Data analysis

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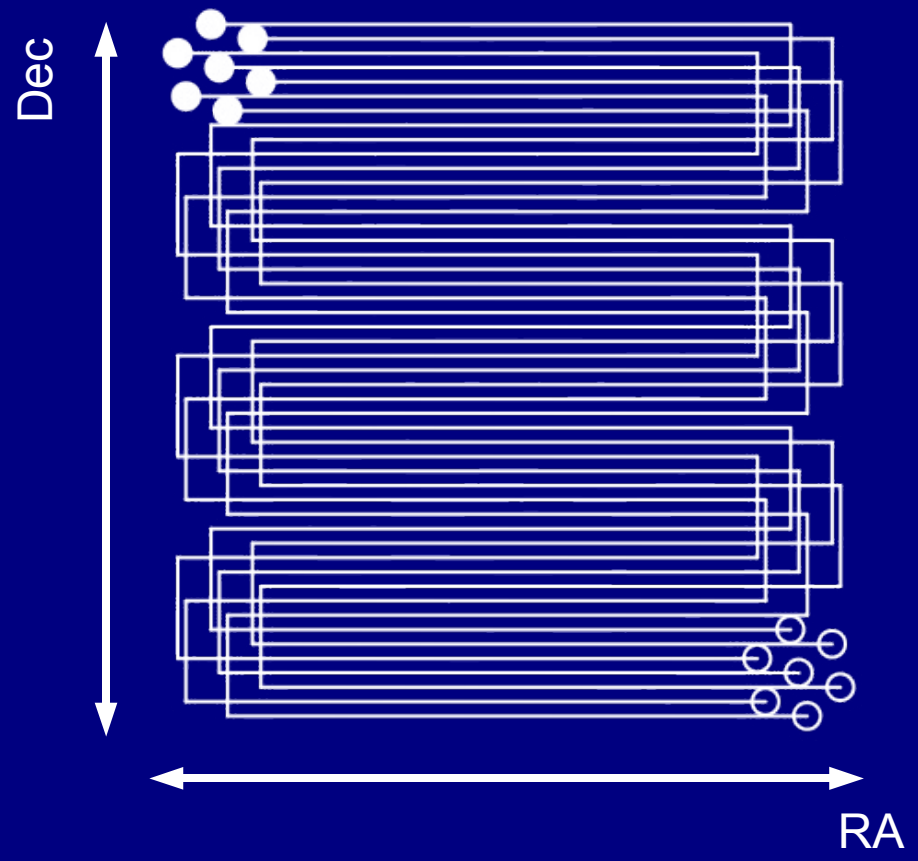
Map observations (spectroscopy)

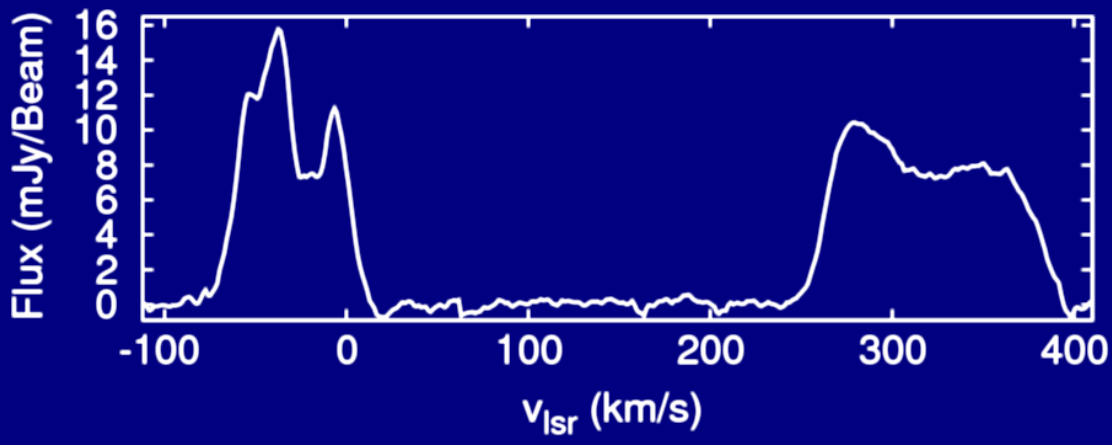
Map observations (spectroscopy)

e.g., Zig-Zag scanning

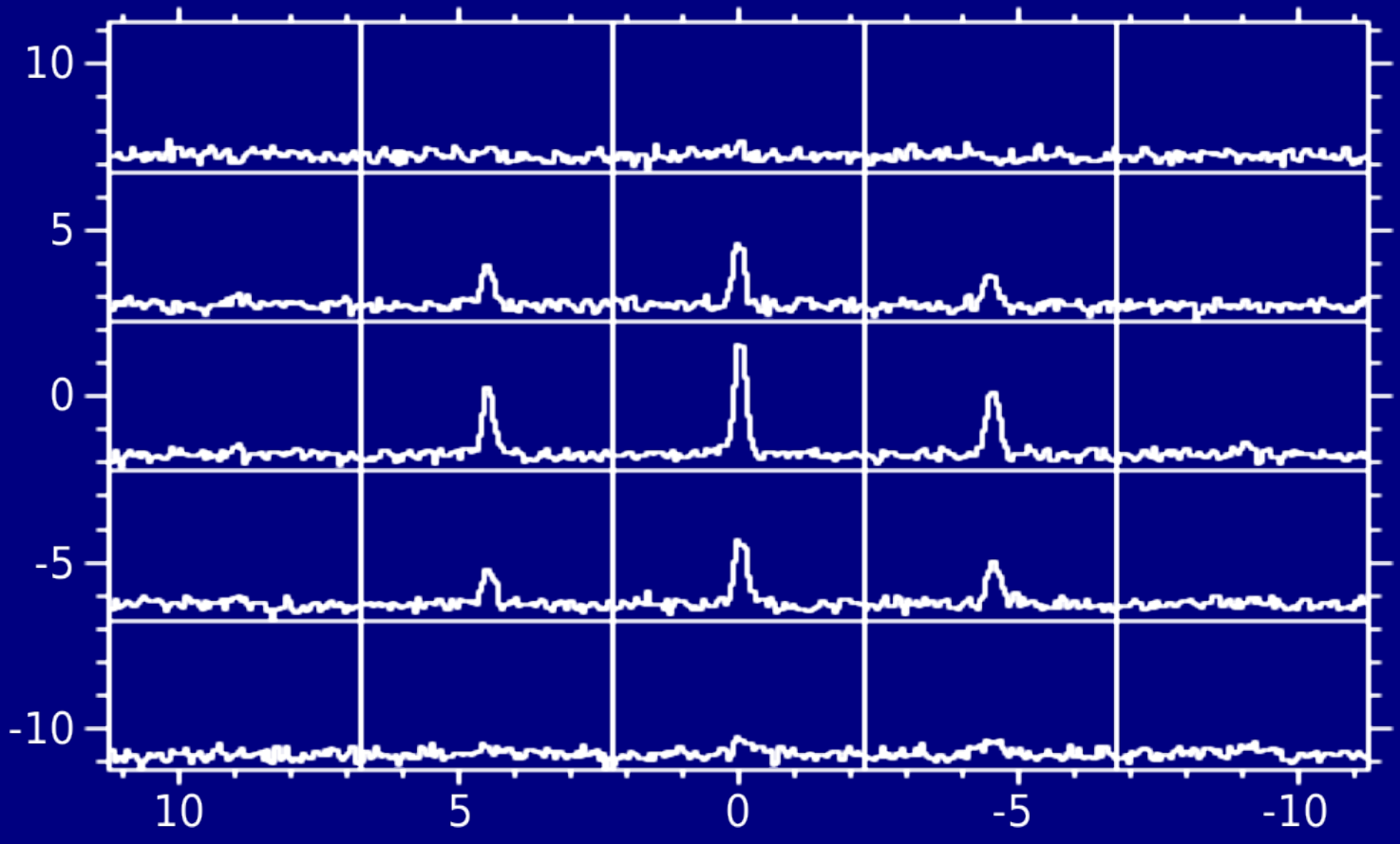


Map observations (spectroscopy)

N ×

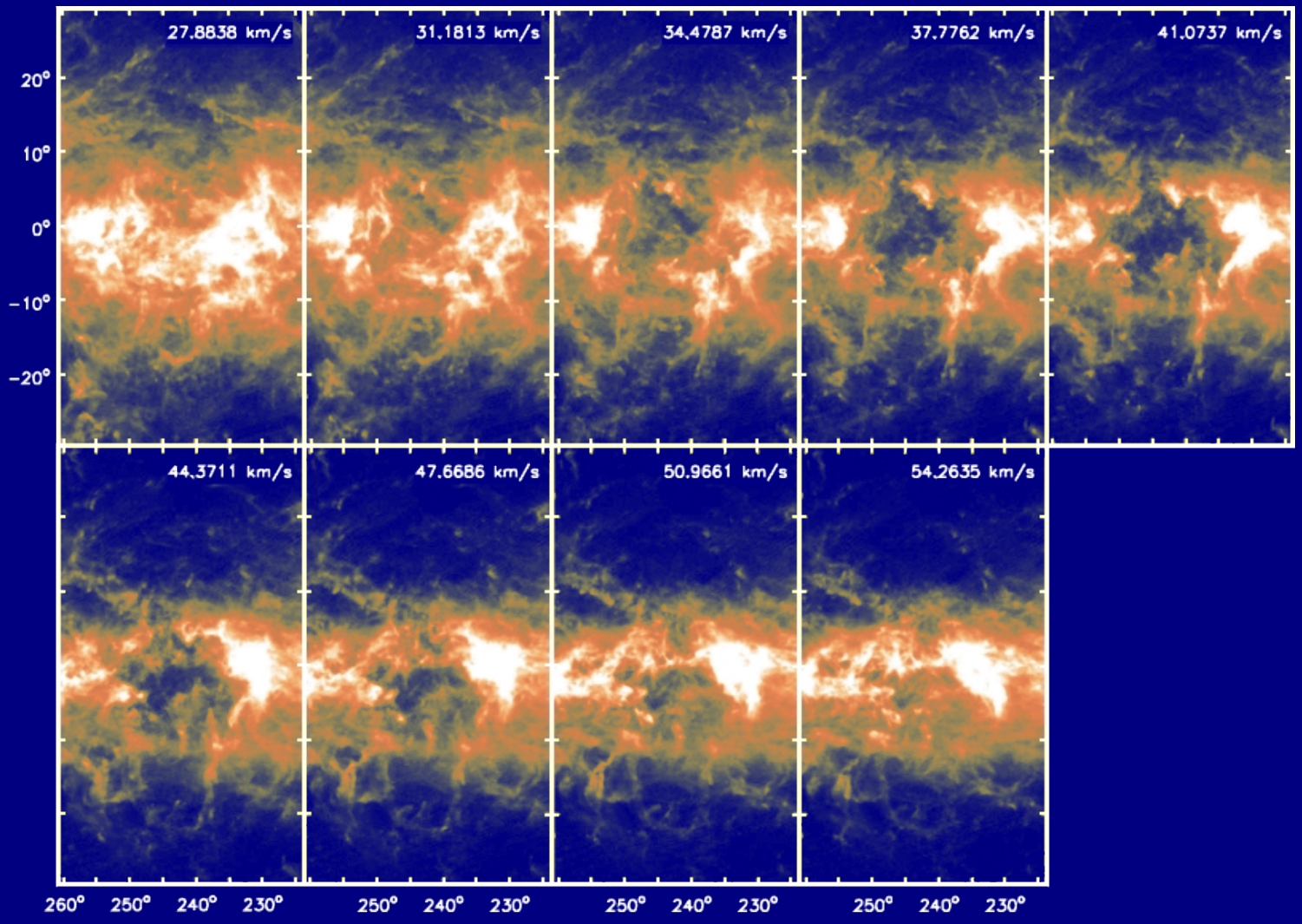


Map observations (spectroscopy)



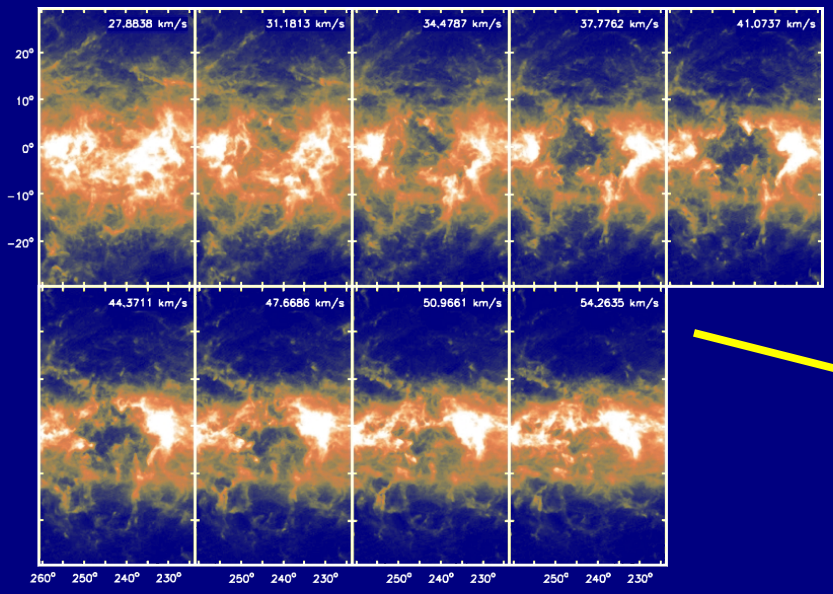
Brüns & Westmeier 2004

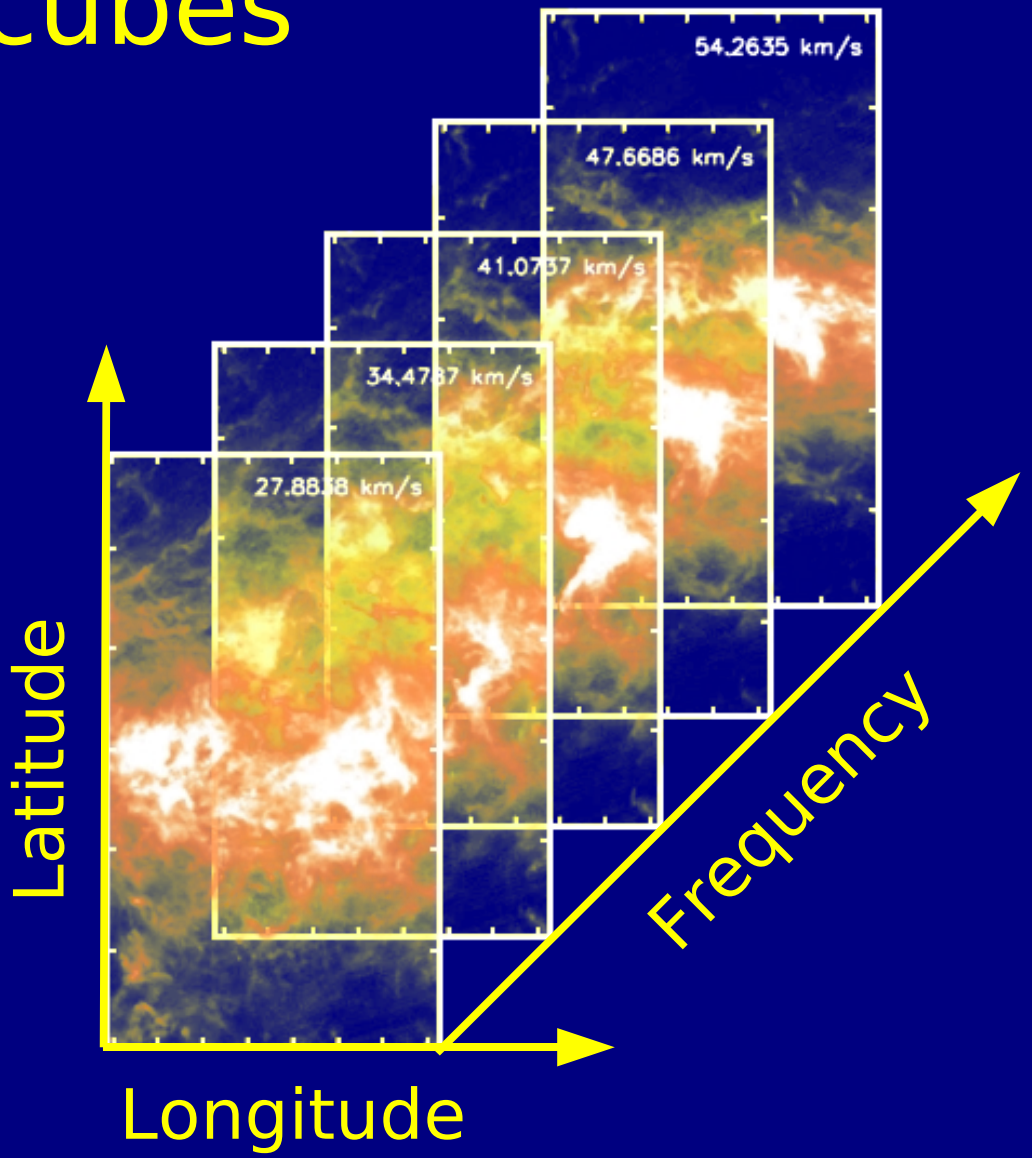
Map observations (spectroscopy)



McClure-Griffiths et al. 2006

Data cubes



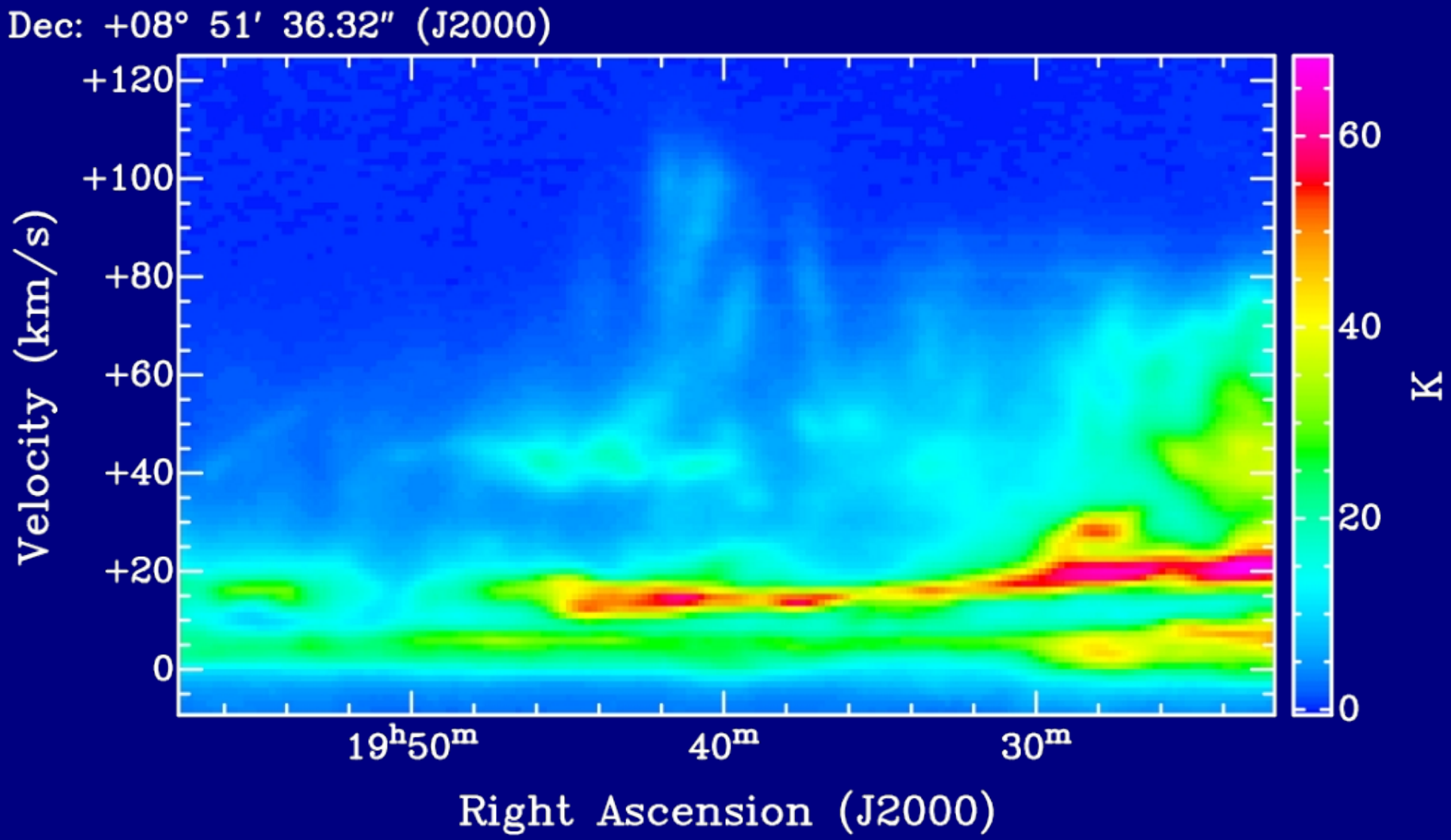


- 3D data structure
- But: objects in the data cube not 3D!

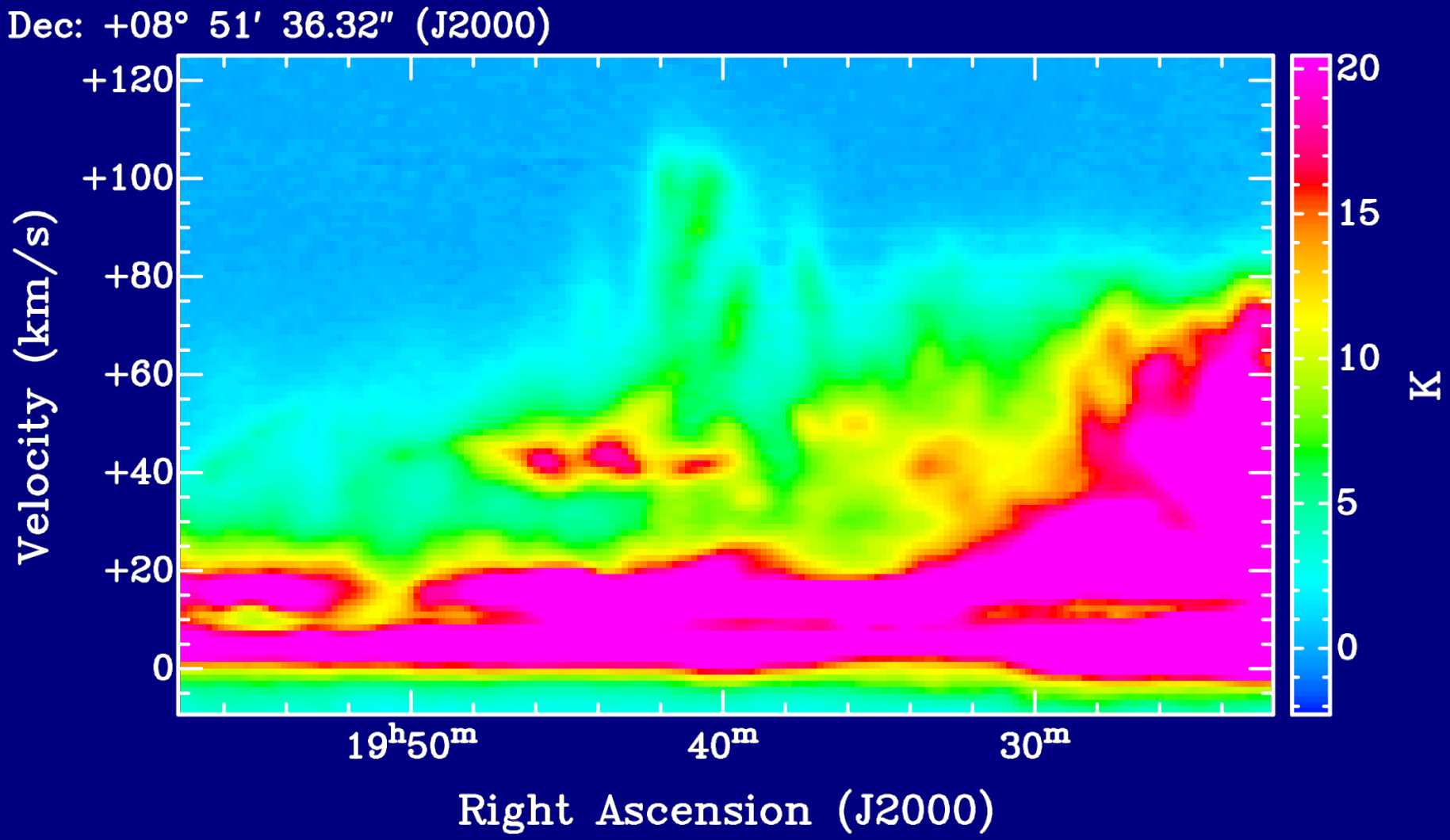
Data cubes

Movie...

Data cubes: P-V diagrams



Data cubes: P-V diagrams



Data cubes: P-V diagrams

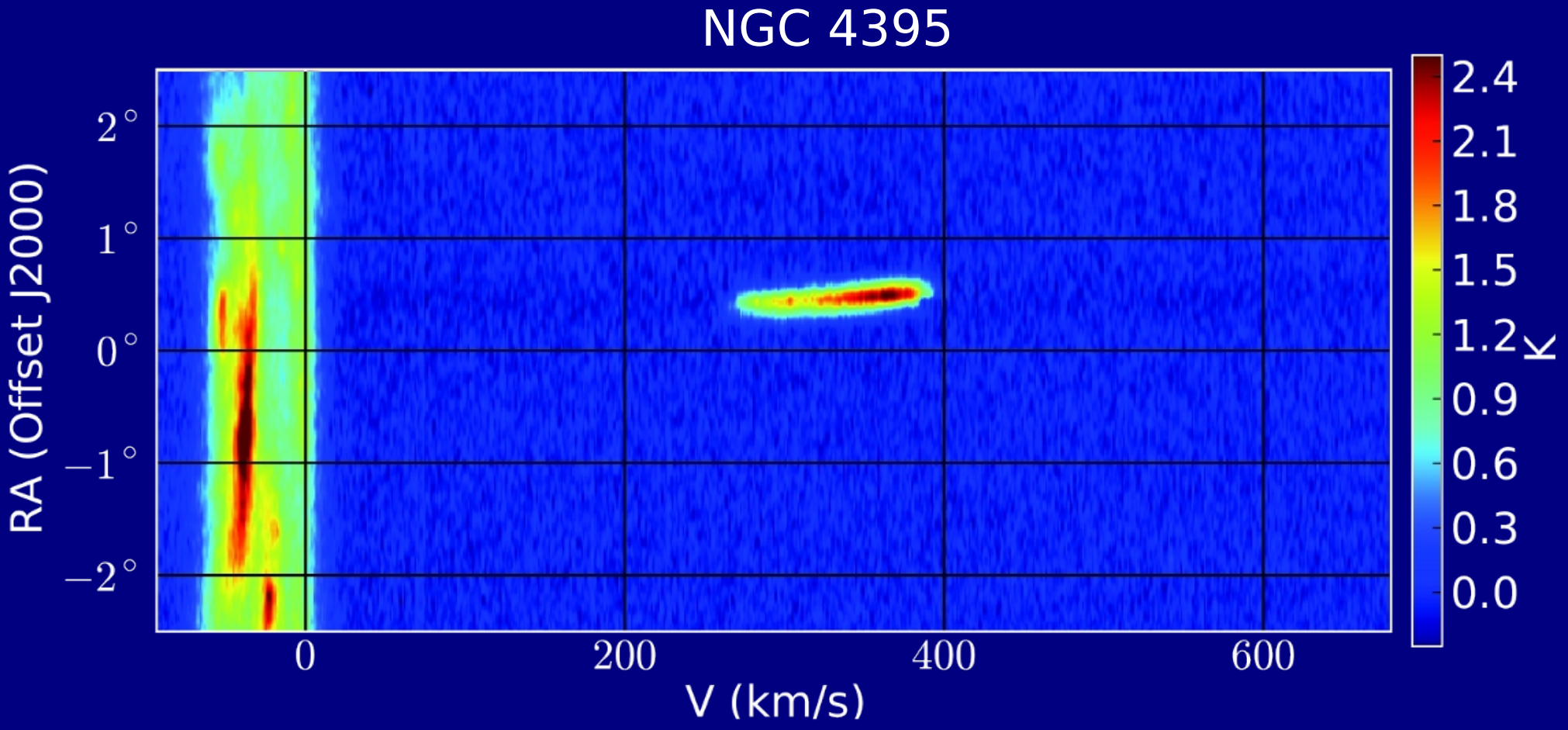


Image moments

Total intensity $\mathcal{M}_0 = \Delta v_i \sum_i p_i \quad [\mathrm{K\,km/s}]$

Velocity field $\mathcal{M}_1 = \frac{1}{\mathcal{M}_0} \sum_i p_i v_i \quad [\mathrm{km/s}]$

Dispersion $\mathcal{M}_2 = \sqrt{\frac{1}{\mathcal{M}_0} \sum_i p_i \left(v_i - \mathcal{M}_1\right)^2} \quad [(\mathrm{km/s})^2]$

$p_i \ldots$ flux in spectral channel i

$v_i \ldots$ velocity of spectral channel i

$\Delta v \ldots$ width of a spectral channel

Image moments

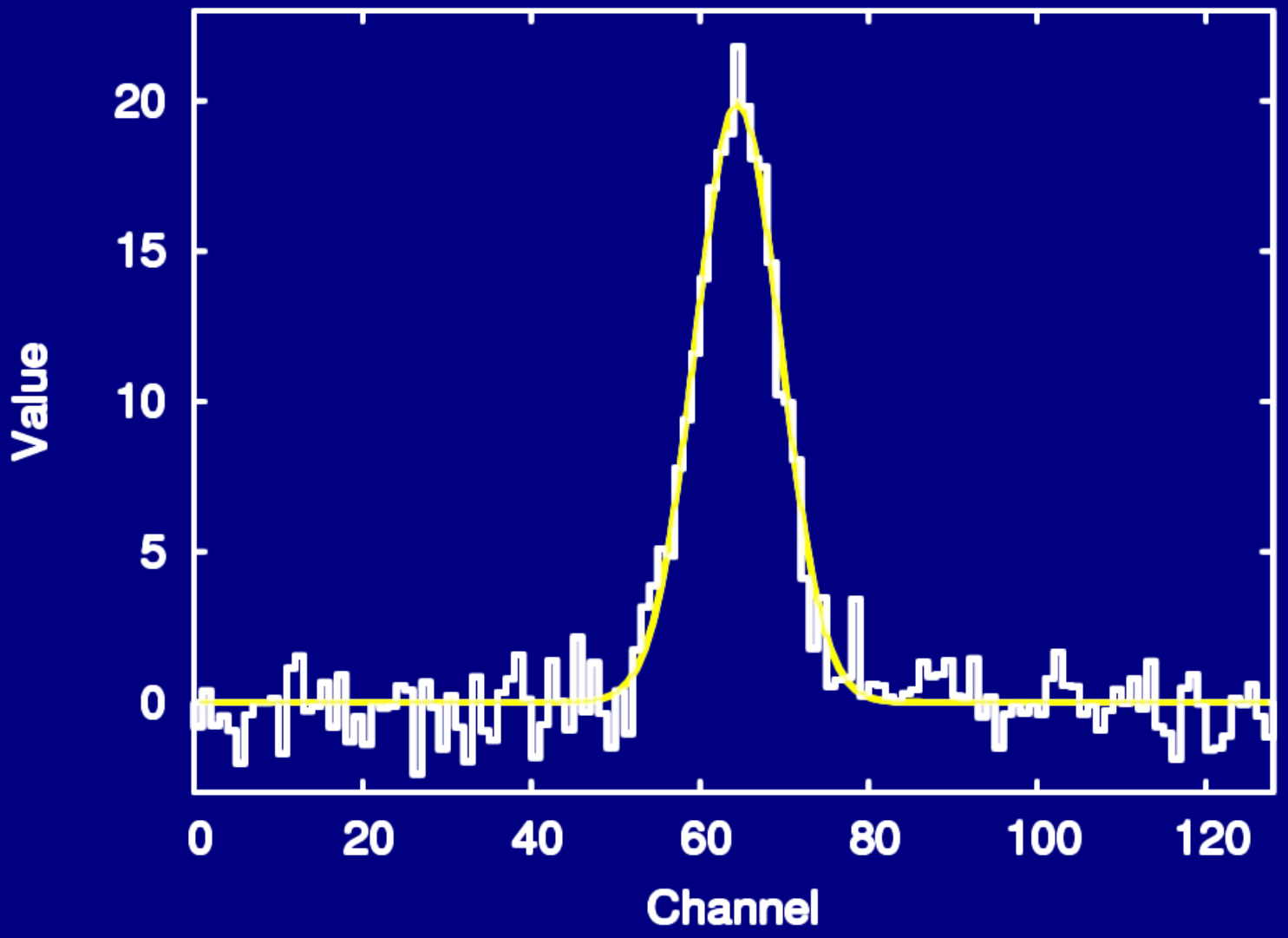
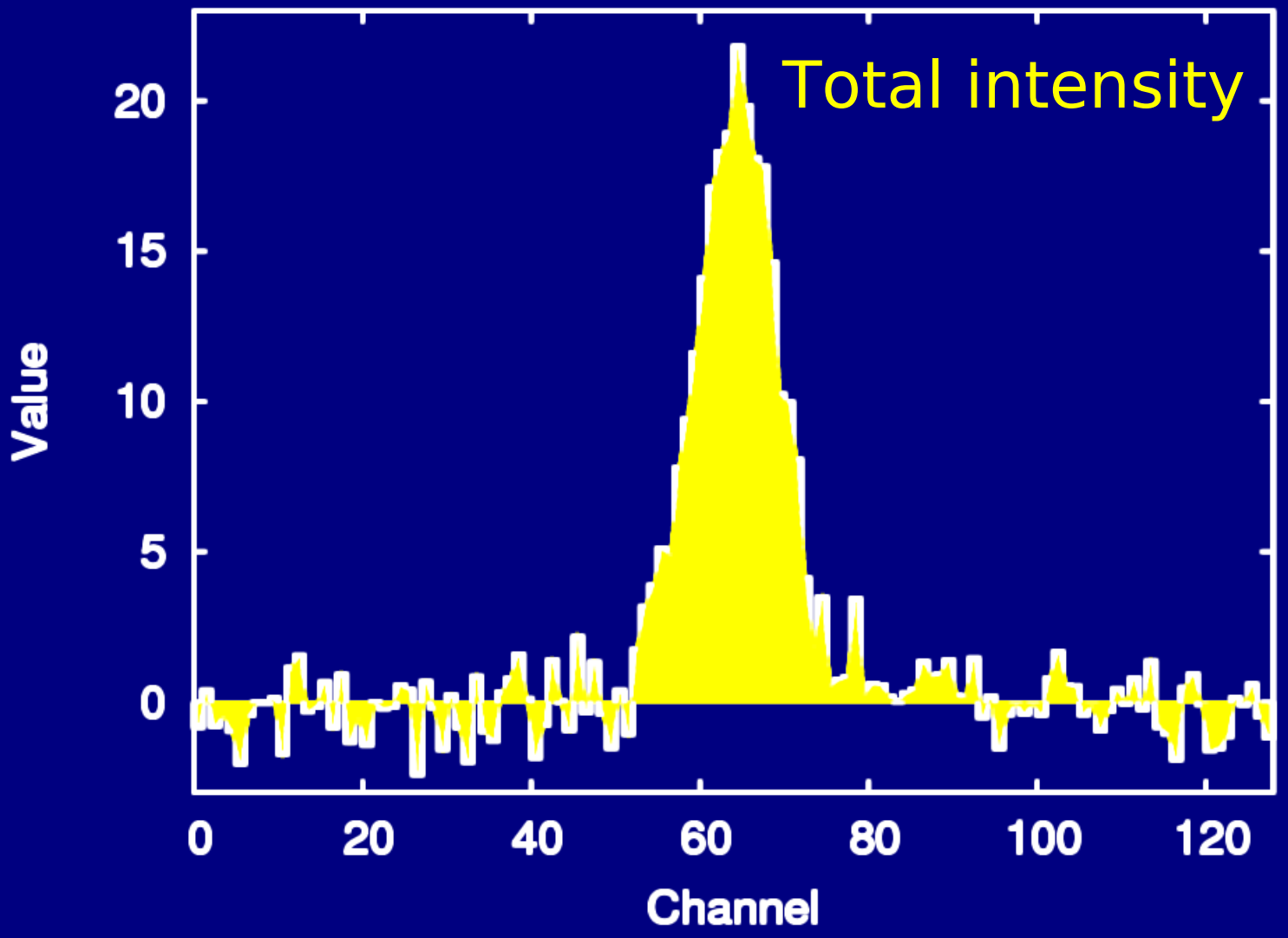


Image moments



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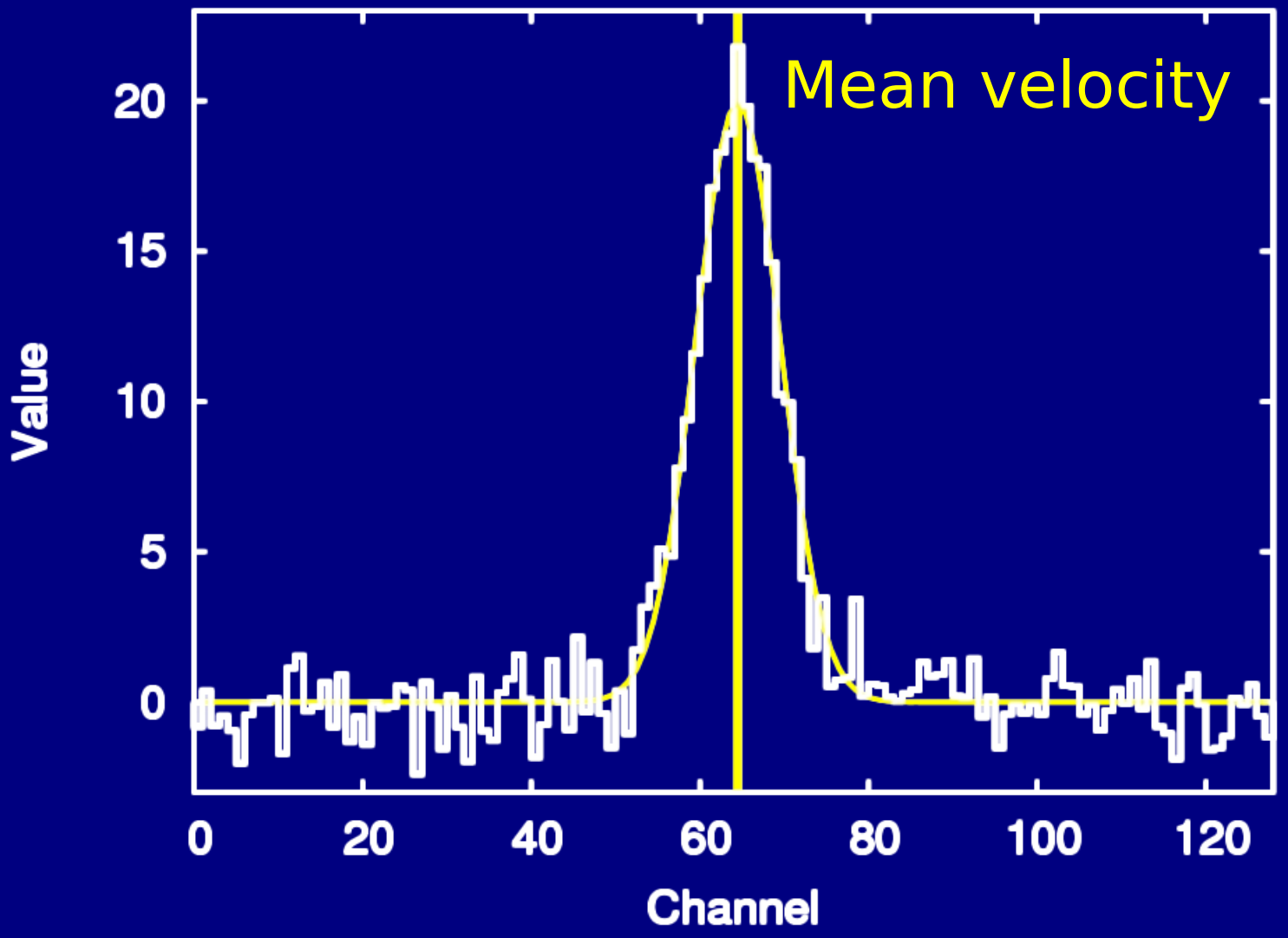

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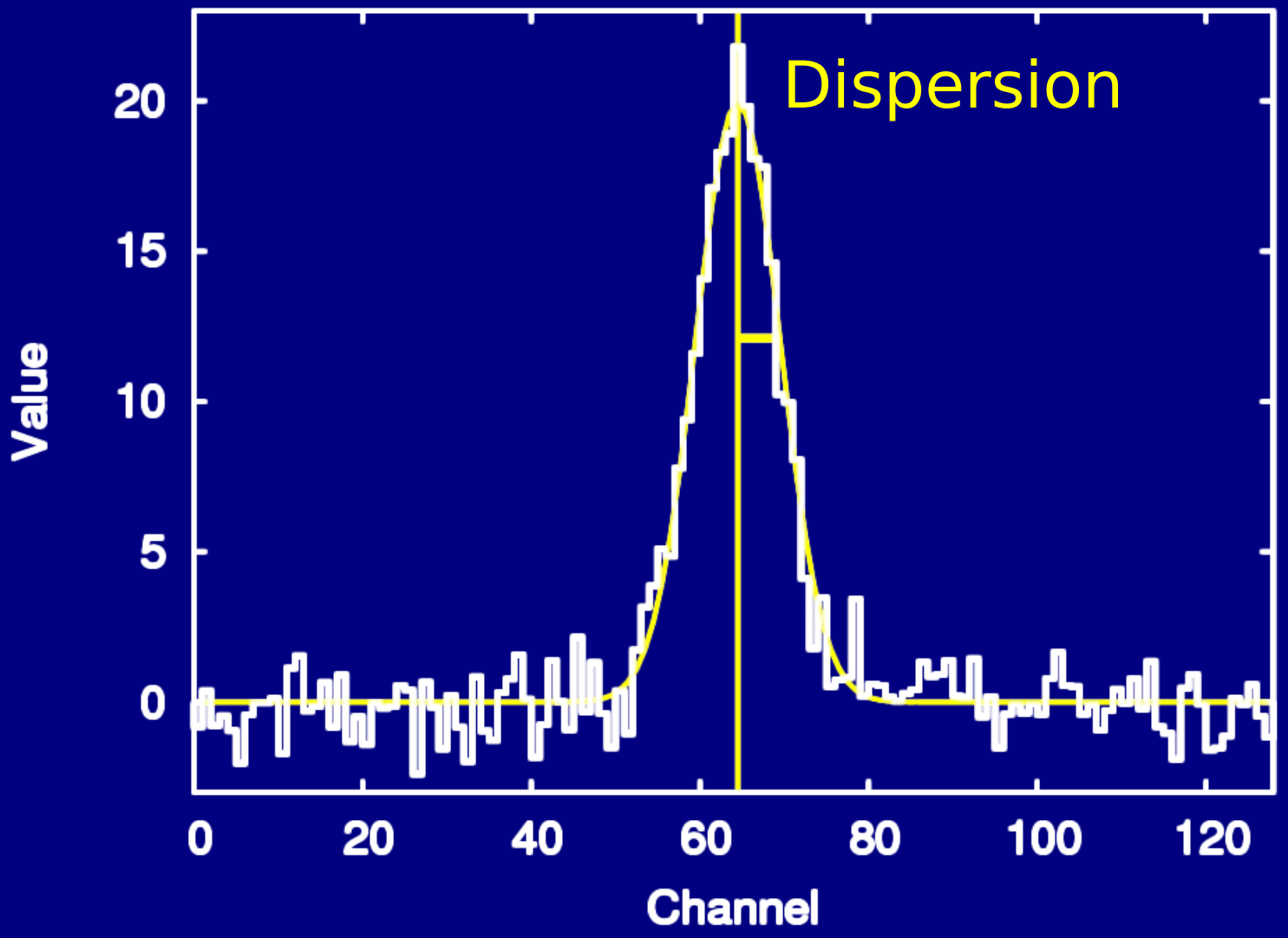
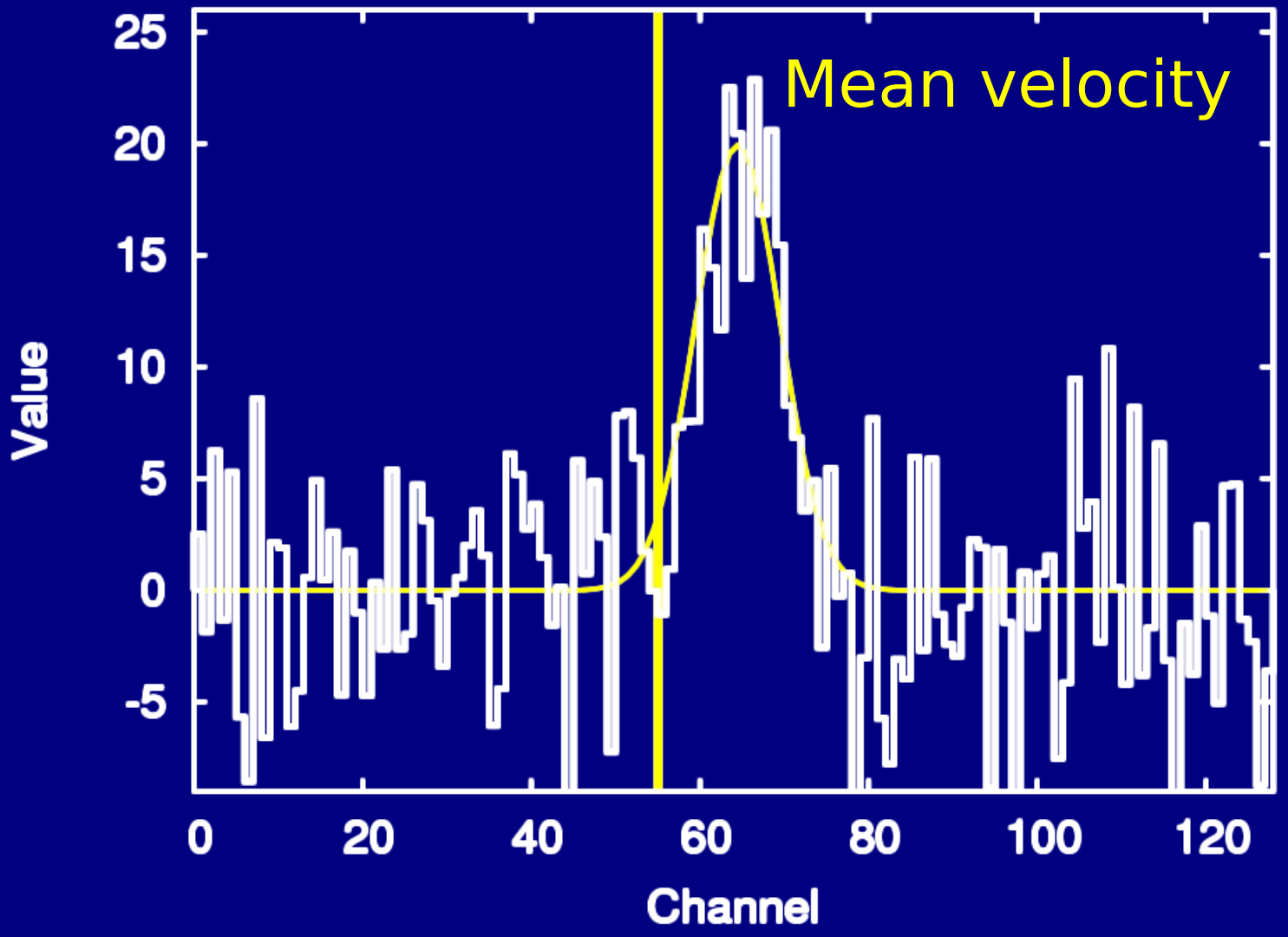


Moments: bottlenecks



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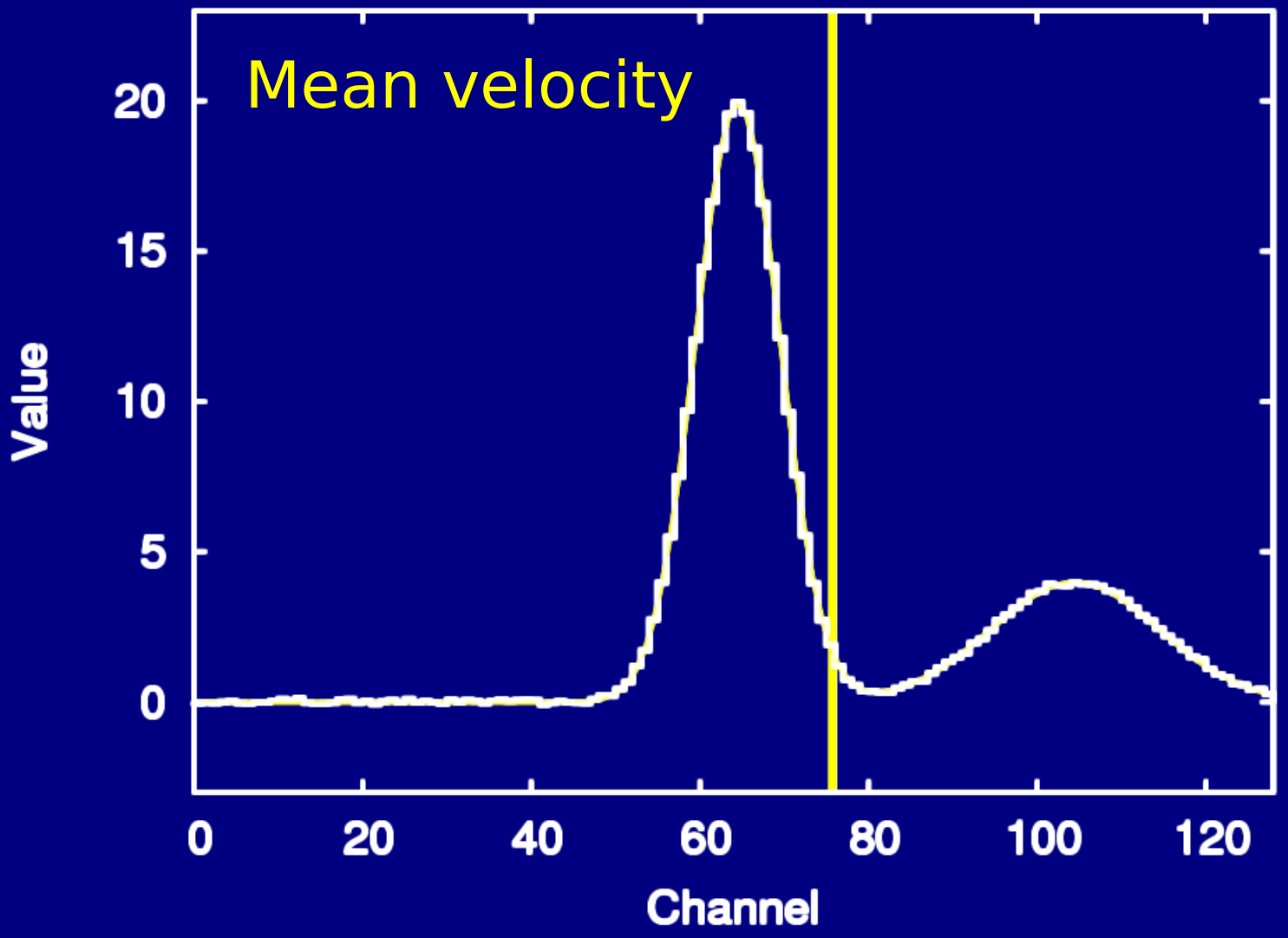
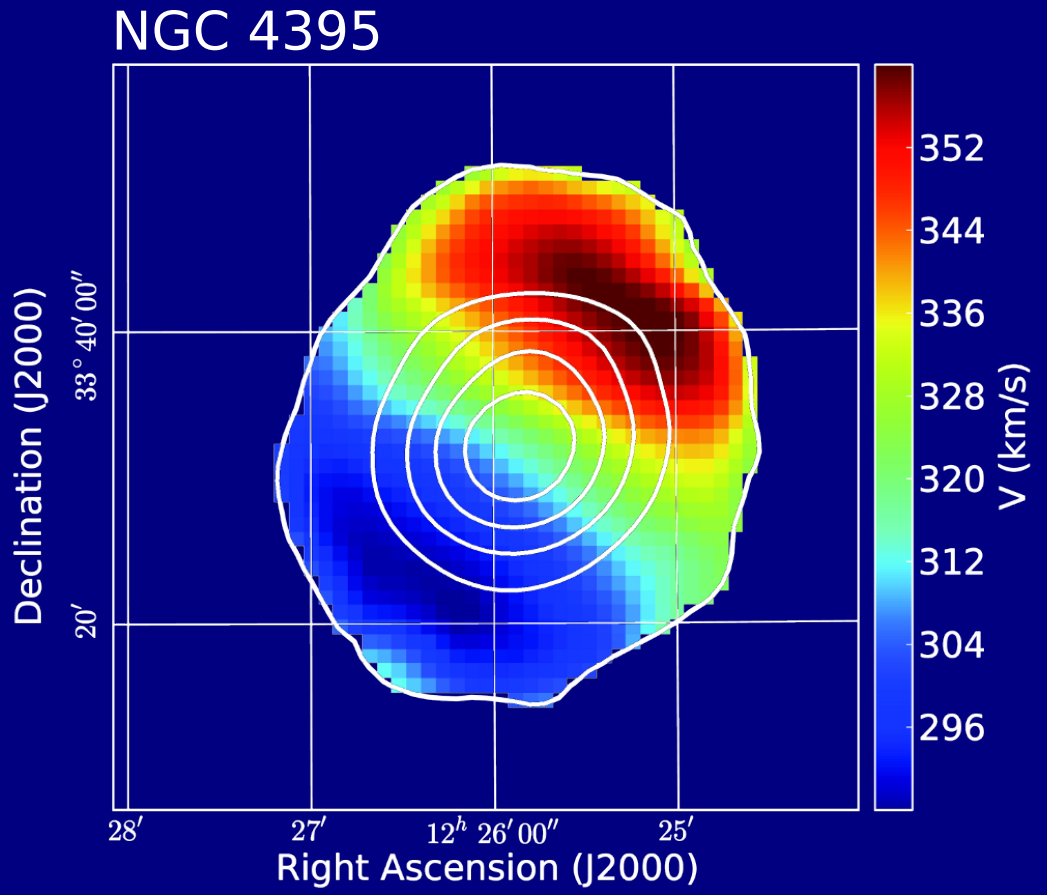
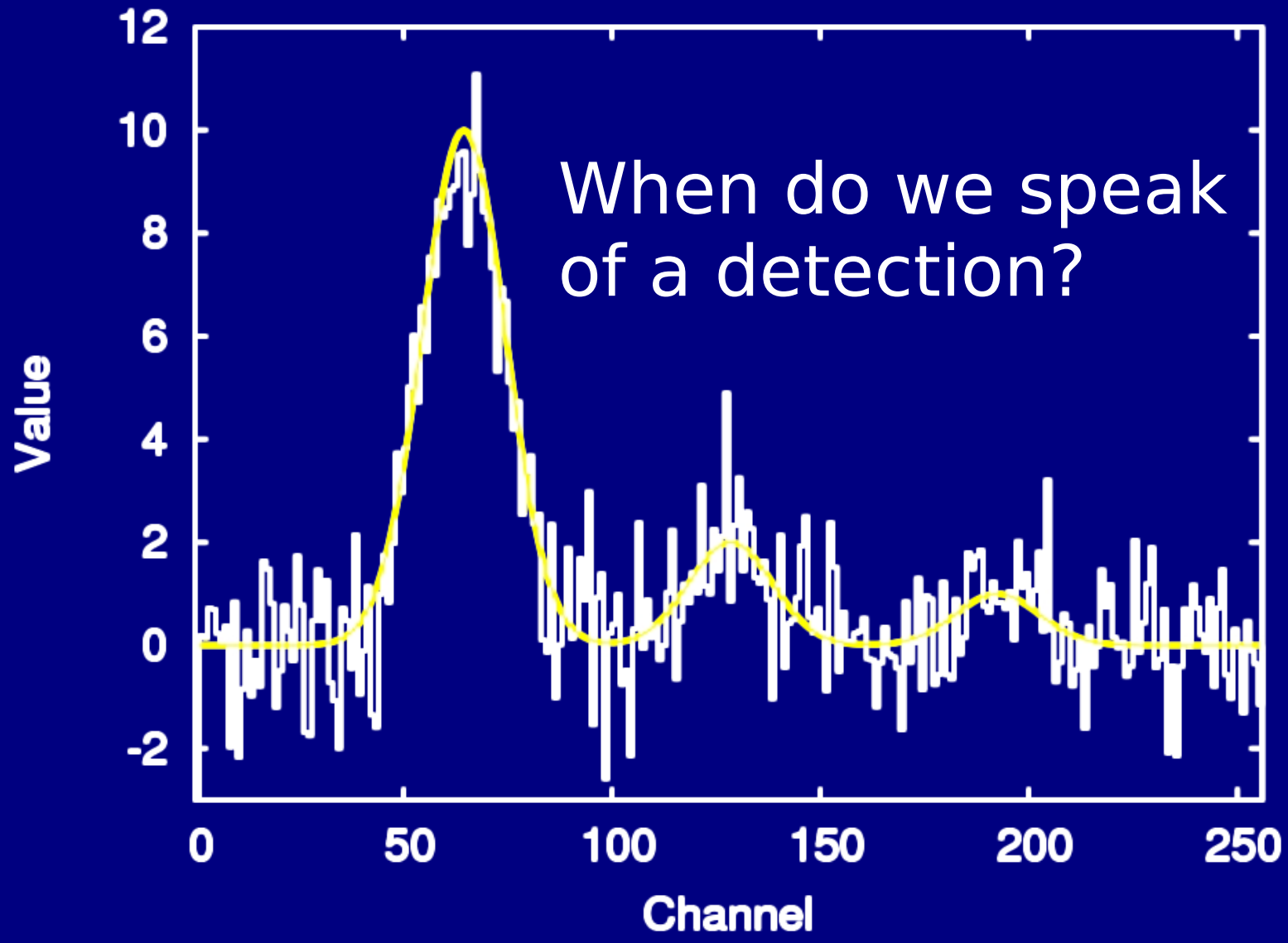


Moments and data cubes

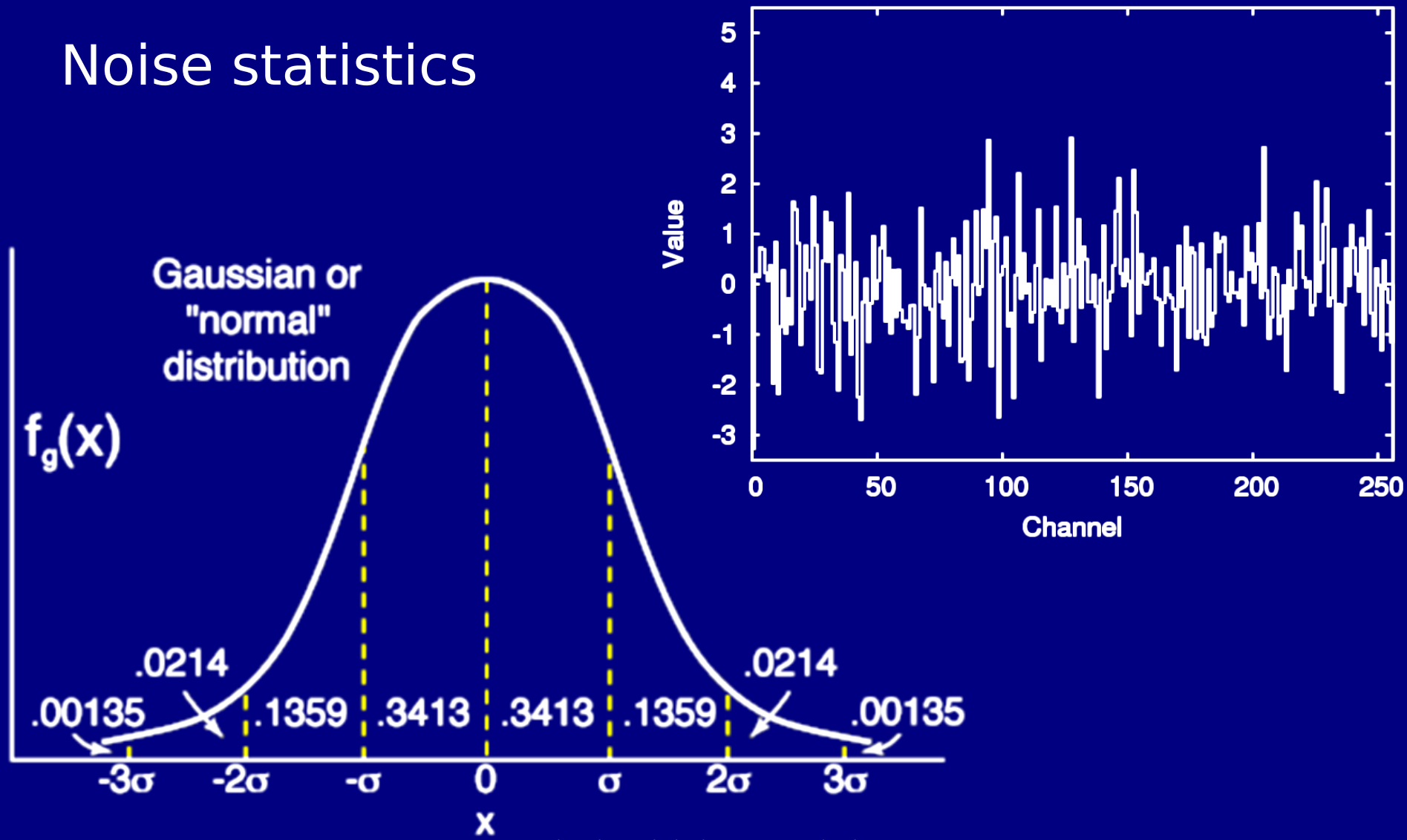


Noise and detections



Noise and detections

Noise statistics



Noise and detections

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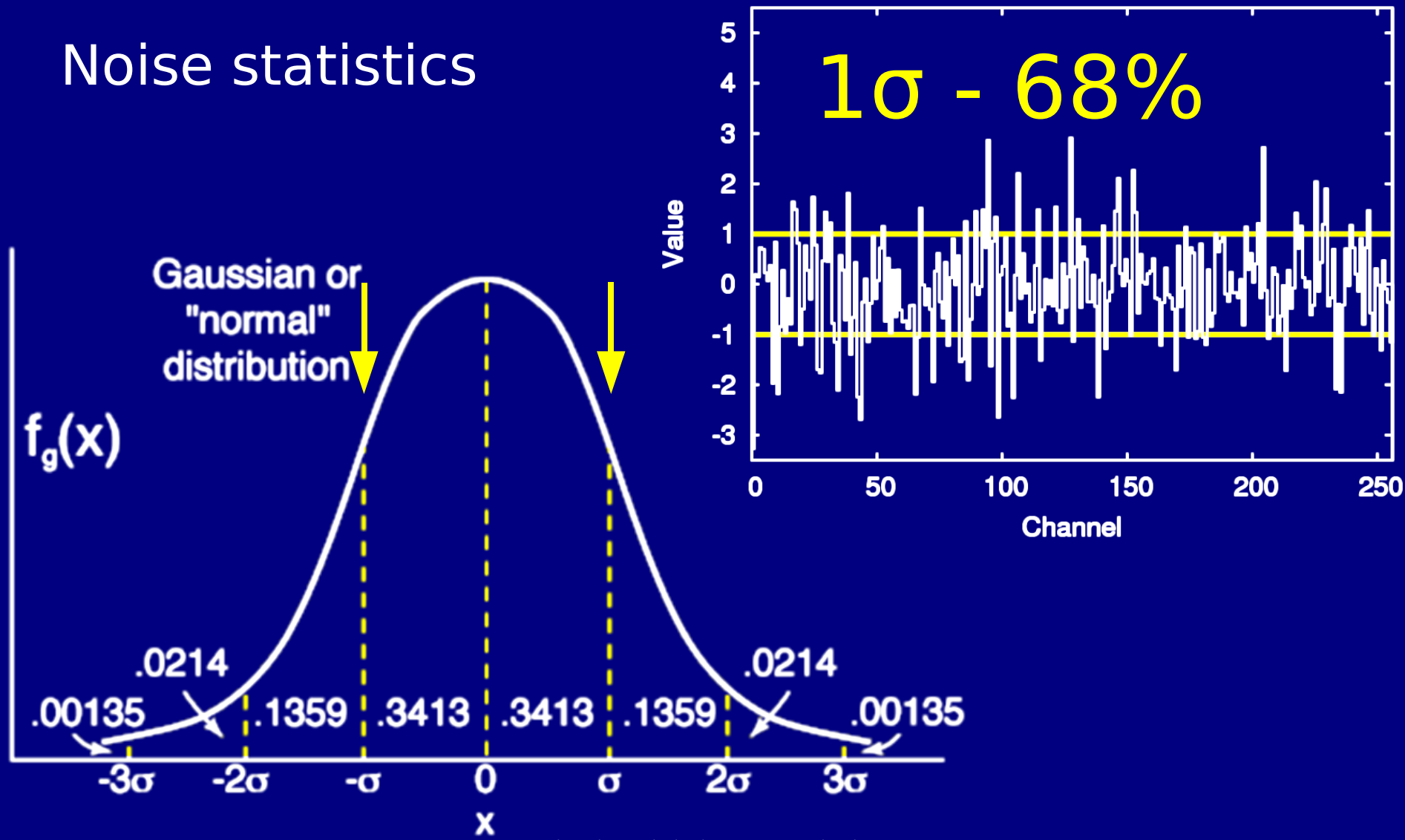

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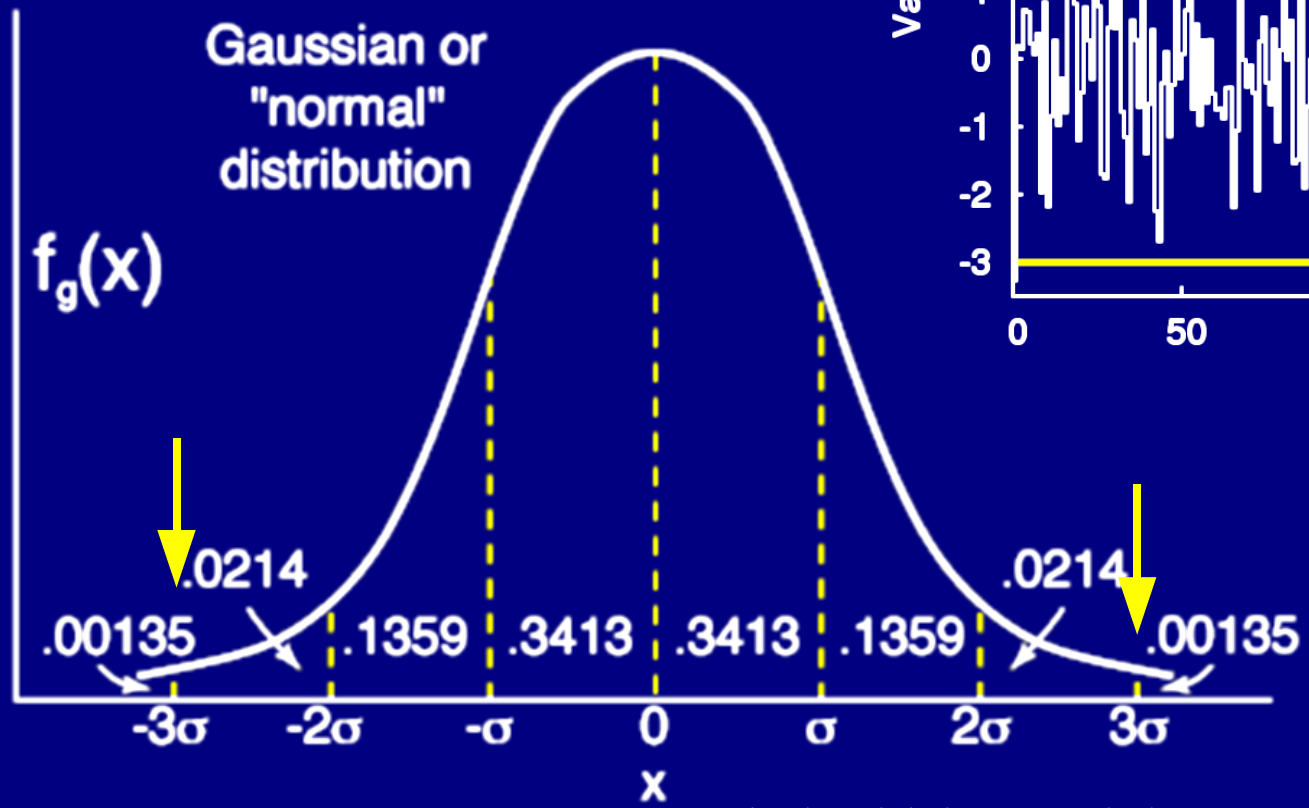
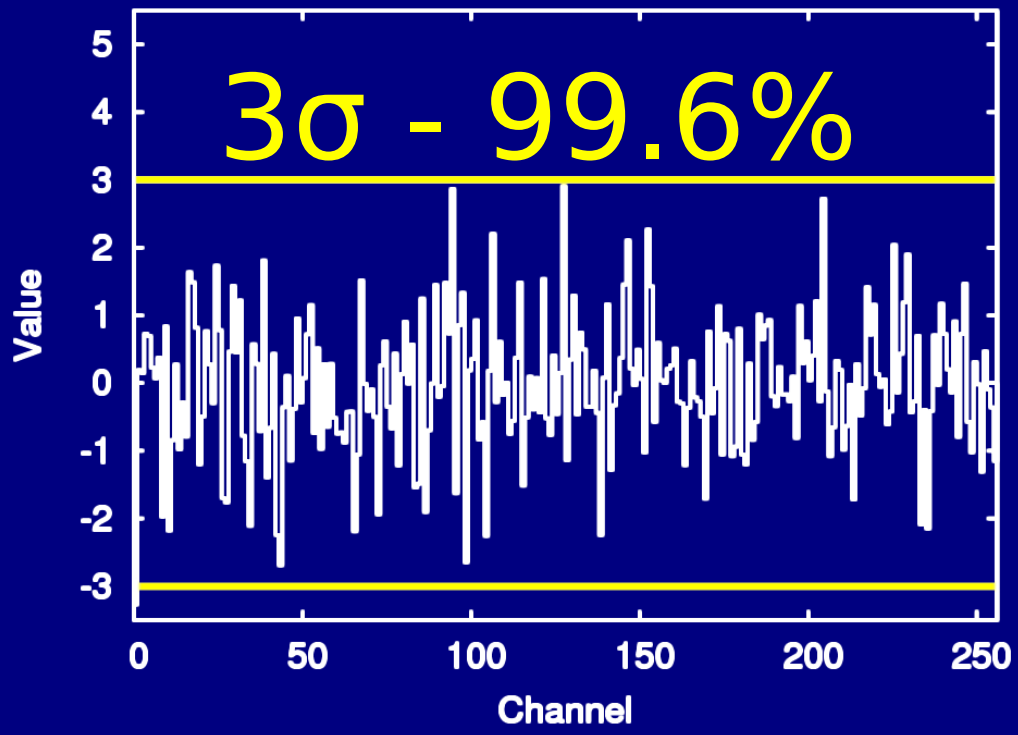




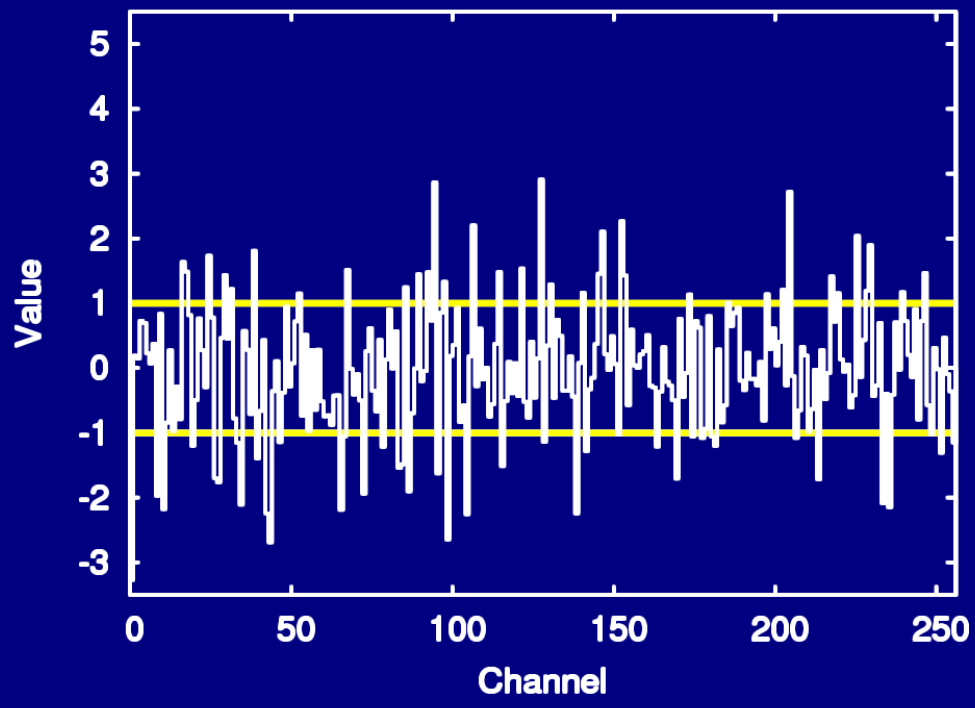
Noise and detections

How to estimate the noise

$$\sigma = \sqrt{\frac{1}{N}\sum_i (x_i - \overline{x})^2}$$

$$\sigma = \sqrt{\frac{1}{N-1}\sum_i (x_i - \overline{x})^2}$$

$$\mathrm{RMS} = \sqrt{\frac{1}{N}\sum_i x_i^2}$$



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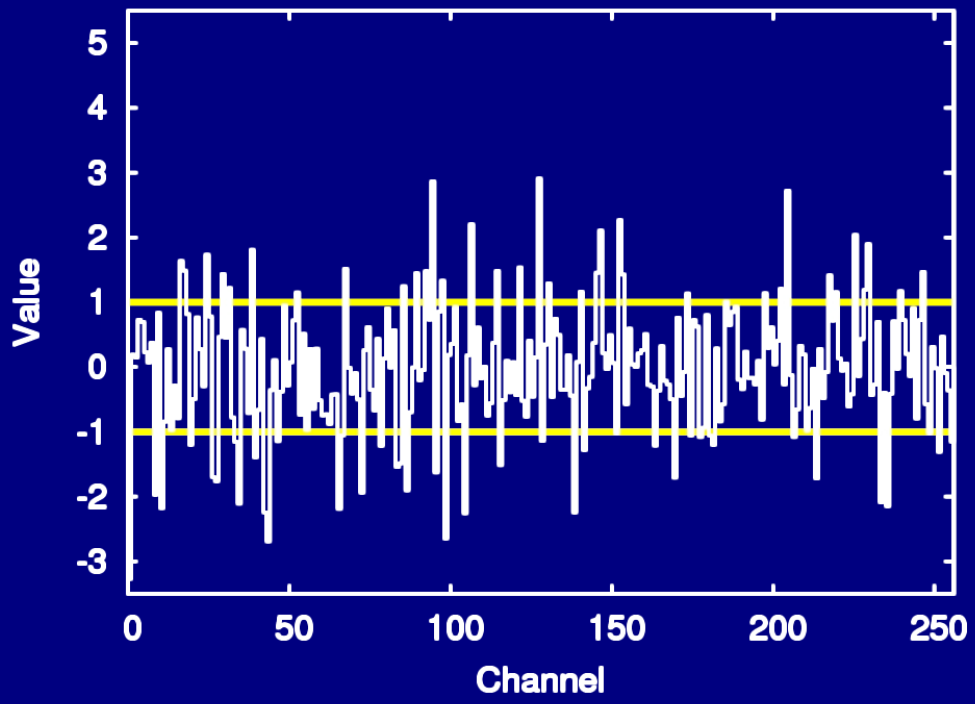
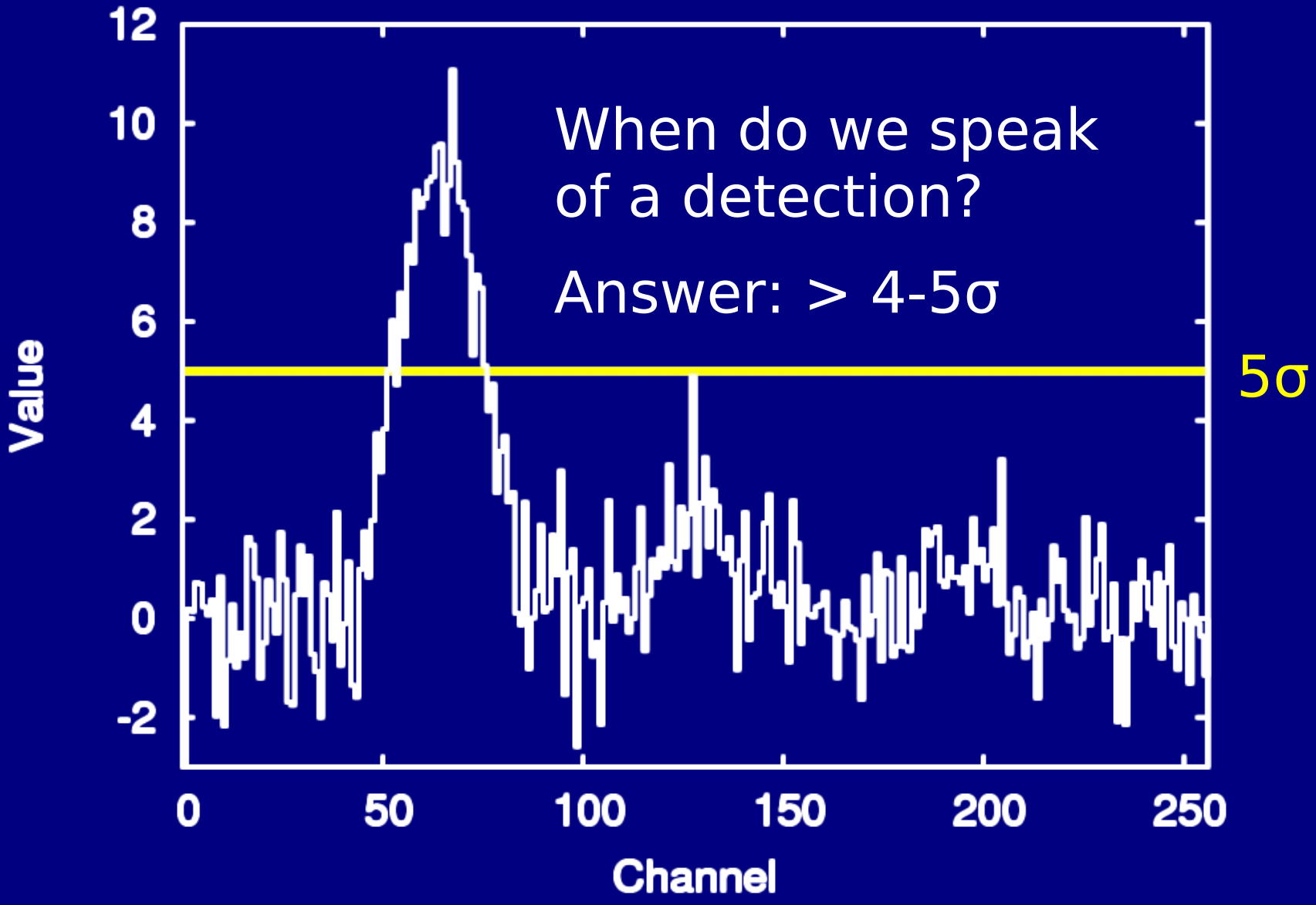


Noise and detections



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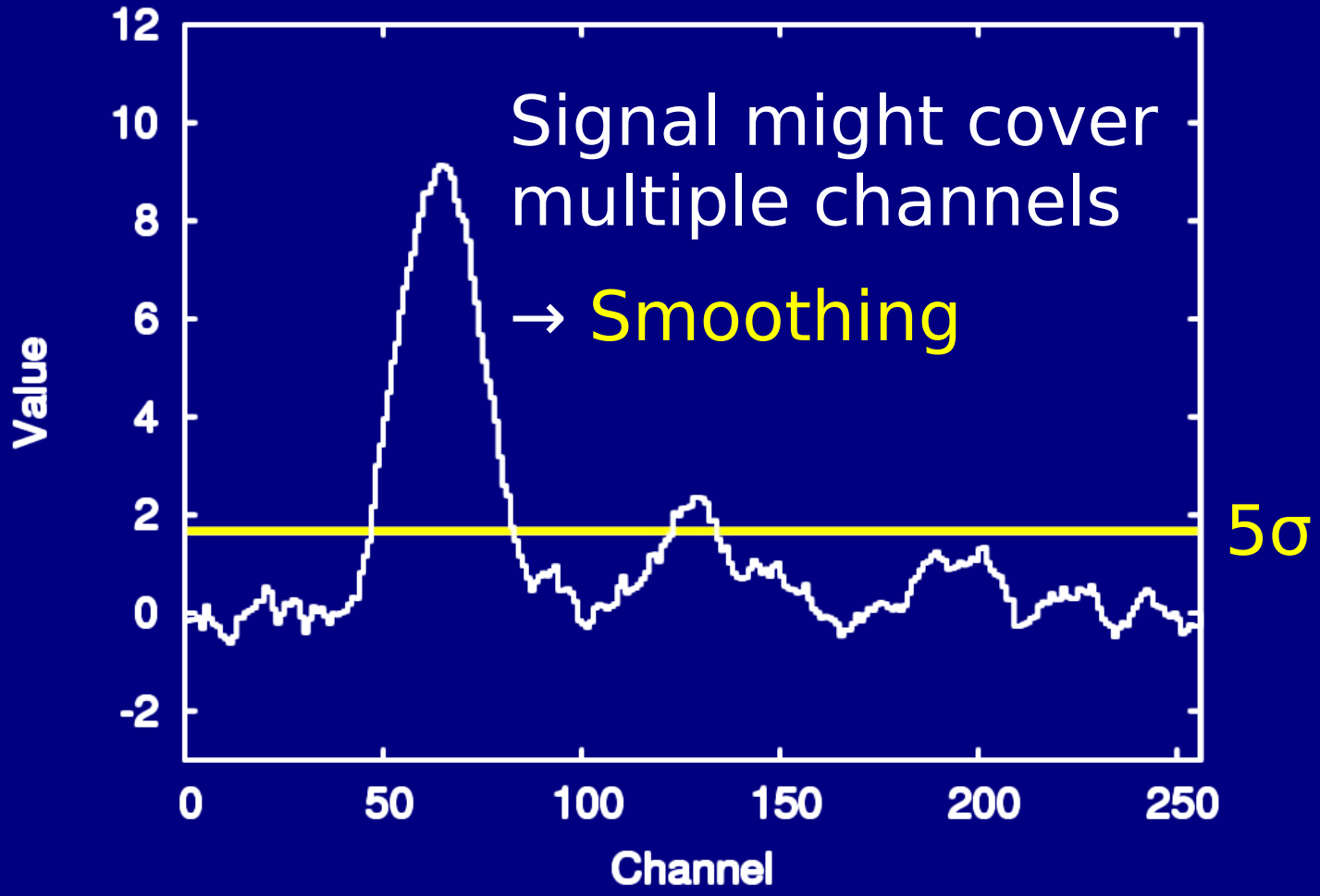
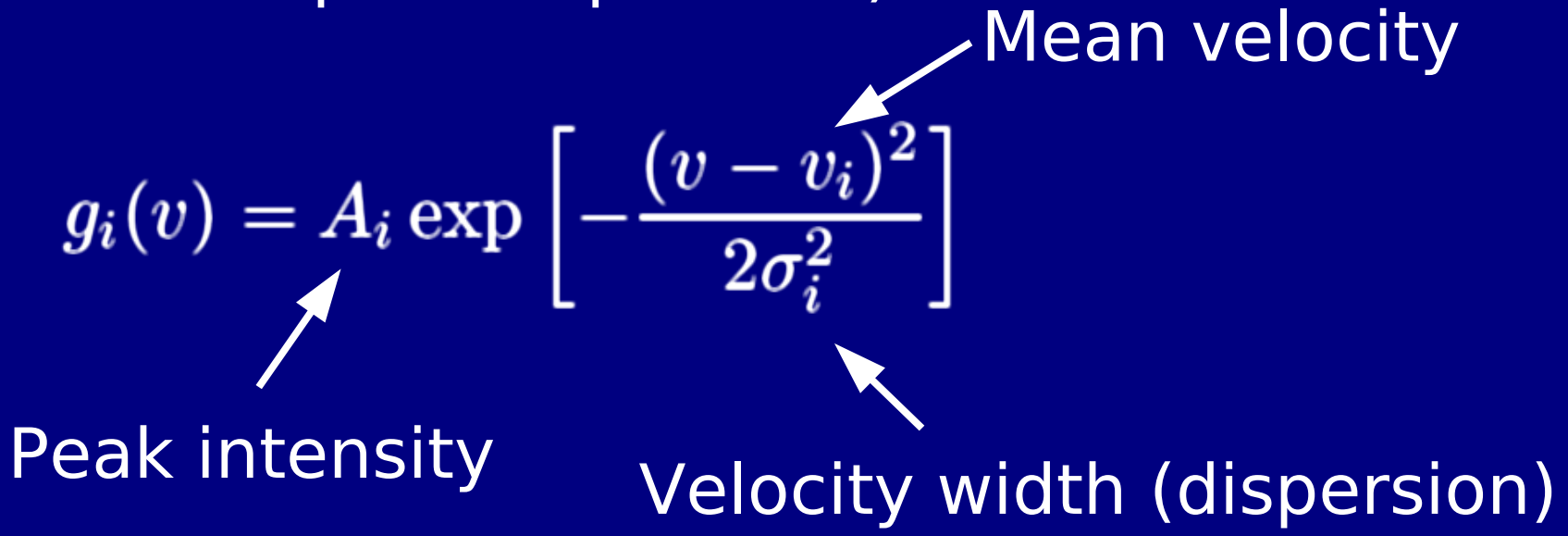


Noise goes down with 1/sqrt of number of averaged spectral channels

Useful formulae

- Can use Gaussians to fit emission lines (also multiple components)



- Often, the Full-Width Half-Maximum is used:

$$\Delta v_{\mathrm{fwhm}} = \sqrt{8 \ln 2}\, \sigma$$

Useful formulae

- Column density

$$N_{\mathrm{HI}}[\mathrm{cm}^{-2}] = 1.823 \cdot 10^{18} \underbrace{\int T_{\mathrm{B}}\,\mathrm{d}v}_{=\text{ Moment 1}}\ [\mathrm{K\,km\,s^{-1}}]$$

→ Column density map follows directly from the Moment 1 map

- Upper kinetic temperature limit (for HI)

$$T[K] = 21.8 \cdot \Delta v_{\mathrm{fwhm}}[\mathrm{km/s}]^2$$

Useful formulae

- Mass

$$M_{\mathrm{HI}}\,[\mathrm{M}_\odot] = 7.95 \cdot 10^{-9}\,(d[\mathrm{Mpc}])^2 \tan^2\varphi \sum_i N_{\mathrm{HI}}^{(i)}[\mathrm{cm}^{-2}]$$

Angular size of pixels

Distance

Column density in pixel *i*
(of the column density map)

Problem: distance often unknown

Thank you!