# Interferometric Polarimetry

## TUTORIAL & EXERCISES

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# Tutorial Scope

1. Installation of PolSolve (GNU/Linux & Mac).
2. Data simulation and inspection.
   - Visibilities and closure traces.
3. Simple case (unresolved calibrator): PolCal vs. PolSolve.
4. PolSolve on resolved calibrator.
5. Real Data (VGOS PolConverted visibilities).

# Exercise 1

# Installation of the CASA PolTools

# Installation of the CASA PolTools

1. Install CASA and figure out the CASA path.
2. Download the CASA PolTools into your favourite directory.
3. Compile the CASA PolTools using CASA.
4. Update your configuration script.
5. Enjoy.

# Installation of the CASA PolTools

## What is my CASA path?

- Just start CASA and run this couple of lines:
  - `import os`
  - `os.environ.get('CASAPATH').split()[0]`

# Installation of the CASA PolTools

## How do I get the CASA PolTools?

- You already have a copy of the package in the Workshop documentation.
- Anyway, you can always get the latest version from GitHub:
  - `git clone https://github.com/marti-vidal-i/casa-poltools.git`
- Move the CASA PolTools to your favourite directory:
  - `mv casa-poltools /my/favourite/directory/`

# Installation of the CASA PolTools

## How do I compile the CASA PolTools?

- Do you remember the CASA path (a.k.a. CASAPATH) that you got a few minutes ago? You'll need it!
- If you have a Mac:
  - `cd /my/favourite/directory/casa-poltools`
  - `CASAPATH/MacOS/python3 setup.py build_ext --inplace`
- If you have GNU/Linux:
  - `cd /my/favourite/directory/casa-poltools`
  - `CASAPATH/bin/python3 setup.py build_ext --inplace`

# Installation of the CASA PolTools

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**How do I set my configuration script?**

- If you don't have it yet, you must create it:
  - In Mac, it is `/Users/yourName/.casa/config.py`
  - In GNU/Linux, it is `/home/yourName/.casa/config.py`
- Just write the following lines into that file:
  - `import sys`
  - `sys.path.append("/my/favourite/directory/casa-poltools")`

**That's it! From now on, you can load all the CASA PolTools, by just loading the modules into CASA. For instance:**

- `from task_polsolve import polsolve`
- `from task_polsimulate import polsimulate`
- `from poltools_helper import plotPolTraces`

# Exercise 2

# Simulation and Visualization

# Data Simulation. PolSimulate

**We will use `polsimulate`.**

It is a very flexible function that can simulate realistic full-polarization (and spectral-line) observations of *almost* any interferometer (J-VLA, ALMA, VLBI, ...).

Some important keywords:

- The antenna coordinates (and sizes) are given in `array_configuration`.
- Polarization basis and antenna mounts are in `feed` and `mounts`.
- Frequency configuration is given in `LO`, `BBs`, `spw_width` and `nchan`.
- Source structure (and full-polarization spectrum) can be given in several ways:
  - Complex structures: `model_image` and `spectrum_file`.
  - Set of deltas: `I`, `Q_frac`, `U_frac`, `V_frac`, `RM`, `spec_index`, `RA_offset`, `Dec_offset`.
- Schedule: `H0`, `onsource_time`, `observe_time`, `nscan` (can also use a listobs!).
- Corruption: `tau0`, `t_sky`, `t_receiver`, `model_Dt_0`, `model_Dt_1`, ...

# Data Simulation: PolSimulate

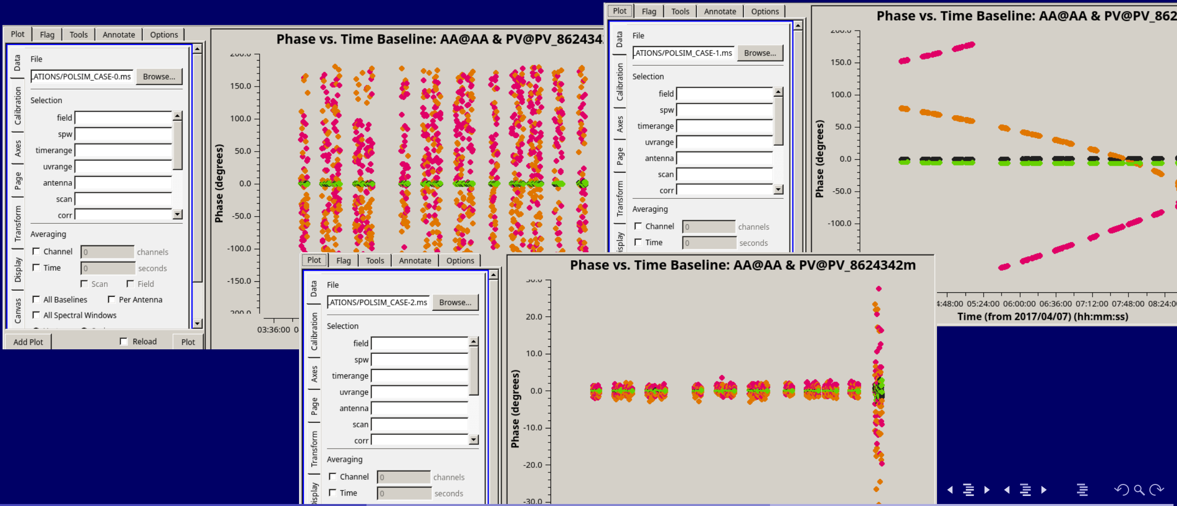
**We will simulate several datasets and inspect the data.**

For the simulation, we will run the script `EXERCISE-2_PolSimulate.py`, which generates the following datasets (all of them mimicking the UV coverage of the EHT observations made on 11 April 2017):

- CASE 0: Unpolarized point source with no instrumental polarization (Dterms).
- CASE 1: Unpolarized point source corrupted with Dterms.
- CASE 2: Polarized point source with no Dterms.
- CASE 3: Polarized point source with Dterms.
- CASE 33: Polarized point source with Dterms and all antennas with alt-az mounts.
- CASE 4: Polarized double source with no Dterms.
- CASE 5: Polarized double source with Dterms.
- CASE 6: Polarized double source (rotated EVPAs) with Dterms.

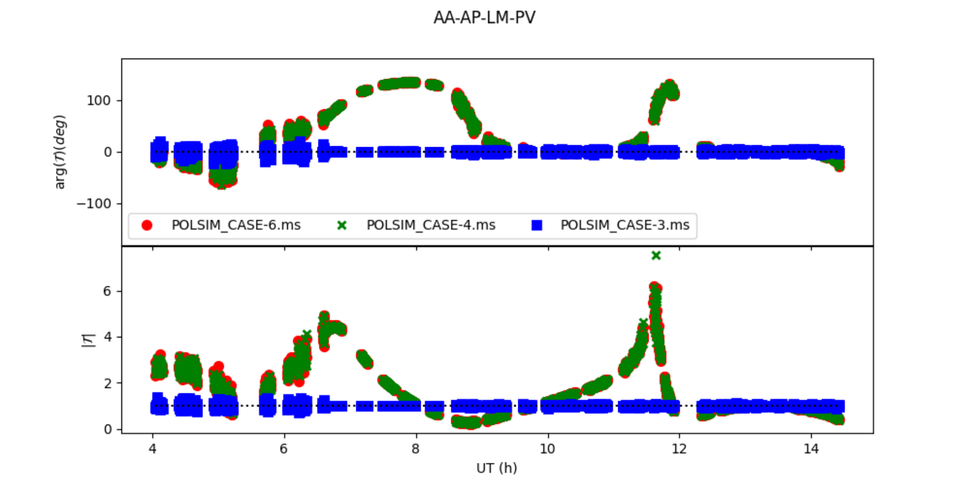
# Data Inspection: plotms and plotPolTraces

Plot amp & phase vs. time, showing all polarizations and baselines. Discuss!



# Data Inspection: plotms and plotPolTraces

Use the script `EXERCISE-2_TracesPlots.py` to plot Traces. Discuss!



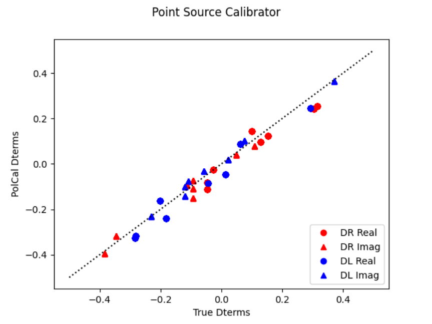
# Exercise 3

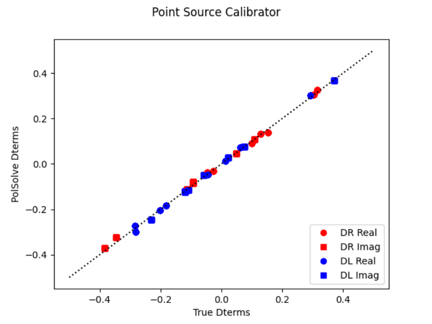
# Point Source & Alt-az Mounts

# PolCal vs. PolSolve

**BEWARE!** `polcal` only works on data that have *not* been corrected for parallactic angle.

- Generate a calibration table with `polcal`.
  - `vis = ''POLSIM_CASE-33_for_PolCal.ms''; poltype = ''D+QU''.`
- Run `polsolve` to generate an equivalent Dterm solution.
  - `vis = ''POLSIM_CASE-33.ms''; PolSolve = True`
  - `CLEAN_models = [1.0]; frac_pol = [0.0]; EVPA = [0.0]`



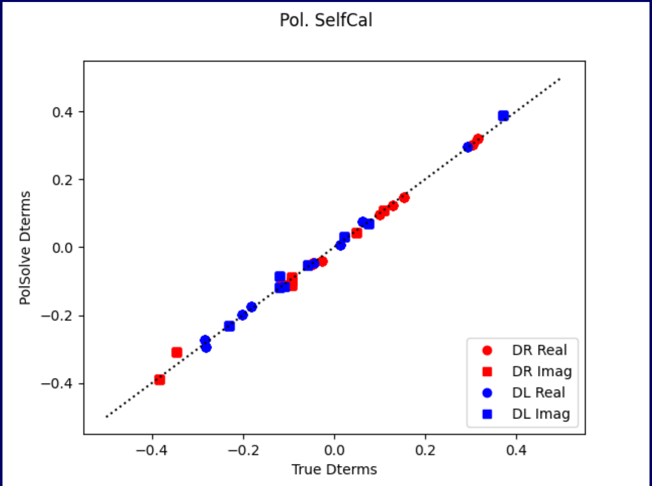
# Exercise 4

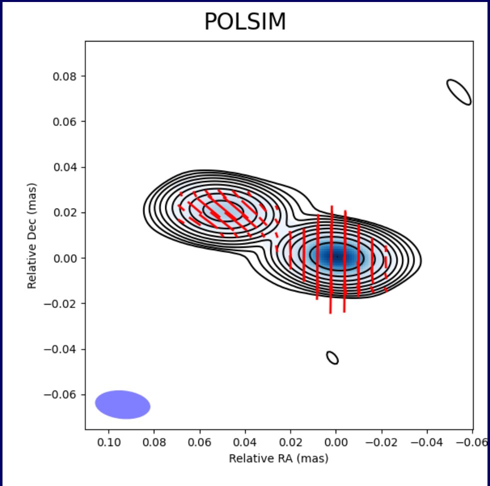
# Resolved Calibrator(s)

# Resolved Calibrator(s): CASE 5

Two approaches: similarity and Dterm self-calibration.

- Use either of the `EXERCISE-4*.py` scripts. Discuss!



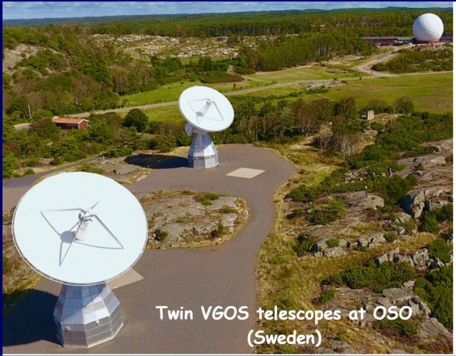



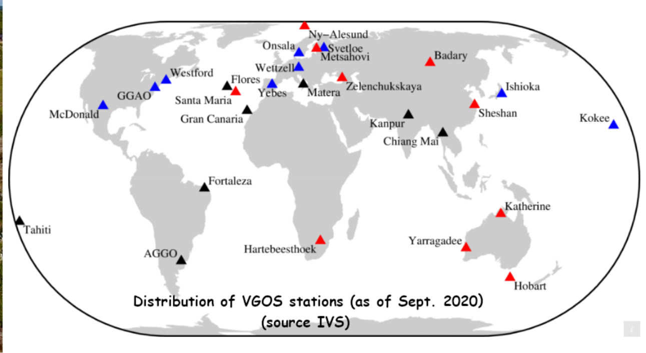
# Exercise 5

# Real Data

# Real Data: IVS/VGOS

- International VLBI Service (IVS).
- Geodesy with a 1 mm precision (in 24 h experiments).
- Earth Orientation Parameters continuously monitored (i.e., 24/7!!).
- Frequency coverage spaced between 2–14 GHz (recording rate up to 16 Gbps).
- Currently, one full session every 2 weeks (correlated at MIT/Haystack).



# IVS/VGOS. Epoch VO2187

- 6–7 July 2022 (24h observing time).
- 8 antennas (7 locations).
- 1024 total bandwidth (8×32 MHz)
- Freq. from ∼3 to ∼11 GHz.
- 74 sources and 1 950 scans (30 s).
  - 1803+784, OJ287, 3C418, 1849+670, ...

**V. Pérez, I. Martí-Vidal et al. (in prep.)**

We have splitted a few sources for you to play with.

The data are "polconverted" and fringe-fitted.
You can use `polsolve` in a normal way.
ENJOY!