Science Case and Science Requirements

- Science Case developed by Science Team
- Key science cases used to develop instrument design drivers
- Individual cases are in the form of an observing proposal with science and technical cases using conceptual instrument design and estimated sensitivity
- Science requirements flow down from science cases

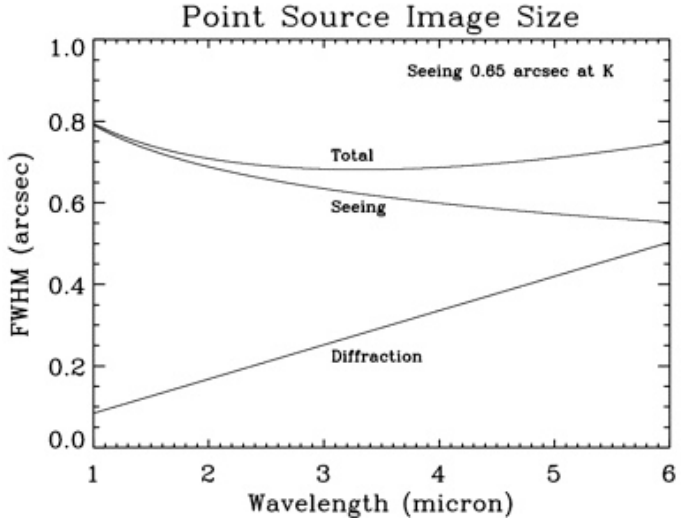
Key Science Cases

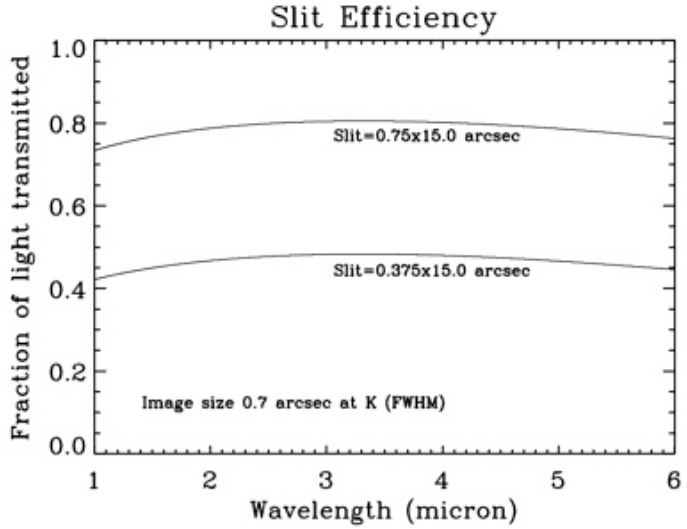
- Composition of comets (*L*)
- Minor constituents in the atmosphere of Mars (*L*)
- Ion winds in Jupiter's upper atmosphere (H_3^+ and Juno support) (*L*)
- The atmospheres of Jupiter and Saturn (*LM'*)
- Probing the atmospheres of hot giant planets (*KL*)
- Finding the youngest planets with iSHELL (precision RV) (*K*)
- Young binaries of PMS calibration (*HK*)
- Structure and kinematics of protostellar envelopes (*M'*)
- Protostellar evolution (*LM'*)
- Magnetic fields and rotation – understanding accretion (*HK*)
- Preplanetary disks and astrobiology (*L*)
- Stellar library (*JHKLM'*)

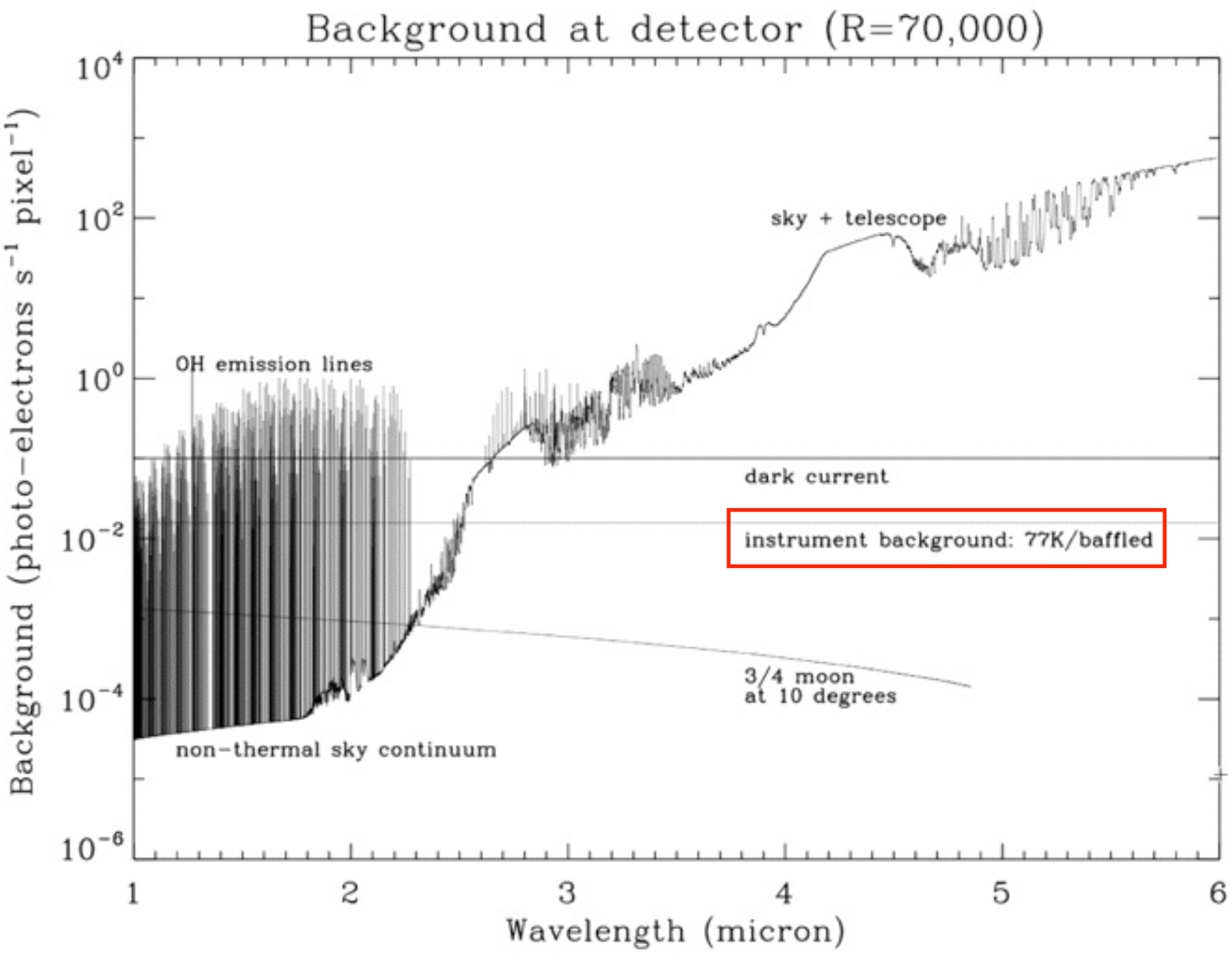
Developing requirements: Sensitivity

Derived from a model of the instrument and atmosphere (ATRAN)

Parameter	*iSHELL*
Resolving power (R)	70,000
Spectral sampling	3 pixels per slit width
Wavelength coverage	1.15-5.3 μm
Spatial sampling	0.125″ per pixel
Slit width	0.375″
Detector	2040x2040 H2RG
Read noise (multiple reads)	5 e RMS
Dark current	0.1 e/s
Throughput	0.10 (see Table 9)






Background at detector (R=70,000)
Background (photo-electrons s^{-1} pixel^{-1})
10^4
10^2
10^0
10^{-2}
10^{-4}
10^{-6}
1
2
3
4
5
6
Wavelength (micron)
sky + telescope
OH emission lines
dark current
instrument background: 77K/baffled
3/4 moon
at 10 degrees
non-thermal sky continuum

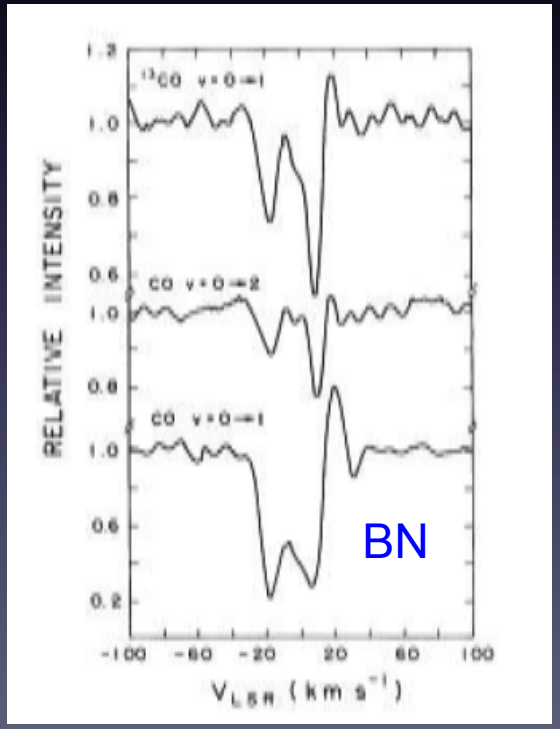
Developing requirements: Sensitivity

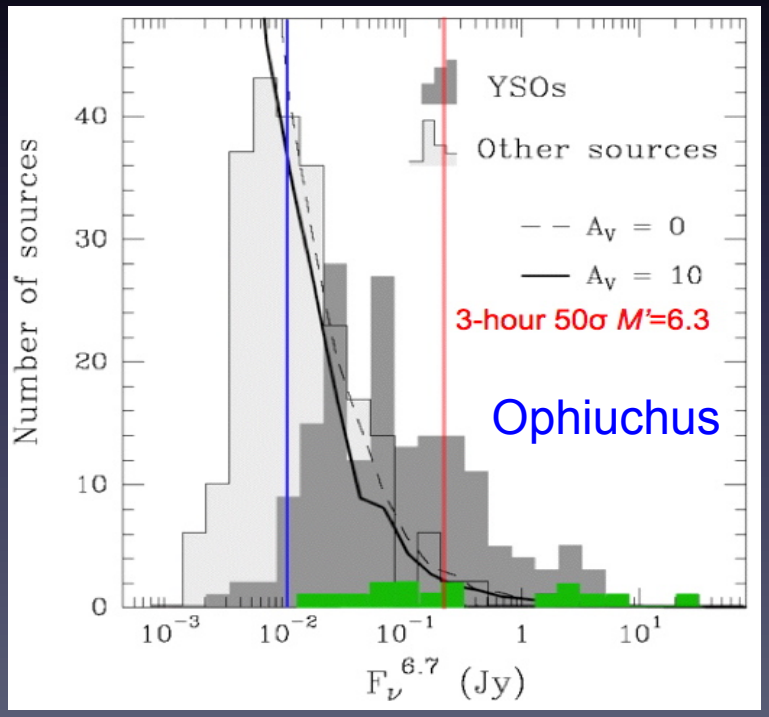
Effect of detector performance on point source one-hour 100 σ, *R*=70,000, seeing 0.7”, throughput 0.10

Read noise (e RMS)	Dark (e/s)	*J*	*H*	*K*	*L*	*M*
20	1.00	9.33	8.84	8.44	7.01	5.03
10	0.10	10.18	9.68	9.28	7.36	5.03
10	0.01	10.34	9.85	9.45	7.40	5.03
5	0.10	10.43	9.94	9.53	7.41	5.03
5	0.01	10.77	10.28	9.87	7.45	5.03

Developing requirements: Protostellar envelopes

Observe CO fundamental band absorption features (*M'*) to derive temperature, density and velocity structure of optically opaque in-falling protostellar core to derive mass inflow rate





Developing requirements: Protostellar envelopes

Parameter	Requirement	
	Essential	Optimum
Resolving power?	R=35,000 (8 km s^{-1})	R=70,000 (4 km s^{-1})
Wavelength coverage?	M′-band, ~λ/10	
Target brightness, number of targets?	3-hour M'=6.3, ~10 Class I in Ophiuchus,	
Required S/N?	30	100
Spatial resolution?′	Point source	
Slit length?	15″	
Rotate slit?	No	
Sky subtraction?	Nod in slit	
Standard star?	Yes	
Wavelength calibration?	Arcs or telluric features	
Acquisition?	$KL'M'$ imaging	
Guiding?	K-band on source or offset	
Imaging?	$KL'M'$ photometry	

Facility Requirements

Strategic and practical considerations. Not derived from Science Case

- FR_1 High resolution 1-5 μm spectroscopy
  Replace CSHELL, use immersion grating
- FR_2 Use one Teledyne H2RG array
  For cost reasons
- FR_3 Provide data reduction tool
  Critical for IRTF that observers reduce data fast and efficiently (like SpeX)

Science Derived Requirements

- SR_1 Resolving power
- SR_2 Sensitivity
- SR_3 Continuous wavelength range
- SR_4 Simultaneous wavelength range
- SR_5 Slit width
- SR_6 Sampling
- SR_7 Slit length
- SR_8 Slit orientation
- SR_9 S/N limit
- SR_10 Wavelength measurement
- SR_11 Radial velocity precision
- SR_12 Spectral response function
- SR_13 Cadence
- SR_14 Observing efficiency
- SR_15 Instrument accessibility
- SR_16 Absolute flux

Top-Level Requirements

These flow down from science derived requirements

- TR_1 Throughput
- TR_2 Read noise
- TR_3 Dark current
- TR_4 Spectrograph detector cosmetics
- TR_5 Spectrograph pixel-field-of-view
- TR_6 Instrument background
- TR_7 Image rotator
- TR_8 Cold stop and pupil viewer
- TR_9 Slit viewer
- TR_10 Image quality at spectrograph detector
- TR_11 Image stability at spectrograph detector
- TR_12 Image quality at slit
- TR_13 Image stability and positioning at slit

Top-Level Requirements

- TR_14 Image quality at slit viewer detector
- TR_15 Image stability at slit viewer detector
- TR_16 Position of slit viewer detector
- TR_17 Position of spectrograph detector
- TR_18 Stray light at spectrograph detector
- TR_19 Calibration unit
- TR_20 Quick look data viewer

Parameter	*CSHELL performance*	*iSHELL requirement*	*Notes*
Type	single order	cross dispersed	
R	40,000	70,000	
Slit width	0.50″	0.375″	match to seeing
Sampling	2.5 pixels 0.20″ pfov	3.0 pixels 0.125″ pfov	
Slit length	30″	5″, 10″, 15″, 25″	
One-shot $\delta\lambda$	≈ 0.006 μm	≈ 0.2 μm (15″ slit)	at 2.2 μm
S/N limit	< 100	> 1000	systematic
RV precision	≈ 50 m/s	< 10 m/s	
Slit viewer	no	yes, 1-5 μm	A&G (night and day), imaging
Image rotator	on telescope	internal	