Polarization and Absorption Maps of ETM Spare Test-Masses

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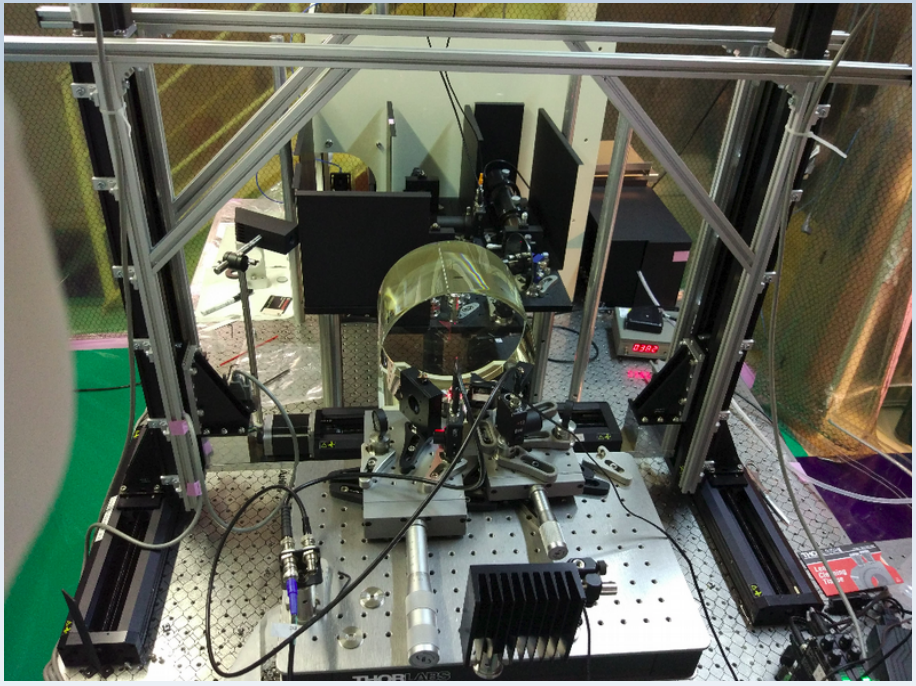
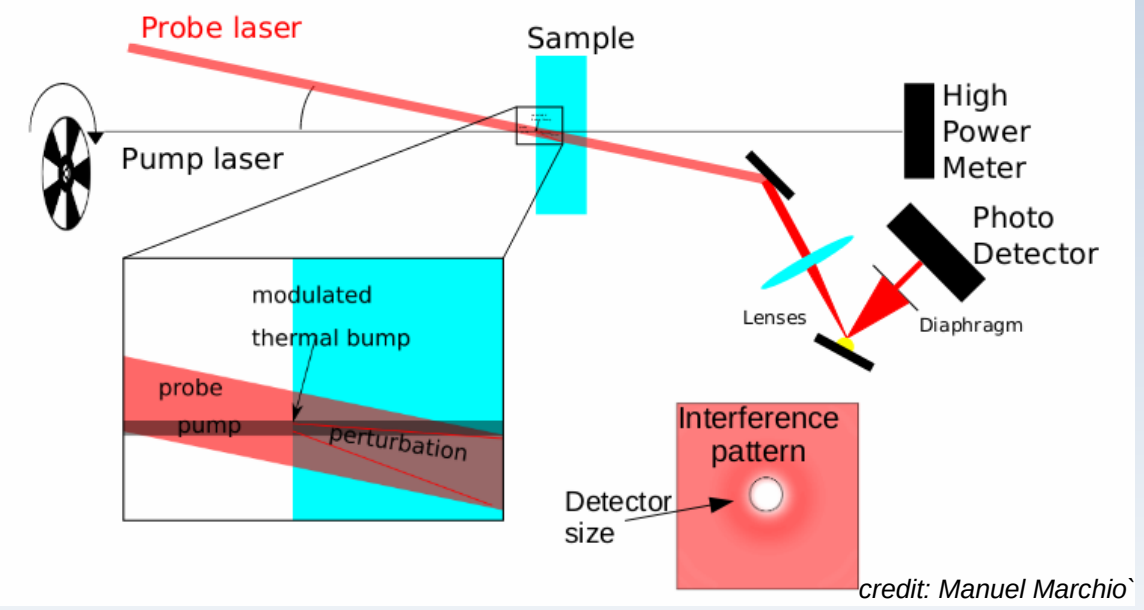
NAOJ

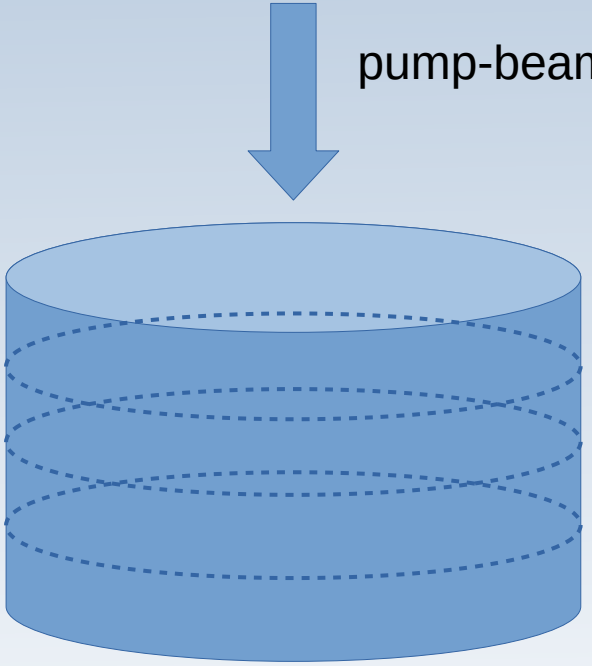
Photothermal Common-Path Interferometer @ TAMA300 (NAOJ)





pump → 1064 nm
probe → 630 nm

Absorption of ETMX Spare Test-Mass

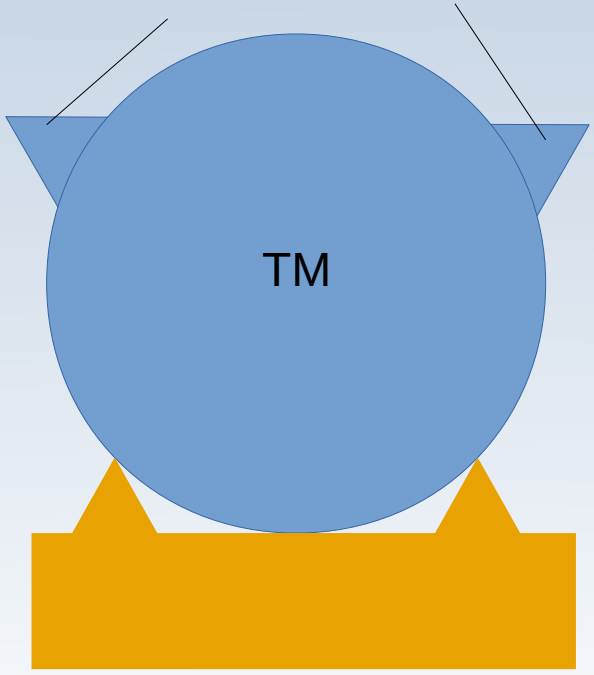


map 1 (center - D)

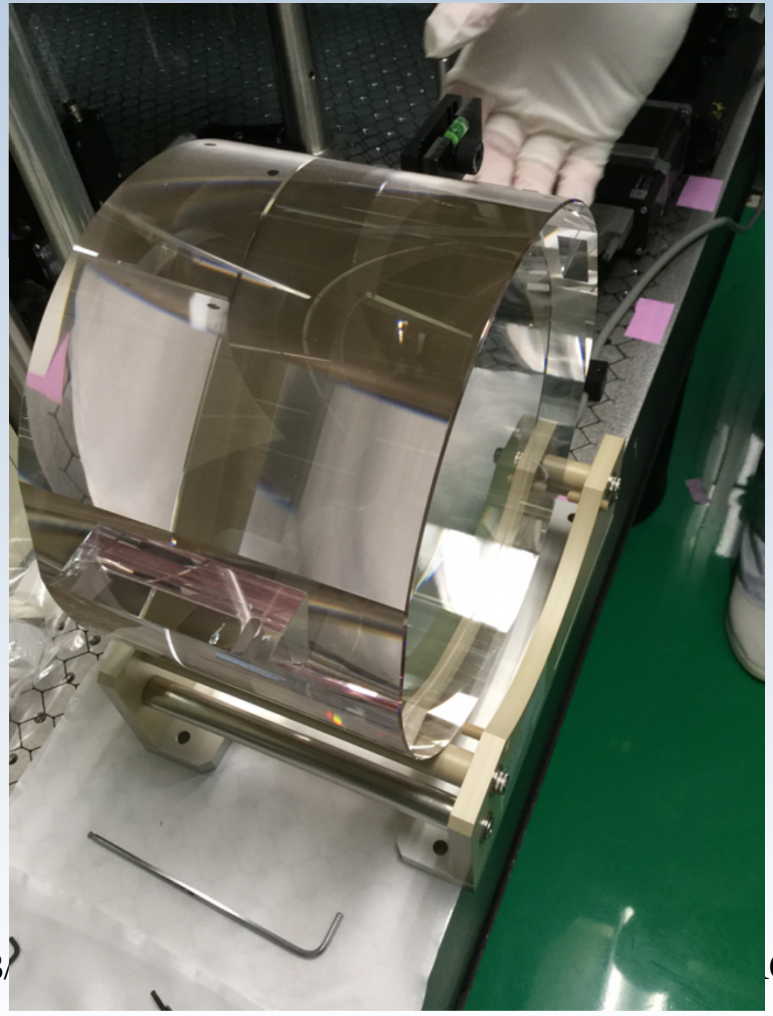
map 2 (center)

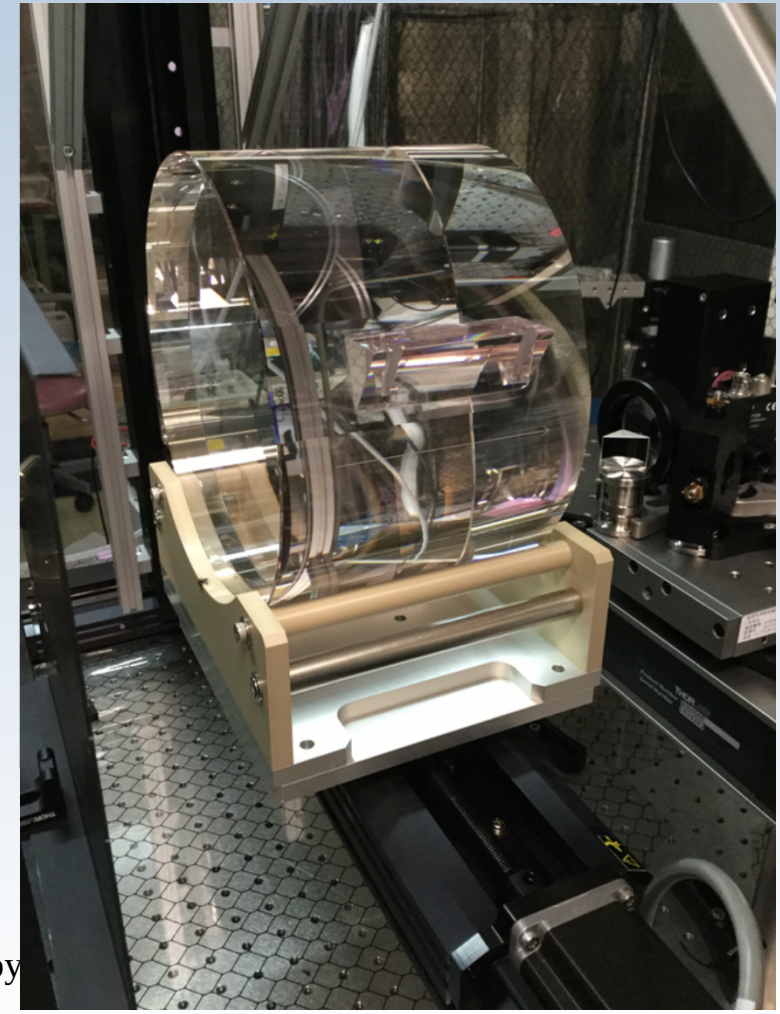
map 3 (center + D)

Ears upside down due to mechanical reasons

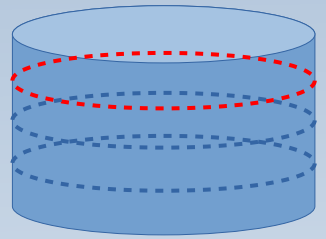


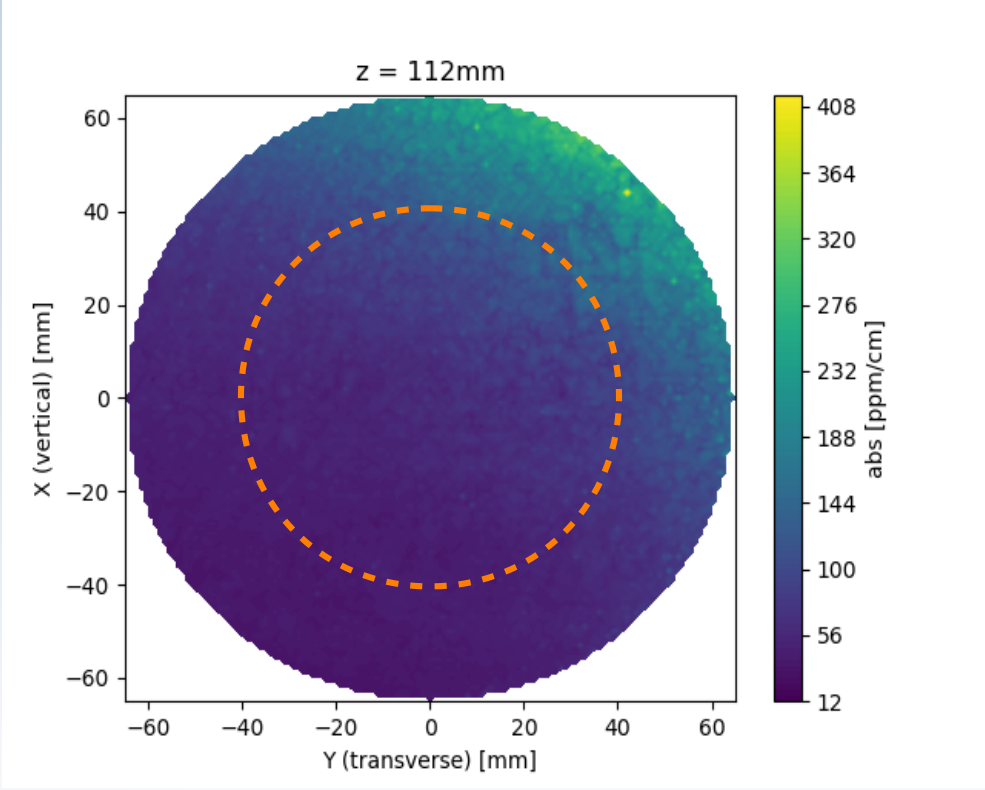
Absorption of ETMX Spare Test-Mass

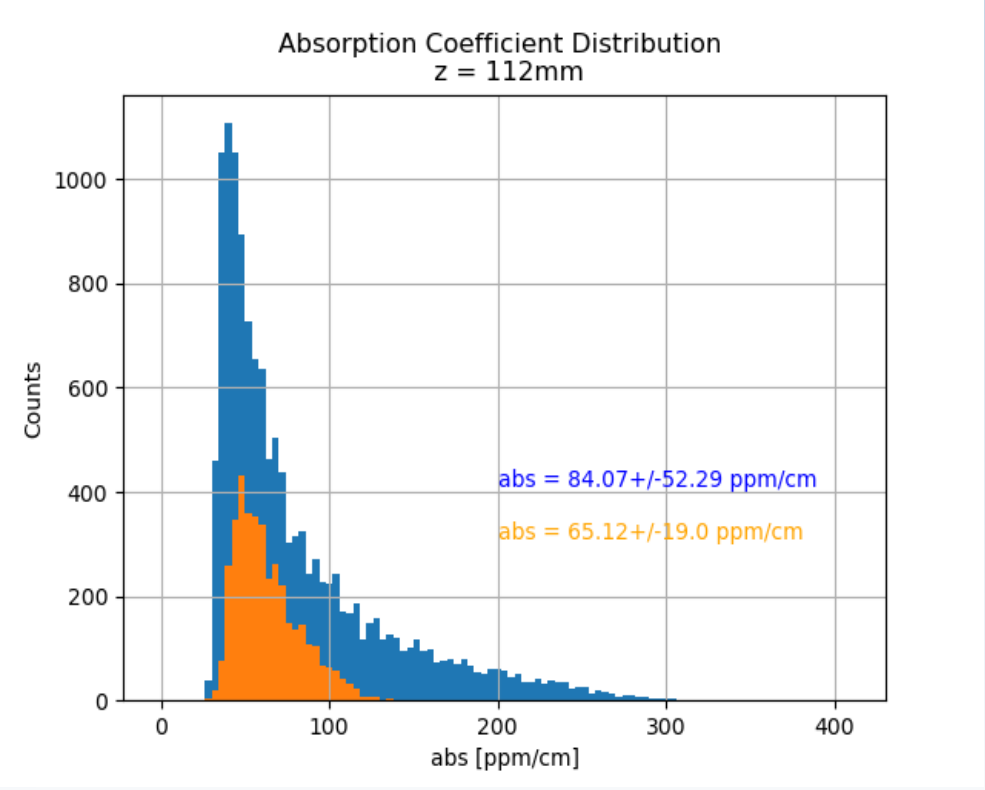




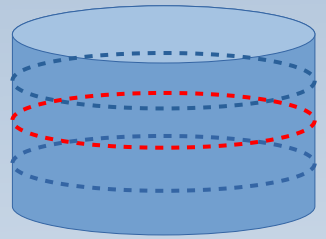
Absorption of ETMX Spare Test-Mass

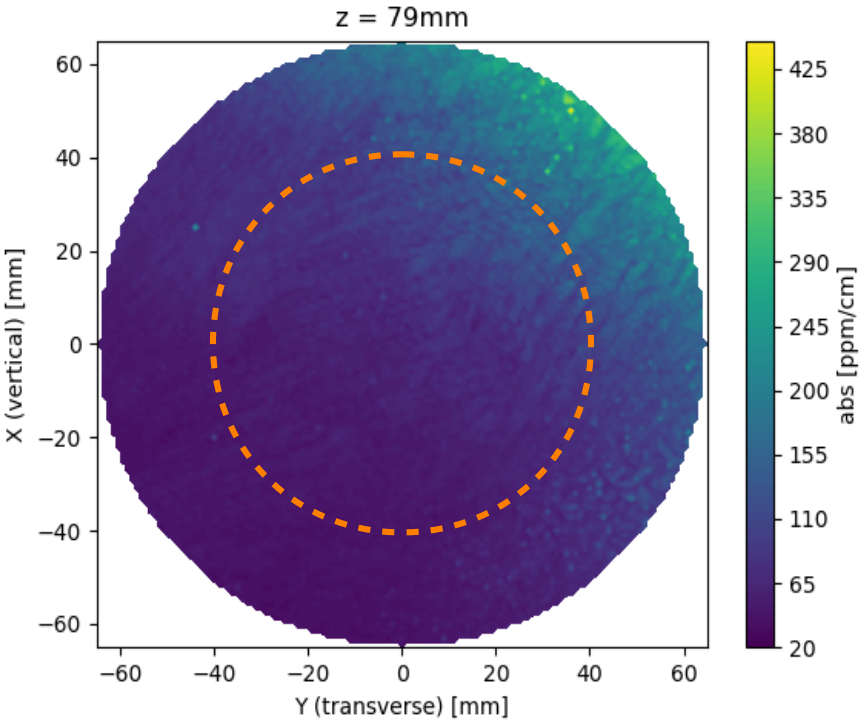


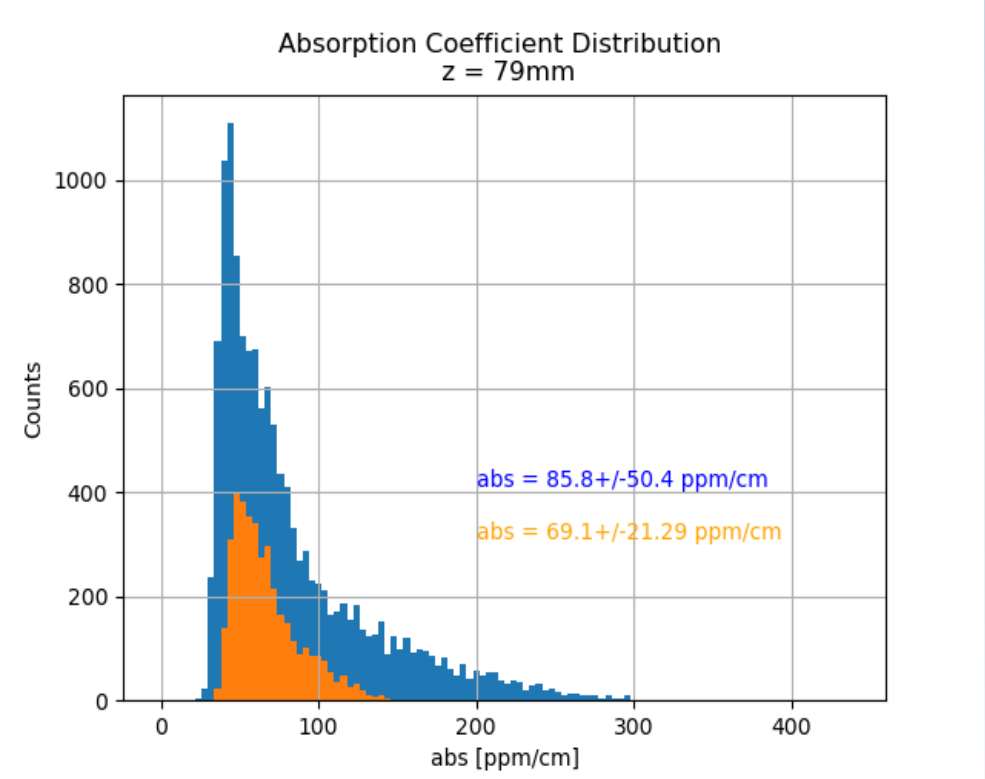




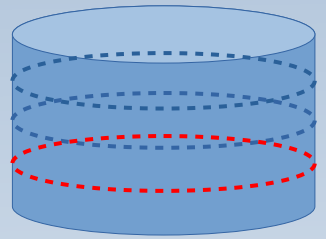
Absorption of ETMX Spare Test-Mass

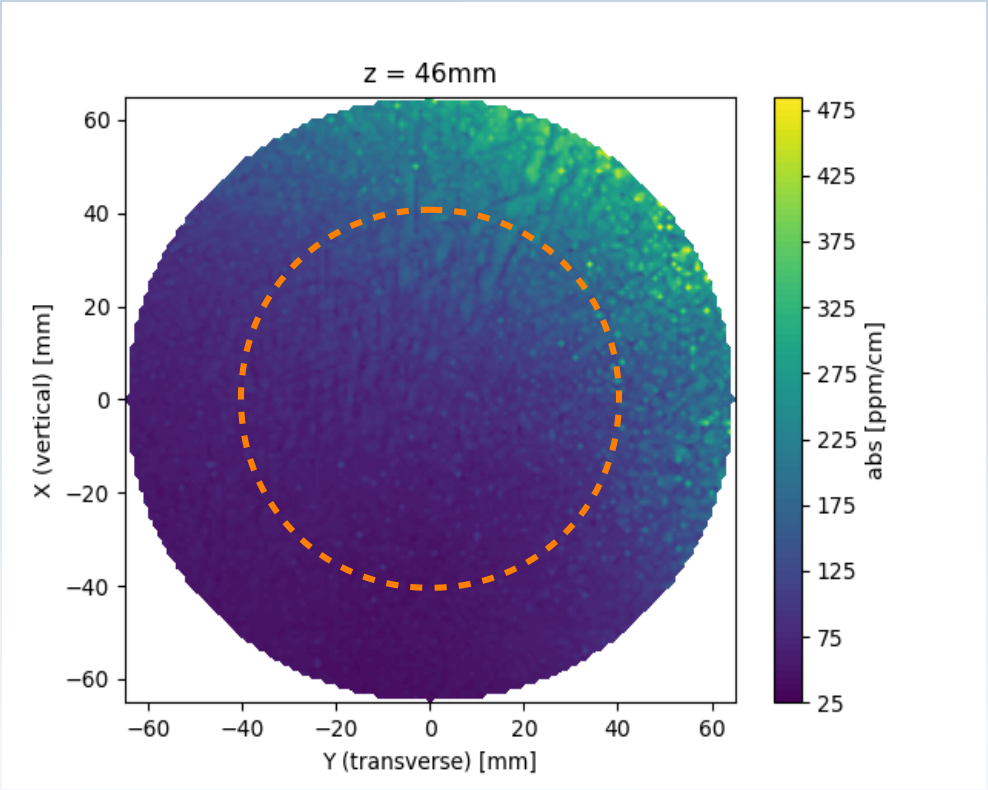


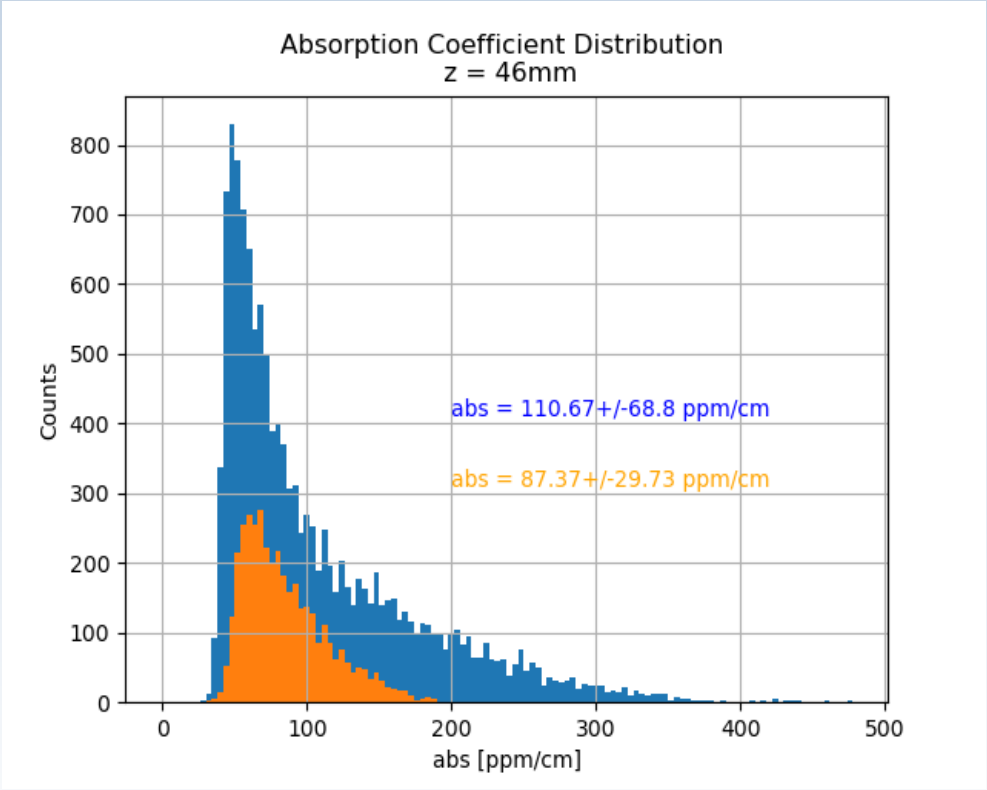




Absorption of ETMX Spare Test-Mass







Absorption of ETMX Spare Test-Mass

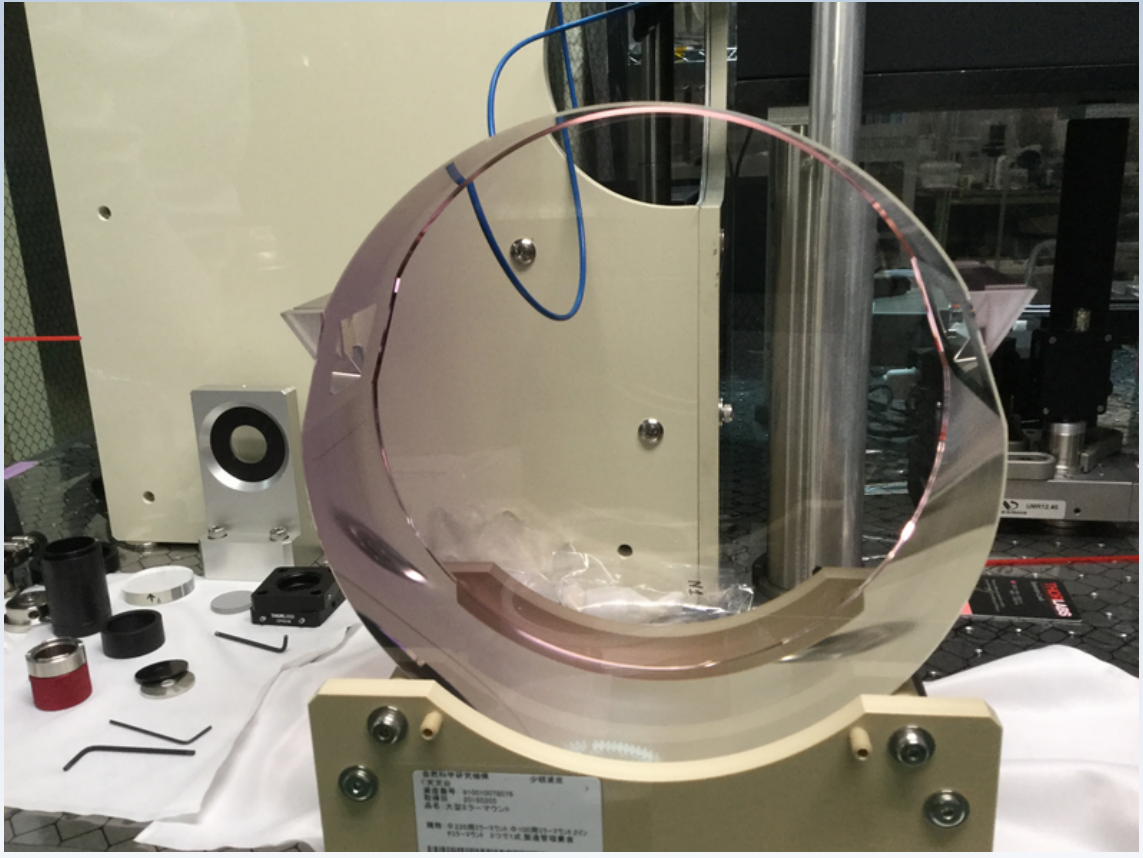
our results:	111 ± 69	84 ± 52	86 ± 50	[ppm/cm]

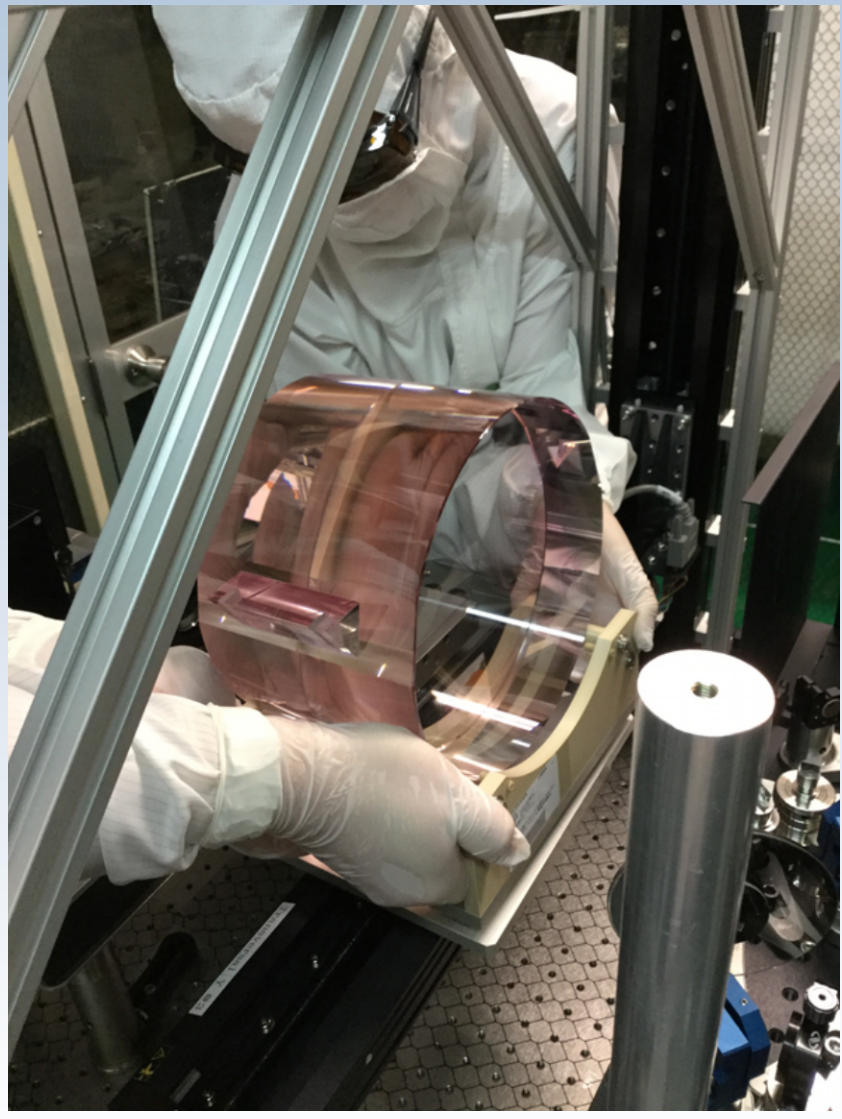
Company A	S1	S2	S3
#1(F62-22)	41.1 (23.1)	64.3 (23.3)	59.9 (19.8)
#2 (F47-21)	72.1 (31.1)	87.3 (38.2)	93.4 (36.5)
#3 (AC-179)	60.6 (76.0)	37.7 (17.3)	47.7 (34.1)
#4 (F39-56)	94.0 (139.6)	305.3 (250.0)	160.2 (171.4)
#5 (MMK-1)	106.98 (45.68)	69.02 (22.91)	76.0 (31.0)
#6 (MMK-2)	216.47 (108.01)	82.82 (30.90)	99.4 (49.5)
#7 (C14-11c)	114.2 (95.5)	79.3 (49.9)	72.4 (42.7)
#8 (OC-1)	86.6 (45.7)	69.5 (35.5)	58.0 (25.2)

ETMs

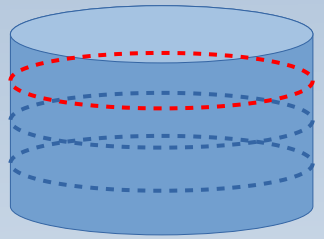
bubbles inside

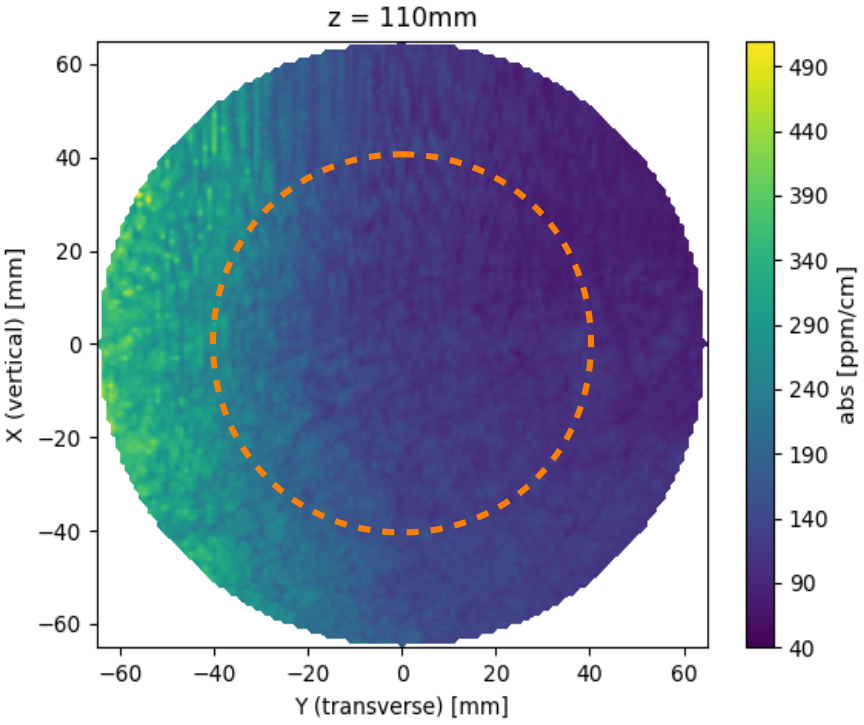
Absorption of ETMY Spare Test-Mass

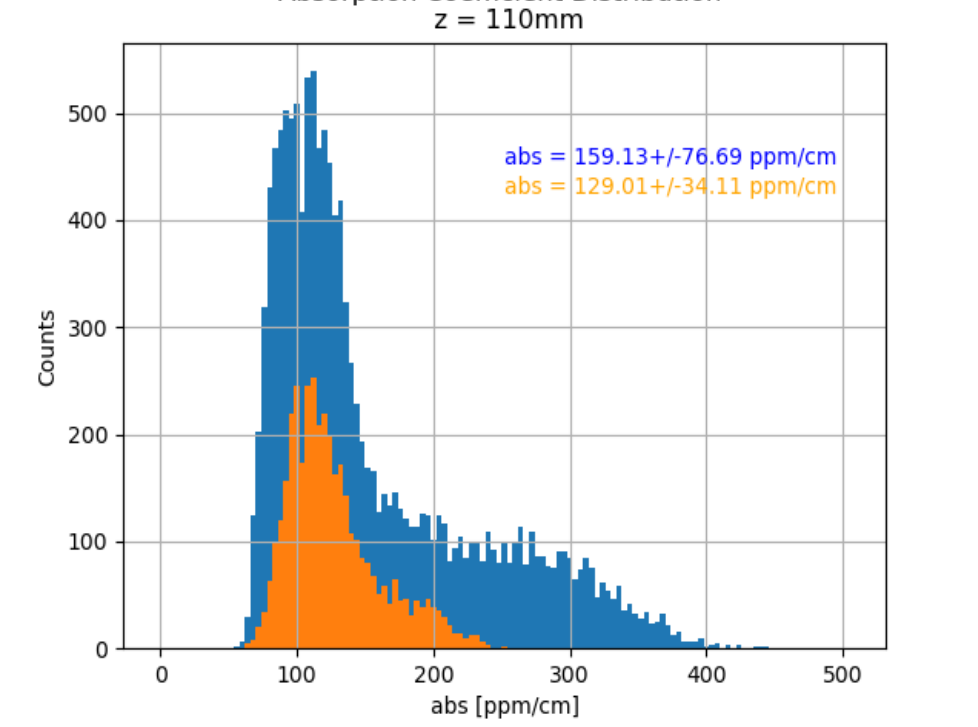




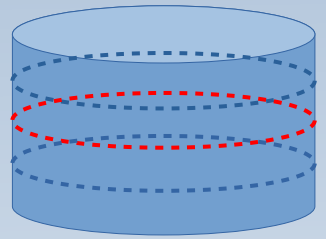
Absorption of ETMY Spare Test-Mass

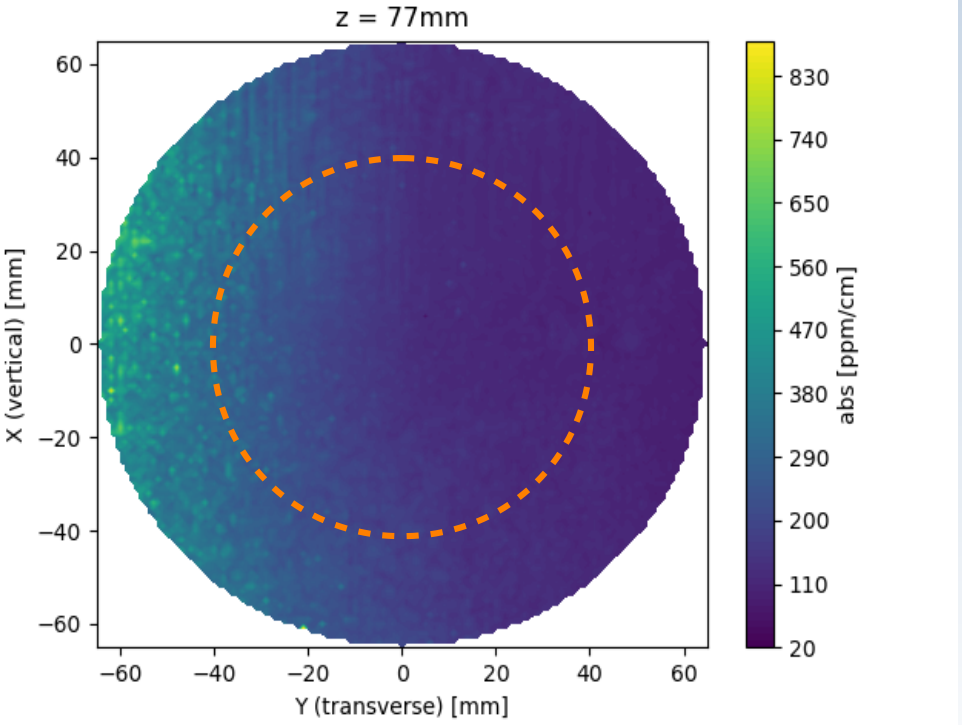


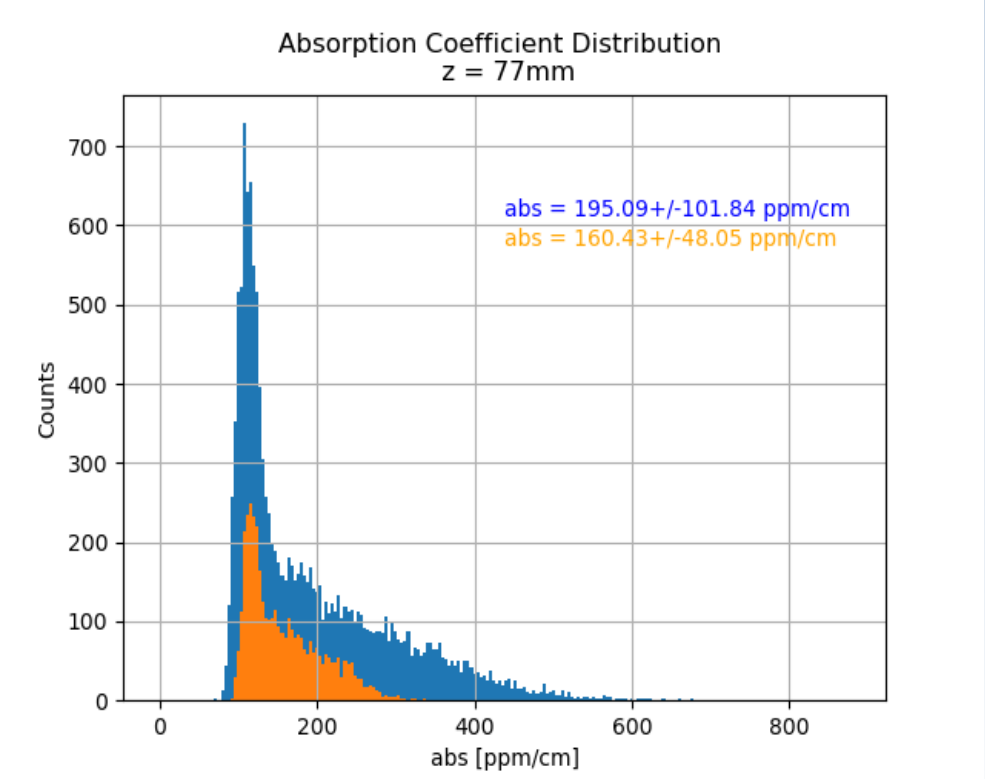




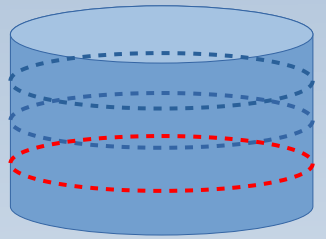
Absorption of ETMX Spare Test-Mass

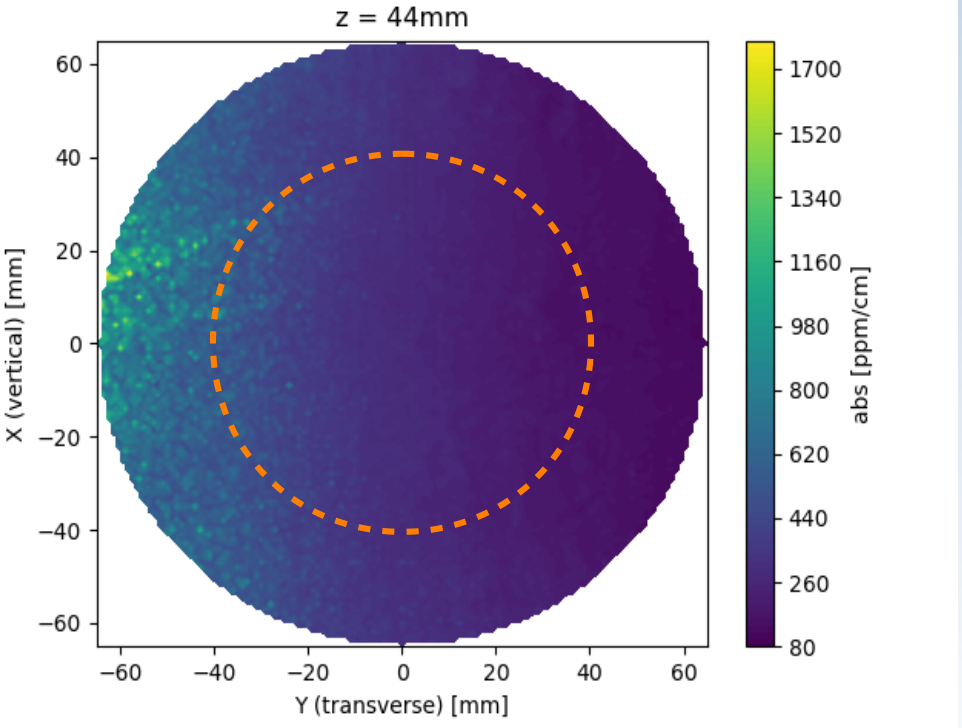


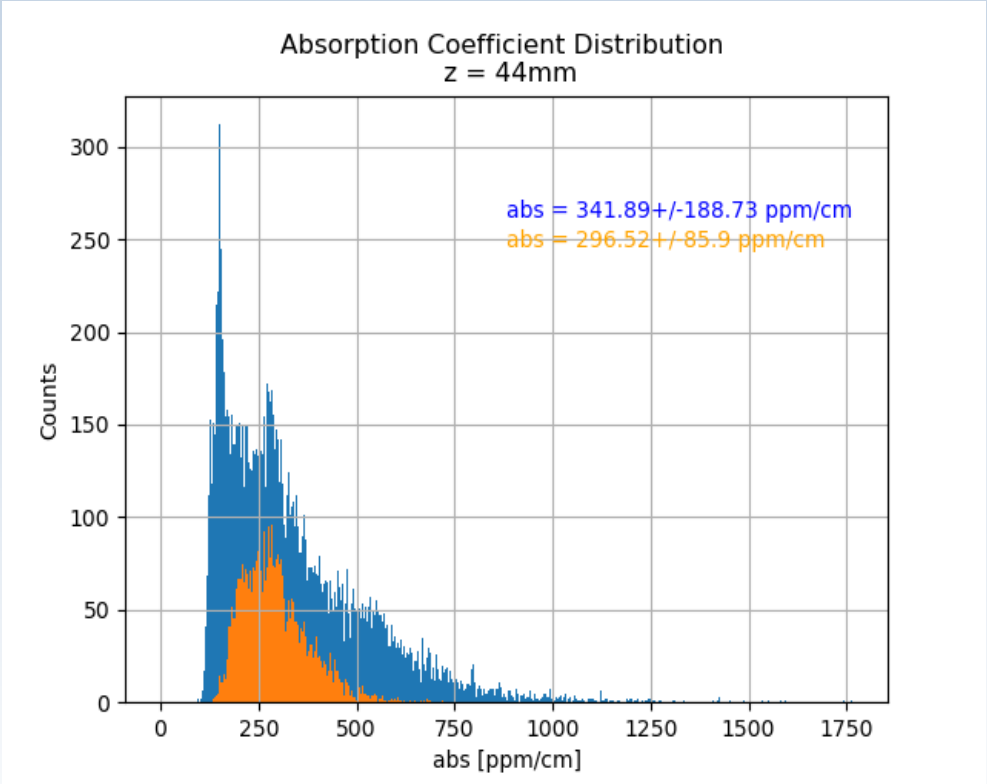




Absorption of ETMX Spare Test-Mass







Absorption of ETMY Spare Test-Mass

our results:	342 ± 189	159 ± 77	195 ± 102	[ppm/cm]

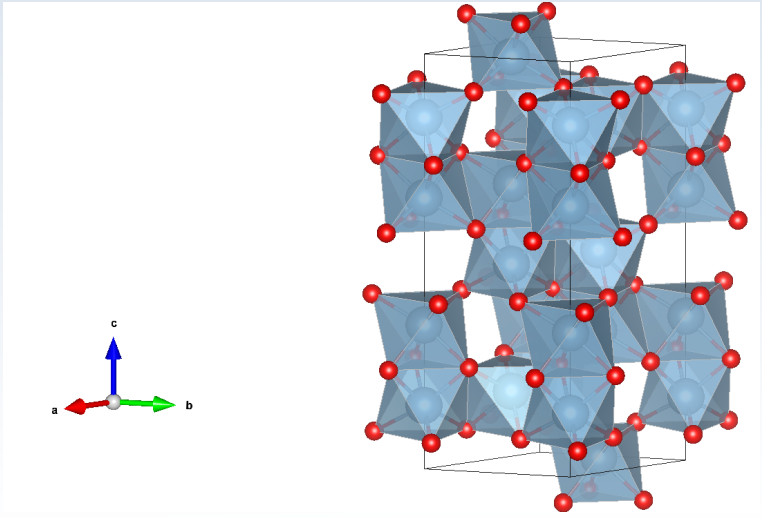
Company A	S1	S2	S3	
#1(F62-22)	41.1 (23.1)	64.3 (23.3)	59.9 (19.8)	ETMs
#2 (F47-21)	72.1 (31.1)	87.3 (38.2)	93.4 (36.5)	
#3 (AC-179)	60.6 (76.0)	37.7 (17.3)	47.7 (34.1)	bubbles inside
#4 (F39-56)	94.0 (139.6)	305.3 (250.0)	160.2 (171.4)	
#5 (MMK-1)	106.98 (45.68)	69.02 (22.91)	76.0 (31.0)	
#6 (MMK-2)	216.47 (108.01)	82.82 (30.90)	99.4 (49.5)	?
#7 (C14-11c)	114.2 (95.5)	79.3 (49.9)	72.4 (42.7)	→ spare ETMX
#8 (OC-1)	86.6 (45.7)	69.5 (35.5)	58.0 (25.2)	

The Problem of Birefringence and Inhomogeneity

Sapphire is a non-cubic crystal
(Trigonal – Hexagonal) → Birefringence

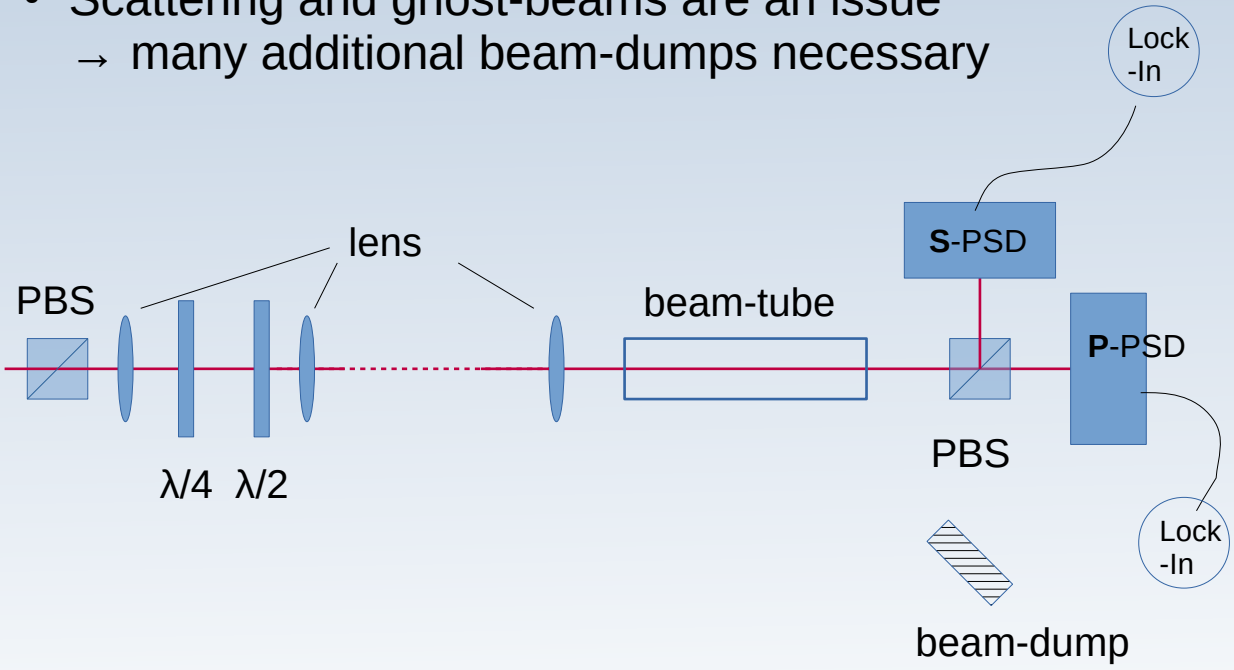
- n_o = 1.768 (perp. c-axis)
- n_e = 1.76 (parallel c-axis)

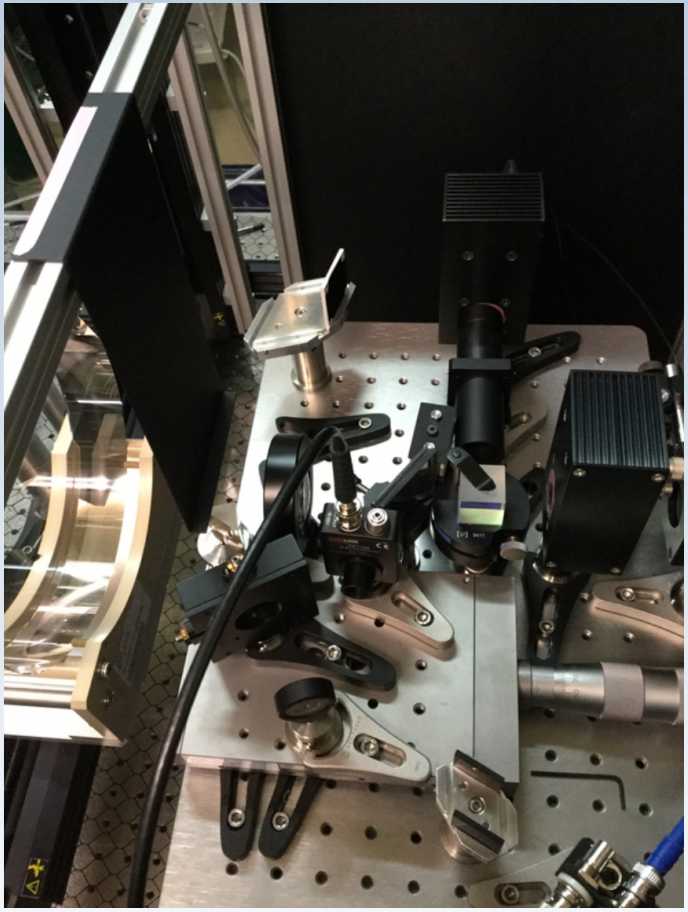
Inhomogeneities in crystal lattice (lattice-distortions) can lead to birefringence effects



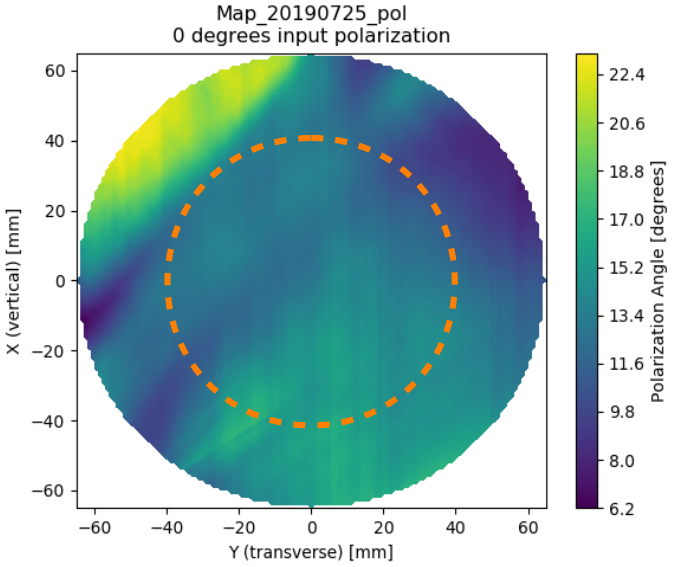
Reconfiguration to Measure Polarization

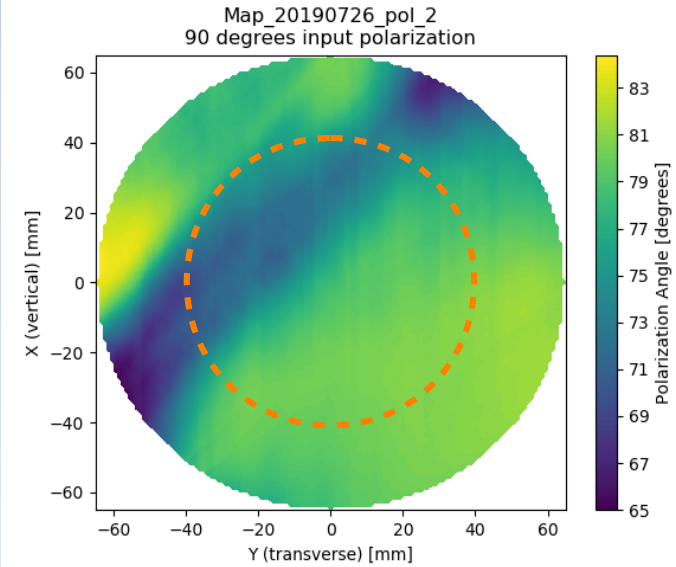
- Using PCI pump-beam to map the polarization
- Splitting the transmitted beam in S and P
- Scattering and ghost-beams are an issue
  → many additional beam-dumps necessary





Polarization Map of ETMX Spare Test-Mass





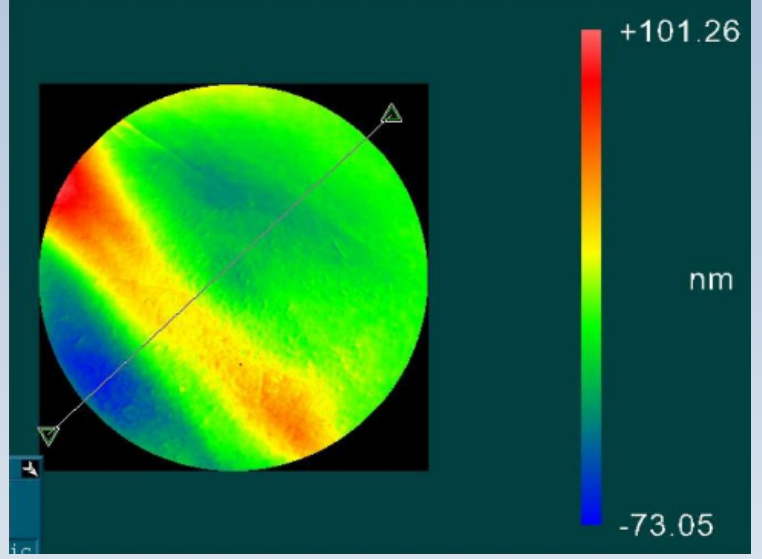
- pol.-angle:

$$\theta = \arctan\left(\sqrt{\frac{S_{PSD}}{P_{PSD}}}\right)$$

- 0° → P-polarization (E-field parallel to optical table)
- 90° → S-polarization (E-field perpendicular to optical table)

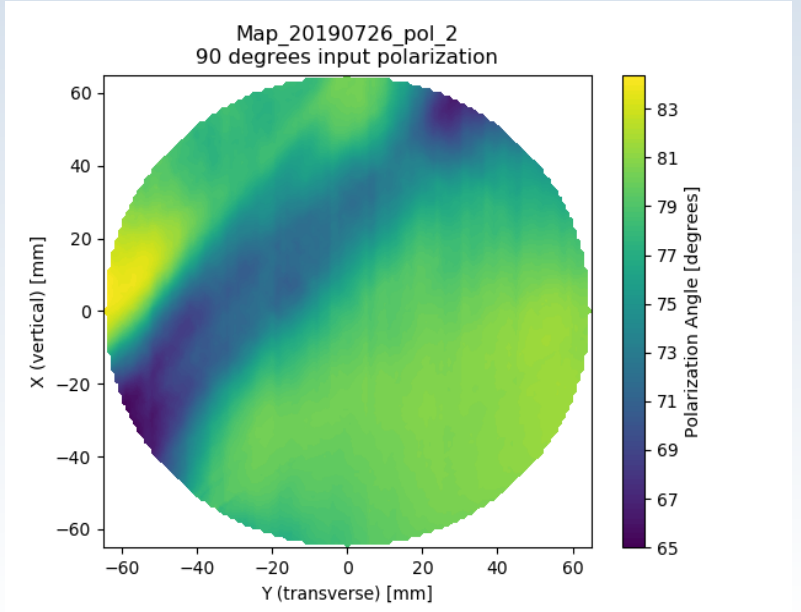
Comparison with TWE Maps

- TWE from **JGW-T1909948-v1** → RMS @140mm = 25.9 nm

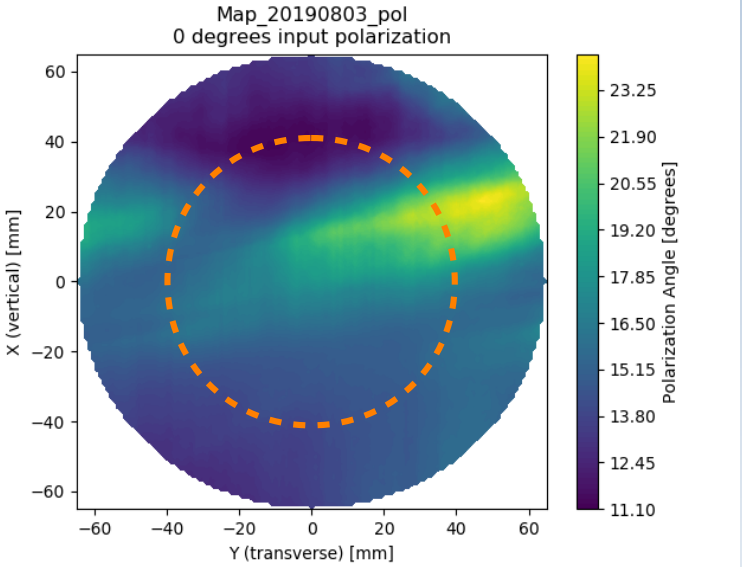


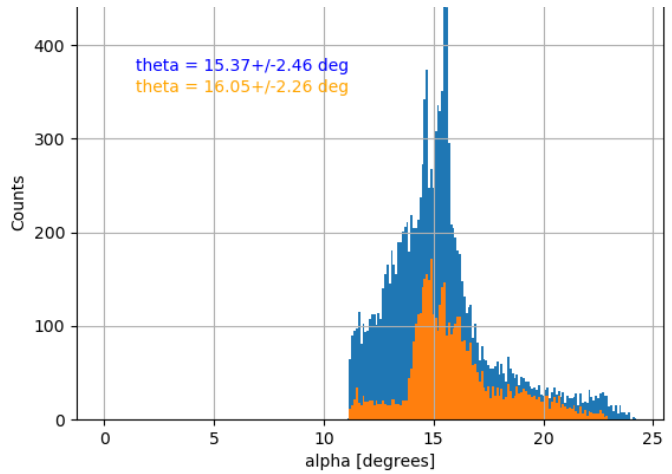
- S-polarized input beam
  φ-STD ~ 6.38° → 18.8 nm

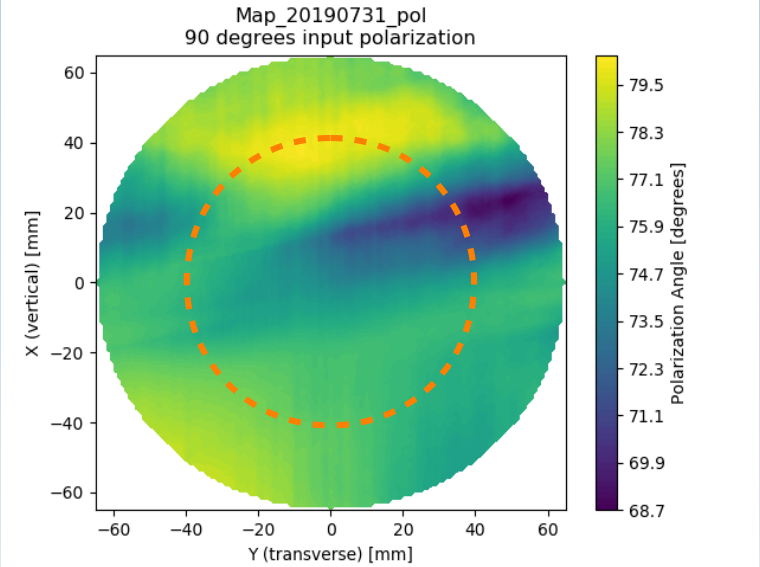
$$\Delta l_b = \frac{\phi \cdot \lambda}{2\pi} = \Delta n \cdot L$$

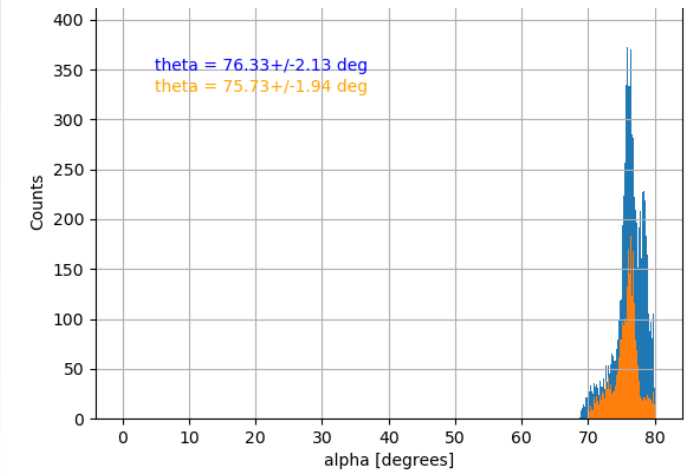


Polarization Map of ETMY Spare Test-Mass





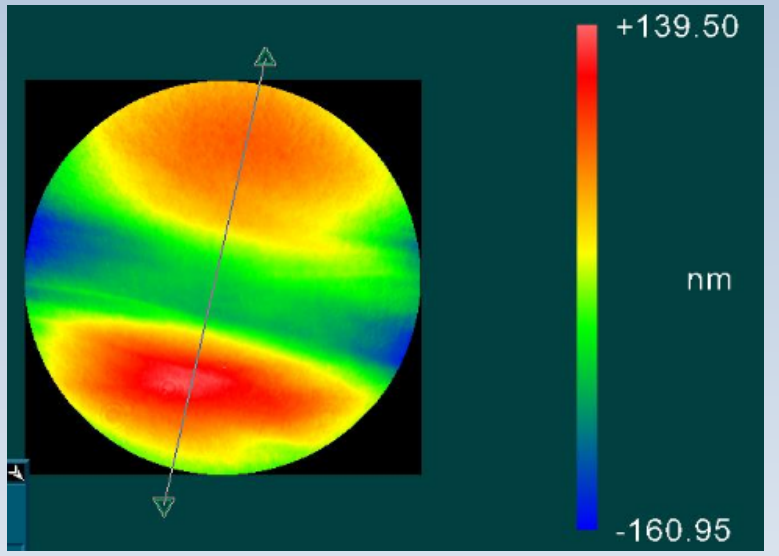




- 0° → P-polarization (E-field parallel to optical table)
- 90° → S-polarization (E-field perpendicular to optical table)

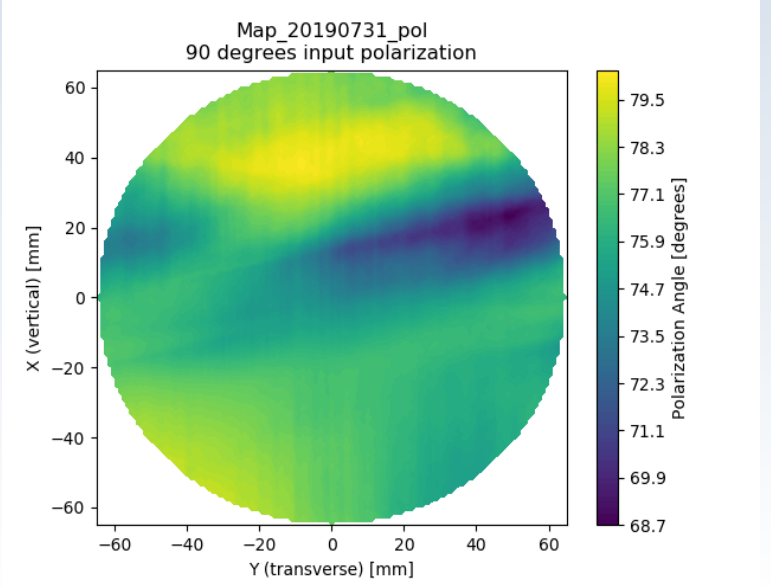
Comparison with TWE Maps

- TWE from **JGW-T1909948-v1** → RMS @140mm = 59.3 nm



- S-polarized input beam
  φ-STD ~ 4.26° → 12.6 nm

$$\Delta l_b = \frac{\phi \cdot \lambda}{2\pi} = \Delta n \cdot L$$



Summary and Outlook

- Characterized ETM spare TMs in terms of absorption and polarization-homogeneity
- Can reset the PCI absorption-bench at TAMA300 for polarization characterization with minimum efforts!
- Identified ETMX spare TM in the documents
  → **absorption acceptable; homogeneity comparable to ITM**
- Maybe identified ETMY spare TM
  → **absorption too high(?); homogeneity comparable to ITM**
  → Will re-calibrate the PCI system to be sure about the absorption
- Next steps:
  - Characterizing two substrates from Shinkosha
  - Using colored Sapphire-samples to improve calibration of PCI system in the future
  - Doing annealing experiments with Sapphire (?)

Thank you for your attention!