KMOS @ the VLT: Commissioning and Early Science

Ray Sharples

Centre for Advanced Instrumentation

Durham University

and the KMOS Team

GALAXIES IN 3D ACROSS THE UNIVERSE

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Acknowledgements

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Durham UK ATC Oxford MPE USM ESO

Talk Outline

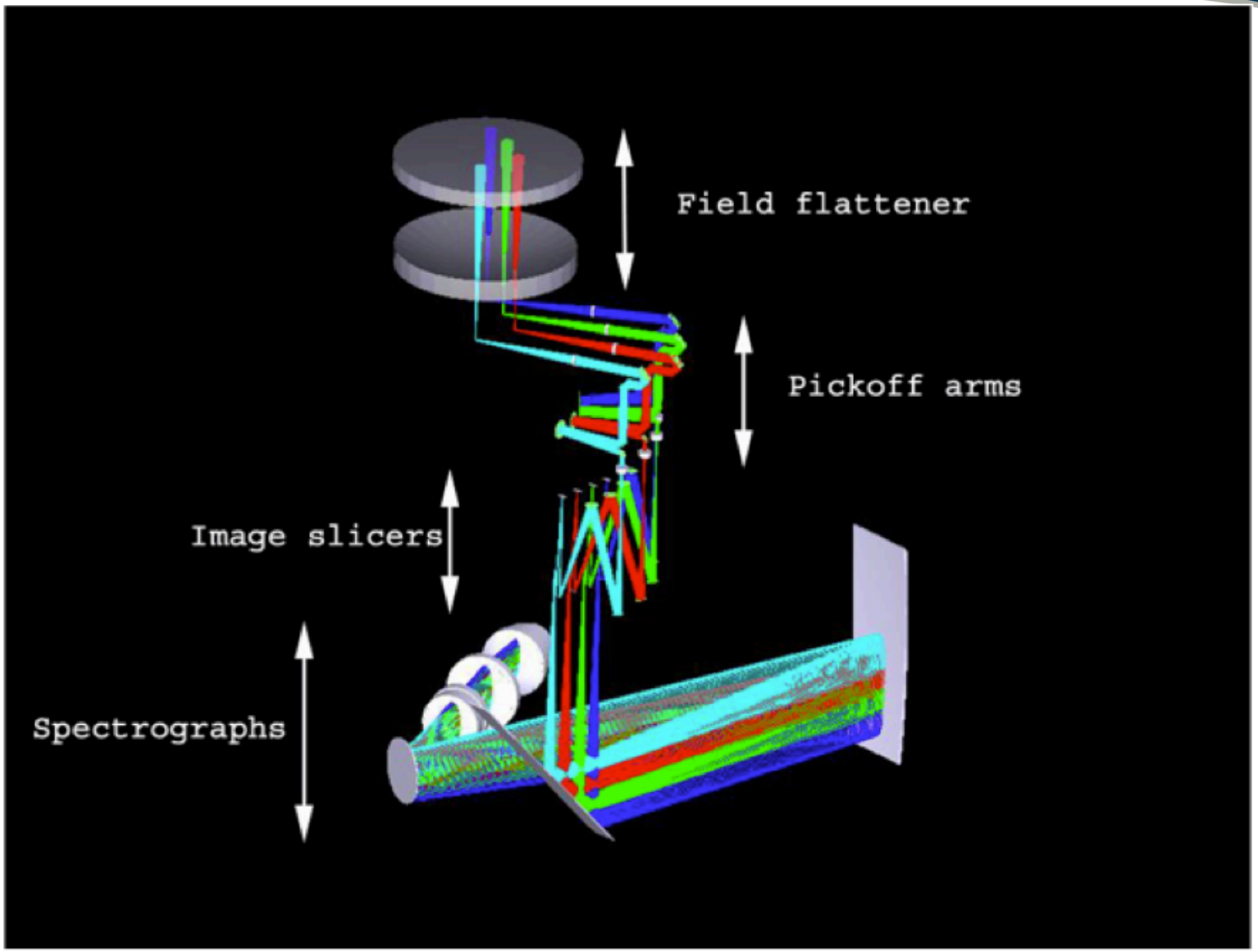
- Technical Description
- On-Sky Performance
- Recent Modifications
- Early SV/GTO Science

See also papers by Natascha Foerster Schreiber, David Sobral, John Stott, David Wilman, Stijn Wuyts and Eva Wuyts later this week.

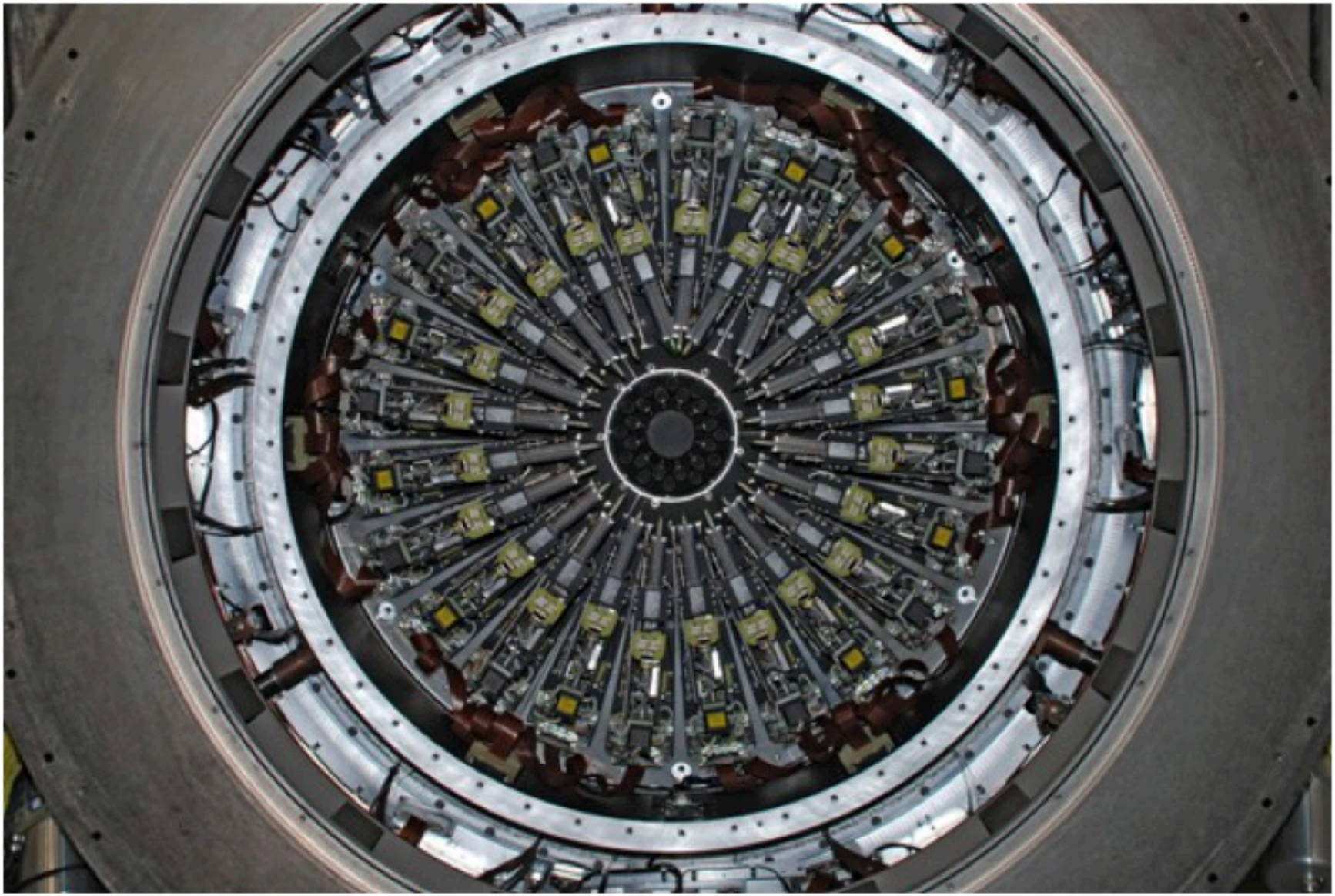
Functional Requirements

Requirement	Value
Instrument Throughput	YJ>20%, H>30%, K>30%
Wavelength coverage	0.85 to 2.5 μm
Spectral Resolution	R>3300,3400,3800,3800 (IZ,YJ,H,K)
Number of IFUs	24
Extent of each IFU	2.8 x 2.8 sq. arc seconds
Spatial Sampling	0.2 arc seconds
Patrol field	7.2' diameter field
Close packing of IFUs	≥3 within 1 sq arcmin
Closest approach of IFUs	≥2 pairs separated by 6 arcsec

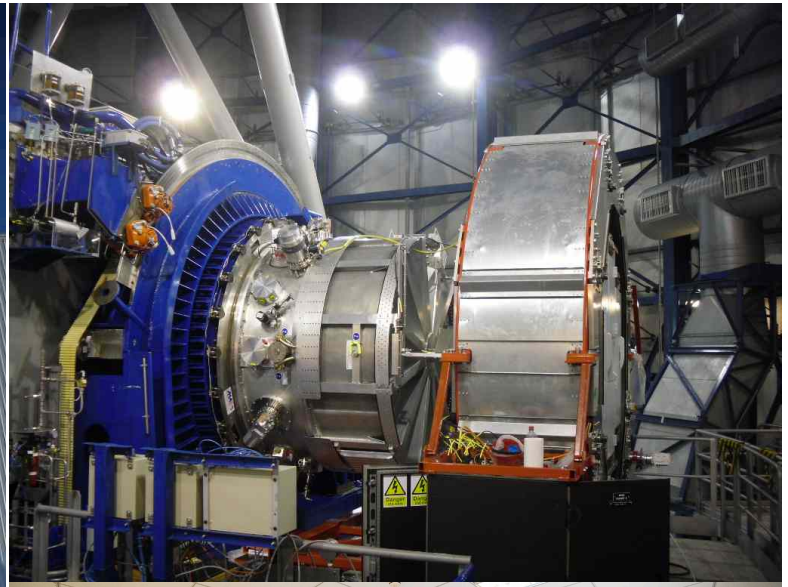
Optical Layout (8 arms)



Pickoff Module: 24 arms

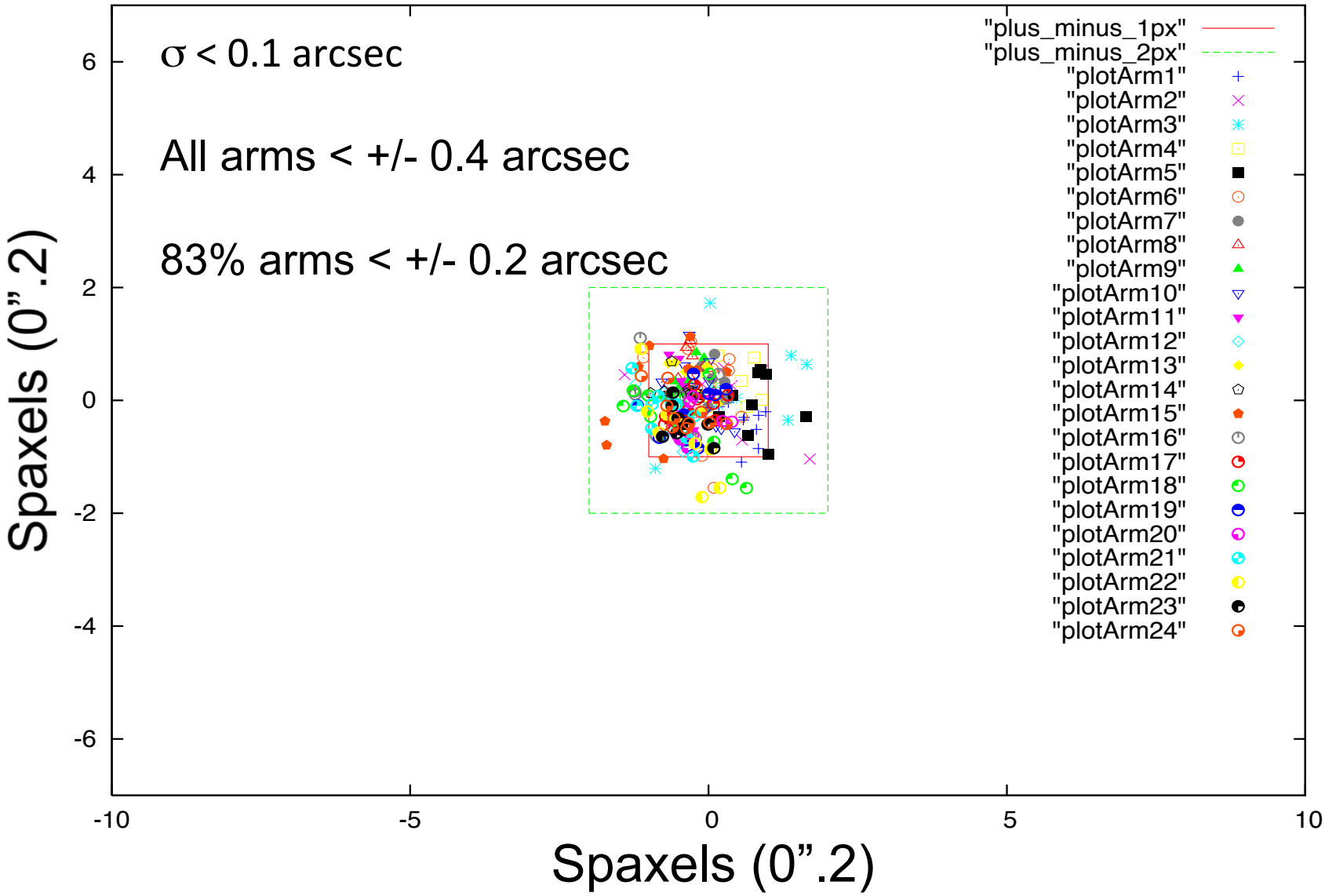


Performance @ UT1 (Antu)

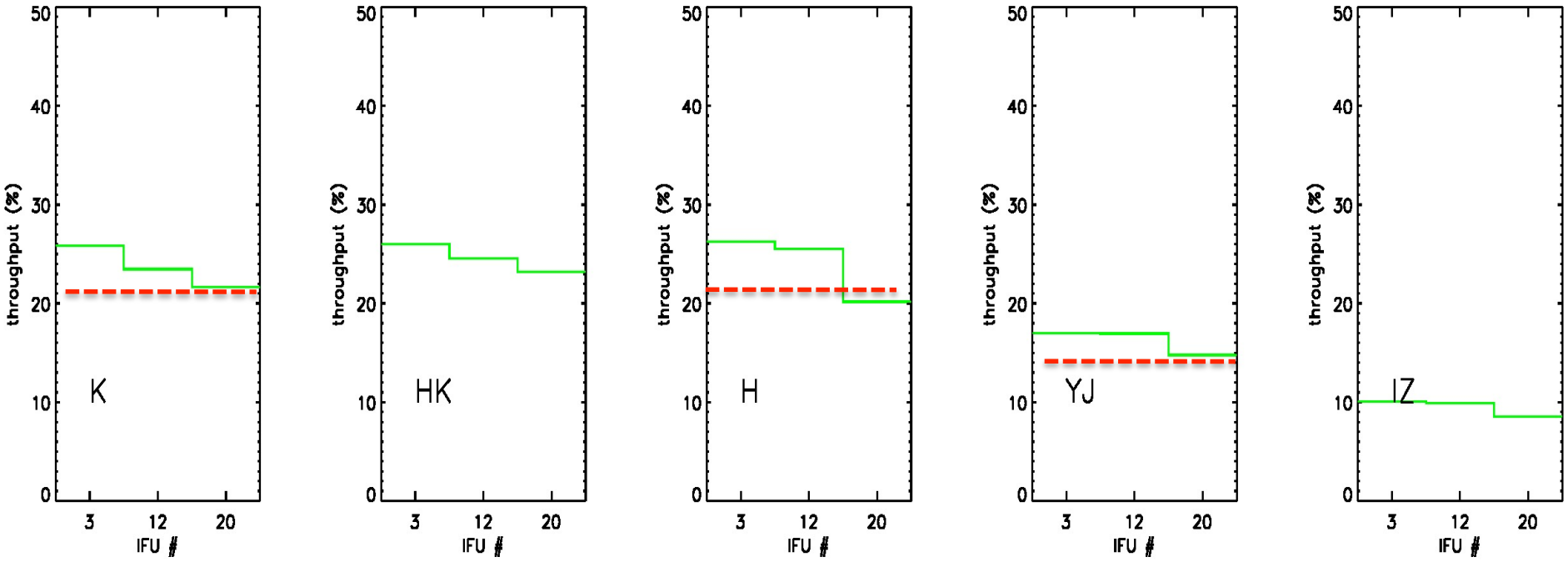


First light 21 Nov 2012

Pickoff Arm Accuracy



Total System Throughput

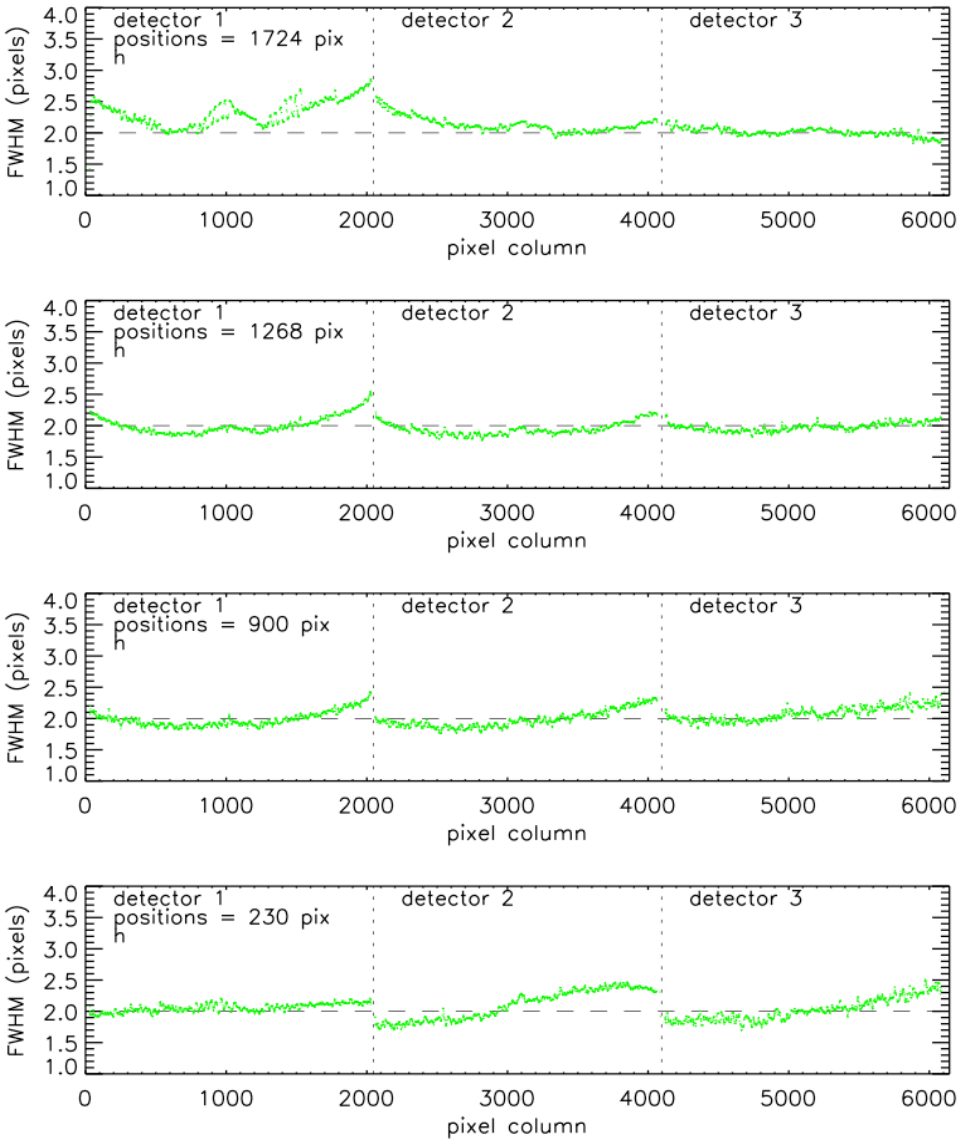


Red dotted lines show the minimum requirements from the Tech Spec scaled by 90% for the detector, 85% for the telescope, and 95% for the atmosphere. Segment#3 has worst performance. IZ & HK on ‘best efforts’ basis.

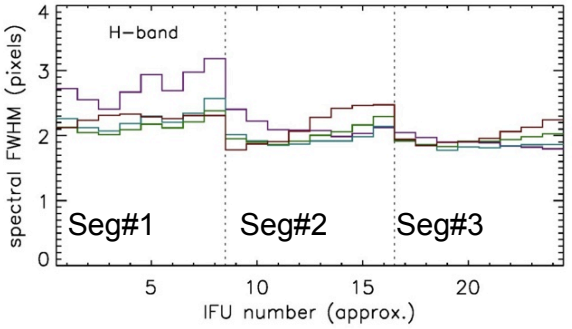
Spectral Resolution

red

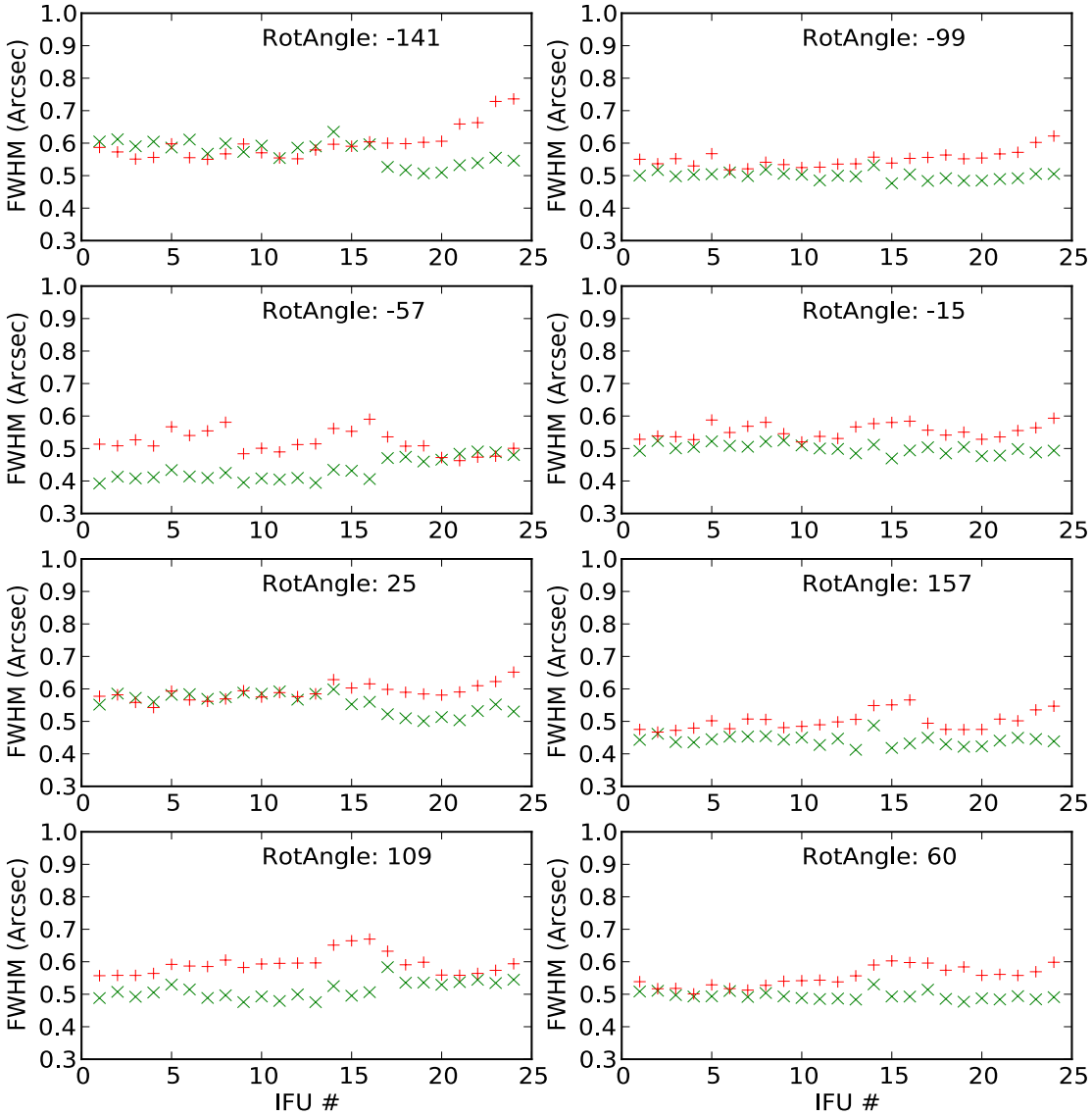
blue



- Resolution is close to two pixels FWHM over all spatial channels.
- Graphs show the measurements in four quartiles of H-band.
- Segment #3 seems slightly better than Segment #1



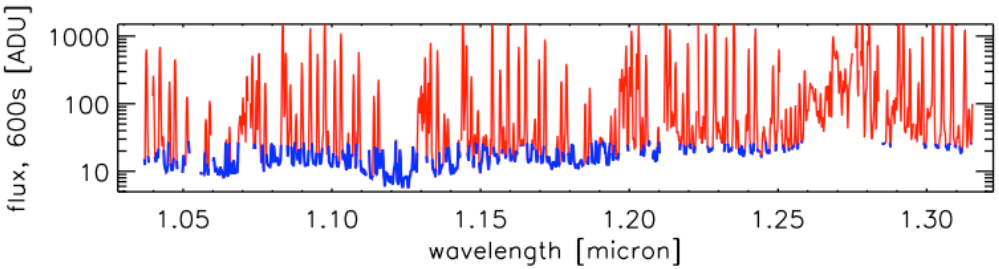
Spatial Resolution



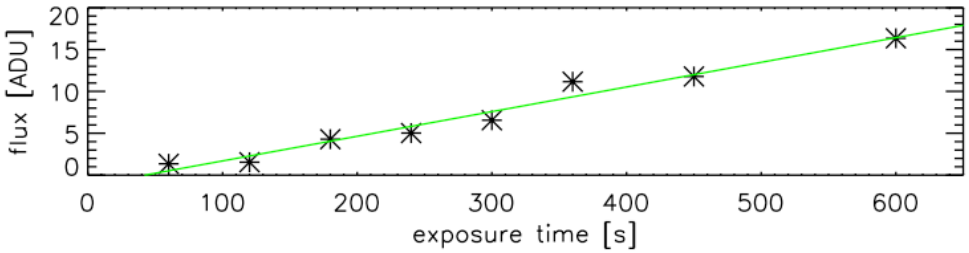
Rot. Angle:	-141	-99	-57	-15	25	157	109	60
<FWHM_Y>	0".57	0".50	0".43	0".50	0".56	0".44	0".51	0".49
<FWHM_Z>	0".60	0".55	0".52	0".55	0".60	0".50	0".59	0".55

- In good seeing and S/N the PSFs in reconstructed cubes are well-behaved.
- FWHM along (Z) the slice (red) is slightly broader (+0".05) due to the additional aberrations in spectrograph (consistent with FWHM~0.2 pixel instrumental PSF)
- Worse in IFU#17-24 at some Nasmyth PAs (still investigating)

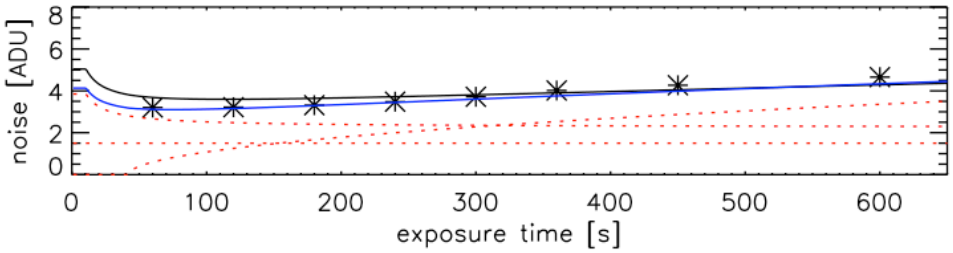
Background Noise Limit



Blue = inter-line continuum



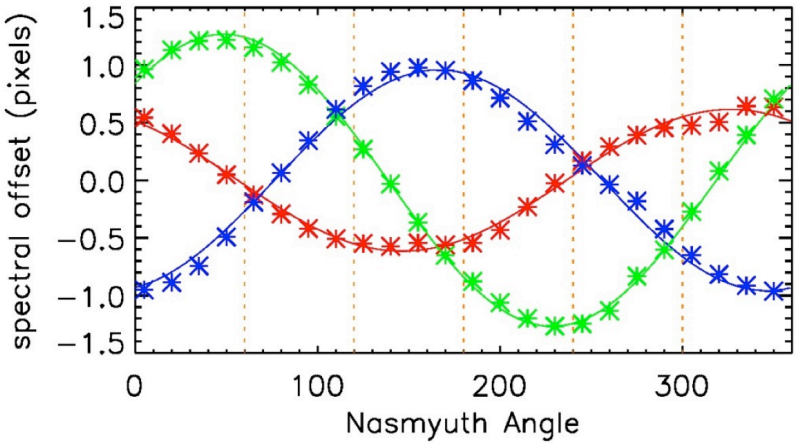
YJ band 1.025-1.344μ



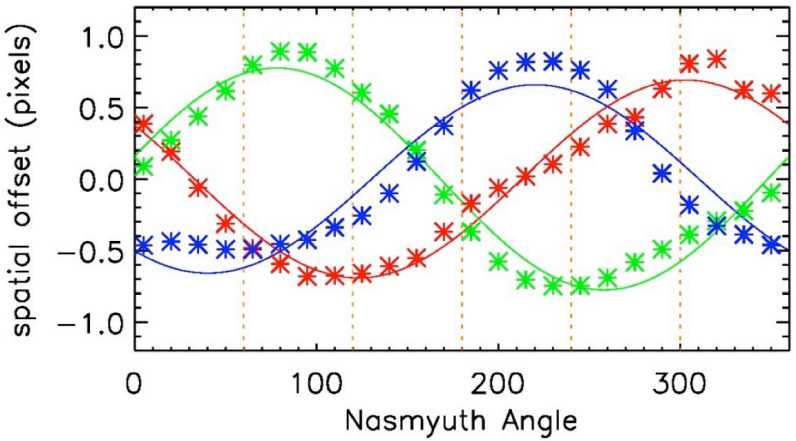
Gain 2.08 e^-/adu

Photon-noise limited exposure times (DIT) of 300 sec.
Threshold Limited Integration at 50,000 counts.

Instrument Flexure

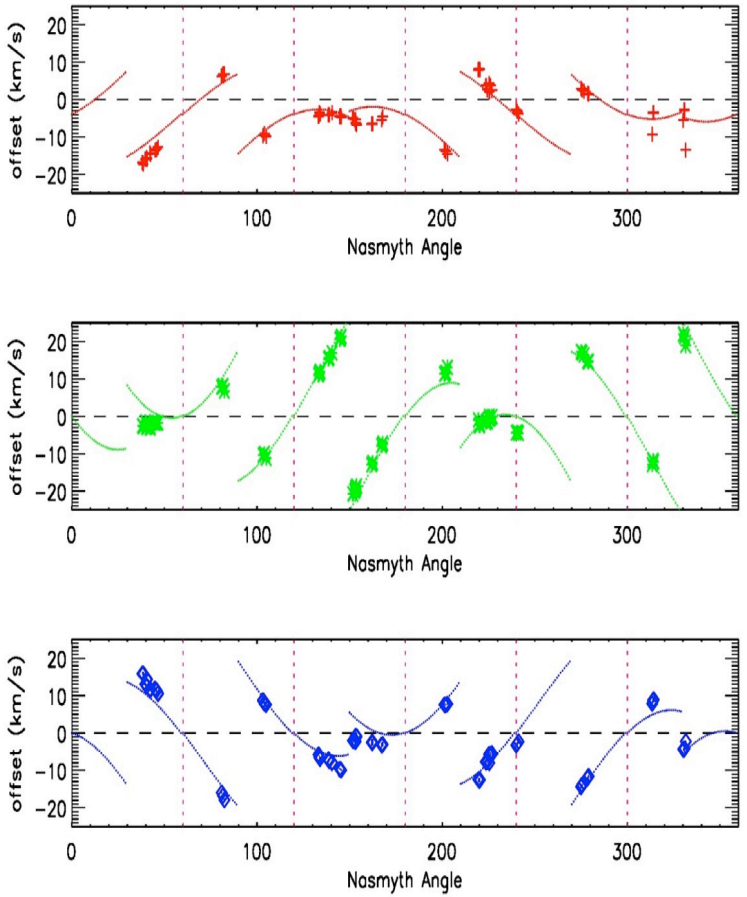


Spectral



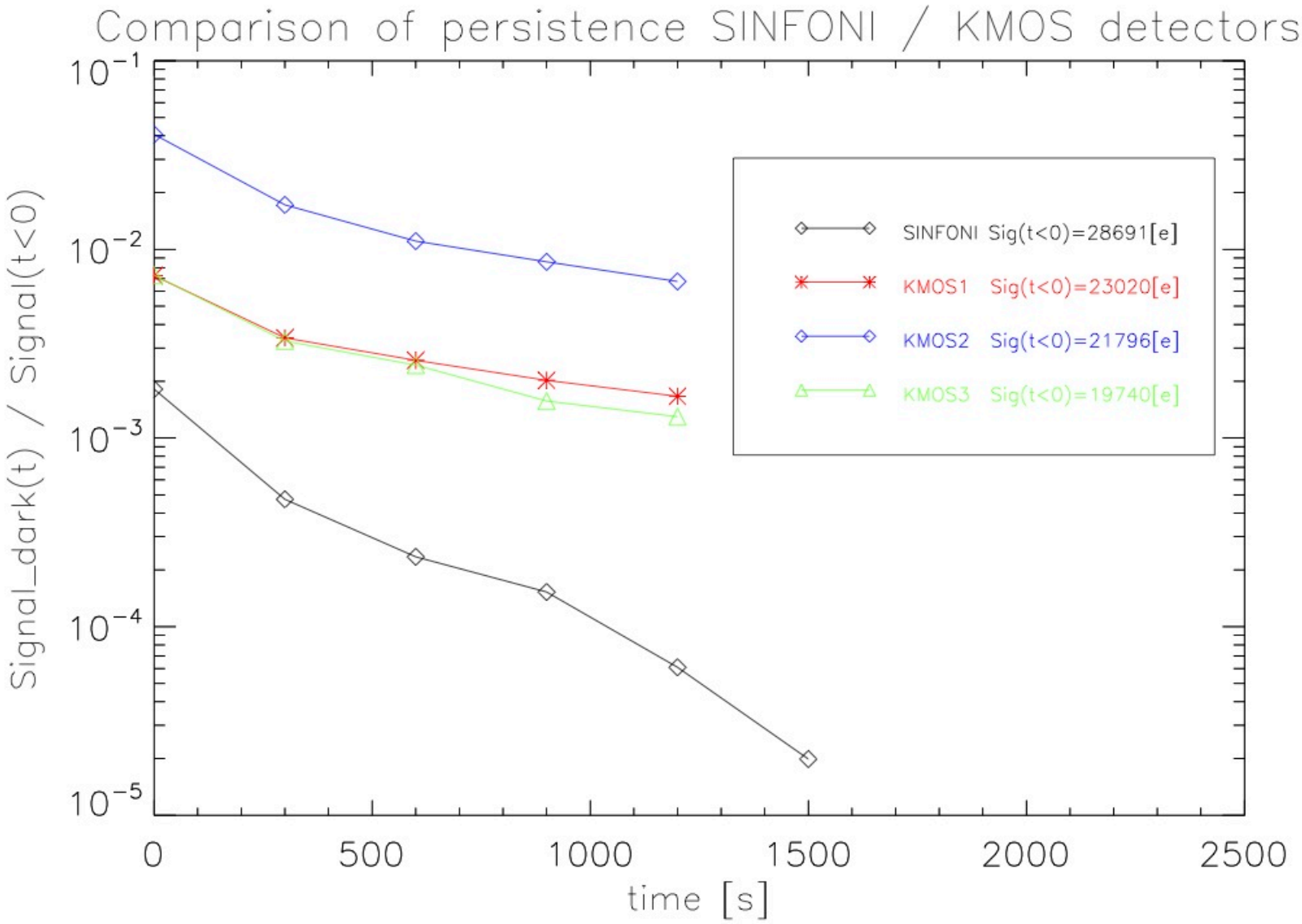
Spatial

Arcs/Flats taken every 60 degrees

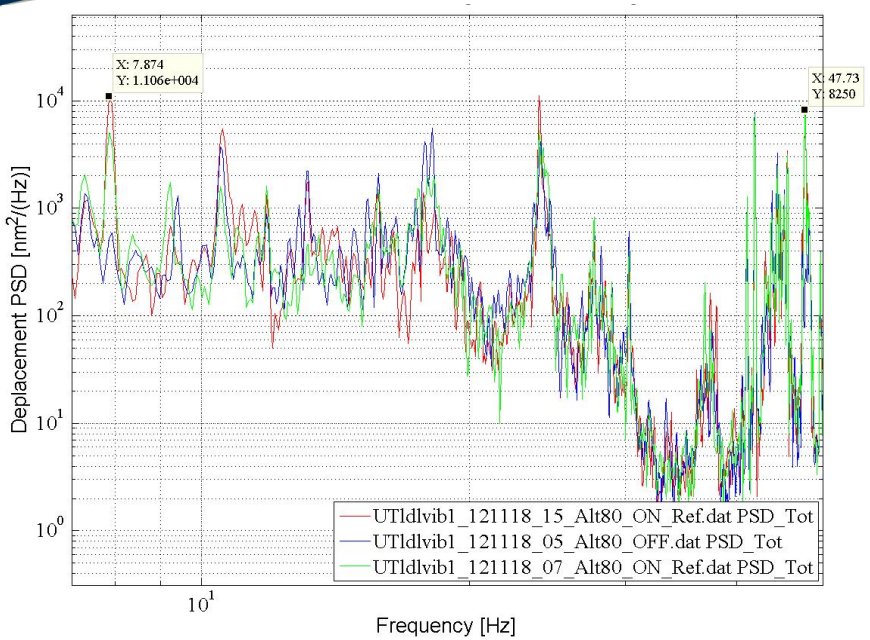


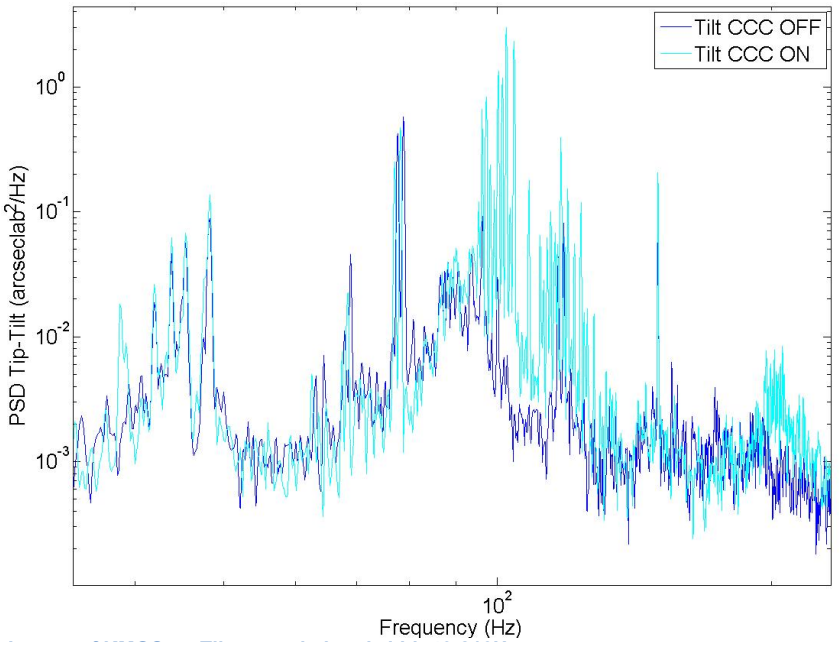
Residual Night Sky
(5 km/s)

Detector Persistence



Cold Head Vibrations



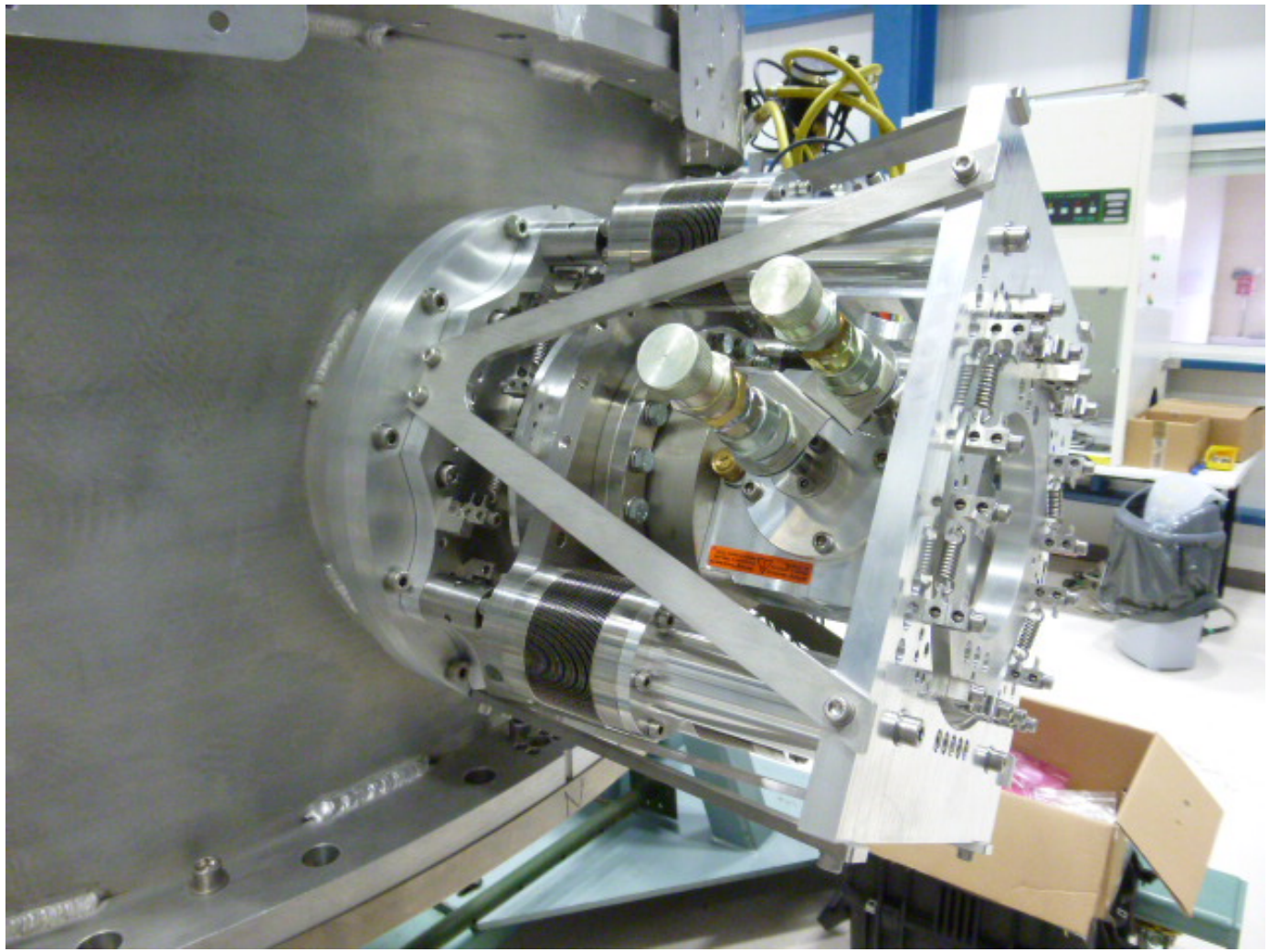


M1-M3 accelerometer test - OK

UT1 Coude test (IRIS) – deemed unacceptable

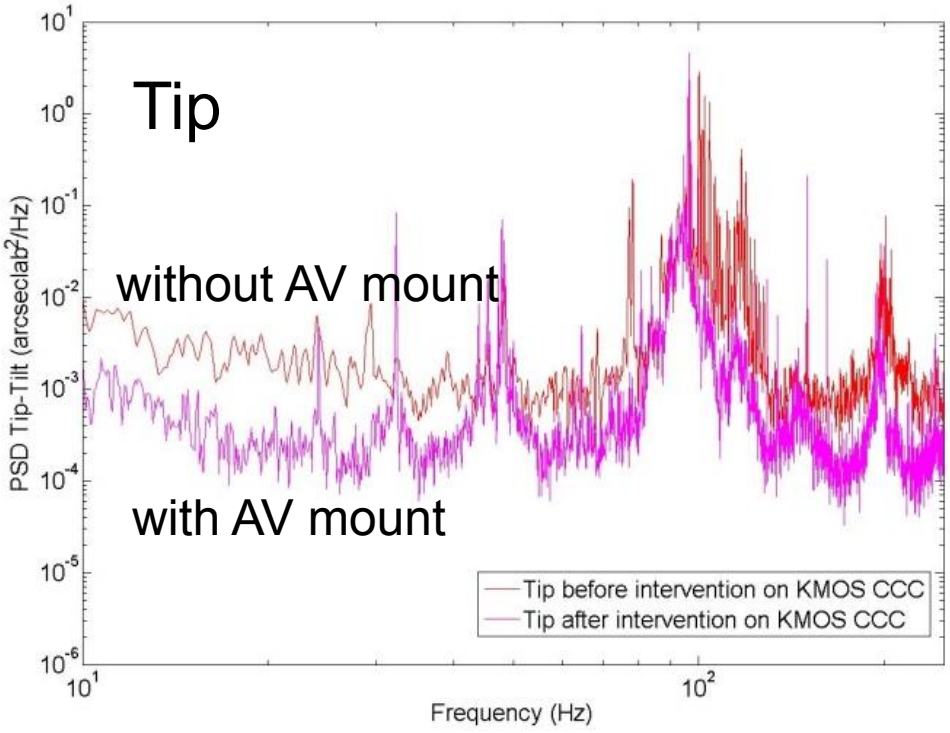
KMOS operations since Comm-1 have required closed cycle coolers to be switched off during all VLTI runs. Adverse impact on arm reliability.

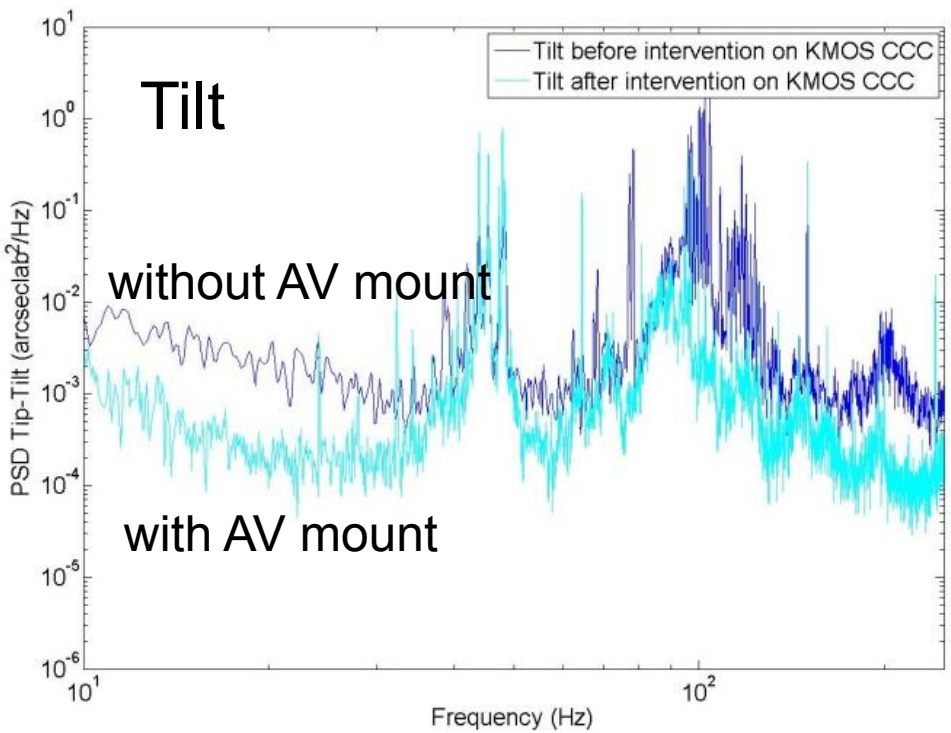
Cold Head Vibrations



Anti-vibration mounts fitted Feb 2014.

Cold Head Vibrations



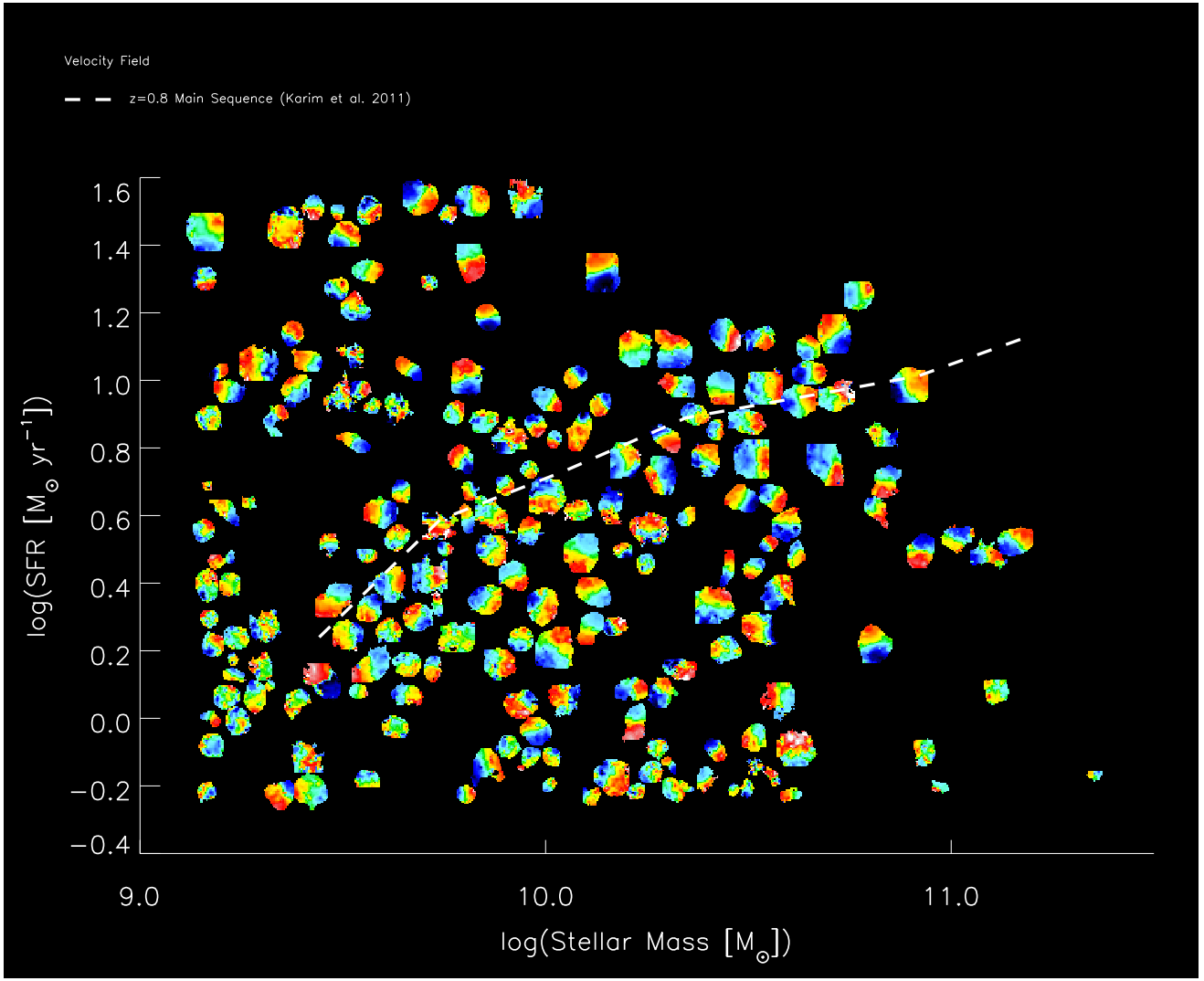


No significant impact on tip-tilt of UT1 coude train mirrors, as measured with IRIS, following installation of AV mounts.

SV/GTO programmes

- Science Verification (21 proposals):
  - KMOS confirmation of Spitzer-selected galaxy clusters at z > 1.4
  - Looking for low luminosity lensed galaxies with KMOS
  - Near-Infrared line strength gradients in IC4296
  - Outflows from massive young stellar objects
  - Exoplanet transits with KMOS
- Guaranteed Time Observations (8 projects underway):
  - KMOS^{3D}
  - KMOS Deep Survey
  - KMOS Kinematic Survey
  - Chemical Evolution of Galaxies using AGB Stars
- UT1 oversubscription: P92 (7.8), P93 (6.7)

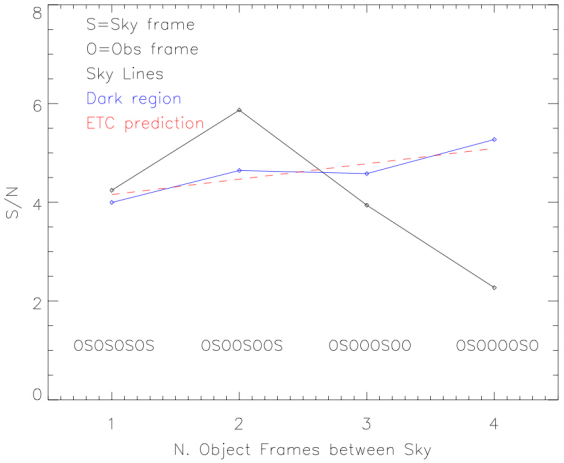
Resolved Galaxy Kinematics



$0.7<z<1.5$

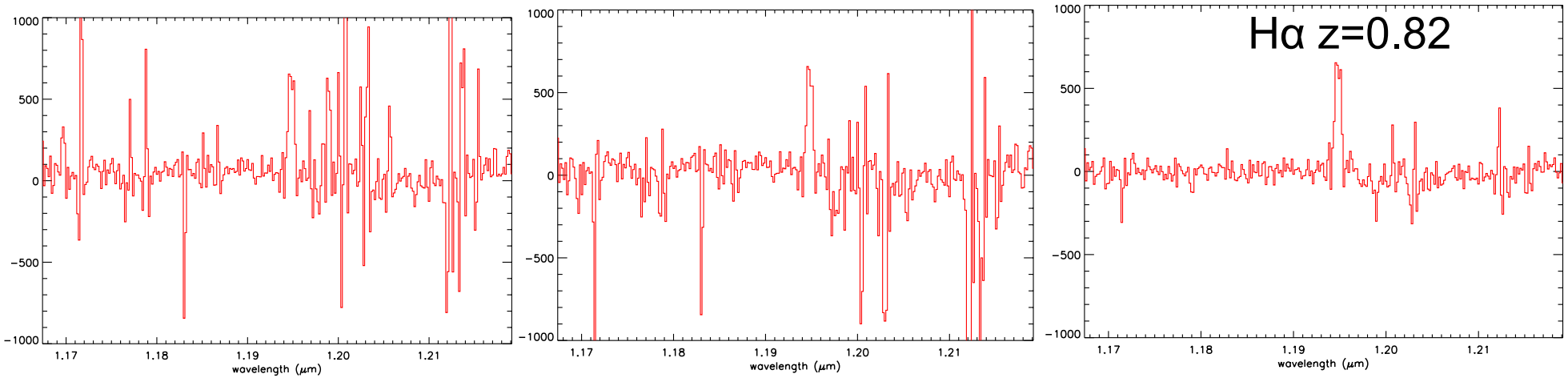
$10^9<M^*<10^{11}$

Resolved 185 galaxies out of 258 targetted



Resolved Galaxy Kinematics

Sky subtraction

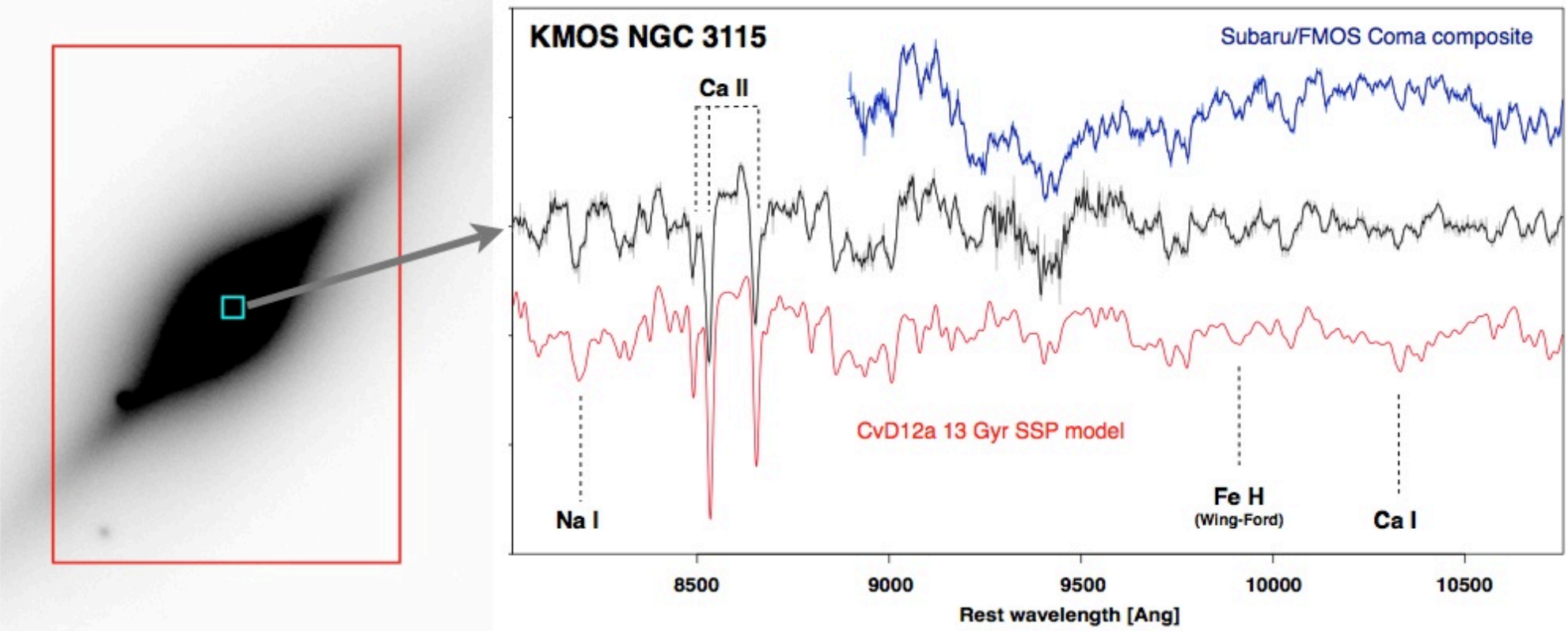


OSO

OSO + Davies SkySub

Bootstrap all IFUs

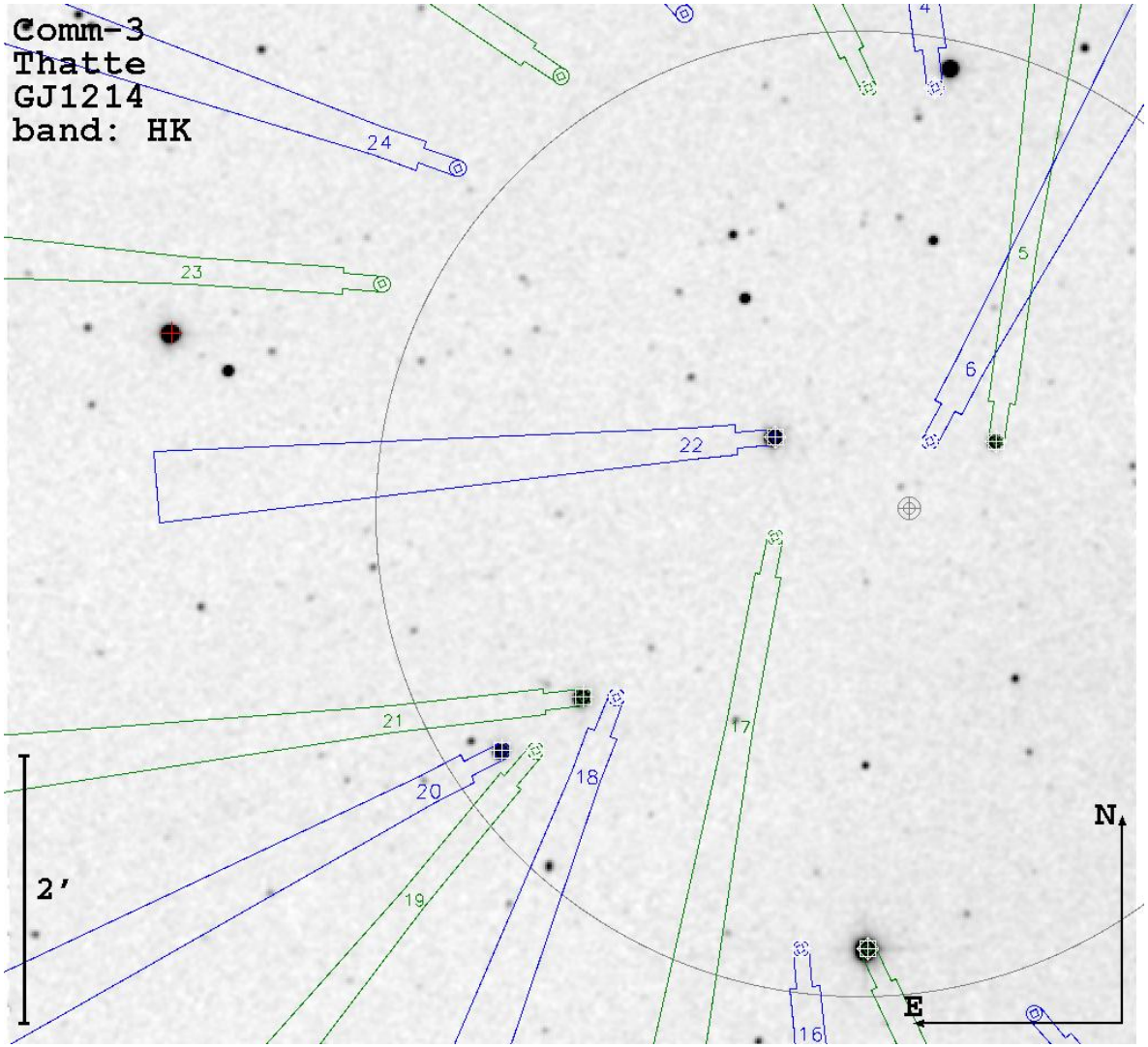
Low-Z Galaxies (IZ)

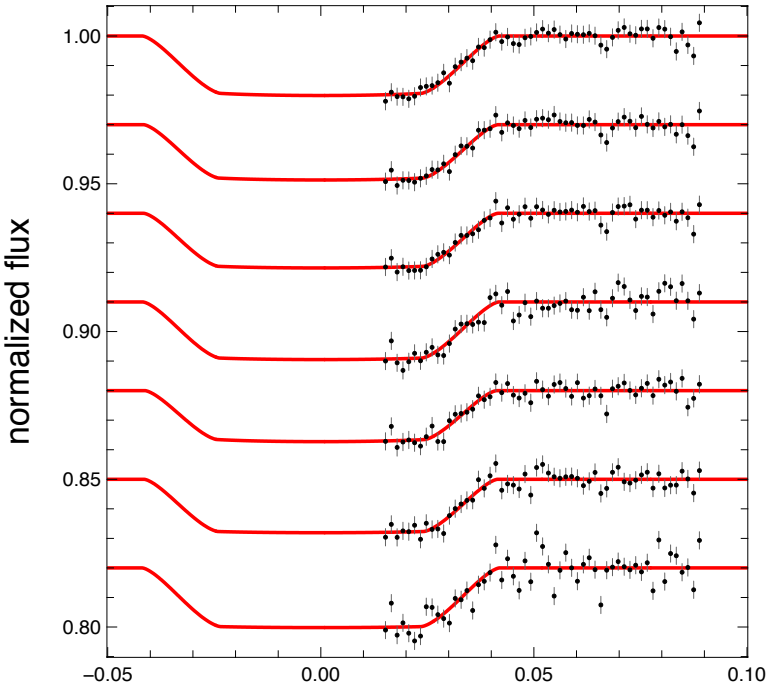


Russell Smith et al.

Transit Spectroscopy (?)

HK 1.484 – 2.442 μm



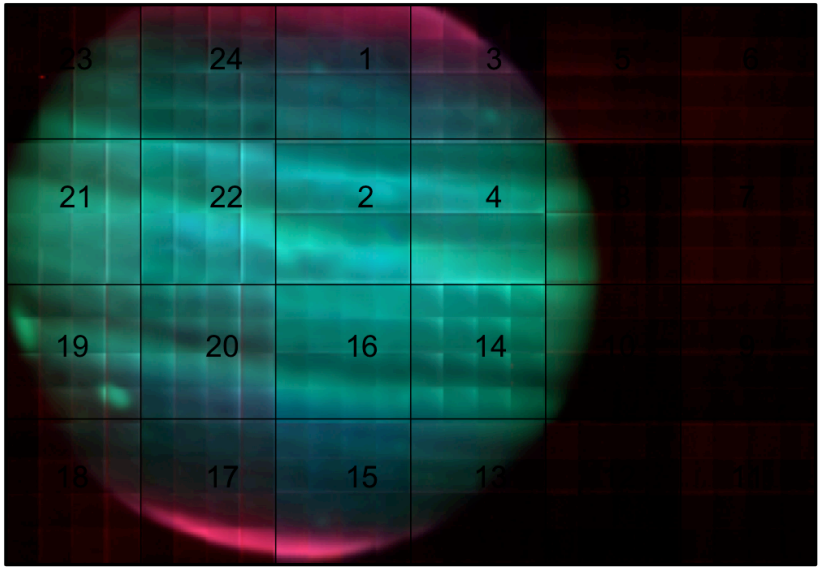


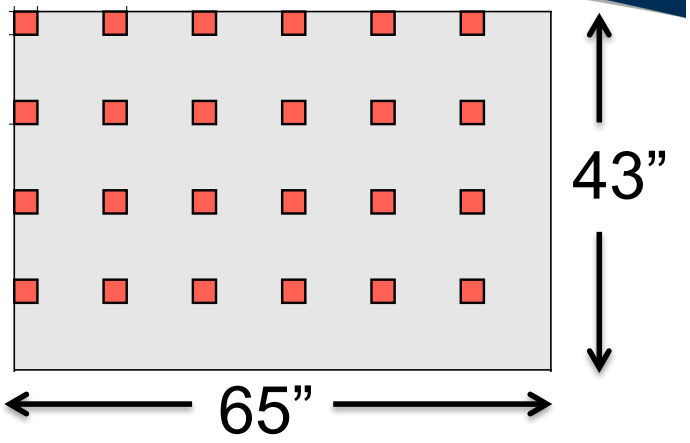
1	1.5-1.6 μm
2	1.6-1.7 μm
3	1.7-1.8 μm
4	1.95-2.05 μm
5	2.05-2.15 μm
6	2.15-2.25 μm
7	2.25-2.35 μm

Saglia, Koppenhoefer et al.

KMOS Mosaic Mode

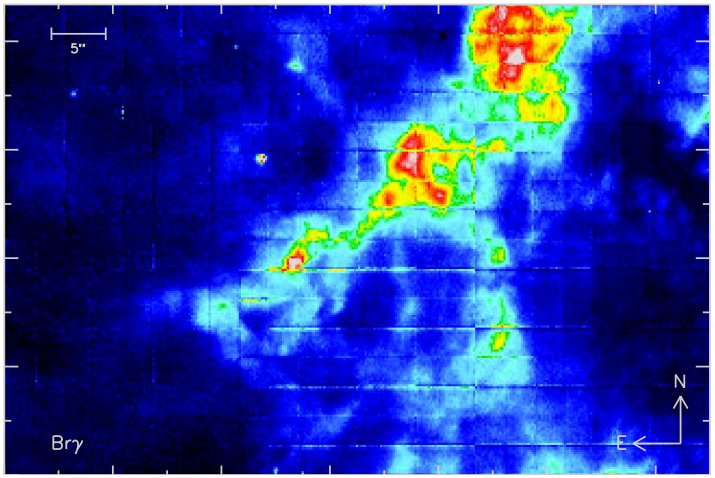
Jupiter methane bands



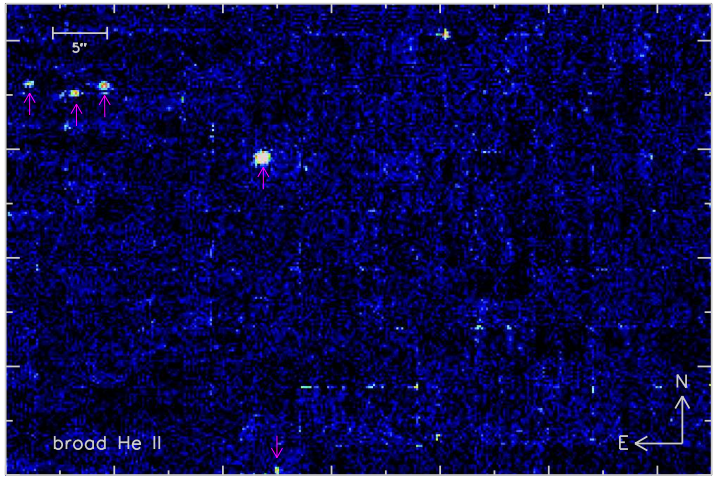


16 pointings
384 IFUs
75,000 spectra

R136 (30 Dor)
R Davies et al
A&A 558, 56 (2013)



Br-γ outflows



HeII Wolf-Rayet stars

Science Papers

- KMOS science papers now starting to hit the press:
  - Davies et al 2013, A&A 558, 56
  - Sobral et al 2013, ApJ 779, 139
  - Wuyts et al 2014, arXiv1405.6590
  - Genzel et al 2014, arXiv1406.0183
  - Stott et al 2014, arXiv1407.1047

Summary

- KMOS is a new multi-object near-infrared integral field spectrograph now available at the ESO VLT.
- Performance has been verified through and extensive series of technical and scientific tests at Paranal.
- KMOS is already beginning to make its mark in 3D spectroscopic surveys of a wide variety of different science areas.

Thank You