X-Ray Imaging and Spectroscopy Mission

# Current development status and calibration plan of the X-ray CCDs onboard XRISM

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**on behalf of the XRISM/Xtend team**

The 14th IACHEC meeting @ the Shonan Village Center on 2019/05/20

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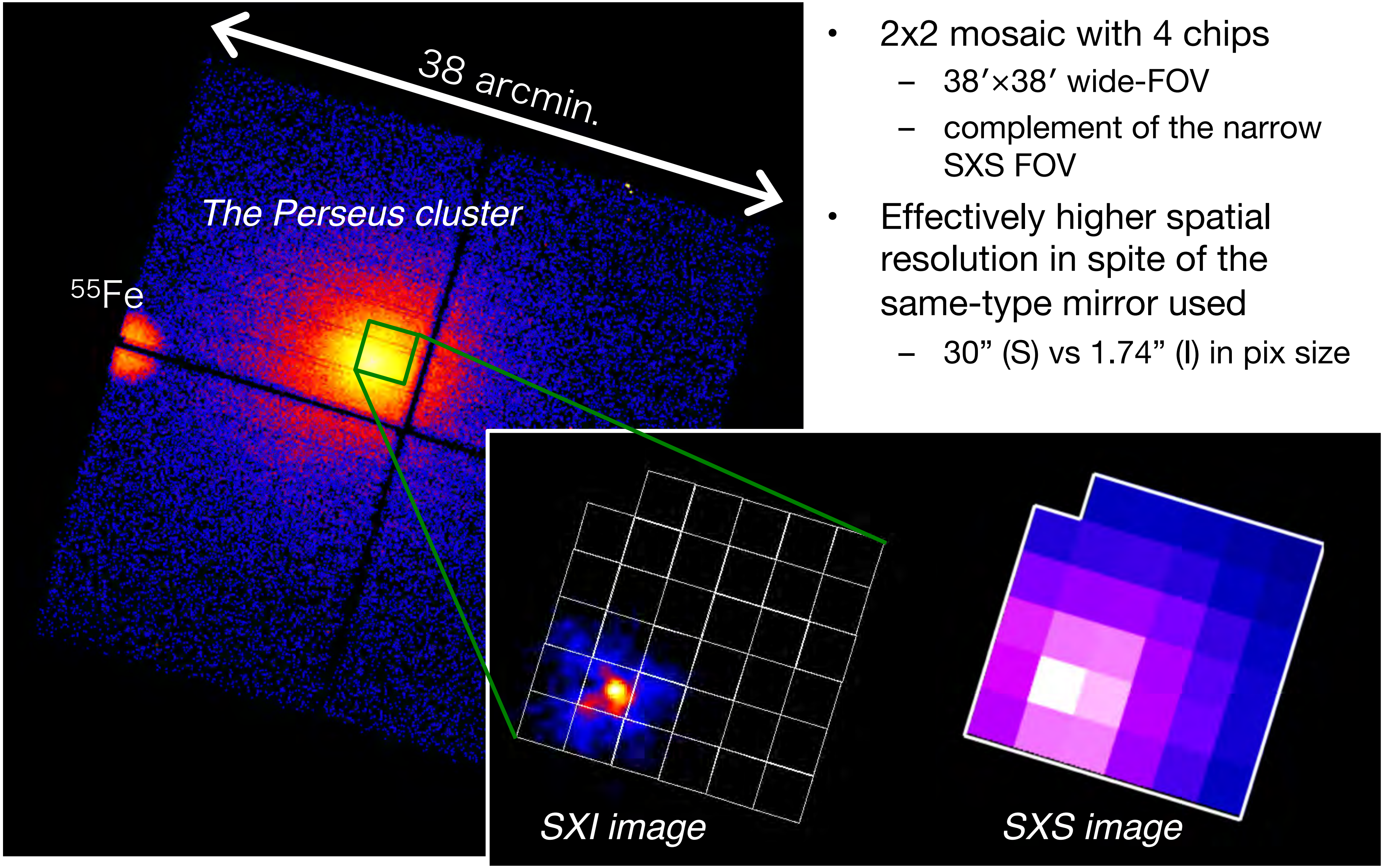
**and the XRISM Xtend Team**

**Xtend = X-ray Mirror Assembly (XMA) + Soft X-ray Imager (SXI)**

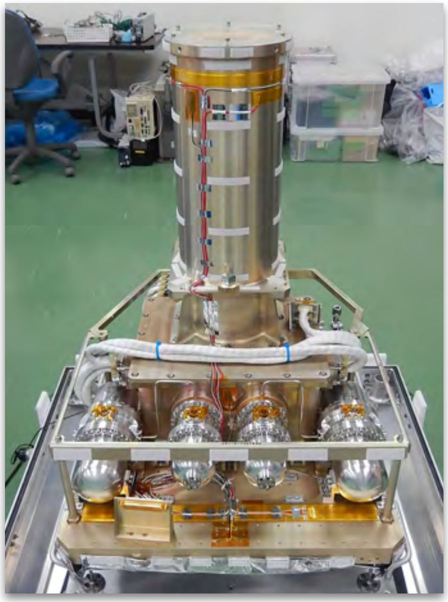
**1:Osaka Univ., 2:ISAS/JAXA, 3: Univ. of Miyazaki, 4: Kanto Gakuin Univ., 5:Kyoto Univ., 6: Tohoku Gakuin Univ., 7: NASA/GSFC, 8: Tokyo Univ. of Science, 9: Shizuoka Univ., 10: Nagoya Univ., 11: Nara Univ. of Education, 12: Nara Women's Univ. , 13: Kwansei Gakuin Univ.,**

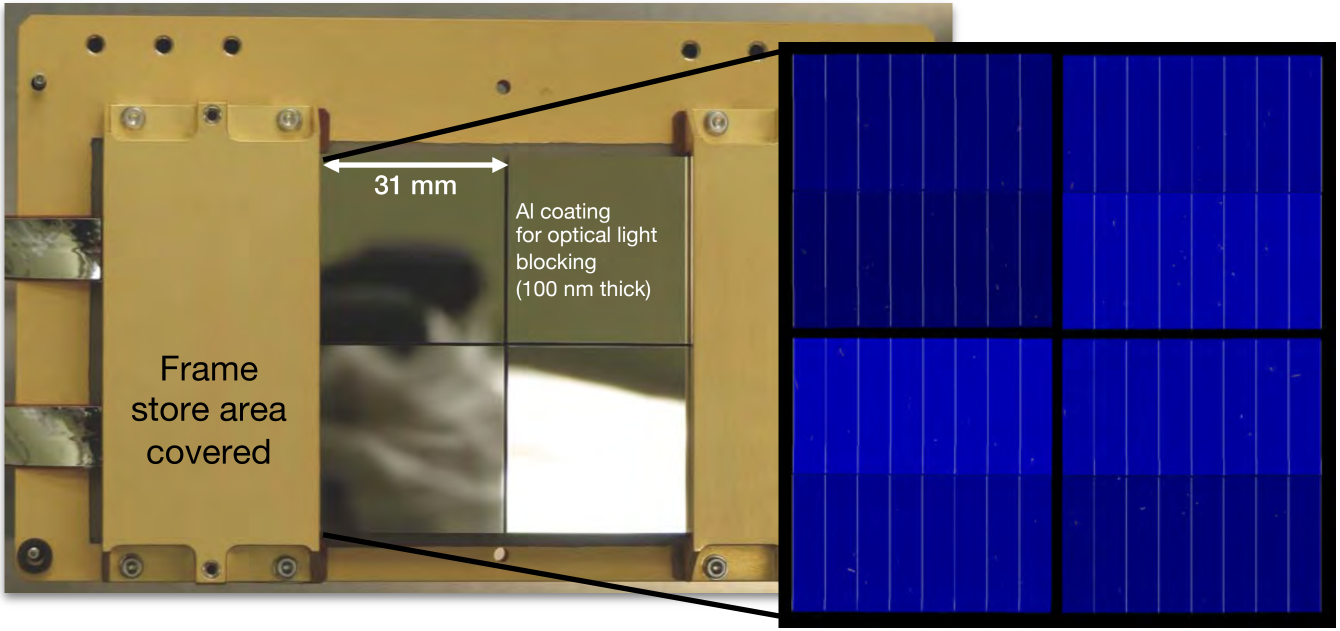
# Role in XRISM




- 2x2 mosaic with 4 chips
  - 38′×38′ wide-FOV
  - complement of the narrow SXS FOV
- Effectively higher spatial resolution in spite of the same-type mirror used
  - 30” (S) vs 1.74” (I) in pix size

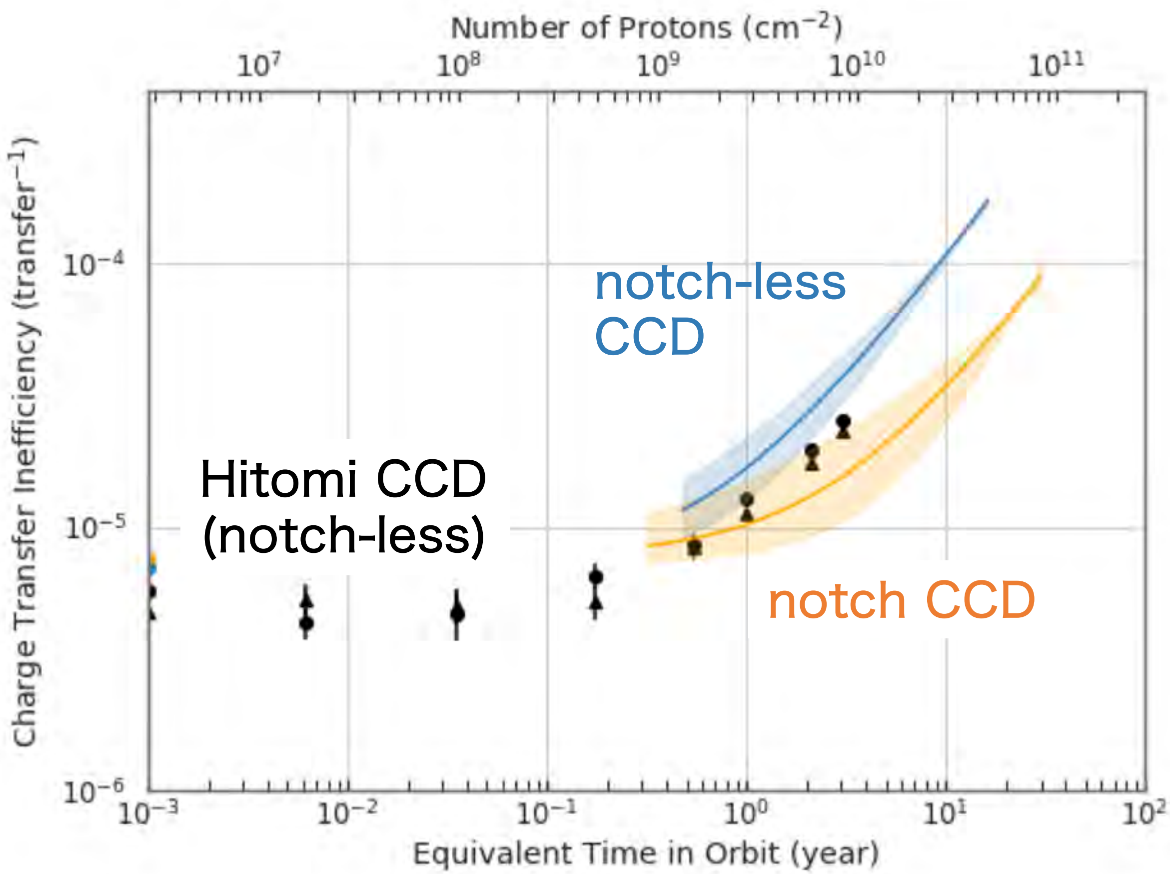
# from A-H/SXI to XRISM/SXI





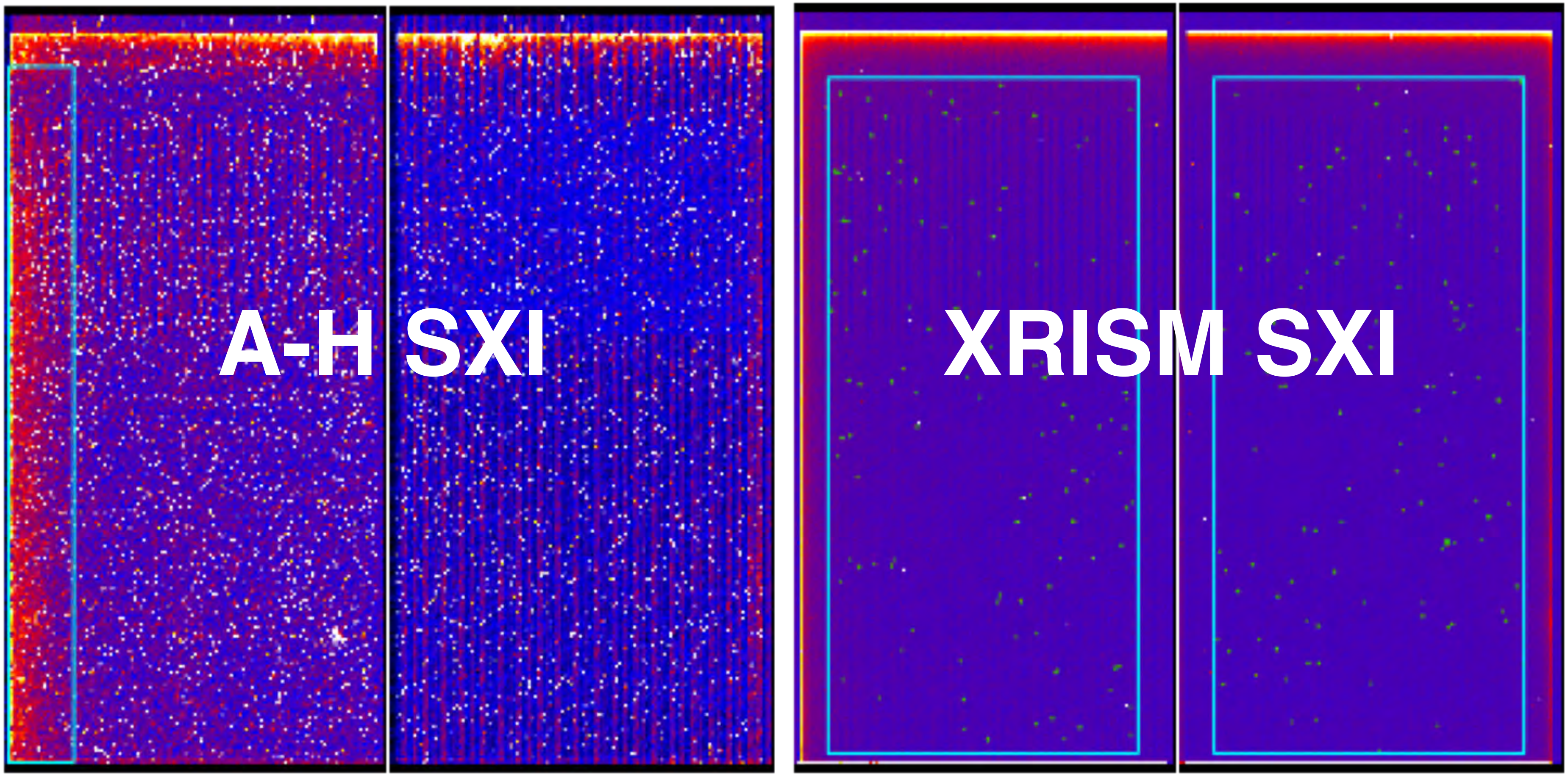

- Basically the same characteristics as the one used in the previous ASTRO-H satellite (Hitomi)
  - 2x2 mosaic with 4 P-ch BI CCD with a 200 μm thickness
- Two improvements
  - a notch structure of potential for signal charges by increasing the implant concentration in the channel
  - optical blocking power

# Improvement in radiation tolerance



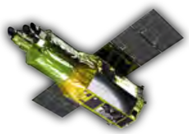

- We performed proton radiation experiments on our new CCDs, and confirmed that introduction of a notch structure improves radiation tolerance

# Improvement in optical blocking power

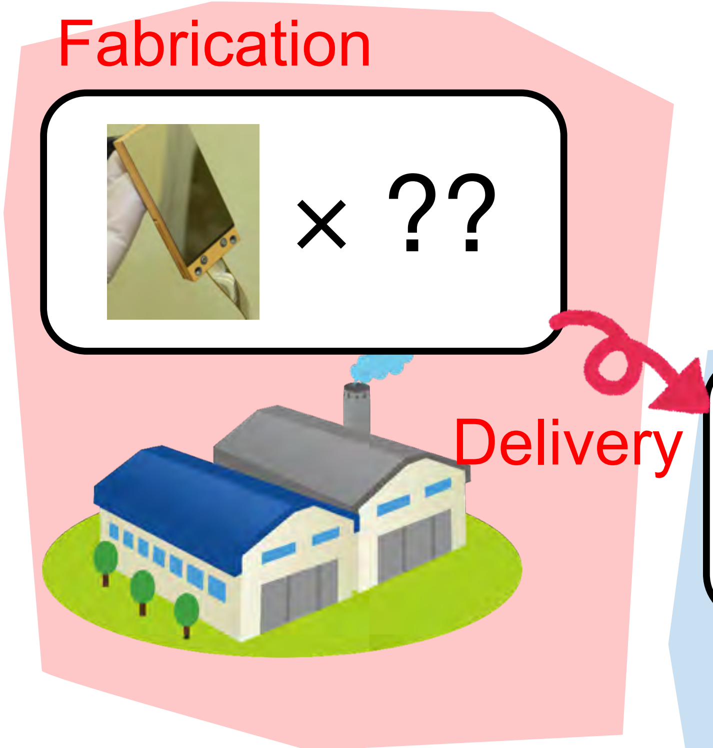


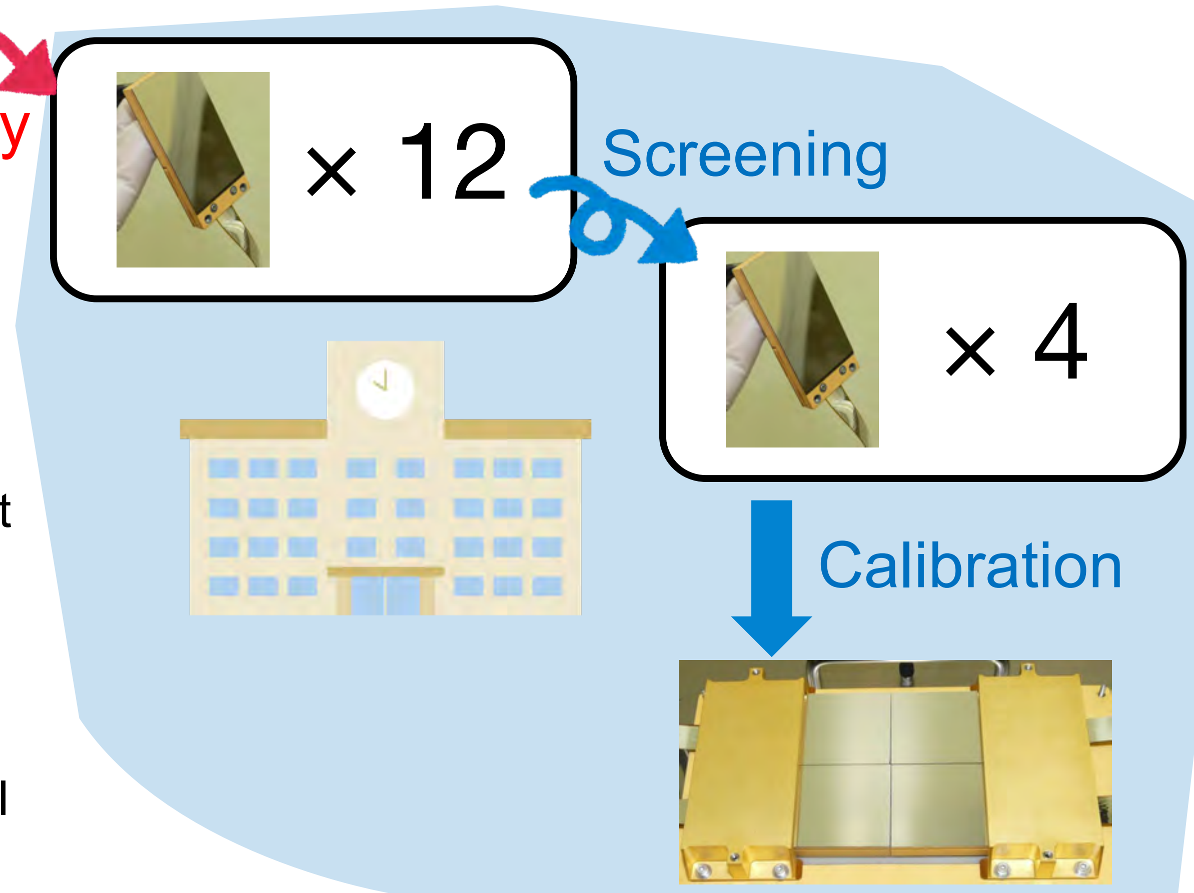

- Doubling optical blocking layer significantly reduces the number of pinholes (6%→0.1%)
- Light leak from the side edge is also reduced

# CCD screening strategy



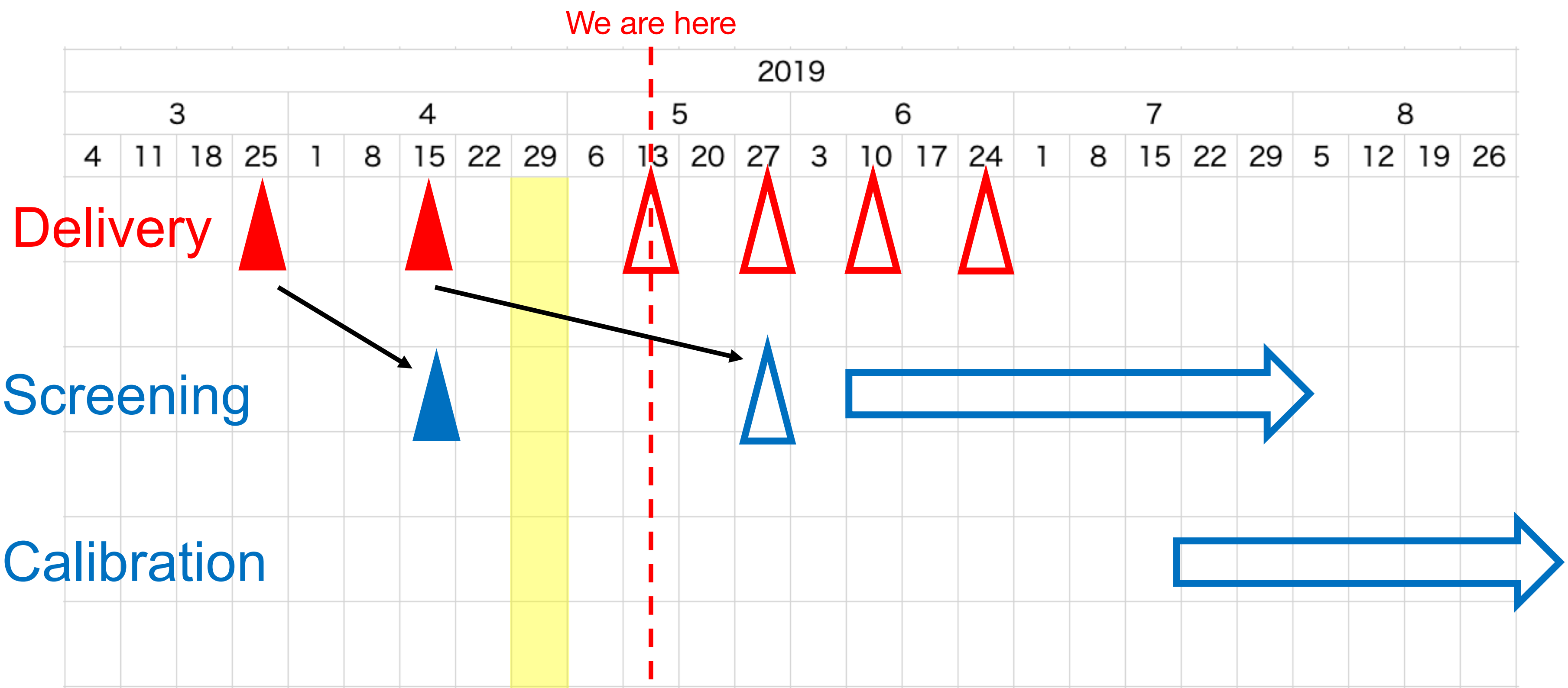
- Several X-ray lines are available in our lab system
- 4 flight CCDs will be selected through screening experiments
- A ground calibration data will be taken from the 4 selected flight CCDs



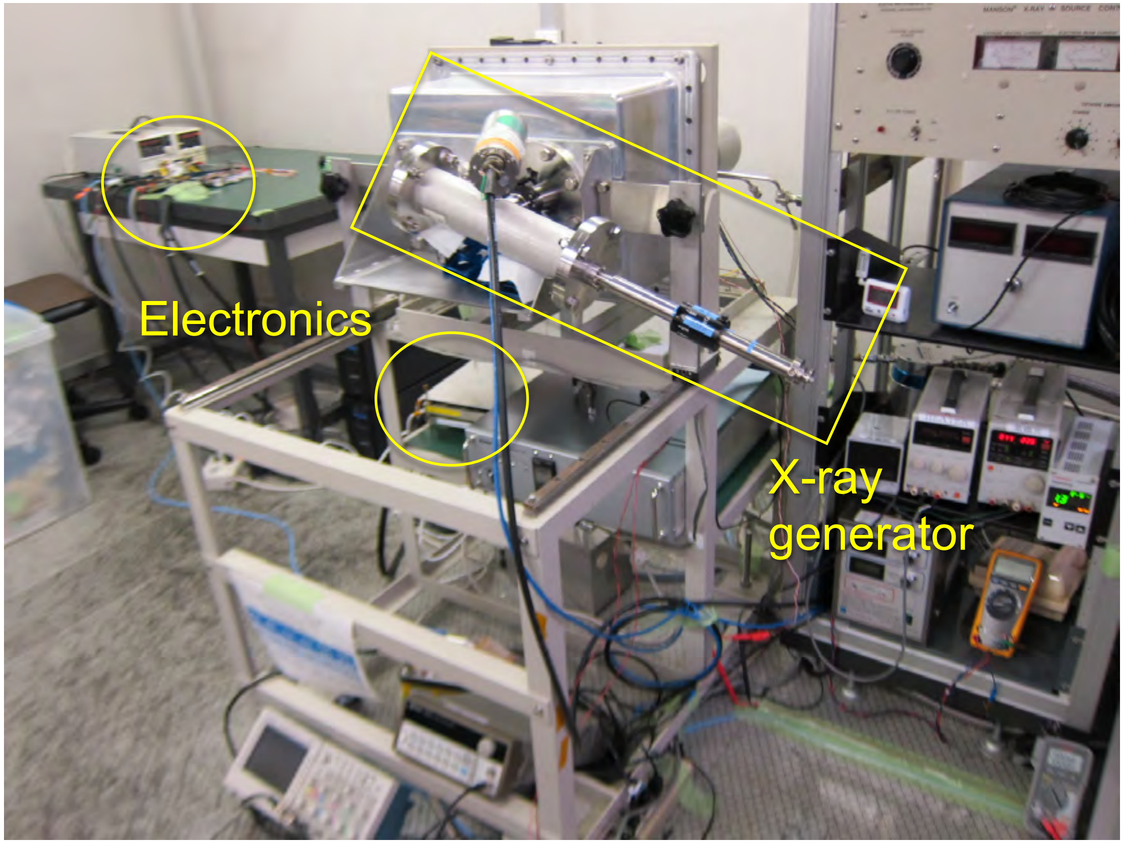

- Hamamatsu fabricates a lot of CCDs
- X-ray responses with $^{55}$Fe can be measured
- 12 CCDs which satisfy the specification we agreed will be delivered to us

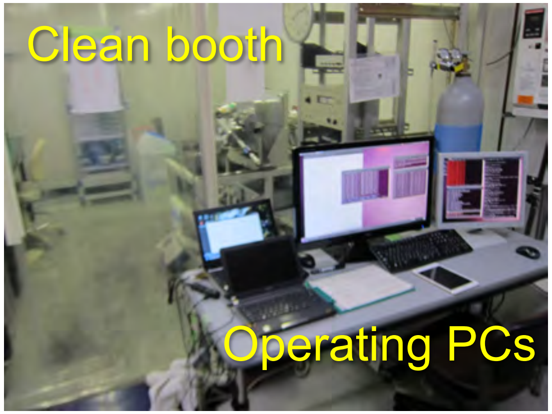
# Schedule

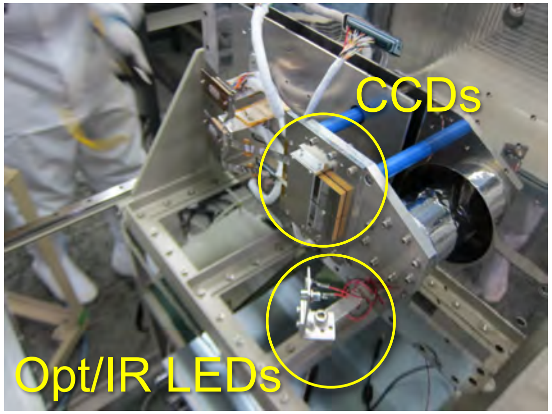



- Two CCDs are delivered to us almost every two weeks
- Two deliveries were made so that we have four CCDs in our lab
- We performed the first screening experiment on April 18th
- The two CCD first delivered were examined

# Whole Screening System

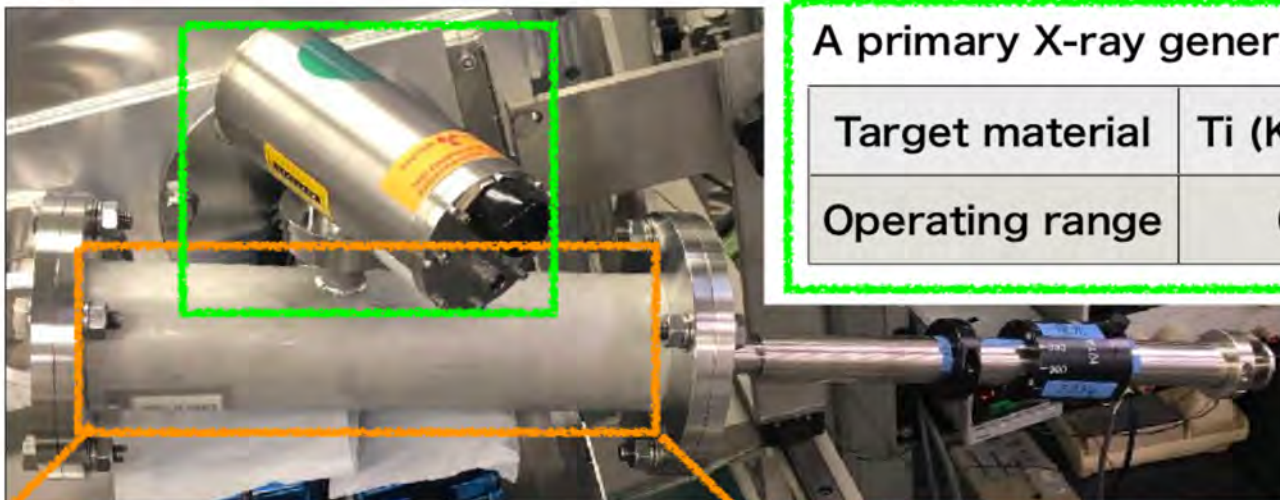


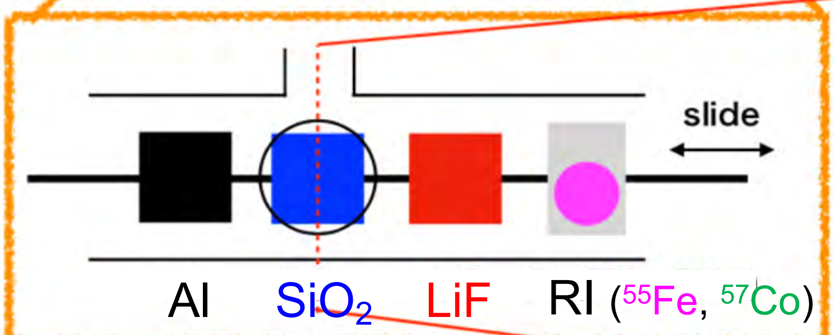

- The screening system is built at a clean booth in a labo. of Osaka Univ.
- The CCDs are kept at -110℃ and ~$10^{-6}$ Torr, and operated by electronics and PCs. Temperature, pressure, voltage, and current are all always monitored.
- ON/OFF of the X-ray generator and LEDs can be controlled from outside.

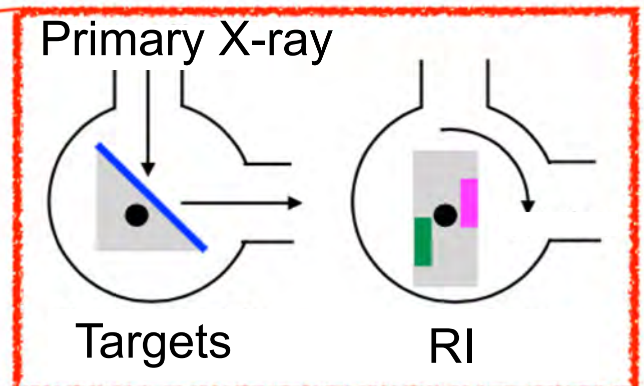
# X-ray Generator



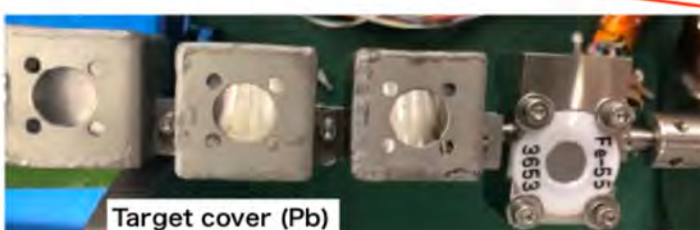

**A primary X-ray generator "Oxford"**

| | |
|---|---|
| Target material | Ti (K$\alpha$: 4.5 keV) |
| Operating range | 0–50 kV |



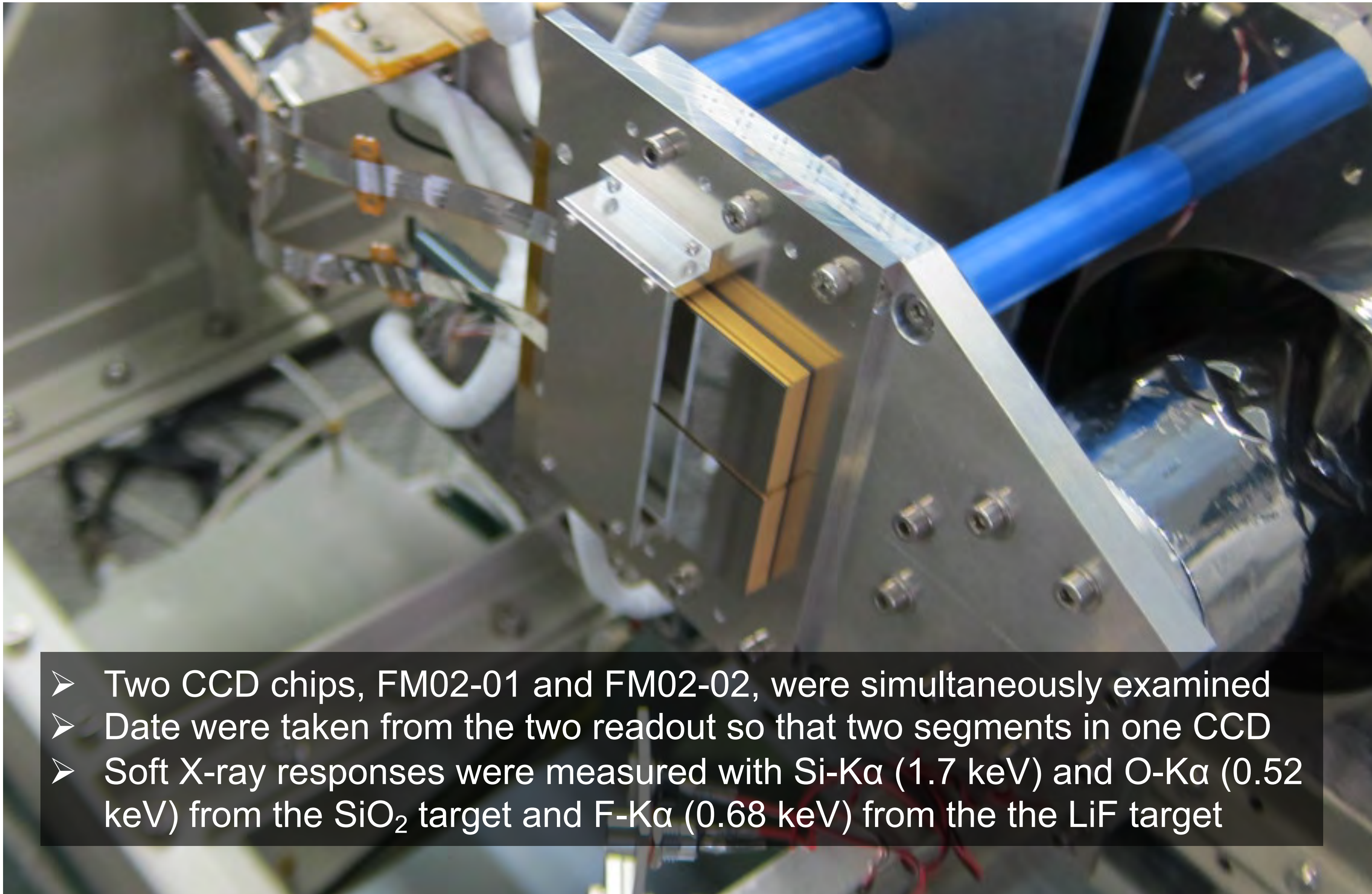




Cross-sectional view



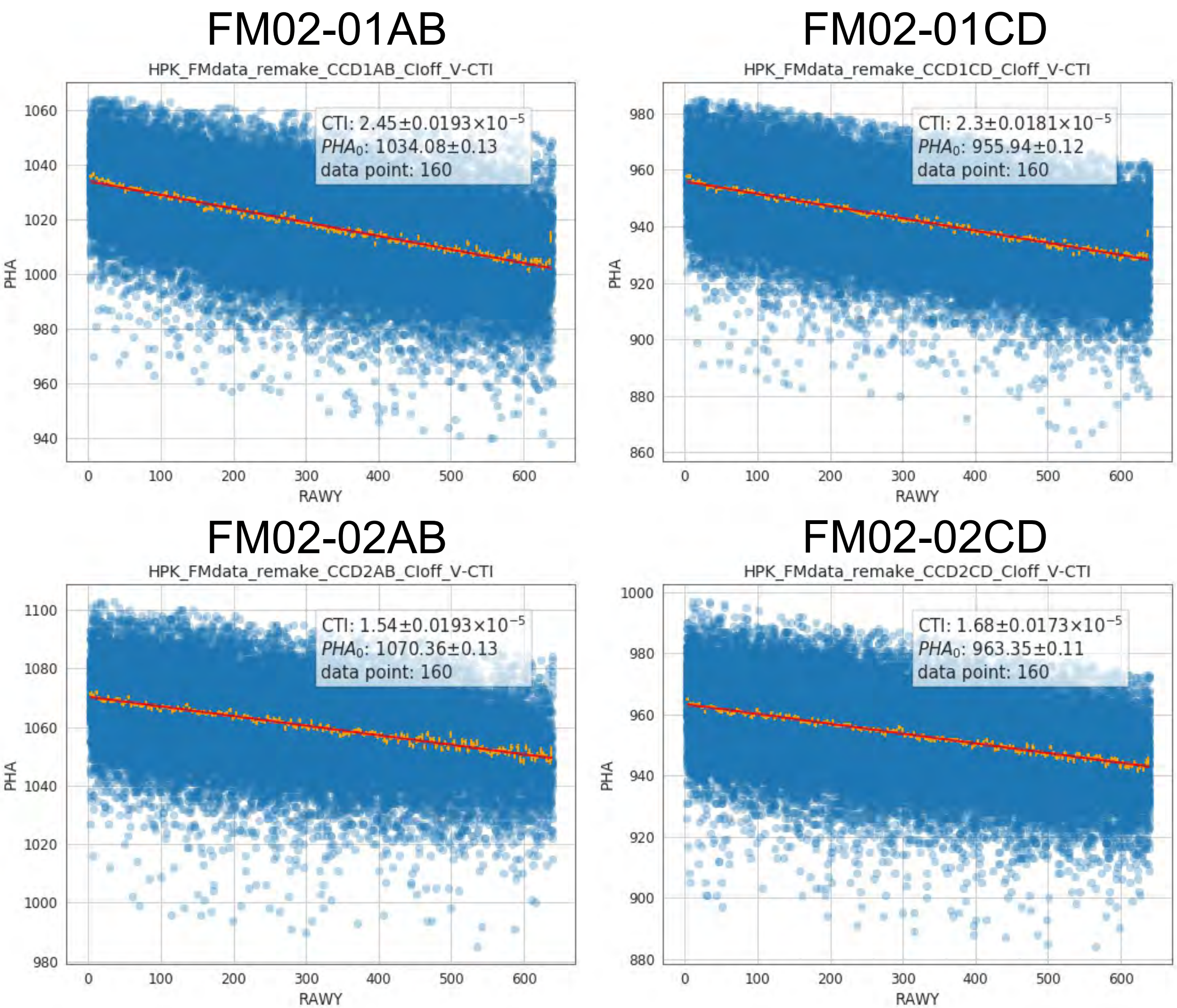

- We can choose lines from Al (1.49 keV), SiO2 (0.53 keV), LiF (0.68 keV), $^{55}$Fe (5.9 keV), and $^{57}$Co (14.4 keV).

# 1st screening experiment



- Two CCD chips, FM02-01 and FM02-02, were simultaneously examined
- Date were taken from the two readout so that two segments in one CCD
- Soft X-ray responses were measured with Si-Kα (1.7 keV) and O-Kα (0.52 keV) from the $SiO_2$ target and F-Kα (0.68 keV) from the the LiF target

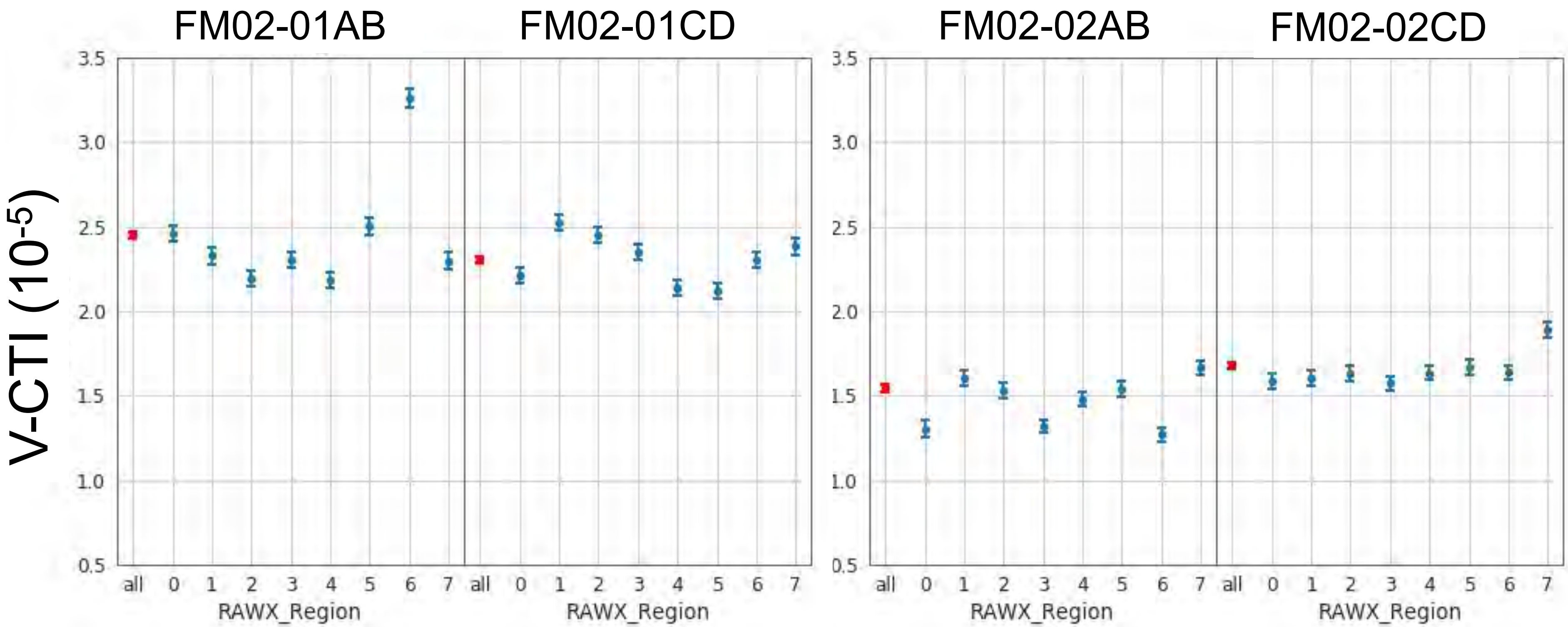
# $^{55}$Fe: CTI (1)





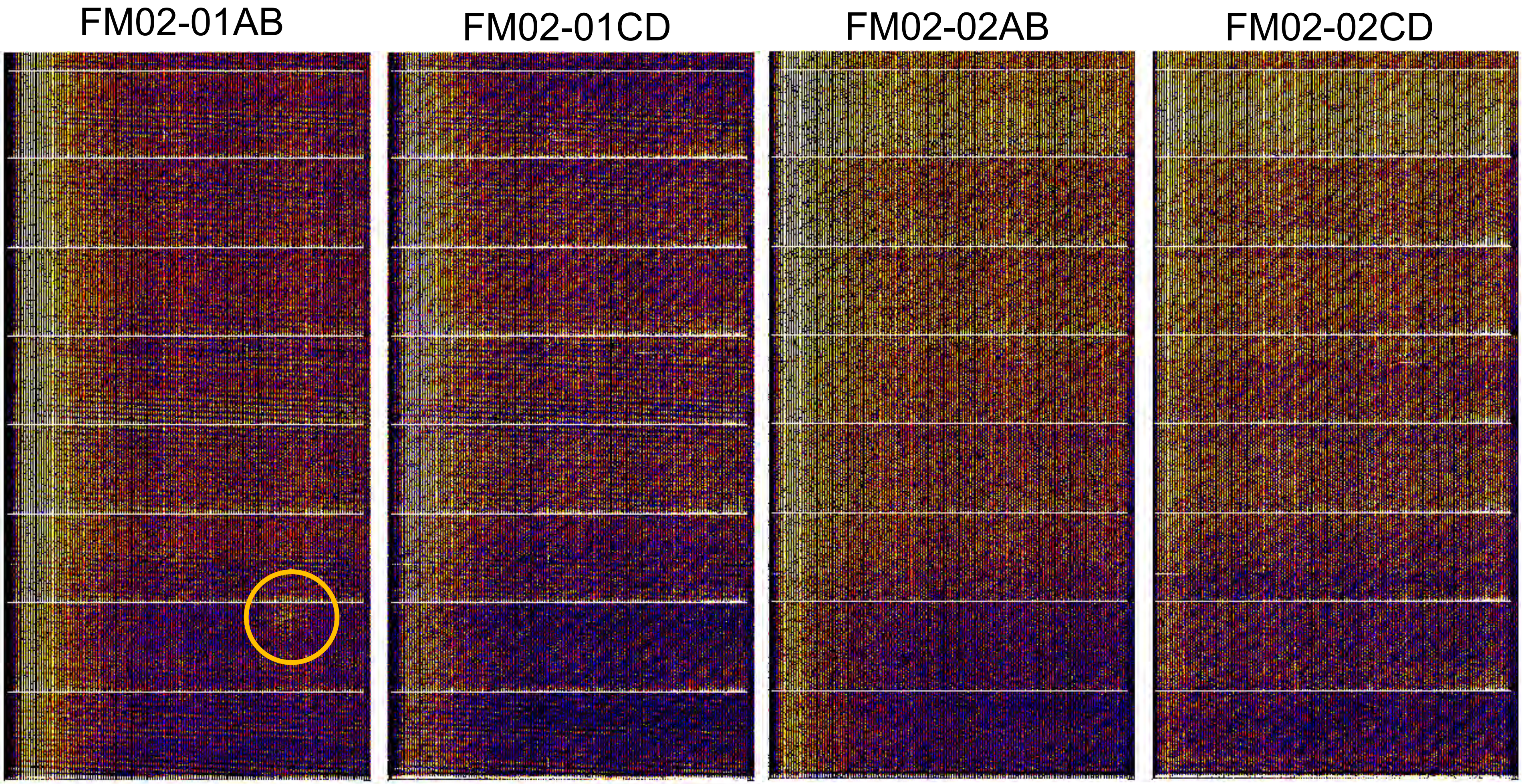
- Charge injection is not applied for CTI evaluation and G0 only
- Each figure shows "pulse height vs Y (number of transfer)"
- Blue dots indicate Mn-Kα data (Mn-Kβ data are excluded)
- Orange points with bar indicate average and standard deviation of the pulse heights at the Y value
- Red line indicate the best fit of the orange points
- The slope shows a charge transfer inefficiency (CTI)

# 55Fe: CTI (2)

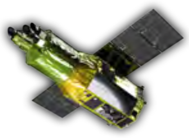



- The CTI values (red) are ~$2.4 \times 10^{-5}$ and ~$1.6 \times 10^{-5}$ for FM02-01 and FM02-02, respectively.
- The CTI values was also measured in the 1/8 region along the X direction (blue)
- One of the 1/8 regions in segment AB of FM02-01 shows an extraordinary high value (region 6 in the left half of the left figure)

# 55Fe: hotspot

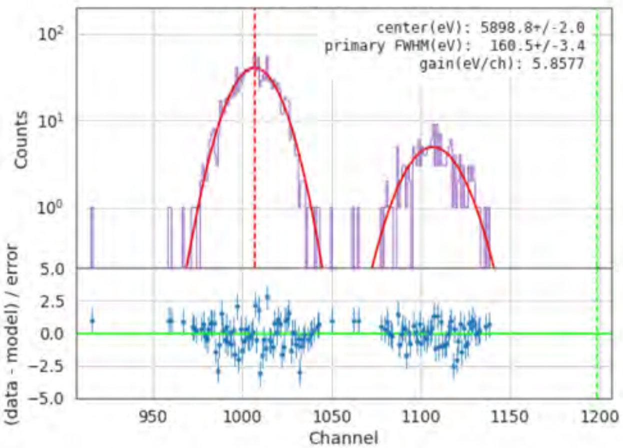



- A hotspot, localized region with high a CTI value, was observed in Segment AB of FM02-01

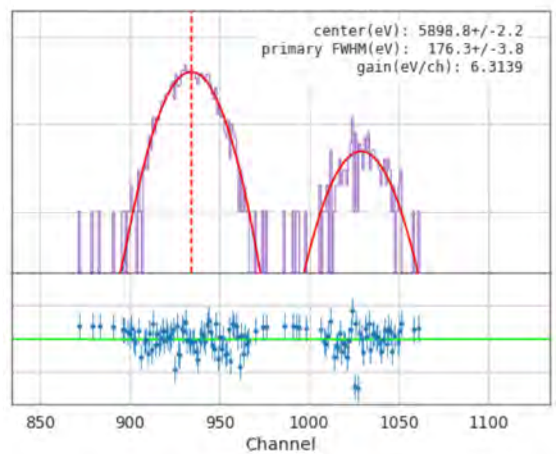


# $^{55}$Fe: Energy resolution

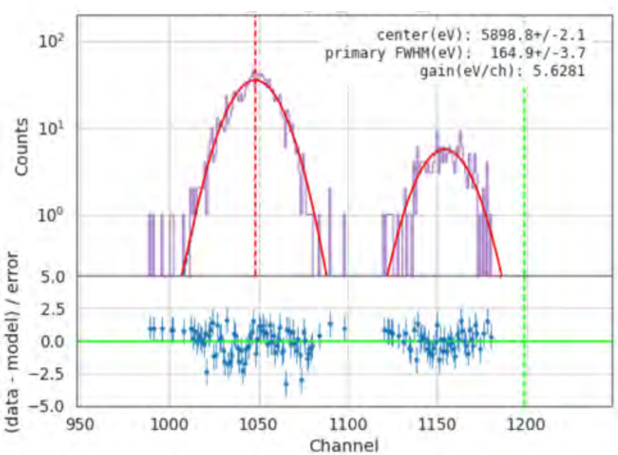
FM02-01 AB



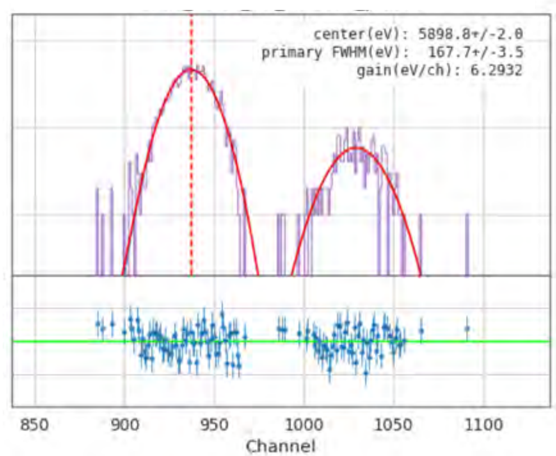

FM02-01 CD

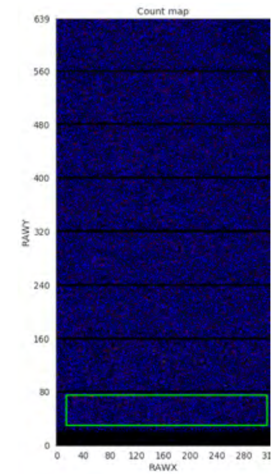



FM02-02 AB




FM02-02 CD

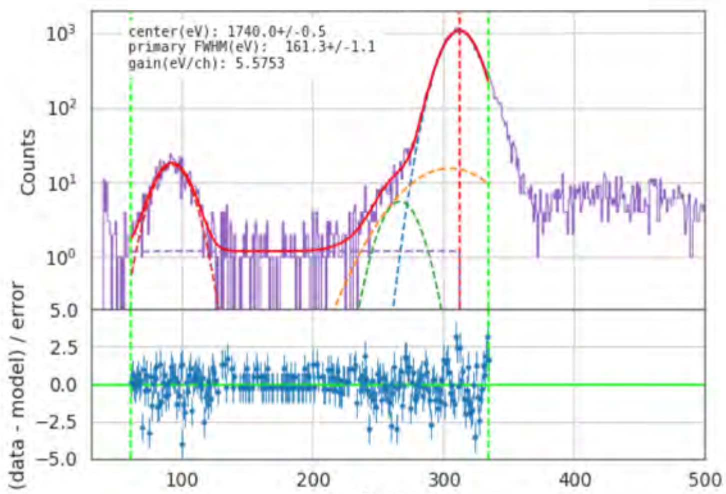


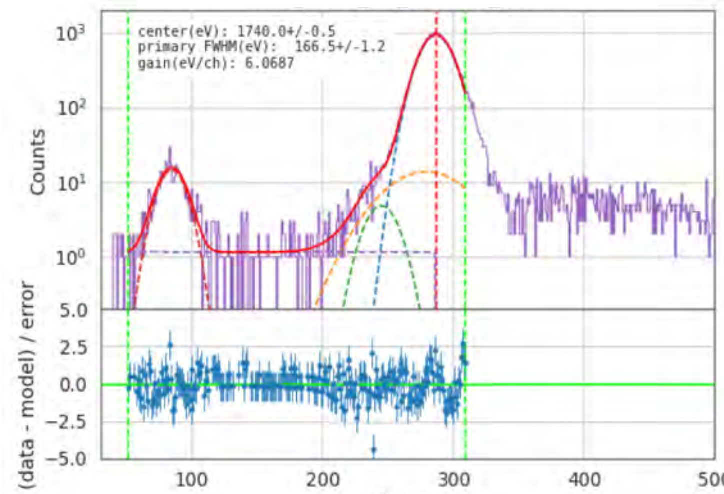

- Charge injection is applied and data taken in the low Y region are analyzed in order to know the best performance
- Grade0 only
- The energy resolution is 160~175 eV (FWHM at 5.9 keV), which is comparable with the ASTRO-H SXI performance

# $SiO_2$: dead layer (1)

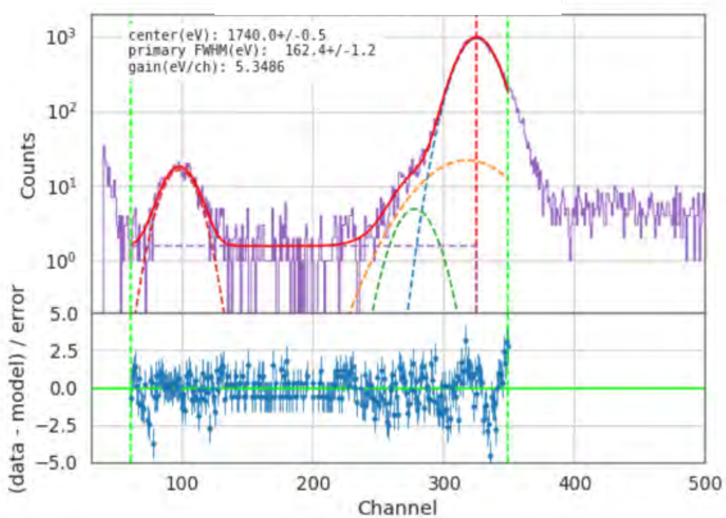
FM02-01 AB



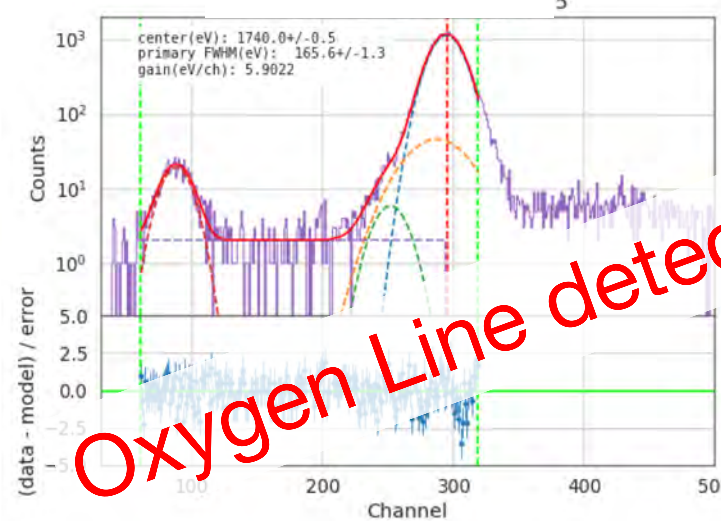

FM02-01 CD




FM02-02 AB



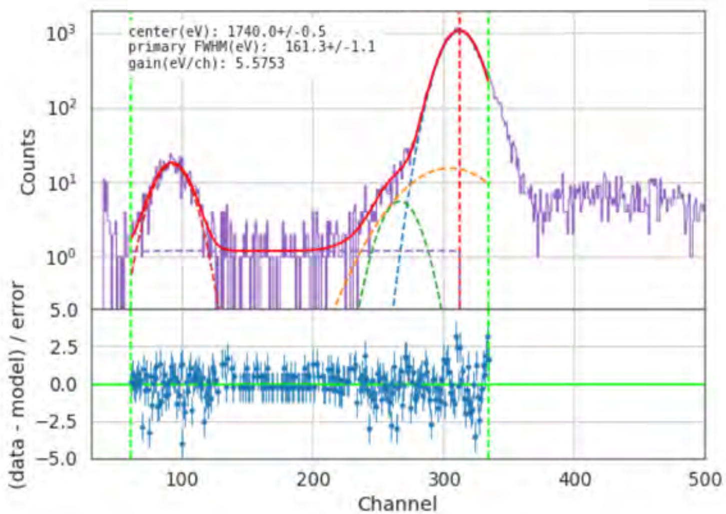

FM02-02 CD



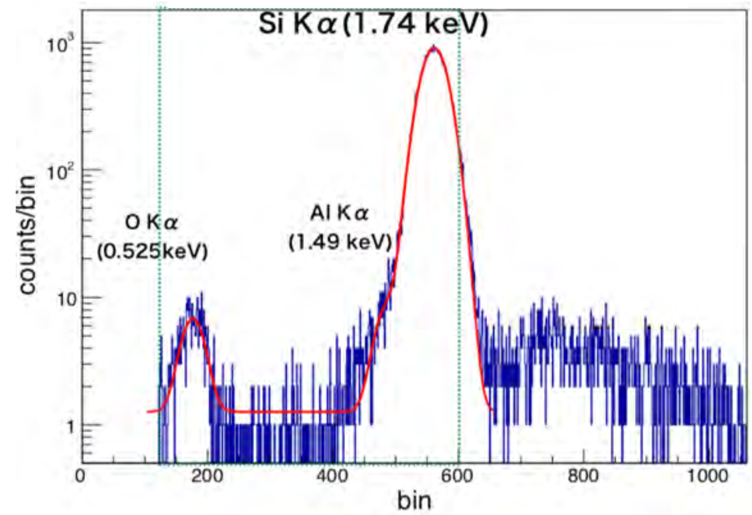

Oxygen Line detected

# SiO2: dead layer (2)

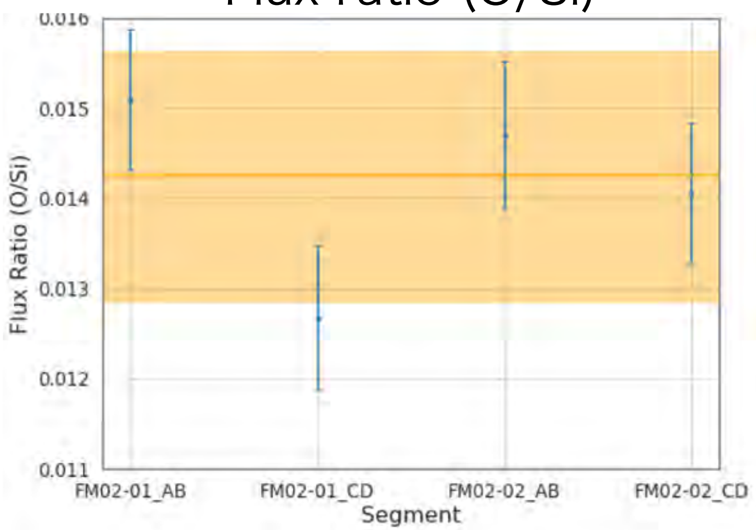
FM02-01 AB




SDD spectrum

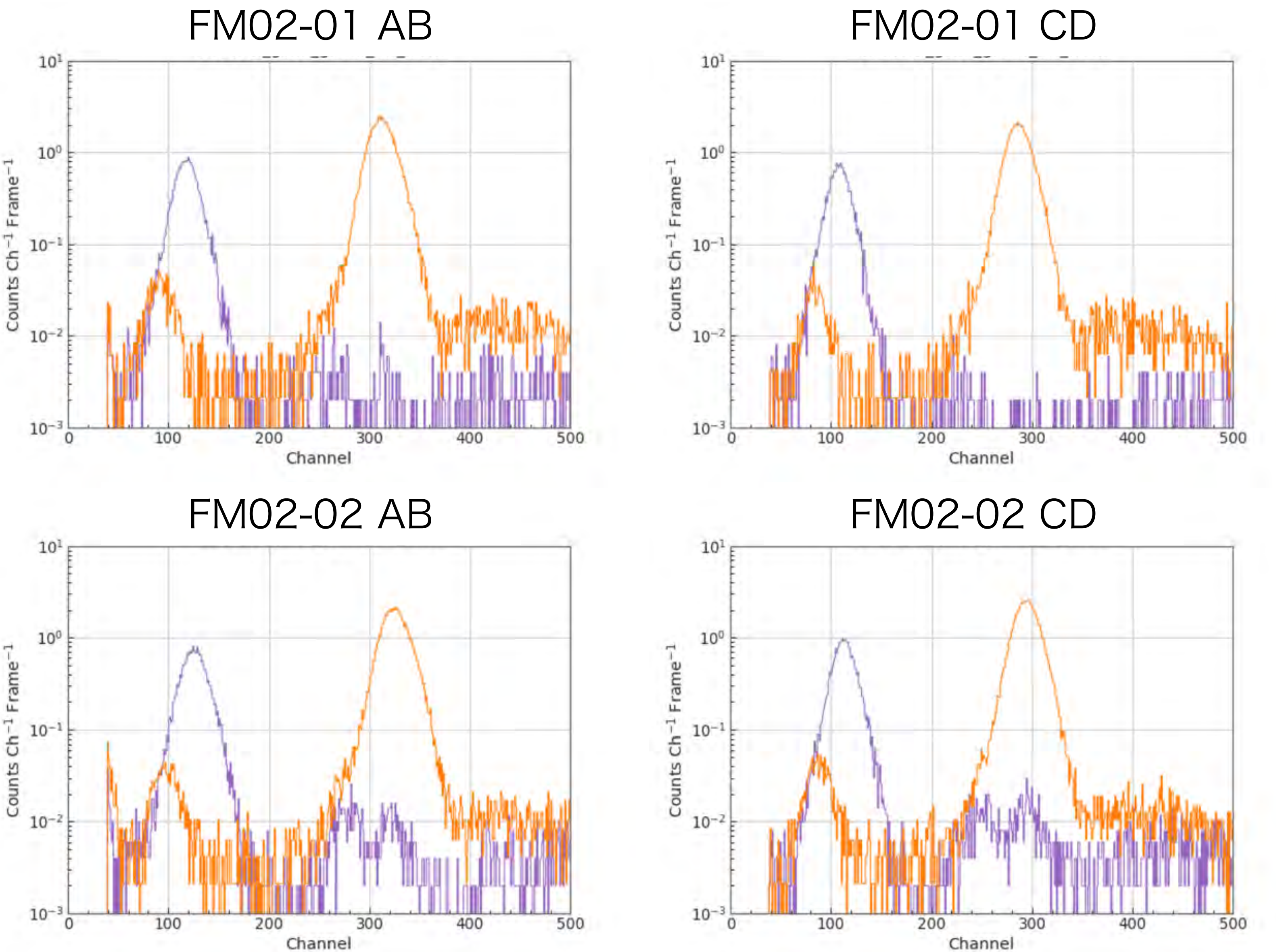



Flux ratio (O/Si)




- The flux ratio of the O and Si lines from our system were measured with a silicon drift detector (SDD) with known quantum efficiency (Up right)
- The flux ratios of O/Si measured with the CCDs (G02346) are consistent with no dead layer case although uncertainty is still large (Bottom left)
- At least, no thick (>100 nm) dead layer exists

# LiF: another example



# Summary

- Xtend/SXI is the X-ray CCD camera for XRISM, basically the same characteristic with A-H/SXI but some improvements included
- We set up the X-ray screening/calibration system in our lab, and selecting four flight CCDs
- First two CCDs are as good as ASTRO-H/SXI flight CCDs