

硬X線で探る 銀河系内宇宙線加速起源の解明



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1. 1. 宇宙線加速と超新星残骸衝撃波

宇宙線: 宇宙を飛び交う超高エネルギー粒子
衝撃波面を往復するたび加速される?
(diffusive shock acceleration)

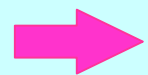
加速源・加速機構は発見以来100年の謎

加速源の探し方

TeV electronのgyro半径 $\sim$ pc

粒子の到来方向からは加速源を突き止められない

TeV electron
星間磁場 ($\sim \mu\text{G}$)

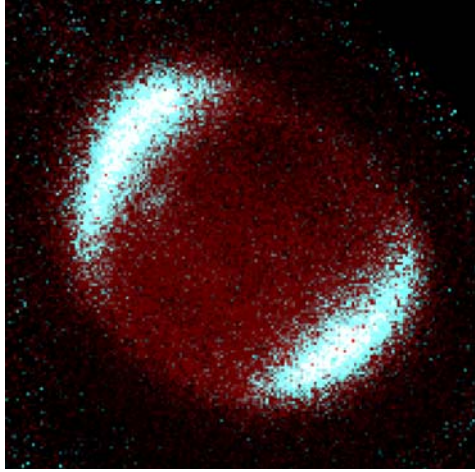


硬X線シンクロトロン放射

硬X線観測は加速源探査に最適!

1.2. 過去の硬X線観測による成果

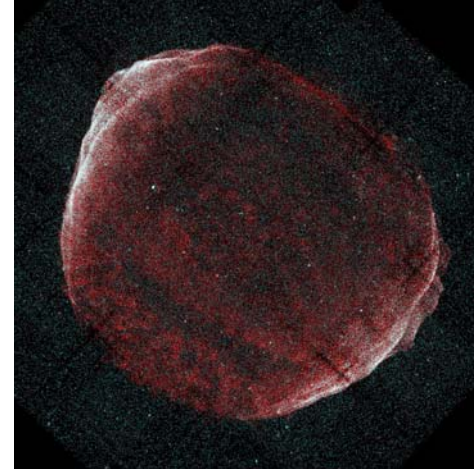
1995 Koyama et al.



SNR衝撃波面からsync. X-rays

衝撃波面は加速現場!

2003 Bamba et al.



thin filament

加速は局所的で高効率!?

硬X線観測

-> 超新星残骸衝撃波面は効率よい電子加速現場

...しかし、多くの問題が残っている。

1.3. Remaining problems

宇宙線全体に対する超新星残骸の寄与は?
宇宙線の主成分protonの加速源は???

total No.
of SNRs



wide-band spectra
(radio - TeV)
-> topic 1

acc. possibility
of protons



wide-band spectra
(radio - TeV)
-> topic 2

plasma condi.
of acc. sites



plasma diagnostics
in X-rays
-> topic 3

For all of these remaining problems,
X-rays are the strong tool !

本日は「すざく」衛星の最新成果をお見せいたします。

2.1. Suzaku

Successfully launched
on 2005 July 10th.

XRT (X-Ray Telescope)

Large effective area
 410cm^2 @1.5keV

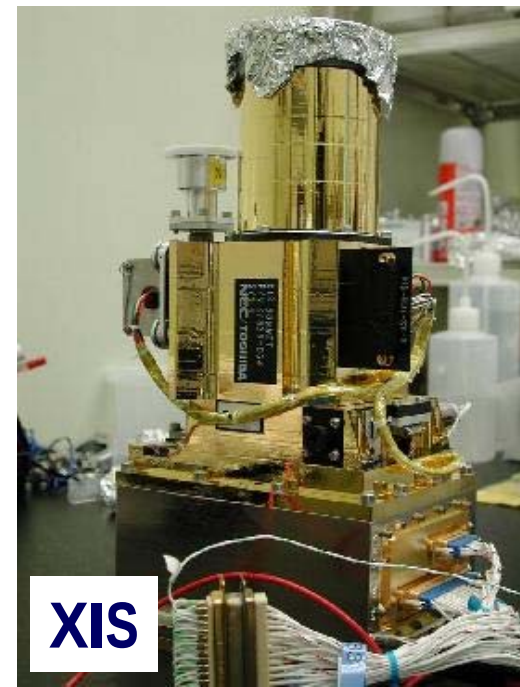


XIS (X-ray Imaging Spectrometer)

Improved X-ray CCD with high efficiency
and good energy resolution

Low Background

Energy band : 0.2-12keV



HXD (Hard X-ray Detector)

Wide energy band

Si-PIN (10-70keV) & Scintillator (30-600keV)

Non-imaging detector, but low background

best for
dim & diffuse sources



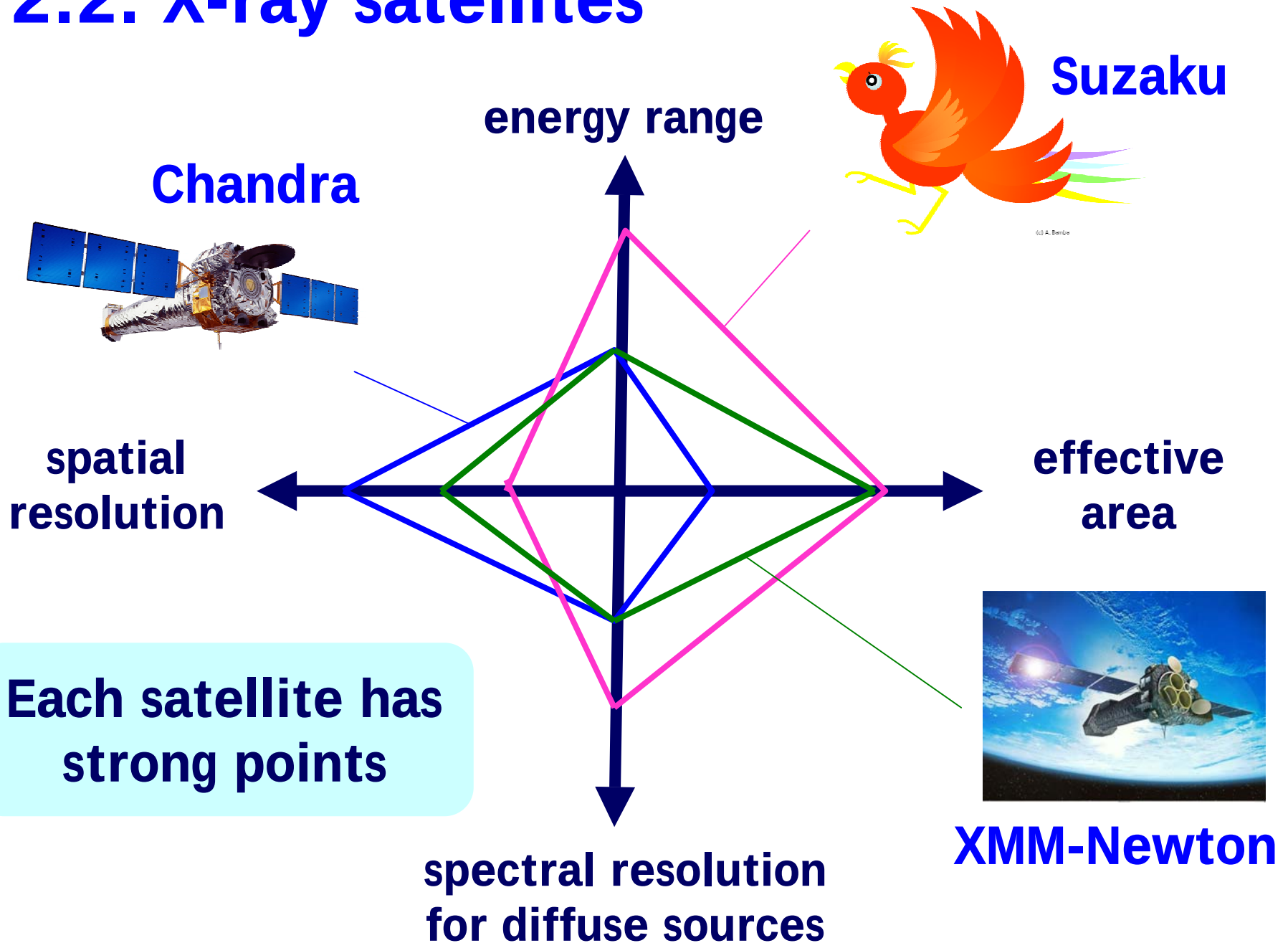
一年間
がんばったよ!



(c) A. Bamba

2006.07.10

2.2. X-ray satellites

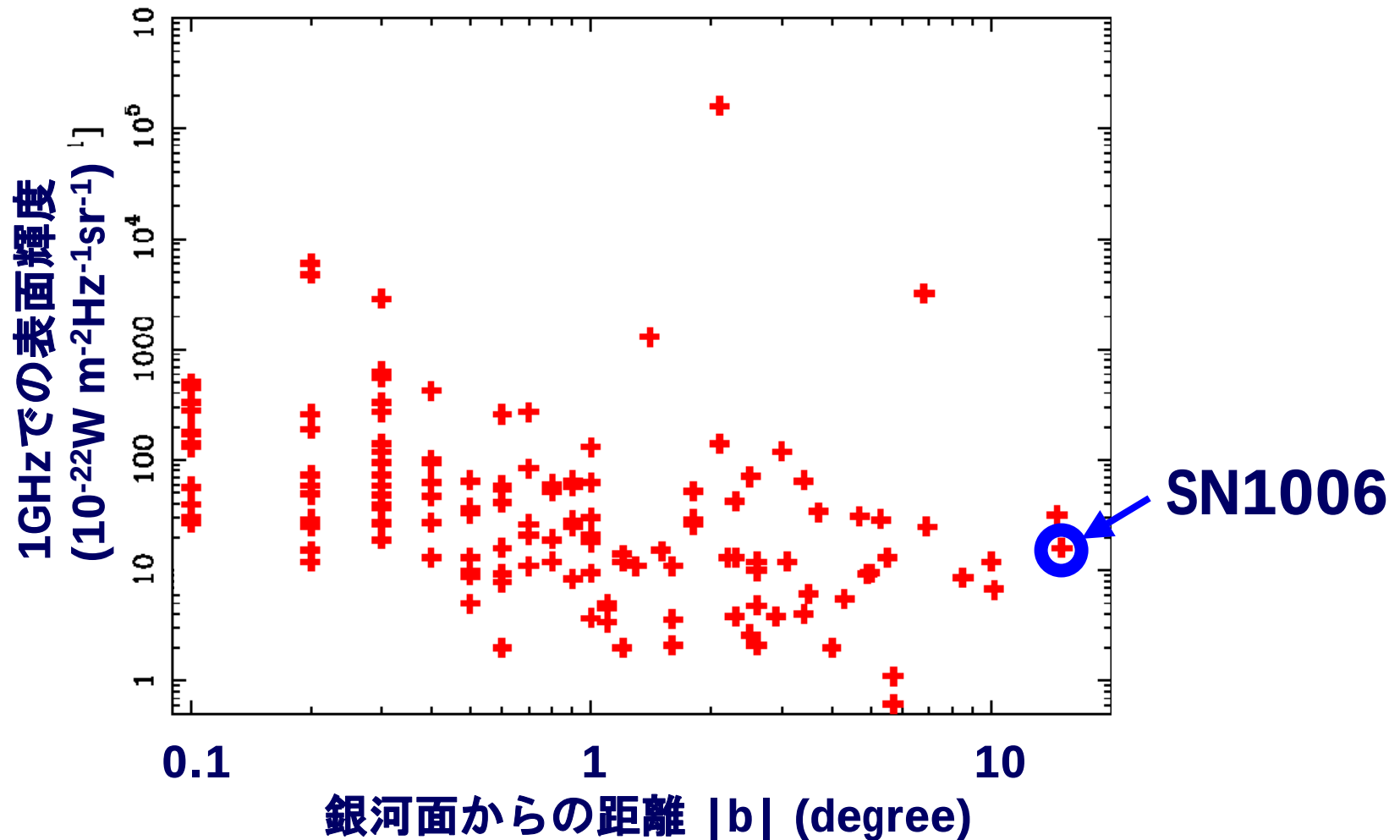


topic 1.

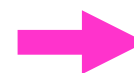
硬X線による超新星残骸探査

3.1. 未知の超新星残骸探査

今までのSNR探査: 電波中心 (265個: Green et al. 2006)



電波サーベイは銀河面近くで弱い
SN1006型は電波で暗い



硬X線探査

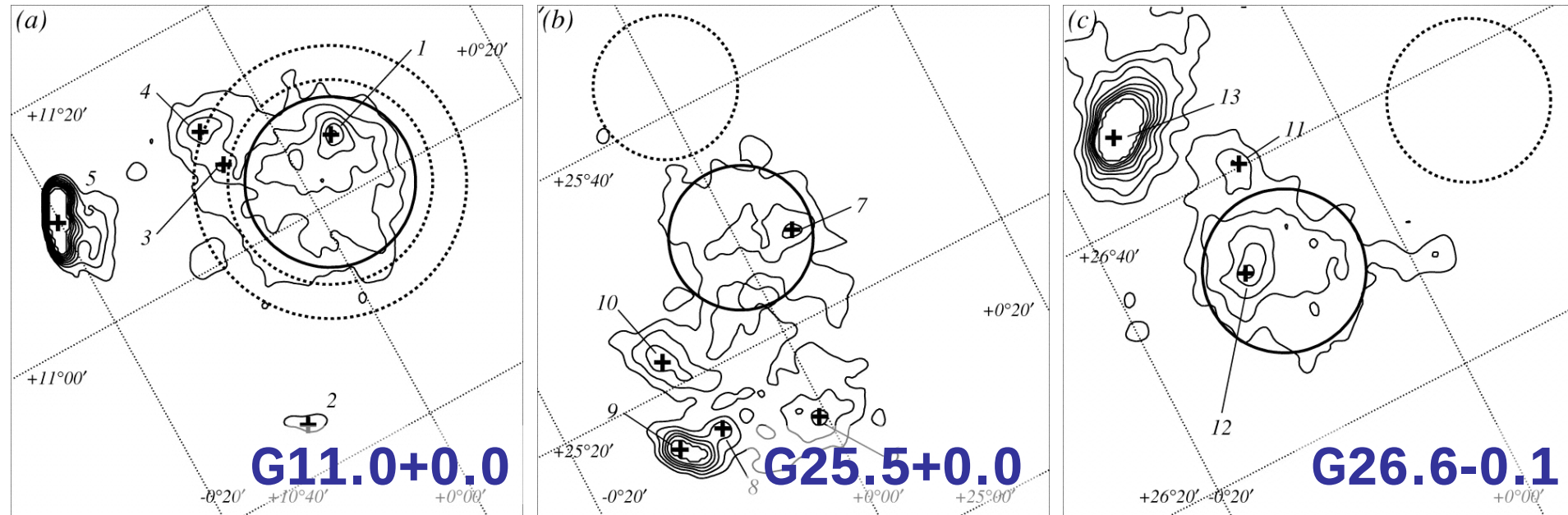
3.2. ASCAによる無バイアス銀河面探査

探査領域:

$$|l| < 45^\circ, |b| < 0.4^\circ$$

硬X線無バイアス探査としては
おそらく最大・最高感度探査

複数の未同定宇宙線加速SNR候補を発見



Bamba et al. (2003b)

このようなSNR ... ~20個?

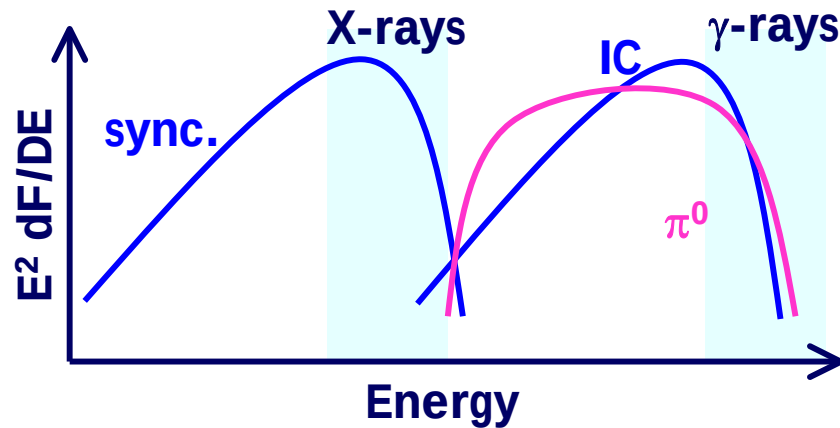
topic 2.

硬X線による陽子加速源探査

4.1. How to search proton accelerators ?

The efficiency of electron acceleration is so high.
however ...

How about protons ?



electrons

-> synch. X-rays + IC γ-rays

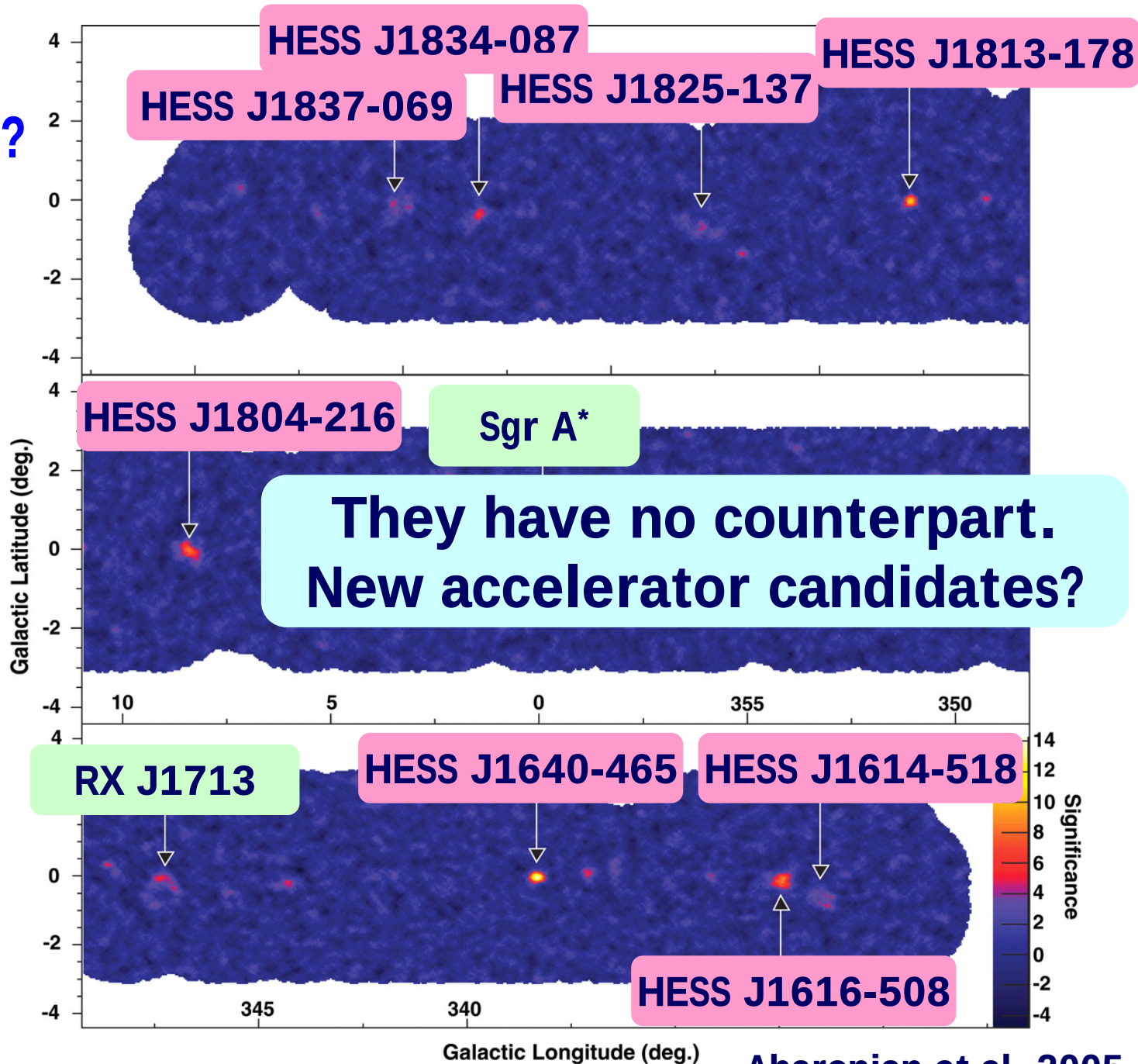
protons

-> γ-rays via π^0 decay

To find out proton accelerators ...

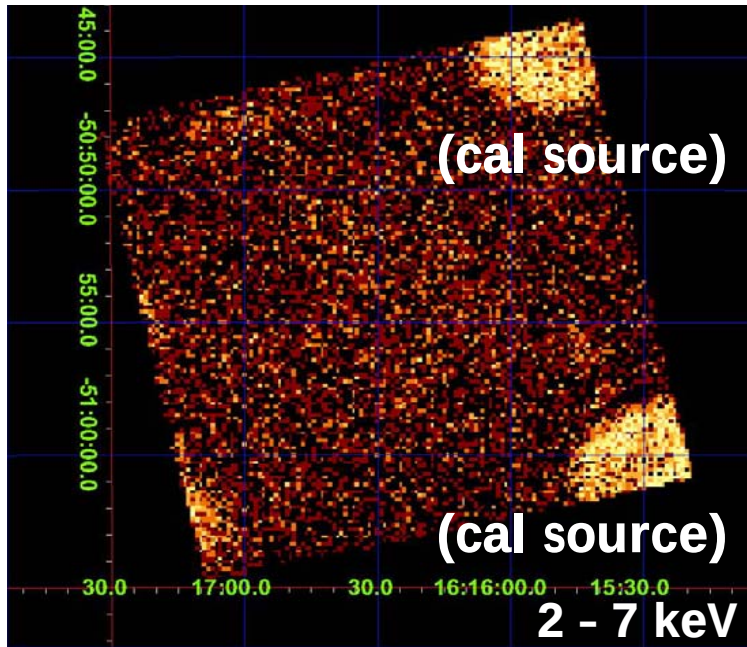
searching for X-ray dim & γ-ray bright sources
TeV & X-ray observations are strong tool!

4.2. 新SNR候補?



4.3. Suzaku observation of HESS unID sources

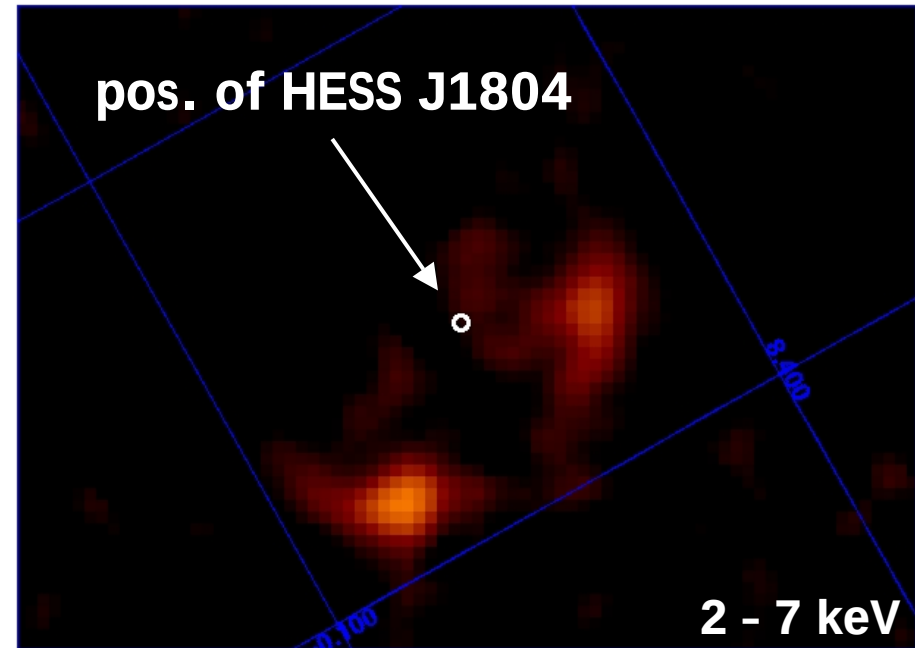
HESS J1616-508



strong upper limit !

(Matumoto et al. PASJ in press
astro-ph/0608475)

HESS J1804-216



dim counterpart ?!

hard, absorbed, compact

(Bamba et al. PASJ in press
astro-ph/0608310)

Suzaku will catch the nature of TeV unID sources

4.4. F_{TeV}/F_X ratio

target	F_{TeV}/F_X
Crab	$\sim 2.7 \times 10^{-3}$
RX J1713	~ 0.06
HESS J1804-216	~ 8
HESS J1616-508	$> 55?$

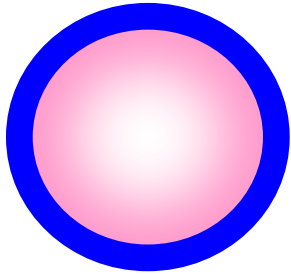
HESS unID sourcesは
本当にproton acceleratorかもしれない!

4.5. One possible scenario for TeV unID sources:

Emission from SNRs in various phases

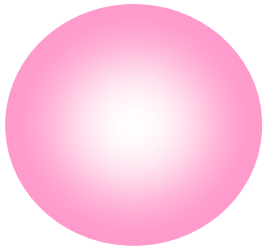
(Yamazaki et al. MNRAS in press, astro-ph/0601704)

young SNRs



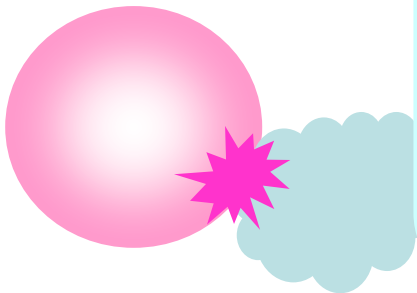
large shock speed
both e and p are accelerated
strong synchrotron X-rays

old SNRs



small shock speed
electrons are decelerated

SNRs colliding with MCs



TeV unIDs are old SNRs
colliding with MCs?

Their nature is still unknown,
but wide band obs. will solve it !

topic 3.

硬X線によるCR加速現場の環境探査

5.1. how to measure acc. efficiency of protons ?

**Thin thermal plasma (~keV) emits lines
in the X-ray band.**

**X-ray plasma diagnostics
can determine precise plasma parameters.**

**Suzaku XIS has good spectral resolution
-> best for the study !**

from Rankine-Hugoniot relation

$$kT_d = \frac{2(\gamma-1)}{(\gamma+1)^2} m v_s^2 \quad \sim 0.19 E_{\text{shock}} \text{ (no acc.)}$$
$$< 0.19 E_{\text{shock}} \text{ (efficient acc.)}$$

6. Summary

- 硬X線は宇宙線加速源・機構解明に強力な手段!
- 「すざく」は銀河系内宇宙線加速源探査に最適のX線天文衛星である。
 - 低バックグラウンド、高感度、高E分解能
- 「すざく」は多くの新しい超新星残骸候補を発見するだろう。
- 同時にHESS未同定天体の正体もつかめるだろう。
- 「すざく」による超新星残骸の高E分解能観測で、宇宙線加速現場の状況をつかめるだろう。

Notice !

Suzaku is providing a lot of fruitful data, and many results of Suzaku observation are reported !

We will hold the conference
“**The Extreme Universe in the Suzaku Era**” at Kyoto
on December 4-8, 2006 !

Topics are not only SNRs
but all high E topics.

We are looking forward to
your participating !!

<http://www-cr.scphys.kyoto-u.ac.jp/conference/suzaku2006/>

**The Extreme Universe
in the Suzaku Era**
Kyoto, Japan December 4 - 8, 2006

Diffuse X-ray Sources in Galaxies
Extended Thermal X-rays
Non-thermal X-ray/GeV/TeV Sources
The Galactic Center and its Environments

X/γ-rays from Stars and Compact Objects in Galaxies
White Dwarf and Neutron Star Binaries
Isolated Compact Stars
Normal Stars, Planets and Nebula

Structure and Evolution of Galaxies and Clusters
Chemical Compositions and Evolutions
Thermal and Non-thermal Structures

Stellar/Intermediate/Super Mass Black Holes
Accretion Physics on Black Holes
Outflow/Jets from AGNs and Micro-Quasars

Extremely High Energy Objects
Gamma Ray Burst
GeV/TeV Emissions
Cosmic Rays and Neutrino

Special Session:
“The millennium of SN 1006: Particle acceleration”

締切: 9/1!

SOC:
M. Bautz (MIT, USA)
C. Done (U. Durham, UK)
A. Fabian (Cambridge, UK)
G. Hasinger (MPE, Germany)
J. Hughes (Rutger U., USA)
R. Kelley (GSFC/NASA, USA)
K. Makishima (Kyoto Univ., Japan)
D. McCammon (MIT, USA)
K. Mitsuda (ISAS, Japan)
R. Mushotzky (GSFC/NASA, USA)
A. Parmar (ISTEC, The Netherlands)
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www-cr.scphys.kyoto-u.ac.jp/conference/suzaku2006/