Skydip calibration

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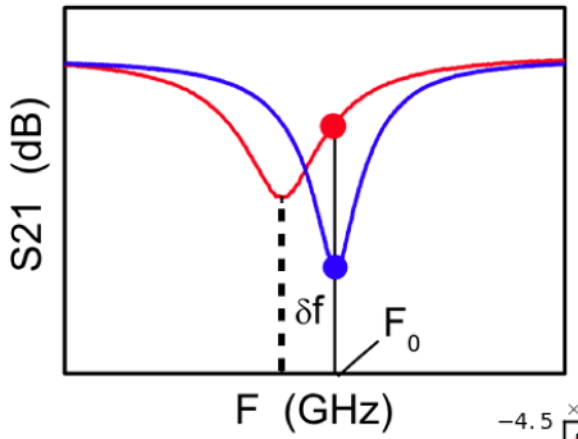
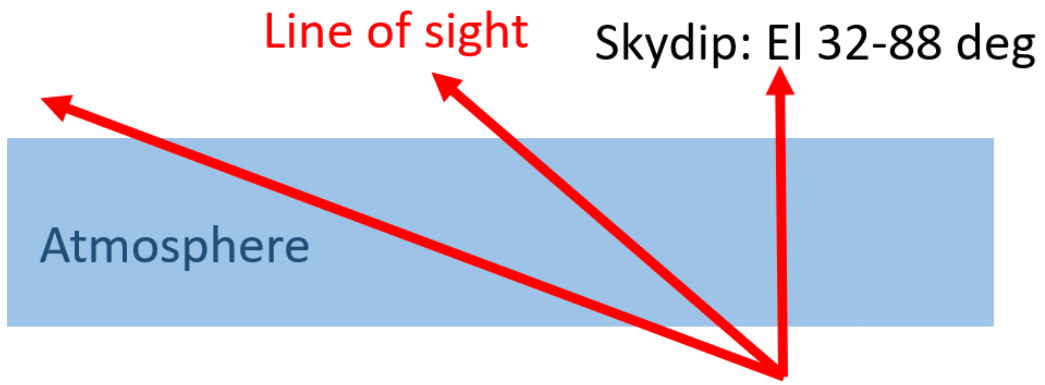
- Skydip calibration methodology
- Currnet DESHIMA 2.0 result
- Toward TIFUUN: calibration strategy

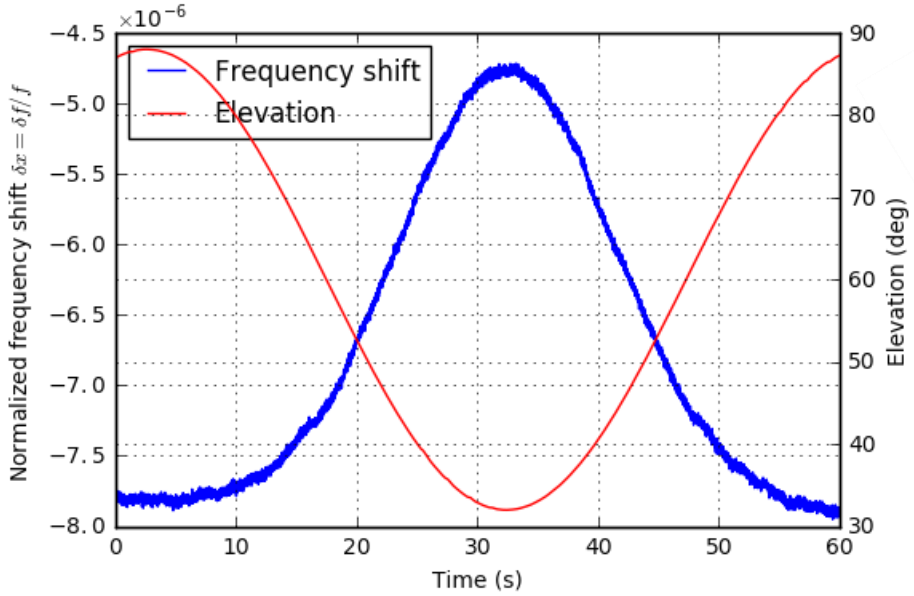
Responsivity calibration method

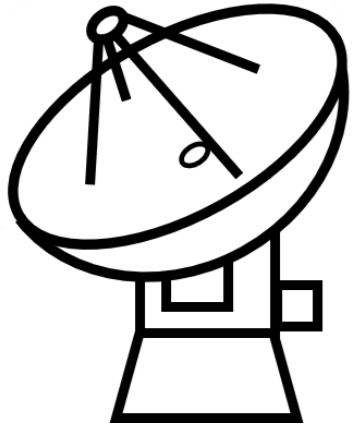
- MKID readout $\delta x = \delta f / F_0$ ➔ line-of-sight brightness temperature T_{sky}



Baselman+2017, A&A 601, A89 (2017)



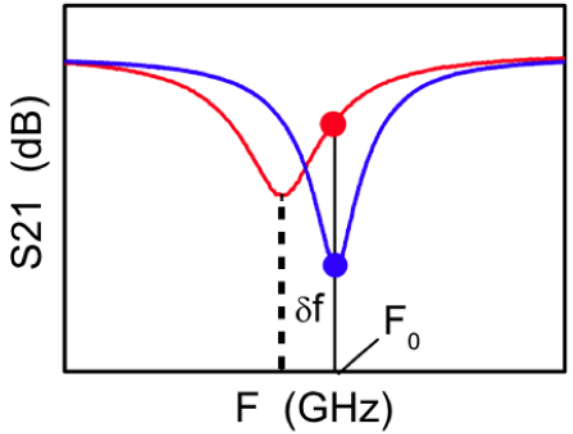




Takekoshi et al. (2020)

On-sky calibration equation

- MKID readout $\delta x = \delta f/F_0$ ➔ line-of-sight brightness temp. T_{sky}



Baselman+2017, A&A 601, A89 (2017)

$$\delta x(T) = p_0(\sqrt{T_w - T_0} - \sqrt{T_{load} - T_0})$$

$T_0 = -\frac{h\nu}{2k_b}$(=-8.4K@350GHz): 2nd order RJ approx. term

T_{load}: Chopper temperature

$$T_w = \eta_{fwd} T_{sky} + (1 - \eta_{fwd}) T_{amb}$$

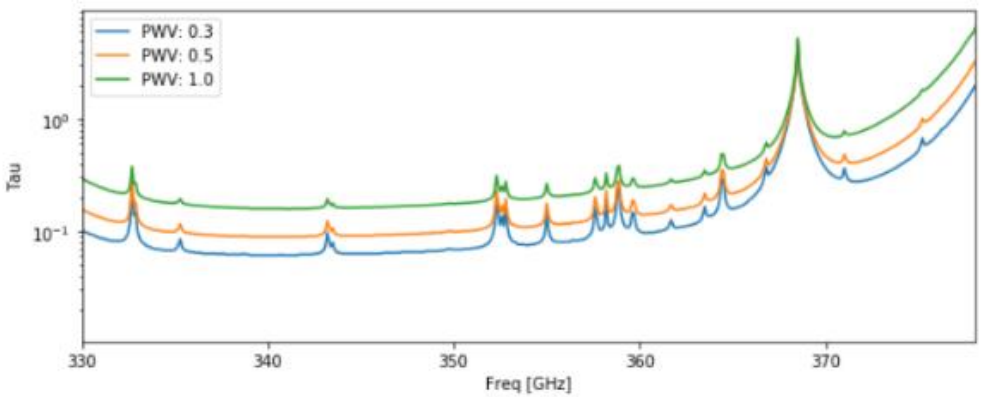
$$T_{\rm sky}^{\rm resp}(\delta x) = \frac{1}{p_0^2 \eta_{\rm fwd}}(\delta x + p_0\sqrt{T_{\rm load} + T_0})^2 - \frac{1}{\eta_{\rm fwd}}(T_0 + (1 - \eta_{\rm fwd})T_{\rm amb}).$$

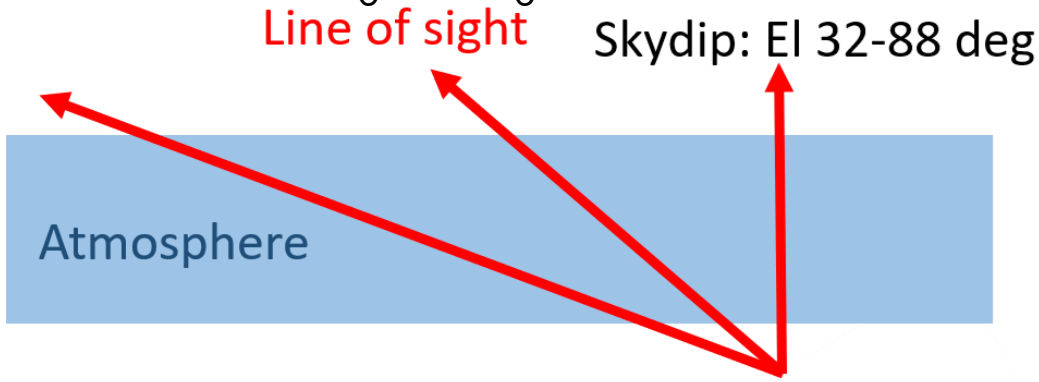
Parameter: p0 and η fwd

Takekoshi et al. (2020)

Tsky estimate from PWV and El

- PWV: precipitable water vaper (mm)
- Assume ATM model (Pardo 2001) → $\tau_0 = \tau_0(\nu, \mathrm{PWV})$





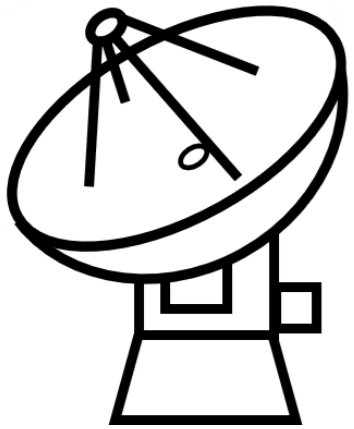
- Atmospheric transmission

$$\eta_{\mathrm{atm}}(El, PWV) = \frac{\int g(\nu) e^{-\tau_0(\nu, PWV)\csc(El)} \mathrm{d}\nu}{\int g(\nu) \mathrm{d}\nu}$$

g(ν): Response function of a MKID

- Line-of-sight sky temperature
  - Ignore CMB contribution (<~1% systematics)

$$T_{\mathrm{sky}}^{\mathrm{los}}(El, PWV) = (1 - \eta_{\mathrm{atm}}) T_{\mathrm{atm}}$$



Takekoshi et al. (2020)

Responsivity model in DESHIMA1.0

- **Responsivity calibration using 22 skydip data (El=32-88°)**
- Use PWV obtained by ALMA as initial parameter

Model

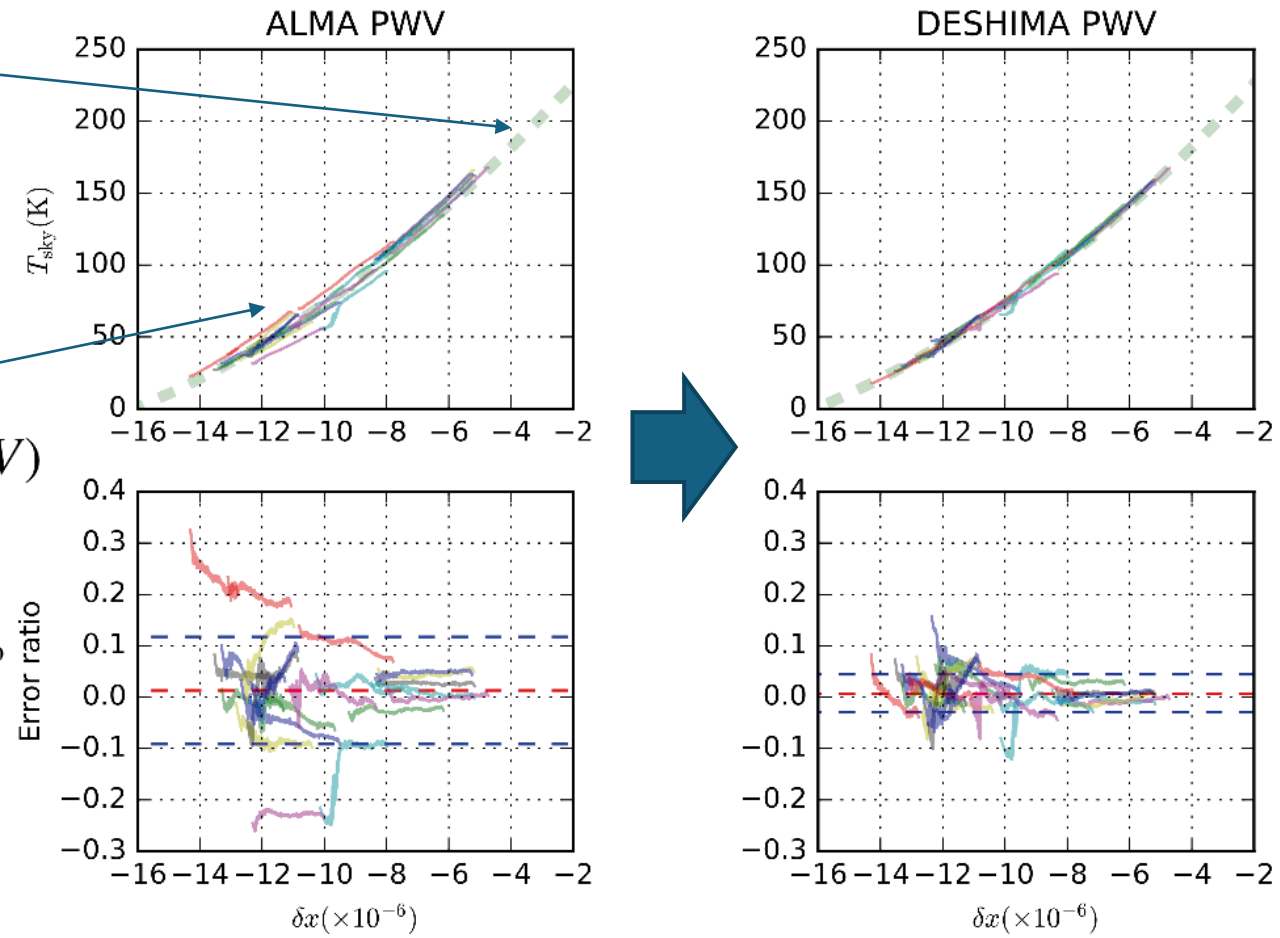
$T_{\rm sky}^{\rm resp}(\delta x)$

Data(skydip)

$T_{\rm sky}^{\rm los}(El, PWV)$

$(T_{\rm sky}^{\rm los} - T_{\rm sky}^{\rm resp})/T_{\rm sky}^{\rm resp}$

ch20
335.5GHz

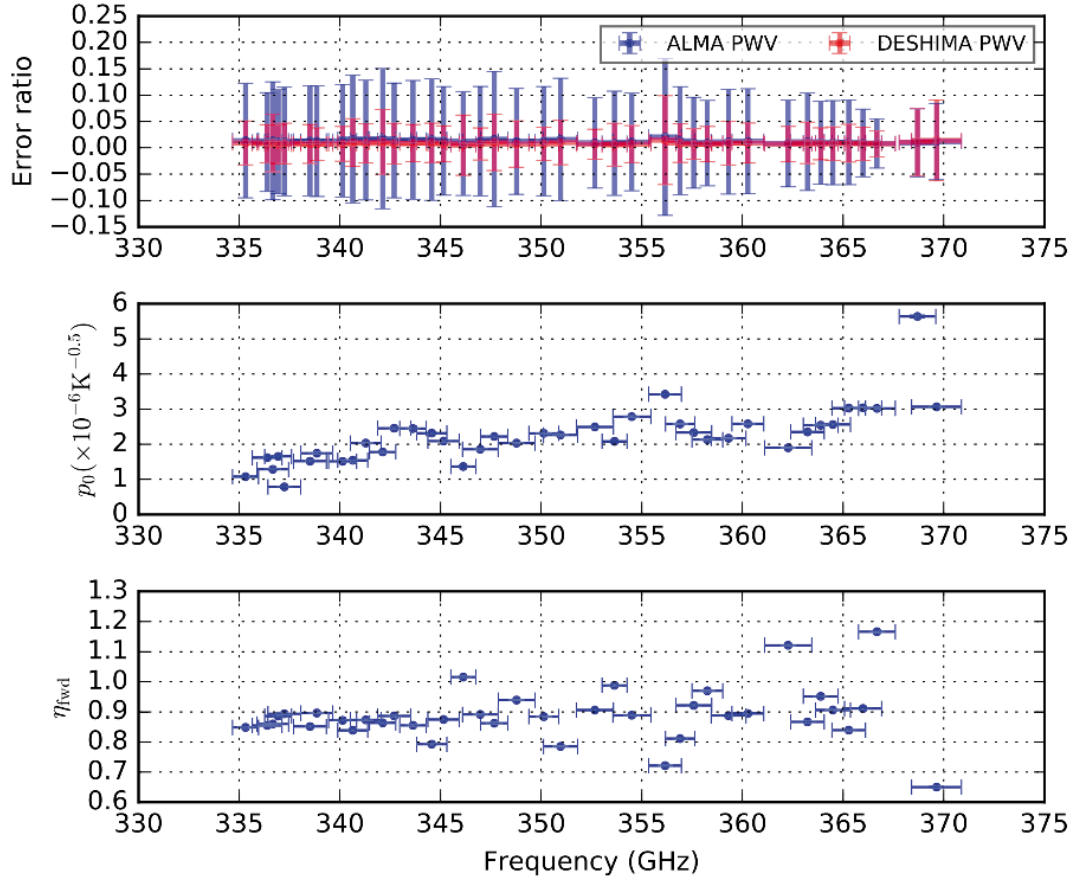


Takekoshi et al. (2020)

Parameters for all channels in DESHIMA1.0

- Error ratio

PWV	Mean offset	Mean 1 σ error
ALMA	1.0 %	9.9 %
DESHIMA	0.8 %	4.0 %



- Forward efficiency

$\eta_{\mathrm{fwd}} = 88 \pm 2\%$

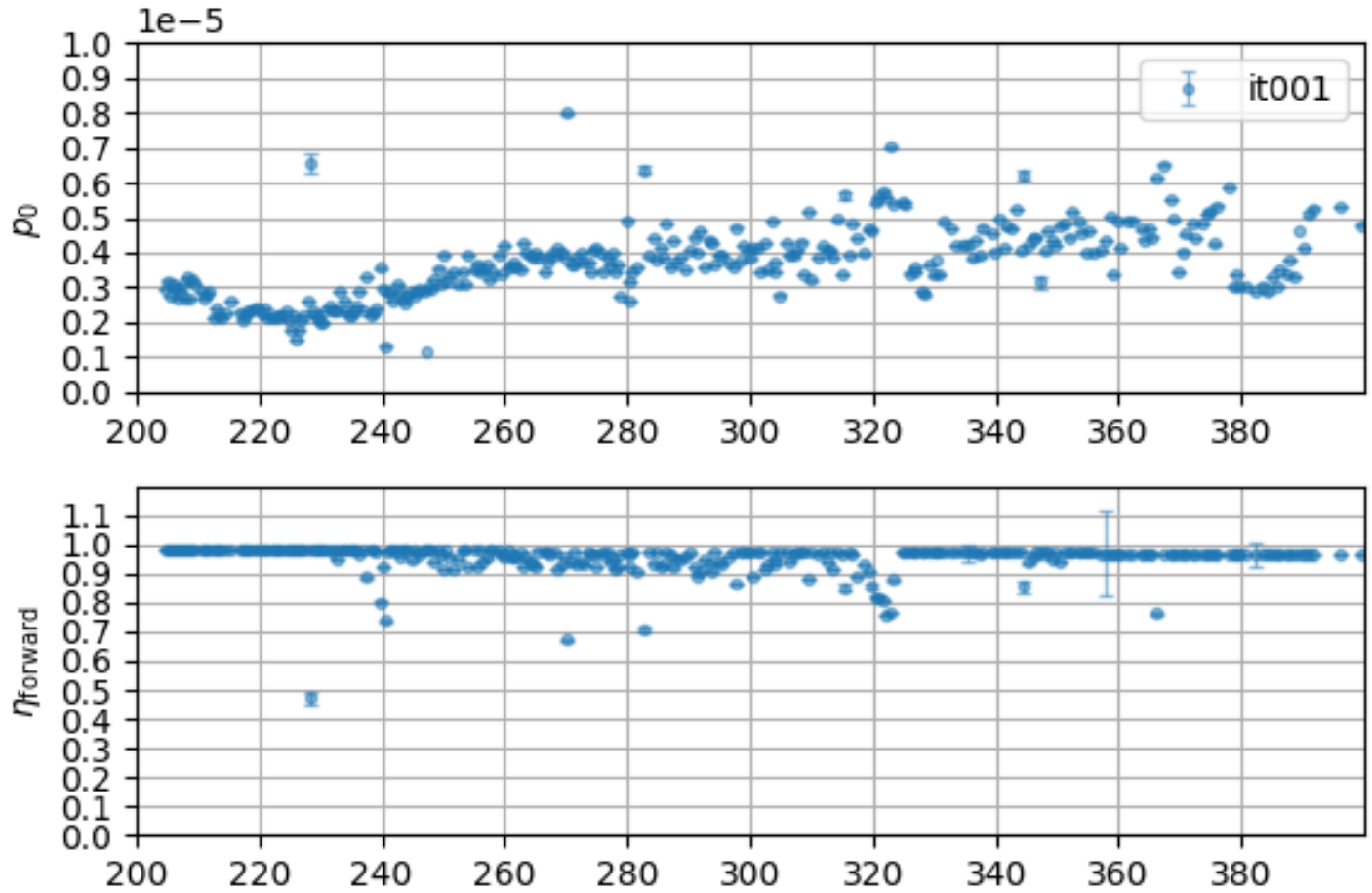
➔Consistent with ASTE expected value of 0.87

Takekoshi et al. (2020)

Skydip calibration in DESHIMA2.0

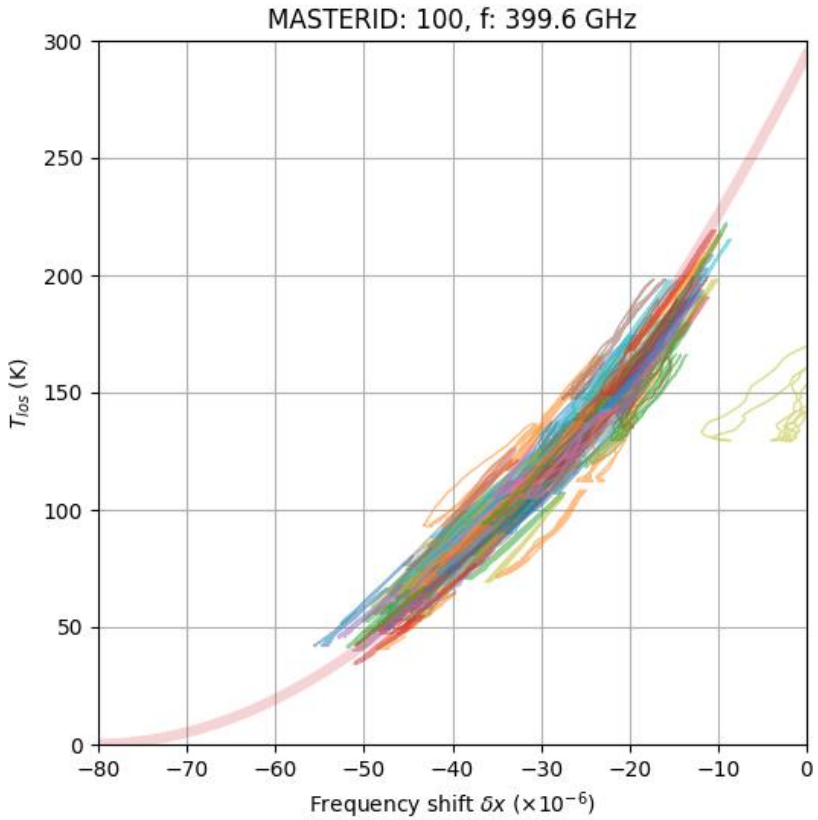
- Data
  - 20240706-20241103
  - az(-)180el60_skydip_beamA: 193 data
  - APEX PWVs
- DDB 20250819
  - https://deshima.kibe.la/@takekoshi/9792
- Available in demerge 2025.8.4
  - https://github.com/deshima-dev/demerge/releases/tag/2025.8.4

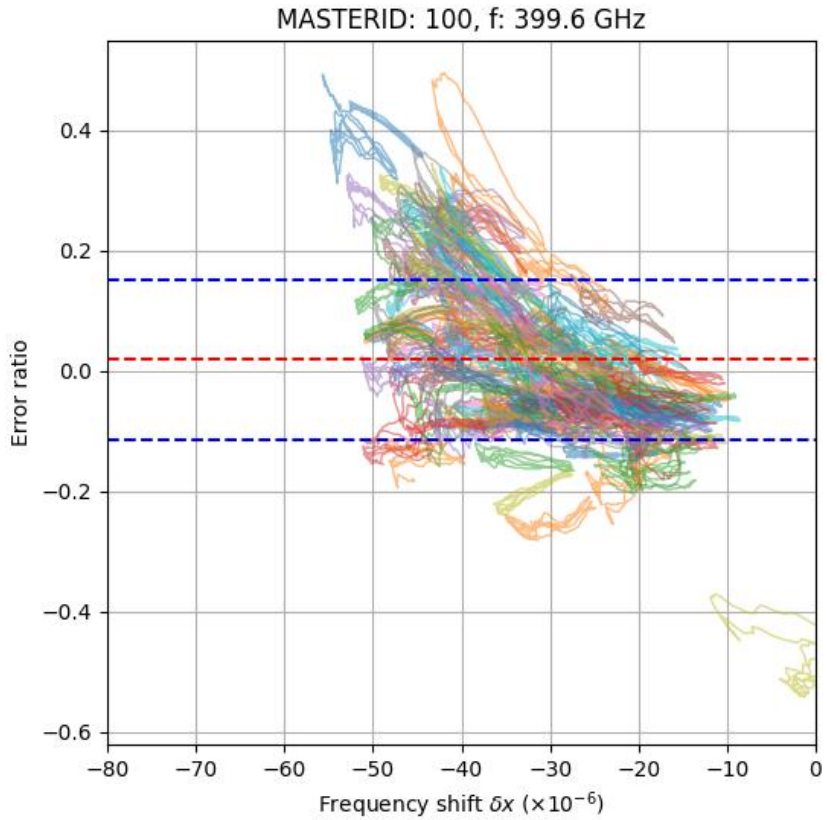
Fit parameters



https://deshima.kibe.la/@takekoshi/9792

MasterID 100, 399.6 GHz

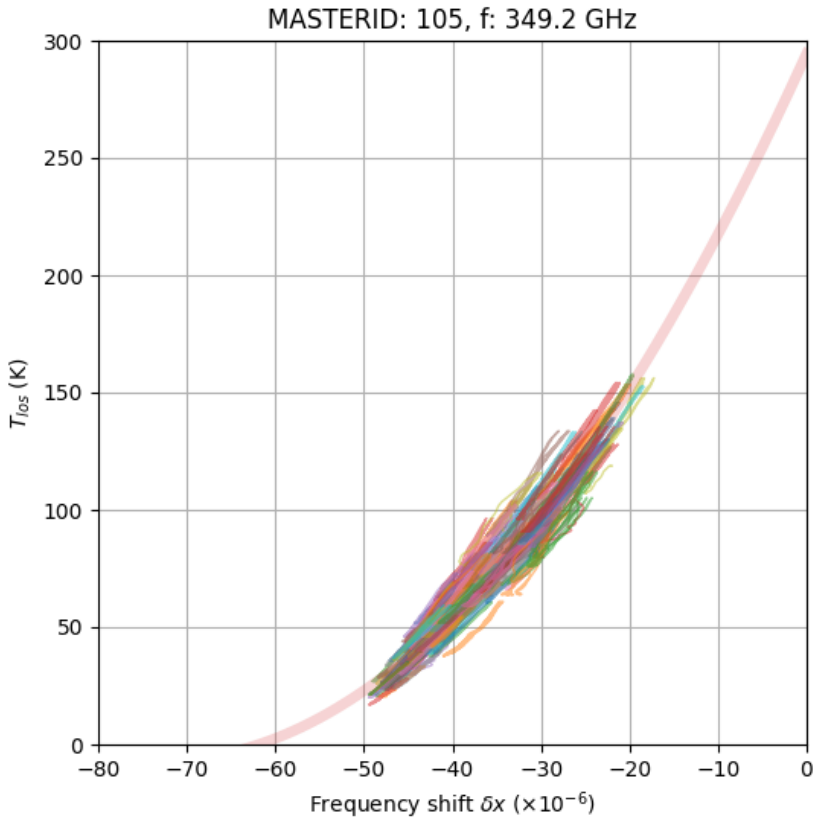


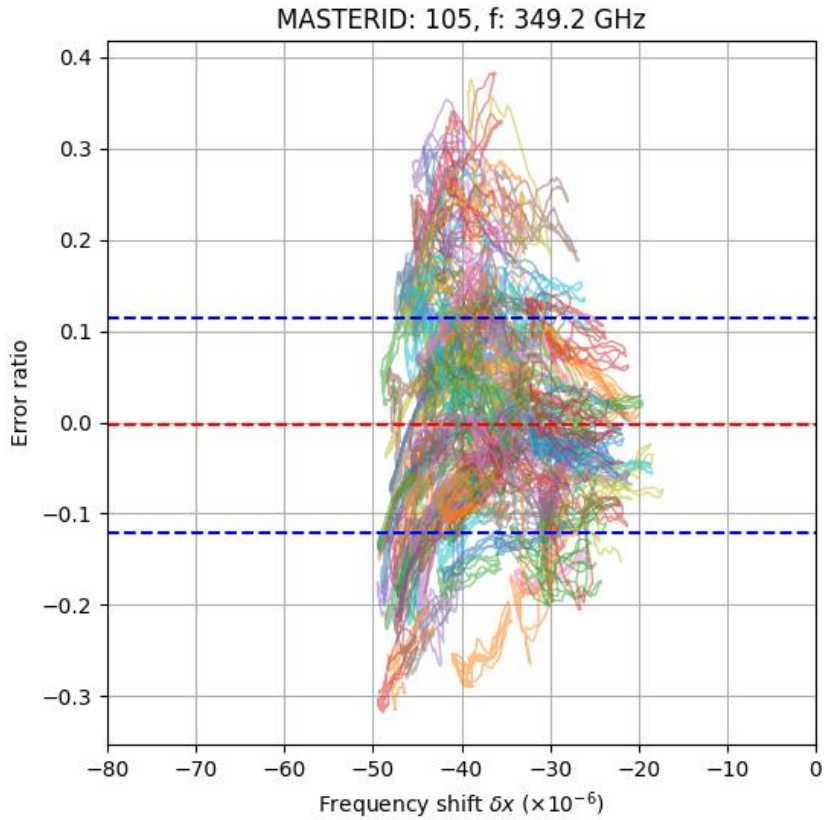


+1sigma

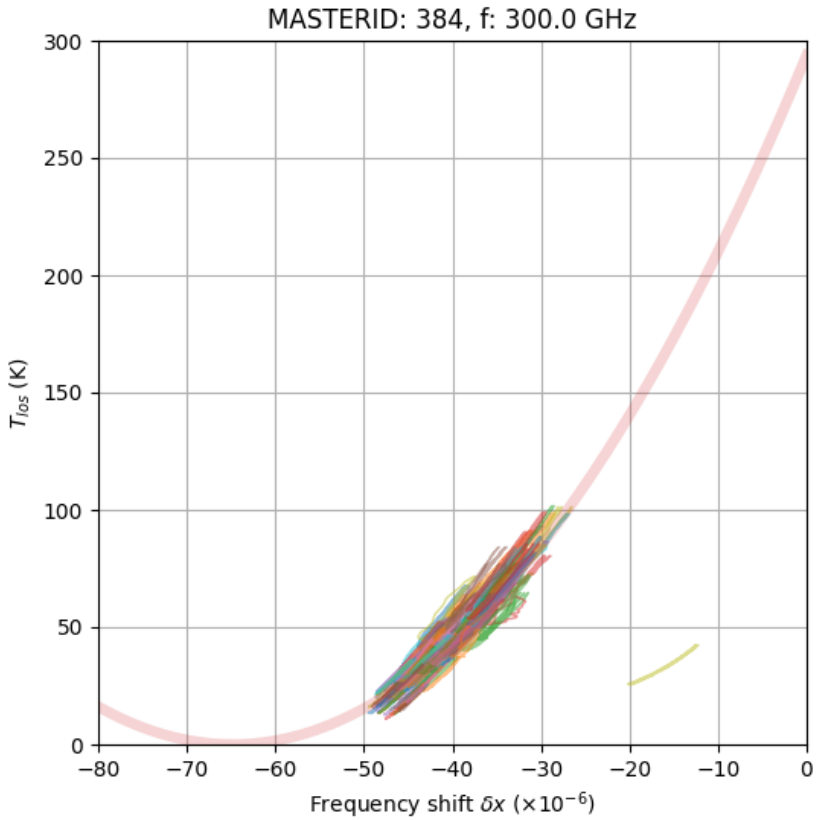
-1sigma

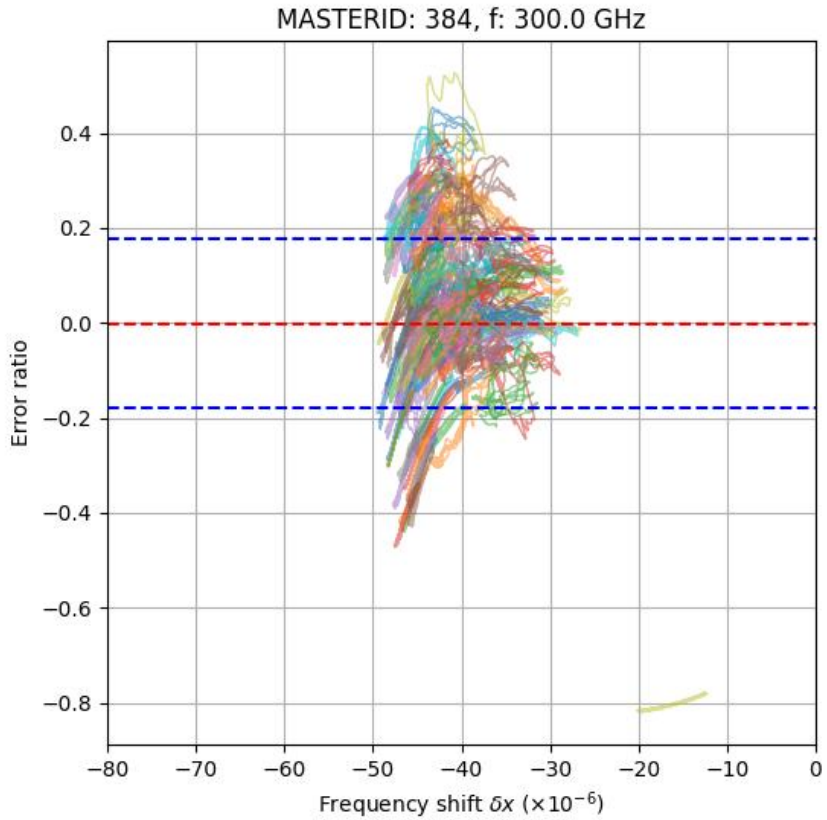
MasterID 105, 349.2 GHz



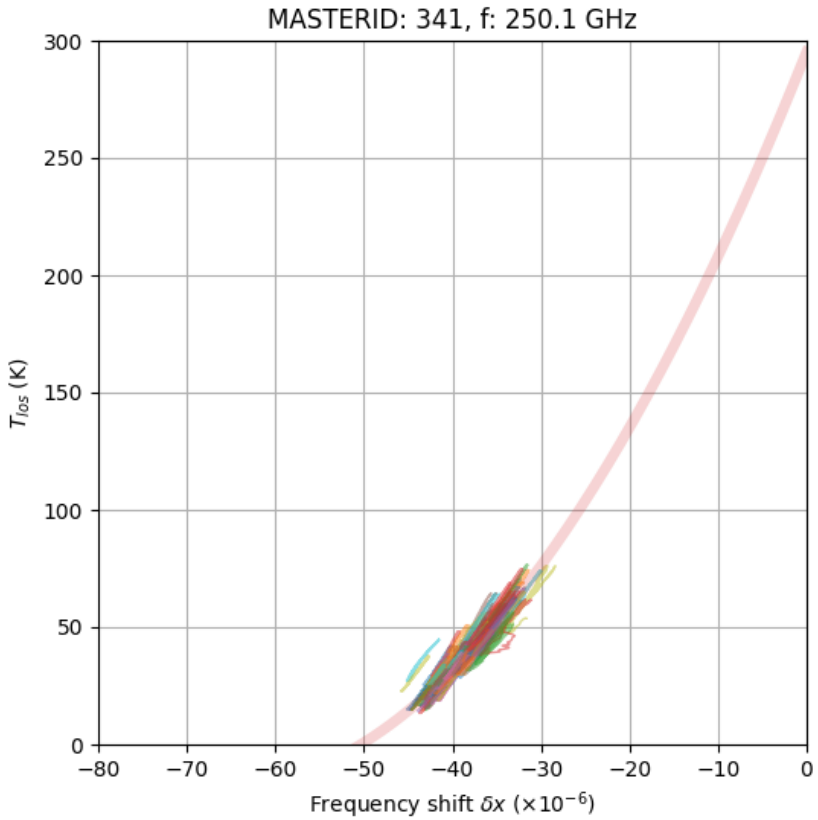


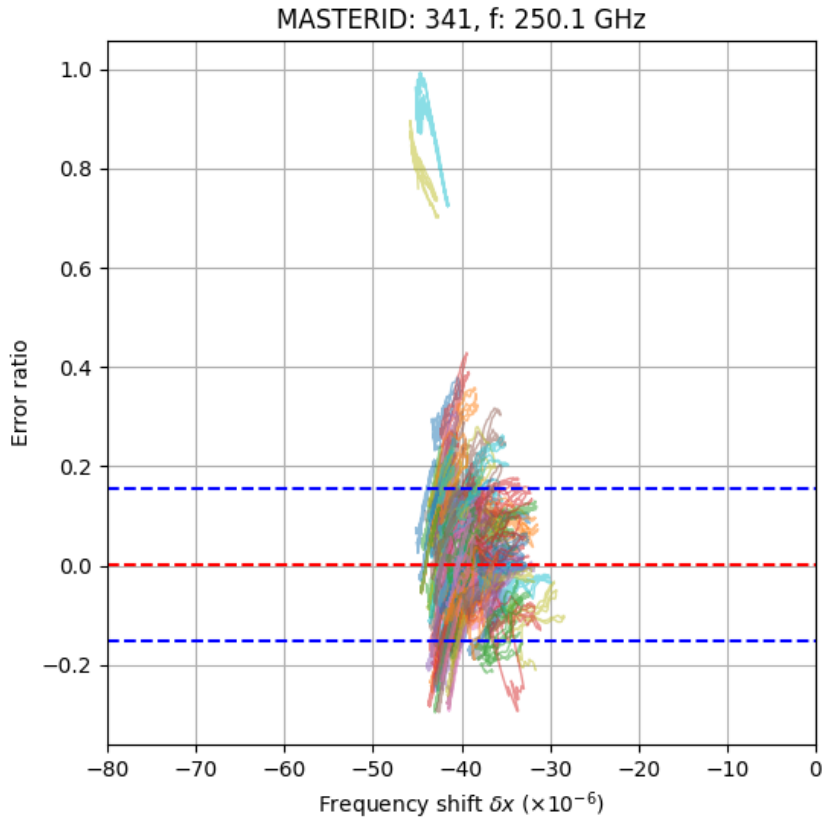
MasterID 384, 300.0 GHz



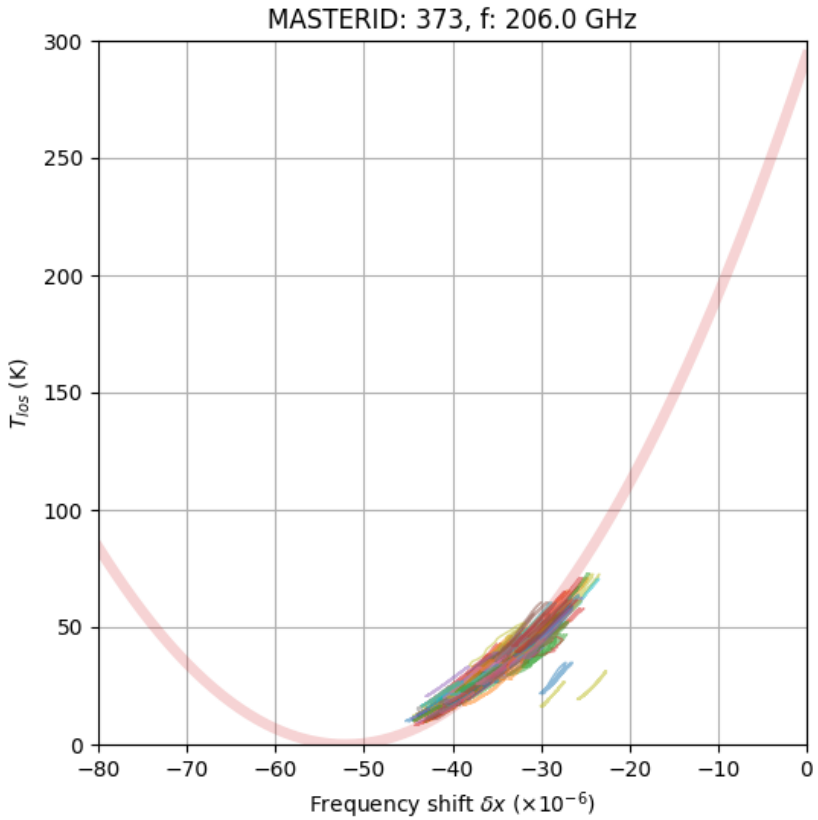


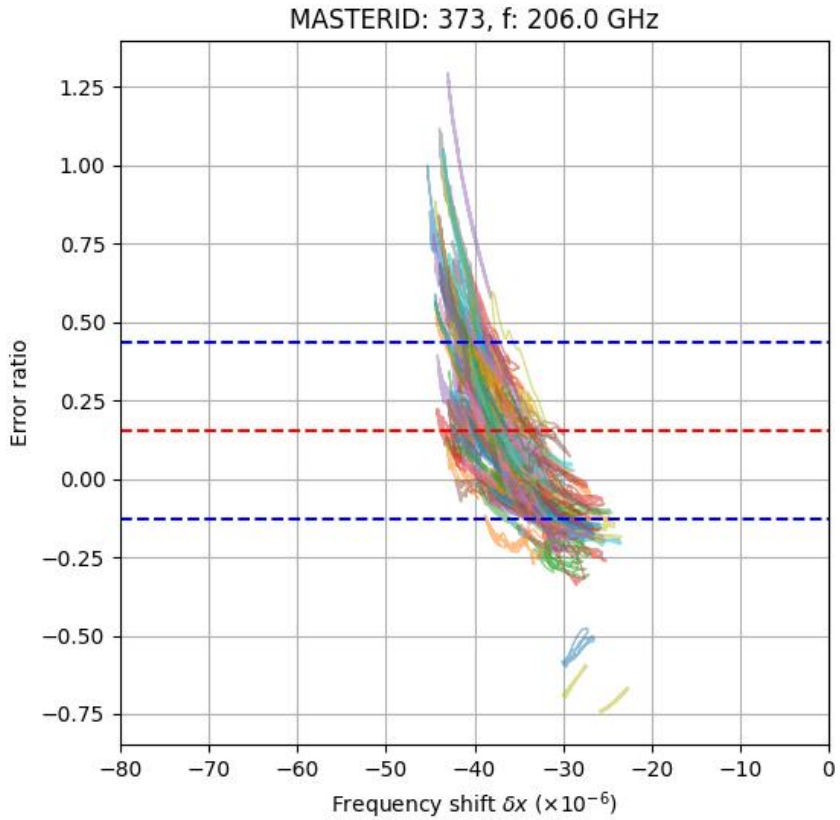
MasterID 341, 250.1 GHz





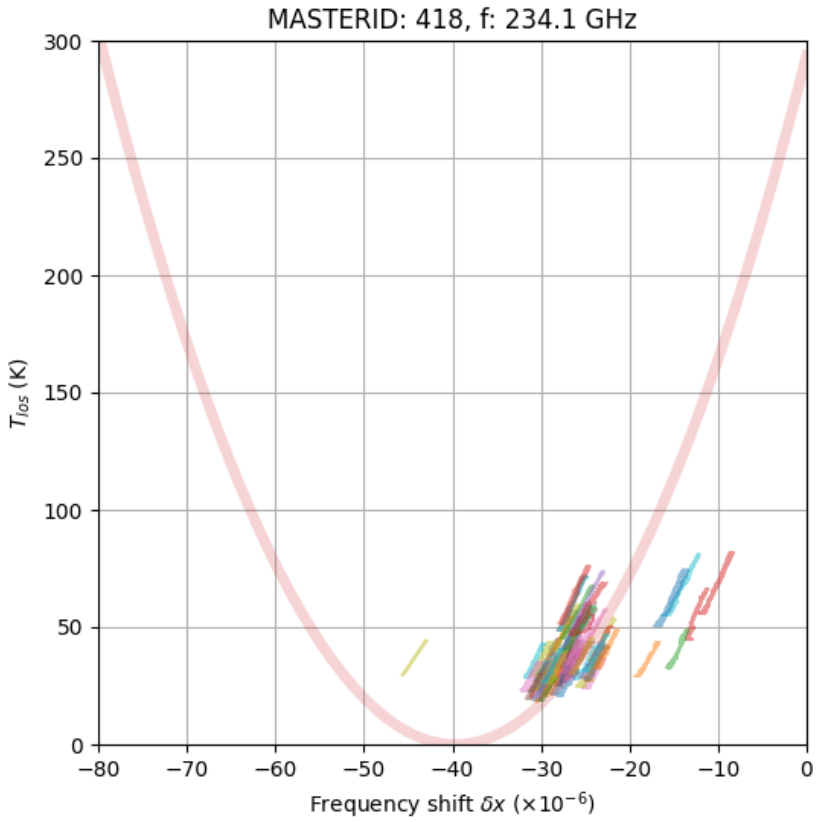
MasterID 373, 206.0 GHz

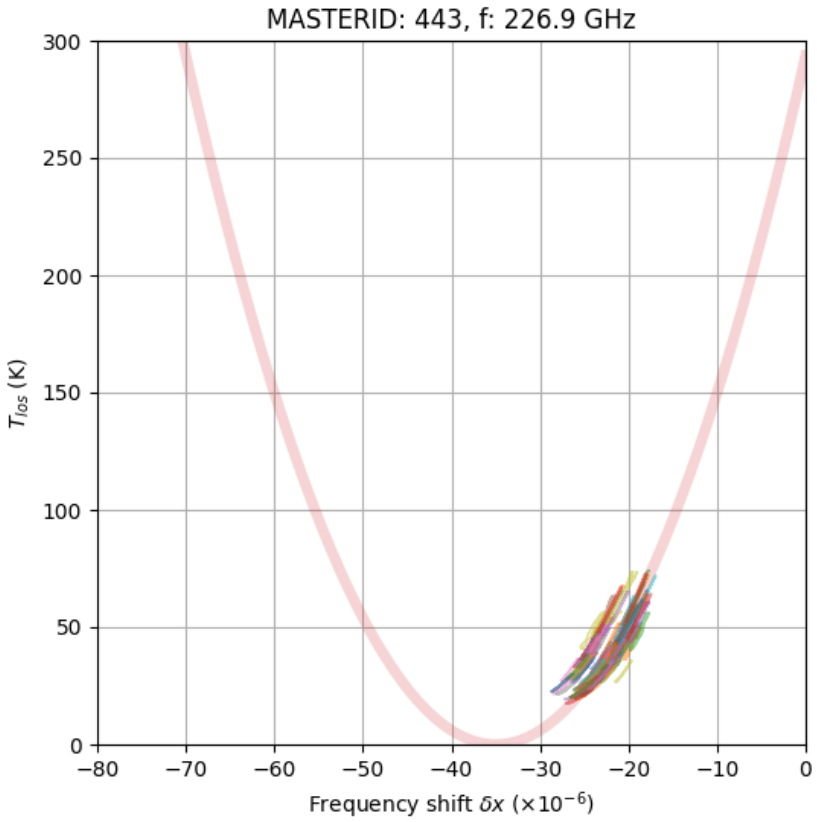




Kid corresp is not perfect?

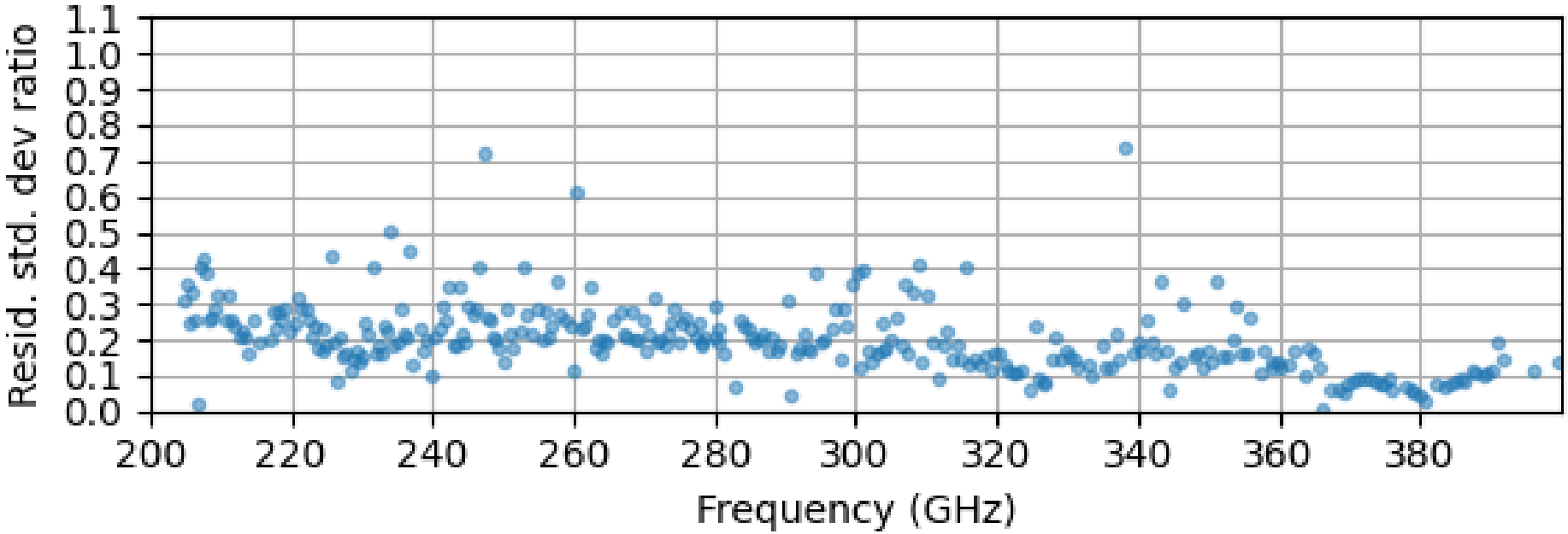
Swapping still exists in some KIDs





Standard deviation

- 10~30%
  - Mainly caused by APEX PWV error?
  - Higher frequency has smaller error
    - ➔ dynamic range of atmospheric emission is important?
    - TODO: PWV re-estimate of calibrated DEMS (for all DEMS)



https://deshima.kibe.la/@takekoshi/9792

Toward TIFUUN

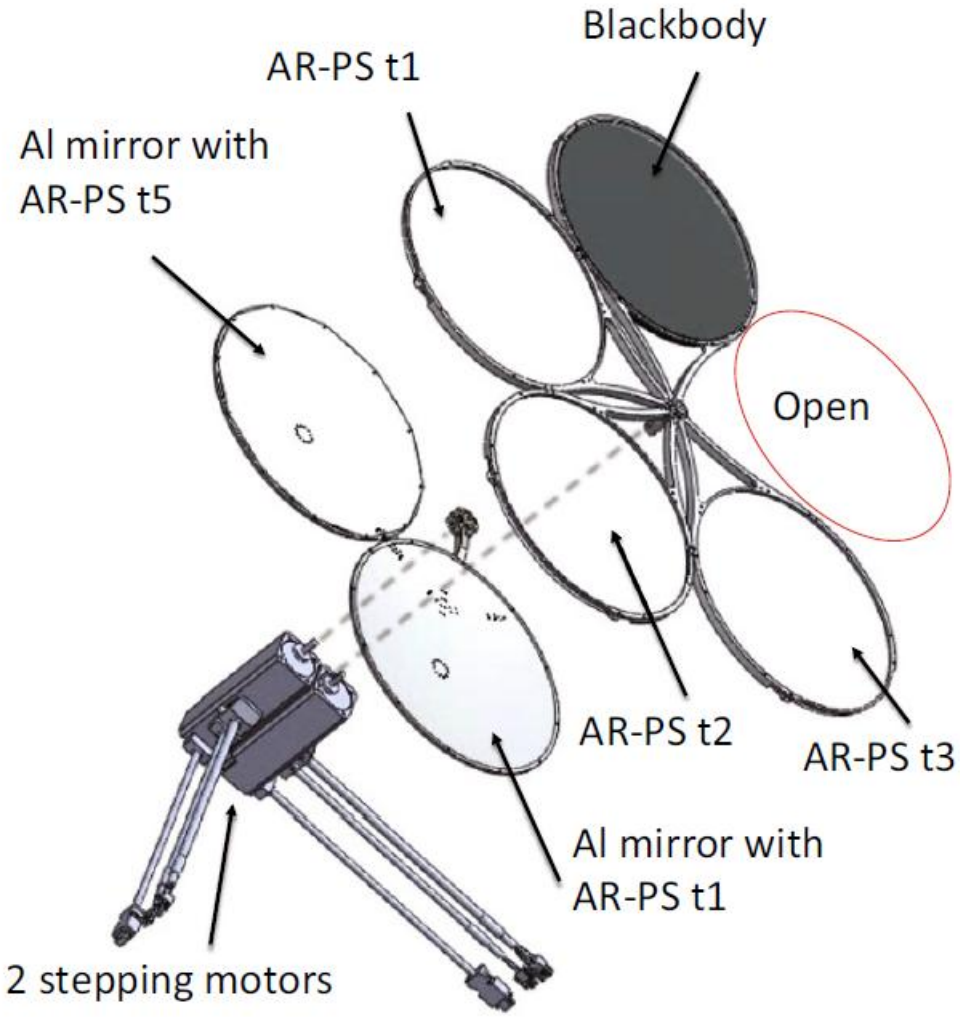
- Skydip calibration model
  - The skydip calibration model can be established in the 200–400 GHz frequency range.
  - But for the TIFUUN LF (130–180 GHz), can the model still be established under smaller dynamic-range conditions?
- Alternative calibration option?
  - TESCAM add-on and cryogen-free calibrator
  - Takekoshi et al. 2018, Oshima et al. 2018

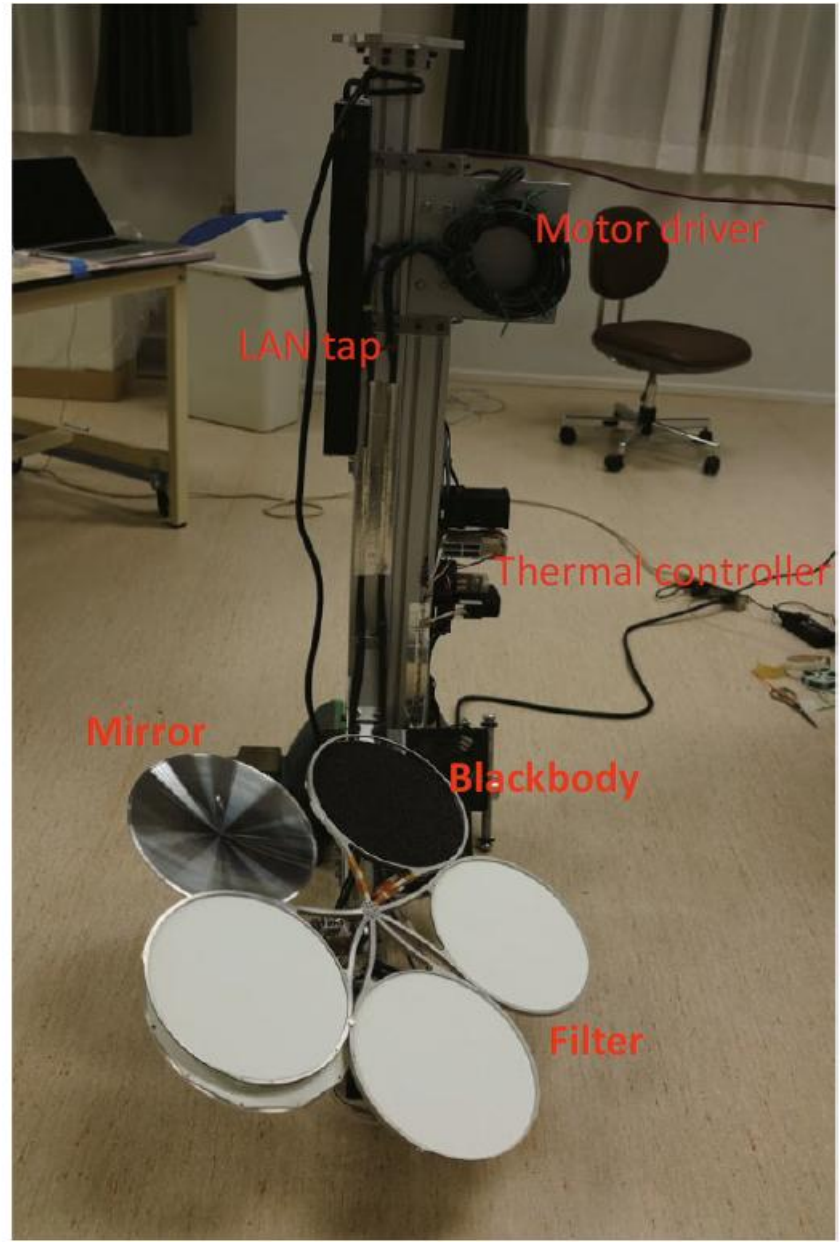
TES bolometer camera for the ASTE telescope 2012-16

- ASTE
  - 10 m submillimeter telescope
  - The Atacama desert, Chile (alt. 4800 m)
- TES bolometer camera
  - 2 band simultaneous observation
  - Band1 at 1.1mm(270GHz): 169 pix
  - Band2 at 0.85mm(350GHz): 271 pix
  - Field of view: 8 arcmin.
- Calibration system was installed in 2016 commissioning.

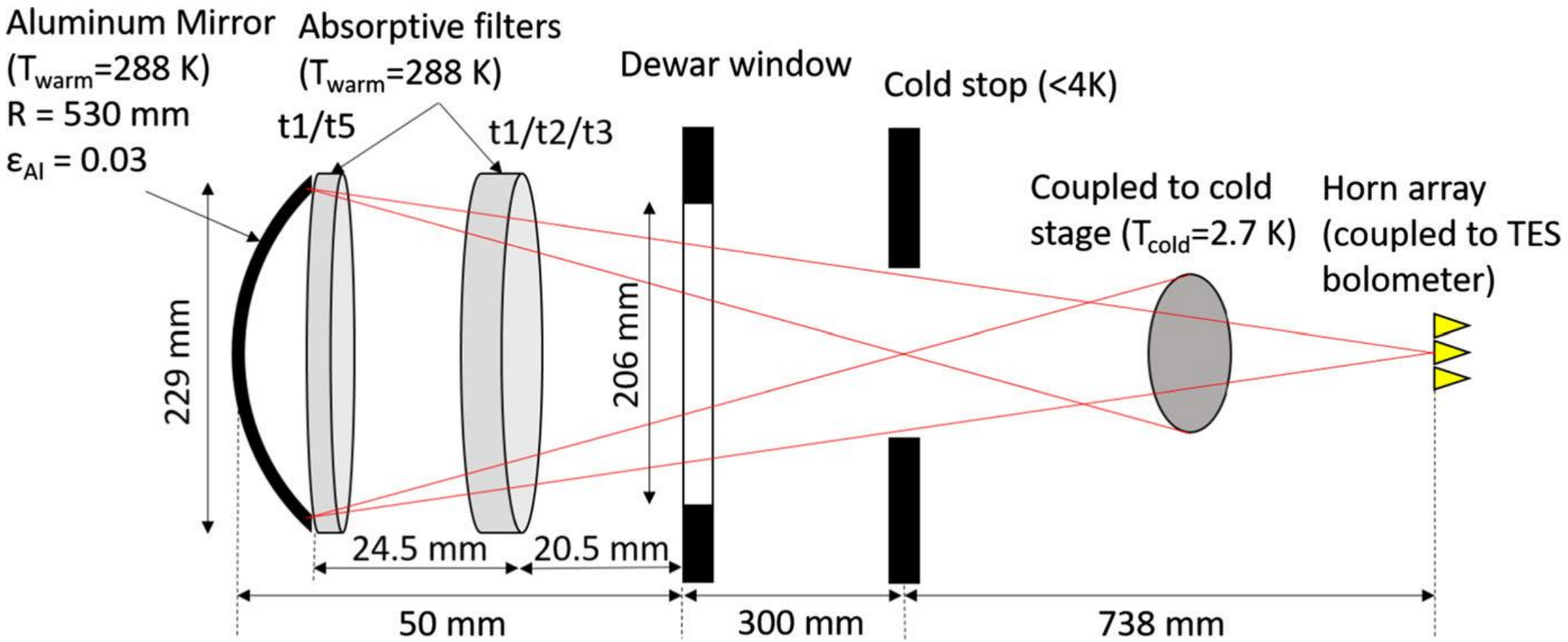
TESCAM Calibrator

Simple add-on, cryogen-free calibrator that imitates typical sky condition in the ASTE site (PWV=0.5—4mm).

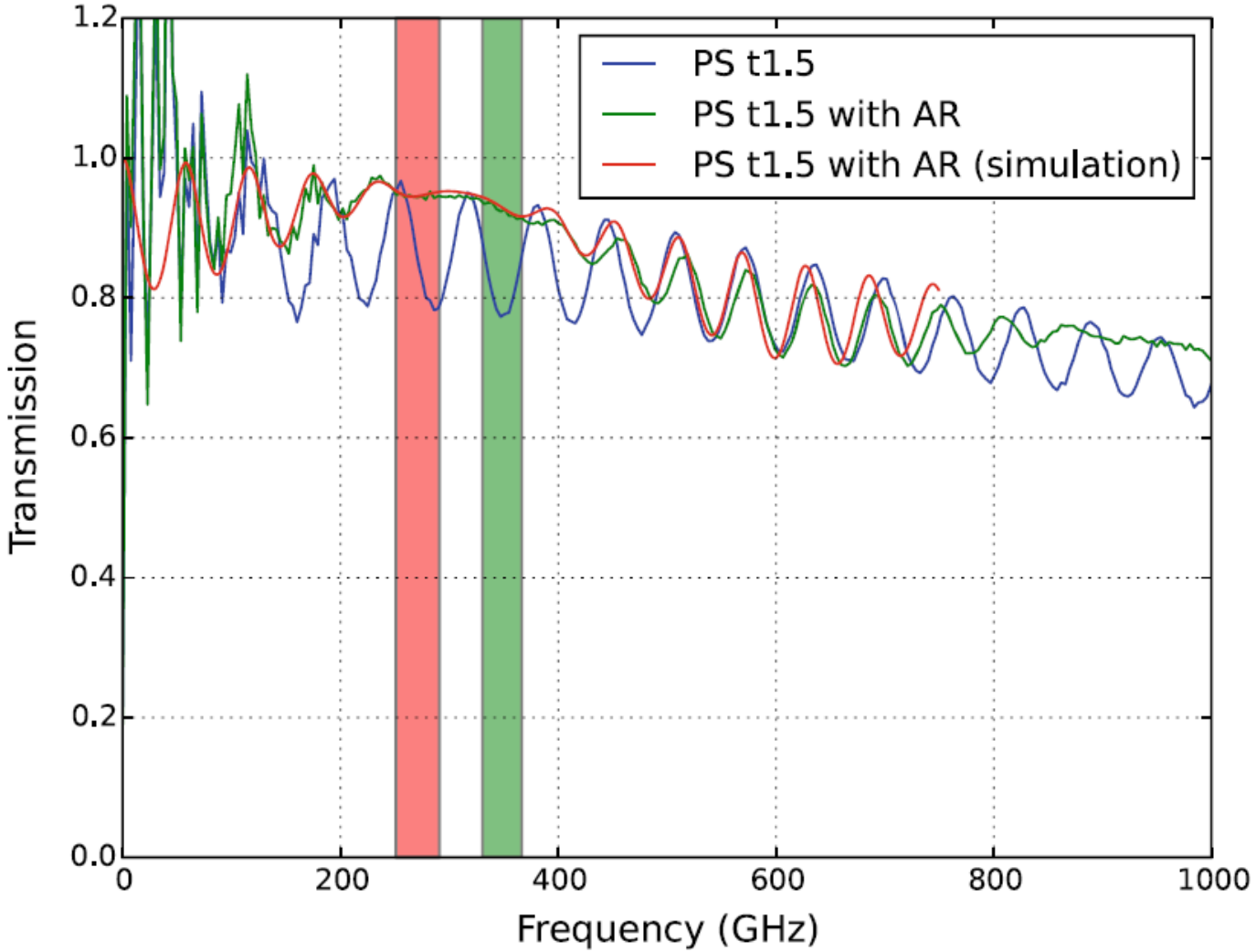




Optical configuration



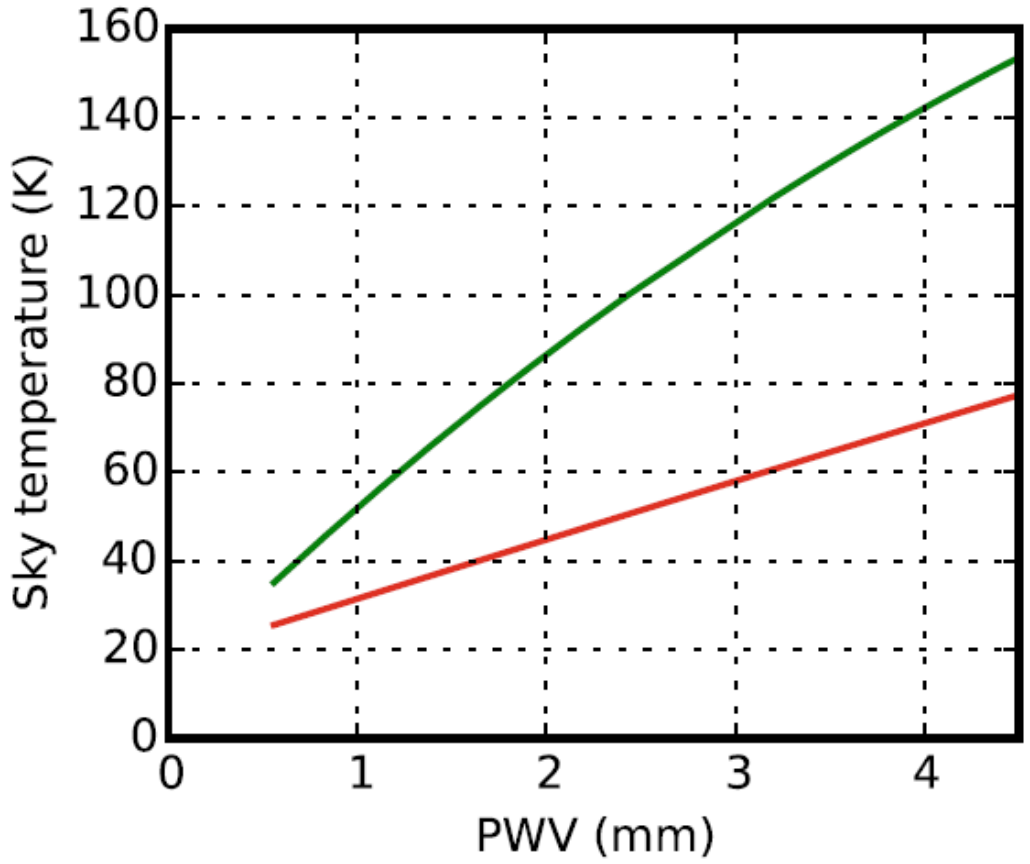
Transmission measurement AR-PS filter

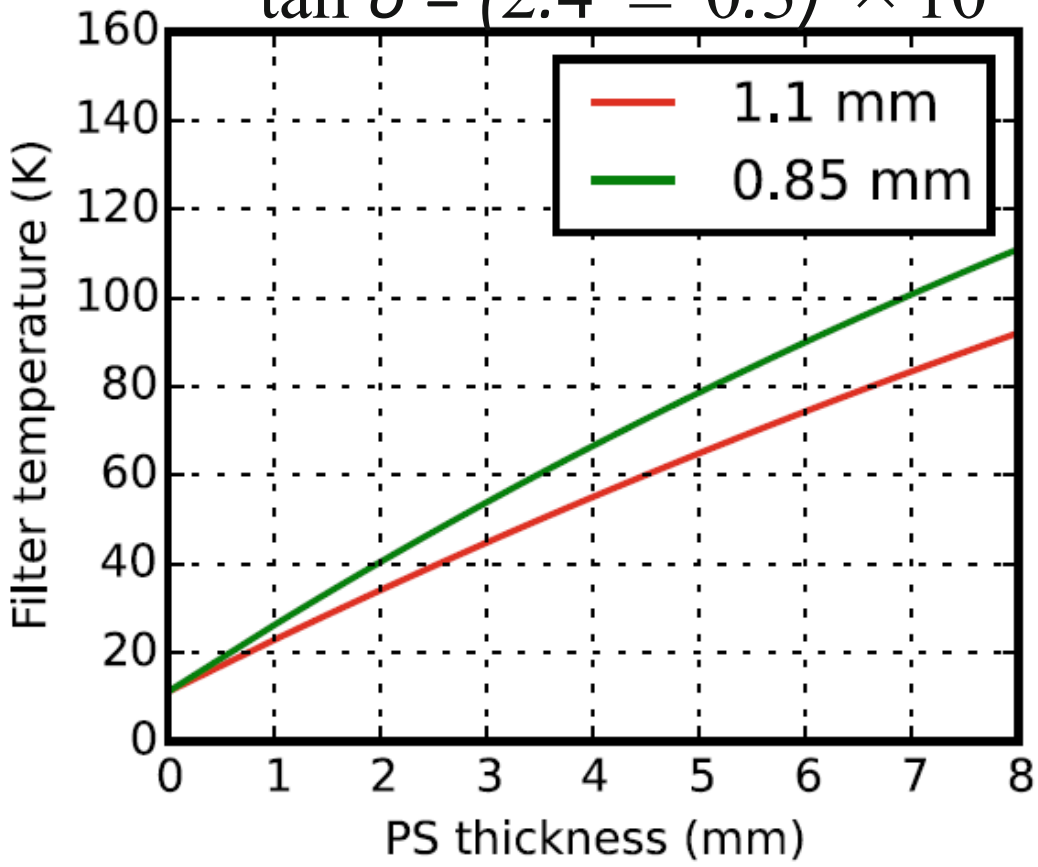


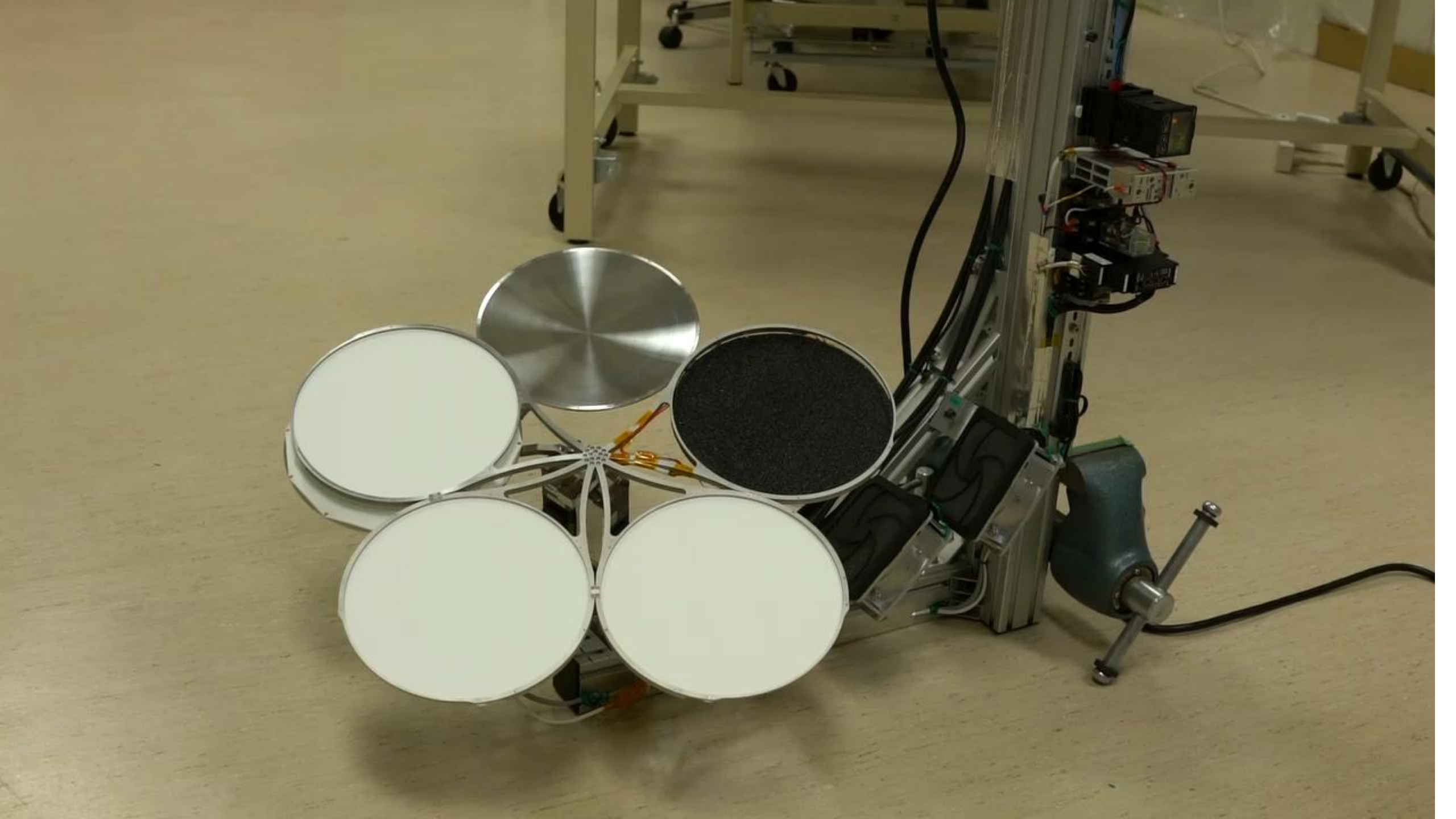
Polystyrene (PS) thickness and PWV

$n = 1.571 \pm 0.001$

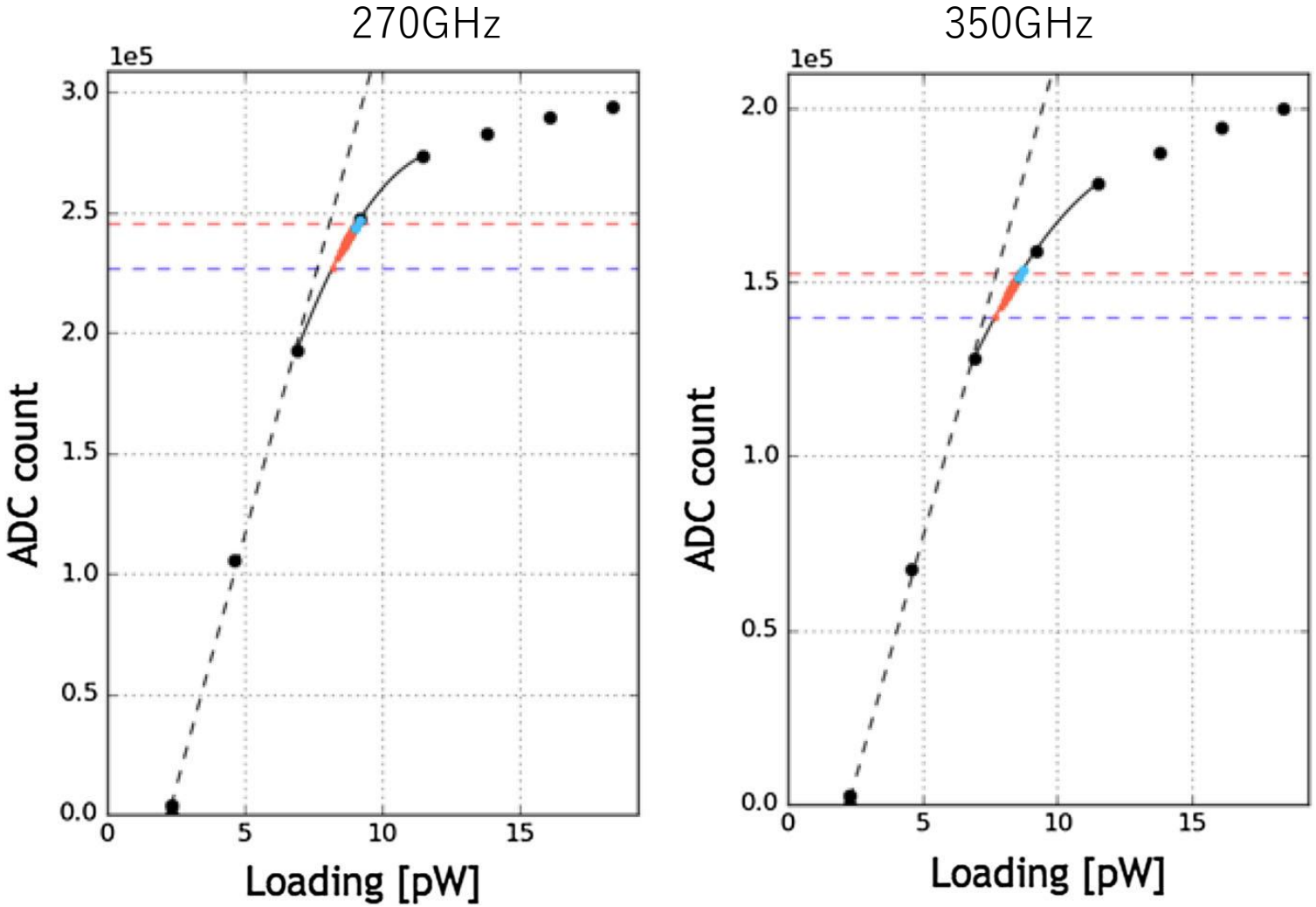
$\tan\delta = (2.4 \pm 0.3) \times 10^{-3}$







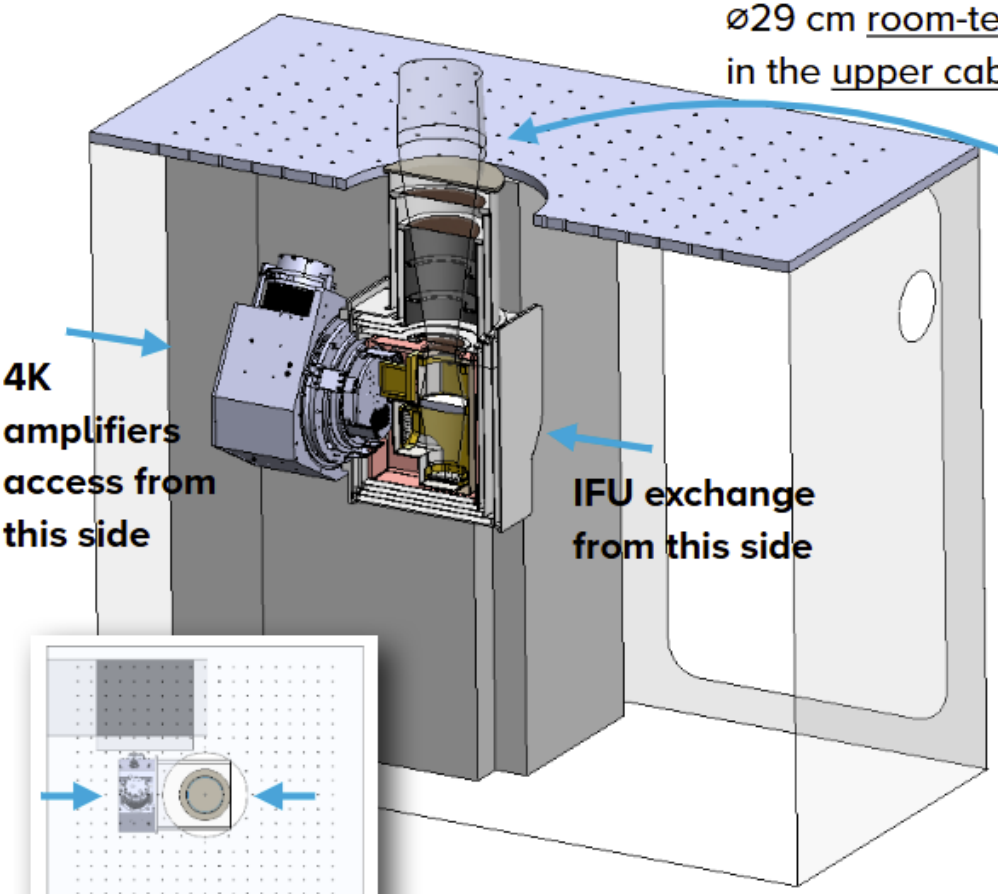
Non-linearity correction (TES bolometers)

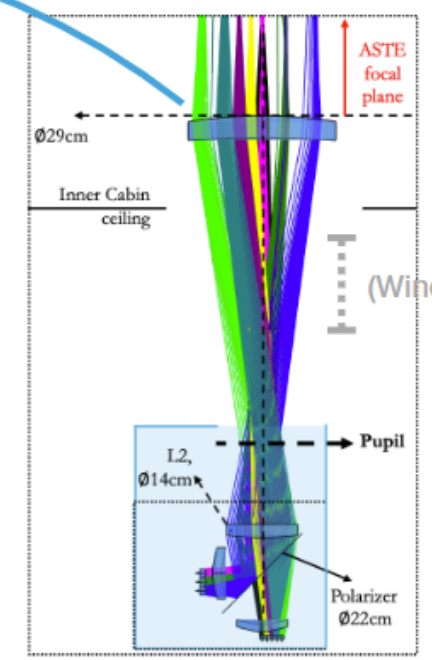


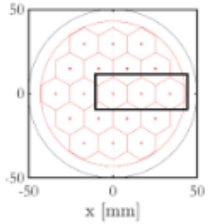
Endo-san's talks

TIFUUN in the ASTE Receiver Cabin

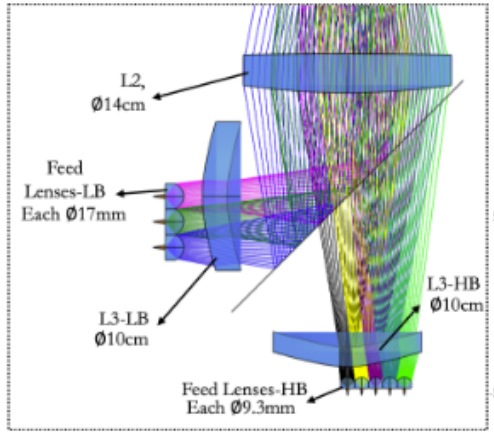
ø29 cm room-temperature Si lens in the upper cabin



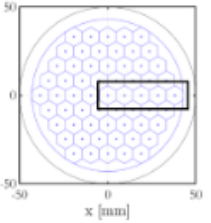




19 independent beams 90-180GHz



61 independent beams 180-360GHz



For details and updates, see presentation by ***Shahab Dabironezare***

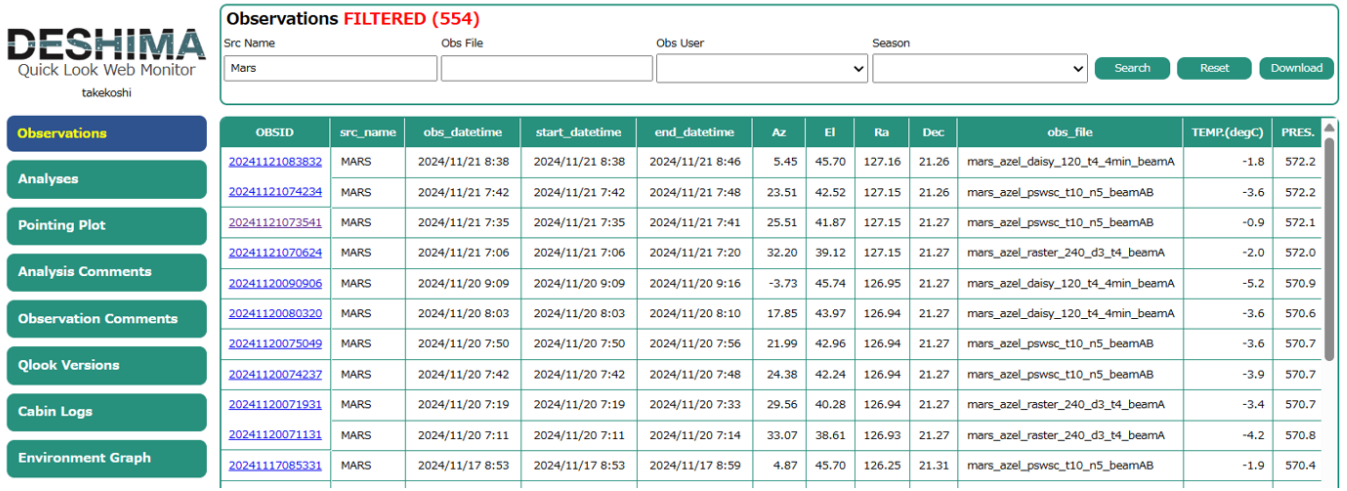
Summary

- Skydip calibration in DESHIMA 2.0
  - 10~30% standard deviation: mainly caused by APEX PWV error?
  - Higher frequency has smaller standard deviation
- Toward TIFUUN
  - More serious dynamic range in LF detectors
  - Add-on type calibrator?

D2 data access

- Data server desql1 (Kitami)
  - Need registration of ssh-key to access
  - Raw and merged (DEMS) dataset
  - https://deshima.kibe.la/notes/8099
- Qlook web monitor
  - Observation log
  - Qlook analysis log
  - etc…
- (The latest DEMSs are also available on Google drive)

(a)



OBSID	src_name	obs_datetime	start_datetime	end_datetime	Az	El	Ra	Dec	obs_file	TEMP.(degC)	PRES.
20241121083832	MARS	2024/11/21 8:38	2024/11/21 8:38	2024/11/21 8:46	5.45	45.70	127.16	21.26	mars_azel_daisy_120_t4_4min_beamA	-1.8	572.2
20241121074234	MARS	2024/11/21 7:42	2024/11/21 7:42	2024/11/21 7:48	23.51	42.52	127.15	21.26	mars_azel_pswsc_t10_n5_beamAB	-3.6	572.2
20241121073541	MARS	2024/11/21 7:35	2024/11/21 7:35	2024/11/21 7:41	25.51	41.87	127.15	21.27	mars_azel_pswsc_t10_n5_beamAB	-0.9	572.1
20241121070624	MARS	2024/11/21 7:06	2024/11/21 7:06	2024/11/21 7:20	32.20	39.12	127.15	21.27	mars_azel_raster_240_d3_t4_beamA	-2.0	572.0
20241120090906	MARS	2024/11/20 9:09	2024/11/20 9:09	2024/11/20 9:16	-3.73	45.74	126.95	21.27	mars_azel_daisy_120_t4_4min_beamA	-5.2	570.9
20241120080320	MARS	2024/11/20 8:03	2024/11/20 8:03	2024/11/20 8:10	17.85	43.97	126.94	21.27	mars_azel_daisy_120_t4_4min_beamA	-3.6	570.6
20241120075049	MARS	2024/11/20 7:50	2024/11/20 7:50	2024/11/20 7:56	21.99	42.96	126.94	21.27	mars_azel_pswsc_t10_n5_beamAB	-3.6	570.7
20241120074237	MARS	2024/11/20 7:42	2024/11/20 7:42	2024/11/20 7:48	24.38	42.24	126.94	21.27	mars_azel_pswsc_t10_n5_beamAB	-3.9	570.7
20241120071931	MARS	2024/11/20 7:19	2024/11/20 7:19	2024/11/20 7:33	29.56	40.28	126.94	21.27	mars_azel_raster_240_d3_t4_beamA	-3.4	570.7
20241120071131	MARS	2024/11/20 7:11	2024/11/20 7:11	2024/11/20 7:14	33.07	38.61	126.93	21.27	mars_azel_raster_240_d3_t4_beamA	-4.2	570.8
20241117085331	MARS	2024/11/17 8:53	2024/11/17 8:53	2024/11/17 8:59	4.87	45.70	126.25	21.31	mars_azel_pswsc_t10_n5_beamAB	-1.9	570.4

(b)

Observation

OBSID	Src Name	Obs Datetime	Temperature Outside	Pressure Outside
20241121073541	MARS	2024/11/21 7:35	-0.925	572.09

Start Time	2024/11/21 7:35	**End Time**	2024/11/21 7:41	**Season**	2.1
Az	25.512	**Az Min**	24.546	**Az Max**	26.284
El	41.871	**El Min**	39.361	**El Max**	44.364
Ra	127.151	**Ra Min**	127.151	**Ra Max**	127.152
Dec	21.265	**Dec Min**	21.265	**Dec Max**	21.265

Project	**Group**
proj0	a23007
Obs User	**Obs File**
csv	mars_azel_pswsc_t10_n5_beamAB
Rx Name	**Scan Categ**
DESHIMA	

300 K chopper

- Action: R (300K BB), sky (through), 10Hz(rotation)
  - Local sweep (before each observation): R
  - Calibration: sky or 10Hz
  - Science: 10Hz