The Unified MBFits Writer for APEX, Effelsberg, and SOFIA

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APEX, Effelsberg, SOFIA - upGREAT

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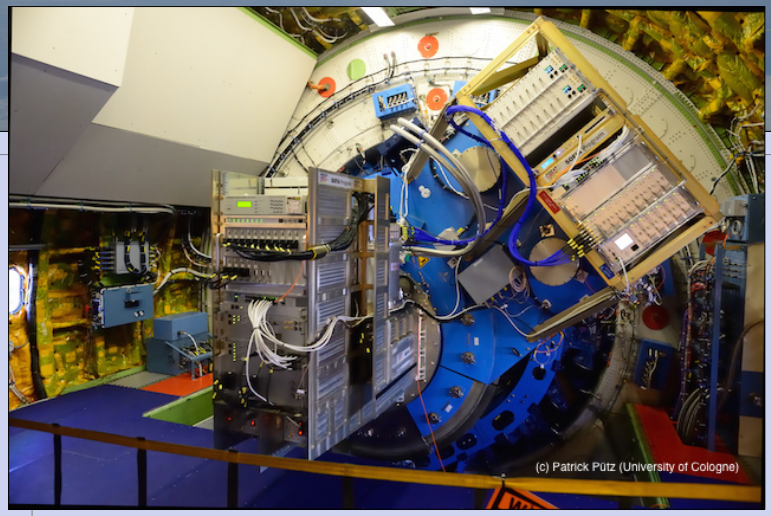

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The Unified MBFits Writer

- All three telescopes write (or plan to write) raw data in MBFits format
- FFTS spectrometers developed at MPIfR at all three telescopes
- Wish to have common software for data taking and writing based on APEX FitsWriter

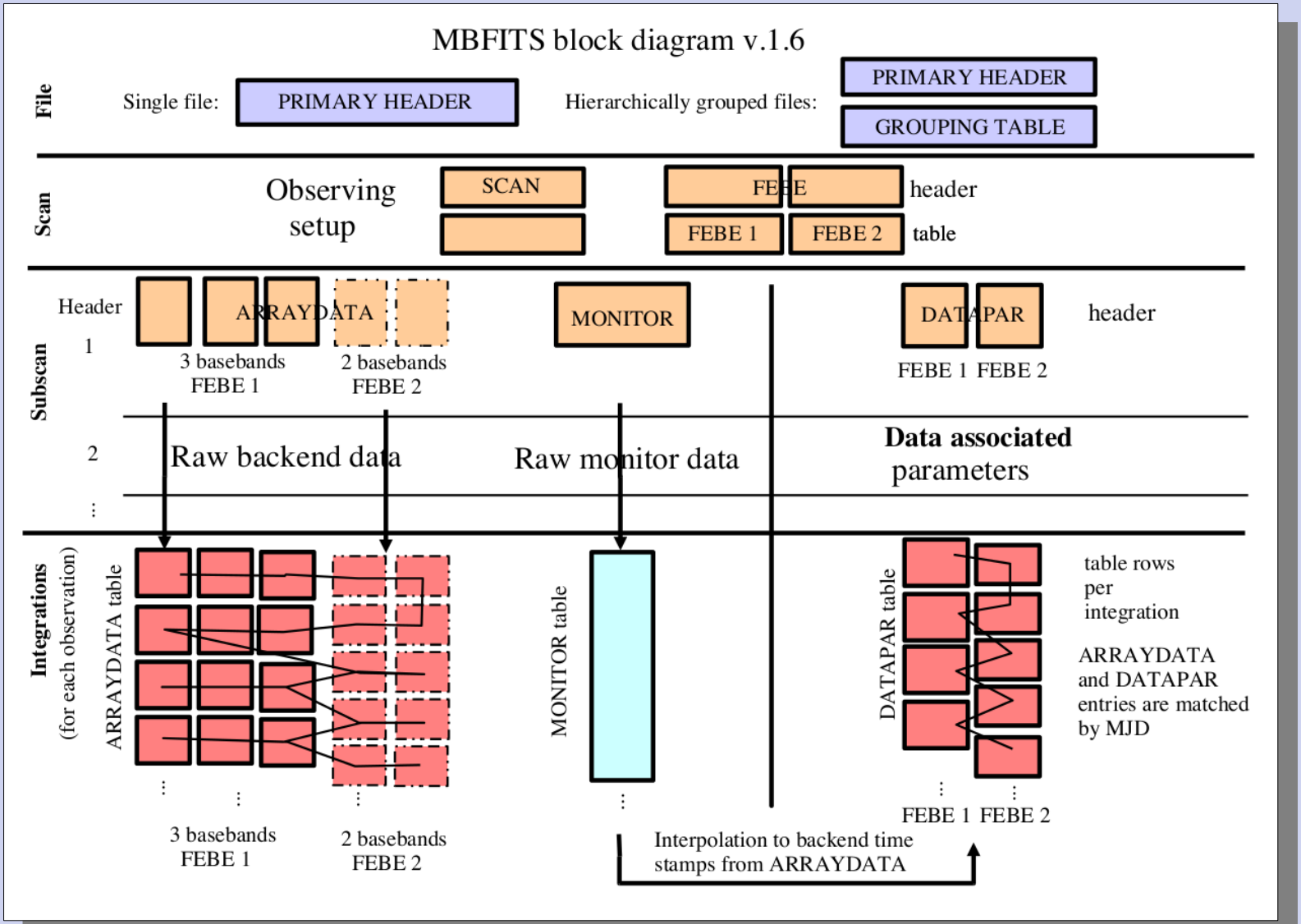
MBFits Raw Data Format

- For single-dish, multi-beam, continuum and spectral observations
- Official FITS convention, fully documented
- MBFits Dataset is a set of FITS files in a directory structure that contains all data of a scan relevant for interpretation of the data

MBFits Raw Data Format

- Self-contained, contains all data for
  - Instrumental setup
  - Backend data
  - Interpolated telescope and wobbler position at BE time
  - Commanded and actual telescope position
  - Wobbler position
  - Instrument-specific monitor data
  - ...

MBFits Raw Data Format



APEX FitsWriter

- Developed 2004, reliable and performant working horse since then
- Implemented in Python
- Writes MBFits raw data datasets for all spectral resolving and continuum instruments
  - Exceptions: VLBI and some PI instruments

APEX FitsWriter

- Used for all possible frontend-backend combinations without modifications
  - No need to modify code for new instruments
  - Configured during runtime
  - Any number of frontend-backend combinations (FEBEs) during one observation

APEX
Most demanding instruments

- A-MKID (continuum)
  - 21,600 (850 µm) + 3,520 (350 µm) Pixels, 30 ms integration time
  - ~3 MB/s
- PI230 (heterodyne)
  - 1 Pixel (32 GHz bandwidth), 524,288 spectral channels, 200 ms integration time
  - ~10 MB/s
- LASMA (heterodyne, 2016)
  - 7 Pixels (345 GHz), each 524,288 spectral channels, 200 ms integration time
  - ~70 MB/s

Effelsberg

- New K-band receiver
  - 18 – 26.5 GHz, up to 8 GHz bandwidth
  - 2 pixels, each with 2 polarizations and 4 spectral windows, each with 65,536 spectral channels, 100 ms
  - Zoom mode (0.3 GHz bandwidth) with 28 x 65,536 spectral channels
  - ~70 MB/s
- Decision to switch to APEX FitsWriter for all receivers
  - Exceptions: VLBI, Pulsar receivers

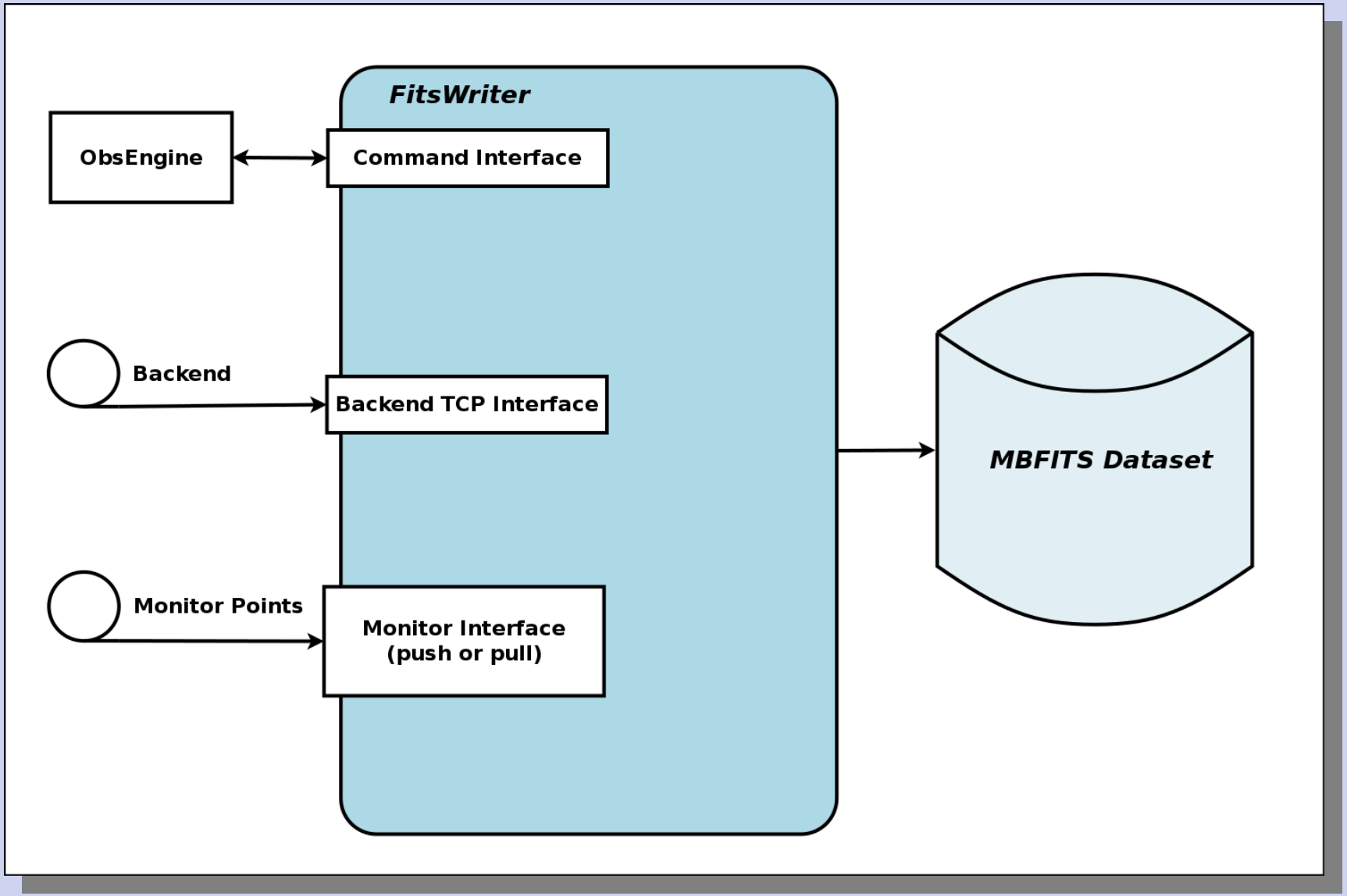
SOFIA - upGREAT

- upGREAT developed by MPIfR and University of Cologne
  - 14 (1.9 – 2.5 THz) + 7 (4.7 THz) pixels, each 131,072 spectral channels, 200 ms integration time
  - ~55 MB/s

The challenge

- Formats of backend data (main input) and raw data (output) are common, but
- Software environments vastly different otherwise
  - APEX: ESO's ACS with CORBA-based communication
  - Effelsberg: communication based on UDP and TCP
  - SOFIA – upGREAT: KOSMA file IO
- Separate observatory specific parts from generic parts (Unified MBFits Writer)

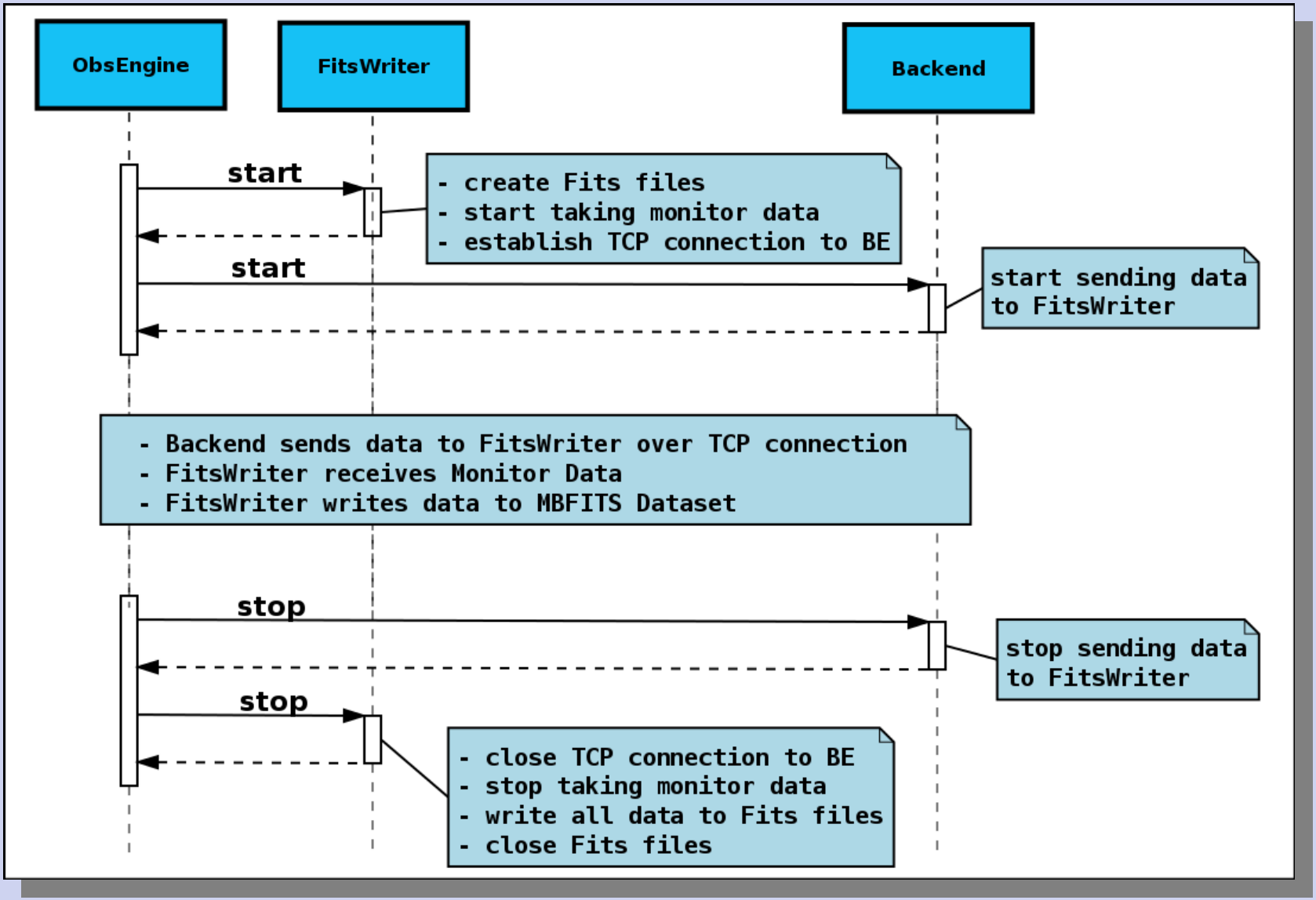
FitsWriter - Interfaces



Command Interface

- Implements 2 commands
  - `start(scanObject)`
  - `stop(status)`
  - Synchronous commands with return values (ok or error message)
- Implementation depends on software environment
  - APEX: ACS (based on CORBA)
  - Effelsberg: TCP multicast messages
  - upGREAT: KOSMA file IO

Observing cycle



Scan Object

- Hierarchically structured Python object with complete description of scan
  - Frontend and backend setup
  - Source and off positions
  - Description of scan pattern
  - Pointing parameters
  - ...
- Passed by start command in serialized form, must be de-serialized in FitsWriter
  - APEX: pickeled Python object
  - Effelsberg: YAML string
  - upGREAT: YAML string

Backend TCP interface

- FitsWriter receives data from each backend involved in scan over TCP connection
- One binary data package per integration
- Header:
  - Timestamp (midpoint of integration interval)
  - Phase number
  - Structural Information
- Payload
- Format identical for APEX, Effelsberg, upGREAT

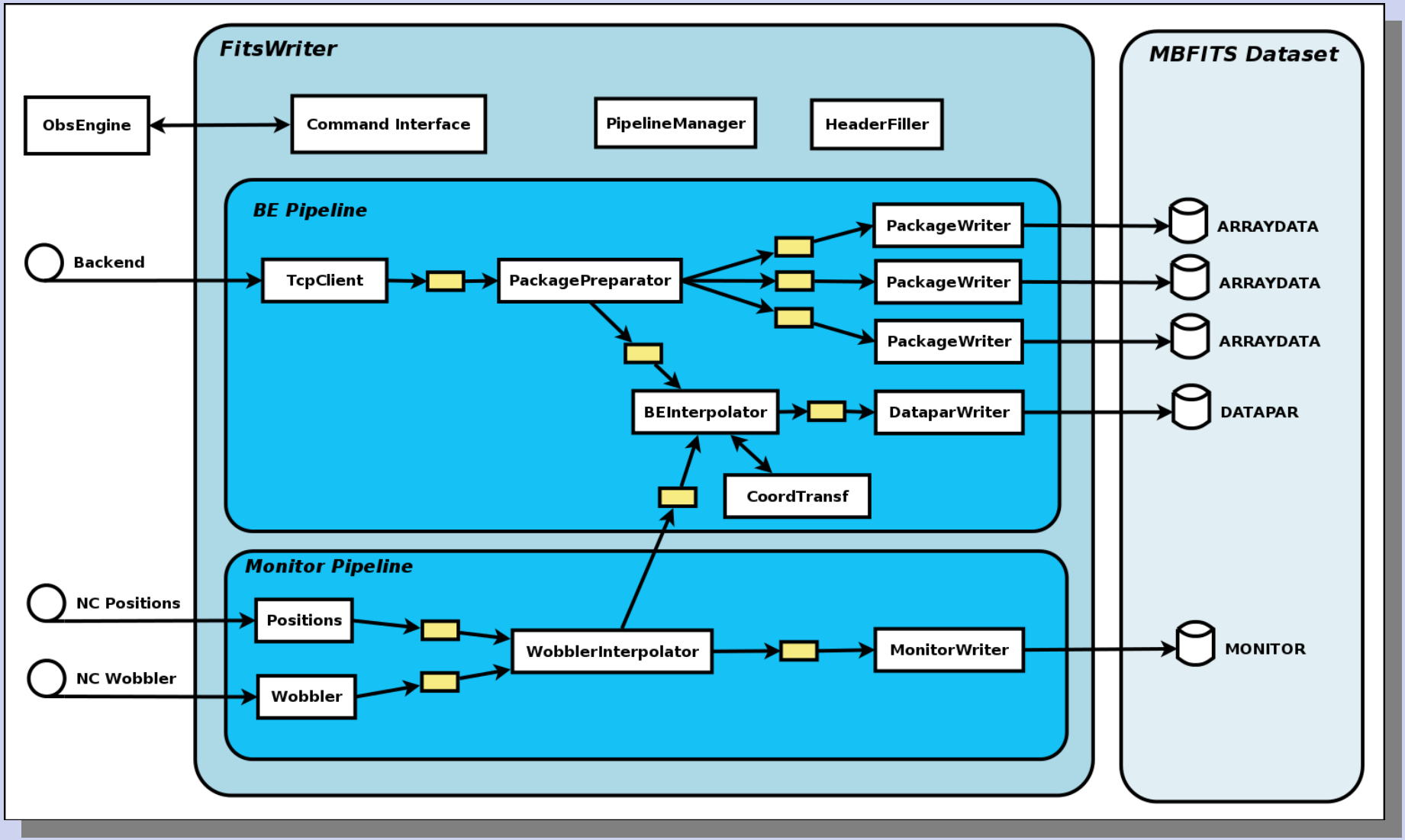
Monitor Interface

- Monitoring data pushed to or pulled by FitsWriter:
  - Telescope and Wobbler positions
  - Environmental data
  - Instrument specific data
- Monitoring data must bear timestamp of data generation
  - Times of telescope and wobbler positions independent off backend timestamps

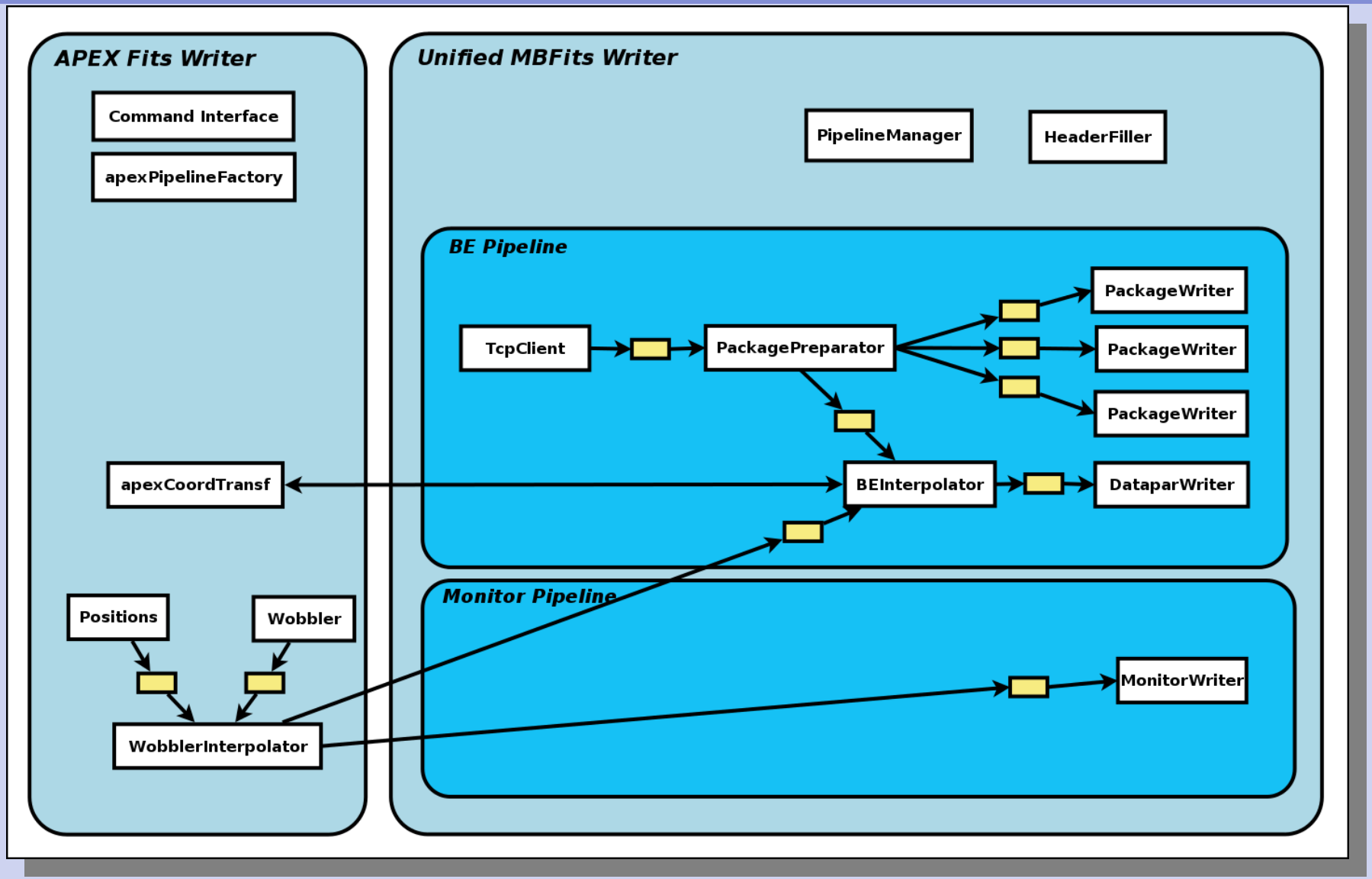
Monitor Interface

- Implementation depends on software environment
  - APEX: ACS Notification Channels and ACS-specific polling methods
  - Effelsberg: TCP multicast messages
  - upGREAT: KOSMA file IO

APEX FitsWriter Internal Structure

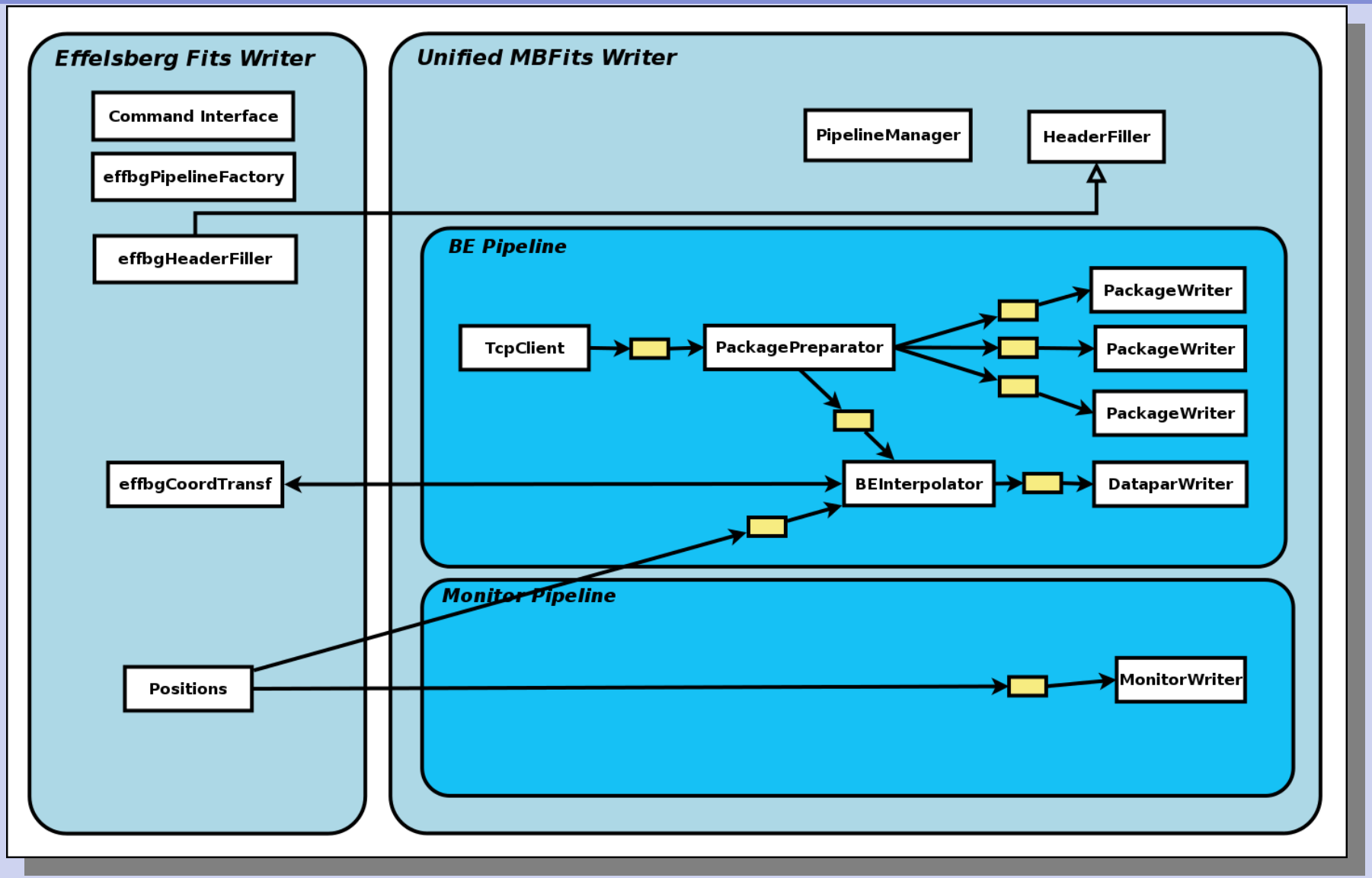


Unified MBFits Writer



LOC: ~4,000 ~16,000

Unified MBFits Writer



LOC: ~3,000 ~16,000

Current Status

- APEX:
  - In production since September 2015
- Effelsberg:
  - In final development phase, will go in test operation in the next weeks, production later 2015
  - Successful performance tests to limit of available backend hardware (~70 MB/s)
- SOFIA – upGREAT:
  - In early development phase
  - Planned for spring 2016