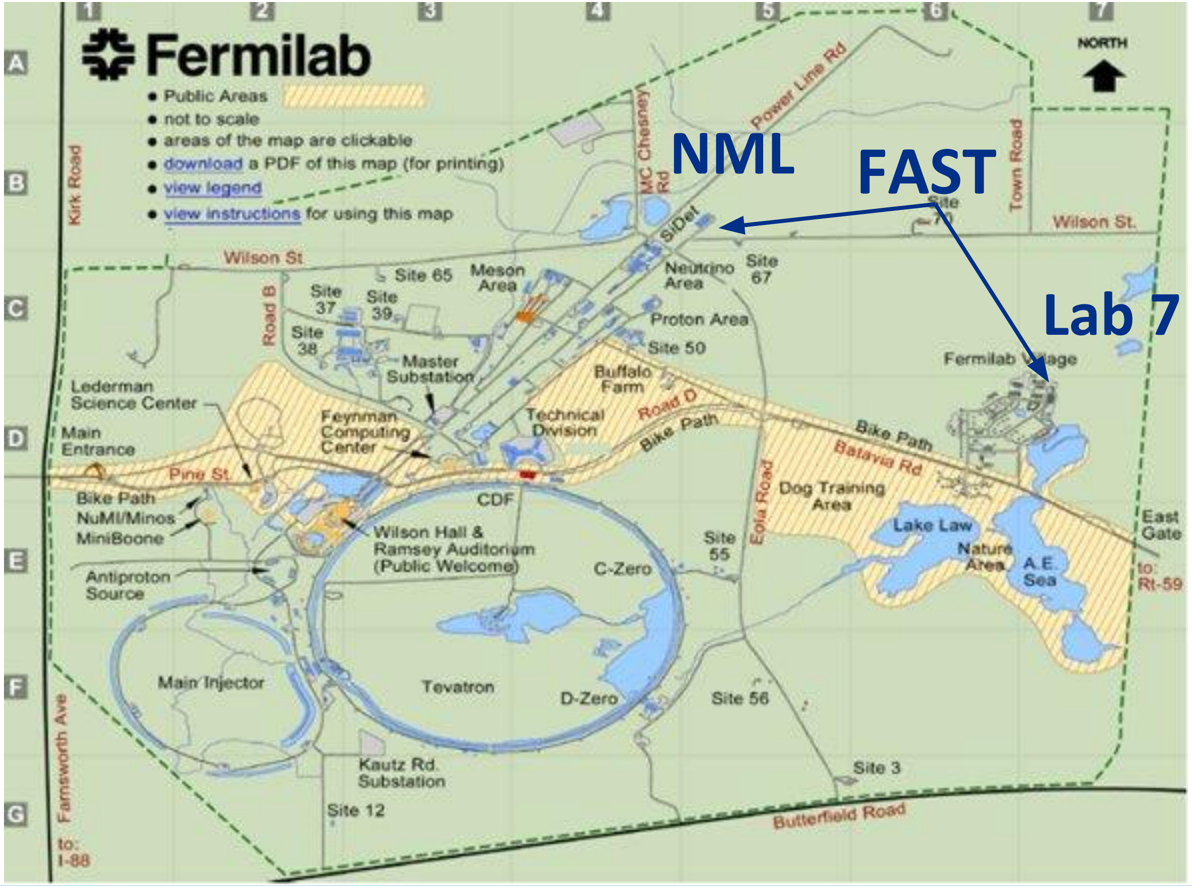
Facility Overview and FAST Linac Performance

Dan Broemmelsiek

FAST/IOTA Collaboration Meeting

15 June 2020

Location

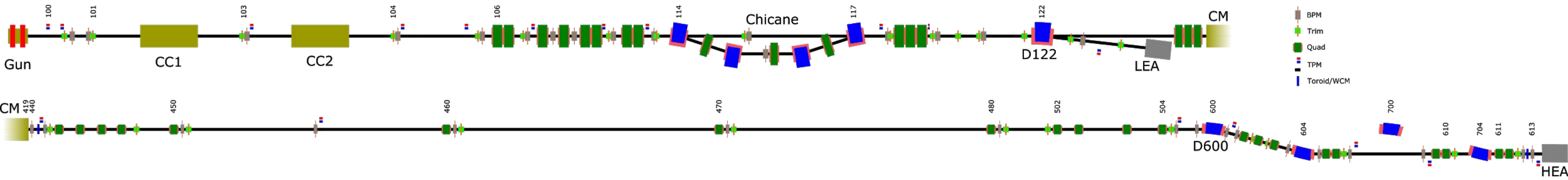


- NML
  - Northern Most Lab
  - No Man's Land
  - No More Letters
  - Ninety Meters Long
- Lab 7
  - Cathode Prep

A Brief History

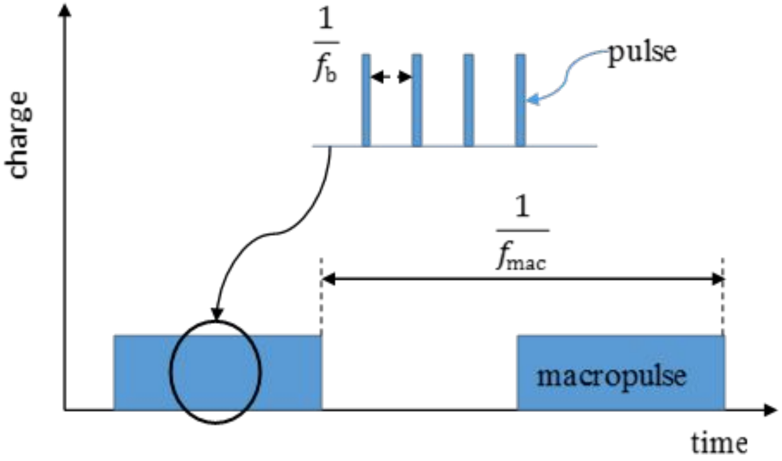
- Advanced Accelerator R&D Facility (AARD)
  - Test and operate a full ILC “RF unit” with “ILC beam intensity”.
    - An RF unit consists of 3 ILC cryomodules driven by a single 10 MW klystron.
    - ILC beam intensity is 3.2 nC/bunch @ 3 MHz in a 1 msec long pulse (3000 bunches), with a 5 Hz repetition rate. The RMS bunch length is 300 mm.
- Advanced Superconducting Test Accelerator (ASTA)
- New Muon Lab (NML, actually NMS) renamed to NML
- FAST is a Fermilab “Facility for Accelerator Science and Technology”
  - Not a DOE Users Facility
- Injector for Integrable Optics Test Accelerator (IOTA)
- Prioritize IOTA -> IOTA/FAST

Electron Linac



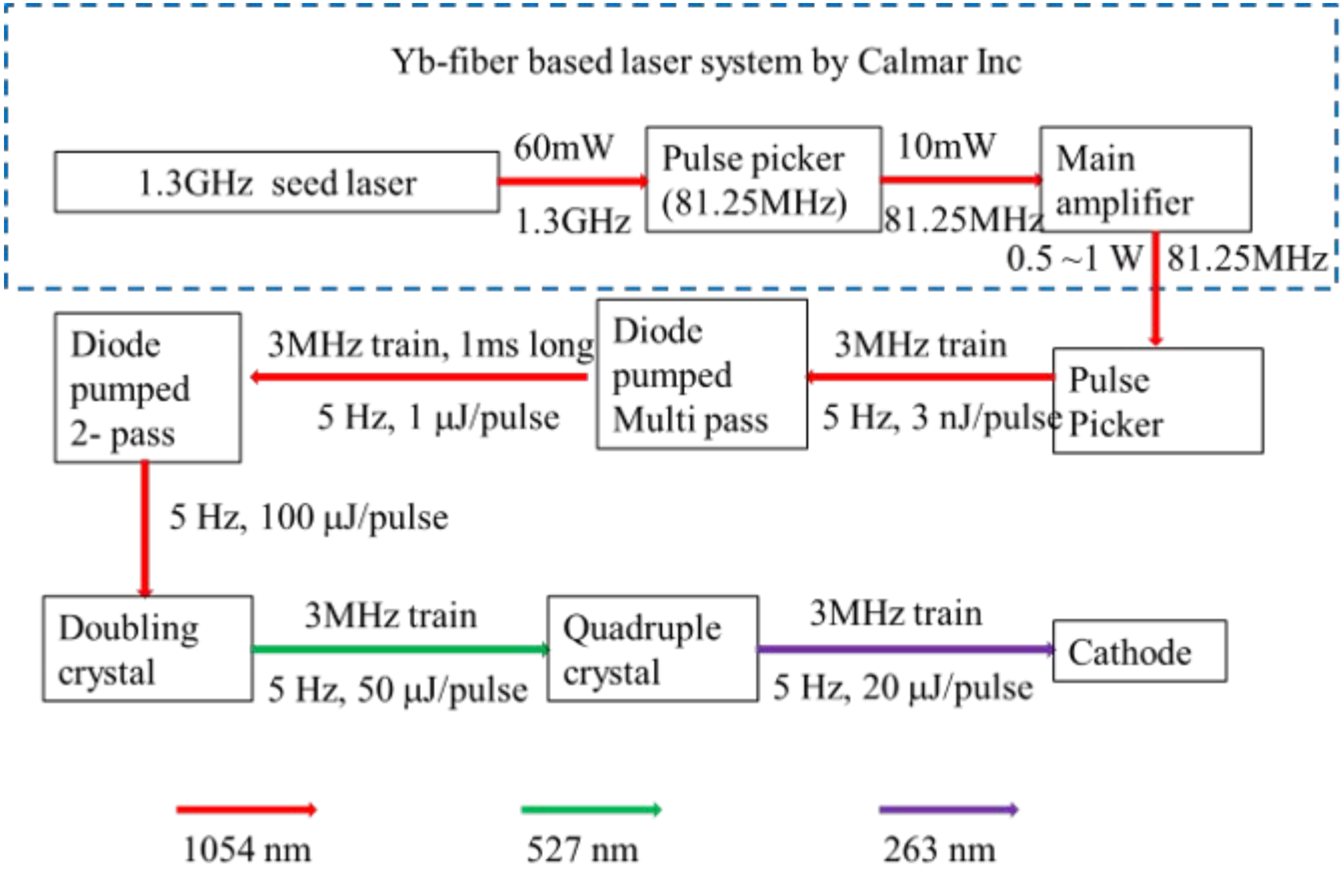
The lectron injector comprises a number of components, including a 5 MeV electron RF photoinjector, a 25-meter-long low energy (≤50 MeV) beamline and a ~100-meter-long high energy (≤300 MeV) beamline.

Parameter	*Value*
Beam Energy	20 MeV – 300 MeV
Bunch Charge	< 10 fC – 3.2 nC per pulse
Bunch Train (Macropulse)	0.5 – 9 MHz for up to 1 ms (3000 bunches, 3 MHz nominal)
Bunch Train Frequency	1 – 5 Hz
Bunch Length	Range: 0.9 – 70 ps (Nominal: 5 ps)
Bunch Emittance 50 MeV, 50 pC/pulse	Horz: 1.6 ± 0.2 µm Vert: 3.4 ± 0.1 µm



JINST 12 T03002—2017, S. Antipov, D. Broemmelsiek, D. Bruhwiler, et al

Laser



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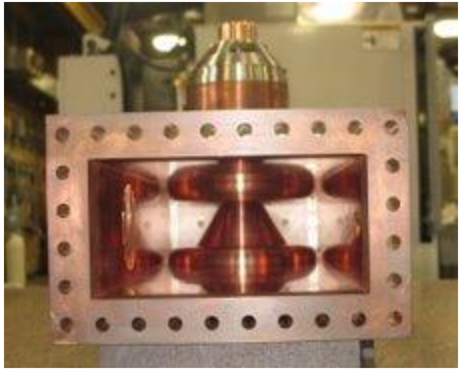
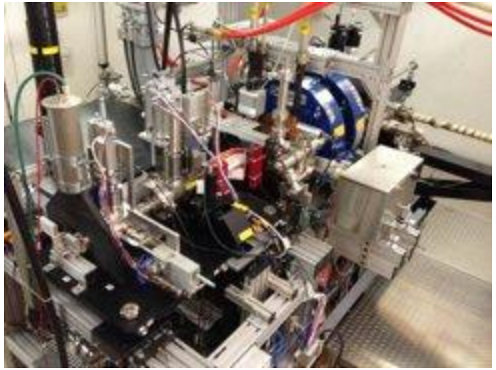
Laser Capabilities/Upgrades

- Nominal laser bunch train is at 3MHz. 9MHz is tested inside laser room.
  - Higher frequency is also possible with the current laser configuration. However, the pulse energy is expected to drop linearly with the frequency change.
- Current laser is operated at 1Hz.
  - 5Hz operation is tested for the system as well.
- IR transport from gun to D600. Laser will be available basically anywhere.
- Seed laser is at 1.3GHz.
  - In principle it is possible to pick 2 bunches separated at integer number of spacing(~720ps) to do pump probe measurement.
- Have demonstrated pulse shaping (IPAC2015 MOPMA043)

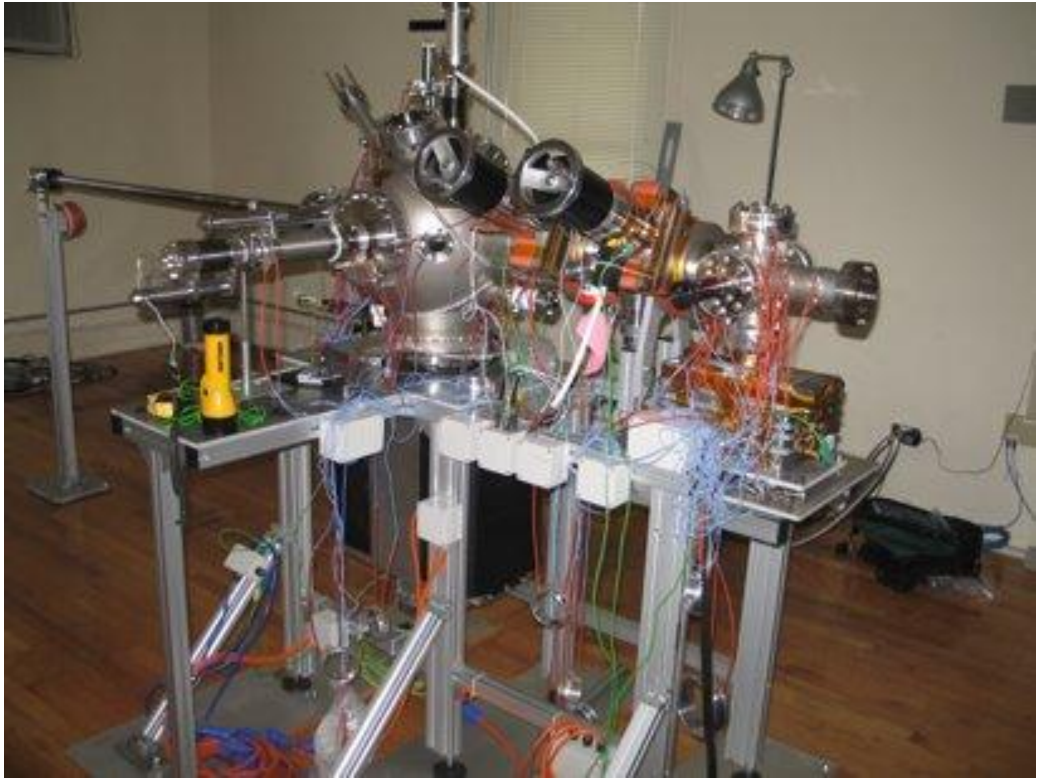
Electron Gun

- 1.3 GHz, normal conducting, 1.5 cell copper cavity (DESY/PITZ design)
- Up to 45 MV/m accelerating field at the cathode; requires 5 MW klystron; 20 KW average power at full ILC pulse length and repetition rate
- Cs_2Te photocathode excited by 263 nm UV laser
- 2 identical solenoids for emittance compensation
- Coaxial RF waveguide coupler
- 3 cavities have been fabricated
  - 1 by DESY – completed and shipped to Fermilab; 1st spare
  - 3 by Fermilab – 1 shipped to KEK; 1 completed and commissioned at NML; 1 as 2nd spare



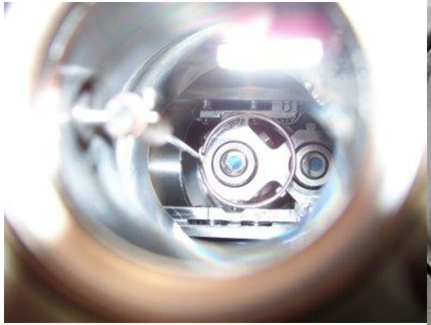


Cathode Preparation

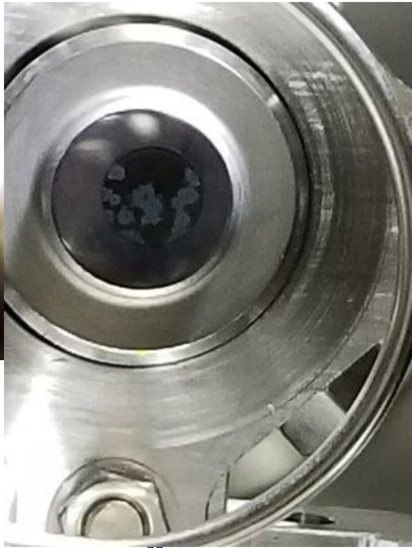


Cathode preparation chamber at Lab 7

- Cathode chambers were fabricated at INFN Milano, Daniele Sertore
  - Preparation chamber
  - Transport chamber
  - Transfer chamber



Newborn vs. 6 year old



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Capture Cavities

- Two 1.3 GHz 9-cell SRF cavities
  - CC1 at 27.5 MV/m
  - CC2 at 17 MV/m
- Parameter scaling, spectrometer based beam energy > 50 MeV

Fermilab

High Energy Beamline

- CM commissioned. ILC goal reached. 250 plus MeV for beam.
- Some conditioning will be done in the upcoming run for long bunch train. Currently we did 500 bunches at 3MHz maximum.
- Several beam line locations are available for R&D.
- Possible space for more R&D.
  - Undulator
  - High energy chicane

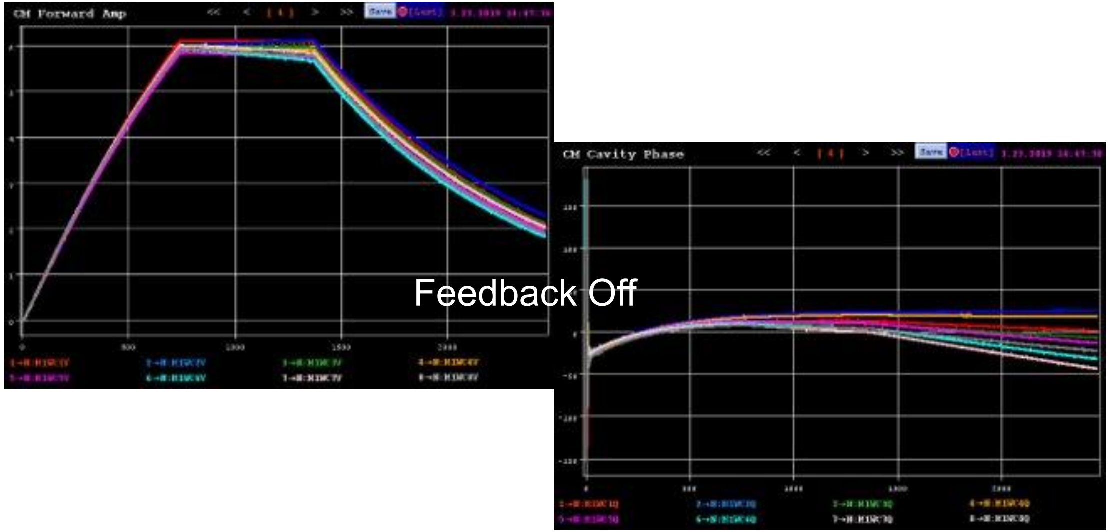
FAST Linac Instrumentation

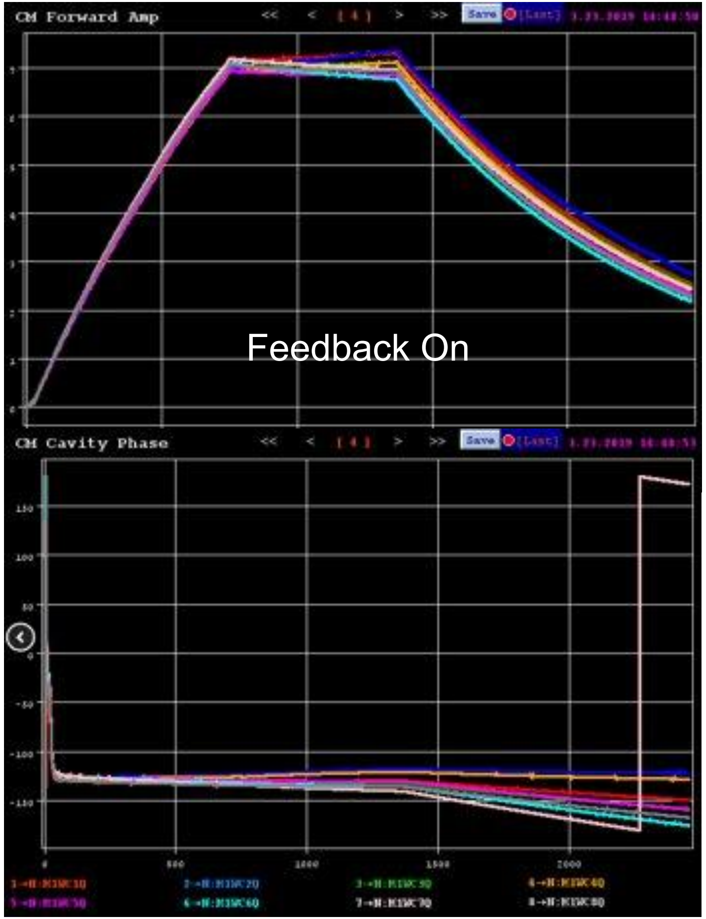
- BPM
  - Capable of doing bunch by bunch monitoring at 3MHz
  - Can handle charge from 50pC to 3.2nC with different gain setting
- Transverse profile monitor
  - Live display
- Longitudinal profile measurement
  - Streak camera
  - Ceramic gap (non-interruptive)
- Charge measurement
  - Faraday cup, Wall current monitor
- HOM detector with Capture cavity and CM

Return to the ILC

ILC Beam requires long pulse operation of the cryomodule

- Feedback
- Lorentz Force Detuning Compensation
- Variable RF Power Taps





Conclusions

- Electron Linac functions well in short pulse mode operation
  - LLRF and laser upgrades to achieve stable long pulse operation
- High bunch charge improvements possible
  - Cathode uniformity - revisit cathode production facility.
  - Laser spot intensity/uniformity

Thanks for your attention.