

# AGILE Pulsars...two years after

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on behalf of the  
AGILE Team & AGILE Pulsar Working Group

# AGILE Pulsar Working Group:

## AGILE Team & ASDC (PSR SW development and Data Analysis):

A.Pellizzoni (chair), M.Pilia, A.Trois, P.Santolamazza, F.Verrecchia  
F.Fuschino (MCAL), E.DelMonte (SuperAGILE), A.Chen, A.Giuliani,  
P.Caraveo, S.Mereghetti ... + other collaborators from the AGILE  
Galactic WG.

## Radio-astronomers:

A.Possenti, M.Burgay, M.Kramer, P.Weltevrede, S.Johnston, A.Hotan,  
J.Palfreyman, I.Cognard, A.Lyne, J.Halpern, A.Corongiu, G.Hobbs,  
R.N. Manchester

X-rays: P.Esposito, A.DeLuca.

## Radiotelescopes:

European Pulsar Timing Array (Jodrell Bank, Nancay),  
Australia Telescope National Facility (Parkes) & Un. Of Tasmania  
(Mt.Pleasant)

# The European Pulsar Timing Array



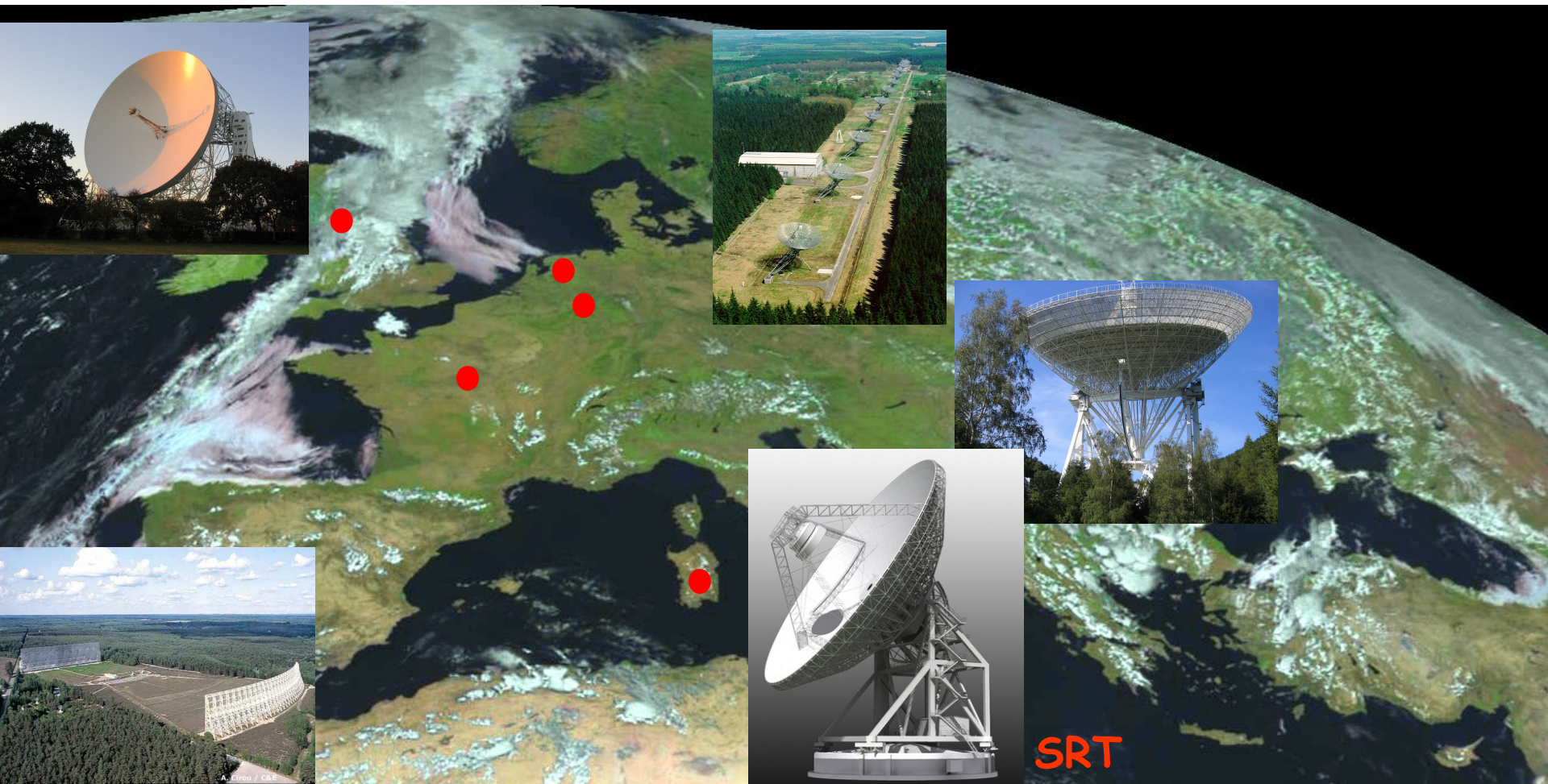
UK - JBCA/University of Manchester

DE - MPIfR

NL - UvA/ASTRON

FR - Nancay/CNRS

IT - INAF Cagliari, Sardinia





Parkes, Australia



Hobart, Tasmania



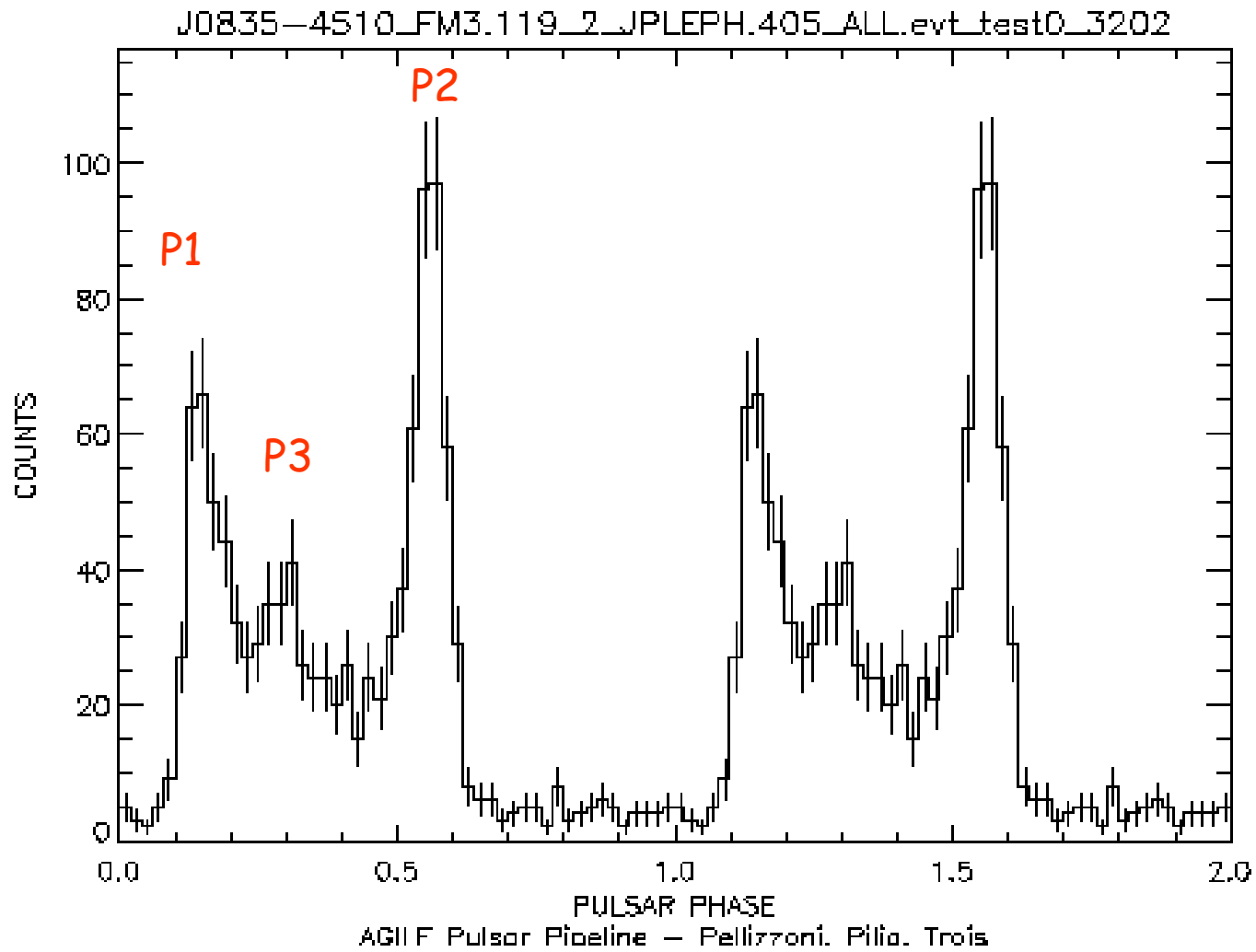
GBT, West Virginia

AGILE Pulsars... two years after:

We collected about 40000 pulsed counts from  
Vela!

And...

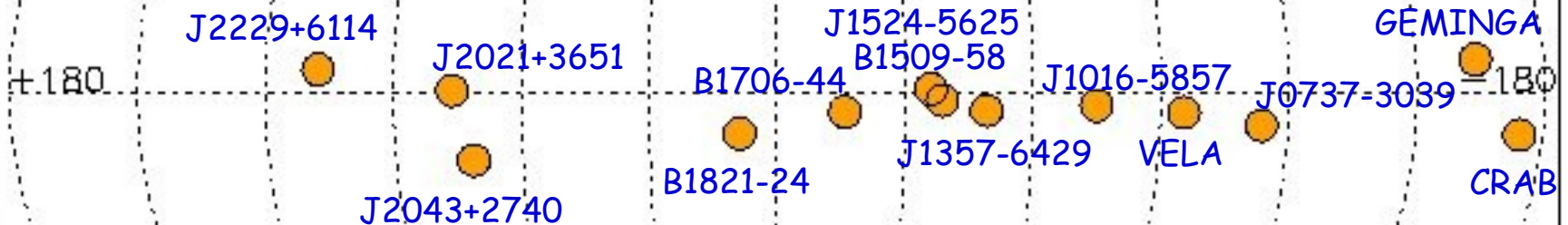
$E > 1 \text{ GeV}$





## AGILE Pulsars... two years after...

AGILE data on 12 Pulsar published so far including  
>40% of AGILE Team pulsar targets (AO1 & AO2)

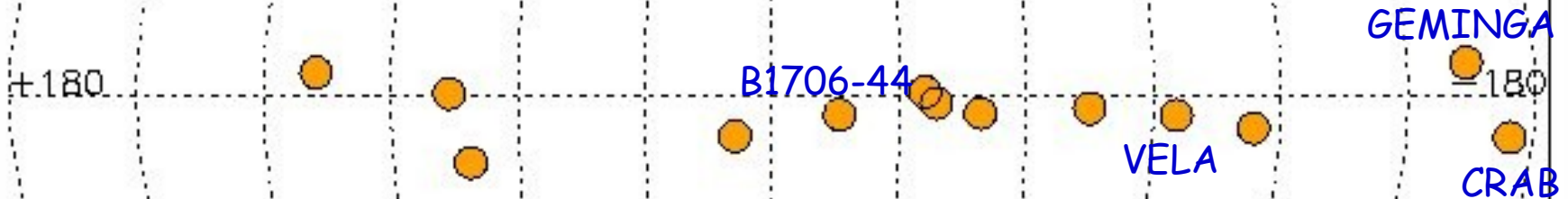


AGILE doubled the EGRET pulsar sample  
in only two years of scientific operations!

# AGILE Pulsars... two years after...

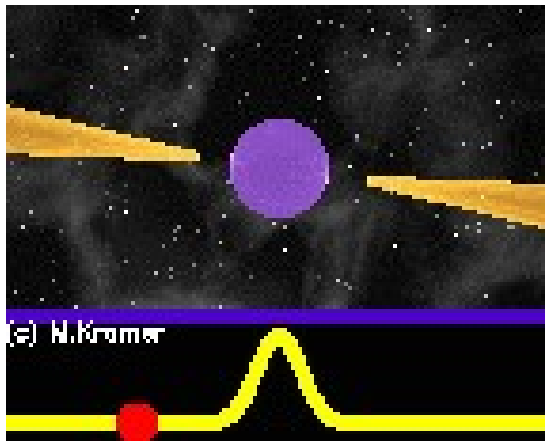
"High-Resolution Timing Observations of Spin-Powered Pulsars  
with the AGILE gamma-ray Telescope"

(Pellizzoni et al., ApJ, 691, 1618, 2009)...

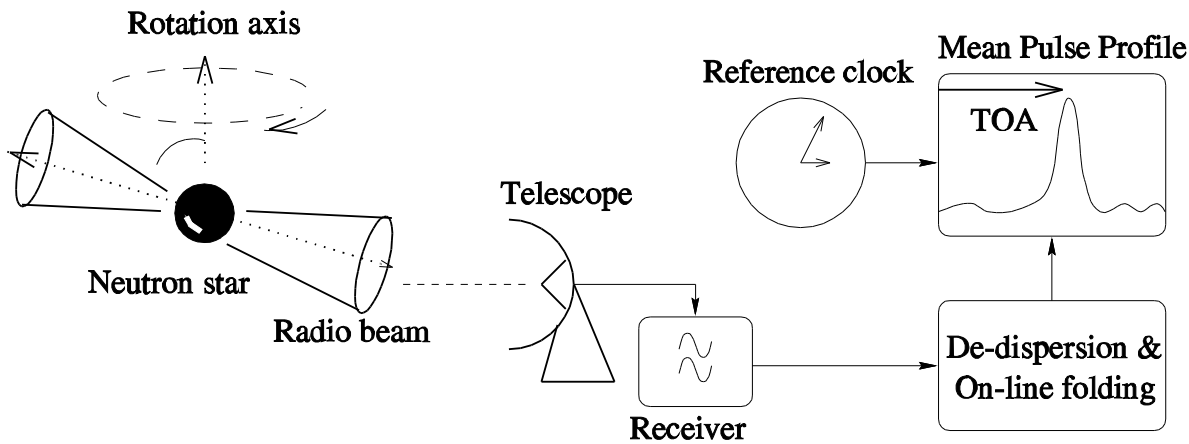
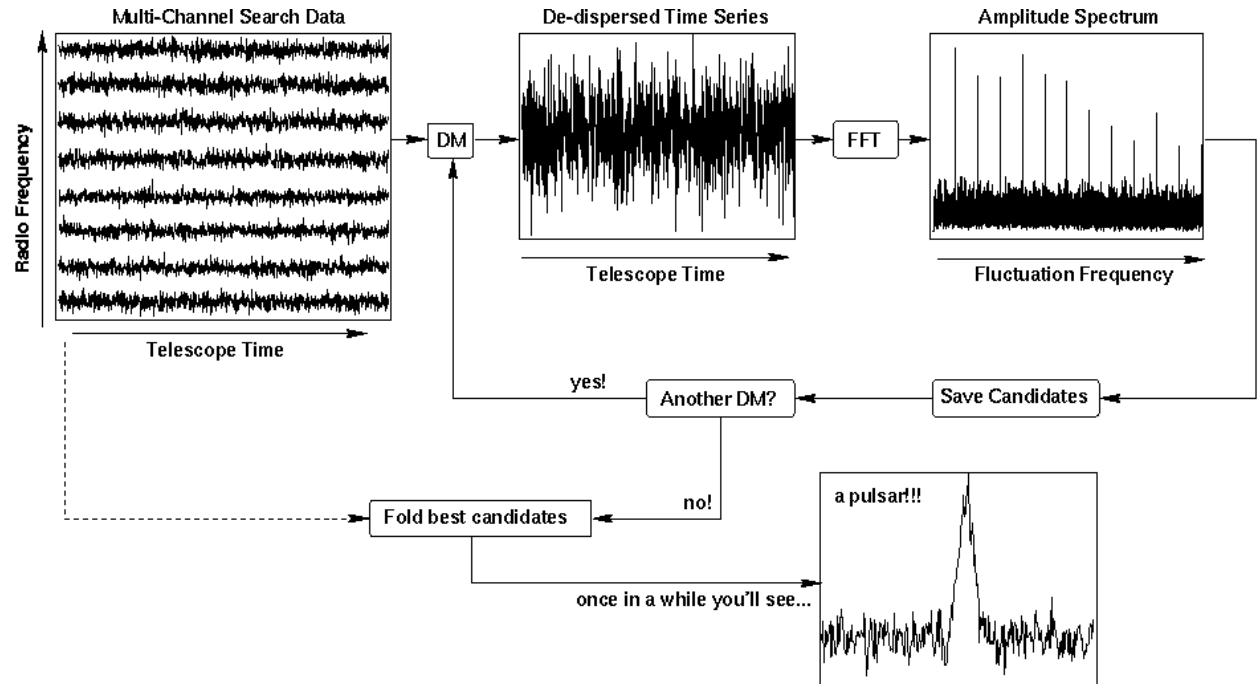


...a 16-pages long paper also describing pulsar timing  
calibration and new tools aimed at precise photon phasing

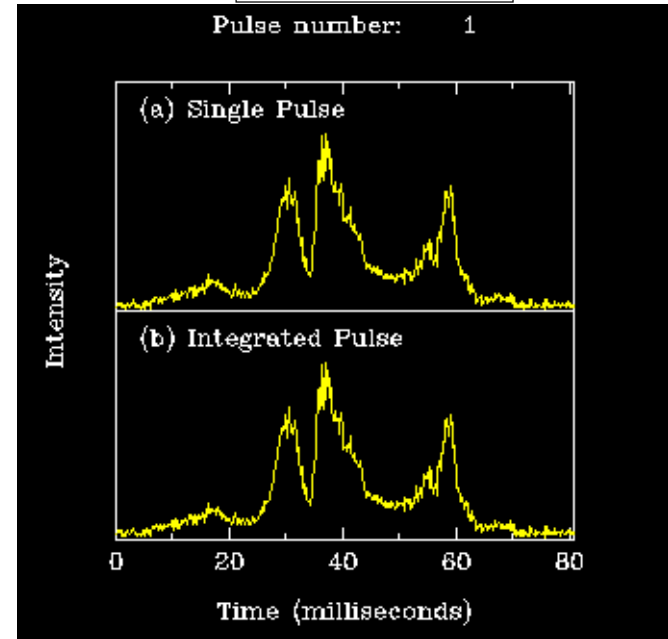




# RADIO SEARCH



# RADIO TIMING

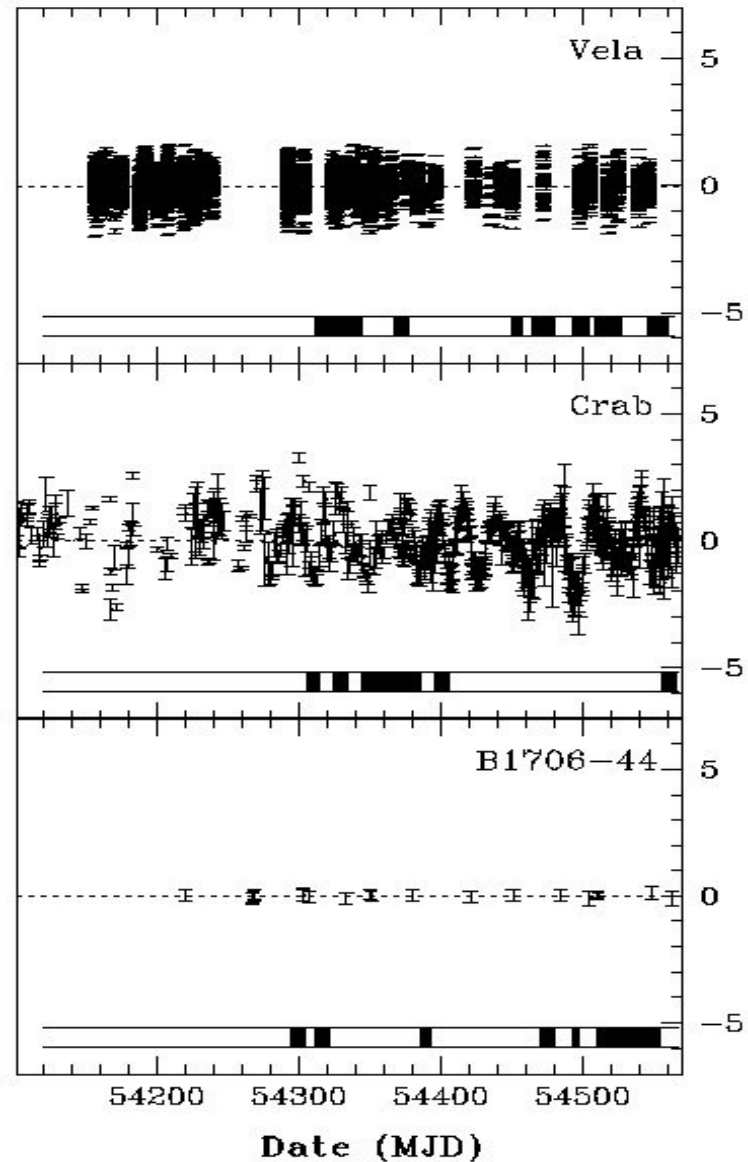
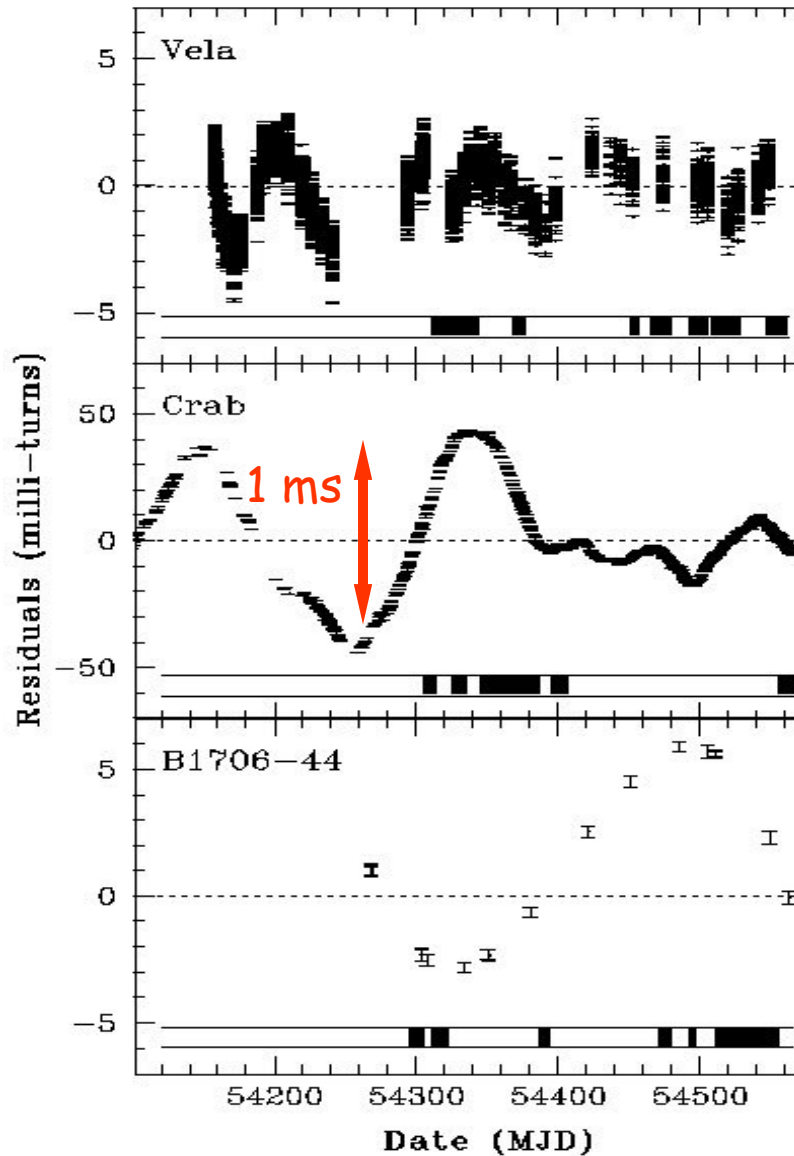


Timing noise uncorrected

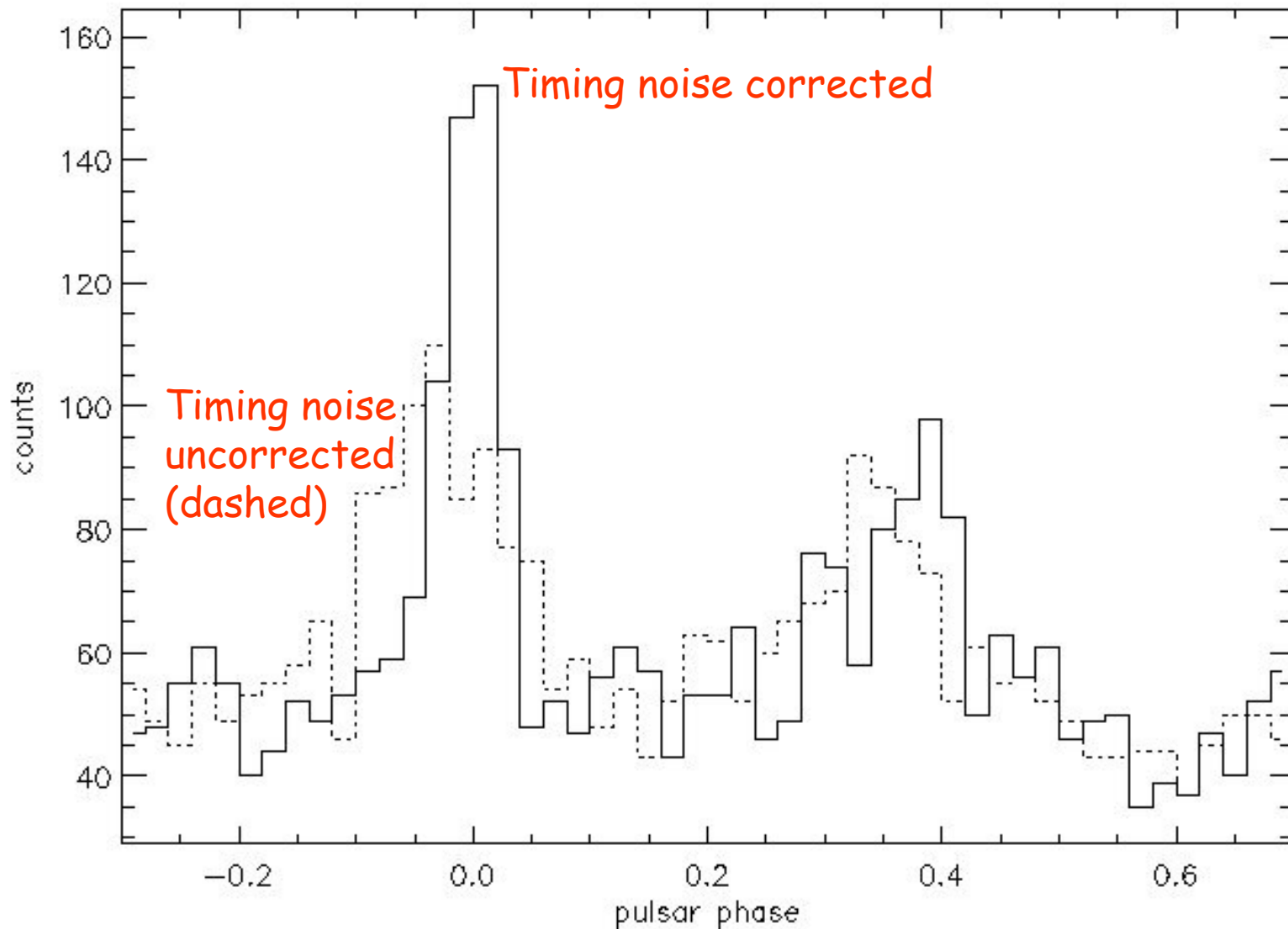
PRE-WHITENING

Timing noise corrected

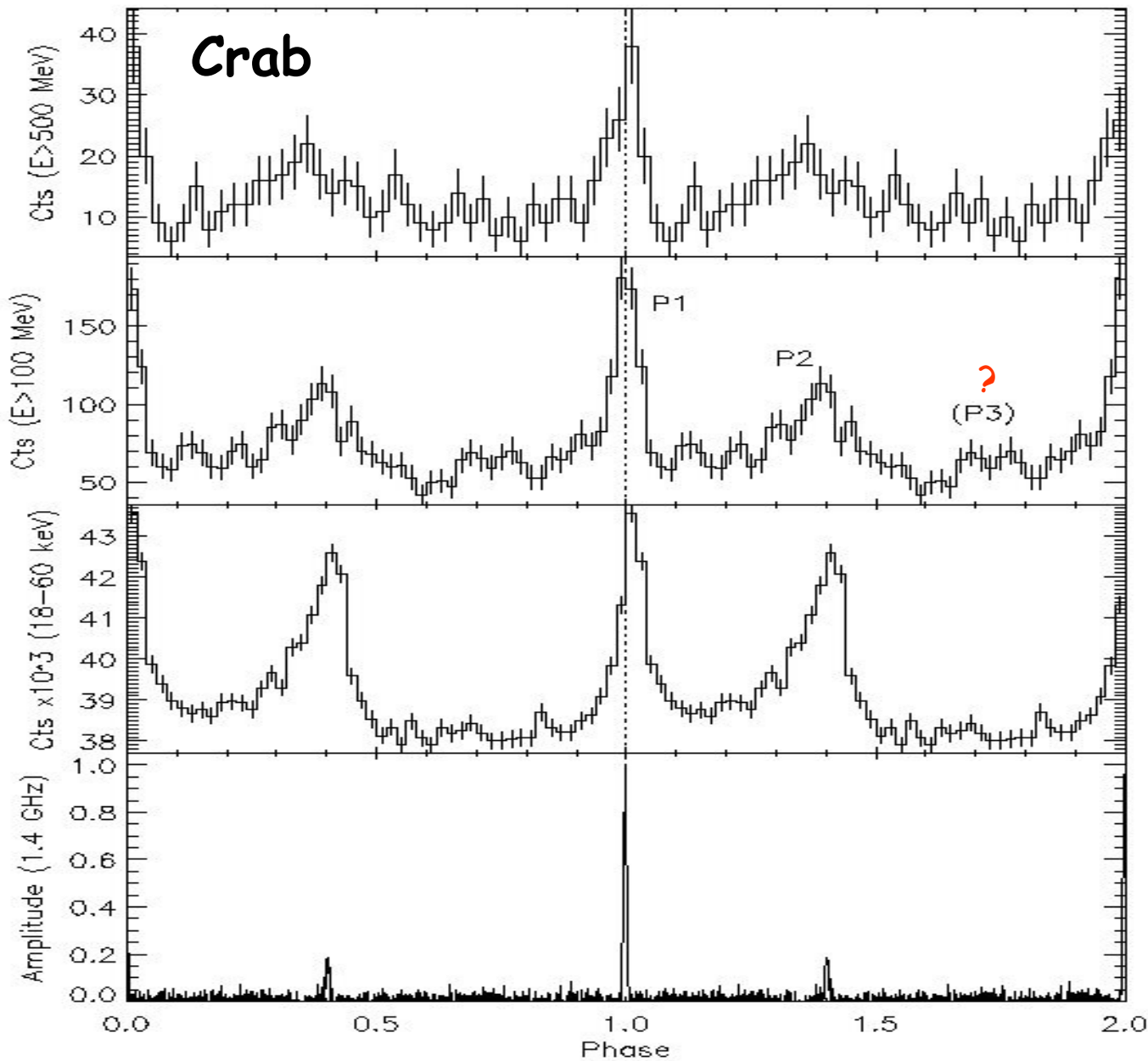
WHITENED



# Crab PSR



No light-curve "smearing" even in very long observations



$0.5 < E < 30$  GeV

**AGILE**

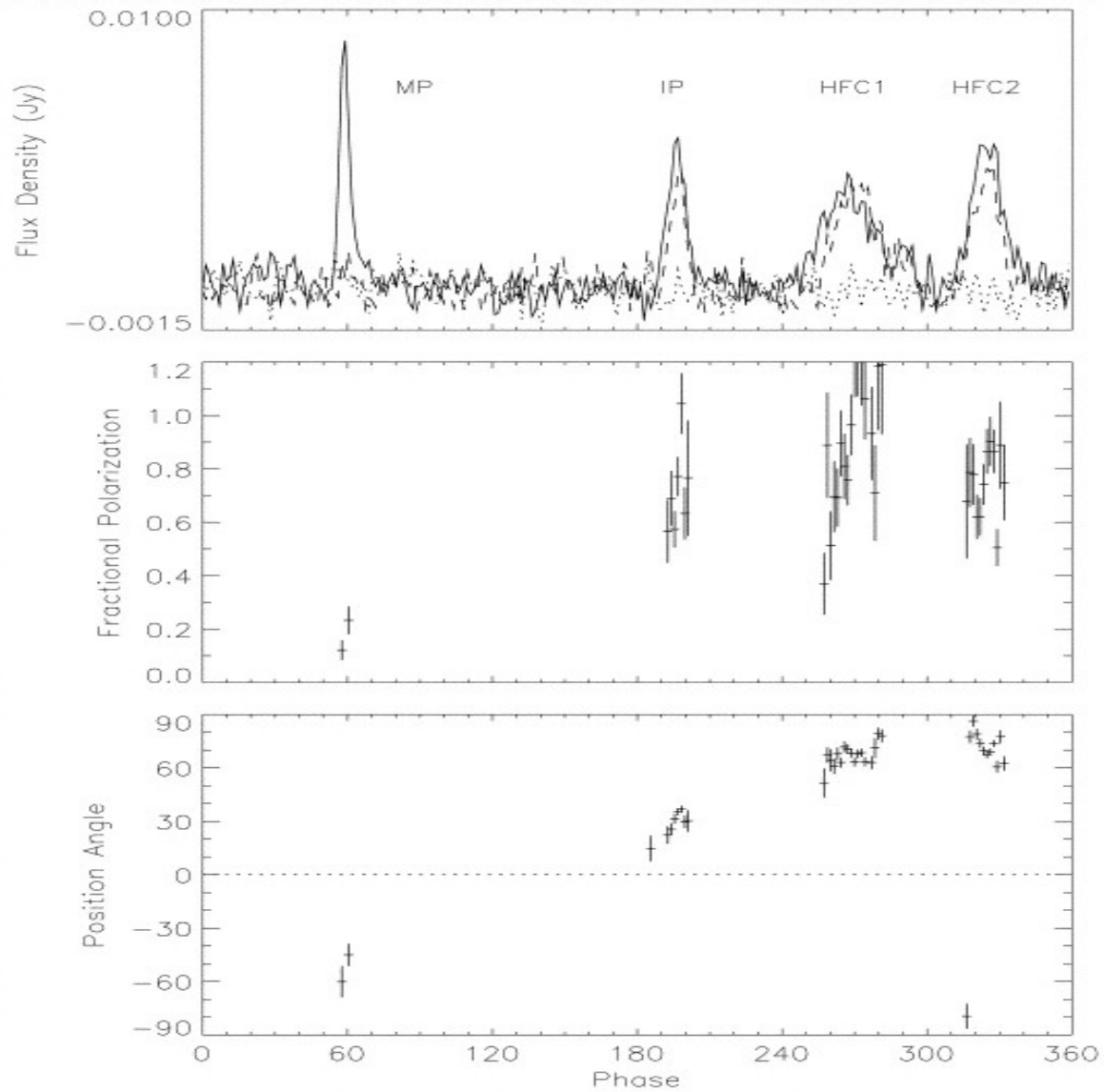
$E > 100$  MeV

$\leftarrow 0.7$  ms bins

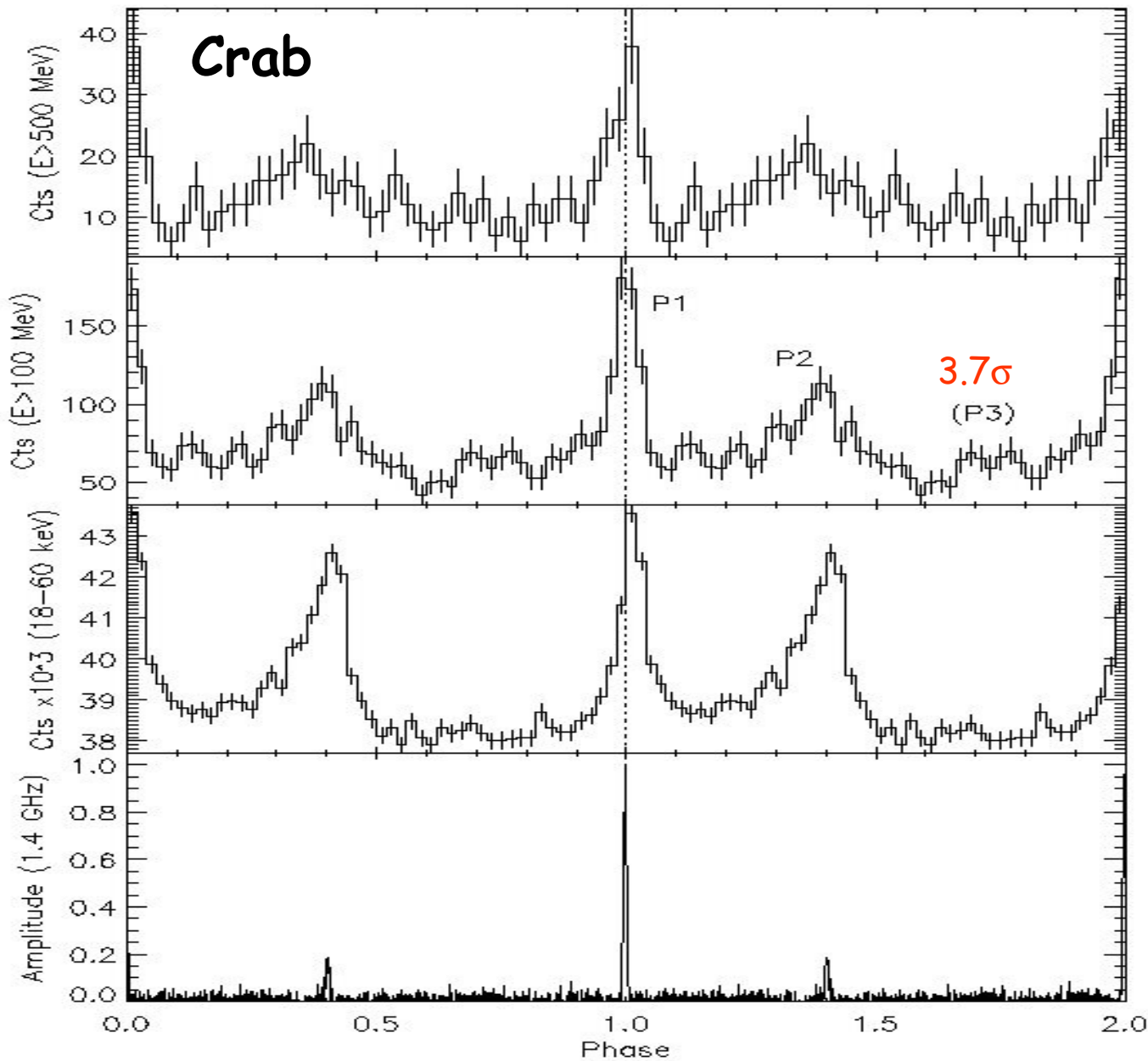
**SuperAGILE**

18–60 keV

Radio



(Moffet & Hankins; 1996, 1999)



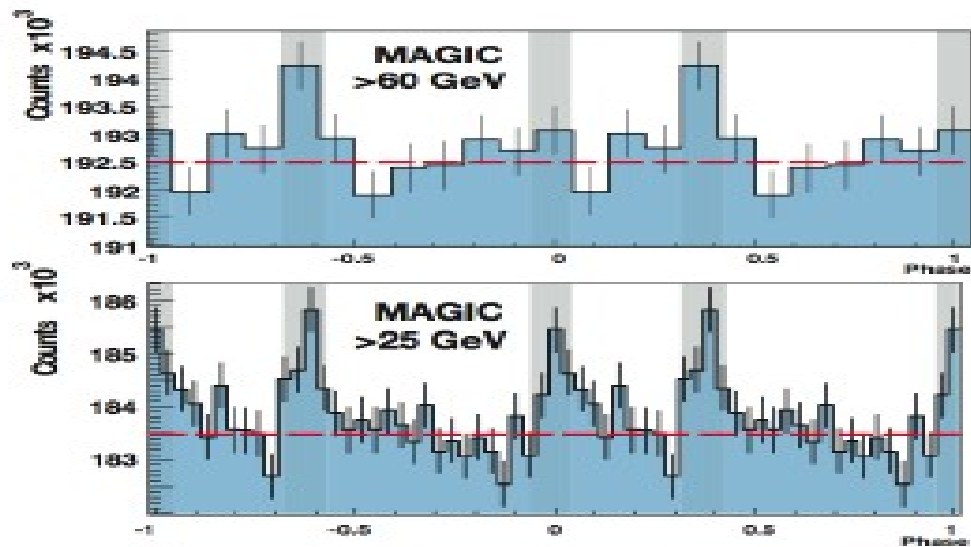
P3 is coincident with the feature HFC2 that appears in the radio profile above 4 GHz.

HFC2 polarization suggest that this peak may come from a lower emission region, near polar cap

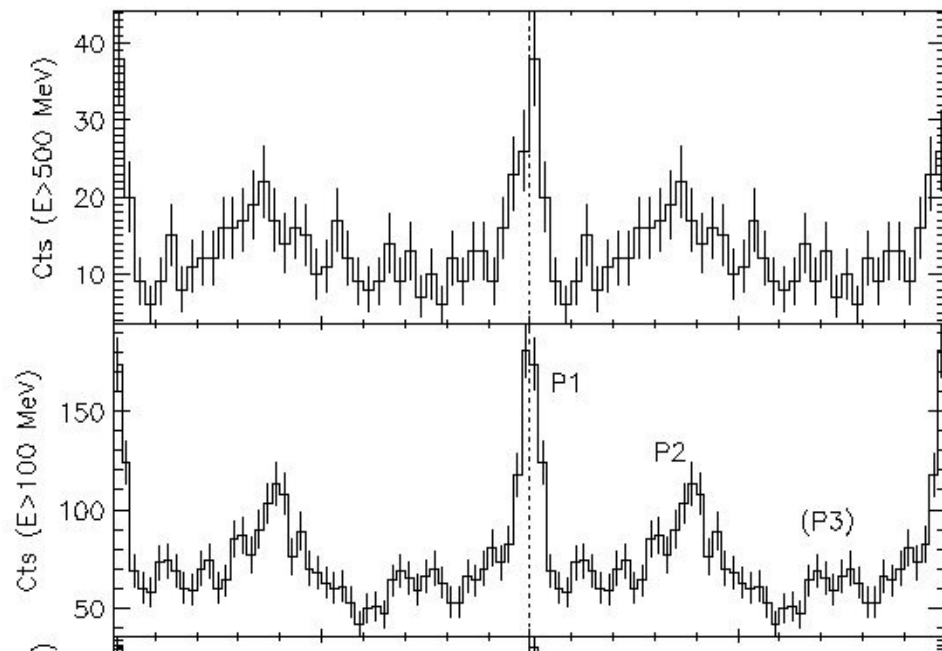
(Moffet & Hankins; 1996, 1999)

P3: low altitude cascades?





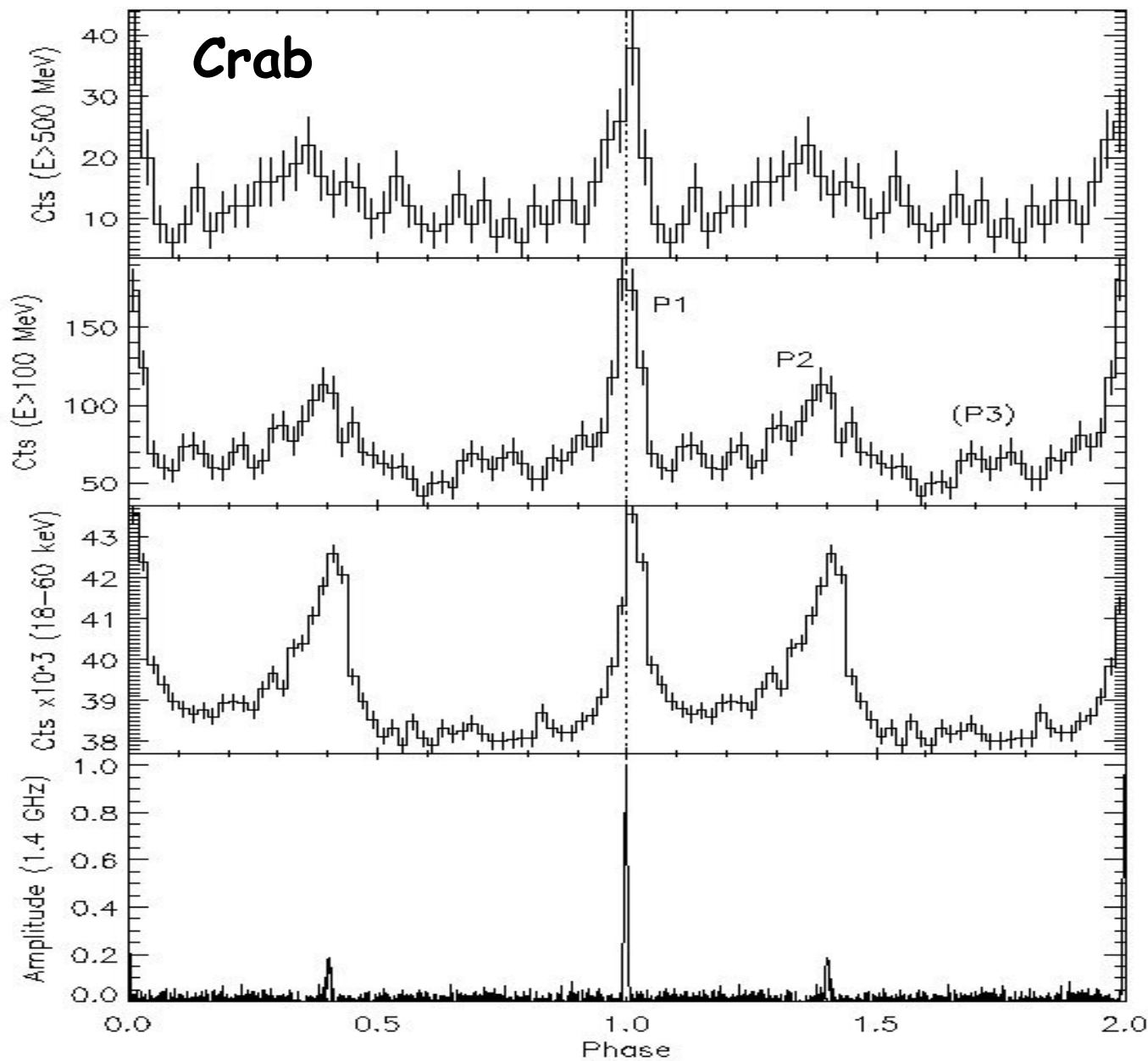
**MAGIC** (The Magic Collaboration, 2008Sci...322.1221C)



**AGILE**

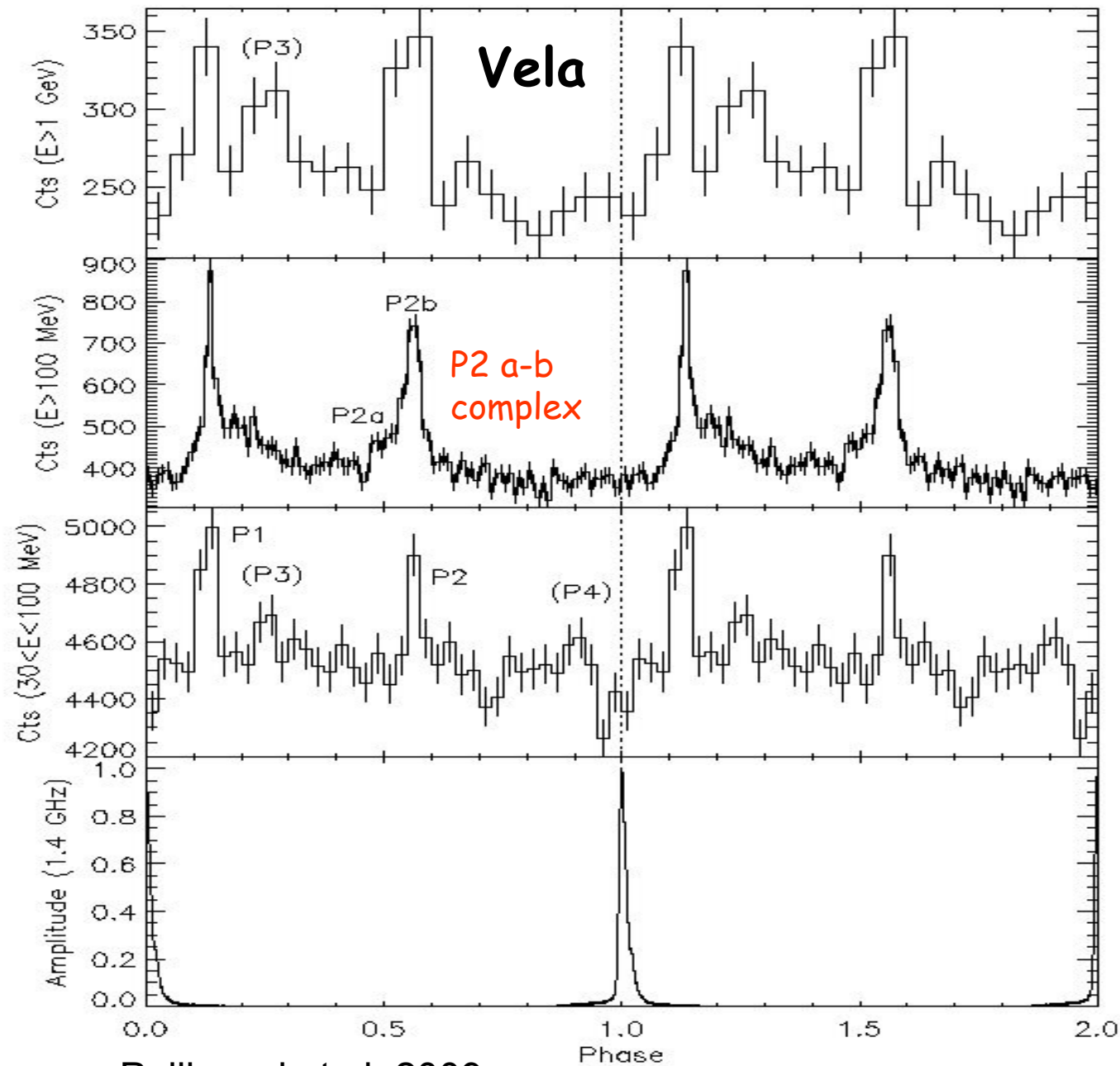
P3: low altitude cascades?

P1-P2: High-altitude gap (MAGIC)?



P3 from Giant Pulses?

We can tag GPs from radio observations and fold at high-energy GPs events only...



$E > 1 \text{ GeV}$

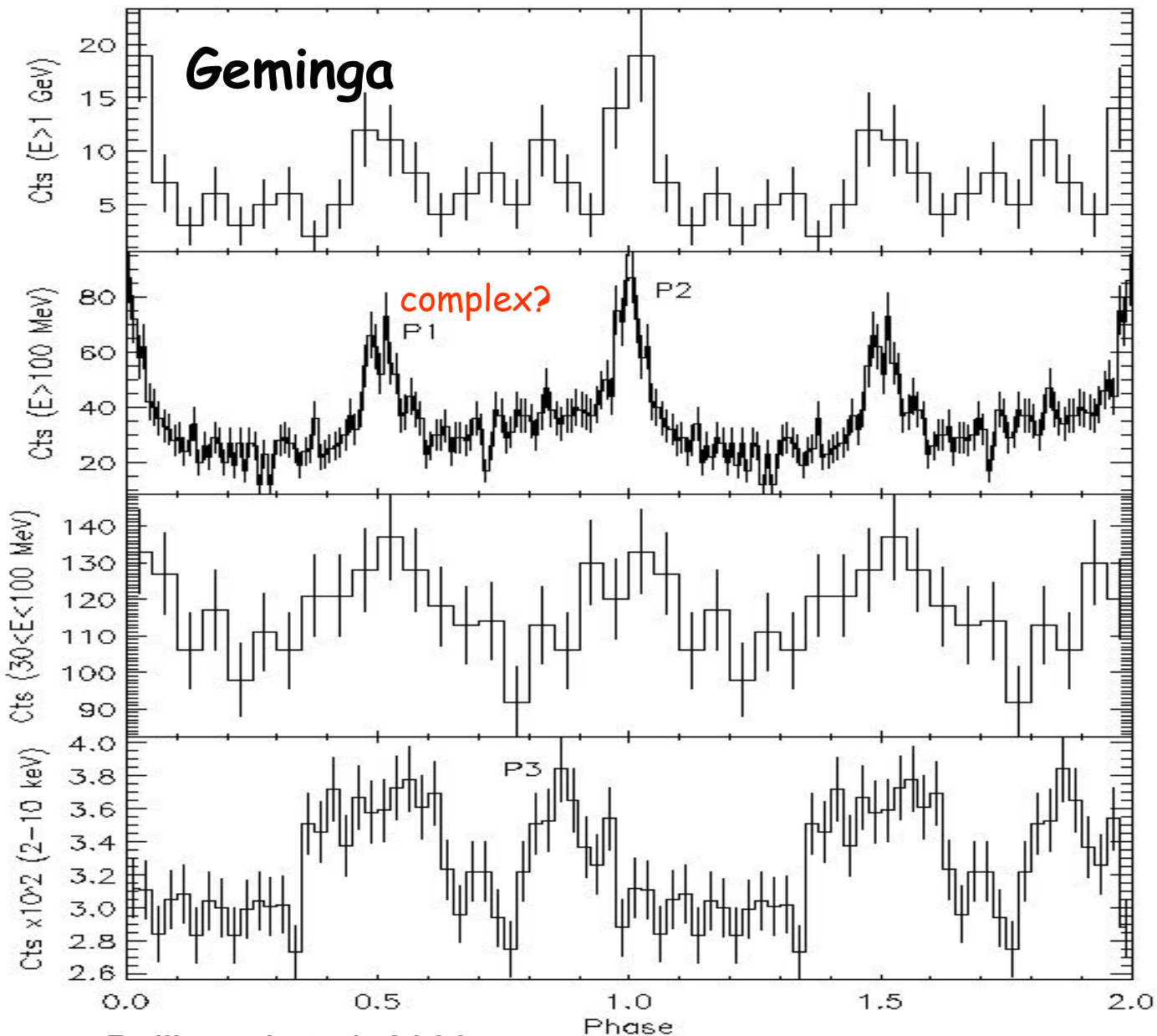
$E > 100 \text{ MeV}$

$\leftarrow 0.9 \text{ ms res.}$

$30 < E < 100 \text{ MeV}$

Radio

# Geminga



E > 1 GeV

E > 100 MeV

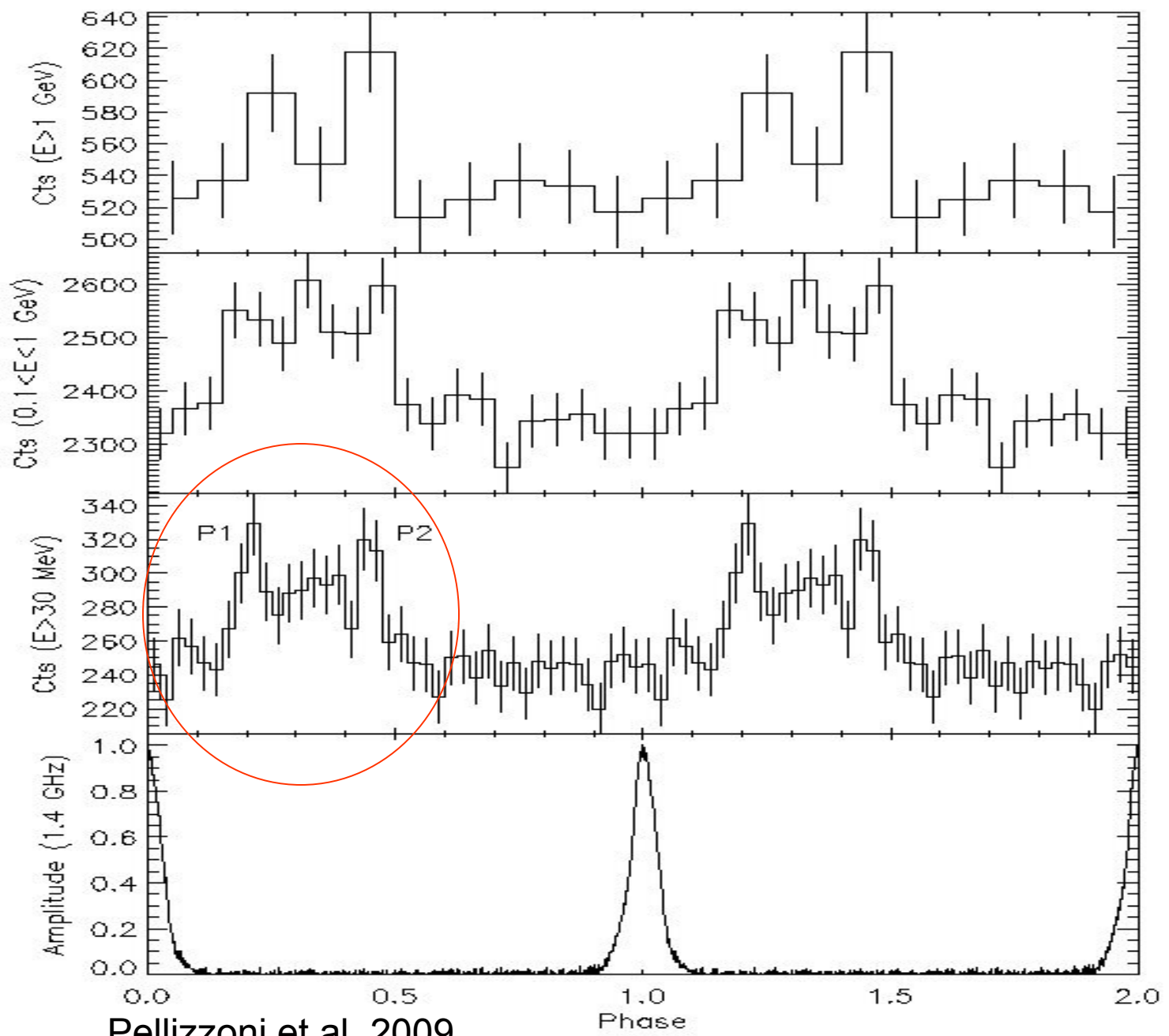
← 2.4 ms

30 < E < 100 MeV

X-rays  
(XMM)

2-10 keV

B1706-44



$E > 30$  MeV

$\leftarrow 2.6$  ms

Structured energy-dependent peaks (more than two) are evident in the light curves.

How many particle acceleration sites in the pulsars magnetospheres? And where?

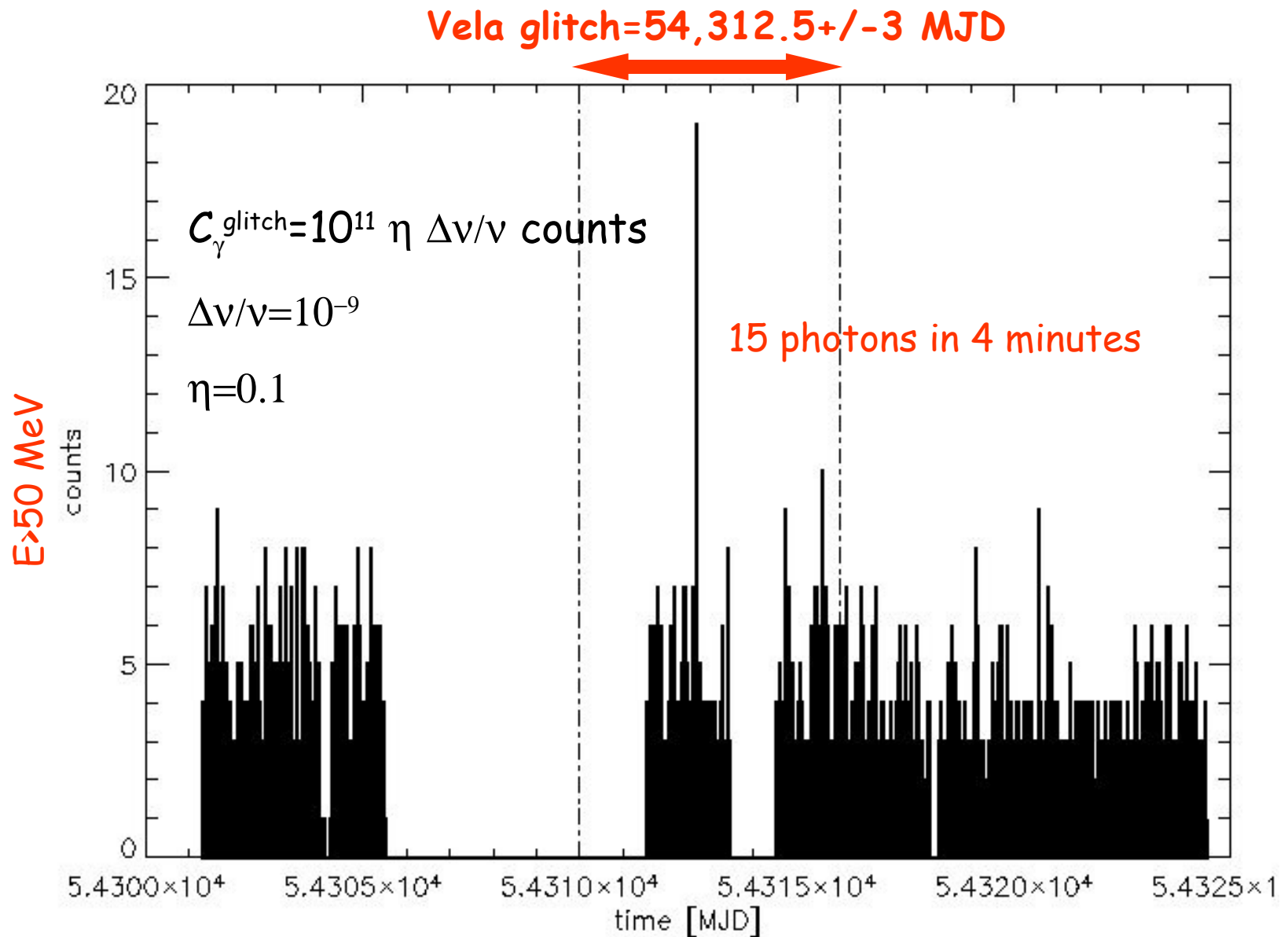
Multiple gap models may be invoked... find more in Pellizzoni et al., 2009.



# Gamma-ray emission from pulsar glitches?

- Vela has shown 10 major glitches since 1969.
- The chance occurrence of a strong Vela glitch in the wide AGILE field of view over three years of mission is 20%.
- Starquake waves can “shake” magnetic fields generating strong electric fields which accelerate particles to relativistic energies, possibly emitting a **burst of high-energy radiation** (Ruderman, 1976, 1991; Alpar et al., 1994).
- $C_{\gamma}^{\text{glitch}} = 10^{11} \eta \Delta v/v$  counts,

where  $\eta$  is the unknown conversion efficiency of the glitch energy to gamma-ray emission (Pellizzoni et al., 2009)



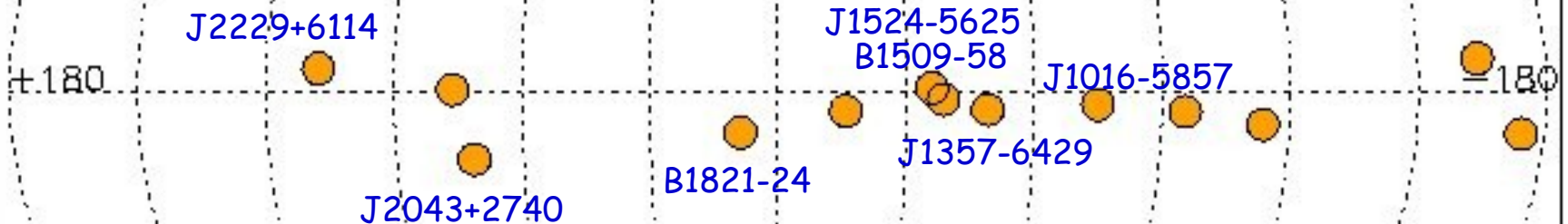
Small Vela glitch in August 2007: burst emission possibly detected by AGILE

NEW GAMMA-RAY PULSARS!

# AGILE Pulsars... two years after...

**"Discovery of New Gamma-ray Pulsars with AGILE"**

(Pellizzoni et al., ApJ, 695, L115, 2009)



Many previously unidentified EGRET sources  
and new AGILE sources are Pulsars!

# New Gamma-Ray Pulsars

**J2229+6114, J2021+3651, ...: Vela-like**

**J1513-5908: High B pulsar**

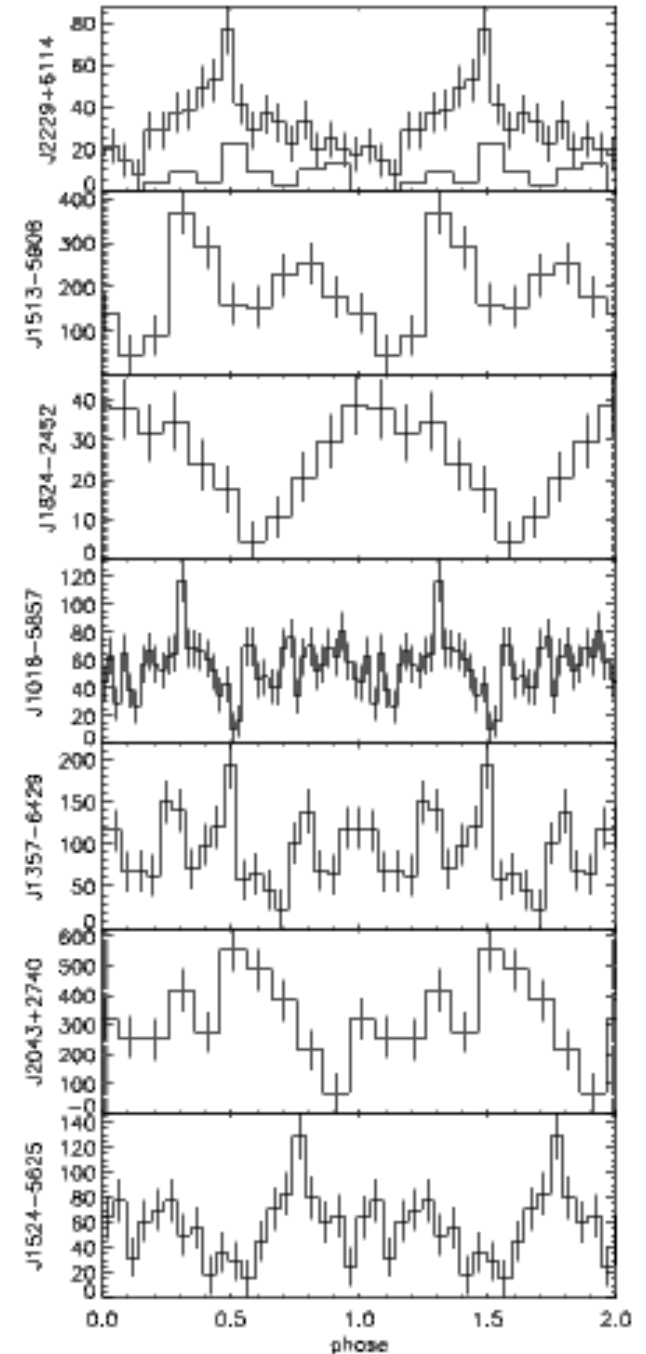
**J1824-2452: ms PSR in Globular Cluster**

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**J1016-5857: possibly 3EG source**

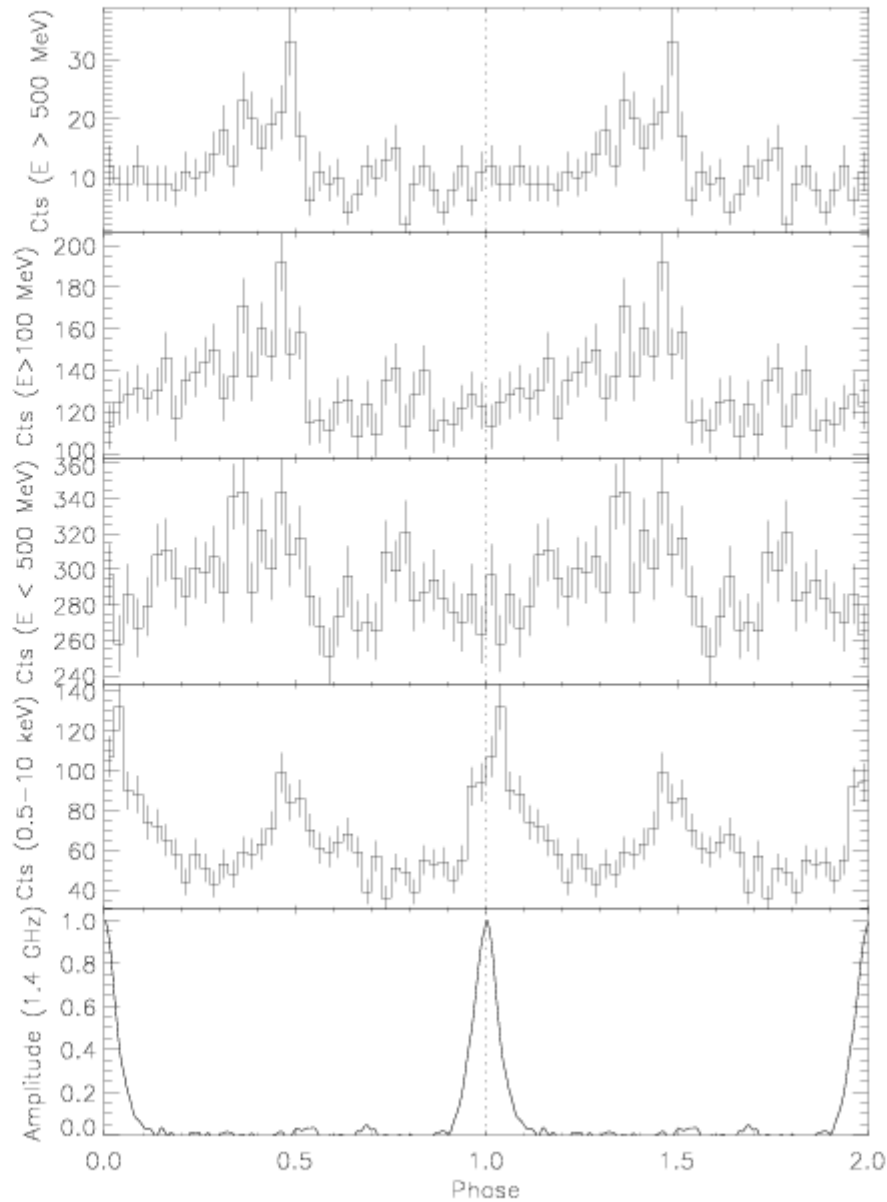
**J1357-6429**

**J2043+2740: oldest gamma-ray pulsar**

**J1524-5625**



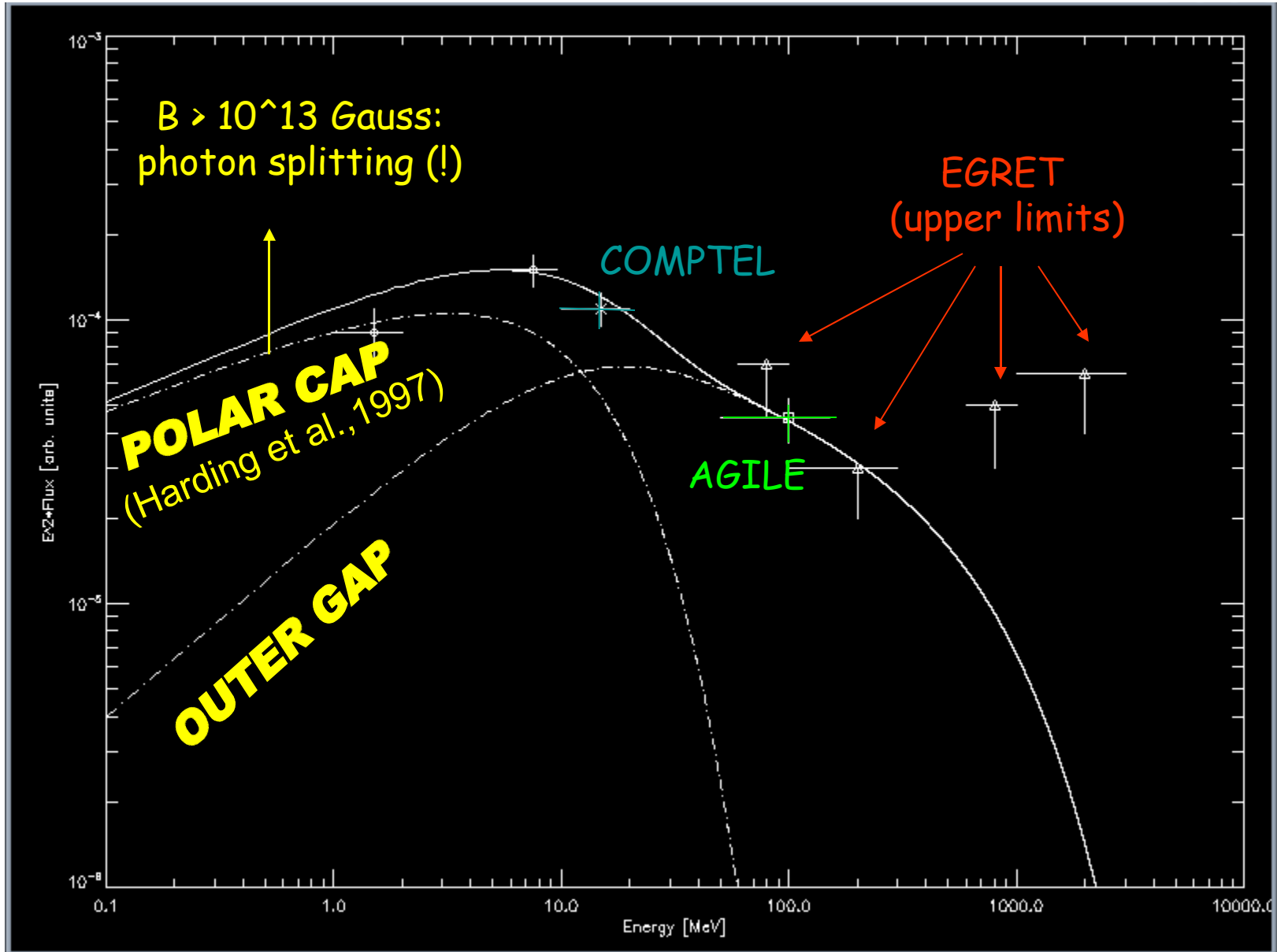
# PSR J2229+6114



Pilia et al., in preparation



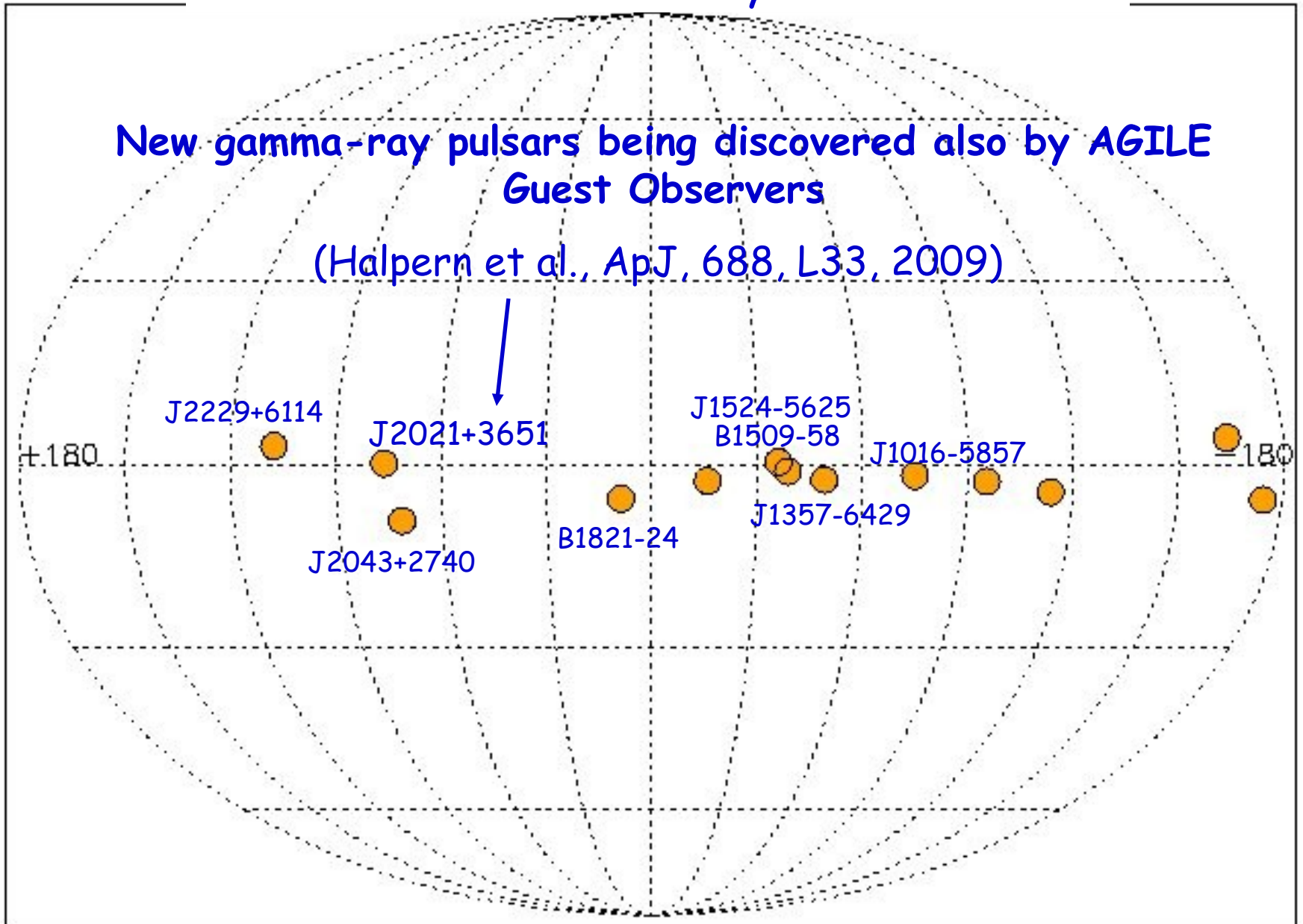
# B1509-58: multi-gap model... under construction!



# AGILE Pulsars... two years after...

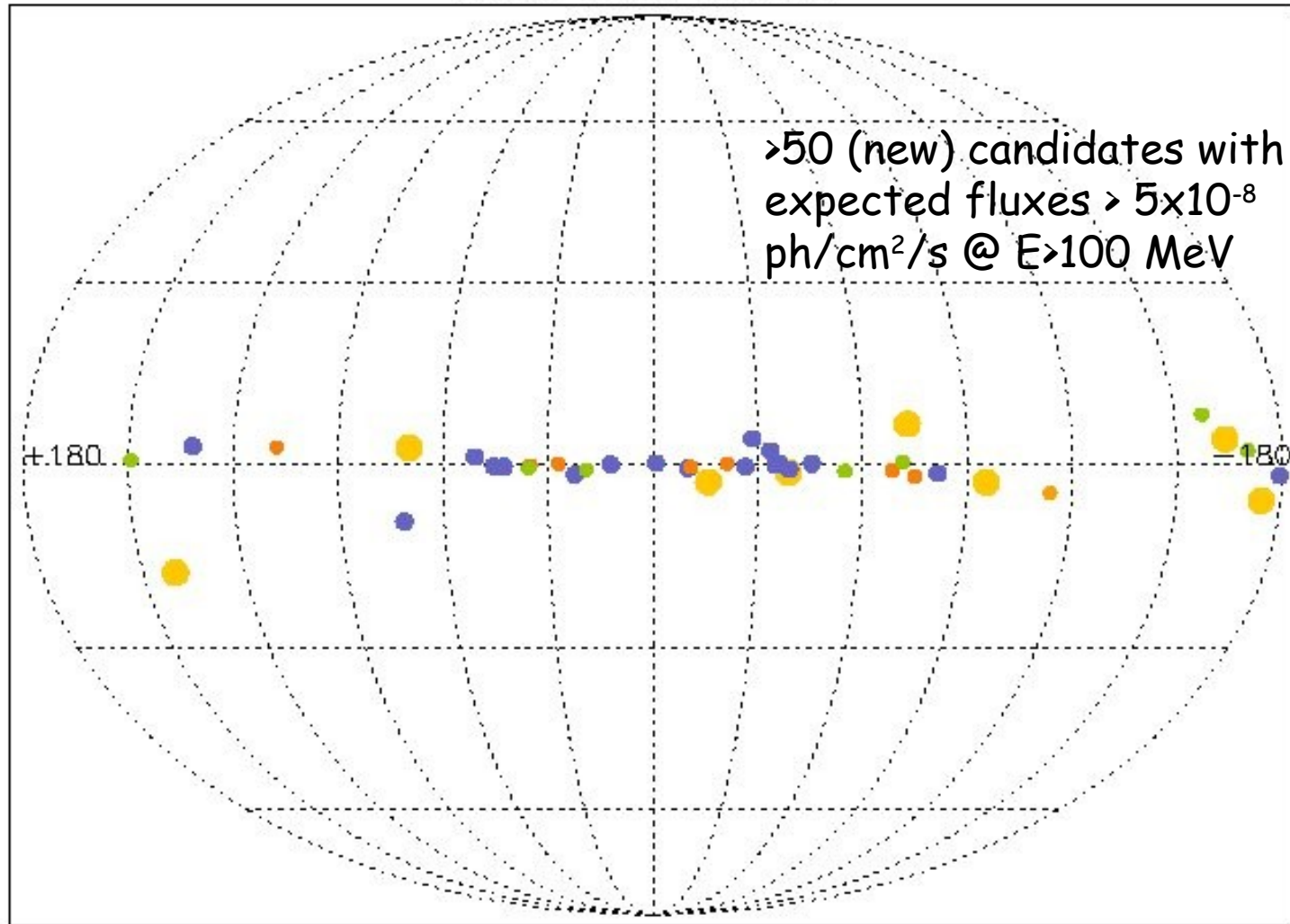
New gamma-ray pulsars being discovered also by AGILE  
Guest Observers

(Halpern et al., ApJ, 688, L33, 2009)



# Radio PSRs candidates as strong gamma-ray emitters (Pellizzoni et al., 2004)

AGILE PSRs TARGETS



$$L_{\gamma} = k \sqrt{\dot{E}_{ROT}}$$

## Future plans:

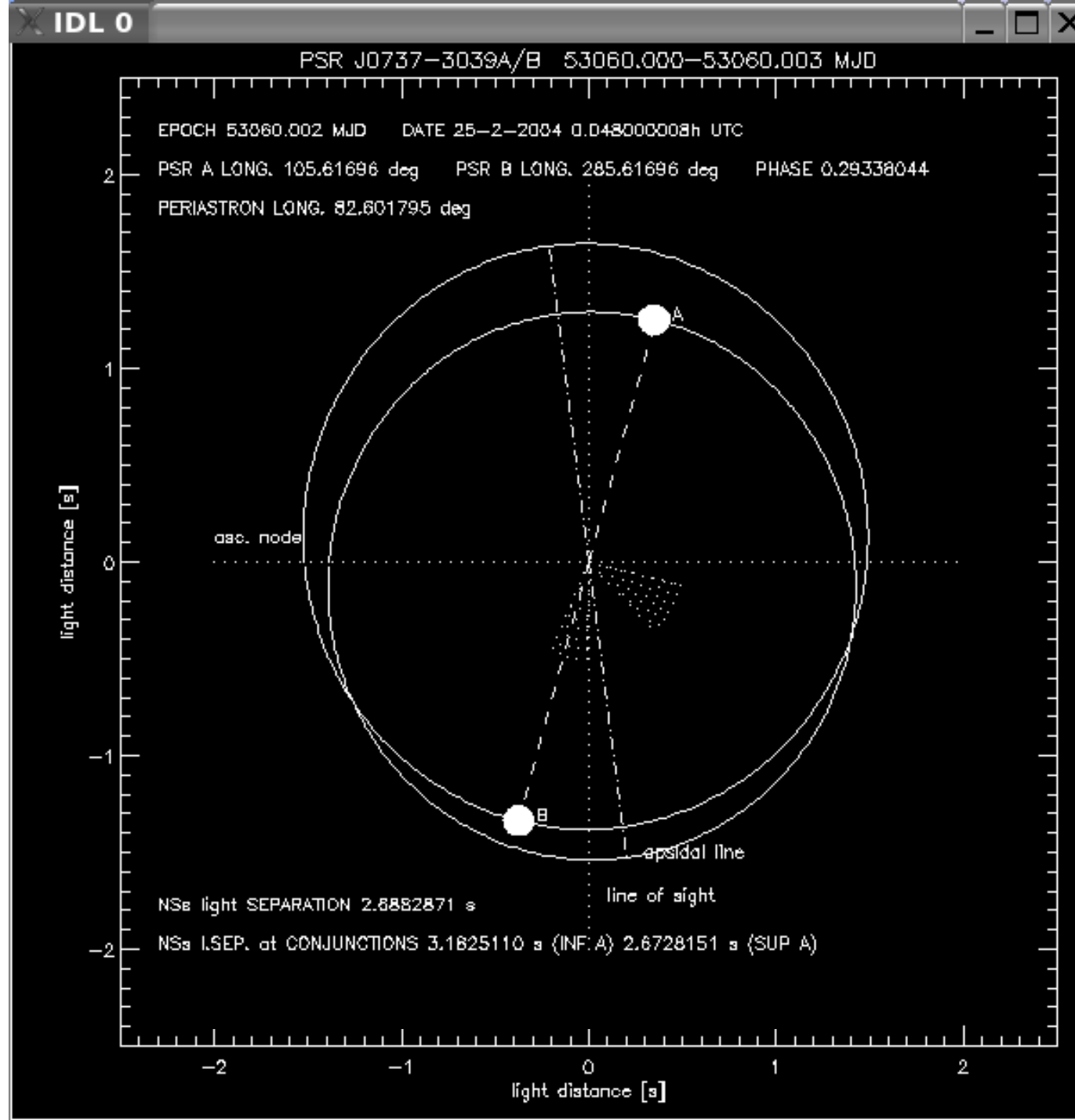
- The search for new gamma-ray pulsars is a non-stop job.
- Full exploitation of  $<100$  MeV band (exposure competitive with Fermi)
- Phase-resolved spectra of bright gamma-ray pulsars.
- "Blind-search" of radio-quiet pulsars.
- Gamma-rays from pulsars in binary systems.

# Double neutron star system 0737-3039

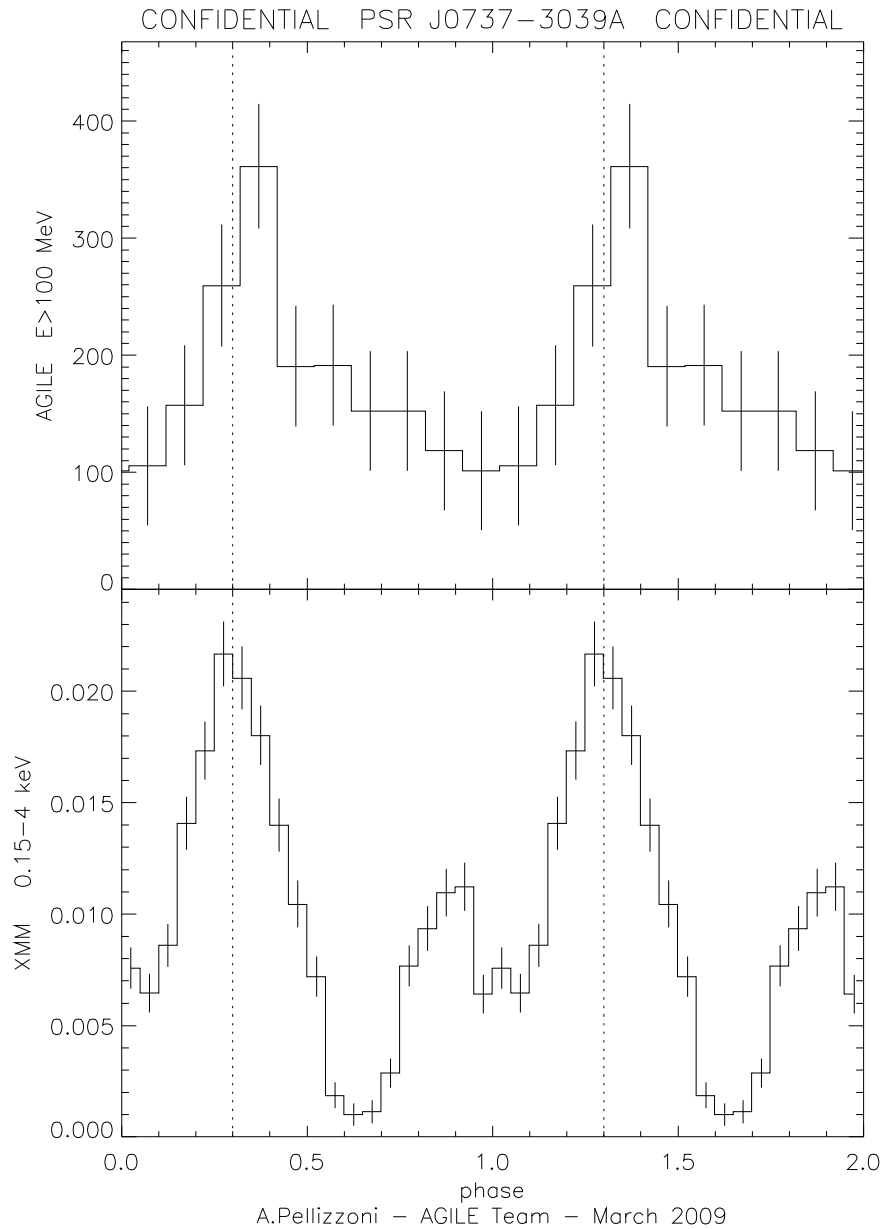
Orbital period: 2.4 h  
eccentricity=0.09

(Burgay et al., 2003;  
Lyne et al., 2004)

Pellizzoni et al., 2008



# PRELIMINARY





# Thank You!

For information and collaboration, please contact us:

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[apellizz@ca.astro.it](mailto:apellizz@ca.astro.it)