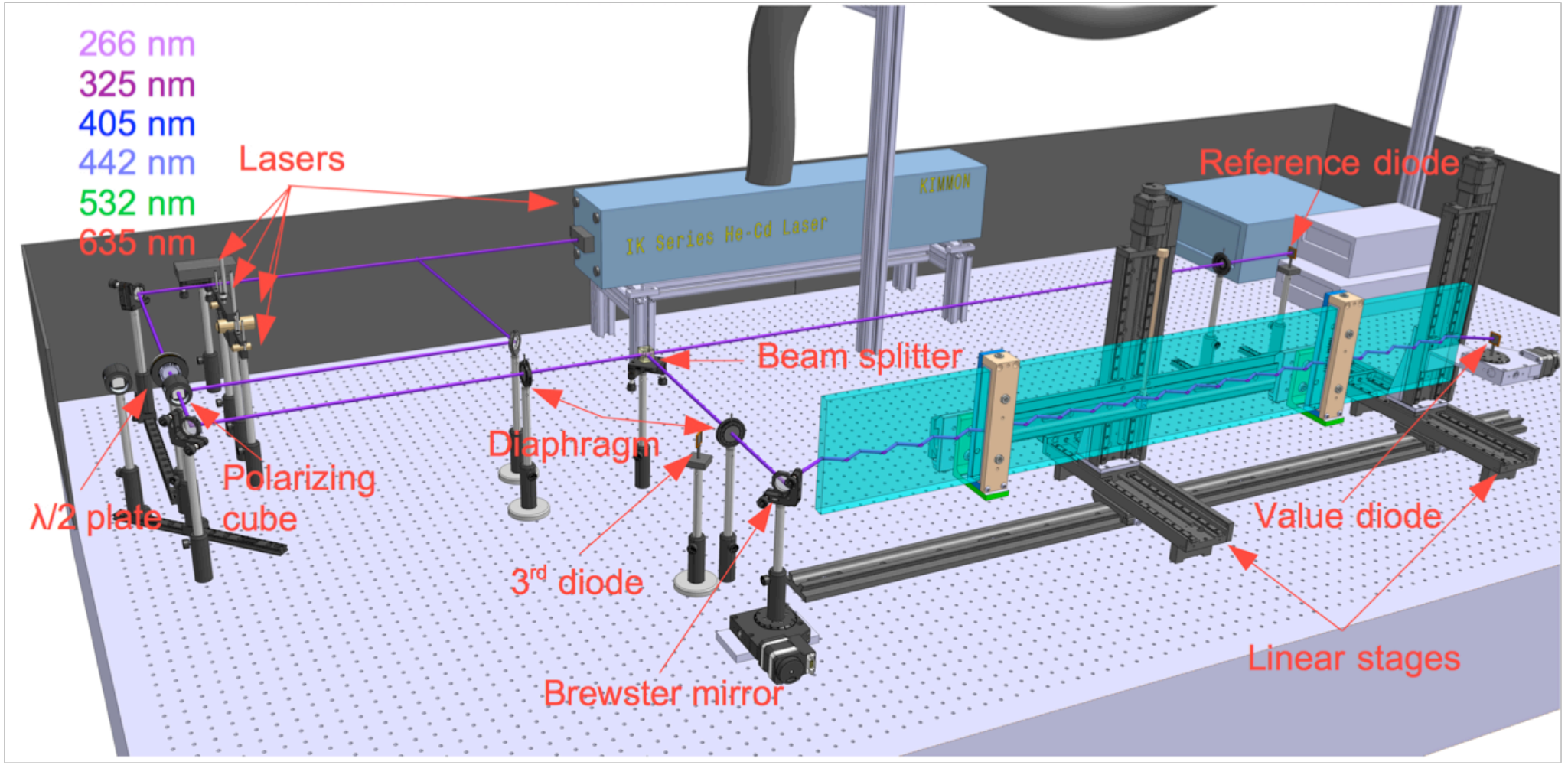
Marvin Krebs DPG, 2018



Examples:
Reflecion coefficient **R** ->
Number of Photons after 50 reflections (120 cm Bar)

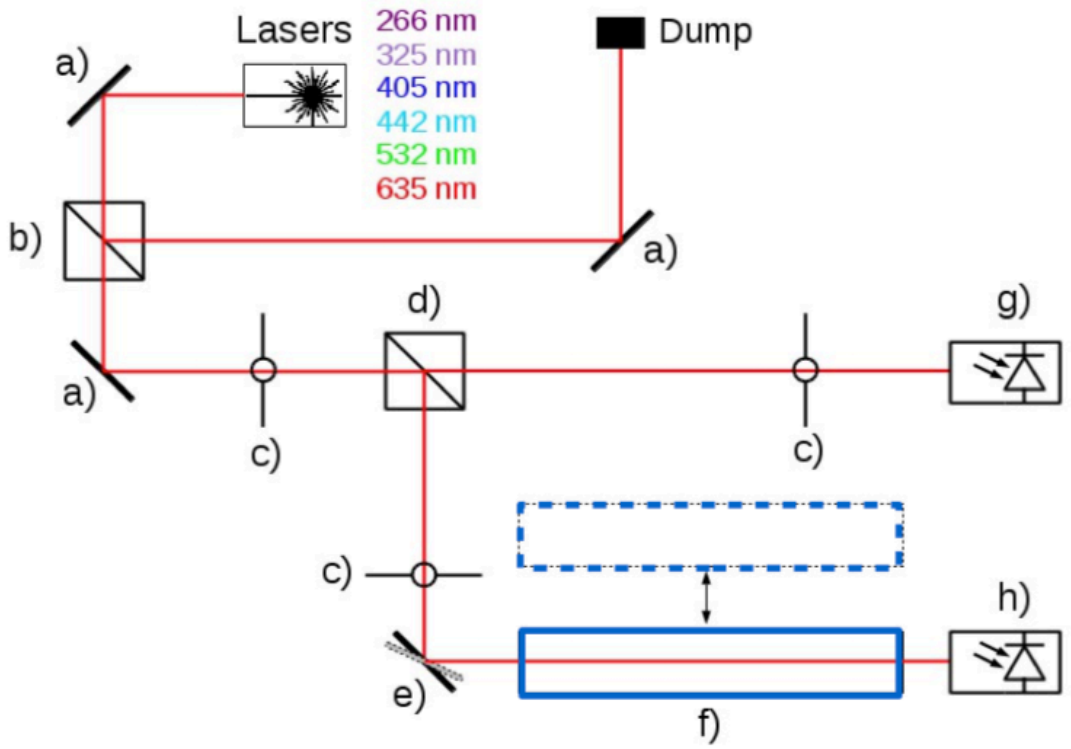
R	N_{ph}
0.997	0.86
0.995	0.77
0.99	0.6

Laser setup Optical Lab



Measurement Bulk Absorption

Bulk Transmission



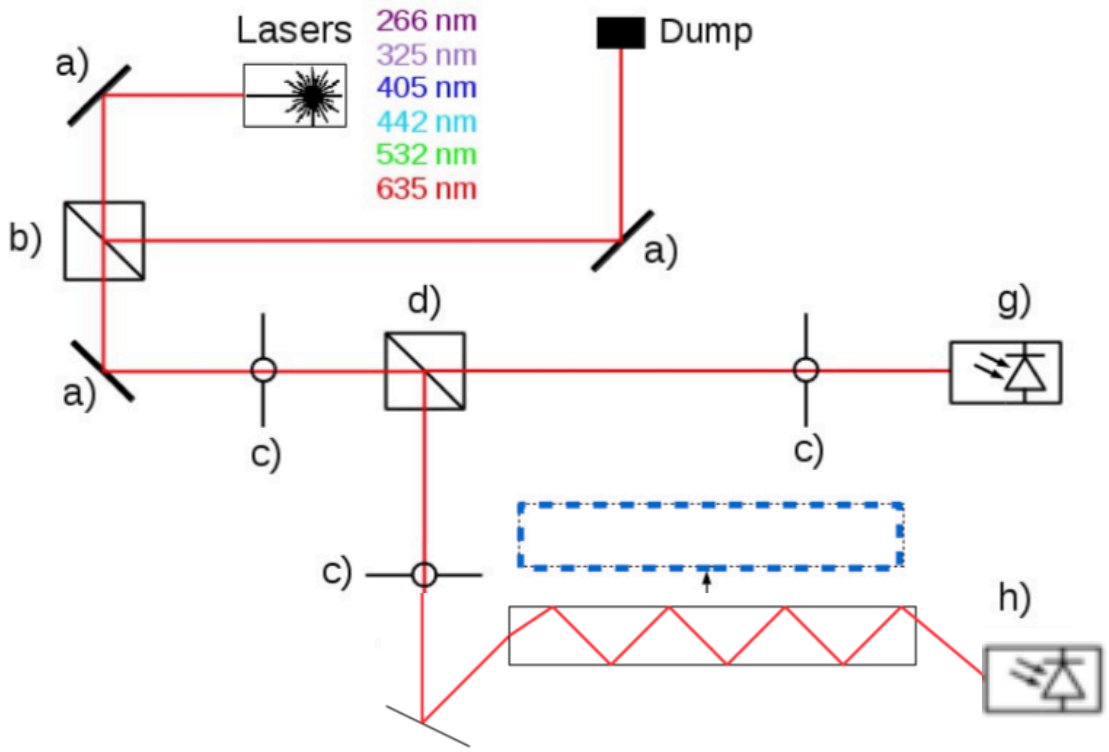
a) Mirror
b) Beam polarizing cube
c) Diaphragm
d) Beam splitter
e) Brewster mirror (rotatable)
f) Radiator
g) Reference diode
h) Value diode

$$I_{meas} = \frac{\frac{I_{val_{bar}}}{I_{ref_{bar}}}}{\frac{I_{val_{air}}}{I_{ref_{air}}}}$$

→ Radiator is moved in and out of the beam
→ Measured intensities (I_{meas}) are corrected for Fresnel loss
→ Determination of attenuation length Λ

Measurement Internal Reflexion

Bulk Transmission



a) Mirror
b) Beam polarizing cube
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$$I_{meas} = \frac{\frac{I_{val_{bar}}}{I_{ref_{bar}}}}{\frac{I_{val_{air}}}{I_{ref_{air}}}}$$

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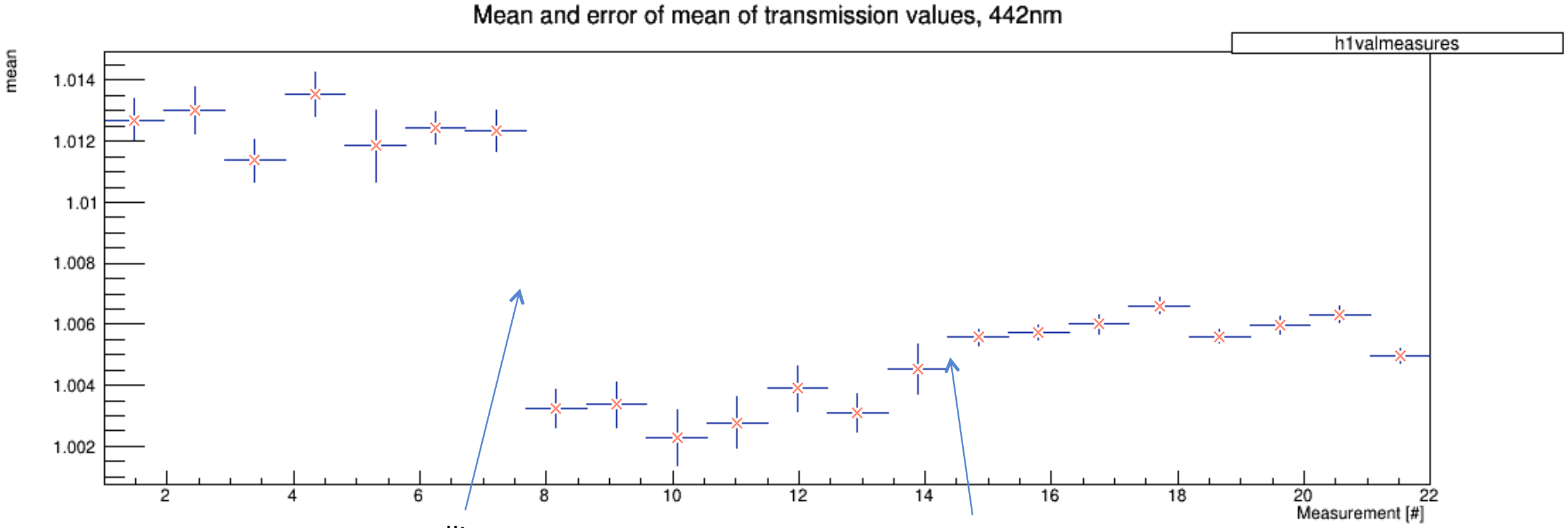
Bulk Absorbtion

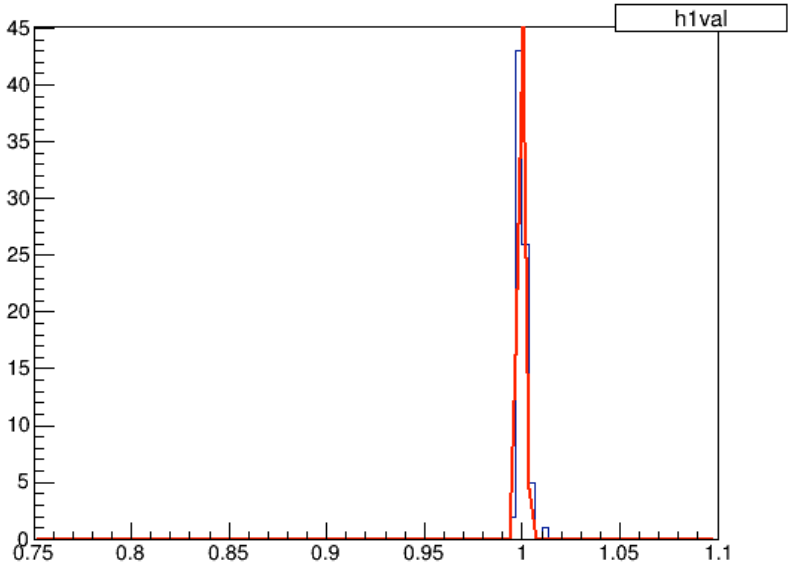


re-allignment

change to larger resitors for the diodes

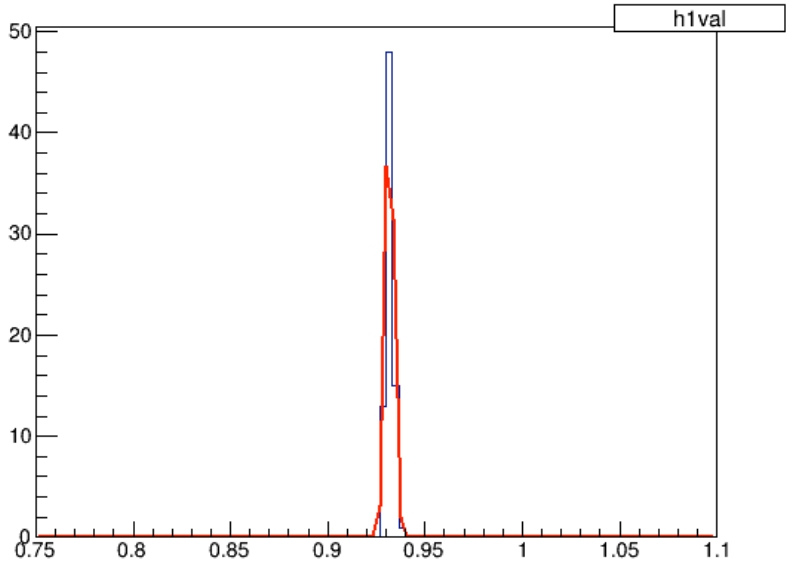
Bulk Absorbtion

Green Laser, 532 nm



Air

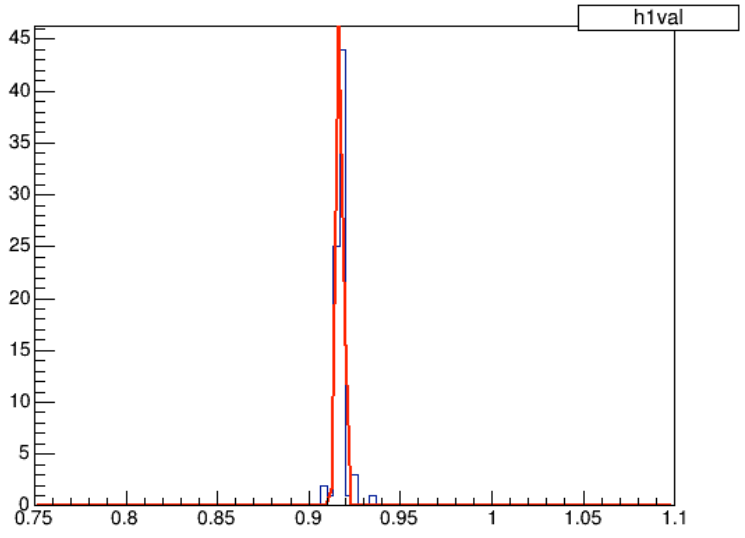
T = 0.999597 ± 2.49058e−04



Bar across the faces

T = 0.931787 ± 2.53389e−04

expected T = 0.930



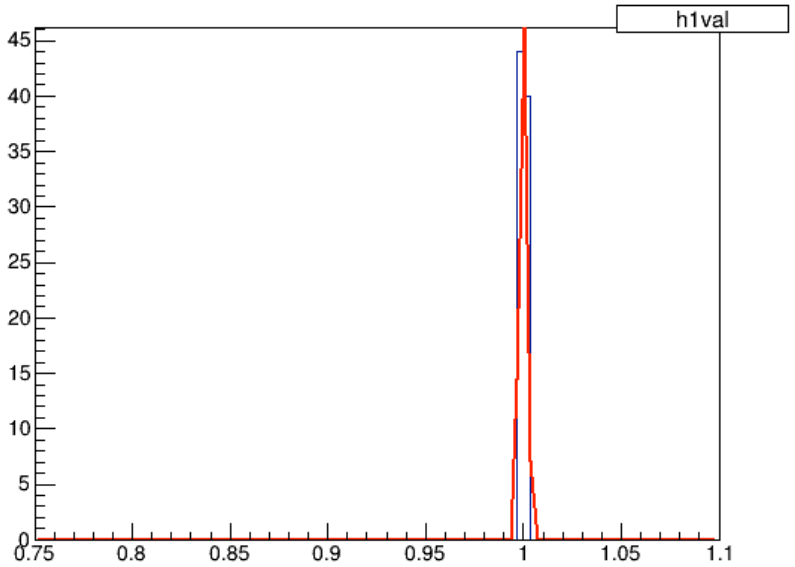
Glas plate

T = 0.917093e−01 ± 1.85000e−04

“expected” T = 0.913

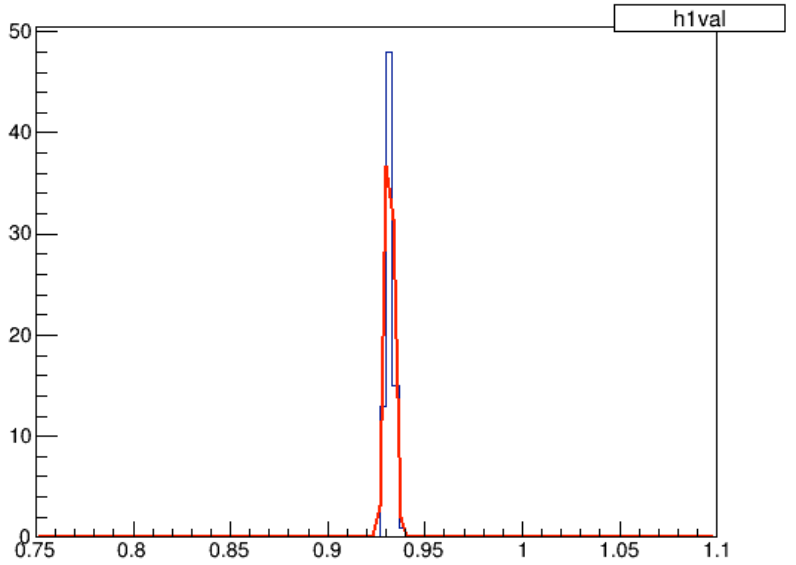
Bulk Absorbtion

Light Blue (HeCd) Laser, 442 nm



Air

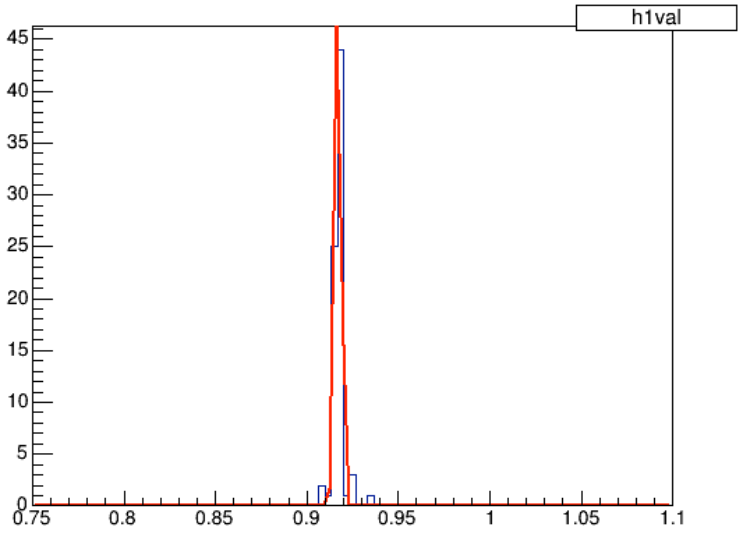
T = 0.999904 ± 4.92688e−03



Bar across the faces

T = 0.943054 ± 1.85707e−03

expected T = 0.928



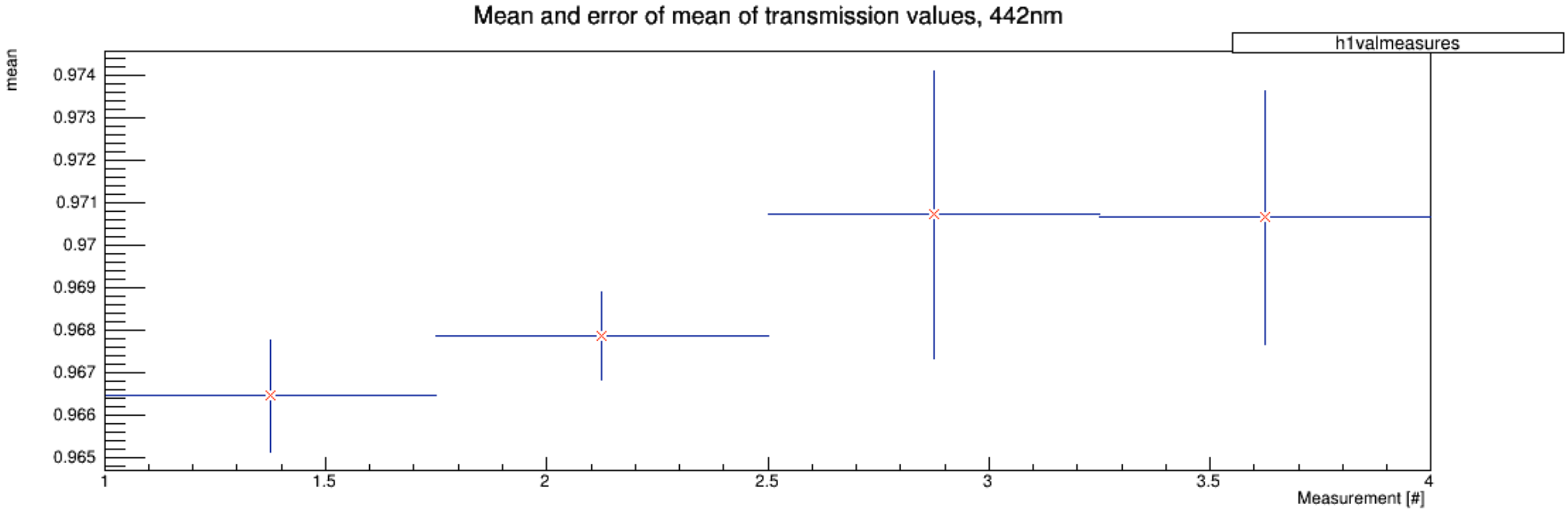
Glas plate

T = 0.915859 ± 3.47247e-04

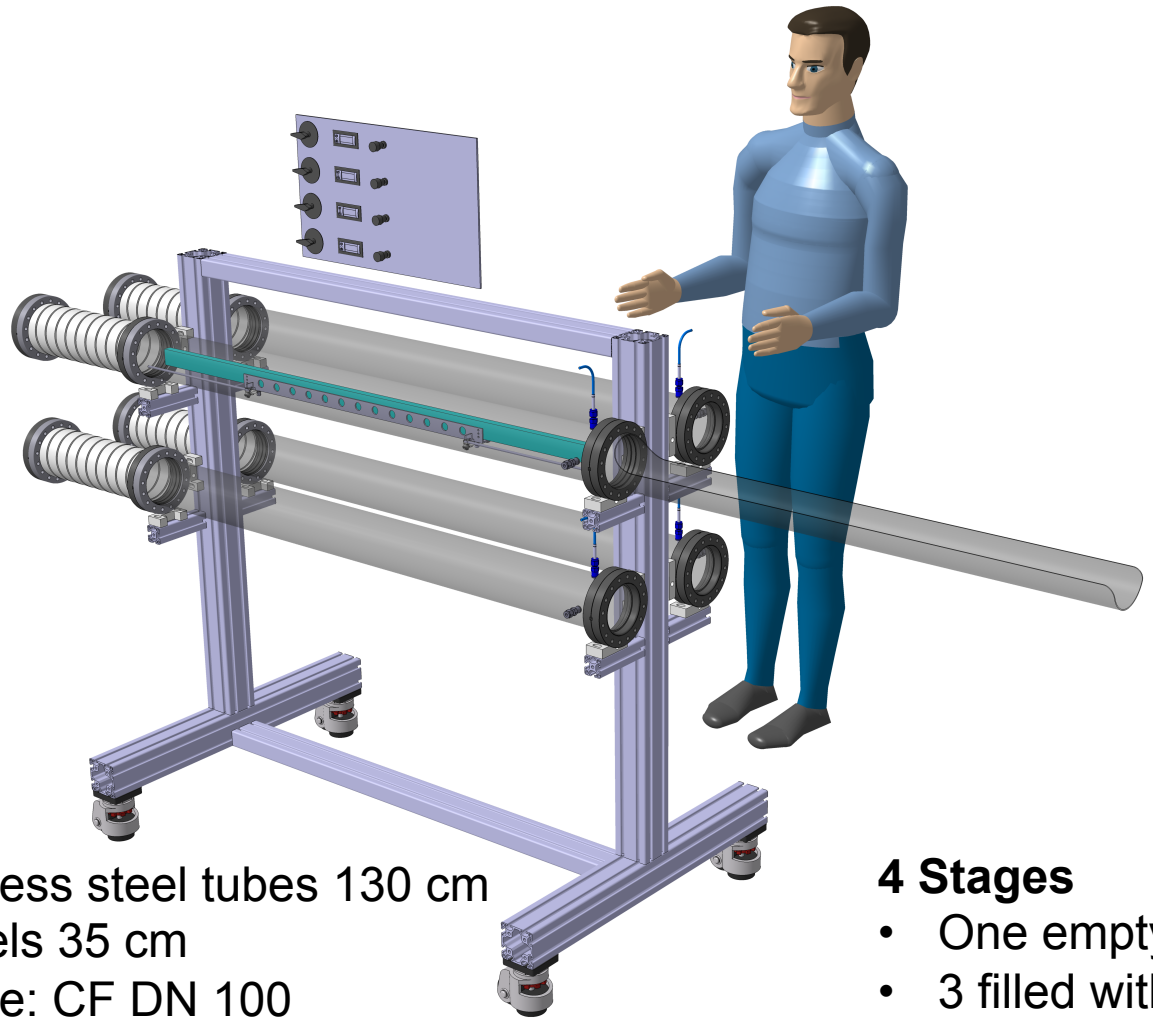
“expected” T = 0.913

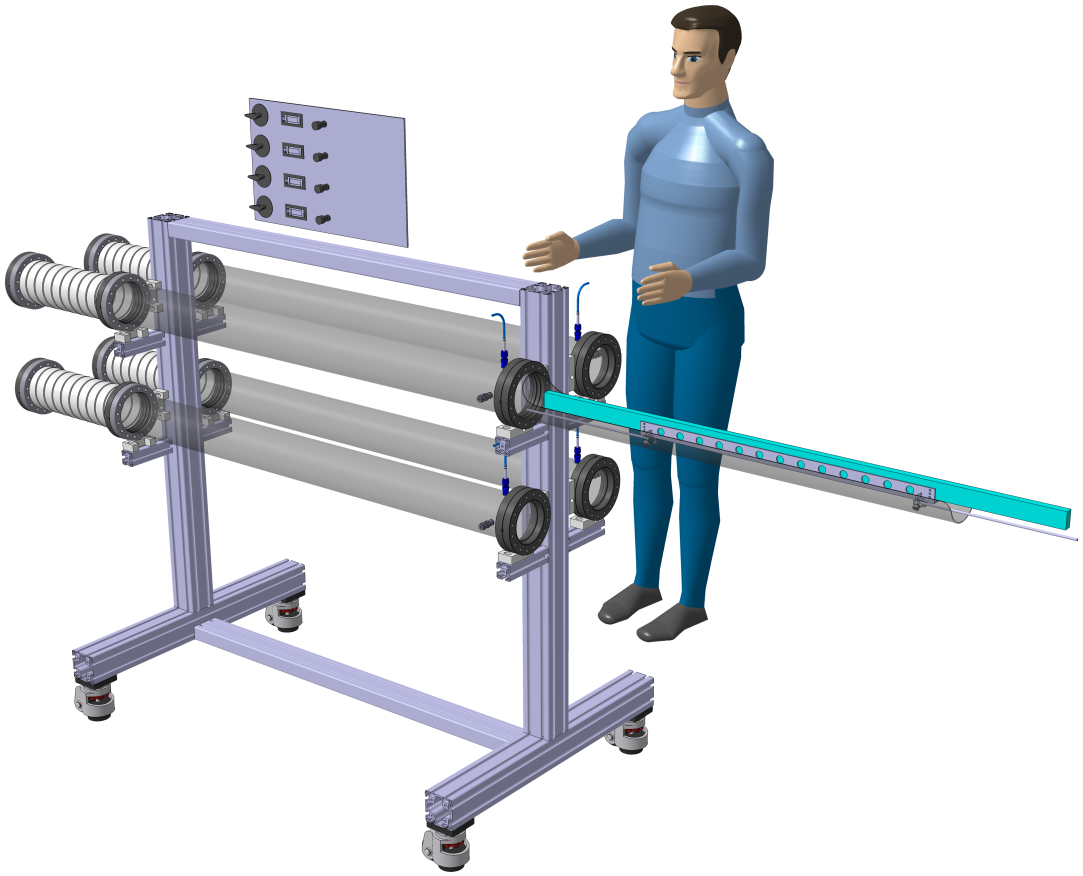
Internal Reflection

on a “polluted bar”



Pollution Setup with Loading Procedure





- Stainless steel tubes 130 cm
- Vessels 35 cm
- Flange: CF DN 100

4 Stages

- One empty vessel: reference bar
- 3 filled with pollutants

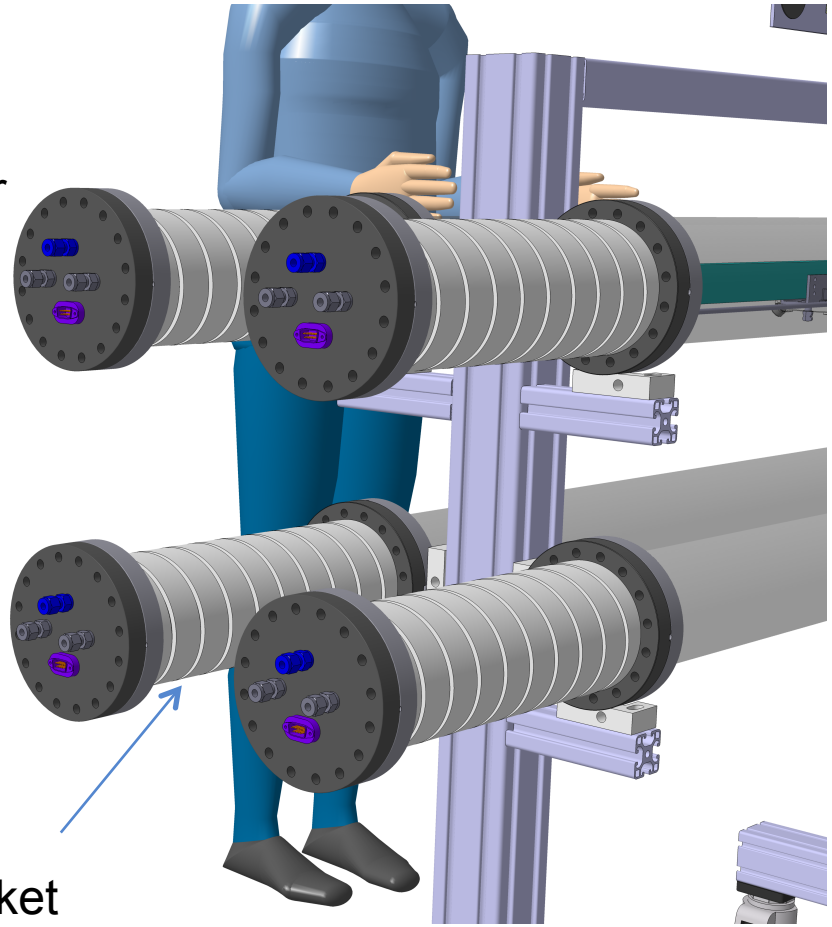
Pollution Setup: Connections

Nitrogen Gas Flow

Temperature sensor

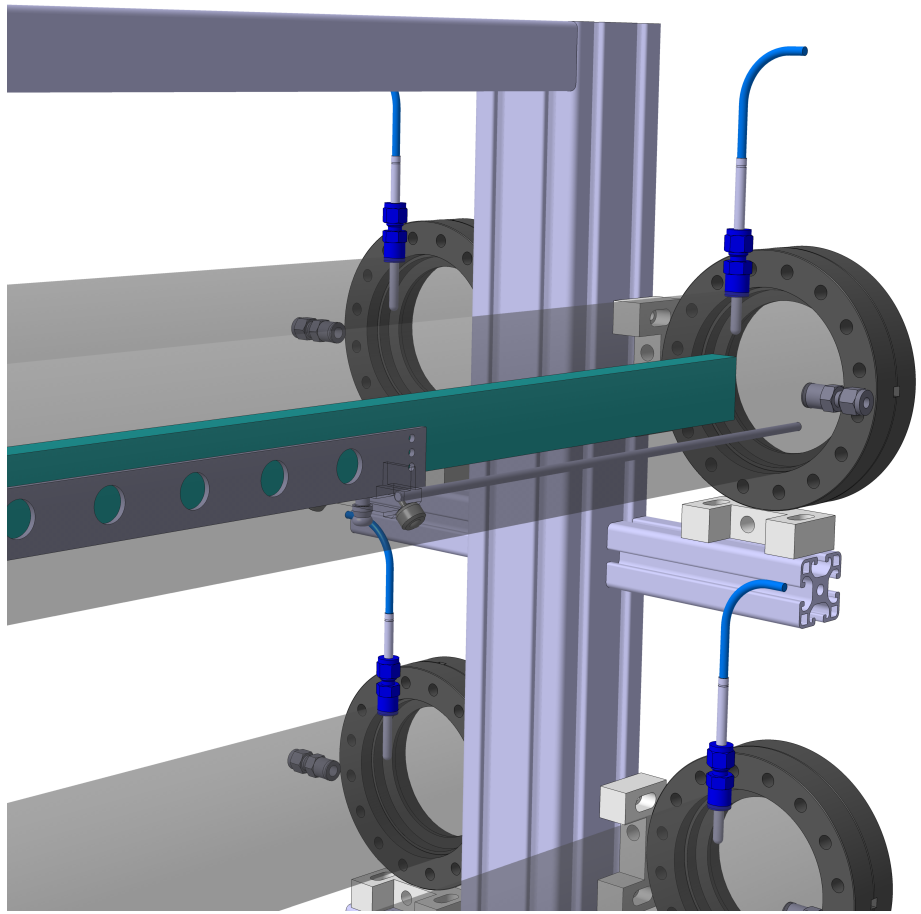
Humidity sensor

Pressure (1 Bar)



Heating jacket
up to 70 degrees Celsius

Temperatur sensor

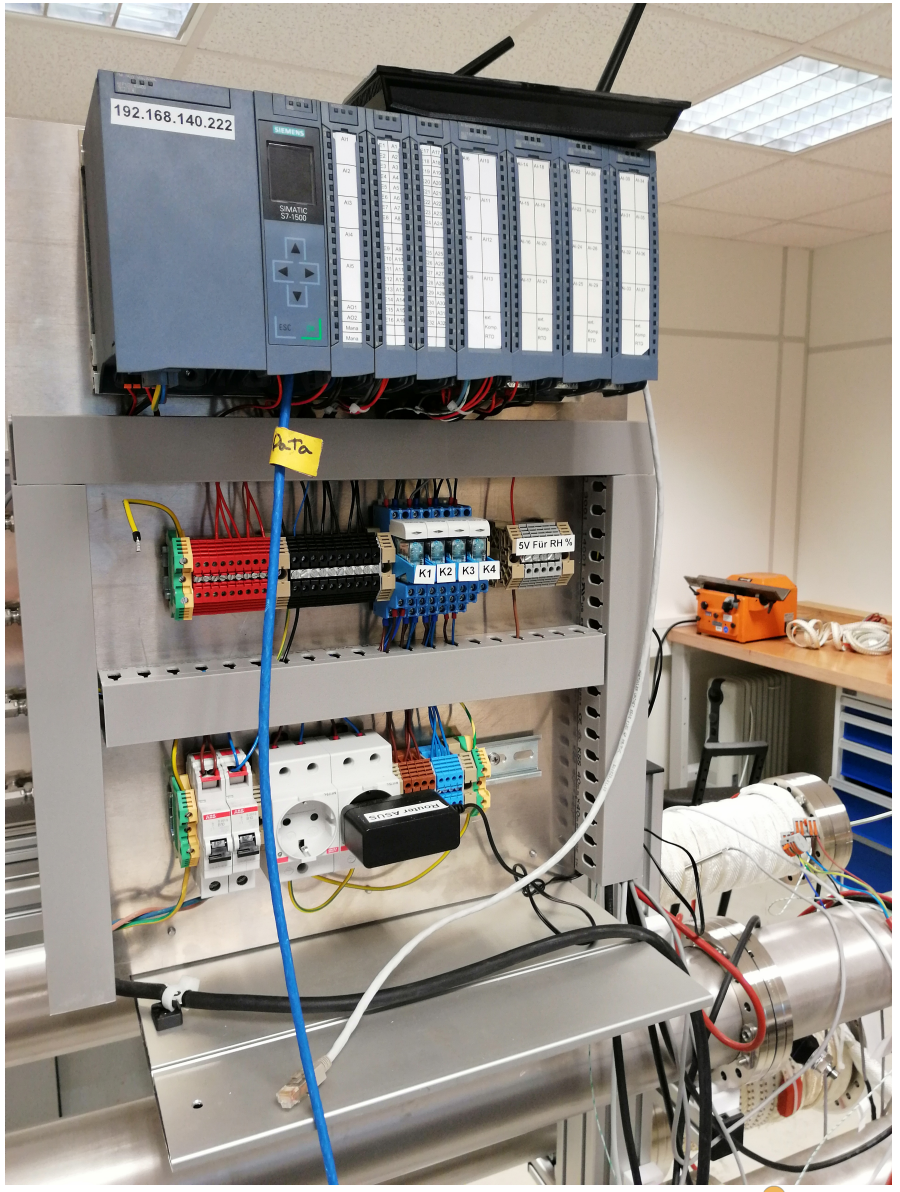


Final Design

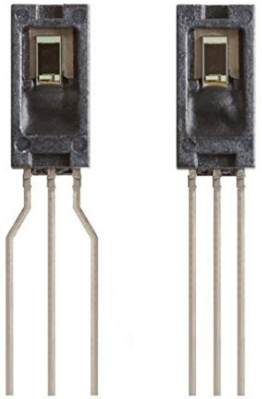
Flow meter (FESTO)
from 0.002 l/min
to 200 l/min

Siemens SIMATIC S7

Pressure sensor (Wika)
A-10, 0 – 1000 bar



Sensors



Humidity:

Honeywell HIH 4000, 0 to 100% RH, -40 to 85 degrees Celsius

Temperature:

Thermoelement Typ K -50 – 400 degrees Celsius

PT100 -25 – 250 degrees Celsius

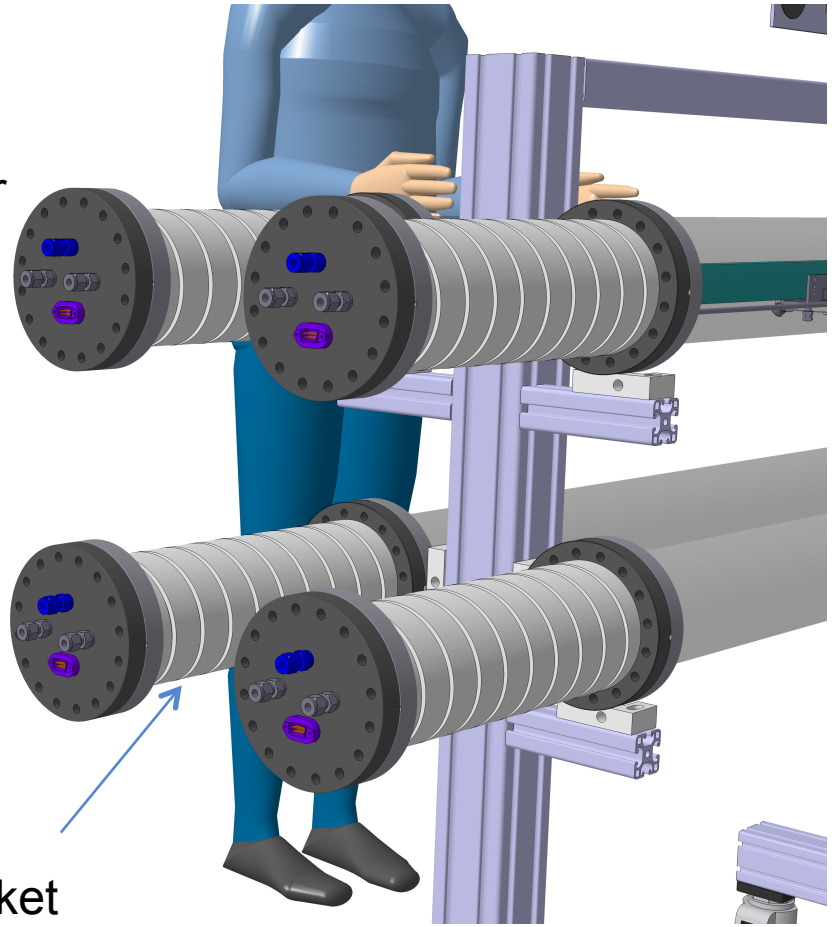
Pollution Setup: Connections

Nitrogen Gas Flow

Temperature sensor

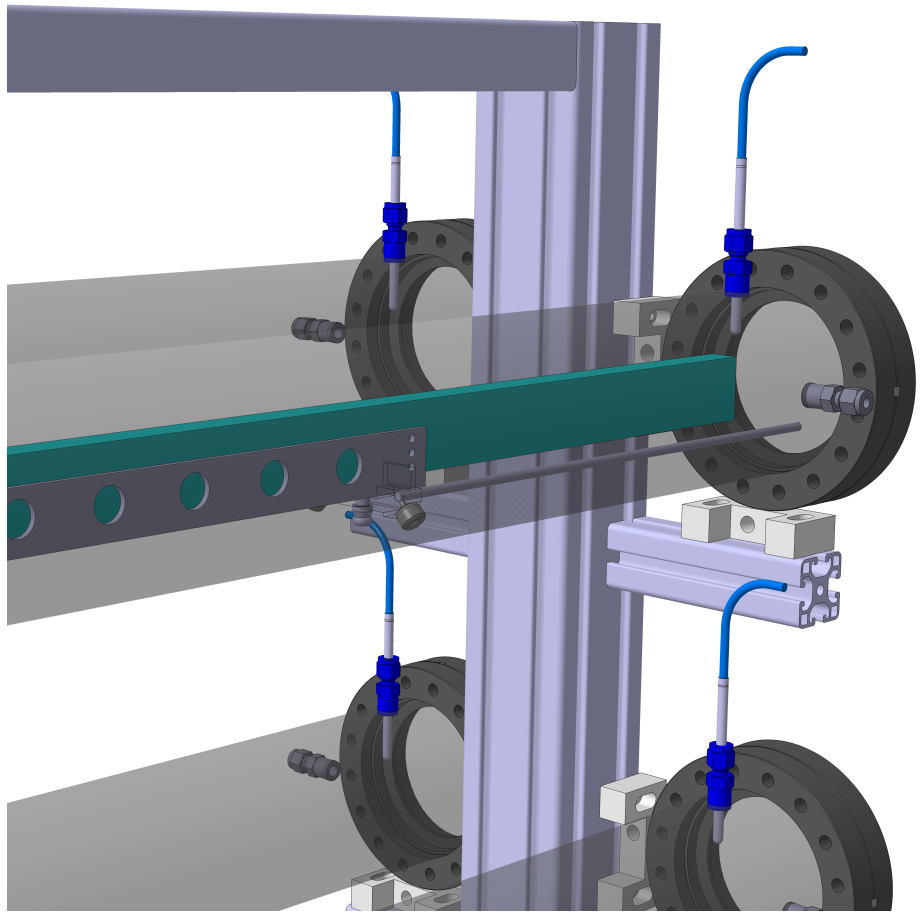
Humidity sensor

Pressure (1 Bar)



Heating jacket
up to 70 degrees Celsius

Temperatur sensor



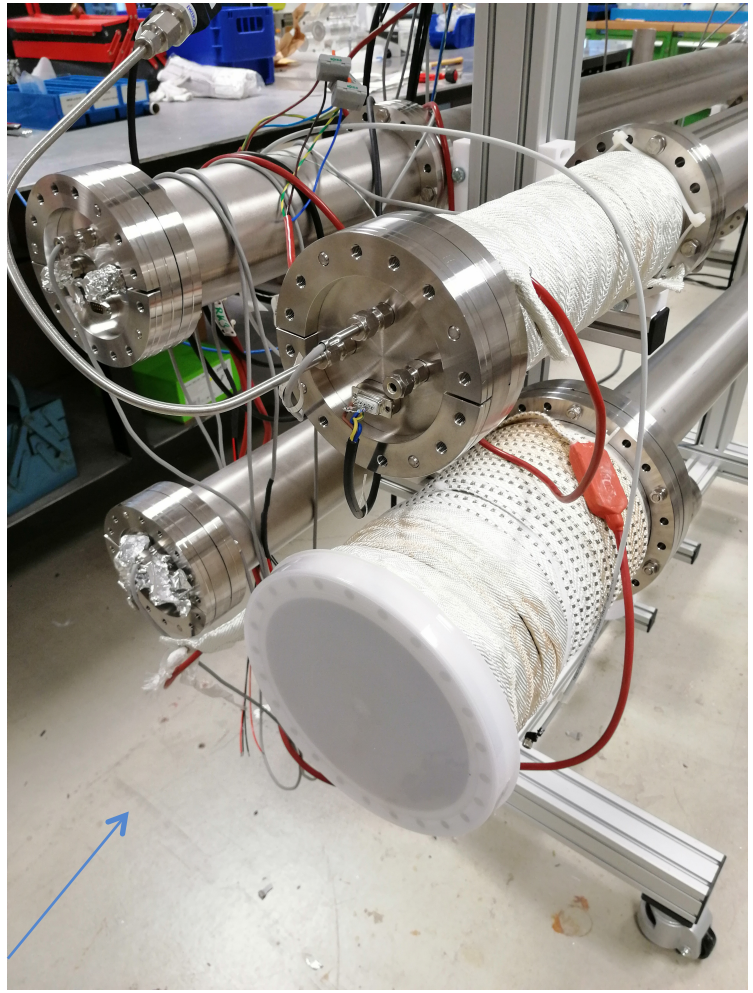
Pollution Setup: Connections

Nitrogen Gas Flow

Temperature sensor

Humidity sensor

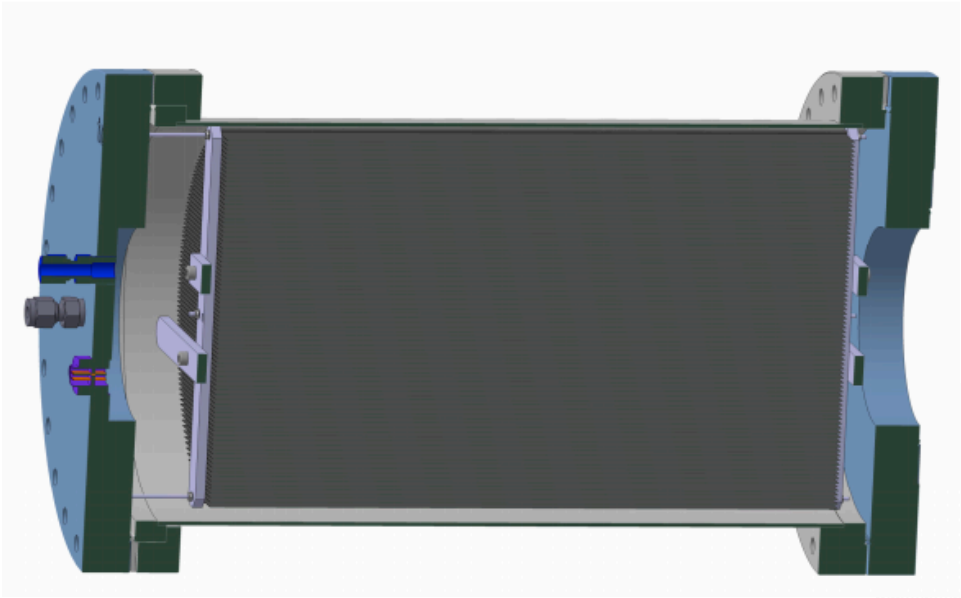
Pressure (1 Bar)

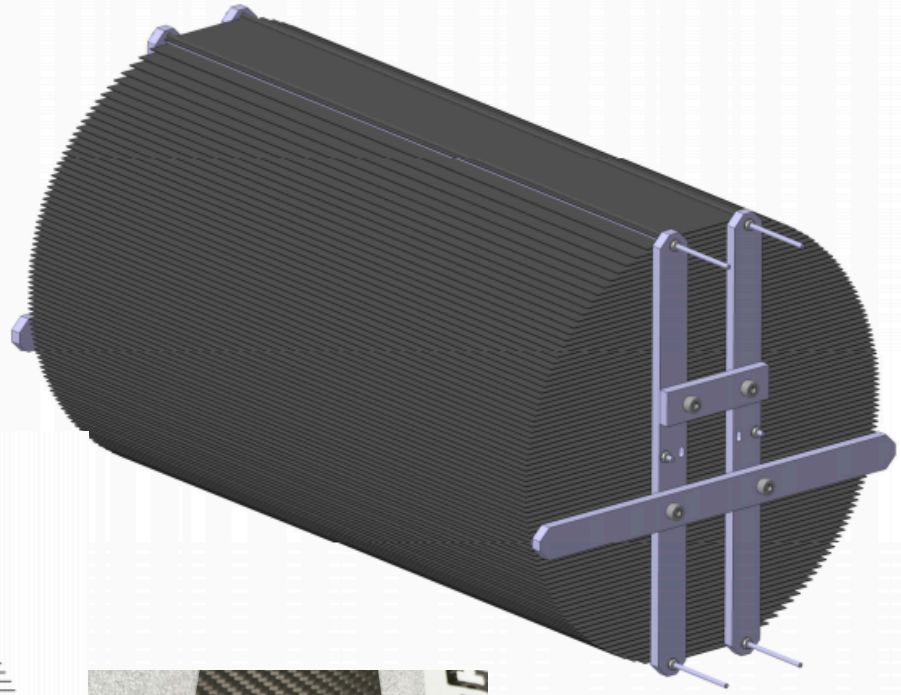


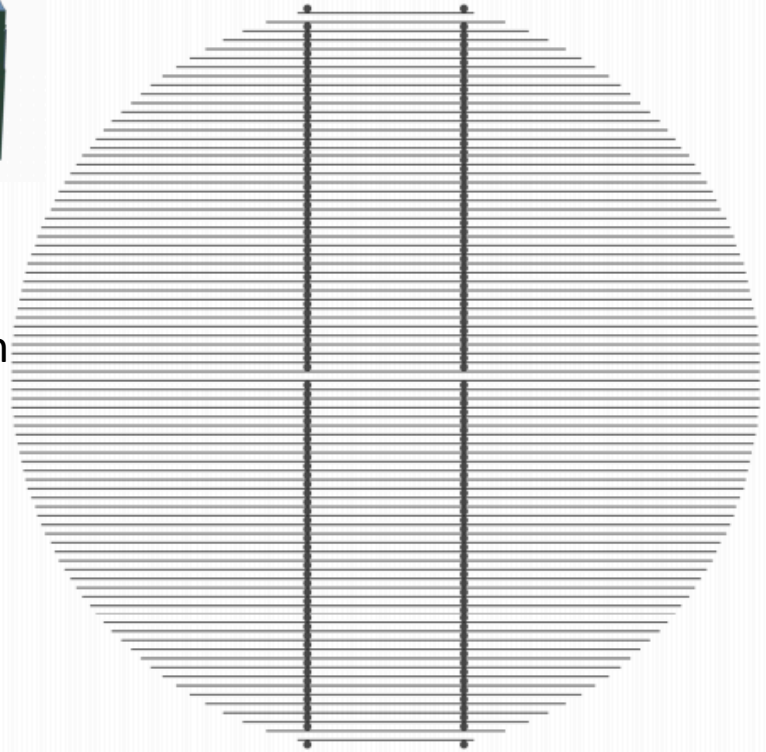
Heating jacket
up to 70 degrees Celsius

Temperatur sensor

“Pollutant”: Carbon Fiber Laminate







Sheets of 0.3 mm with 2mm space in between

Surface of several Bar boxes

Time Scedule for Pollution Tests

- **Bar delivery: Contract + 10-12 month**
- Q3 2019 Contractor found
- Q3 2019 Contract
- Q4 2020 First Bars delivered
- Q1 2021 Glueing of Bars finishedQA
- Q3 2020 -Measurements for box material

- **BarBox construction 6 Month**

- 2019/2020 Order of First BarBox

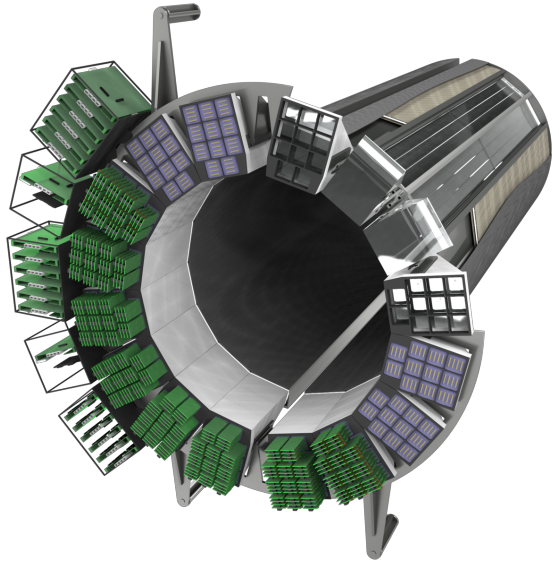
- **Pollution Test Period Q3 2019 – Q1 2020 < 6 month**

- Longest Period of test with a single pollutant < 4 month (BaBar Tests)

Summary and Outlook

Surface Pollution of the Radiator Bars can be a severe Problem at long term

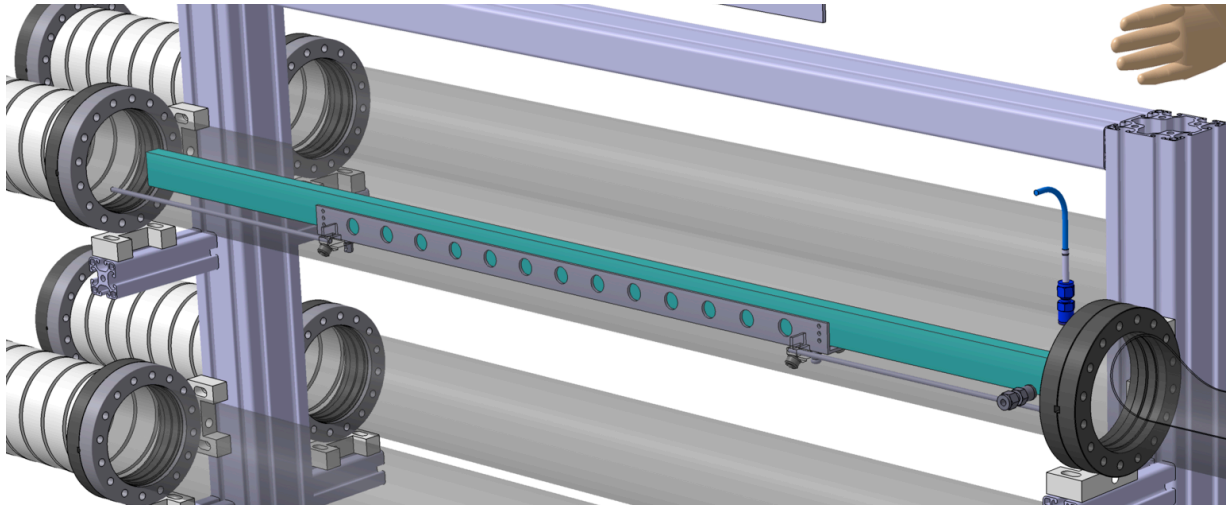
- with the actual Laser setup pollution candidates can be detected
- Pollution setup is designed and parts are about ready to be installed

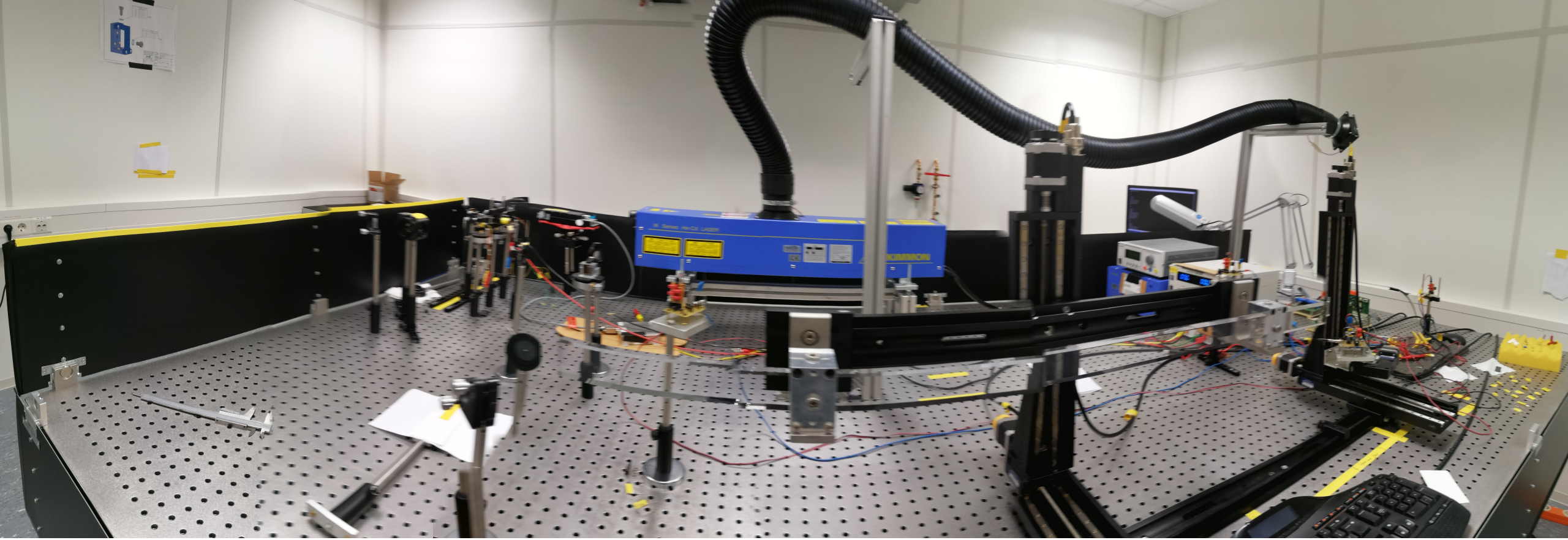


2018-2023: Component Fabrication, Assembly, Installation

- 2018/2019: Finalize specifications, MoUs, call for tenders and contracts
- 2019-2021: Industrial fabrication of main components (sensors, bars, lenses, prisms)
- 2019-2020: Production and QA of readout electronics
- 2019-2022: **Industrial fabrication of bar boxes** and mechanical support frame;
  QA of all components; gluing of long bars, assembly of complete sectors
- 2023/2024: Installation in PANDA, commissioning

Thank you for your attention





Carbon or Aluminum

Carbon Fiber vs Aluminum

Vergleichswerte verschiedener Werkstoffe im Bezug zu CFK

Density

Werkstoff	Einheit	Kiefernholz	Dural-Alu	Titan	Stahl	GFK*	CFK*
Dichte	g/cm^3	0,5	2,8	4,5	7,8	2,1	1,5
Zugfestigkeit	MPa	100	350	800	1100	720	900
E-Modul	MPa	12000	75000	110000	210000	30000	88000
Spez. Festigkeit Reißlänge	km	20	13	18	14	34	60
Spez. E-Modul	km	2400	2700	2400	2700	1400	5900

- GFK/CFK = quasiisotrope Laminate, nahezu gleiche Festigkeit in jede Richtung

Bei Leichtbauteilen entscheidet eine mit herkömmlichen Werkstoffen vergleichbare Festigkeit bei geringerem Gewicht über die Verwendung.
Bei gleichem Gewicht hat CFK (Carbon Gewebe) die fünffache Zugfestigkeit und Steifigkeit von Stahl. 1 kg CFK kann 5 kg Stahl ersetzen.

part	$X_o(g/cm^2)$	$\rho_o(g/cm^3)$	$X_o(mm)$	g/m^2	d (mm)	$X/X_o(\%)$
Rohacell	40.8	0.075	5440		16	0.294
fibers	45.2	0.068	6647		32	0.481
carbon fiber	42.7	1.8	237	190		0.045
mylar	45.2	0.9	503		0.024	0.005
Aluminum	24.01	2.7	88.9		0.006	0.007
Glue	42.6	1.2	354.9	150		0.035
Air	37.1	0.0012	318425.2		31.4	0.01
Sum						0.877

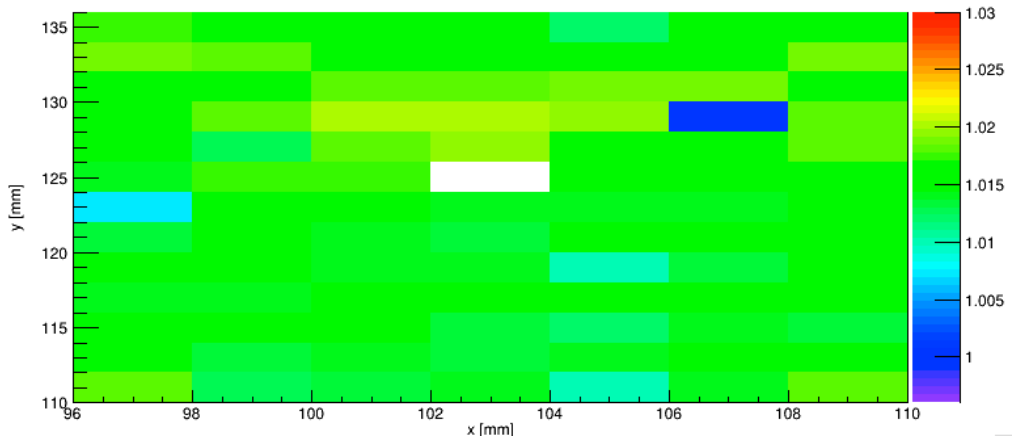
Final Design

- Longest Period of test with a single pollutant < 4 month
- Pollutants to be tested first Carbon fiber laminate, epoxy
- 4 “Pollution stations” One empty with reference bar
- One CFK @20 deg
- One CFK @70 deg
- One screws, cockies... @70 deg
- (epoxy @ 50 deg)

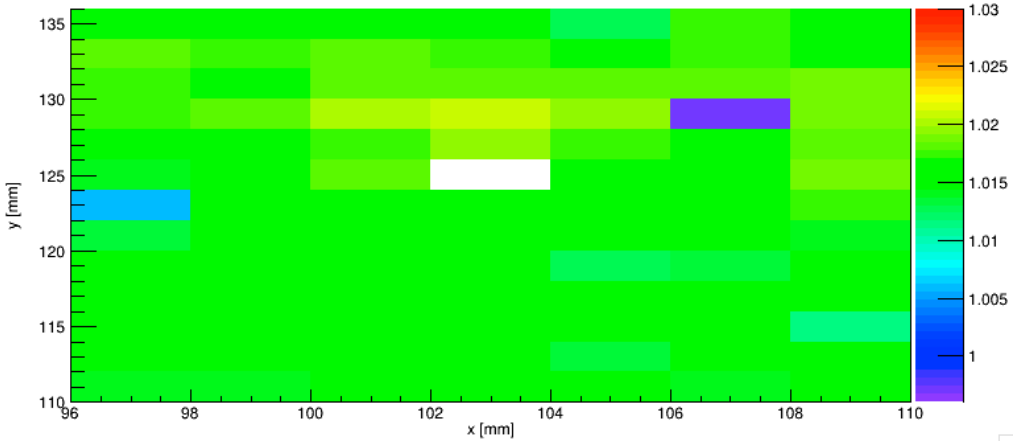
Bulk Absorbtion

Two Scans an one day with Red Laser

Scan 1



Scan 2



Difference