One year of development with EDNA

Focus on non-MX applications

Layout

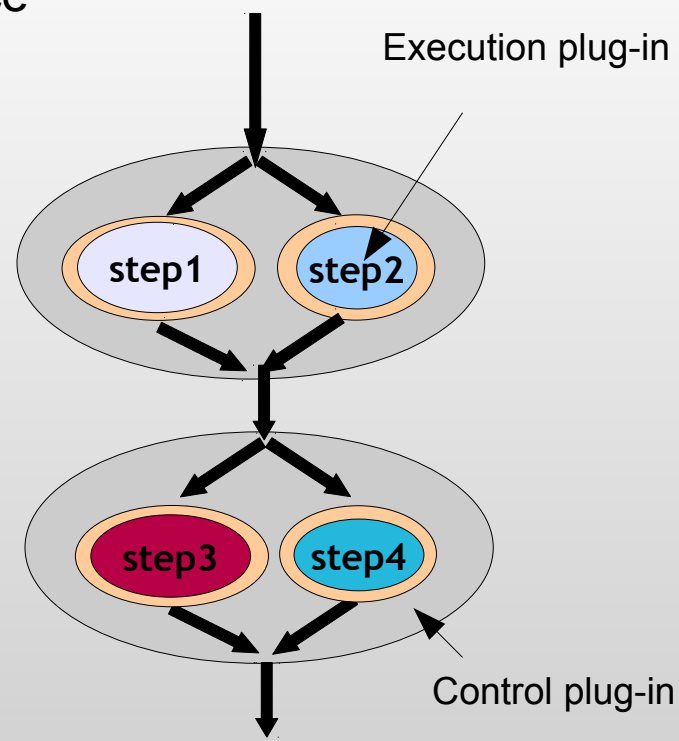
- My vision of EDNA as a developer
  - Strength
  - Weaknesses
- Experience of diffraction tomography
  - Description of the experiment
  - Solutions based on SPD & HDF5
  - Spreading of the solution (ID11, ID13)
- Other application: Saxs / BioSaxs
- Versatility in developments
  - EDNA tool box
  - Documentation, training sessions, code camps

One year of development with EDNA

Strength & Weaknesses

Strength of EDNA

- EDNA is a robust pipe-lining tool for on-line data analysis
  - It has been tested with thousands of tasks at once
- EDNA allows hi-performances
  - Multi-threaded implementation
- EDNA relies on data-models
  - Visual communication with scientists
  - Automatic bindings with the code
- EDNA has a strong testing framework
  - Unit & Execution tests
  - Non regression test before nightly builds
- EDNA is efficient to program
  - Plugin generator for execution plug-ins based on the data-model
  - Re-use of plug-ins already written by others: EDNA-Toolbox
- EDNA is an international collaboration (with DLS, CCP4, ...)



Weaknesses of EDNA

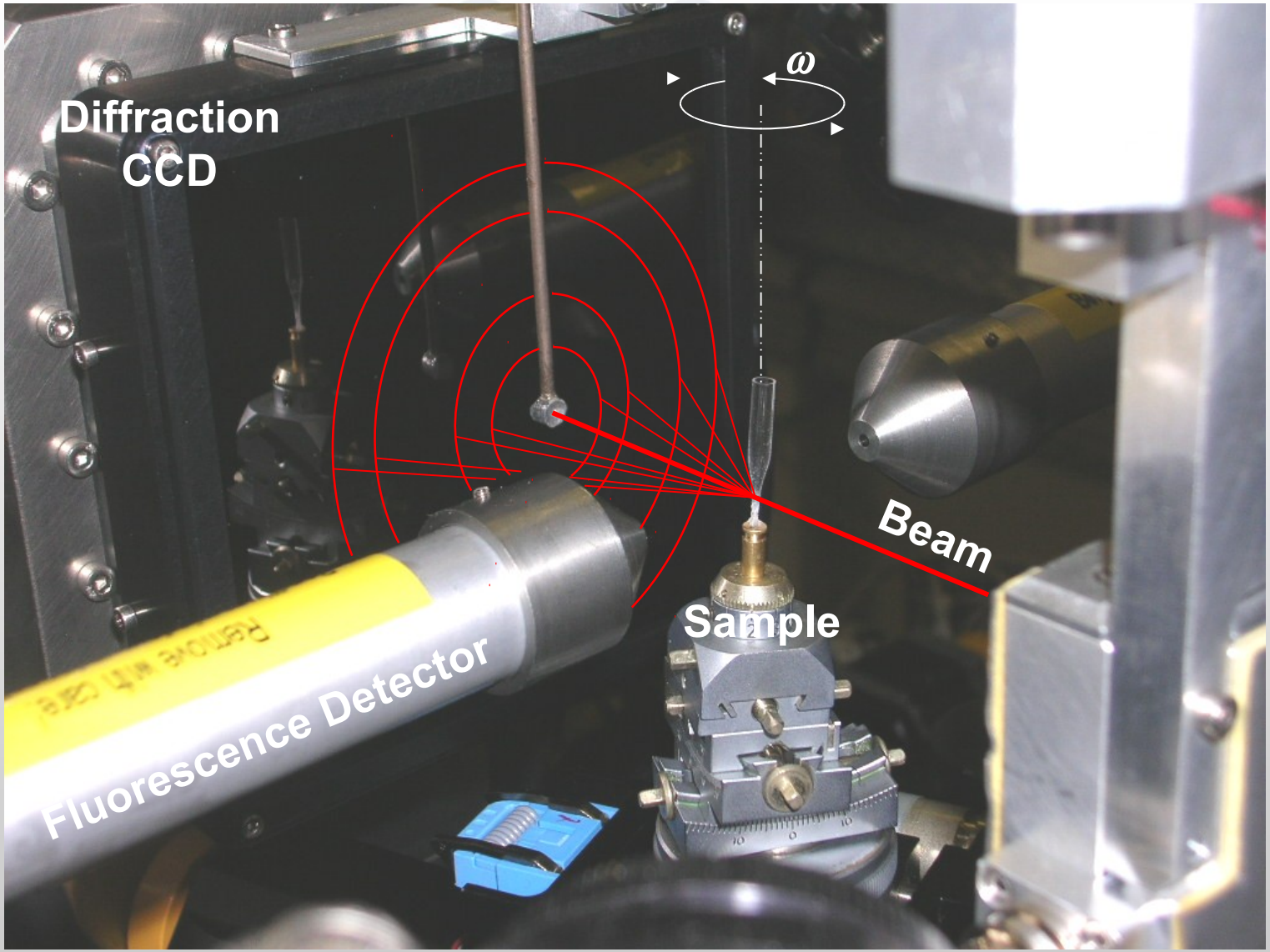
- Technical weaknesses:
  - Learning curve is (too ?) steep
    - After one year, most of it is justified
  - Multi-threading limited by the GIL in C-Python
    - Issue only in pure python plugins
    - No problem if the GIL is released (Numpy, external programs ...)
  - Databinding does not (yet) allow the transmission of large arrays
    - Will be addressed in next code camp.
- Communication weaknesses:
  - Few scientists know EDNA, mainly IT staff.
  - Too much MX-related for most people not involved in the project
  - Lack of documentation (even if better since last code-camp)
  - Lack of manpower in the project working on the kernel

Diffraction tomography

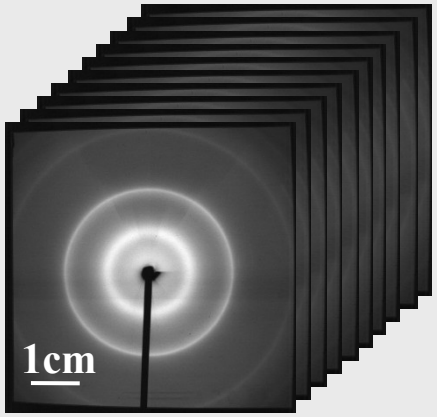
Online pre-processing for azimuthal integration

Generation of sinograms with (live) ROIs

ID22 – Fluorescence-Diffraction Tomography



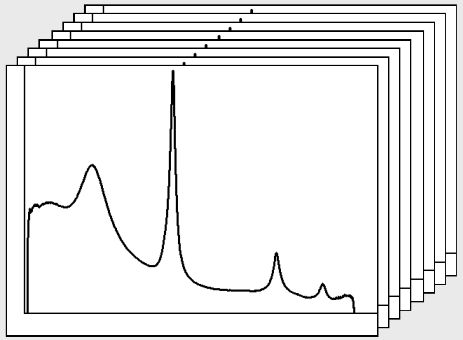
Original idea: 20h data acquisition, 30h treatment



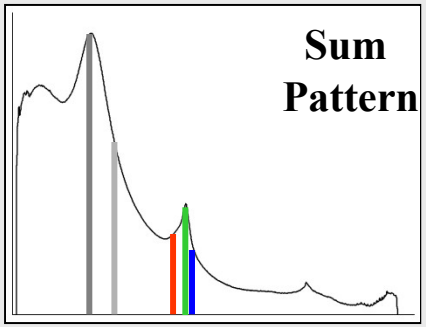
$N_y \times N_\omega$ Diffraction Images

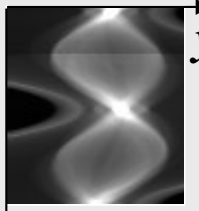
Azimuthal Integrations

Fit2d software



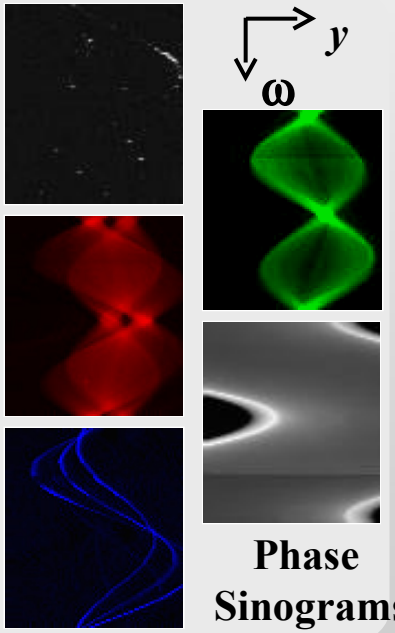
$N_y \times N_\omega$ Diffraction Patterns



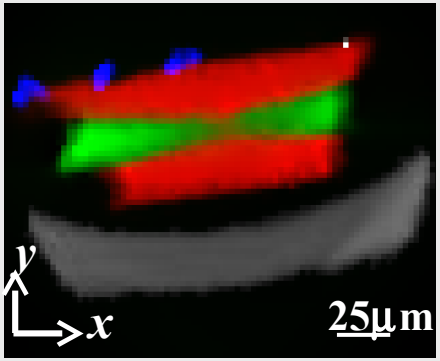


Sum Sinogram

PyMca software



Phase Sinograms



Reconstruction

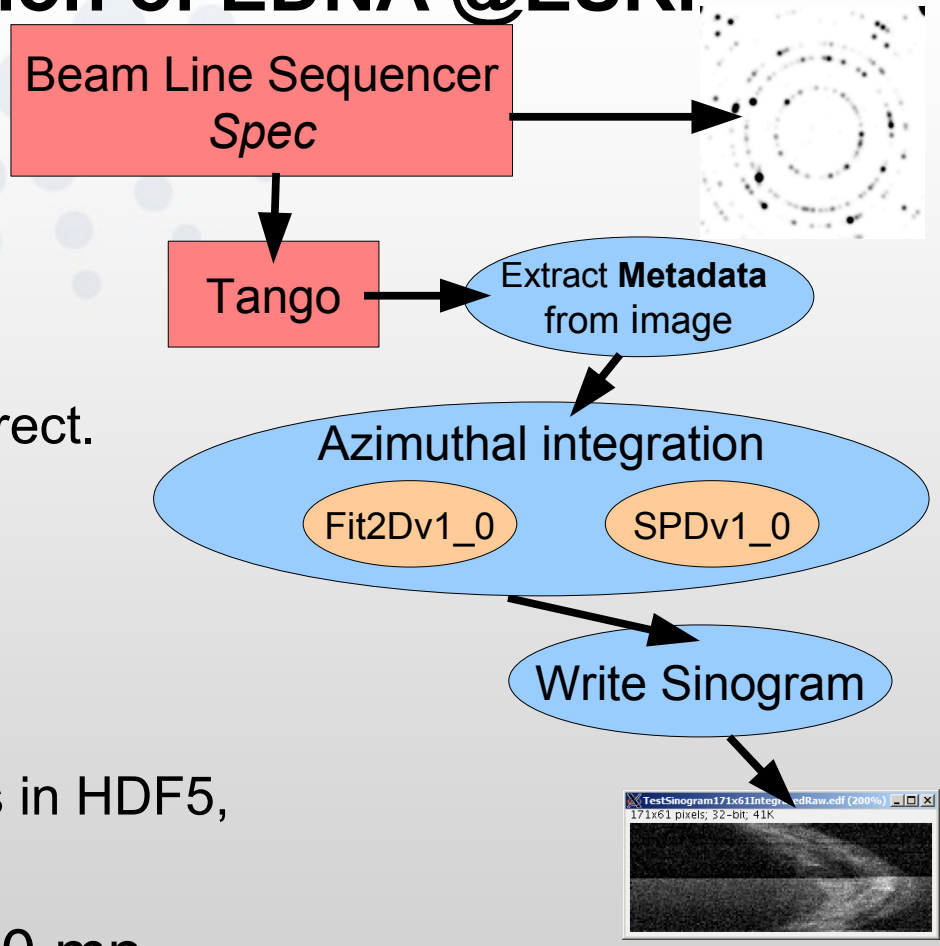
Capillary
Calcite
Ferrite
sp3
Cubic

Acknowledgements: Pierre Bleuet CEA - Grenoble

First non-MX application of EDNA @ESRF

Diffraction tomography on ID22

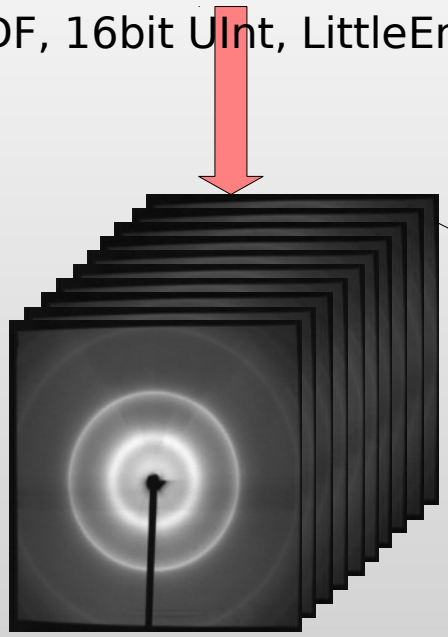
- Mesh 60 x 170 (10 000 images)
- All data processed on the fly:
  - Meta-data extraction
  - Dark-noise & flat field intensity correct.
  - Tilt & distortion corrections
  - Azimuthal integration
    - With fit2D (2 plugins)
    - With SPD (4 plugins)
  - Sinogram generation as 3D objects in HDF5,
    - live ROI with PyMca
- Performances: full treatment in 40 mn
  - 1.5 sec / image with SPDCakev1.5
  - EDNA processed 10k images @ 4.3 images/second (8-core, 7x speed-up)



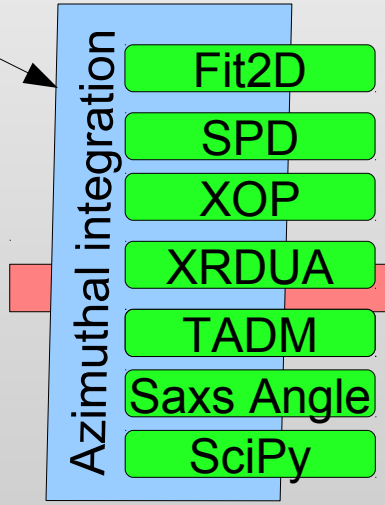
Online data Analysis for NINA

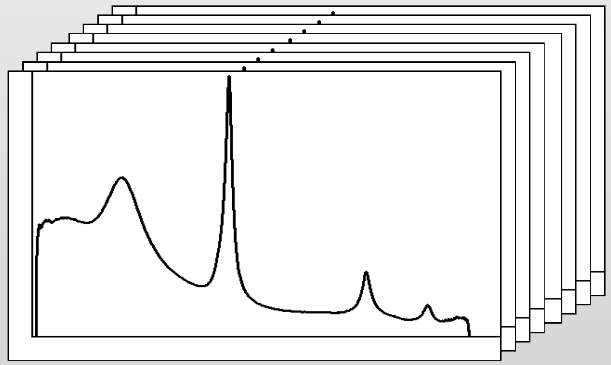
- Focus on most CPU demanding application: DiffractionCT

FReLoN2k
(EDF, 16bit UInt, LittleEndian)



N x **ω** 2D Diffraction Images





N x **ω** 1D diffraction patterns

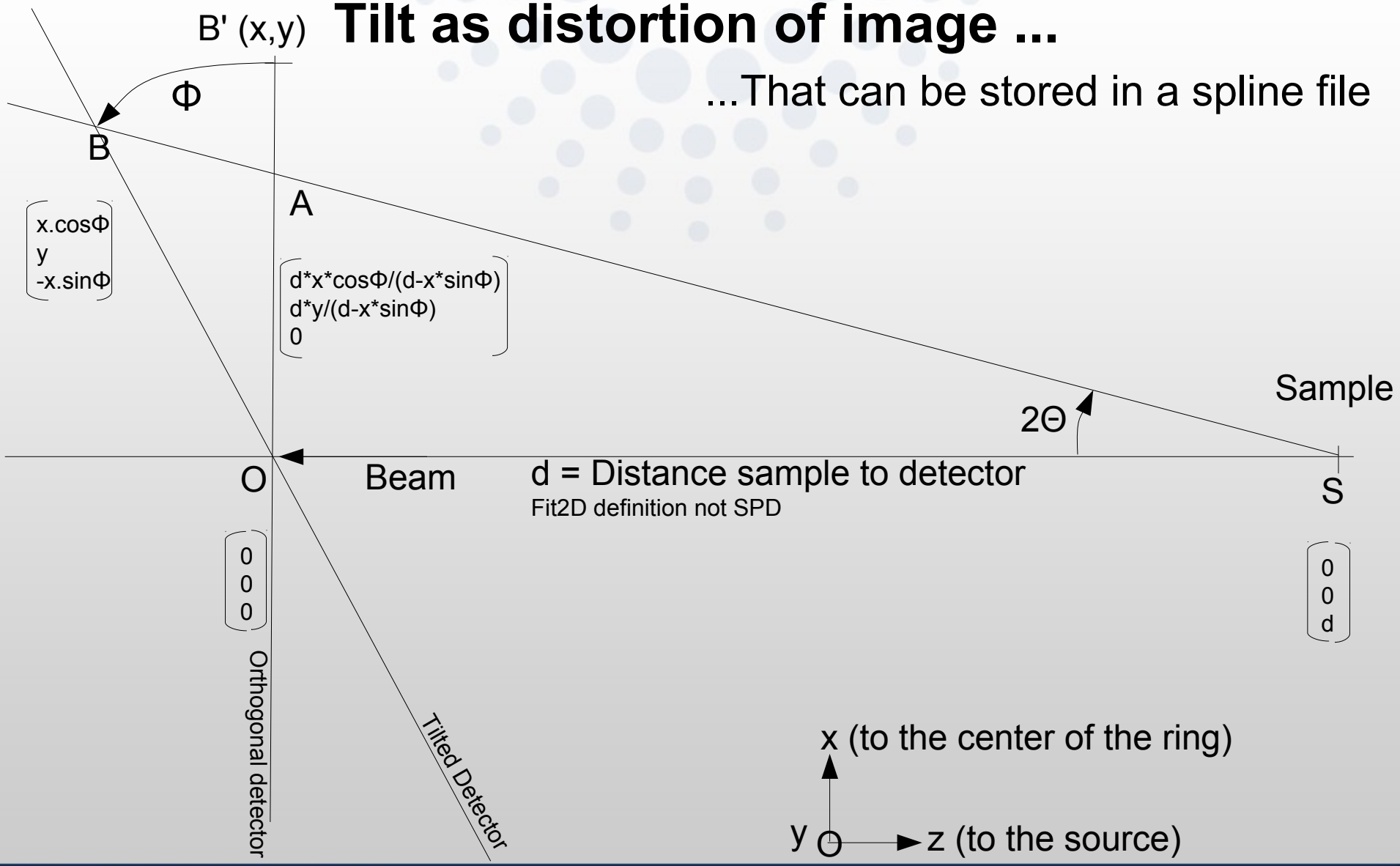
Integration of many tools
Need plugin gestion

Evolution of the SPD integration

- SPDCake v1.0:
  - Lookup-table re-generated for each image, no tilt ...
  - 9 sec per 4M image
- SPDCake v1.1:
  - Lookup-table re-generated for each image, no tilt
- SPDCorrect v1.0:
  - Many SPD processes under control (configured)
  - Tilt is integrated in the distortion of the detector
  - 7 sec for initialization, 0.5 sec for each new image to correct
- SPDCake v1.5:
  - Based on SPDCorrect v1.0
  - 7 sec for initialization, +1.5 sec for each image to integrate
  - Compatible with many detector in a single experiment

Tilt as distortion of image ...

...That can be stored in a spline file



Spreading of the SPD-solution

- Soft Condensed Matter Nanofocus beamline (ESRF ID13)
  - SPD plugin tested with the online mode (EDNA Parallel Execute)
  - 10 frames per second (512 x 512 image)
  - 2 SPD processes under control on a 4-core computer (Coral)
  - Image correction (dark, flat, distortion) + azimuthal integration

- Materials science beamline (ESRF ID11)
  - SPD plugin tested with the offline mode (EDNA Parallel Execute)
  - Images coming from 3 different detectors
  - Selection of the right process for correction and azimuthal integration

Image writer issue with multi-threading

EDNA is massively multi-threaded !!!

- Many instances of a single plugin writing at the same time
- Some writing are missed due to consequent access

- Solution found:
  - Modify only a class attribute in memory → only one object
  - Then write it down on disk using a class method (with lock).

- HDF5 implementation:
  - Write the sinograms as map of spectra:
    - Store in a 3D dataset (x, y, spectrum)
  - Allows online ROI selections and sinograms creation

Visualization of HDF5 files for DCT

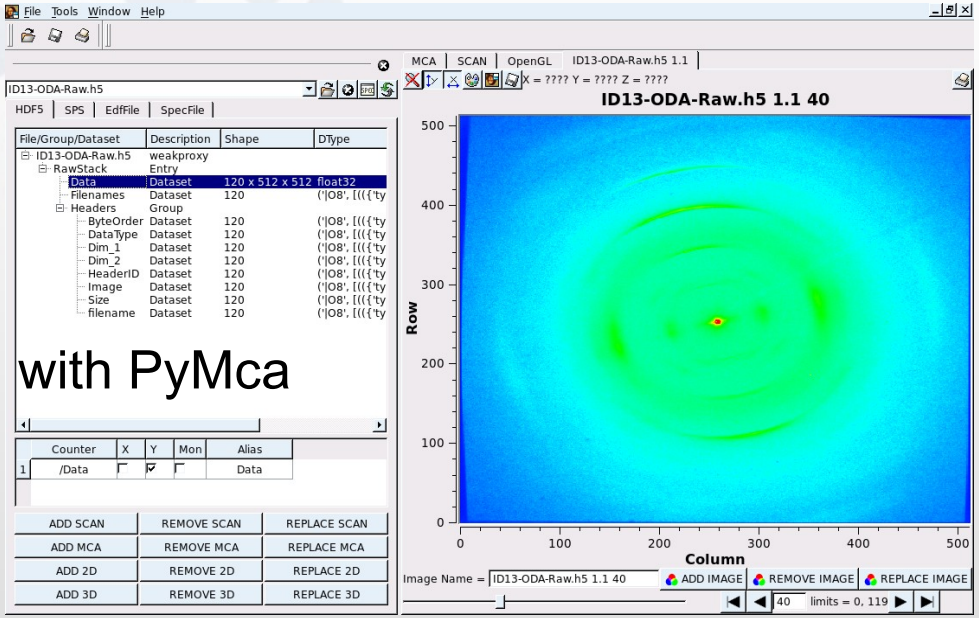
- Images stored as a stack:
  - 3D: (Image, x, y)

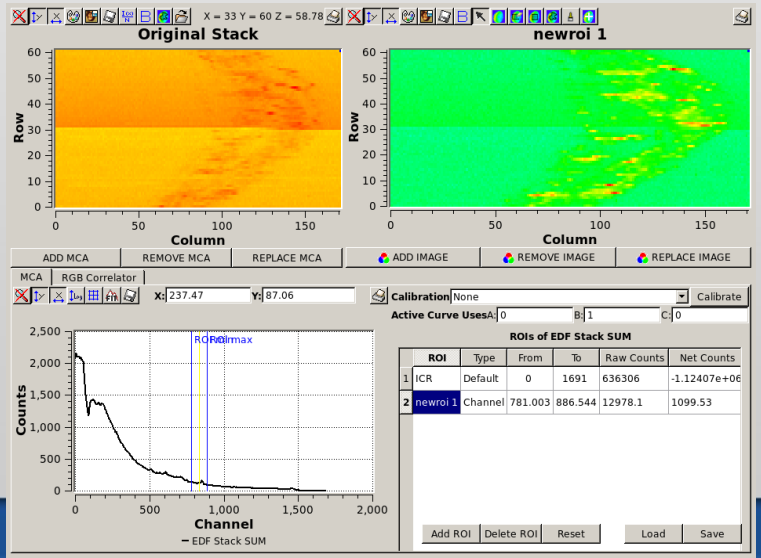
Visualization with PyMca

- Map of Spectra:
  - 3D: (x, y, spectrum)

Live ROI selection for the sinograms with PyMca

- Data visible with HDFview

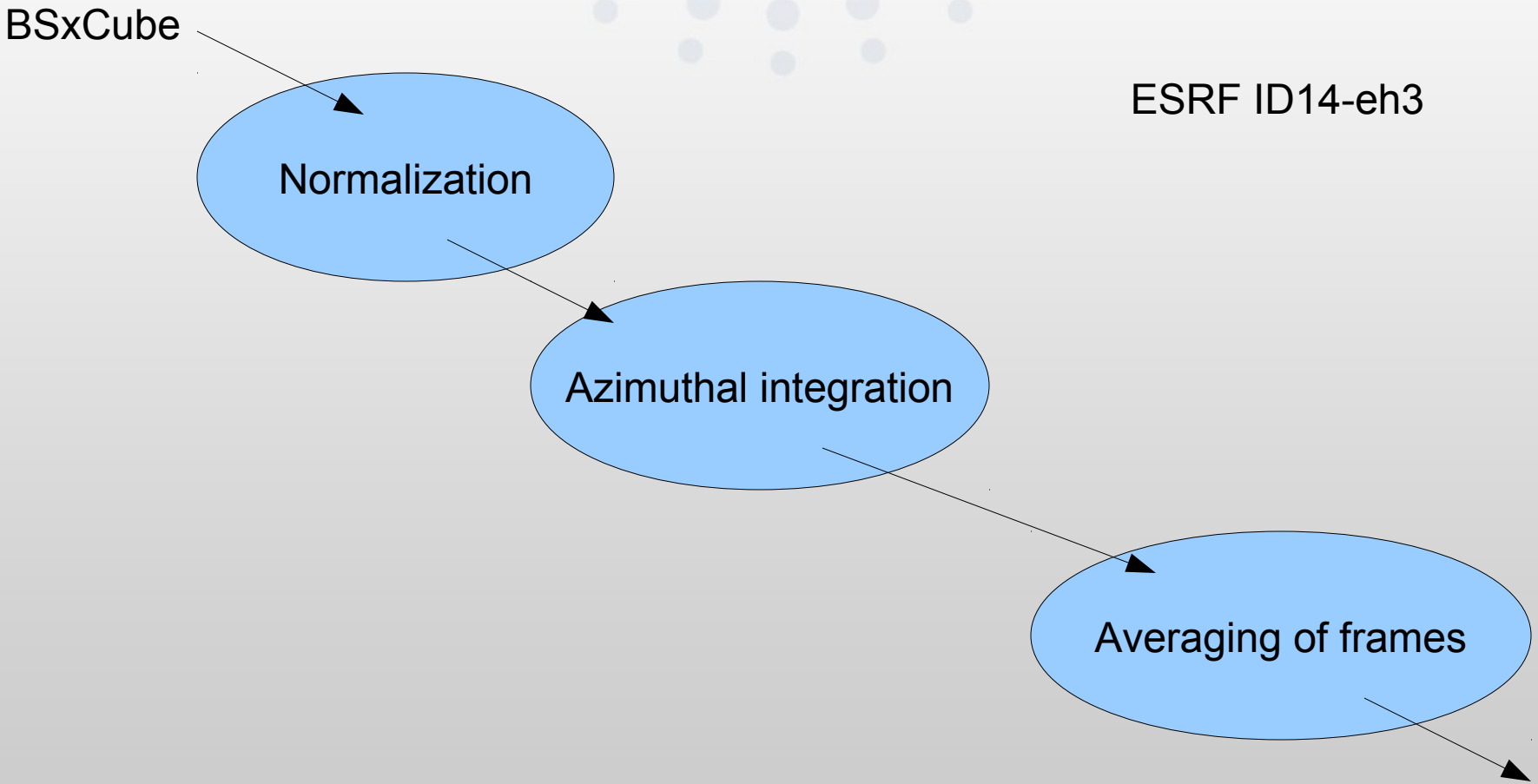




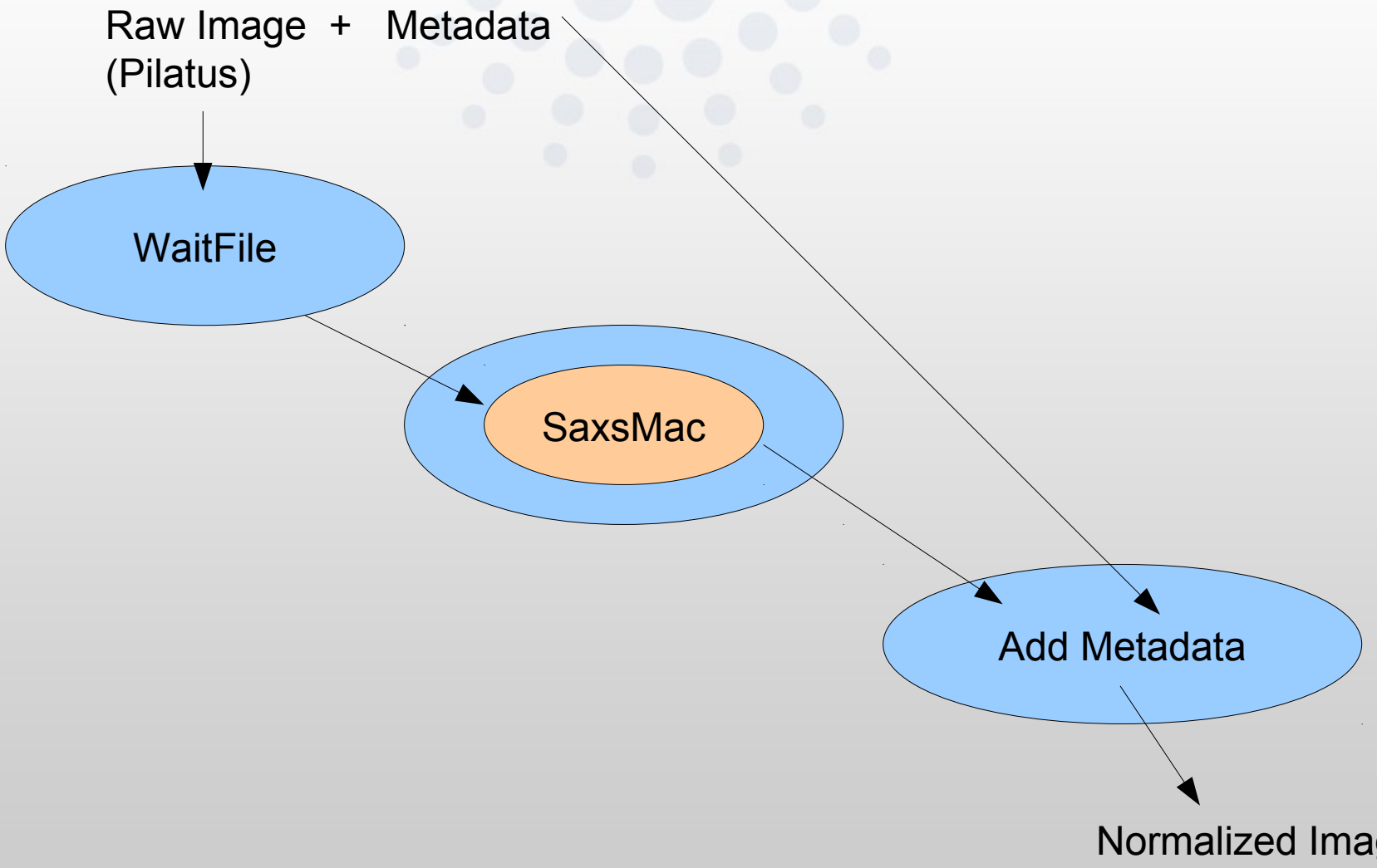
Other Application
Small Angle Scattering:

Application to proteins in solution
EDNA-Preprocessing

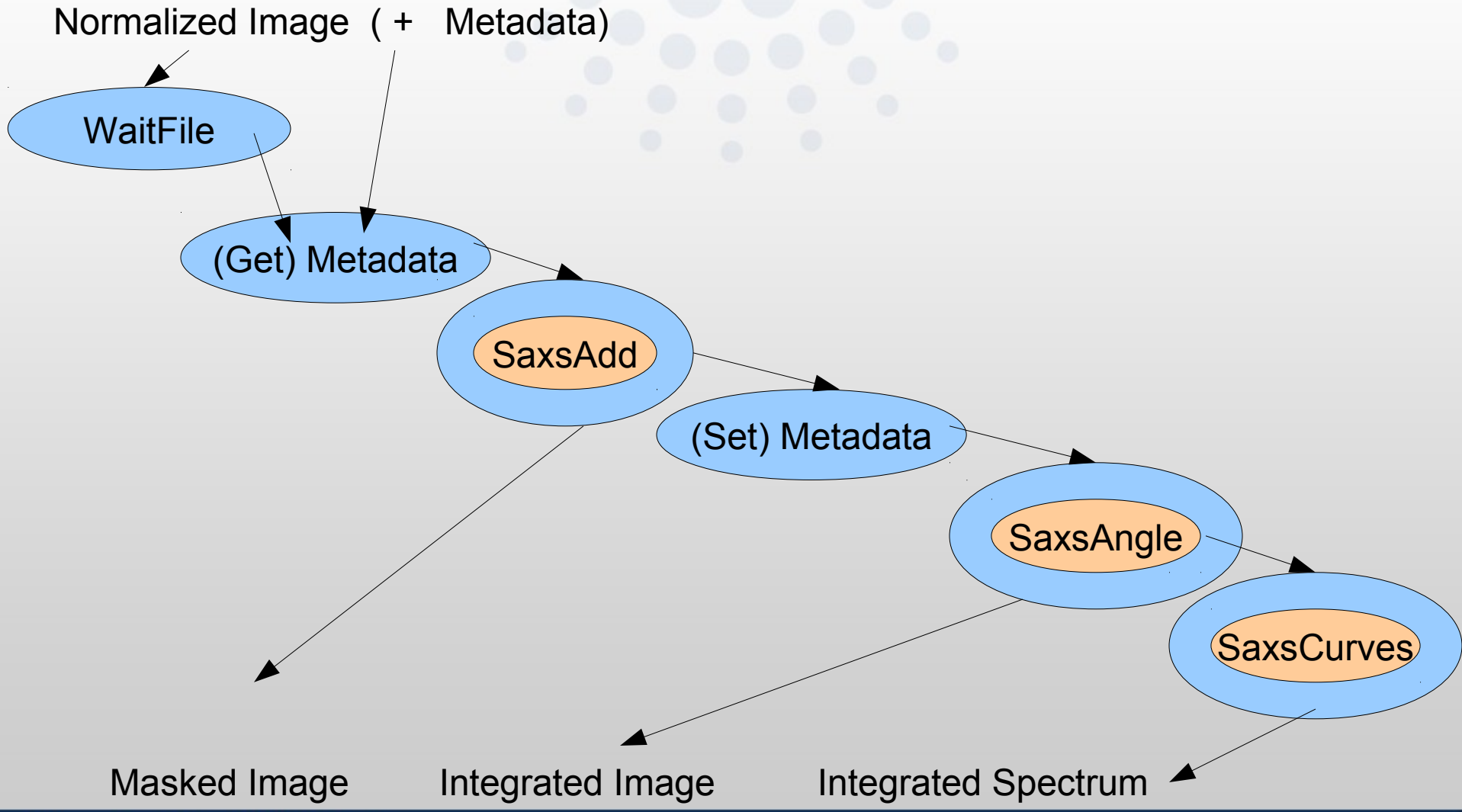
Overview of the preprocessing pipeline



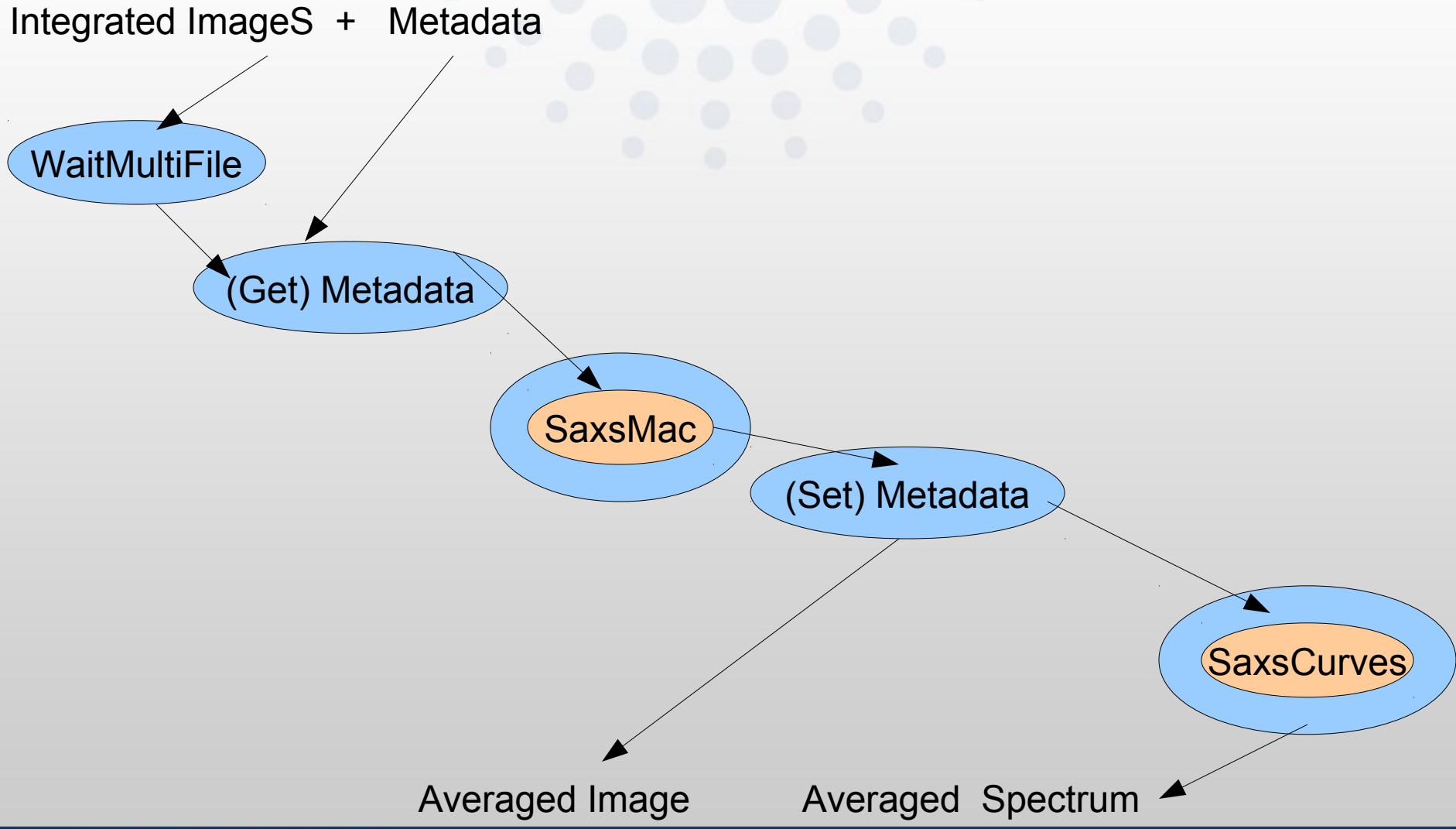
Focus on EDPluginBioSaxsNormalizev1_0.py



Focus on EDPluginBioSaxsAzimutIntv1_0



Focus on EDPluginBioSaxsAveragev1_0



Edna toolbox

- General Execution plugins: 70 plugins
  - Generic command line execution
  - HDF5 writers for stack of images, map of spectra
  - Image conversion, movie making …
  - Conditional branching, accumulator of information
  - Synchronization of tasks
- 5 real applications available from repository
  - BioSaxs
  - Ccp4 (DEMO)
  - DiffractionCT
  - Dimple
  - MX v1 & v2
  - Raw photography development (DEMO)

Coming next: Tutorial & Code Camp in October

- New tutorial
  - Easier subject: Raw digital photography development pipeline
  - Testable and runnable during the training (just need a digital camera)
  - Making use of the EDNA-toolbox (rely on existing code)
  - Tutorial for scientists with skills in Python and developers intested in ODA
  - http://www.edna-site.org/wiki/index.php/DeveloperTutorial
- Code Camp about:
  - Datamodels (go away from Enterprise Architect)
  - Data-bindings (allow the transfer of matrices, units)
  - Per plugin logging
  - Execution under Windows

Acknowledgements

- ID11 (Materials Science)
  - Jon Wright
- ID13 (NanoBeam)
  - Manfred Burghammer
- ID14-eh3 (BioSaxs)
  - Louiza Zerad, Adam Round, Thomas Boeglin
- ID22 (NiNa)
  - Alexander Rack & Remy Tucoulou
- SPD developers
  - Peter Boesecke & Rainer Wilcke
- Online data analysis workgroup
  - Cyril Guilloud, Armando Solé & Olof Svensson

A Light for Science

European Synchrotron Radiation Facility

Diffraction CT implementation in EDNA