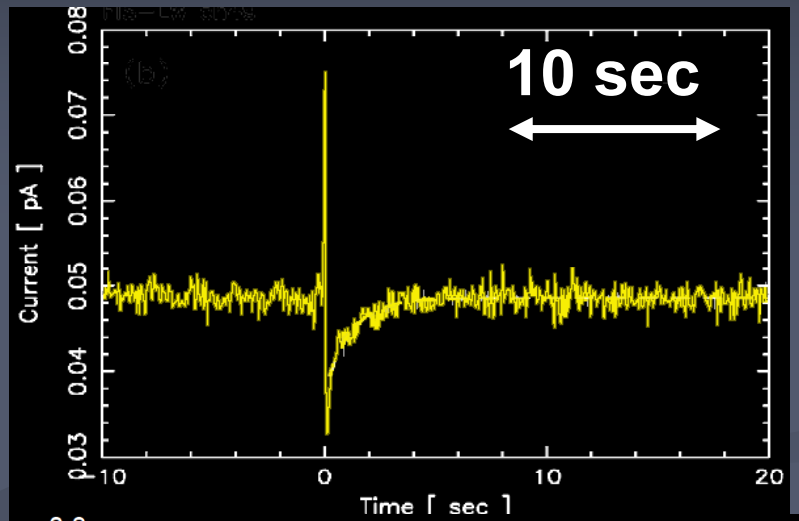
In-orbit characterization of transient response and radiation effects of Ge:Ga array detectors

H.Kaneda (ISAS/JAXA), & AKARI/FIS team

(1) Radiation effects

Cosmic-ray hitting

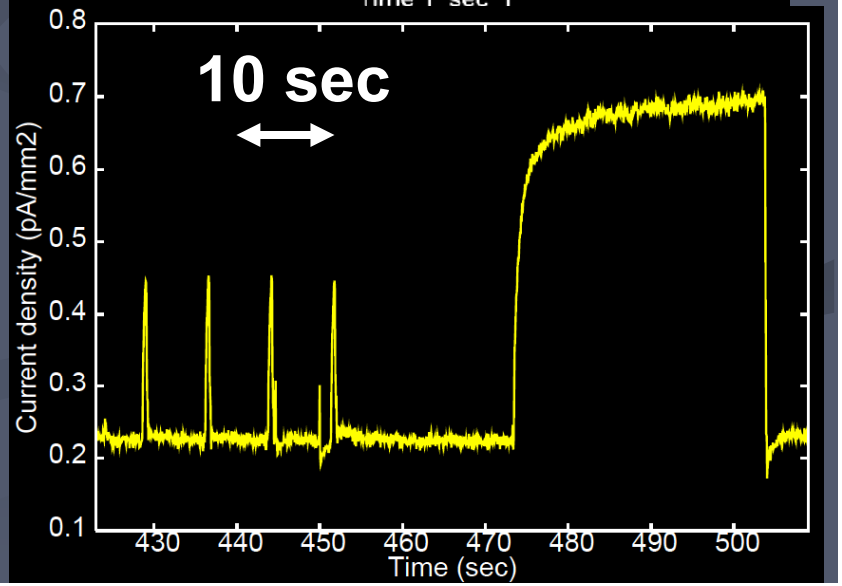
Changes in responsivity & noise +
Glitch after-effects



(2) Transient response

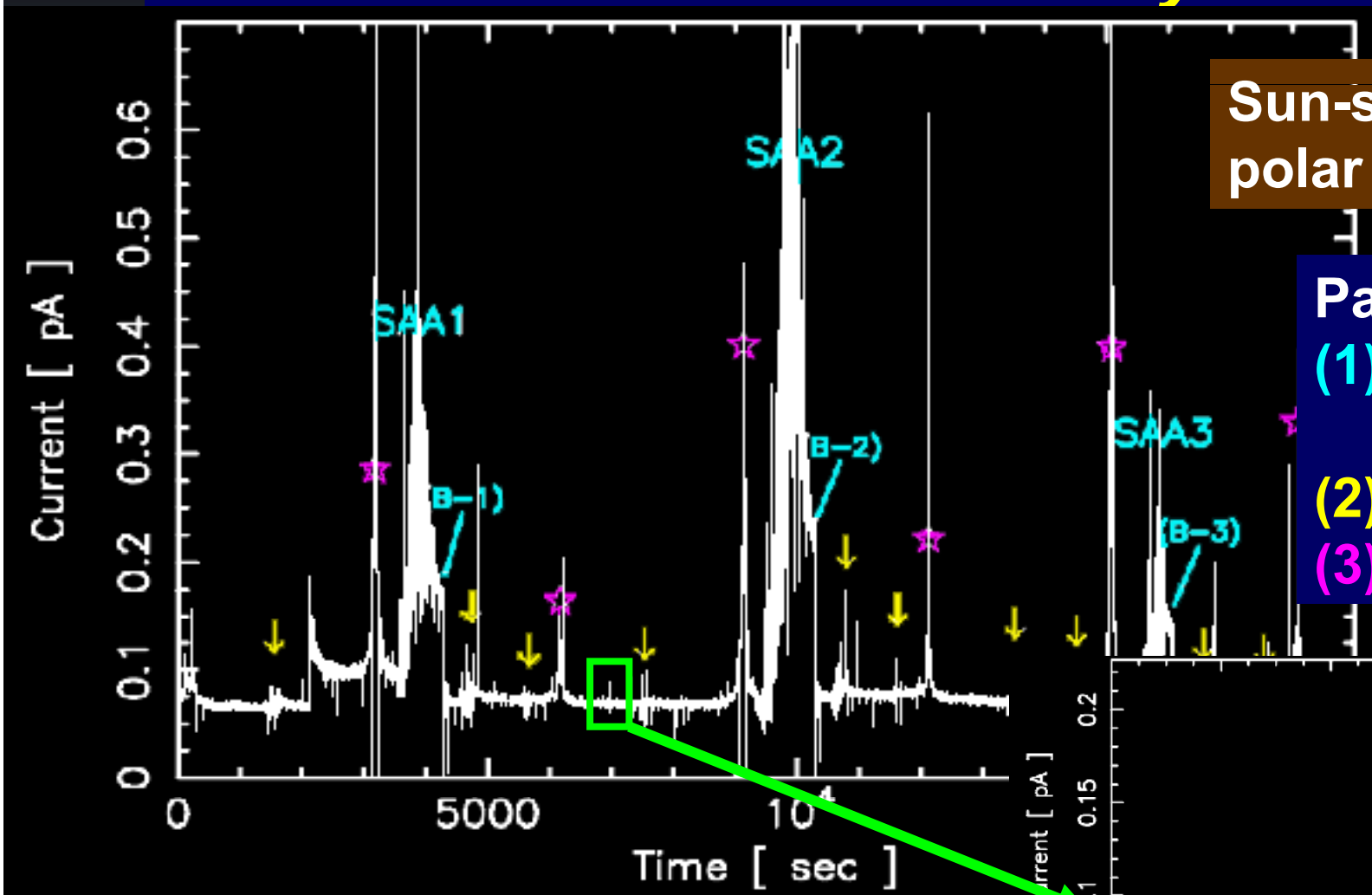
Low photon background

Slow response against signal change
Memory effects, non-linear phenomena



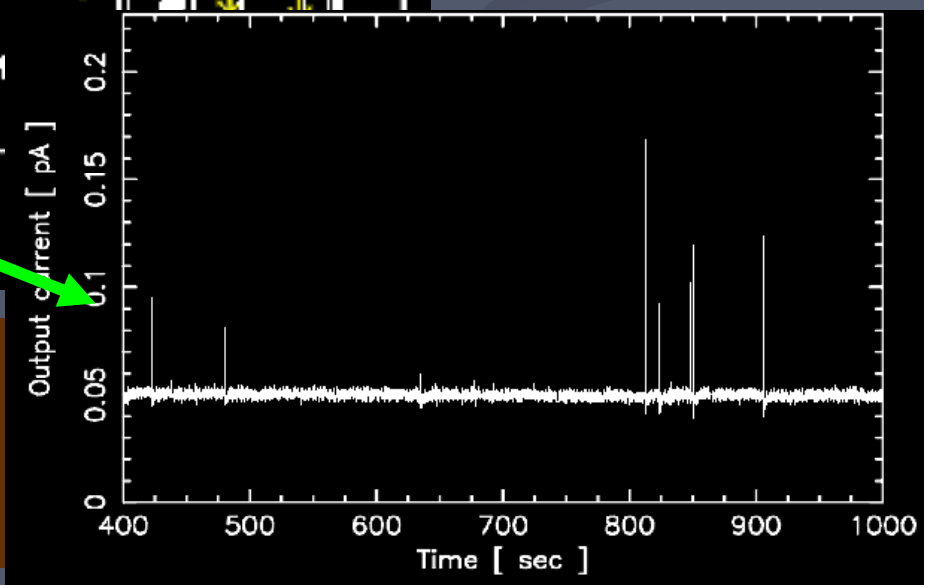
They can degrade FIR data reliability.

In-Orbit FIS Data Affected by Glitches



Sun-synchronous polar orbit at 700 km

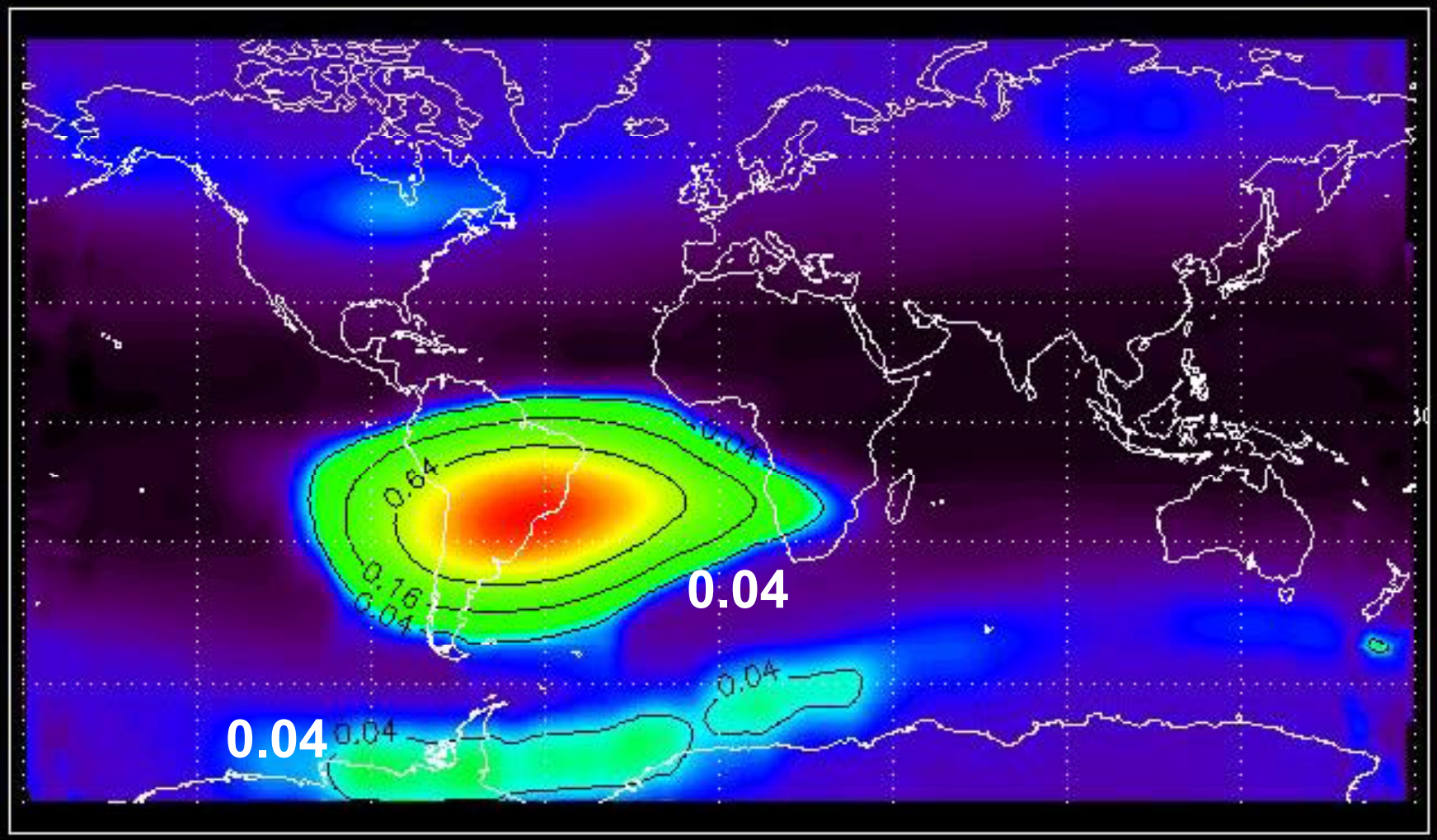
Passage of
(1) SAA
+Bias-boosting
(2) Polar region
(3) Galactic plane



Outside the SAA
Glitch rate: ~0.02 s^{-1} $pixel^{-1}$
(0.5 mm cubic pixel)

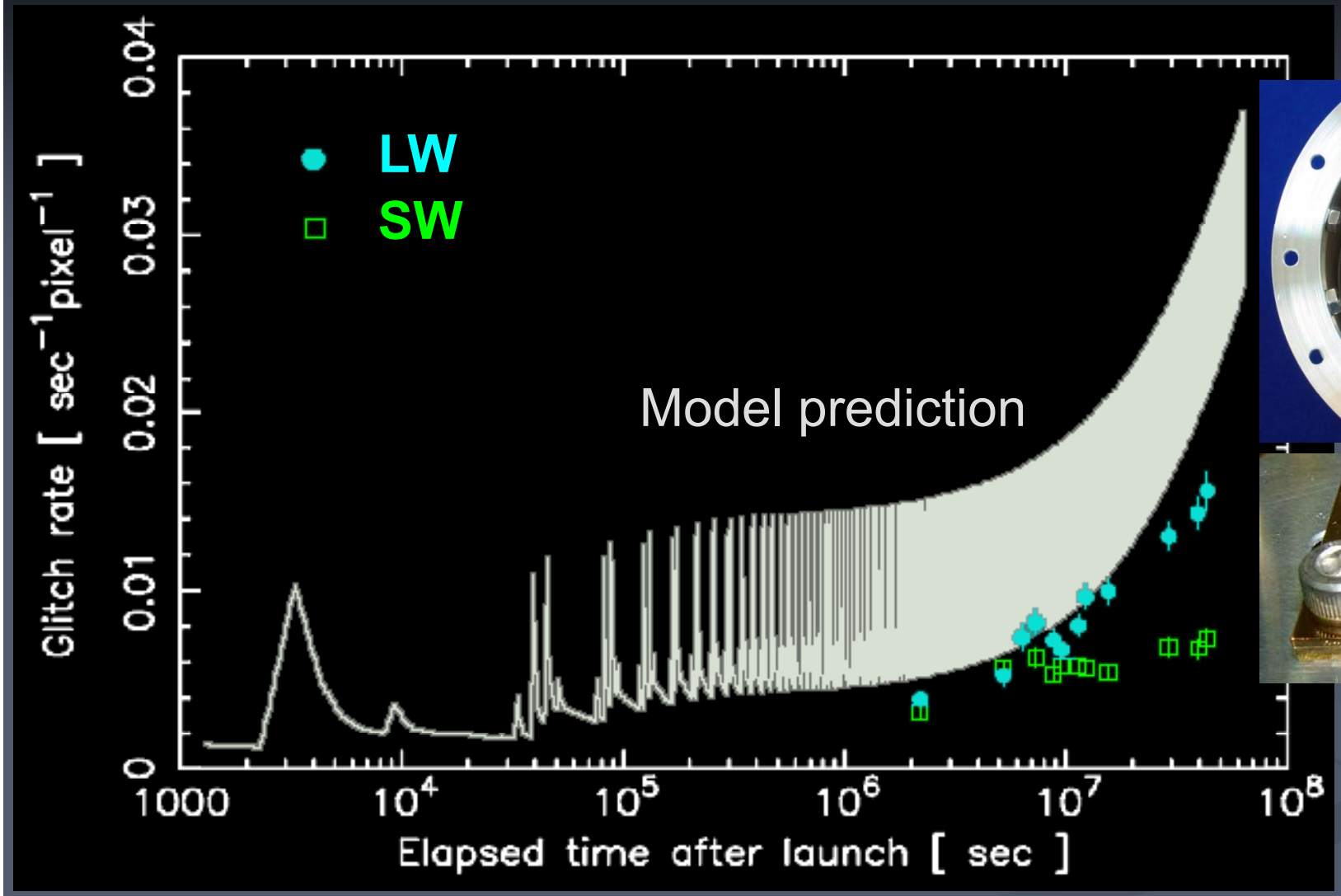
World Map of Glitch Rates

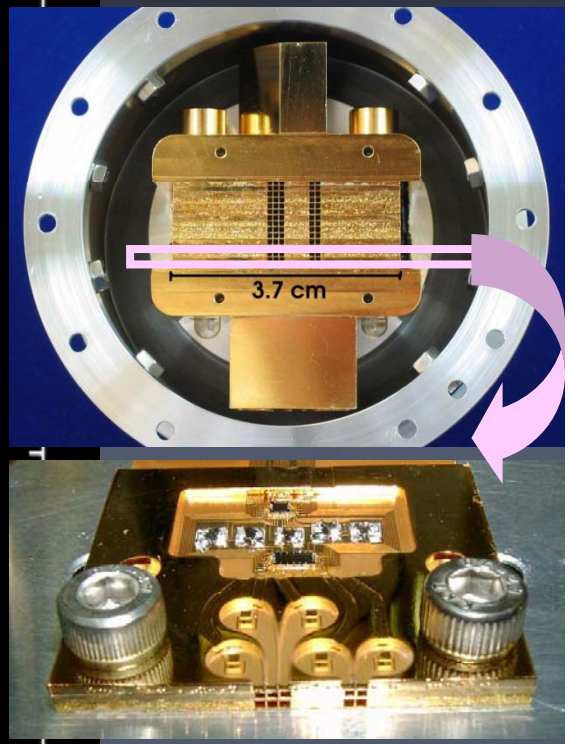
LW glitch rates in units of $s^{-1}pixel^{-1}$ (10 Apr – 10 Aug 2006)



Besides SAA, detectors sense high-energy electrons in polar cap.

Increase of Glitch Rates with Time

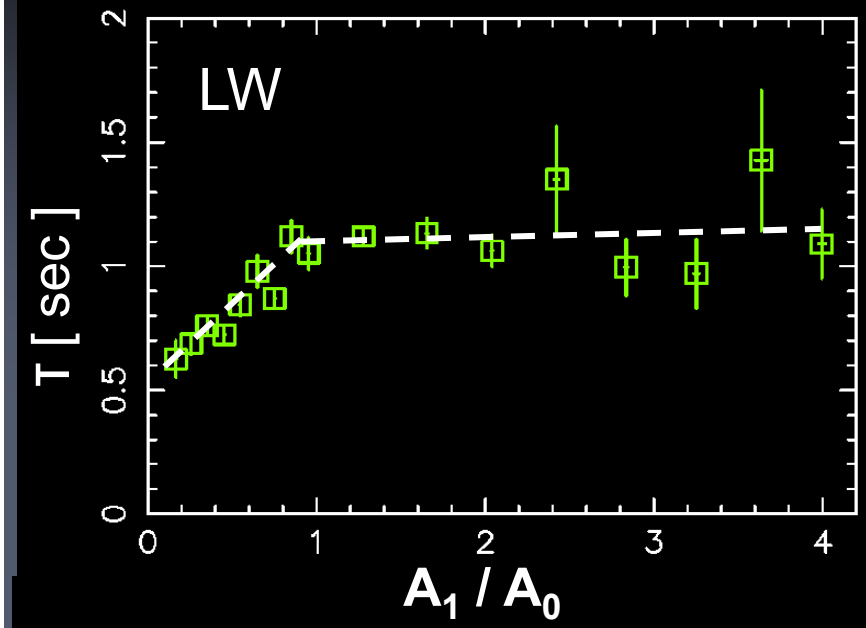


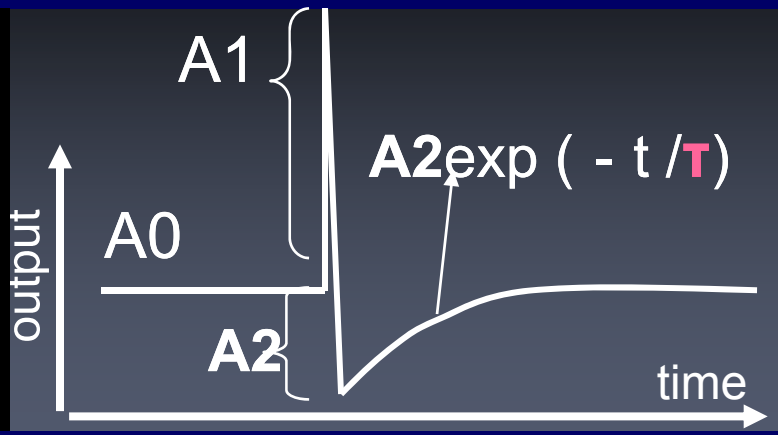


LW array

Radio-activation of stressed detector housing can be serious for space missions in similar orbits with longer lifetime.

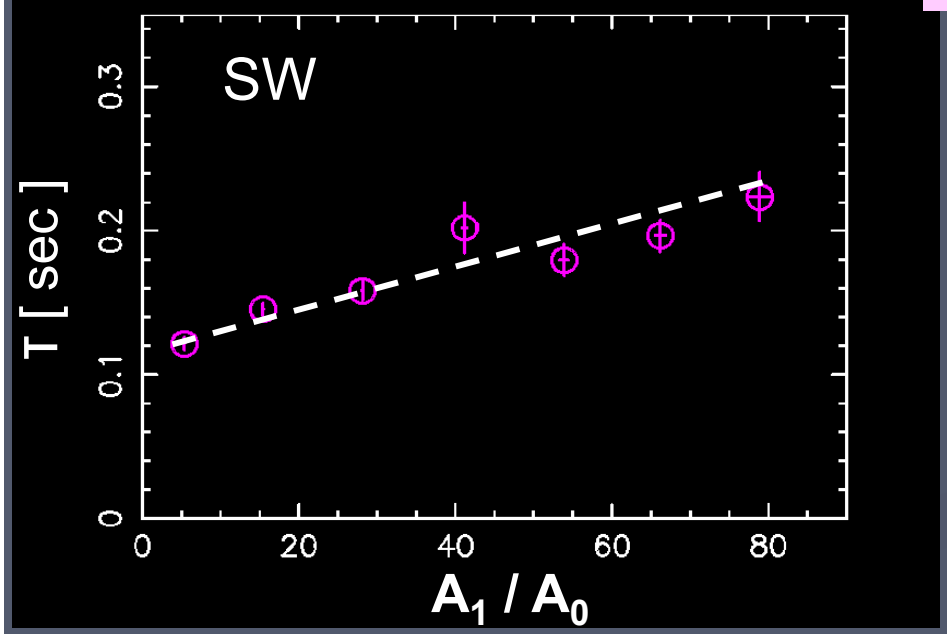
Characterization of Glitch After-Effects

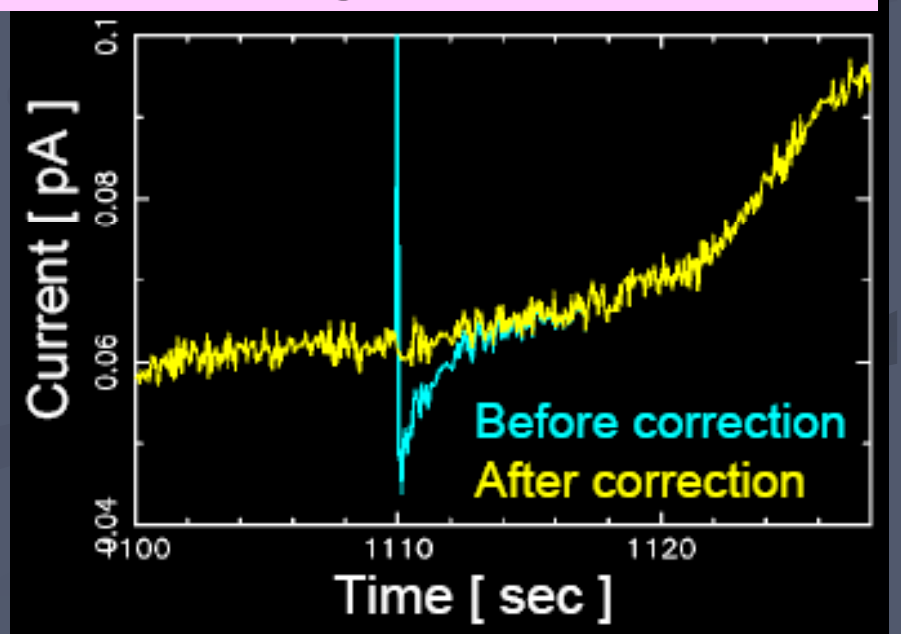




~60 % of glitches have tails with ~1 s

Tight correlation found between time constant and glitch parameters

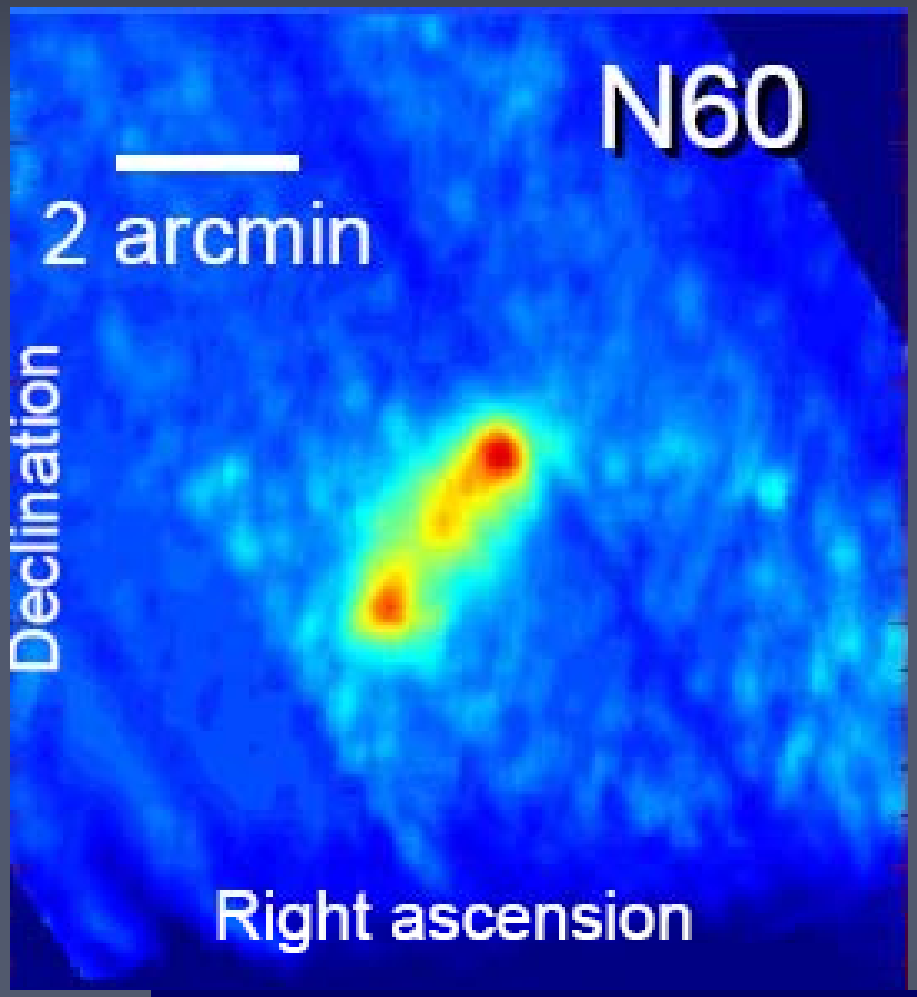


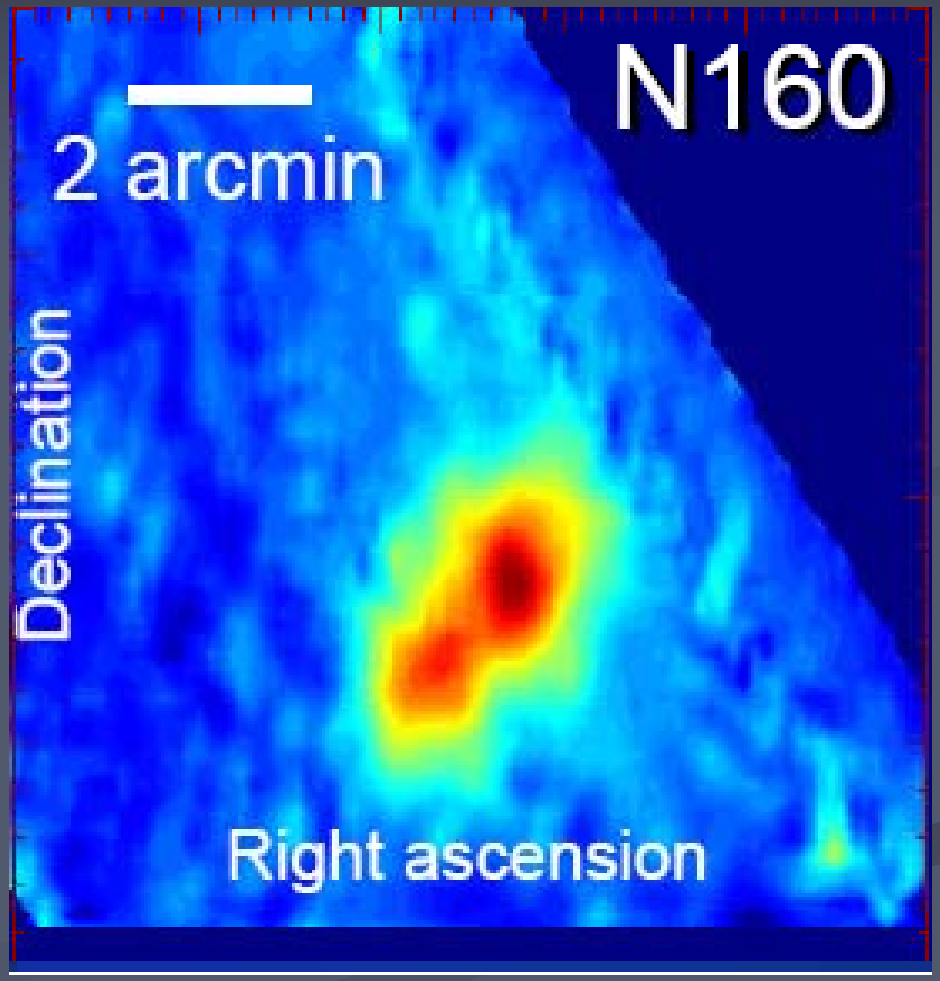


Results of Corrections for Glitches

Slow-scan observation of a nearby edge-on galaxy

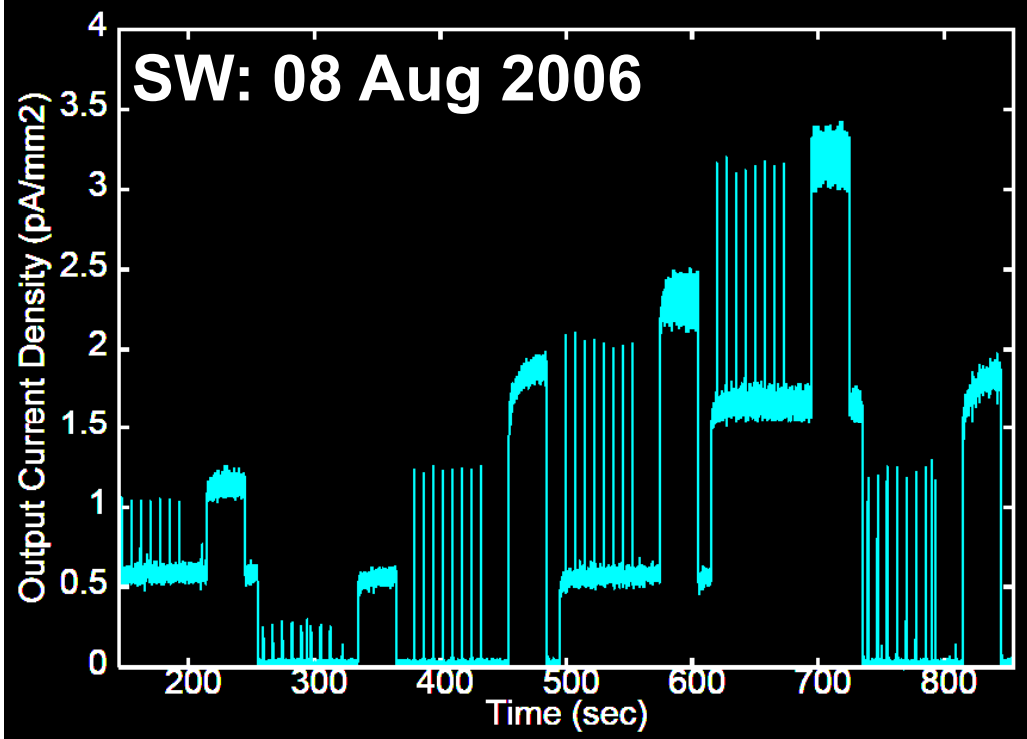
Slow scan: 7010-12 by Shirahata et al.

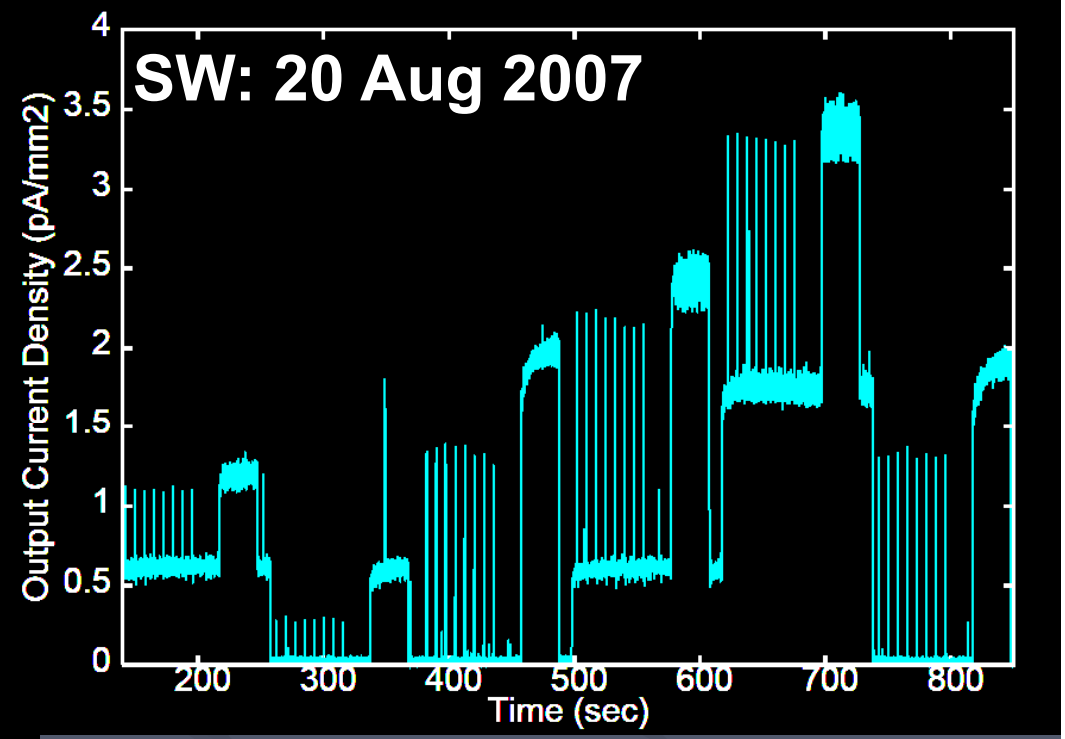




Successful removal of glitch spikes & after-effects

In-Orbit Measurements of Transients





No changes in properties of LW & SW transients in ~1 year.
LW is much severer than SW in transient behavior →
Difference in contact geometry (LW: transverse, SW: longitudinal)

Used as measures for transients of point sources in all-sky survey
General transient correction model is required.

Modeling for Transient Corrections

Simplified bulk equations:

$$\begin{cases} \dfrac{J}{A} = e\mu\, pE + \dfrac{\kappa}{4\pi}\dfrac{\partial E}{\partial t} \\ \dfrac{\partial E}{\partial x} = \dfrac{4\pi e}{\varepsilon} N(f - f_0) \\ N\dfrac{\partial f}{\partial t} = \dfrac{p - p_0}{\tau} \\ \int_0^l dx E(x,t) = V_0 \equiv E_0 l \end{cases}$$

$$eV_0 \gg T$$

Boundary condition for them:

$$p(0,t) = p^+ \exp[-e[\varphi_c + \Delta\varphi_c(t)]/T] =$$
$$= p_0 \exp[-e\Delta E(0,t)L/T]$$

$$p(0,t) = p_0 \exp[\Delta E(0,t)/Ej]$$

$$\Delta E(0,t) = E(0,t) - E_0$$

$$E_j = T/eL$$

$$L \approx \left(\kappa T \ln(N_d/p_0)/2\pi e^2 N_d\right)^{1/2}$$

Bulk equations + approximated boundary condition (Fouks 1981)

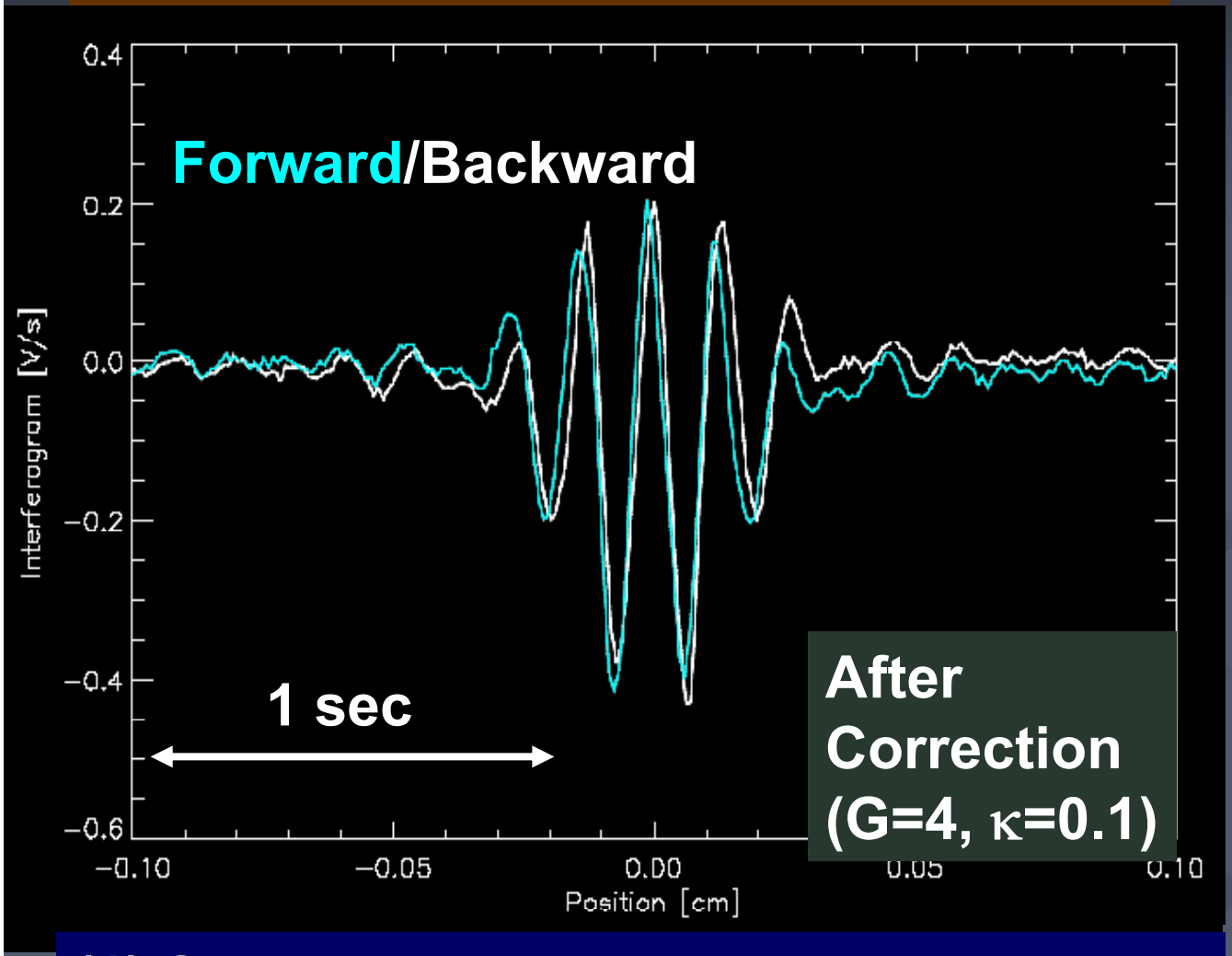
(1) $\mu\tau(E_0)$ E_0: bias field
(2) $\mu\tau(E)$ I-V curve
(3) Ej contact barrier

} are needed for numerical calculation.

Measured I-V curves. *G* and κ (=E_0/Ej) as variable parameters.

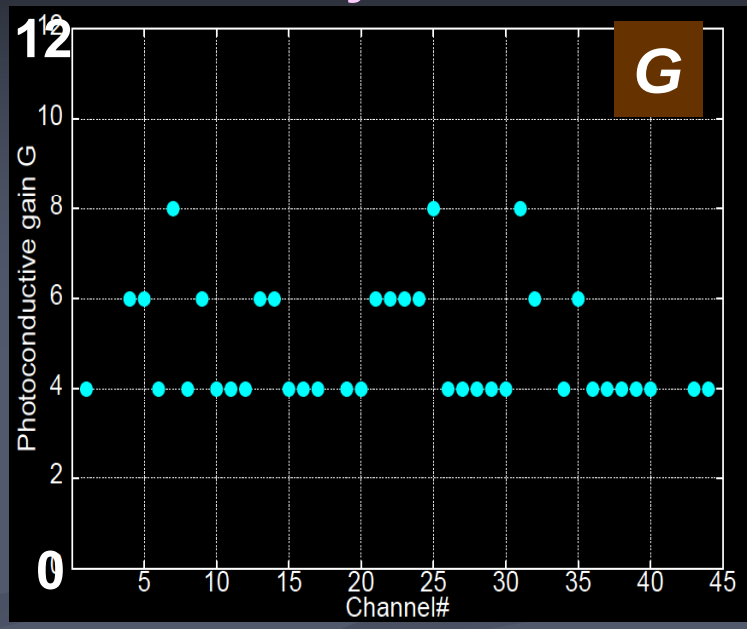
Results of Transient Corrections: FTS data

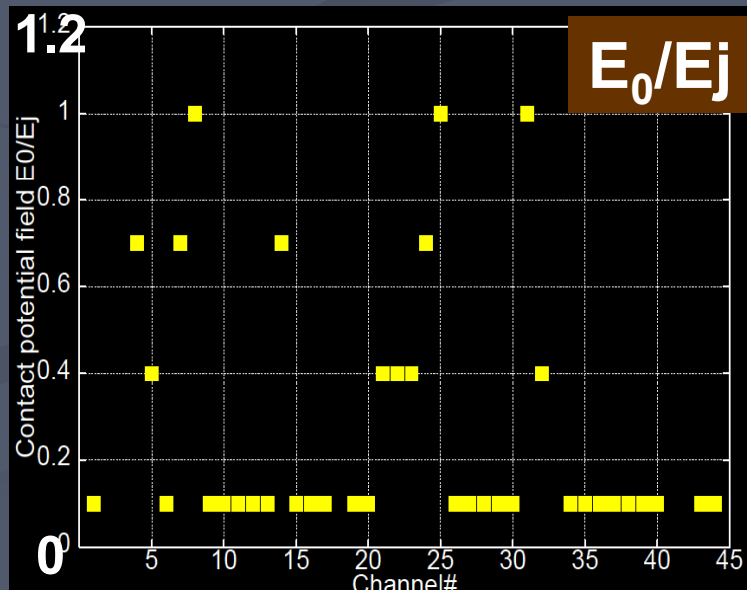
FTS interferogram of LW 34th channel



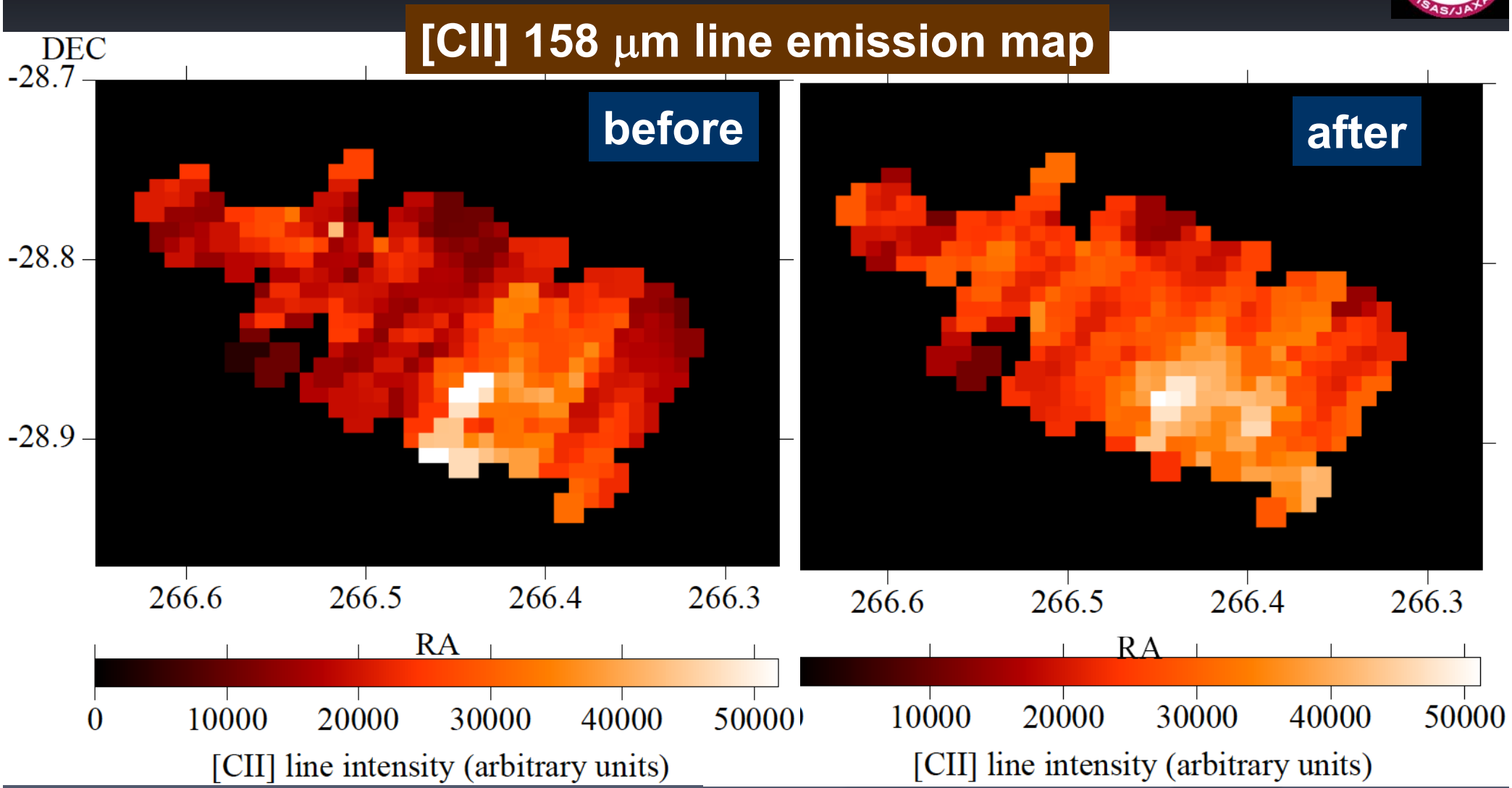
(1) Symmetry
(2) Coincidence between forward & back

FTS: 7010-14 by Kawada et al.



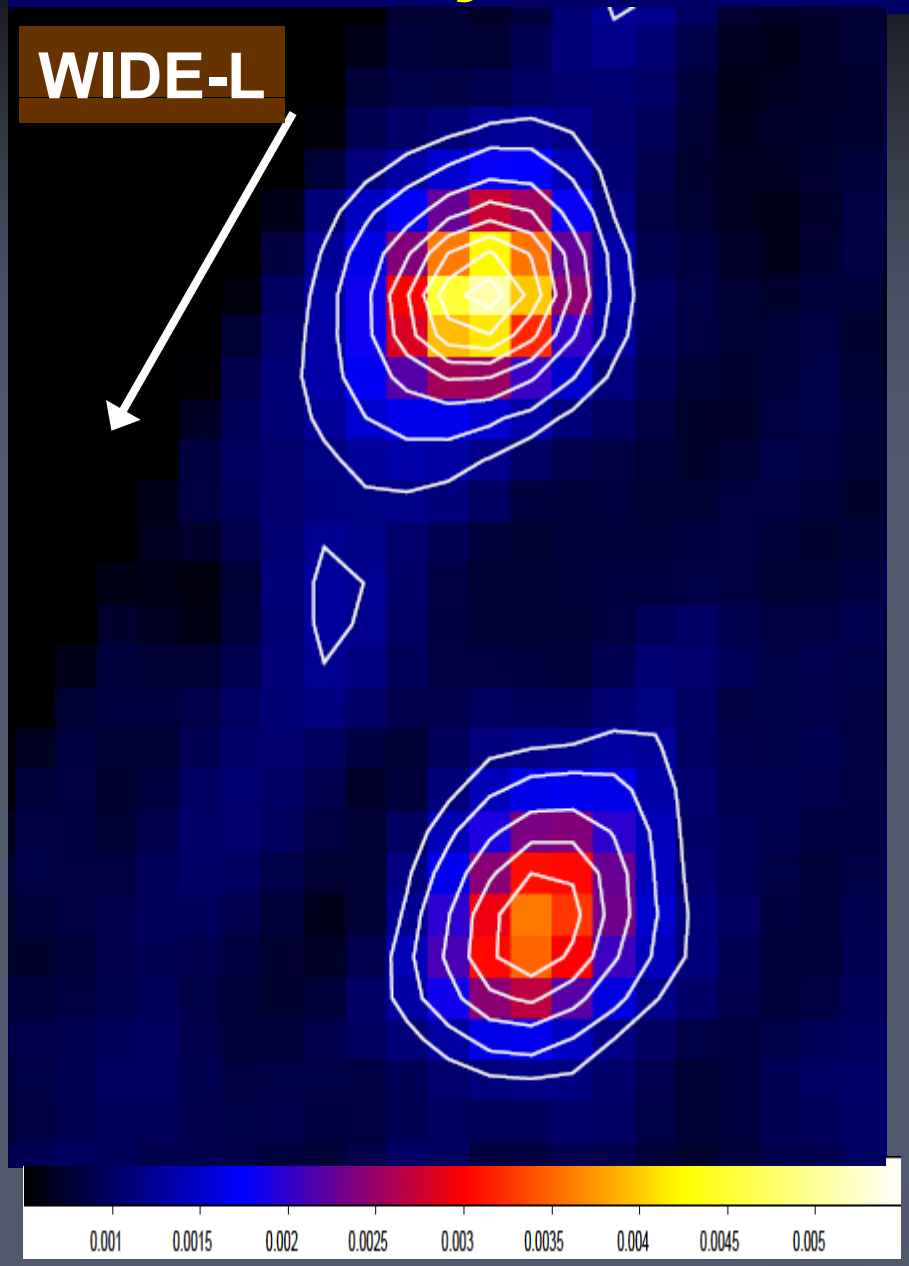


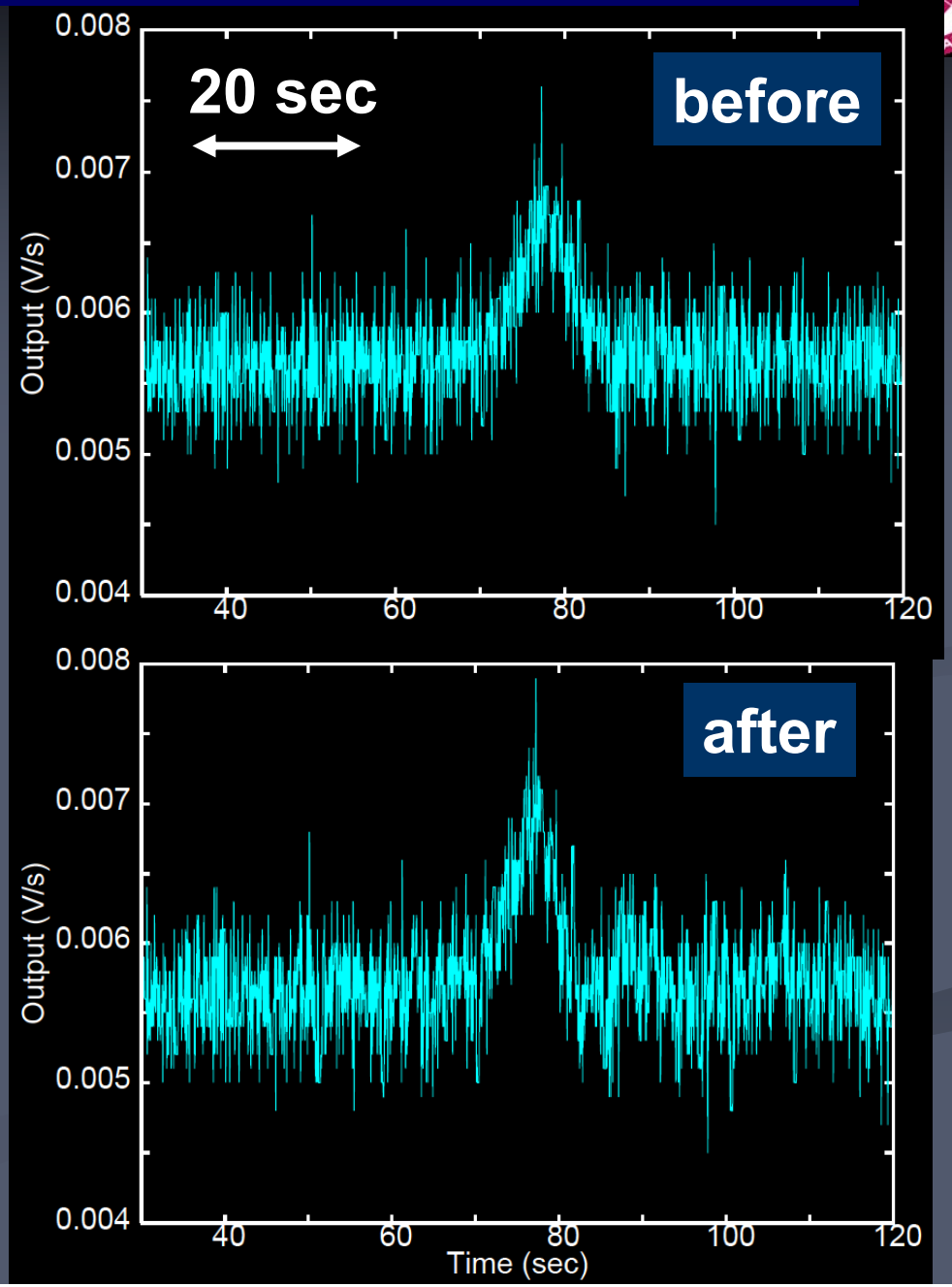
Effects of transient correction on line maps



Strategy:
Optimal parameters from FTS are applied to slow scan & survey.

Preliminary results of corrections: slow scan



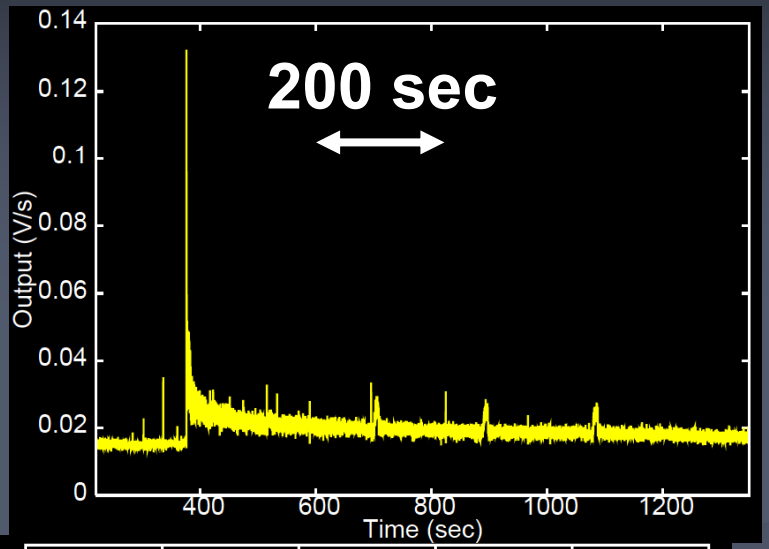


Slow scan: 7010-12 by Shirahata et al.

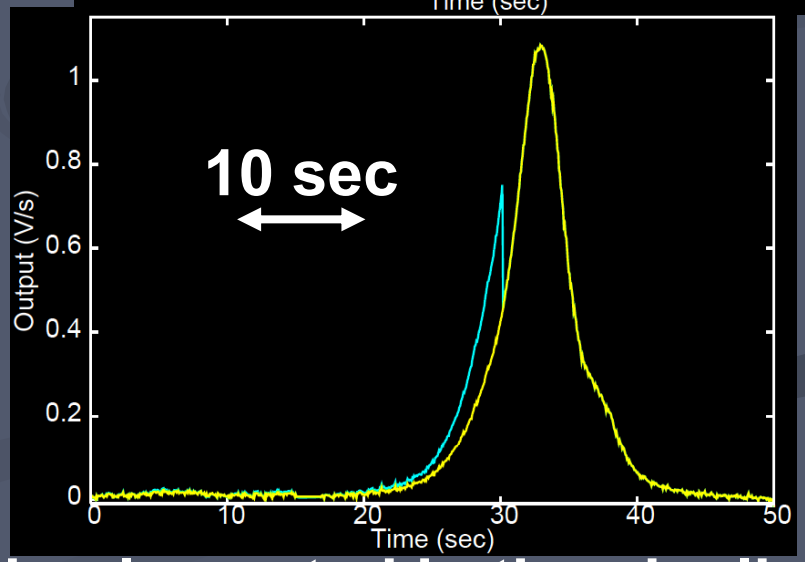
Summary & Future Work

(1) Separately treated for glitch effects and transient corrections.

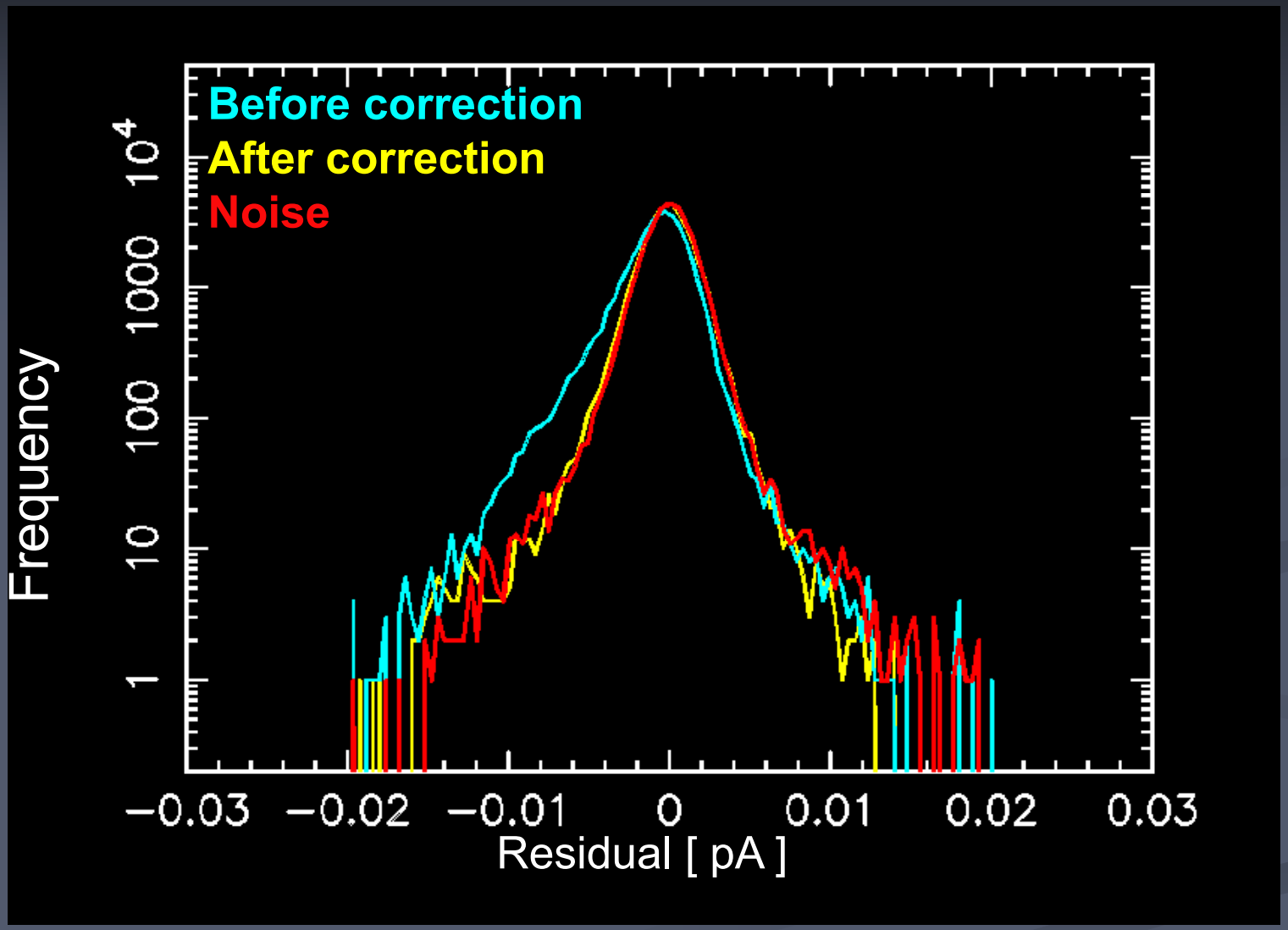
(2) Glitches: empirical model.
Successfully corrected for glitches with time scales up to ~10 s, but not for those with long tails:



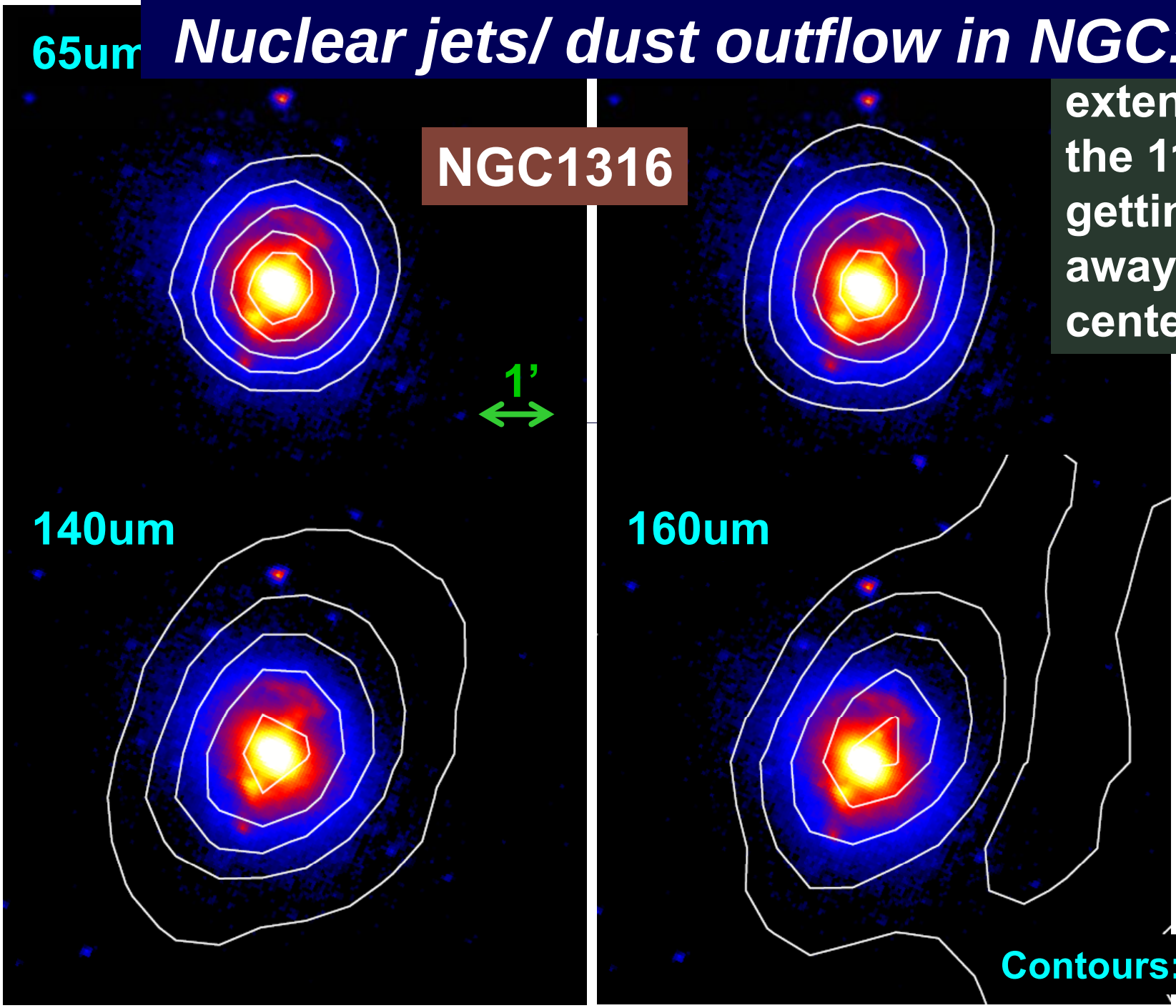
(3) Transients: physical model.
Almost successfully corrected for transients of FTS data.
Next steps to transients of slow-scan & all-sky survey.
Failure for very bright sources:



(4) Both corrections have not yet been implemented in the pipeline.

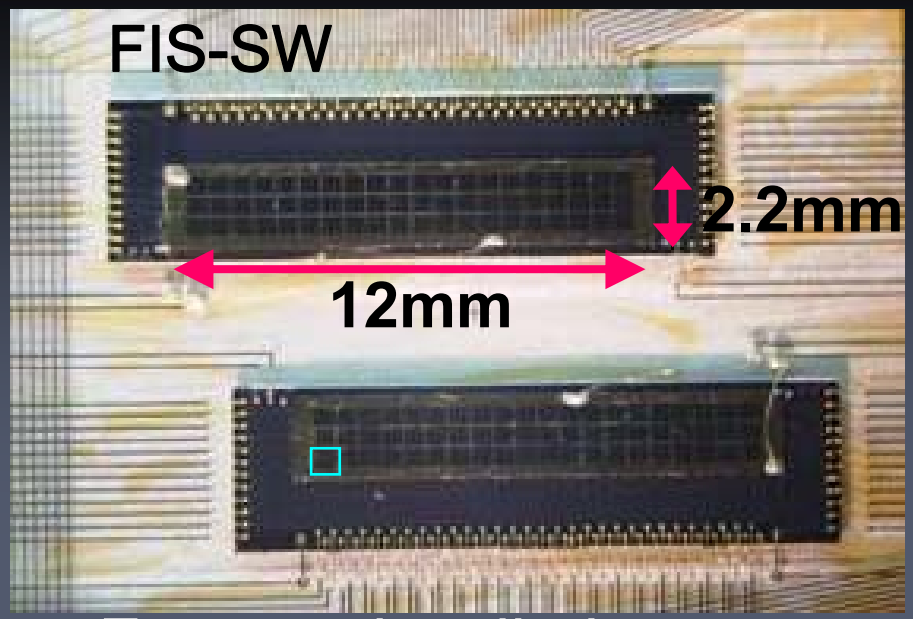

Before correction
After correction
Noise
Frequency
1
10
100
1000
10^4
−0.03
−0.02
−0.01
0
0.01
0.02
0.03
Residual [pA]

Nuclear jets/ dust outflow in NGC1316

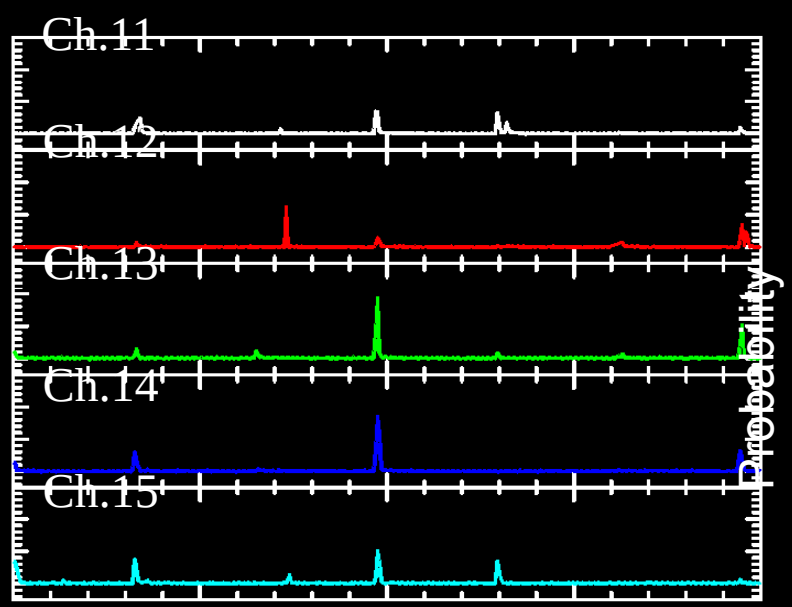


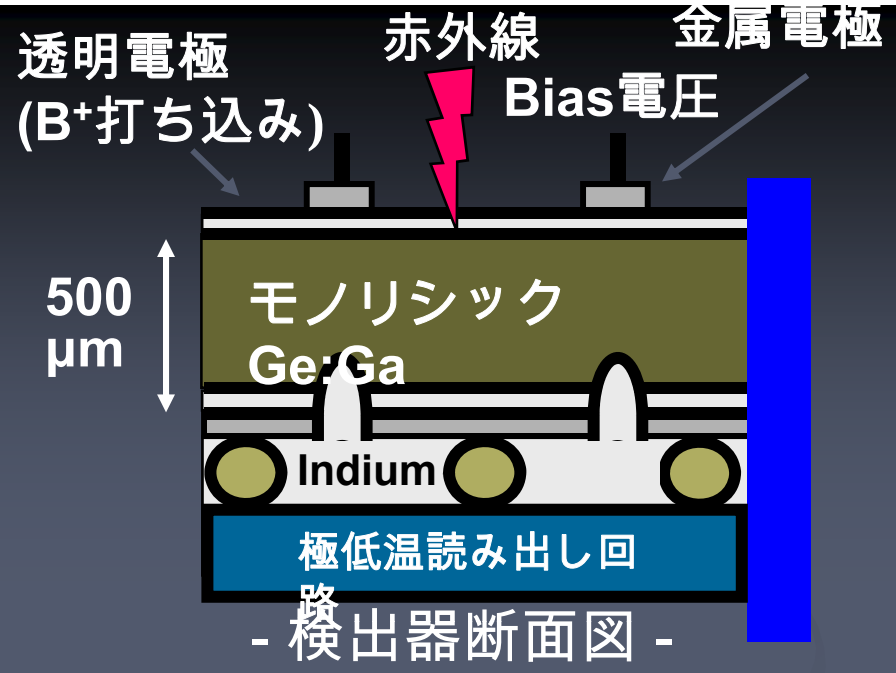
extending along the 11um jets, getting softer away from the center.

Contours: 10 - 80% log.

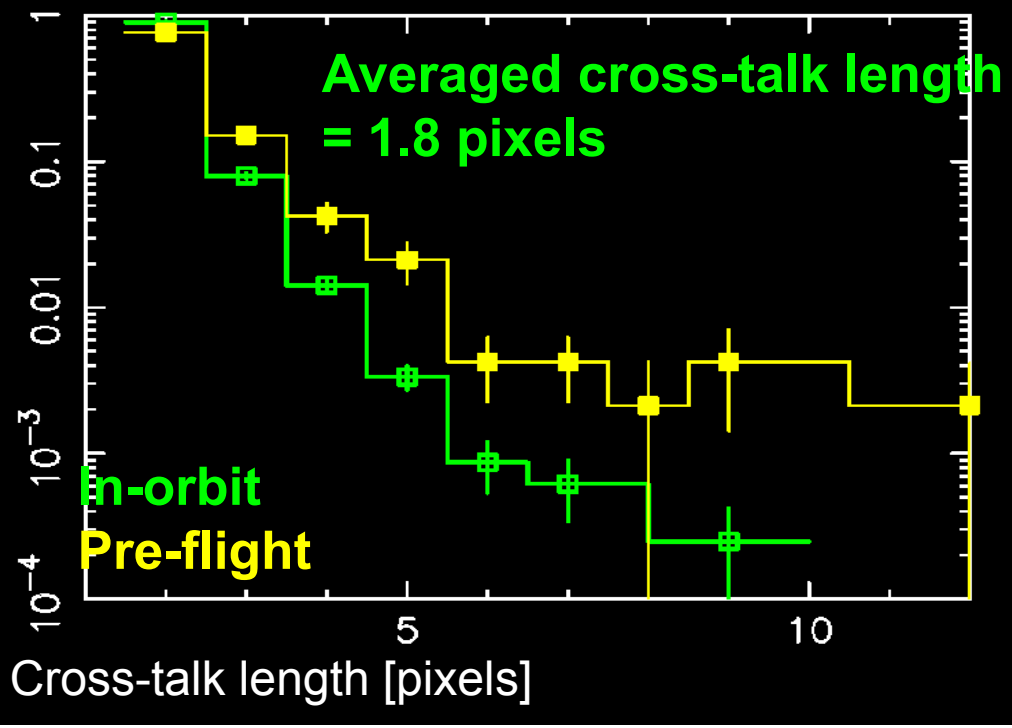


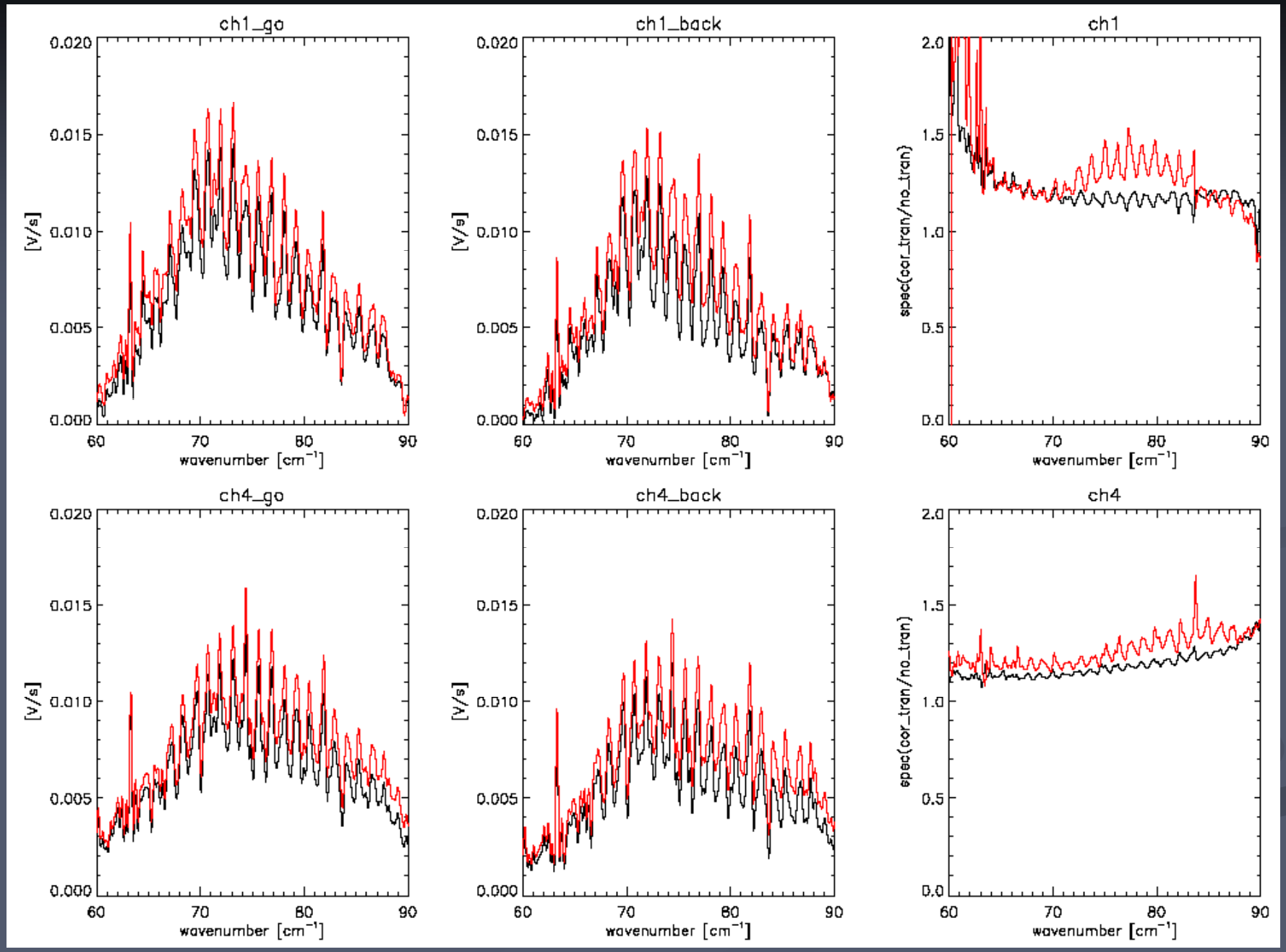
Face-on irradiation

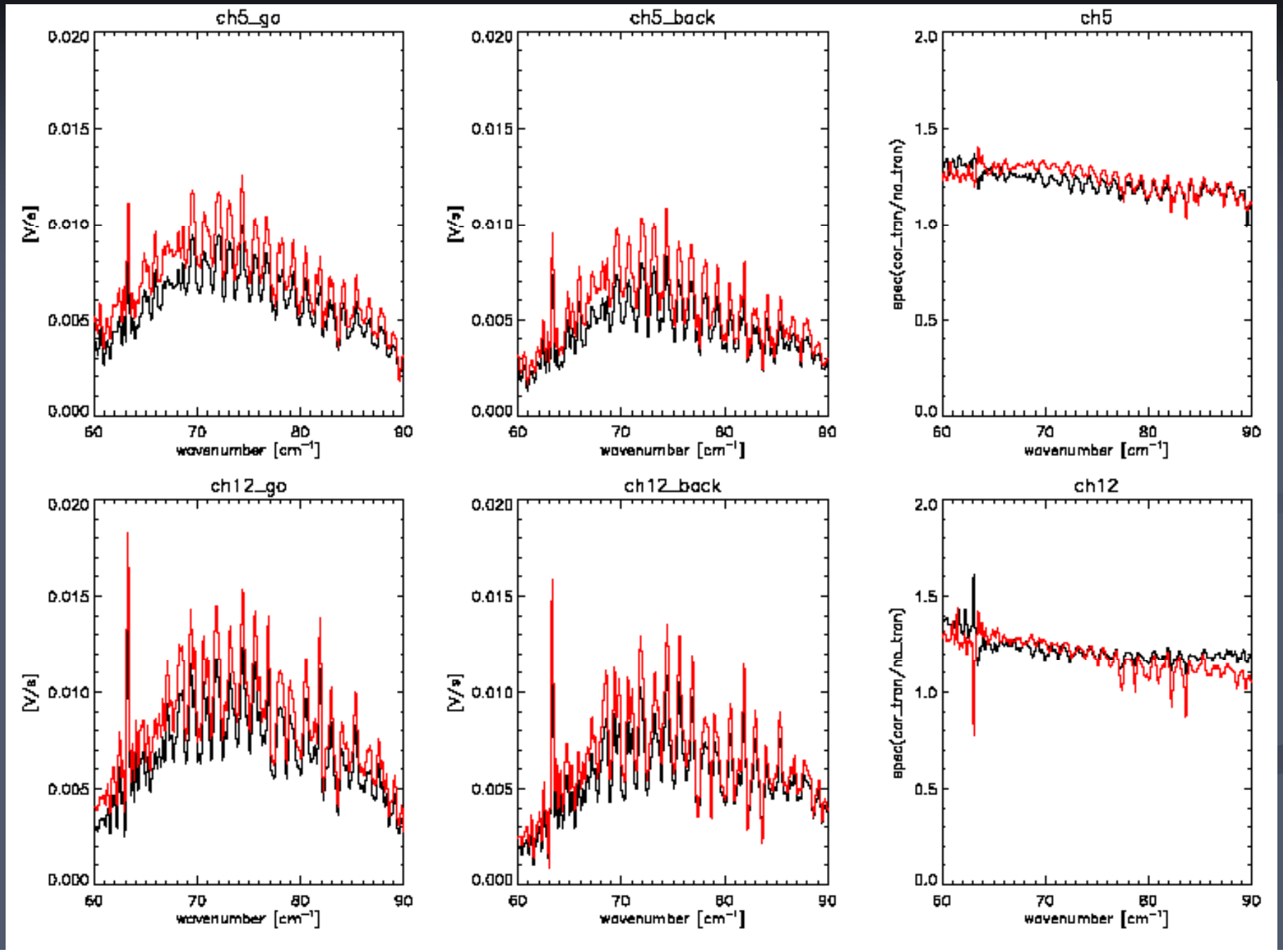




- 検出器断面図 -




ch1_go
ch1_back
ch1
ch4_go
ch4_back
ch4
[V/s]
spec(cor_tran/no_tran)
wavenumber [cm^{-1}]
0.000
0.005
0.010
0.015
0.020
0.0
0.5
1.0
1.5
2.0
60
70
80
90


ch5_go
ch5_back
ch5
ch12_go
ch12_back
ch12
[V/s]
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wavenumber [cm^{-1}]
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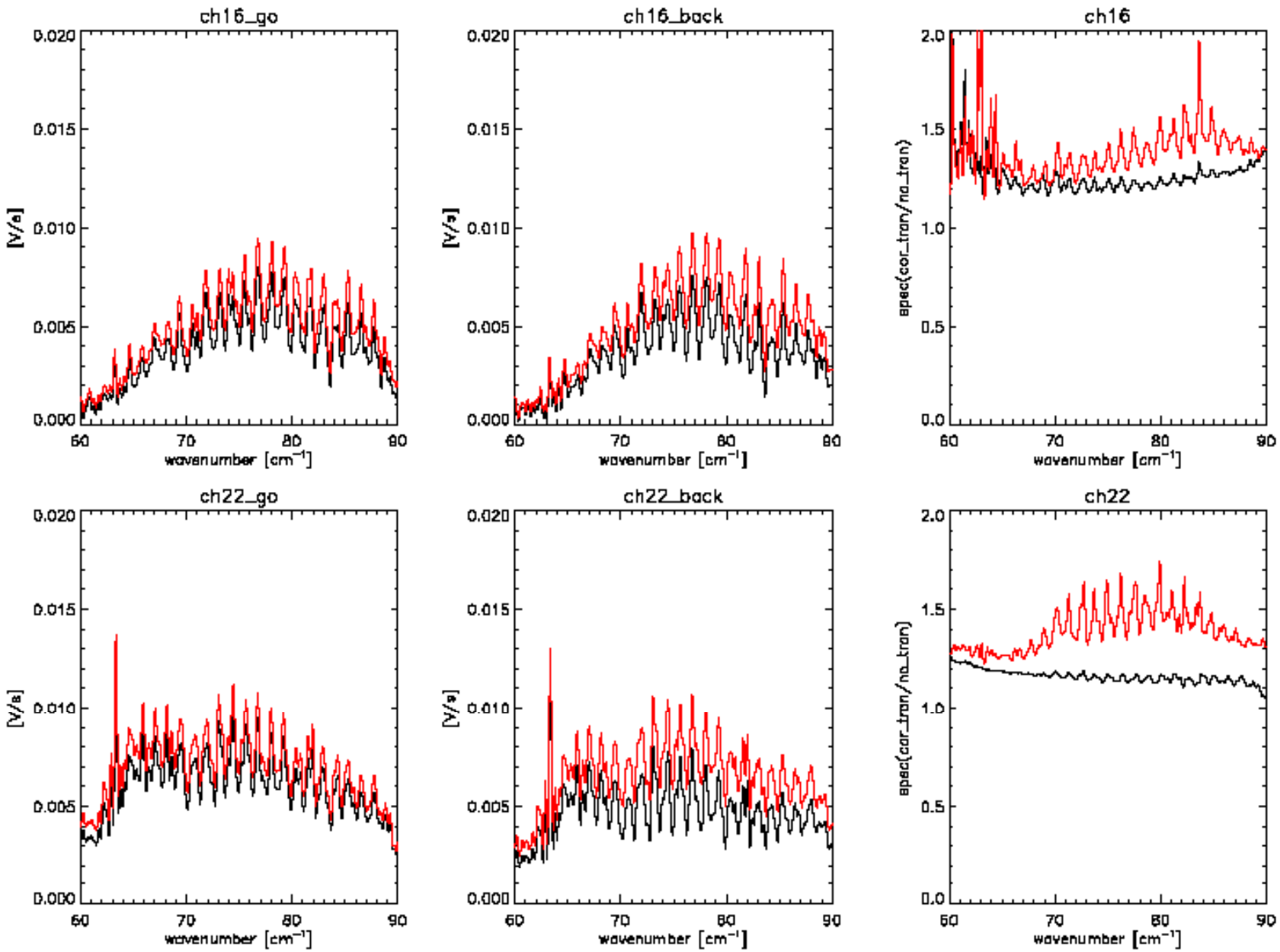
0.005
0.010
0.015
0.020
0.0
0.5
1.0
1.5
2.0
60
70
80
90


ch16_go
ch16_back
ch16
ch22_go
ch22_back
ch22
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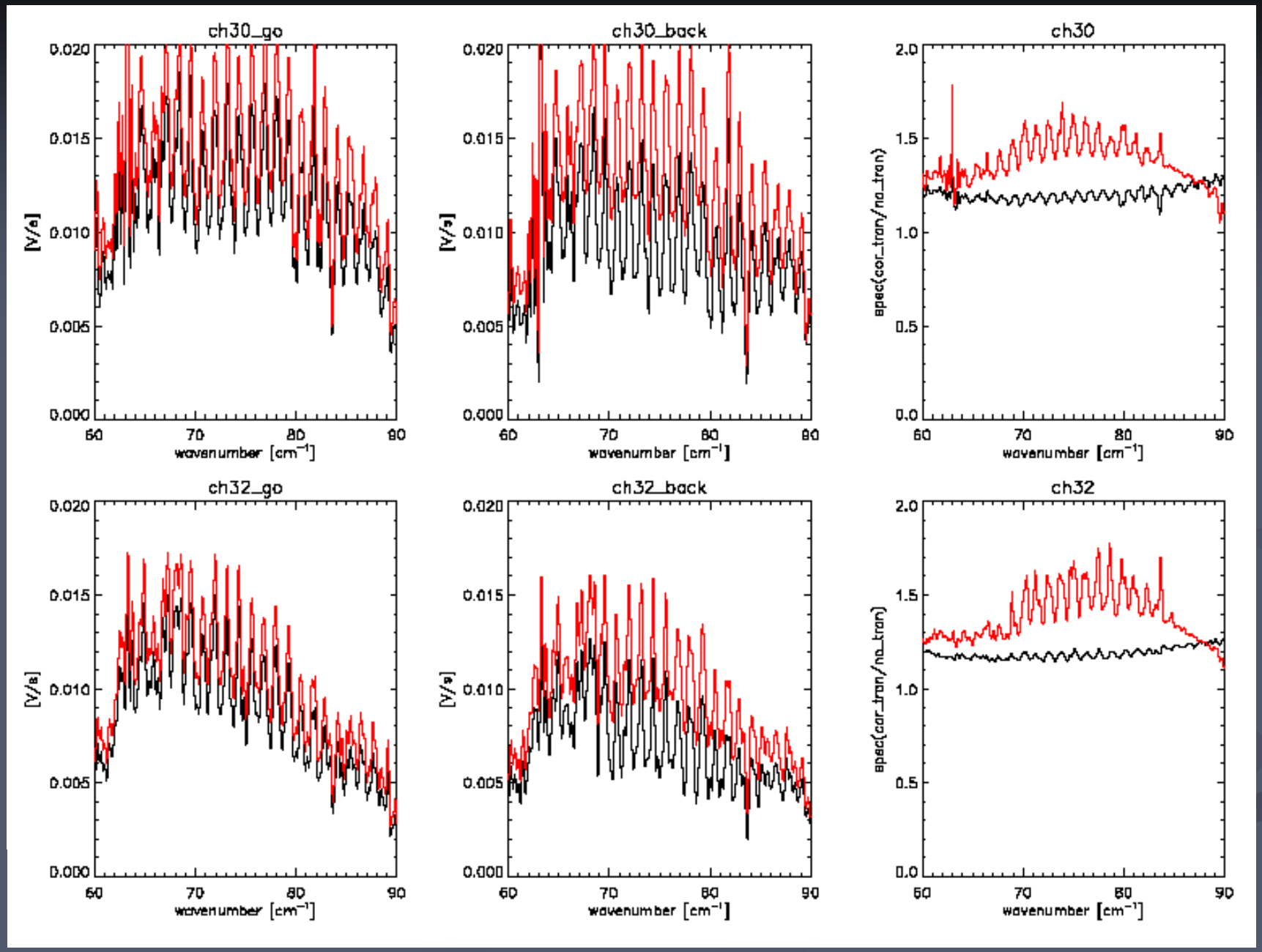
0.0
0.5
1.0
1.5
2.0
60
70
80
90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ch30_back
ch30
ch32_go
ch32_back
ch32
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wavenumber [cm^{-1}]
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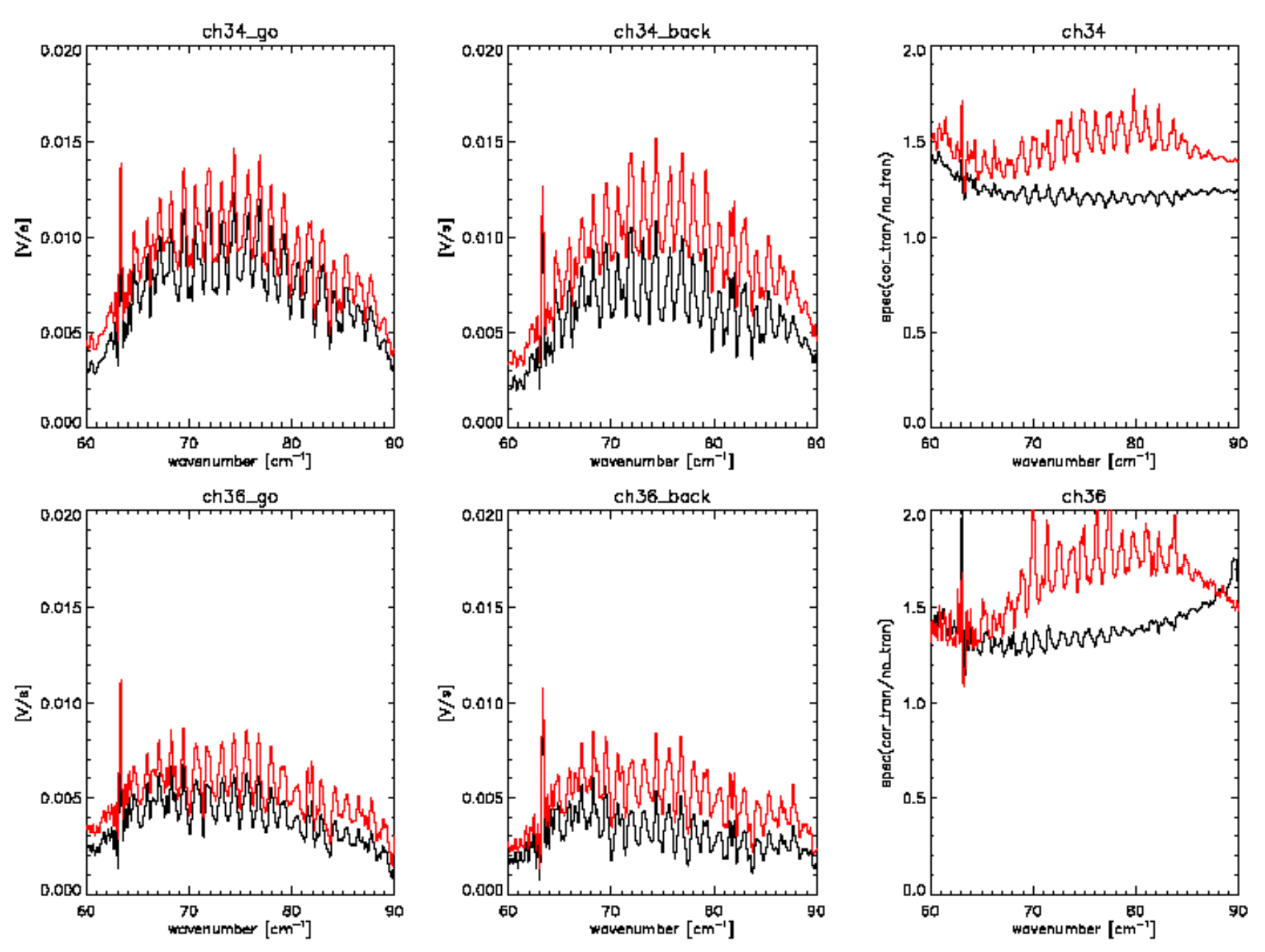
0.010
0.015
0.020
0.0
0.5
1.0
1.5
2.0
60
70
80
90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ch34_back
ch34
ch36_go
ch36_back
ch36
[V/s]
spec(cor_tran/no_tran)
wavenumber [cm^{-1}]
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0.005
0.010
0.015
0.020
0.0
0.5
1.0
1.5
2.0
60
70
80
90