Upgrade of the Cryogenic Solar Absolute Radiometer (CSAR) and the Monitor to measure the Integral TRAnsmittance (MITRA)

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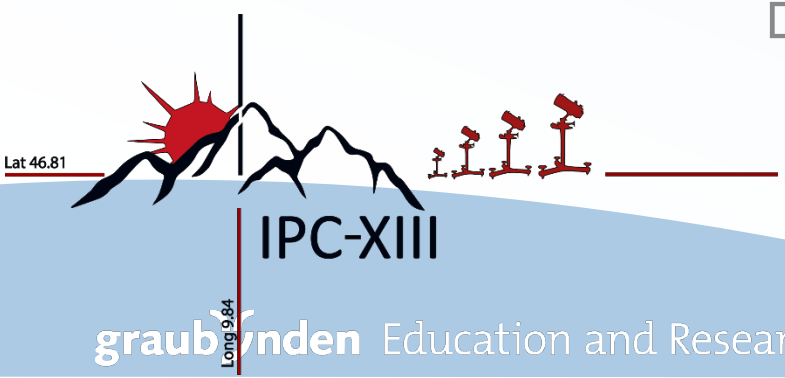
Davos, 07.10.2021

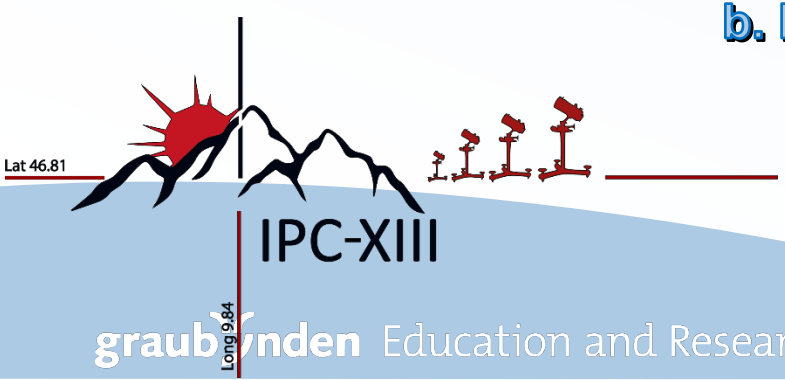


graubünden Education and Research.

pmod wrc

OUTLINE:

1. CSAR instrument:
    a. Design
    b. Measurement principle
2. MITRA instrument:
    a. Design
    b. Measurement principle
    c. Previous modifications
3. Latest upgrade:
    a. CSAR
    b. MITRA



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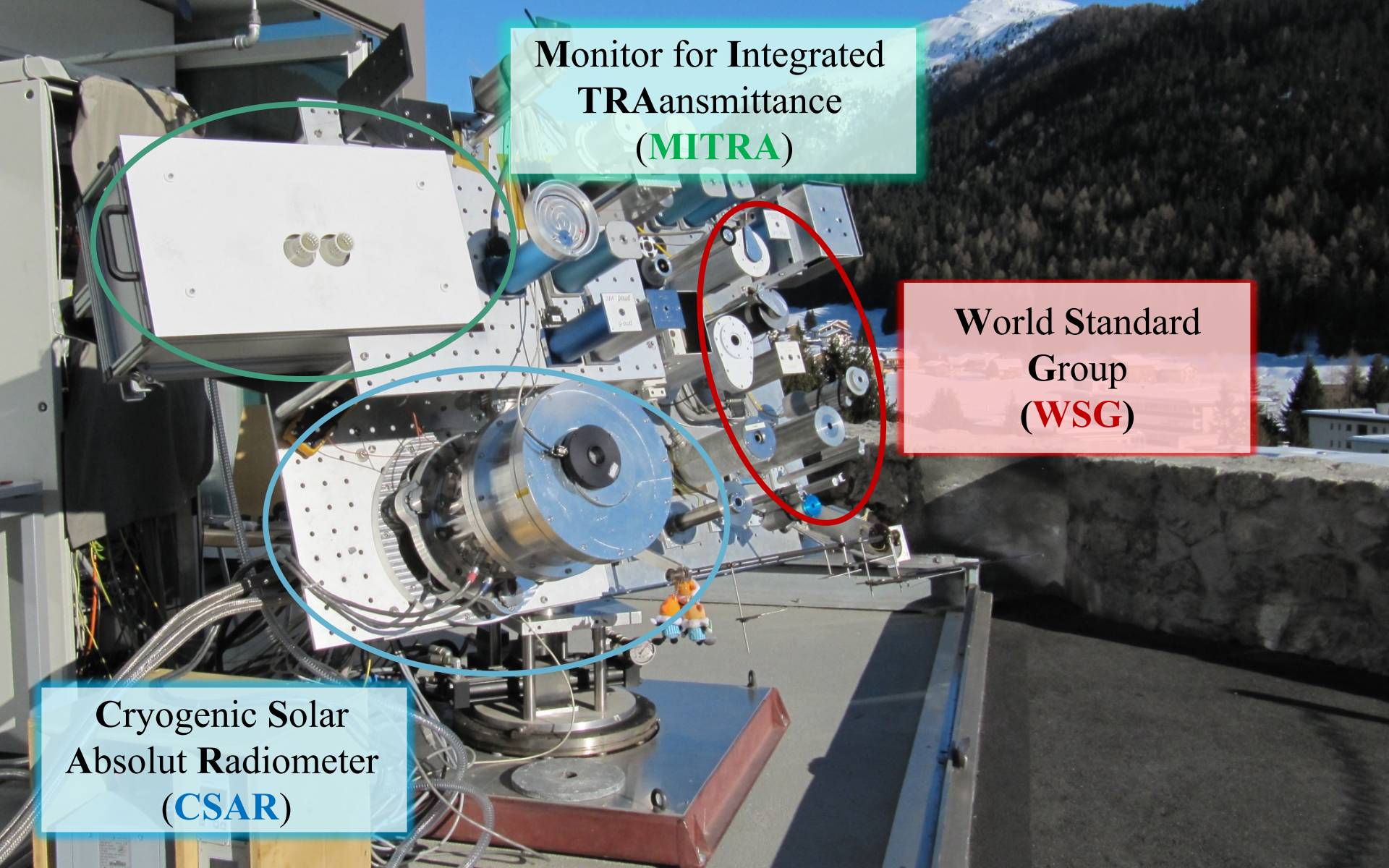
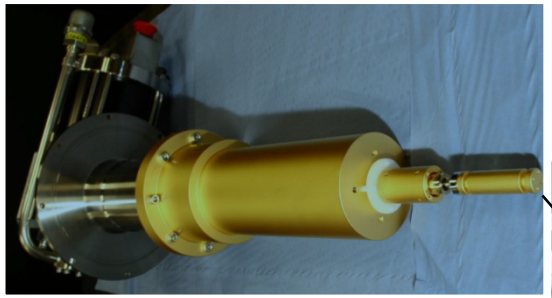
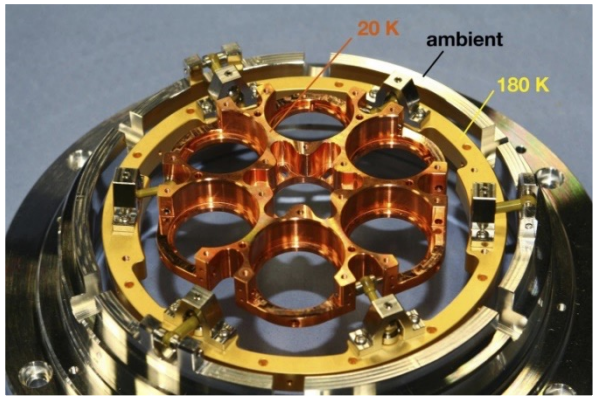

Monitor for Integrated
TRAansmittance
(MITRA)
World Standard
Group
(WSG)
Cryogenic Solar
Absolut Radiometer
(CSAR)

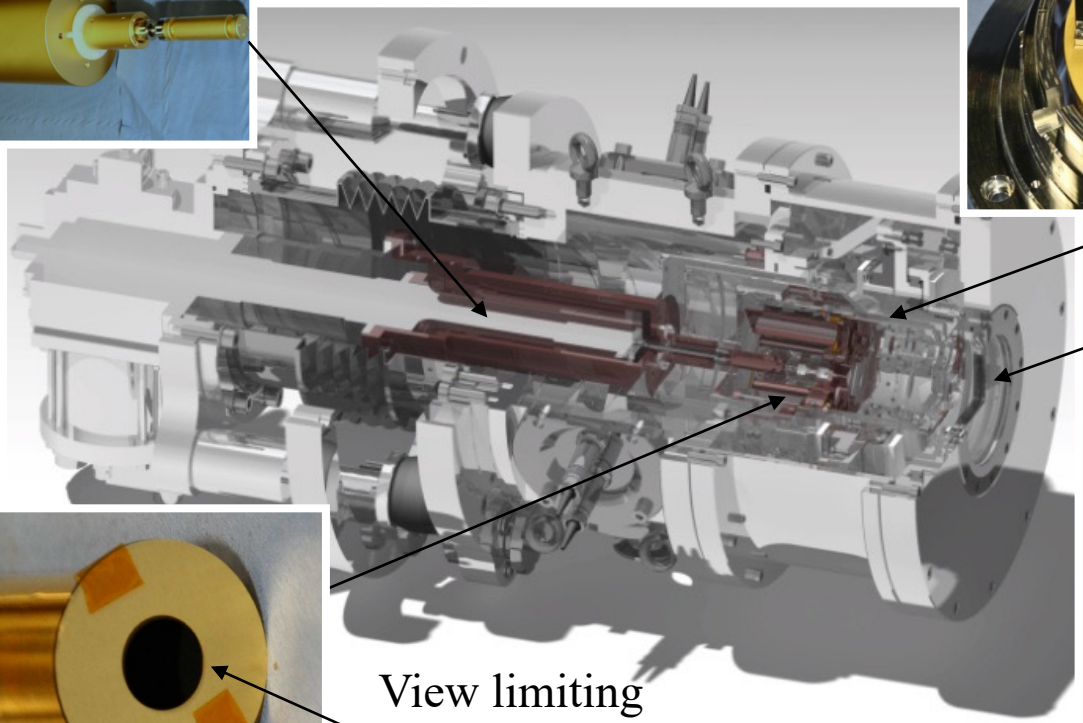
Cryogenic Solar Absolute Radiometer

Cryocooler (Helium)



20 K
Reference
block





Quartz window

Cavity

View limiting
aperture, d = 10 mm

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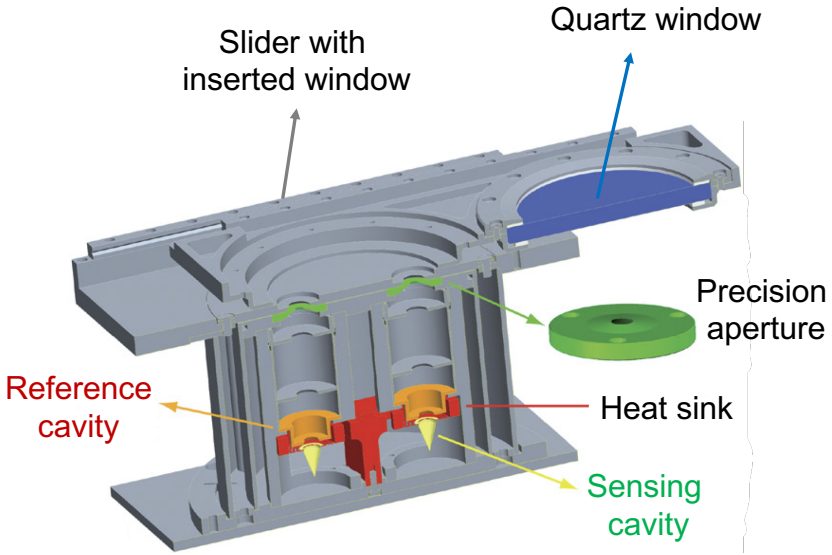
Cryogenic Solar Absolute Radiometer

Cavity characterisation: $P_{IR} = F(R)$

Monitoring transmittance with MITRA



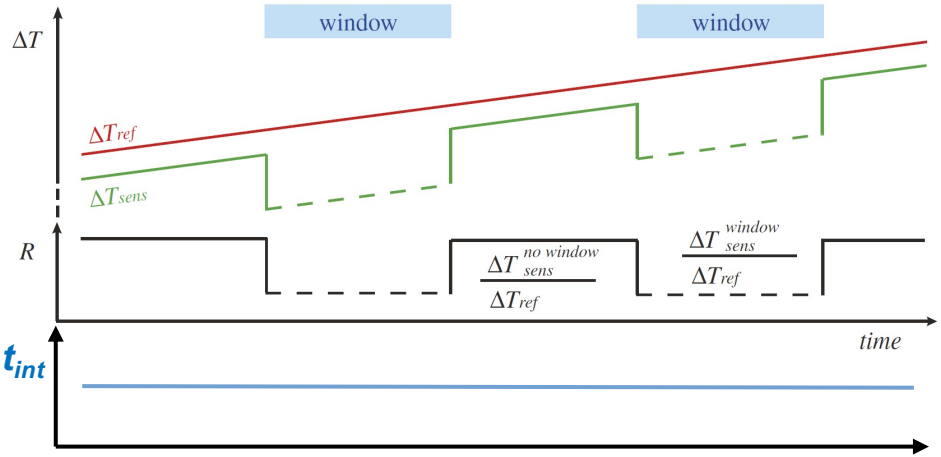
$$\Delta T_{SEN} = T_{SEN} - T_{HS} \sim P_{IR}$$

$$\Delta T_{REF} = T_{REF} - T_{HS} \sim P_{IR}$$

$$\text{Detector ratio } \boldsymbol{R} = \frac{\Delta T_{SEN}}{\Delta T_{REF}}$$

Window integrated transmittance

$$t_{int} = \frac{\left(\frac{T_{SEN}-T_{HS}}{T_{REF}-T_{HS}}\right)^{window}}{\left(\frac{T_{SEN}-T_{HS}}{T_{REF}-T_{HS}}\right)^{no\ window}} = \frac{R^{window}}{R^{no\ window}}$$



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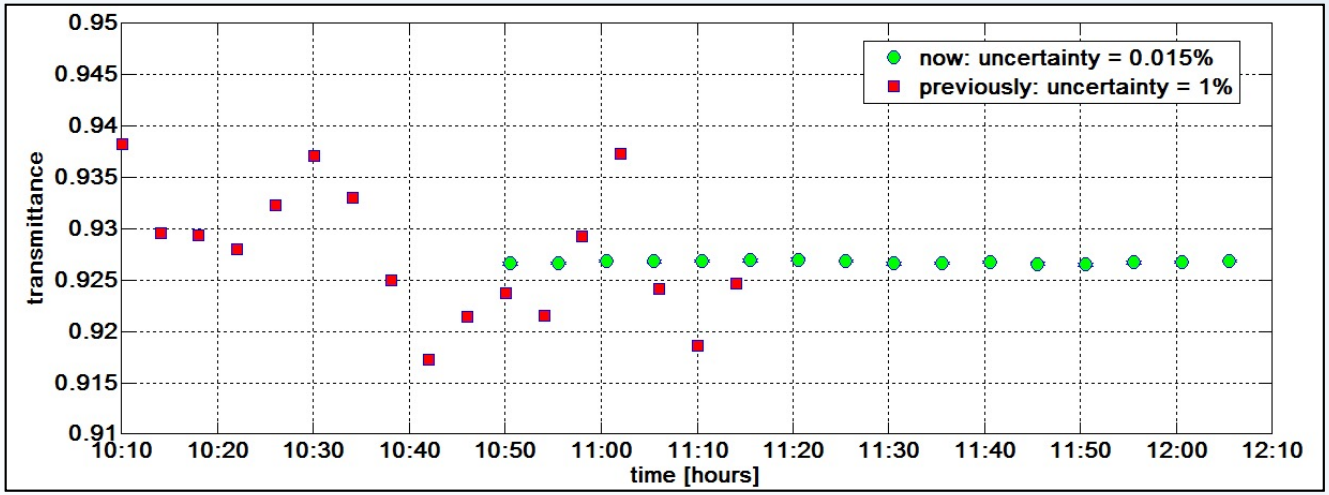
Monitoring transmittance with MITRA



2014:

MITRA uncertainty: **≈ 1% (k = 1)**

2016:

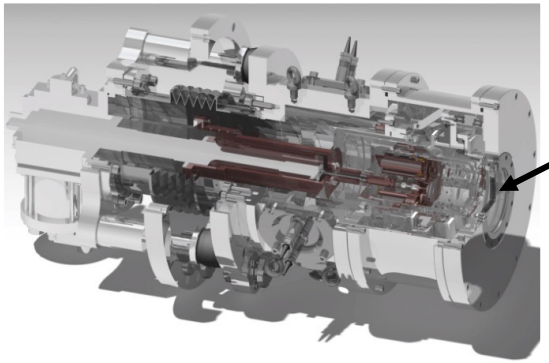
Measurement stability: **≈ 0.015% (k = 1)**

MITRA uncertainty: **≈ 0.036 – 0.05% (k = 1)**

MITRA improvements:

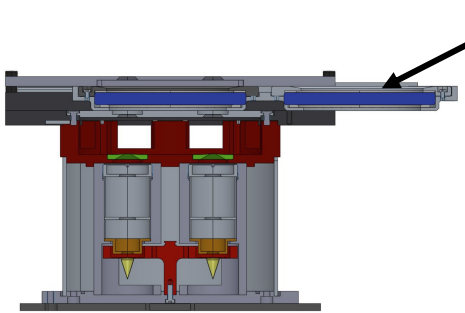
- Well-insulated box
- Wind fences
- Direct-to-Air PLT-cooling

Window contamination



CSAR
quartz window

MITRA
quartz window



Non-equivalence of windows because of contamination

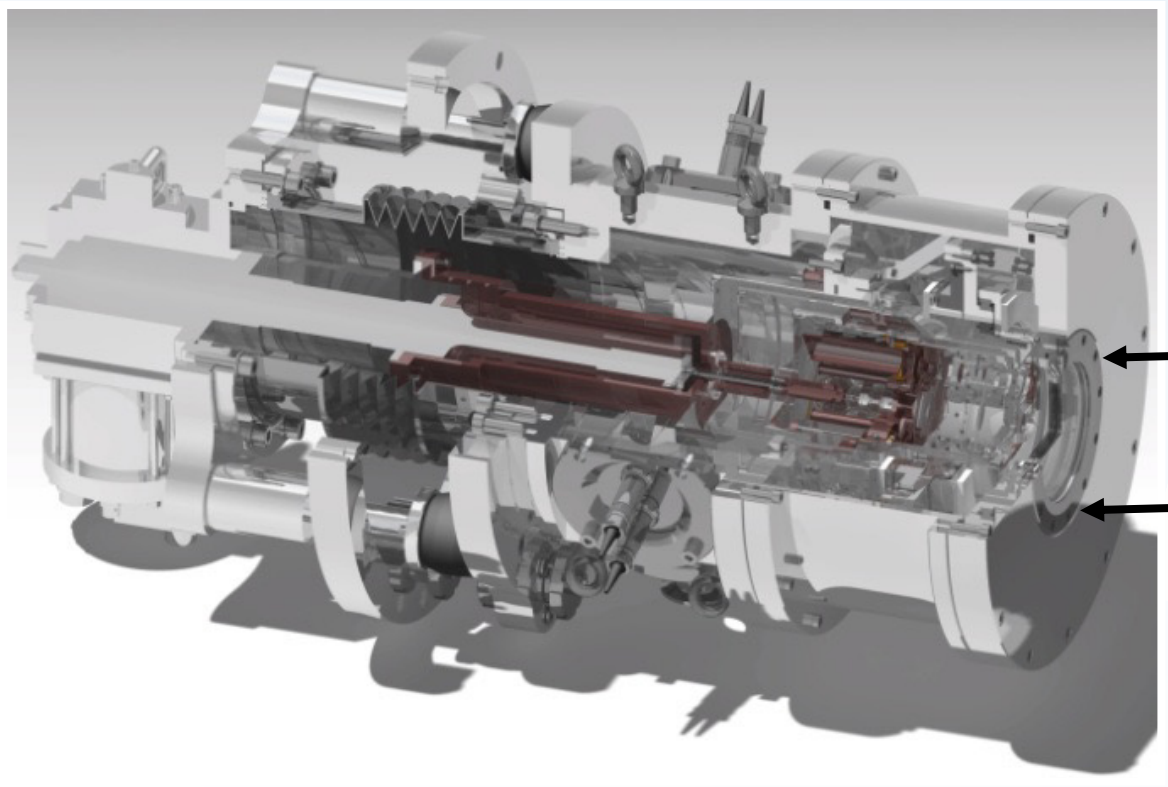
Number of particles (IPCXII):
CSAR = 764
MITRA = 345

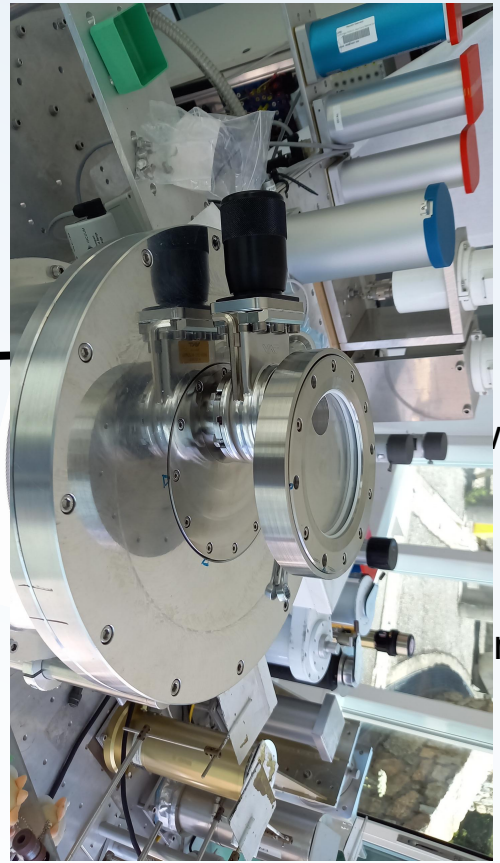
Dust particles with diameters of ≈ 10 - 50 µm
2 - 20 can be in front of the detector

Influence of sticky particles: 0.001% – 0.2%

Ultrasonic bath with Isopropanol
(typically < 10 particles per window)

CSAR upgrade: Vacuum gate

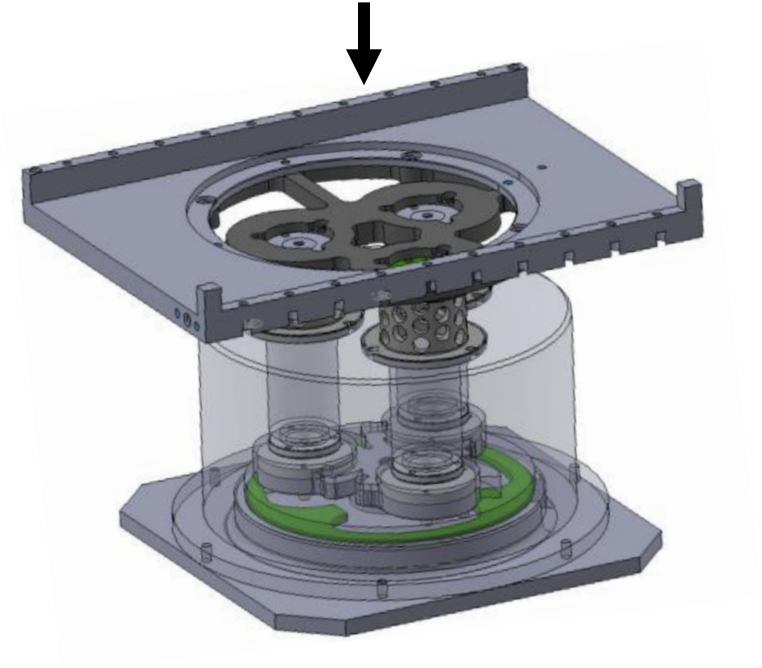


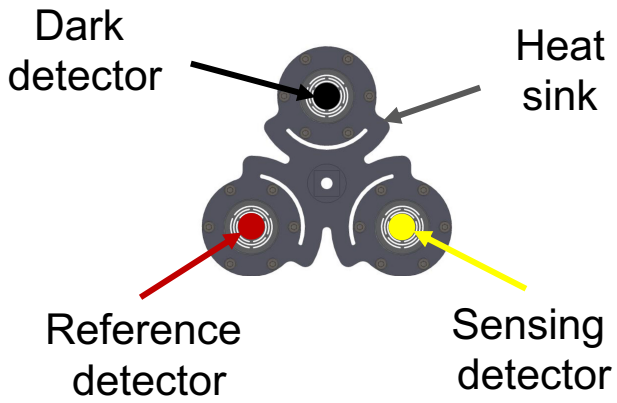


indow

mp

MITRA upgrade: Dark detector



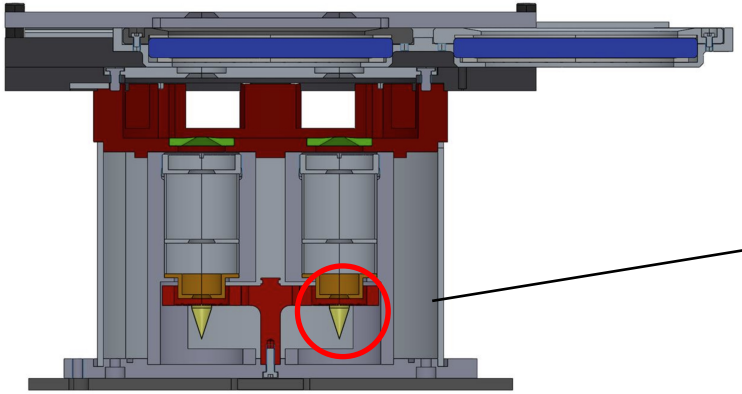


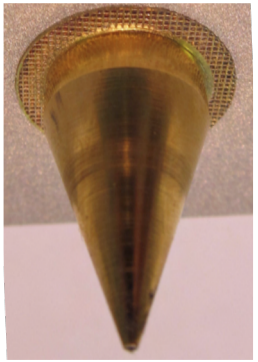
Detector ratio $R = \frac{\Delta T_{SEN}}{\Delta T_{REF}}$

Window integrated transmittance

$$t_{int} = \frac{\left(\frac{T_{SEN}-T_{DARK}}{T_{REF}-T_{DARK}}\right)^{window}}{\left(\frac{T_{SEN}-T_{DARK}}{T_{REF}-T_{DARK}}\right)^{no\ window}} = \frac{\left(\frac{\Delta T_{SEN}}{\Delta T_{REF}}\right)^{window}}{\left(\frac{\Delta T_{SEN}}{\Delta T_{REF}}\right)^{no\ window}}$$

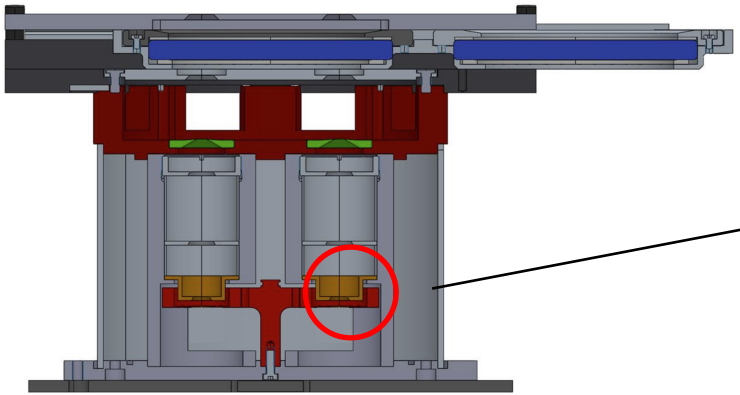
MITRA upgrade: New type of detector

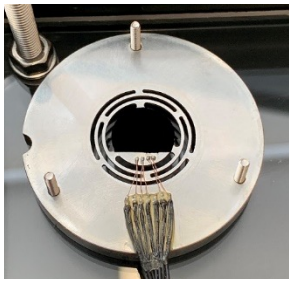




Old detector:
Silver cavity coated with gold outside and painted with a black paint Aeroglaze Z302 inside

Absorptivity: > 95% (99.90%)

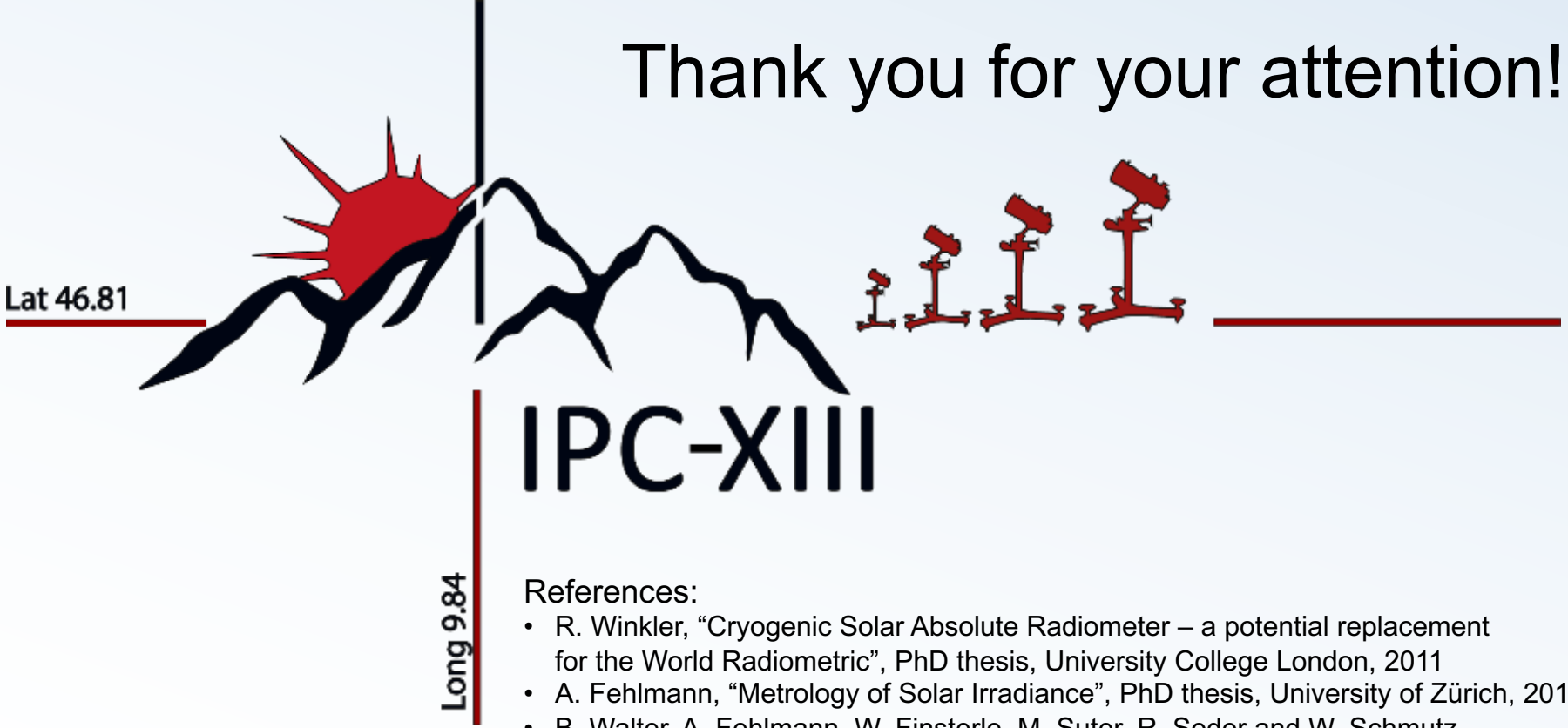




New detector:
Flat receiver coated with carbon nanotubes (CNT)

Absorptivity: 99.85% (99.97%)

Thank you for your attention!



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- A. Fehlmann, “Metrology of Solar Irradiance”, PhD thesis, University of Zürich, 2011
- B. Walter, A. Fehlmann, W. Finsterle, M. Suter, R. Soder and W. Schmutz, Metrologia 51, 344-349 (2014)
- B. Walter, R. Winkler, F. Graber, W. Finsterle, N. Fox, V. Li and W. Schmutz, AIP Conference Proceedings 1810, 080007 (2017)