

The Filter Wheel System for the X-ray Spectrometer onboard Astro-E2

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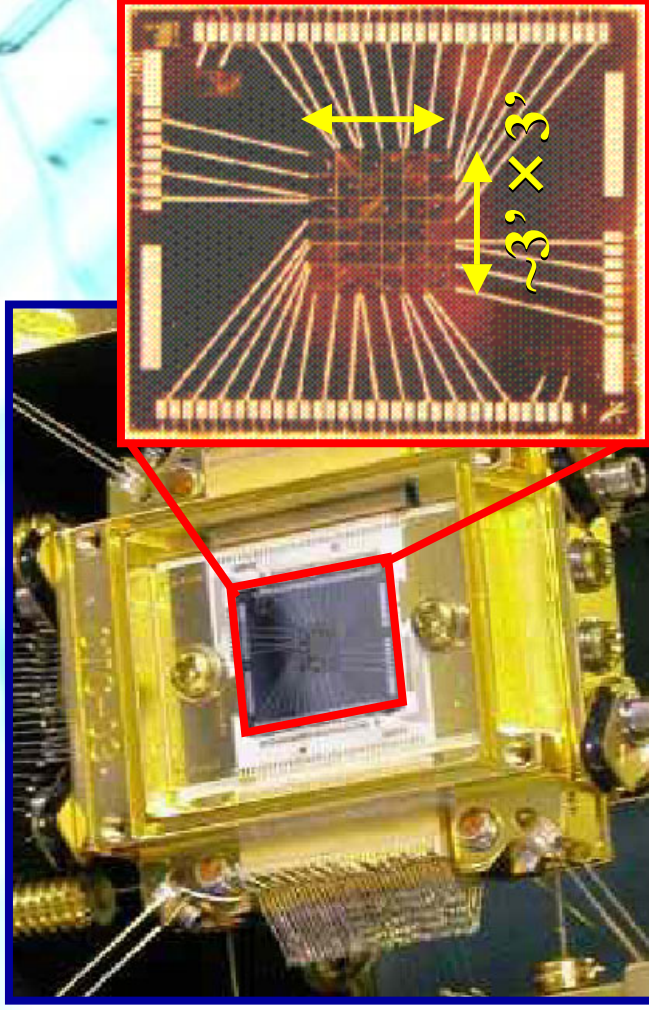
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Contents

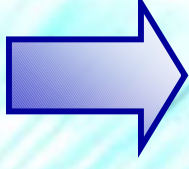
- The X-ray spectrometer XRS
- The Filter Wheel System
- Measurement of filter transmission
- Summary

X-ray micro-calorimeter (XRS)

- **Main detector of Astro-E 2** (Japanese fifth X-ray astronomy satellite to be launched early in 2005)
- High energy resolution : $\Delta E = 6\text{eV@}6\text{keV}$
- Detects X-ray as **Temperature change**.
- Structure : 6×6 array mercury-telluride (HgTe) square pixels
(pixel size : $625\mu\text{m}$)
- Field of view: $3' \times 3'$



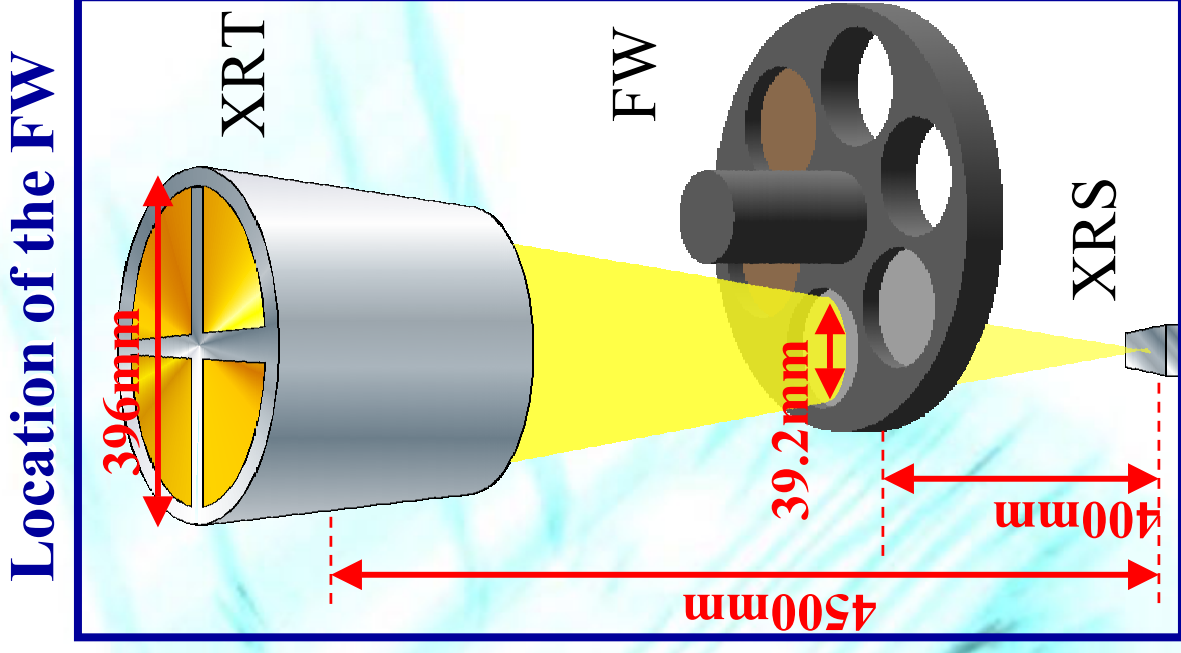
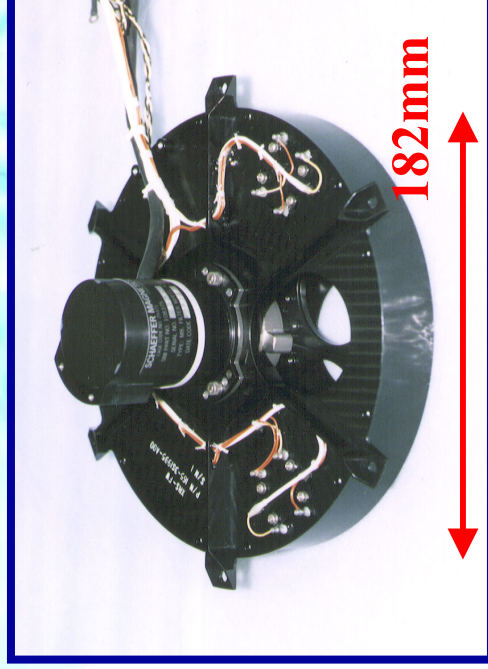
- Limit the count rate
&
- Gain monitor



The Filter Wheel system

Filter Wheel

- **FW system :**
 - ◆ **The FW itself**
 - ◆ **Stepping motor**
 - ◆ **Filter disk**
 - ◆ **Filter Elements: ϕ 49mm**
 - ◆ **(Be, Neutral Density, Open)**
 - ◆ **Calibration Source (^{55}Fe , ^{41}Ca)**
 - ◆ **Filter-wheel Driving Electronics(FDE)**
- **Exchange the filter element by rotating the filter disk.**



Filter Element & Cal. source

● Filter element (filter diameter = **49mm**):

◆ 2-Open

◆ 2-ND Filter → Reduce photons independent of energy

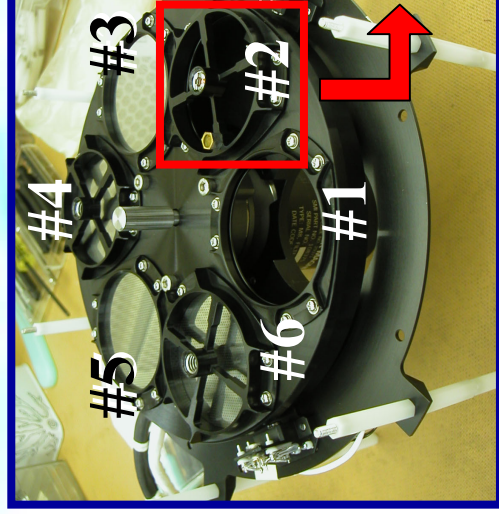
● 200 μm thickness Mo plate with 1802 pin-holes ($\phi=320\mu\text{m}$)

◆ 2-Be Filter → Reduce low energy photons (<2keV)

● 300 μm thickness Be plate

● Calibration source (3–⁵⁵Fe: 5.9keV & 1–⁴¹Ca: 3.3keV)

→ Monitor the gain variation of the XRS



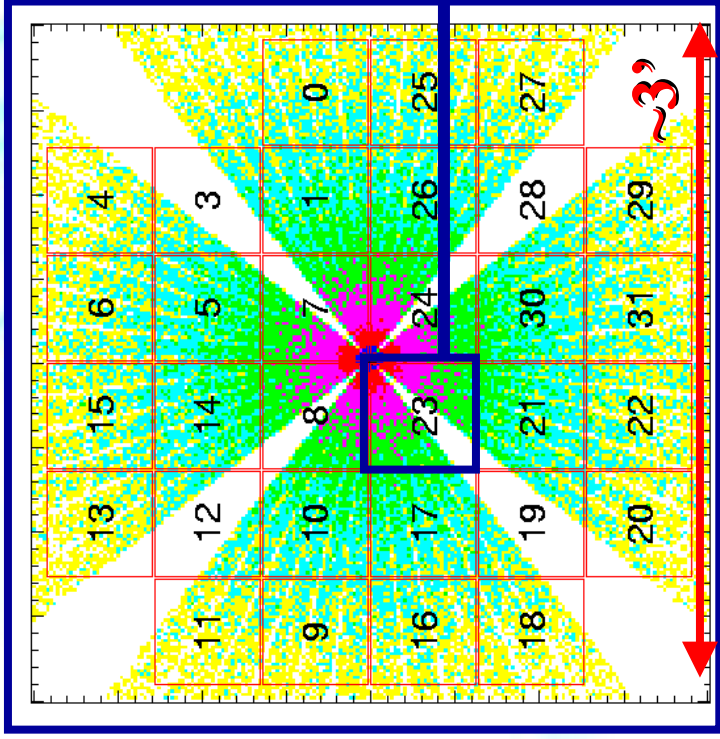
ND-2 Be-2
ND-1 Be-1

Cross bracket

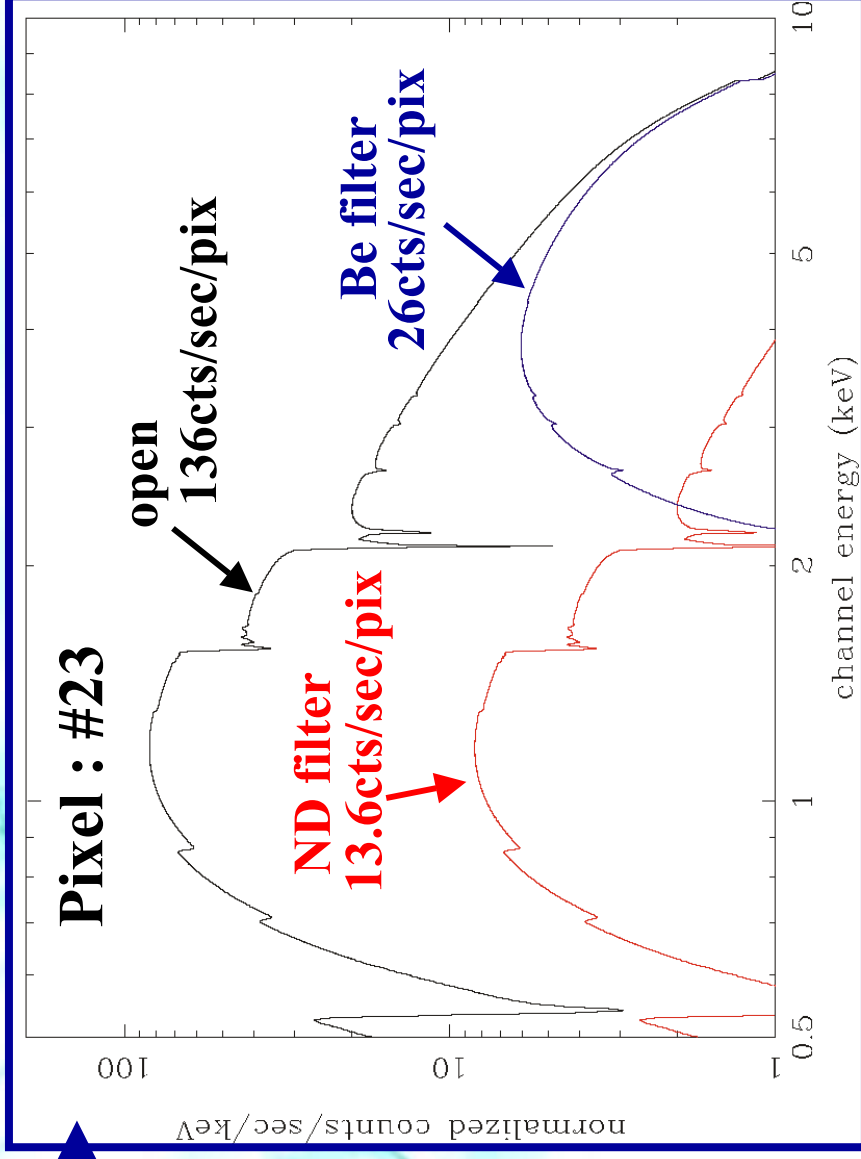


Filter ID	#1	#2	#3	#4	#5	#6
Filter Element	Open		ND Filter		Be Filter	
Transmission	100%		10%		Depend Energy	
Cal Source	-	⁴¹ Ca ⁵⁵ Fe	-	⁵⁵ Fe	-	⁵⁵ Fe

Simulation



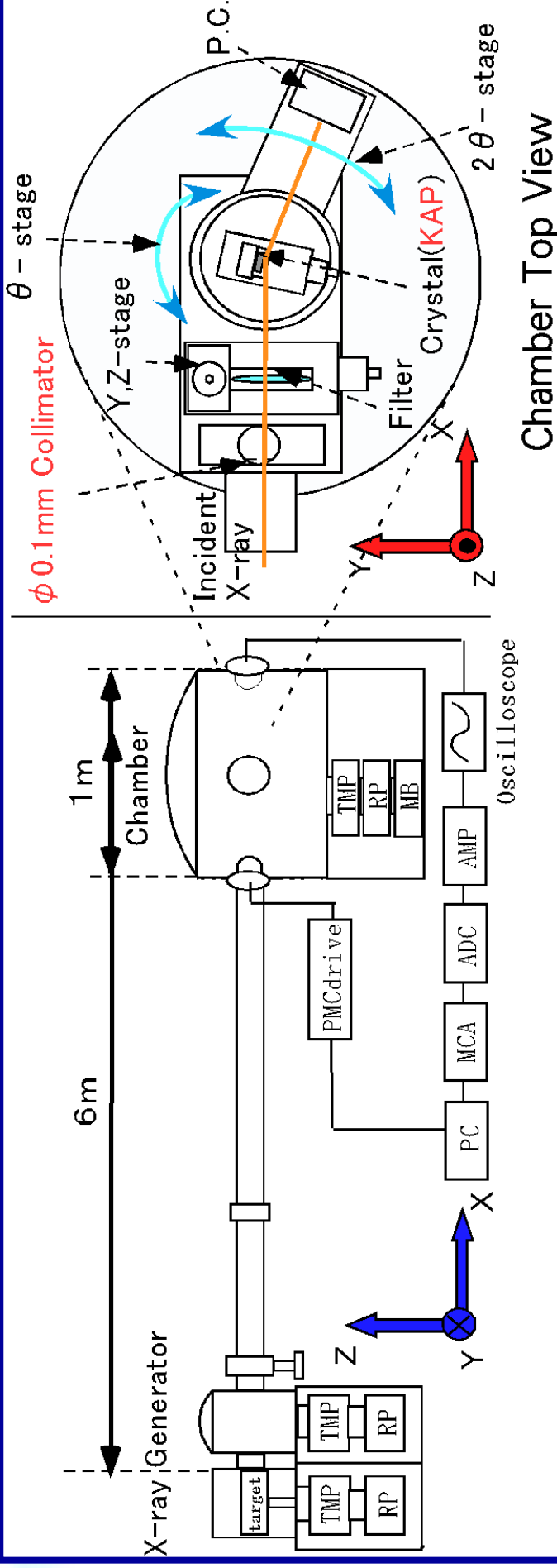
Spectrum of the Crab nebula



- Focus on XRS center
- Red square : XRS pixel
- Simulated for pixel #23

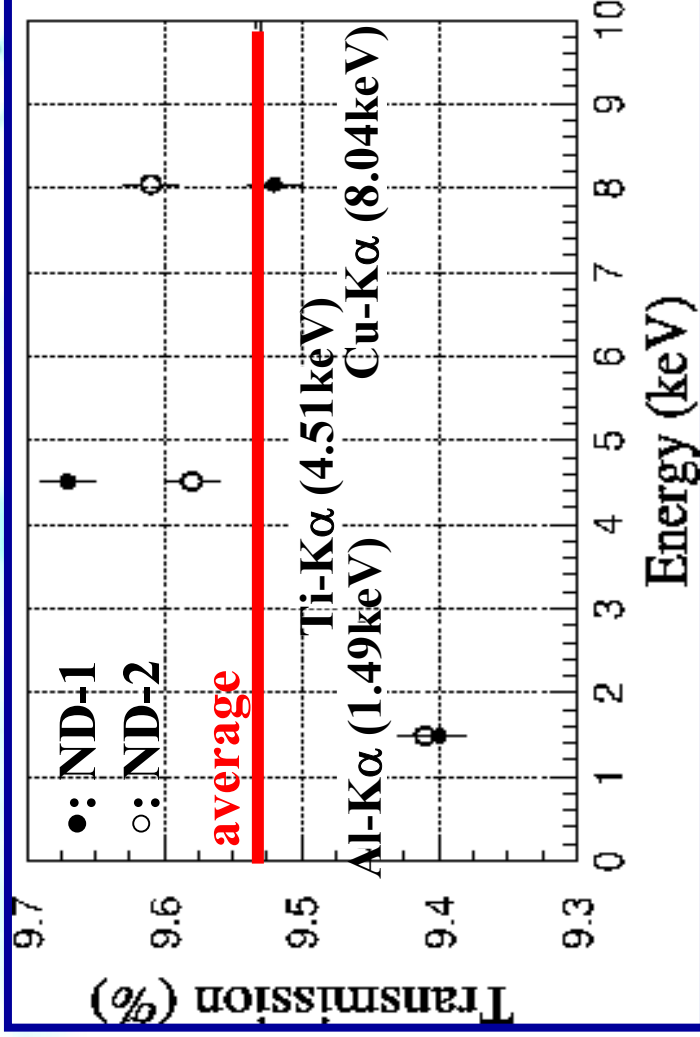
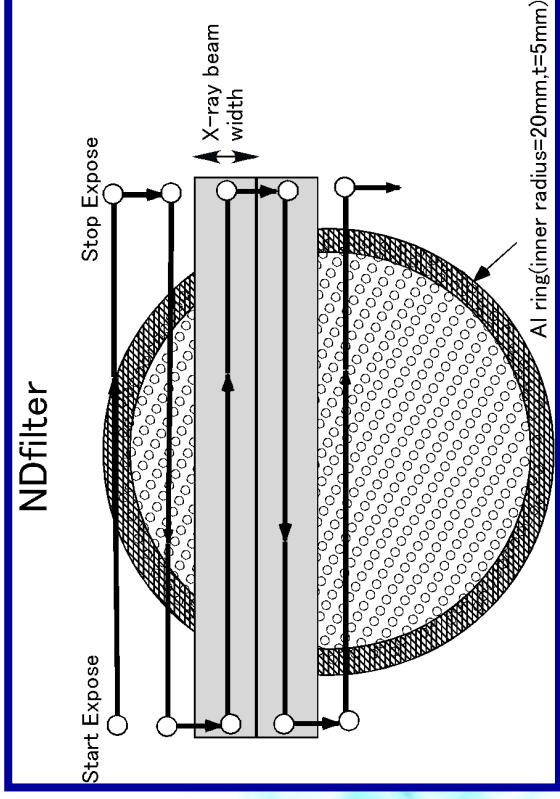
Measurement System

- ISAS **6m X-ray beam facility**
- X-ray beam collimation : **pin-hole ($\phi=0.1\text{mm}$) or vertical slit ($0.45\text{mm} \times 2\text{mm}$).**
- Monochromatization : **KAP ($2d=26.4 \text{ \AA}$) or super-graphite ($2d=6.708 \text{ \AA}$) crystals.**
- Detector : **proportional counter.**



ND Filter

- **Raster scan method**
- **Energy : Al-K α (1.49keV),
Ti-K α (4.51keV),
Cu-K α (8.04keV)**

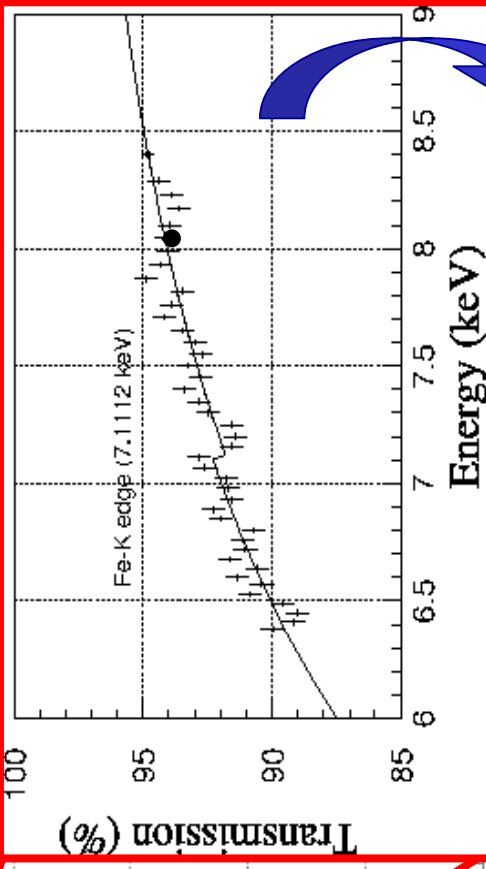
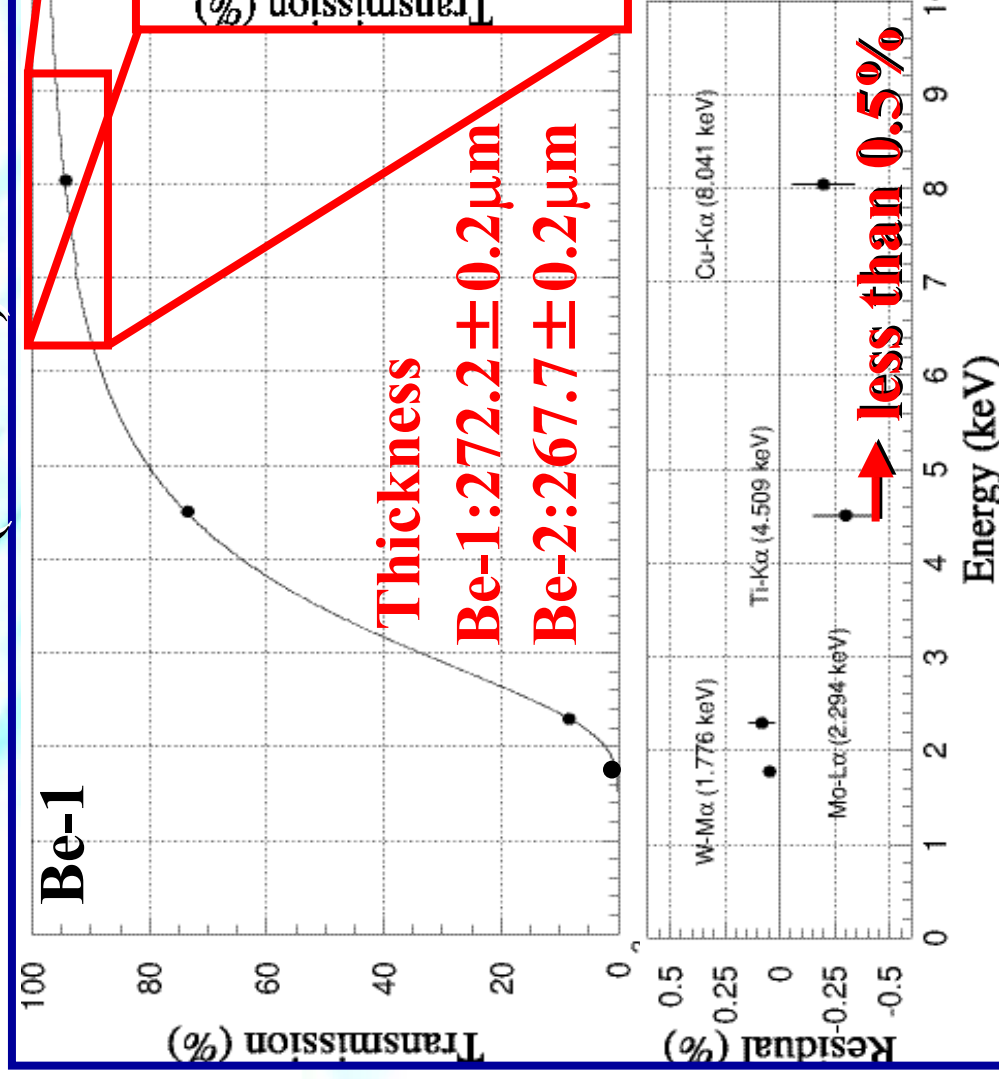


- **Energy dependence : $\sim 0.2\%$
(possible beam fluctuation).**
- **Average transmission of two
ND filters : both $9.53 \pm 0.02\%$**

Be Filter

✧ Energy dependence

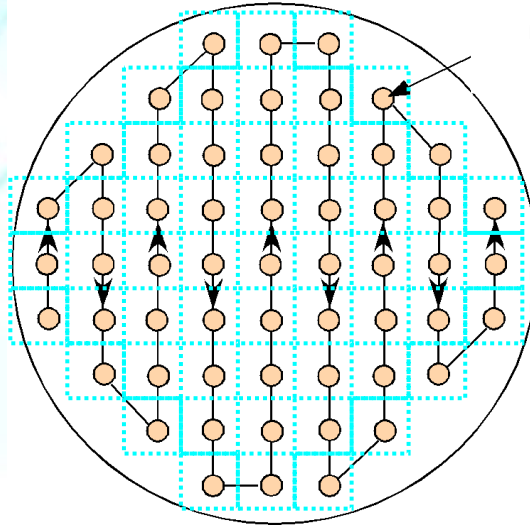
- Pointing at filter center
- Energy : W-M α (1.78keV), Mo-L α (2.29keV), Ti-K α (4.51keV),
Cu-K α (8.04keV)



**Fe fractional weight =
 $0.03 \pm 0.02\%$ @90% confidence**

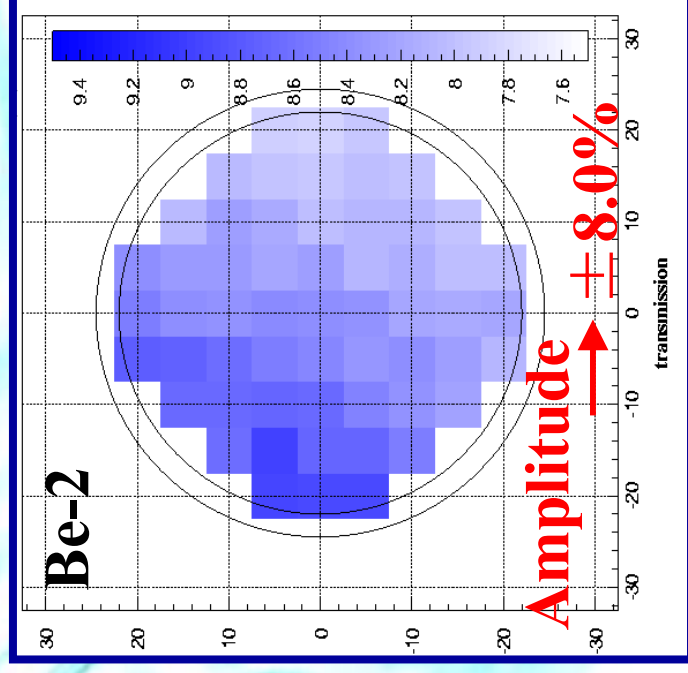
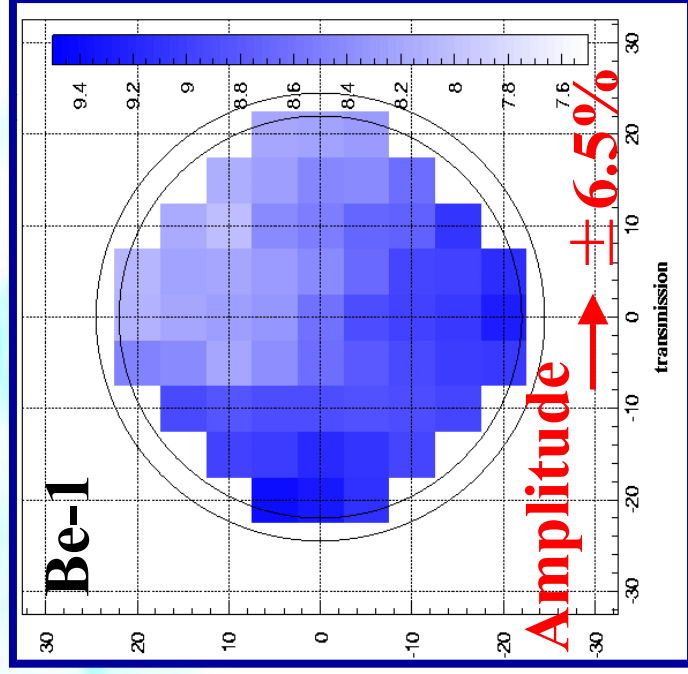
**Consistent with
the specification sheet**

❖ Thickness Uniformity of Be Filter



- Energy : Mo-L (2.293keV)
- Divide the filter into 5mm × 5mm cell, and measure the transmission of all cells.

Measurement Point



Summary

➤ Modification from Astro-E to Astro-E2

● Filter Elements

◆ Six different type filters

→ 2 – Open, 2 – Be filter, 2 – ND filter

● Calibration source

◆ None → 3 – ^{55}Fe sources, 1 – ^{41}Ca sources

➤ Measurement of the filter elements

● ND filter

◆ Average transmission : $9.53 \pm 0.02\%$ for both

● Be filter

◆ Fe Contamination : $0.03 \pm 0.02\%$ @90% confidence

◆ Thickness : Be-1 = $272.2 \pm 0.2\mu\text{m}$, Be-2 = $267.7 \pm 0.2\mu\text{m}$

◆ Non-uniformity : Be-1 = $\pm 6.5\%$, Be-2 = $\pm 8.0\%$ (@Mo-L)