MAX PLANCK
GESELLSCHAFT

EFFELSBERG DIRECT DIGITISATION BACKEND

EDD BACKEND

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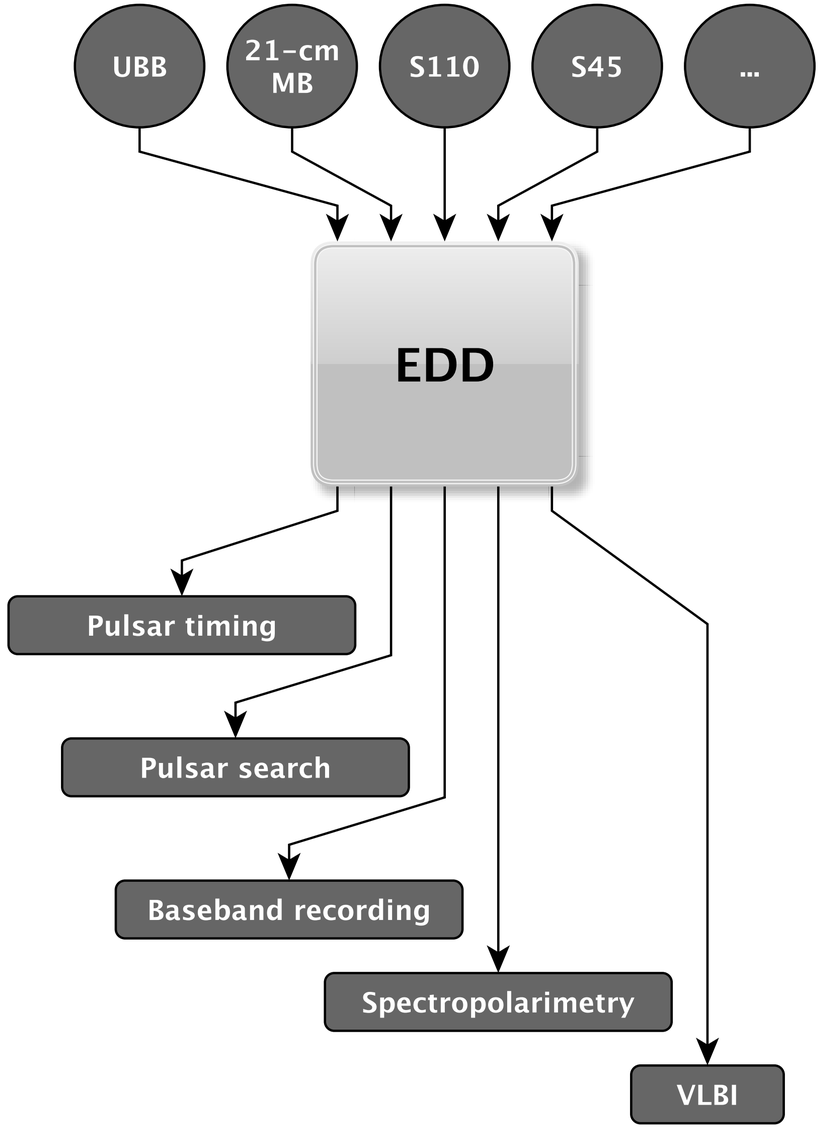
THE EDD SYSTEM

- **Next generation** receiver and backend system for Effelsberg and beyond
- **Wide-band digitisation** performed in the receiver
- **Packetisation** performed local to the receiver in the focus cabins
- **Multicast UDP** data transmission for flexibility
- **COTS** switches and servers for modular, scalable backend computing
- **GPUs and FPGAs** to provide high performance signal processing
- **Extensible** to cover future telescope capabilities



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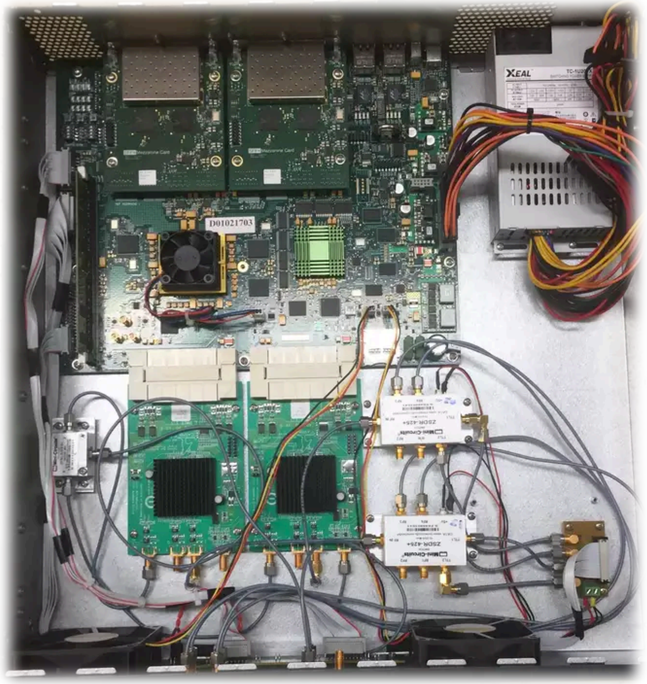
EFFELSBERG BACKENDS (CURRENT/FORMER)

DBBC, MkV/VI/FlexBuff systems for VLBI



ROACH and ROACH2 boards for for pulsars and VLBI

AFFTS/XFFTS/PFFTS for continuum/ spectroscopy/pulsar search

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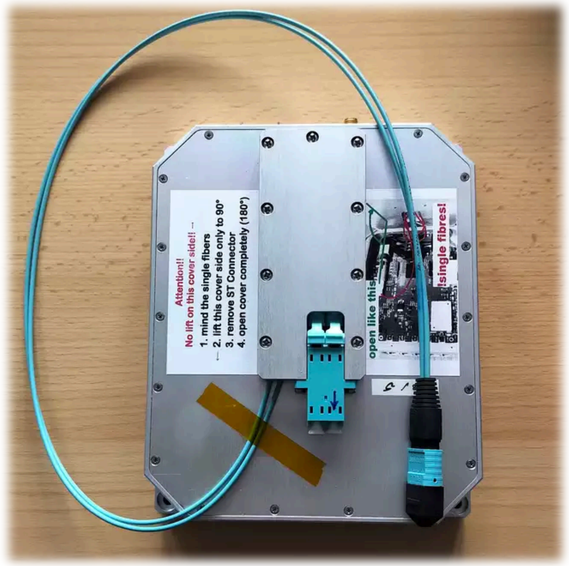
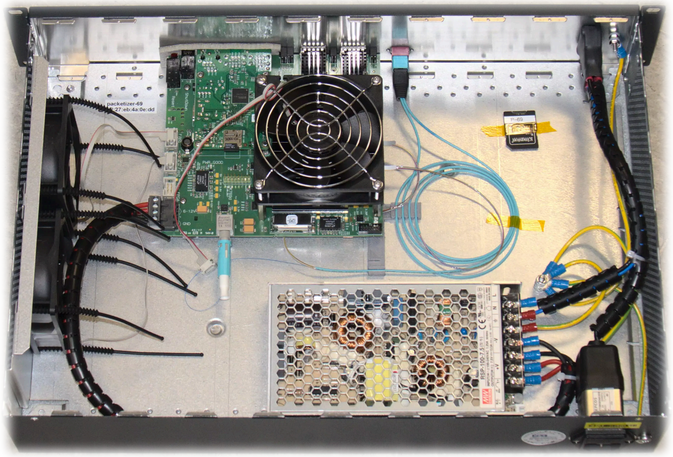
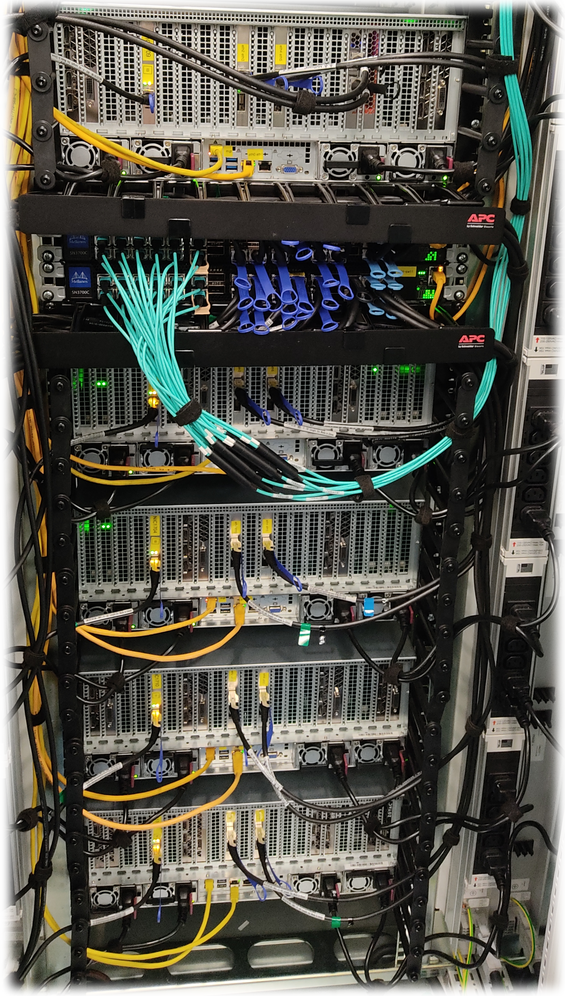


Digitisers



Packetisers

Everything else



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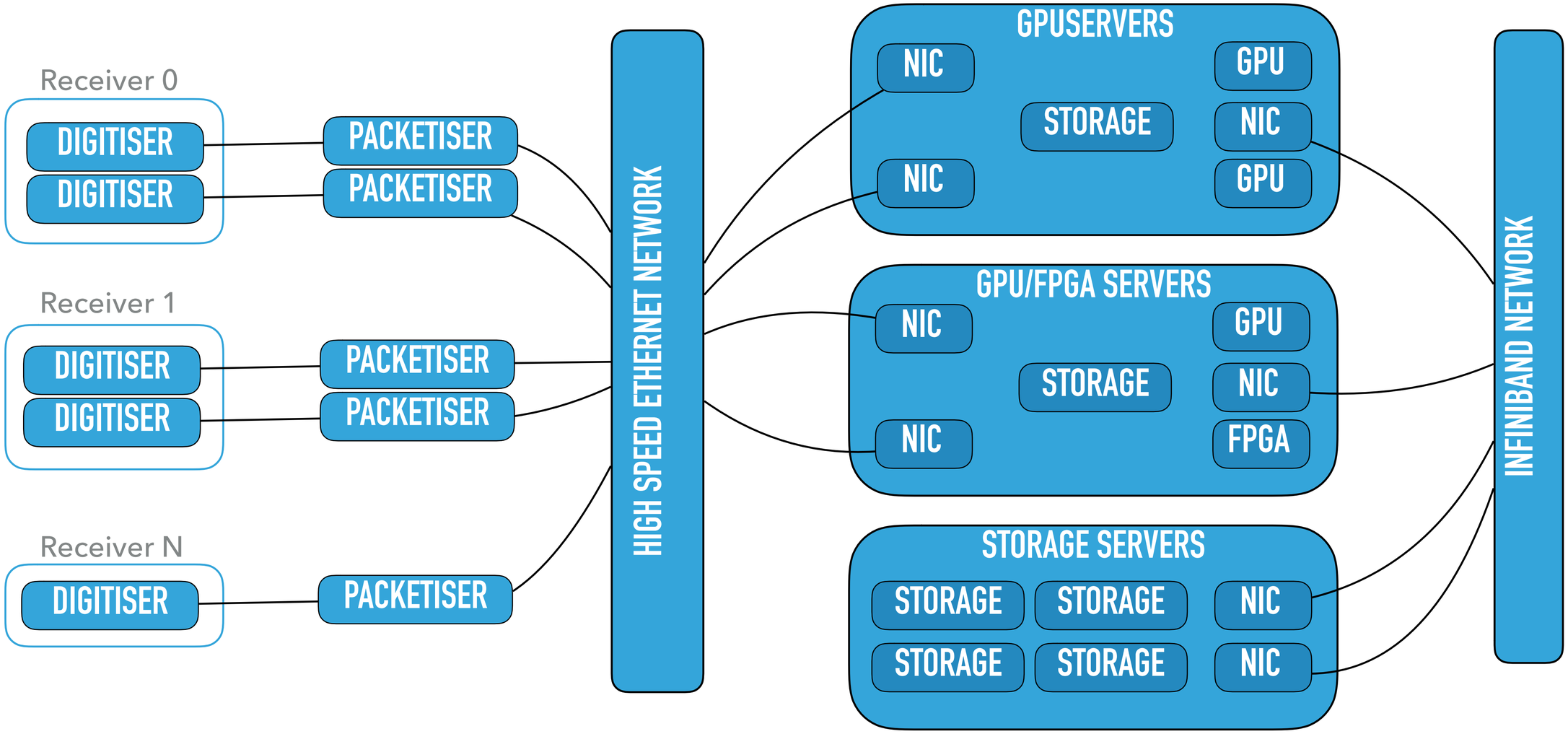
EDD BACKEND CONCEPT



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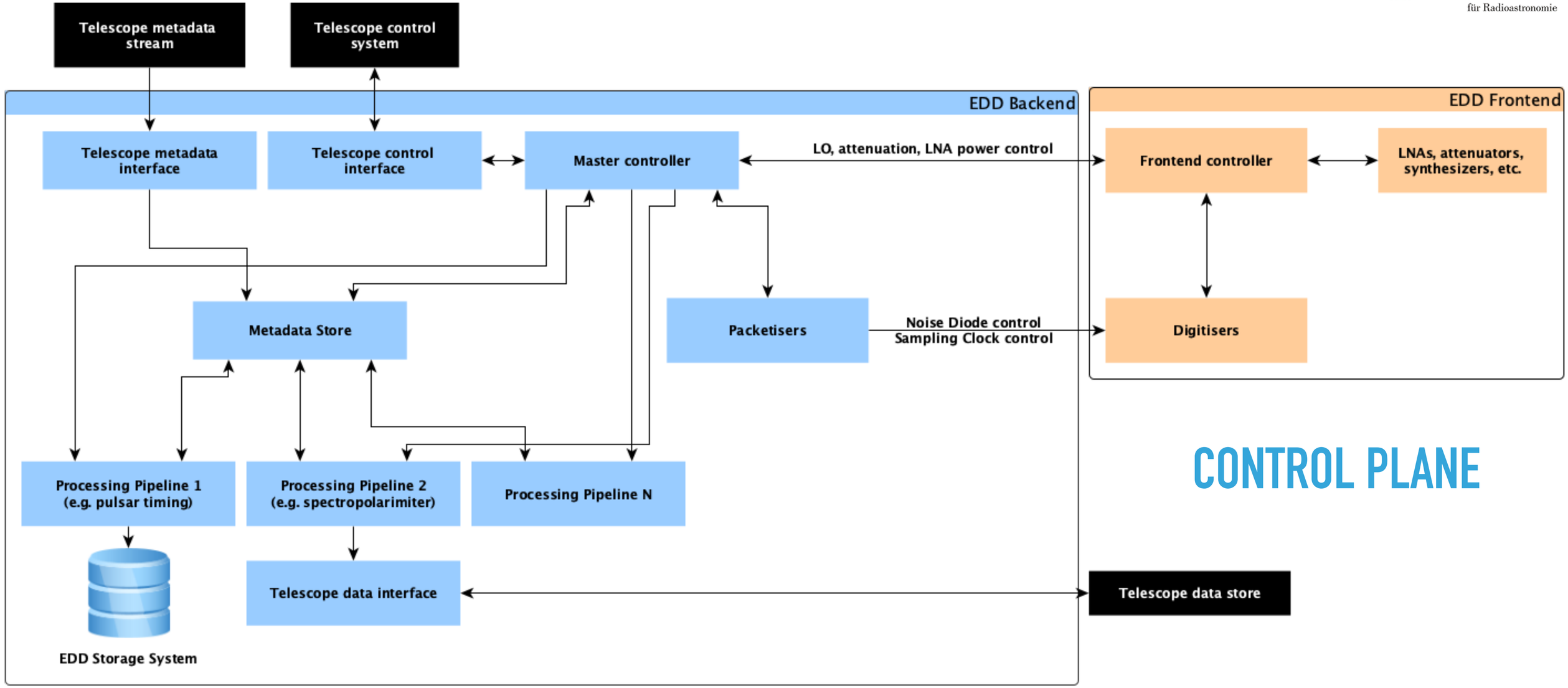

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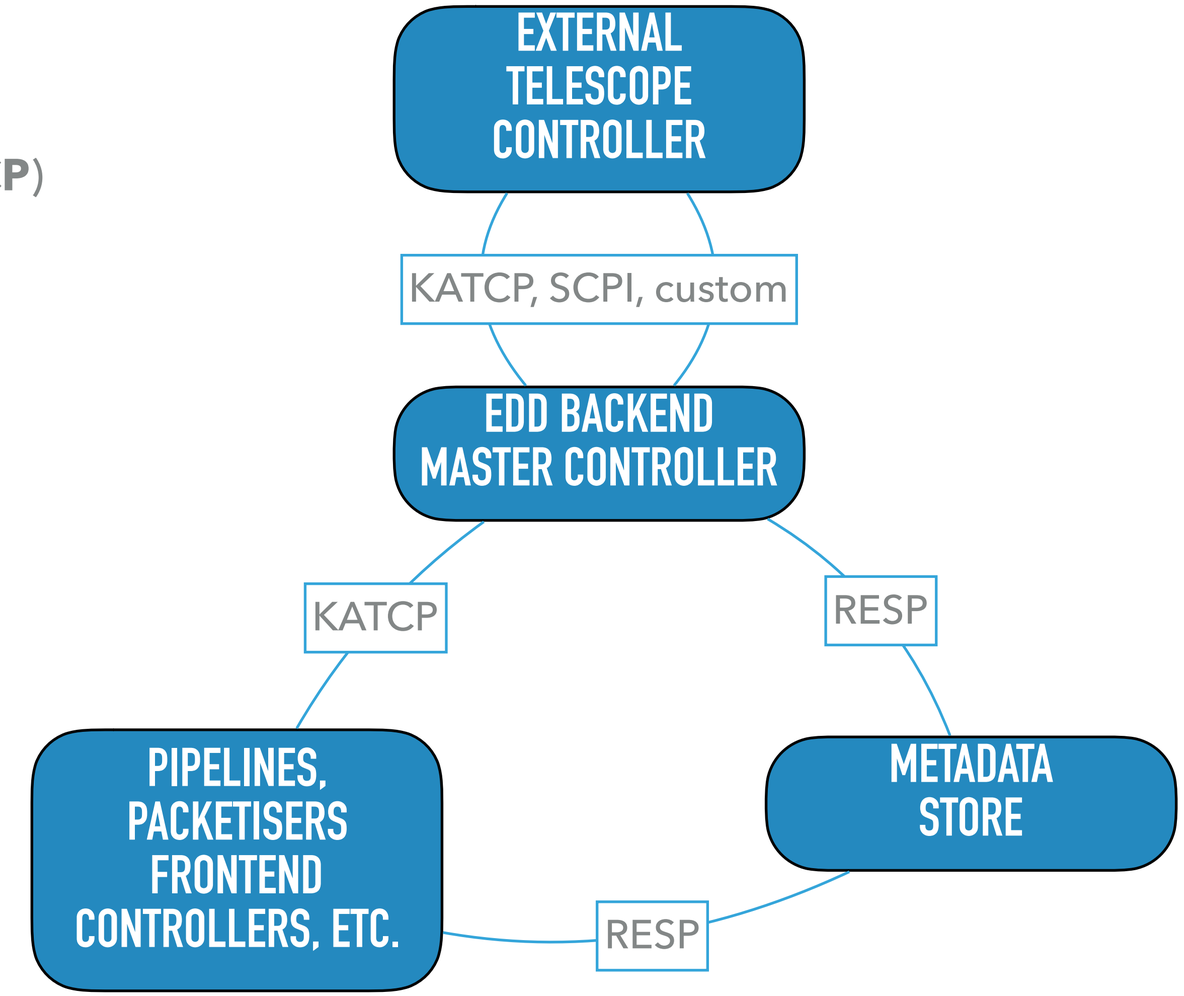
COMMUNICATION

- Karoo Array Telescope Communication Protocol (**KATCP**) used for internal communication
  - **aiokatcp**: https://github.com/ska-sa/aiokatcp
- Custom interfacing for each telescope (e.g. **SCPI** interface for Effelsberg)
- REdis Serialization Protocol (**RESP**) used for metadata writing and reading



https://pythonhosted.org/katcp/_downloads/NRF-KAT7-6.0-IFCE-002-Rev5.pdf

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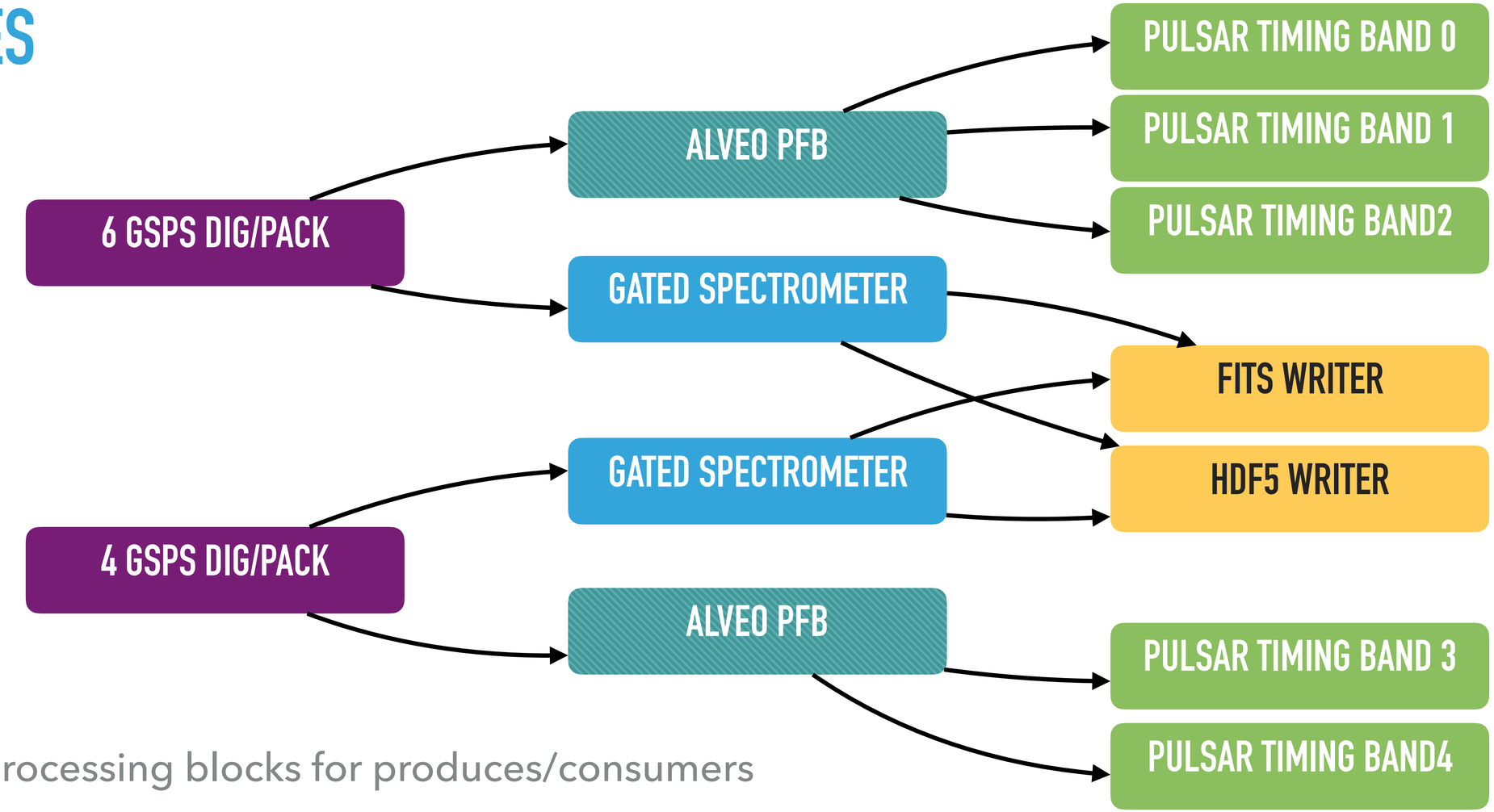
PIPELINES



- Abstract processing blocks for produces/consumers
- Can be written in any language, must support KATCP pipeline interface
- Dockerized for ease of deployment and reproduceabilty

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SOFTWARE STACK

docker — Containerisation / virtualisation

influxdb — Monitoring database

graylog — Logging

BeeGFS® developed by Fraunhofer — Distributed filesystem

Grafana — Monitoring/graphing

redis — Metadata store

ICINGA — Monitoring / alerting

ANSIBLE — Provisioning and deployment

GitLab — Continuous integration / continuous deployment

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PROVISIONING AND CONFIGURATION

- Ansible provides provisioning and configuration for EDD
- Provisioning descriptions specified by deployment site:
  - Lists of available servers, networks, IP ranges, etc.
- Pipelines specified with resource requirement (GPUs, FPGAs, network, etc.)
- Hardware topology determined at provisioning time to allow mapping of pipelines (i.e. containers) to resources
- Once provisioned, all observing configurations propagated via KATCP calls

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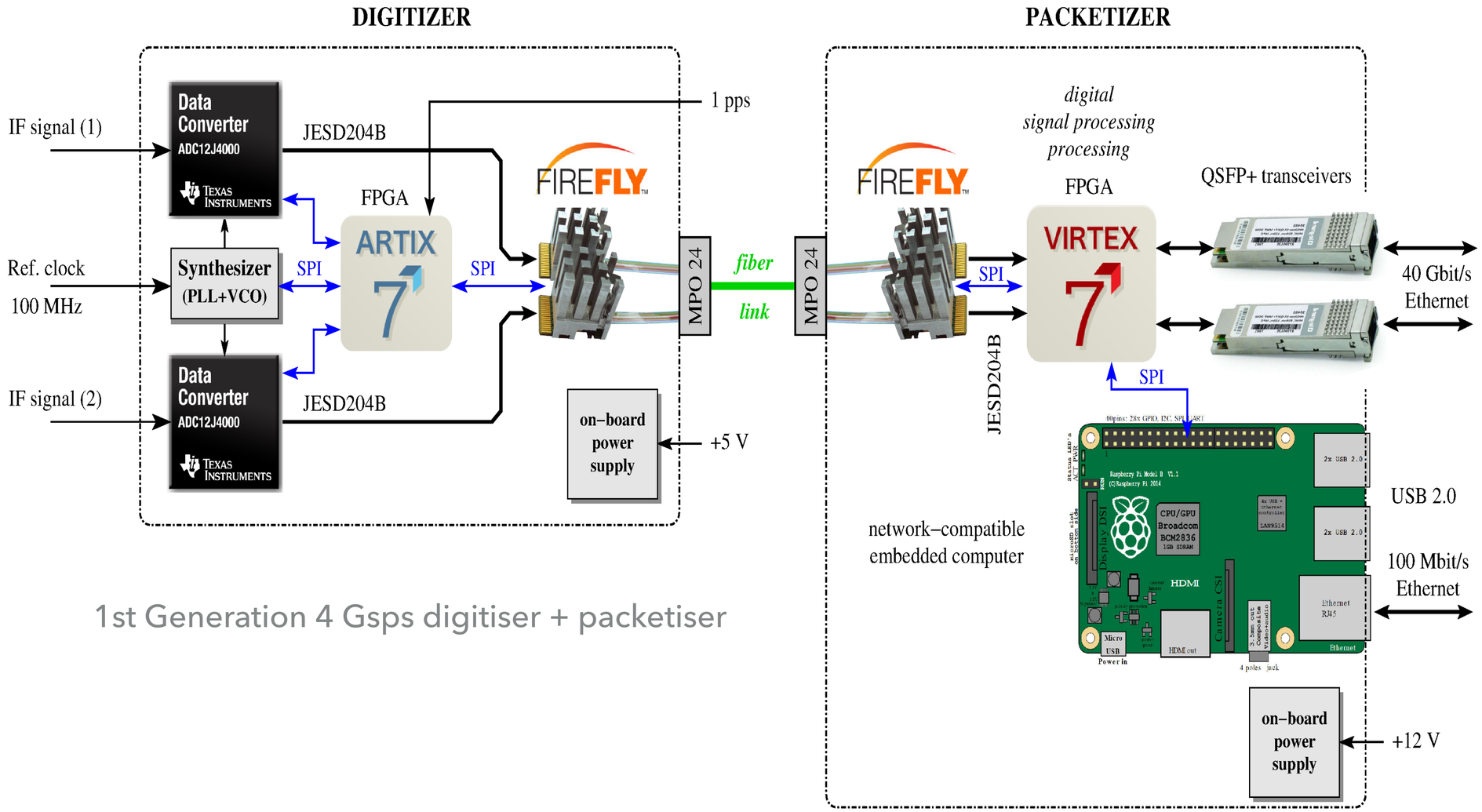
CAPABILITIES: DIGITISATION / PACKETISATION



1st Generation 4 Gsps digitiser + packetiser

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CAPABILITIES: DIGITISATION / PACKETISATION

	Generation 1	Generation 2
Channels	2	
Bandwidth per channel	< 2000 MHz	< 3000MHz
Sampling depth	8 / 10 / 12 bit/sample	
Decimation factors	1 / 2 / 4 / 8	1 / 2 / 4 / 8 / 16 / 32
Max bitrate	2x 35 Gbit/s	2 x 96 Gbit/s
Data Interface	2 x 40 GbE	2 x 100GbE
Format	ETHERNET, IP, UDP, Multicast, SPEAD	
Control Interface	1 GbE	
Additional Outputs	Basic spectrum via TCP	

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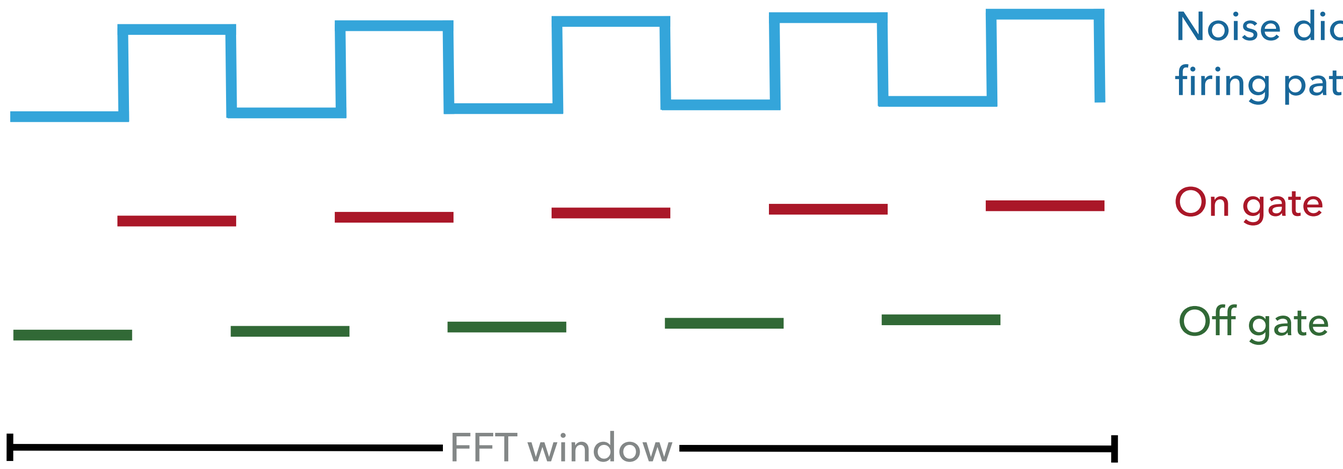
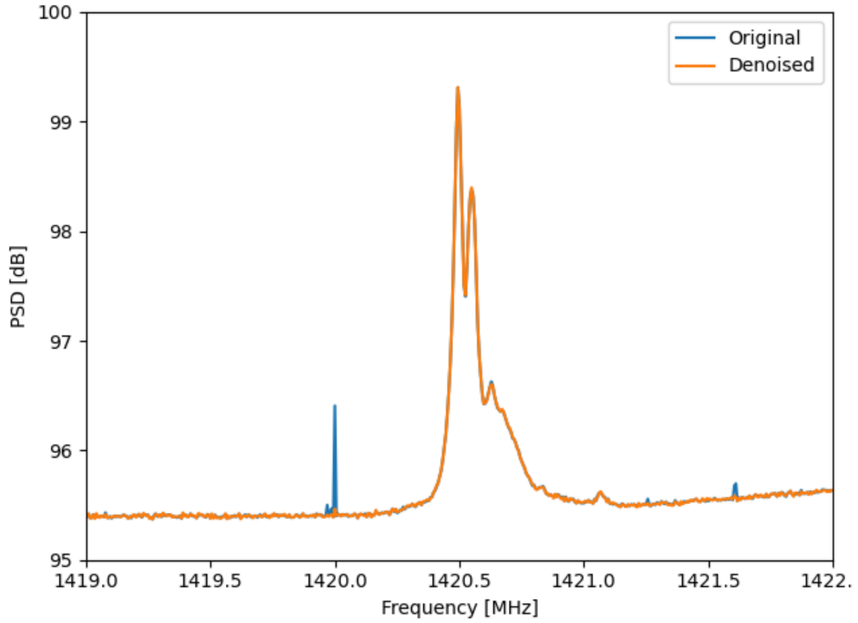
CAPABILITIES: SPECTROSCOPY

- Frontend noise diodes driven by digitisers with configurable period and duty cycle
- Packetisers transmit noise diode status information
- Spectrometer gates on noise diode state outputting two spectra ON / OFF
- Mean padding used to allow for FFT windows larger than the cycle period





- RTX 3090 GPUs produce up to 32 million channels over 3 GHz bands
- Two modes available: Dual-poln & Full Stokes
- Extreme frequency resolution used for RFI mitigation

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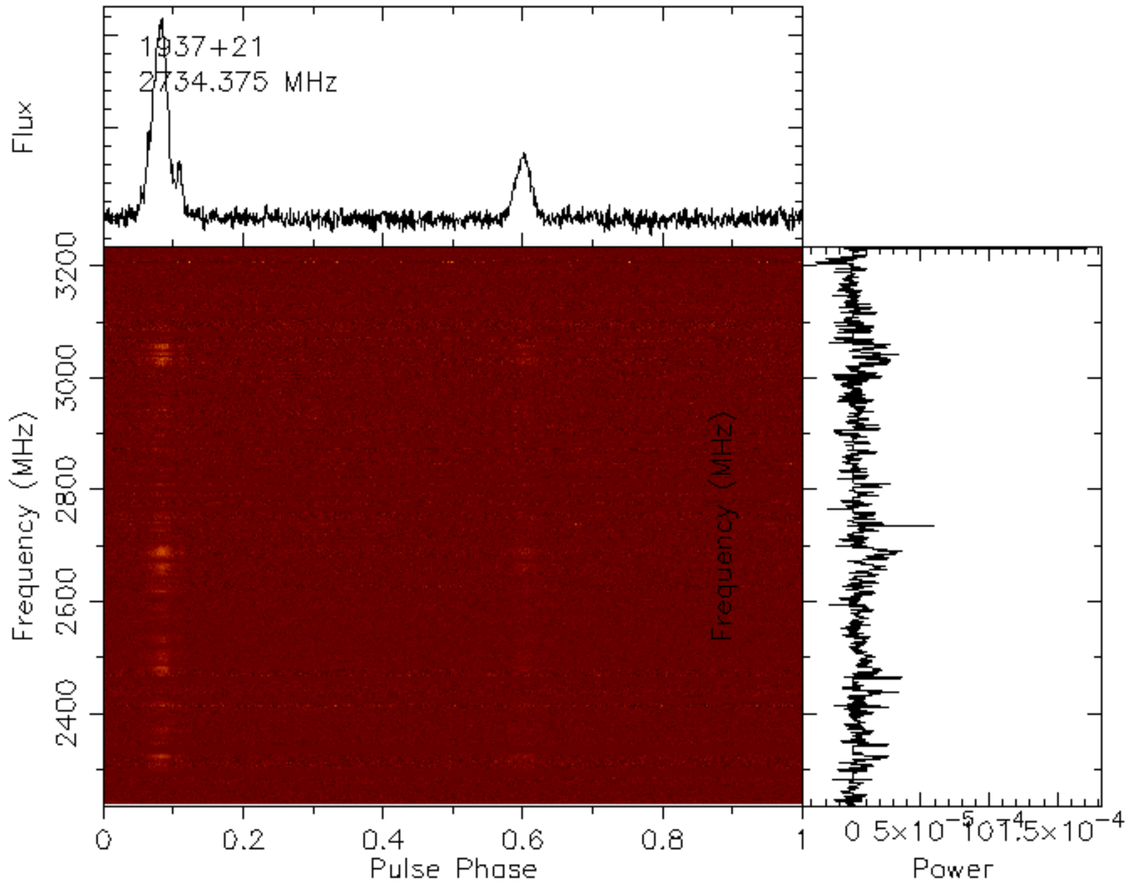
CAPABILITIES: PULSARS

- Multiple capabilities enabled for pulsar science:
  - **Folding** (w/coherent dedispersion) [dspsr & tempo2]
  - **Search mode** (w/coherent dedispersion) [digifits]
  - **Baseband recording**
- Operates in blocks of ~1 GHz when using RTX 3090s
- Horizontal scaling provided by use of a polyphase filterbank on a Xilinx Alveo U55c



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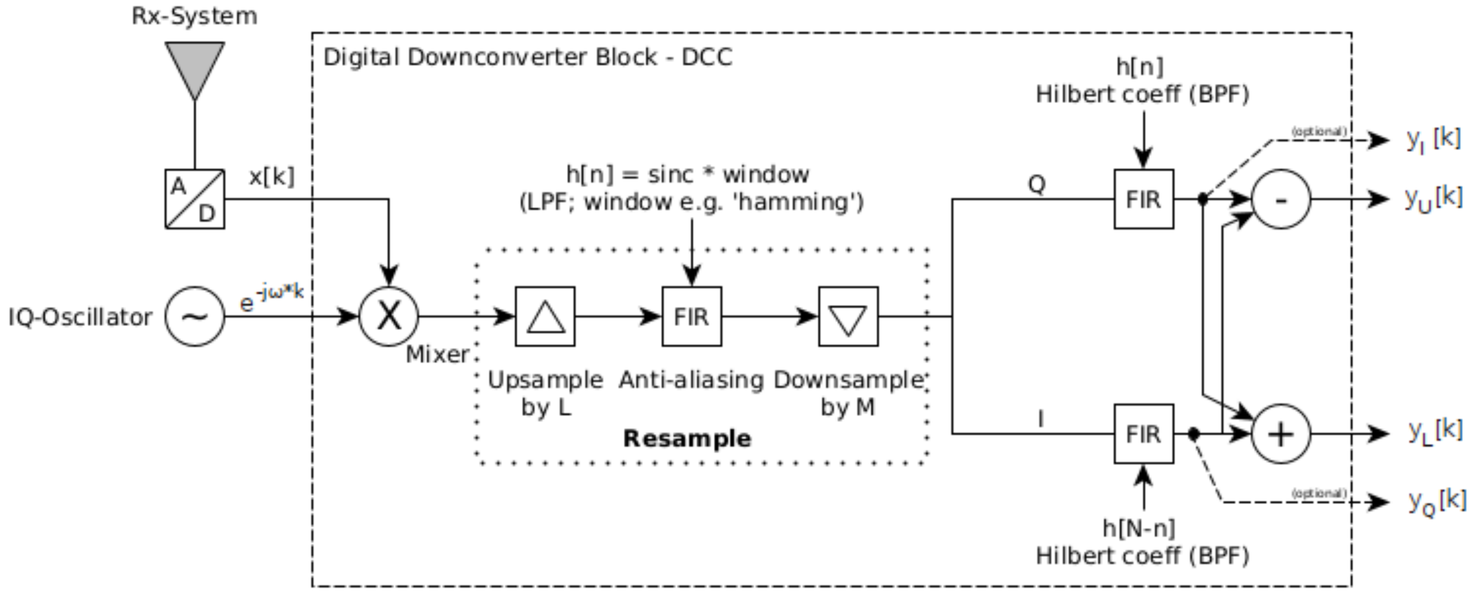
CAPABILITIES: VLBI



- Currently tuneable sampling frequencies and decimation allow for limited support for VLBI (easier with receivers with mixers)
- **WIP:** In collaboration with the MPIfR VLBI technology group we are porting the DBBC3s DDC personality to Nvidia GPUs
- Will produce multiple 16, 32, 64, 128, 256 MHz at arbitrary frequencies within the digitised band.
- Number of bands scales with resources used (currently 2 x 256 MHz sub-bands per GPU)

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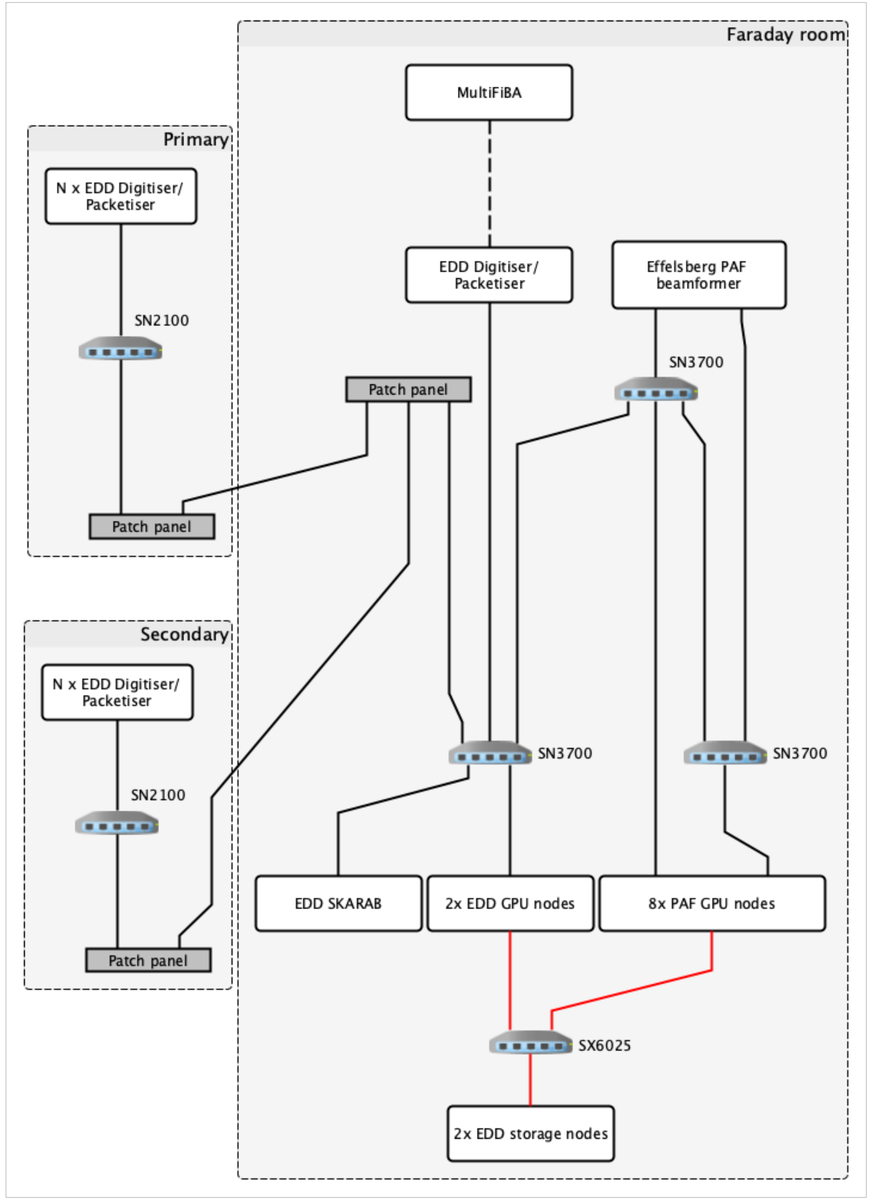

EDD @ EFFELSBERG

SFK
1 x Packetiser Gen 1
1 x Packetiser Gen 2
1 x 100 GbE switch

PFK
1 x Packetiser Gen 1
1 x Packetiser Gen 2
1 x 100 GbE switch

FR
2 x EDD GPU servers (100 GbE, RTX 3090)
8 x Pacifix GPU servers (100 GbE, RTX 2080, Titan X)
1 x Alveo U280 FPGA
2 x Alveo U55c FPGA
2 x Bigfoot storage servers
5 x EDD Infrastructure servers
1 x FDR IB switch
3 x 100 GbE switches
2 x Packetiser Gen 1

SUMMARY

- The EDD backend consolidates the main single-dish radio telescope capabilities into a single instrument
- It is designed to be extensible with a modular approach based on interoperable pipelines
- System is built on an array of industry-standard technologies for high-speed ethernet, virtualisation, monitoring, distributed storage and more
- Deployed and used successfully to Effelsberg and SKA-MPI, with integration at TNRT underway
- Architecture of the system is well suited to supporting PAF science (see N. Esser talk)
- All EDD backend software is open source!