

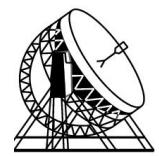
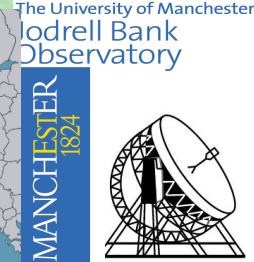
Spectral issues

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- Wide bandpasses
- Calibration transfer
- Continuum subtraction
- Dynamic range in narrow channels
- Combining arrays
- Multi-channel cleaning
- Make 'doable' fast & easy



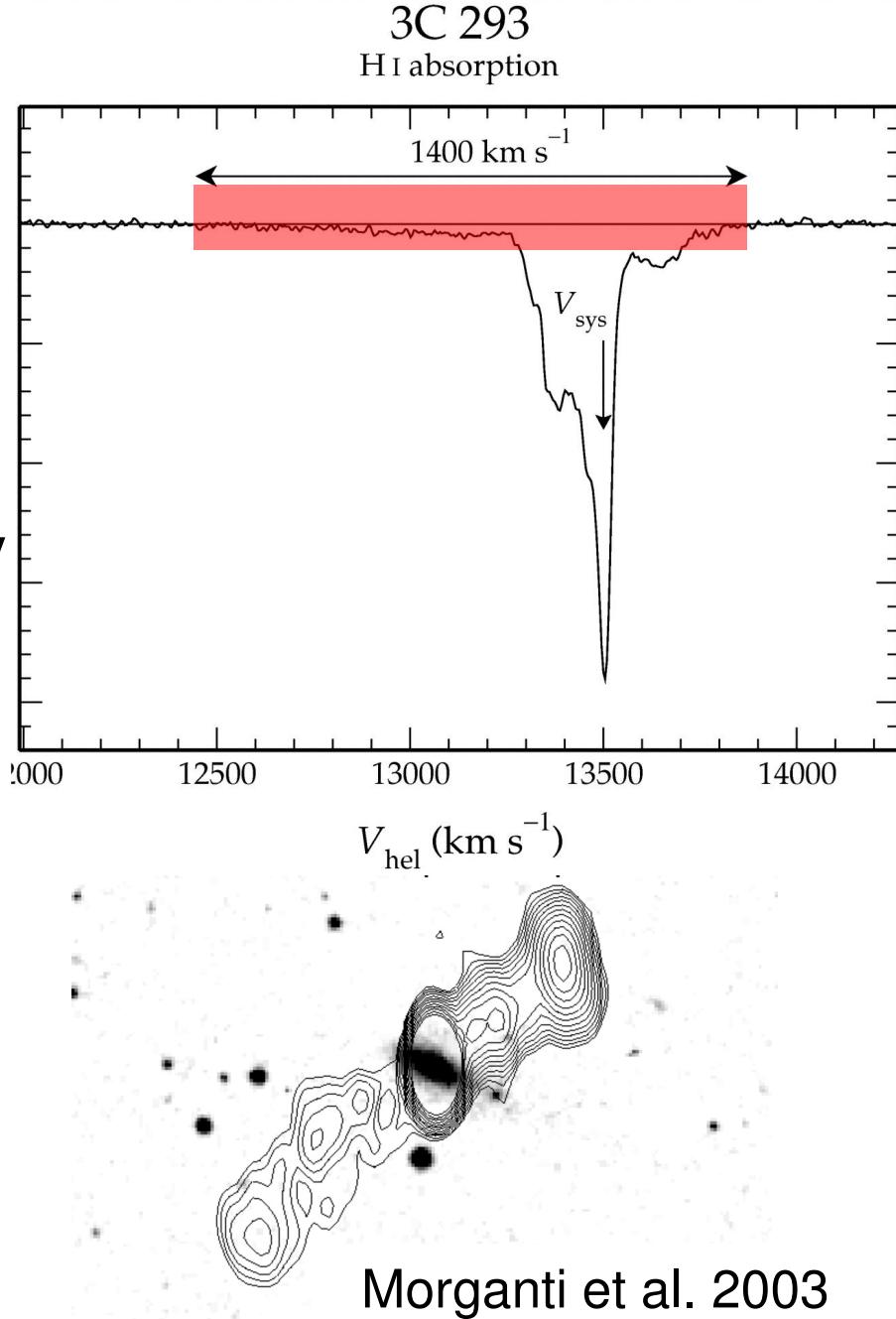
Hanny's Voorwerp and IC 2497: Dan Smith,
Peter Herbert, Matt Jarvis & the ING



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Ultra-wide lines

- Thousands km/s
 - Few km/s resolution
 - Very wide, shallow wings
 - WSRT flattens bandpass by shifting central frequencies
- Need absolutely flat band
 - Distinguish instrumental and astrophysical ripples
- Can we take guesswork out of fitting polynomials?
 - 'Search' facility in BP task?
 - Check synthesised BP?

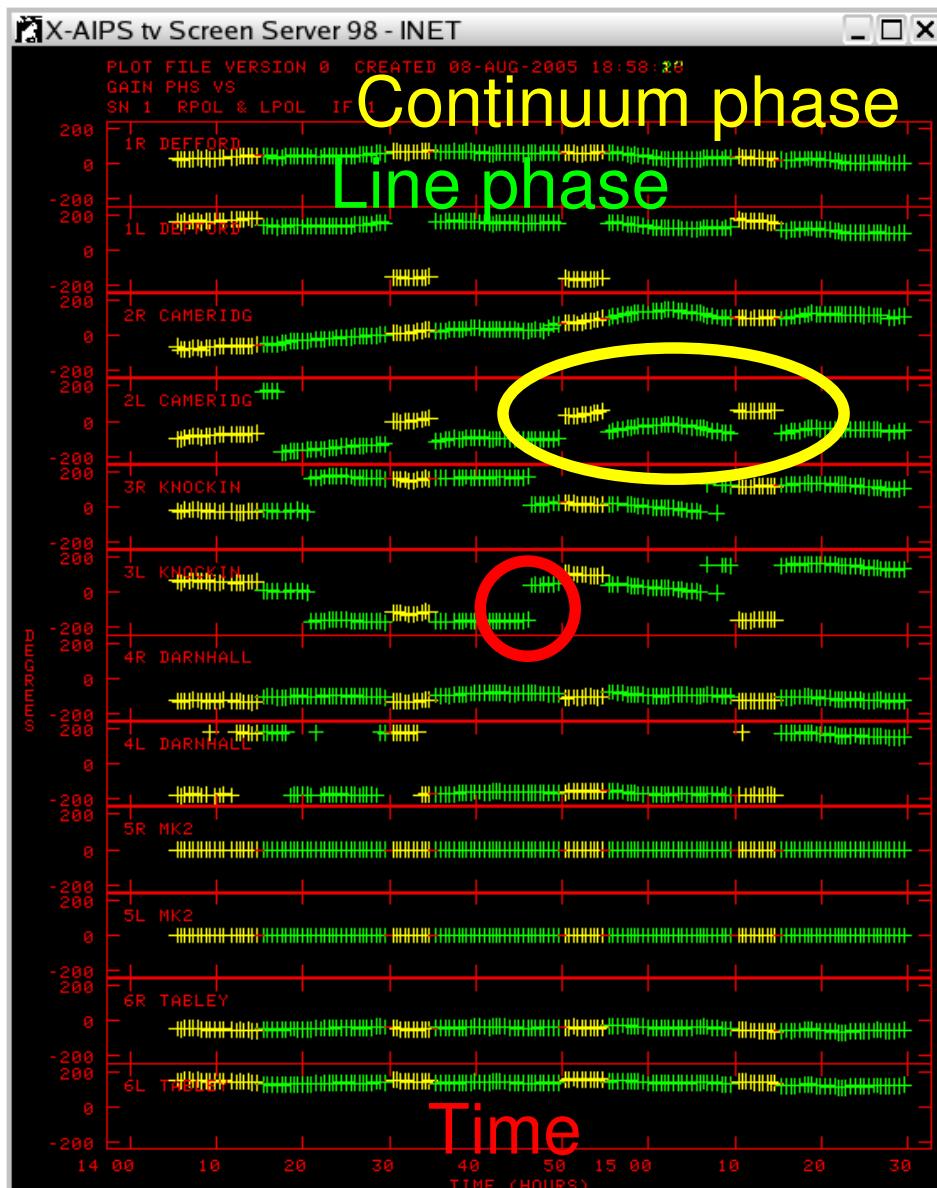


Long-baselines &/or large D/ λ

- Similar issues for any multi-chan interferometry
 - Stability and consistency in wide bands/fields
 - Required for continuum and spectral imaging
- High spatial/spectral resolution > sparse *uv*-plane
 - Long baselines/narrow channels
 - Dynamic range limitations
- Instrumental (& atmospheric) effects (high v)
 - Different solution intervals
 - Multiple BP cal sources
 - Numerical precision effects
 - Need incremental BP solutions
- $\sim \infty$ config. combinations in multiple sub-bands
 - Can't afford to hand-craft every variant

Wide/multi band calibration

- Transfer phase-reference &/or self-cal solutions
 - Not necessarily adjacent
 - Phase-ref \leftrightarrow line target
 - OH 1612/1667
 - Align ALMA lines
 - Slopes and **jumps**
 - Find **offset** stability timescales
 - Multi-config observations of BP cal sources
 - Crucial to select good data



Bandpass errors

- Delay, amplitude and phase
 - Multiple sub-bands, not necessarily adjacent
 - Multi-band delay, clock errors not covered here (?)
- Errors over relatively large $\Delta\nu$ /multiple channels
 - Instrumental slope (including Rx saturation)
 - Atmospheric transmission
- Errors in narrow channels
 - Averaging data with uncalibrated time-dependent phase/amp errors
 - Correlator/filter glitches
 - RFI/telluric lines
- Transfer calibration across up to ~30% $\Delta\nu$
 - Continuous or from non-adjacent sub-bands
 - Between different pointings and/or bands

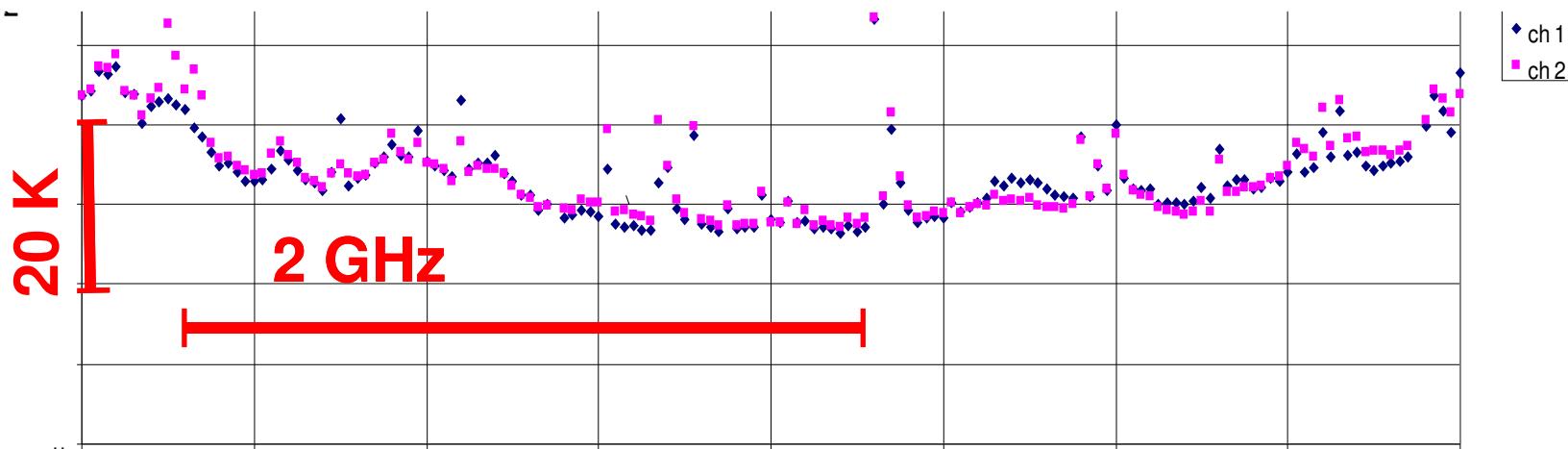
Bandpass calibration



- Signal-to-noise on BP cal(s) must > target snr
 - Model whole BP field to required sensitivity
 - Phase, amplitude self-cal as required incl. SED
 - Lines in ~all fields at some ALMA frequencies?
 - Channel width/sensitivity may vary 100-/10-fold
 - What is implication of using too sensitive a model?
- Narrow channel problem: $\sigma_{\text{rms}}(n\delta\nu) > \sigma_{\text{rms}}(\delta\nu)/\sqrt{n}$
 - Bandpass cal data too noisy
 - Delay errors
 - Digitisation noise
 - Dynamic range/deconvolution issues?

Bandpass sensitivity

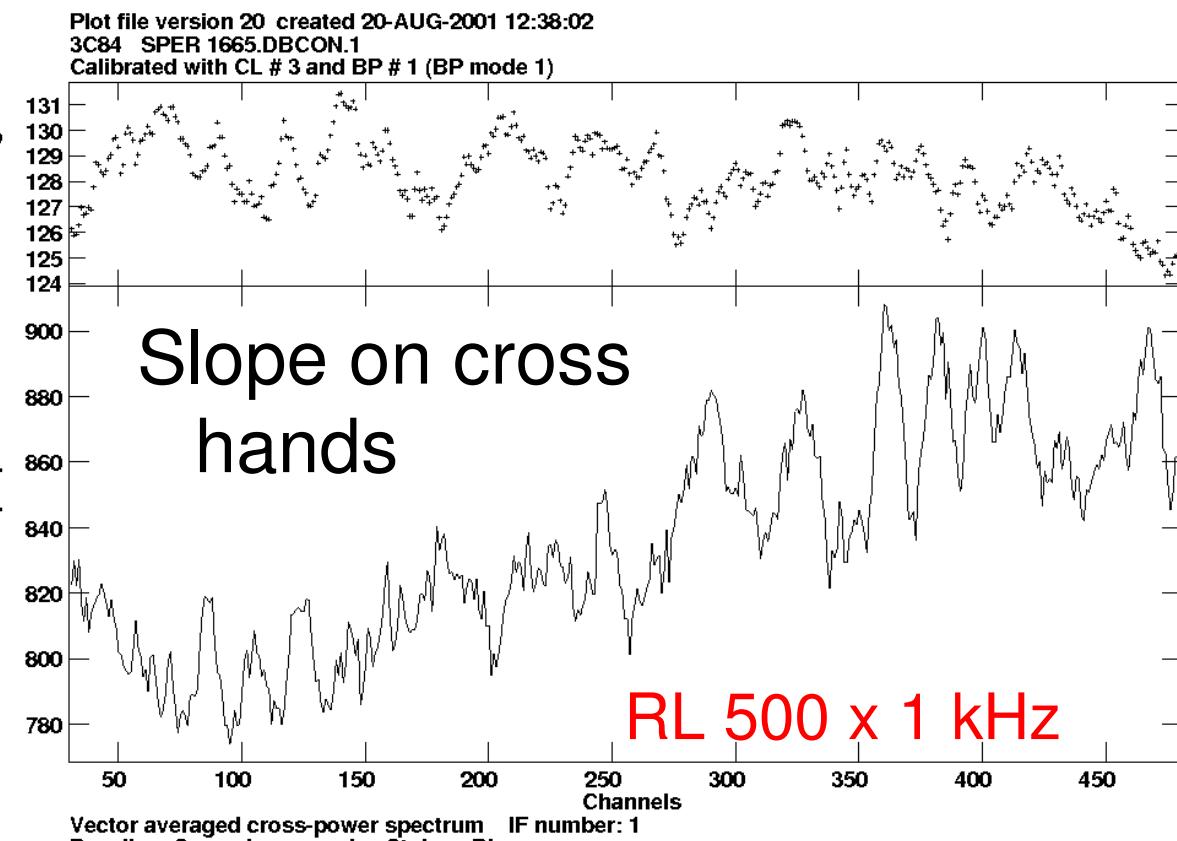
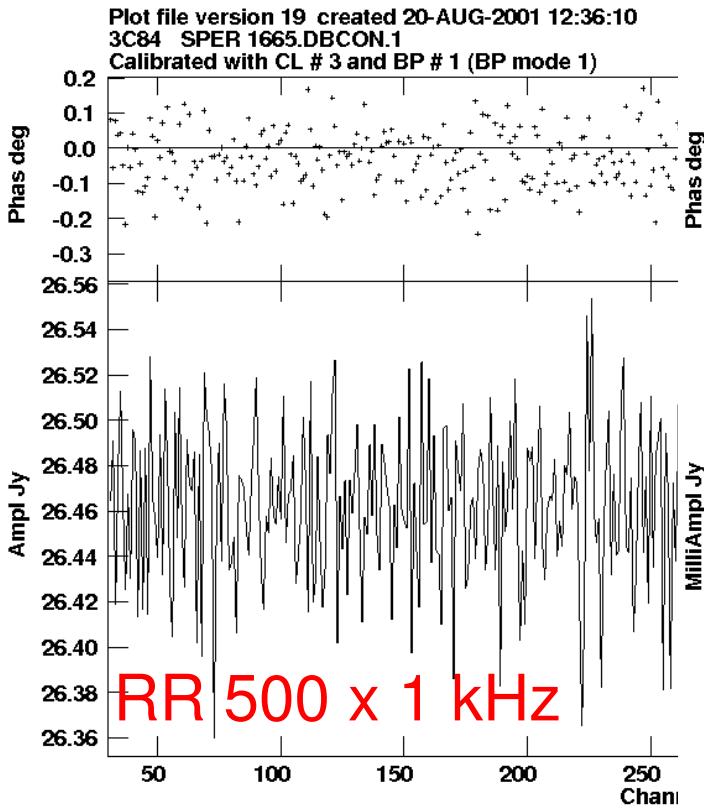
- Changes in instrumental sensitivity
 - 16 e-MERLIN sub-bands
 - Lowest or highest may be ~20% less sensitive
 - How do you know to go for uniform noise or flux scale?
 - Do you have the choice?



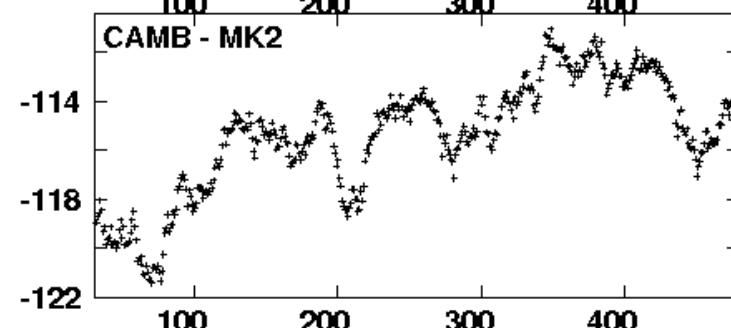
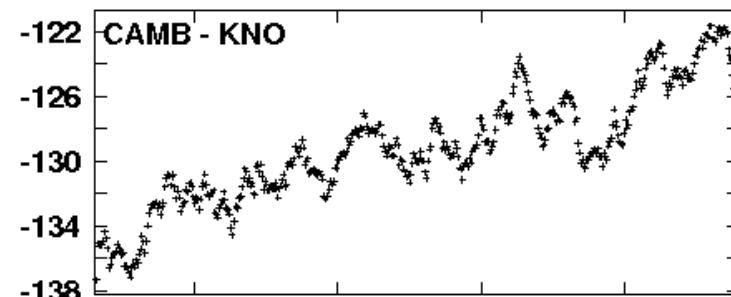
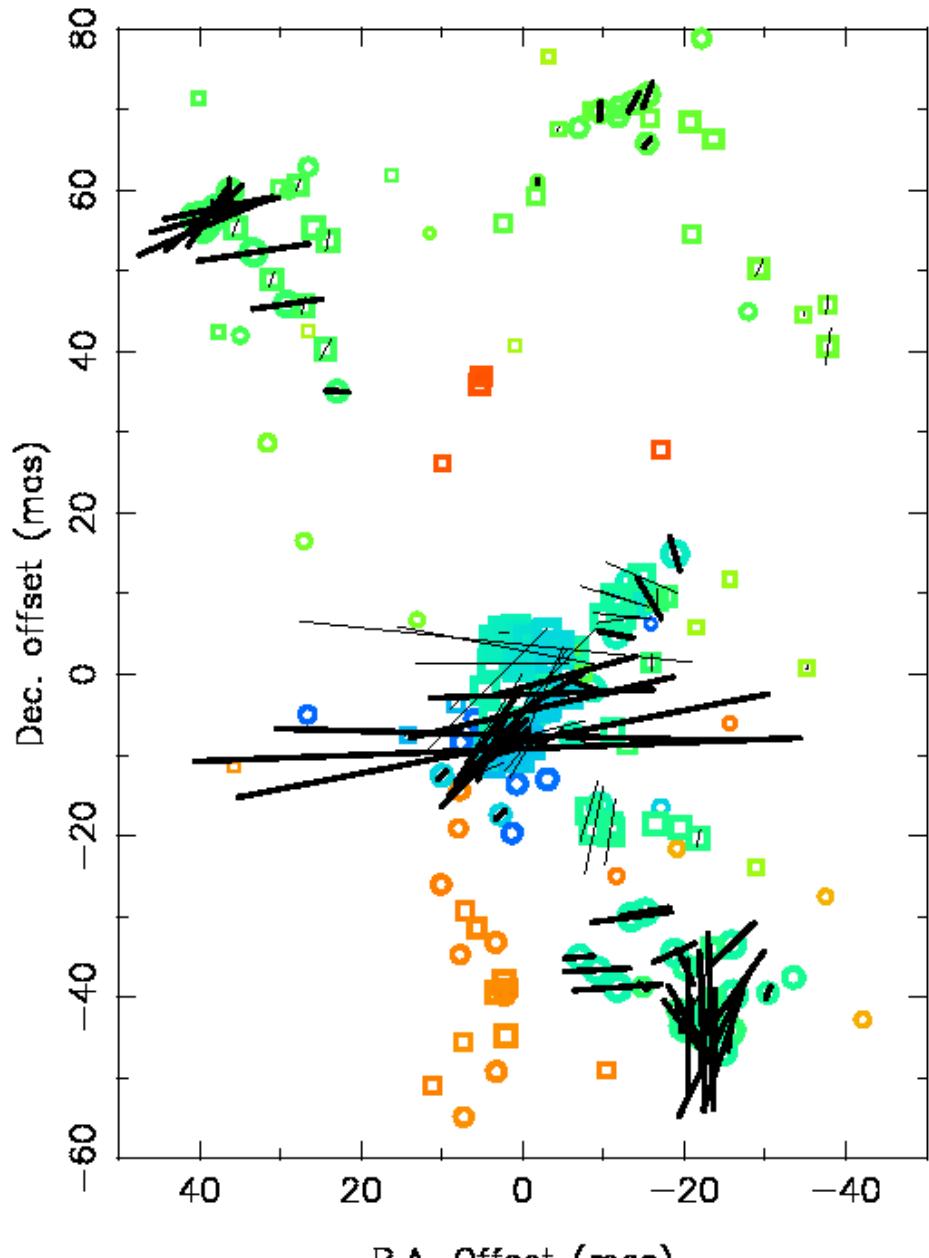
- Weighting for heterogeneous arrays
 - Need flexibility e.g. by antenna not sample

Polarization

- (Spectral line. VLBI. Polarization. AARGHHHHH!)
- Flattened bandpass in parallel hands



Polarization



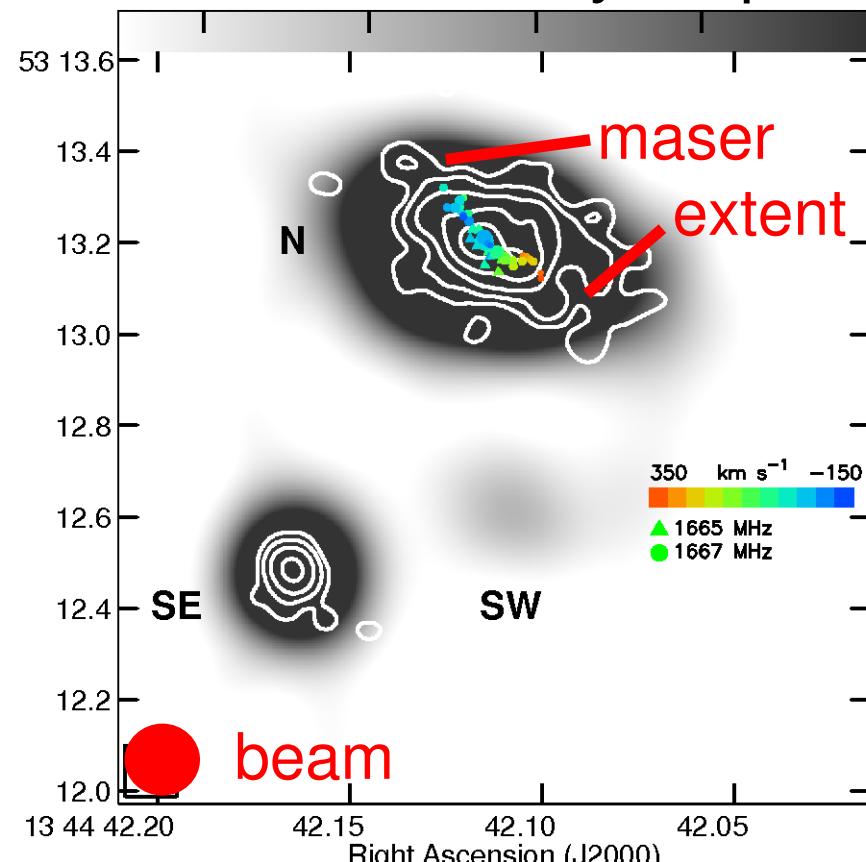
- Slope of up to $10^\circ/50 \text{ km/s}$
 - Baseline-dependent
- Similar to claimed Faraday rotation e.g. in OH shells...

The cross hands

- Delay errors in cross hands
 - Degrades all sensitivity
 - Makes Faraday rotation unreliable
- Antenna-dependent solutions doable
 - Baseline-dependent errors painful
 - Will it get worse with wider bands...
- Even if no apparent phase slope, why does averaging interval affect 'constant' polarization angle?
 - Confusion (for users) over whether/how tasks do vector averaging?
 - Some other data error?

Continuum subtraction

- *uv*-plane subtraction allows flexible CLEANing
 - Important for extended sources with sparse arrays
- Current tasks only work within v. few beams of centre
 - Markarian 273 megamaser - have to subtract dirty maps
 - All emission within one facet
 - Maser within spatial frequency limit
- Use UVSUB?
 - Spectral slope?
- Is it possible to subtract in *uv*-plane?
 - To 'flat sky' limit?
 - To full imageable extent?

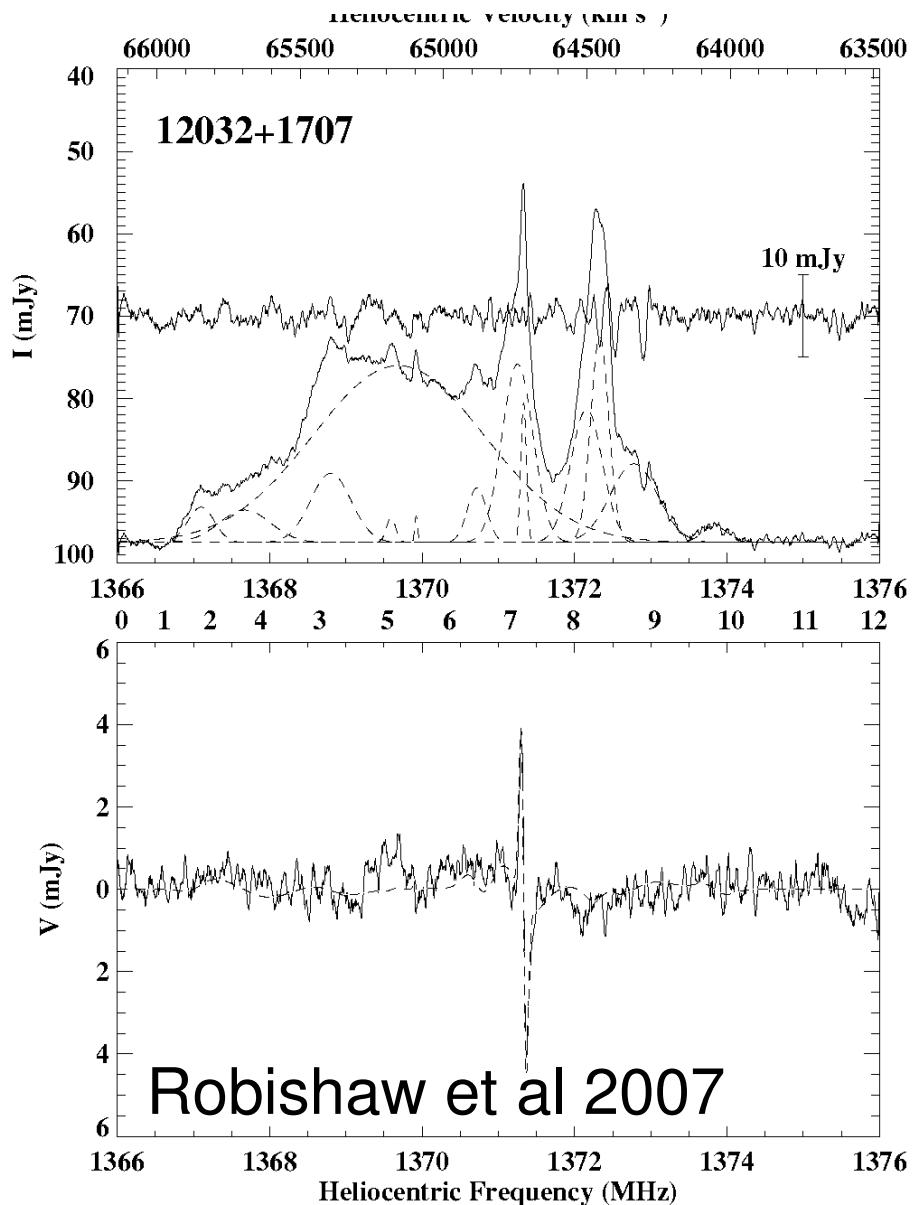


Combining configurations/arrays

- Different spectral configurations/arrays
 - Apply all external calibration separately, previously
 - Want to combine matched configs in uv plane
 - Spec. line strategy if central v or δ don't factorise?
 - e.g. 2 kHz v. 3.25 kHz channels
 - Resampling only possible in (dirty?) map plane?
 - Continuum strategy for different channel configs
 - Could combine in uv gridding for each major cycle?
 - Require a priori spectral index models for each?
 - Combining matching but offset configurations
 - Should be possible in uv plane?

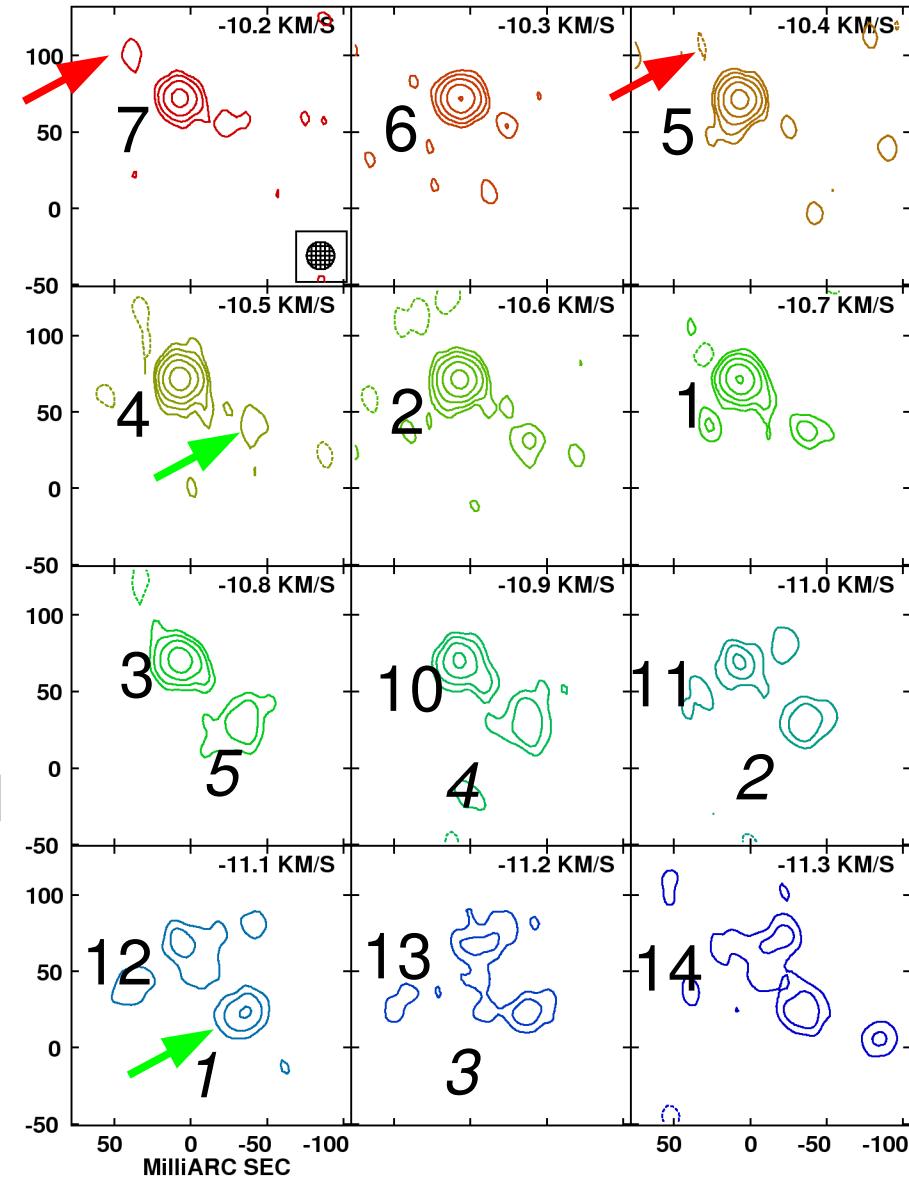
Comparing images/spectra

- OH megamaser Zeeman splitting
 - Aricebo for sensitivity in narrow channels
 - VL(B)A imaging
 - Decompose spectrum into spatial components
- Method used for any complex spectral source
 - Can spectral templates be used to automate finding lines in cubes?



Multi-channel deconvolution

- Spectral components extend over several chans
 - Hard to tell **faint components** from **sidelobes**
 - Map **components** get brighter; **sidelobes** go -ive
- Conventional deconvolution chan-by-chan
 - Too many to box by hand
 - Pick peak and then CLEAN adjacent channels also until reach noise?
 - *Then next brightest peak*
 - Position can drift with vel...



Wish List

- Automate stages not requiring human judgement
 - e.g. directional component of fixed v > fixed V conversion
- Incremental bandpass calibration
 - Large and small scale corrections (ripples v. spikes)
- Automate solving for instrumental (sub) band offsets
- Better uv plane continuum subtraction
- Combining arrays/different configurations
- Multi-channel deconvolution
 - Adaptive? smoothing for different brightness/noise
 - Spectral templates for complex analysis
- Solve for baseline-dependent delay errors
 - Including in cross-hands
- Diagnostics for non-stochiastic narrow chan noise