# All-sky search of EXPLORER data for continuous sources


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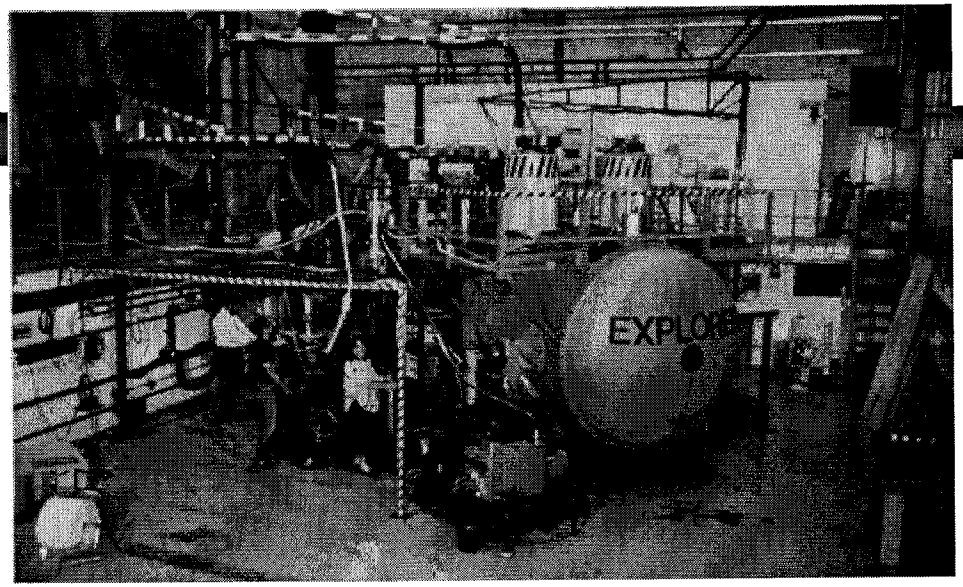
# All-sky Search of the EXPLORER Data

**EXPLORER resonant bar detector**



The EXPLORER detector is operated by Italian group called ROG currently led by Eugenio Coccia. The analysis is performed by a team consisting of Pia Astone, Kazik Borkowski, Piotr Jaranowski, Andrzej Królak, Maciej Piętka and is carried out on the basis of Memorandum of Understanding between the ROG group and Institute of Mathematics of Polish Academy of Sciences.

http://www.astro.uni.torun.pl/~kb/AllSky/AllSky.html

# Linear parameterization of the response

- For observation time of few days and a few Hz bandwidth linear representation is an adequate approximation.

$$h(t) = \sum_{j=1}^{2} a_j(t)[C_j \cos\Phi(t) + D_j \sin\Phi(t)]$$

$$\Phi_s = p_o t + p_1 t^2 + A\cos(\Omega t) + B\sin(\Omega t)$$

# Maximum likelihood detection

$$F = \ln \Lambda_r = \frac{2}{S_h(f) T_o} \sum_{j=1}^{2} \frac{|T_j|^2}{\langle a_j^2 \rangle}$$

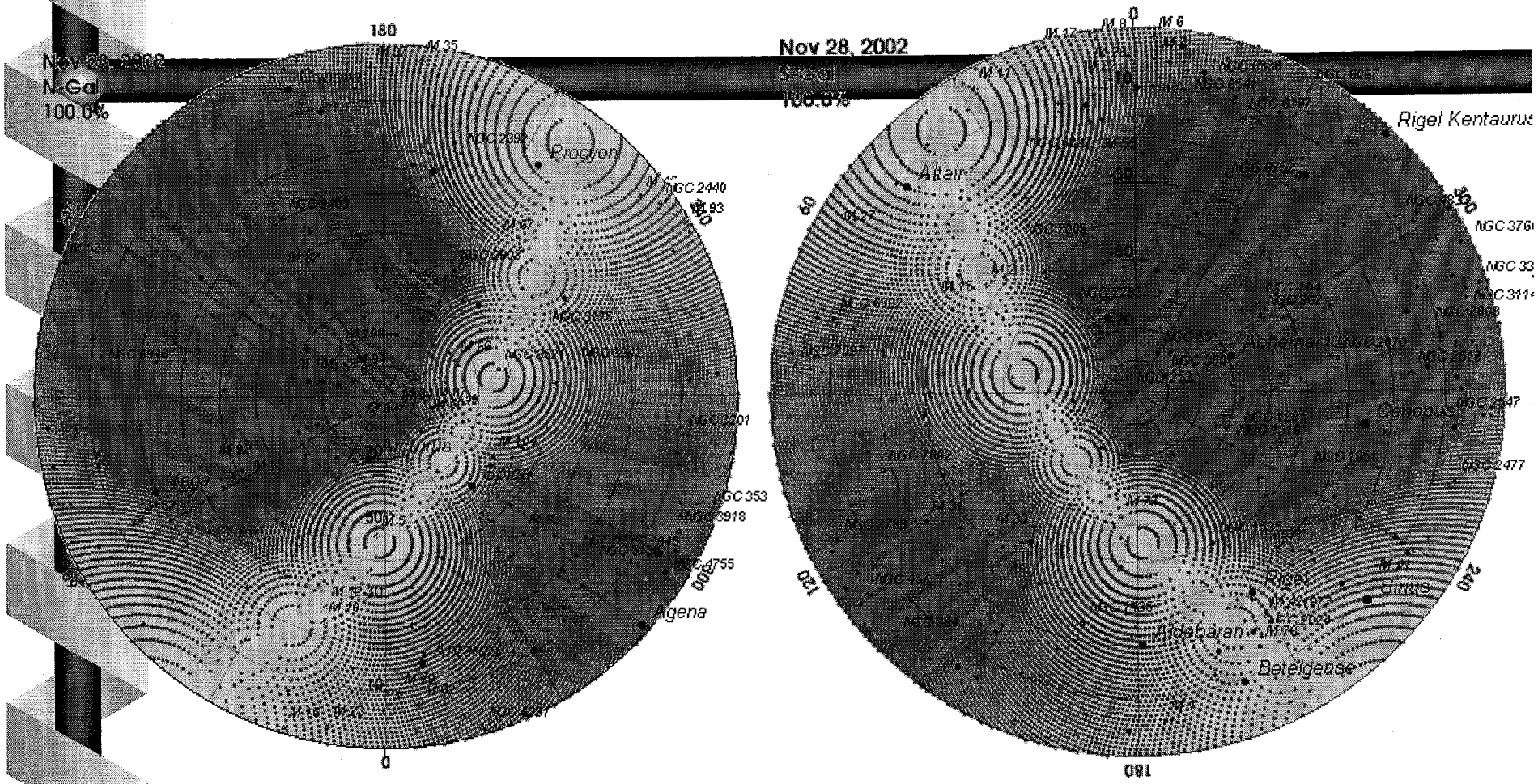
$$T_j = \int_0^{T_o} x(t)\, a_j(t) \exp[-i \Phi_{NS}(t)] \exp[-i p_0 t]\, dt$$

$$C_j + i D_j = 2 \frac{T_{\max j}}{\langle a_j^2 \rangle}$$

# Parameters of the search

- **Parameters of the data:**
- **The Modified Julian Date of the first sample: 48580.7908507**
- **Length of observation time: 2 days**
- **Bandwidth of the search: 920.9992 -- 921.7598 Hz**
- **Parameters of the search:**
- **Spin down range: -9.1762 $10^{-8}$ -- +9.1762 $10^{-8}$ Hz $s^{-1}$**
- **No. of spin downs 2868**
- **Sky positions: All sky, no. of pointings 31915**
- **No. of filters = 183064440**
- **Sensitivity of the search**

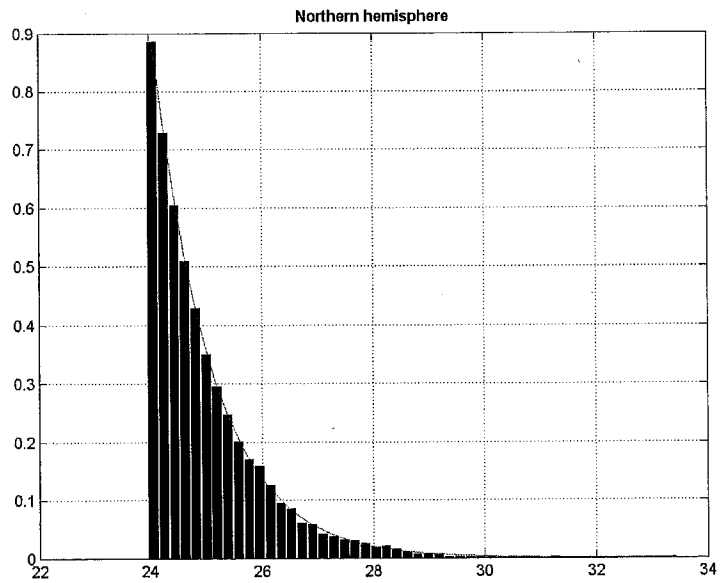
# Search progress

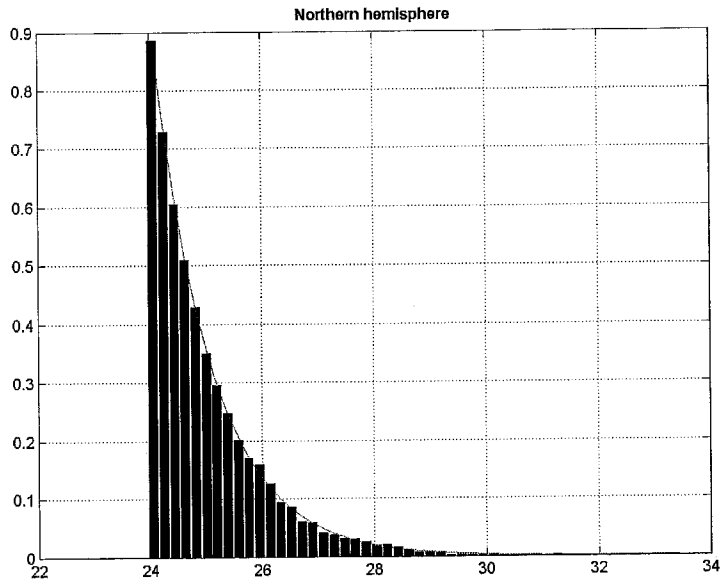


# Candidate statistics

**If there is no noise *F* has $\chi^2$distribution with 4 degrees of freedom.**

$$d_{tr} = 6.7$$

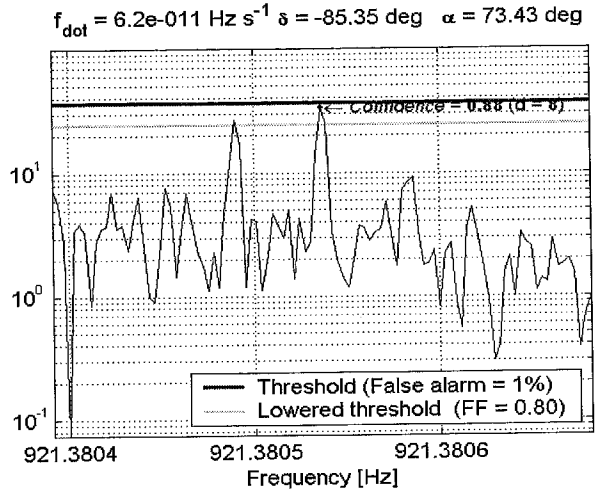


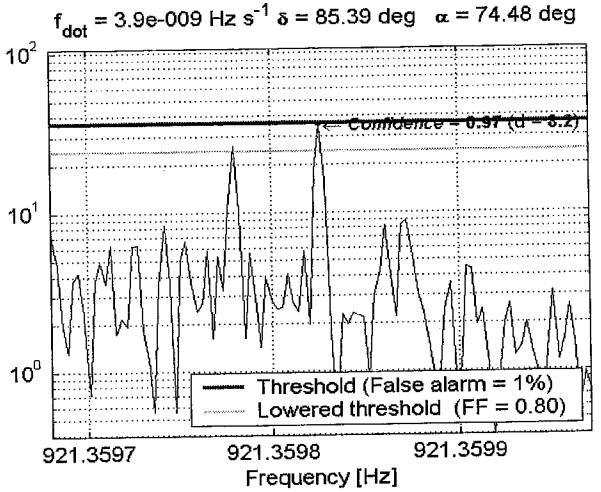



# Candidate verification

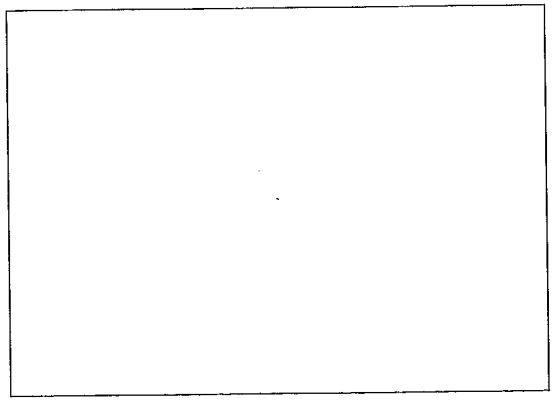
1. **Transformation from parameters ($p_0$,$p_1$,A,B) to astrophysical parameters (f, $f_1$, $\alpha$, $\beta$) .**
2. **Search on a small grid around astrophysical parameters.**
3. **Search in a different 2-day stretch of data.**
4. **Search in a 4-day stretch of data containing the original 2-day stretch.**

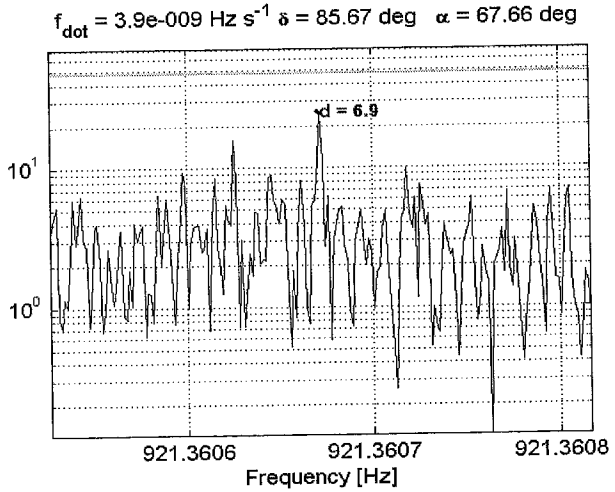
# Candidate verification: an example




NO SIGNAL FOR DIFFERENT OBSERVATION TIME





# Upper limit

$$p_1(d,F) = \frac{\sqrt{2F}}{d} I_1(d\sqrt{2F}) \exp(-F - \frac{1}{2}d^2)$$

$$p_D(d,F_o) = \int_{F_o}^{\infty} p_1(d,F)dF \qquad F_{\max} = \frac{1}{2}d_{\max}^2 + 2$$

$$p_D(d_{UB}, F_{\max}) = 0.01$$

99% confidence upper limit

$$d_{UB} = 5.9 \Leftrightarrow h = 2\times10^{-23}$$