# Commissioning Progress and FY23 Beam Parameters

FACET-II

Facility for Advanced Accelerator Experimental Tests

## FACET-II PAC Meeting 2022

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SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

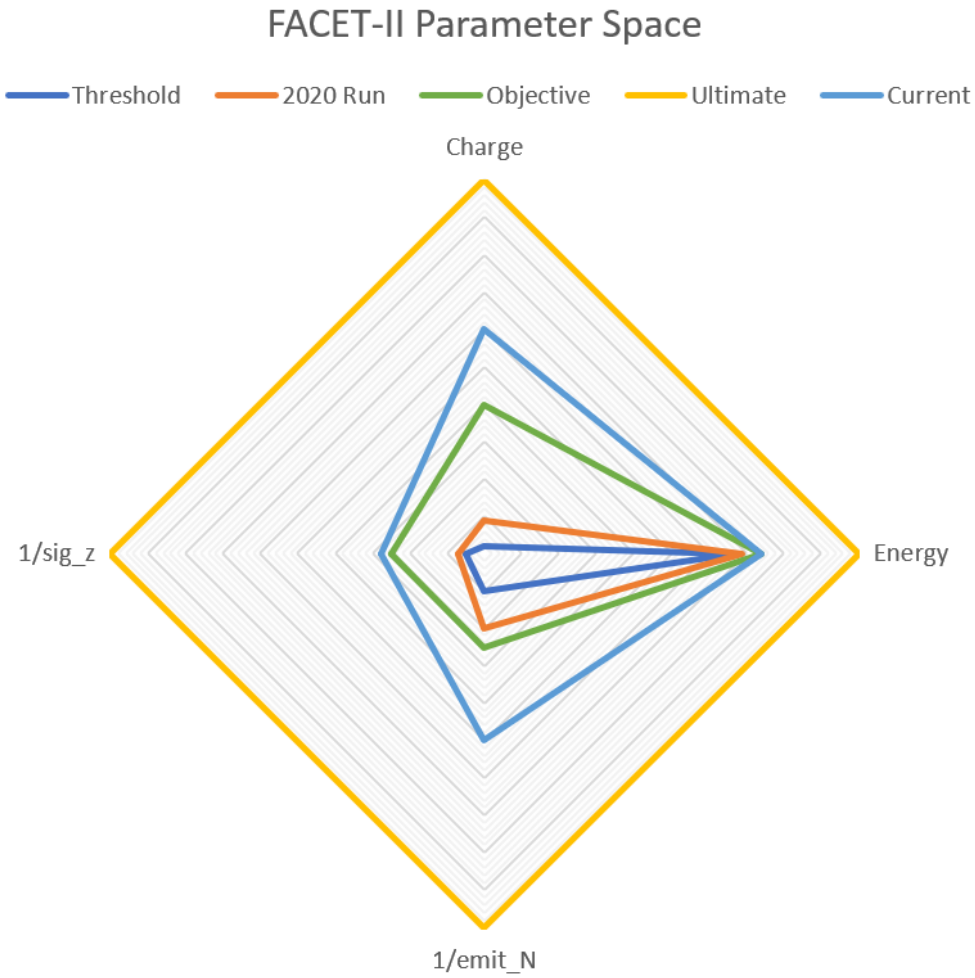
# Outline

- KPPs
- FY22 Parameters
- Selected Machine Development
- Improvements to Beam Delivery
- Expected FY23 Run Parameters

# Objective KPP

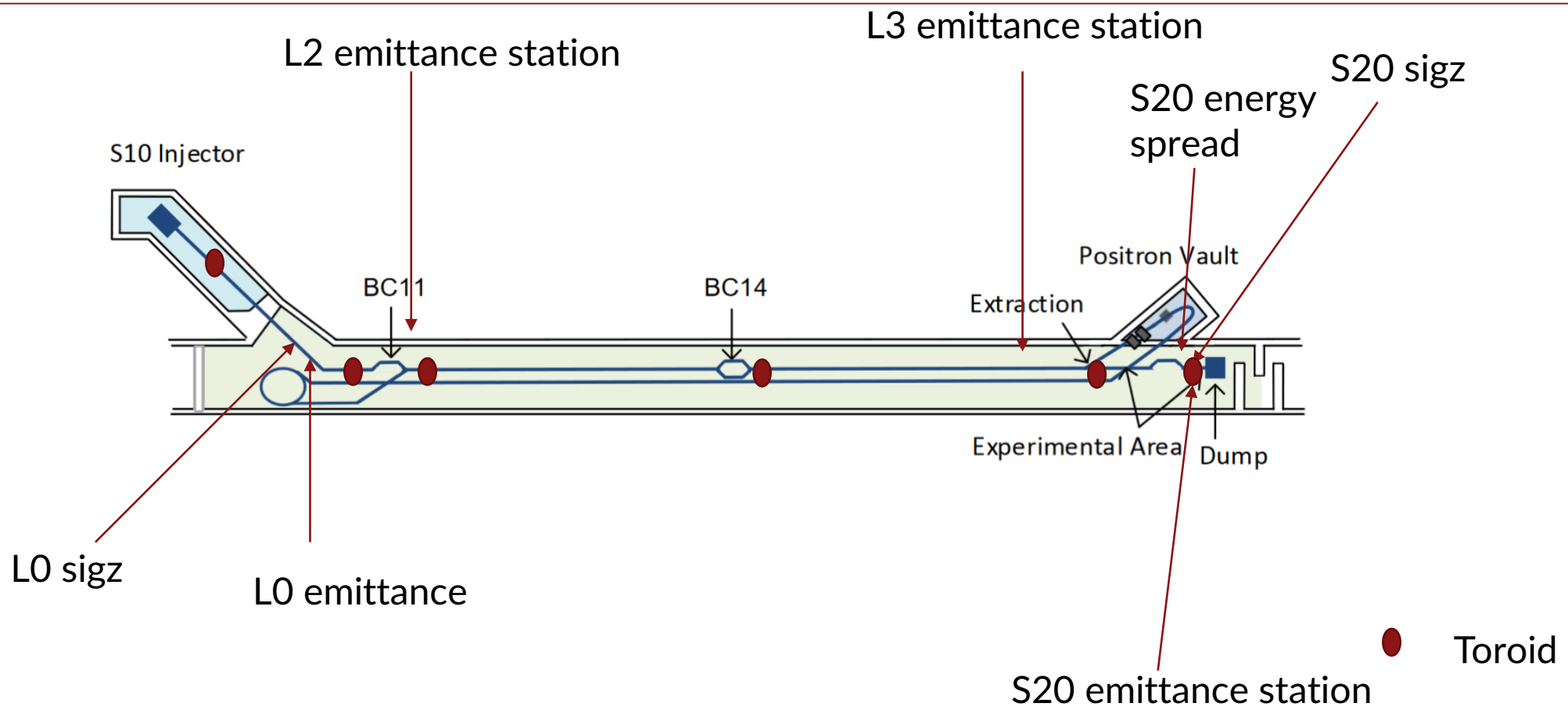
- 10GeV energy through S20 chicane
- 2nC charge
  - 3.4nC achieved in MD
- 20um L3 linac emittance
  - Sub-10um emittance achieved regularly
- 20um IP bunch length
  - Sub-15um bunch length achieved regularly

- Not all parameters can be pushed simultaneously, e.g.
  - Pushing energy up reduces available compression
  - Higher charge produces more beam loading reducing both highest energy and peak compression in addition to complicating wakefield emittance compensation in the linac




**Objective KPP met**

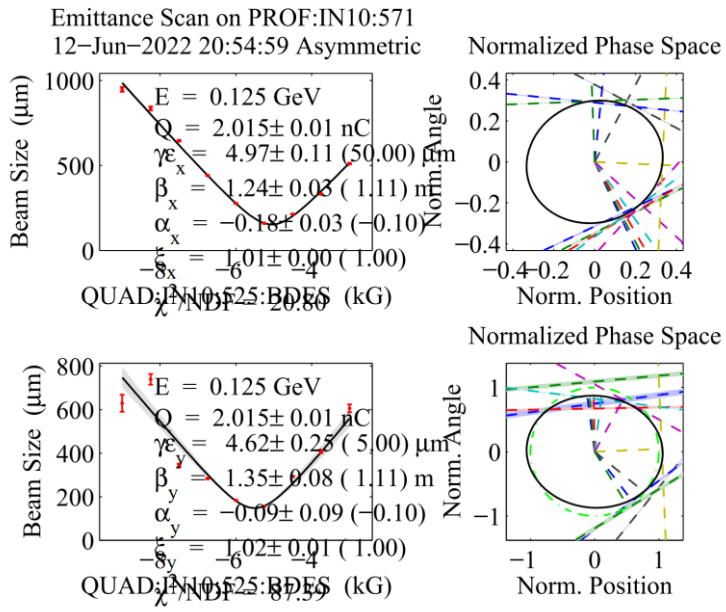
# Diagnostics




- Bunch length measurements performed with transverse deflecting cavities
- L0 emittance measurement performed with screen
- L3 & S20 emittance measurements performed with wires

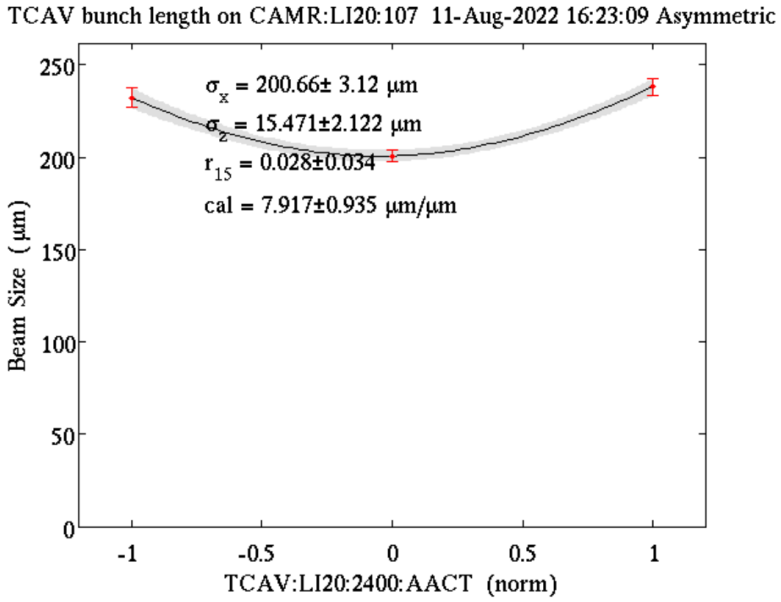
# FY22 Parameters

- QE 1.2e-4 after wavelength change, mirror replacement, laser cleaning
- 5um emittance in injector
  - Very consistent
- 6um emittance at L2
  - Stability issues
- 10um emittance at L3
  - Stability issues
- 20um bunch length in S20
  - Stability issues
- 1.6nC typical charge
  - 1.6nC very stable, sufficient for User activities FY22




Typical Injector Emittance

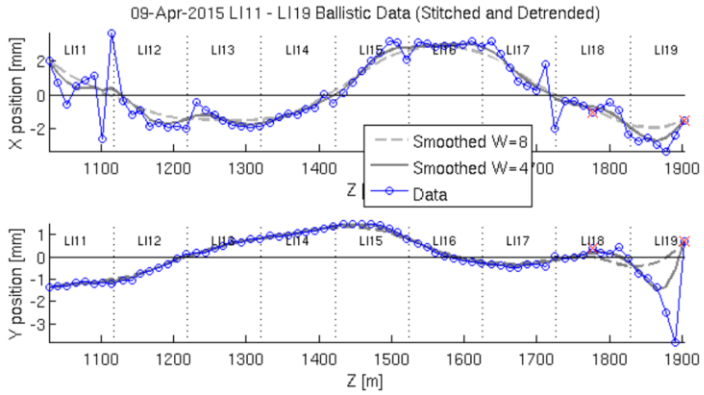
S20 XTCAV Bunch Length Measurement



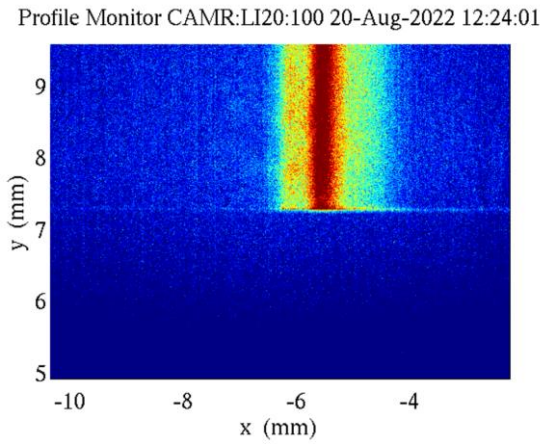

Parameters from the FY22 run

# Selected Machine Development

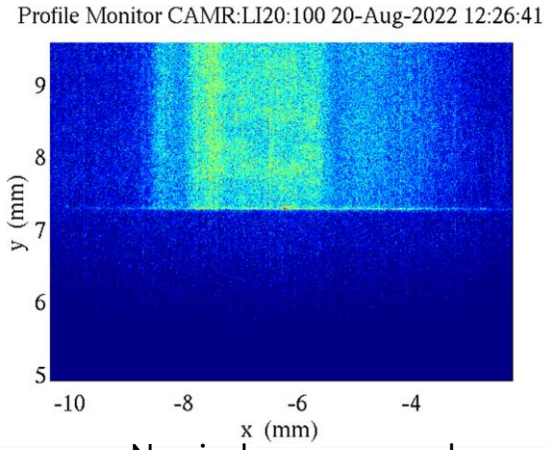
- Ballistic Beam Alignment
  - Smooth discontinuities in linac for better emittance preservation
- S20 IP and Spectrometer Beam Based Alignment
- RF and Magnet Stability
  - Hardware stability contributed to variation in deliverable beam parameters
- 2nC Machine Stability
- Configuration Switching
  - Develop consistent, quick configuration changes between beams with differing compression profiles




2015 FACET ballistic beam alignment example




Low energy spread



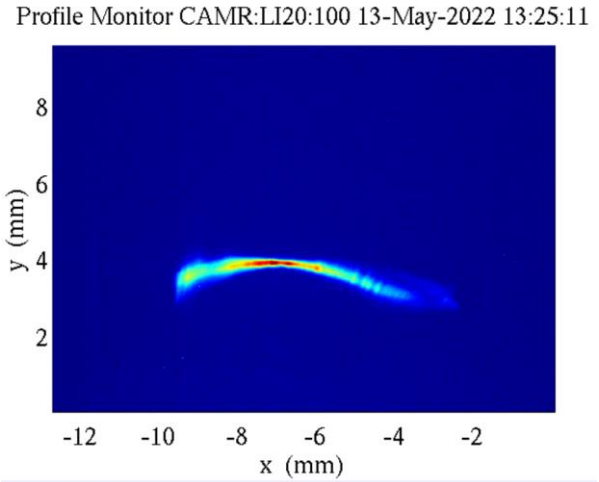

Nominal energy spread

**Selected MD's will improve reliability and consistency of beam delivery**

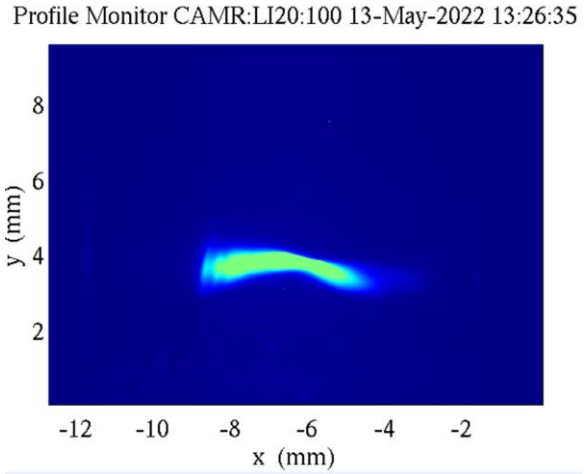
# Improvements to Beam Delivery

- Laser Heater (see Carsten's/Glen's talks)
- Two-bunch Commissioning (see Glen's talk)
  - Will allow for drive and witness bunch through linac rather than collimation with the notch in S20
  - Will also recommission notch-collimator
- Injector Emittance Optimization
  - 10deg Schottky phase is FACET-II design and will provide best injector emittance
  - FY22 initially ran at 30deg Schottky phase to allow more charge overhead when QE was low, but stayed there since injector emittance sufficient (<5um)
- L1 LLRF Upgrade
  - Significantly improve stability of delivered beams

Microbunching observed on beam at SYAG




Upstream profile monitor inserted: Suppresses micro-bunching, but blows up emittance




**These tasks will improve the capability of beam delivery**

# Expected FY23 Single Bunch Parameters

- 500pC to 2nC charge
  - MDs to investigate RF and DC magnet stability, tuning techniques for higher charge, configuration switching/development
- 4um gun emittance
  - Gun emittance has been stably reproducible at 4-5um
  - Further improvement expected after spending time developing 10deg Schottky phase configuration
- 8um linac emittance
  - Focus this run will be to maintain the consistency of L3 linac emittance rather than push the minimum size down
- 10um-100um bunch length
  - Focus will be reproducibility and stability
- 9GeV to 11GeV energy
  - Long term project to increase klystron availability in L3

**Improvements in stability and capability will enable better, more consistent beam quality**

# Summary

- Objective KPP of 2nC, 10GeV, <20um linac emittance established during FY22 run
- New hardware will extend the capabilities of the FACET-II accelerator for User Delivery, e.g., two-bunch, laser heater, etc.
- Machine Development shifts will focus on improving stability and reproducibility

FY22 run was successful and FY23 run will improve upon those parameters