# 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 ~ pc

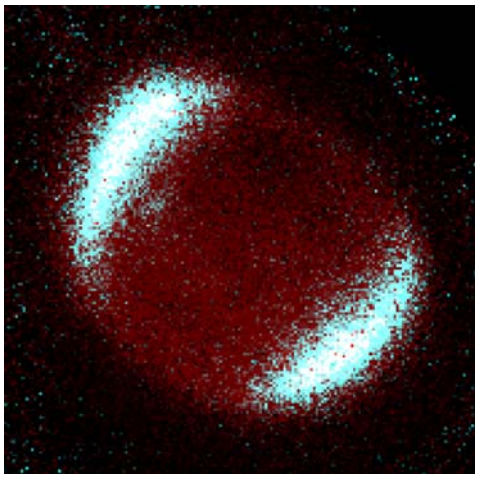
粒子の到来方向からは加速源を突き止められない

TeV electron
星間磁場 (~μG) ➡ 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

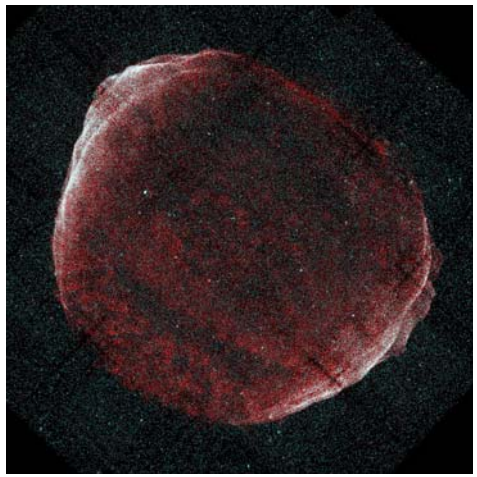
1995 Koyama et al.



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???

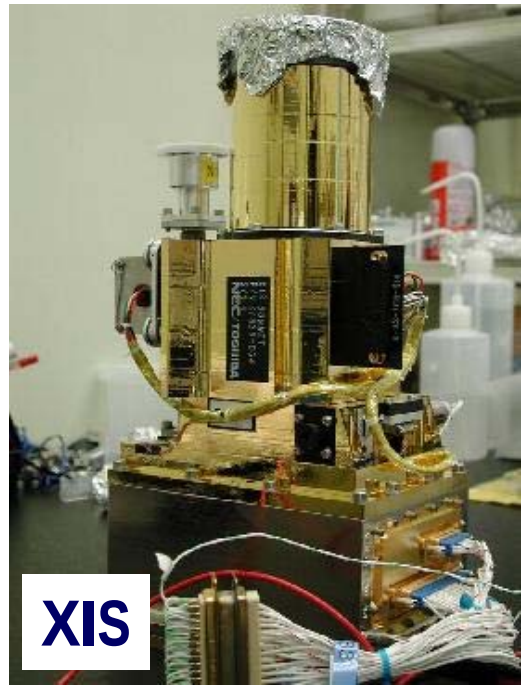
| total No. of SNRs | acc. possibility of protons | plasma condi. of acc. sites |
|---|---|---|
| ↑ | ↑ | ↑ |
| wide-band spectra (radio - TeV) -> topic 1 | wide-band spectra (radio - TeV) -> topic 2 | plasma diagnostics in X-rays -> topic 3 |

**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**

**410cm² @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**

**best for dim & diffuse sources**

**HXD (Hard X-ray Detector)**

**Wide energy band**

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

**Non-imaging detector, but low background**

一年間
がんばったよ!



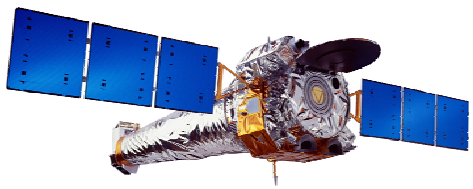

2006.07.10

# 2.2. X-ray satellites

Suzaku

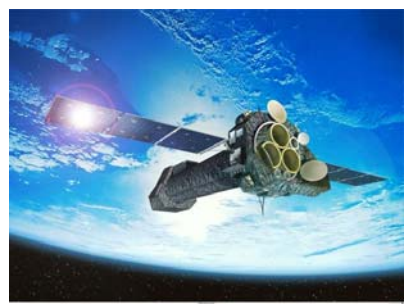
energy range

Chandra



spatial resolution

effective area



XMM-Newton

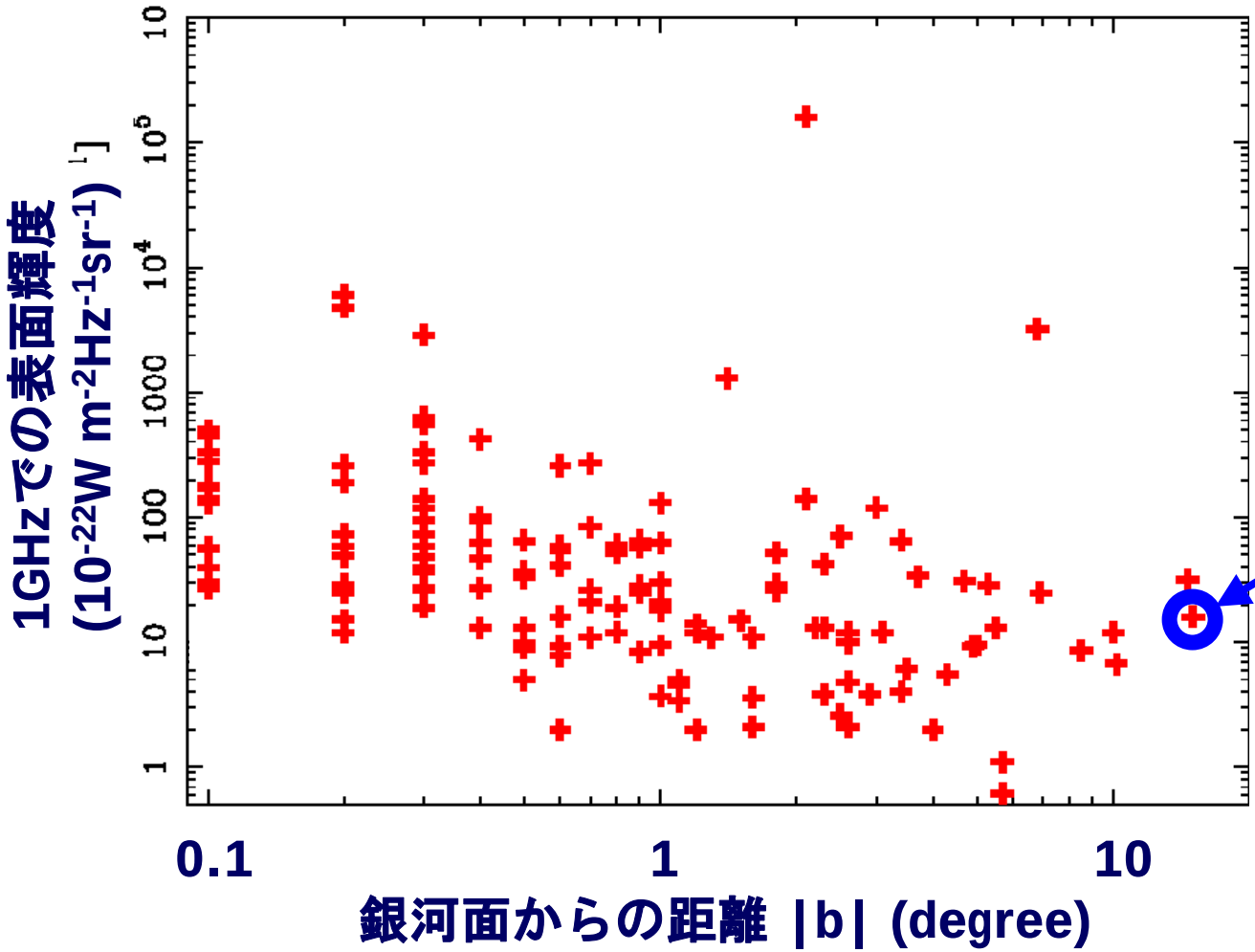
Each satellite has strong points

spectral resolution for diffuse sources

# 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

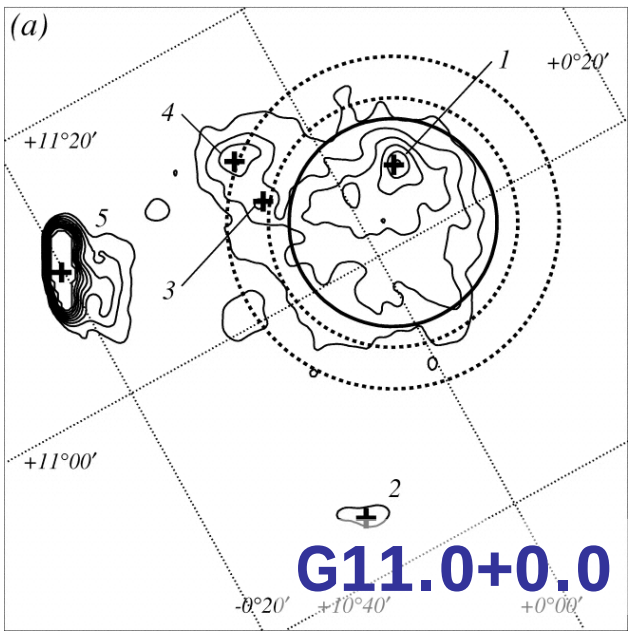
→ 硬X線探査

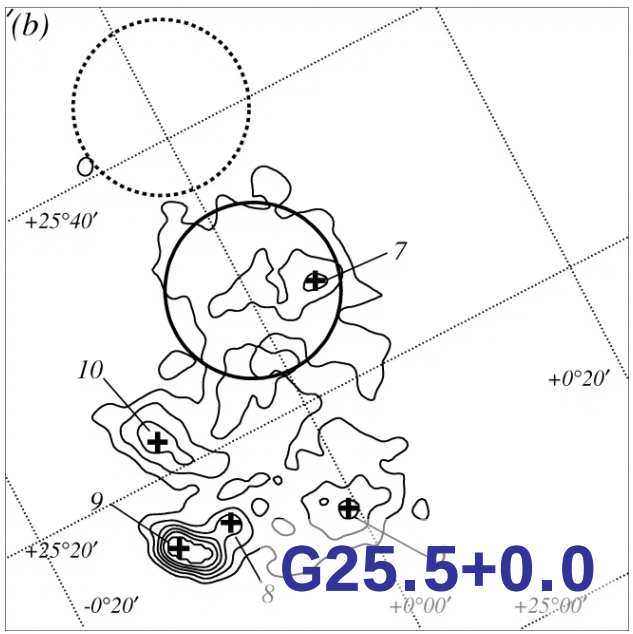
# 3.2. ASCAによる無バイアス銀河面探査

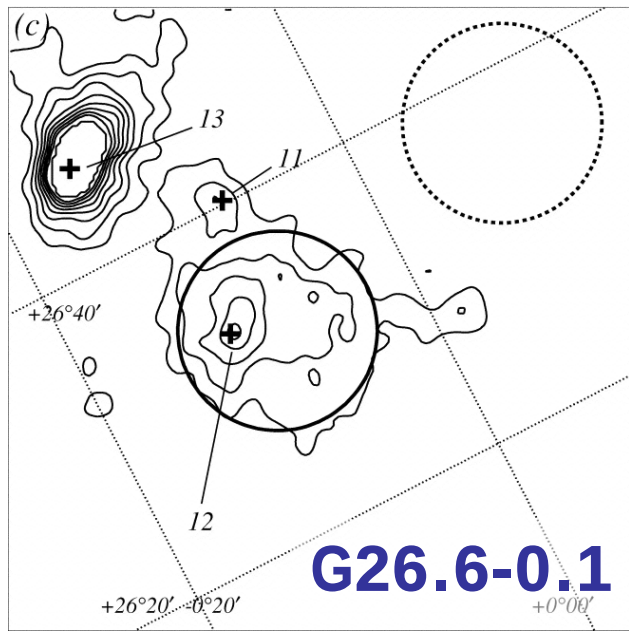
**探査領域:**
**$|l| < 45^o$, $|b| < 0.4^o$**

**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)

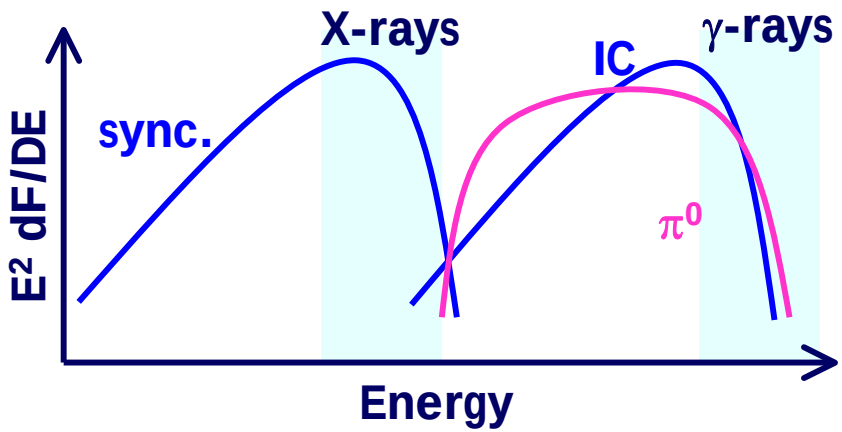
**このようなSNR ... ~20個?**

# 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 ?

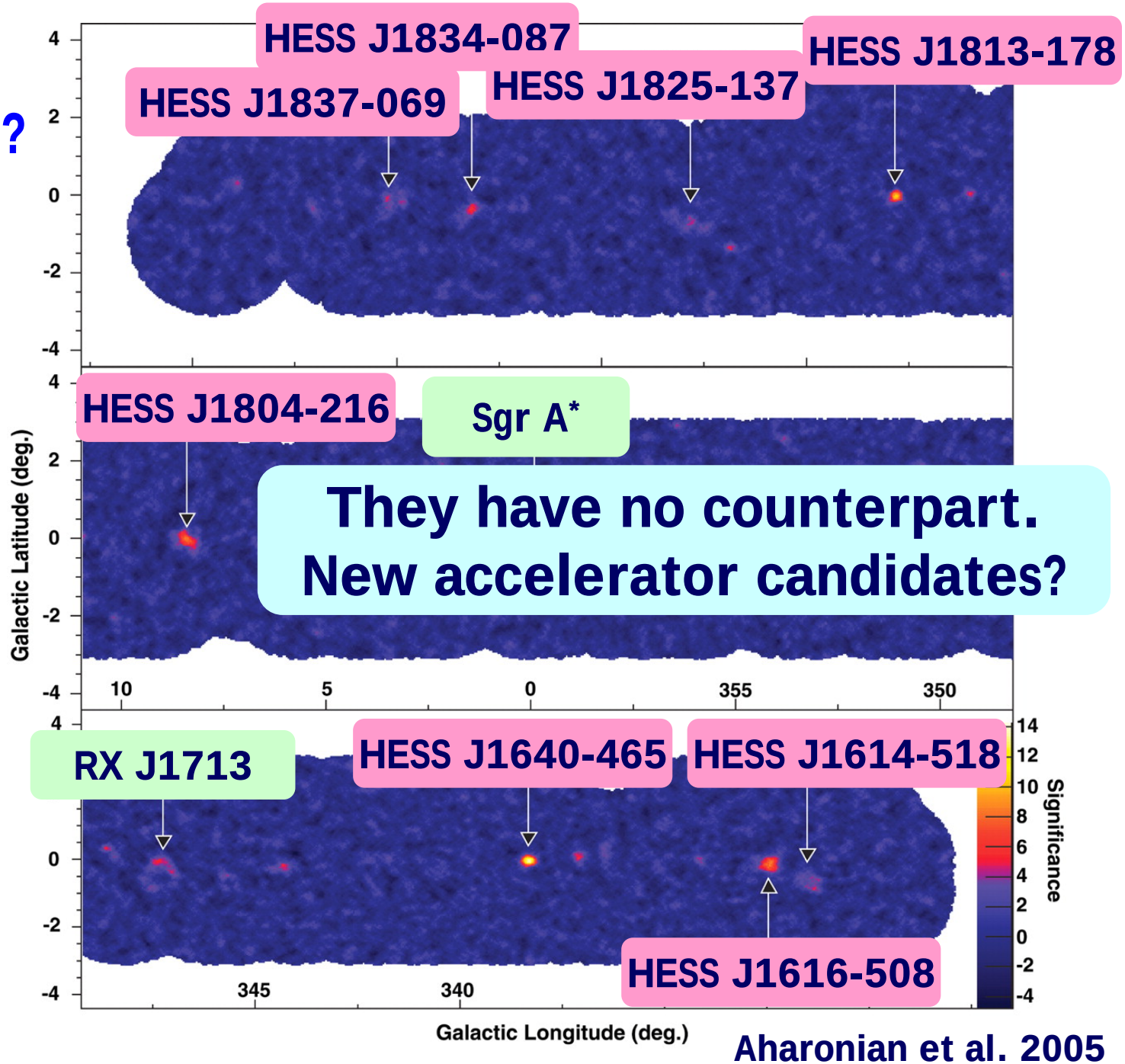



**electrons**
**-> synch. X-rays + IC γ-rays**
**protons**
**-> γ-rays via $\pi^0$ decay**

**To find out proton accelerators ...**

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

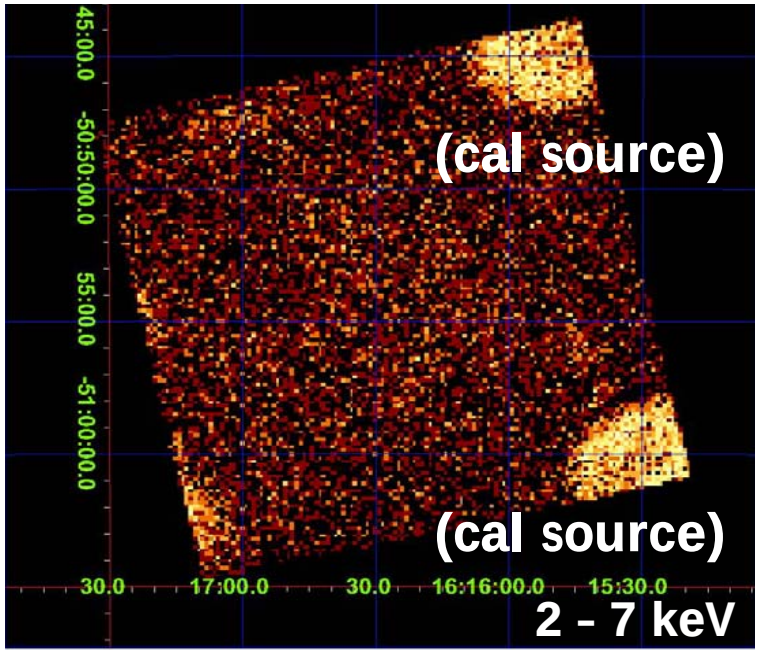
# 4.2.
# 新SNR候補?




Aharonian et al. 2005

# 4.3. Suzaku observation of HESS unID sources

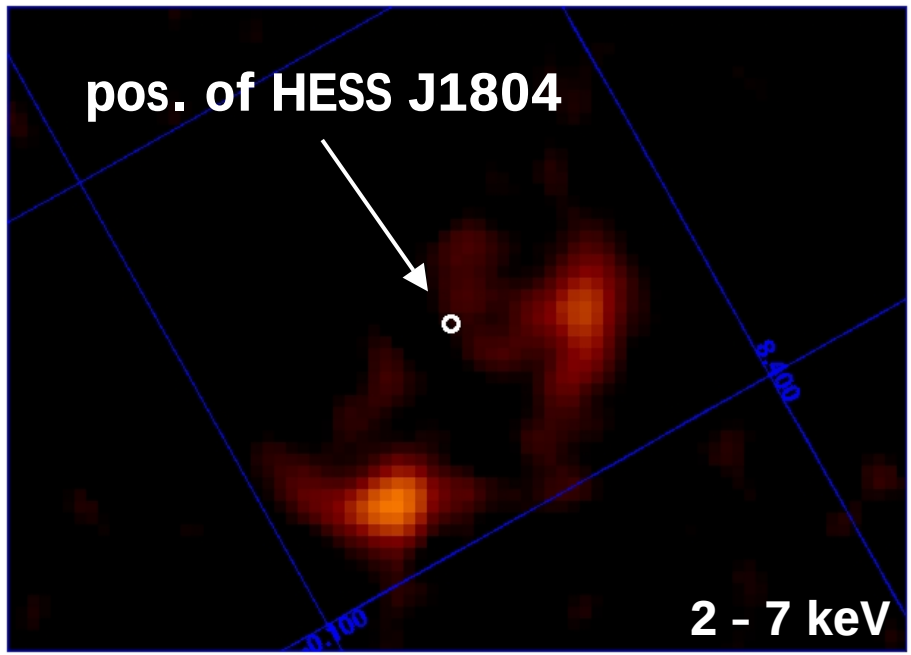
## HESS J1616-508




**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

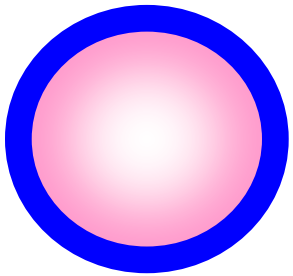
| target | $F_{TeV}/F_X$ |
|---|---|
| Crab | ~2.7e-3 |
| RX J1713 | ~0.06 |
| HESS J1804-216 | ~8 |
| HESS J1616-508 | >55? |

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

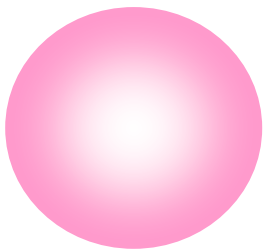
(Yamazaki et al. MNRAS in press, astro-ph/0601704)

young SNRs



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

old SNRs



small shock speed
electrons are deccelerated

SNRs colliding w

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**

$$kT_d = \frac{2(\gamma-1)}{(\gamma+1)^2} mv_s^2$$

**~ 0.19 $E_{shock}$ (no acc.)**
**< 0.19 $E_{shock}$ (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。

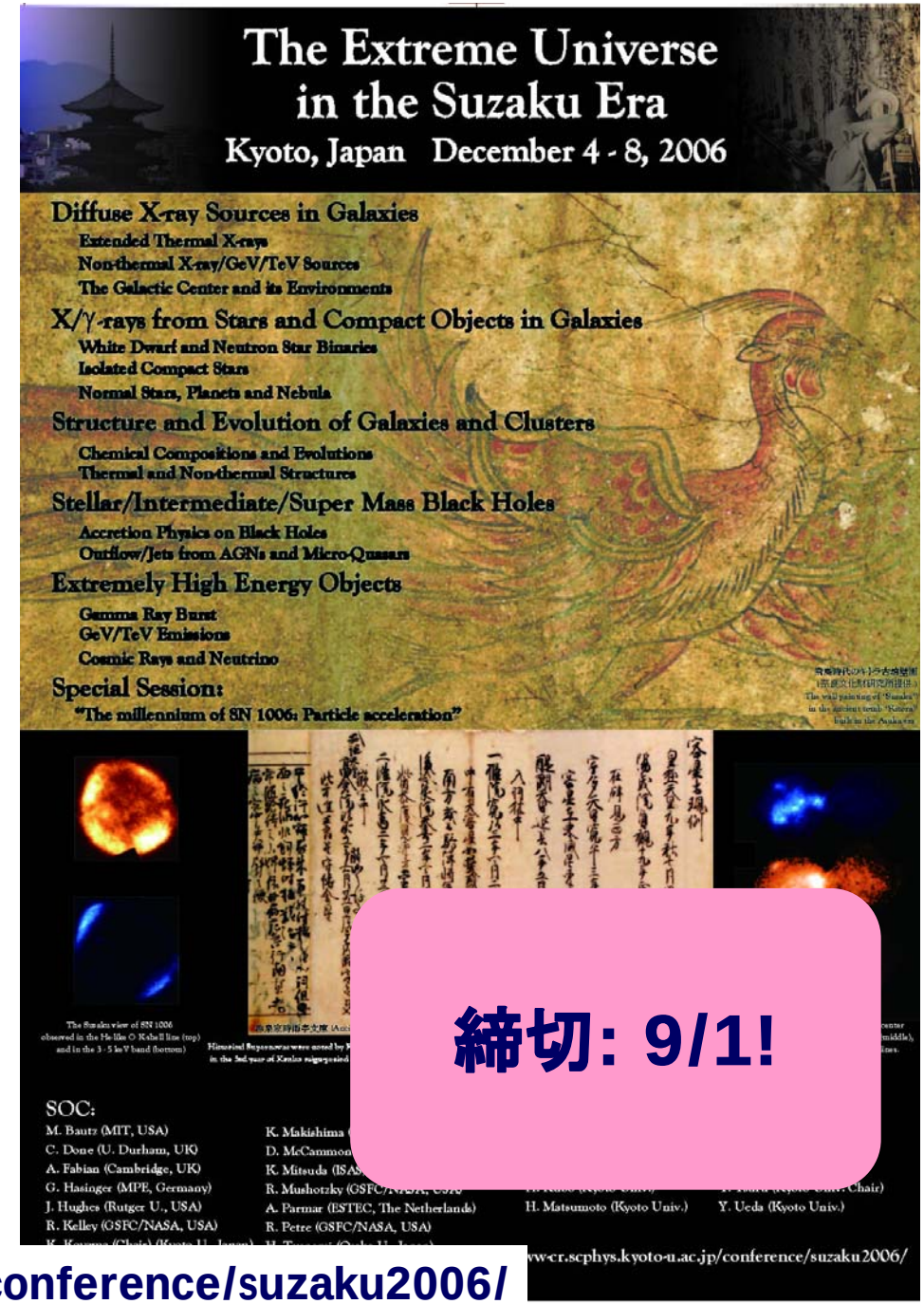
# Notice !

**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/**