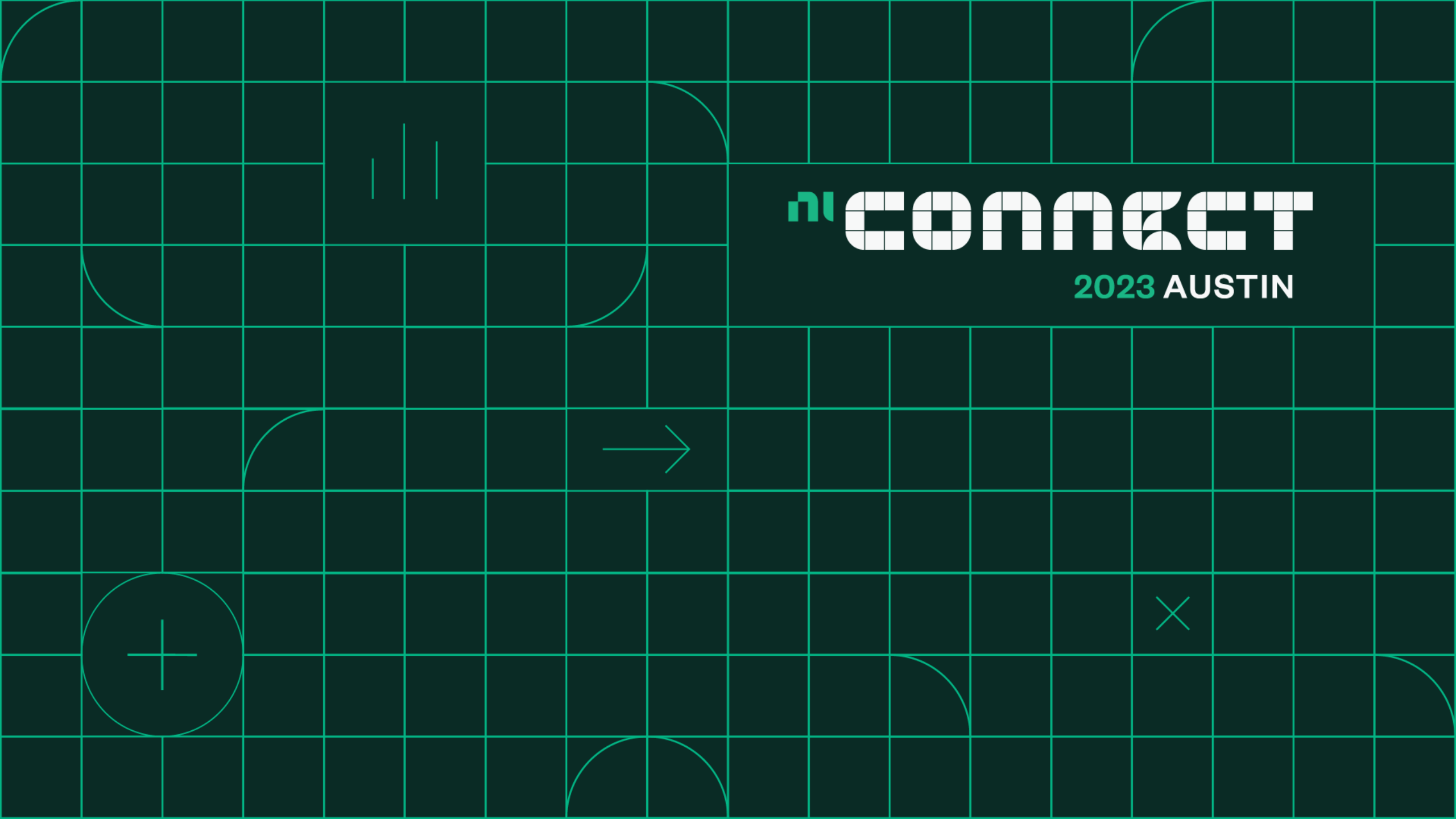

WELCOME TO AUSTIN


CONNECT
2023 AUSTIN

Multichannel RF Data Record and Analysis

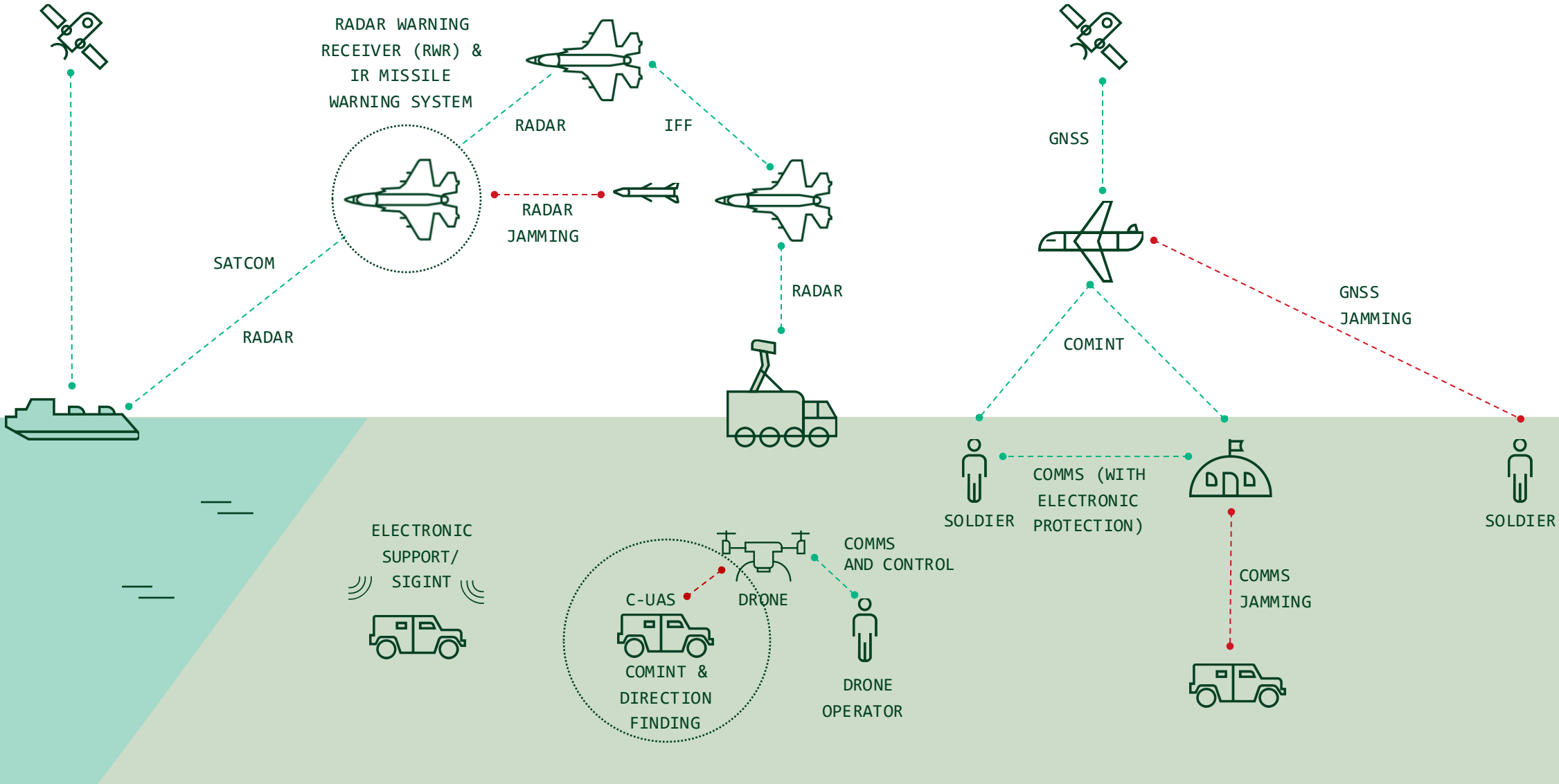
Ahmed Khalid
Principal Offering Manager – ADG BU
Radar, EW, Communications, and Navigation

Brad Sherman
Principal Systems R&D Engineer – ADG BU

Agenda

- Introduction
- Requirements
- Challenges
  - Hardware Abstraction
  - System Calibration
  - Data Movement
  - Software Architecture

The Contested & Congested Electromagnetic Battlefield



Multi-channel Multi-function RF Systems Stimulus & Monitoring

Complex RF System Test Challenges

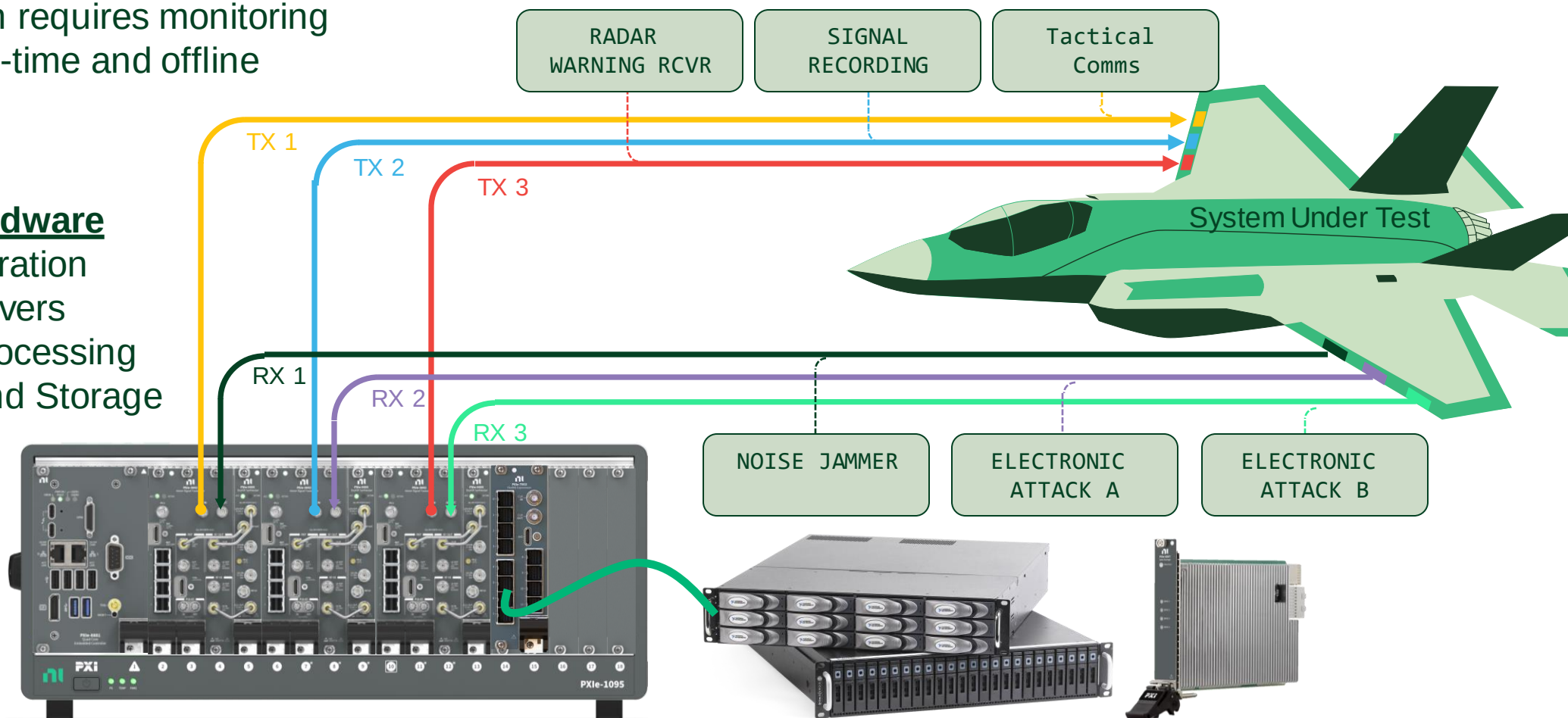
- Modern RF systems often have many ports spanning function, frequency, and signal types
- Complete System level test involves stimulus of :
  - Multiple Bands / Multiple Threats / Multiple Ports
- System validation requires monitoring responses in real-time and offline

Common Signal Types

Modulated Comms Waveform
Adversarial Signal
Threat Radar Signal
Broadband Transmission
Active DRFM response Band A
Active DRFM response Band B

Common STE Hardware

- RF Signal Generation
- RF Signal Receivers
- In-line Signal Processing
- Data Logging and Storage



Multichannel RF Record & Playback Solution

Q3 - 2023

RF / Digital Systems Performance

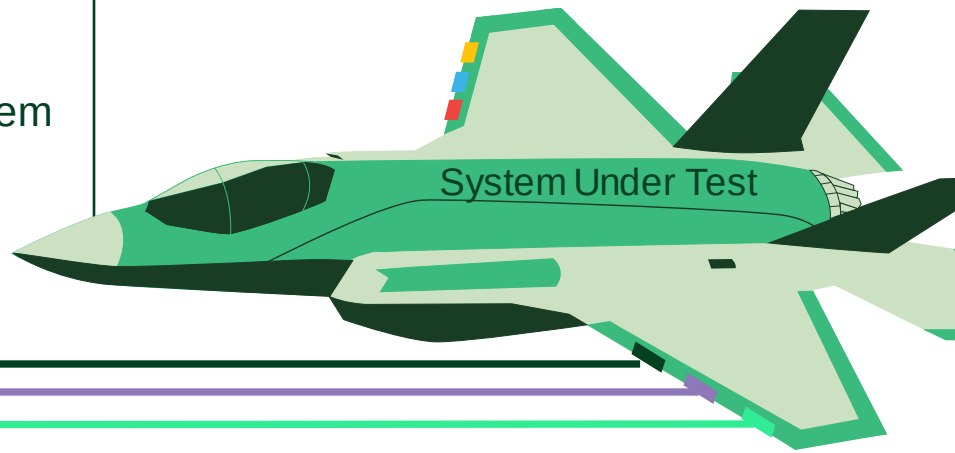
- Wideband RF Recording
  - 1 GHz IBW per channel
- 100 GbE Stream To Disk
  - 40 GB/s (8 GHz IBW)
    360 TB = 2.5 hours at max IBW
- Multi-Channel / Frequency
- Inline Processing Capable
- Offline Analysis

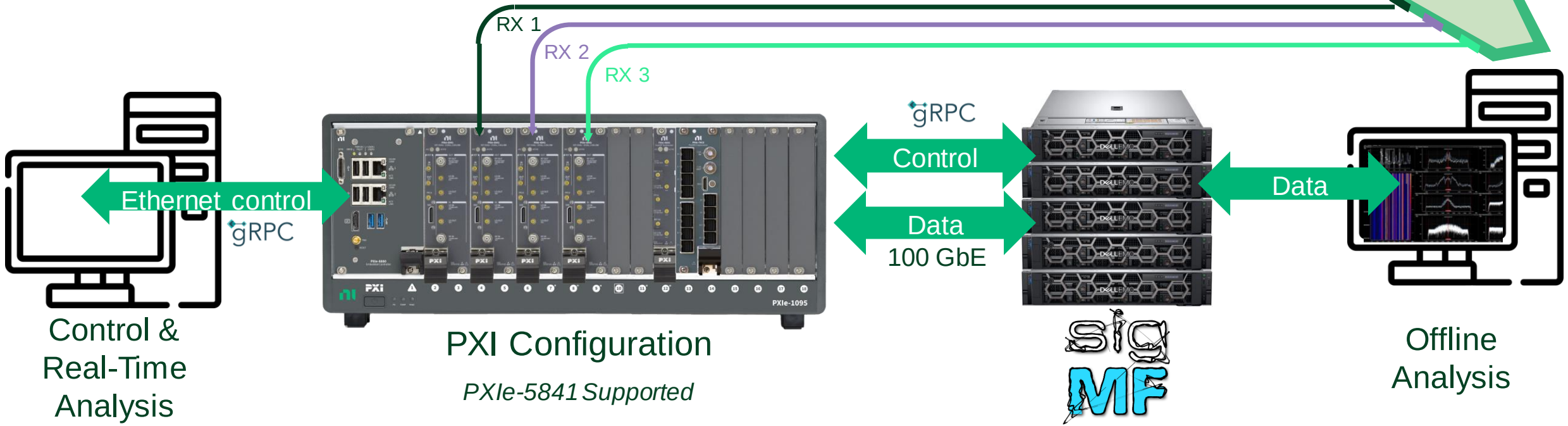
System Calibration & Sync

- Time Synchronization w/ NI-TClk
- Record Trigger Options
  - Software, Digital
- LO Power Calibration
- Wideband Multi-Channel System Equalization Calibration

System Software

- Remote-access with gRPC
- SigMF metadata file format





Requirements

- Scale data storage capacity method with increasing channel count and data rates
- Scale channel count and RF bandwidth to 16 with a plan to scale to hundreds of channels
- Lossless raw IQ data recording and playback
- System calibration for improved channel-to-channel phase performance

Requirements

- Scale data storage capacity method with increasing channel count and data rates
  - External storage due to limited PXIe slots
- Scale channel count and RF bandwidth to 16 with a plan to scale to hundreds of channels
  - PCIe enumeration limit = 256 buses ~= 7-8 PXIe Chassis
  - Greater than 8 chassis requires multi-controller configurations
- Lossless raw IQ data recording and playback
  - Larger data rates require more and more drives for storage
- System calibration for improved channel-to-channel phase performance
  - Wideband calibration method
  - Staged calibration for large channel counts

Challenges

Multichannel Hardware Abstraction

- One interface for N number channels
- Acquisition and/or generation devices
- Single-chassis, multi-chassis, or no synchronization
- High-speed serial, DMA, or no streaming
- Hooks to enable system level calibration
- LO sharing

System Calibration

- LO star power calibration
- Wideband RF calibration
- Calibration files

Data Movement

- Scale to 20 GB/s per RF channel to/from external storage devices
- Scale to 320 GB/s with one or more storage devices
- Scale offline analysis to parallel data analysis

Software Architecture

- UIs for calibration and system use
- gRPC API

Challenges

Multichannel Hardware Abstraction

- One interface for N number channels
- Acquisition and/or generation devices
- Single-chassis, multi-chassis, or no synchronization
- High-speed serial, DMA, or no streaming
- Hooks to enable system level calibration
- LO sharing

System Calibration

- LO star power calibration
- Wideband RF calibration
- Calibration files

Data Movement

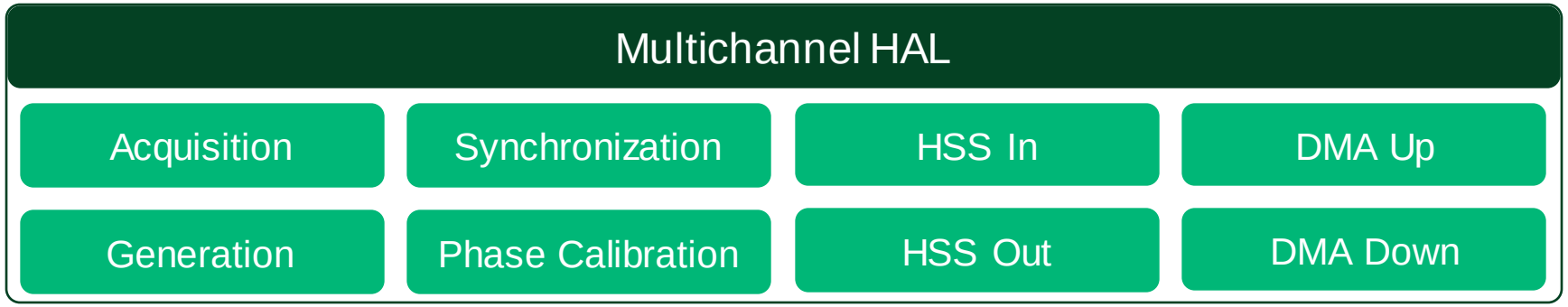
- Scale to 20 GB/s per RF channel to/from external storage devices
- Scale to 320 GB/s with one or more storage devices
- Scale offline analysis to parallel data analysis

Software Architecture

- UIs for calibration and system use
- gRPC API

Multichannel Hardware Abstraction

- Decoupling features at a system level is challenging
- Simpler to support various combinations of functionality if all the information exists in one place
- Hardware functionality can be developed and tested separately from the rest of the system



Challenges

Multichannel Hardware Abstraction

- One interface for N number channels
- Acquisition and/or generation devices
- Single-chassis, multi-chassis, or no synchronization
- High-speed serial, DMA, or no streaming
- Hooks to enable system level calibration
- LO sharing

System Calibration

- LO star power calibration
- Wideband RF calibration
- Calibration files

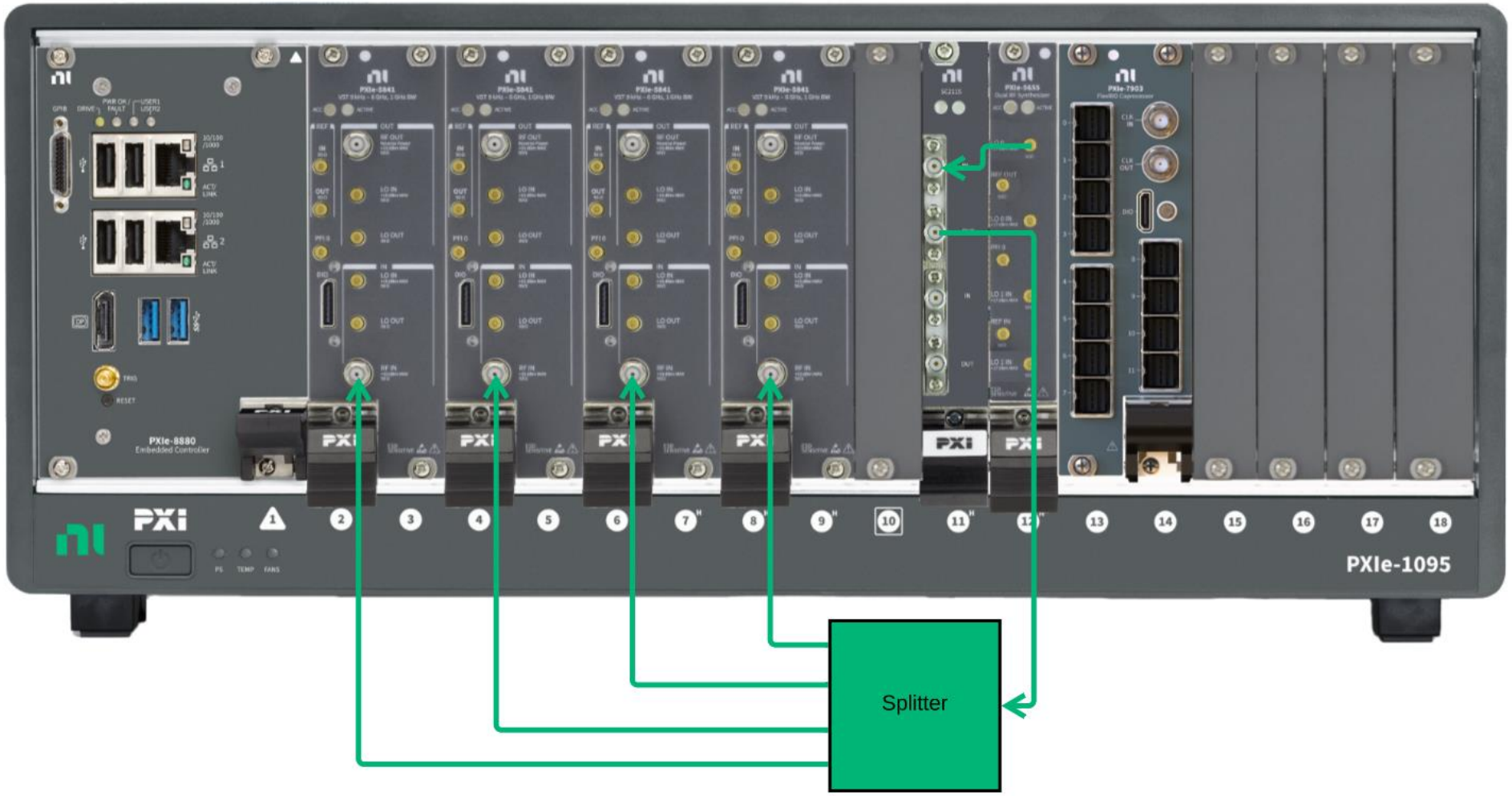
Data Movement

- Scale to 20 GB/s per RF channel to/from external storage devices
- Scale to 320 GB/s with one or more storage devices
- Scale offline analysis to parallel data analysis

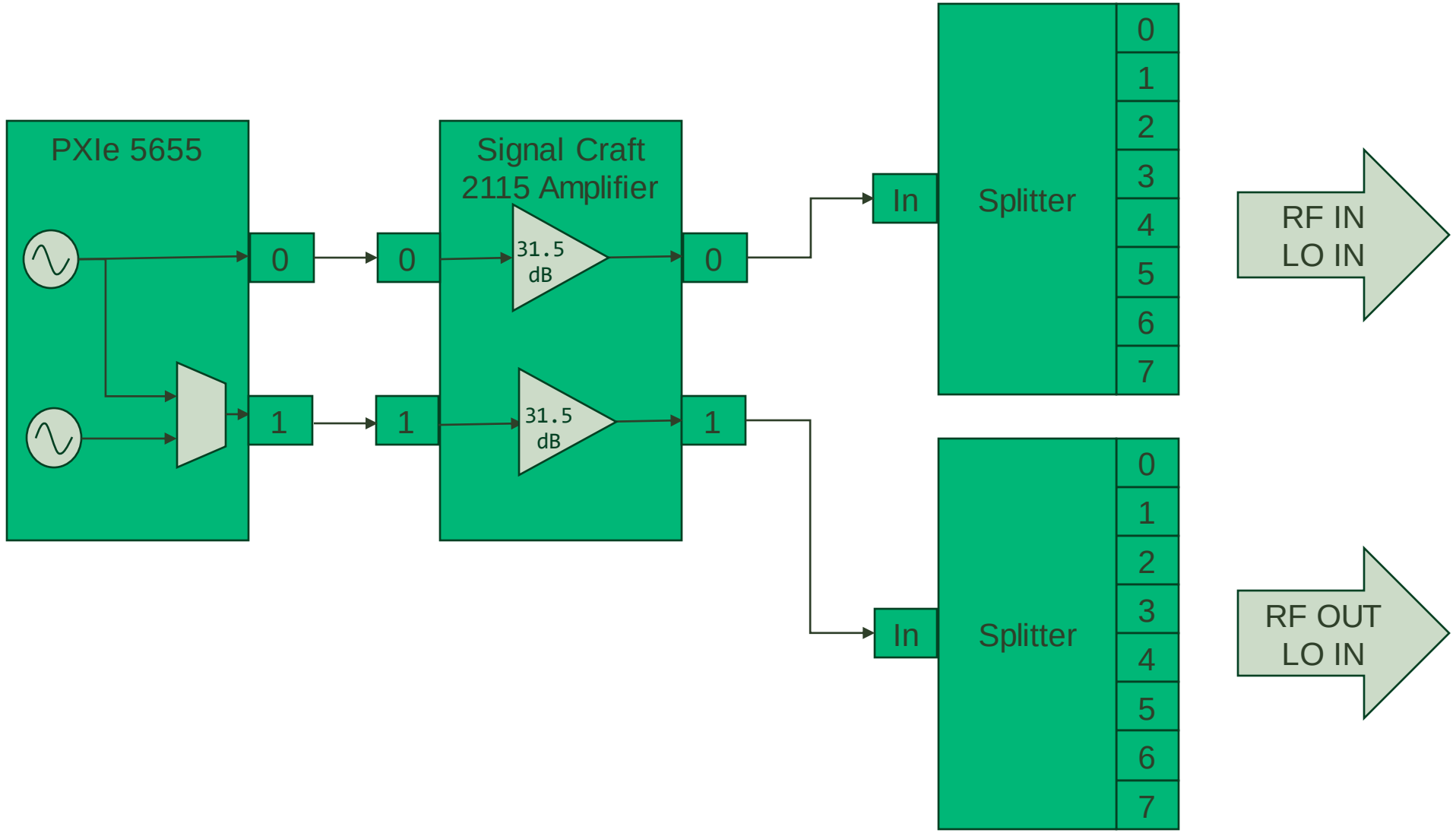
Software Architecture

- UIs for calibration and system use
- gRPC API

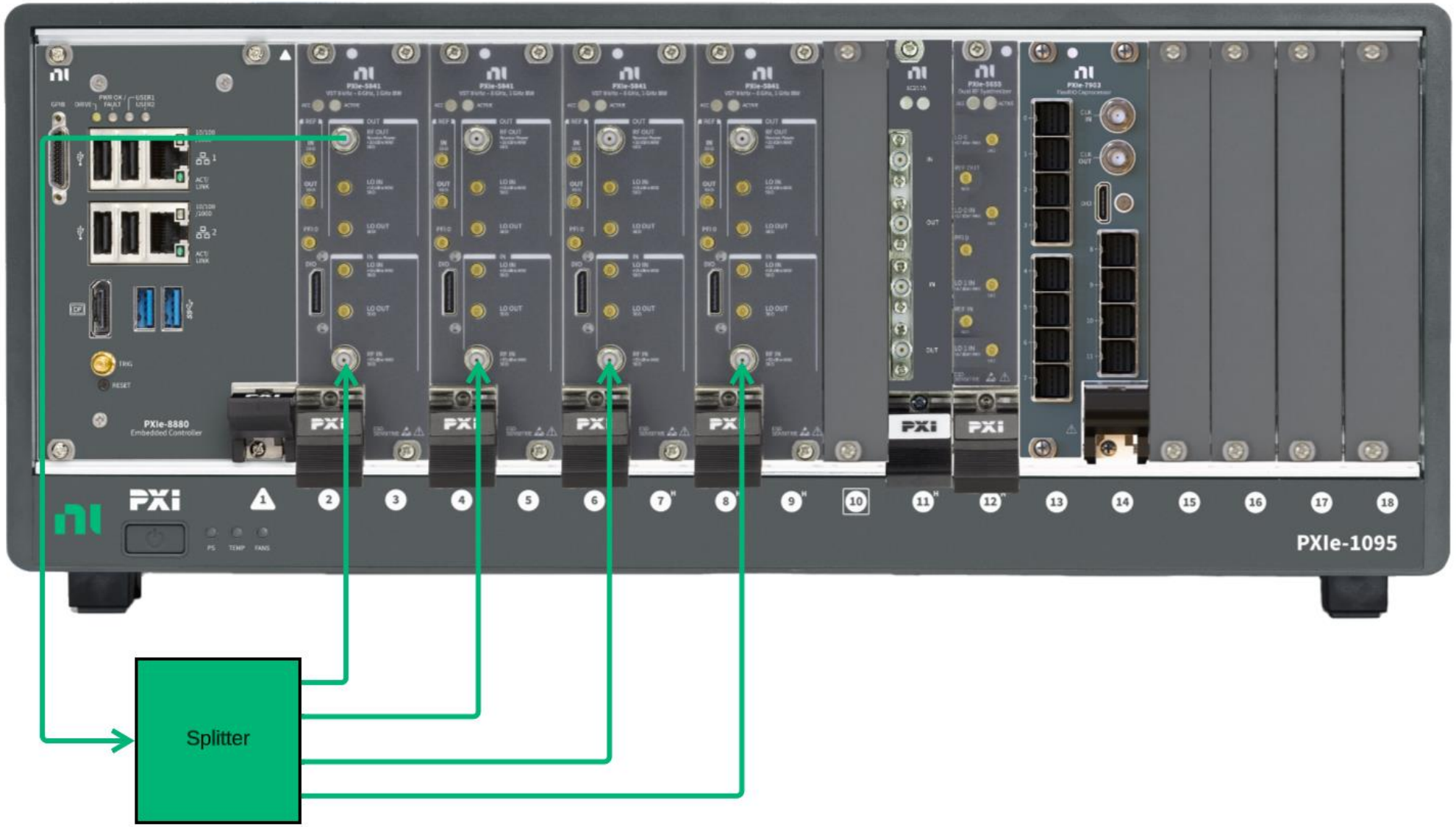
System Calibration: Star LO Power



System Calibration: Star LO Power



System Calibration: Acquisition Wideband



System Calibration: Generation Wideband

Challenges

Multichannel Hardware Abstraction

- One interface for N number channels
- Acquisition and/or generation devices
- Single-chassis, multi-chassis, or no synchronization
- High-speed serial, DMA, or no streaming
- Hooks to enable system level calibration
- LO sharing

System Calibration

- LO star power calibration
- Wideband RF calibration
- Calibration files

Data Movement

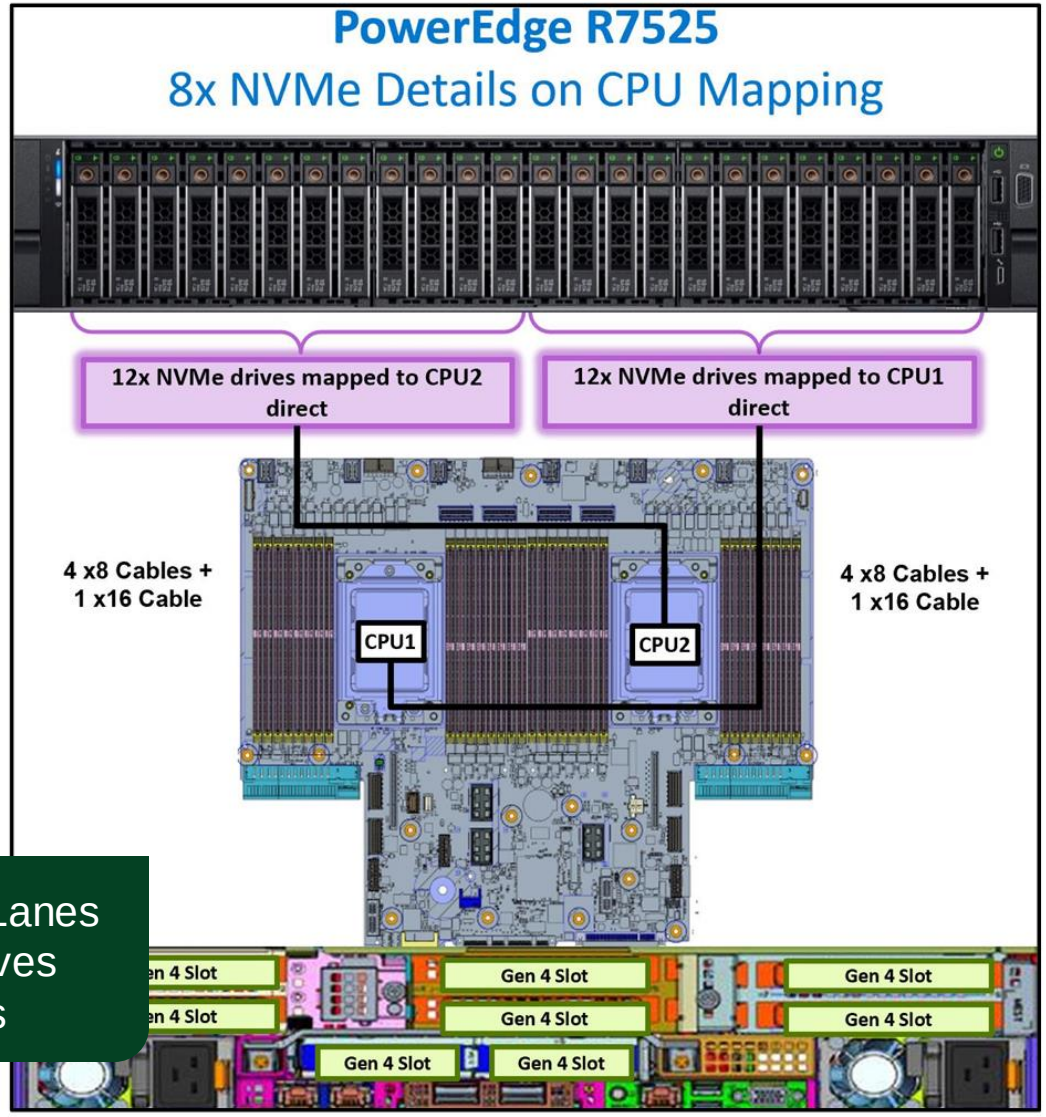
- Scale to 20 GB/s per RF channel to/from external storage devices
- Scale to 320 GB/s with one or more storage devices
- Scale offline analysis to parallel data analysis

Software Architecture

- UIs for calibration and system use
- gRPC API

Data Movement

???



128 Gen 4 PCIe Lanes
- 96 for NVMe drives
- 32 for PCIe slots

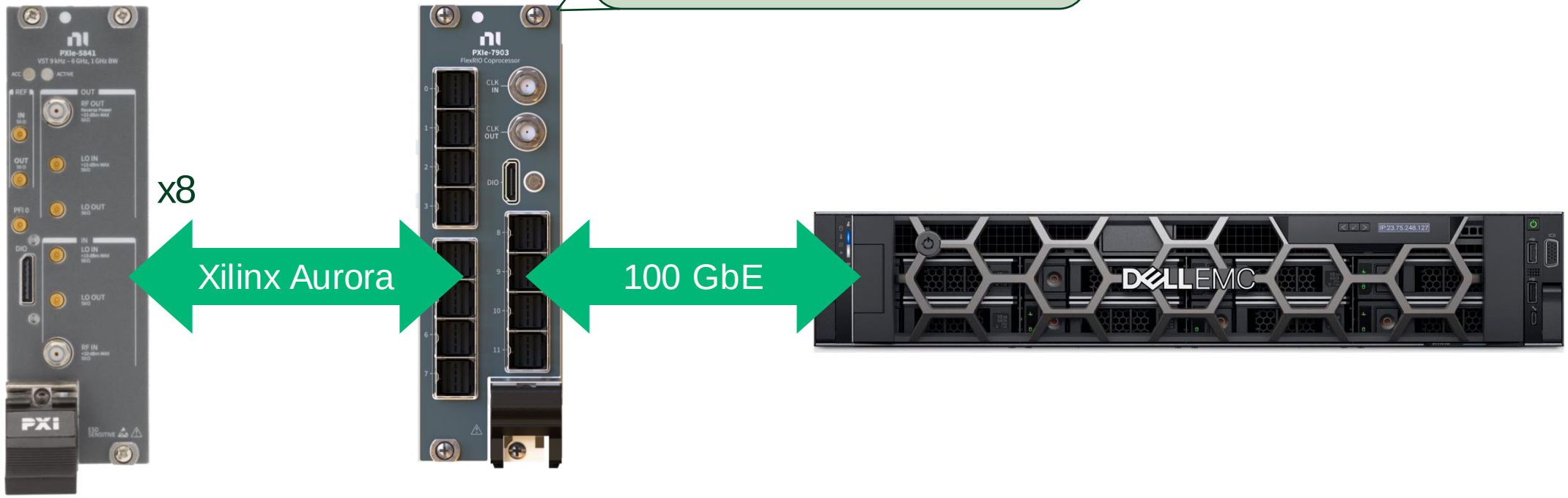
Figure 17: PowerEdge R7525 CPU mapping with twenty-four NVMe drives

https://dl.dell.com/manuals/common/dellemc-nvme-io-topologies-poweredge.pdf

Data Movement

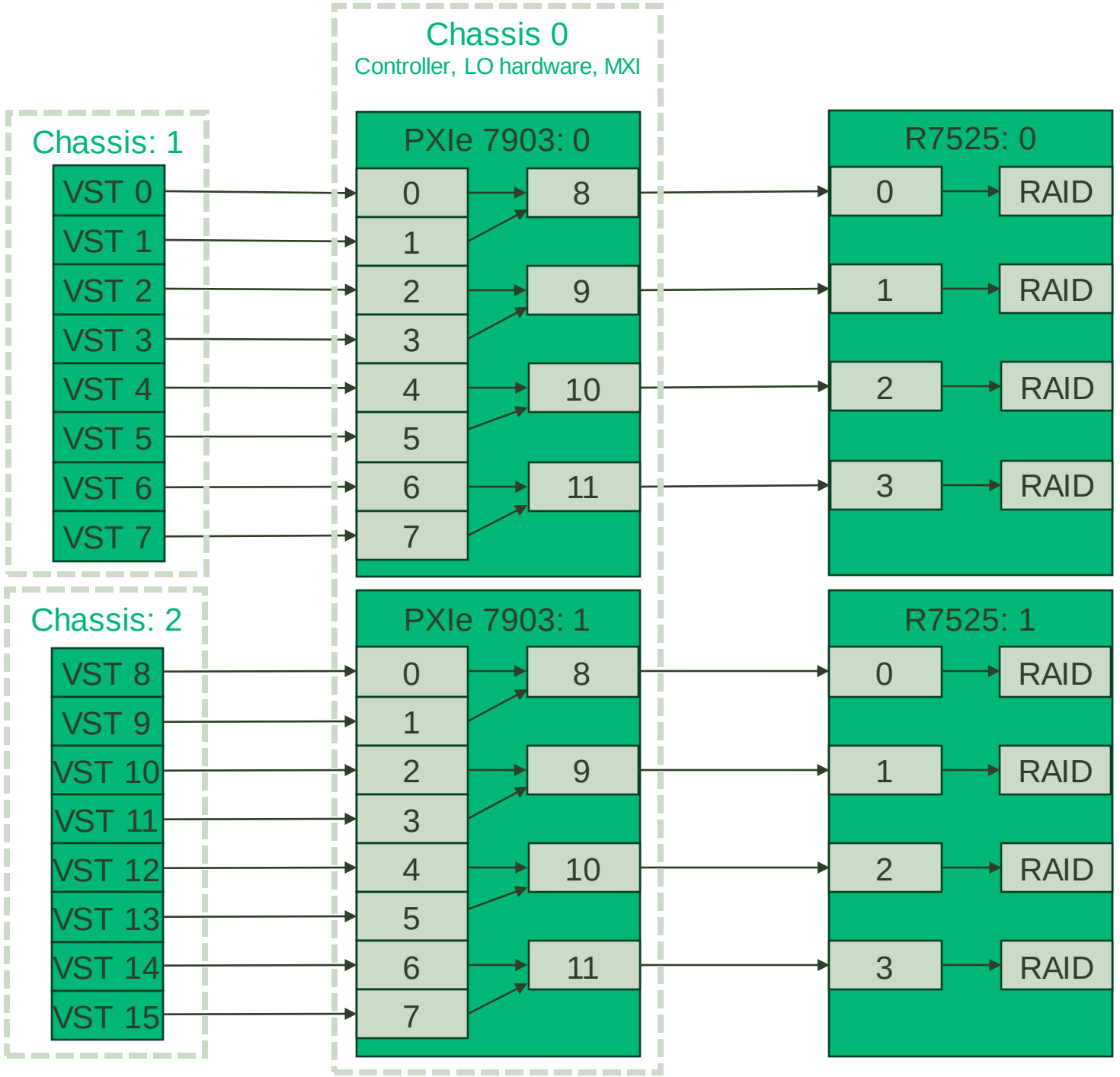
Product Launch: High Speed PXI FlexRIO FPGA Coprocessor

Ballroom F, 11:30 am to 12:30 pm



- Using an NI PXIe-7903 Coprocessor we can receive 8 x NI PXIe-5841 VSTs
- Data is transmitted via 100GbE UDP packets to 2 NICs on the Dell PowerEdge R7525
- At max capacity, each R7525 can hold up to 24, 15TB NVMe drive
- This can be replicated until we run out of PXIe slots for the VSTs in 8 chassis

Scalability



Scalability

8 to 16 Channels

Challenges

Multichannel Hardware Abstraction

- One interface for N number channels
- Acquisition and/or generation devices
- Single-chassis, multi-chassis, or no synchronization
- High-speed serial, DMA, or no streaming
- Hooks to enable system level calibration
- LO sharing

System Calibration

- LO star power calibration
- Wideband RF calibration
- Calibration files

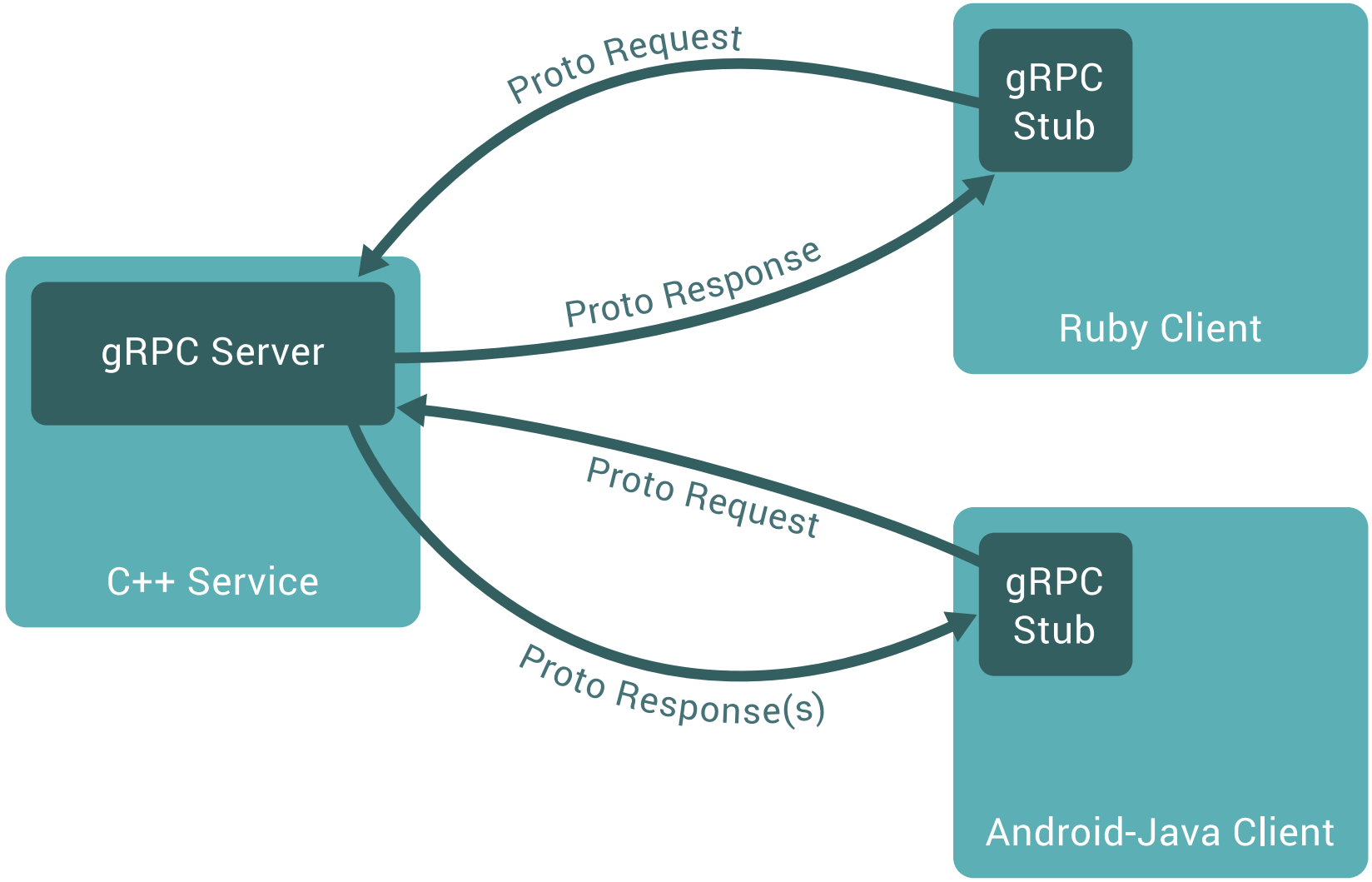
Data Movement

- Scale to 20 GB/s per RF channel to/from external storage devices
- Scale to 320 GB/s with one or more storage devices
- Scale offline analysis to parallel data analysis

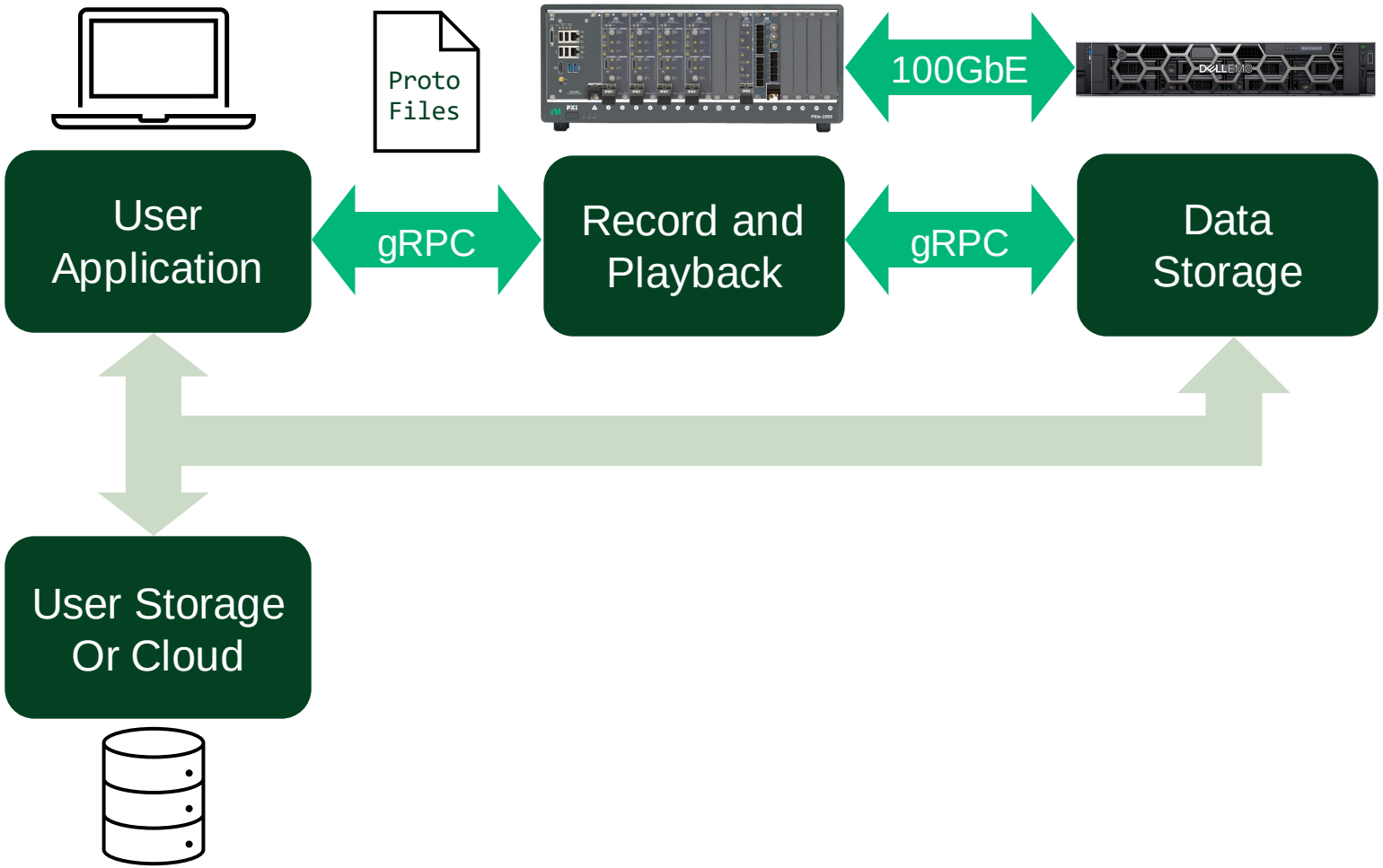
Software Architecture

- UIs for calibration and system use
- gRPC API

gRPC


Proto Request
gRPC Stub
Ruby Client
Proto Response
gRPC Server
C++ Service
Proto Request
gRPC Stub
Android-Java Client
Proto Response(s)

Software Architecture



Multichannel RF Record & Playback Solution

Q3 - 2023

RF / Digital Systems Performance

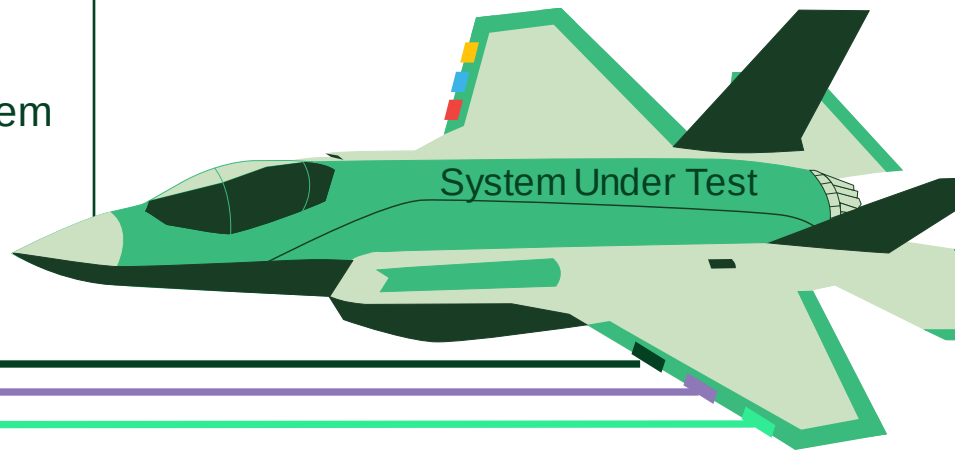
- Wideband RF Recording
  - 1 GHz IBW per channel
- 100 GbE Stream To Disk
  - 40 GB/s (8 GHz IBW)
    360 TB = 2.5 hours at max IBW
- Multi-Channel / Frequency
- Inline Processing Capable
- Offline Analysis

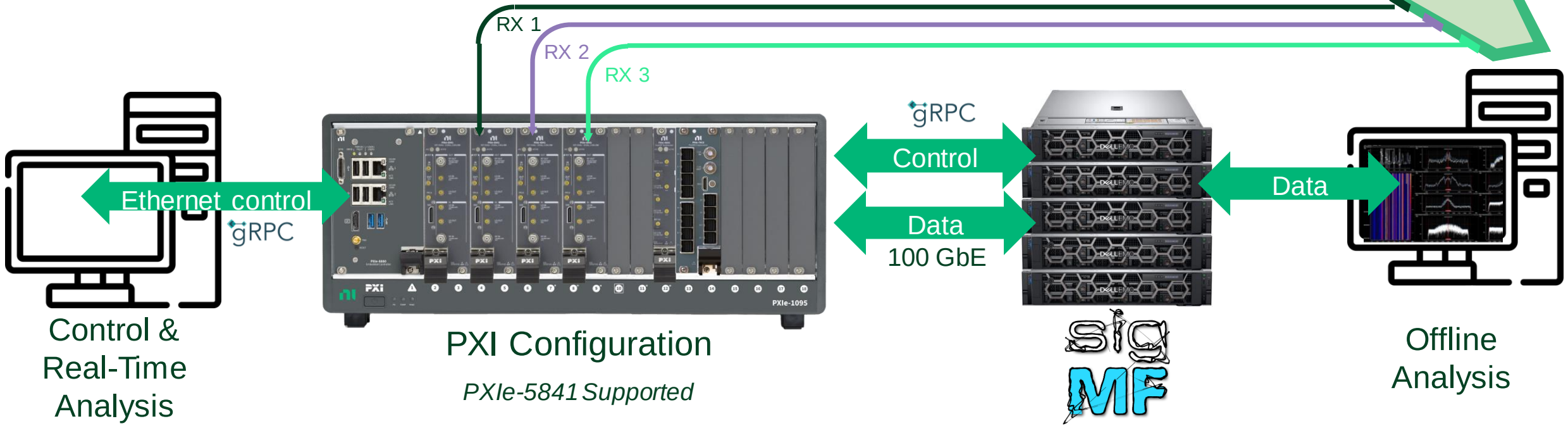
System Calibration & Sync

- Time Synchronization w/ NI-TClk
- Record Trigger Options
  - Software, Digital
- LO Power Calibration
- Wideband Multi-Channel System Equalization Calibration

System Software

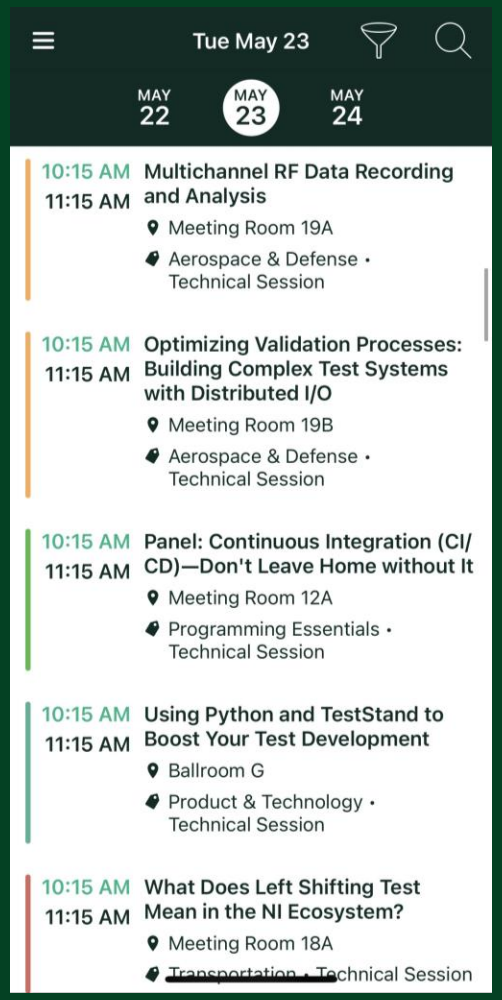
- Remote-access with gRPC
- SigMF metadata file format

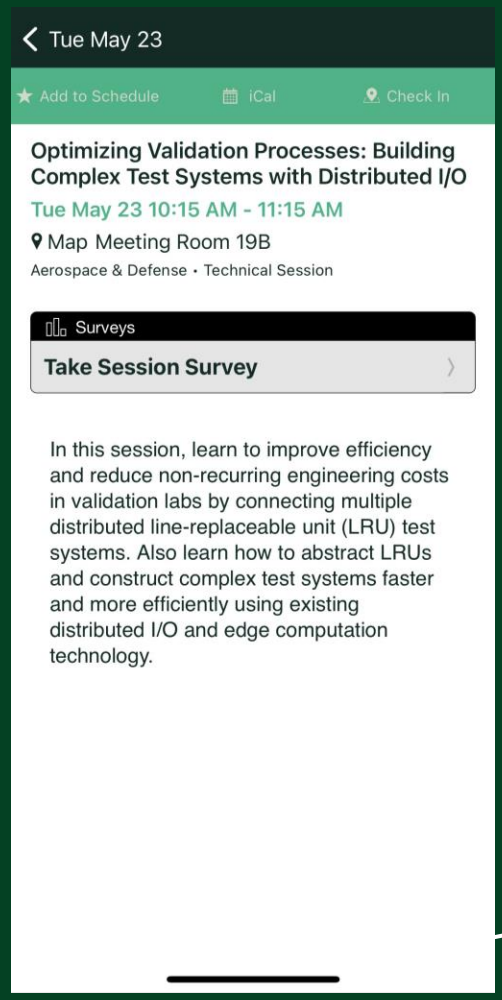




Give us your feedback! Quick 2 Question Survey

In the mobile app, click into the session you would like to provide feedback for





Click “Take the Session Survey”

Thank you!
Questions?