First Operation of a Superconducting RF Electron Test Accelerator at Fermilab

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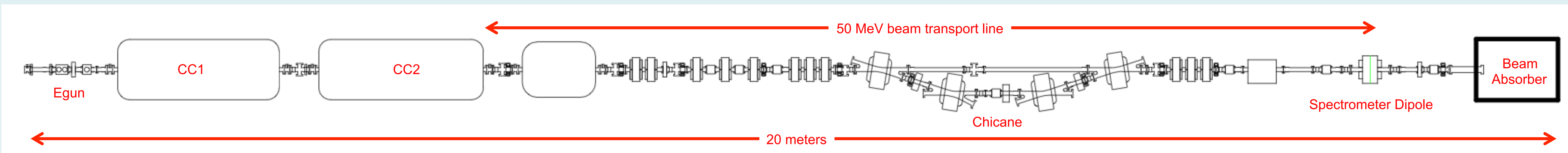
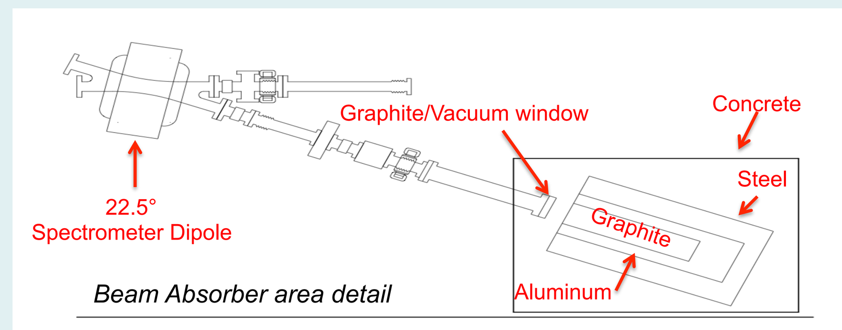
A test accelerator utilizing SRF technology recently accelerated its first electrons to 20 MeV at Fermilab. Foreseen enhancements will make acceleration to 300 MeV possible at a maximum beam power of 80 kW. A summary of commissioning steps and first experiments as well as current beam parameters compared to design is presented. Plans for expansion and the future physics program are also summarized.

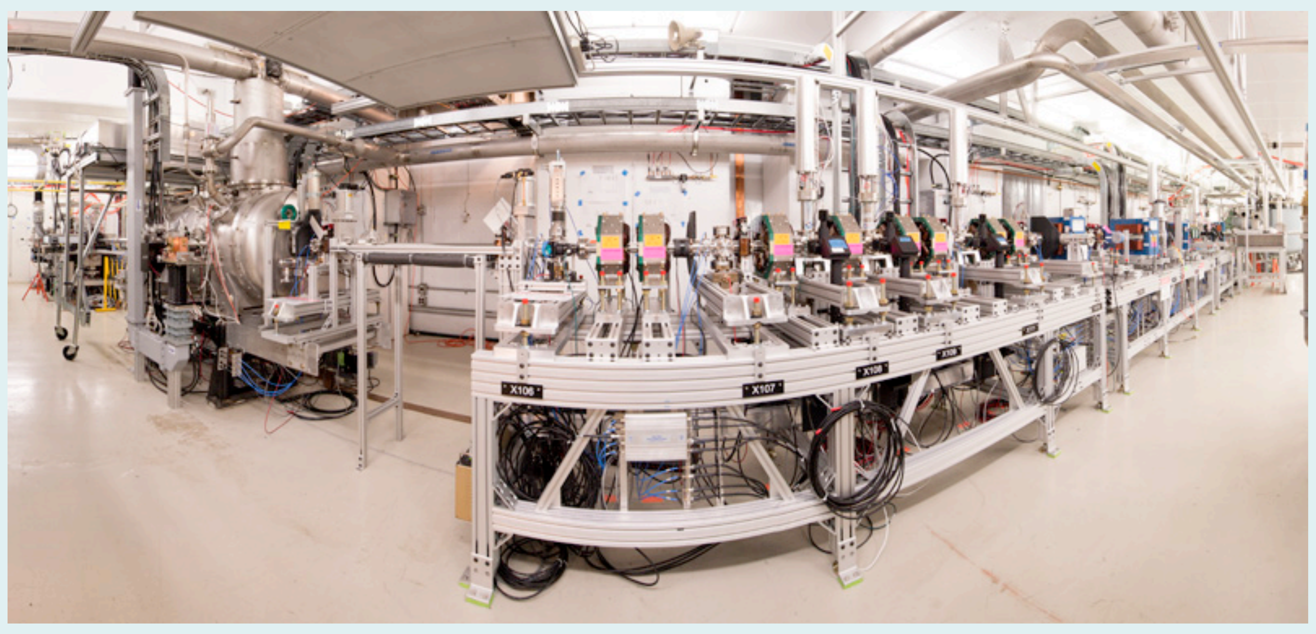
FAST Layout

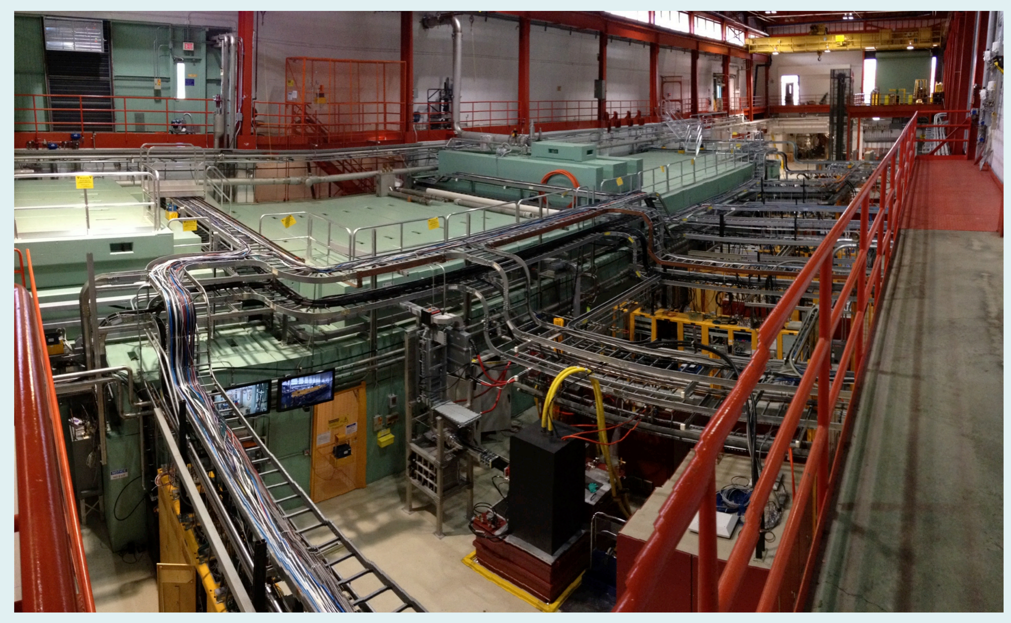


The Fermilab Accelerator Science & Technology (FAST) facility injector consists of

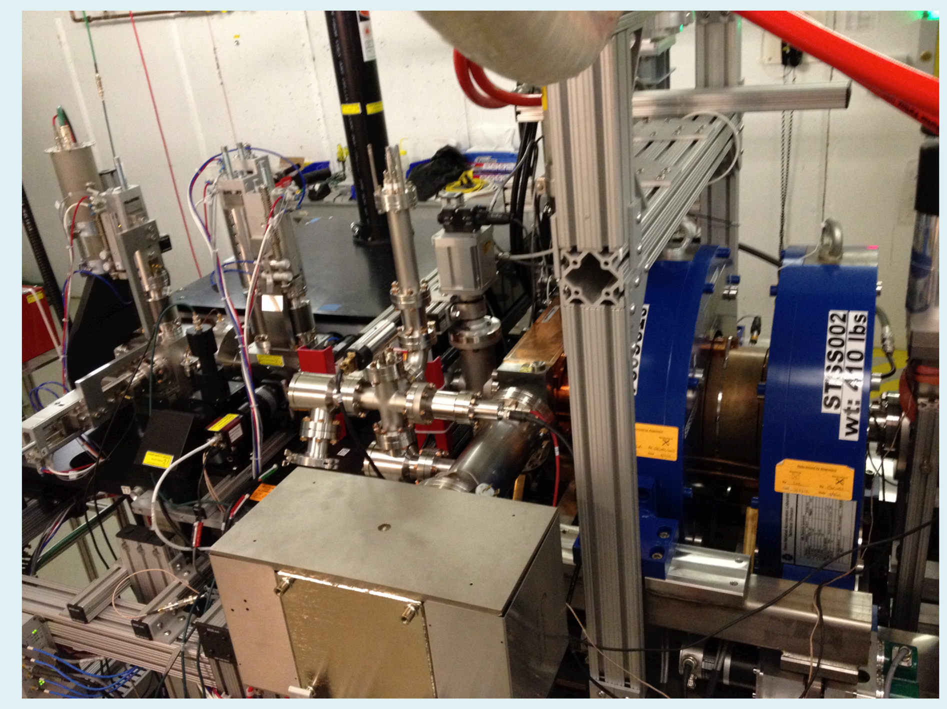
- Normal conducting Photoinjector gun
- Two 'booster' SRF cavities
- 50 MeV beam transport line including a bunch compressing chicane
- Spectrometer magnet which bends the beam down by 22.5° into a
- Beam absorber





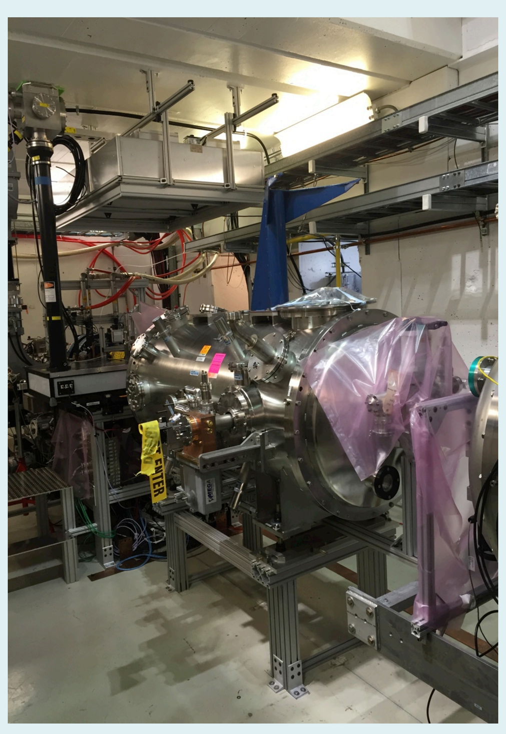


Photoinjector Gun



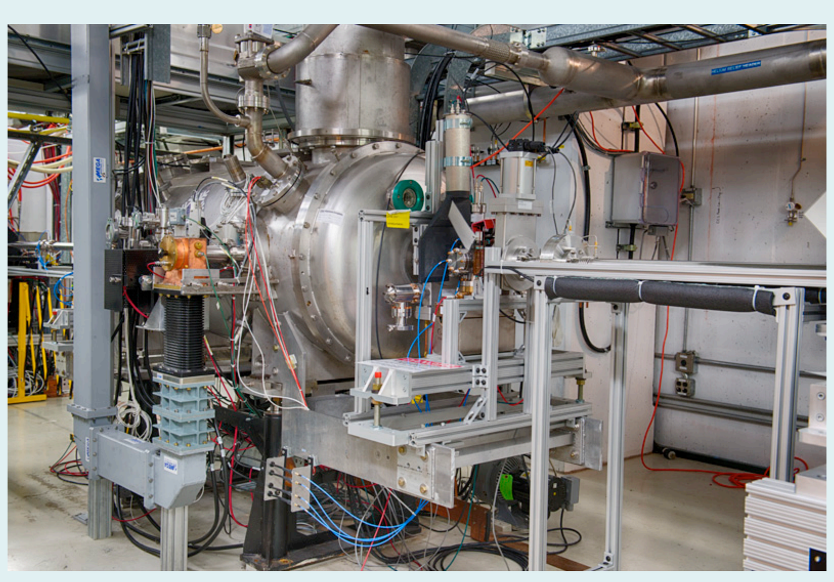
The RF photocathode electron gun is identical to the guns developed at DESY Zeuthen (PITZ) for the FLASH facility. It is a normal conducting 1-½ cell 1.3 GHz RF cavity operated in the TM010 π-mode, with a Q_L of 11,700, and driven by a 5 MW klystron. The gun is capable of average DC power dissipation of 20 kW and the temperature feedback system will regulate cooling water temperature to less than ±0.02° C for good phase stability. The gun is routinely operated at peak gradients of 40-45 MV/m, and output beam kinetic energy of 4.5 MeV.

SRF systems

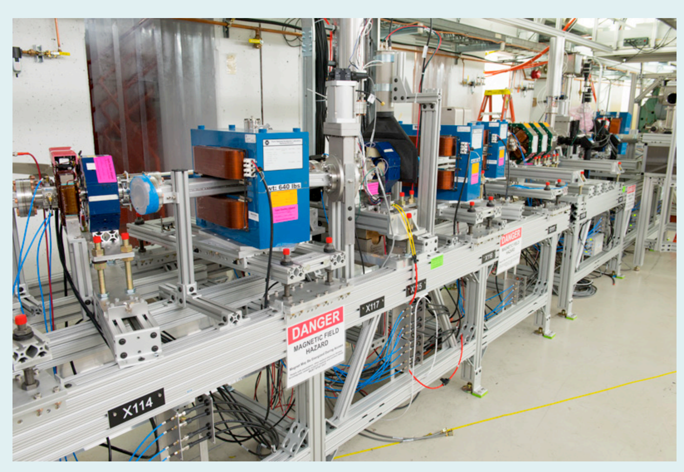


Capture Cavity 1 (CC1) upgrade work is now completed. The cryomodule has been installed on the FAST beam line. CC1 re-commissioning and operation is expected to occur in late 2015/early 2016. Based on cavity horizontal tests it is expected to operate at gradients up to 29 MV/m.

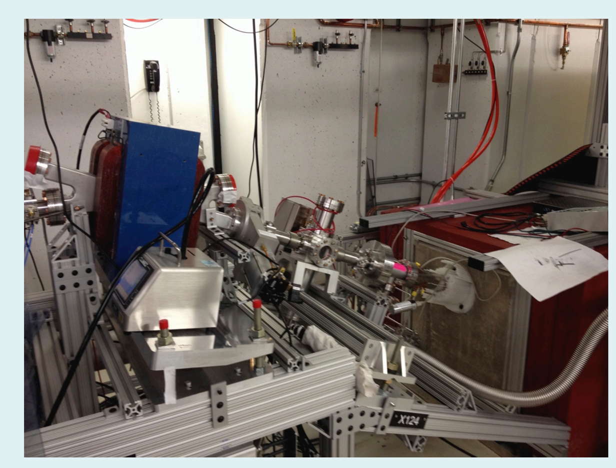
Capture Cavity 2 (CC2) has routinely operated at a gradient of 16 MV/m for FAST injector and has demonstrated capability of operating at ~20 MV/m. CC2 does have a fast tuner to compensate for LFD and this will be brought in to operation in the near future.



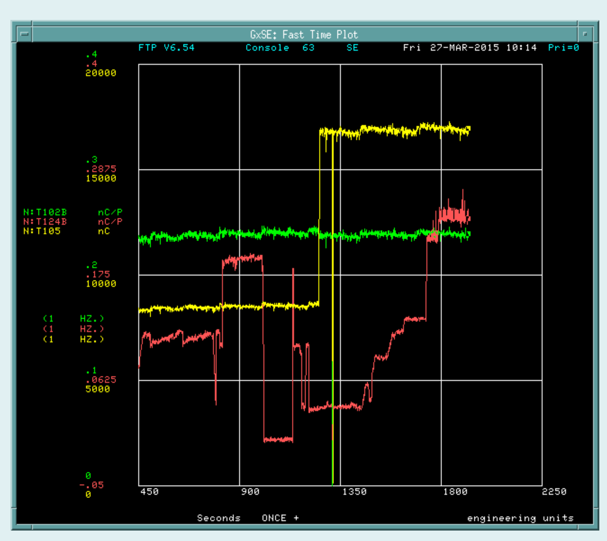
50 MeV Beam line

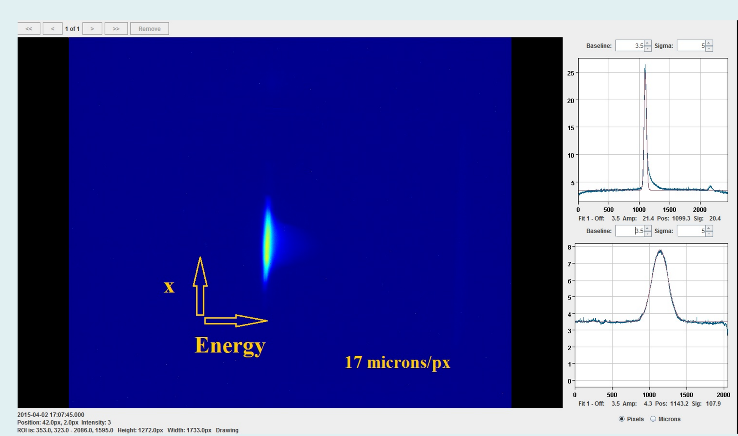


The 50 MeV beam transport line immediately follows CC2. The electron beam passes through a quadrupole doublet for controlling the beam size for emittance measurements, a matching section, and then into a 4-dipole chicane for bunch compression (R56 = -0.18 m), and a matching section, thence into a 22.5° vertically downward bending dipole. This dipole, upstream of the absorber, serves as the low energy spectrometer. The 50 MeV beam absorber is capable of accepting up to 550 W of beam power.



First accelerated electrons – 27 March 2015





The first attempt to systematically transport beam through CC2 and thence to the beam absorber began on late in the day on 25 March 2015.
By the end of the next day electrons had been verified to pass through and be accelerated by CC2.
On the morning of the third day of commissioning there was confirmation of beam to the absorber at the end of the line.

Current Situation & Future Plans

FAST is currently off and the SRF systems, including CM-2, at room temperature to facilitate installation of CC-1 and integrate it to the cryogenics infrastructure. Once installation is complete, cool down and commissioning of CC-1 will occur with a goal of achieving 50 MeV electrons through the FAST injector, expected in Spring 2016.

The high energy beam line from CM-2 to the beam absorber at the very end of FAST will be installed following achievement of 50 MeV electrons. The goal for FY2016 is then to realize 300 MeV electrons through CM-2 and the high energy beam transport line beyond. IOTA installation will occur in parallel with the expectation of first injection of electrons into IOTA in FY2017.

Typical Operating Parameters

Parameter	Value	Units
Bunch Charge	0.25	nC
Gun Gradient	42	MV/m
CC2 Gradient	16	MV/m
Beam Energy	20	MeV
Bunch Length	6-8	ps (rms)

Summary

The FAST facility at Fermilab is now in operational having accelerated its first electrons to 20 MeV by means of a superconducting RF cavity. In the coming months a second cavity will come on-line making 50 MeV operation possible. In the longer term the injector will be joined to CM-2 making energies up to 300 MeV possible. Its primary function as an electron injector for IOTA is expected to be realized in 2017.

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