

BEAM INSTRUMENTATION HARDWARE ARCHITECTURE FOR UPGRADES AT THE BNL COLLIDER-ACCELERATOR COMPLEX AND THE FUTURE ELECTRON ION COLLIDER

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Collider-Accelerator
Dept.

Electron-Ion Collider

BROOKHAVEN
NATIONAL LABORATORY

Jefferson Lab

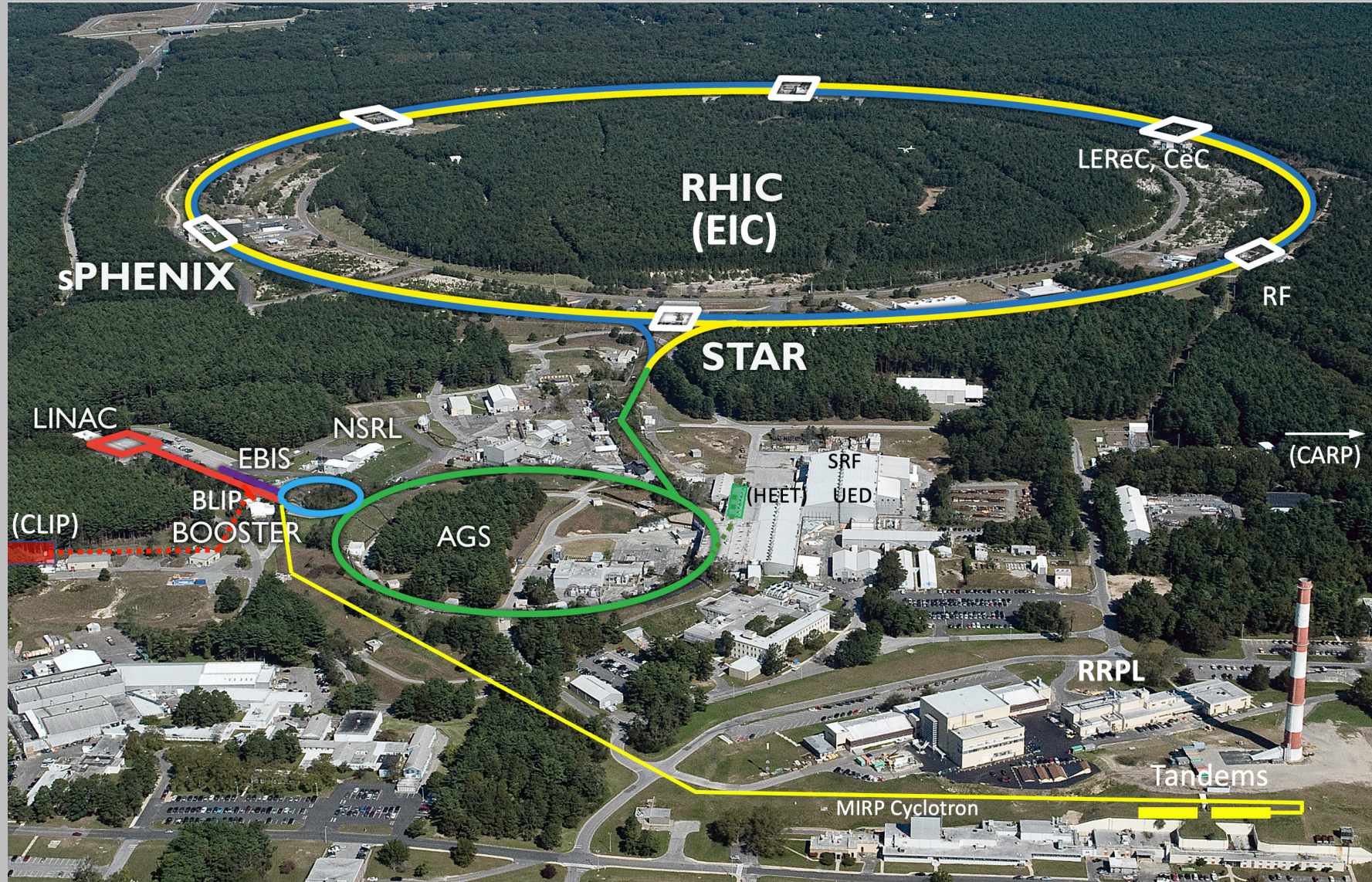


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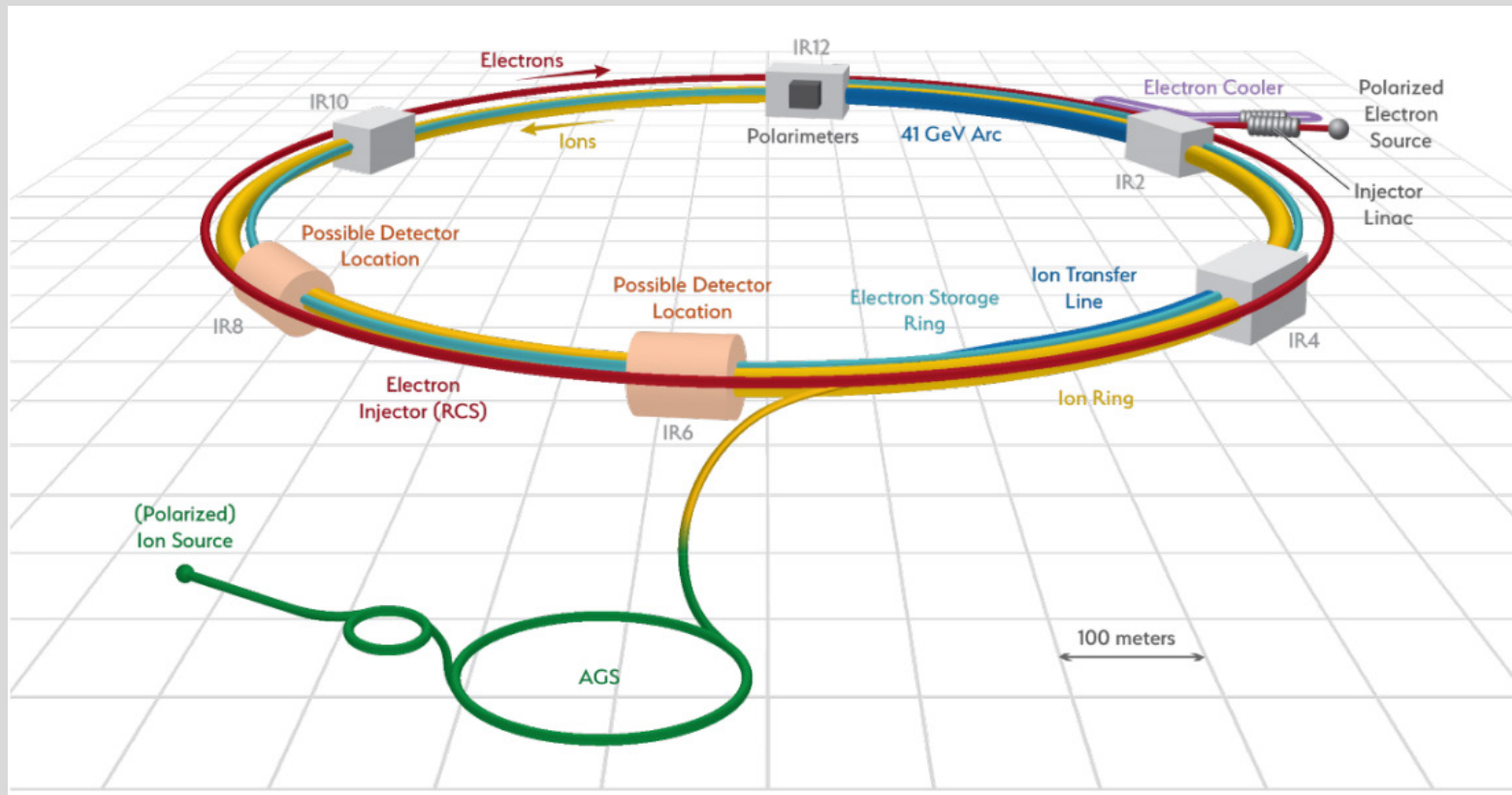
Outline

- Brookhaven National Lab (BNL) Collider-Accelerator Complex
- BNL Electron Ion Collider and required beam instrumentation
- Common platform architecture overview
- Custom modules to support beam instrumentation systems
- Summary

BNL's Collider-Accelerator Complex

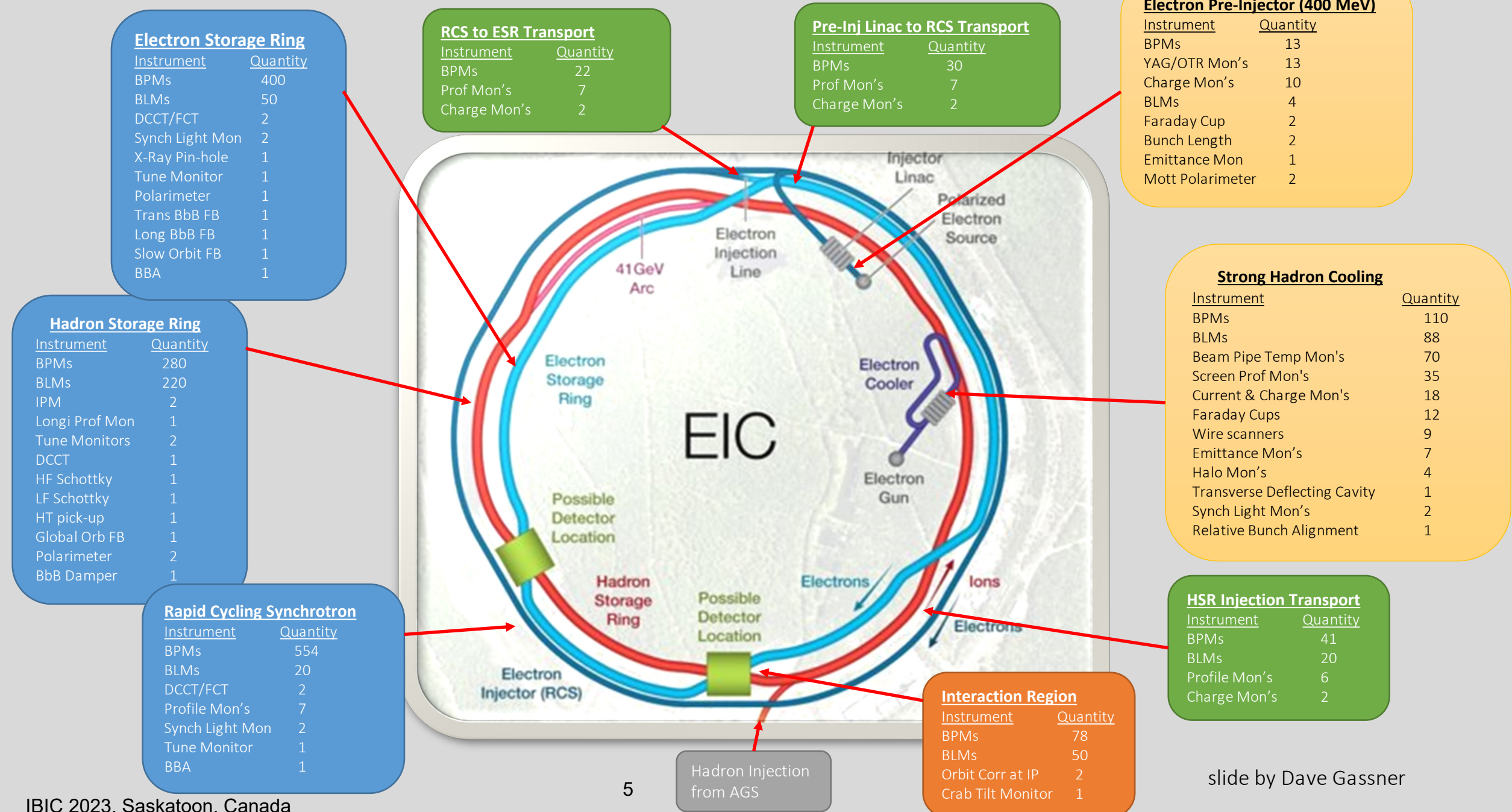


Layout of the Electron Ion Collider presently being designed



Estimated EIC full
completion date:
2034

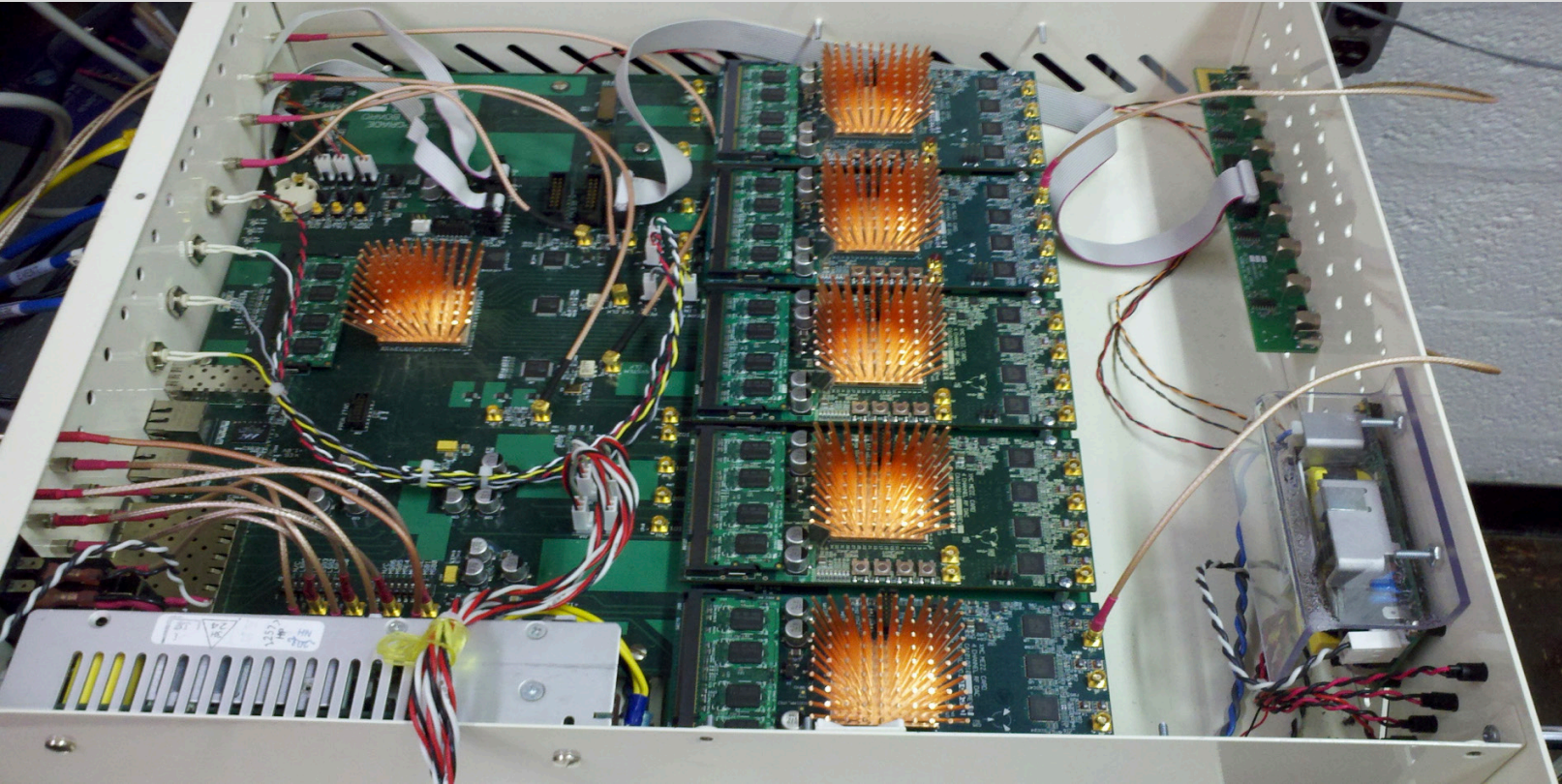
EIC Beam Instrumentation



Architecture options

- There are so many architecture platforms available. Making a decision is not a simple task.
 - VME, pizza box, uTCA, TCA, VPX, and so much more
- We have opted to develop a custom 2U chassis
- But first... a short history of a few other developments at RHIC

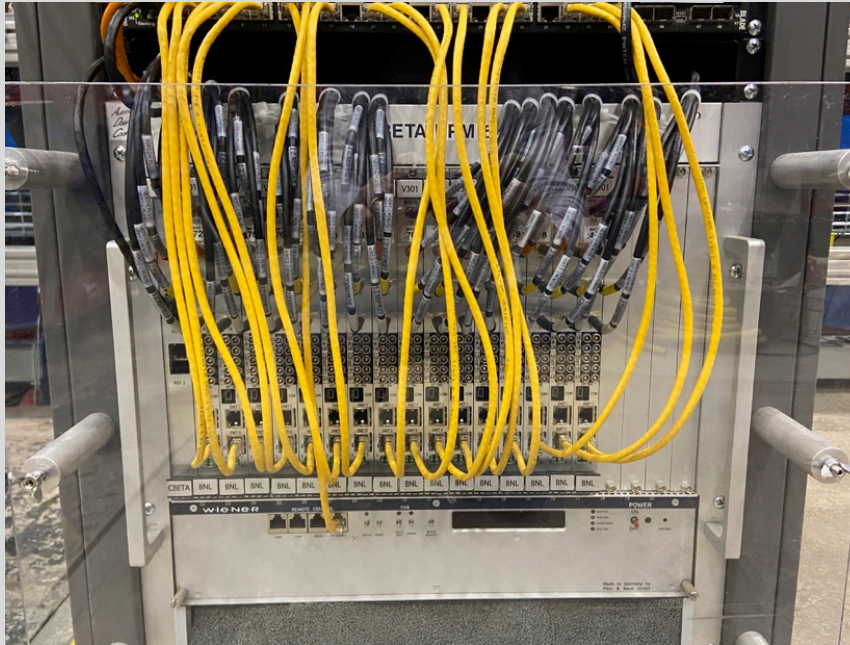
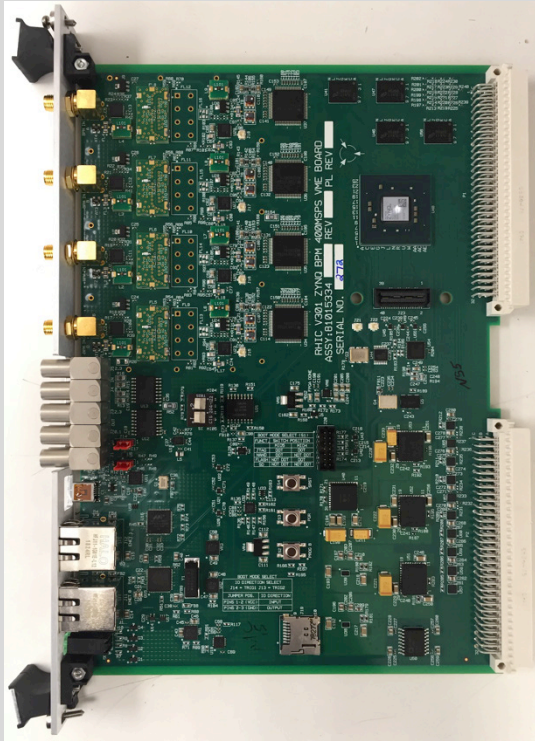
RHIC low level RF controller chassis



LLRF Controller Features

- Developed in 2009
- Custom 3U chassis
- Direct Ethernet for interface to control system
- Xilinx Virtex 5 FPGA
- vxWorks running on embedded processor in Virtex-5
- RHIC ADO software resident on board
- 6 XMC sites for application specific modules
- Ability to synchronize RF clocks between multiple chassis
- Successfully used at RHIC for many years

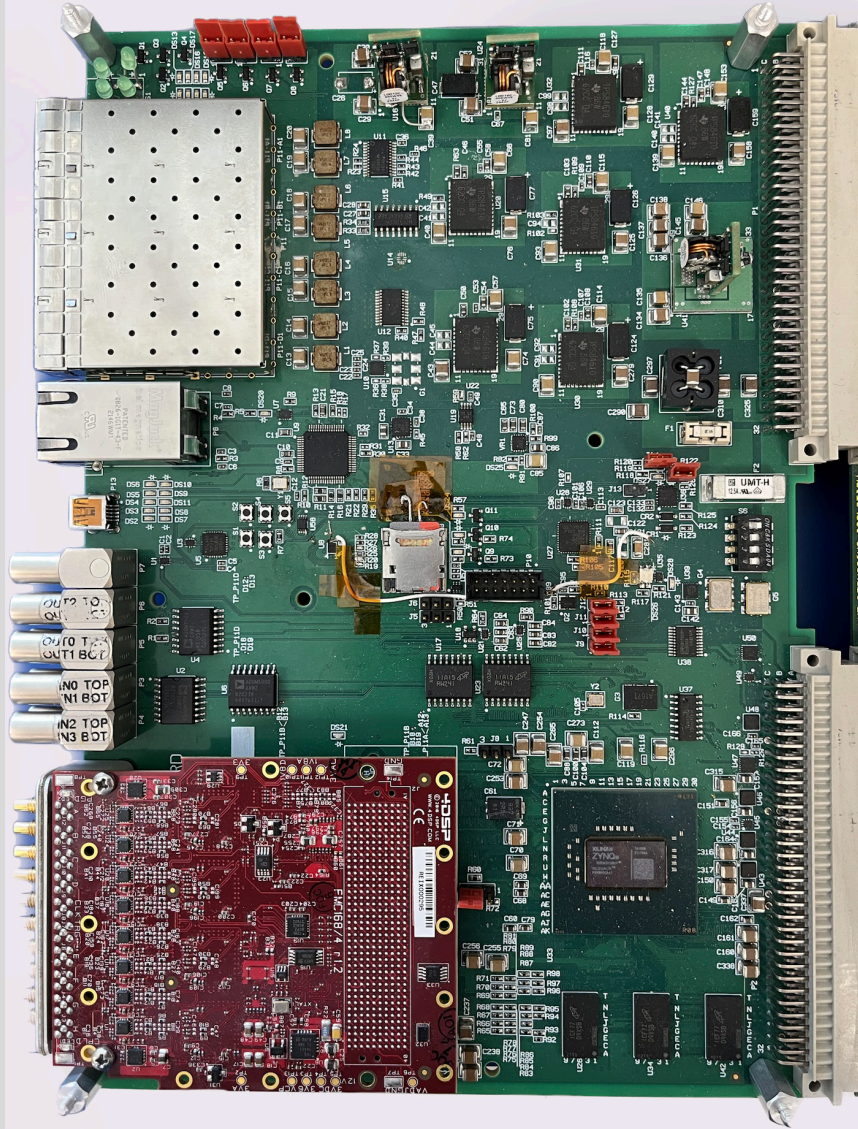
V301 BPM module



V301 FEATURES

- Developed in 2015
- VME form factor, but no VME interface
- Direct Ethernet for interface to control system
- Xilinx Zynq XC7Z030-3FBG676E
- Linux running on embedded processor in Zynq
- EPICS IOC or RHIC ADO software resident on board
- Supports one 4-pickup BPM per board
- Beam sync clocks and timing links distributed to all V301s in chassis from board in slot 1 via unused P2 pins
- Up to 15 V301s installed in VME chassis
- Successfully used for RHIC, Linac, LEReC, CBETA

V340 General purpose module



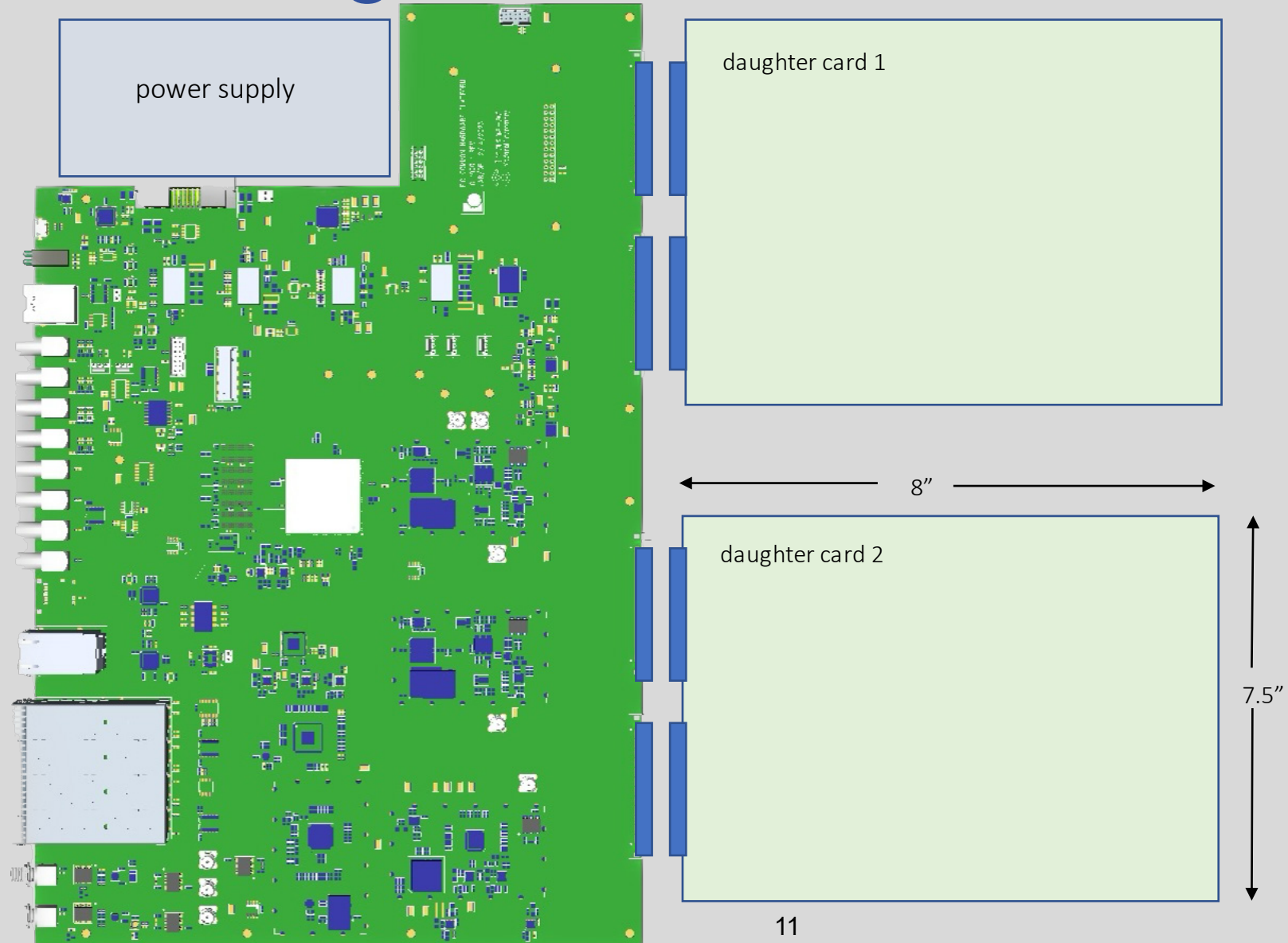
V340 FEATURES

- Developed in 2022
- Modeled from the V301, but with FMC connector instead of BPM RF front-end circuit
- VME form factor, but no VME interface
- Direct Ethernet for interface to control system
- Xilinx Zynq Ultrascale+
- Linux runs on embedded processor in Zynq
- EPICS IOC or RHIC ADO software can be resident on board
- FMC high pin count connector
- Beam sync clocks and timing links distributed to all V340s in chassis from board in slot 1 via unused P2 pins
- Up to 15 V340s can be installed in VME chassis
- One application for the V340 is beam current/charge measurements

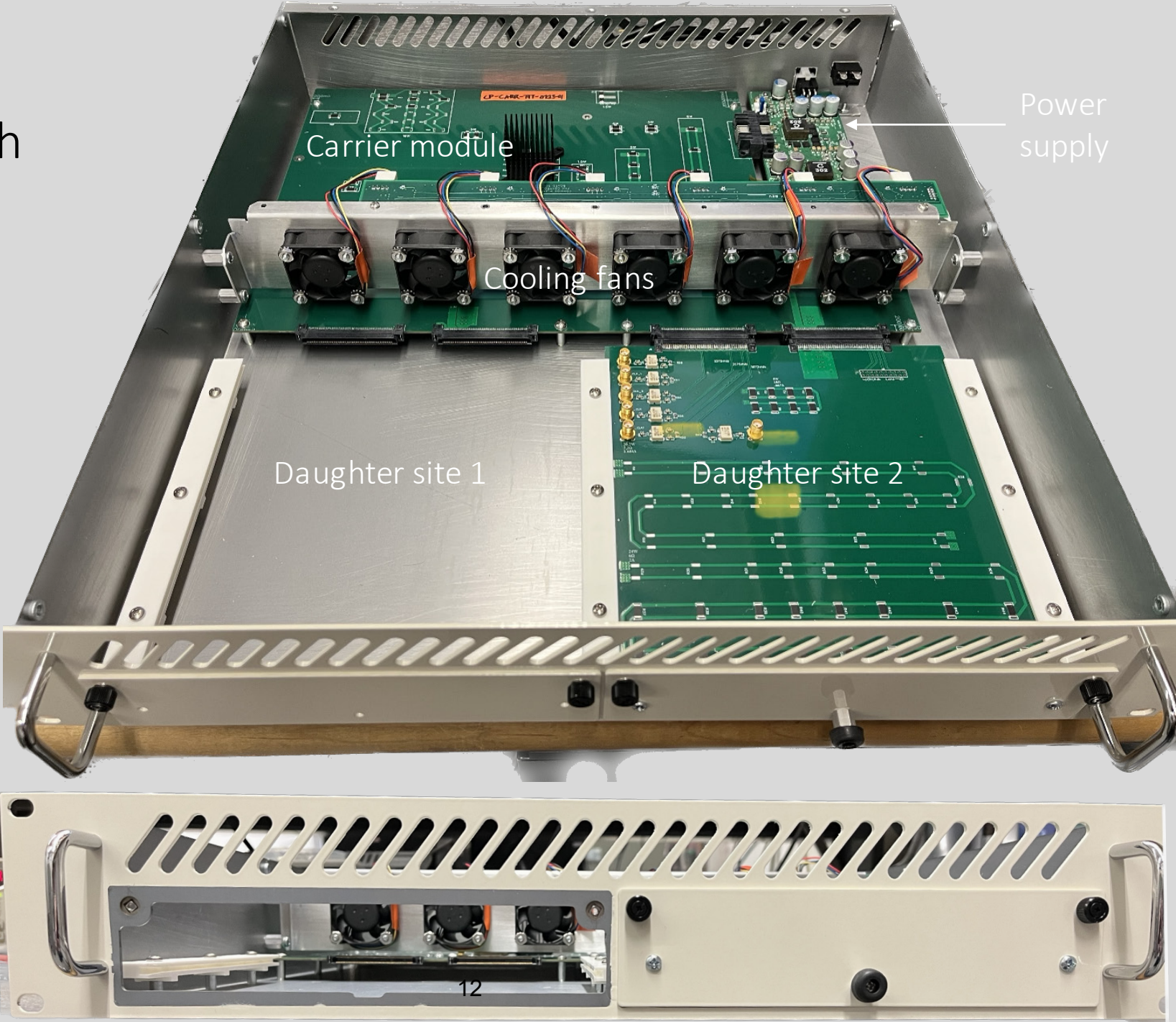
Common platform overview

- For EIC and upgrades at the existing injector complex, a custom common platform system is in the process of being developed, consisting of:
 - Custom 2U rack mount chassis
 - Carrier module, with connectors for 2 daughter cards
 - Custom daughter cards to support application specific requirements
- First prototype of the carrier module is expected to be received in October 2023
- **This talk will focus on the beam instrumentation applications**

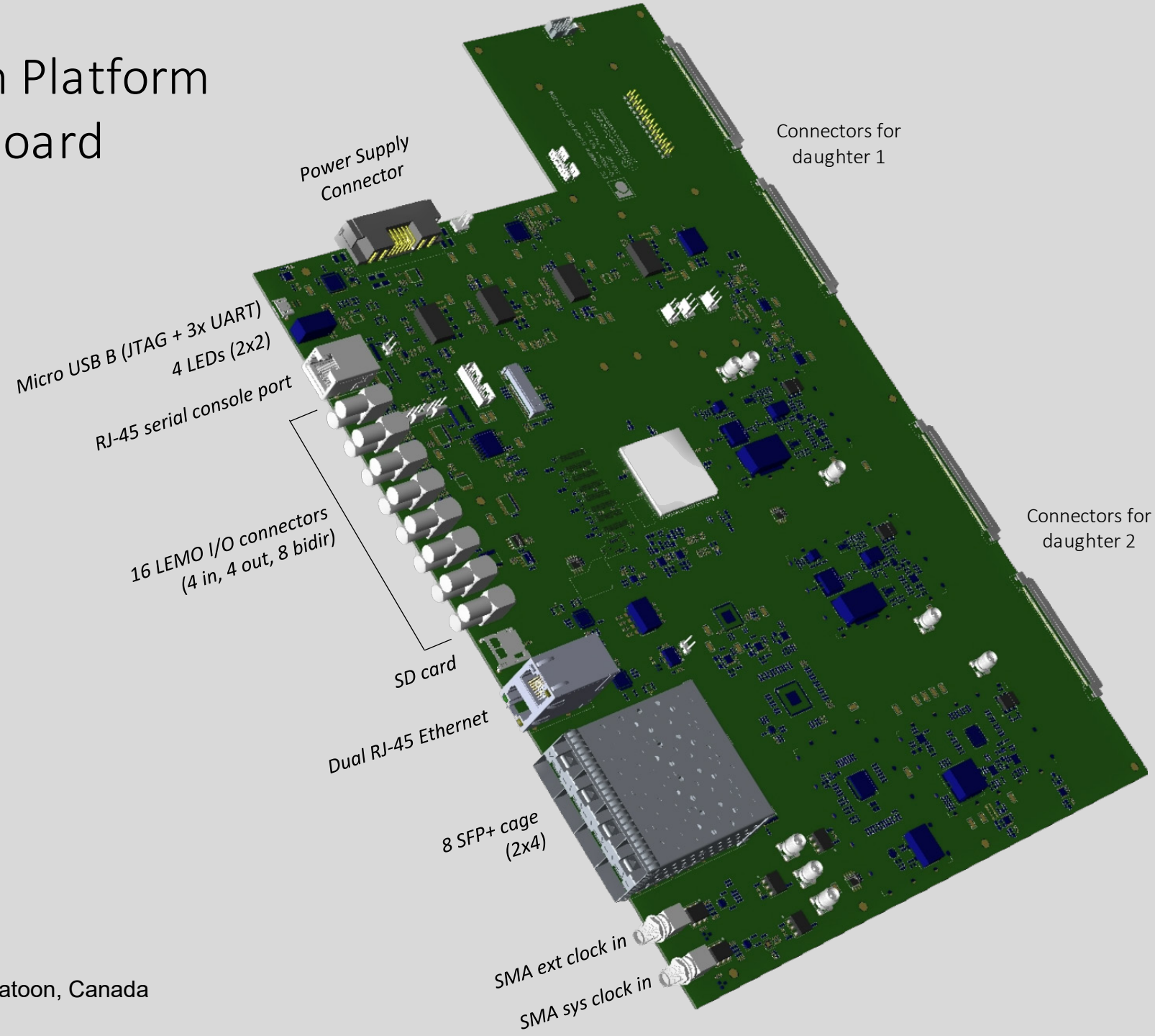
Layout of common platform carrier module and daughter cards

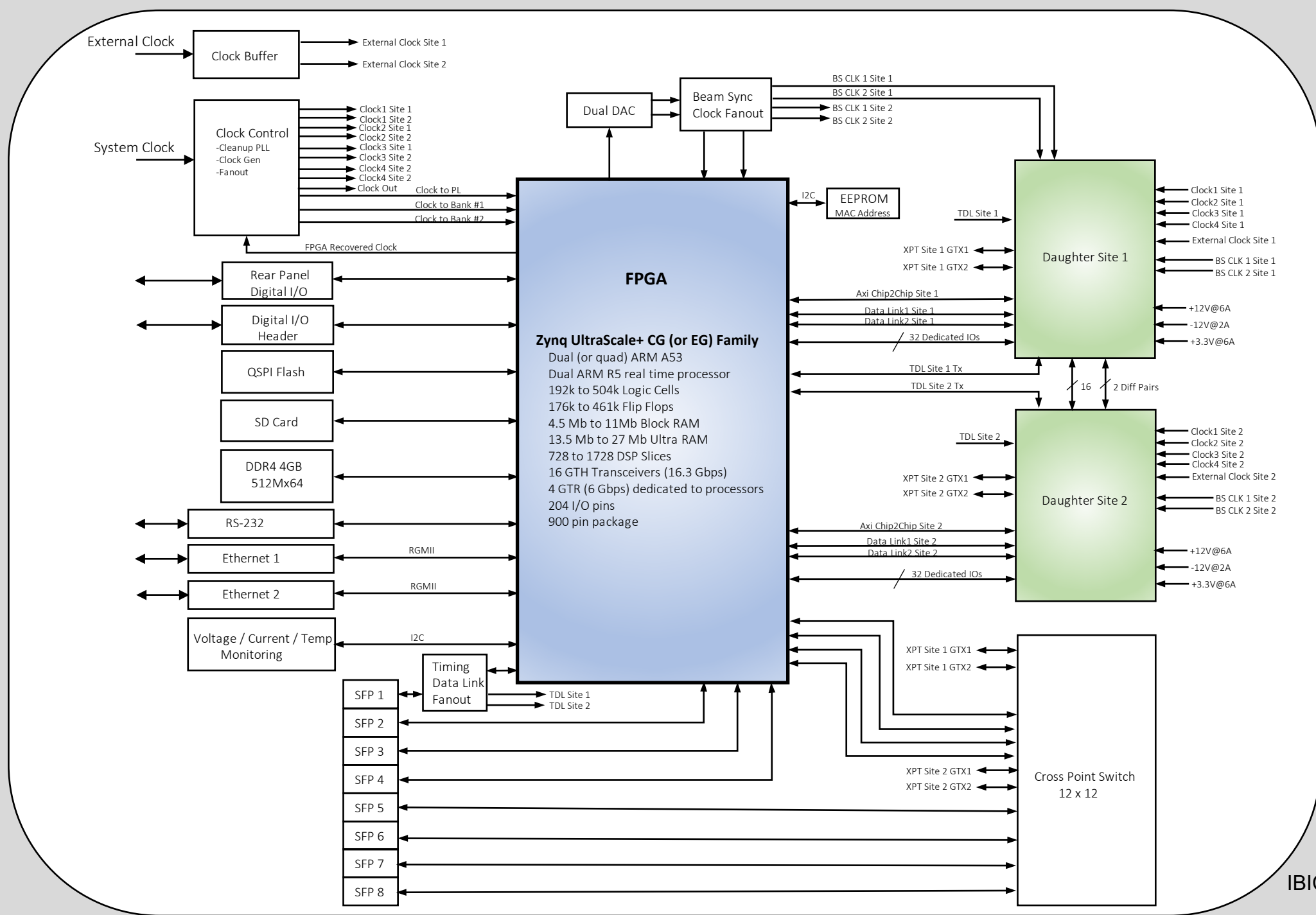


Common Platform
mockup chassis with
carrier board and
one daughter card



Common Platform Carrier Board

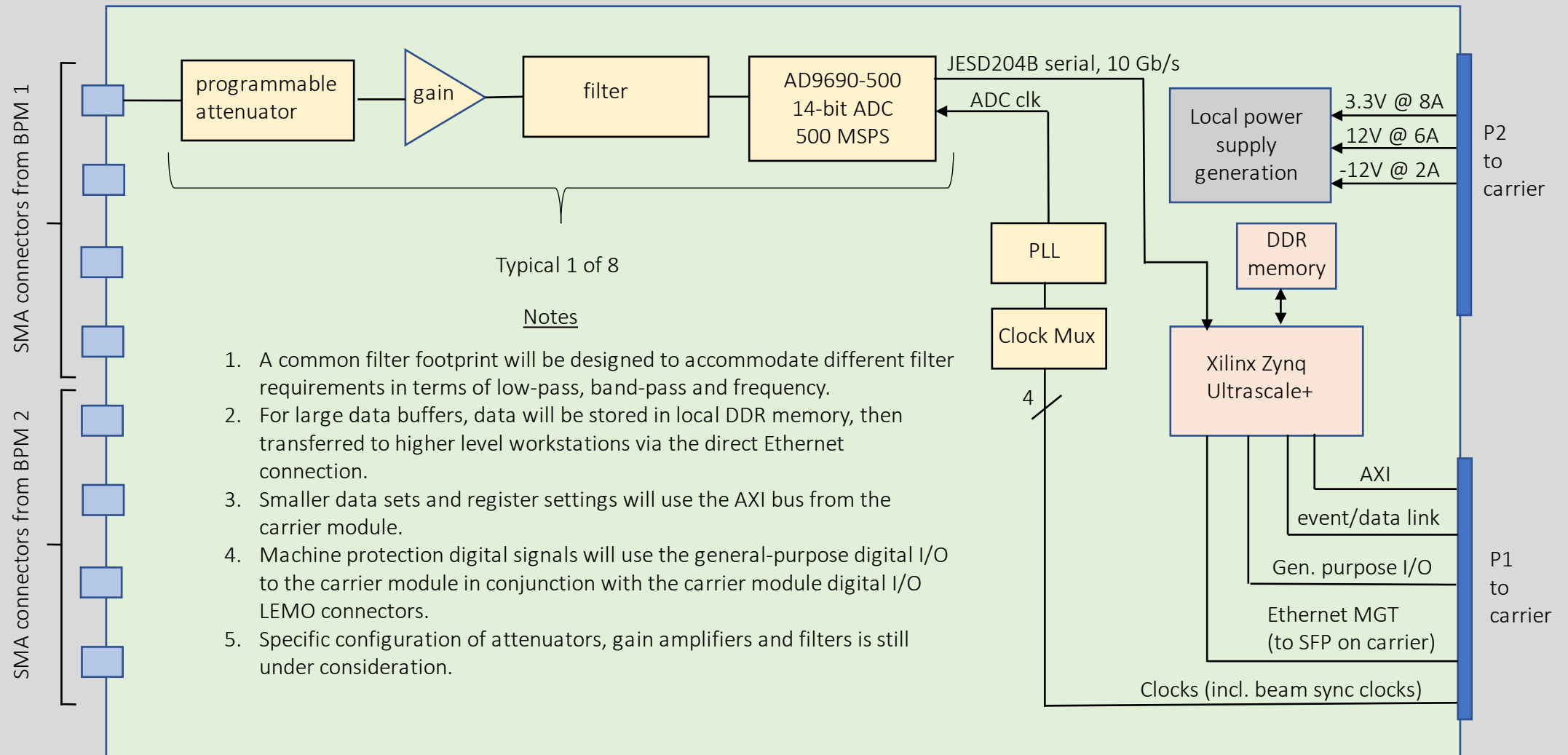




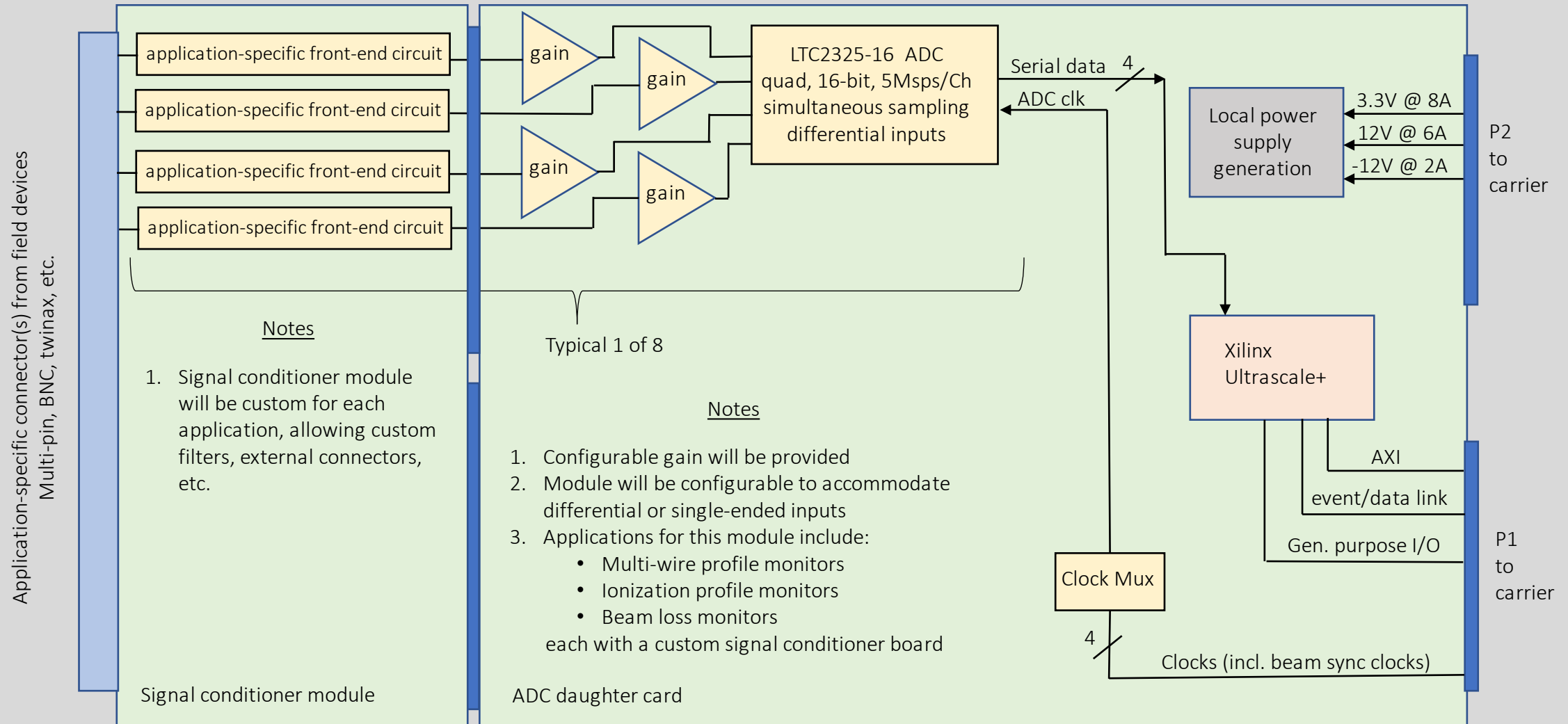
Common
Platform

Carrier
Board
block
diagram

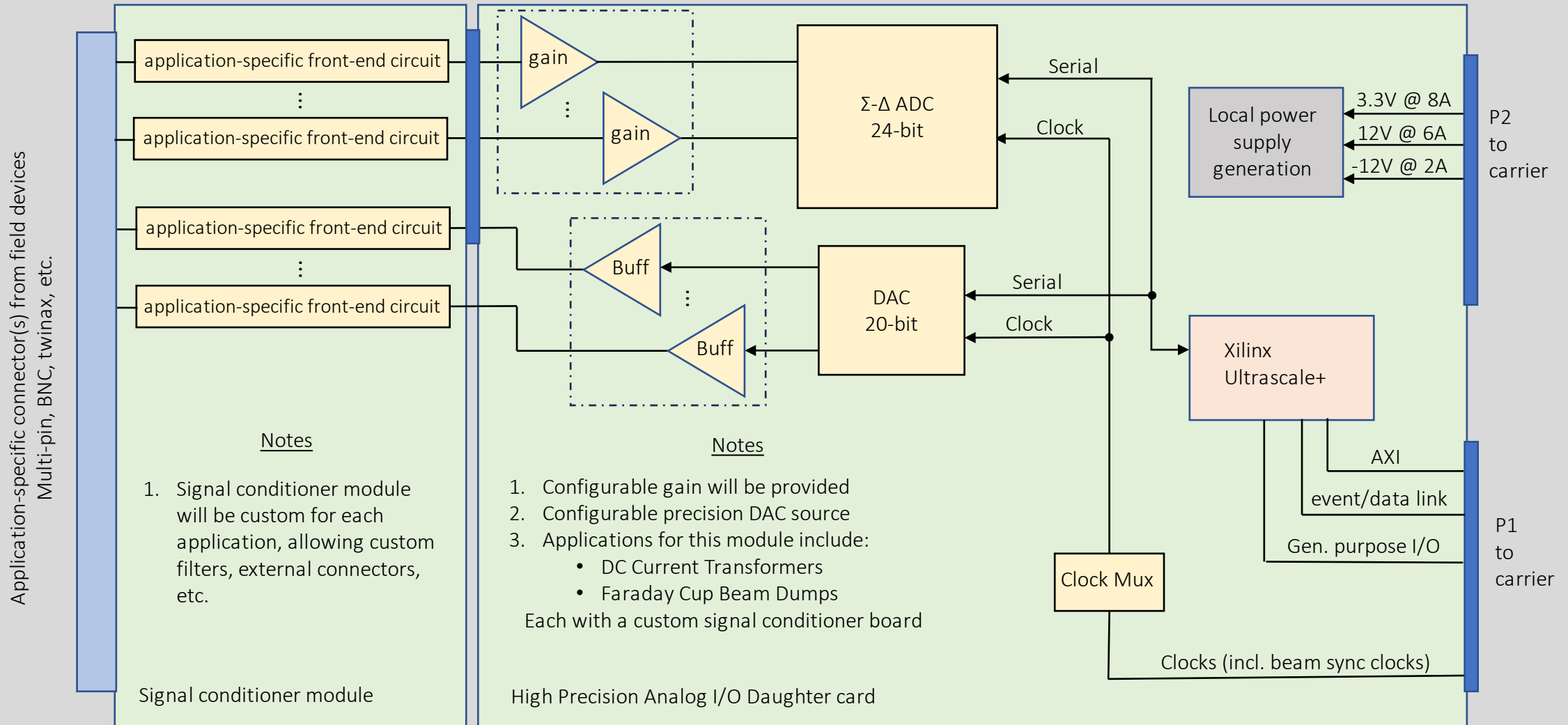
Beam position monitor daughter card block diagram



General purpose 32-chan 5MSPS per chan analog input daughter card



High precision analog input/output daughter card



Bunch charge monitor daughter card

- For bunch charge measurements (Wall Current Monitor, Integrating Beam Current Transformers, Fast Current Transformers, etc.) another daughter card will be developed with the following features:
 - DC coupled inputs
 - 1 GSPS ADCs or faster
 - 4 channels
- This module is still in the very early design phase

The daughter card suite

- The suite of daughter cards is expected to grow for applications in:
 - Beam instrumentation
 - RF
 - Controls
 - Feedback systems
 - And more
- Other daughter cards presently being developed include:
 - General purpose module with FMC interface (1 LPC, 1 HPC) to accommodate applications with 3rd party or custom FMC boards
 - General purpose module with 16 SFP ports for data link and clock fanouts, as well as other applications

Summary

- The BNL Collider-Accelerator and EIC Instrumentation, Controls, RF and other groups are combining efforts to develop a custom hardware platform with a suite of custom daughter cards to satisfy the hardware and software requirements for new EIC systems and upgrades at the existing collider-accelerator complex.
- The first carrier prototype module is expected to be received in October 2023
- Several daughter card modules are in the process of being designed
- If anyone is interested in joining our endeavor, please contact us

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Thank you!