SAND

All-axis radio interferometric data analysing pypeline

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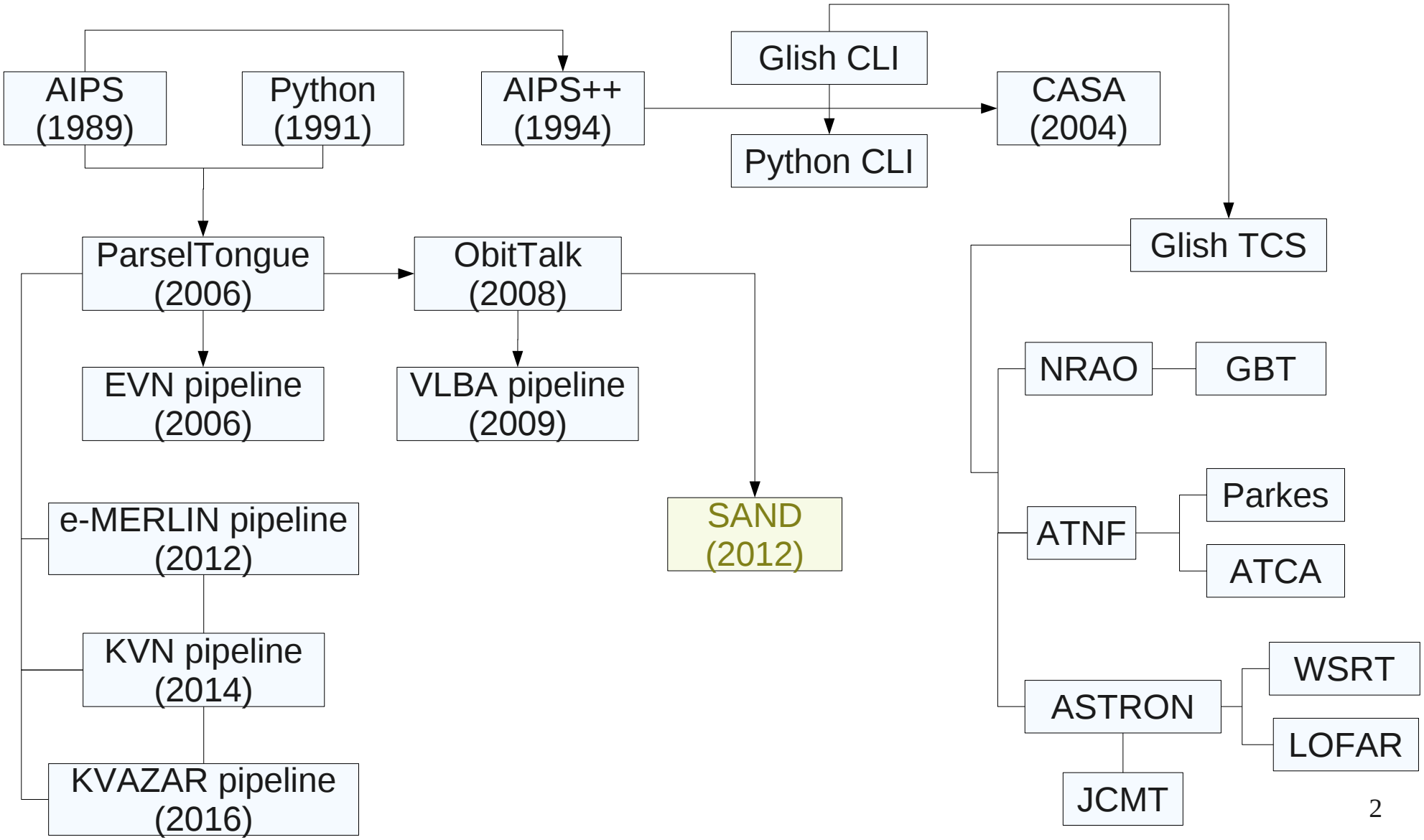
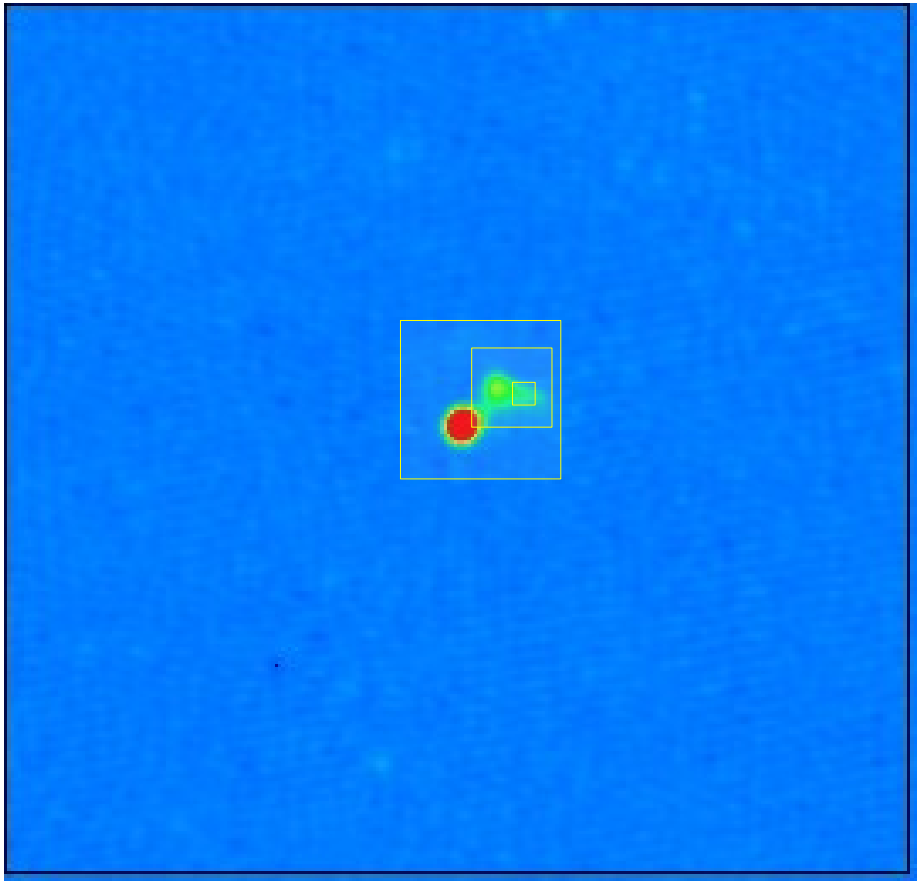
China-VO & Astroinfomatics, Dali, 2017.11.30

Pythondome


AIPS (1989)
Python (1991)
AIPS++ (1994)
Glish CLI
Python CLI
CASA (2004)
ParselTongue (2006)
ObitTalk (2008)
EVN pipeline (2006)
VLBA pipeline (2009)
SAND (2012)
e-MERLIN pipeline (2012)
KVN pipeline (2014)
KVAZAR pipeline (2016)
Glish TCS
NRAO
GBT
ATNF
Parkes
ATCA
ASTRON
WSRT
LOFAR
JCMT

Pitfalls of manual VLBI reductions

- Subjective
  - Eye guidance
  - Human errors
  - Selection bias
- Non cross-comparable
  - By reducers
  - By datasets
- Unrepeatable
- Unautomated



SAND

- Etymology
  - **S**earch **A**nd **N**on-**D**estroy <=> **SAD**
  - Sand-like (Dune du Pyla)
    - Solid – AIPS task wraper
    - Fluid – Pythonic freestyle
    - Loose – Modular structure
    - Grainy – Multiple files
    - ~~Unstable – Buggy ensemble~~
    - Sandbox
      - A platform to play everything

Search **A**nd **N**on-**D**estroy

- SAND >= Python + ObitTalk + AIPS
- Automated imaging and analysing
  - Heterogeneous datasets
  - Image cataloguing
  - Source extraction
  - Image/*uv*-plane model fitting
  - Spatial morphology – profile, trajectory, rotation, etc
  - Temporal variablity – light curve, correlation, etc
  - Polarization – rotation, etc
  - Multi-epoch spectra

Compositions

- Dozens files

AND...

- Many functions
- Some pipers

- ~3000 lines

Member programmes

srls.py - The source lister for RDV
are indicated for every observat

cata.py - The catalogue generator
searching conditions are narrov
words.

sand.py - The core programme of
through ObitTalk interface to
mapping, model-fitting, catalo
output data are stored in a uni

psls.py - The catalogue plotter. Th
plotted in sequence.

reop.py - The output reporting pro
and returns the digested outpu

coft.py - The linear proper motion

dfpz.py - The model-fitting compar

psud.py - The linear/non-linear pat
distribution (for testing purpos

mult.py - The post-processing prog
light curves and multi-epoch spectra.

The **SAND** Manual

Version 1.4

Multi-axis information

Source extraction

Spectra

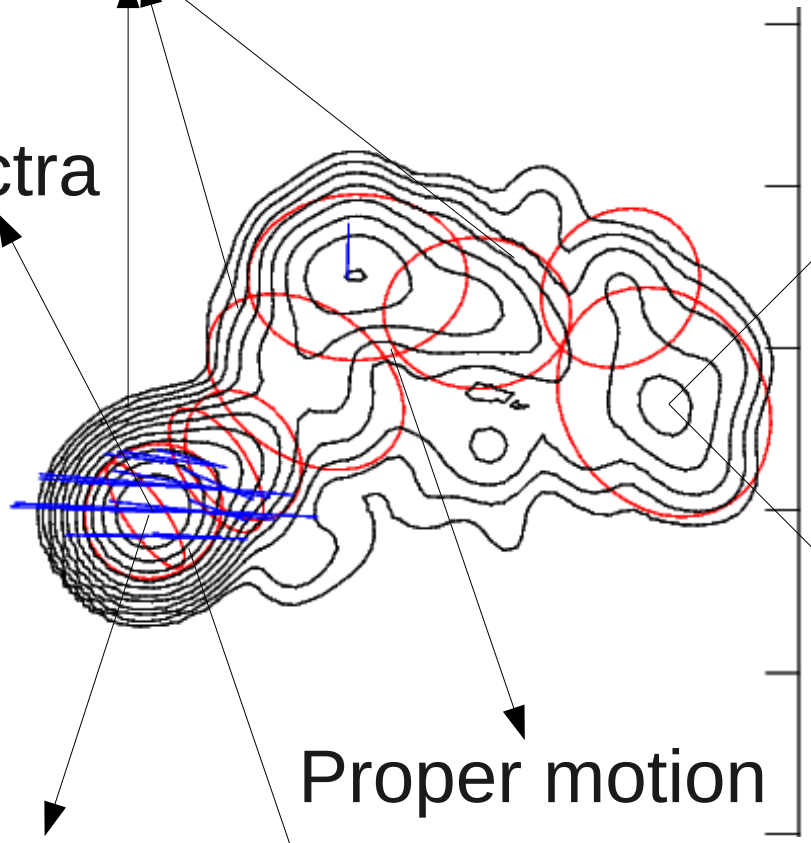


Image-plane model fit
- Gaussian
- Decomposition

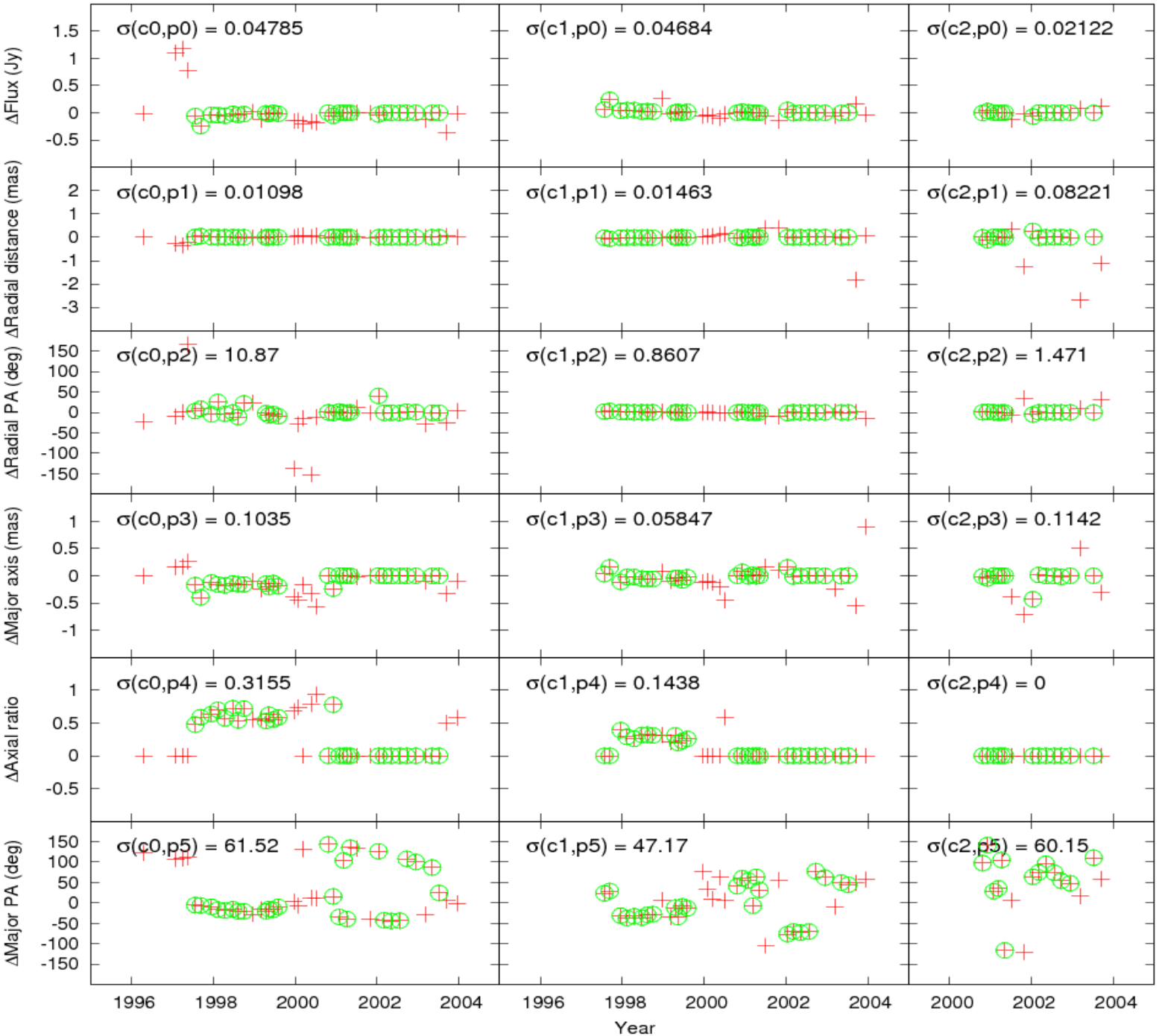
uv-plane model fit
- Gaussian

Proper motion

Light curve

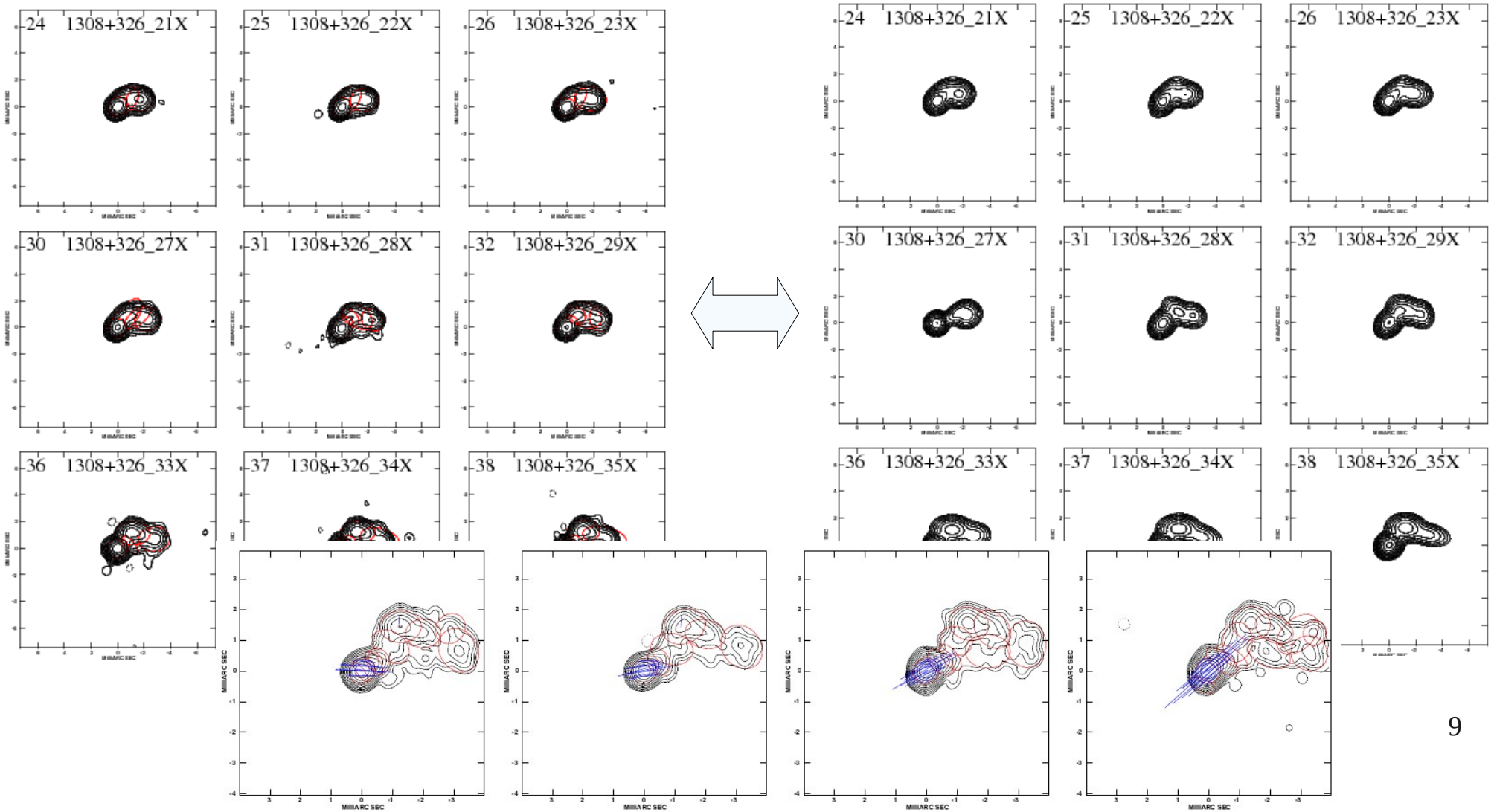
Polarization

- Comparison with manual reduction



Cataloguing

- CLEANed image and model reconstruction



External pipers

- NED quasar database
  - “nedqry” - search and distill the redshift information

```
# 0014+813
[5]1    [HB89] 0014+813                00h17m08.5s +81d35m08s QSO    >30000  3.366000      16.5     ...  [6] 194  [7]   2 [8]
  12 [9]   2     0    0  [10]1 [11]Retrieve [12]Retrieve [13]1
# 0048-097
[5]1   *FBQS J0050-0929                00h50m41.3s -09d29m05s QSO    >30000  0.537000      17.44    ...  [6] 223  [7]  12 [8]
  56 [9]   6     0 [10]   30 [11]Retrieve [12]Retrieve [13]1
```

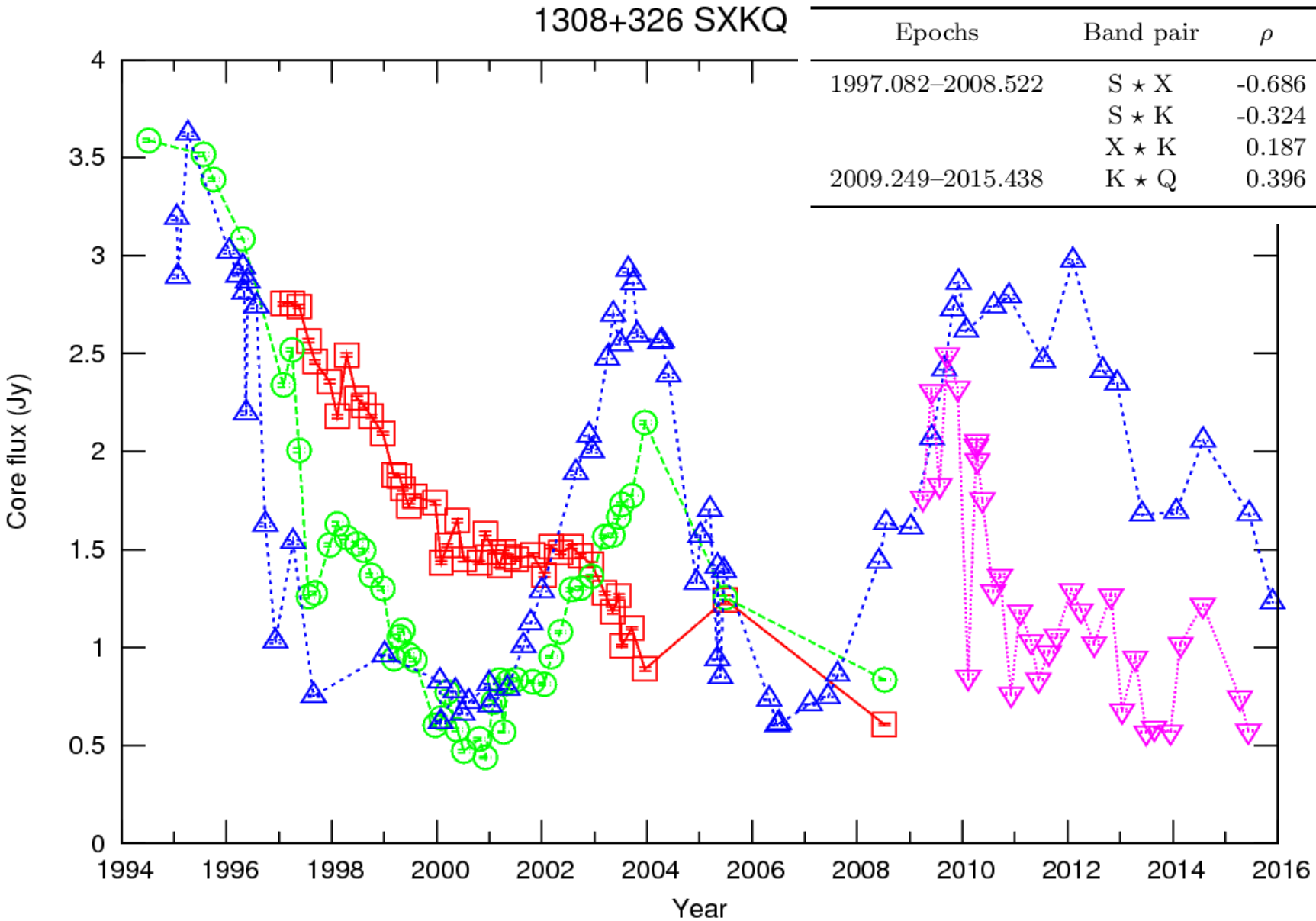
- Cosmological calculator
  - “distans” - calculate the angular diameter distance

```
mzhang@tarim[05:20]~> distans 0 1
-----------------------------------------------------
Spatial curvature        : -0 (flat)
Deceleration parameter   : -0.55
Linear growth factor     : 0.778981
Time since Big Bang      : 13.0932 Gyr
Light travel time        : 7.50119 Gyr
Comoving distance (rad)  : 3212.06 Mpc 10.4766 Gly
Comoving distance (tan)  : 3212.06 Mpc 10.4766 Gly
Comoving volume          : 138.815 Gpc^3
Comoving horizon size    : 4163.78 Mpc 13.5807 Gly
Angular diameter distance: 1606.03 Mpc 5.23828 Gly
Linear to angular scale  : 7.78624 kpc/"
Luminosity distance      : 6424.11 Mpc 20.9531 Gly
-----------------------------------------------------
```

```
omfit:
y = (0.414 +/- 0.013)*x + (-825.981 +/- 26.273) ; vel_app = 20.955880 c , acc = 0.
y = (0.447 +/- 0.020)*x + (-893.489 +/- 39.999) ; vel_app = 22.636014 c , acc = 0.
No enough points in peak bin [PA]!
sad:
y = (0.386 +/- 0.018)*x + (-771.394 +/- 36.894) ; vel_app = 19.567247 c , acc = -0
y = (0.417 +/- 0.033)*x + (-833.190 +/- 66.789) ; vel_app = 21.109945 c , acc = -0
No enough points in peak bin [PA]!
mzhang@tarim[15:40]data>
```

Light curves

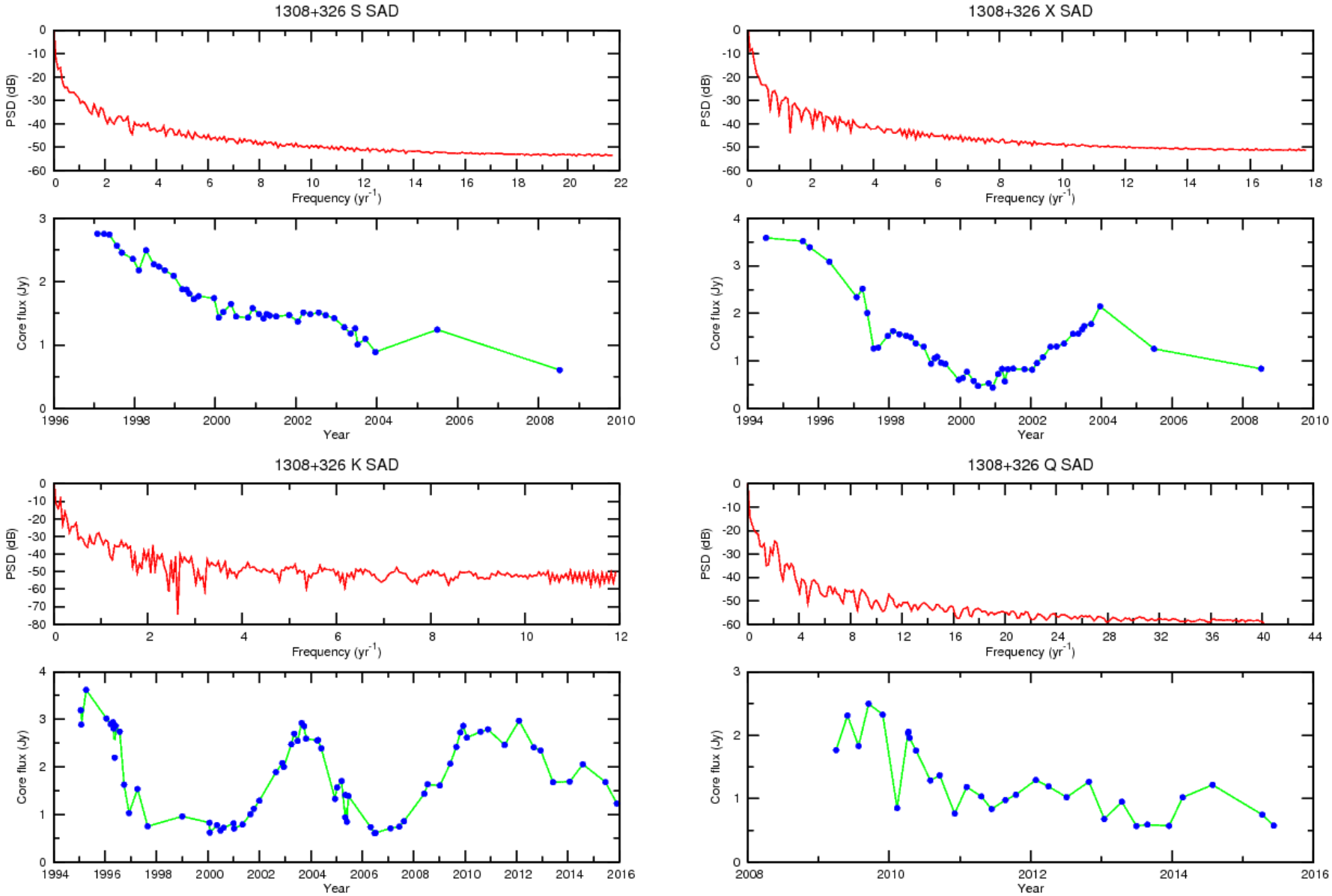
- Epoch overlap and cross-correlation



Epochs	Band pair	ρ	p-Value
1997.082–2008.522	S ⋆ X	-0.686	2.477E-17
	S ⋆ K	-0.324	4.091E-4
	X ⋆ K	0.187	4.516E-2
2009.249–2015.438	K ⋆ Q	0.396	1.420E-3

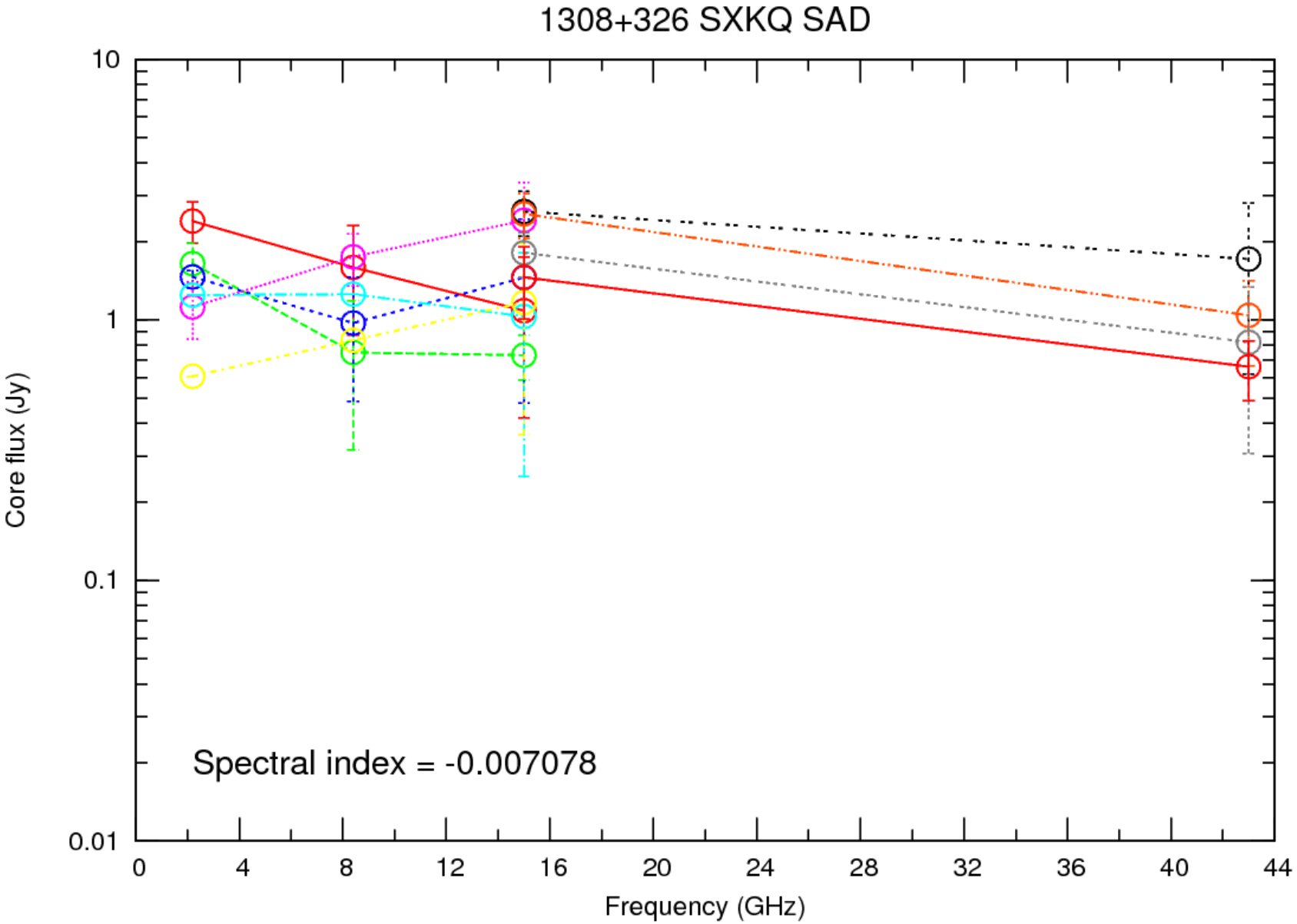
Light curves

- Power spectral density & periodicity



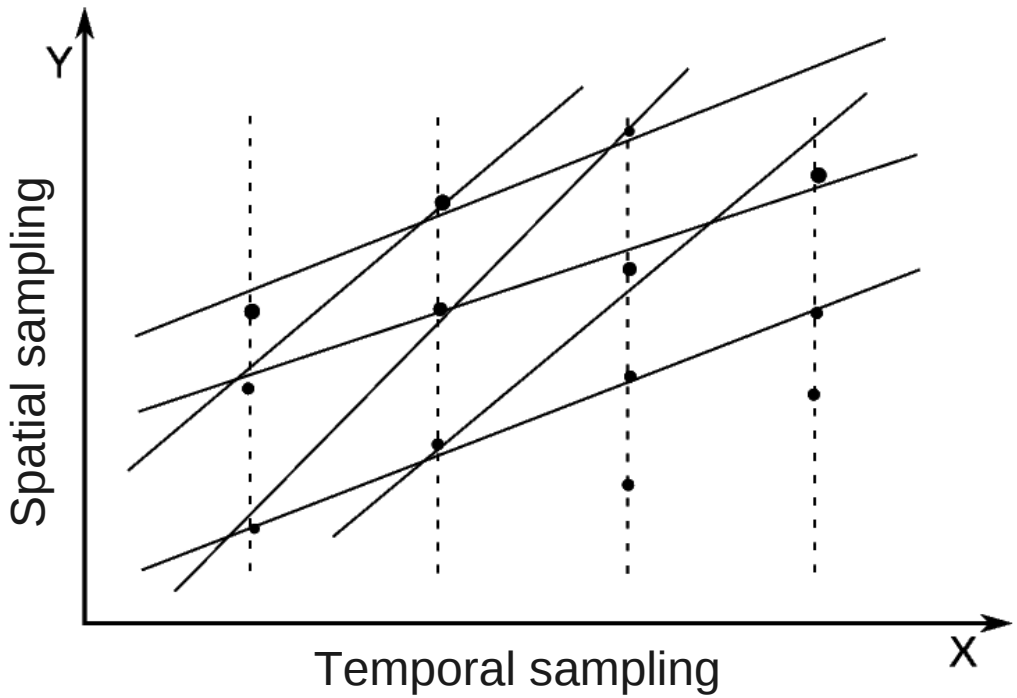
Spectra

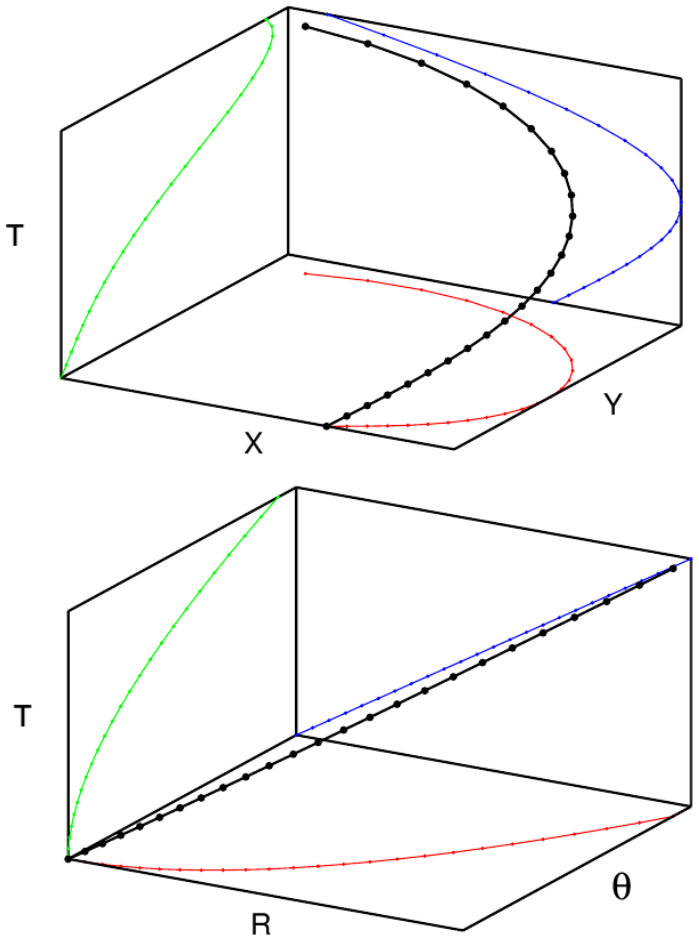
- Epoch-binned spectra



Trajectory representation

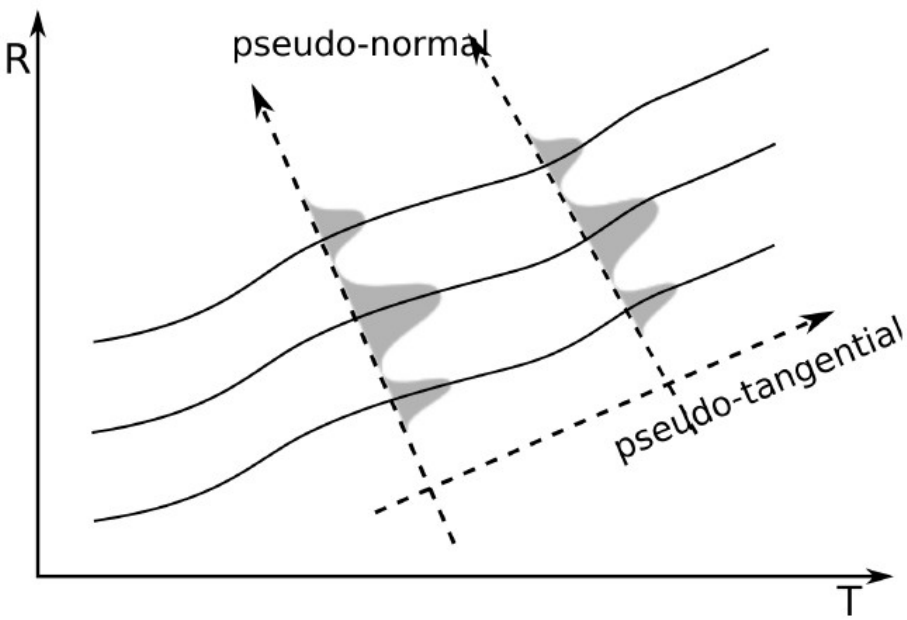
- Correspondence confusion

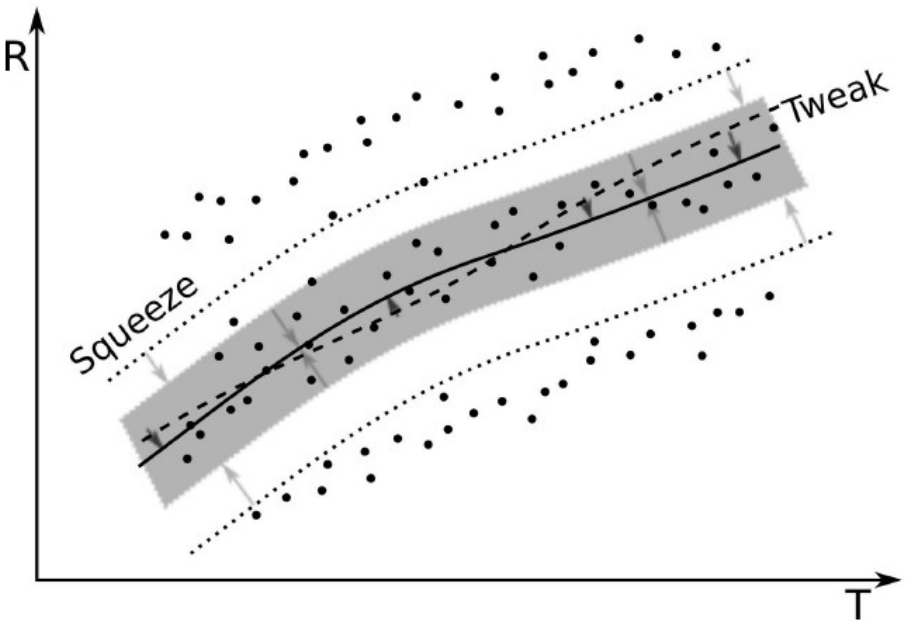




Regression STRIP algorithm

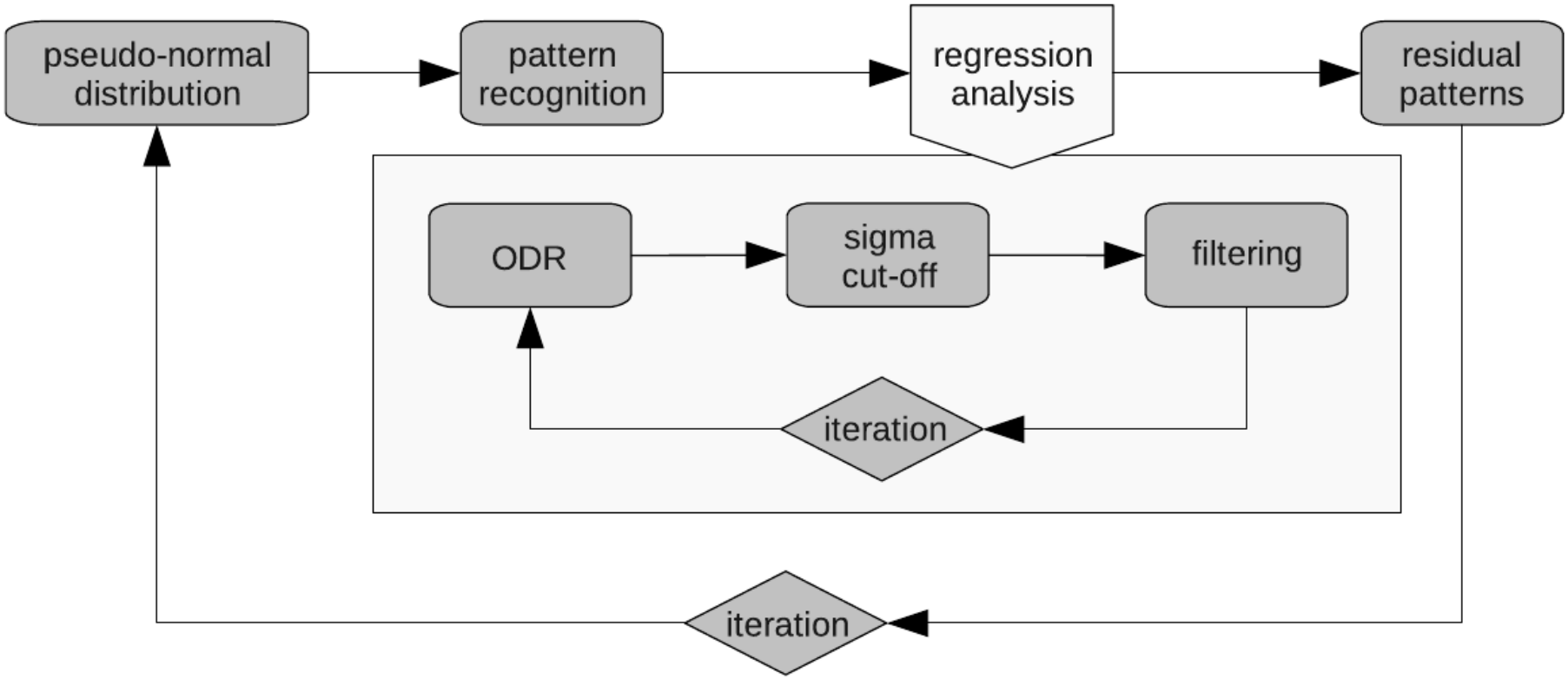
- Pseudo-normal distribution & Squeez-'n'-Tweek





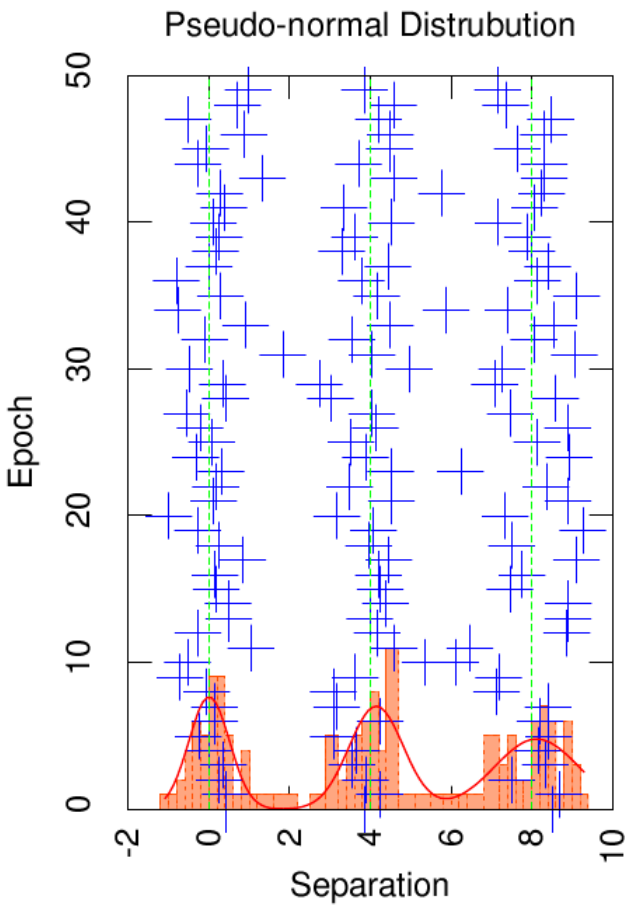
Regression STRIP algorithm

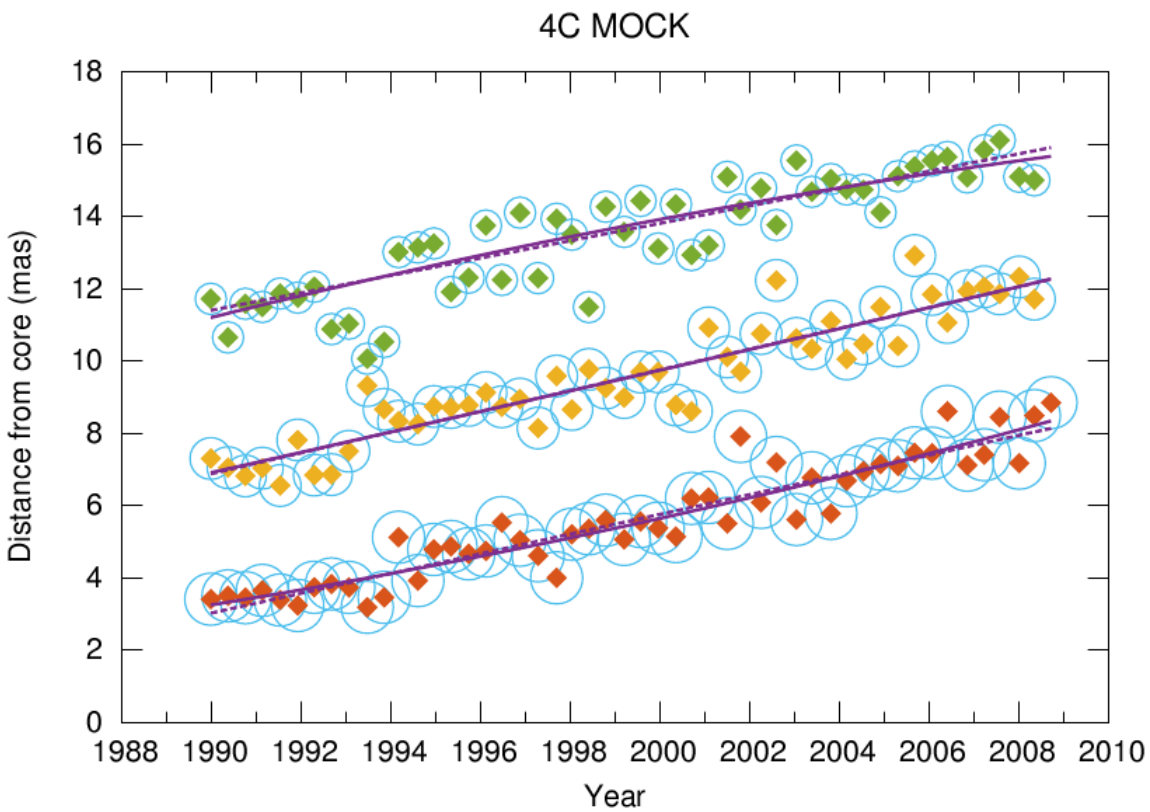
- CLEAN-like flowchart



Proper motion patterns

- Mock data tests





Proper motion patterns

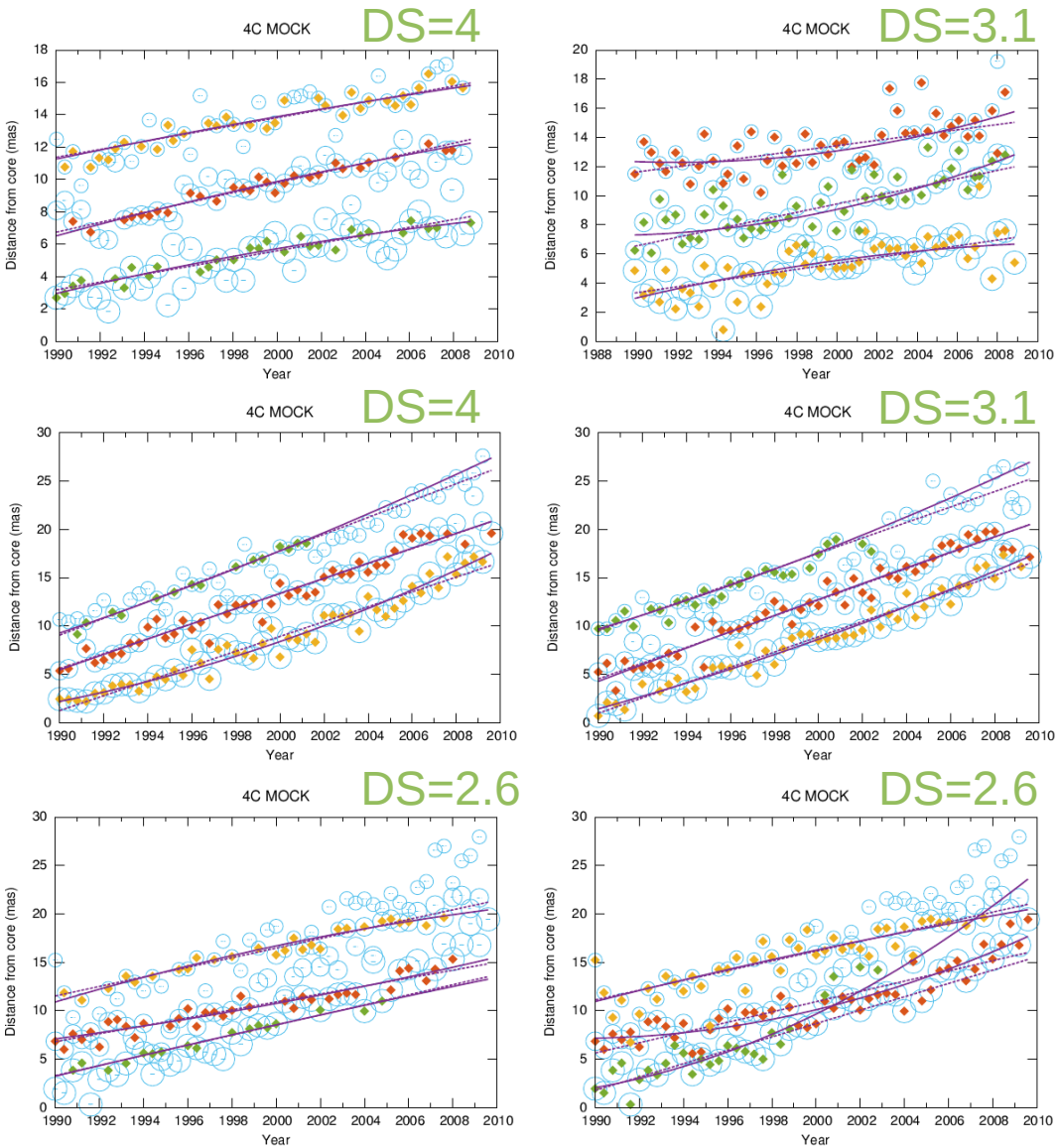
- Degree of separation

$$DS := \frac{\Delta\mu}{\sigma_{\max}}$$

- Confusion limit

$$DS < 3$$

- Undersampling
  - Magic numbers
    - Number of bins
    - Sigma cut-off



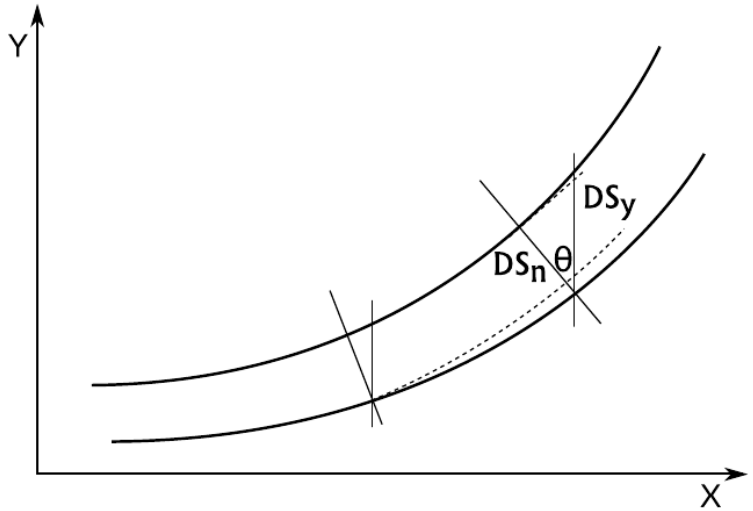
Proper motion patterns

- DS-curvature degeneracy
  - Scaled quadratic

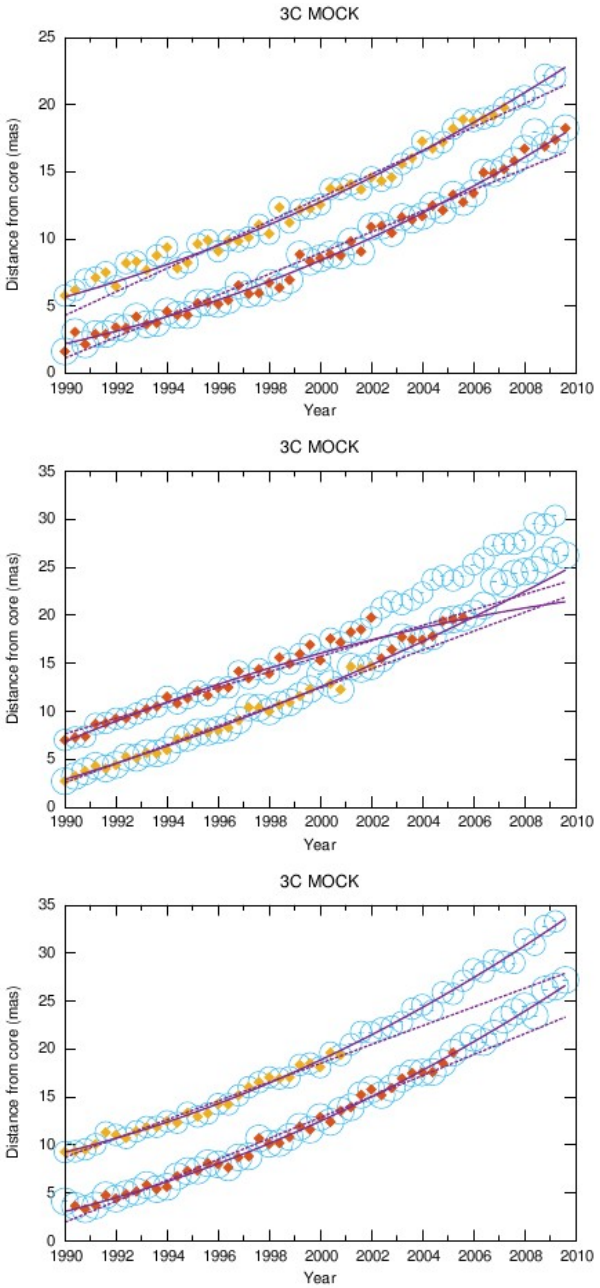
$$k = \frac{y''}{(1+y'^2)^{3/2}} = \frac{2a}{[1+(2ax+b)^2]^{3/2}} \leqslant 2a$$

$$\Rightarrow k_{\max} = 2a$$

  - Tail separation

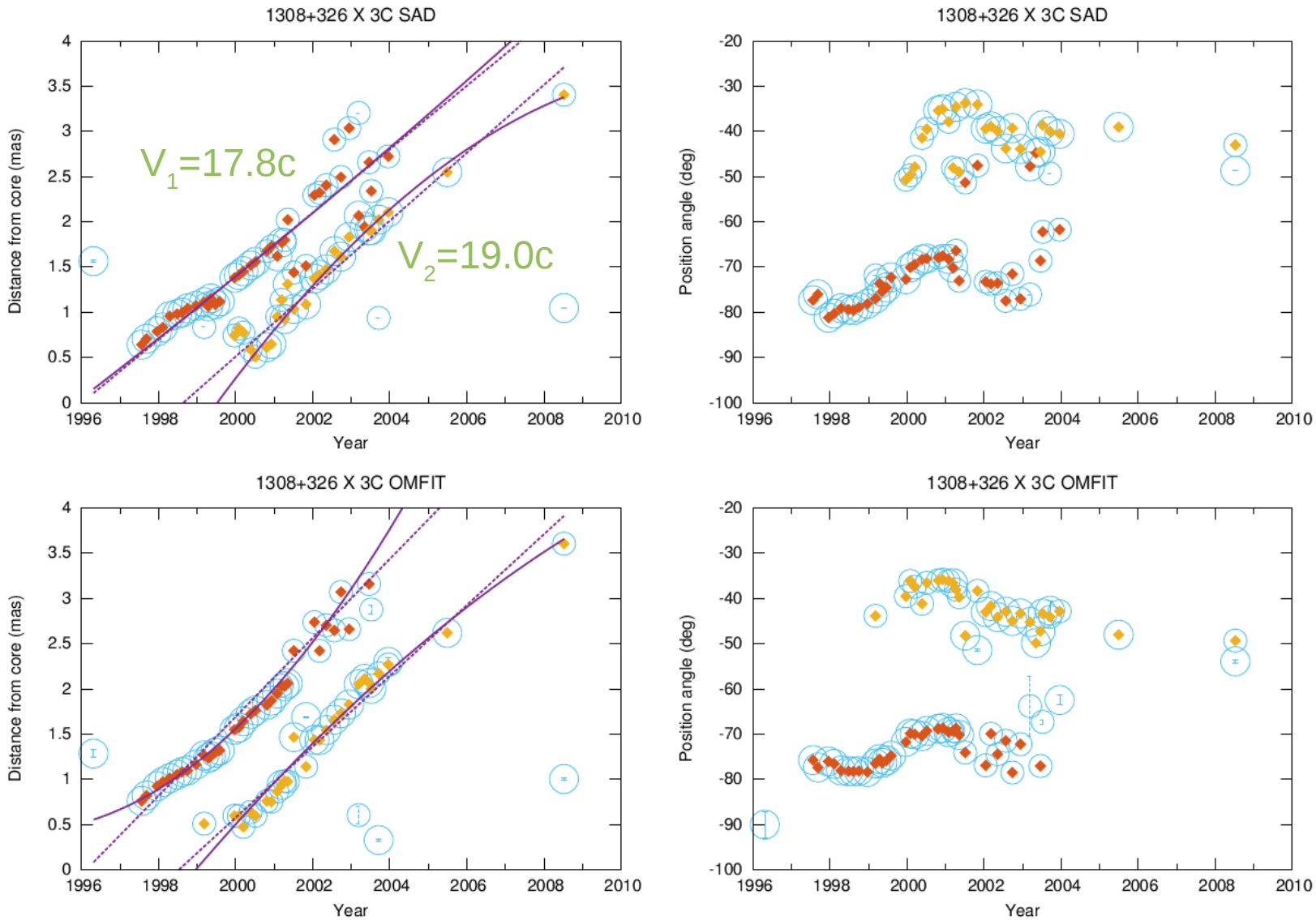


$$DS_n \leqslant DS_y \cdot \cos\theta, \quad \text{and} \quad x \uparrow \ \theta \downarrow \ DS_n \uparrow \ DS_y \uparrow$$



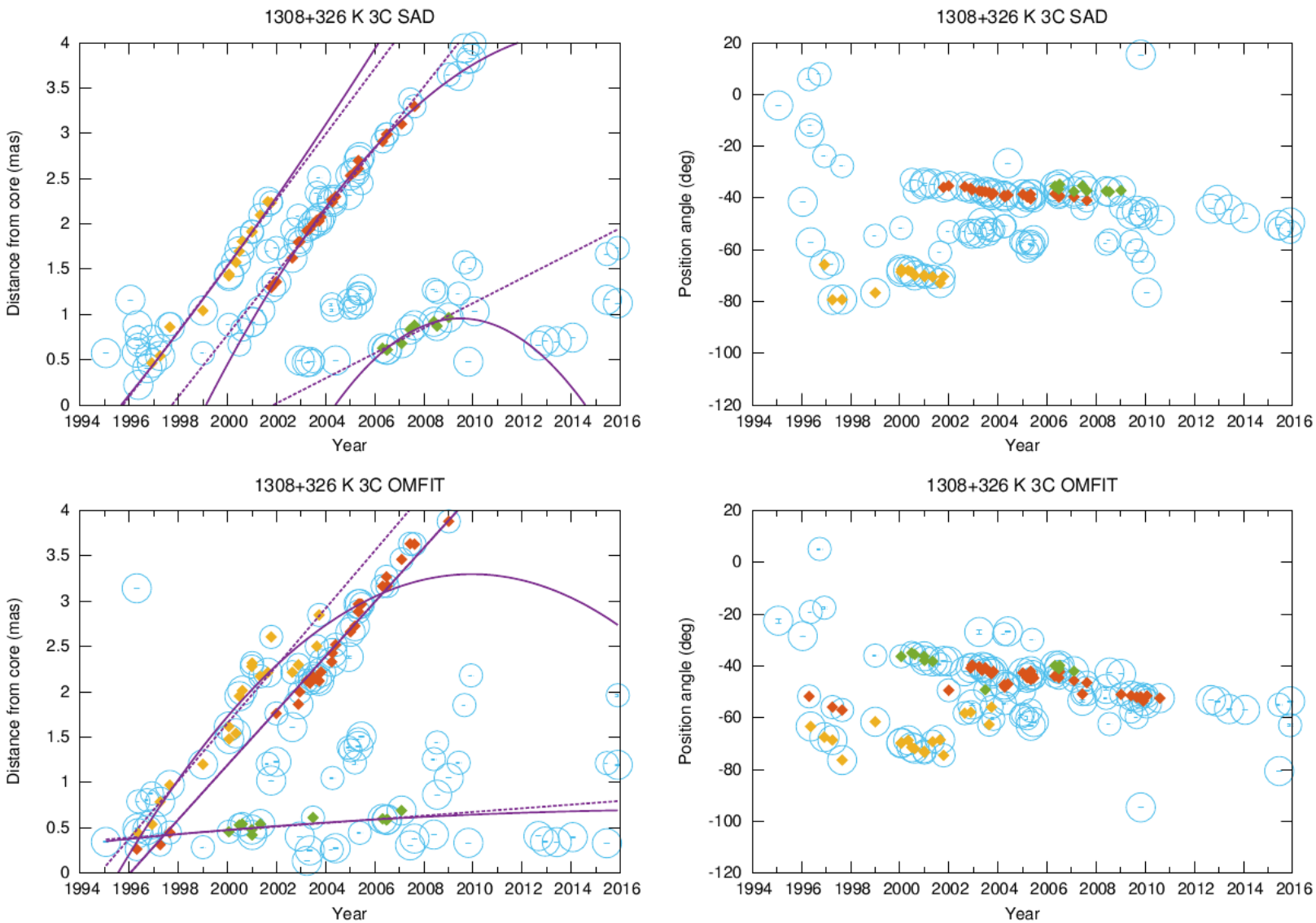
Proper motion patterns

- Linear and non-linear pattern (RDV)



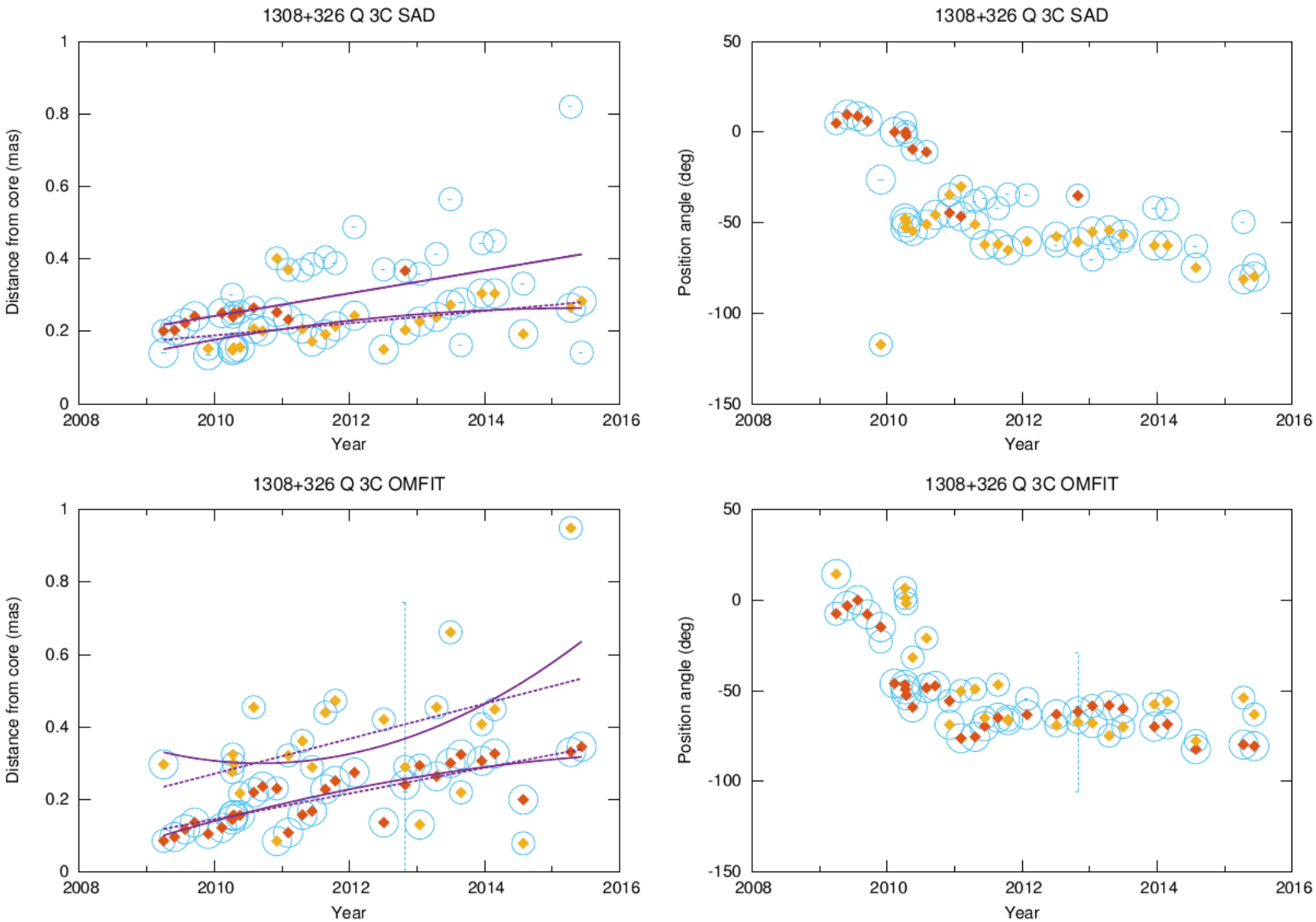
Proper motion patterns

- Linear and non-linear pattern (MOJAVE)



Proper motion patterns

- Linear and non-linear pattern (BU-Blazar)



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ASCL Code Record

[ascl:1605.015] SAND: Automated VLBI imaging a

Zhang, Ming

The Search And Non-Destroy (SAND) is a VLBI data reduction pipe based on the AIPS interface provided by ObitTalk. It is designed fo monitoring research. It can automatically investigate calibrated visi given noise floor and do the model fitting either on the CLEANed in model-fitting results, intelligently identifies the multi-epoch jet comp or non-linear proper motion patterns. The outputs including CLEAN animation cube, proper motion fitting and core light curves. For un modules to do the calibration and self-calibration in a batch for a s

Code site: https://sourceforge.net/projects/sand-py

Bibcode: 2016ascl.soft05015Z

MONTHLY NOTICES
of the Royal Astronomical Society

Article Navigation

SAND: an automated VLBI imaging and analysing pipeline – I. Stripping component trajectories

M. Zhang, A. Collioud, P. Charlot

Monthly Notices of the Royal Astronomical Society, Volume 473, Issue 4, 1 February 2018, Pages 4505–4522,
https://doi.org/10.1093/mnras/stx1513

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Abstract

We present our implementation of an automated very long baseline interferometry (VLBI) data-reduction pipeline that is dedicated to interferometric data imaging and analysis. The pipeline can handle massive VLBI data efficiently, which makes it an appropriate tool to investigate multi-epoch multiband VLBI data. Compared to traditional manual data reduction, our pipeline provides more objective results as less human interference is involved. The source extraction is carried out in the image plane, while deconvolution and model fitting are performed in both the image plane and the *uv* plane for parallel comparison. The output from the pipeline includes catalogues of CLEANed images and reconstructed models, polarization maps, proper motion estimates, core light curves and multiband spectra. We have developed

Prospects

- Piping monitoring data
  - G-VLBI – RDV
  - VLBA – MOJAVE & BU-Blazar
  - e-MERLIN legacy
- Evolving algorithms
  - Statistics – Data mining – Machine learning – AI
    - Pattern recognition
    - Deconvolution
    - Compressive sensing
- VO backend app?