FACET-II Data Acquisition System

**WEPP33**

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FACET

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Introduction

The Data Acquisition System (DAQ) at FACET-II is designed to address the challenge of collecting synchronized, time-stamped data from a variety of diagnostics spread throughout the kilometer-long linac and experimental area. The EPICS control system is used to read out data from devices at FACET-II via Channel Access (CA) over the network. This poses a problem for collecting image data at the 30 Hz beam rate. With image sizes ranging from 0.3-10 Megapixels, the data rate from a single camera can be as high as 0.6 Gbps and there are nearly 100 cameras deployed at FACET-II. Simultaneous image acquisition from just a few of these cameras would overwhelm the network. The FACET-II DAQ solves this problem by coordinating the camera IOCs to write their image data to network-attached storage (NAS) and then validating time-stamps to confirm synchronization.

FACET-II Layout
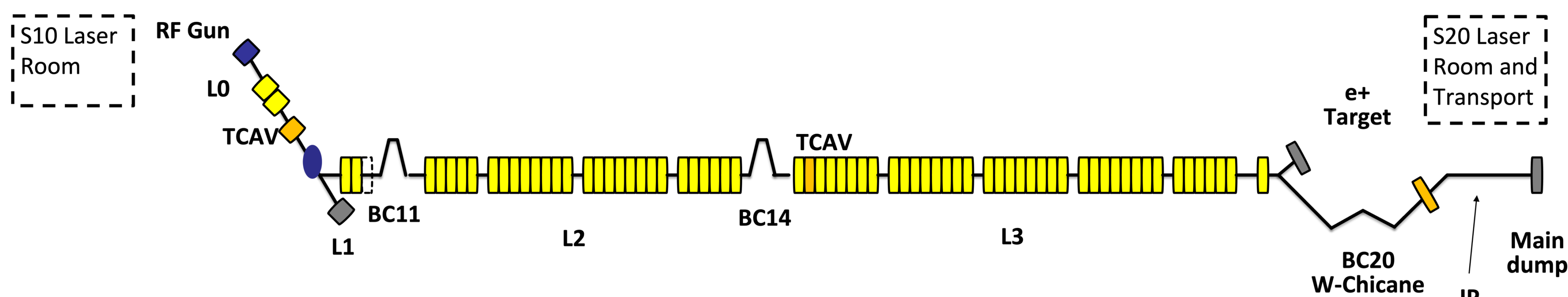
Region	S10 Laser Room	Injector Vault	L1 and BC11	L2 and BC14	BC20	S20 Laser Room + Transport	IP Area	Spectrometer Line	Total
Cameras Deployed	7	3	6	2	2	21	18	12	76
Cameras Planned	10	5	10	6	2	21	24	16	94

Overview and Key Features of the FACET-II DAQ

- The DAQ code is written in MATLAB. Communication with IOCs is handled by lab-CA, a MATLAB wrapper for Channel Access developed at SLAC. The GUI interface is created with MATLAB's App Designer.
- All camera IOCs run EPICS areaDetector with the NDFileTIFF plugin: https://areadetector.github.io/master/index.html
- The servers running the camera IOCs mount the NAS file system.
  - Most of the data-taking cameras are on the same switch as the NAS. Data from these devices are written to disk without passing through the network.
  - The NAS ports are bonded on the switch to ensure maximum data throughput.
  - The server that runs the DAQ and Data Analysis (DAN), is also on this switch.
- Devices that produce scalar data at beam rate (e.g. BPMs, toroids, bunch length monitors, . . .) are read out using the Beam Synchronous Acquisition (BSA) infrastructure.
- FACET uses Event Codes (EC) to determine which pulses in a 360 Hz cycle contain beam events. The ECs can be specified both by rate (e.g. 30 Hz) and conditions (e.g. safe-for-beam). The ECs contain a Pulse ID which is used to uniquely identify shots.
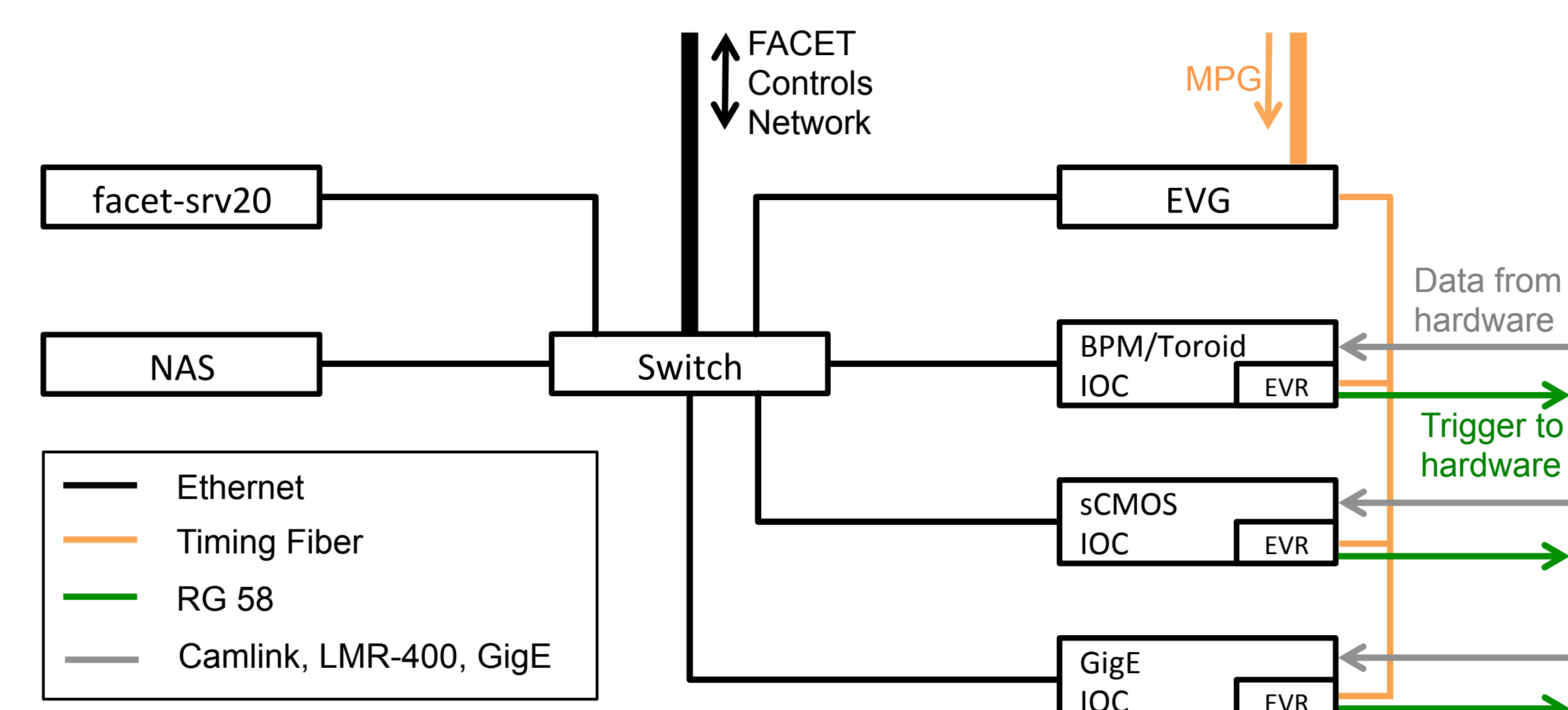
Functionality

At the start of a DAQ, a subset of the cameras are identified for inclusion in the run and the desired data rate is specified with an EC. The data rate may be less than the beam rate. The number of shots are specified (up to a maximum of 2800) as well as the number of steps if a parameter is being scanned. The procedure follows:

1. Space is allocated on the NAS for the new dataset.
2. The NDFileTIFF is configured with the location on the NAS and number of shots.
3. BSA acquisition is configured with an Event Definition analogous to the EC.
4. Acquisition starts via CA commands to the BSA infrastructure and NDFileTIFF plugins.
5. Non-BSA data (e.g. magnet settings) is acquired asynchronously over CA at 1 Hz.
6. Once acquisition is complete an all data has been written to disk, the timestamps (Pulse IDs) of the image data are aligned with timestamps of the BSA data.
7. This process repeats if running a scan. Otherwise, a metadata file is written to disk.

Planned Improvements to the DAQ

At present, the start of data acquisition is triggered by a series of CA calls. While this works in practice, it is non-ideal because the calls are asynchronous: different devices may start to acquire data at different times. This issue will be resolved by creating a new Event Code that is otherwise identical to the ones used to control beam and data rates, but can be set turned on and off for devices participating in the DAQ. All devices that listen to the new EC will start and end acquisition on the same shot. Additional improvements include:

- Acquisition from legacy (SLC Control Program) devices.
- Acquisition of non-BSA waveforms.
- Metadata files written in both MATLAB and HDF5 format.
- Pulse ID vectors for camera timestamping.

Network Topology in S20

There are 6 servers hosting up to 57 GigE interface cameras and 4 servers hosting up to 8 sCMOS cameras on the switch in the experimental area (S20). These devices can write data to the NAS without sending data over the network.

Camera Types

AVT Manta

AVT Mako

Hamamatsu ORCA Flash 4.0v3

Make	Model	Interface	Chip Type	Size (MP)
AVT Manta	G-033B	GigE	CCD	0.33
AVT Manta	G-095B	GigE	CCD	0.95
AVT Manta	G-125B	GigE	CCD	1.2
AVT Manta	G-146B	GigE	CCD	1.4
AVT Manta	G-895B	GigE	CMOS	8.9
AVT Mako	G-125B	GigE	CCD	1.2
AVT Mako	G-507B	GigE	CMOS	5.1
PCO	Edge	CameraLink	sCMOS	5
Hamamatsu	Flash 4.0v3	USB3	sCMOS	4
Hamamatsu	Fusion	USB3	BT-sCMOS	4

DAQ GUI

The DAQ GUI allows users to select cameras for inclusion in the DAQ, as well as lists of BSA and non-BSA variables. 1D and 2D scans can be run from the GUI. It is possible to run N-dim scans with the DAQ using the DAQ API.