

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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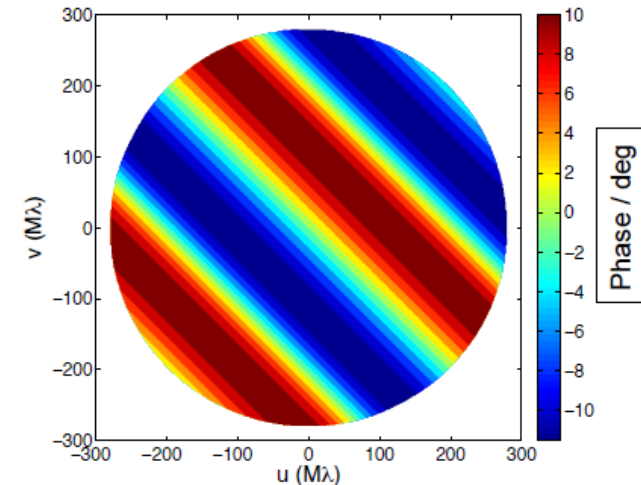
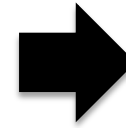
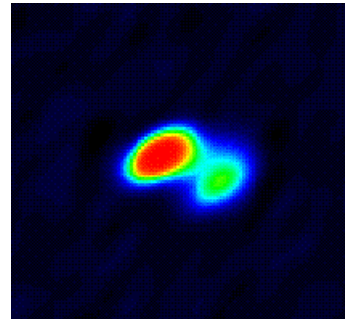
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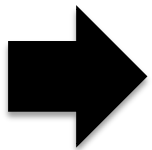
SOURCE STRUCTURE IN GEODESY

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)

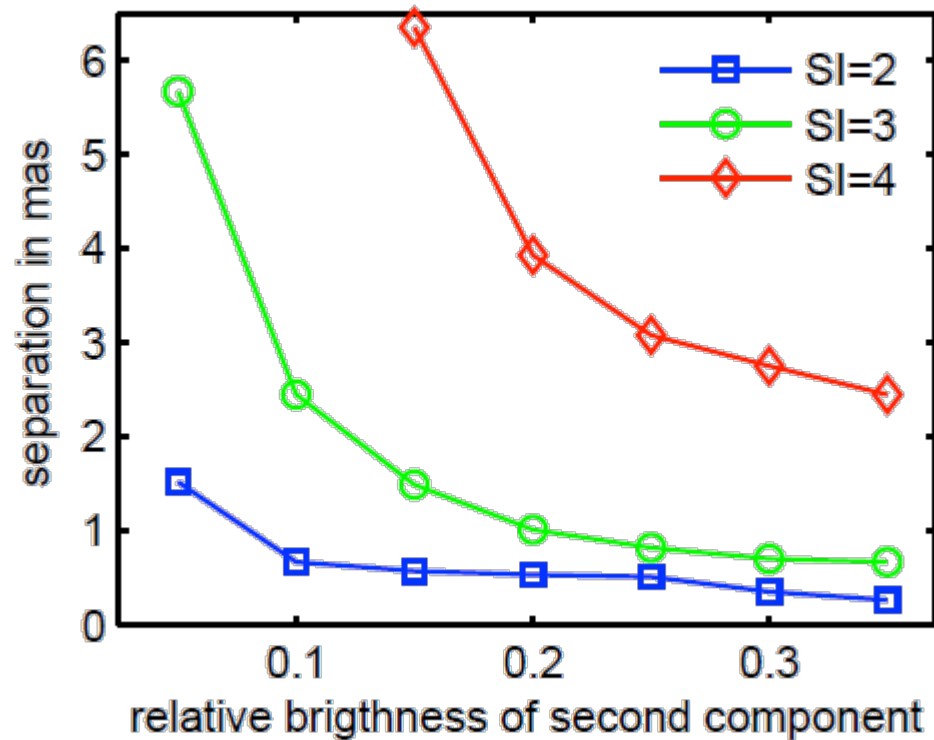
- Mock two-component sources
- Apply to one year of R1/R4 schedules
 - Identical model for all sources, random jet directions

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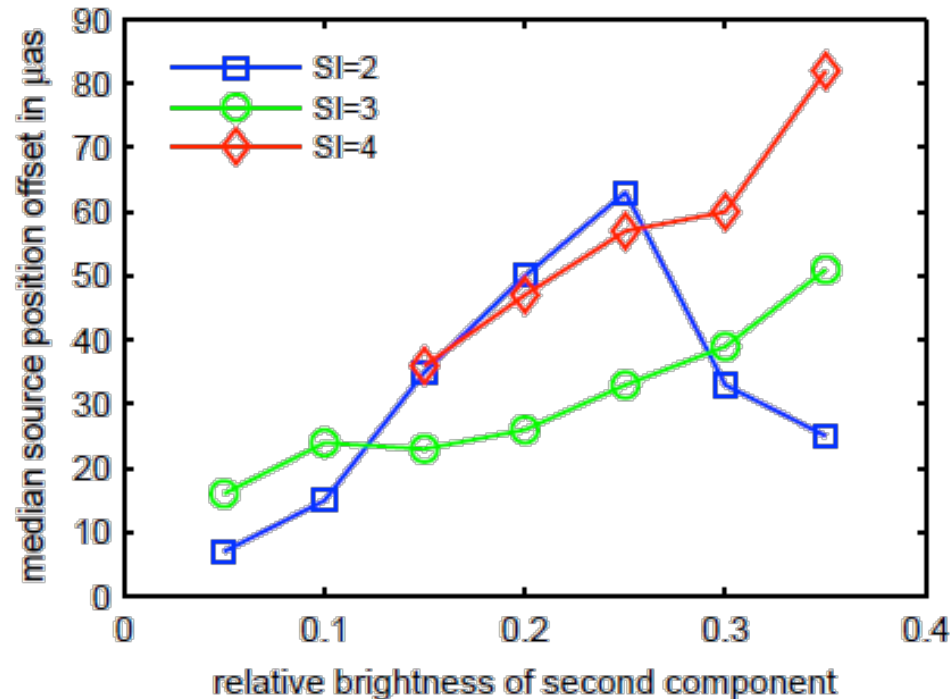
- Mock two-component sources
- Apply to one year of R1/R4 schedules
 - Identical model for all sources, random jet directions
- Structure-only
- structure+troposphere+noise
(VGOS Simulations)
- Globally estimated source positions
(loose constraints)

DIFFERENT STRUCTURE MODELS



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

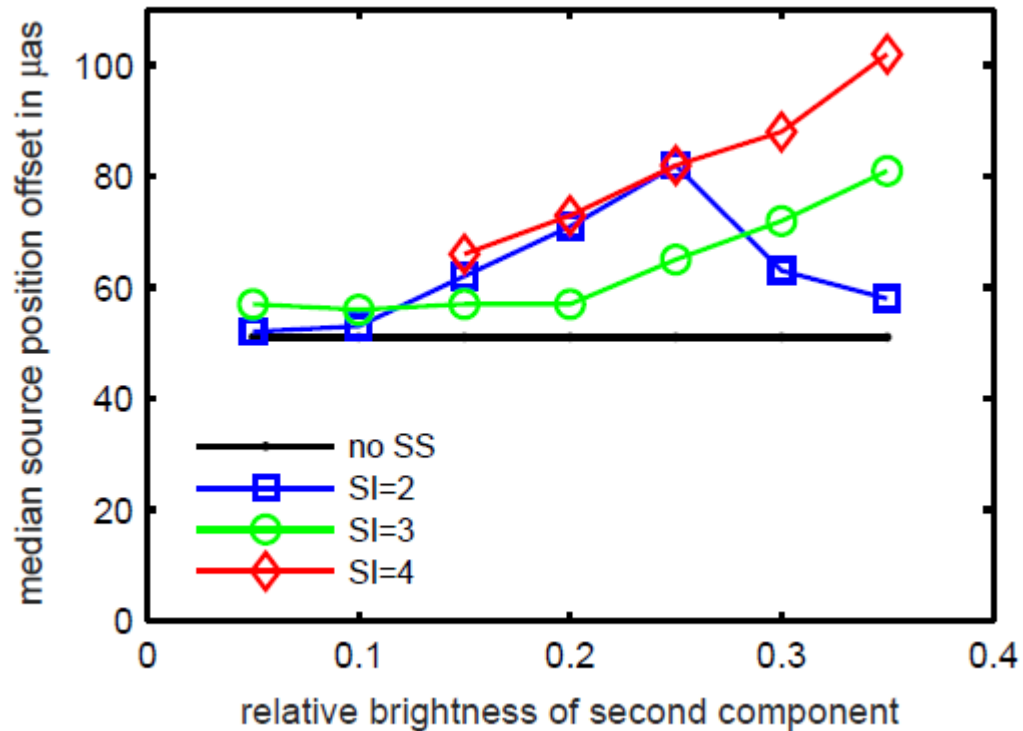
MEDIAN SOURCE DISPLACEMENT



- Systematic displacements of several tens of μas

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.

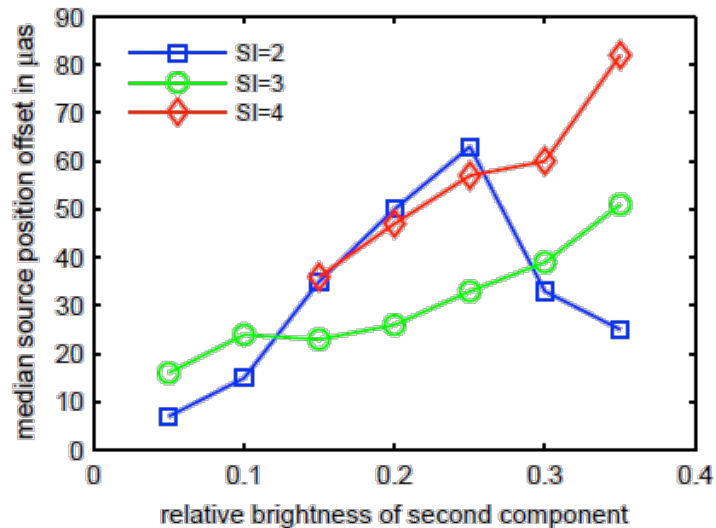
EXCEEDS THE TROPOSPHERE



Systematic displacements of several tens of μas .

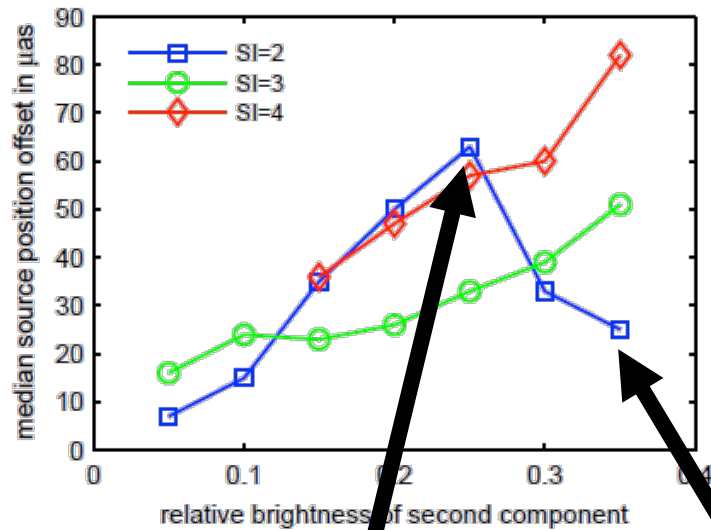
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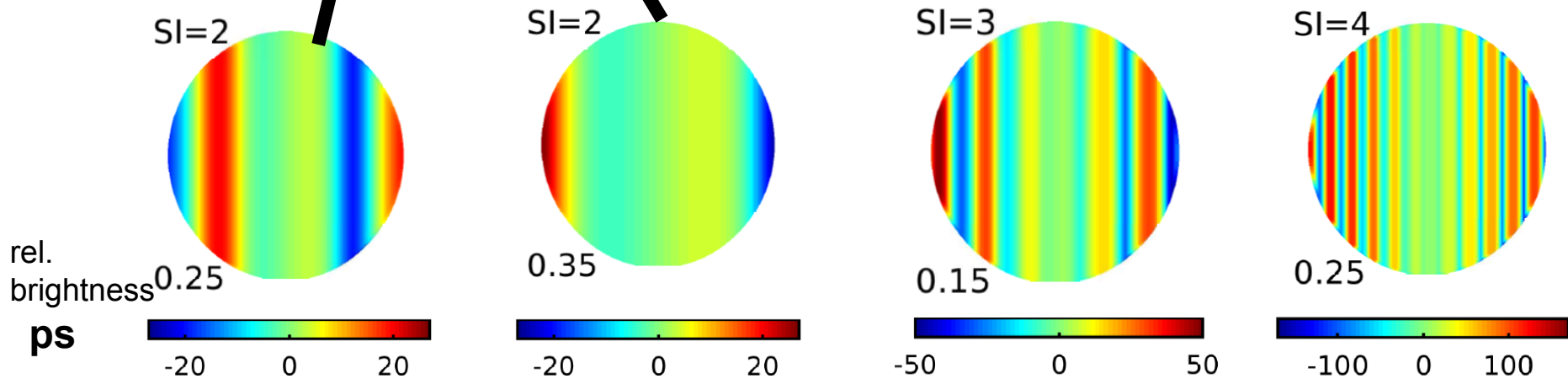


- SI=3, 4:
Larger displacement for stronger secondary component close by.

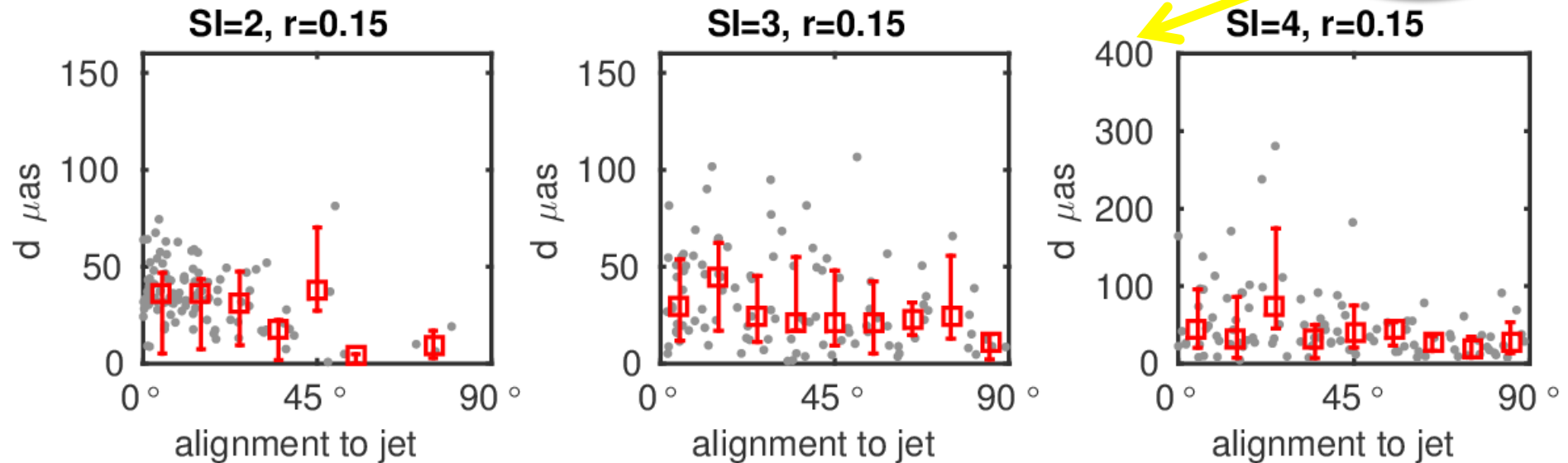
DIFFERENT STRUCTURE MODELS



- SI=3, 4:
Larger displacement for stronger secondary component close by.
- SI=2:
smaller effect, but more systematic



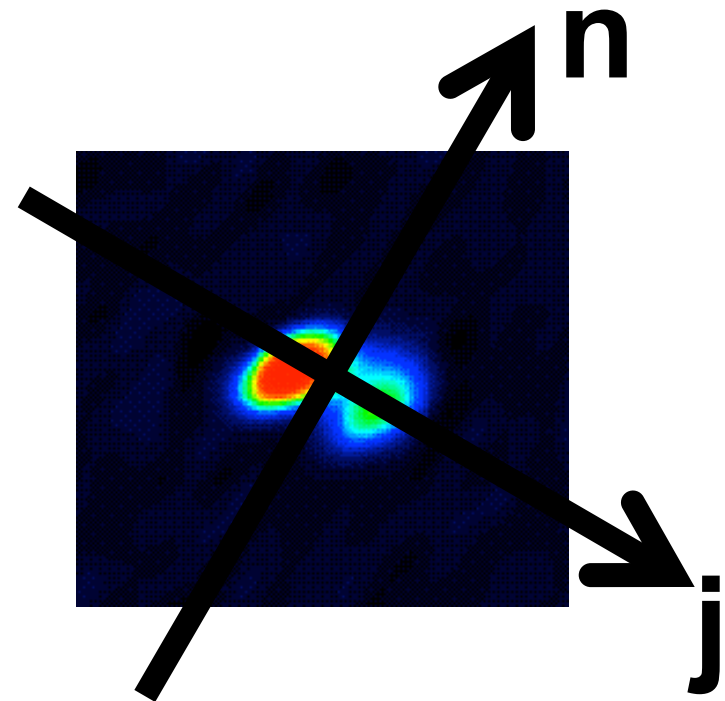
SYSTEMATIC VERSUS NOISE



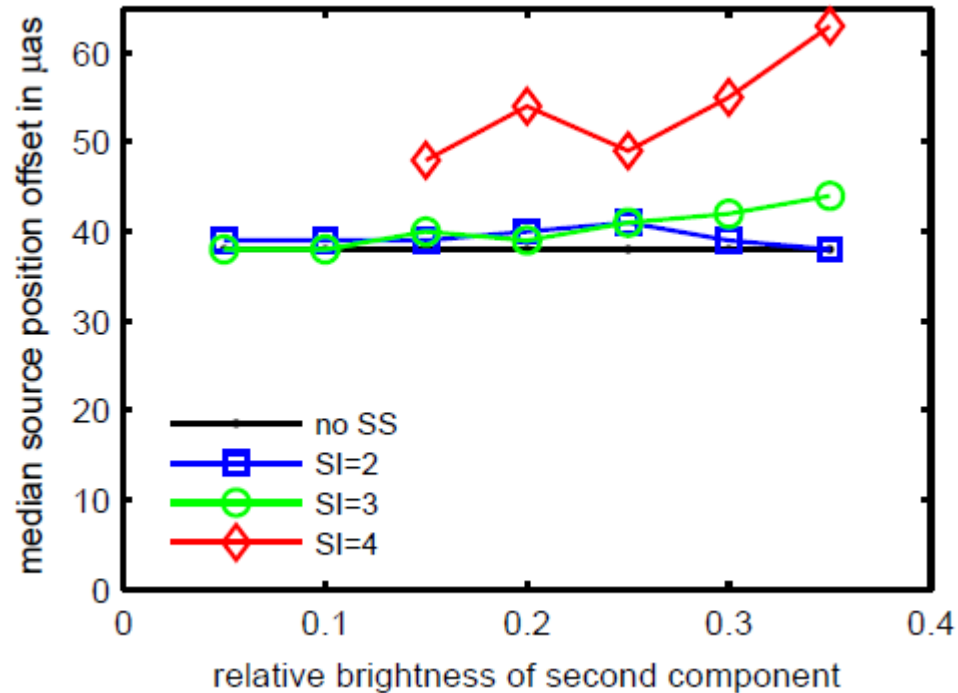
- Sources of lower structure indices (SI=2) tend to displace the sources along the jet direction
- The displacement for higher SI (3,4) are more noise-like

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)

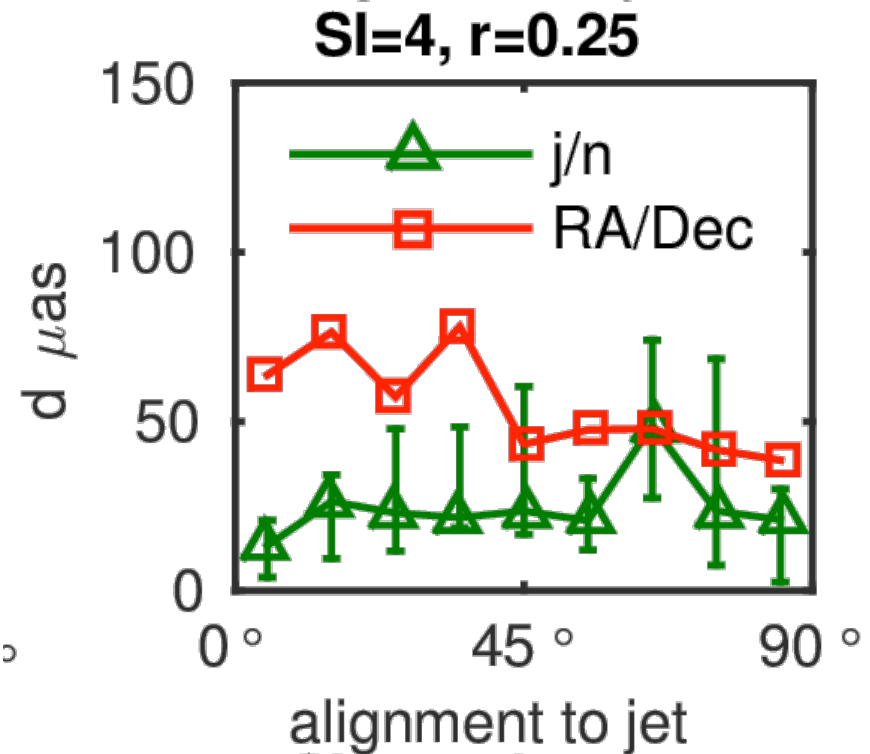
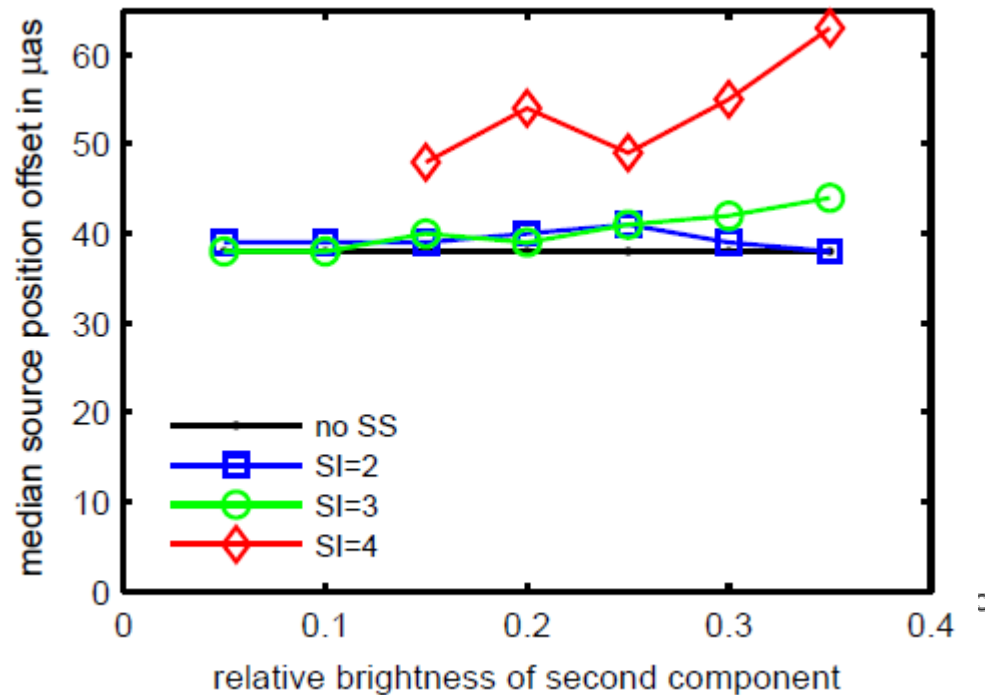


NEW METHOD



- 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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