

# Constellation

## Flexible DAQ and control system for test beam environments

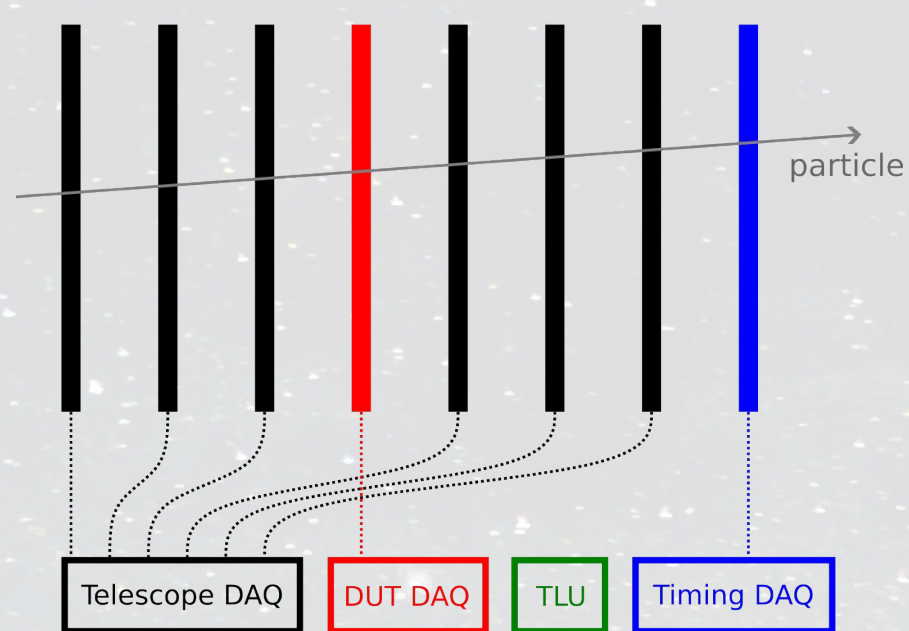
Stephan Lachnit for the EDDA collaboration



### Why do we need a new framework?

#### Test Beam

- Synchronous operation of different devices
- Integration of device-specific DAQ software
- Communication between multiple systems
- Frequent changes of the setup



#### Lab Experiments

- Auxiliary devices like lasers
- Custom control function and data formats
- Monitoring of multiple setups

#### Usability

- Easy to use and well documented
- Fast integration of new devices
- Reliable error handling
- Flexible for many use cases

### Where is it already used?

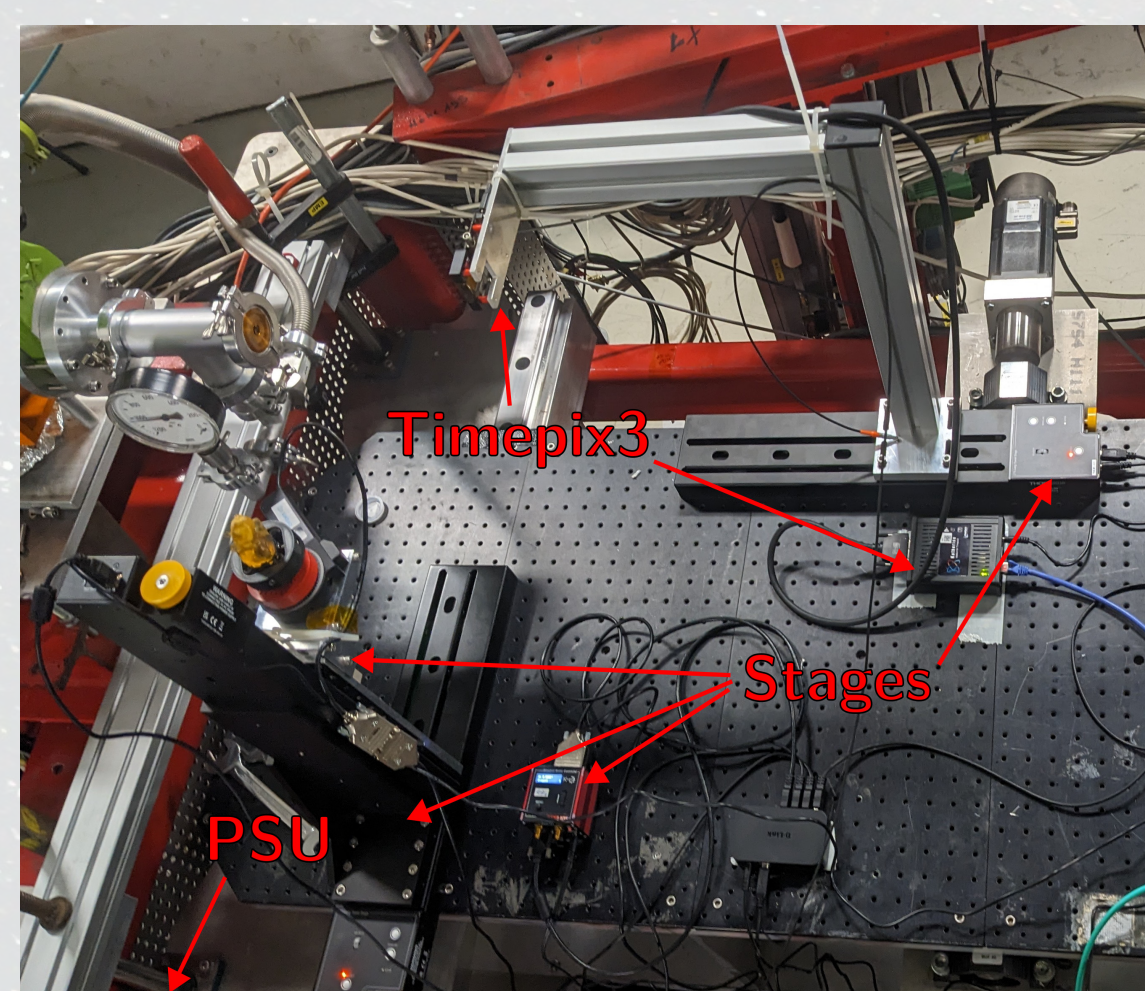
#### H2M Test Beam

- Caribou DAQ system with H2M MAPS prototype
- Adenium Telescope
- AIDA2020 TLU
- Keithley 2410 SMU
- Data stored in backwards-compatible EUDAQ2 format



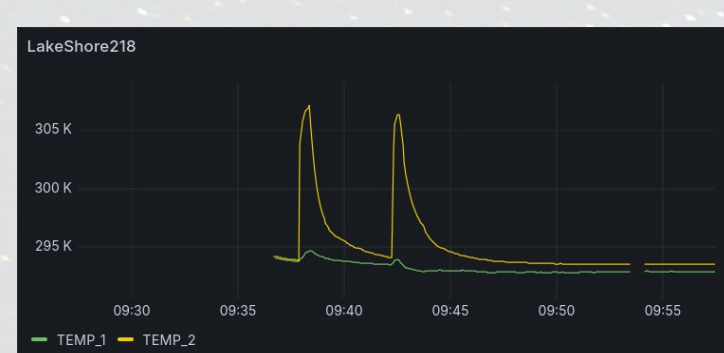
#### electronCT Test Beam

- Katherine readout system with Timepix3
- 4D stage for samples
- Keithley 2410 SMU
- Data stored in HDF5



#### Preliminary Tests for the MADMAX Experiment

- 8-channel temperature monitor for the MADMAX cryostat
- Communication via serial port
- Implementation <100 lines of code in one afternoon



### How is it developed?

#### Hackathons

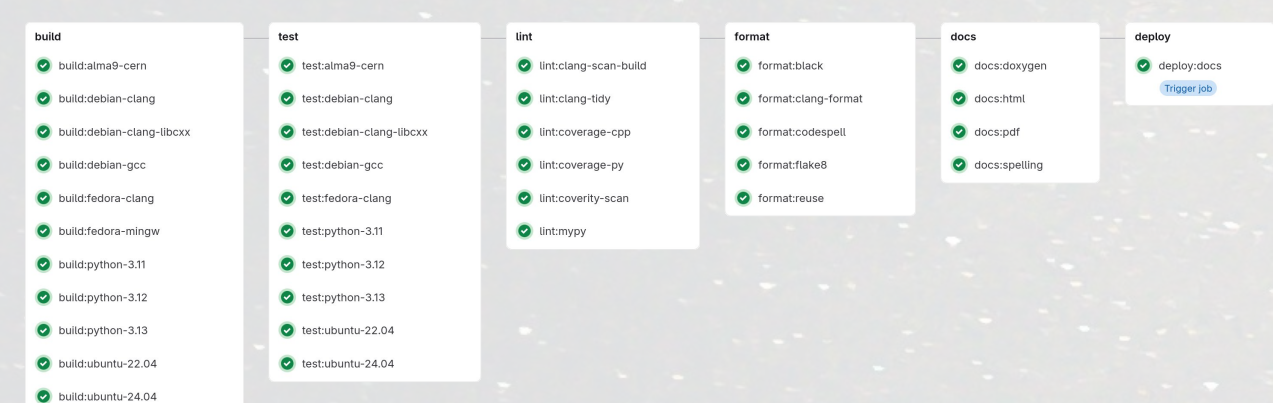
- Hackathons in Lund & Hamburg
- Share user stories, discuss ideas, code demos, iterate concepts



#### Open Source



- Open development on GitLab
- All changes go through a review
- Extensive CI for building & testing on multiple operating systems



### What is Constellation?

#### Satellites

- Program controlling an instrument
- Operation governed by a finite state machine (FSM)

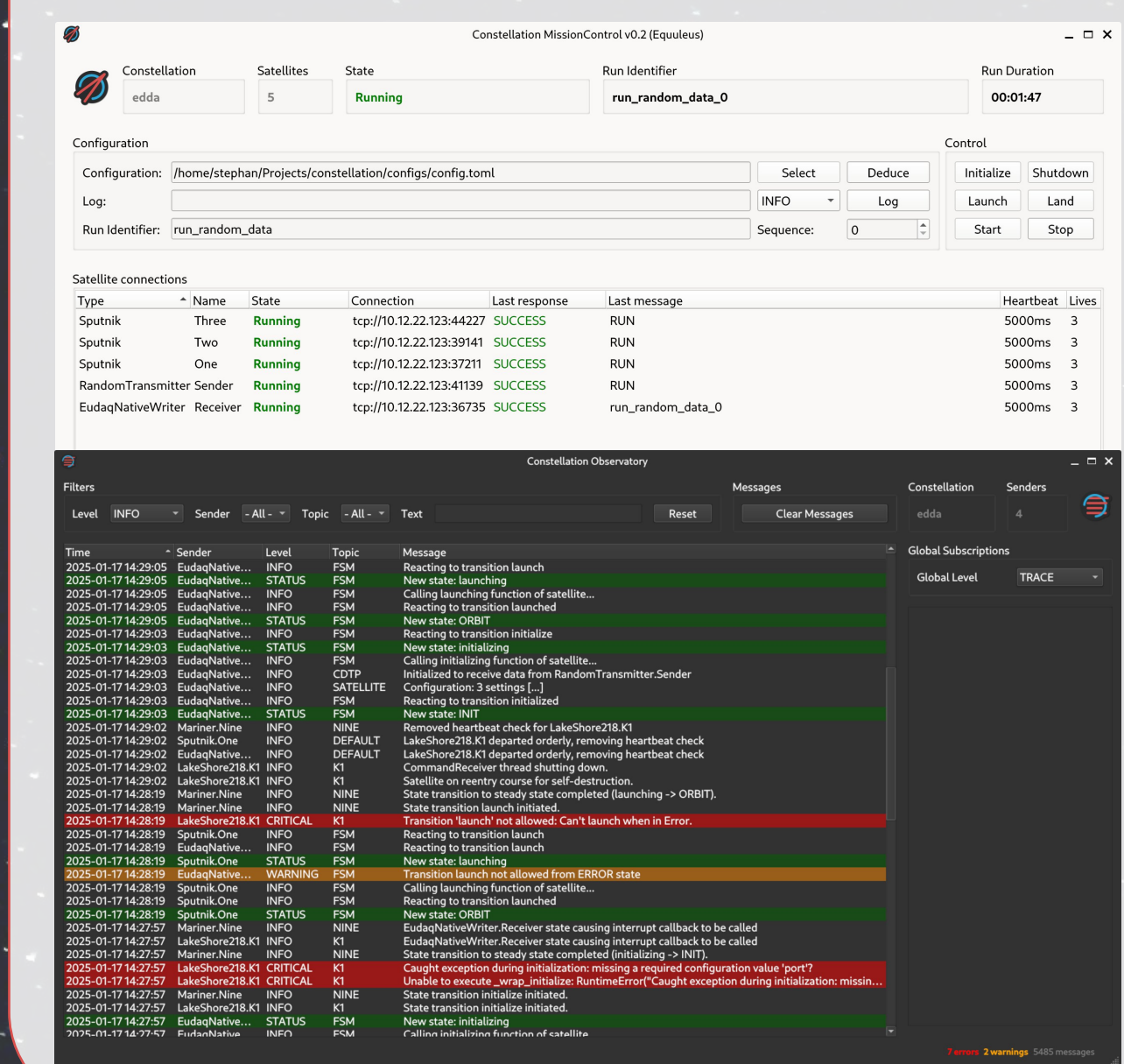
#### Autonomy

- Satellite operate autonomously => no central point of failure
- Possibility to react to failures or crashes of other satellites

#### Protocols

- All network communication is defined in RFC-style network protocols
- Allows for independent implementations => C++ & Python available

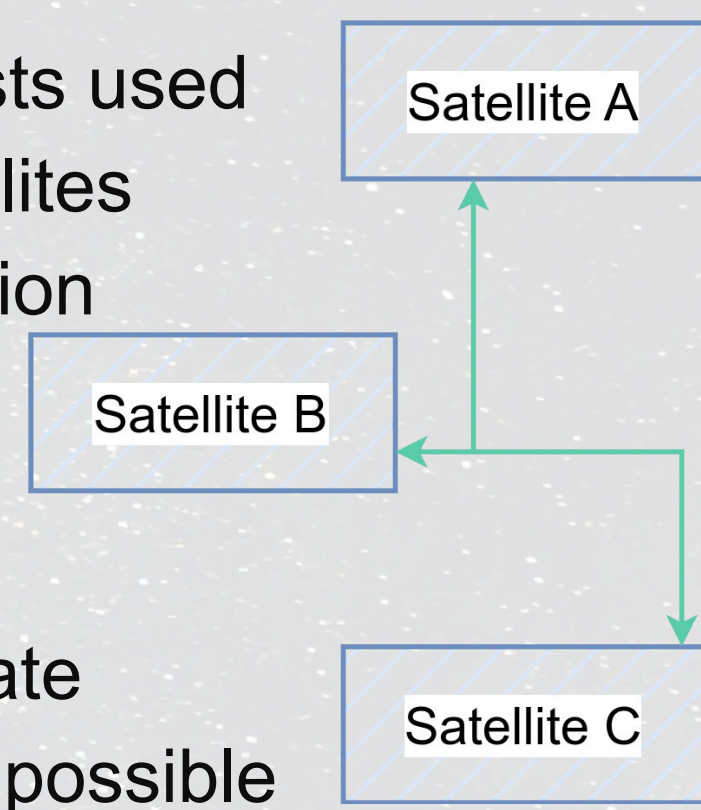
#### User Interfaces



### How does it work?

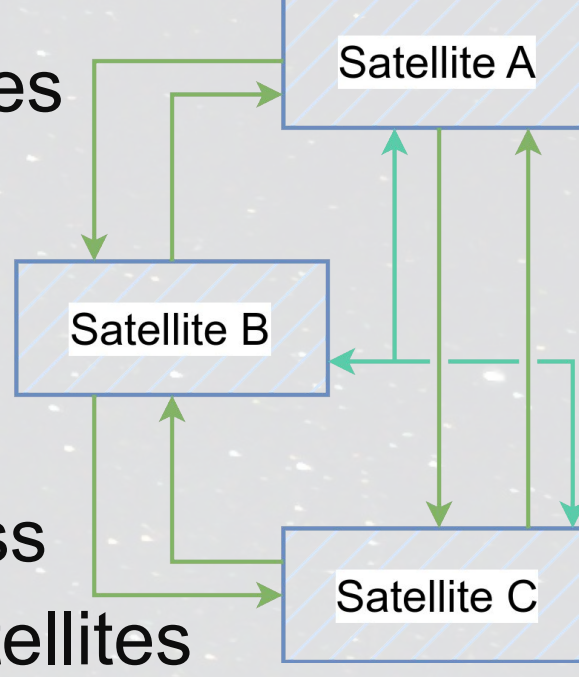
#### Network Discovery

- No fixed IP addresses required
- UDP broadcasts used to find all satellites in a Constellation
- REQUESTs & OFFERs
- Multiple separate Constellations possible



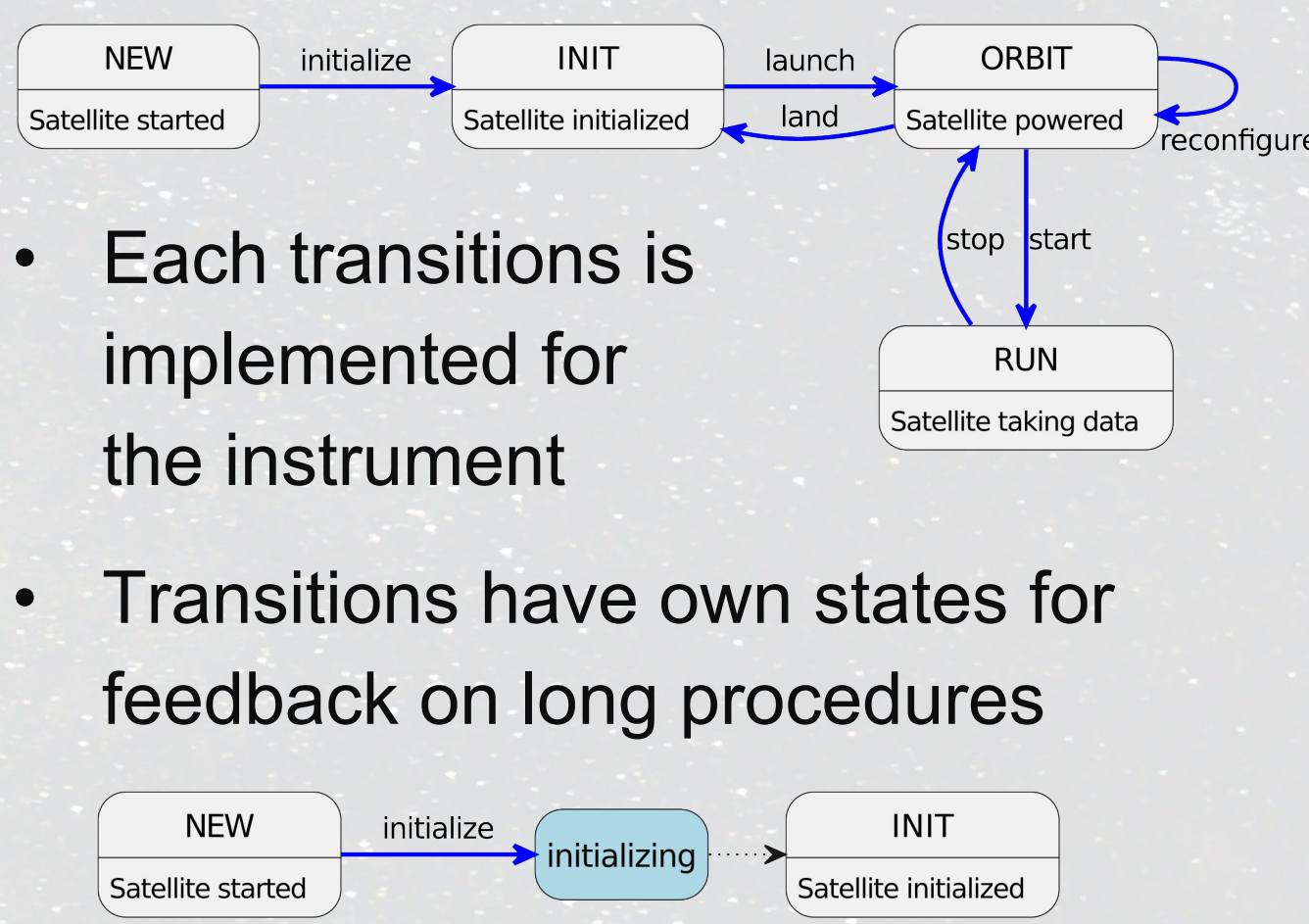
#### Heartbeating

- Satellites emit regular messages with their current FSM state
- Missing messages can be used to detect crashes or network loss
- Used for stateless monitoring of satellites



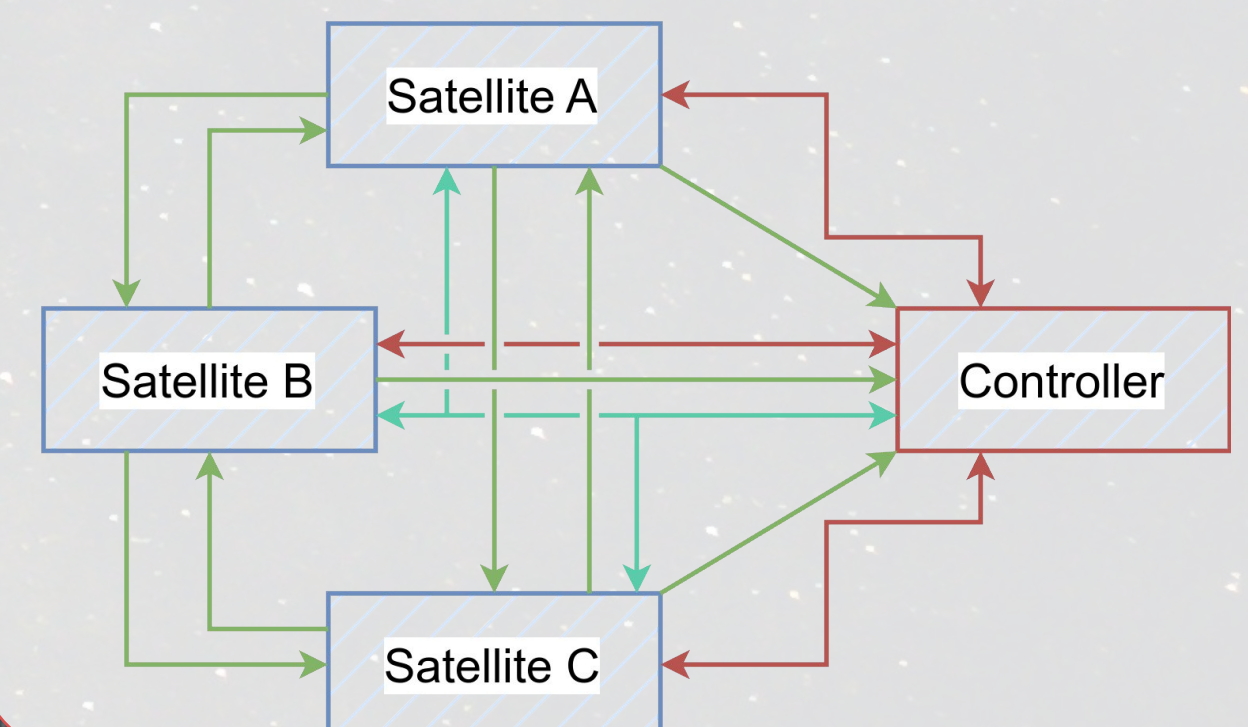
#### Satellite FSM

- Instrument always in defined state
- Each transitions is implemented for the instrument
- Transitions have own states for feedback on long procedures
- Additional SAFE and ERROR states for error handling



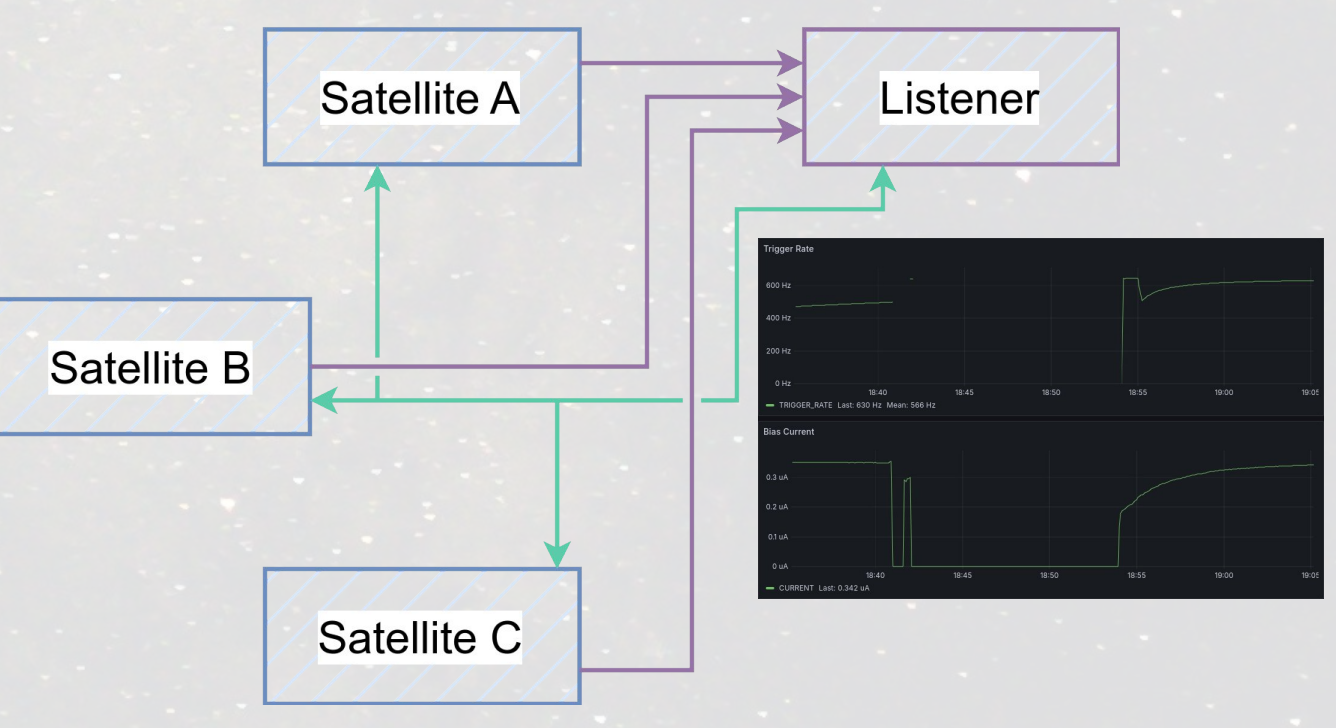
#### Control

- Controller finds satellites & connects to receive heartbeats
- Controller sends commands to single or all satellites
- Request-reply pattern
- Custom commands possible
- Controllers are stateless



#### Monitoring

- Telemetry and log messages
- Publish-subscribe pattern
- Only subscribed monitoring data is actually transmitted
- Grafana integration



#### Data

- Data can be sent over network to a receiver satellite
- Fast integration (simple API)
- Useful for embedded systems like Caribou
- Data formats:
  - EUDAQ2
  - HDF5

