LSST 3D Data Compression (3DDC) Taskforce

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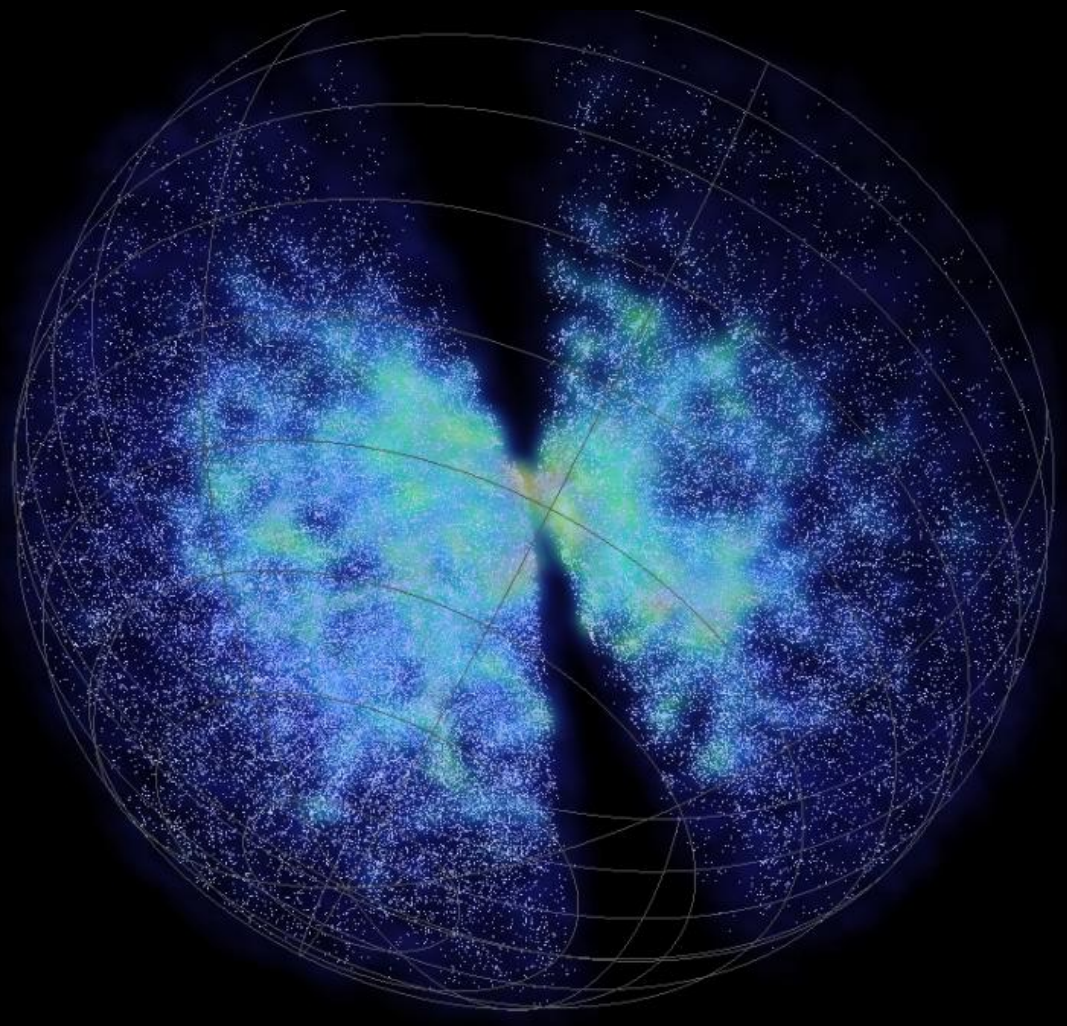
Mullard Space Science Laboratory (MSSL)
University College London (UCL)

LSST DESC collaboration meeting, University of Oxford, July 2016

3D LSS data



Credit: SDSS

Confluence wiki page

https://confluence.slac.stanford.edu/pages/viewpage.action?pageId=195857648

LSST Dark Energy Science Collaboration / Home / Taskforces 2015-16

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3D Data Compression (3DDC)

Created by Boris Leistedt, last modified by Hiranya Peiris on Jun 20, 2016

Quick Start

Slack

Register on the slack channel: https://lsst3ddc.slack.com. Some academic email addresses will be automatically accepted. If yours is not, feel free to email any of the coordinators (see list below).

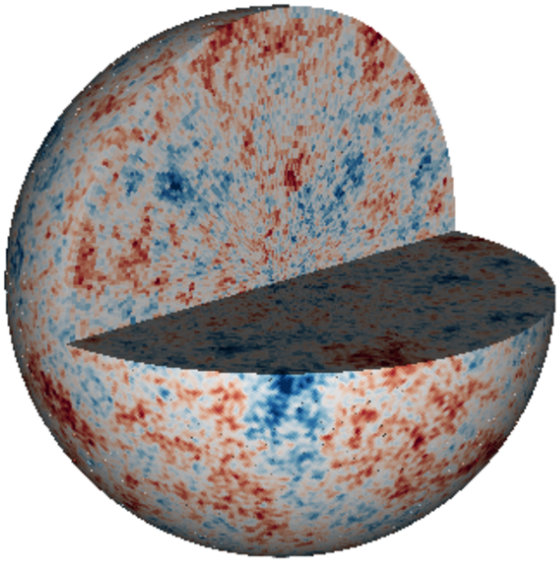
Bluejeans

Bluejeans info / Participant code: https://bluejeans.com/176885536

Telephone call-in numbers: see http://bluejeans.com/numbers

Contributors: Franz Elsner, Jean-Eric Campagne, Benjamin Joachimi, Thomas Kitching, Francois Lanusse, Boris Leistedt, Jason McEwen, Hiranya Peiris, Will Percival, Layne Price, Anze Slosar, Edo van Uitert, . . .

Scope

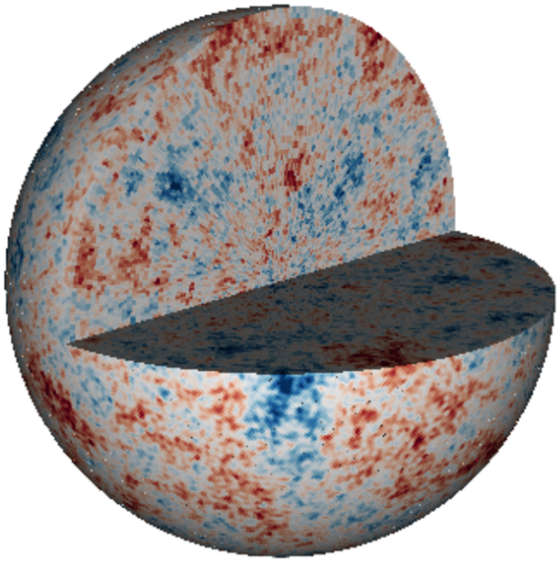


3D visualization of the gravitational potential. Copyright Franz Elsner.

We plan to develop a framework to easily create, manipulate and plot 3D data sets from galaxy clustering and cosmic shear observables. A strong emphasis will be put on developing user-friendly tools to facilitate the adoption by interested members. We will specifically aim to integrate existing tools and maintain compatibility with widely used formats, such as Healpix. We will study the scaling of the algorithms in detail. The goal is to provide a standard data compression tool to transform and store huge galaxy and shear catalogues into pixelised 3D signals that can be readily analysed with tools such as the Fourier-Bessel transform. Since grouping galaxy positions onto a grid is a lossy form of data compression, we will explore dedicated approaches to characterize and propagate errors on radial distances resulting from photometric redshift uncertainties in typical science analysis use cases. We will interface these maps with 3D power spectrum estimators and cosmological likelihoods that can deal with spatially-varying systematics via template marginalisation. The method can be applied to data from ongoing surveys as well as LSST simulations, and contributes to the development and testing of tools to optimally analyse LSST data when they arrive.

DESC SRM task LSS4.1: Robust 3D pixelizations and transforms

Scope



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DESC SRM task LSS4.1: Robust 3D pixelizations and transforms

Goals, challenges and uses

- Why 3D?
  - Extract more information
  - Fewer approximations
  - Filtering (*e.g.* non-linear scales)
  - Build spatial-spectral representations (*e.g.* wavelets)
- Challenges
  - Fast transforms for data and theory
  - 3D pixelisations
  - Masks, selection effects, covariances, systematics
- Uses
  - Cosmic shear
  - Galaxy clustering
  - Joint probes
  - ...

What is 3D?

Everything that is not redshift tomography!

- Fourier-Bessel basis:

$$j_\ell(kr)\, Y_{\ell m}(\theta, \varphi)$$

- Fourier-Laguerre basis:
(introducted by Leistedt & McEwen 2012; arXiv:1205.0792)

$$K_n(r)\, Y_{\ell m}(\theta, \varphi)$$

Connecting Fourier-Bessel and Fourier-Laguerre

- Connect Fourier-Bessel and Fourier-Laguerre via

$$J_{\ell np} \propto \int_0^\infty \mathrm{d}r\, r^2\, j_\ell(k_{\ell p} r)\, K_n(r)$$

- Difficult numerical problem (require accurate computation up to high orders)
- Analytic expression in terms of hypergeometric functions (Leistedt & McEwen 2012)
- Studied extensively by Jean-Eric Campagne (`LagSHT`)
  - Limber expansion
  - Discrete Fourier Bessel transforms
  - Clenshaw-Curtis quadrature
  - Chebyshev transform with use of Discrete Cosine Fourier Transform

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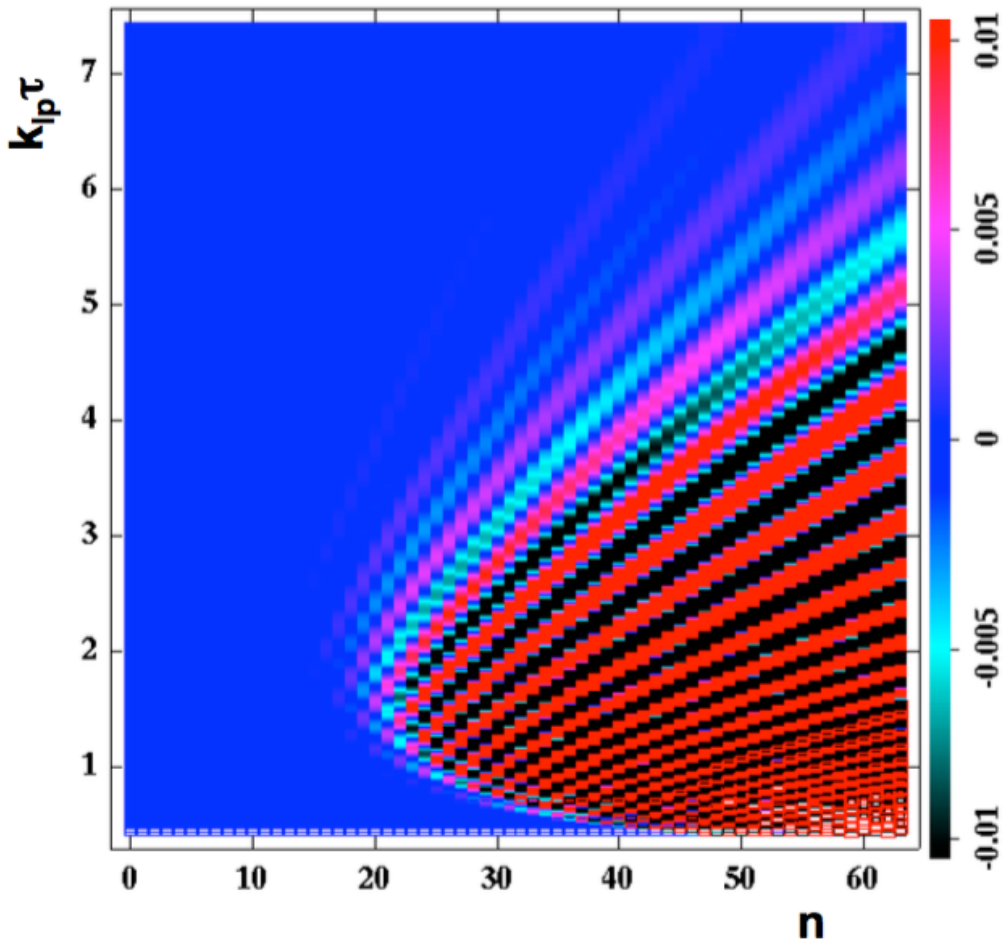


Credit: Jean-Eric Campagne

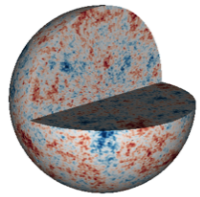
Codes

Identified existing codes for 2D/3D transforms

Add yours!	**CosmicPy**	C++, Py	Theory Fourier-Bessel
	MRS3D	C++	Fourier-Bessel + wavelets
	3DEX	F90 (!)	Fourier-Bessel transform
	HEALPIX	C, F90, Py, IDL	2D Spherical harmonics
	SSHT	C, Matlab	2D Spherical harmonics
	FLAG(LET)	C, Py, Matlab	3D Fourier-Laguerre + wavelets
	LagSHT	C++	3D Fourier-Laguerre + Bessel
	3DFast	C	Flat-sky Fourier-Bessel

Plan to start **Uber 3D code** TM

Get in touch if you'd like to contribute!



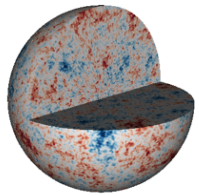
Uber3D code

Uber 3D code™

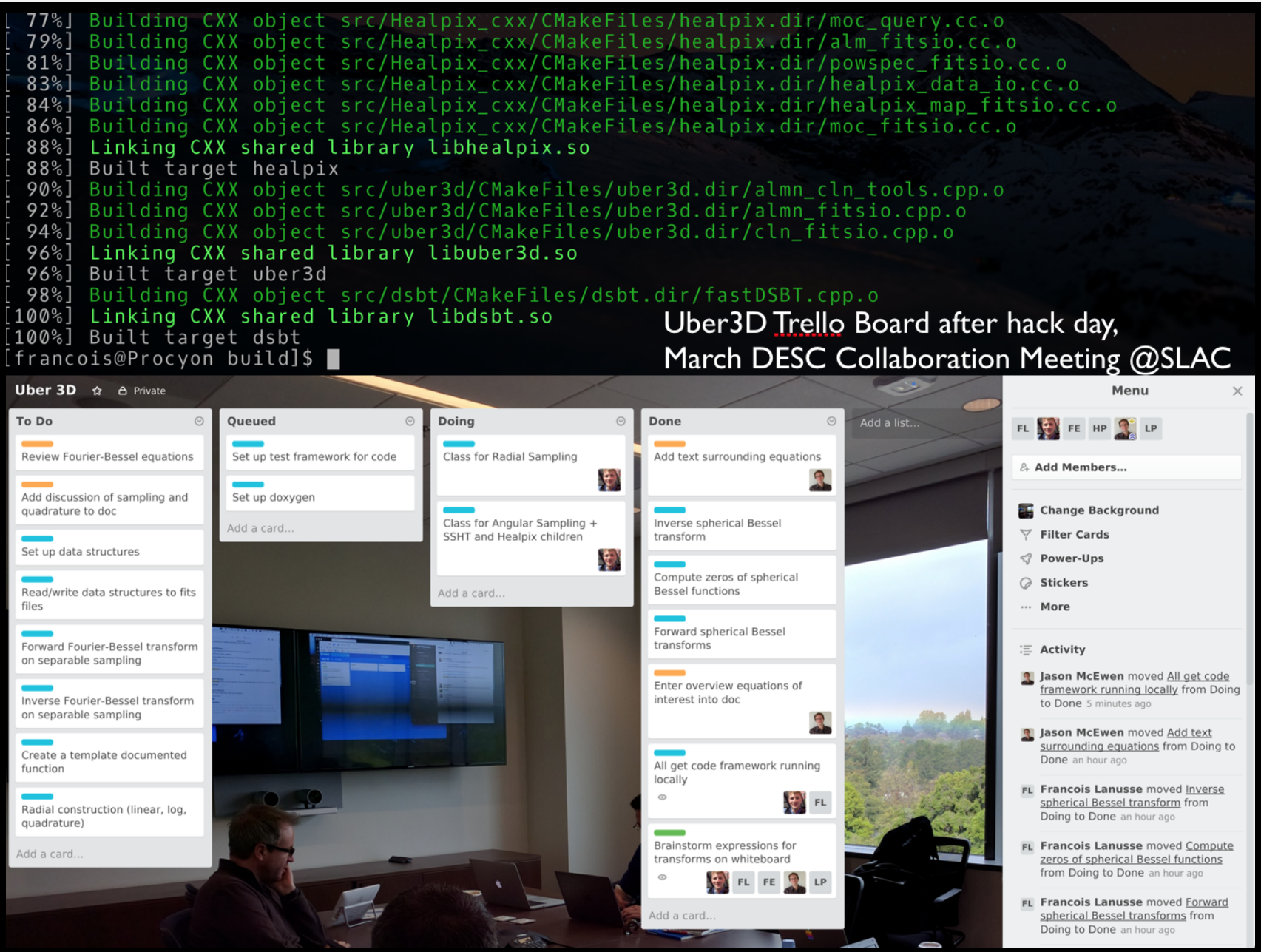
https://github.com/astro-informatics/uber3d

- **Data**: survey => 3D clustering+shear power spectra
- **Theory**: interfaced with cosmology library

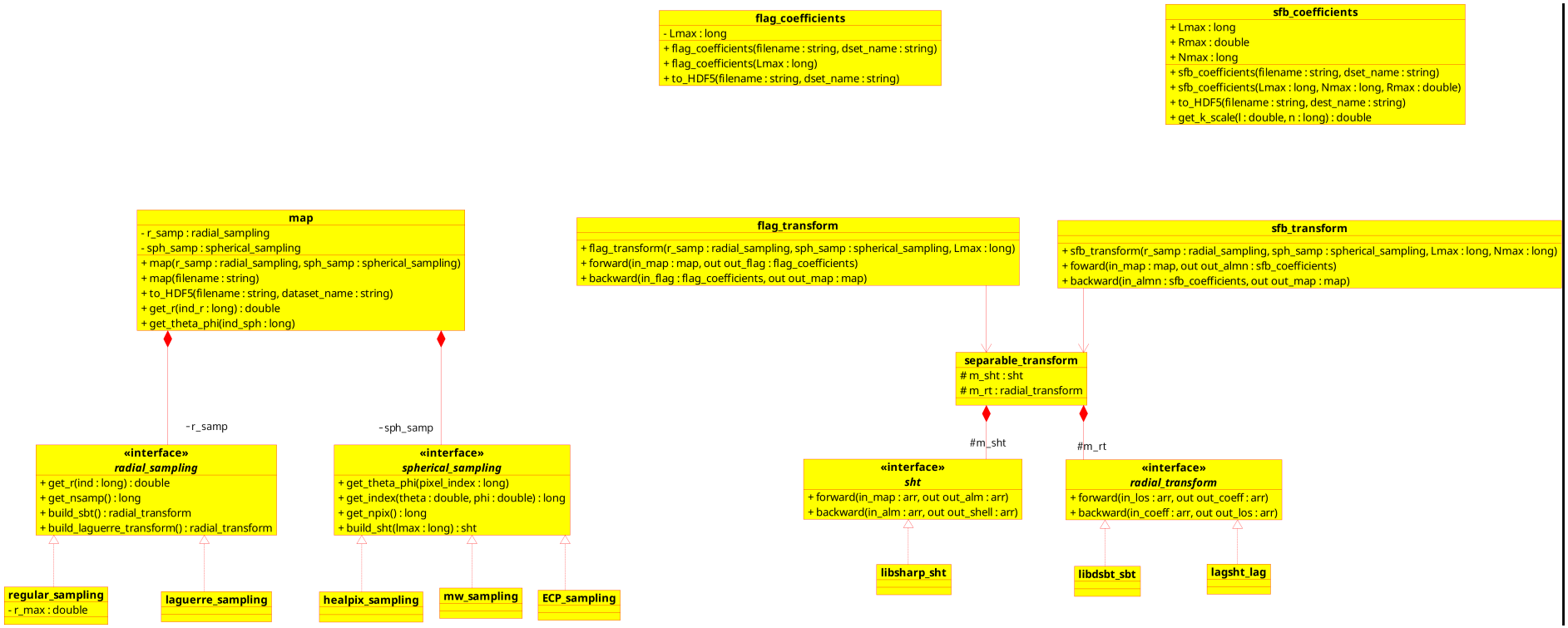
  Supports all existing transforms and pixelizations
- **Extras**: likelihoods, systematics mitigation, etc



SLAC DESC hack in March



Oxford DESC hack



Credit: Francois Lanusse

BASP workshop 2017

Dedicated LSST informatics and statistics session organised by Tim Eifler.

http://www.baspfrontiers.org/

BASP
Biomedical and Astronomical Signal Processing

IMPORTANT DATES

01.06.2016 Session proposal deadline

01.09.2016 Abstract submission opening

About the workshop

The **International Biomedical and Astronomical Signal Processing (BASP) Frontiers workshop** was created to promote synergies between selected topics in astronomy and biomedical sciences, around common challenges for signal processing.

Building on the success of the first workshops (2011, 2013 and 2015), BASP Frontiers 2017 will gather around 100 participants and open its floor to many interesting hot topics in theoretical, astrophysical, and biomedical signal processing, with a particular focus on imaging.