Operative Manual of FAQ3 software Ver.2.50

FAQ3 is a program for CCD exposure calculation takes with photometric BVRcIc filters by Johnson-Cousin-Bessel system. The U band output is not currently available and, I hope, coming soon.

Just enter the characteristics of the your equipment that you use, CCD, filters, characteristics of the observative site and obviously magnitude of the stars, to calculate the best exposure time for any single image and total. This for each photometric band, relatively to the magnitude of the faintest star, (lower limit) and brightest star magnitude (upper limit) in your star field.

This software is developed for an aid in differential photometry where the comparison star are essentially in the same field of variable star. The resulting values are indicative.

The algorithms and data used in the program come from the following sources:

U. Munari: FAQ n°3 ANS collaboration group comunications.

U Munari M. Fiorucci and D. Moro: Asiago Database on Photometric Systems (ADPS) http://ulisse.pd.astro.it/Astro/ADPS/.

W Romanishin: An Introduction to Astronomical Photometry Using CCDs University of Oklahoma wjr@nhn.ou.edu.

P. Camaiti: Guida ai CCD per l'astronomia Ed. Castello.

For the algorithms of saturation time's calculating see the Appendix of this manual.

Program files:

FAQ3 software consists of the following files:

FAQ3.EXE	executable file
SETTING.TXT	setting file
EXPHOT.INI	path file
MANUAL.PDF	this file

If you want is possible to save your stellar field's magnitude values in a file with .FAQ extension.
One different file for each stellar field.

Installation:

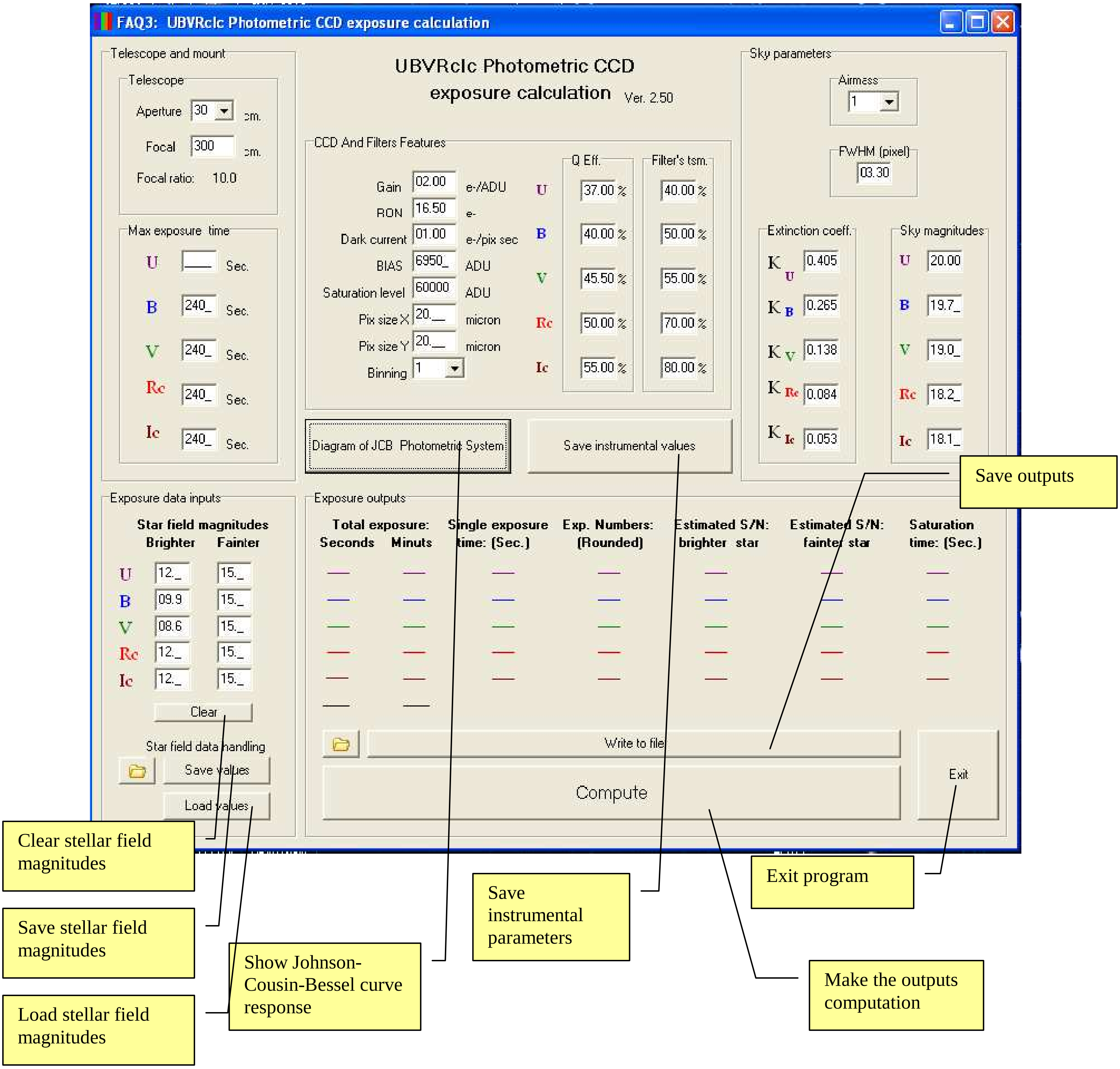
The program no requires a real installation, just unpack it in a directory of your choice and run the file FAQ3.EXE.

Use:

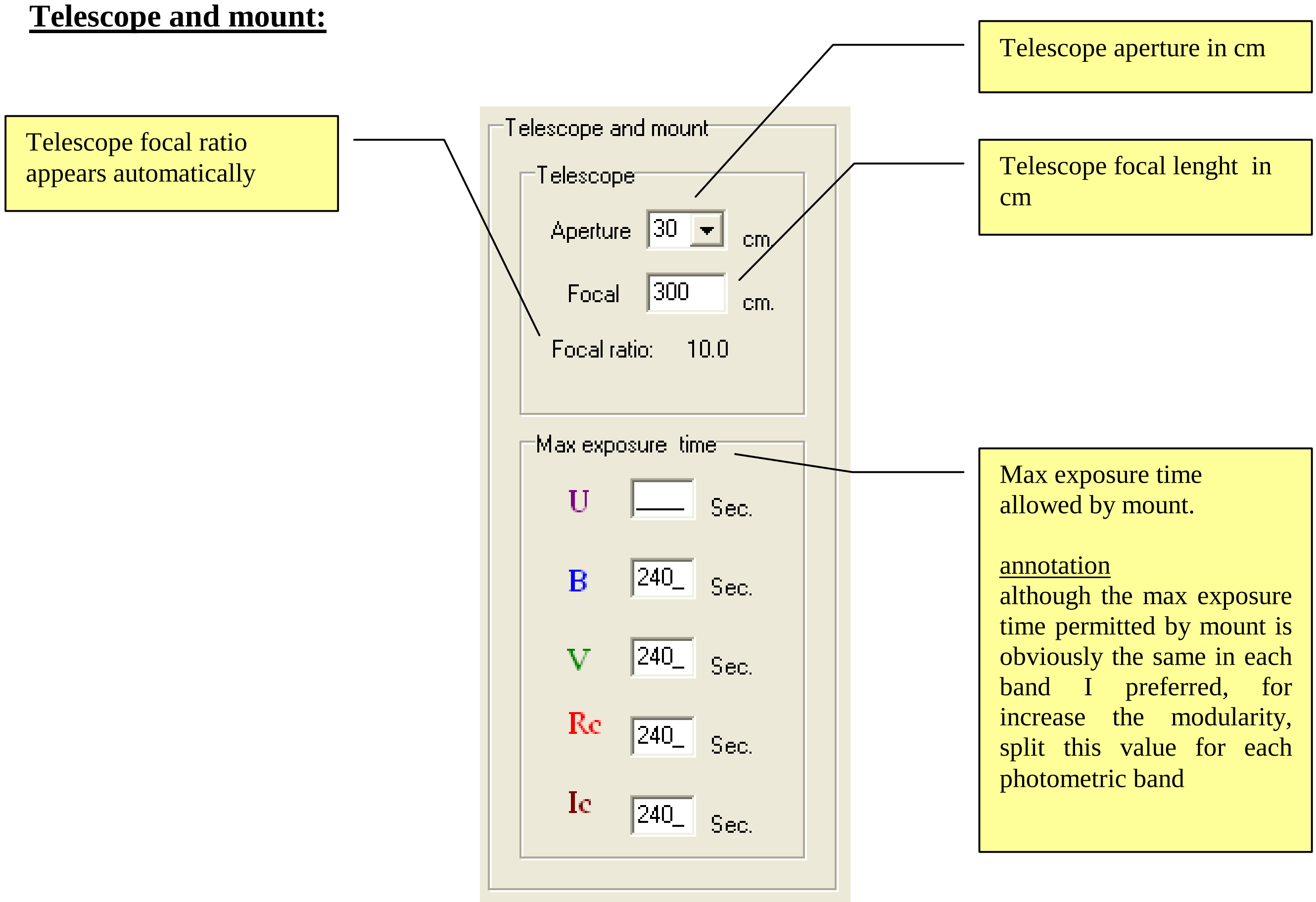
In the upper half of window's program are to be entered the instrumental and sky imputs data, obviously you can save this values; while the bottom side is for input of stellar field (left side) and display the results (right side). It 'also possible to save a file with stellar field and/or data of output. Finally you can visualize a graph of the system of Johnson-Cousin-Bessel which is your master reference in the data calculation.

The following images for a better explanation:

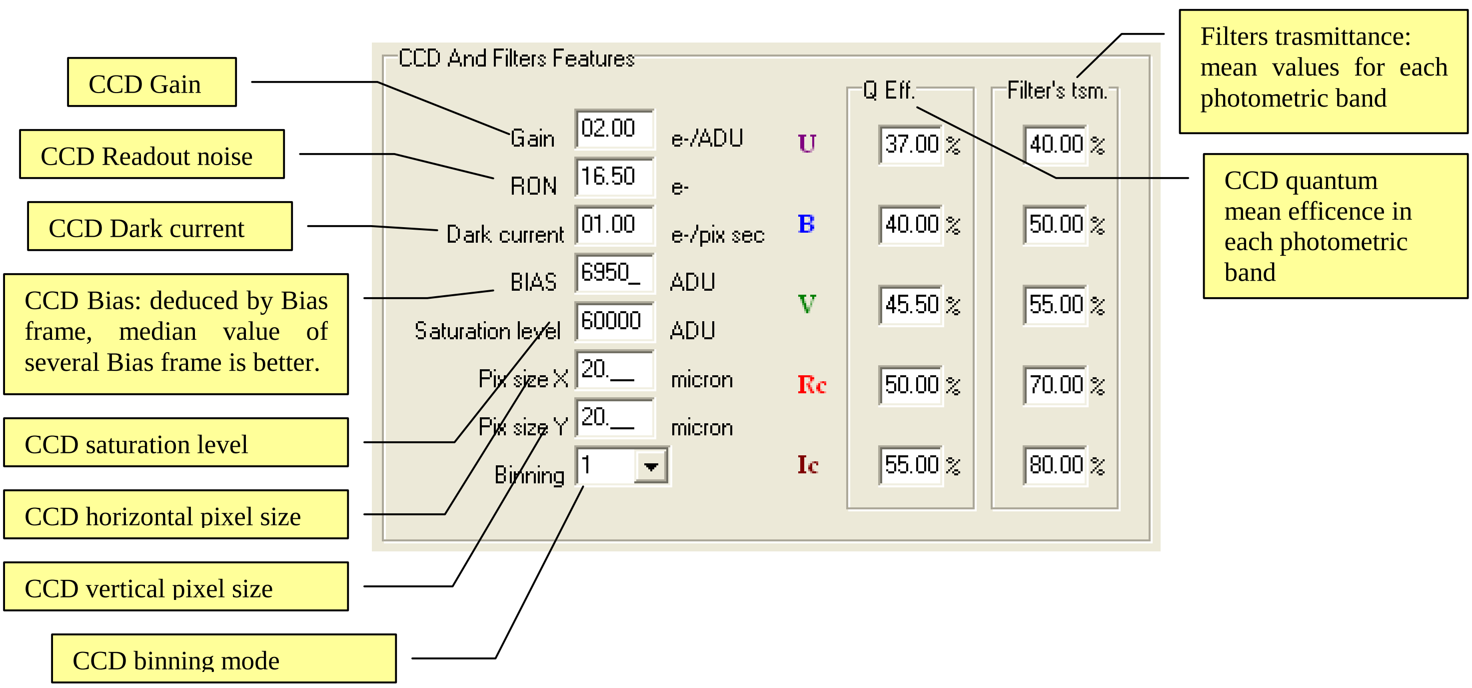
Overall view:



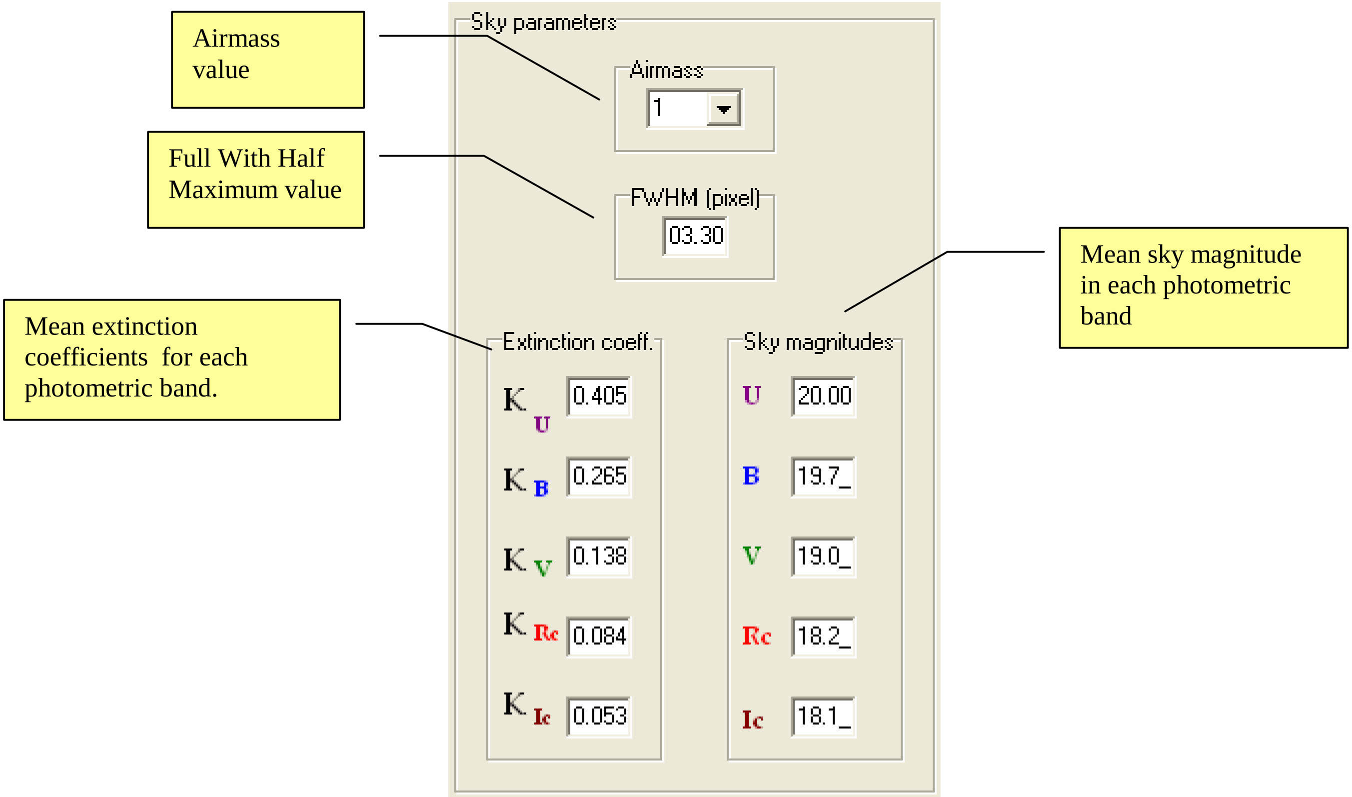
Telescope and mount:



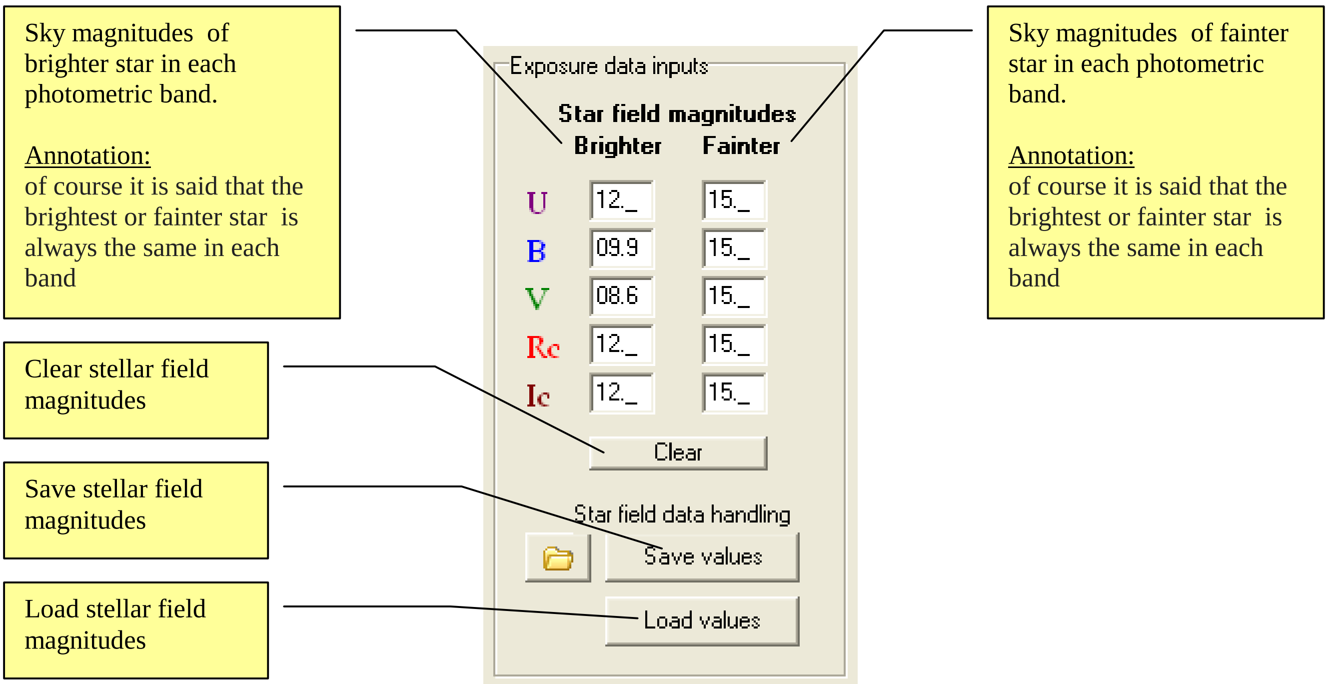
CCD and Filters features:



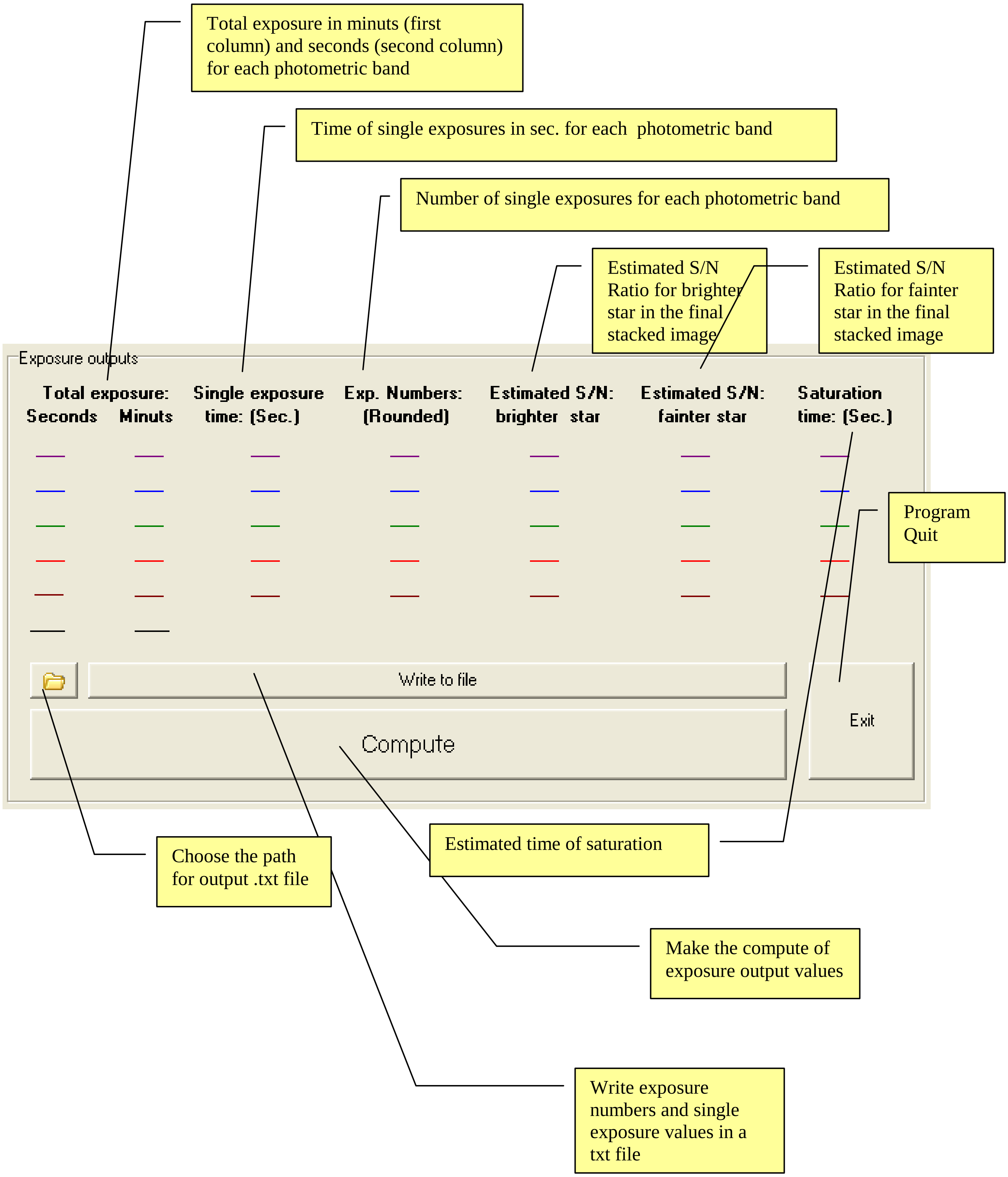
Sky parameters:



Exposure data inputs:



Exposure outputs:



Appendix:

The Calculus of time saturation is originated from a personal approach to the problem, I confide and hope this approach be formally corrected.

I have proceeded in this mode:

In first time I inferred a formal equation for found the ADU value. This equation is:

1) $$ADU = BIAS + \frac{RON}{G} + \frac{DCURR * t}{G} + \frac{SKY * t}{G} + \frac{STAR * t}{G}$$

Reducing it become :

2) $$ADU = BIAS + \frac{RON}{G} + (DCURR + SKY + STAR) * \frac{t}{G}$$

Where :

ADU = Analogic to Digit Unit total of a star image
BIAS = Noise from CCD's electronic in ADU
RON = Readout noise in electrons*sec^{-1}
G = Gain in electrons
DCURR = Dark current in electrons*pixel* sec^{-1}
SKY = electrons flux originates by skylight photons * sec^{-1}
STAR = electrons flux originates by star light photons * sec^{-1}
t = time of exposure

SKY and ***STAR*** electrons are calculated from their incidents photons in this mode:

3) $$e_n^- = \frac{(Phot_n) * (Phot_e)}{3.65}$$

Where:

e_n^- = electrons number create from photons
$\boldsymbol{Phot_n}$ = number of incident photons from the star or sky
$\boldsymbol{Phot_e}$ = energy of each inciden photons from the star or sky expressed in eV

3,65 is the eV value for the Silicon efficency conversion Photon to electron. In other word the eV energy of photons's pack divided 3.65 result the electrons number was originated in the CCD pixel.

At this point if we use the saturation value of ADU (that we know well) and solve the equation 1 respect exposure time we obtained:

4) $$t_s = \frac{(ADU_s - BIAS - \frac{RON}{G}) * G}{DCURR + SKY_p + STARmip}$$

Where :

t_s = saturation time exposure
ADU_s = ADU saturation value of each pixel that depending from Analogic to Digit Converter (ADC) of our CCD camera. i.e. a sensor with a 16 bit ADC have a ADU saturation of 65536 counts
BIAS = Noise from CCD's electronic in ADU
RON = Readout noise in electrons*sec^{-1}
G = Gain in electrons
DCURR = Dark current in electrons*pixel* sec^{-1}
SKY_p = electrons flux originates by skylight photons * sec^{-1} from a single pixel
$STAR_{mip}$ = electrons flux originates by star light photons * sec^{-1} from a **more illuminated** pixel

Infact sky photons are approx uniformed in the sky, and I can divide the total incident flux of sky photons for pixel area for result the number of sky photons for each pixel, but star photons are distribuited in gaussian mode dependently from FWHM, therefore I can't assumed a simply mean value. The best way is the calculation of brighter pixel among all. This is possible precisely through the gaussian equation:

5) $$f(x) = \frac{1}{\sigma * \sqrt{2 * \pi}} * e^{-\frac{(x-x_o)^2}{2*\delta^2}}$$

and the followed relation between σ and $FWHM$:

6) $$FWHM \sim 2.335 * \delta$$

and then σ is:

7) $$\delta \sim \frac{FWHM}{2.335}$$

In equation 5 σ is the dispersion of the curve, x is the value of independent variable and x_o is the value of x at curve's peak. But we searched exactly the $f(x)$ value at peak, therefore the equation 5 simply become:

8) $$f(x) = \frac{1}{\sigma * \sqrt{2 * \pi}}$$

f(x) is a value between 0 and 1.

At this point it's sufficient , in equation 8 to substitute σ with equation 7 and subsequently multiplied for ***STAR*** value for obtaining finally the value of more illuminated pixel.

9) $$STAR_{mip} = STAR * \frac{1}{\frac{FWHM}{2.335} * \sqrt{2 * \pi}}$$

That's all folks!..

<u>Thanks:</u>

A very special thanks for: Prof. U. Munari for his competence and patience and S. Tomaselli for his valuable suggestions and ideas.

Writed in August 2013 Alfonsine (RA) Italy

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