State of the absolute astrometry by 2018.01.01

The state-of-the-art catalogue: the Radio Fundamental Catalogue

sources: 14786

Percentile of accuracy:

20%	< 0.30	mas
50% (median)	< 0.90	mas
80%	< 2.5	mas
90%	< 5.2	mas
94.8%	< 10	mas

Contributors:

VLBA:	87%
LBA:	8%
CVN:	4%
IVS:	1%

Flux density @ X-band: [0.003, 22] Jy, median: 101 mJy

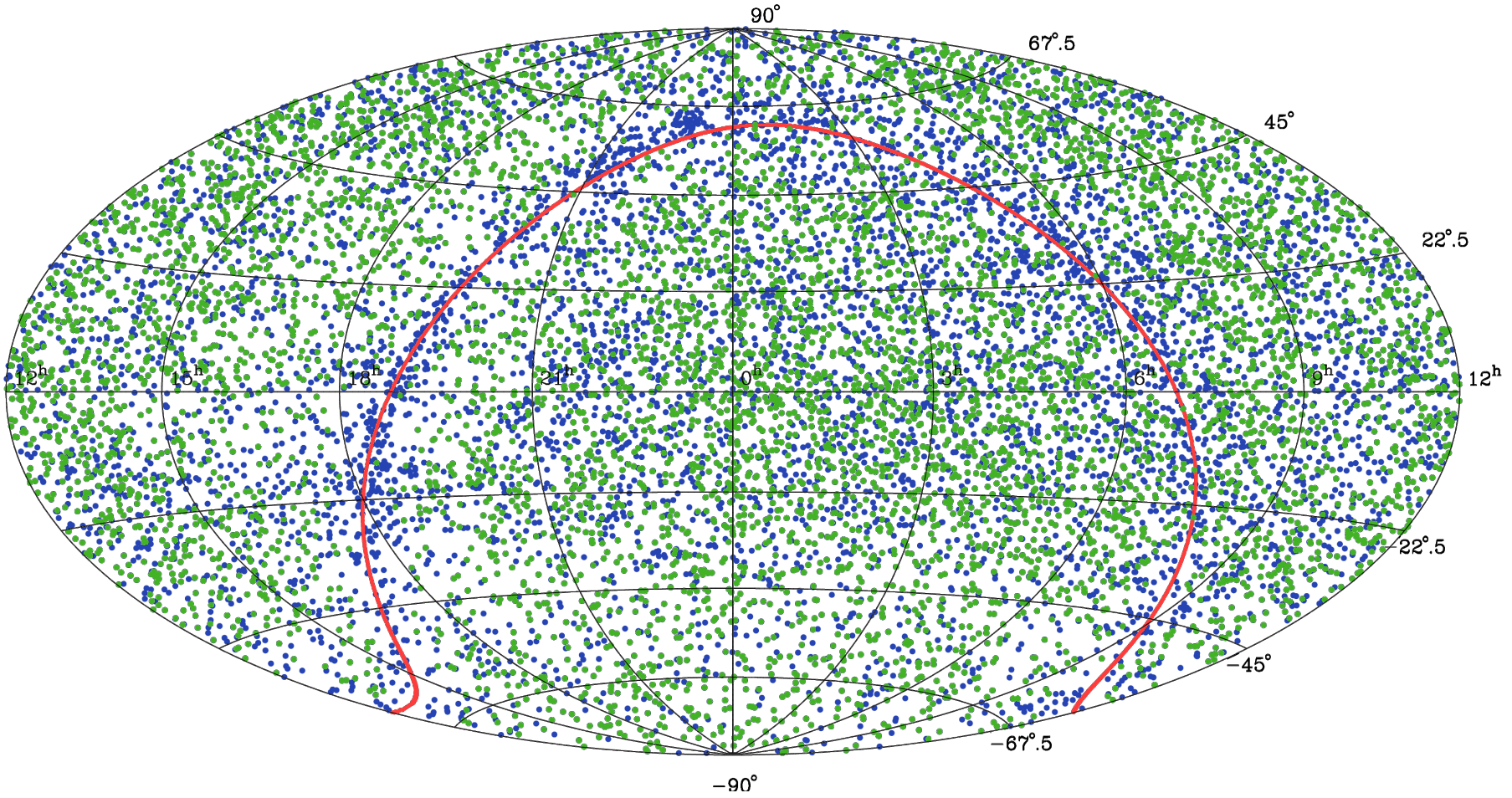
Results of ongoing dedicated VLBI absolute astrometry programs for 27000 sources since 1997 using over 8000 hours.

56,811 images of 9311 compact radio sources were generated

The number of matches of the RFC:

γ-ray	Fermi:	15%
X-ray	Chandra	3%
infra-red	WISE:	74%
infra-red	2MASS:	36%
optic	$Gaia$:	52%
optic	PanSTARRS:	69% (78% at $\delta > -30^\circ$)
optic	known redshifts:	42%
radio	NVSS	91% (99.8% at $\delta > -40^\circ$)
radio	TGSS	72% (76% at $\delta > -53^\circ$)

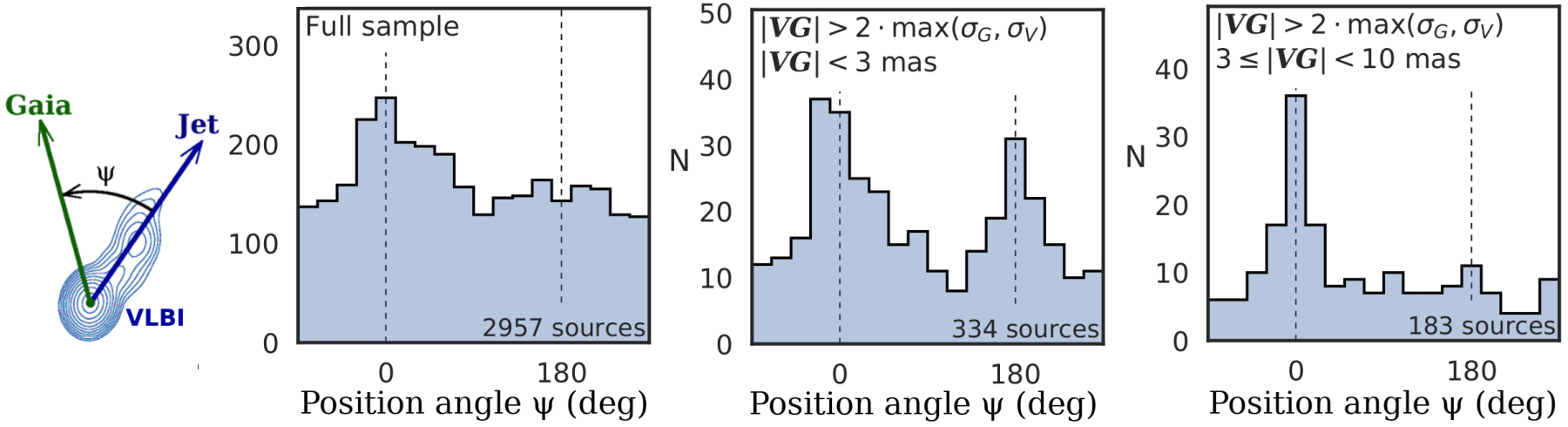
VLBI Radio Fundamental Catalogue (**14,786 sources**) on 2018.01.01 and *Gaia* DR1 ($1.14 \cdot 10^9$ objects)



Green: 7,716 VLBI/*Gaia* matches $P < 0.0002$

Blue: VLBI sources without *Gaia* matches

VLBI/*Gaia* offsets favor direction along the jet!



Mean *systematic* contribution: **1–2 mas**

Explanation: presence of an optical jet at mas scales

Why **VLBI** and **Gaia** give different AGN positions?

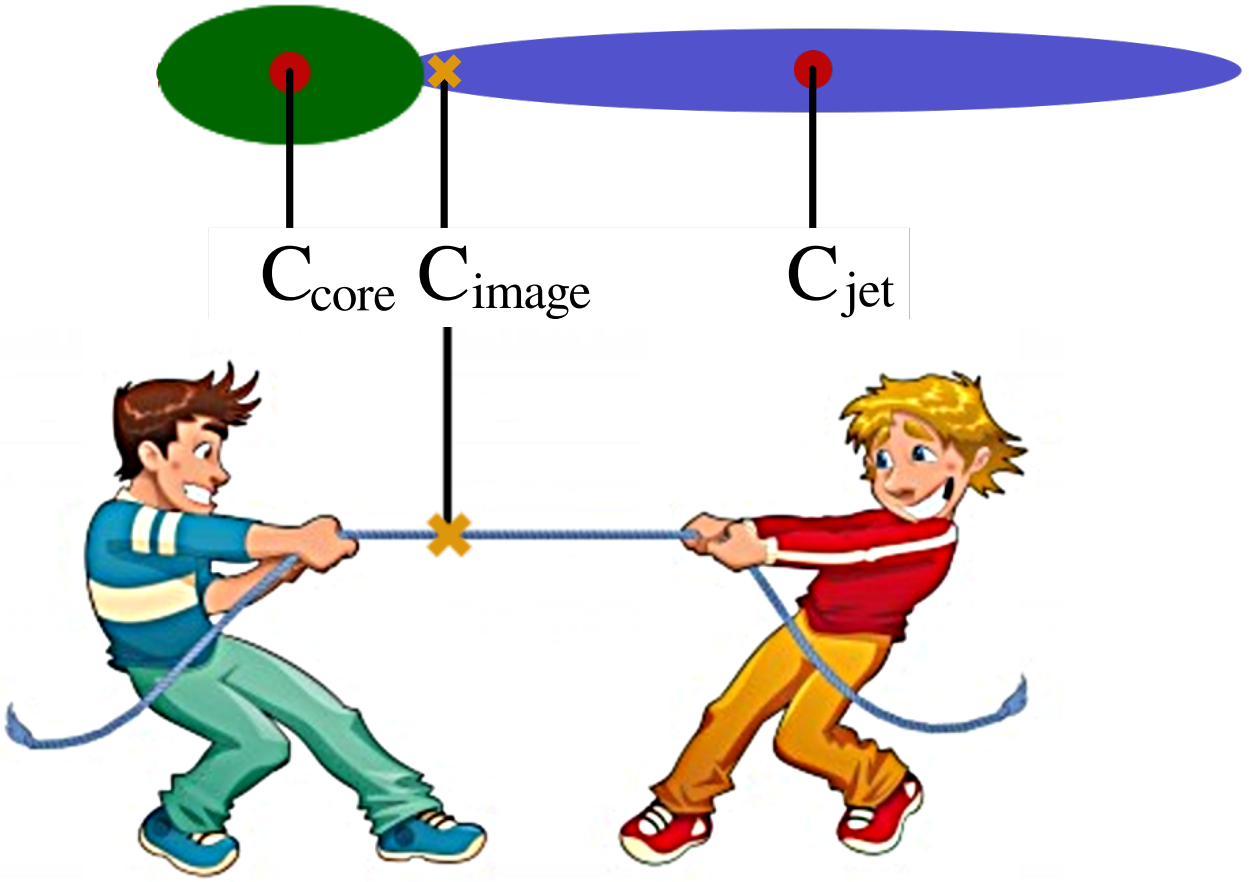
	Gaia	**VLBI**
Records:	power	voltage
Position of an extended source:	centroid	the most compact detail

Gaia minus **VLBI** offset = position of the **centroid** wrt the **compact detail**.

Consequences to fundamental astronomy

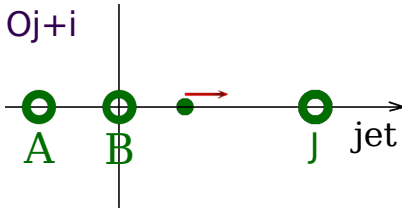
- We still do not know unmovable sources (AGNs are not);
- There is a limit beyond that positions from technique A and B are not comparable;
- For VLBI/$Gaia$ this limit is **1–2 mas**;
- The fundamental coordinate systems from different techniques have to coexist;
- Impossible to say which is the best: $Gaia$-DR99, or RFC, or ICRF-2100;
- Future comparison of VLBI/optic will focus on astrophysics interpretation.

What will happen of one of the components will become brighter?

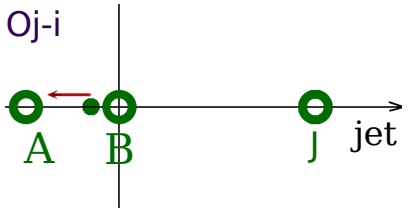


Prediction: **Gaia** centroid will jitter.

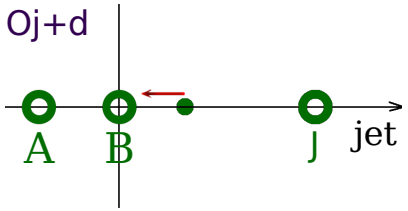
Direction of the centroid change after a flare

- 

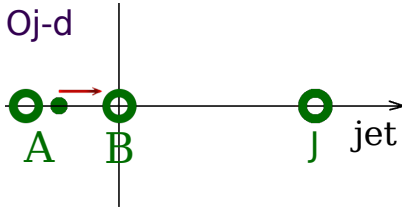
Flare happened at the jet

- 

Flare happened at the accretion disk

- 

Flare happened at the core or accretion disk

- 

Flare happened at the core or the jet

Analysis of $\mathcal{O}_{\mathrm{j}}$ time series will allow us to answer the question where the flare happened

Summary:

- VLBI/$Gaia$ residuals have systematic caused by core-jet morphology;
- VLBI position is related to the most compact detail, an AGN core;
- $Gaia$ position is related to the image centroid within the PSF;
- The most plausible explanation: optical jet at scales 1–200 mas;
- Consequence of the optical jet presence: source position jitter;
- Position jitter + light curve = optical resolution at mas scale;
- VLBI + $Gaia$ $\longrightarrow$ we can determine the region of optical flares its kinematics and its flux density.

References: arxiv.org/abs 1611.02630, 1611.02632, 1704.07365

RFC preview: **http://astrogeo.org/rfc**