IRCS-HRU

Subaru IRCS High Resolution Unit

Hiroshi TERADA
(NAOJ, Hawaii)

Project

『 Man-power 』

Terada (NAOJ) : PI
Pyo (NAOJ): IRCS-related work
Colley, Lamos, Weber (NAOJ) : Electronics, and software
Kobayashi (U-tokyo), Ikeda (Kyoto-SU) :
Immersion grating, and instrument overall
Hayashi, Usuda, Tamura (NAOJ), Kawakita (Kyoto-SU),
Matsunaga (U-Tokyo), Sato (TITech) … : Science
Tokunaga, Rayner (IfA) : Array Electronics, and instrument calibration
Seifahrt (UCD) : Infrared Gas Cell

『 Budget 』

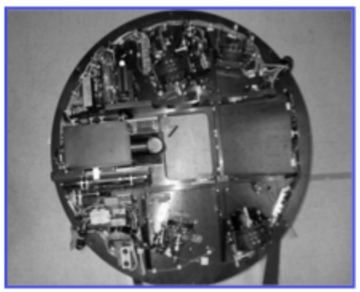
Si immersion grating development : $ 240K
FY18-21 Research promotion budget (PI: Terada)
IRCS-HRU development : $ 300K
FY21-24 Kakenhi (Kiban(A); PI: Hayashi)

Subaru IRCS: Current Status

2000.02--: IRCS

2001.12--: IRCS+AO36

--2005.06



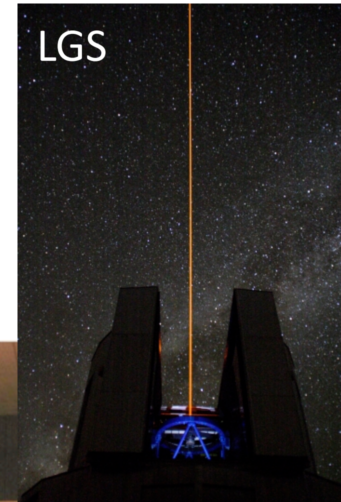
AO36

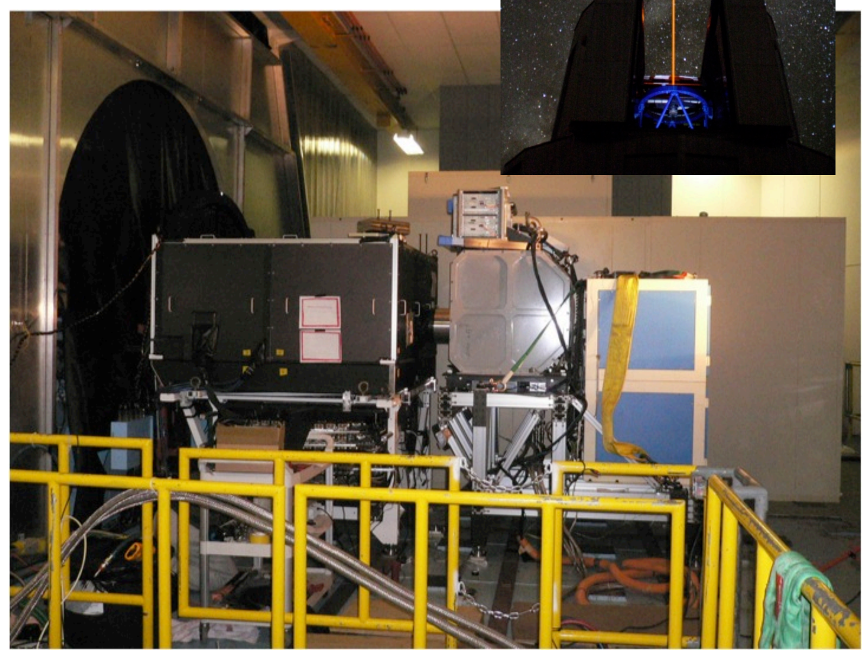
IRCS@Cs

2005.12-- : IRCS

2008.08-- : IRCS+AO188

2011.XX-- : IRCS+AO188 w/ LGS

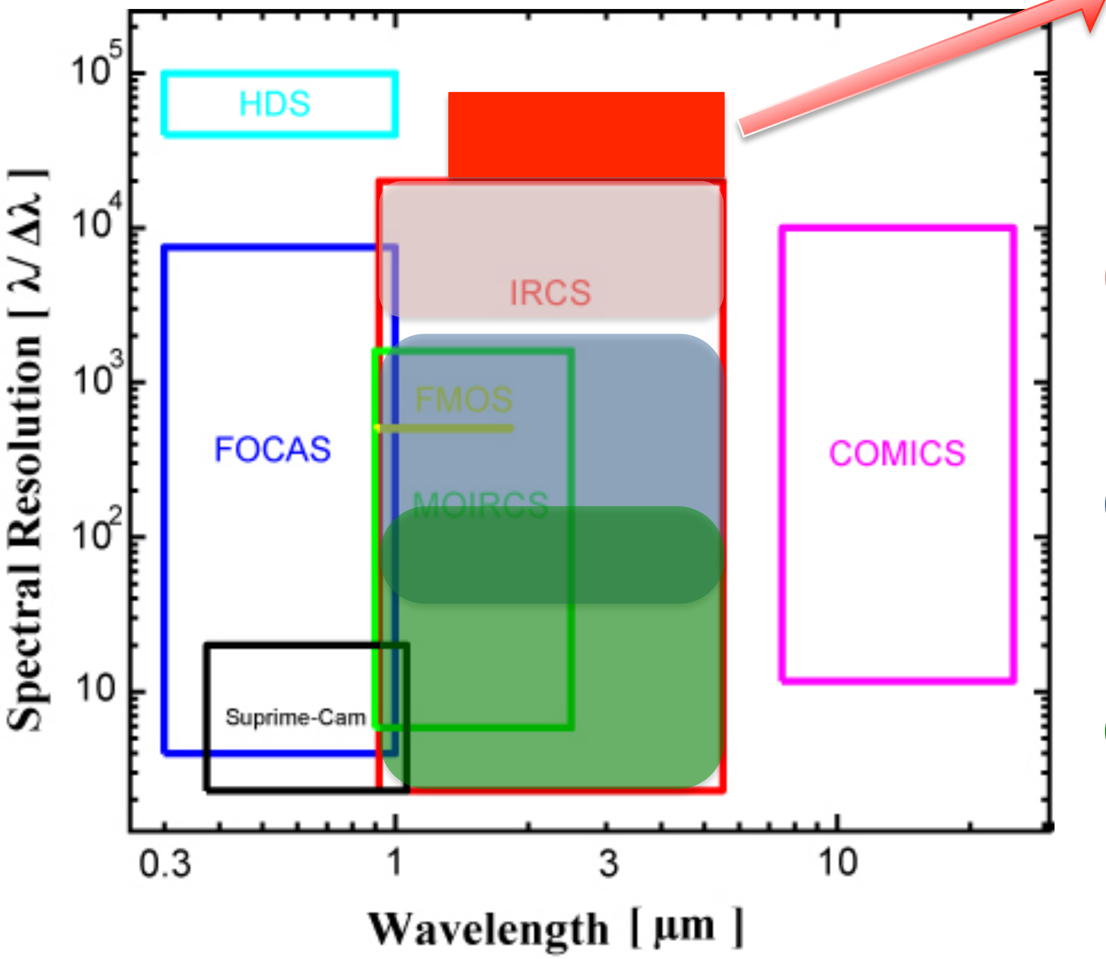




AO188 IRCS@Ns

High Efficiency Spectroscopy w/ AO

Subaru IRCS: Toward Higher Resolution



New feature
R~70,000

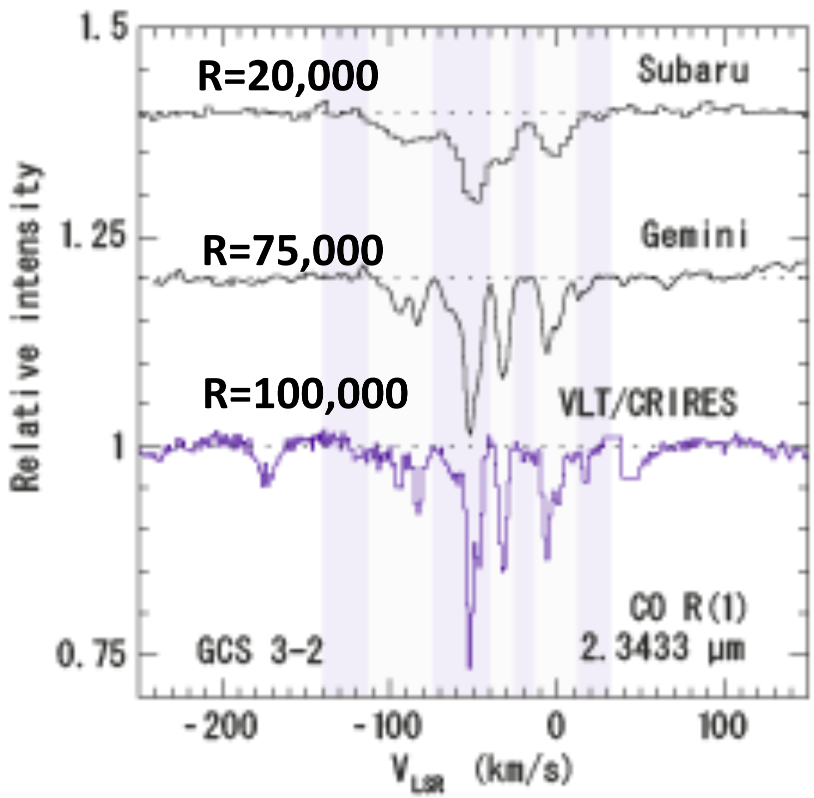
✓Echelle Spectroscopy
0.9-5.5um; R=5,000-20,000
(32mas, 54mas/pix)

✓Grism/Prism Spectroscopy
0.9-5.5um; R=50-2,000
(12mas, 20mas, 52mas/pix)

✓Imaging
0.9-5.5um; NBF & BBF
(12mas, 20mas, 52mas/pix)

Infrared High Resolution Spectroscopy: Merits

- ✓ Narrow Emission/Absorption
  - ✓ Detailed structure of Velocity component



Goto, M. et al. (2007)

Science Cases

- Terrestrial Planet Search
- Interstellar Medium
- Absorption toward QSOs
- Chemistry in Proplyds
- Jet/Outflow from YSOs

. . . . .

Benefit for wide variety of astronomy fields

Infrared High Resolution Spectroscopy: Planet Detection

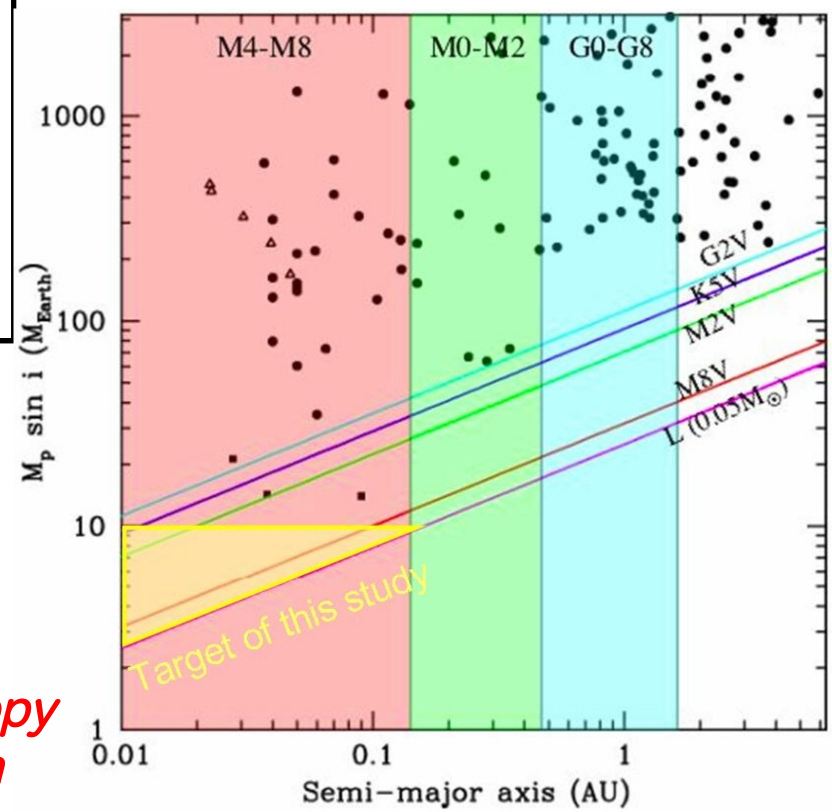
<u>Lower Mass Stars ⇒</u>
<u>Lower Mass Planet Detection</u>

$$K = 28.4 \left(\frac{P}{1\ \mathrm{year}}\right)^{-1/3} \left(\frac{M_p \sin i}{M_\mathrm{J}}\right) \left(\frac{M_*}{M_\odot}\right)^{-2/3} \mathrm{m\,s^{-1}}$$

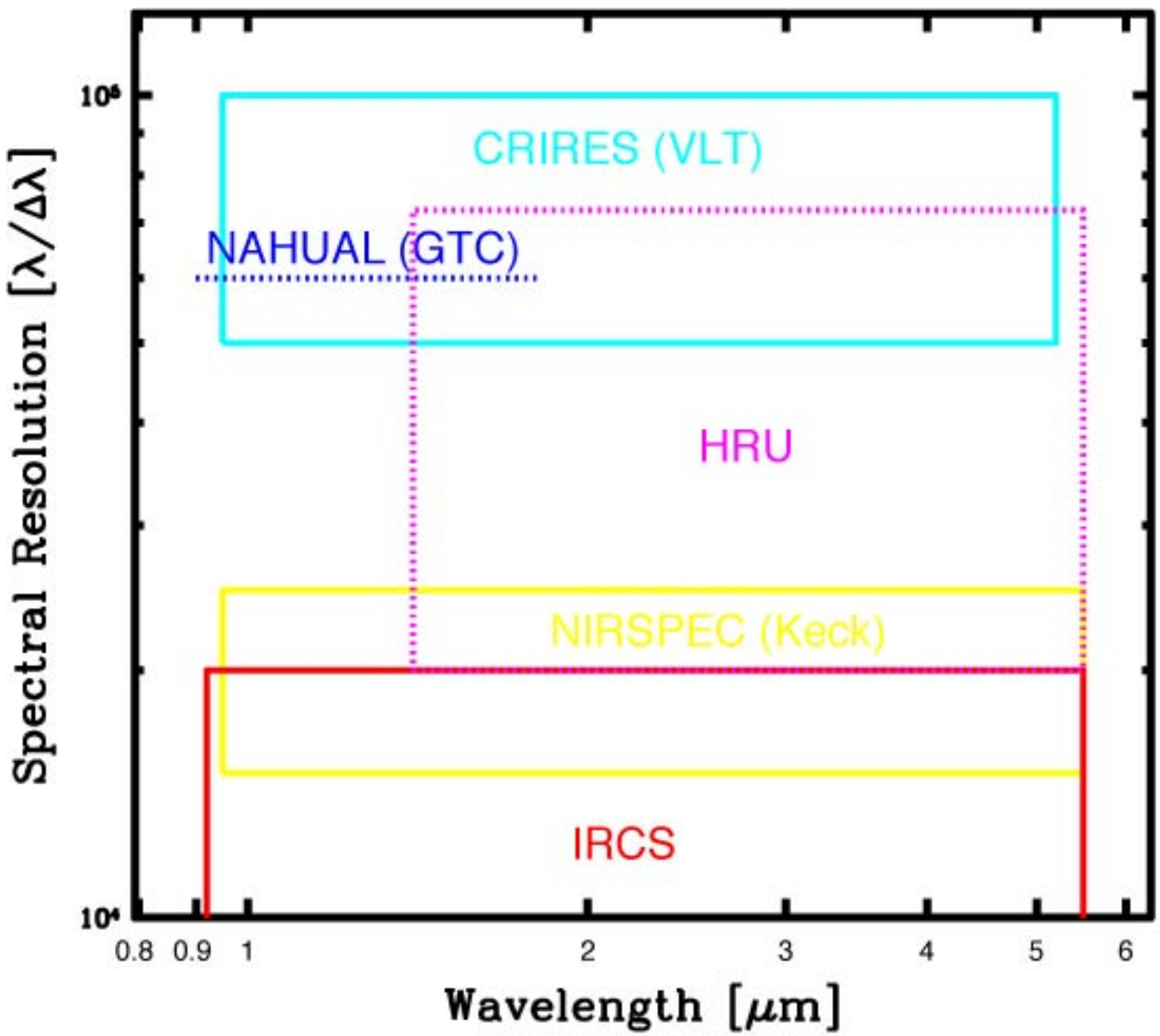
"Doppler search" <10m/s
Terrestrial Planet Detection around M,L-type stars (0.05--0.25 M_solar)

M,L-type stars:
Faint in Optical, but Bright in IR

IR High Resolution (R~70,000) Spectroscopy
Essential for Terrestrial Planet Detection



IR High Resolution Spectroscopy at 8-10m class telescopes

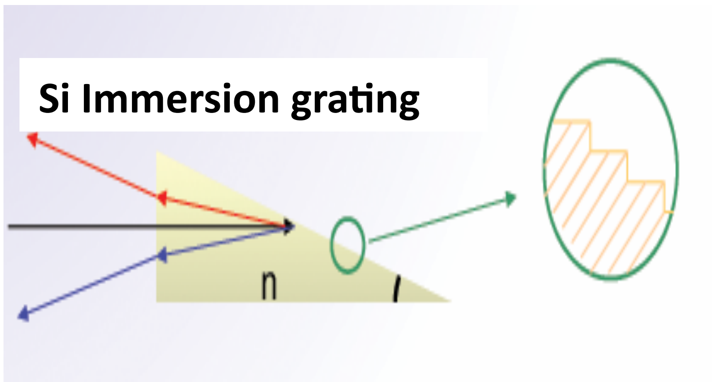


✓ ***First***
in northern hemisphere

✓ ***Only one***
with LGS function

IR High Resolution Spectrograph
At Large telescope / High sensitivity

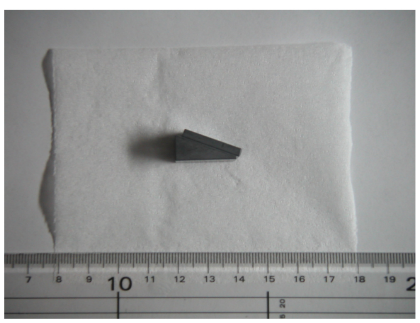
Our Approach:
Si Immersion Grating

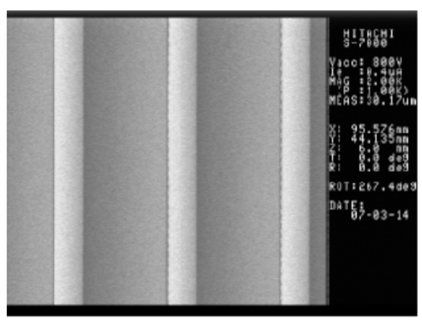


Resolution ∝ Refractive index:(n~3.4)

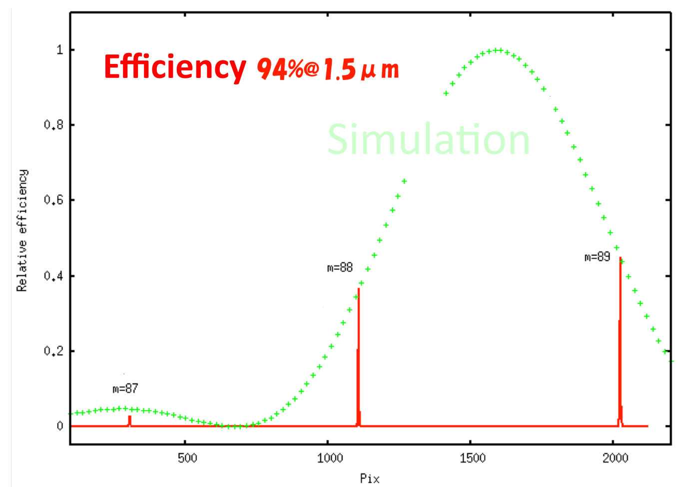
Significantly reduce Optics (dewar) size by 1/n (1/3.4)

Si Immersion Grating
10mm x 20mm Test Groove





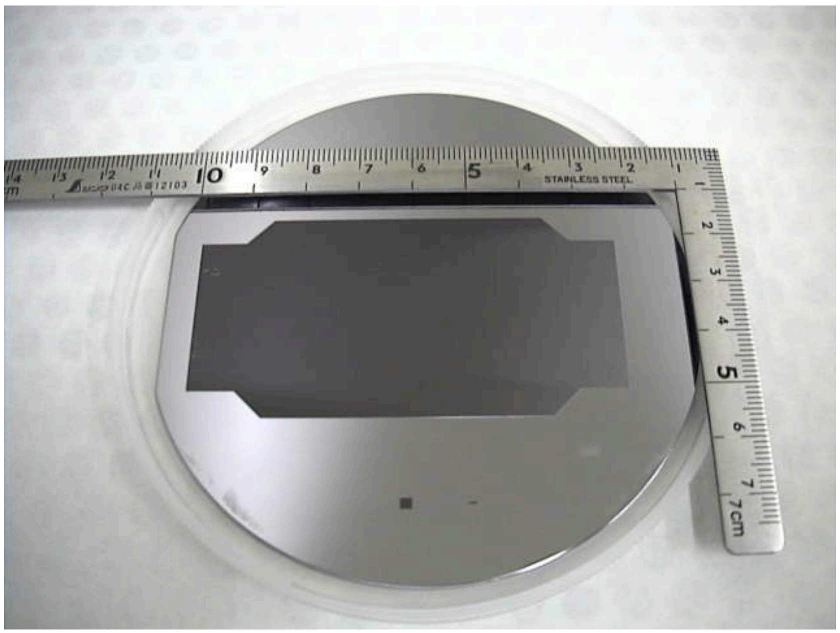
Fabricated by NTT-AT N



Achieved the best efficiency in the world

Si Immersion Grating Development

Si Immersion grooving
on large area (~40mmx~70mm)



Fabricated by NTT-AT N

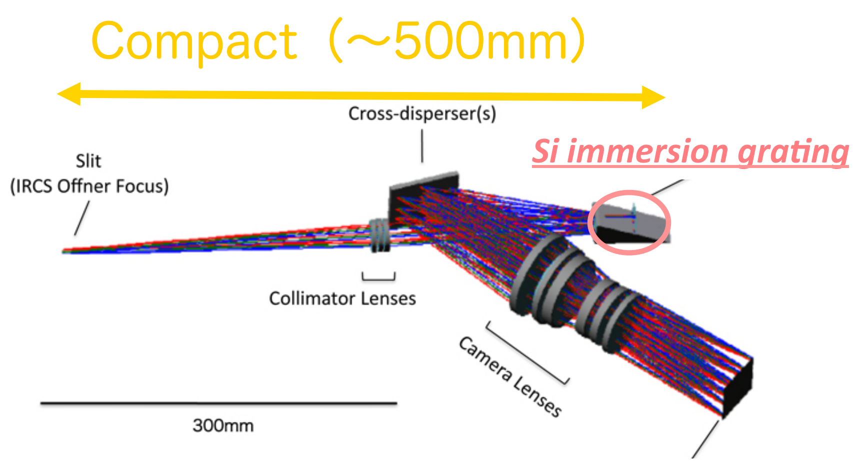
- Si optical contact
  T ~ 90%
- Au coating
  on reflective surface
  R > 90% (1.4-5.5um)

Good total performance as a grating

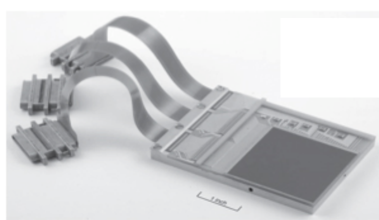
Good quality also for large area groove

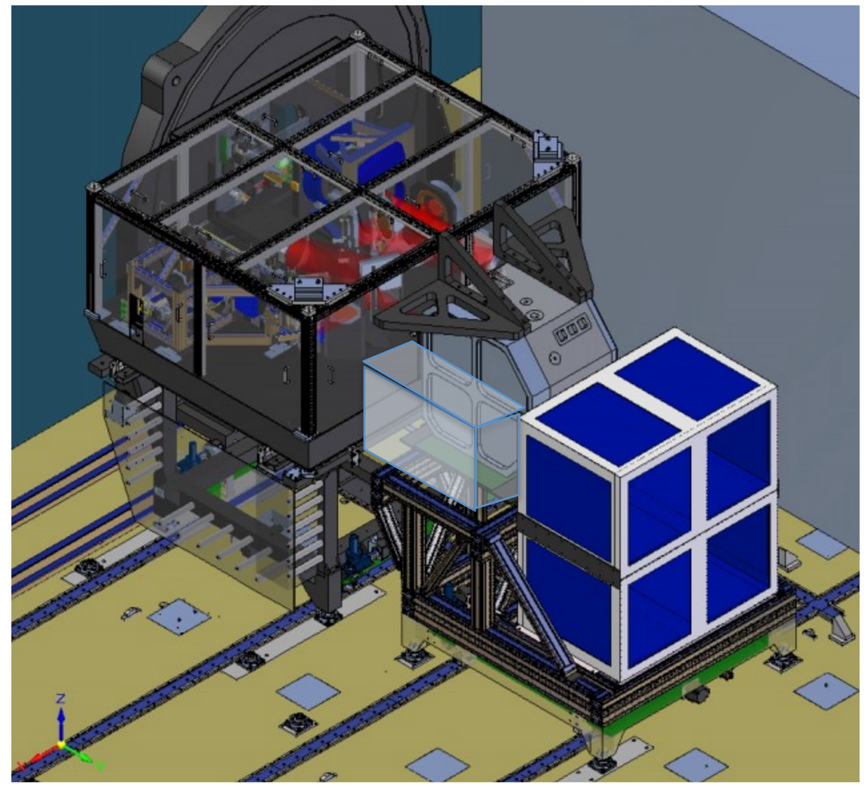
Detailed evaluation ongoing..

IRCS-HRU Layout



Orion 2kx2k InSb



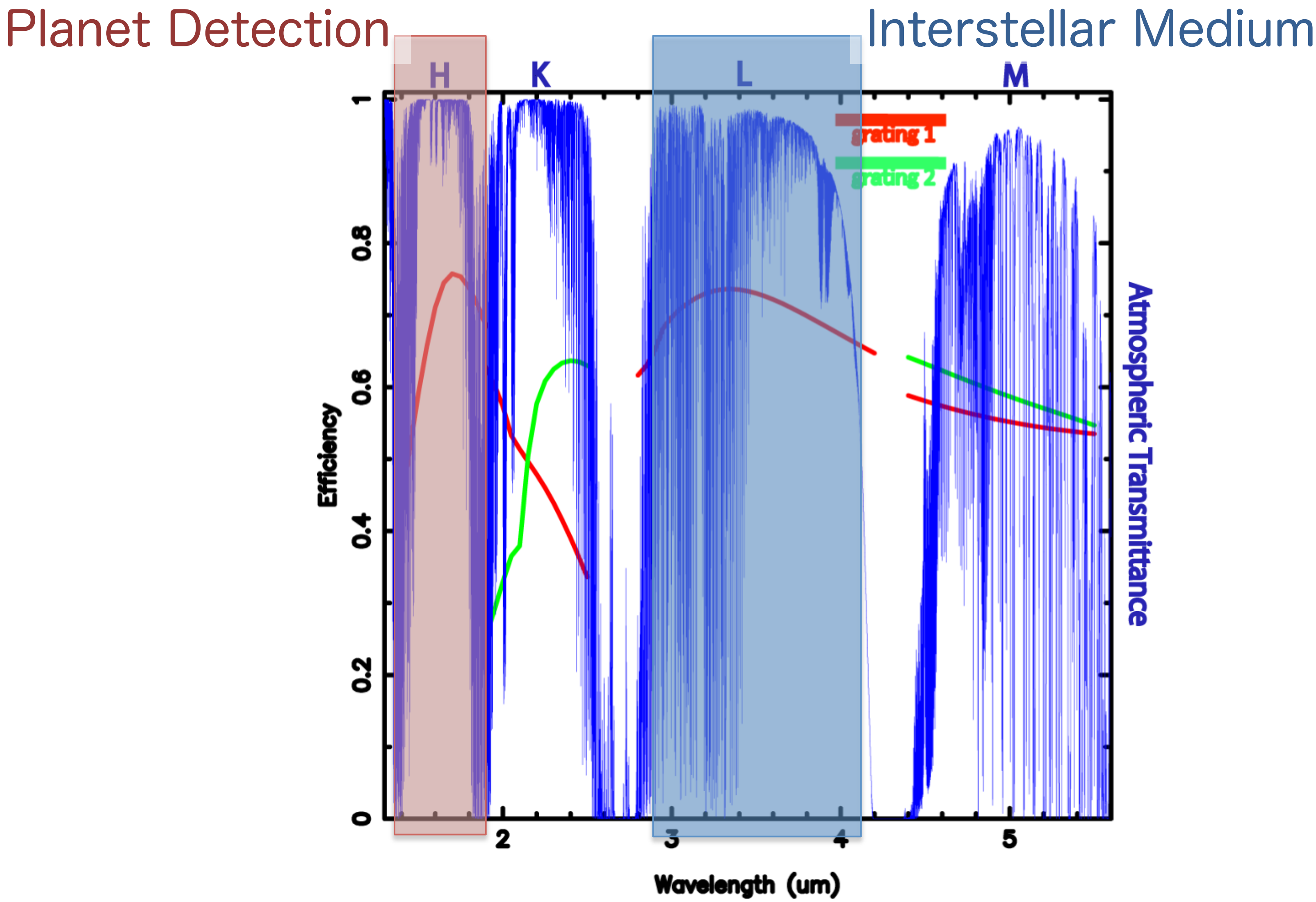


Attach onto IRCS -> Prompt commissioning /
Minimum impact on current IRCS

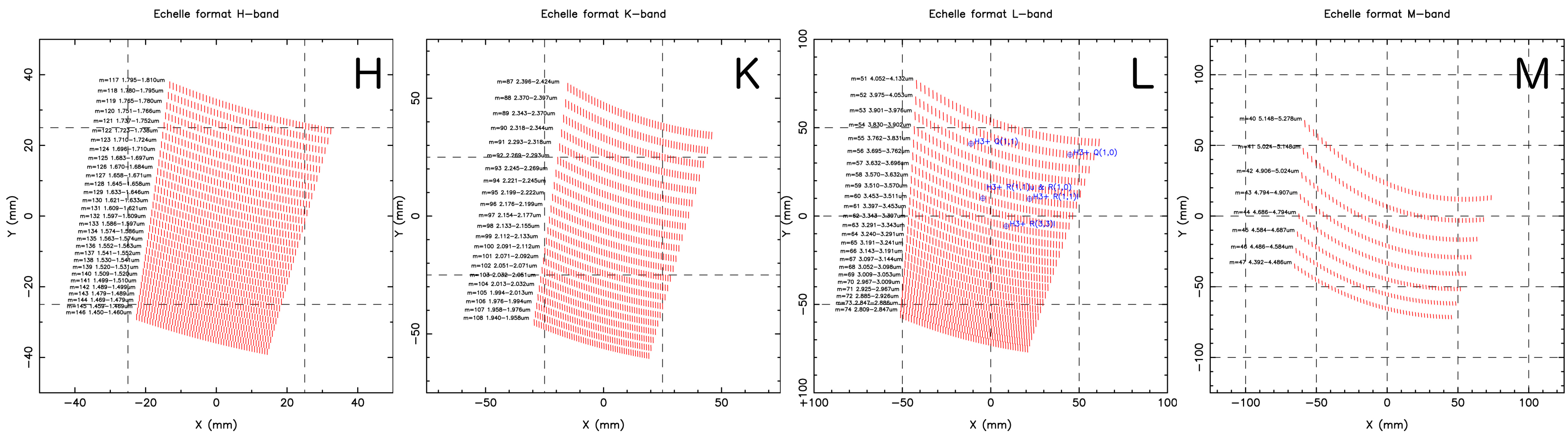
Instrument Specification

Items	Specifications
Wavelength coverage	1.4—5.5μm
Resolving power	72,500 @ 2.2μm
Pixel scale	66—72mas/pixel
Image Quality	Strehl ratio > 0.8 @ 2.2μm
System Throughput	> 15%
Sensitivity	15.3mag (@K, 1hr exposure, S/N=5)
Velocity accuracy	<10m/s

X-disperser Efficiency

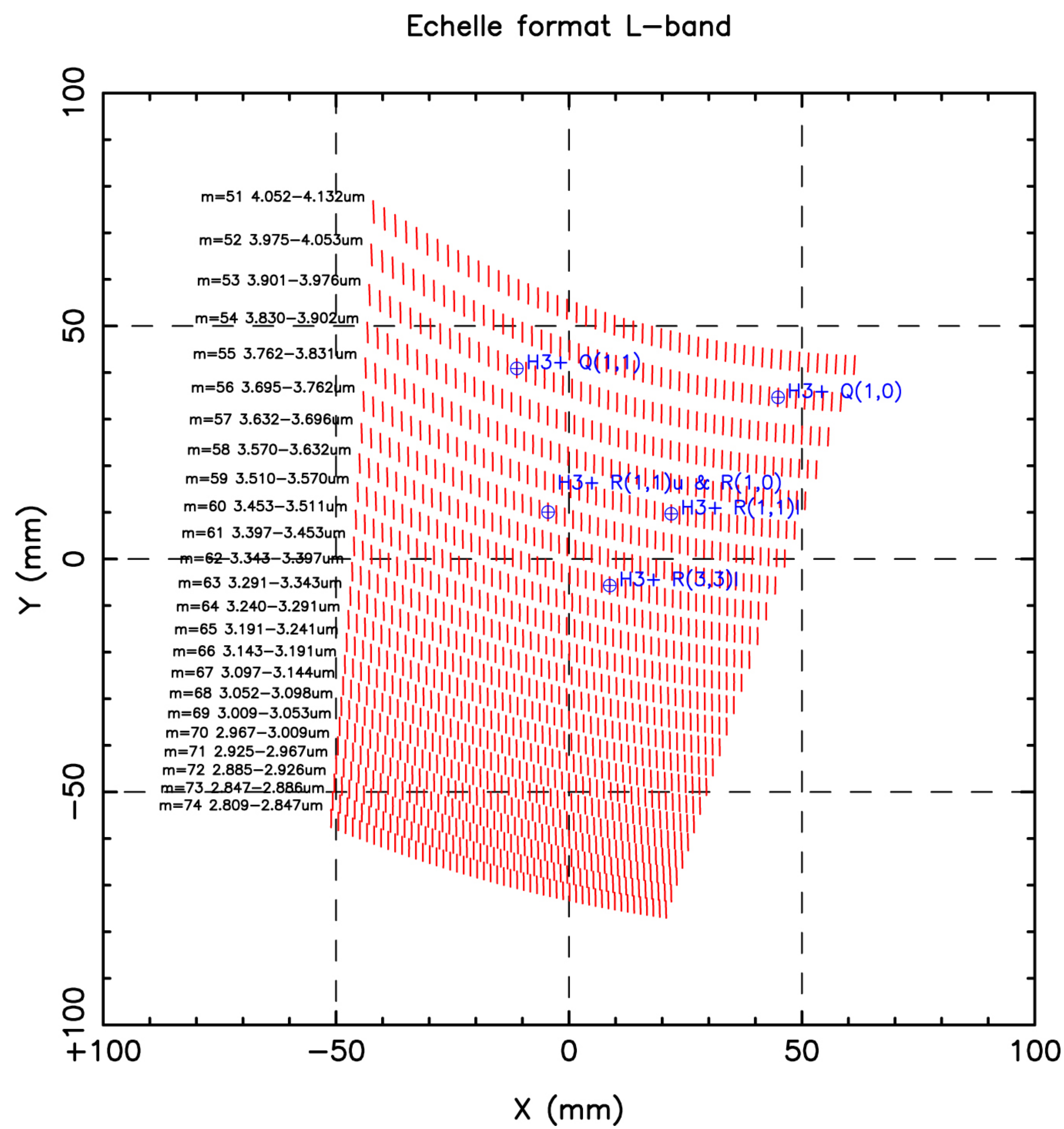


Echelle format



Number of format

BAND	ECHELLE	CROSS-DISPERSER	SUBTOTAL
M	3	3	9
L	3	3	9
K	2	2	4
H	1	2	2
TOTAL			24

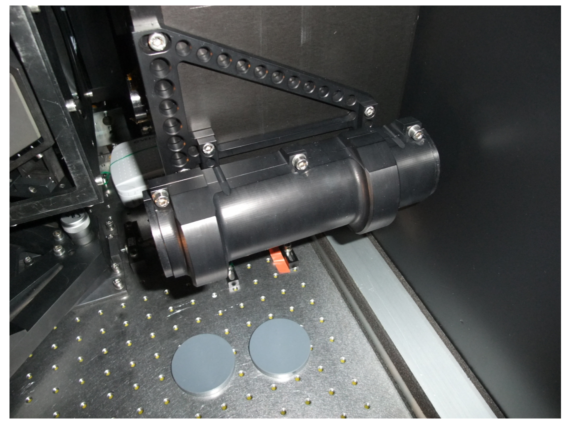


Echelle format L−band
m=51 4.052−4.132um
m=52 3.975−4.053um
m=53 3.901−3.976um
m=54 3.830−3.902um
m=55 3.762−3.831um
m=56 3.695−3.762um
m=57 3.632−3.696um
m=58 3.570−3.632um
m=59 3.510−3.570um
m=60 3.453−3.511um
m=61 3.397−3.453um
m=62 3.343−3.397um
m=63 3.291−3.343um
m=64 3.240−3.291um
m=65 3.191−3.241um
m=66 3.143−3.191um
m=67 3.097−3.144um
m=68 3.052−3.098um
m=69 3.009−3.053um
m=70 2.967−3.009um
m=71 2.925−2.967um
m=72 2.885−2.926um
m=73 2.847−2.886um
m=74 2.809−2.847um
H3+ Q(1,1)
H3+ Q(1,0)
H3+ R(1,1)u & R(1,0)
H3+ R(1,1)l
H3+ R(3,3)l
Y (mm)
X (mm)
100
50
0
−50
−100
−100
−50
0
50
100

Calibration

1. Infrared Gas Cell (attached at AO188)

NH3 gas cell (IRCS; K-band)

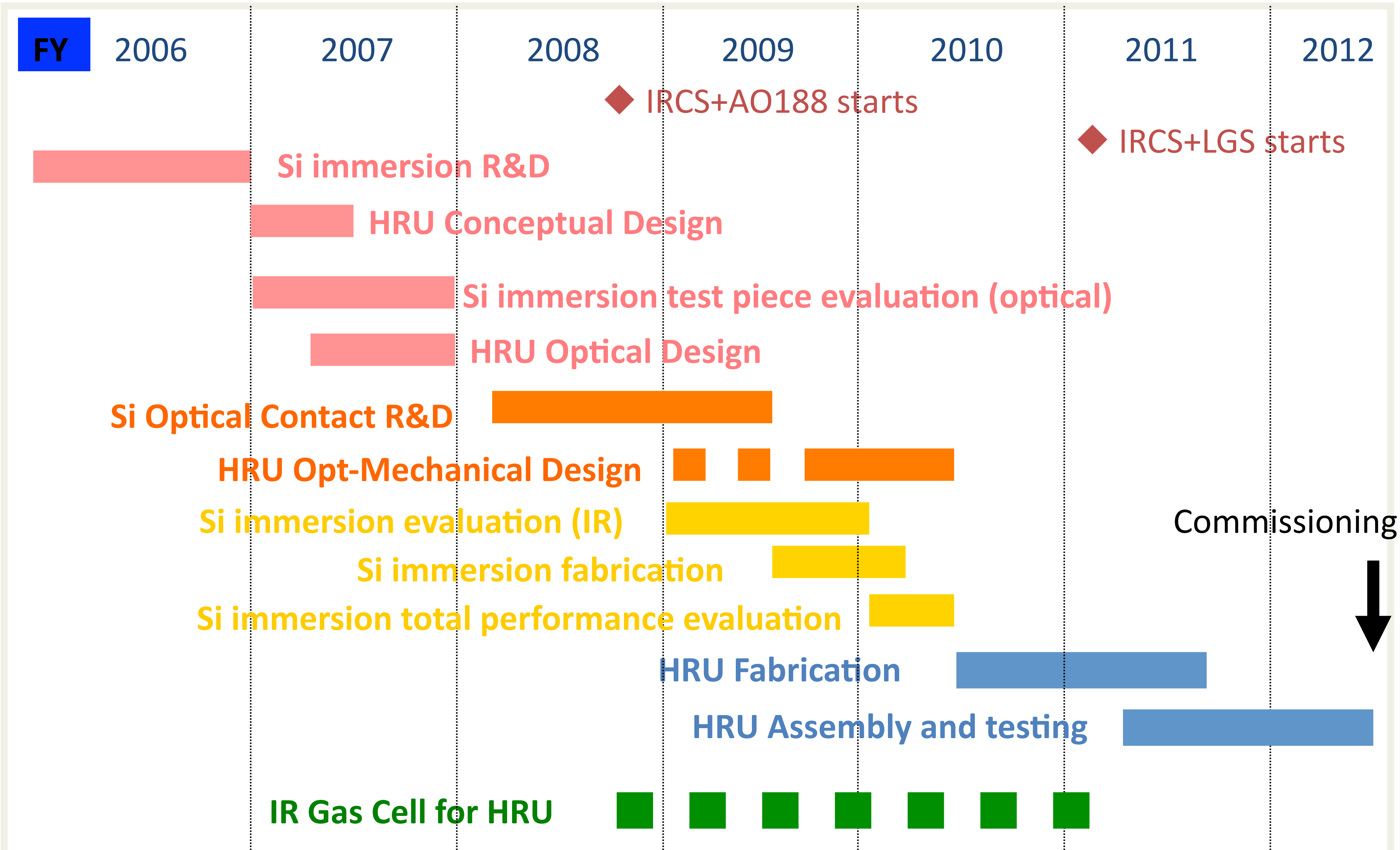


Seifahrt et al.

2. Atmospheric absorption lines

✓ Under testing w/ Velocity standard stars (IRCS; H-band)

Schedule



FY
2006
2007
2008
2009
2010
2011
2012
IRCS+AO188 starts
IRCS+LGS starts
Si immersion R&D
HRU Conceptual Design
Si immersion test piece evaluation (optical)
HRU Optical Design
Si Optical Contact R&D
HRU Opt-Mechanical Design
Si immersion evaluation (IR)
Commissioning
Si immersion fabrication
Si immersion total performance evaluation
HRU Fabrication
HRU Assembly and testing
IR Gas Cell for HRU