





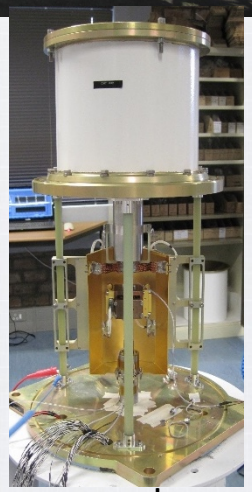
SKA AFRICA
SQUARE KILOMETRE ARRAY

MEERKAT: PROGRESS AND PLANS

Fernando Camilo

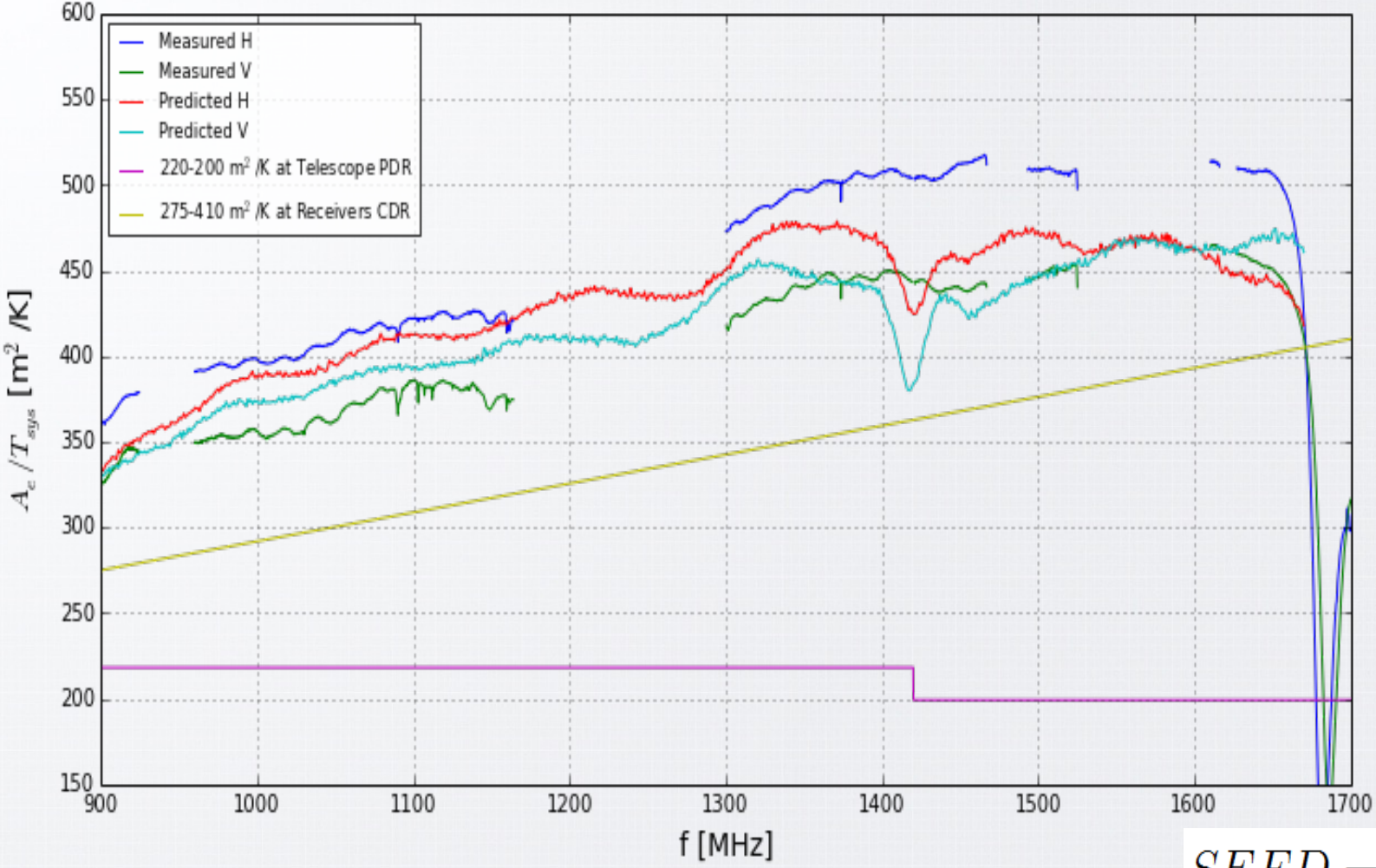
SWISS SKA DAYS 2017 (MAY 22, LAUSANNE)

MeerKAT in the Karoo: SKA precursor under construction



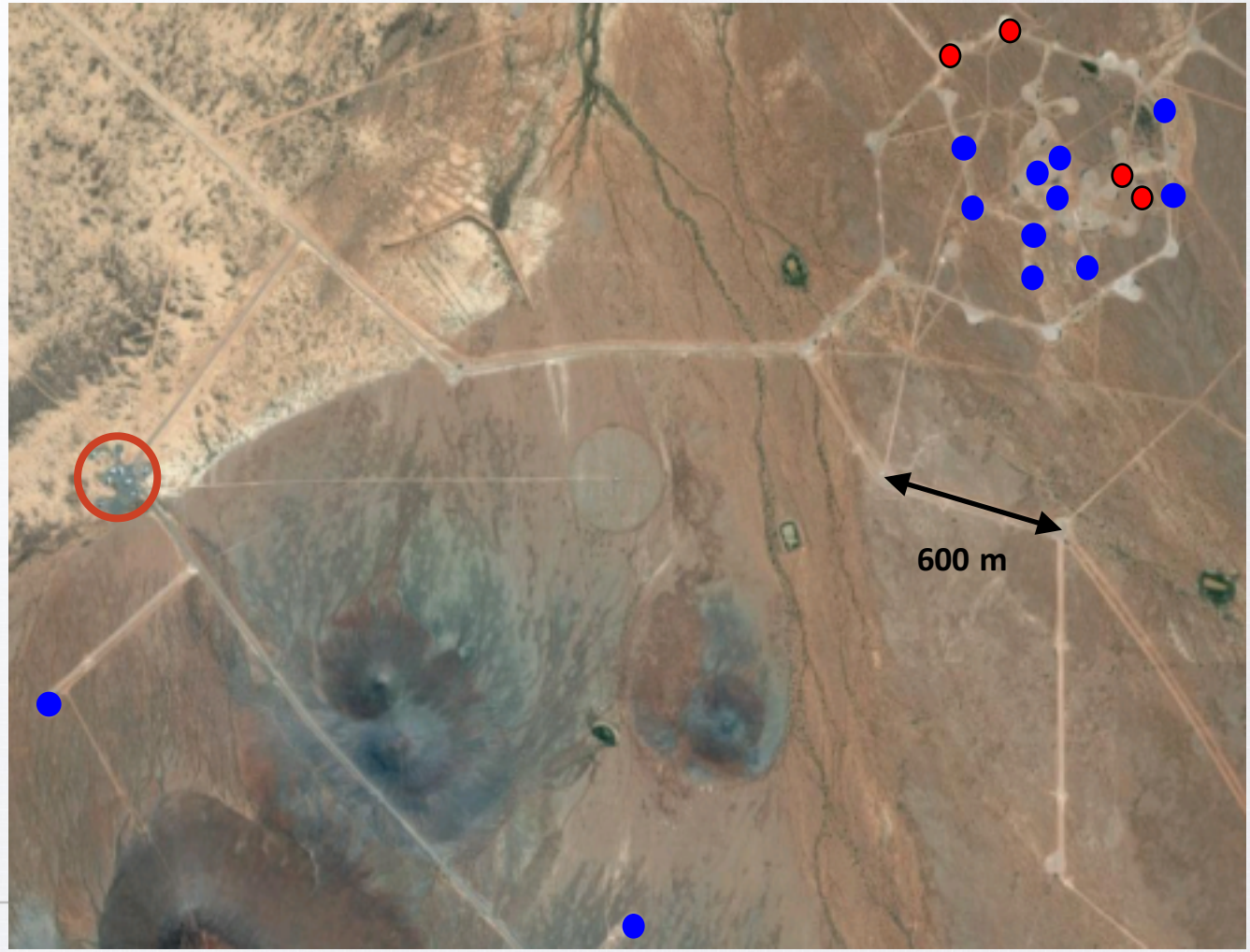
64 x 13.5-metre highly efficient offset Gregorian dishes spread over 8 km (~75% within ~1 km diameter); superb L-band receivers (0.9–1.67 GHz); also UHF (0.58–1.0 GHz) and S-band (1.75–3.5 GHz).

Extremely good L-band performance

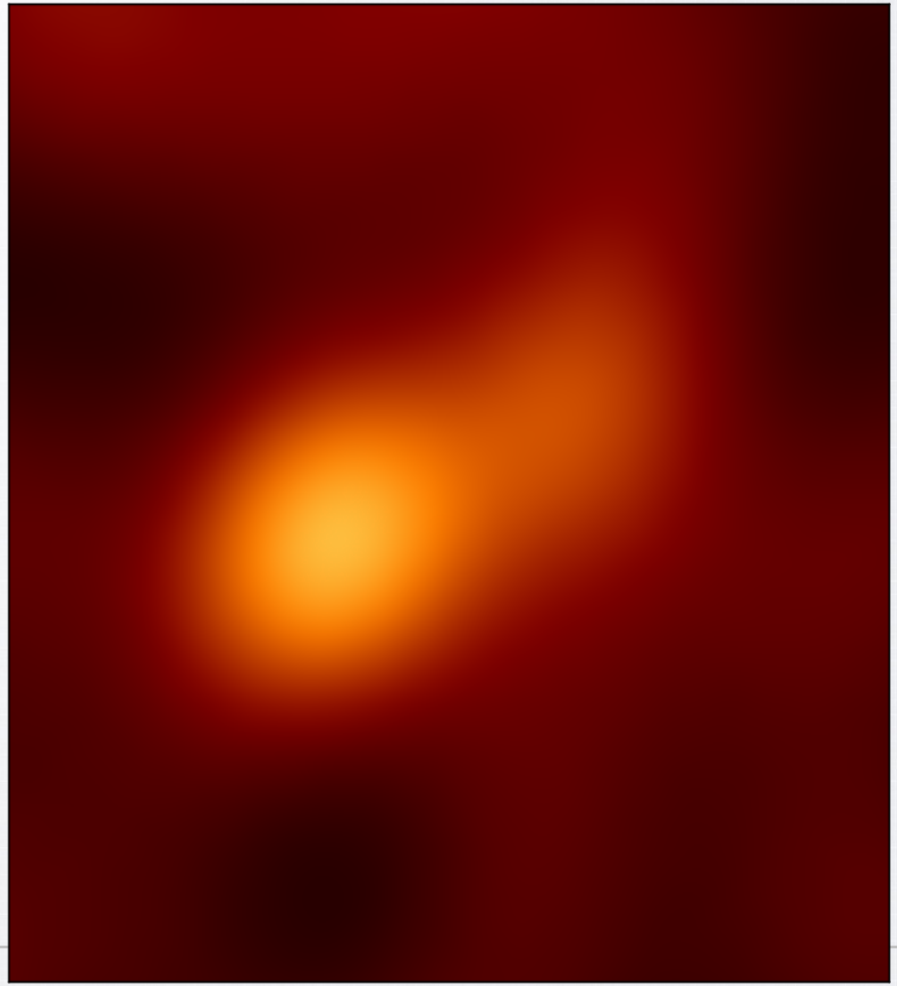


$$SEFD = \frac{2kT_{sys}}{\eta_a \frac{\pi}{4} D^2}$$

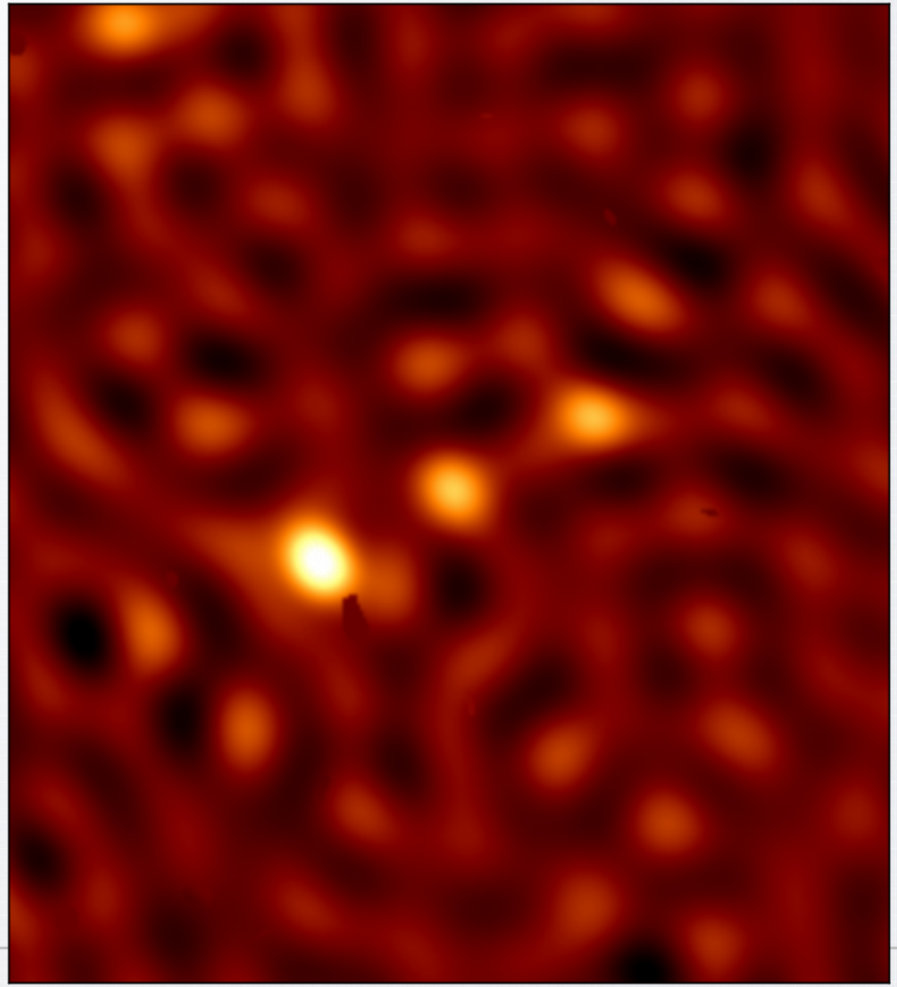
The SKA South Africa Karoo site: ever improving radio telescopes



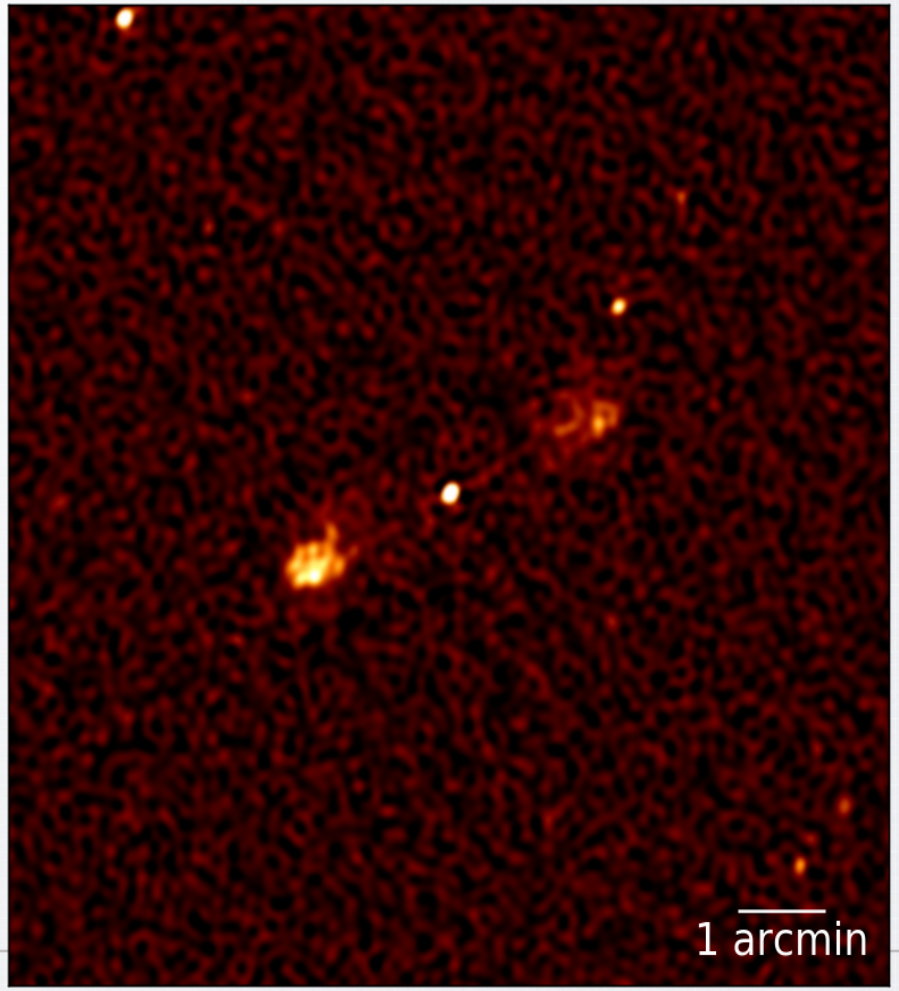
KAT-7 (engineering testbed) L-band image in 2012



4-dish MeerKAT in May 2016 (commissioning)

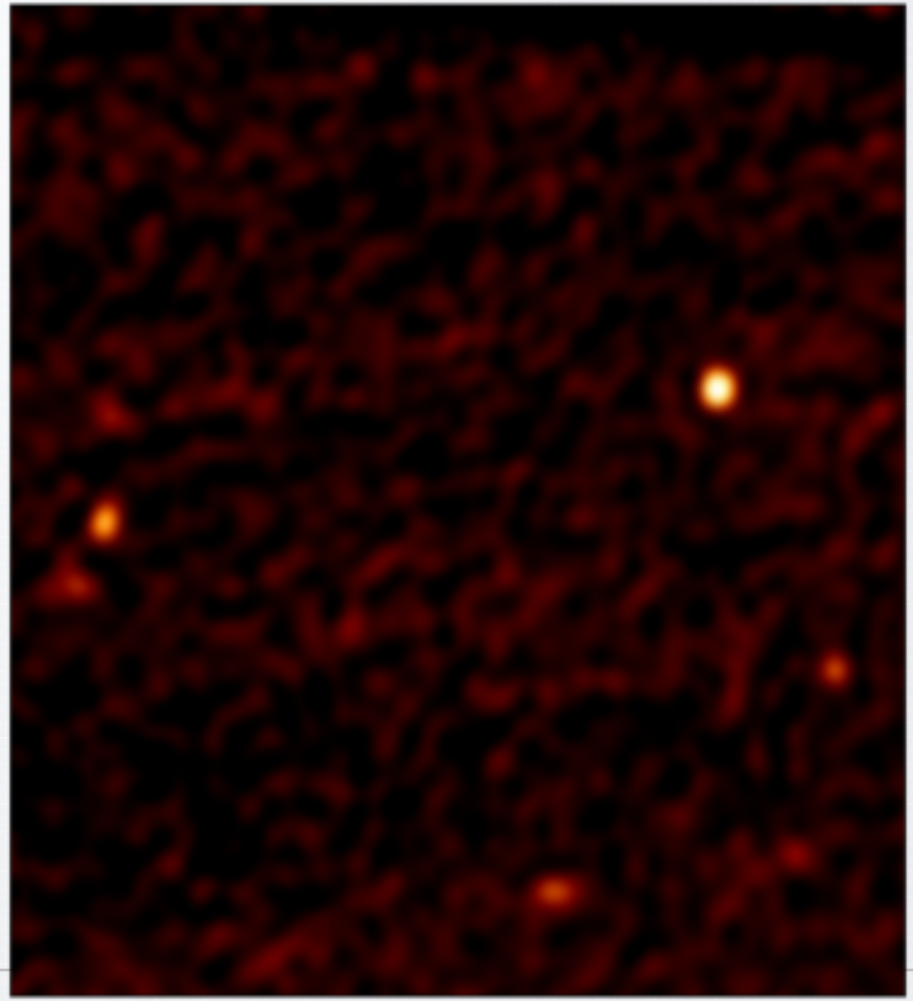


16-dish MeerKAT in June 2016 (Array Release 1)

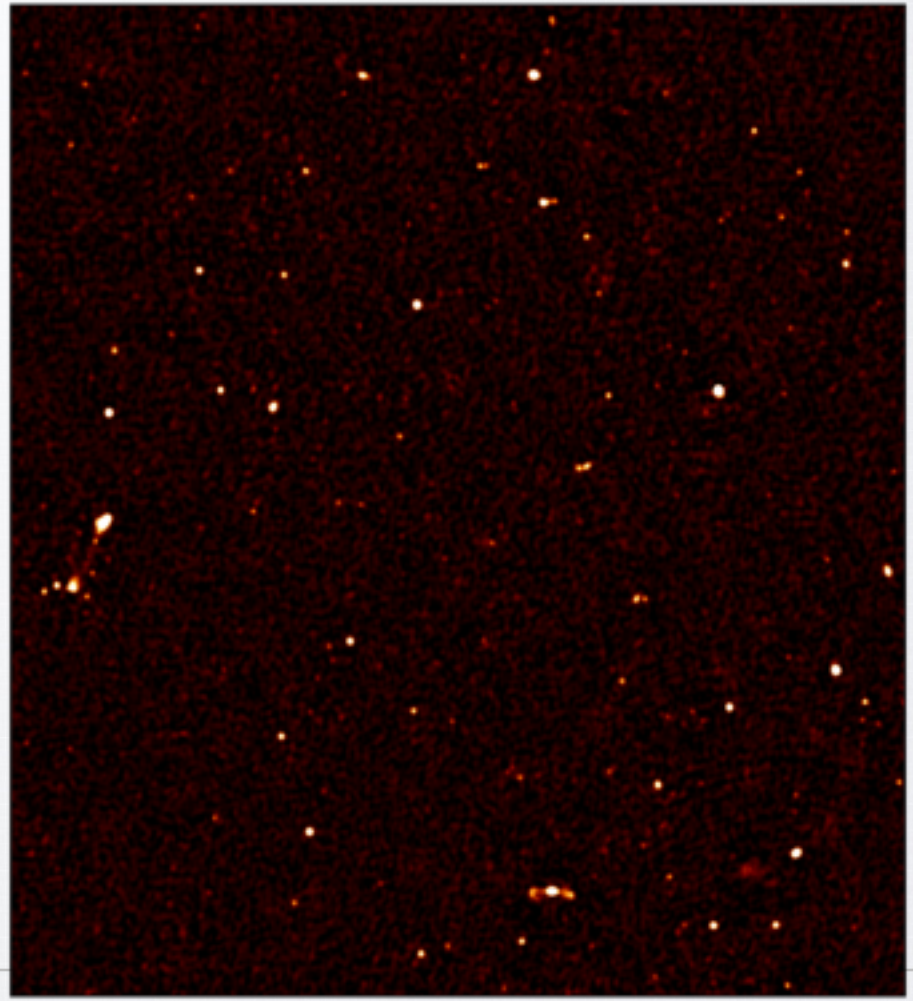


1% of First Light image

Best image of this patch of sky before MeerKAT

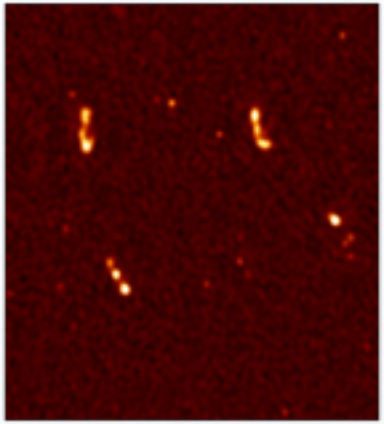


The MeerKAT sky



10% of First Light image

MeerKAT First Light



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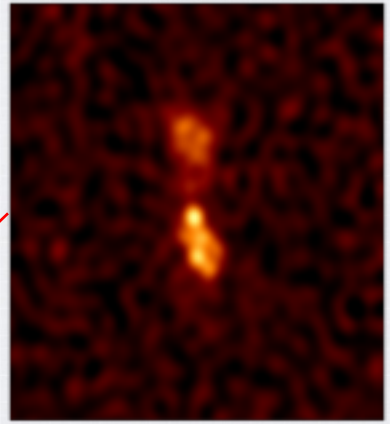
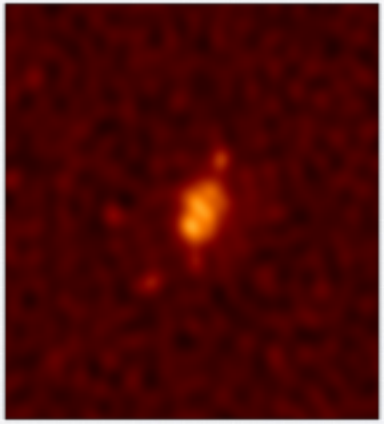
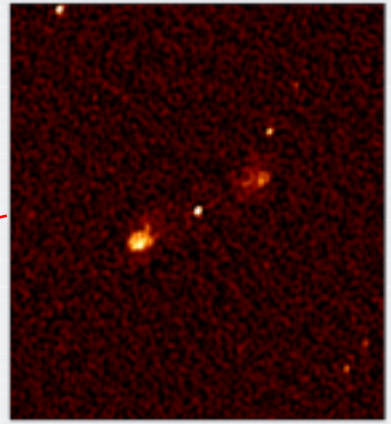


FR1 radio galaxy



Star forming galaxy



FR2 radio galaxy

MeerKAT science program

- 2010: Open invitation by SKA SA to propose MeerKAT "Key Project Science" resulted in 10 approved "Large Survey Projects" (LSPs; each >1000 hours of telescope time over 5 years)

- 2016: Scientific context has evolved; also, particularly at L-band, MeerKAT has improved sensitivity (but with shorter baselines, & lower frequencies)

- Therefore, in mid 2016 we requested revised LSP proposals (review underway)

- Plan to allocate ~70% of telescope time over 5 years to LSPs, ~30% to "Open Time" (to be allocated via periodic calls, open to researchers worldwide)

- Expect to have 64 antennas operational by April 2018 (+ continued development)

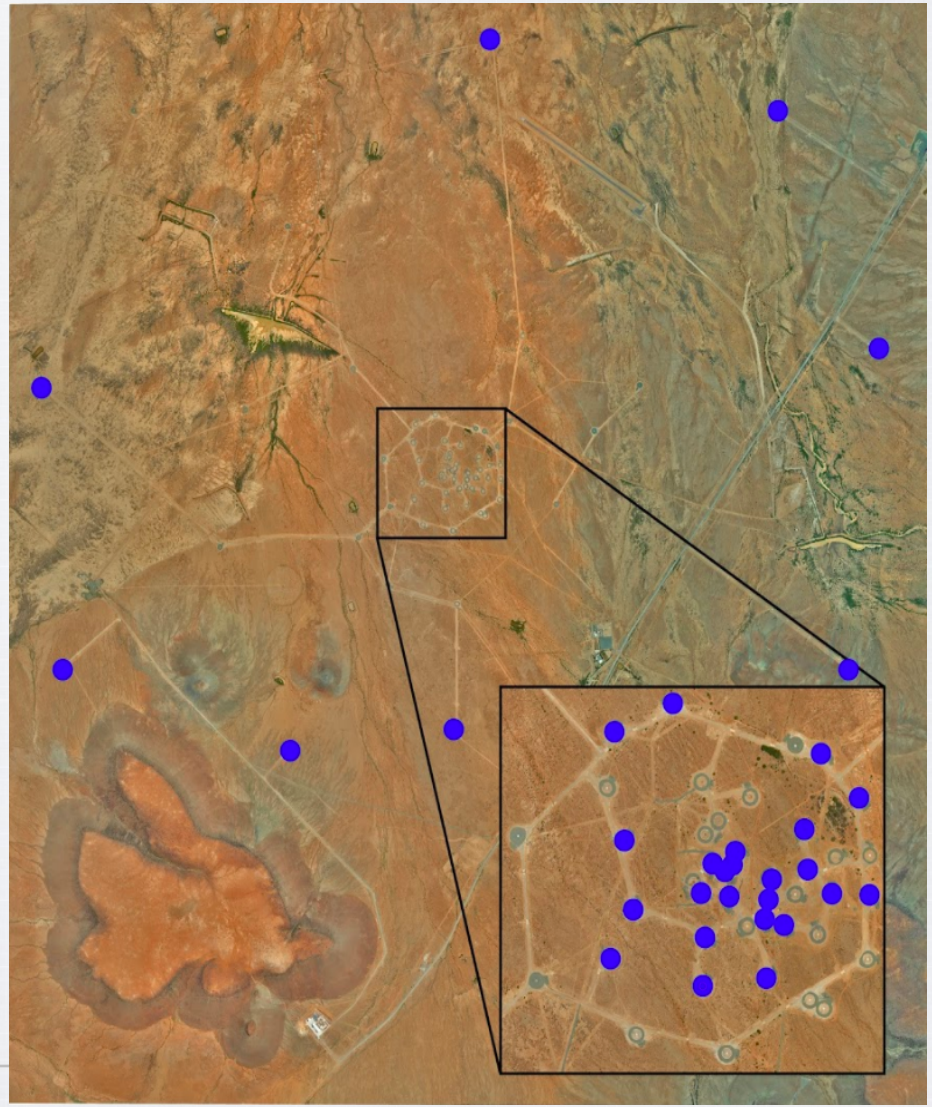
- Eventually MeerKAT will be integrated into the SKA Phase 1 MID-frequency array

MeerKAT science: LSPs approved in 2010

Radio Pulsar Timing	Bailes (AU)	7860 h
Testing Einstein's theory of gravity and gravitational radiation - Investigating the physics of enigmatic neutron stars through observations of pulsars		
LADUMA	Blyth, Holwerda, Baker (SA,NL,US)	5000 h
An ultra-deep survey of neutral hydrogen gas in the early universe		
MESMER	Heywood (UK)	6500 h
Searching for CO at high red-shift (z>7) to investigate the role of molecular hydrogen in the early universe		
MeerKAT Absorption Line Survey	Gupta, Srianand (NL, IN)	4000 h
Survey for H and OH lines in absorption against distant continuum sources; OH line ratios may give clues about changes in the fundamental constants		
MHONGOOSE	de Blok (NL,SA)	6000 h
Investigations of different types of galaxies; dark matter and the cosmic web		
MeerKAT HI Survey of Fornax	Serra (NL)	2450 h
Galaxy formation and evolution in the cluster environment		
MeerGAL	Thompson, Goedhart (UK,SA)	3300 h
Galactic structure and dynamics, distribution of ionised gas, recombination lines, interstellar molecular gas and masers		
MIGHTEE	Jarvis, van der Heyden (UK,SA)	1950 h
Deep continuum observations of the earliest radio galaxies		
TRAPUM	Stappers, Kramer (UK, DE)	3080 h + **commensal (timing)**
Searching for, and investigating new and exotic pulsars		
ThunderKAT	Woudt, Fender (SA,UK)	3000 h + **commensal (imaging)**
Study of explosive radio transients with MeerKAT; accretion-induced outflow from compact stellar remnants, e.g. relativistic jets and (super)novae		

Array configuration

(April 2017, 32 antennas to choose from)



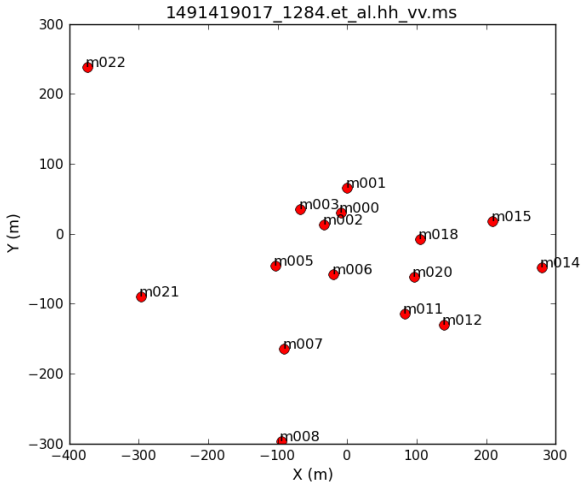
Commissioning in April 2017, up to 32 antennas

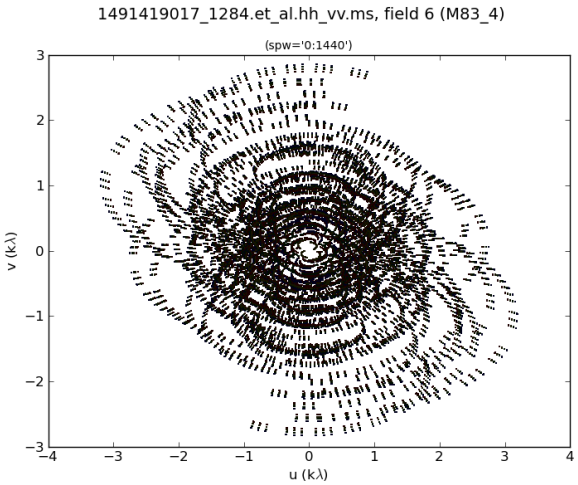
(but only 32 inputs into ROACH2 correlator)

HI emission in M83

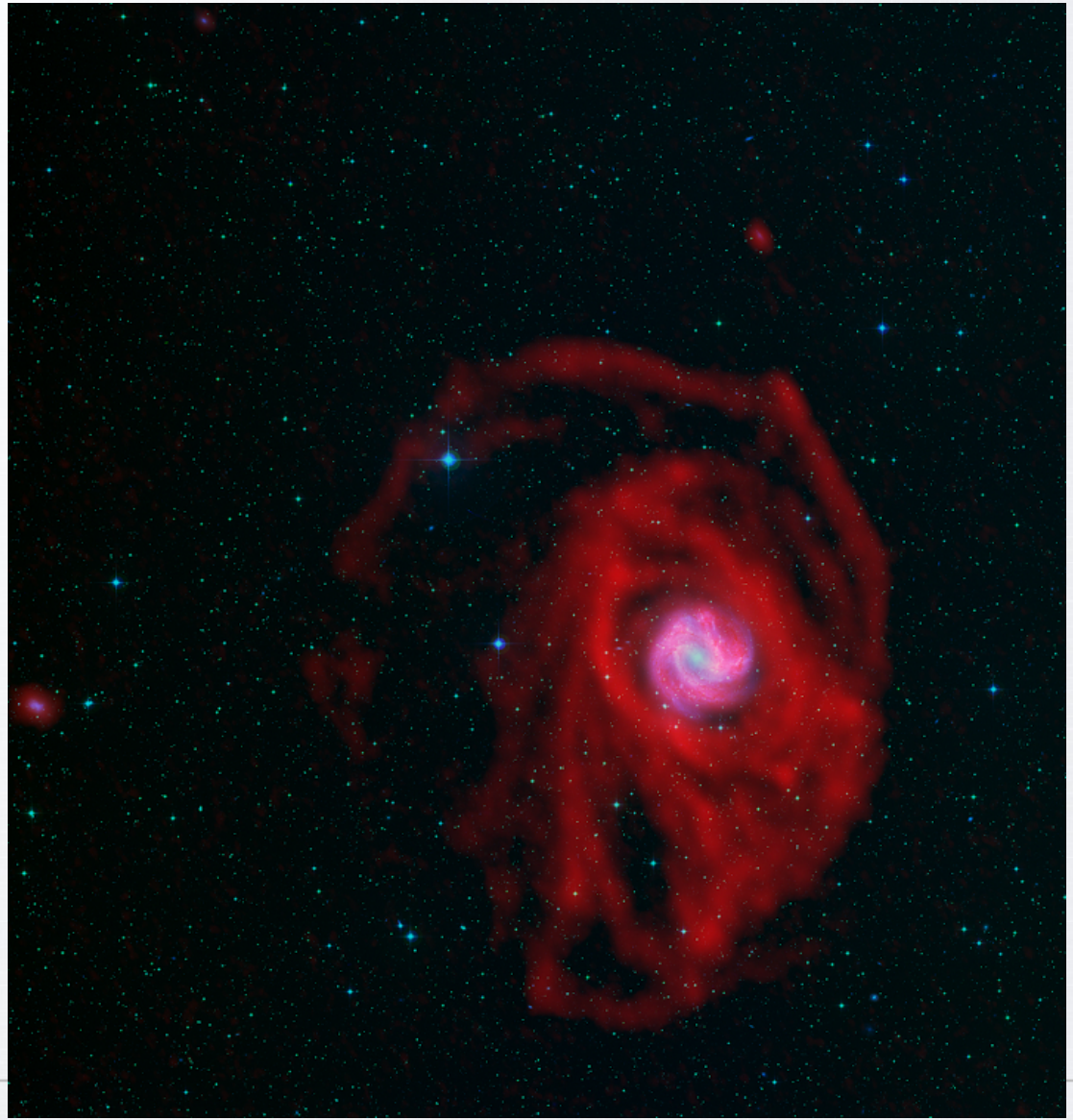
(famous spiral galaxy discovered in Cape Town in 1752 by Nicolas Louis de La Caille)

- 9 hour track, 2017-04-05
- 32K (26 kHz) channels (140 imaged)
- 16 core antennas, dual polarisation
- Mosaic: 7 pointings
- ~50 minutes per pointing
- Min baseline (projected) 16 m
- Max baseline 711 m
- Beam 90x70 arcsec
- Measured rms 2.8 mJy (emission-free channel) vs 2.3 mJy theoretical

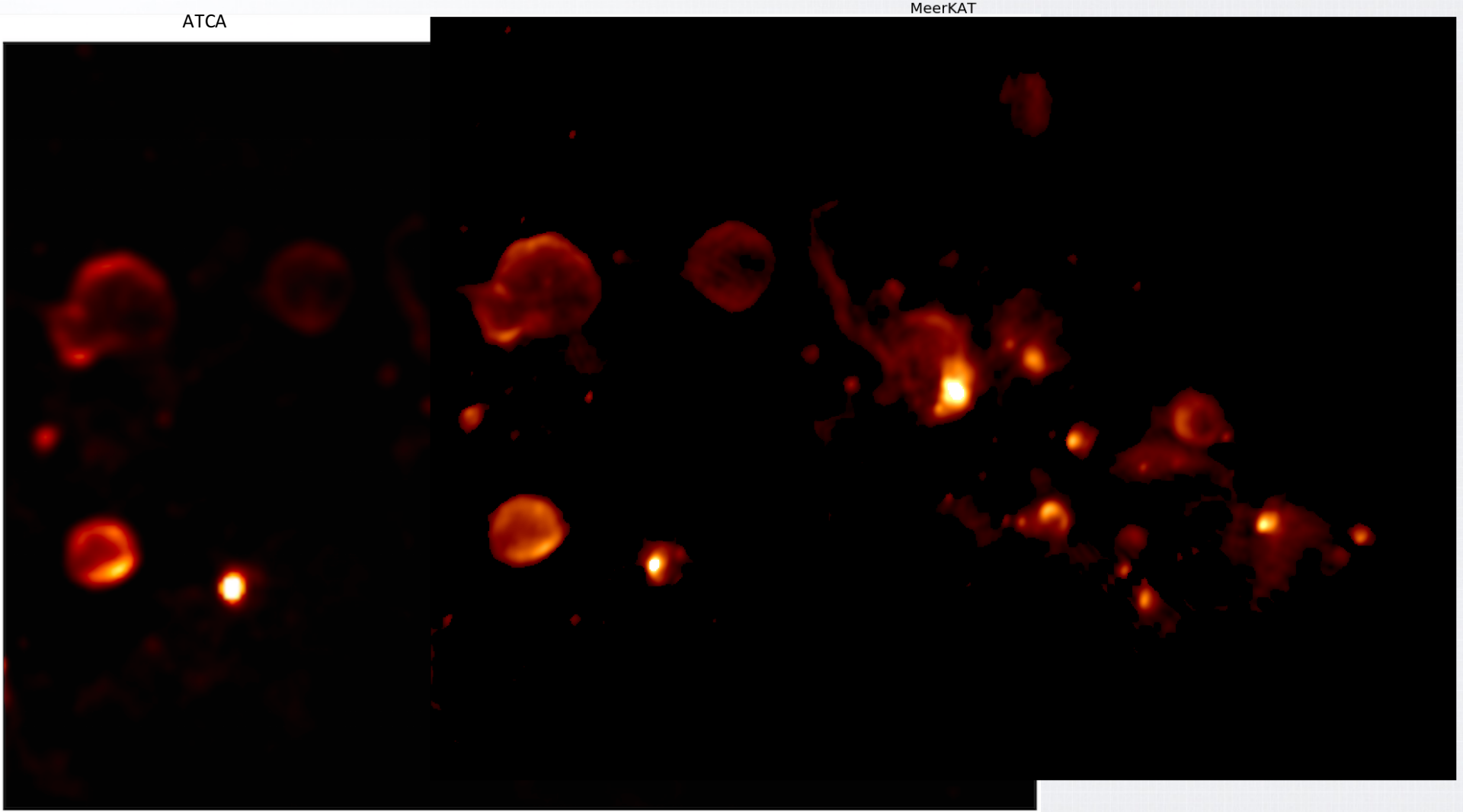




M83

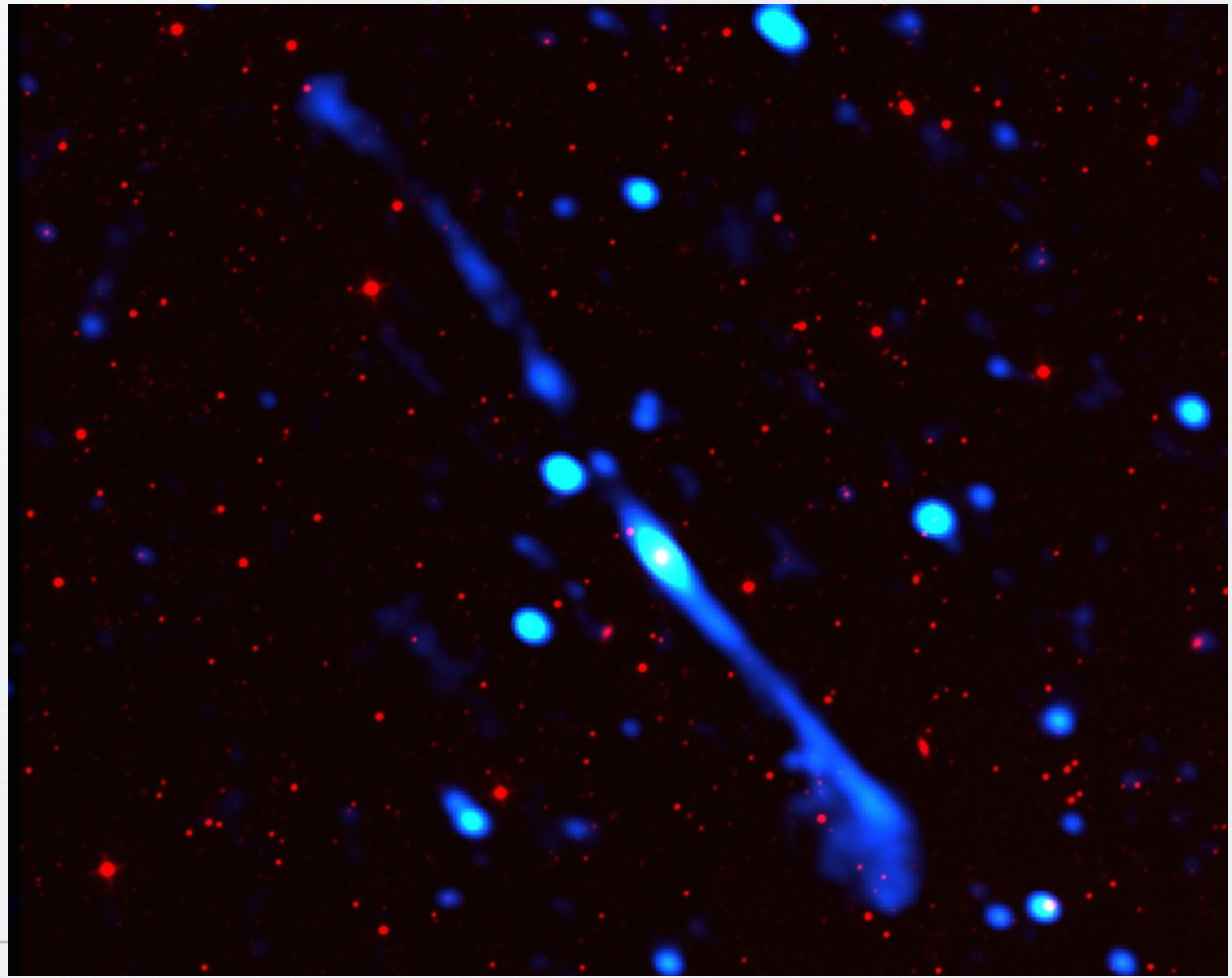


G330.89-0.36 star forming region (continuum, 32k mode)

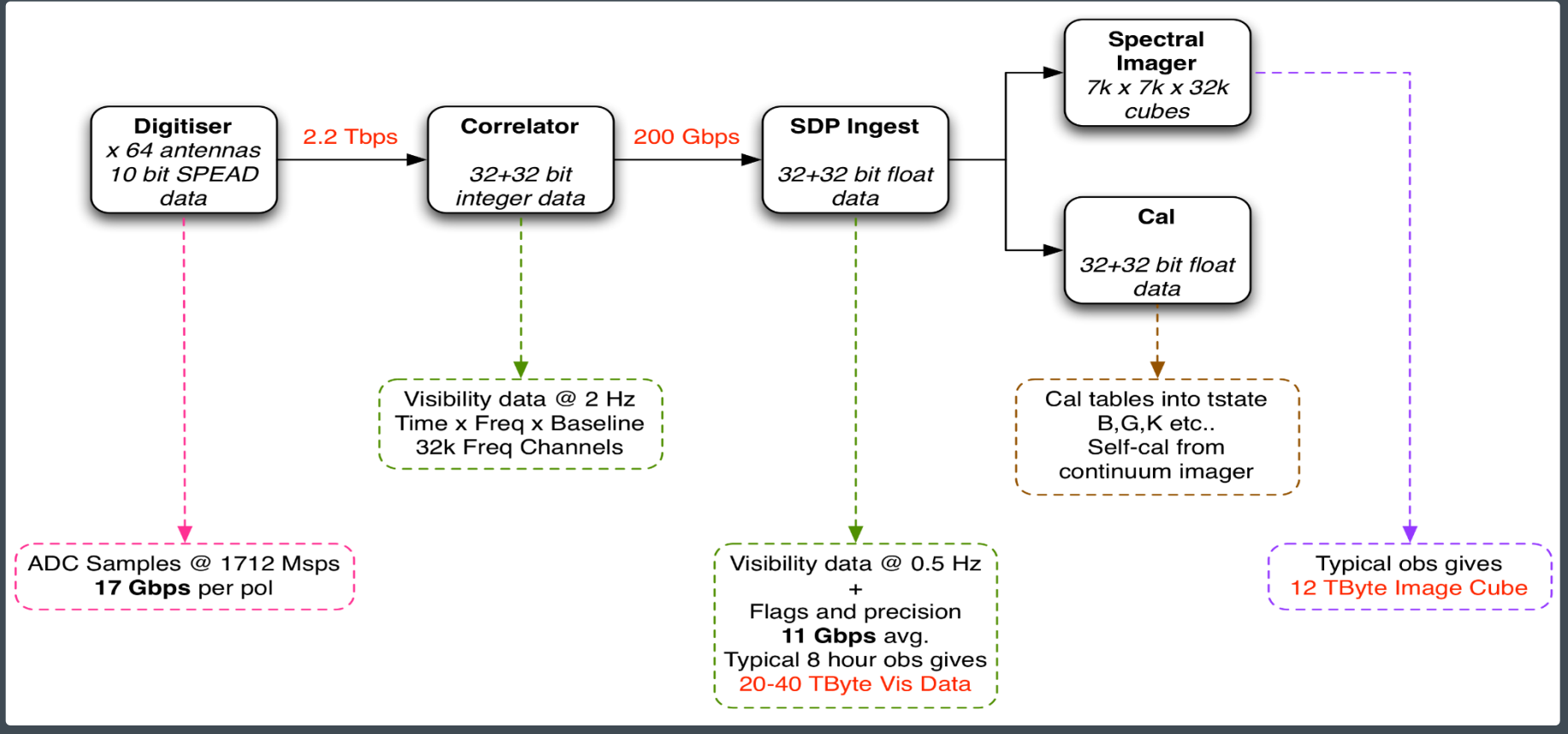


A newly identified Giant Radio Galaxy

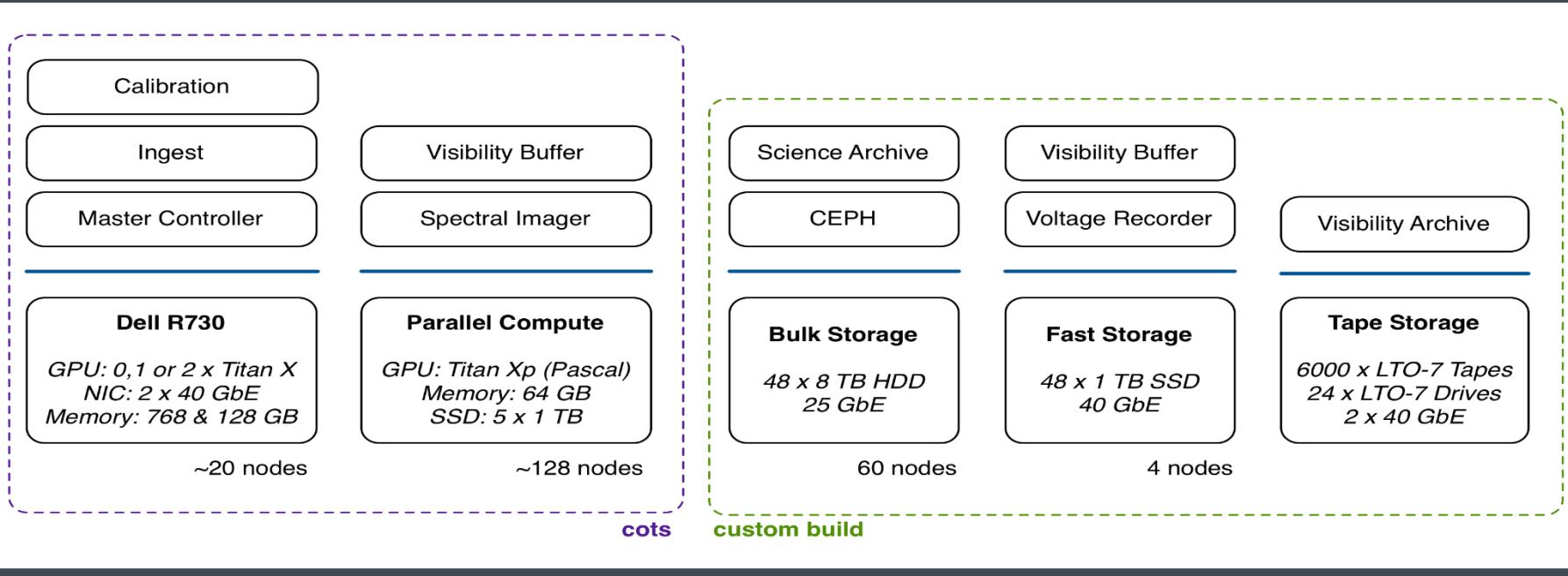
- Hint of extended source in SUMSS
- 7-point MeerKAT mosaic in 4K mode
- Radio source (blue) angular size = 0.8 deg; elliptical galaxy (red/IR) at z = 0.02; linear size = 1.2 Mpc: GRG



MeerKAT Data Rates



MeerKAT SDP Hardware Landscape

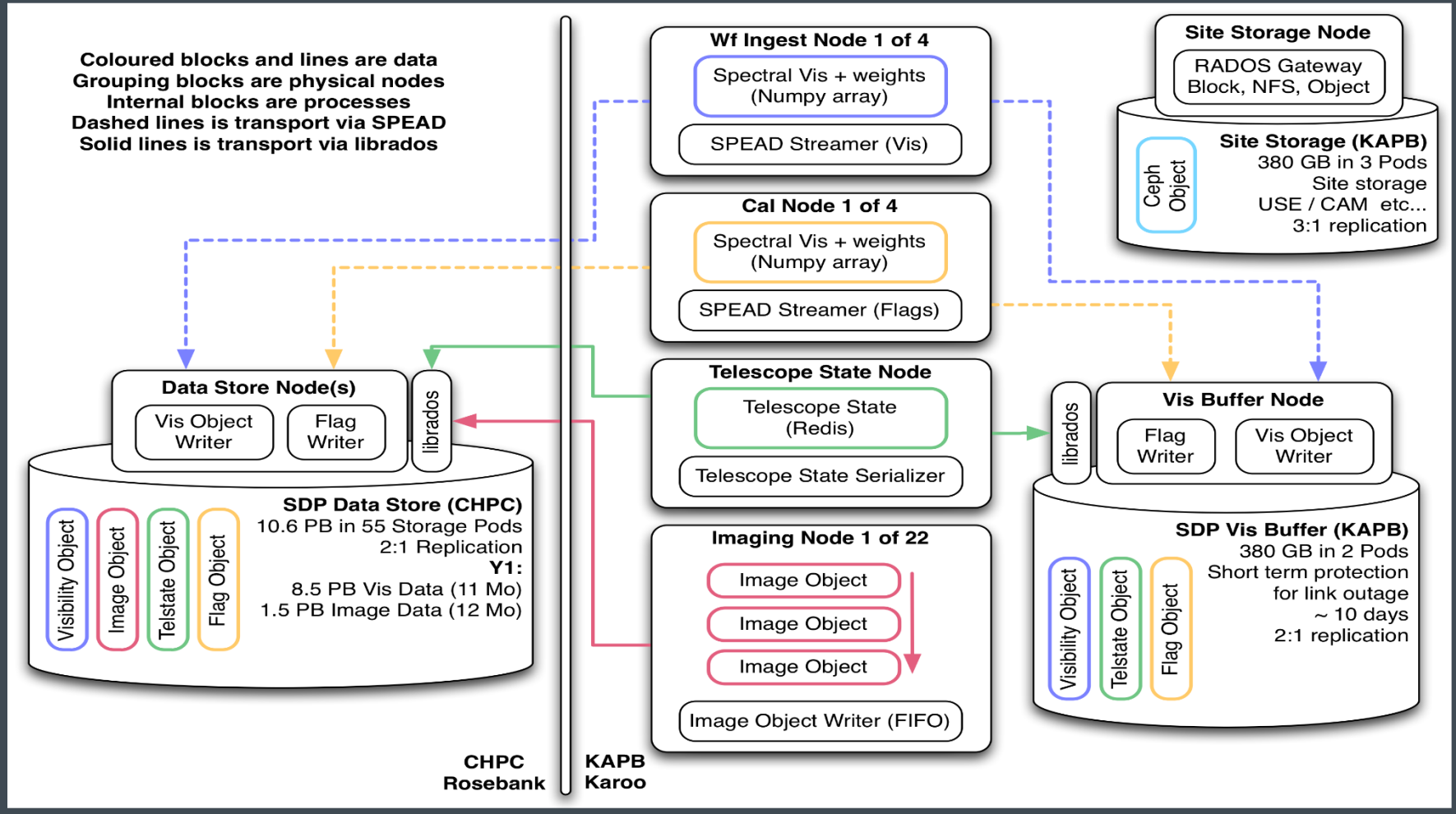


1.6 PFLOPs (GPU)

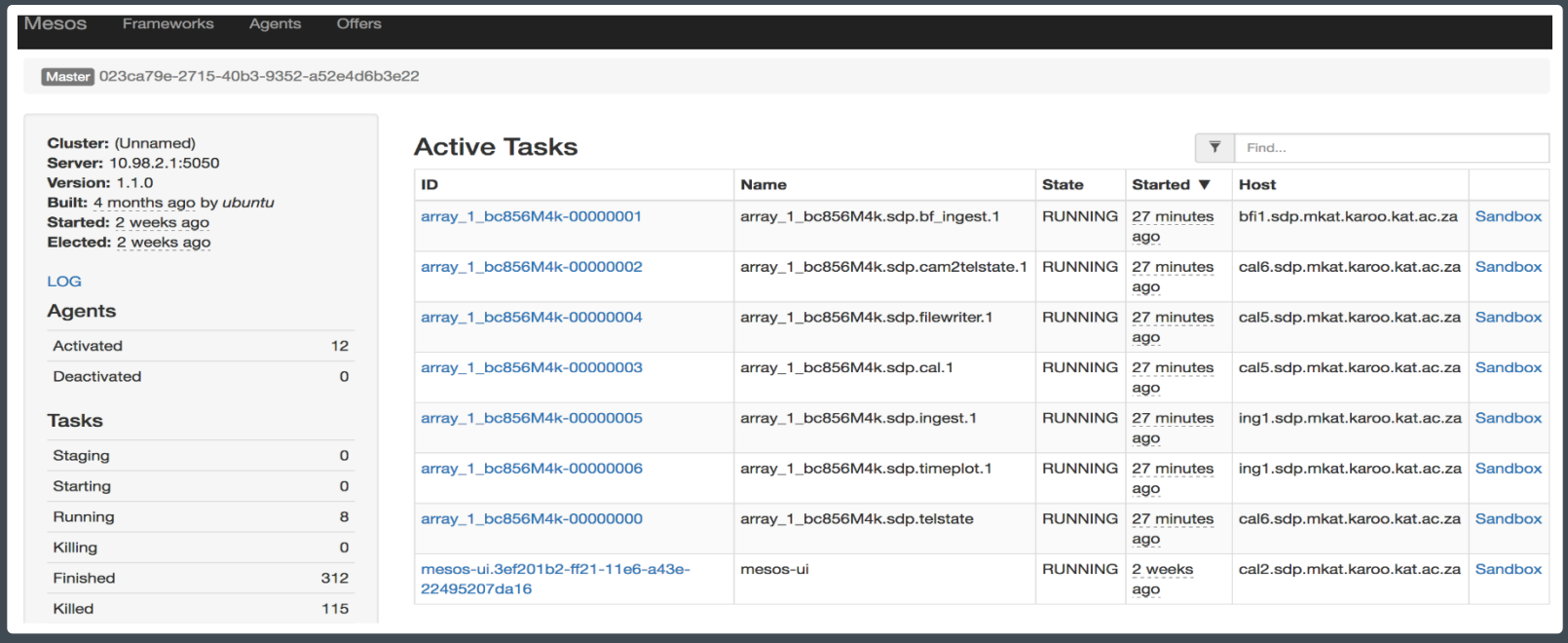
23 PBytes (Disk - CEPH)

40 PBytes (Tape)

Data Flows and Hardware Location



Dealing with the Data – Execution Framework

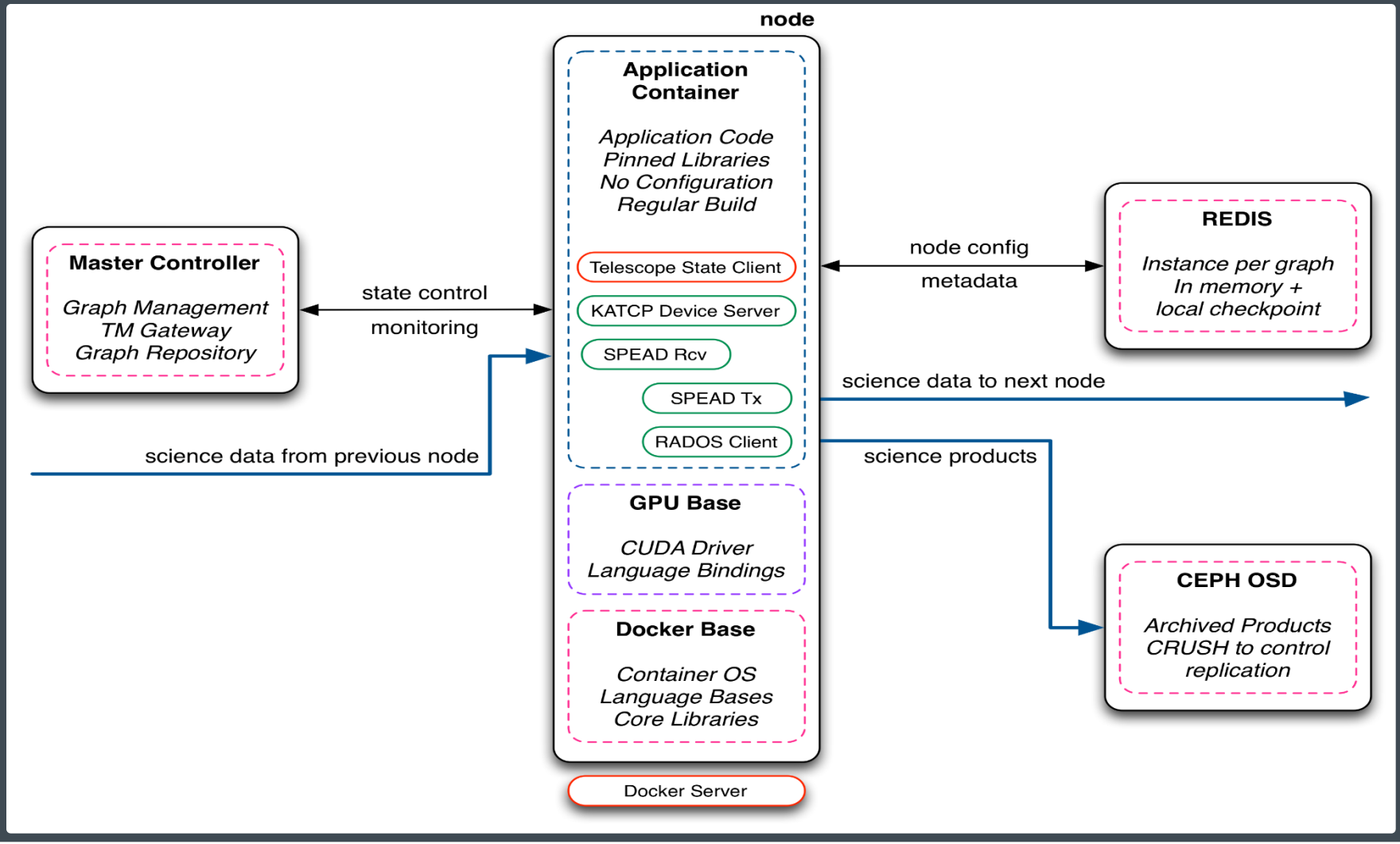


Pipelines expressed as graphs of operations (nodes) and data transfer (edges).

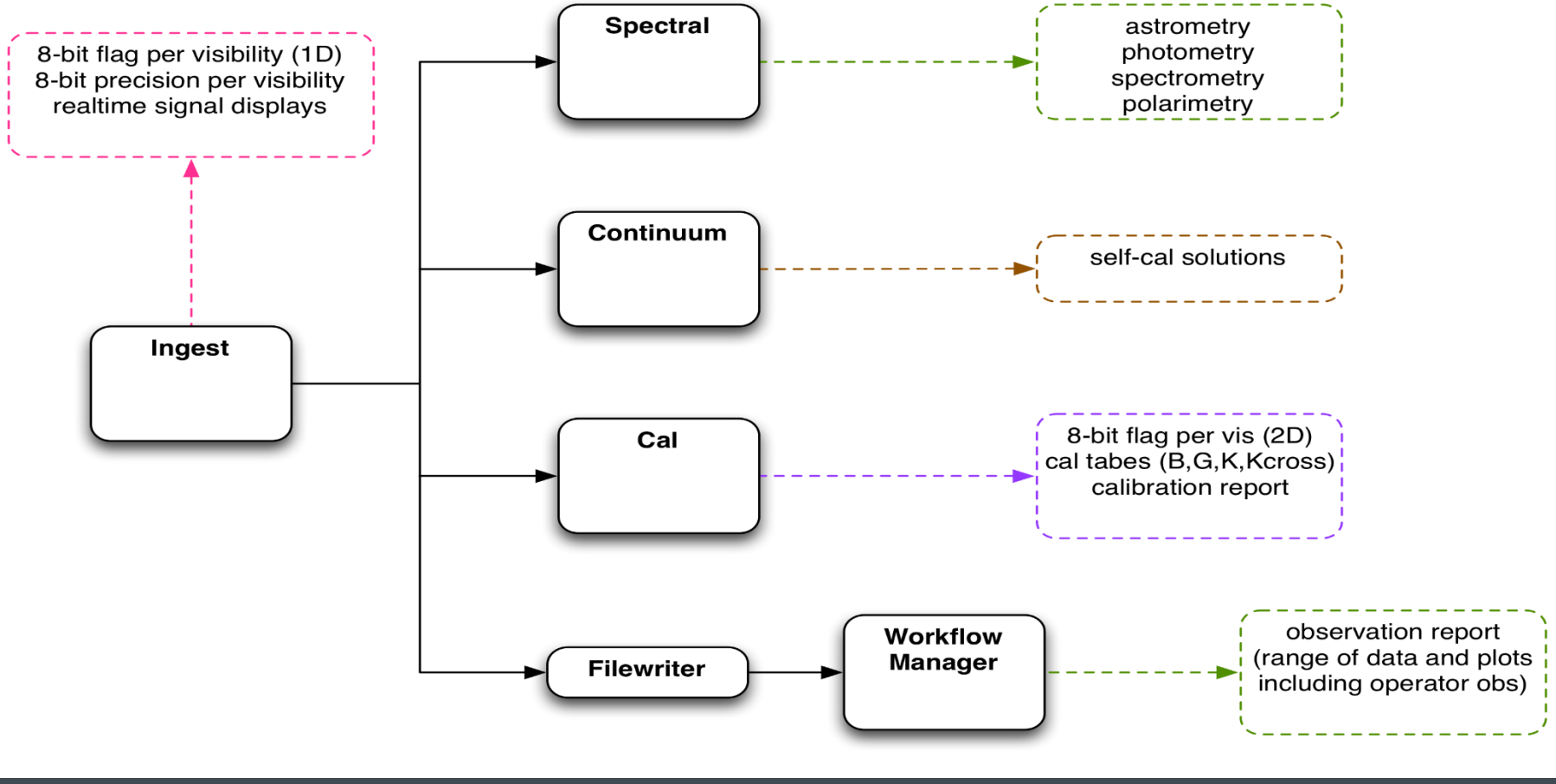
Execution Framework (based on Apache MESOS) deploys and manages graph at scale.

Container approach allows easy deployment of new algorithmic ideas within the pipeline infrastructure.

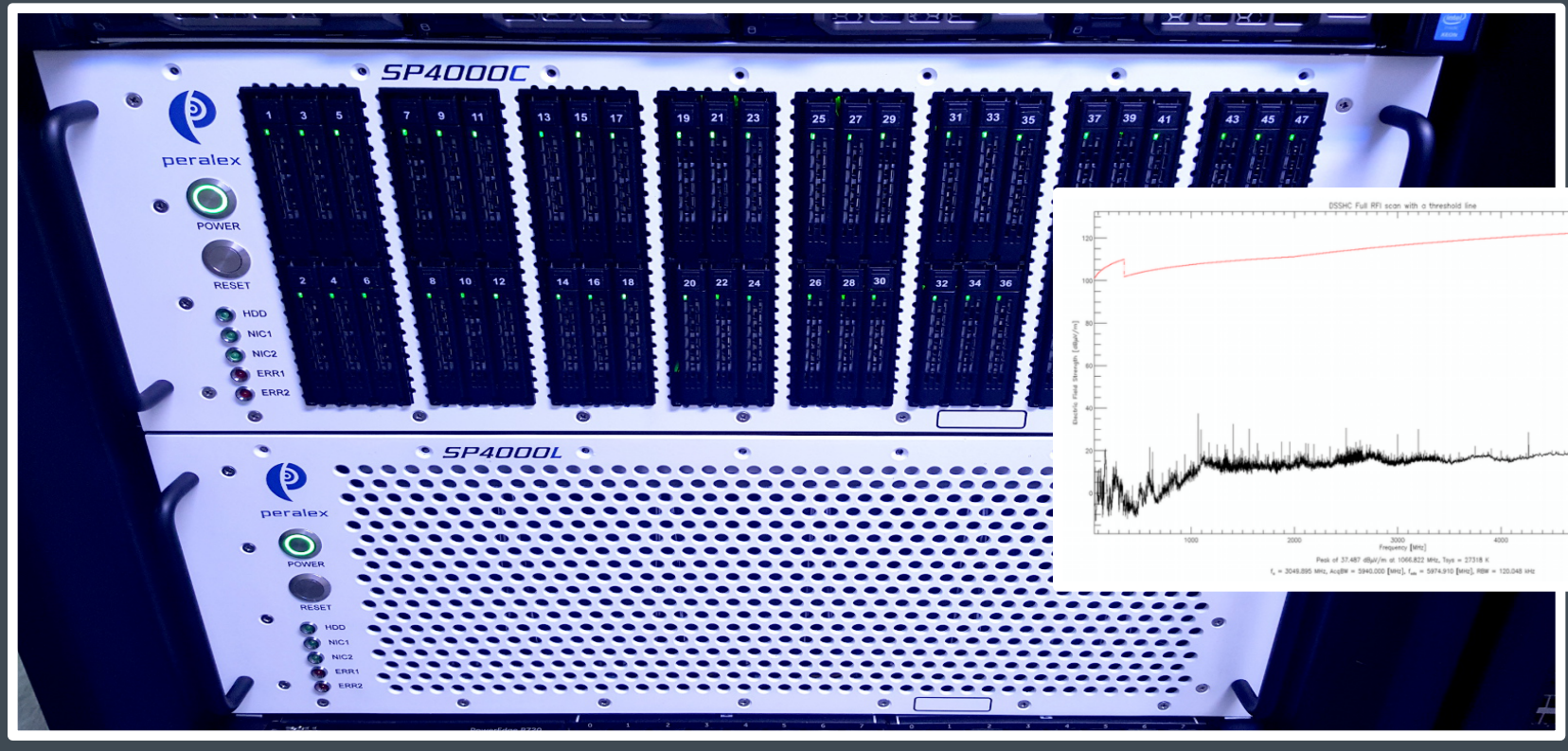
Dealing with the Data – Execution Environment



Dealing with the Data - Quality Metrics



CEPH Cluster – Custom Hardware

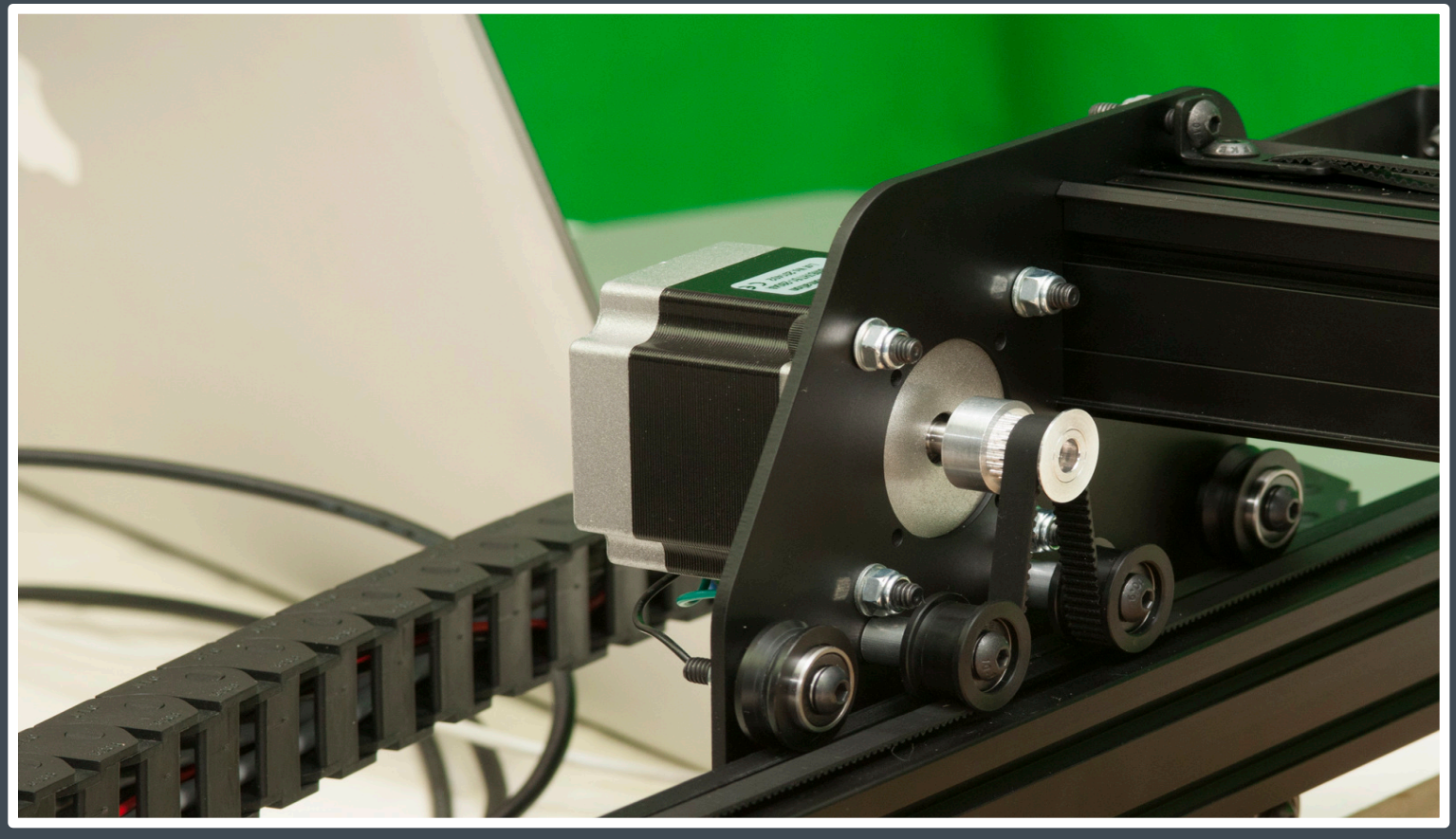


High Speed Pod: 40 Gbps to disk / 40 TiB

Bulk Pod: 25+Gbps to disk / 360 TiB

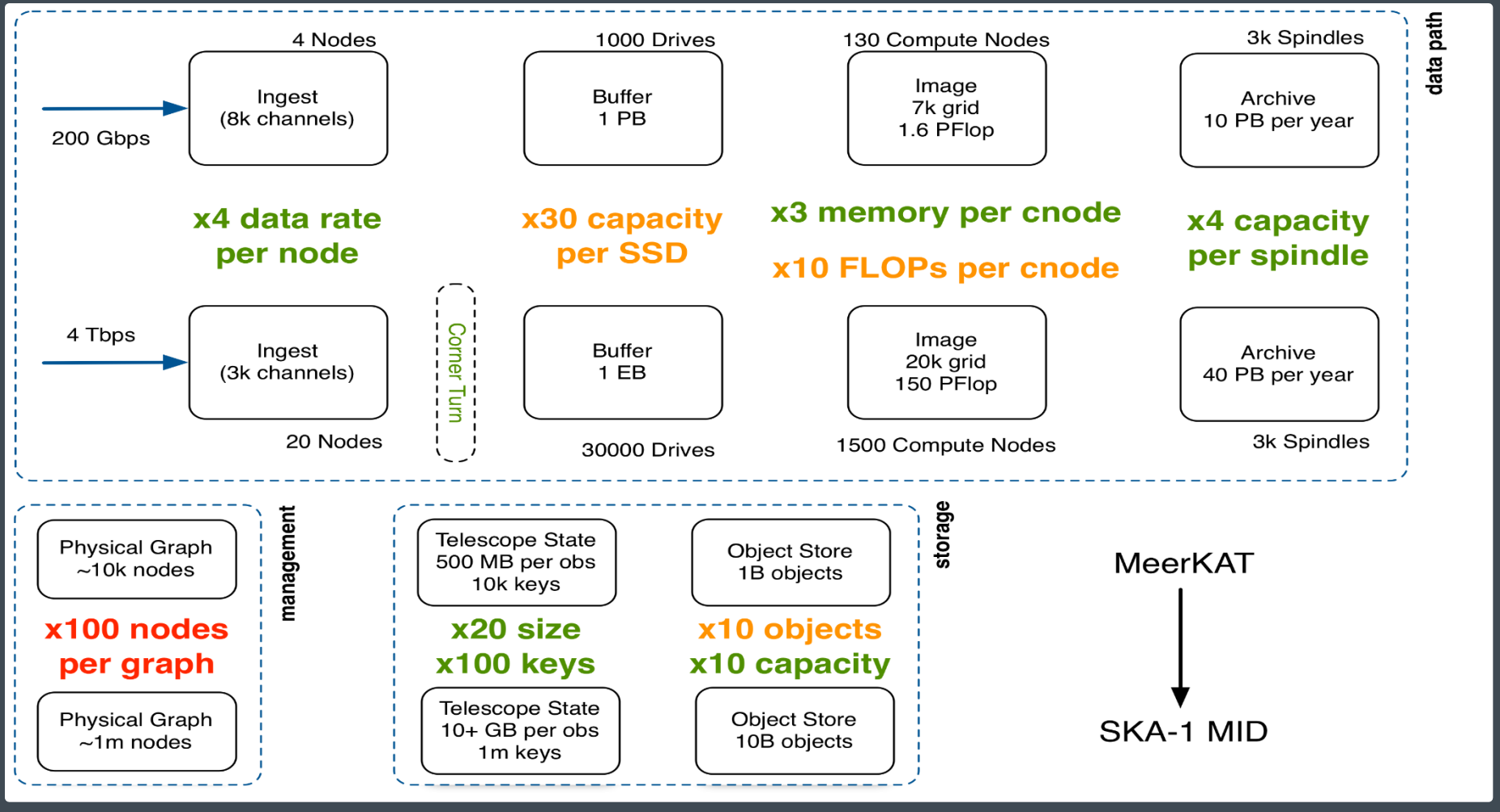
23 PB CEPH Cluster ~ $1.2 million all in

Custom Tape Robotics



3k – 50k slot LTO tape library at 10x cheaper

Scaling to SKA-1 MID



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National Research Foundation

SKA South Africa, a Business Unit of the National Research Foundation, is supervising South Africa's involvement in the SKA on behalf of the Department of Science & Technology.

Thank you