Linking the ICRF and the future Gaia optical frame

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The Gaia astrometric mission

- Gaia will observe 1 billion stars and 500 000 QSOs
- Astrometric accuracy

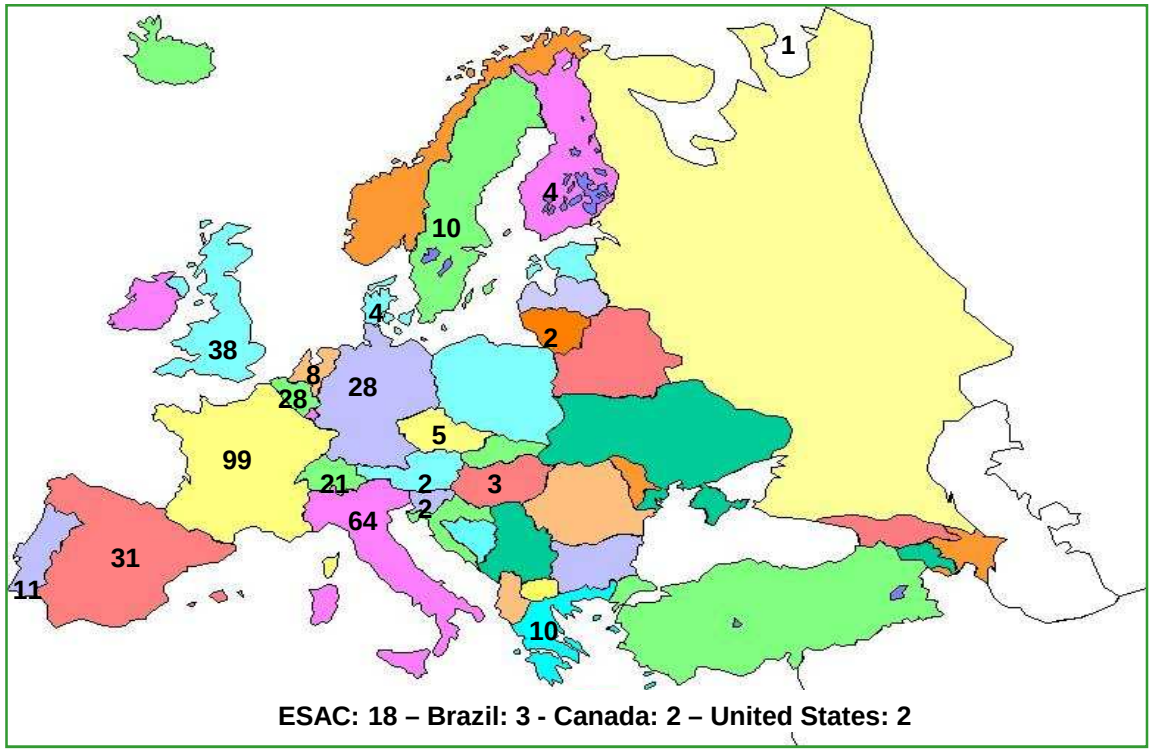
V magnitude	6 - 13	14	15	16	17	18	19	20	mag
Parallax	8	13	21	34	55	90	155	275	μas
Proper motion	5	7	11	18	30	50	80	145	μas / an
Position @2015	6	10	16	25	40	70	115	205	μas

- Launch: 2012
- Preliminary catalog: ~ 2015
- Final catalog: 2018-2020

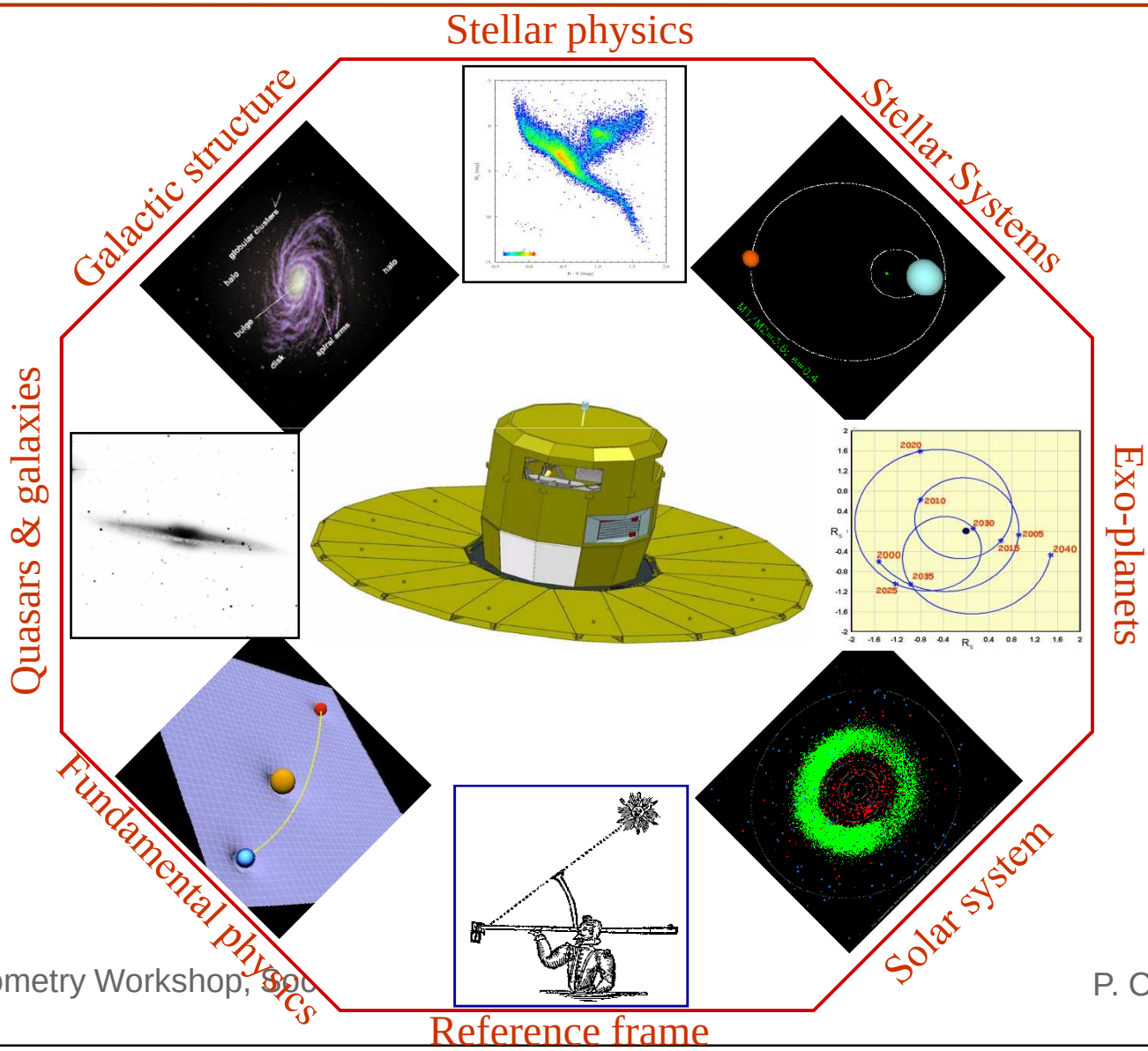
Gaia organization

- Satellite and instruments built by ESA and industry
- Data analysis conducted by the DPAC (Data Processing and Analysis Consortium)
  - 400 members
  - 22 funding agencies in Europe

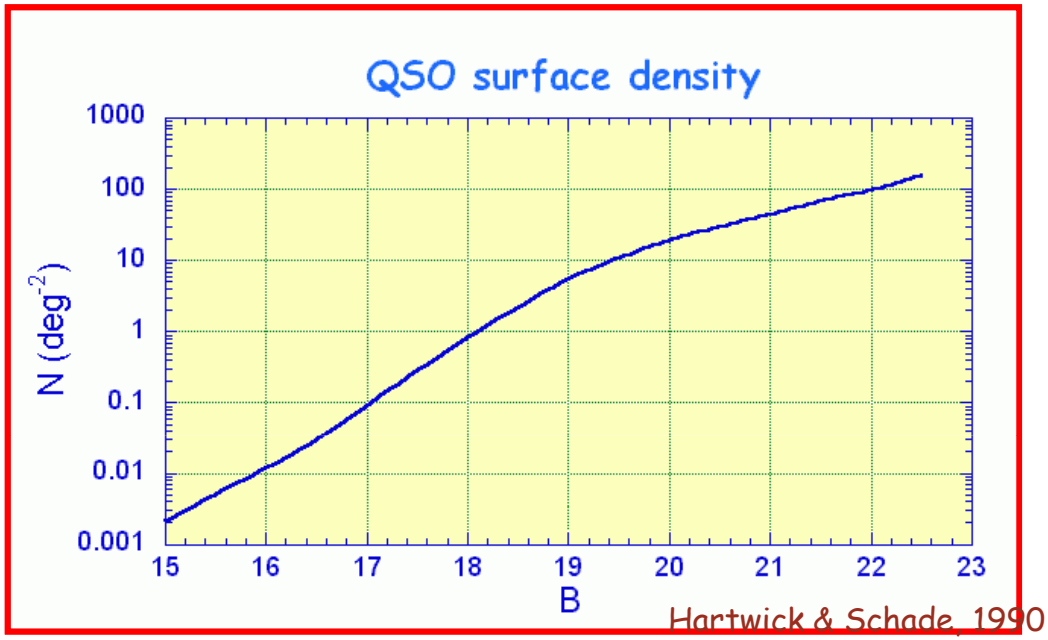
DPAC active members



Which science with Gaia?



QSO Reference Frame



With a flawless selection : GAIA will observe on ~ half of the sky

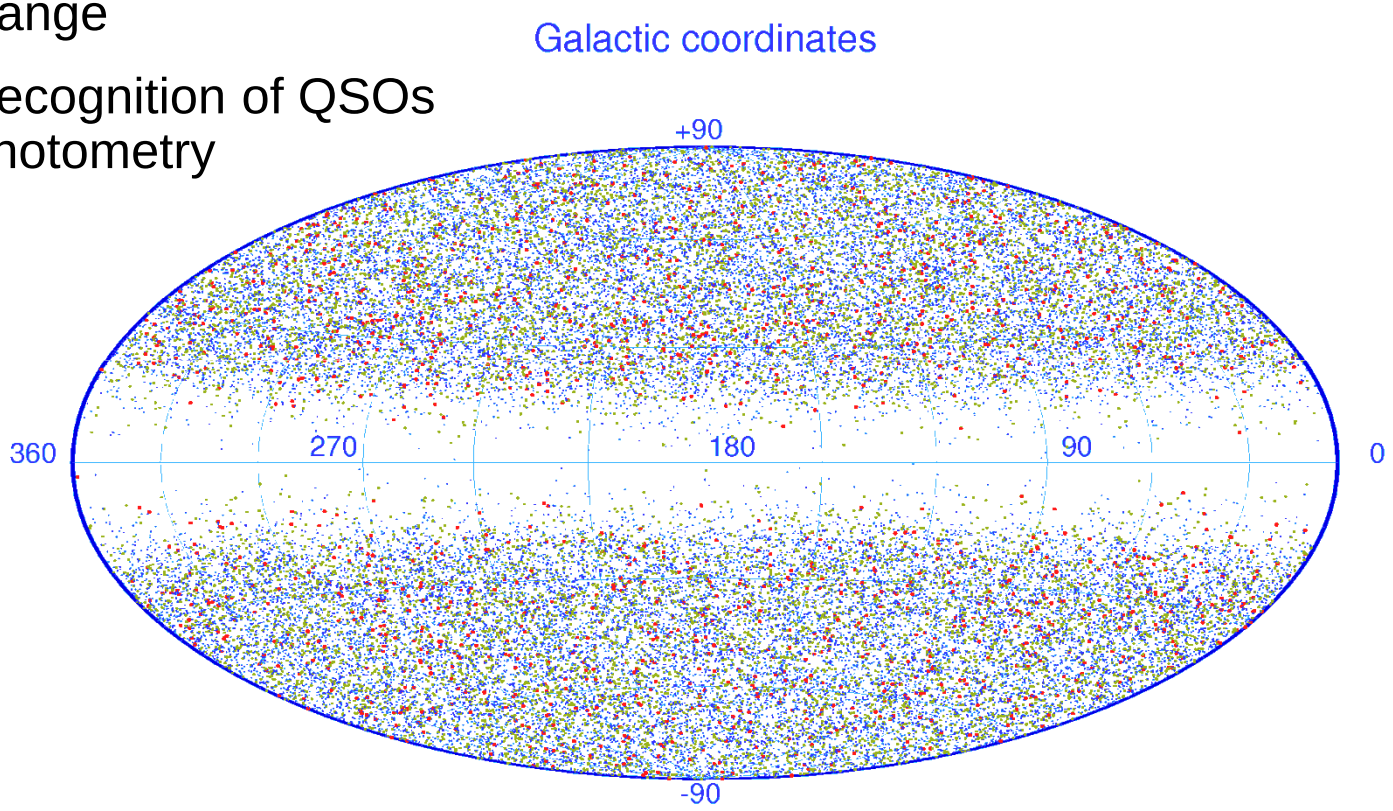
- B ≤ 16 200
- B ≤ 18 20 000
- B ≤ 20 400 000

Simulations of Gaia catalog

(Slezak and Mignard 2008)

Galactic absorption included in the visible range

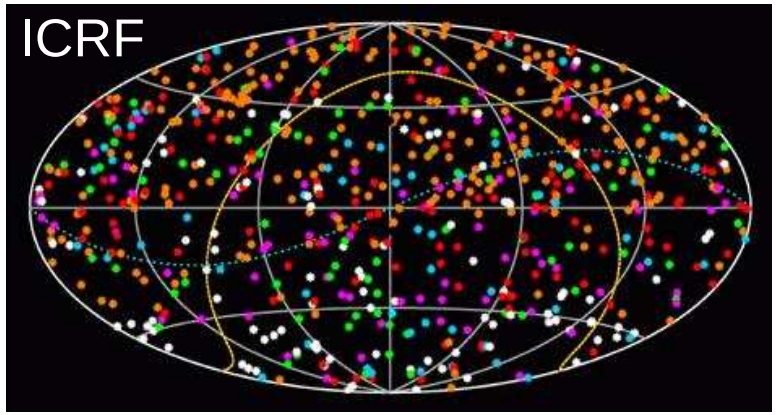
Automatic recognition of QSOs based on photometry

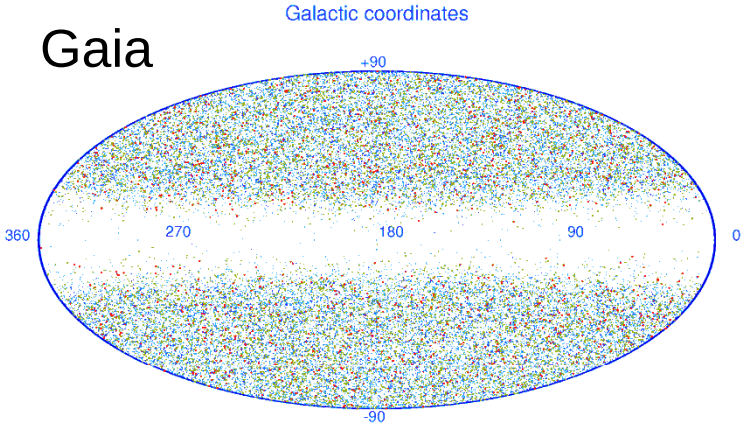


• G < 18 • 18< G < 19 • 19< G < 20

Reference frames in the next decade

By 2015-2020, two extragalactic celestial reference frames will be available





ICRF position accuracy:

1998: ICRF1: $\sigma(\alpha\cos\delta,\delta) \geq 250$ μas

2009: ICRF2: $\sigma(\alpha\cos\delta,\delta) \geq 40$ μas

2015: ICRF3? $\sigma(\alpha\cos\delta,\delta)$???

Gaia position accuracy:

$16\ \mu as \leq \sigma \leq 70\ \mu as$ @ $15 \leq V \leq 18$

Linking the two frames is important

- to ensure continuity of the reference frame
- to register optical and radio positions with the highest accuracy

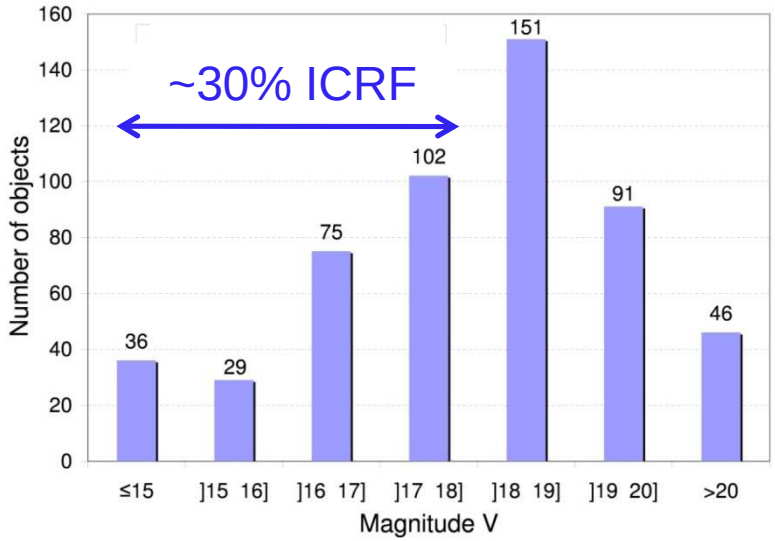
Current status of the ICRF-Gaia link

(Bourda et al. 2008)

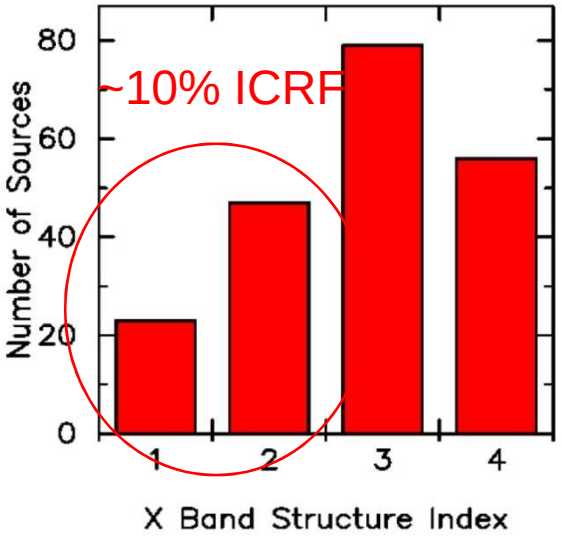
Link sources must have:

- accurate Gaia positions ➔ magnitude V $\leq$ 18
- accurate VLBI positions ➔ good astrometric quality (no structure)

Optical magnitude of ICRF sources



Astrometric source quality

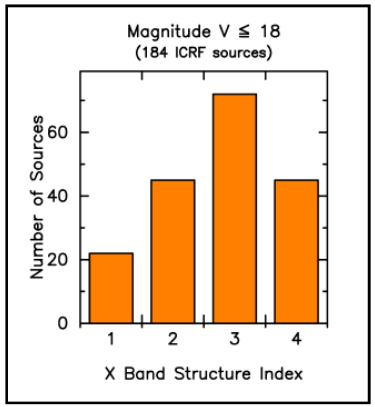


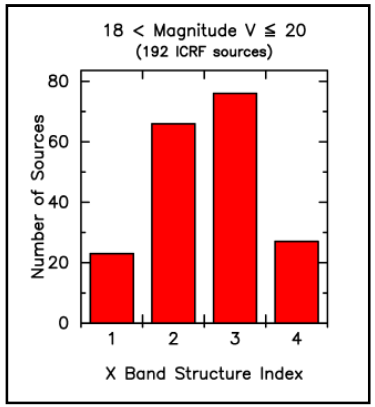
Only 10% of the current ICRF sources are suitable for the ICRF-Gaia link

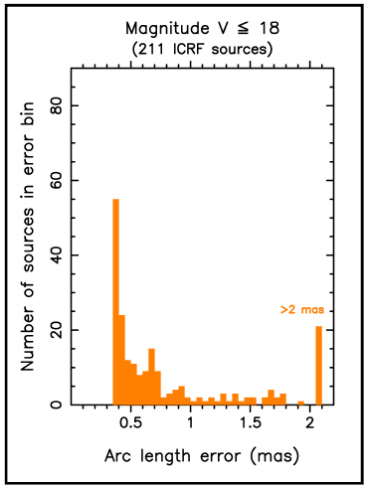
Astrometric source quality

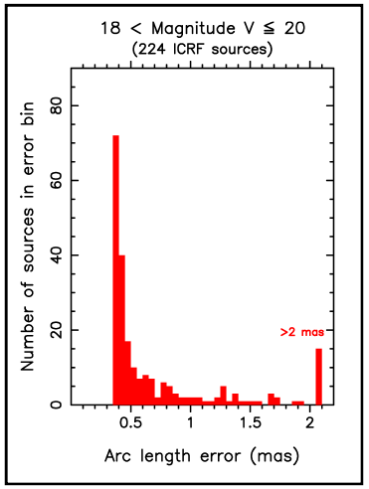
(Bourda et al. 2008)

- Astrometric quality is worse for the V<18 sources than for the 18<V<20 sources
- Result confirmed by comparison of ICRF position accuracies for the V<18 and 18<V<20 sources









The potentially best Gaia sources for the alignment with the ICRF are not the best ICRF sources !!!

➔ Must find new candidates

➔ Specific VLBI (EVN and VLBA) observing program designed for this purpose

Overview of VLBI observing program

- 447 sources selected from the NVSS (excluding ICRF and VCS sources) with the following criteria:
  - Optical magnitude $V \leq 18$
  - Total flux density (NVSS) ≥ 20 mJy
  - $\delta \geq -10^{o}$

- Observing Strategy
  1. VLBI detection
  2. Imaging
  3. Accurate astrometry (for the most compact sources)

Step 1: VLBI detection

- Two 48-hour EVN experiments (S/X geodetic style @ 1Gbps)
  - 224 sources observed in June 2007 (project EC025A)
  - 223 sources observed in October 2007 (project EC025B)

- 4 or 5-station network
  - Effelsberg (100m), Medicina (32m), Noto (32m), Onsala (25m)

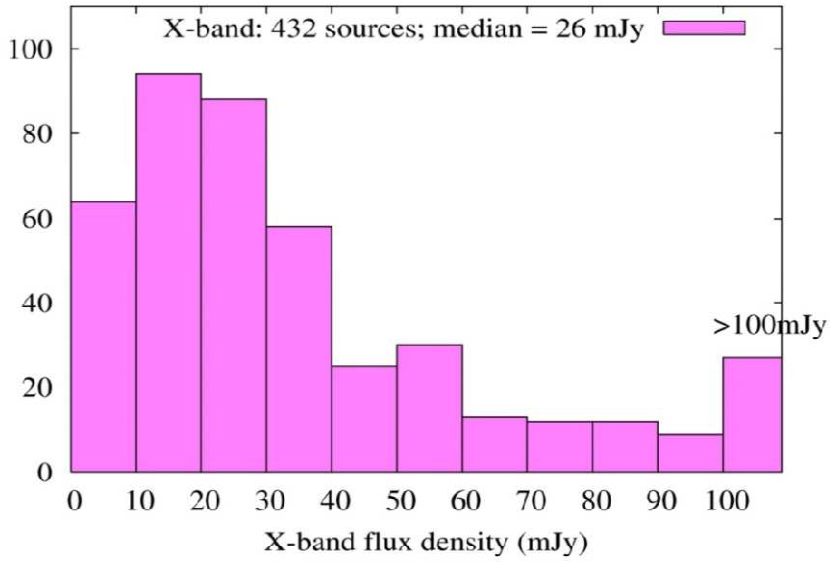
  + Robledo (70m) for EC025B

- S and X detection rates
  - EC025A: 96%
  - EC025B: 82%

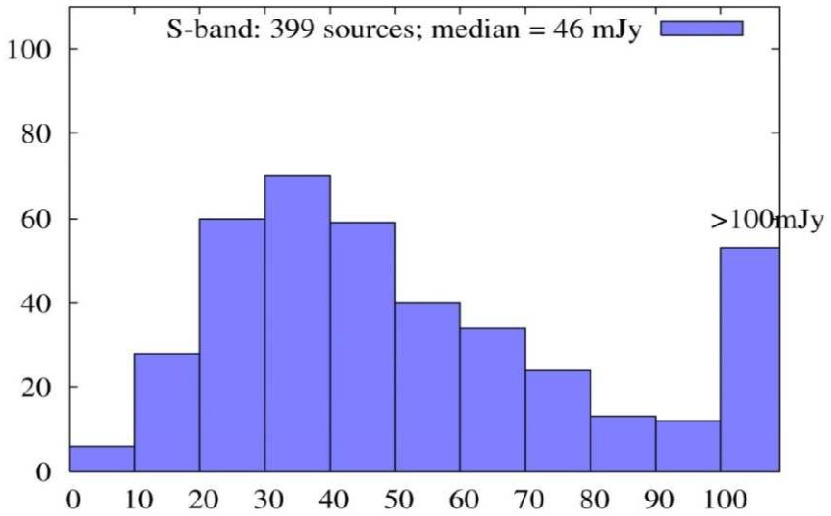
→ **Overall detection rate: ~ 89 % (398 sources)**

Flux density distribution (1)

X-band (mJy)

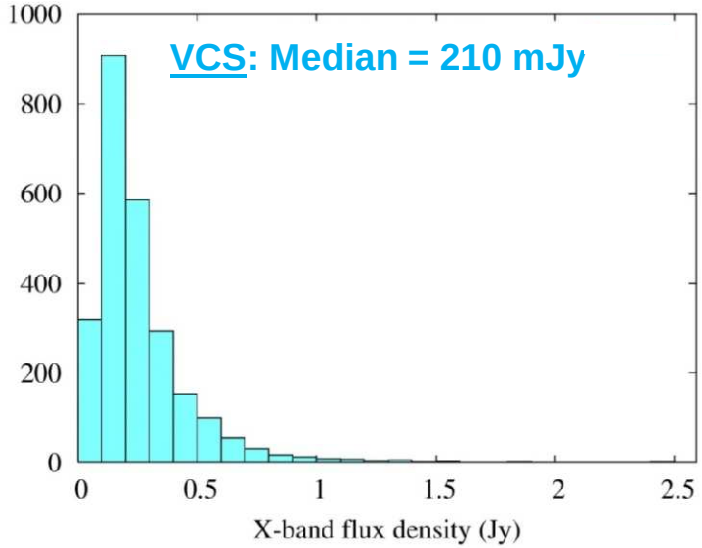


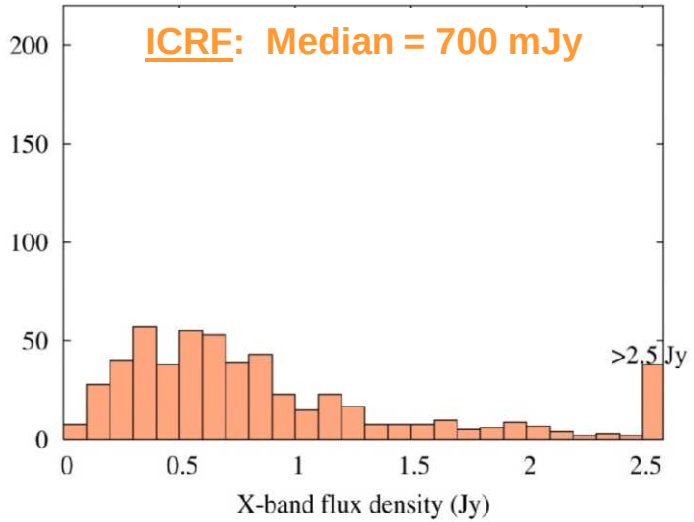
S-band (mJy)

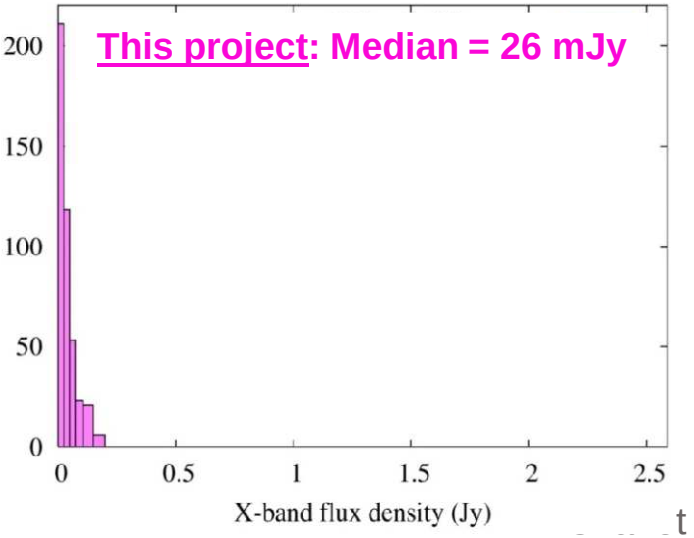


All flux densities are the mean correlated flux densities over all baselines

Flux density distribution (2)

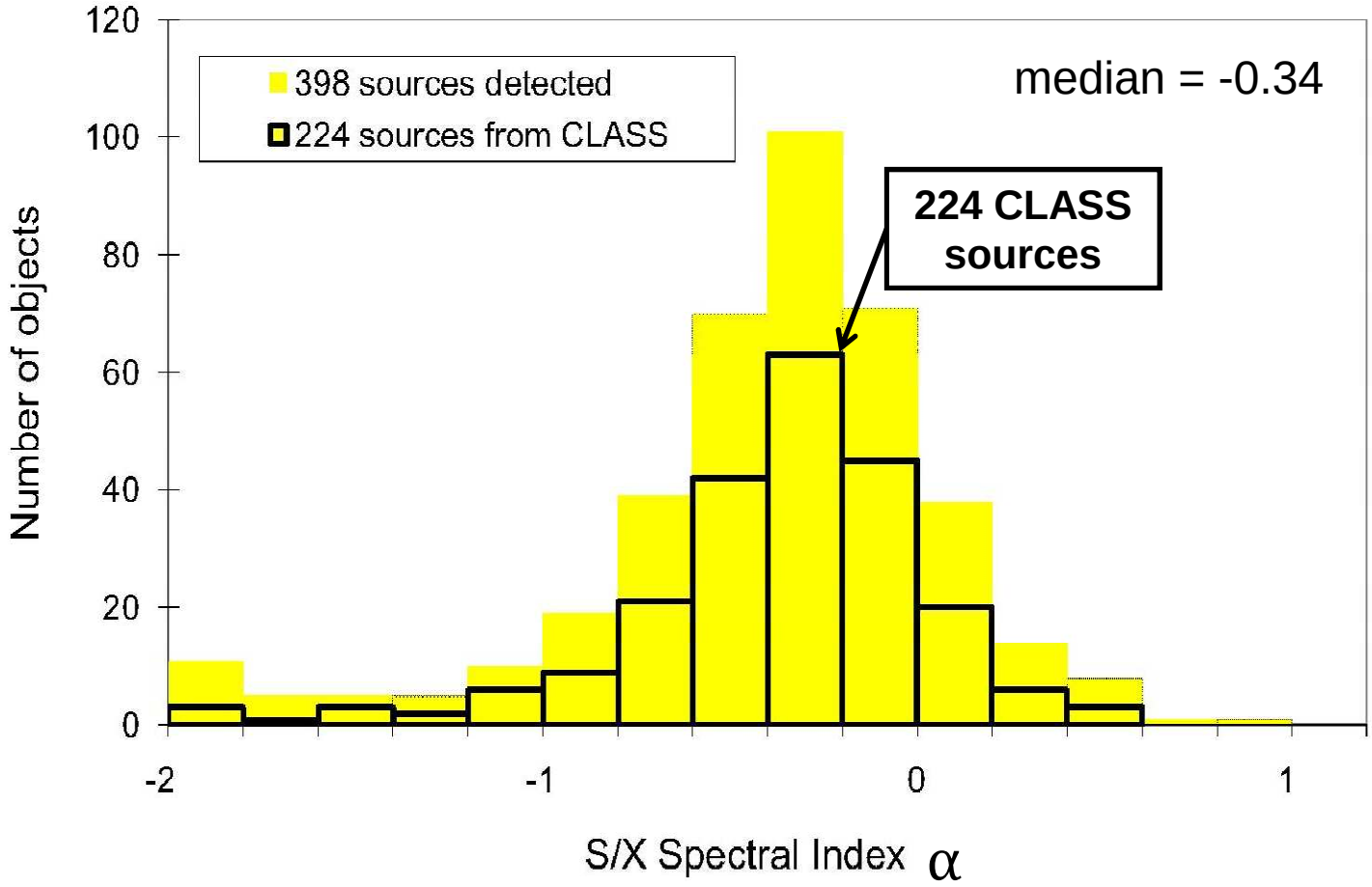






Comparison of X-band flux density distribution in ICRF, VCS and for this project

Spectral index distribution



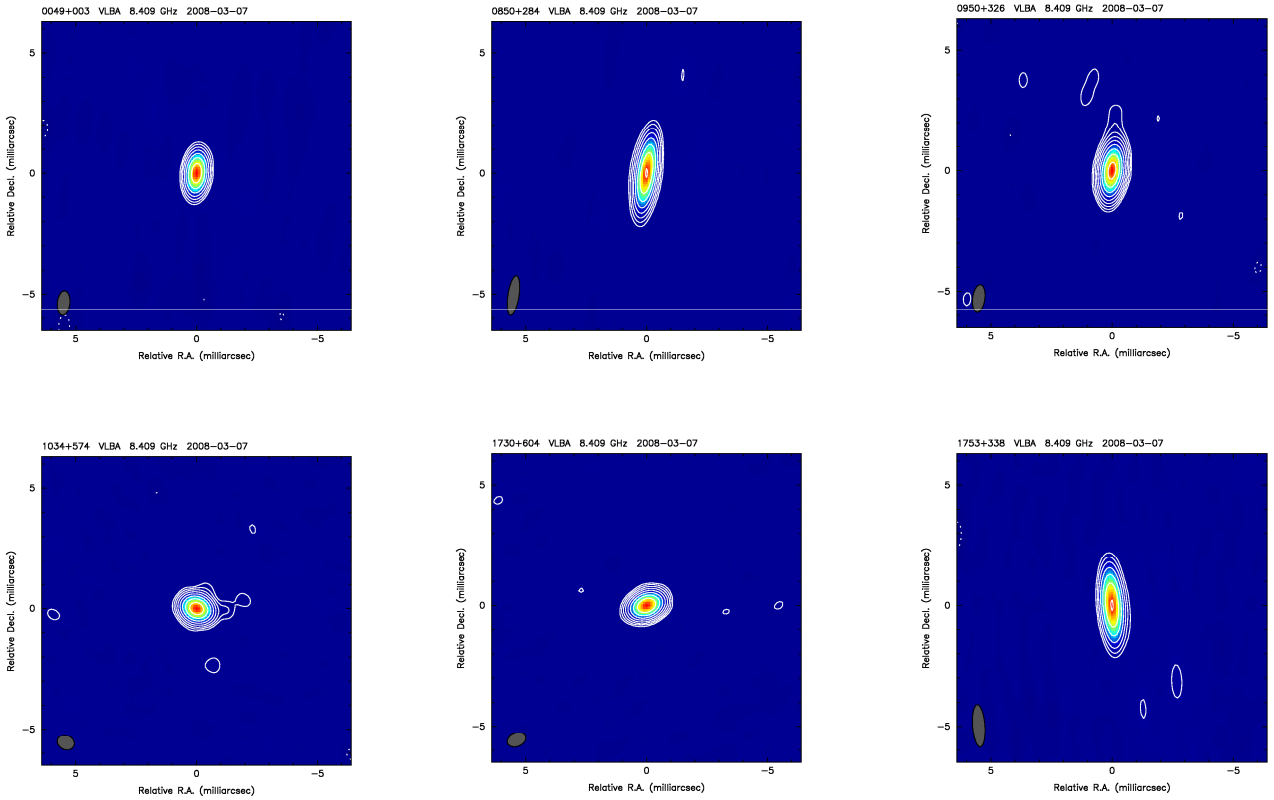
Step 2: imaging

- 105 sources observed with global VLBI (VLBA + EVN) in March 2008 (selected from EC025A)
- 48-hour dual-frequency S/X @ 512 Mbps
- Schedule optimized for imaging

- Results
  - All 105 sources successfully imaged at both X + S bands
  - Dynamic range: ~ 1%

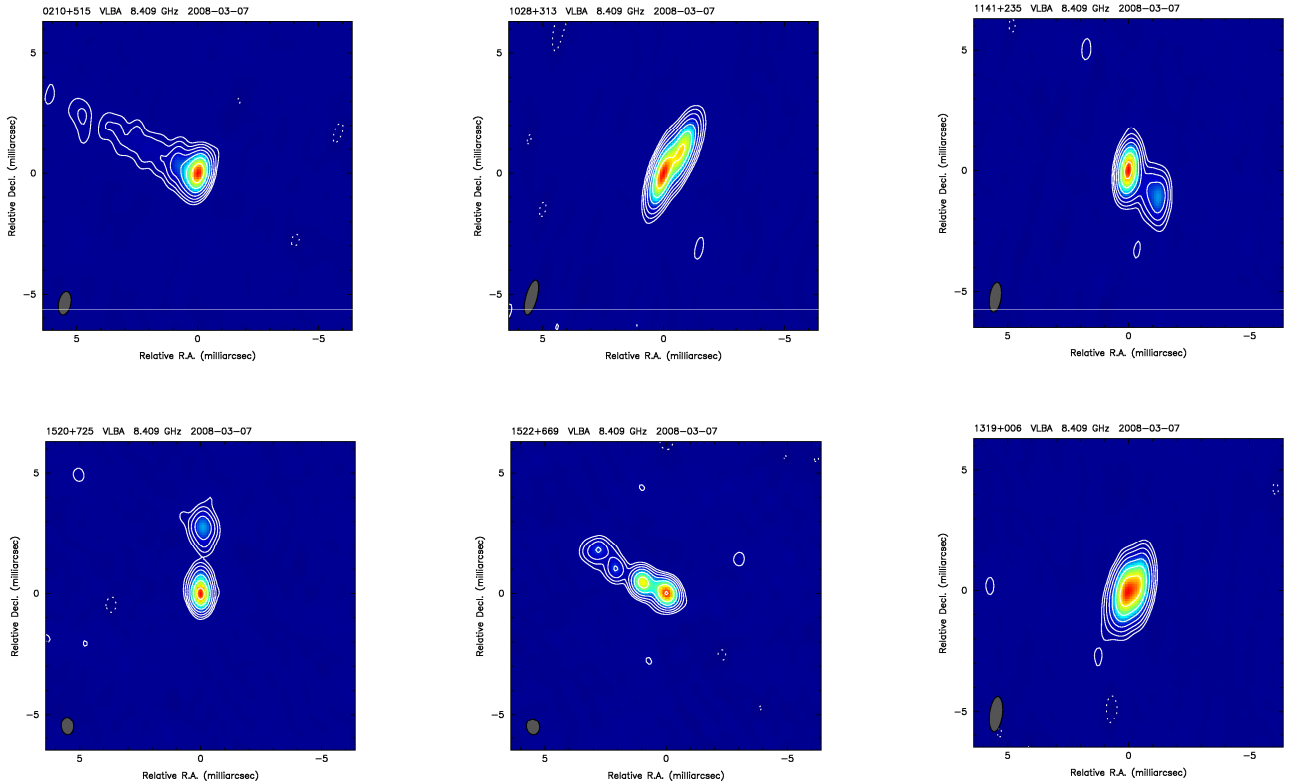
X-band images (1)

Some very good link sources



X-band images (2)

but also some not so good link sources…



Future prospects

- Image the remaining 293 targets in our sample
- Carry out global astrometry on the most compact sources and get their position to better than <100 μas

- Search for more candidates in the ICRF-2/VCS lists
- Attack the southern hemisphere
- Issues of core shifts

- Task now officially recognized as part of the Gaia DPAC (Data Processing and Analysis Consortium)
- Ultimately the Gaia link sources should form the basis of ICRF-3 to be constructed by ~2015