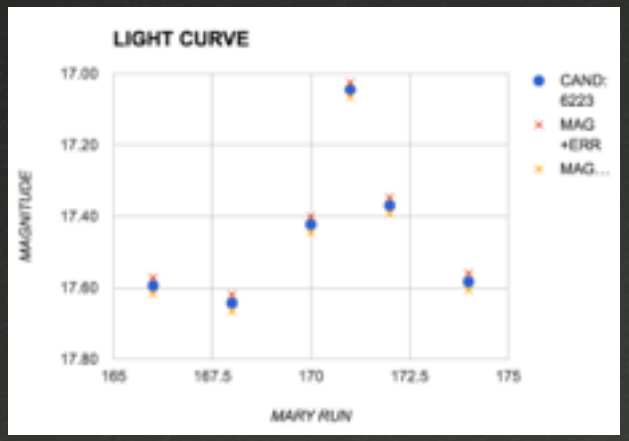
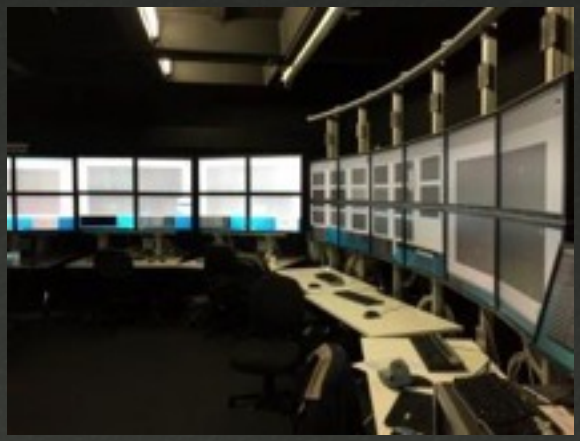
Optimised workspaces enhance time-critical astronomy



Bernard Meade
Christopher Fluke
Jeffrey Cooke
Tyler Pritchard
Igor Andreoni



DWF

CAASTRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

THE UNIVERSITY OF MELBOURNE

Background of *Deeper, Wider, Faster*

- Fast transient events, such as Fast Radio Bursts (FRB), are challenging to capture for imaging and spectroscopy (within minutes)
- Coordinating simultaneous telescope observations to capture these events in multiple wavelengths
- DWF workflow combines automatic candidate detection with visual inspection of DECam CCD difference images (Cooke et al. *in prep*, Andreoni et al. *in prep*, Vohl et al. *in prep*)

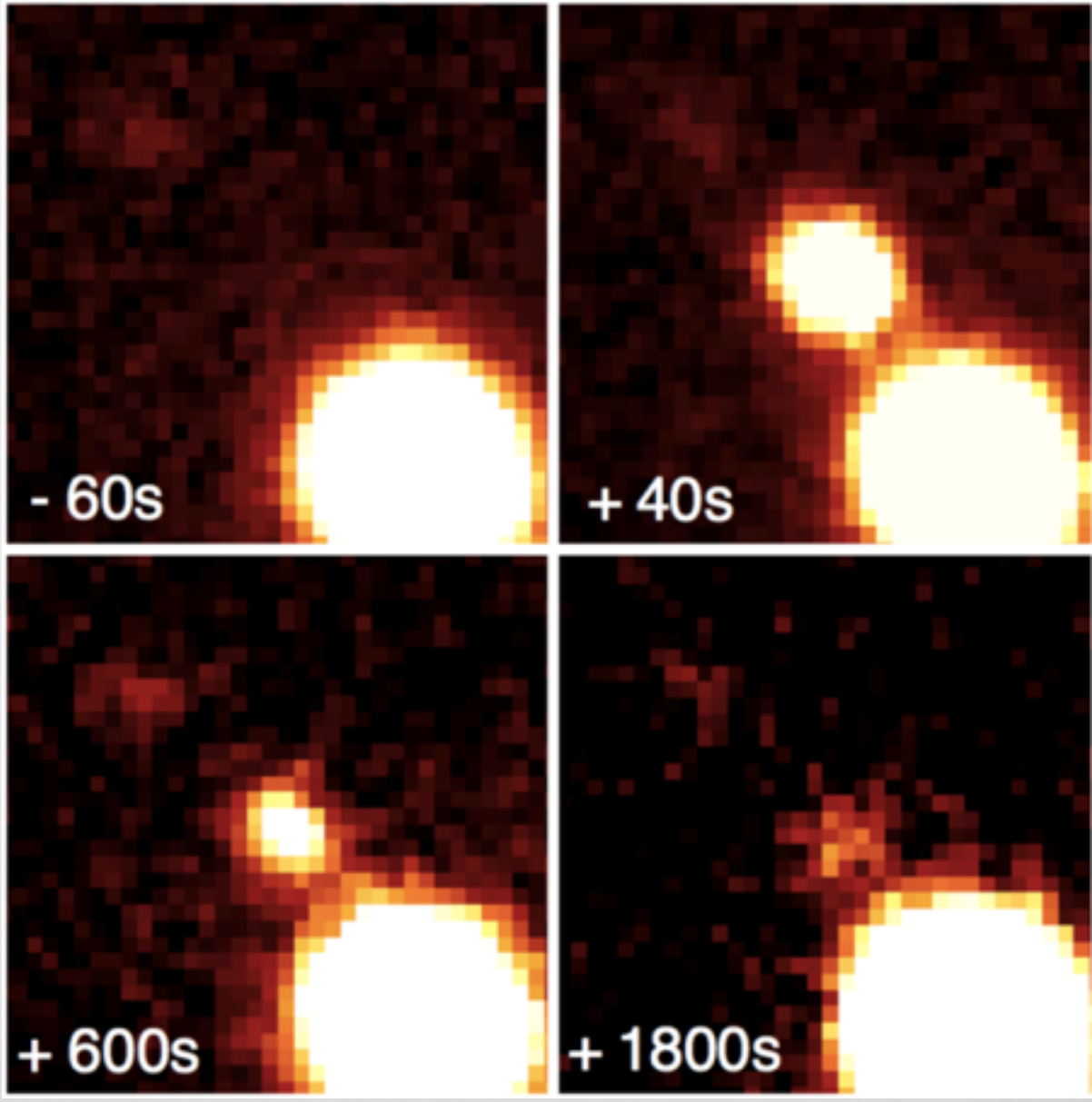
LIGO
MoU in place

Simultaneous observations

MLO
VLA
Geo
Keck
Virgo
Swift
XMM
ANU2.3m
ATCA
Parkes
Molonglo
AAT
SkyMapper
SALT
VLT
REM
DECam
Gemini
AST3-2

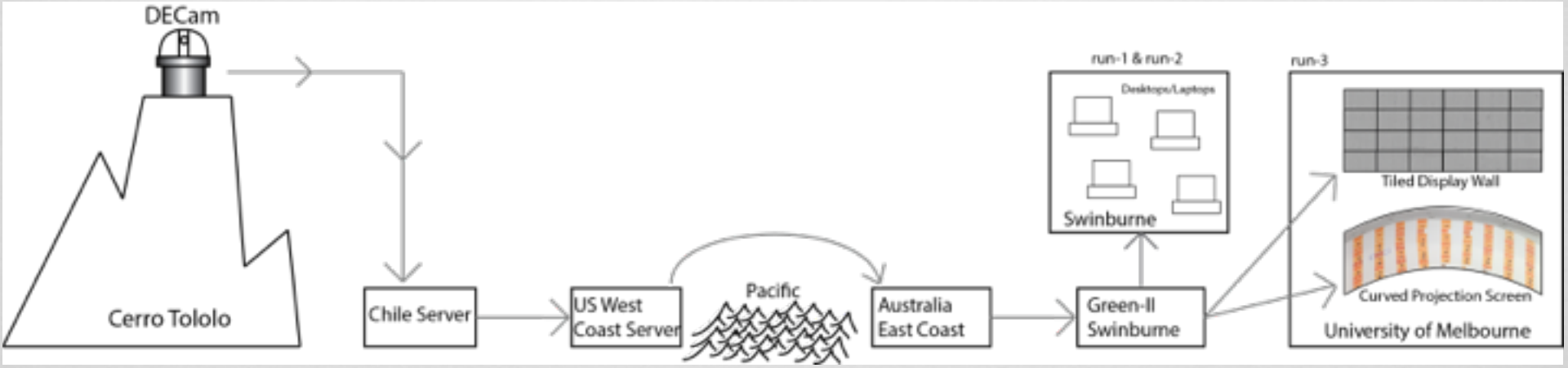
What we are trying to find

- Fast Radio Bursts
- Supernova shock breakouts
- Kilonovæ
- Gamma-ray bursts
- Flare stares
- Any previously unseen fast transient event

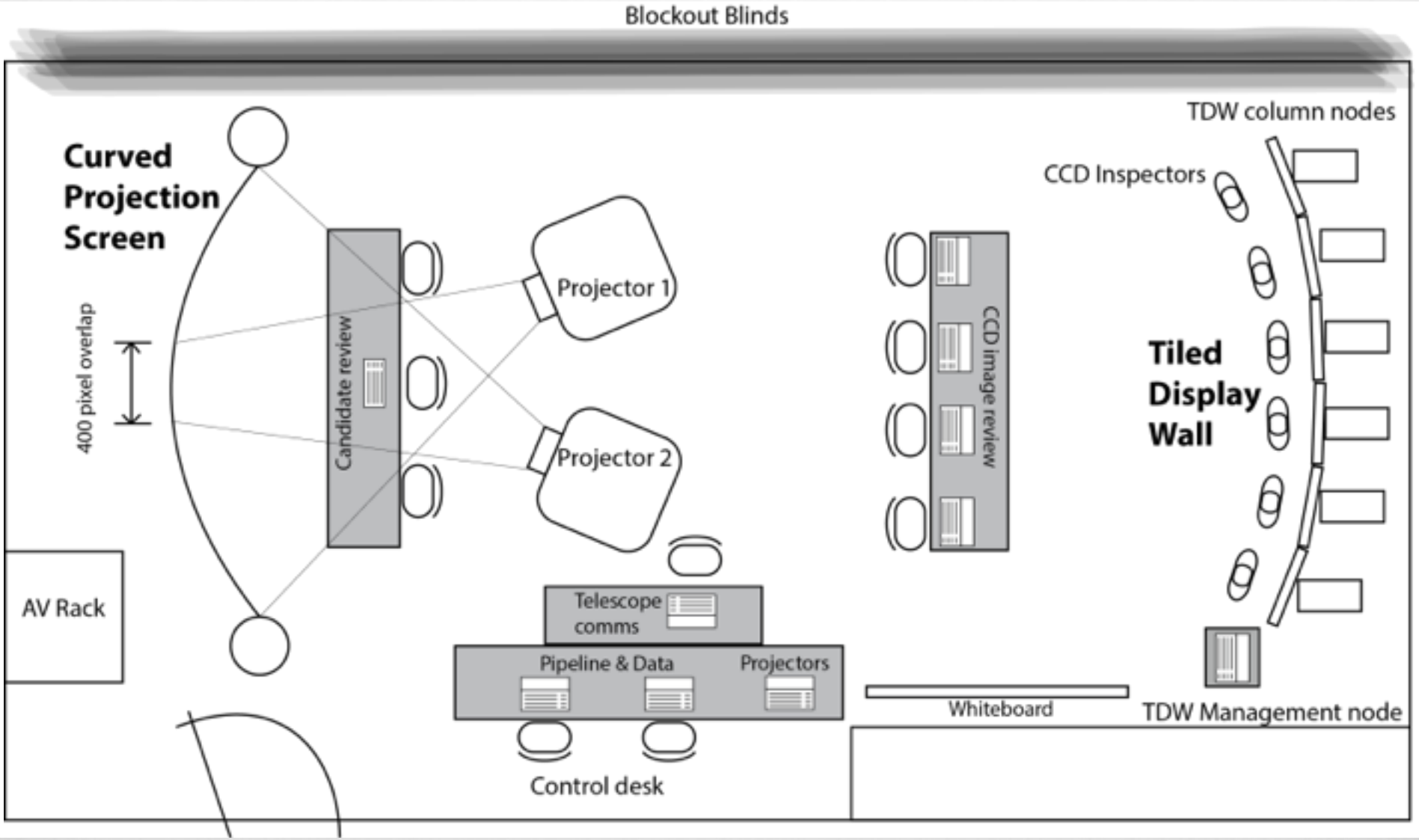


The Challenge

- Processing thousands of images (4096 x 2160 pixels) each observing session as fast as possible
- Reduce thousands of potential candidates to a few tens
- Catch an event with a rising light curve
- Training volunteer inspectors
- Create a useful **display ecology** to support the workflow



Layout for December 2015 campaign



December 2015 campaign workflow

- Images captured at DECam (CTIO) are transferred to Green II cluster at Swinburne University for processing (Vohl et al. *in prep)*
- Calibrated science images have a template subtracted to produce a difference image showing residuals
- ***Mary*** pipeline combines several processing and detection pipelines to identify high-value potential candidates, which are presented on the curved projection screen (Andreoni et al. *in prep*)
- Full CCD subtraction images are simultaneously displayed on the Tiled Display Wall (TDW) for manual inspection by astronomers
- Results detailed in Meade et al. 2016 (*submitted*)

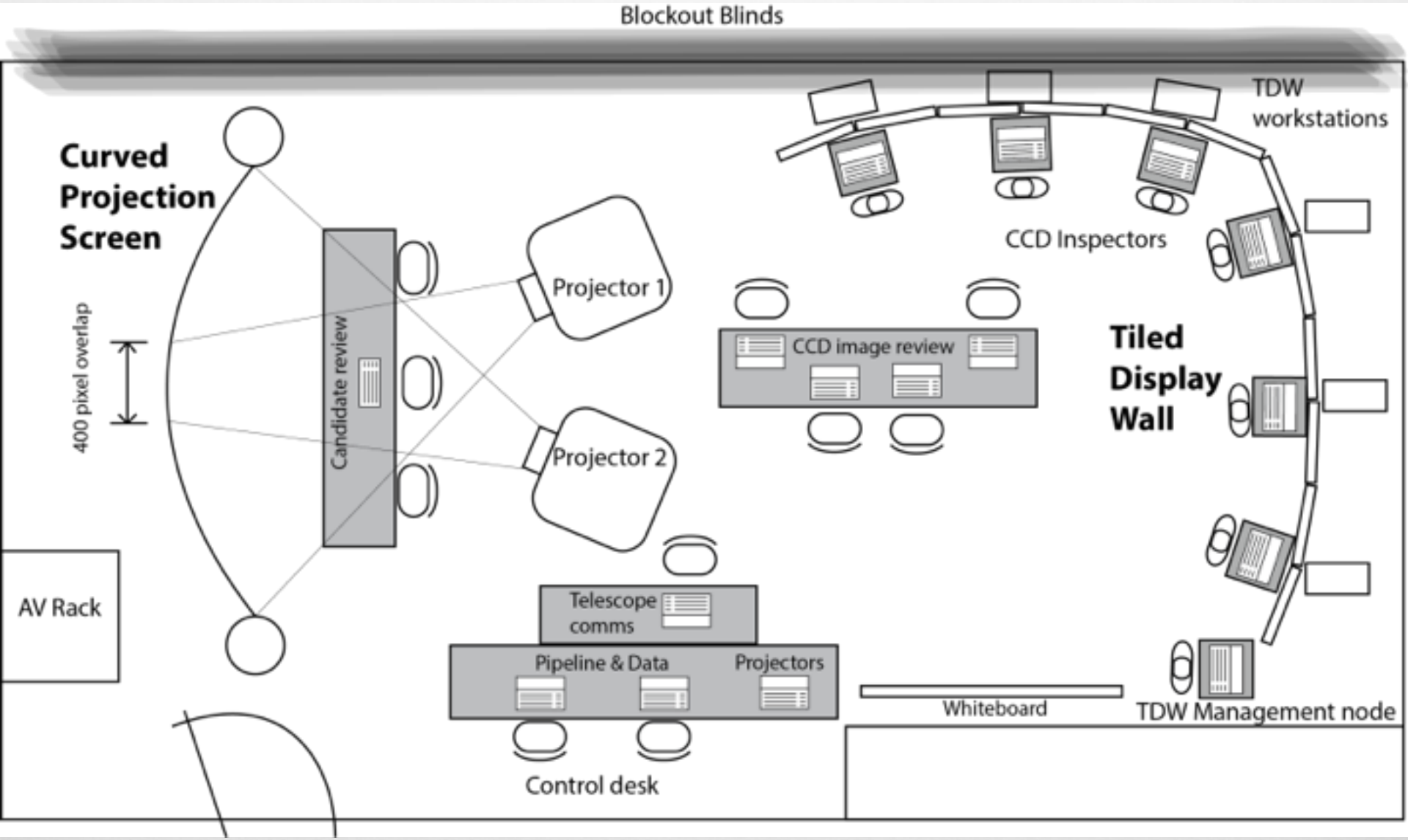
Issues with December 2015 campaign

- Rudimentary potential candidate logging
- Slow distribution of images on TDW for review
- SAGE2 lacked FITS support and accurate location of targets
- No persistent candidate IDs or light curves

July 2016 campaign workflow

- Potential candidates automatically assigned a persistent ID and given a rank (1-5)
- Potential candidates presented in triplets (science, subtraction, template) on curved display screen for review
- Objects of interest logged in a Google spreadsheet, including monitoring light curves via users' laptops
- Sets of 10 images assigned to inspectors to review, monitor and flag for principal reviewers for potential triggers
- Split up the TDW to create 6 individual 2x2 display review workstations running DS9 to view the full CCD subtraction images with ***Mary*** candidate regions shown (Andreoni et al. *in prep*)

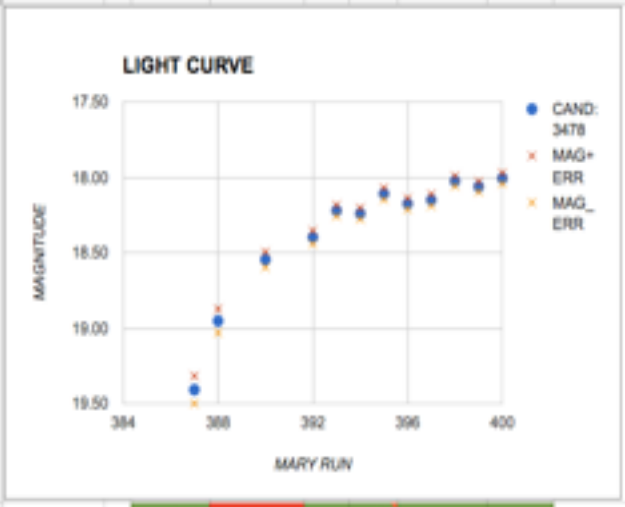
Layout for July 2016 campaign

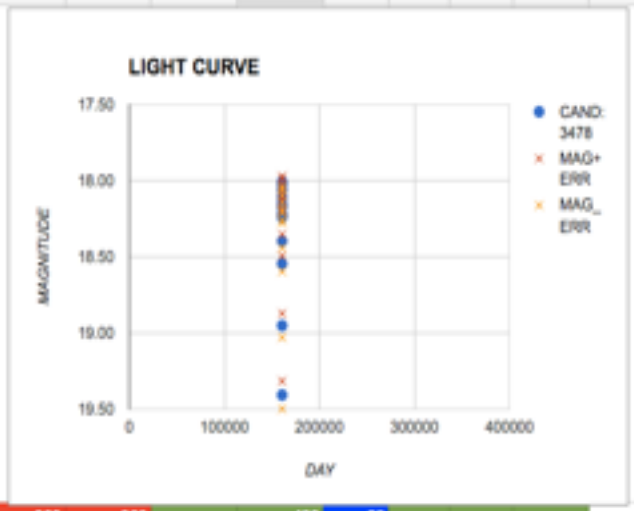


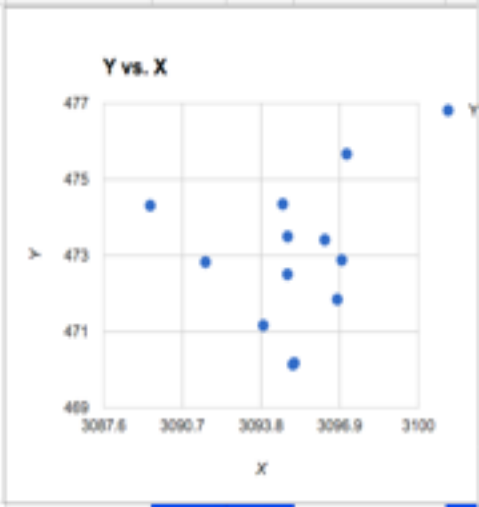
Google spreadsheet

EVAL_NGC6744_CCD1-10_1607

File Edit View Insert Format Data Tools Add-ons Help All changes saved in Drive







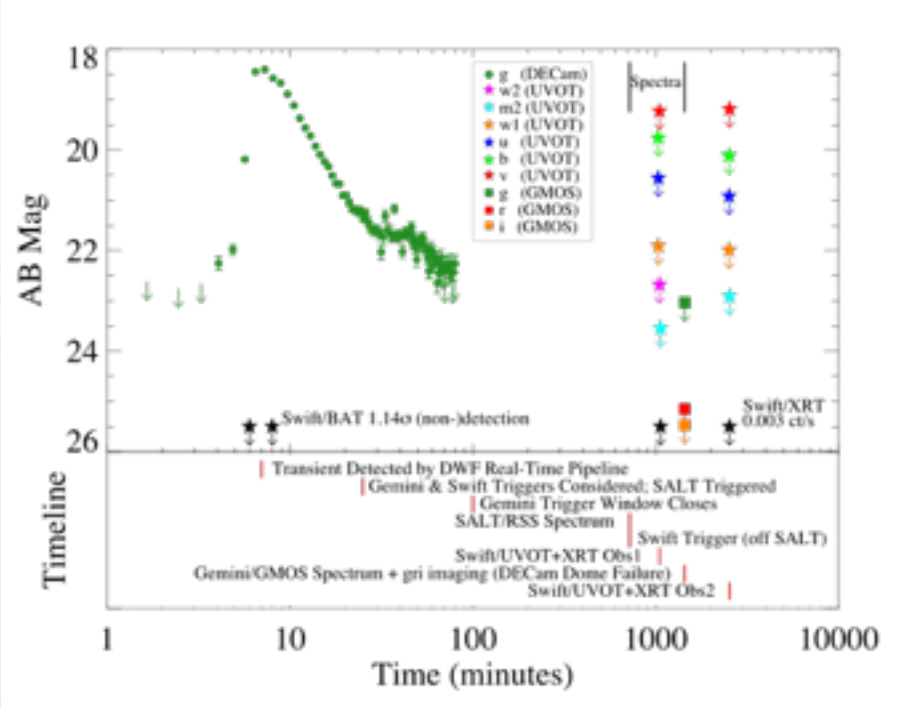
2	FILTERS:		3478	NGC6744		430					360	360		480	23							5	200		
3	SORT COL:	1	=	=		384					-360	-360		470								-1	-1		
4	SORT DIR:	0	0/1	YOUR NAME:	jeff						360/-360	360/-360	MAG RANGE:		1..48		MAG AVG:	18.36				5/-1	200/-1		5/-1
5	COLUMN #:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
6	12	CAND	FIELD	CCD	RUN	DAY	CCD CAND	UT	RA	DEC	X	Y	MAG	ERR	MARY PRI	CAT CLASS	CAT OTHER	MARY NOTES	EVAL STATUS	EVAL BY	EVAL NOTES	EVAL PRI			
7	12	3478	ngc6744	8	387	160804	2				3097.1721	475.66329	19.4071	0.091	2	103	non-star 1 1995.I								
8	12	3478	ngc6744	8	388	160804	2				3095.1098	470.17449	18.9512	0.0786	2	103	non-star 1 1995.I								
9	12	3478	ngc6744	8	390	160804	4				3095.0527	470.13699	18.5452	0.0508	2	103	non-star 1 1995.I								
10	12	3478	ngc6744	8	392	160804	3				3096.8010	471.84509	18.3976	0.0432	2	103	non-star 1 1995.I								
11	12	3478	ngc6744	8	393	160804	2				3096.9772	472.87860	18.2216	0.037	2	103	non-star 1 1995.I								
12	12	3478	ngc6744	8	394	160804	3				3094.8417	472.50399	18.2407	0.0367	2	103	non-star 1 1995.I								
13	12	3478	ngc6744	8	395	160804	2				3094.6552	474.34820	18.1096	0.0379	2	103	non-star 1 1995.I								
14	12	3478	ngc6744	8	396	160804	2				3094.8471	473.49679	18.1755	0.0361	2	103	non-star 1 1995.I								

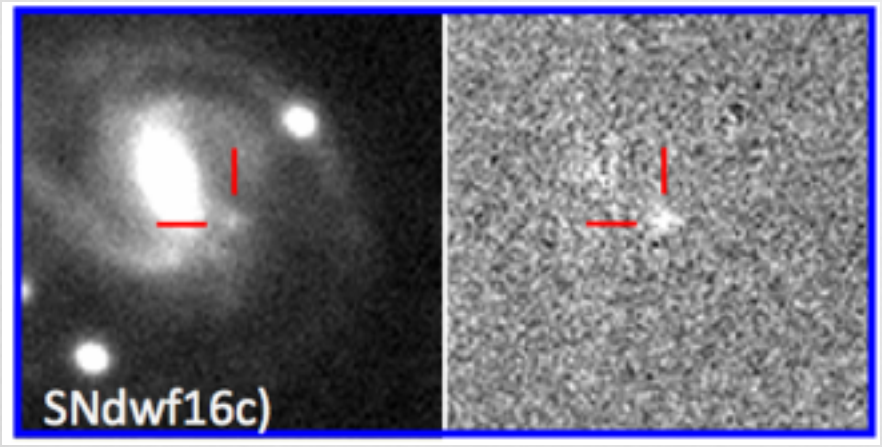
Assessing the new workflow

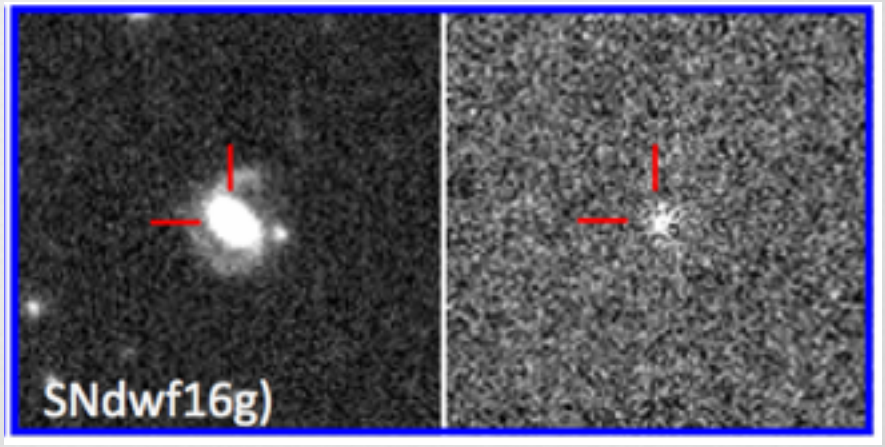
- Excellent logging tool supported active monitoring of light curves and subsequent follow up of potential candidates (special thanks to Chuck Horst)
- Reviewing full CCD subtraction images with regions using DS9 on individual workstations was much better
- Display ecology proved to be far more effective than for previous runs
- Training and collaboration was improved with the new display ecology

What we found

- Gemini-South - 3 triggers
- SALT - 4 triggers
- AAT - ~570 spectra in total
- Zadko - >40 targets
- SkyMapper - ~10 targets







Concluding remarks

- An appropriate display ecology that closely matches the demands of a time-dependent workflow is critical to optimizing that workflow
- It also greatly improves the user experience, which becomes increasingly important for long observing periods with a largely volunteer workforce
- The cost-effectiveness of a suitable display ecology should be considered in the same way as the value of telescope and computer time is considered

Deeper, Wider, Faster team

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Optical: Tyler Pritchard [1], Tim Abbott [7], Chris Curtin [1], Stephanie Bernard [8], Chuck Horst [9], Mansi Kasliwal [10], David Coward [11], the SkyMapper team, the Zadko team, and the Gemini-South and SALT support astronomers

UV/x-ray/gamma-ray: Tyler Pritchard [1], Igor Andreoni [1], Amy Lien [12], Neil Gehrels [13]

Real-time processing: Igor Andreoni [1], Tyler Pritchard [1], Armin Rest [12,14], Alex Codoreanu [1],
Phil Cowperthwaite [14], Chuck Horst

Data Science: Dany Vohl [1], Colin Jacobs[1], Vincent Morello [15]

Visualization: Bernard Meade [1,8], Chris Fluke [1], Dany Vohl [1], Sarah Hegarty [1]

Real-time data Inspection and Analysis: Uros Mestric [1], Chuck Horst [9], Garry Foran [1], Stephanie Bernard [8], Rebecca Allen [1], Michael Murphy [1], Katie Mack [8], Srdan Kotus [1] Albany Asher [1], Bernard Meade [8], Shivani Bhandari [1], Chris Curtin [1], Wael Farah [1], Sarah Hegarty [1], Eric Howell [11], Colin Jacobs [1], Fabian Jankowski [1], Regina Jorgenson [16], Vivek Venkatraman Krishnan [1] Aditya Parthasarathy [1], Tristan Reynolds [8], Geoff Bryan [1], Frederic Robert [1], Themiya Nanayakkara [1], Fanual Rumokoy [8], Luciana Sinpetru [16], Cameron van der Veldon [8], Ibnul Hussaini [8], Pamela Bain, Dany Vohl [1], SAO students [1]

DWF in action