The Advanced Superconducting Test Accelerator (ASTA)

Mike Church
Fermilab User's Meeting
June 12, 2012

Fermilab

Outline

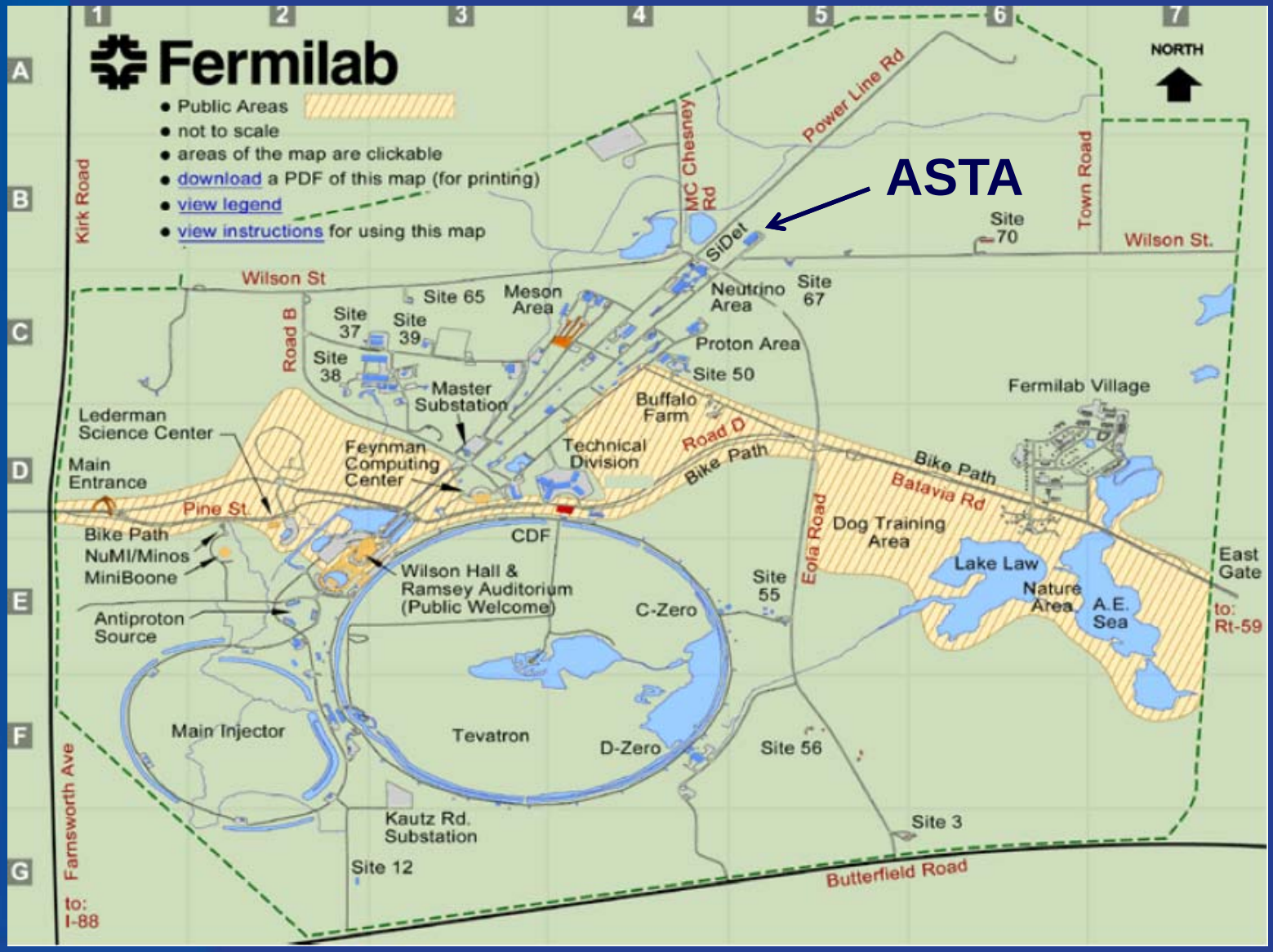
- What is ASTA?
- ASTA experiments
- Status and Goals

Purpose of ASTA

- **Test and operate a full ILC "RF unit" with "ILC beam intensity" (S2 R&D task)**
  - **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 with a 5 Hz repetition rate. The RMS bunch length is 300 μm (45 KW beam power). ! Electrons !**
- **Establish an advisory committee-reviewed, proposal-driven user beam facility to carry out advanced accelerator R&D by the accelerator physics community (similar to ATF at BNL)**

ASTA is a unique beam facility in the U.S. Similar to FLASH at DESY, which is an FEL user facility.

Location


Fermilab
Public Areas
not to scale
areas of the map are clickable
download a PDF of this map (for printing)
view legend
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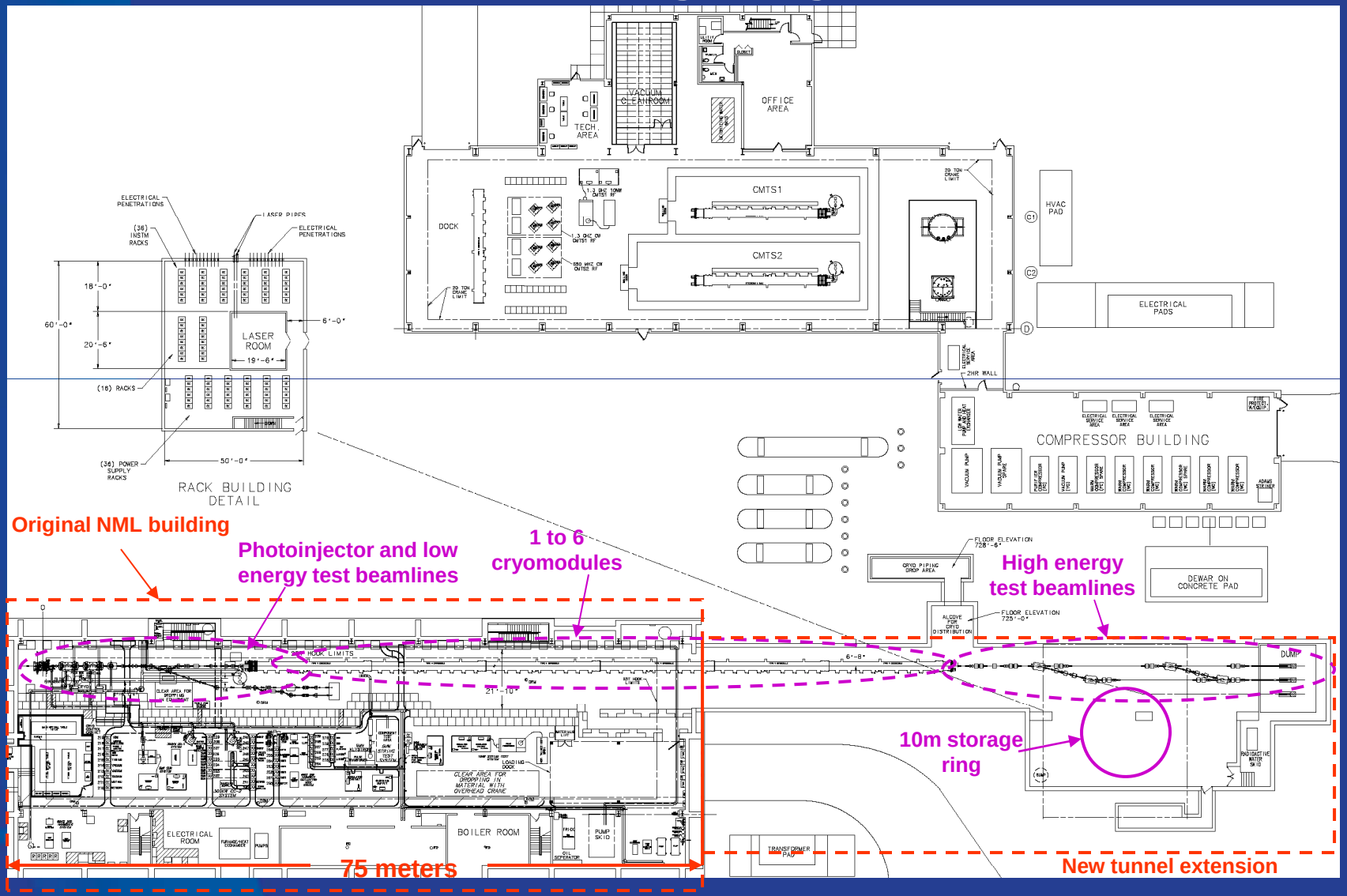
NORTH
ASTA
SiDet
Power Line Rd
MC Chesney Rd
Town Road
Wilson St.
Site 70
Kirk Road
Wilson St
Site 65
Meson Area
Neutrino Area
Site 67
Road B
Site 37
Site 39
Site 38
Proton Area
Site 50
Master Substation
Buffalo Farm
Fermilab Village
Lederman Science Center
Main Entrance
Feynman Computing Center
Technical Division
Road D
Bike Path
Batavia Rd
Pine St.
Bike Path NuMI/Minos MiniBoone
CDF
Dog Training Area
Eola Road
Lake Law
Nature Area
A.E. Sea
East Gate
to: Rt-59
Wilson Hall & Ramsey Auditorium (Public Welcome)
Site 55
Antiproton Source
C-Zero
Main Injector
Tevatron
D-Zero
Site 56
Kautz Rd. Substation
Site 3
Site 12
Farnsworth Ave
Butterfield Road
to: I-88

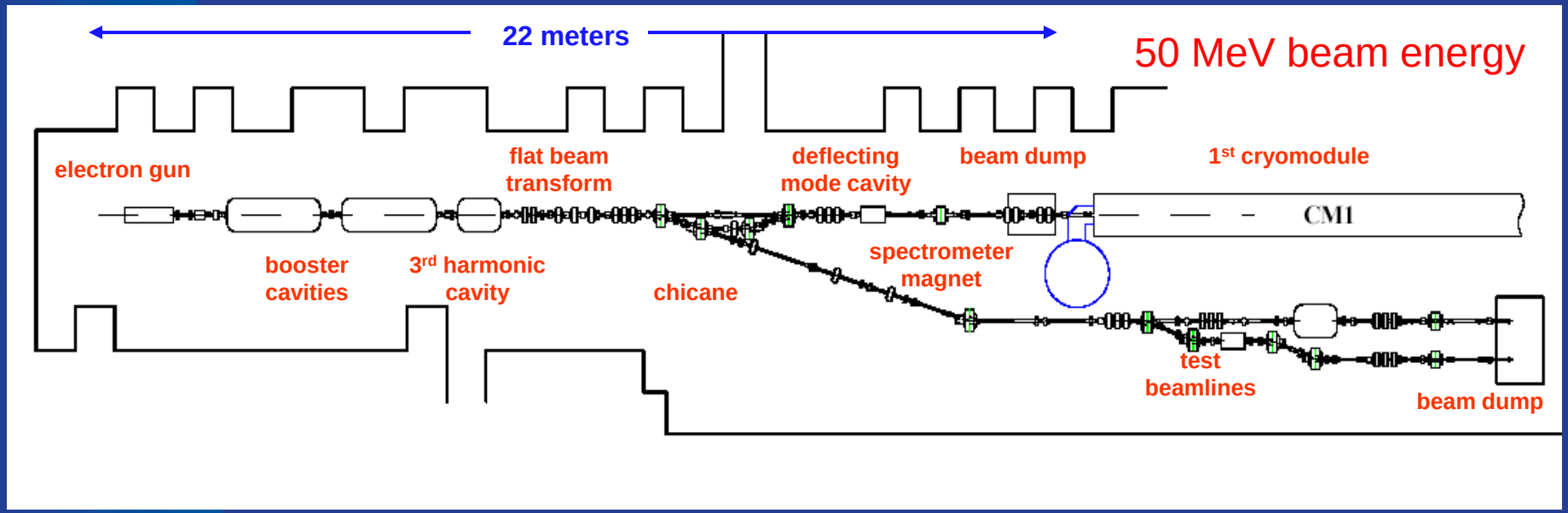
Aerial View

Facility Layout



ASTA Building Interior

Low Energy Beamline Layout



Electron Gun

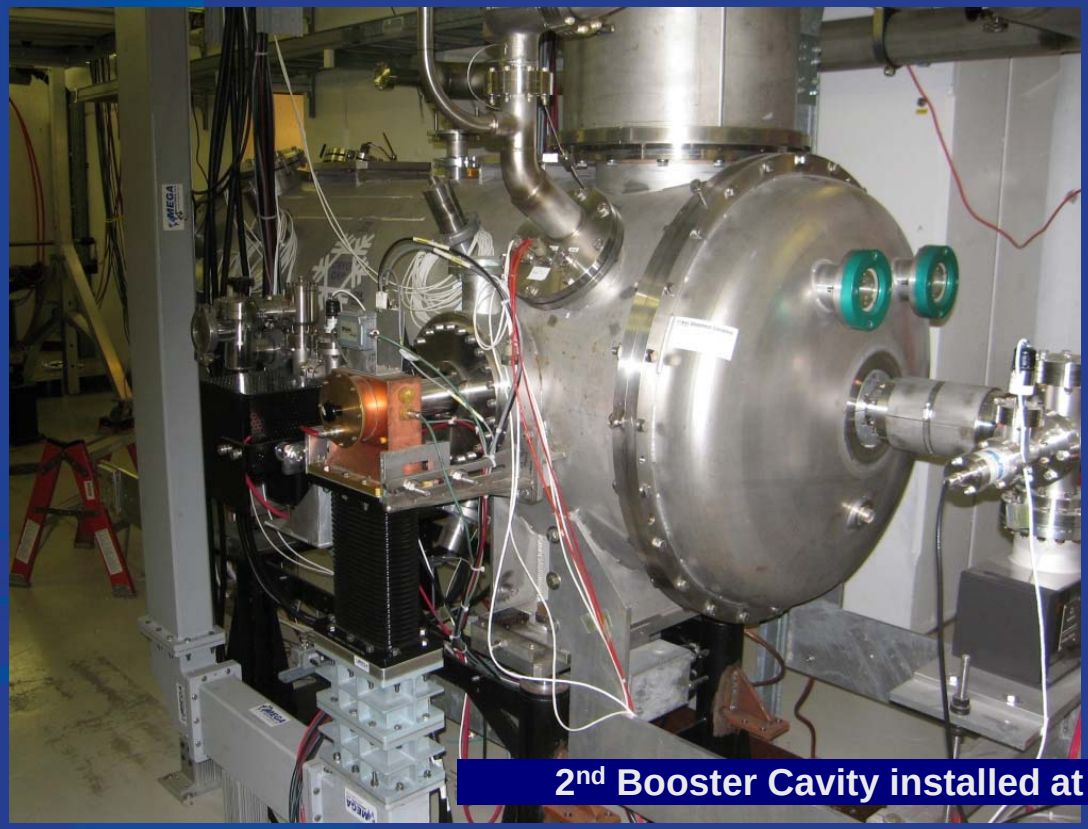
- 1.3 GHz, normal conducting, 1.5 cell copper cavity RF electron gun (DESY/PITZ design)
- Up to 45 MV/m accelerating field at the cathode; requires 5 MW klystron; 20 KW average power at full ILC pulse length and repetition rate; output beam energy is 5 MeV
- Cs_2Te photocathode excited by 254 nm uv laser

gun cavity

Gun, solenoids, and RF coupler

Booster Cavities

- 2 superconducting 1.3 GHz 9-cell booster cavities will boost energy out of gun to 50 MeV
  - One is already commissioned at ASTA
  - Another has been removed from A0PI and is being refurbished with higher gradient cavity



2nd Booster Cavity installed at ASTA

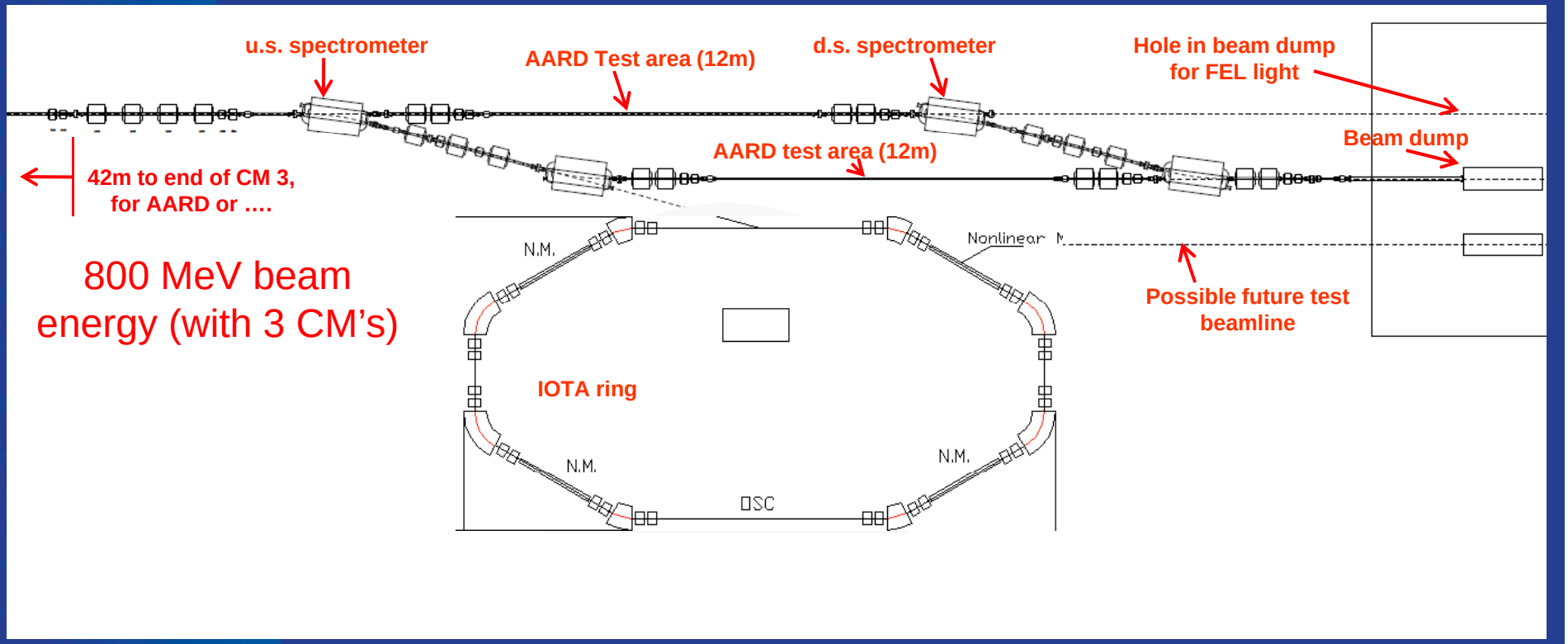
SRF Cryomodules

- 1.3 GHz superconducting RF cryomodules, each containing 8 9-cell cavities
  - 1st cryomodule was assembled at Fermilab from a kit from DESY; it was operated at ASTA to gradients of 20 to 28 MV/m; and then removed for refurbishing with higher gradient cavities
  - 2nd cryomodule was entirely built in the U.S.; currently being installed at ASTA; all individual cavities have reached gradients of 35 MV/m in the vertical test stand

Cryomodule 1 Installed at ASTA

Cryomodule 2 Installed at ASTA

Downstream Beamline Layout



Workshops to develop experimental program

--- Mini-workshop organized by Fermilab ---

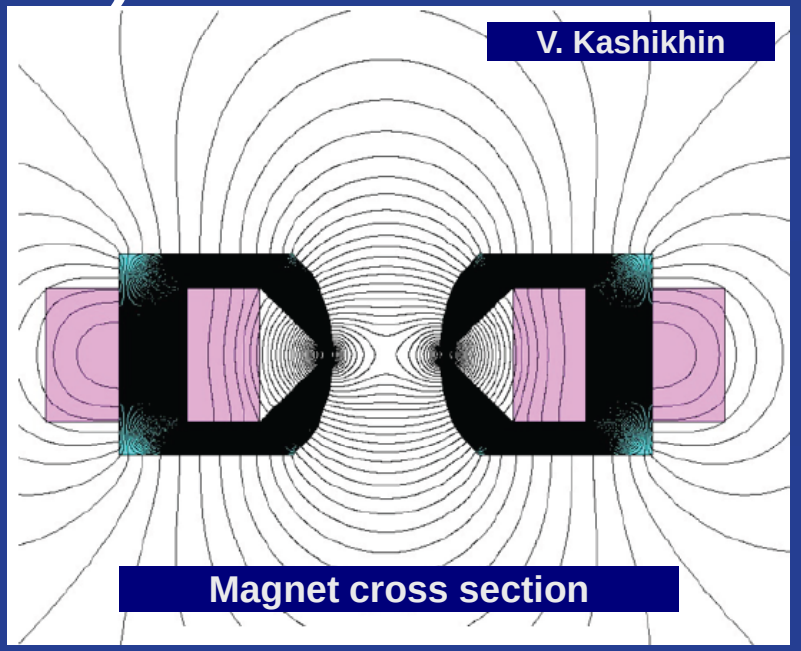
Possible Directions for Advanced Accelerator R&D at the ILC test accelerator at Fermilab

Tuesday November 28th, 2006,
Fermilab, Wilson Hall room 1 North

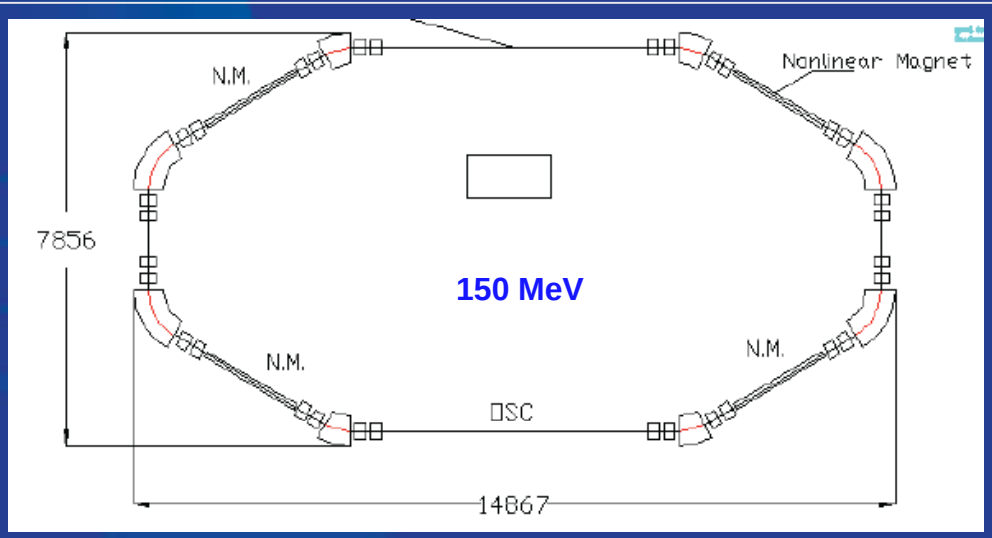
Joint Fermilab-Argonne Working Group on Scientific Opportunities for Advanced Accelerator R&D at ASTA

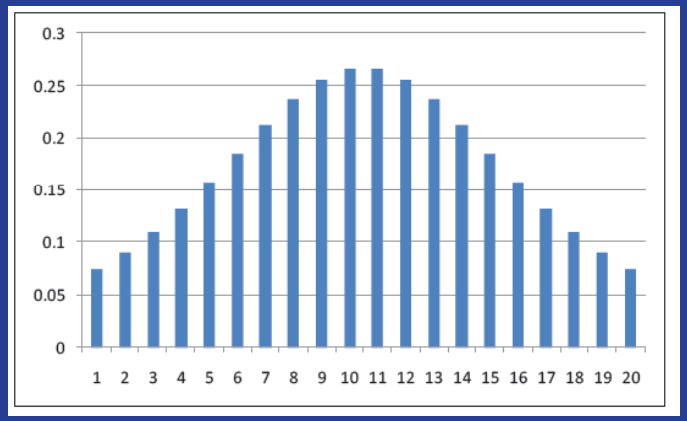
IOTA - Integrable Optics Test Accelerator (FNAL/ORNL)

Recent calculations **(Danilov, Nagaitsev, PRSTAB 13, 084002)** indicate a solution using nonlinear focusing elements to produce a nonlinear lattice in a storage ring able to support stable beam with tune spread of ~0.5. The large tune spread provides sufficient Landau damping to support stable intense beams.



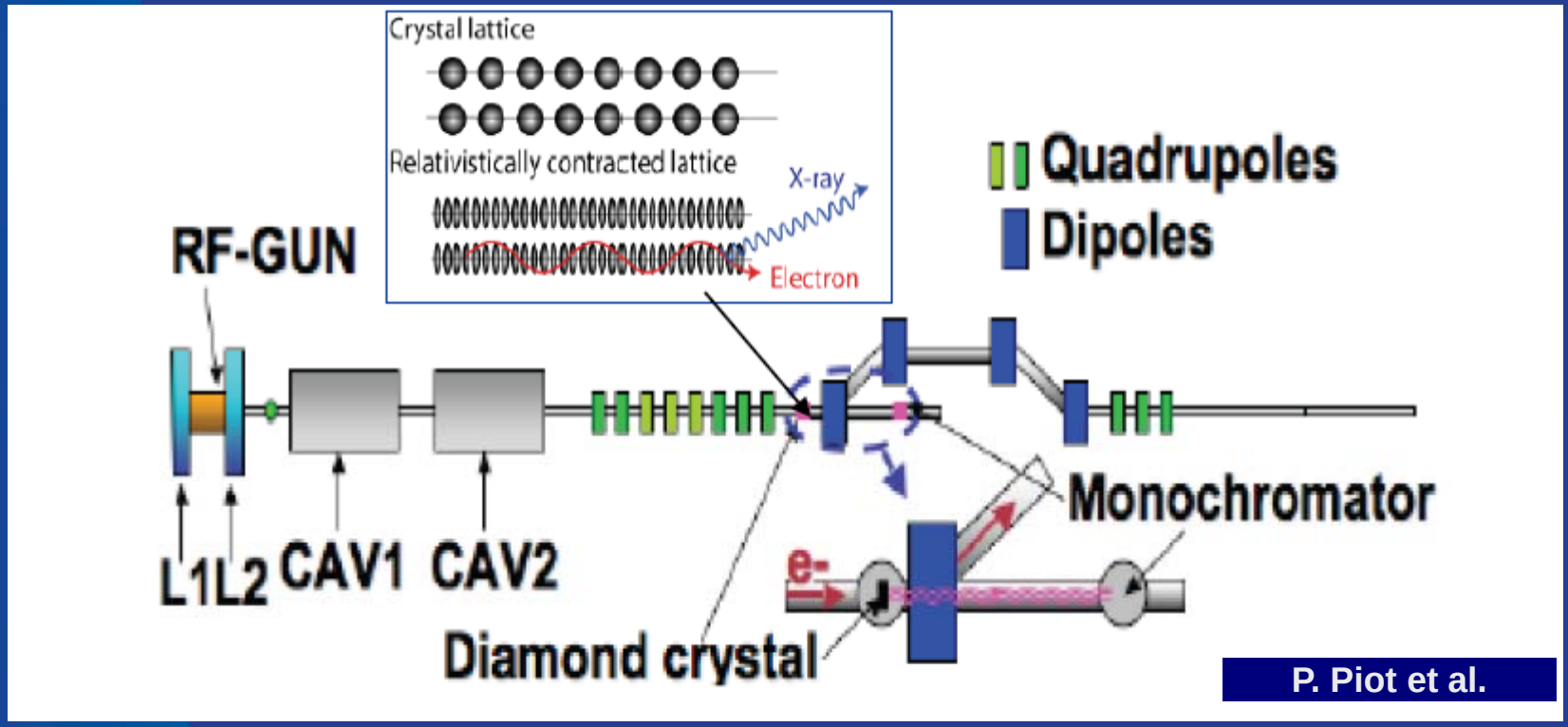
Magnet cross section





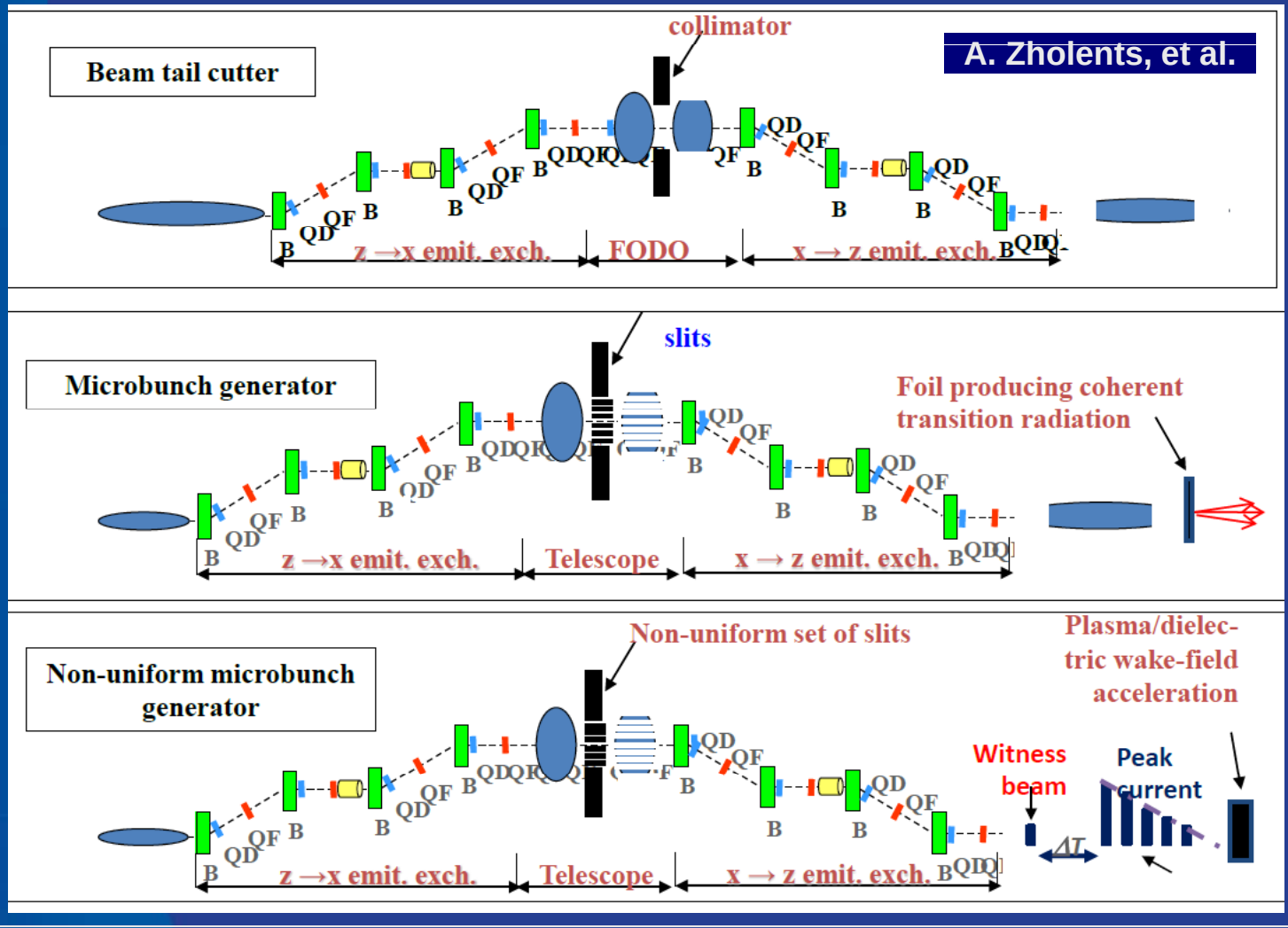
Quadrupole moment as a function of s

X-Ray Production from Crystals



- Will be installed in the 50 MeV beamline at the 1st chicane dipole
- NIU/Vanderbilt/Tech-X/Radiabeam/FNAL collaboration
- Intended to address the DOD challenge for high intensity X-ray beams
  - 10^{12} photons/sec/mm^2/mrad^2/0.1%BW

Double Emittance Exchange



- **Will be installed in the 42 m long section just downstream of the 3rd cryomodule and upstream of the 1st high energy spectrometer magnet**

Other potential experiments (1)

Experiment	Energy	proponent	Motivation/ application
Slit microbunching generation	low	FNAL	For wakefield investigations;
Ellipsoidal beam generation	low (egun)	NIU/FNAL	Low emittance beams
Microbunching investigations	low, high?	ANL/FNAL	Beam physics; diagnostics
ODR instrumentation development	high	ANL/FNAL	Non-invasive emittance diagnostic
Flat beam transform and image charge undulator	low	FNAL/NIU	Compact UV/ soft X-ray source
Flat beam transform	high	LANL	Proof-of-principle for MaRIE
Emittance exchange	high	LANL	Proof-of-principle for MaRIE
6-D muon cooling	high	IIT/FNAL	Proof-of-principle for muon collider
Optical stochastic cooling	high	IIT	Proof-of-principle; muon collider

Other potential experiments (2)

Experiment	Energy	proponent	Motivation/ application
PIC lattice test	high	FNAL/Muons Inc	Muon collider
Reverse emittance exchange	Low?, high?	FNAL/Muons Inc	Muon collider
Dielectric Wall Accelerator section	Low? high?	FNAL	Muon collider; induction linac
Measure plasma wakes with long bunch trains	high	USC	Application to 2-beam plasma acceleration
Measure plasma wakes with laser interferometry	high	USC	Application to 2-beam plasma acceleration
Photoproduction of muons @ 300 MeV	high	FNAL	Homeland security; verify production model
High harmonic light generation in undulator	high	LBNL	Tests for NGLS
High gradient wakefield acceleration with dielectric structures	Low?, high?	ANL/NIU	many

Overall Goals and Schedule

- 2012
  - Replace cryomodule 1 with cryomodule 2 and commission
  - Commission the electron gun – 5 MeV beam
  - Commission the 2nd SRF booster cavity
- 2013
  - Establish 50 MeV beam to the low energy dump
  - Establish high energy beam through 1 cryomodule to the high energy dump
  - Perform diamond radiator experiment
  - Start installation of IOTA experiment
- 2014
  - Install and commission 2nd and 3rd cryomodules
  - Commission new refrigeration plant
  - Establish high energy beam through 3 cryomodules
- 2015
  - Perform ILC RF string test
  - Start installation of double emittance exchange experiment (and others?)
- 2016 ---
  - Directions to be determined … -- reconfiguration for FEL? addition of 2nd bunch compressor and 4th cryomodule ? addition of 3 more cryomodules ? future AARD experiments ?