OH Suppression Fibre Test Unit

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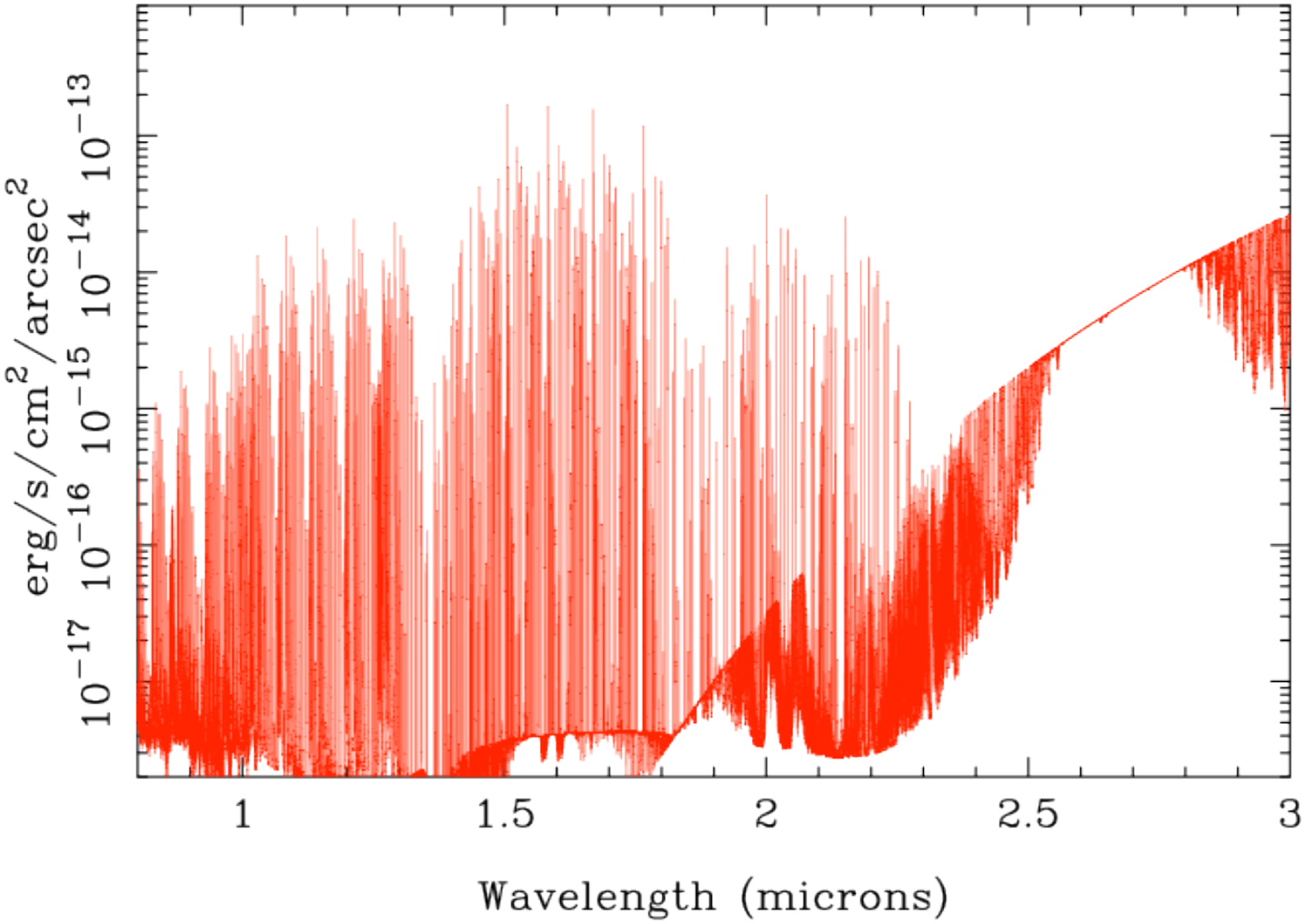
OH Airglow: Major Obstacle for Deep NIR Observation

- Numerous OH Emission lines Dominate Night Sky from the Ground at $\lambda<2\mu m$
- Very Narrow: FWHM<0.1Å (Dominated by Doppler Broadening)
- Short Time-Scale Variability: ~ 5 min



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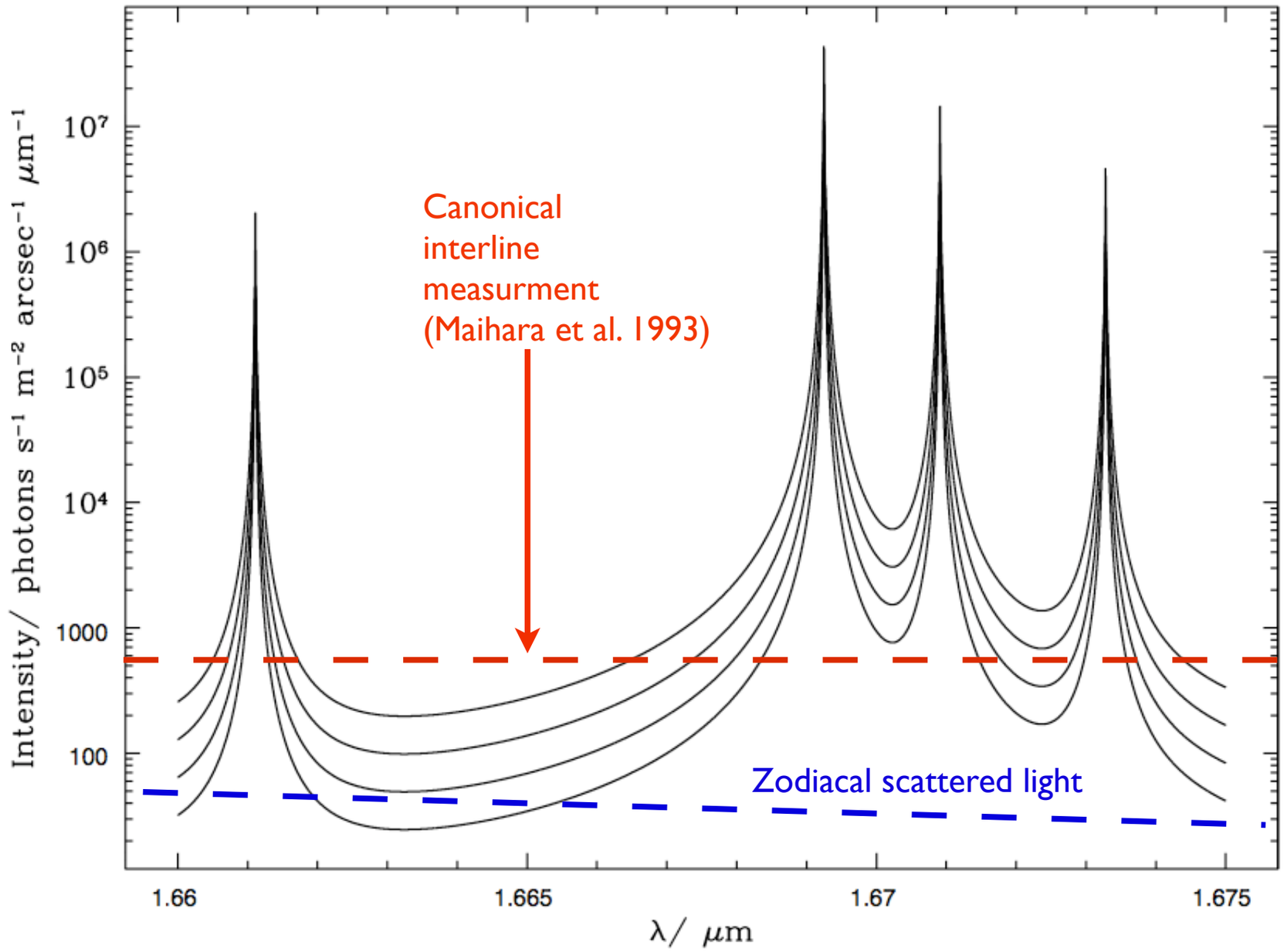
Scattering

$$Y_{\rm fit} = \frac{\omega^2}{(\lambda - \lambda_0)^2 + \omega^2} + A_{\rm B},$$

$$\omega = \frac{\lambda_0}{N\pi\sqrt{2}}.$$



U. Hawaii 2.2m Coudé spectrograph.
600 lines mm^{-1} B&L grating

Woods et al. 1994

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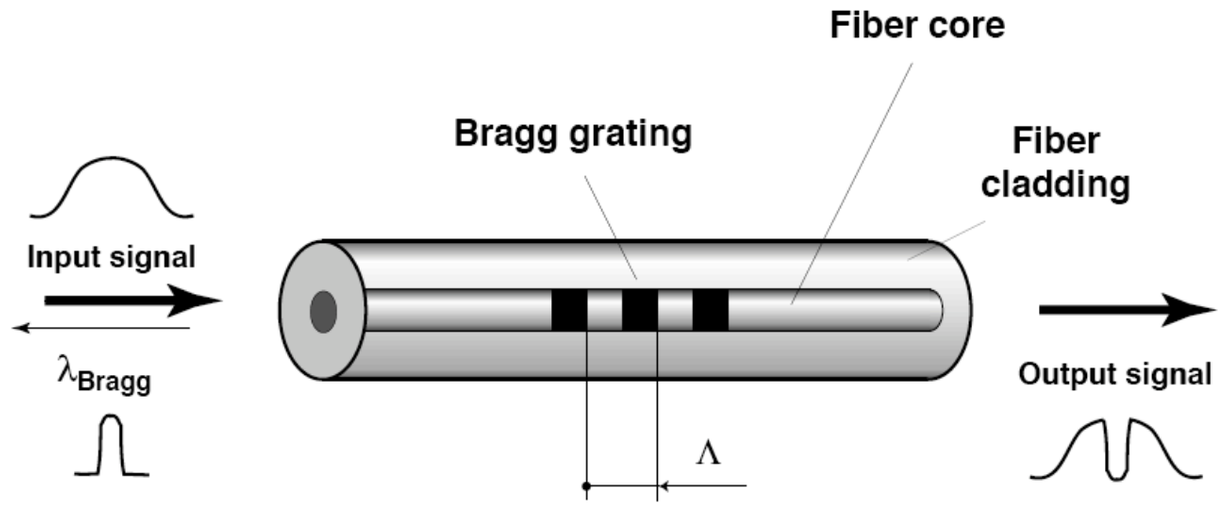
Fibre Bragg Gratings

- Optical fibres with a periodic variation in refractive index
- Fresnel reflections at each boundary
- Small, *but* in phase

  ⇒ high reflection at a single wavelength



Fibre Bragg Grating

- R~10,000 Suppression of OH Line Wavelengths
- Suppress Inter-line Light, which Cannot be Removed by OHS Mask inserted in Dispersed Spectra
- Applicable to Single-Mode Fibres
- In Order to Collect Photons from Astronomical Objects, Multi-mode Fibre is Necessary
- → Need to Convert Multi-mode and Single-mode Fibres

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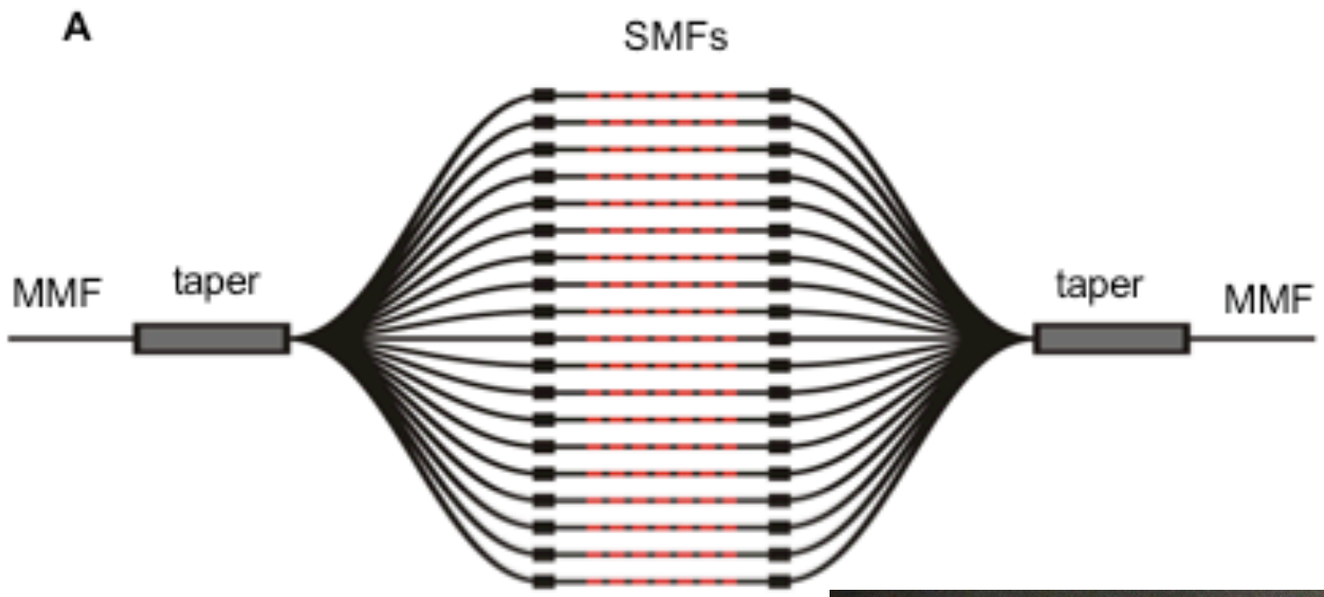
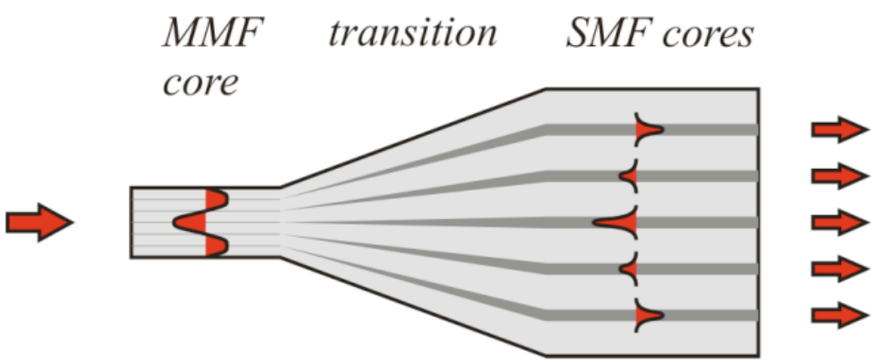
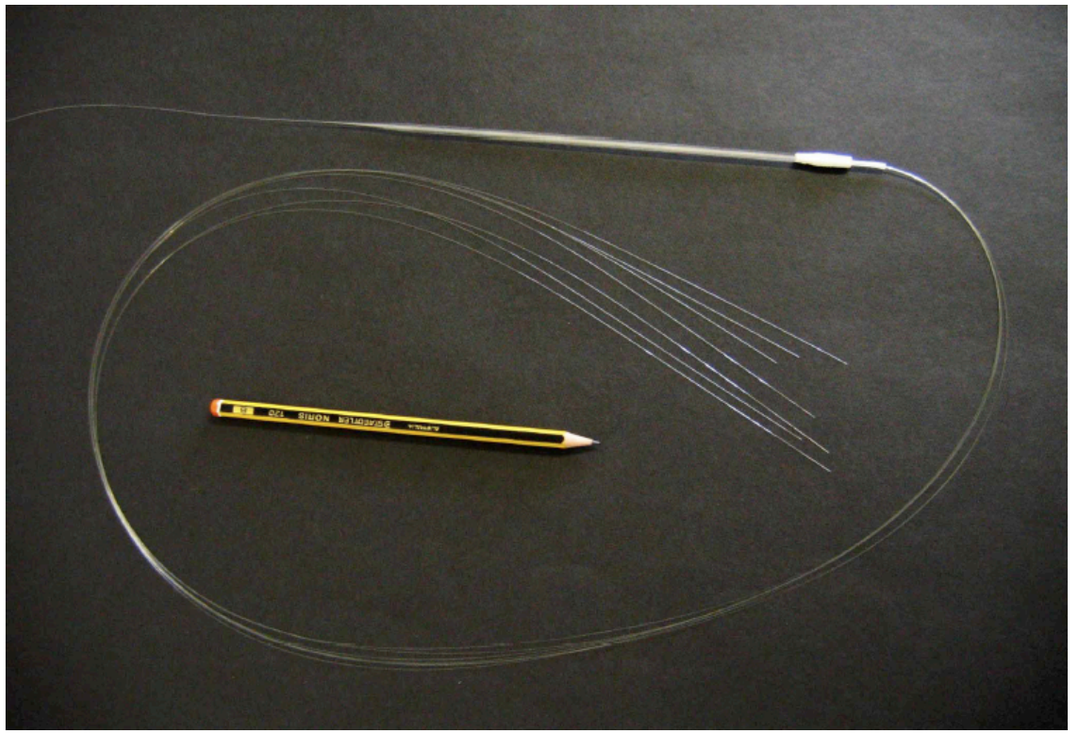
Photonic Lantern







Leon-Saval, Birks, Bland-Hawthorn, 2005
Bland-Hawthorn et al. 2007

Univ. Sydney Photonics Lab. Feb. 2011

FBGs for GNOSIS

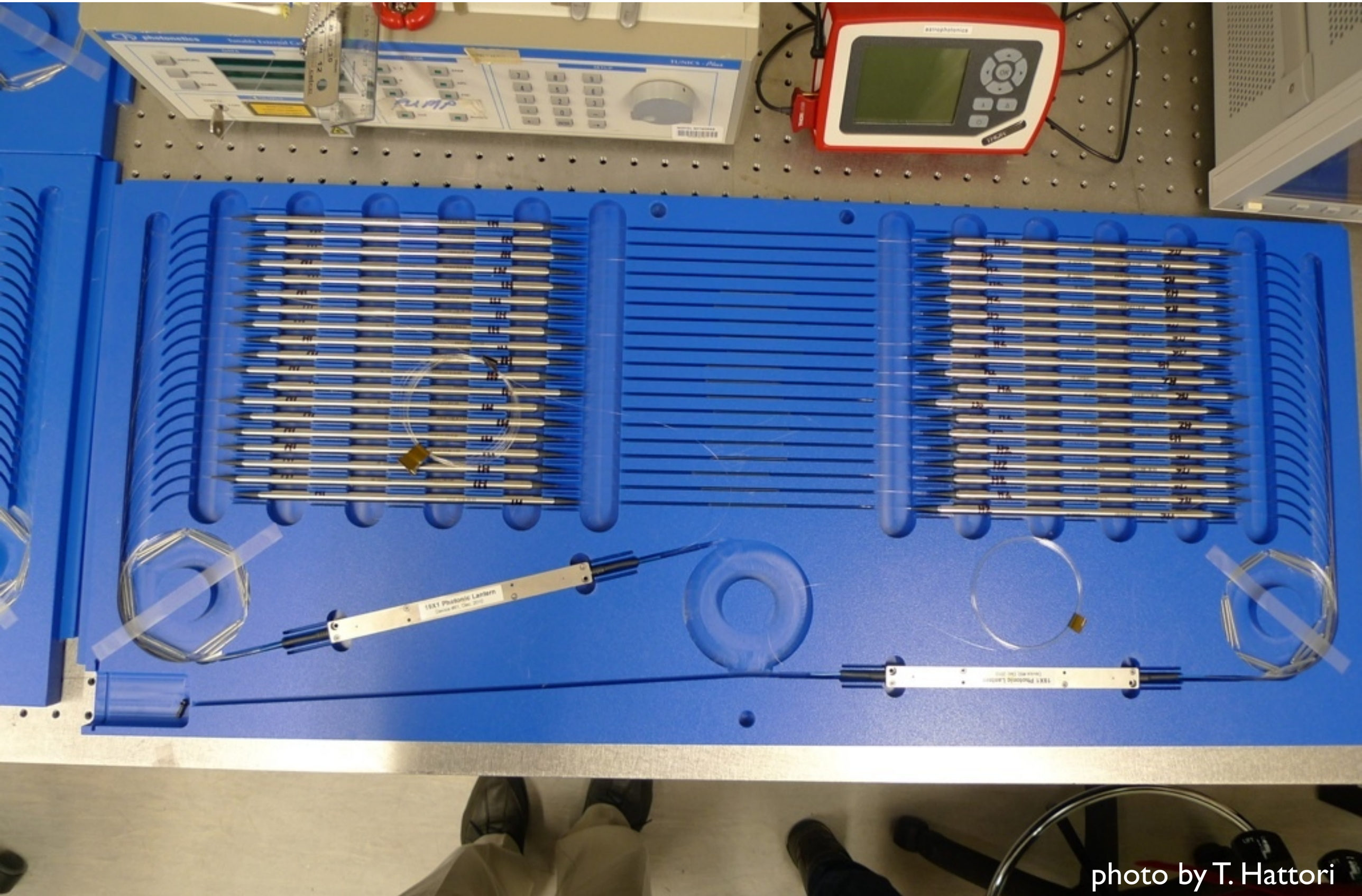
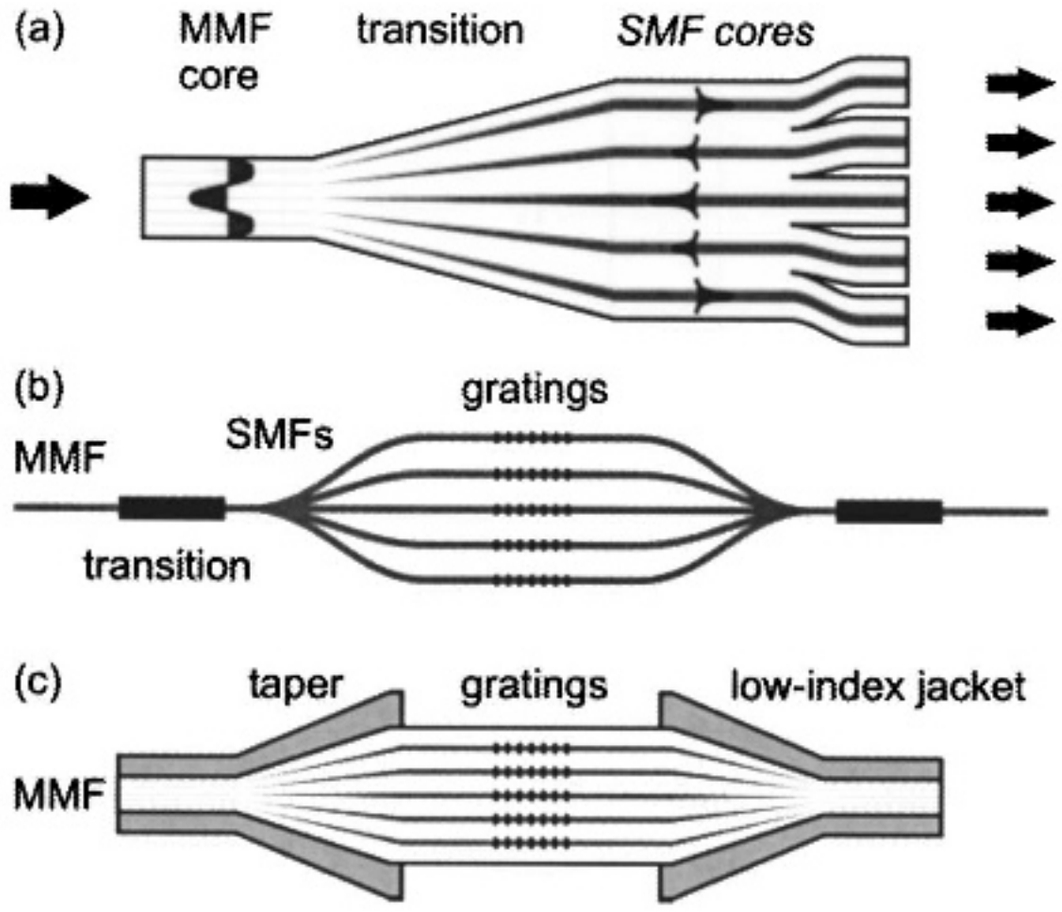


photo by T. Hattori

Multi-Core Fibre Bragg Grating (FBG)

- Current Test Unit (GNOSIS) uses Photonic Lantern which Converts a Multi-mode Fibre to 19 Independent Single-mode FBGs
- Cumbersome to Make and Expensive
- If We use This Technique to Integral Field Spectroscopy, Too Many FBGs Will be Required.
- Implement FBG on Multi-Core Single-mode Fibres



Leon-Saval et al. 2005, Optics Letters 19, 2545

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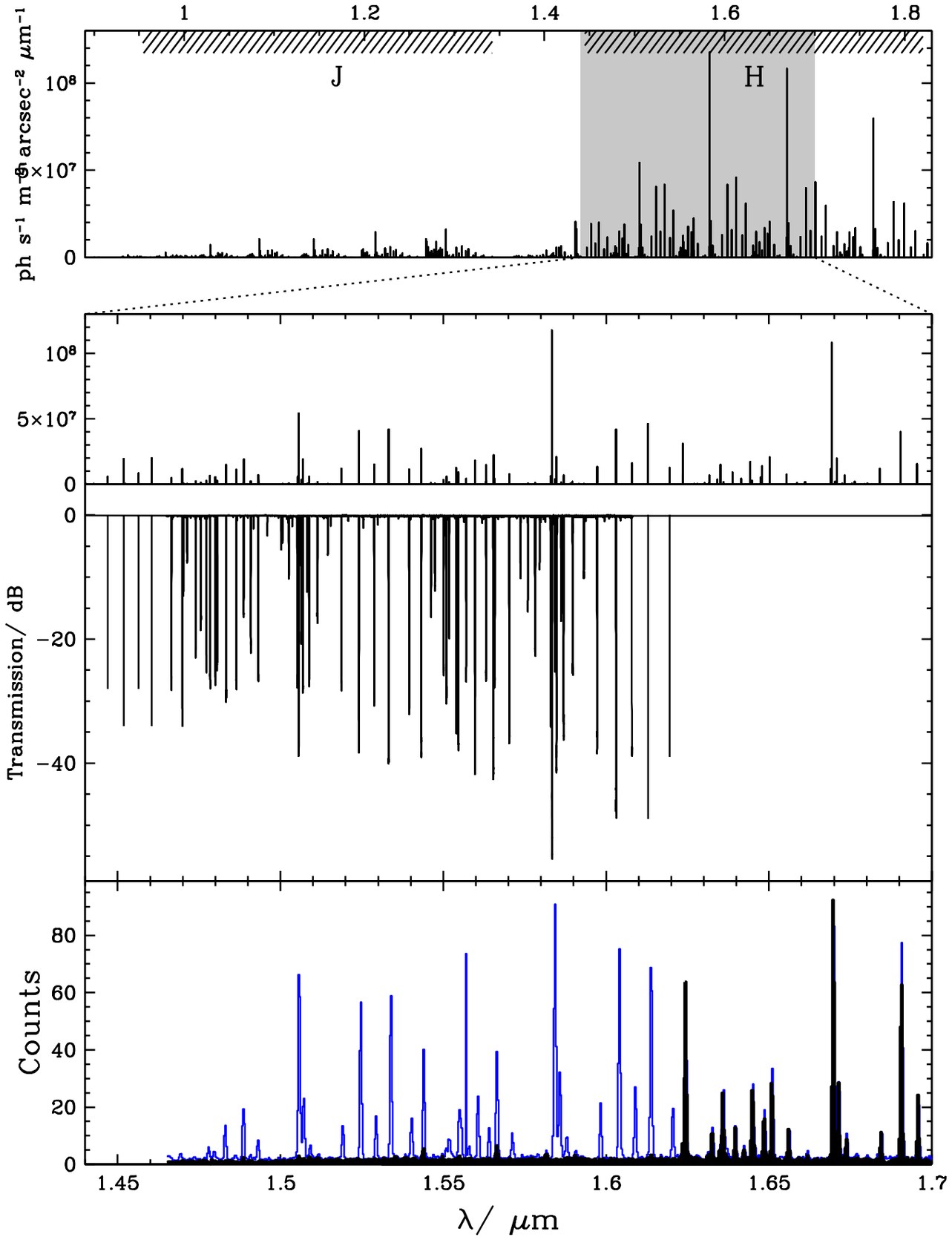
On-sky demonstration



2 x 60μm core fibres pointed directly at sky

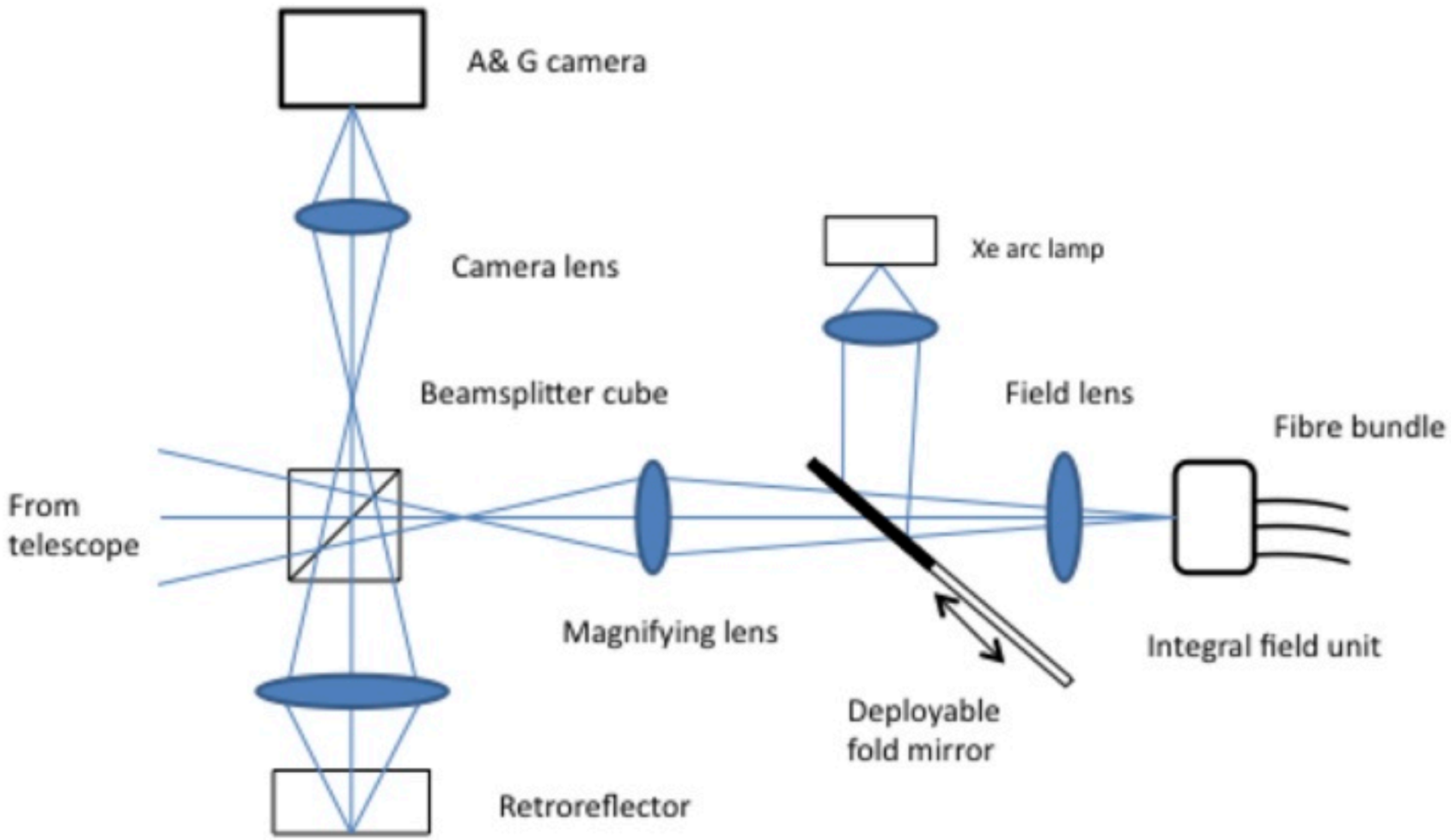
Both fed 1x7 lanterns
- one with FBGs
- one control

Lanterns feed IRIS2

H band spectrum with R=2400

Slide by S. Ellis, Feb. 2011

GNOSIS - Fore optics



GNOSIS will be mounted at AAT f/8 Cassegrain focus

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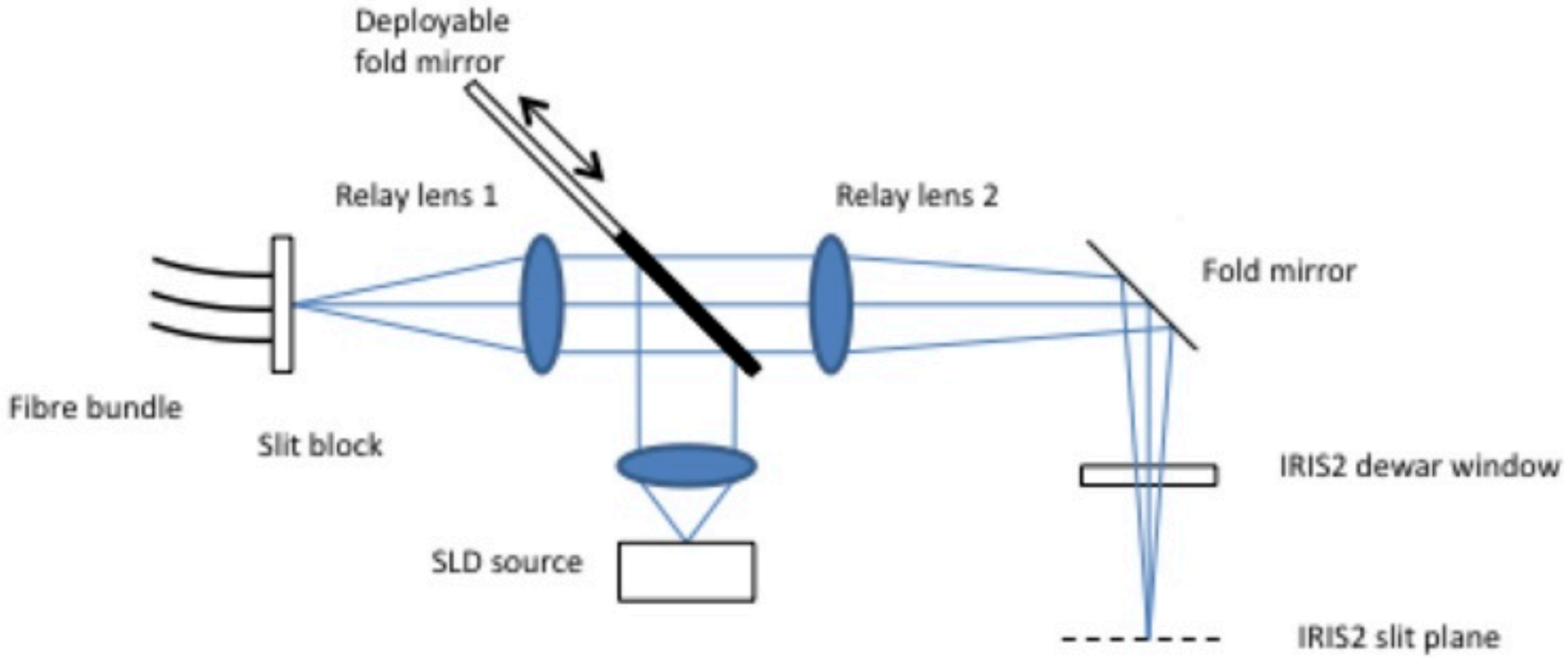
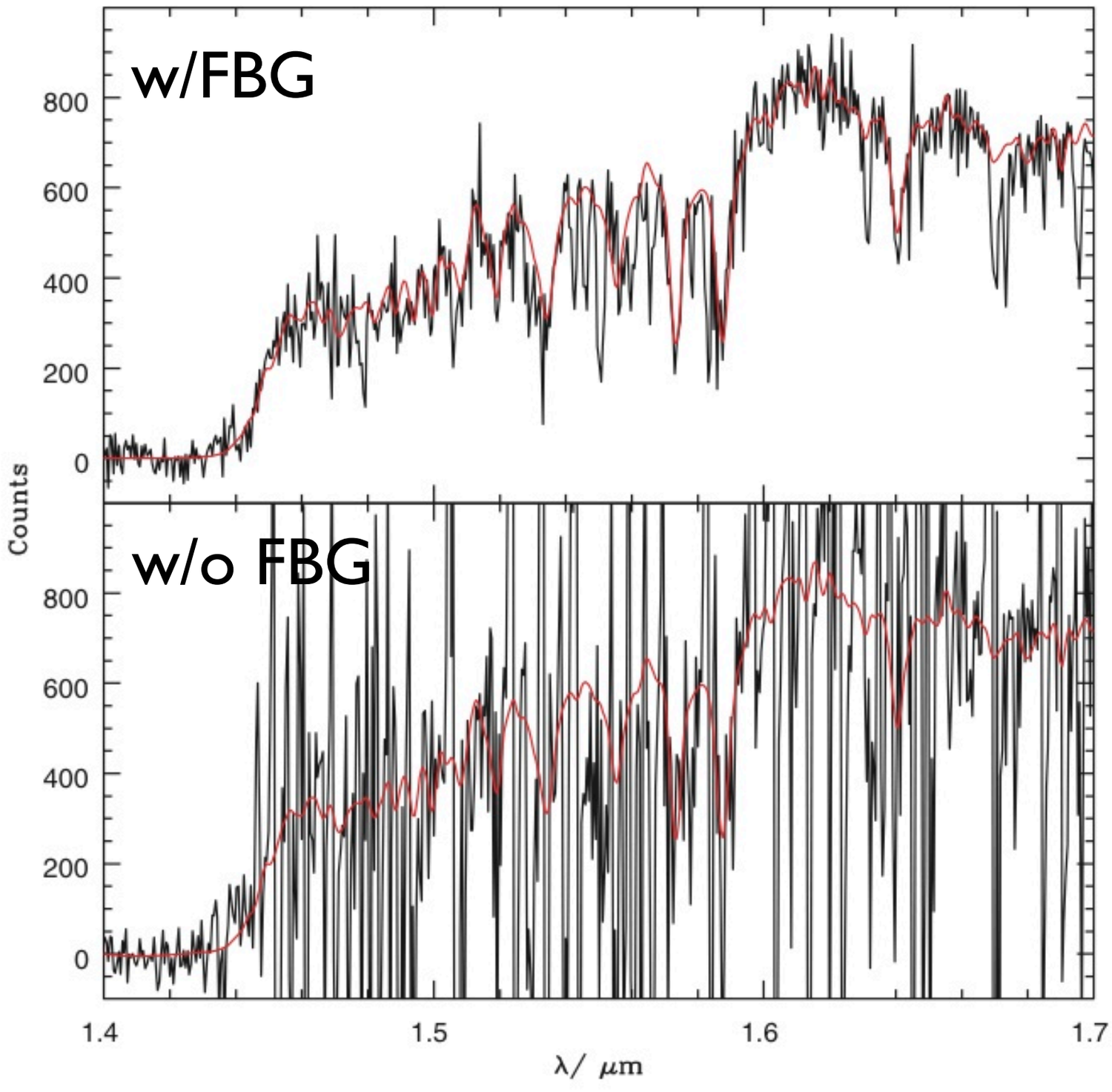
GNOSIS - relay optics



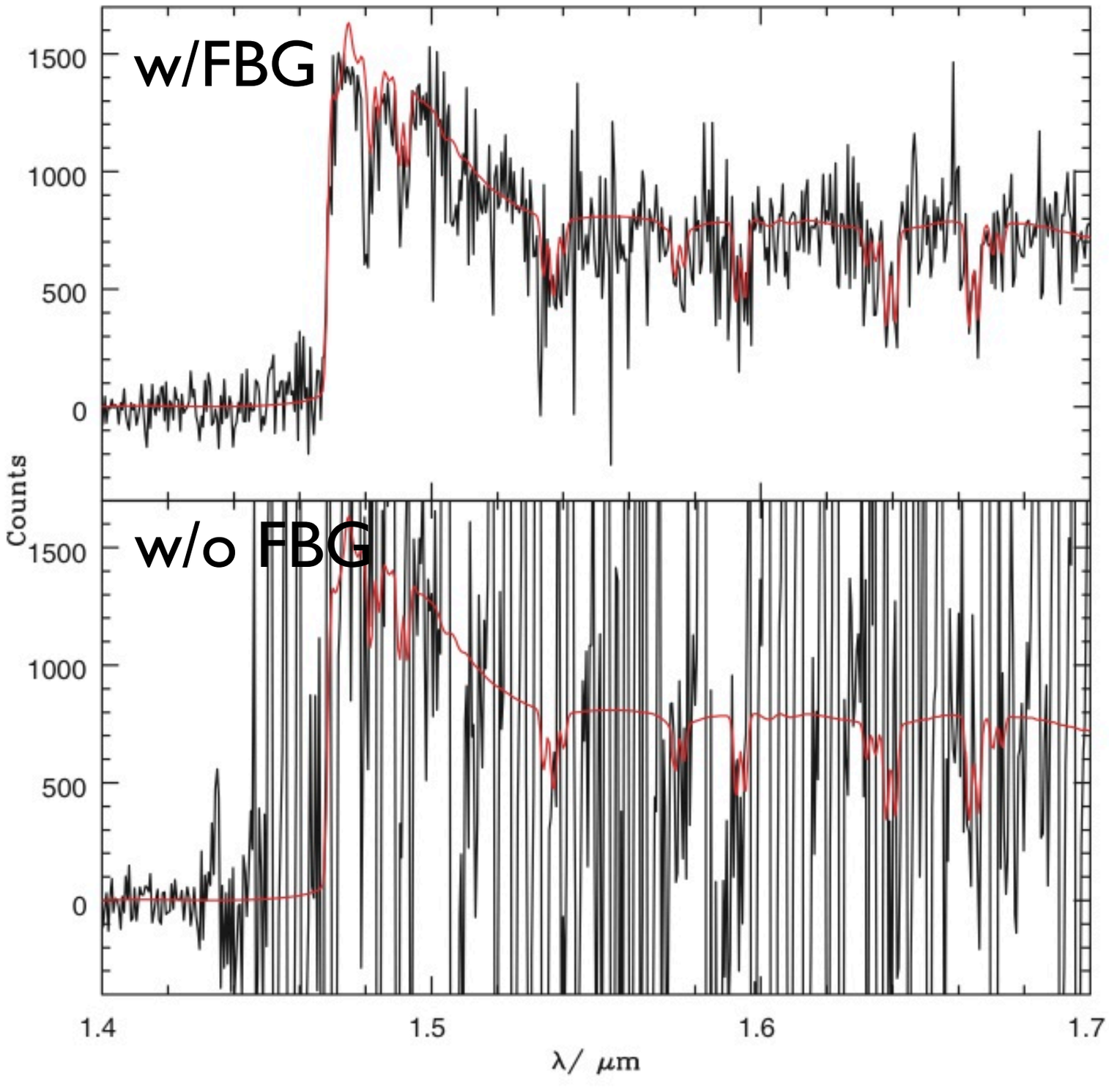
Simulated Spectra



- z=3 Passive Galaxy (age=1 Gyr) with H=23 mag. (Vega)
- 8m Telescope
- R=1,000
- 8 hours

Ellis and Bland-Hawthorn 2008
MN 386, 47

Simulated Spectra



- z=11 QSO with H=24.6 mag. (Vega)
- 8m Telescope
- R=1,000
- 70 hours

Ellis and Bland-Hawthorn 2008
MN 386, 47

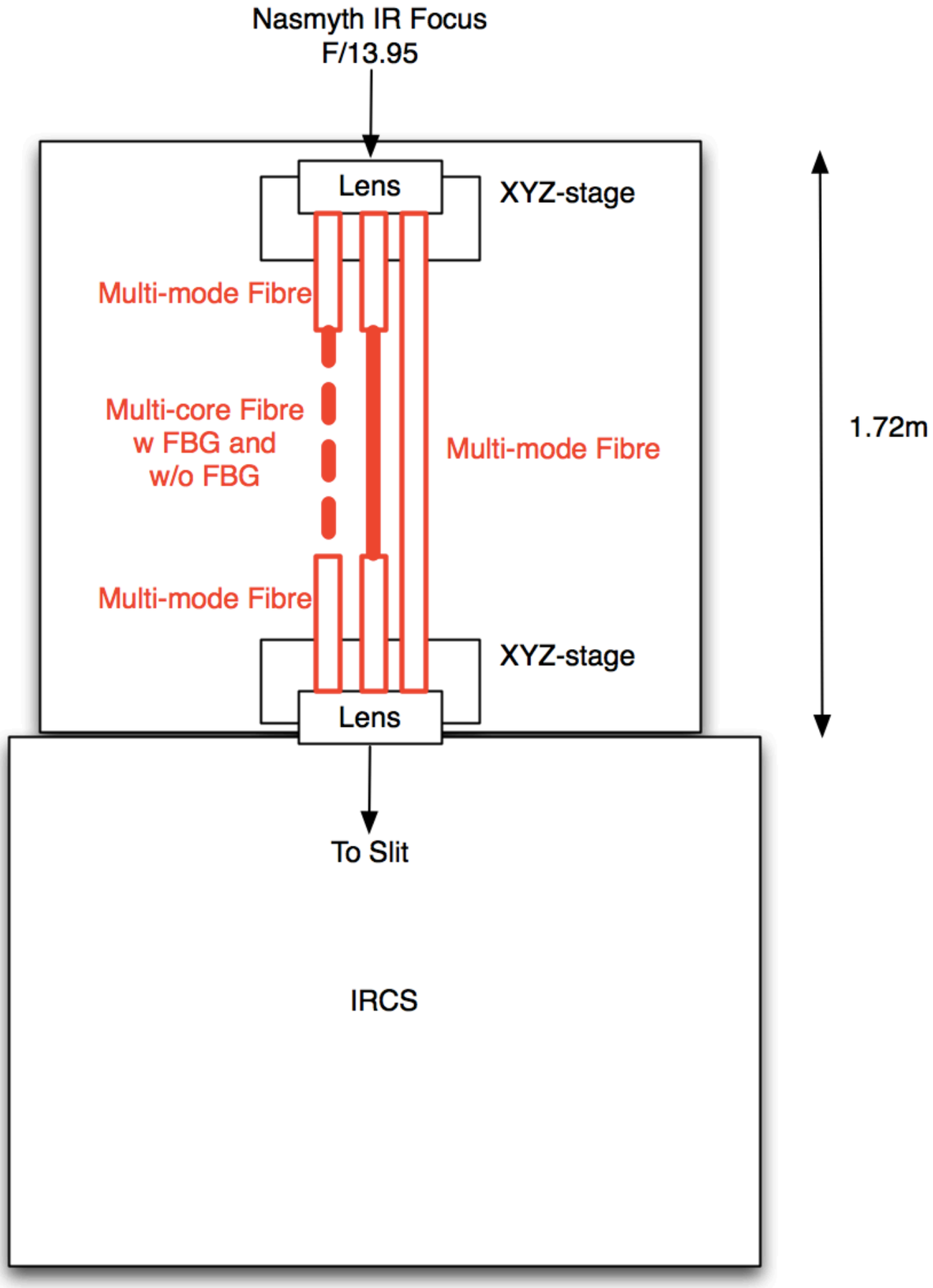
Test Device Development

Plan for FY2011 (~ March 2012)

- Fabricate a Multi-Core Fibre Bragg Grating Unit
  - Only a part of H-band OH lines will be suppressed
- Test with IRCS
  - Relay Optics Between Nasmyth Focus and IRCS
  - Measure Throughput, by Comparing with and without FBG?
  - Taking Sky Spectrum and Verify OH Suppression
  - No Astronomical Object Observation
  - Dispersion R~5000 (Echelle mode) with 0.54” Slit

Relay Optics at the position of AO188

No Modification to IRCS



Future Perspective

- Step 1: Multi-Core Test Unit (This Year)
  - Test with IRCS
- Step 2: Full Wavelength Coverage Test Unit
  - Test with IRCS?
    - Kakenhi (JSPS grant-in-aid)
- Step 2.5: Science Operation
  - Require a Target Acquisition Mechanism
- Step 3: New Instrument?

Summary

- OH Suppression Fibre or Fibre Bragg Grating May be a Break-through Technology for Deep Observation in Near-IR
  - Lower Cost, Effective Observation
- Test Observations of a Proto-type are On-going at AAO
- Fabricate the First Multi-core FBG for Subaru / IRCS
- Future: Integral-Field Spectroscopy with FBG?