GMACS Exposure Time Calculator, v2.1

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ABSTRACT

This document collects the assumptions, models, and references used in the GMACS exposure time calculator. Version 2.1 is based on the original GMACS ETC created by Ting Li, modified by Luke Schmidt with layout and design by Nate Peirson.

Assumptions

1. Effective area of the telescope is 368 m^2 for full size (7 mirrors) and 222 m^2 for first light size (4 mirrors).

2. CCD read noise is 2e$^-$ px^{-1}, 15μm pixels. The dark current is $0.02 e^- px^{-1} hr^{-1}$.

3. GMACS consists of a blue channel (320-600 nm), and a red channel (500-1000 nm). Dichroic transition is at 558 nm.

4. Stars are treated as point sources and the slit transmission factor given by
   $T_x = erf\left[\frac{\frac{slit_{arcsec}}{2}}{\sqrt{2}\frac{seeing_{arcsec}}{2.35482}}\right]$ where $erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x exp^{-t^2} dt$

   Galaxies, are treated as extended sources and therefore the slit transmission factor is always one.

5. Noise is a combination of sky background, CCD read noise, and dark current.

6. PSF of the object is Gaussian and the seeing is the FWHM of the PSF.

7. The extraction aperture is equal to the seeing $\times$ slit width.

8. SNR is calculated for every pixel. For the default $0.7''$ slit, a resolution element is 12px (equivalent to 3.7Å for low resolution and 1.4Å for high resolution), binning options include 1×1, 2×2, 3×3, and 4×4 pixels as well as Nyquist (resolution element binned to two superpixels) and resel (resolution element binned to a single pixel) Actual allowed instrument binning modes have yet to be determined. The default 4×4 binning is roughly $1/3$ of a resolution element.

Source Templates

1. **Star** templates are from Pickles 1998[1].

2. **Extended Source** templates are from Kinney et al. 1996[2]. Flux below 1300 Angstrom is zero in rest frame. So the Flux for high redshift(z>4) at short wavelength will be also zero and thus is not correct. For example, template flux is zero in u band for an object at z=5; in this case, SNR is set to be zero at all wavelengths.

3. **Sky backgrounds** are from Steven Villanueva et al. 2012[3]. You can select the sky background for different moon phases.

4. **User-defined magnitudes** are computed with SDSS filters for ugriz (`http://www.sdss3.org/instruments/camera.php#Filters`), with Johnson/Bessell filters for UBVRI from Bessell et al. (1990)[4].

5. **User Submitted** sources may be sent to lschmidt@physics.tamu.edu. They should be formatted as a text file with two columns, wavelength [Å] and flux $[erg\ cm^{-2}\ s^{-1}\ \text{Å}^{-1}]$ a sample file can be downloaded at `http://instrumentation.tamu.edu/gmacs/etc_gmacs/core/kinney/ellipticals` (this sample has a third column, the standard deviation of the flux, which is not necessary to include).

Throughput

1. **Atmospheric extinction** is created by libRadTran[5] with the atmospheric parameters measured by aTmCam[6] at CTIO at airmass=1.0.
2. **Telescope** The primary and secondary mirrors of the GMT are assumed to be coated with Aluminum. Reflectivity values taken from in situ measurements of the Subaru 8.3 primary mirror[7], `https://subarutelescope.org/Observing/Telescope/Parameters/Reflectivity/`
3. **Optics** throughput for the collimator and camera lenses are 0.59 (Blue) and 0.63 (Red).
4. **Dichroic** throughput is based on vendor performance estimates.
5. **Grating** throughput is based on low resolution VPH gratings designed by KAISER.
6. **Detectors** are assumed to be the e2v Astro Multi-2 (NIMO DD) CCD for the red channel and e2v Astro BB (NIMO std Si) CCD for the blue channel.

Acknowledgements

The following software was used to develop the GMACS exposure time calculator. Python[8], Spectres[9], Astropy[10,11], Bokeh[12], Numpy[13], and Scipy[14].

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