# *Extending the ICRF To Higher Radio Frequencies:*

# *24 and 43 GHz Astrometry*

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# Outline

- Motivation for a radio frame above 8 GHz (X-band)
- Game plan
- Initial Observations
- Results
- Accuracy
- Future Plans/Conclusions

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# Collaborators on Astrometry

| | |
|---|---|
| • P. Charlot | Observatory of Bordeaux |
| • D. Gordon | Goddard/NASA |
| • C. S. Jacobs | JPL/Caltech NASA |
| • G.E. Lanyi | JPL/Caltech NASA |
| • C. Ma | Goddard/NASA |
| • C.J. Naudet | JPL/Caltech NASA |
| • O.J. Sovers | RSA Systems/JPL |
| • L.D. Zhang | JPL/Caltech NASA |

**This team is a subset of the larger KQ VLBI Collaboration which includes:**

**National Radio Astronomical Observatory**

**U.S. Naval Observatory**

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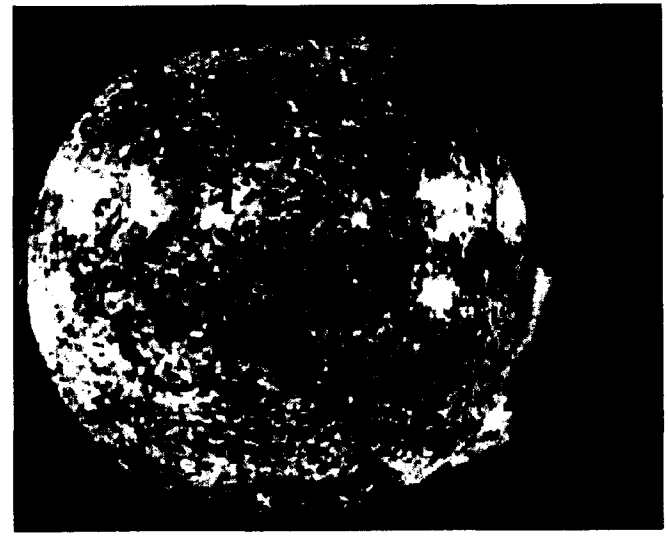
# Motivation

- Astrometry, Geodesy and Deep Space navigation, now at 8.4 GHz (X-band)

<u>Going to Higher radio frequencies allows</u>

- Potentially more compact sources
  Potentially more stable positions
- Higher Telemetry Rates to Spacecraft
- Avoid 2.3 GHz RFI issues
- Ionosphere & solar plasma down 16X !! at Ka-band (32 GHz)



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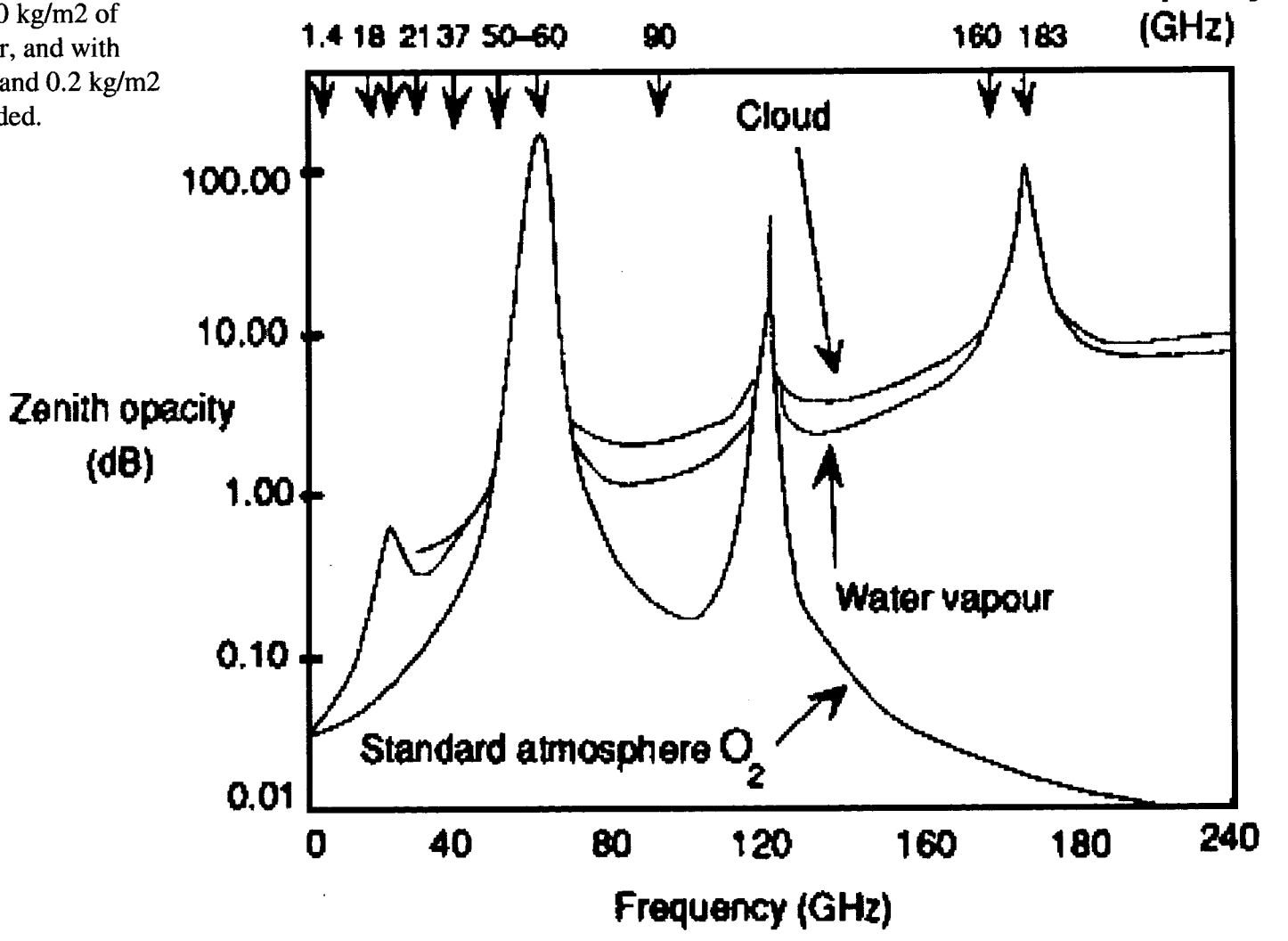
# Why Ka-band?

The three curves show absorption in a dry atmosphere, in the same atmosphere with 20 kg/m2 of added water vapour, and with both water vapour and 0.2 kg/m2 of stratus cloud added.

## *Valleys are microwave windows*



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# Game Plan

- Long term - simultaneous 8.4 and 32 GHz (X/Ka-bands)
  at present instrumentation not all in place

- Interim plan: Bracket 32 GHz with currently available
  24 GHz (K-band)
  43 GHz (Q-band)
  - Interpolate behavior at 32 GHz (Ka-band)
    identifies likely detectable sources

- Now: Exercise short baseline Ka-band instrumentation
  at Goldstone California (DSS 13 - DSS 25)

- Exploring potential single baseline Goldstone CA to Kashima

- Eventually Goldstone-Australia ('05 or '06?)
  and Goldstone-Spain ('07?)
  VLBA ?? Others??

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# Initial Observations

- VLBA ten 25m antennas

  3 sessions each 24 hours

  ~ 60 sources per session

  3-5 snapshots, 2 min each

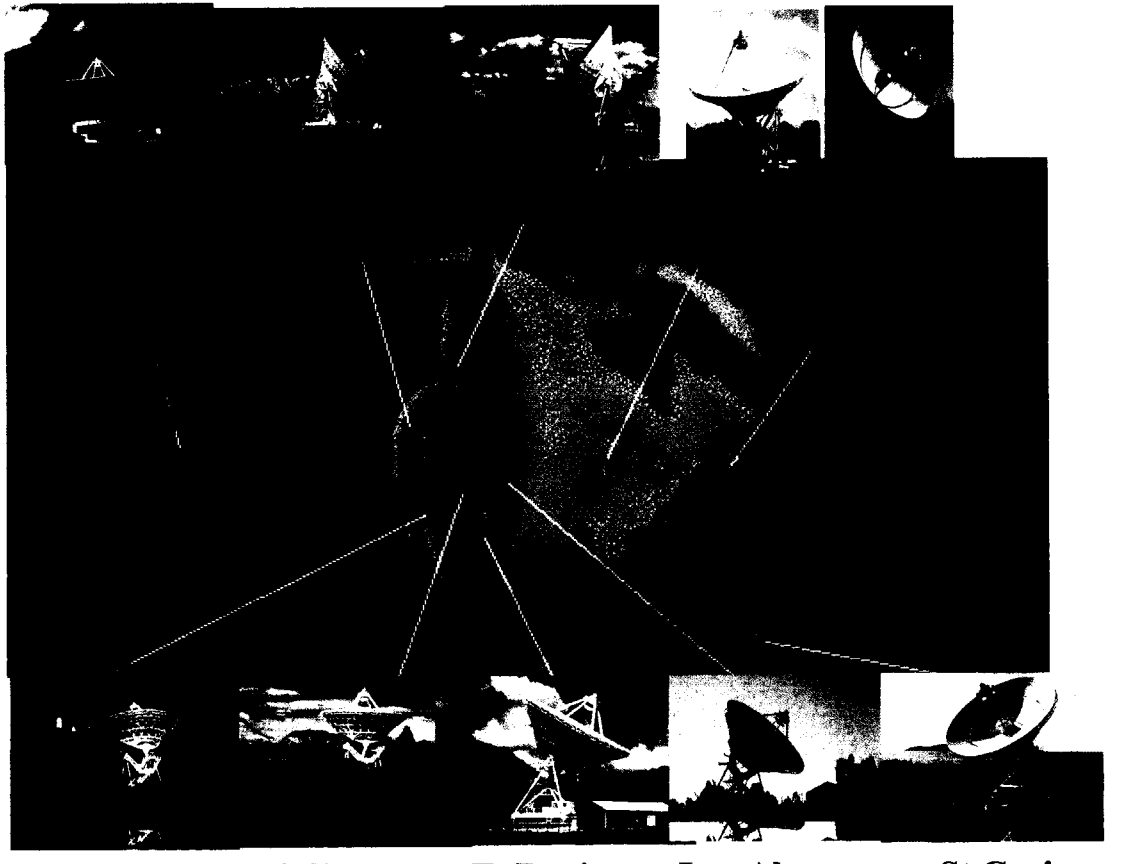
  400 MHz spanned bandwidth

  128 Mbps record rate

- Simultaneous astrometry and imaging

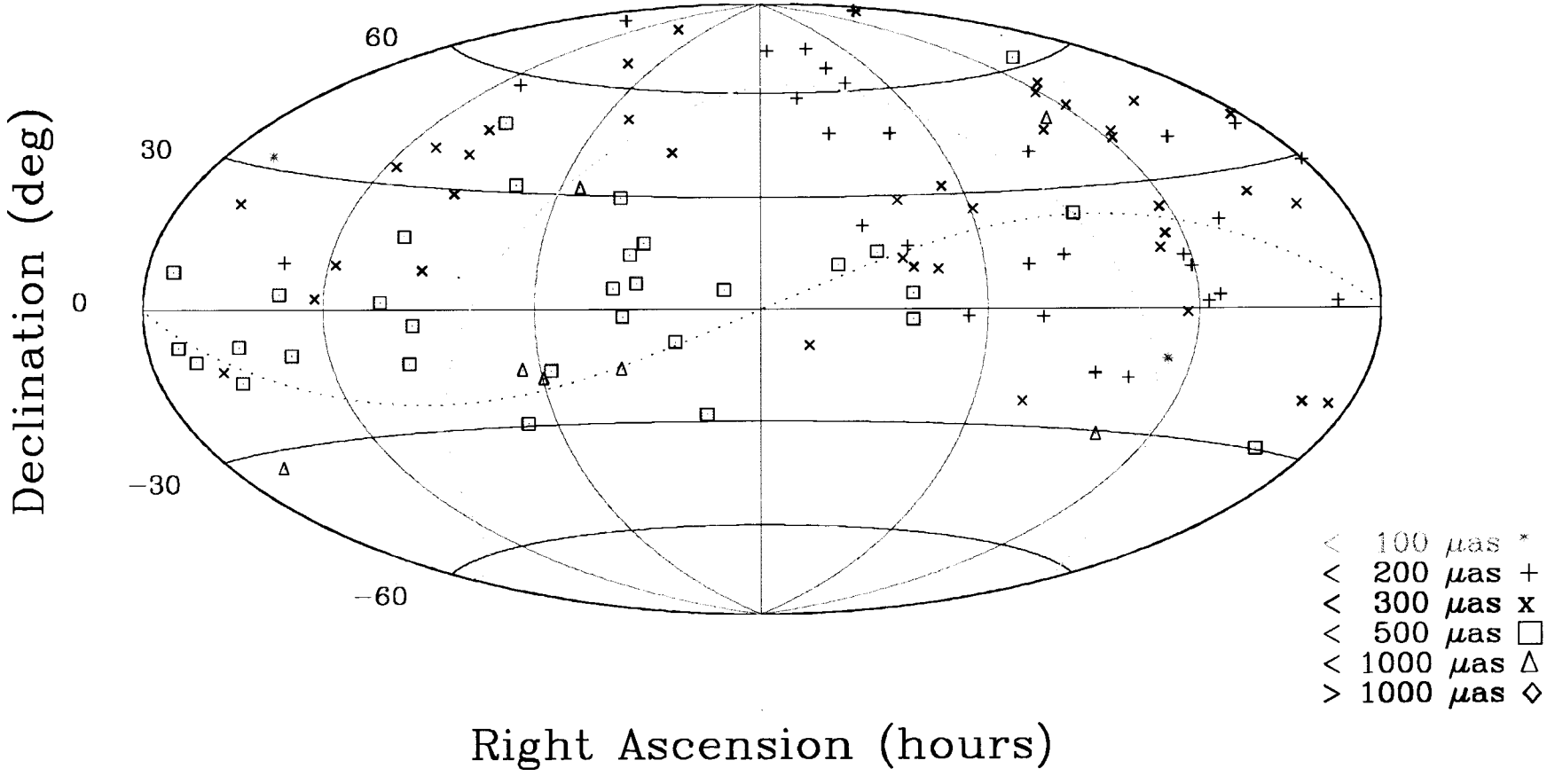
- Four more sessions planned for 2003

Mauna Kea OVRO Brewster N. Liberty Hancock

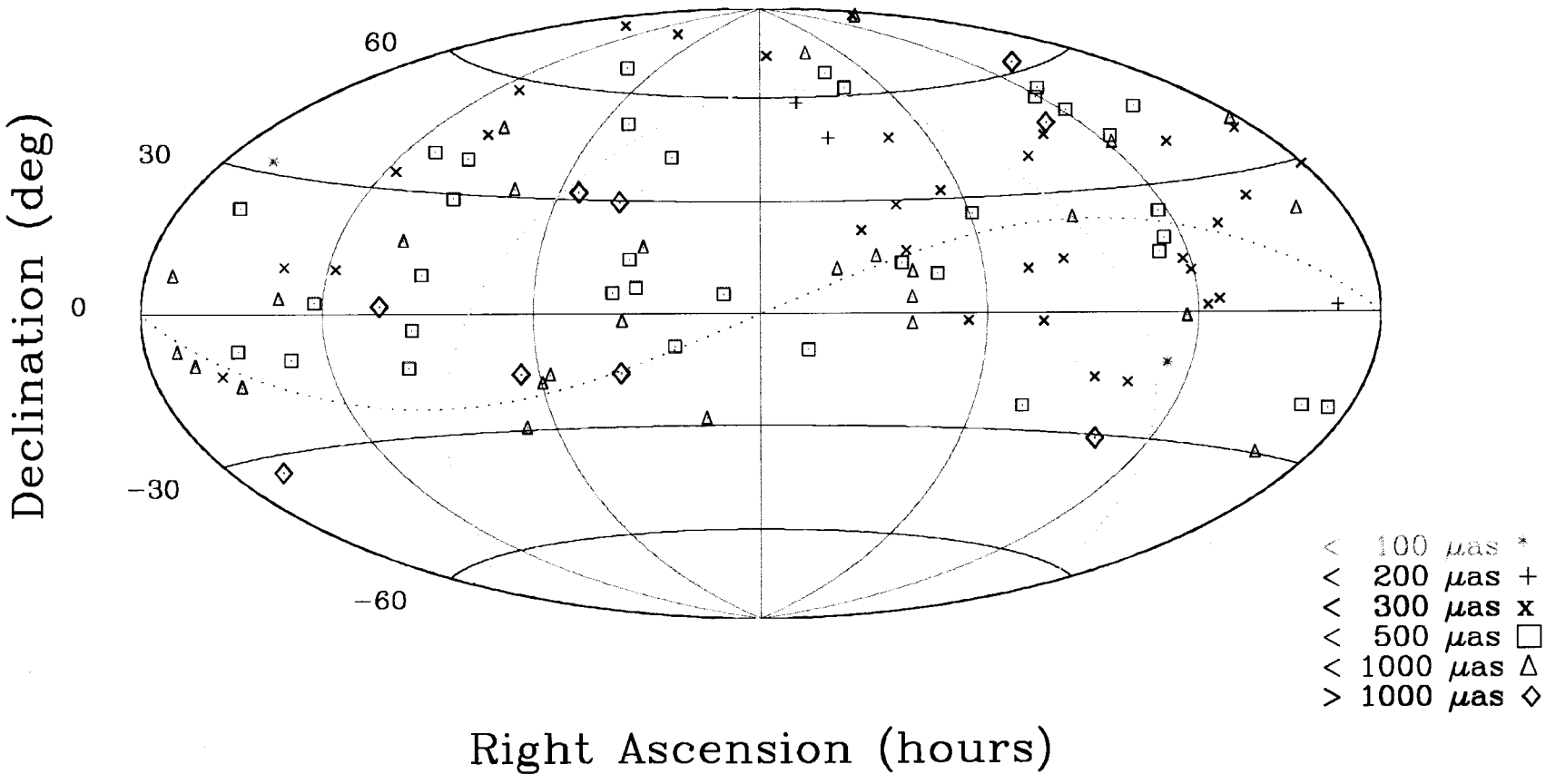


Kitt Peak PieTown Ft Davis Los Alamos St Croix

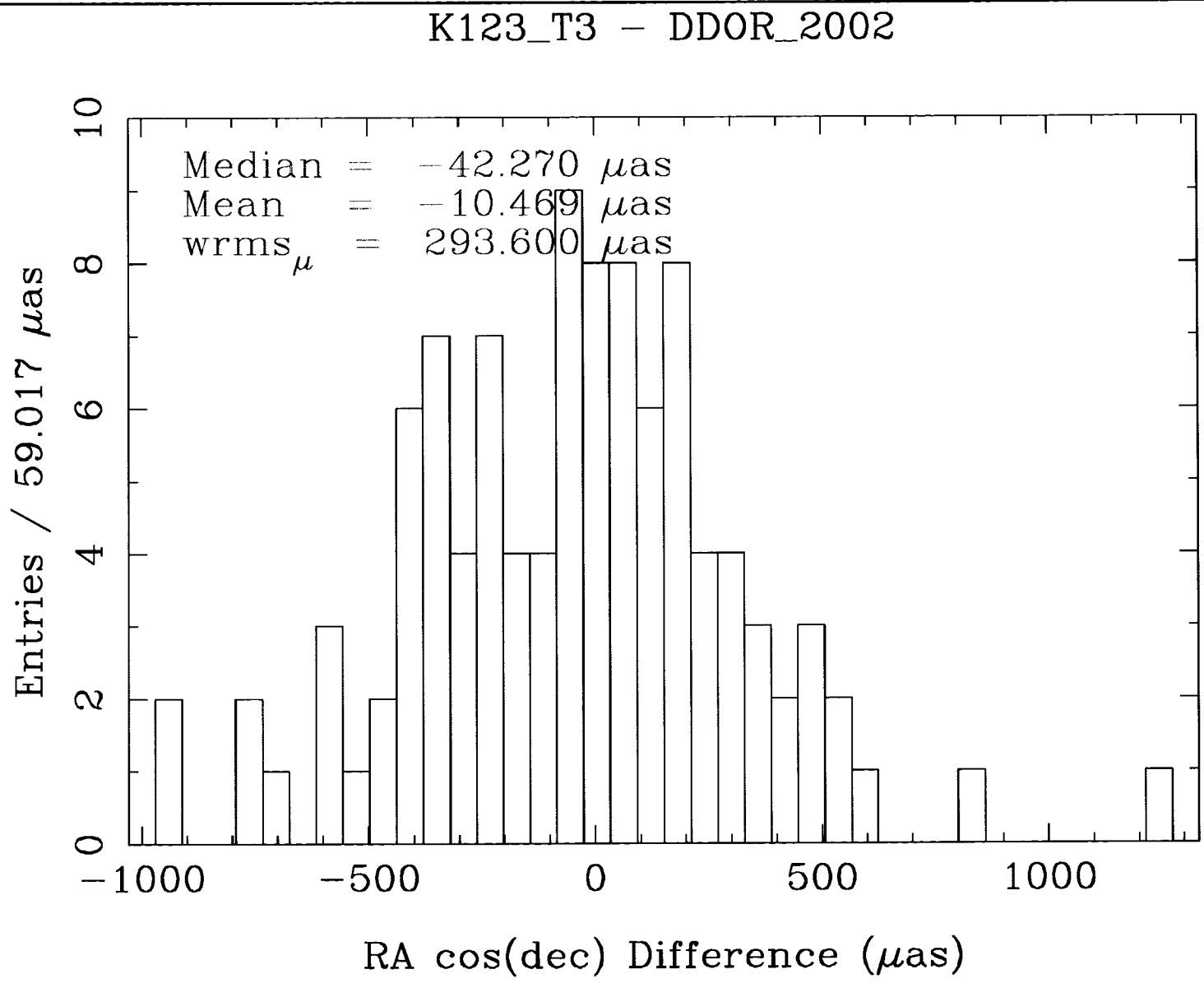
# Results: 24 GHz Celestial Frame



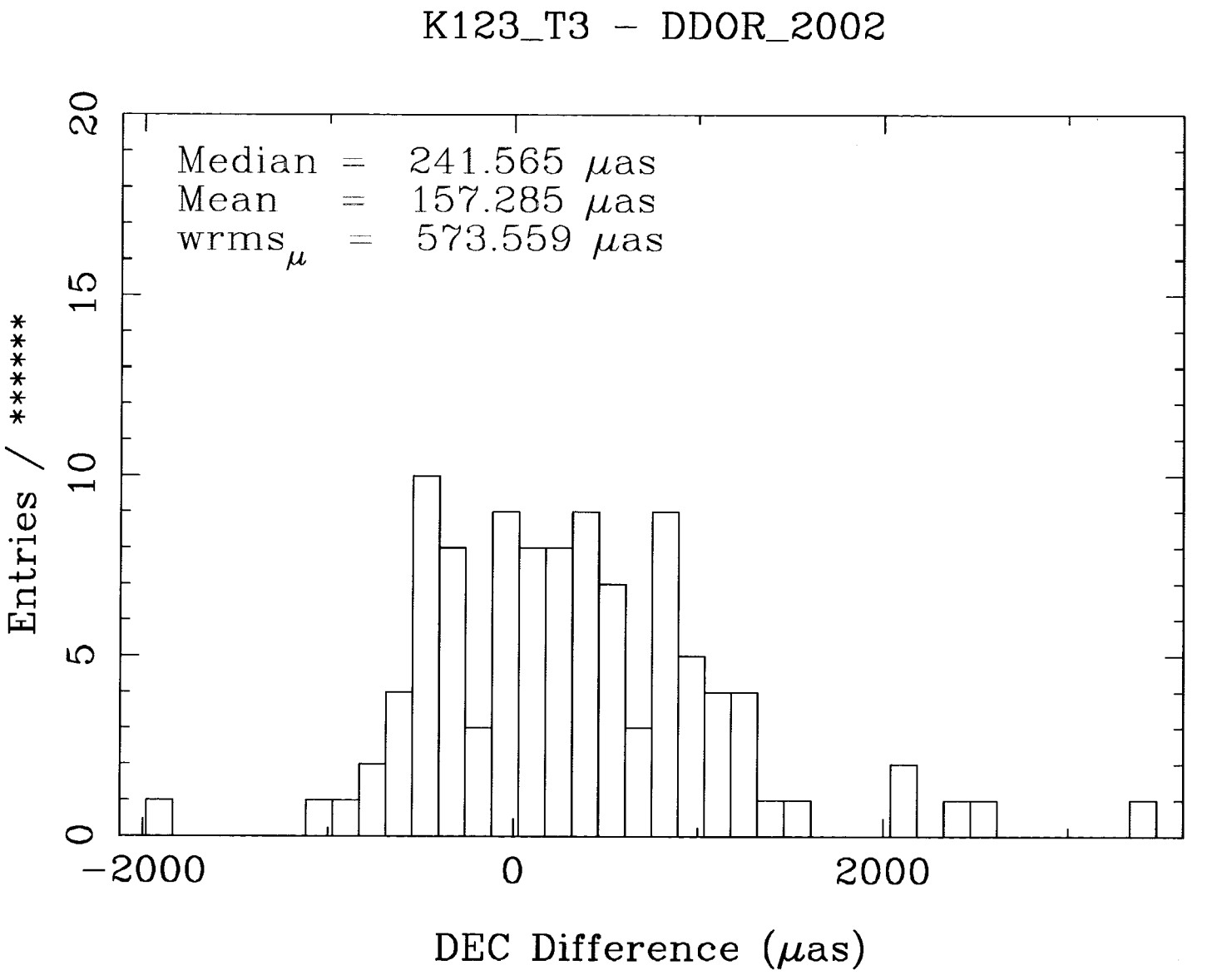
# Results: 43 GHz Reference Frame



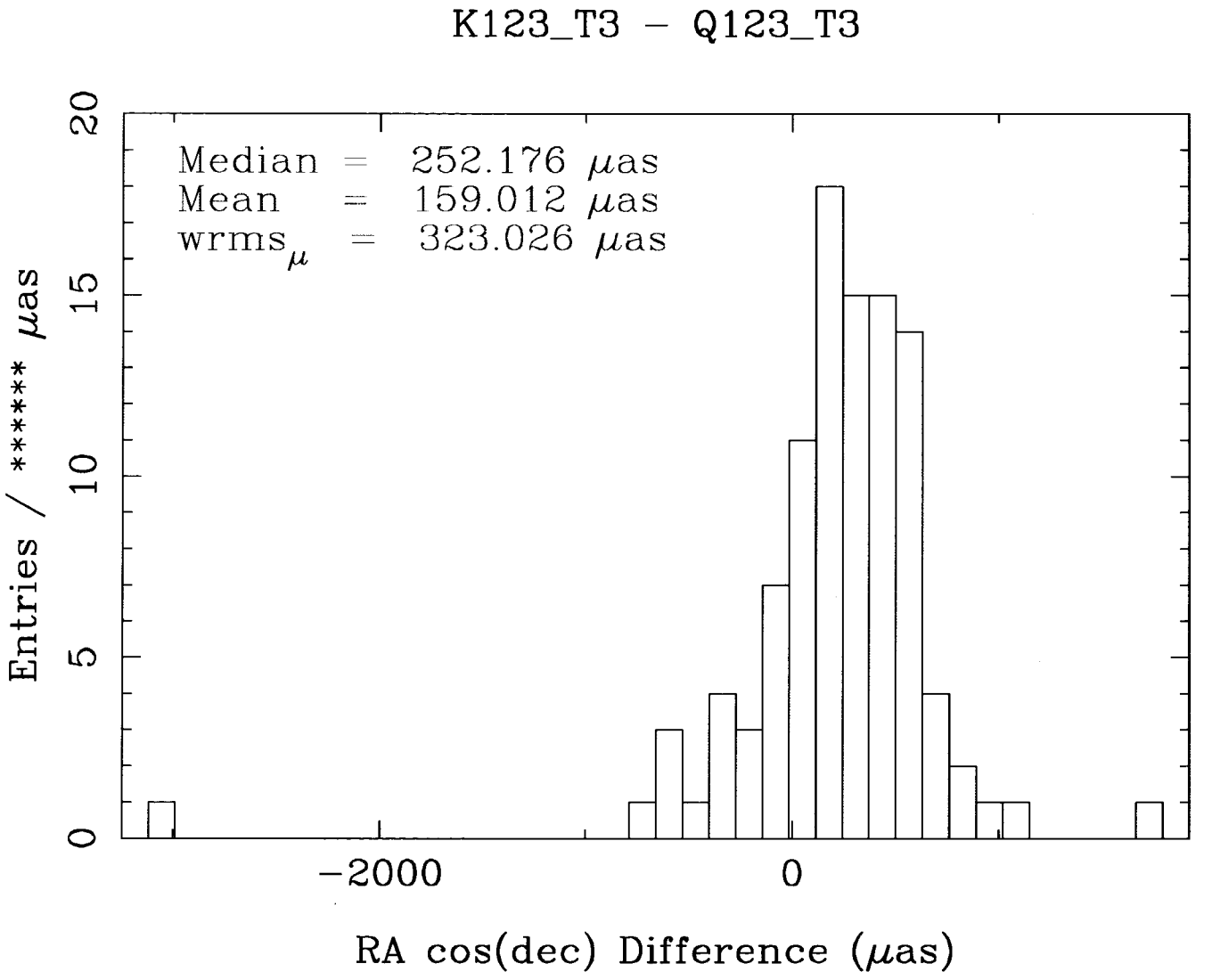
# ΔRA accuracy: K vs. S/X ICRF ext "1.5"



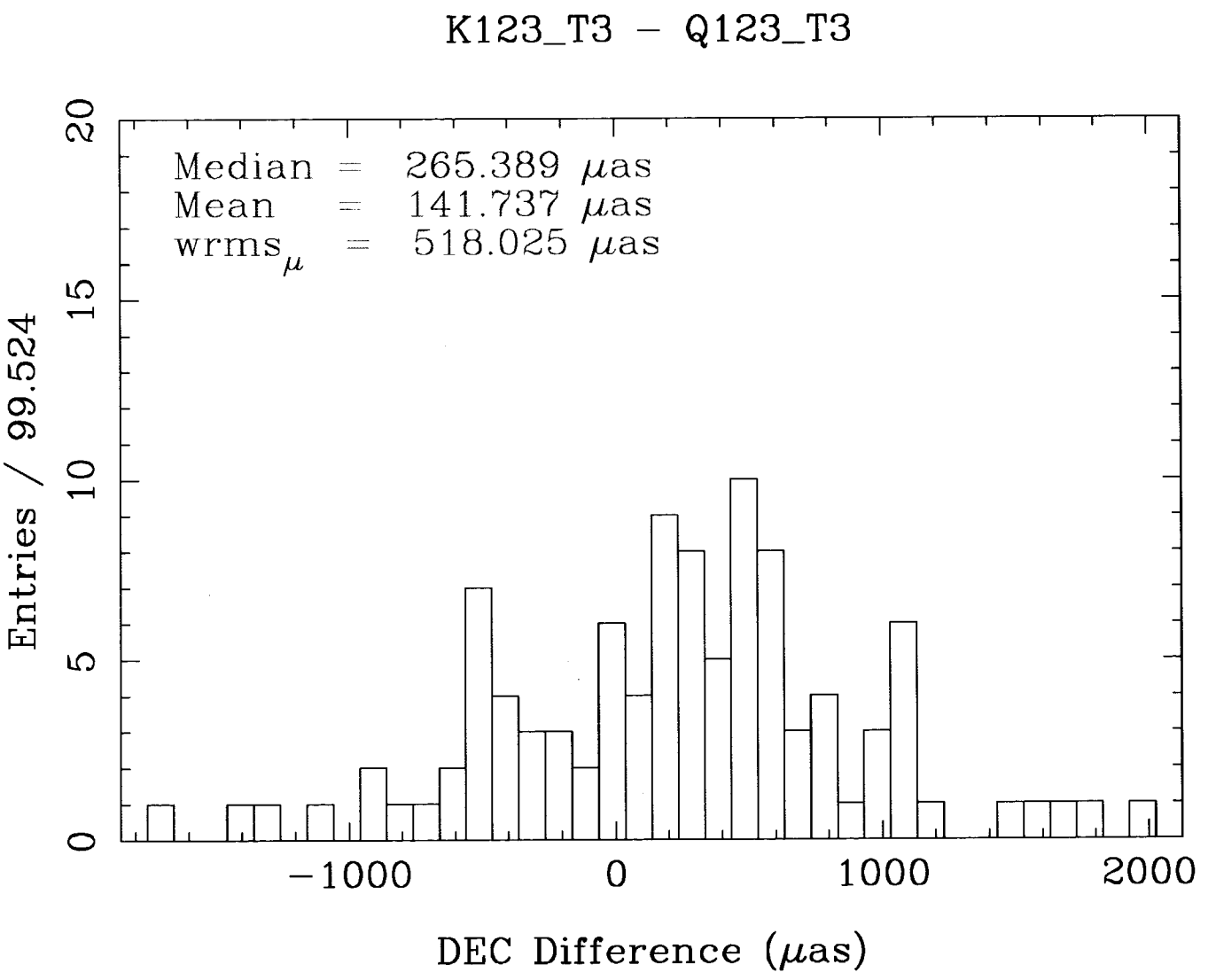
# ΔDec accuracy: K vs. S/X ICRF ext "1.5"



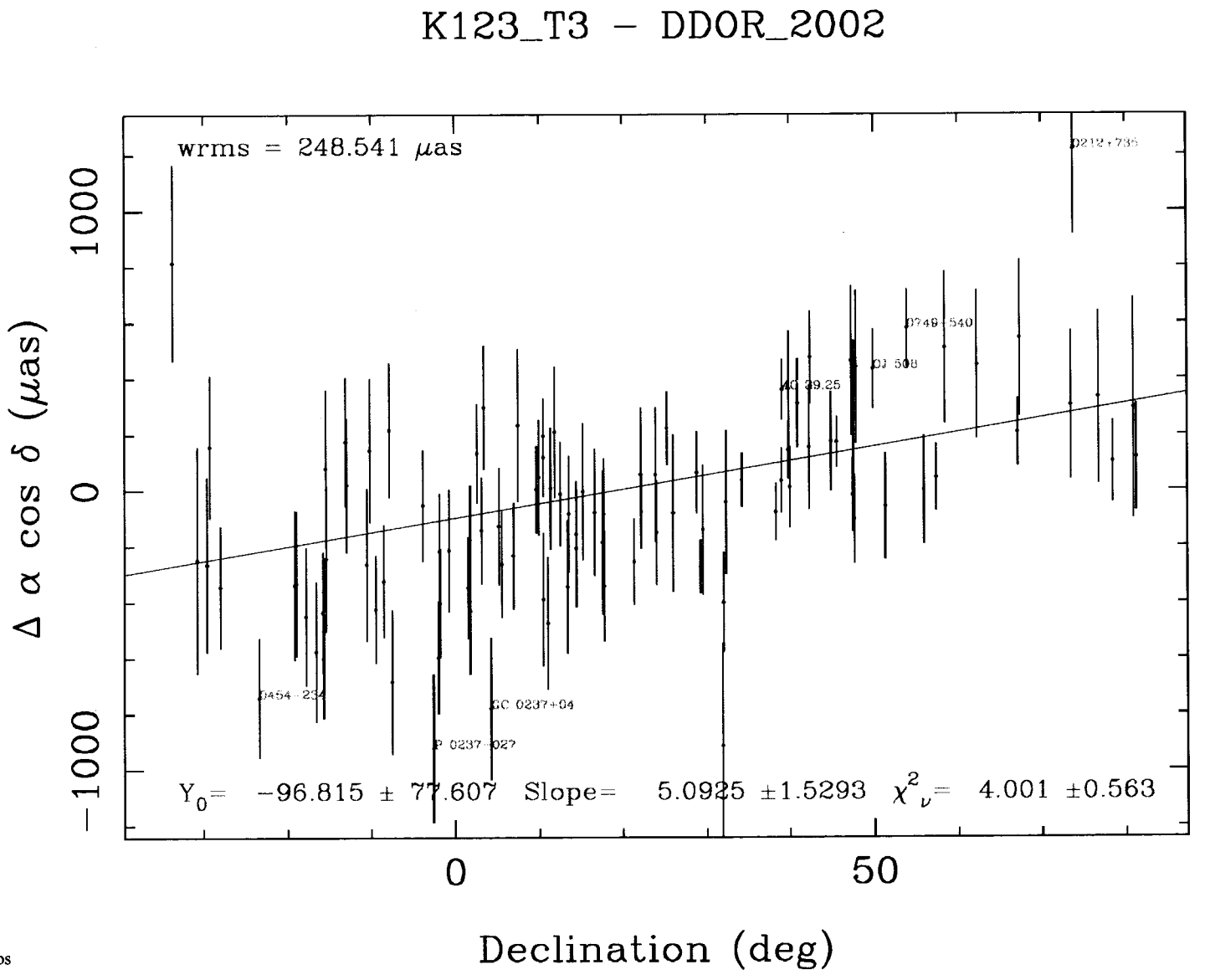
# Internal consistency: K - Q ΔRA



# Internal Consistency: K - Q ΔDec

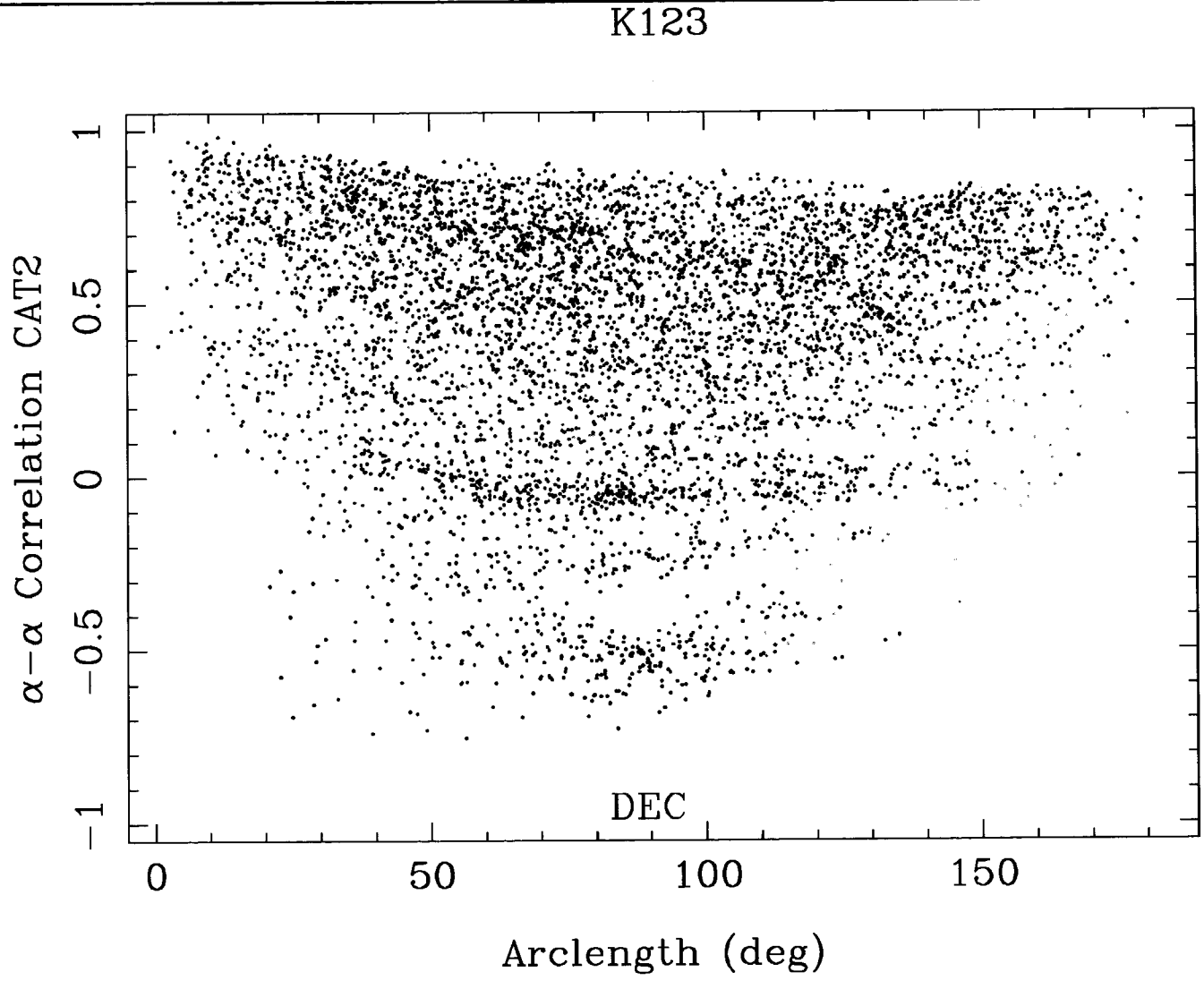


# Zonal Errors: ΔRA vs. Dec



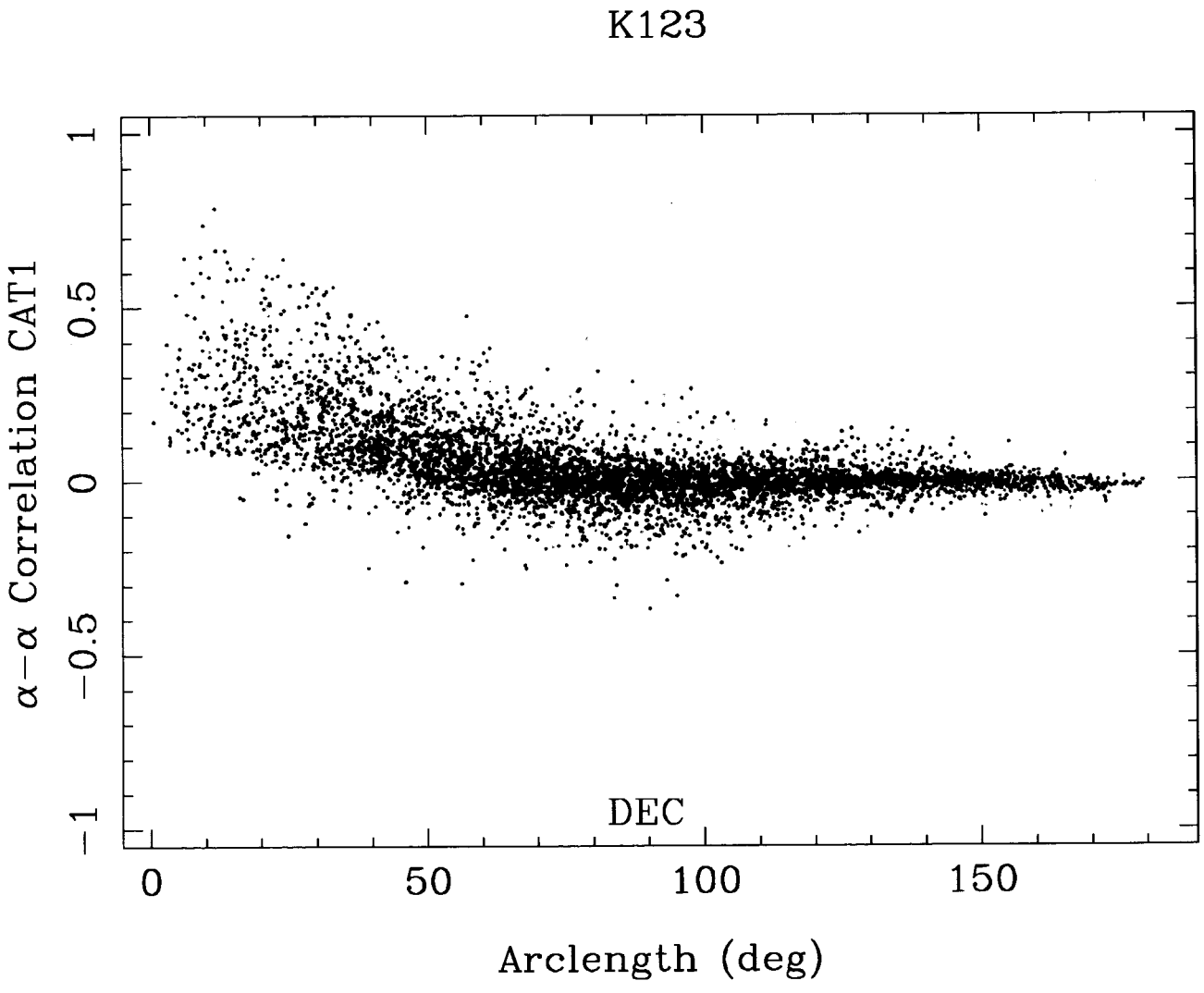
# RA-RA corr. vs. Arc: Minimal constraint

- 3-D orientation set by fixing 1.5 sources
- RAs not well separated by least squares
- Only 3 days data



# JPL RA-RA correlations: 4 source constraint

- 3-D orientation set by fixing 4 sources
- RAs now better separated by least squares
- Still only 3 days data
- Cost: Impose 5 pieces of external information from S/X ICRF



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# Conclusions

- *ICRF now extended to K and Q-bands at sub mas accuracy !*

**24 and 43 GHz observations: 3 sessions**
**108 sources**
**~ 250 μas formal precision**
**systematics at 500 μas level or less**

**Source parameters not yet well separated with only 3 days data - more data needed.**

- *Future Plans*

**More K and Q-band data on the way.**

**Planning for simultaneous 8.4 / 32 GHz (X/Ka) data**