



FACET-II

Facility for Advanced Accelerator Experimental Tests

FACET-II Diagnostics Overview

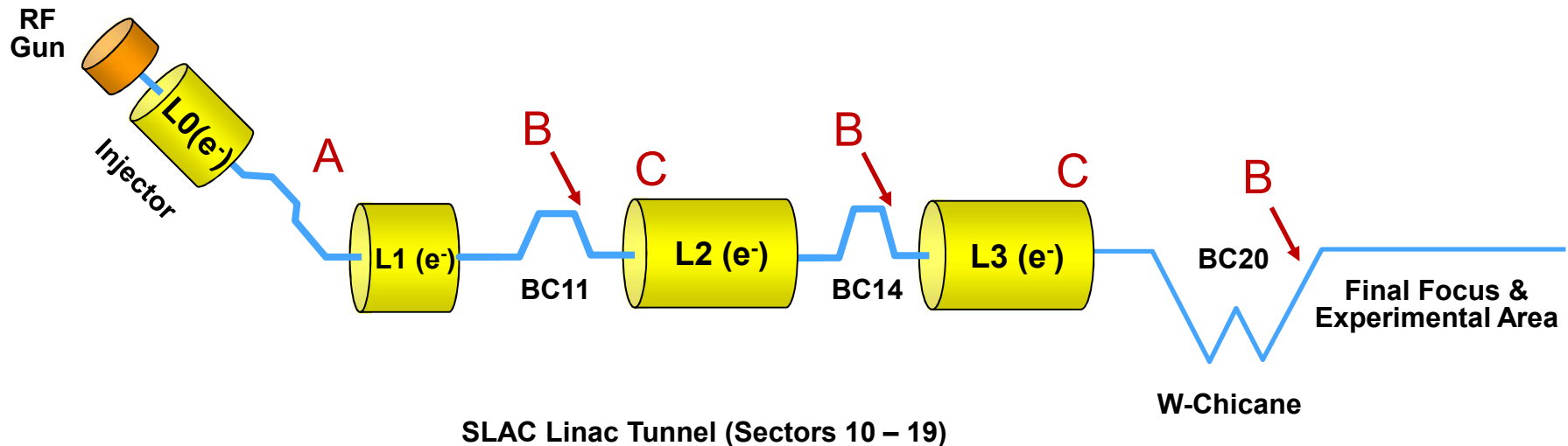
FACET-II Science Workshop
October 29 – November 1, 2019

Nate Lipkowitz
Engineering Physicist
Diagnostics & Controls



FACET-II Stage 1 Diagnostics Overview

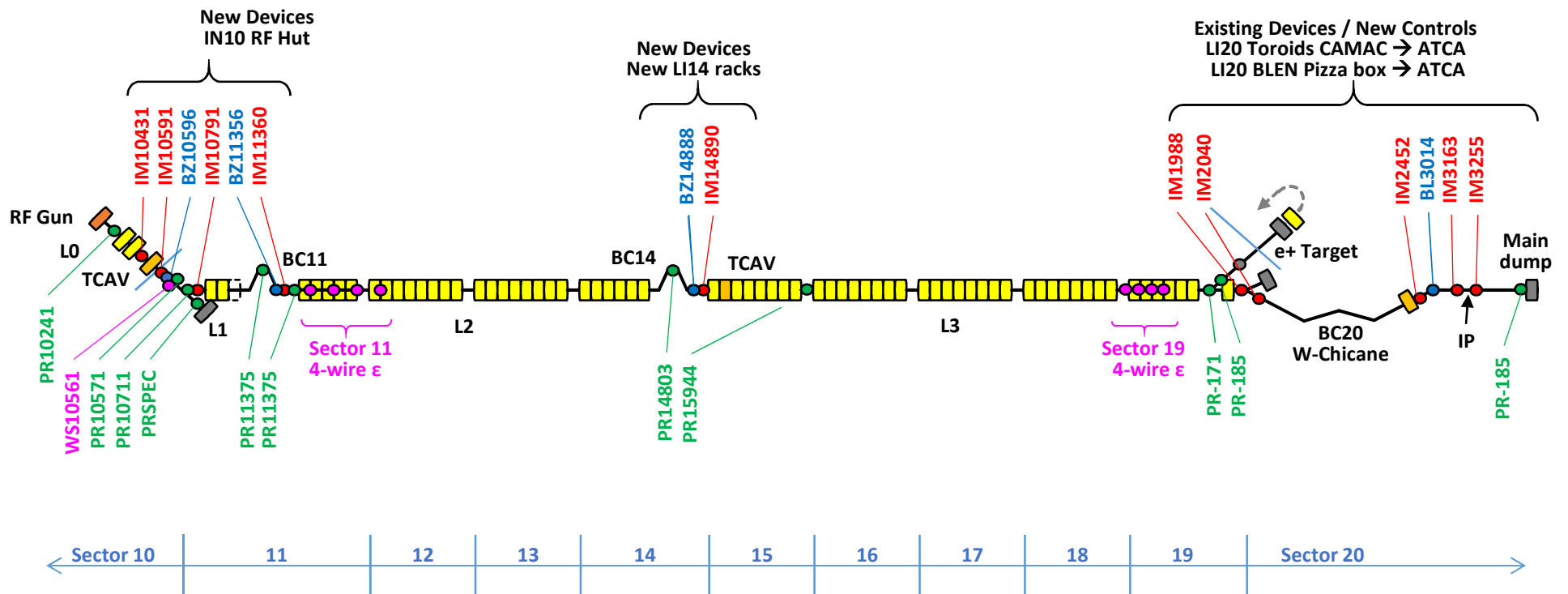
- **Goal:** Deliver compressed electron beam from S10 to experiments in S20
- e- diagnostics support this beam delivery goal by measuring:
 - A. After injector: fully characterized beam (6D)
 - B. After each BC: longitudinal (E, z) distribution and charge
 - C. Into & out of Linac: transverse (x, y) emittance
- Retain the existing diagnostics in the FF → IP → Dump



FACET-II Diagnostics

Stage 1 Diagnostics Overview

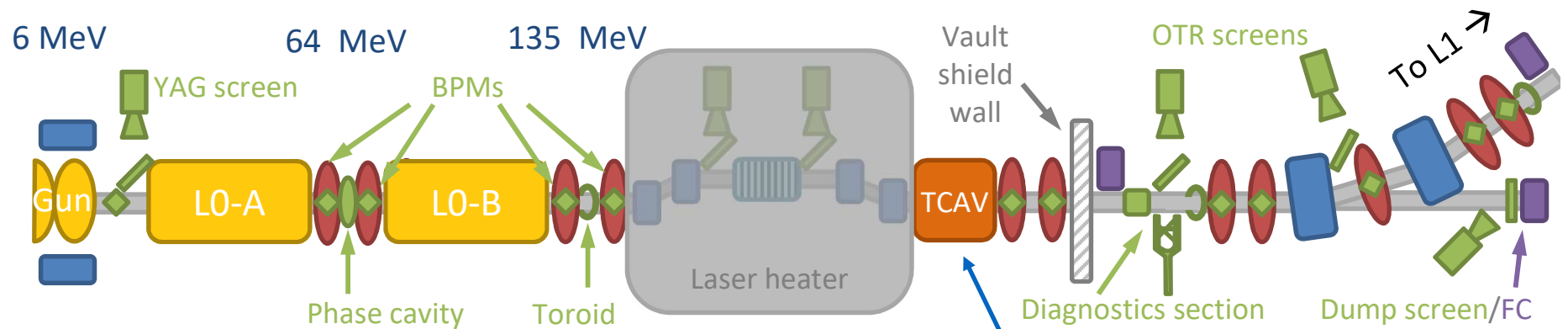
- BCM Toroid
- Profile Monitor
- Bunch Length
- Wire scanner



FACET-II Diagnostics

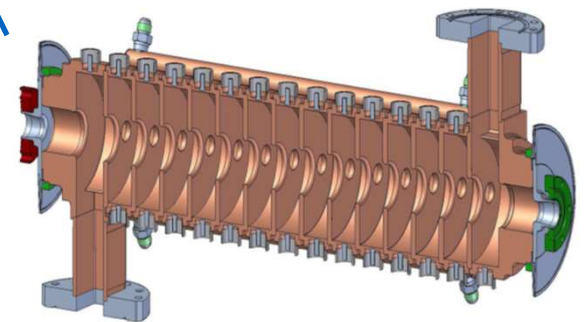
Injector e- Diagnostics Overview

SLAC



Provide to linac a beam of known:

- Charge
- Arrival time
- Bunch length & distribution
- Energy, energy spread & distribution
- Transverse emittance (projected and sliced)



- 1.4 MV crest deflection
- 2 MW from klystron 10-5

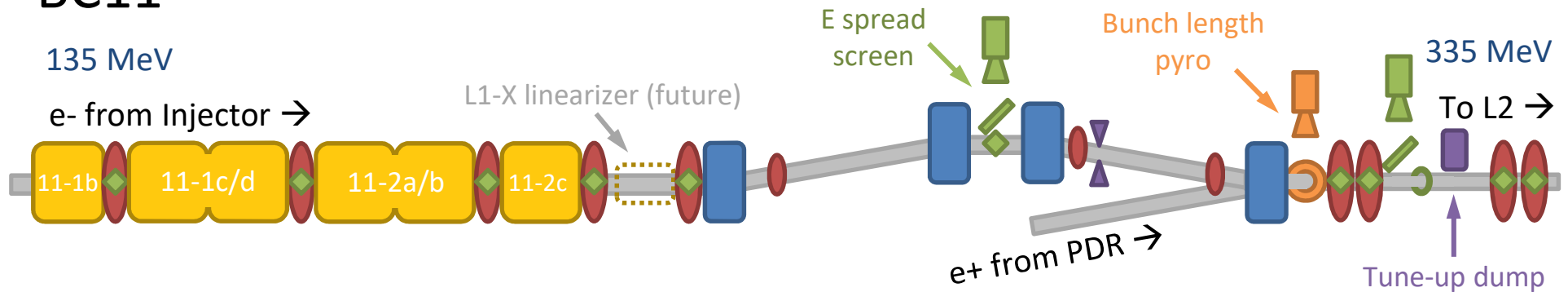
The most useful LCLS injector diagnostics are reproduced for the FACET-II injector

FACET-II Diagnostics Linac L1, BC11 and BC14 Overview

BC11

135 MeV

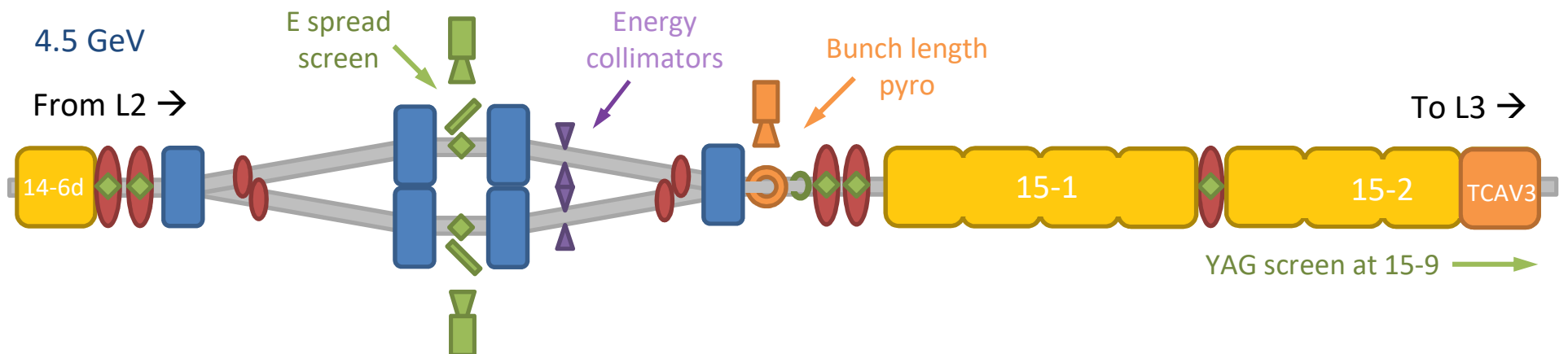
e- from Injector →



BC14

4.5 GeV

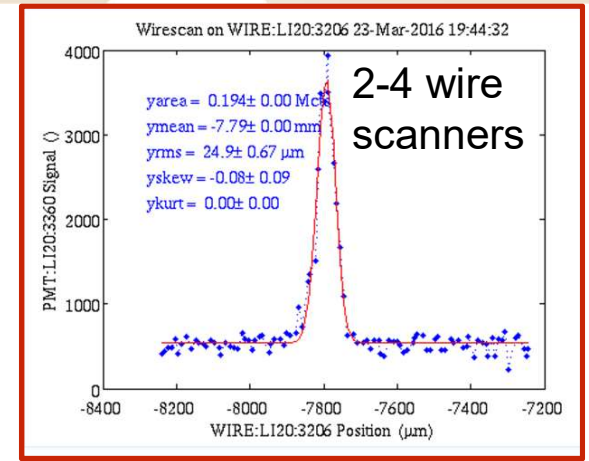
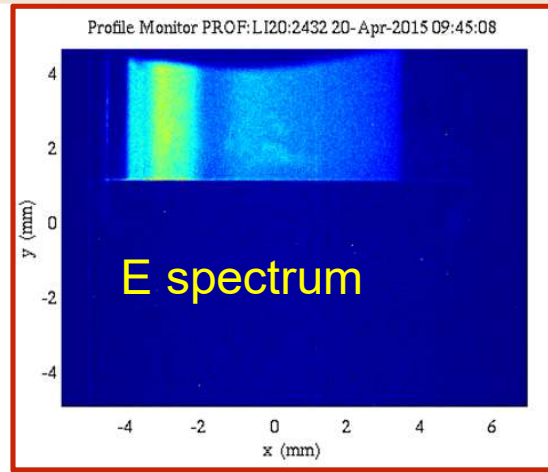
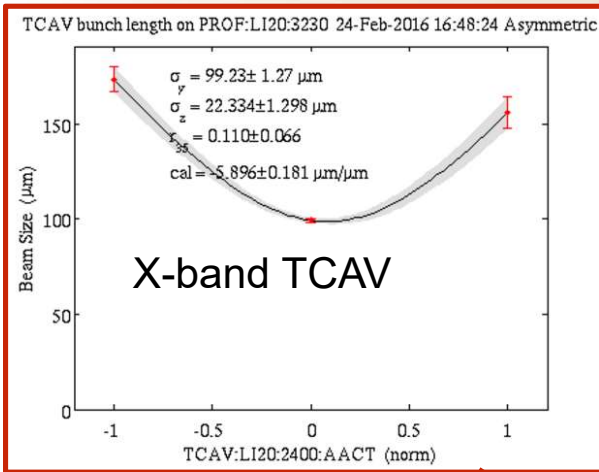
From L2 →



Bunch compressors have longitudinal phase space diagnostics

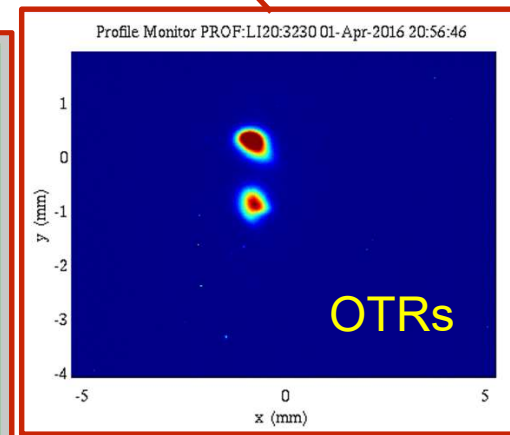
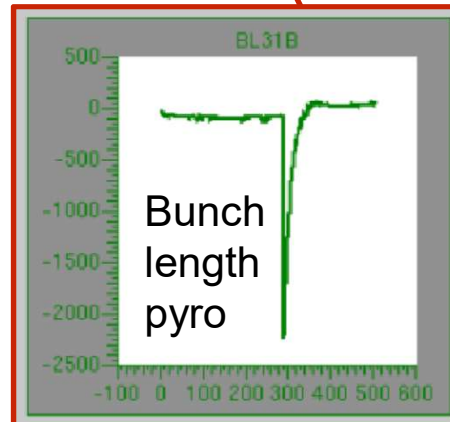
FACET-II Diagnostics

Important Existing Sector 20 Devices



- Bend Magnet
- De-focusing Quadrupole
- Focusing Quadrupole
- Horizontal/Vertical Correctors
- Sextupole
- Wiggler
- Vacuum Gauges
- Vacuum Pump
- Vacuum Valves
- Ion Chamber
- Wire Scanner
- Beam Position Monitor
- Toroid
- Profile Monitor
- Deflecting Cavity

W chicane and IP area diagnostics all new for FACET.

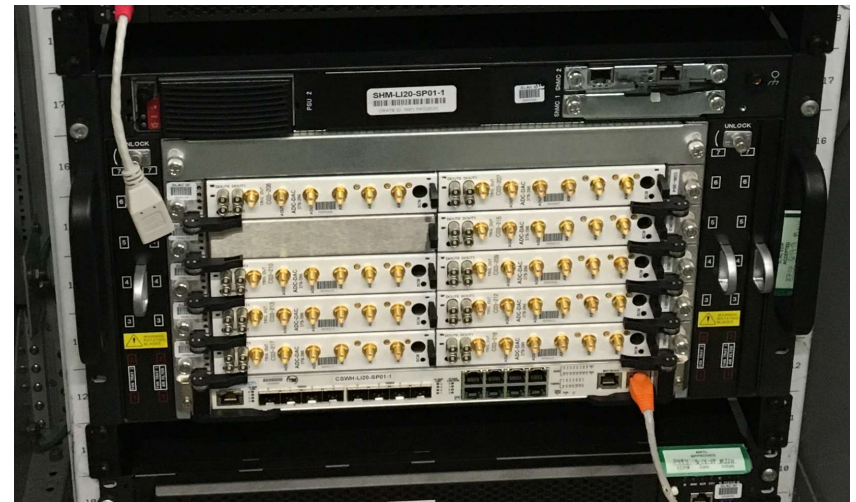


FACET-II Diagnostics

ATCA Common Platform Controls

Where possible, adopted the LCLS/LCLS-II HPS common platform architecture (ATCA):

- Existing designs for BPM, BCM, BLEN (and LLRF)
- Shared components, bulk order discounts, etc
- Already integrates with MPS, timing, control system standards
- High performance (MHz beam)
- Growing pool of general and special purpose IO modules

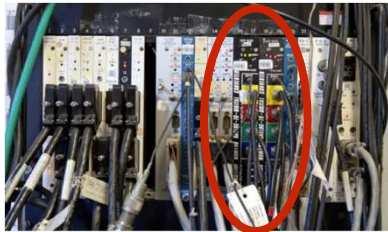


<https://slacspace.slac.stanford.edu/sites/lcls/lcls-2/sei/Review%20Presentation%20Background%20Documents/Accel/2017-04-002/Presentations/>

FACET-II Diagnostics Beam Position Monitor Processors

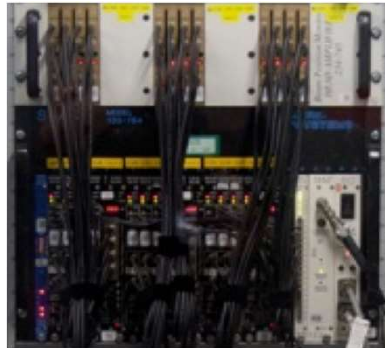


Linac, BC11, BC14,
e+ source, e+ return



CAMAC 605/972
SLC, 1983
Hybrid mixer
3x self-triggering
track-and-hold
10-bit gated ADC
50 μm precision
~800 pC min.

BC20 + IP



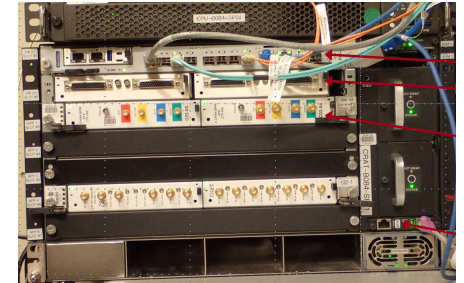
CAMAC NiTnH
FFTB, 1991
Preamp/stretcher
2x self-triggering
track-and-hold
16-bit latching ADC
< 5 μm precision
~100 pC min.

FACET IP



VME XTA BPM
LCLS/XTA, 2008
4x 140 MHz BP filter
+ 4x preamp
~100 MHz 12-bit
digitizer
< 5 μm precision
~10 pC min.

e- Injector

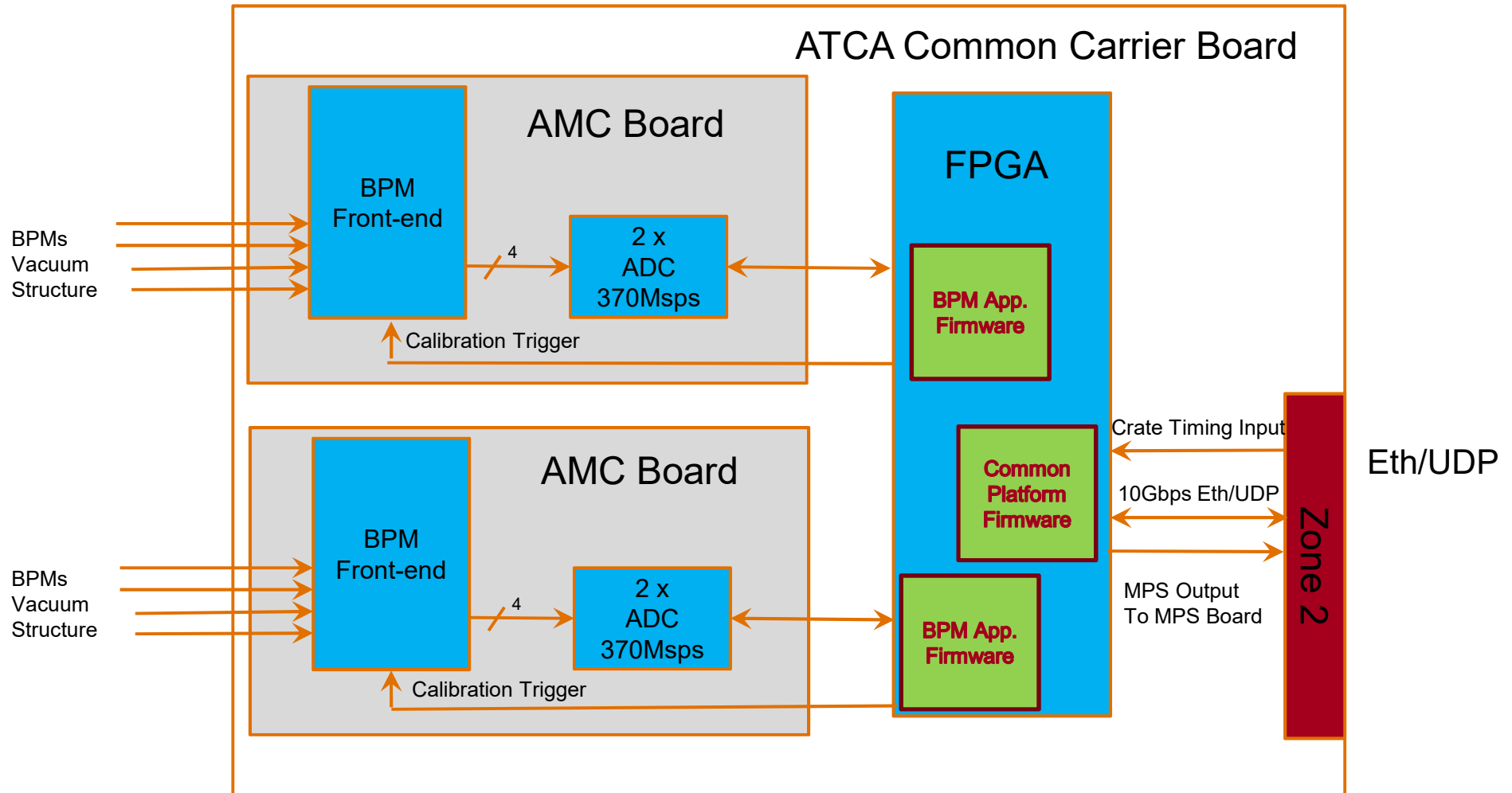


ATCA BPM
LCLS/FACET-II, 2018
4x 140 MHz BP filter +
4x preamp
370 MHz 16-bit ADC
< 1 μm precision
~10 pC min.

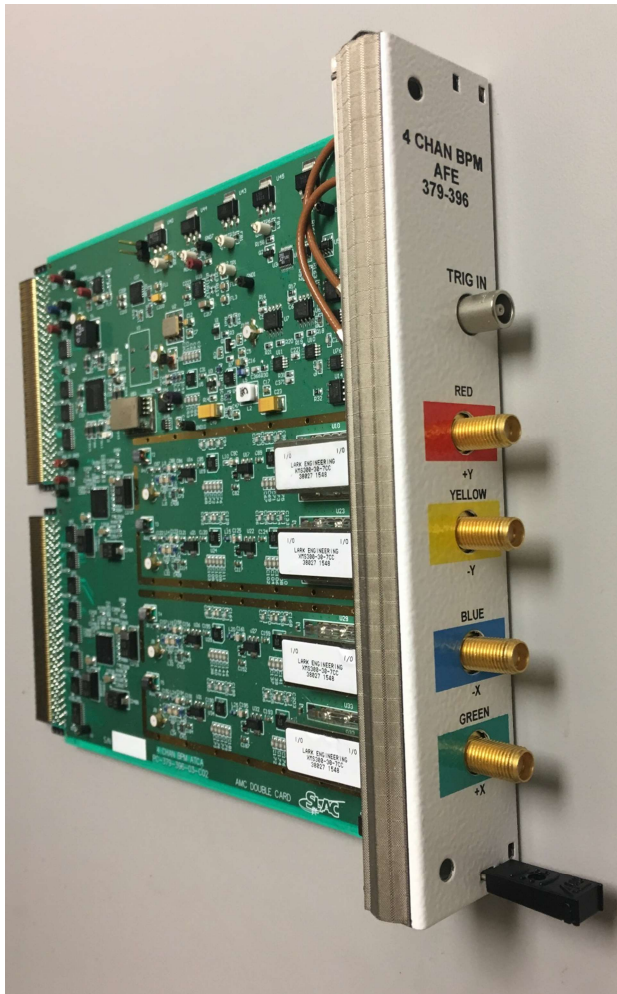
BPMs are the primary diagnostic for monitoring, feedback and tuning

Stripline and Cold Button BPM Block Diagram & Interfaces

Two BPM's serviced by on a single ATCA Common Carrier Board

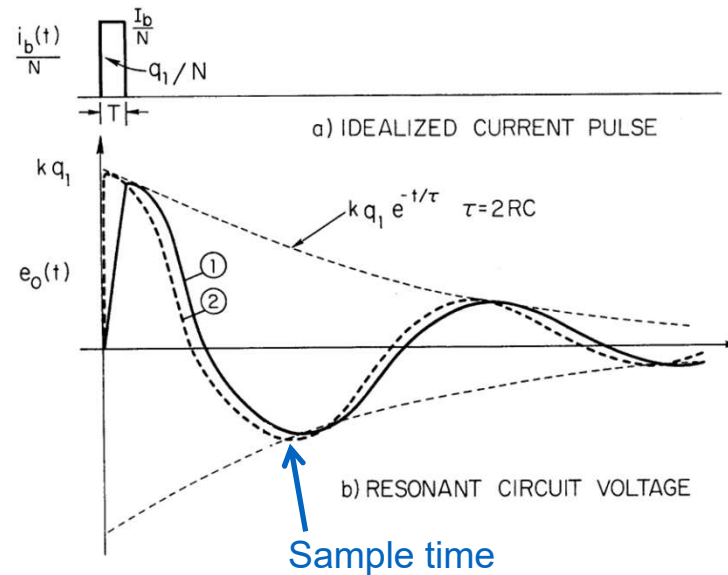
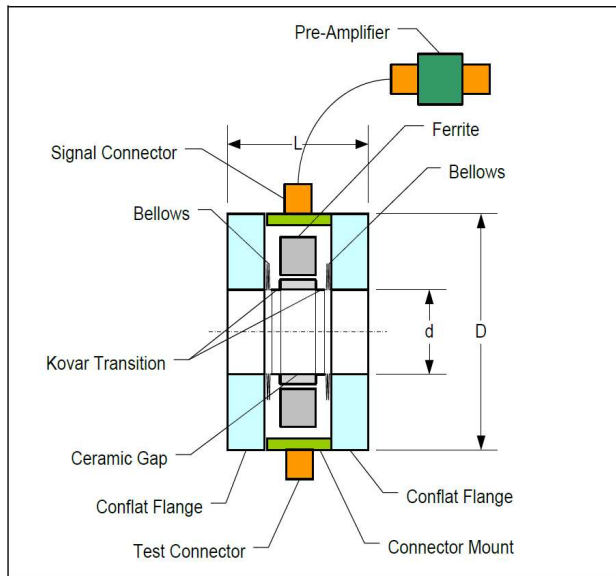


FACET-II Diagnostics ATCA Stripline BPM AMC



FACET-II Diagnostics Toroid Beam Charge Monitors

Resonant toroid current transformers with calibration winding



Typically:

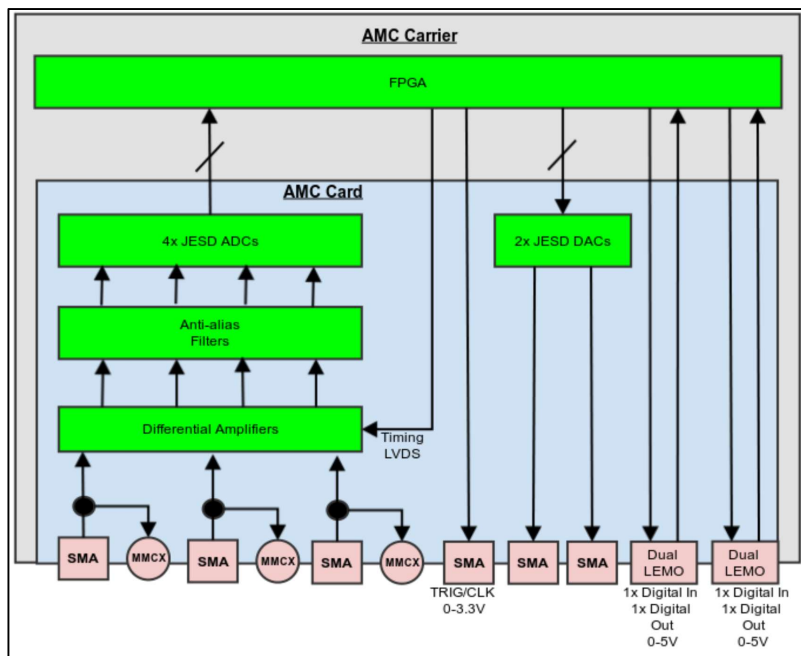
- 8-turn signal
- 1-turn calib.
- $f \sim 50$ kHz

CAMAC TCM module + SLAC preamplifier – used at FACET

- Rectifier to S&H circuit to 10-bit gated ADC
- $\sim 5\%$ absolute accuracy and precision at 3 nC

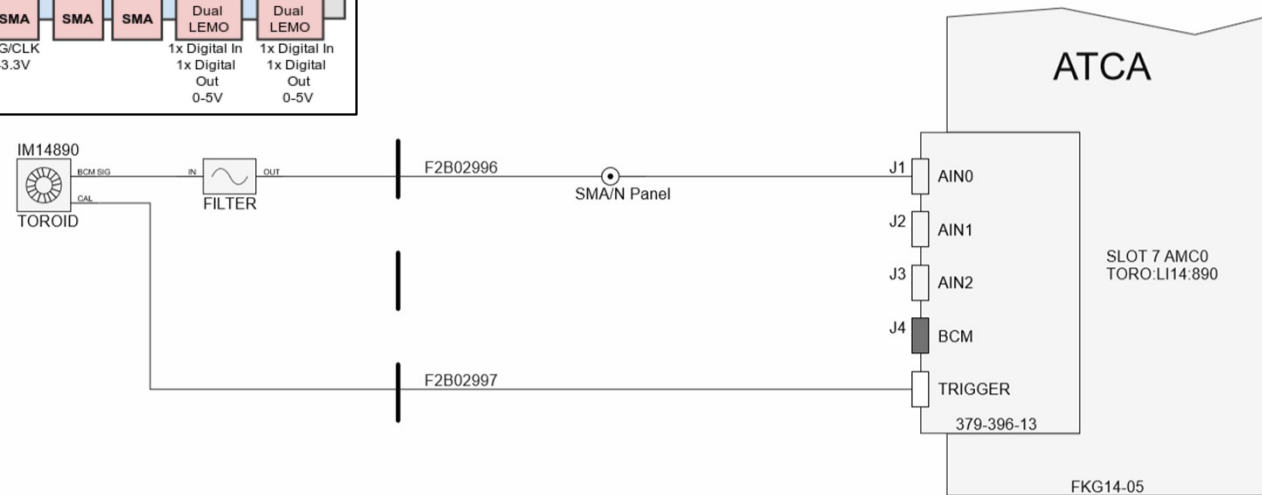
Toroids in FACET-II monitor total beam charge at boundaries of functional areas

Architecture – BCM Hardware

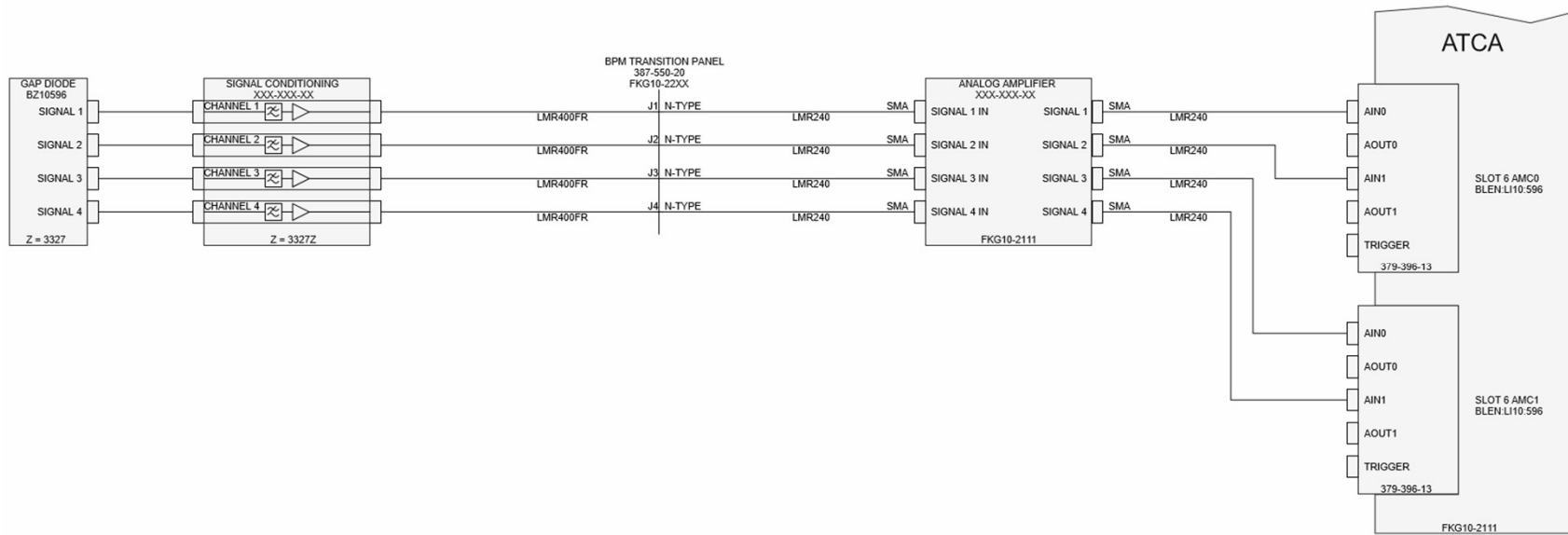


Mission Readiness BCM

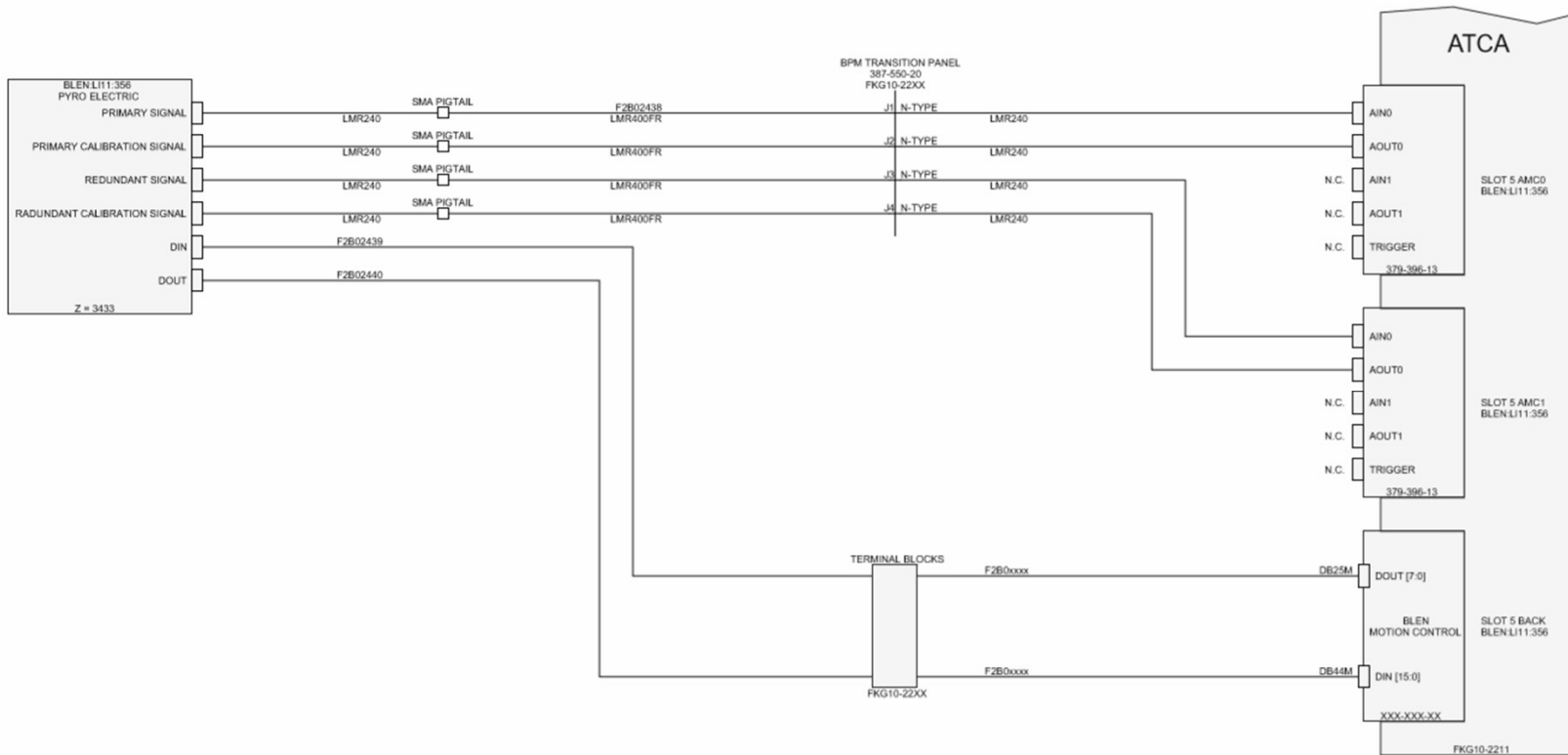
- Designed for LCLS, first use at FACET-II
- 370 MHz, 16 bit ADC
- <1 % error, at 150 pC



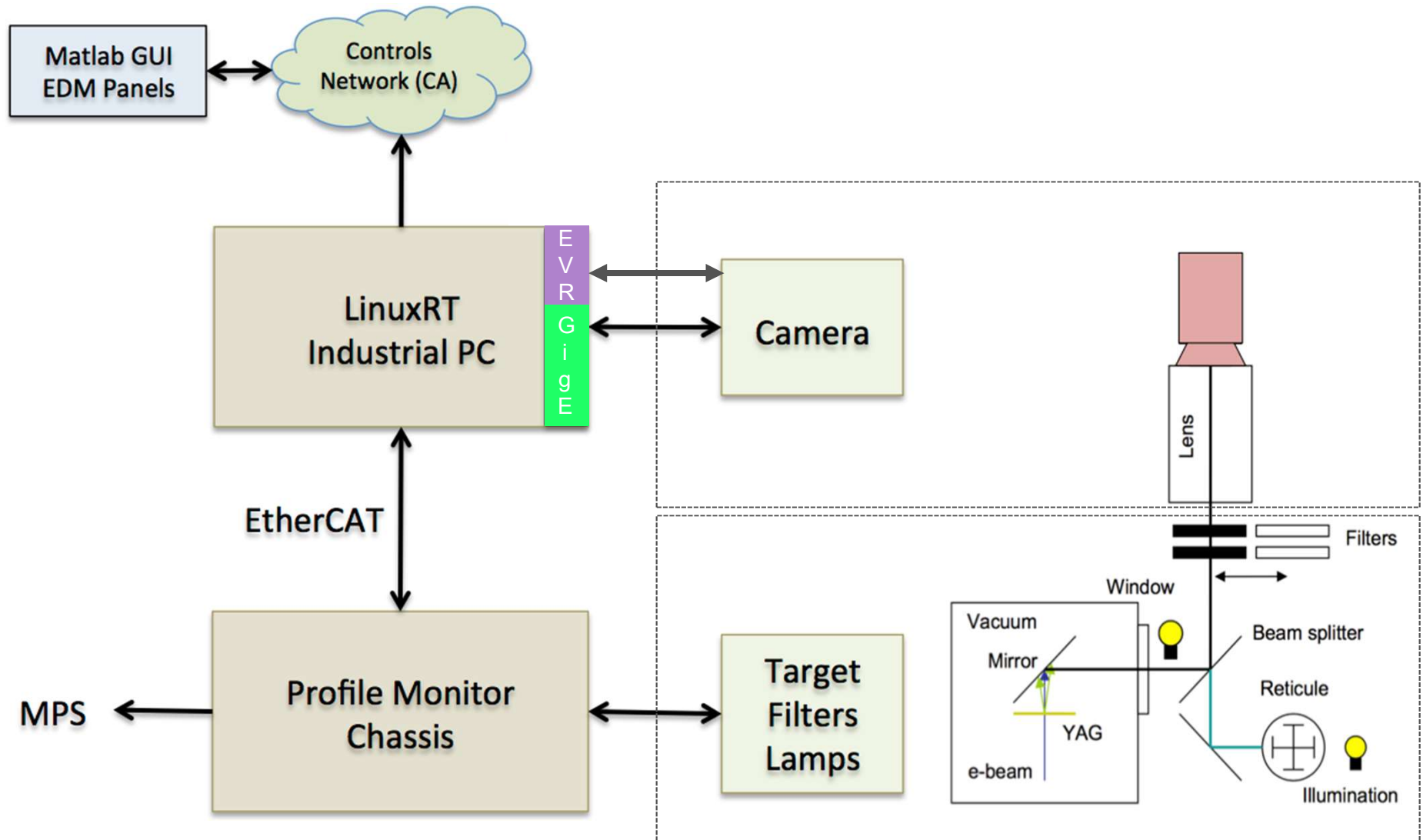
Architecture – Hardware BLEN GAP DIODE



Architecture – Hardware BLEN PYRO



FACET-II Diagnostics Profile Monitor Architecture



- Advantech SKY-8200



- Small size – 2U, 20” depth
- 8 PCIe x8 full size
- Diskless
- LinuxRT OS
- Intel Xeon processors (8 cores, 2GHz)
- Operating temperature range 0-50°C
- Up to 10 Gbps connection to controls network
- Camera server and interface to chassis

Cameras

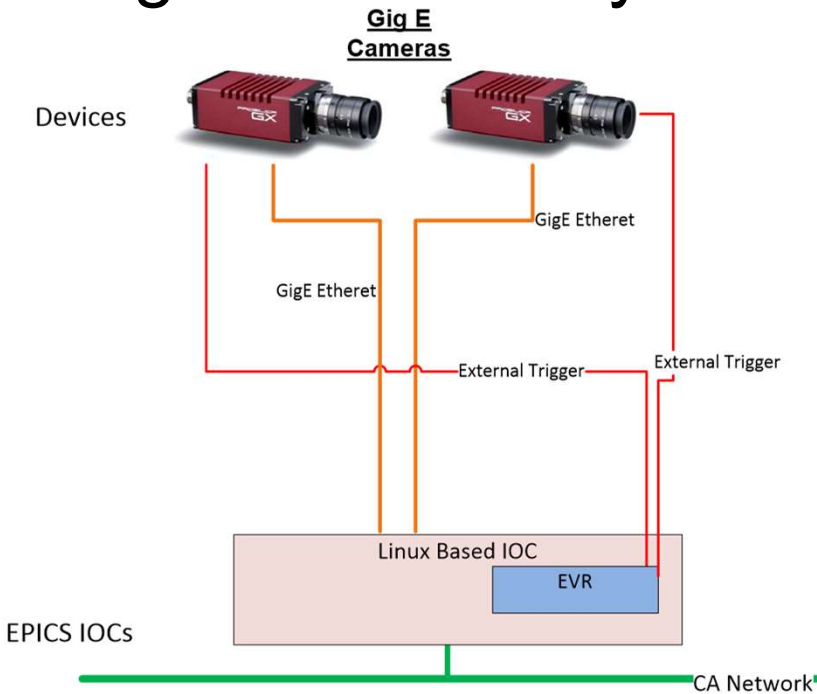
SLAC

Allied Manta 146b Gig-E Camera System

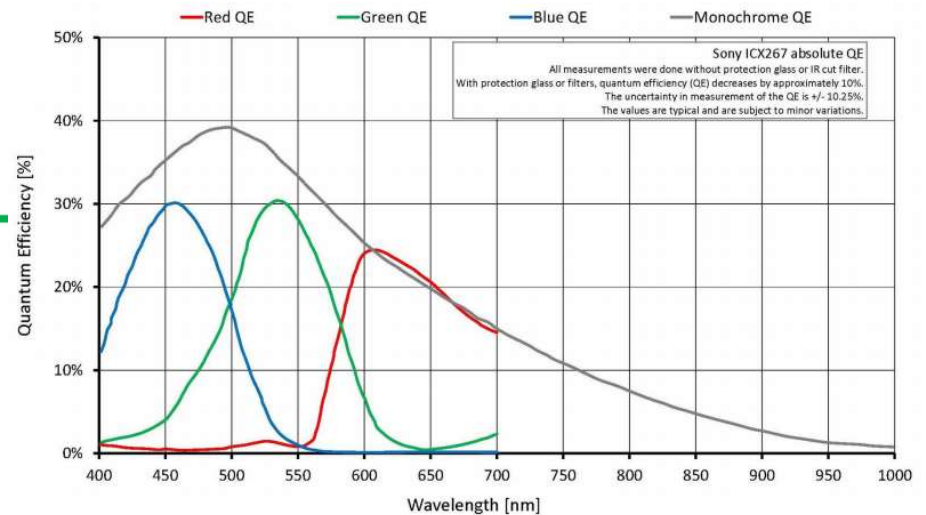


Manta G-146

- 17.8 fps @ full resolution
- PoE option
- Angled head and board level variants
- Video-iris lens control

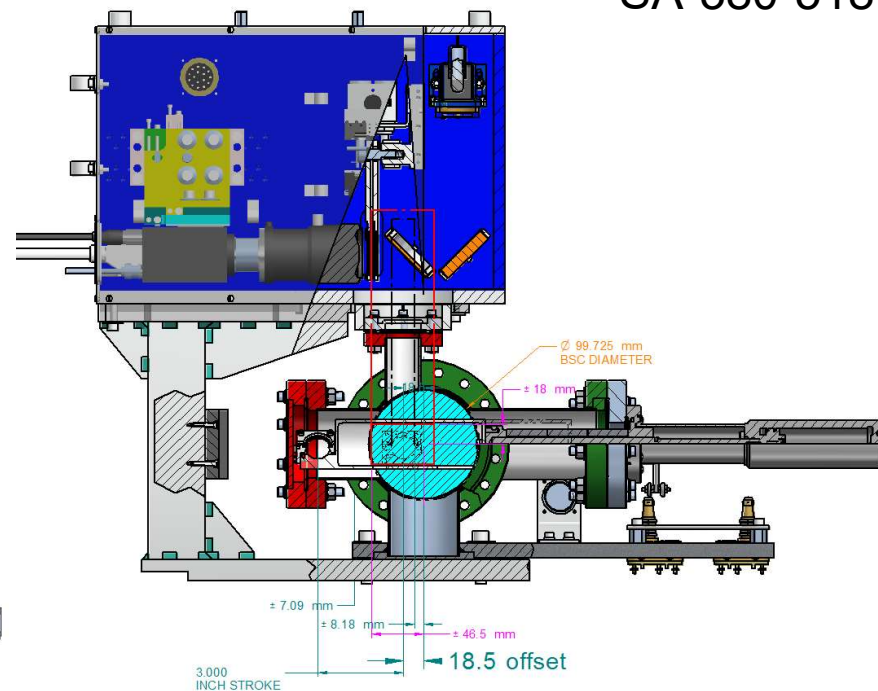
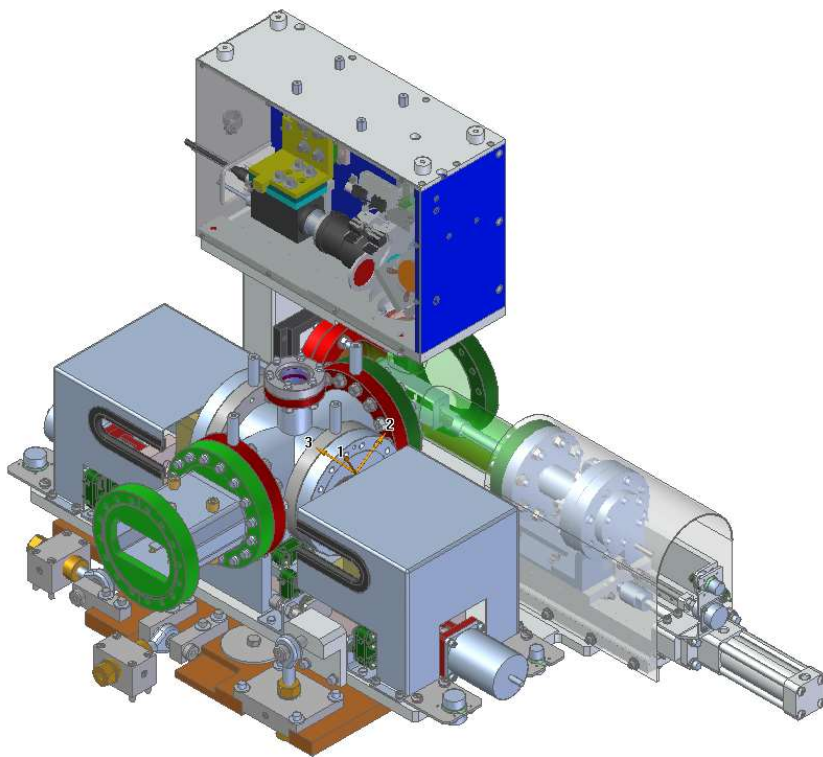


Cameras and PoE injectors are on hand



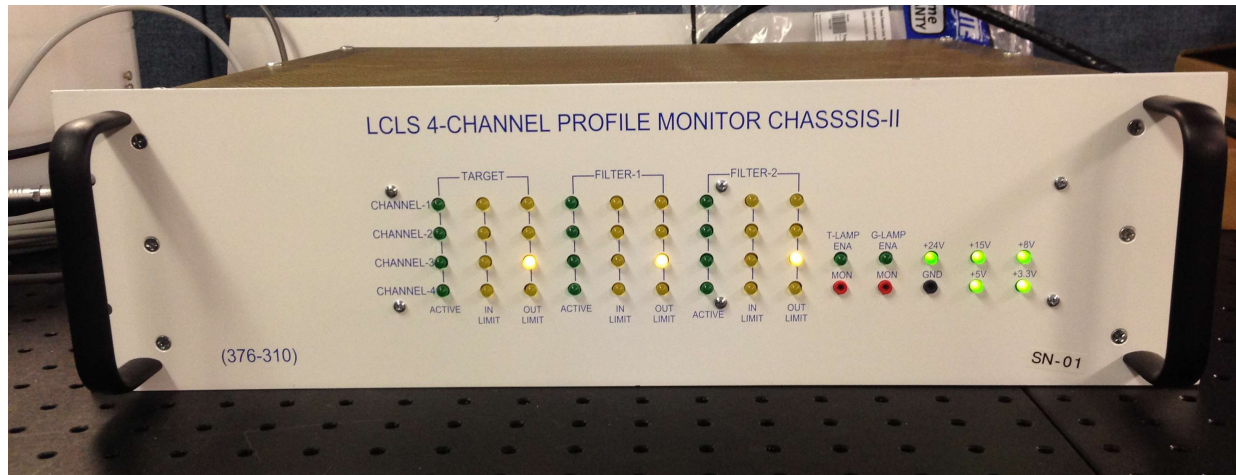
Optics Box

For example:
SA-380-903-29
SA-380-518-70

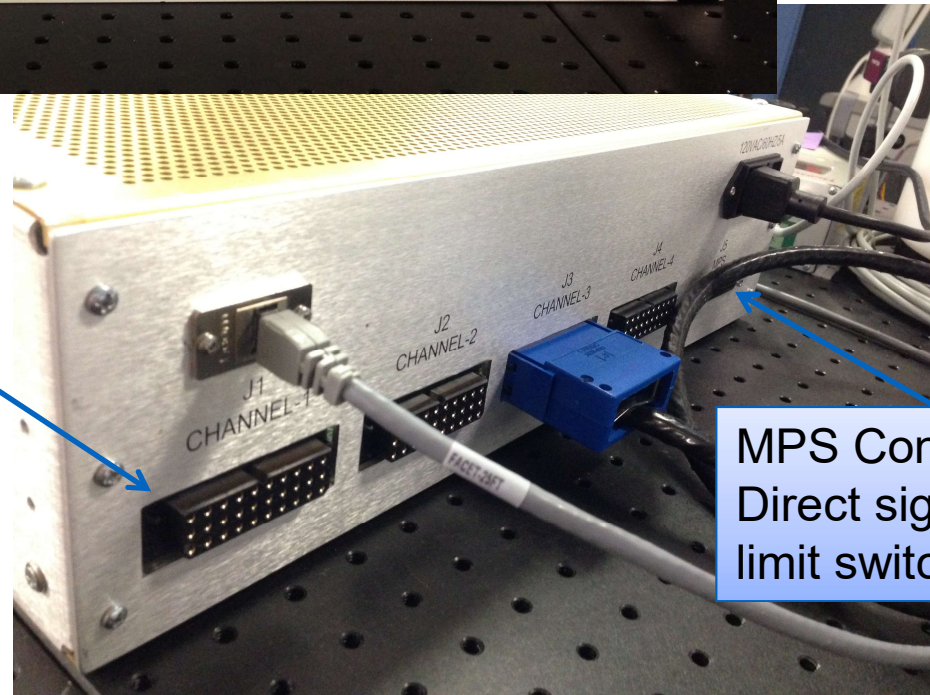


Not my scope, but parts have been ordered
Pigtail cable drawings nearly complete, fast turnaround in house to fab

Profile Monitor Chassis



- Controls:
- Target
 - Filters
 - Illuminators
 - Camera power
 - Lens motors
- Status:
- Limit switches

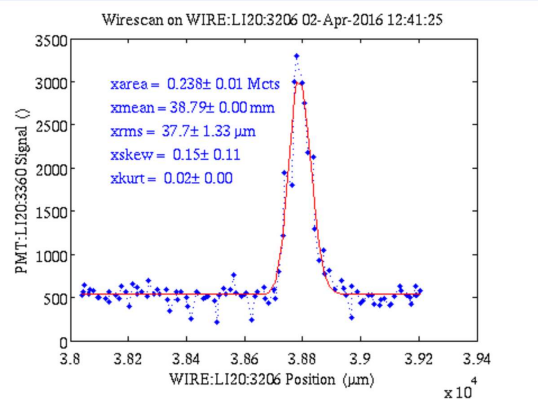


MPS Connector
Direct signal from
limit switches

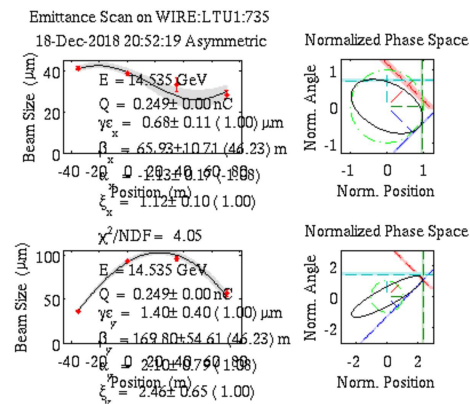
FACET-II Diagnostics Linac Emittance Measurement

Location	Sector	Energy [GeV]	σ_x (μm)	σ_y (μm)	# of wire scanners	# existing
After BC11	Sector 11	0.335 – 1.0	145-215	110-215	4	4
End of L3	Sector 19	9.0 – 10.0	35-57	38-56	4	1

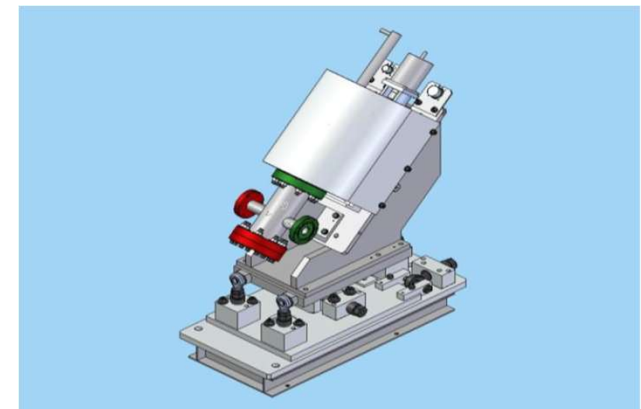
- Relocated wire scanners from Sectors 1 & 2 to FACET-II linac (S11 & 19)
- Replaced standard 10-foot RF structures with modified 9.4-foot sections



1 wire beam profile



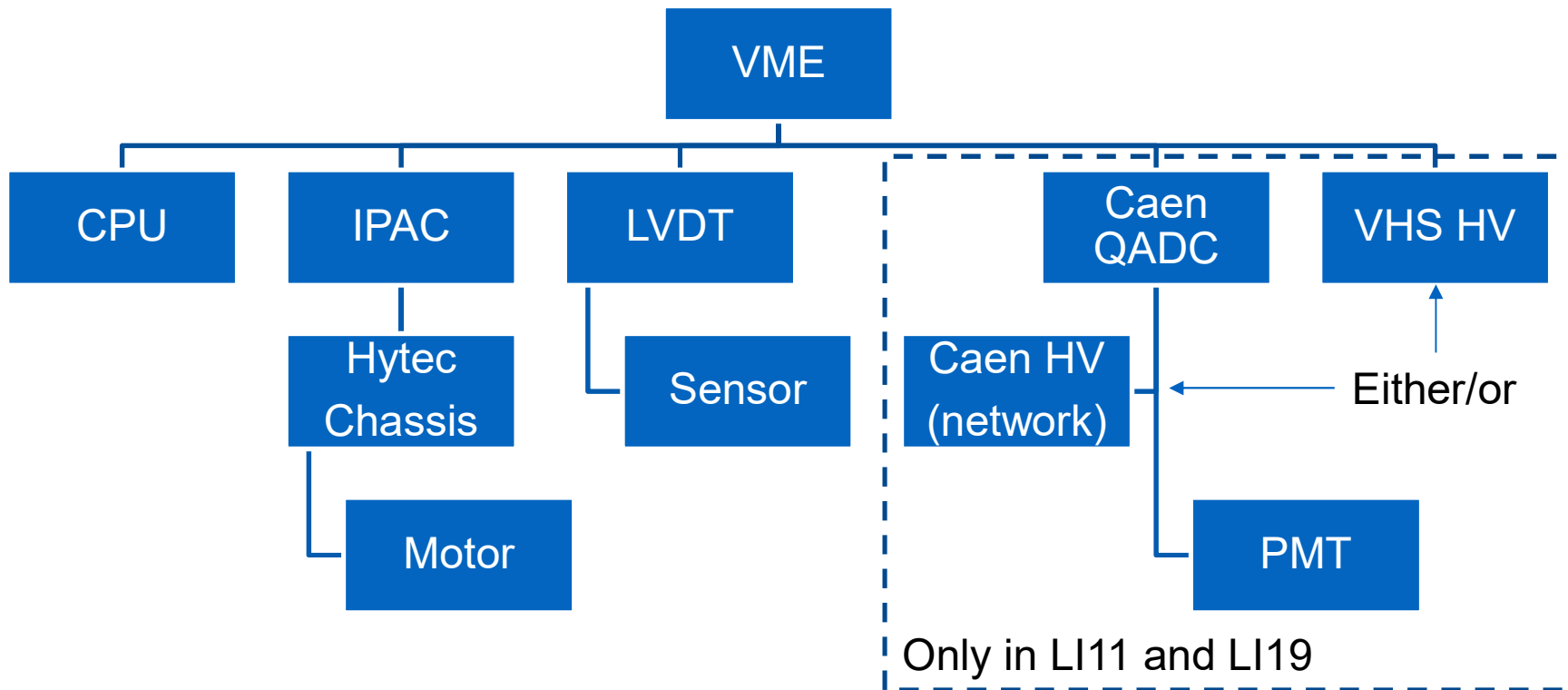
4-wire ϵ measurement



Wire scanner design

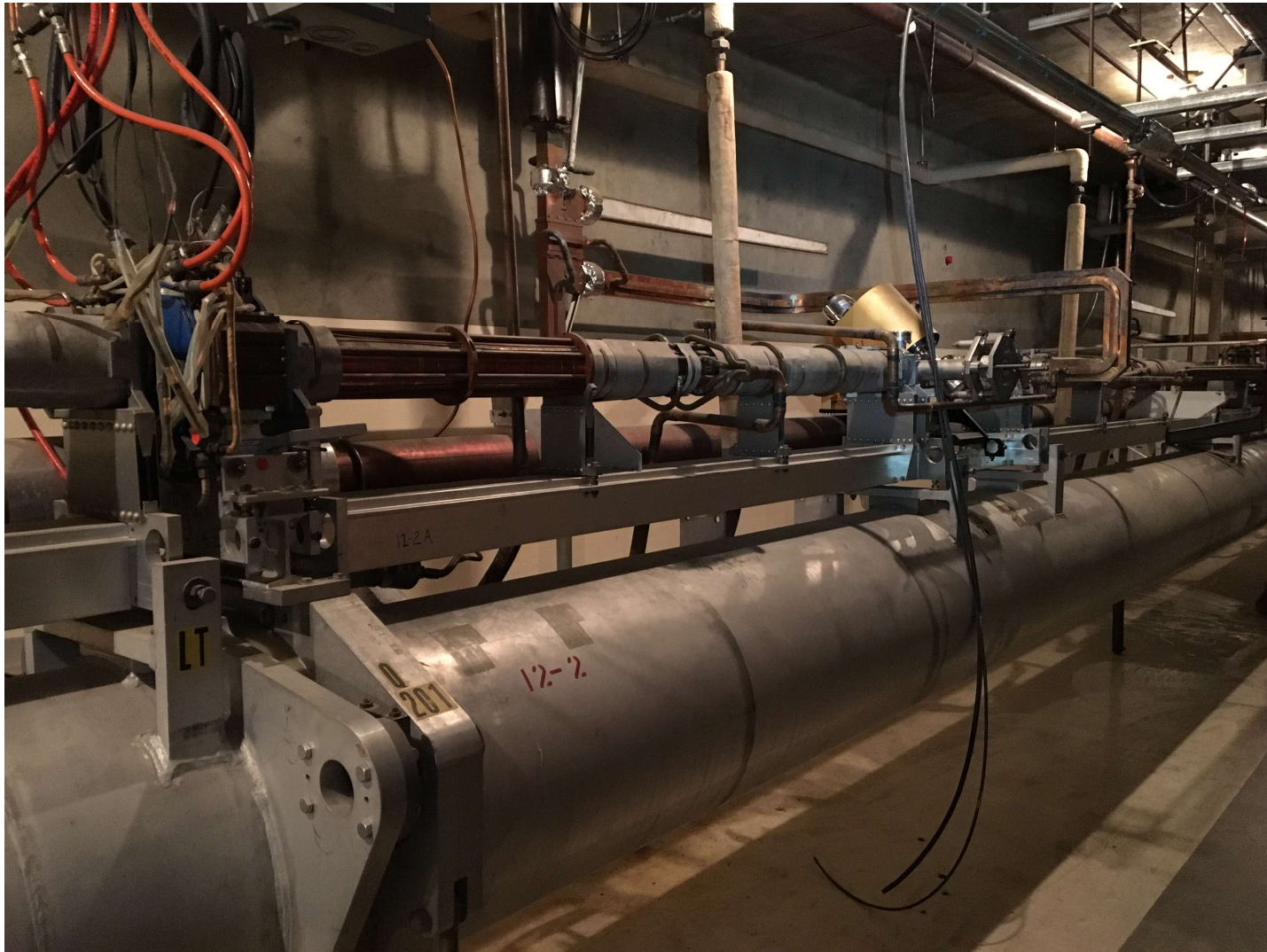
Wire scanners characterize emittance preservation across linac-BC system

Wire Scanner / Motion Architecture



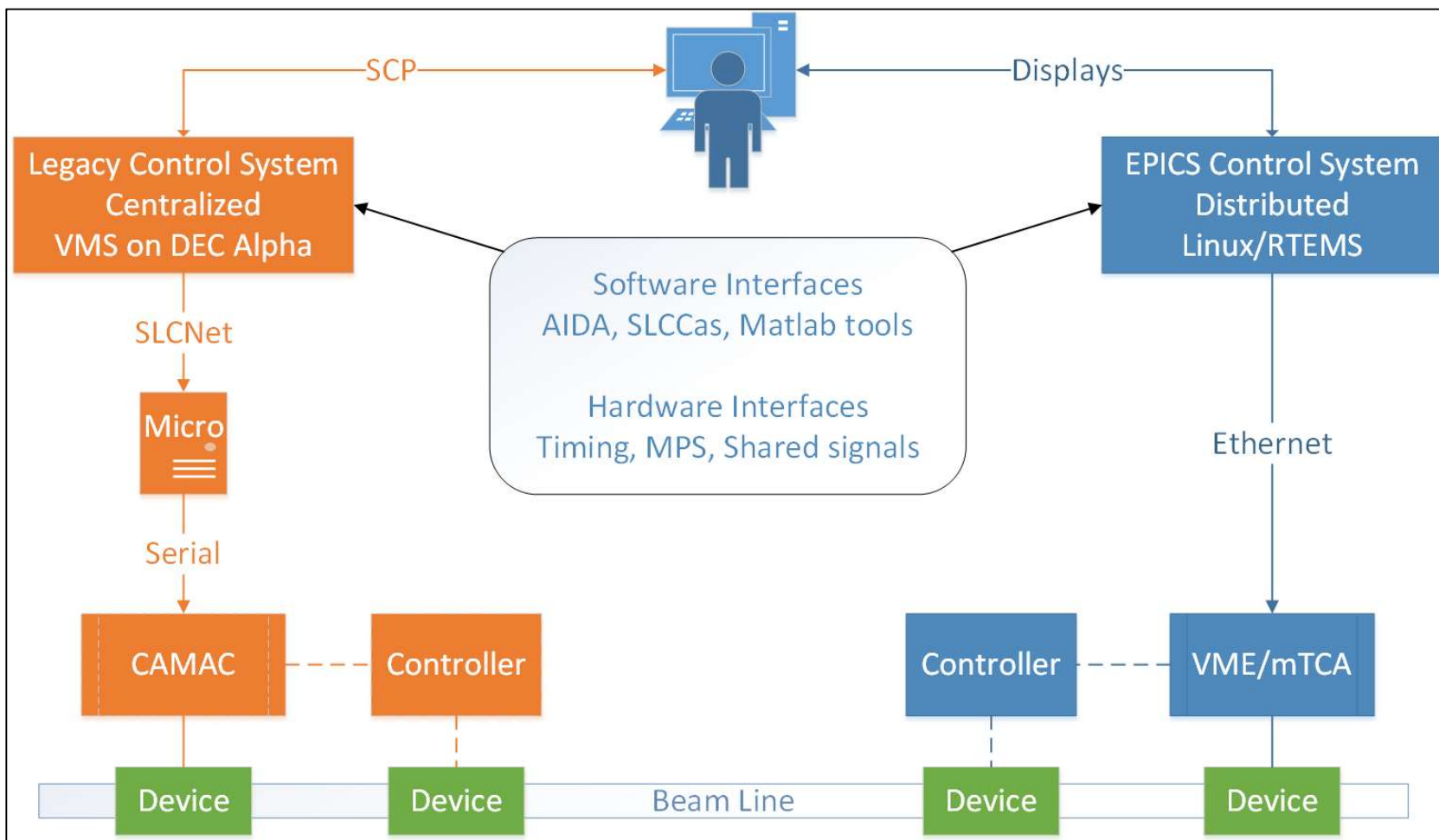
FACET-II Diagnostics

Wire scanner in Sector 12



FACET-II Diagnostics Overview

Hybrid Control System Architecture



FACET-II employs a mixture of legacy and modern controls with tools developed for FACET and LCLS to pass data back and forth

FACET-II Stage 1 Diagnostics Overview

Standard e- beam diagnostics (**existing** and **new**)

	Injector	L1 & BC11	BC14	L2 & L3	BC20 & IP	Total (Stage 1)
BPM	12	6 + 3	5 + 2	66	19	112
Toroid	3	1	1		5	10
Wire scanner	1			4 + 4	2	11
Profile monitor	4	2	1	1	3 + 8	21
TCAV	1 S		1 S		1 X	3
Bunch Length	1	1	1		1	4
Collimator		1	1	1	1	4

FACET-II re-uses existing FACET e- beam diagnostics where possible



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Facility for Advanced Accelerator Experimental Tests

Questions

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SLAC

NATIONAL
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