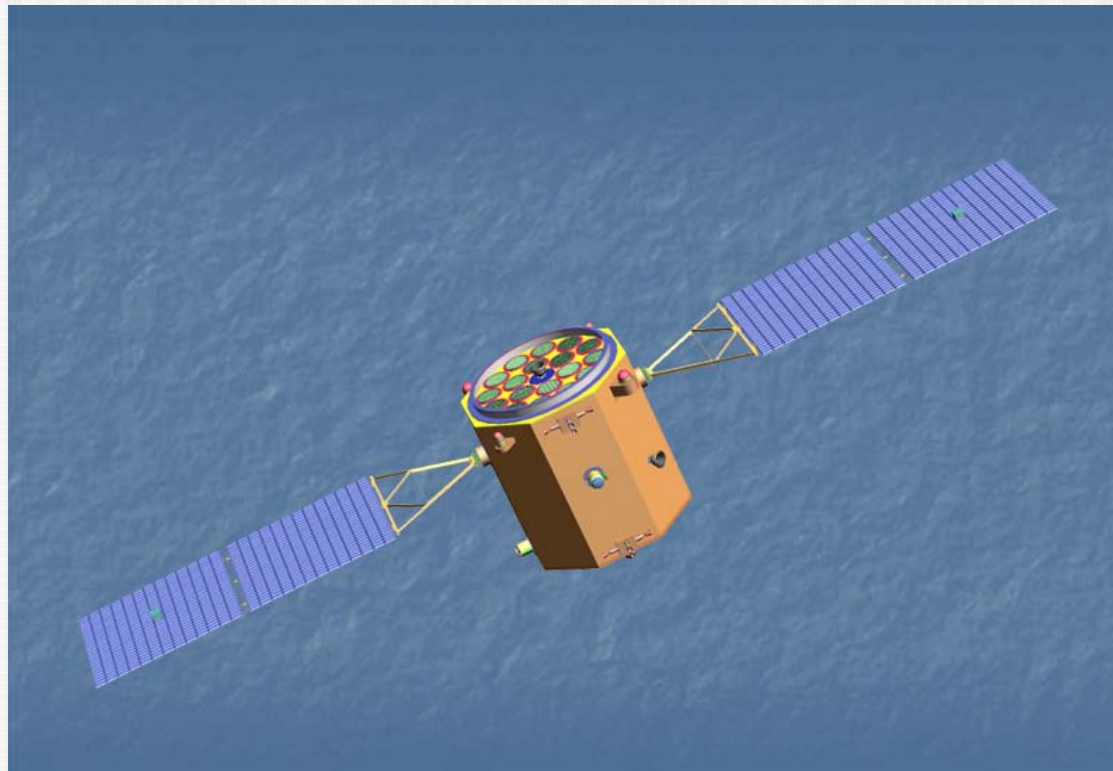


HXMT

– A Chinese High Energy Astrophysics Mission

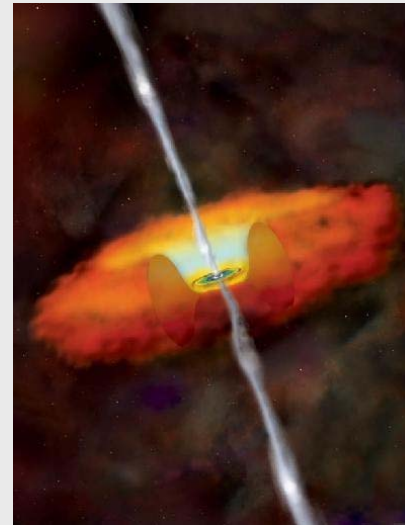
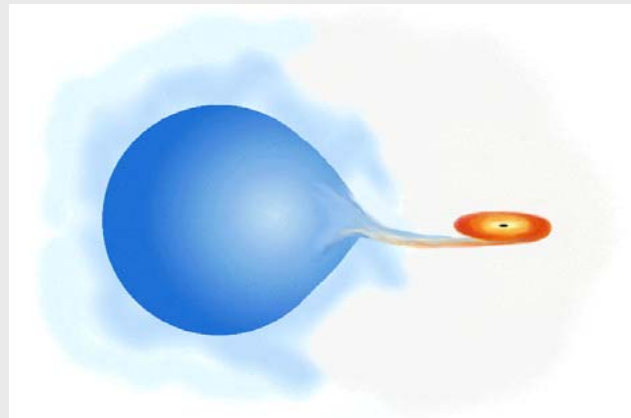
Ti-Pei LI

*Center for Astrophysics, Tsinghua University
Inst. Of High Energy Physics, Chinese Academy of Sciences*



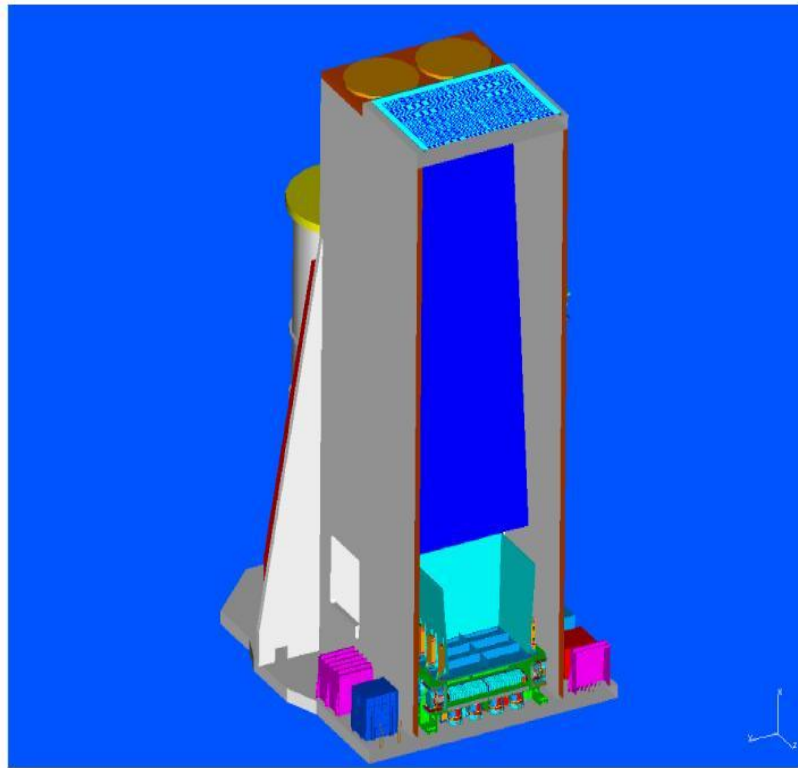
Hard X-ray is a key waveband for our understanding of the high energy Universe:

- Physical processes and curved spacetime close to the event horizon



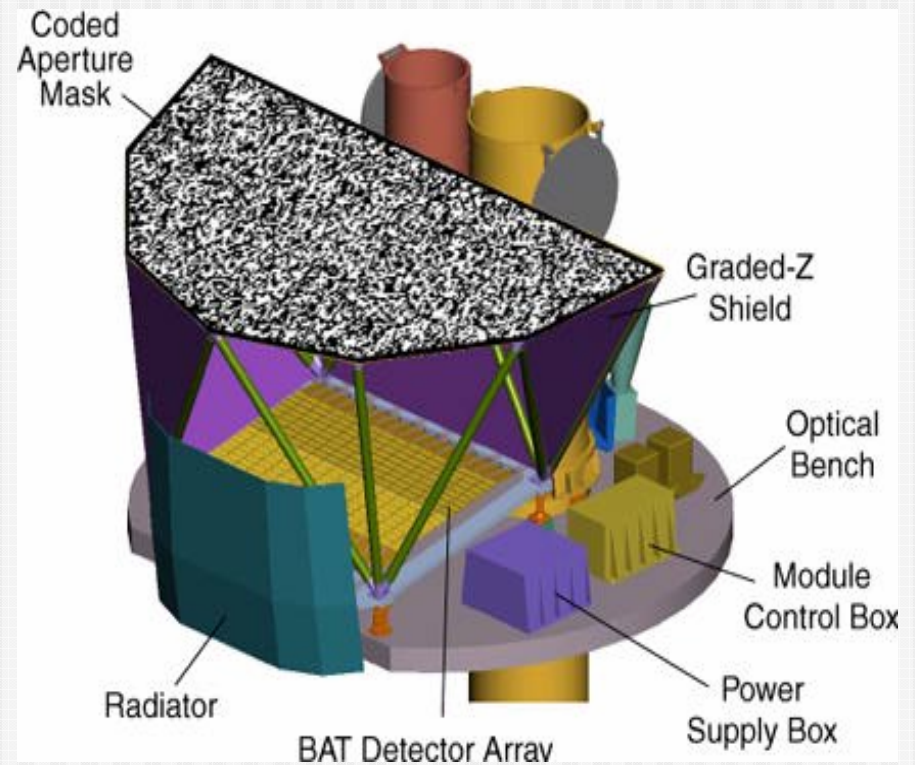
- Formation and evolution of supermassive black holes over the history of the Universe
- The cosmic X-ray background

Integral and Swift : coded mask telescope



Integral (2002 -)

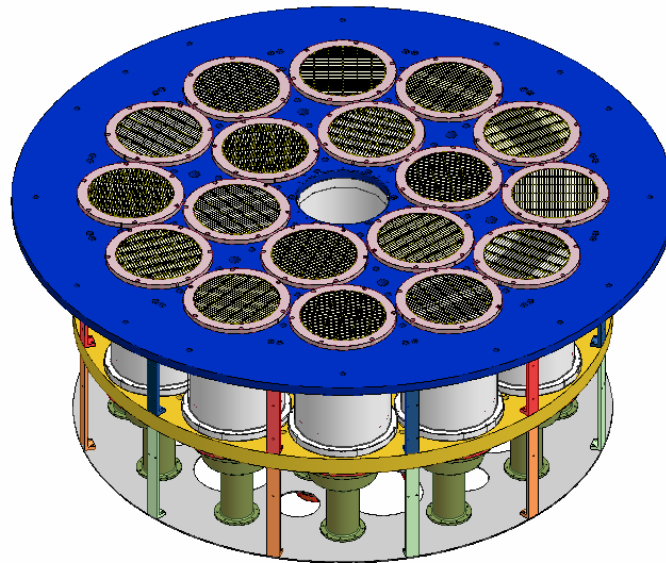
Coded mask imager IBIT (2500 cm^2)



Swift (2004 -)

Coded mask telescope BAT (5200 cm^2)

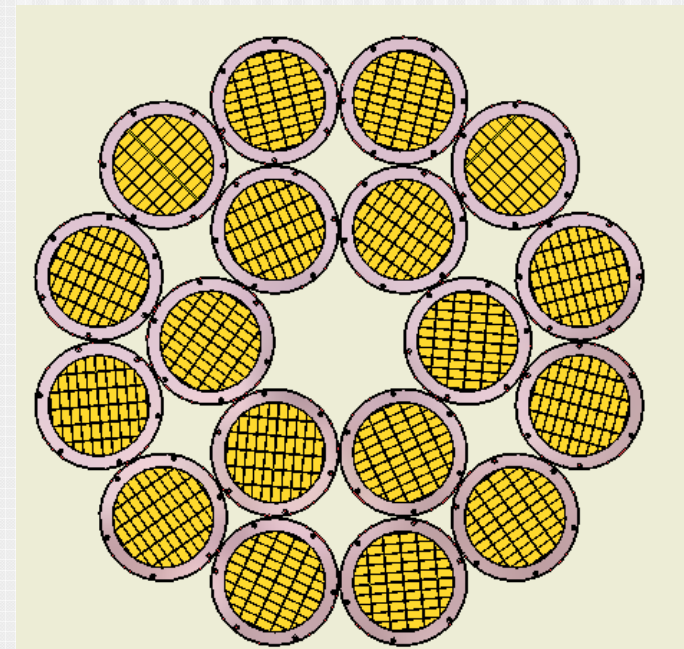
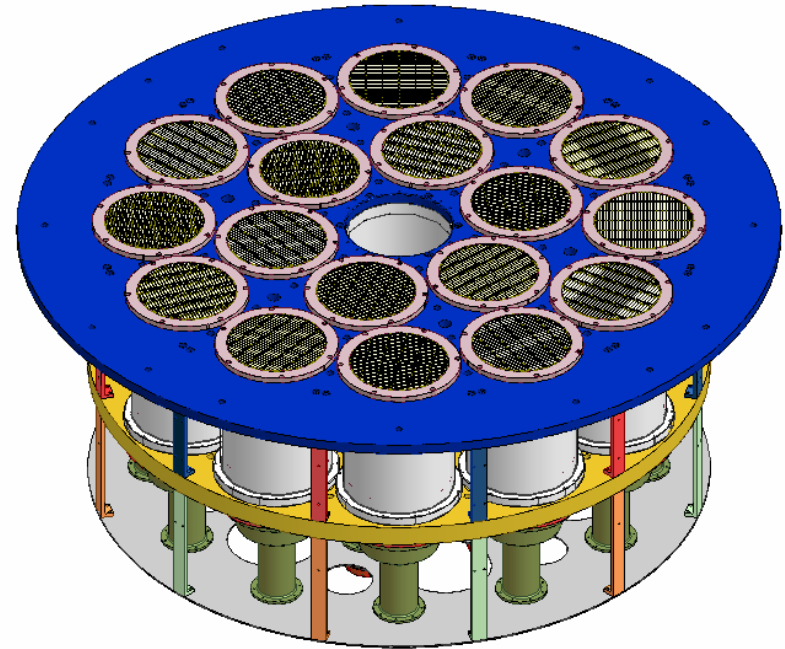
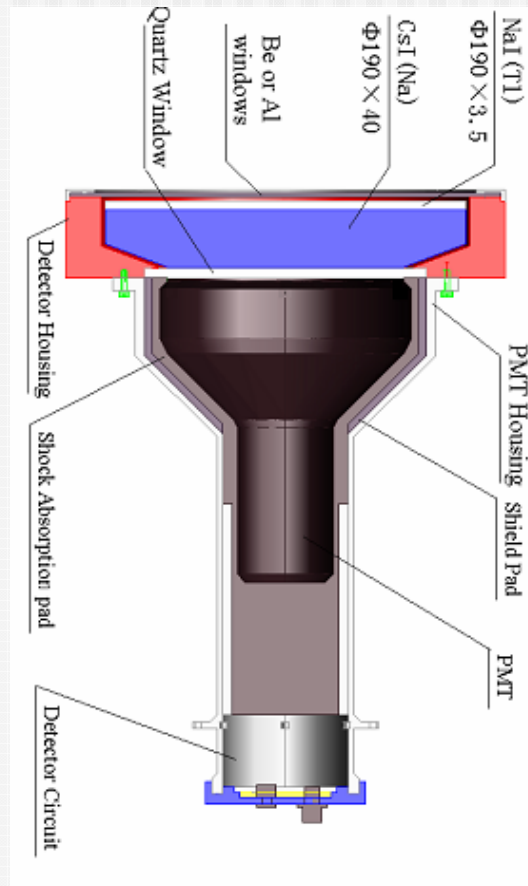
Hard X-ray Modulation Telescope HXMT



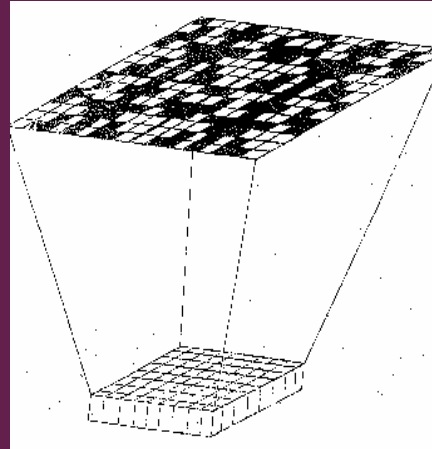
Based on a new inversion technique – the direct demodulation method, HXMT can make both full-sky 10-250 keV hard X-ray survey with highest spatial resolution and sensitivity, and high signal-to-noise ratio pointing observation of scientific hot spot sources for temporal and spectral studies.

HXMT: slat collimator telescope

($1^\circ \times 5^\circ$ 5100 cm² 10-250 keV)



Coded Mask



Collimator



SNR

(signal to noise ratio)

Bad

Good

Angular Resolution

with CC (Cross Correlation)

Mid

Bad

with DD (Direct Demodulation)

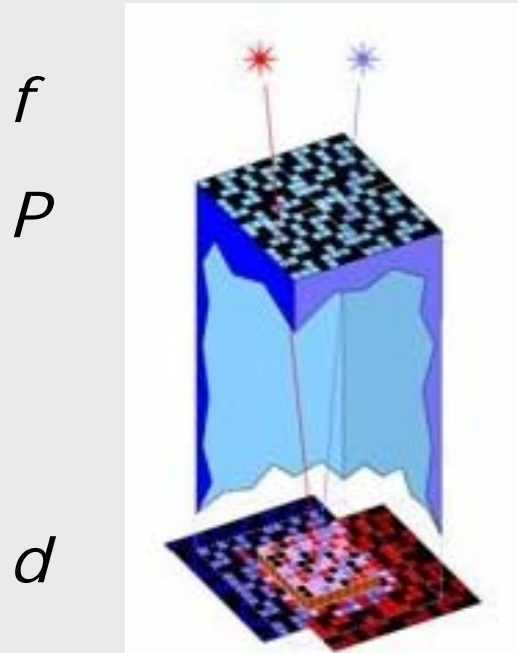
Good

Best

The DD technique makes use of information in the collected photons more sufficiently than traditional inversion technique

$$\Delta_{dd} = f(\Delta_{cc}, S, SNR)$$

Coded Mask Telescope

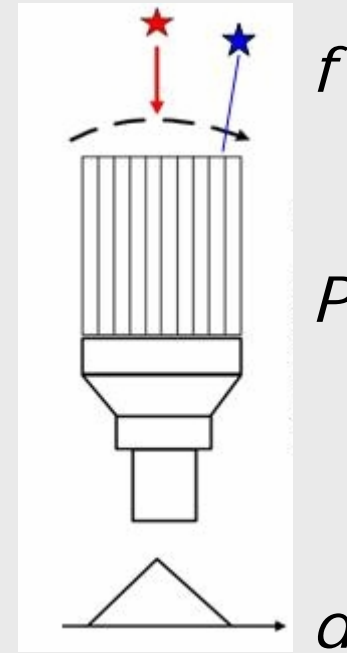


CC Inversion

1、 obs. eq. $P f = d$

2、 **Cross-Correlation** $f \approx c = P^T d$

Collimated Telescope



Direct Demodulation

1、 obs. eq. $P f = d$

2、 CC transf. $P^T P f = P^T d$

correlated eq. $P^* f = c$

3、 solve corelated eq.
iteratively with constaints

- Direct reconstruction

- Direct demodulation algorithm

(Li & Wu 1993, AP&SS , 1, 1; astro-ph/0503126)

*iteratively solving correlation equations
with constraints*

Observation equations $Pf = d$

Correlation transform $P^T Pf = P^T d$

Correlation equations $P^* f = c$

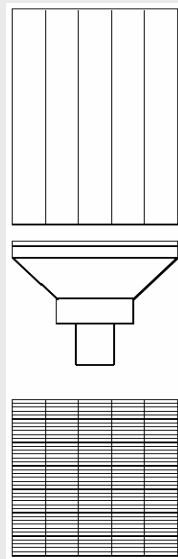
Iterative calculations $f_i^{(l)} = \frac{1}{p_{ii}^*} (c_i - \sum_{j \neq i} p_{ij}^* f_j^{(l-1)})$

Constraints $f_i \geq b_i$

- Stability, convergence & global optimality

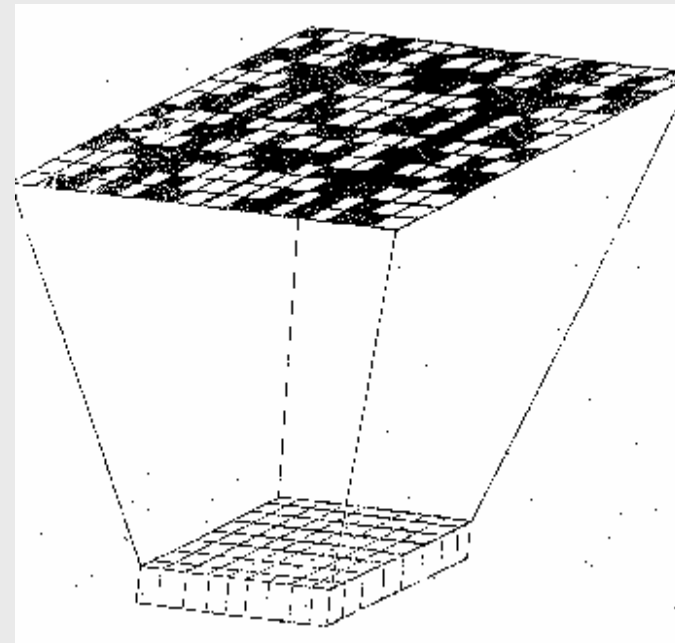
DD calculations converge to a globally optimal solution

Imaging: Collimator vs Coded Mask



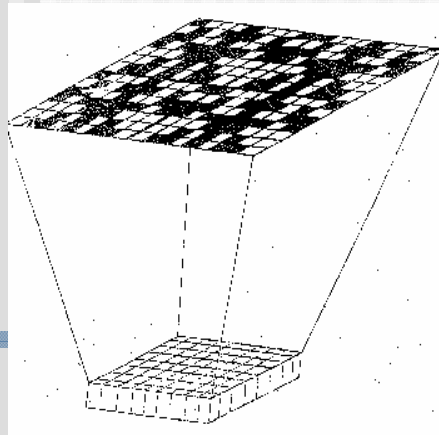
$2 \times 700 \text{ cm}^2$ $5^\circ \times 0.5^\circ$ FWHM aperture

$(\Delta_0 \cong 2.5^\circ)$

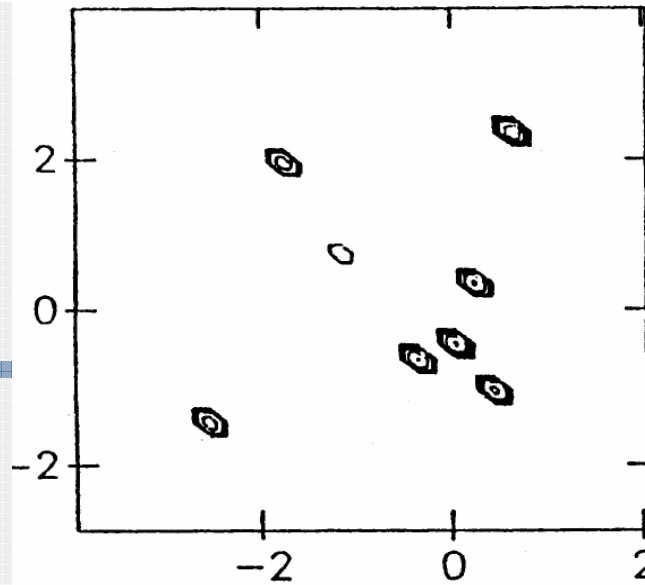


1473 cm^2 93×99 pixels

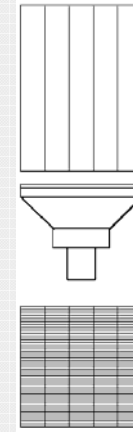
$(\Delta_0 = 0.3^\circ)$



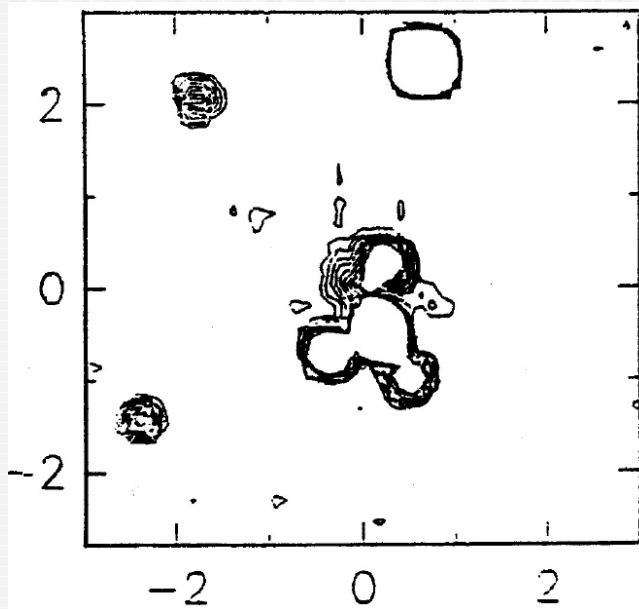
1473 cm² 93×99 pixels



Object

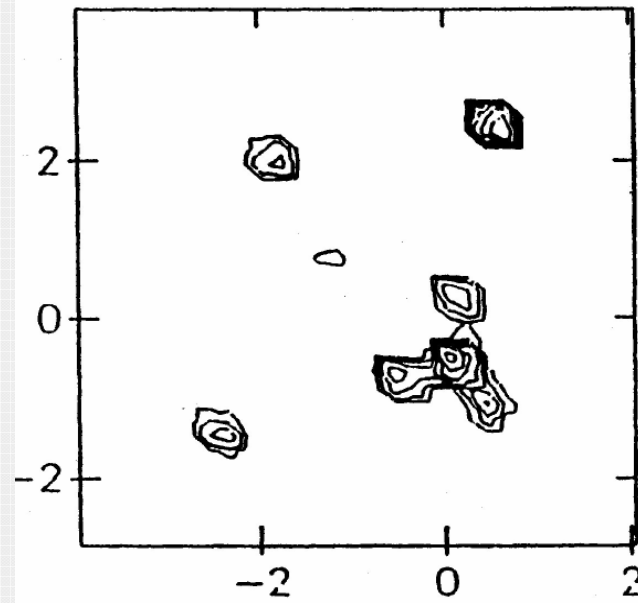


2×700 cm² 5°×0.5°



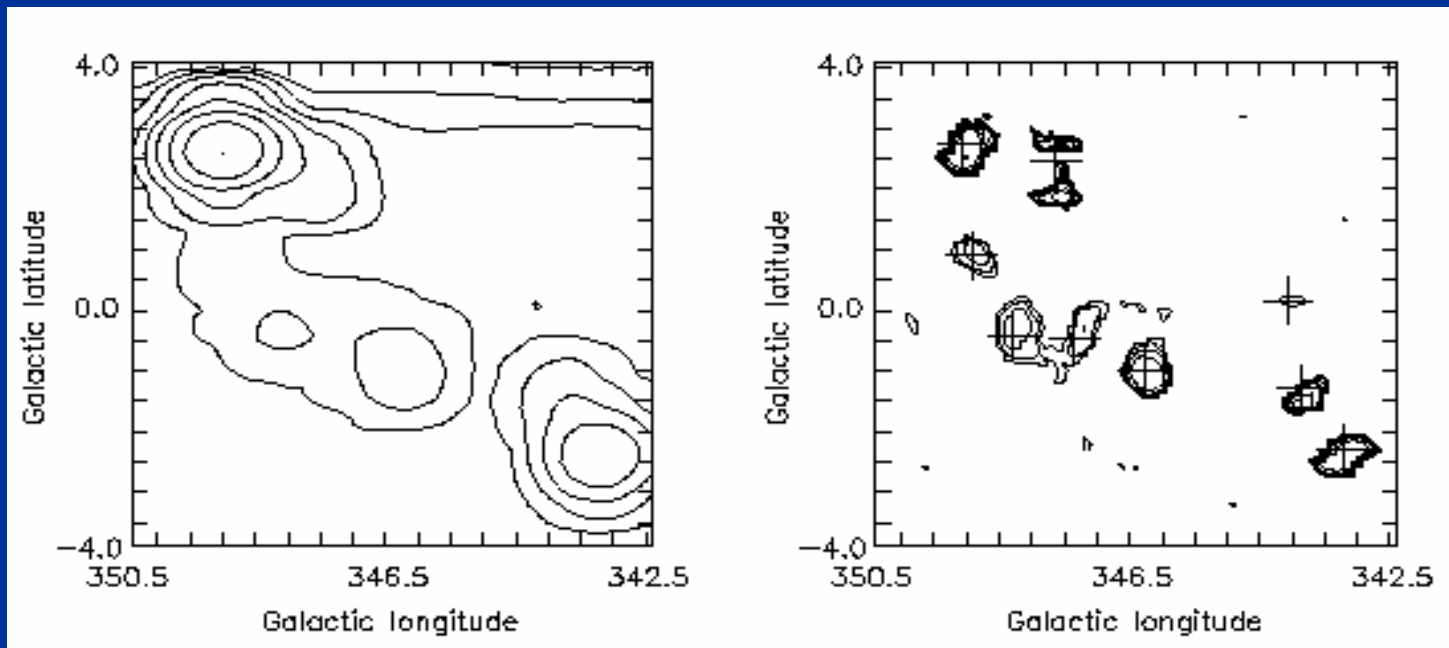
CAM ($\Delta_0 = 0.3^\circ$)

Lei F. et al., *Exper. Astron.* 1, 285 (1991)



SCT ($\Delta_0 \cong 2.5^\circ$)

Li T.P & Wu M., *Astrophys. Space Sci.*, 215,213 (1994)

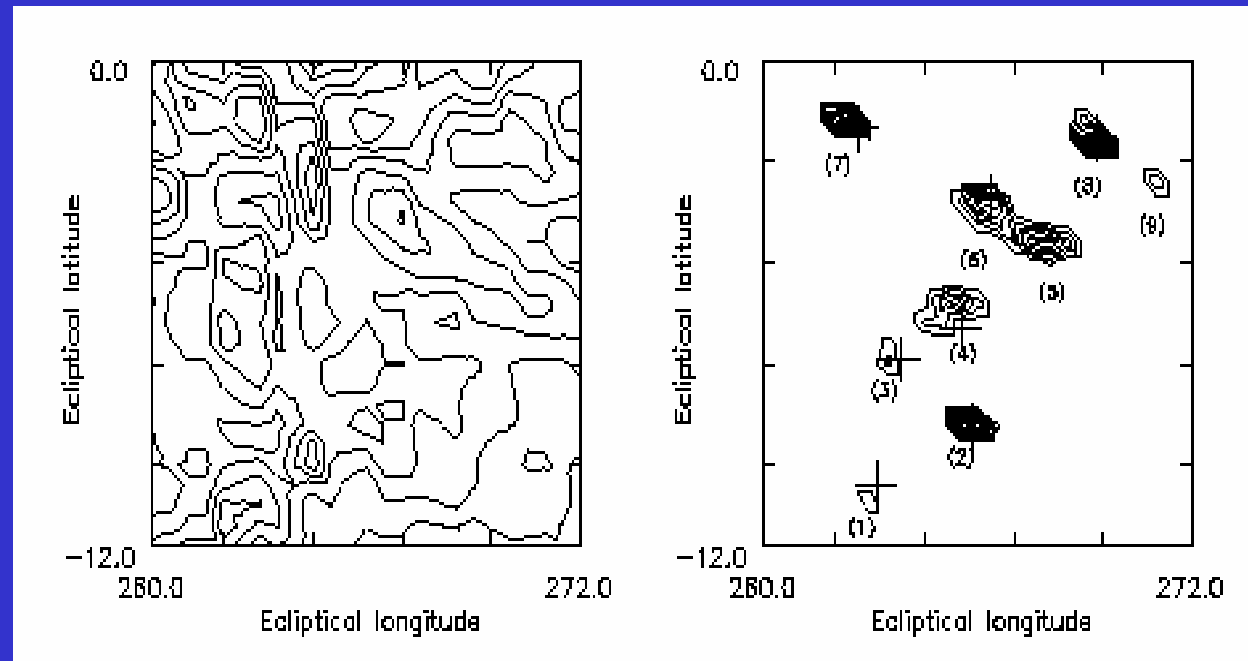


Cross-Correlation

Direct Demodulation

X-ray map from EXOSAT-ME slew observations

(from Lu et al. 1996, *Astron. Astrophys. Suppl.* 115, 395)



Cross-Correlation

Direct Demodulation

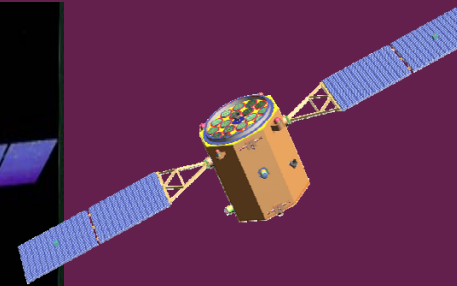
Map of Hard X-ray the galactic center region from HEA01-A4 survey

(from Lu et al. 1995, *Proc. CHEP'95*, 848)

Integral/IBIS (2002-)



HXMT



Swift/BAT (2004-)



Angular Resolution

12'

< 5'

14'

Source Location (2 mCrab 0.5year)

15'

3'

5'

Sensitivity

pointing(10^5 s, 3σ @100keV, in mCrab) 3

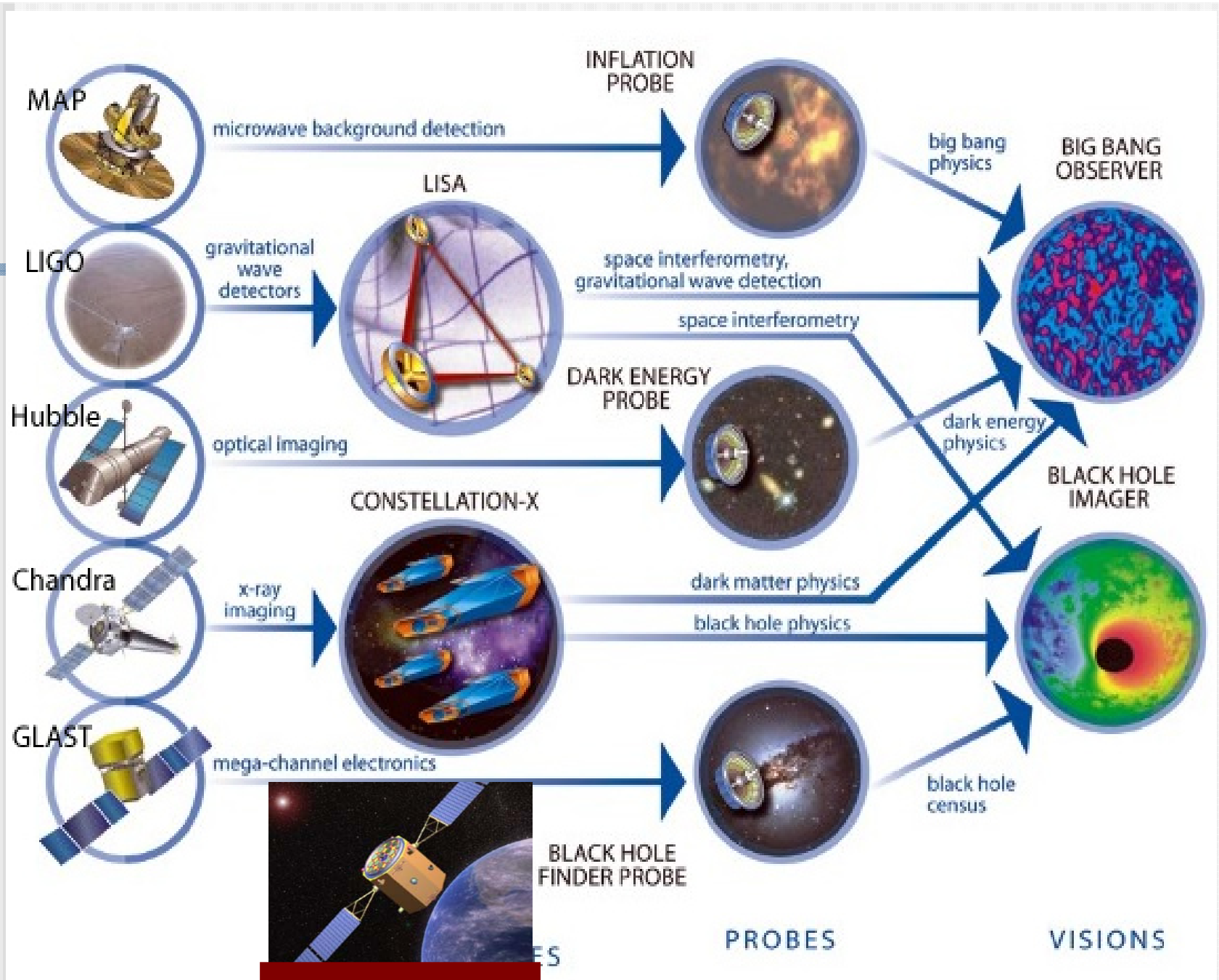
0.5

4.4

imaging(0.5year survey, 5σ , in mCrab) **6.8**

0.5

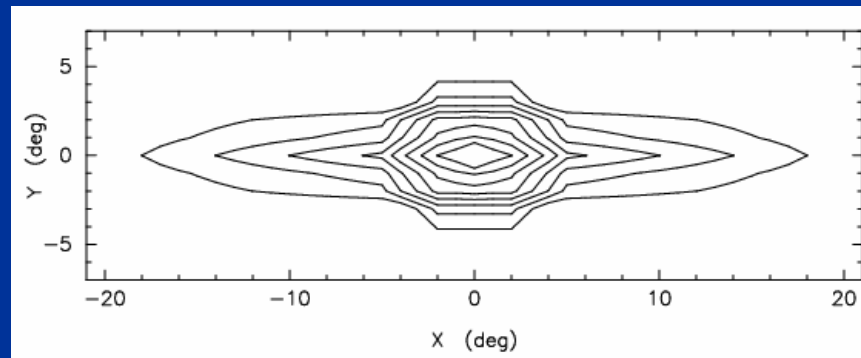
1



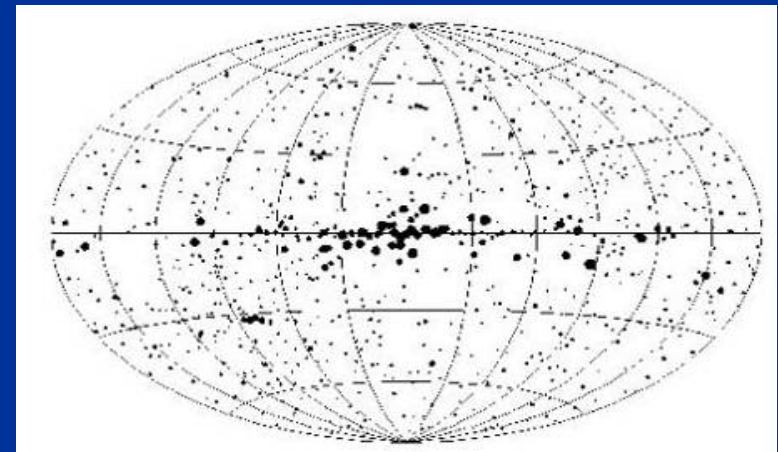
HXMT

Around 2010, HXMT will provide

- *unique fast timing studies of black holes*
- *unique cosmic hard X-ray background imaging studies*



- *more than 1000 obscured supermassive black holes and more black holes in our Galaxy*



HXMT is an stepping stone from
INTEGRAL/IBIS and Swift/BAT to future
black hole probes in NASA's Beyond
Einstein Program or ESA's Cosmic Version

Status of HXMT mission

H A P I — 4 (*Inst. Of High Energy Phys., CAS*)



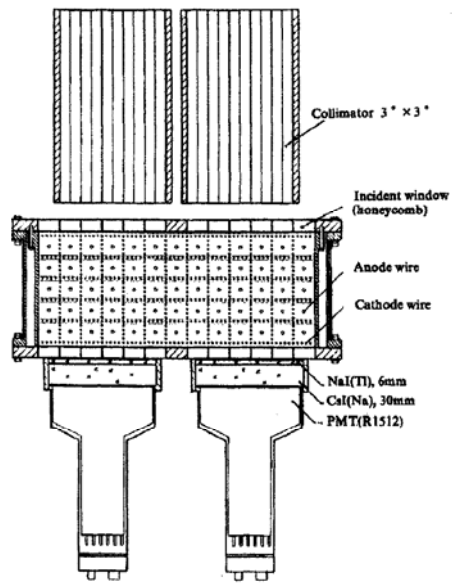
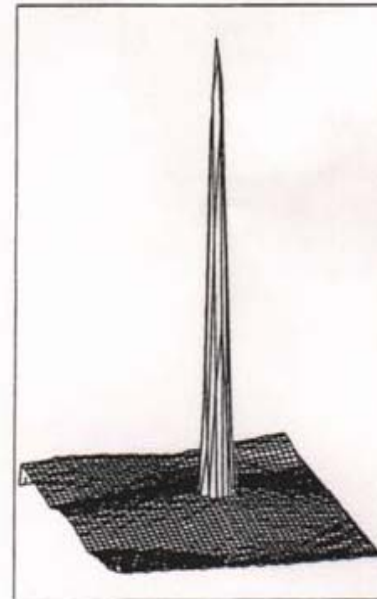


Figure 3.5 Sectional view of HAPI-4 detector.



HAPI-4
(IHEP, Beijing)

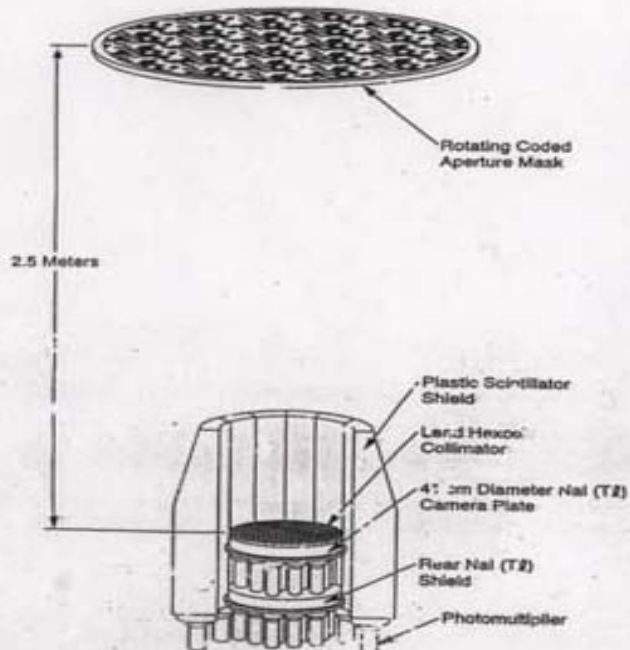
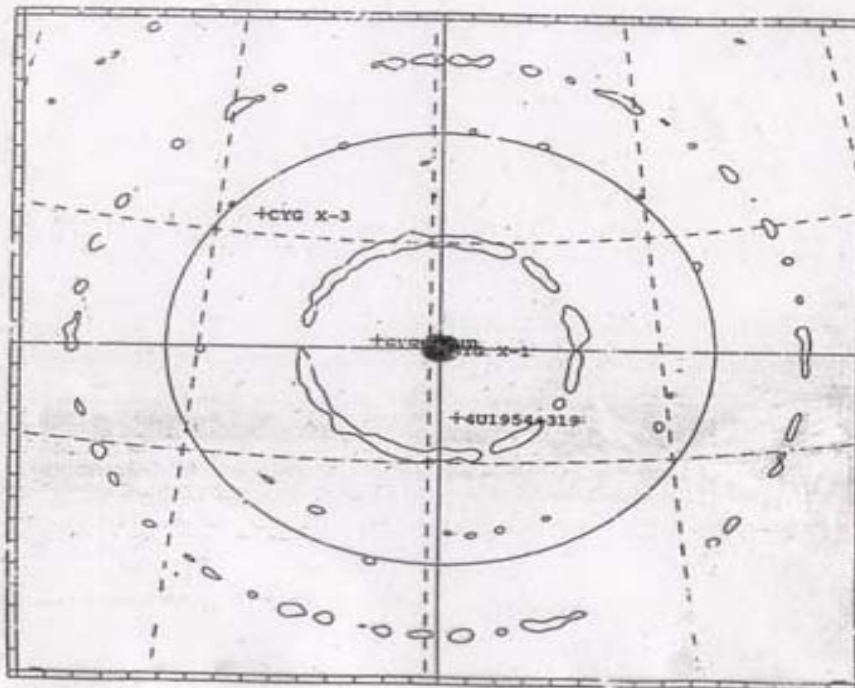


FIG. 1.—Schematic diagram of the GRIP instrument as configured for the 268, D 1, and D771 observations. For the D86 observation the collimator is absent, and a different coded mask was used as described in the text.



GRIP
(Caltec, US)

2000-2005 Phase A study:

A project under **the Major State
Basic Research Program in China**

Founded by

**Ministry of Science and Technology
Chinese Academy of Sciences
Tsinghua University**

2005.9: Phase B study



The ground test system

Partners

China Academy of Space Technology

Chinese Academy of Sciences

Institute of High Energy Physics

Academy of Opto-Electronics

Center for Space Science & Applied Res.

Tsinghua University

International Cooperation

International Workshop on HXMT

2006. 1. 16-20 Sanya, Hainan

Andy Fabian

Josh Grindlay

Phil Kaaret

Filippo Frontera

Tony Dean

T. Couvoisier

M. Matsuoka

R. Staubert

.....



Thank You!



Center for Astrophysics
Tsinghua University



Particle Astrophysics Lab.
Inst. of High Energy Physics