UH Linear Accelerator / FEL status and plans

US-Japan Beam Monitor Workshop

Bidault Niels
University of Hawaii at Manoa
Department of Physics and Astronomy

February 19th, 2025

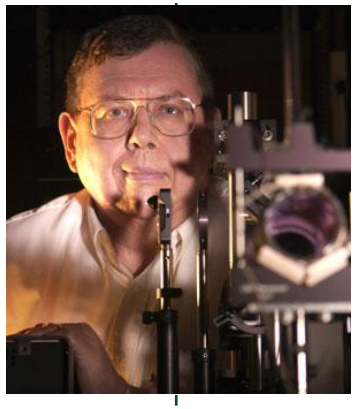
UH Linear Accelerator / FEL status and plans

- Brief overview of the accelerator
- Operating Configurations
- Recommissioning of the linac
- Planning

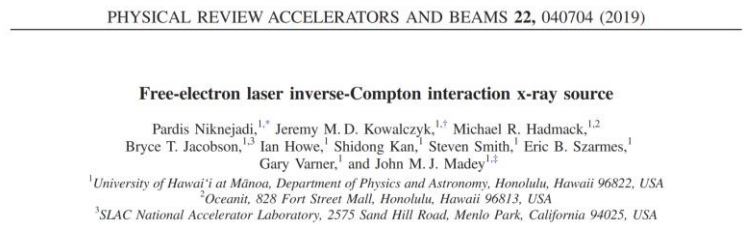
Brief Overview of the Linear Accelerator

Prof. John Madey brings FEL science to UH

MkIII transferred to UH and upgraded to MkV



First IR light observed from MkV



PHYSICAL REVIEW ACCELERATORS AND BEAMS **22,** 040704 (2019)

Free-electron laser inverse-Compton interaction x-ray source

Pardis Niknejadi,[1,*] Jeremy M. D. Kowalczyk,[1,†] Michael R. Hadmack,[1,2] Bryce T. Jacobson,[1,3] Ian Howe,[1] Shidong Kan,[1] Steven Smith,[1] Eric B. Szarmes,[1] Gary Varner,[1] and John M. J. Madey[1,‡]

[1]*University of Hawai'i at Mānoa, Department of Physics and Astronomy, Honolulu, Hawaii 96822, USA*
[2]*Oceanit, 828 Fort Street Mall, Honolulu, Hawaii 96813, USA*
[3]*SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, California 94025, USA*

X-ray scattering chamber

First X-ray light detected

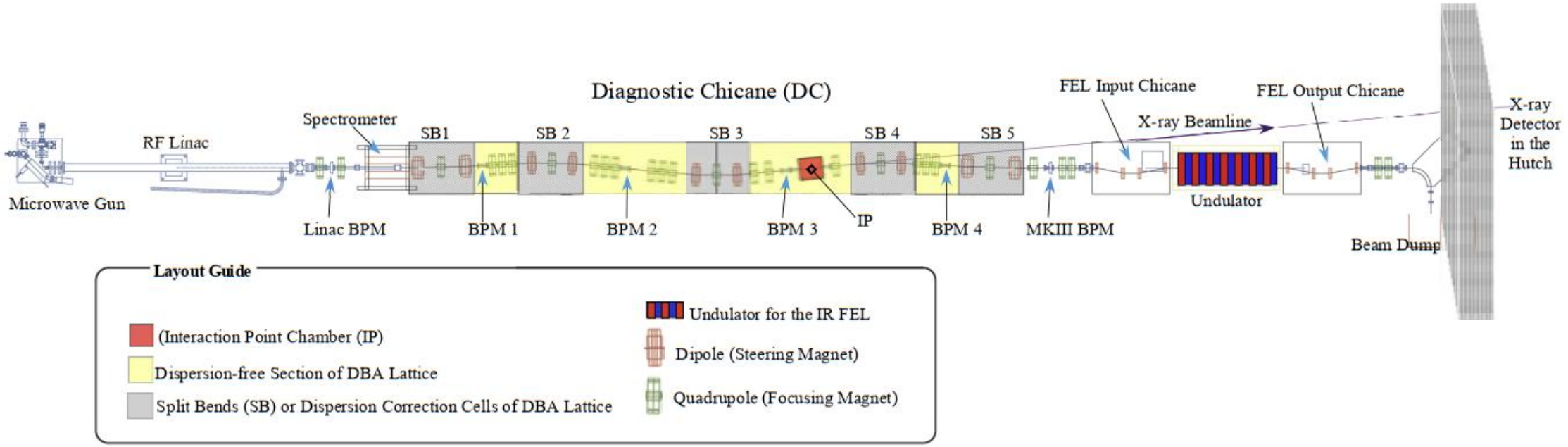
Restart of a group

1998 2002 2009 2012 2015 2024

Brief Overview of the Linear Accelerator

A broad spectrum of research

Cavity-enhanced X-ray sources, Inverse-Compton Scattering, LIDAR, Remote Sensing, Spontaneous Harmonic Radiation, Remote Sensing, Interferometers for FELs, Accelerator R&D, etc.

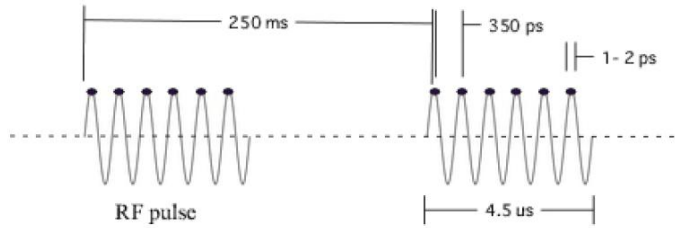


A few numbers

- 14 graduate students (from 2006 to 2016)
- More than 5 fully funded proposals, including a $19M grant sponsored by the US Army Space and Missile Defense Command
- More than 10 refereed journal publications; 5 conference proceedings; 1 book (from 2012 to 2016)

Operating Configurations

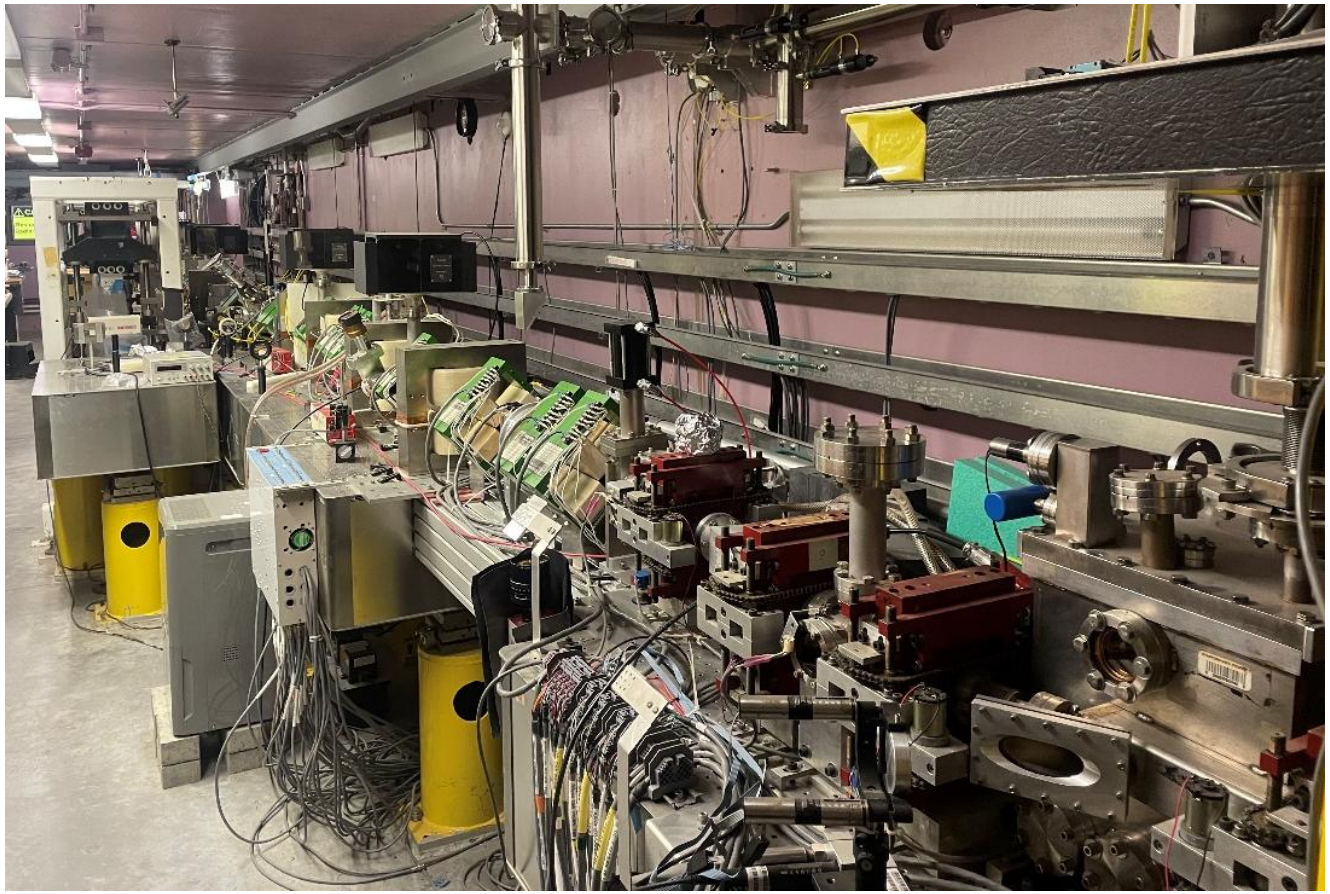
	Design value		Operating value until 2016
Machine Timing			
Linac Frequency		S-band	2856 MHz
Micropulse duration	1 – 2 ps		1 – 2 ps
Macropulse duration	4 – 8 us		4 us
Macropulse rep rate	4 – 100 Hz		4 Hz
Electron Beam			
Energy	5 – 45 MeV		35 – 45 MeV
Transverse Emittance	8 pi.mm.mrad		20 pi.mm.mrad
Min. Waist spot size	40 um		200 um
IR FEL			
Wavelength	1.5 – 9 um		2 – 6 um
Energy	10 – 100 mJ		1 – 4 mJ
Peak Power	5 MW		5 MW



Recommissioning of the LINAC

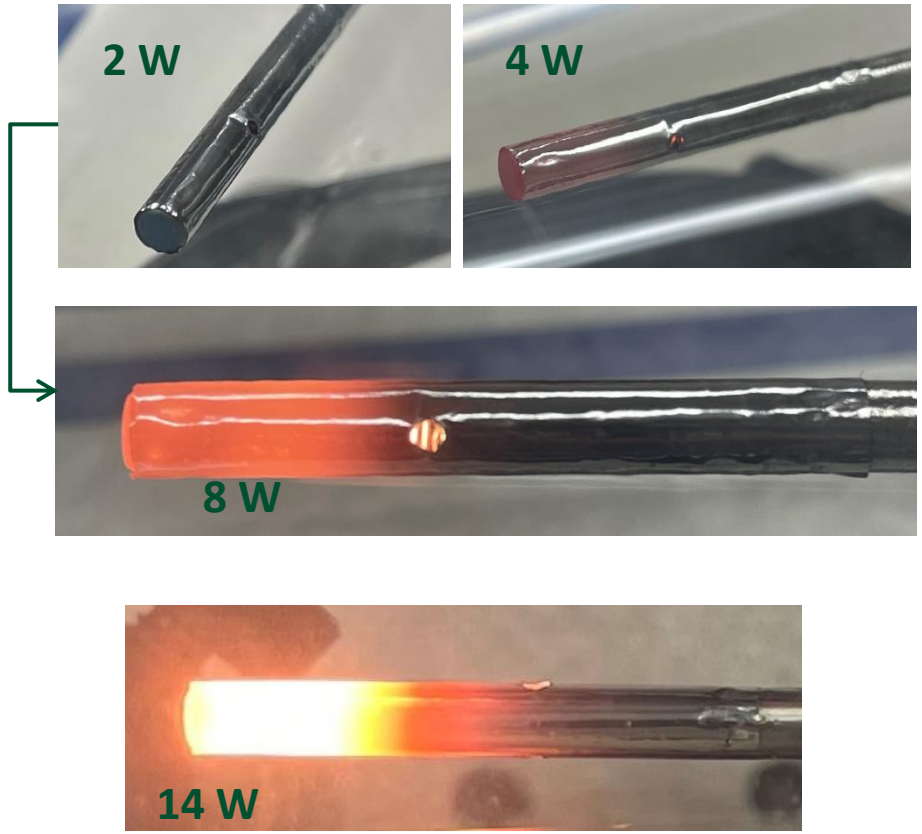
Steps done towards the linac recommissioning

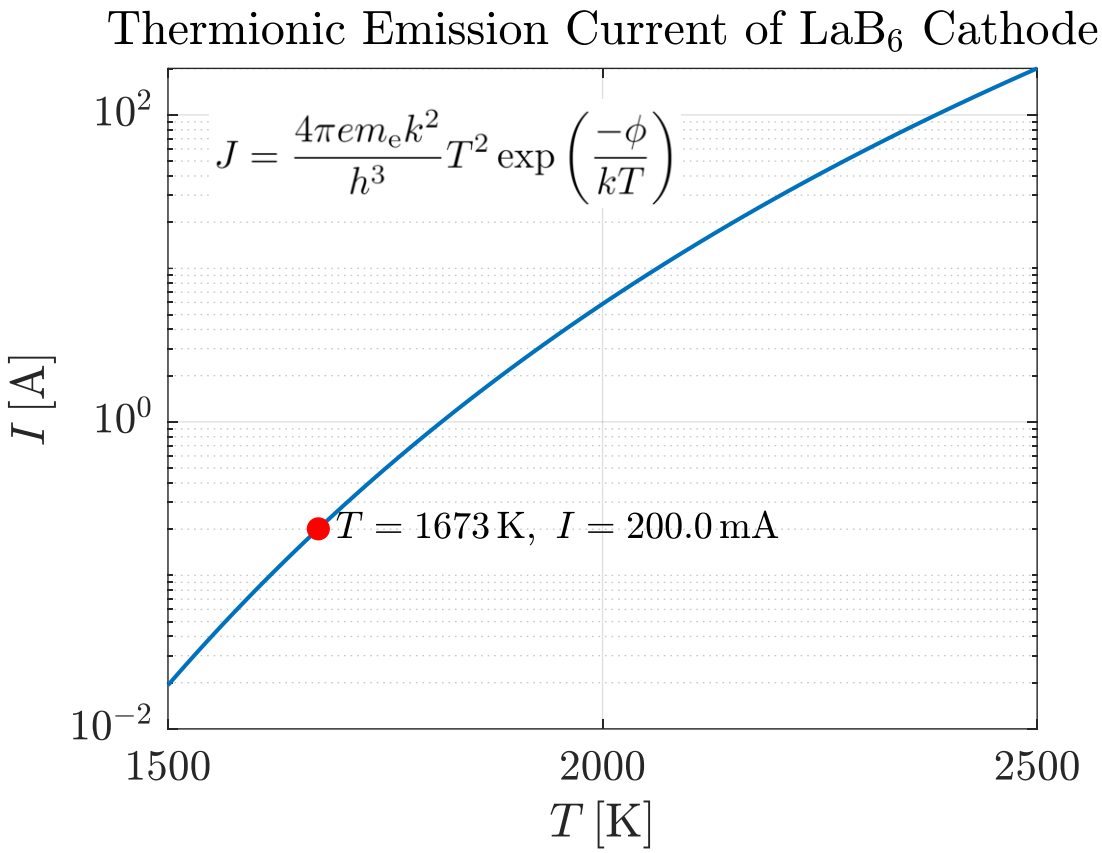
- High-voltage conditioning
- Low RF power tests
- New RF amplifier to drive the klystron
- Solved vacuum leaks in the RF gun
- Fabrication of a new cathode for the RF gun
- Powering tests of the magnets
- Other subsystems…

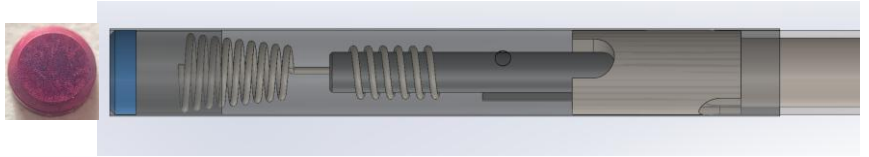


Recommissioning of the LINAC: new cathode

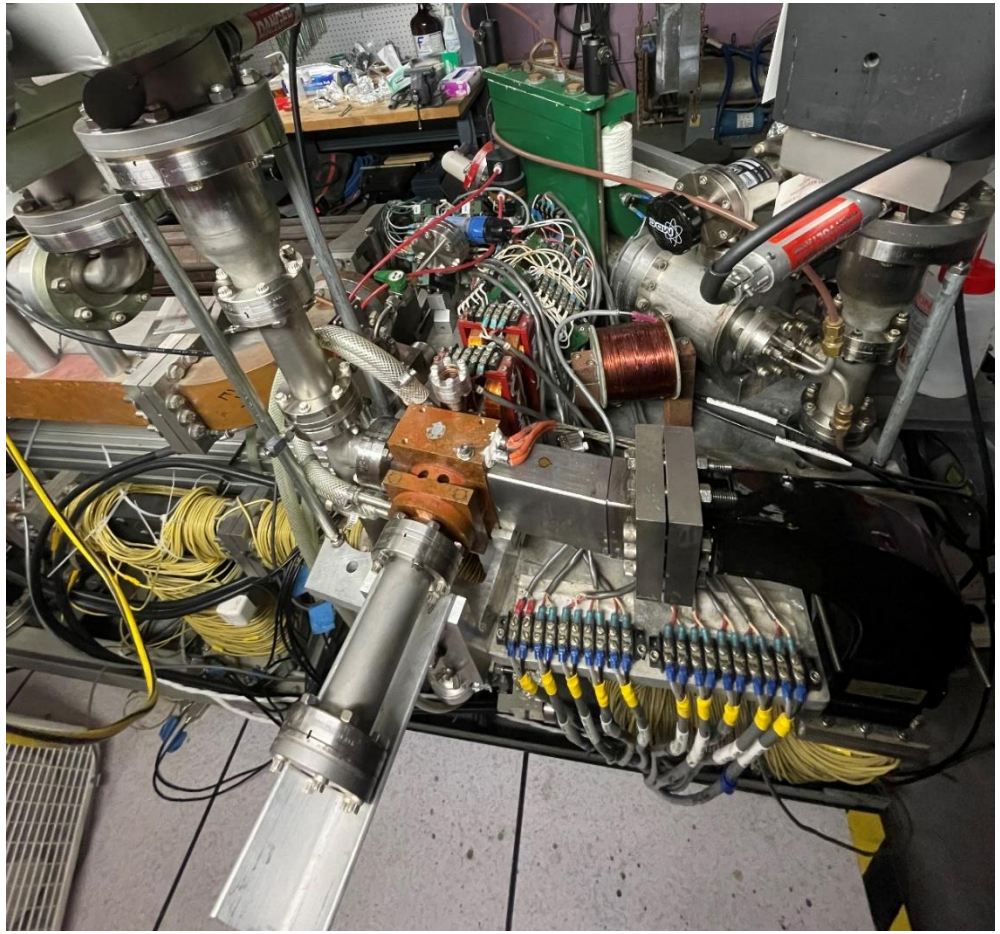
Aspects of the cathode during the powering steps







Recommissioning of the LINAC: hunt for vacuum leaks



Recommissioning of the linac: hunt for vacuum leaks

Cathode removal

Bake-out gun

Leak detection
- Fix leak on Gun Toroid 1
- New gaskets on vacuum column
- Apply VacSeal

Exchange of Ion Pumps

Leak detection
- Leak detected on the H-bend
- H-bend offline testing
- More VacSeal

Vacuum upgrade
- Installation of a new Turbo
- Installation of a new Ion Pum
- Even more VacSeal

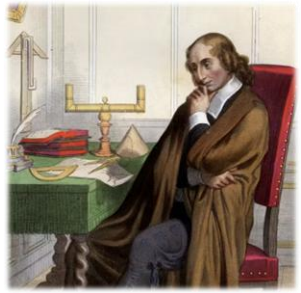
3/24 4/24 5/24 6/24 7/24 8/24 9/24 10/24 11/24 12/24 1/25

1e-7

P = 5e-7-> 5e-6

P = 5e-6 -> 1e-6

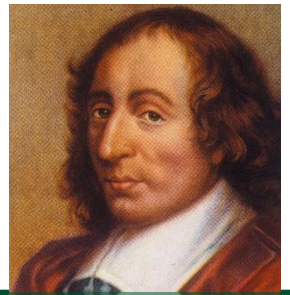
P = 1e-6-> 7e-5



P = 5e-5-> 1e-5

P = 1e-5-> 9e-4

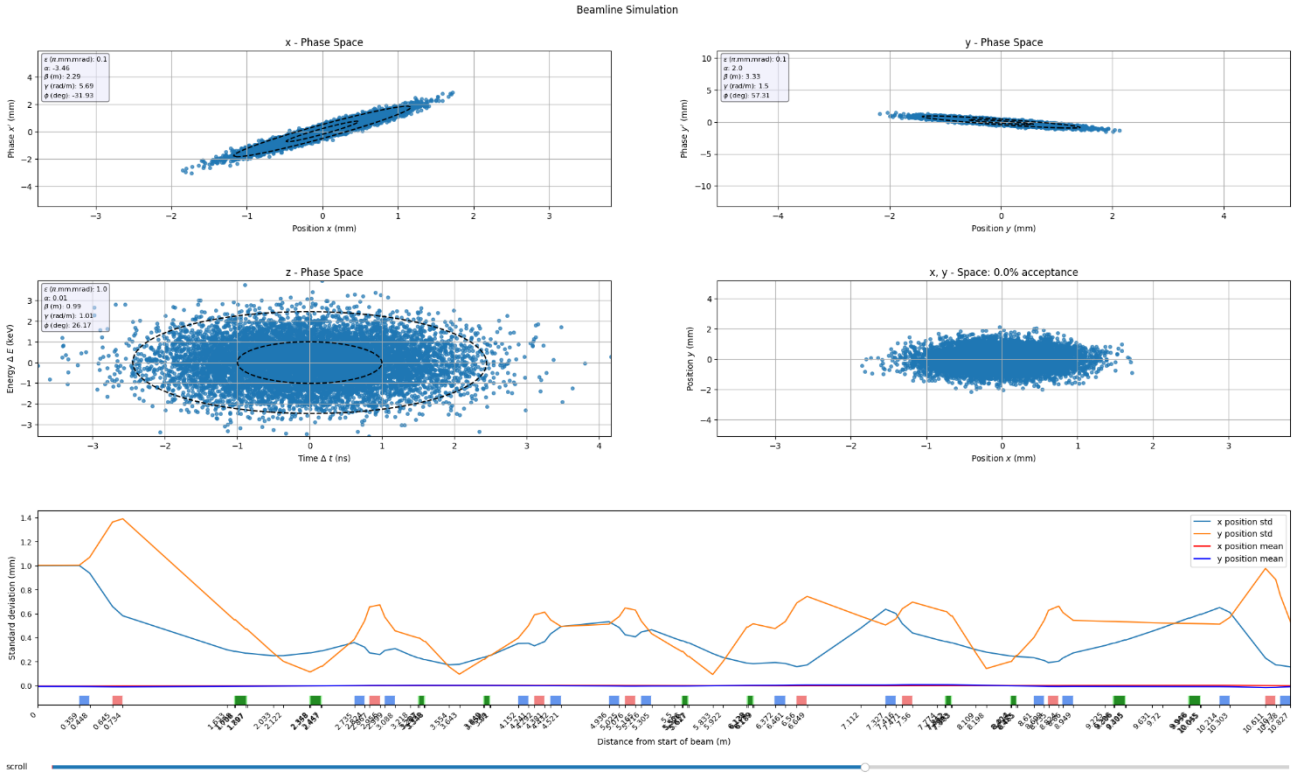
P = 7e-4 ->



Blaise Pascal
1623 – 1662

Recommissioning of the linac: Beam Dynamics Simulations

Framework for linac beam dynamics simulations developed with undergrad student Christian Komo in Python (GitHub link)



Done

- Provides 1st order dynamics with fringe fields
- Flexible beamline integration
- Flexible beam input
- Provide optimization tools

Remaining

- Integration of beam loading
- Treatment of non-linearities
- Integration of existing codes: Bmad, MADX, COSY-INFINITY

Planning

Ongoing research program

ESPCOR grant obtained by Siqi Li:

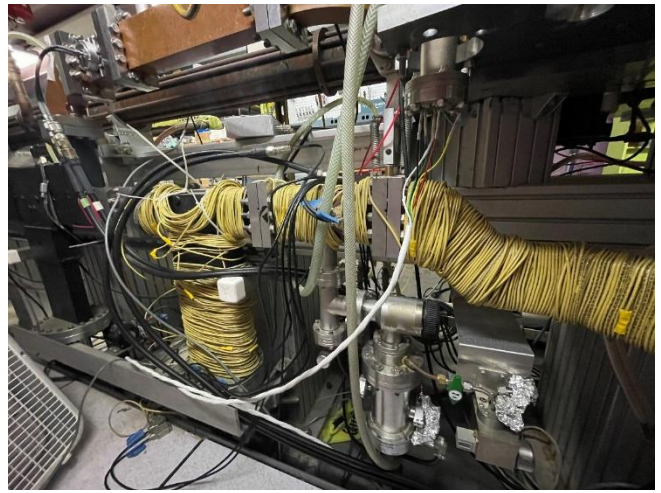
- Cavity Based FEL with a Michelson interferometer for phase coherence
- Machine learning-based applications for tuning and optimization

Short-term:

- First accelerated beams to the spectrometer (Q1 2025)
- Beam transport to MkV (Q2 2025)

Continuous Technical Upgrades:

- Vacuum systems
- RF preamplifier for the Klystron
- SF6 injection for the waveguide
- Laser-enhanced thermionic emission from the cathode
- Control Systems
- Beam diagnostics (technology transfer)



Thank you for your attention

Questions and Remarks

UNIVERSITY of HAWAI'I®
MĀNOA