LESVEPHOTOMETRY

AN AUTOMATIC PHOTOMETRY SOLUTION

BASED ON A COMPARISON STAR DATABASE

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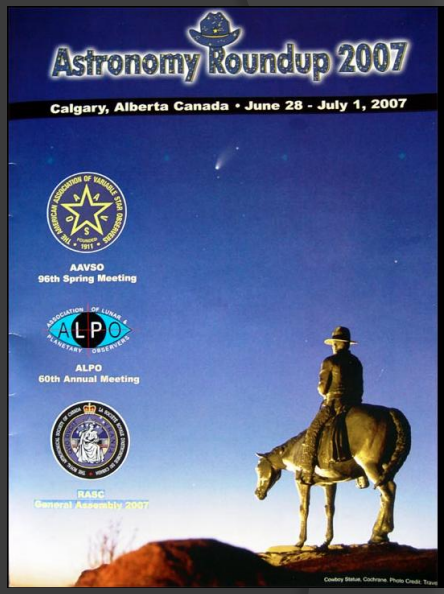
LesvePhotometry
First ideas

- RASC – AAVSO Calgary 2007
  - presentation of preliminary version of VPHOT ancestor
  - ➔I started a first version based on Microsoft ACCESS database



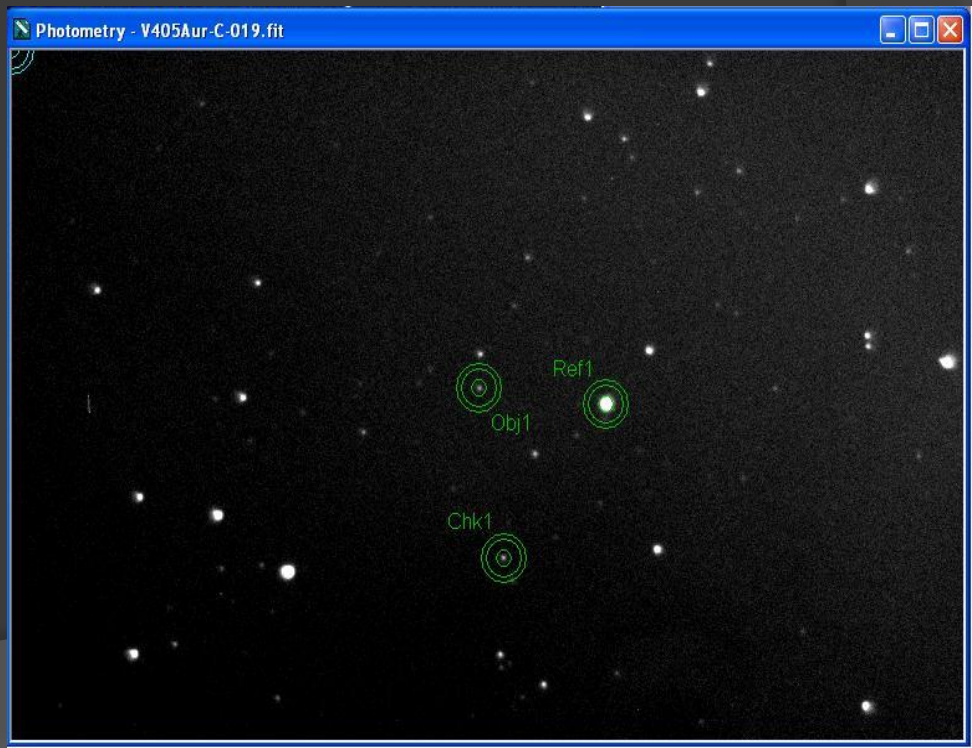
- SAS – CBA - AAVSO Big Bear 2009
  - big impulse from Josch Hambsch and Tom Krajci

Automatic Photometry Why?

- Better reliability
  - less prone to mistakes
  - comparison stars are in a database
- Faster
- Easy
  - avoid tedious tasks
  - no need to look for a star chart at each session
  - stars are identified by the program and comparison star magnitudes are extracted from a database

With classical programs
(e.g. MaximDL)

- For each observation you need
  - sky chart (AAVSO)
  - comparison star magnitudes
- Manually
  - identify stars
  - position aperture
  - provide comparison magnitudes



LesvePhotometry inputs

- Sky images
  - FITS header contains all needed information
- Comparison star database
  - easily populated from AAVSO VSP
- Star catalogs
  - GSC
  - USNOA2, USNOB1
  - USNO UCAC2, UCAC3, UCAC4

LesvePhotometry process

- Calibration : bias, darks, flats
  - have to be performed before calling LesvePhotometry with your favorite software
- Detection of stars in sky image
  - using PinPoint (dc3.com $149)
- Astrometry
  - PinPoint – table of stars (RA, DE)
- Differential aperture photometry
  - for variable and comparison stars
    - magnitudes, snr, airmass,…
- Automatic generation of reports
  - AAVSO, CBA, xls
- Interactive tool to determine maxima or minima of the light-curve

FITS header

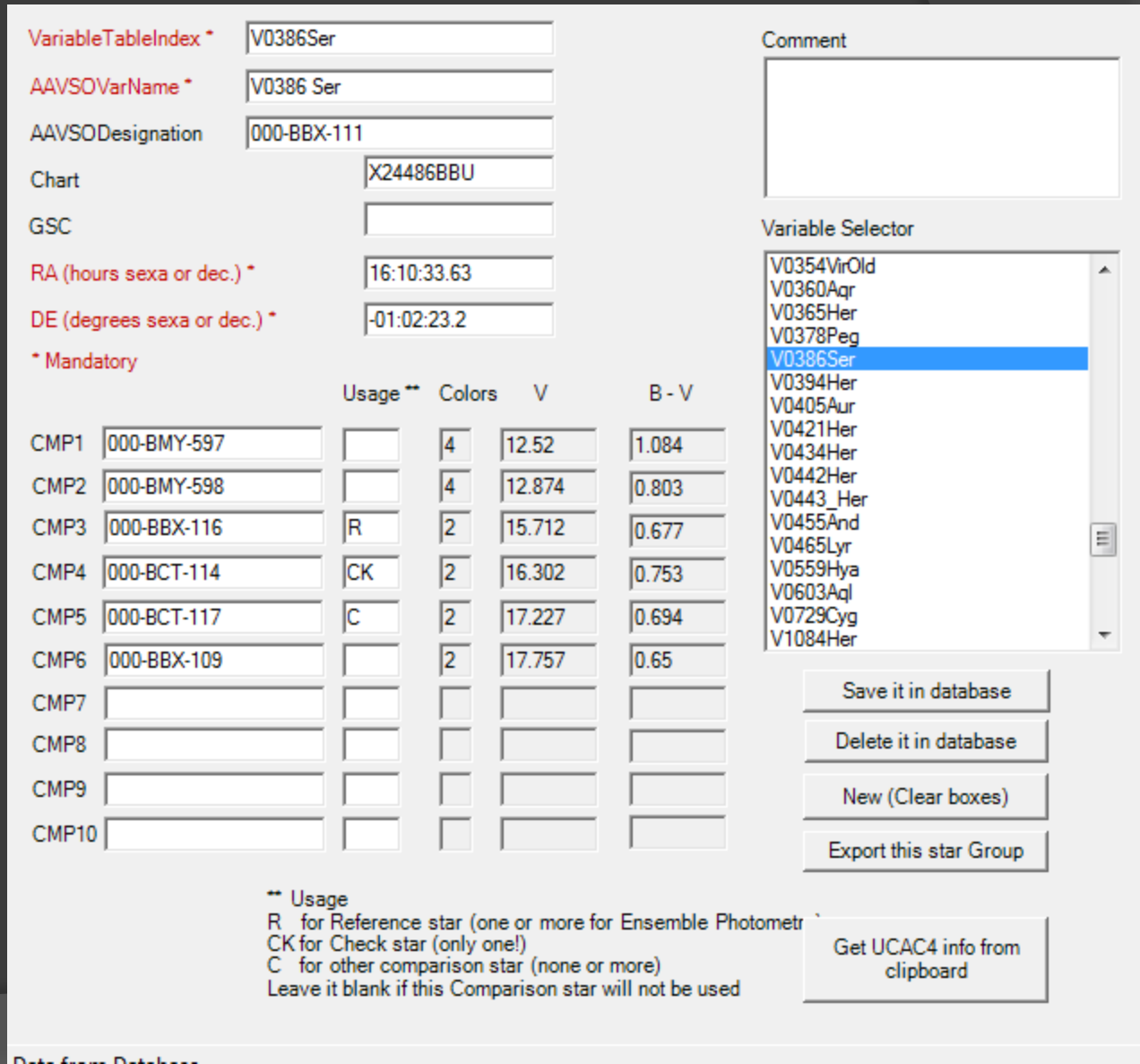
```
SIMPLE   = T
BITPIX   = 16 /8 unsigned int, 16 & 32 int, -32 & -64 real
NAXIS    = 2 /number of axes
NAXIS1   = 1679 /fastest changing axis
NAXIS2   = 1268 /next to fastest changing axis
BSCALE   = 1.0000000000000000 /physical = BZERO + BSCALE*array_value
BZERO    = 32768.000000000000 /physical = BZERO + BSCALE*array_value
DATE-OBS = '2019-07-08T22:29:57' / [ISO 8601] UTC date/time of exposure start
EXPTIME  = 4.80000000000E+002 / [sec] Duration of exposure
EXPOSURE = 4.80000000000E+002 / [sec] Duration of exposure
SET-TEMP = -35.000000000000000 /CCD temperature setpoint in C
CCD-TEMP = -35.062500000000000 /CCD temperature at start of exposure in C
XPIXSZ   = 10.800000000000001 /Pixel Width in microns (after binning)
YPIXSZ   = 10.800000000000001 /Pixel Height in microns (after binning)
XBINNING = 2 / Binning level along the X-axis
YBINNING = 2 / Binning level along the Y-axis
XORGSUBF = 0 /Subframe X position in binned pixels
YORGSUBF = 0 /Subframe Y position in binned pixels
READOUTM = 'Normal  ' /          Readout mode of image
FILTER   = 'C       '            / Filter name
IMAGETYP = 'Light Frame' /       Type of image
FOCALLEN = 1661.0000000000000 /Focal length of telescope in mm
APTDIA   = 304.00000000000000 /Aperture diameter of telescope in mm
APTAREA  = 72583.358688354492 /Aperture area of telescope in mm^2
EGAIN    = 0.37000000476837158 /Electronic gain in e-/ADU
SBSTDVER = 'SBFITSEXT Version 1.0' /Version of SBFITSEXT standard in effect
SWCREATE = 'MaxIm DL Version 6.20 190919 2XFUC' /Name of software
SWSERIAL = '2XFUC-JMYVR-N3VST-WC6UY-EHJWR-NC' /Software serial numb
OBJCTRA  = '16 10 02.59'       / [hms J2000] Target right ascension
OBJCTDEC = '-01 06 42.0'       / [dms +N J2000] Target declination
OBJCTALT = '33 08 00'          /          Nominal altitude of center of image
OBJCTAZ  = '214 15 41'         /          Nominal azimuth of center of image
SITELAT  = '50 23 00' /          Latitude of the imaging location
SITELONG = '04 48 00' /          Longitude of the imaging location
```

missing keywords
in Header

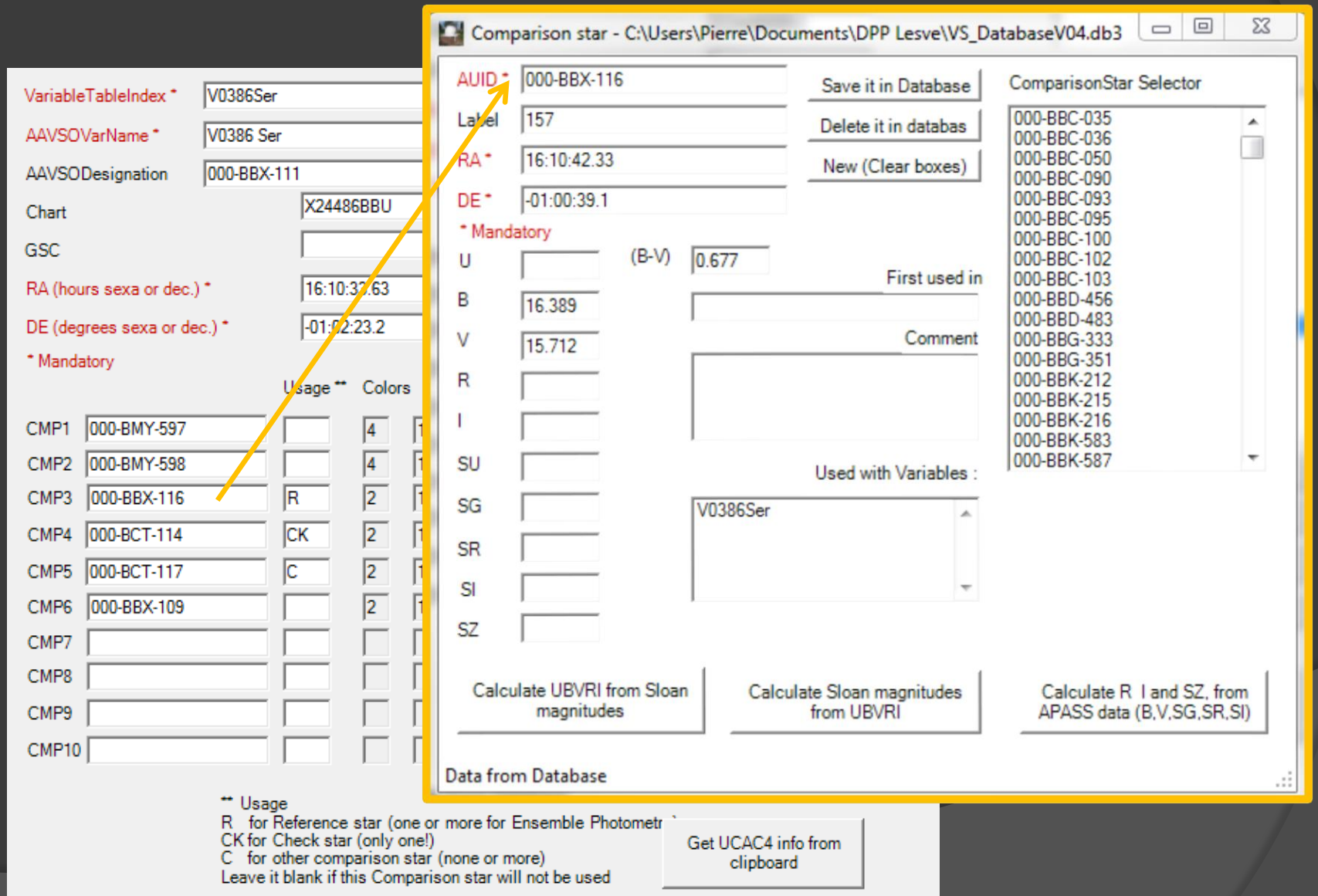
may be defined
in a configuration file

Database : Variables stars

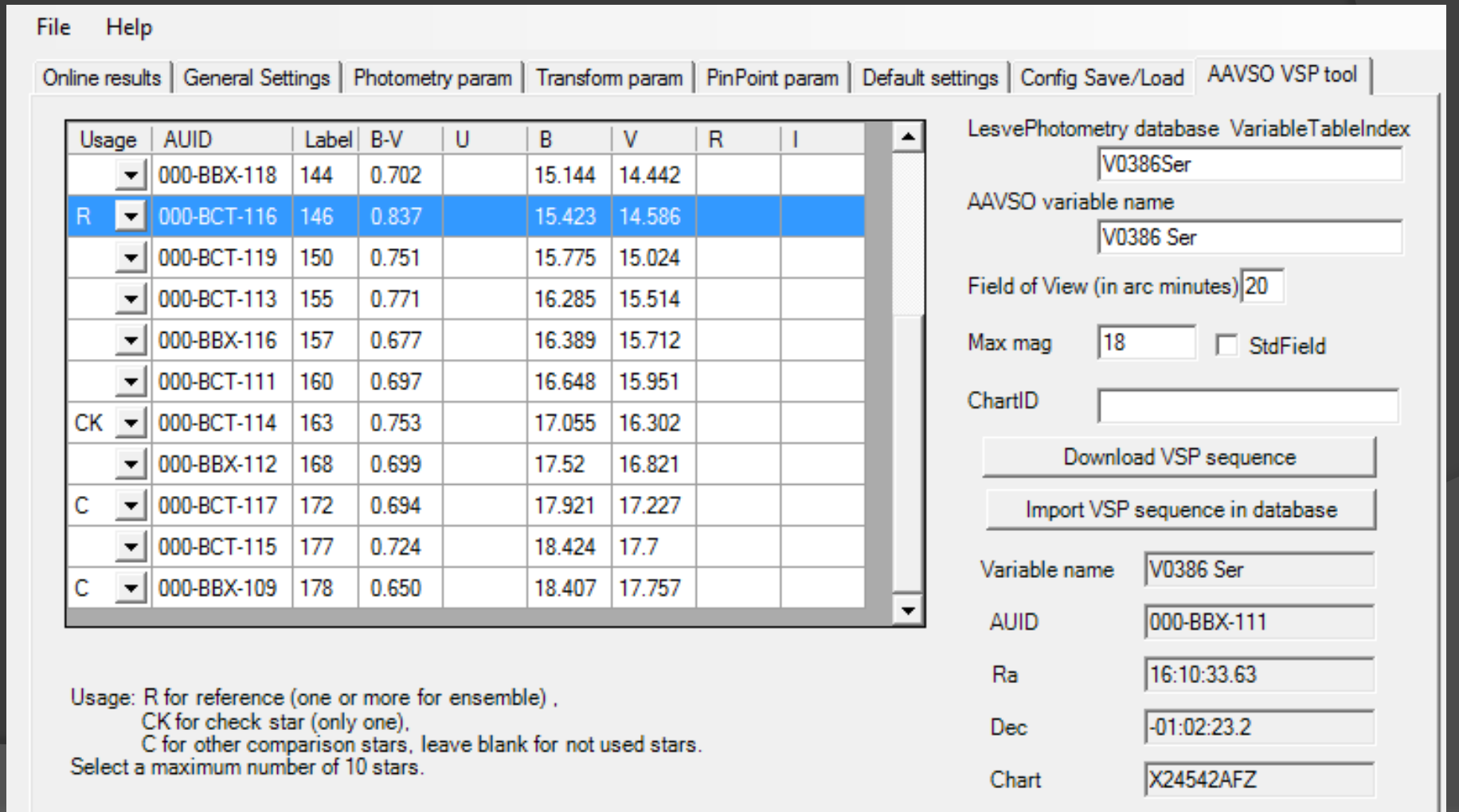
- SQLite.Net database engine is embedded in LesvePhotometry



Database : Comparison stars



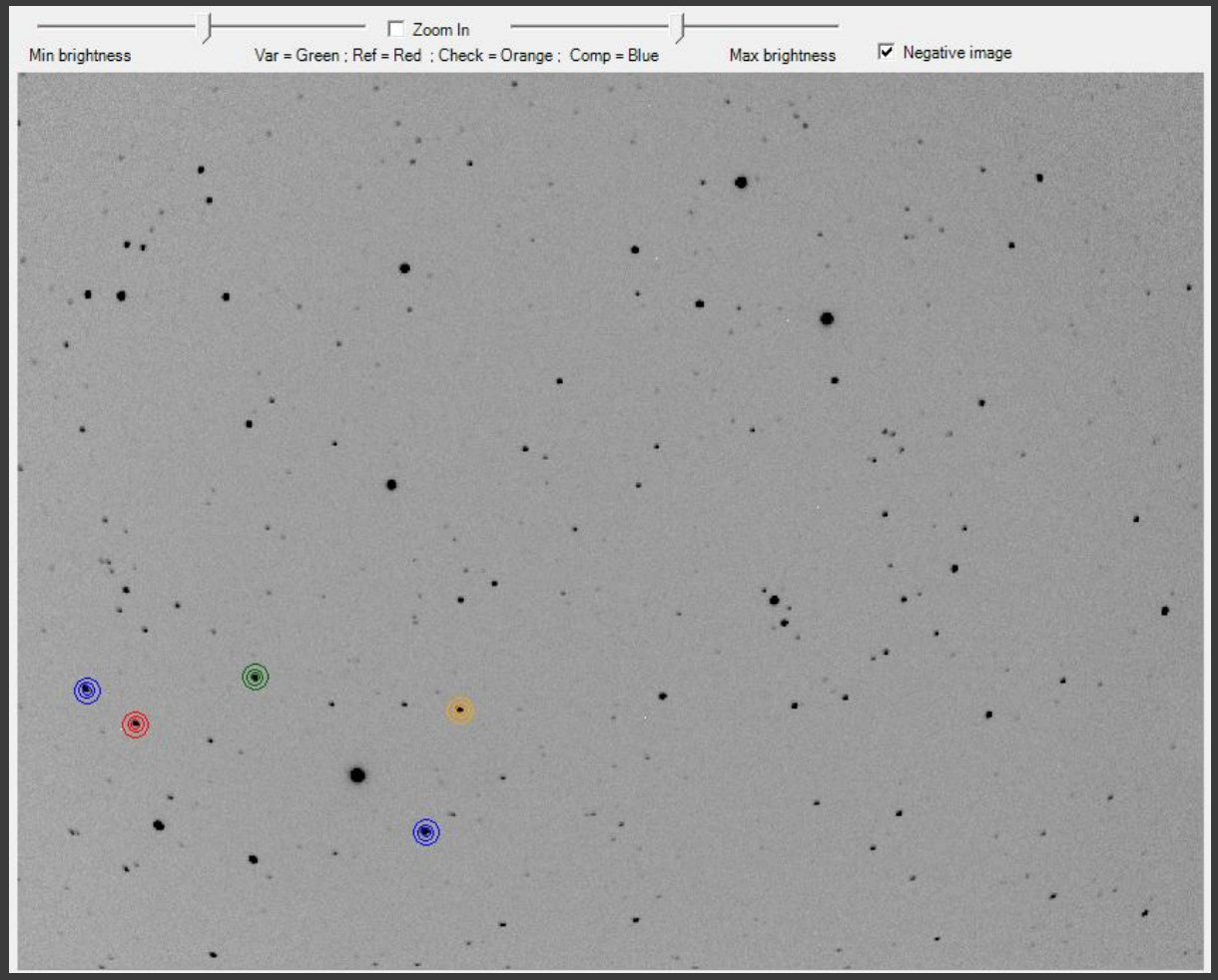
Populate database
with embedded AAVSO VSP tool

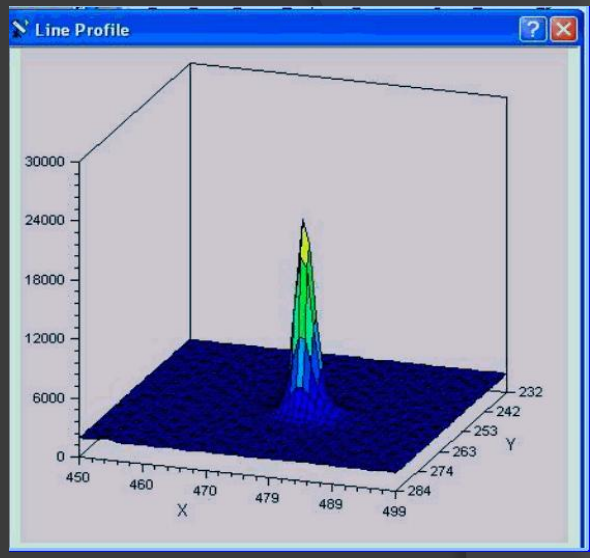


First step – Astrometry

- Solve the images with PinPoint of dc3.com ($149)
  - detection of stars
  - matching the detected stars with stars of one catalog
    - GSC, USNOA2, USNOB1, UCAC2-3-4
- List of detected stars
  - RA, DEC Image position x,y in pixels
- Pixel coordinates are used to position the aperture circles for Variable and Comparison stars

Aperture measurement

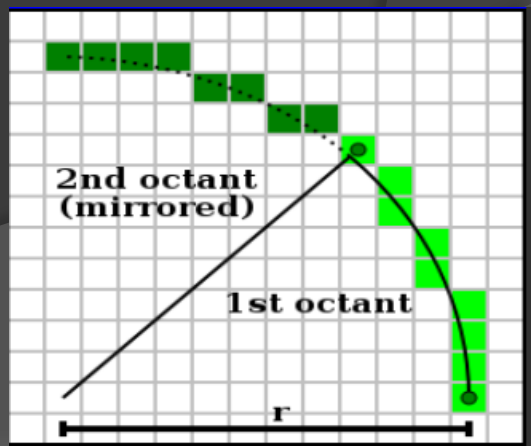




- Aperture : pixel value = star + background + pedestal
- Annulus : pixel value = background + pedestal
- Flux : Sum (Aperture – Annulus)

Aperture measurement

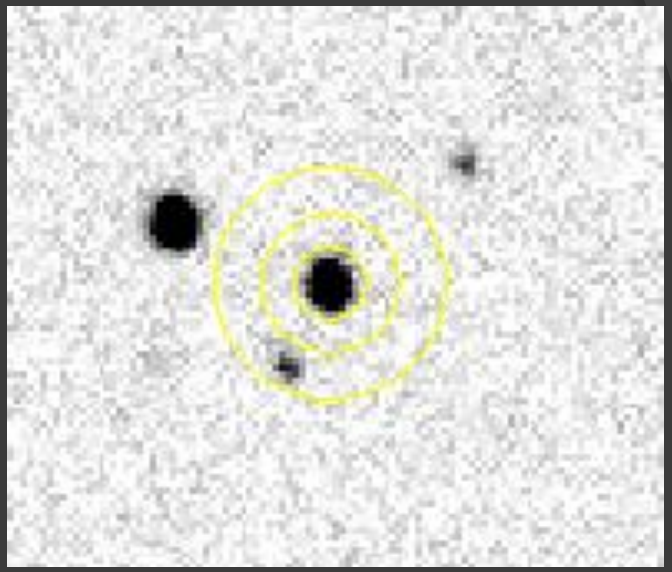
- Sum the ADU of pixels inside the circle
- To speed up the process integers are used for circle center and radius
- Pixel distance to circle center
  - calculated with Bresenham's algorithm
  - most of the calculations are additions / subtractions of integers
- Pixels straddling the circle are divided in 10 by 10 pixels and algorithm is repeated
  remaining straddling sub-pixels are counted for ½
- Error on circle surface less than 0.2%
  for a circle radius of 5 pixels



Close stars??

- Stars in annulus affect
  - background value
  - SNR
- Astrometry provides a list of stars
- If a “spurious” star is in the annulus

  the program doesn’t use this part of the annulus



Differential photometry

- F_{obj} = Variable star flux
- F_{ref} = Comparison star flux
- M_{ref} = Comparison star magnitude
  - from the database

- $m_{obj} = M_{ref} – 2.5 \log (F_{obj} / F_{ref})$

- More than one star may be used for the reference
  - ensemble photometry
    - fluxes of reference stars are added (master star) or
    - mean value of magnitudes obtained for each reference stars

Error estimation

- Poisson noise
- Background noise

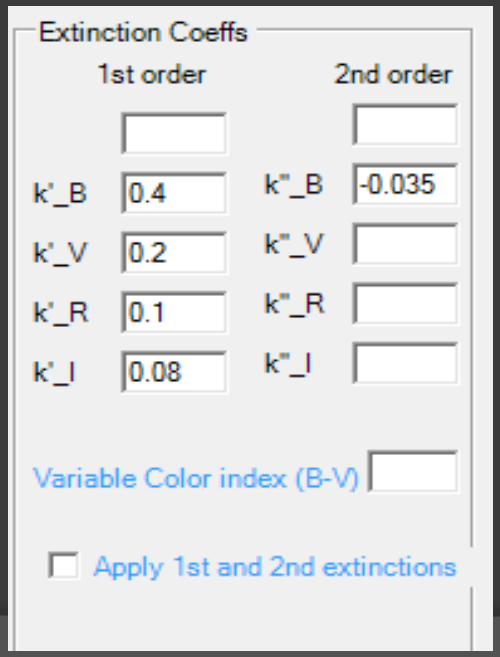
$$S/N = \frac{N_{ADU} \times G}{\sqrt{(N_{ADU} \times G) + n_{pix} \times ((N_{ADU,sky} \times G) + N_{dark} + (N_{r.n.})^2)}}$$

- Errors on Variable and reference stars are added
  in quadrature

1st and 2nd extinctions

- $V_o = V – k' X – k'' X (B-V)$

V measured magnitude
V_o exoatmosphere magnitude
X airmass > 1
k' 1st extinction coefficient
k" 2nd extinction coefficient
(B - V) star color-index



extinction corrections become important when you observe :

- in B band

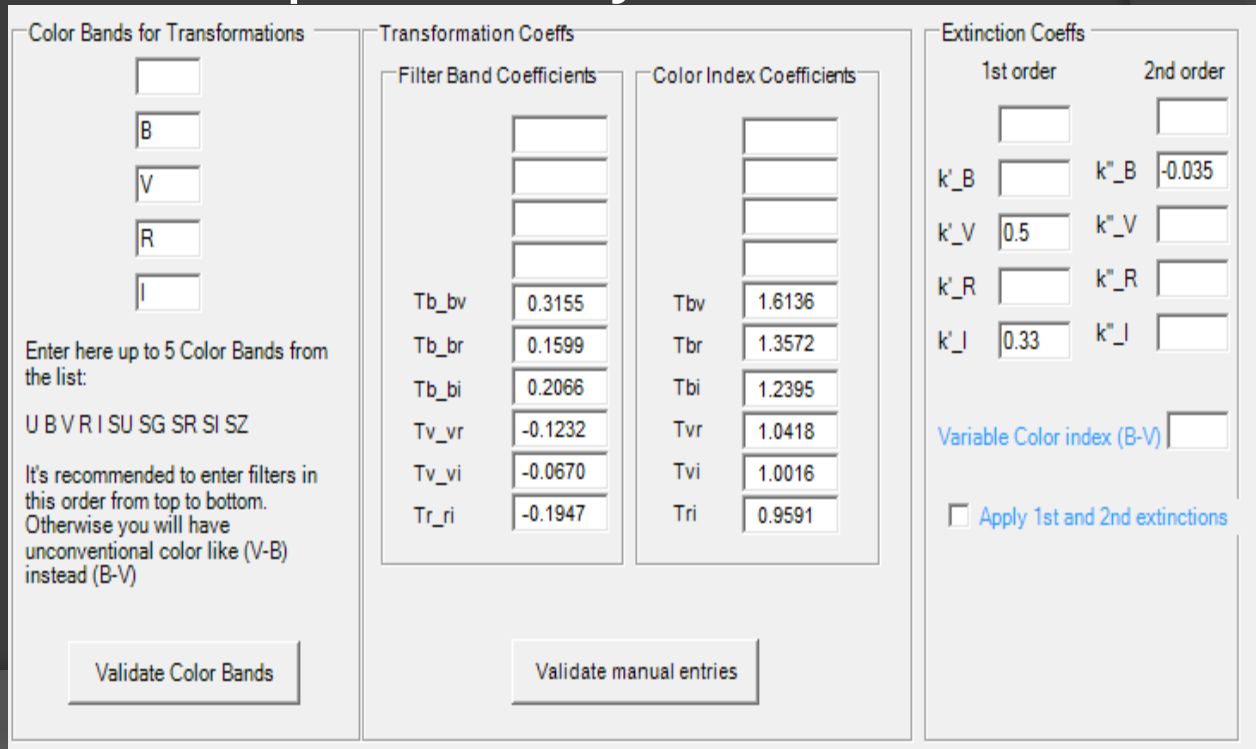
- at low altitude
(e.g. X = 3 for 20 deg above horizon)

-with a large distances between comparison stars (X_2-X_1)
e.g. with large FOV as in DSLR

Transformation to Standard system

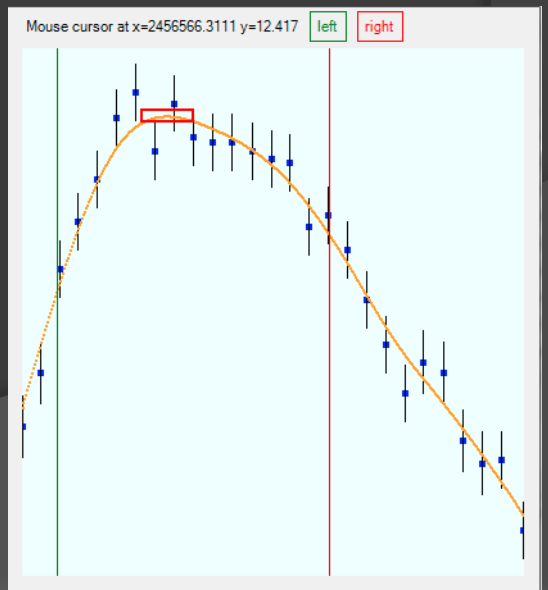
- Transformation coefficients
  (Filter Band and Color Index)
  derived with LesvePhotometry from image measurement of a Standard field (e.g. M67)
- Applied after differential photometry

up to 5 colors bands may be used



Reports

- AAVSO report
  ready to be uploaded to AAVSO database
- CBA report (text report)
  table with JD, magnitudes, airmass, a.s.o
- Excel report
  with a graph of the light curve
- Graphical interface to estimate the extrema (JD, Mag) based on Reinsch spline algorithm



Software installation

- LesvePhotometry
  - available as freeware www.dppobservatory.net
  - User guide and FAQ pages for documentation
  - Discussion group (46 members) http://groups.yahoo.com/neo/groups/lesvephotometry/info
- OS XP, Win7, Win8, Win10
- Office 2007 or later
- PinPoint from dc3.com ($149)
- Sky catalogs (used for astrometry)
  - GSC
  - USNOA2, USNOB1
  - USNO UCAC2, UCAC3, UCAC4

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Josch Hambsch
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Tom Krajci
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for their

- improvement suggestions
- spent time for testing beta versions

LesvePhotometry
an amateur astronomer collaboration