Followup observations of Gaia alerts with
SKYNET robotic telescopes

Staszek Zola

Astronomical Observatory, Jagiellonian University
and
Mt. Suhora Observatory, Pedagogical University

Collaborators: D. Reichart, V. Kouprianov (UNC), D. Caton (DSO)

10th Gaia Science Alerts Worhshop 2019
Catania,   Dec 18th – 20th

Talk layout

- SKYNET telescopes: an observer's perspective

- Scientific results based on SKYNET data:
   long term monitoring of OJ287, Gaia19bld

- Using Cambrige Photometric Calibration Server

SKYNET Telescopes

- Started in 2004 by D. Reichart (UNC) with a goal to observe GRBs

- PROMPT telescopes in Chile, Australia & Canada

- Currently ~20 optical telescopes (40cm -1m)

- 20m radio telescope (GB20)

- Funded mostly by NSF, but also by NASA and Mt. Cuba Astronomical Foundation

- Software (TERMINATOR) controls the network and scheduling of observations

- Works with most commercially available hardware (telescopes, domes, CCDs, filter wheels, focusers etc.)

credit: Dan Reichart

PROMPT-CTIO, 2004

Skynet: Radio

Green Bank Observatory 20m
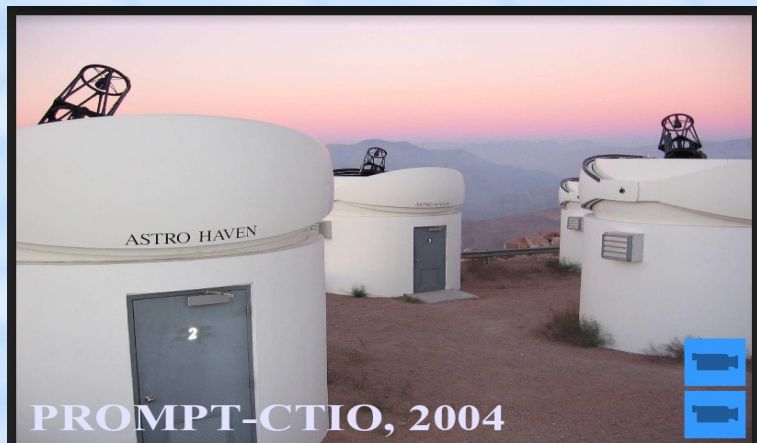
SKYNET Telescopes

credit: Dan Reichart

SKYNET Partners

Requirements:

Telescope 40cm or bigger

Hardware capable of controlling by MaximDL + compatible weather station

Internet connection allowing reliable control in real time

credit: Dan Reichart

- Any remotely and reliably controllable telescope can join
- Must have knowledgeable and dedicated local support
- Use Skynet – or don't!
- When on Skynet, up to 10% of observing time may go to Skynet education and science programming
- Take advantage of Skynet's web and API interfaces, dynamic scheduler, account management infrastructure, image analysis interfaces
- Can allocate observing time to anyone, or trade it with other Skynet telescope owners

Skynet: Partners

SKYNET Science

Skynet's Mission

- **50% Research**
  - **Publish Every ~20 Days**
  - **5 Times in Nature/Science**
  - **Leading NEO Tracker in S. Hem.**

- **50% Education / Public Engagement**
  - **Have Served ~50,000**
  - **3 Large NSF Programs**

Skynet Science

- Gamma-Ray Bursts
- Gravitational-Wave Sources
- Fast Radio Bursts (radio)
- Blazars (optical and radio)
- Supernovae
- Supernova Remnants (radio)
- Novae
- Pulsating White Dwarfs and Hot Subdwarfs
- Wide Variety of Variable Stars
- Wide Variety of Eclipsing Binaries
- Exoplanetary Systems
- Trans-Neptunian Objects and Centaurs
- Asteroids
- Near-Earth Objects

credit: Dan Reichart

SKYNET Operation

credit: Dan Reichart

Observing with SKYNET Telescopes

Observers submit observations using a web API

Observing with SKYNET Telescopes

List of telescopes and detailed info available. Several sites have allsky cameras for inspecting weather conditions

Observing with SKYNET Telescopes

Images are calibrated soon after gathering and available for viewing (jpg) or download (fits/jpg)

Observing with SKYNET Telescopes

An account in the SKYNET system required for observations

Observing credit: buy time, time assigned as DDT, by a partner

Credit deducted only when data have been taken

Observing with SKYNET Telescopes: advantages

Telescopes located on 4 continents → almost uninterrupted observations possible

Redundancy of telescopes at similar longitudes, request for observations can be submitted to a subset of scopes

Easy to use, mostly flexible WEB interface

Possibility to check results almost in real-time: images are calibrated for bias, dark and flatfield and displayed as jpg file

No need to stay awake the entire nights

Observing with SKYNET Telescopes: pitfalls

Many users: longer runs can be interrupted (even several times) on oversubscribed telescopes (e.g. PRMOPT5)

"Normal" hardware issues: images out of focus, bad pointing, filter wheel failures

Algorithm for flat taking not efficient enough, especially when CCD supports several binnings and several filters – flats can be infrequent, deteriorating quality of the data

Sometimes, data are taken in poor conditions

CCDs "memory" issues

R filter is here
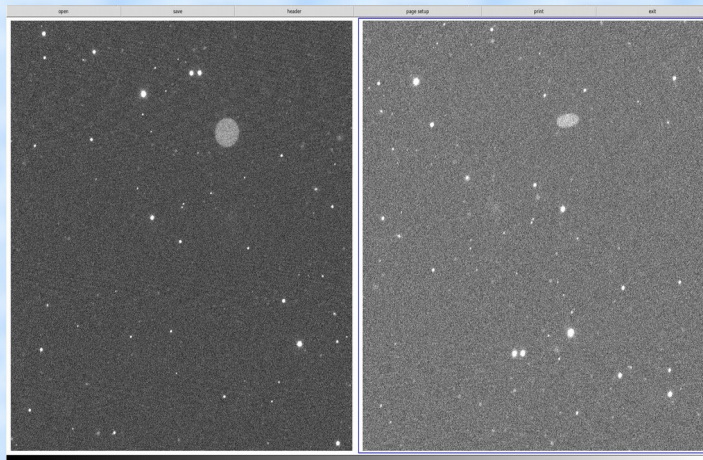
Observing with SKYNET Telescopes: pitfalls

CCDs "memory" issues can be severe, visual examination of images recommended if a pipeline is used for data reduction

CDK500 telescope at Astronomical Observatory of the Jagiellonian University, soon a new member of SKYNET

CDK500   20191216.180501

CDK500 telescope at Fort Skala soon a new member of SKYNET
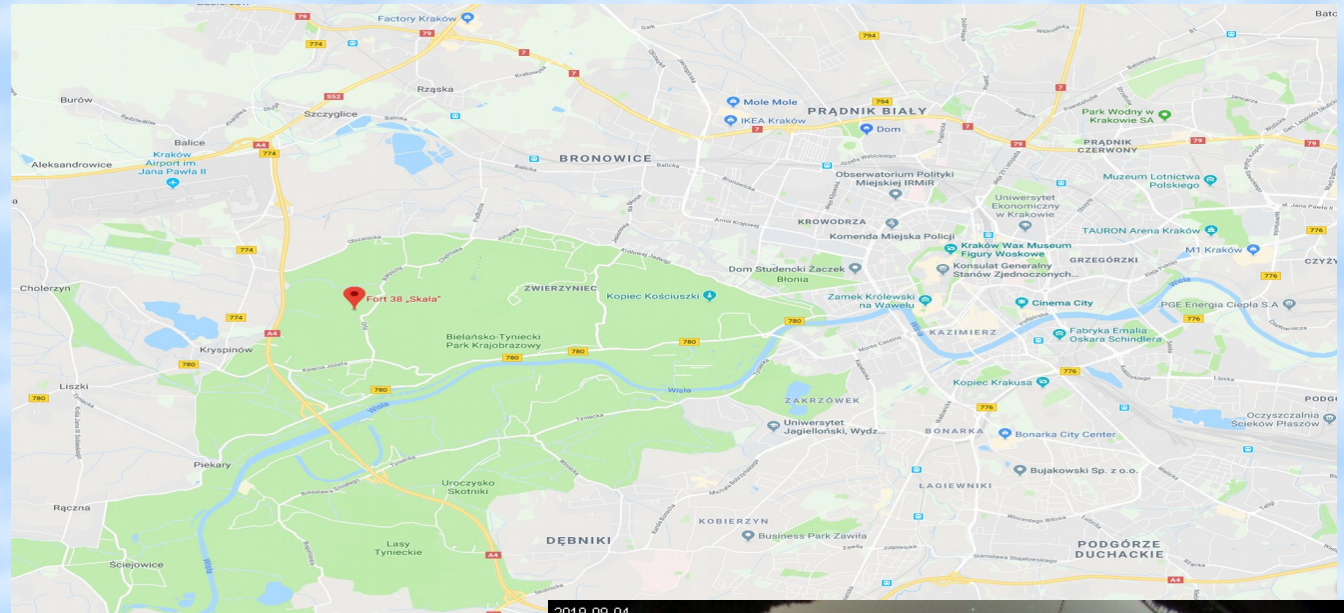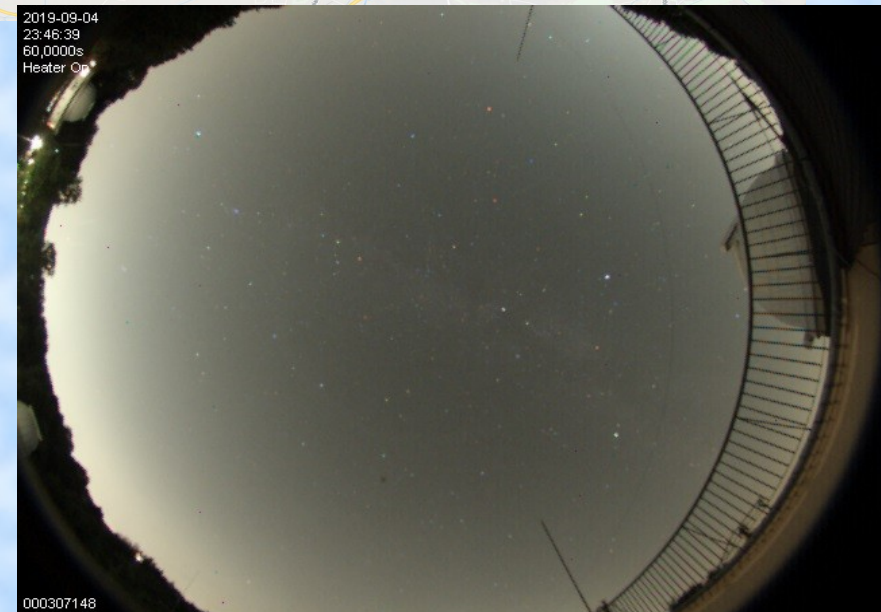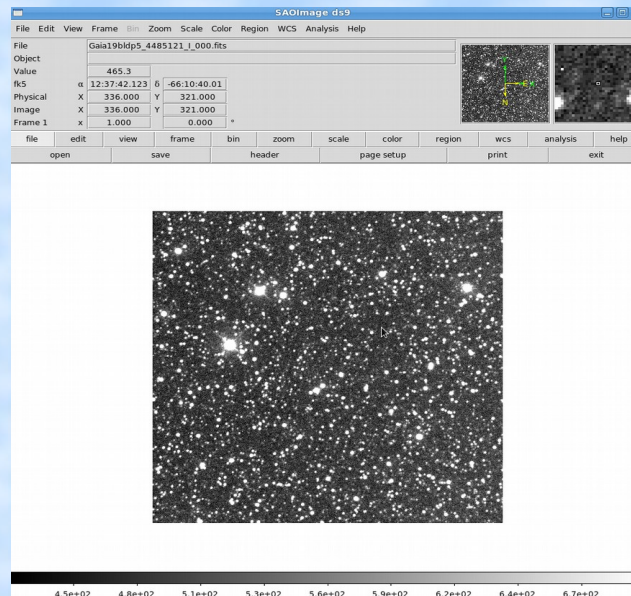
12 km from

city center

Images taken with the SKYNET Telescopes

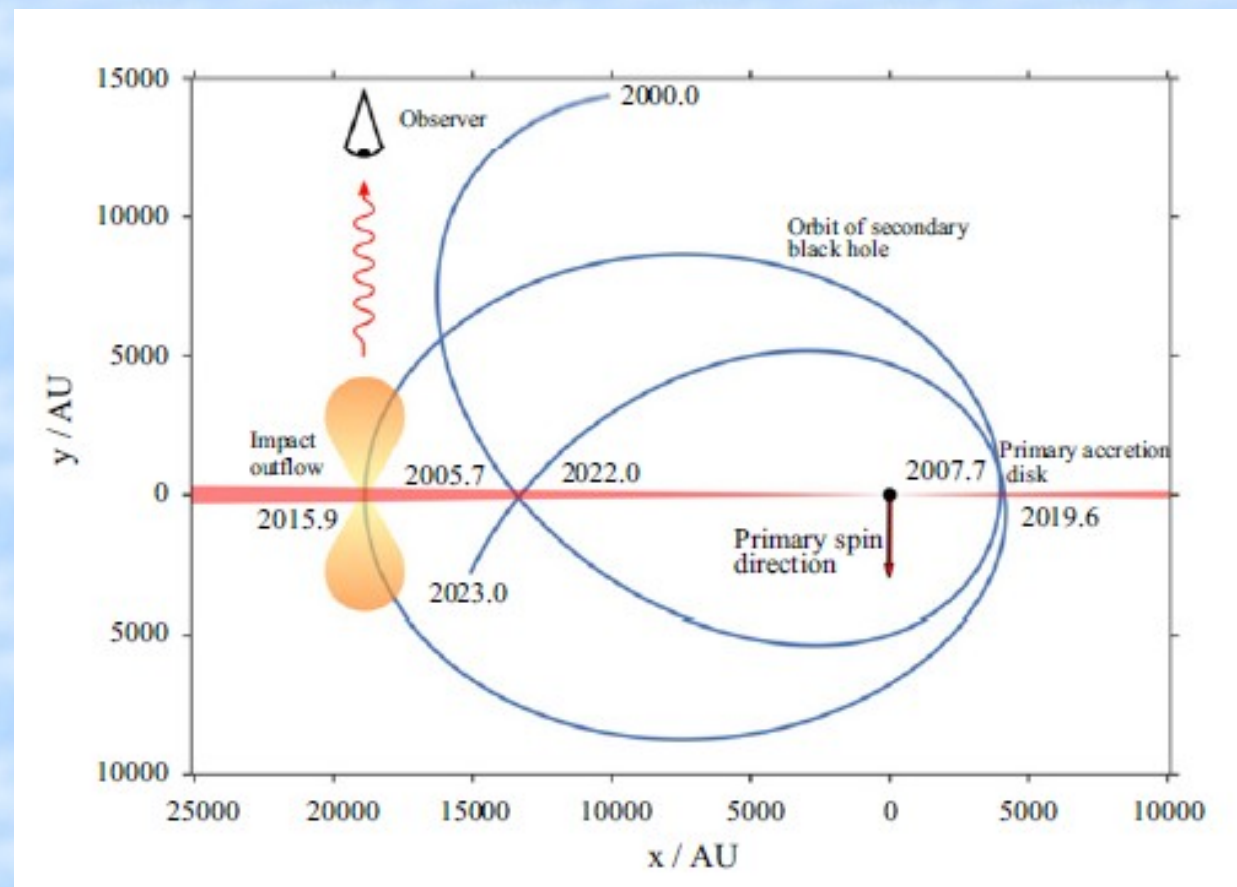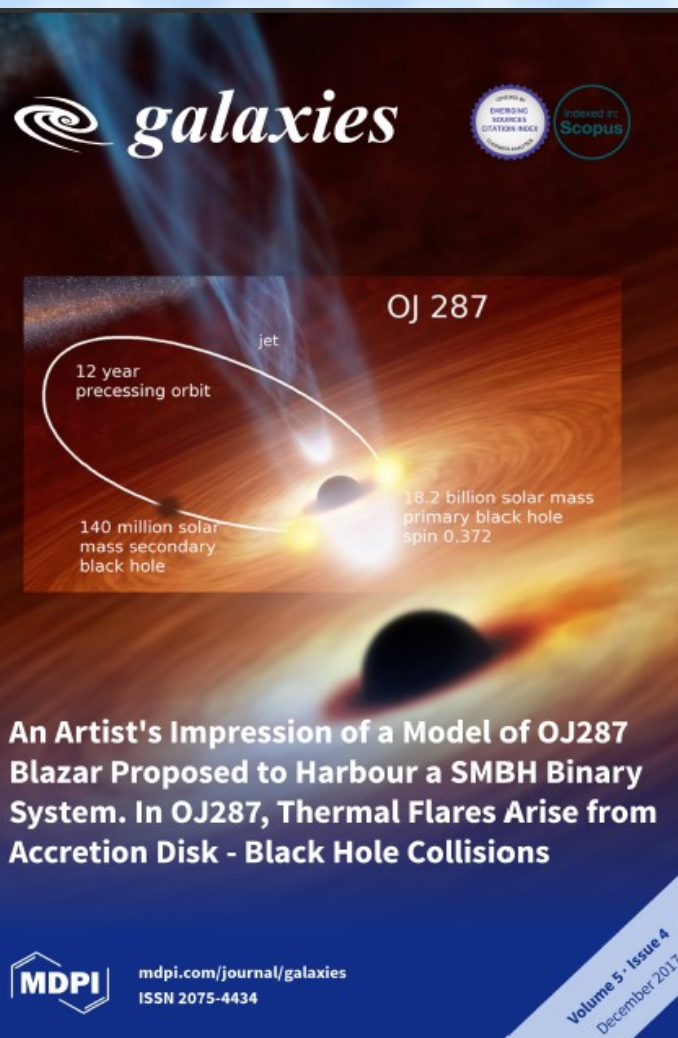Network pipeline does calibration for bias, dark and flatfield almost in real time

Astrometry applied as well

Images ready for extraction

of magnitudes

Long term monitoring of QSOs OJ287

AGN best-known candidate to hosts a SMBH binary
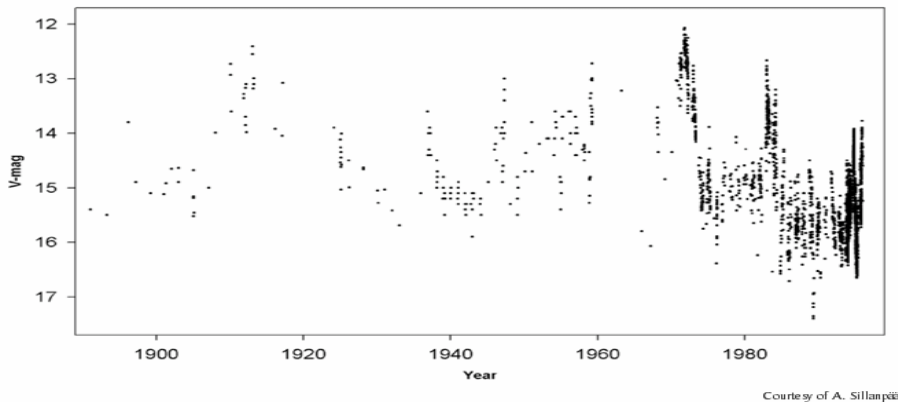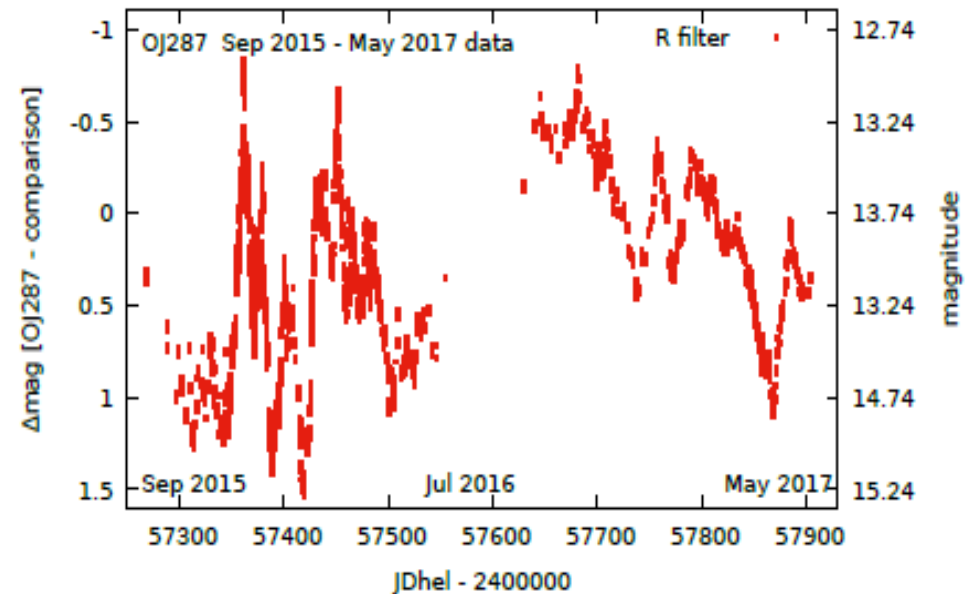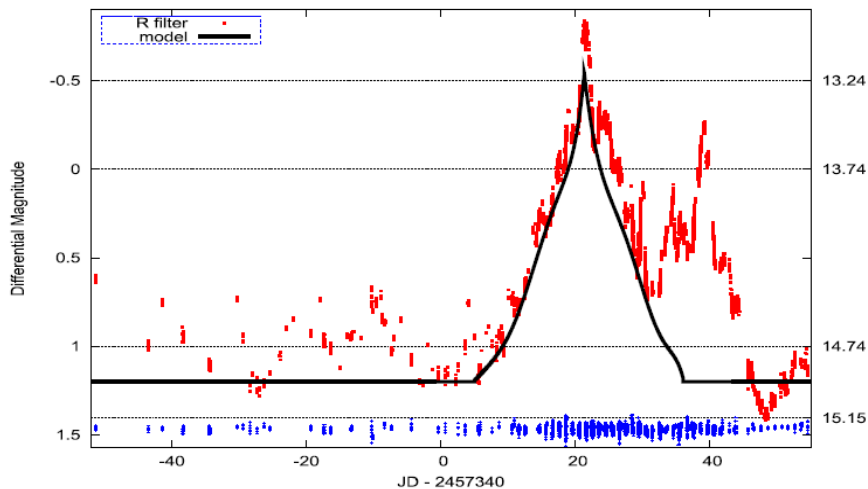
Long term monitoring of QSOs OJ287

Light curve monitoring performed since 2006, extensive usage of SKYNET telescopes since 2015 led to almost daily (or more frequent) coverage

Primary SMBH spin: 0.31 (0.01)
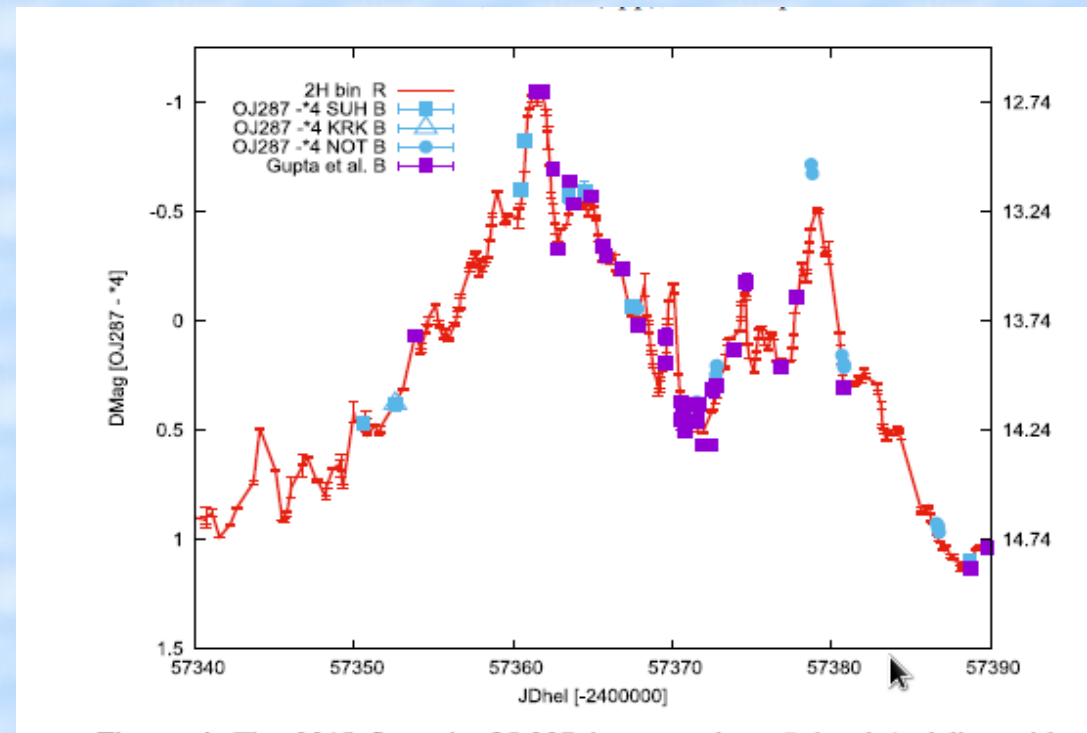
(Valtonen + 2016)

Long term monitoring of QSOs OJ287

Analysis of disturbance propagation in the disk after the 2015 big flare led to estimation of the accretion disk parameters (Valtonen+ 2019):

Disk viscosity: 0.26(0.1) → magnetic disk

Accretion rate: 0.08(0.04)

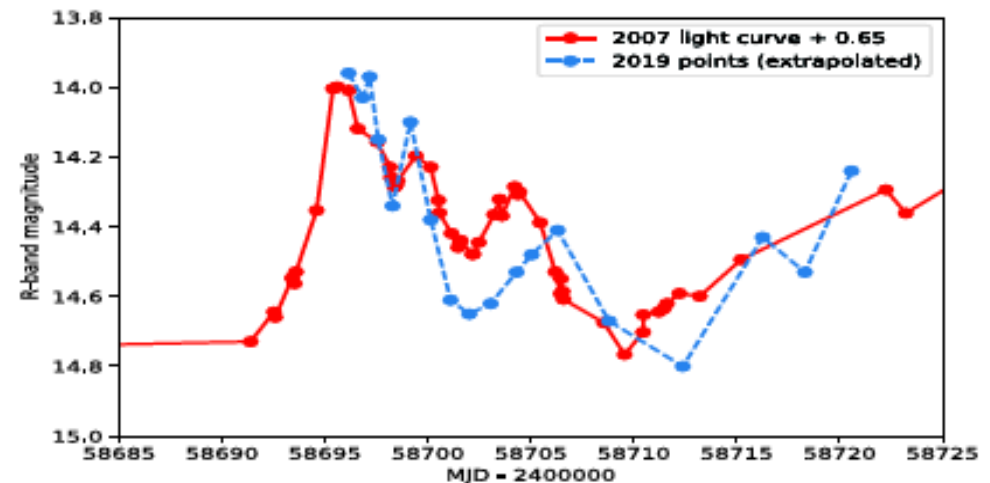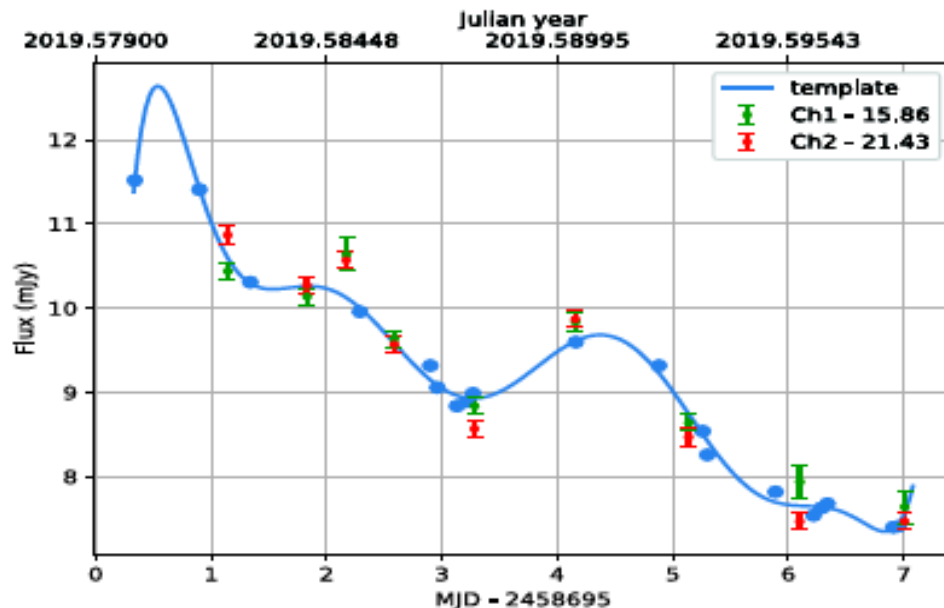Prediction for summer 2019 thermal outburst

Long term monitoring of QSOs OJ287

Spitzer IR observations in summer 2019, cross-calibrated with optical data from ground based telescopes (Feb & Sep 2019)

Lane+ 2019

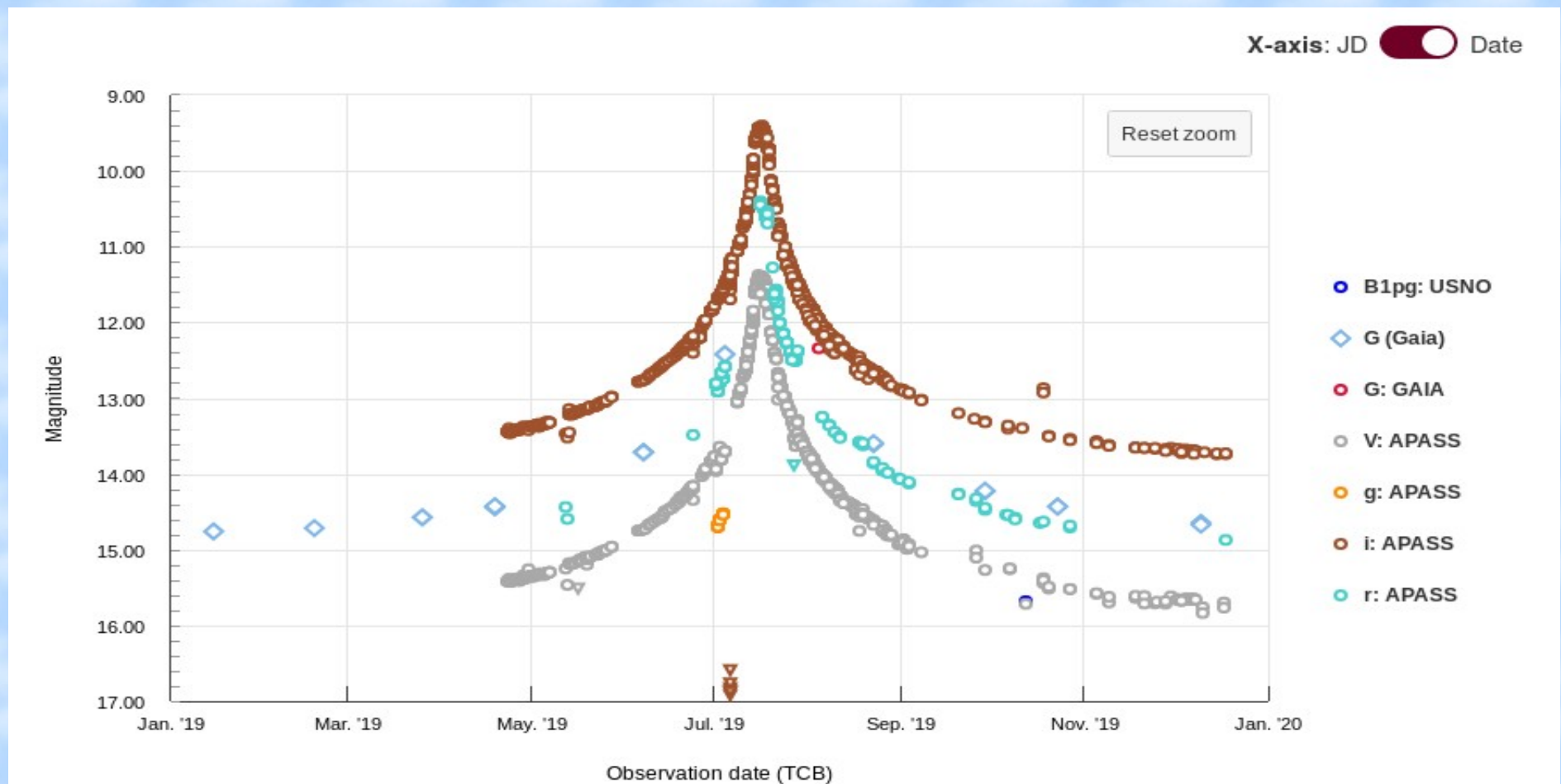Detection of OJ287 host galaxy (Nilsson+ submitted)

2019 Spitzer Light Curves And Comparison to 2007 Flare

Gaia16aye + Gaia19bld

Gaia16aye: Yerkes-41 telescope, sloan filters

Gaia19bld: Prompt5, Prompt8, Prompt-MO, R-COP

CPCS: data upload
Please make an observer's life easier

- JD vs MJD

- Exposure time

CPCS: data upload
Please make an observer's life easier

Data upload requires: MJD, exposure time

live run as default

MJD most often source of mistakes

CPCS: photometric system calibration

There is an offset between Sloan i' and wide band I filters
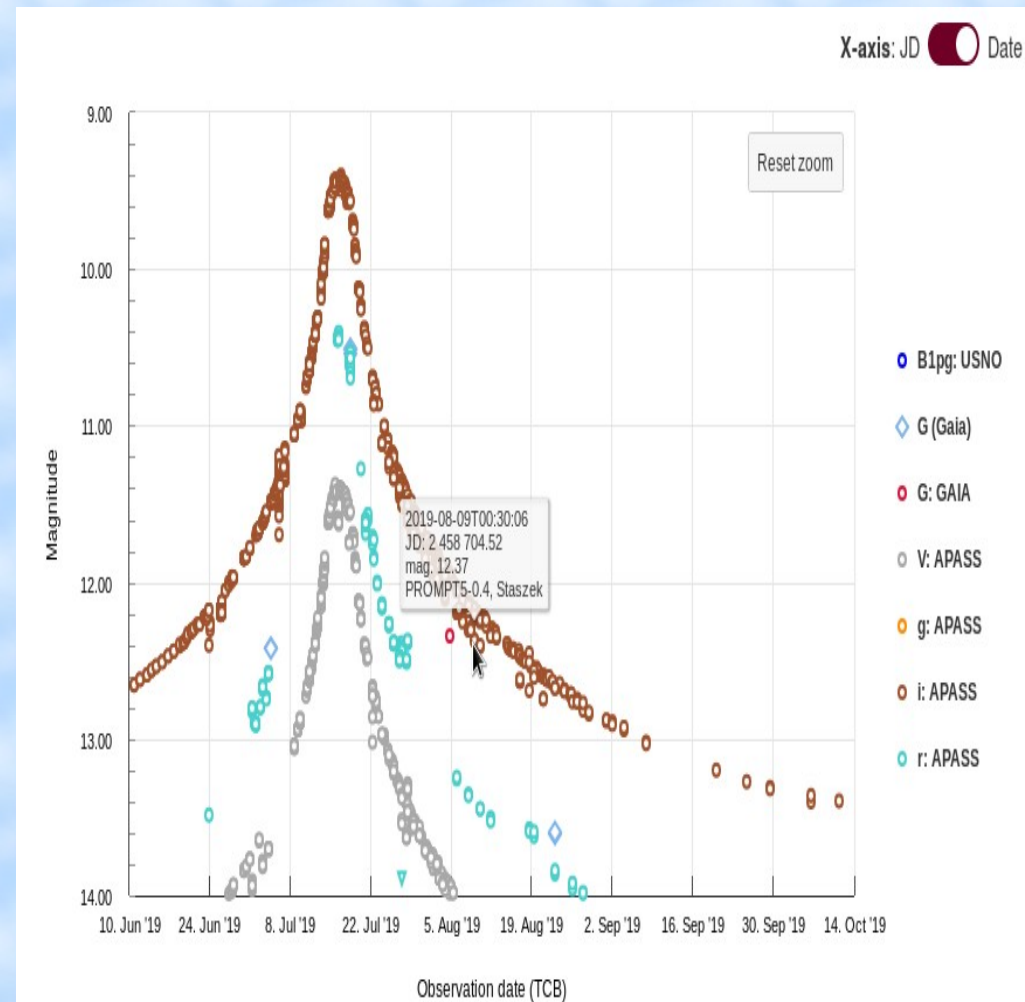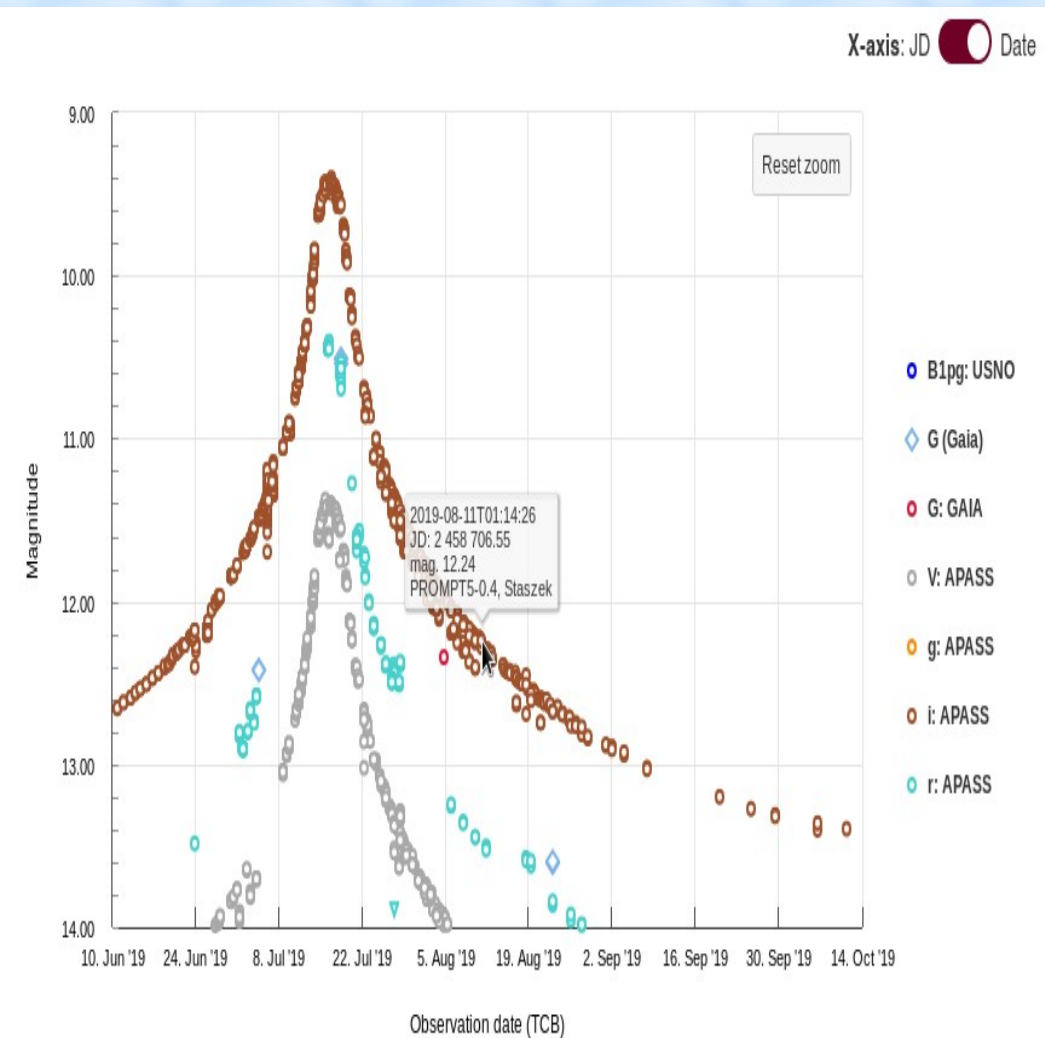
Multisite long term campaigns need coordination

Wyrzykowski+ 2019
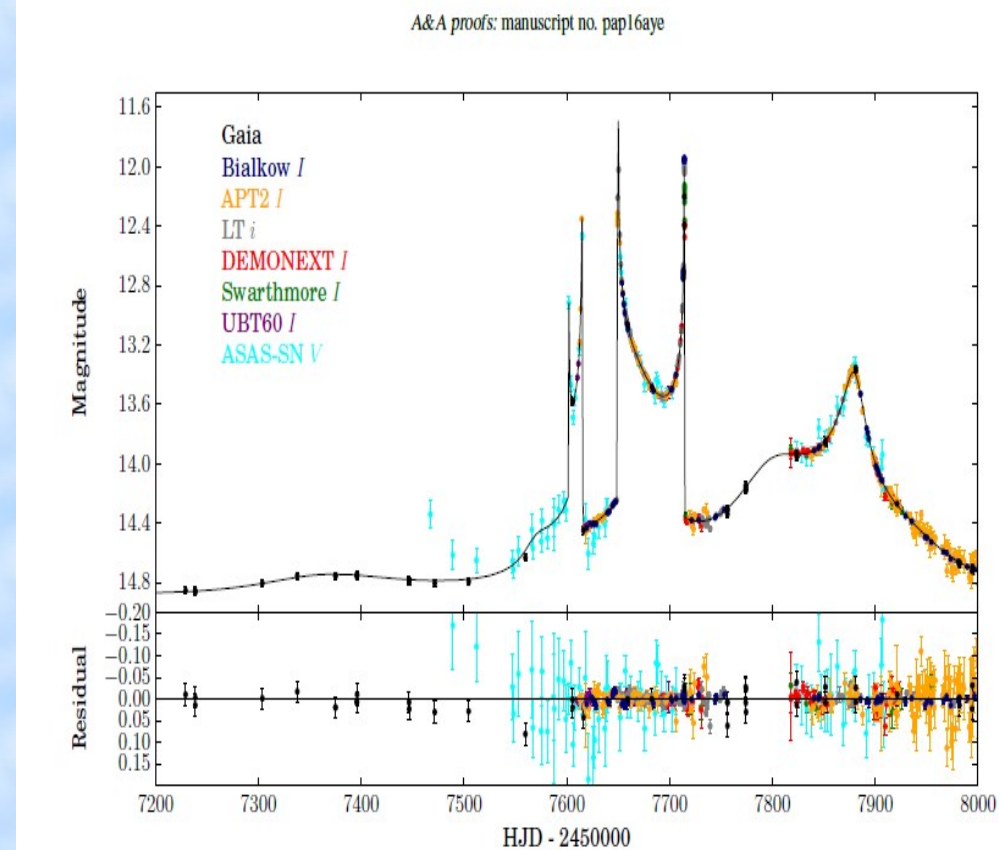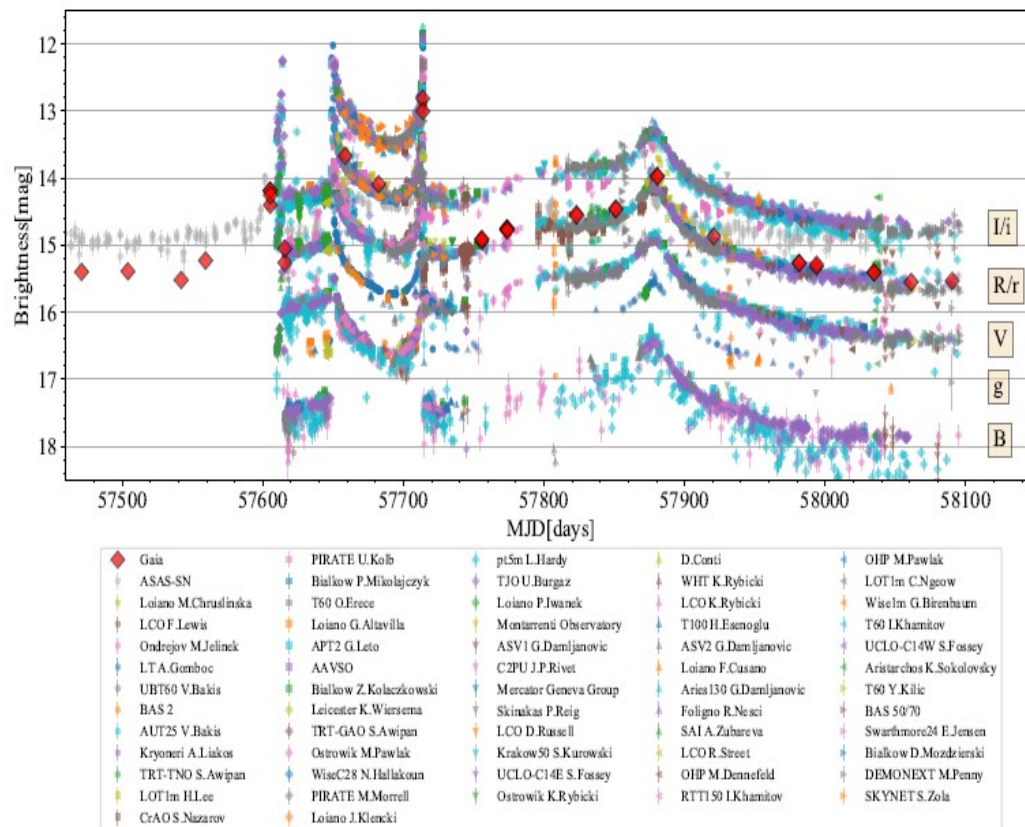
Instead of conclusions:
a wish list (CPCS v 1.0)

Use data stored in FITS header !

If not standard keywords are used → "punish" an observer by

requesting manual typing of required numbers e.g. MJD

Make a dry run as a default, introduce a button to store data after

a dry run is completed and results checked

Create a library of subset of events to be stored in a user account on
the server

Make some coordination of long term campaigns, especially provide an
info on filters to be used, cadence, S/N

as of Dec 19 morning

Instead of conclusions: a wish list (CPCS v 1.0)

Use data stored in FITS header ☺ (ver 2.0)

If not standard keywords are used → "punish" an observer by requesting manual typing of required numbers e.g. MJD

Make a dry run as a default, introduce a button to store data after a dry run is completed and results checked

Create a library of subset of events to be stored in a user account on the server ☺ (BH TOM)

Make some coordination of long term campaigns, e.g. provide recommendations on filters to be used, ~~cadence~~, S/N

Thank you !