ALMA Development

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24th Mar 2009

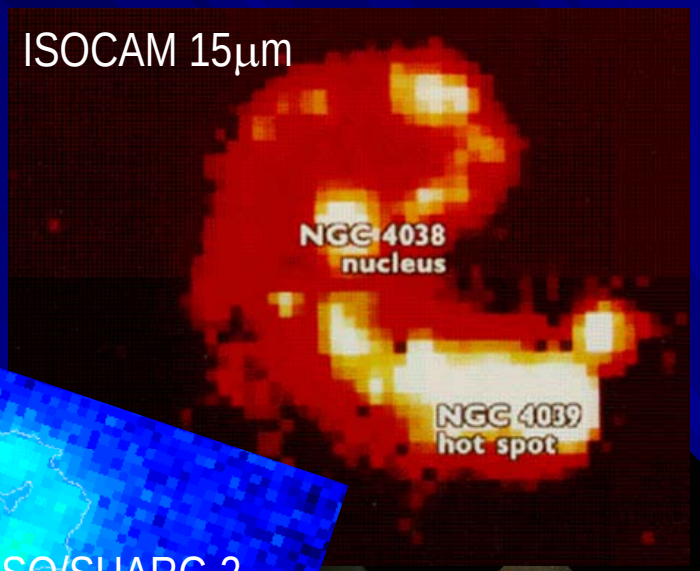
ESO Garching

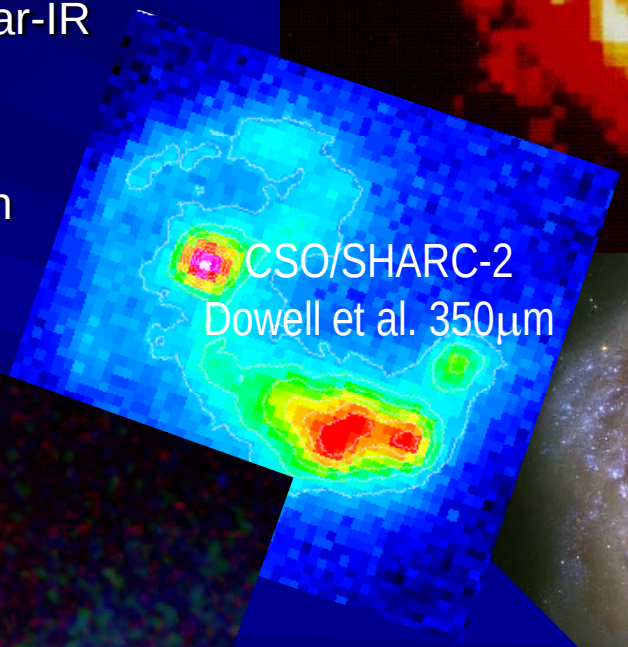
Contents

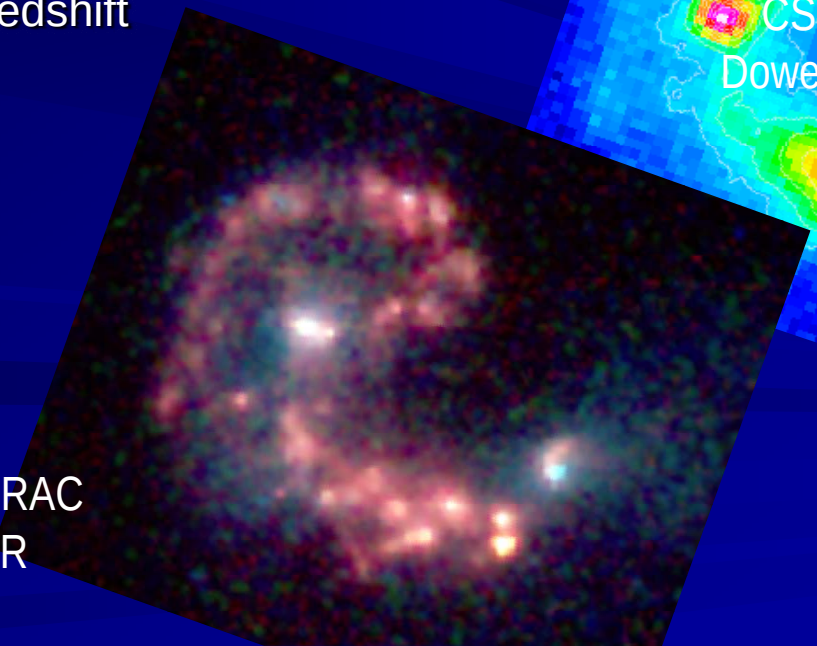
- ALMA will be ‘transformational’ and unprecedented
  - Order of magnitude improvement in sensitivity, resolution, image fidelity and cost
  - Probe the detailed astrophysics of the ISM in normal high-redshift galaxies
  - Reveal low-mass star formation anywhere in the Galaxy
  - Match *HST, JWST* resolution, natural match to deep AO observations
  - All ALMA partners have assigned support for developing the array
- How to develop
  - Those already in the RSM community: hard to see what we’re going to need to learn
  - Those welcomed into RSM community: new ground, and tough to foresee too
  - Motivated by science requirements
- Special features of ALMA for development
  - Need a full suite of XXX: interferometer, existing arrays can test ideas
  - Receivers are already really good
  - Industrial process
- Immediate possibilities
  - Subarrays, solar optics, VLBI compatibility, phase correction tools
- Longer-term possibilities
  - New bands, multi-receiver operation, multi-beam feeds
- Efficiency gains
  - Software tools, weather forecasting, incremental Rx improvements, $N_{antenna}$

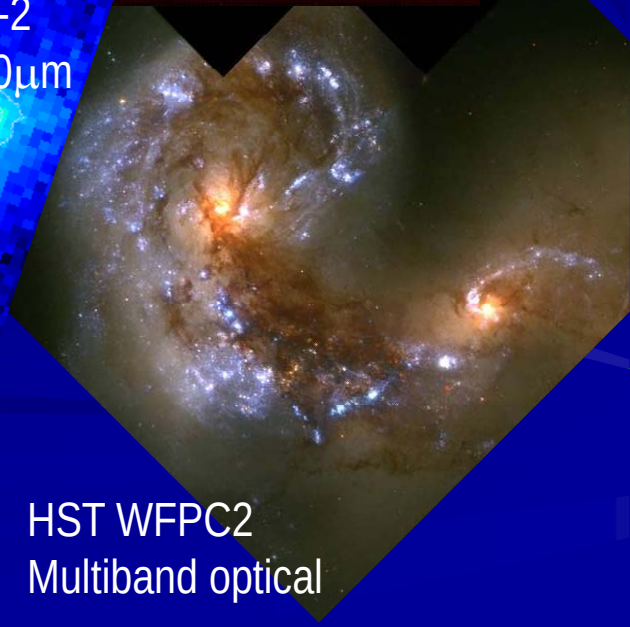
Resolved ‘example’: the Antennae

- Excellent example of distinct opt/UV and IR luminosity; BUT modest luminosity
- Interaction long known, but great IRAS luminosity unexpected
  - ~90% energy escapes at far-IR wavelengths
- Resolved images important
  - Relevant scales ~1” at high redshift







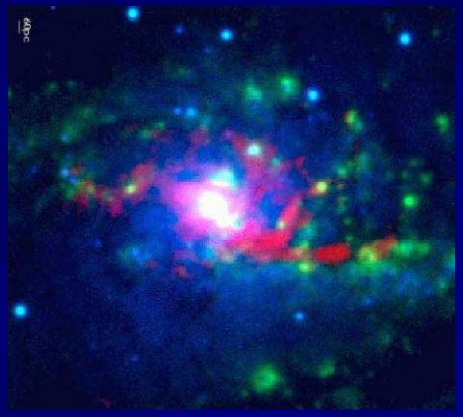


Current ALMA

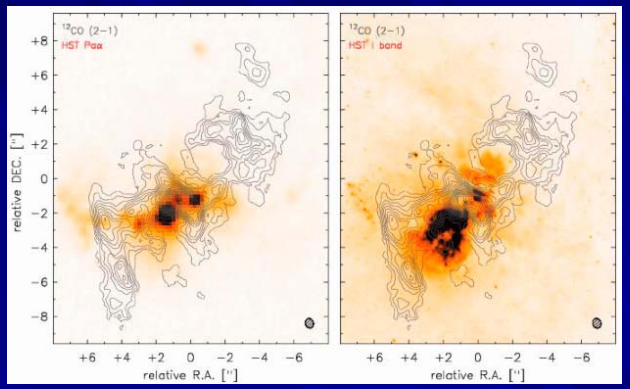
- Descoped in 2005, review chaired by Roger Blandford
  - 3 primary science drivers
  - MW at z~3 in 24 hours (area)
  - velocity structure in protostar/disk at 150pc (baseline)
  - imaging quality 0.1% on 0.1” scale (configuration)
- Science requirements currently being reviewed within project
  - To announce milestones, test deliverables
- 50 antennas, bands 3-10; 3,6,7,9 initially, 5 partial.

Local example of best results

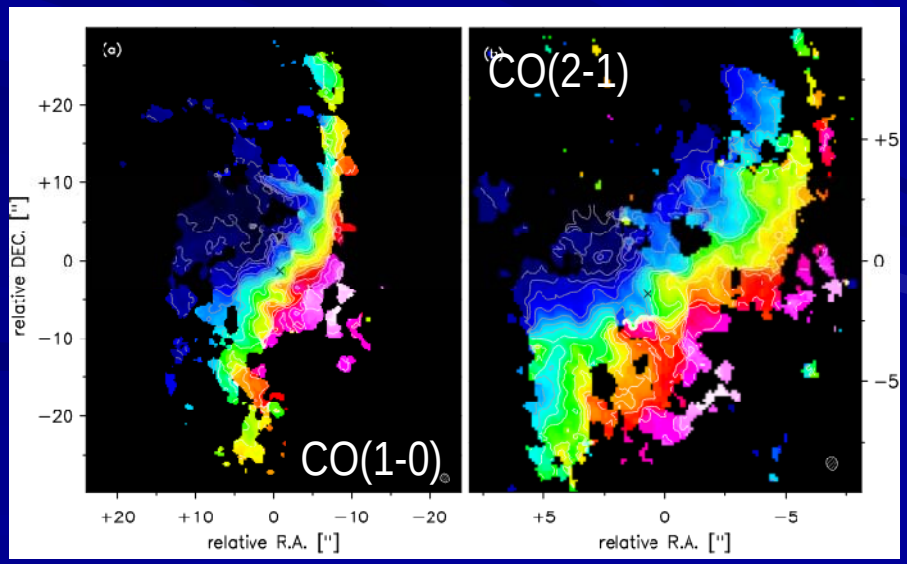
- IRAM PdB CO in NGC 6946 (Schinner et al. 2006)
- Spatial structure & gas dynamics
- ALMA can probe at z~3
  - Resolution
  - Primary beam
- Note synergy with eVLA/eMERLIN
  - Ultimately SKA



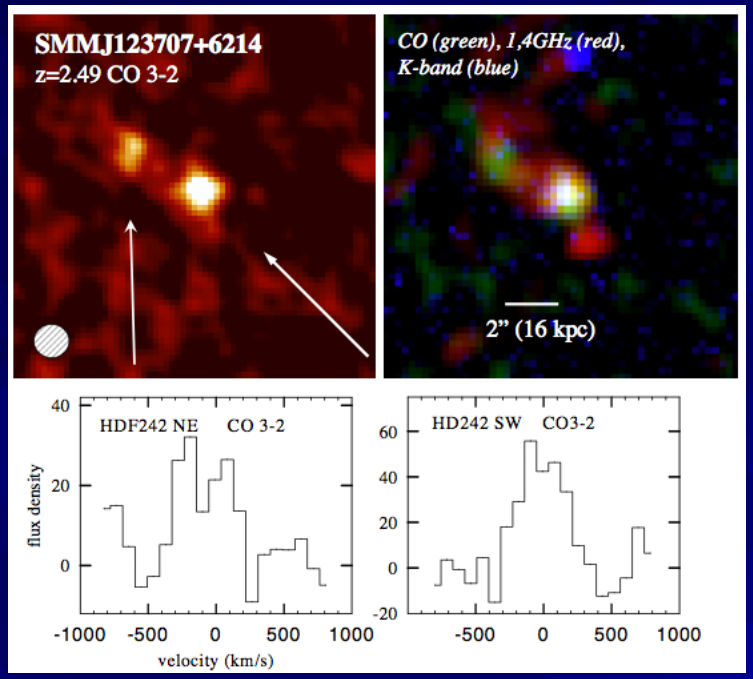
Red: CO; green: Hα; blue: continuum



CO(2-1) contours
HST: Paα & I band

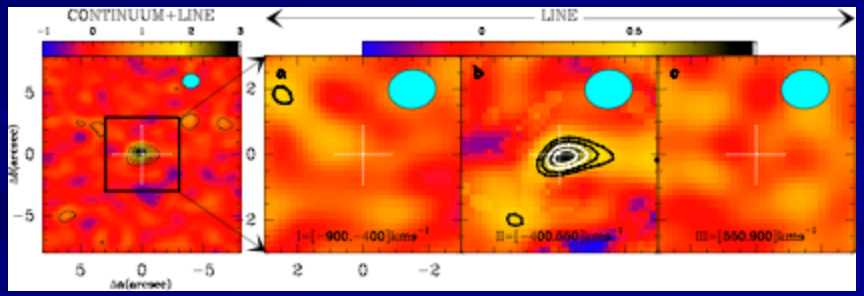


Best performance now - distant



Genzel/Tacconi et al PdB

- Only marginal spatial resolution possible
- Spectral bandwidth narrow
- Situation will improve dramatically with ALMA, a step in imaging quality tested at CARMA & IRAM



8'x8' field PdB HCO^+(5-4) Garica-Burillo et al (2006)

Development process

- ASAC, regional SACs, ad hoc working group
  - Charged by ALMA board to develop plan
  - Initial search for science drivers (hopefully complete)
  - Recent prioiritization
- Wide range of cost, timescale, interdependencies
  - Add more antennas?
  - Complete Band 5, add Band 1,2 & 11 (THz)
  - Revise correlator
  - Software tools, for efficient use & analysis

Ideas and priorities

- Immediate possibilities
  - Return to 6 (4 science) subarrays: comets/planets
  - Solar sub-illumination optics
  - VLBI compatibility: Galactic center imaging
  - Atmospheric phase correction tools
- Longer-term possibilities
  - New bands: 5, then 1, 2 & 11: water, high-redshift galaxies, protostar power
  - multi-receiver operation: transients, solar system objects
  - Wider-bandwidth receivers, more high-resolution correlator output: high-z galaxies
  - multi-beam feeds, especially at high frequencies: mapping nearby galaxies
  - Require more powerful correlator to get most out of these developments
  - Longer baselines: masers, inner protostellar disks
- Efficiency gains: for all science areas
  - Software tools for analysis, archiving, correlator setup
  - Weather forecasting/operations planing
  - Incremental Rx improvements, during maintenance?
  - $N_{antenna}$

Next steps

- US decadal process / economic stimulus
  - This year
  - Also, French review process underway
- More ideas from community (&ELT community?)
- Timescale for developments is very flexible
  - Initial baseline ALMA is a great tool. Nevertheless it's not perfect
- Work to maintain skills & capability
- Spitzer archive. Herschel results. WISE results
- Your contribution. Via me / ASAC
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