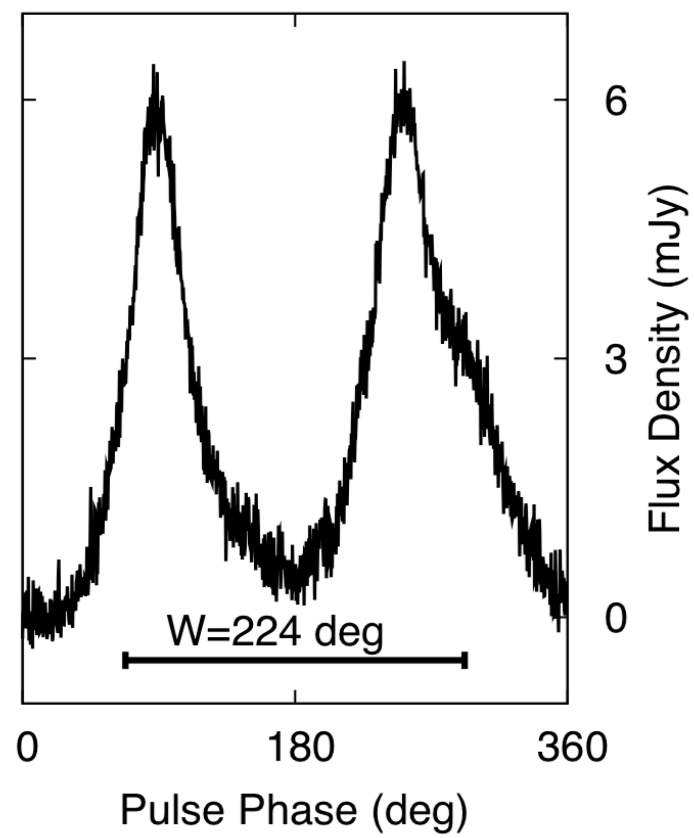
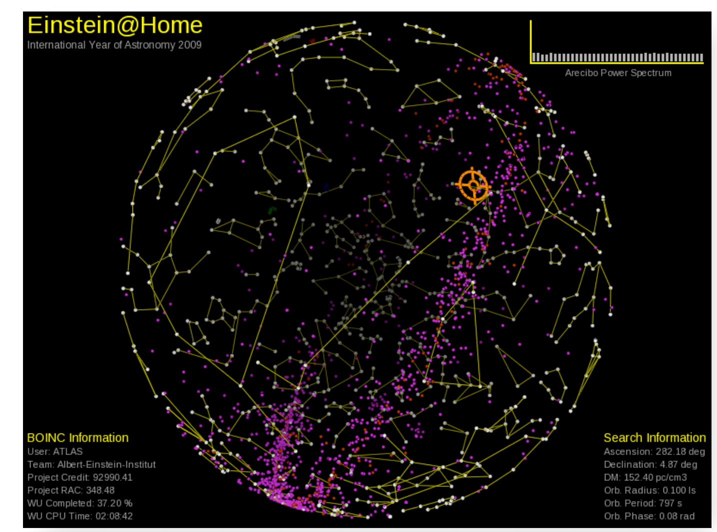
Finding Radio Pulsars with Einstein@Home

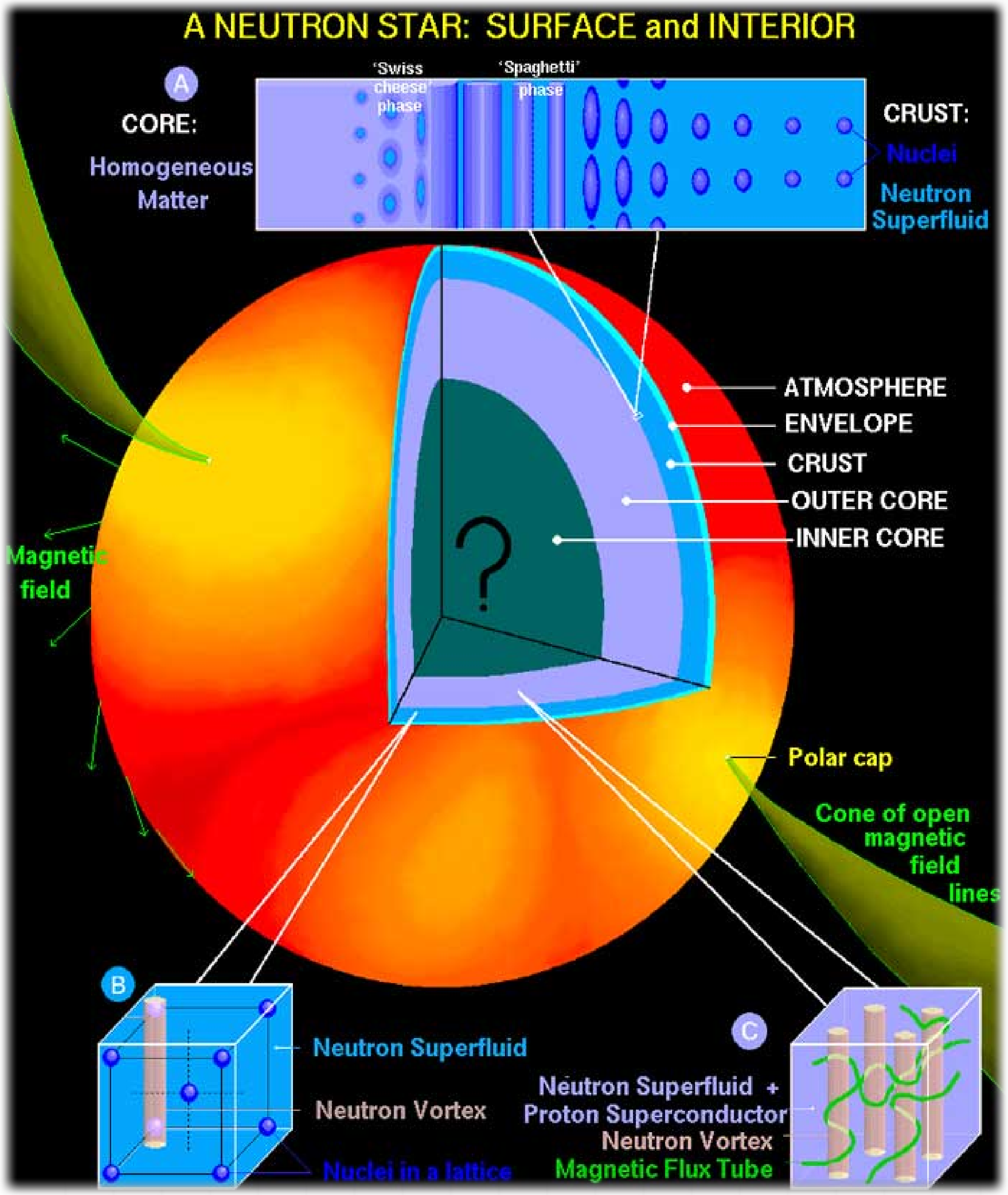




B. Knispel, B. Allen, C. Aulbert, O. Bock, H. Fehrmann,
B. Machenschalk, C. Messenger, M. A. Papa, H. J. Pletsch, R. Prix
and the PALFA consortium

Pulsars

- **massive star remnants**
- **>1.4 M_{sun} atomic nucleus:** ~20 km diameter
- **strong field gravity:** $R_{Schwarzschild} = 0.3\ R_{NS}$
- **strong magnetic fields:** 10^8 to 10^{14} G
- **lighthouse-like emission**
  - magnetic field + fast rotation
- **first discovered:** 1967 by Bell and Hewish
  - 1/8 Hz to 761 Hz spin frequency
  - 1900 radio pulsars known
  - 140 in **binary systems**, detection of short orbits limited by computational power
  - **GR testbed**



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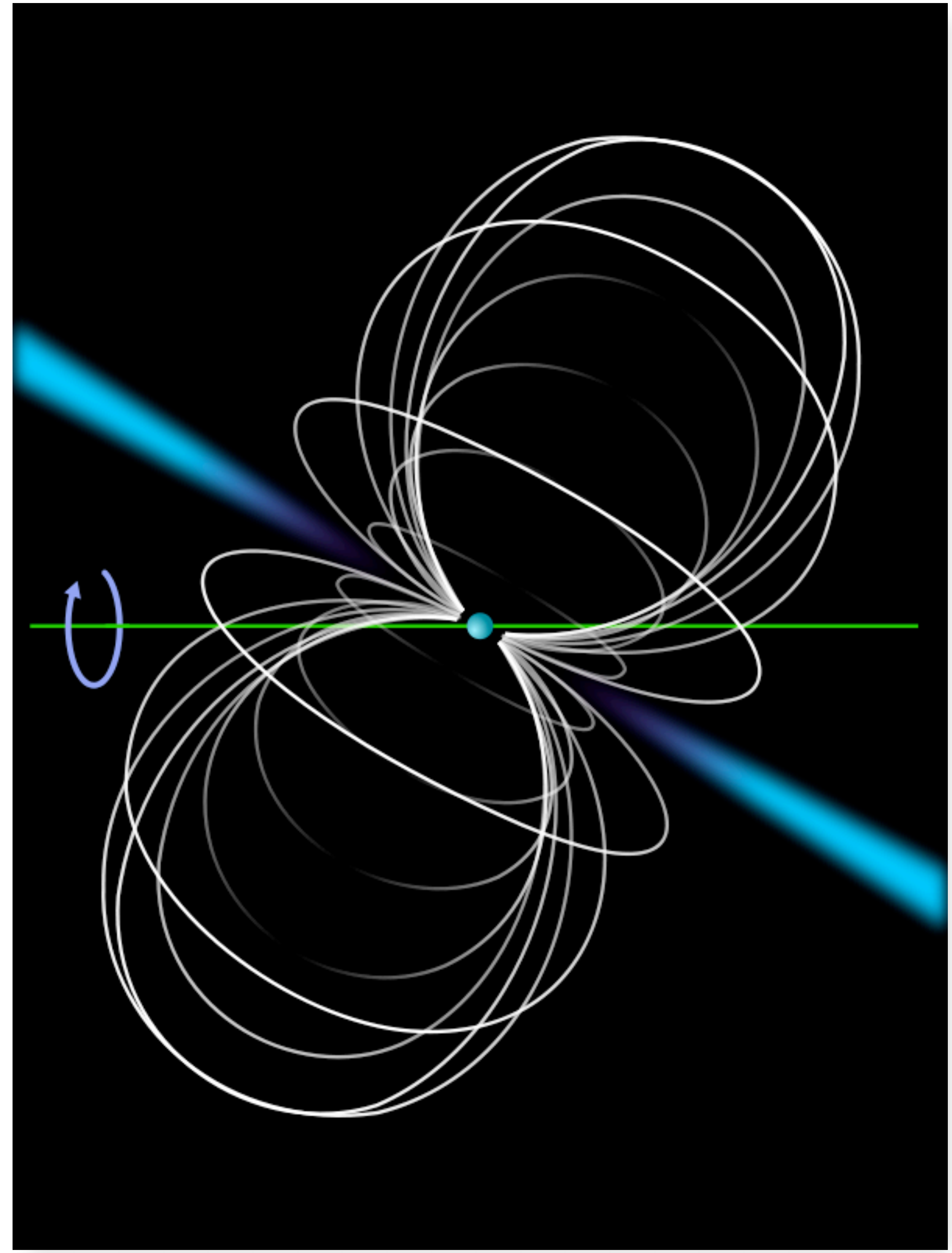

Arecibo Observatory

- **Arecibo Observatory (AO) Puerto Rico**
- **305 m dish:** world's largest radio telescope
    - astronomy and atmospheric science
- **PALFA consortium:** pulsar survey with 7-pixel "camera"
- share data for analysis, data taking since 2005
- **analysis:** 3 different pipelines
    - **most difficult:** detection of close binary systems

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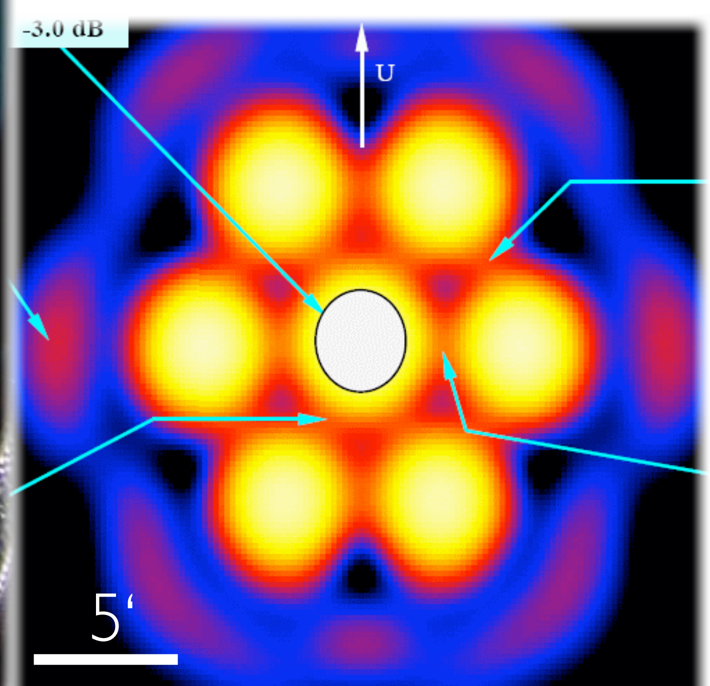

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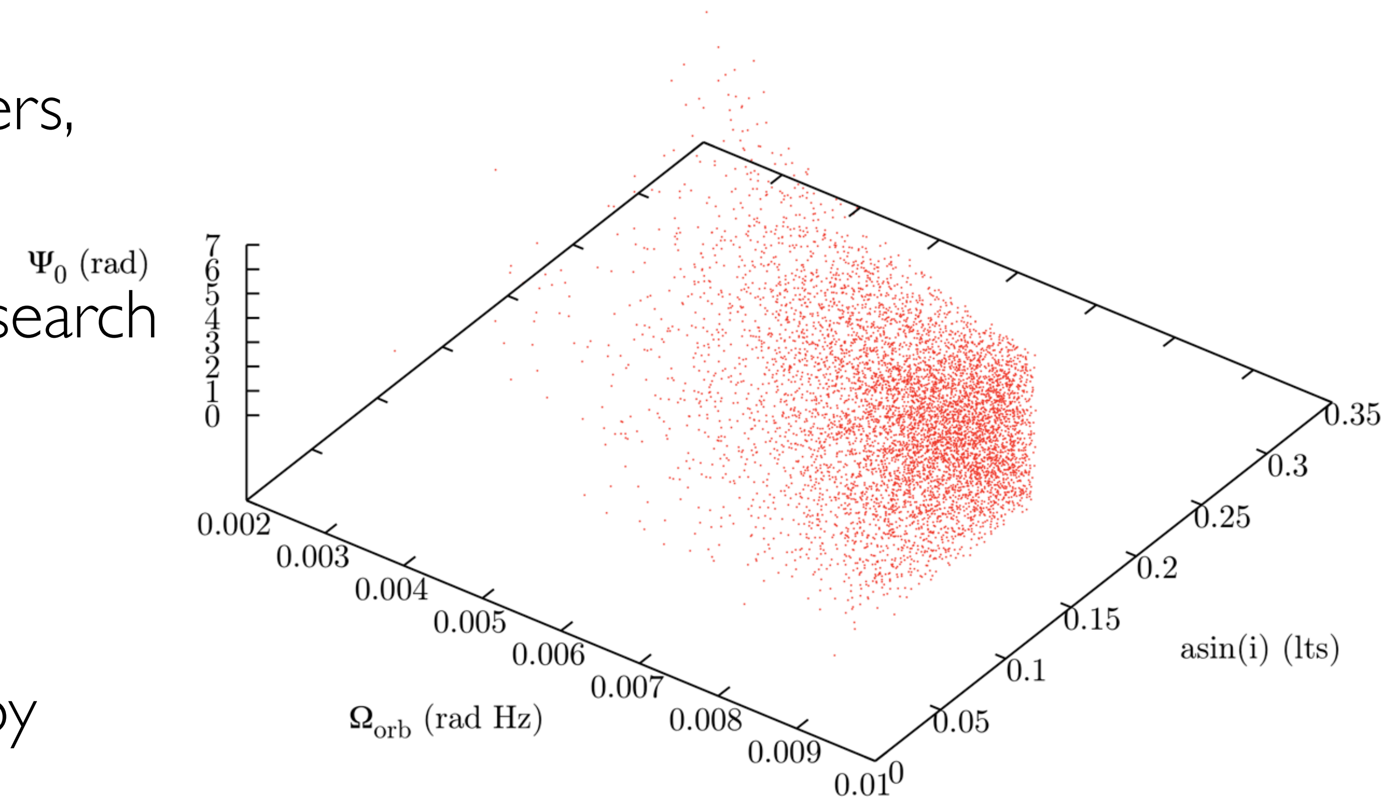
Binary Radio Pulsar Search

- 270,000 volunteers with 1.8 million computers, 300 Tflop/s total computing power
- 65% (195 Tflop/s) gravitational wave (GW) search
- 35% (105 Tflop/s) **radio pulsar search:**
    - launched in March 2009
    - make discoveries to keep volunteers happy
    - re-use tools from GW search

      i) parameter space metric

      ii) random and stochastic template bank

      iii) new coordinates for post-processing



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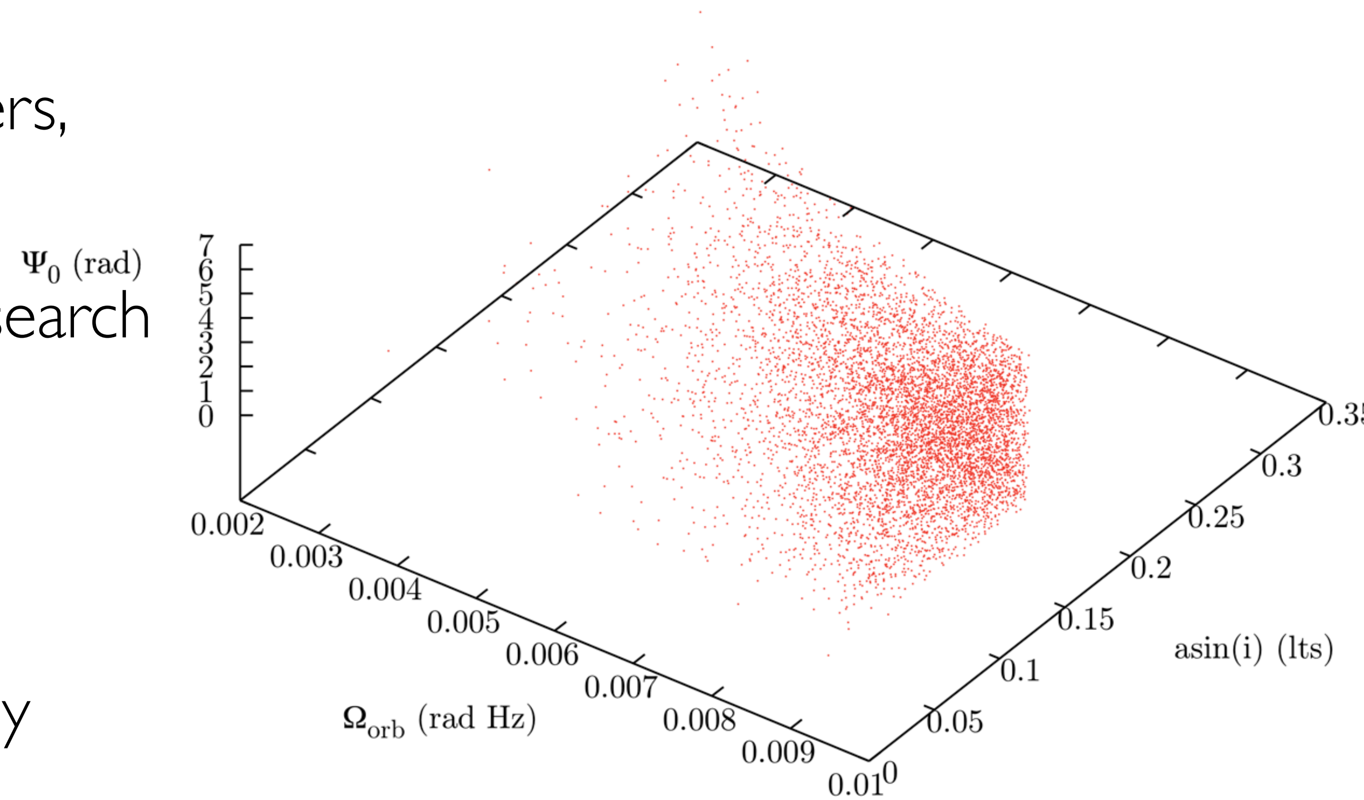
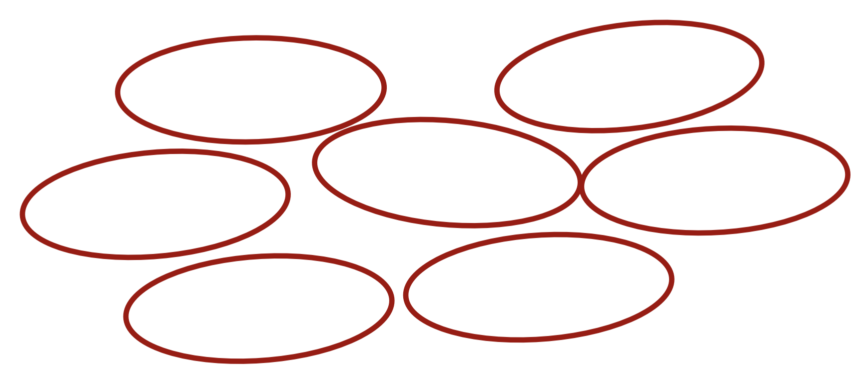
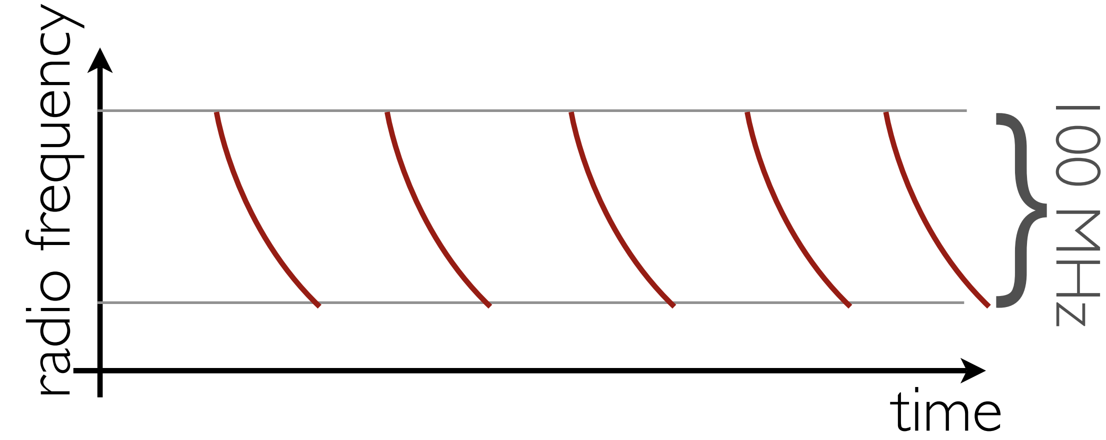




building a stochastic template bank

Data Analysis



- **three unknowns:**
  - distance (dispersion)
  - orbital parameters
  - spin frequency
- **Einstein@Home binary pulsar search:**
  - data archive at Cornell, transfer to AEI Hannover
- **E@H servers:** dedispersion
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  - template bank: orbital parameters ($P_{orb} > 11$ min)
  - demodulation in time domain
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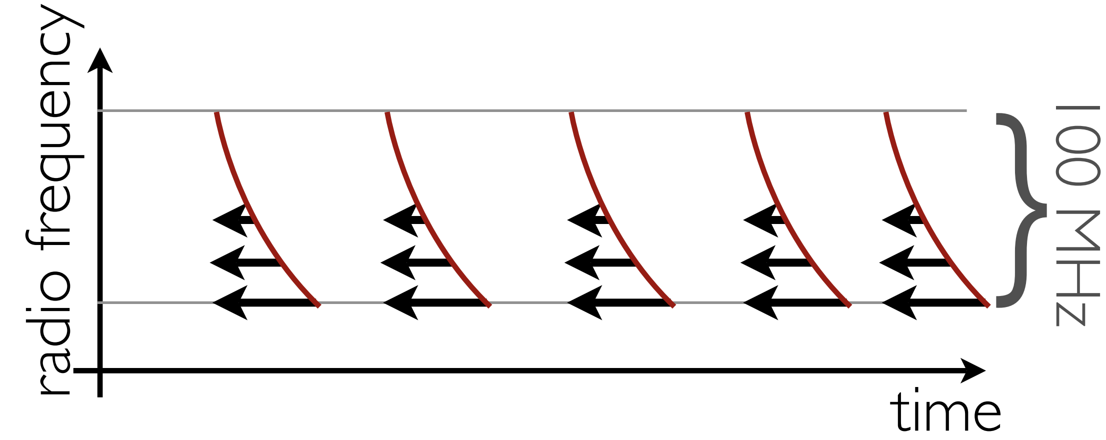

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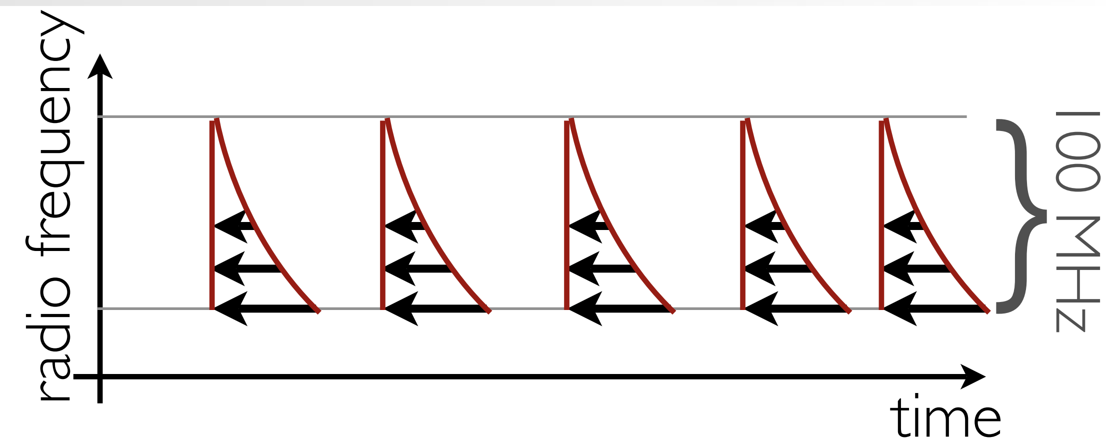

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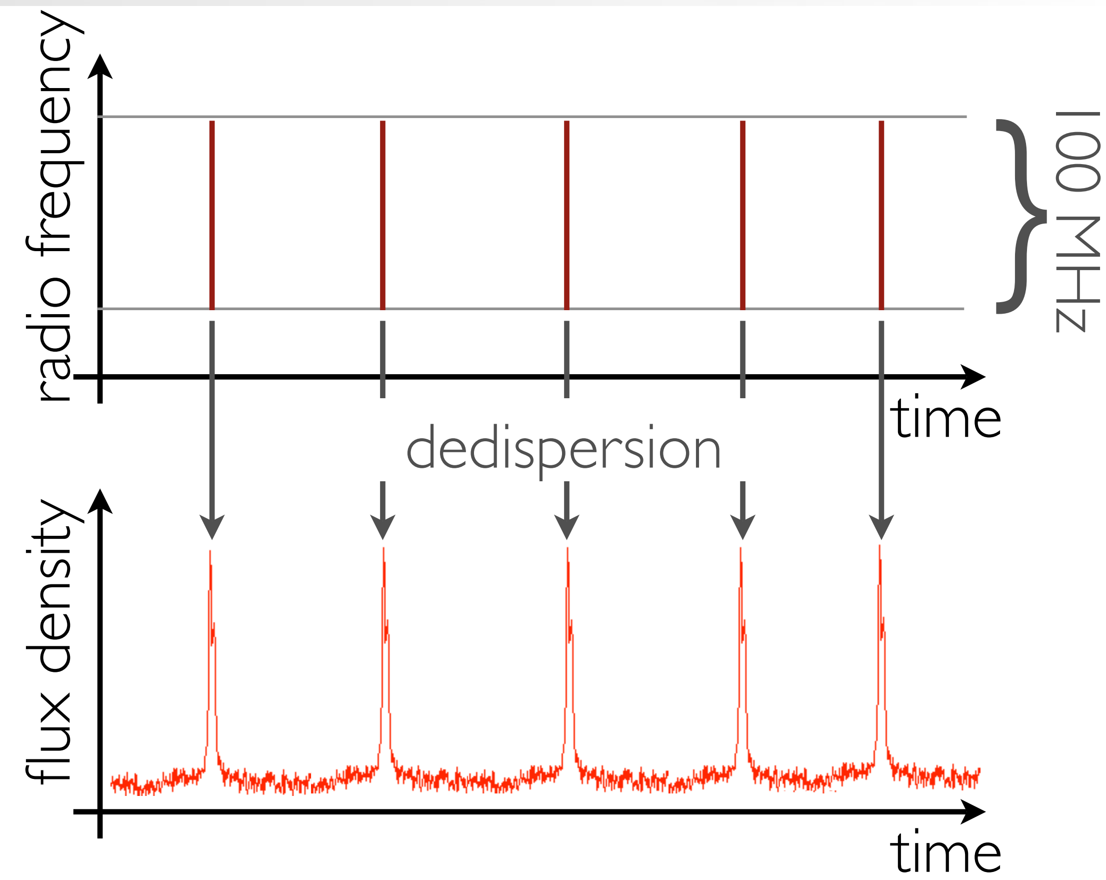

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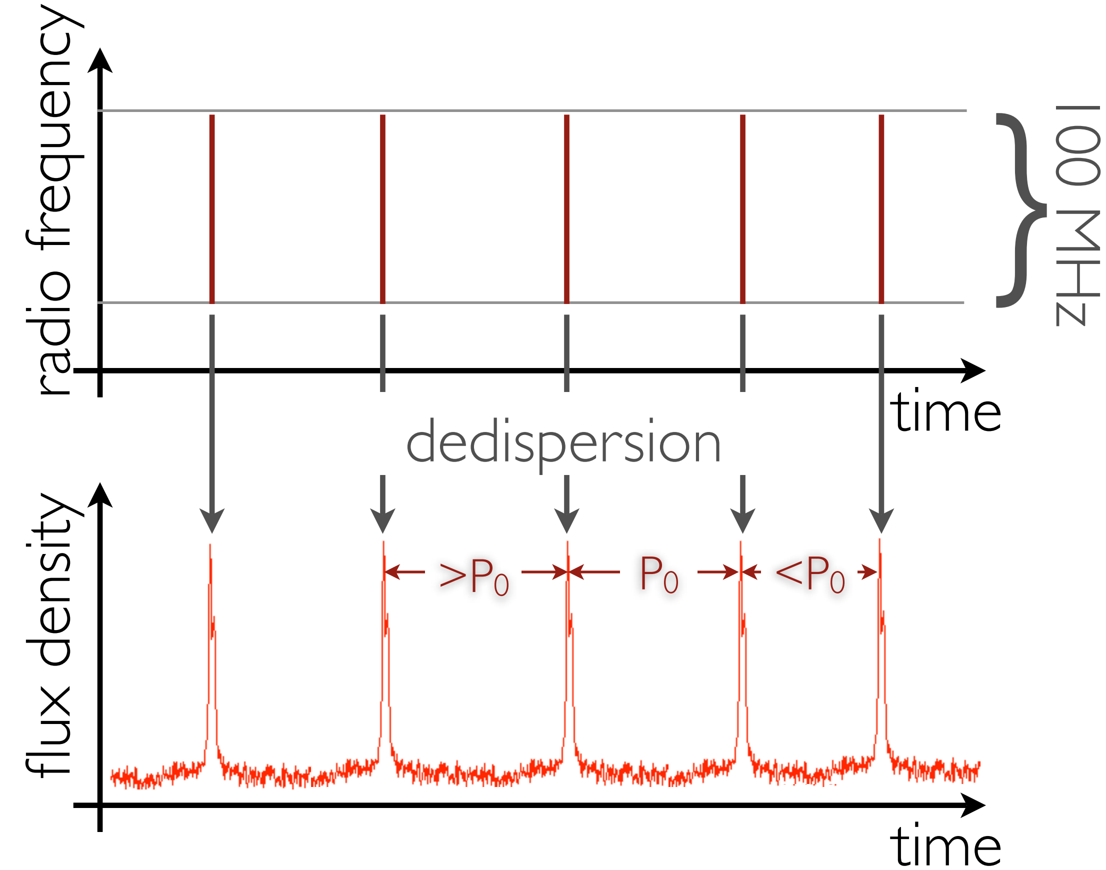

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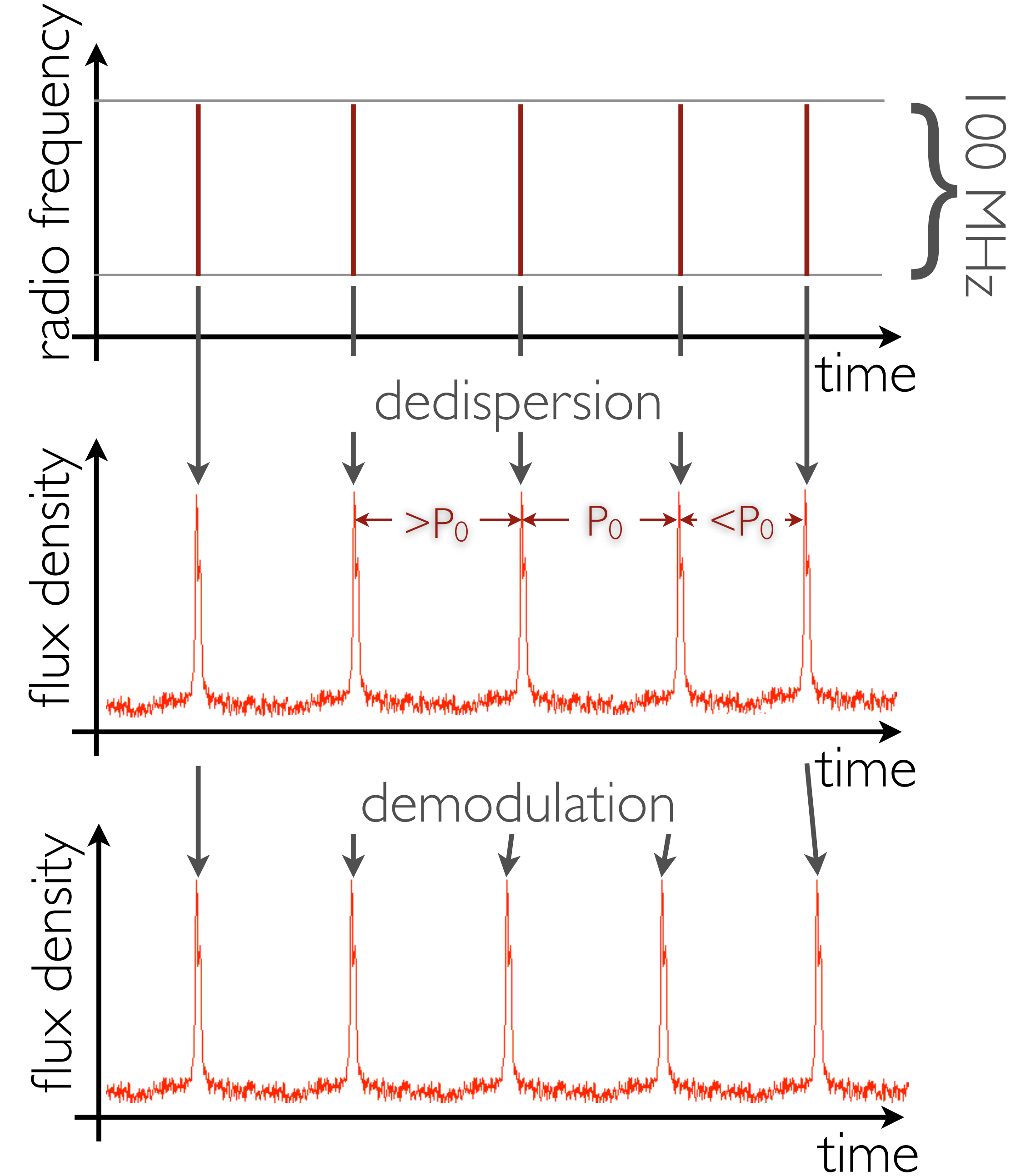

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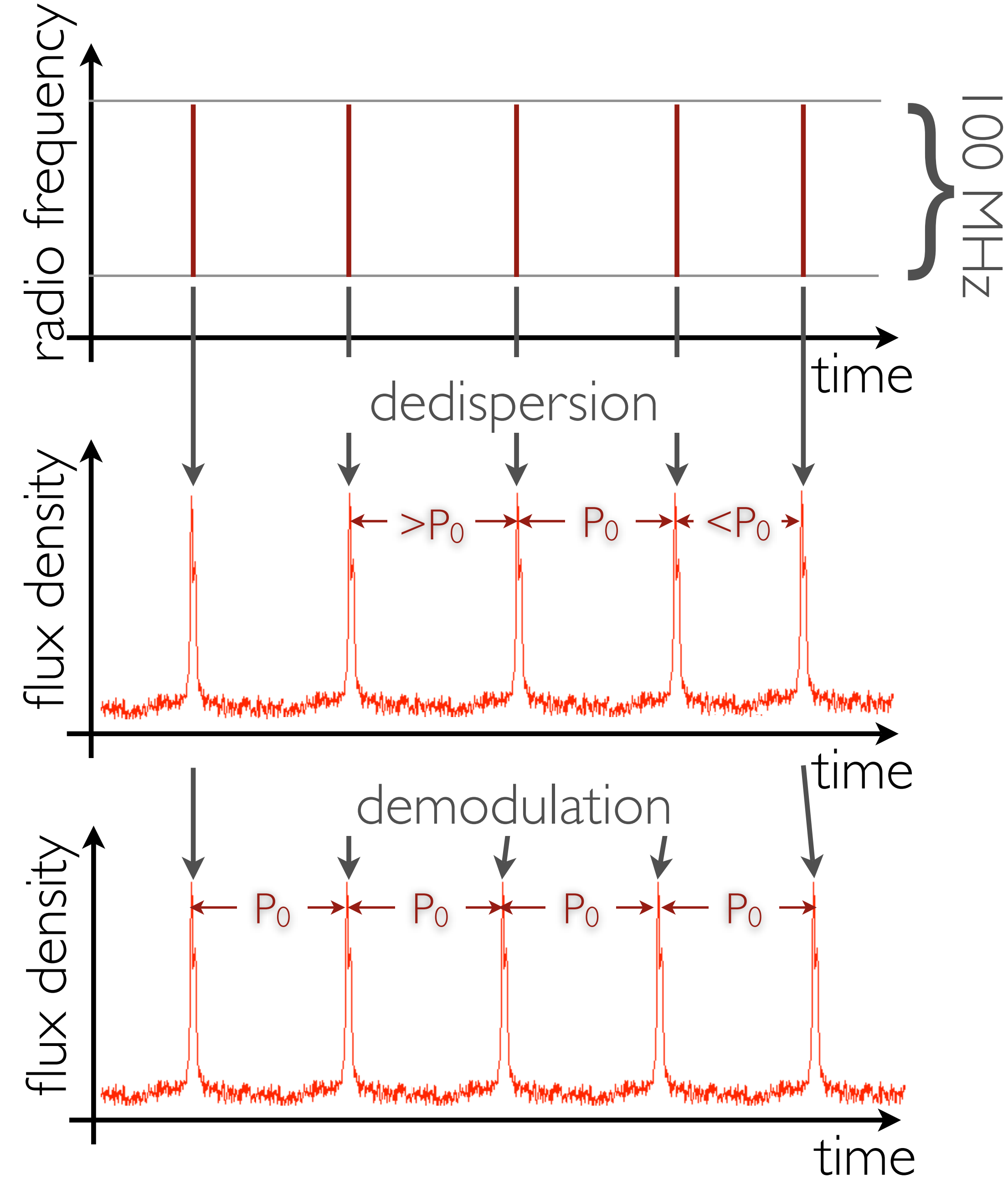

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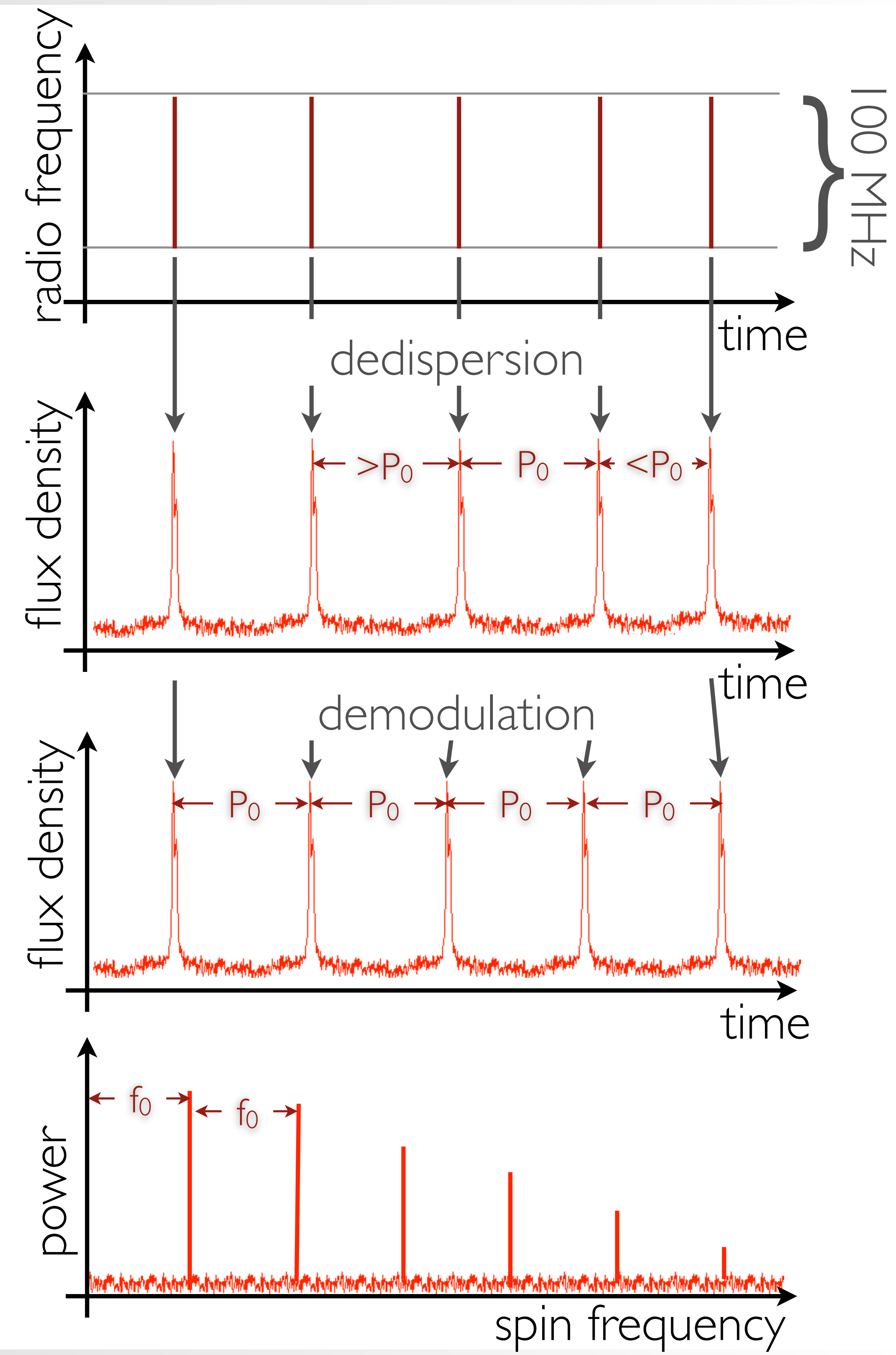
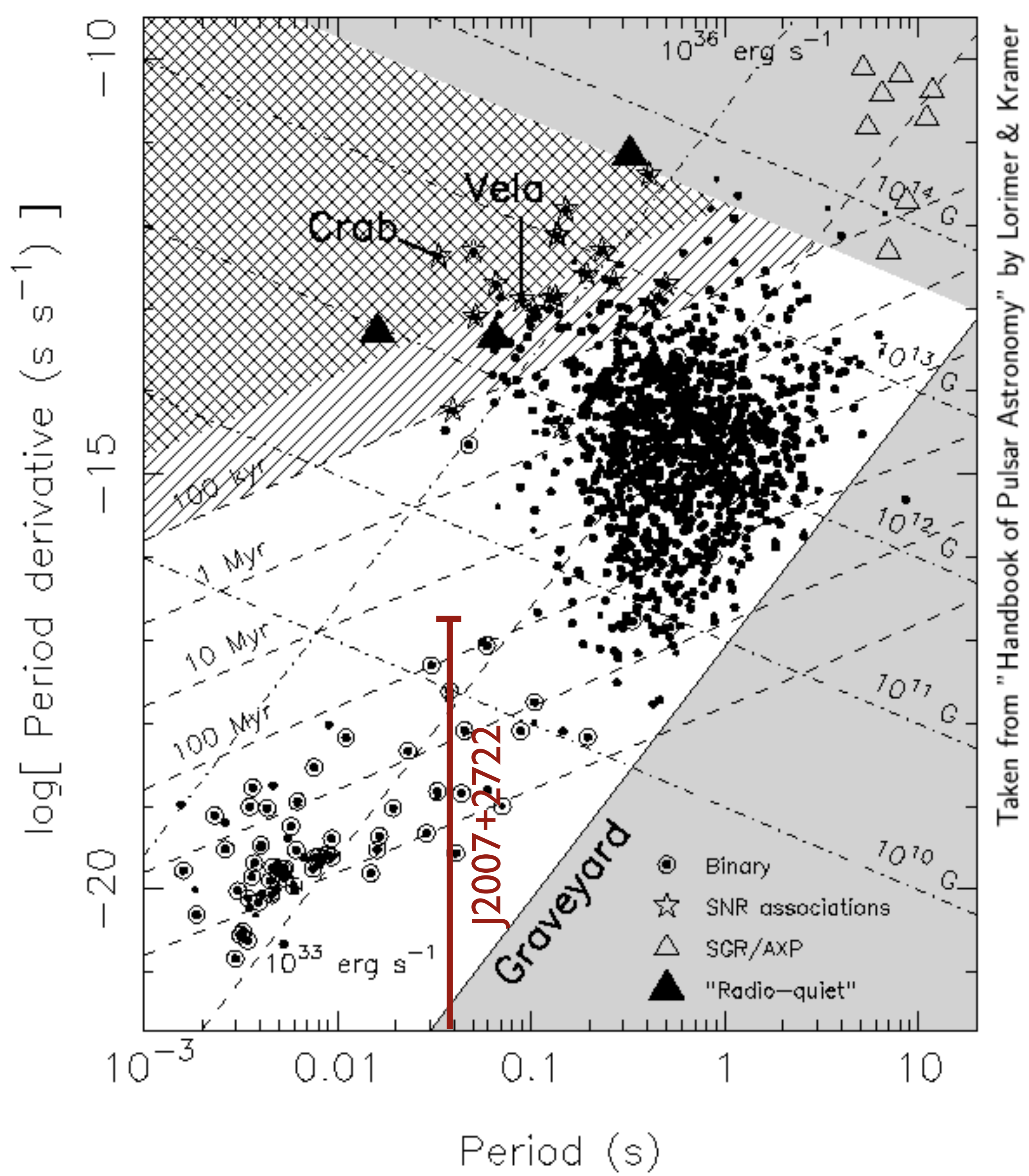


First Einstein@Home Pulsar

- **First pulsar discovery by global volunteer computing** *(Science Express, Aug 12)*
- **volunteers:** C. and H. Colvin (Ames, Iowa, USA) and D. Gebhardt (Mainz, Germany)
- **July 11:** candidate in data from Feb 2007, confirmation on Jul 13
- **observations:** **AO** (Puerto Rico), **Westerbork** (Netherlands), **GBT** (United States), **Effelsberg** (Germany), **Jodrell Bank** (United Kingdom)
- **spin:** f = 40.820677620(6) Hz
- **unusual low-$\dot{f}$ pulsar**
- **remarkable pulse profile**



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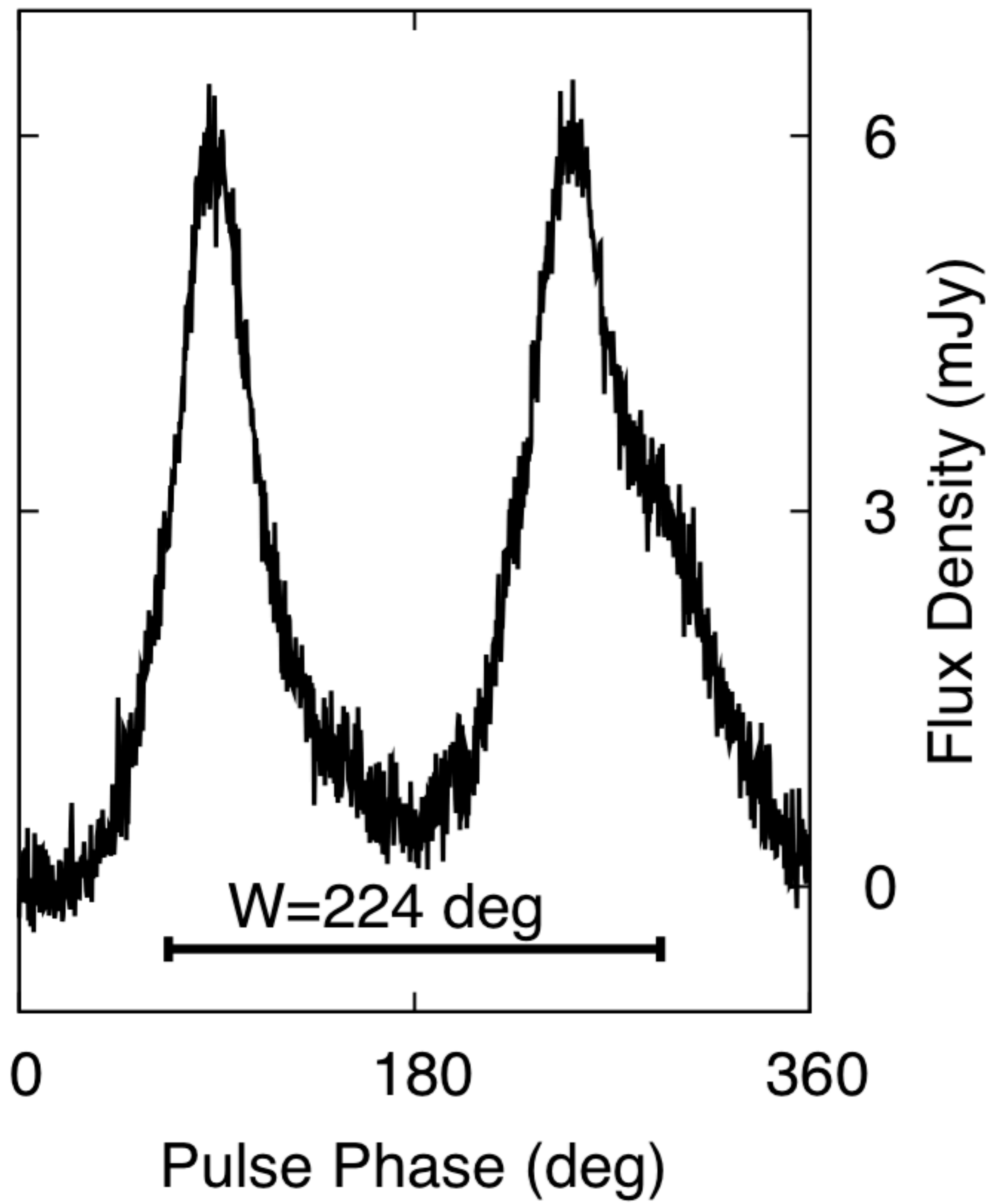
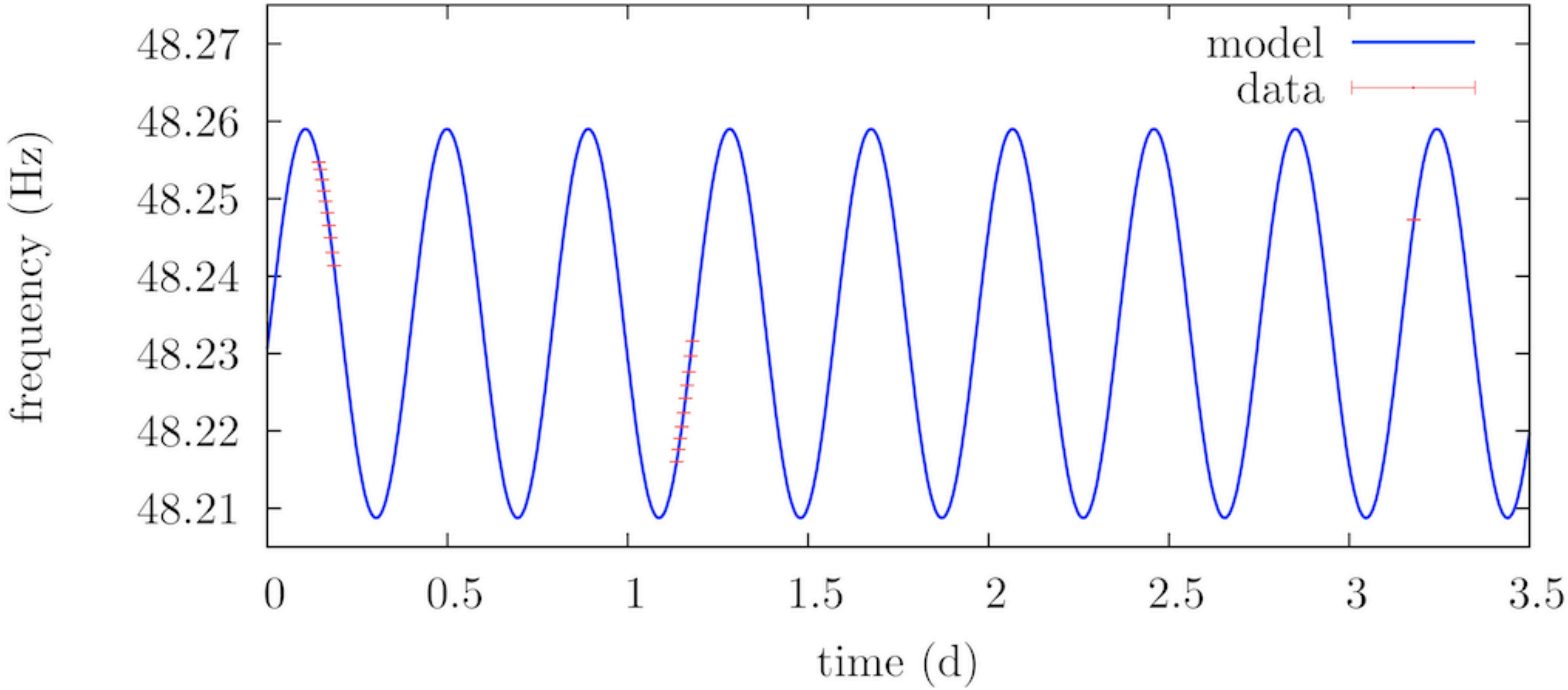


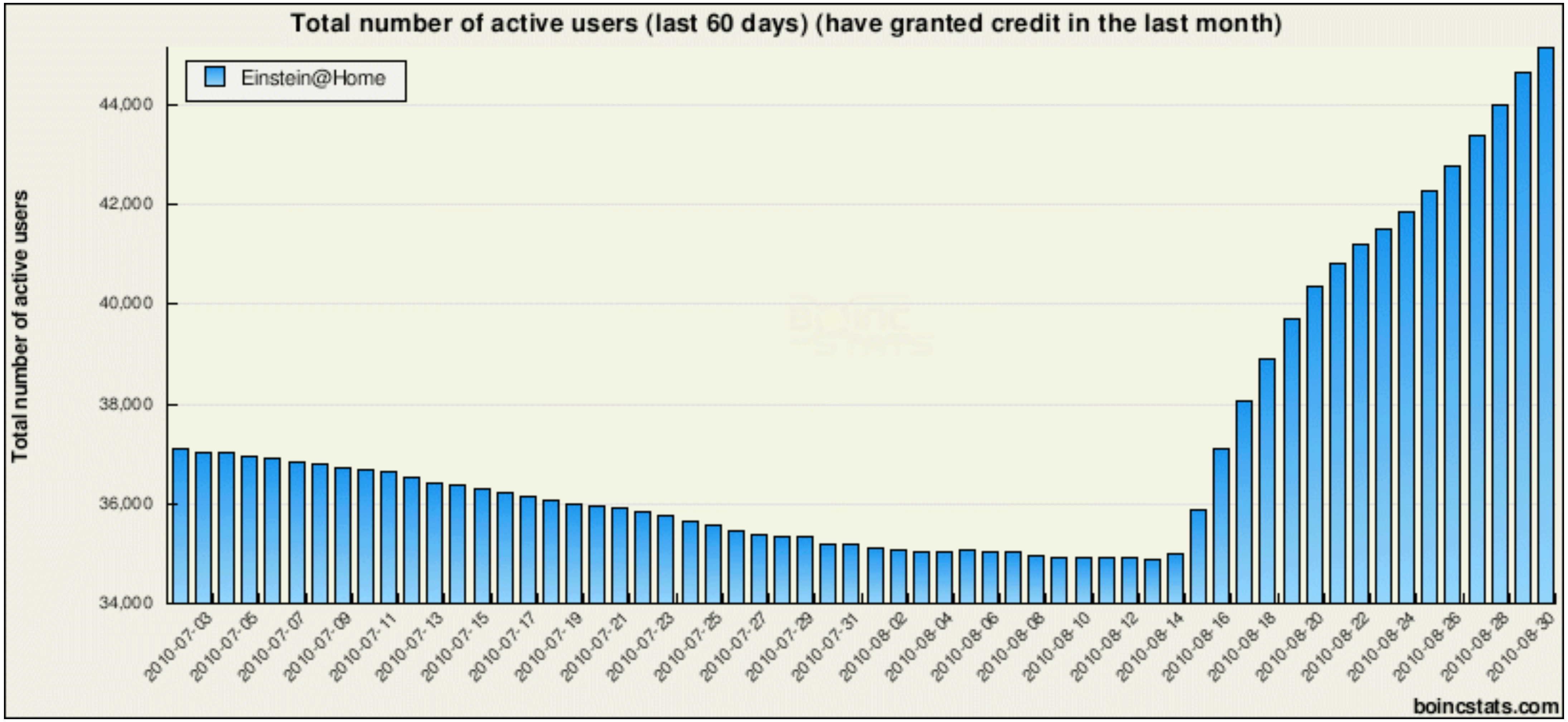
Second Einstein@Home Pulsar

- **users:** from UK and Russia
- **spin:** f = 48.233787(5) Hz
- **NS-WD binary**
- candidate for Shapiro delay measurement

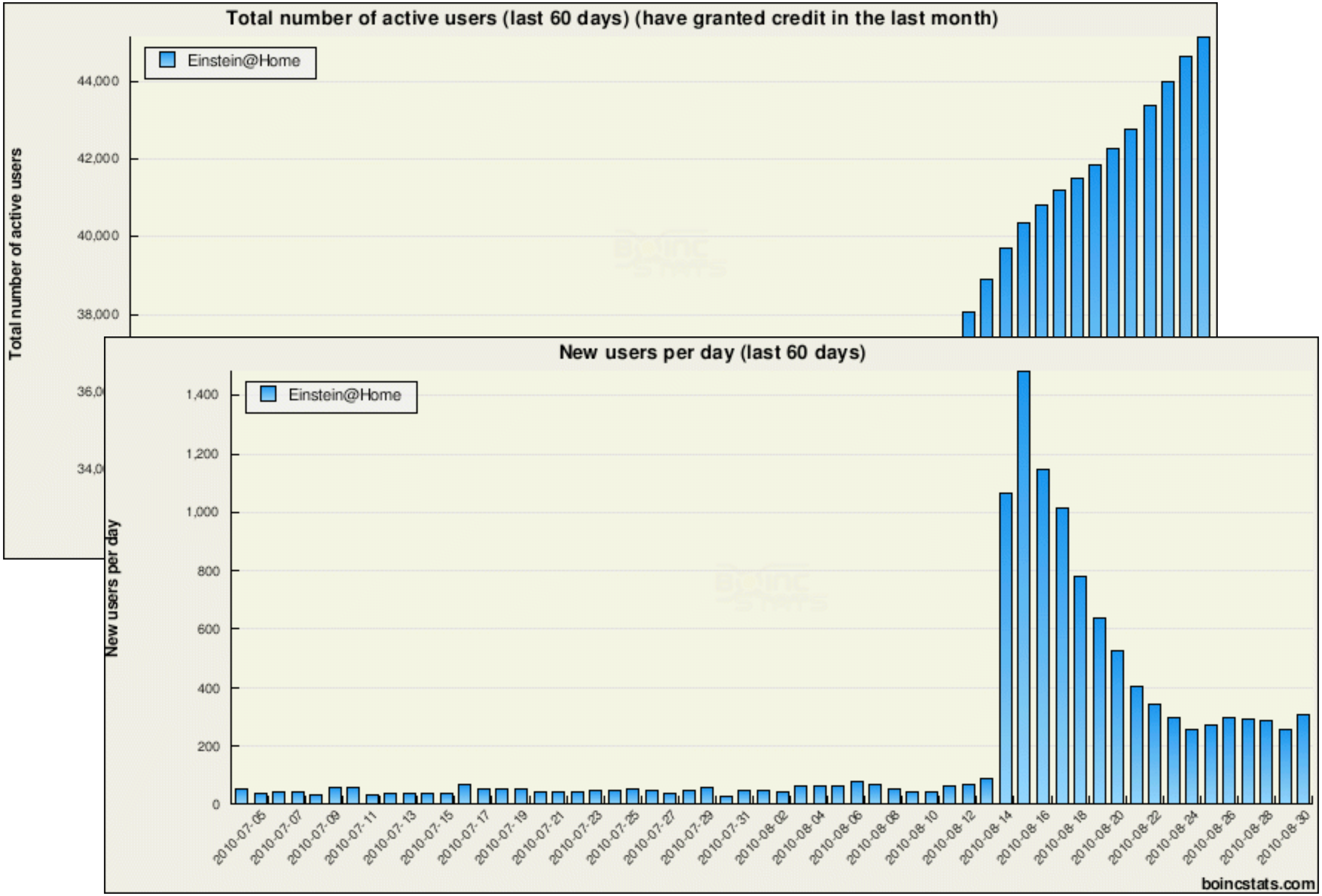
- P_{orb} = 9.41 h
- e ≈ 0
- 0.93 $M_{sun} \leq M_{comp}$
- median M_{comp} = 1.13 M_{sun}
- a sin(i) = 2.798 lts



Users


Total number of active users (last 60 days) (have granted credit in the last month)
Einstein@Home
Total number of active users
44,000
42,000
40,000
38,000
36,000
34,000
2010-07-03
2010-07-05
2010-07-07
2010-07-09
2010-07-11
2010-07-13
2010-07-15
2010-07-17
2010-07-19
2010-07-21
2010-07-23
2010-07-25
2010-07-27
2010-07-29
2010-07-31
2010-08-02
2010-08-04
2010-08-06
2010-08-08
2010-08-10
2010-08-12
2010-08-14
2010-08-16
2010-08-18
2010-08-20
2010-08-22
2010-08-24
2010-08-26
2010-08-28
2010-08-30
boincstats.com

Users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New users per day (last 60 days)
Einstein@Home
New users per day
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1,200
1,000
800
600
400
200
0
boincstats.com