Candidate Cosmic Filament in the GJ526 Field Mapped with the NIKA2 Camera

NIKA2 Science Verification Program GJ526

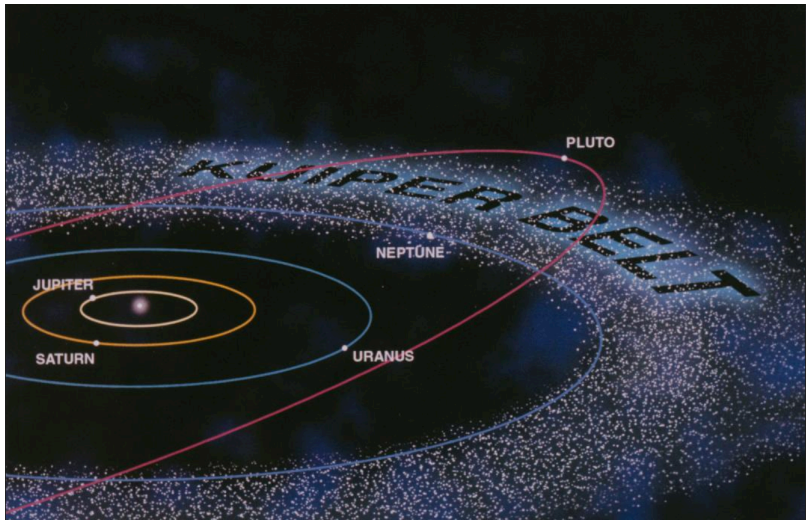
Jean-François Lestrade (Observatoire Paris)
on behalf of the NIKA2 collaboration

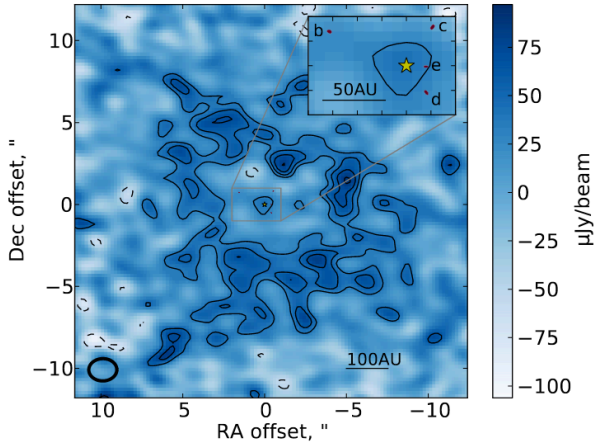
mm Universe @ NIKA2 - Roma - 28-2 july 2021

Outline

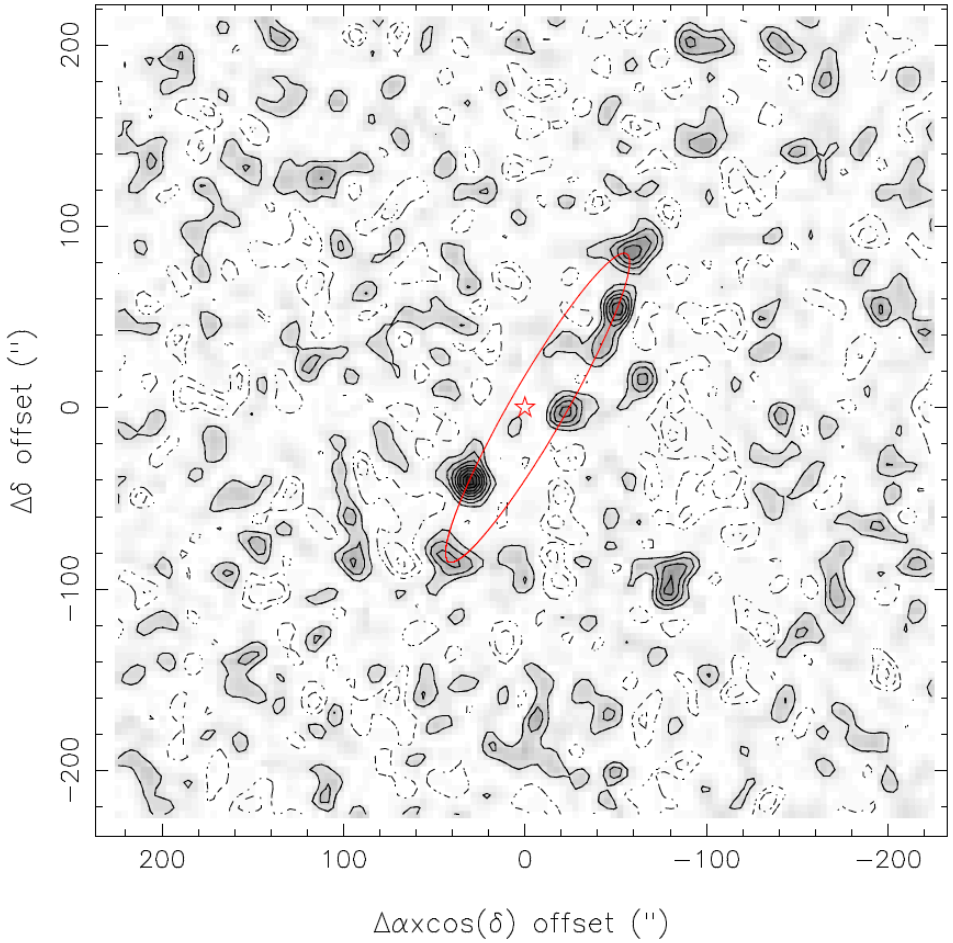
- Initial project : possible dusty circumstellar disk around the nearby red dwarf GJ526
- NIKA2 maps of the GJ525 field : noise caracterisation and source extraction
- Spatial distribution of the background sources : **candidate** cosmic filament

Initial motivation





Debris disk around HR8799
Booth et al 2016. ALMA



SNR map of the Field GJ526 with the camera MAMBO/IRAM 30m at 1.2mm, epoch 2007
Contours -3σ, -2σ,-1σ, +1σ, +2σ, +3σ…. *Lestrade et al (2009)*

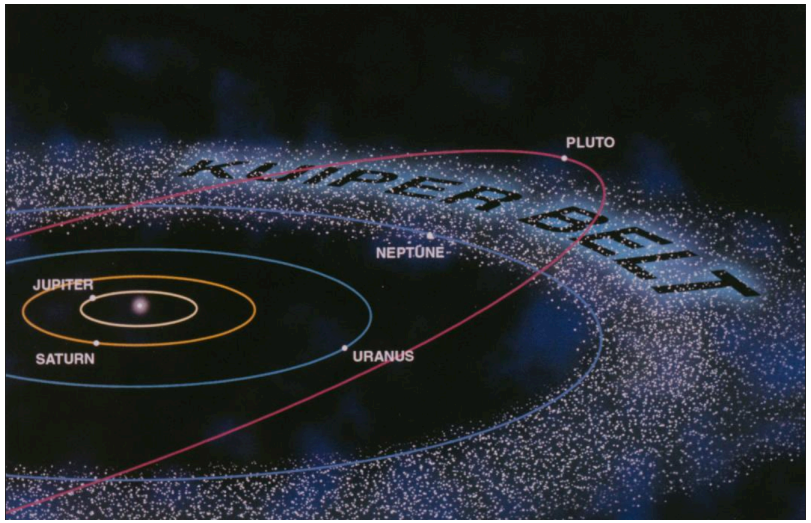
Proper motion of star GJ526 :

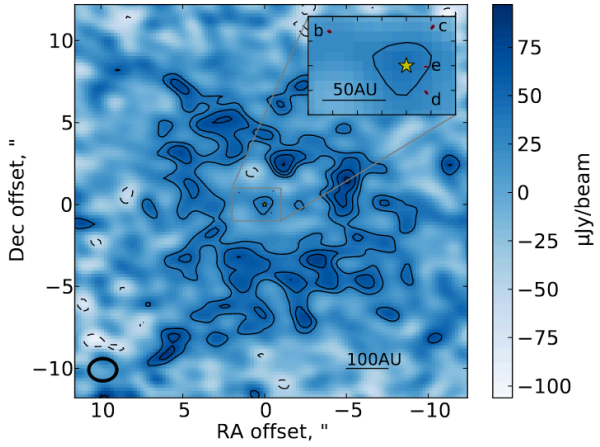
$\cos\delta\mu_\alpha$ =+1.77 arcsec/yr

μ_δ = -1.45arcsec/yr

Displacement expected in 10 years : 22.6” to south-east

Initial motivation





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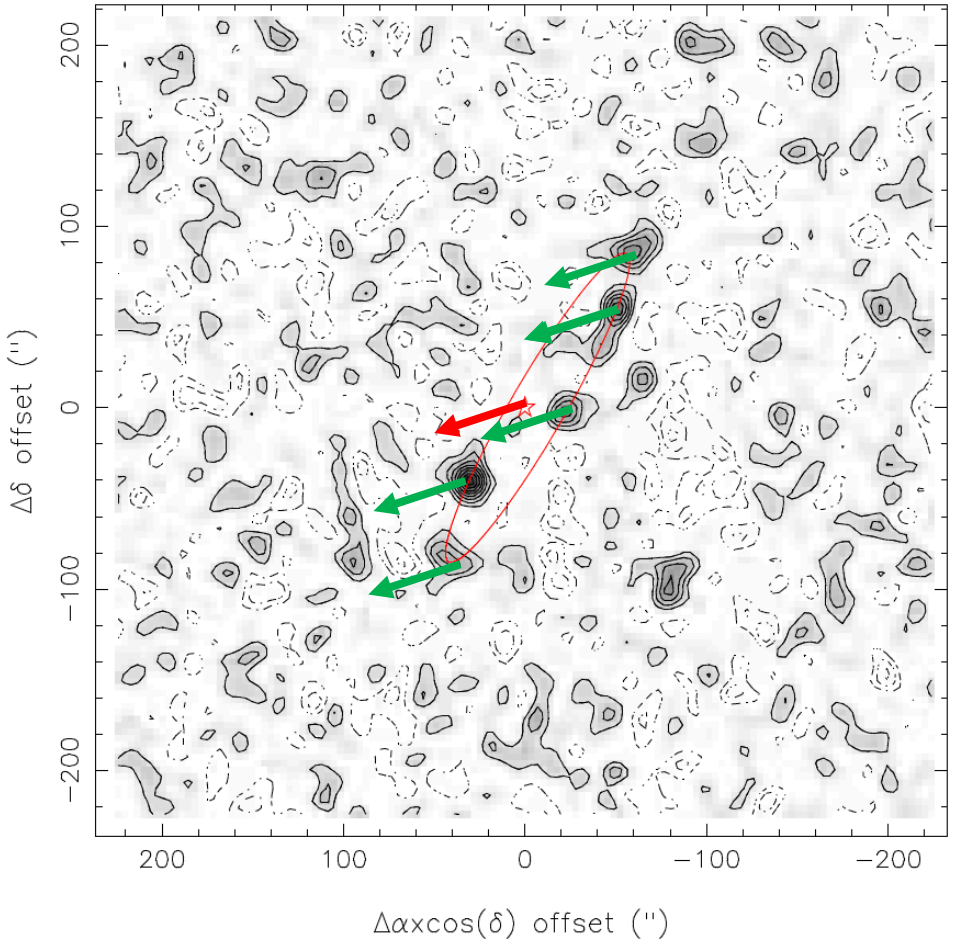

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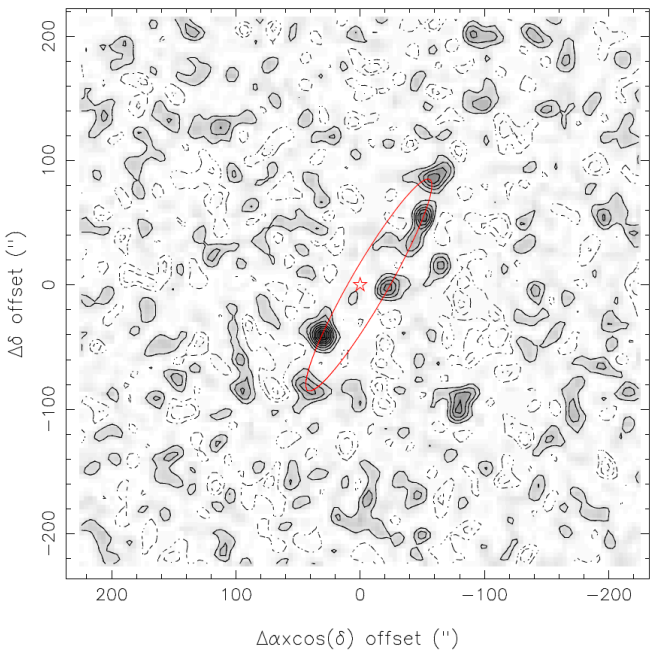
Contours -3σ, -2σ,-1σ, +1σ, +2σ, +3σ…. *Lestrade et al (2009)*

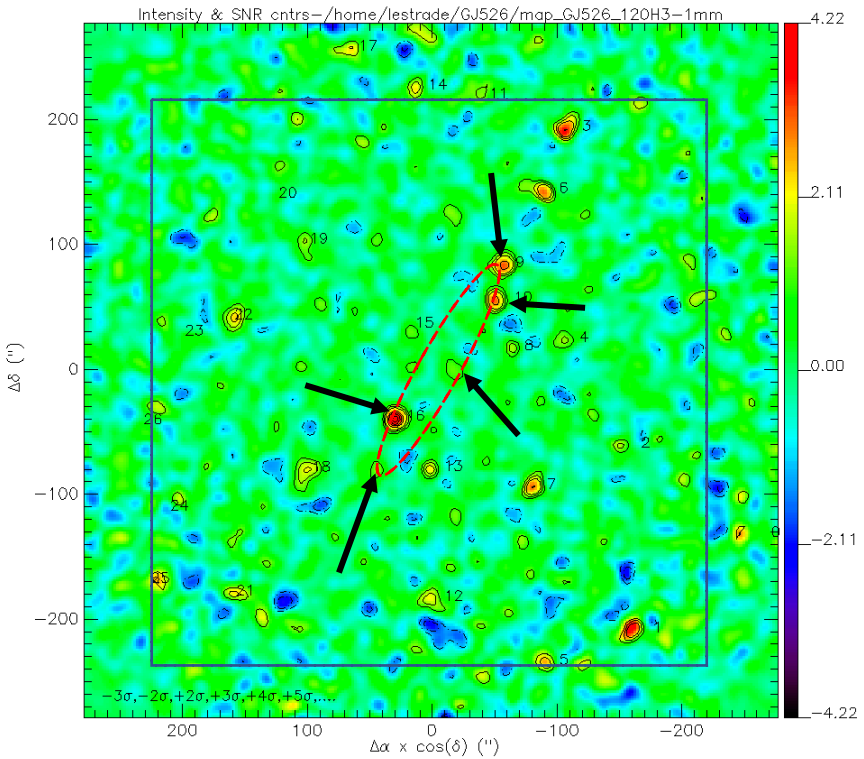
Preliminary

MAMBO map and NIKA2 maps

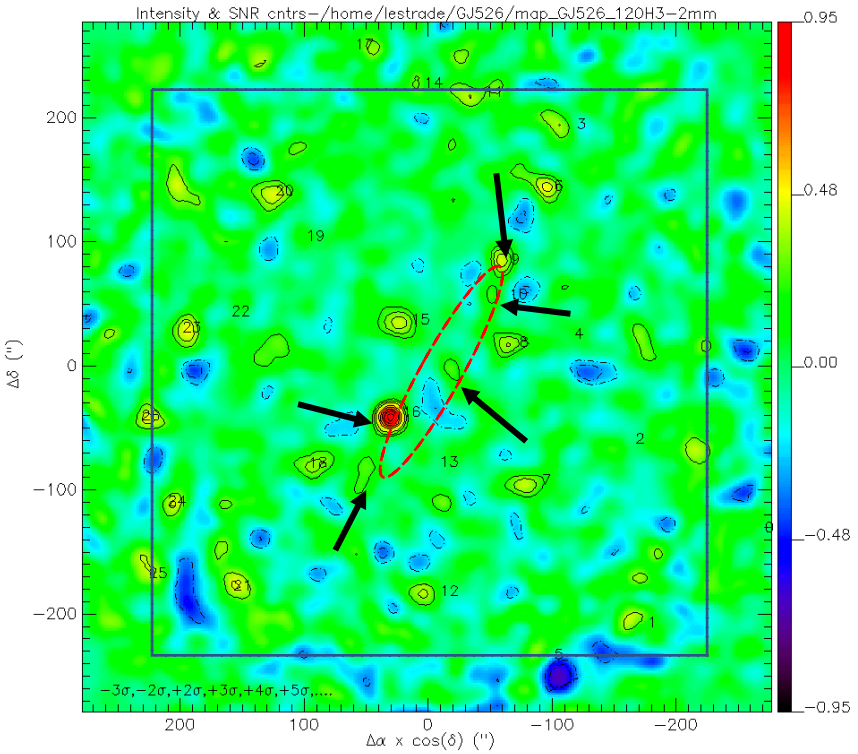
MAMBO – 1.2mm



NIKA2 – 1.15mm (A1+A3)



NIKA2 – 2.0mm (A2)



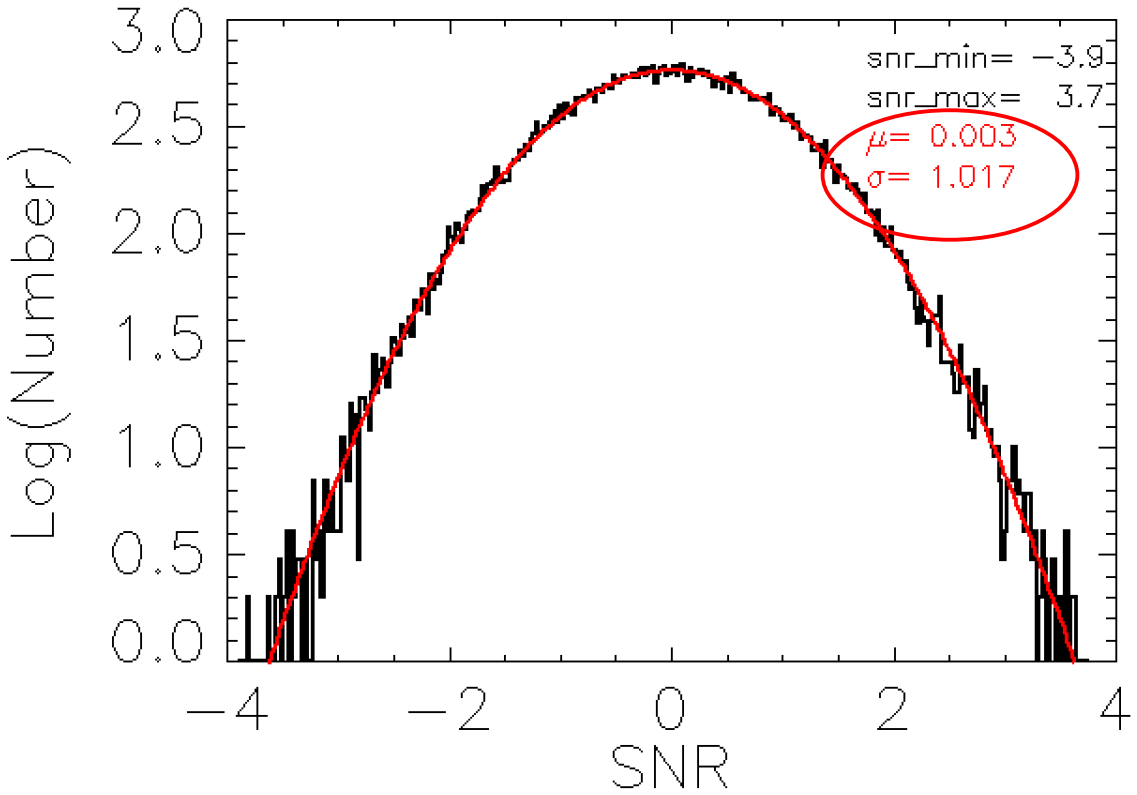
MAMBO epoch 2007 (16 hours)
Contours=SNR : -3σ, -2σ,-1σ, +1σ, +2σ, +3σ, ...
1σ=0.7mJy/beam
(*Lestrade et al 2009)*

NIKA2 epoch 2017 (9.3hours)
Color scale = surface brightness mJy/b
Contours = SNR :-3σ,-2σ, +2σ, +3σ, +4σ, …. (1σ=0.6mJy/beam)

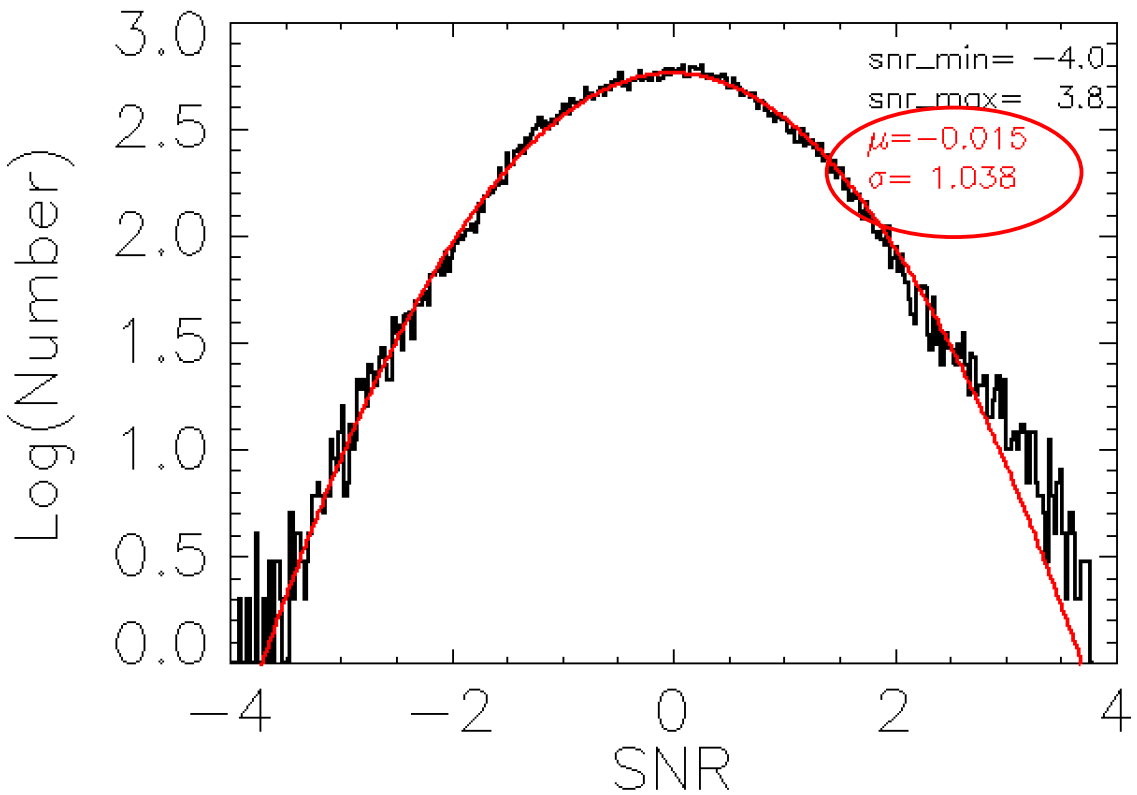
NIKA2 observations : april 2017, february 2018 (9.3hrs)
Map making method : IMCM (Iterative Multi Correlated Modes)
opacity_1mm : 0.20 – 0.45 (2mm : 0.10 – 0.25)

Caracterization of the noise : Jack-knifed maps

1 mm



2 mm



Point-source extraction and statistics

Statistically, no spurious source with |SNR| > 4 is expected in our 1mm NIKA2 map with its 2630 independant beams (500''x500''/(π(11''/2)^2))

Satistically, 7 spurious sources with |SNR| > 3 are expected

		NIKA2						MAMBO	NIKA2 – MAMBO		Comments
#Mbo	ID H3	α_{2000} ($h\ m\ s$)	δ_{2000} (° ′ ″)	S_{260GHz} (mJy)	SNR 260GHz	S_{150GHz} (mJy)	SNR 150GHz	S_{250GHz} (mJy)	$cos(\delta)\Delta\alpha(''')$	$\Delta\delta(''')$	
		Unambiguously detected NIKA2 sources (snr ≥ 4 at 1 mm)									Comments
	1	13:45:33.48	14:49:50.5	3.96± 0.75	5.3	0.41± 0.17	2.4	out*			
	3	13:45:37.18	14:56:31.9	3.67± 0.60	6.1	0.39± 0.13	3.0	n**			*filament*
	6	13:45:38.36	14:55:42.2	2.95± 0.52	5.7	0.37± 0.11	3.3	?	+5	+1	*filament* ; 2.5σ MAMBO feature
6	**7**	**13:45:38.97**	**14:51:45.4**	2.87± 0.47	6.1	0.41± 0.11	3.9	3.2±0.7	0	+6	
4	**9**	**13:45:40.61**	**14:54:42.8**	3.13± 0.45	6.9	0.42± 0.10	4.3	4.3±0.8	−3	−2	*filament*
3	**10**	**13:45:41.09**	**14:54:14.8**	2.97± 0.44	6.8	0.23± 0.09	2.4	6.3±1.0	−3	−2	*filament*
	13	13:45:44.69	14:51:59.4	2.08± 0.44	4.7	0.06± 0.10	0.6	n			
1	**16**	**13:45:46.63**	**14:52:39.7**	4.11± 0.43	9.6	0.98± 0.09	10.3	5.6±0.7	0	−1	*filament*
	18	13:45:51.51	14:51:59.0	2.15± 0.48	4.5	0.34± 0.11	3.1	n			*filament*
	22	13:45:55.51	14:54: 1.1	2.40± 0.52	4.6	0.02± 0.11	0.2	n			
2								3.0±0.7	?	?	4.3σ MAMBO source, 2.8σ NIKA2 feature
		Possibly detected NIKA2 sources (3 ≤ snr < 4 at 1 mm or snr >4 at 2 mm)									Comments
	0	13:45:27.41	14:51: 6.8	2.68± 0.79	3.4	0.20± 0.18	1.1	out			
	2	13:45:34.13	14:52:18.1	1.67± 0.52	3.2	0.16± 0.11	1.4	n			
	4	13:45:37.30	14:53:43.1	1.55± 0.45	3.4	0.08± 0.10	0.8	n			
	5	13:45:38.33	14:49:24.6	2.57± 0.71	3.6	0.28± 0.16	1.7	out			
7	**8**	**13:45:40.15**	**14:53:36.2**	1.52± 0.43	3.6	0.39± 0.09	4.1	?	+2	+7	3σ MAMBO feature
	11	13:45:42.34	14:56:57.8	1.12± 0.60	1.9	0.41± 0.13	3.2	out			
	12	13:45:44.66	14:50:15.4	2.15± 0.56	3.8	0.41± 0.13	3.2	n			
	14	13:45:45.51	14:57: 5.0	2.20± 0.61	3.6	0.27± 0.13	2.0	out			
	15	13:45:46.18	14:53:54.2	0.40± 0.43	0.9	0.44± 0.09	4.8	n			
	17	13:45:49.08	14:57:36.4	2.25± 0.72	3.1	0.14± 0.15	0.9	out			
	19	13:45:51.63	14:55: 1.6	1.57± 0.49	3.2	0.15± 0.11	1.4	n			
	20	13:45:53.23	14:55:38.3	0.47± 0.55	0.9	0.48± 0.12	4.0	n			
	21	13:45:55.42	14:50:19.7	2.20± 0.67	3.3	0.48± 0.15	3.1	n			
	23	13:45:58.06	14:53:48.1	0.47± 0.57	0.8	0.51± 0.13	4.0	n			
	24	13:45:58.82	14:51:28.1	0.27± 0.65	0.4	0.47± 0.15	3.1	out			
	25	13:45:59.81	14:50:29.8	2.61± 0.79	3.3	0.38± 0.18	2.1	out			*filament*
	26	13:46: 0.19	14:52:36.8	0.17± 0.64	0.3	0.49± 0.14	3.4	out			

*out=outside the MAMBO map

**n= not detected at snr ≥ 4 in the MAMBO map

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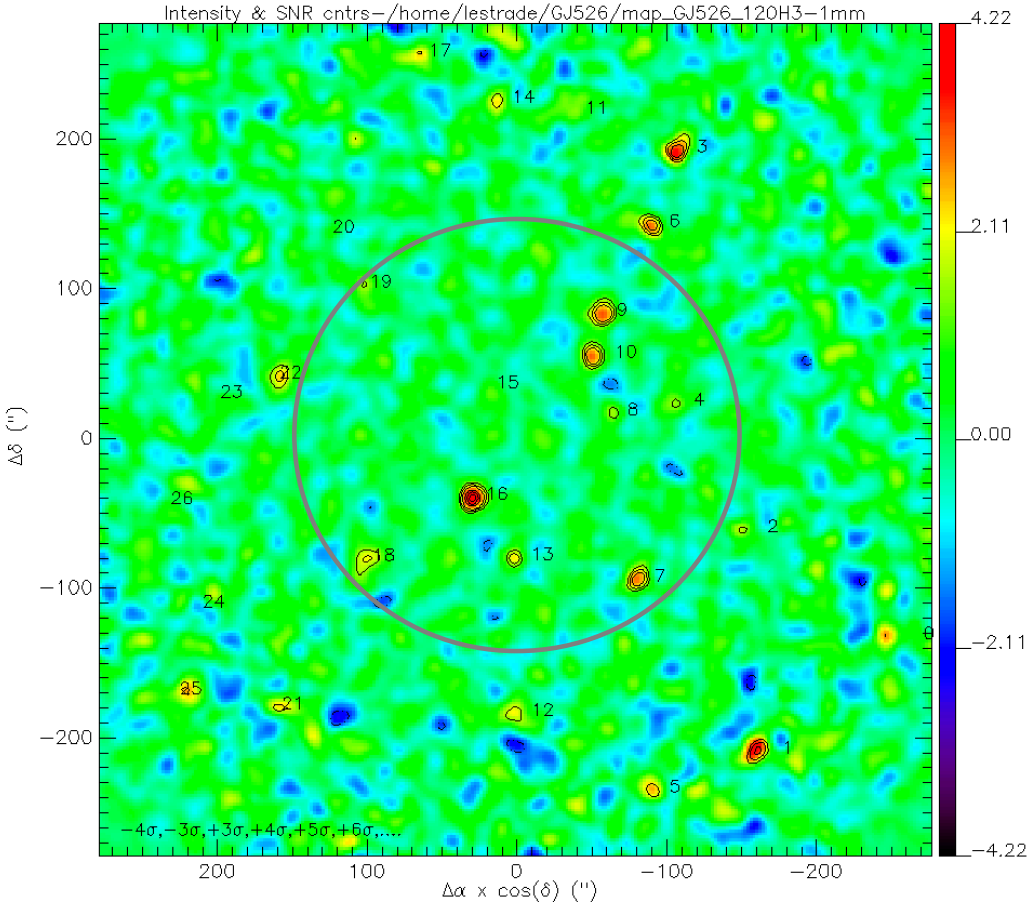
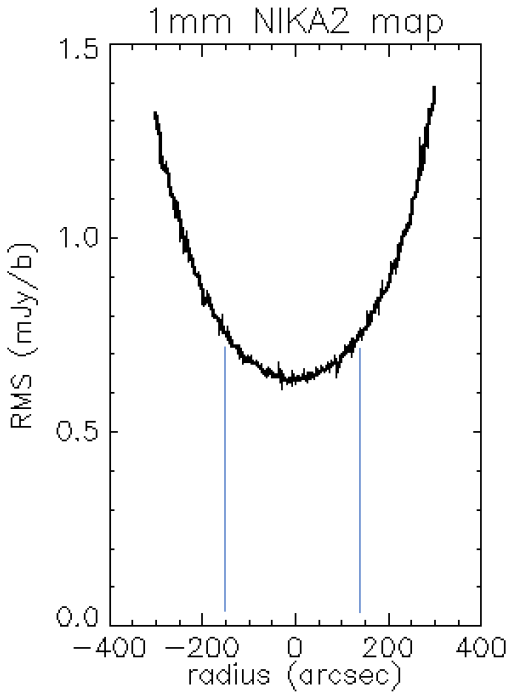
Overdensity of SMGs in the GJ526 Field



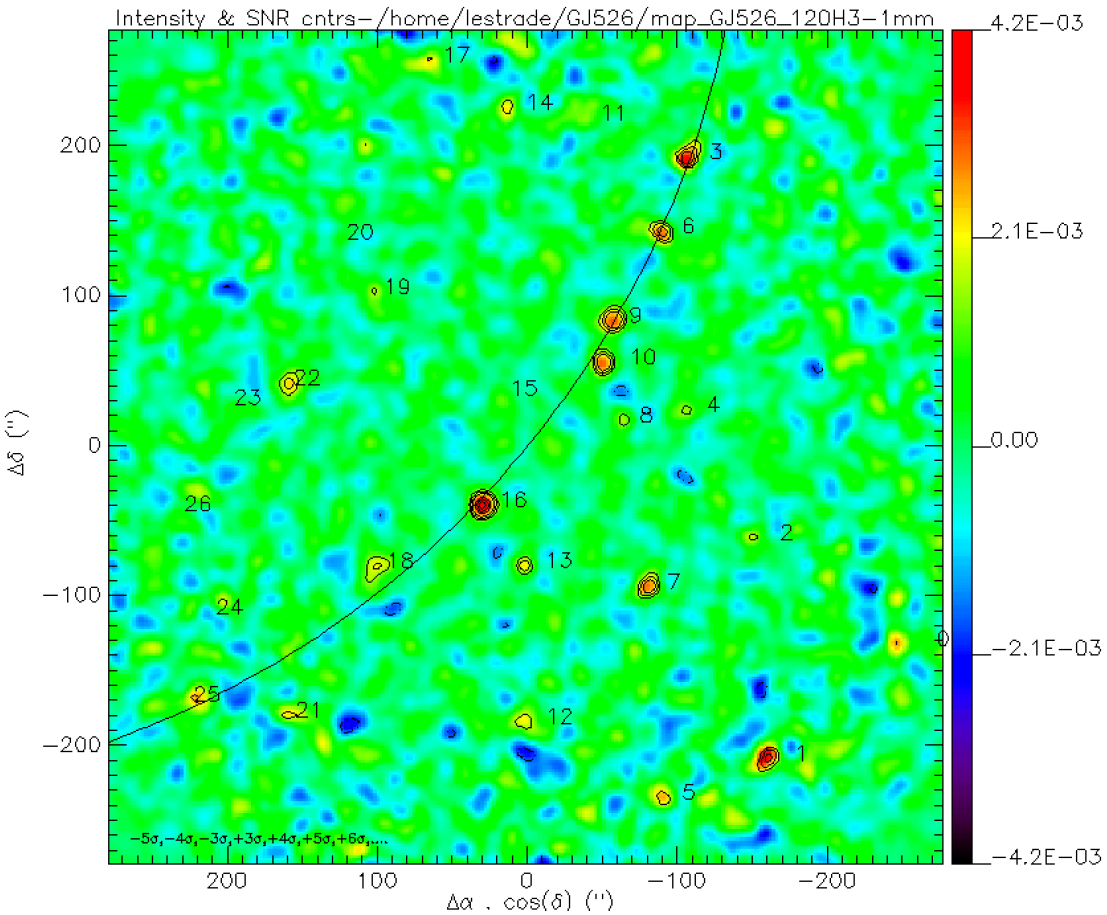


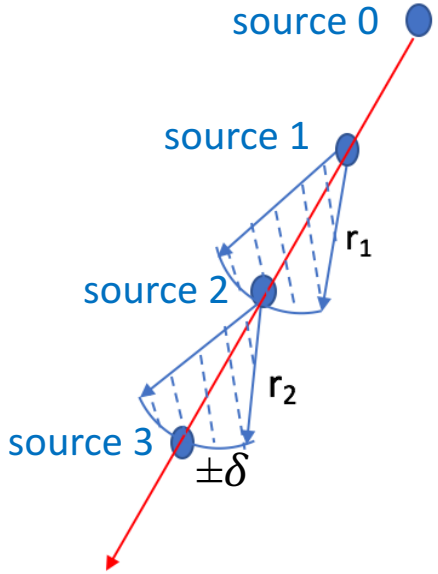
In the central region (r < 150’’) : 6 sources (ID 9, 10, 16, 13, 18, 7) are unambiguously detected (SNR >4)

Previous cumulative source count at 1.2mm in the COSMOS field : N($S_\nu > 4\sigma = 2mJy$)=500 sources/deg^2

Poisson probability with COSMOS source surface density is 1.5% → overdensity

Alignment of sources in the GJ526 field



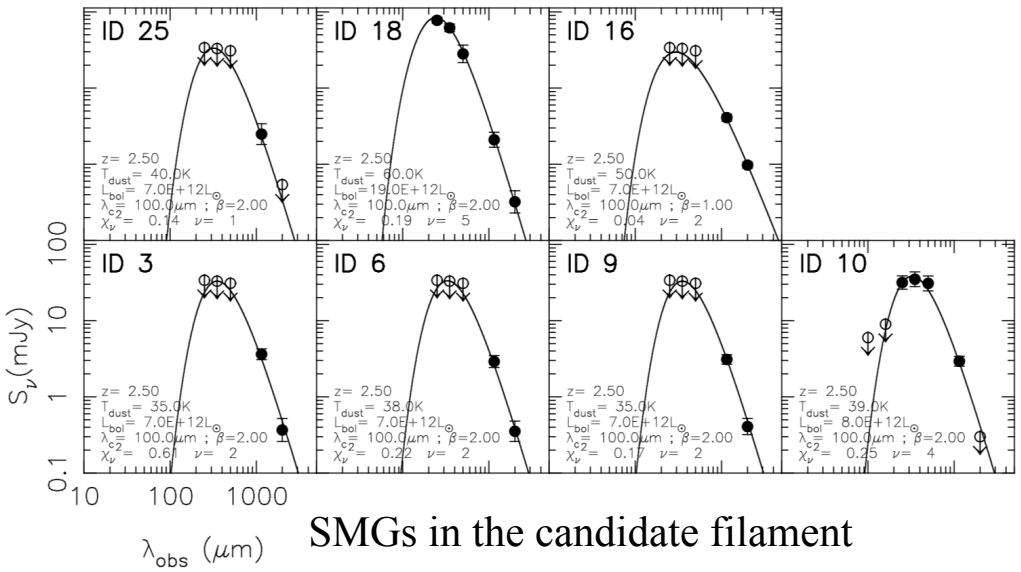


Probability of chance alignment of sources ID 3, 6, 9, 10, 16, 18, (25)

Using source number surface density N($S_\nu > 4\sigma = 2mJy$)=500 sources/deg^2 (COSMOS field) and δ=10°

$$\text{Probability} = \prod_{i=1,6} 500 \text{ sources/deg}^2 \,.\, \pi\,(r_i)^2 \,.\, (2\delta/360°) = 1.5\ 10^{-6}$$

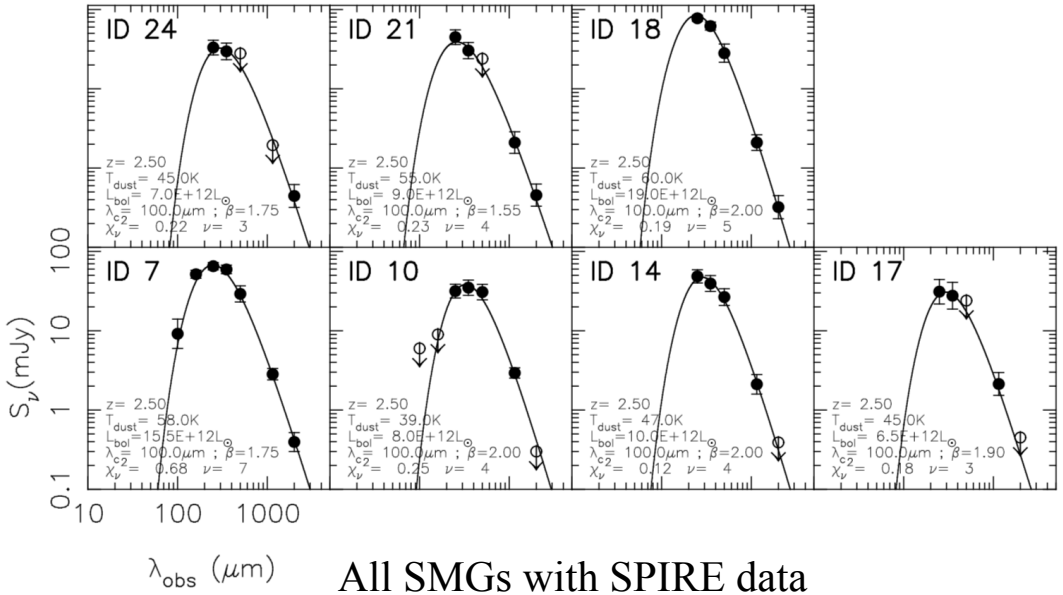
SEDs and photometric redshift of SMGs



SMGs in the candidate filament

Adopting the same redshift *z=2.5* for all sources yields reasonable fits for all SEDs, *i.e.*

$35\ K < T_{dust} < 60\ K$,
$6.5 < L_{bol} < 19\ 10^{12}\ L_{bol}$
$1 < \beta < 2$



All SMGs with SPIRE data

$$S_\nu = \frac{1+z}{4\pi D_L^2} L_{bol} \frac{f_{\nu(1+z)}}{\int f_{\nu'} d\nu'}$$

(Blain et al 2002)

Data : NIKA2 and Herschel/SPIRE photometry

Cosmological simulations

The intersections of filaments become the locations at which galaxy clusters form and evolve. (*Springel et al 2005*)

Narrow streams of cool gas falling along filaments fuel the growth of galaxies at cosmic dawn (1 < z < 3). (*Dekel et al 2009)*

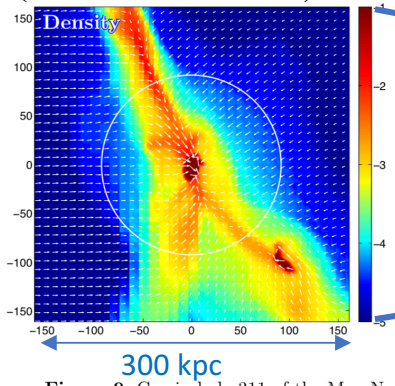
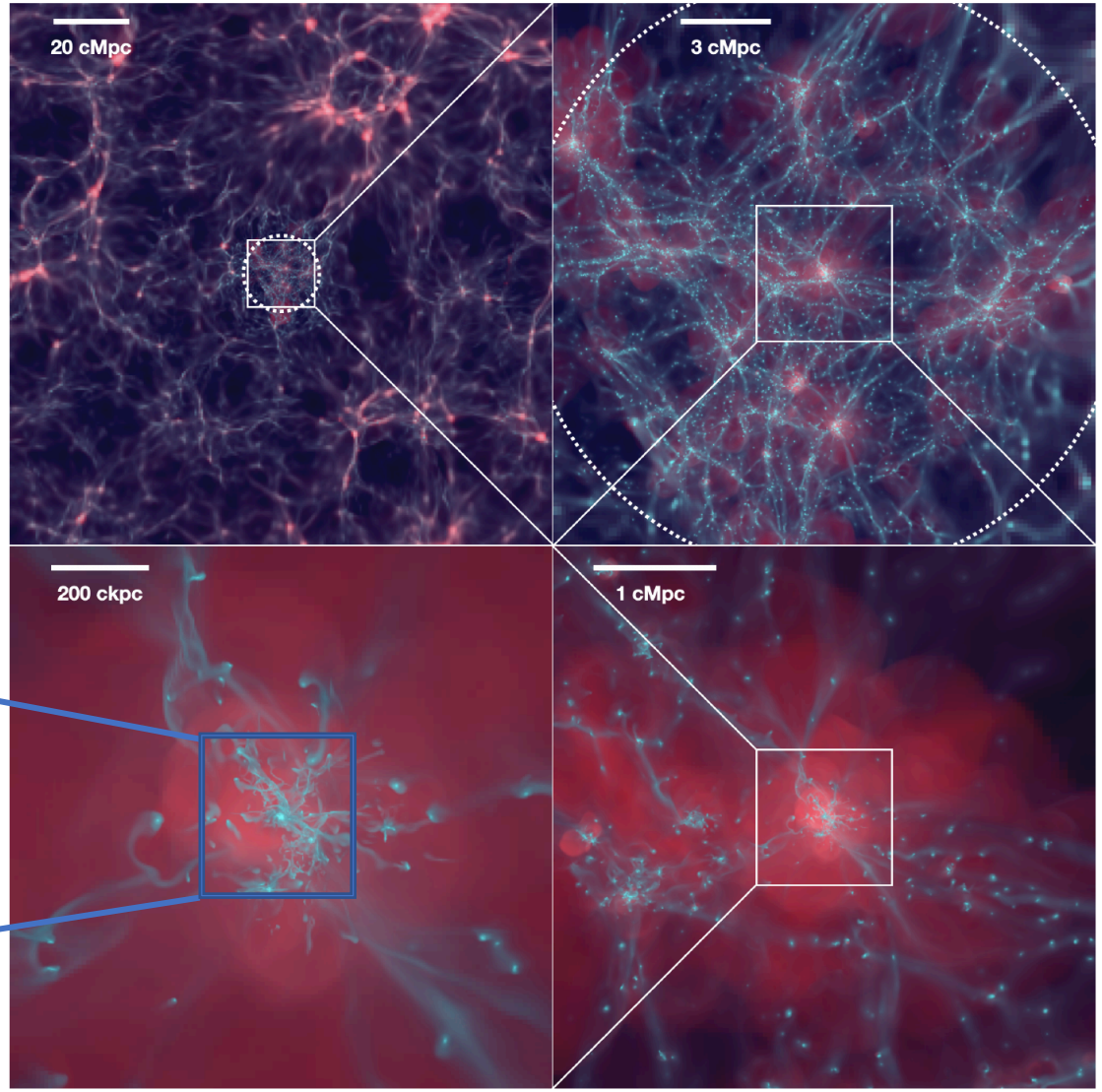
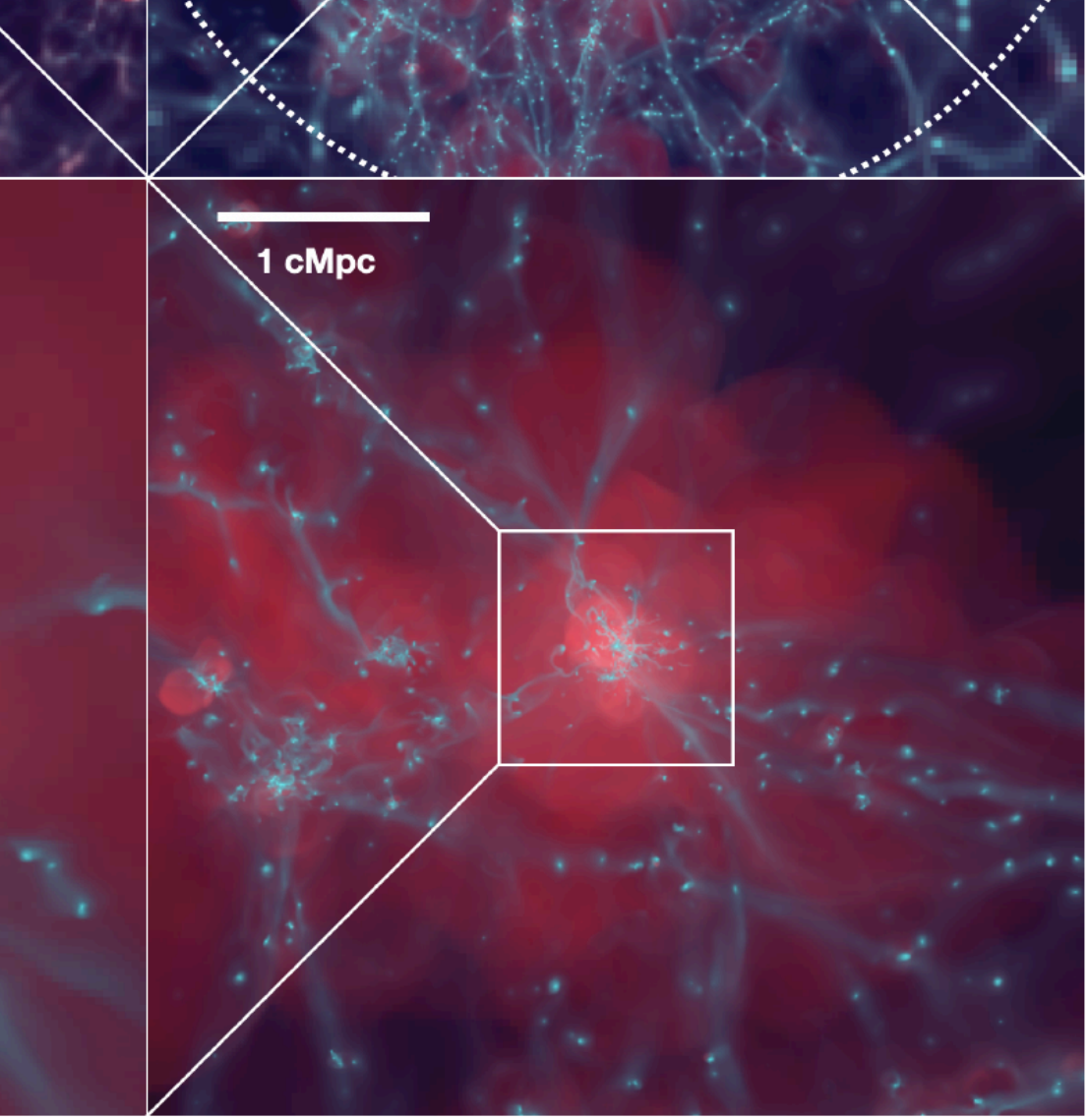


Figure 9. Gas in halo 311 of the MareNostrum



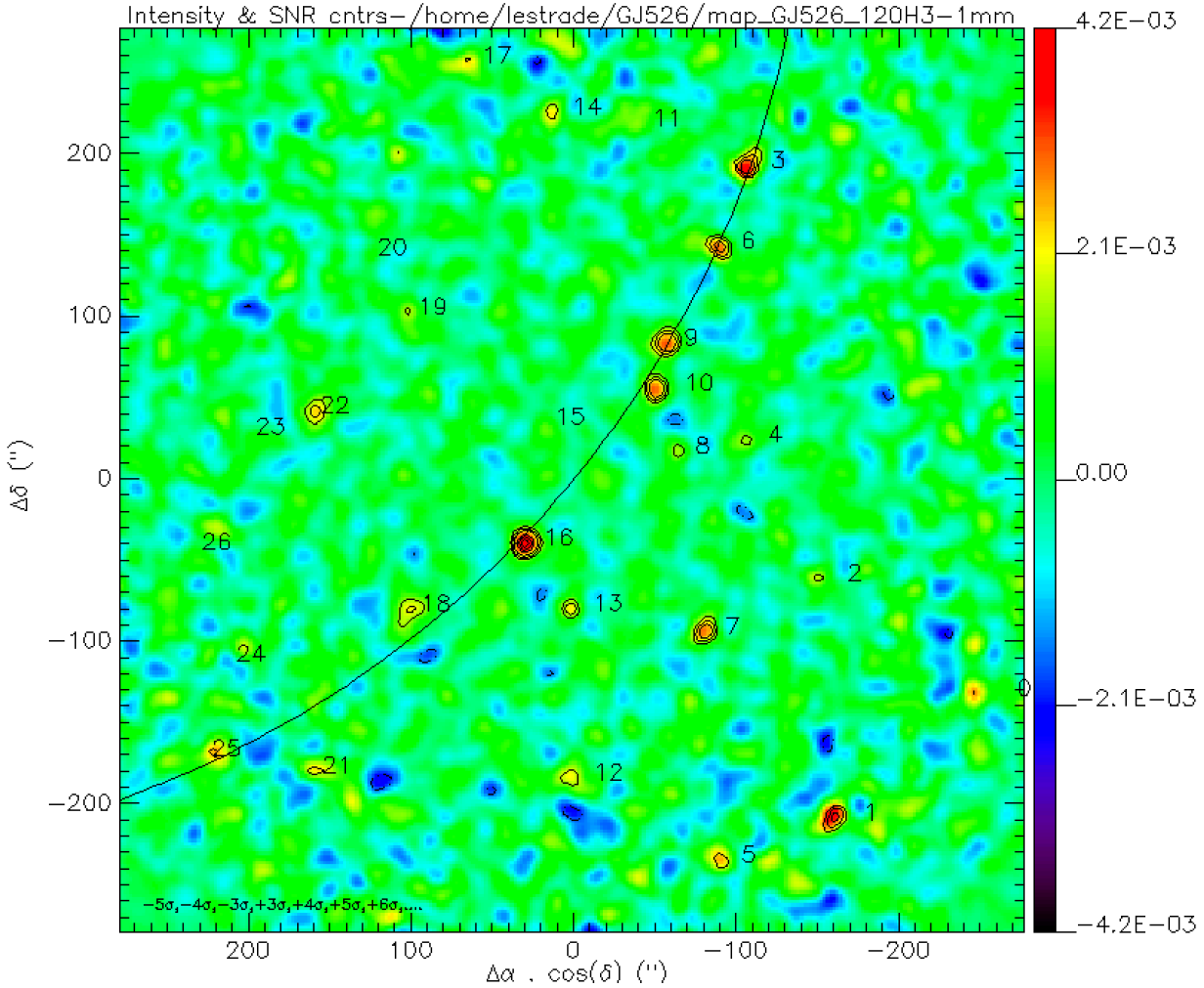
Λ-CDM model **NewHorizon** simulation : snapshot at z=2 of projected density (DM and gas) in silver blue and temperature in red.
(*Dubois et al 2014, 2020*)

Cosmic web is a vast, foam-like network of filaments and voids stretching throughout the Univers and tracing DM, gas and galaxies.



Size = 4.6 Mpc at z=2

Candidate Cosmic filament in the NIKA2 map of the GJ526 field



size = 4 Mpc at z=2 (500'' x 8.521kpc/'')

Proto-cluster SSA22 at z=3.095 : SMG's and Ly α emission of two cosmic filaments

MUSE V-,R-,I' bands ALMA 1.1mm Chandra X-ray

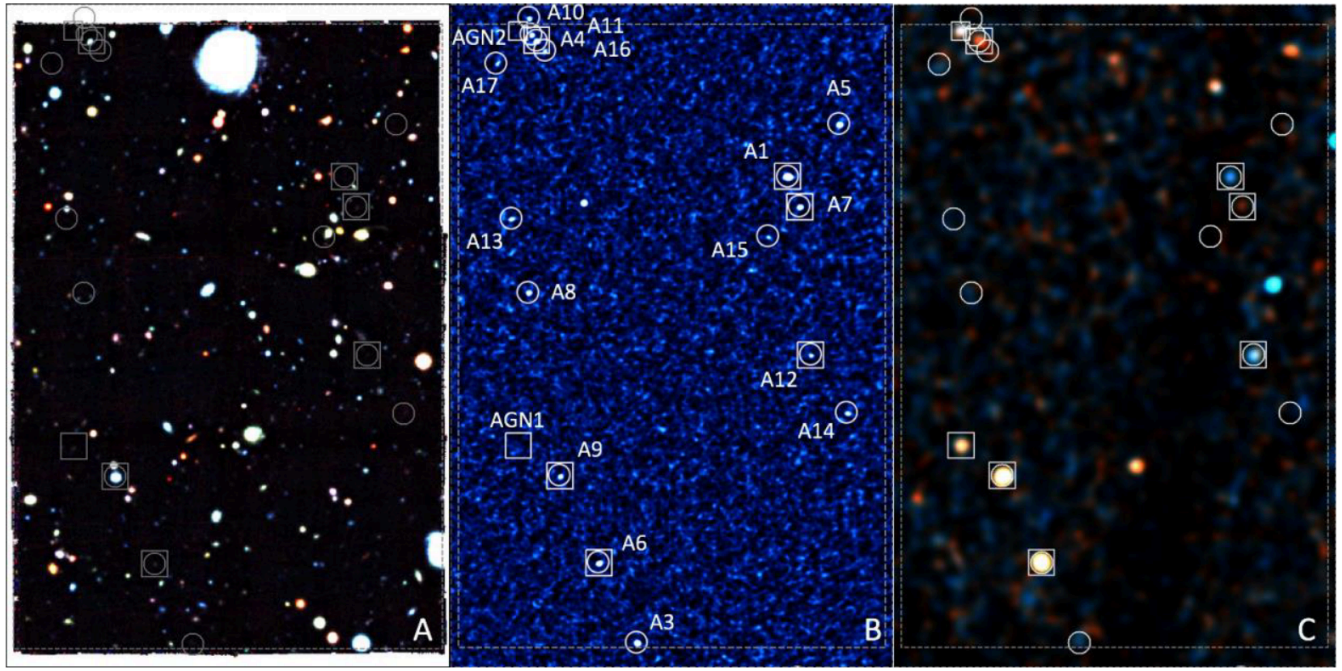
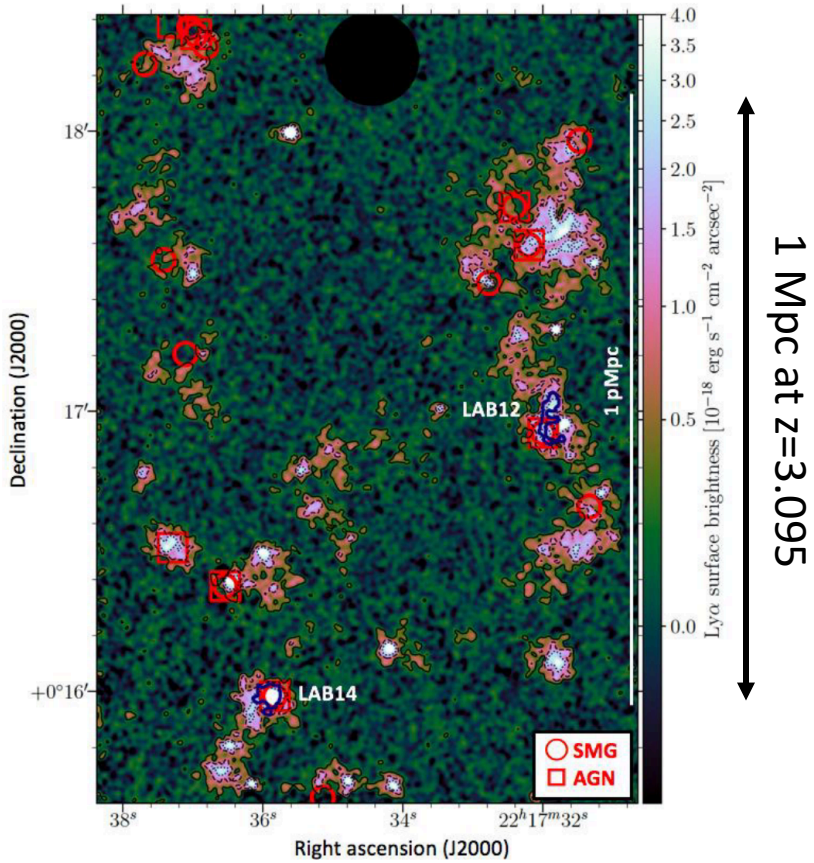


Fig. 1. Multi-wavelength images of ADF 22, illustrating the overdensity of galaxies and AGNs in a narrow redshift range at z=3.09. Each panel is centered at (α, δ) =

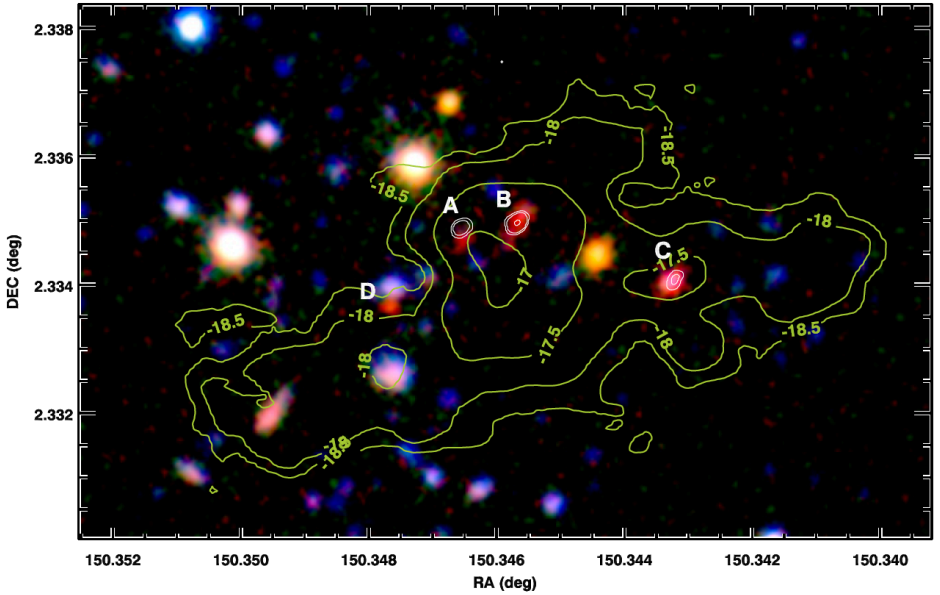
Lyman_alpha



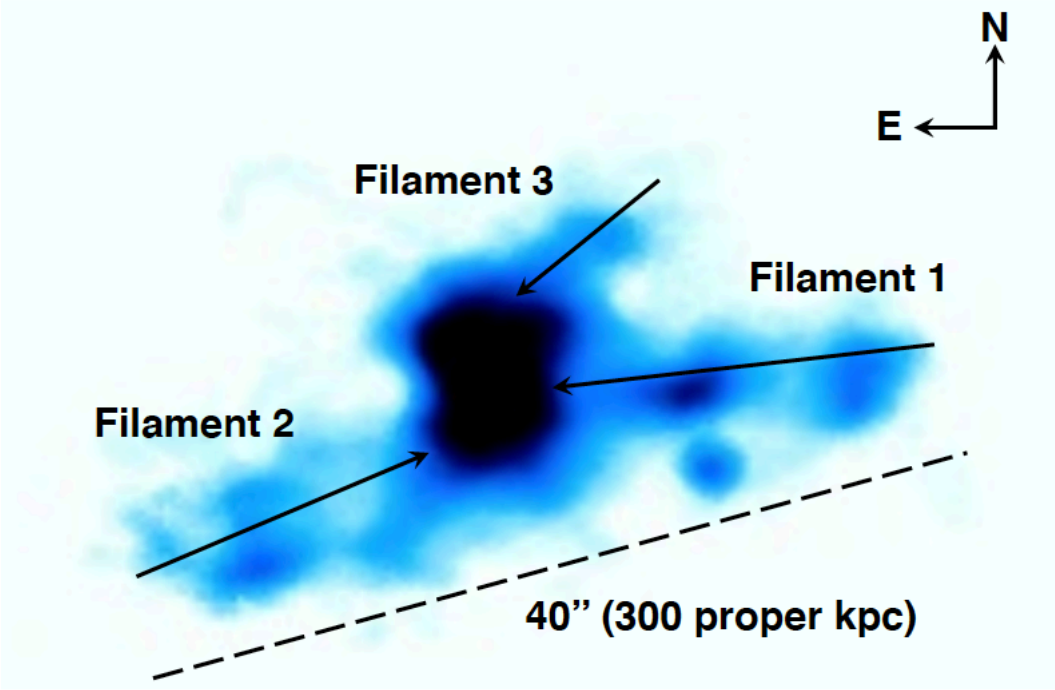
Ly α emission map optimally extracted from the MUSE observations,

Umehata et al 2019

The massive galaxy group RO-1001 at z=2.91



Group RO-1001 : contours are the Lyα surface brightness. Sources ABC are ALMA SubMillimeter Galaxies and D is a massive Galaxy and quiescent object in the structure.



Group RO-1001 : Lyα image and the three extended filaments labeled.

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Concluding remarks

Follow up observations (spectroscopic z of SMGs with CO and Lyman alpha image) to fu
characterise the **candidate** cosmic filament(s) of the GJ526 field.

Moderately deep millimeter map (*i.e.* 1σ=0.5mJy) over relative large field (~100 arcmin^2,
a few Mpc^2 at cosmic dawn ($1 < z < 3$) can be conducted efficiently (10hrs) thanks to the l
mapping speed of the NIKA2 camera.

This capability could be used to peak up the large scale structure of the Early Univers trac
by milliJanky SubMillimeter Galaxies (SMGs).