Pulsar Blind search in the DC2 data

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Data Selection

As input all sources listed in the LATSourceCatalog_v1 were used (=> 380 sources)

James Chiang and Johann Cohen helped to write a Python script to:
- Pick a source from the catalog
- Select all photons within a 2° radius around the source
  (energy dependent cut based on GLAST PSF did not improve the signal)
- Correct the photon arrival time
- Output the data into a text file

-> Calculate differences and Perform the FFT
Finding a Pulsar Candidate

Source MRF0035

Look for frequency with the highest power

Found F0 = 19.371213 1/s
DC2 Catalog = 19.371221 1/s
Test statistic (signal/noise)

-> Calculate the RMS of the power spectrum

Test Statistic (signal to noise) = \( \frac{\text{max\_power\_in\_FFT}}{\text{RMS}} \)

Take a closer look at sources with s/n > 45

Work with Joe Dolan in progress to get a measure of the significance of the found peaks. (See how likely it is that a random fluctuation created a peak of the same height)
Sources with large s/n

- **Beacon MRF0054**: Unknown large s/n source in the galactic plane. No matching pulsar in the database.

- **Vela**:

- **Geminga (2nd harmonic)**
Covered phase space

Scan for pulsars (0.5 Hz to 64 Hz)  
$F_{\dot{}}/F$ up to $3 \times 10^{-9}$ (300 steps @ $1 \times 10^{-11}$)

Scan for ms pulsars (0.5 Hz to 512 Hz)  
$F_{\dot{}}/F$ up to $3 \times 10^{-11}$ (6 steps @ $0.5 \times 10^{-11}$)

A maximum time difference of 65,000s was used
-> Calculation took about 2 weeks on a PC

Scan found
16 Radio Loud pulsars
3   Radio Quiet pulsars
## Blind Search Catalog with reprocessed DC2 Data

<table>
<thead>
<tr>
<th>Source_Name</th>
<th>L</th>
<th>B</th>
<th>Test Stat.</th>
<th>F0</th>
<th>F1</th>
<th>Comment</th>
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<tbody>
<tr>
<td>MRF0054</td>
<td>60.7250</td>
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Flux Sensitivity

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<tbody>
<tr>
<td>Entries</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>RMS</td>
</tr>
</tbody>
</table>

Pulsar with lowest flux:
Off plane (b=11.9):
PSR_J1852m2610  flux $3\times10^{-7}$ Ph/cm$^2$s

In plane  (b= -0.9):
PSR_J1856p0113  flux $7\times10^{-7}$ Ph/cm$^2$s
Recover light curve for source MRF0168 (Vela)

Vela Radio Position \( Ra = 128.83 \) \ Dec = -45.18
MRF0168 Position \( Ra = 128.842 \) \ Dec = -45.168701

Light curve:
Barycenter time correction for MRF0168 position. Pulsar spin parameter from radio position.

Barycenter time correction for MRF0168 position. Optimized pulsar spin parameter for MRF0168 pos.

Radio : \( Ep = 220838550 \) \( F0 = 11.19723954 \) \( F1 = -1.5664e-011 \) \( F2 = 6.26E-22 \)
Optimized : \( Ep = 220838550 \) \( F0 = 11.19723929 \) \( F1 = -1.5578e-011 \) \( F2 = -2.30E-20 \)
Light curves of pulsars without radio data

- **Light_Curve MRF054 100 bins**
  - Epoch MET = 220838550
  - F0 = 5.885928323969
  - F1 = -1.306230 e-012
  - F2 = 1.0 e-021

- **Light_Curve MRF0058 100 bins**
  - Epoch MET = 220838550
  - F0 = 3.91691474178
  - F1 = -1.936137 e-013
  - F2 = 6.0 e-022

- **Light_Curve MRF0155 100 bins**
  - Epoch MET = 220838550
  - F0 = 3.766282209980
  - F1 = -3.677283 e-013
  - F2 = -3.3 e-021

- **Light_Curve MRF0155 100 bins**
  - Epoch MET = 220838550
  - F0 = 3.766282209980
  - F1 = -3.677283 e-013
  - F2 = -3.3 e-021
Summary + Future plans

Thank you for this excellent data set to perform a realistic blind search!

Bill’s differencing method is an easy and fast way of finding pulsations from pulsars

16 + 3 pulsars were found and the spin parameters/light curve can be derived

Things to improve

- Add up harmonics to increase the sensitivity
- Understanding statistical significance
- Get PC with more memory to perform larger FFTs
  (we are also looking into a hardware FFT implementation)
- Implement the algorithm into the the science tools
Basic Idea

Calculate the Fourier-Transform of the time differences of the photon arrival times $\Delta t_n$. 

\[ \text{take only differences with } \Delta t < \text{max} \_ \text{diff} \]

max_diff used for DC2 data = 65 000s