ON THE ESTIMATION OF A CELESTIAL REFERENCE FRAME IN THE PRESENCE OF SOURCE STRUCTURE

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GEODESY MEETS ASTRONOMY

We know that,

- quasars are NOT ideal sources

  and that

- quasars change with time

Source structure can corrupt our geodetic/astrometric VLBI measurements!

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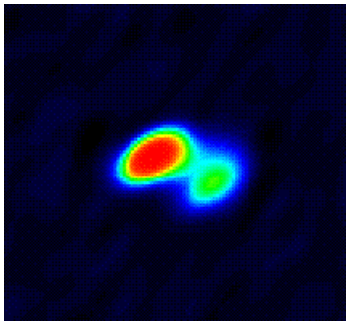
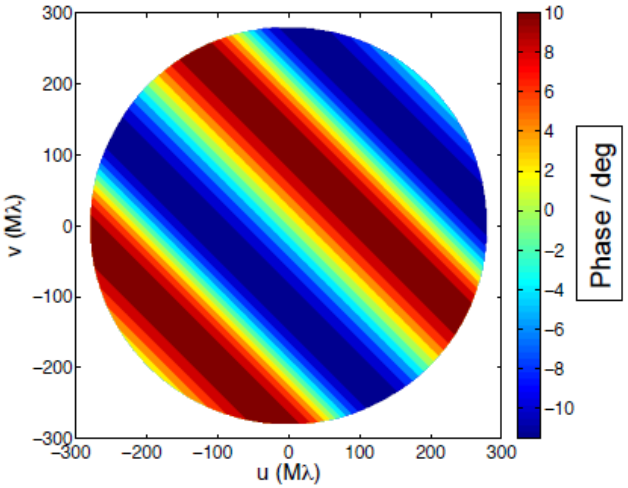
SOURCE STRUCTURE IN GEODESY

Additional Phase in dependence of the

- frequency,
- length &
- orientation of the baseline





- Effect is different at each of the 8 sub-bands at X-band, resp. different at S-band

group delay (= slope across band) changes due to structure

SOURCE STRUCTURE SIMULATIONS

- VieVS structure simulator (Shabala et al. JoG 2015)
  - Calculate delay due to source structure based on multi-component source models.
  - Apply in analysis and/or use it in simulations.

THOROUGH INVESTIGATION

Plank et al. MNRAS 2015 (soon)

- Mock two-component sources
- Apply to one year of R1/R4 schedules
  - Identical model for all sources, random jet directions

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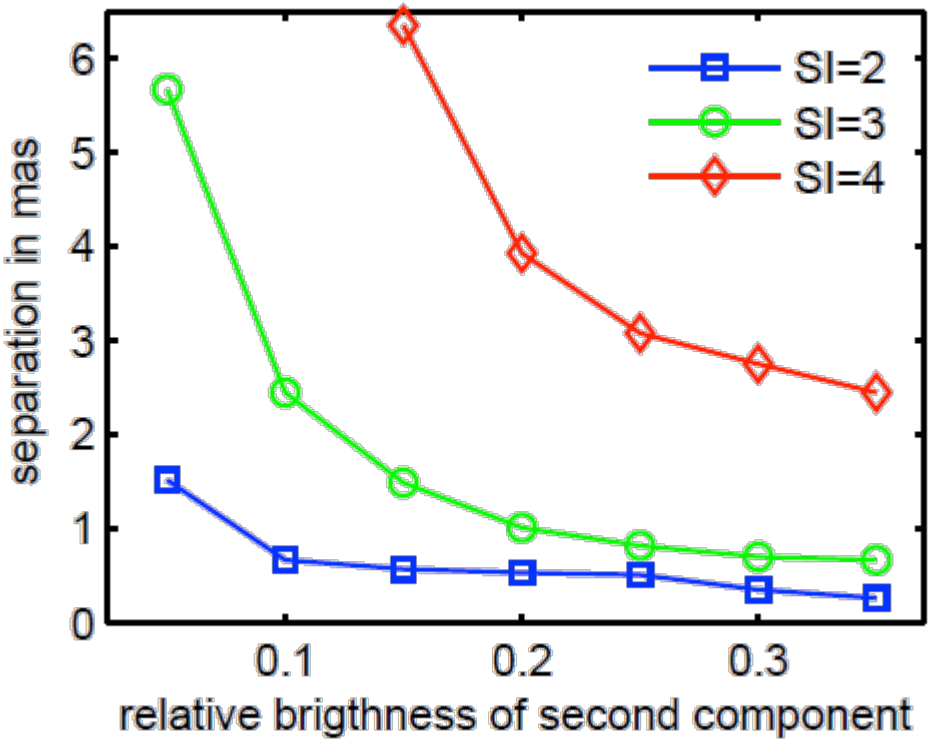
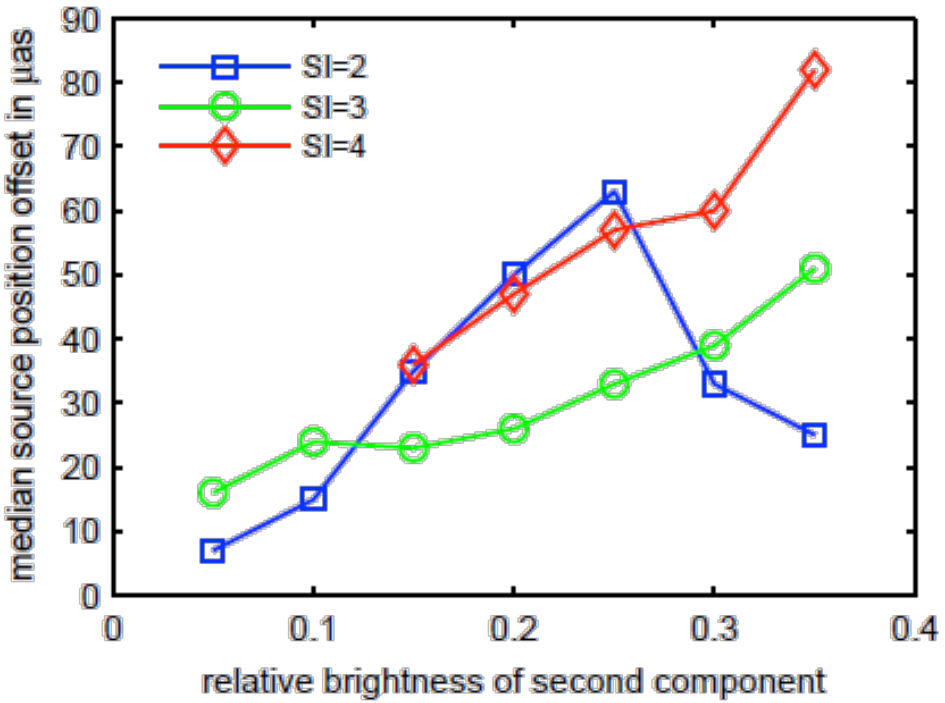
- Apply to one year of R1/R4 schedules
  - Identical model for all sources, random jet directions
- Structure-only
- structure+troposphere+noise
  (VGOS Simulations)
- Globally estimated source positions
  (loose constraints)

DIFFERENT STRUCTURE MODELS



- Apply models of various structure indices (SI=2,3,4).

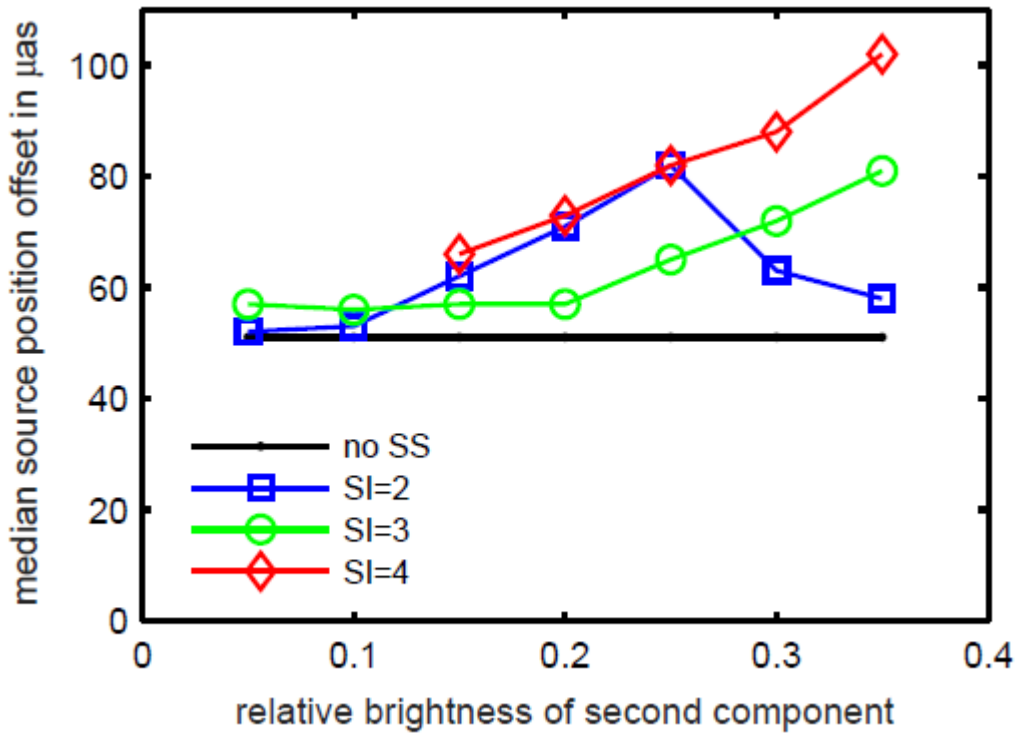
MEDIAN SOURCE DISPLACEMENT



Simulated median source position offsets d due to source structure using various two-component source models with nominal structure indices SI=2, 3, and 4 and a relative brightness of the second component between 0.05 and 0.35 of the main component. These are structure-only simulations.

- Systematic displacements of several tens of µas

EXCEEDS THE TROPOSPHERE



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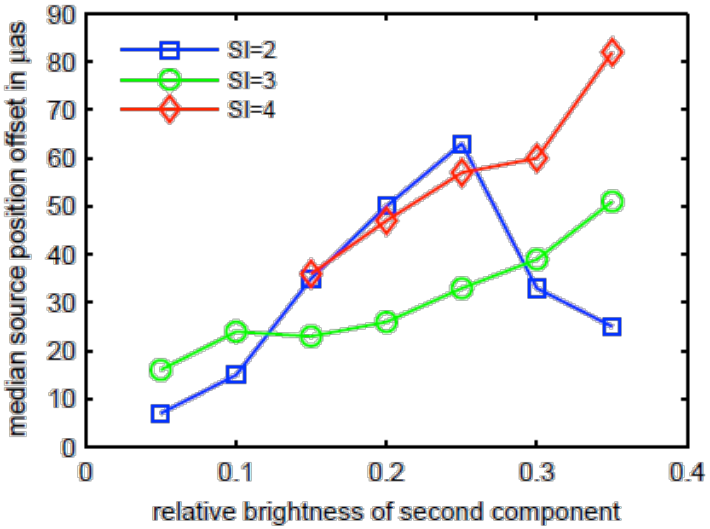

- SI=3, 4:

  Larger displacement for stronger secondary component close by.

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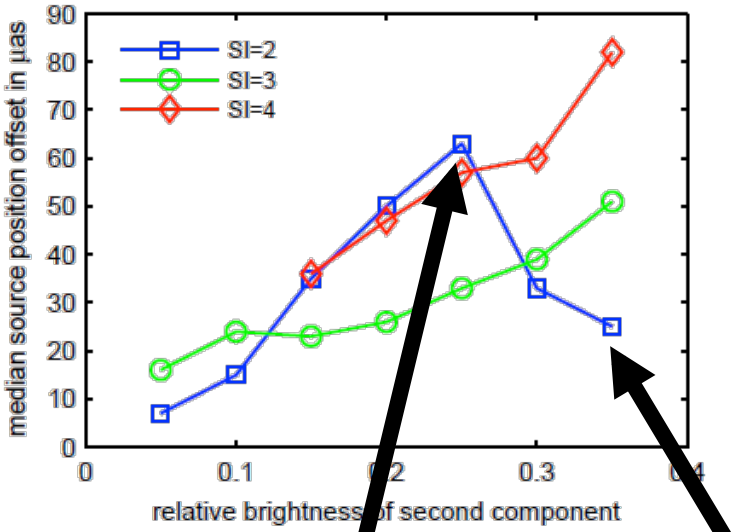
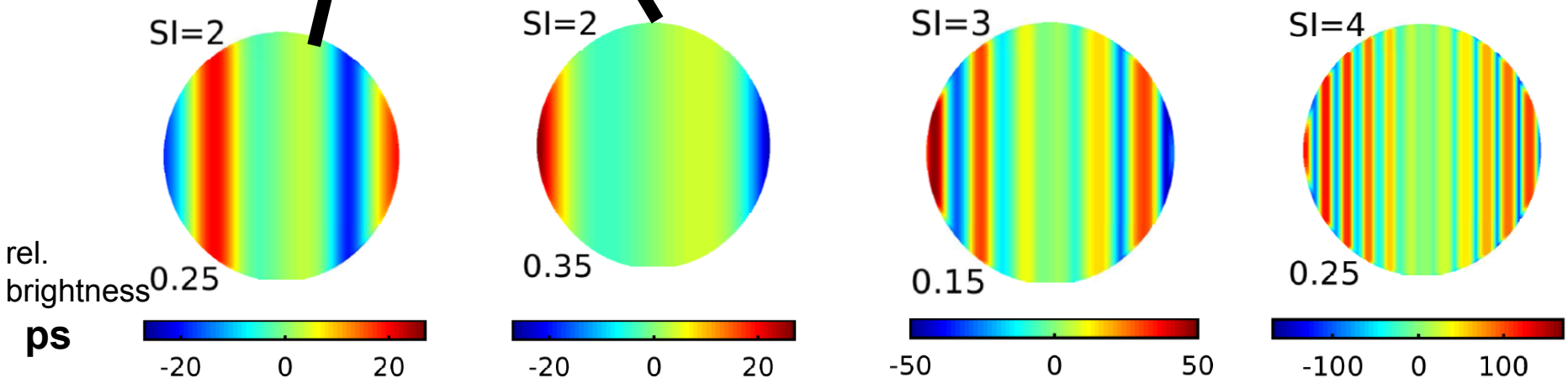


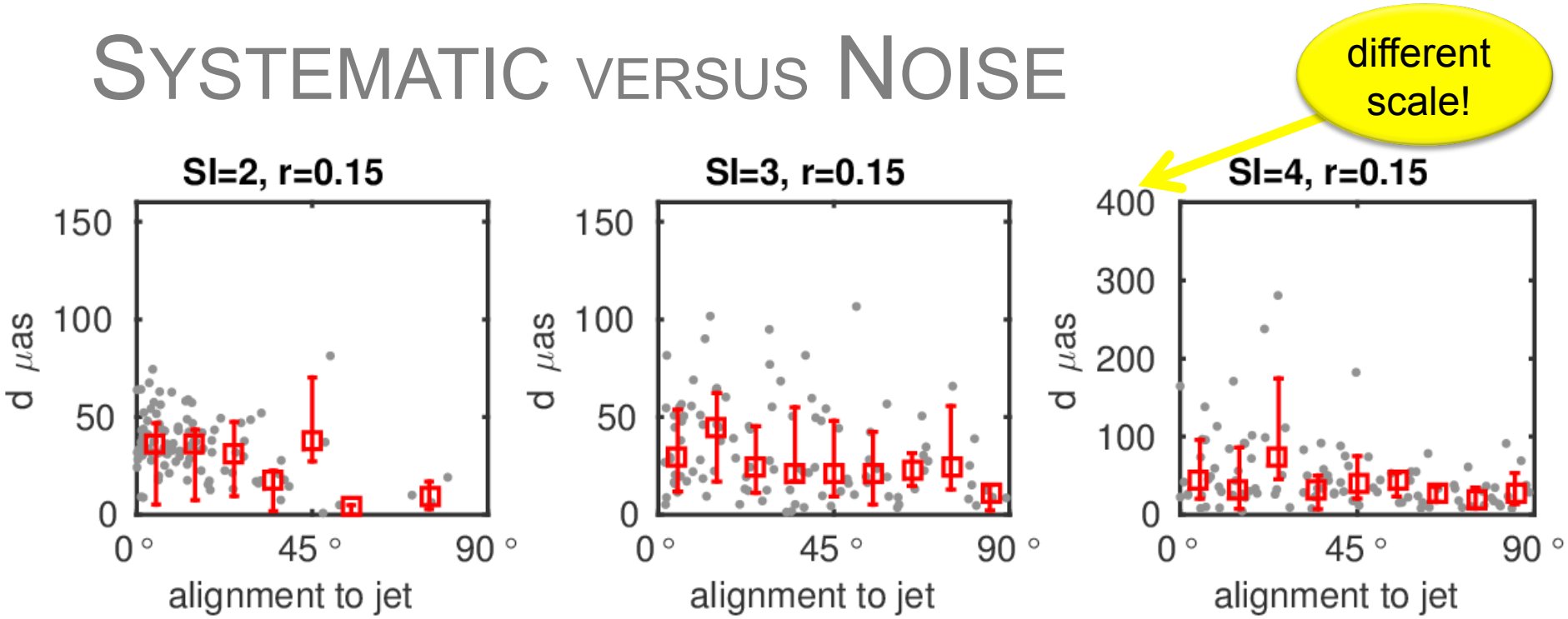
- SI=3, 4:

  Larger displacement for stronger secondary component close by.
- SI=2:

  smaller effect, but more systematic

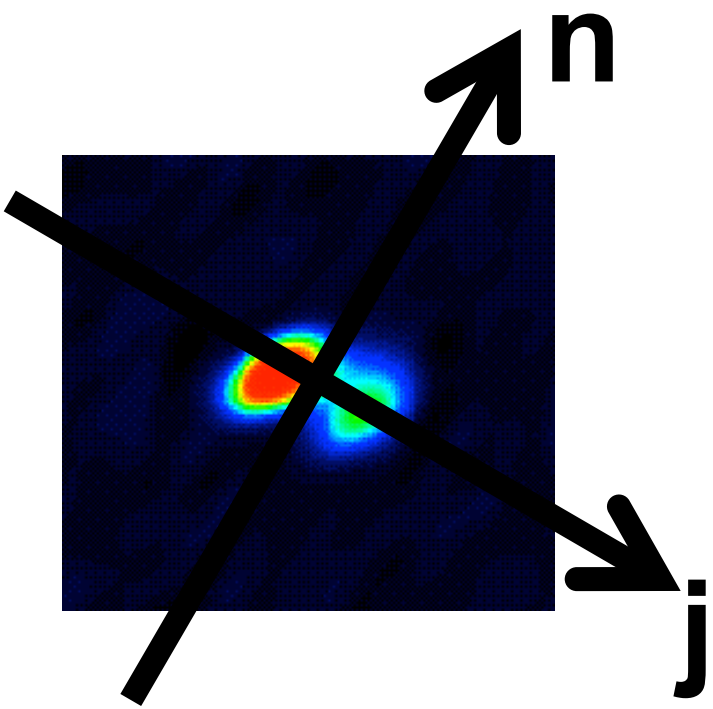


SYSTEMATIC VERSUS NOISE



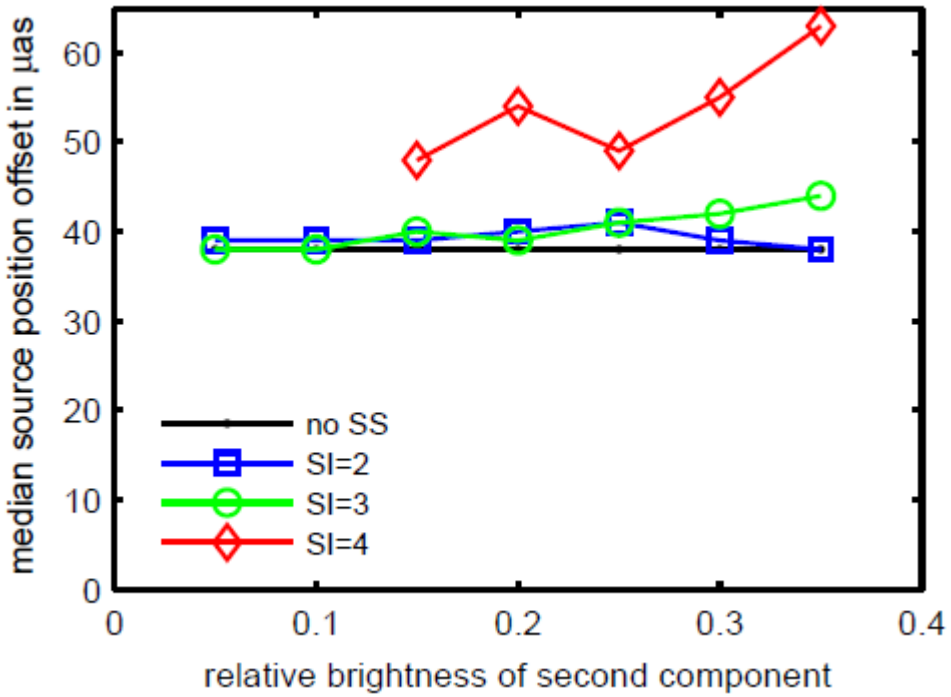
- Sources of lower structure indices (SI=2) tend to displace the sources along the jet direction
- The displacement for higher SI (3,4) are more noise-like

IDEA



- Parameterise the source position in components along the jet (j) / cross jet (n)
- Reduce the j-component session-wise and
- Estimate the n-component in a global solution of all sessions (1 year)

NEW METHOD



- For SI=2,3 the new j/n parameterisation reduces the median effect down to the level of tropospheric errors.

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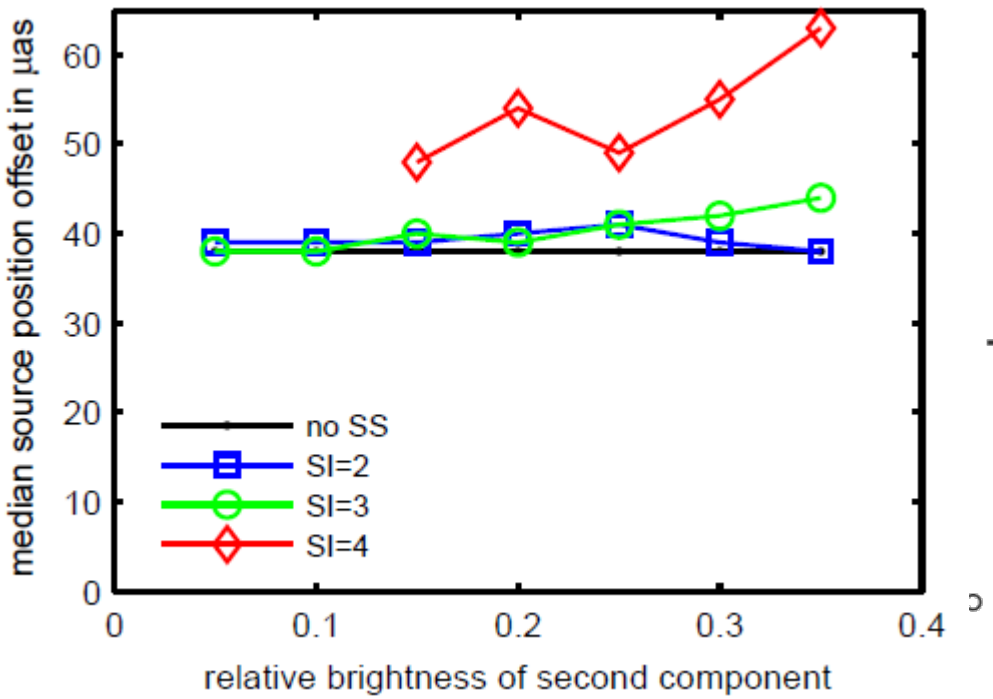

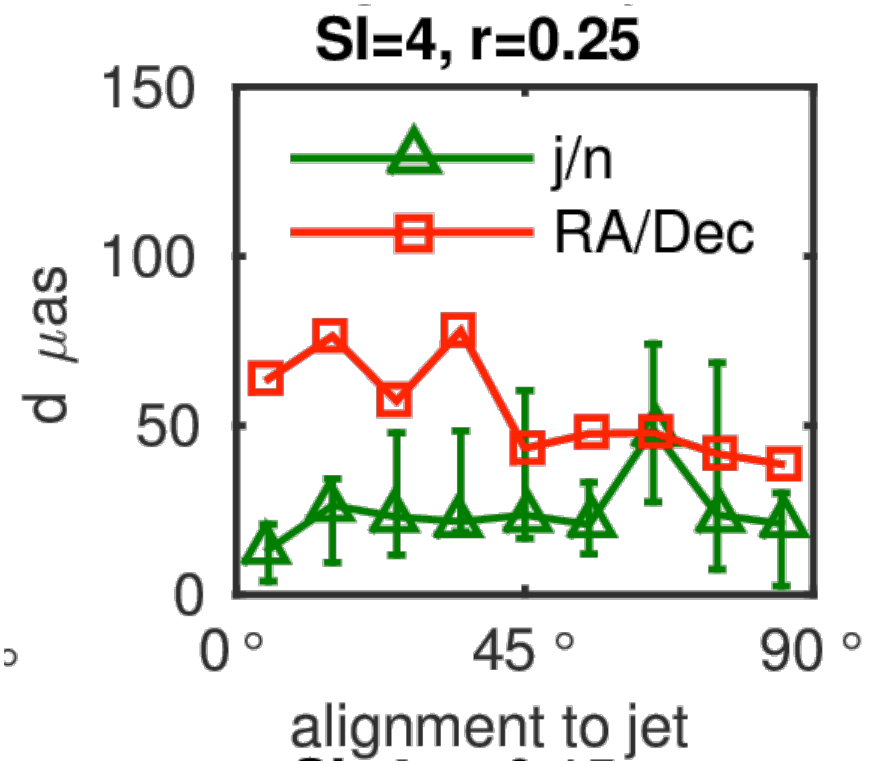

- For SI=2,3 the new j/n parameterisation reduces the median effect down to the level of tropospheric errors.
- However, it does not perfectly work for structure SI=4.

SUMMARY

- In VieVS, we can apply source structure corrections (based on real or mock source models) in VLBI analysis and simulations.
- Source structure can systematically displace source positions
  - Two component models, stable with time.
  - which is not necessarily connected to the nominal SI of the source.
- Sources of lower structure indices (SI=2) tend to move the source along the jet direction, while the displacement for higher SI (3,4) are more noise-like.
- A new modelling strategy (along jet and cross jet) could be a way to absorb this effect .

THANK YOU FOR YOUR ATTENTION!

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