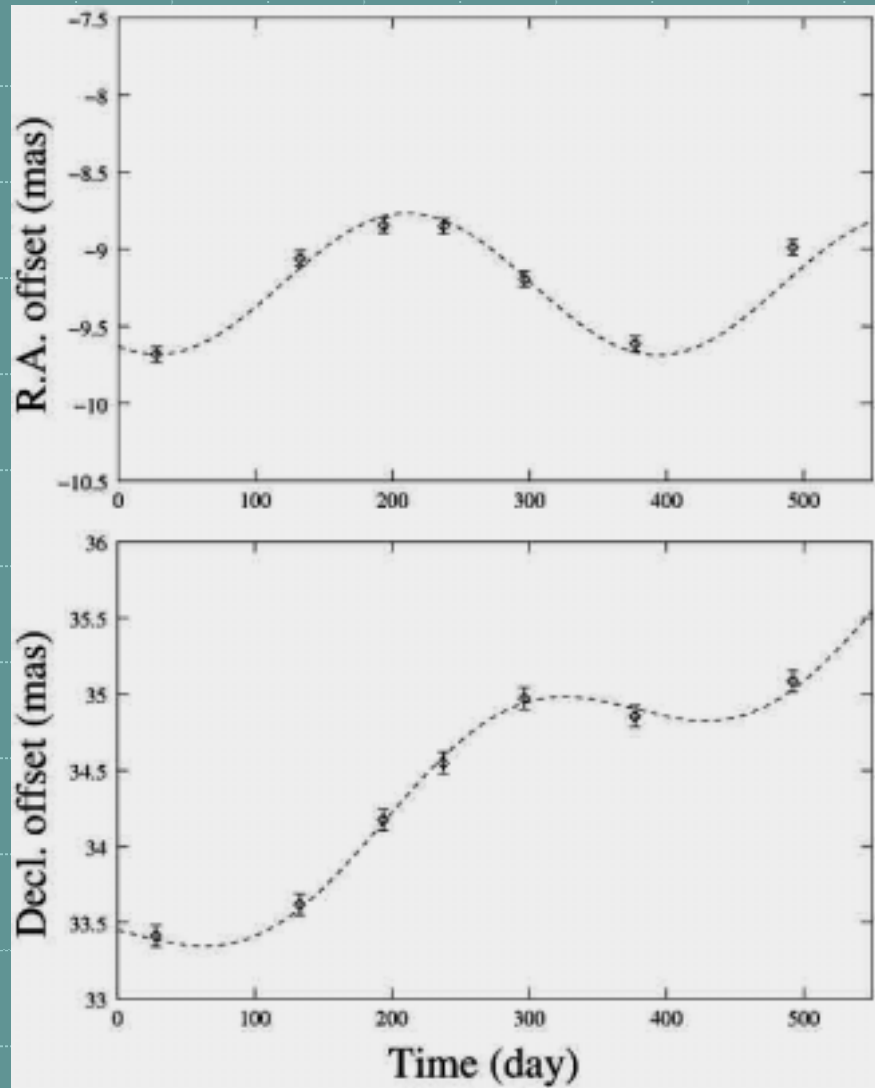# Status of VLBI data analysis with AIPS

Hiroshi Imai (Kagoshima University)

- Status of AIPS
- Calibration in AIPS
- Automatic pipeline for AIPS
- Future prospective

The greatest astrometric accuracy obtained with AIPS

~10 μ as
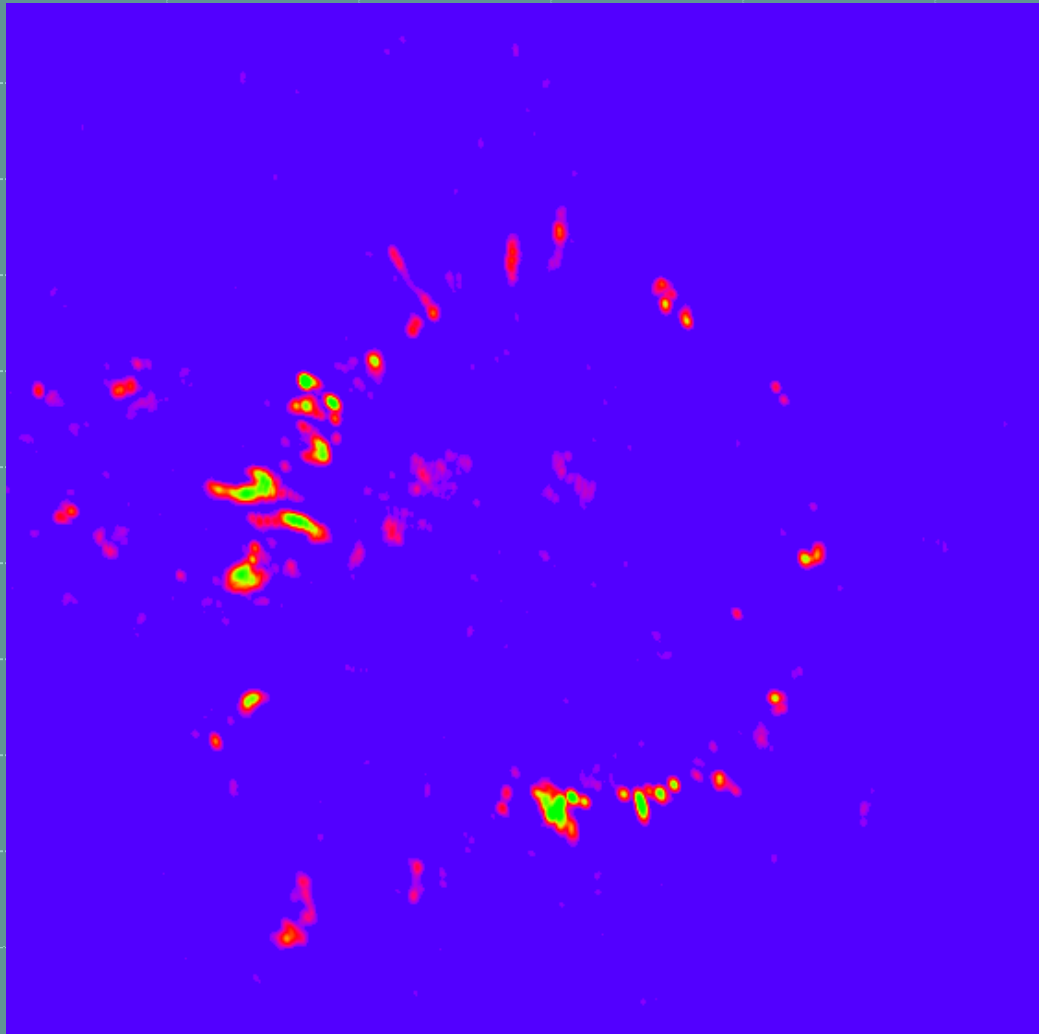
**with VLBA
+ phase referencing
+ astrometric calibration**

For IC10 H_2O masers
(Brunthaler et al. 2003)

For W3 (OH) H_2O masers
(Hachisuka et al. 2004)

Annual parallax of an H_2O
maser spot at 2.1 kpc
(Hachisuka et al. 2004)

The movie of an SiO maser source

Not only entertainment!

- ◆ **TX Cam**
  (Diamond &
      Kemball 2003)
  - ◆ **75 image cubes**
  - ◆ **A graduate student has created 2 image cubes per week.**
  - ◆ **(I, Q, U, V) image cubes**
- ◆ **Other sources**
  - ◆ **R Cas, S Per**
  - ◆ **Orion KL, Cep A**
  - ◆ **NGC4258**
  - ◆ **W43A, ...**

What is necessary in VLBI data analysis more?

◆ **Accurate and reliable data calibration**

  ◇ Complex gain factor (amplitude & phase, delay, rate)
  ◇ Antenna gain (Tsys, A_e, τ_0)
  ◇ Systematic delays (**instrument**, **atmosphere**, **geometry**)
  ◇ **100 μ as-level astrometry may be achievable with AIPS.**

◆ **Fast (automatic) data analysis**

  ◇ Full calibration >> **full imaging** >> **full image analysis**
  ◇ **Automatic data flagging**
  ◇ **A-few-day mapping is achievable with AIPS.**

◆ **Archiving the analyzed data**

  ◇ **AIPS plots, history, calibration tables, ...**

             (**Not available now**, **in construction**)

Calibration with AIPS

♦ **Necessary items for calibration**

  ♦ **Observation log**

    ♦ **Status and valid time range of each station**

    ♦ **Azimuth-elevation data of telescopes**

  ♦ **Tsys data from VERA stations (every 30-60s)**
        (automatically shipped to mtksp1)

  ♦ **Antenna gain information (Ae/2k~constant)**

  ♦ **Delay information of**
    the VERA dual-beam system(every 10s)
       (automatically shipped to mtksp1)

Calibration with AIPS

◆ **AIPS extension tables (SN, TY, GC) are attached in FITS files (by Suda).**

　◆ **No shipping calibration files**

　◆ **Applying only "APCAL".**

　◆ **Caution the tables from multiple FITS files.**

◆ **Data reduction recipe will be published.**

◆ **Station coordinate will be maintained by VERA correlation operation team.**

　◆ **Caution the coordinates in data recently released ($\Delta D \sim 30$ cm).**

Current VERA astrometric results with AIPS

◆ **QSO-QSO pair: 3C345-NRAO512 (Inomata's presentation, sub-mas astrometry)**
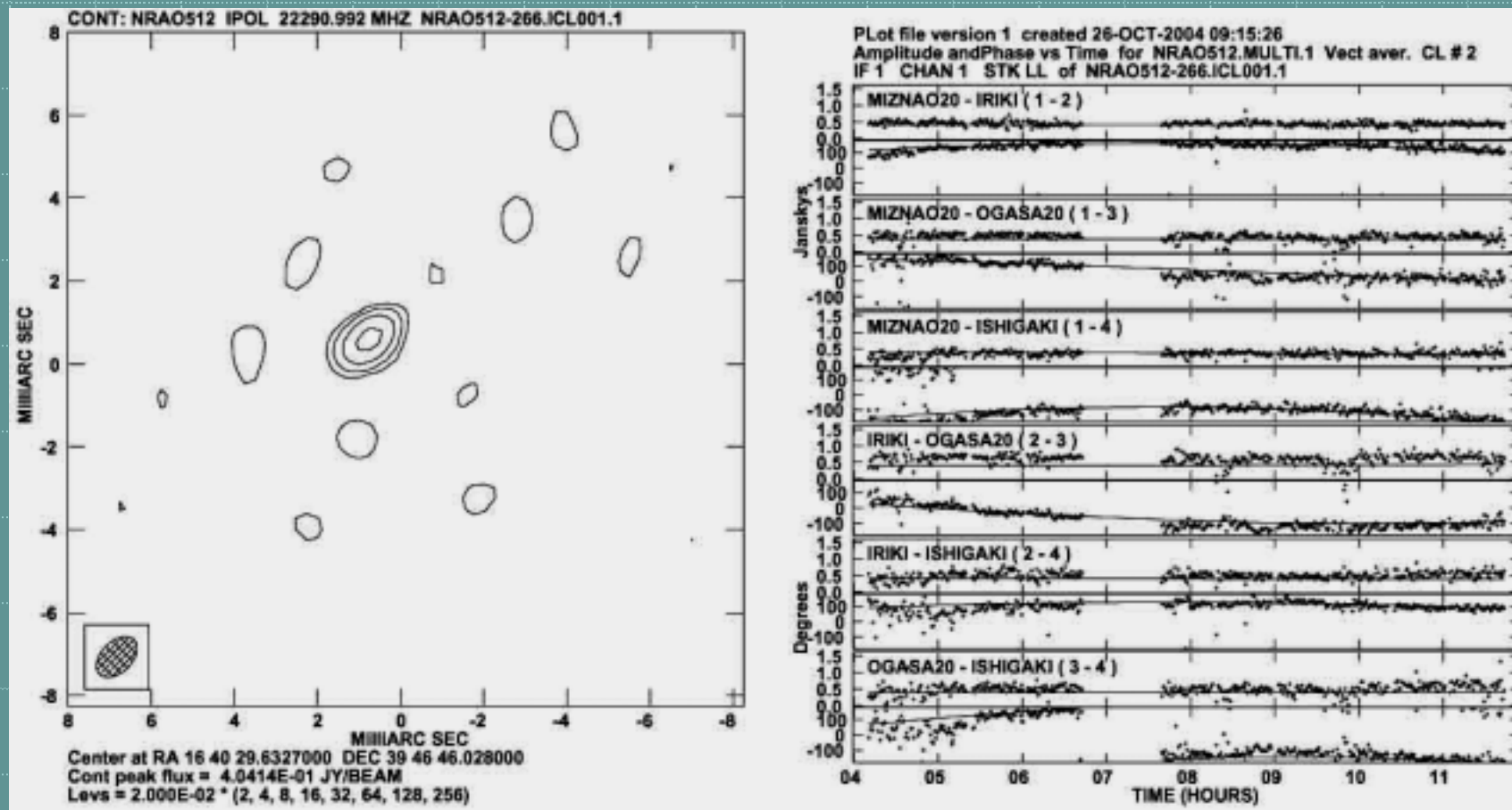
Current VERA astrometric results with AIPS

- **QSO-maser pairs**
  - **Dual-beam focussing success:**
    - ρ **Oph East -- J1625-2527 (Nakashima's poster)**
    - **Mon R2 -- J0607-0834 (Hirota's poster)**
    - **W3(OH) -- J0244+6228 (Kameya's presentation)**
    - **W49N-- OH43.8 (Honma's presentation, not with AIPS)**
  - **Dual-beam focussing failure:**
    - **W51M -- 2 reference sources (Kan-ya's poster)**
    - **Many other sources**
    - **Due to poor (u, v, w) accuracy**
    - **Due to weak emission of reference sources**
    - **Due to missing atmospheric delay information**

Current VERA astronomical results with AIPS

- **Maps of H$_2$O masers**
  - **Full mapping (scanning for ~8 hours):**
    W3(OH), Orion KL, VY CMa, ρ Oph East,
      W51 North/Main/South/West, IRAS19312+1950,W75N,
      S140, ... (see posters and presentations)
  - **Snap-shot mapping successful**
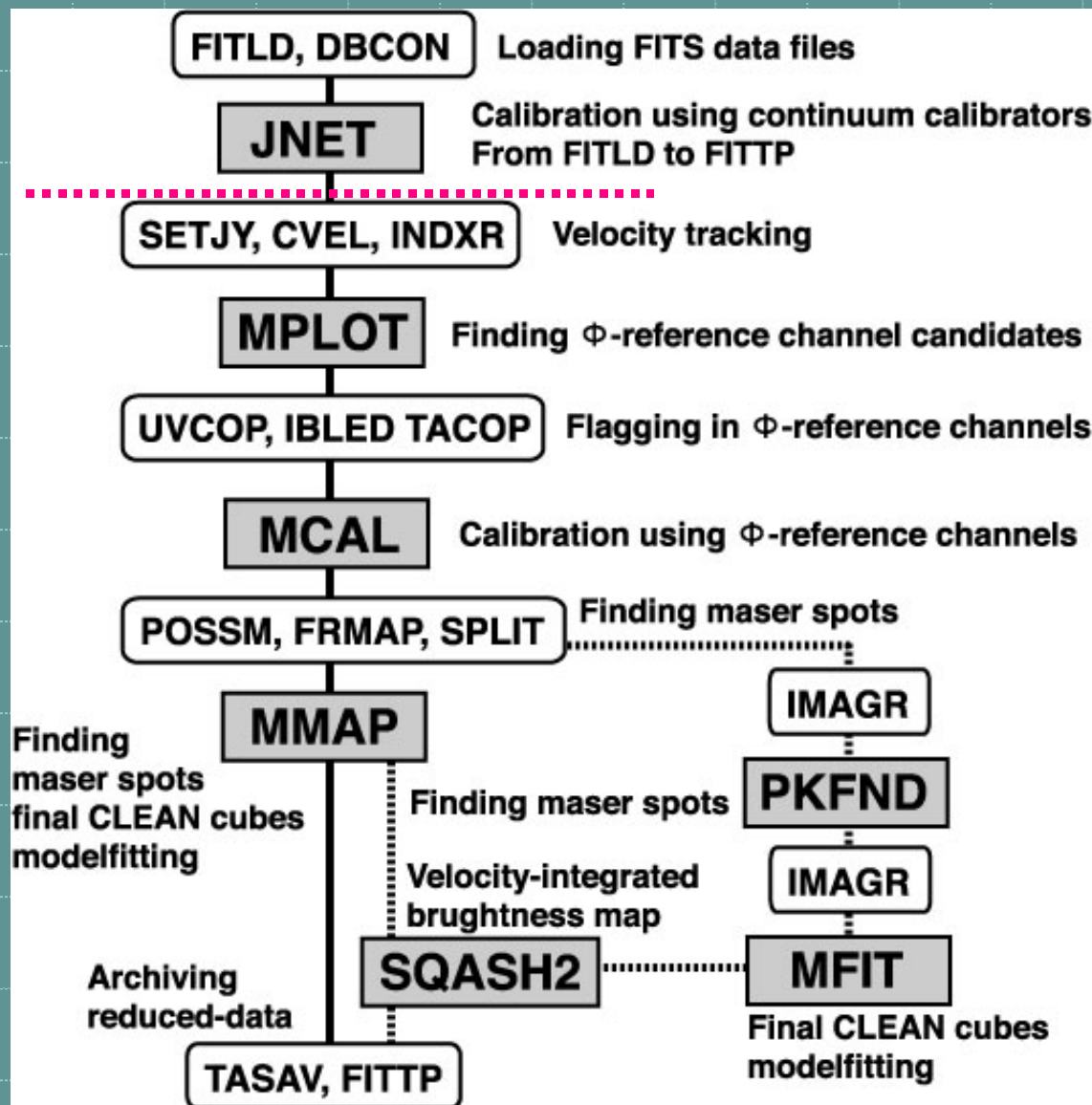   - scanning for ~1 hours, observing for ~4 hours
    - with 3 or 6 baselines
- **SiO masers (v=1 &2, J=1--0)(Shimizu's poster)**
  - **Phase calibration of v=1 data with v=2 data**
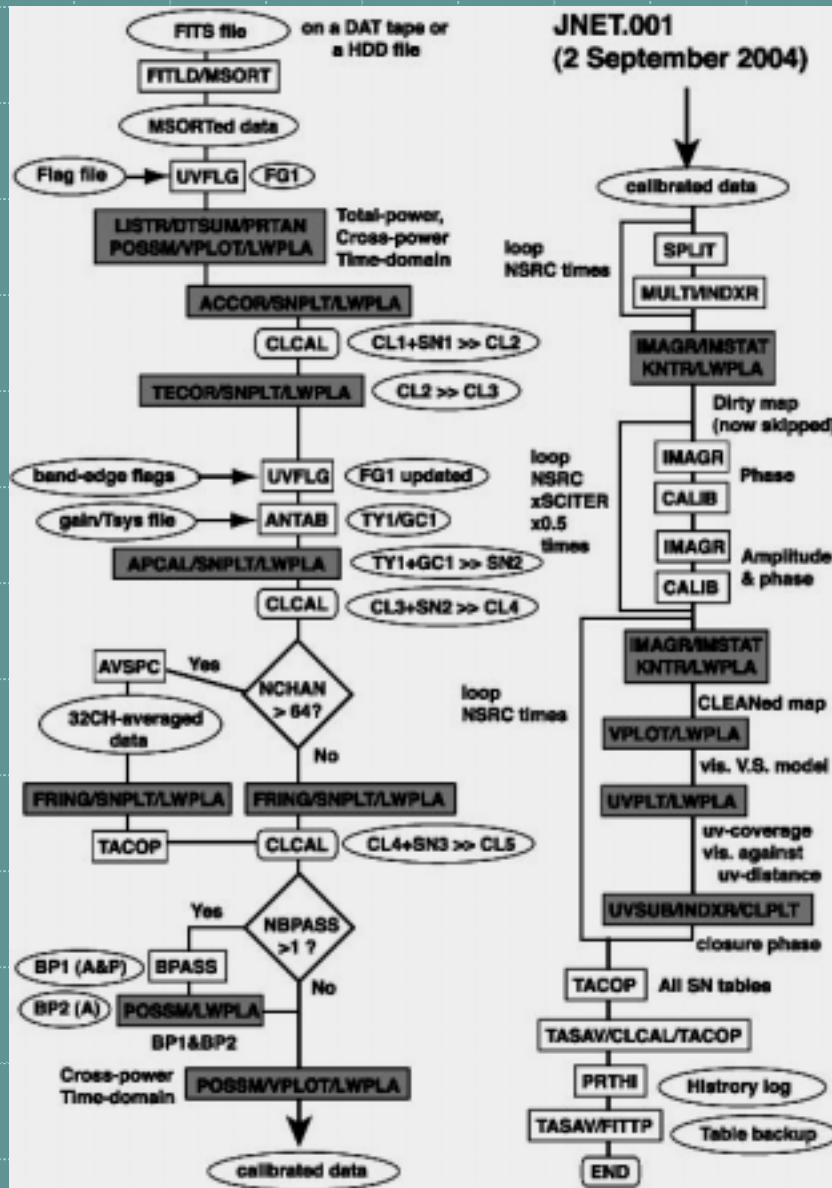- **Cotinuum sources:**
  - **Mainly fringe finding and phase-calibrating**
  - **Calibrator mapping (Nakagawa's poster)**
  - **Scientific result: Cyg X-3 (Kim's presentation)**

Automatic pipeline for AIPS

- ♦ **Fundamental (continuum)+ advanced(maser)**
- ♦ **Wide-field image-cube synthesis and analysis**

- ♦ **Pipeline available (contact to Imai)**

Fundamental functions in the pipelines

- ♦ **Automatic processing**
  - ♦ **Fringe fitting**
  - ♦ **Self-calibratiion**
- ♦ **Creating temporary analyzed results**
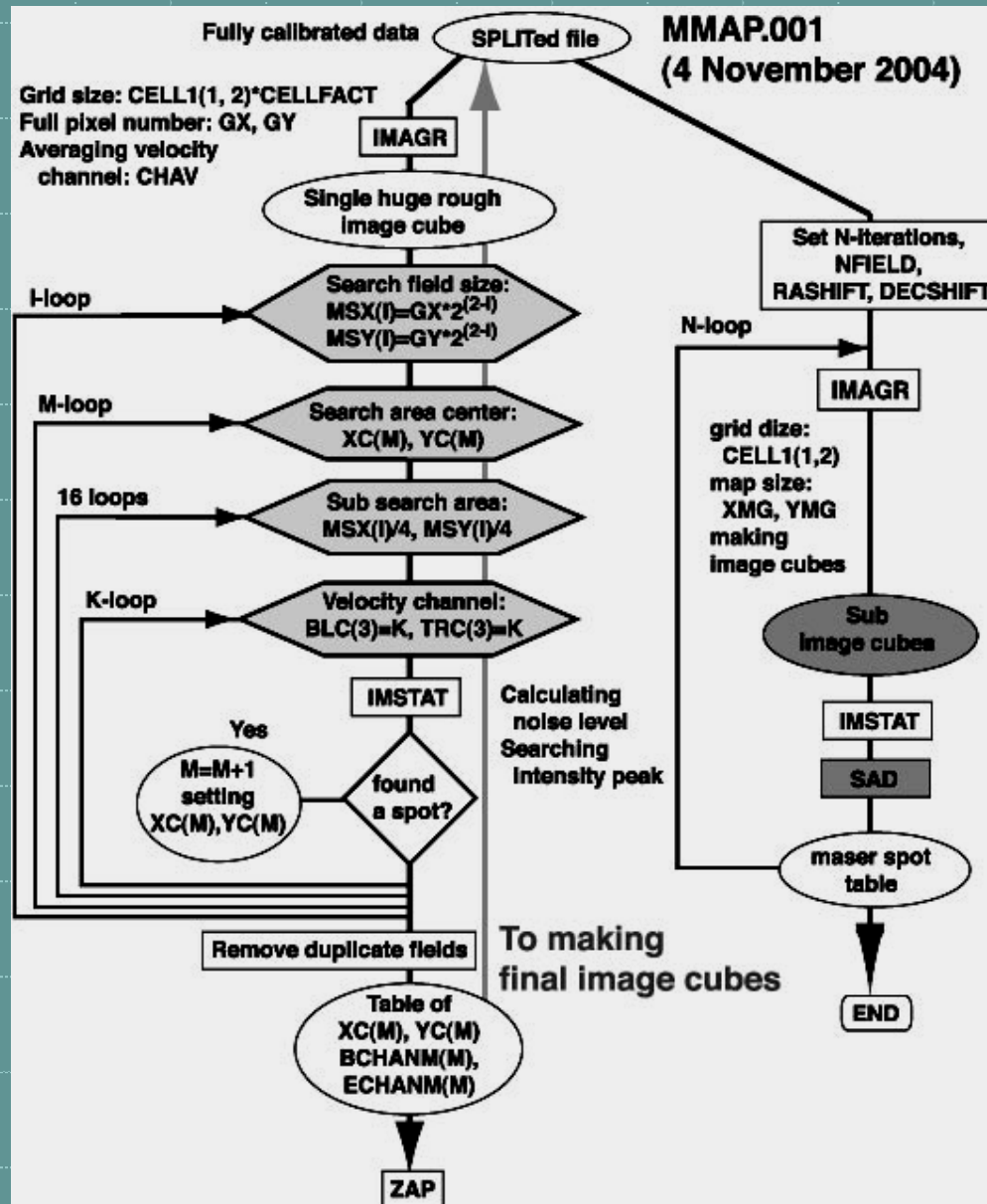 - ♦ **Plots (PostScript files)**
  - ♦ **Messages (text files)**
  - ♦ **History (text files)**
- ♦ **Creating archival data**
  - ♦ **Calibration (extension) tables (CL, SN, FG, TY, GC, ...)**
  - ♦ **Trial & final images**

Advanced functions in the pipelines

- ◆ **Wide-field image-cube synthesis +analysis**
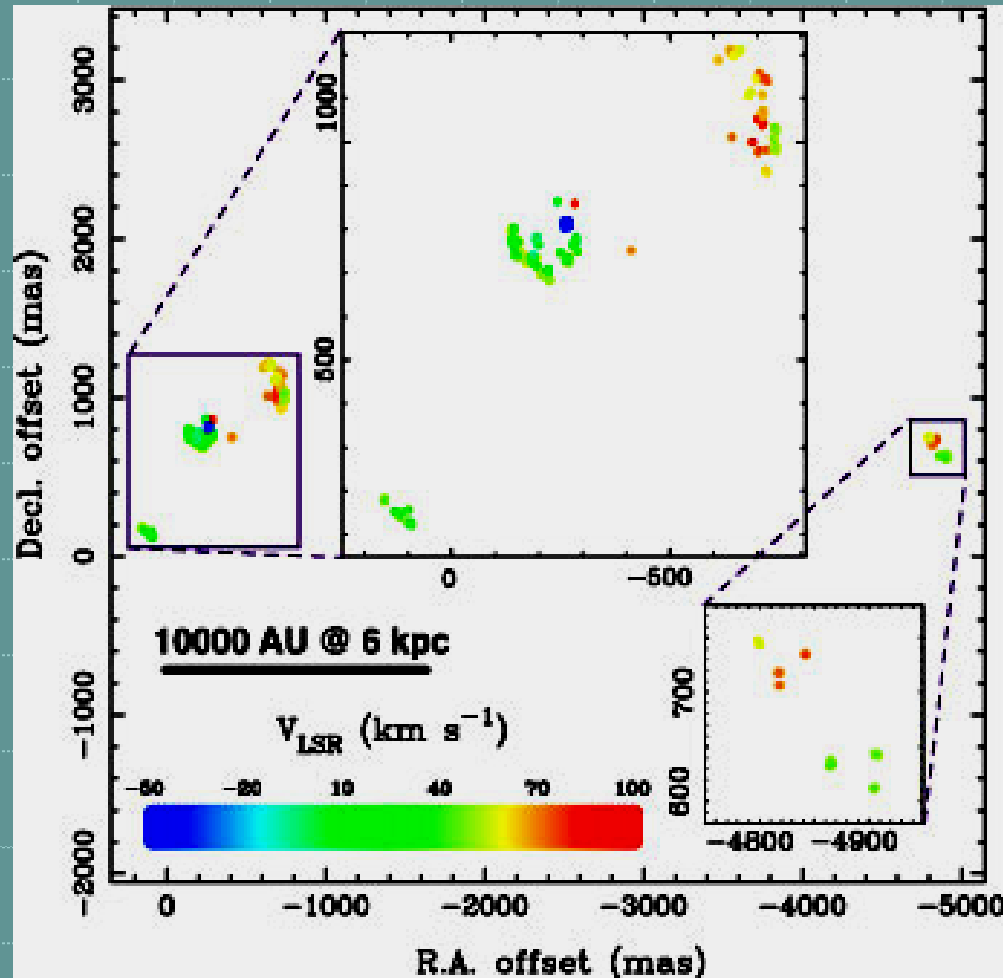 - ◆ **Image statistics (rms noise, peak intensity)**
  - ◆ **Rough to fine image cubes**
  - ◆ **"SAD" ≒ "CLUMP FIND" (Gaussian fitting)**

Future prospective

- **Estimating unknown zenith atmospheric excess path delays**
  - LISTR >>> fitting >>> CLCOR (OPCODE'ATMO')
  - Using GPS data
- **Automatic bad-data flagging**
  - Flag information from the scheduling program
  - An automatic log creator for each station
  - Automatic bad-visibility flagging in AIPS
- **Semi-full automatic data analysis**
  - Analyzing <u>cross-power spectra</u> and images
  - Analyzing gaussian fitting results
- **Pipeline know-how will be transported to the new VERA analysis program.**