

G-CLEF Summary

1. Instrument Motivation

- G-CLEF has been designed to simultaneously satisfy the need for a general purpose high dispersion spectrograph meeting the requirements for a high resolution visible spectrograph and a precision radial velocity spectrograph.

- While G-CLEF will be a powerful tool for many scientific programs, focus is made on programs that are specifically enabled by the large GMT aperture (Table 1), where G-CLEF on the GMT crosses new thresholds of discovery space.

Table 1: G-CLEF performance parameters required to achieve key science objectives.

Science Goal Required	Performance Parameter
Abundance studies Detection and census of metal poor stars	High resolution Extended blue response to 3500Å
High z IGM and ISM/Gamma Ray Bursts	Rapid instrument changeover Extended red response
Exoearth science	Very high resolution Long term wavelength stability
Detailed chemical composition beyond the Local Group	Long slit length for multiobject capability

2. G-CLEF Concept

The G-CLEF is a fiber fed, optical echelle spectrograph

Table 2: G-CLEF Design Parameters

Parameter	Value	Parameter	Value
Modes	HT, PA, PRV & MOS	Cameras	Red & Blue
Res	25k, 40k & 120k	Input f/#	f/8
Peak Efficiency	> 35%	Camera Beam Diameter	200mm
Passband	3500Å-9500Å		

a. Multiobject Capability

G-CLEF, when first commissioned, will be a single-object spectroscopy (with 1~2 sky fibers). When MANIFEST (MANY Instrument FibrE SysTem) becomes available, it will be able to observe ~40 simultaneous object (MOS or IFU, depending on the capability of MANIFEST).

b. Wavelength Coverage

G-CLEF provides good blue and red response (3500Å-9500Å). Stellar astronomy programs require high efficiency to a blue limit of 3500Å, while cosmology programs are enabled by good red response. This broad operational passband is enabled by a two-camera model with a red and blue beams split with a dichroic in the parallel beam (Figure 1).

c. Fiber Feeds & Spectral Resolutions

The G-CLEF will provide multiple fiber feeds, which will enable the broad range of scientific missions. At present, the following distinct fiber feeds are envisioned.

- The **High Throughput (HT)** Feed maximizes the light collecting efficiency of G-CLEF. The resolution is currently planned to be 25,000, providing a 1.2 arcsec diameter slit on the sky.
- The **Precision Abundance (PA)** Feed provides higher resolution ($R \sim 40,000$) than the HT Feed, especially designed for stellar abundance investigations by reducing the slit size (fiber diameter 0.7 arcsec), hence the light collection efficiency.
- A **Precision Radial Velocity (PRV)** Feed will be pupil-sliced into seven 8.4m subapertures. These fibers will provide an $R > 100,000$ with 0.7" fiber.
- A High Resolution (HR), image sliced feed, where a 1" image delivered by the full primary aperture will be sliced seven-fold to achieve $R \sim 150,000$. It is yet to be decided if this mode will be available.
- Feeds from the MOS Fiber System will deliver resolution 40,000 for ~ 40 sources (with limited λ -coverage), and may potentially implement an IFU or Extremely High Resolution Mode.

Table 2: G-CLEF Design Parameters

Feed	Resolution	Fiber Dia. (arcsec)	Comments
HT	25000	1.2	
PA	40000	0.7	
PRV	120000	0.7	Pupil Sliced & Scrambled
MOS	40000	0.7	limited λ -coverage

3. G-CLEF Design

G-CLEF consists of several major subsystems (see Figure 2):

- The **spectrograph** itself will be placed at Azimuth Platform (gravity invariant, co-moving location on the GMT; Figure 3) for wavelength scale stability. It will have several fiber slits that connected to the optical interface to the telescope.
- Several distinct **fiber feeds** that provide a variety of observational capabilities. One set of fibers runs to the telescope interface (“front end”) on the IP, all of which are for single-object observations. A second set of fibers, supplied by the MANIFEST MOS team, run to a MANIFEST feed at the Gregorian focus for multiobject observing.
- The **front end**, that is the optical interface to the telescope and the calibration system, will be located at the Instrument platform near the Gregorian focus.

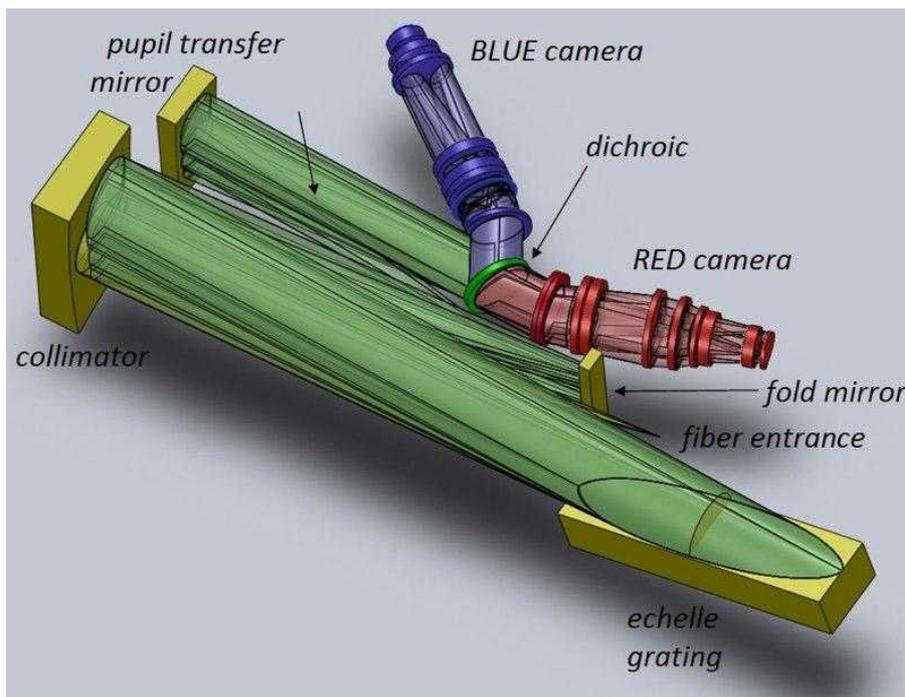


Figure 1: G-CLEF Optics

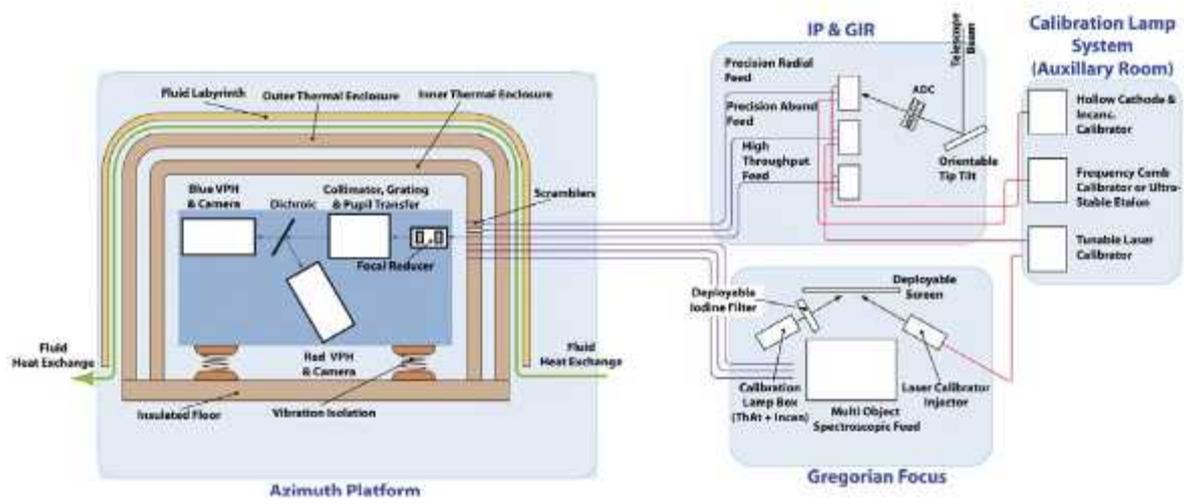


Figure 2: System diagram of G-CLEF

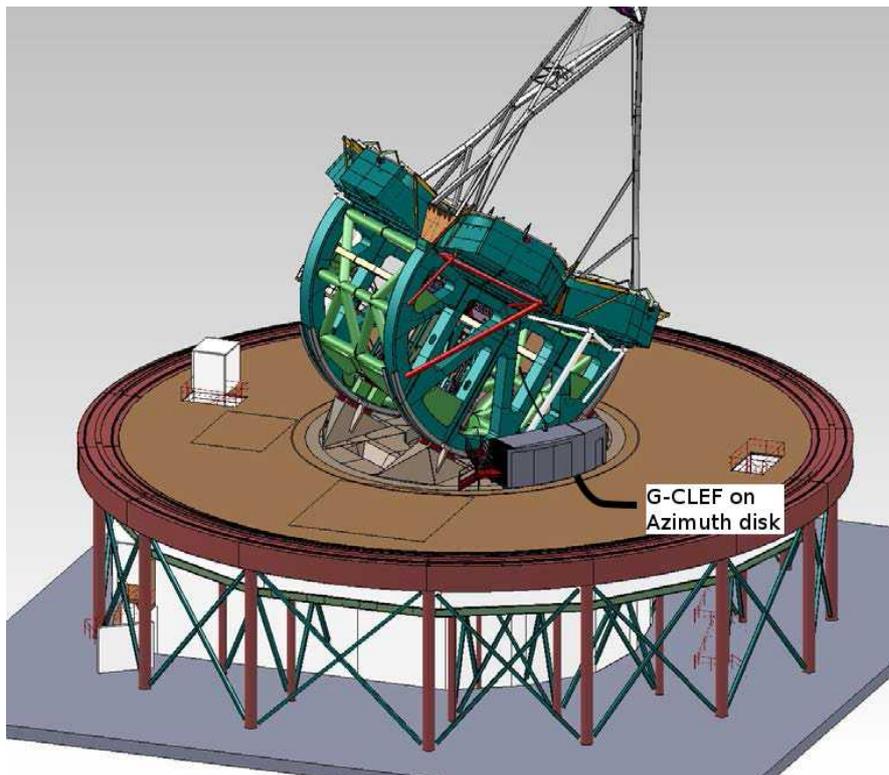


Figure 3: Installed location of G-CLEF

4. Science Drivers for G-CLEF

G-CLEF is designed to address several of the highest science priorities in the most recent Decadal Survey.

- A census and characterization of the most metal poor halo and Local Group dwarf galaxy stars
- The discovery and characterization of exoearths and exosolar systems, especially habitable planets
- Abundance in and evolution of galaxies in the Local Group and beyond
- Probing the IGM and ISM at high z

5. Estimated Sensitivity

The peak efficiency of the spectrograph is $>35\%$ and the passband is 3500-9500Å. The overall efficiency of the spectrograph is plotted in Figure 4. Both the spectrograph alone and the spectrograph efficiency with all attendant losses (e.g. slit losses for a 0.7 arcsec slit, telescope reflectivity, etc.) are plotted.

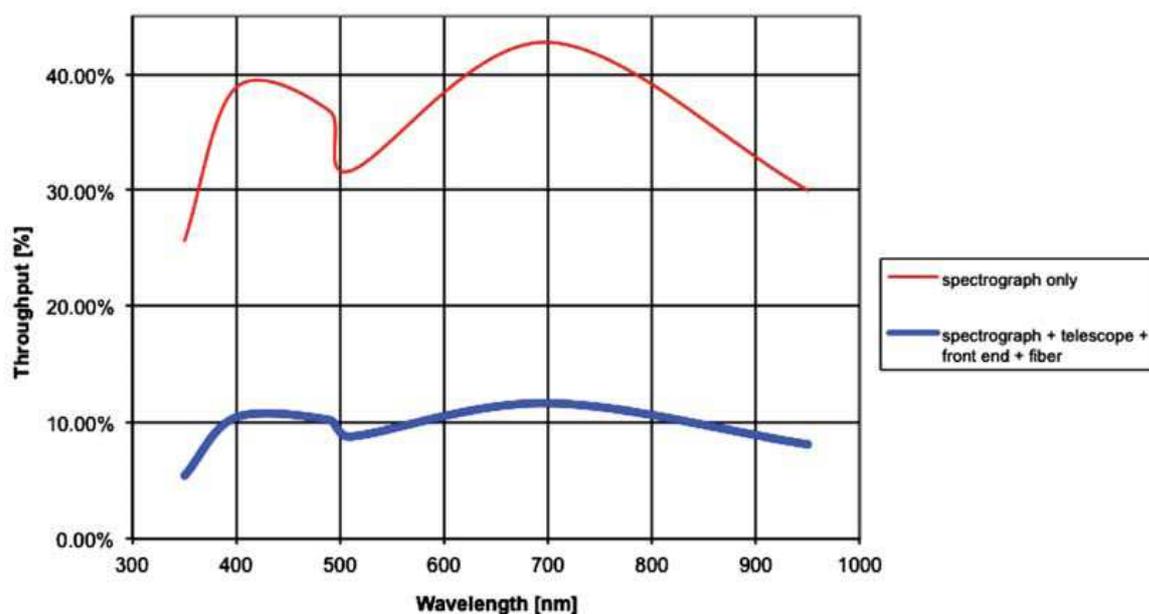


Figure 4: Efficiency of the G-CLEF spectrograph (red/thin line) and with the losses associated with the telescope included (blue/thick line).

- In 1 hour integration with 7 mirrors,
- S/N = 10 ~15 per resolution element : for V=19 mag @ R~100,000 (see Figure 5).

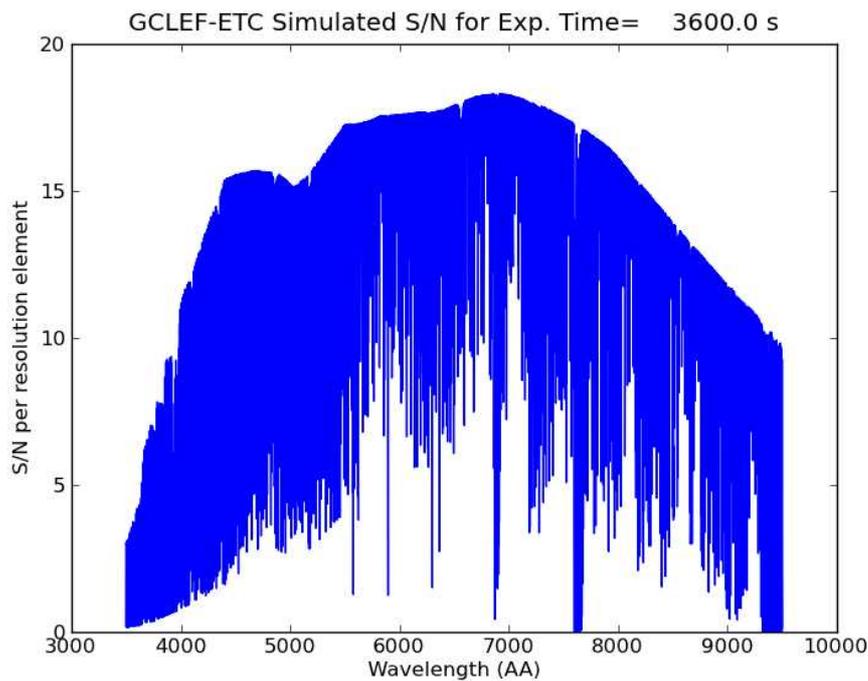


Figure 5: G-CLEF simulate S/N for 1 hour integration of star of V=19 mag at R~100,000.

Exposure Time Calculator (beta)

- <http://alerce.astro.puc.cl/gclef.html>
- Note that the ETC uses different modes than described above. R=100,000 for the high-resolution (HR) mode; R=35,000 for the medium resolution (MR) mode; R=20,000 for the low resolution (LR) mode.