

Aligning VLBI and Gaia Extragalactic Celestial Reference Frames

G. Bourda, P. Charlot & A. Collioud

+ Other Collaborators

Laboratoire d'Astrophysique de Bordeaux (LAB) – FRANCE
Observatoire Aquitain des Sciences de l'Univers (OASU)
Centre National de la Recherche Scientifique
Université de Bordeaux

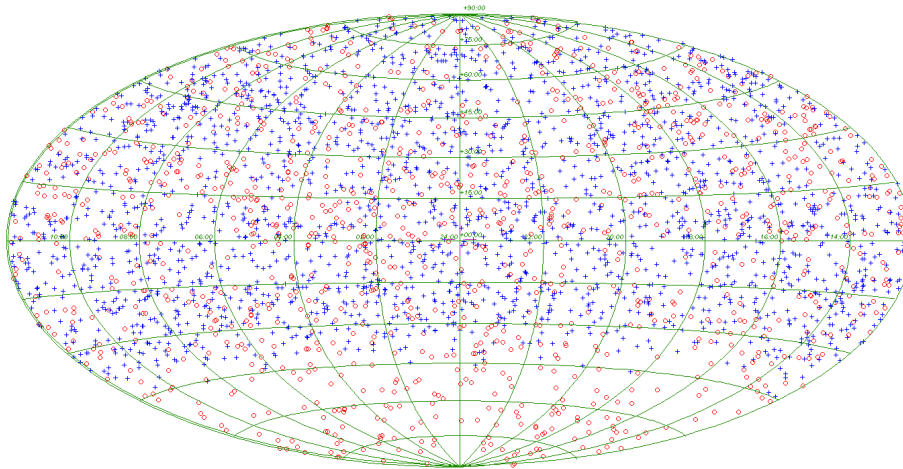
Gaia

- Gaia scans the whole sky until magnitude 20
- Gaia scanning law, see:
<https://www.youtube.com/watch?v=BnFyzZGWuYs>
- Quasars will be observed on average 80 times during the 5-yr mission (between 45 and 150 times)
- Gaia will observe ~500 000 quasars, a lot of them being new (~2/3)
- Gaia scientific performances (after commissioning phase), see:
<http://www.cosmos.esa.int/web/gaia/science-performance>

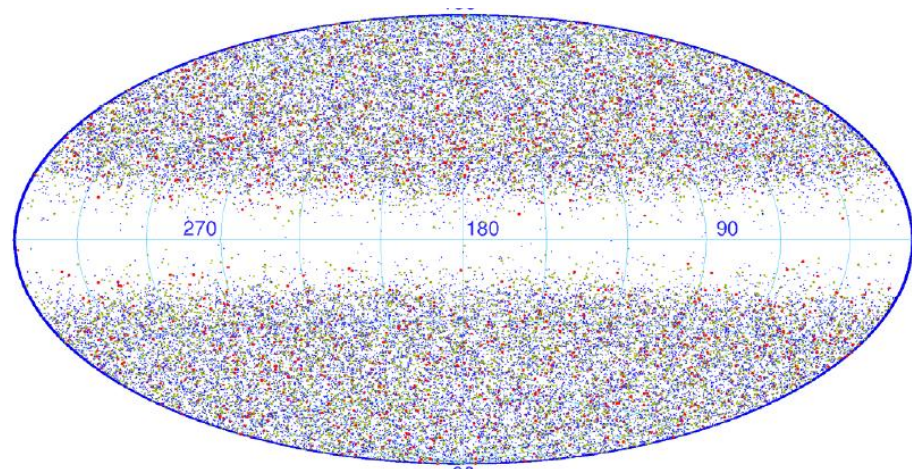
Motivation – 1

2021: Two extragalactic celestial reference frames will coexist

VLBI – Radio



Gaia – Optical



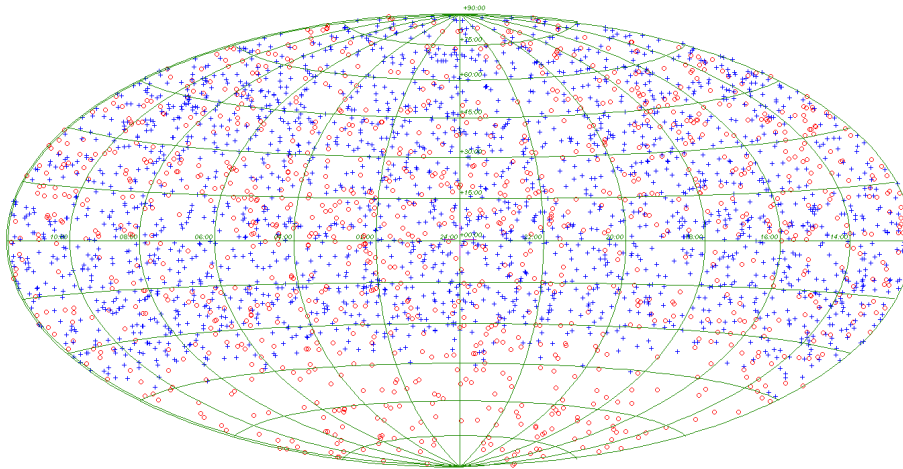
ICRF2		GCRF
3 414	<i># of objects</i>	~10 000 – 20 000
@ best 40 μ as	<i>Position accuracy</i>	~100 μ as @ G=18 ~300 μ as @ G=20

3 problems revealed during commissioning phase → Re-assessment of astrometry
[straylight, water ice, basic angle variations] *Rough estimates (Mignard, priv. com.)*
http://www.cosmos.esa.int/web/gaia/news_20140729
http://www.cosmos.esa.int/web/gaia/news_20141217

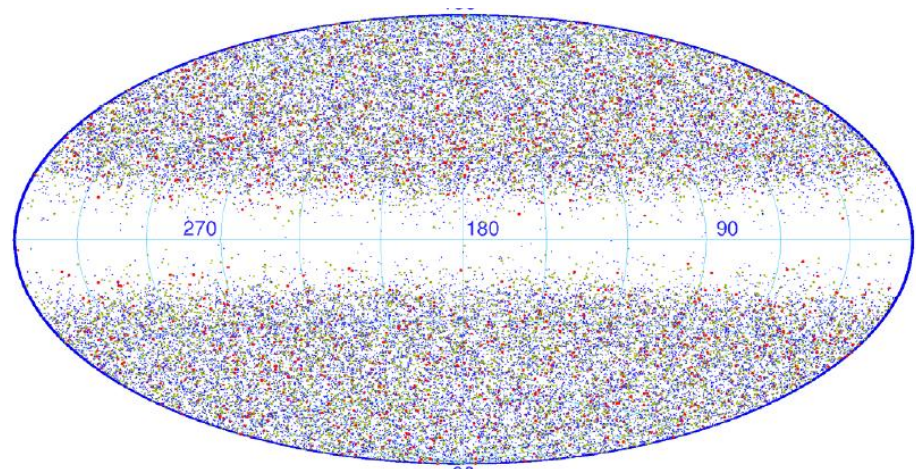
Motivation – 1

2021: Two extragalactic celestial reference frames will coexist

VLBI – Radio



Gaia – Optical

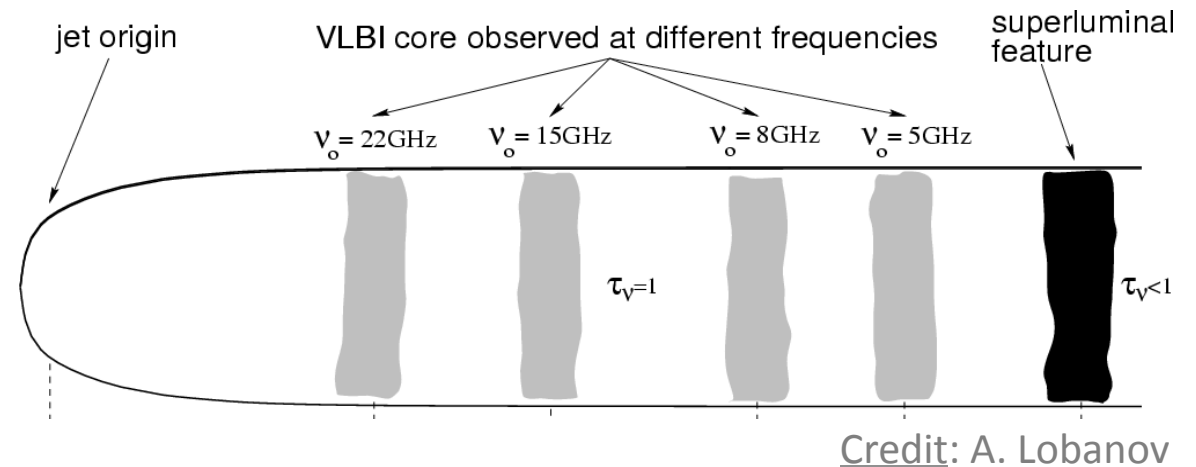
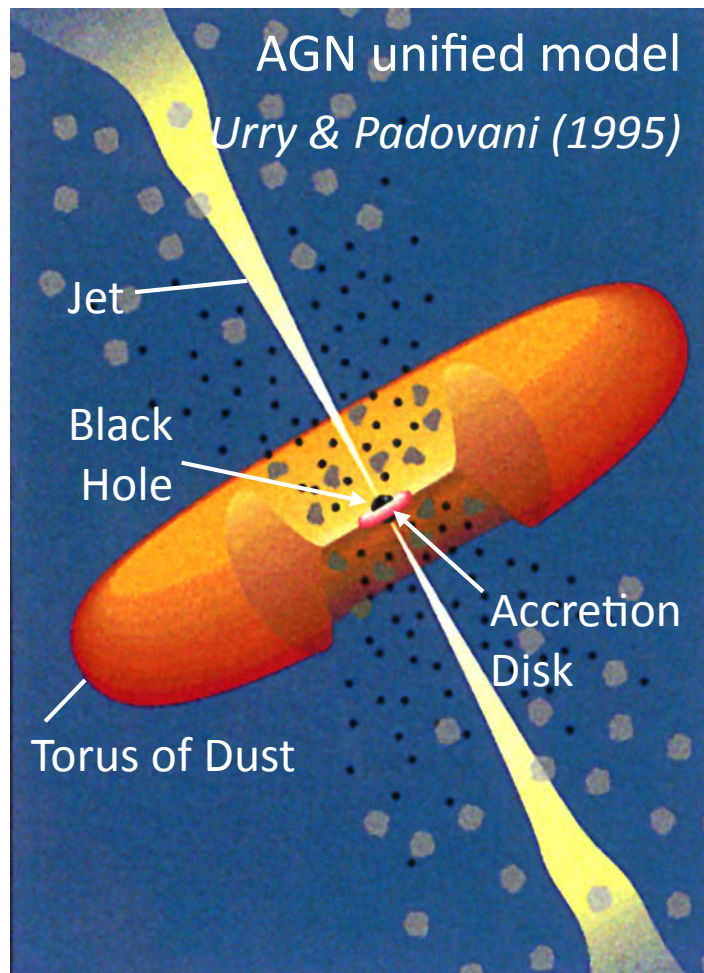


ICRF2		GCRF
3 414	<i># of objects</i>	~10 000 – 20 000
@ best 40 μ as	<i>Position accuracy</i>	~100 μ as @ G=18

Alignment of the two frames is mandatory to ensure consistency of the measured optical and radio positions for any celestial object

Motivation – 2

Astrophysics: probe AGN geometry and physics

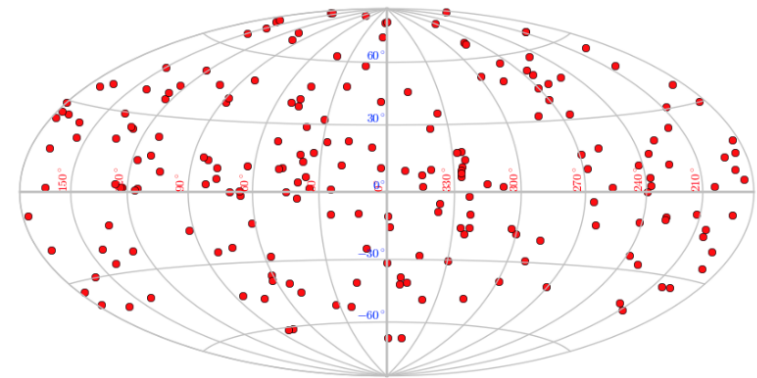


Expected shift between the optical and radio emission regions: up to 100-200 μas (theory; e.g. Kovalev et al. 2008)

Comparison of the optical and radio positions to a few tens of μas may permit to detect directly these shifts and reveal clues about AGN physics

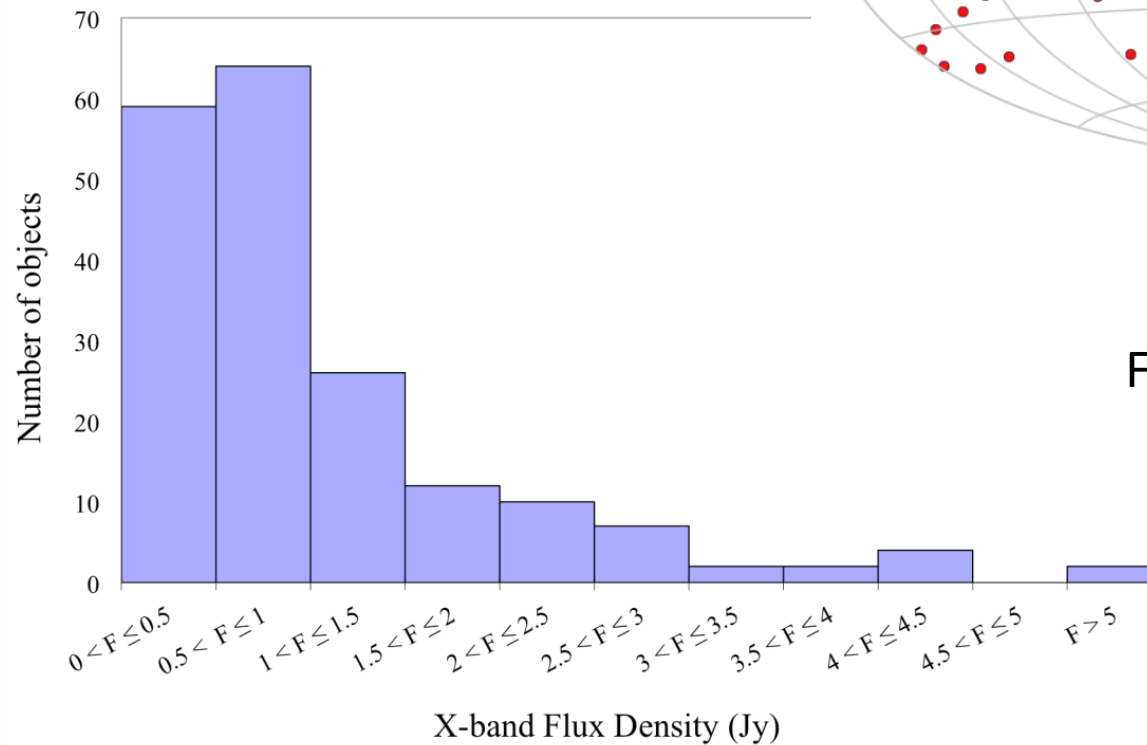
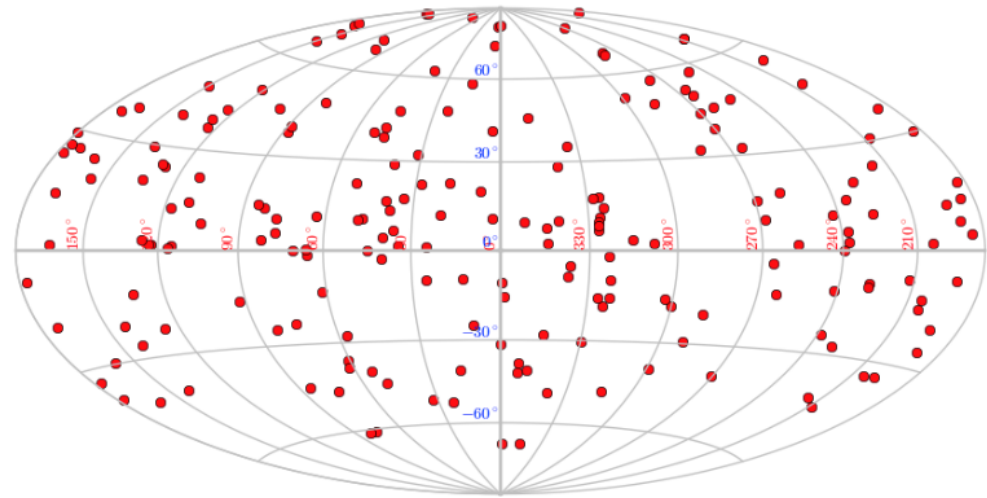
Transfer sources selection – 1

- Requirements
 - Several hundreds of common sources
 - With a uniform sky coverage
 - Accurate Gaia positions → Magnitude ≤ 18
 - Accurate VLBI positions → Good astrometric quality (*e.g. no structure*)
- Situation in 2007
 - Only 70 ICRF sources match the criteria ([Bourda et al. 2008](#))
- ICRF2 current situation
 - 195 ICRF2 transfer sources identified
 - IVS proposal ([Bourda & Charlot 2012](#))
 - 4 categories identified
 - Recommendations given
 - Regular observations since 2012 ([cf. poster K. Le Bail](#))



ICRF2 transfer sources

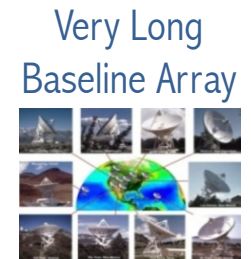
Sky distribution of the 195 ICRF2 transfer sources



Flux density of the 195 ICRF2 transfer sources

Transfer sources selection – 2

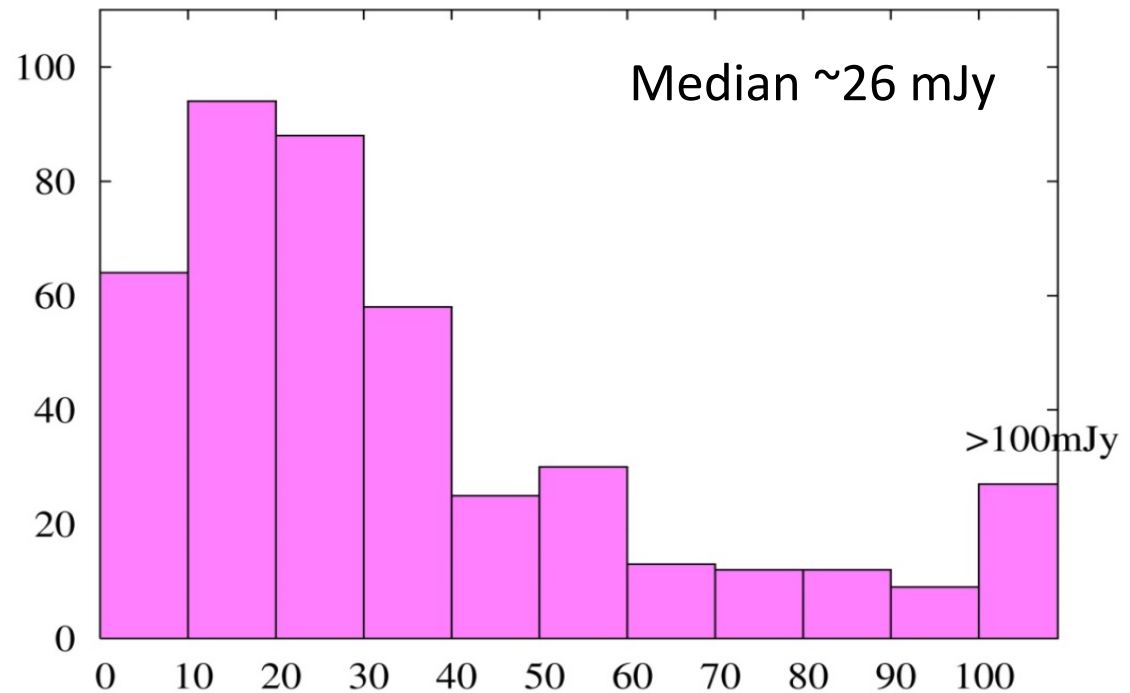
- VLBI project initiated to find additional transfer sources using EVN and VLBA
- Original sample:
 - 447 weak sources selected from NVSS ($\delta \geq -10^\circ$)
 - Proper optical counterpart
 - Not in ICRF2
- Three observational stages
 - Detection: 96 hours EVN @ 1Gbps
 - Sample reduced to 398 sources ([Bourda et al. 2010](#))
 - Imaging: 192 hours EVN+VLBA @ 512 Mbps
 - 250 sources imaged
 - 119 with appropriate structure index ([Bourda et al. 2011, 2012, ...](#))
 - Astrometry: 72 hours EVN+VLBA @ 512 Mbps
 - 119 suitable sources observed



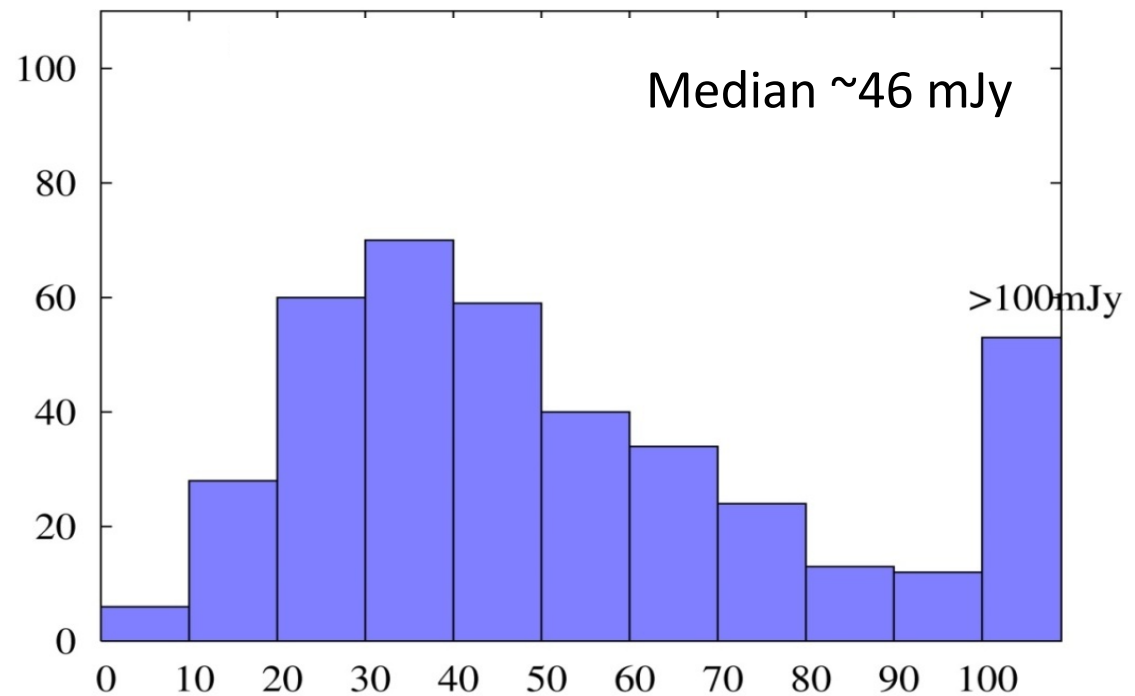
Mean correlated
flux density
distributions:

EC025A/B

X-band (mJy)

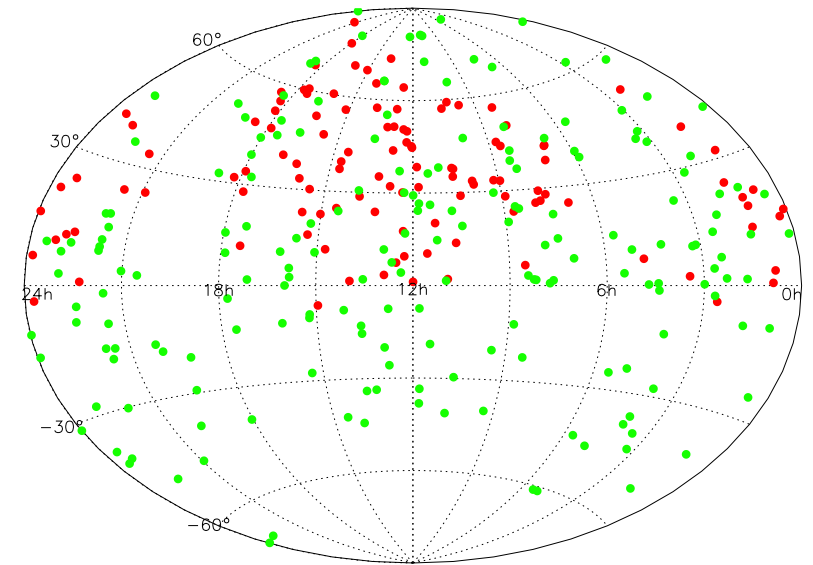


S-band (mJy)



Transfer sources selection – 3

- VCS → To be done (VCS-II)
- LCS: LBA Calibrator Survey
 - Collab. South Africa (A. de Witt *et al.*) & Australia (S. Shabala *et al.*)
 - Cover southern hemisphere
 - 190 sources / proper optical counterpart
 - Imaging experiment: 1st quarter 2015
 - Astrometry to carry out



- Higher frequencies
 - X/Ka: Collab. JPL *et al.* (cf. poster C. Jacobs)
175 sources out of 660 with a proper optical counterpart
 - K-band: Beginning collab. A. Bertarini, A de Witt, C. Jacobs *et al.* (cf. poster A. de Witt)

Summary

- Current # of transfer sources:
~400 VLBI-Gaia transfer sources being identified (S/X)
→ 195 ICRF2 + 119 « weak » non-ICRF2 + ~100 potential southern (?)
- All transfer sources should be part of the core of the future ICRF3



ICRF3 Working Group

Obrigado !!

