NenuFAR and the calibration, imaging, confusion, and decorrelation issues

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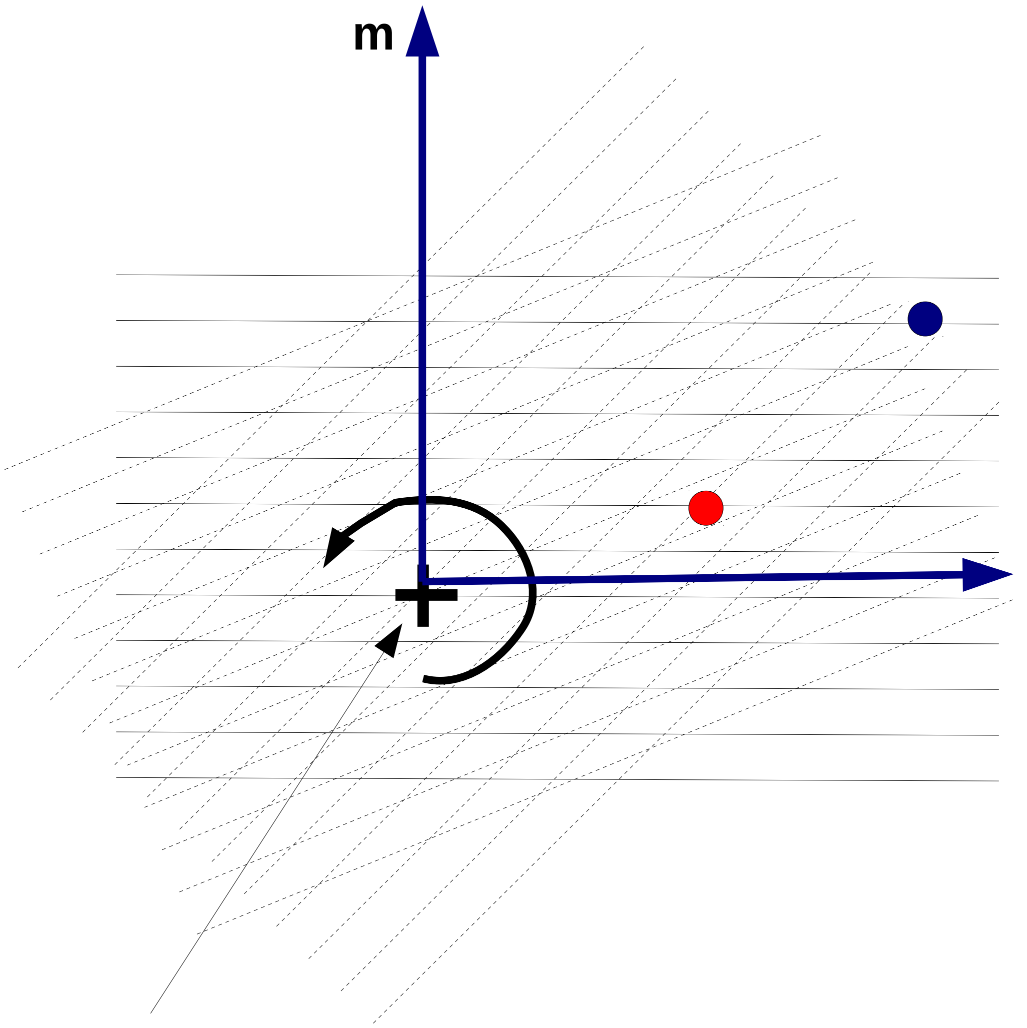
Summary

I am not going to talk about the long-baseline!

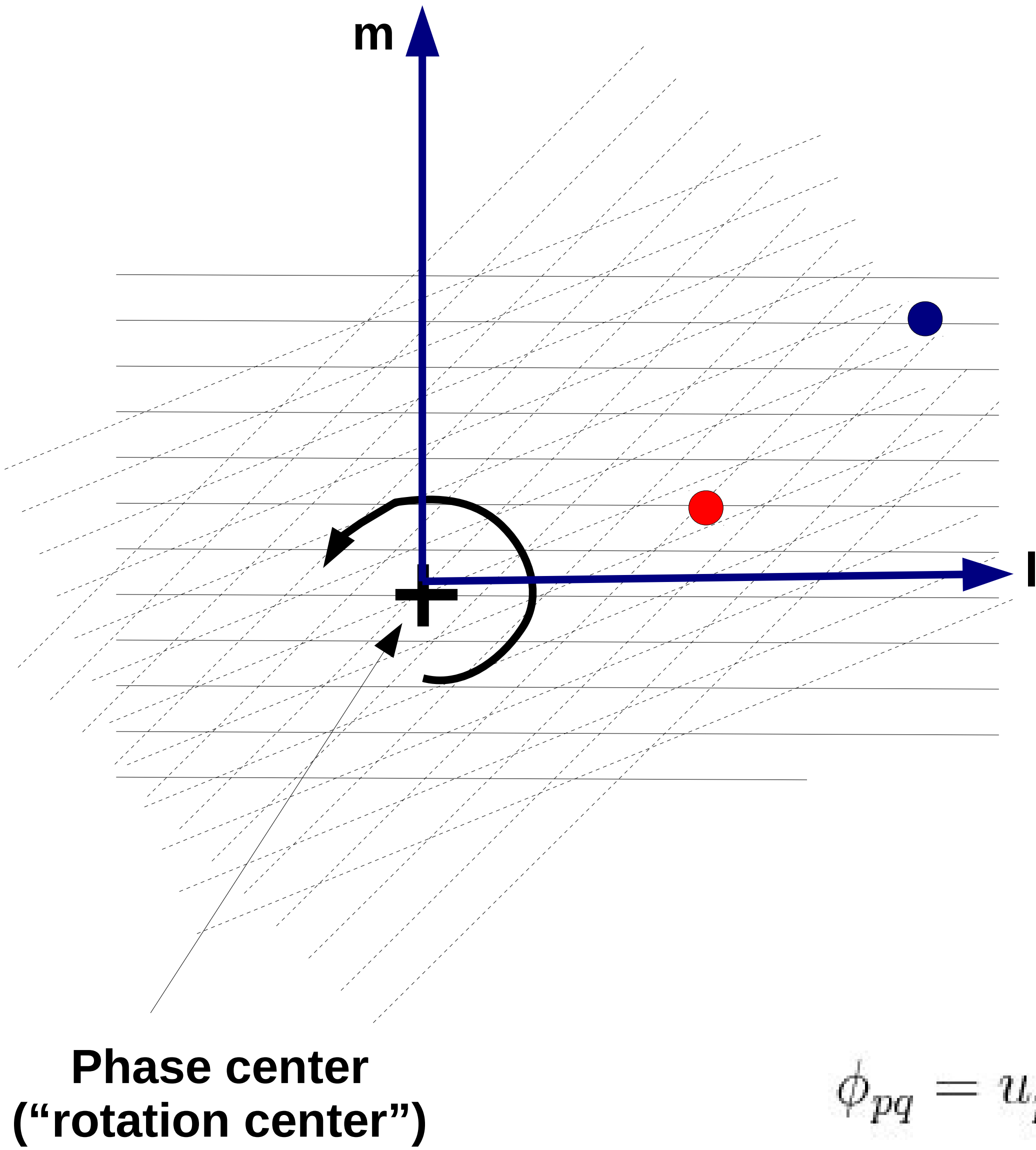
- Decorrelation
- Confusion limit
- Calibration and imaging

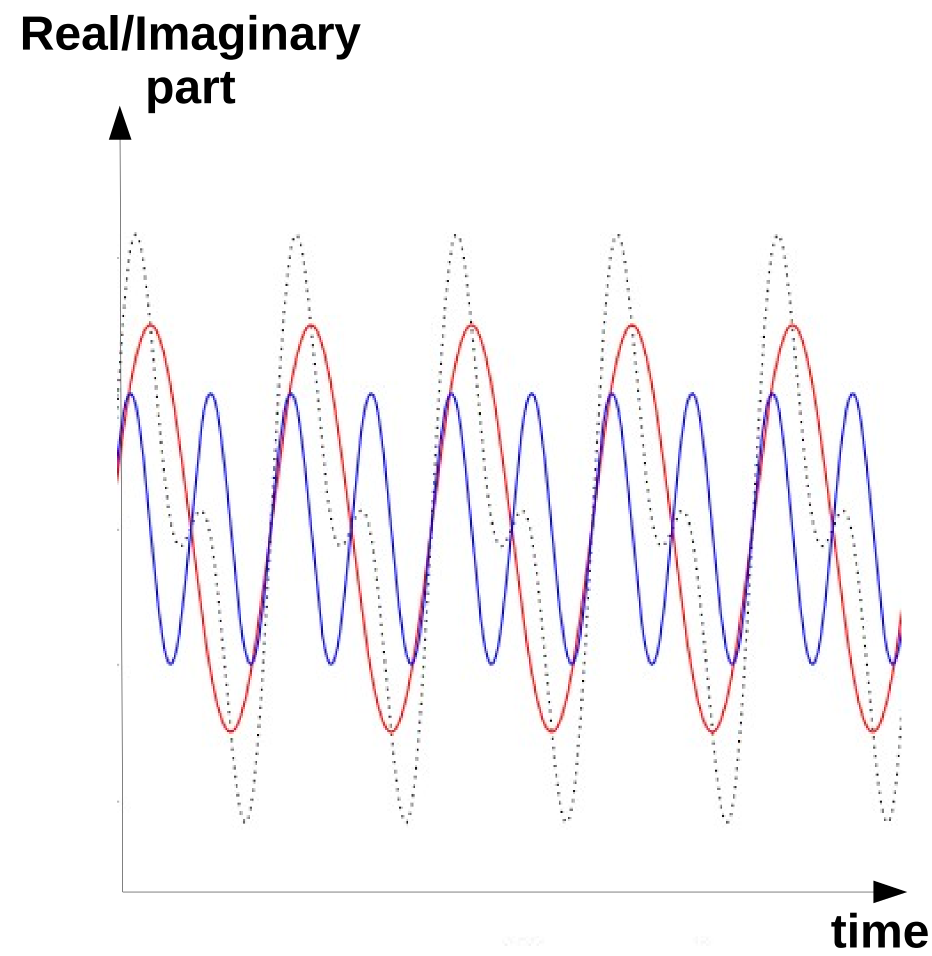
Time/Frequency Smearing ("decorrelation"): For one baseline



Phase center
("rotation center")

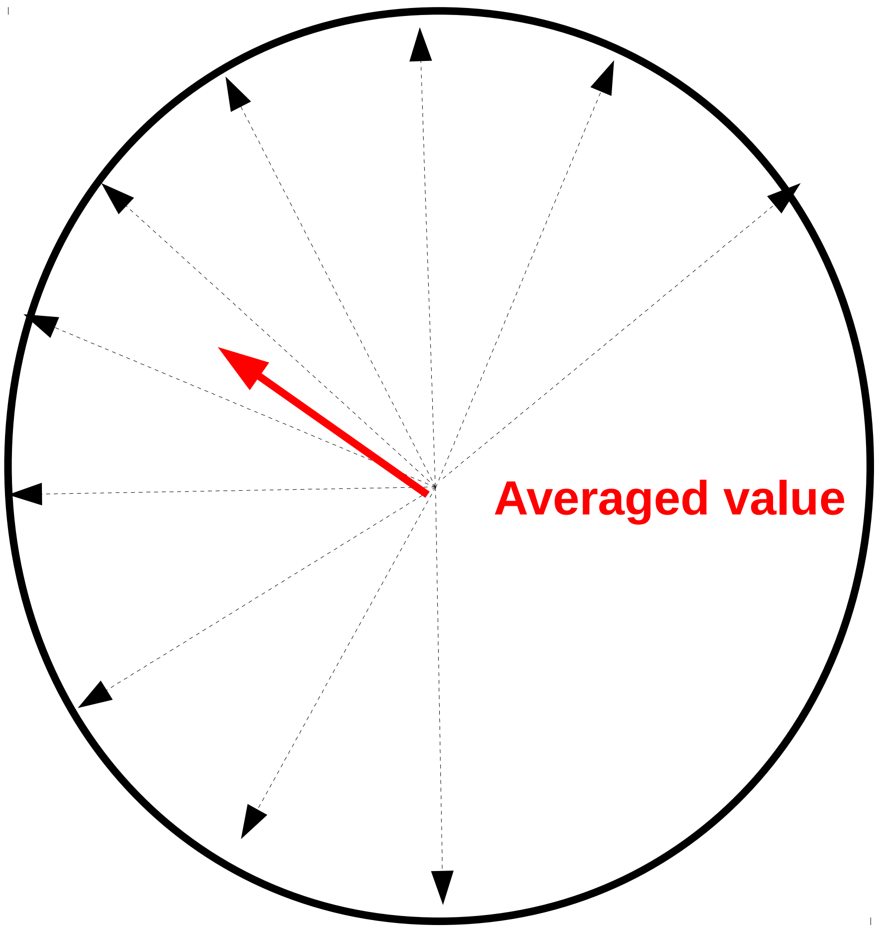
Time/Frequency Smearing (“decorrelation”): For one baseline

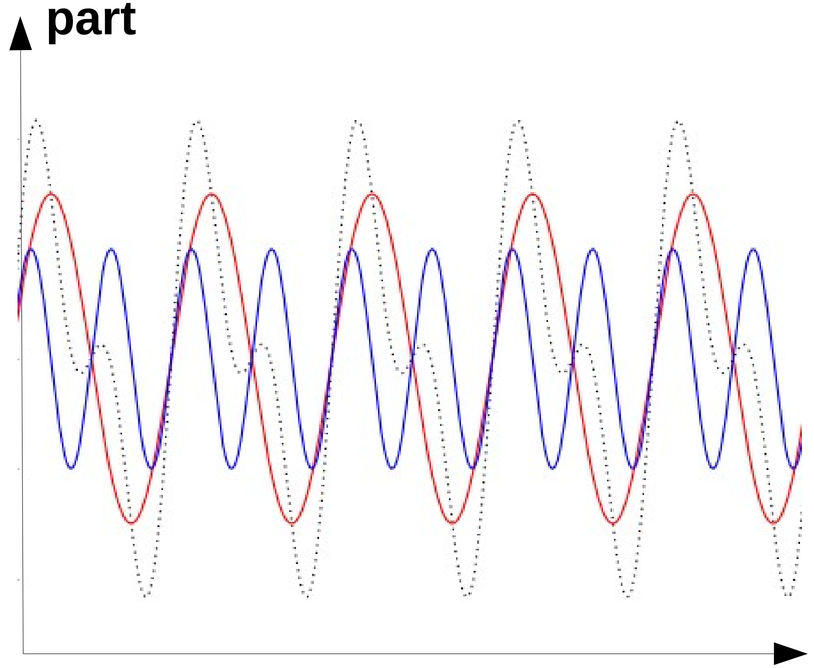




$$\phi_{pq} = u_{pq}l + v_{pq}m + w_{pq}(\sqrt{1 - l^2 - m^2} - 1)$$

Time/Frequency Smearing ("decorrelation"): For one baseline





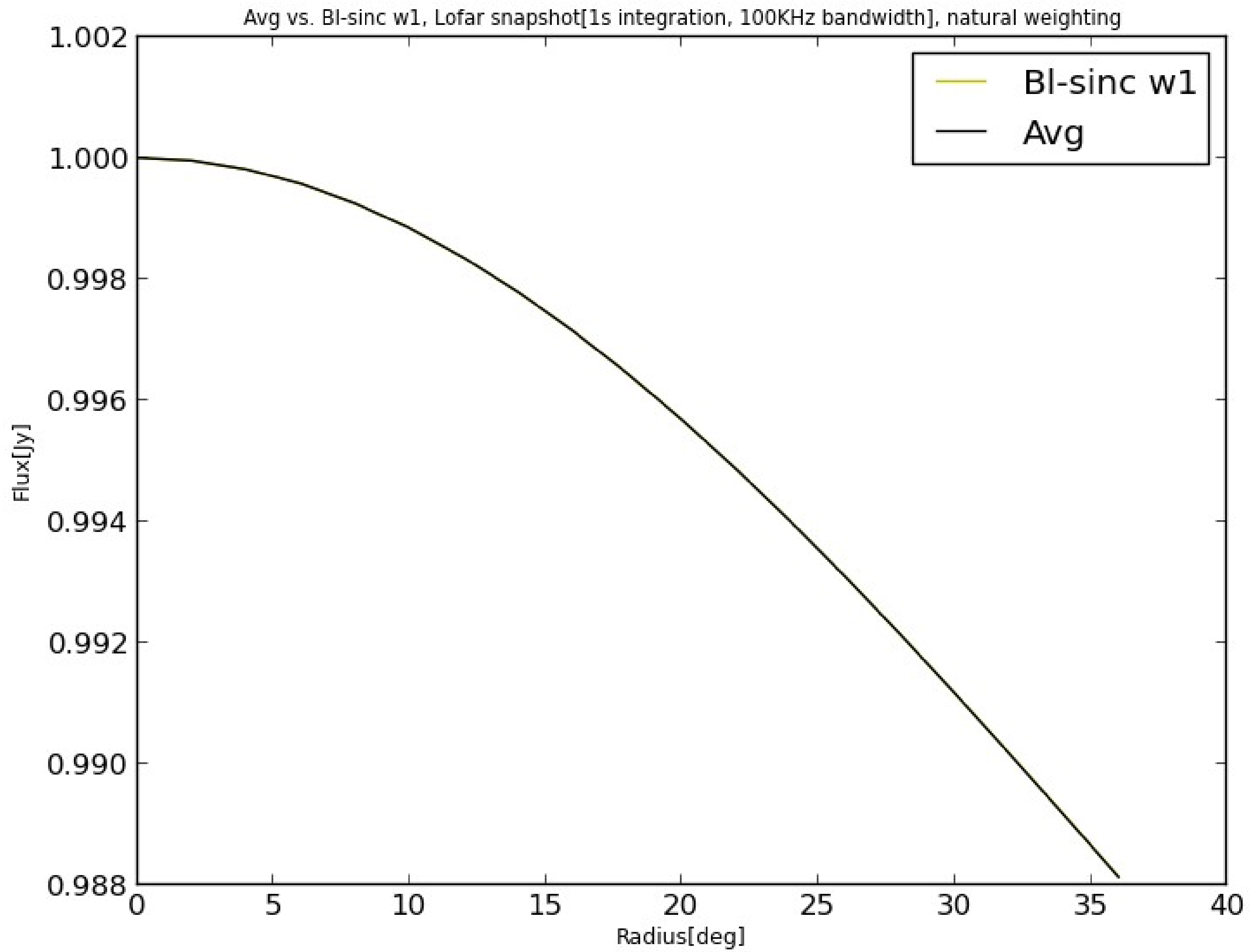
$$K_p K_q^+ = \exp(-2i\pi\phi_{pq}) \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$\phi_{pq} = u_{pq} l + v_{pq} m + w_{pq}(\sqrt{1 - l^2 - m^2} - 1)$$

Time/Frequency Smearing ("decorrelation"): For one baseline

Simulation for NenuFAR
Courtesy: Oleg Smirnov
And Marcellin Atemkeng

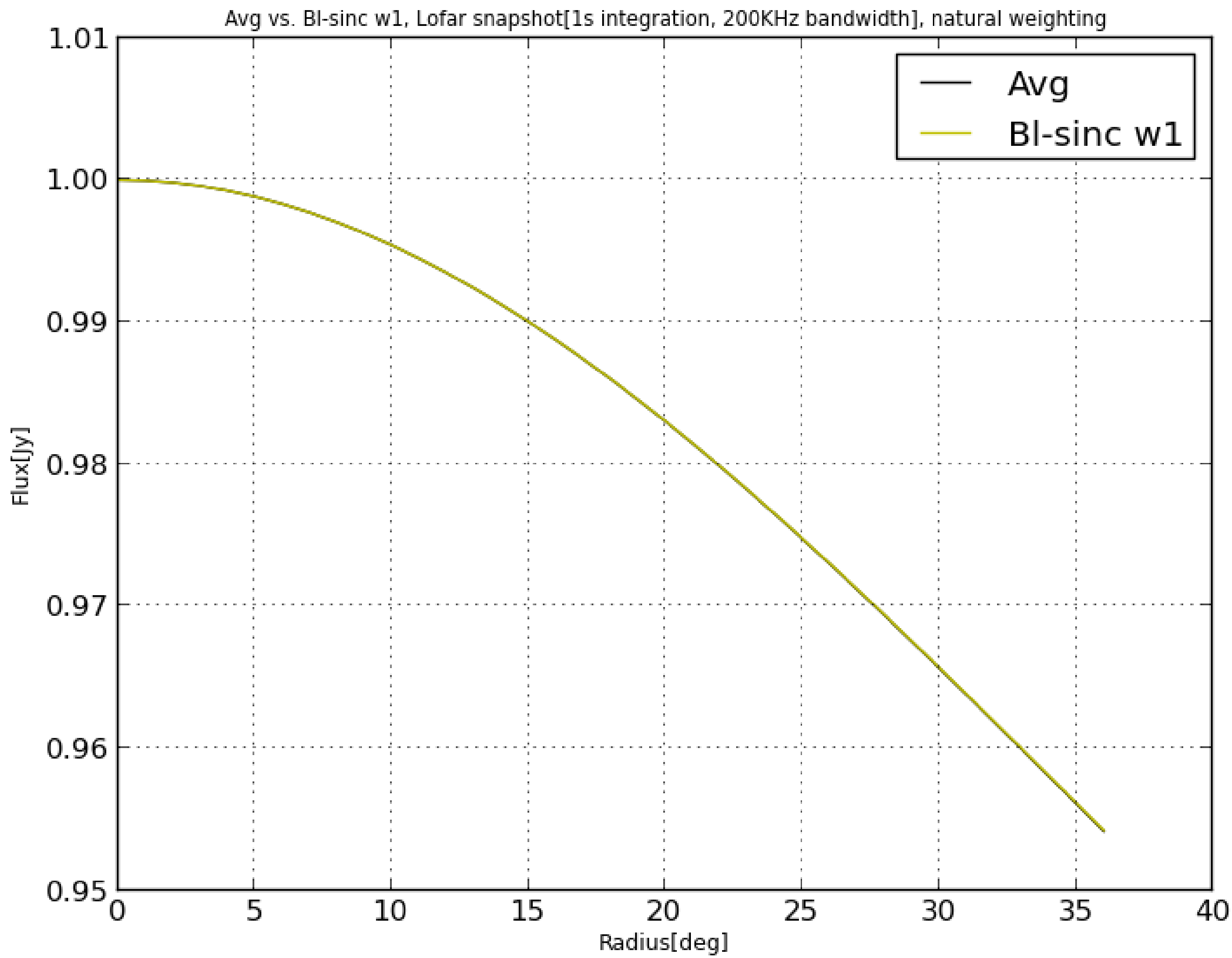
delta-t=1s
delta-f=100kHz



Time/Frequency Smearing ("decorrelation"): For one baseline

Simulation for NenuFAR
Courtesy: Oleg Smirnov
And Marcellin Atemkeng

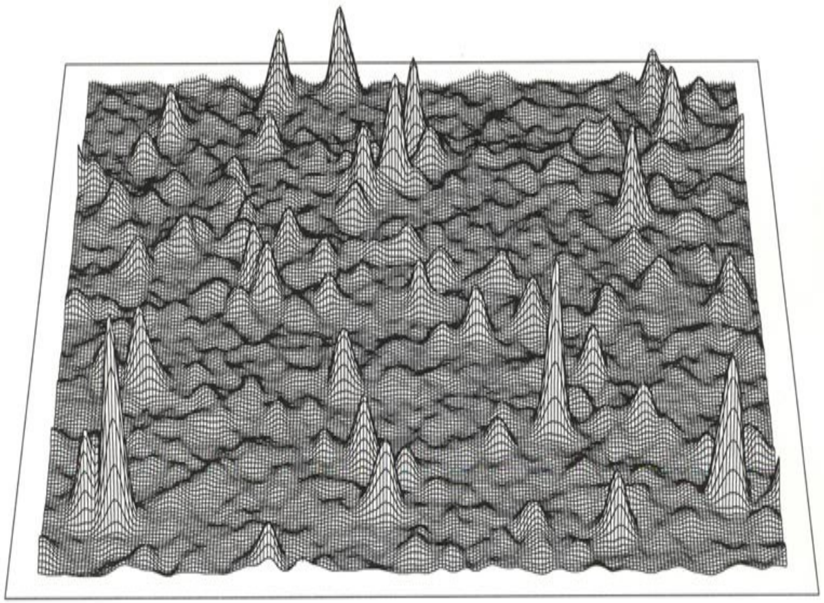
delta-t=1s
delta-f=200kHz



Confusion limit

- Source density is too high
    Cannot be separated anymore

- Confusion limit:
    Depth beyond which **thermal noise** is lower than **confusion noise**



Confusion limit

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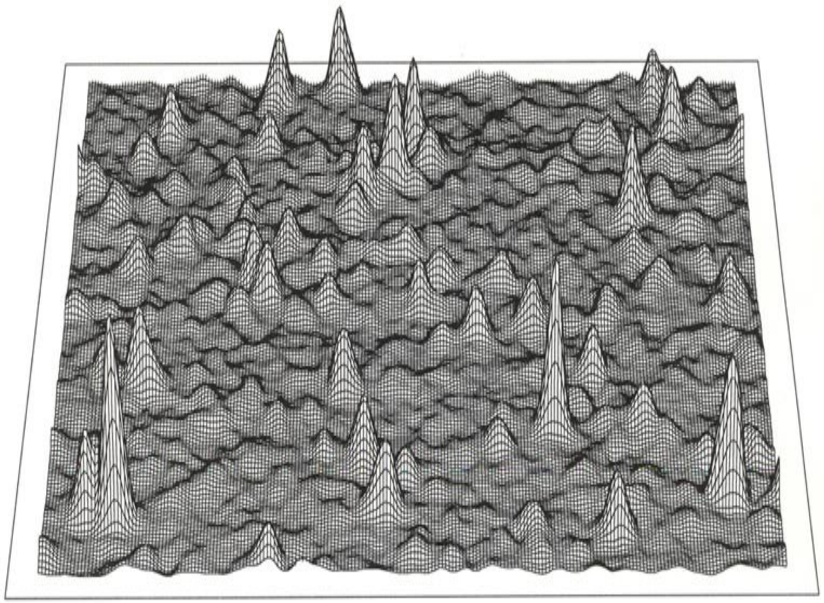


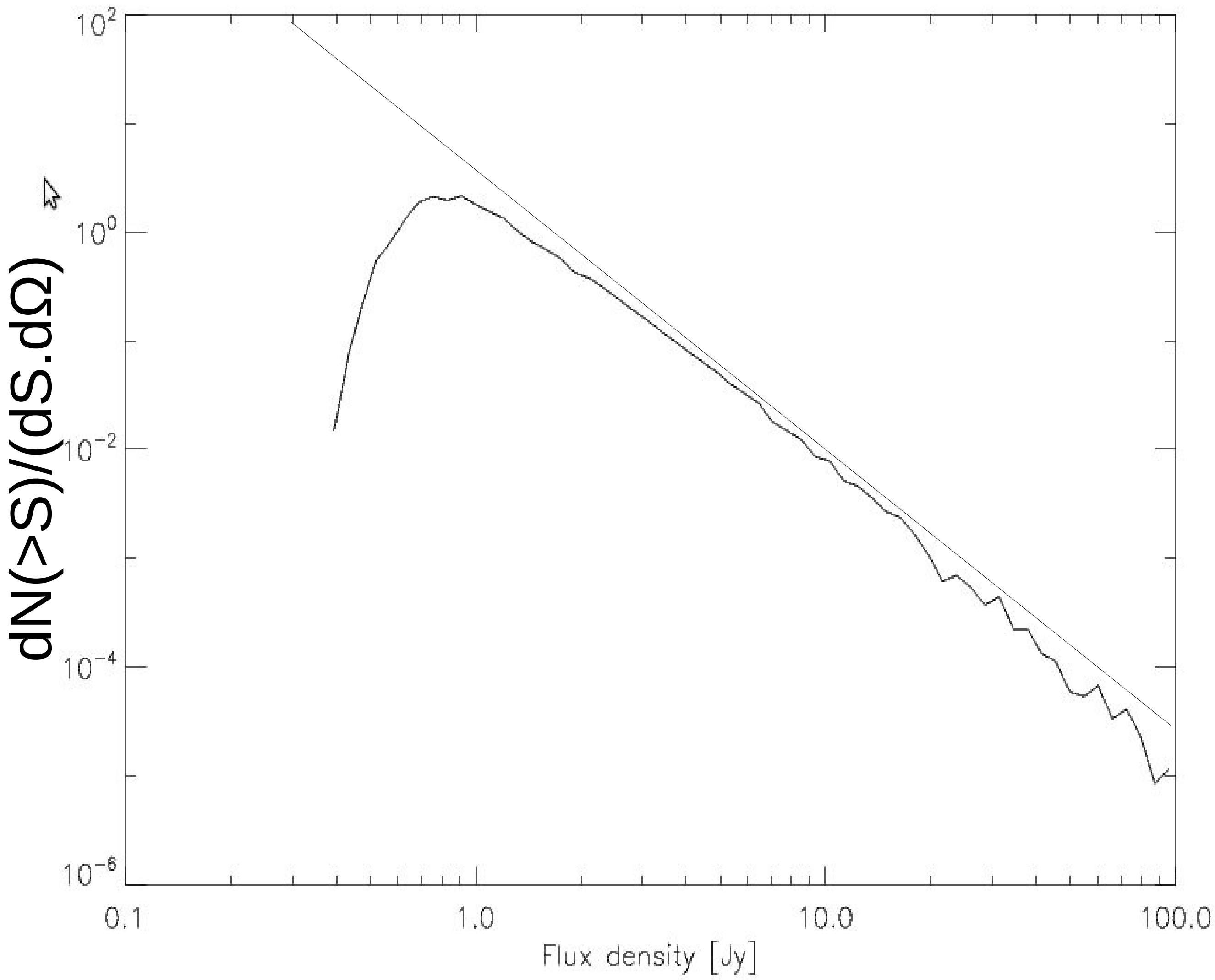
- Confusion limit:
  Depth beyond which **thermal noise** is lower than **confusion noise**

- ***Deflection*** (Condon 74) is the intensity observed in a beam taken at random assuming:
  - Poissonian spacial distribution of sources
  - a source count: n(S)=k.S^gamma

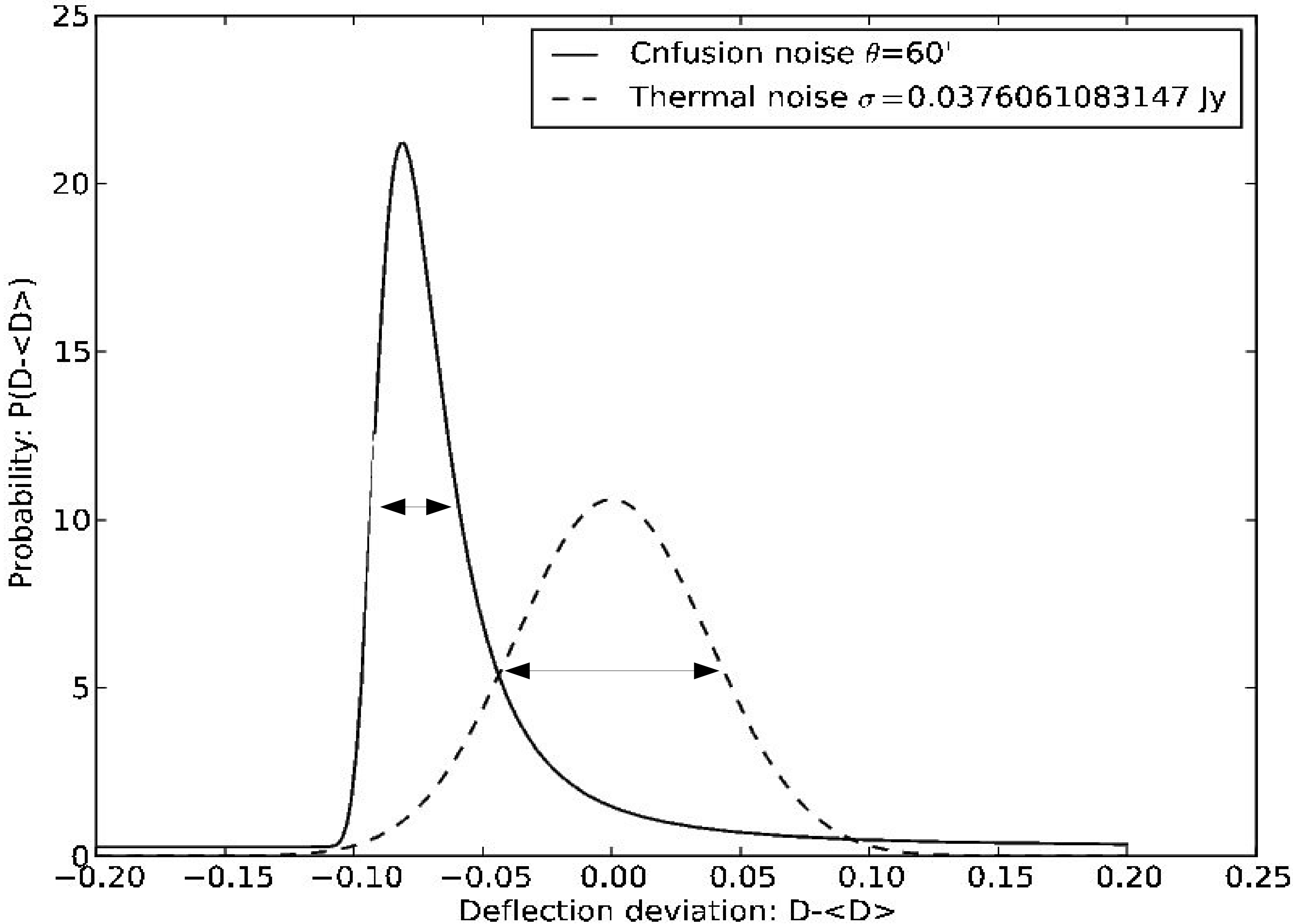
VLSS (74 MHz) source counts

We assume:
n(S)=k*S^gamma

Then go to 50 MHz: S=a*nu^-0.8

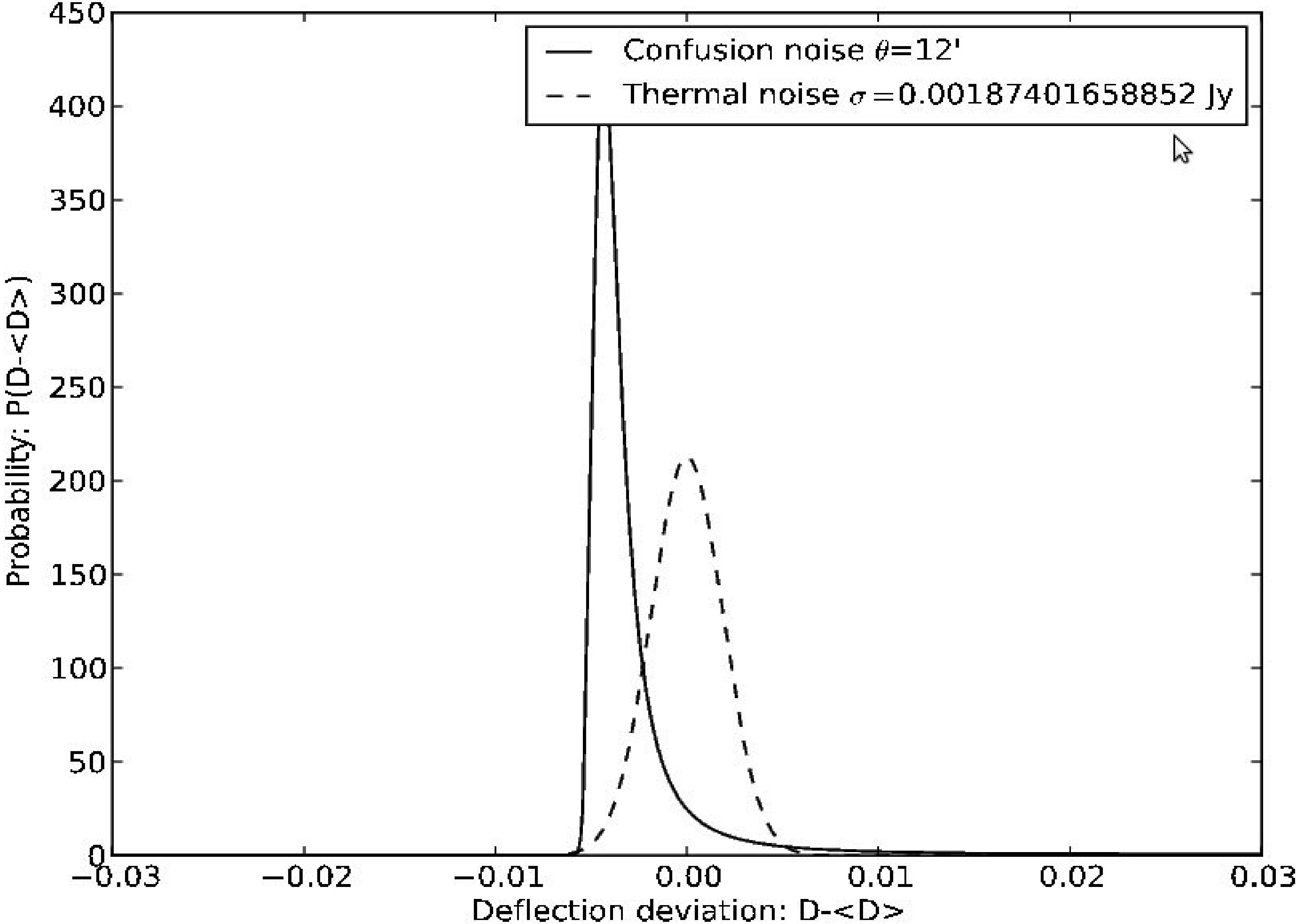


P(D-<D>)

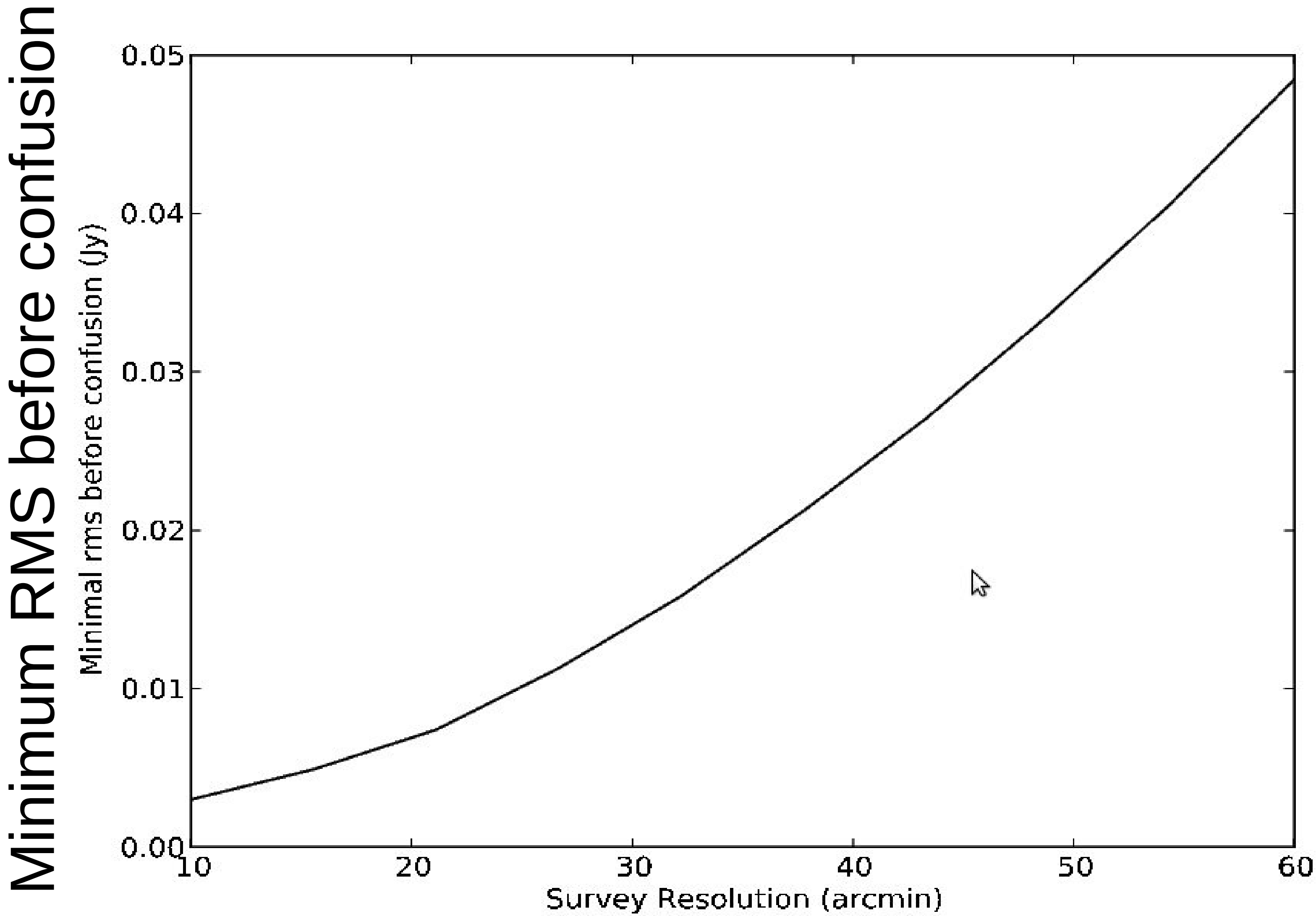


Cnfusion noise θ=60'
Thermal noise σ=0.0376061083147 Jy
Probability: P(D-<D>)
Deflection deviation: D-<D>
0
5
10
15
20
25
−0.20
−0.15
−0.10
−0.05
0.00
0.05
0.10
0.15
0.20
0.25

P(D-<D>)

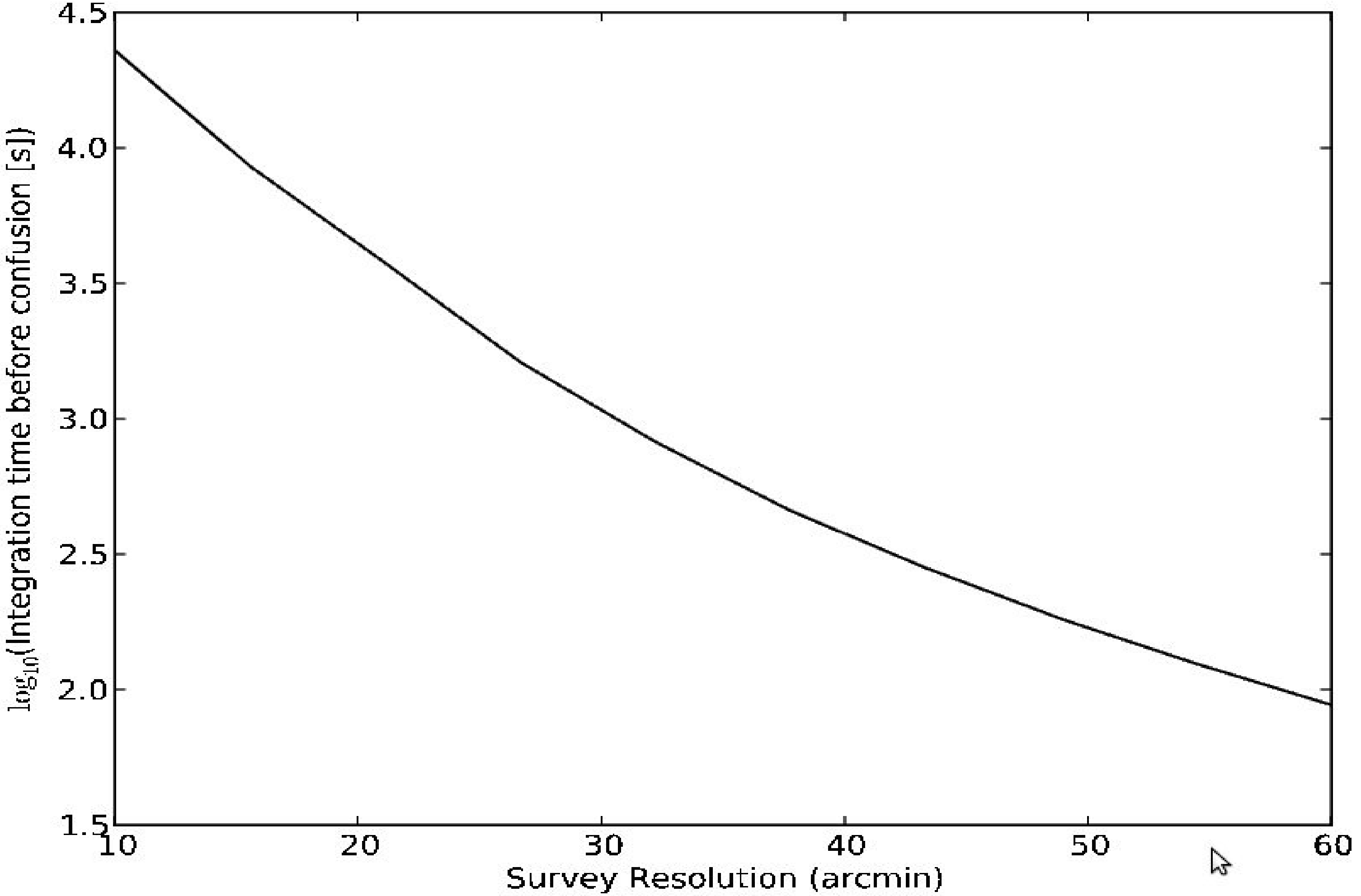

Confusion noise θ=12'
Thermal noise σ =0.00187401658852 Jy
Probability: P(D-<D>)
Deflection deviation: D-<D>
0
50
100
150
200
250
300
350
400
450
−0.03
−0.02
−0.01
0.00
0.01
0.02
0.03

Minimal thermal noise before confusion



Maximum integration time before confusion

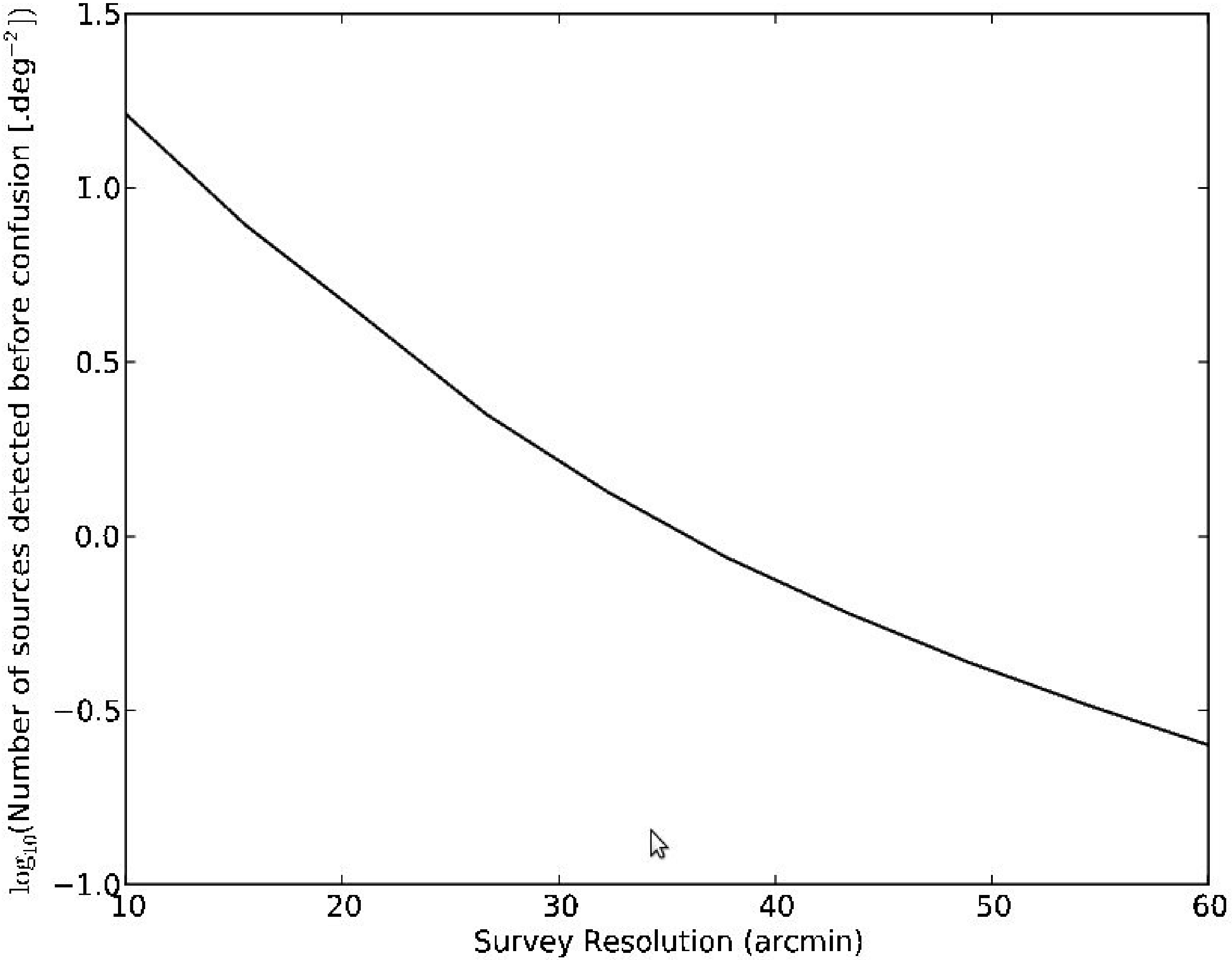
Integration time



Tsky=1.15.10^8/f^2.5 (K): @ f=40 MHz, T=20000K

Number of sources detected before confusion

Maximum number of resolved sources



Calibration and imaging (Standalone)

- **Ionosphere:**
  - Simple TEC gradient: simplifies a lot the problem
  - Faraday rotation, BUT differencial Faraday rotation

- **Phased array beam:**
  - Need good model of individual elementary antenna
  - Need to measure the errors in cable length (inside mini-arrays)
    (we won't be able to correct that because of the analog beam former)

- **Calibration ("Classic" calibration):**
  - Low-frequency skymodels available from MSSS/VLSS
  - Importance of short baselines, and extended emission?

- **Imaging:**
  - Ionosphere is present but array is compact
  - Fast imaging for transients?

- **EoR/Dark Ages:**
  - The big difference with LOFAR EoR: confusion
  - We'll have to think of working on alternative schemes:
    - Individual baseline 1D images
    - Power spectrum as is done for PAPER

Conclusion

NenuFAR: high sensitivity, low resolution

- **Confusion:**
  - Confusion limit comes after tens to a hundreds seconds
  - Is the main difference with other interferometers

- **Smearing / decorrelation:**
  - Is not a problem in terms of amplitude loss

- **Calibration:**
  - Good calibration should be trivial
    (and inspired by Stefan Wijnholds work on LOFAR stations)
  - High quality calibration is more tricky perhaps