Exploring the Gamma-ray Skies with the Fermi Gamma-ray Space telescope and the Fermi Asian Network (FAN)

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What is Fermi?

Two Instruments:

Large Area Telescope (LAT)

PI: P. Michelson (Stanford University)

20 MeV - 300 GeV

>2.5 sr FoV

Gamma-Ray Burst Monitor (GBM)

PI: W. Paciesas (NASA/MSFC)

Co-PI: J. Greiner (MPE)

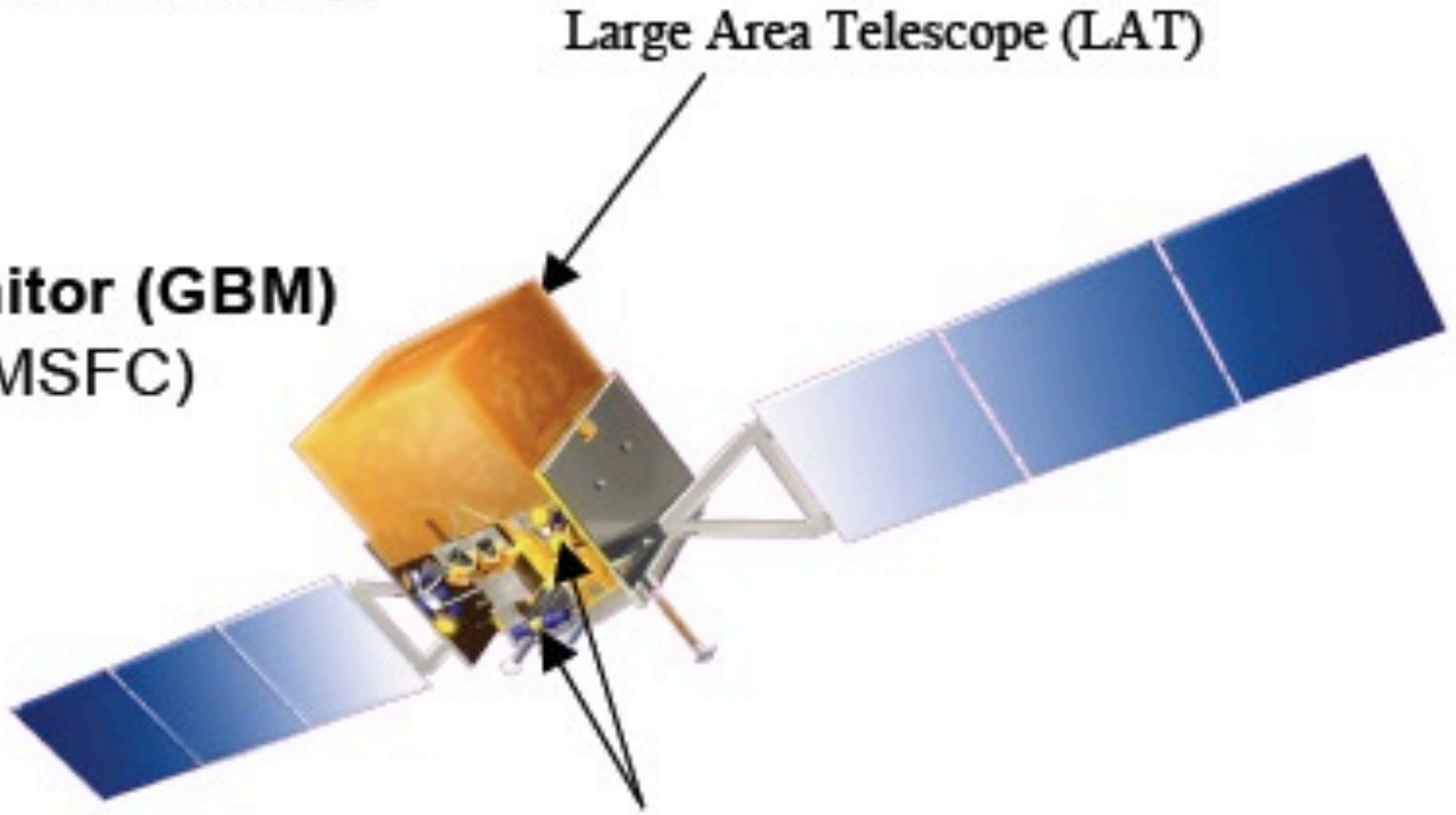
8 keV – 40 MeV

9 sr FoV

Launch: June 11 2008

Lifetime: 5 years (req)

10 years (goal)



Fermi reveals the universe above 10 GeV

超新星遺跡
Supernova remnants and pulsar wind nebulae
5%

脈衝星
Pulsars
5%

大質量雙星
High-mass binaries, other sources in our galaxy
Less than 1%

Unknown
34%

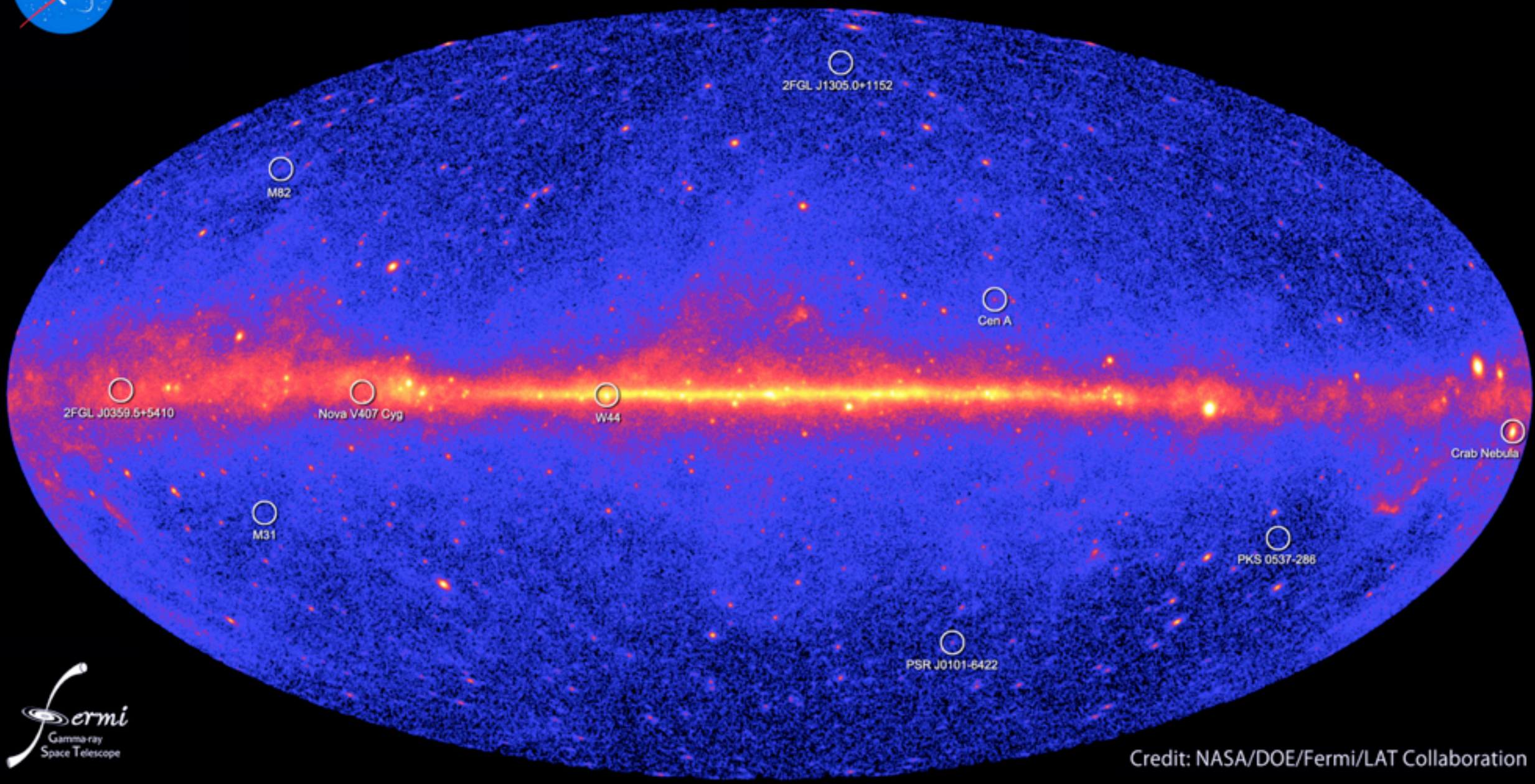
About 2000 gamma-ray sources have been discovered.

活躍星系
Active galaxies
55%

星系
Other galaxies
Less than 1%

Credit: NASA/Goddard Space Flight Center

Fermi two-year all-sky map



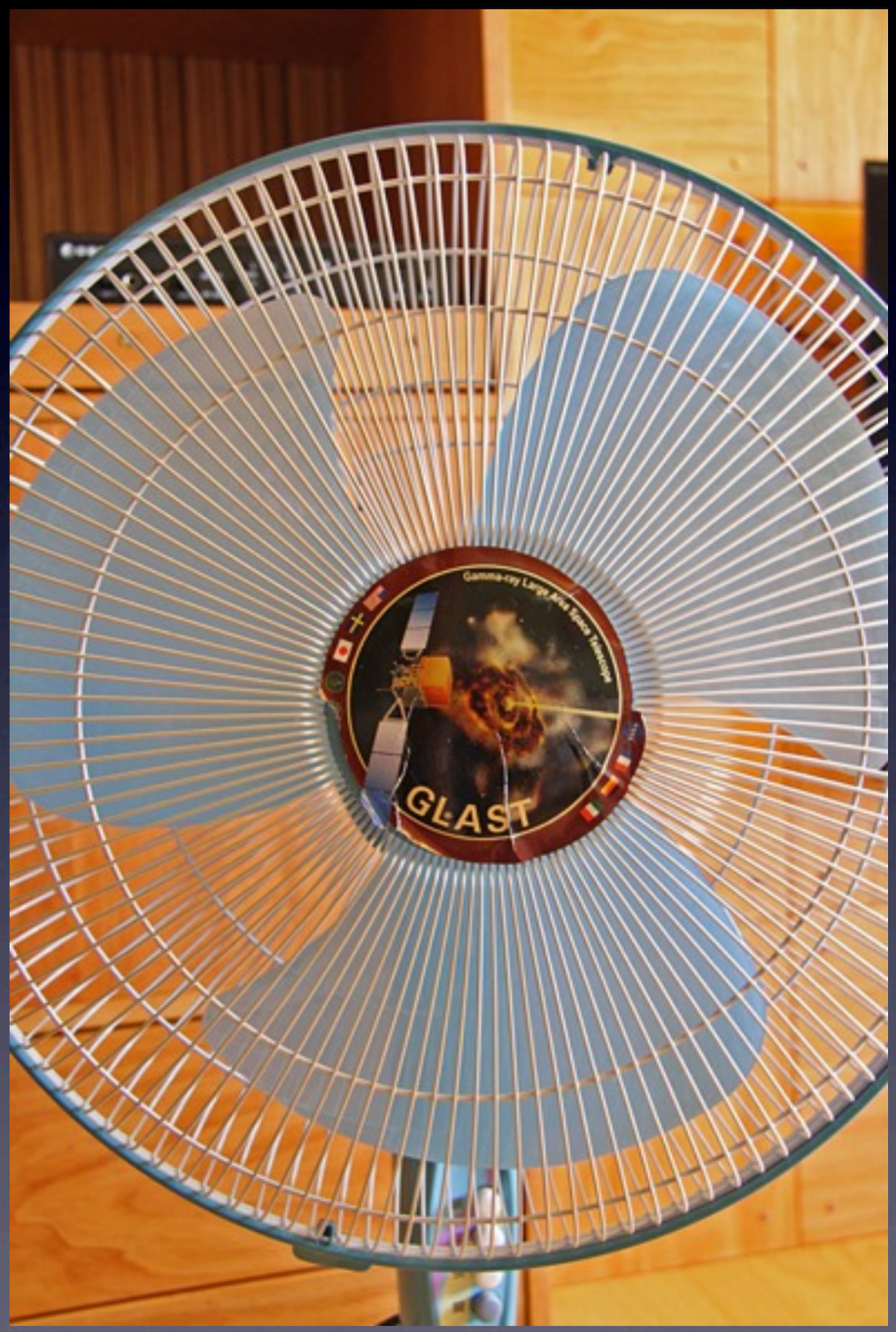
Fermi Gamma-ray Space Telescope

Credit: NASA/DOE/Fermi/LAT Collaboration

The Era of Fermi

- The Fermi Gamma-ray Space Telescope was launched on 2008 June 11. Nominal observations start in 2008 August.
- After 2009 summer, *all* data are in public domain *immediately*.
- Analysis tools and manuals are provided by NASA.
- Archival data are proven to be very important in astrophysics.
- Why don’t we make use of Fermi data to do some interesting science?

What is FAN?

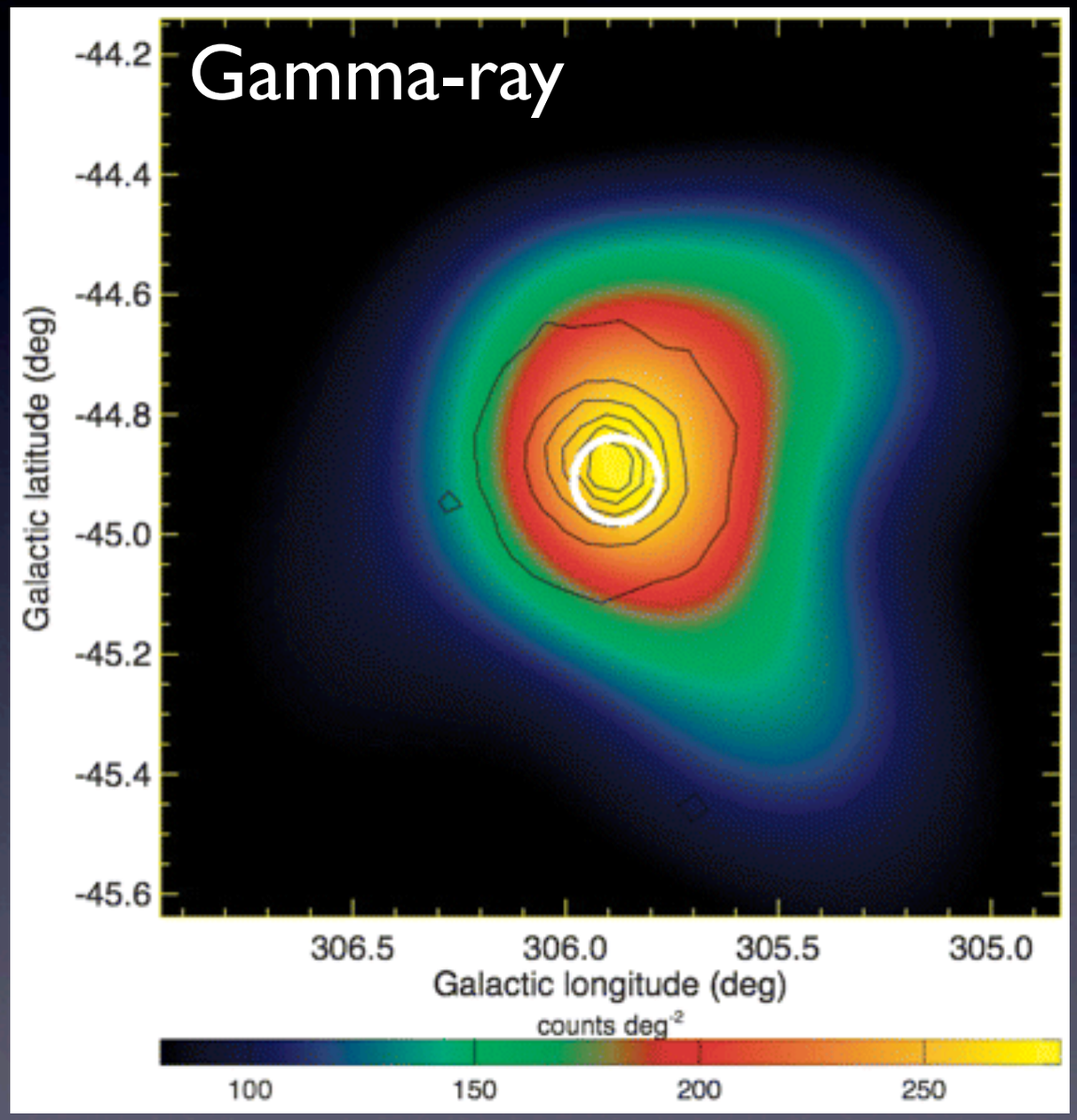


- FAN is Fermi Asian Network
- FAN's members: Taiwan (NTHU +CMU+NCU), Hong Kong (HKU), and Korea (Chungnam). ~15 academic staffs and students
- We aim to promote Fermi science in Asia (e.g. helping Purple Mountain Observatory (紫金山天文台) to organize a course in 2012 June)
- We also have collaboration with Japan

FAN Publications

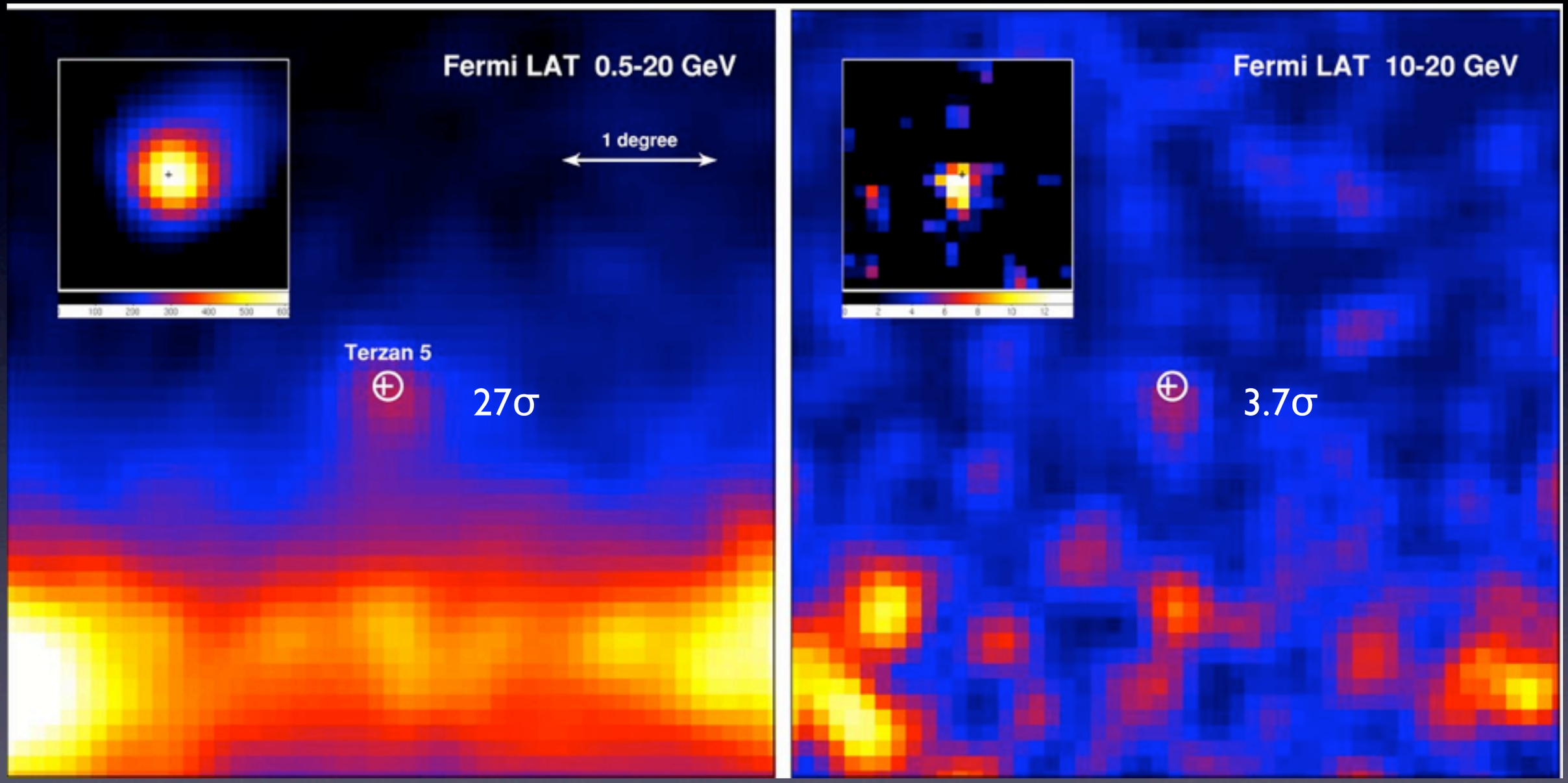
- Largest number of Fermi papers (18 Astrophysical Journal + 5 ATels + 3 GCN in 2010-2013) outside the NASA-led Fermi collaboration
- Globular clusters: Kong+ 2010; Cheng+ 2010; Hui+ 2011; Tam+ 2011; J. Wu+ 2013
- Pulsars: Lin+ 2010; Tam+ 2010; Tam+ 2011; J. Wu+ 2012; Huang+ 2012; E. Wu+ 2012
- Unidentified Fermi objects: Hui+ 2011; Kong+ 2012
- Gamma-ray bursts: Tam & Kong 2011; Tam, Kong & Fan 2012; Tam+ 2013
- Supernova remnants: J. Wu+ 2011; J. Wu+ 2012
- We published some of the results faster than the Fermi collaboration
- For comparison: Fermi collaboration published ~130 papers from 2008

First Gamma-ray detection from a globular cluster (47 Tuc)
Abdo et al. 2009, Science



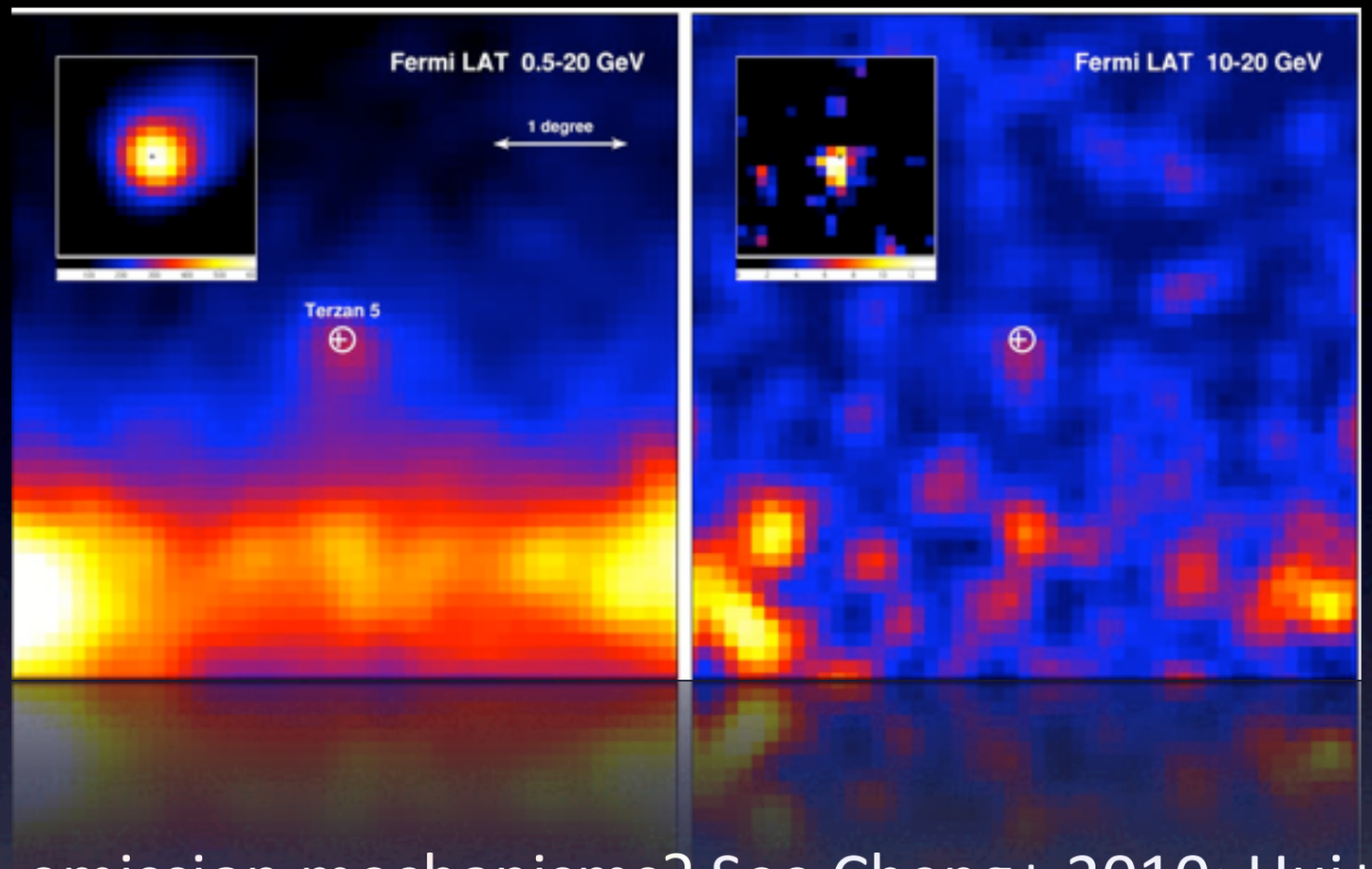
Stellar density: ~100 stars/light year^3

Fermi 17-month Observations of Terzan 5



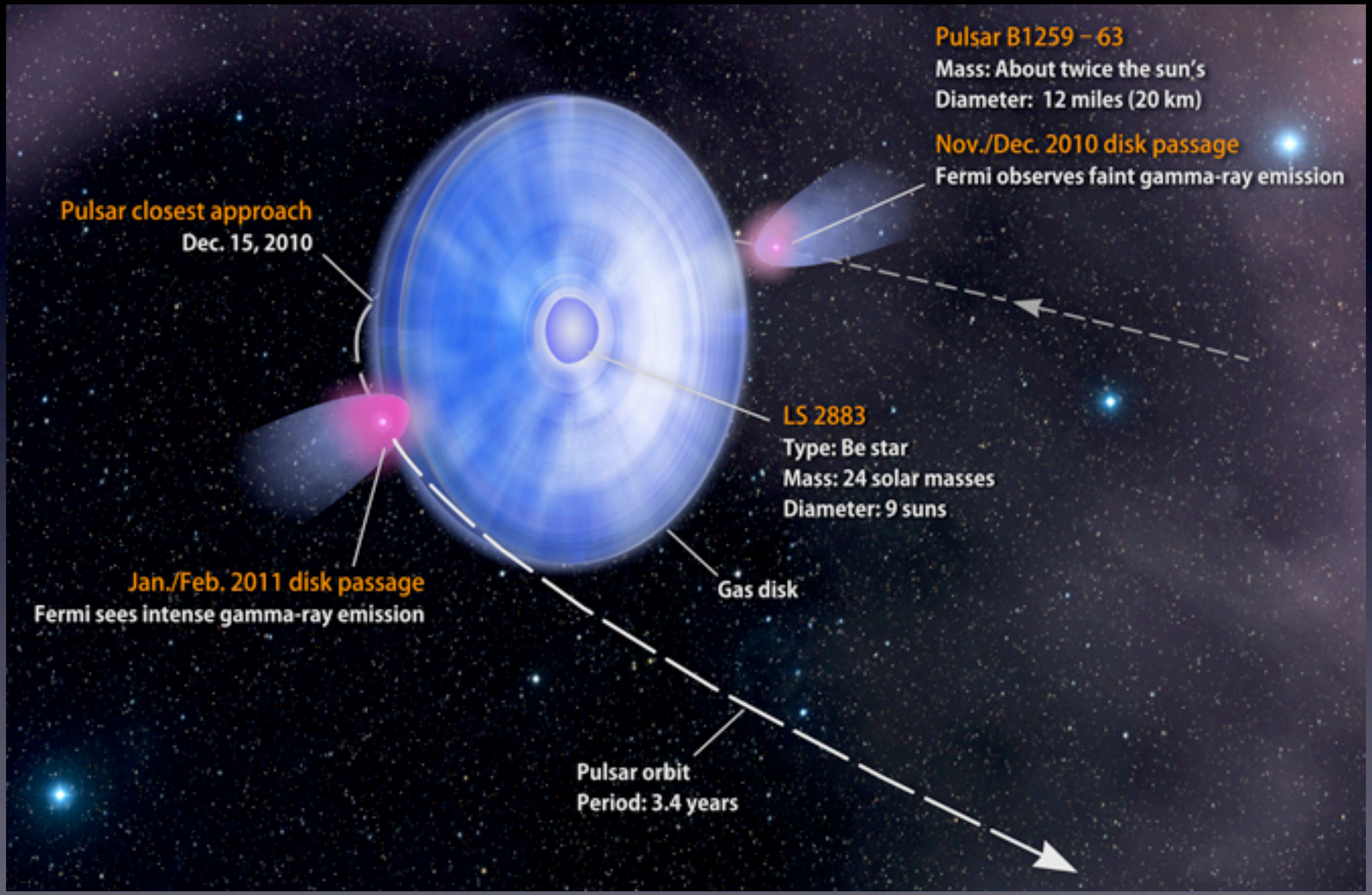
Kong et al. 2010

Questions and followup works

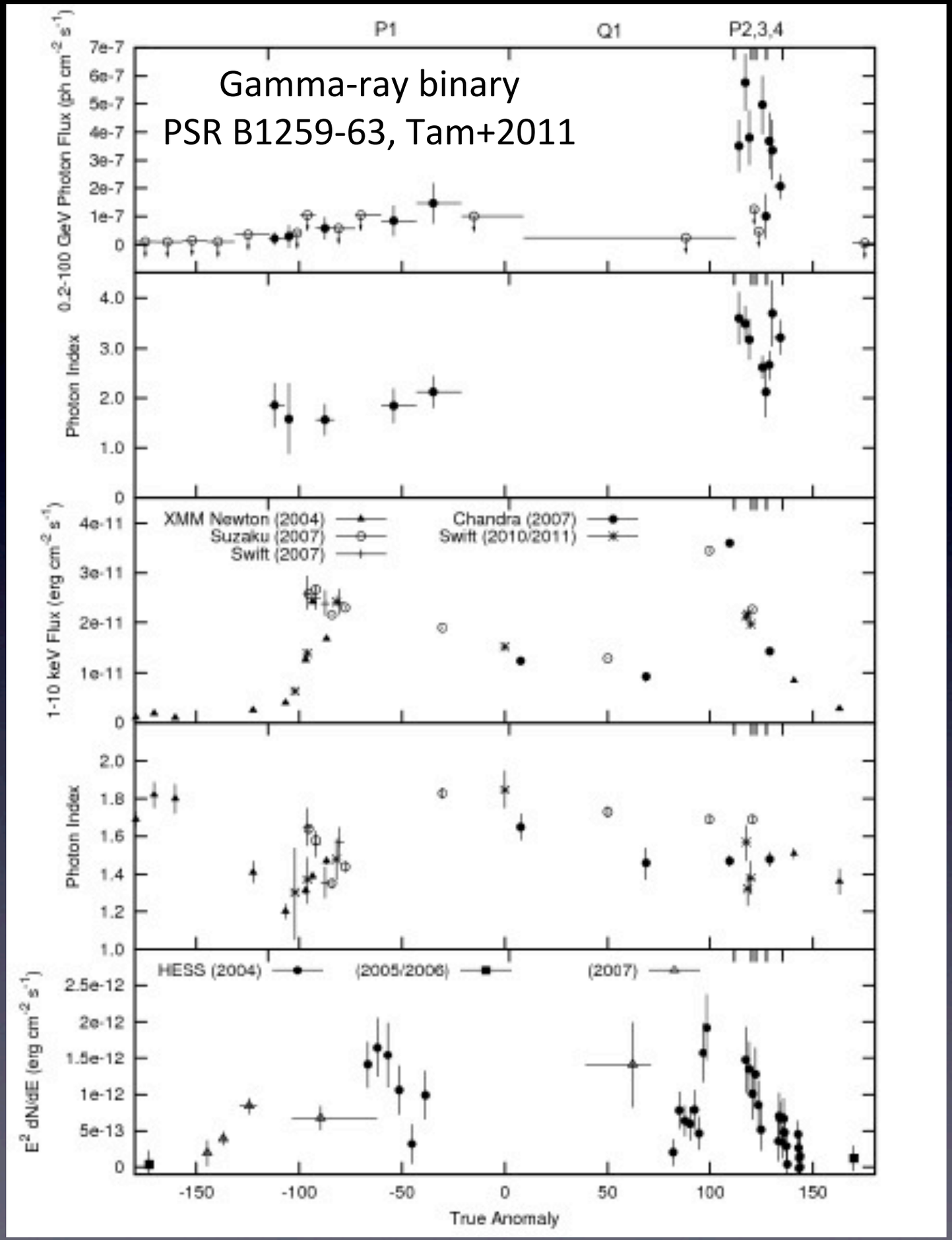


- What is the emission mechanisms? See Cheng+ 2010; Hui+ 2011
- Can we detect GeV emission from other GCs? Abdo+ 2009; Kong+ 2010; Abdo+ 2010; Tam+ 2011
- We now have more than 15 detections including 2 with pulsations (e.g., Wu+ 2013)
- What is the relationship among different physical parameters? Hui+ 2011

A Gamma-ray outburst of a gamma-ray binary



Gamma-ray binary
PSR B1259-63, Tam+2011



In the news


人間福報 Merit Times

寄居蟹 住玻璃豪宅

清大6人 擊敗NASA 173位科學家

率先偵測雙星系互動機制重要線索—伽瑪射線 天文學界肯定

發現「γ射線瞬變」清大領先全球

【記者蔡永彬／台北報導】去年11月20日，清華大學天文研究所一個6人小團隊在位於南十字座旁的雙星系統發現「γ（讀作gamma、伽瑪）射線瞬變現象」，這項發現領先全球。研究成果登在昨天的《The Astrophysical Journal Letters》（天文物理期刊通訊）上。

清大校長陳力俊指出，他們發現了一個人類並不十分理解的「奇異現象」，未來人類對「中子星」的了解可能要修正了。

清大天文所博士後研究員譚桓軒是第1位發現此現象的天文學家。從去年10月起，他觀察位於南十字座附近的一顆中子星「PSR B1259-63」和一顆質量是太陽24倍的大質量恆星「LS 2883」組成的雙星系統，中子星以傾斜橢圓軌道繞大恆星運行，周期3.4 年。

譚桓軒表示，一般的雙星系統大多放出X光，放出γ射線的系統非常罕見；有天文學家預期，這兩星距離很近時，就可能會放出γ射線。去年11月20日前，譚桓軒沒任何收穫，當天卻突然探測到微弱γ射線，「很高興！」今年1月中旬，研究團隊又觀測到γ射線，而且強度增加好幾倍。

團隊的博士後高田順平推測，γ射線可能起因於這兩顆星的粒子互動，目前無法完全解釋成因。清大天文所副教授江國興說，雖然有理論解釋中子星經過大恆星會是什麼狀況，不過以前也沒人真的看過。

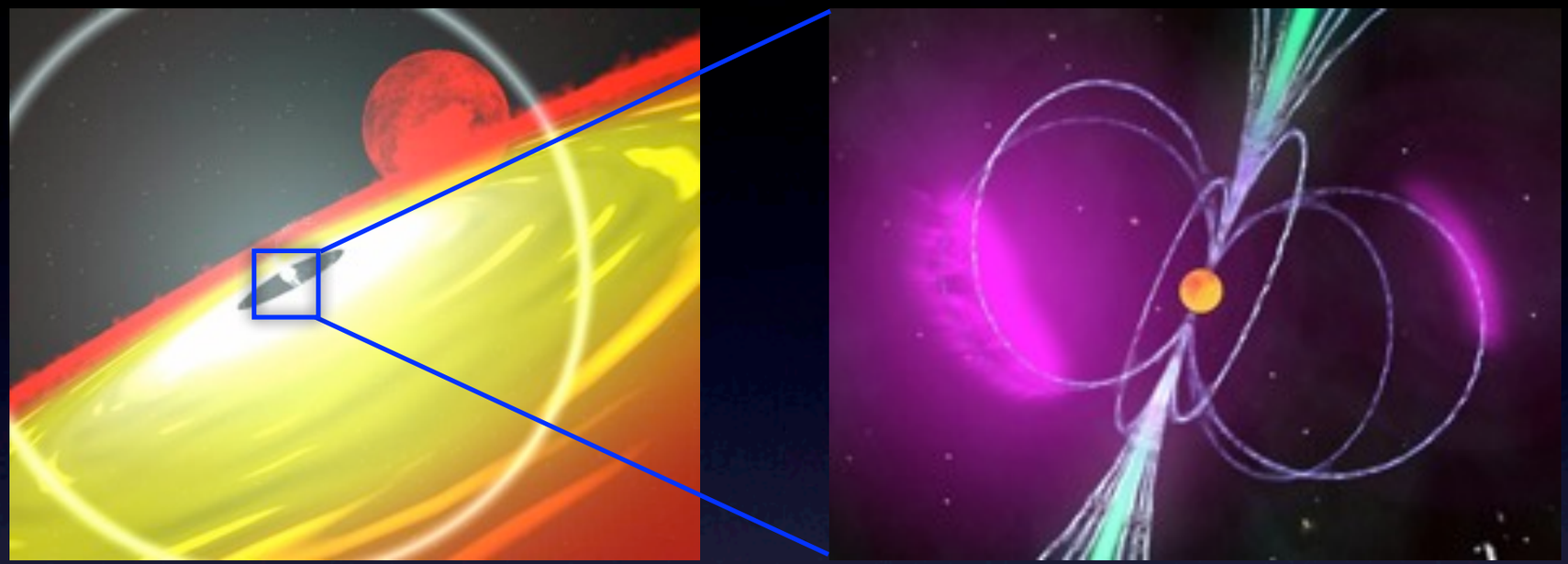
清大團隊在位於南十字座的雙星系統發現「γ射線瞬變現象」。圖中人物爲清大天文研究所副教授江國興。

記者蔡永彬／攝影

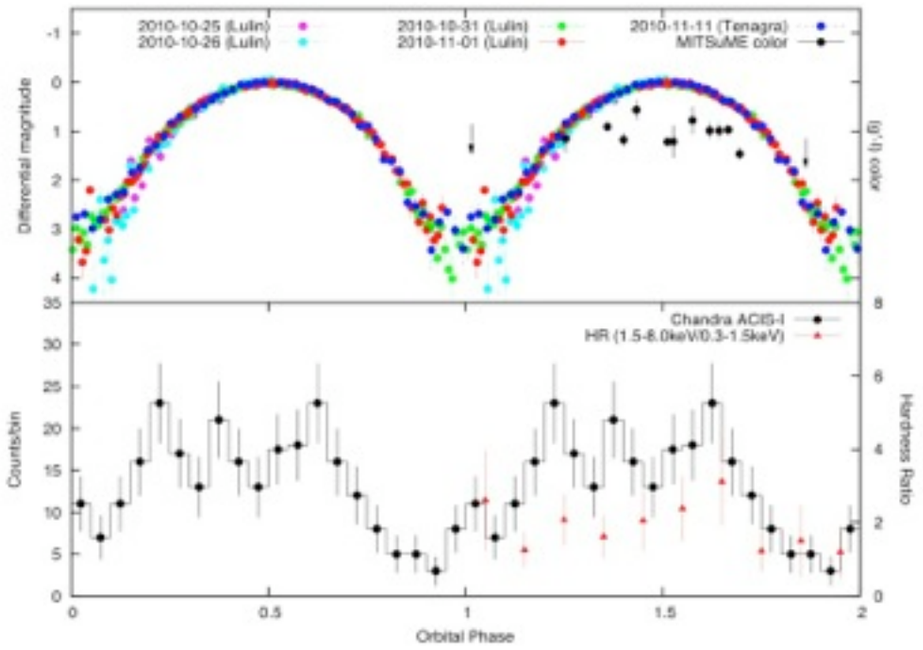
Unidentified Fermi object (UFO) as a ``radio-dim'' gamma-ray emitting millisecond pulsar in

- ``Radio-dim'' millisecond pulsars have not been identified yet
- It is not consistent with theories
- Traditionally, pulsars are discovered mainly from radio timing observations
- No radio => Need X-ray/gamma-ray data
  - Also requires optical data to support

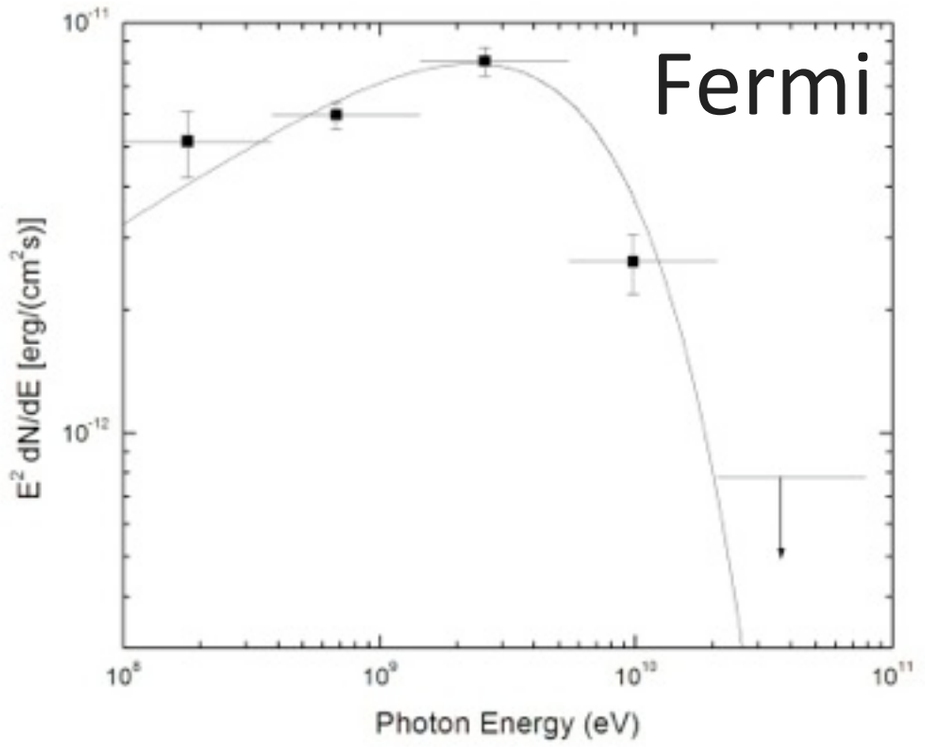
Unidentified Fermi object (UFO) as a ``radio-dim'' gamma-ray emitting millisecond pulsar in



Optical/X-ray @4.6hr



Kong+ 2012



主星：中性子星 → X線・ガンマ線
（半径10km, 1.4太陽質量）

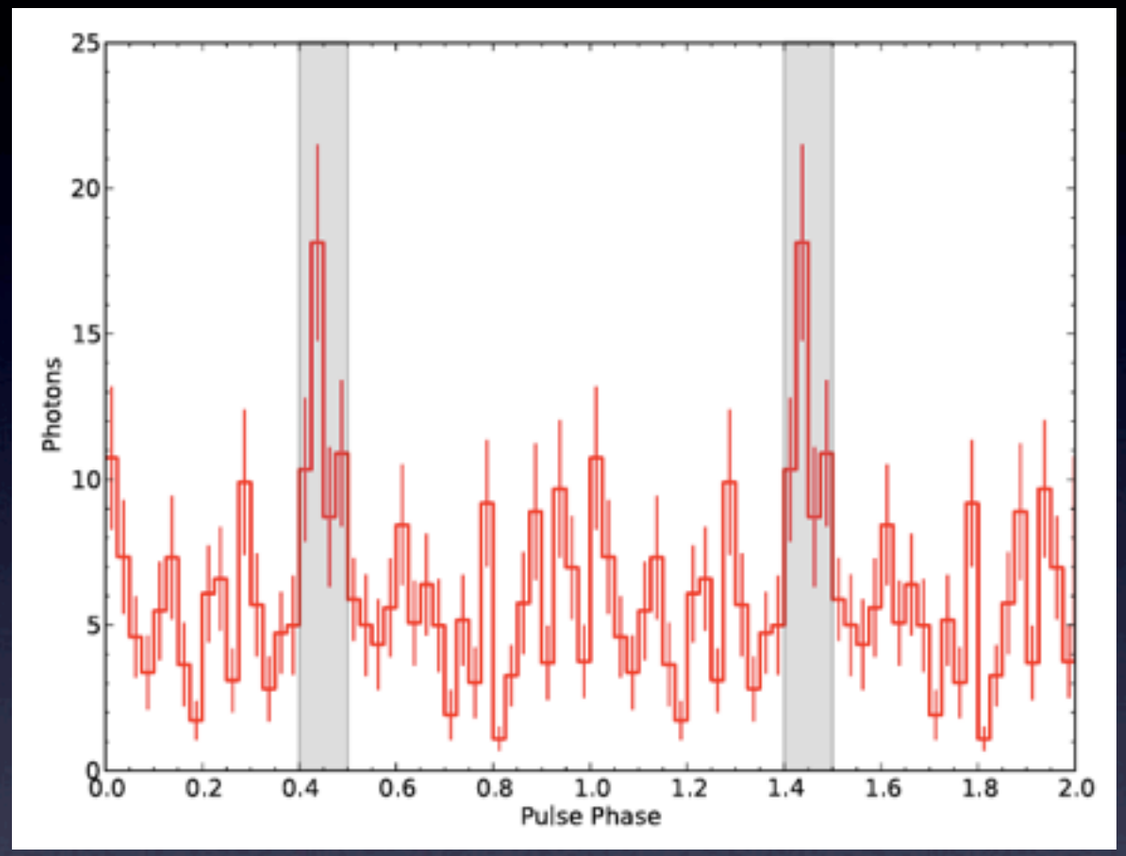
伴星：小型の恒星 → 可視光
（半径 ~10万km, 0.1太陽質量）

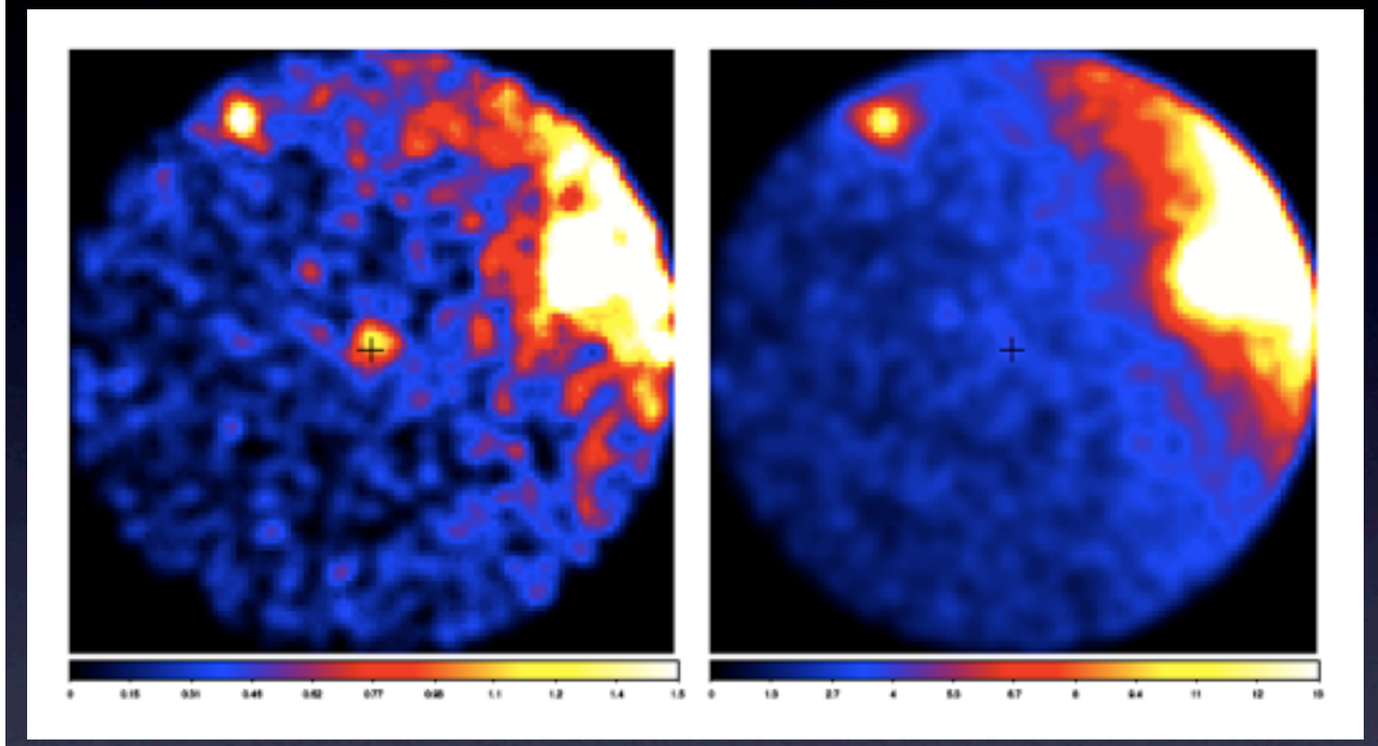
吹き飛ばされたガス
→ 赤外線

軌道半径 100万km
周期4.63時間

パルサーからのプラズマ風
→ X線・ガンマ線

Gamma-ray pulsation of a millisecond (3.05 ms)pulsar in the globular cluster M28





Wu+ 2013

- So far only 1 globular cluster known to have gamma-ray pulsation (based on Fermi observations; Preire+ 2011, Science)
- M28 is the second one and is the fastest one

FAN Workshops

- 1st workshop: 2010 June 21-25 @HKU
- 2nd workshop: 2011 Aug 1-5 @NTHU
- 3rd workshop: 2012 June 20-24 @Korea
- 4th workshop: 2013 July 8-12 @HKU
- 5th workshop: 2014 July @Taiwan
- Science talks + hand-on sessions + discussion
- We publish while practising.....
- The workshop has evolved into many interesting projects. Since then, a few graduate students and post-doc have been working together.