Data Acquisition at FACET-II

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Outline

- High-level overview of SLAC data system including EPICS

- Beam synchronous vs. non-beam synchronous data

- Quasi-BSA options with motion controllers

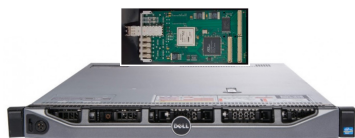# Four Layers to Data Acquisition

User/Client
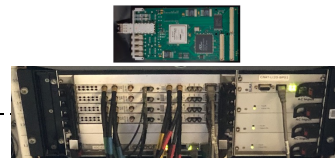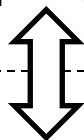
Python Matlab GUIs DAQ

Timing

Channel Access (CA)

EPICS

Controls Server

EVG (S10 RF Hut)

Driver

XPS Controller Camera Server VME Crate
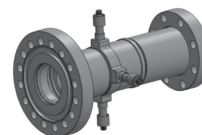
Fiber

EVR
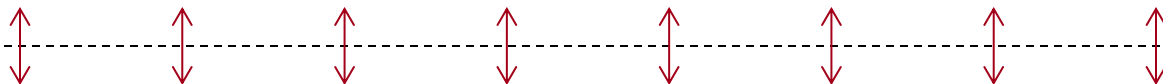
Device

UTS Stage GigE Camera BPM

Timing

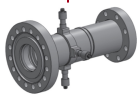EVG (S10 RF Hut)   Beam Rate (e.g. 10 Hz)
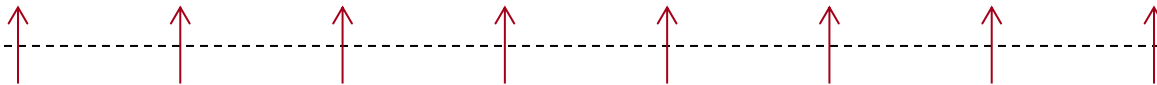
TTL Camera Trigger

EVR (camera server)

Software interrupt with timestamp and Pulse ID

Software interrupt with timestamp and Pulse ID

EVR (VME Crate)

BPM does not receive trigger

EPICS in one slide

- EPICS is a unified interface for communicating with devices on the controls network.

  - It is widely used: https://epics-controls.org/

- Devices are controlled by Input-Output Controllers (IOCs). IOCs exist for many devices:

  - Hardware devices: https://epics.anl.gov/modules/manufacturer.php
  - Software devices: https://epics-controls.org/resources-and-support/modules/soft-support/
  - Cameras: https://areadetector.github.io/master/index.html
  - SLAC devices: https://github.com/slac-epics

- It is *relatively* easy to create an IOC if the manufacturer provides firmware and an SDK.

- The IOC exposes Process Variables (PVs) that you can "get", "set", and "monitor".

- We interact with PVs using the Channel Access, a TCP/IP protocol.

  - All data flows over the network!

There are a lot of resources on EPICS! For a very detailed tutorial, check out this 2019 USPAS class.
https://controlssoftware.sns.ornl.gov/training/2019_USPAS/

Beam Synchronous Acquisition

- Some devices record "scalar" data on every beam event. These include BPMs, toroids, and beam loss monitors.
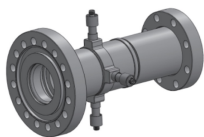
BPM

Toroid

PMT

- Data from these devices are stored in buffer of length 2800 (SLC convention).
  - The buffer contains the data AND the timestamp/Pulse ID.

- The EVG coordinates buffers between devices and allows you to get synchronous data from many devices. The is called "Beam Synchronous Acquisition" (BSA).

Non-Beam Synchronous Acquisition

- Many devices do not support BSA. These include magnet and motor settings:

UTS Stage

Quadrupole

- The devices that control magnets and motors typically do not include EVRs. The devices do not know the timestamp and PulseID of a current event.

- Nevertheless, the controller *can* provide precise timestamps and this might be "good enough" for some applications.

Quasi-BSA option for motion control

User/Client

Python:
- 10 Hz Get/Set for motion controller
- 10 Hz (or triggered?) polling for EPICS IOC
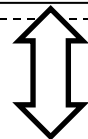- 10 Hz Get/Monitor for camera (works for 1 camera)

Timing

EPICS

↕ Channel Access (CA)

Controls Server

Network

Driver

XPS Controller

Camera Server

EVG (S10 RF Hut)

Fiber

EVR

Device
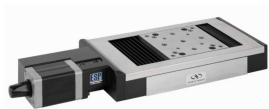
UTS Stage

GigE Camera

Multi-Camera Raster Scan with FACET DAQ

SLAC

Positron Beam

Gold Mirror with hole

Kinoform

TRA

Laser

Plasma Channel

YAG Screen

Imaging Quadrupoles

Dipole Spectrometer

LANEX Screen

$$I(r,z) \propto k_z z J_m^2(\vec{k}_\perp r)$$

$$\Psi_m = k_\perp r + m\phi$$

YAG Screen Kick Map

Laser Displacement Y [μm]
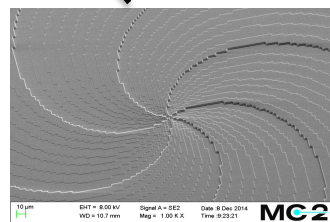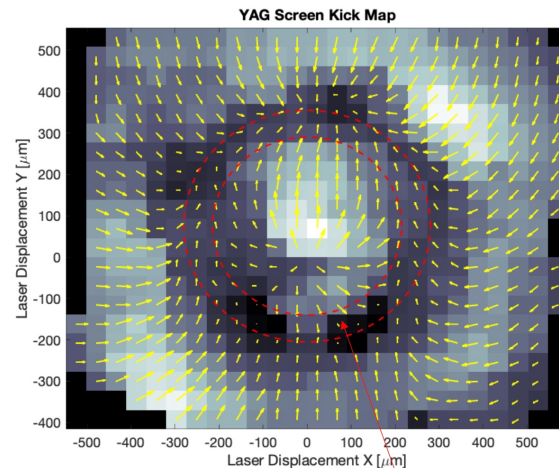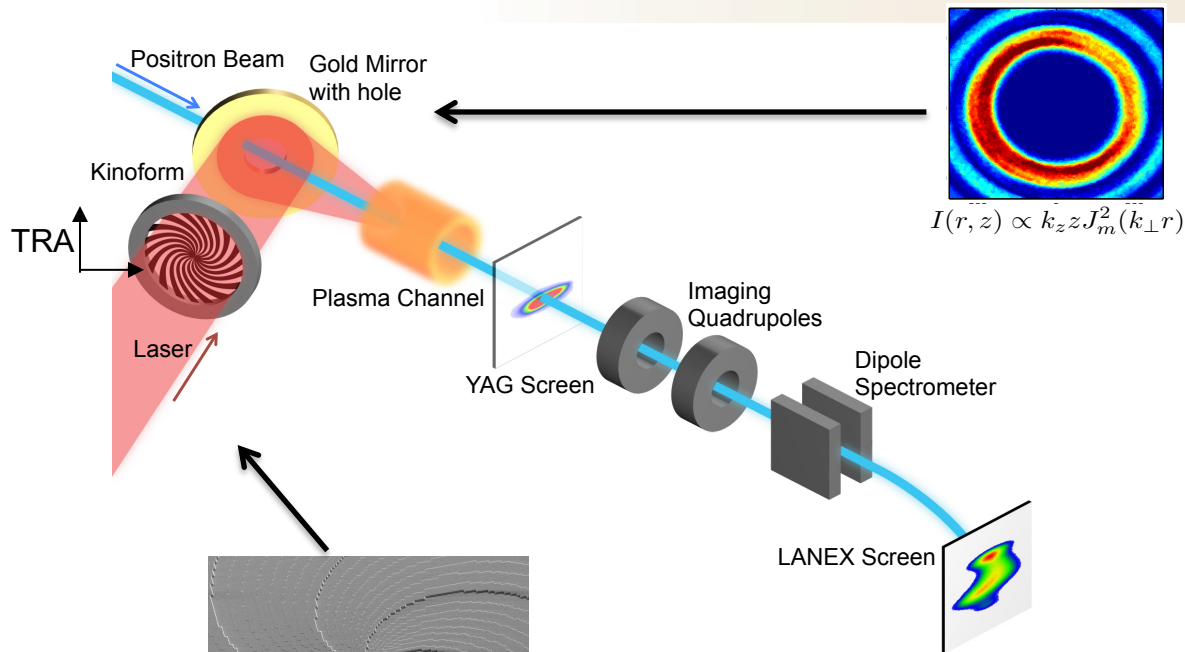
Laser Displacement X [μm]

Raster scan dataset with 2700 shots
(about 15 minutes to acquire and analyze)

FACET DAQ

- FACET DAQ is designed to handle the problem of recording data from multiple cameras simultaneously.

- There are 60 cameras in use at FACET-II.

- At 10 Hz, the data from 10 cameras may overload the network.

- Data is written to Network Attached Storage (NAS) instead of being streamed over the network.

S20 Network Topology

FACET-II Camera System

SLAC

Network

S10 RF Hut

Timing Fiber

EVG

B244 Trailer

Server EVR

S20 Laser Room

Server EVR

Laser Transport

S10 Laser Room

Server EVR

S10 FKG10-13

Server EVR

S14 FKG14-06

Server EVR

S16 KF16-1A

Server EVR

S20 FKG20-01

Server EVR

FKG20-20

Server EVR

facet-srv20

nas-li20-pm00

Gallery

Triggers   Data/Ethernet   Data/Fiber

Tunnel

Injector   S10 Linac   S14 Chicane   S16 TCAV   S20 Upstream Chicane and Positron Line   S20 IP Area and Dump Table

FACET-II Camera System

Network

S10 RF Hut

EVG

Timing Fiber

B244 Trailer

Server EVR

S20 Laser Room

Server EVR

Laser Transport

FKG20-20

Server EVR

facet-srv20

nas-li20-pm00

Client

- Client can see data from devices in real time.
- Client can launch FACET DAQ which organizes data collection and writes synchronized data to disk.

Gallery

Data/Fiber

ACR

Tunnel

S20 IP Area and Dump Table

FACET-II Camera System

Network

S10 RF Hut

EVG

Timing Fiber

B244 Trailer

Server EVR

S20 Laser Room

Server EVR

Laser Transport

FACET DAQ via facet-srv20

Client

Data coordination

FKG20-20
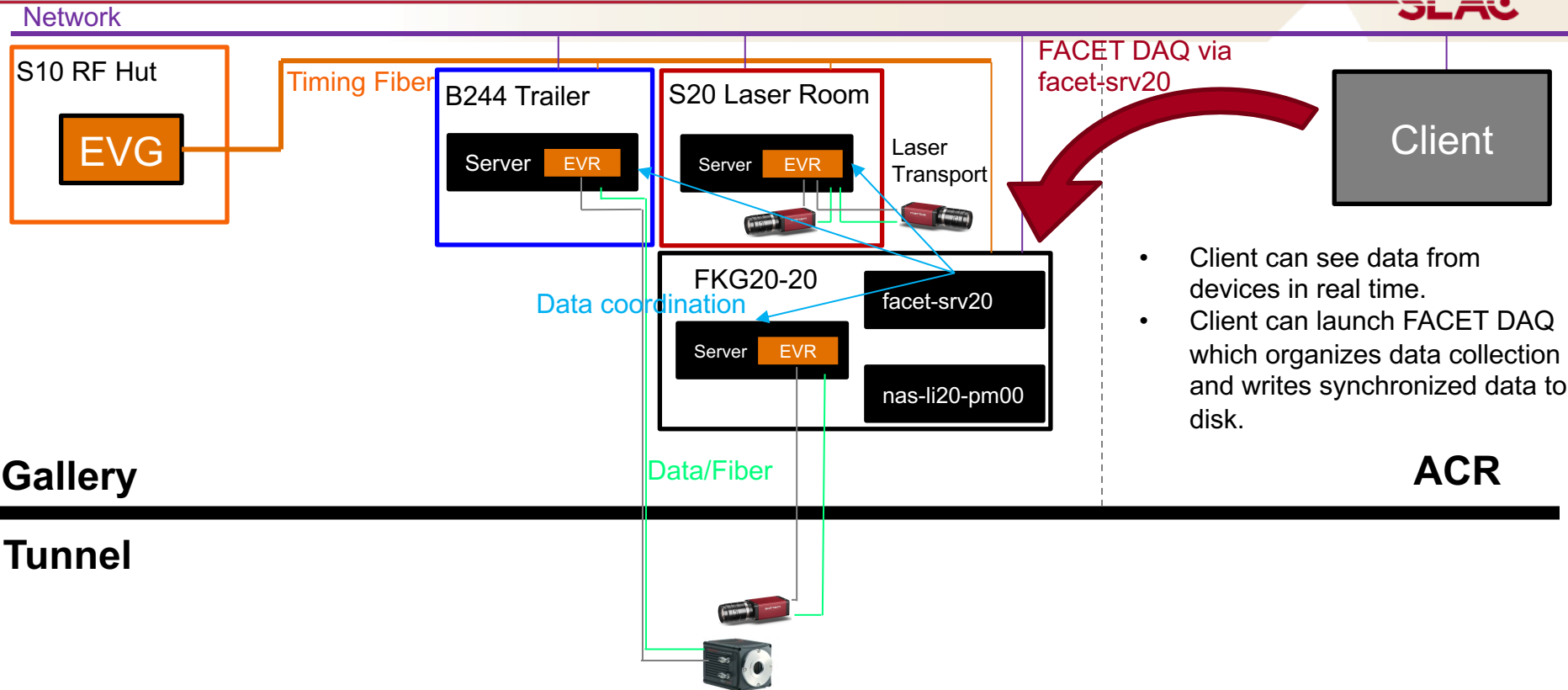
facet-srv20

Server EVR

nas-li20-pm00

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Laser Transport

FACET DAQ via facet-srv20

Client

FKG20-20
Data saving

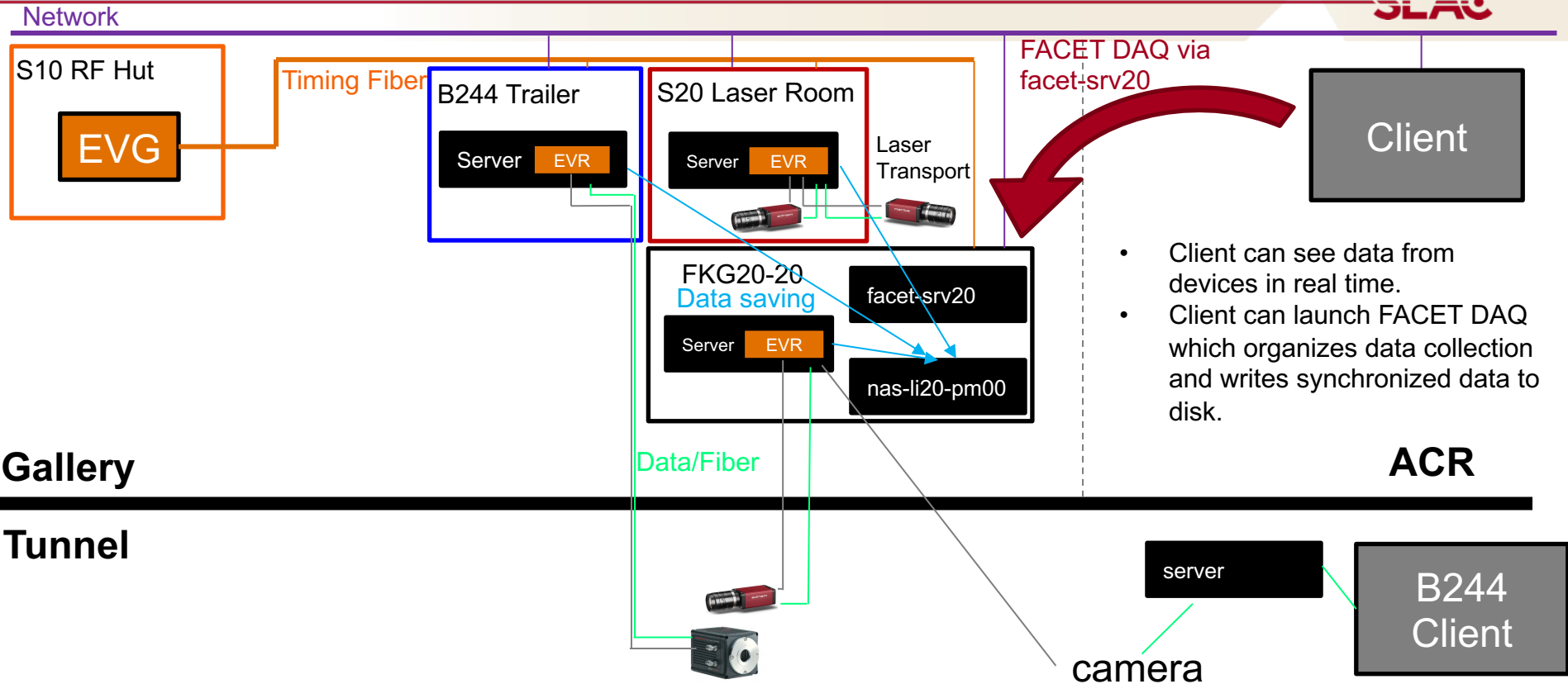Server   EVR

facet-srv20

nas-li20-pm00

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Gallery

ACR

Data/Fiber

Tunnel

server

camera

B244 Client

S20 IP Area and Dump Table