VLBI astrometry: IAA CRF solution

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IAA CRF activity

- QUASAR VLBI data processing software
- Global VLBI data processing for source positions
- Optimal defining sources selection
- Systematic differences between CRF realizations
- Galactic aberration
- Source positions time series

QUASAR features

- Reduction parameteres
  - Most calculations done according to the IERS Conventions (2010)
  - Various options
- Single and multi session estimations
- Estimation options
  - Various parameters can be estimated
  - Every parameters can be global, arc or stochastic
  - Every parameters can be estimated as polynomial trends
- Least Square Collocation method
- Stochastic signal of clock-offset and WZD
  - Mean correlation function
  - Individual variance values for each station

Global Solution Parameters

- Global:
  - RA, DE
  - Stations coordinate and velocities
  - Antenna offset
  - Galactic aberration parameters
- Arc
  - Earth orientation parameters (Xp,Yp,UT1-UTC,Xc,Yc)
  - Linear trend of wet zenith delay
  - Troposphere gradient east and north
  - Quadratic trend of station clock offset
- Stochastic
  - Stochastic component of WZD
  - Stochastic component of clock offsets

Constraints

- no-net-rotation for 212 defining sources ICRF1
- no-net-rotation/translation for positions and velocities of 15 stations (BR-VLBA , FD-VLBA , FORTLEZA, HN-VLBA , KP-VLBA , LA-VLBA , MATERA , NL-VLBA , ALGOPARK, WESTFORD, WETTZELL, HARTRAO , KOKEE , NYALES20, ONSALA60)
- Not estimated sources observed less than 15 times and stations velocities of less than one year observation period (soft constraints)
- Sum of clock offsets is equal to zero in one session
- Soft constraint for EOP for sessions with low geometry
- Equal stations velocities for stations on same site

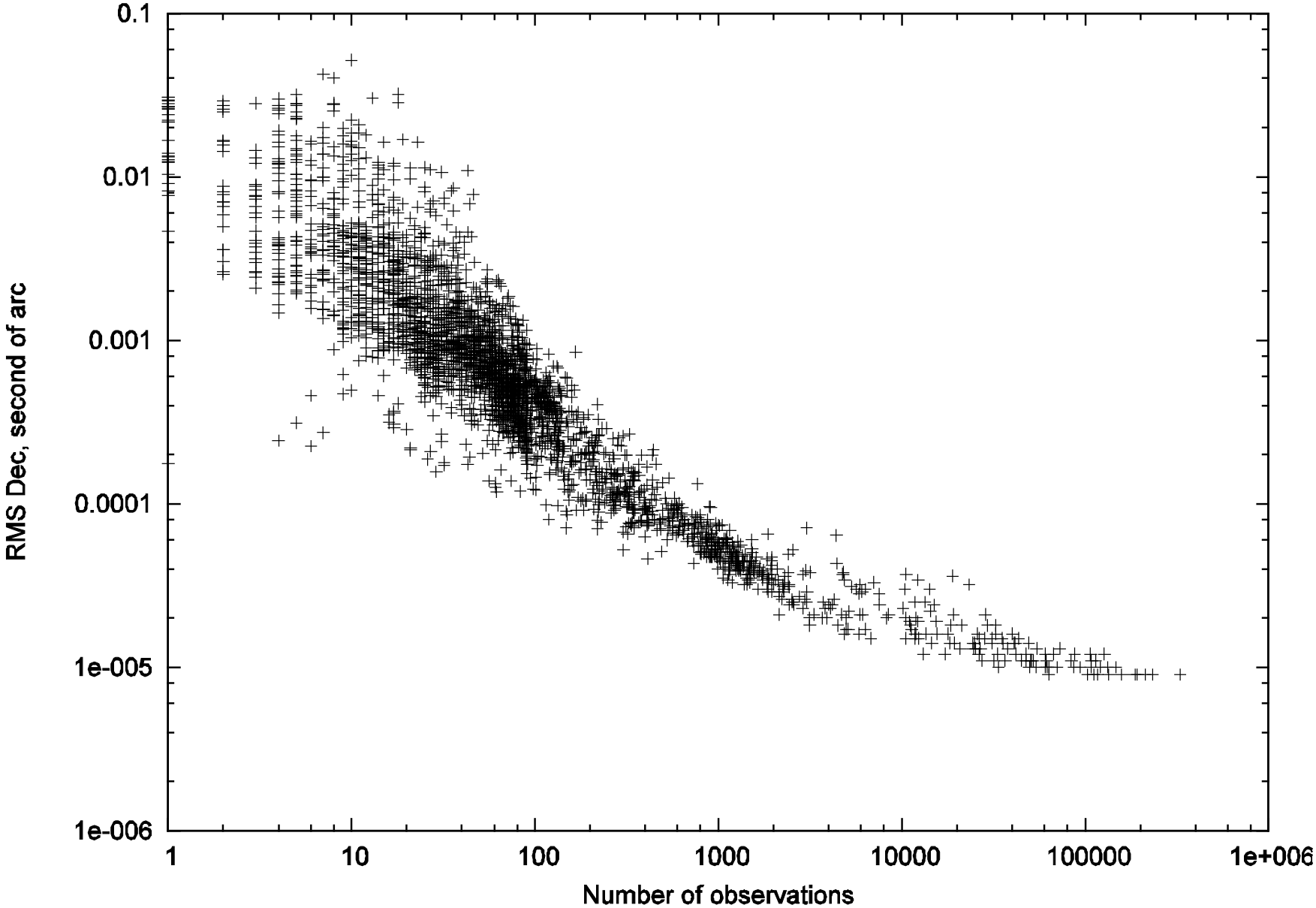
IAA global solution for ICRF2

- 4404 VLBI sessions
- Aug 1979 - Jan 2011
- 6721880 delays
- 132 stations (15 with discontinuous motion)
- 3493 radio sources

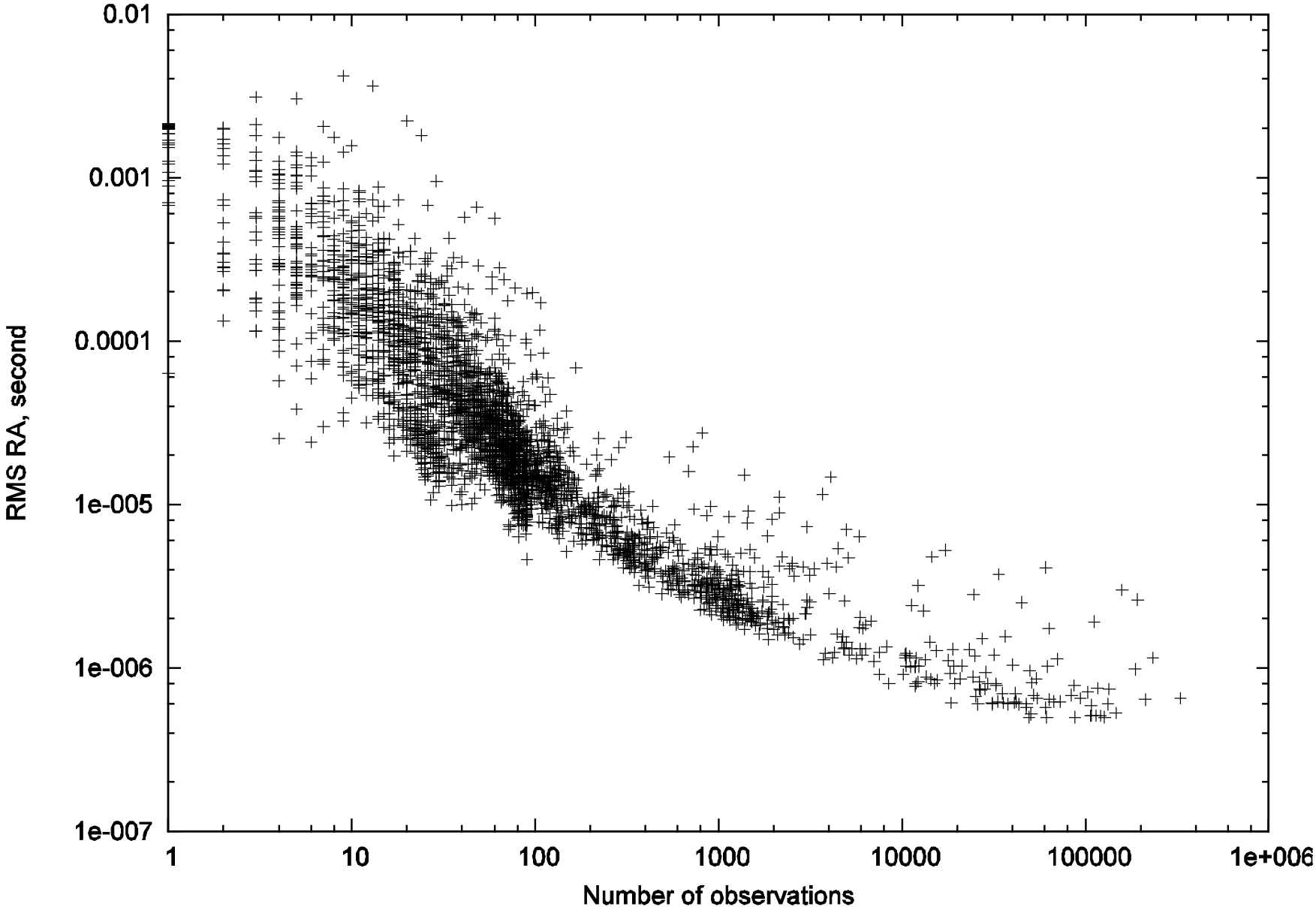
Comparison of CRF catalogue with the ICRF2

	Mean Sigma, mas	WRMS vs ICRF2, mas
RA	0.2	0.05
DE	0.2	0.07

Source positions formal errors vs number of observations chart



Source positions formal errors vs number of observations chart



International VLBI Service web site

http://ivscc.gsfc.nasa.gov/products-data/products.html

ftp://ivs.bkg.bund.de/pub/vlbi/ivsproducts/CRF/

iaa2006a.crf
iaa2007a.crf
iaa2007b.crf
iaa2008a.crf
iaa2009a.crf
iaa2011a.crf
iaa2012a.crf
iaa2014a.crf

Estimation of Solar system acceleration from VLBI

1. With fixed source positions the acceleration:

$a_x = -1.9 \pm 0.2 \cdot 10^{-10}$ m/s²,

$a_y = -4.2 \pm 0.2 \cdot 10^{-10}$ m/s²,

$a_z = -0.2 \pm 0.4 \cdot 10^{-10}$ m/s².

2. With estimation of source positions:

$a_x = -1.5 \pm 0.2 \cdot 10^{-10}$ m/s²,

$a_y = -4.4 \pm 0.2 \cdot 10^{-10}$ m/s²,

$a_z = -0.1 \pm 0.4 \cdot 10^{-10}$ m/s ².

- Calculation was performed by the global adjustment of the VLBI data
- The estimated value of acceleration vector $a=(4.7\pm0.5) \cdot 10^{-10}$ м/с², $\alpha=288°\pm5°$, $\delta=0°\pm5°$ significantly differs from the theoretical one but comparable with the other results.
- Results presented at 20th EVGA Meeting & 12th Analysis Workshop, March 29 - 31, 2011

Optimal defining sources selection

- Given catalogue RA, DE, arbitrary catalogue ra, de.
- Rigid rotation transformation model

$$dRA_i = RA_i - ra_i$$

$$dDE_i = DE_i - de_i$$

$$dRA_i = A_1 \tan(RA_i)\cos(RA_i) + A_2 \tan(DE_i)\sin(RA_i) - A_3$$

$$dDE_i = A_1 \sin(RA_i) + A_2 \cos(RA_i)$$

- Least Square for A1, A2, A3 estimation

$$\mathbf{C} = \frac{\partial(dRA, dDE)}{\partial \mathbf{A}}; \mathbf{N} = \mathbf{C}^T\mathbf{C}; \mathbf{A} = \mathbf{N}^{-1}\mathbf{b}$$

$$\sigma_A = \sigma_0 \operatorname{tr}(\mathbf{N}^{-1})$$

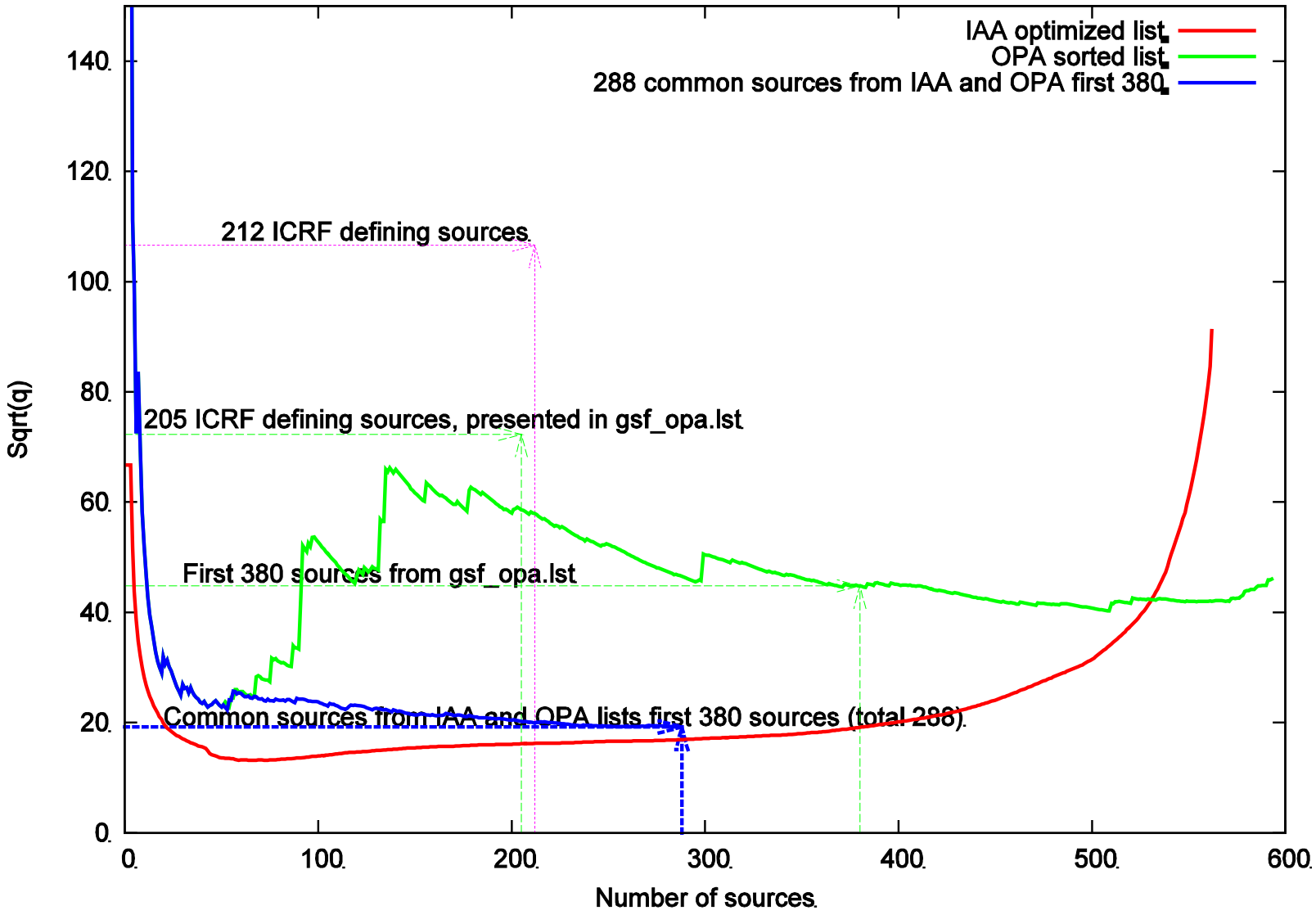
Inaccuracy of positions part

Geometry part

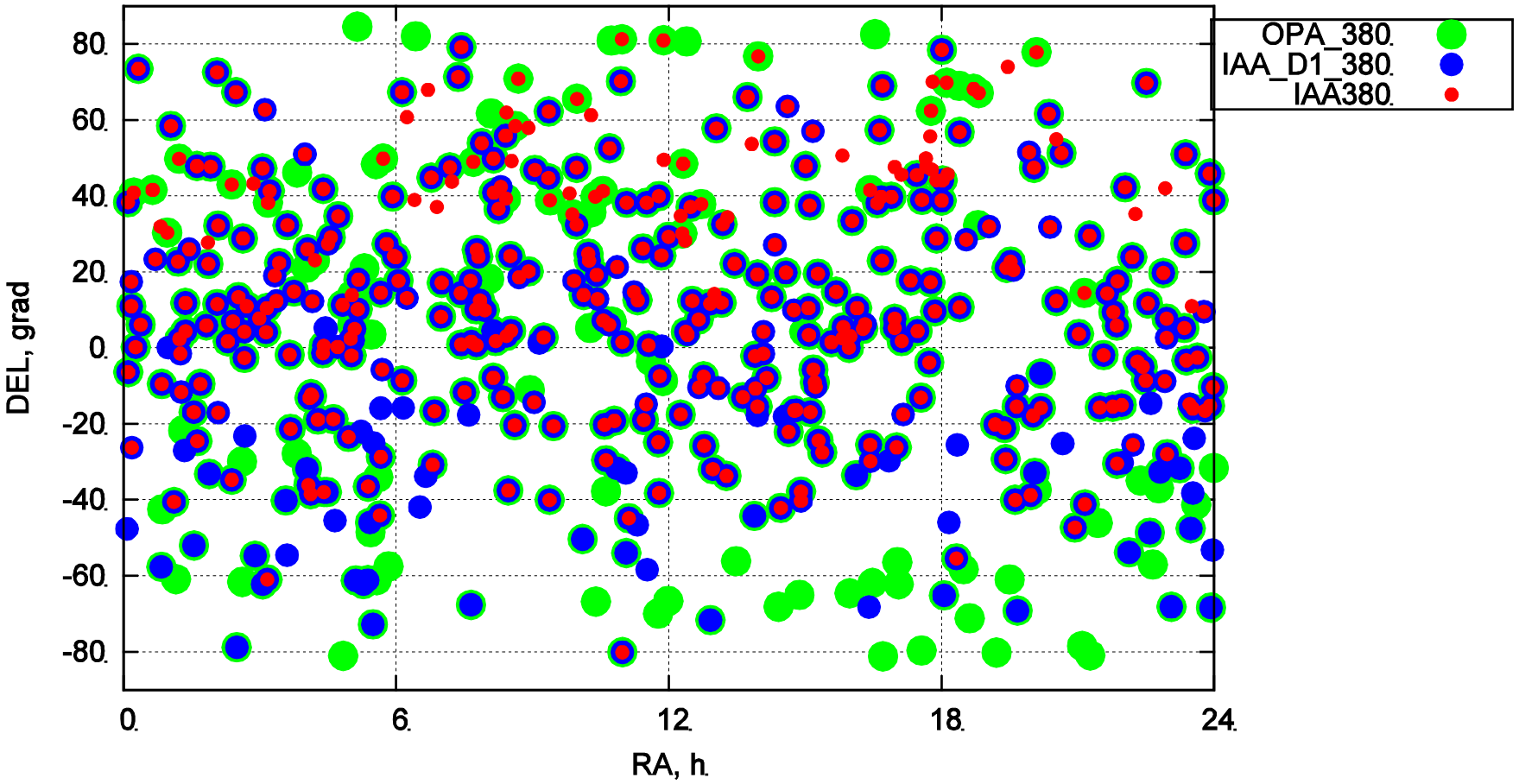
Algorithm

1. For each catalogue in analysis:
   - Triple loop over all sources in order to find the best trio what gives minimum to the *q,* thus obtain optimal set for N=3
   - Search over all remaining sources in order to minimize *q* for N+1 sources
   - The sequence of source sets obtained and parameter *q* as function of number of sources in the set
   - For all catalogues that function has a minimum in the N_k point.
2. Take the common part of the “minimum” sets N_k
3. Make 1. and 2. for both global solution σ_{RA}, σ_{DE} and time series and obtain common set

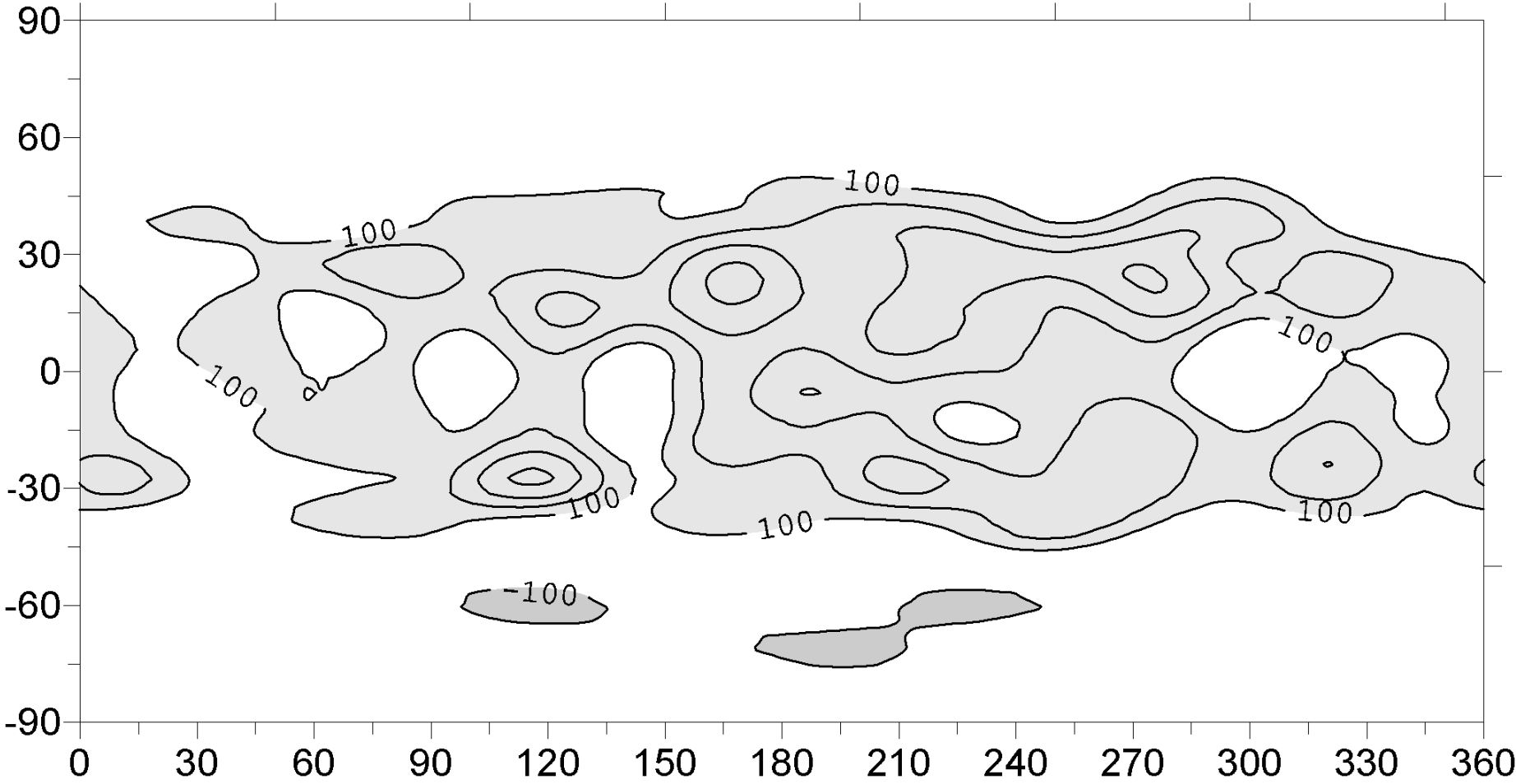
Comparison of IAA list, and 380 sources OPA list, set of defining sources ICRF1 and combined set



IAA core sets in comparison with the OPA set



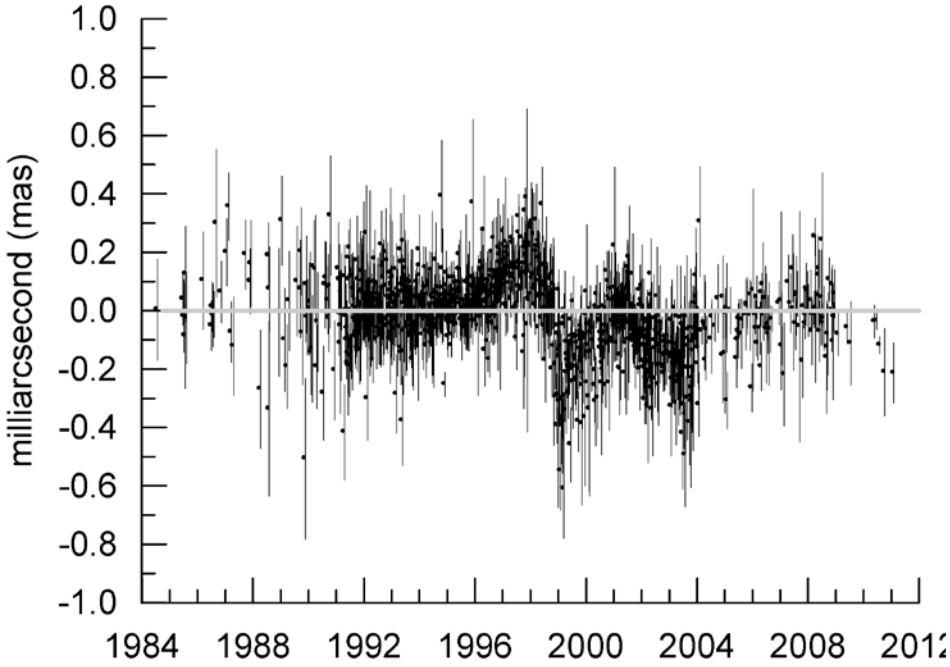
Systematic differences ICRF2(752) Δ δ, uas



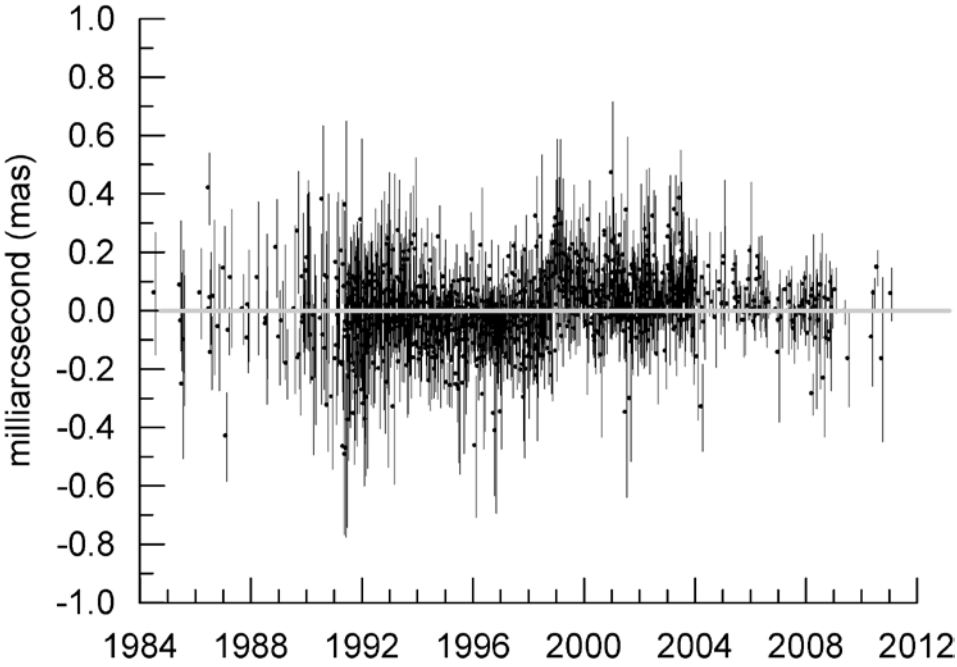
Source positions estimations

- Global solution for mid-point position
- Estimate one source position with fixed all another sources
  - minimize the session set of sources effect
  - loose constraints or NNR-minimal constraints give differs results

Source positions variations 2145+067



α



δ

18

Radio source proper motion solutions

Source	Nobs	Epoch	Position				Proper motion (mas/(10y))			
			R_0	SR_0	D_0	SD_0	R_1	SR_1	D_1	SD_1
0059+581	1370	2002.6	-.025	.001	-.022	.002	.009	.003	-.021	.003
0336-019	961	2002.8	-.020	.004	.007	.004	-.001	.007	-.022	.007
0458-020	834	2000.4	-.007	.003	-.004	.004	-.068	.007	-.023	.007
0528+134	1243	1998.1	-.008	.003	.012	.003	-.003	.006	.028	.006
0552+398	2102	1997.7	-.002	.001	.014	.001	-.005	.002	-.014	.002
0851+202	1669	1998.8	.003	.002	.010	.002	-.022	.003	.041	.003
0923+392	**1865**	**1997.1**	**.019**	**.002**	**.014**	**.002**	**.131**	**.003**	**-.041**	**.003**
1228+126	689	2002.8	.006	.005	.004	.006	-.006	.010	-.017	.011
1308+326	1087	1998.2	.022	.003	.027	.003	.060	.006	.017	.008
1404+286	751	1998.3	.002	.003	.047	.005	.032	.005	.063	.009
1638+398	765	2000.4	.003	.002	.024	.003	-.018	.006	-.002	.007
1739+522	1323	1999.8	.006	.002	-.004	.002	-.015	.003	.011	.004
1741-038	1597	2000.9	.009	.002	-.003	.002	-.015	.003	.013	.004
1807+698	718	2004.8	-.005	.005	-.010	.005	.016	.007	.000	.007
2037+511	1000	2004.9	-.002	.004	-.008	.005	-.006	.005	.039	.006
2121+053	504	1999.6	.007	.007	-.002	.005	.066	.012	-.027	.008
2145+067	1049	1997.9	-.009	.003	.013	.003	-.083	.007	.056	.006
2200+420	538	1992.4	.004	.003	.026	.005	-.065	.005	-.049	.011
2201+315	518	2000.7	.009	.005	.055	.007	-.011	.012	.018	.016
2223-052	714	2003.8	-.016	.004	-.028	.006	.038	.009	.047	.010

ICRF3 solution under way

- BIG session vs LSC
  - sharing method affect source position
  - inversion of BIG matrices
- Sources with only one-base observations
- Cable-calibration issues for several stations
- Sources for NNR-constraints
- Low geometry sessions
- Low observations sources