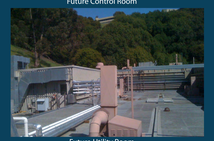
Building 71 (April 2008)


Future LASER BAY

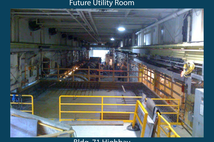

Future Experimental Cave


Future Experimental Cave Labyrinth


Future Control Room


Future Utility Room


Future Utility Room


Bldg. 71 Highbay

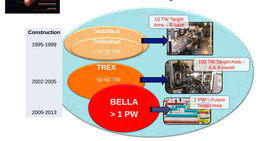
CD-0 Project Origins (July 2008)

Approve Mission Need

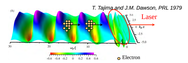
BELLA (BErkeley Lab Laser Accelerator)10 GeV laser plasma accelerator (LPA) that will be driven by a PW-class laser system and of the BELLA Project, under which the required Ti:sapphire laser system for the acceleration experiments is being installed. The basic design of the 10 GeV stage aims at operation in the quasi-linear regime, where the laser excited wakes are largely sinusoidal and allow acceleration of electrons and positrons. Simulations show that a 10 GeV electron beam can be generated in a meter scale plasma channel guided LPA operating at a density of about 1017 cm-3 and powered by laser pulses containing 30-40 J of energy in a 50-200 fs duration pulse, focused to a spotsize of 50-100 microns.

- **Publications (total 91) in top journals:**
  - Nature: 1 (cover story September 2004 – 273 citations since 9/04)
  - Nature Physics (2006): 1 (82 citations since 10/06)
  - Science (1996): 1 (188 citations since 10/96)
  - Phys. Rev. Lett.: 18
  - Phys. Rev. E: 10
  - Phys. Rev. STAB: 3
  - Phys. Plasmas: 22
  - IEEE Trans. Plasma Science: 4
  - Trans. Royal Society London: 1
  - Comptes Rendus de l'Academie: 2
  - Optics Letters: 3

LOASIS Program



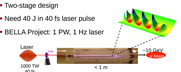
Principle of laser/plasma wakefield accelerators



- Space charge wave
- Extremely large E-fields
- Laser or beam driver
- Linear or non-linear regime

Demonstration of 10 GeV module

- Two-stage design
- Need 40 J in 40 fs laser pulse
- BELLA Project: 1 PW, 1 Hz laser



- Will be followed by staging at multi-GeV energies with BELLA
- 10 GeV beam will allow positron production experiments

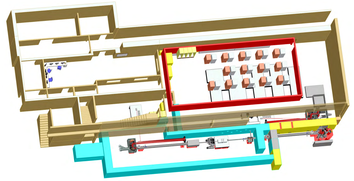
CD-1 Development (July 2009 Review)

Approve Alternative Selection and Cost Range

Facility development and design to accomodate laser system and experimental requirements
- Vibration analysis of building site
- Functional analysis of various layout options
- Value engineering, optimization, and design trade off studies

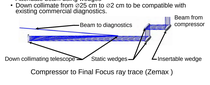
Laser specifications finalized and approval to proceed with long lead procurement

Preliminary design of :
- Opto-mechanical system
- Vacuum system
- Elecronic and control systems
- Safety and Protection systems



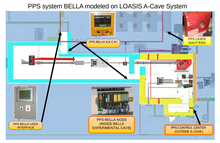
BELLA CD-1 Layout

- Purpose: Characterize laser beam up to full power
  Properties include:
  - Energy
  - Pulse Duration
  - Pulse shape
  - Wave front
- Approach:
  - Attenuate beam using wedges
  - Down collimate from ≥25 cm to ≥2 cm to be compatible with existing commercial diagnostics.

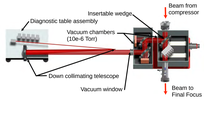


Compressor to Final Focus ray trace (Zemax)

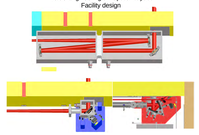
PPS system BELLA modeled on LOASIS A-Cave System



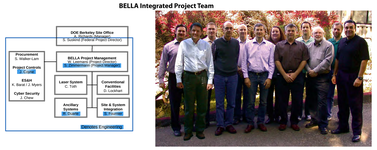
- Technical challenges:
  - Use of X/10 optics required to maintain wavefront quality.
  - Beam dumps to be able to handle the full power beam.
  - Attenuation filters



Value Engineering on Optical Layout
Facility design



BELLA Integrated Project Team

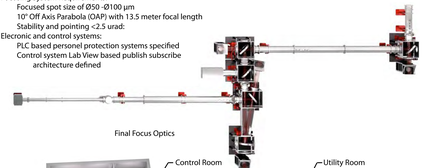


CD-3 Design (June 2010 Review)

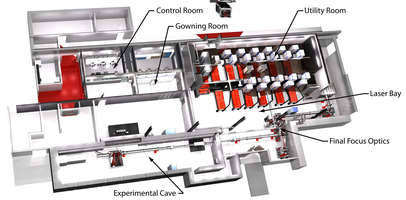
Approve Performance Baseline, Approve Start of Construction

Detailed design of all systems and components finalized and procurement and fabrication begin.
Opto-mechanics: Final focus and beam transport system that is independant of vacuum system.
Focusing System Requirements:
- Focused spot size of Ø50 -Ø100 µm
- 10° Off Axis Parabola (OAP) with 13.5 meter focal length
- Stability and pointing <2.5 urad:

Elecronic and control systems:
- PLC based personel protection systems specified
- Control system Lab-View based publish subscribe architecture defined

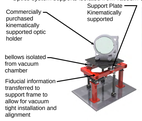


Final Focus Optics



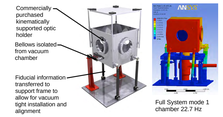
BELLA CD-3 Layout

Optics system supports isolated from vacuum chamber supports



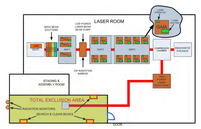
Optic Only Support first mode 23.14 Hz

Optics system supports isolated from vacuum chamber supports

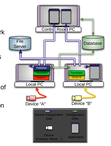


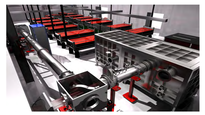
Full System mode 1 chamber 22.7 Hz

RSS Layout



- Publish/Subscribe framework to handle common tasks
  - Transmitting data across network
  - Tracking shot number
- Enterprise-level file server ensures reliable, available storage
- Configuration/Status Database
  - Moves device configuration out of specialized programs
  - Enables automated configuration
  - Simplifies status monitoring

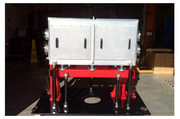




BELLA Final Assembly, Installation & Operational Projects

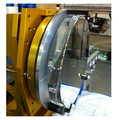
Site & System

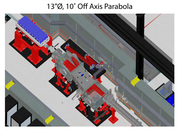

Mirror Chambers


Plasma Region Chamber


18" Optic Mounts


High Power Diagnostic Swing Mirror

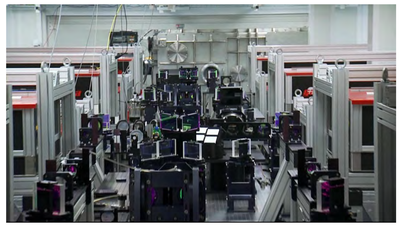

13"Ø, 10° Off Axis Parabola


(Operations) High Power Diagnostic and Spectrometer


High Power Diagnostic Zemax layout

BELLA Laser bay and Final Focus Optocs (January 2012)
waiting for THALES laser system t o be delivered

BELLA Laser System Manufactured by THALES Optronics (FRANCE)
Specifications: 1 Hz Repetition rate, 820 nm ± 20 nm , > 40 J, < 30 fs, 1.3 Petawatts
Energy Fluctuation < 2.5 % (r.m.s), Wavefront Quality > 0.7 Strehl ratio,
Beam pointing stability < 1.2 micro-radian (r.m.s)
(Currently being installed and commissioned)



BELLA (January 2012)

LASER BAY

Experimental Cave

Experimental Cave Labyrinth

Control Room

Utility Room

Utility Room Inside

Bldg. 71 Highbay

LOASIS: Eric Esarey, Cameron Geddes, Tony Gonsalves, Wim Leemans, Kei Nakamura, Carl Schroeder, Thomas Sokollik, Csaba Tóth, ...
Facilities: Doug Lockhart, George Sanen, ... – EH&S: Ken Barat – Procurement: Sue Walker–Lam
Engineering: Dennis Baum, Adam Brown, Samantha Brown, Mike Baldwin, Mark Coleman, Dan Colomb, Curtis Cummings, Mike Decool, Aalhad Deshmukh, Rob Duarte, Zach Eisentraut, Dan Ellis, Dave Evans, Jennifer Fish, Steve Fournier, Alex Gavidia, Dennis Gibson, Bob Gunion, Chris Hernikl, Dave Humphries, Mark Kirkpatrick, John Mackintosh, Greg Mannino, Harry Meyer, Vlad Moros, Dawn Munson, James Osborn, Kem Robinson, Ohmar Sowle, Thorsten Stezelberger, Don Syversrud, Marek Szajbler, Nathan Ybarrolaza, Sergio Zimmerman, ...

BERKELEY LAB

BELLA BERKELEY LAB LASER ACCELERATOR

U.S. DEPARTMENT OF ENERGY