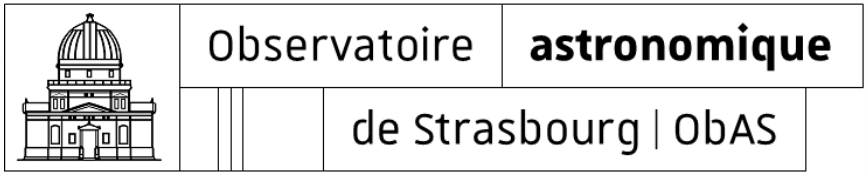
Can I get a paper's worth of science done in one single Jupyter notebook?

Dot Astronomy TO

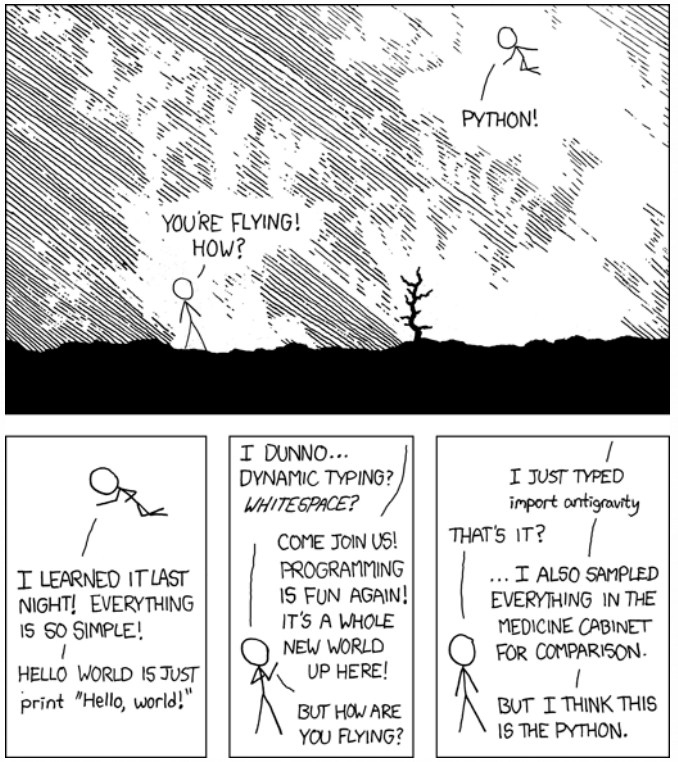
October 2019

KATHARINA LUTZ



Motivation

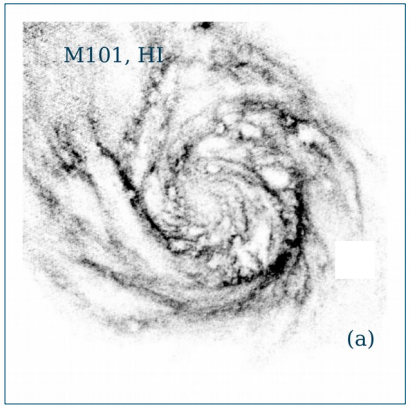
- Emergence of Science Platforms
- On offer: Jupyter hubs / notebooks
- Focus on Python because it's versatile
- Play with/ test CDS developments



Short intro to the science

Star formation – gas cycle

Accretion

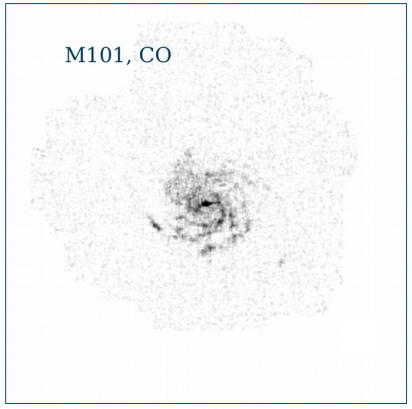


Cooling

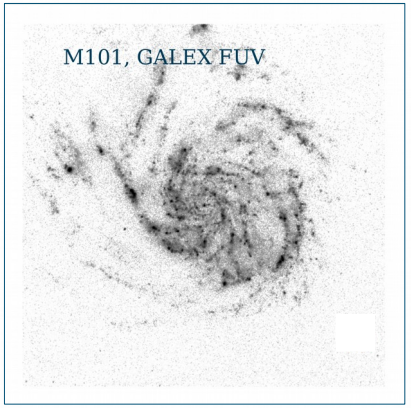
Old stars:
Stellar winds
Supernovae

Stars

Condensation



Star formation

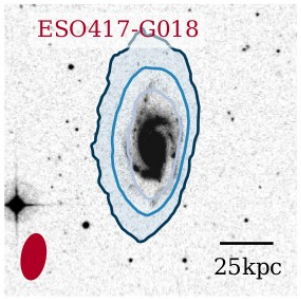


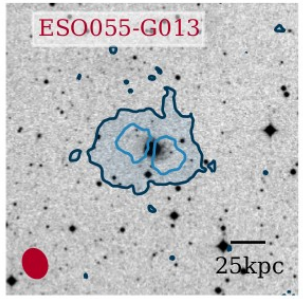
Short intro to the science

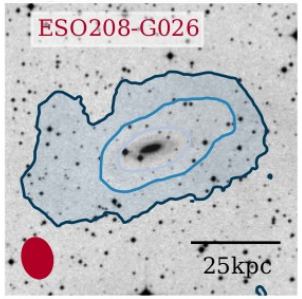
The HIX galaxy survey

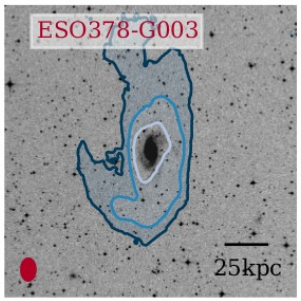
Why do HI eXtreme galaxies have more massive HI discs than other galaxies?

- More gas accretion
- Less efficient star formation







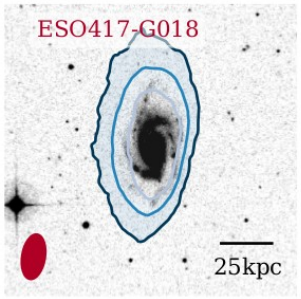


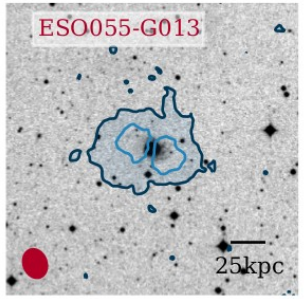
Short intro to the science

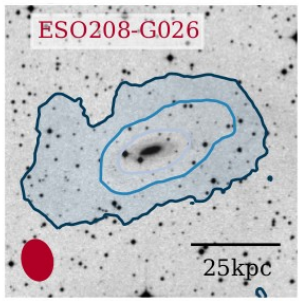
The HIX galaxy survey

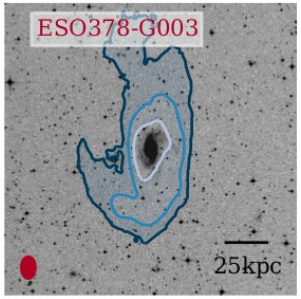
Why do HI eXtreme galaxies have more massive HI discs than other galaxies?

- More gas accretion ???
- **Less efficient star formation due to high spin / some gas does not contribute to star formation**









Quest

- We have observed optical images in g and r band with DECam for 4 HIX galaxies
- Now we want to:
  - Find optical CCD imaging for more galaxies
  - Measure photometry
  - Model the SEDs → dust and SF history
  - Compare results to more average galaxies

Quest

Imagine I am working on a cloud space where I can access (VO) archives and do “pip install [any pypi package]”:

Can I do the science for the next paper within one Jupyter notebook?

Getting Data

- No worries as long as data are available via astroquery or VO standards
- Lots of ongoing development (hips2fits)

Getting Data

In [2]:
```
catalog_list_alfalfa = Vizier.find_catalogs('Alfalfa')
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tap_vizier = pyvo.dal.TAPService('http://tapvizier.u-strasbg.fr/TAPVizieR/tap')
dustpedia_set = tap_vizier.search("SELECT  *  FROM tables " +
                                  "WHERE description LIKE '%Clark%' AND " +
                                  "table_name LIKE '%A+A/609%'").to_table()
dustpedia_set['table_name', 'description']
```

Out[4]: *Table masked=True length=4*

table_name	description
bytes36	object
J/A+A/609/A37/sample	Galaxy sample (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
J/A+A/609/A37/apphot	Aperture-matched photometry for 27 bands (GALEX, SDSS, 2MASS, WISE, Spitzer, and Herschel) (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
J/A+A/609/A37/irasphot	Ancillary photometry from IRAS SCANPI (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
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dustpedia_photo = tap_vizier.search("SELECT * " +
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for col in dustpedia_photo.colnames:
    if col not in dustpedia.colnames:
        dustpedia[col] = dustpedia_photo[col]
dustpedia.write('Tables/dustpedia.vot', format='votable', overwrite=True)
dustpedia = Table.read('Tables/dustpedia.vot')
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recno	Name	RAJ2000	DEJ2000	MType	MClass	D25	Incl	HV	HVcorr	Distcorr	Dist0	HVH	DistH	Dist0H	Dist	Simb
		deg	deg			arcmin	deg	km / s	km / s	Mpc	Mpc	km / s	Mpc	Mpc	Mpc	
int32	object	float64	float64	float64	bytes4	float64	float64	int16	int32	float64	float64	int32	float64	float64	float64	
41	NGC0678	27.35355	21.99728	3.0	SBb	3.0903	90.0	2835	2766	37.76625	27.87	2793	38.1349	--	27.87	N
44	NGC0855	33.51495	27.87685	-4.8	E	2.9512	90.0	592	693	9.46204	9.28	592	8.08301	9.63829	9.63829	N
52	NGC1056	40.70145	28.57372	1.0	Sa	1.8621	46.700001	1545	1561	21.31349	26.8	1544	21.08138	31.18893	31.18893	N
56	UGC02392	43.9434	33.76658	5.9	Sc	1.3183	76.599998	1548	1583	21.61387	26.52	1546	21.10868	--	26.52	UC
125	UGC03016	65.33325	36.76014	5.9	Sc	1.122	90.0	5897	5806	79.27362	30.05	2458	33.5609	--	30.05	UC
48	NGC0925	36.82035	33.579	7.0	Scd	10.7152	58.700001	553	676	9.22993	8.61	554	7.56417	9.20449	9.20449	N

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```
In [6]:
dp_alf = XMatch.query(cat1=open('Tables/dustpedia.vot'),
                      cat2='vizier:J/ApJ/861/49/table2',
                      max_distance=1.75 * u.arcmin, colRA1='RAJ2000',
                      colDec1='DEJ2000')
dp_alf
```

Out[6]: *Table masked=True length=343*

angDist	recno_1	Name_1	RAJ2000_1	DEJ2000_1	MType	MClass	D25	Incl	HV	HVcorr	Distcorr	Dist0	HVH	DistH	Dist0H
float64	int64	str23	float64	float64	float64	str4	float64	float64	int64	int64	float64	float64	int64	float64	float64
14.287441	41	NGC0678	27.35355	21.99728	3.0	SBb	3.0903	90.0	2835	2766	37.76625	27.87	2793	38.1349	--
31.099272	44	NGC0855	33.51495	27.87685	-4.8	E	2.9512	90.0	592	693	9.46204	9.28	592	8.08301	9.63829
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J/A+A/576/A16 :  H{alpha}3 V. Coma cluster (Gavazzi+, 2015)
J/AJ/133/2569 :  Arecibo legacy fast ALFA survey III. (Giovanelli+, 2007)
J/AJ/135/588 :  Arecibo legacy fast ALFA survey V. (Saintonge+, 2008)
J/AJ/136/713 :  Arecibo legacy fast ALFA survey. VI. (Kent+, 2008)
J/AJ/138/338 :  Arecibo Legacy Fast ALFA Survey. IX. (Stierwalt+, 2009)
J/AJ/142/170 :  ALFALFA survey: the {alpha}.40 HI source catalog (Haynes+, 2011)
J/AJ/143/133 :  Properties of dwarf galaxies from the ALFALFA survey (Huang+, 2012)
J/AJ/143/145 :  Emission-line objects from ALFALFA H{alpha} survey (Kellar+, 2012)
J/AJ/145/149 :  ALFALFA discovery of Leo P. II. BVR photometry (Rhode+, 2013)
J/AJ/146/145 :  ALFALFA discovery of Leo P. IV. VI photometry (Mcquinn+, 2013)
```

In [4]:
```
tap_vizier = pyvo.dal.TAPService('http://tapvizier.u-strasbg.fr/TAPVizieR/tap')
dustpedia_set = tap_vizier.search("SELECT  *  FROM tables " +
                                  "WHERE description LIKE '%Clark%' AND " +
                                  "table_name LIKE '%A+A/609%'").to_table()
dustpedia_set['table_name', 'description']
```

Out[4]: *Table masked=True length=4*

table_name	description
bytes36	object
J/A+A/609/A37/sample	Galaxy sample (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
J/A+A/609/A37/apphot	Aperture-matched photometry for 27 bands (GALEX, SDSS, 2MASS, WISE, Spitzer, and Herschel) (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
J/A+A/609/A37/irasphot	Ancillary photometry from IRAS SCANPI (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)
J/A+A/609/A37/plnkphot	Ancillary photometry from Planck CCS2 (Clark C.J.R., Verstocken S., Bianchi S., Fritz J., Viaene S., Smith M.W.L., Baes M., Casasola V., Cassara L.P., Davies J.I., De Looze I., De Vis P., Evans R., Galametz M., Jones A.P., Lianou S., Madden S., Mosenkov A.V., Xilouris M.)

In [5]:
```
dustpedia = tap_vizier.search("SELECT * FROM \"J/A+A/609/A37/sample\"").to_table()
dustpedia_photo = tap_vizier.search("SELECT * " +
                                    "FROM \"J/A+A/609/A37/apphot\"").to_table()

for col in dustpedia_photo.colnames:
    if col not in dustpedia.colnames:
        dustpedia[col] = dustpedia_photo[col]
dustpedia.write('Tables/dustpedia.vot', format='votable', overwrite=True)
dustpedia = Table.read('Tables/dustpedia.vot')
dustpedia
```

Out[5]: *Table masked=True length=875*

recno	Name	RAJ2000	DEJ2000	MType	MClass	D25	Incl	HV	HVcorr	Distcorr	Dist0	HVH	DistH	Dist0H	Dist	Simb
		deg	deg			arcmin	deg	km / s	km / s	Mpc	Mpc	km / s	Mpc	Mpc	Mpc	
int32	object	float64	float64	float64	bytes4	float64	float64	int16	int32	float64	float64	int32	float64	float64	float64	
41	NGC0678	27.35355	21.99728	3.0	SBb	3.0903	90.0	2835	2766	37.76625	27.87	2793	38.1349	--	27.87	N
44	NGC0855	33.51495	27.87685	-4.8	E	2.9512	90.0	592	693	9.46204	9.28	592	8.08301	9.63829	9.63829	N

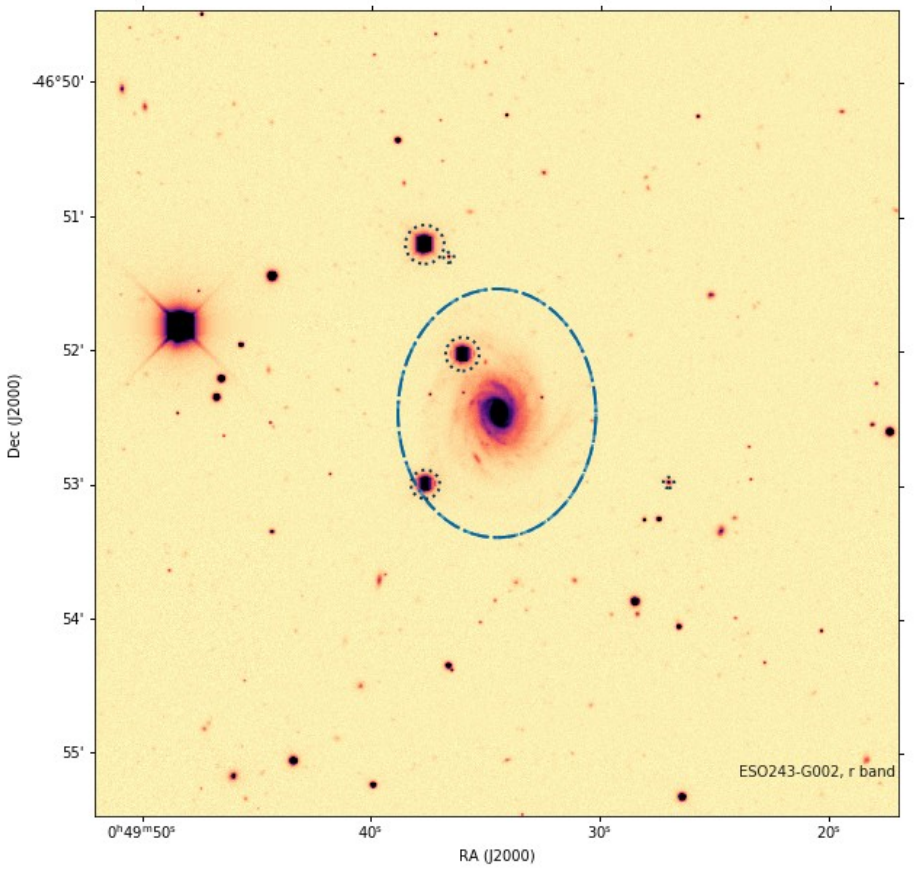
In [6]:
```
dp_alf = XMatch.query(cat1=open('Tables/dustpedia.vot'),
                      cat2='vizier:J/ApJ/861/49/table2',
                      max_distance=1.75 * u.arcmin, colRA1='RAJ2000',
                      colDec1='DEJ2000')
dp_alf
```

Out[6]: *Table masked=True length=343*

angDist	recno_1	Name_1	RAJ2000_1	DEJ2000_1	MType	MClass	D25	Incl	HV	HVcorr	Distcorr	Dist0	HVH	DistH	Dist0H
float64	int64	str23	float64	float64	float64	str4	float64	float64	int64	int64	float64	float64	int64	float64	float64
14.287441	41	NGC0678	27.35355	21.99728	3.0	SBb	3.0903	90.0	2835	2766	37.76625	27.87	2793	38.1349	--
31.099272	44	NGC0855	33.51495	27.87685	-4.8	E	2.9512	90.0	592	693	9.46204	9.28	592	8.08301	9.63829
8.557775	52	NGC1056	40.70145	28.57372	1.0	Sa	1.8621	46.700001	1545	1561	21.31349	26.8	1544	21.08138	31.18893

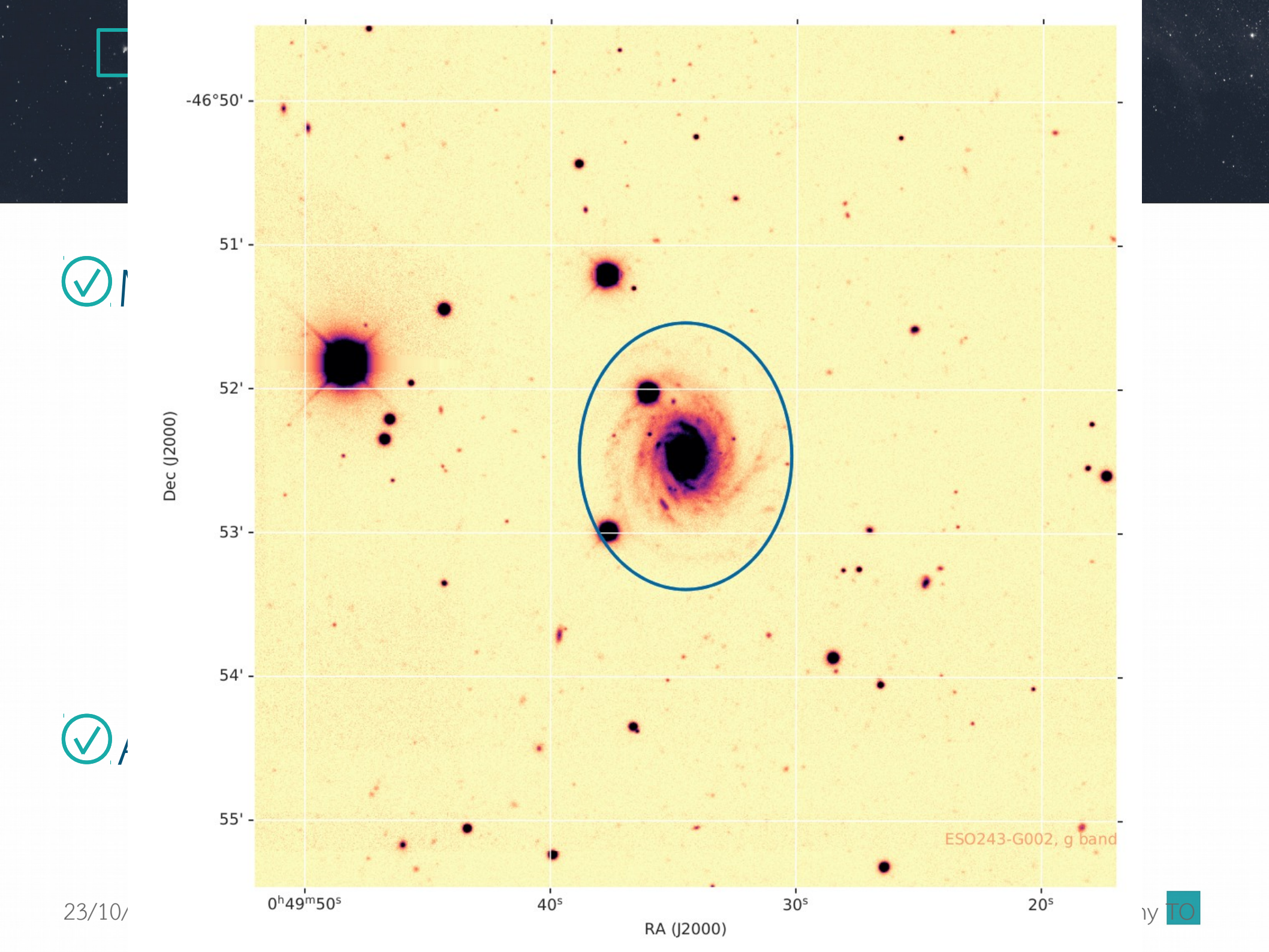
Measuring photometry

- Photutils works
  - Find stars
  - Measure aperture photometry
  - Mask stars
  - Visualise aperture for double-checking

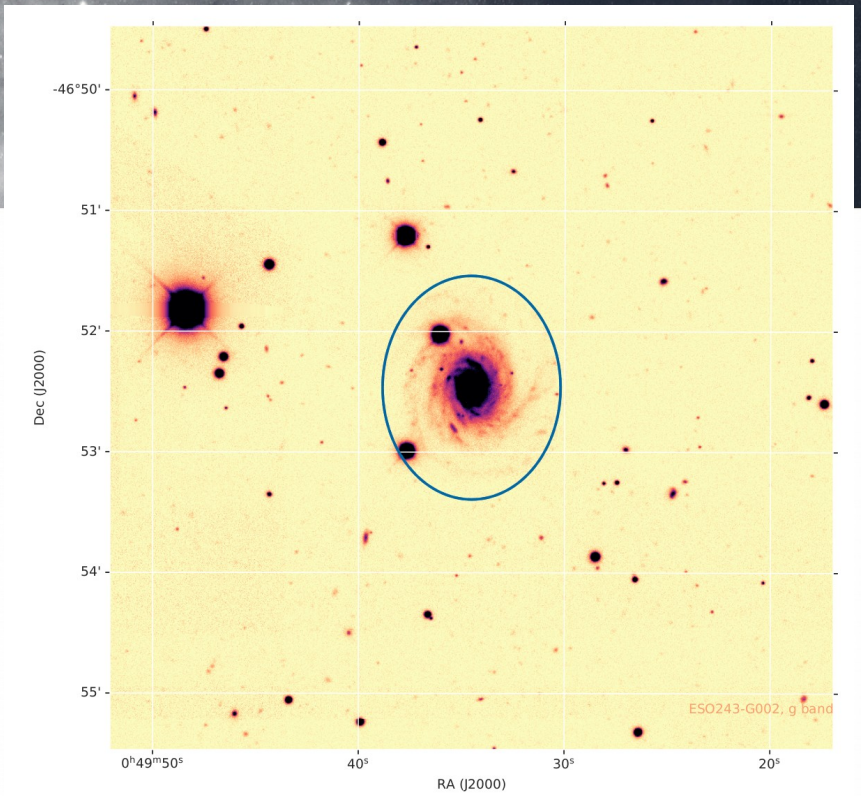


Visualisation

- Matplotlib PLUS
  - Plot functions for special objects
  - WCS axes
  - astropy.visualisation
- Aladin Lite widget

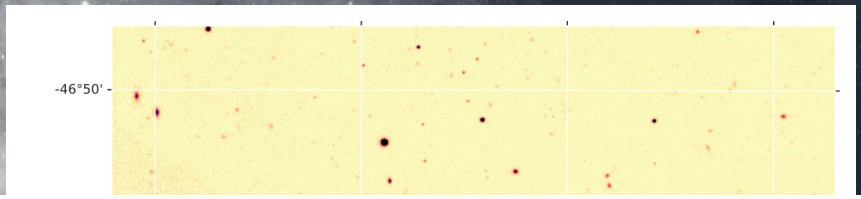

-46°50'
51'
52'
53'
54'
55'
Dec (J2000)
0h49m50s
40s
30s
20s
RA (J2000)
ESO243-G002, g band

Visualisation



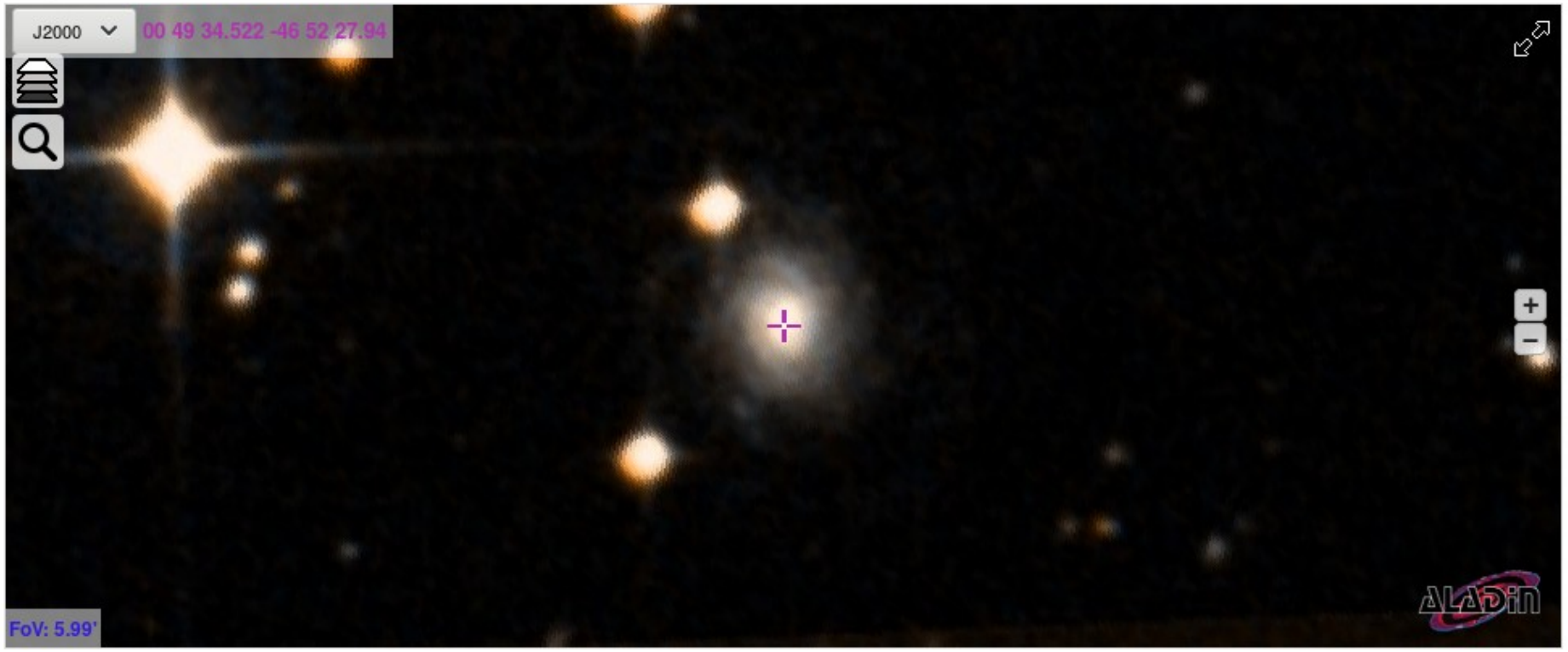
- Matplotlib PLUS
  - Plot functions for special objects
  - WCS axes
  - astropy.visualisation
- Aladin Lite widget

Visualisation



In [7]:

```
1 aladin1 = ipyal.Aladin(survey='P/DSS2/color', fov=0.1,
2                        target='ESO243-G002')
3 aladin1
```



Aladin Lite widget

Visualisation

- Matplotlib PLUS
  - Plot functions for special objects
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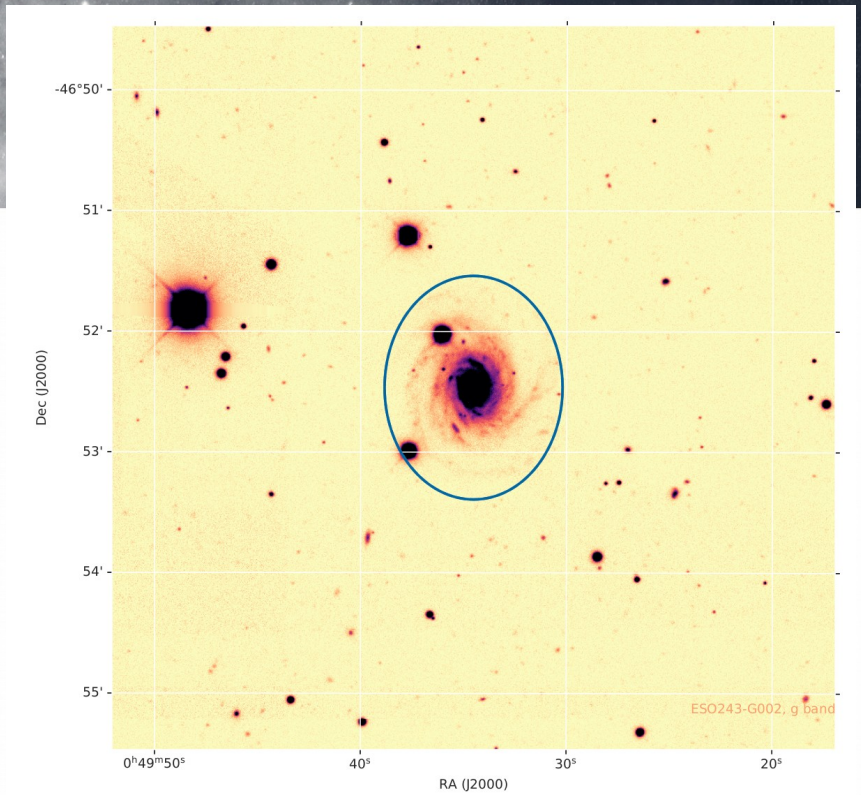
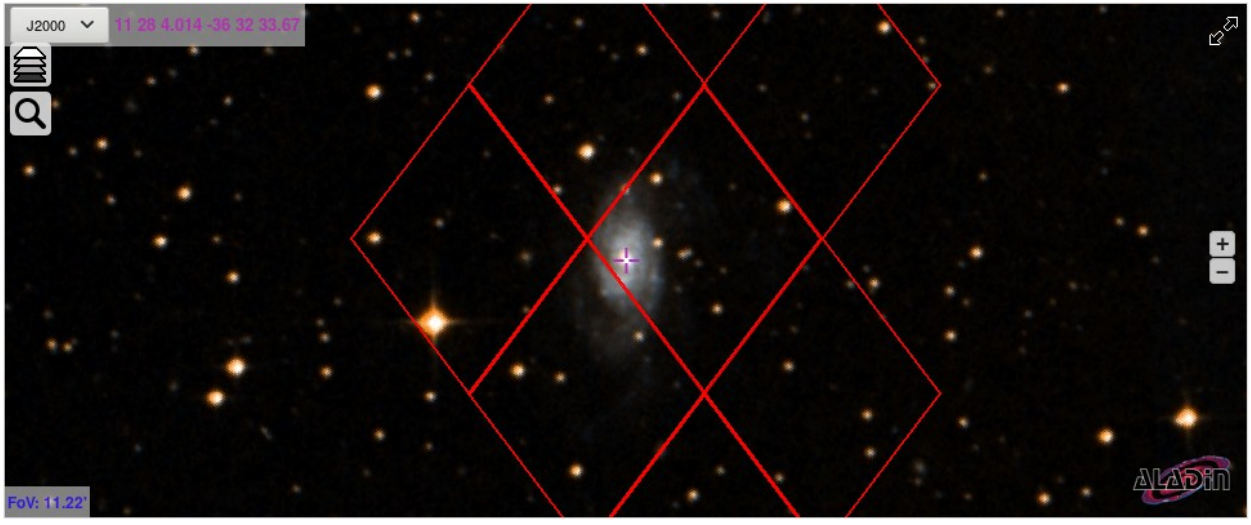
- Aladin Lite widget



CDS developments in context

- Aladin Lite widget nice for quick visualisation
- MOC help to avoid source confusion

```
In [6]:
1 aladin= ipyal.Aladin(survey='P/DSS2/color', target='ESO378-3', fov=0.5)
2 aladin
```

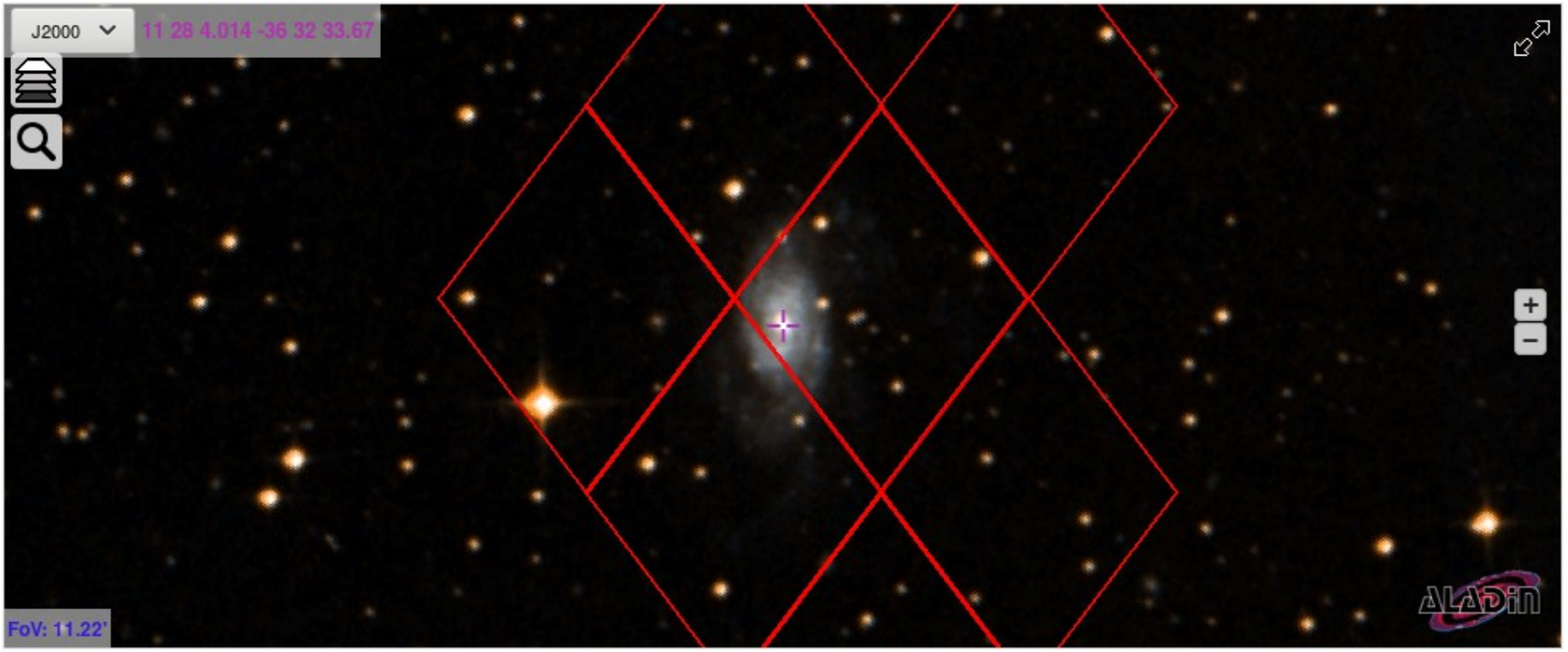



```
In [9]:
1 aladin.add_moc_from_dict(my_moc.serialize(format='json'), {'color': 'red'})
```

CDS developments in context

- Aladin Lite widget nice for quick visualisation

In [6]:
```
1 aladin= ipyal.Aladin(survey='P/DSS2/color', target='ESO378-3', fov=0.5)
2 aladin
```



In [9]:
```
1 aladin.add_moc_from_dict(my_moc.serialize(format='json'), {'color': 'red'})
```

SED modelling

- ⊗ Both MAGPHYS and CIGALE are command line tools
- ? Maybe the astropy modelling + table of model?

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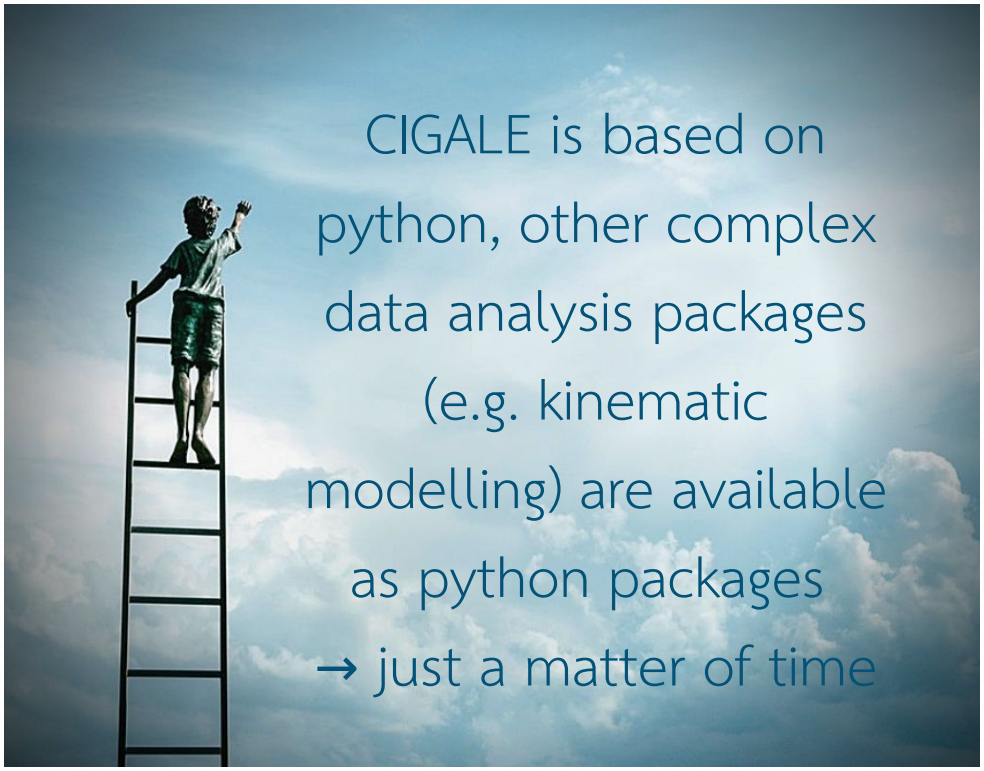

Quest

Imagine I am working on a cloud space where I can access the VO resources and do “pip install [any pypi package]”:

MOSTLY

Can I do the science for the next paper within one Jupyter notebook?

Conclusion & Outlook

- Lots of heavy lifting can already be done in Jupyter notebooks:
  - Background measurements
  - Data cube analysis
- Many good things are on the best way:
  - Hips2fits module for astroquery (in development)
  - ESAsky widget for Jupyter notebooks (pyesasky)
- Crucial: access to outside databases!