

Interferometry Practice Sessions

The exercises made by the teacher :-)

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Active Galactic Nuclei at the highest angular resolution: theory and observations

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Practical session 2: UV coverage and source observability.

I have followed the exercises using ASPRO (and an image processing software for superposition of the graphs: GIMP) to give you an idea of what you should get with ASPRO.

1 Source observability

1.1 Setting up an observations

Here is what you should get in your shell when setting “View Object Catalog”, showing you rightly loaded the catalog.

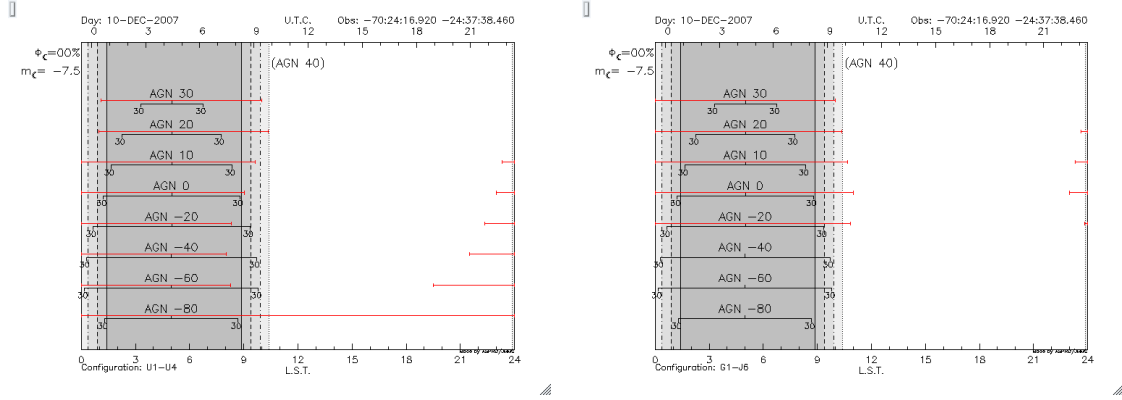
```
Aspro>
!-----
! made by Florentin Millour
!-----
AGN_40  EQ 2000.000  5:00:0.0  40:00:0.0  MV  0 MR  0 MI
AGN_30  EQ 2000.000  5:00:0.0  30:00:0.0  MV  0 MR  0 MI
AGN_20  EQ 2000.000  5:00:0.0  20:00:0.0  MV  0 MR  0 MI
AGN_10  EQ 2000.000  5:00:0.0  10:00:0.0  MV  0 MR  0 MI
AGN_0   EQ 2000.000  5:00:0.0   0:00:0.0  MV  0 MR  0 MI
AGN_-20 EQ 2000.000  5:00:0.0 -20:00:0.0 MV  0 MR  0 MI
AGN_-40 EQ 2000.000  5:00:0.0 -40:00:0.0 MV  0 MR  0 MI
AGN_-60 EQ 2000.000  5:00:0.0 -60:00:0.0 MV  0 MR  0 MI
AGN_-80 EQ 2000.000  5:00:0.0 -80:00:0.0 MV  0 MR  0 MI
```

1.2 Observability of sources at different declinations and delay lines constrains

Here you can find the observability for the first catalogue of sources. The gray shade correspond to the night and the black lines correspond to the observability of sources by their height above the horizon (here 30°). First you can see that the source at declination $+40$ is not observable at all, due to the latitude of Paranal: about 30° . The additional constraints coming from the interferometer are displayed in red: left graph is for the stations UT1-UT4 and right one is for

*Based on the practice work session of D. Ségransan, J.-P. Berger and F. Malbet at the Goutelas summer school

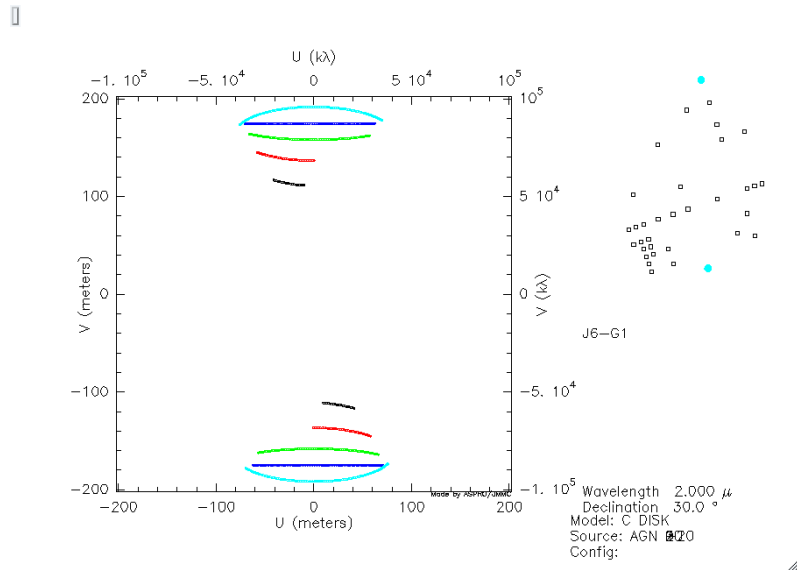
G1-J6. You can see the difference for 2 extreme cases: a (roughly) East-West baseline (UT1-UT4) and a North-south baseline (G1-J6). The North-south baseline restrict the access to northern sources whereas the East-West baseline restricts the observability during the night.



2 Sampling the (u, v) plane with the VLTI

2.1 (u, v) tracks for a North-South baseline

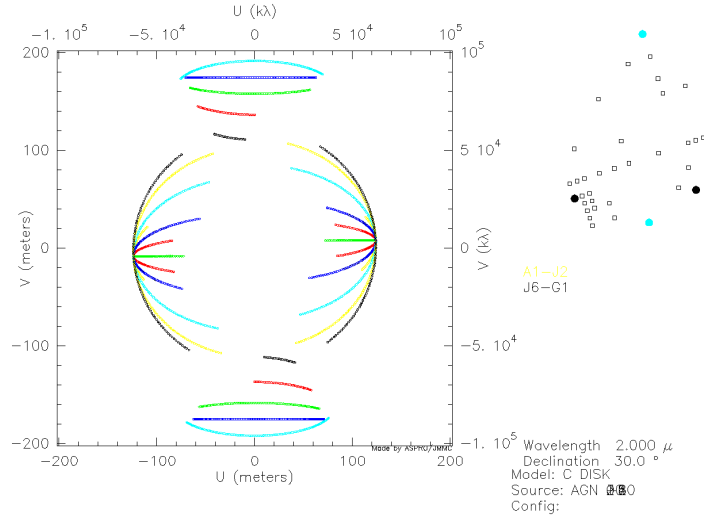
Now we've seen the observability, let's have a look to the (u,v) tracks: The colours are the following: cyan for -20° , blue for 0° , green for 10° , red for 20° and black for 30° . The North-South baseline gives you roughly North-South (u,v) tracks, but the limitations here are quite severe since we used a very long baseline (G1-J6). You can see that the 0° declination target gives a line in the (u,v) plane.



2.2 (u, v) tracks for a East-West baseline

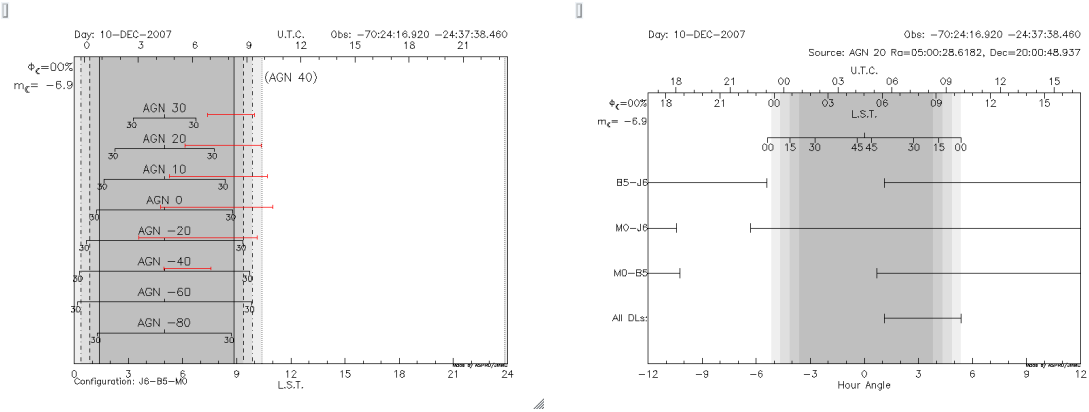
Now I have added the East-West baseline to the previous one. As one can see, East-West baselines will never give a North-South (u,v) projection on sky. Also, the total range of (u,v) plane projected angles is maximum for high declination targets (either positive or negative). As for the precedent

case, a 0° target gives a straight line in the (u,v) plane and therefore gives a reduced coverage than a high declination target.

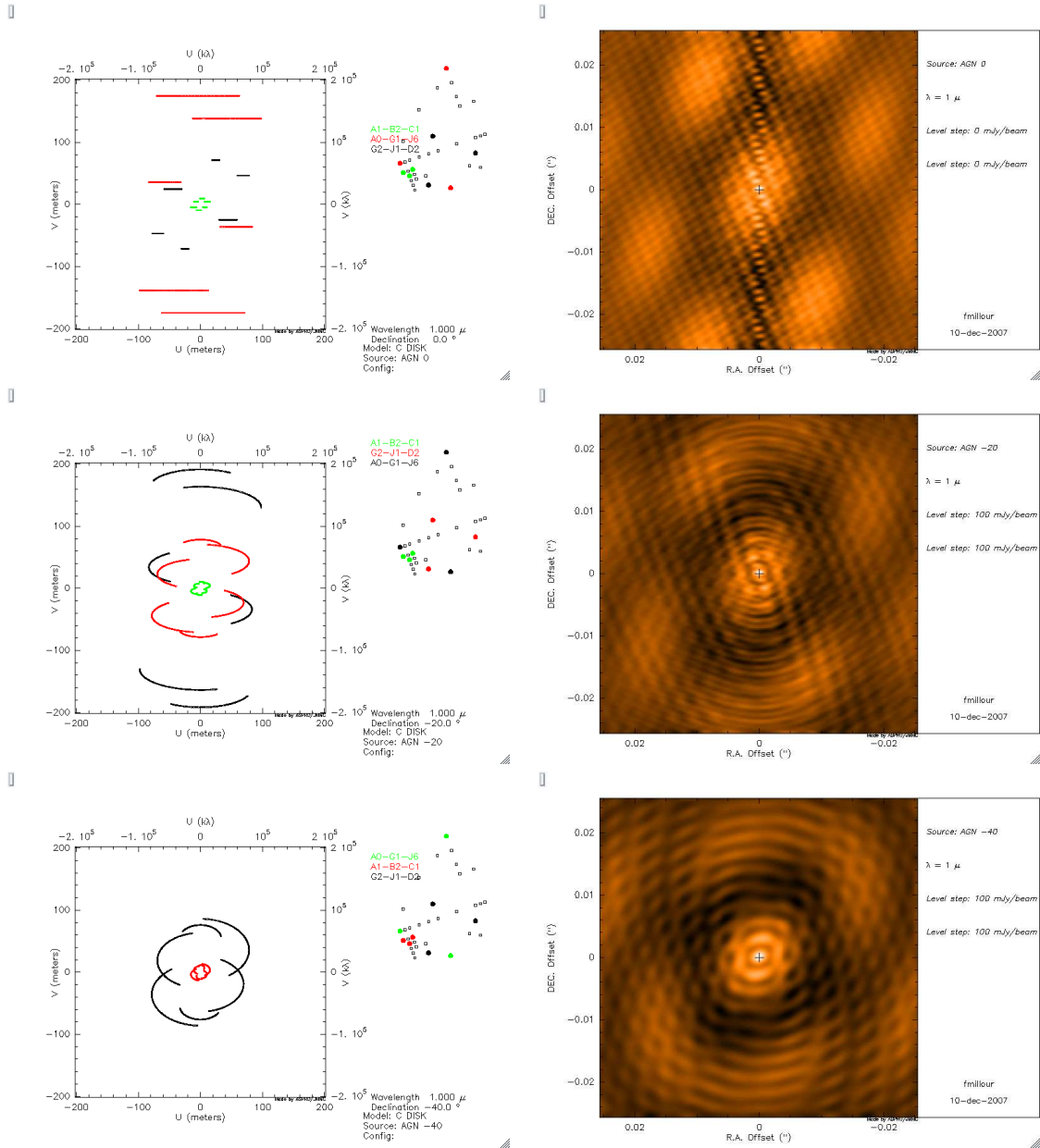


2.3 (u, v) tracks for a 3-telescope-array

First, let's check for the observability when taking a big triangle (B5-J6-M0, left panel). As you can see, the observability constraints are very much more stringent than before, using a lower amount of telescopes. The "Observability limits due to delay lines" panel (right side) gives you now a meaningful information, i.e. splitting the constraint by delay line. Here you see that the most constraining baselines are the B5-J6 and M0-B5, and the M0-J6 baseline does not constrain too much the observability.



Now, here are the (u,v) tracks for the different triangles and different declinations of the object (0° , -20° and -40° from top to bottom). One can see that many aspects will affect the (u,v) coverage and therefore the quality of the PSF: declination is the first thing, affecting the quality of different position angles and giving irregular secondary lobes to the PSF. Then comes the delay lines constraints which prevents from observing with large baselines (bottom graph). And then of course, the available baselines which gives an elongated PSF in the N-S direction.

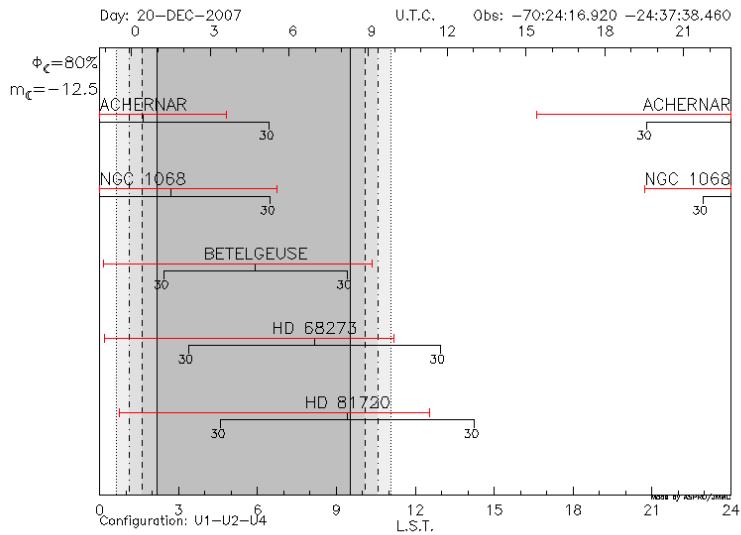


3 Radius measurements and binary parameter determination

3.1 Direct radius measurement

First of all you have to set up an observation. The optimal date of observation would be the 15th of december but the moon is full the 20th. Therefore I choose this date since interferometry is insensitive to moonphase. I choosed also the UT1-UT3-UT4 triplet since there is a faint target in my sample (NGC 1068) and check it does not put too much constraints on the observability of the source.

First of all, you need to have a look to the expected accuracy of the instrument you will use



to be able to tell reliable things about your observations: the ESO *Call for Proposal*¹ gives you information about AMBER and MIDI (the two offered instruments) accuracy you can expect: for AMBER in P81, the accuracy is 3% for an uncalibrated visibility point, i.e. about 5% for a calibrated one. If you have a look to the different targets here (I have taken a diameter of 3 mas for NGC 1068), you can see that with this accuracy, both the star Betelgeuse and HD 68273 (γ^2 Vel) are unreachable for diameter measurement. The star HD 81720 will be measurable but with a poor accuracy on the diameter. Therefore the targets you will be really able to observe using these baselines will be Achernar, NGC 1068 and partially HD 81720. For the two other stars (HD 68273 and Betelgeuse) you will need other configurations (a short baselines triplet for Betelgeuse and the longest available baselines for HD 68273) to reach your goal of measuring a diameter.

You must also notice that limb-darkening measurements, which needs at least one point in the second lobe of visibility, are not achievable, except for Betelgeuse. Finally, one baselines setup is not sufficient to measure all the stars diameters: you will need at least 3 baselines setup to reach your proposal goal (one short setup for Betelgeuse and one very long baseline setup for HD 68273 and also for HD 81720 to reach a better accuracy).

3.2 Binary parameter determination

I guess now you are experts in UV coverage understanding, so I let you do this exercise alone ;-)

¹<http://www.eso.org/sci/observing/proposals/>

