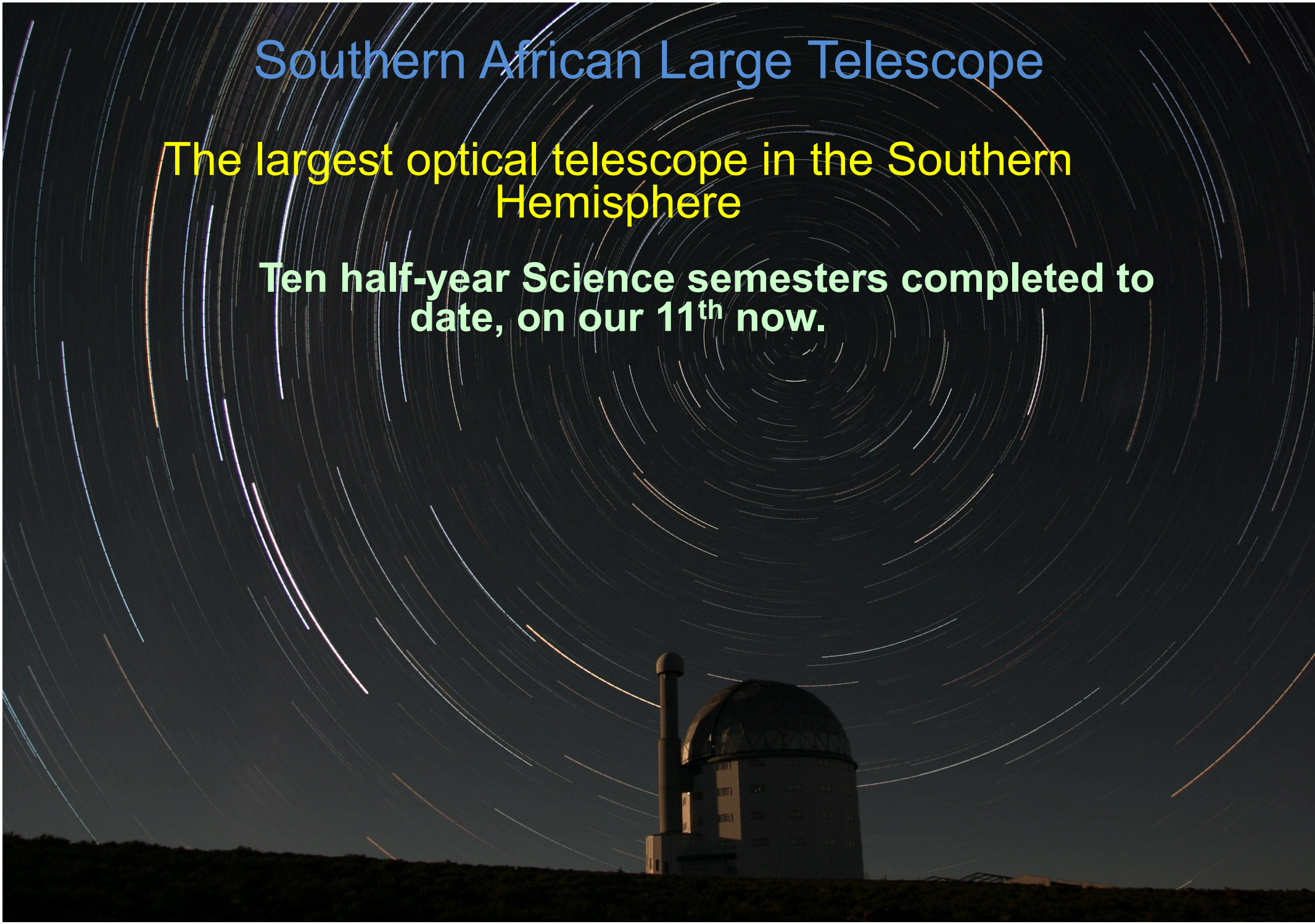
SALT overview

Petri Vaisanen &
the SALT Astronomy Operations

Outline:

Instruments and modes
Some SALT observing basics
How to make most of your observations?
Status now



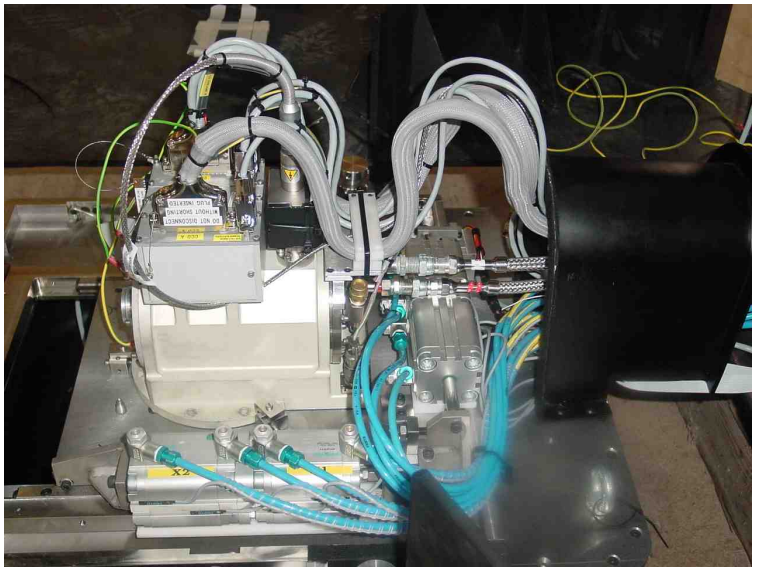
Southern African Large Telescope

The largest optical telescope in the Southern Hemisphere

Ten half-year Science semesters completed to date, on our 11th now.

SALT INSTRUMENTS

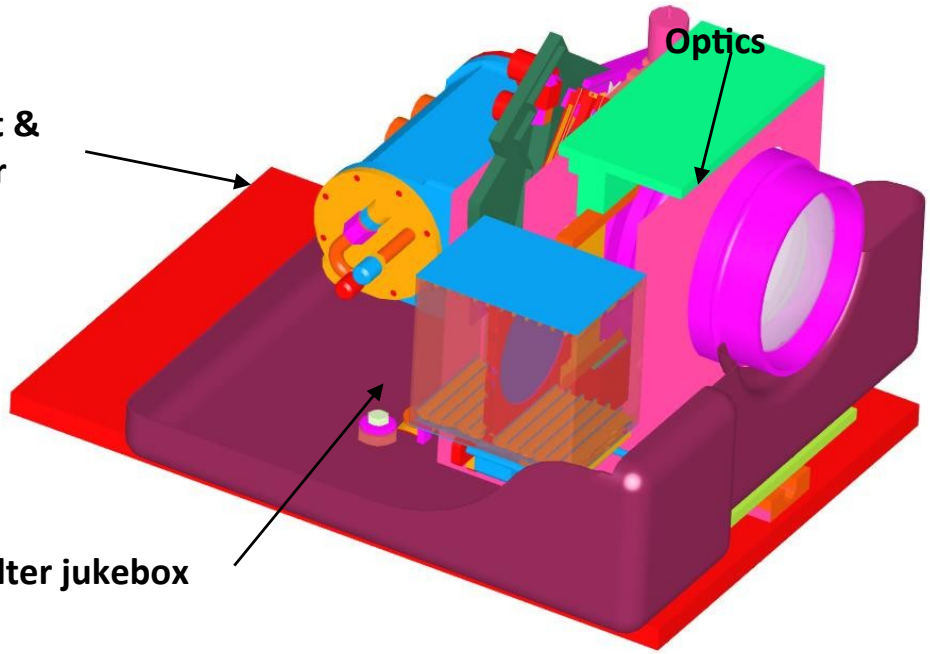
SALTICAM – first instrument on SALT



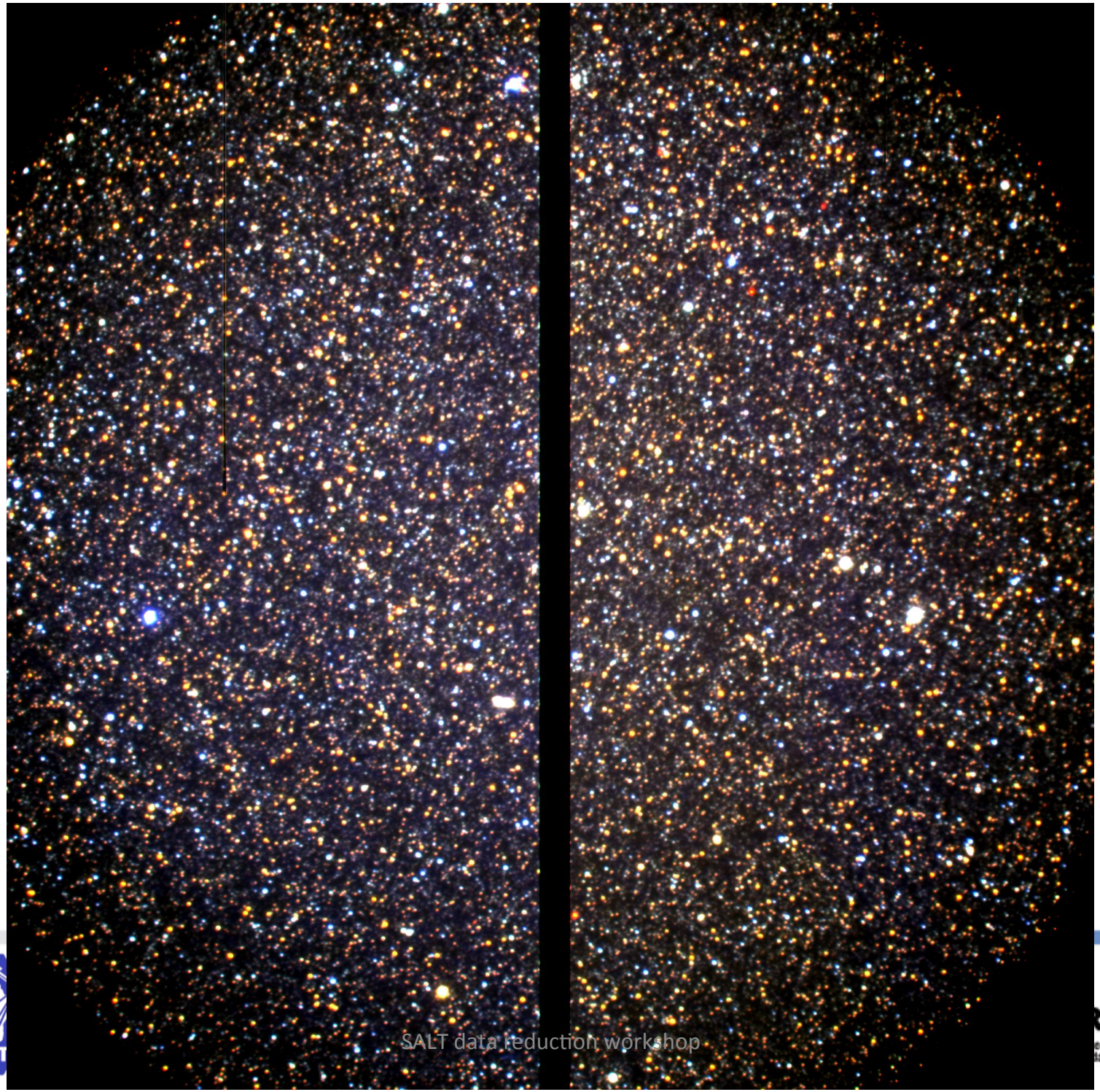
An imager over 8 arcmin (SAAO)

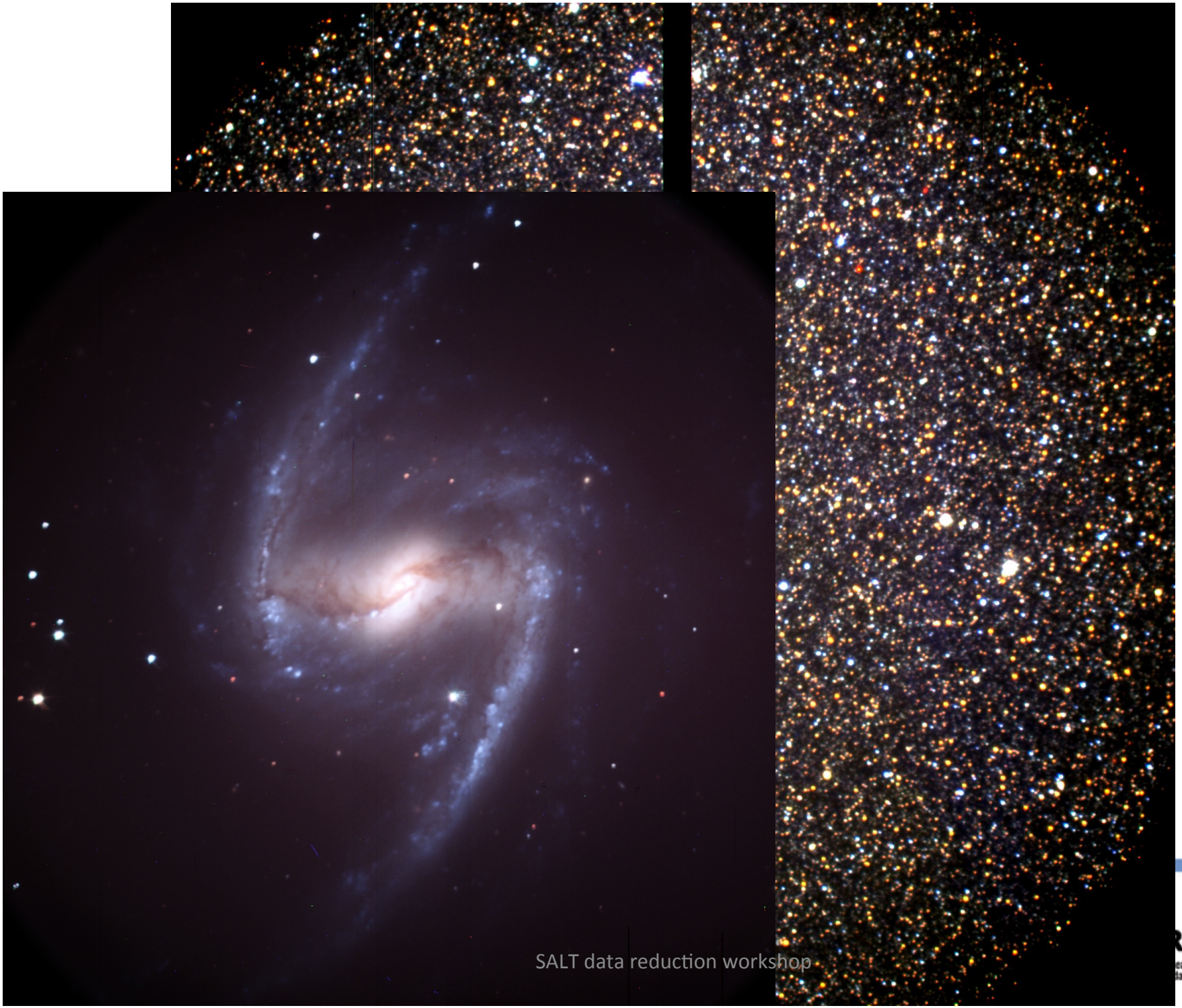
Capable down to 320nm, high sensitivity in the UV and blue.

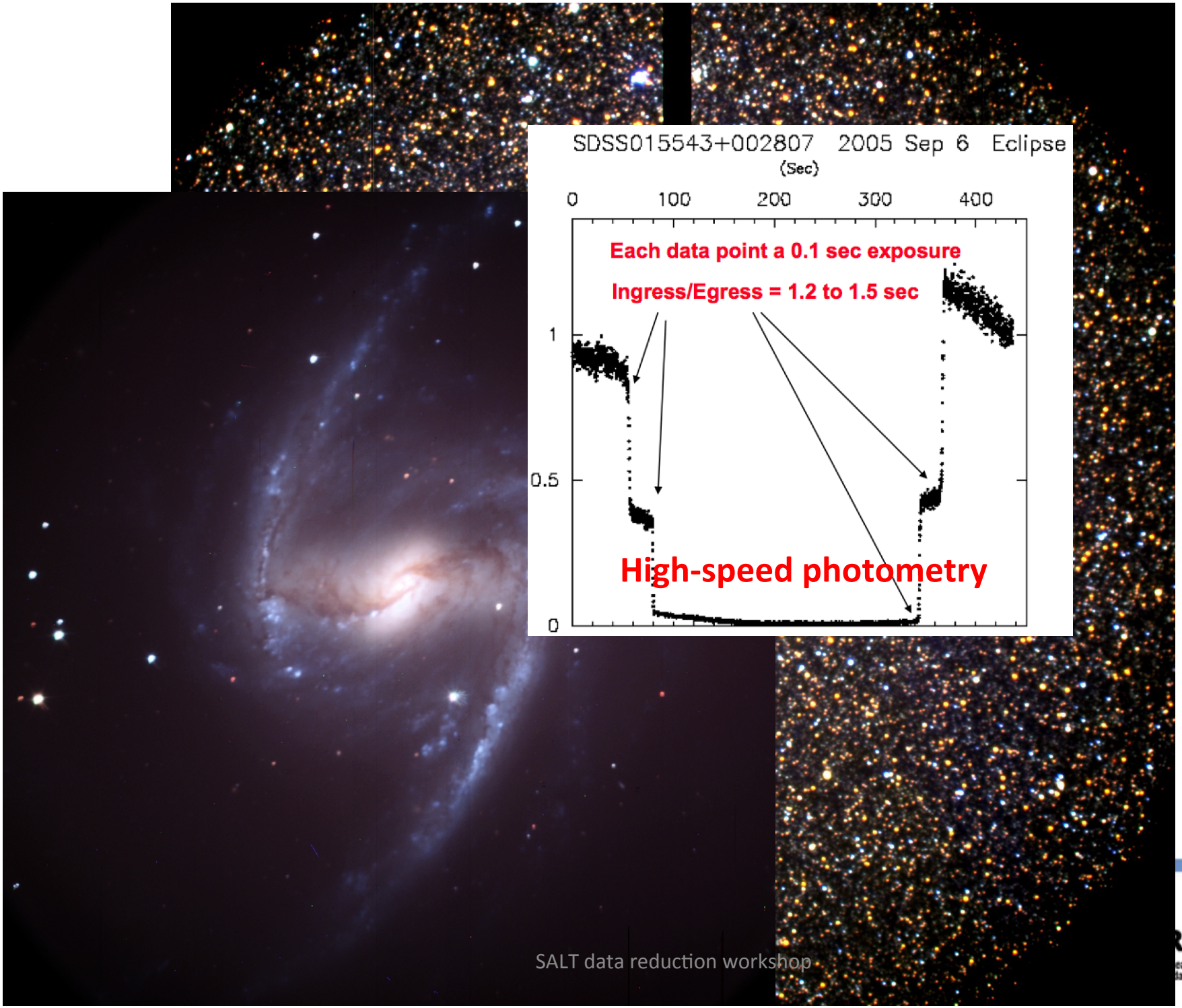
Broad and intermediate-band imaging and *high time-resolution photometry* (down to 50 ms).



- So far have done imaging down to about r~24.5 or 25 mag.






SDSS015543+002807 2005 Sep 6 Eclipse
(Sec)
0
100
200
300
400
Each data point a 0.1 sec exposure
Ingress/Egress = 1.2 to 1.5 sec
1
0.5
0
High-speed photometry

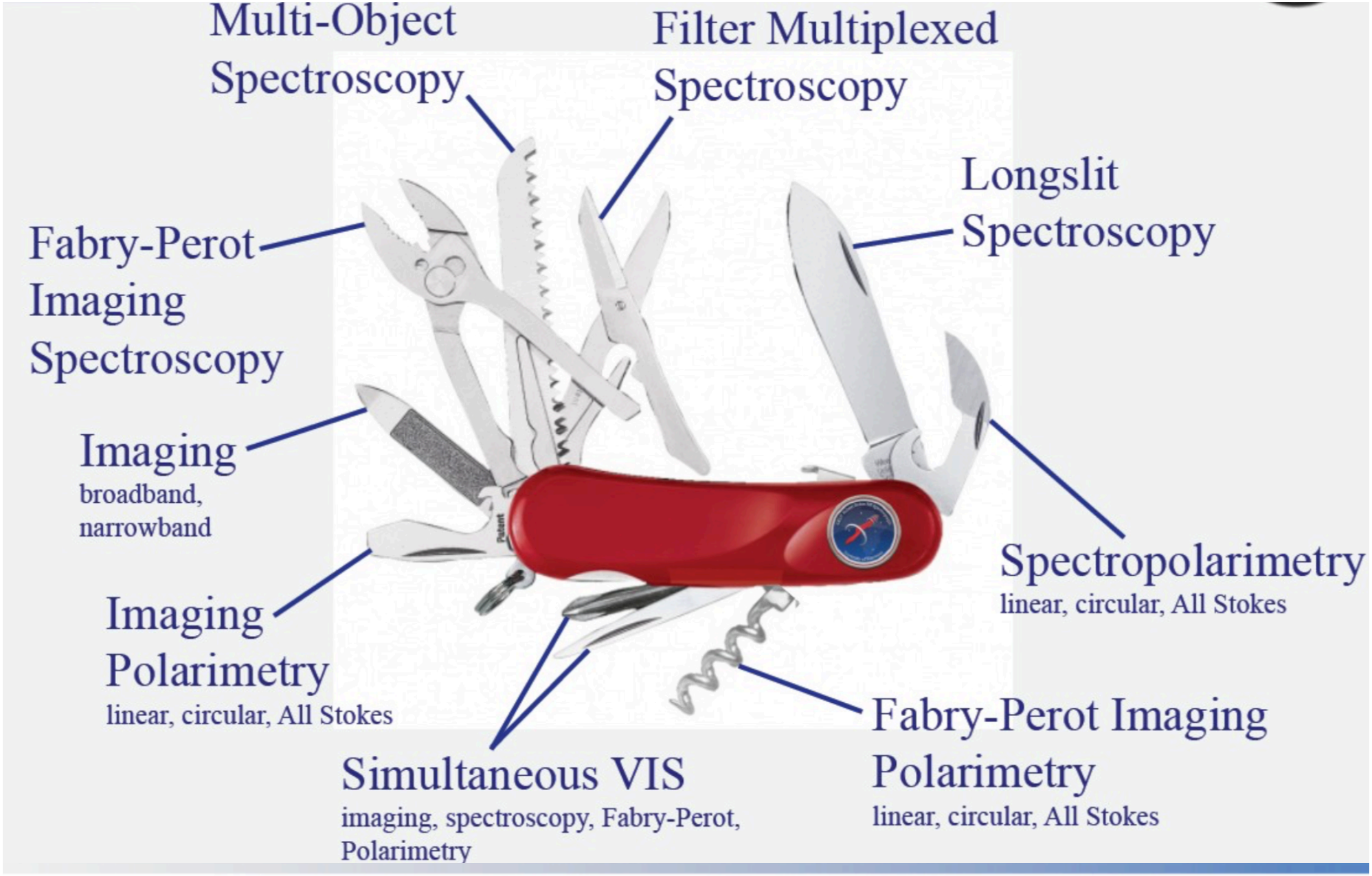
RSS: Robert Stobie Spectrograph

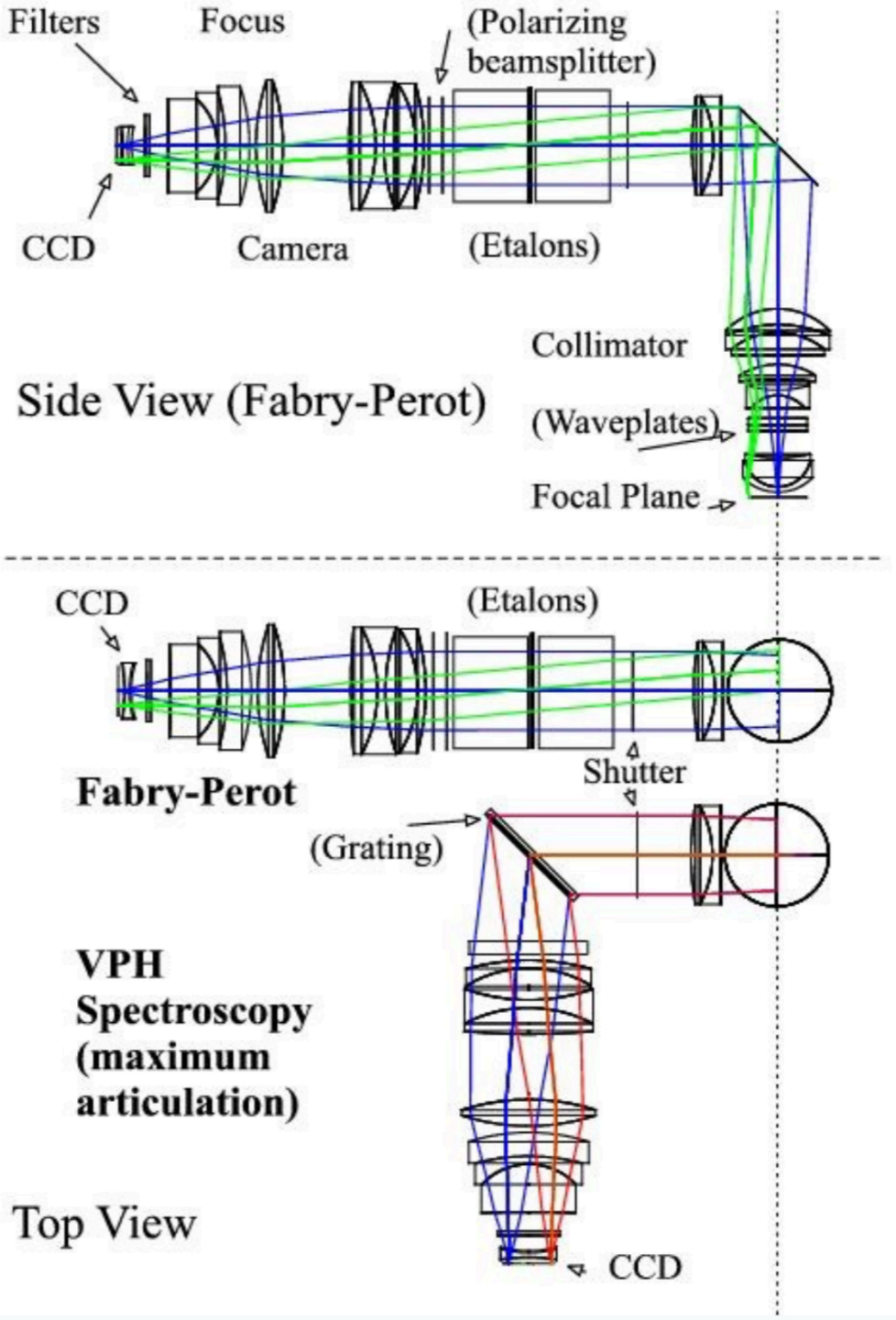
University of Wisconsin-Madison

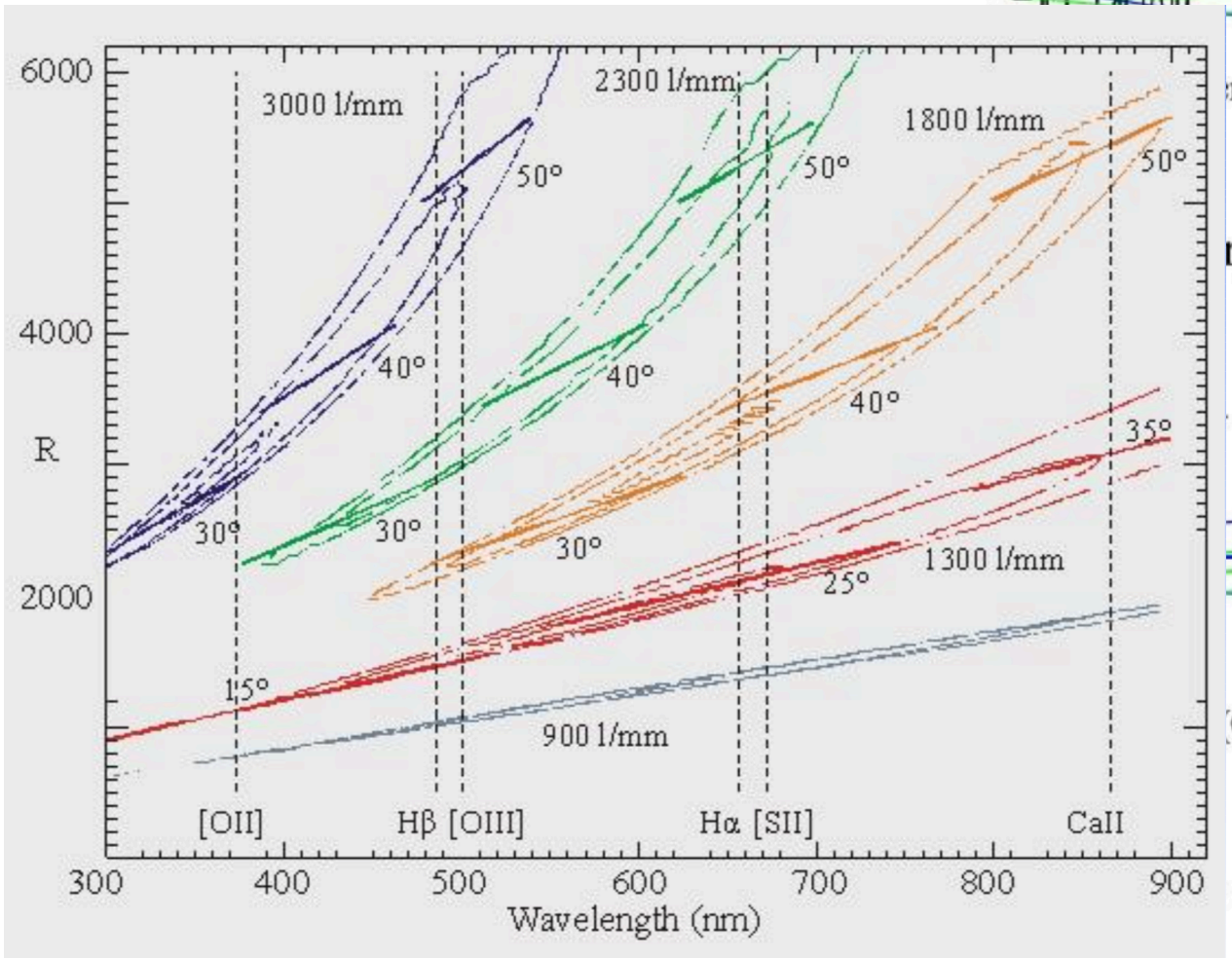
- Long slit and multi-object (>100) spectroscopy
  medium resolution, *R* to 10,000
- very flexible Resolution and wavelength coverage.
- Fabry-Perot imaging spectroscopy
- Imaging polarimetric and spectropolarimetric modes
- High Time resolution ~100 ms spectroscopy

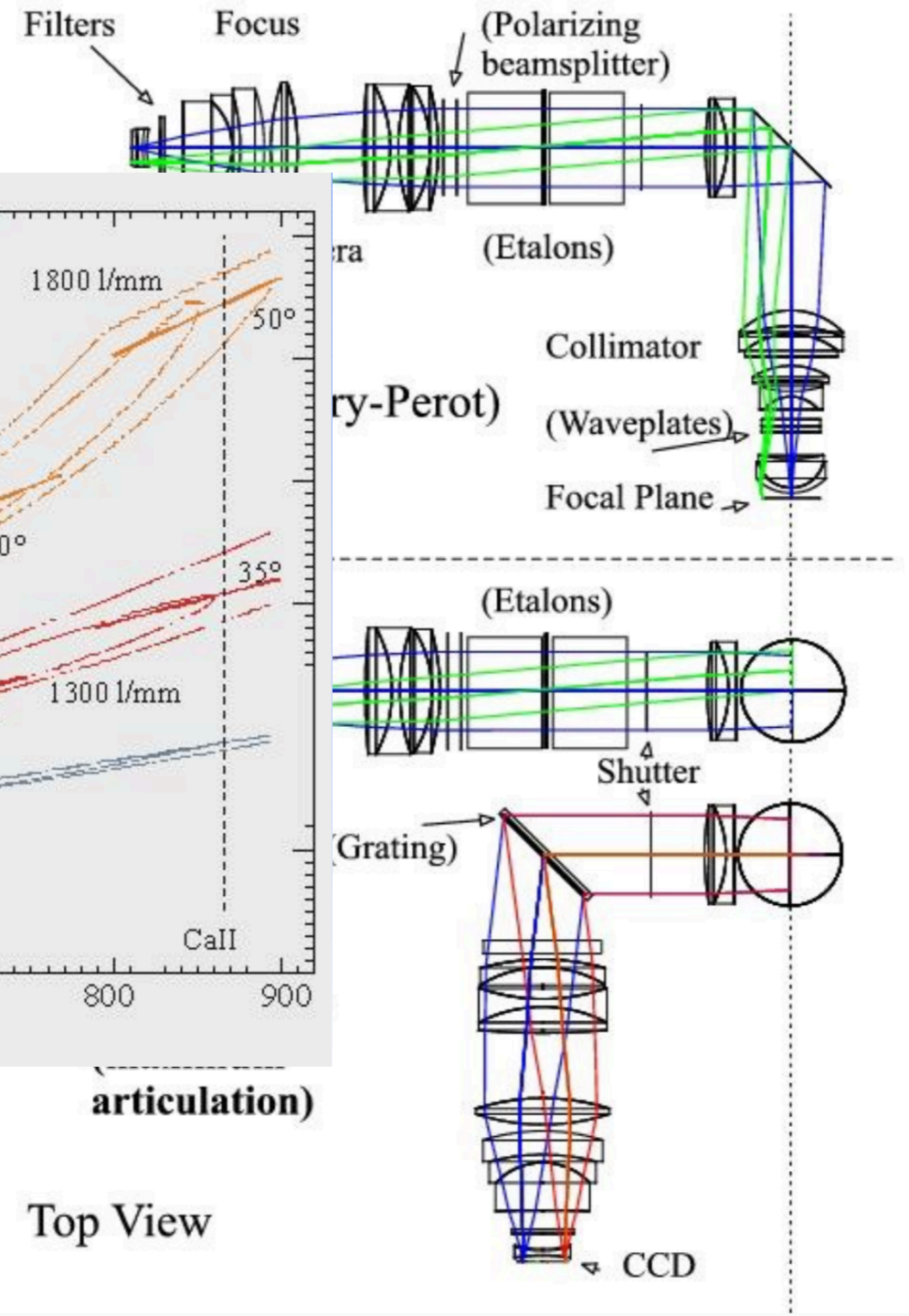
- **The work-horse instrument on SALT**

- Upgrade to near-IR beam IFU unit (J,H) in 2019

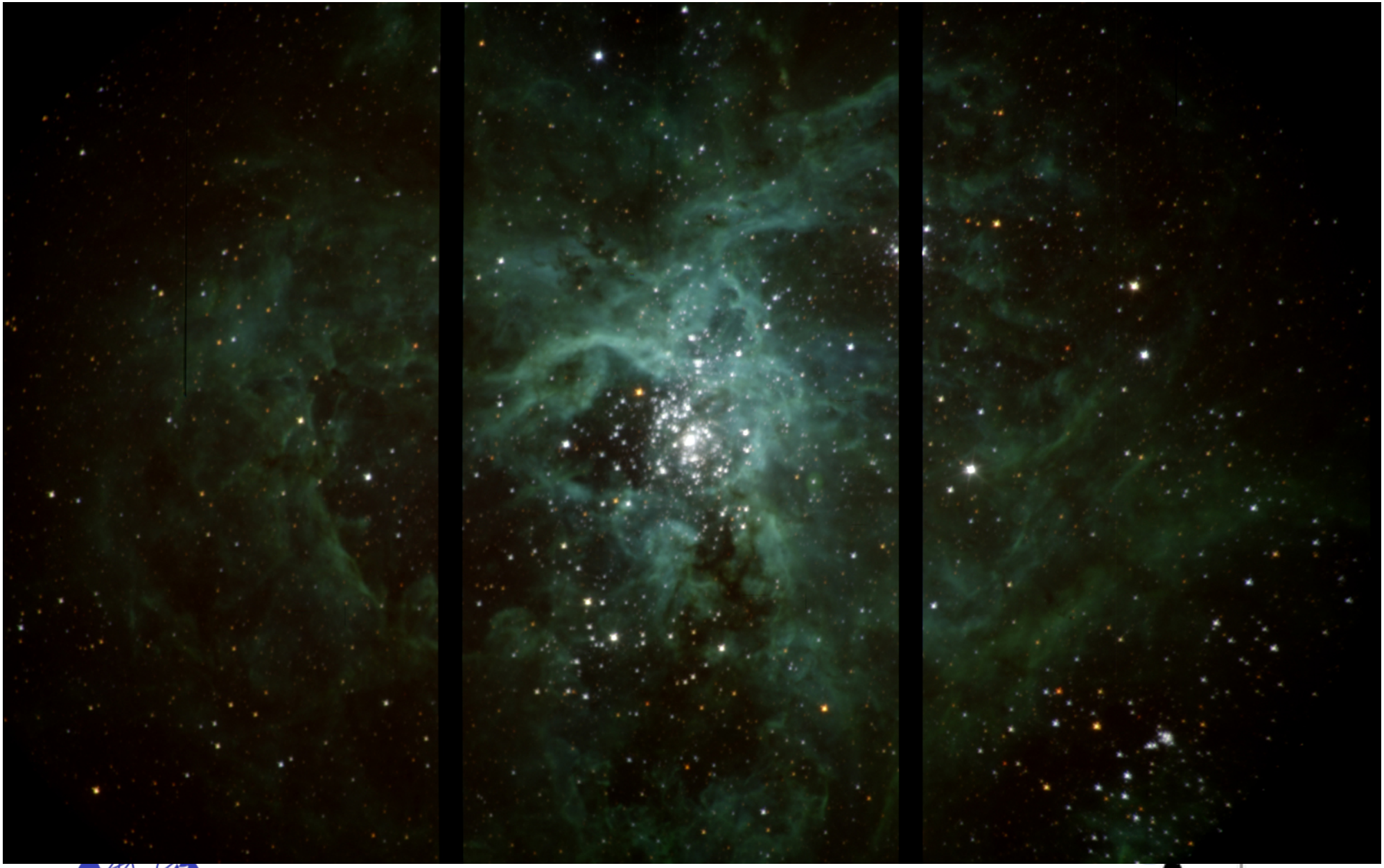

Multi-Object Spectroscopy
Filter Multiplexed Spectroscopy
Longslit Spectroscopy
Fabry-Perot Imaging Spectroscopy
Imaging
broadband, narrowband
Spectropolarimetry
linear, circular, All Stokes
Imaging Polarimetry
linear, circular, All Stokes
Simultaneous VIS
imaging, spectroscopy, Fabry-Perot, Polarimetry
Fabry-Perot Imaging Polarimetry
linear, circular, All Stokes

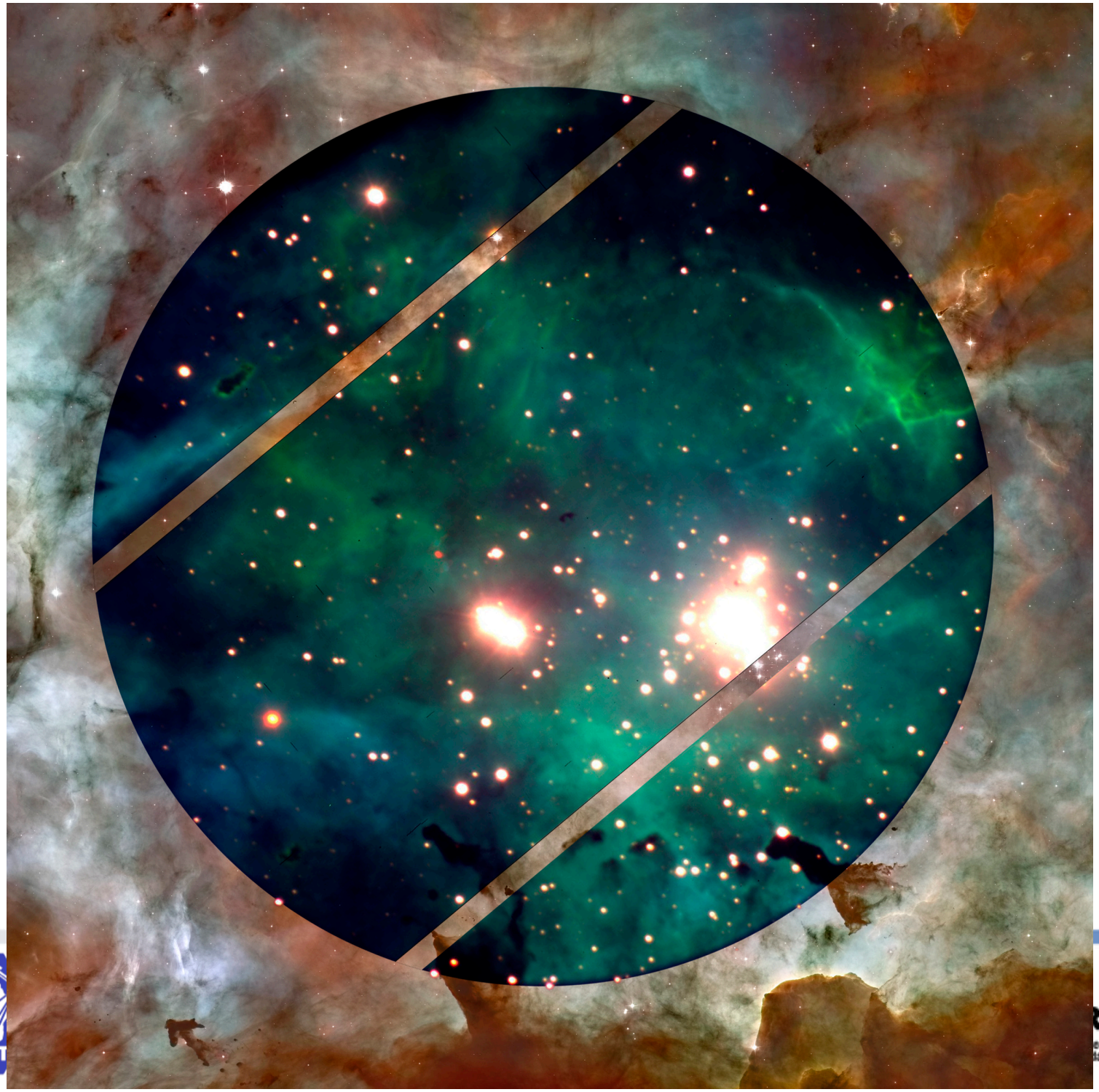

Filters
Focus
(Polarizing beamsplitter)
CCD
Camera
(Etalons)
Collimator
(Waveplates)
Focal Plane
Side View (Fabry-Perot)
CCD
(Etalons)
Shutter
Fabry-Perot
(Grating)
VPH Spectroscopy (maximum articulation)
Top View
CCD


6000
4000
2000
R
3000 l/mm
2300 l/mm
1800 l/mm
1300 l/mm
900 l/mm
50°
40°
30°
35°
25°
15°
[OII]
Hβ [OIII]
Hα [SII]
CaII
300
400
500
600
700
800
900
Wavelength (nm)

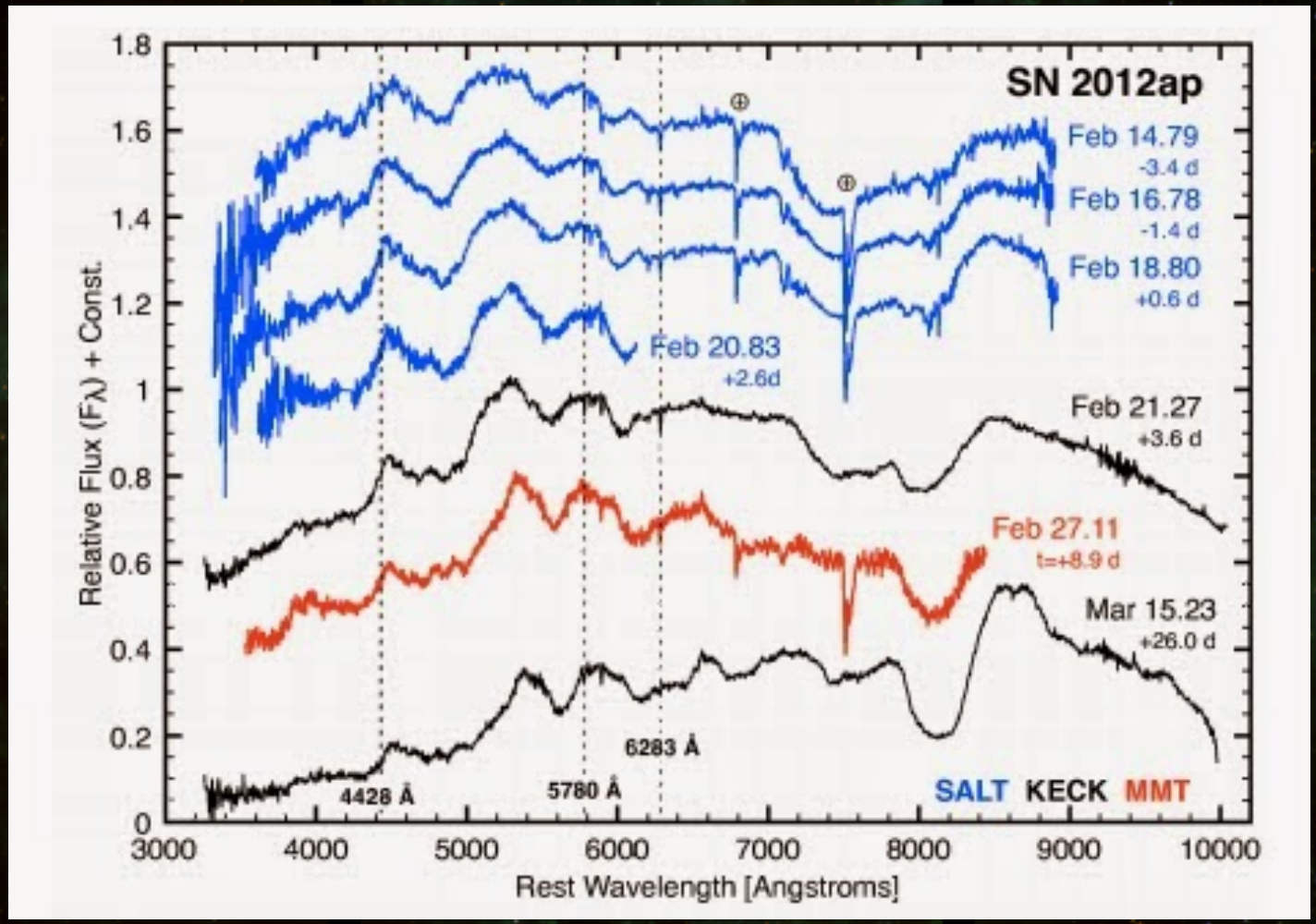

Filters
Focus
(Polarizing beamsplitter)
(Etalons)
Collimator
(Waveplates)
Focal Plane
(Etalons)
Shutter
(Grating)
CCD
Top View

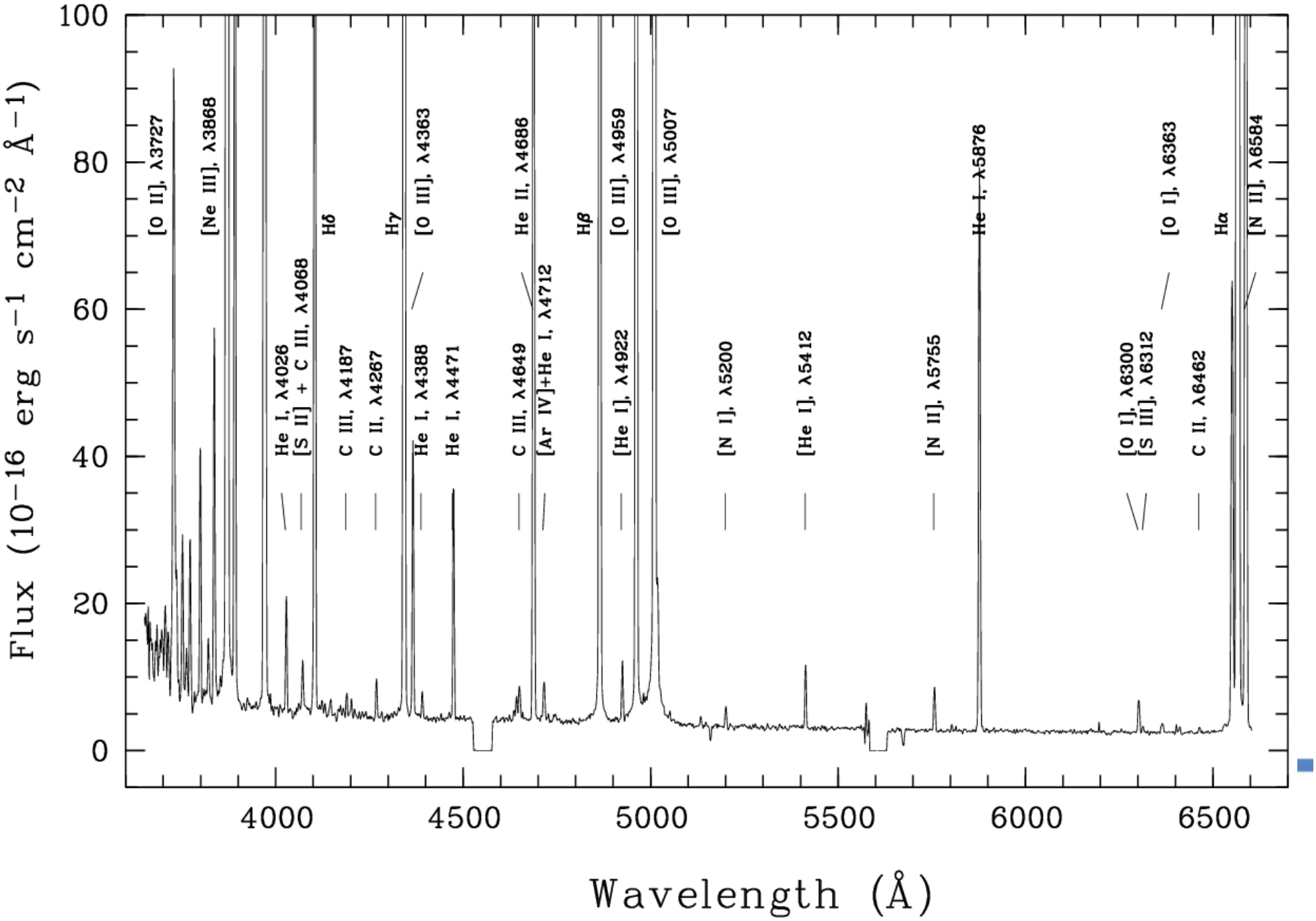
Narrow-band imaging

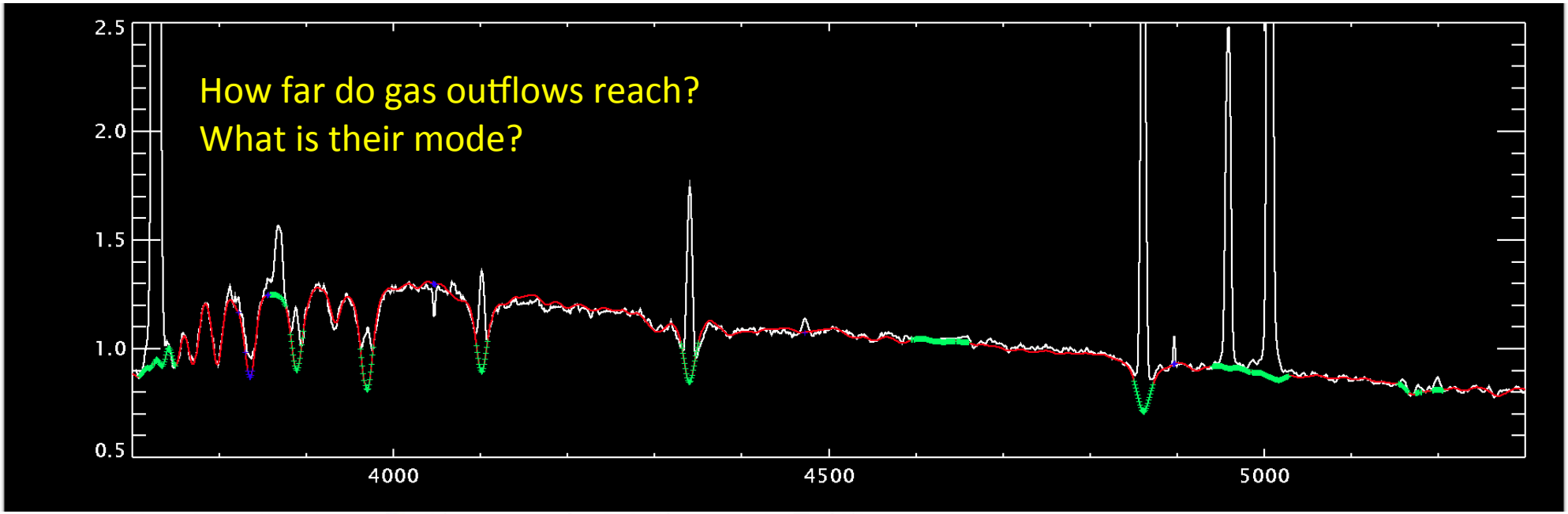


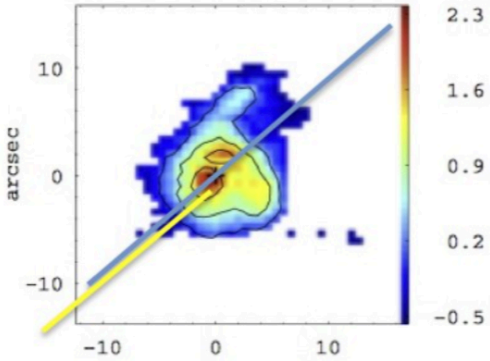


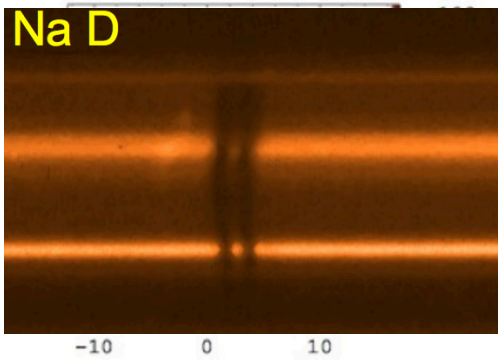
Long-slit spectroscopy (also in high-speed modes)

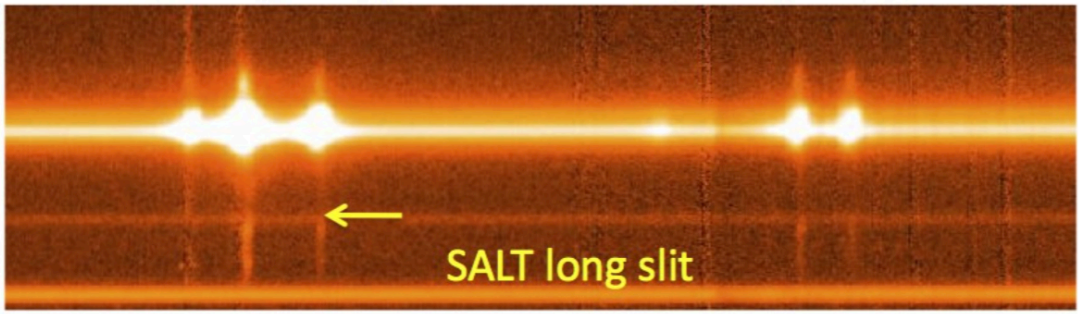



Flux (10−16 erg s−1 cm−2 Å−1)
Wavelength (Å)
0
20
40
60
80
100
4000
4500
5000
5500
6000
6500
[O II], λ3727
[Ne III], λ3868
He I, λ4026
[S II] + C III, λ4068
Hδ
C III, λ4187
C II, λ4267
Hγ
He I, λ4388
[O III], λ4363
He I, λ4471
C III, λ4649
He II, λ4686
[Ar IV]+He I, λ4712
Hβ
[He I], λ4922
[O III], λ4959
[O III], λ5007
[N I], λ5200
[He I], λ5412
[N II], λ5755
He I, λ5876
[O I], λ6300
[S III], λ6312
[O I], λ6363
C II, λ6462
Hα
[N II], λ6584



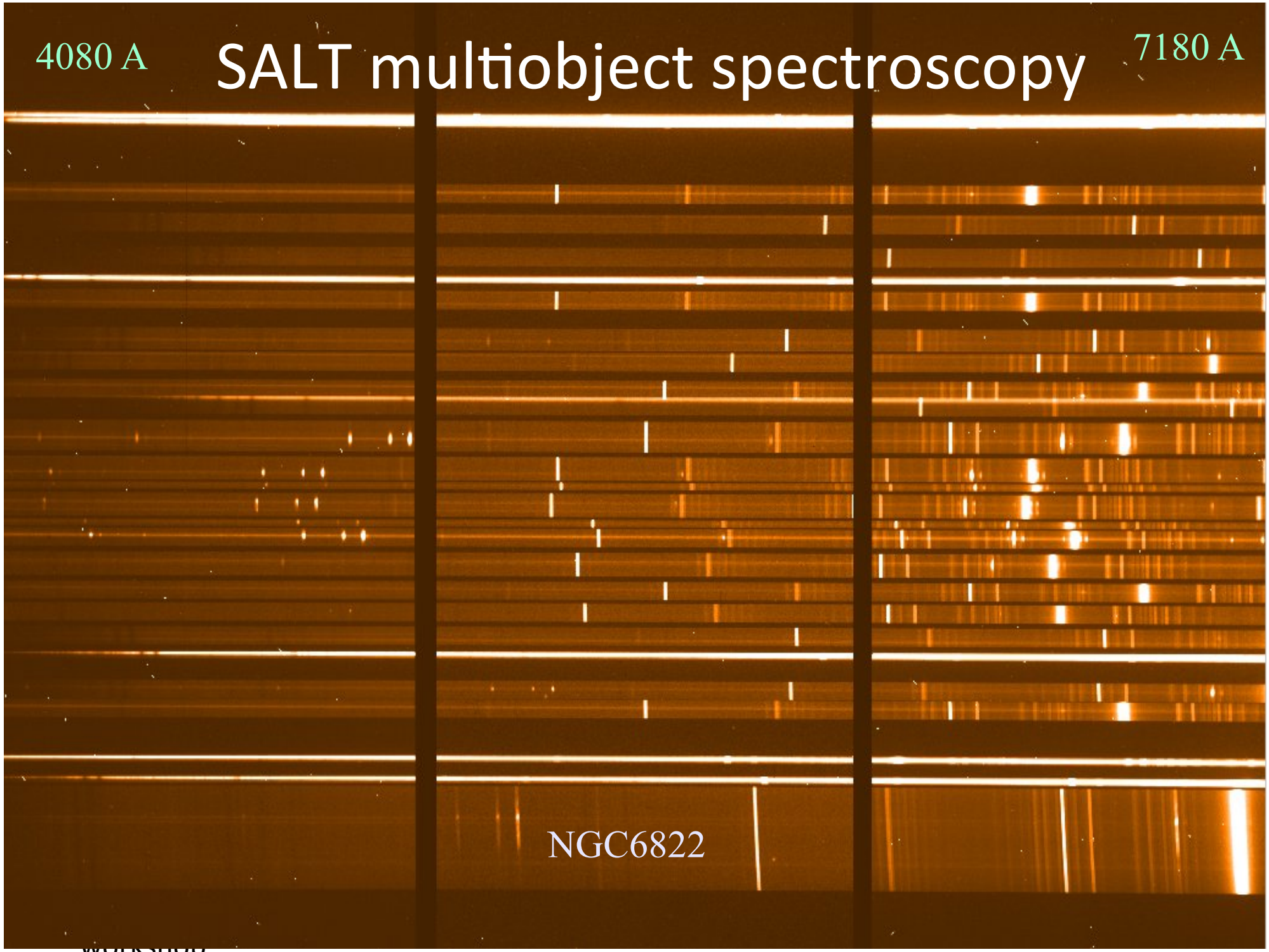






SALT longslit detects narrow line emission extending 25 arcsec to the SE that was not seen in VLT data. We agree with VLT near the galaxy.

SALT multiobject spectroscopy



RSS sensitivities

Roughly, in dark median-seeing conditions:

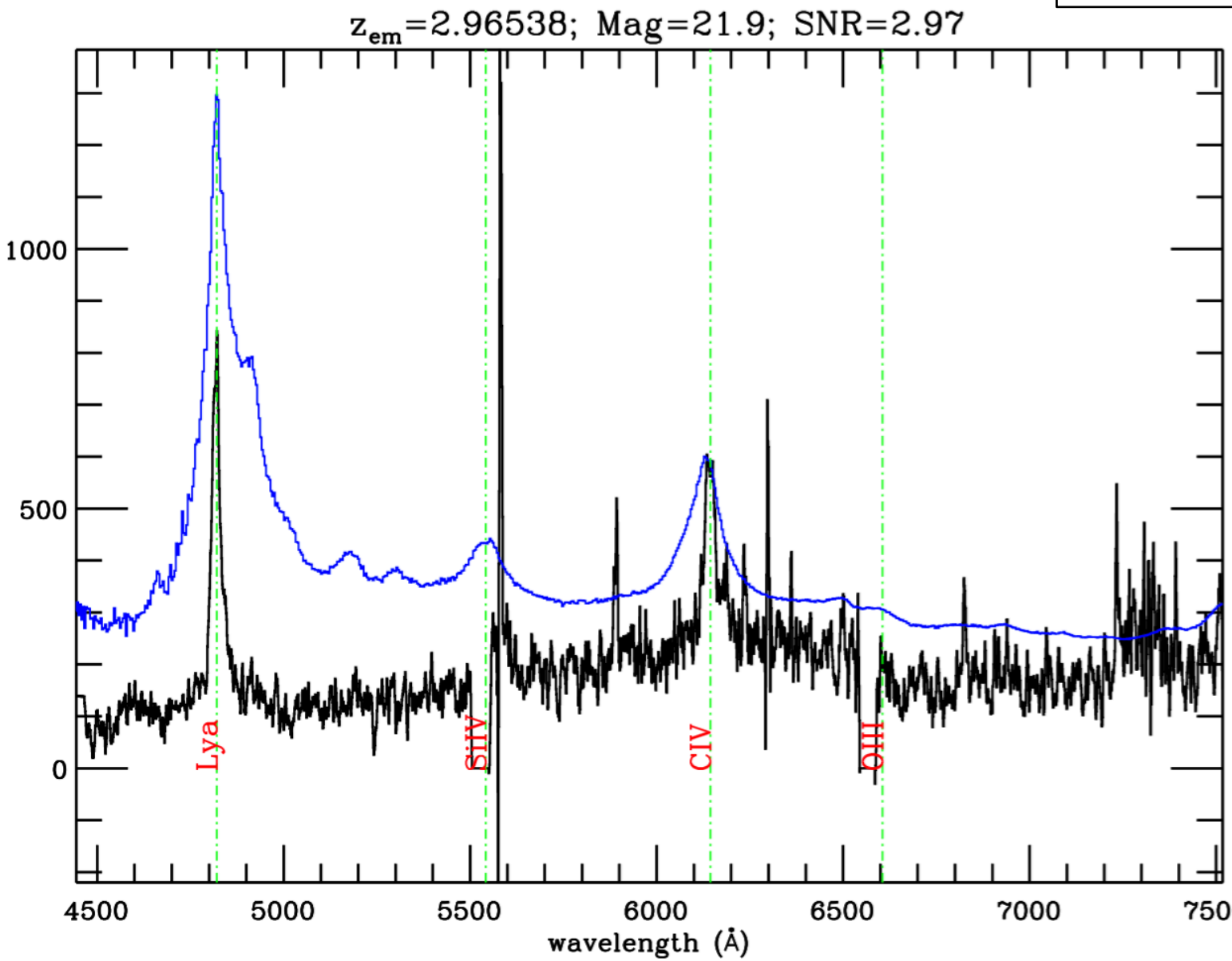
- You can get S/N ~ 5 on r ~ 21.5 mag points sources in 30 mins in medium-resolution

- 22-23 mag emission-line redshifts also secured
  (e.g. z ~ 1 galaxy clusters)

Play with the RSS Simulator (watch the seeing button, and watch for the kind of magnitude you have)

RSS sensitivities

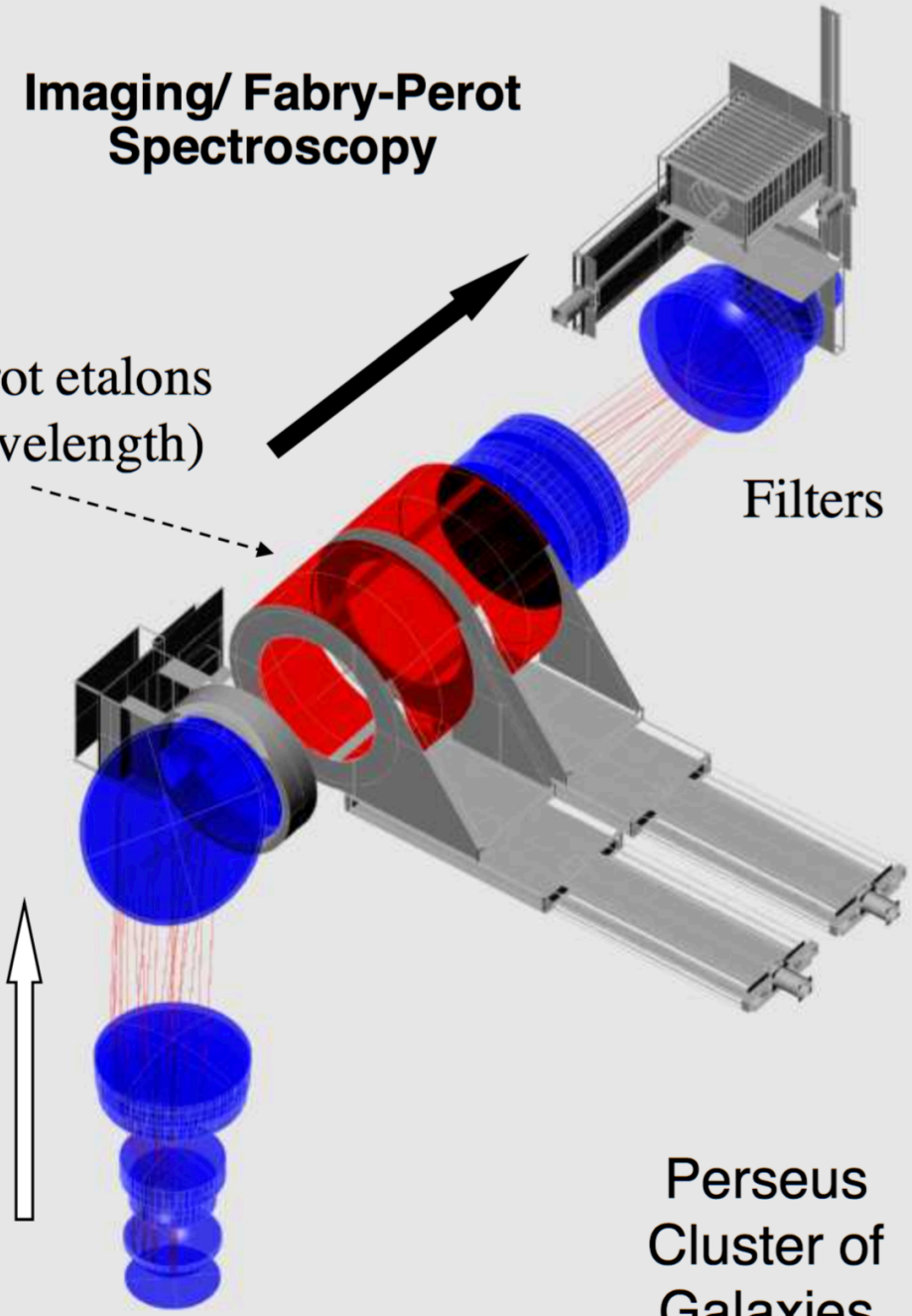
20 min exposure
PG900



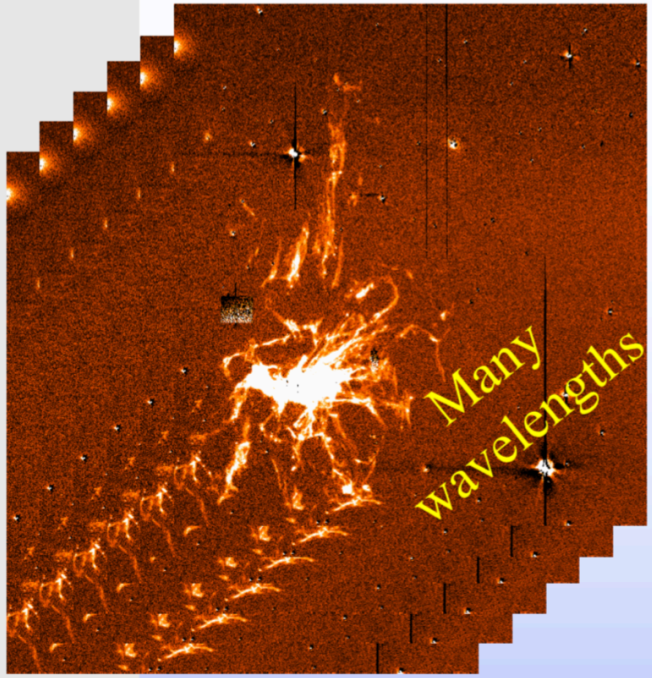
Imaging/ Fabry-Perot Spectroscopy

Fabry-Perot etalons
(scans wavelength)

Filters



Perseus Cluster of Galaxies

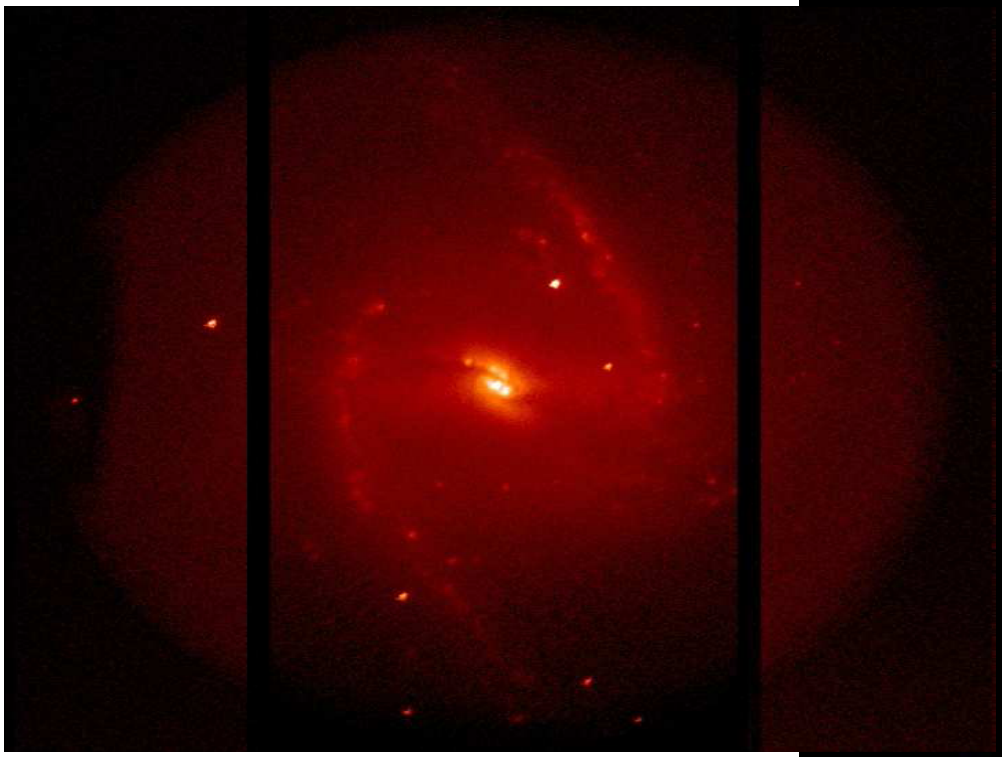


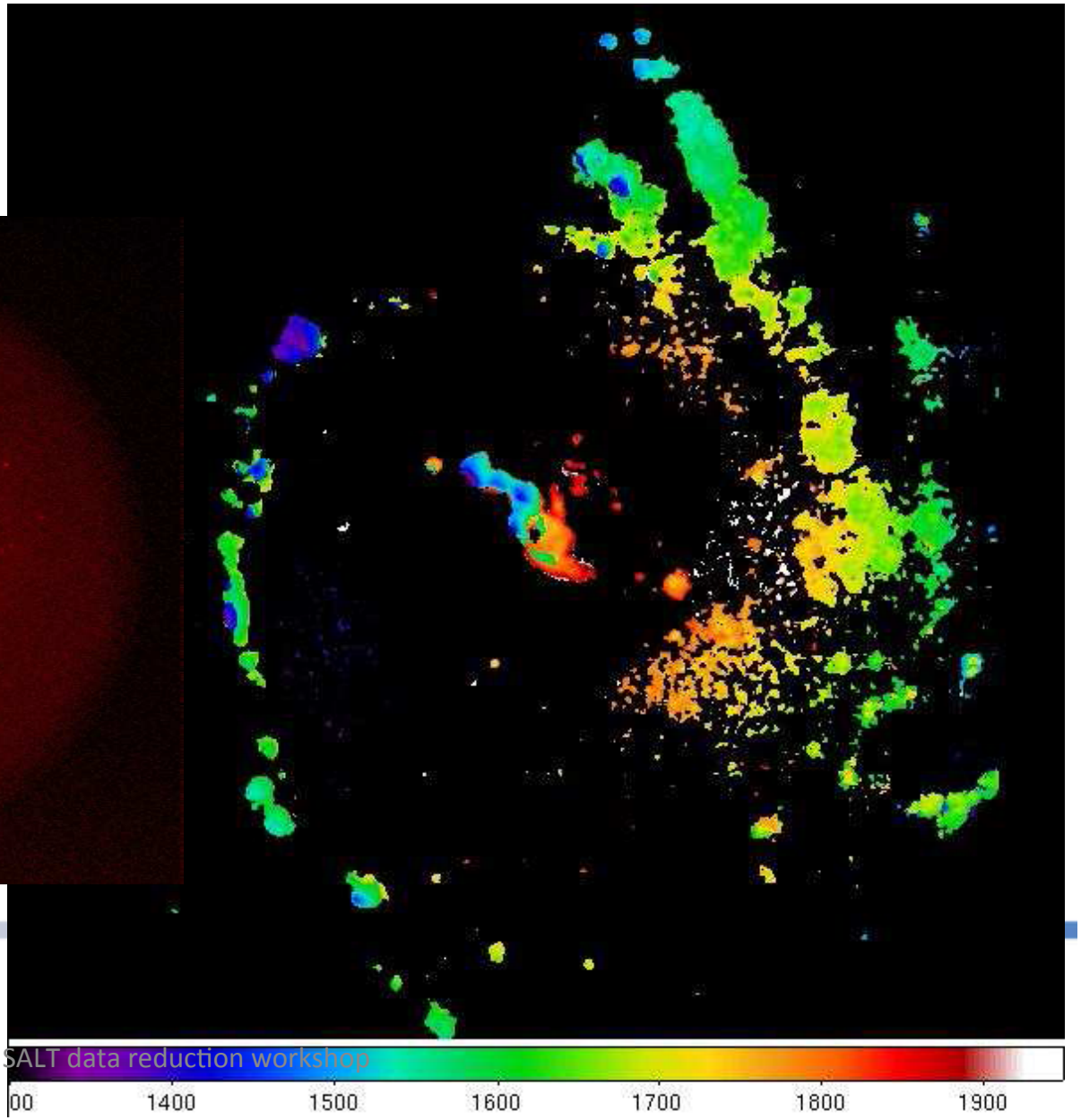
Perseus A in Hydrogen Light

Using Fabry-Perot imaging spectroscopy

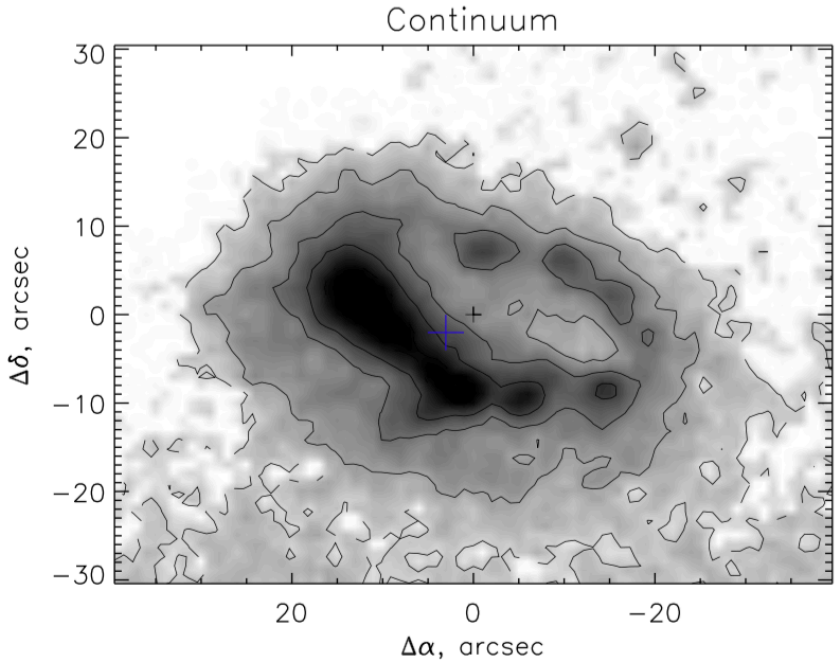
spectral resolutions between 300 and 9000
Velocity fields ionised gas of star-forming regions in spirals

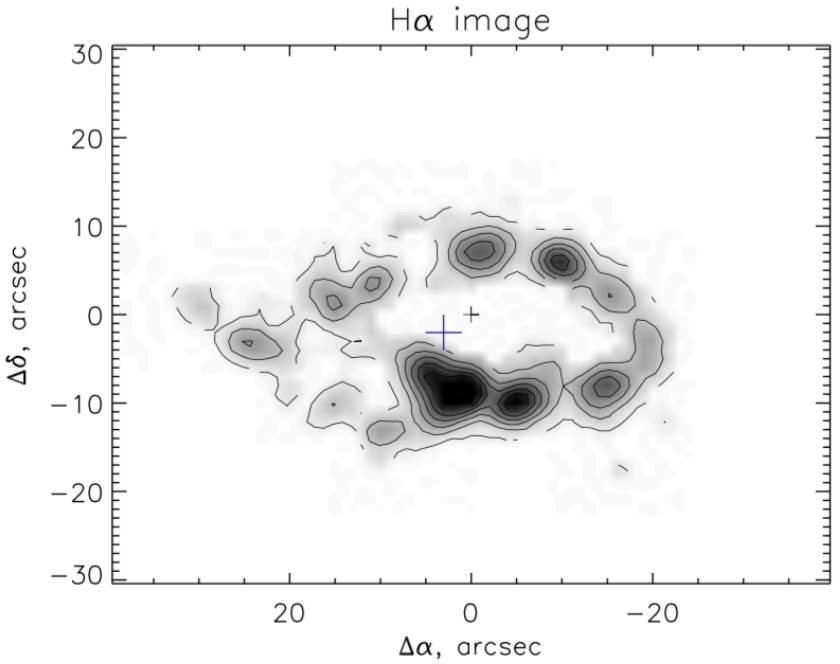
NGC1365

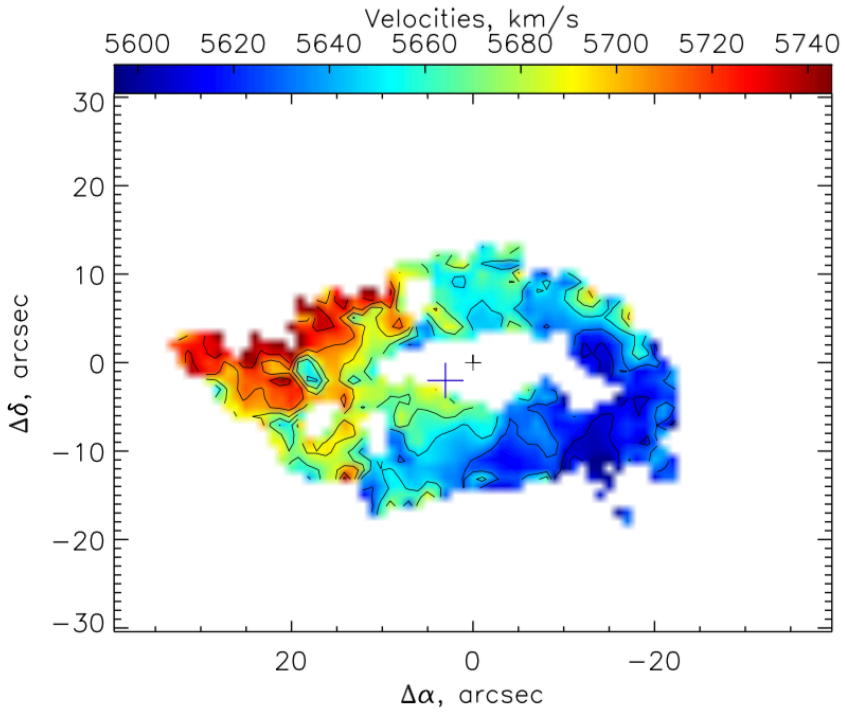


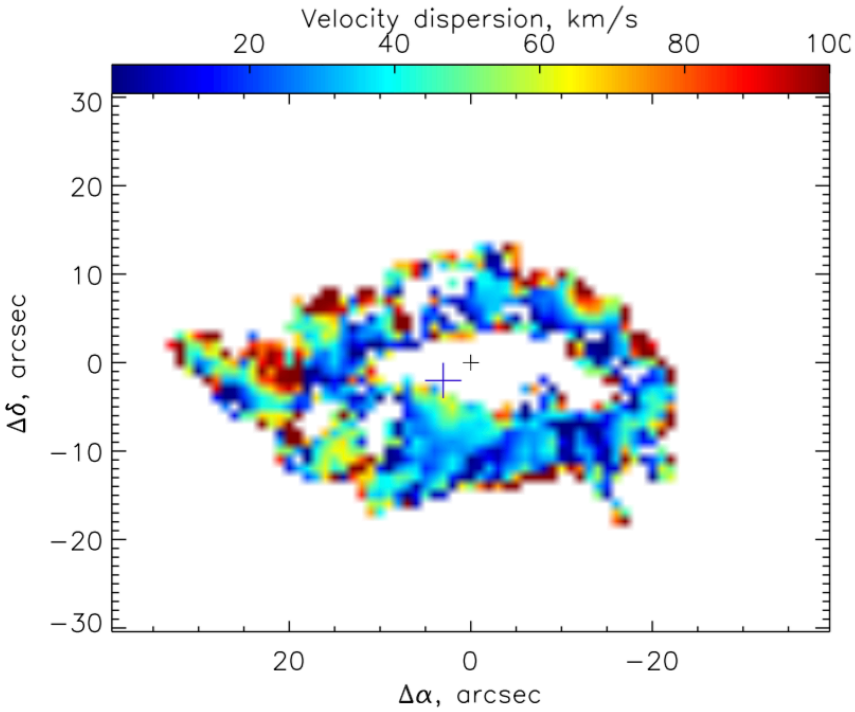


Blue- approaching;
Red- receding

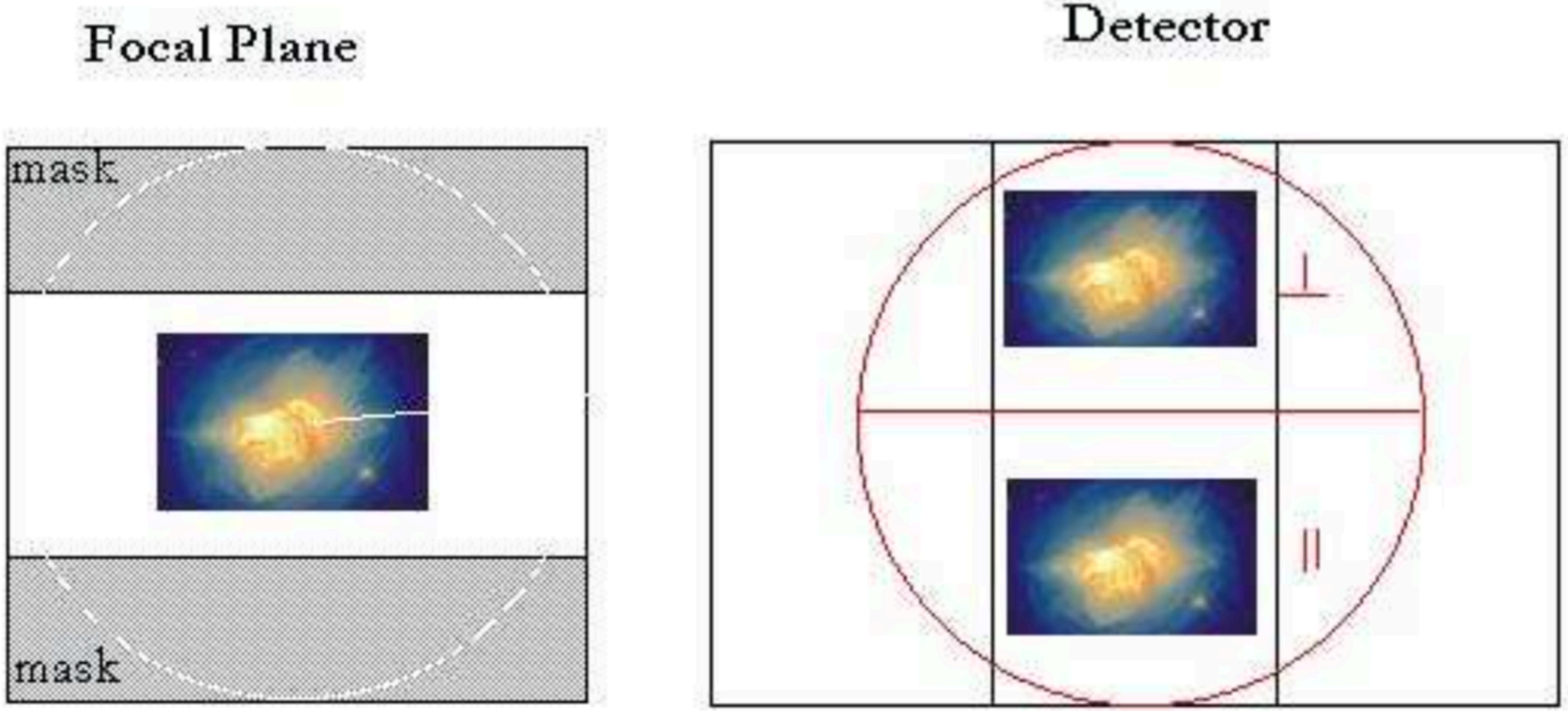

Continuum
30
20
10
0
−10
−20
−30
Δδ, arcsec
20
0
−20
Δα, arcsec


Hα image
30
20
10
0
−10
−20
−30
Δδ, arcsec
20
0
−20
Δα, arcsec


Velocities, km/s
5600 5620 5640 5660 5680 5700 5720 5740
30
20
10
0
−10
−20
−30
Δδ, arcsec
20
0
−20
Δα, arcsec

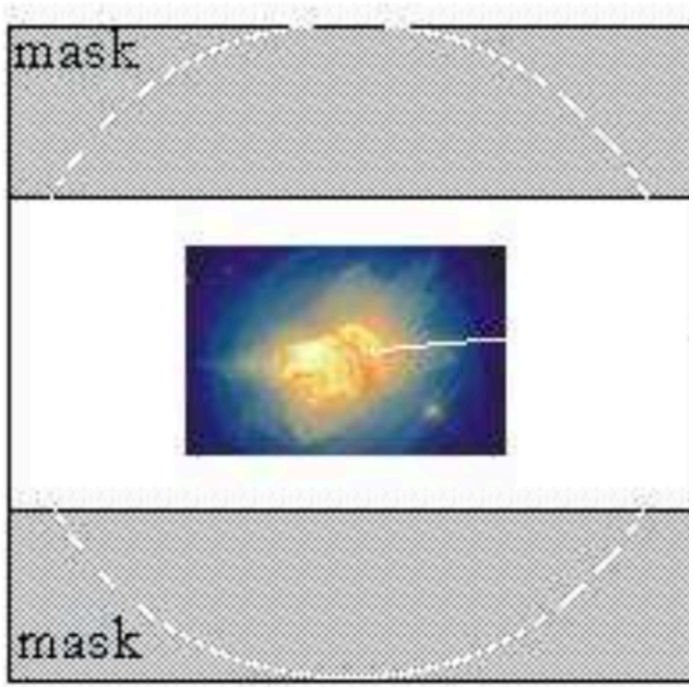

Velocity dispersion, km/s
20 40 60 80 100
30
20
10
0
−10
−20
−30
Δδ, arcsec
20
0
−20
Δα, arcsec

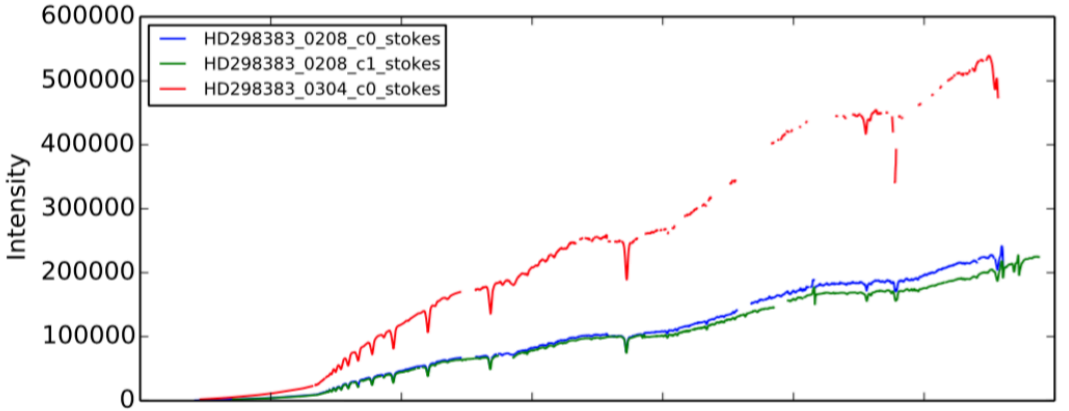
Polarimetry

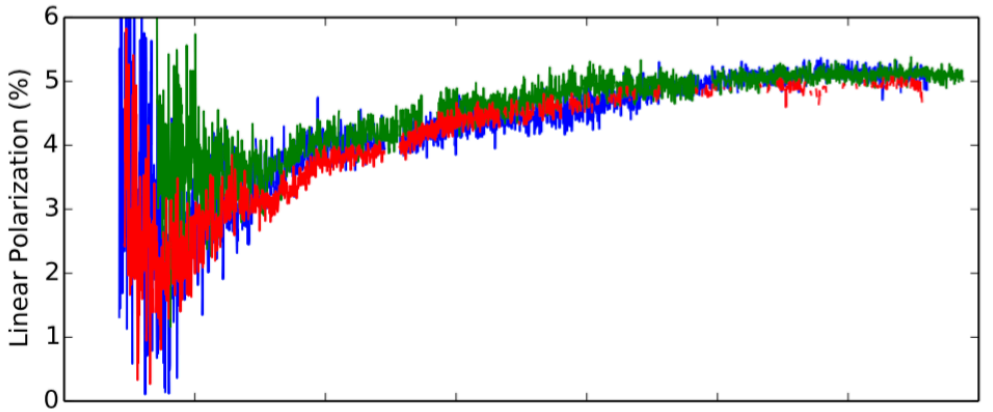


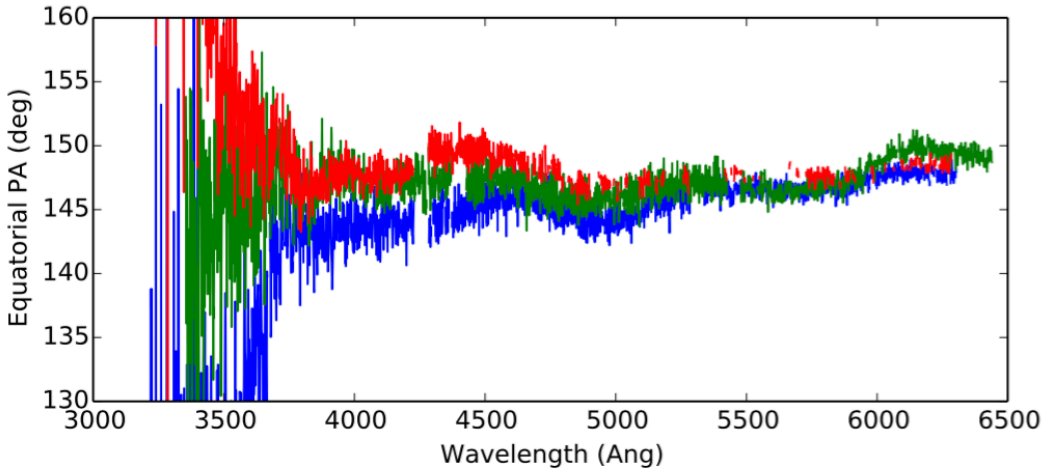
Pipeline available for point-source spectro-polarimetry

Po





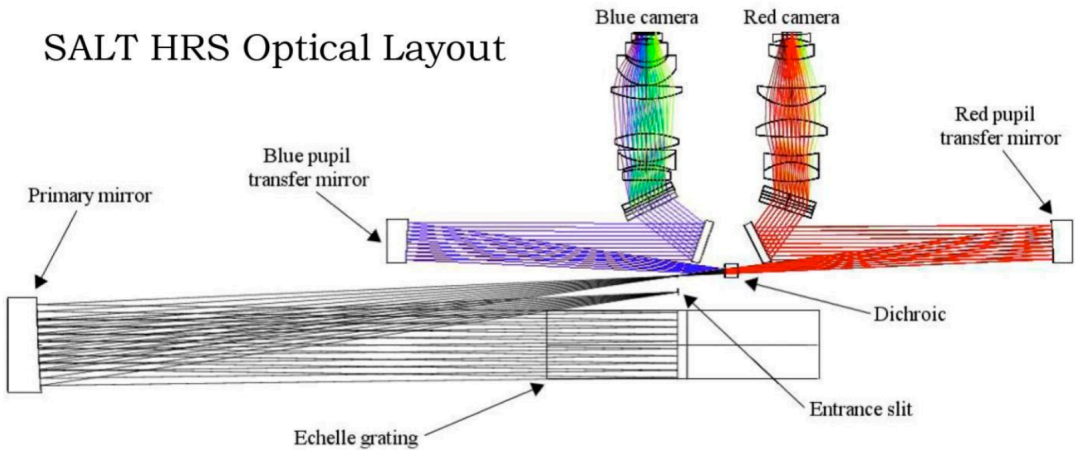




HRS: High Resolution Spectrograph

Durham University

- Low Resolution (LR)
  - R ~ 14000
- Medium Resolution (MR)
  - R ~ 40000
- High Resolution (HR)
  - R ~ 65000



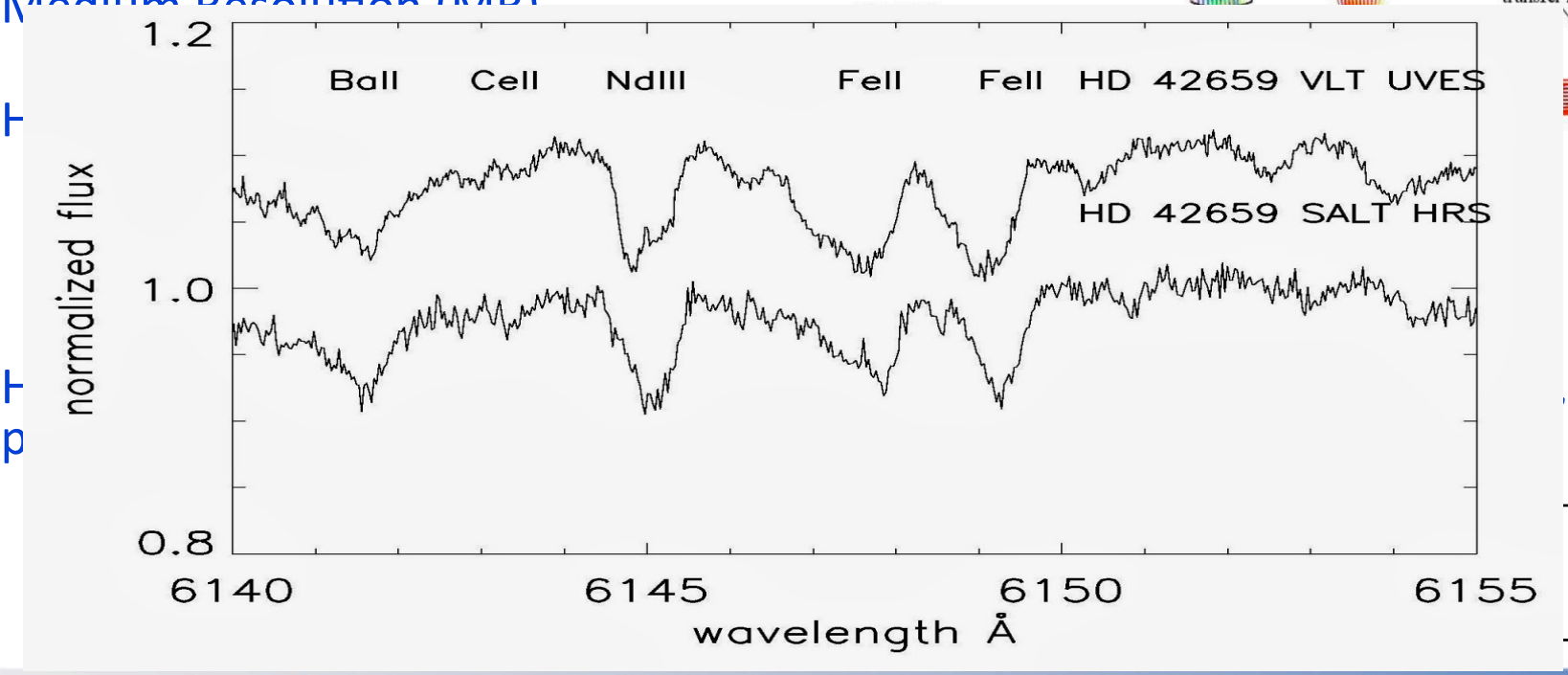
- High Stability Mode – same as HR, but with highest wavelength accuracy, in principle down to few m/s [exoplanet science]

Pipeline now available! Wavelength calibrated extracted spectra.
Out-of-the box velocity accuracy <300 m/s for all modes.

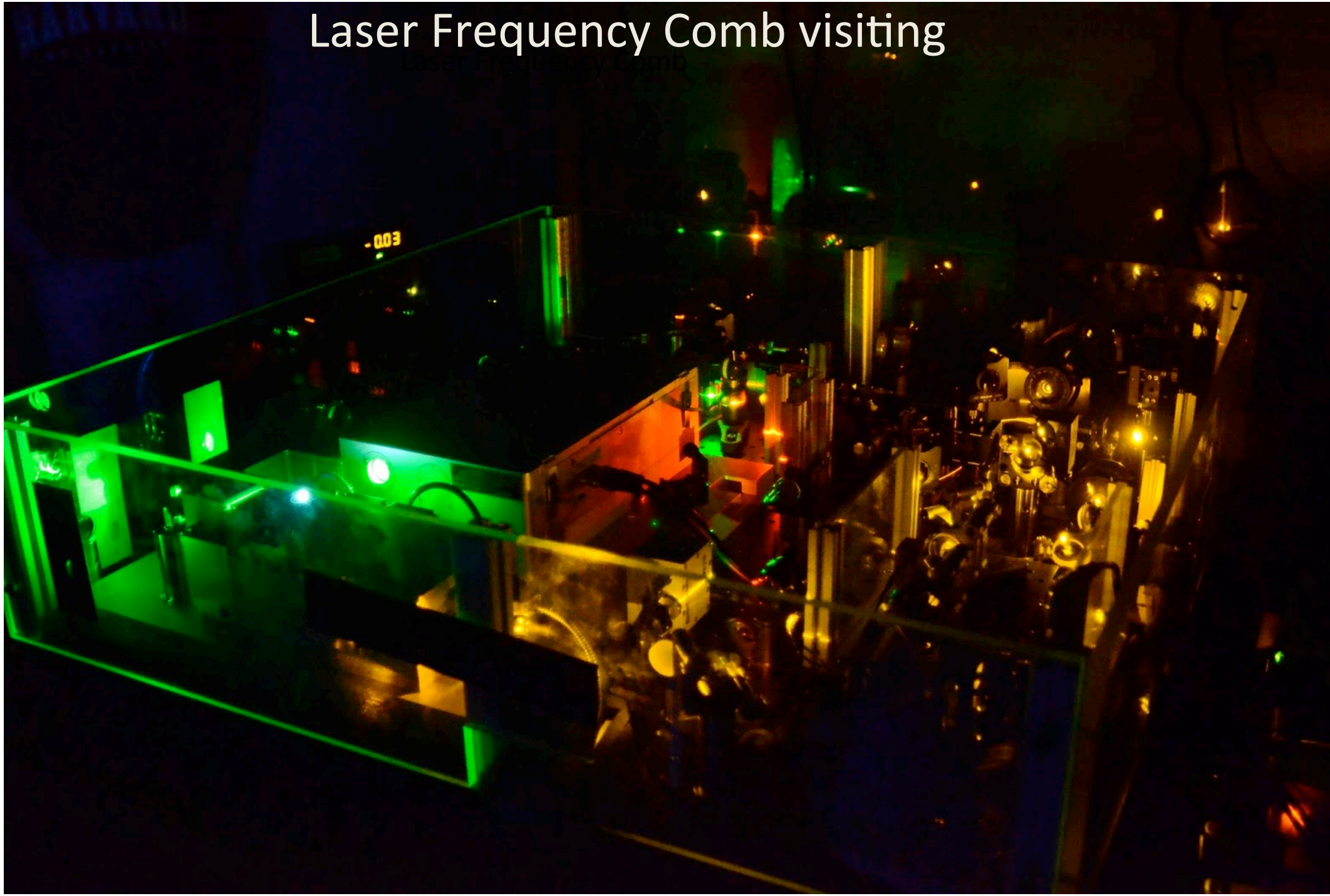
HRS: High Resolution Spectrograph

Durham University

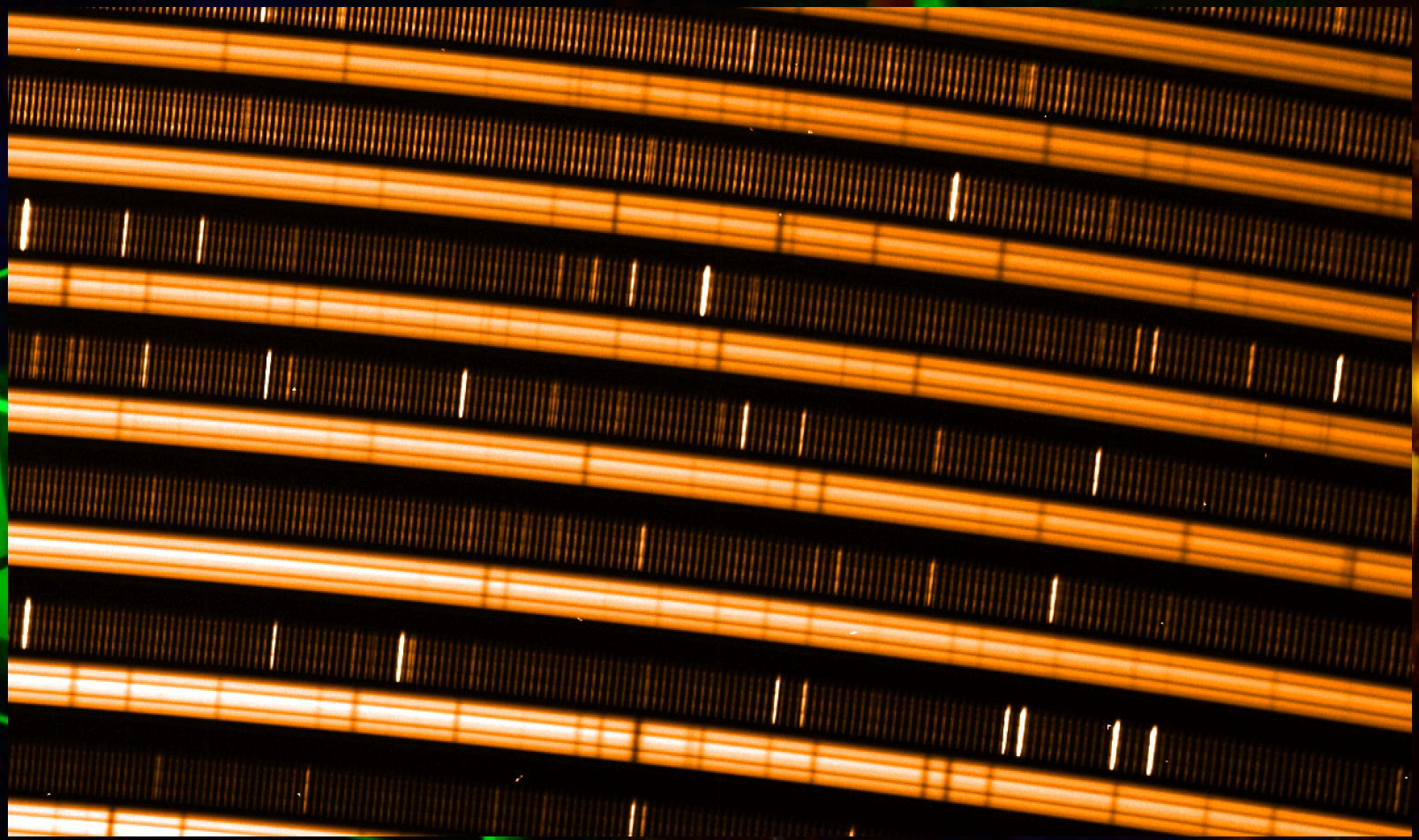
- Low Resolution (LR)
  - R ~ 14000
- M
- H
- H in p



Laser Frequency Comb visiting



Laser Frequency Comb visiting



<10 m/s absolute RV accuracy with LFC

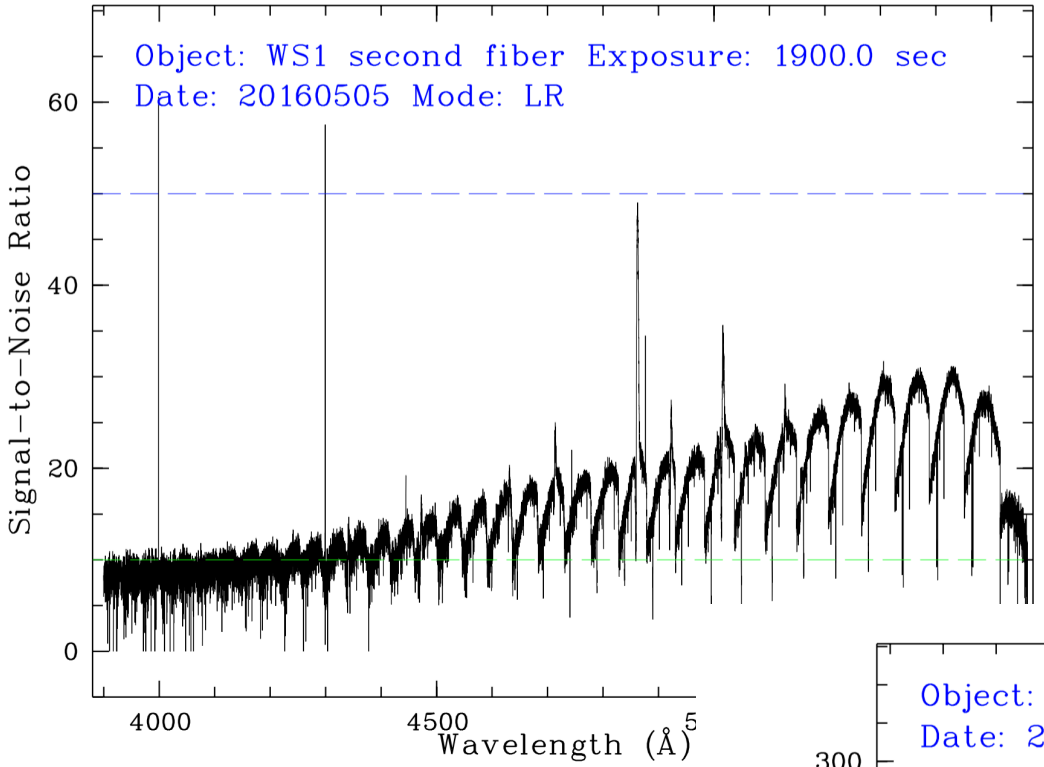
HRS sensitivities

Roughly, in good seeing conditions:

- You can get S/N ~ 5-10 on V ~ 17-17.5 mag points sources in one hour in LR modes

- You can get S/N ~ 10 on V ~ 16.5 mag points sources in one hour in HR modes

Play with the HRS Simulator (watch the seeing button, and watch for the kind of magnitude you have)

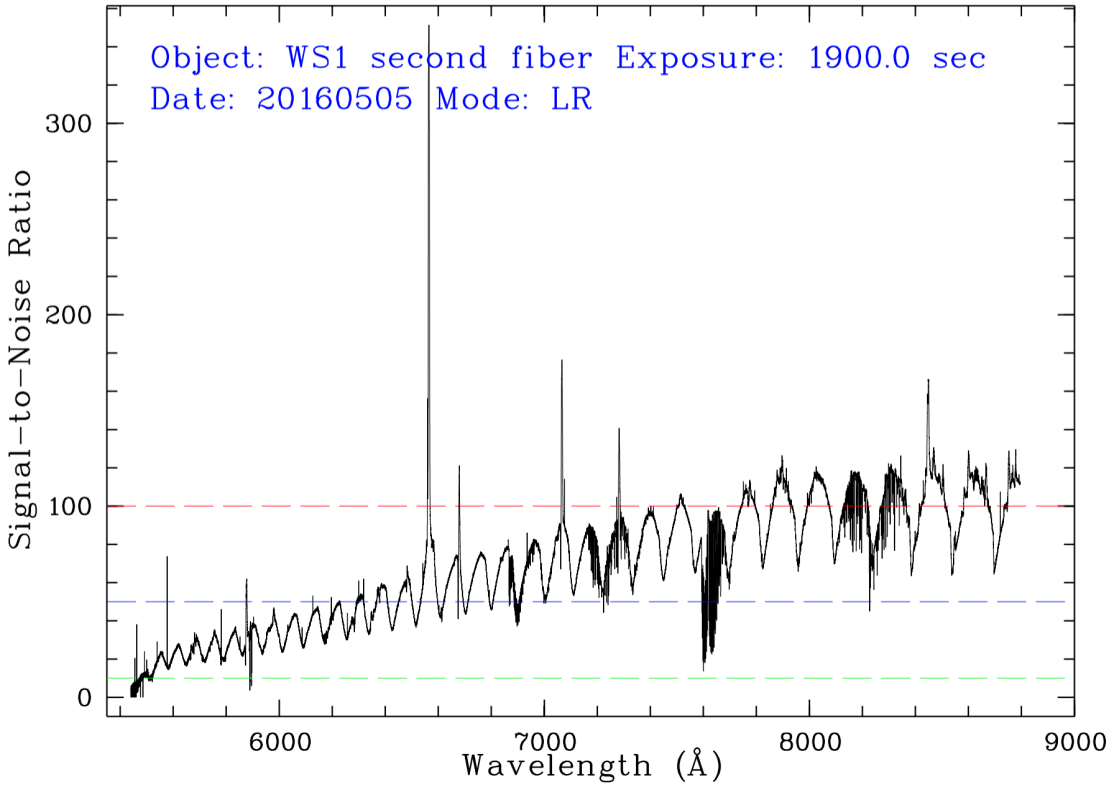


es

Low Resolution
30 min exposure
V ~ 15.1 mag

ints sources in one

Play with the HRS Simulator (w
the kind of magnitude you have



SOME SALT BASICS

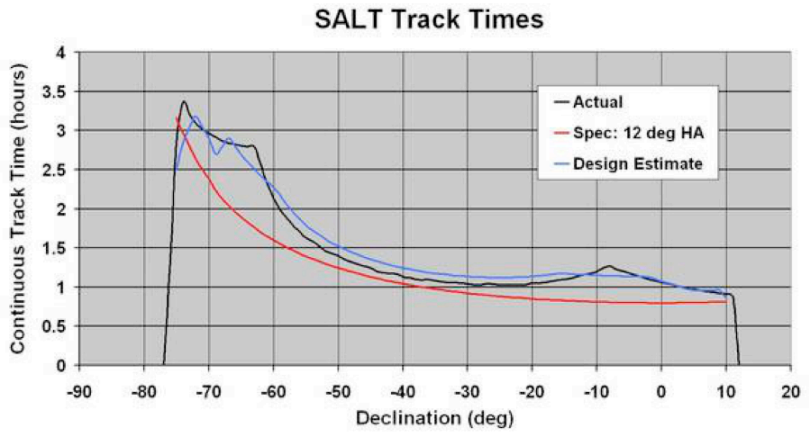
SALT Basics: Visibilities and Track times

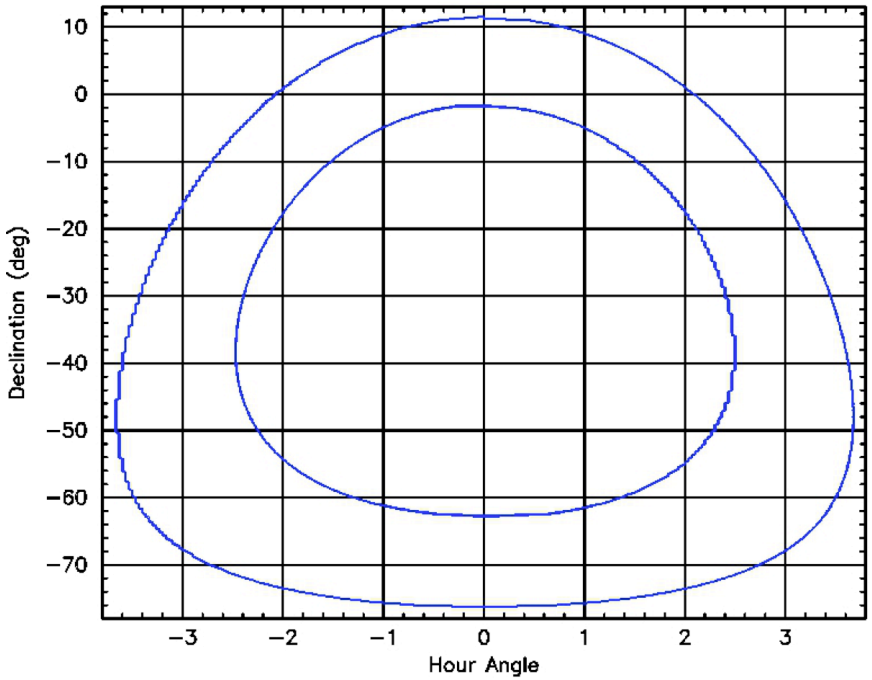
Fixed-altitude SALT visibilities often non-intuitive for new users

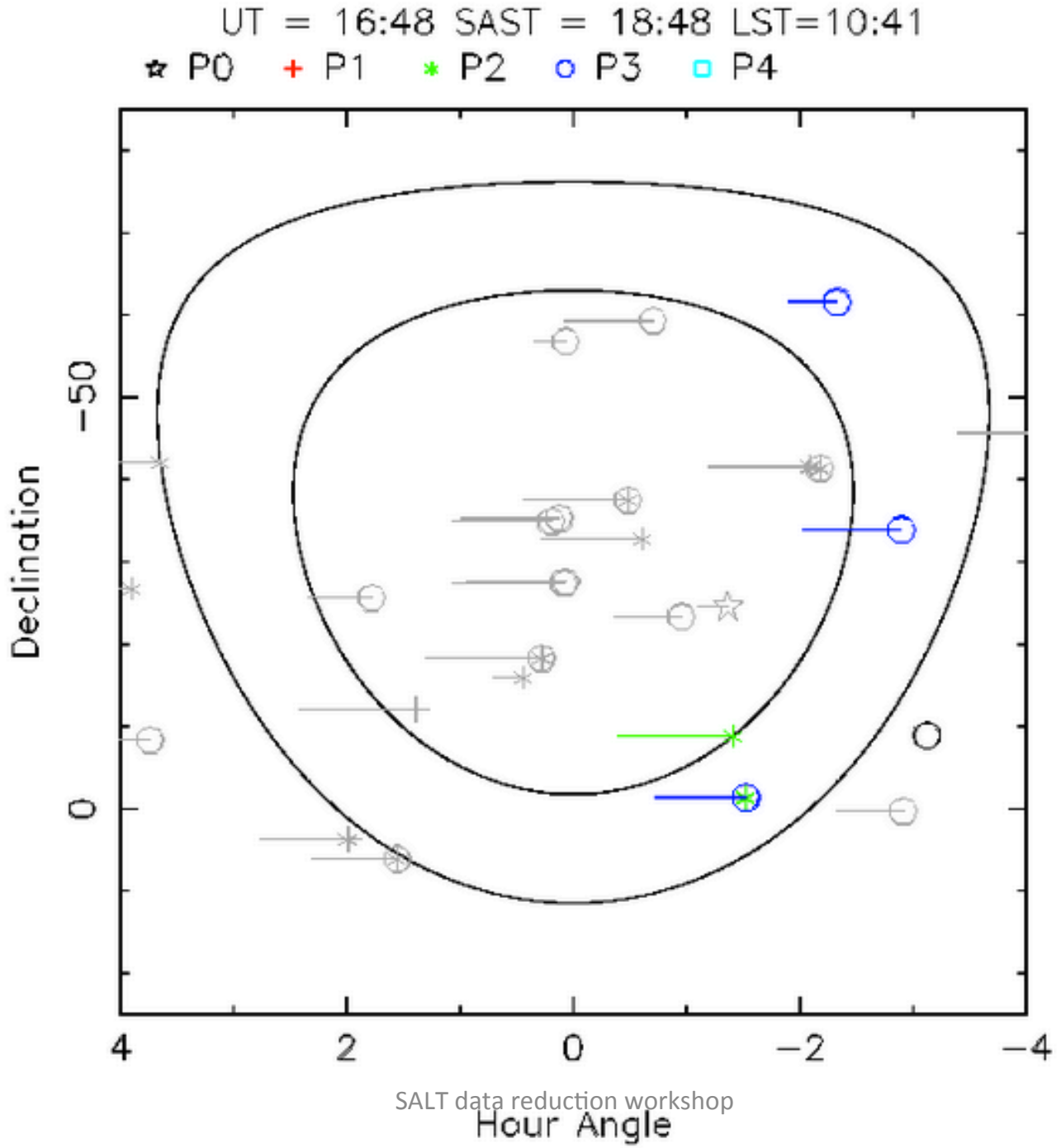
Visibilities (possibility of accessing target)
vs. Track times (visibility with single pointing)

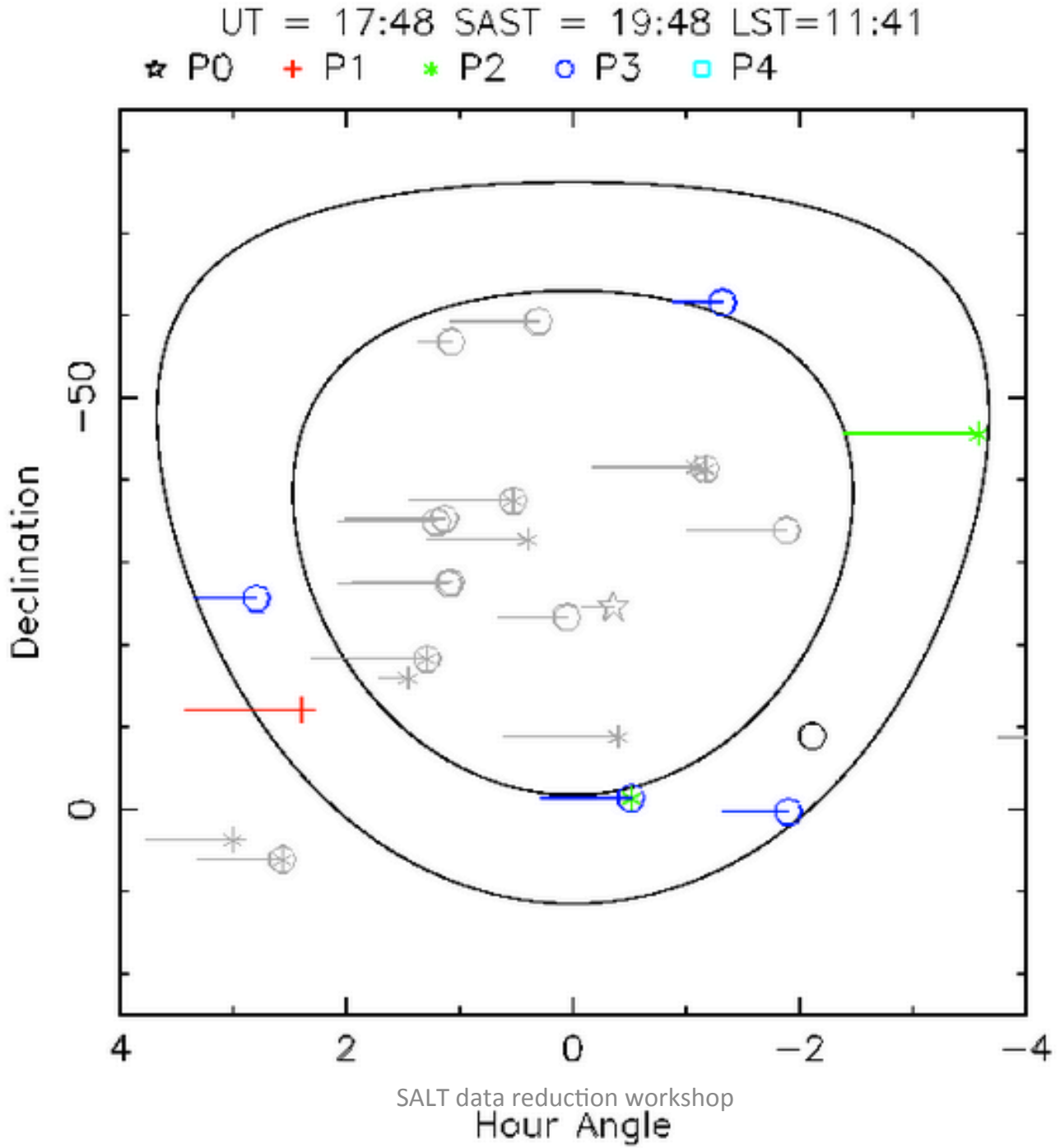
Annulus 12.5% of sky

Dec range: +10 to -75 deg






UT = 16:48 SAST = 18:48 LST=10:41
P0
P1
P2
P3
P4
Declination
−50
0
4
2
0
−2
−4
Hour Angle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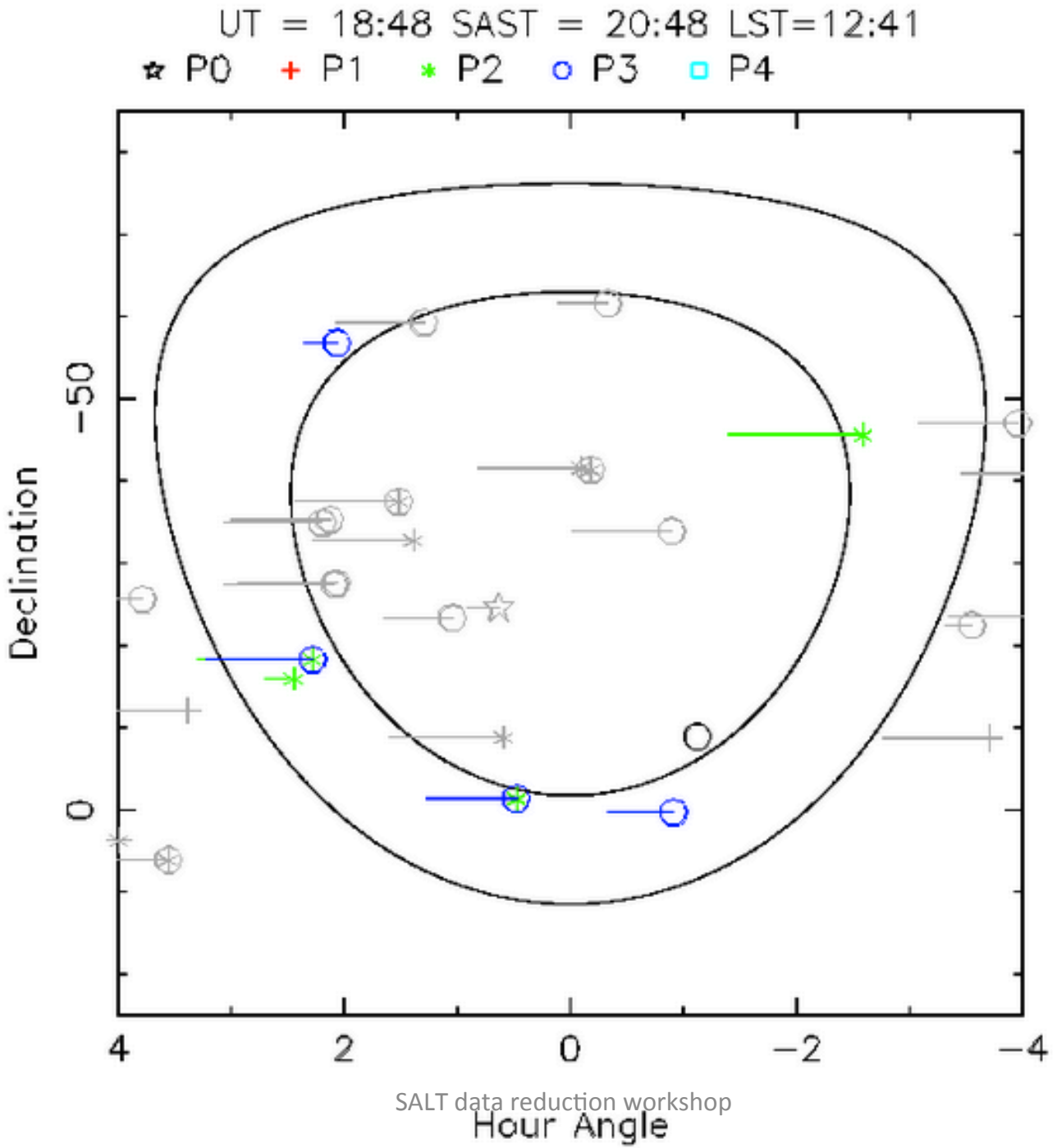
P0
P1
P2
P3
P4
Declination
−50
0
4
2
0
−2
−4
Hour Angle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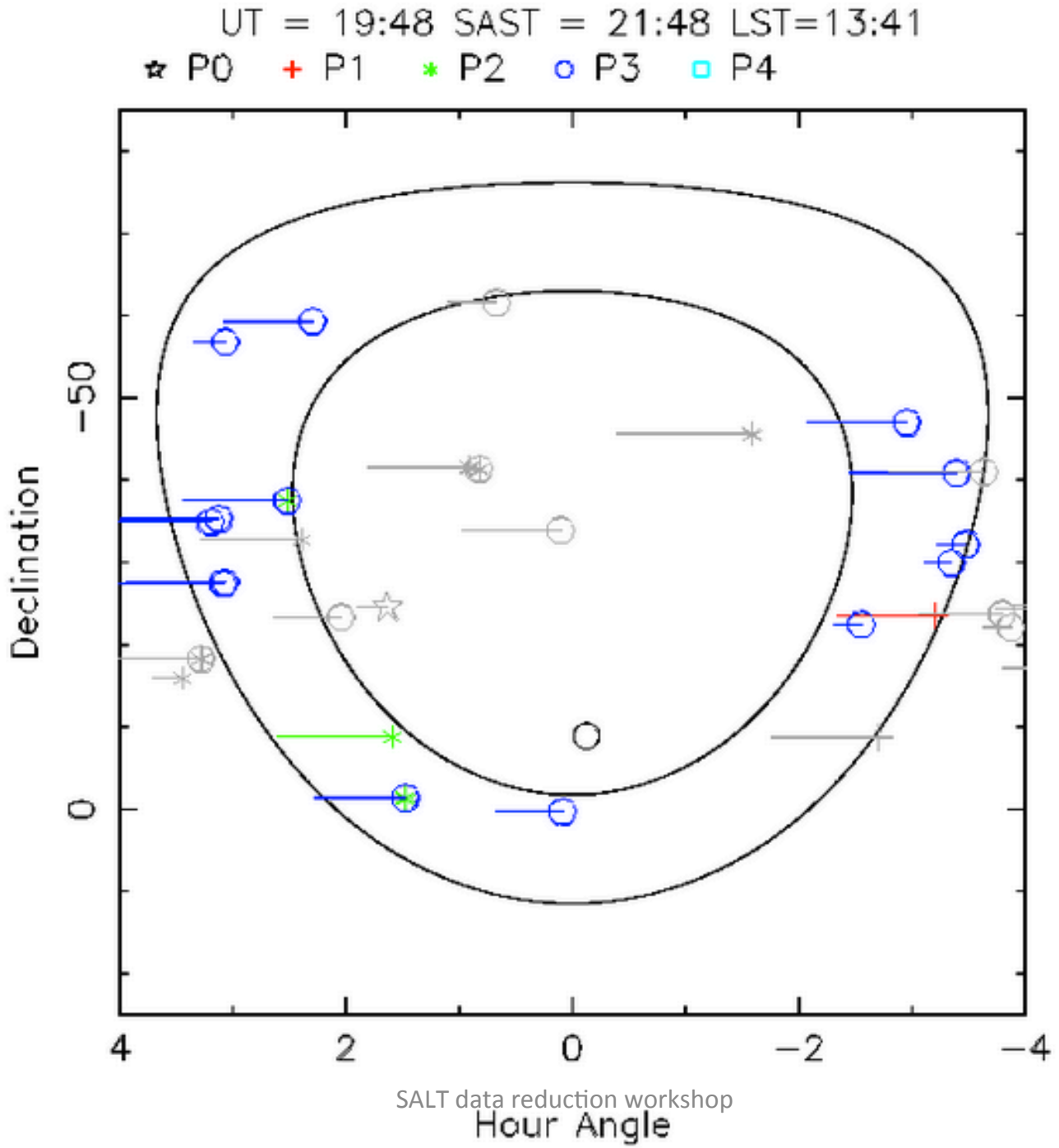
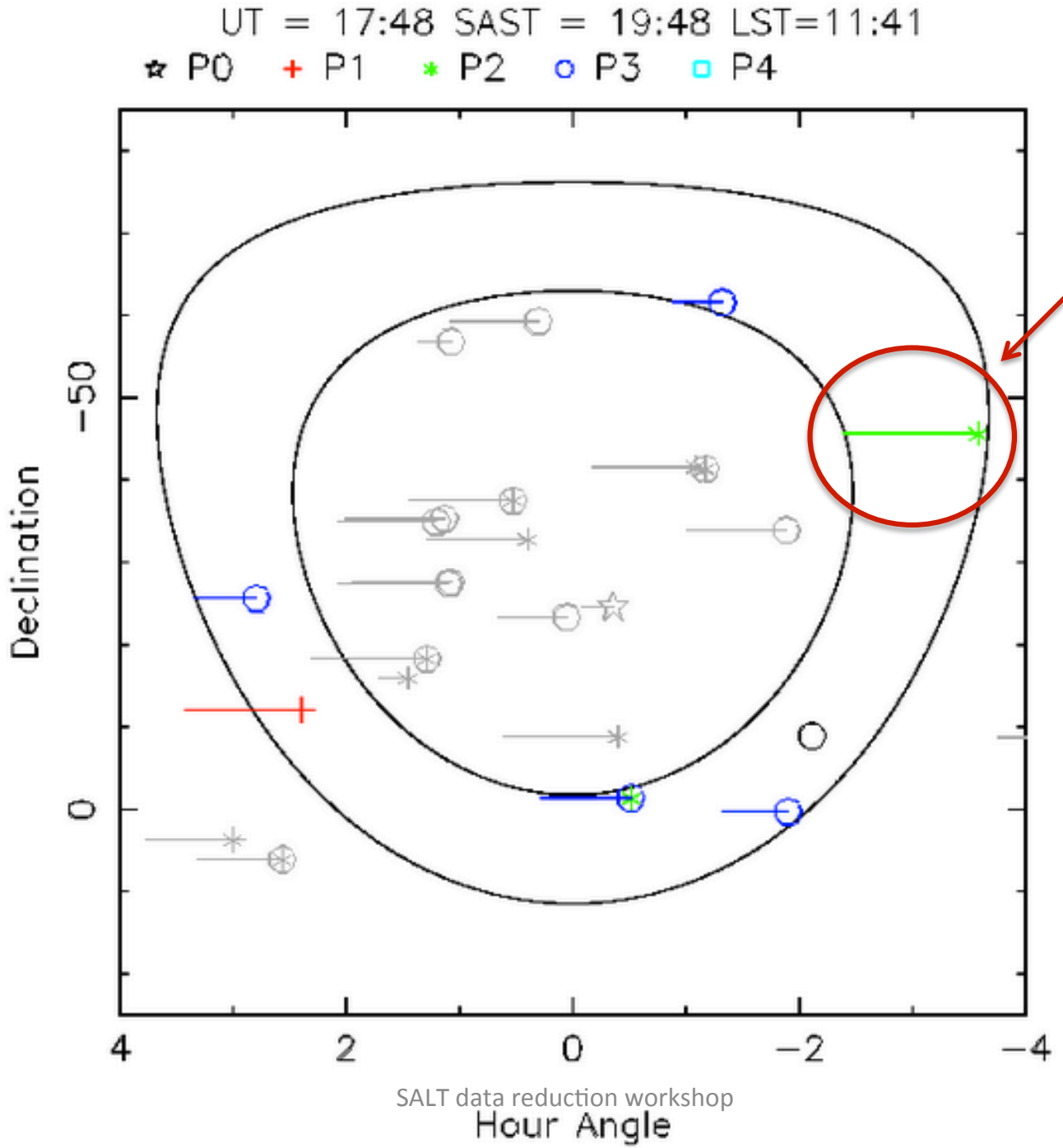
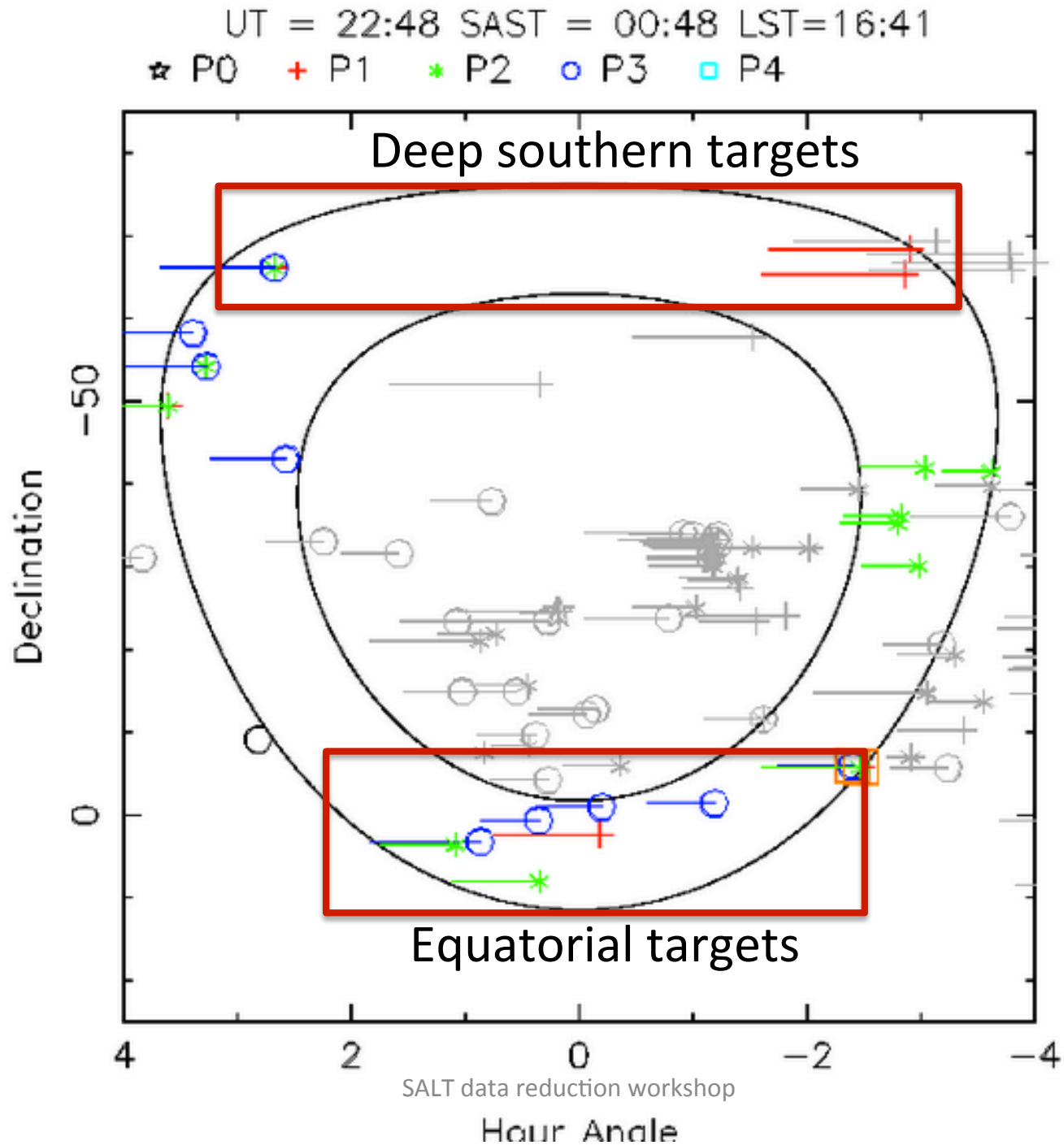
P0
P1
P2
P3
P4
Declination
−50
0
4
2
0
−2
−4
Hour Angle


UT = 19:48 SAST = 21:48 LST=13:41
P0
P1
P2
P3
P4
Declination
−50
0
4
2
0
−2
−4
Hour Angle


UT = 17:48 SAST = 19:48 LST=11:41
P0
P1
P2
P3
P4
Declination
−50
0
4
2
0
−2
−4
Hour Angle

Too Tight


UT = 22:48 SAST = 00:48 LST=16:41
P0 P1 P2 P3 P4
Deep southern targets
Equatorial targets
Declination
−50
0
4
2
0
−2
−4
Hour Angle

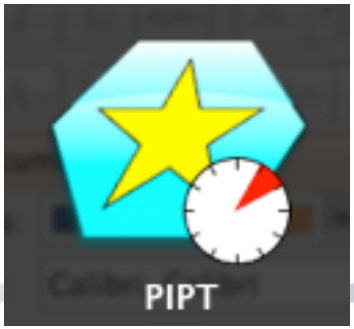
SALT observing basics: Blocks

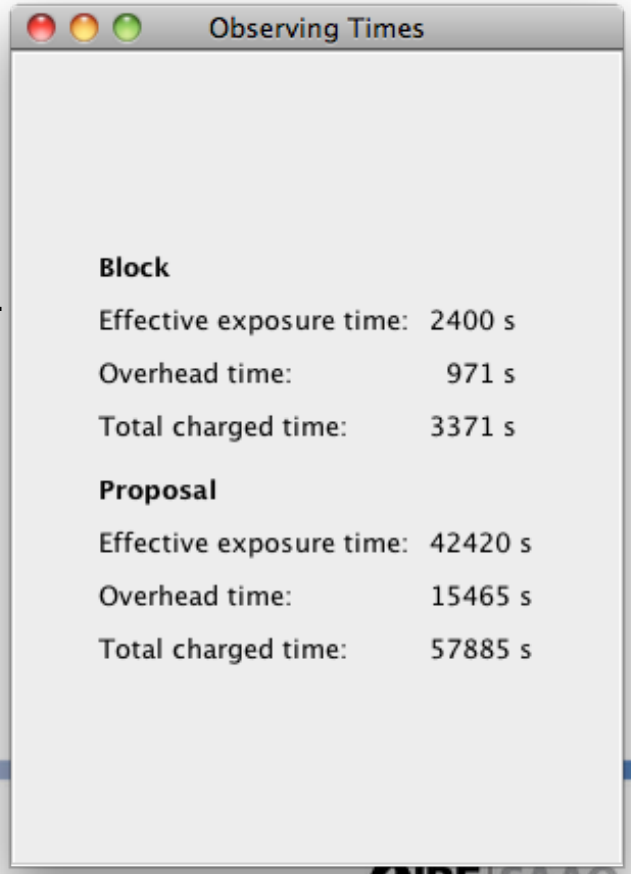
Block:

- A minimum schedulable unit
  - one acquisition, one pointing, one target
  - can have multiple configurations (but simplicity is a virtue)
  - (can tie blocks together, talk to your liaison SA)

- Acquisition time is 600s (MOS is 900s)
- Other overheads from readout times, calibrations, dither etc.

- Play with PIPT to check results





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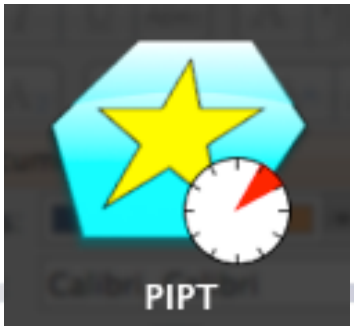
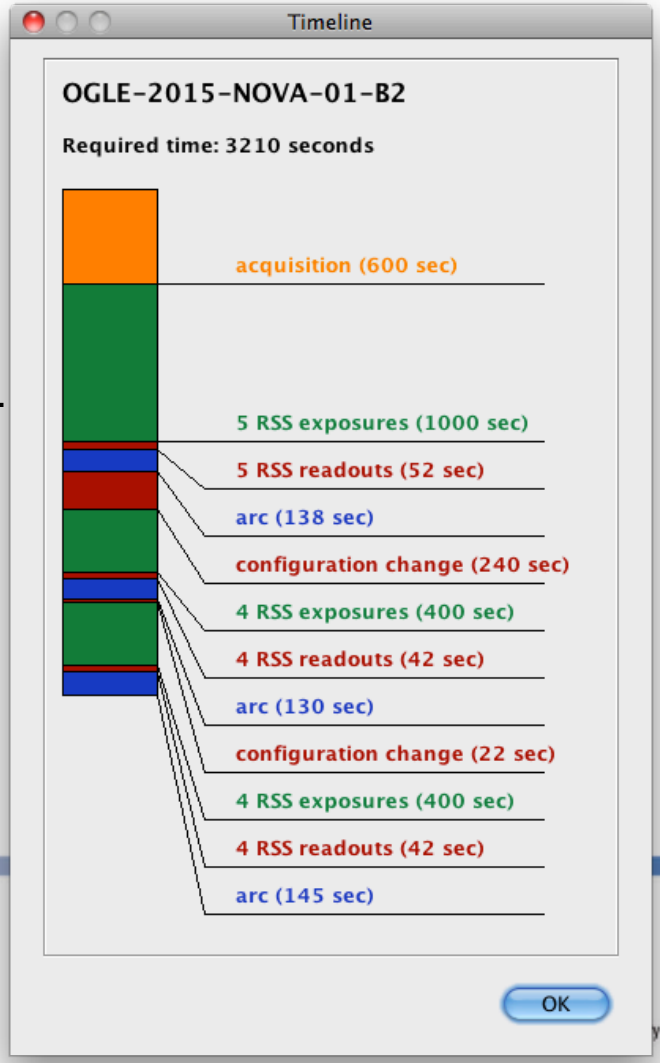


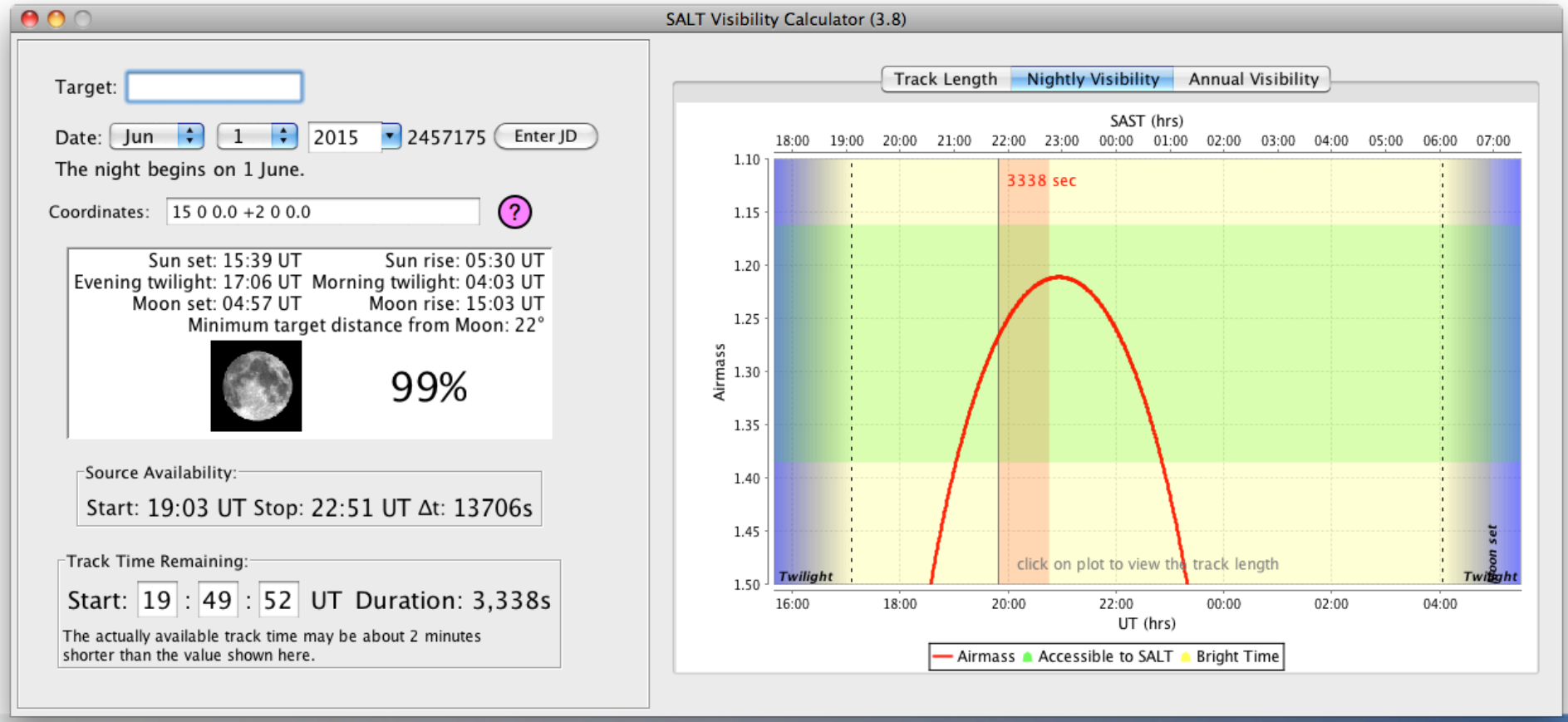


ENHANCING YOUR CHANCES OF GETTING OBSERVATIONS DONE

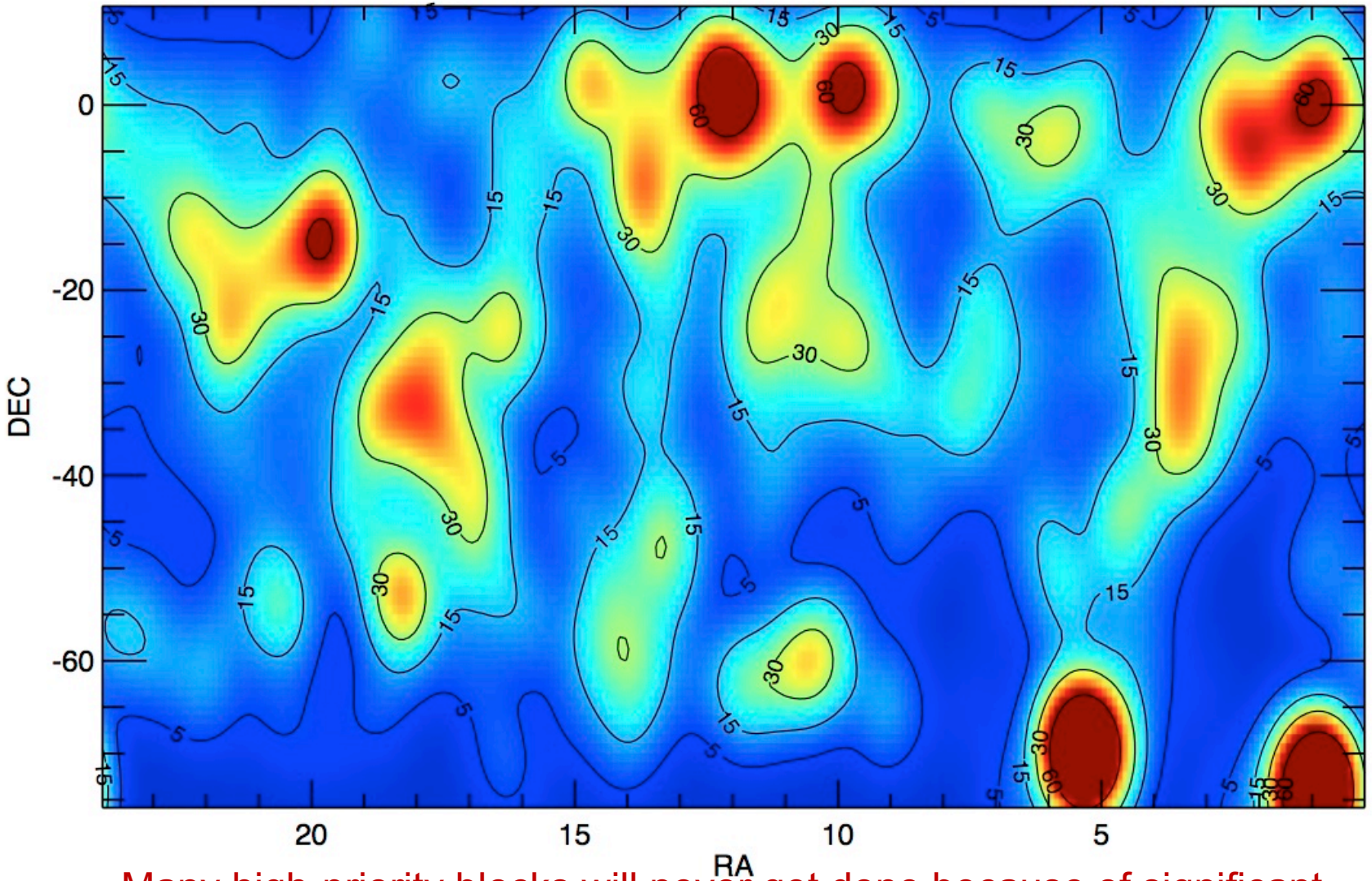
SALT basics: Visibilities and Track times

Do not make your track too tight within a visibility window!

Do not make your Block too tight within a track!



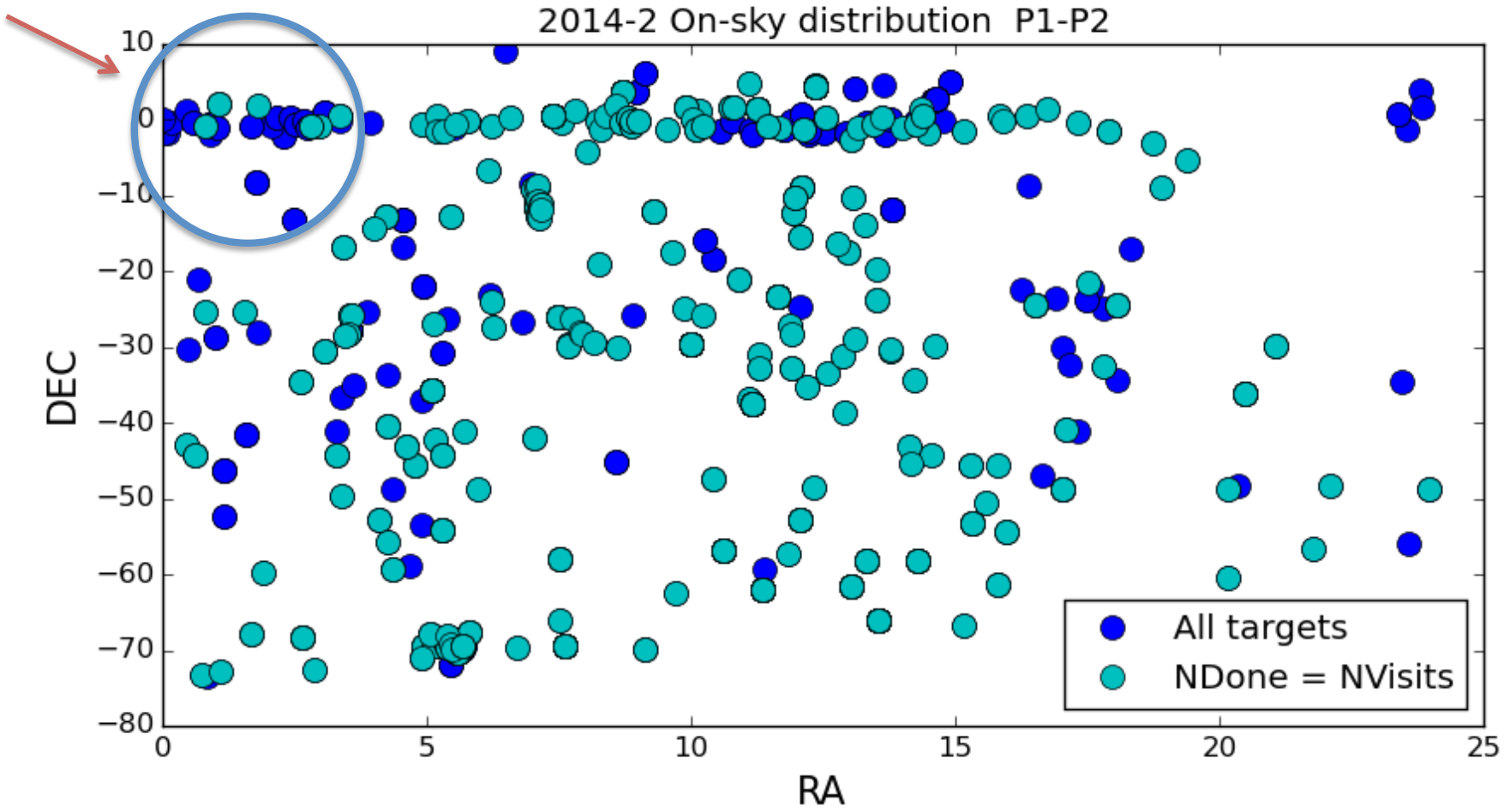
Number of P0-P2 Block visits 2015 - 2016



Many high-priority blocks will never get done because of significant visibility overlaps

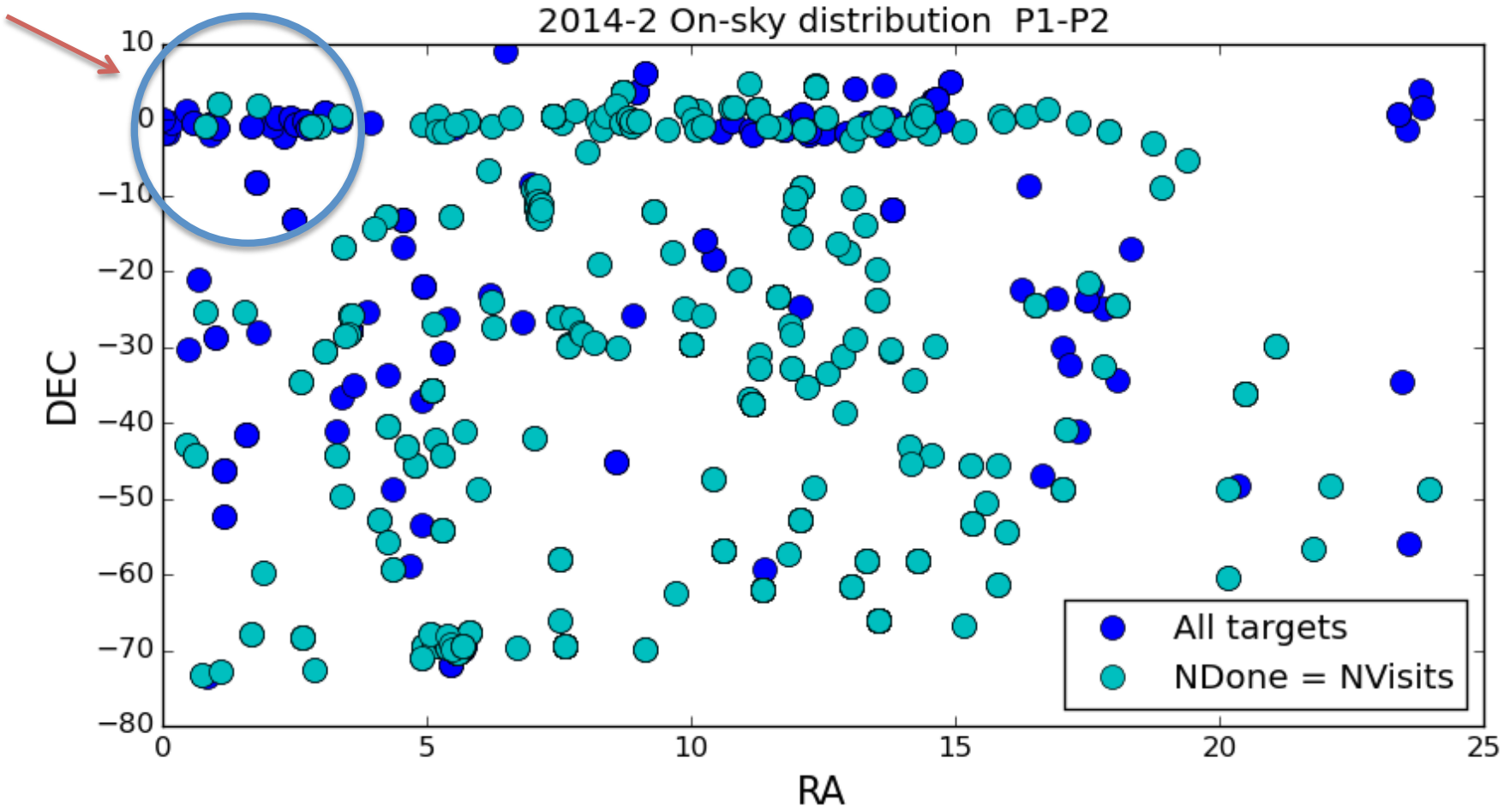
Check the visibilities and probabilities of your Blocks on Web Manager

Too many early semester targets



Propose for multi-semester (MLT) programs when your targets straddle semester boundaries.

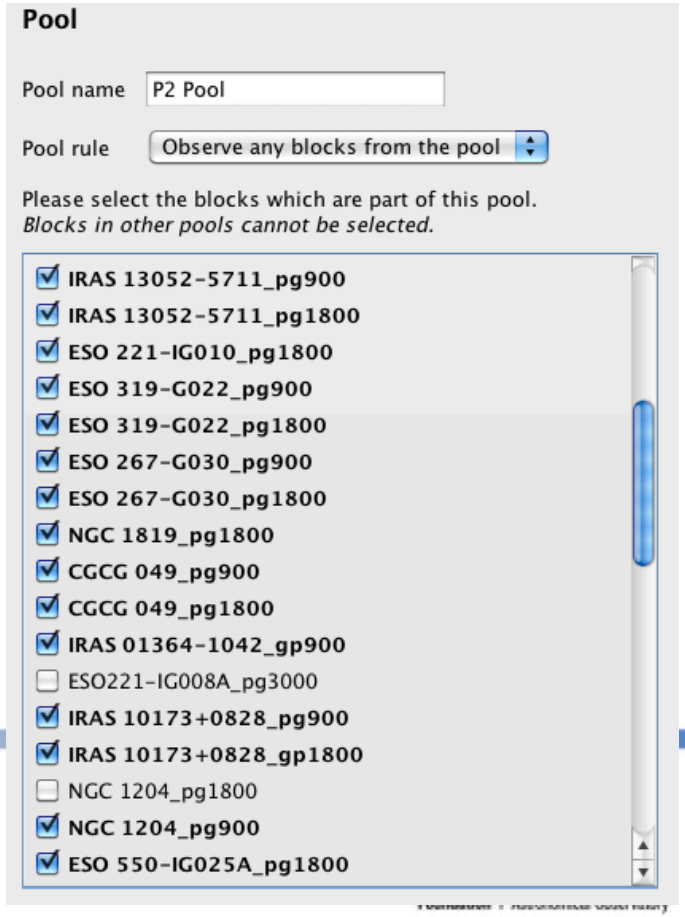
Too many early semester targets



Pools

Use Optional Targets (Pools)

- If you e.g. need 10 targets of a certain type observed for a sample, submit 40 of them in the queue in phase-1 already.
- The wider the RA-range the better. Chances really go up.



What else can you do to enhance your chances ?

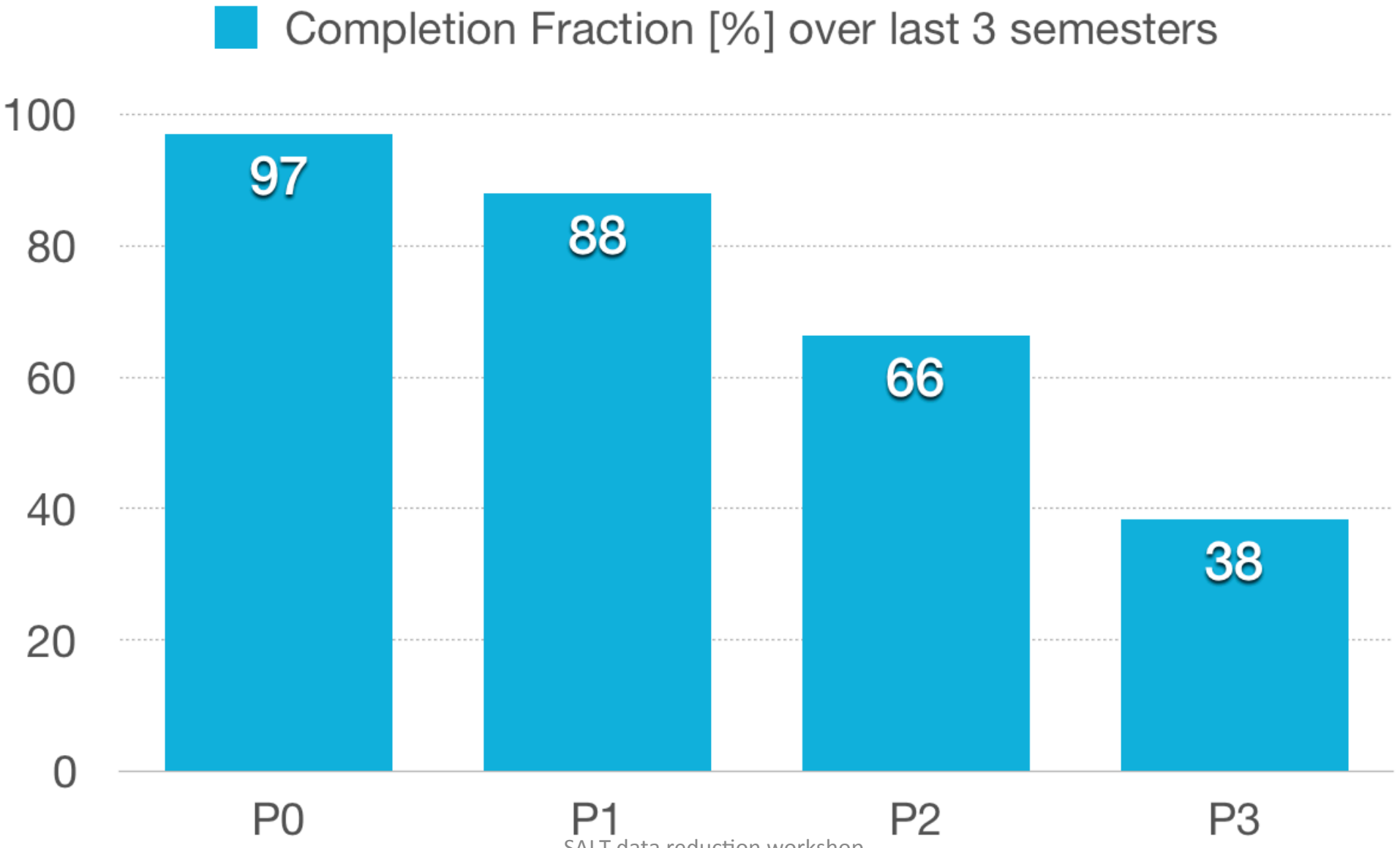
- Bright time is always under-subscribed – think of science which can use it.

- P4 time is unrestricted, uncharged, unlimited. Best ones are easy, short, relaxed-constraint blocks.

- Poor seeing time is also less over-subscribed, at seeing 2.0” or 2.5” and over.

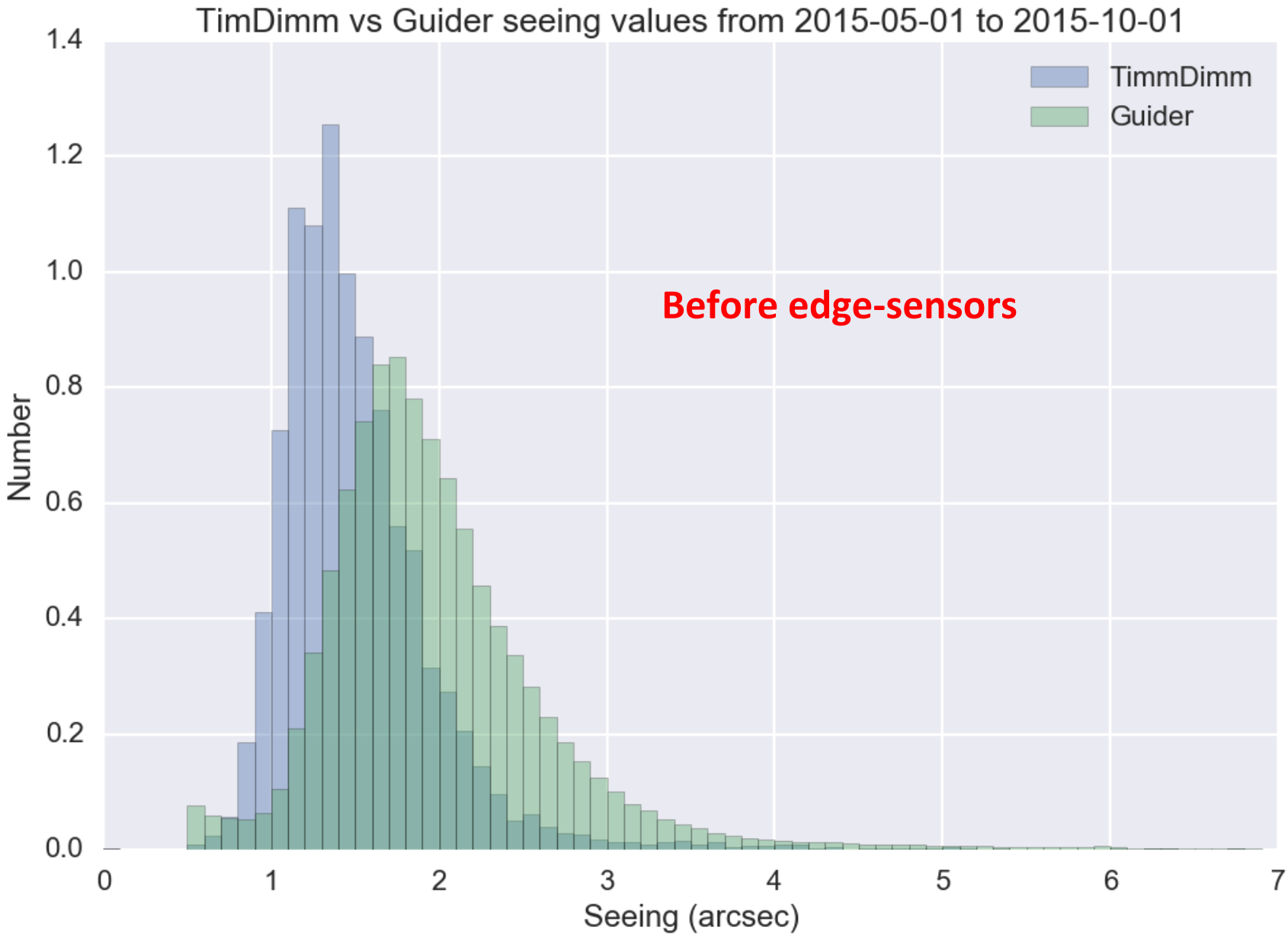
- Be pro-active, check your data, give feedback, remind us of e.g. time critical windows coming up.

What should you expect?

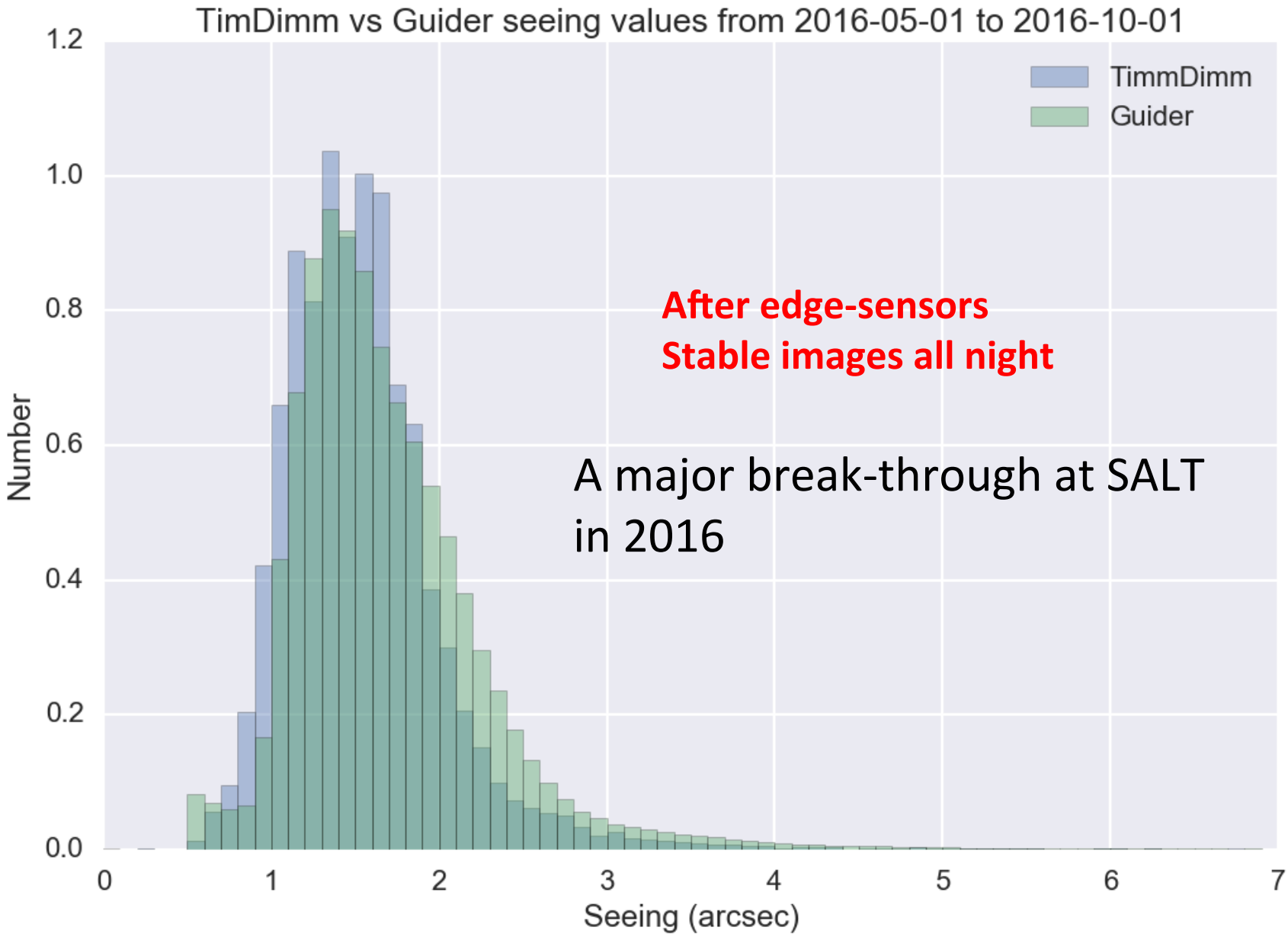


SALT STATUS

Intrinsic vs. extrinsic SALT seeing



Intrinsic vs. extrinsic SALT seeing



After edge-sensors
Stable images all night

A major break-through at SALT in 2016

Current SALT Status

RSS modes available:

RSS / long-slit and NB imaging
RSS / MOS
RSS / Fabry-Perot (no MR)
RSS / Polarimetry (diffuse still comm)

HRS modes available:

HRS / LR,MR,HR,HS

Salticam modes available:

normal, slot-mode, frame-transfer

Improvements since 2014:

RSS throughput better by 40% to early values.
RSS stray-light decreased by 50% – improves faint target SNR.
New RSS guide-probe funded – no more rotational drift in 2017 (MOS)
Data pipelines receiving more attention now.

Active alignment is now reality – image quality much better and stable !

What is SALT especially good at?

Telescope: Huge collecting power.

Site: Skies are very dark (22 mag/arcsec^2). Seeing only modest (median 1.4")

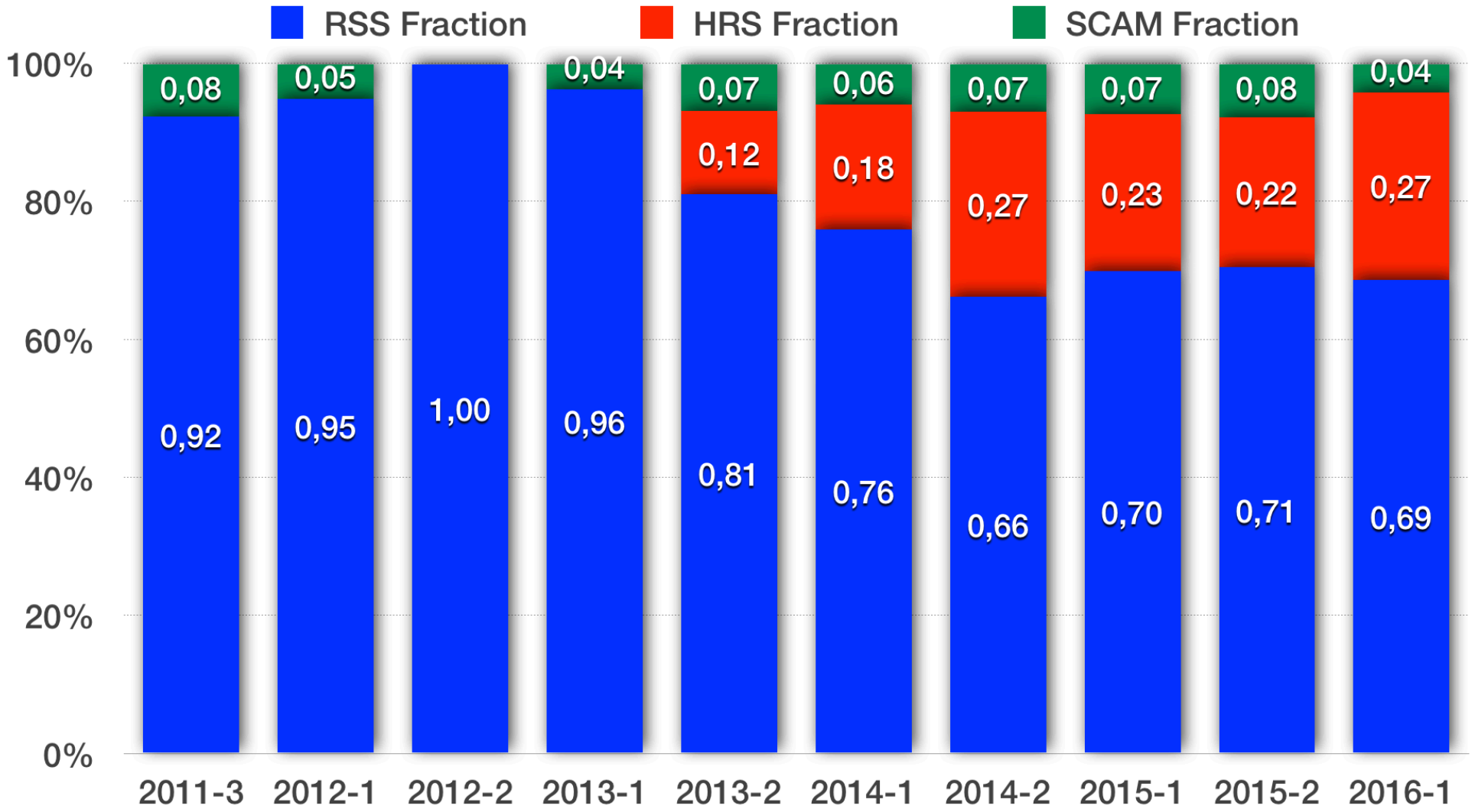
- Diffuse low-surface-brightness spectroscopy very competitive.
- Objects above background also observed very efficiently.
- Can change instruments and observing modes in seconds.
- Rapid reaction to ToOs.
- Some rare modes for large telescopes (FP, Pol, mixed modes, high-time res)

• SALT as a *spectroscopic survey telescope.* Most efficient programs are surveys with large pools of targets over the sky.

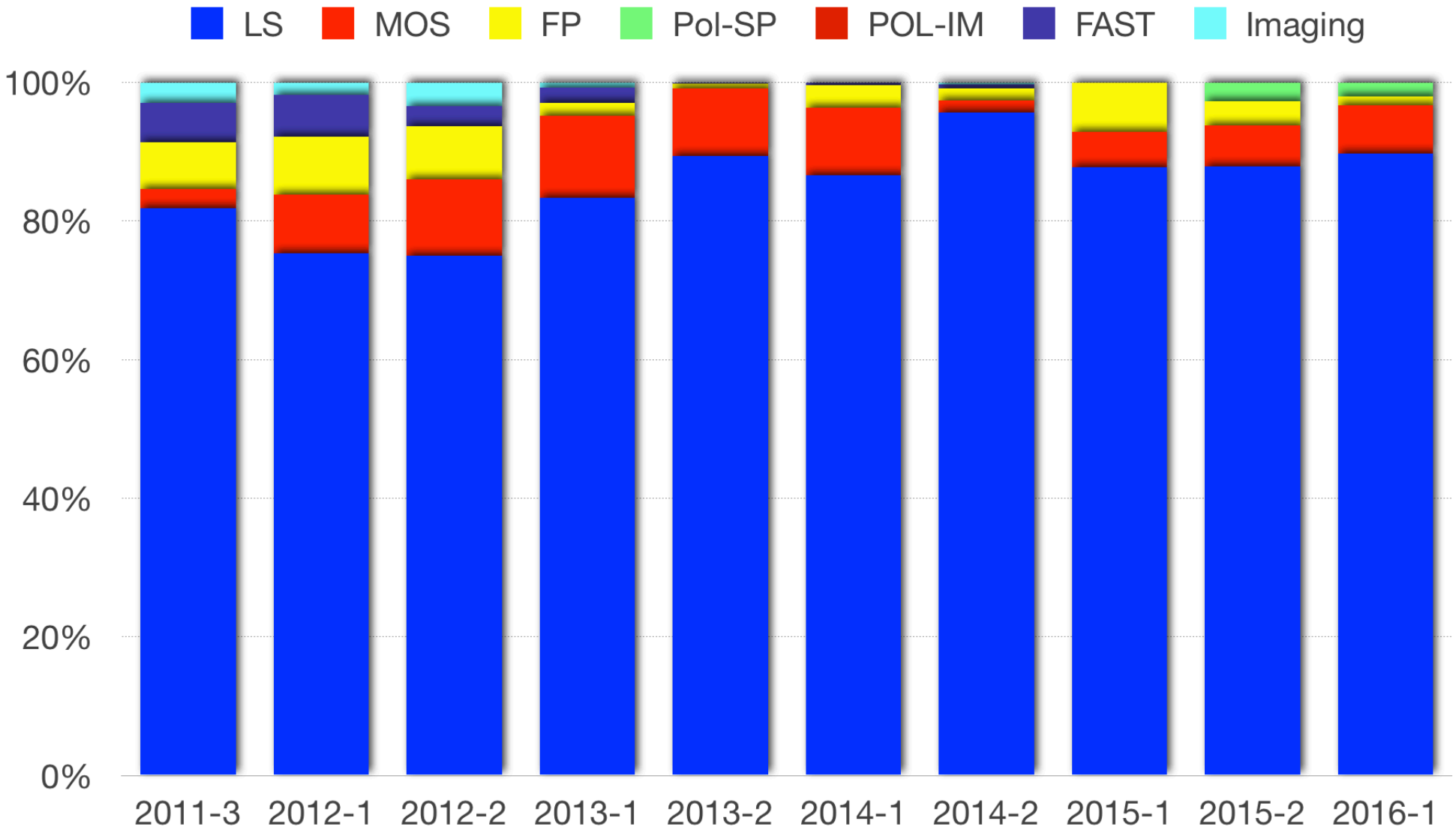
What kind of science is done ??

N = 120 refereed SALT data *publications* (03/2016)	
Stellar	59%
Extragalactic	27%
Supernova follow-up	10%
Solar System	4%
Target-of-opportunity (ToO)	15%
More than 10 targets/observations	11%

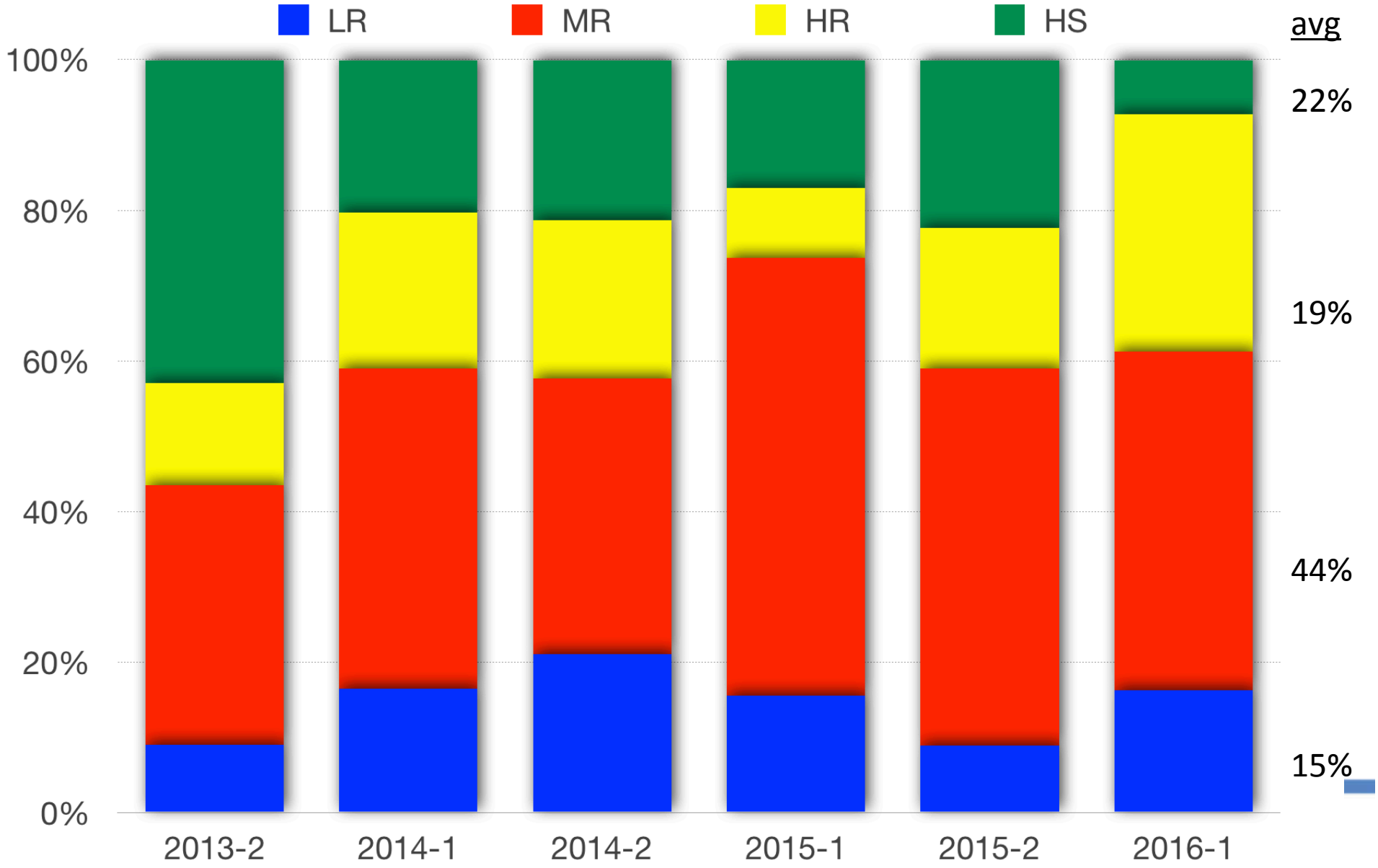
Instrument usage



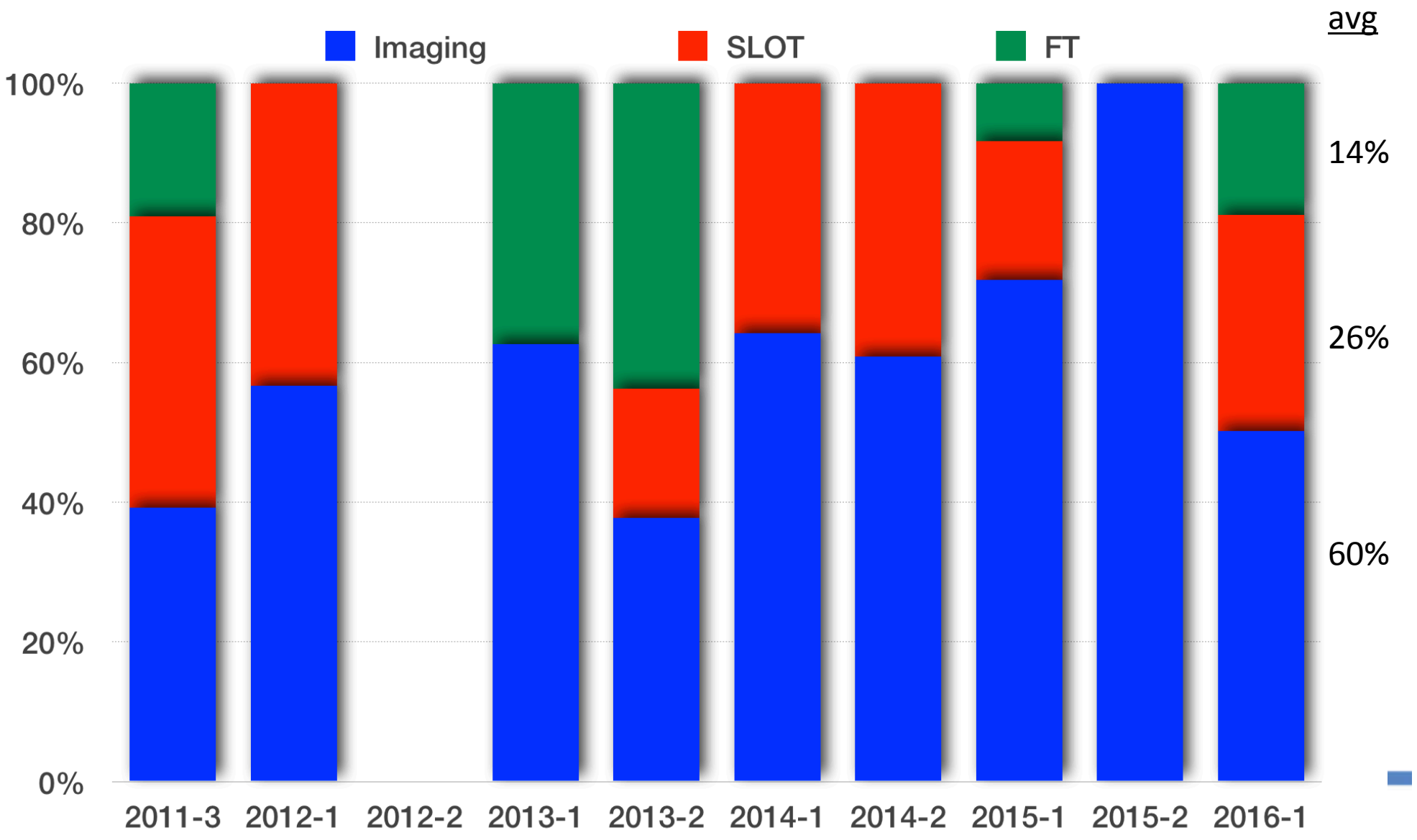
RSS modes


LS
MOS
FP
Pol-SP
POL-IM
FAST
Imaging
100%
80%
60%
40%
20%
0%
2011-3
2012-1
2012-2
2013-1
2013-2
2014-1
2014-2
2015-1
2015-2
2016-1

HRS modes


LR
MR
HR
HS
avg
100%
80%
60%
40%
20%
0%
22%
19%
44%
15%
2013-2
2014-1
2014-2
2015-1
2015-2
2016-1

Salticam modes – 60% normal imaging on average



Pipeline reduction situation

- HRS – yes!
- RSS
  - Long-slit: only user-contributed ones for now
  - FP: close, but needs work still, maybe 2017
  - Polarimetry: point-sources yes. Others not yet.
  - MOS: starting, maybe 2017-2018
  - NIR: not started yet
- Salticam:
  - tools for slotmode
  - Flat-fielding still an issue for full-frame photometry

Summary

SALT is an amazing opportunity for South African astronomers and students !!

Use it for great science

Be careful with your Block visibilities and tracks, nightly and seasonal

Use Optional Targets / Pools

Try to think of areas not used by others (e.g. Bright, P4s)

Be active in checking your data, asking help, communicating.

Pipelines starting to appear.

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http://astronomers.salt.ac.za/