Weighing the IMBH candidate CO-0.40-0.22* in the Galactic Centre

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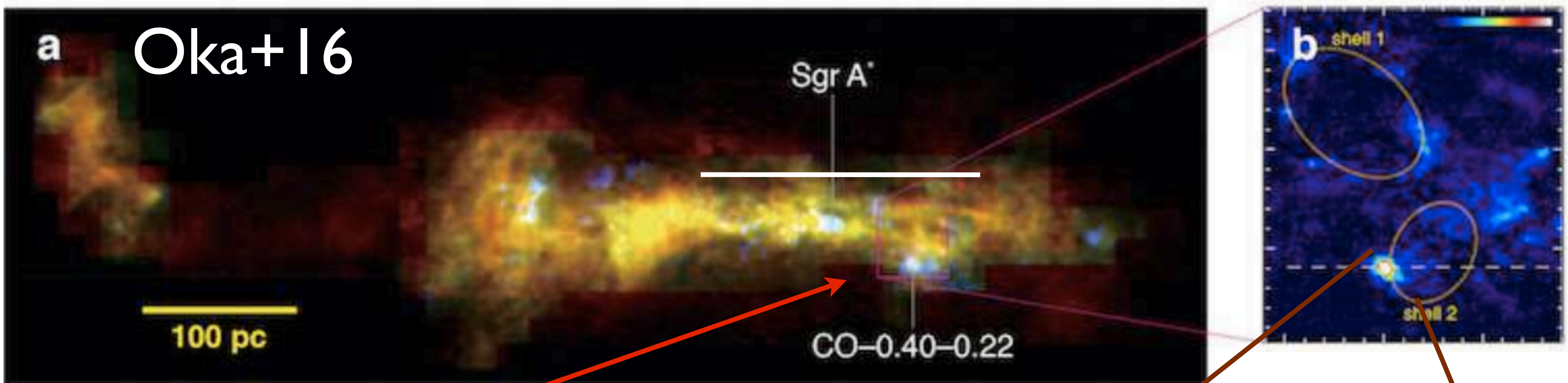
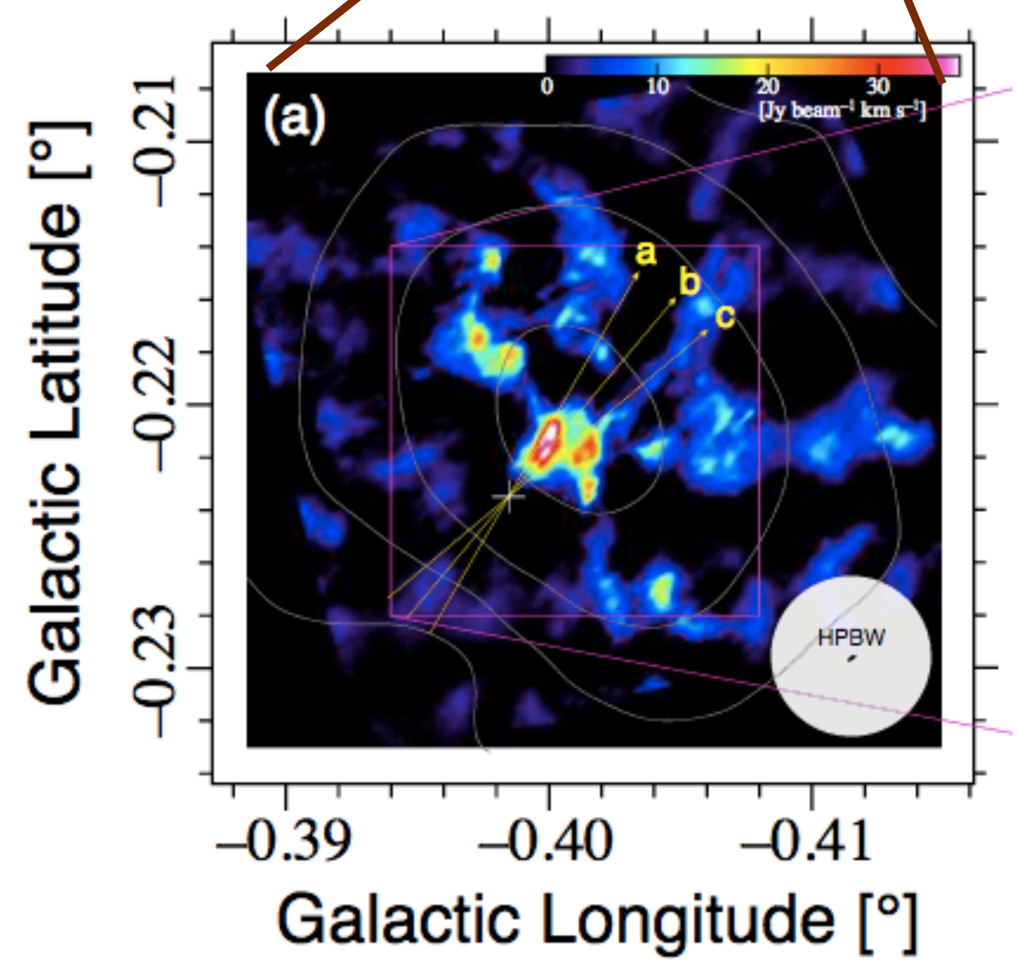
A High Velocity Compact Cloud



In the CMZ, at a projected distance of 60 pc, Oka+16 detected with ASTE a compact cloud with a high internal velocity gradient. Later they reobserved it at much higher resolution with ALMA (Oka+17).



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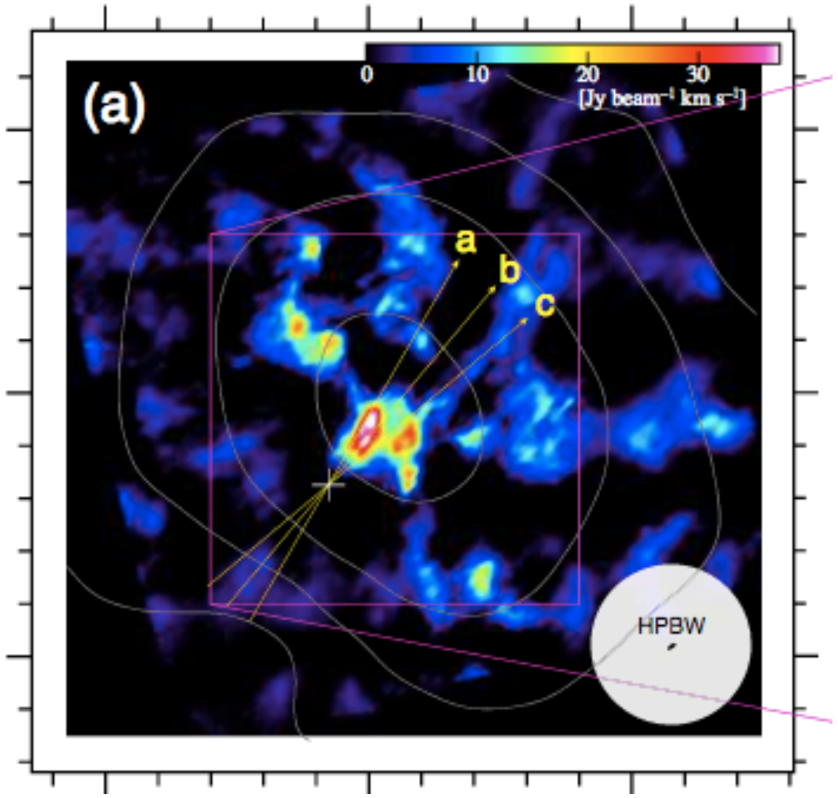
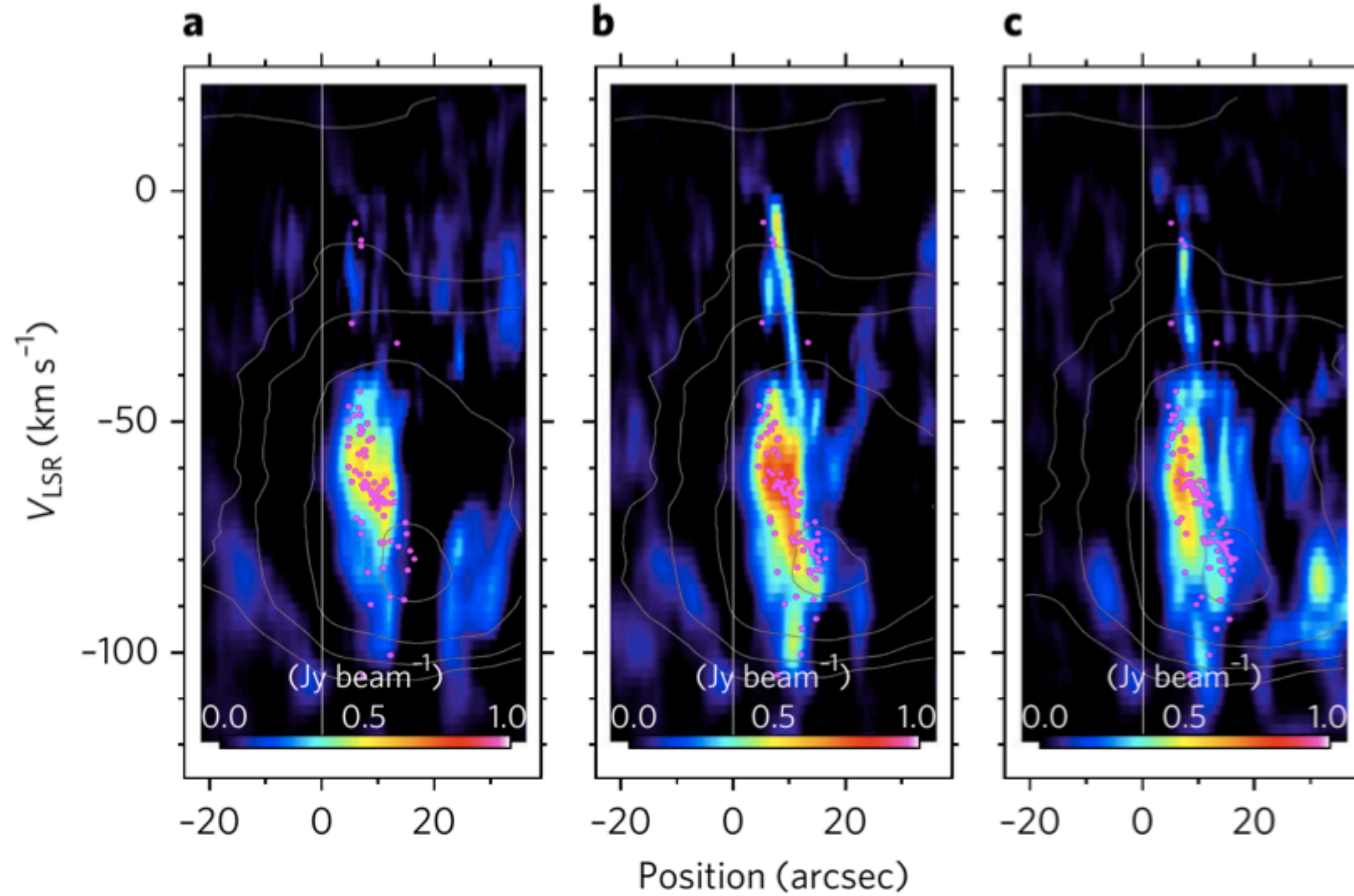
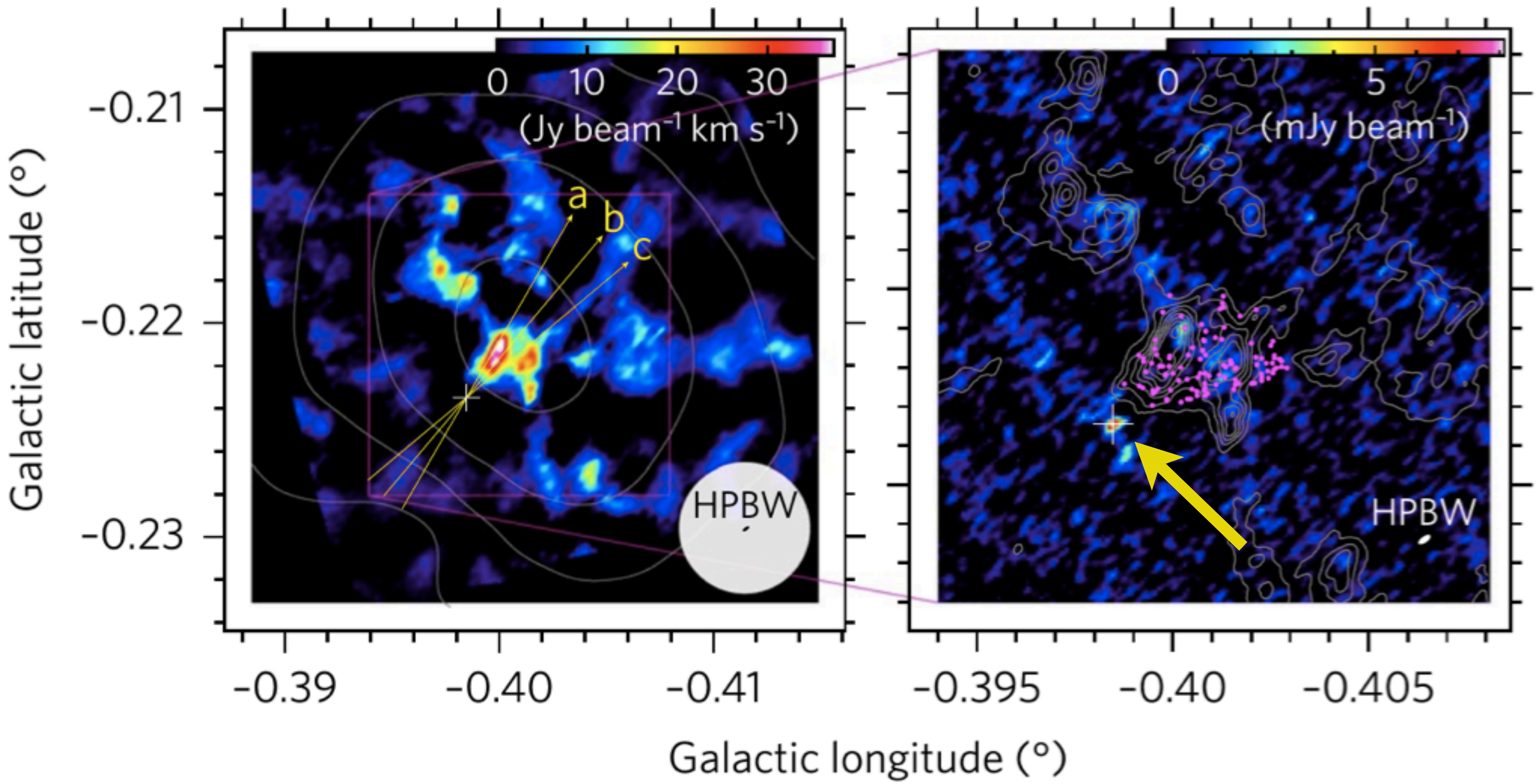




The cloud is very compact (its size is about 0.5 pc) and it shows a velocity gradient, across its length, of 20-40 km/s, as visible in position-velocity diagrams (Oka+17). What is causing it?

An Intermediate Mass Black Hole?



Close to the cloud, a point source emitting in continuum. Among few different explanations: an IMBH with very low accretion?

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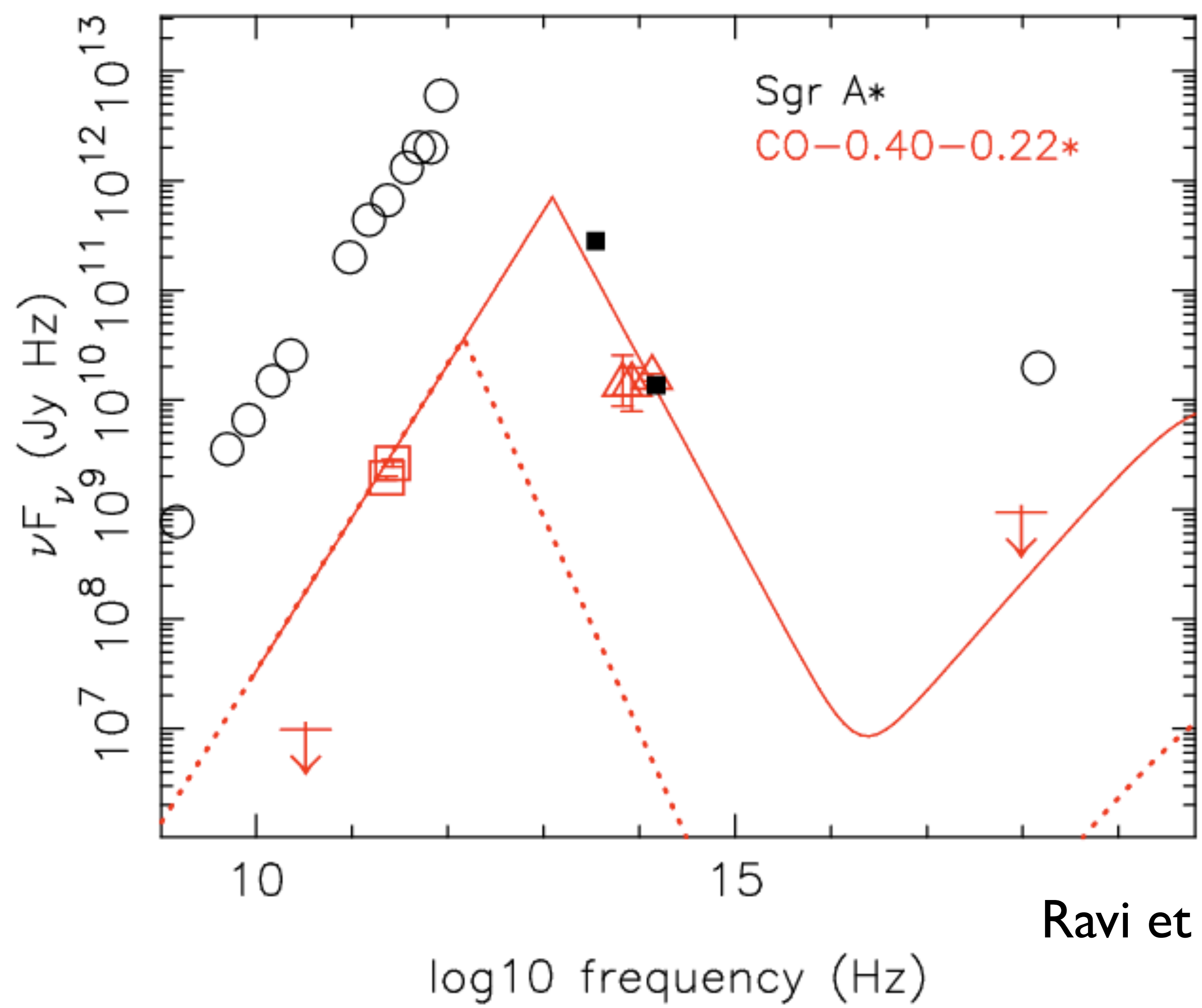


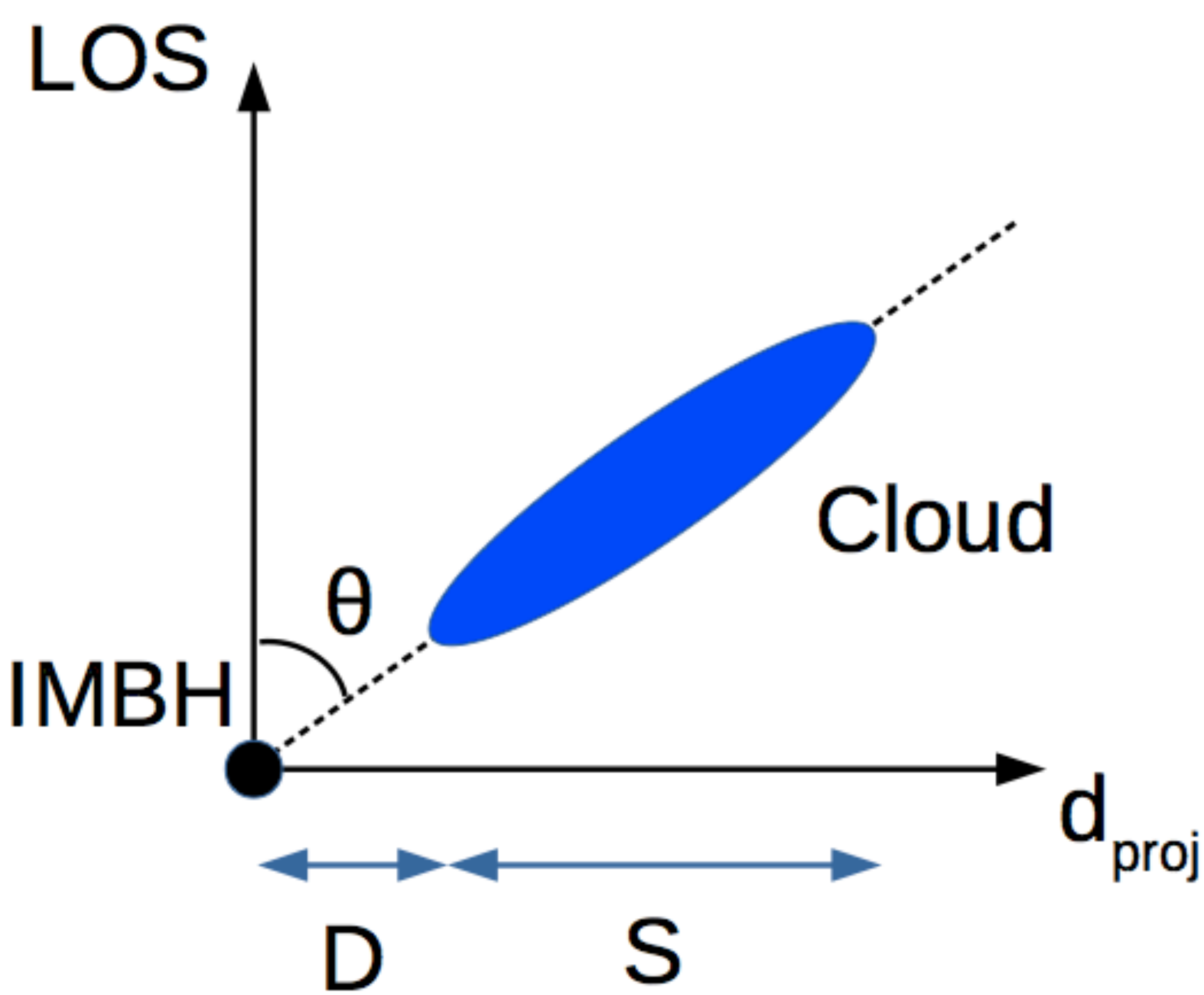
Ravi et al. (2018)

Close to the cloud, a point source emitting in continuum. Among few different explanations: an IMBH with very low accretion?

Weighing the IMBH: a simple model

Can we get a lower limit for the mass of the black hole?

The most favourable case: a plunge on a radial orbit.



$$v_{orb} = \sqrt{\frac{2GM_{BH}}{d_{BH}} + 2E_{orb}}$$

For $E_{orb} \approx 0$:

$$\Delta v_{LOS} = \sqrt{2GM_{BH} \sin\theta} \cos\theta \left[\frac{1}{\sqrt{D}} - \frac{1}{\sqrt{S+D}} \right]$$

$$M_{BH} > \frac{3\sqrt{3}}{2} \frac{(\Delta v_{LOS})^2}{G} \frac{D(S+D)}{(\sqrt{S+D} - \sqrt{D})^2}$$

$$2/(3\sqrt{3}) = \max(\sin\theta \cos^2\theta) \qquad \theta \simeq 35^\circ$$

Weighing the IMBH: a simple model

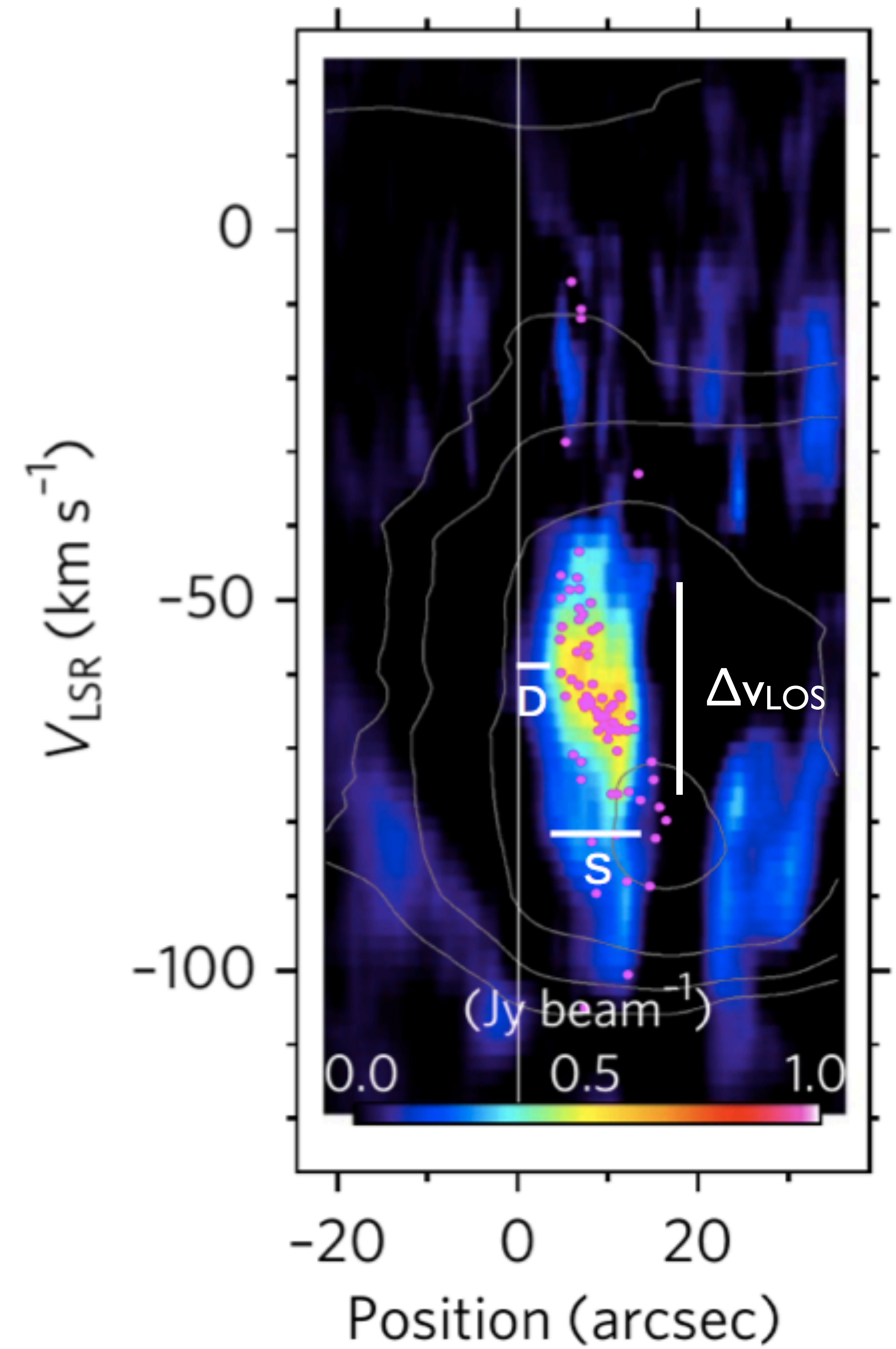
With (D,S)=(2",14")
and Δv_{LOS} = 30 km/s

(22" = 0.9 pc; Oka+17)

<u>**$M_{BH} > 5.7 \times 10^4\ M_\odot$**</u>

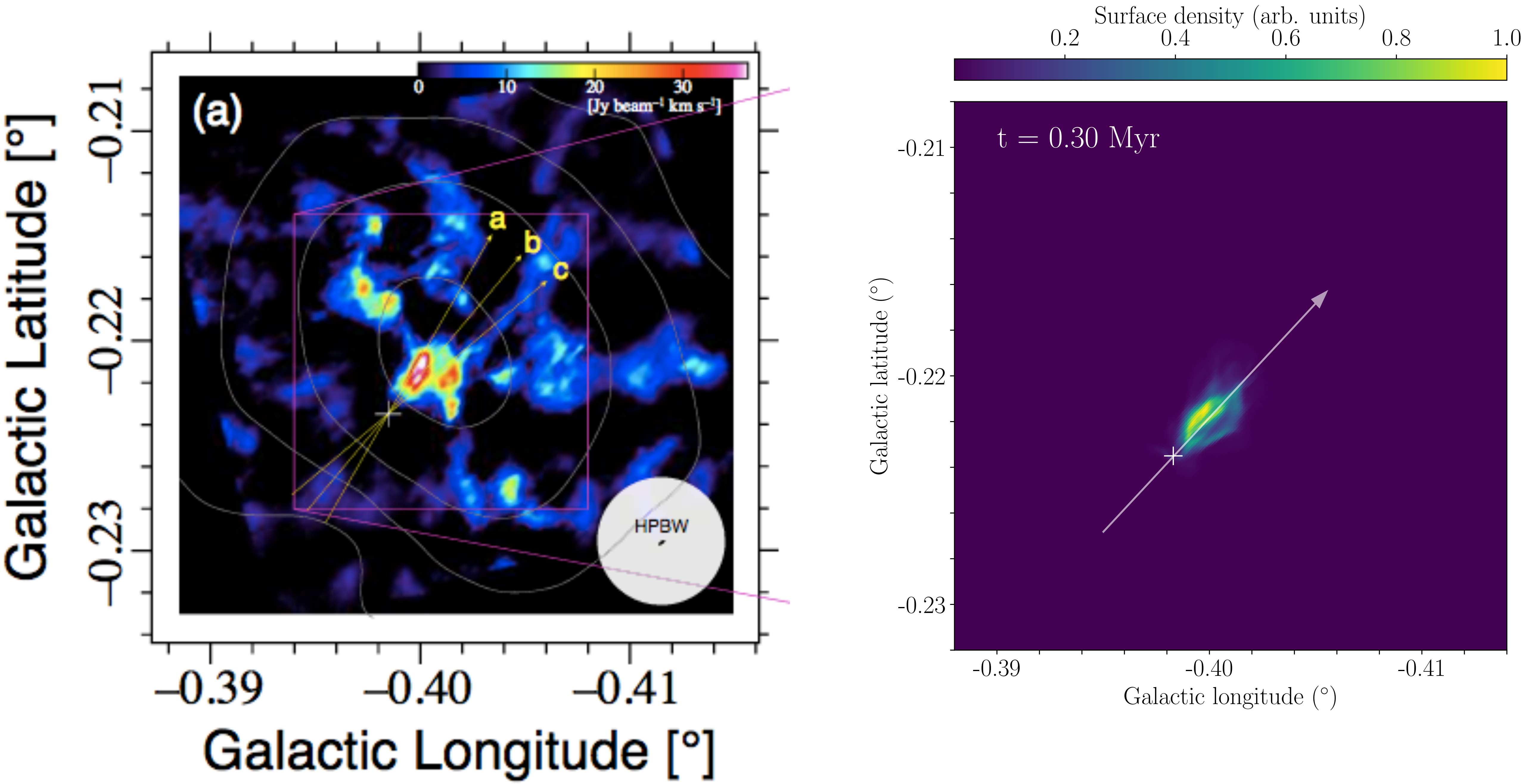
It is a very high mass!

(and the calculation is assuming the best possible case!)



Weighing the IMBH: a simple model

We tested the previous case ($M_{BH} = 5.74 \times 10^4\ M_{\odot}$) with an adaptive mesh refinement (AMR) simulation with RAMSES



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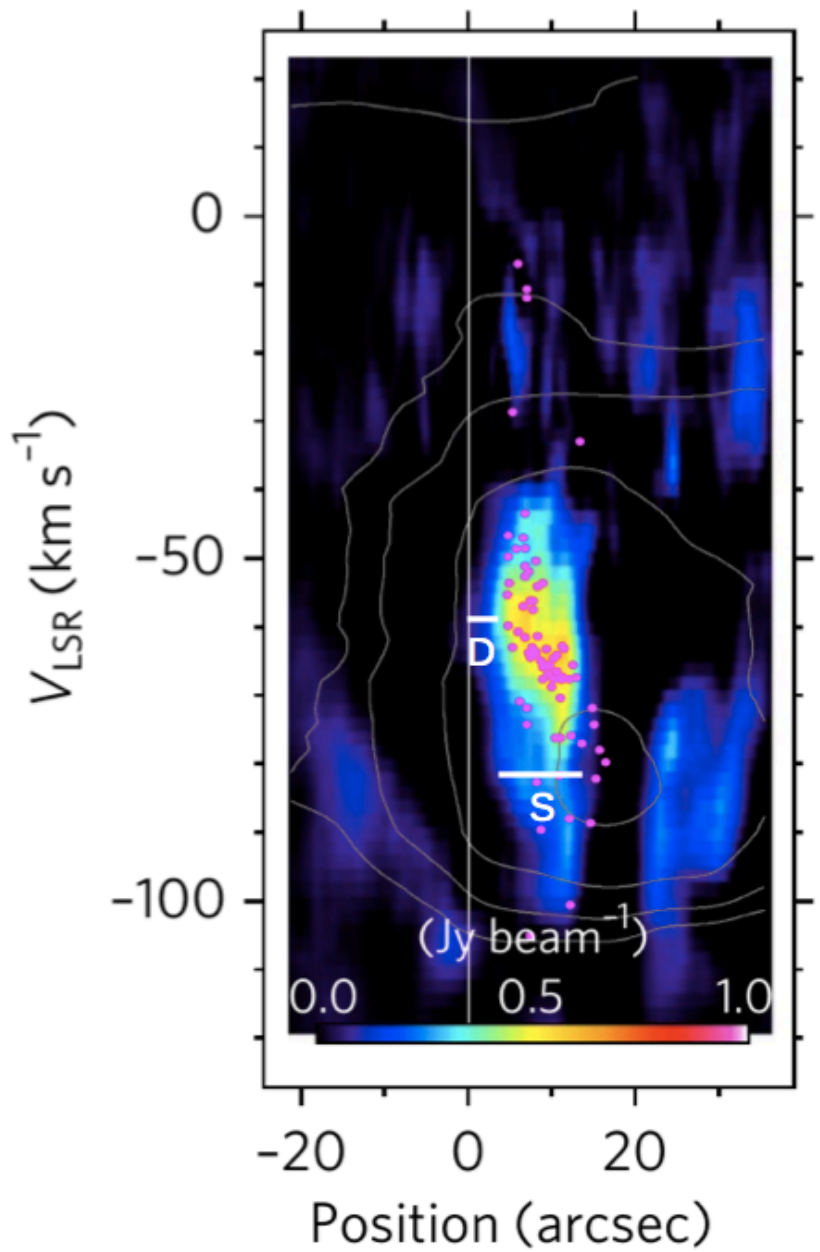
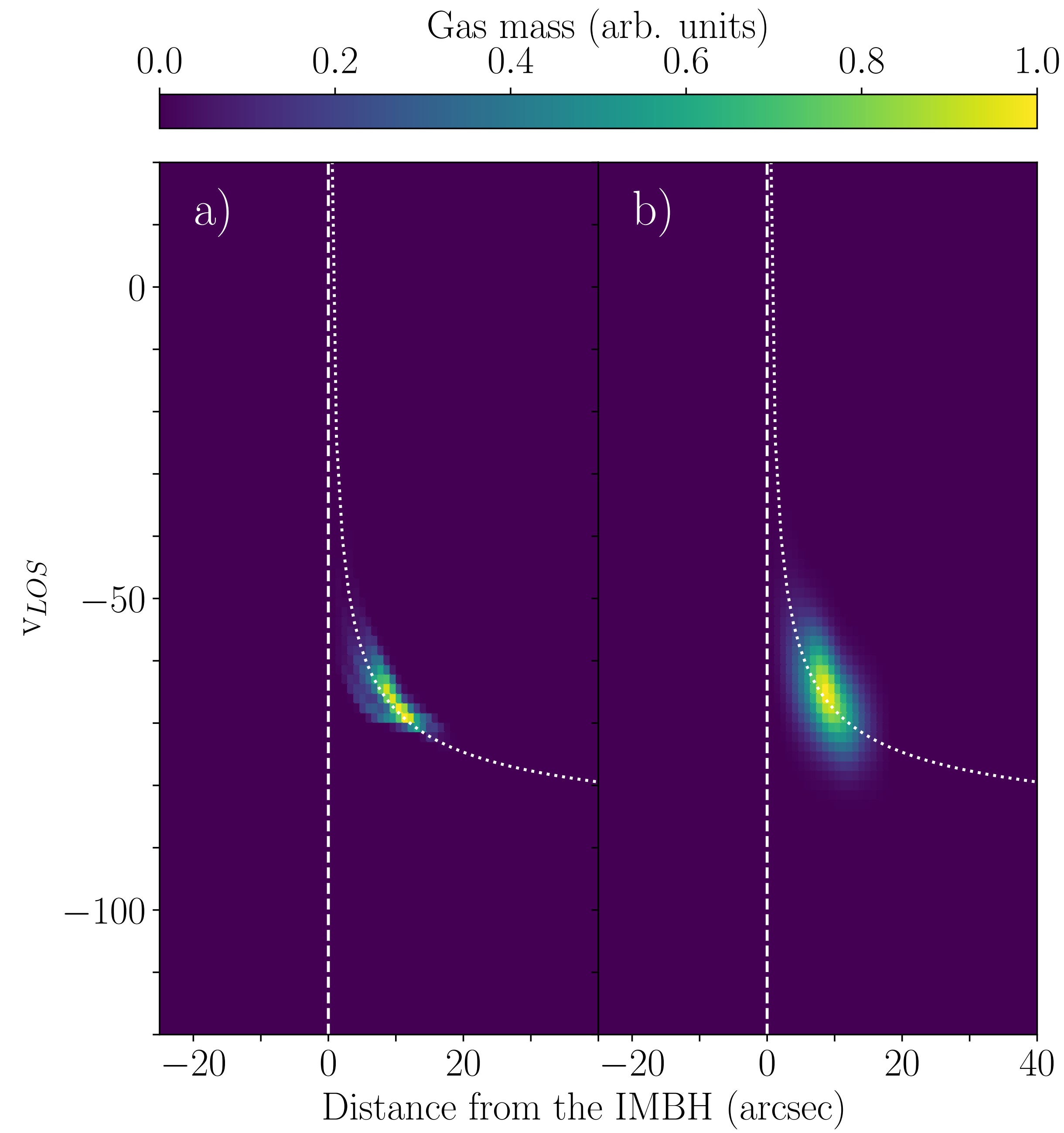
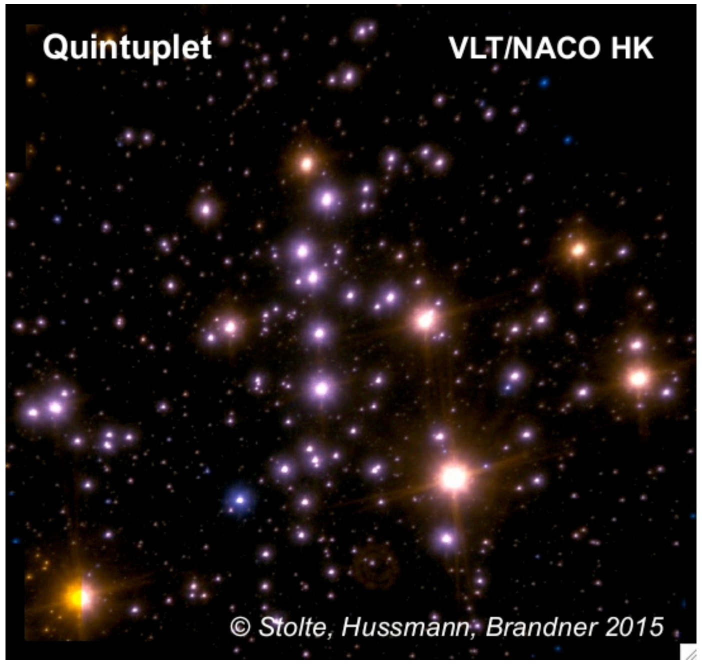




Weighing the IMBH: a simple model

1) What is the chance of finding such a massive IMBH at those distances from SgrA*?

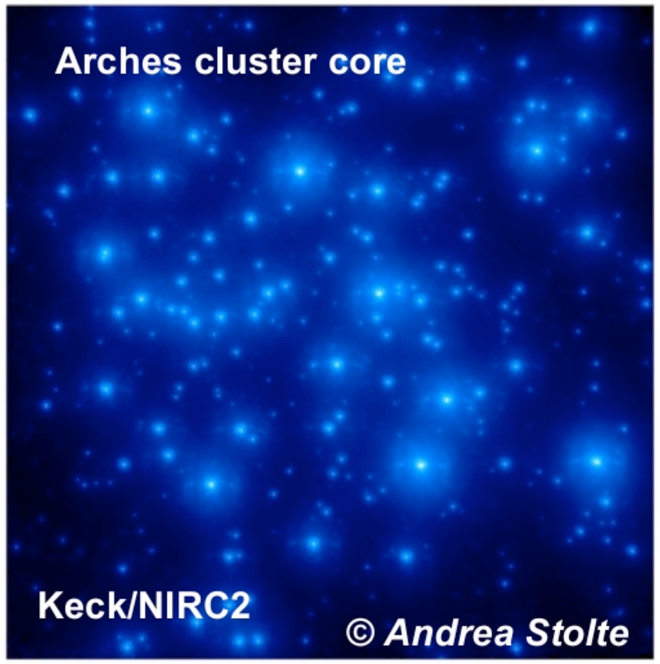


t_{df} > 1 Gyr... Not so unlikely

2) Where could it be born?

A stellar cluster...

But "local" stellar clusters (Arches, Quintuplet) are too small. Probably in the halo...



Summary

A compact high velocity (gradient) cloud at about 60 pc from SgrA*.

Could an IMBH producing such high velocity gradient?

Such IMBH should be very massive. $M_{BH} > \text{few} \times 10^4\ M_\odot$.

Not in tension with theoretical expectations, but if it is really an IMBH, it probably formed in the halo of the Milky Way and then migrated to its current position in a Hubble time.

Dynamical friction timescale

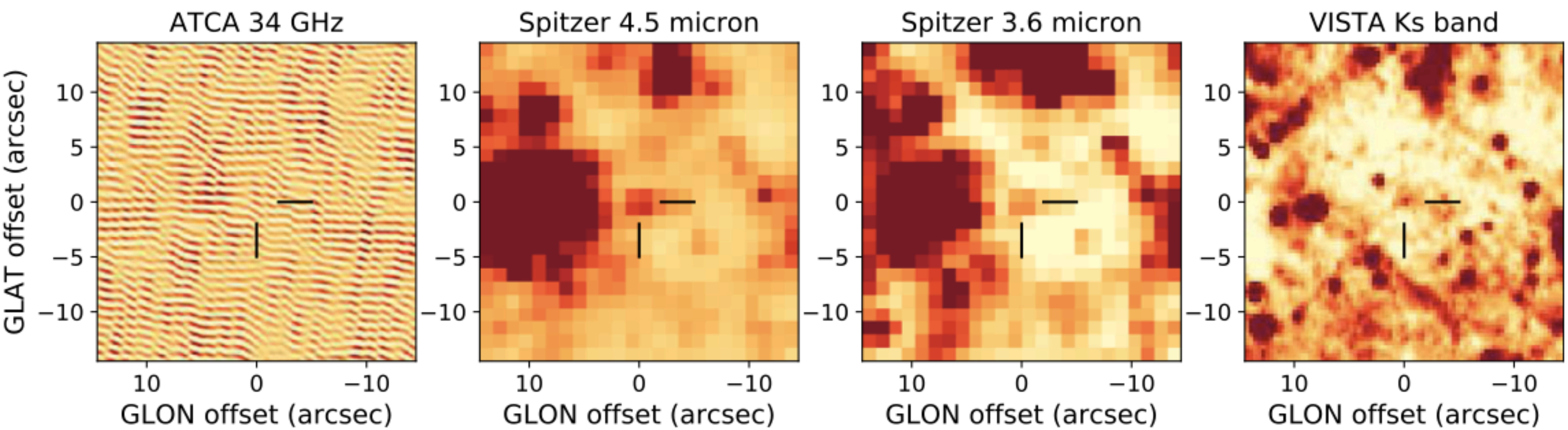
For the GC, the nuclear star cluster and the outer distribution of stars

$$M(r) = M_0(r/R_0)^\alpha$$

$M_0 = 2 \times 10^8\ M_\odot$, $R_0 = 60$ pc, $\alpha = 1.2$

$$t_{df} = \frac{\alpha+1}{\alpha(\alpha+3)} \frac{1}{\chi \ln\Lambda} \left(\frac{M_0}{G}\right)^{1/2} \frac{R_0^{3/2}}{m_{BH}} > 1 Gyr$$ (if naked...)

(Equation formulated by McMillian & Portegies Zwart, 2003)



ATCA 34 GHz
Spitzer 4.5 micron
Spitzer 3.6 micron
VISTA Ks band
GLAT offset (arcsec)
GLON offset (arcsec)
10
5
0
−5
−10