Danish telescope – Czech participation
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• Danish national telescope
• Operated since 1979
• Located on ESO La Silla observatory
• Complete robotization since 2012
• Remote control and observing

• Off-axis mount
• Diameter of mirror - 1.54 m
• Pointing restriction due to the limited space inside dome

Current state

• CCD controller (Danish Copenhagen)
• CCD chip E2V – CCD44-82
• 2048 by 4096 pixels, used 2kx2x
• Pixel size 13.5 μm
• Resolution 0.395“/pixel
• Field of View 13.48 x 13.48 arcmin
CCD Chip improvement

Close future:

CCD231-42-0-F61 (Danish)

- 2048x2046 pixels
- Pixel size 13.5 μm
- Lower noise

<table>
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<th>λ [nm]</th>
<th>QE [%]</th>
<th>QE [%]</th>
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<td>FWHM [nm]</td>
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<td>Ha</td>
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Time schedule

Good news:

- Totally 50% of Danish observing time for Czech side
- 25% OT for interplanetary matter group
- 25% OT for three different stellar groups

- Totally for Czech astronomers – 180 observing days
- For interplanetary group 90 observing days
- For stellar groups also 90 observing days together

- Data storage located in Ondrejov contains all photometric observations made by Czech and Danish astronomers

Bad news:

- 30 observing days for one group
- Random distribution from October to April
Data processing

- Automatical data reduction based on MuniPack
- One whole observing night ~ 2 hours of CPU
- VO compatible output
- VO database under construction

Scientific projects:

- mostly short and middle time variability
  LMC, SMC and GSEP region

- Eclipsing binaries
  Double Periodic Variables
- LMC and SMC Be stars monitoring
  Gaia alerts follow-up

- Target of opportunity cooperation between stellar groups
Munipack
A general astronomical image processing software

- photometry corrections (bias, flat-field)
- astrometry (including matching)
- full photometry calibration (photon-based, colour system transformations, atmospheric corrections)
- robust statistical estimators
- Virtual observatory access
- basic FITS utilities
- command-line and GUI interface
- Open source (Fortran and C++), GPL
Calibration By Photons

- CCD is photon counting detector
- Flux in filter by Gauss-Hermite quadrature

Flux $F$ and photon flux $\Phi$ relations

$$ F = \int_0^\infty f_\lambda(\lambda) \ t(\lambda) \ d\lambda = \int_0^\infty \Phi_\lambda(\lambda) \ \frac{hc}{\lambda} \ t(\lambda) \ d\lambda. $$

Approximation of deconvolution

$$ N_V = AT \ \Phi_V \approx \sqrt{2\pi} \ AT \ f_V \delta_V \ \frac{l_V}{hc} \ \frac{l_V}{hc} \ \approx \ ATF_V \ \frac{l_V}{hc} \ . \ 10^{-0.4 \ m_V}. $$
Robust Statistics

The effective attenuation

\[ C = t N \]

Normalisation

\[ N(0, 1) \sim \frac{C - t N}{\sqrt{C + \sigma^2 + \ldots}}, \ N \gg 1 \]

Parameter is solved by the equation

\[ L = \prod_{i=1}^{N} \frac{1}{s \sqrt{\sigma_{n_i}^2 + t^2 \sigma_{c_i}^2}} f \left( \frac{c_i - t n_i}{s \sqrt{\sigma_{n_i}^2 + t^2 \sigma_{c_i}^2}} \right). \]

where \( f(x) = \exp(-\varphi(x)) \) is a robust function:

\[ \varphi(x) = \begin{cases} 
-ax - a^2/2, & x < -a \\
x^2/2, & -a < x < a \\
ax - a^2/2, & x > a 
\end{cases} \]
Spread Bessel Profile

Bessel Convolution profile

\[ I(r) = \frac{1}{\sqrt{2\pi s}} \int_{-\infty}^{\infty} e^{- (r-x)^2 / 2s^2} \cdot \left[ \frac{2J_1(x)}{x} \right]^2 \, dx. \]

Approximation

\[ I(r) = -\frac{8}{\sqrt{\pi}} \sum_{j=1}^{n} H_j \frac{4J_1(r - \sqrt{2s}a_j)^2}{(r - \sqrt{2s}a_j)^2}. \]
Astro-mill
Reduction pipe-line on base of Munipack

- Fully automatics reduction
- Mean bias and flat-fields
- Astrometry on base UCAC4
- Photometry with OSPS
  Photometry Catalogue
- (July 2015): 702 nights,
  146261 RAW frames
OSPS Photometry Catalogue
Ondřejov Southerland Photometry Survey

- about 3600 stars (Landolt fields, SMC, LMC)
- magnitude range 12 - 17 in Johnson UBVRI filters
- alone stars above 10 FWHM
- more than 3 different nights
- verification required
Double periodic variable observation

- LMC DPV (Poleski+, 2010)
- OGLE-LMC-DPV – 056

Mean magnitude(I): 15.37
Period(1): 176.146d
Observed during 2014/2015
OGLE15mg

Ra = 2:09:02.37
Dec = -73:24:41.8

m_V ~ 20.94 mag
Thank for your attention

Reference:

**MuniPack**
http://munipack.physics.muni.cz/

**OGLE IV transients**
http://ogle.astrouw.edu.pl/ogle4/transients/transients-lite.html