SALT RSS-NIR
MID-TERM REVIEW
MAY 20 & 21, 2009

Functional Performance Requirements, Expected Performance and Science/Engineering Trades

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FPRD

- OCCD defines the scientific requirements of the instrument and describes operational scenarios.
- These are translated into technical requirements in FPRD
- Controlled document signed by the Instrument PI and SALT PS
- All functional requirements must be testable
- Functional requirements are the criteria for acceptance of the instrument

Optical

- Field Size: **8 arcminutes linear**
- Plate Scale: **76 microns/arcsec, 4.22 pixels/arcsec**
- Wavelength Coverage: **0.8-1.7 um**
- Slit Widths: **0.5”-1.25”**
- Spectral Resolution: **R=7000**/arcsecond in z, J or H band
- System sensitivity: **J=20.2, H_{short}=18.7**, in 3600 s at SNR=10
- Scattered Light: below **2%** of total input radiation
- Ghost Images (focusing optics): **<5e-4** at 2” from parent image
- Polarimetruic Sensitivity: TBD
- Calibration: SALT facility, PenRay lamps:Ar-Hg,Xe,Ne, Kr
- Increase in RMS spot radius: **<10 um** spectroscopic, **15 um** imaging
- Telescope Alignment: **< 1%** of primary DIA on grating
- Focusing: L4-L5 group

Optical continued

- The total amount of thermal background light at the science detector must **less than the intra-OH sky background** at an R=7000 using one of the 3 wavelength cutoff filters. (not including dust)
- Throughput: of ≥ **40% at peak blaze and 28% at the edge of the order if SolGel coatings are used and** ≥ 35% at peak blaze and 25% at the edge of the order if conventional AR coatings are used, including grating, dichroic and filter losses.
- Filters: shall have a bay of **12 filters**, which will be changeable with no impact to the optical system during the daytime operations support.
- Coatings: All optics will have conventional dielectric AR coatings or hardened SolGel.
- All coatings shall be unaffected by repeated thermal cycling over the operating, storage, and transportation temperature ranges.

Detector

- Readnoise: RSS-NIR will employ read noise reduction techniques, to achieve an effective read noise of **< 20 e**.
- Dark Current :The **RSS-NIR** detector should have a dark current < **0.1 e s^{-1} pix^{-1}** with a goal of < 0.01 e s^{-1} pix^{-1}
- Bias variations shall be less than the read noise for t= 3600 s, .
- Gain variations shall be less **1%** for t=3600s.
- The detector shall be mounted such that, once adjusted, it can be removed and reinstalled without necessitating optical realignment.

Mechanical

- Flexure: Residual image motion **< 1 pixel rms** over 3600 s integration
- Where adequate mounting precision cannot be provided by dead reckoning, convenient means will be provided to measure the misalignment of optical components of the spectrograph under ambient conditions, and then adjust their alignment with a precision that allows the optical performance specification to be met. Where thermally induced misalignment is significant, theoretically derived compensation will be applied.
- Cool Down Time: The RSS-NIR cryogenic cooling system shall have the capability to cool the instrument from room temperature to operating conditions in **7.2 hours** or less.
- The RSS-NIR Pre-Dewar cooling system shall have the capability to cool the instrument from room temperature to operating conditions in **2.5 hours** or less.

Mechanical

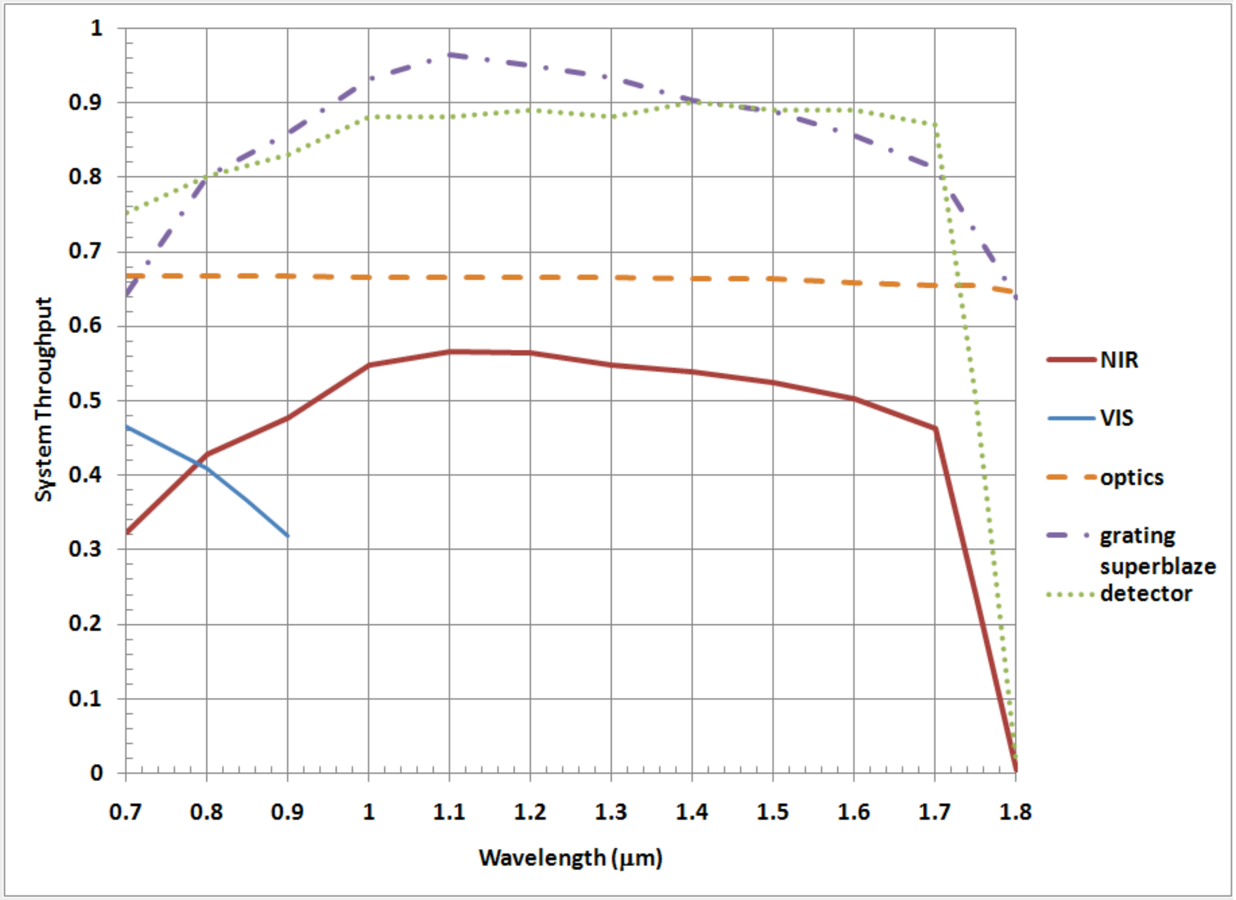
- Warm Up Time: RSS-NIR shall not require more than **7.2 hours** to warm up the entire instrument from operating conditions to room temperature.
- Thermal Stability of cryogenic Dewar: The RSS-NIR detector assembly shall have an active temperature control system providing a variable temperature to be set at the optimum temperature for the detector between **100 K** and **140 K**, with a stability of **≤ ± 0.1 K**.
- Thermal Stability of Pre-Dewar: The interior volume of the Pre-Dewar in which the optical system is mounted shall have an active temperature control system providing a variable temperature to be referenced to the center of the cold work surface between **-33C** and **-40C** with a stability of ±**0.5 K**.
- Limiting Rate of Temperature Change-cryogenic Dewar: the temperature control system shall limit the rate of change at the detector to **0.5 K per minute**.

Mechanical

- Limiting Rate of Temperature Change-Pre-Dewar: the temperature control system shall limit the rate of change in the Pre-Dewar to **0.5 K per minute.**
- Warming Up of the Dewar: If the thermal characteristics of RSS-NIR are such that warming up by turning off the cryo-coolers will not meet the requirement in section 6.6.2, the temperature control system shall actively heat the detector and the cold plate to speed the warming up, so that RSS-NIR meets this requirement, but the rate of change of temperature shall be limited to **0.5 K per minute**.
- Warming Up of the Pre-Dewar : If the thermal characteristics of RSS-NIR are such that warming up by turning off the Pre-Dewar chiller will not meet the requirement in section 6.6.2, the temperature control system shall actively heat the Pre-Dewar to speed the warming up, so that RSS-NIR meets this requirement, but the rate of change of temperature shall be limited to **0.5 K per minute**.

INSTRUMENT THROUGHPUT

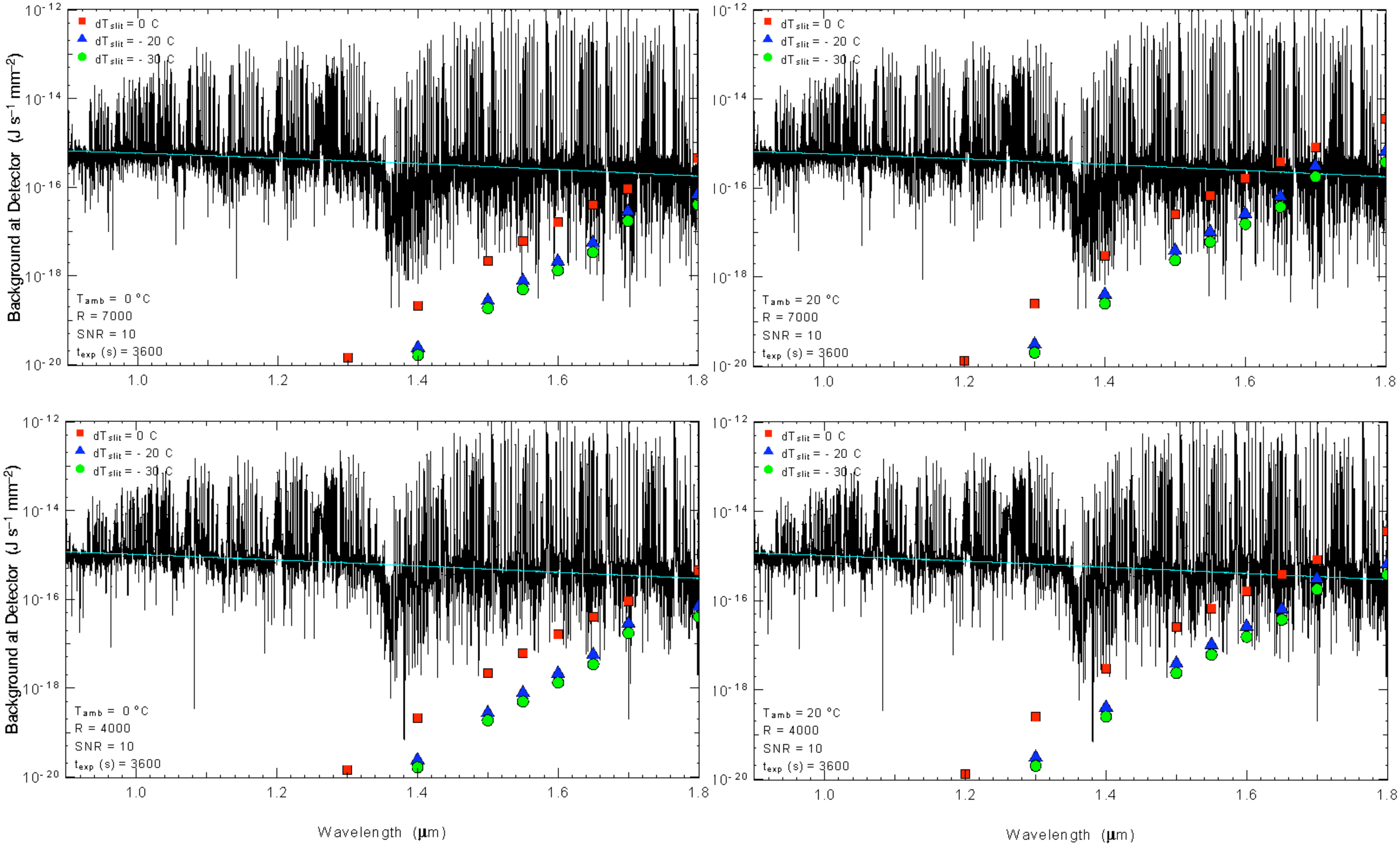
- T of all optical materials
- 1% R coatings
- Grating superblaze predicted by Kolgelnik approximation
- Hawaii-2RG-1.7μm measured QE
  - Beletic et al. 2008 SPIE



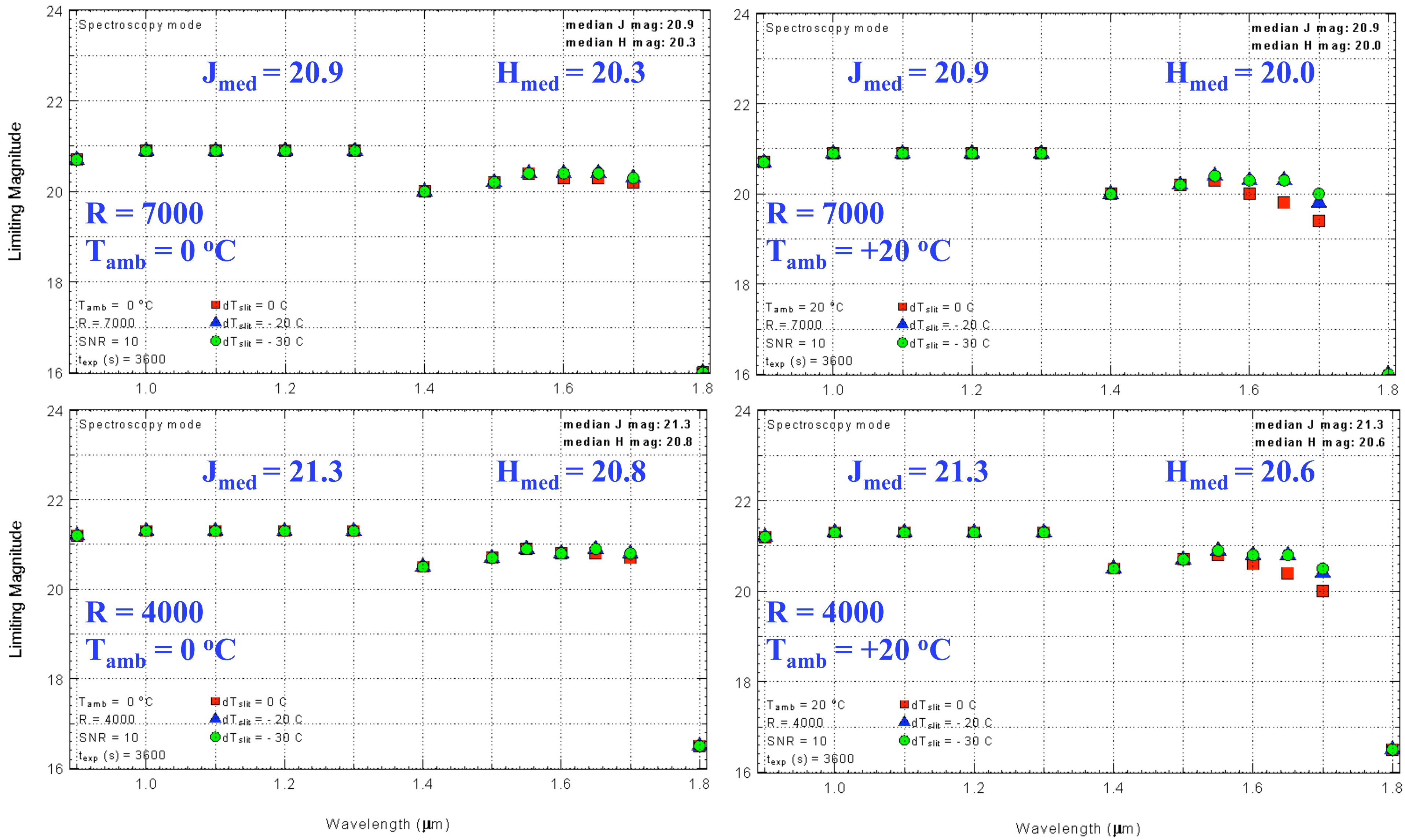
PERFORAMCE MODEL

- Instrument throughput from previous slide
- Telescope
  - Primary mirror: R = 89%
  - 4 SAC mirrors: R = 96% each
- Thermal backgrounds predicted by ASAP
- Night sky spectrum from Maunea Kea
  - airmass = 1.5
  - H_2O = 1.6 mm
  - $\Delta\lambda$ = 0.04 nm (R ~ 33750)
  - Smooth to our spectral resolution and find continuum level between lines at specific wavelengths

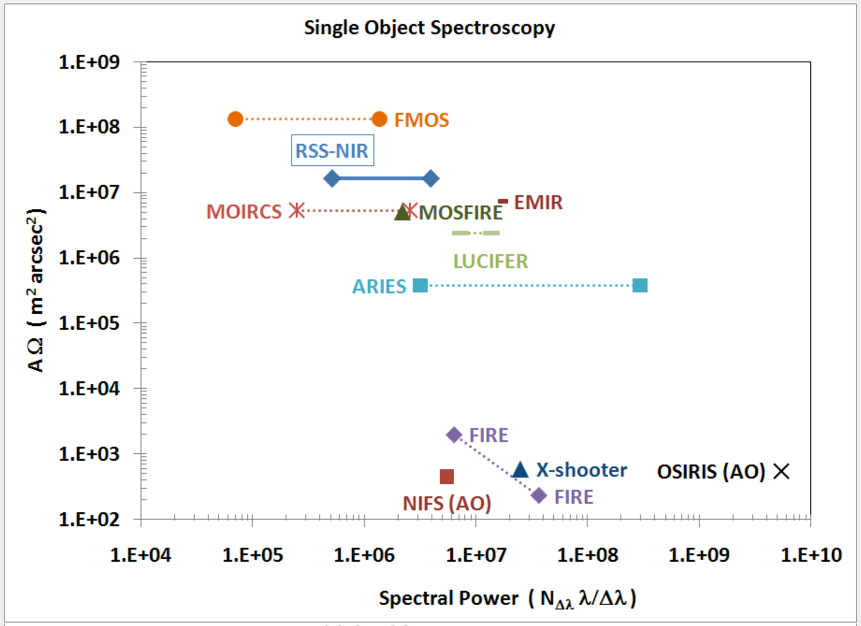
BACKGROUNDS

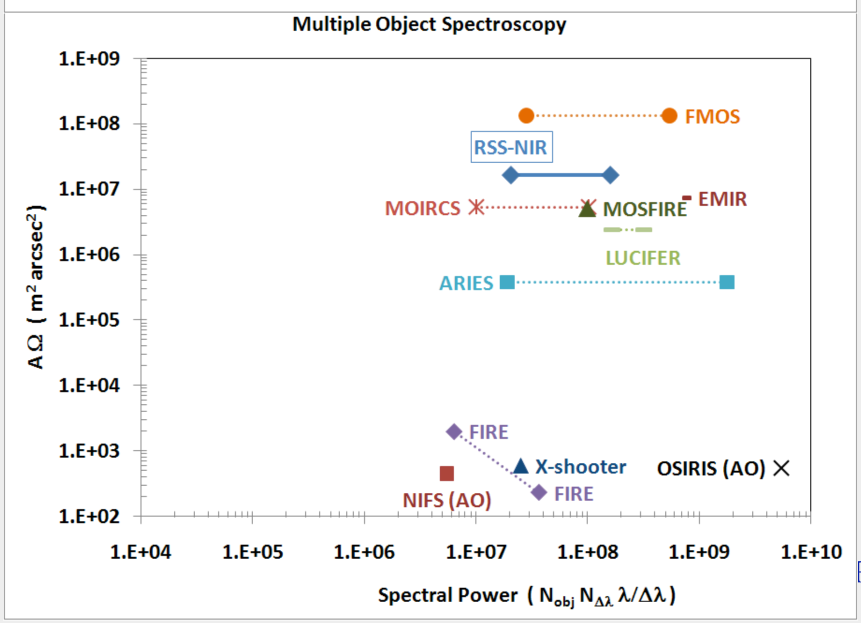


LIMITING VEGA MAGNITUDES



COMPARISON TO OTHER INSTRUMENTS





Telescope	Instrument	Resolution	A Ω	$N_{\Delta\lambda}$ λ/Δλ	N_{obj} $N_{\Delta\lambda}$ λ/Δλ
SALT	RSS-NIR	4000	4.41E+04	1.12E+06	4.50E+07
	RSS-NIR	7000	4.41E+04	3.95E+06	1.58E+08
Keck	MOSFIRE	3270	5.09E+06	2.21E+06	9.92E+07
Subaru	MOIRCS	500	5.32E+06	2.50E+05	1.00E+07
	MOIRCS	1600	5.32E+06	2.56E+06	1.02E+08
Subaru	FMOS	500	1.34E+08	7.03E+04	2.81E+07
	FMOS	2200	1.34E+08	1.36E+06	5.45E+08
VLT	X-shooter	5000	5.90E+02	2.50E+07	2.50E+07
GTC	EMIR	4000	7.34E+06	1.60E+07	7.20E+08
LBT	LUCIFER	10000	2.39E+06	1.38E+07	3.16E+08
	LUCIFER	5000	2.39E+06	7.19E+06	1.65E+08
Magellan	FIRE	6000	2.32E+02	3.65E+07	3.65E+07
	FIRE	2500	1.99E+03	6.33E+06	6.33E+06
MMT	ARIES	2000	3.80E+05	3.15E+06	1.89E+07
	ARIES	30000	3.80E+05	2.98E+08	1.79E+09

COMPARISON TO OTHER INSTRUMENTS

$$P = \frac{R\left(\frac{\lambda_2}{\lambda_1}\right)}{t}$$

R = spectral resolution
λ_2 = longest wavelength in FSR
λ_1 = shortest wavelength in FSR
t = time to S/N=10 $Å^{-1}$ for H_{AB} = 19.5

Telescope	Instrument	Resolution	Time (s)	P (single)	P (MOS)
SALT	RSS-NIR	4000	652.17	6.58	263.21
	RSS-NIR	7000	1125.45	6.74	269.67
Keck	MOSFIRE	3270	127.52	31.36	1411.25
Subaru	MOIRCS	1600	21493.27	0.21	8.27
VLT	X-shooter	5000	4586.19	6.90	6.90
GTC	EMIR	4000	524.93	21.17	952.50
Magellan	FIRE	6000	6698.35	2.53	2.53
MMT	ARIES	2000	7219.09	0.58	3.48
	ARIES	30000	1846.29	23.14	138.83

Science-Engineering Trade