

ALMA OT: Sensitivity Calculator

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EUROPEAN ARC

ALMA Regional Centre || Germany



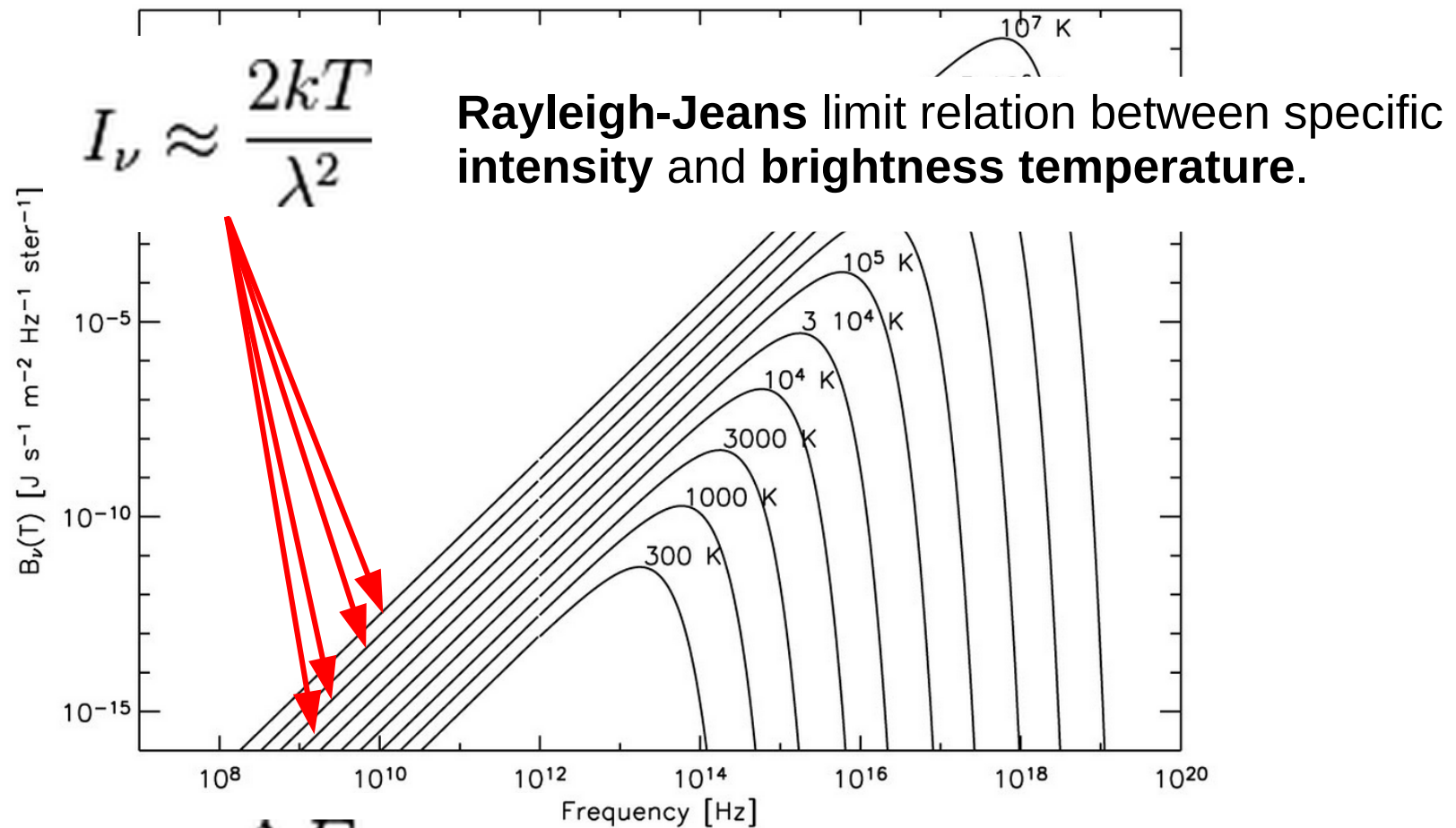
ALMA OT: Sensitivity Calculator

Brief outline:

- What are we measuring (brief theoretical discussion)
- How to use the sensitivity calculator
- What to look out for
- Minor wrap-up



ALMA OT: Sensitivity Calculator



$$I_\nu = \frac{\Delta E}{\Delta \Omega \Delta A \Delta t \Delta \nu} \quad [\text{erg s}^{-1} \text{ cm}^{-2} \text{ Hz}^{-1} \text{ Sr}^{-1}]$$

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$$P_\nu = I_\nu dA d\Omega$$

$$= \frac{2kT_{src}}{\lambda^2} dA d\Omega$$

RJ limit means: power ~ specific intensity
~ (brightness) temperature

$$= 2kT_{src}$$

$$T_{sys} = T_{sky} + T_{Rx} \quad \text{Something we don't need!}$$

$$T_{sys} \gg T_{src}$$

We need T_{src} ! What to do?

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$$T_{sys} \gg T_{src} \leftarrow \text{This is usually the case!}$$

$$T_{src} > T_{rms} \leftarrow \text{This is what we need to get a measurement!}$$

$$T_{rms} = \frac{T_{sys}}{\sqrt{N}} \leftarrow \text{Reduce } T_{rms} \text{ by sampling } T_{sys} \dots$$

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$$T_{rms} = \frac{T_{sys}}{\sqrt{N}}$$

The noise when measuring T_{sys} decreases with increasing N (sampling points)

But what *is* N ?

$N \sim n(n-1)/2$ = number of baselines, n is the number of antennas

$\sim \Delta\nu$ = frequency range (bandwidth) in Hz

$\sim t$ = exposure time (on source time) in seconds

~ 2 = a factor for double polarization mode

$$T_{rms} \simeq \frac{T_{sys}}{\sqrt{n(n-1) \cdot \Delta\nu \cdot t}} [\text{K}]$$

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Back to flux and Jansky... or milliJansky (mJy):

$$SEFD = \frac{T_{sys}}{(K/Jy)} = \frac{T_{sys}}{A_e/2k}$$

System Equivalent Flux Density

$$S_{rms} \approx \frac{SEFD}{\sqrt{n(n-1) \cdot \Delta \nu \cdot t}} [\text{Jy}]$$

$n(n-1)$ ~ number of baselines, n is the number of antennas

$\Delta \nu$ = frequency range (bandwidth) in Hz

t = exposure time (on source time) in seconds

ALMA OT: Sensitivity Calculator

Inputs to calculator:

- declination (for elevation)
- frequency (e.g. for atmospheric absorption etc.)
- weather (optional)
- number of antennas (gives number of baselines)
- resolution (gives the Δv)
- integration time (gives the value of t)

Output:

- Sensitivity reached

The screenshot shows the ALMA OT Sensitivity Calculator interface. It is divided into two main sections: 'Common Parameters' and 'Individual Parameters'. Red arrows point to input fields, and green arrows point to output fields.

Common Parameters:

- Dec: 10:00:00.000
- Polarization: Dual
- Observing Frequency: 100.0 GHz
- Bandwidth per Polarization: 5.0 km/s
- Water Vapour Column Density: 5.186mm (7th Octile)
- tau/Tsky: tau=0.054, Tsky=16.480 K
- Tsys: 83.464 K

Individual Parameters:

| | 12m Array | 7m Array | Total Power Array |
|--------------------|-------------|------------------|-------------------|
| Number of Antennas | 34 | 9 | 2 |
| Resolution | 5.0 arcsec | 20.612211 arcsec | 61.836633 arcsec |
| Sensitivity(rms) | 0.92236 mJy | 10.65809 mJy | 21.84647 mJy |
| (equivalent to) | 0.00451 K | 0.00307 K | 0.00070 K |
| Integration Time | 1 h | 1 h | 1 h |

Integration Time Unit Option: Automatic

Buttons: Calculate Integration Time, Calculate Sensitivity, Close

ALMA OT: Sensitivity Calculator

Inputs to calculator:

- declination (for elevation)
- frequency (e.g. for atmospheric absorption etc.)
- weather (optional)
- number of antennas (gives number of baselines)
- resolution (gives the Δv)
- desired sensitivity (gives the value of S_{rms} or T_{rms})

Output:

- Integration time required

The screenshot shows the ALMA OT Sensitivity Calculator interface. It is divided into two main sections: Common Parameters and Individual Parameters.

Common Parameters:

- Dec: -20:00:00.000
- Polarization: Dual
- Observing Frequency: 100.0 GHz
- Bandwidth per Polarization: 5.0 km/s
- Water Vapour Column Density: Automatic Choice (selected), Manual Choice (unselected)
- tau/Tsky: tau=0.054, Tsky=16.480 K
- Tsys: 79.838 K

Individual Parameters:

| | 12m Array | 7m Array | Total Power Array |
|-------------------------------------|---------------------------|---------------------|---------------------|
| Number of Antennas | 34 | 9 | 2 |
| Resolution | 5.0 arcsec | 20.612211 arcsec | 61.836633 arcsec |
| Sensitivity(rms) (equivalent to) | 10.00000 mJy 0.04891 K | 10 mJy 0.00288 K | 10 mJy 0.00032 K |
| Integration Time | 28.02397 s | 1.03941 s | 4.36707 s |

Integration Time Unit Option: Automatic

Buttons: Calculate Integration Time, Calculate Sensitivity, Close

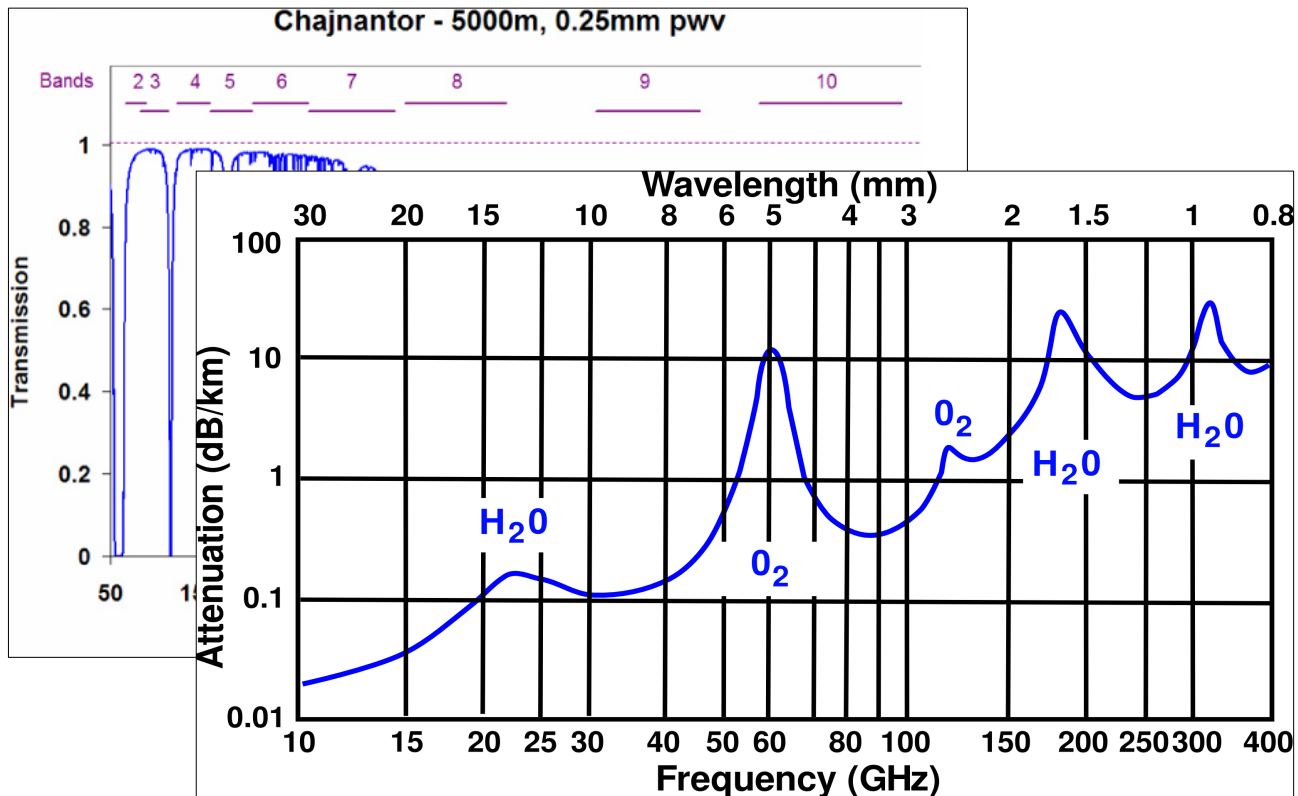
Red arrows point to input fields: Dec, Polarization, Observing Frequency, Bandwidth per Polarization, Water Vapour Column Density, Number of Antennas, Resolution, Sensitivity(rms), and Integration Time for all three array types.

Green arrows point to output fields: Integration Time for all three array types.

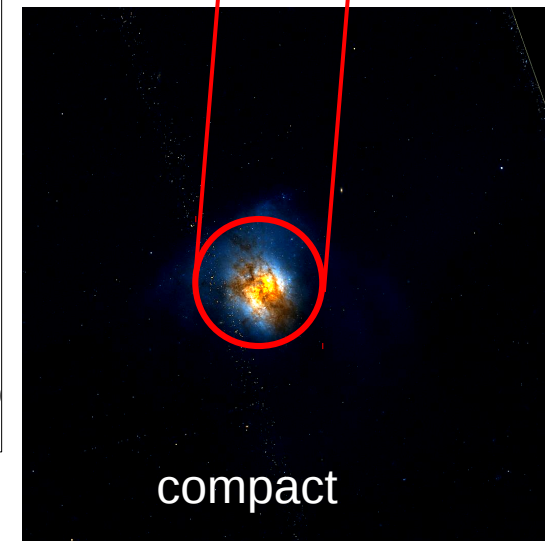
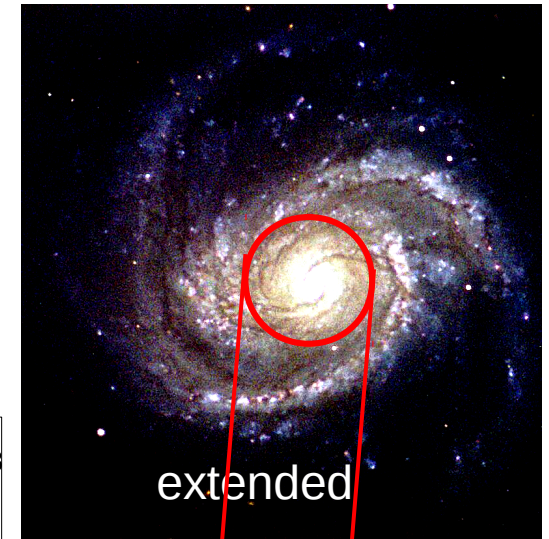
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What to look out for?

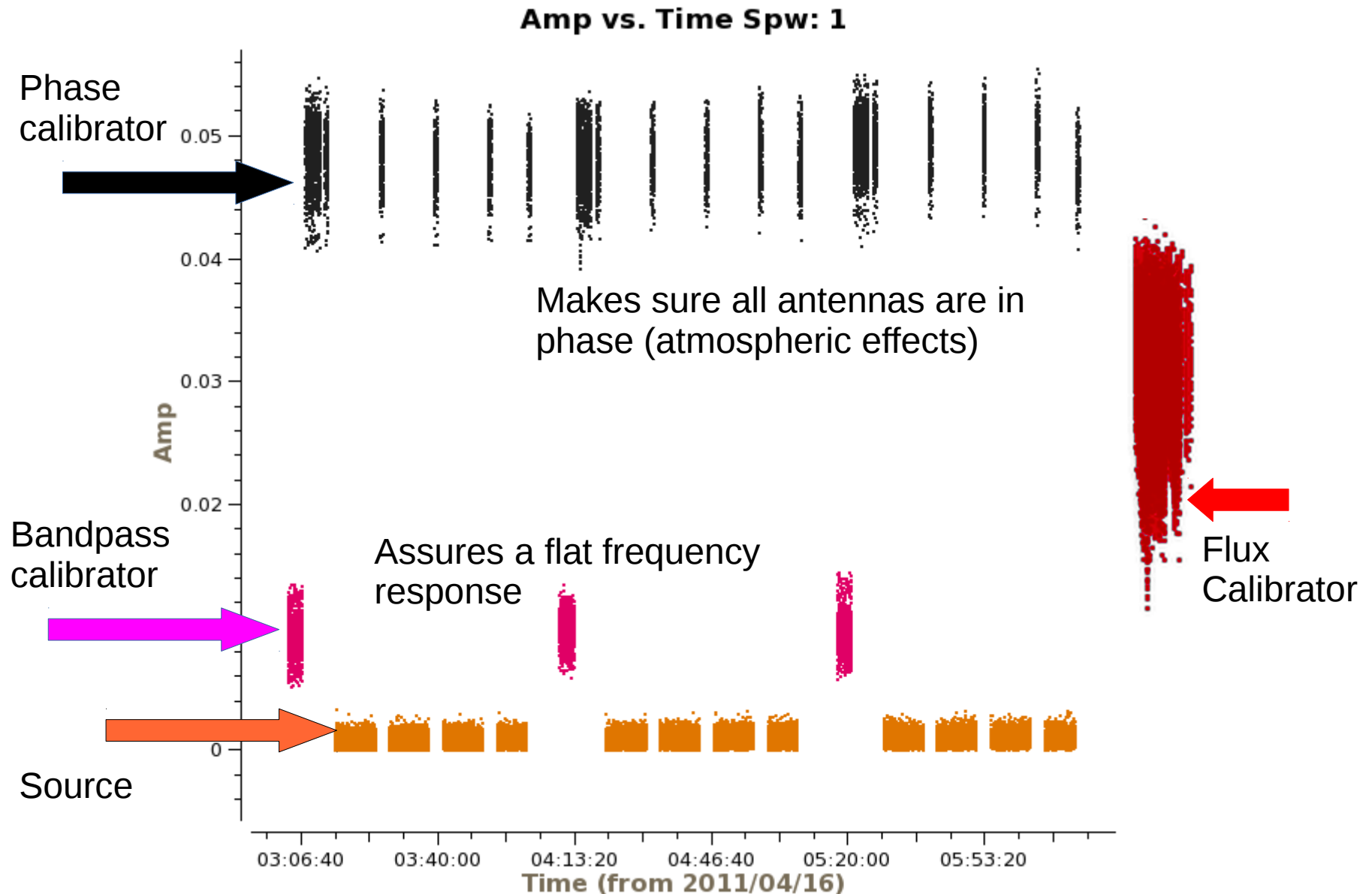
Atmospheric absorption:



Source size:



Notes on calibration:





Thank you,
and make sure to check the summary slides in the
afternoon