UPDATE ON ILMT PIPELINE and DATA SHARING

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on behalf of ILMT pipeline team

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Jean Surdej & many more for python/modules discussion.
Flow diagram: Pre-processing

- Calibration:
  - Astrometry
  - Magnitude calibration

- Transient detection:
  - Template substraction
  - Data Sharing
Observing Mode: Time Delay Integration (TDI)

- **CCD**: 4k x 4k (4098 x 4896 pixels),
  - Transit time of source: 102s
  - CCD: readout continuous

- **FOV** of 4k x 4k imaged saved is: 27'x 27'

- **TDI**: Transfer the charge from one column to another along RA direction in CCD

- 104 sec integration:
  - charge transfer rate= sky velocity
**Observed Image: TDI mode**

- **TDI mode:**
  - Source is transiting, and its charge in CCD-pixels, also transferred.
  - Just before exiting from the CCD, accumulated charge, registered in image pixel.

- **In each image-pixels**
  - The flux value is integrated, over 104 sec.
  - Integration, happen during transit at 4096 ccd-pixels, so contain DARK, FLAT-RESPONSE, SKY information of 4k pixel.

- **CCD-pixel NOT SAME as IMAGE-PIXEL in TDI mode**
Master-Dark

**STEPS:**
- TDI mode ON
- Shutter close
- Take multiple 4k x 4k images
- Create super dark
  - science_raw[4kx4k]-dark [4kx4k]

**SETUP:**
- CCD temperature -110° C.
- Gradient (e.g. in DEC direction) in DARK, a low and stable temperature non-significant
Master-FLAT: created from science frame

- Fit 2D polynomial on the 4k x 4k image to interpolate onto the masked region.
- Mask pixels with value > 3 x rms background.
- At a given DEC, take median of all the image pixels over RA-axis (4K pixels) values, to make 1D image 1x4K_DEC.

1. Pixel in DEC direction versus median value.
2. Remove the sky variation using low-order polynomial.
Sky-Subtraction: Created from science frame

Science frame (flat corrected)

Mask pixels with value > 3x rms background

Fit 2D polynomial on the 4k x 4k image to interpolate onto the masked region

lower order during stable sky

higher order during twilight or moon, when gradient is large

Example using 1.3m TDI mode observation:

Sky flux and estimated sky in ADUs

Universal time

18 19 20 21 22
Astrometry: assigning RA and DEC to X and Y

\[ X = c_1 \times RA + c_2 \]
\[ Y = c_3 \times DEC + c_4 \]

To compute the \( c_1, c_3, c_3, c_4 \)

Use GAIA co-ordinate J2000 and precess them to Obs-epoch)

Chi-square minimisation to get \( c_1, c_2, c_3, c_4 \)

use \( c_1, c_2, c_3, c_4 \) to get RA/DEC in entire FOV, at Obs-epoch

Precess all the RA-DEC from Obs-epoch to J2000 epoch

Typical accuracy 1.3m accuracy 0.10 & 0.15 in RA and RA & DEC respectively

Accuracy improve with:

- Use source catalogue in field with zero proper motion (e.g., see Mondal et al TALK)
- Magnitude cut for very faint and very bright sources.
Photometric calibration: min. air mass

Compute instrumental magnitude ($m_{\text{ins}}$)

Find $m_{\text{gaia}}$ for all the detected sources

$m_{\text{gaia}} = 1 \times m_{\text{ins}} + c$

- minimisation for offset estimation
- Highly variable sources act as outlier

- Typical precision **0.4 at 1.3m** in with sdss g`-filter
  - Reasonable as response in GAIA broad band and SDSS g`-filter have differences [ILMT pixel size is about 0.4arcsec]

- For further improvements, identify standard, non-variable sources, and use them to improve the precision
TDI data reduction and calibration pipeline: Summary
TRANSIENT detection: Need efficient image subtraction

Tools: A good reference image (from ILMT survey) and an efficient subtraction algorithm [to process at <102 sec, before we get new image].

A difference image analysis (DIA) algorithm proposed by Bramich et al. 2008 takes 150 seconds to run on a 16Gb memory @ 2.3GHz clock speed, with kernel size of 11 x 11 pixels

- The model: \( M_{ij} = (R \ast K)_{ij} + B_0 \)

VARIOUS TRIAL IN PROGRESS, SO PARTICIPATION WELCOME!
DATA SHARING and Archiving (yet to formalise)

PIs and Director ARIES suggestion is to make data public without any proprietary period. So as, to improve scientific efficiency by optimal use of data (along with increase feedback and iterative testing).

What are considered to be data

➢ Images in g, r, i band
  ○ (both RAW and Calibrated data).
➢ Catalogues of various type of sources
  ○ (e.g. based on pipe line or collective effort by core team)
➢ Software and TDI pre-processing tools.

When and how long data are available

➢ Transient alert
  ○ within few minutes (aim <10min).
➢ Regular data upload:
  ○ daily: pipe line products
  ○ weekly: after quality check
  ○ monthly: source catalogue, light curves
➢ Archived: for query and catalogue access, then after pro

--THANKS!