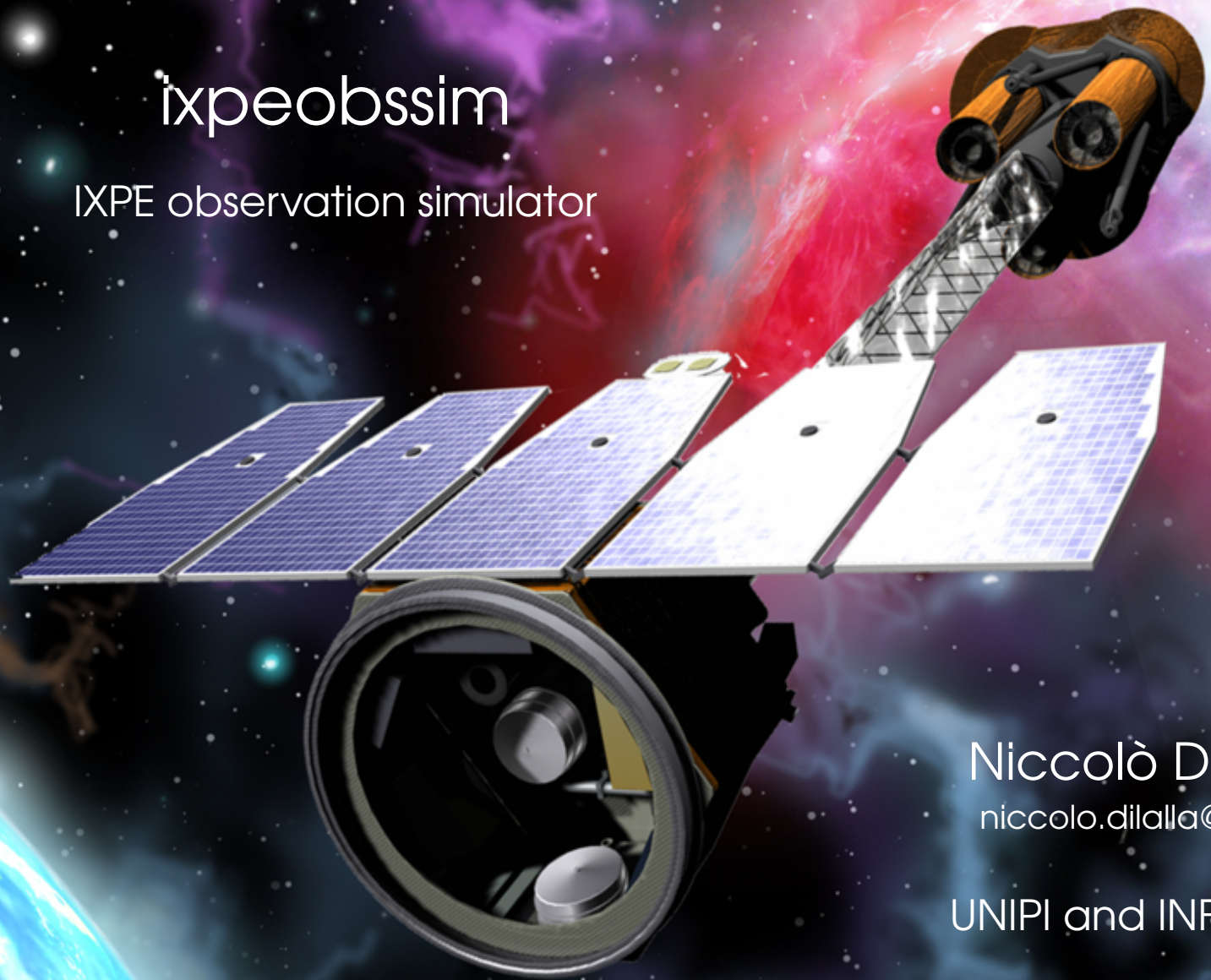
ixpeobssim

IXPE observation simulator



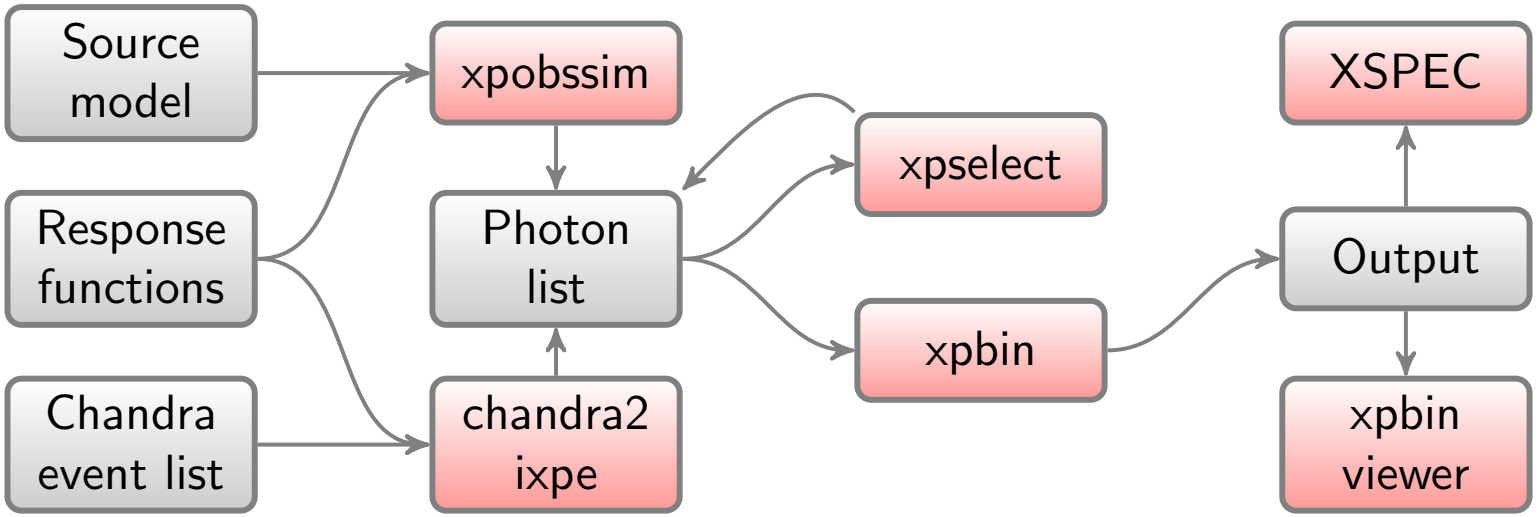
Niccolò Di Lalla
niccolo.dilalla@pi.infn.it

UNIPI and INFN–Pisa

Turin, 09/05/2018

Introduction

Architectural overview



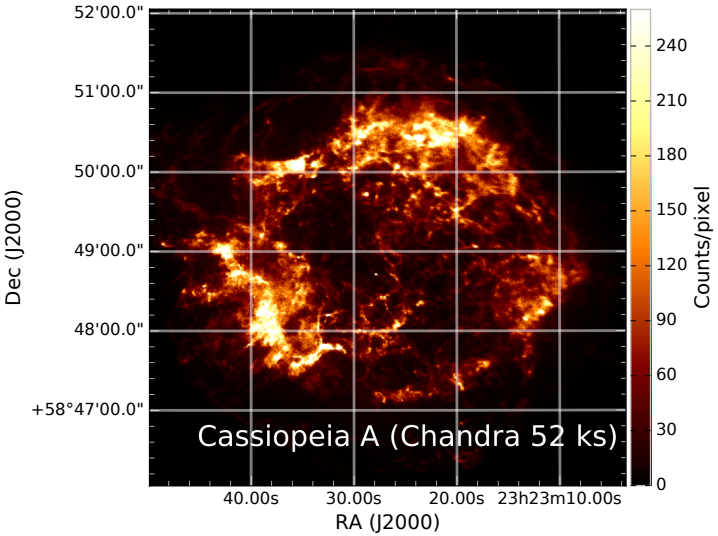
- Generate photon lists corresponding to specific IXPE observations, based on:
  - A set of instrument response functions;
  - An arbitrary source model including morphological, temporal, spectral and polarimetric information;
  - OR a Chandra event file to be converted.

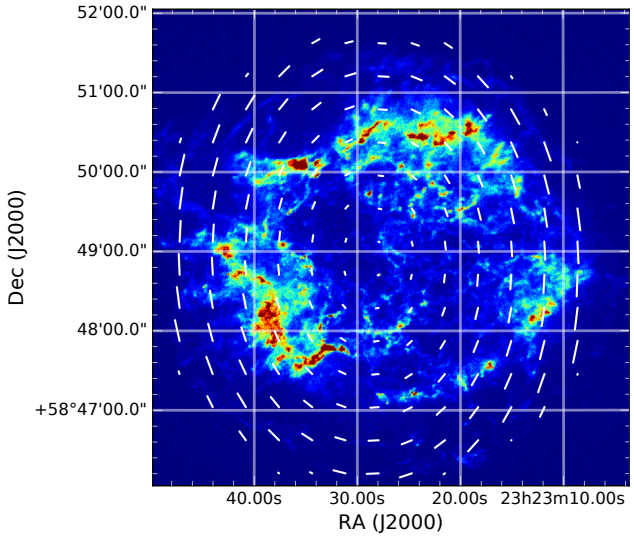
ixpeobssim implementation

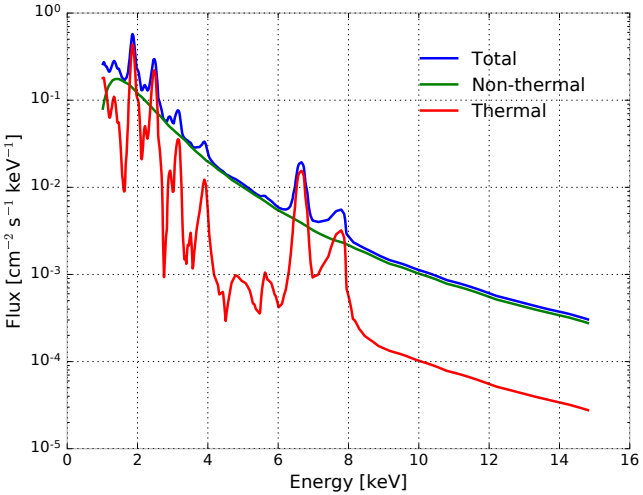
Useful references

- Based on the Python programming language and the SciPy stack;
  - Details and installation instructions on the doc page.
- All I/O is FITS based.
  - The format of the response files is OGIP compliant;
  - Output photon lists and associated response files can be fed into xspec.
- ixpeobssim repository: https://bitbucket.org/ixpesw/ixpeobssim
- ixpeobssim documentation: http://bigfoot.iaps.inaf.it:8080/xwiki/wiki/ixpeglobal/view/Main/IXPE%20Software%20Documentation/?Software%20Documentation

Source model definition





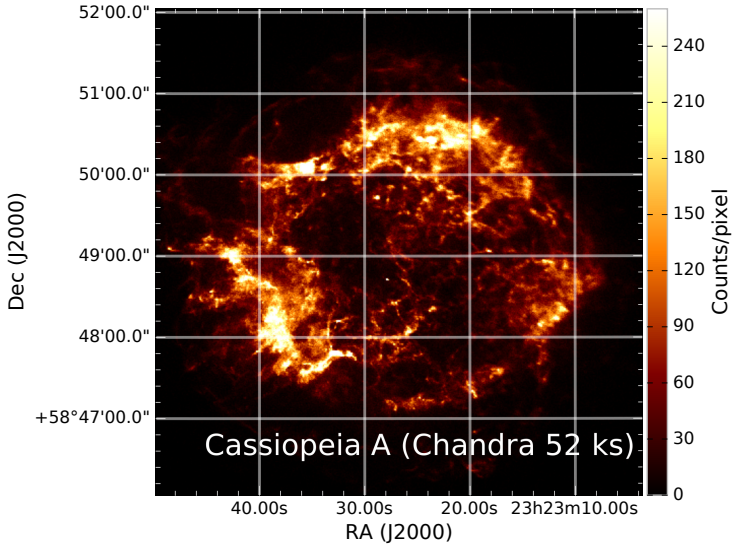


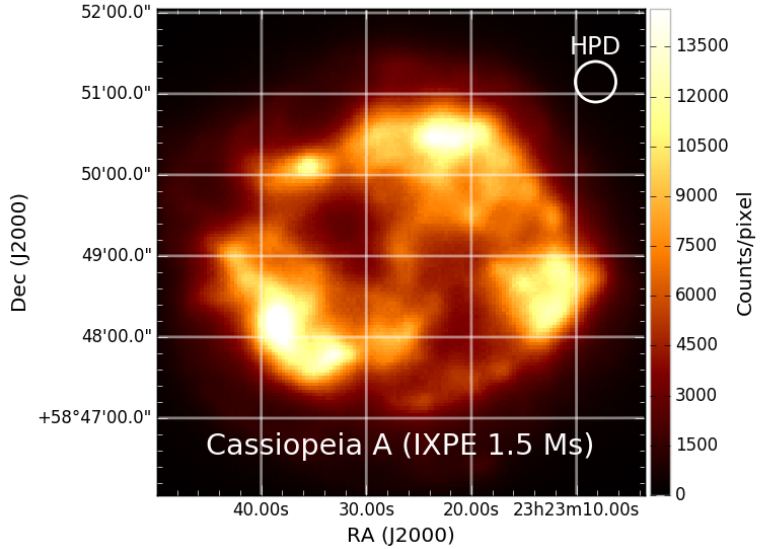
- Need four functions:
  - Morphology: point sources, disks, extended sources;
  - Energy spectrum;
  - Polarization model (degree and angle, or Stokes parameters).
- Support for phase-dependent periodic source;
- Can overlay an arbitrary number of components in the same model;

Observation simulation

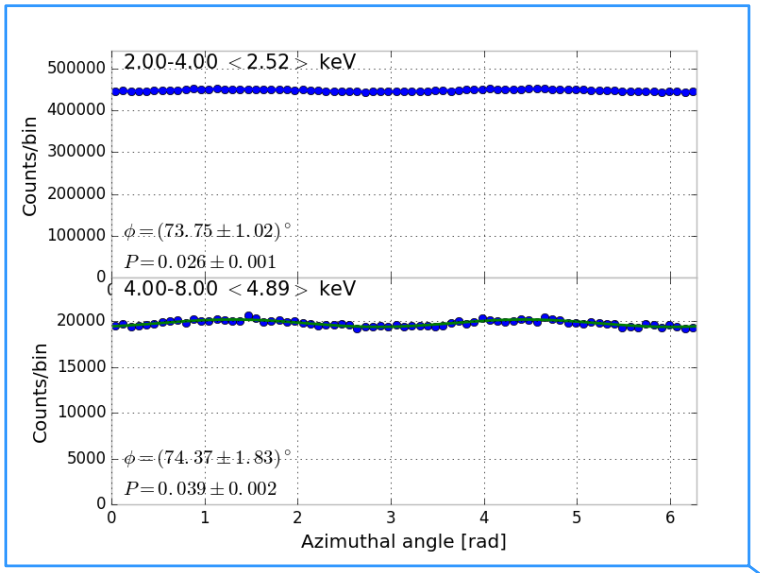
Simulate an observation starting form an arbitrary source model:

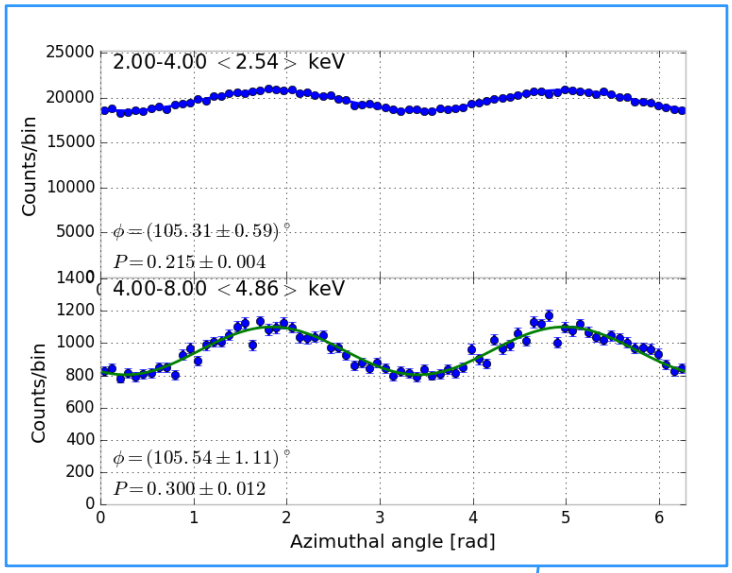
- Calculate the expected number of events based on the source spectrum and the effective are extract the event times;
- Extract the true energies and positions in the sky and smear them with the energy dispersion and the PSF;
- Generate the angular distribution of the photoelectrons according to the polarization model.

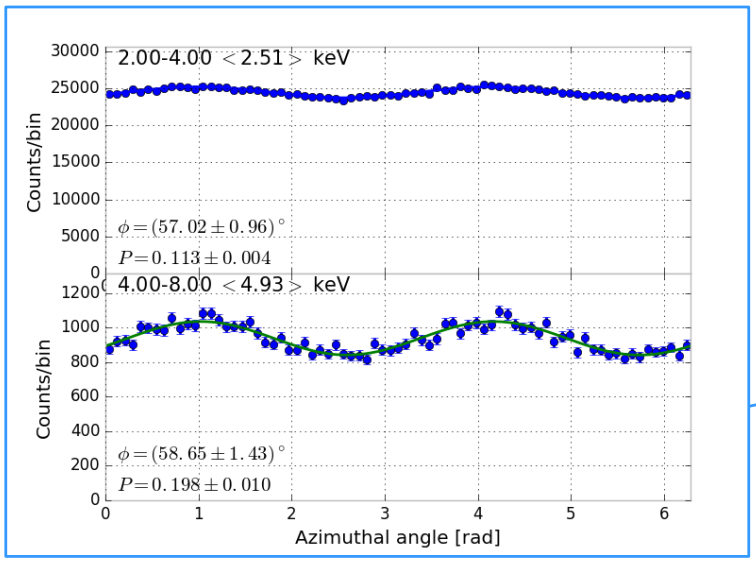


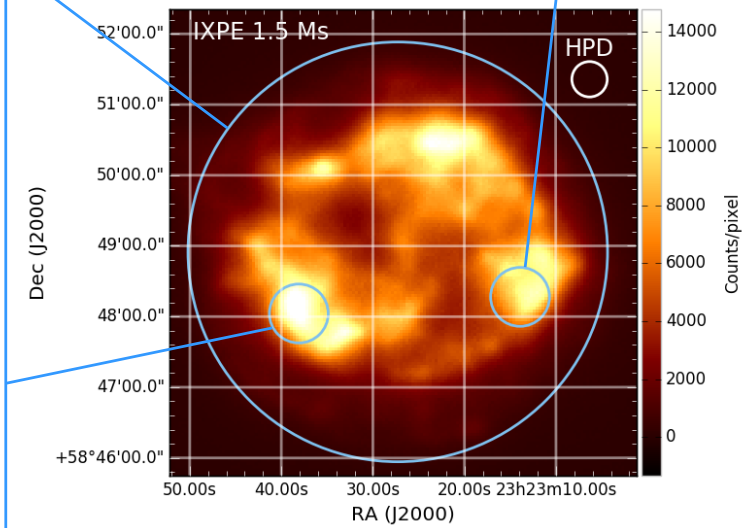


Simulation output







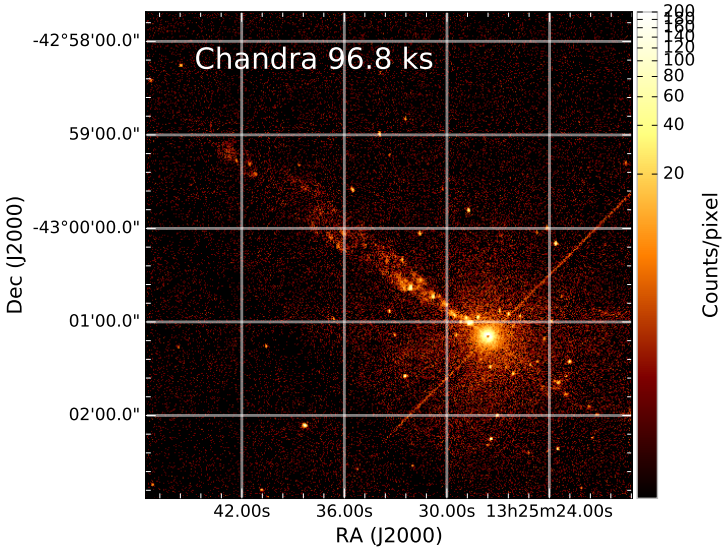


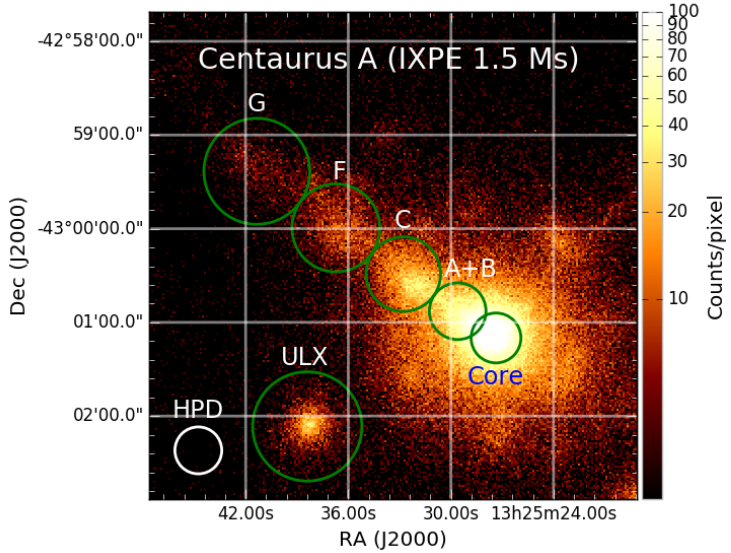
Chandra-to-IXPE

Process a Chandra photon list and produce an IXPE simulation:

- Chandra measured energies, times and positions taken as MC truth;
- Events are down-sampled and smeared with the provided response functions;
- Generate the angular distribution of the photoelectrons according to the polarization model.

Preserve the full correlation between the morphology and the energy spectrum.

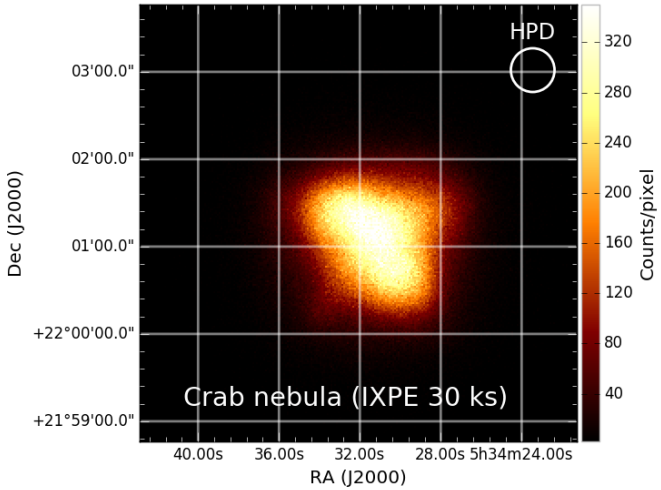


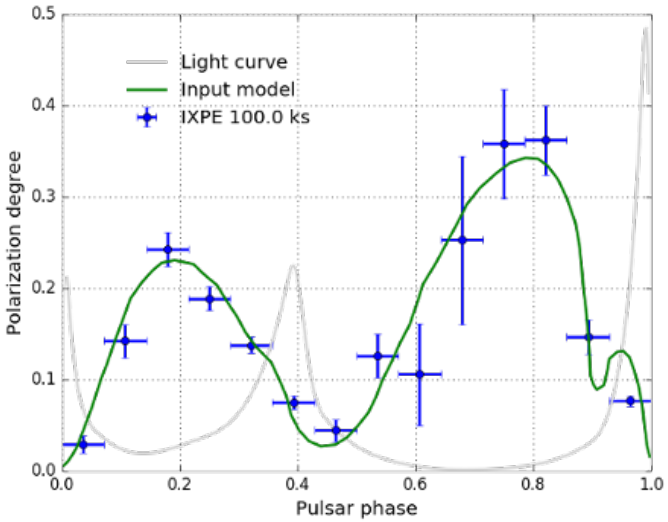


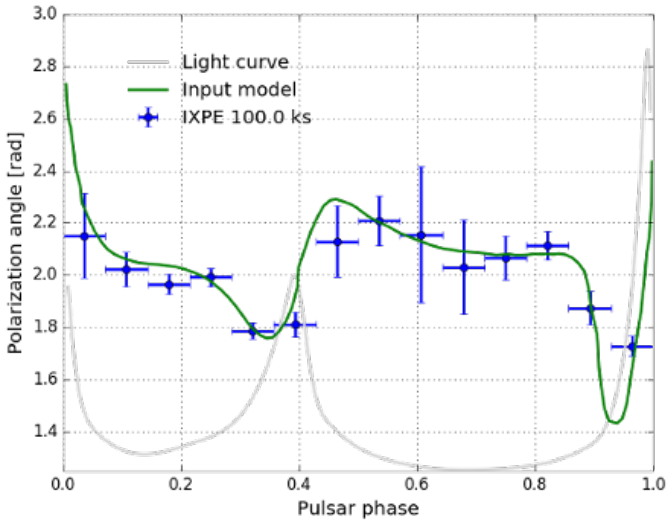
Analysis tools

Basic tools available to:

- Select subsamples of photons based on event energy, direction, time or phase;
- Bin and fit the simulated data, producing count maps, spectra, phasograms, light and modulation curves.



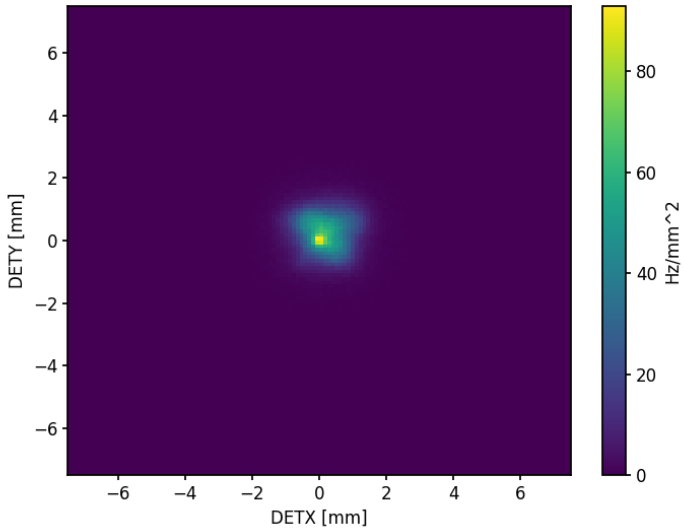


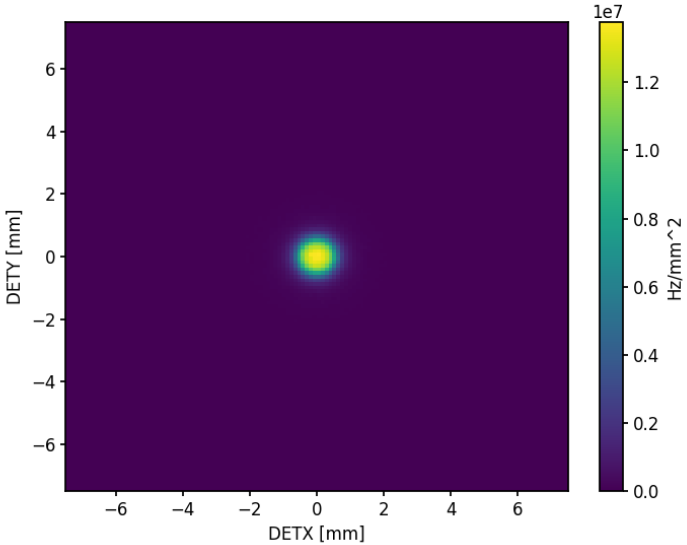


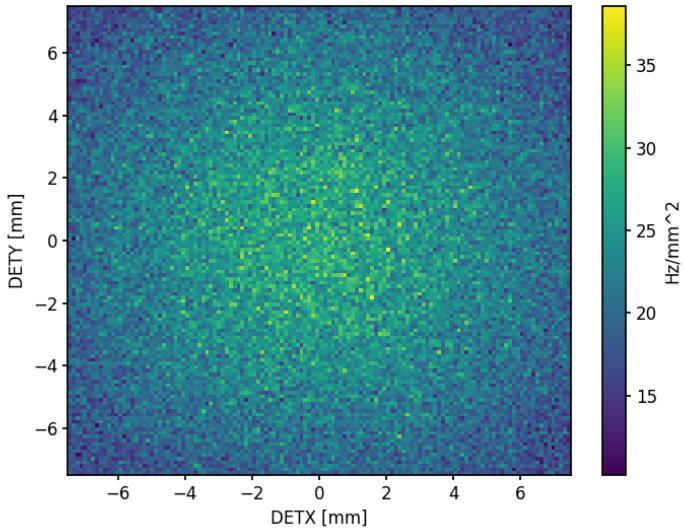
Density rate maps

New binning method in order to:

- Calculate the density rate on the GPD for every sources;
- Evaluate the flux in case of Sun observation (quiet or flaring).







ixpeobssim from a developer standpoint

- Up and running, doing useful things, sophisticated in many respects.
- Large flexibility in terms of input models:
  - Point and extended sources;
  - Steady, variable and periodic sources;
  - Time and energy-dependent polarization signatures;
  - Arbitrary number of sources (and components) in the field of view.
- It surely has rough edges:
  - Essentially a product of four persons, so far;
  - Not really extensively used beyond the limited number of examples in the showcase.
- Need more core developers—please volunteer!
- Need more users providing feedback.

Expect big changes in the short terms!

Not the best time to give this talk...

- A number of major changes in the works:
  - Splitting the event generation into the three detector units (with separate response functions);
  - Updating the format of the output photon lists (Level 2);
  - Updating the format of the response functions (CALDB);
  - Switch from polarization degree/angle to stoke parameters altogether.
- In this phase expect some issues:
  - Examples not fully working;
  - Documentation not updated.
- This should not prevent you from starting working now;
  - Don't wait for things to be perfect.
- You can actually help make this happen.