EUROPEAN VLBI NETWORK

Consortium for Very Long Baseline Interferometry in Europe

Multi-step VLBI observations of weak extragalactic radio sources

Aligning the ICRF & the future Gaia frame

G. Bourda [1], P. Charlot [1], R. Porcas [2] & S. Garrington [3]

(1) Laboratoire d'Astrophysique de Bordeaux (LAB), France
(2) MPIfR, Bonn, Germany
(3) Jodrell Bank Observatory, Manchester, UK

Overview

Multi-step VLBI observations of weak extragalactic radio sources

1. **Context:** Why these observations?

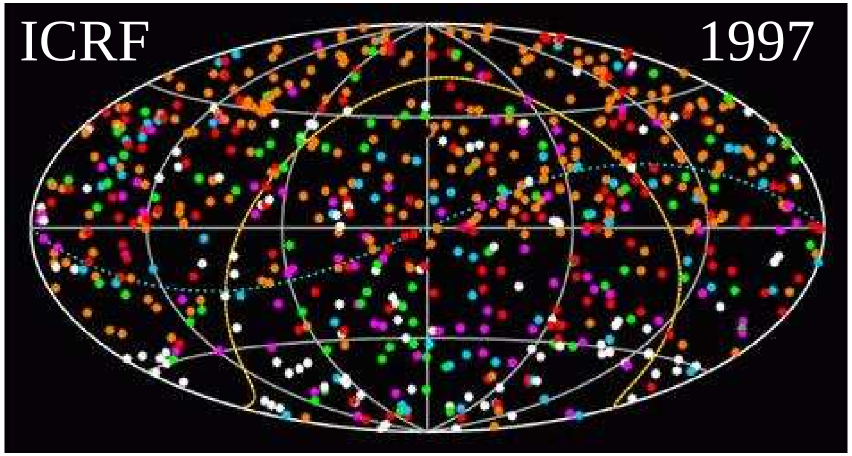
2. **Strategy of observation**

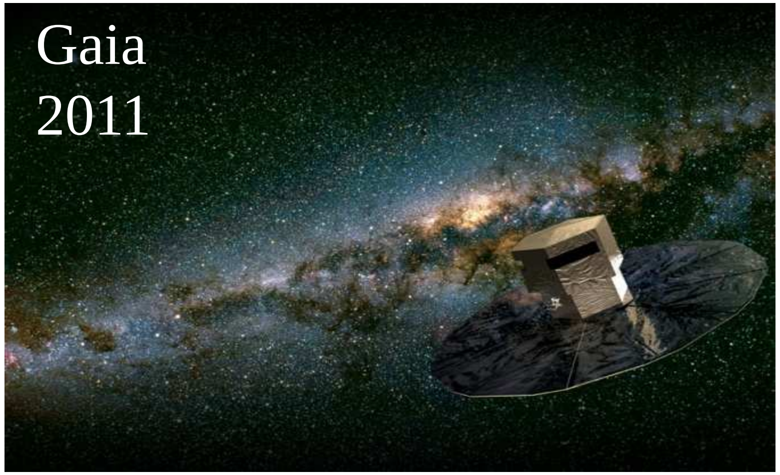
3. **First-step experiments**
   Some results

4. **Conclusions & Prospects**

1. Context

Motivation: 2015-2020 ⟶ 2 extragalactic celestial reference frames





Ma et al. 1998 / Fey et al. 2004
International Celestial Reference Frame

Perryman et al. 2001

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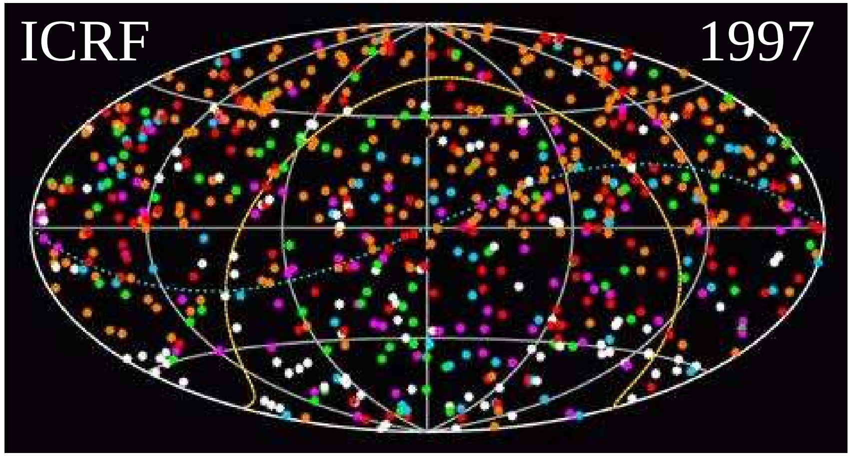

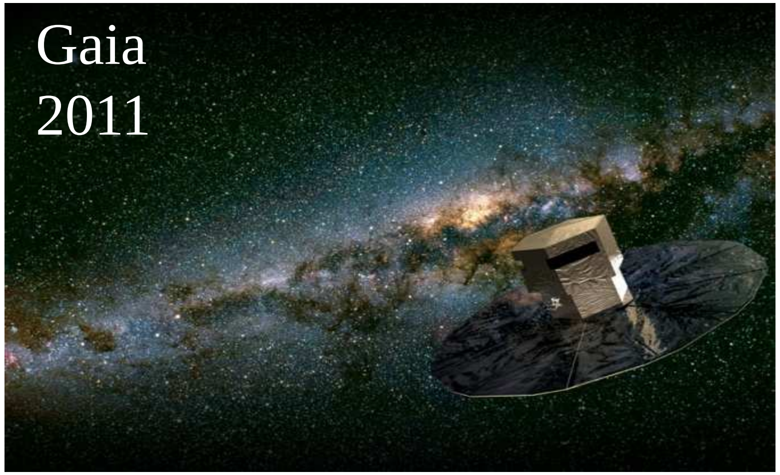

- ✓ ICRF: 717 extragalactic sources
  ICRF-2: ~1000 sources
- ✓ Radio; VLBI (S/X bands; 2/8 GHz)
- ✓ Position accuracy:
  ICRF: σ = 250 μas
  ICRF-2: σ < 100 μas

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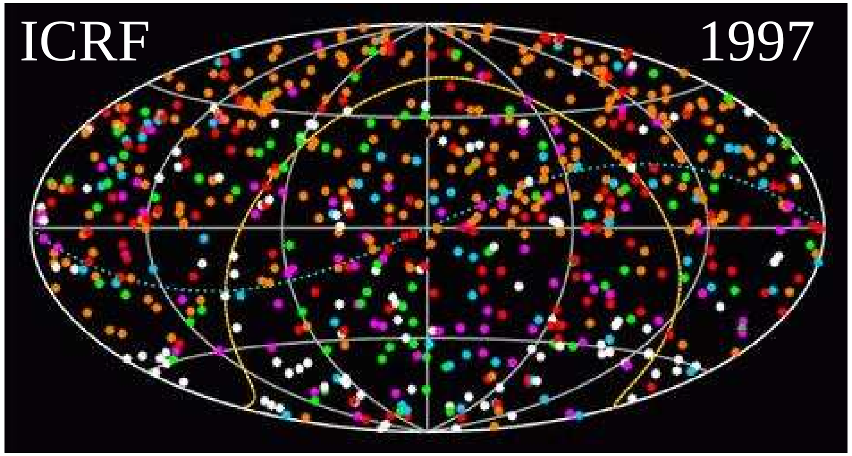

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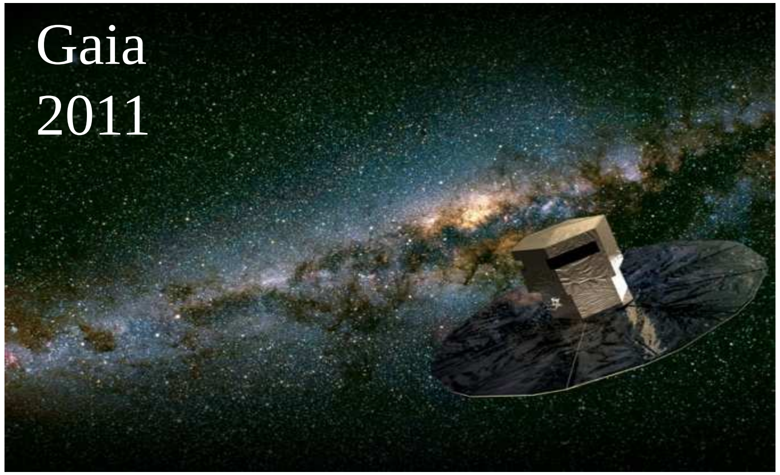

- ✓ ~ 10 000 QSOs
- ✓ Optical domain / V ≤ 20
- ✓ Position accuracy:
  16 µas ≤ σ ≤ 70 µas @ 15 ≤ V ≤ 18

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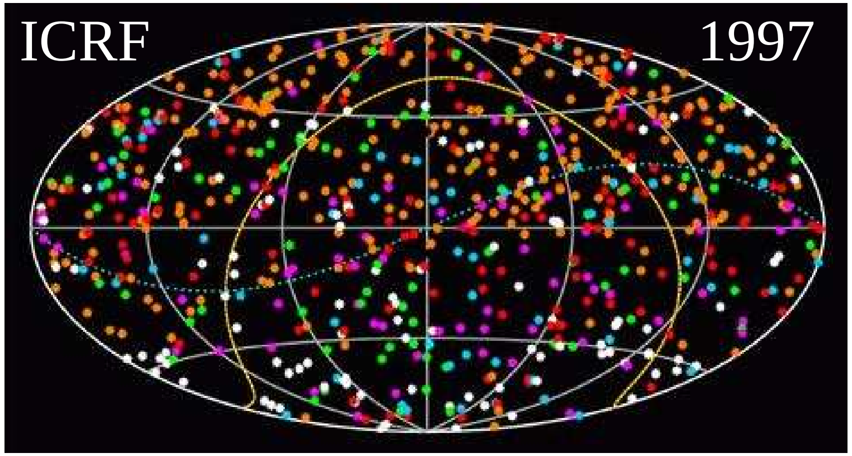

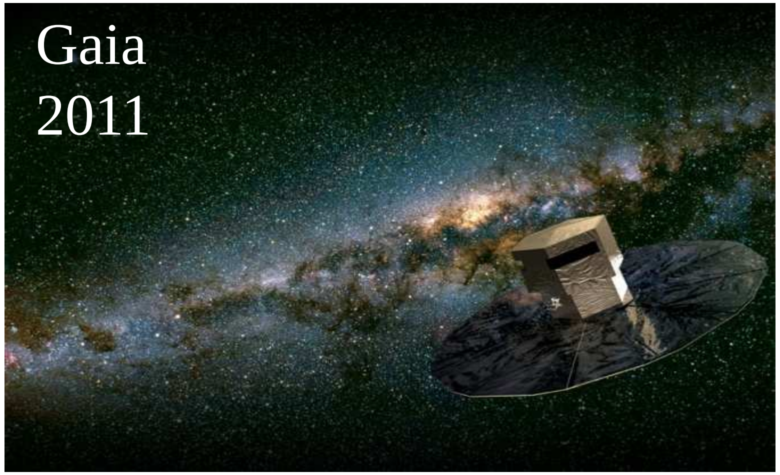

➡ **Important to align accurately the ICRF & the future Gaia frame:**

√ Several hundreds of common sources

√ Precise radio (VLBI) and optical (Gaia) positions:

no extended VLBI structures — V≤18

(Charlot 1990) — (Mignard 2003)

Current Status for this link

Bourda et al. A&A 2008 (in press)

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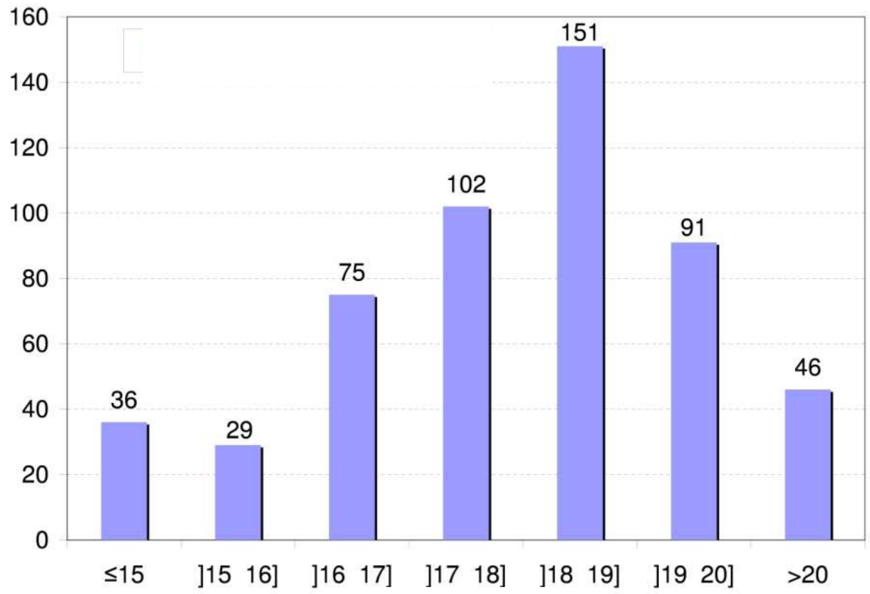

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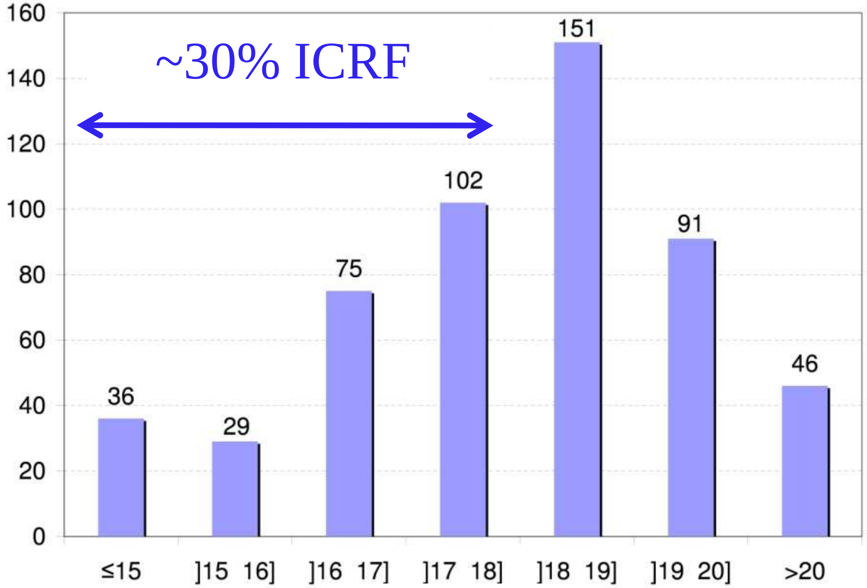

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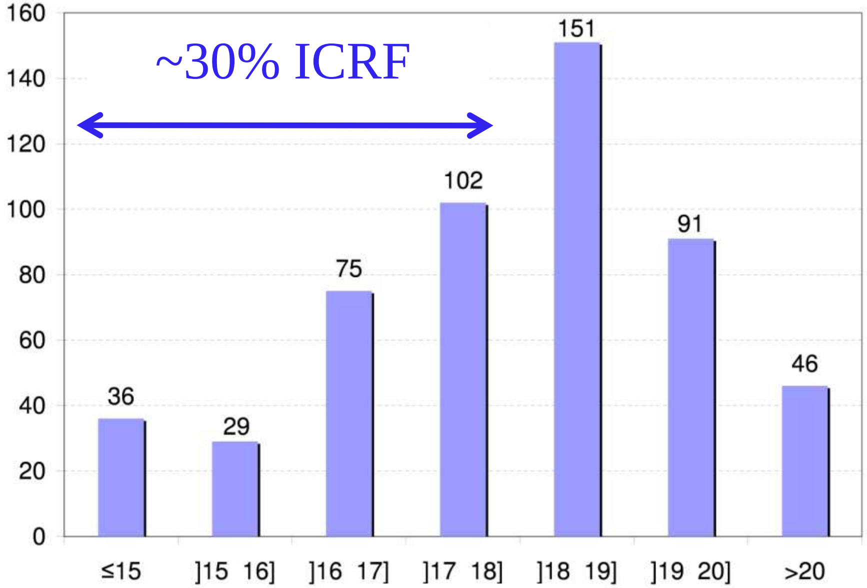
Fey & Charlot 1997, 2000; Charlot et al. 2006



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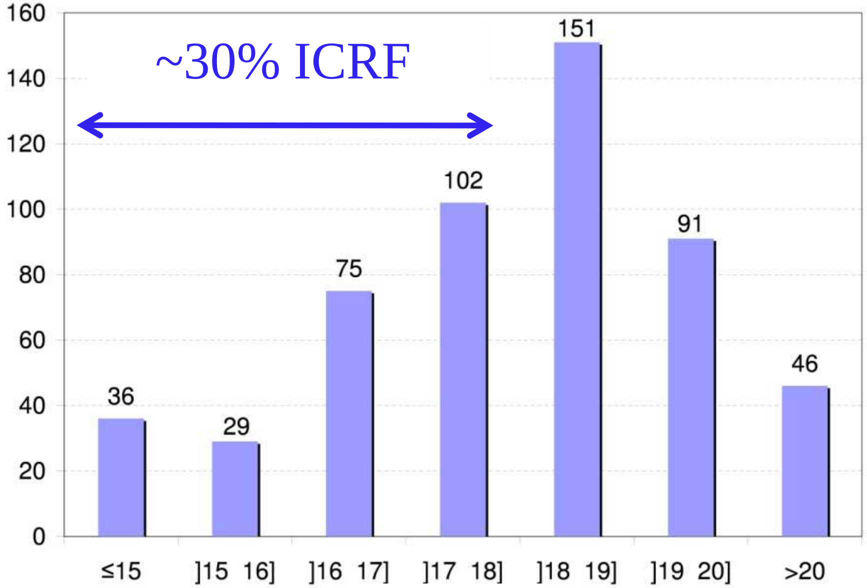

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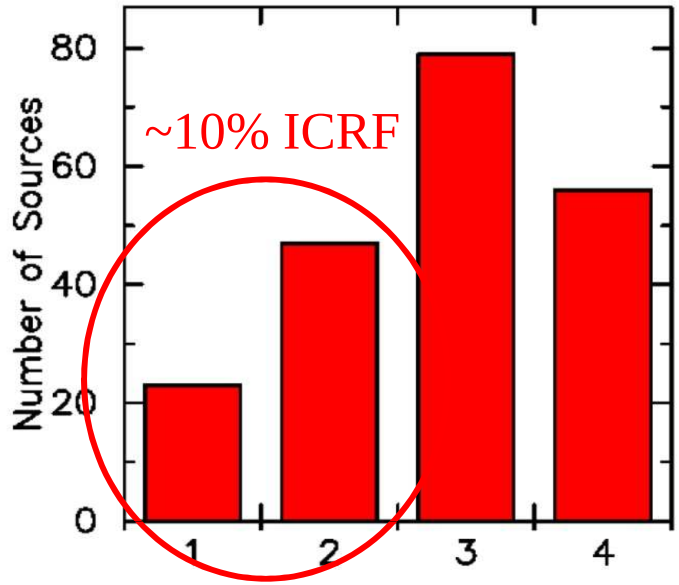

X-band Structure Index distribution

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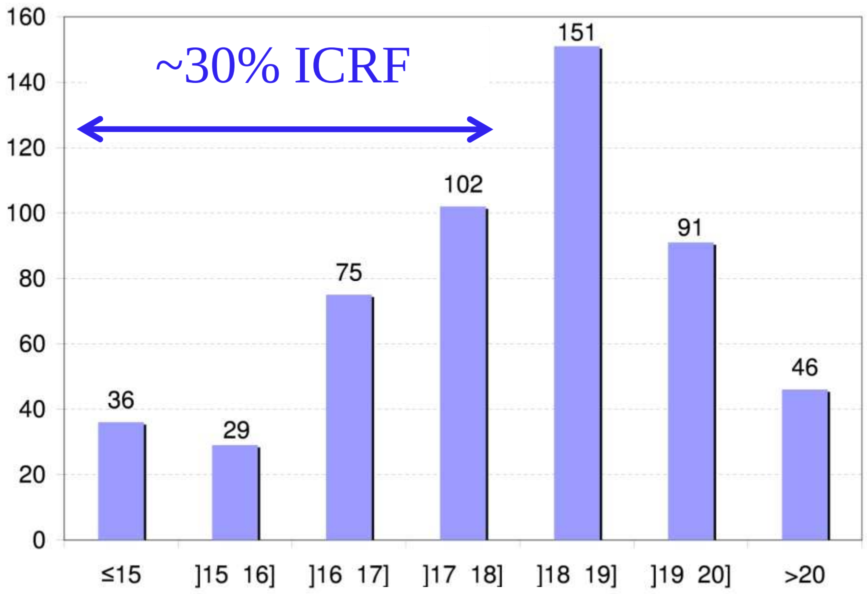
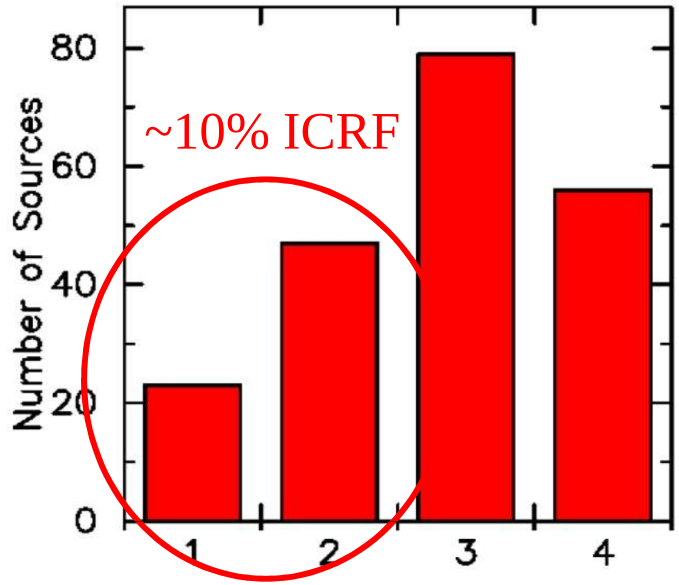
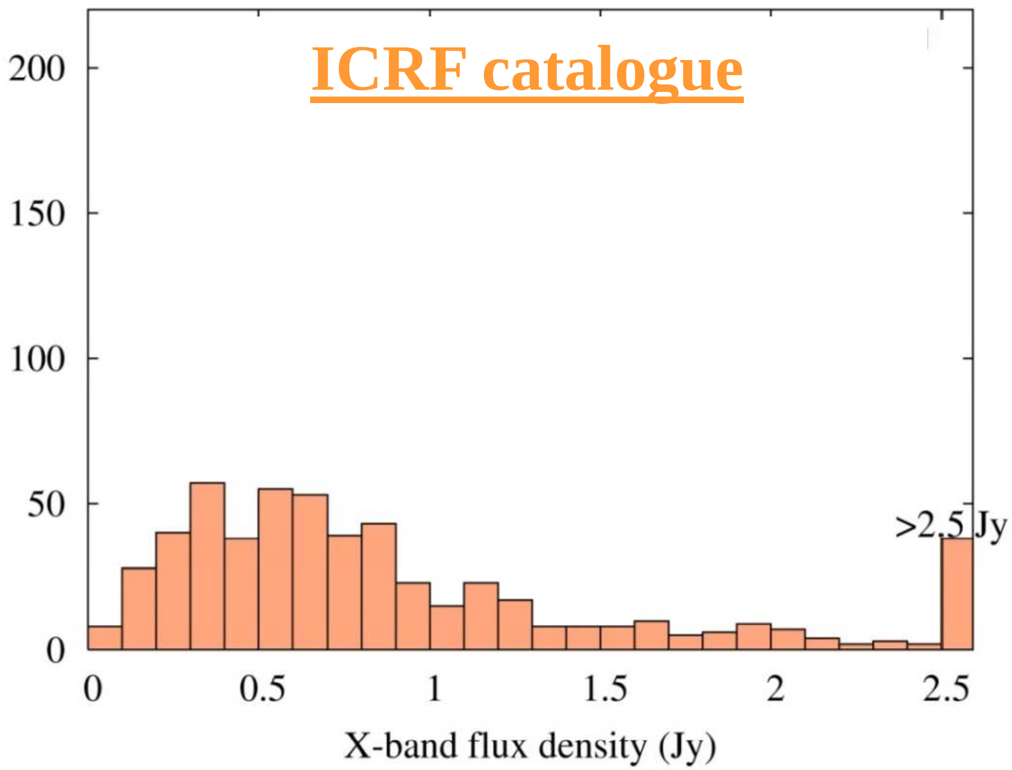


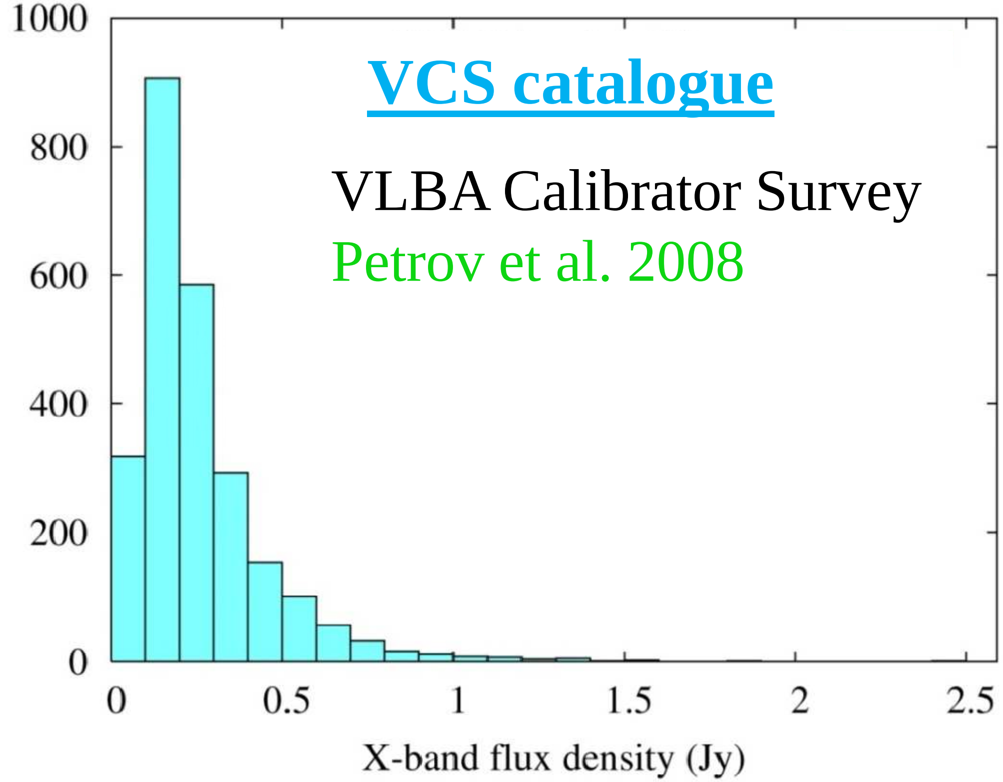


➡ 70 sources is not enough: Necessity to find other VLBI radio sources suitable for aligning accurately VLBI & Gaia frames

One solution

VLBI sources currently available for astrometry & geodesy





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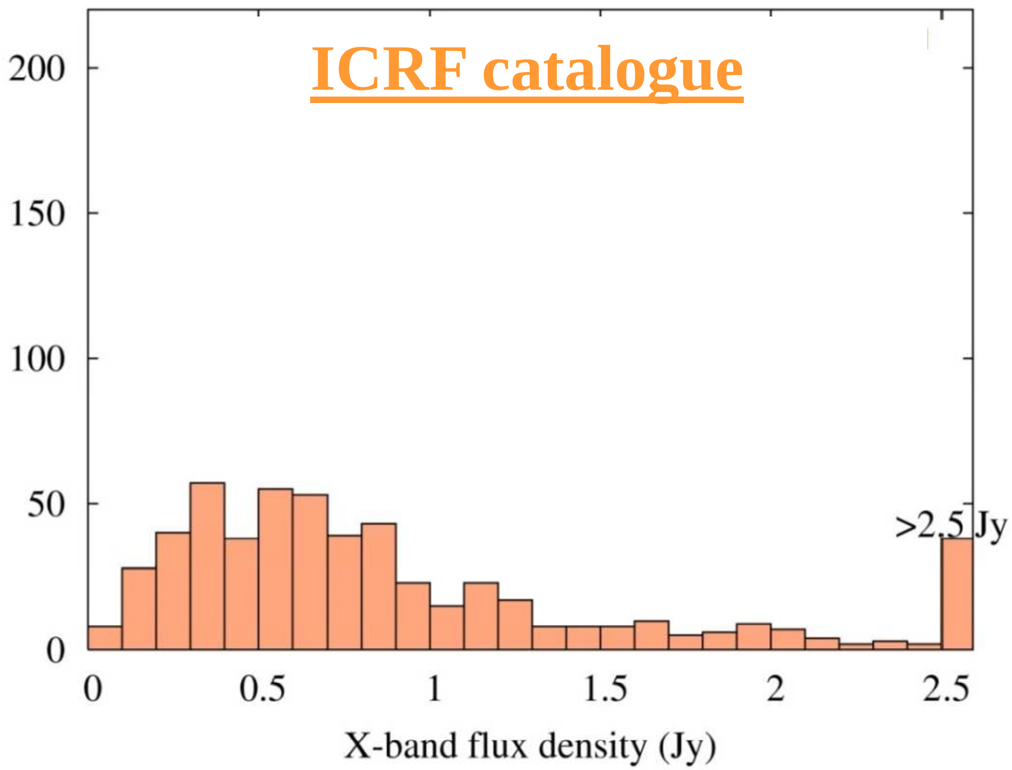

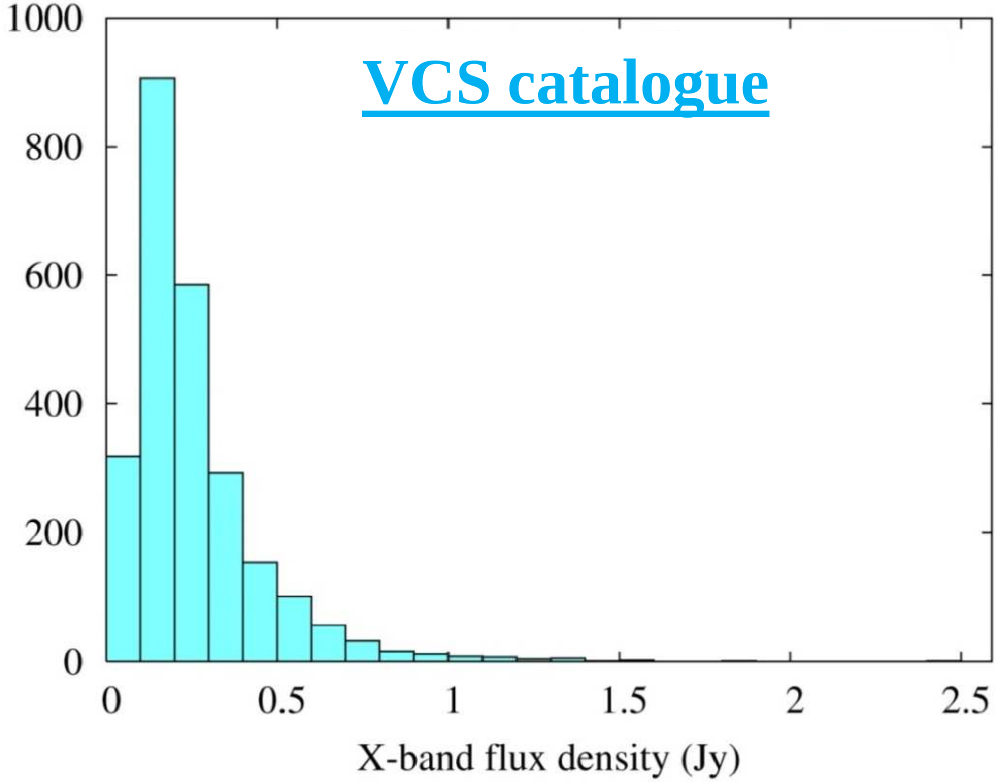

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- X-band flux density ~700 mJy

- ~3000 extragalactic radio sources
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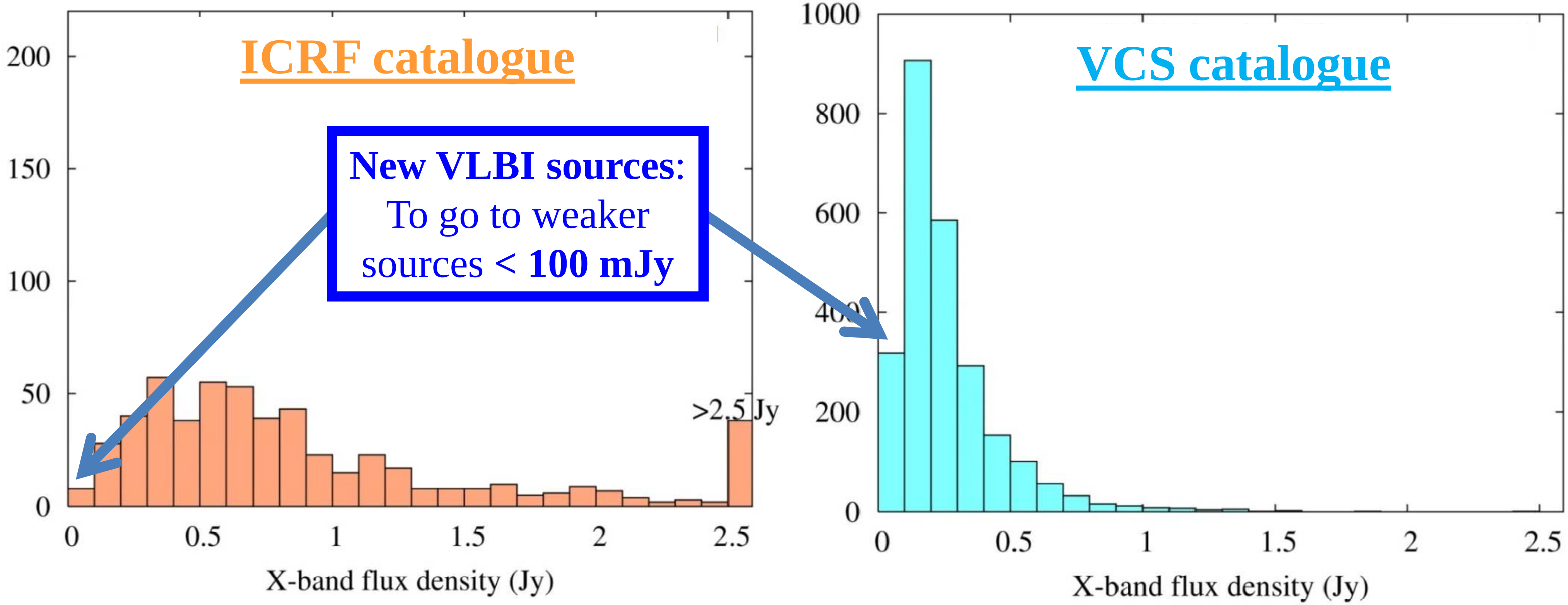

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Multi-step VLBI observations of weak radio sources

- Criteria for the sample: ~ 450 sources

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- Strategy of observation: 3 steps over several years

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  NVSS total flux density ≥ 20 mJy
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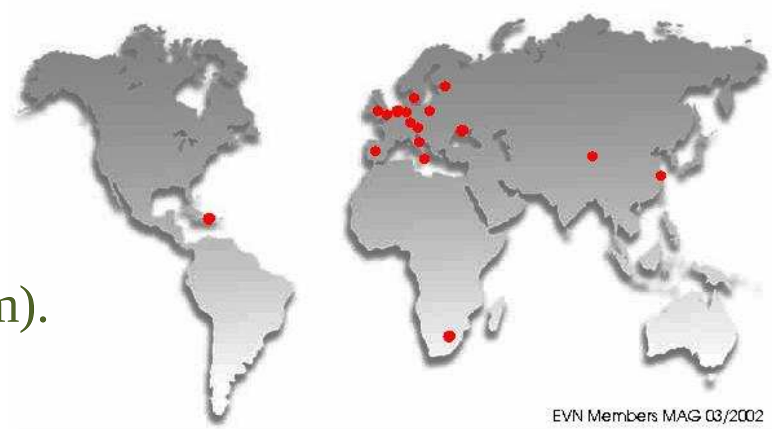
  Large antennas (ex.. Effelsberg, Ø 100 m).

  √ High rate recording (1Gbps)



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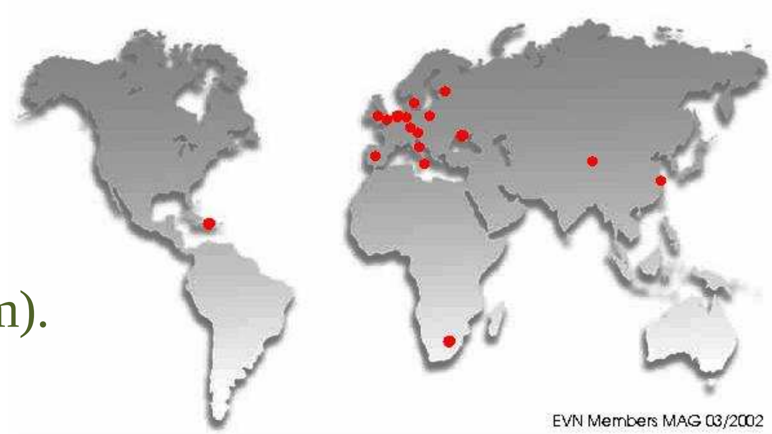

EVN: *European VLBI Network*

- Strategy of observation: 3 steps over several years

1. VLBI detection — Because mostly never observed before in VLBI…
2. Mapping of the sources detected
3. Accurate astrometric positions for the most compact sources.

3. First-step experiments: VLBI detectability

Two 48-hours experiments (S/X dual-frequency geodetic style @ 1Gbps):

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S/X detection rates:

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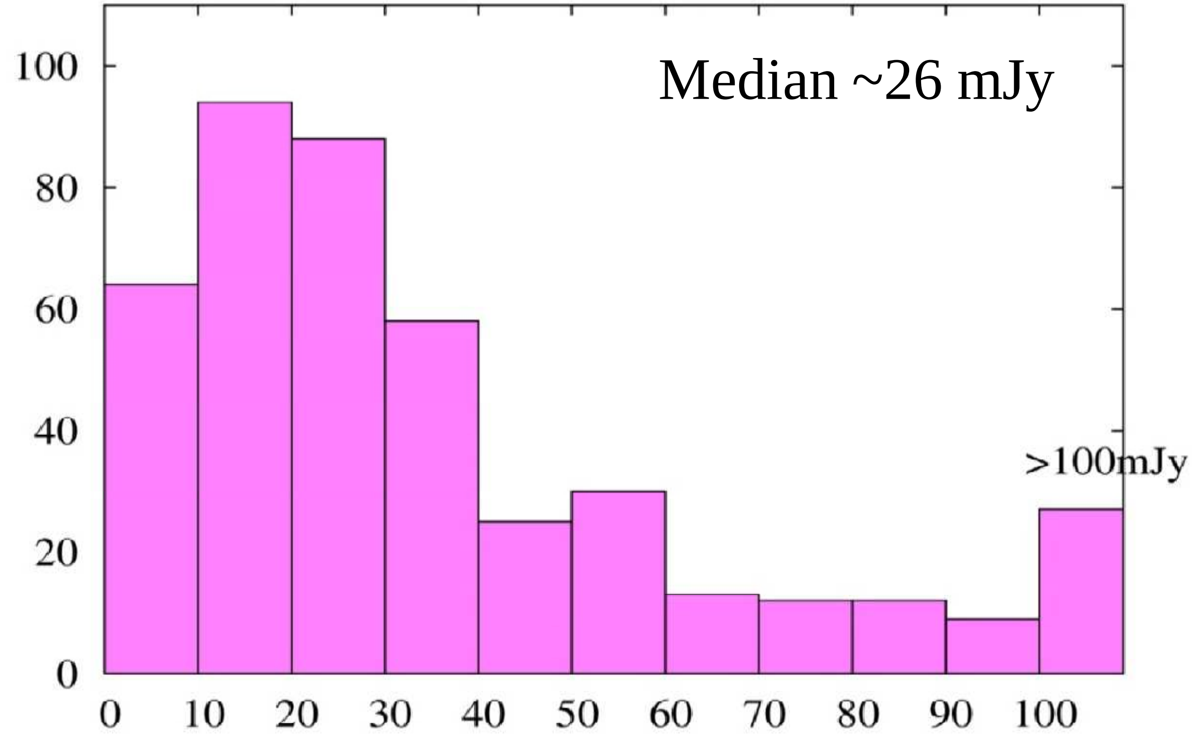
➡ **Overall detection rate: ~ 89 %**

Flux density distributions: EC025A/B

X-band (mJy)



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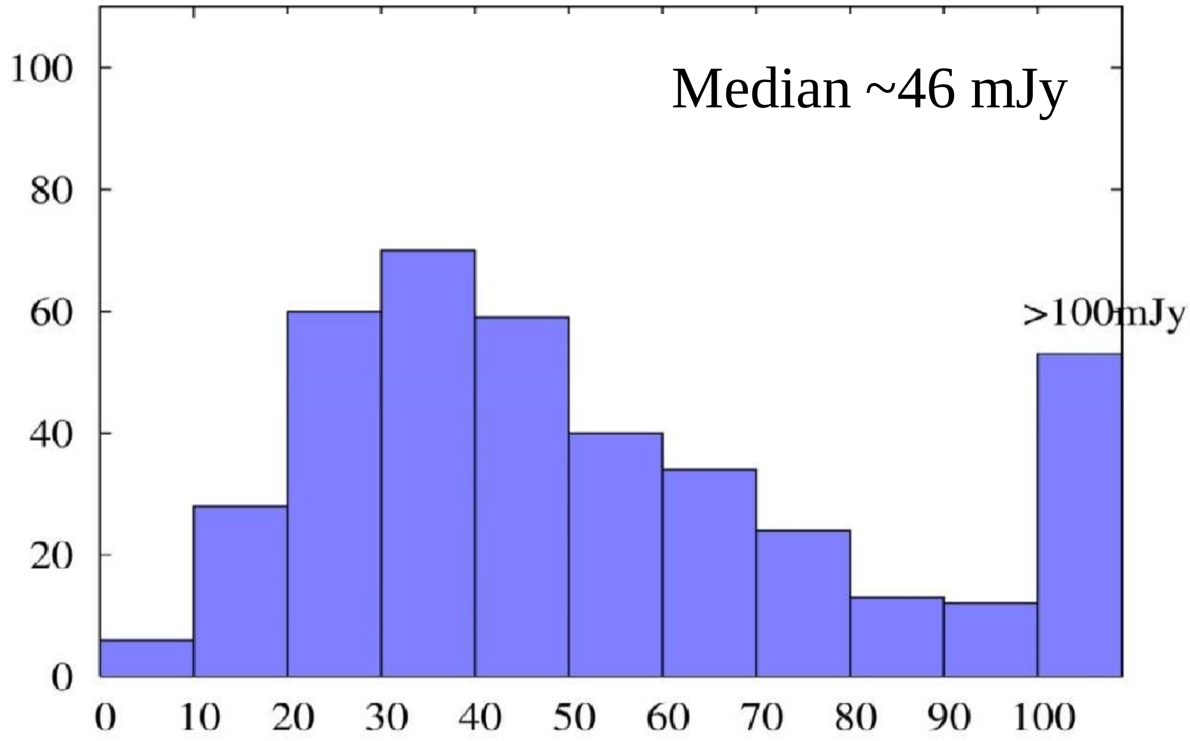
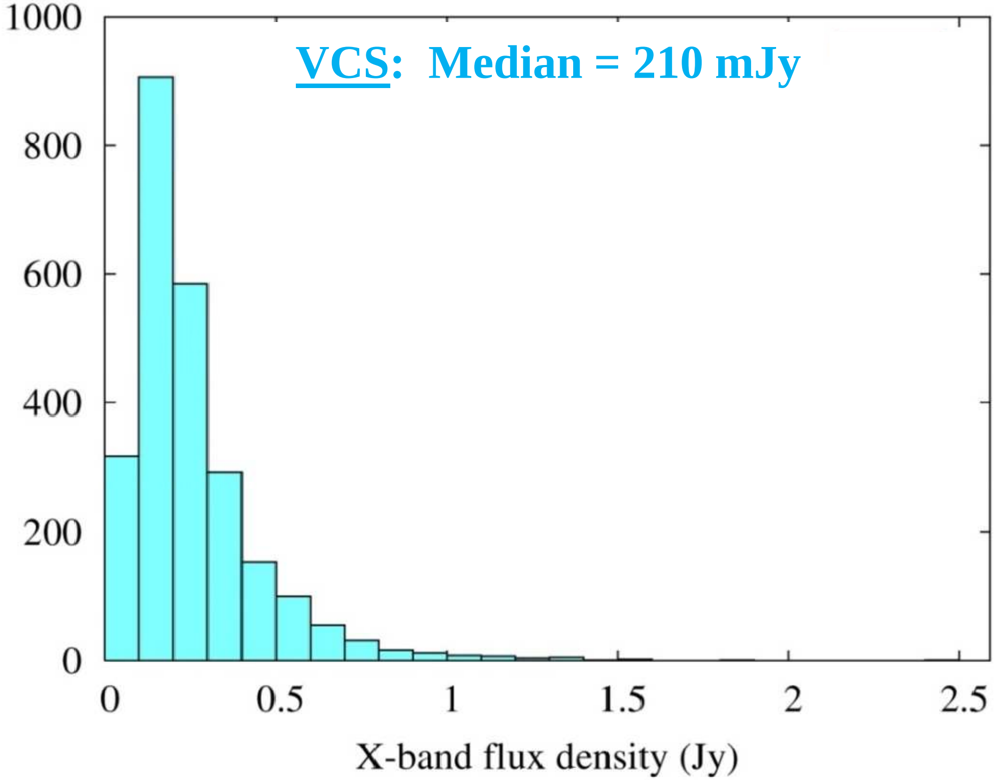
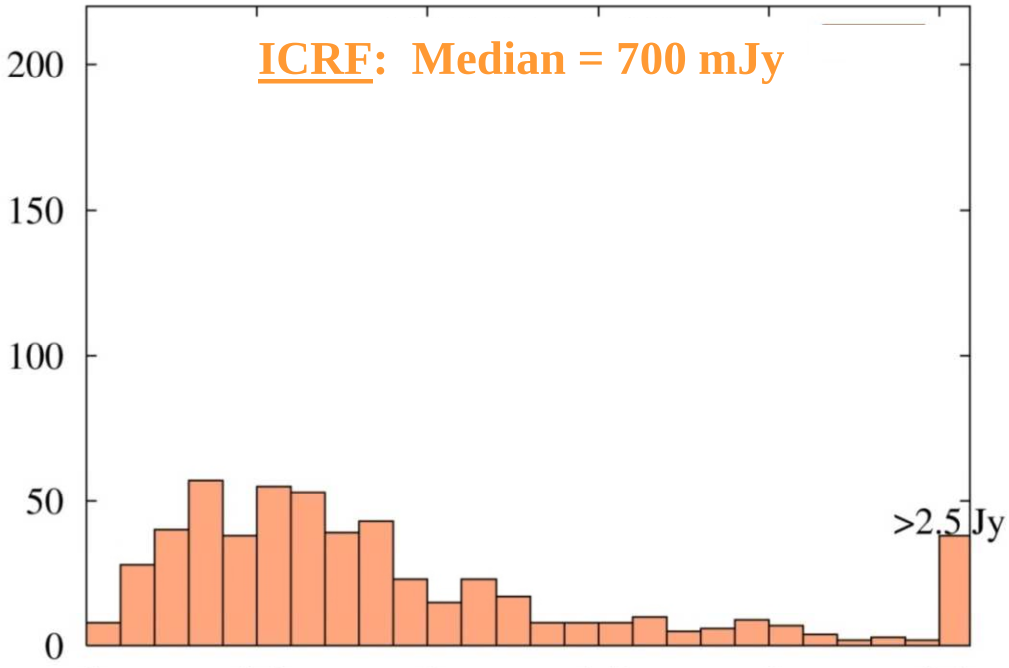
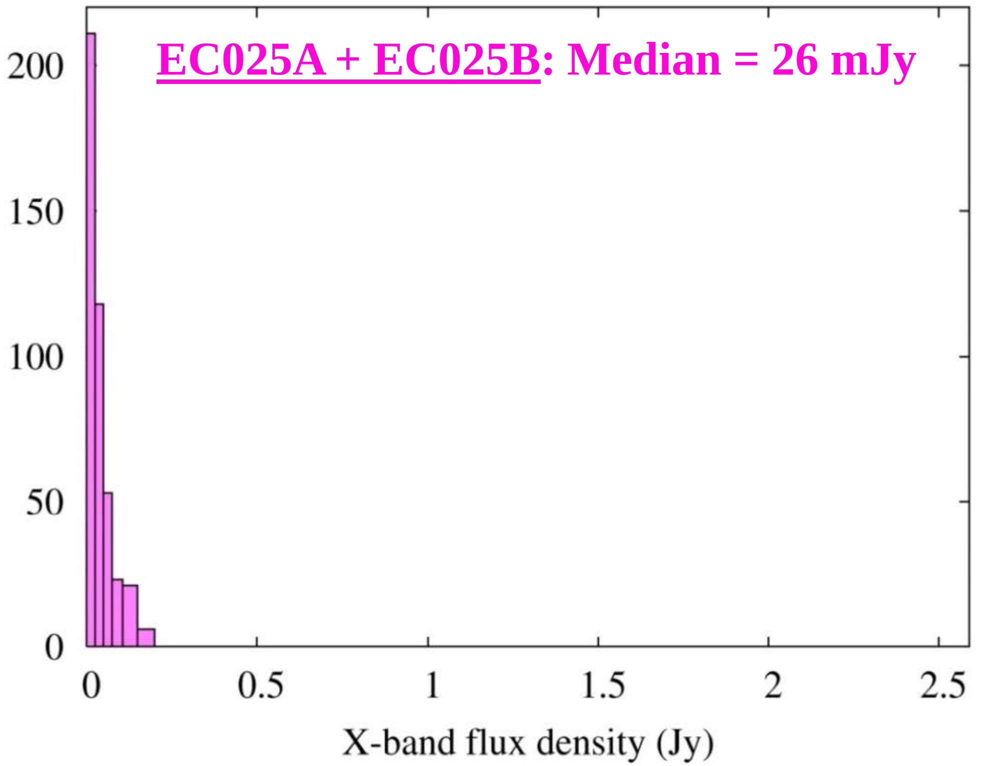


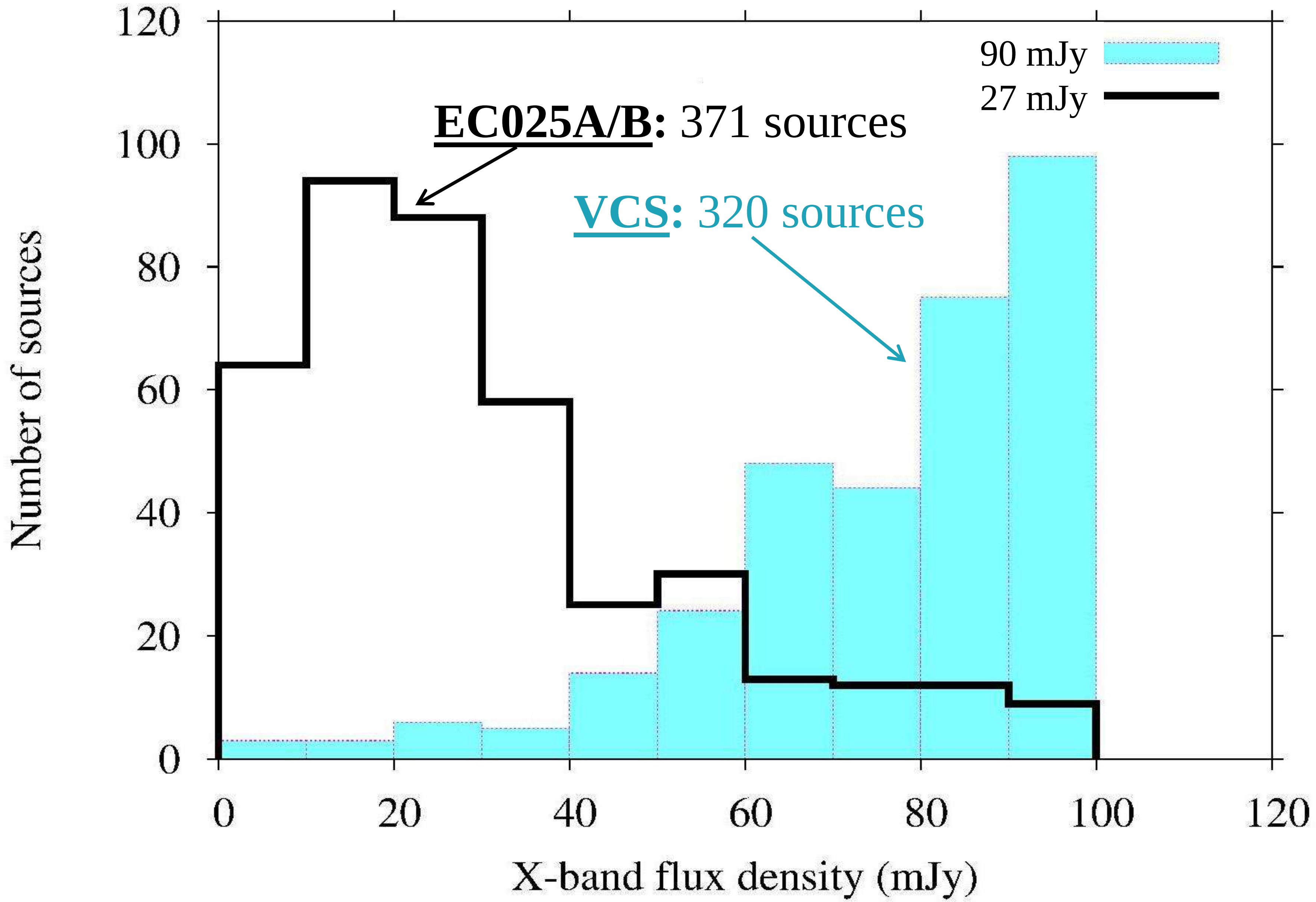




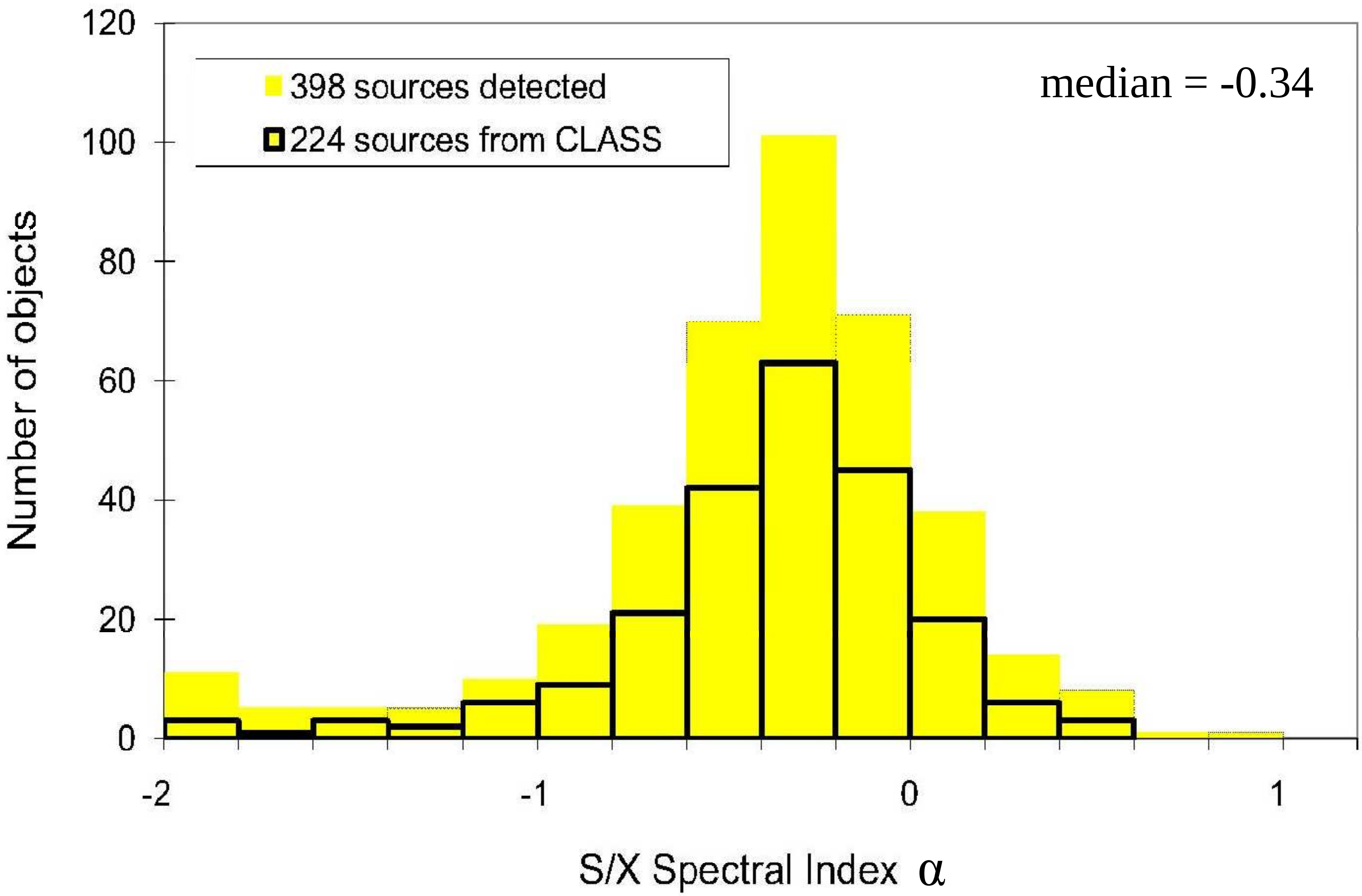
X-band flux density distribution



Zoom: < 100 mJy region



S/X Spectral Index distribution



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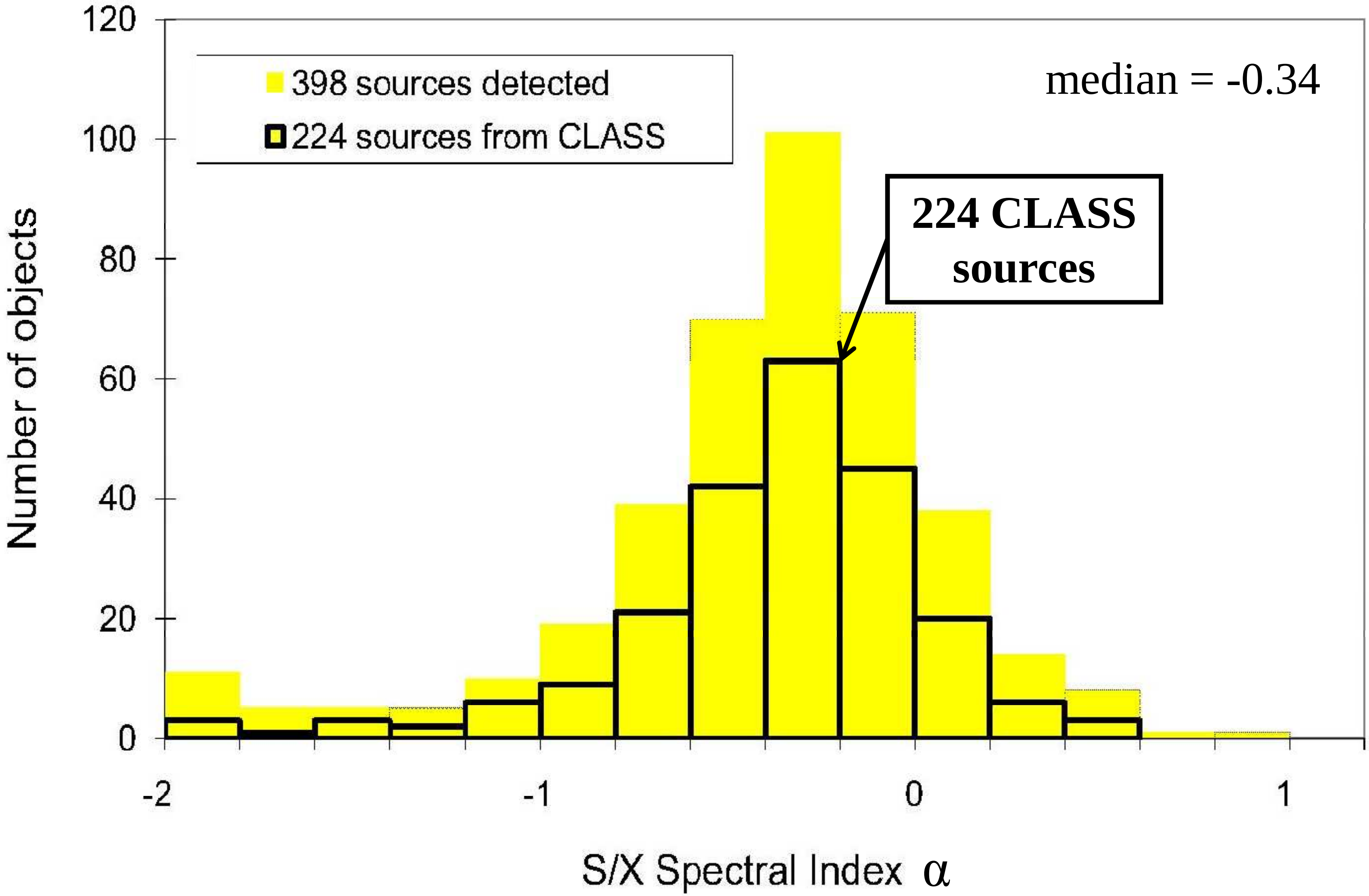

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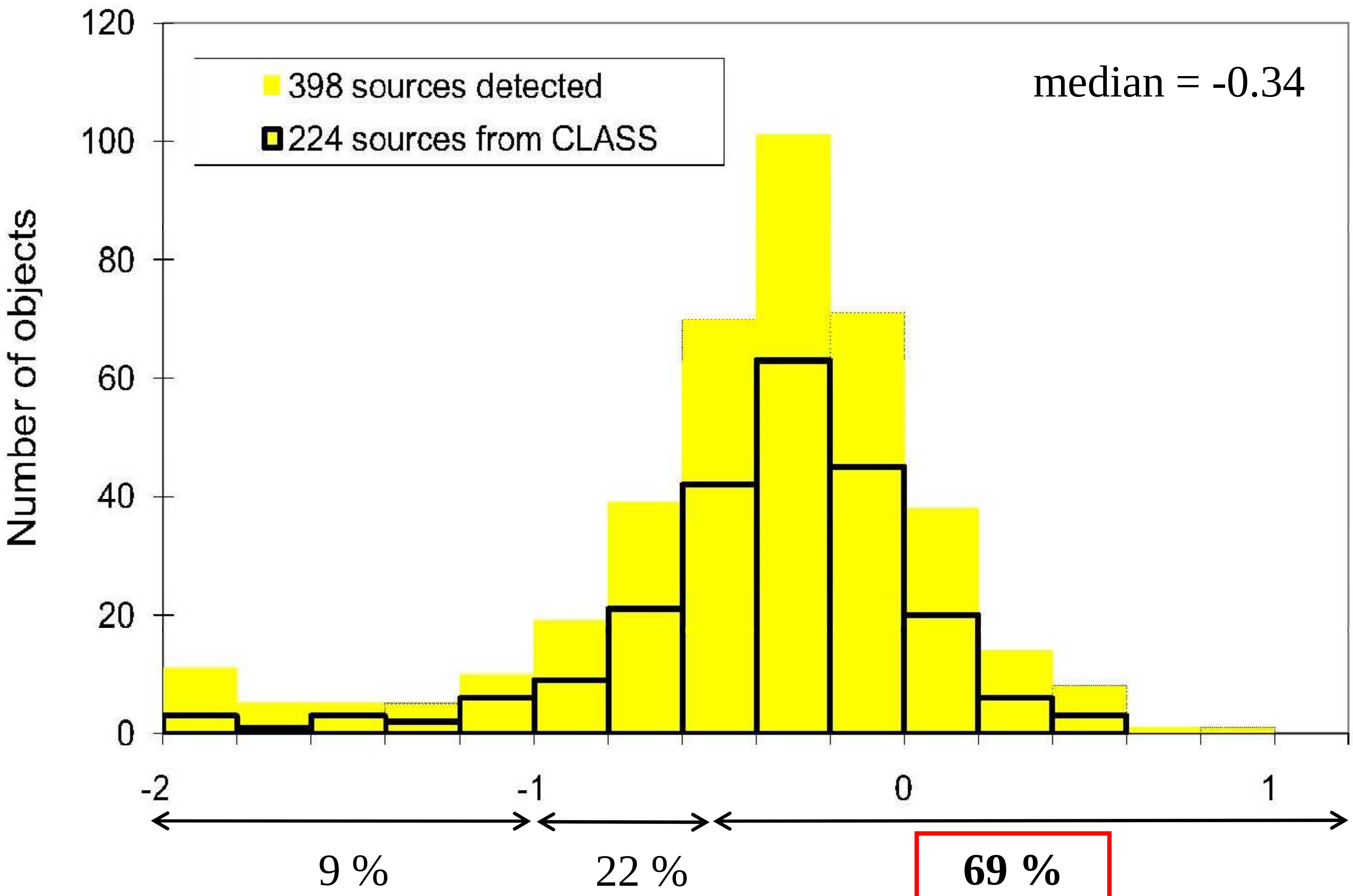

Sources with compact core: α > -0.5

4. Conclusion & Prospects

- What's new?

398 new VLBI sources as candidates for the ICRF−Gaia link

Link sources ~30 x weaker than ICRF sources

⇒ First step very promising

⇒ ~90% detection rate ⟶ Detection step unnecessary?

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  Estimate VLBI positions for the sources detected

  VLBI imaging of the sources detected (second step):

  105 sources observed in March 2008

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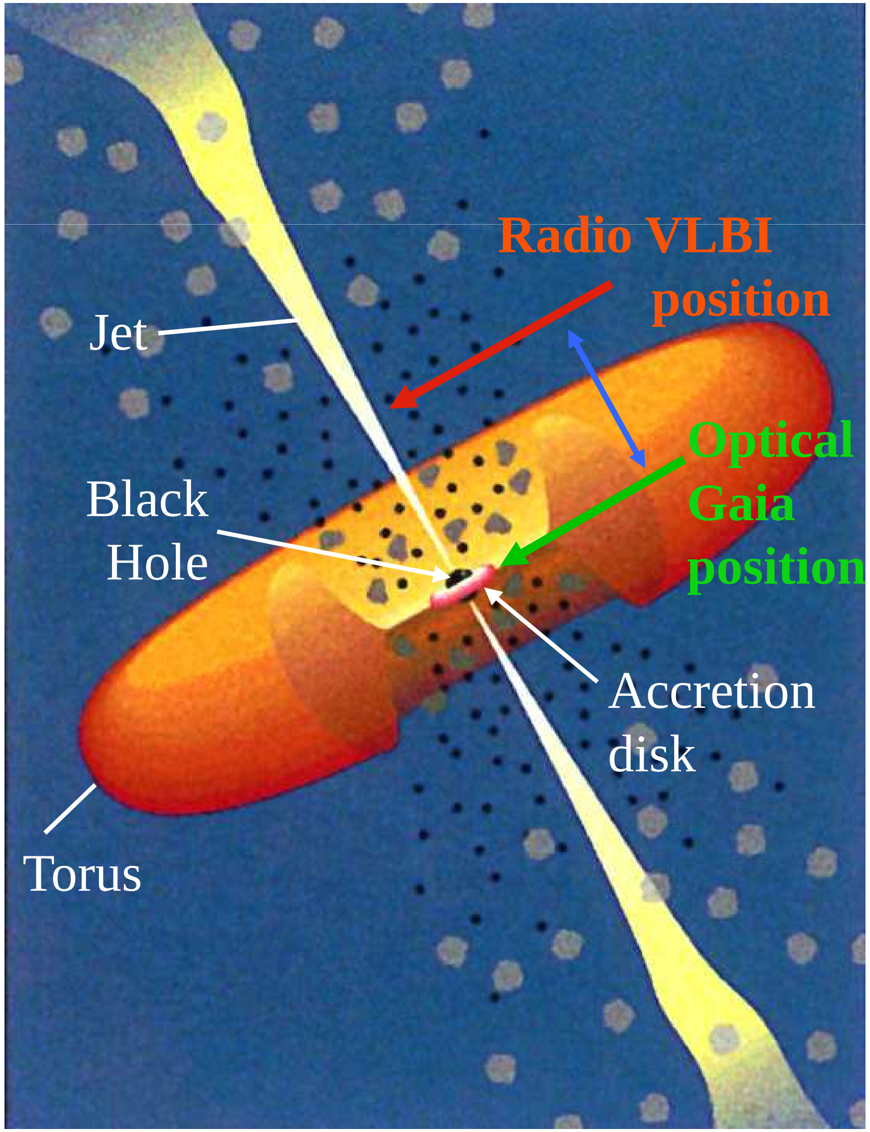
- Further objectives:

1. Optical survey of these weak radio sources for variability studies.
2. Survey in the southern hemisphere (APT)?
3. Study of physical properties of weak sources.

AGN geometry/physics & ICRF–Gaia alignment

AGN unified model
Urry & Padovani, 1995



ICRF−Gaia alignment:

Determining AGN optical/radio core shifts

⇒ Constrain AGN general geometry

Recent estimation: ~100 μas (Kovalev et al. 2008)

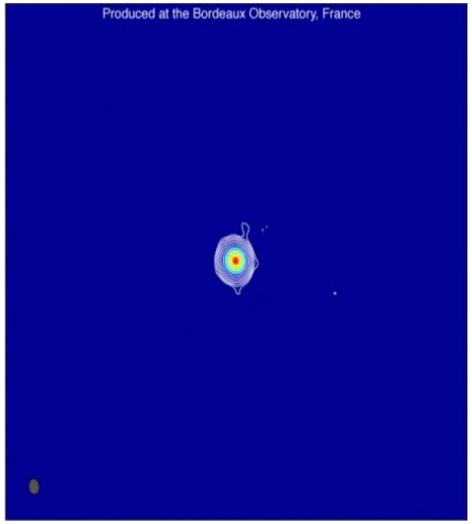
Acknowledgements

- John Gipson (SKED)
- Dave Graham / Walter Alef (Correlation)
- Alexander Andrei (optical positions delivery)
- RadioNet for financial support during the 9th EVN Symposium

Structure Index (X-band)

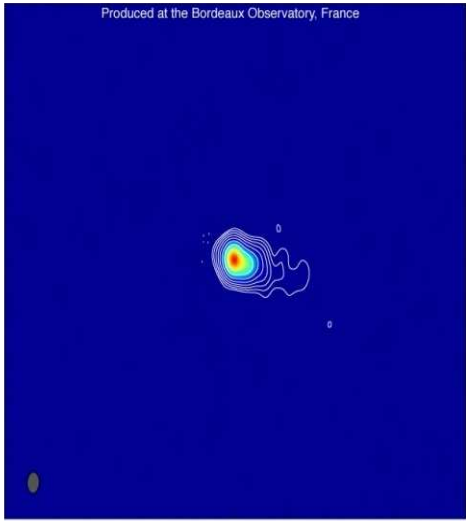
Fey & Charlot 1997, 2000
Charlot et al. 2006

0642+449



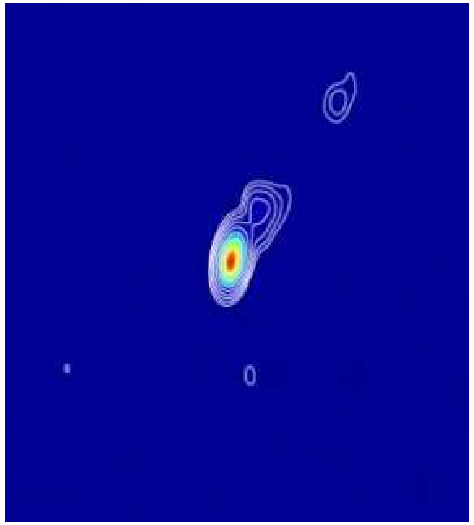
SI = 1
Point-like source

OJ287



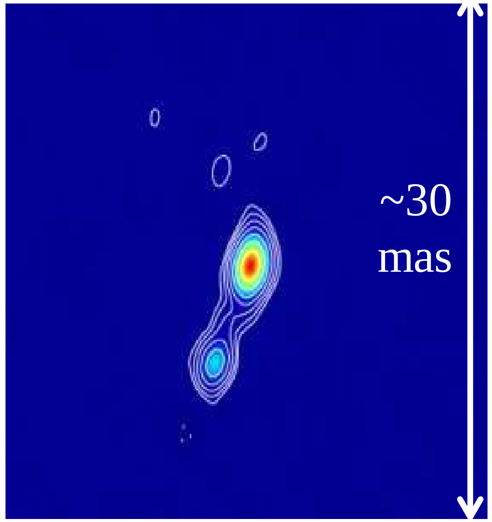
SI = 2
Source not extended

0656+082



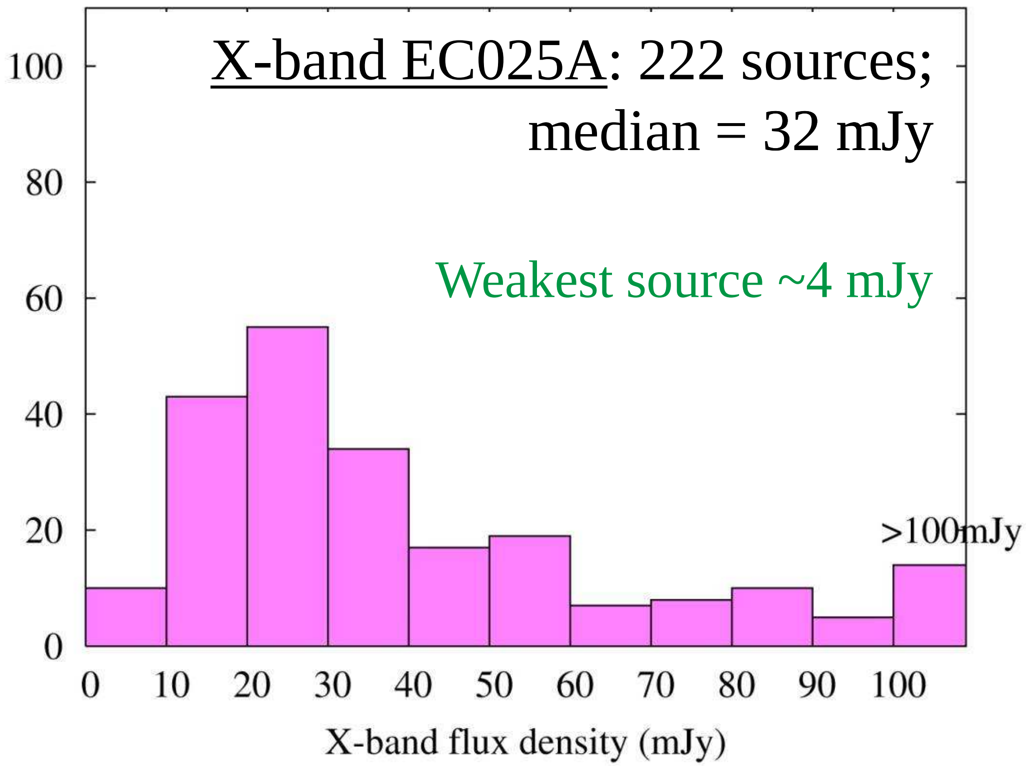
SI = 3
Extended source

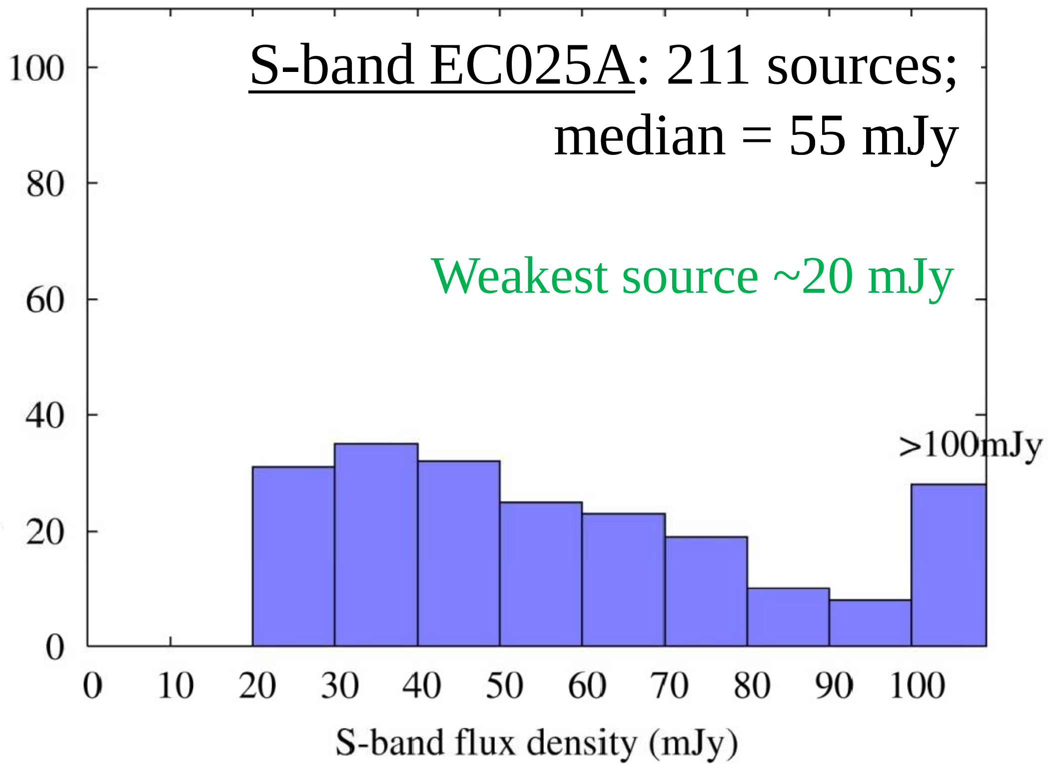
0711+356



SI = 4
Source very extended

Flux density distributions





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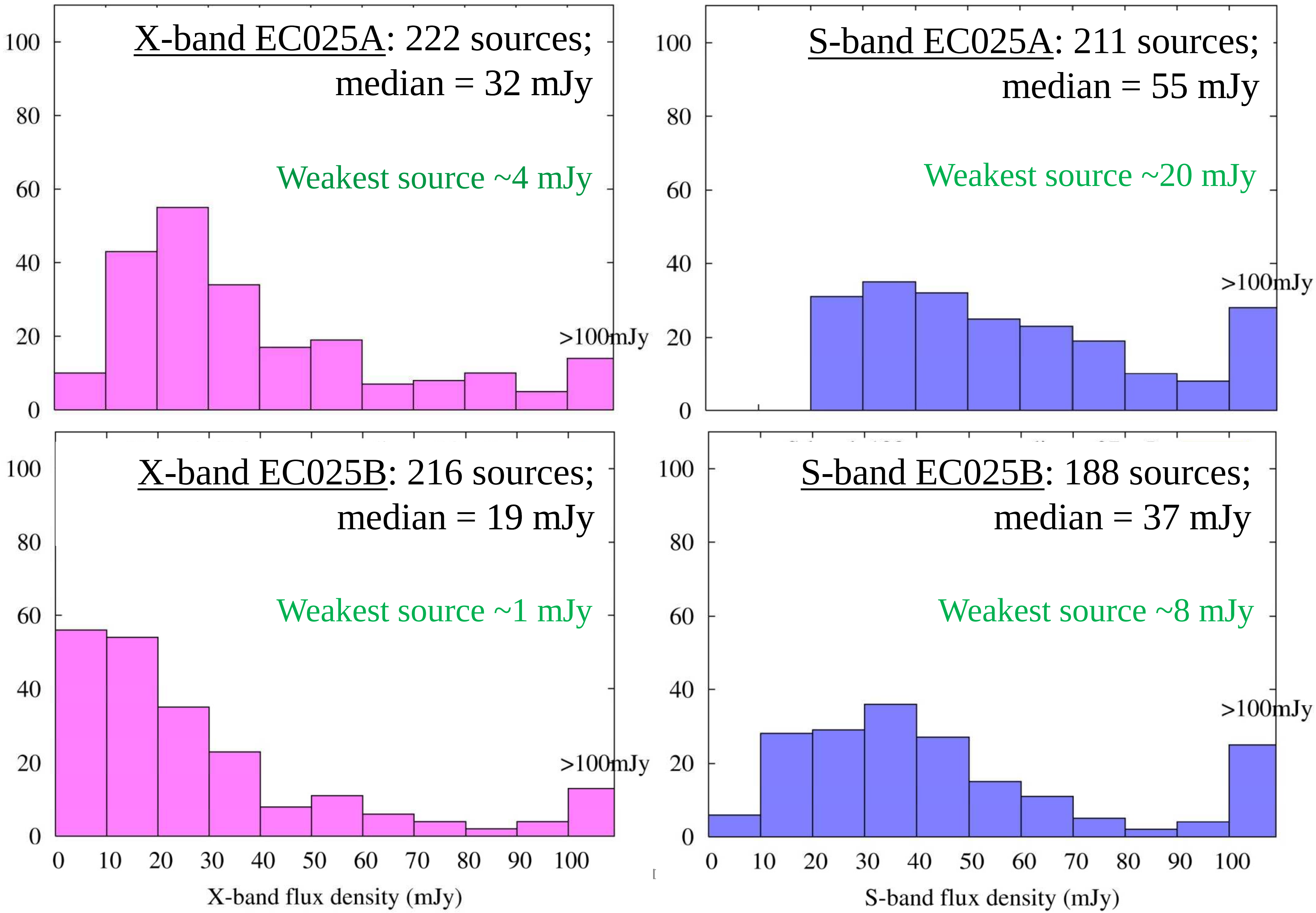
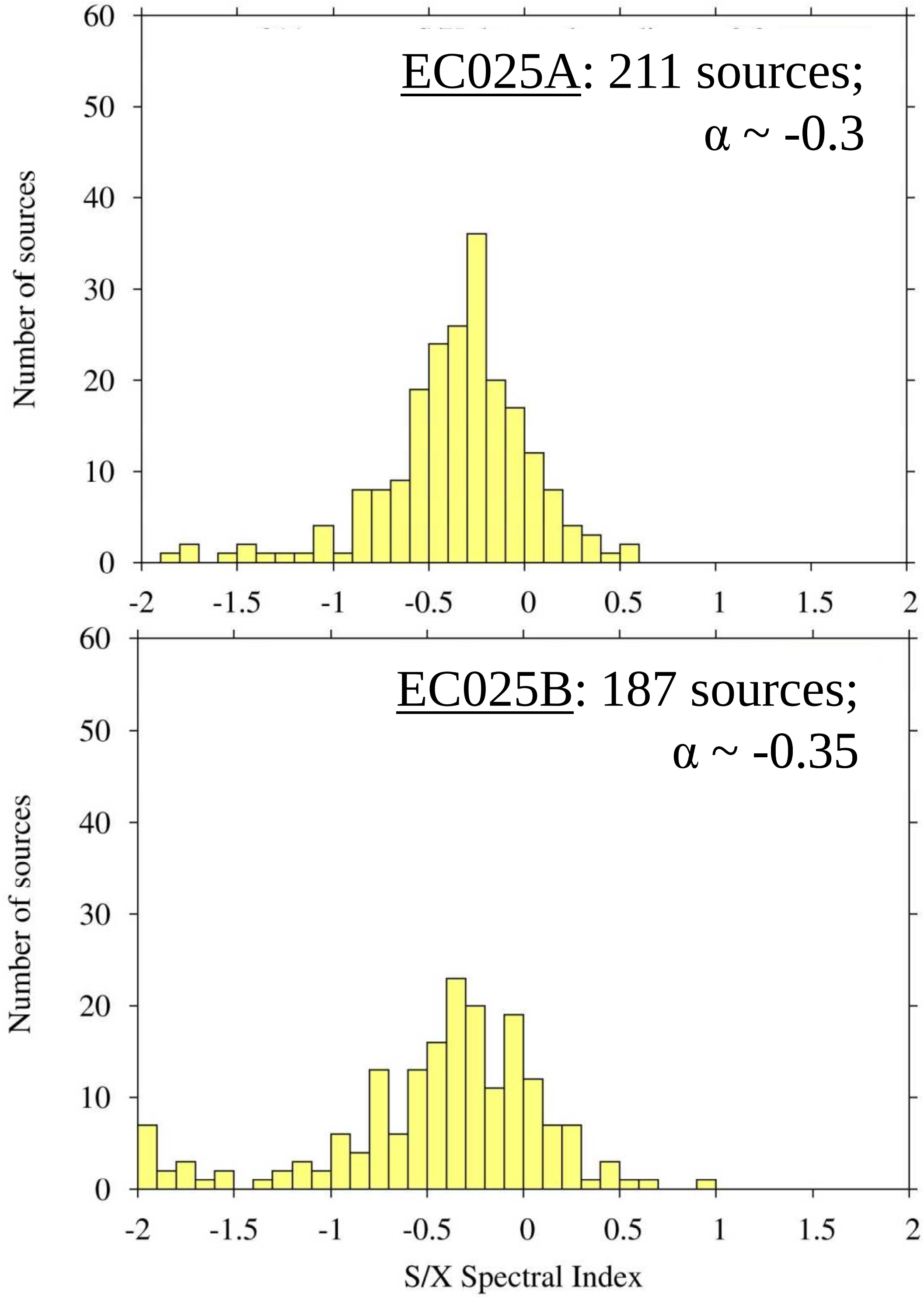


S/X Spectral Index distribution

$$\frac{\text{Flux (S-band)}}{\text{Flux (X-band)}} = \left(\frac{2.3}{8.4}\right)^{\alpha}$$

Sources with compact core: α > -0.5



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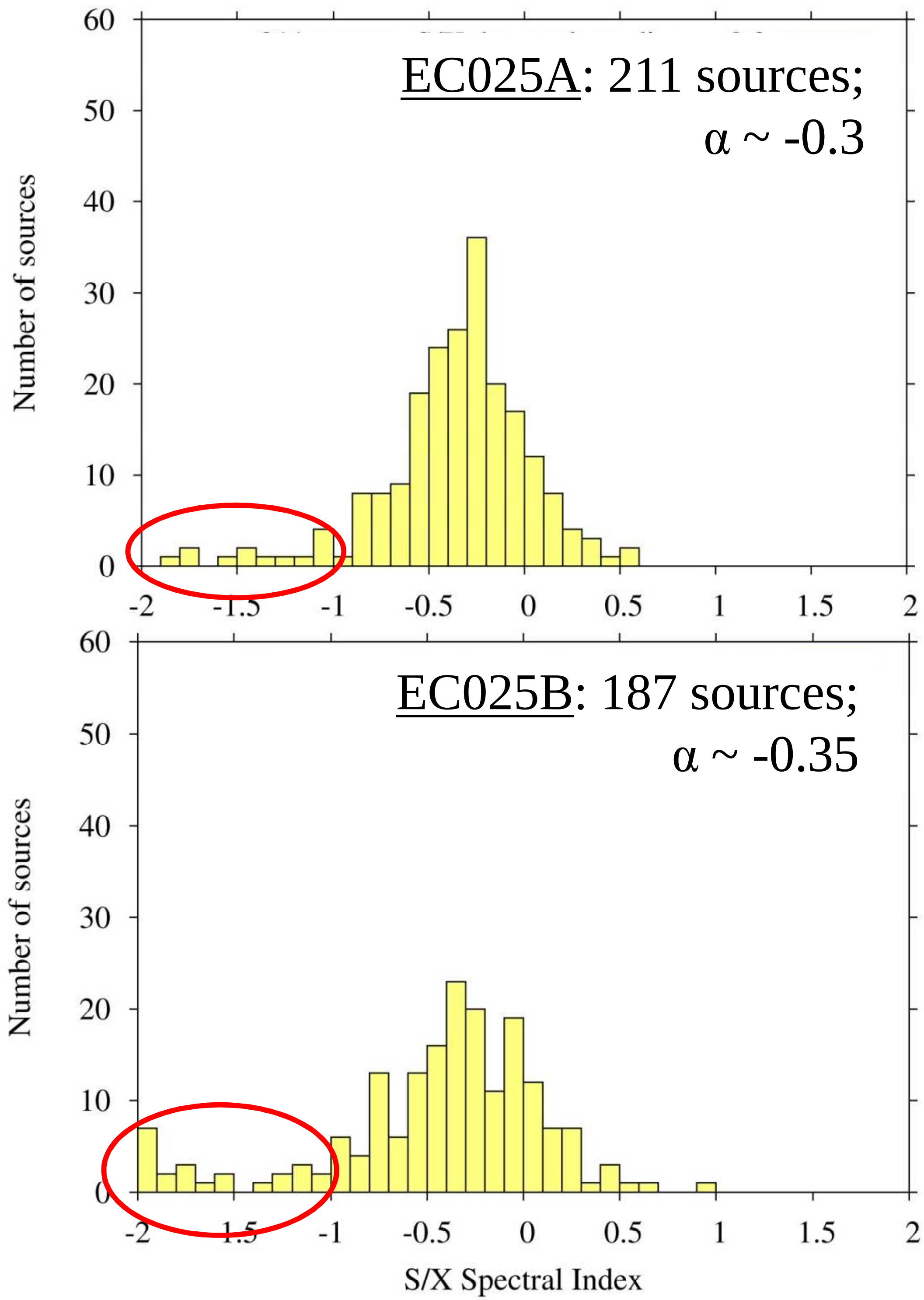
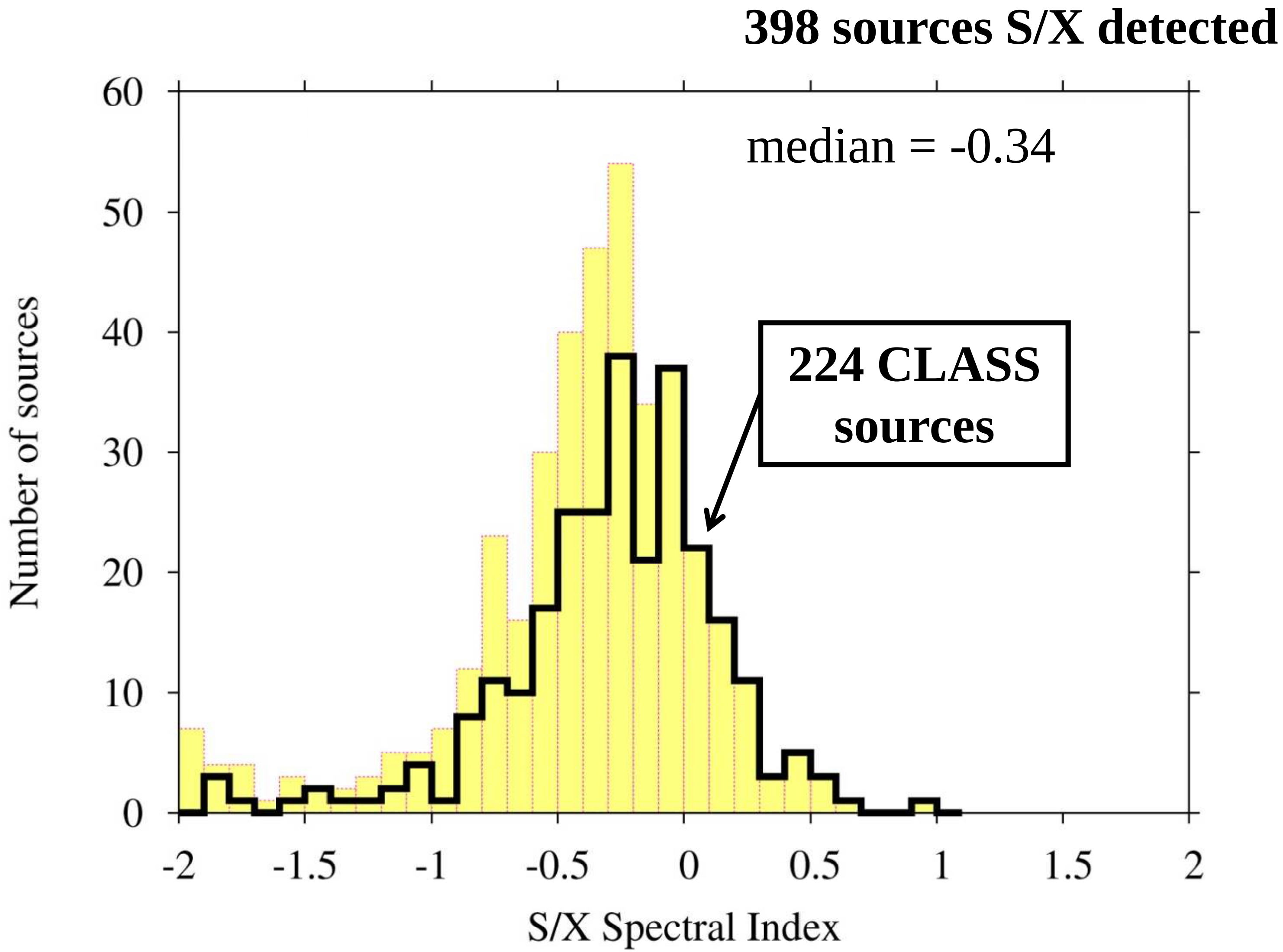


Results summary:

EC025A + EC025B



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