



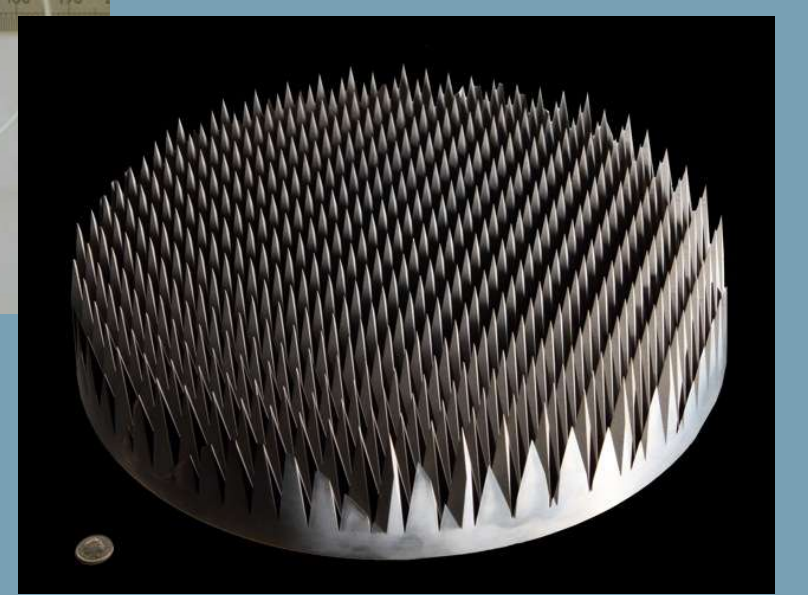
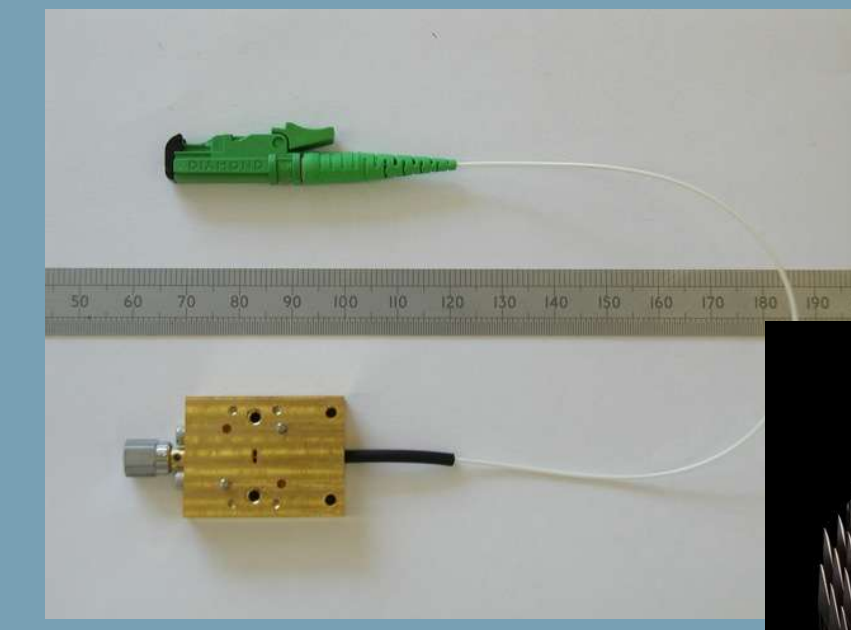
# ALMA Development in the UK

The STFC is undertaking a broad and vital technical contribution to the construction of the ALMA Observatory. The activities are performed within expert teams located at leading UK institutes, in close association with industry, and are overseen by the ALMA UK Project Office, which is located at the Rutherford Appleton Laboratory.

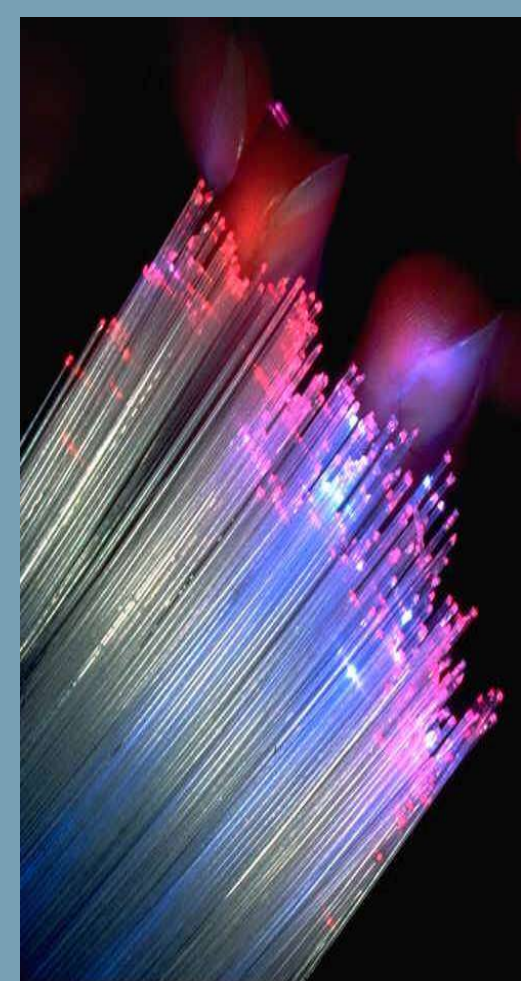
## Receiver Front-End Production Engineering



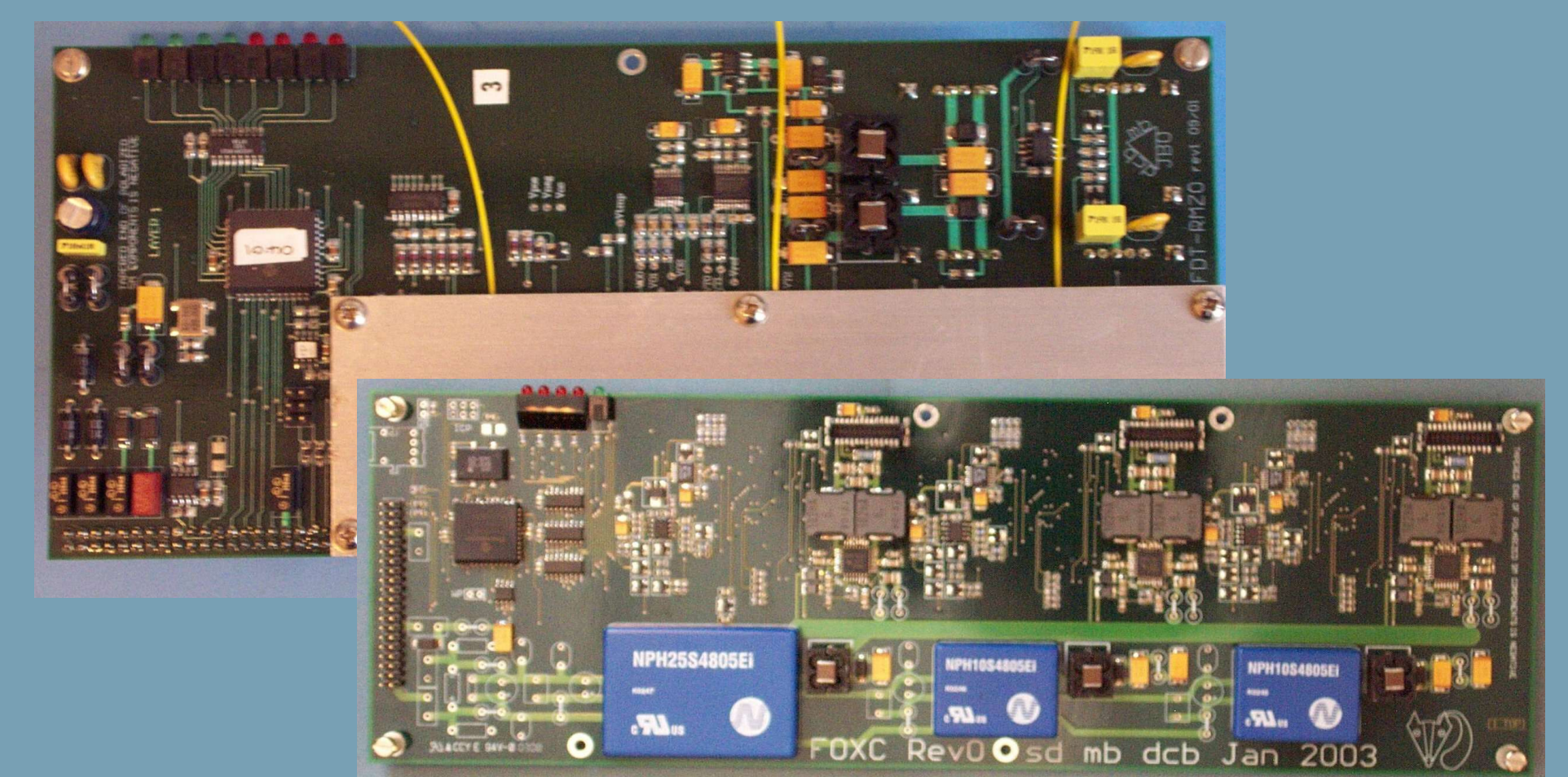
The Rutherford Appleton Laboratory (RAL) is supplying: receiver front-end cryogenic systems that are necessary to cool the sensitive receiving elements to temperatures as low as 4K; millimetre wave photomixers for the receiver phase reference, essential for maintaining coherence of the array (right upper image); prototype calibration loads, necessary for calibration of the instrument (right lower image). RAL is also hosting the European receiver Front-End Integration Centre, which performs integration and test of receiver systems. One of 26 such units, being prepared for shipping to Chile, is shown on the left.



## Data Transmission/Optical Fibre Management



ALMA data is delivered from each telescope to the correlator using an optical fibre transmitting 120 Gbps over distances of up to 20 km. Twelve laser diodes per telescope each produce 10 Gbps, all multiplexed onto a single fibre. The University of Manchester (JBO) designed the optical system, including receiver boards (upper right), transmitters (lower right), optical multiplexers, amplifiers and de-multiplexers. Overall system development was a cooperative effort between JBO and the US NRAO (who designed the digital components), sharing some aspects with the EVLA and e-MERLIN. The University of Kent, in addition to developing prototype optical comb generation technology, has contributed towards the complex task of optical fibre management at the ALMA site.



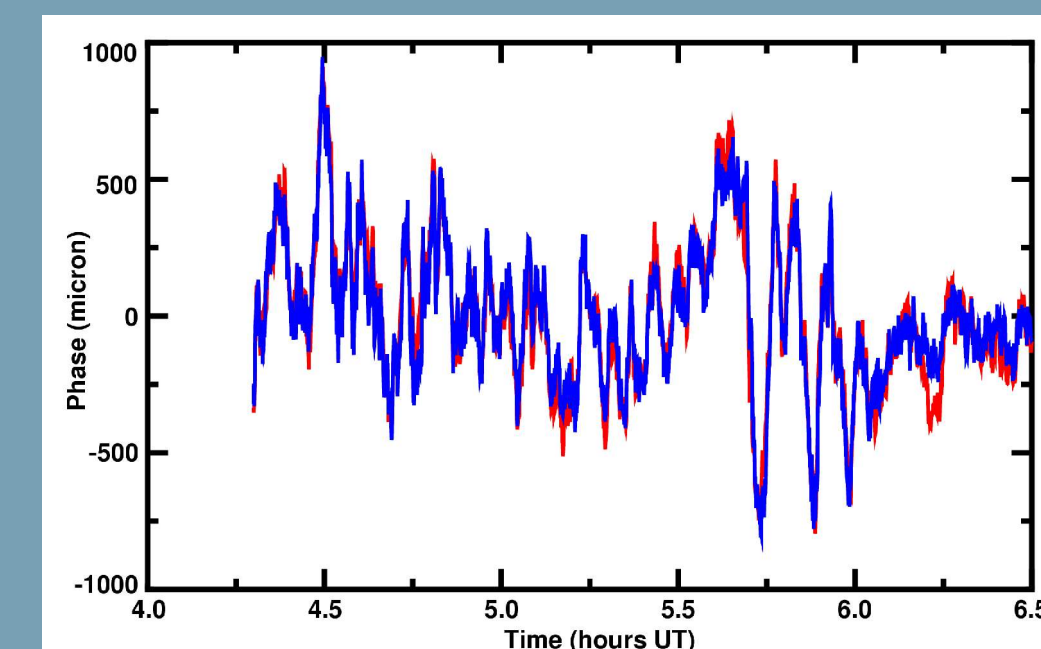
## Water Vapour Radiometry for Phase Correction



Phase corrections derived from measurements of atmospheric water vapour are crucial for ALMA observations. The University of Cambridge, in collaboration with Onsala Observatory, designed and built 2 prototype 183-GHz water vapour radiometers (WVR). Subsequently, they have led the effort to understand and simulate WVR-based phase correction techniques. Ongoing work involves developing advanced algorithms for radiometric phase correction (funded under the EU FP6) and procuring and commissioning additional instrumentation for the remote sensing of the atmosphere, e.g. via oxygen sounding.

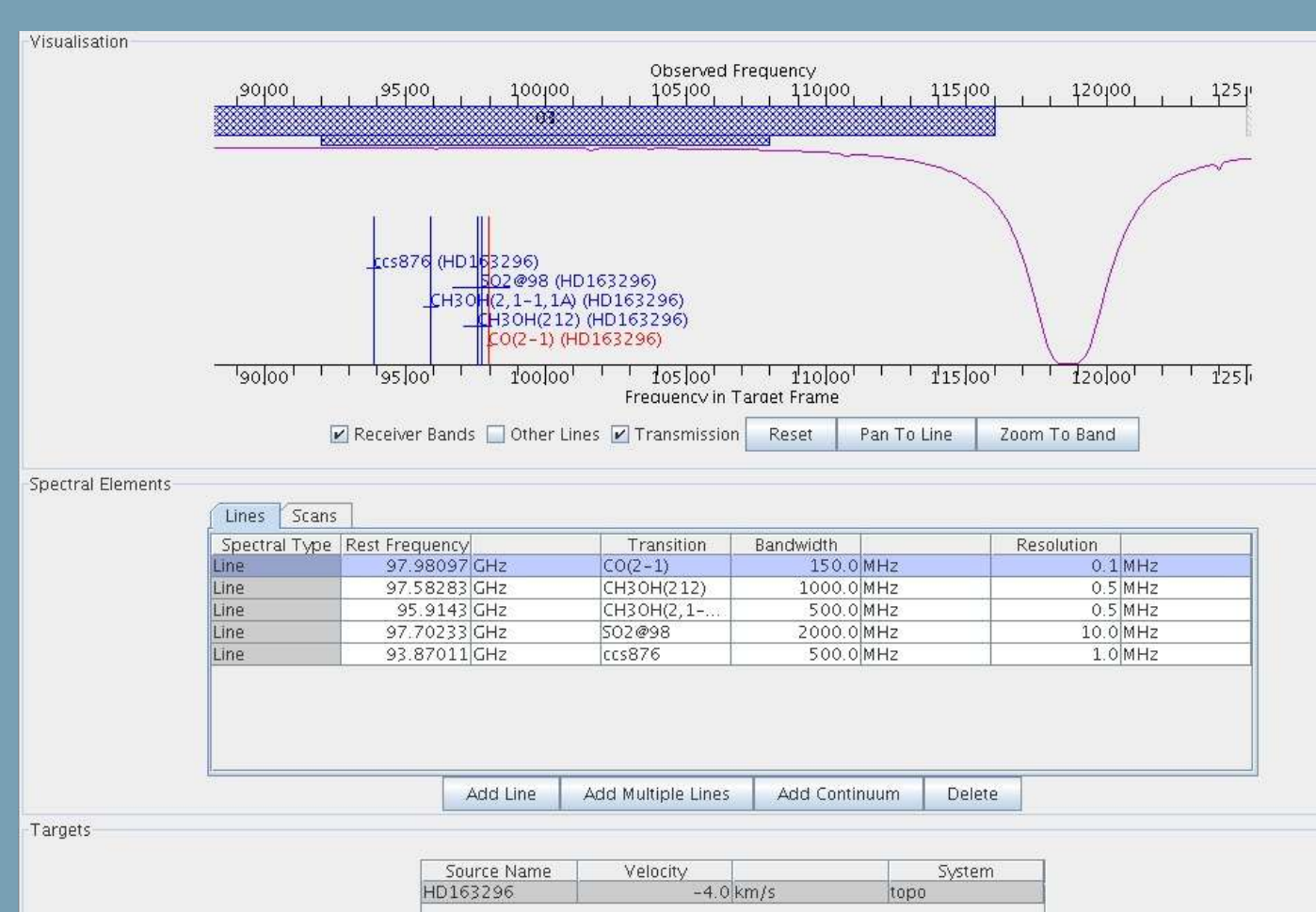


The WVR were tested in collaboration with the CfA who operate the SMA on Mauna Kea. The red line shows the observed phase whilst tracking a quasar. The blue line shows that the phase fluctuations predicted using the WVR are an excellent fit. The phase rms goes from 271  $\mu\text{m}$  to 75  $\mu\text{m}$  after correction.



## ALMA Observing Tool and Pipeline

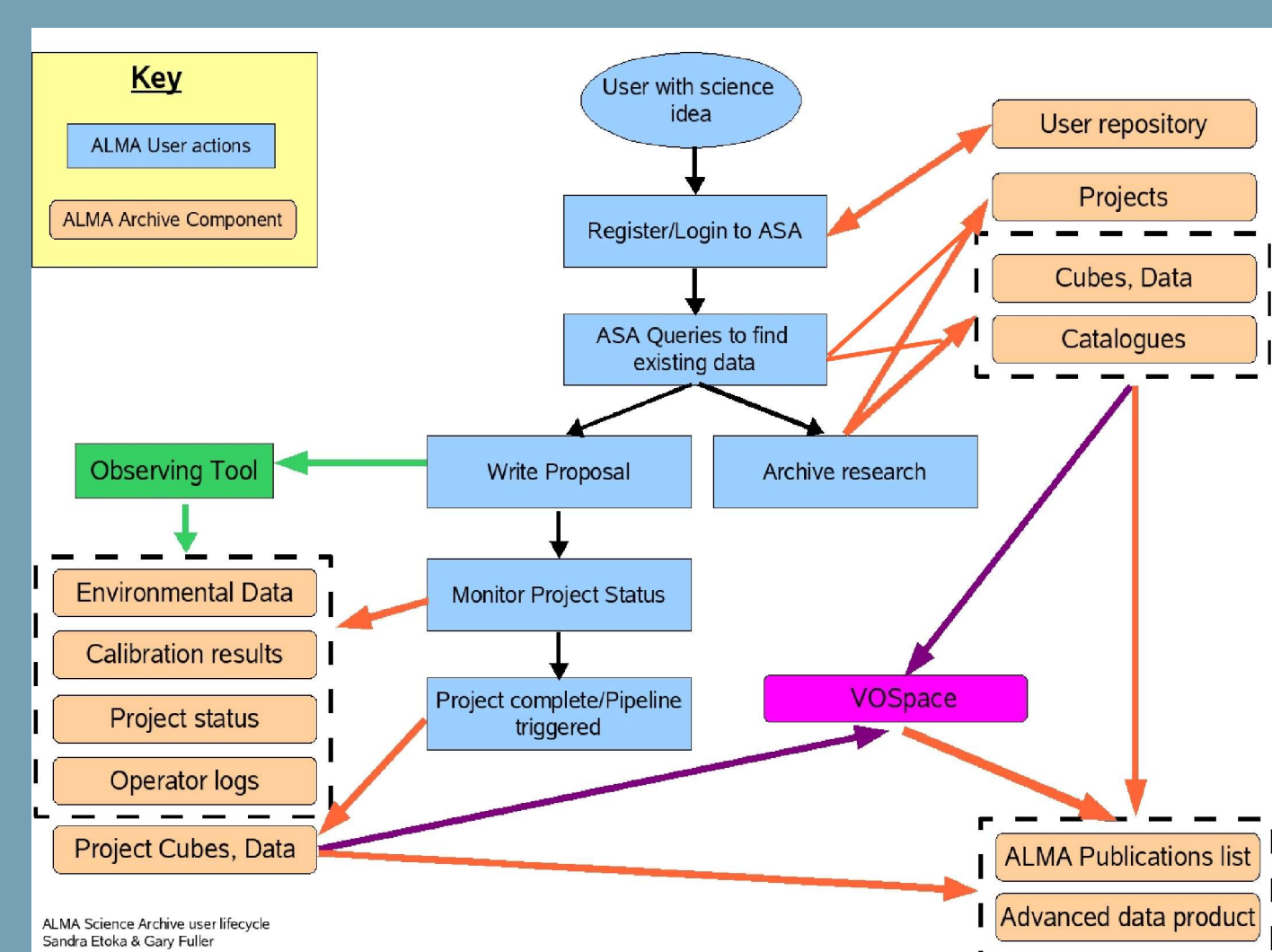
The UK ATC in Edinburgh is leading the development of the ALMA Observing Tool, in collaboration with developers from ESO and NAOJ. This software will provide the astronomer's primary interface with ALMA: an easy-to-use tool which will enable observers without prior experience of submillimetre wave aperture synthesis to create observing programmes that meet their science goals, whilst also supporting the needs of experienced observers.



The UK ATC is also playing a significant role in developing the Pipeline data reduction scripts. The high volume and complexity of ALMA data require automated processing. The pipeline will edit bad data, remove instrumental effects and derive and apply calibration. The system also generates logs to allow users to trace and verify the reduction process. The output will be in the form of images and spectra suitable for scientific analysis by astronomers.



## The ALMA Archive



The ALMA science archive (ASA) will ultimately reside in Chile, mirrored to the three main ALMA Regional Centres in the USA, Europe and Japan. It will contain: *Bulk data* from observations and science pipeline products; *Metadata* describing these; *Event data* logging instrumental and environmental information. All ALMA data will be accessible through its interface but the ASA provides optimised access for astronomers in a scientifically meaningful way. The European effort is coordinated by ESO. The University of Manchester is developing science requirements and use cases as well as providing data and handling methods for source, calibration, spectral and other catalogues.

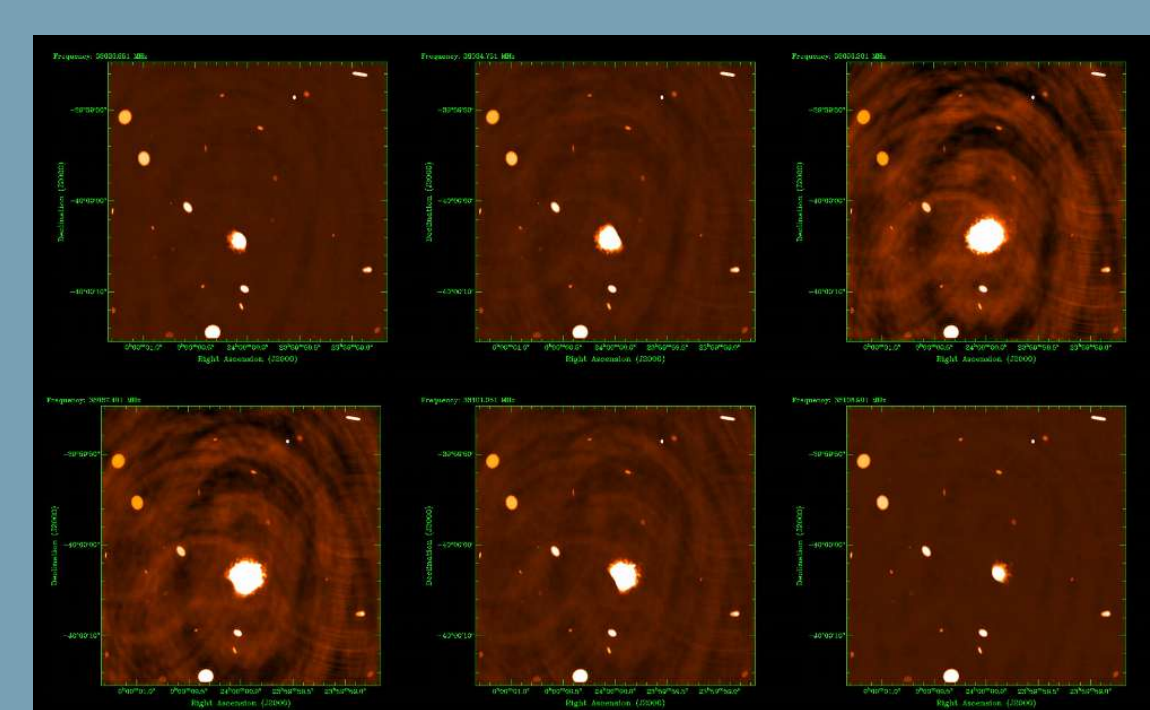
Astronomers will use the ASA to:

- Investigate whether appropriate data already exist and retrieve these if so;
- Extract information to help plan new observations;
- Retrieve science products from their observed data;
- Acquire supporting information to improve data quality and interpretation.



## Simulations for ALMA

Oxford University is creating simulations programs encompassing both instrumental simulations and models of the radio/sub-mm sky. They use current (AIPS) and next-generation (MeqTrees) packages. The framework incorporates atmospheric and other data corruption, primary beam effects and so on, at realistic levels for ALMA. Such simulated data sets predict plausible limits on the science returns for particular configurations and conditions. The extragalactic radio sky databases describe the properties of  $\sim 200$  million simulated galaxies out to  $z \sim 20$ . Continuum and line emission is included and additional galaxy properties can be applied.



Simulated ALMA CO cube for a galaxy at  $z \sim 2$ , plus continuum background sources.

Integrated intensity of simulated CO sources over a 2-arcmin field from the Semi-Analytic eXtragalactic database (SAX, Obreschow et al. in prep, 2009). The frequency range of 30-80 GHz corresponds to the CO J 1-0 transition at  $0.438 < z < 2.833$ .

