X-ray Transient Localization Experiment aboard a micro-satellite for multi-messenger counterpart search

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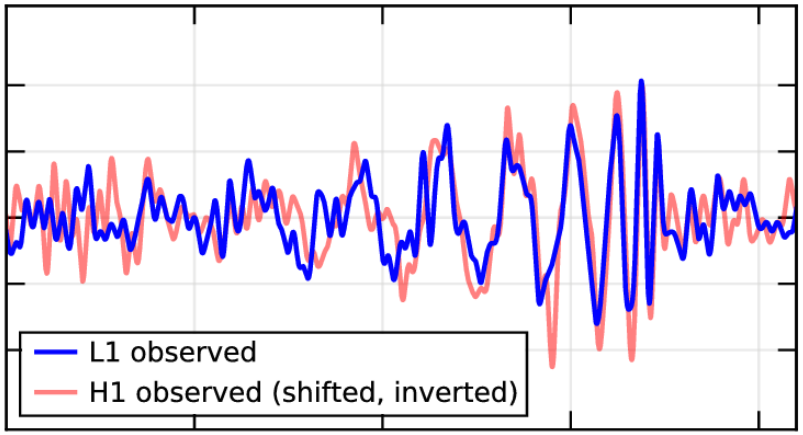
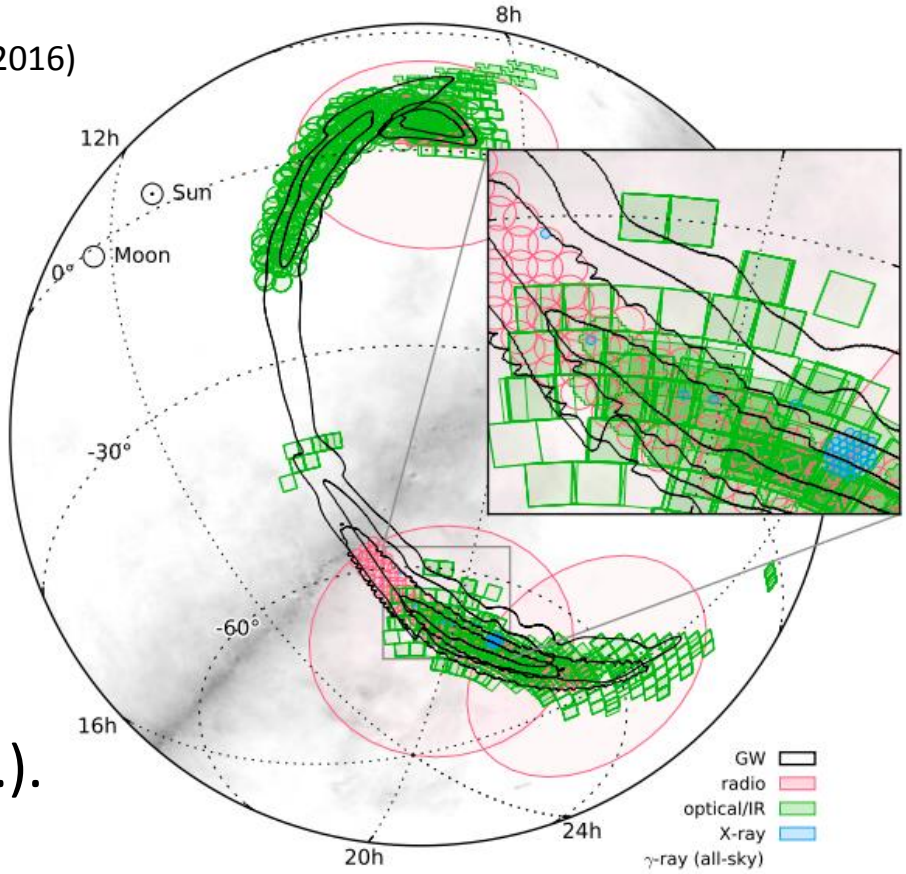
Era of Gravitational wave astronomy

GW 150914

The LIGO Scientific Collaboration, the Virgo Collaboration (2016)



B.P. Abbott+ **ApJL** 826 (2016)

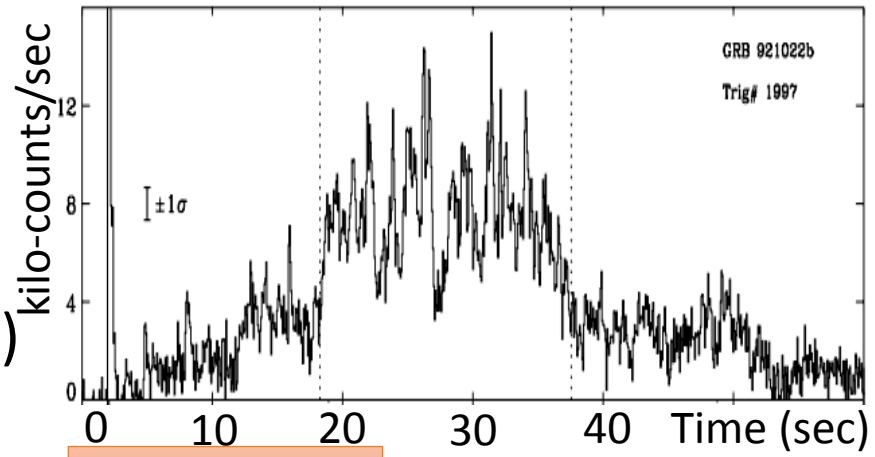


- The constraint on the position of GW 150914 is ~ 600 deg^2 (90% C.L.).
- Localization region for near future GW detector network will be still ~ 10 deg^2.
- Joint observation with EM radiation is necessary for identification of host galaxy.

Short GRBs as multi-messenger events

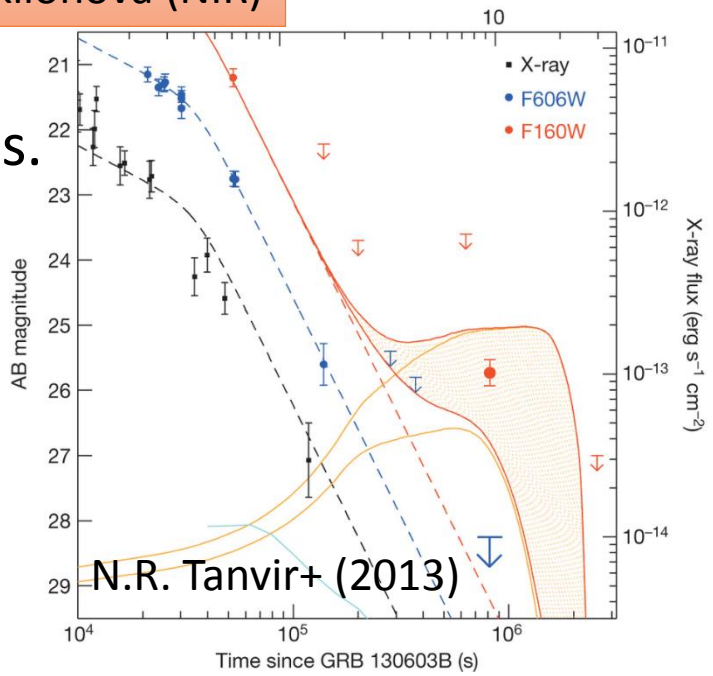
Hard prompt emission &
Soft X-ray extended emission

J.P.Norris & J.T.Bonnell (2006)

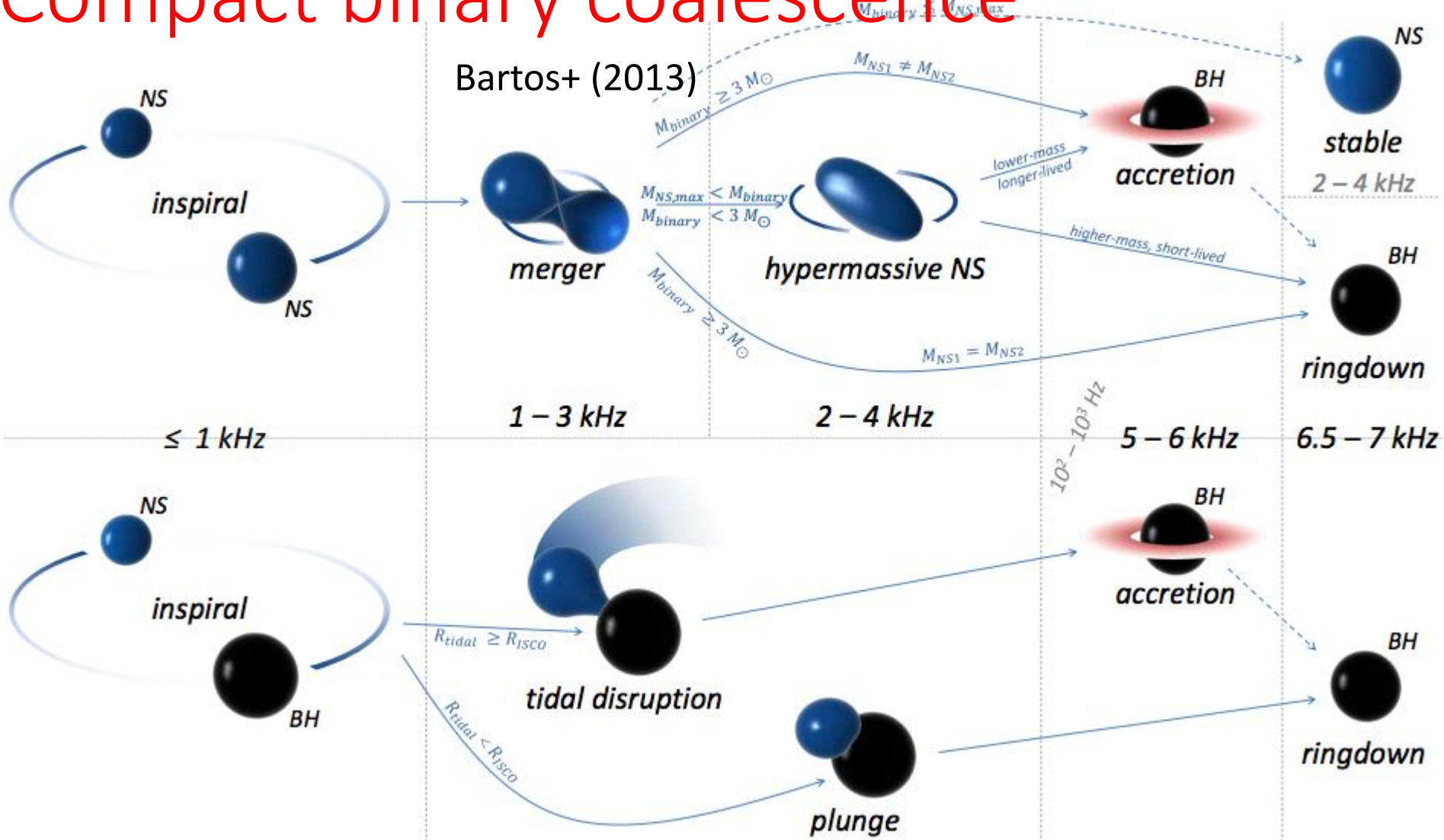


- ~ 10^{50} erg within 2 sec
- Soft X-ray Extended emission
  - 7% (CGRO-BATSE: Bostanci+ 2013)
  - 25% (Swift-BAT: Norris+ 2010)
  - 40% (Swift-BAT+XRT: Kagawa+ 2015)
- NS-NS/BH-NS mergers?
  e.g. Paczynski+ (1986)
  Eichler+ (1989)
- Some of them occur at early type galaxies.
  e.g. Belczynski+ (2006)
  Zheng & Ramirez-Ruiz (2007)
- NIR emission from
  r-process enriched ejecta

kilonova (NIR)



Compact binary coalescence



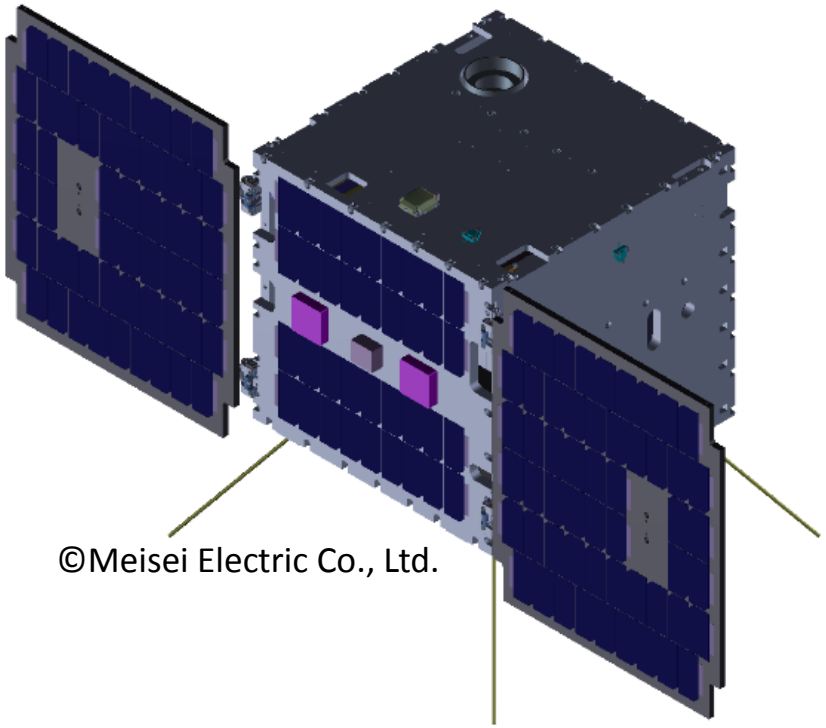
- A hypermassive neutron star (HMNS) possibly formed (Shibata+ 2005, 2006)
- Lifetime of HMNS: 1 msec – 1 sec
- Which branch is related to the formation of SGRBs?

Micro-satellite “Kanazawa-SAT^3”

Mission objectives

- To monitor if there are X-ray transients associated with gravitational wave events
- To provide the position and timing info. of X-ray transients to other telescopes

Satellite & Payload Configuration (preliminary)	
Mission Life	> 1 year
Satellite Size	50 cm × 50 cm × 50 cm
Satellite Weight	~ 50 kg
Launch Target	late 2018 or 2019
Detector	1-d coded aperture imaging
Energy Range	1 - 20 keV
Detector Size	0.3mm pitch coded mask 6.4 cm × 7.68 cm × 2 ~ 100 cm^2
Localization Accuracy	~ 15 arcmin (geometrical)
Field of View	~ 1 str



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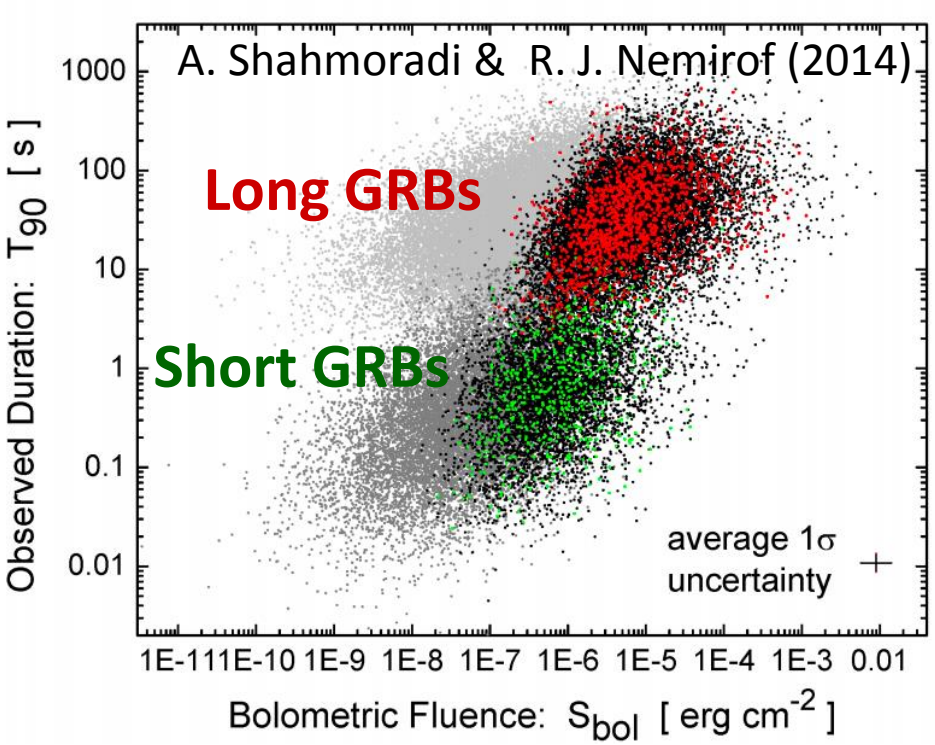
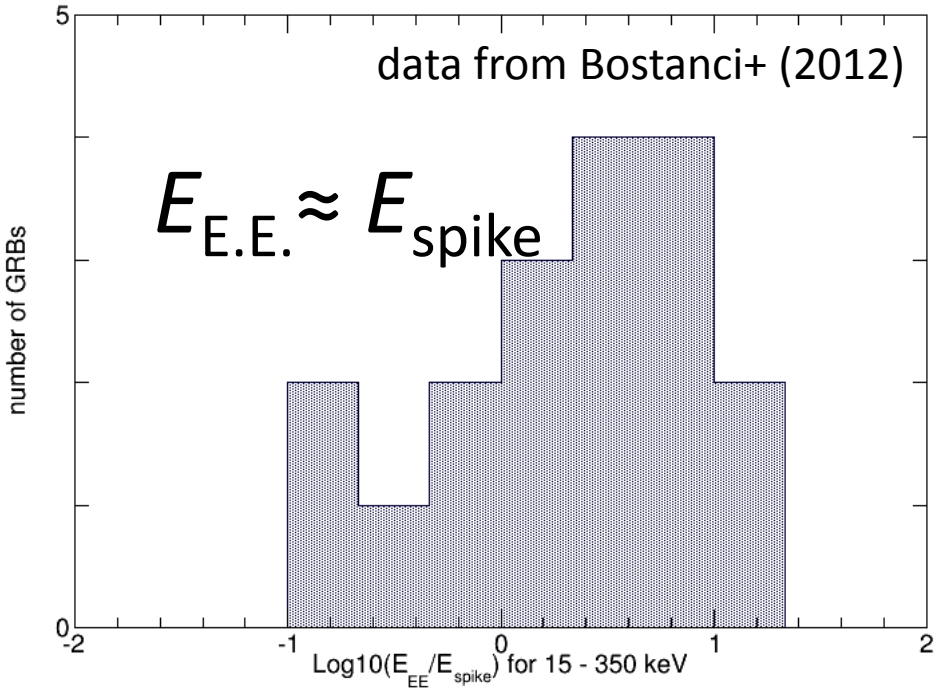
Detector Sensitivity





Normal Short GRBs (10^{-6} erg/cm^2) with T-LEX (1 – 20 keV, 1 sr, 100 cm^2)

Prompt burst fluence : ~ 150 photons (@*E*p = 500 keV)

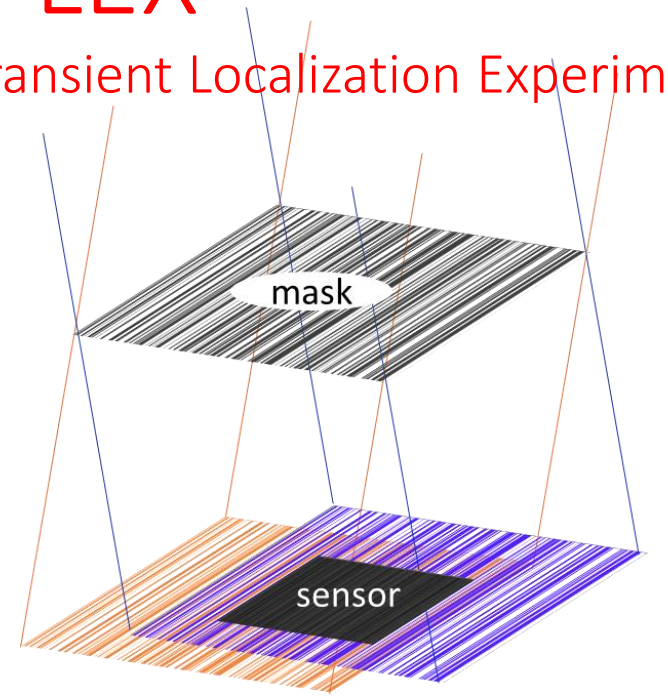
Extended Emission : ~ 5000 photons (given $\propto E^{-2}$)

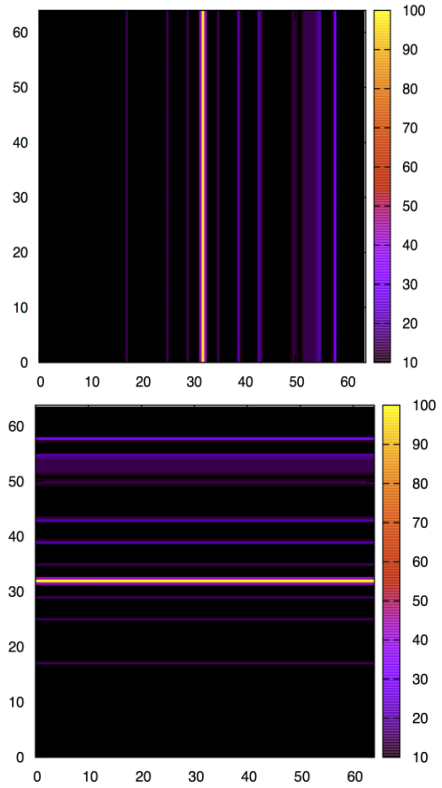
Cosmic X-ray Background : ~ 100 photons @ 0.1 sec

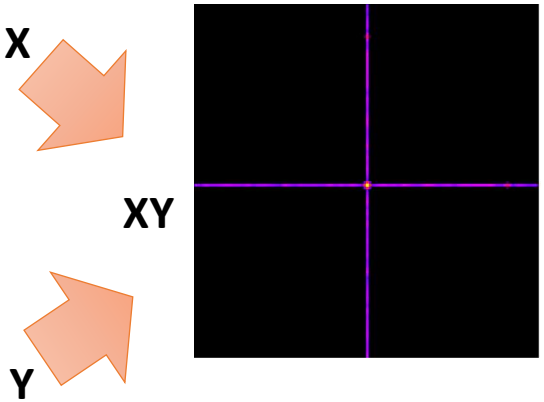
Nearby SGRBs are > 10x brighter due to the geometrical effect.
We can observe them by small instruments with 100 cm^2.

T-LEX

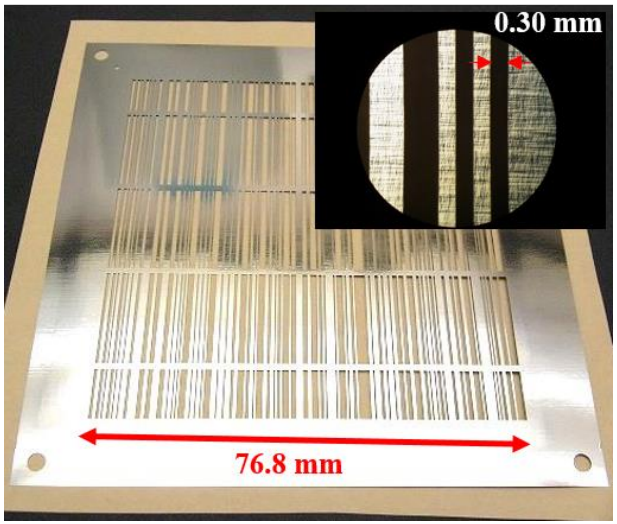
(Transient Localization Experiment)







Cross correlation between X-ray intensity pattern and mask pattern

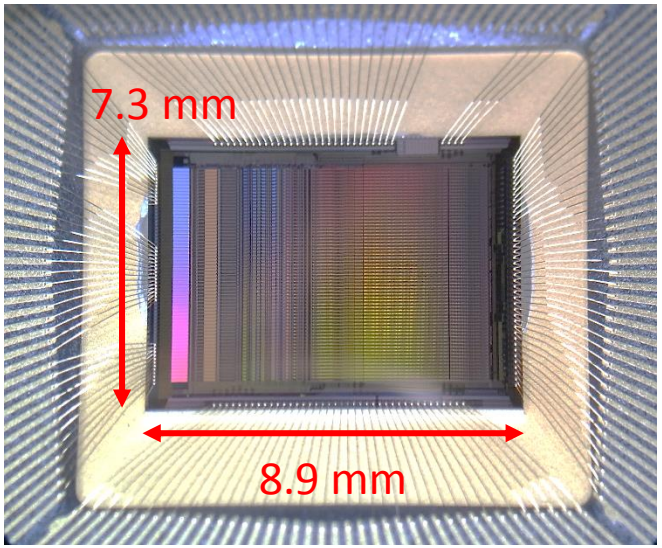


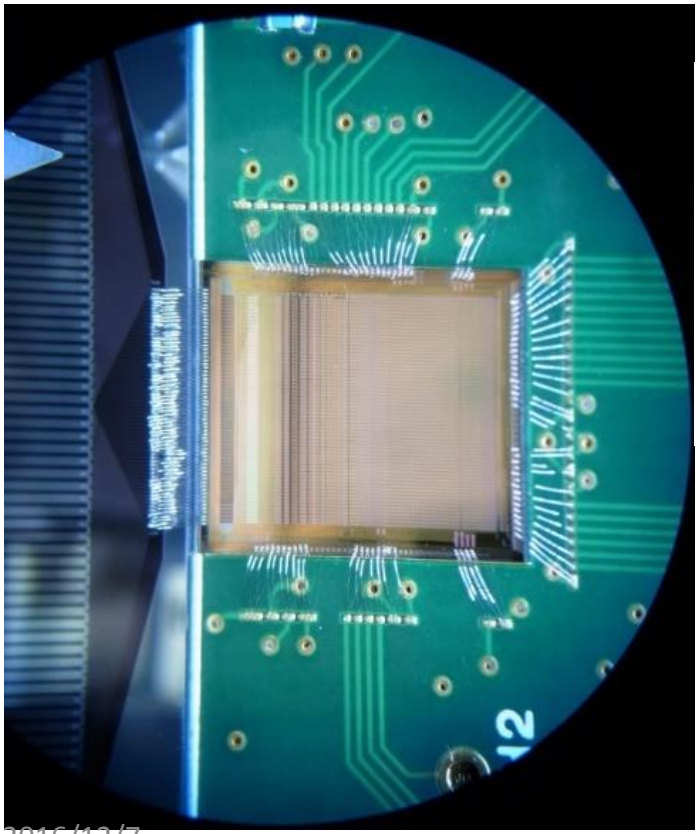
tungsten random aperture mask

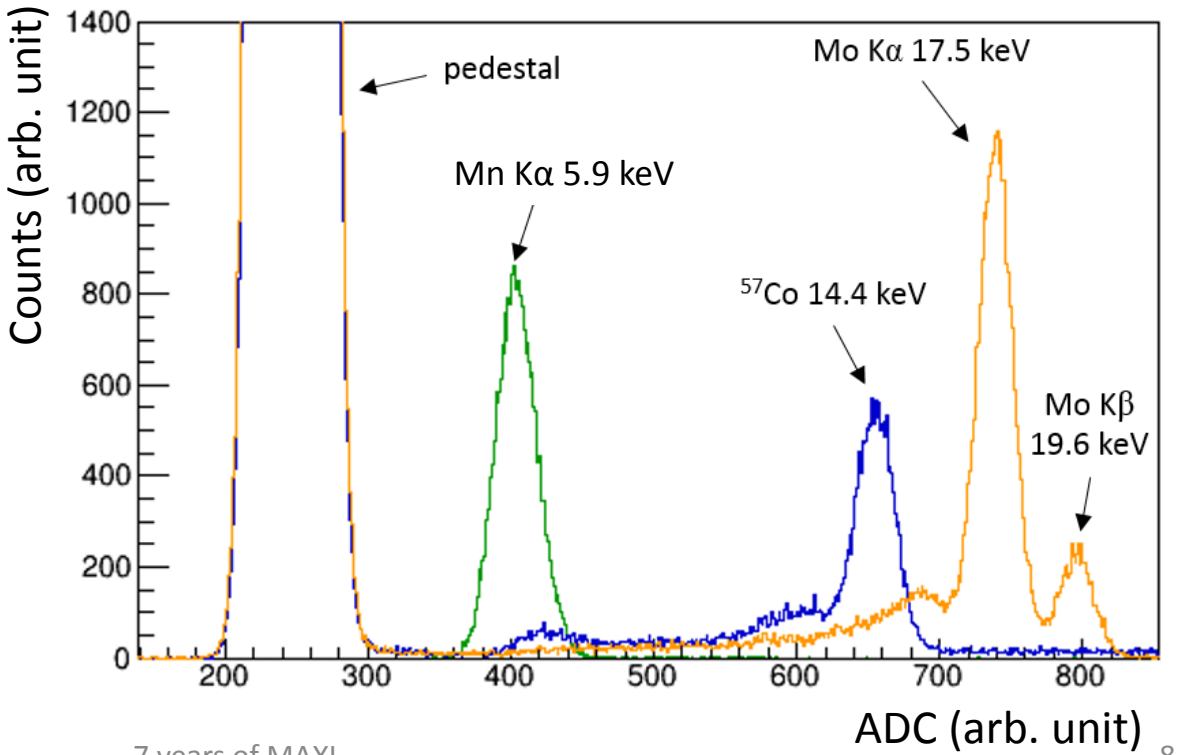
silicon strip detector (SSD)

Readout ASIC

- 64-channel analog inputs
- very high gain of ~ 750 mV/fC
- 10-bit Wilkinson-type ADCs
- Power consumption of ~ 2 mW/ch

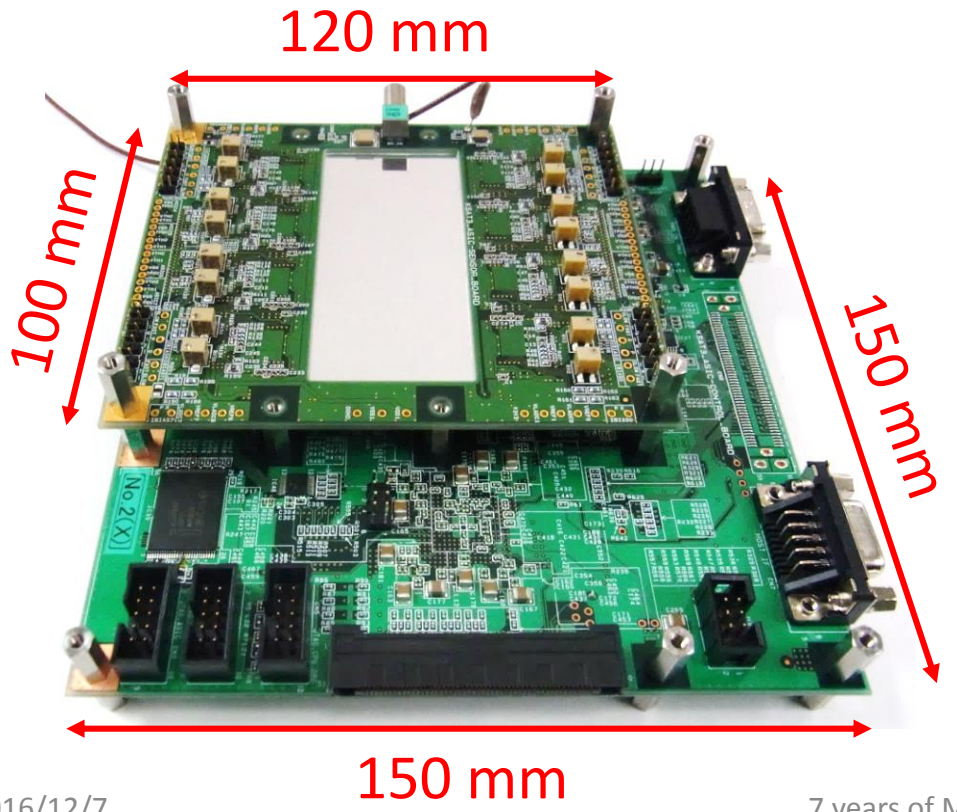






engineering model

- 256 x 2 channel strips
- Effective area ~ 25 cm^2
  (1/2 scale of flight model)
- 8 readout ASICs



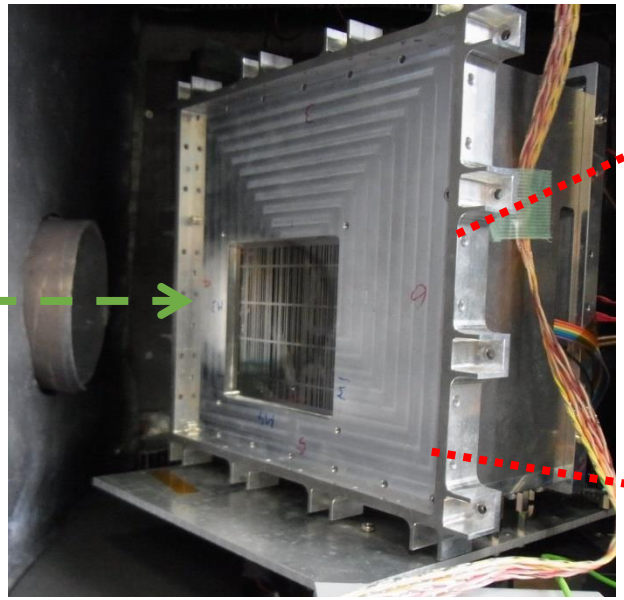
Sensor board

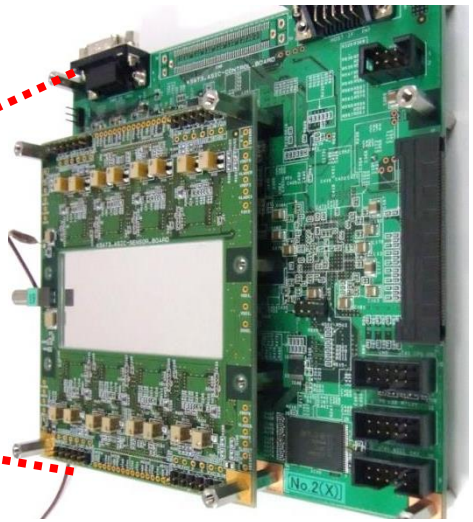
Control board

imaging test setup

Beamline at lab. of Kanazawa Univ.

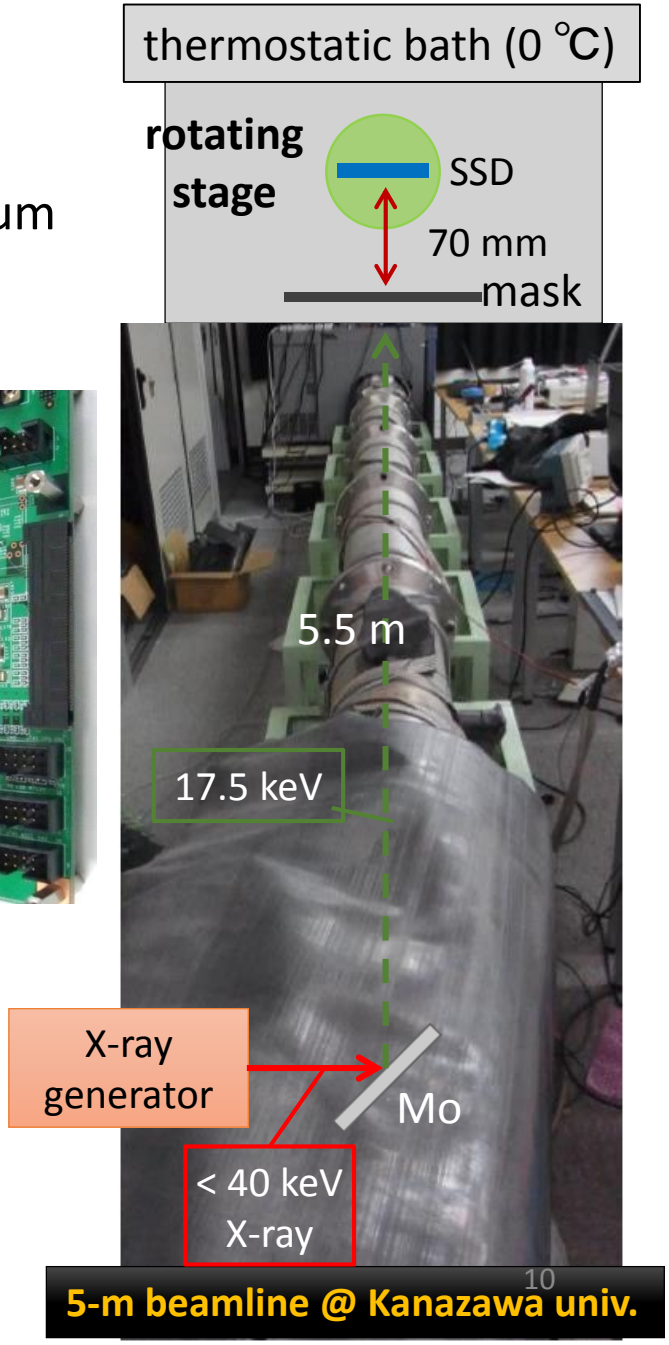
- Mono-energy of 17.5 keV produced from molybdenum
- Source divergence ~ 20 arcmin.





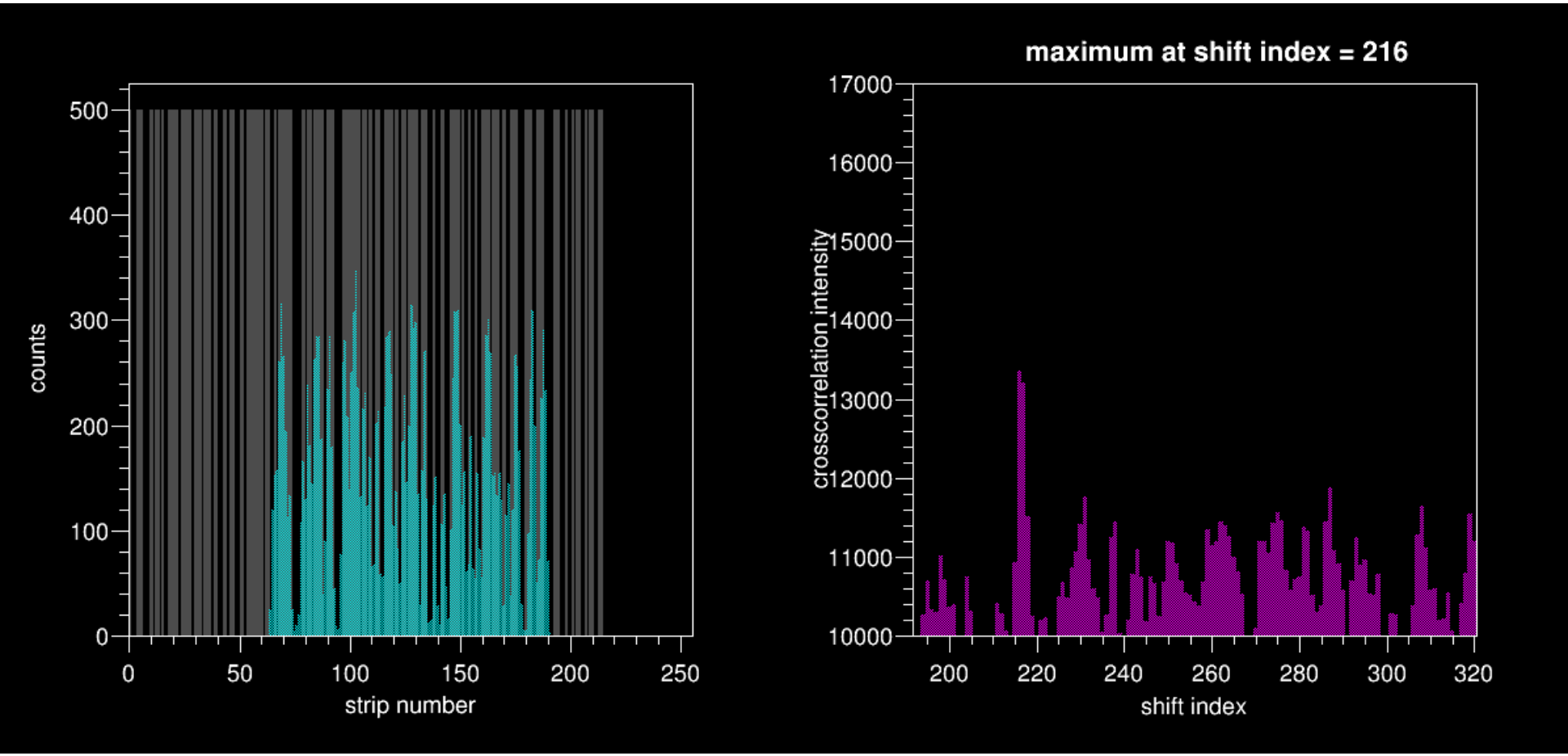
Detector

- Engineering Model
- tungsten mask with a thickness of 35 μm
- Geometrical angular resolution of 15 arcmin.



imaging test result

1 shift index corresponds
15 arcminutes for the line-of-sight.



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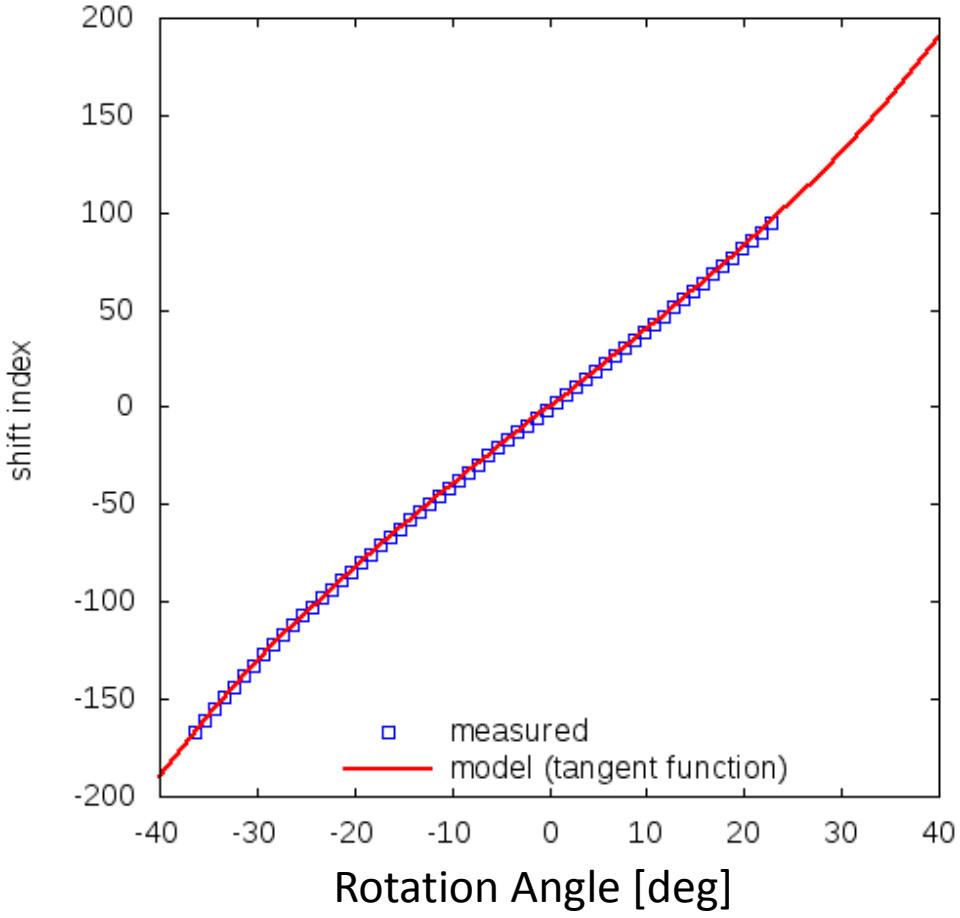

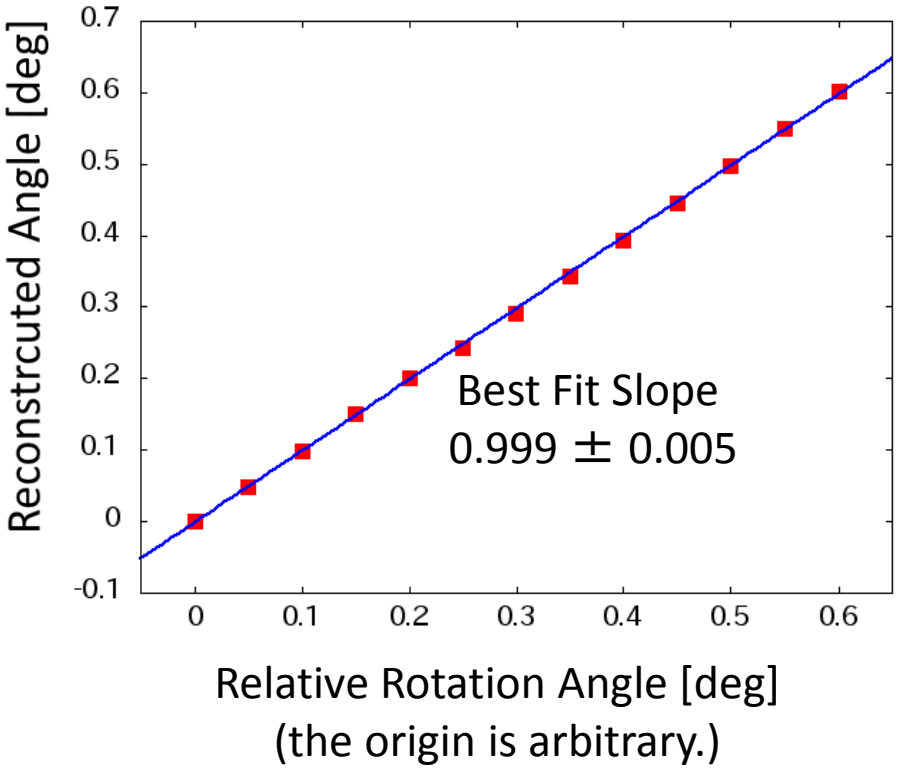

Summary

- Kanazawa-SAT^3
  - to monitor if there are X-ray transients associated with gravitational wave events
  - to provide the position and timing info. of X-ray transients to other telescopes
  - planned to be launched in late 2018 or 2019
- T-LEX Detector
  - developed an Engineering Model
  - considered that basic design of EM is OK
  - design of the Flight Model in progress