Data Products levels

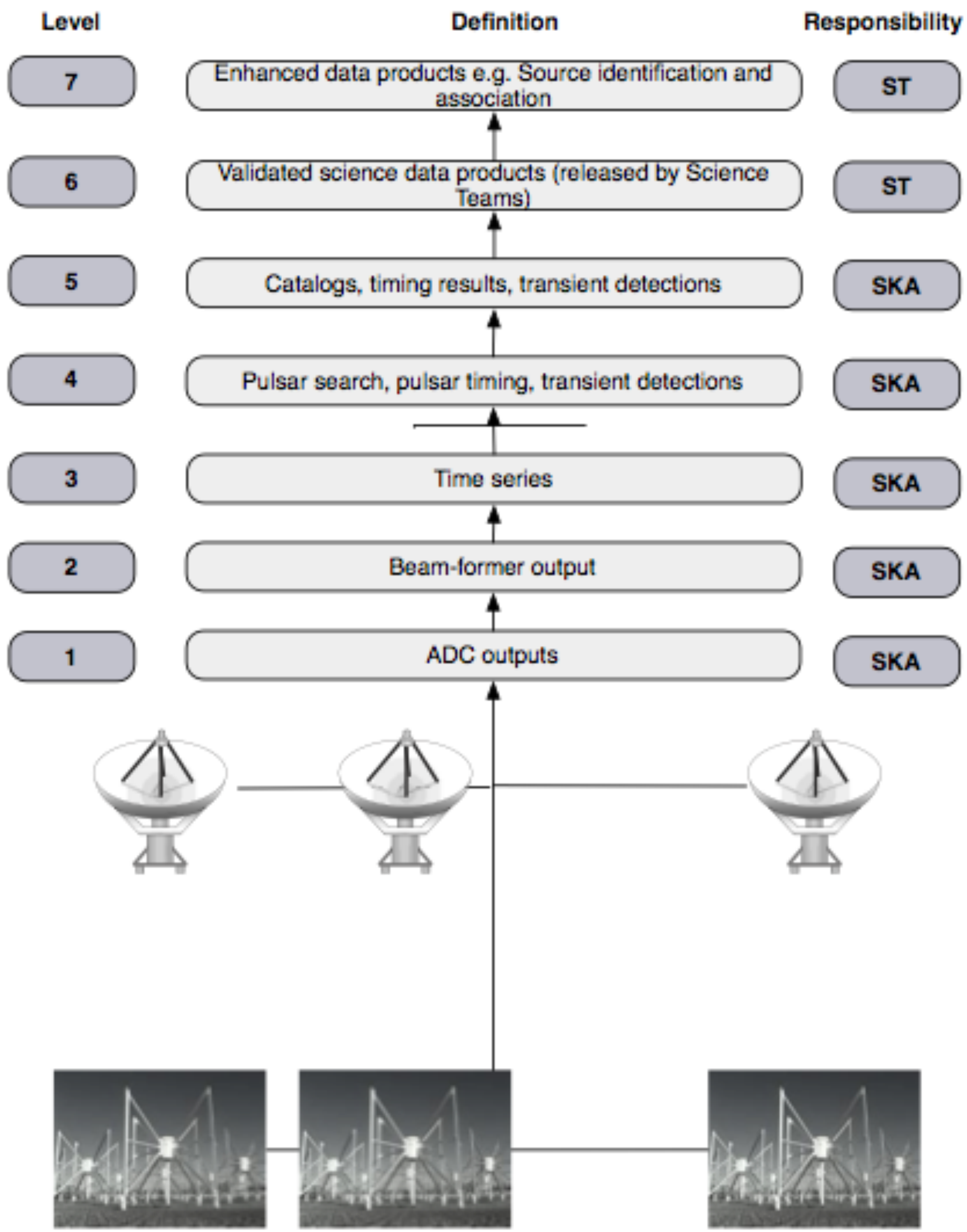

Figure 27 Classification of data levels for time-series processing.

Survey Data Products

Table 5-1. Pulsar Survey Scientific Requirements

Parameter	Value
Pulsar luminosity	0.1 mJy kpc^2 at 1400 MHz
Pulsar period	0.5 ms–10 s
Dispersion measure	At least 1000 pc cm^{-3}
Sky coverage	Entire sky visible from its latitude on Earth, above notional elevation limit of 10 deg (TBC)
Pulsar orbits	Orbital periods at least as short as 30 minutes

Table 5-2 Pulsar Survey Technical Requirements

Parameter	Requirement	Comment
A_{eff}/T_{sys}	500 m^2 K^{-1}	Pulsar luminosity, period, DM
Frequency range	0.3–3 GHz	Pulsar spectra, period, DM
Frequency resolution	< 10 kHz	DM
Temporal resolution	50 μs	Pulsar duty cycle, period, DM
Array filling factor	"high"	Pulsar luminosity, processing; see text
Array data product	voltage time series over entire FoV	Processing, pulsar period, DM

5.5. Data Products

For a candidate periodic dispersed signal, the data products are sky position, pulse-average total intensity flux density, period, DM, and, if a binary orbit is found, a preliminary indication of the orbital parameters, as well as with the de-dispersed time series for each candidate.

For a candidate non-periodic dispersed signal, the data products are sky position and DM.

Search Data Products + Archiving

N.ro observations per SKA1-mid survey = 105120 (600 s)
N.ro beams per observation ≈ 2000

Tot. number of searched sky locations ≈ 210 10^6

Size of a dedispersed time-series = 12 Msamples

Storage required for keeping 1 candidate for any searched sky location = 2.5 10^{15} samples ≈ 2 PB

How many candidates per sky location can we retain?

Timing Data Products

Table 6-1. Pulsar Timing Scientific Requirements

Parameter	Value
Pulsar luminosity	0.1 mJy kpc^2 at 1400 MHz
Sky coverage	$> 2\pi$ sr
Gravitational wave strain	10^{-16}
Time resolution capability	100 ns

Table 6-2. Pulsar Timing Technical Requirements

Parameter	Requirement	Comment
A_{eff}/T_{sys}	> 1000 m^2 K^{-1}	Pulsar luminosity
Array data product	multiple independent voltage time series, notionally at least 20 such data streams	Processing
Frequency range	0.8–3 GHz	Pulsar spectra, timing precision
Frequency agility	switch between observing frequencies within 10 minutes or less	Timing precision
Polarization purity	40 dB	Timing precision, coupled to Array Data Product requirement; see text
Timing stability	connect pulse time of arrivals over at least 10 yr	Longer programs lead to ever higher precision tests; see text

6.5. Data Products

Folded pulse profiles, at full polarization, and pulse times of arrival, with estimates of the uncertainties on those, in the solar system barycenter for a specified ephermeris, as derived from full polarization observations, for a specified list of timed pulsars, which specifies the cadence and integration time for each pulsar.

Timing Data Products + Archiving

Any pulsar has its known optimal combination of parameters for the folded profile to be stored

N.ro of bins ≈ 10000
N.ro of freq channels = 1-10 (coherent dedispersion)
1000-10000 (incoherent filterbank-like dedispersion)
N.ro of Stokes = 4
N.ro of sub-integrations = 60 (for folding over 10 min obs)
up to 600 for single-pulse 1sec PSR
up to 600000 for single-pulse 1ms MSP

Size for 8 bit representation = (typical case) 24 MBy
Size for 8 bit representation = (worst case) 240 TBy

48 hours every month ≈ 250 10-min obs per month x 10 beams x 1 psr/beam = 2500 obs-psr/month

Storage required for 1 year = (for typical obs) 24 Mby x 2500 x 12 ≈ 720 Gby

Astrometry Data Products

Table 7.1. Scientific Requirements

Parameter	Value
Positional Accuracy	20 mas at low signal-to-noise ratio (5) 1 mas at high signal-to-noise-ratio (100)
Sky coverage	> 2π sr

Table 7.2. Pulsar Astrometry Technical Requirements

Parameter	Requirement	Comment
Observing Frequency	1 – 3 GHz	High signal-to-noise ratio, resolution, ionosphere calibration
Maximum baseline	100 km	positional accuracy
Instantaneous Accessible Solid Angle	> 0.25 deg^2	In-beam calibrators
Pulsar gating	Enable correlator to only record when pulsar is "on"	Improve signal-to-noise ratio of the pulsar

7.5. Data Products

Total intensity images and positions, at specified epochs and relative to the then-current realization of the ICRF, at a specified frequency within the SKA Phase 1 operational frequency range as well as information about the geometric model used in the correlation.

Data Transport

Table 19 Data Transport: Karoo Correlation Centre to Cape Town

Bit rate output of the SKA1_mid correlator	~27 Tbps	Including 3250 Gbyte/s max raw data output from the correlator, transient and pulsar candidates and meta-data distribution to the SDP. No provision has been made in this budget for concurrent VLBI transmission.
Distance Correlator to HPC in Cape Town	~670 km	Along transport corridors.

South Africa Site

Table 18 Data Transport: Boolardy Correlation Centre to Perth

Bit rate output of the SKA1-survey correlator	~39 Tbps	Including 4670 GByte/s max raw data output from the correlator, transient and pulsar candidates and meta-data distribution to the SDP. No provision has been made in this budget for concurrent VLBI transmission.
Bit rate output of the SKA1-low correlator	~11 Tbps	Including 842 Gbytes/s max raw data output from the correlator for SKA1-low.
Distance Correlator to HPC in Perth	~820 km	370 km MRO to Geraldton and 450 km Geraldton to Perth.

Australia Site

Synchronisation and clocks

Aim is to limit coherence losses to about 2% for 20 GHz obs, and much less for lower frequencies

At every antenna or station, the synchronisation system will provide a standard reference sine wave from which clocks for digitisation and/or local oscillator signals can be derived, and a pulse-per-second (1-PPS) signal (or similar) from which time-tags can be derived.

Coherence can be maintained through the use of accurate independent clocks or by a frequency reference distribution from a central reference clock

Lesson from LOFAR:
a single distributed clock signal
makes calibration much easier

Sufficiently accurate Coordinated Universal Time (UTC), converted to sidereal time using Earth-rotation data (UT1 – UTC and higher order corrections), is fundamental on each site for absolute pointing of antennas and array beams (beamformers of all types).

- Shielding induced RFI
- Provide redundancy in clocks

An initial analysis of time requirements that will be able to support decade-long tracking of pulse arrival times for gravitational wave detector experiments indicates that accuracy of 10 ns will be needed over 10 years, equivalent to Allan variance of 3×10^{-16}

ONE MASER-ish clock per site, synchronised to TAI using GPS signals, is enough?