

Pulsar Planning Update

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10 February 2003

(w/ thanks to Dave Thompson)

Basic challenge

- Goal: fold time-tagged GLAST photons at pulsar period
- Obstacle: pulsar period varies
 - deterministically because of spin-down, binary motion, and observatory motion
 - unpredictably because of “timing noise” and discrete “glitches”
- Plan:
 - monitor radio pulsars over GLAST life
 - provide mean parameters and piecewise polynomial fit to pulsar phase (collectively, an “ephemeris”)

Pulsar catalog

- Most recent published catalog: 558 pulsars (1993)
- Just over 700 pulsars in Princeton catalog available at <http://pulsar.ucolick.org/>
- Parkes survey
 - Over 600 pulsars found so far
 - About 220 are “published” with another 150 “in prep”
 - 519 currently available from ATNF web site (and from HEASARC)
- Some sources found in various other surveys

Old catalog format

```
@-----  
PSRB      0531+21                sr68                PSRJ 0534+2200  
RAB       05:31:31.405          5                mc71  
DECB      +21:58:54.39          6                mc71  
PMRA      -12                   3                wm77  
PMDEC     5                     4  
POSEPOCH          40675  
P          0.0334033474094      2                lp92  
Pdot      420.9599              2  
F2        9.76E-21              7  
PEPOCH    48743.0  
DM        56.791                1                cr71  
RM        -42.3                 5                man72  
We        1.2                   rcc+70  
W50       3.0                   lylg95  
W10       4.7                   lylg95  
S400      646                   70              lylg95  
S1400     14                   3                lylg95  
Dmin      1.5                   tri68  
Dmax      2.5                   tri68  
DIST      2.0  
NOTE      GS In the Crab Nebula; has glitches and large timing noise  
NOTE      GS  $\dot{\nu} = (9.76 \text{ pm} 0.07) \times 10^{-21} \text{ s}^{-3}$   
TYPE      I H  
Tau       -5.82                 cwb85  
S600      211                   37              lylg95  
S925      45                   10             lylg95  
@-----
```

Need for a new catalog format

- Old format:
 - difficult to maintain, especially as number of pulsars and file size grows
 - difficult to extract data except with very customized software
 - difficult to extend (must add new parameter names)
 - impossible to include other information of interest, e.g.:
 - pulsar integrated profile data
 - multiple timing ephemeris blocks
 - old measurements (often useful for statistical work)

UCSC catalog format

```
<pulsar jname="0534+2200" bname="0531+21" discovered="sr68" glitched="true" snr="true">
<g name="position" frame="B" epoch="40675" cite="mcn71">
  <p name="ra" value="05:31:31.405" error="5" />
  <p name="dec" value="+21:58:54.39" error="6" /></g>
<g name="pm" cite="wm77">
  <p name="pmra" value="-12" error="3" />
  <p name="pmdec" value="5" error="4" /></g>
<g name="period" epoch="48743.0" cite="lp92">
  <p name="p" value="0.0334033474094" error="2" />
  <p name="pdot" value="420.9599" error="2" />
  <p name="f2" value="9.76E-21" error="7" /></g>
<p name="dm" value="56.791" error="1" cite="cr71" />
<p name="rm" value="-42.3" error="5" cite="man72" />
<p name="tau" value="-5.82" cite="cwb85" />
<p name="dmin" value="1.5" cite="tri68" />
<p name="dmax" value="2.5" cite="tri68" />
<p name="assocdist" value="2.0" />
<p name="flux" frequency="400" value="646" error="70" cite="lylg95" />
<p name="flux" frequency="600" value="211" error="37" cite="lylg95" />
<p name="flux" frequency="925" value="45" error="10" cite="lylg95" />
<p name="flux" frequency="1400" value="14" error="3" cite="lylg95" />
<p name="w10" value="4.7" cite="lylg95" />
<p name="w50" value="3.0" cite="lylg95" />
<p name="we" value="1.2" cite="rcc+70" />
<note>$.ddot\nu=(9.76\pm0.07)\times10^{\{-21\}},\$,s\$\^{\{-3\}}\$/</note>
</pulsar>
```

logically grouped
parameters are structurally
grouped

attributes keep track
of qualifying information

Advantages of new format

- Standard XML can be easily read and manipulated from any programming language (with right style sheet can even be displayed directly in browser)
- New parameters easily added:

```
<p name="glastflux" value="?e??" error="1" cite="abc+06" />
```
- New data types easily added:

```
<profile freq="430">2.3,5.4,...,2.2</profile>
```
- Note: “cite” in both old and new catalog is index into BibTeX database (stored at UCSC, but updated worldwide) with bibliography data for over 5280 pulsar-related references

Pulsar parameters

- Basic timing parameters (spin-down rate, etc.) needed to estimate pulsar ages, magnetic fields, and spin-down luminosities have either been measured or are being measured (for Parkes pulsars)
- Biggest uncertainty relevant for GLAST is distance estimation
 - Two new efforts to build Galactic dispersion model (Cordes and Lazio, and Gomez, Benjamin, and Cox)
 - Major new push on pulsar parallax measurements (we now get to 0.1 mas or better for bright pulsars, so can do meaningful distances to a few kpc)

Ephemeris calculation

- Radio timing data is reduced to ephemeris estimate using the standard TEMPO software package
- Current plan is to provide GLAST with “GRO format” data (example from Andrew Lyne):

```
0531+21 05 34 31.972 22 00 52.07 52487 52518 52502.000000366 29.8151800347813 -  
3.73834D-10 -7.67D-20 3.4 J DE200 0531+21  
0531+21 05 34 31.972 22 00 52.07 52518 52548 52533.000000117 29.8141787457896 -  
3.73810D-10 1.65D-20 0.7 J DE200 0531+21  
0531+21 05 34 31.972 22 00 52.07 52548 52577 52562.000000063 29.8132421570543 -  
3.73778D-10 3.76D-20 0.6 J DE200 0531+21  
0531+21 05 34 31.972 22 00 52.07 52580 52610 52595.000000258 29.8121765140558 -  
3.73761D-10 -7.19D-21 1.5 J DE200 0531+21  
0531+21 05 34 31.972 22 00 52.07 52609 52640 52624.000000157 29.8112400629906 -  
3.73735D-10 2.91D-21 0.6 J DE200 0531+21
```

Observing plans

- Still rather unclear
- Most pulsars are either
 - in the north, where facilities are reasonably abundant,
 - “quiet” enough that very frequent timing is unnecessary,
 - and/or distant/old enough that chances of a GLAST detection are small
- Some others (e.g., Vela) are observed regularly with small telescopes
- *probably*, most of what GLAST wants/needs will be doable with fairly small incremental effort

Pulsar advisory group

- Group established to plan observing strategy and make recommendations to mission for needed support or special coordination requirements
- Current membership:
 - Dick Manchester, Matthew Bailes (Parkes)
 - Andrew Lyne (Jodrell)
 - Don Backer (ATA)
 - David Nice (Green Bank, EGRET experience)
 - Roger Romani (theory)
 - Maura McLaughlin (population modeling)
 - Dave Thompson (GLAST)

Schedule

- Catalog: After Parkes survey publications are finished, a combined catalog will be published and made available on web
- Data formats: discussions will continue between pulsar community and science support center (and NRAO for EVLA effort), but main interface format (ephemeris file) probably done
- Observing: discussions over next year should help identify key issues; regular observations don't need to begin until around start of 2006