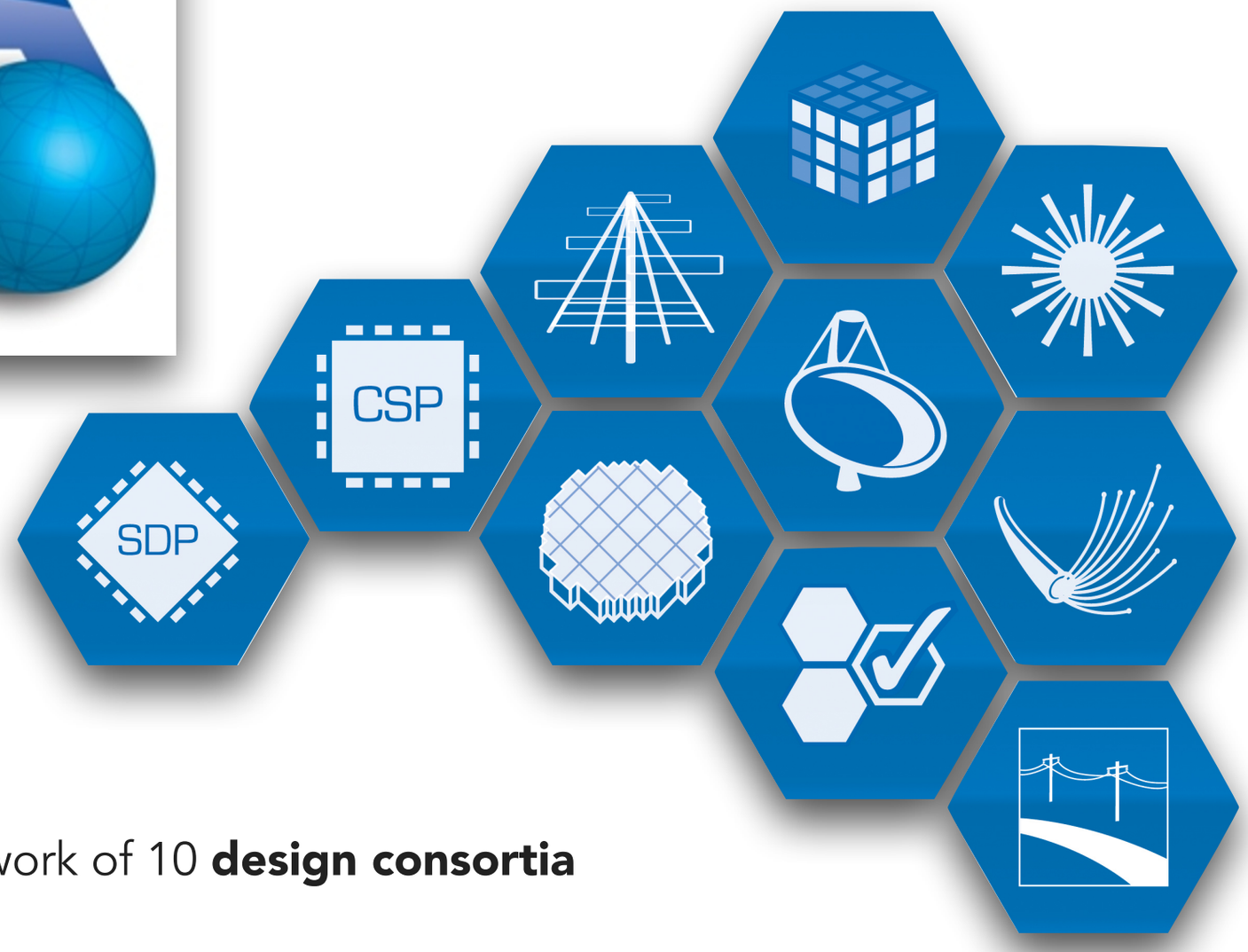
Advanced European Network of E-infrastructures for Astronomy with the SKA AENEAS - 731016

SKA

Anna Scaife
Jodrell Bank Centre for Astrophysics

Interferometry Centre of Excellence

The Square Kilometre Array International Organisation (**SKAO**)



The SKAO oversees the work of 10 **design consortia**

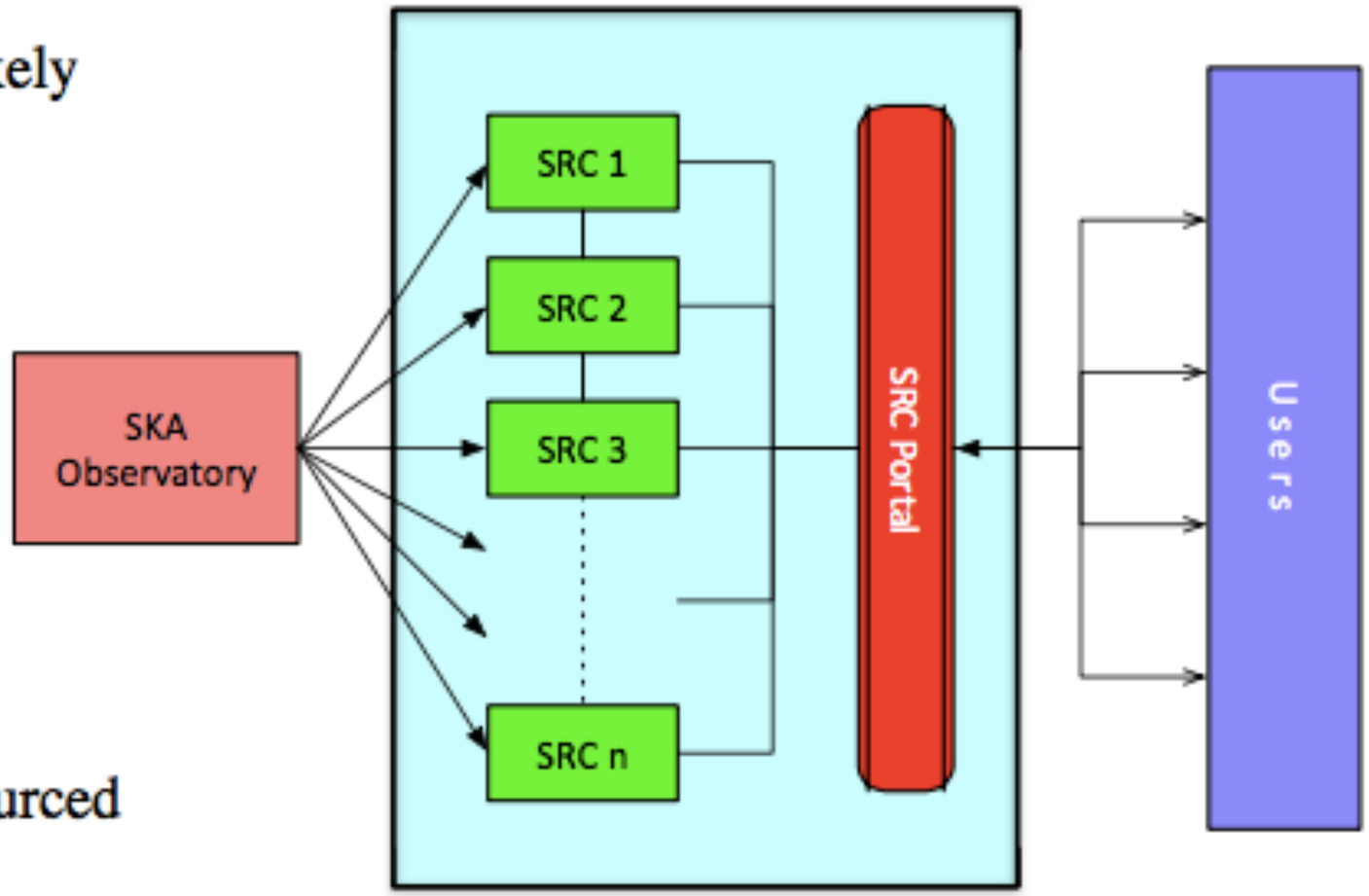

SKA
SQUARE KILOMETRE ARRAY

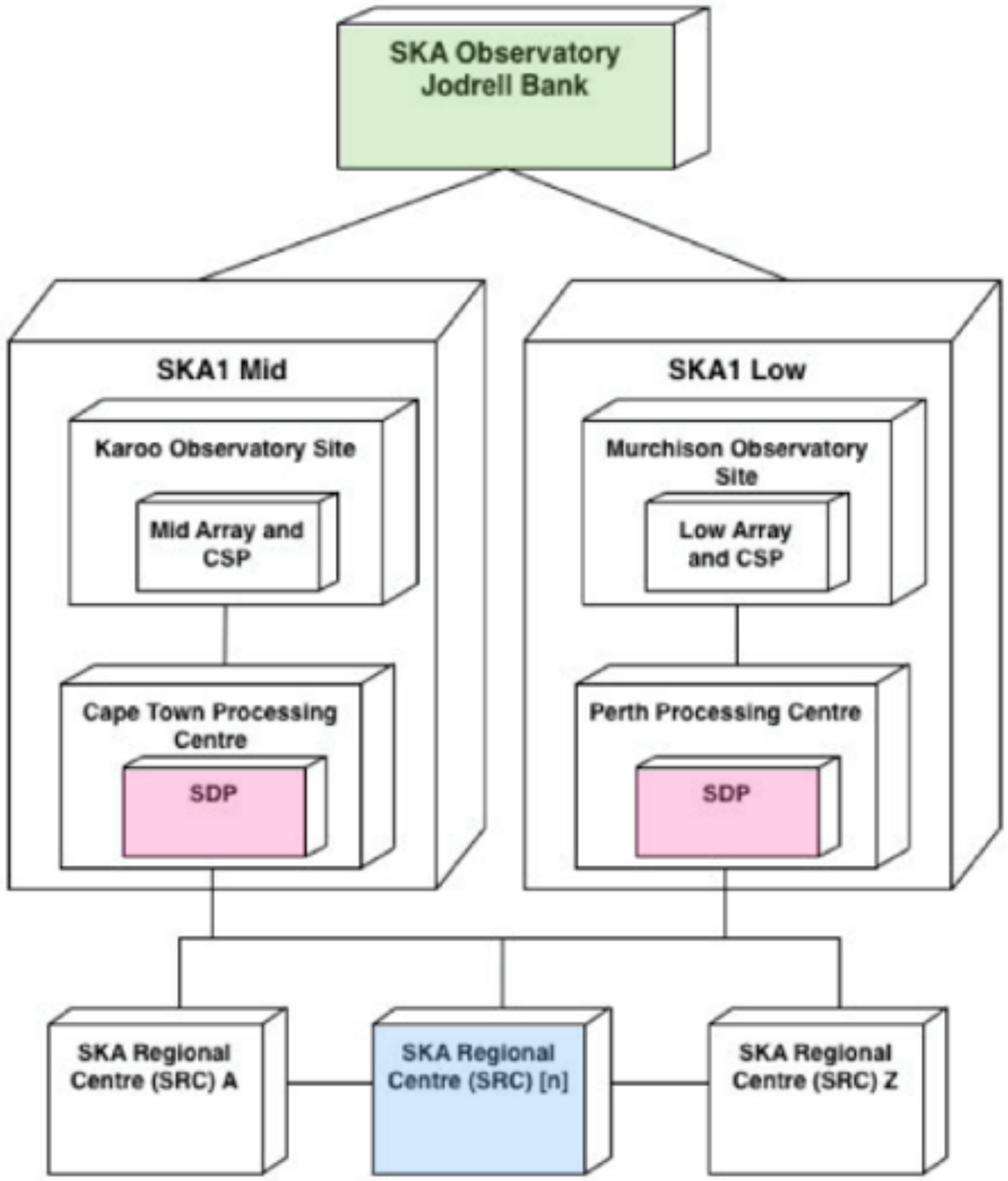

SKA
SQUARE KILOMETRE ARRAY
SDP
SCIENCE DATA PROCESSOR


Aeneas
Advanced European Network of E-infrastructures
for Astronomy with the SKA

SKA Regional Centres

- Science Data Centres (SDCs) will likely host the SKA science archive
- Provide access and distribute data products to users
- Provide access to compute and storage resources for users
- Provide analysis capabilities
- Provide user support
- Multiple regional SRCs, locally resourced

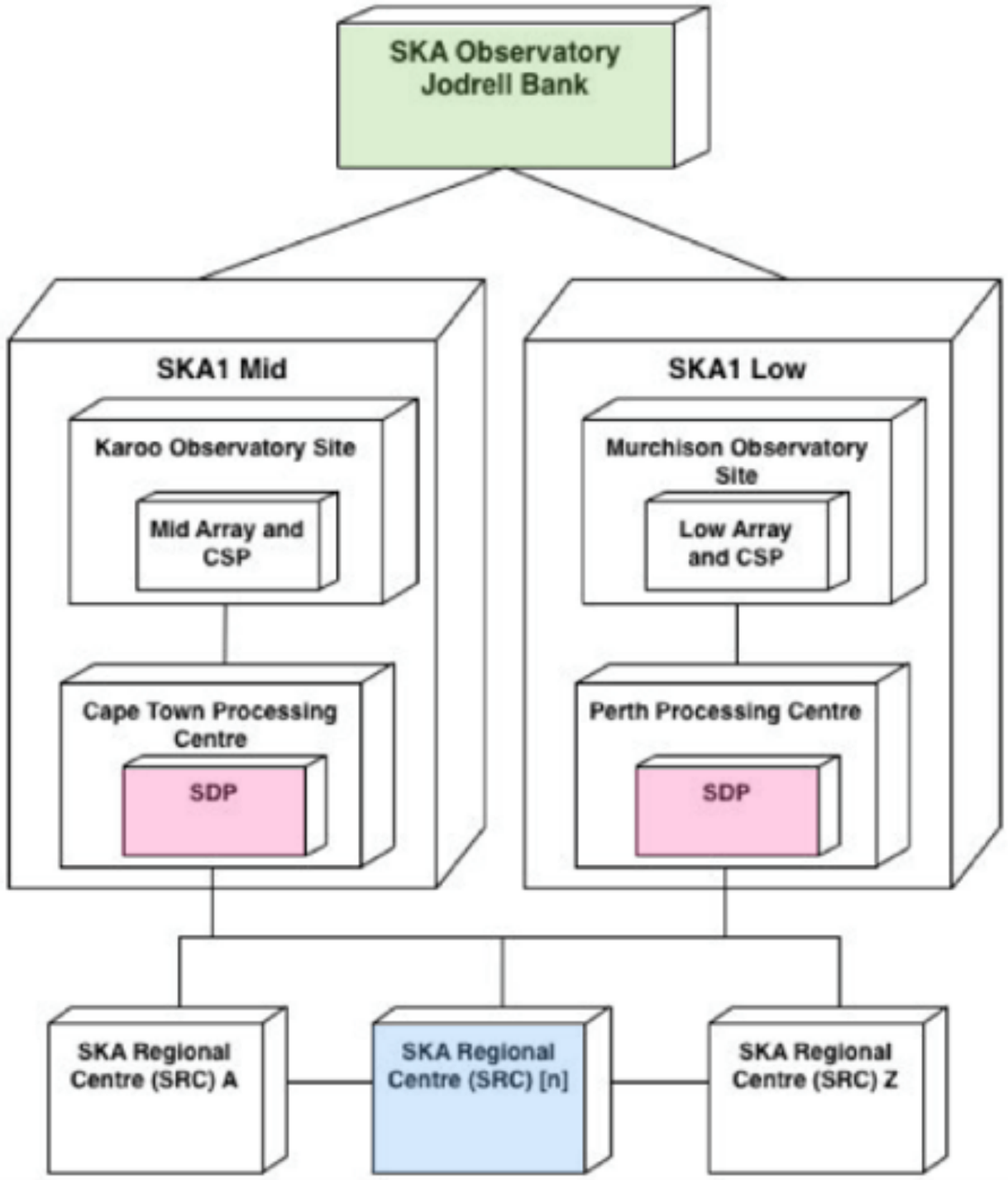




CENTRAL SIGNAL PROCESSING

SCIENCE DATA PROCESSING

REGIONAL DATA CENTRE



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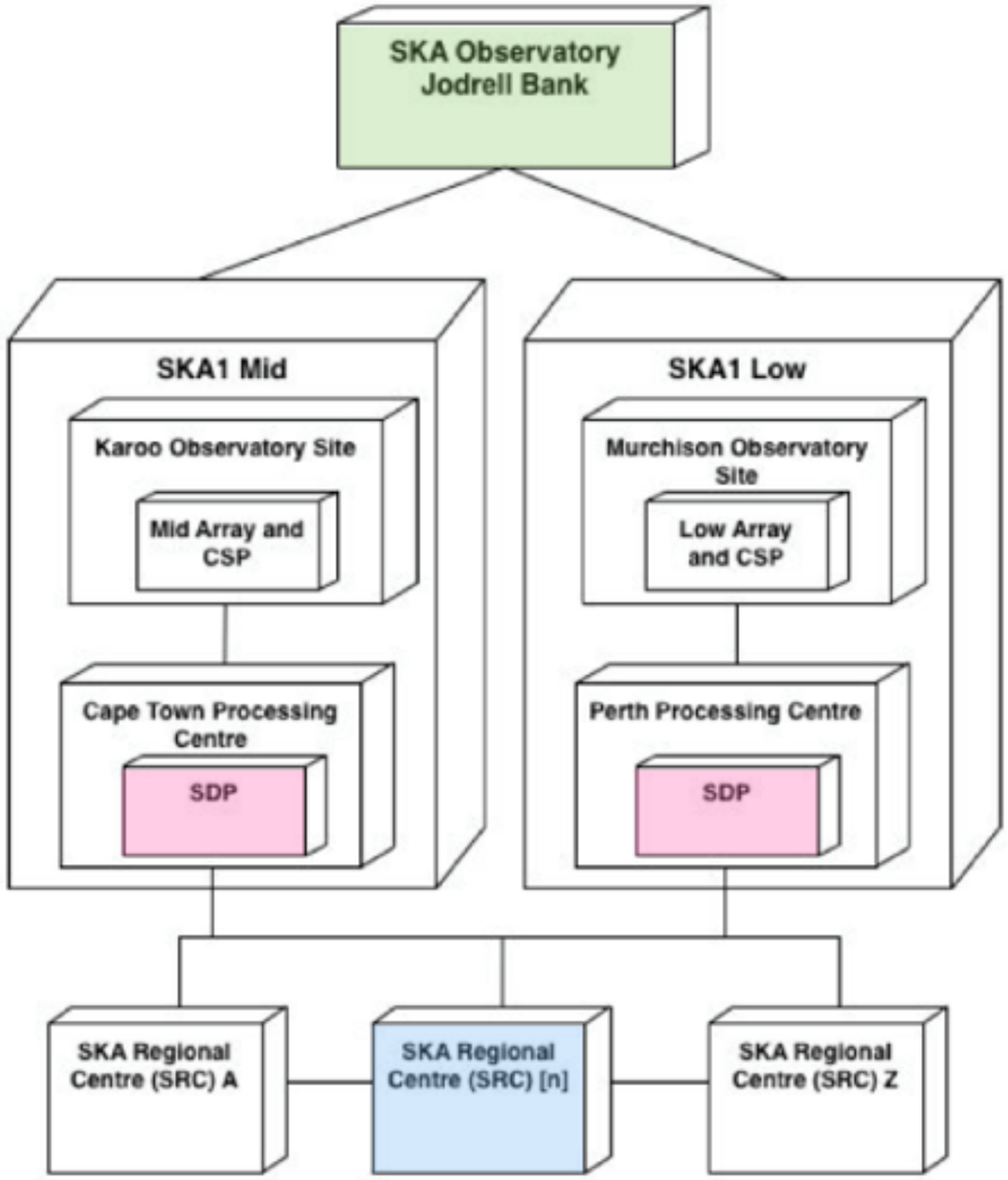

SQUARE KILOMETRE ARRAY

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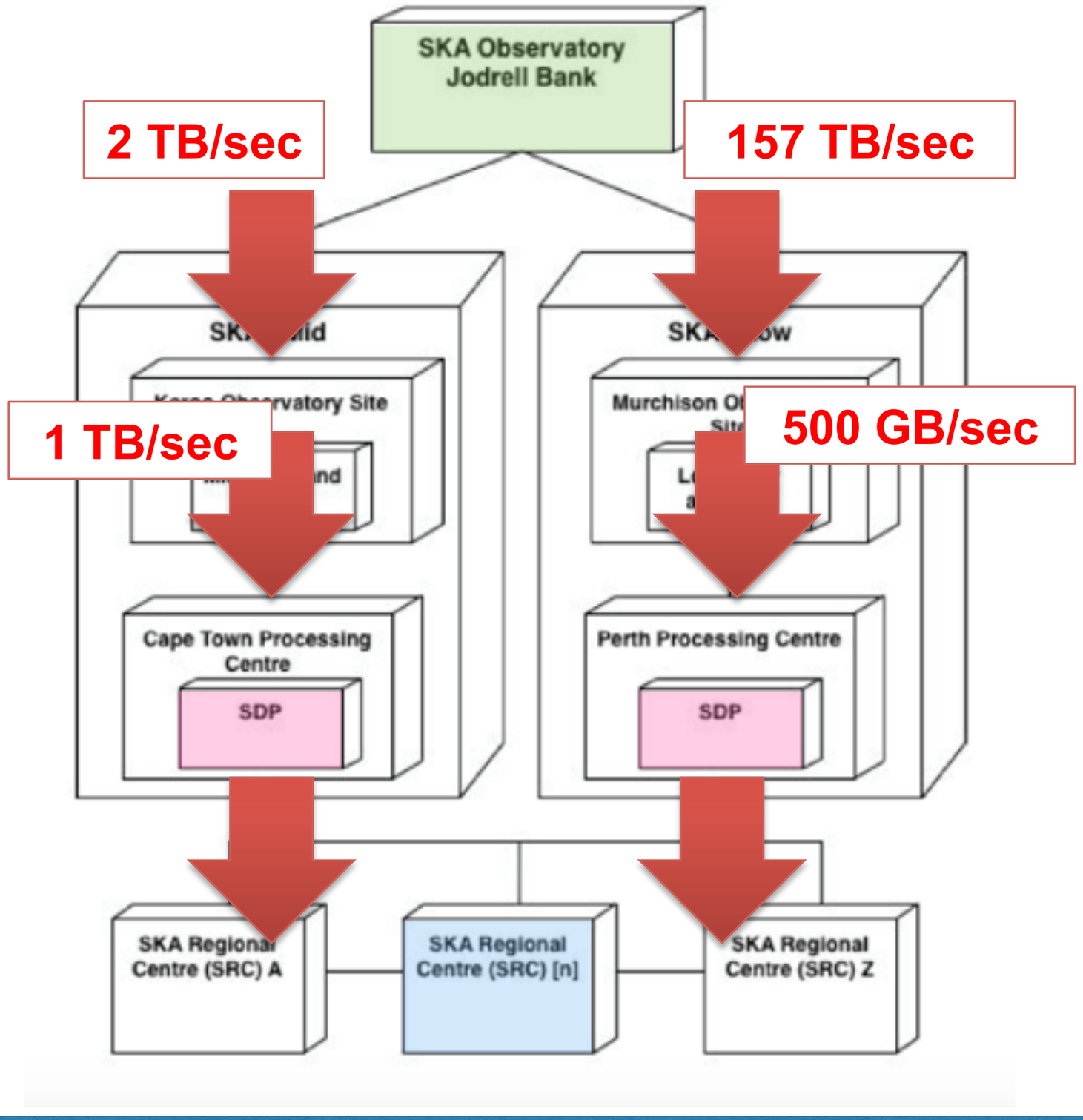

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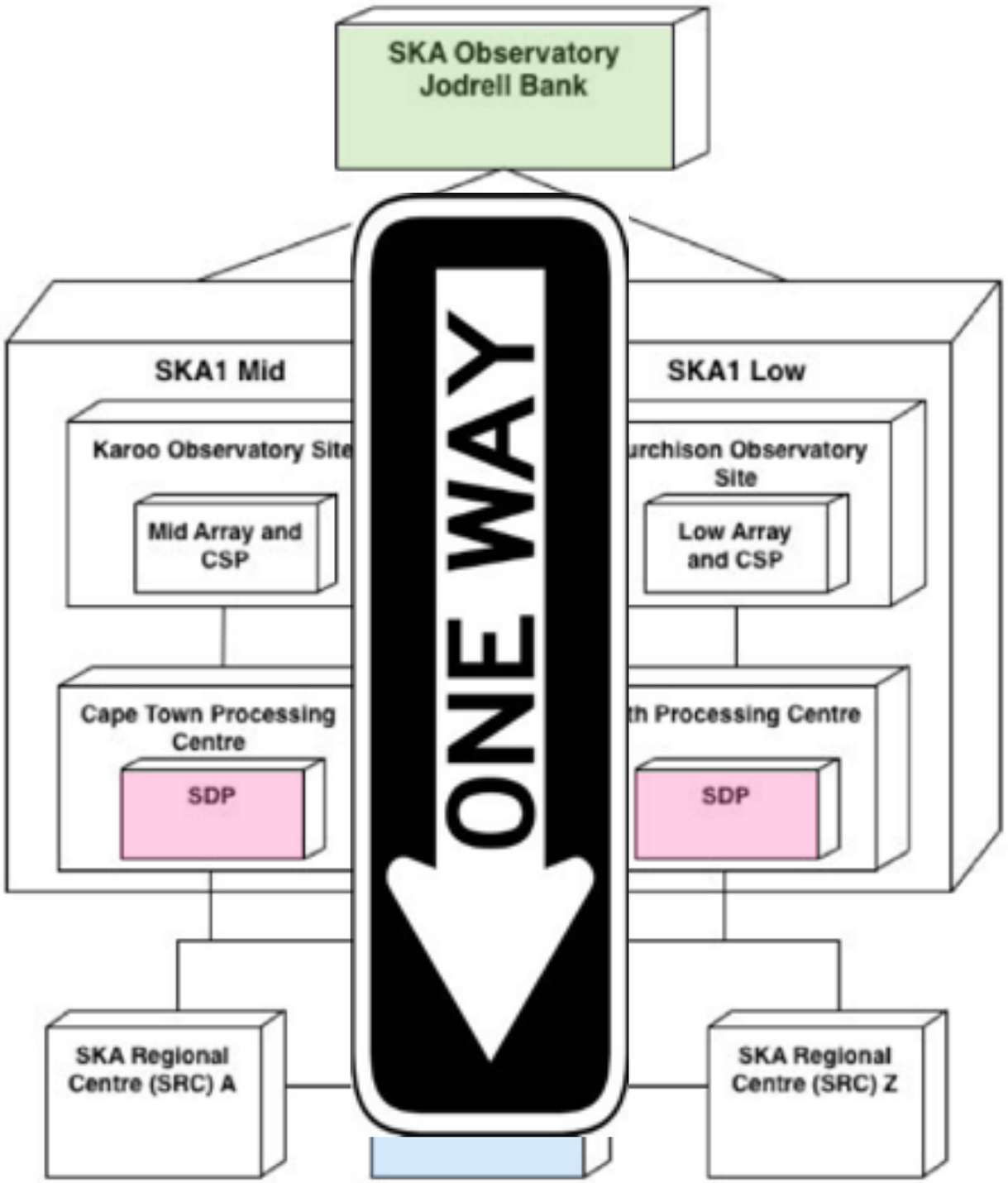


Standardized data products

A standard SKA1-MID image data product has
30k x 30k pixels

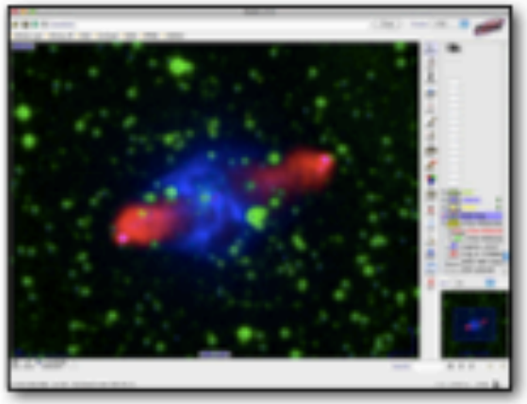
SKA1 will have up to **65k frequency channels**
and **4 polarisations**

At 4 Bytes per voxel that equates to
30k x 30k x 65k x 4 x 4
= **936 TeraBytes**

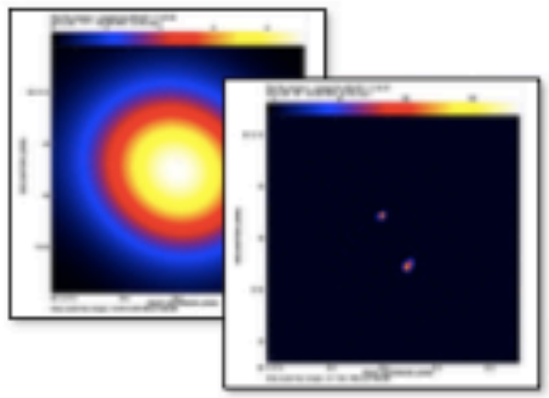
Regional Centre Functionality

Data Discovery

- Observation database
- Quick-look data products
- Flexible catalog queries
- Integration with VO tools
- Publish data to VO



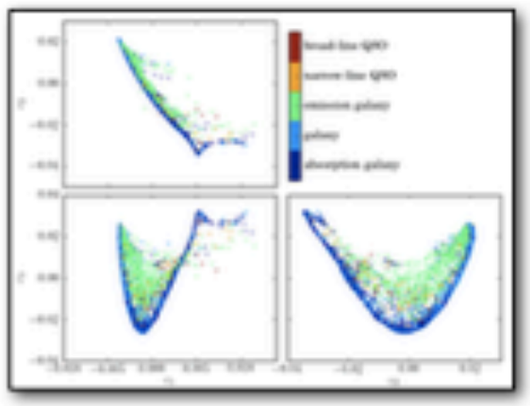
Data Processing



- Reprocessing
- Calibration and imaging
- Source extraction
- Catalog (re-)creation
- DM searches

Data Mining

- Multi-wavelength studies
- Catalog cross-matching
- Transient classification
- Feature detection
- Visualization



What do we know about data and its consumption

- Hierarchical data structure within each experiment, key science based namespaces – further extended to be PI-based
- Granularity at which data is managed varies from experiment to experiment
- Pre-determined ”push” mechanism from the SDP to Regional centres
- Data storage will be at various locations possibly under different administrative domains
- Number of users would be a few thousand
- “Passive users” consuming data will also be generating secondary data which may not be smaller than raw data
- Likely X.509 certificates for authentication
- Commonly used tools are CASA, AIPS, Miriad, PRESTO, SIGPROC

Data Products at the Regional Centre

- Image type data products
  - Image cubes
    - Continuum Survey, Magnetism, Hi Kinematics, ISM
    - Data archive for these experiments would range from a fraction of a PB to 120 PB
    - Since hours of telescope time differ, it is useful to look at data generated per 6 hour observation. This will range from 0.1 to 100 GB
  - U-V Grid – calibrated visibilities
    - EoR experiments on SKA1 LOW
    - Data archive of almost 220 PB
    - Per Observation ~270 GB
- Non-image data products
  - Pulsar search and timing experiments
    - Data archive of 250 GB to a few PB, per observation less than 3 GB
    - LSM Catalogue, Transient catalogue, Pulsar timing solutions, Transient buffer data, Sieved pulsar and transient candidates

Experience with existing e-Infrastructure

- SKA.GridPP meeting in Manchester 2016
- skatelescope.eu VO established
- Testing on GridPP started in 2017 as part of AENEAS
- Lots of help from Andrew & Alessandra

Three initial programs:

1. Interferometric imaging compute model
2. Object detection & classification (image based)
3. Synergistic science incorporating multi-wavelength surveys (catalogue based)

Alessandra Forti

Andrew McNab

Rohini Joshi

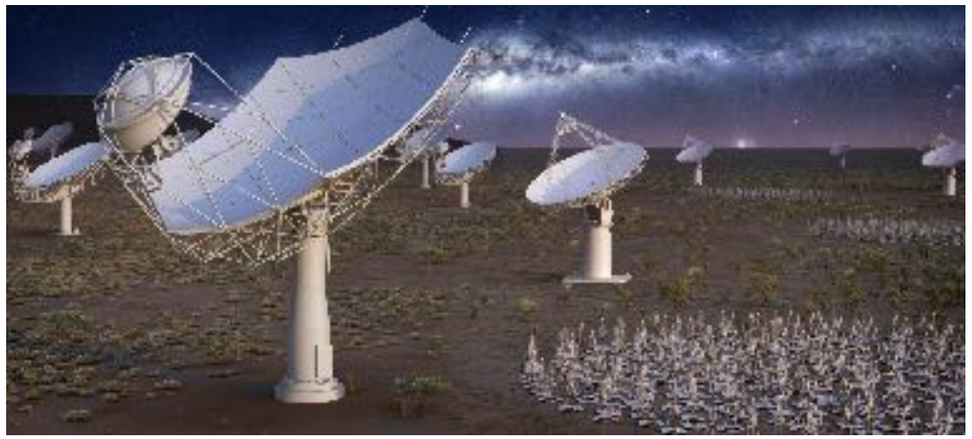
Thérèse Cantwell

Alex Clarke

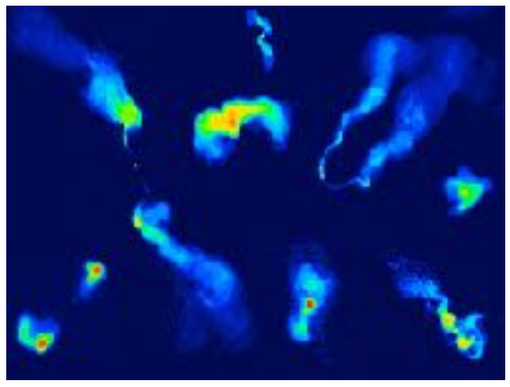
(1) Interferometric Imaging

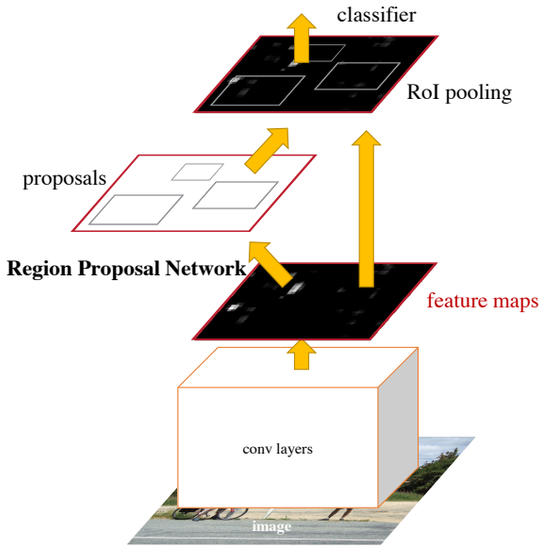
- LOFAR data – GOODS-N survey. One observation is 3.5 TB
- Uploaded to the Manchester storage nodes using LTA's HTTP interface and a parametric set of jobs
- Accessed using Logical File Names (LFNs)
- Time-slice sub-bands into manageable chunks to process them
- Calibration using LOFAR software on CVMFS being tested on GridPP – looking into singularity as an alternative
- Using DIRAC's DMS and WMS
- GridPP liaisons - Andrew McNab and Alessandra Forti

(2) Object detection & classification (image based)



Classifying sources by eye takes too much time!





- **Using region-based CNN to detect objects in a field and classify them**
- **Specifically using a python based implementation of faster R-CNN for CPU**

Automatically generate source catalog including

- **https://github.com/rbgirshick/py-faster-rcnn**
- **Plan to containerise using Singularity for testing on GridPP**

```
[vagrant@localhost 8237808]$ ls
cow_file.txt  StdOut
[vagrant@localhost 8237808]$ cat cow_file.txt
 ---------------------------
< The cow is on the grid! >
 ---------------------------
        \   ^__^
         \  (oo)\_______
            (__)\       )\/\
                ||----w |
                ||     ||
[vagrant@localhost 8237808]$
```

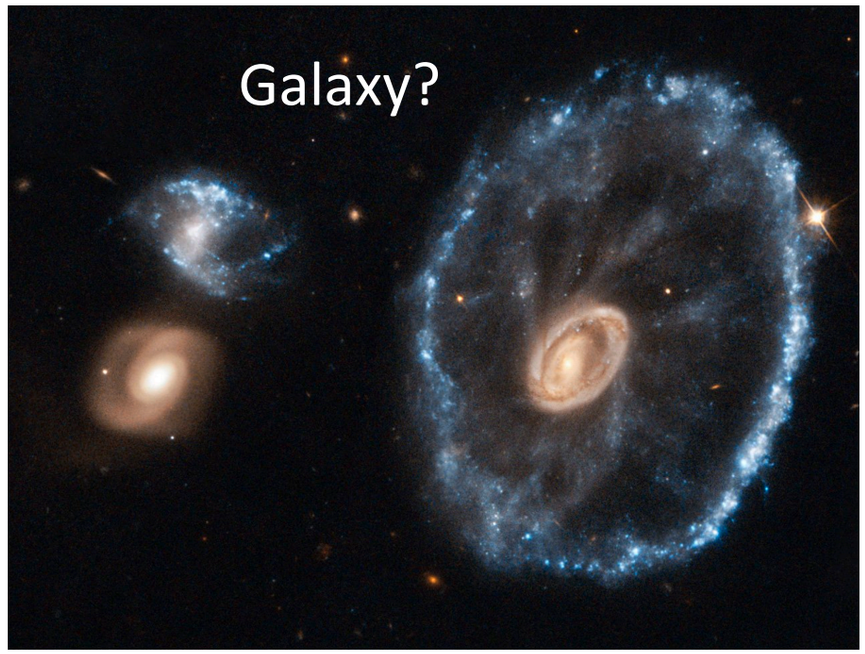
(3) Synergistic science incorporating multi-wavelength surveys (catalogue based)

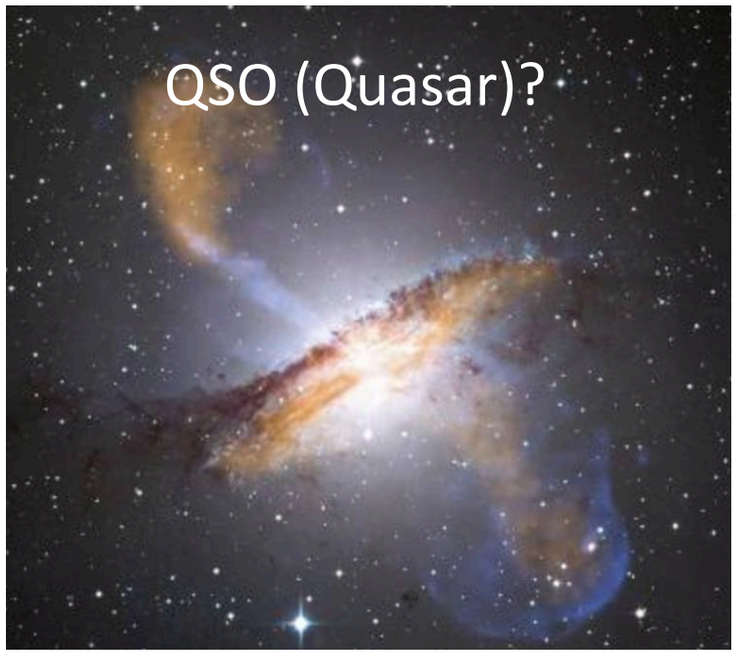
SciServer is an online system for accessing & analysing scientific big data projects in astronomy, and other areas.

Identify source position and morphology from SKA image → Cross-match with archival multi-wavelength survey data from SciServer → Apply Machine Learning algorithms to inform about SKA sources

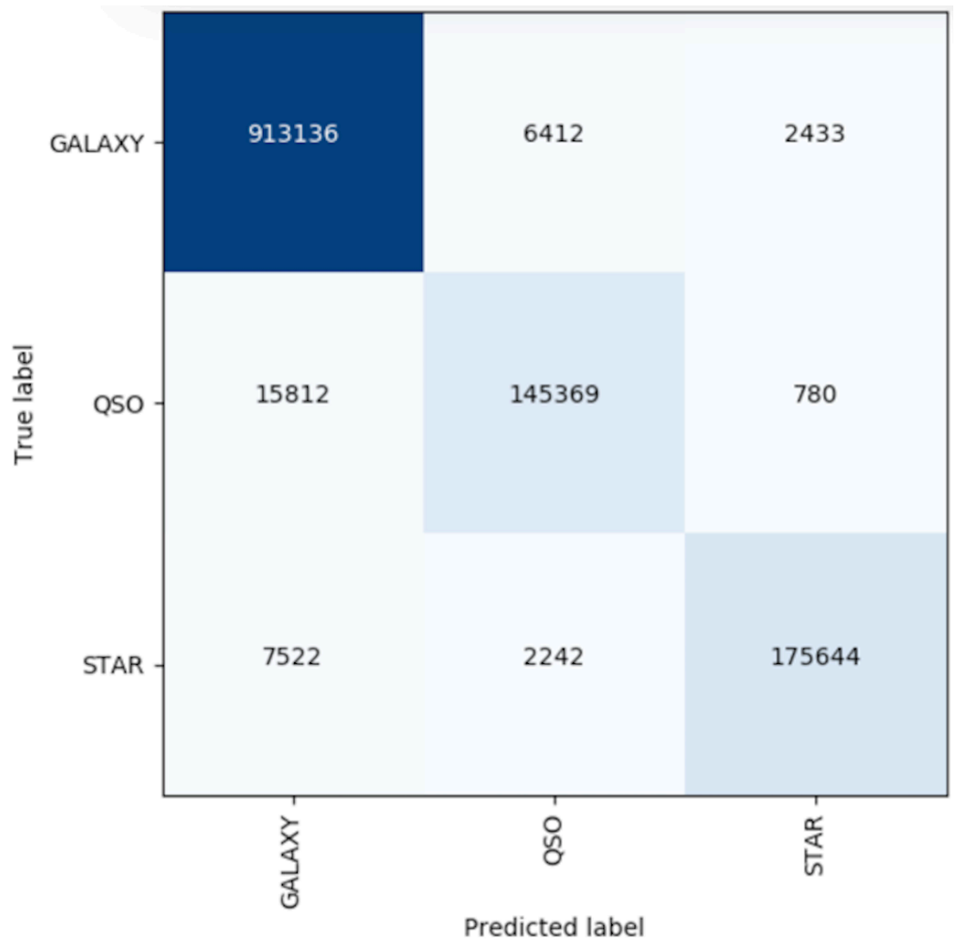
Apply this schematic in a distributed computing set up to run analysis on millions of objects, each with hundreds of data points describing them

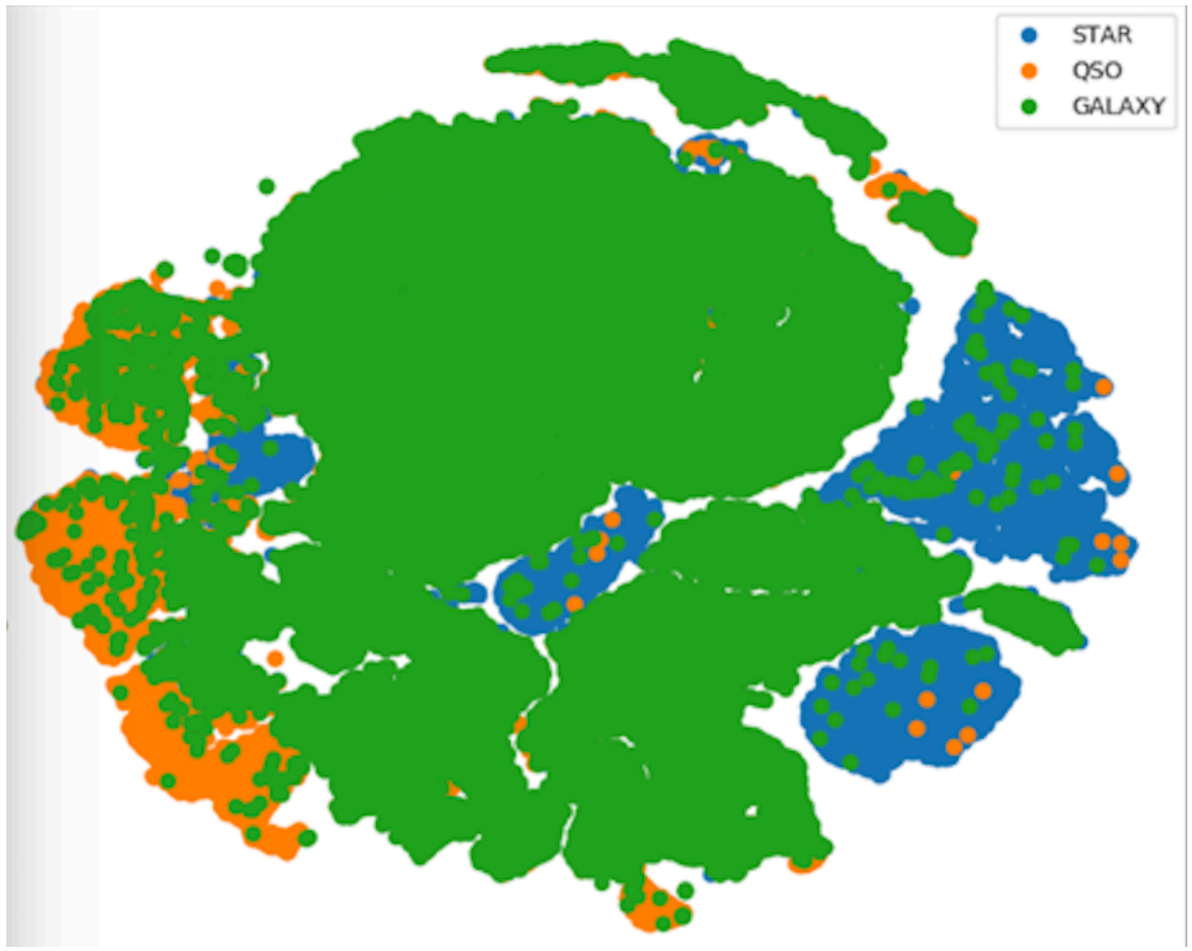
The more data available, the more complex and unique sources a computer can learn to recognise and describe





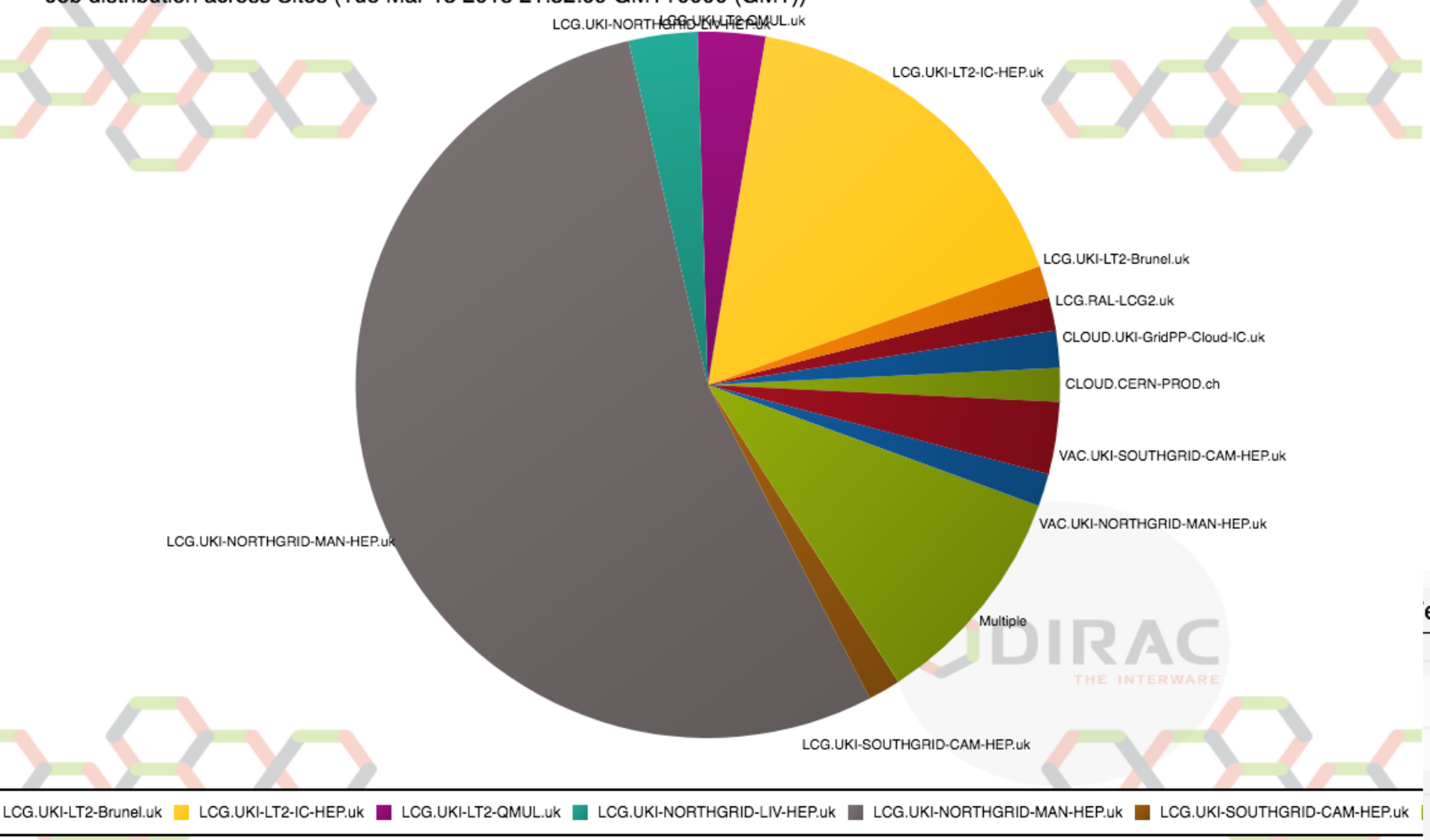
Clustering algorithms and decision trees learn what objects are from the data





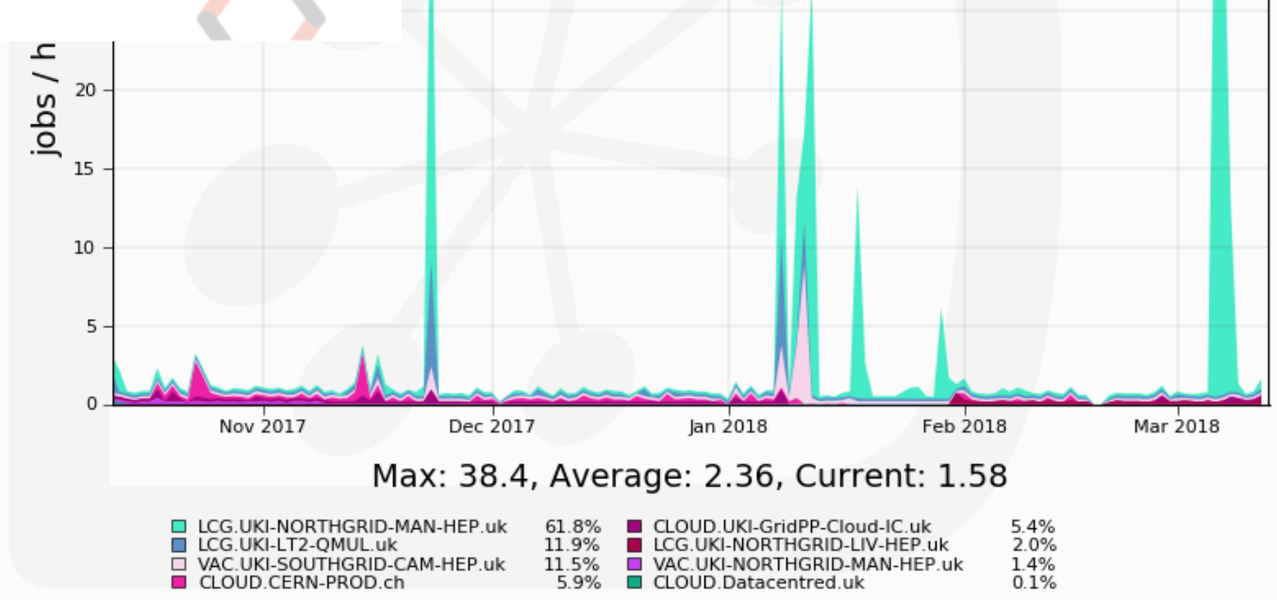
>1e6 objects - 16 photometry data points describing each from optical, IR, radio

Job distribution across Sites (Tue Mar 13 2018 21:32:09 GMT+0000 (GMT))



Jobs by Site

eeks from Week 41 of 2017 to Week 10 of 2018



Max: 38.4, Average: 2.36, Current: 1.58

LCG.UKI-NORTHGRID-MAN-HEP.uk	61.8%	CLOUD.UKI-GridPP-Cloud-IC.uk	5.4%
LCG.UKI-LT2-QMUL.uk	11.9%	LCG.UKI-NORTHGRID-LIV-HEP.uk	2.0%
VAC.UKI-SOUTHGRID-CAM-HEP.uk	11.5%	VAC.UKI-NORTHGRID-MAN-HEP.uk	1.4%
CLOUD.CERN-PROD.ch	5.9%	CLOUD.Datacentred.uk	0.1%

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Next steps…

- Time domain compute model: identify critical elements & prototype;
- Memory restrictions - options;
- skatelescope DIRAC instance? Rucio+PANDA?