TECHNISCHE UNIVERSITÄT WIEN
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Geodetic VLBI scheduling with VieSched++

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Geodetic VLBI scheduling

- 24-hour sessions (or 1-2-hour intensives) with fixed network
  https://ivscc.gsfc.nasa.gov/sessions/
- source list of ~330 sources suitable for geodesy
  extended version of ~700 sources

maximize number of observations, sky-coverage…

we typically observe 60-110 sources during the 24-hour session

every station has different observing time T

$$T_{1,2} = \left(\frac{SNR}{\eta F}\right)^2 \cdot \left(\frac{SEFD_1 \cdot SEFD_2}{rec}\right)$$

SNR = *target signal to noise ratio*
η = *efficiency factor*
F = *source flux density*
$SEFD$ = *station sensitivity*
rec = *recording rate*

Sky-coverage

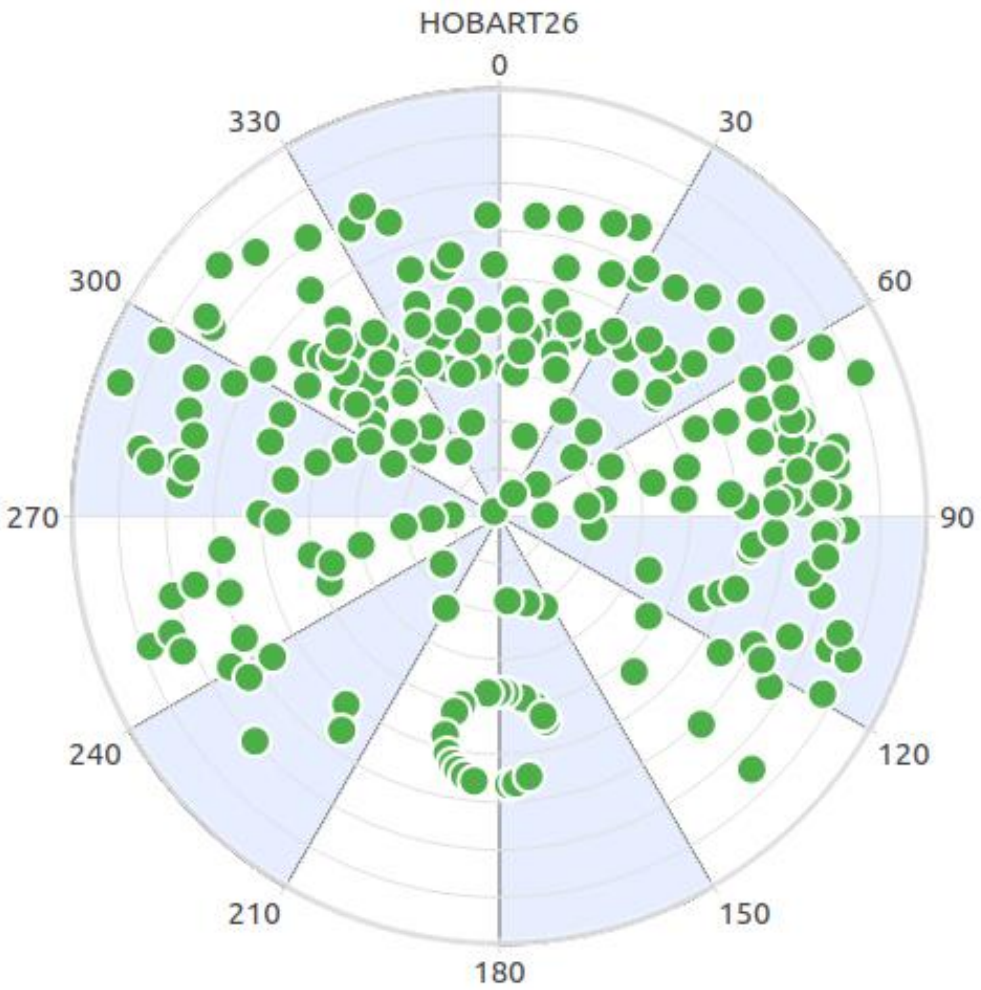
- troposphere is big error source
- distribute observations (az, el)

→ introduces slew time

Problematic!

- we also want high number of observations

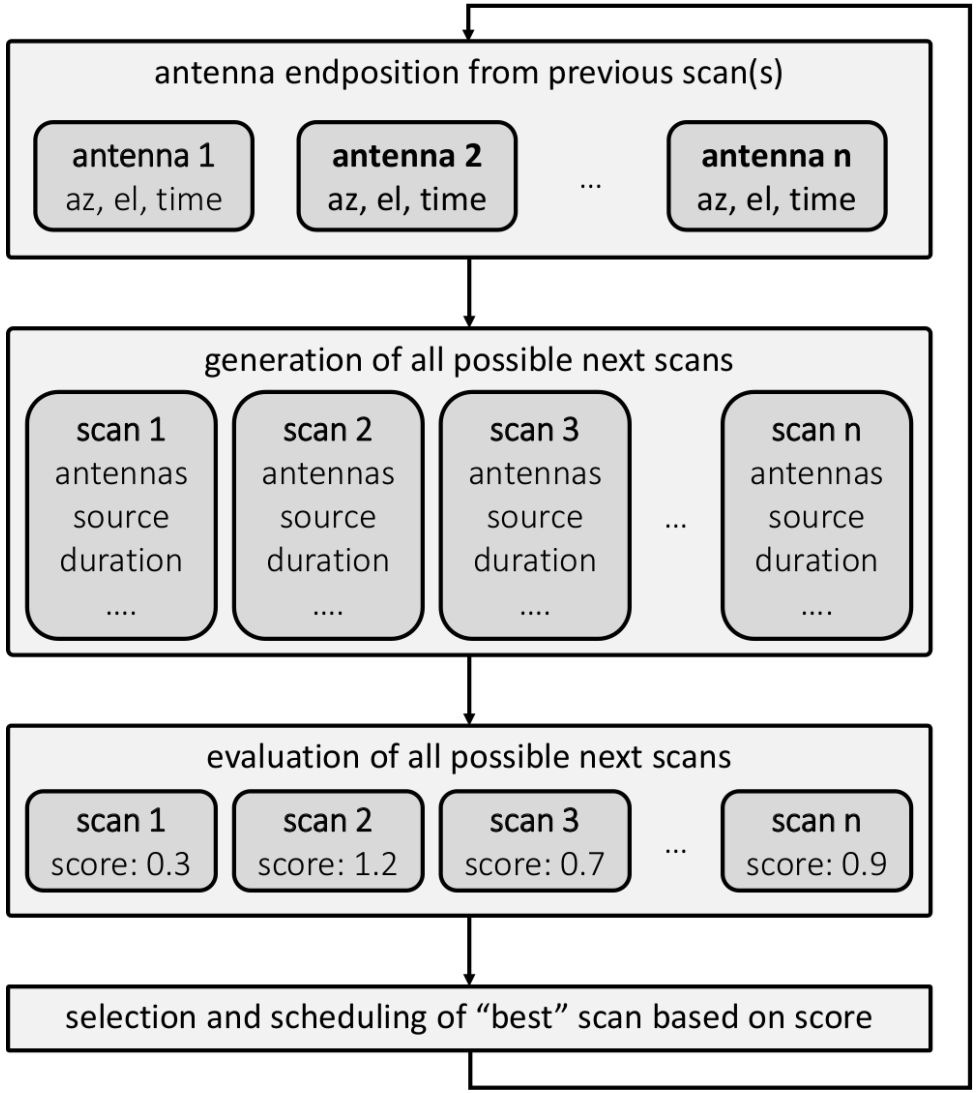
→ **compromise**



Geodetic VLBI scheduling

- brute-force approach:
  - schedule generated scan after scan
  - testing all possibilities
  - calculate scores per scan based on optimization conditions $score_i$
    - sky-coverage
    - scan duration
    - number of observations…
  - selection of "best" scan based on weighted sum of these scores
    → **"weight factors" ω_i**

$$score = \sum_i \omega_i \cdot score_i$$



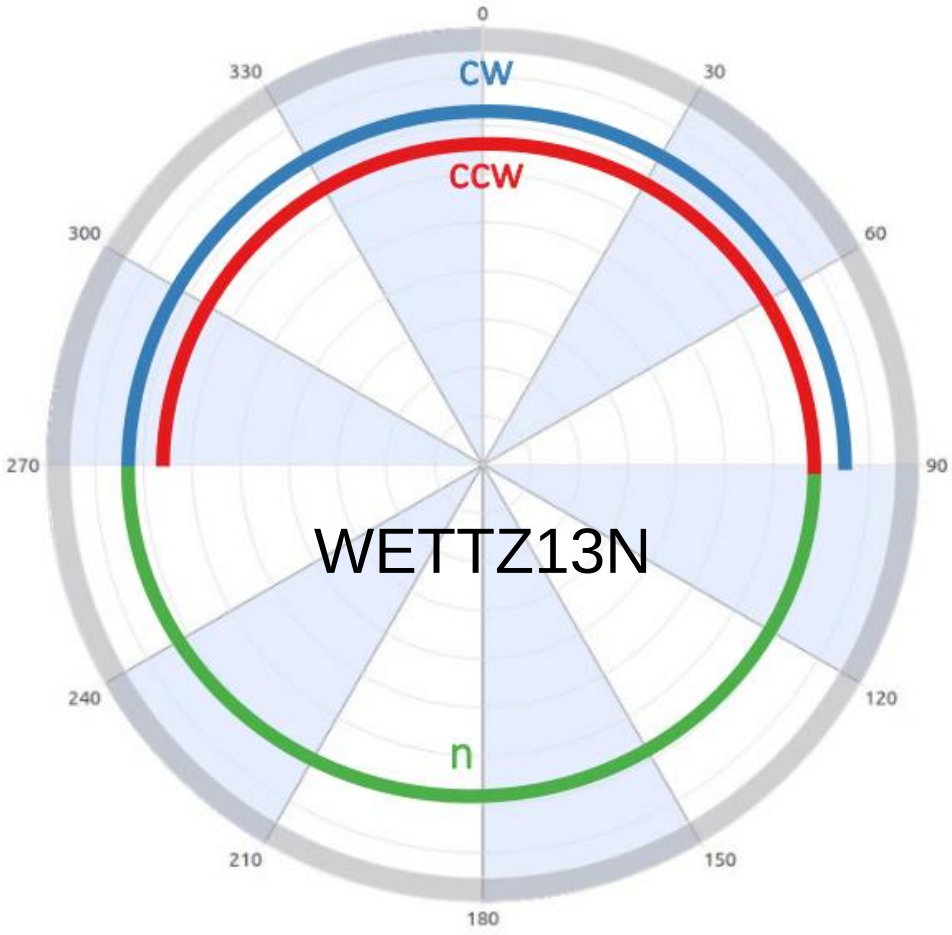
What do we need?

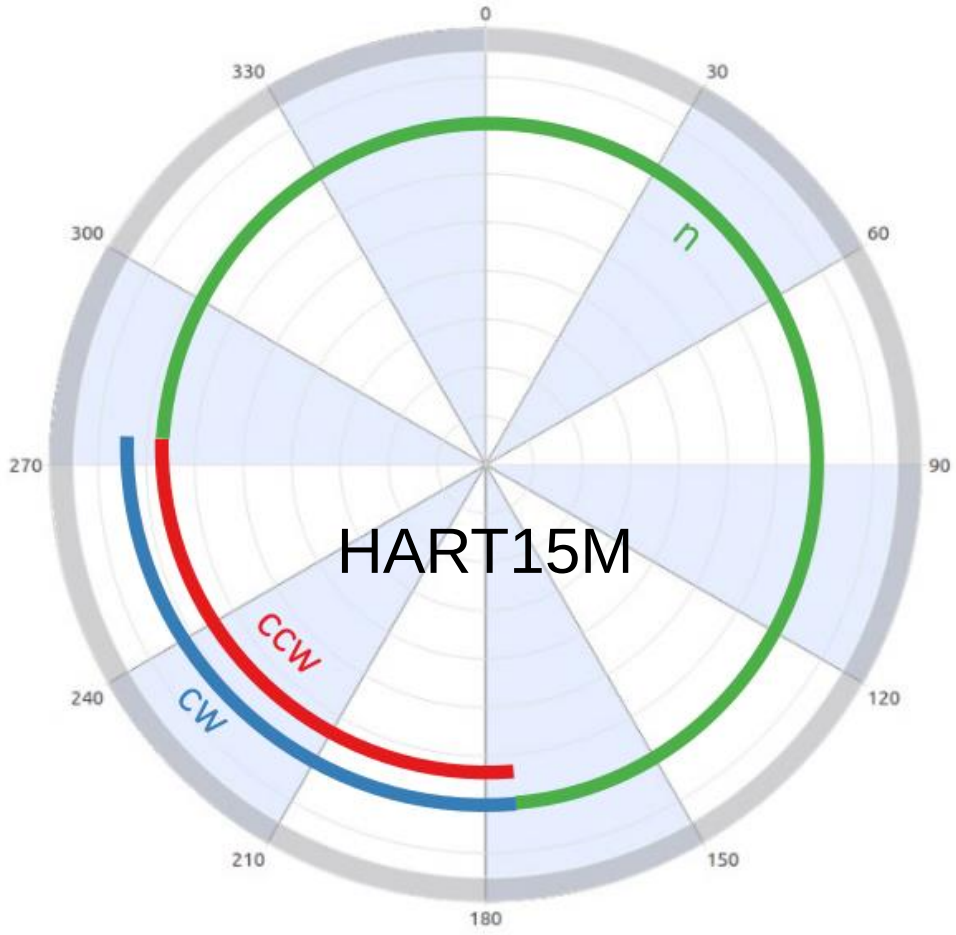
- a lot of models
  - stations
  - sources
  - observing-mode
- scheduling logic and algorithms
  - scan sequence
  - source selection
  - (sub)network selection…

Where do we get that from?

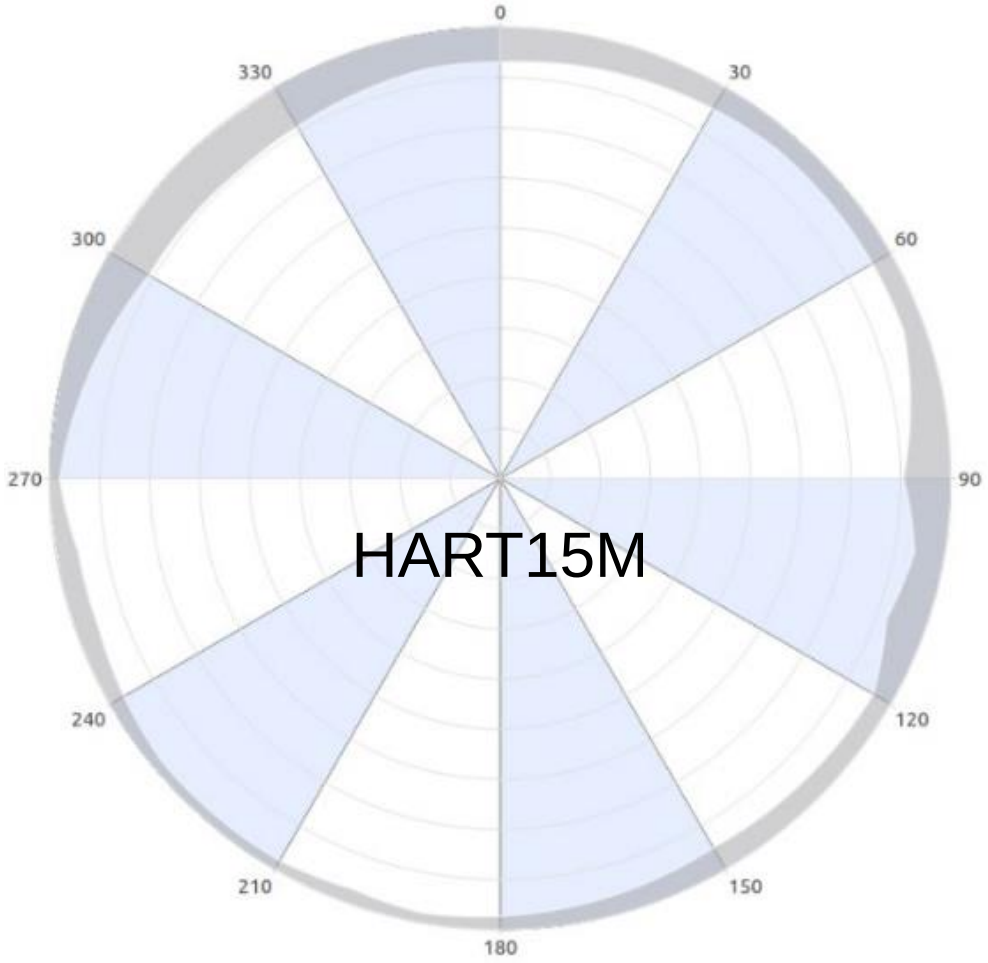
- sked catalogs
- scheduling software
  - sked
  - VieSched++
  - sched…

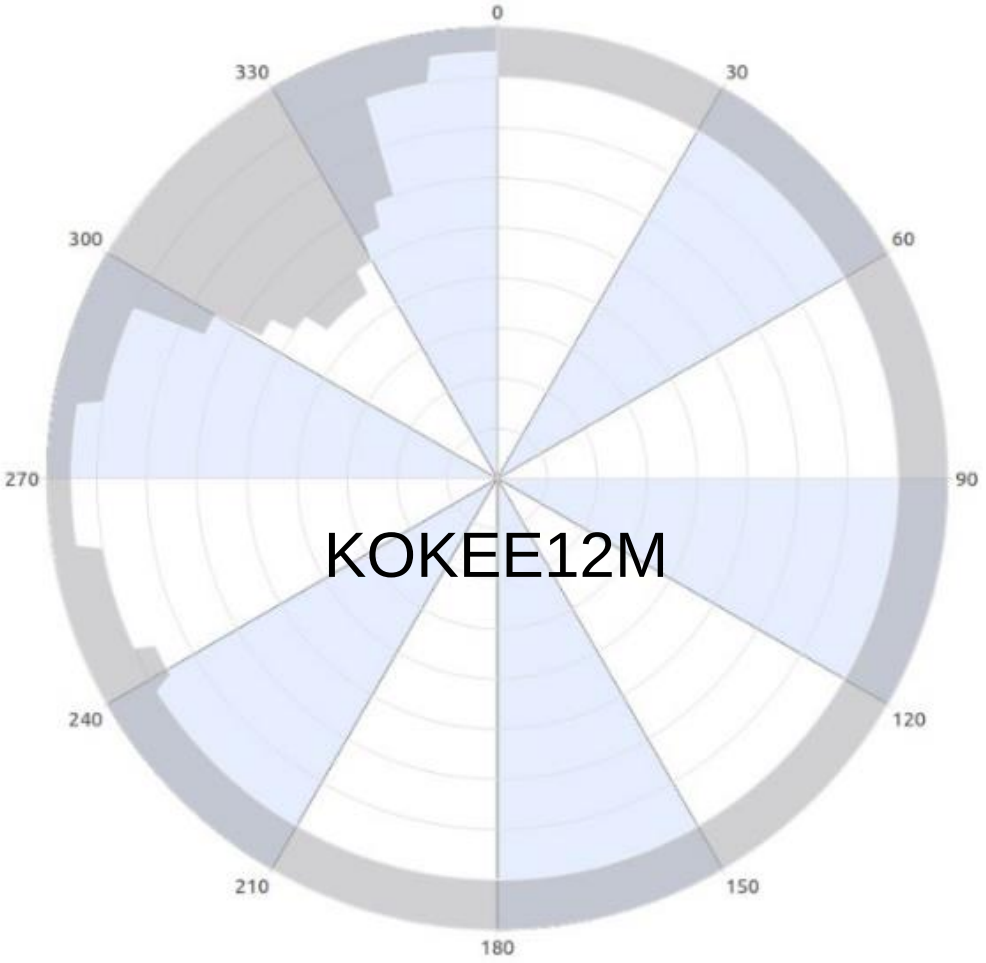
Station models: cable wrap



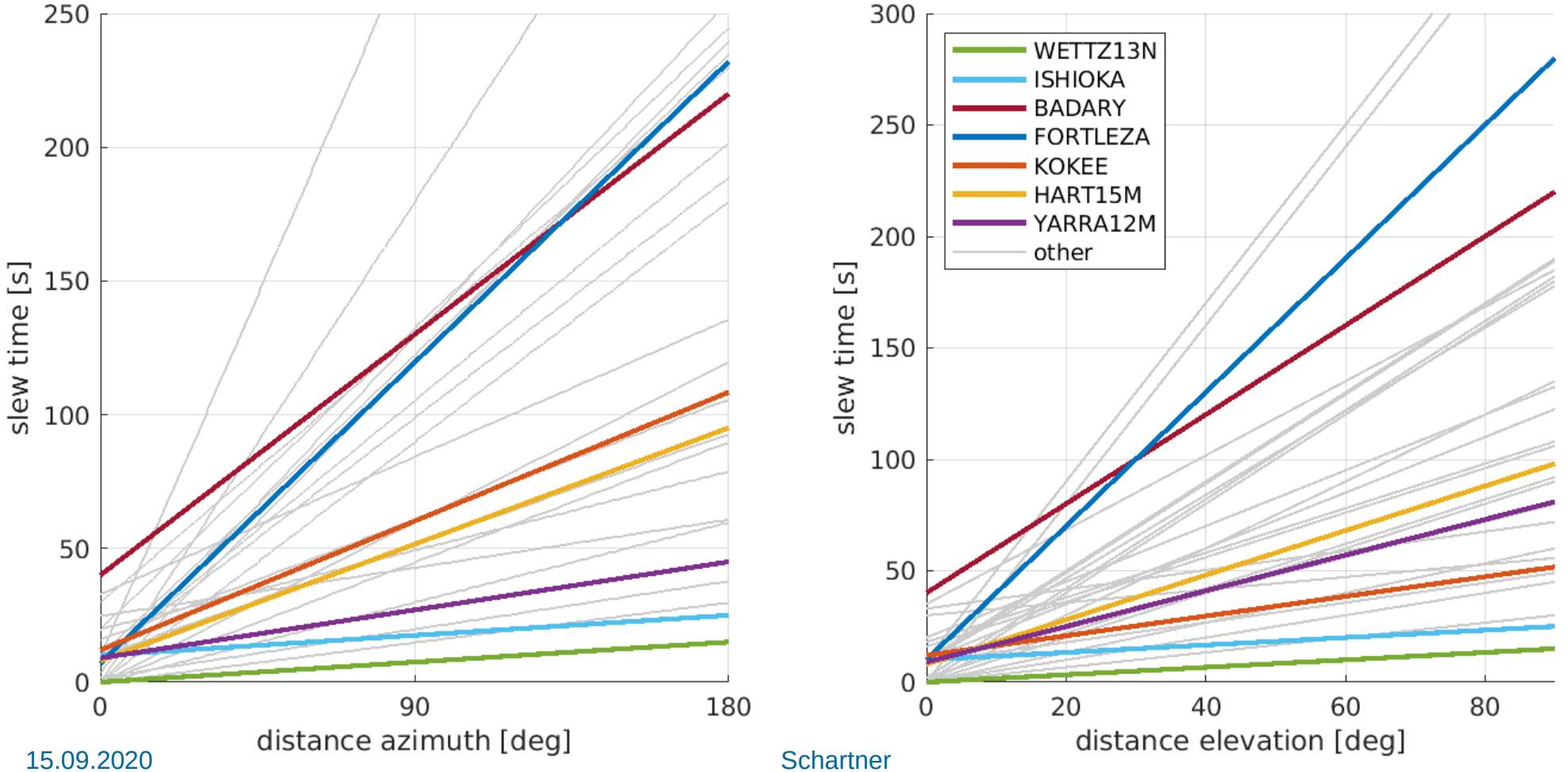


Station models: horizon mask

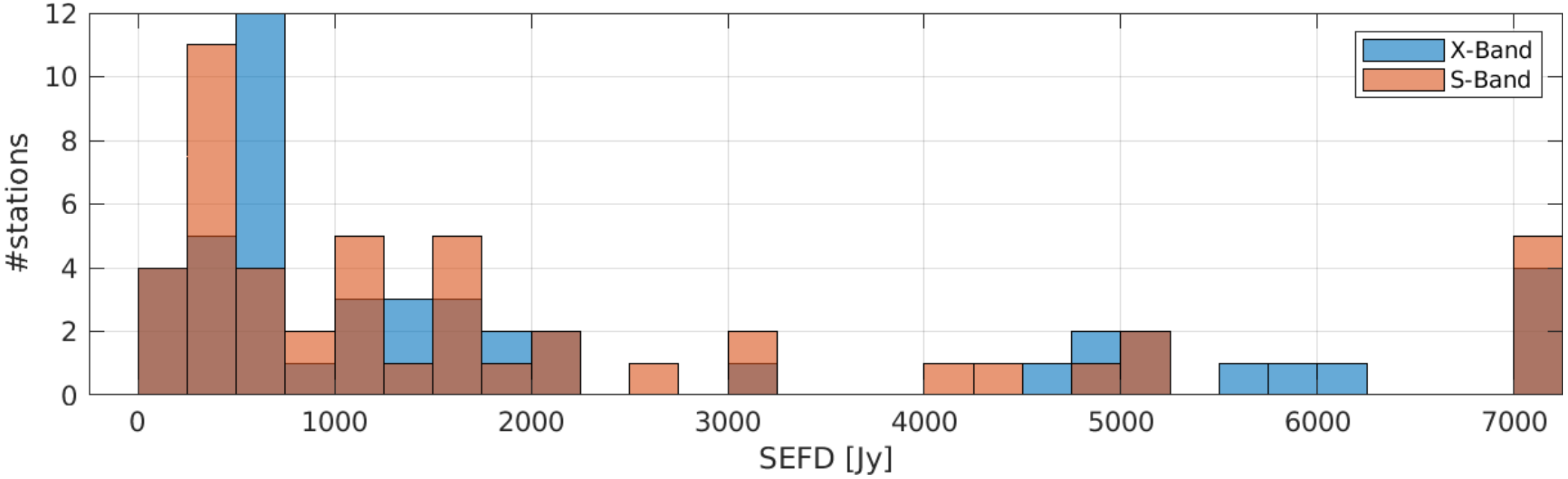




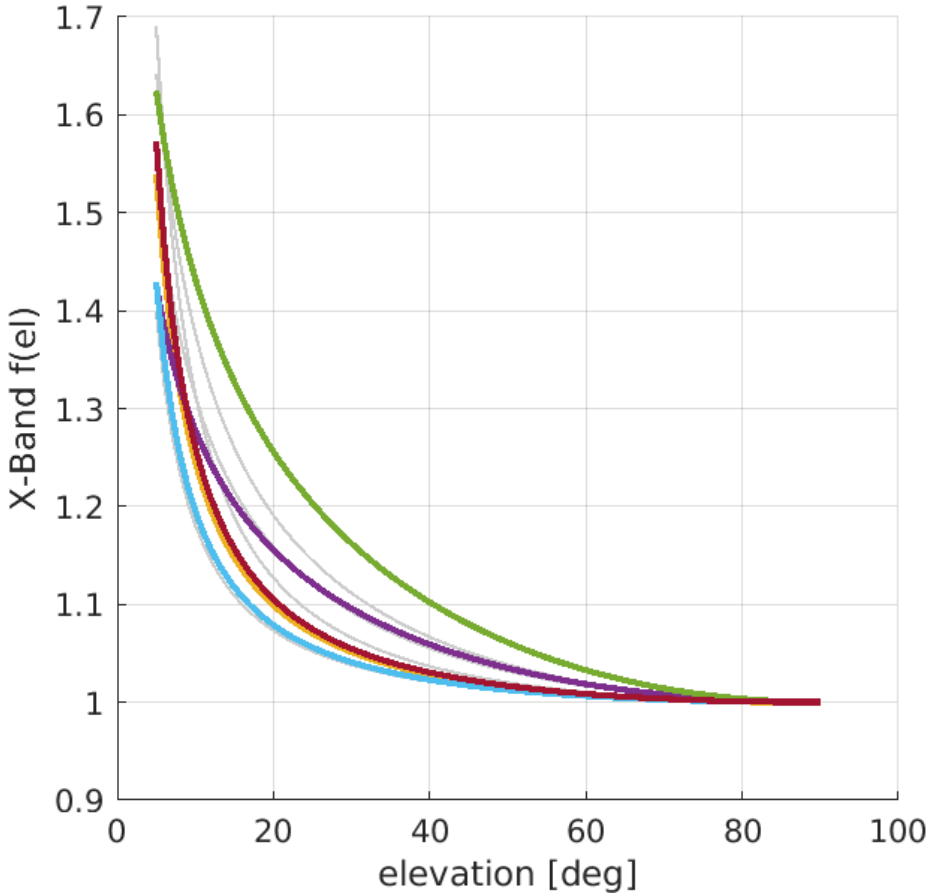
Station models: slew time

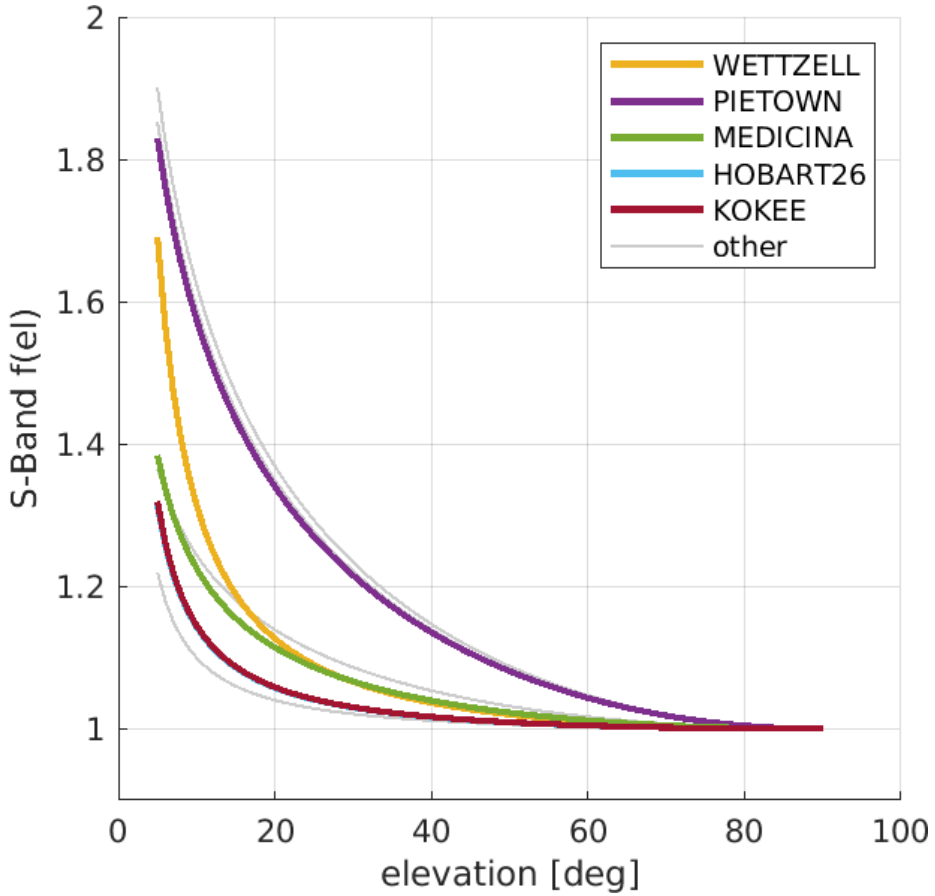


Station models: sensitivity (SEFD)

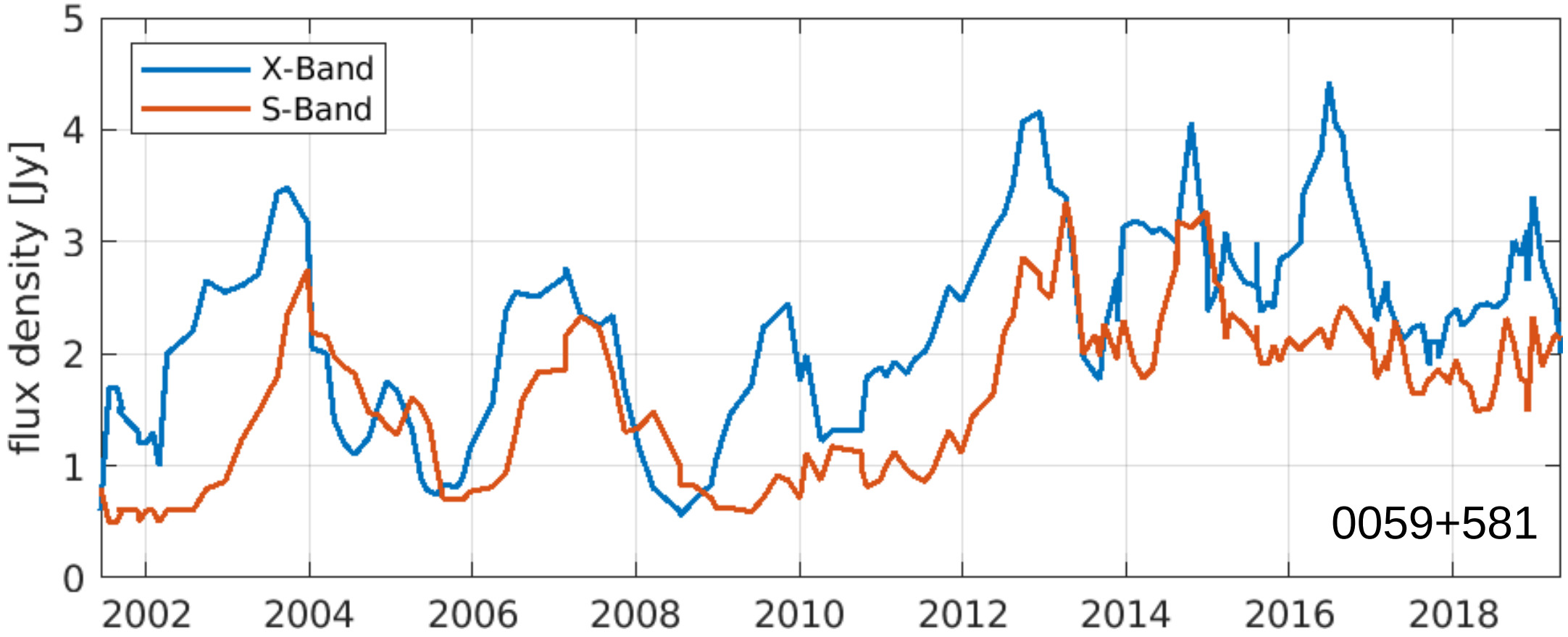


Station models: elevation dependent sensitivity

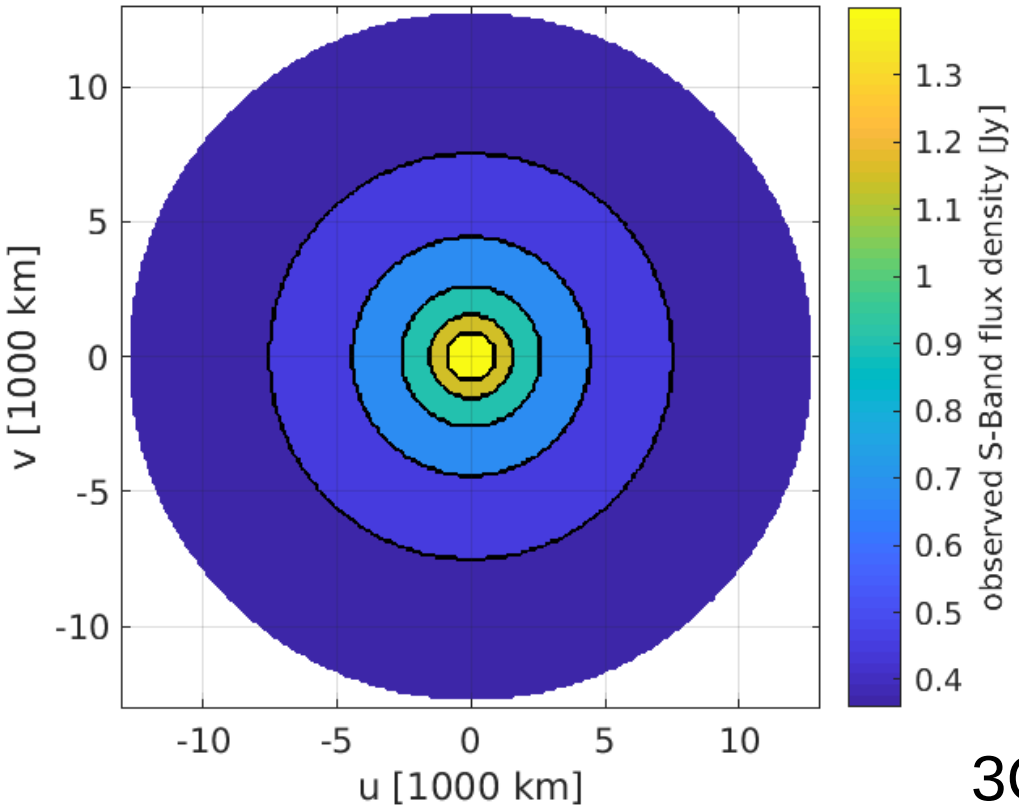


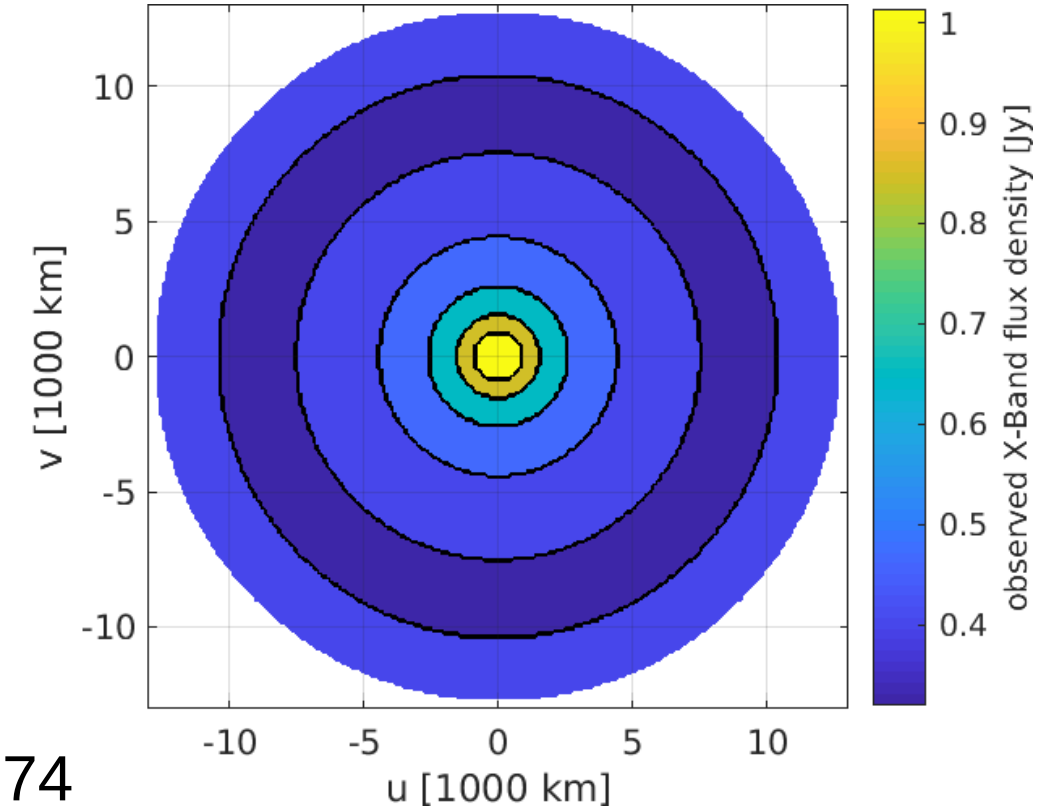


Source models: flux density



Source models: flux density, baseline model





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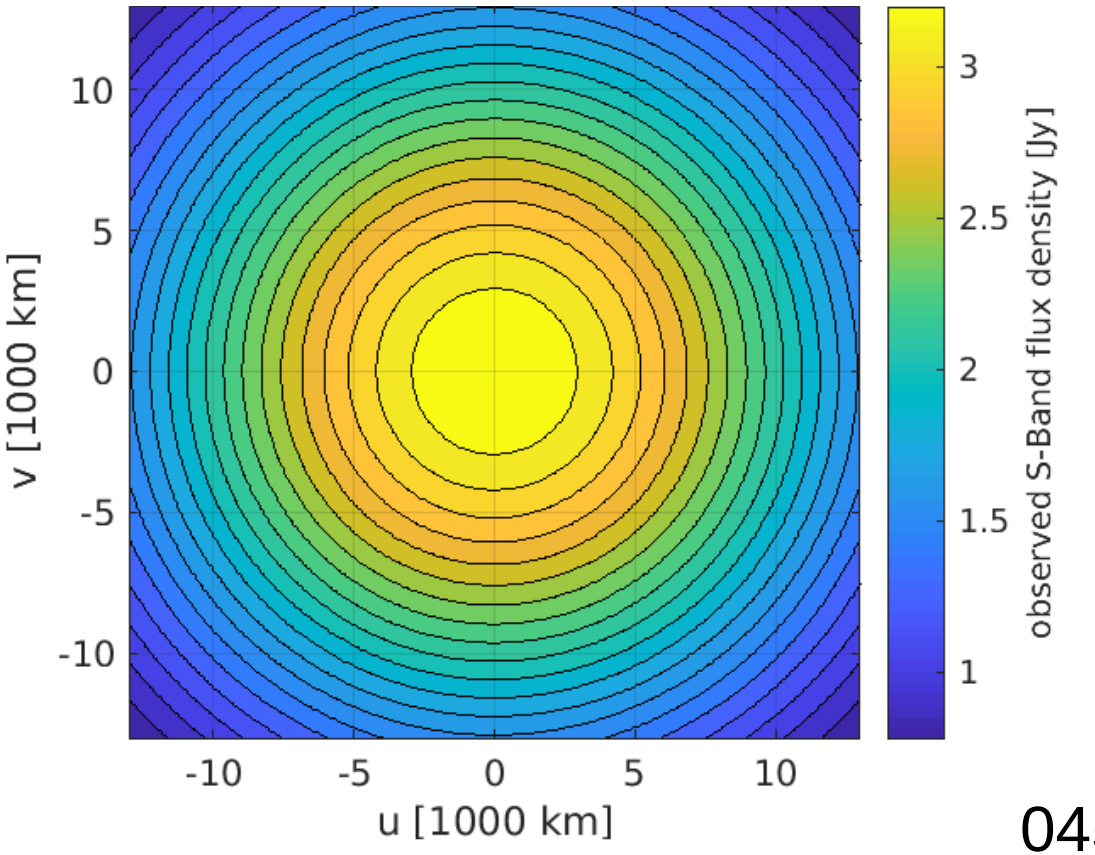
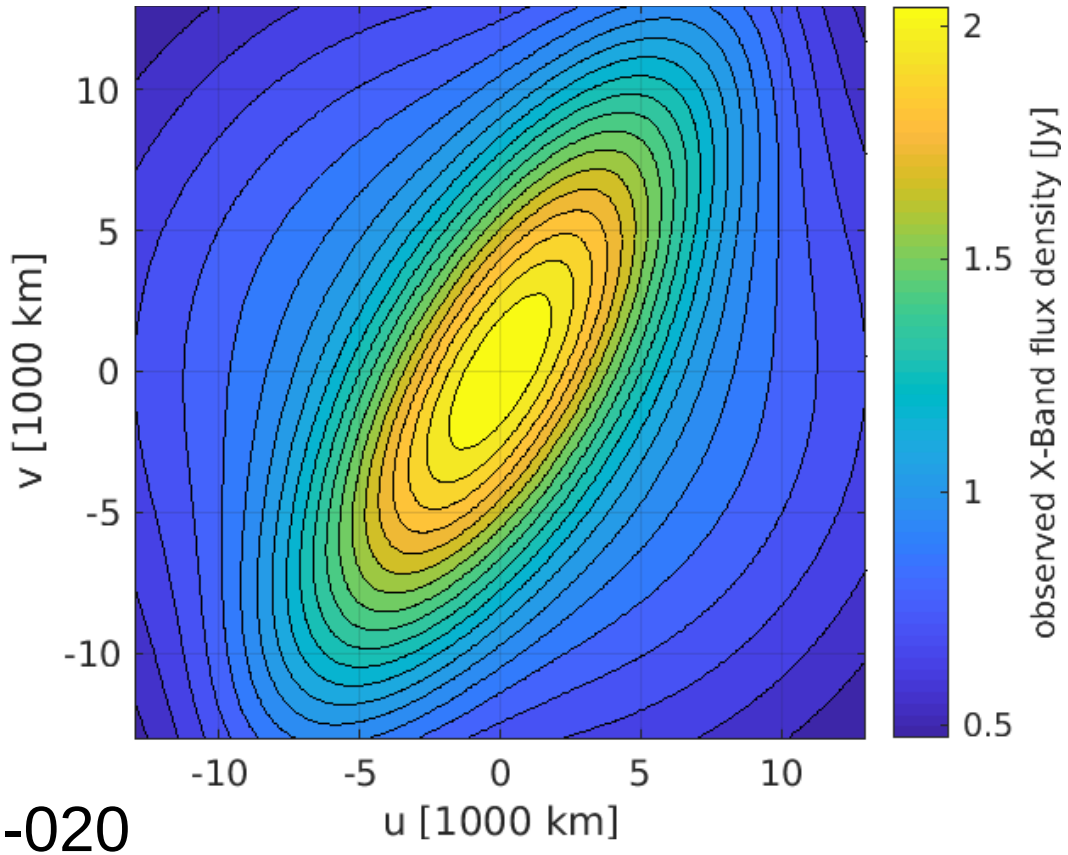
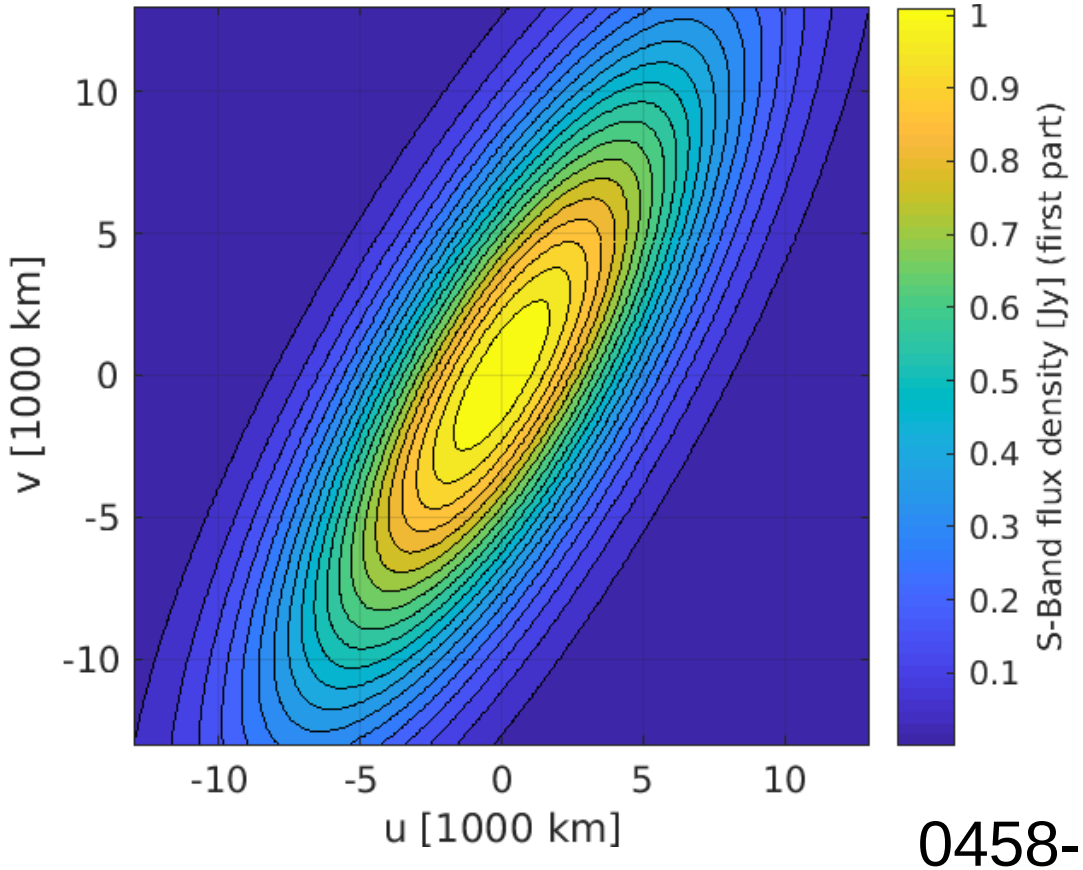
Source models: flux density, elliptical Gaussian model

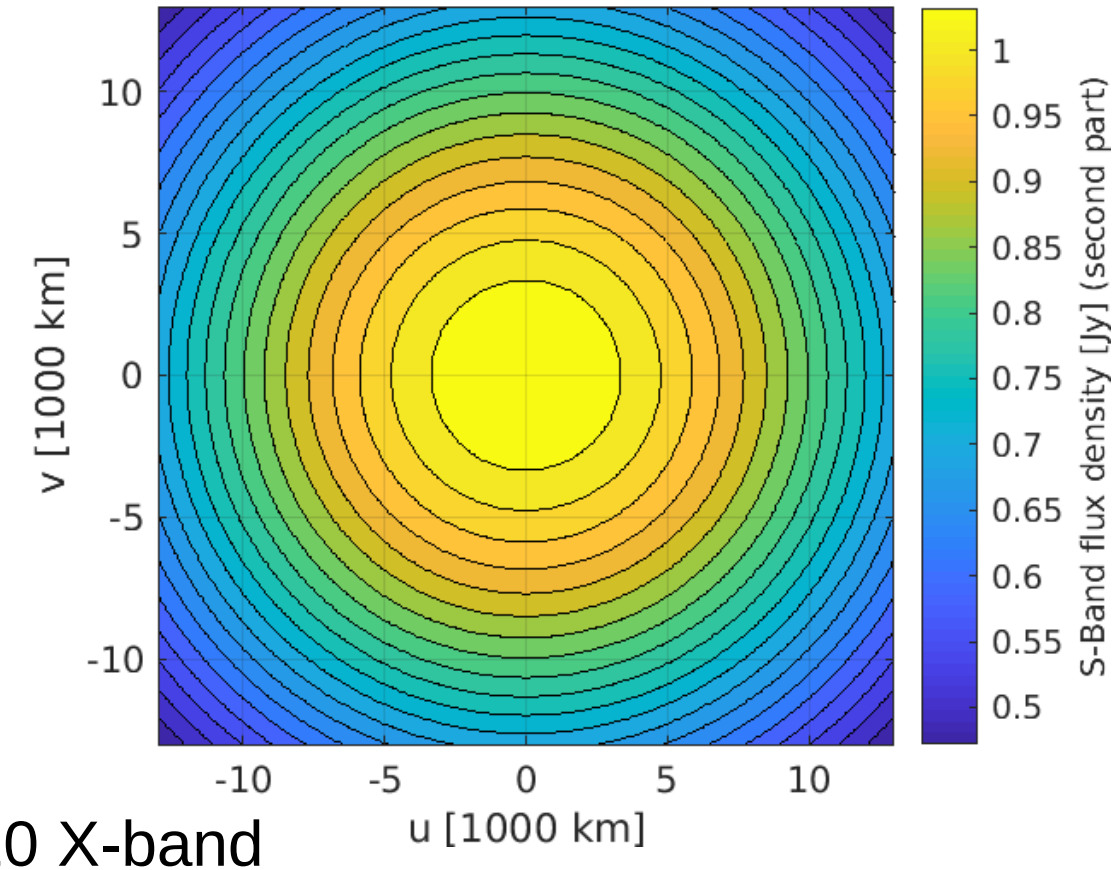




0458-020

Source models: flux density, elliptical Gaussian model





0458-020 X-band

Observation duration

$$\mathrm{T}_{band,1,2} = \left(\frac{SNR_{band}}{\eta F_{band}}\right)^2 \cdot \left(\frac{SEFD_{band,1} \cdot SEFD_{band,2}}{rec_{band}}\right)$$

$T_{band,1,2}$ = observation duration between station 1 and 2 on this band

SNR_{band} = target signal to noise ratio for this band

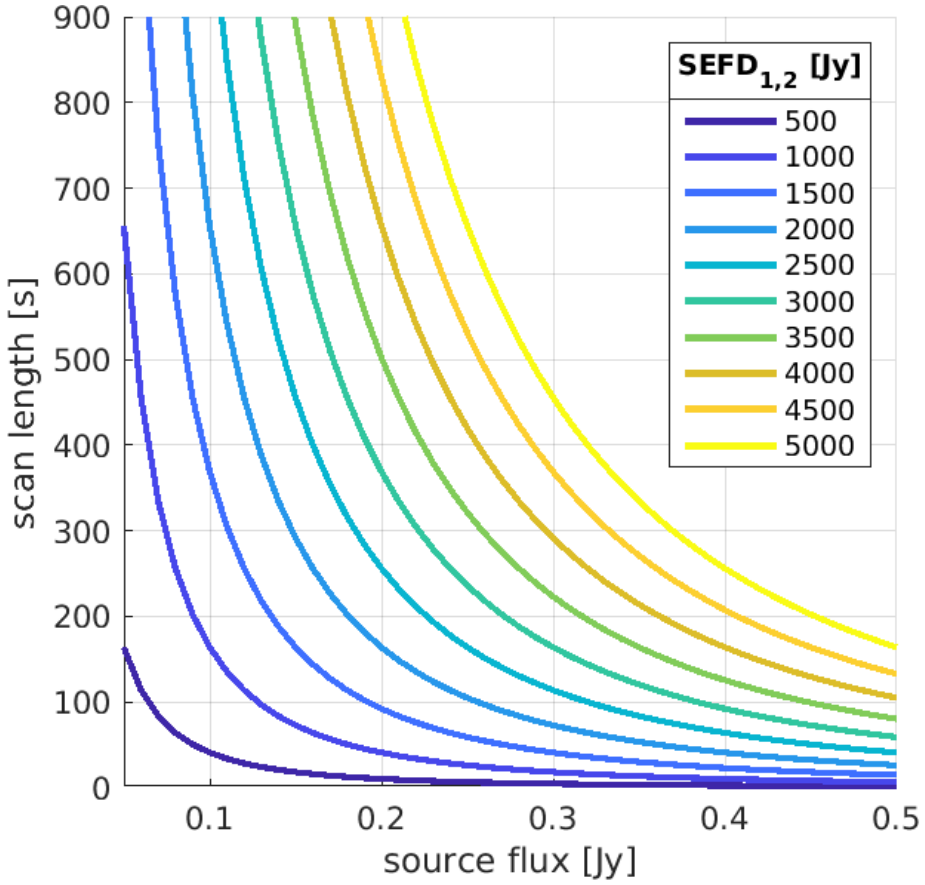
η = efficiency factor

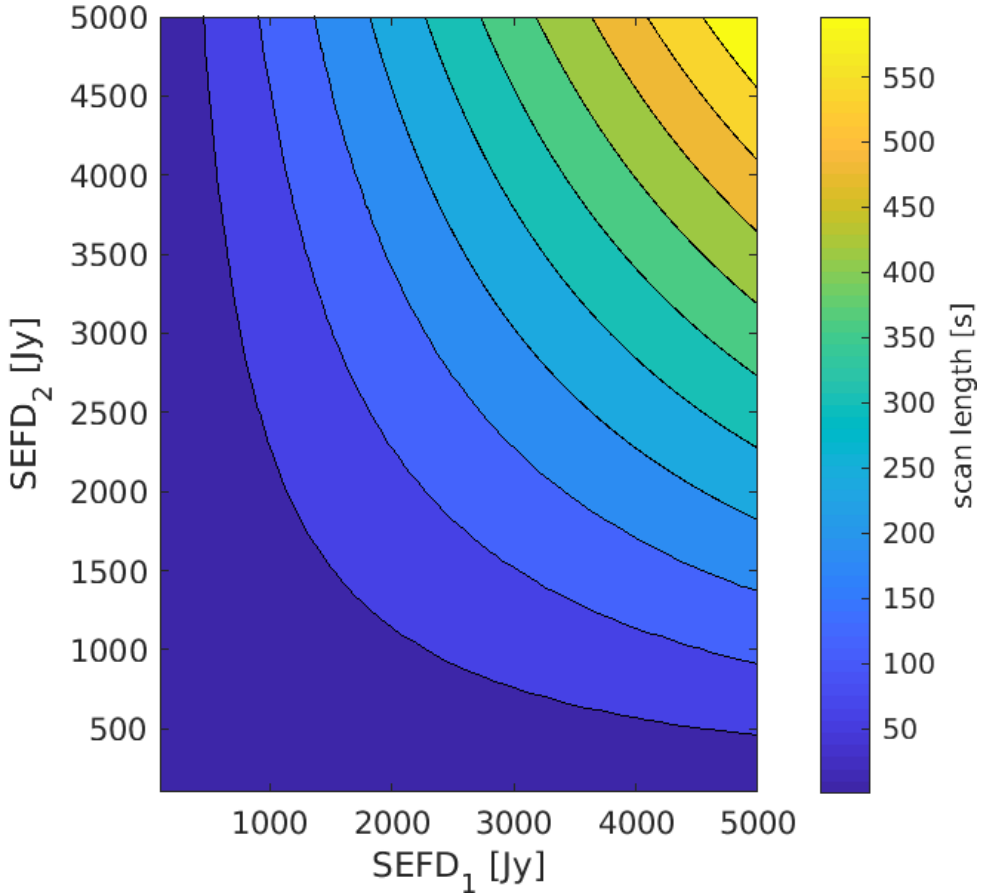
F_{band} = source flux density on this band

$SEFD_{band}$ = station sensitivity (for station 1 and 2)

rec_{band} = recording rate on this band

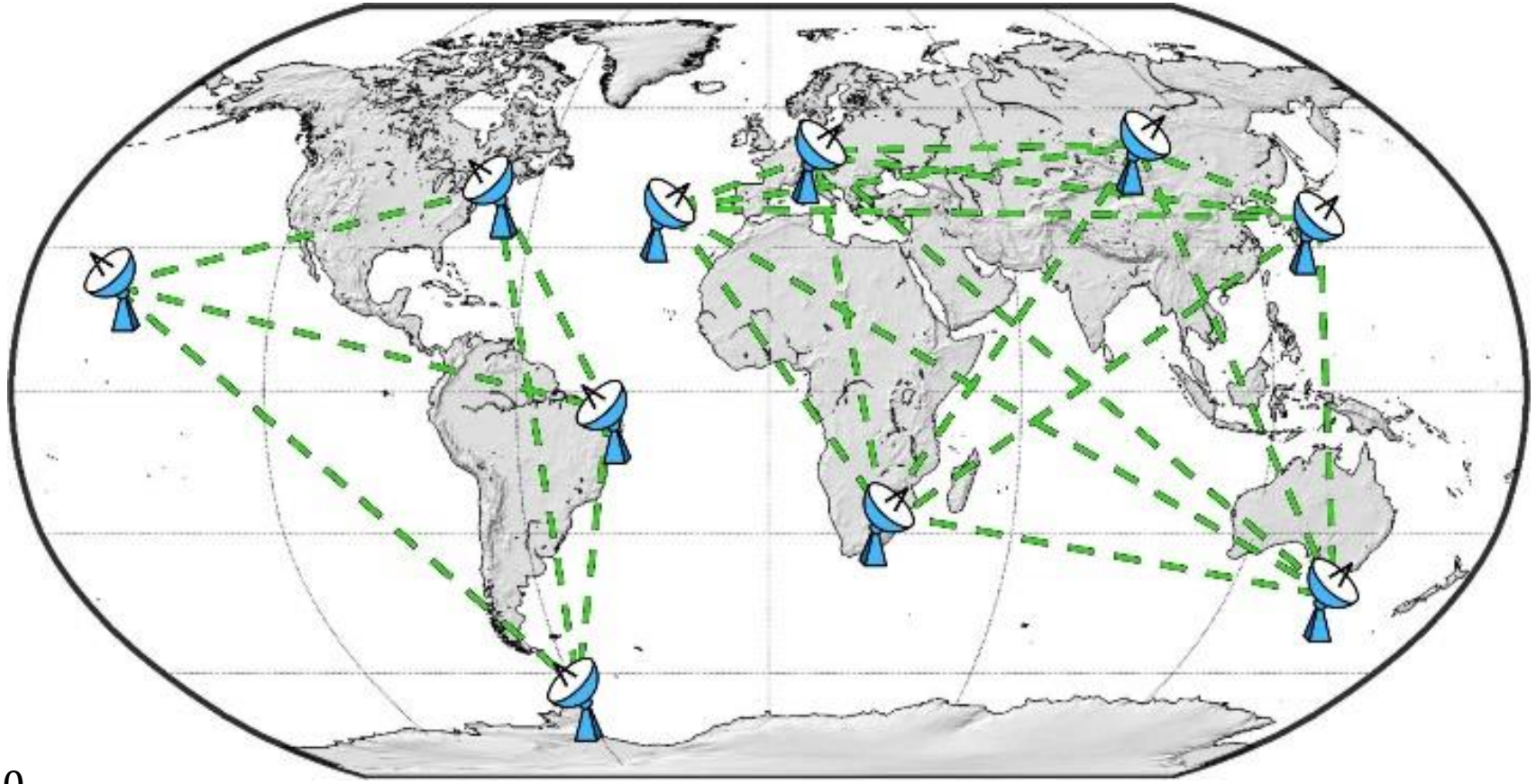
Observation duration





Subnetting

- global network
→ source visibility
→ split network
- observe multiple sources simultaniously



$$n_{obs} = \frac{(n_{sta} - 1) \cdot n_{sta}}{2}$$

$$n_{sta} = 10 \rightarrow n_{obs} = 45$$

$$n_{sta} = 2 \cdot 5 \rightarrow n_{obs} = 2 \cdot 10 = 20$$

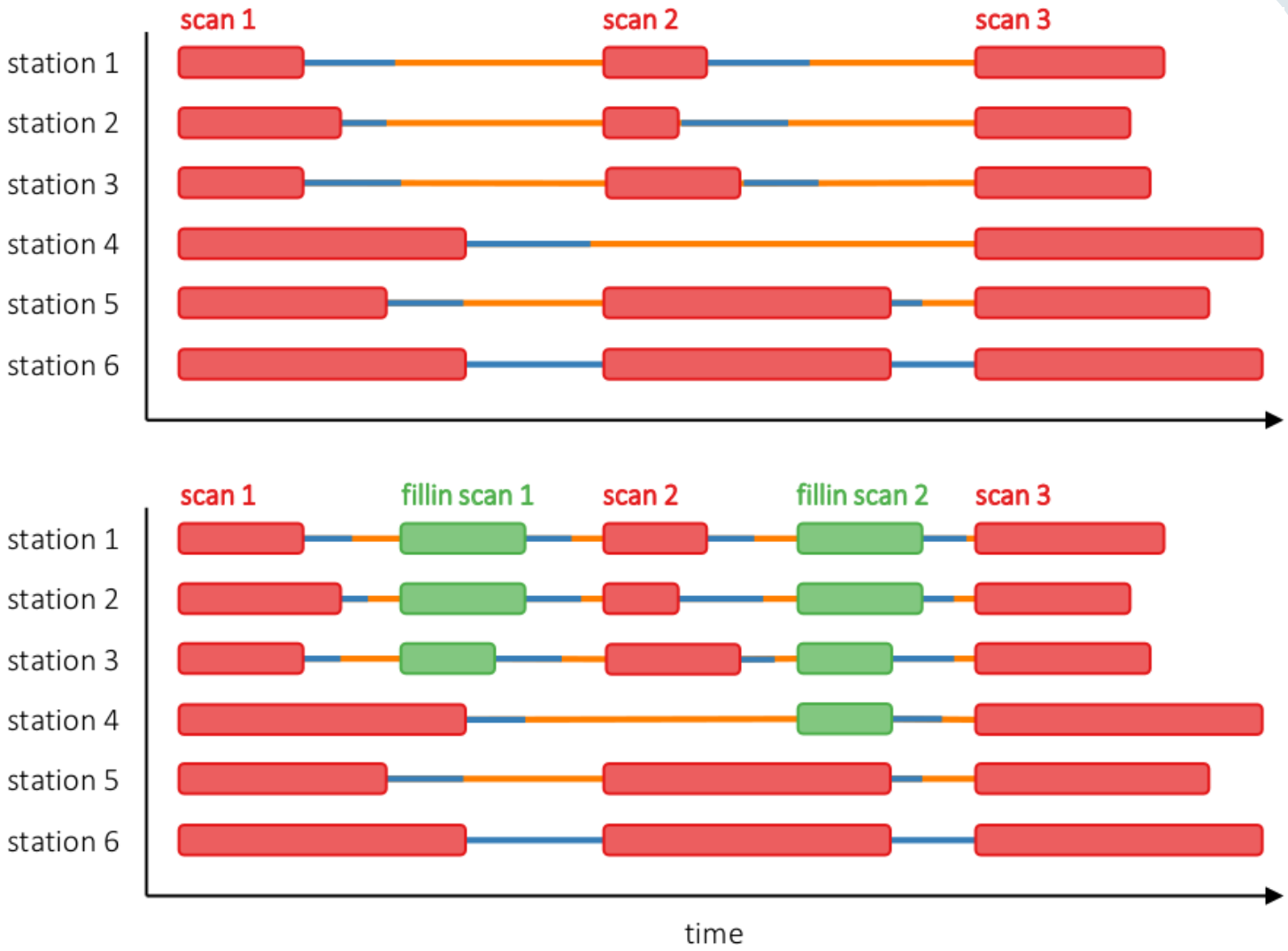
Fillin-mode

- different observing time per station
- different slew time per station

→ introduces idle time

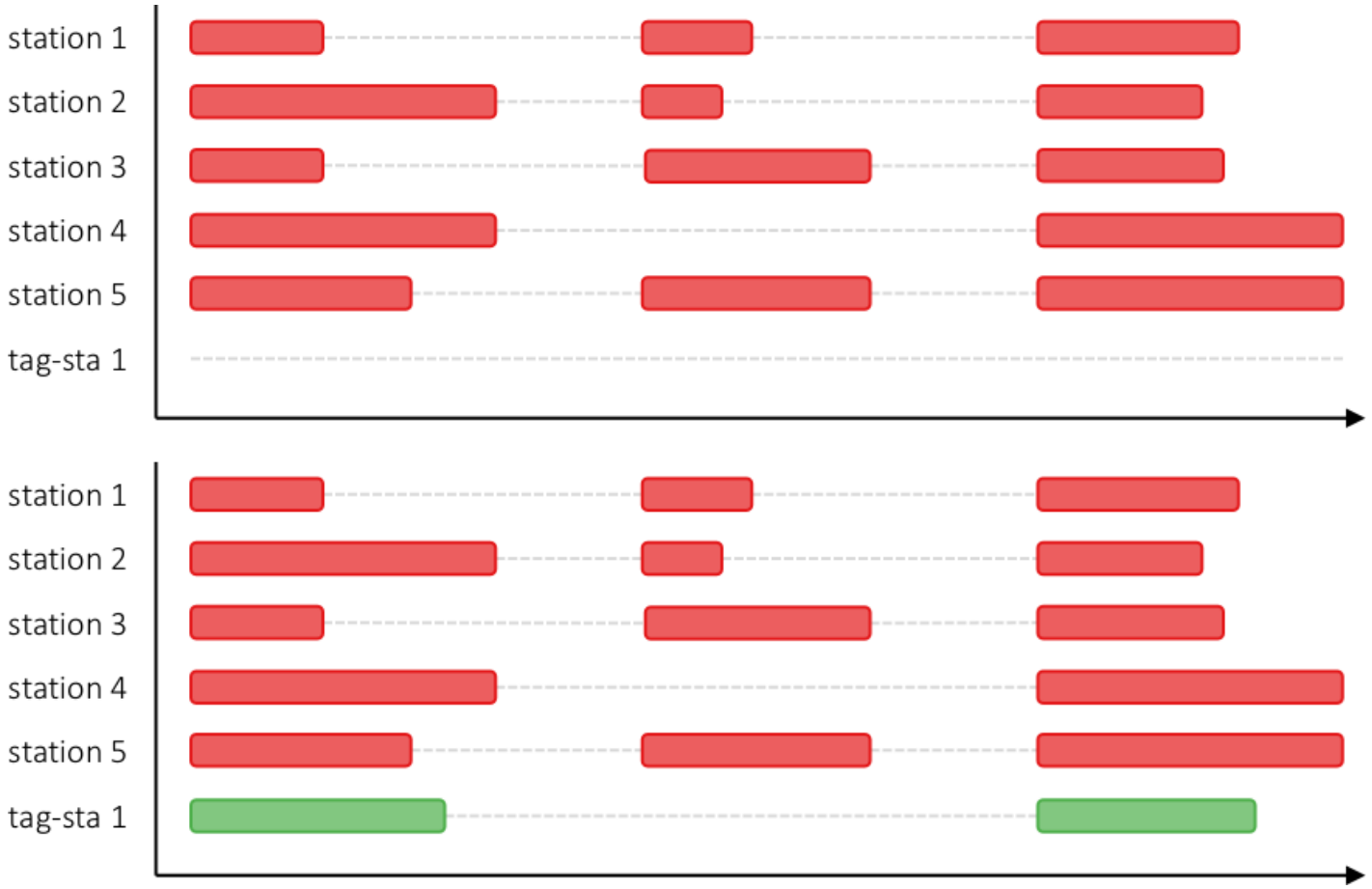
→ fillin-mode scans

red:	*standard observing time*
green:	*fillin mode observing time*
blue:	*slew time*
orange:	*idle time*



Tagalong-mode

- sometimes unsure if station can participate
- generate schedule without this station
- add station to already existing schedule

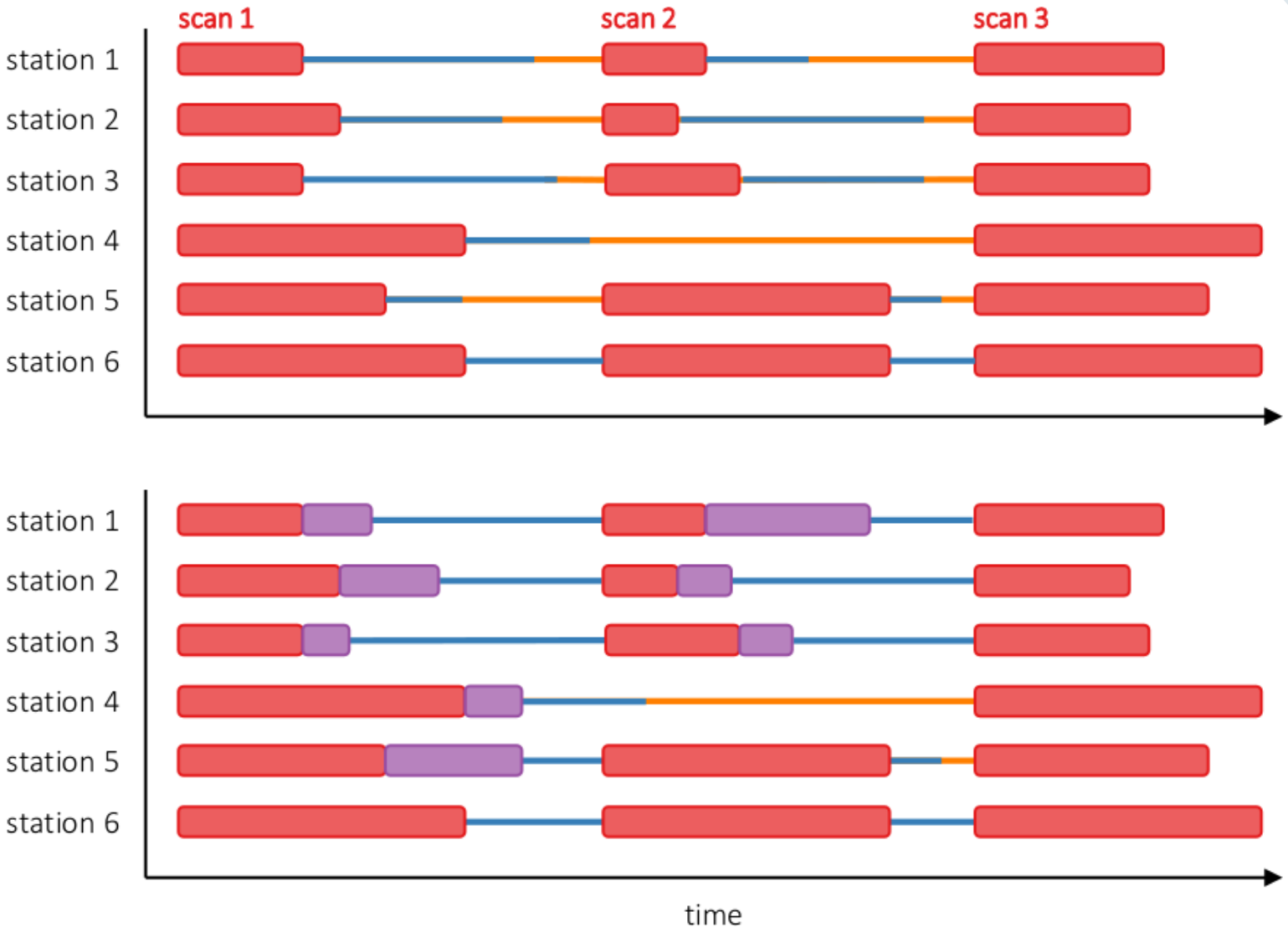


red:	*standard scan*
green:	*tagalong station*

Extend observing time

- avoid idle time
- use existing idle time to extend observing time
- reach higher SNR
- collect more data

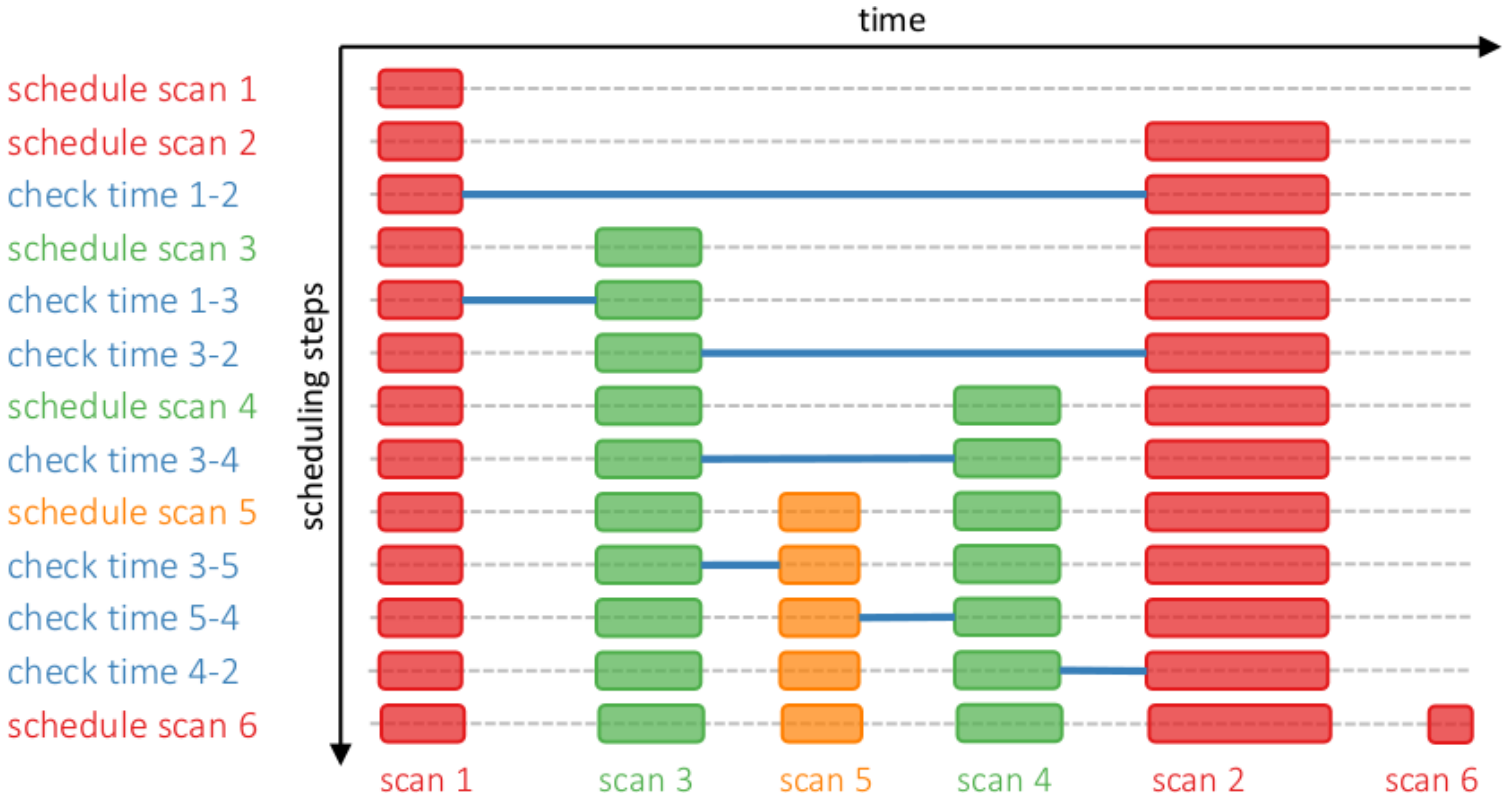
red:	*standard observing time*
purple:	*extended observing time*
blue:	*slew time*
orange:	*idle time*



VieSched++: Recursive scan selection

- recursively generate schedule
- minimizes idle time

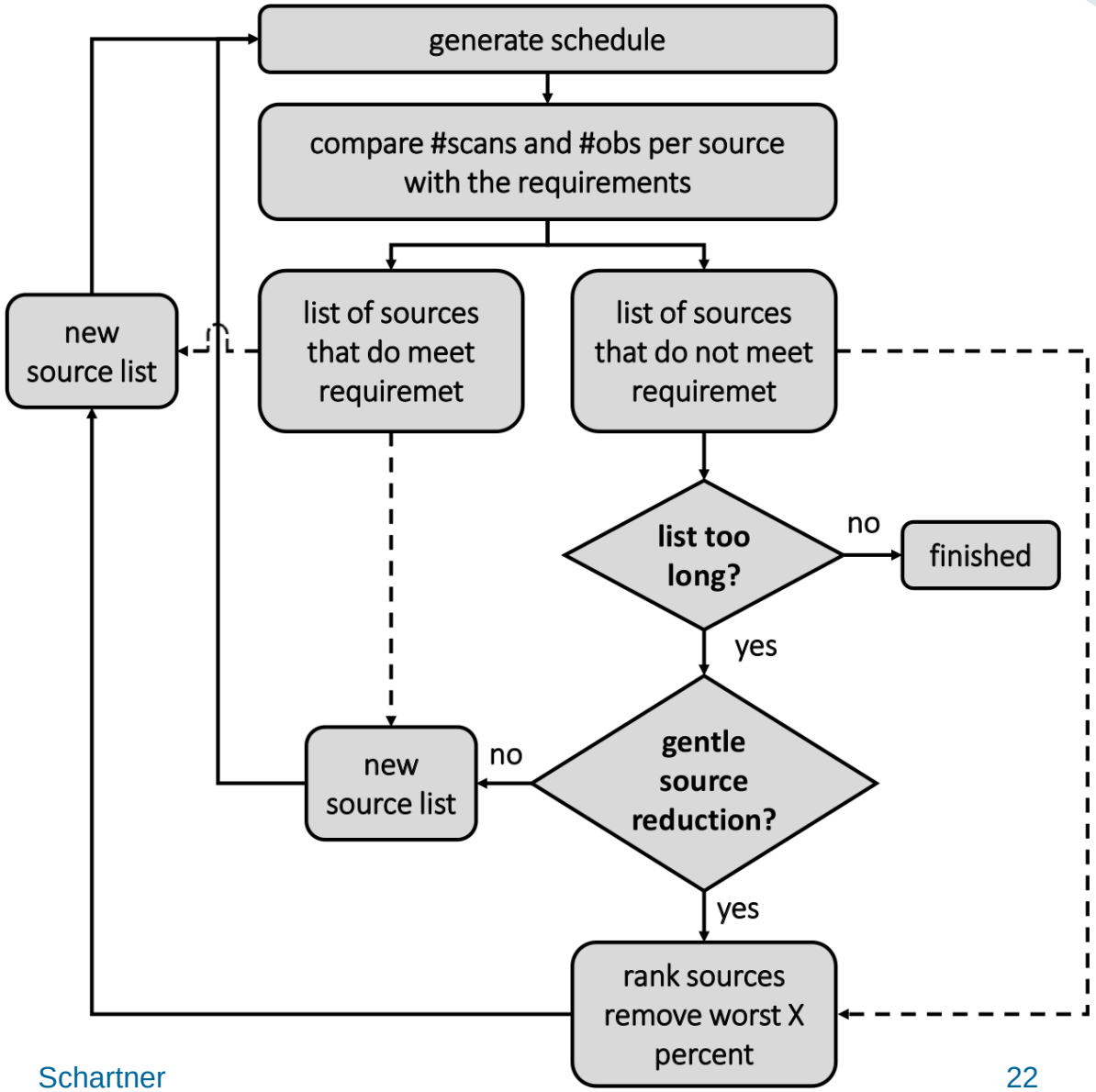
- possible to start by fixing the most important scans and build schedule around



more information: https://repositum.tuwien.at/handle/20.500.12708/1466

VieSched++: source selection

- iterative source selection based on number of scheduled scans and observations per source



Multi-scheduling

- scan sequence is important
  - 1000 scans with 300 possible sources → 300^{1000} possible schedules
- not generating only one schedule
- instead generating hundreds of schedules per session
- simulating each schedule multiple times
- analyze every simulation
- decide based on simulation results which schedule is best

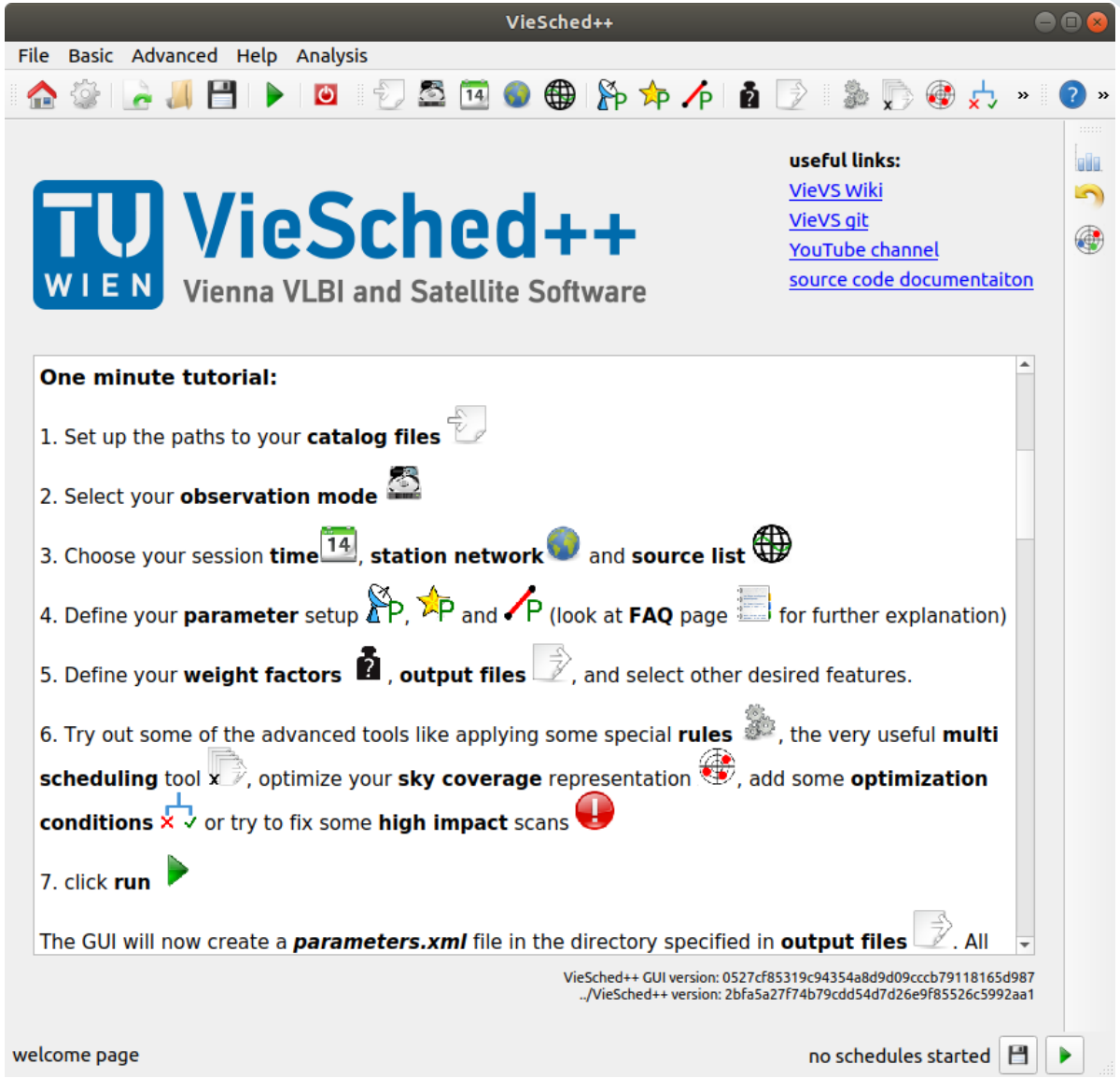
more information: https://repositum.tuwien.at/handle/20.500.12708/1466

VieSched++

Vienna VLBI and Satellite Software

- written in C++
- main focus is geodetic VLBI
- written from scratch
- easy to use
  - graphical user interface
  - installer (Linux, Windows)

- current reference
  https://doi.org/10.1088/1538-3873/ab1820



The VieSched++ software packages

VieSched++

scheduler (C++)
controlled via XML file
https://github.com/TUW-VieVS/VieSchedpp

VieSched++ GUI

graphical user interface (C++)
generates XML files
testing, leraning, special scheduling
https://github.com/TUW-VieVS/VieSchedppGUI

VieSched++ AUTO

automation (Python)
controlled via XML file templates
operational scheduling (IVS sessions)
https://github.com/TUW-VieVS/VieSchedpp_AUTO

Useful links:

- Handout for this webinar:
  https://vievswiki.geo.tuwien.ac.at/lib/exe/fetch.php?media=scheduling%20and%20simulations%20with%20VieSched%2B%2B.pdf
- Manuals:
  https://vievswiki.geo.tuwien.ac.at/doku.php?id=public:vieschedpp:vieschedpp
- YouTube:
  https://www.youtube.com/watch?v=Tsn7qg8j3bc&list=PLxSgY16KcDTuH3QBsN-gnS5HKtrSaqksx&ab_channel=VieVS