The 1st INTEGRAL Data Analysis Workshop,
ISDC, Versoix

A new timing analysis of ISGRI data combining Rayleigh test and PIF method

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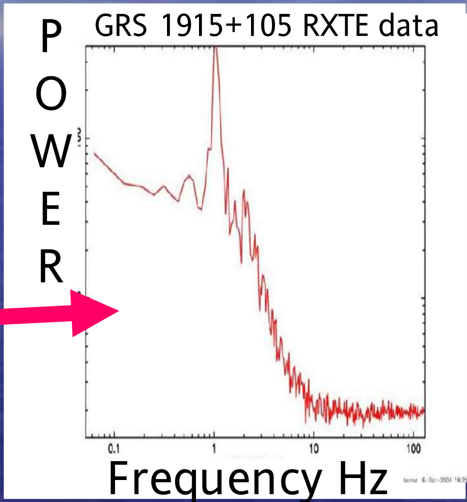
SHERPAS

Standard timing analysis

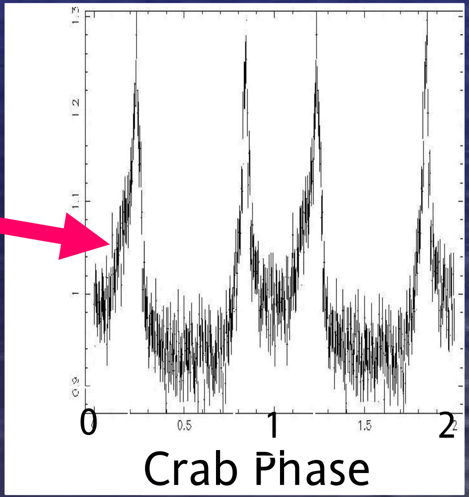
EVENT FILE
Time of arriving Photons, Energy

LIGHTCURVE
Flux vs time

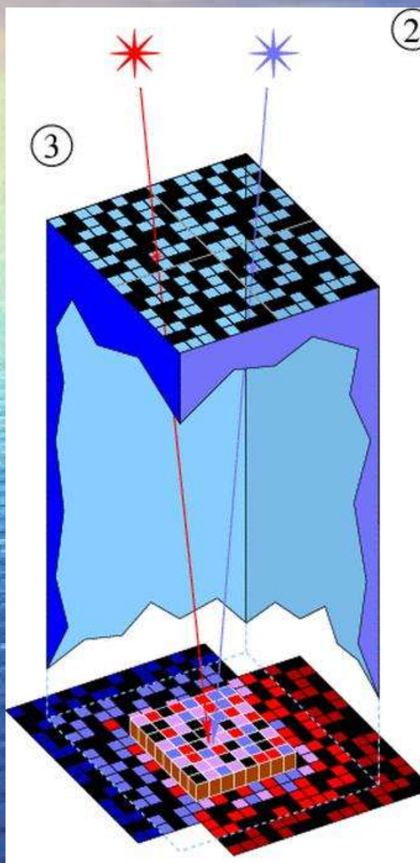
FOURIER ANALYSIS:
PSD



- EPOCH FOLDING
- RAYLEIGH/ KUIPER TEST



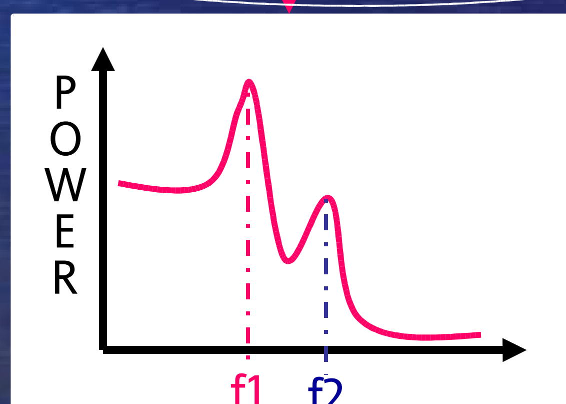
Problem with coded mask aperture



TWO SOURCES ILLUMINATE THE SAME PIXEL

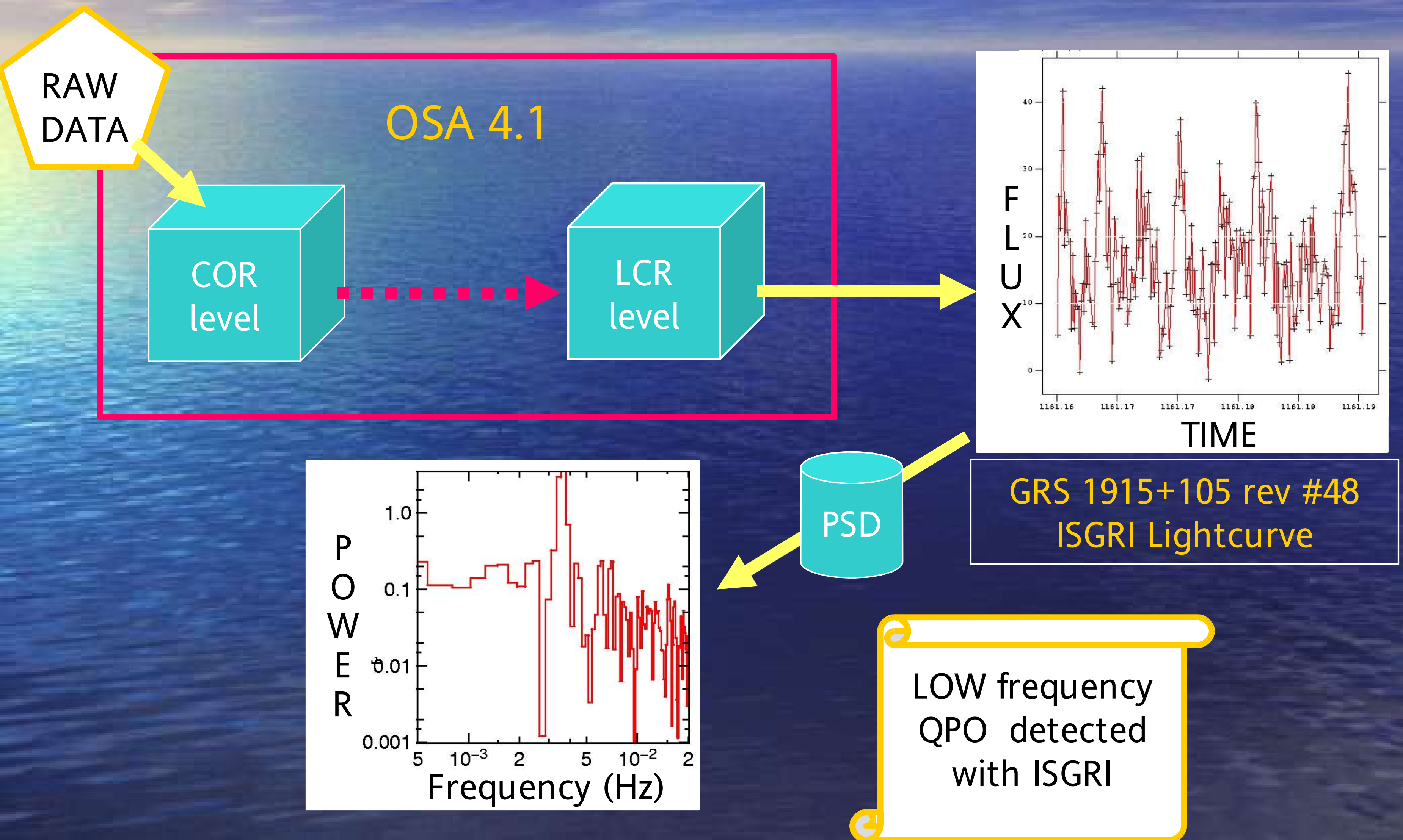
If SRC1 luminosity sinusoidally oscillating at frequency f1 and SRC2 luminosity oscillating at frequency f2

PSD on full detector



CONFUSION between both sources signal

Standard timing analysis with ISGRI data



Back to the event files··· And the PIF···

- At shorter time scales, less statistic

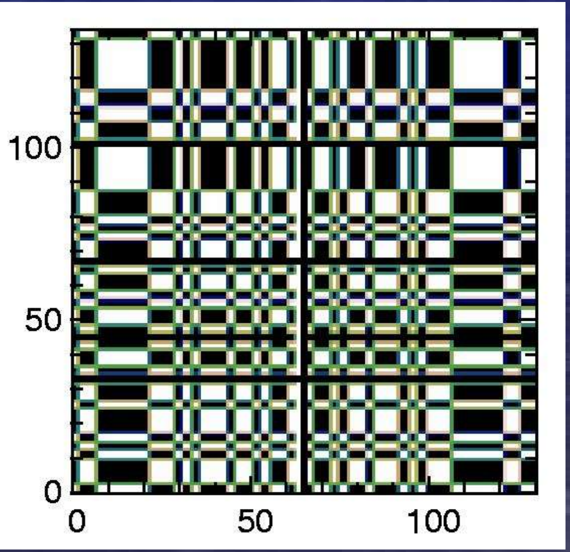
  → difficulty to analyze the signal at high frequency

- Idea : using directly the event file produced by the command evts_extract available with OSA 4.1 package.

	TIME 1D d	PIF_1 1D	PIF_2 1D
1	1.160362912531E+03	0.000000000000E+00	7.441939115524E-01
2	1.160362912541E+03	8.988144993782E-01	0.000000000000E+00
3	1.160362912546E+03	0.000000000000E+00	1.000000000000E+00
4	1.160362912574E+03	0.000000000000E+00	7.079735398293E-01
5	1.160362912580E+03	2.442847341299E-01	9.948028326035E-01
6	1.160362912589E+03	0.000000000000E+00	0.000000000000E+00
7	1.160362912597E+03	5.593928694725E-01	1.000000000000E+00
8	1.160362912607E+03	0.000000000000E+00	3.708754181862E-01
9	1.160362912646E+03	0.000000000000E+00	1.000000000000E+00
10	1.160362912650E+03	0.000000000000E+00	1.000000000000E+00
11	1.160362912717E+03	3.039270937443E-01	0.000000000000E+00

Typical event files

- PIF : "Pixel Illumination Factor" $\in [0,1] \approx$ probability that each source illuminates a considered pixel
- Each event k ($k \in [1, n_{event}]$) described by its arriving time t_k on the detector and its PIF value $p_{k,j}$ ($j \in [1, \#\text{source in the FOV}]$).



The Rayleigh test

- Case of a non pulsating source

Choice of a pulsation ω

Phase $\varphi_k = \omega.t_k$ of each event randomly distributed

$$\Rightarrow \sum_{k=1}^{n\_event} e^{i.\omega.t_k} = 0$$

- Case of a pulsating source emitting at

$\omega_1 = 2\pi.f_1$

More photons detected by detector at each period

$T_1 = 1/f_1$

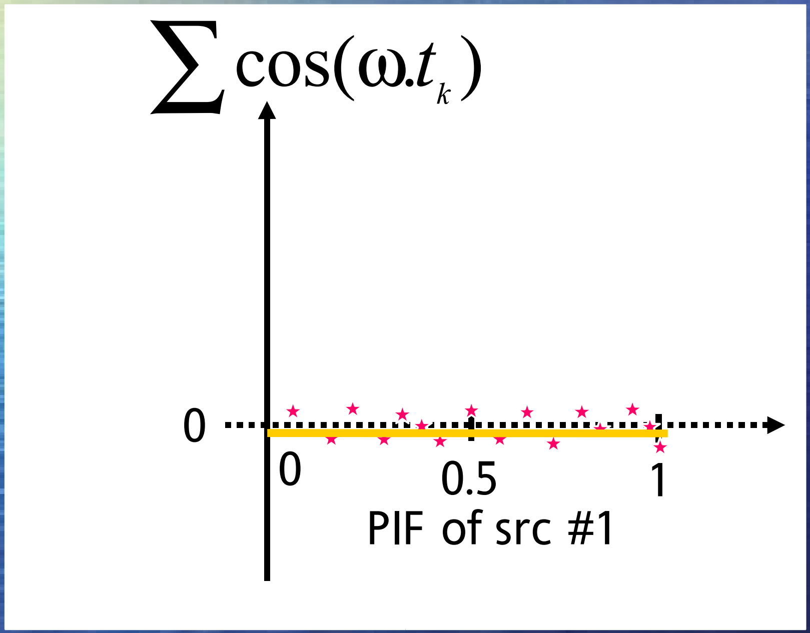
- If $\omega = \omega_1$ a lot of cos(ω.tk) (or sin(ω.tk)) added constructively

$$\Rightarrow \sum_{k=1}^{nevent} e^{i.\omega.t_k} \approx I_\omega.e^{i.\Psi} \neq 0$$

$\forall \ \omega \neq \omega_1$

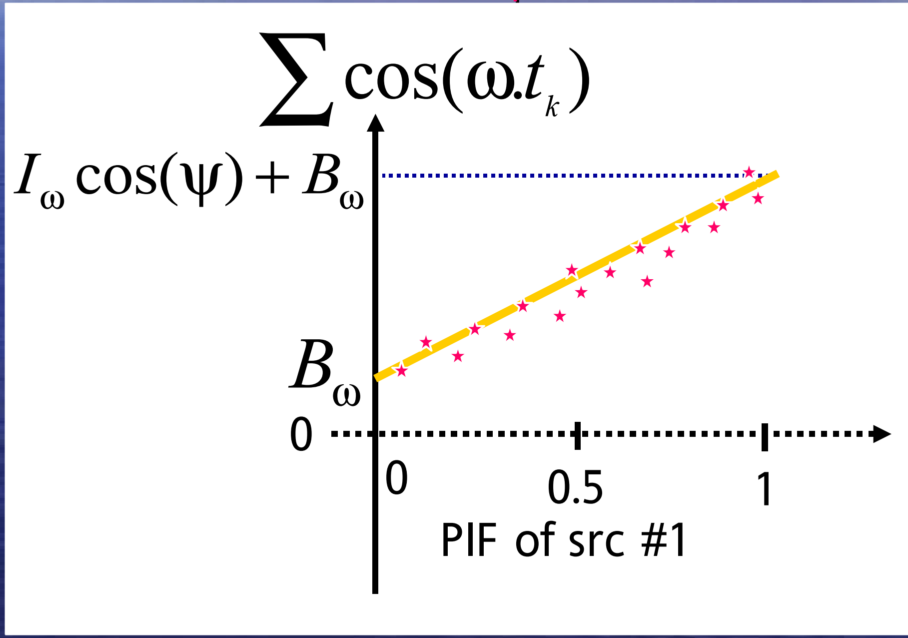
PIF method and Rayleigh test

Non pulsating source or $\omega \neq \omega_1$



- Here $I_\omega = B_\omega = 0$

$\omega = \omega_1$

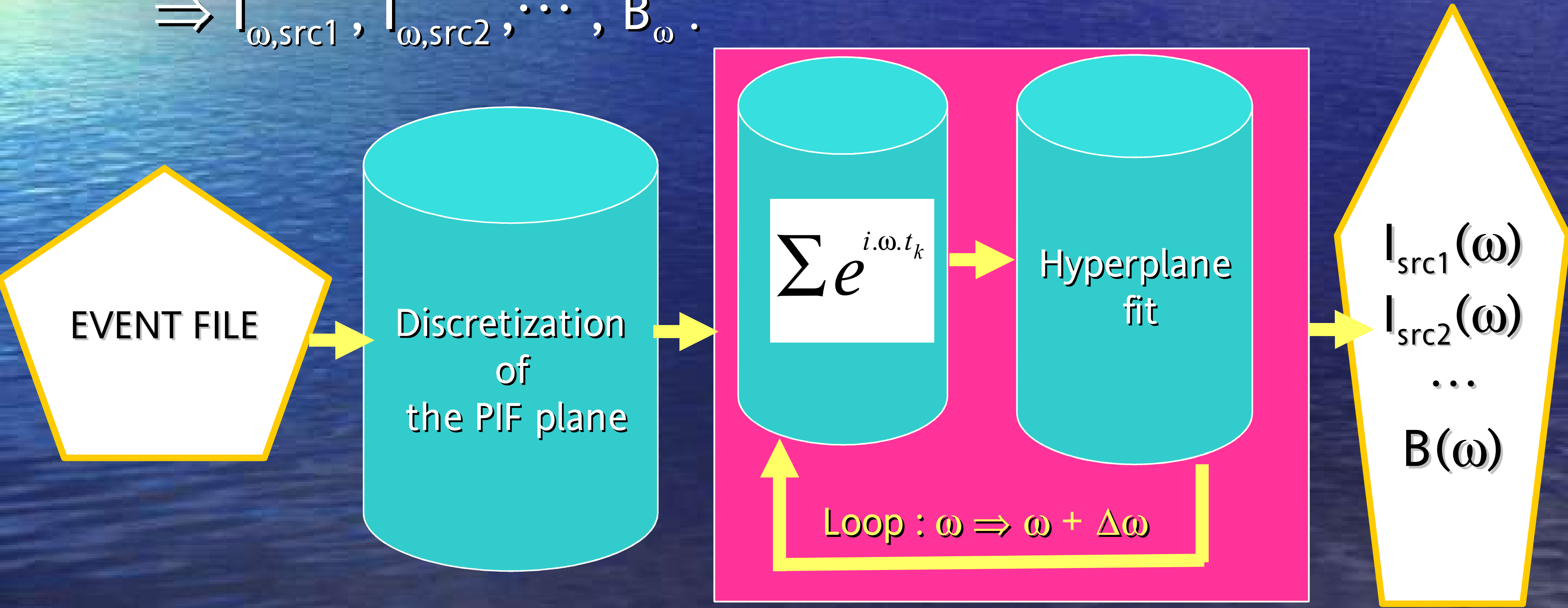


- Fit of the straight line $\Rightarrow$ I_ω, B_ω
- $B_\omega \neq 0 \Rightarrow$ background (residuals) oscillating at ω.

Principles of the algorithm

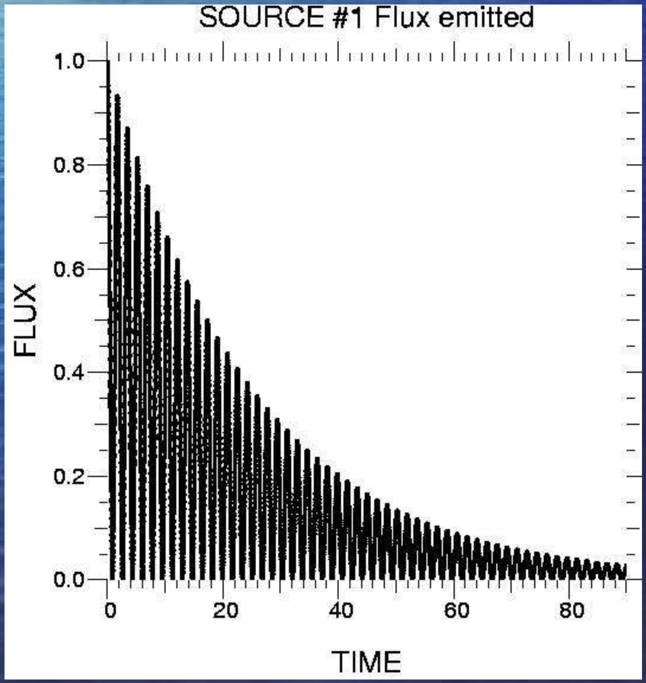
- In reality more than 1 source in the FOV
- Linear fit ⇒ Hyperplane fit (in PIF_{src1}, PIF_{src2}, ⋯ plane)

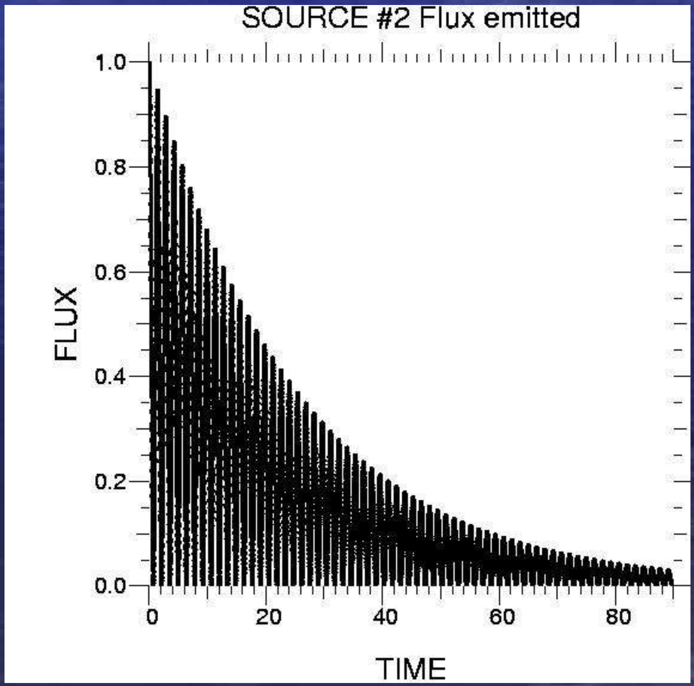
  ⇒ $I_{\omega,src1}$, $I_{\omega,src2}$,⋯ , B_{ω} .



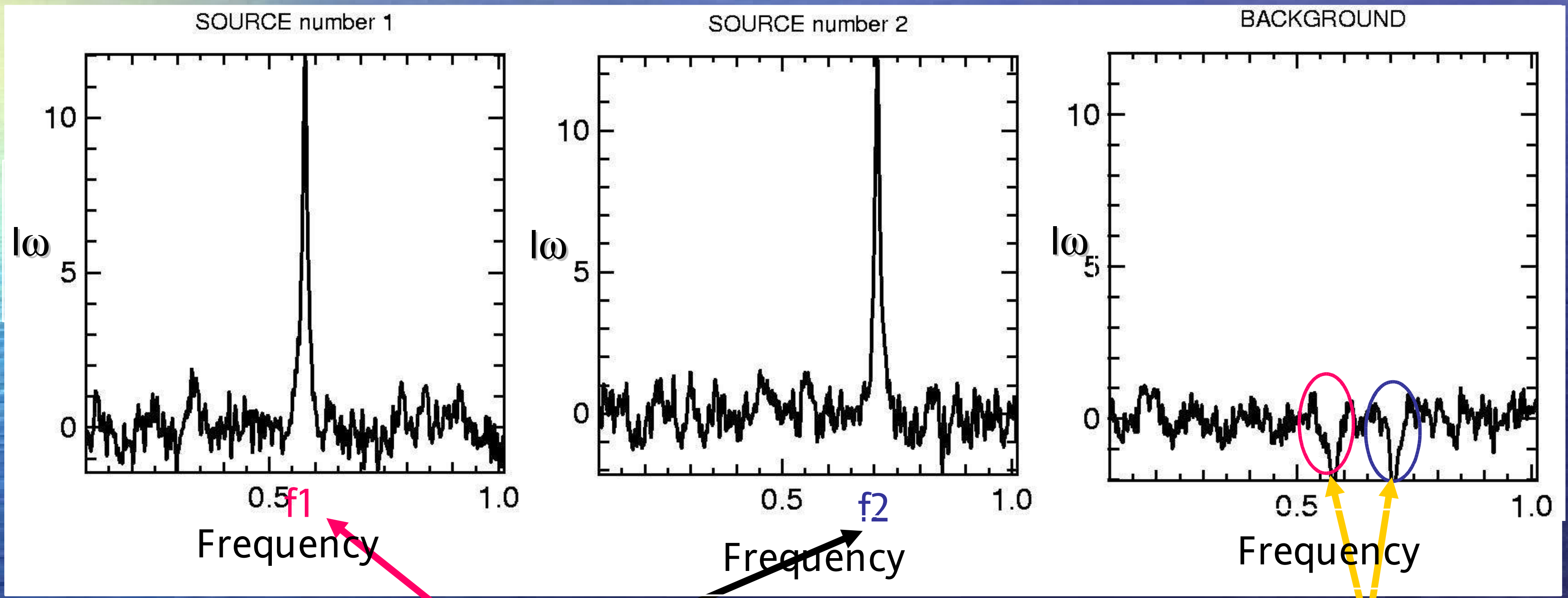
Two oscillating simulated sources

- Two sources (distant from 1° in the sky) emitting through the mask & oscillating at f1 = 0.58 & f2 = 0.71 by a MonteCarlo-like procedure + background (constant). => 9000 events (3000 for each source and 3000 for background)





Preliminary results



SEPARATED SIGNAL !!!

Residual signal of the sources

Conclusion and perspectives

- Detection of each signal separately.
- Background contribution cancelled if constant.
- Adapted for signal where phase = constant (pulsar)
- Code written in Yorick

- Tests on real data (two pulsars in ISGRI FOV = ideal)
- Improvement of the algorithm to detect QPOs (phase of the signal non constant)
- A lot of application in sight…
- Work in progress…

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