OOF Software
Its Structure and How to Extend It

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Outline

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Mixing C++ and Python

In C++

1. All of the algorithms
2. Definitions of all data structures

In Python

1. Top level flow control
2. Some Input/Output

Python $\longleftrightarrow$ C++: SWIG

1. The binding is automatically generated by SWIG
2. Standard way of doing this!

Motivation for mixed C++ and Python

- Python is interactive:
  1. Can easily inspect or change the data structures at any time
  2. Easy and flexible control of algorithm parameters
  3. Can build more complex algorithms from routines available in C++ code
  4. Excellent environment to interactively test C++ code
- Good Input/Output support (including FITS and HDF5)
- Good plotting (matplotlib and PyX)
- This combination is now becoming the standard in astronomy....

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Modules

BNMin1: generalised minimisation and inference

1. Non-linear least-squares fitting (primarily Levenberg-Marquardt)
2. Markov Chain Monte Carlo (Metropolis algorithm)
3. Nested Sampling

AstroMap: Support for two-dimensional astronomical maps

1. Coordinate systems
2. Re-gridding data
3. FFTs, convolution

OOF: The application module which brings everything together

1. Description of the effect of defocus
2. ...

Auxiliary modules

BNFits: FITS file handling

BNLib: General utility routines

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OOF Input Tasks

1. Read data from the telescope specific format
2. Compute the offset from the centre of source of each sample of the beam (antenna coordinate system of course!)
3. Remove atmospheric signal and any obvious instrumental effects, e.g., by:
   - Fitting a linear trend to end of scans
   - Using a line-free channels when doing spectral line
4. Compute noise estimate for each sample
5. Do not regrid the data!

OOF Input format

Standard FITS file format

Primary header

No data: just keywords specifying basic parameters (telescope name, observing wavelength, etc)

1st Extension HDU: Binary table

Data for in-focus map:

Dx	Dy	Fnu	dFNu	Time
...	...	...	...	(Not used)

2nd Extension HDU: Binary table

Data for first out-of focus map

Dx	Dy	Fnu	dFNu	Time
...	...	...	...	...

Available scripts

1. Python fragments to write the FITS file with binary tables using the `PyFITS` library
2. Fitting to linear trend to end-of-scan (T. Hunter)
3. Creating of simulated time series and corresponding FITS files

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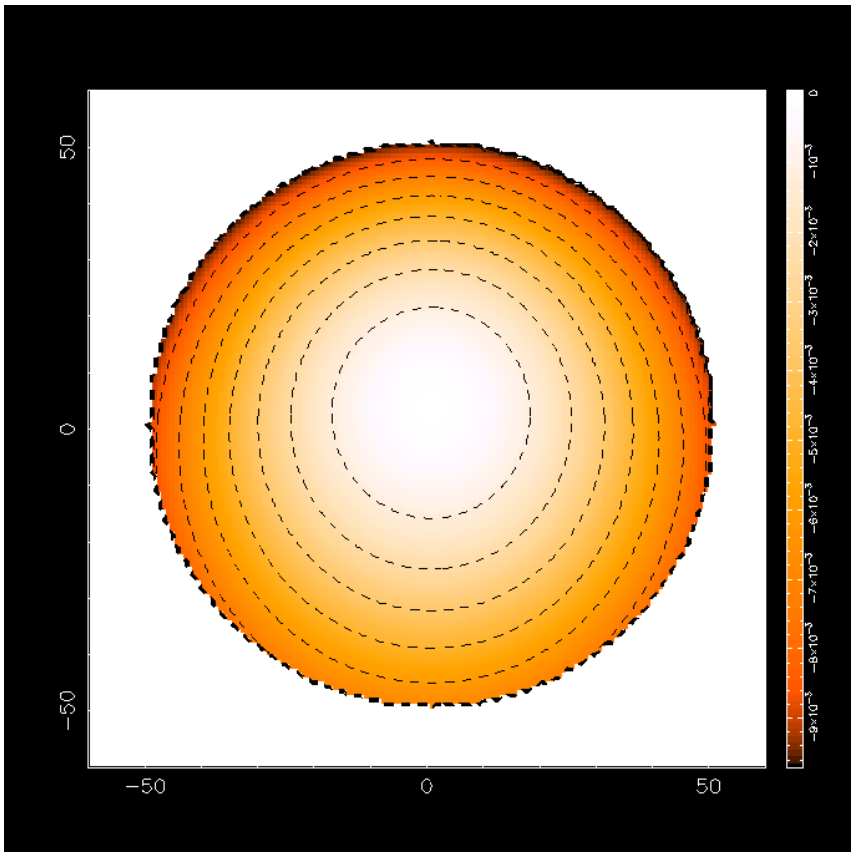
Calculation of the effect of de-focus

I.e.: How does the aperture plane phase change when the sub-reflector is move?

Offset Gregorian

Simple Cassegrain



How to implement

- Current implementations are all in C++
- See `oof/src/telgeo/cassegrain.hxx` and `oof/src/telgeo/gbtgeo.hxx`
- Correct routine chosen on basis of telescope name in `oof/src/telgeo/telswitch.hxx` (Add the new telescope here!)
- A prime focus also exists (`oof/src/telgeo/primefoc.hxx`) but so far only used for simulation/testing

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Interpreting the results

1. Look to see if the best-fit model beams look like the observed beams (plots are automatically generated)
2. Look at the χ^2 value and compare to number of input data points
3. Look at the correlation matrix (`cvmatrix.csv`) – are any of the parameters very degenerate?
4. Look at the retrieved surface
5. Repeat this process starting with maximum Zernike order one (i.e., just pointing) and up to 5 or 6 for typical applications