Fast astrophysical multi-messenger/ wavelength strategies

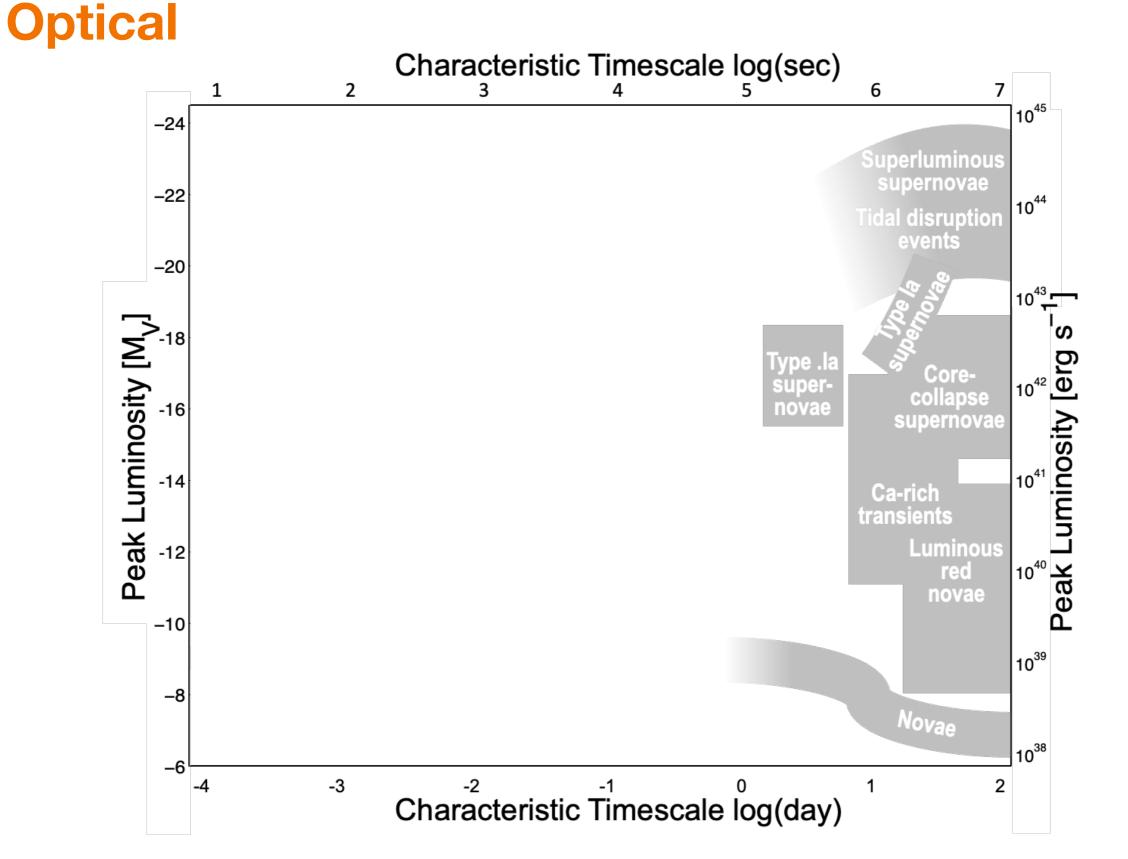


Anais Möller

-----OzGrav-

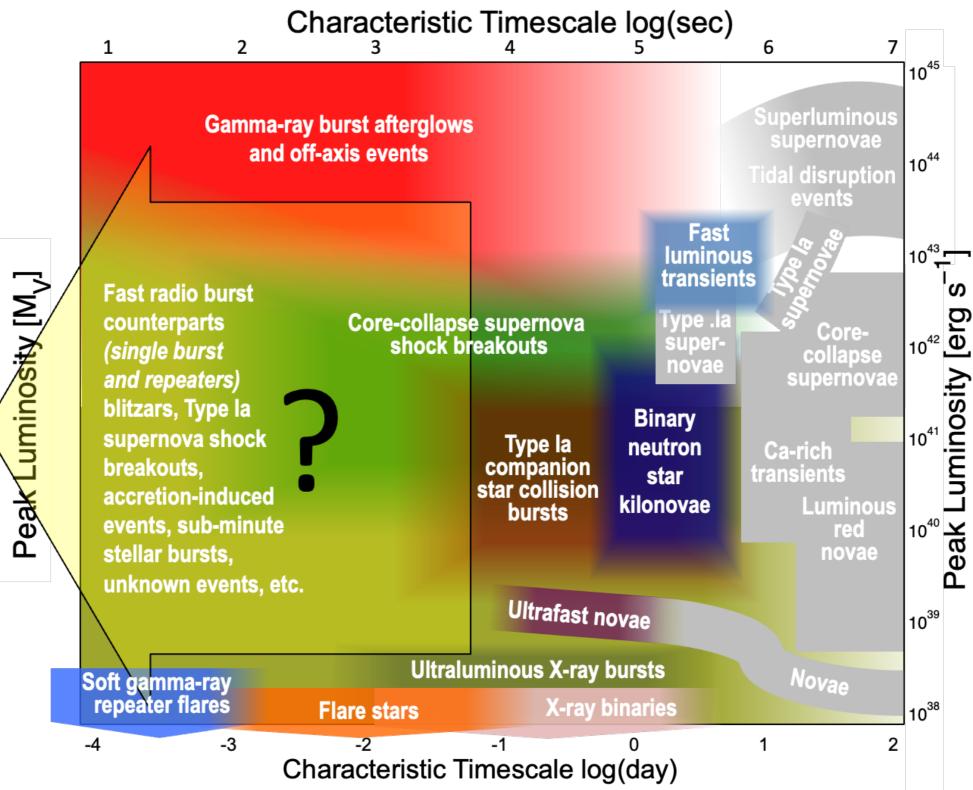


Fast astrophysical transients



Fast astrophysical transients



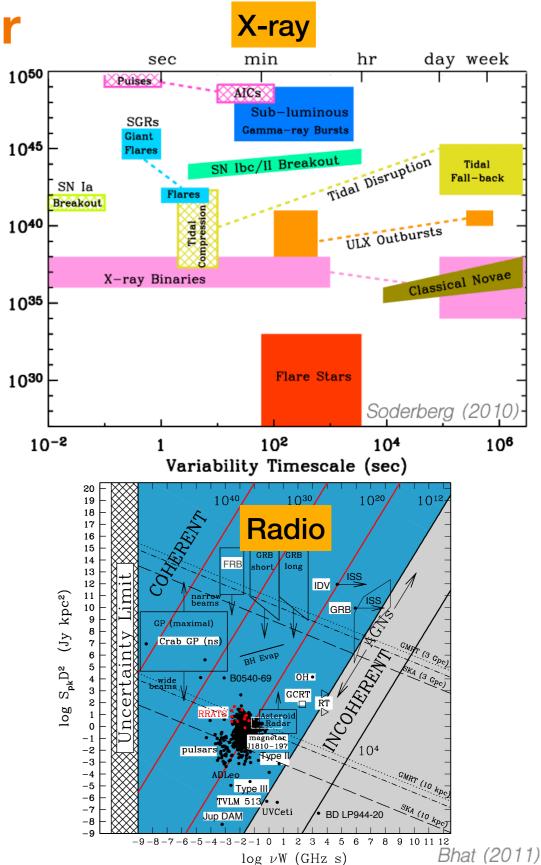


Fast astrophysical transients

X–ray Luminosity (erg s^{–1})

Multi-wavelength & messenger

- Occur in one, multiple, or all wavelength regimes
- Some include high-energy particles and gravitational waves
- Timescales may not overlap between different wavelengths/messenger



Strategies ToO-like Surveycoincidence Simultaneous observations

Strategies ToO-like

Strategies ToO-like

Localised



Get spectra/ photometry

Strategies ToO-like

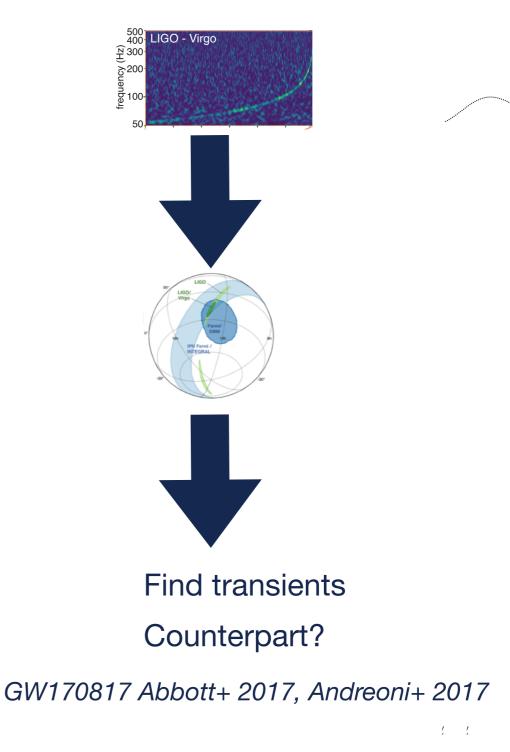
Localised





Get spectra/ photometry

Footprint



FRB170827 Farah et al. 2018, FRB180301 Price et al. 2018

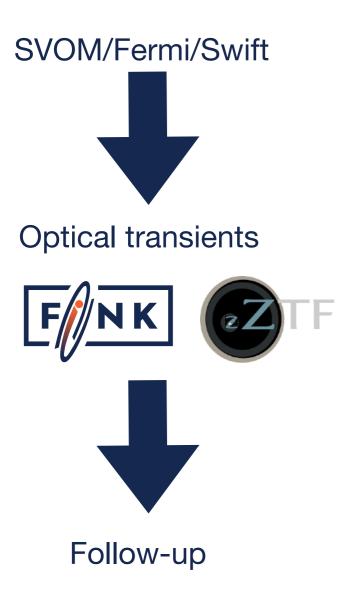
Strategies Survey-

More at Thursday's seminar!

Strategies Survey-

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Footprint



Möller et al. 2021 Work by D. Turpin, J. Peloton +

Strategies Survey-

More at Thursday's seminar!

Orphans

Optical transients



GRANDMA+ Fink 2022

EXPECTED NUMBER OF KNE FOUND IN EACH SAMPLE.

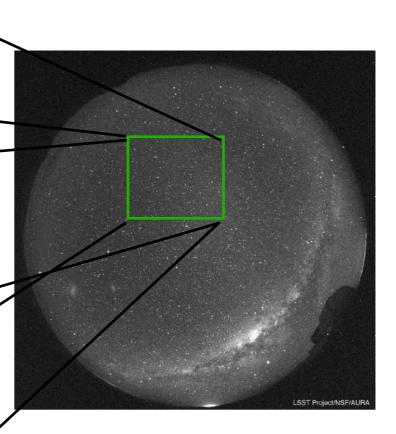
		Survey	KN Redshift
Survey	$\# \text{ KNe}^{a}$	Years	Range
SDSS	0.13	2	0.02 - 0.05
SNLS	0.11	4	0.05 - 0.20
PS1	0.22	4	0.03 - 0.11
DES	0.26	5	0.05 - 0.20
ASAS-SN	< 0.001	3	
SMT	0.001	5	0.01 - 0.01
ATLAS	8.3	5	0.01 - 0.03
ZTF	10.6	5	0.01 - 0.04
LSST WFD	69	10	0.02 - 0.25
LSST DDF	5.5	10	0.05 - 0.25
WFIRST	16.0	2	0.1 - 0.8

*Disclaimer: with 2017 data, observing strategy, etc Scolnic+ 2017

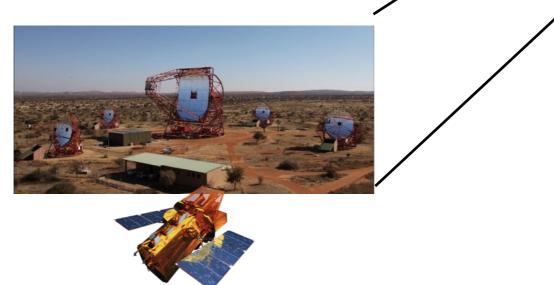
Strategies Simultaneous observations

Optical

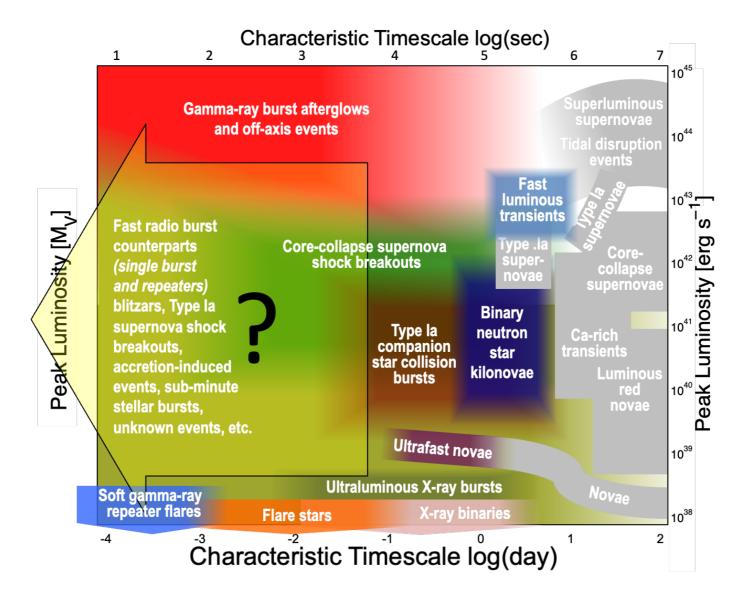
Radio



High-energy

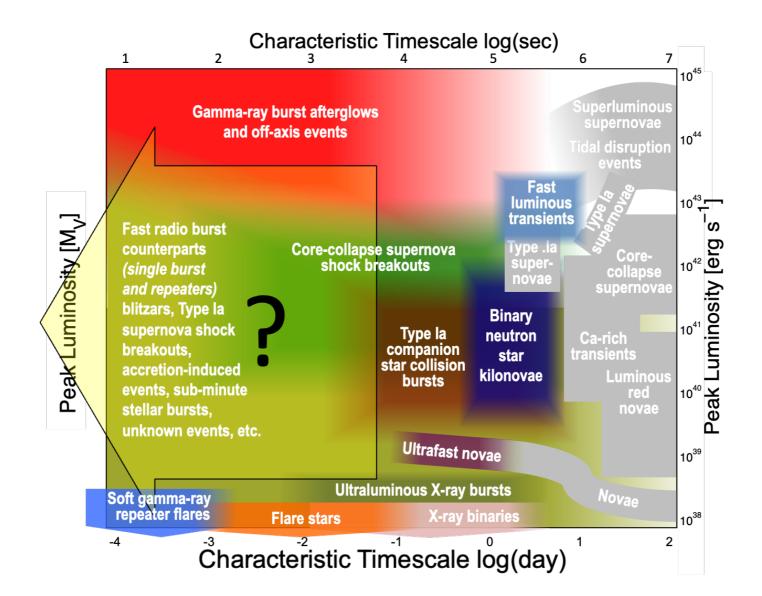


Deeper Wider Faster



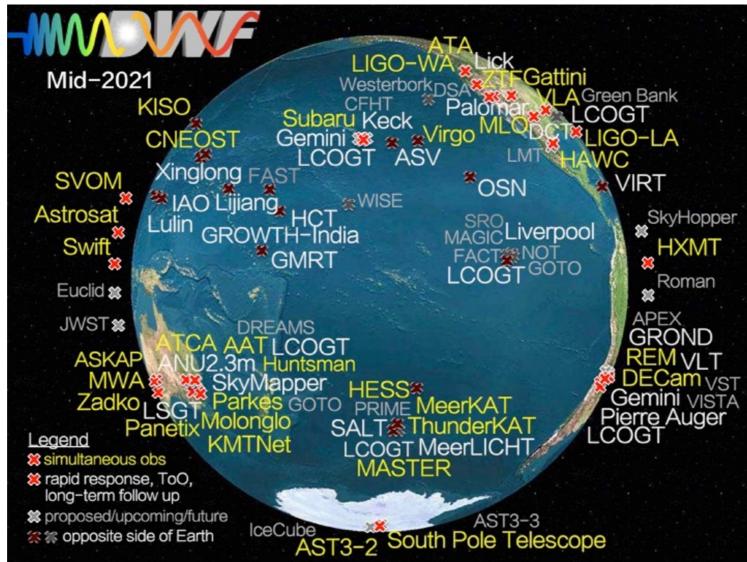
Deeper Wider Faster

- Fast exposures (= shallow)
- Simultaneous all-wavelength observations
- Process events fast to trigger follow up
- Rapid-response spectroscopy and imaging

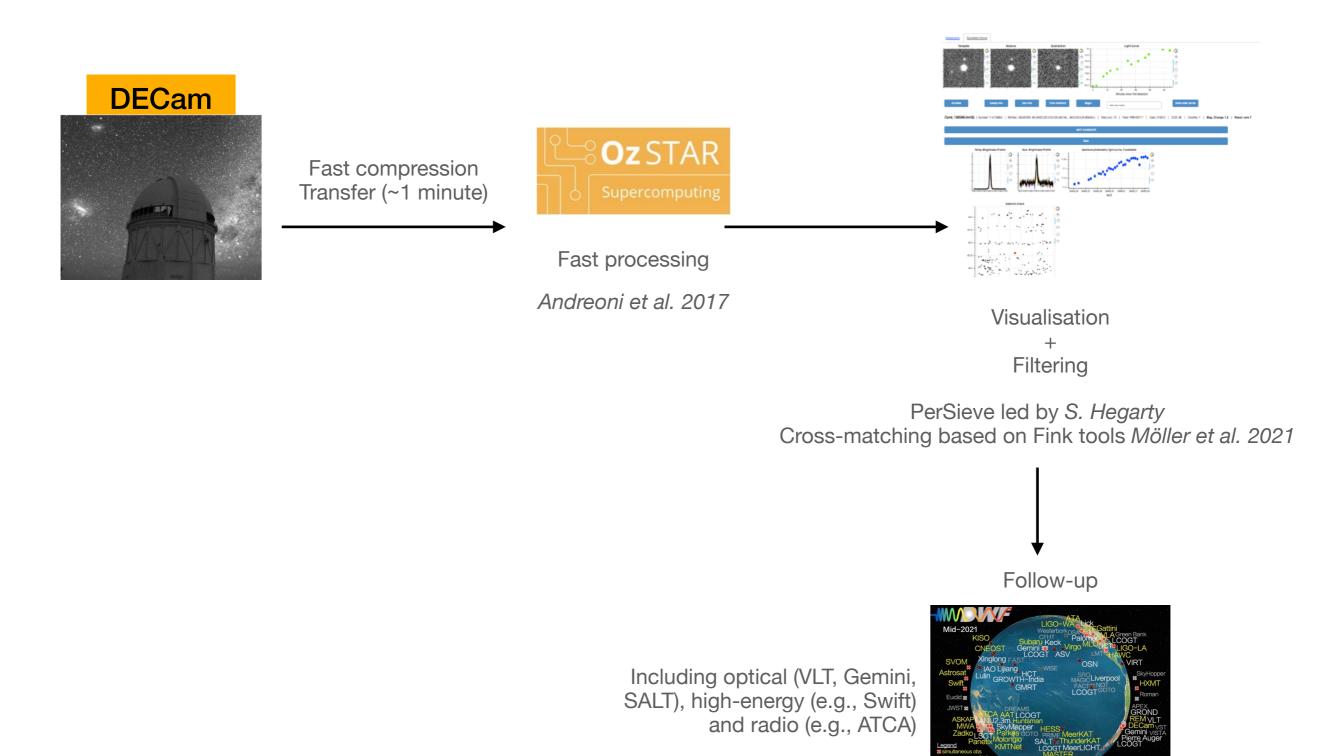


Deeper Wider Faster Strategy

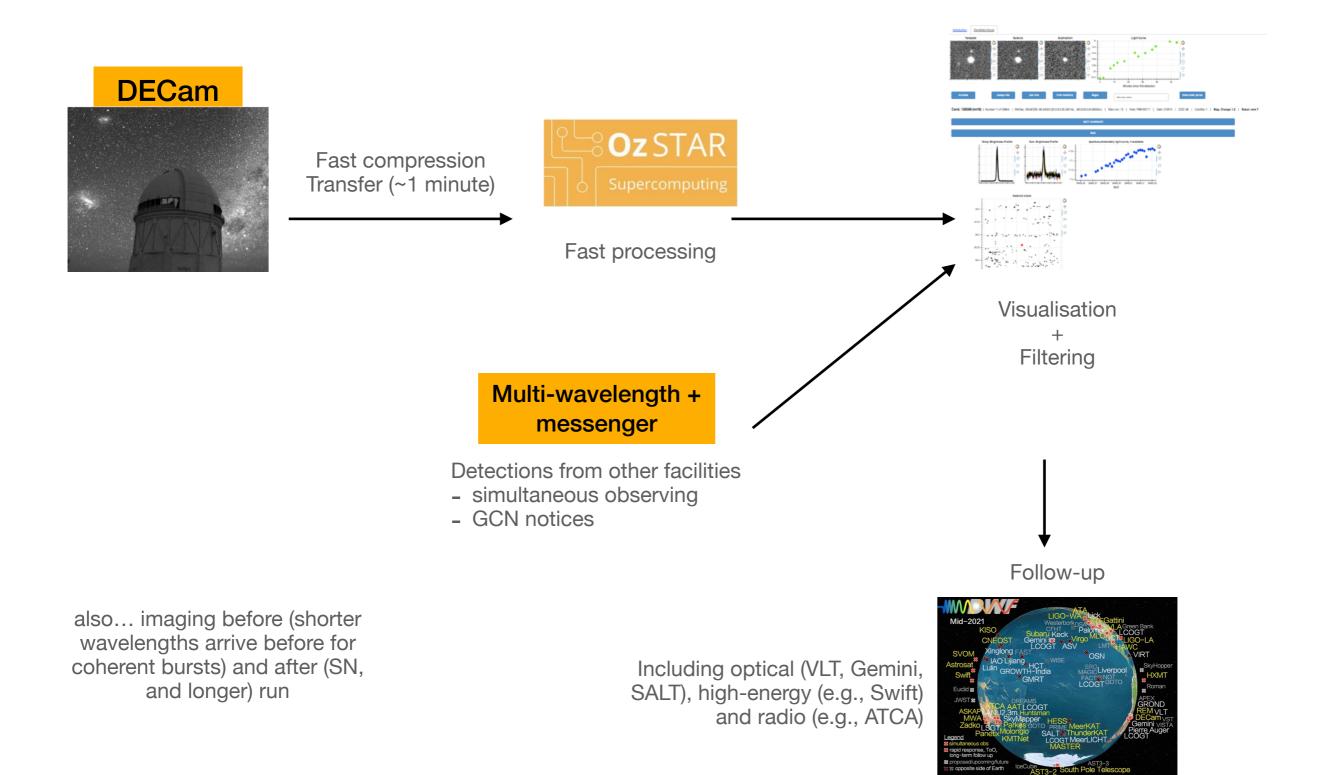
- DECam 30s exposures in g-band ~23 mag
- Simultaneous observations for ~one week twice per year
- Follow-up + late monitoring observations



Deeper Wider Faster Strategy

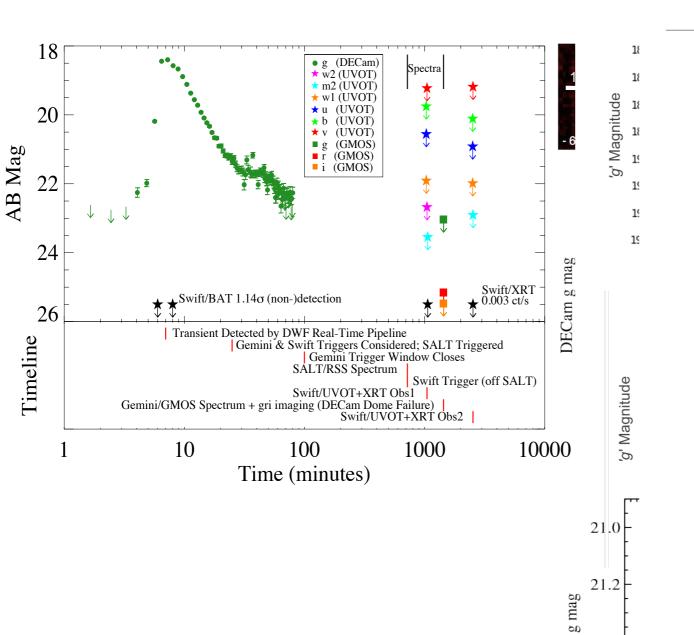


Deeper Wider Faster Strategy



Deeper Wider Fasterice, that also enable temporal image stacking permutations. This is that are predicted by the state of the state of

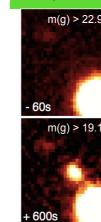
First results



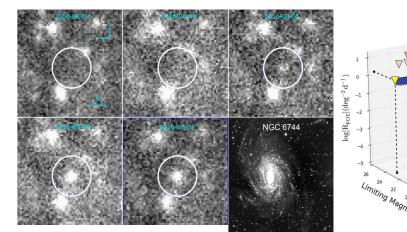
Panetix, GROND, INAF REM, SP1, and Molonglo.

DECam observations - We request 6 consecutive dark half nights (grey the Moon is low or down) to achieve the goals in this proposal. We perfo imaging in the g filter, reaching to $m_a(20 s) = 23-23.8$ and $m_a(nightly) = 26$ $z \sim 3$, where the Lyman α forest does not begin to attenuate sources in the g DWF q filter observations provide valuable reference images to aid in acquiri detections. We employ r, i, and z filter sequences nightly of each field to obt

Fields and data - Our fields have either previous DWF/DECam imag fields, nearby galaxy clusters, or fields with previous FRB detections to sear Facility longitude and latitude constraints enable ~ 3 hrs on each field per nig are cross-checked with star, variable, and asteroid catalogs and other data Stellar aflakes perform a careful and dExtragalactic fast, a



Webl



3

Figure 2: Left: Illustration of DWF fast transient sensitivity. Each frame is a DI $m_a \sim 23$ (nightly stacks to $m_a \sim 26-26.5$), seeing/weather dependent. Centre: nova at outburst in NGC 6744 at ~10 Mpc [5]. Kilonovae can be detected to $z \sim 0$ population. Right: Rate of fast optical extragalactic transients (R_{FOT}). A 3-D plo space of our DWF data [11]. The proposed observations are $\sim 30 \times$ faster than any \sim complement these data with multi-wavelength data, real-time data processing and r

References: [1] Soderberg et al. 2008, Nature, 453, 469 [2] Thornton et al. 2013, al. 2015, MNRAS, 447, 246 [4] Chatterjee et al. 2017, Nature, 541, 58 [5] Andreoni a Cooke et al. 2018, in prep [7] Howell et al. 2015, PASA, 32, 46 [8] Meade et al. 201 et al. 2017, PASA, 34. 37 [10] Vohl et al. 2017, PASA, 34, 38 [11] Petroff et al. 2017, PASA, 34, 34, 34 [11] Petroff et al. 2017, PASA, 34, 34 [11] Petroff et al. 2017, PASA, 34 [11] PasA, 34 [11 Bhandari et al. 2018, MNRAS, 474, 71 [13] Andreoni et al. in prep [14] Spitler et a

g ma

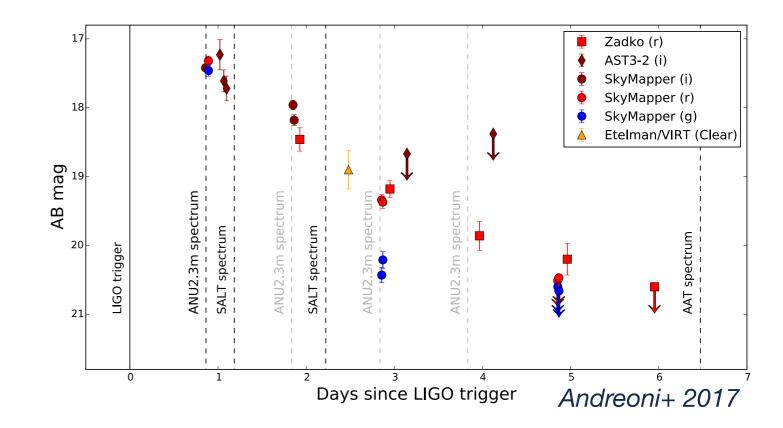
20F

Deeper Wider Faster

First results

Kilonovae

- 14 of 70 telescopes for GW170817
- Triggered and coordinated optical, infrared, radio observations



FRBs

- Early wide-field optical searches (DECam)
- Detected 2 FRBs in Sept. 2020 (Zhang et al. in prep)
- Mapping line-of-sight galaxies to FRBs to constrain ionised IGM

Take away

Deeper Wider Faster

Simultaneous observations allow to study a wide-variety of transients in an unexplored space

Some challenges:

- Processing is facility dependent...
- As we go fainter catalogues are less complete
- Chip gaps and other unfortunate events

Take away

Deeper Wider Faster

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Fast multi-messenger/wavelength strategies

- Strategies are highly complimentary.
- Fast triggering and coordination remains a challenge.
- A breath of science is possible!