X-ray Imager for Gamma-ray Bursts Associated with Gravitational Waves

Tatsuya Sawano (Kanazawa University)

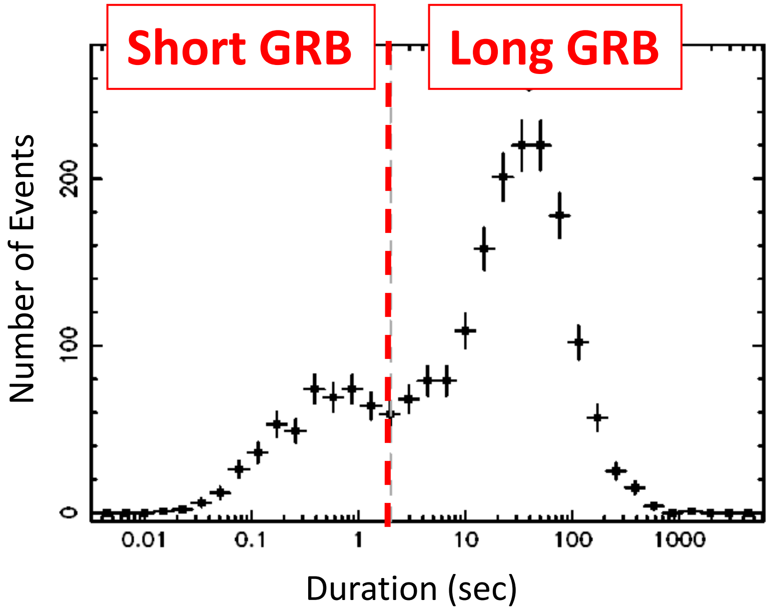
Short GRB formation rate

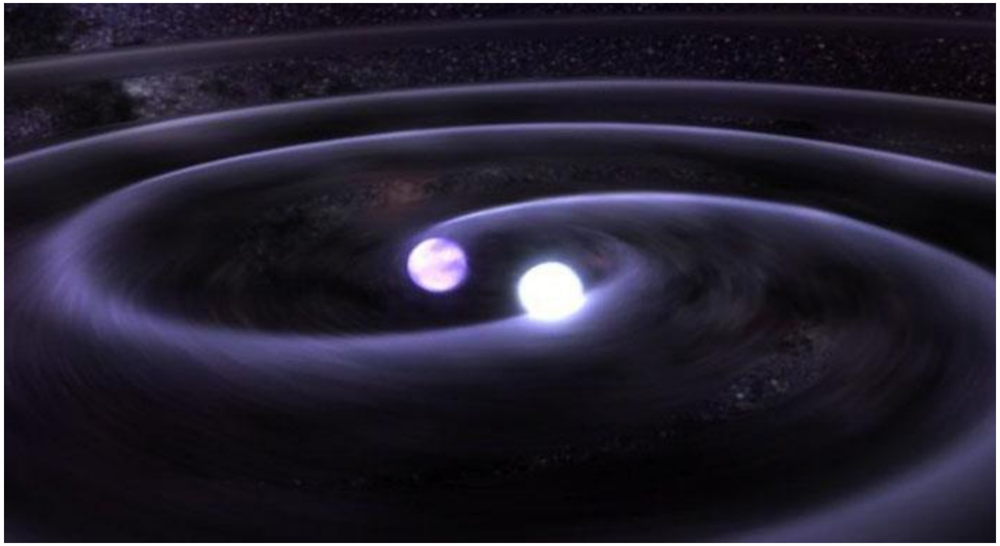
Daisuke Yonetoku (Kanazawa U.), Takashi Nakamura (Kyoto U.), Keitaro Takahashi (Kumamoto U.), and Asuka Toyanago (Kanazawa U.)

Detector development

Daisuke Yonetoku, Shunsuke Takata, Hiroki Seta, Kazuki Yoshida, Asuka Toyanago (Kanazawa U.), Hirokazu Ikeda, and Atsushi Harayama (ISAS/JAXA)

Short GRBs





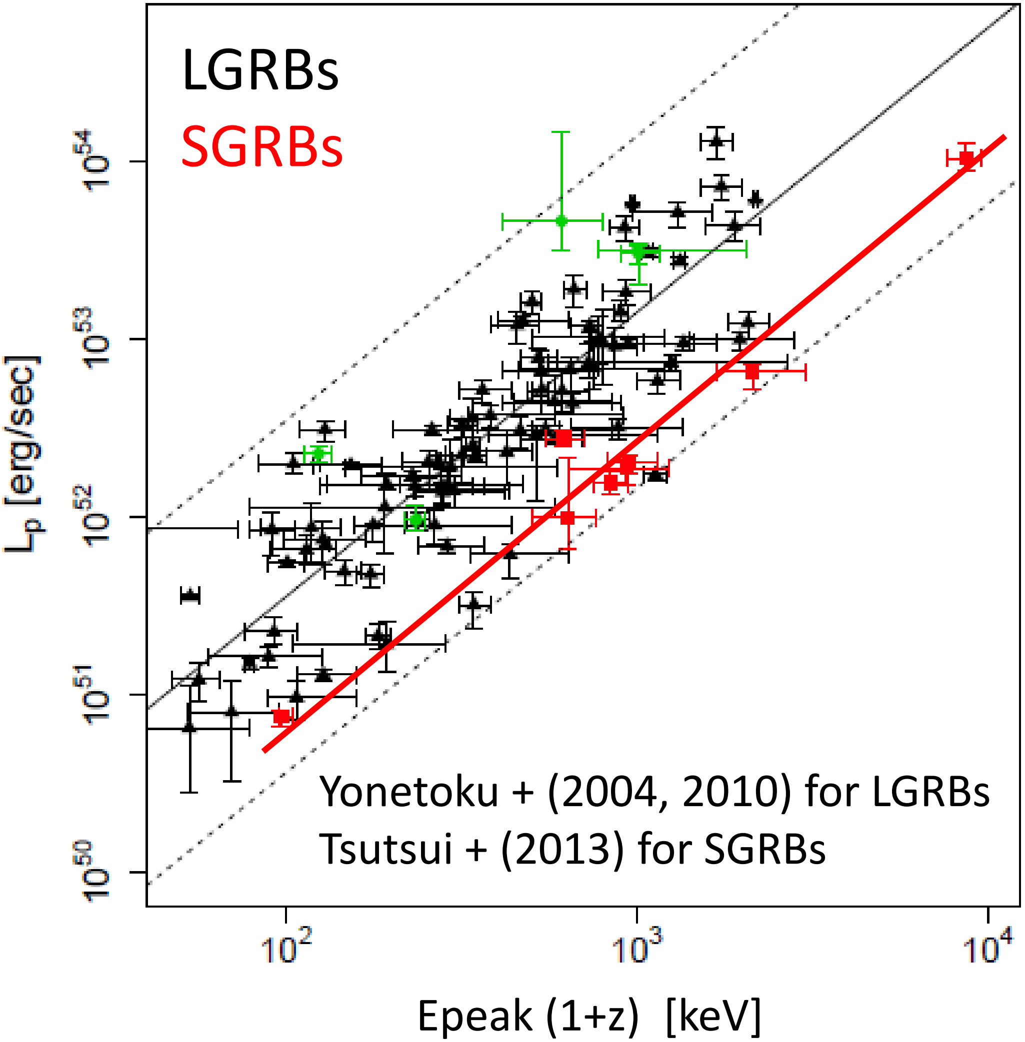
credit NASA

- $T_{90} < 2$ sec
- Associated with the coalescence of a binary system of compact objects(?)

What would be the keys to the progenitor?

- gravitational-wave transients coincident with SGRBs
  - KAGRA, advanced LIGO, & advanced VIRGO (2018-)
  - X-ray imager with wide field of view from Kanazawa Univ. -> latter talk
- formation rate
  - only ~ 20 of SGRBs with known redshift!
  - We need more and more samples…

E_{peak} – Luminosity Correlation of LGRBs/SGRBs



LGRB (Yonetoku et al. 2004, 2010)

$$L_p = 4\pi d_L^2 F_p = A[E_p(1+z)]^{1.6}$$

$$\Rightarrow \frac{d_L^2}{(1+z)^{1.6}} = \frac{A}{4\pi F_p}\left(E_{peak}\right)^{1.6}$$

SGRB (Tsutsui et al. 2013)

$$L_p = 4\pi d_L^2 F_p = B[E_p(1+z)]^{1.6}$$

$$\Rightarrow \frac{d_L^2}{(1+z)^{1.6}} = \frac{B}{4\pi F_p}\left(E_{peak}\right)^{1.6}$$

We can use the correlation as the Luminosity/Distance indicator.

Hereafter we used
$\Omega_m = 0.3$, $\Omega_\Lambda = 0.7$, and $H_0 = 71$ km s^{-1} Mpc^{-1}.

Event selection

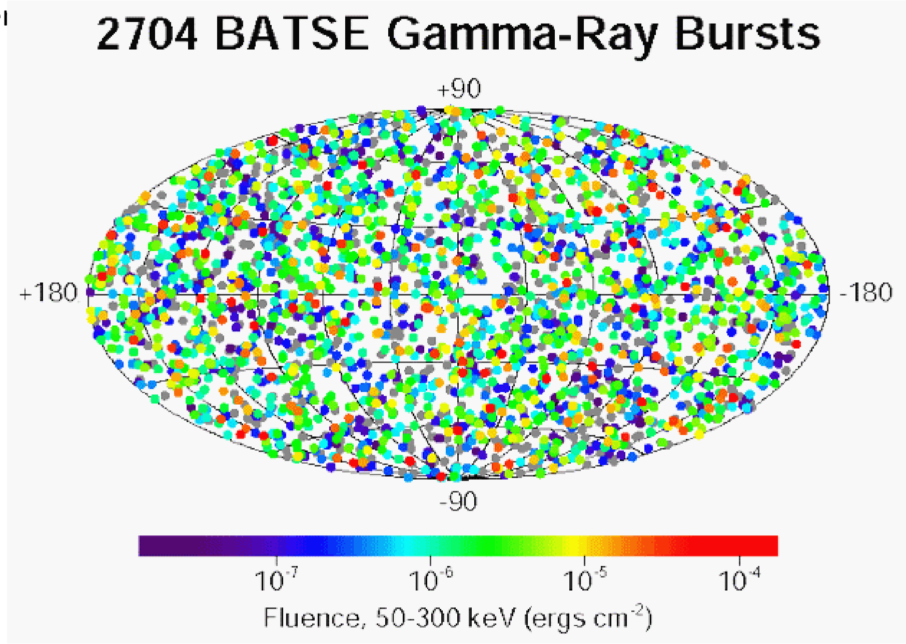
CGRO/BATSE current burst catalog

(1) 100 brightest SGRBs with T_{90} < 2 sec

(2) Spectral parameters are obtained for 72 SGRBs.
(for remaining 28, poor statistics and variable BGD condition)

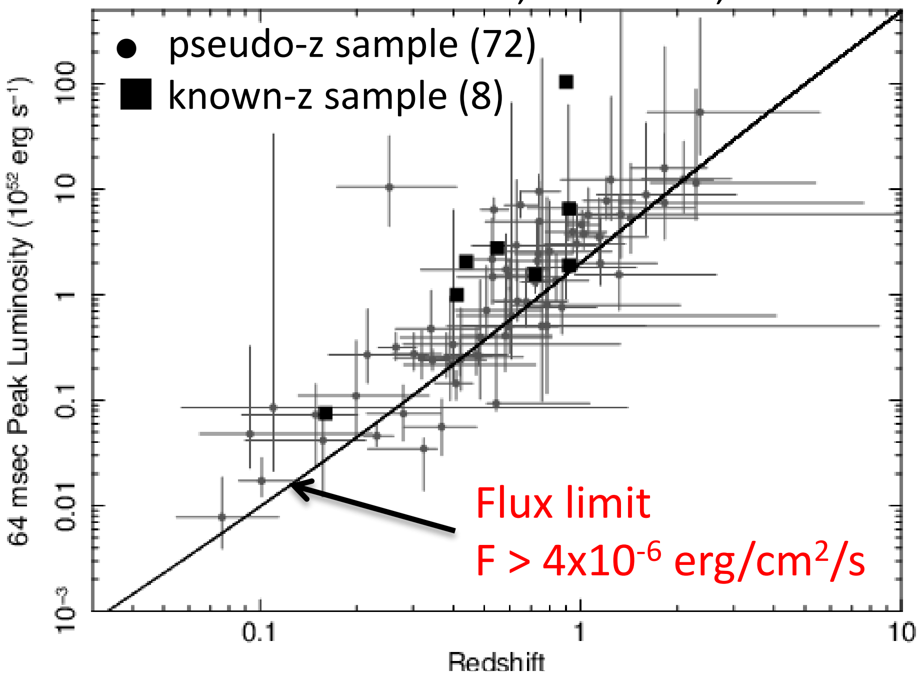
(3) We succeeded in calculating the pseudo-z for all 72 SGRBs.

BATSE life time = 9.2 years
Fraction of sky coverage = 0.483
Trigger efficiency > 99.988 % for F = 1 ph/cm2/s
Effective life time = 4.4 years



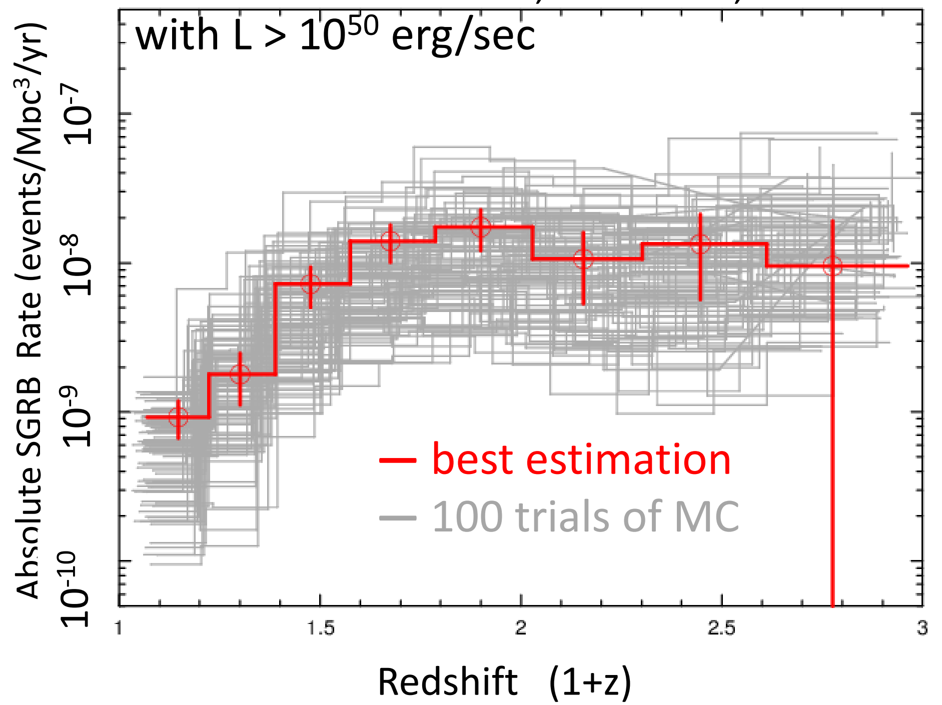
Redshift Distribution

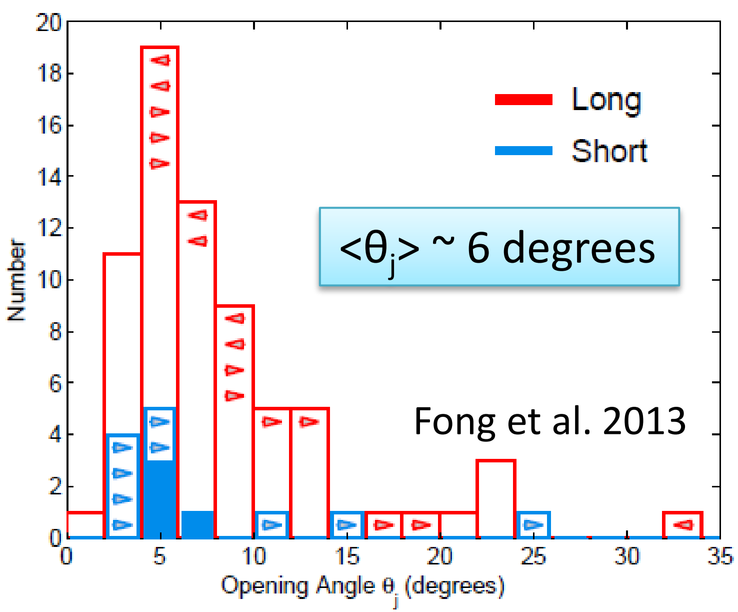
Yonetoku, Nakamura, TS + 2014



SGRB Formation Rate

Yonetoku, Nakamura, TS + 2014





We used a non-parametric method.
(Lynden-Bell 1971, Petrosian 1993, etc.)

Local Rate including geometrical factor

> 1.15 x 10^{-7} events/Mpc^3/yr (Lower Limit)

> 3.8 event/year in (200Mpc)^3 (Lower Limit)

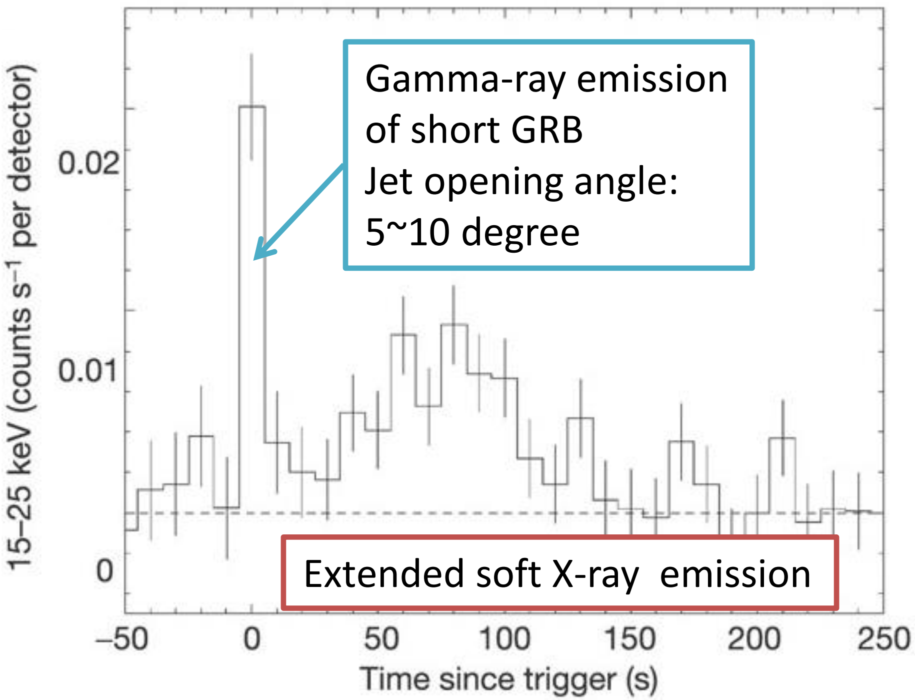
expected to detect GW

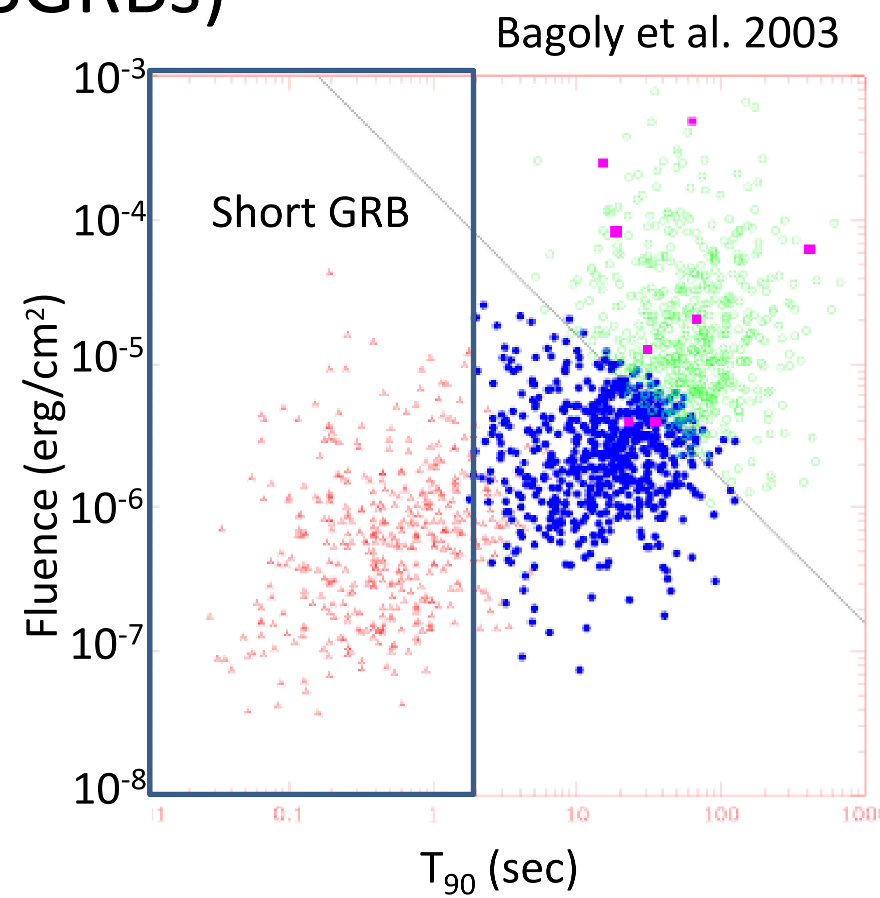
~ 10 events/year in (200 Mpc)^3

Development of X-ray Imaging Sensor for Short GRBs

Tatsuya Sawano
Daisuke Yonetoku, Shunsuke Takata, Hiroki Seta,
Kazuki Yoshida, Asuka Toyanago (Kanazawa U.),
and Hirokazu Ikeda, Atsushi Harayama (ISAS/JAXA)

Short Gamma-Ray Bursts (SGRBs)



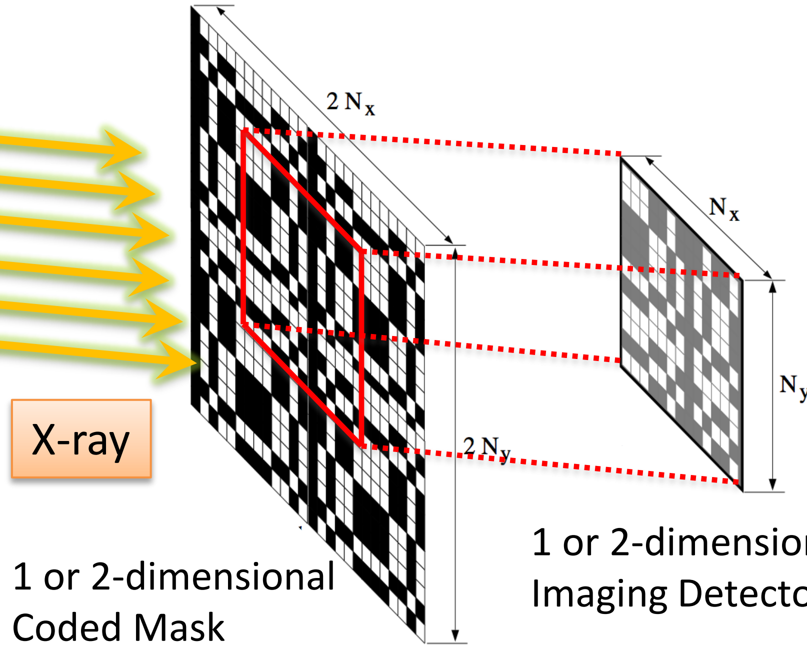


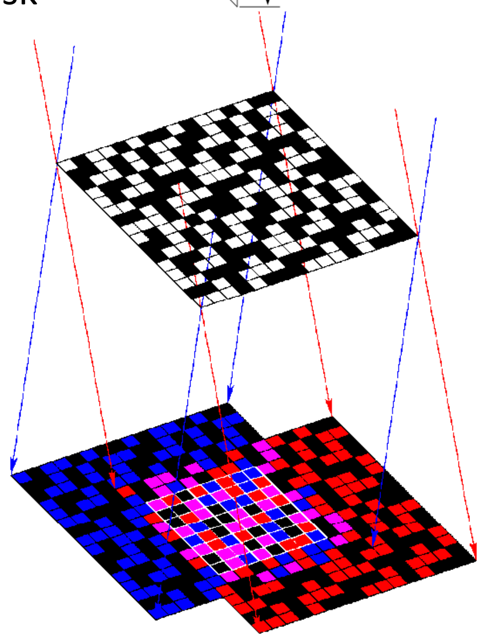
Extended Emission ($\propto E^{-2}$, 1~10 keV):

Expected photon flux : 10^{-6} erg/cm^2 ~ 300 photon/cm^2

Extended emission of nearby SGRBs is enough bright.
We can observe them by small instruments with 100 cm^2.

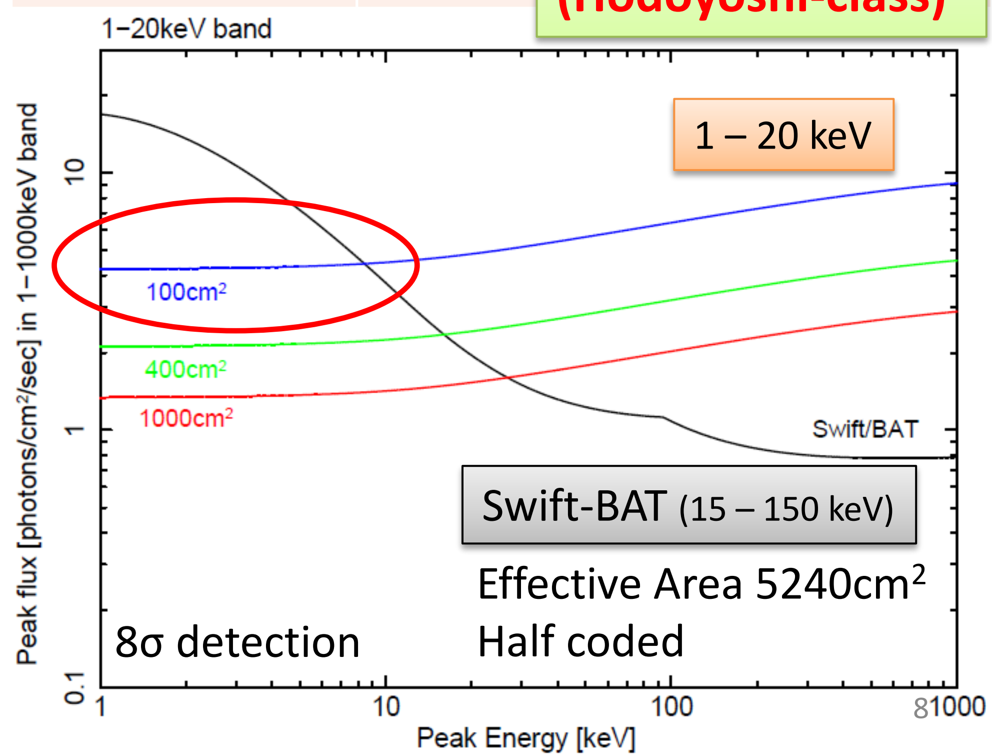
X-ray Imaging Detector



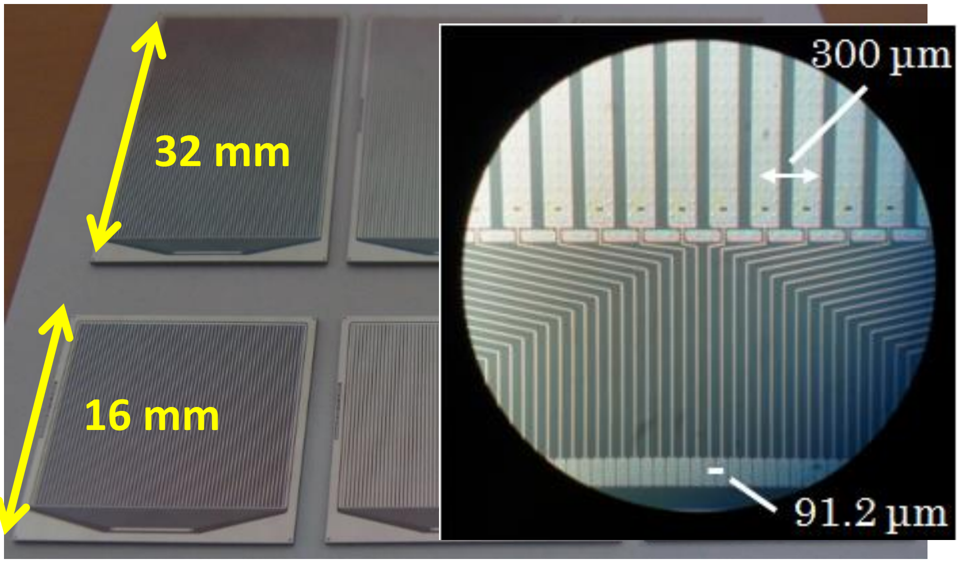


	X-ray Imaging Detector
Detector	Si single side strip (X and Y)
Energy	1〜20 keV
Size	0.3mm pitch coded mask 10cm × 10cm × 2
Effective Area	100cm2 @ ~1 keV (Half Coded)
Spatial Resolution	~7 arcmin (geometrical)
Field of View	~ 1 str
Weight	5~10 kg
Electric Power	~ 20 W

Possible to Realize small satellite (Hodoyoshi-class)



1-dimensional Si sensor



Si strip sensor (Hamamatsu Photonics)

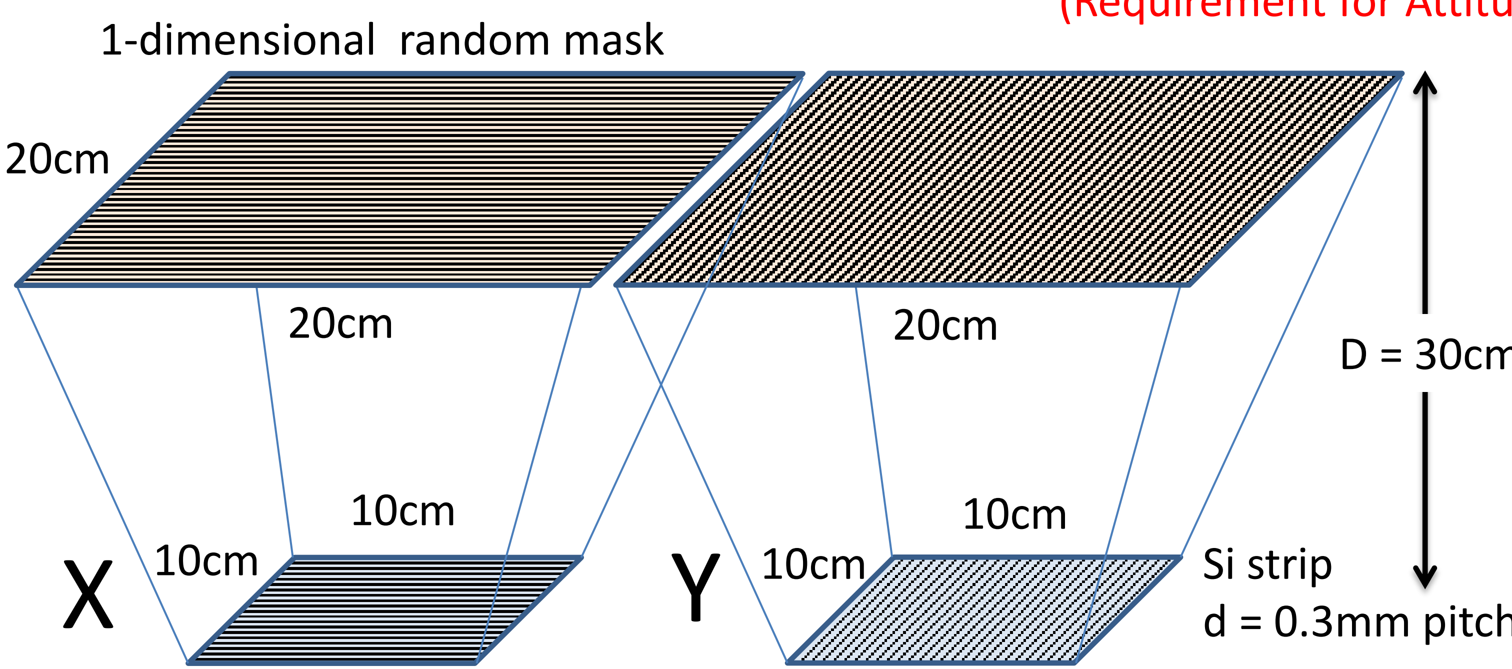
- 64 strips (0.3mm pitch)
- 0.5mm thickness (1~20 keV)
- Fan-out structure to connect ASIC
- Capacitance 5 ~ 10 pF each strip
- 30 ~ 50 pieces of Si detectors

Angular resolution

$$\theta = \tan^{-1}(2d/D) = 7 \text{ arcmin}$$

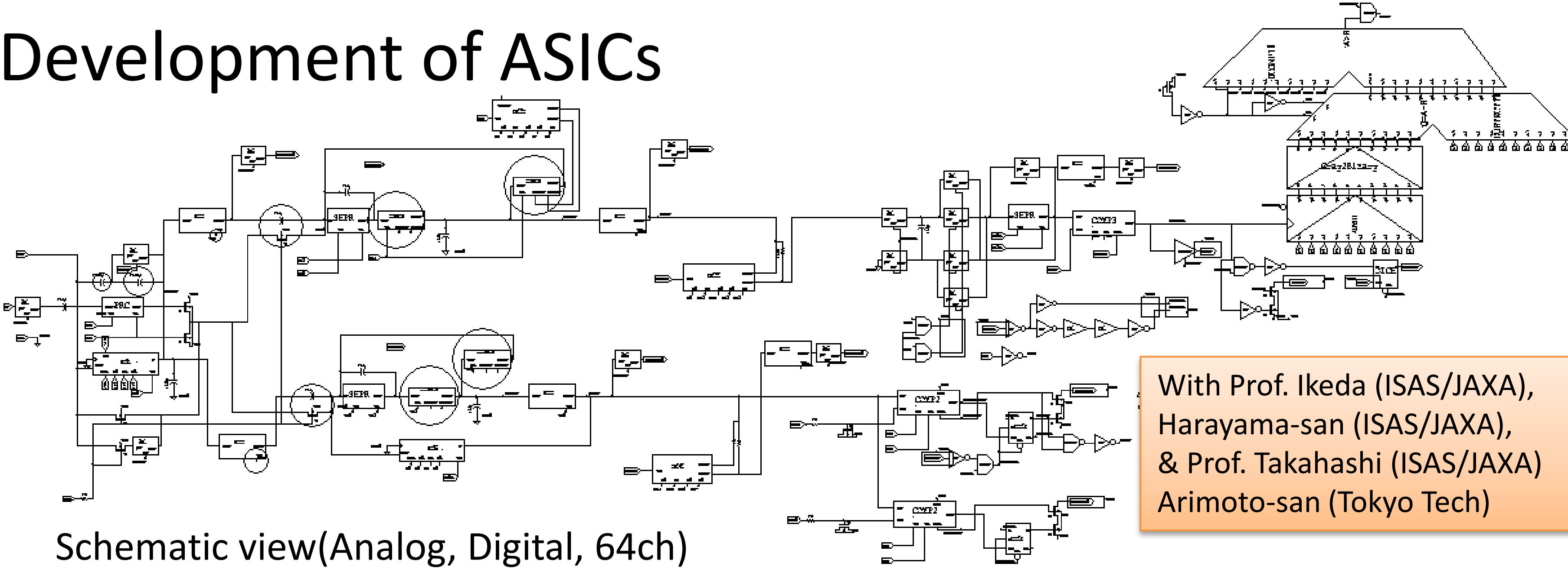
for d = 0.3mm, D = 30cm

(Requirement for Attitude Stability)



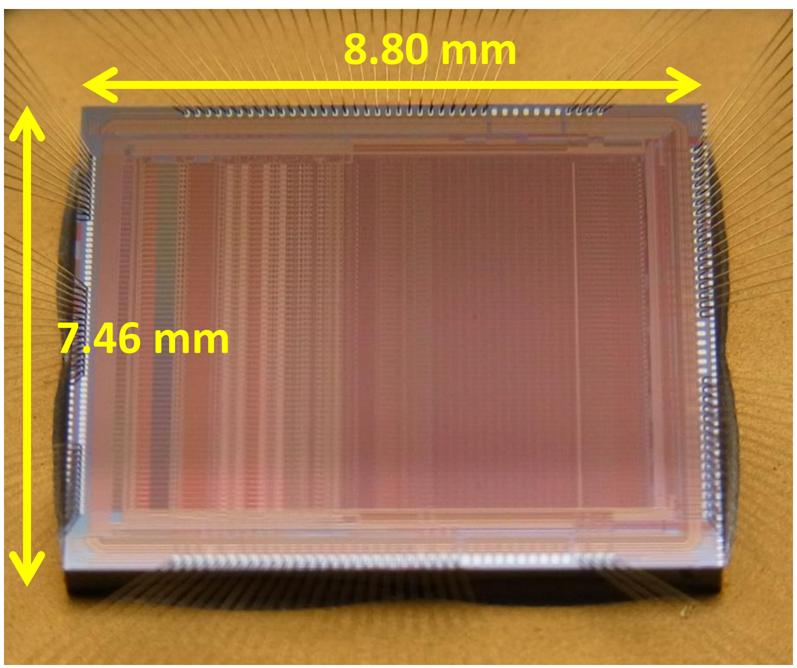
5 ~ 10 kg

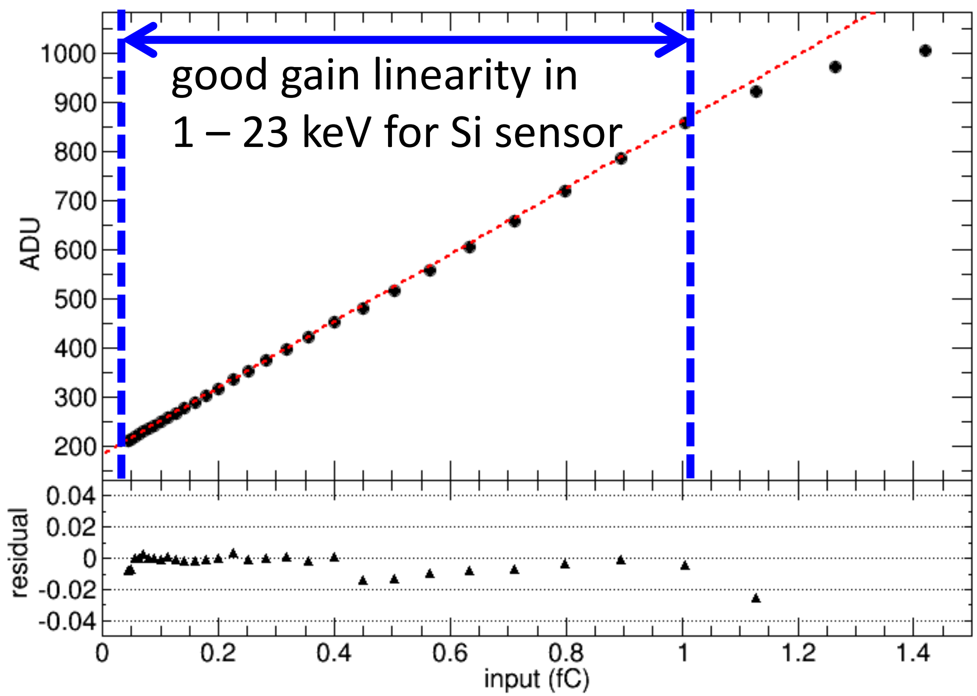
Development of ASICs



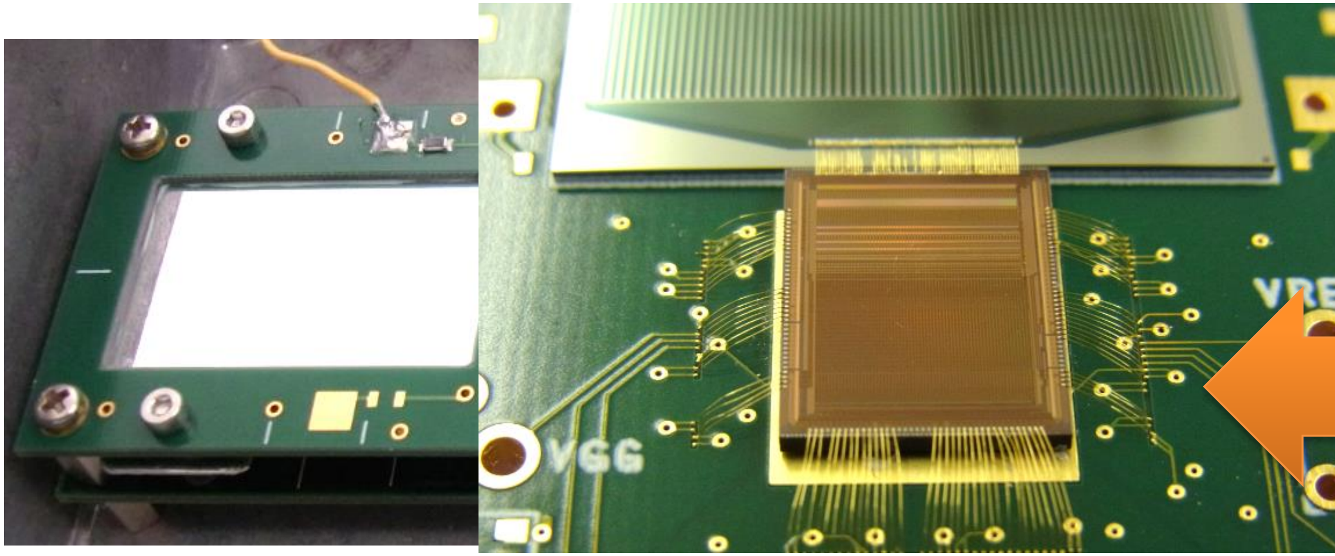
Schematic view(Analog, Digital, 64ch)

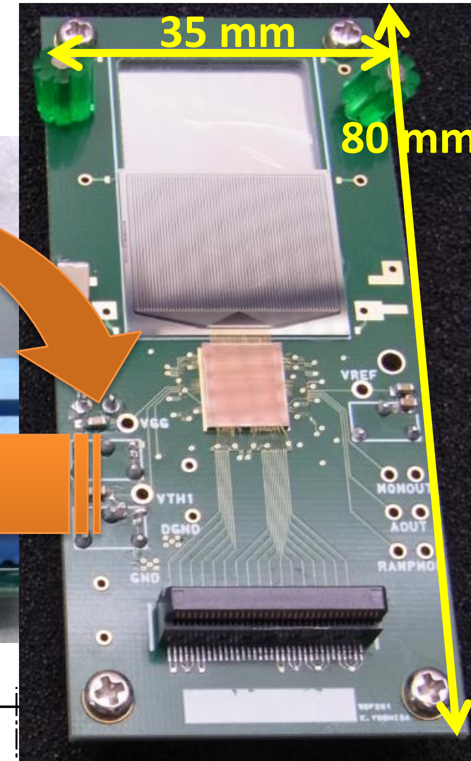
With Prof. Ikeda (ISAS/JAXA),
Harayama-san (ISAS/JAXA),
& Prof. Takahashi (ISAS/JAXA)
Arimoto-san (Tokyo Tech)

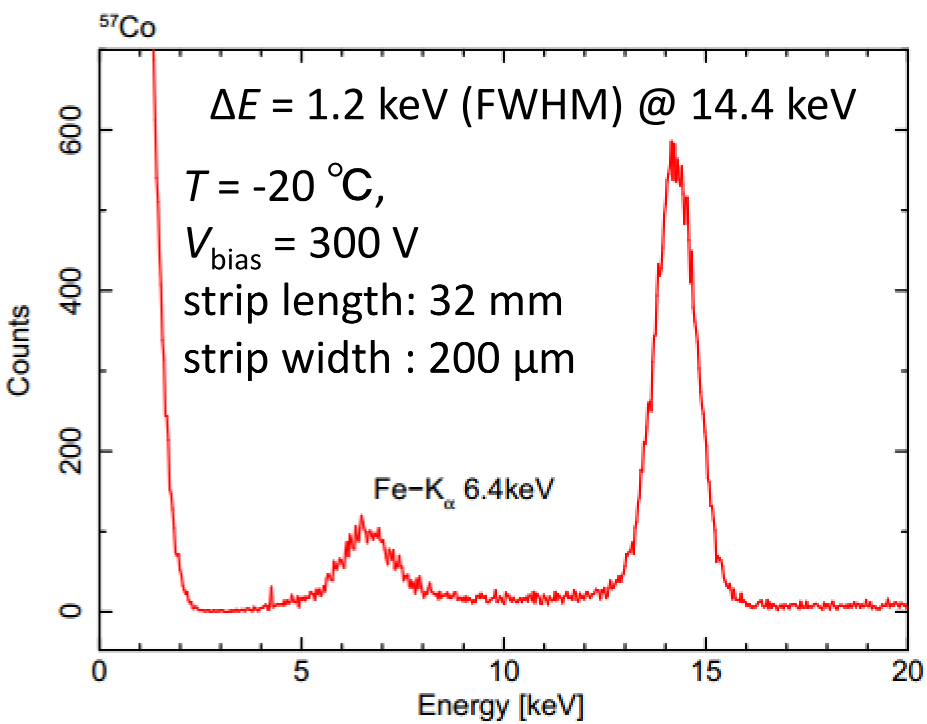


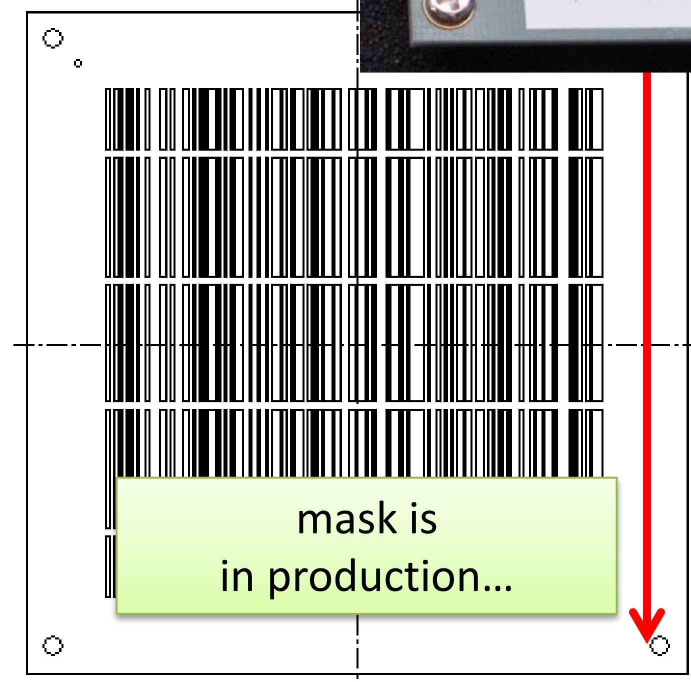


Development of X-ray imager board









北國新聞

（31） 社会3 2013年（平成25年）12月27日（金曜日）

金大 超小型衛星開発へ

来年度から 宇宙担う人材を育成

金大は来年度から、安価で実用的な人工衛星の設計・製作に取り組む。５年計画で超小型衛星を開発する。製作過程を学生の教育プログラムとして活用し、次世代の宇宙科学・工学を担う人材を育成する。新年度政府予算案に初年度の事業費４６００万円が盛り込まれた。

初年度は衛星試作モデルの設計やカリキュラム作成に向けた情報収集を進める。理工研究域が主体となり、先端宇宙理工学教育プログラムの構築や大学院の宇宙理工学コース設置を目指す。

金大はこれまで日欧共同の水星探査計画の機器開発や、宇宙で最大の爆発とされる「ガンマ線バースト」の光の振動方向の測定などに参加しており、実績やノウハウを活用する。

このほか、肝臓病に対する幹細胞・再生医療の研究を強化する。脂肪組織由来の幹細胞を用いて、再生医療による肝硬変の治療法確立を目指す。初年度の事業費は１８００万円。

From FY2014,
Our university will start to establish
Educational course of
Space Science and Technology,
and develop 50 kg class of Small Satellite.

We are planning to install
the wide field X-ray imaging system
to observe the short GRBs,
and to support the GW observations.

Summaries

- Short GRBs are the most important candidates of GW detection, and local SGRB rate is > 1.15×10^{-7} events/Mpc^3/yr.
  (> 3.8 event/yr within $(200 Mpc)^3$, maybe ~ 10 event/yr)
- Now we are developing the X-ray imaging system with coded aperture mask system.