

Rosseland
Centre
for Solar
Physics

Development of
research with

tools for solar ALMA at RoCS

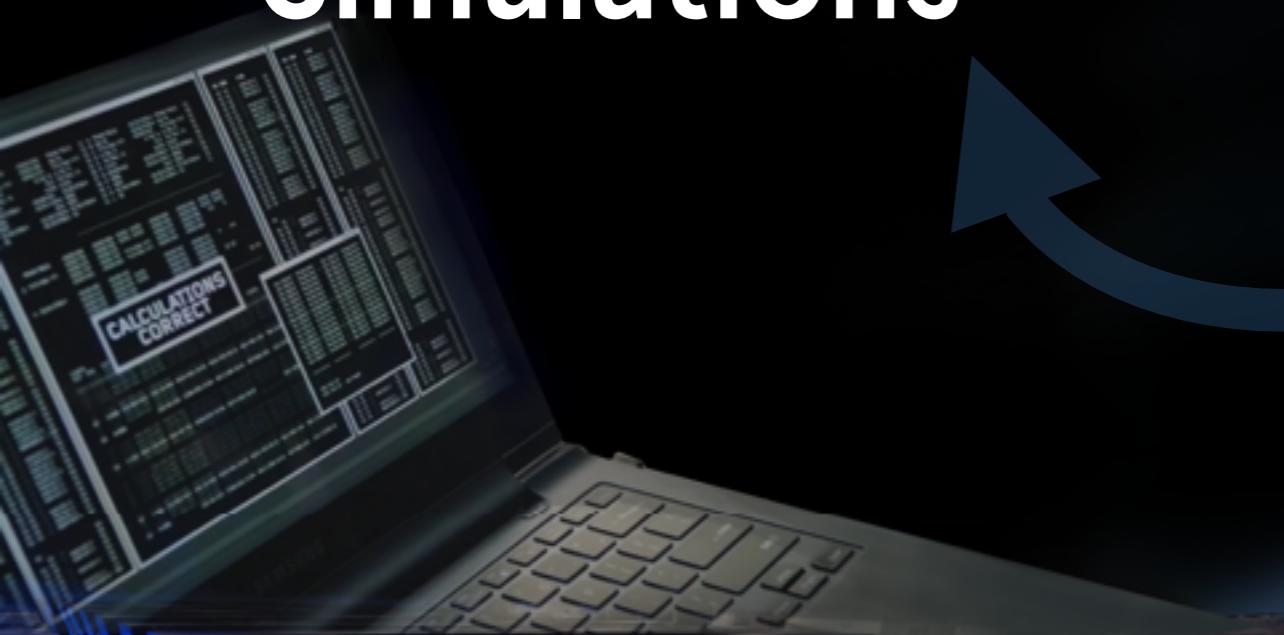
Sven Wedemeyer
Rosseland Centre for Solar Physics, Univ Oslo
Oslo, 2 March 2020

This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 682462).



Simulations

Observations



ALMA

ALMA @ RoCS

PRIMARY MISSION

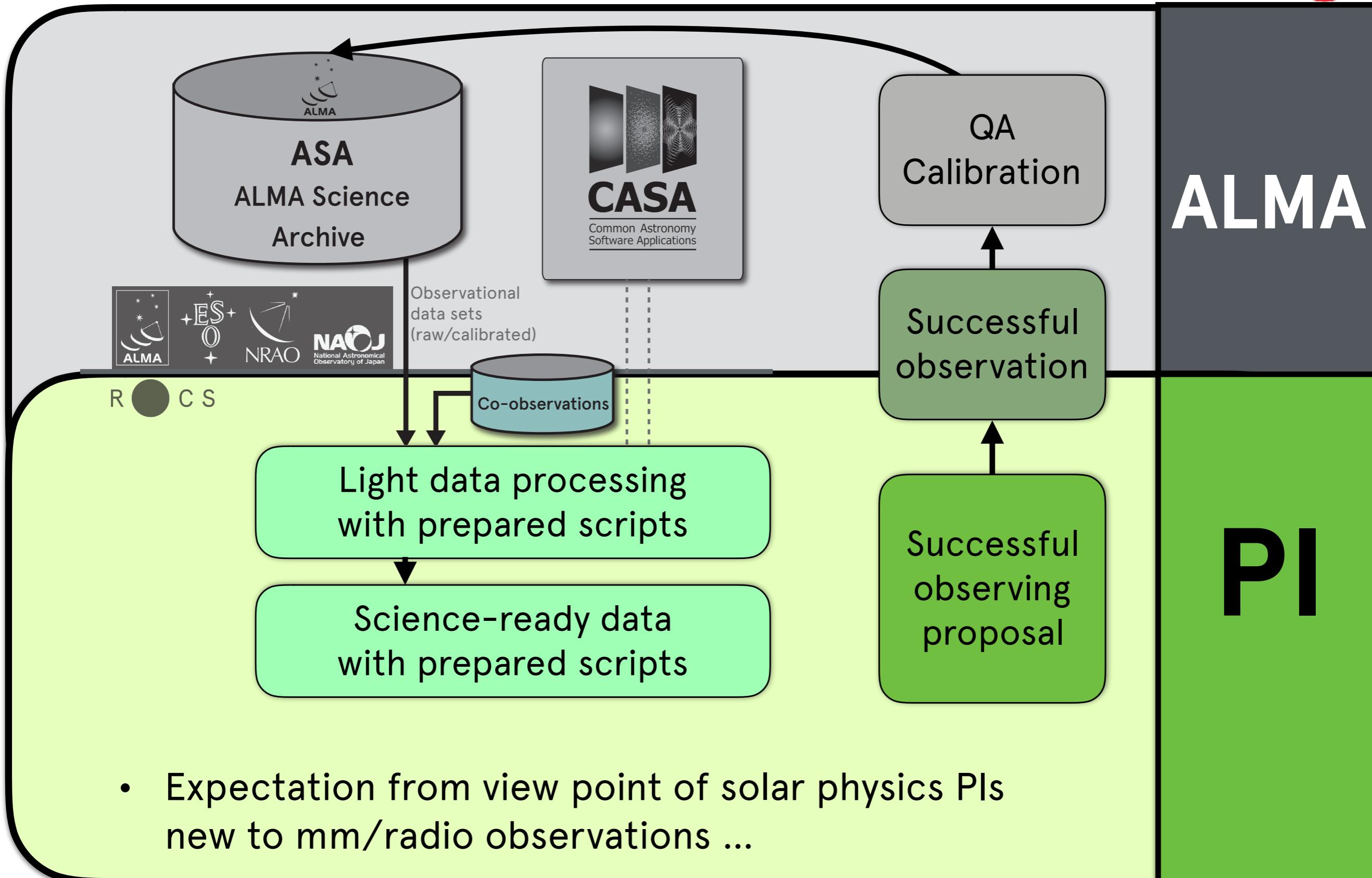
TECHNICAL GOAL:

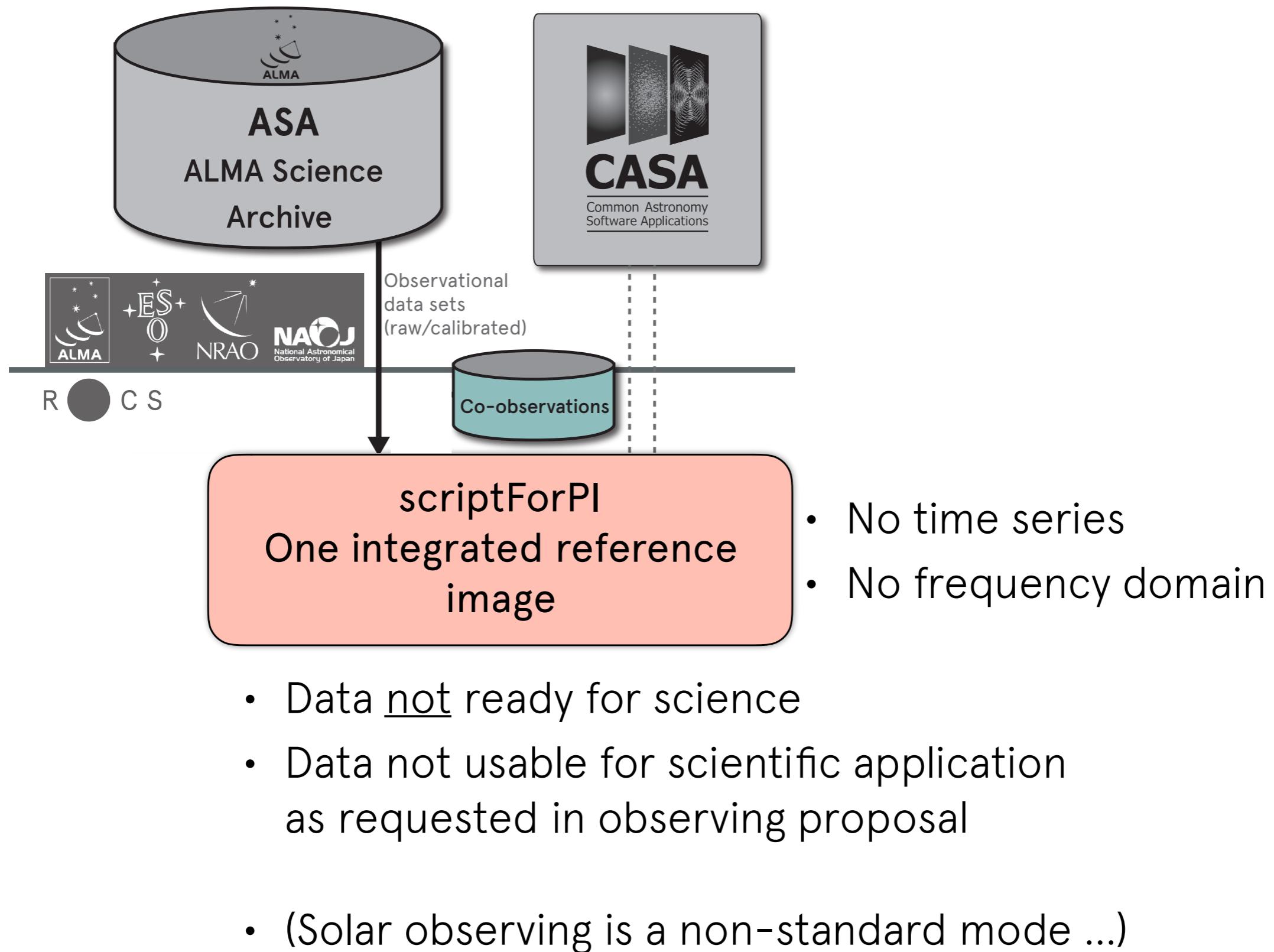
Develop and utilise **diagnostic tools**
based on the solar observing capabilities of the
Atacama Large Millimeter/sub-millimeter Array (ALMA)

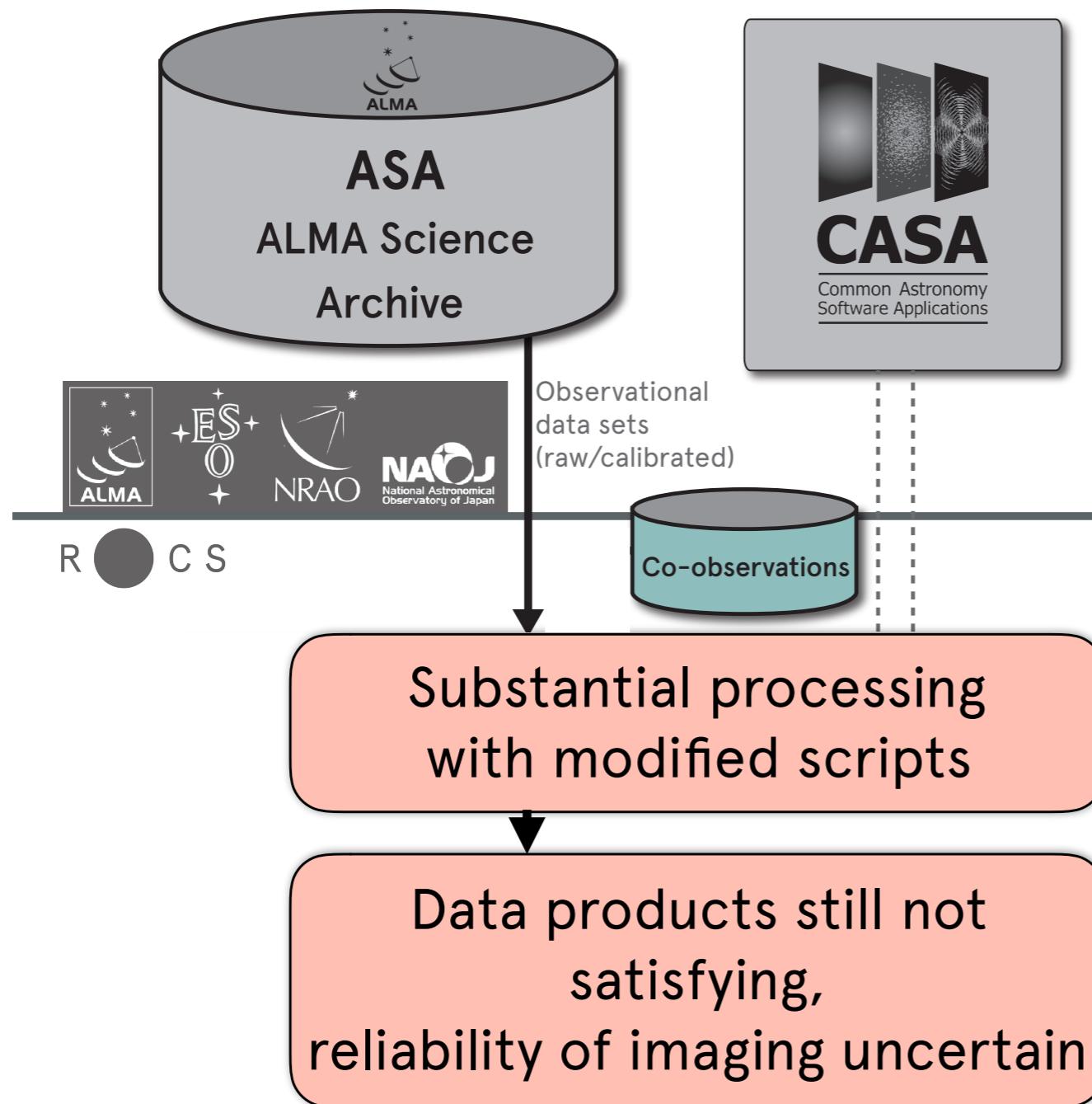
SCIENTIFIC GOAL:

New complementary studies of the
**small-structure, dynamics and energy balance of the solar
chromosphere** with ALMA

ALMA







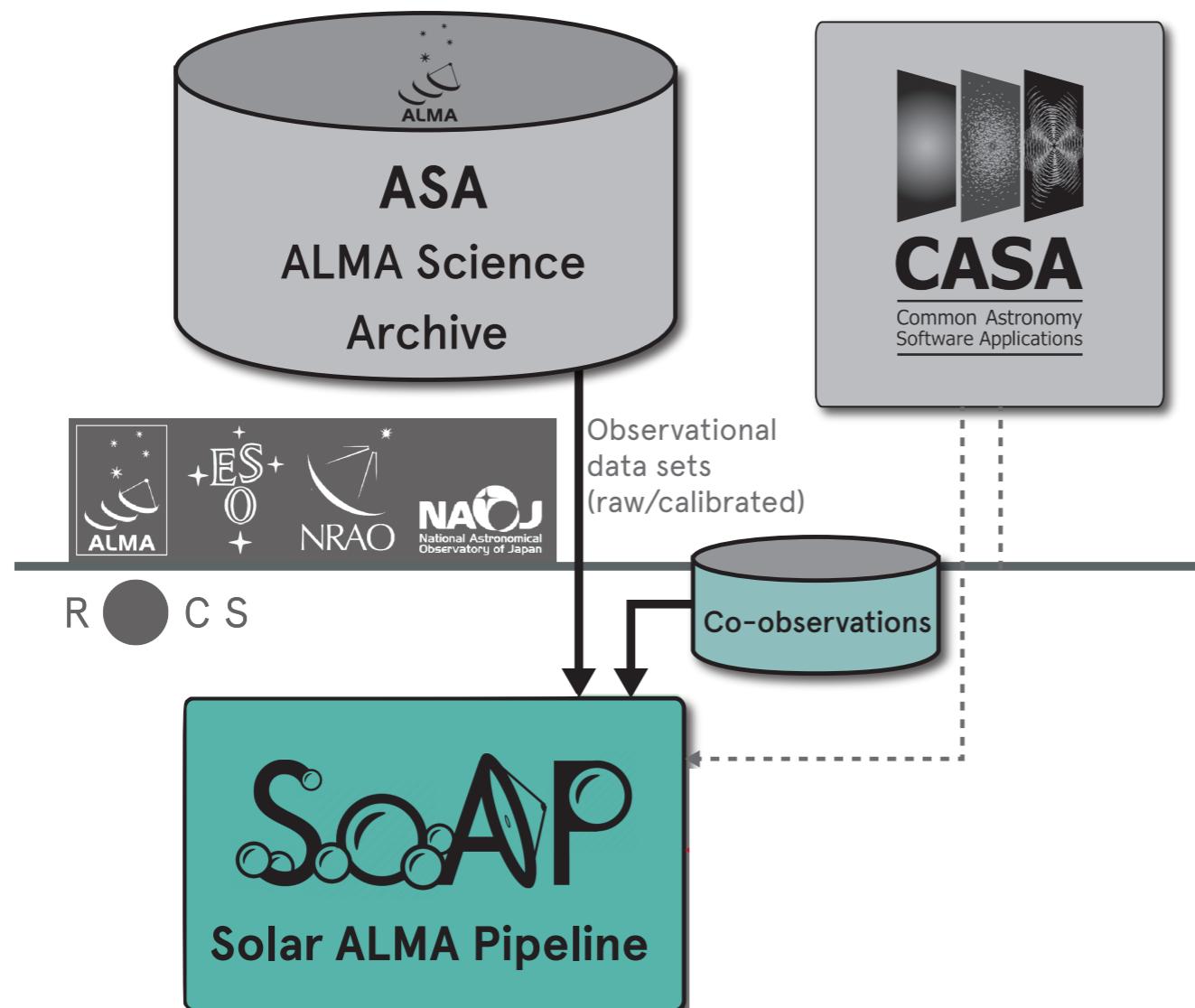
Experimental phase

- Split in time series
- Split in spectral bands
- Data not ready for science

→ How to set the parameters for CLEAN?

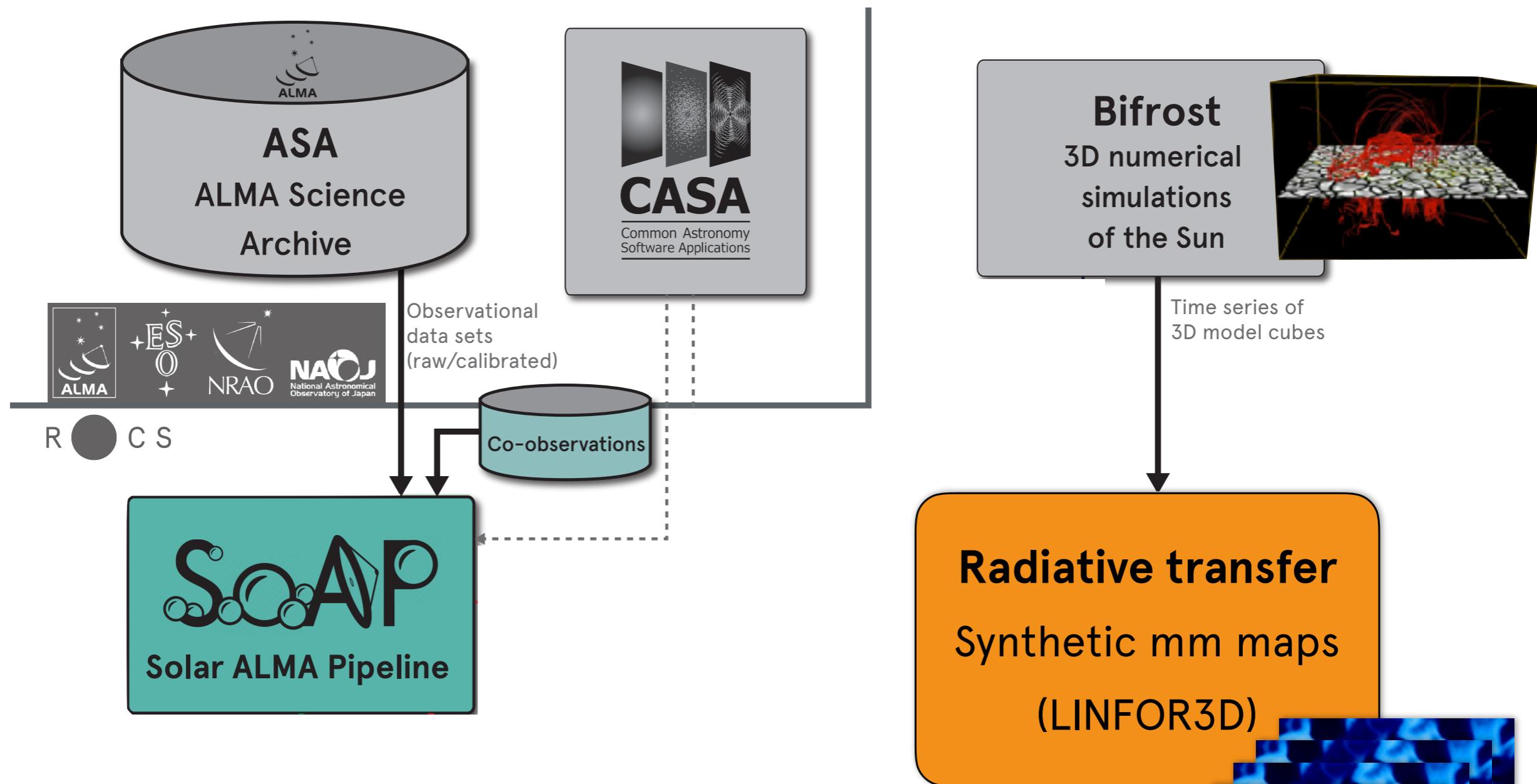
→ Are the resulting images reliable?

- Some features appeared/disappeared depending on parameters



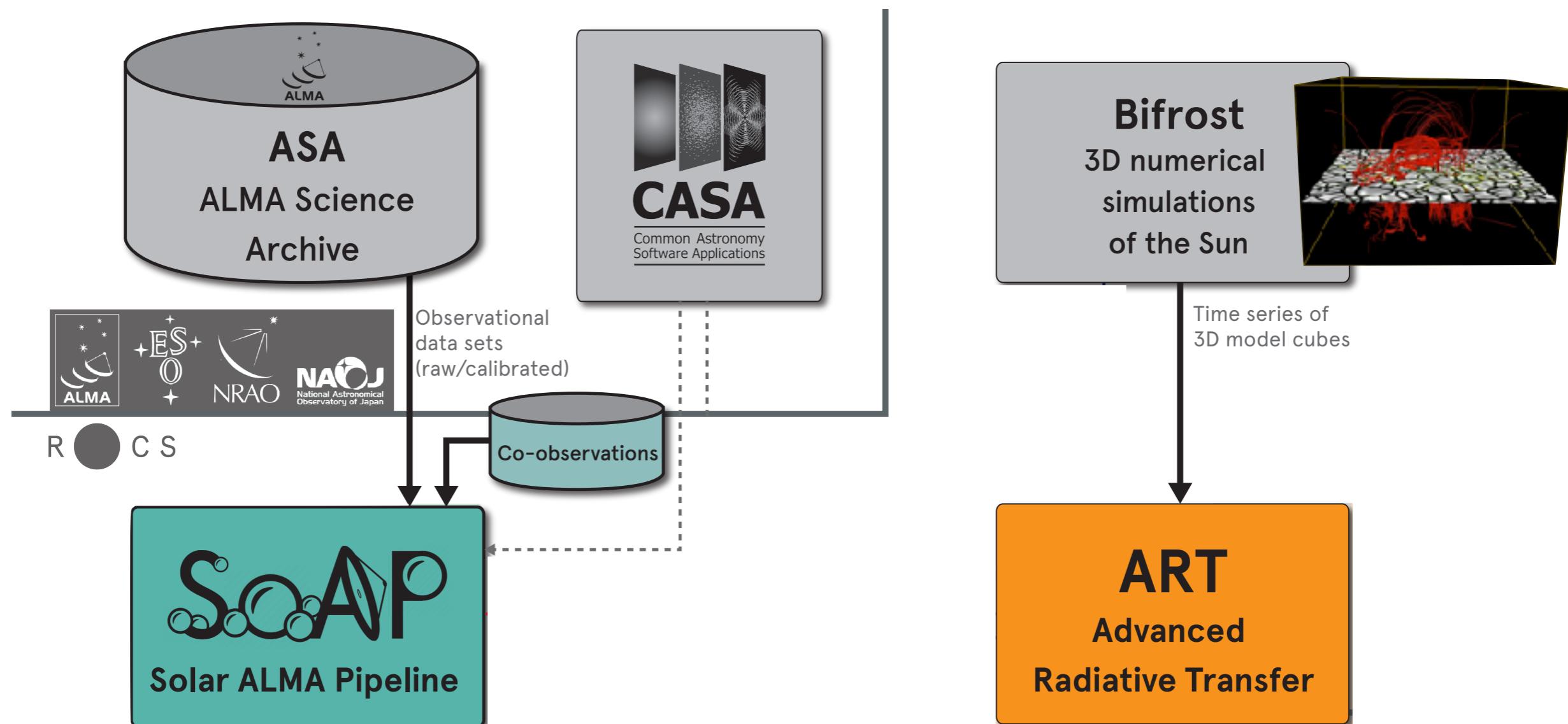
- Accuracy of the produced brightness temperatures?
- How to assess that?
- Needs a "ground truth" to compare to.

- Development of a data pipeline with scriptForPI as starting point
- Routine data processing resulting in stable time series of brightness temperature maps
- Co-alignment with other observations (SDO, IRIS,...)
→ Science-ready data!



- Synthetic mm maps produced with RT code
- Use for artificial observations as **test case** for SoAP!?
- Needs time series with 4×128 channels
- **RT code not efficient enough**



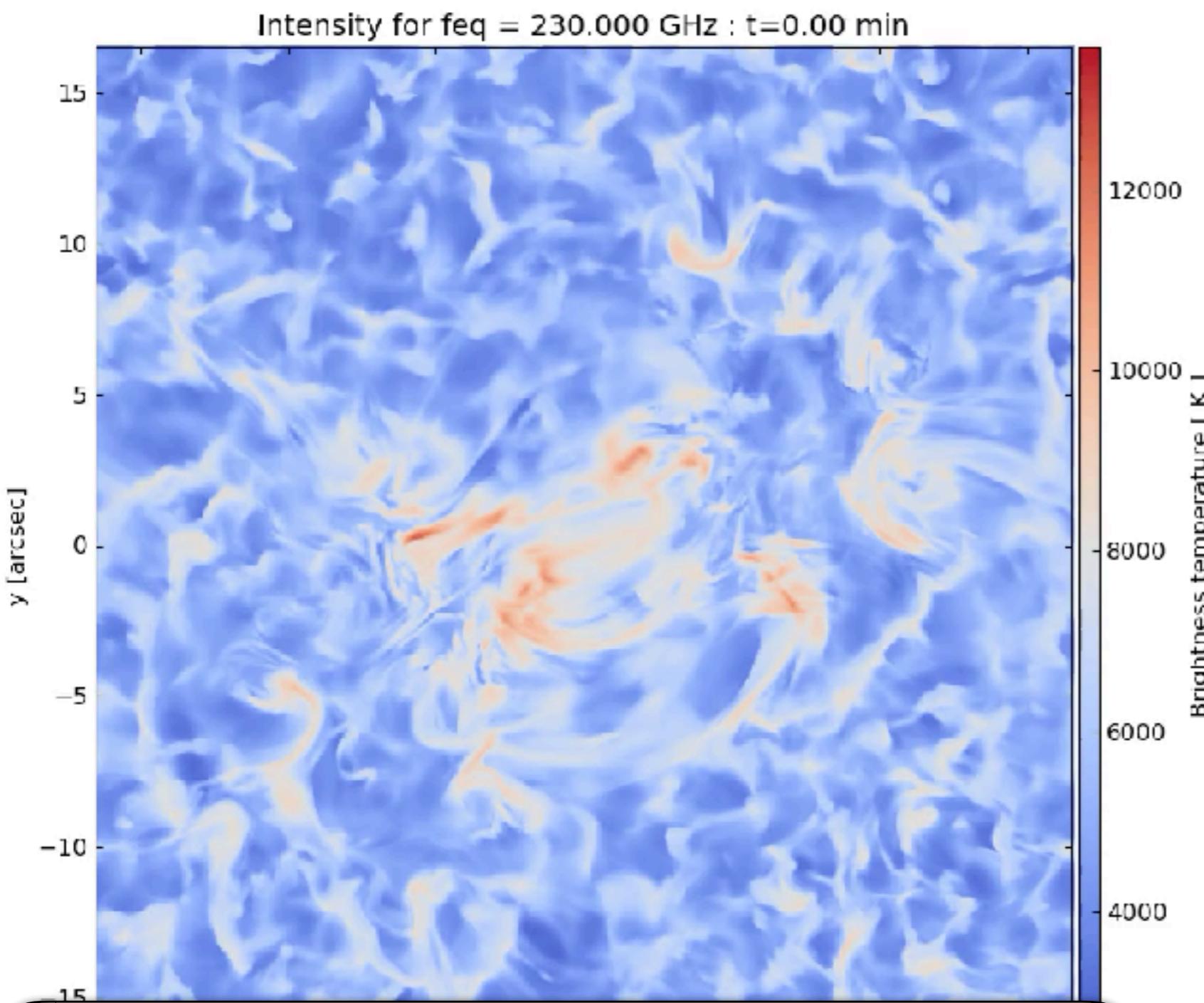


- **PRACE Preparatory Access Type D (8/2017 – 6/2018)**

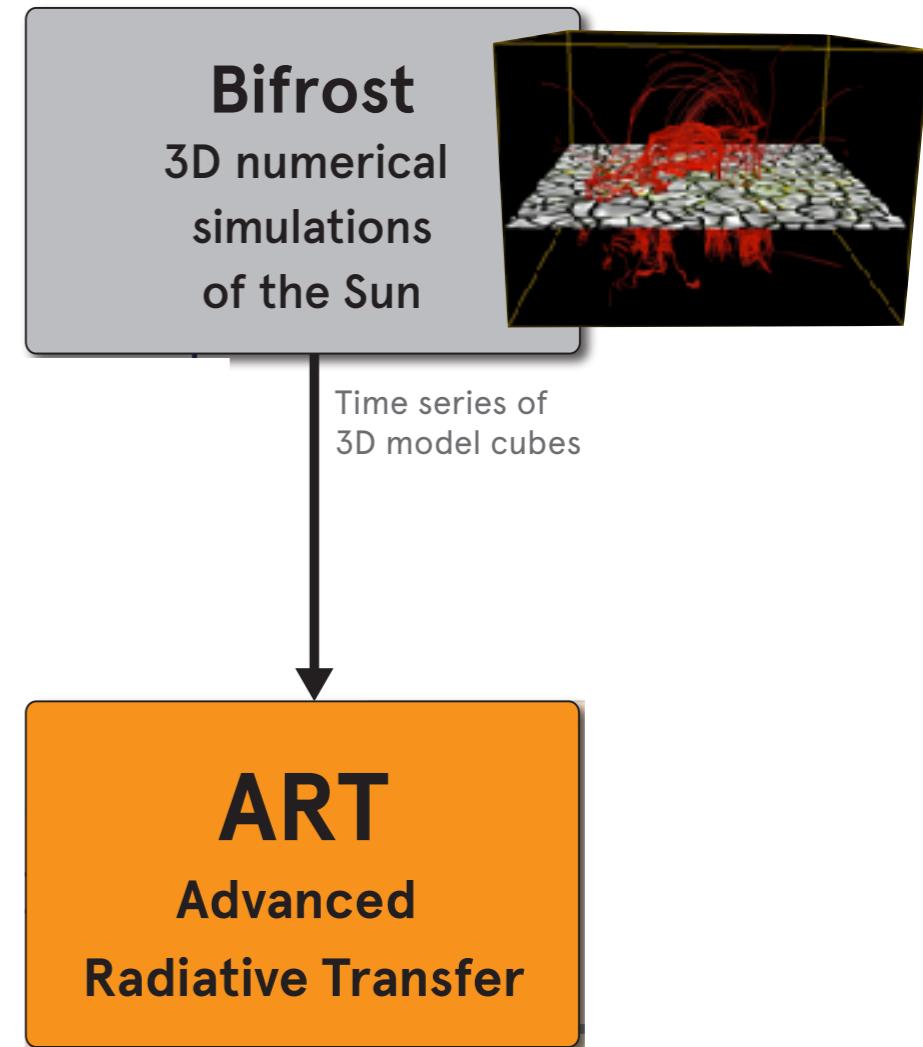
- Mikolaj Szydlarski, Marcin Krotkiewski (SIGMA2 / UiO)
- Per-core performance improvement of optimised code:
 - MPI implementation scales with 95% efficiency on 2048 cores.
 - **Optimized ART 110 times faster** in terms of time/core/wavelength for same problem size than previously used LINFOR3D

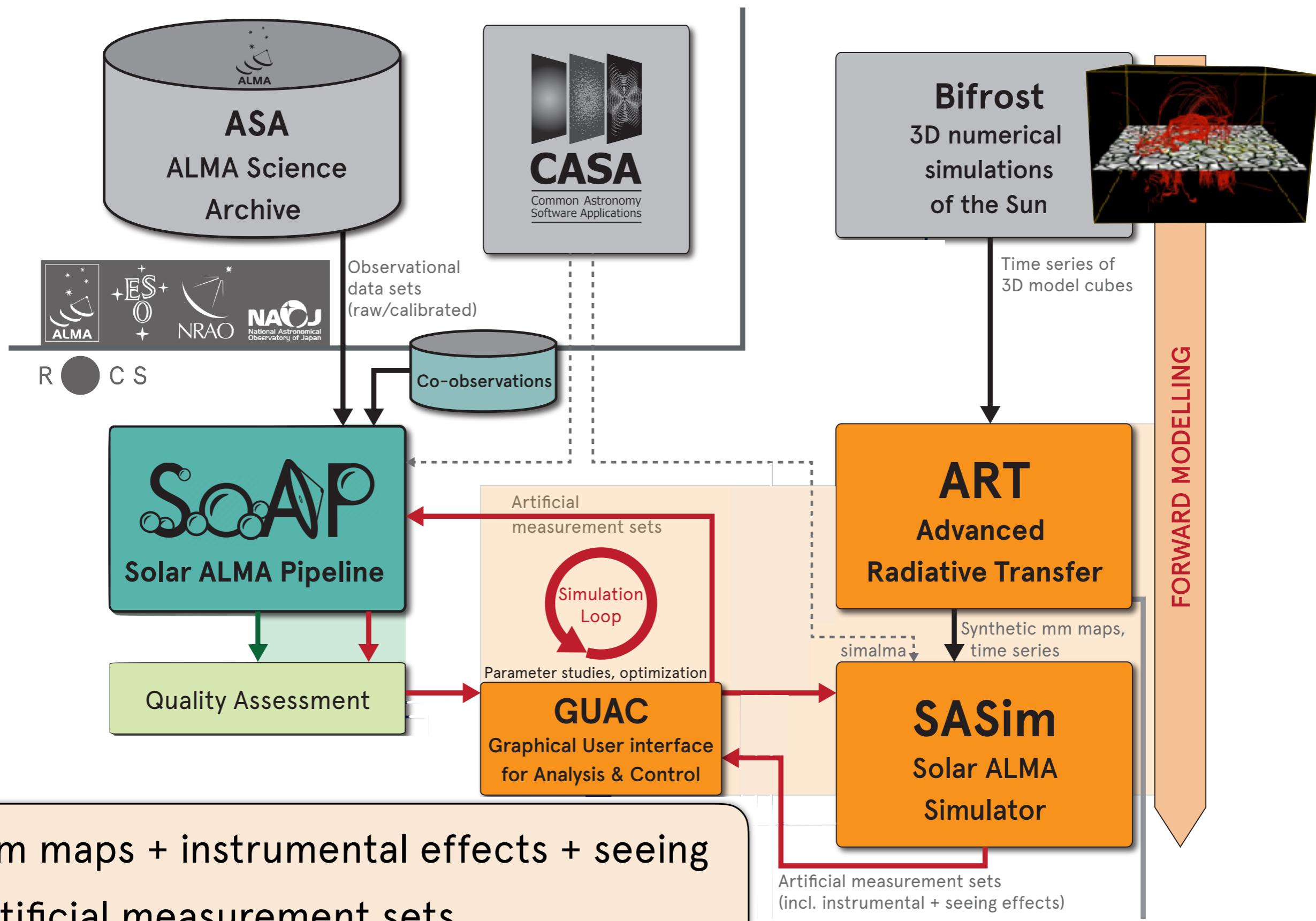
(original version by Jaime de la Cruz Rodriguez, Stockholm University)

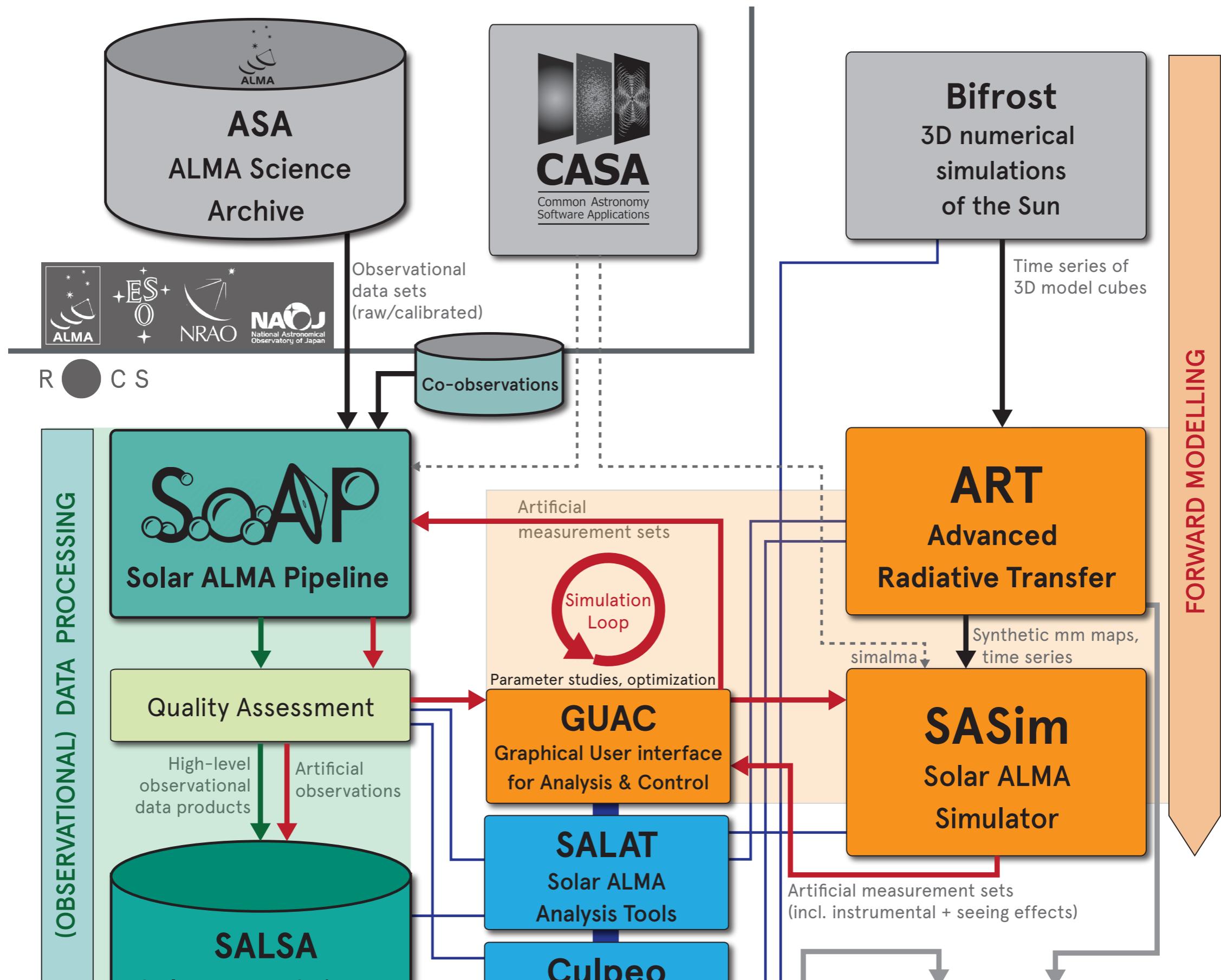




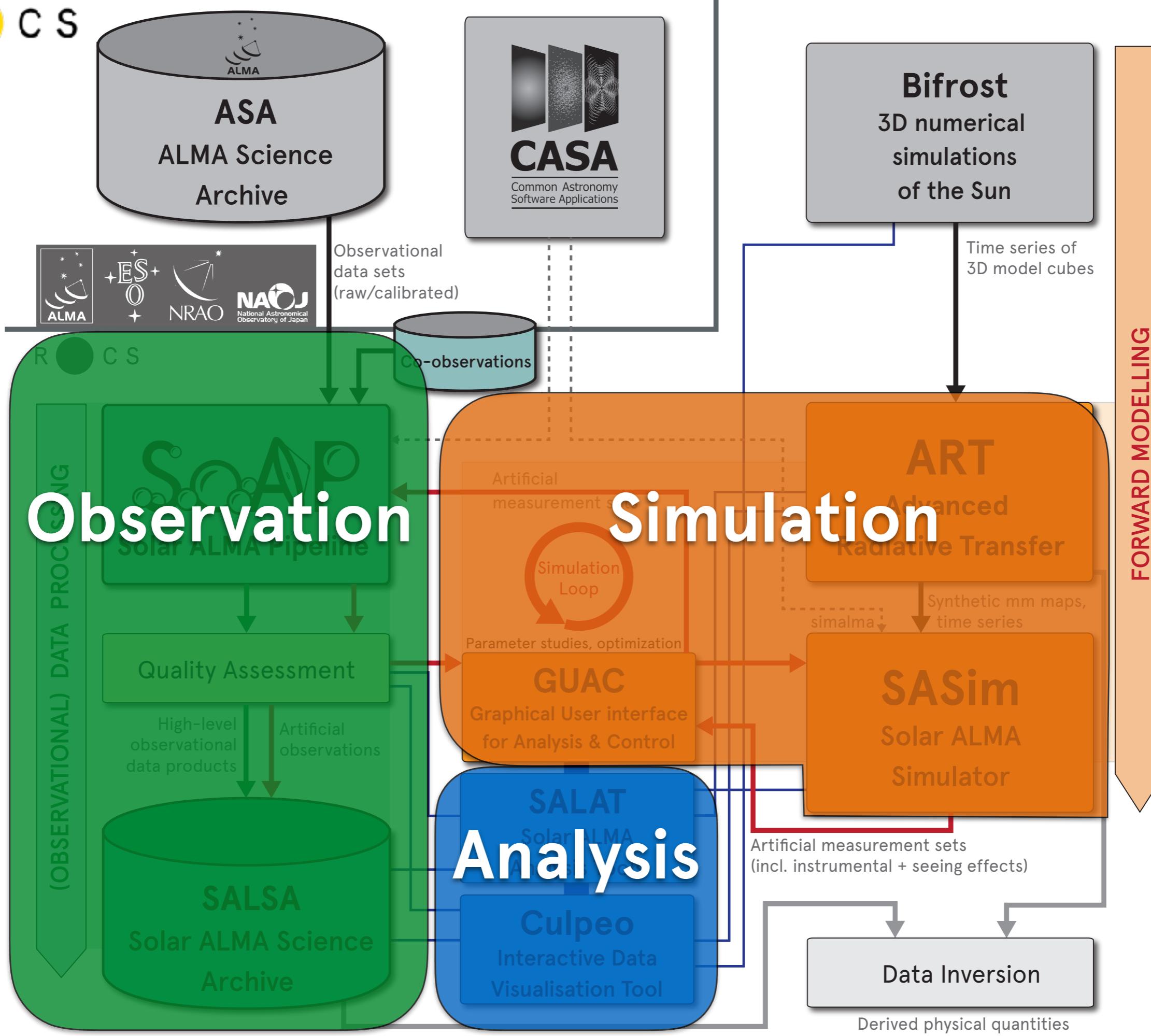
- mm maps + instrumental effects + seeing
- Artificial measurement sets





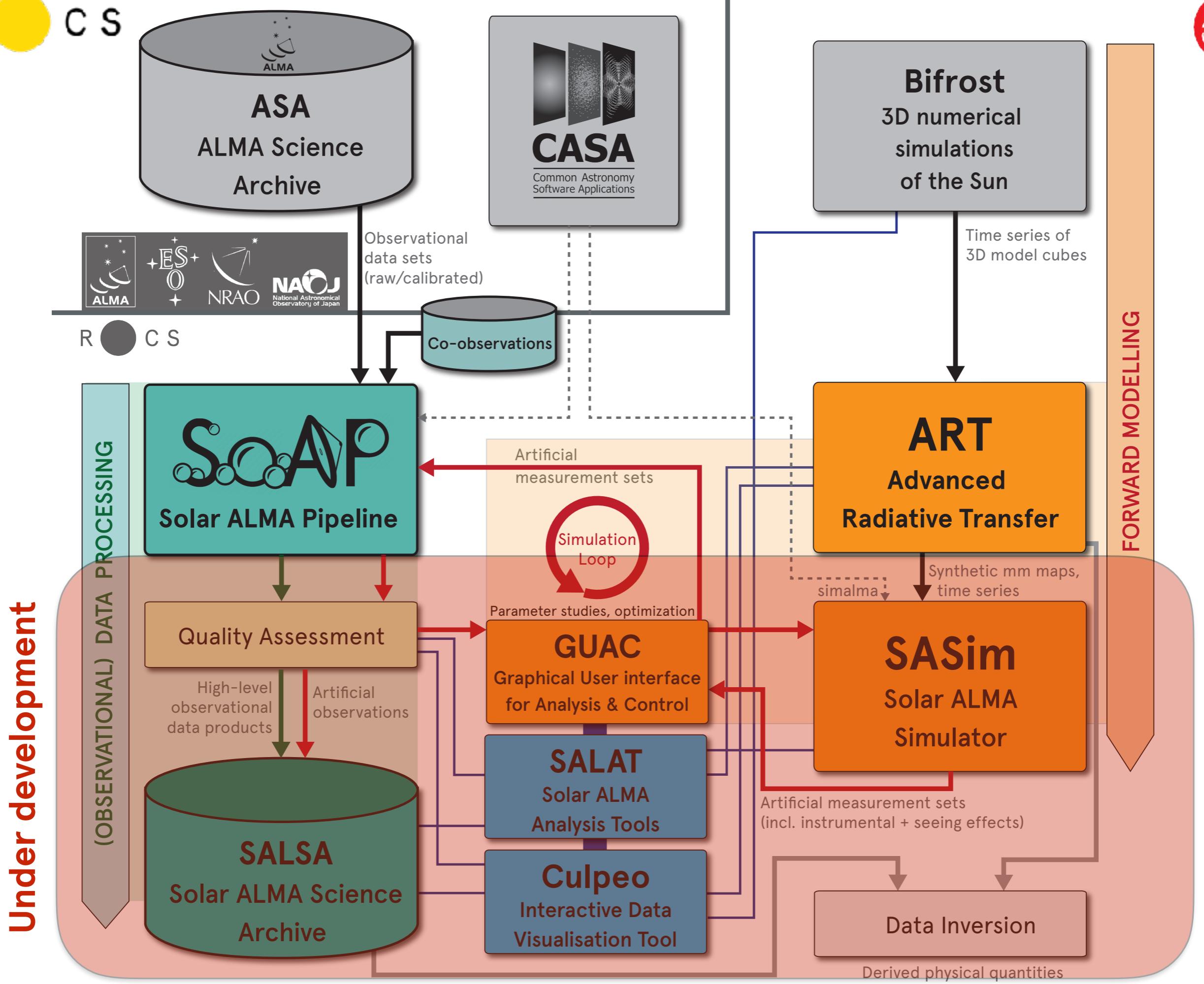


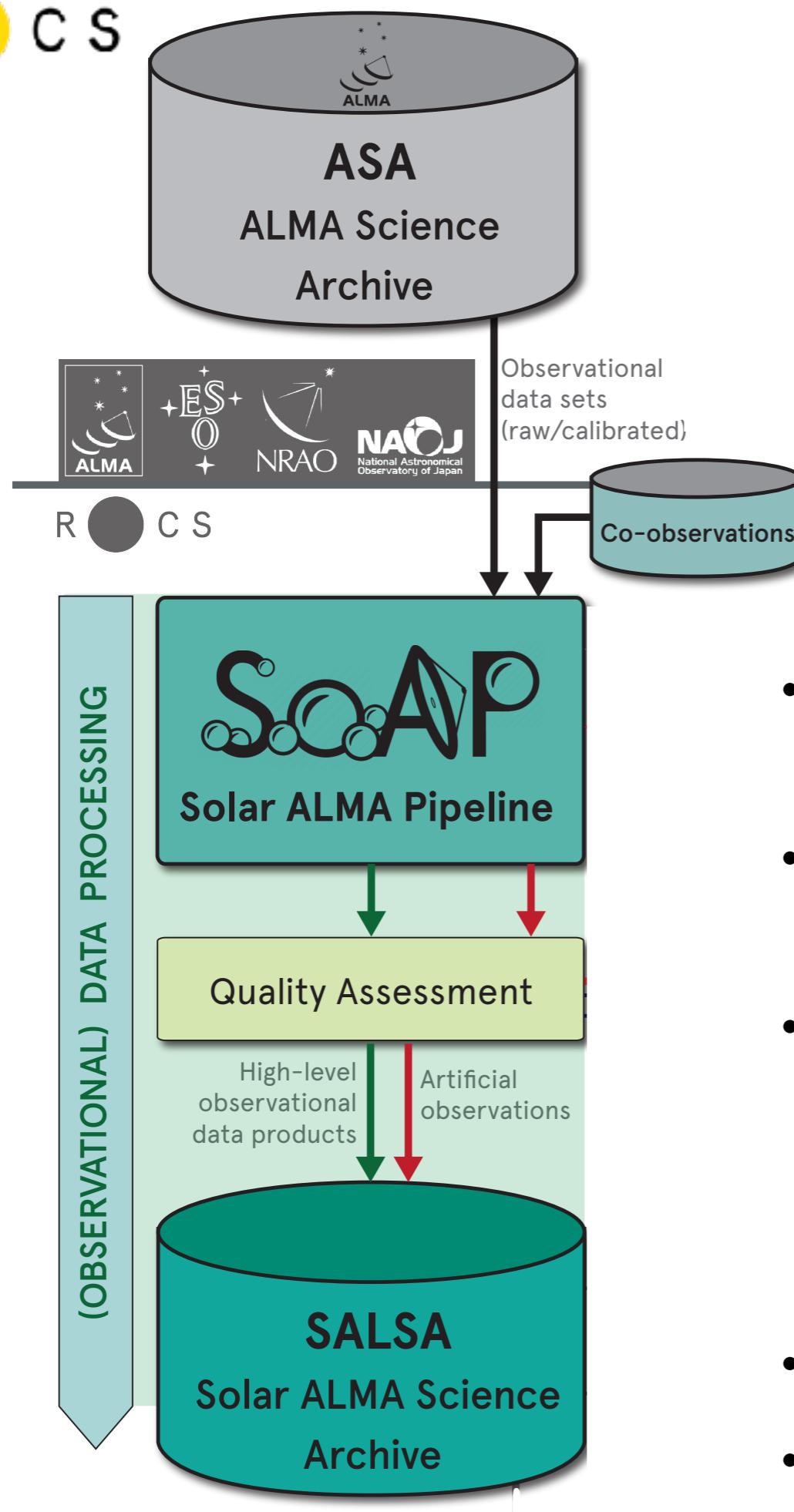
R C S



Derived physical quantities

R C S





SALSA

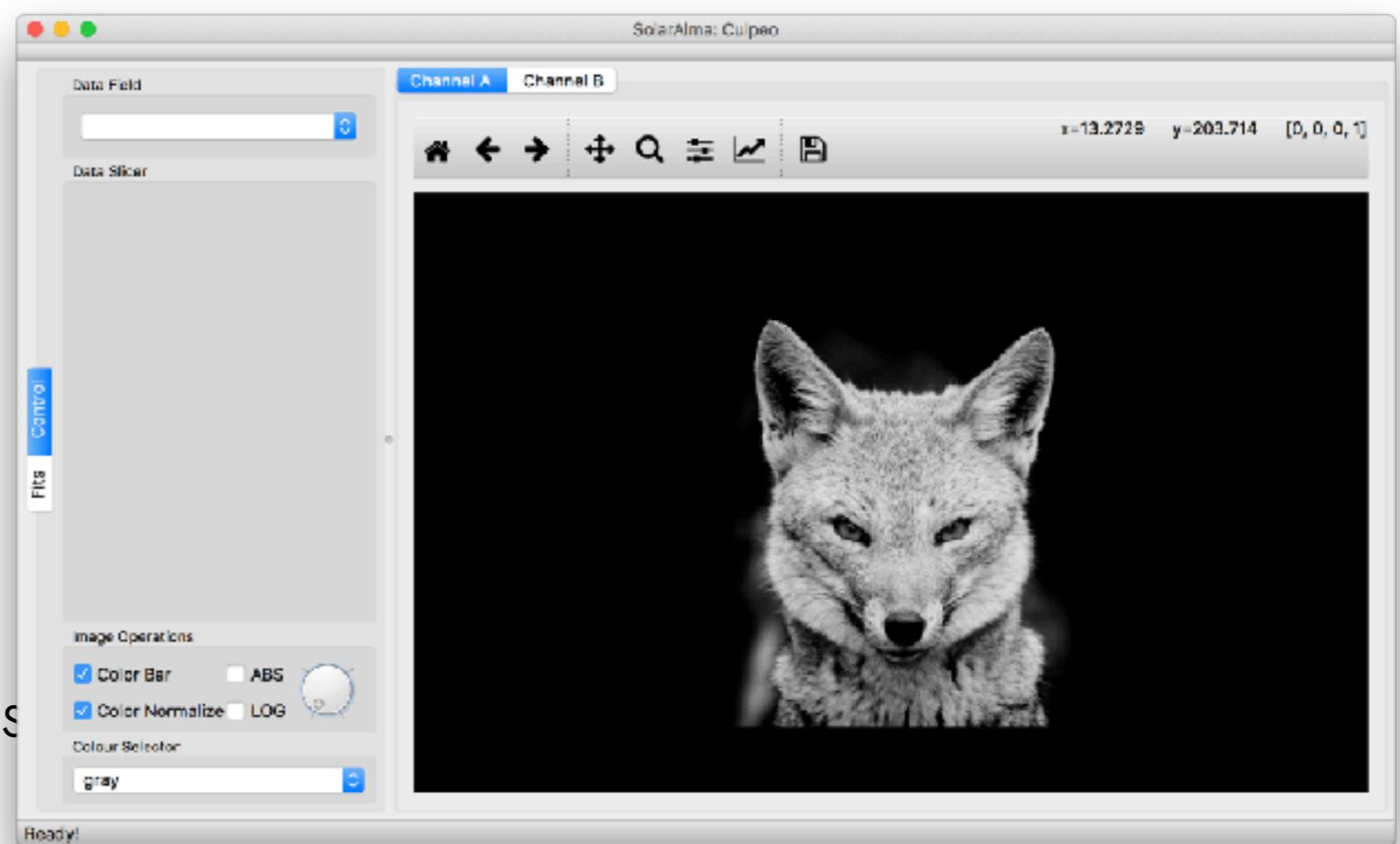
Solar ALMA Science Archive

- Science-ready data
- Data usable by non-expert users (i.e. without expertise in solar mm)
- Only high-level data products as produced with SoAP
- No duplication, no conflict with official ALMA Science Archive
- Planned: Integration into the **(Hinode) Science Data Centre Europe** hosted here at ITA/UoI
 - Web-interface
 - Eventually opened to the public
 - International collaboration wanted

CULPEO

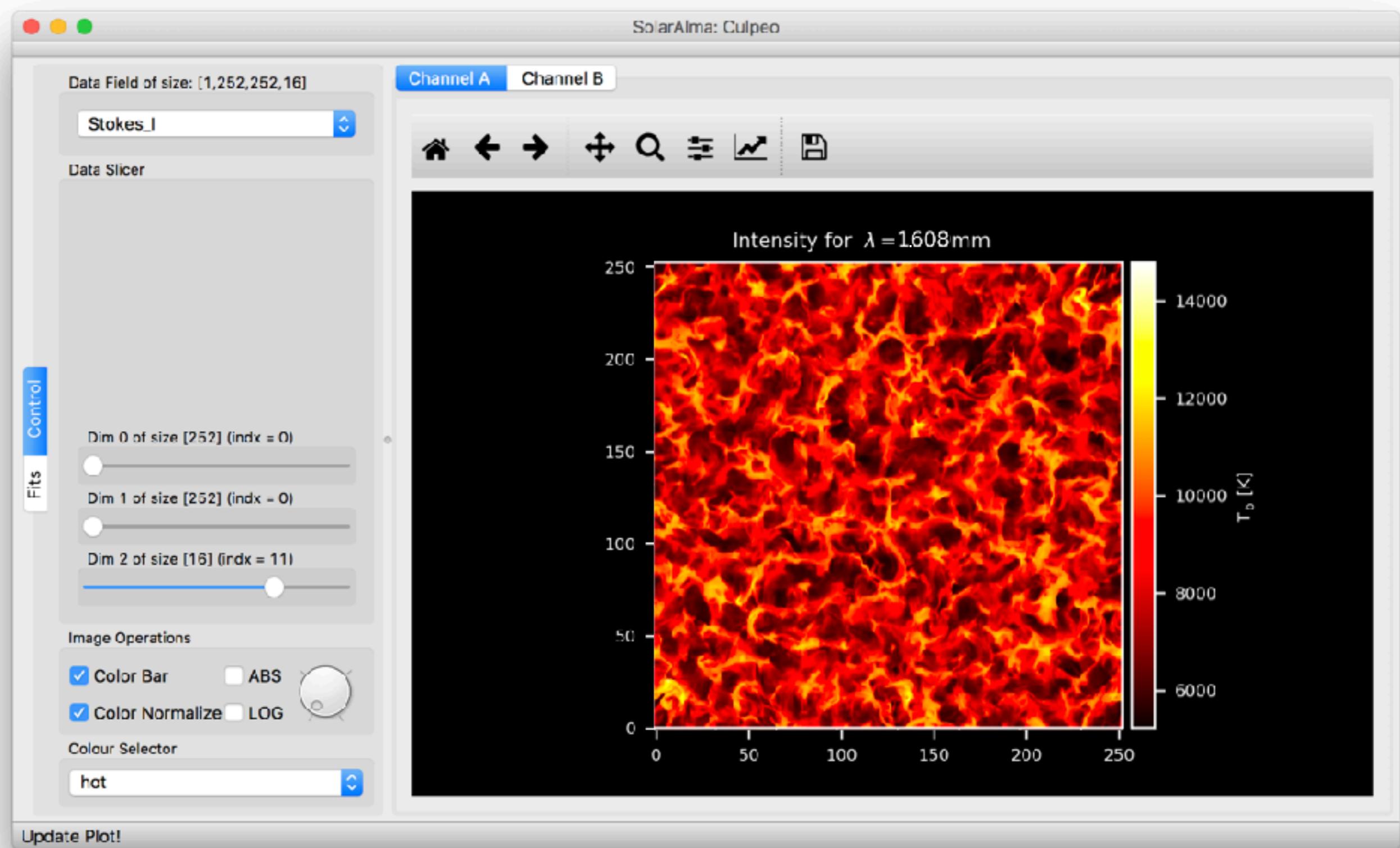
INTERACTIVE DATA VISUALISATION & ANALYSIS

- Quick-look & analysis tool for:
 - 3D simulations
 - synthetic mm maps
 - ALMA observations
- Python-based (multi-OS) GUI
- Handles 4D cubes $[x,y,t,v]$, $[x,y,z,t], \dots$
- Real-time radiative trans (GPU accelerated)
- Launch pad for more focused analysis tools



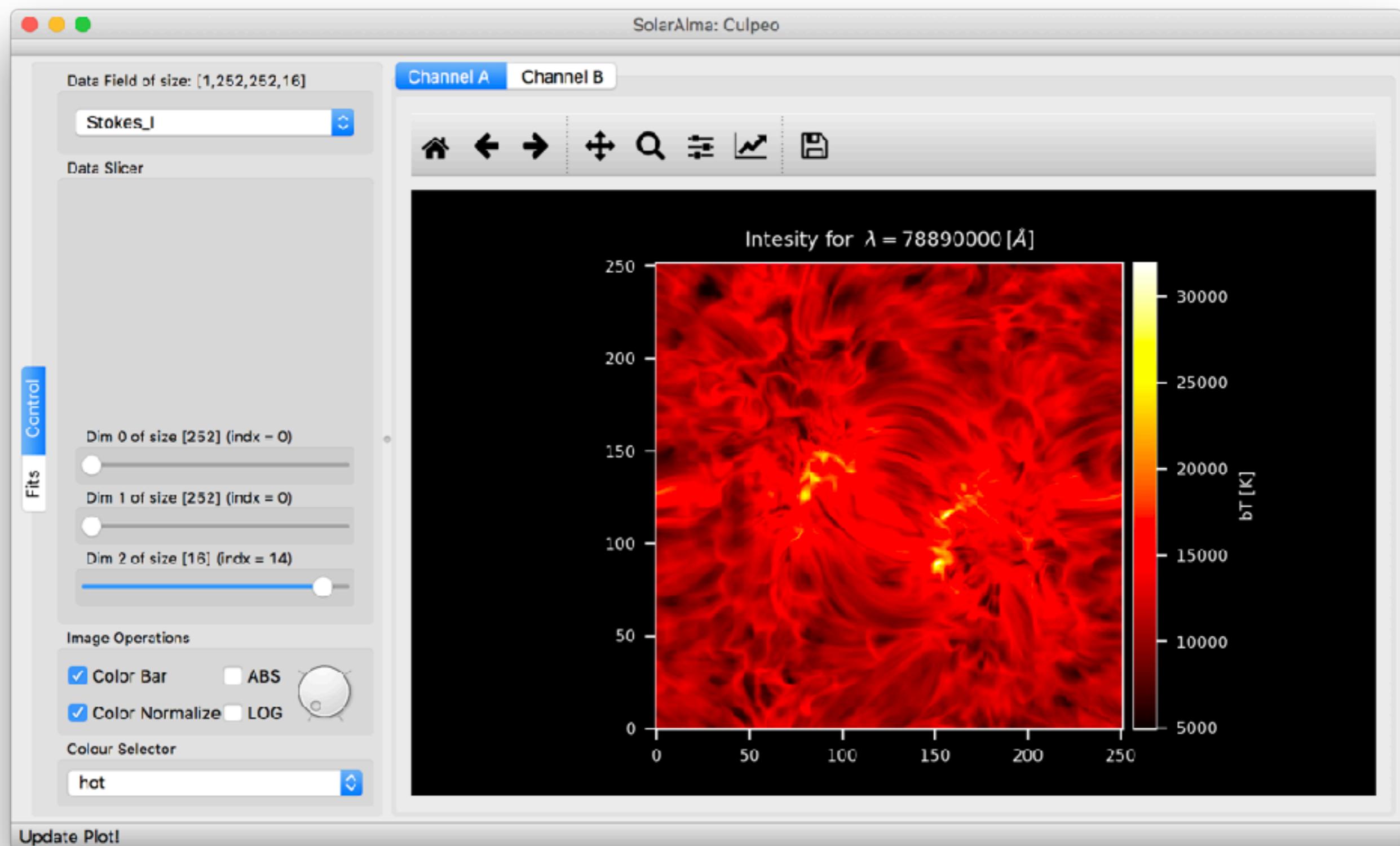
CULPEO

INTERACTIVE DATA VISUALISATION & ANALYSIS



CULPEO

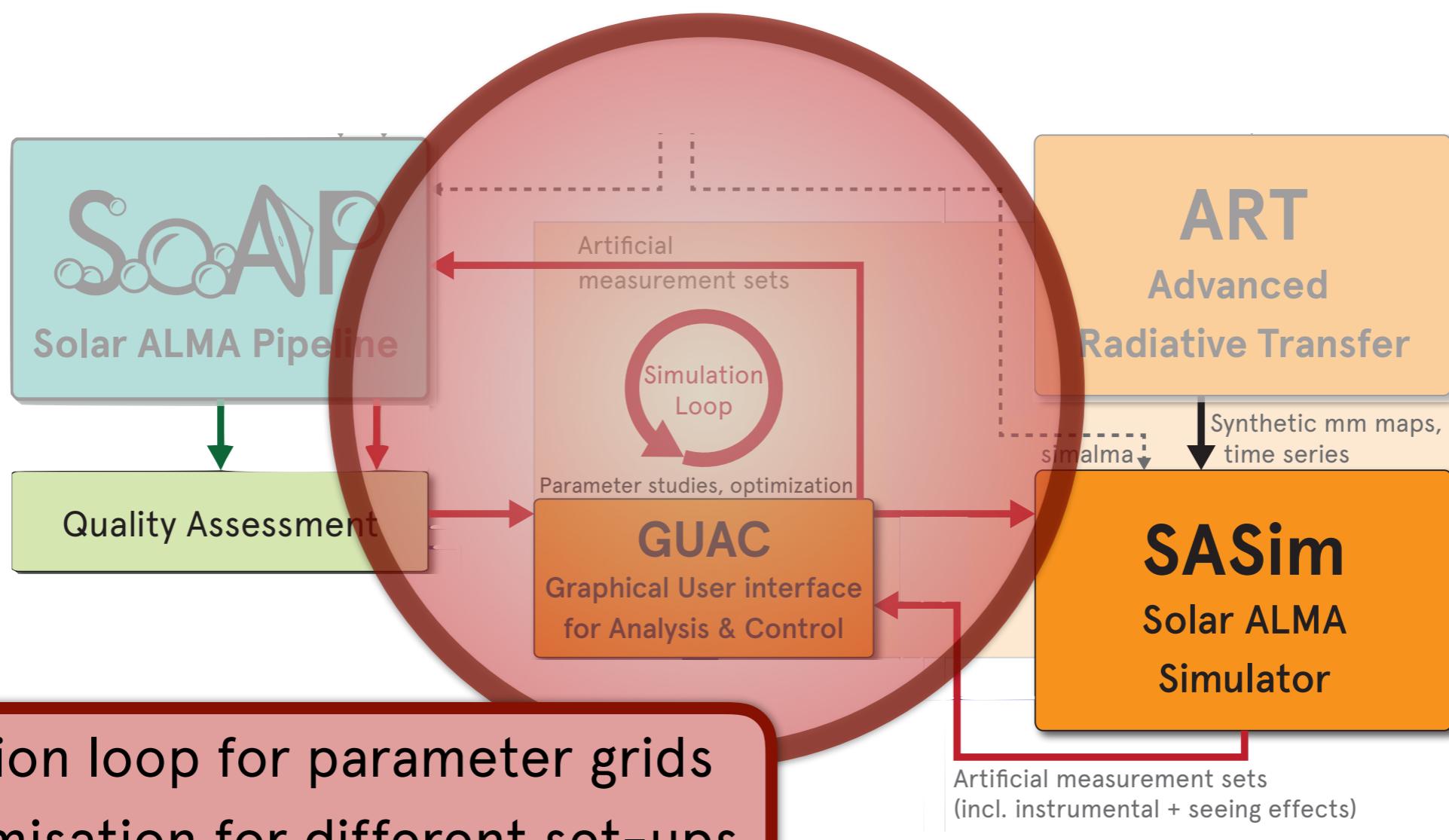
INTERACTIVE DATA VISUALISATION & ANALYSIS



SASIM

SOLAR ALMA SIMULATOR

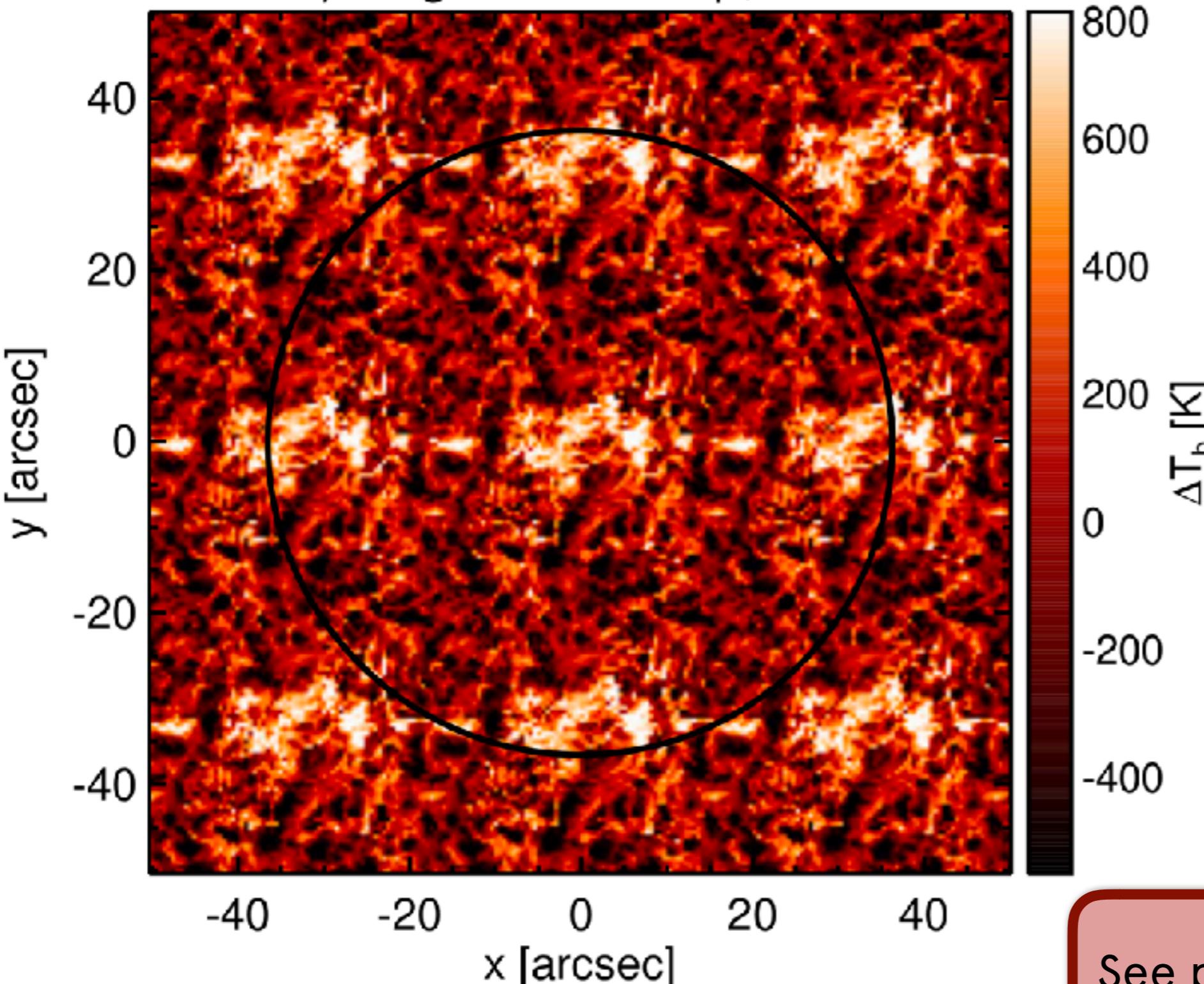
- Starting point: simalma
- Developed in connection with ESO ALMA Development Study
- Primary aim: simulation-based optimisation of high-cadence solar imaging



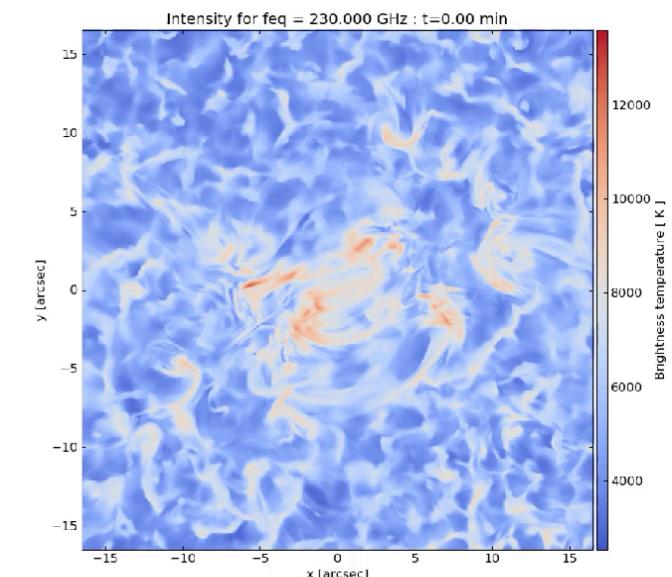
Band 3

One snapshot only

a) Original mm map, SB4



- Synthetic mm map (periodically repeated for increased extent)

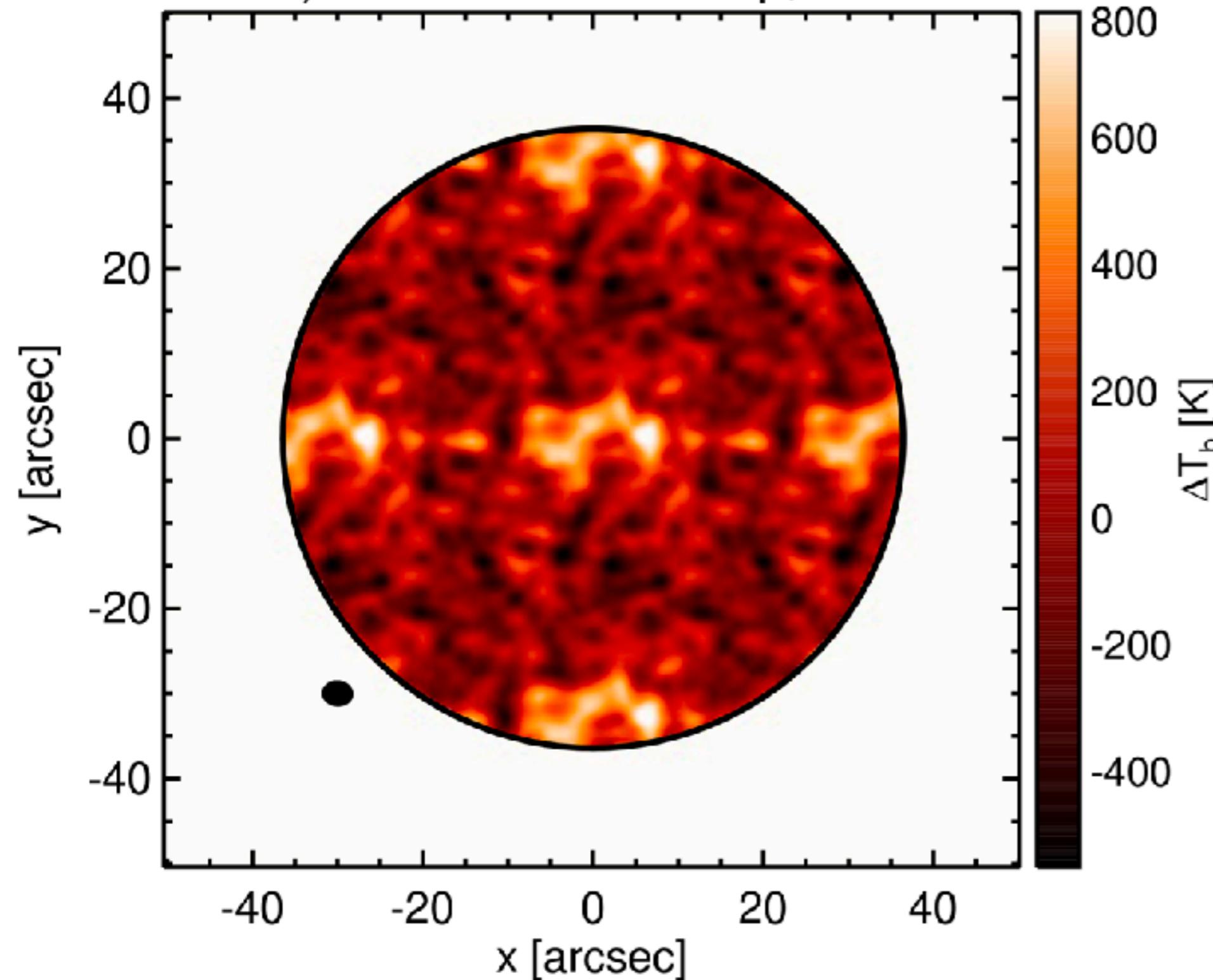


See poster by Henrik Eklund

FIRST EXPERIMENTS

Band 3

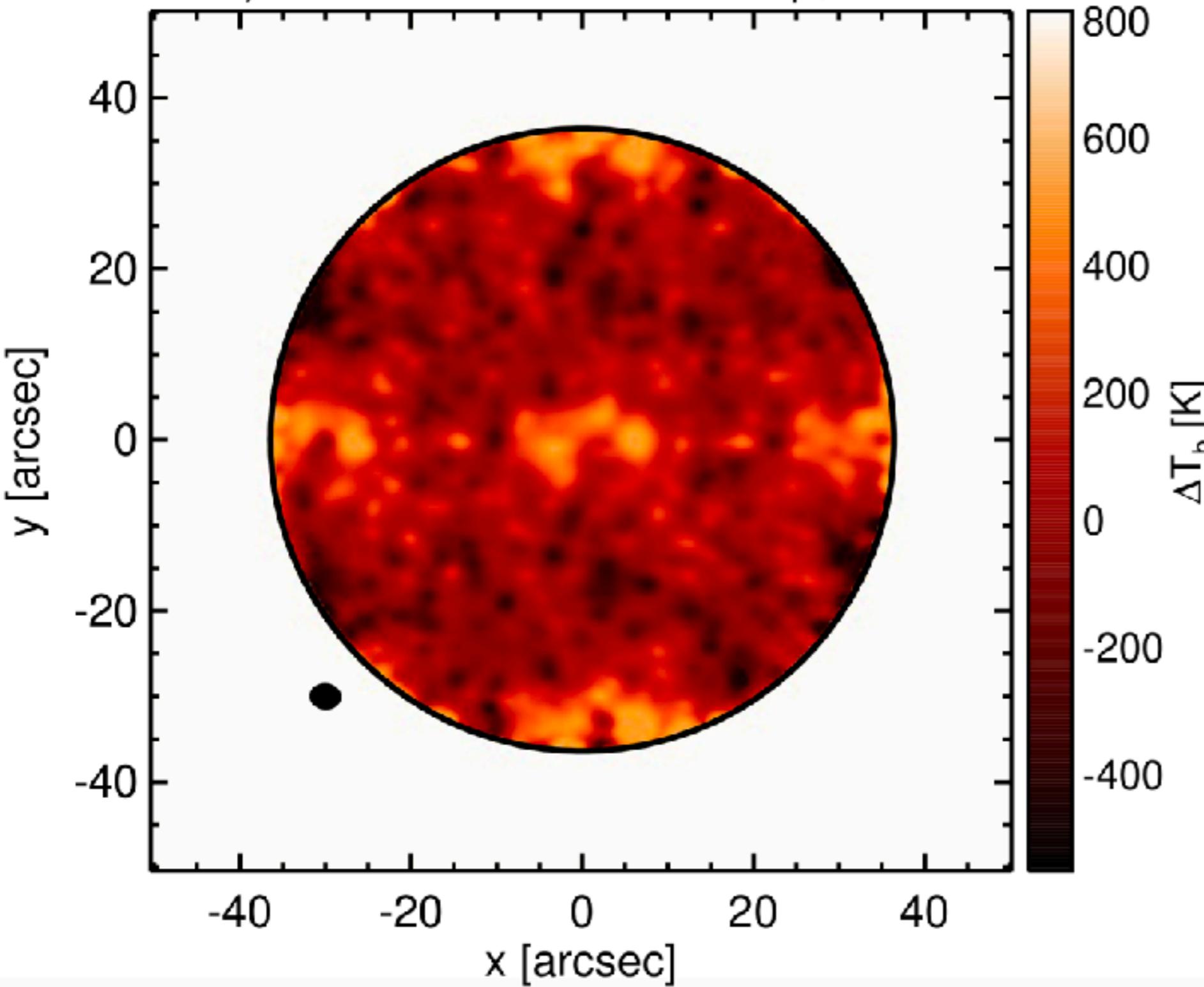
b) Convolved mm map, SB4



- Result for perfect image reconstruction and complete uv coverage
- Small scales lost here due to angular resolution and limited number of baselines

Band 3

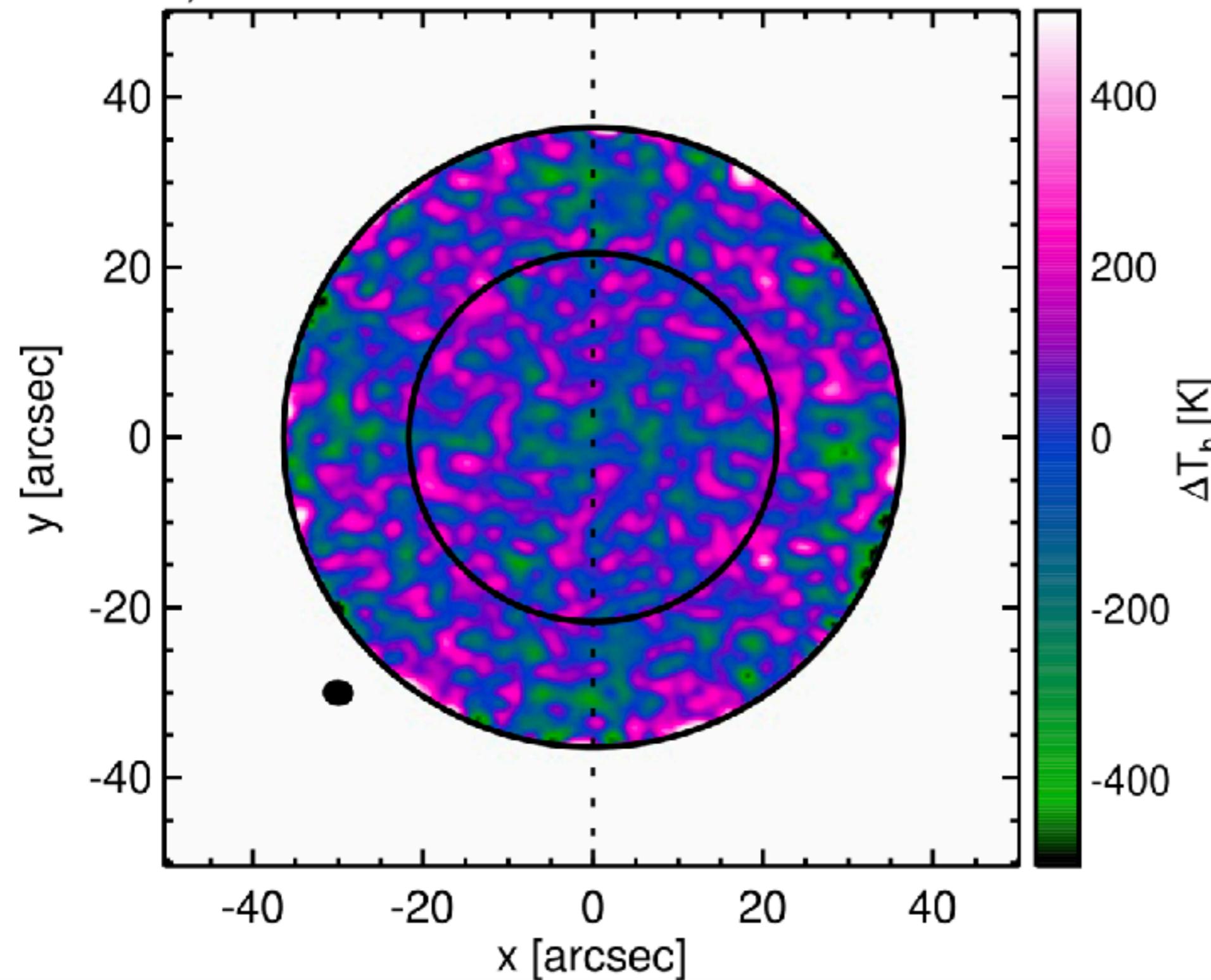
c) Reconstructed mm map, SB4



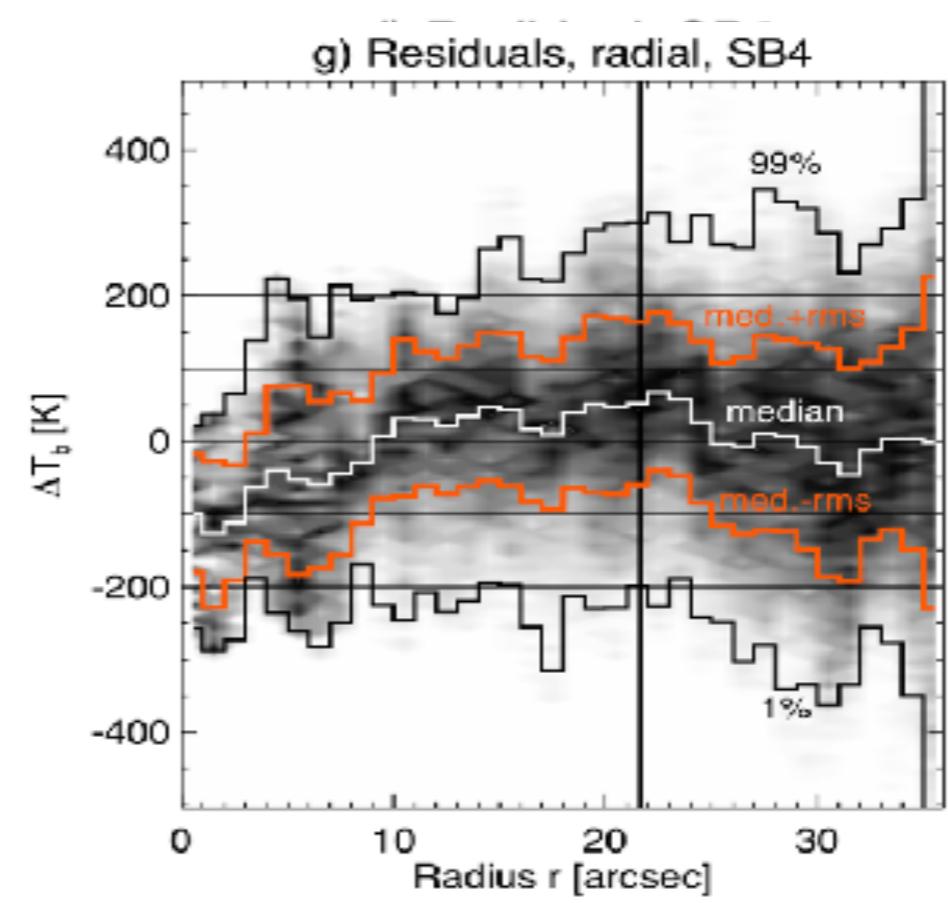
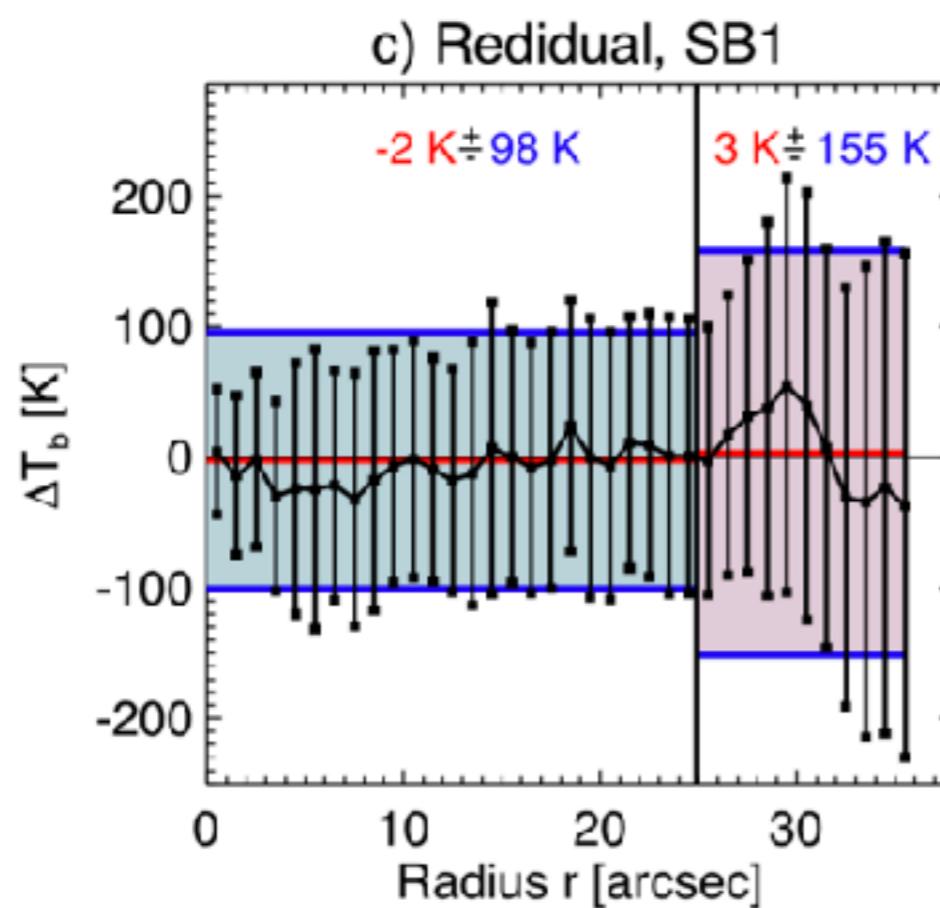
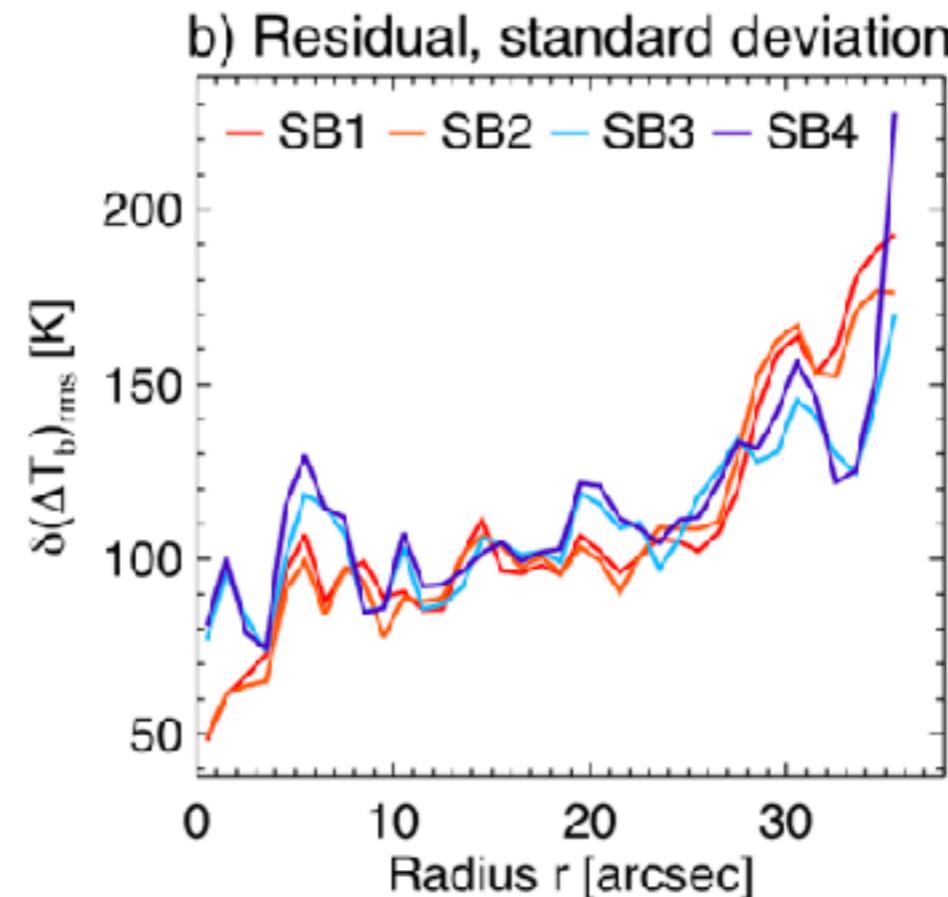
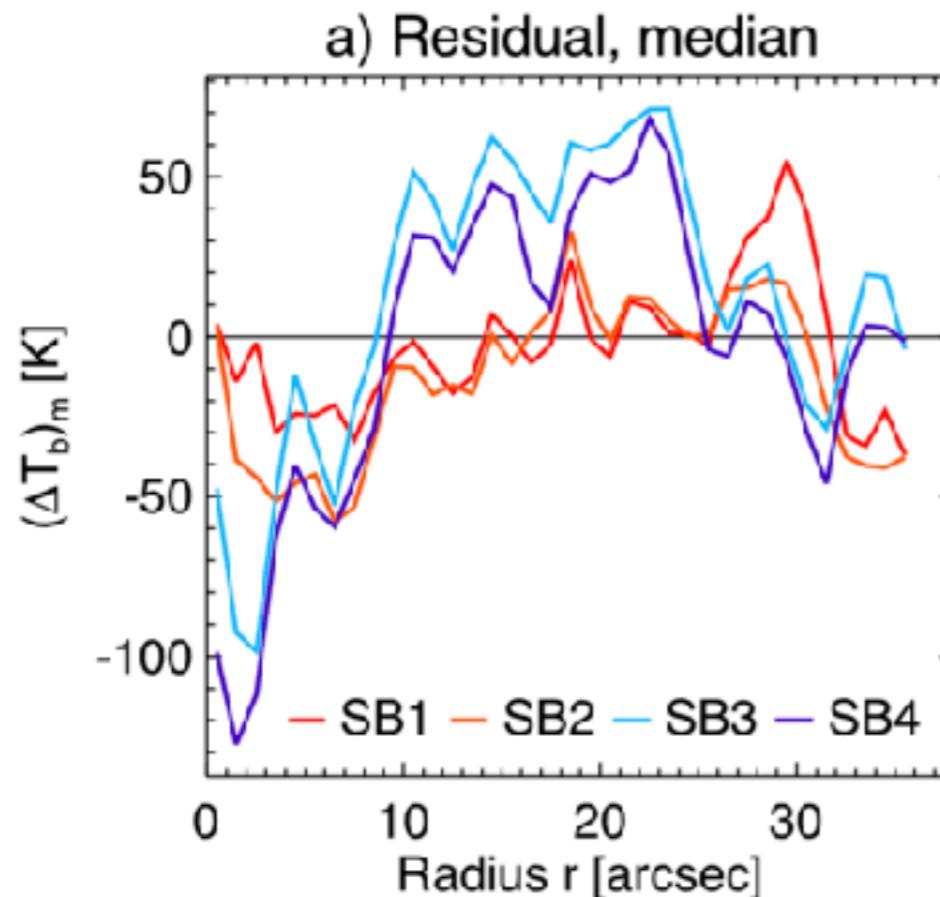
- Reconstructed map
- Same parameters as currently used for real Cycle 4 ALMA observations
- Reconstruction not perfect

Band 3

d) Residual: reconstructed - convolved



- Comparison of input and output
 - Residuals can be used as primary quality indicator
- To be repeated for parameter grid

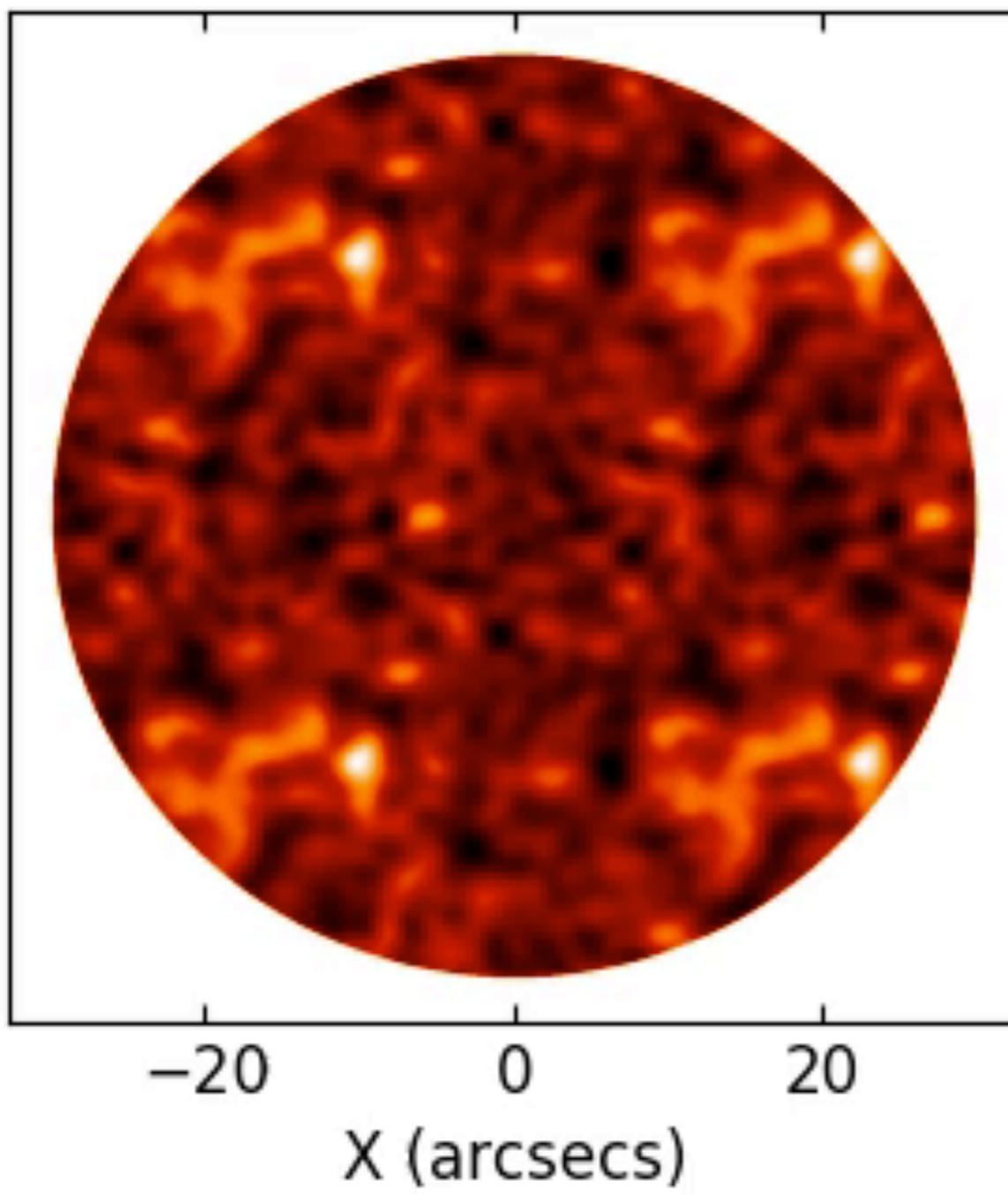


SASIM

SOLAR ALMA SIMULATOR

Case: Cycle 5.1

Convolved



ARRAY CONFIGURATION

Produced by Szydlarski, Gilchrist-Millar et al.

- To be developed into a versatile tool for testing new observing modes and optimised imaging of resulting data

OBSERVATIONS

- User-friendly data pipeline
- Optimisation for different scientific applications
- Co-alignment with other solar observations (ground-based/space-borne)
- Database for processed data for everybody (incl. non-expert users)

ANALYSIS & VISUALISATION

- User-friendly interactive tools
- Multi-purpose visualisation & analysis tools for various data products from observations and simulations
- Versatile tool library (python/CASA/IDL)

SIMULATIONS

- Realistic models of the solar atmosphere
- Detailed modelling of instrumental and seeing effects
- Simulation loop for testing and optimising imaging routines and new observing modes
- Artificial observations in support of interpretation of observations

OUTLOOK

- Development of tools for solar research with ALMA is an integral activity of the Rosseland Centre for Solar Physics.
 - Dedicated resources and efforts
 - International collaboration

★AIM: Providing easy access to science-ready data for the solar physics community



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