Practical Examples

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Italian ARC, Tutorial per ALMA Cyclo 1

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Scope of the presentation

- Provide tips to fill in the Observing Tool Fields

  - Field Setup: expected source properties
    - Peak continuum flux density per beam
    - Peak line flux density per beam

  - Control and performance
    - Largest angular scale
    - Use of ACA

  - Spectral line issues

Flux and Brightness Temperature

- Temperature and Fluxes (Rayleigh-Jeans)
  - S = Flux density (Jy, Jy per beam)
  - T = brightness temperature (K)
  - k Boltzmann constant
  - Ω_s solid angle (steradian)
  - θ_b HPBW of a gaussian

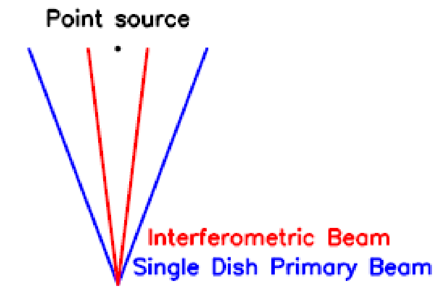
$$S = \frac{2\,k\,T\,\Omega_S}{\lambda^2}$$

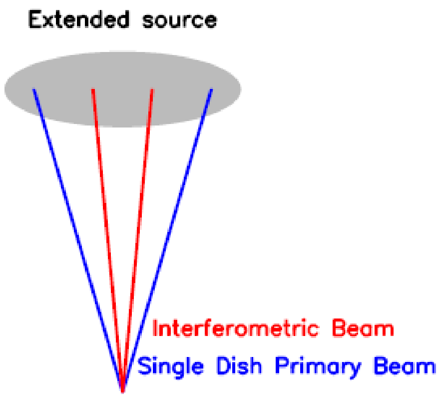
$$T = \frac{\lambda^2\,S}{2\,k\,\Omega_S}$$

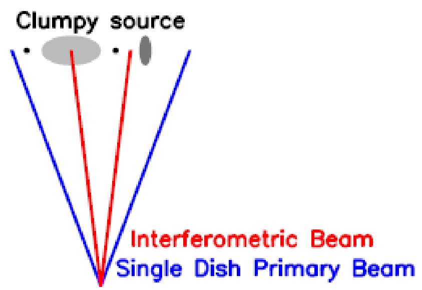
$$\Omega_S = \frac{\pi\,\theta_b^2}{4\,ln2}$$

Peak Flux estimation

- From observations at different resolution
  - Point source:
    - Flux (Jy or Jy/beam) independant of the Beam
    - T (K) ∝ 1/BeamSolidAngle (BeamSize^2) [beam dillution]
  - Extended uniform source
    - T independant of the beam
    - Flux (Jy /beam) ∝ BeamSolidAngle (BeamSize^2)
      - [if brightness is uniform over the source]
    - Largest recoverable angular scale !
      - Flux loss because a part extended emission is filtered out by the interferometer
  - Fragmented/Clumpy source
    - Number of clumps, size, relative strength, positions ?







Peak Flux estimation

- From Single Dish (10'') to Interferometry (1'')

T_{mb} = 1 K (km s^{-1}) in 10'' @ 300 GHz
Flux = 7.36 Jy (km s^{-1}) in 10'' @ 300 GHz

- Point source
  - $T \propto BeamSolidAngle^{-1}$
    - Interferometric Beam : 1''
    - $T_{mb}=1x(10^2)/(1^2) = 100$ K
  - Peak Flux = 7.36 Jy /beam

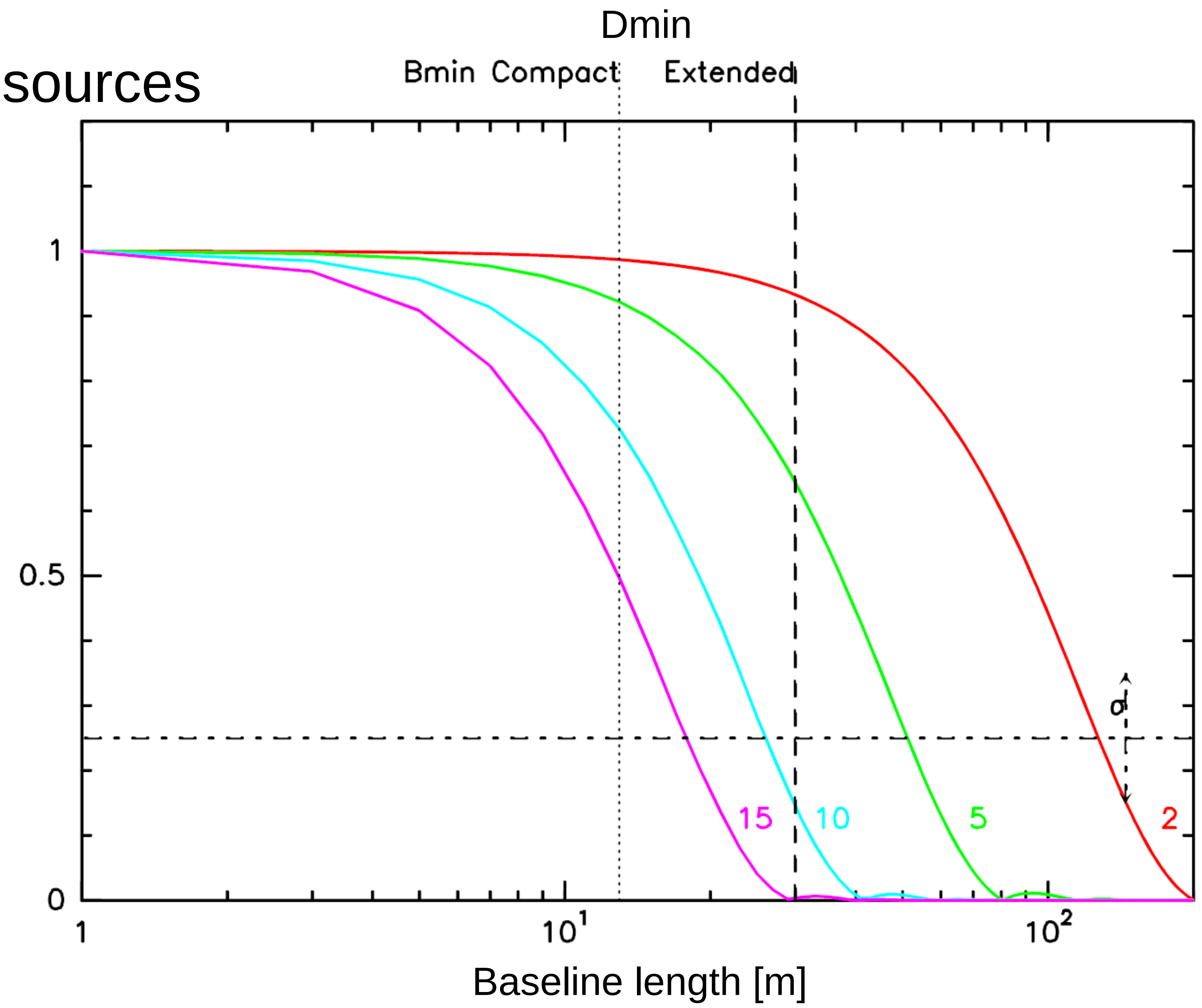
- Extended (uniform) source
  - T = 1 K everywhere
  - Flux $\propto$ BeamSolidAngle
    - Interferometric Beam 1''
    - $S_{int} = S_{SD}$ x (1^2) /(10^2) = 0.0736 Jy/beam
    - !! Largest recoverable scale !!

Largest recoverable scale

- Baselines > antenna size
  - Short spacing are missing in interferometry
  - Filtering of large scale emission
- LRS [´´] = $37200/D_{min}[m]/\nu[GHz]$
- ALMA Cycle 1 at 300 GHz
  - Compact configurations LRS ~ 6-8''
  - Most extended configurations LRS ~ 2''

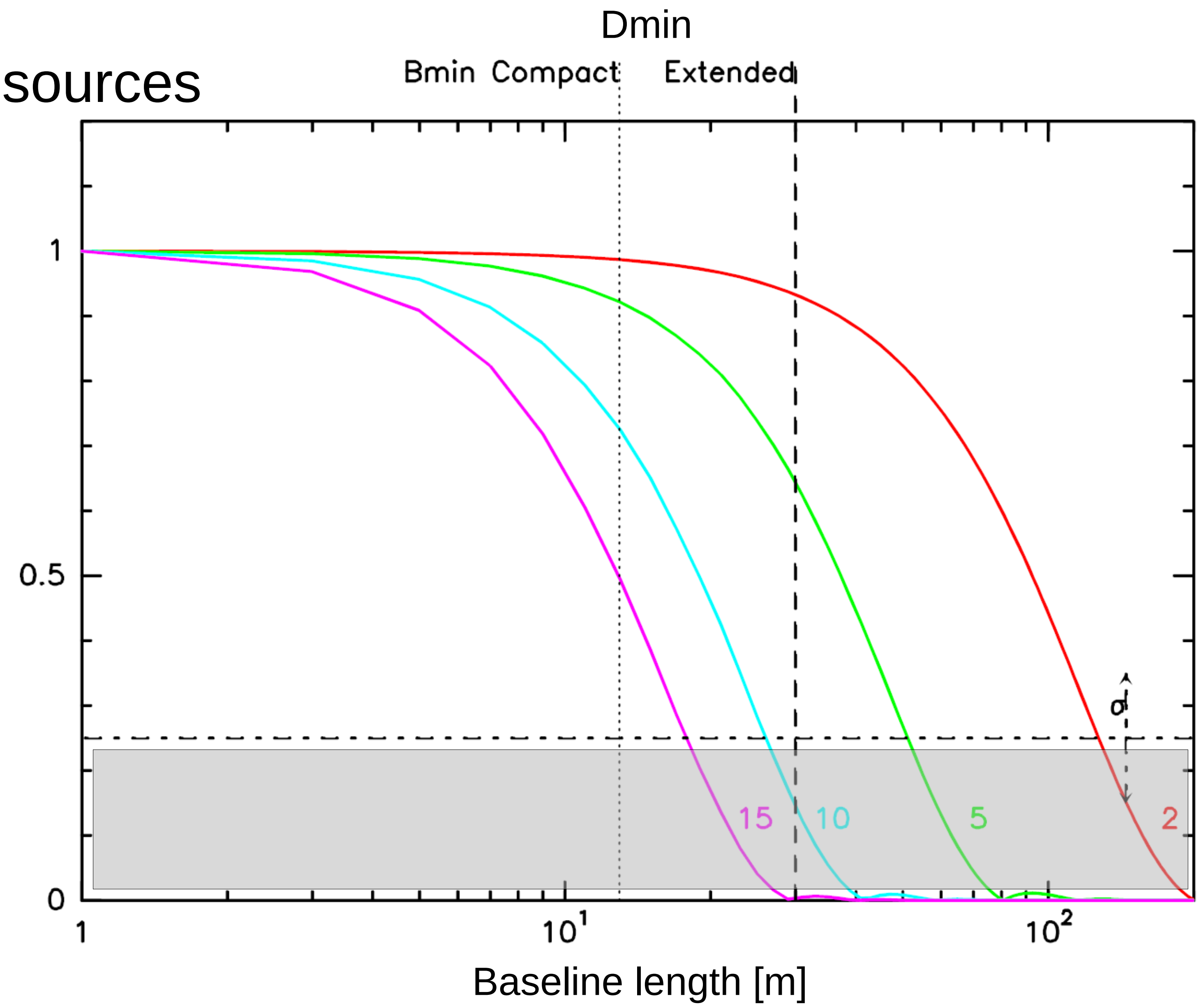
Largest recoverable scale

- Gaussian sources



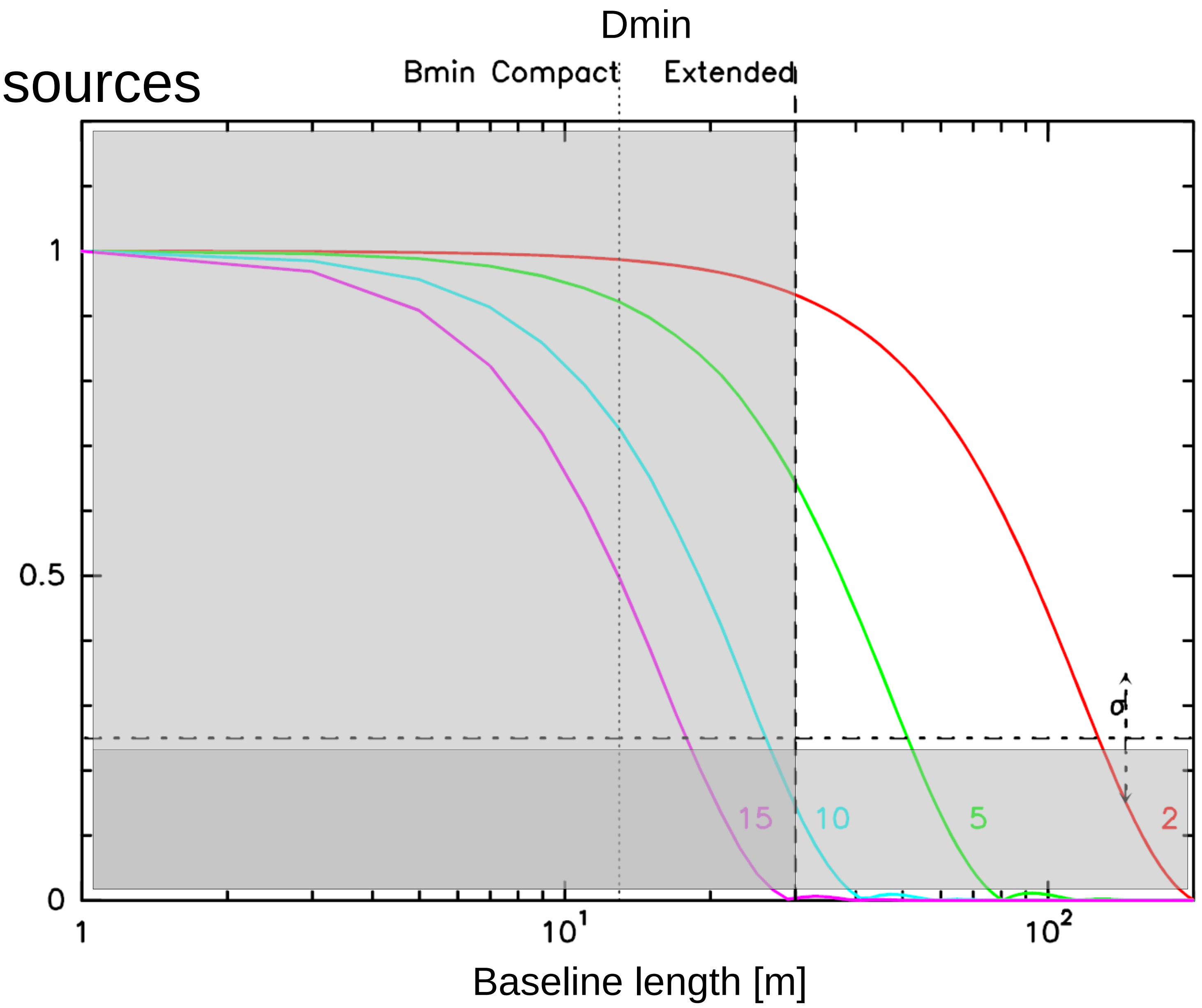
Largest recoverable scale

- Gaussian sources



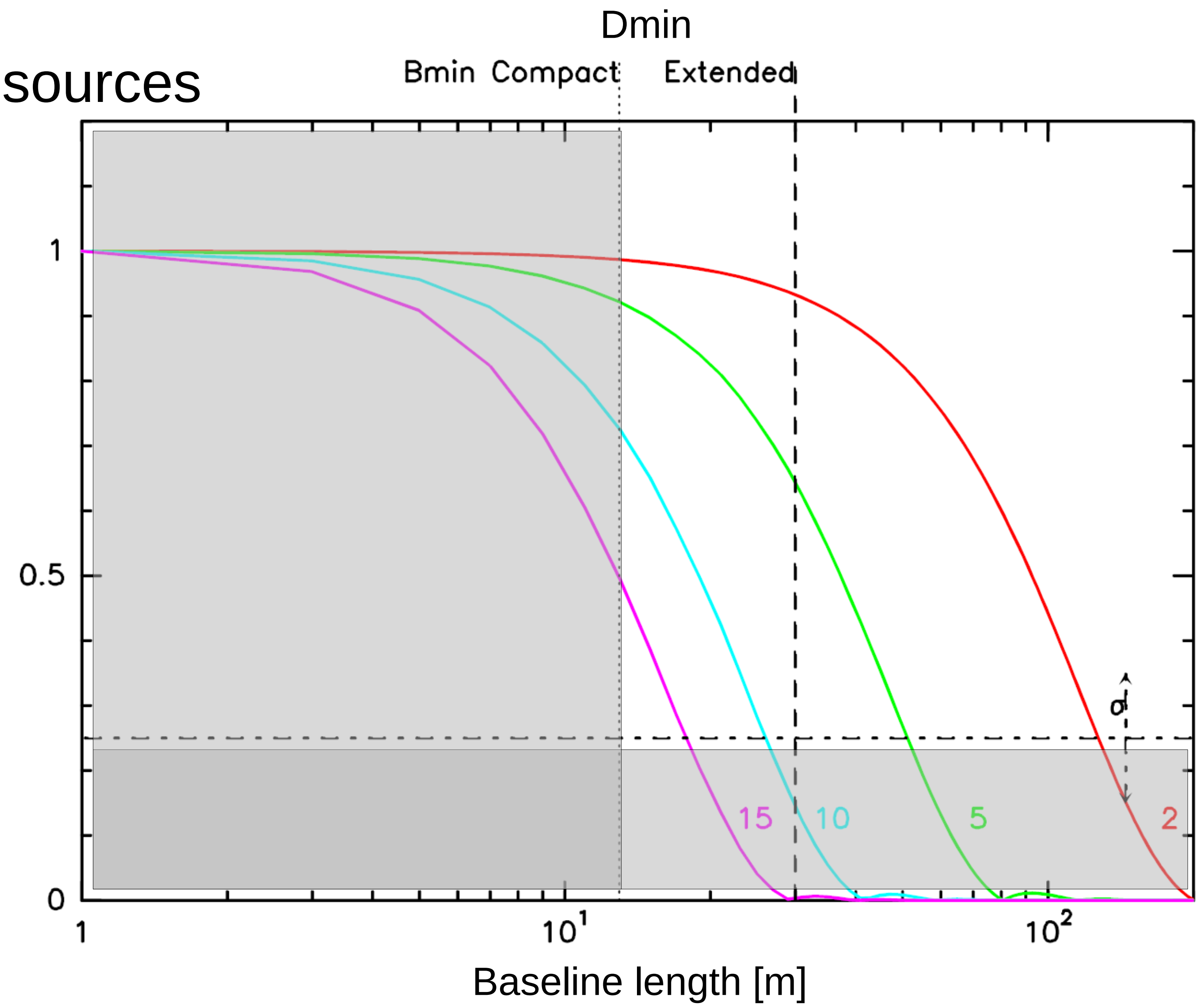
Largest recoverable scale

- Gaussian sources



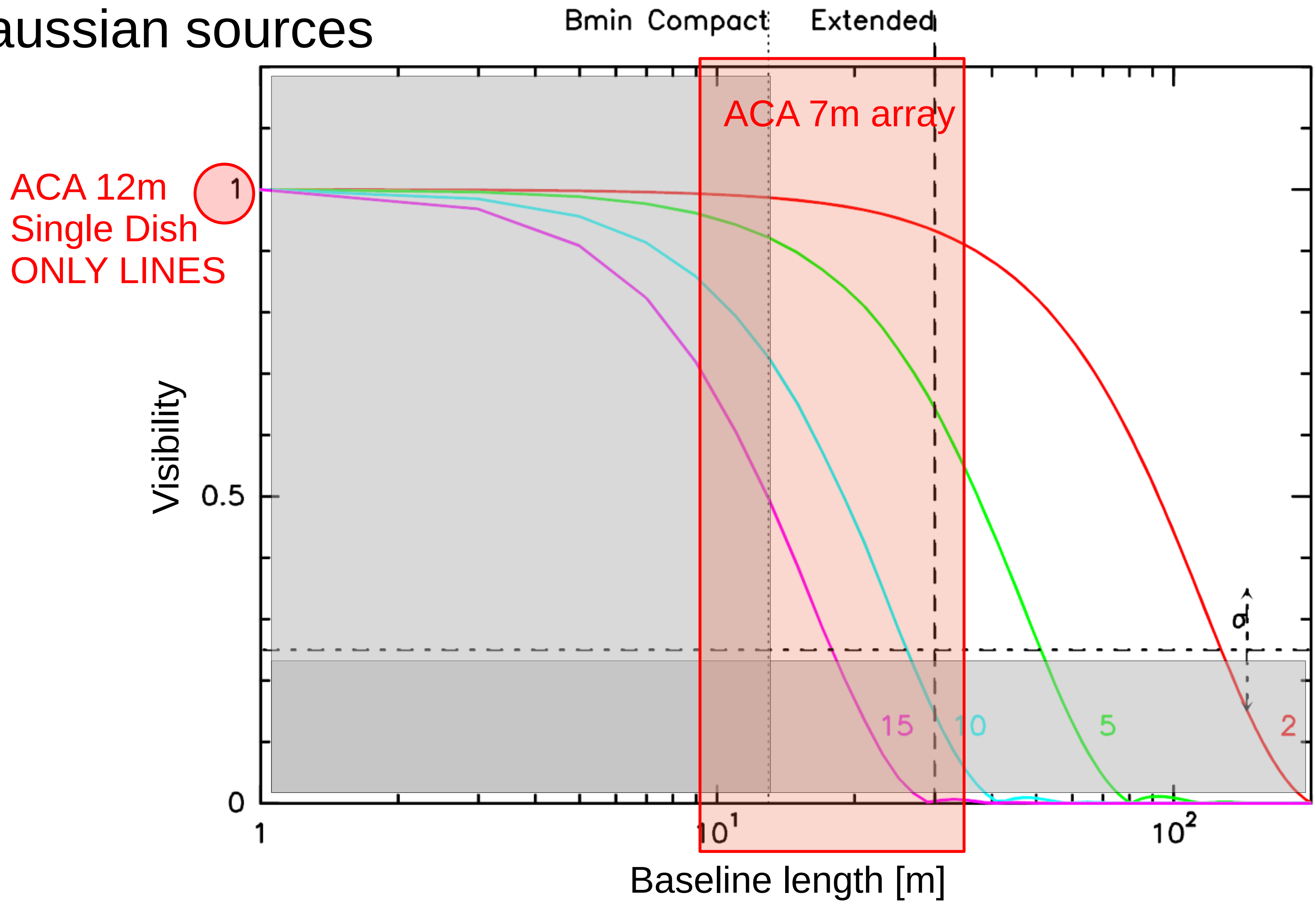
Largest recoverable scale

- Gaussian sources



Largest recoverable scale and ACA

- Gaussian sources



Largest recoverable scale and ACA

- Gaussian sources at 300GHz
  - FWHM 10'' (total flux ~14Jy)

Config.	Beam ''	Peak Flux Jy/beam	Total Flux Jy
1	1.4 x 1.3	0.36	~3
2	0.9 x 0.8	0.10	~1.5
4	0.6 x 0.4	0.009	~0.5
6	0.5 x 0.25	0	<0.01
ACA alone	5.8 x 5.5	5.7	~10

  - FWHM 3'' (total flux ~1.2 Jy)

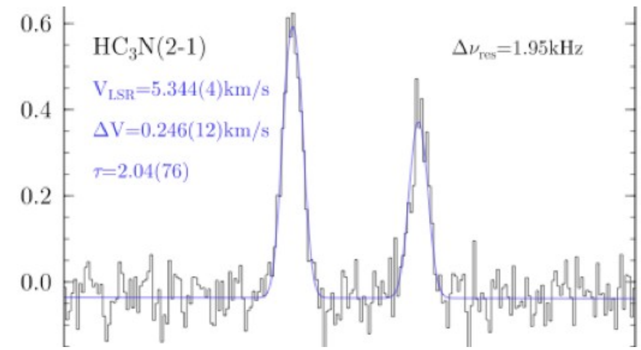
Config.	Beam ''	Peak Flux Jy/beam	Total Flux Jy
1	1.4 x 1.3	0.42	~1.2
2	0.9 x 0.8	0.2	~1.1
4	0.6 x 0.4	0.05	~0.5
6	0.5 x 0.25	0.008	~0.1
ACA alone	5.8 x 5.5	1.13	~1.2

ALMA cycle 1:
-ACA is not compatible with most extended configs (5-6) [lack of overlapping baselines]
-ACA alone cannot be requested

Spectral lines issues

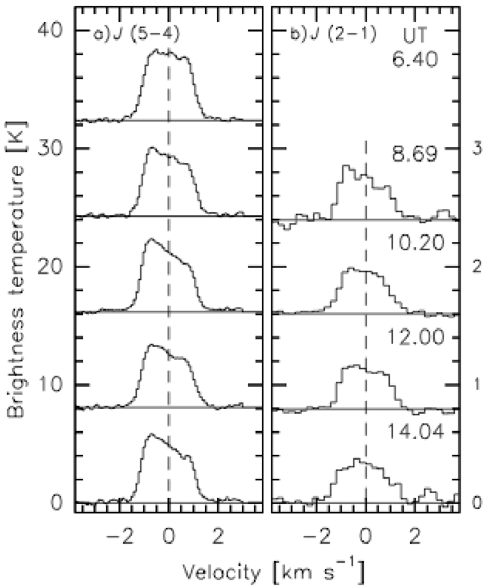
- Gaussian profile
  - Area(Jy kms^{-1}), FWHM (kms^{-1}) → Flux Peak (Jy)
    - SN on the peak

$$rms(Jy) = \frac{Area(Jy \cdot kms^{-1})}{FWHM(kms^{-1}) \cdot SN}$$

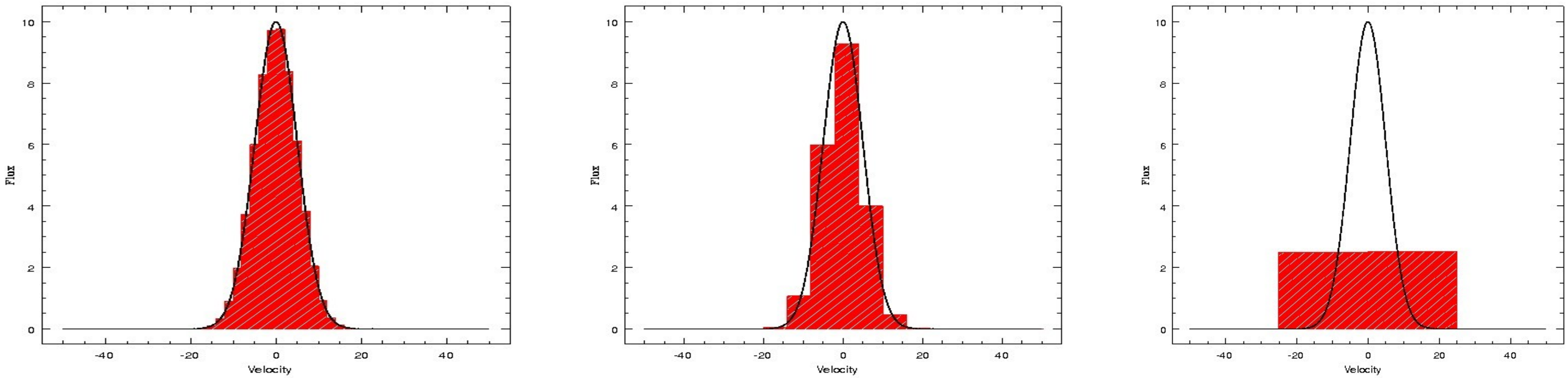


- Undefinied Profile
  - SN on the area (>SN on the peak)

$$rms(Jy) = \frac{Area(Jy \cdot kms^{-1})}{N_{chan}^{1/2} \cdot \Delta v(kms^{-1}) \cdot SN}$$



- Flux Peak doesn't depend on channel spacing (when FWHM > chan width)



- Sensitivity depends on channel spacing

$$\Delta S \propto \frac{T_{sys}}{D^2\left[n_p N(N-1)\Delta\nu\Delta t\right]^{1/2}} Wm^{-2}Hz^{-1}$$