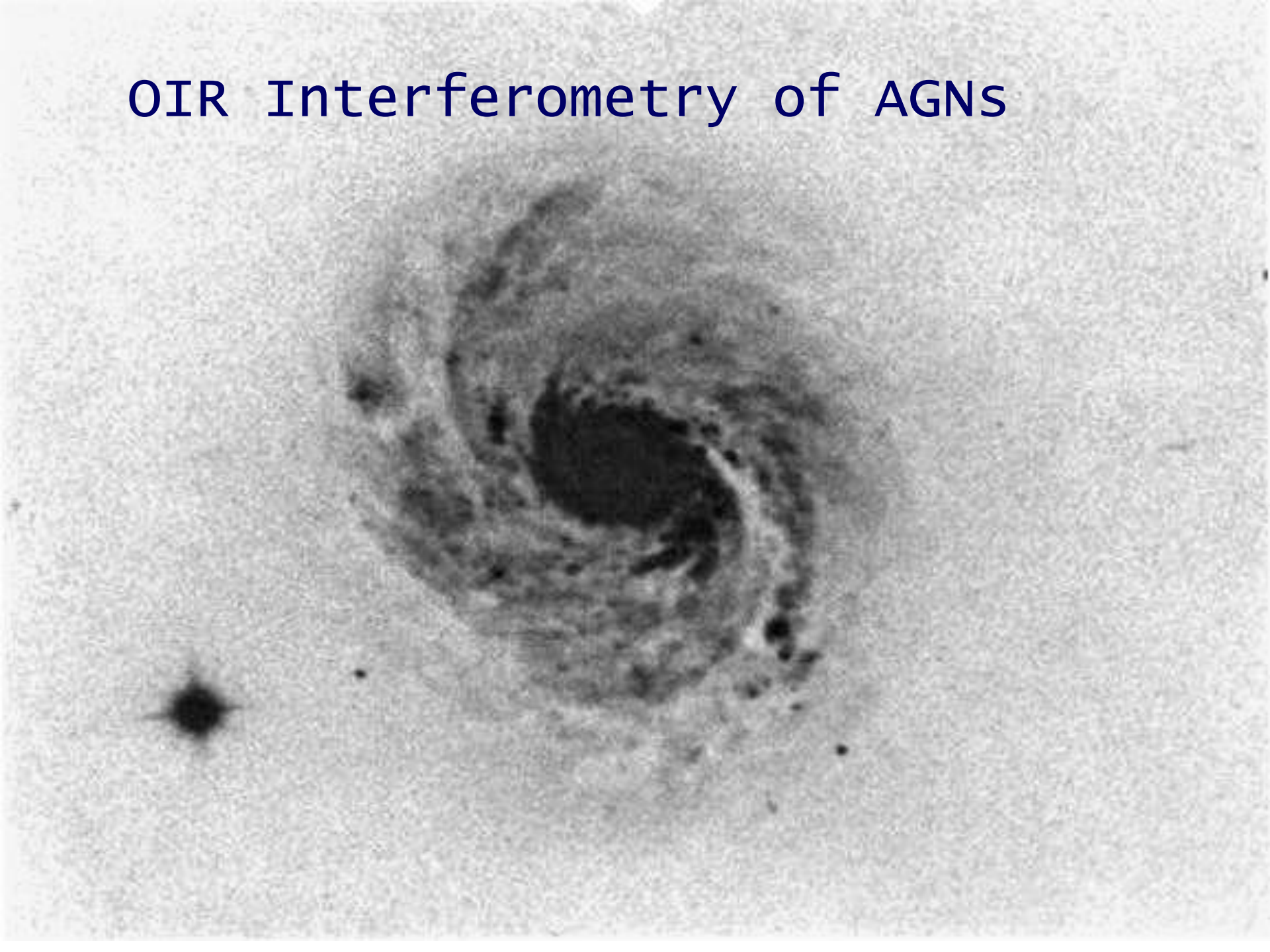
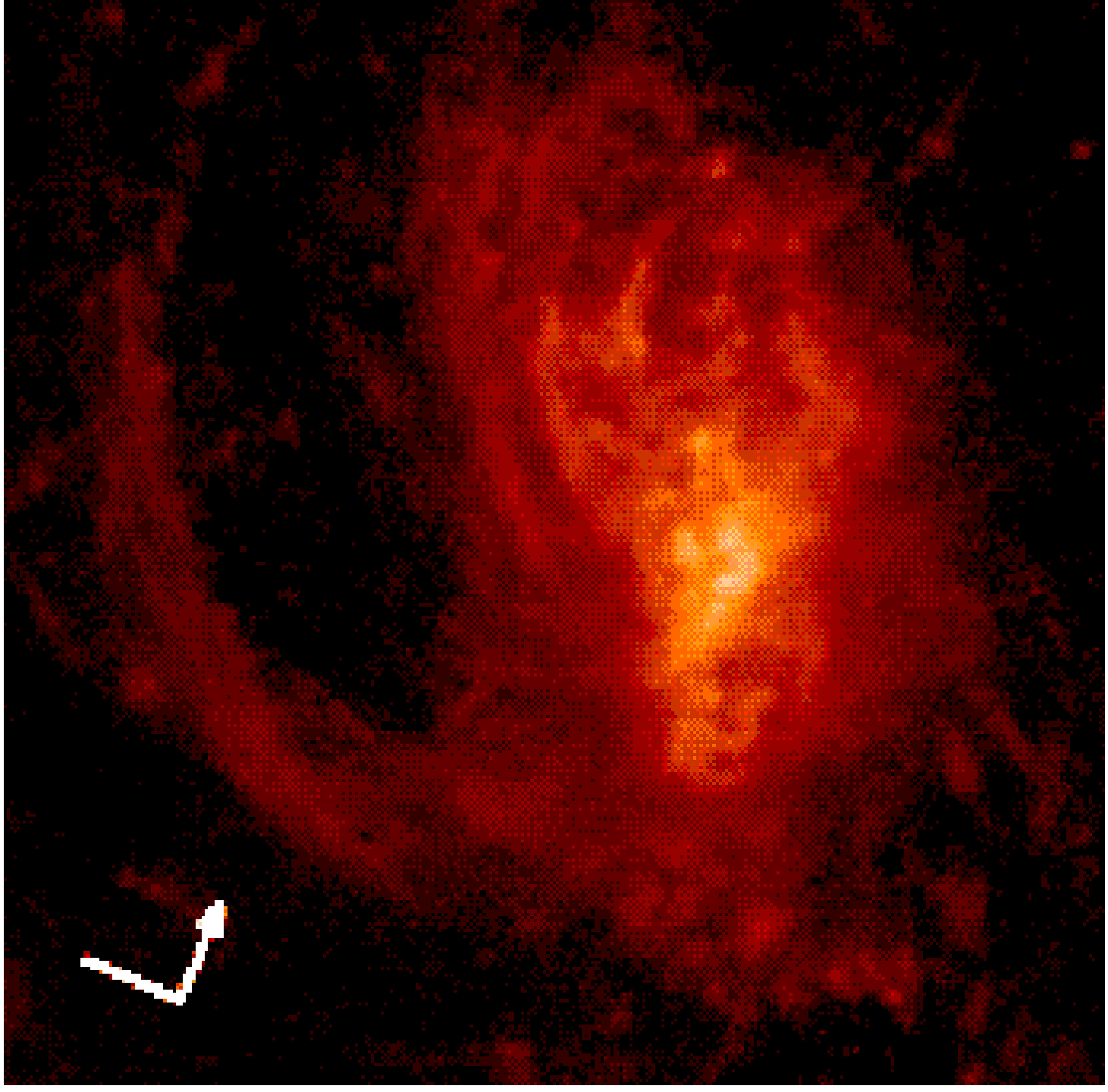
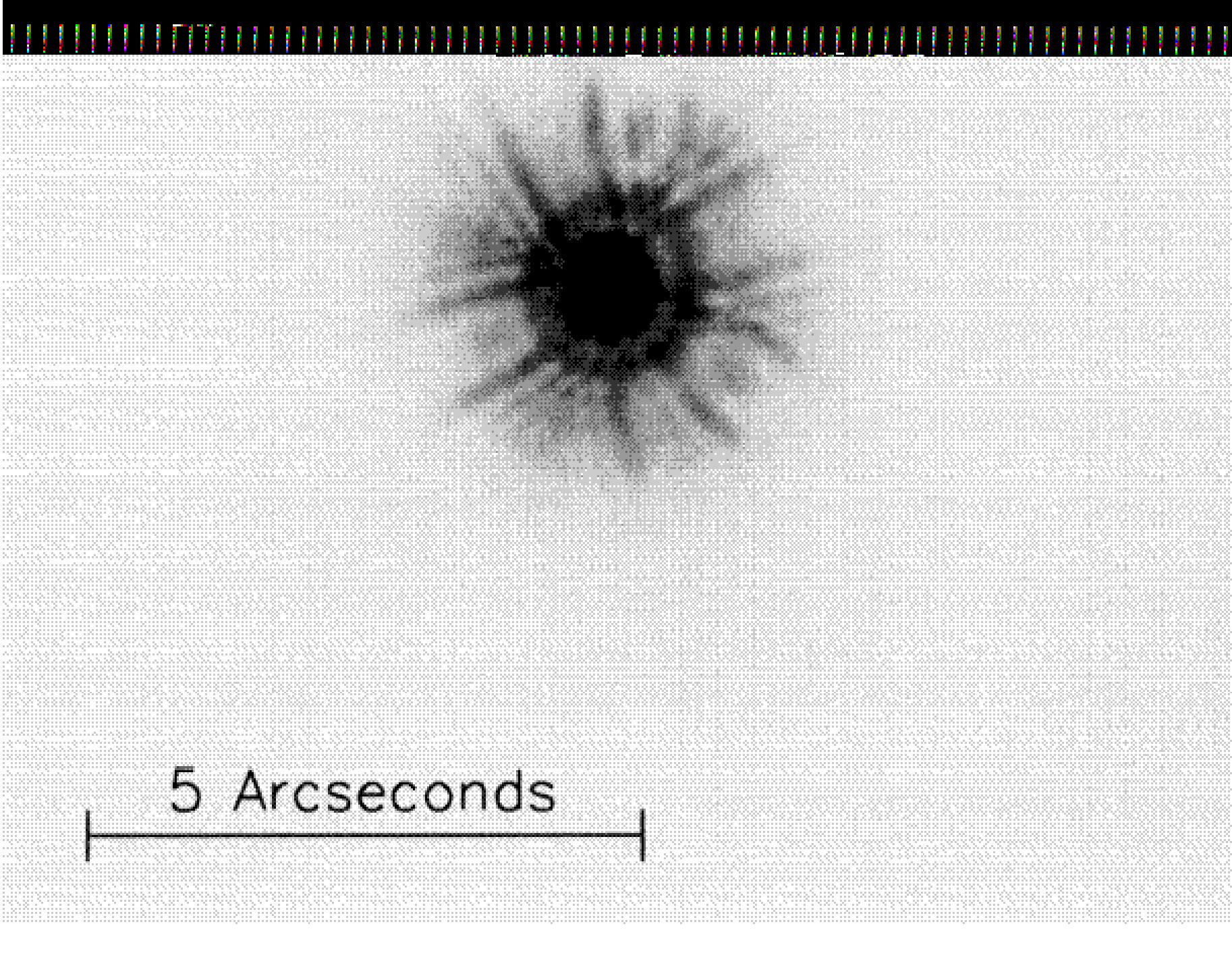
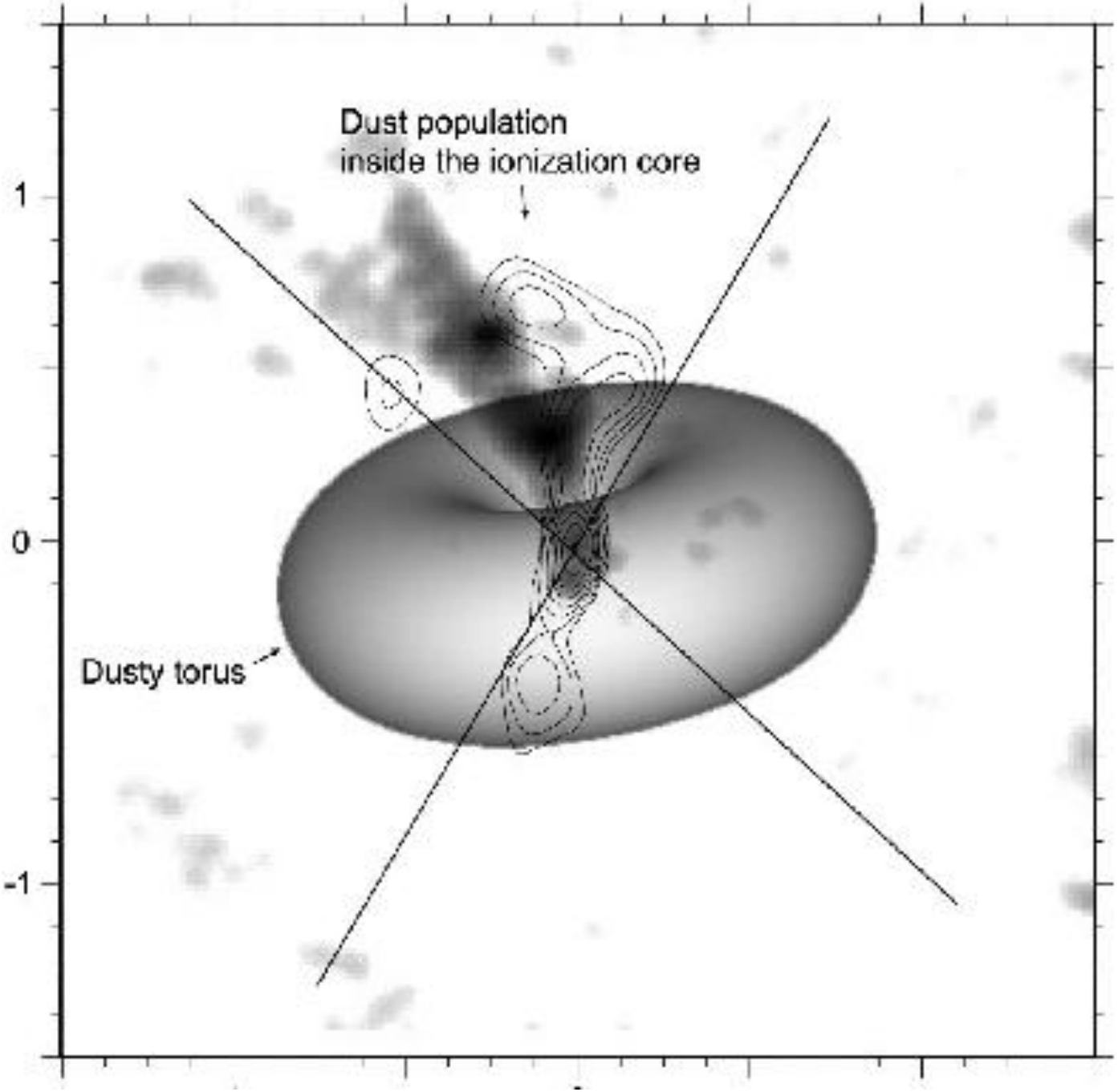
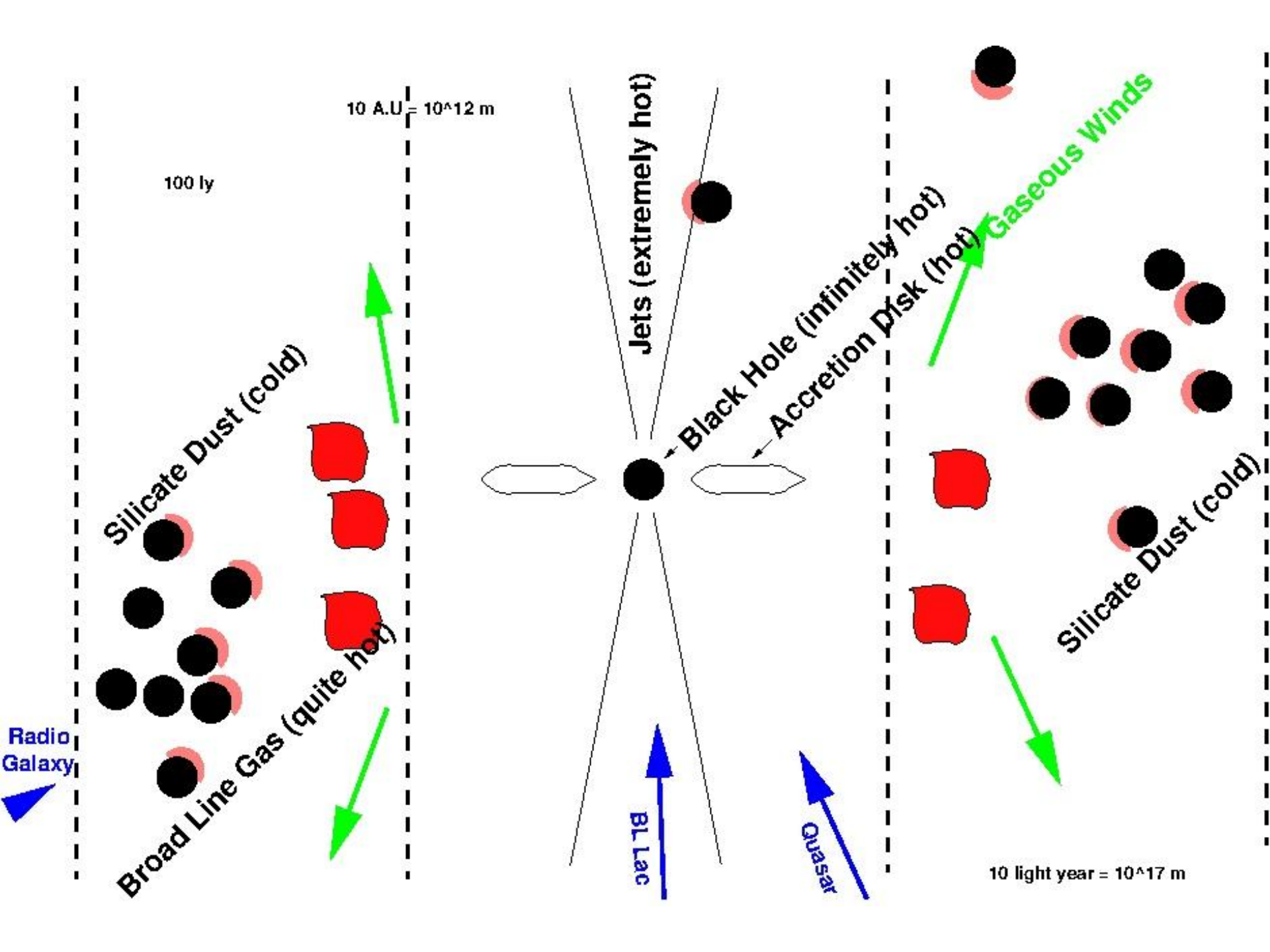
OIR Interferometry of AGNs






5 Arcseconds


Dust population
inside the ionization core
Dusty torus
1
0
-1


10 A.U = 10^12 m
100 ly
Silicate Dust (cold)
Broad Line Gas (quite hot)
Radio Galaxy
Jets (extremely hot)
Black Hole (infinitely hot)
Accretion Disk (hot)
Gaseous Winds
Silicate Dust (cold)
BL Lac
Quasar
10 light year = 10^17 m

region	Size MBH=10^8	Angular size at 14 Mpc (nanorad)	Typical wavelength
BH/hot accretion disk/jet forming	Rs=1-10 AU	(1-10*)0.0004	all
BLR	100-1000 AU	0.04-0.4	Optical lines
Dusty disk	1 pc	70	Mid-near IR
NLR	100 pc	7000	Optical lines

Big things that we know that we don't know:

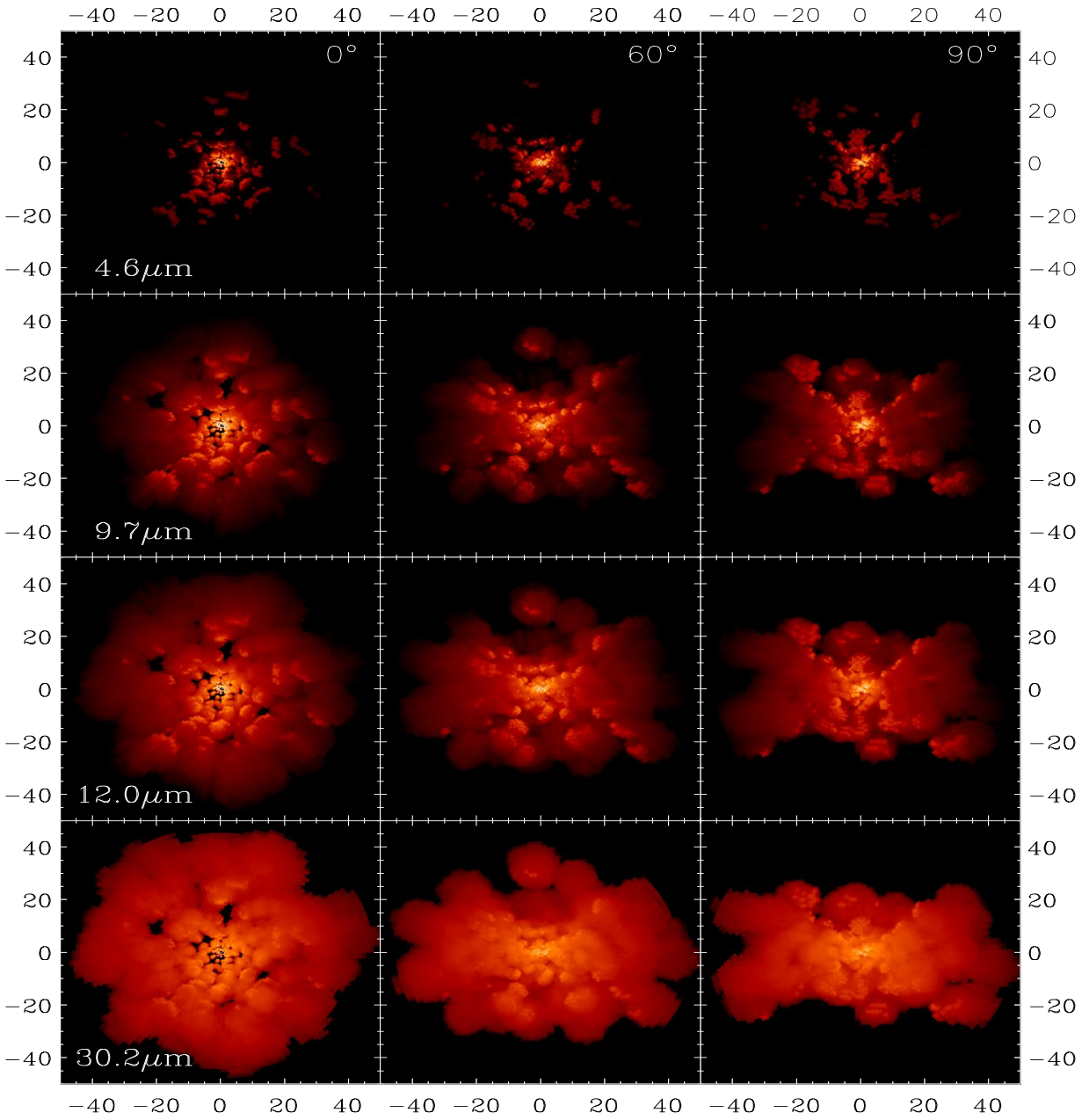
- How does accretion work-where does L go?
- What does supersonic turbulence look like?
- What is the role of magnetic fields?
- Where does the mass come from?
- How do relativistic jets form?

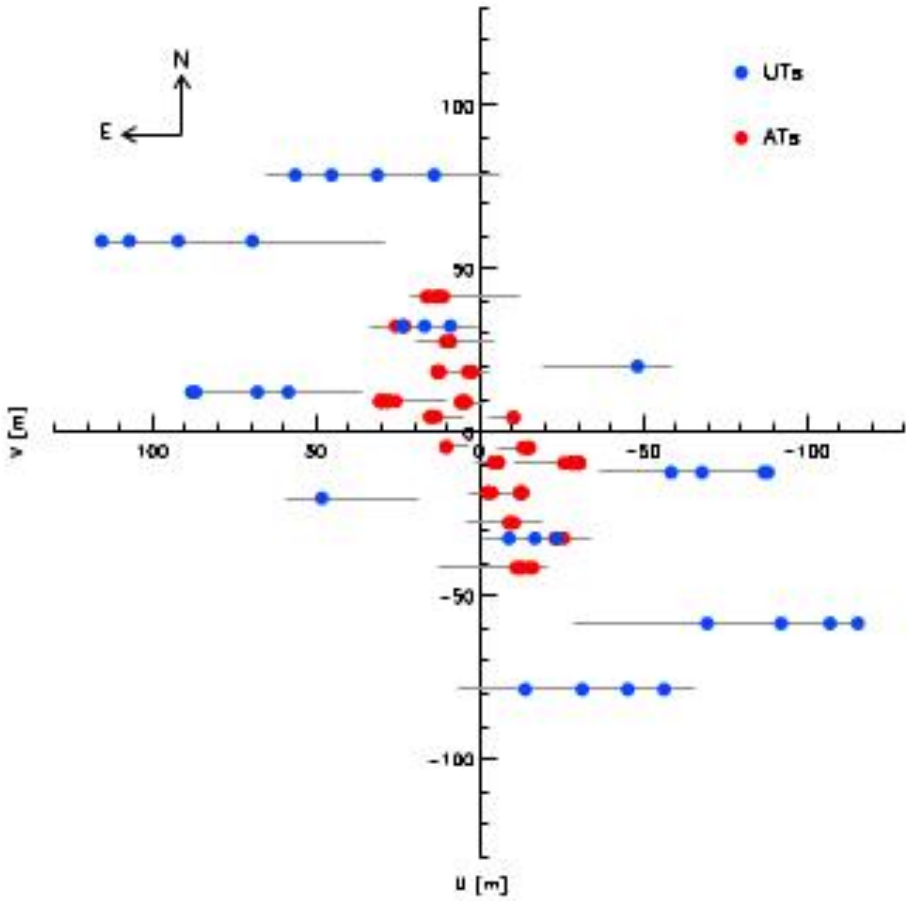
Smaller things that we might learn:

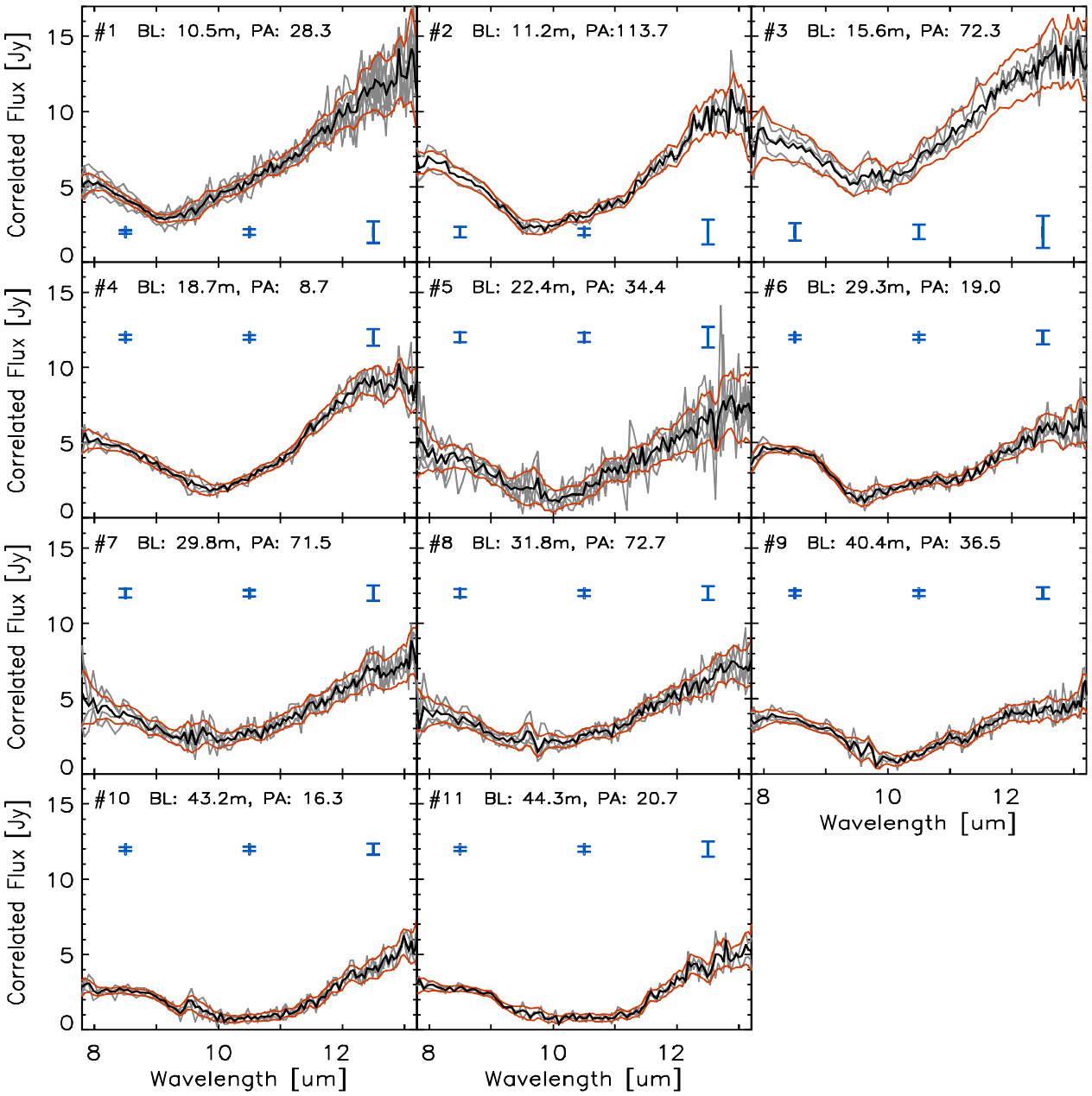
- What is shape of dust distribution?
- How clumpy?
- How does dM/dt (disk) relate to dM/dt(hole)
- Chemistry of dust/gas?
- How does dust influence appearance?
- Physics of inner edge:heating/winds
- Physics of outer limit:mass source

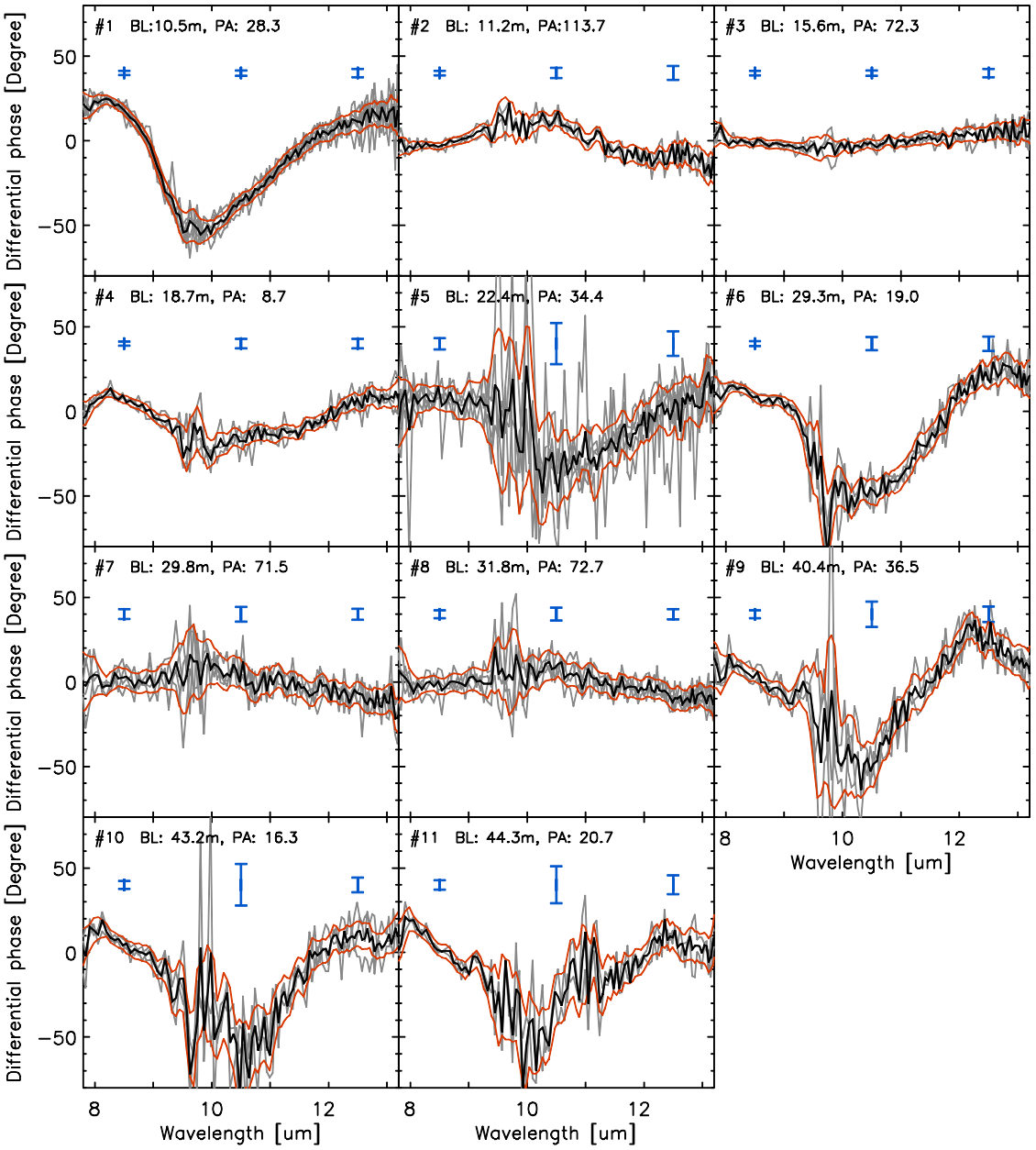
Two Useful approaches:

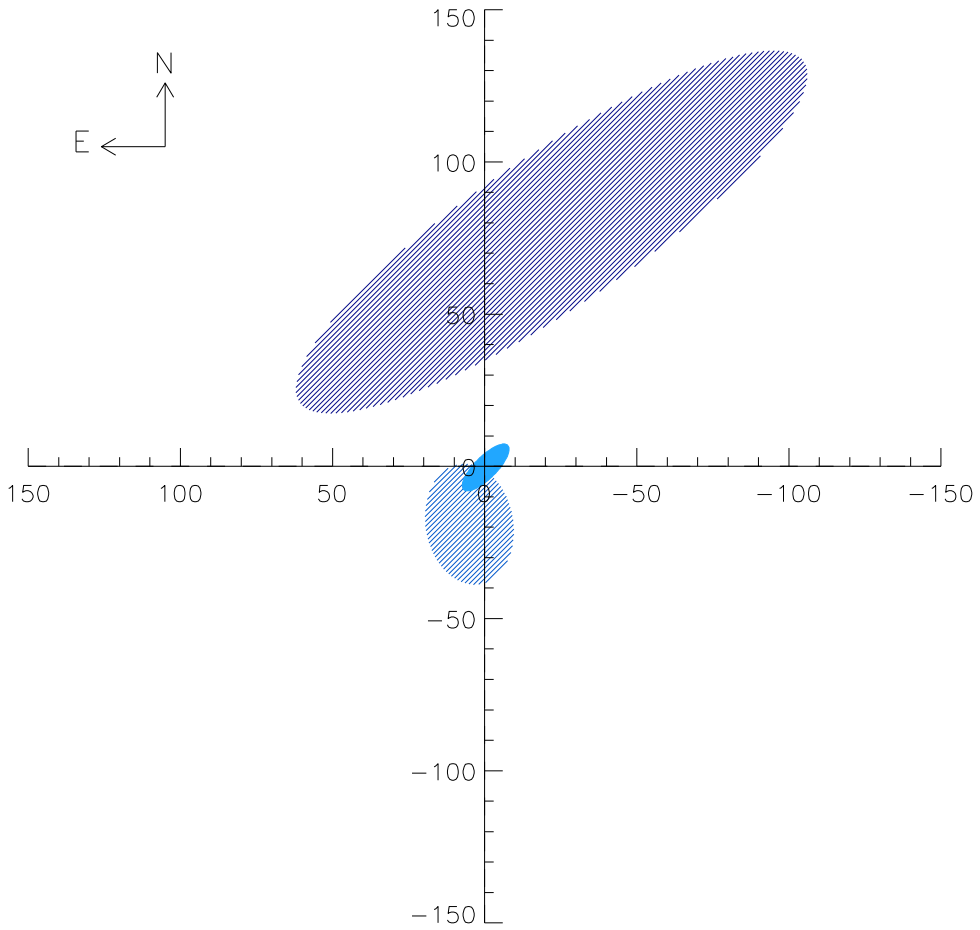
- Detailed “mapping” of a few sources (at as many wavelengths as possible)
- Statistics of many sources

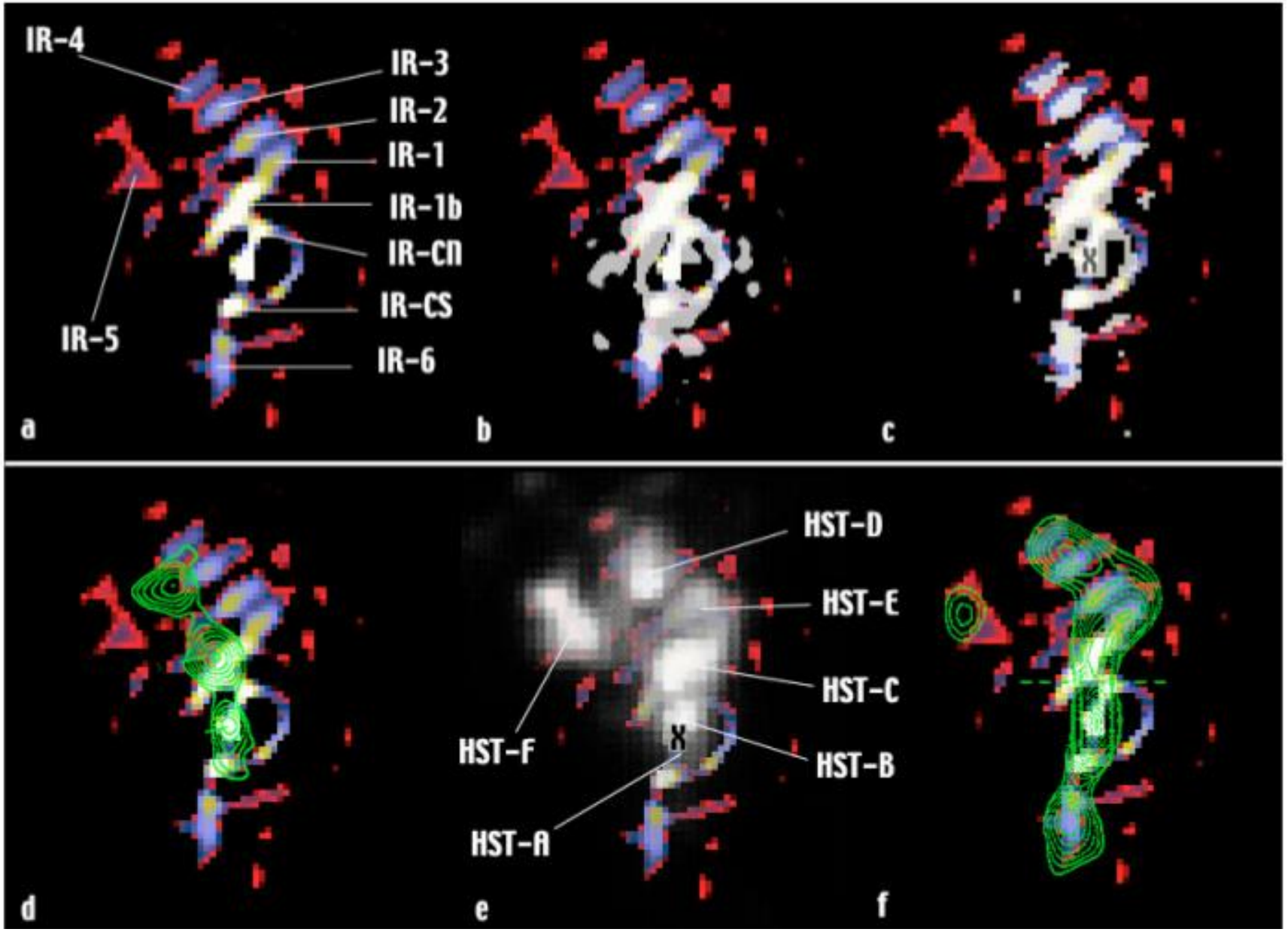

0°
60°
90°
4.6μm
9.7μm
12.0μm
30.2μm
−40 −20 0 20 40


N
E
UTs
ATs
100
50
0
-50
-100
100
50
0
-50
-100
v [m]
u [m]


#1 BL: 10.5m, PA: 28.3
#2 BL: 11.2m, PA:113.7
#3 BL: 15.6m, PA: 72.3
#4 BL: 18.7m, PA: 8.7
#5 BL: 22.4m, PA: 34.4
#6 BL: 29.3m, PA: 19.0
#7 BL: 29.8m, PA: 71.5
#8 BL: 31.8m, PA: 72.7
#9 BL: 40.4m, PA: 36.5
#10 BL: 43.2m, PA: 16.3
#11 BL: 44.3m, PA: 20.7
Correlated Flux [Jy]
Wavelength [um]
0
5
10
15
8
10
12

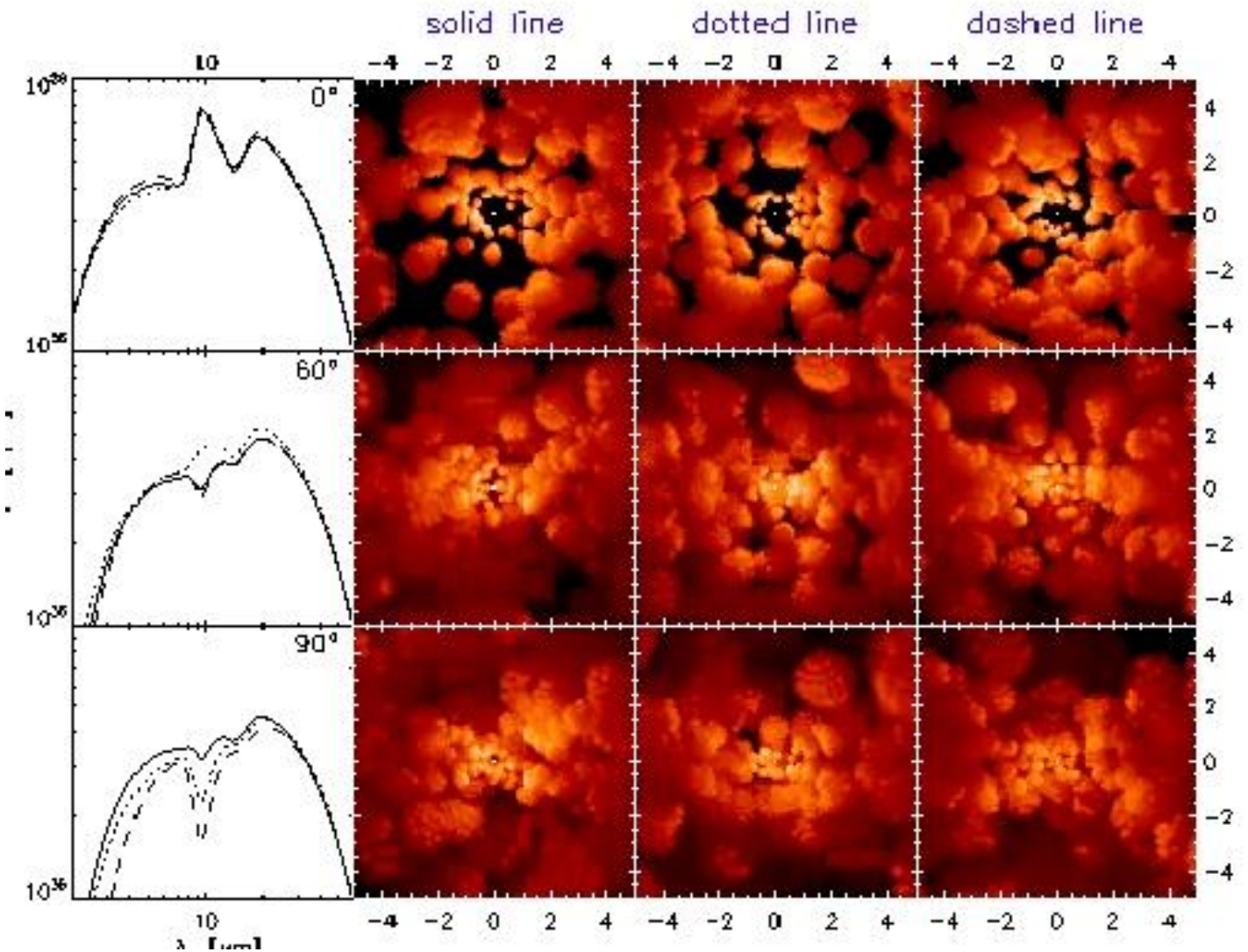

#1 BL:10.5m, PA: 28.3
#2 BL: 11.2m, PA:113.7
#3 BL: 15.6m, PA: 72.3
#4 BL: 18.7m, PA: 8.7
#5 BL: 22.4m, PA: 34.4
#6 BL: 29.3m, PA: 19.0
#7 BL: 29.8m, PA: 71.5
#8 BL: 31.8m, PA: 72.7
#9 BL: 40.4m, PA: 36.5
#10 BL: 43.2m, PA: 16.3
#11 BL: 44.3m, PA: 20.7
Differential phase [Degree]
50
0
−50
8
10
12
Wavelength [um]

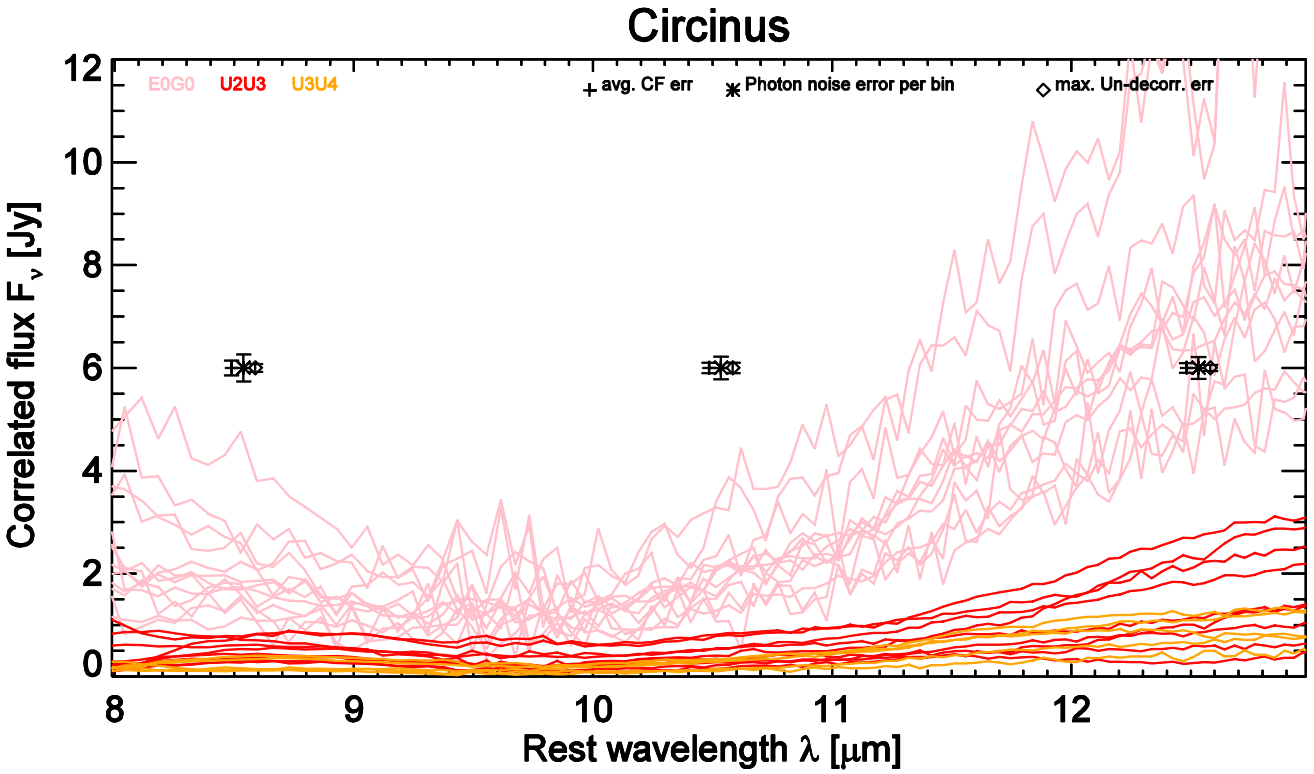

N
E
150
100
50
0
−50
−100
−150
150
100
50
0
−50
−100
−150

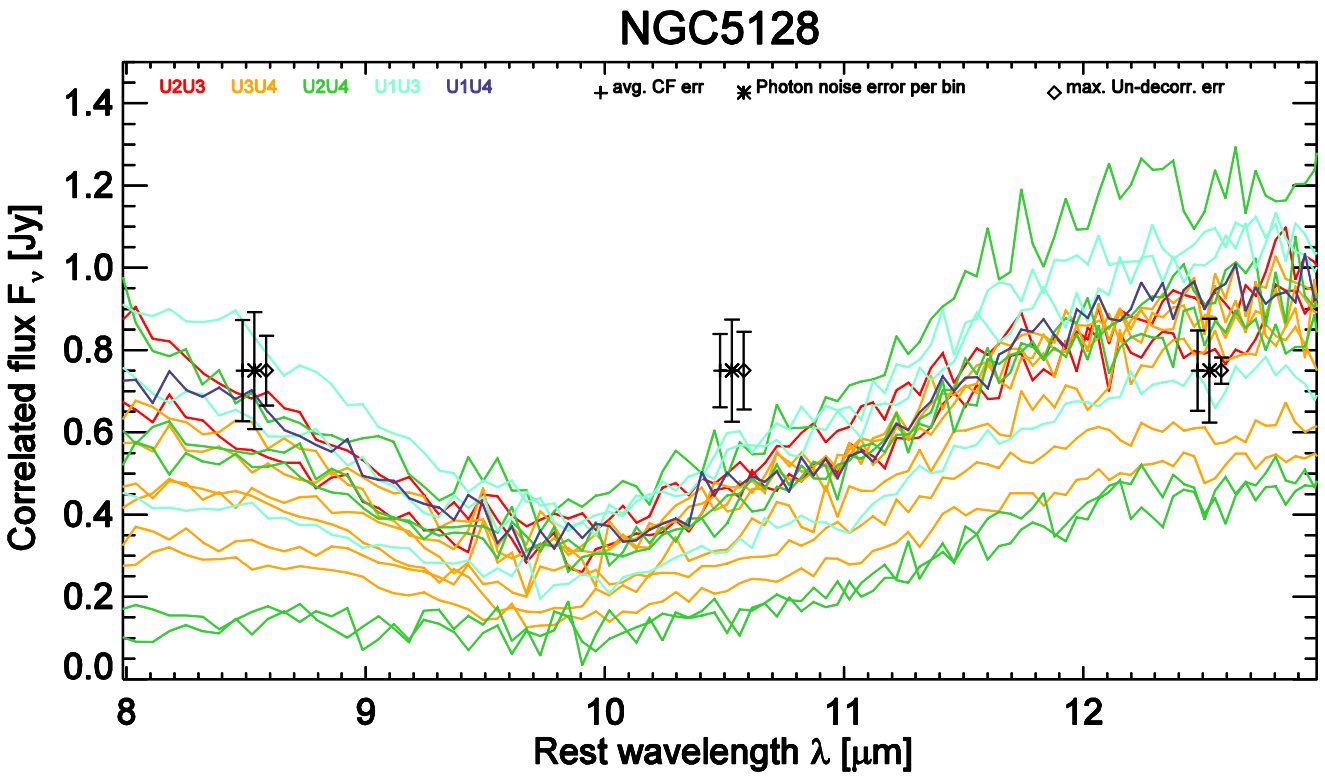

IR-4
IR-3
IR-2
IR-1
IR-1b
IR-CN
IR-CS
IR-5
IR-6
a
b
c
X
HST-D
HST-E
HST-C
HST-F
HST-B
HST-A
d
e
f

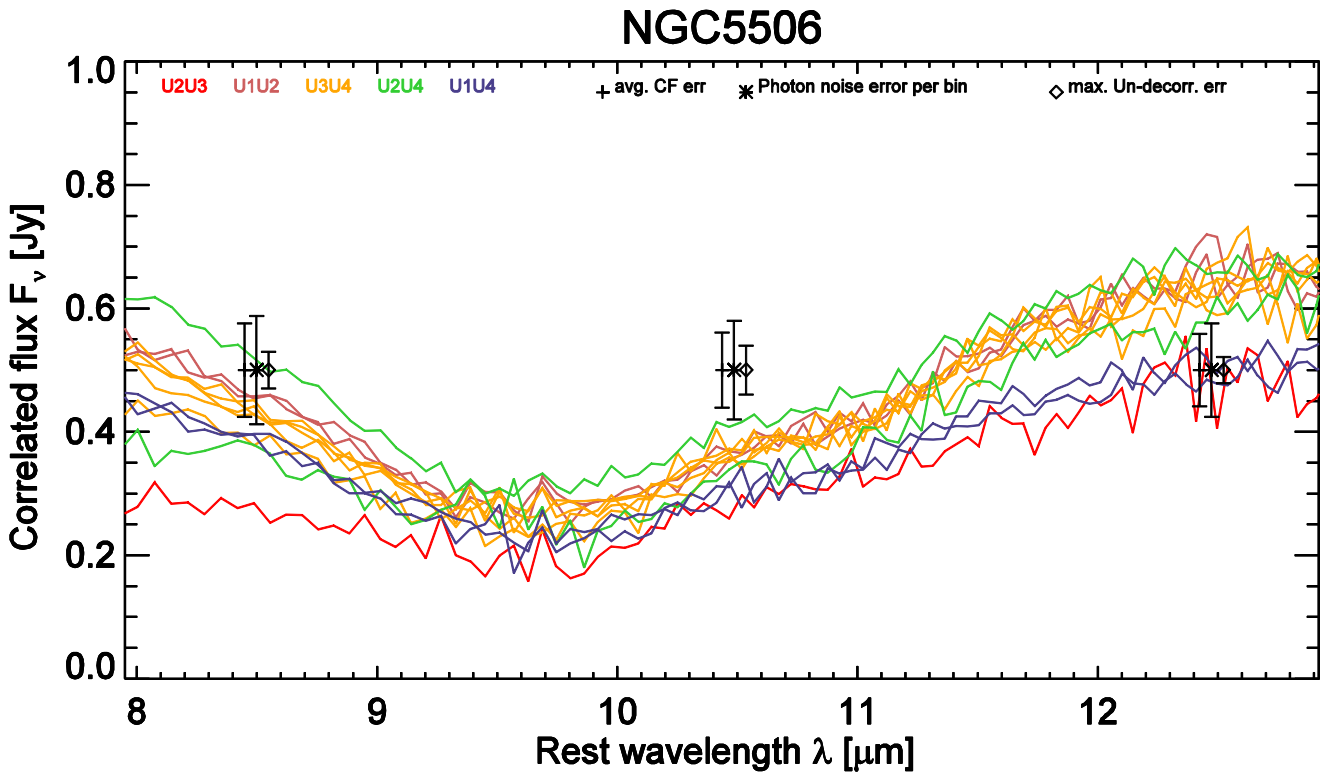
Statistical approaches: things to look for:

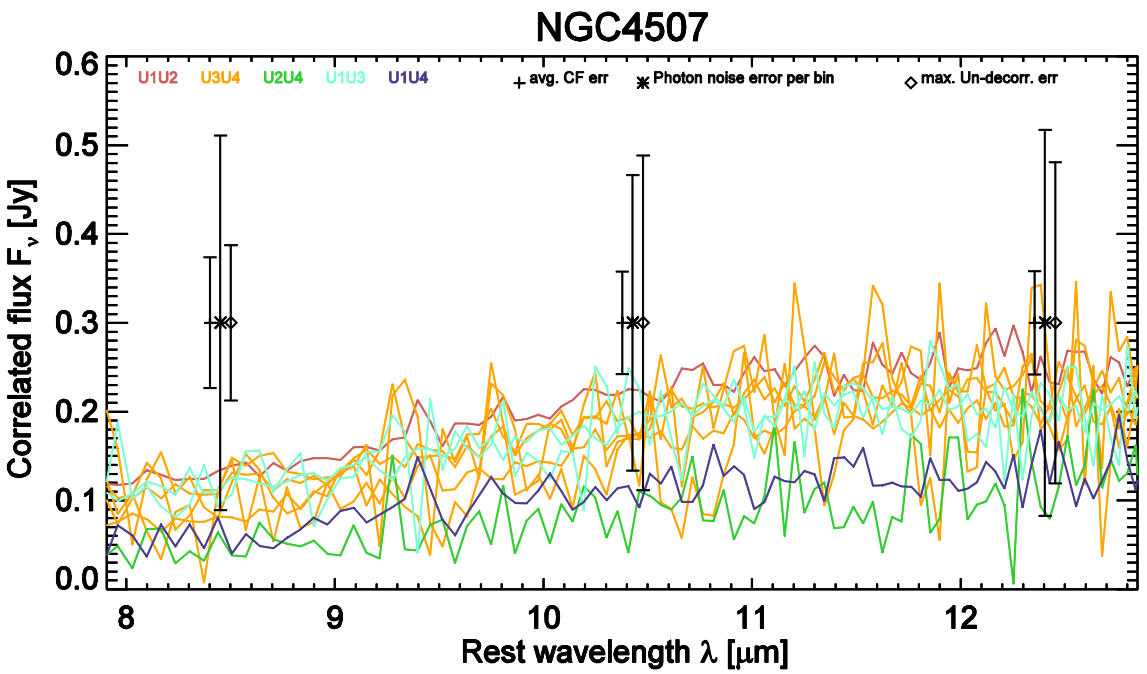
- Seyfert 1-2 dichotomy
- Size as a fn of wavelength and luminosity
- Complexity as a fn of resolution
- Color temperatures
- “Silicate” absorption/emission features

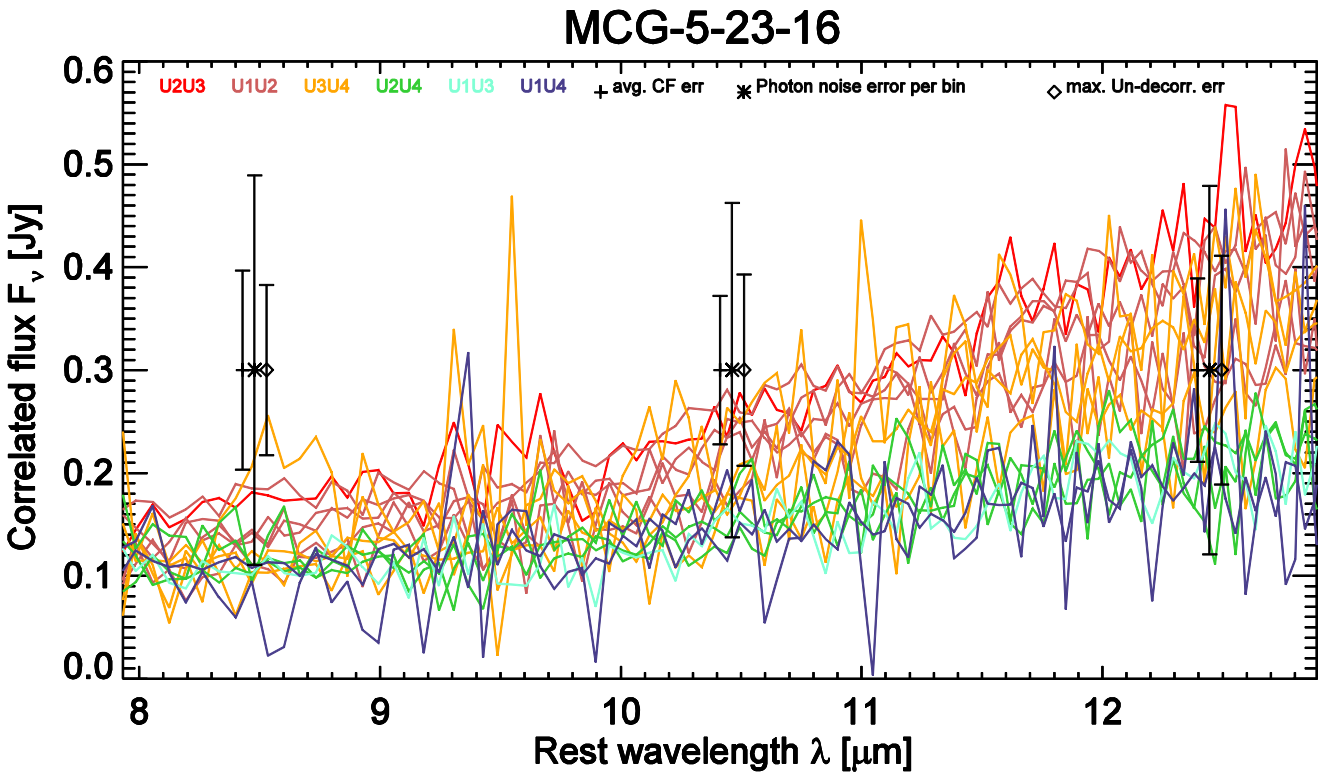

solid line
dotted line
dashed line
0°
60°
90°
λ [μm]

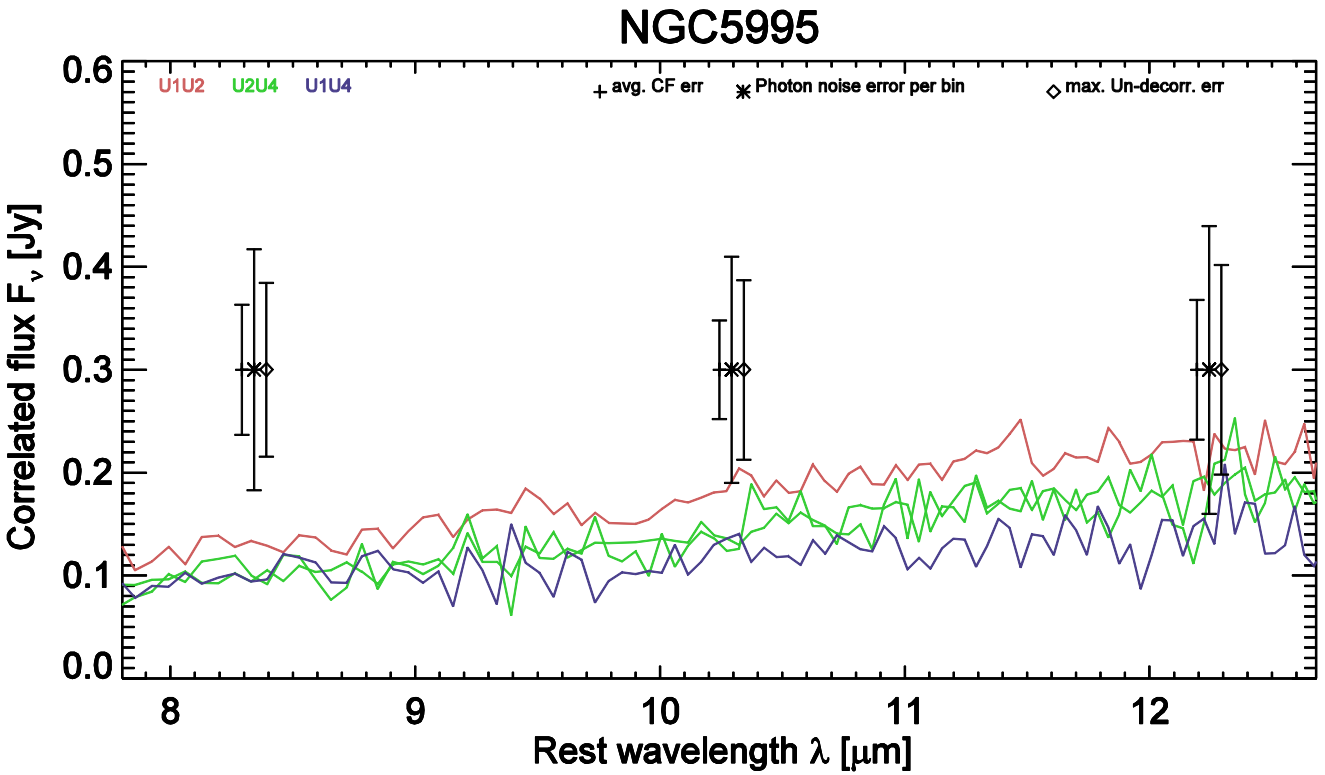

Circinus
E0G0
U2U3
U3U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
0
2
4
6
8
10
12
8
9
10
11
12

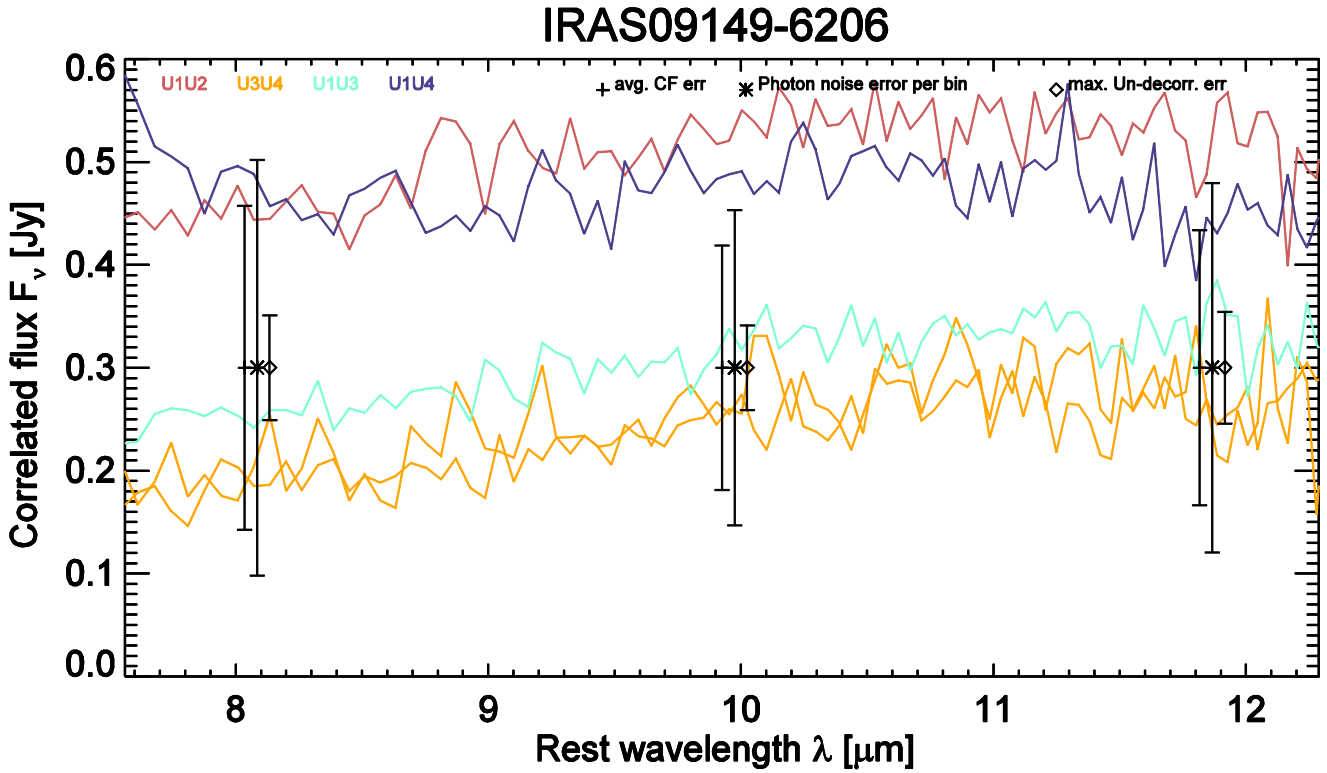

NGC5128
U2U3
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
8
9
10
11
12

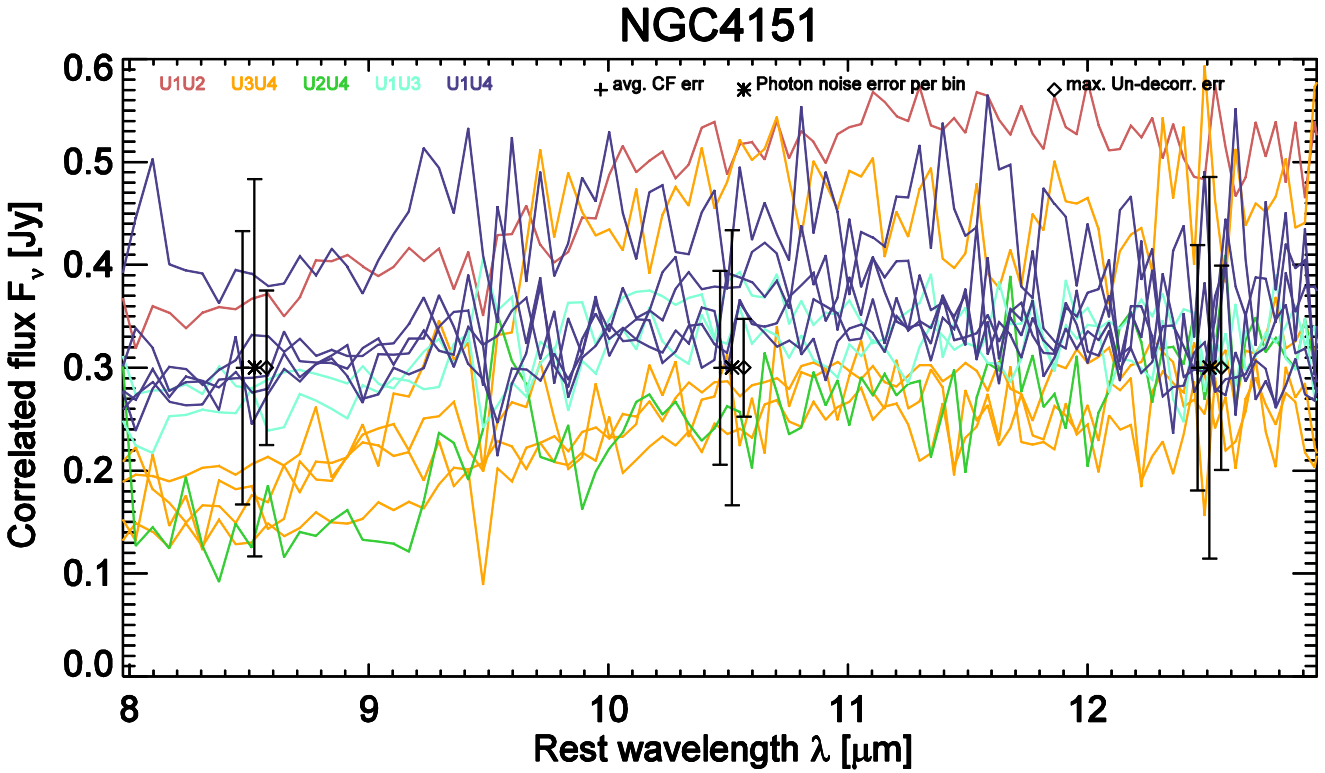

NGC5506
U2U3
U1U2
U3U4
U2U4
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
1.0
0.8
0.6
0.4
0.2
0.0
8
9
10
11
12

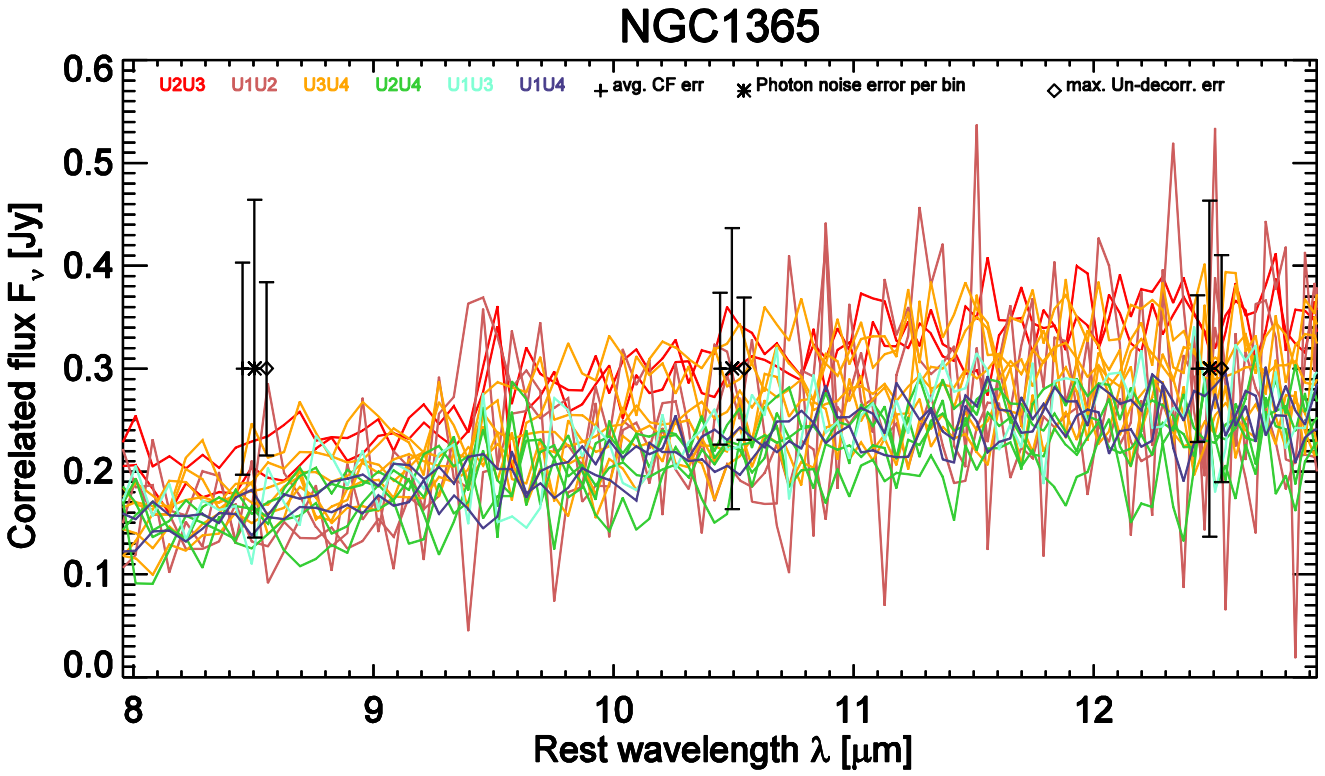

NGC4507
U1U2
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

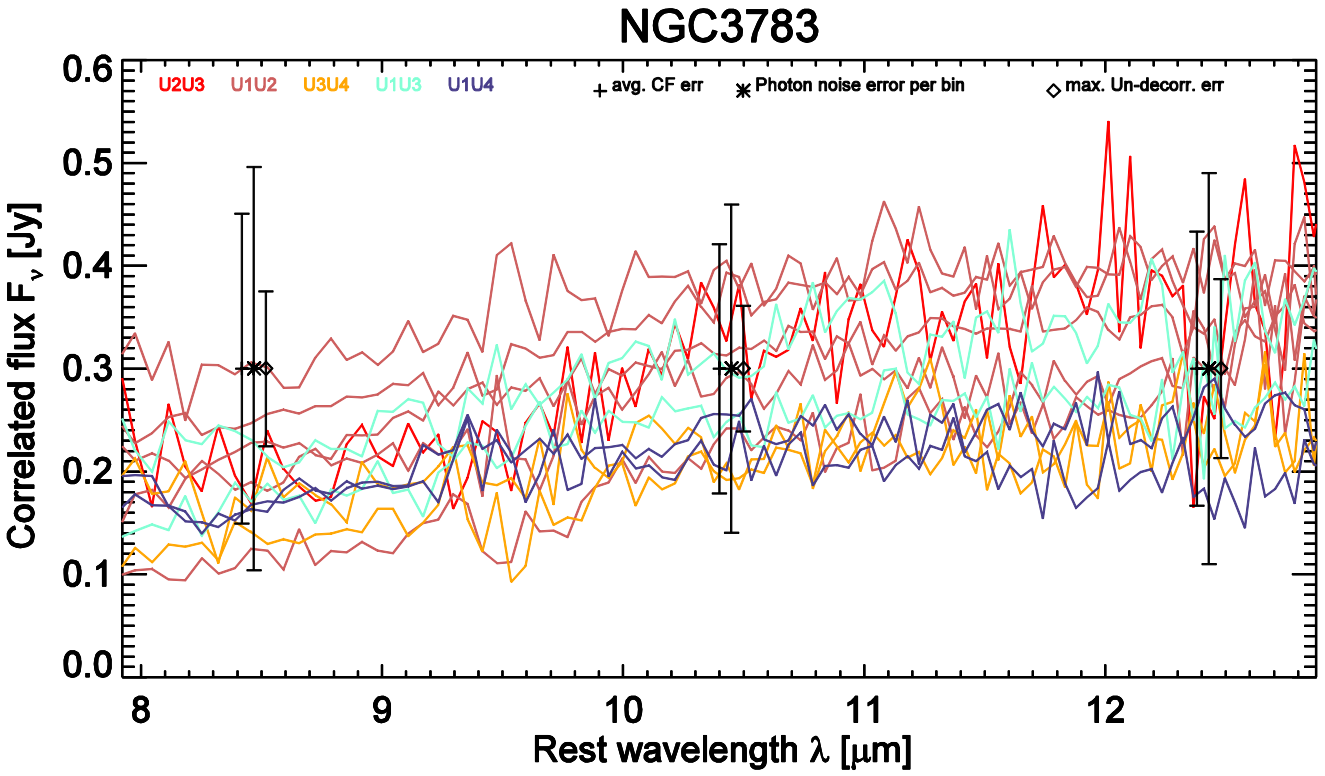

MCG-5-23-16
U2U3
U1U2
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

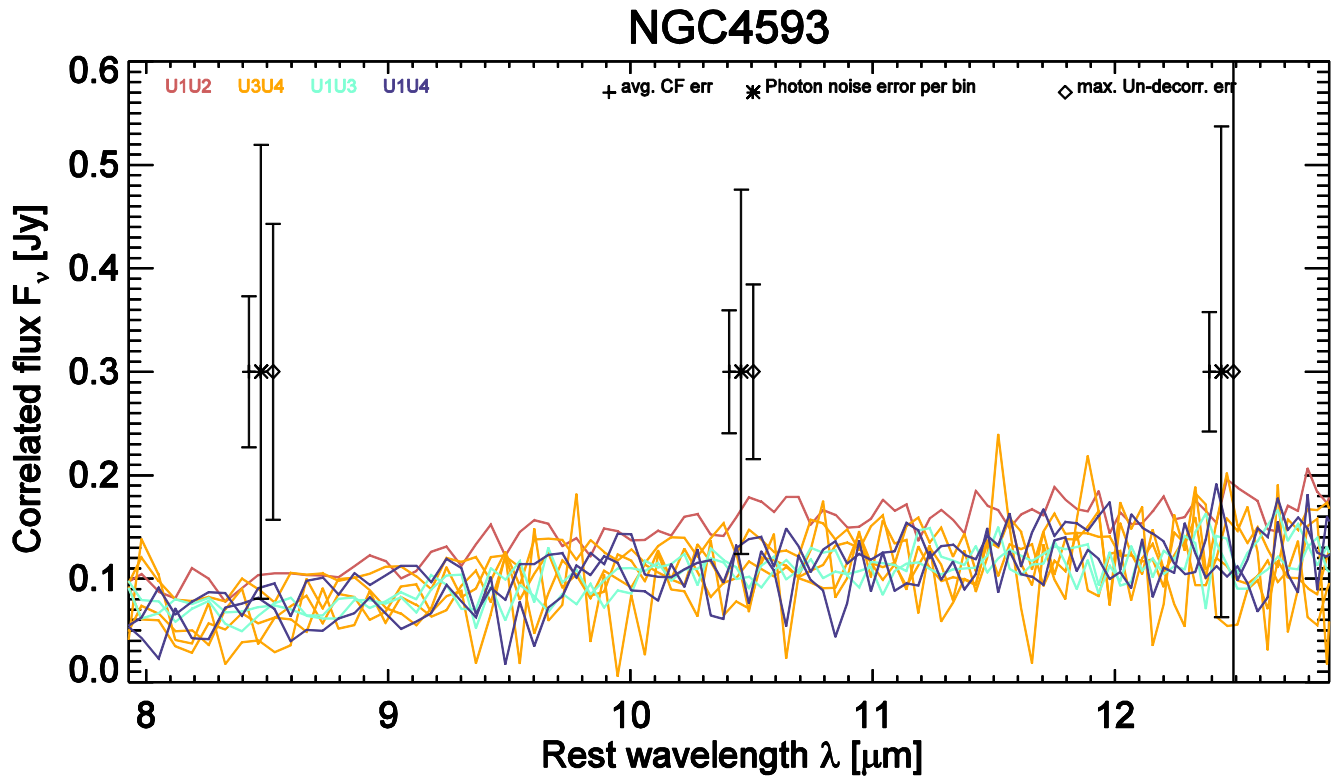

NGC5995
U1U2
U2U4
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

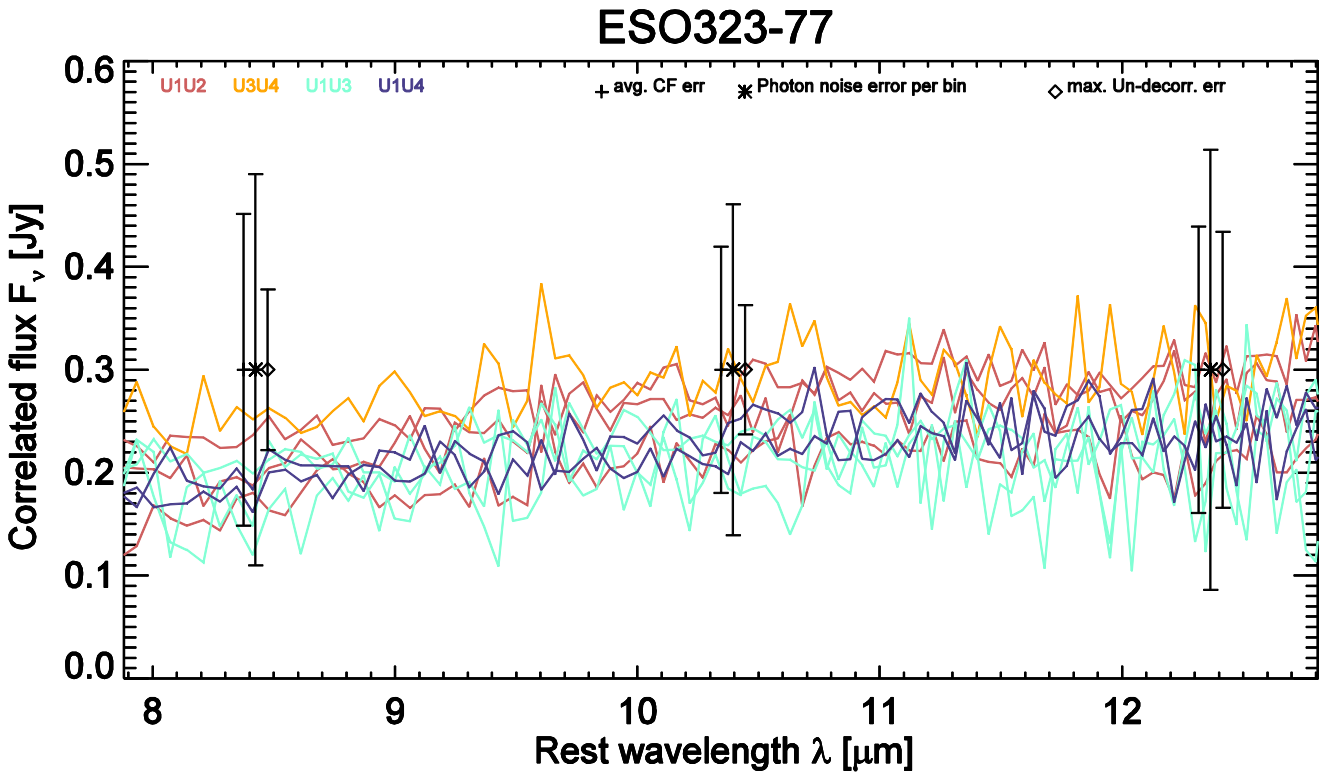

IRAS09149-6206
U1U2
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

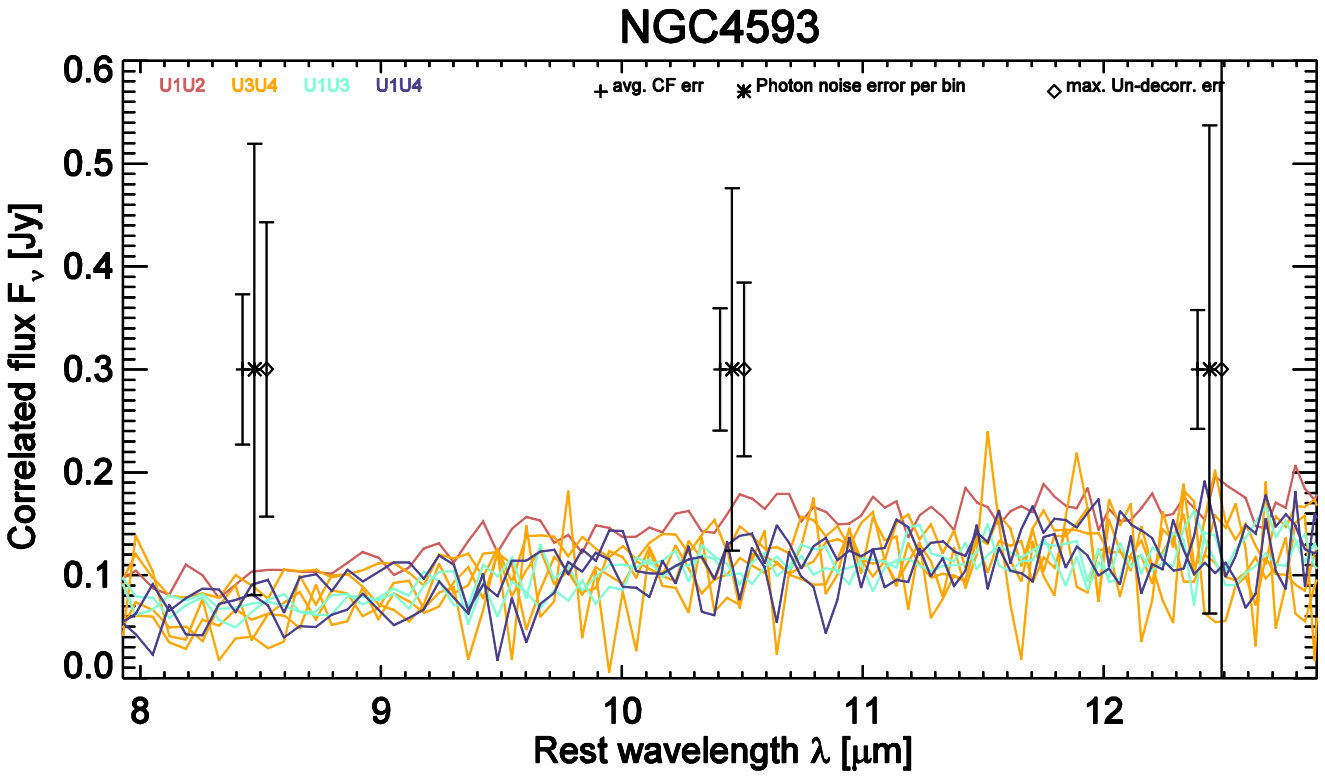

NGC4151
U1U2
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12

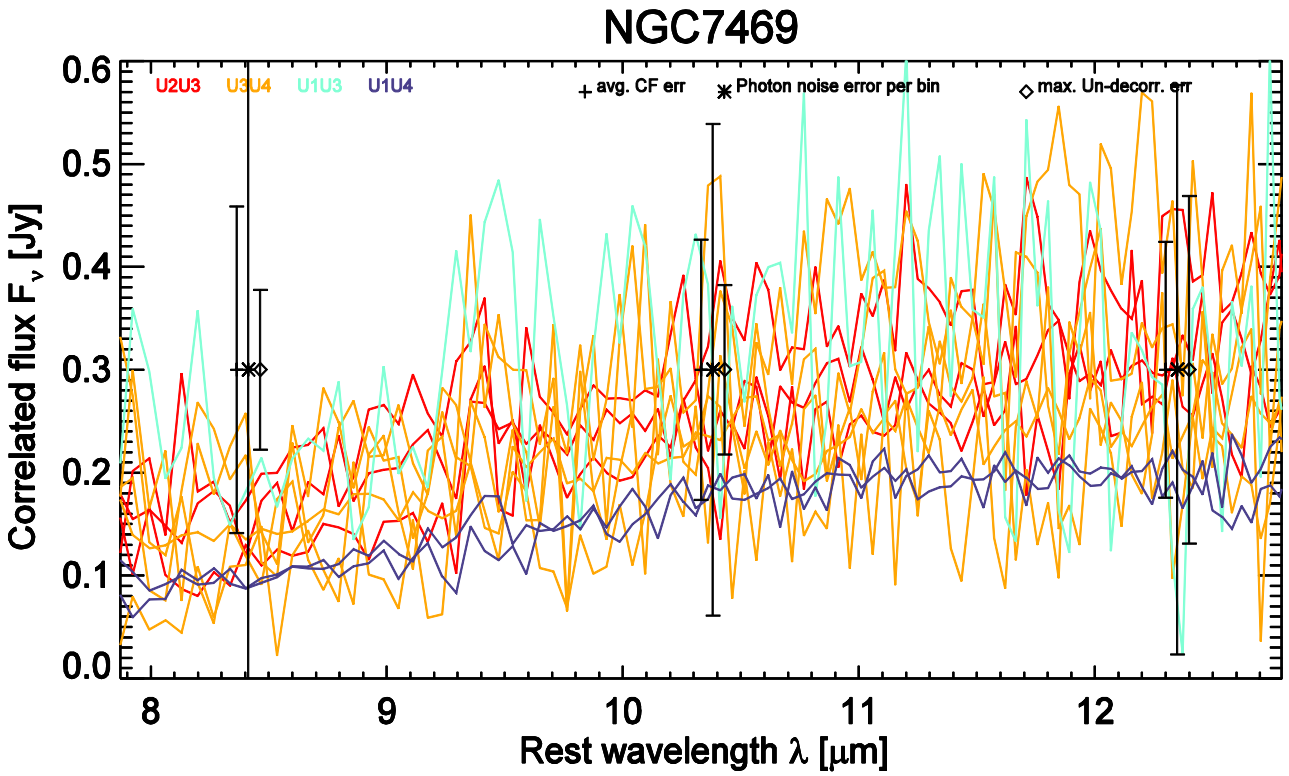

NGC1365
U2U3
U1U2
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

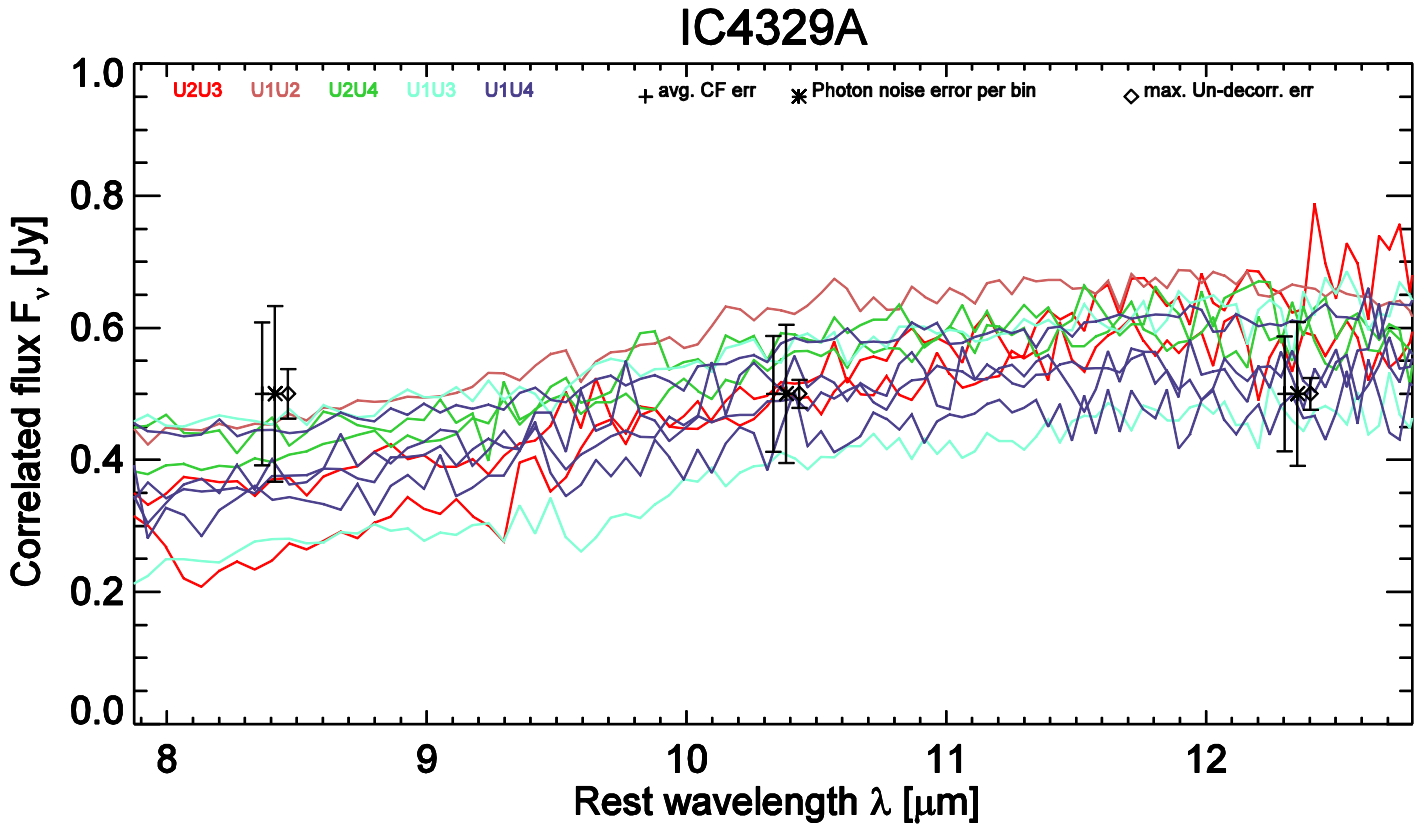

NGC3783
U2U3
U1U2
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12

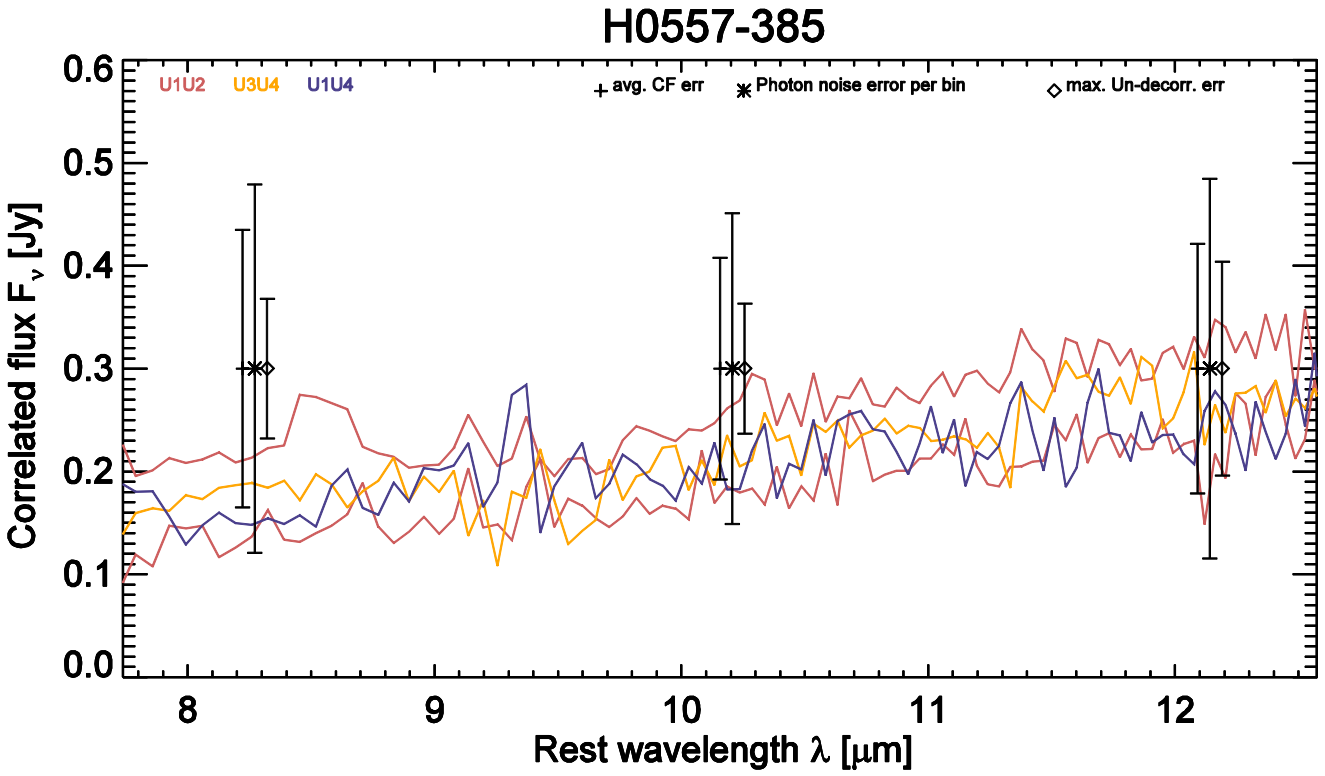

NGC4593
U1U2
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

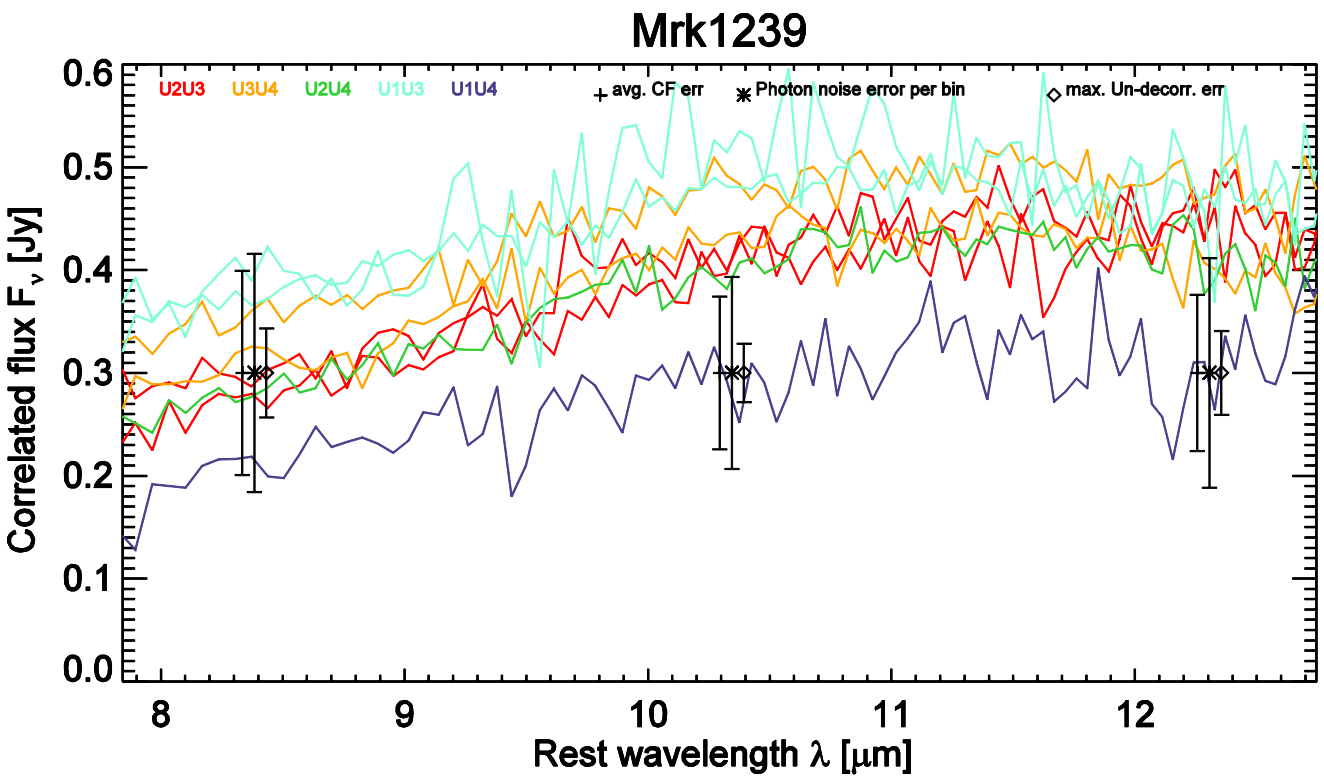

ESO323-77
U1U2
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

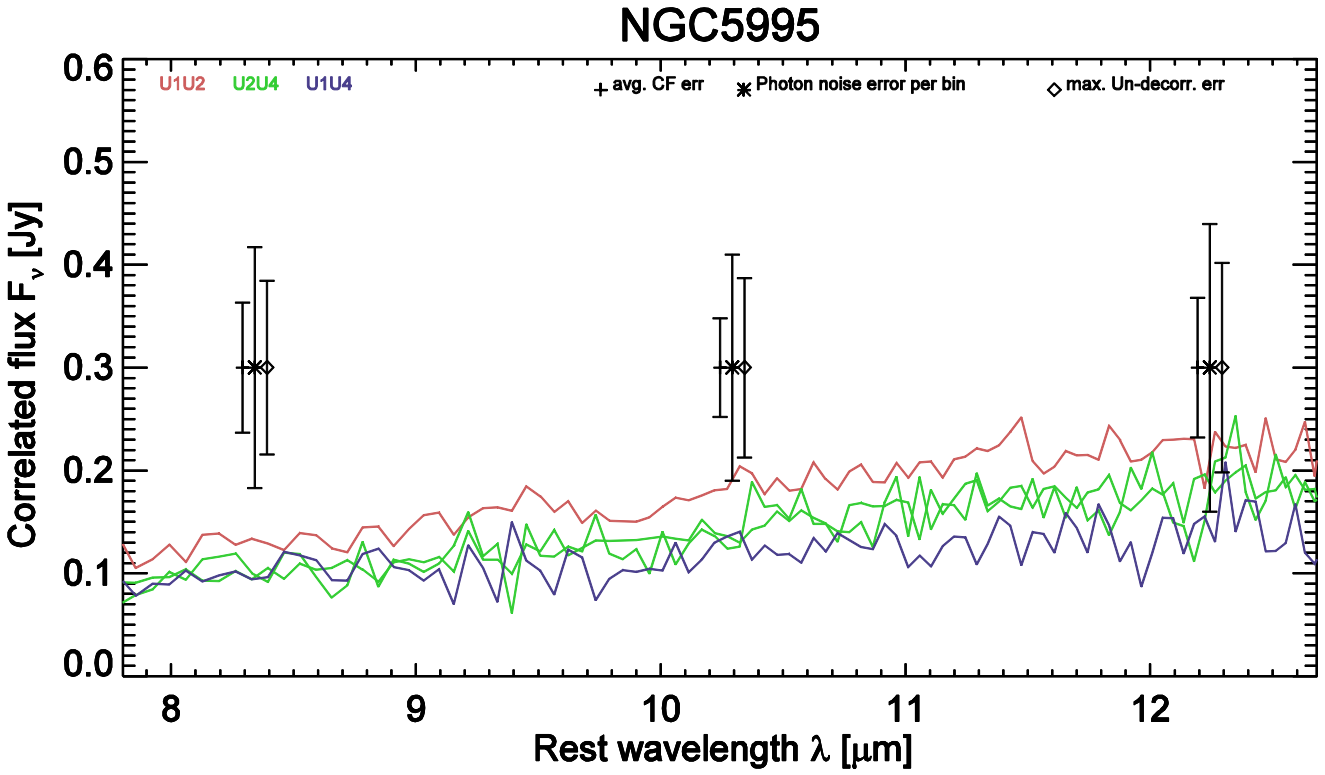

NGC4593
U1U2
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F_ν [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

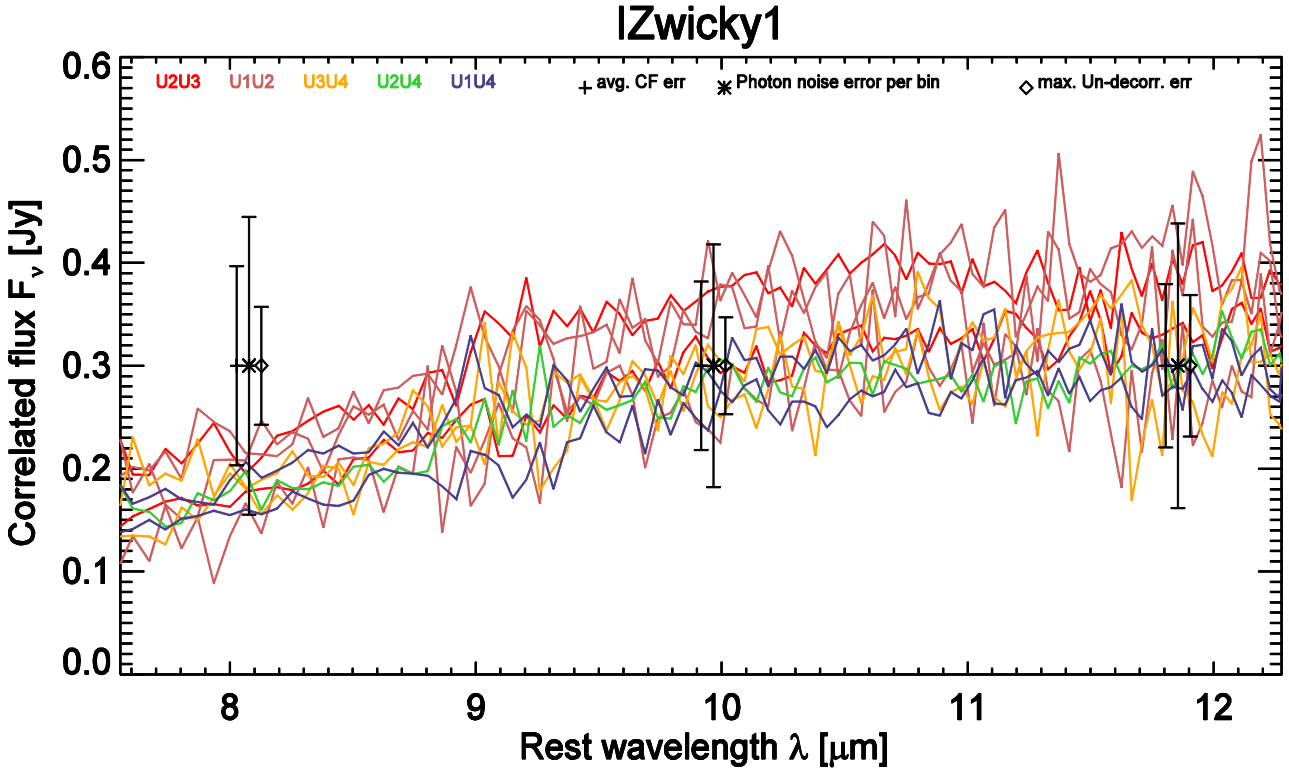

NGC7469
U2U3
U3U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

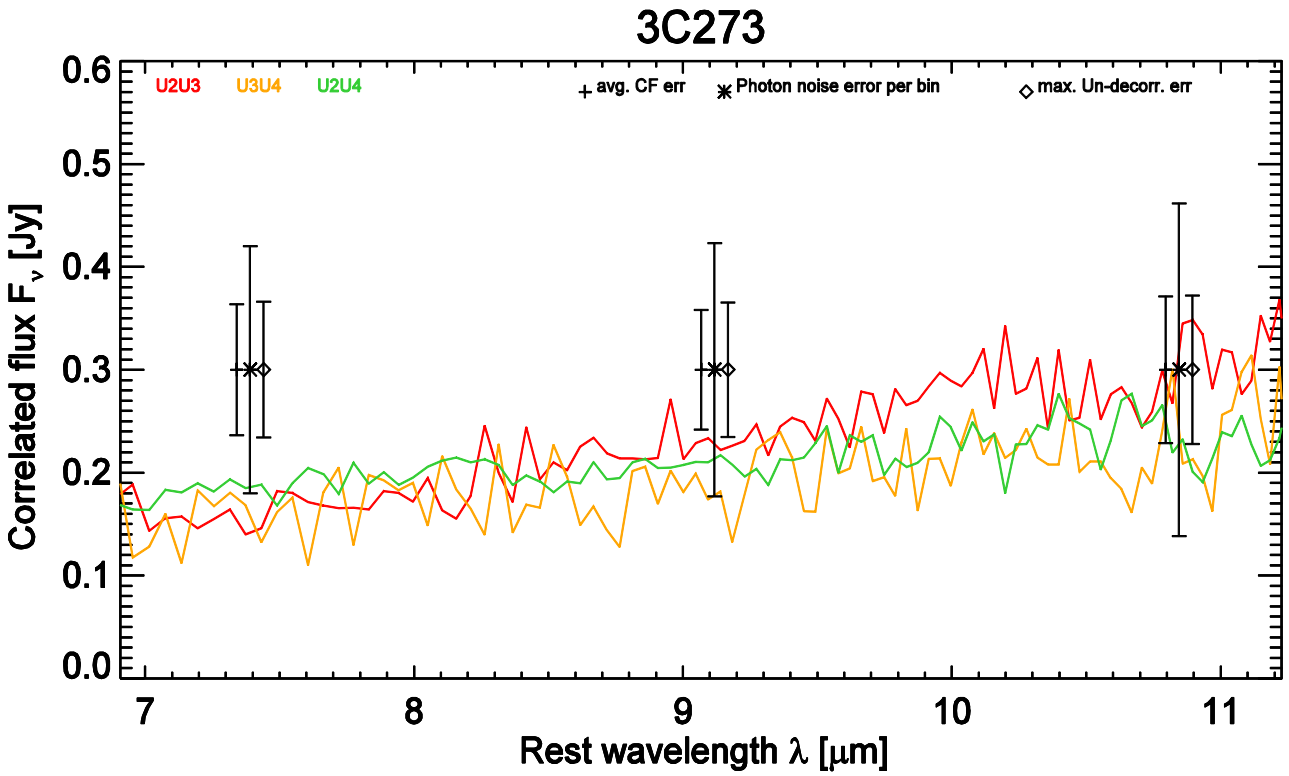

IC4329A
U2U3
U1U2
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
1.0
0.8
0.6
0.4
0.2
0.0
8
9
10
11
12
Rest wavelength λ [μm]

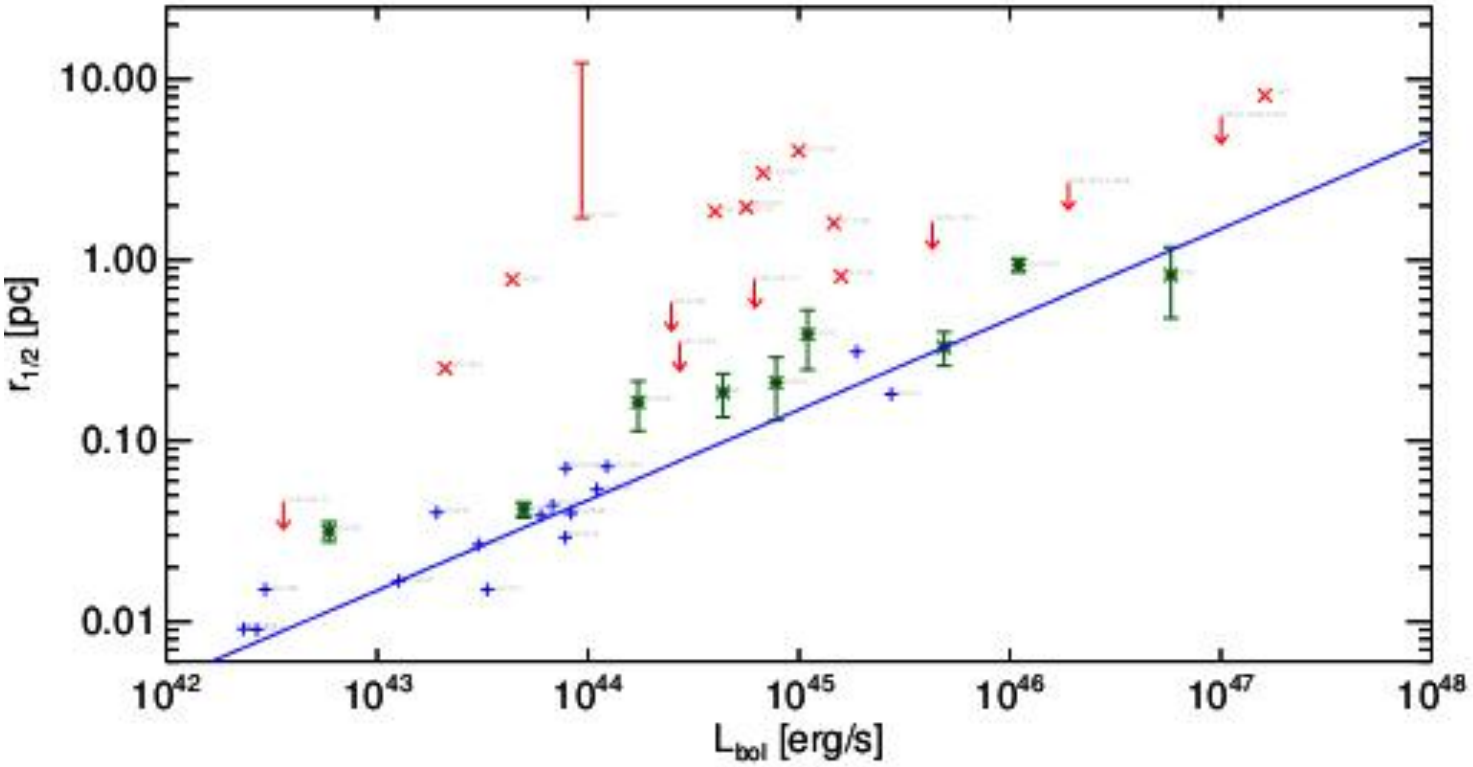

H0557-385
U1U2
U3U4
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

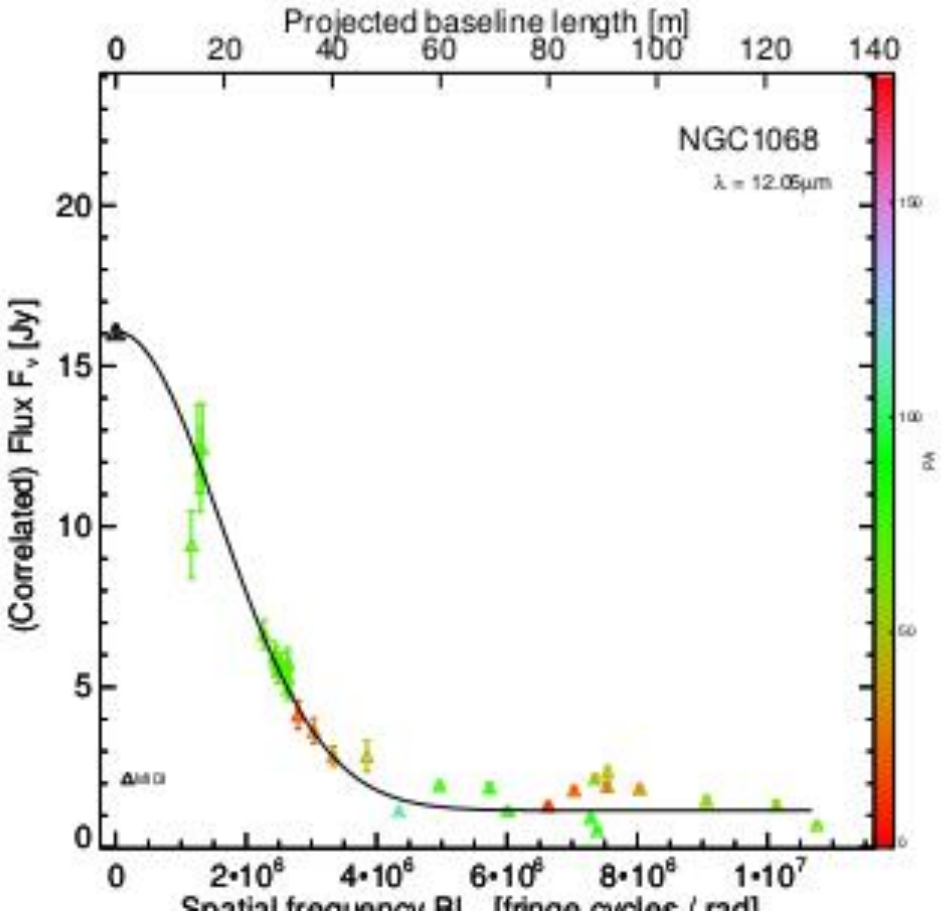

Mrk1239
U2U3
U3U4
U2U4
U1U3
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.6
0.5
0.4
0.3
0.2
0.1
0.0
8
9
10
11
12
Rest wavelength λ [μm]

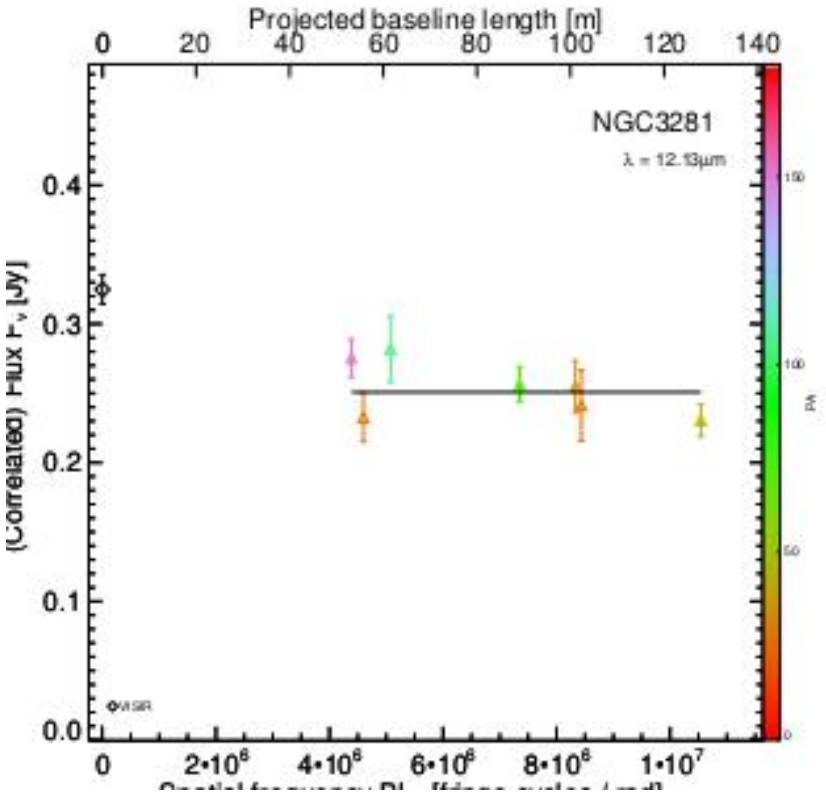

NGC5995
U1U2
U2U4
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
Rest wavelength λ [μm]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12

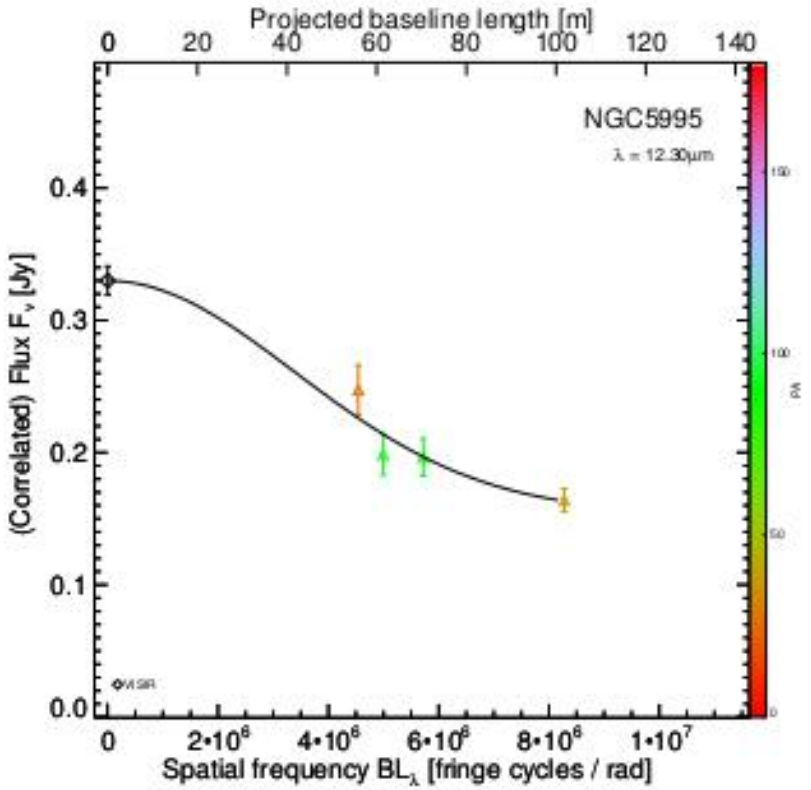

IZwicky1
U2U3
U1U2
U3U4
U2U4
U1U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
8
9
10
11
12
Rest wavelength λ [μm]

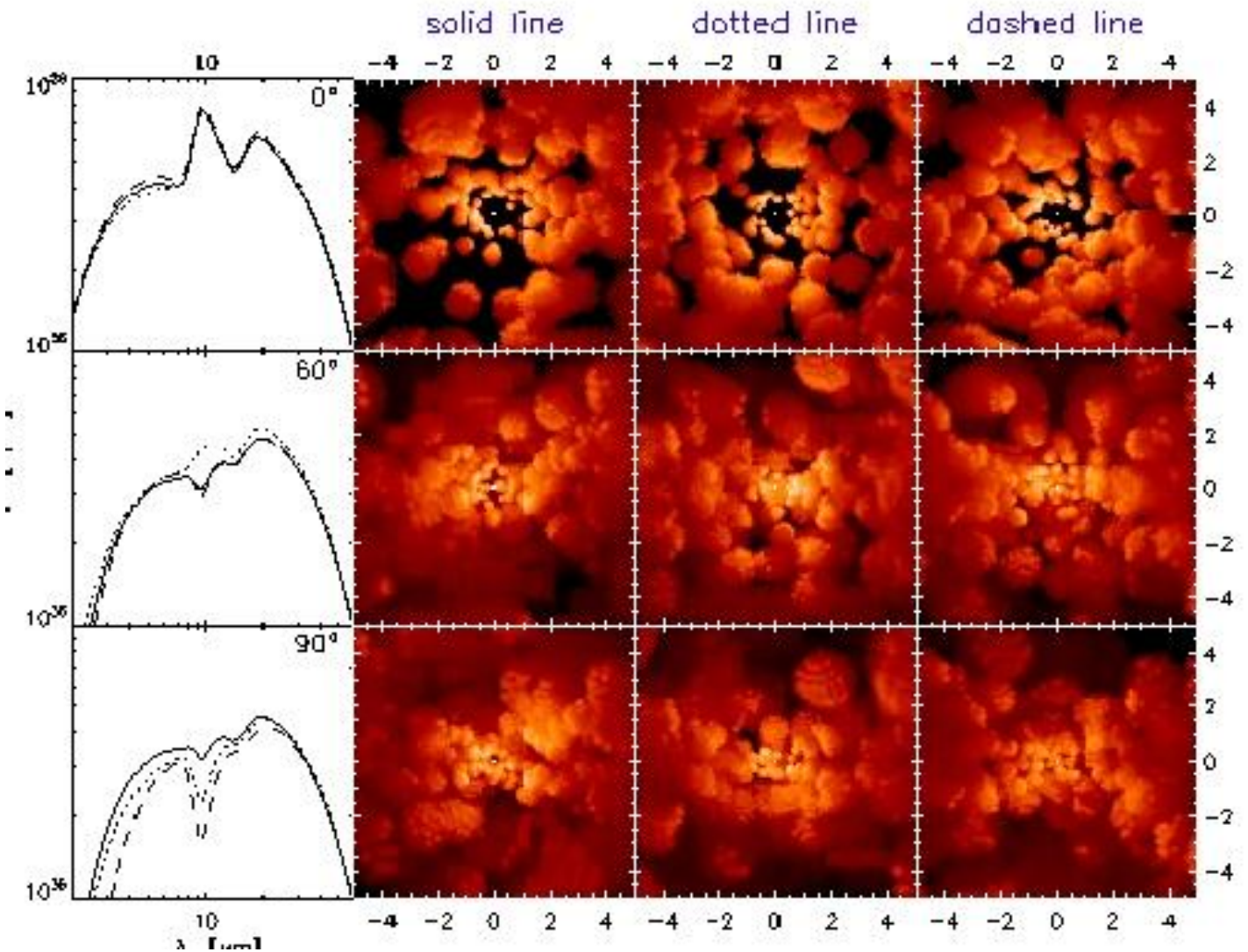

3C273
U2U3
U3U4
U2U4
avg. CF err
Photon noise error per bin
max. Un-decorr. err
Correlated flux F$_\nu$ [Jy]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
7
8
9
10
11
Rest wavelength λ [μm]

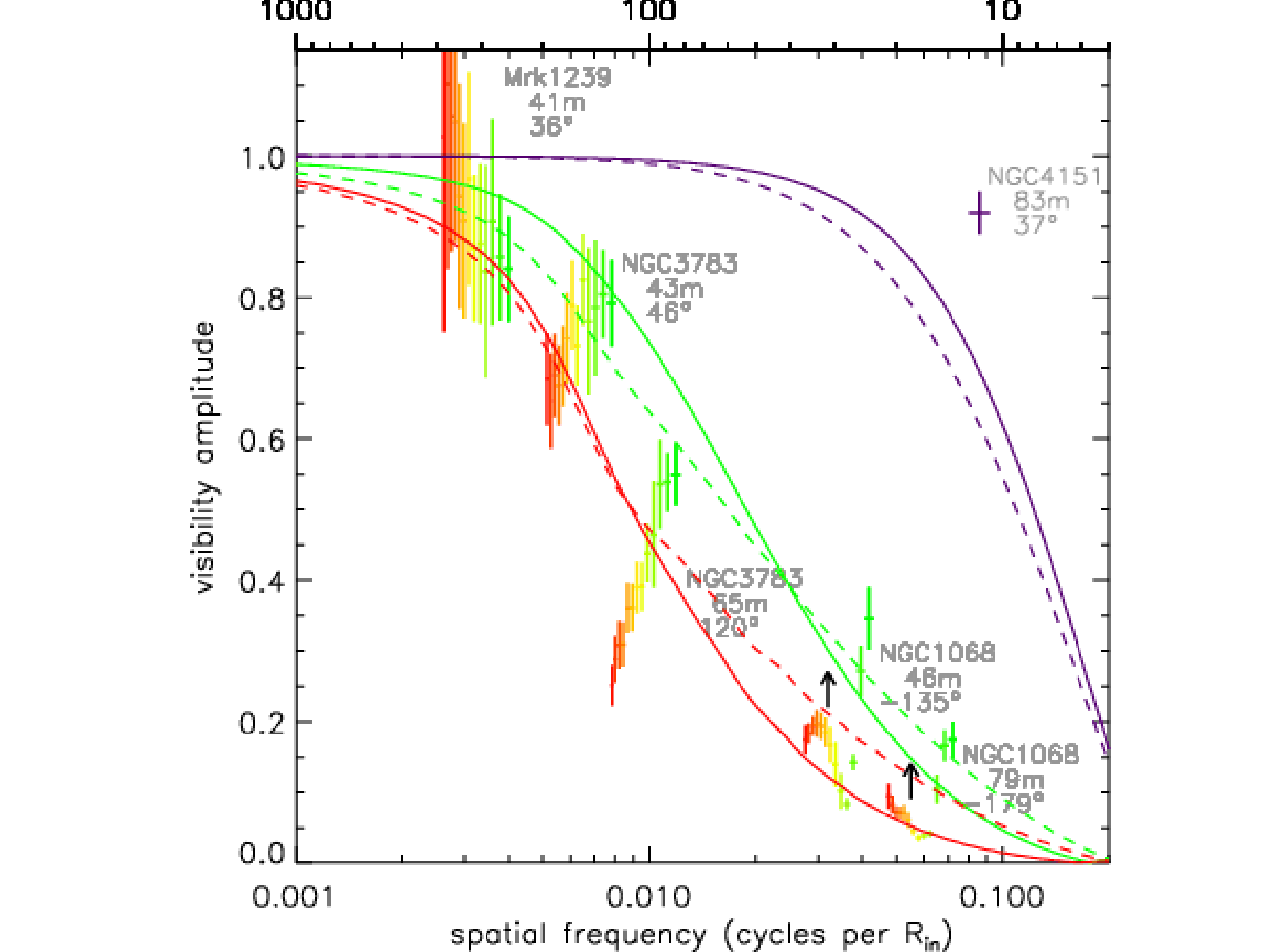

10.00
1.00
0.10
0.01
$r_{1/2}$ [pc]
10^{42}
10^{43}
10^{44}
10^{45}
10^{46}
10^{47}
10^{48}
L_{bol} [erg/s]

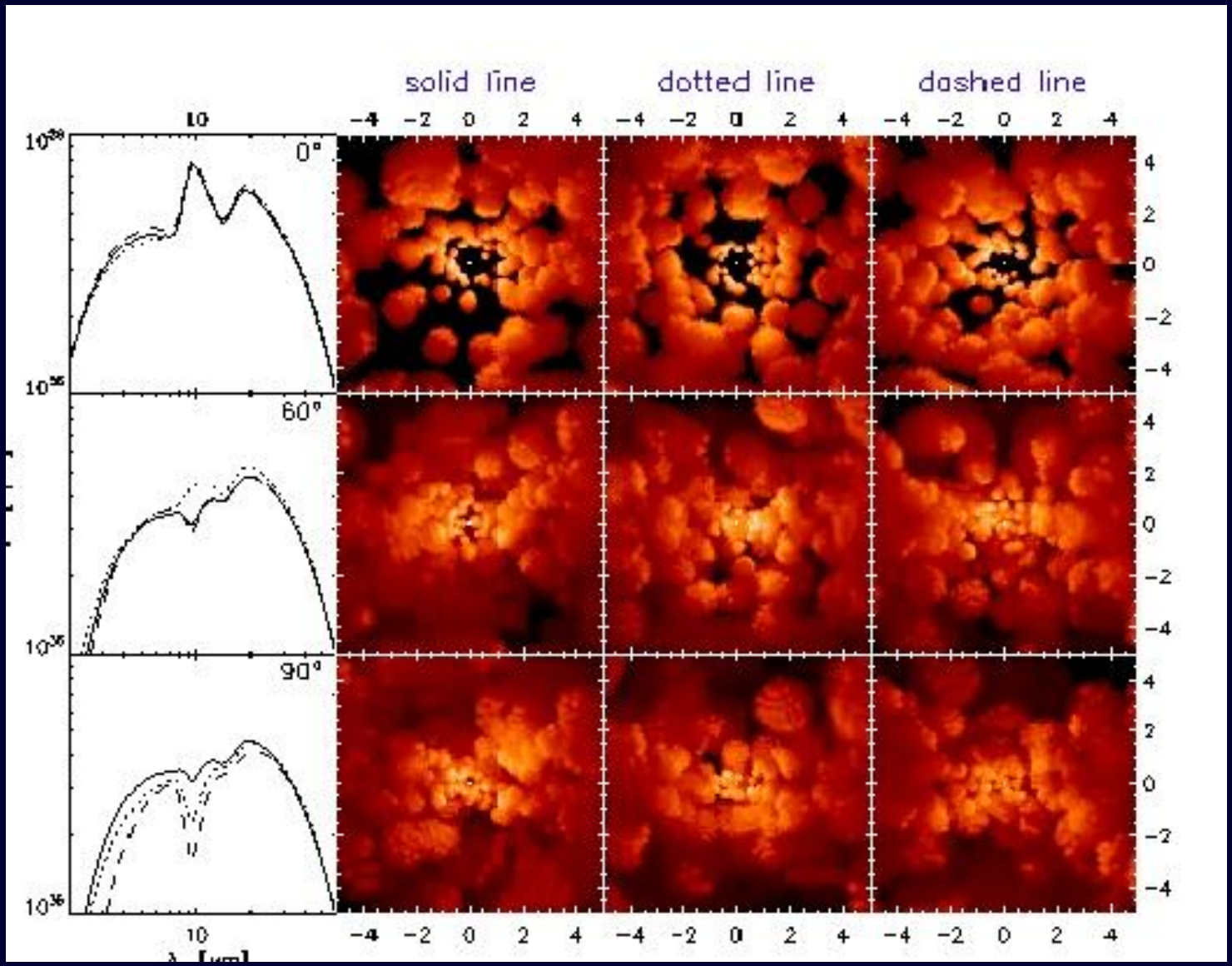

Projected baseline length [m]
0
20
40
60
80
100
120
140
NGC1068
λ = 12.05μm
(Correlated) Flux F$_\nu$ [Jy]
0
5
10
15
20
2•10^6
4•10^6
6•10^6
8•10^6
1•10^7
PA


Projected baseline length [m]
0
20
40
60
80
100
120
140
NGC3281
λ = 12.13µm
0.4
0.3
0.2
0.1
0.0
0
2•10^6
4•10^6
6•10^6
8•10^6
1•10^7
PA


Projected baseline length [m]
0
20
40
60
80
100
120
140
NGC5995
λ = 12.30μm
0.4
0.3
0.2
0.1
0.0
(Correlated) Flux F$_\nu$ [Jy]
VLSR
0
2•10^6
4•10^6
6•10^6
8•10^6
1•10^7
Spatial frequency BL$_\lambda$ [fringe cycles / rad]
PA

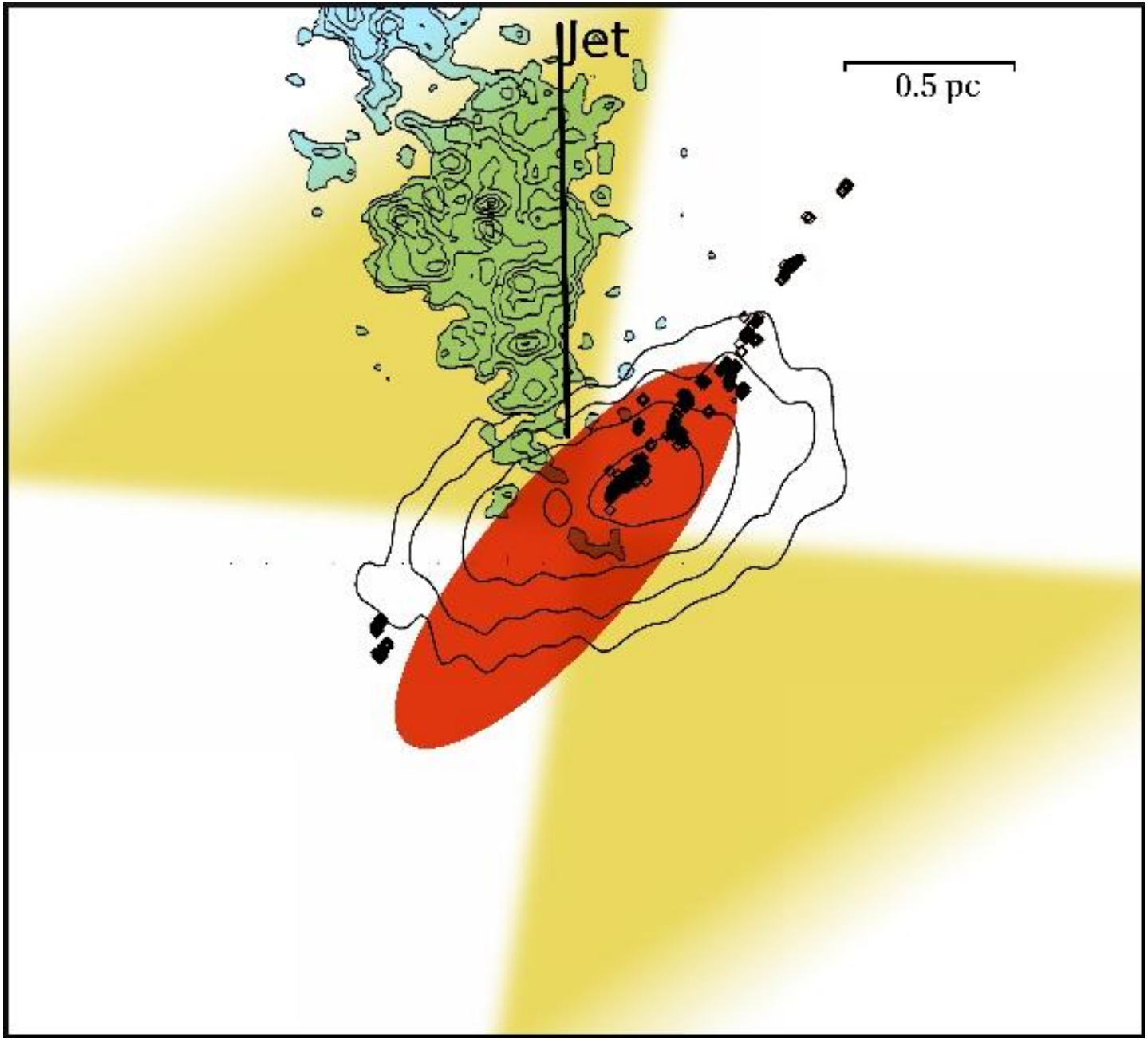

solid line
dotted line
dashed line
0°
60°
90°
λ [μm]

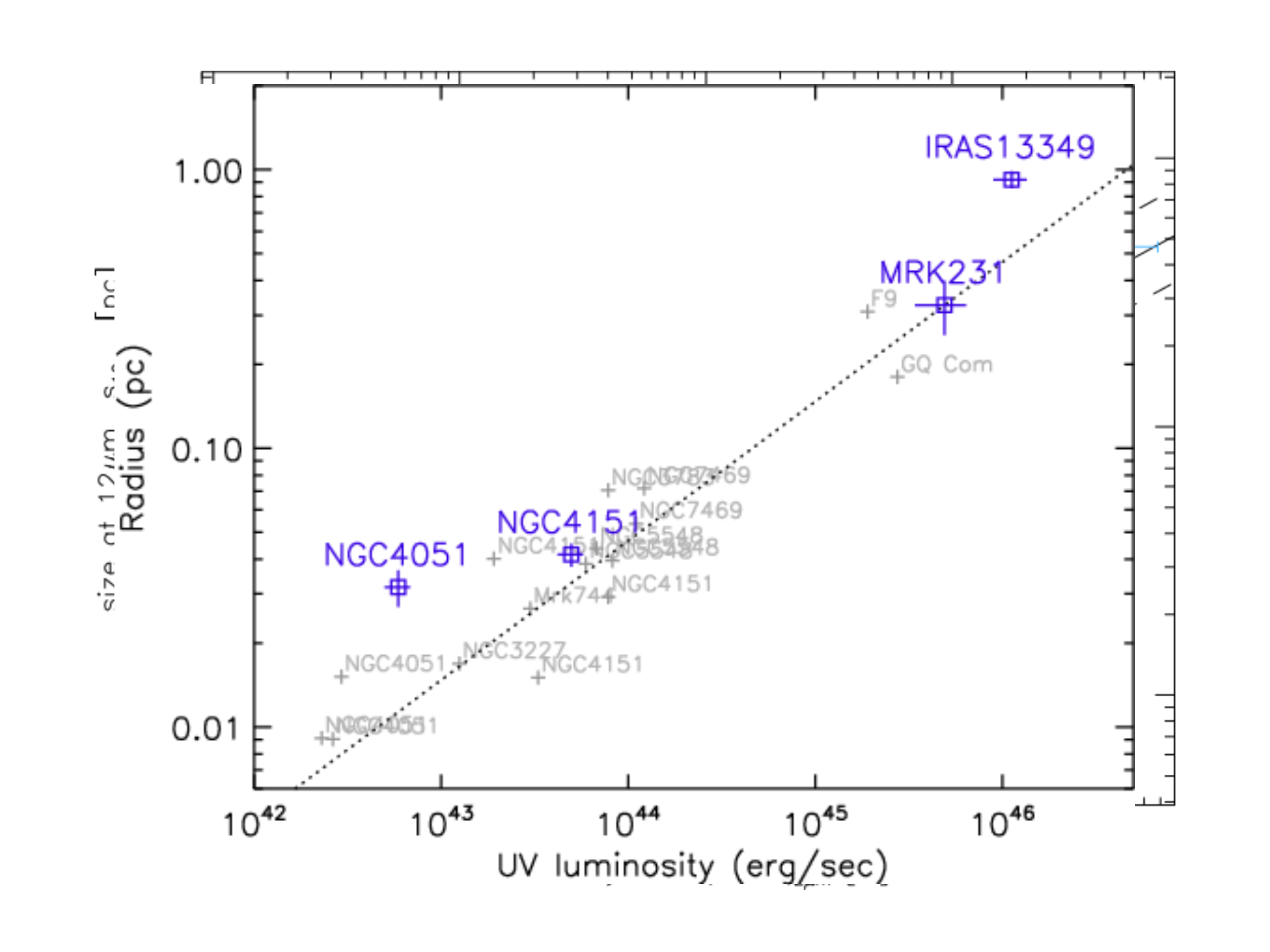

1000
100
10
Mrk1239
41m
36°
NGC4151
83m
37°
NGC3783
43m
46°
NGC3783
65m
120°
NGC1068
46m
−135°
NGC1068
79m
179°
1.0
0.8
0.6
0.4
0.2
0.0
visibility amplitude
0.001
0.010
0.100
spatial frequency (cycles per R$_{in}$)

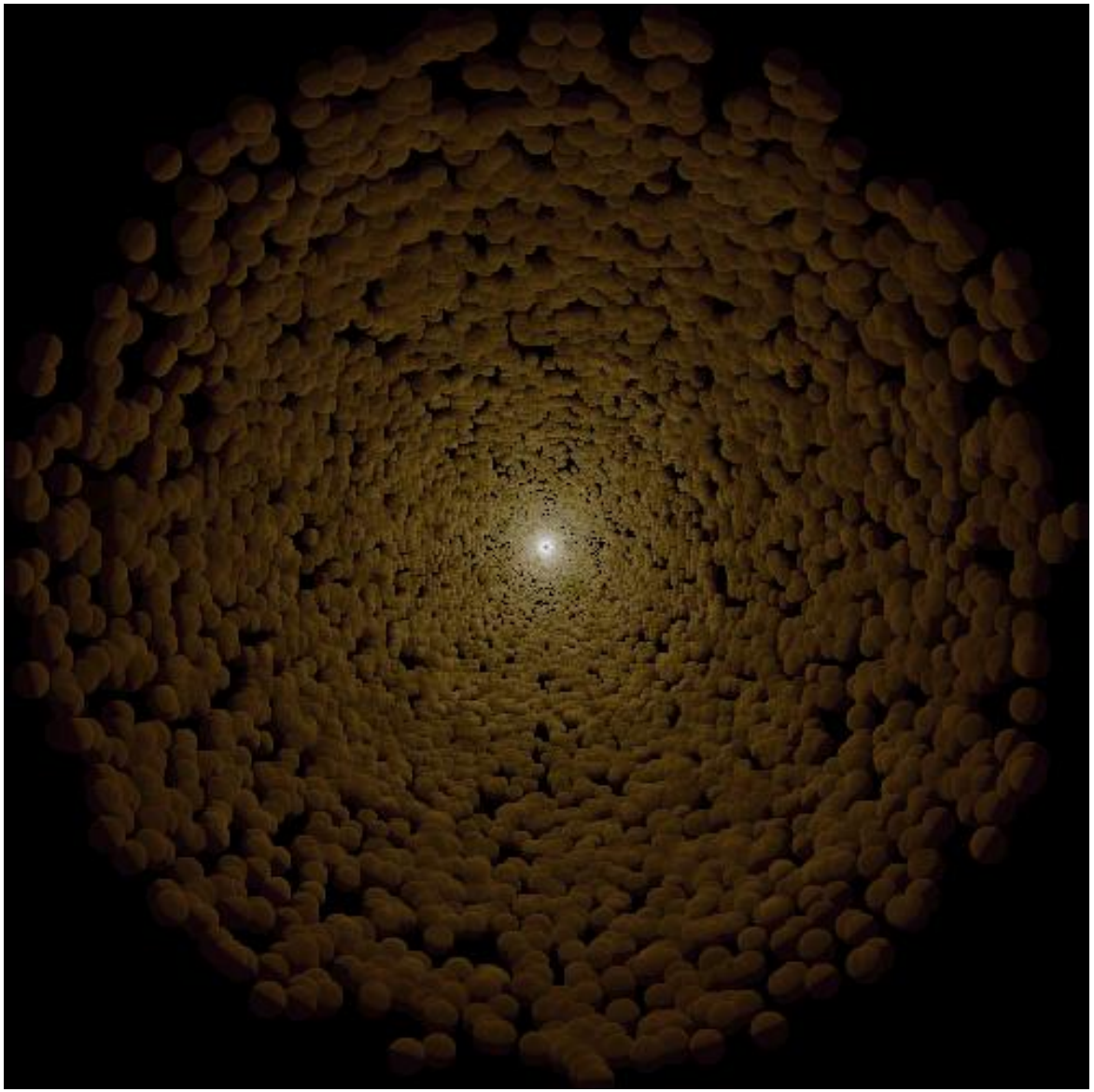

solid line
dotted line
dashed line
0°
60°
90°
10
λ [μm]

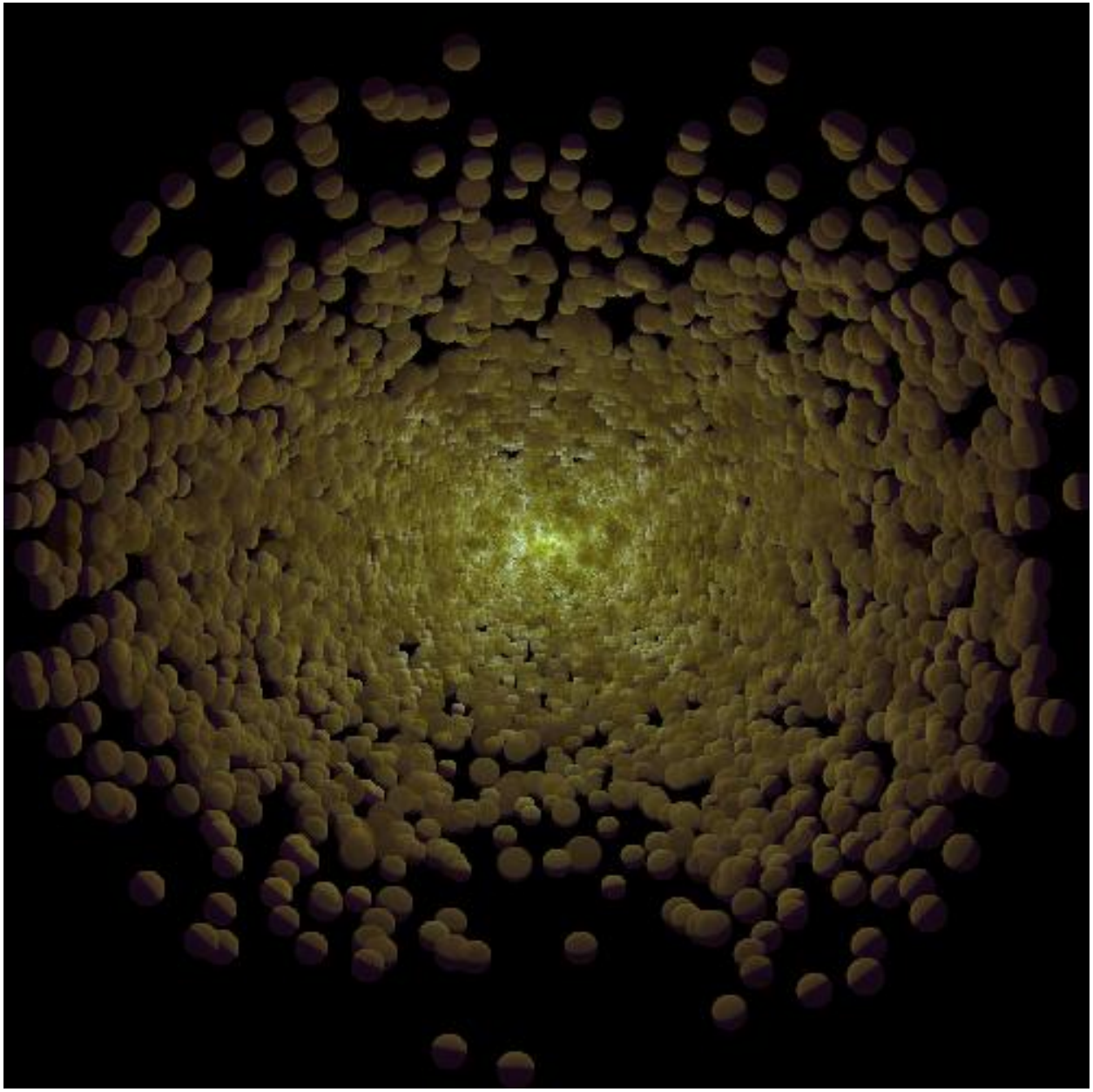
What can we probably answer with MATISSE+GRAVITY+MRO+LBT(+ALMA?)

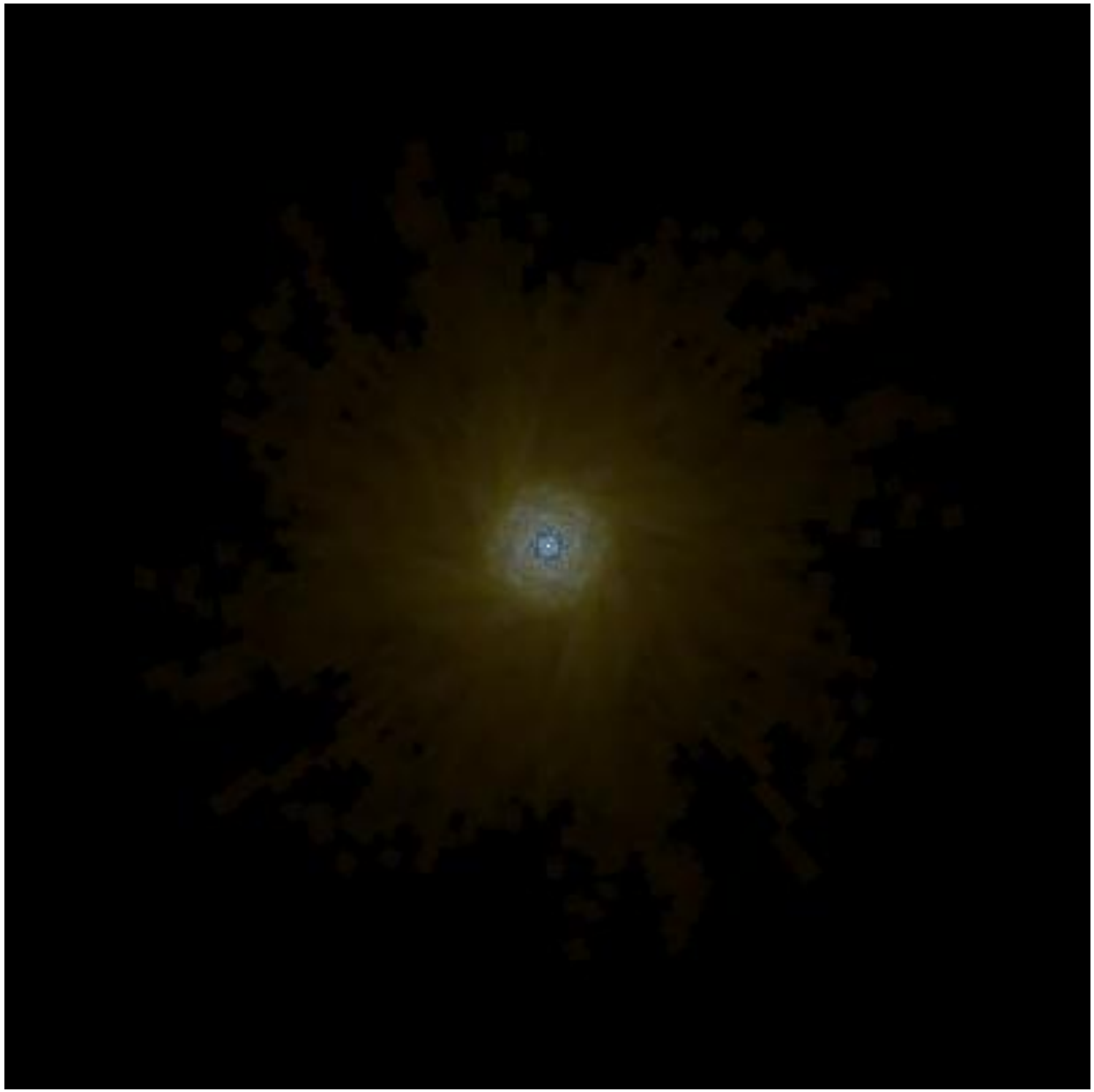
- What kind of clumpiness are we talking about? What are kinematics of disk clumps (measured in CO lines).
- What kind of dust (molecules?) are they made of?
- What determines inner radius?
- What is outer scale?
- How does connection with NLR, NLR winds and circumnuclear star-bursts work?

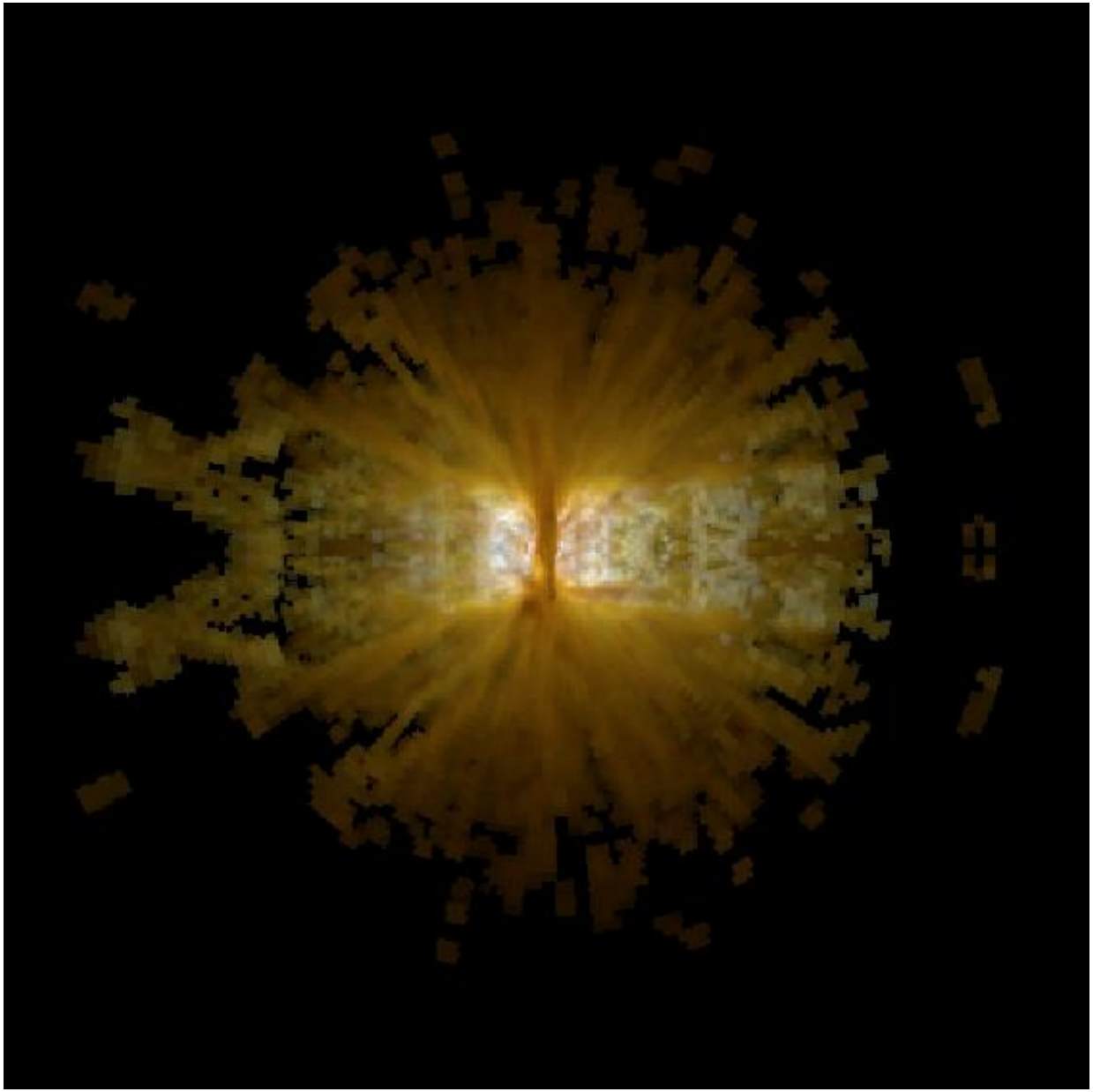

Jet
0.5 pc

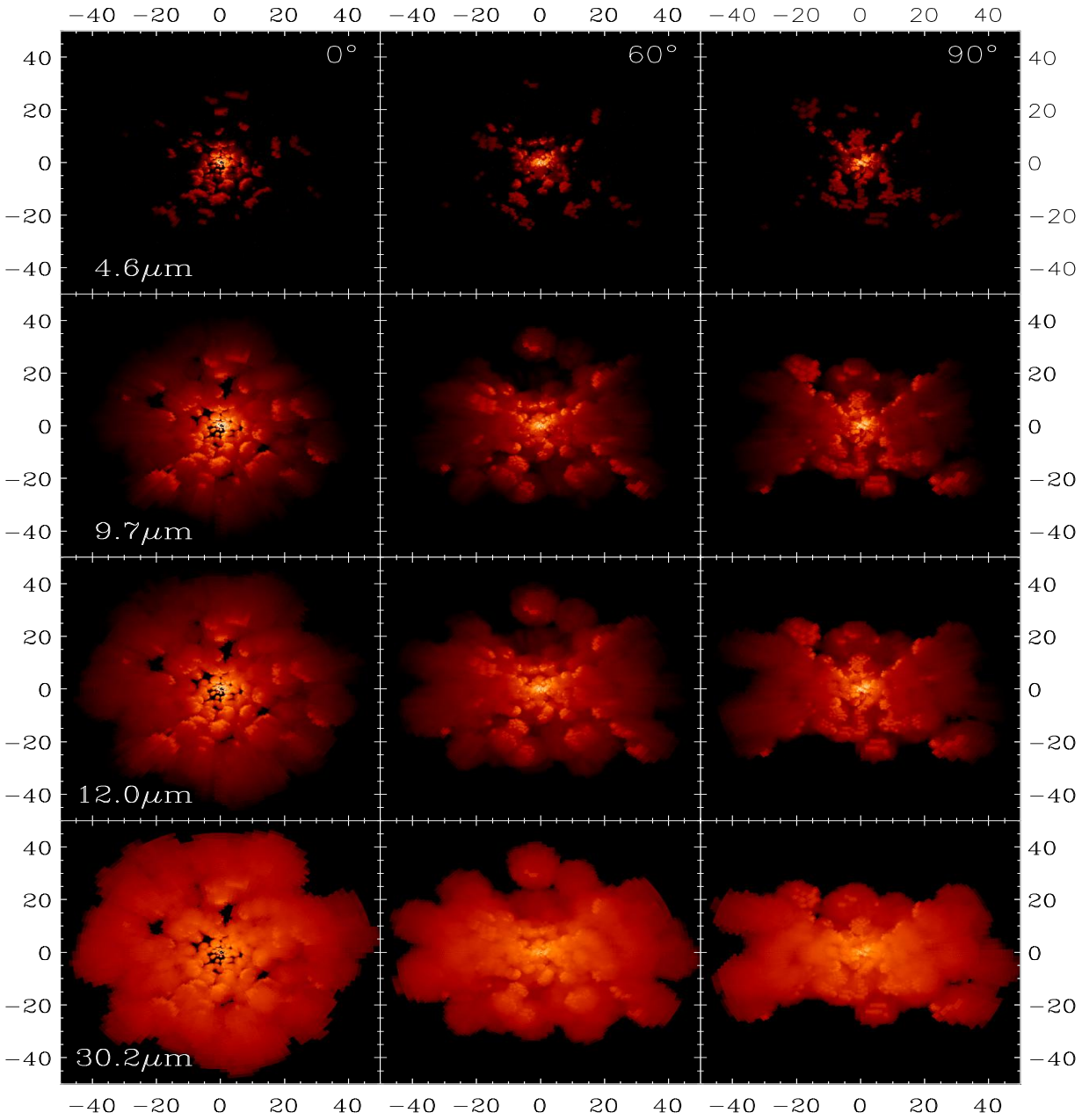

IRAS13349
MRK231
NGC4151
NGC4051
F9
GQ Com
NGC7469
Mrk744
NGC3227
1.00
0.10
0.01
Radius (pc)
10^{42}
10^{43}
10^{44}
10^{45}
10^{46}
UV luminosity (erg/sec)










0°
60°
90°
4.6μm
9.7μm
12.0μm
30.2μm
−40 −20 0 20 40