Combined analysis of free and forced nutations from VLBI group delays

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Nutation estimation from VLBI

- VLBI measures antenna voltage and time
- Voltage data are correlated and Fourier transformed
- Correlation function spectrum is used to compute group delays
- **Group delays are used for estimation of daily nutation offset time series**
- **Nutation time series is used for deriving nutation spectrum**
- **Nutation spectrum is used for evaluation of BEPs**

Do we need last three separate steps?

Deficiencies of the traditional approach

- Correlations between parameters are neglected

  Consequences:

  – Estimates are not optimal
  – Uncertainties are biased

- Change in nutation during experiment is neglected

- Forced nutations and free nutation are treated differently and inconsistently.

Alternative: direct approach

- . . .
- **Group delays are used for estimation of BEPs**

  . . .

  Group delays are used for estimation of Earth rotation spectrum

  . . .

  Group delays are used for estimation of the resonant curve

Spectrum estimation: details

- Estimation of complex spectrum for polar motion $(E_1 + i\,E_2)$, and real valued axial rotation (E_3)

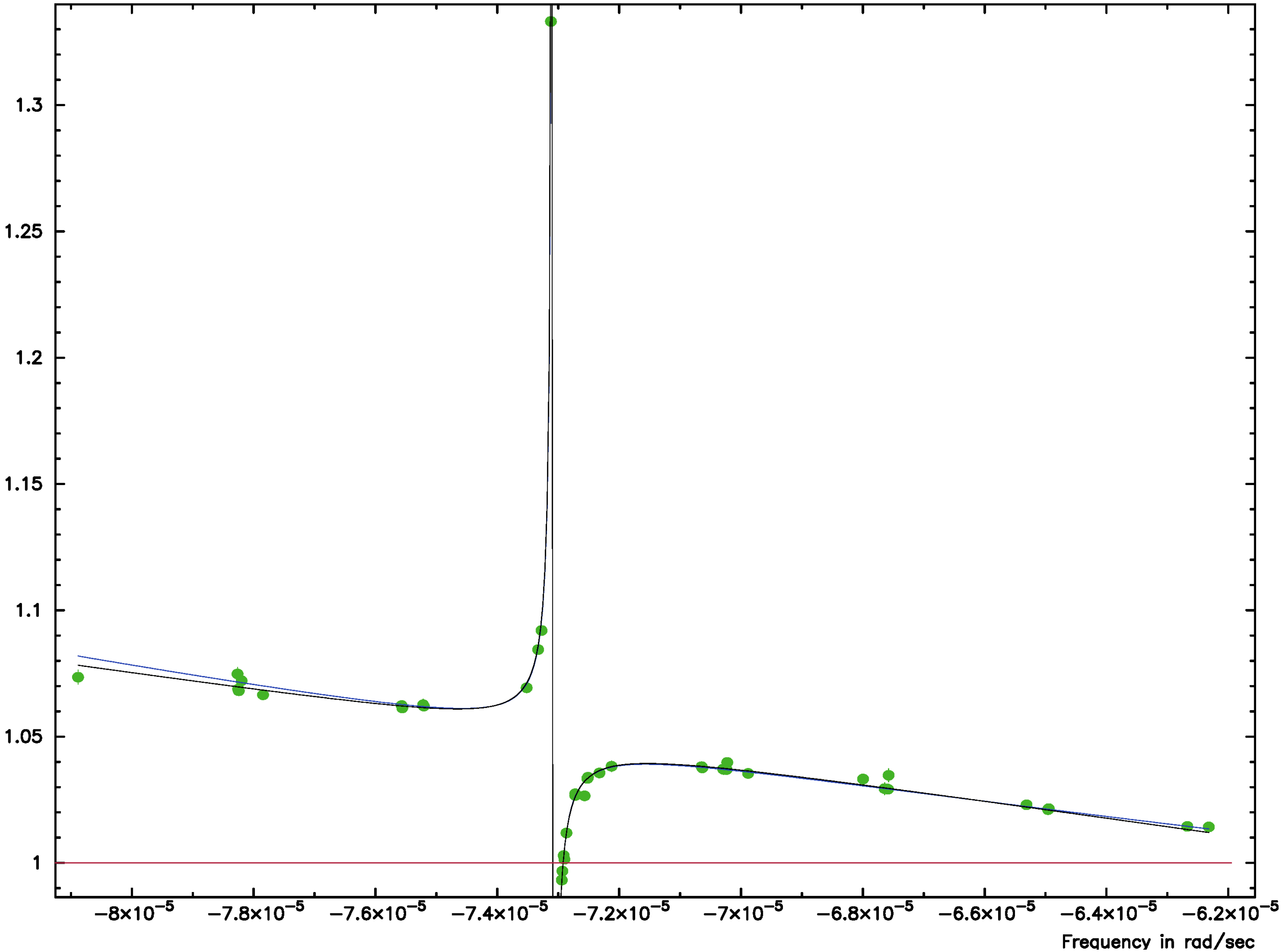
- Crafting the sequence of frequencies:
  - major forced nutations
  - tidal frequencies
  - dense sampling $(f = f_0 + i\; 1/T)$ within the FCN and PIFCN bands
  - ad hoc frequencies cusps around major tidal spectral lines, ter-diurnal signal around S_3–K_3, etc
  - adding constraints to unresolved spectral multiplets

- Estimation of limited EOP spectrum in a global solution. Nutations and high-frequency EOP are captured.

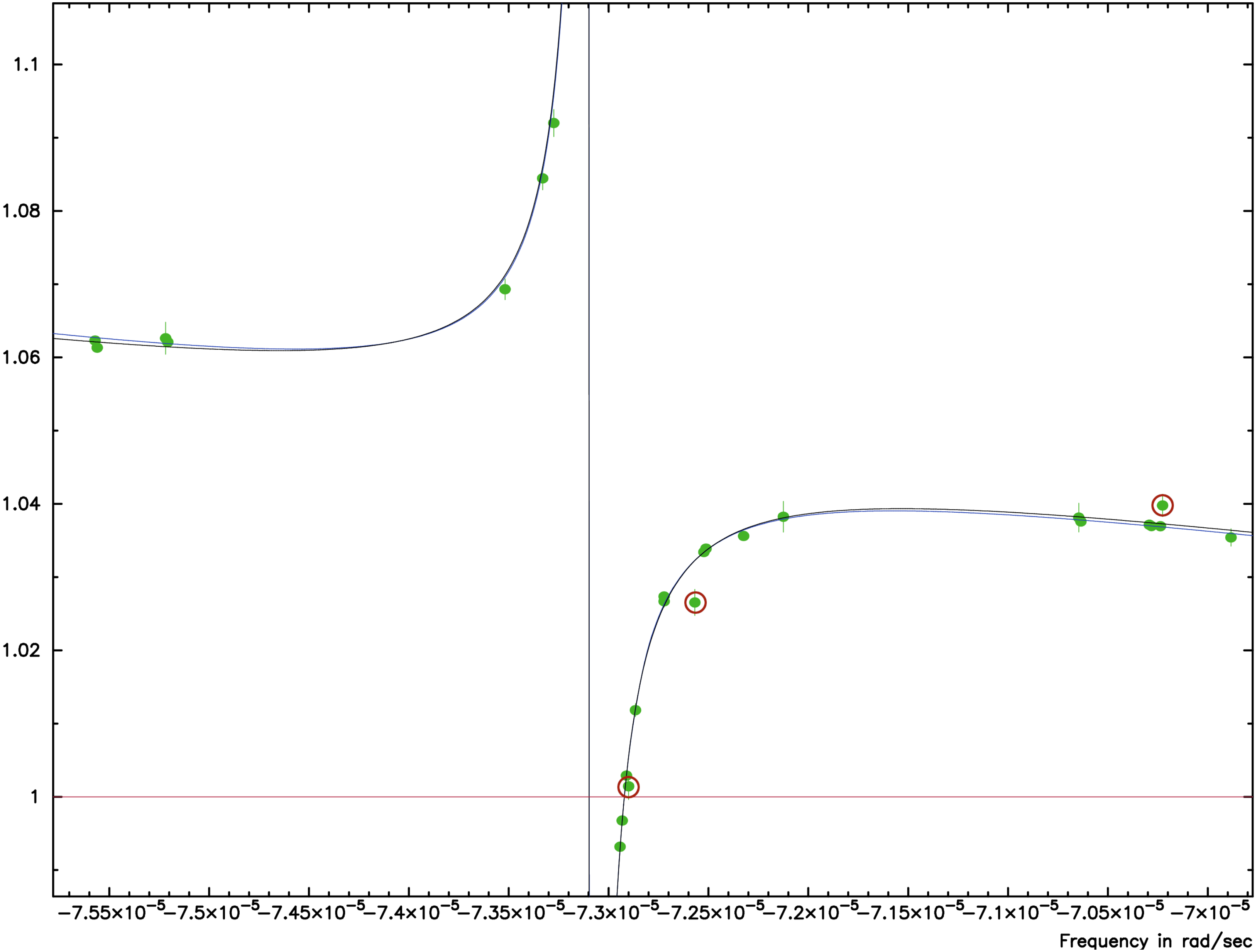
Spectral analysis

- Fitting the forced nutation spectrum
- Incorporation of OAM and AAM
- Fitting the forced nutation spectrum + the FCN

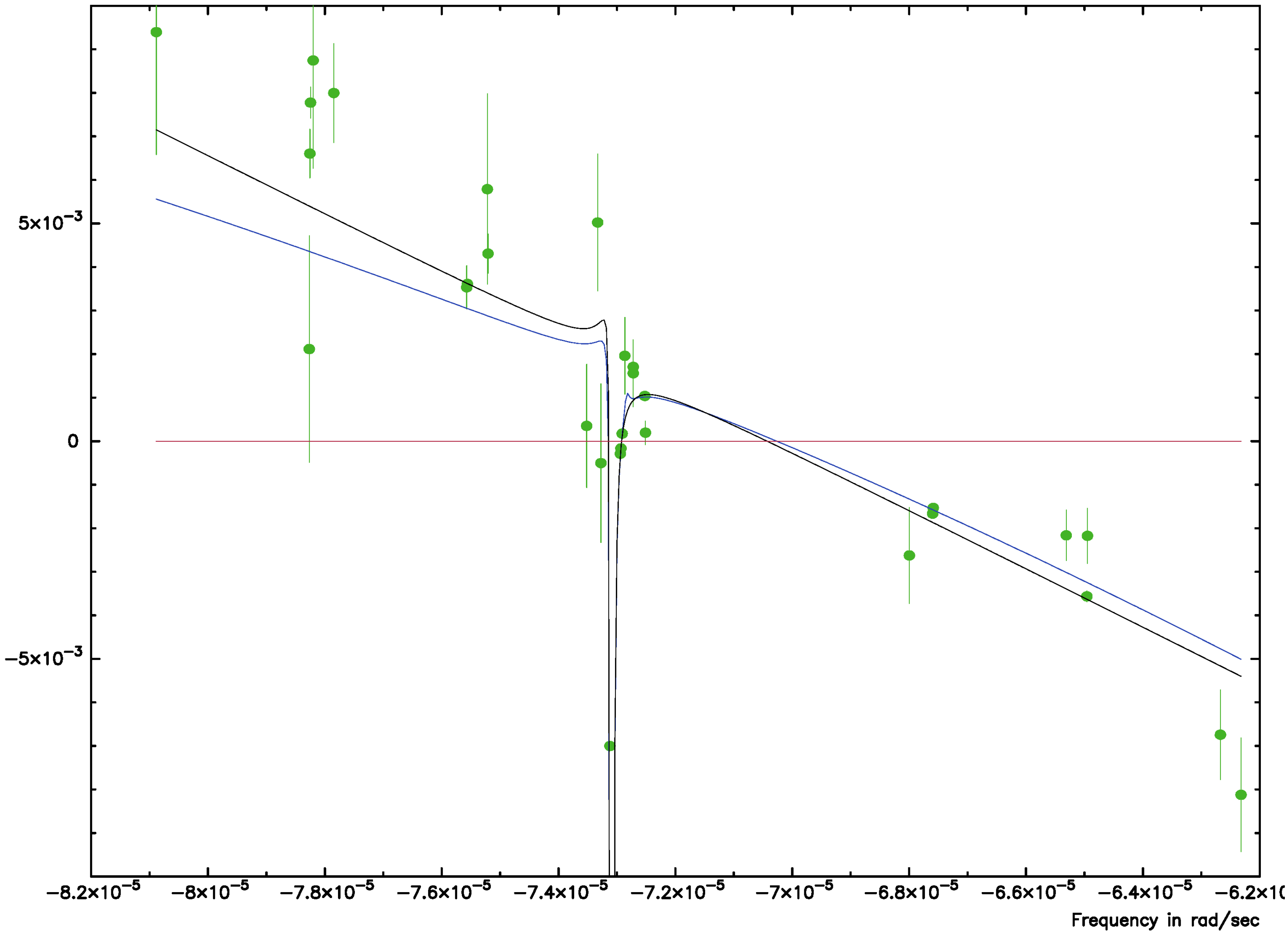
Empirical transfer function (Real part)



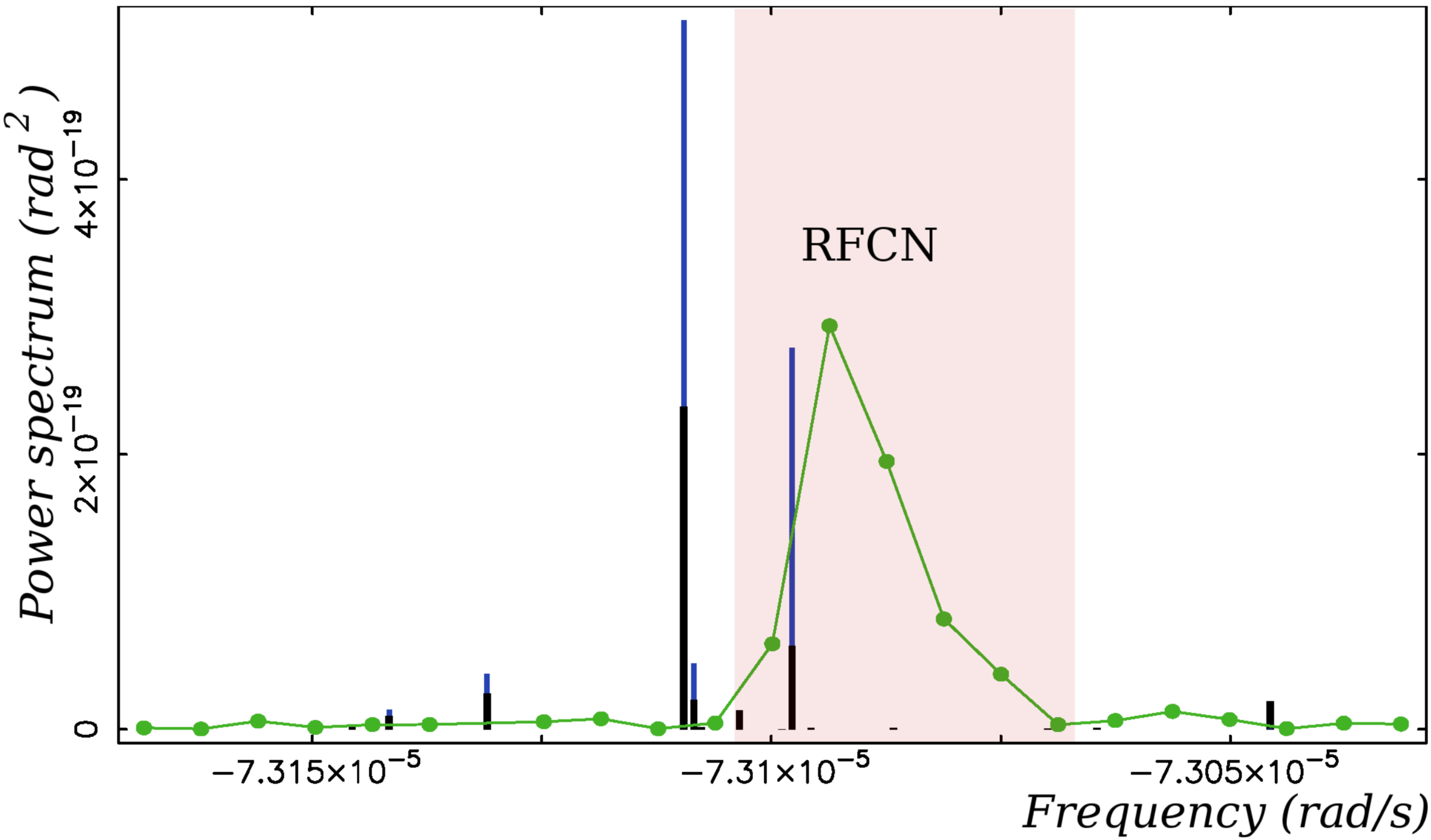
Empirical transfer function, real part (zoom)



Empirical transfer function (Imaginary part)



Free core nutation spectrum



Putting into play geophysical excitations

AAM:

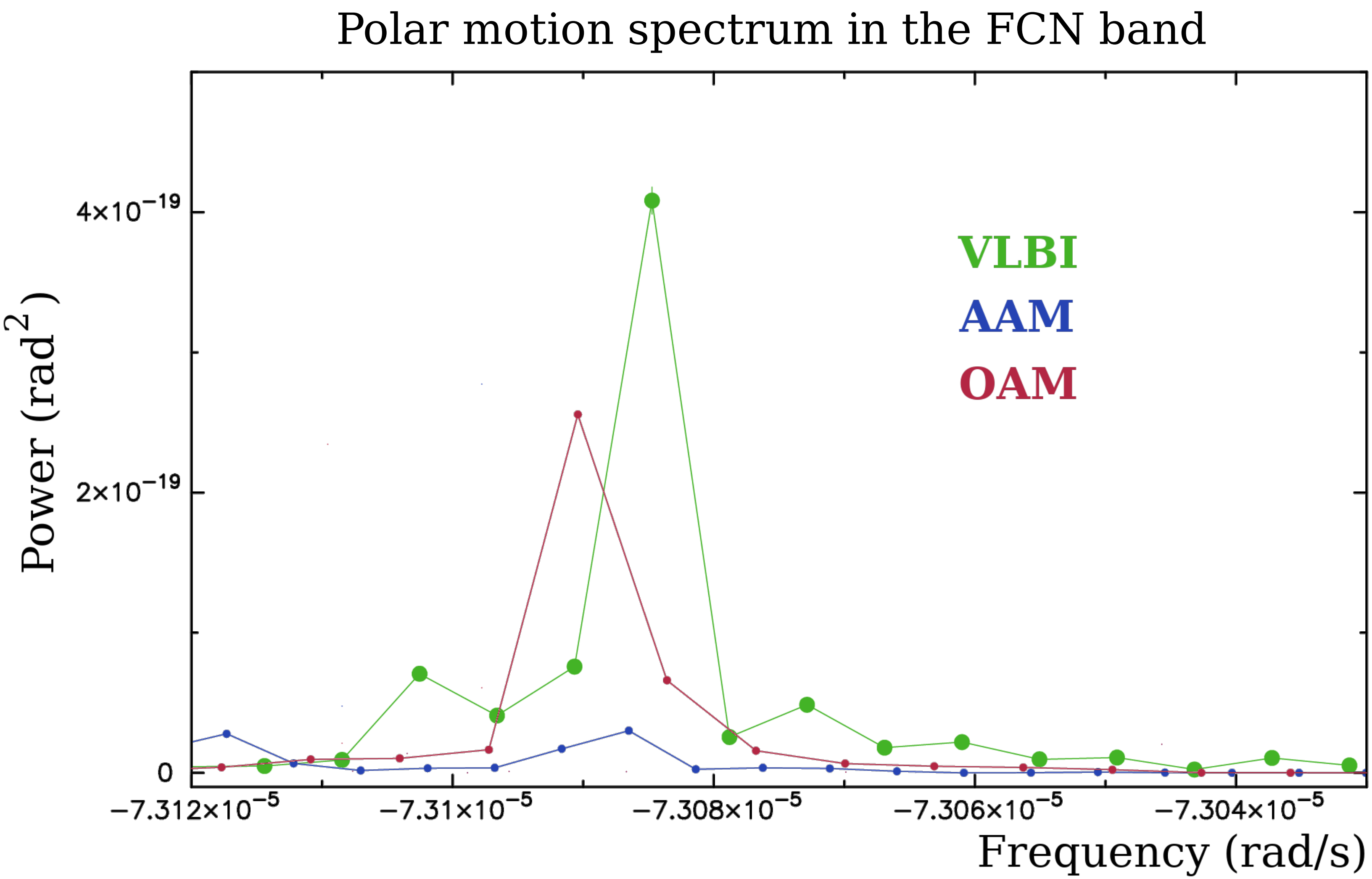
- Take NASA GEOS-FPIT model ($0.625^\circ \times 0.5^\circ \times 3^h \times 72$ layers)
- Extrapolate beneath the model surface layer
- Expand into B-spline basis
- Re-grid to the regular $2' \times 2'$ grid
- Interpolate to the high-resolution surface
- Integrate AAM at the B-spline basis
- Compute the AAM spectrum

OAM:

- pressure term
- motion term (current)
- tidal and non-tidal contribution

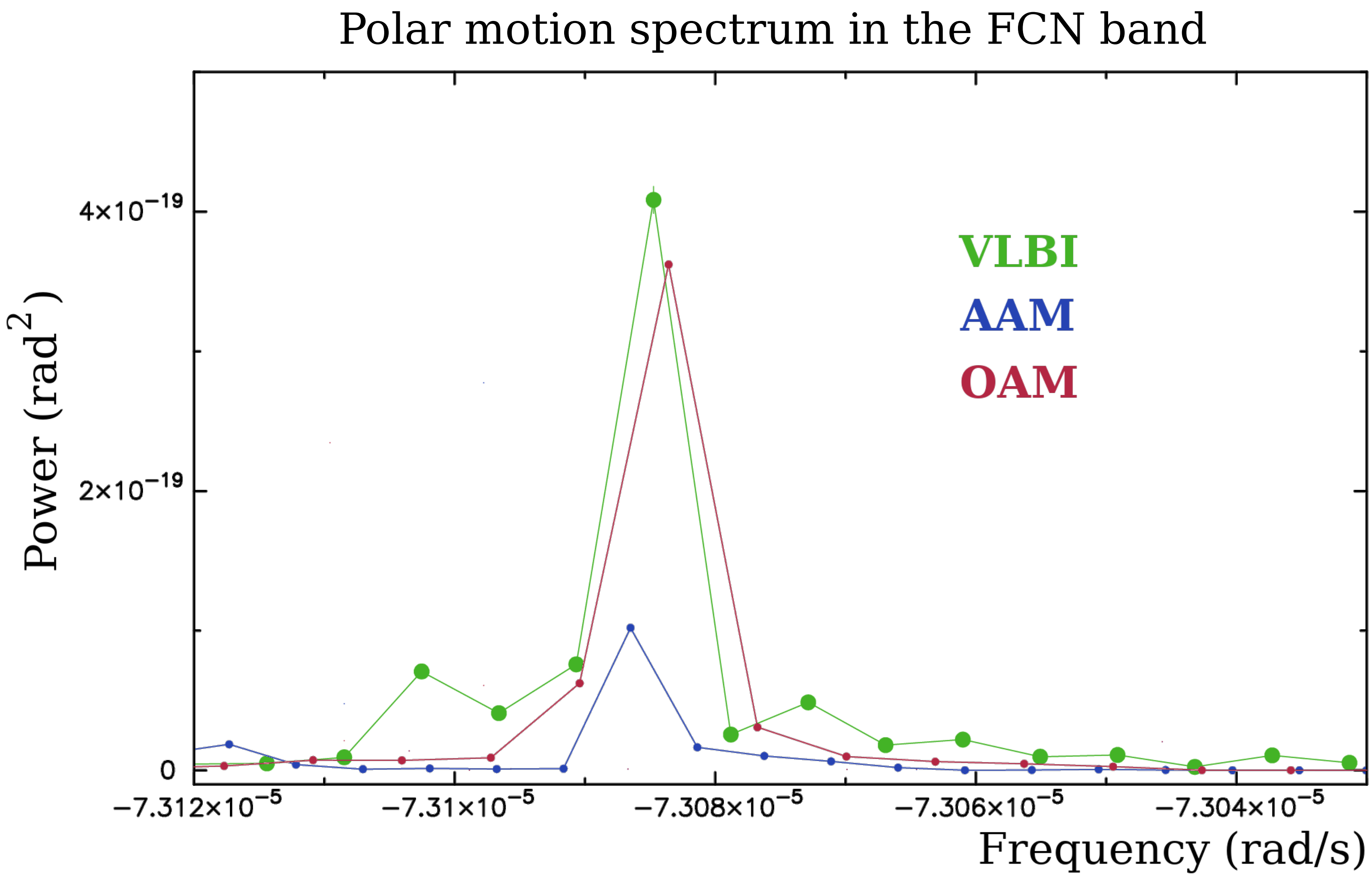
EOP, AAM, and OAM spectra

Resonant frequency is derived from forced nutations



EOP, AAM, and OAM spectra

Resonant frequency is derived from the free nutation



Summary:

- We can directly estimate of the EOP spectra from group delays
- Effect of the ocean tides still needs improvement
- We may close the FCN excitation budget by accounting for ocean and atmospheric excitation