NML (ASTA) Buildout and Operations

The Accelerator Science Test Accelerator ?
The Advanced Science and Technology Accelerator ?
The Advanced Superconducting Test Accelerator ?
The Advanced Superconducting Technology Accelerator ?
None of the above ?

Mike Church

Accelerator Sector Planning and Strategy Workshop
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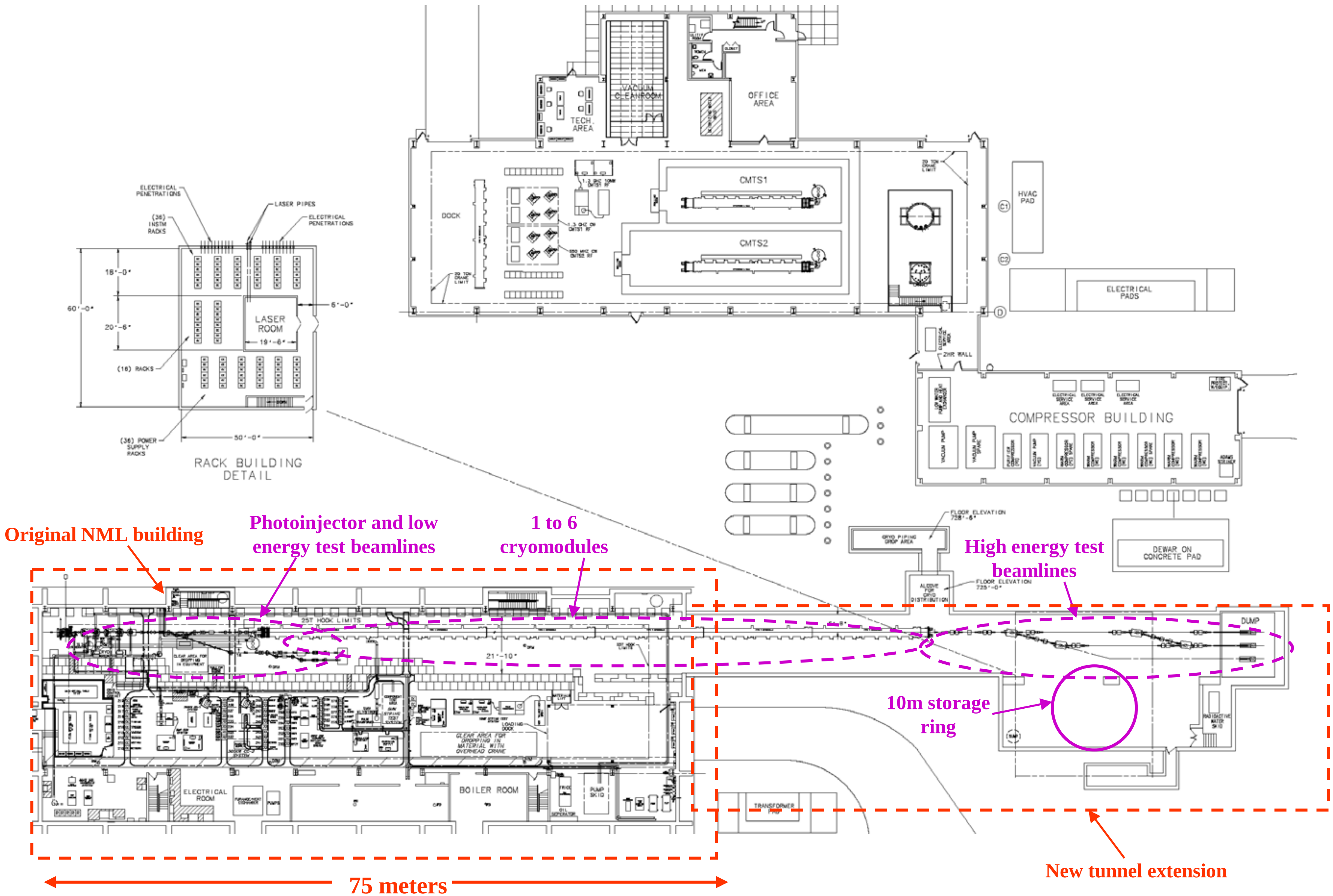
Facility Layout



Beam Parameters

ASTA will be capable of operating with a wide range of beam parameters. As with all photoinjectors, many beam parameters are coupled, especially to the bunch intensity, due to space charge effects.

parameter	ILC RF unit test	range	comments
bunch charge	3.2 nC	10’s of pC to >20 nC	minimum determined by diagnostics thresholds; maximum determined by cathode QE and laser power
bunch spacing	333 nsec	<10 nsec to 10 sec	lower laser power at minimum bunch spacing
bunch train length	1 msec	1 bunch to 1 msec	maximum limited by modulator and klystron power
bunch train repetition rate	5 Hz	0.1 Hz to 5 Hz	minimum may be determined by gun temperature regulation and other stability considerations
norm. transverse emittance	<20 mm-mrad	<1 mm-mrad to >100 mm-mrad	maximum limited by aperture and beam losses; without bunch compression emittance is ~5 mm-mrad @ 3.2 nC
RMS bunch length	1 ps	~10’s of fs to ~10’s of ps	minimum obtained with Ti:Sa laser; maximum obtained with laser pulse stacking
peak bunch current	4 kA	> 10 kA (?)	4 kA based on Impact-Z simulations with low energy bunch compressor
injection energy	40 MeV	5 MeV – 50 MeV	may be difficult to transport 5 MeV to the dump; maximum is determined by booster cavity gradients
high energy	810 MeV	40 MeV – 1500 MeV	radiation shielding issues limit the maximum

Accomplishments to Date

- Project was started in 2006
- Completion of civil construction of new electrical service building and tunnel
- Installation of a large amount of infrastructure – power, water, cryogenics, shielding, HVAC, RF, etc.
- Commissioning and operation of first full Fermilab-assembled cryomodule at high RF power
    - >20 MeV/m average accelerating gradient @ 1 msec flattop pulse length
- Commissioning of SC booster cavity ("CC2") @ 24 MeV/m
- Commissioning of cathode preparation chamber

Strategy

- The long term goal of this facility is to establish an advisory committee-reviewed, proposal-driven user beam facility to carry out advanced accelerator R&D by the world accelerator physics community.
- This research can be aimed at a variety of applications: HEP, light source, homeland security, instrumentation, or other fields where a medium to high energy electron beam is relevant.
  - A discussion of some of the possibilities will follow in P. Piot's talk.
- NML will be unique in the U.S.
  - Dedicated facility; high intensity; high repetition rate; high energy
- The facility will require a dedicated department of ~10 staff to operate efficiently and with high reliability to serve a user community. It will need to be well integrated into Fermilab Accelerator operational practice.

Overall Goals and Plans

- 2012
  - replace cryomodule 1 with cryomodule 2
  - establish 1st beam operation from gun to HE dump with a single cryomodule
- 2013
  - establish high intensity, stable operation with a single cryomodule
  - install 2 more cryomodules
  - commission new refrigerator
  - start 1st AARD experiment (X-ray production from crystal)
  - start installation of IOTA
- 2014
  - establish high intensity, stable operation with 3 cryomodules; start ILC string test
  - start IOTA operation
- 2015
  - continue (complete?) ILC RF string test
  - start installation of double emittance exchange experiment
- 2016 ---
  - Directions undetermined -- reconfiguration for FEL? addition of 2nd bunch compressor and 4th cryomodule ? addition of 3 more cryomodules ? future AARD experiments ?

“Barriers”

- Requires the continuing commitment of Fermilab management and DOE to support AARD even if it is not directly applicable to HEP.
- We are in competition with other facilities for limited R&D funds….
- There are technical challenges, but I do not see any of these as being a “barrier”.
    - Learning to operate this high energy, high intensity accelerator within the Fermilab safety envelope will be a challenge.
- AARD experiments need to be well-chosen and require a reasonable rate of success in order for the facility to maintain credibility.
- We all live with manpower and $$ limitations. I see these potentially delaying the schedule, but not as “barriers.”

FY12 Plans in More Detail

- Complete high power tests and feedback studies with CM1
- Install and commission new photocathode laser (1st complete laser hut)
- Complete high power conditioning of gun RF windows; finish installation of gun RF system; install gun; commission gun
- Replace CM1 with CM2 and recommission
- Remove 9-cell booster cavity from A0 (CC1); refurbish; install at ASTA; commission to high power
- Finish installation of high energy dump and RAW system
- Finish design and installation of low energy dump and RAW system
- Install beamline components – magnets, instrumentation, vacuum components, …
- Reconfigure shielding for beam transport to the high energy dump
- Develop suite of application programs for basic operations
- Complete radiation shielding assessment and SAD
- Install Machine Protection System
- Start beam commissioning – 1st 2 Faraday cup downstream of gun, then to 40 MeV dump, then to high energy dump

- **Deliverable**
    - low intensity ~250 MeV beam to the high energy dump

FY13 – FY14 Plans in More Detail

- Remove 5-cell deflecting mode cavity from A0; refurbish; install at ASTA
- Establish high intensity operation with a single cryomodule
- Install 1^{st} AARD experiment (X-ray production from crystal) in 40 MeV beamline
- Install IOTA ring
- Install and commission 2 more cryomodules
- Commission new refrigerator
- Establish reliable high intensity 800 MeV beam operation

- **Deliverables**
  - High intensity ~800 MeV beam to the high energy dump
  - Installation of IOTA and x-ray production experiment

Resources

- The vast majority of resources for this project come via Project 18
  - see R. Kephart's talk
- FY12:
  - NML buildout has been allotted 2.5 M$ M&S; requests from task leaders amount to 4.4 M$; this has been prioritized so that 3.0 M$ is being requested for FY12
- Future operations:
  - A department of 10 people has been formed in AD (SRF Electron Test Facility Dept.). I believe this is adequate to operate ASTA.
  - I estimate an additional 5 FTE's from support groups will be required to keep the facility operating reliably.
  - This does not include effort for building and installing AARD experiments

Risks

- **Primarily schedule risks**
  - **Installation, RF cavity conditioning, cryo commissioning, and beam operation conflicts may slow down overall progress**
  - **Gun may take longer to commission than anticipated**
- **Technical risks**
  - **Beam energy may be limited by cavity gradients**
  - **Beam intensity may be limited by beam losses, dark current, and radiation**
  - **Beam quality may be limited by problems with the gun**