Astrometry Data Analysis in VERA Project

2004 Aug 9-10
VLBI Correlator Workshop (Kashima)

Tomoharu KURAYAMA
Univ. of Tokyo / NINS NAOJ

Introduction

- The final goal of VERA project is to measure the position and proper motion of the Galactic masers with 10 micro-arcsec level accuracy.

- For this purpose, phase-referenced map of each epoch is important.

Basic Strategy for VERA analysis

- Finally, we are going to analyze VERA data with our original software.

- Until the development is finished, we use AIPS to analyze VERA data.

- This is mainly because AIPS treats (u,v,w) data with float-precision (REAL*4), not double-precision (REAL*8).

(u,v,w) Requirement for VERA Analysis

- In order to measure 2° separation angles in the error less than 10 micro-arcsec, the requirement of (u,v,w) dynamic range is:

$$\frac{10\mu \text{ as}}{2 \deg} = 1.4 \times 10^{-9}$$

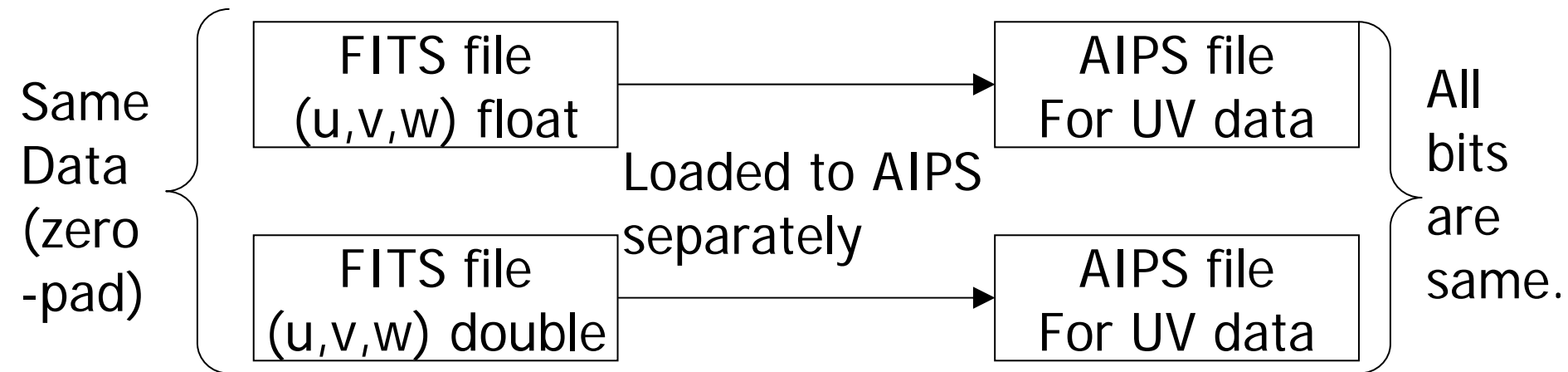- The mantissa (   ) of float-precision (REAL*4) usually has 23 bits. Its dynamic range is:

$$\frac{1}{2^{23}} = 1.2 \times 10^{-7}$$

(W. H. Press et al., Numerical Recipes in C)

- We must treat (u,v,w) data with double-precision (REAL*8).

Importance of Original Software AIPS (u,v,w) Test

- Method :

```
Same          ┌─ FITS file ──────→ AIPS file ─┐   All
Data             (u,v,w) float      For UV data    bits
(zero                    Loaded to AIPS           are
-pad)         ─┤         separately              ├─ same.
                 FITS file ──────→ AIPS file
                 (u,v,w) double     For UV data ─┘
```

Same Data (zero-pad)	FITS file (u,v,w) float	Loaded to AIPS separately	AIPS file For UV data	All bits are same.
	FITS file (u,v,w) double		AIPS file For UV data	

- Result : AIPS accepts double-precision (REAL*8) (u,v,w) data, but truncates it to float-precision (REAL*4)

Importance of Original Software Other Reasons

- AIPS is not suited to handle huge data automatically.
- AIPS is difficult to use those who are not familiar with it.

- By targeting VERA data analysis, we overcome these problems.

Steps towards VERA Astrometry Outputs

- Preprocessing software (1   )
  - Calibrations which do not need try-and-error
- Imaging software
  - From the other calibrations to imaging phase-referenced maps
- Astrometry software
  - Calculate parallaxes and proper motions from each epoch map

- We are going to distribute preprocessed data.
- I hope correlators carry out preprocessing…

Contents of VERA Astrometry Analysis

- Preprocessing software
  - (u,v,w) re-calculation
  - Path-difference calibration for dual-beam system
- Mapping software
  - Amplitude calibration
  - Bandpass calibration

- Doppler-shit calibration
- Fringe fitting
- Phase-referencing
- Self-calibration
- Imaging
- Flagging
- Time/baseline integration
- Astrometry software

Basic Strategy for Development

- Program itself (Command-line interface)
    - C or C++ (Compile with C++)
    - To be developed by VERA team
- GUI
    - Java
    - To be developed by a company (AES).
- Compatible with Mitaka FX correlated database (CODA).
    - In the future, it is compatible with FITS file, too.

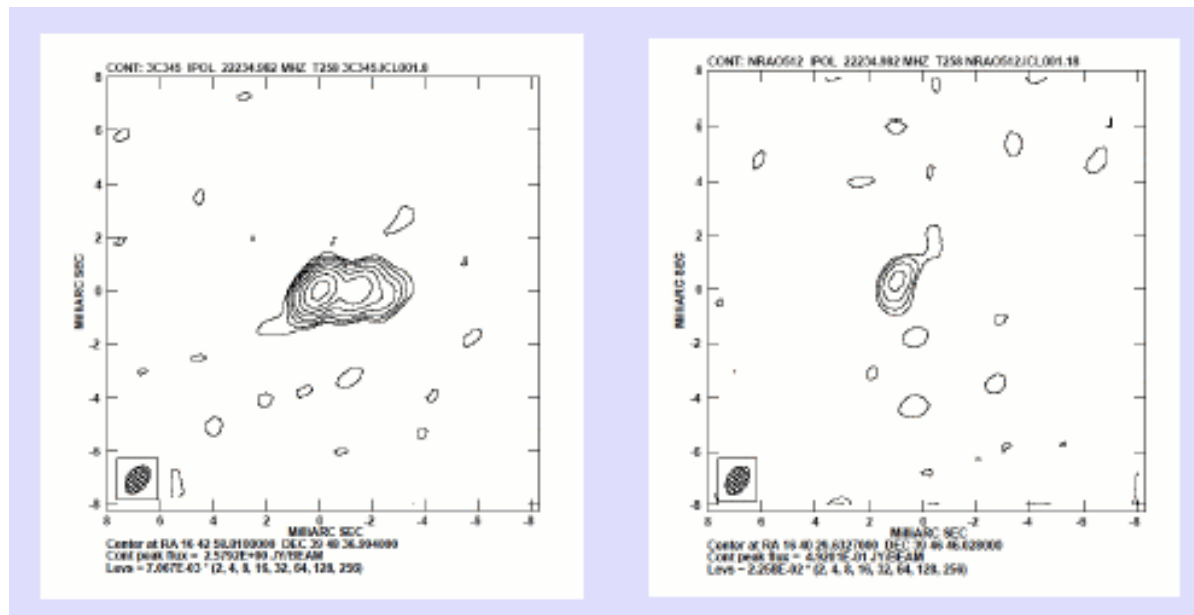# Current Status and Bugs of Original Software

- Current Status
  - Preprocessing software : already released
  - Imaging software : now developing…
  - Astrometry software : now designing…
- Bugs
  - Path-difference calibration for dual-beam system : Because of some bugs and observation troubles, we do not apply this calibration in preprocessing. We are now applying this calibration at the phase-referencing stage.
  - (u,v,w) re-calculation : We are discussing which stage is best to apply it in.
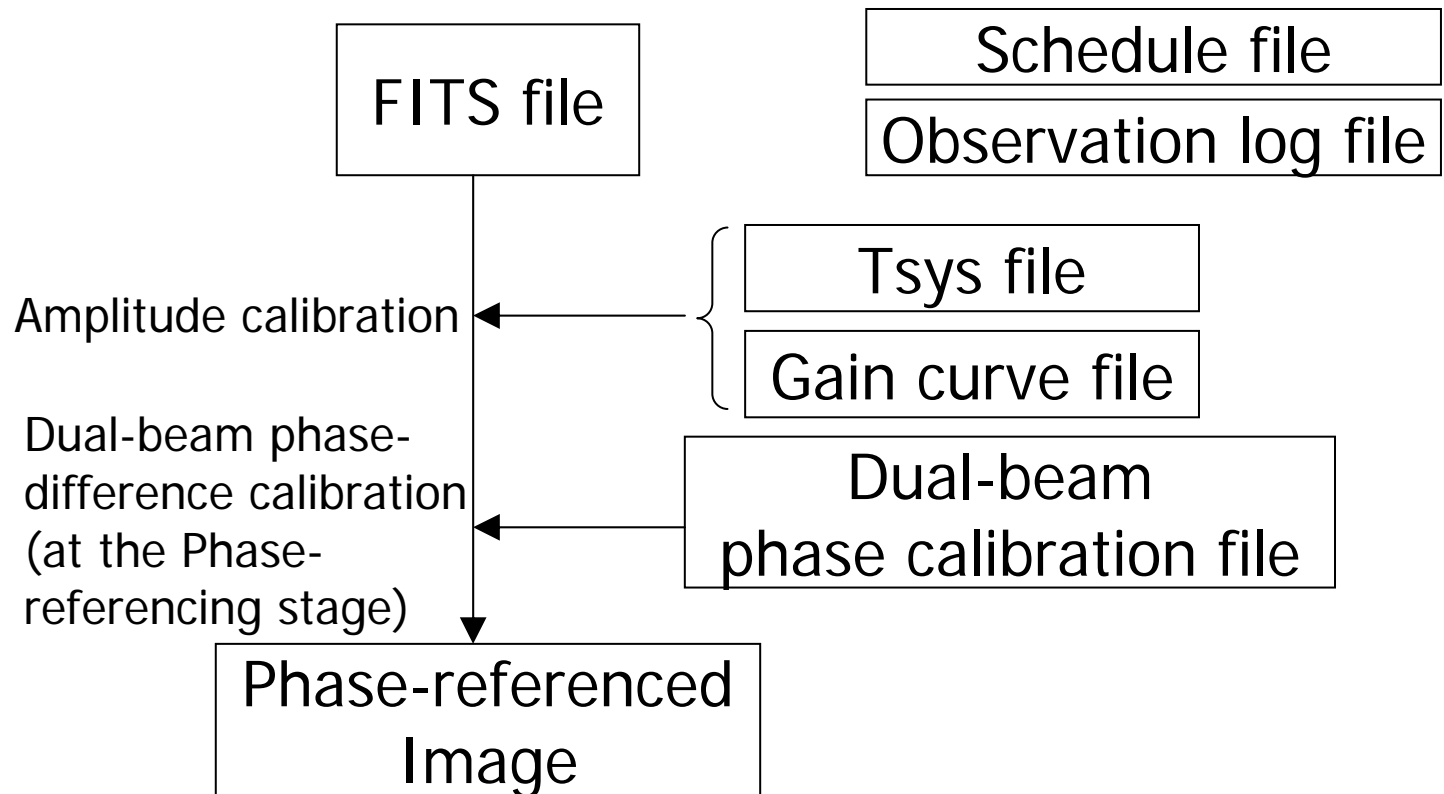
VERA Data Analysis with AIPS

- Mr. Sakakibara obtained phase-referenced map of 3C345 & NRAO512, analyzing with AIPS.

(S. Sakakibara, 2003, Master thesis in Kagoshima Univ.)

There are Some Extra Files!

- Current status :

FITS file

Schedule file

Observation log file

Amplitude calibration

Tsys file

Gain curve file

Dual-beam phase-difference calibration (at the Phase-referencing stage)

Dual-beam phase calibration file

Phase-referenced Image

- We must manage them.

Analysis Result Database

- In order to manage huge numbers of analyses, 'Analysis Result Database' (DB) is made.

- For the compatibility with AIPS and original software, the scheme of analysis is registered as a text file.
    - For AIPS : RUN file
    - For original software : history file

Summary

- Finally, we will analyze VERA data with original software.
    - The reason is the shortage of dynamic range of (u,v,w).
    - Basic strategy and current status is reviewed.
- But temporary, we are analyzing VERA data with AIPS.
- We developed Analysis-result database in order to manage the results.