

BlackGEM Telescope array



BlackGEM-3 installed at La Silla

- Gravitational wave counterparts
- Six-band Southern All Sky Survey
- Three-band Synoptic Survey
- Nearby Universe monitoring program

- At ESO La Silla
- Three telescope array in Phase 1
- Operational end 2018
- Expansion to 15 in Phase 2

PI Paul GrootPM Steven BloemenPS Peter Jonker

Radboud University



BlackGEM Team & Consortium

Principal Investigator:Paul Groot(Radboud University)Project Scientist:Peter Jonker (SRON/Radboud University)Project Manager:Steven Bloemen (Radboud University)

Consortium Institute Partners in Phase 1:



Radboud Universiteit





NOVA = Amsterdam, Leiden, Groningen, Radboud

KU Leuven

Manchester U., Tel Aviv U., UC Davis, Weizmann, Hebrew U, Potsdam, TexasTech, DTU and UCD, Valparaiso have entered at PI level.

Possibility for new partners (for 5 year operation):

- 150 kEuro to join at PI-level (one faculty member + PDRAs/PhDs) (all data, science team, lead science case)
- 1 1.5 MEuro (negotiable) to join at Institute level (full institute) (all data, science team, lead science case, consortium board)
- \rightarrow Combinations with in-kind contributions (e.g. follow-up telescope time) possible

www.blackgem.org ; @BlackGEM_Array



BlackGEM

Science:

- Gravitational wave counterparts
- Southern All Sky Survey
- Fast Transients & Variables
- Nearby Universe Survey

<u>Phase 1:</u>

- 3 wide field telescopes (8.1 square degr. total)
- Primary mirror: 65cm diameter
- Sensitivity: *g=23 in 5 minutes*
- Location: ESO La Silla
- Optical quality: seeing limited, 0.9" median
- Camera: 1 CCD/telescope, 10k x 10k, 0.56"/pixel
- Filters: *u,g,q,r,i,z* filter set, change in 3s

<u>Phase 2:</u>

- Expansion to 15 telescopes
- 40 square degrees total field of view (@ 0.56"/pix)
- Location: ESO La Silla; or combi ESO, NZ and SA







BlackGEM Unit telescope

- Wynne-Harmer design incl. M2 on tip-tilt piezo stage
- 110 Mpix camera (1 STA 1600 chip)
- 2.7 square degree field-of-view @ 0.56"/pix
- 10 second readout + filter change + repointing
- Carbon-fibre structure
- Atmospheric Dispersion Corrector in triplet lens barrel
- Fornax 200 mount
- Fully robotic
- Cooled electronics, in counterweight





MeerLICHT prototype

Design

CCD & Filters

- STA1600, 10.5k x 10.5k CCD, 9 μ pixel : 110 Mpixel chip
- Scale on sky: 0.564"/pix, total field of view: 2.7 sqd/telescope
- Readout time: 7 seconds (at 1 MHz on 16 ports), RON: 5.5 e-





Filters:

Sloan u,g,r,i,z filters plus broad-band q (440-720nm)

Astrodon BlackGEM set (BG-u,BG-g,BG-r,BG-i,BG-z and BG-vr (=q))



Astrodon BlackGEM set (BG-u,BG-g,BG-r,BG-i,BG-z and BG-vr (=q))





Dome & Tower



@ESO La Silla during installation



BlackGEM Surveys

• BlackGEM Trigger Mode: ' Transients Galore'

- → GW error box coverage in multiple colours
- \rightarrow 100s of sqd in multiple times over ~week time scale down to g=23

(TDEs, SN of all types, Dwarf Novae, SN .Ia, SN Iax, etc.)

• BlackGEM Southern Sky Survey: 'Southern Sloan'

- \rightarrow 30 000 sqd down to 22nd mag in *u*,*g*,*q*,*r*,*i*,*z* at 1" median seeing
- → By itself a fantastic resource for all kinds of science: (galactic streams/structure, dwarf galaxies, stellar populations, 'gems', quasars, weak lensing, high-z galaxies, etc.)

BlackGEM Fast Synoptic Survey: 'Kepler on steroids'

- \rightarrow High cadence (1 min), multi-colour (*u*,*q*,*i*: simultaneous), wide-field
- → Kepler Short Cadence-type sampling on millions of objects
- → Deep drilling fields: thousands of exposures over weeks time-scale
- → Flexibility for experiments: continuous read-out, six filters, etc. (fast transients, asteroids, KBOs, early SN, interacting binaries, eclipses etc.)
- BlackGEM Local Transients program: Fast and Early
 - → Survey galaxy clusters (d<100 Mpc) for young/fast transients every three hours in u,q,i



BlackGEM Data Flow



MeerLICHT South Africa



BlackCloud: A cloud solution



- Data flow pipeline based on subpipe data reduction flow SkyMapper
- Aim is to make all BlackGEM data instantly accessible:
 - → A live database of any transient is maintained 'on the fly', live processing of 'previous' image during the night, instant alerts (T+5min)
 - → All images kept on (spinning) disk for re-reductions and target photometry at any time
 - \rightarrow A live database of all sources, including variability.
- Complete set-up ideal for *cloud solution* on compute, database, storage BlackGEM data: the *BlackCloud*.
- 1.8 Pb of data storage, 150 Tbyte of live database (3 telescopes)



MeerLICHT Prototype



Operational at SAAO Sutherland

See @MeerLICHT_ZA on Twitter and www.meerlicht.org for more pictures



部族

3 Guide cameras

Filter wheel

Fornax Cluster

Single Pointing

60s int. in 6 filters









Science Verification

• Instantaneous Photometric calibration using SDSS/PanStarrs/SkyMapper





BlackGEM Status (Mar21)



- All three telescopes are installed at ESO La Silla @ Feb2020
- All three telescopes have seen first light on sky, showing excellent image quality and throughput: 1.3" psf in technical first light: 10s integration → q_{AB} = 20 @ SNR = 5
- All on-site operations halted March 2020 due to covid-19.
- Will resume as soon as situation in Chile and Europe allows





ct 2019) Third telescope being installed (Jan 2020) Radboud University





BlackGEM Phase-2

- Expansion of BlackGEM to 15 telescopes (requires additional 15-18 MEuro)
- On current site at ESO La Silla; site prepared for taking 15 telescopes





BlackGEM Phase-2; Science

Science enabled by Phase 2 expansion

- *Multi-colour* GW follow-up, covering 100sqd per 2 hours in 3-5 filters, getting instantaneous colours
- 1 minute cadence on deep-drilling fields in three filters (u,q,i)
- Shadowing of space missions (e.g. eROSITA, JWST or Gaia)
- Multi-colour (u,q,i) *hourly* observations of Local Universe (d<100 Mpc) galaxies

Planned expansion for 2022-2025 time frame, for 5-year operations