# Electrons to Dance!

*Andrei Seryi, Associate Director, Accelerator Operations and R&D, Jefferson Lab*

**Symposium Celebrating Swapan Chattopadhyay's Retirement on his 70th**

**April 30, 2021**

*Many thanks to Rongli Geng, Geoff Krafft, Matt Poelker, Bob Rimmer, Mike Spata and many other colleagues for materials and stories for this talk*

Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

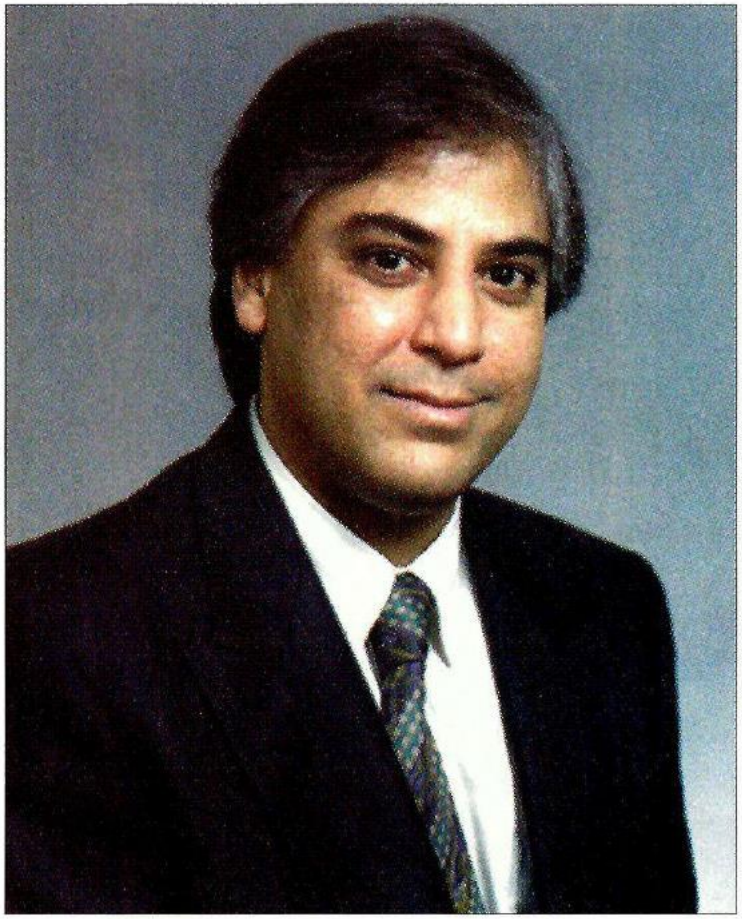
JSA

# Swapan at Jefferson Lab: 2001 – 2007

**Swapan Chattopadhyay**, previously head of Berkeley's Center for Beam Physics, becomes Associate Director of the Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia.

At Jefferson Lab, Chattopadhyay will oversee research and development as well as operations of the main continuous electron beam accelerator facility (CEBAF), plus the lab's free electron laser facility, light sources programme, applied superconductivity and superconducting radiofrequency R&D centre, and its cryogenics and engineering programmes. He will also hold an appointment as the Governor's Distinguished CEBAF Professor of SURA (Southeastern Universities Research Association).

CERN Courier *April 2001*



*Swapan Chattopadhyay, previously head of Berkeley's Center for Beam Physics, becomes Associate Director of the Jefferson Lab, Newport News, Virginia.*

https://cds.cern.ch/record/1733181/files/vol41-issue3-p034-e.pdf

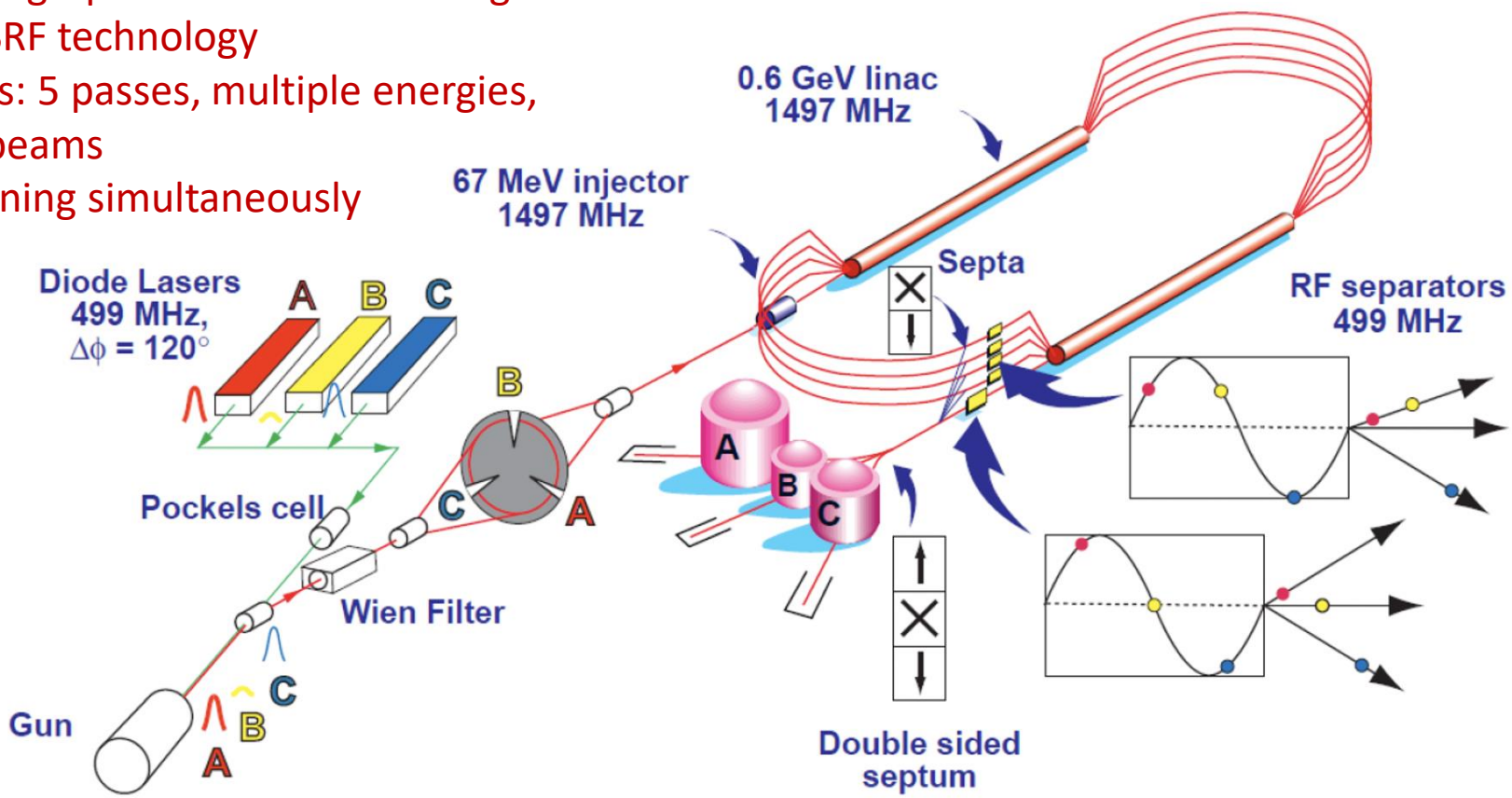
# CEBAF in ~2001 – 6 GeV CW electron machine

- Jefferson Lab was created to build and operate the Continuous Electron Beam Accelerator Facility (CEBAF), a unique user facility for Nuclear Physics – in operations since 1995
- Mission is to gain a deeper understanding of the structure of matter

First large high-power CW recirculating e-linac based on SRF technology

Capabilities: 5 passes, multiple energies, polarized beams

3 Halls running simultaneously



# Nature hits hard, but the team recovers!

- 18 Sep 2003 – hurricane
  - Long power outage, 2/3 or Helium inventory lost
- Recovery efforts: beam back to physics 2 December

*Swapan with team in Cryogenics Control Room during post-hurricane recovery*

JEFFERSON LAB

## Hurricane Isabel gives accelerators a severe test

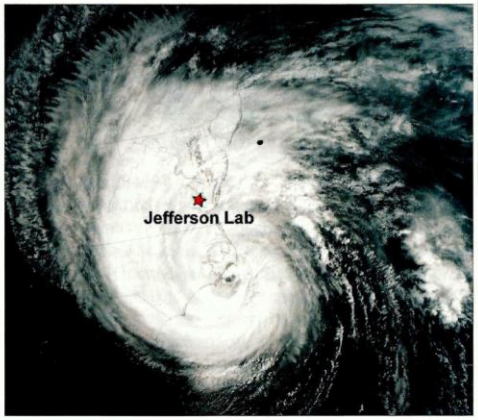
**Swapan Chattopadhyay** reports on the recovery of Jefferson Lab's superconducting linear accelerators in the wake of Hurricane Isabel last September.

Hurricane Isabel was at category five – the most violent on the Saffir–Simpson scale of hurricane strength – when it began threatening the central Atlantic seaboard of the US. Over the course of several days, precautions against the extreme weather conditions were taken across the Jefferson Lab site in south-east Virginia. On 18 September 2003, when Isabel struck North Carolina's Outer Banks and moved northward, directly across the region around the laboratory, the storm was still quite destructive, albeit considerably reduced in strength. The flood surge and trees felled by wind substantially damaged or even devastated buildings and homes, including many belonging to Jefferson Lab staff members.

For the laboratory itself, Isabel delivered an unplanned and severe challenge in another form: a power outage that lasted nearly three-and-a-half days, and which severely tested the robustness of Jefferson Lab's two superconducting machines, the Continuous Electron Beam Accelerator Facility (CEBAF) and the superconducting radiofrequency "driver" accelerator of the laboratory's free-electron laser. Robustness matters greatly for science at a time when microwave superconducting linear accelerators (linacs) are not only being considered, but in some cases already being built for projects such as neutron sources, rare-isotope accelerators, innovative light sources and TeV-scale electron–positron linear colliders.

Hurricane Isabel interrupted a several-week-long maintenance shutdown of CEBAF, which serves nuclear and particle physics and represents the world's pioneering large-scale implementation of superconducting radiofrequency (SRF) technology. The racetrack-shaped machine is actually a pair of 500–600 MeV SRF linacs interconnected by recirculation arc beamlines. CEBAF delivers simultaneous beams at up to 6 GeV to three experimental halls. An imminent upgrade will double the energy to 12 GeV and add an extra hall for "quark confinement" studies.

On a smaller scale, Jefferson Lab's original kilowatt-scale infrared free-electron laser (FEL) is "driven" by a high-current cousin of CEBAF, a 70 MeV SRF linac with a high-current injector. The FEL serves multidisciplinary science and technology as the world's highest-average-power source of tunable coherent infrared light. An upgrade to 10 kW is in commissioning – as it was when Isabel began threatening.




*Hurricane Isabel on her relentless northward track toward Jefferson Lab in southeastern Virginia on the US Atlantic coast.*

*The Jefferson Lab cryogenic group at the critical point of reaching 2.09 K and holding it steady.*

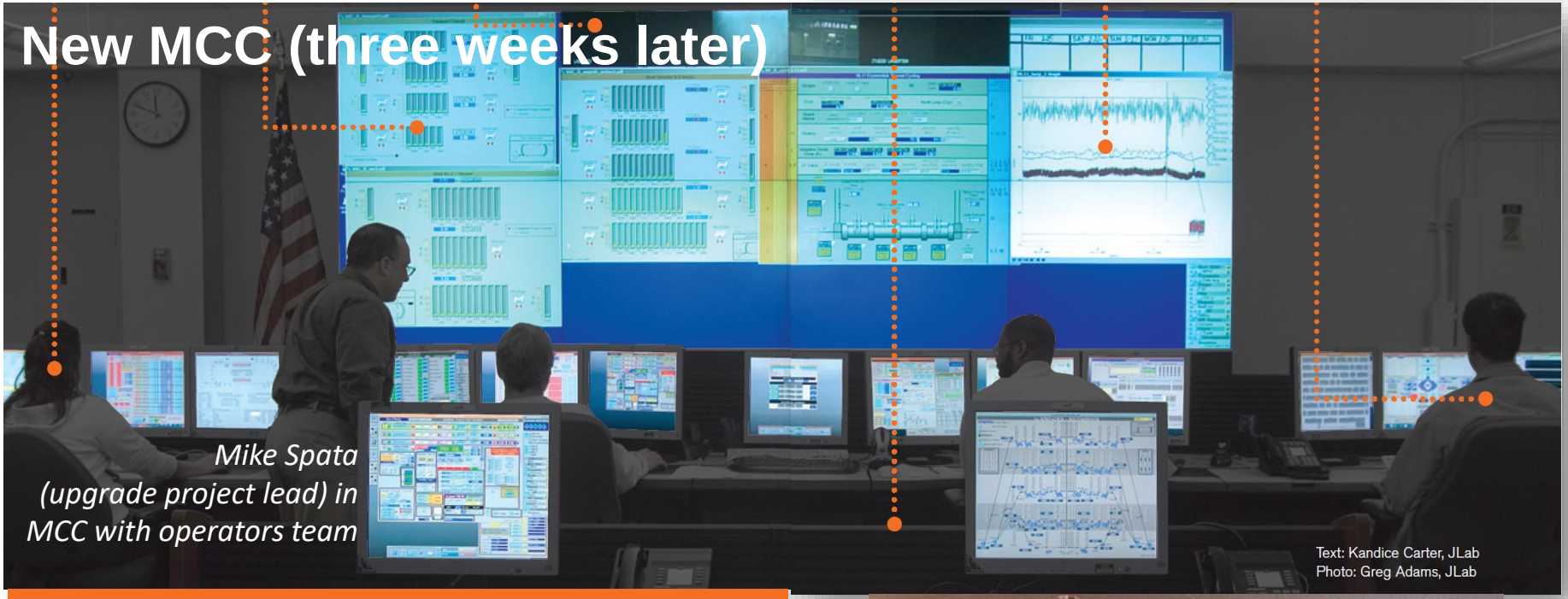
**The power outage**

The accelerator site lost electrical power at approximately 11 a.m. on 18 September during the hurricane, and was not restored until about 8:30 p.m. on 21 September. About an hour later, after the Central Helium Liquefier (CHL) control system was restored, it was ▷

https://cds.cern.ch/record/1733563/files/vol44-issue1-p037-e.pdf

CERN Courier January/February 2004

# Upgrades, upgrades…




Each of the world's particle accelerators has its own custom control room, a nerve center where every detail of accelerator operation is monitored. In the summer of 2004, the Continuous Electron Beam Accelerator Facility (CEBAF) control room at Jefferson Lab was remodeled for the first time since it was built in 1990.

https://www.symmetrymagazine.org/article/april-2005/deconstruction-control-room

# CEBAF – paving the way to 12 GeV upgrade

Key dates:
CD0: Mar 2004
CD1: Feb 2006
CD2: Nov 2007
CD3: Sep 2008

*Spring 2004 – 12 GeV CD0 site visit by the review team*

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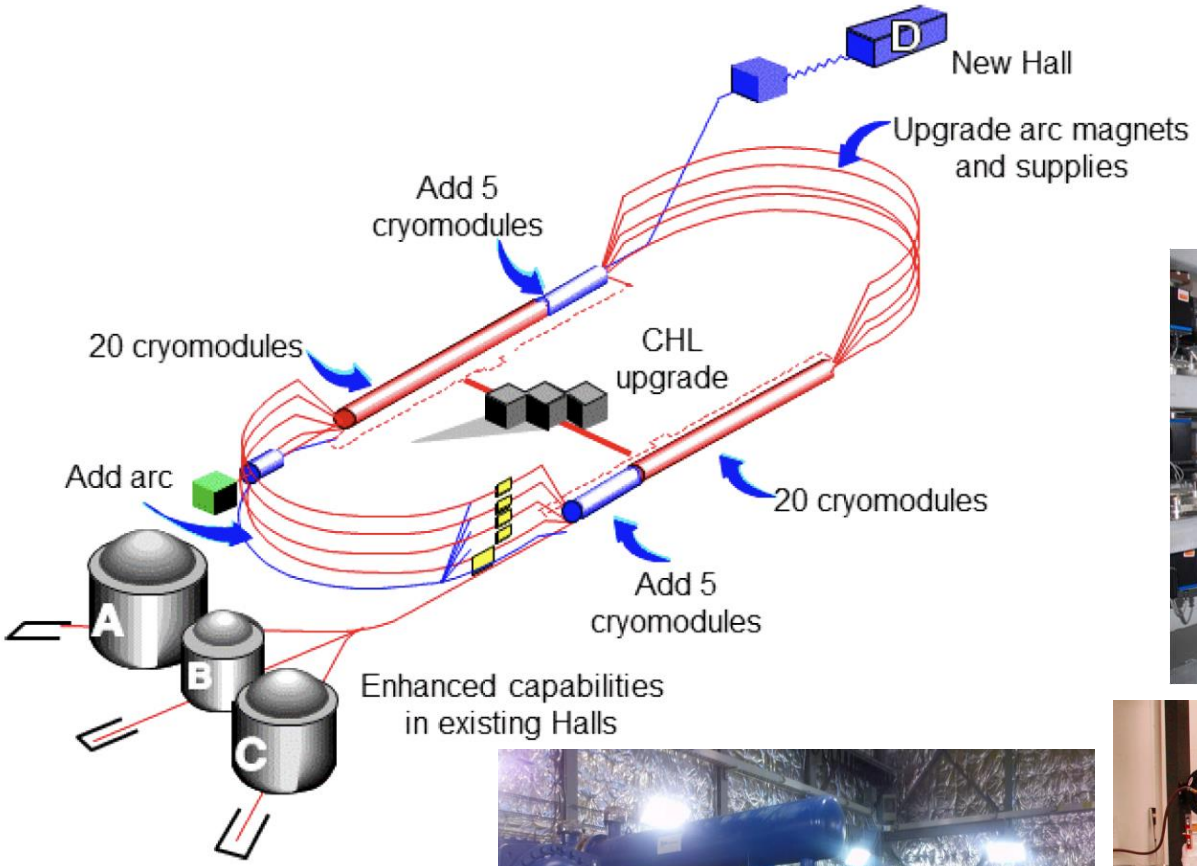
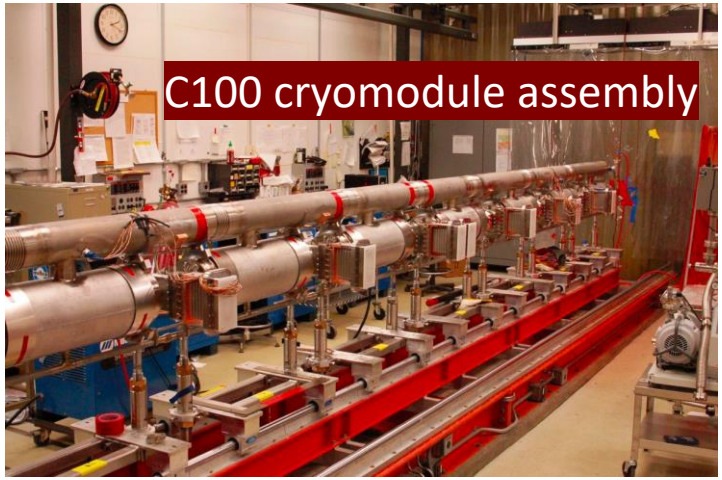
*Winter 2006 – 12 GeV CD1 approval celebration*

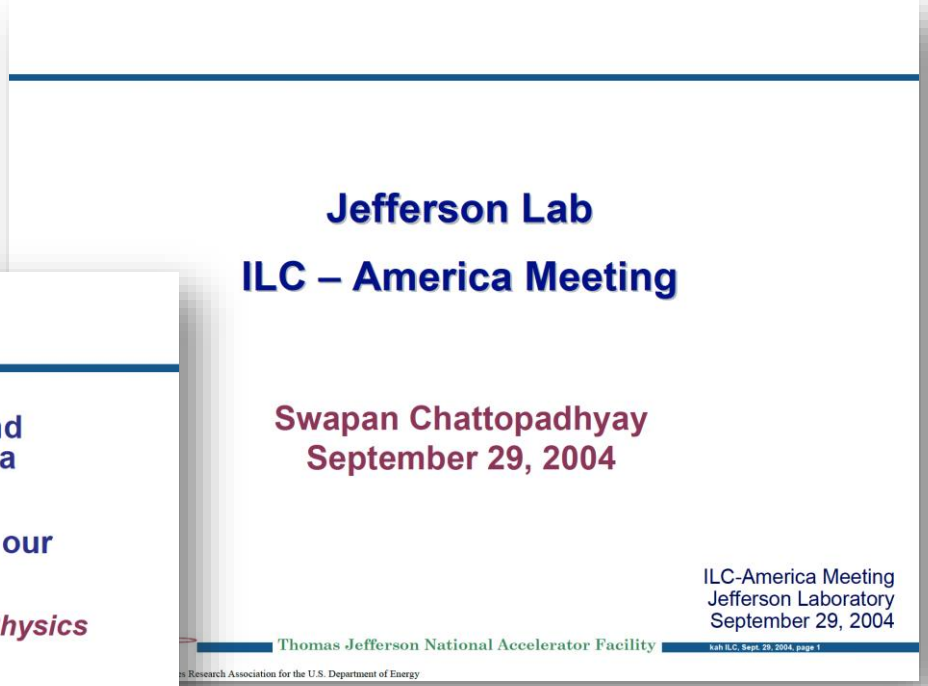
# CEBAF 12 GeV upgrade – complete in 2017 (CD4)

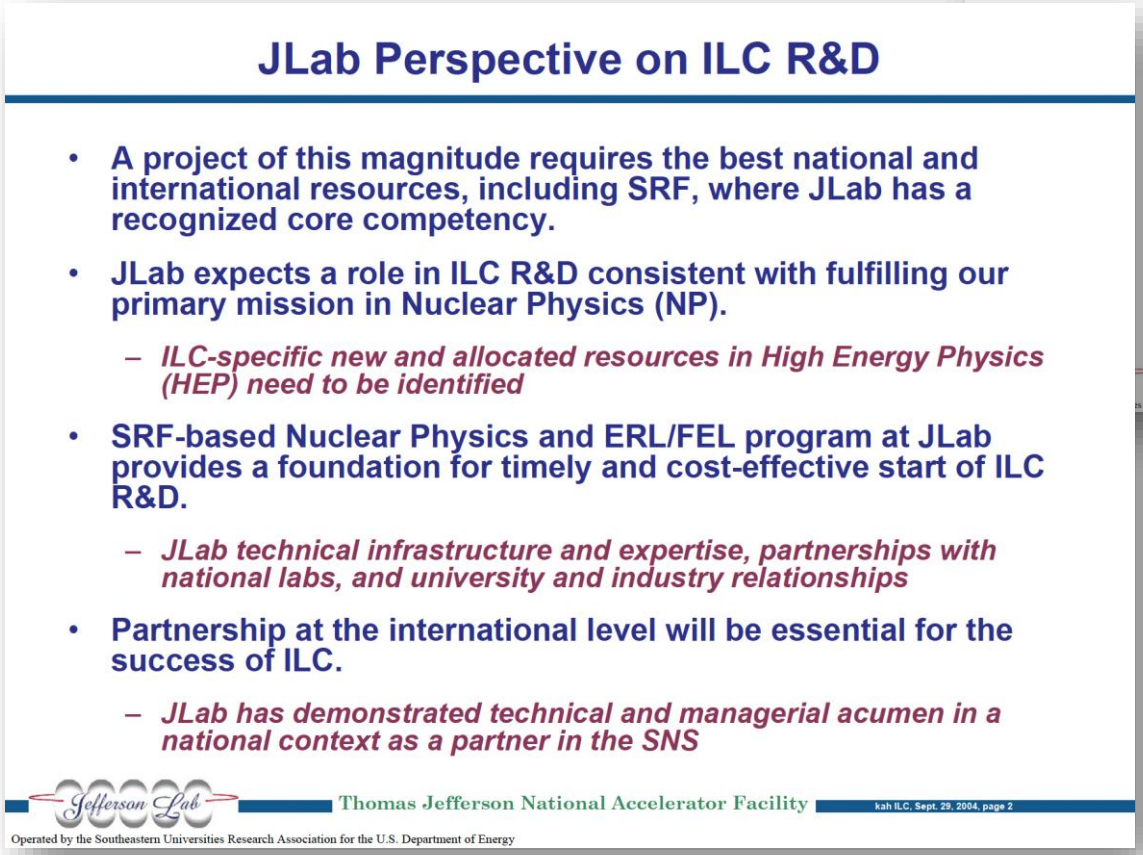




# Efforts to engage JLAB in International Linear Collider

*In August 2004, the International Technology Recommendation Panel (ITRP) recommended a superconducting radio frequency (SRF) technology for the ILC accelerator*




*Slides from Swapan's Sep 2004 talk on advocating for JLAB role in ILC*

https://www.jlab.org/intralab/calendar/archive04/smtf/SMTF_Talks/4Swapan.pdf

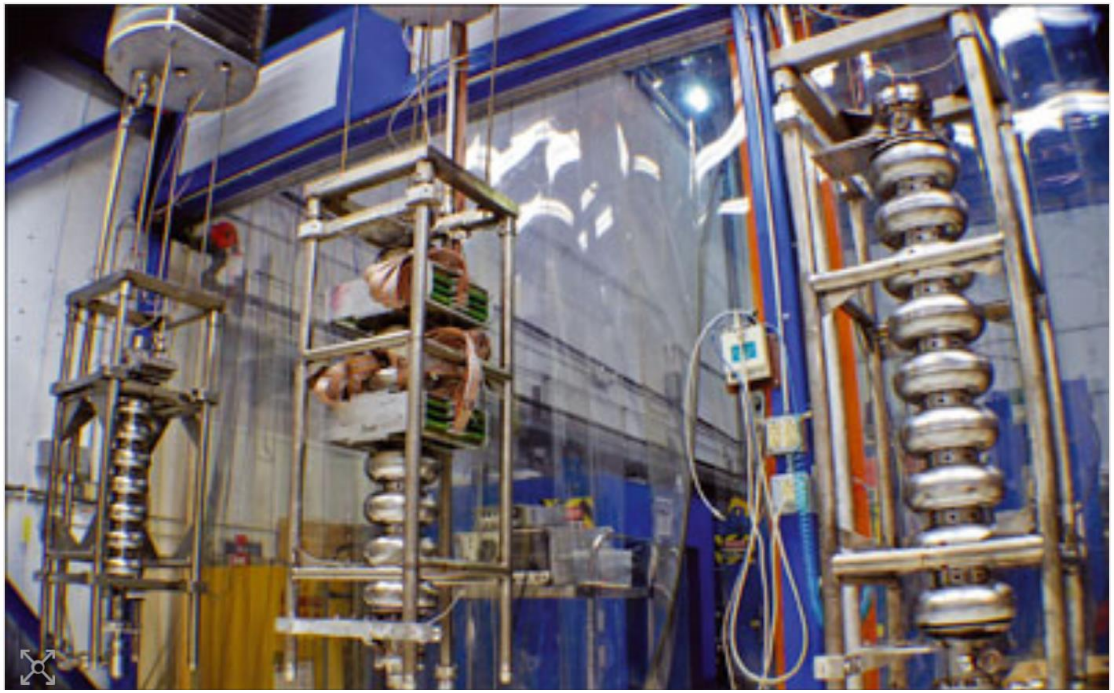
# SRF cavities for ILC – Global Efforts

*Damon Bice, Fermilab, oversees an ILC prototype cavity going through JLab's electro-polishing process in advance of running the Ichiro Cavity through the process – Feb 2008*

https://www.jlab.org/news/stories/jlab-supports-international-linear-collider-cavity-development-work

## US industry-built ILC cavity reaches 41 MV/m

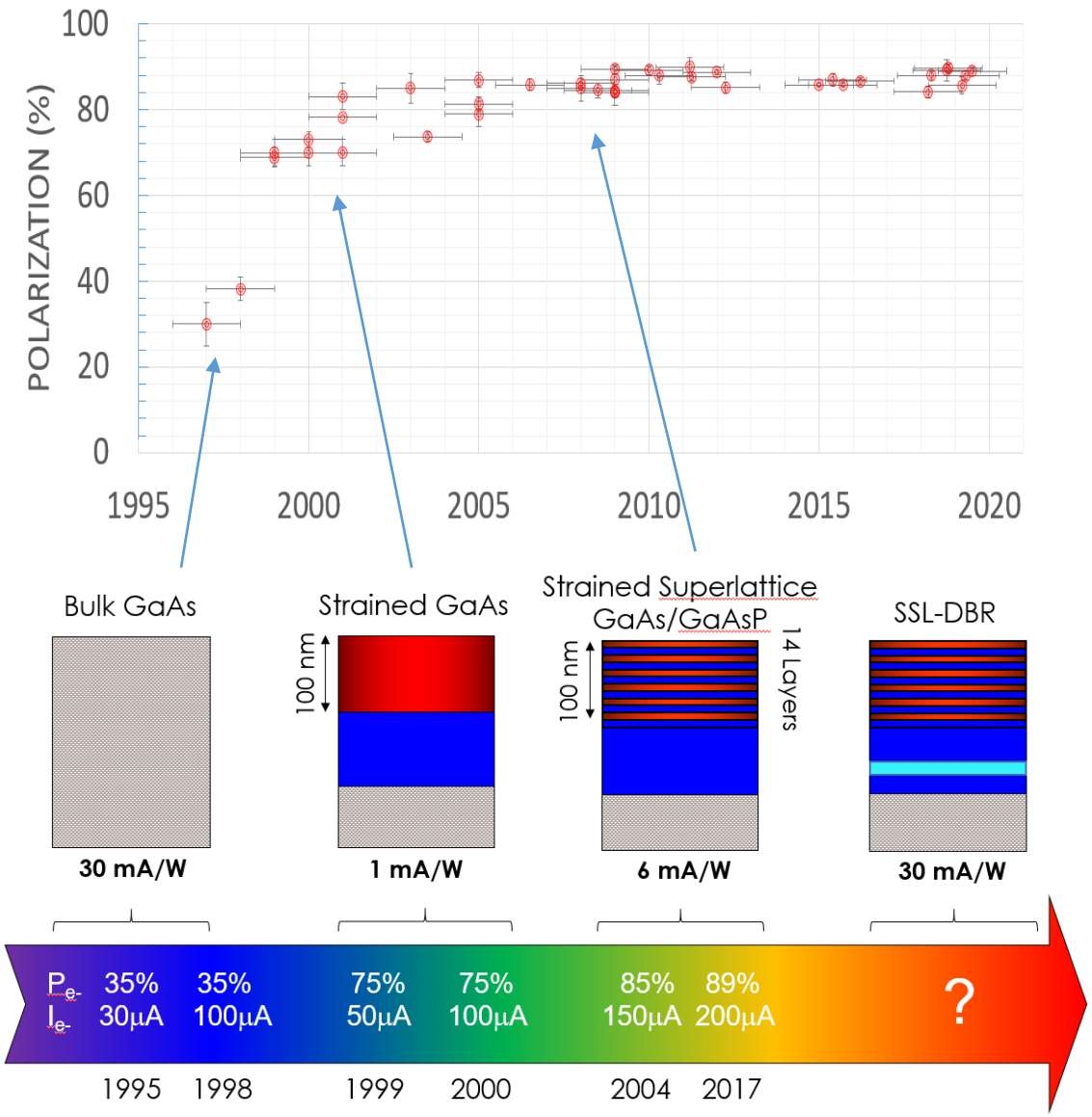
30 October 2009



*Three electropolished cavities await cryogenic testing at Jefferson Lab: an AES cavity (right); a large-crystal niobium cavity, built in-house, with T-mapping system mounted (middle); and a prototype cavity for the facility's CEBAF upgrade (left) processed using the "ILC recipe". Image credit: Jefferson Lab – CERN Courier, Oct 2009*

https://cerncourier.com/a/us-industry-built-ilc-cavity-reaches-41-mv-m/

# Improving Polarized Source Performance

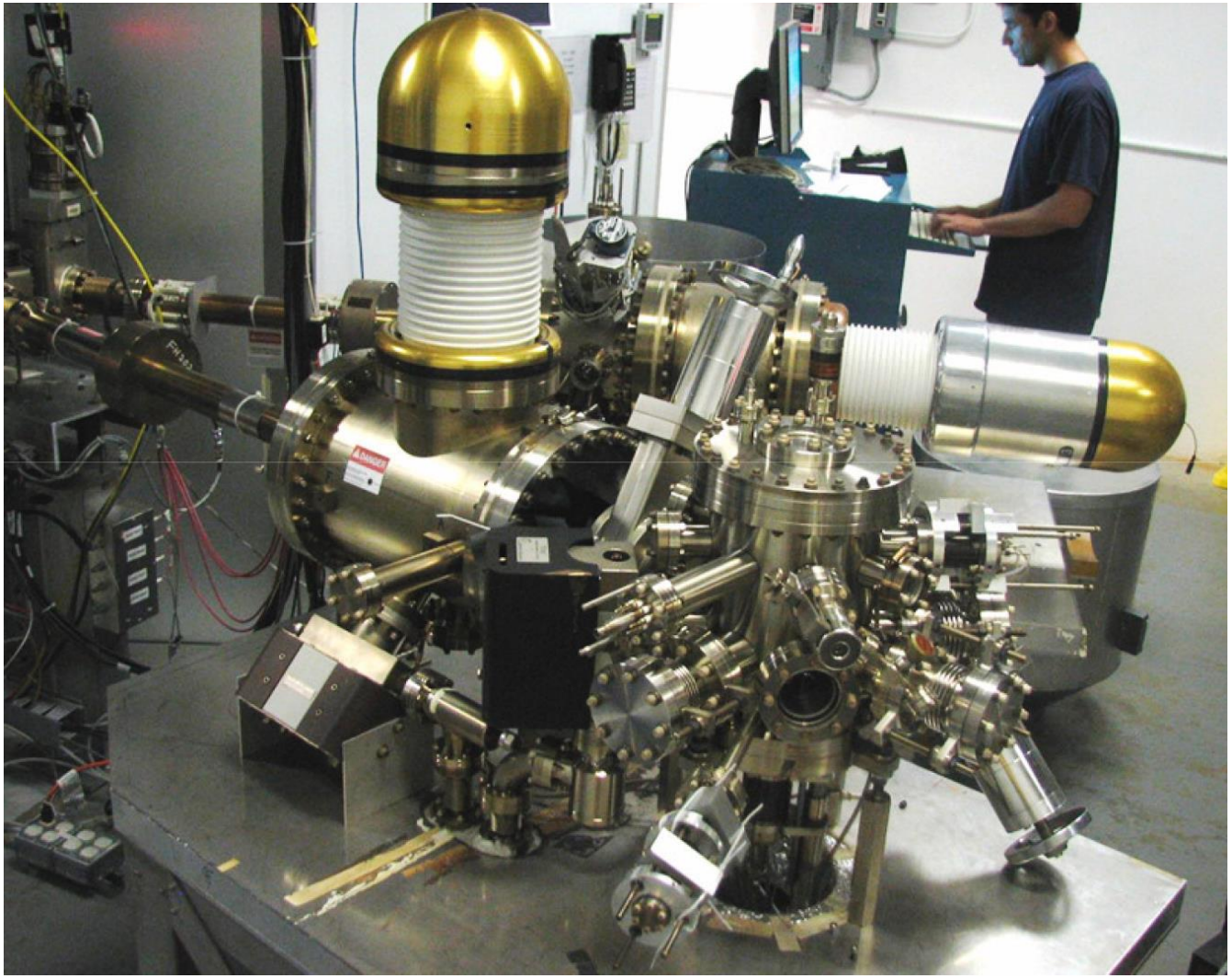



- Technology advances for e-beam polarization improvements
- New experiments demanded longer lifetime of cathodes and new design of guns
- ILC played a stimulating role for development of new ILC/CEBAF "Inverted gun"



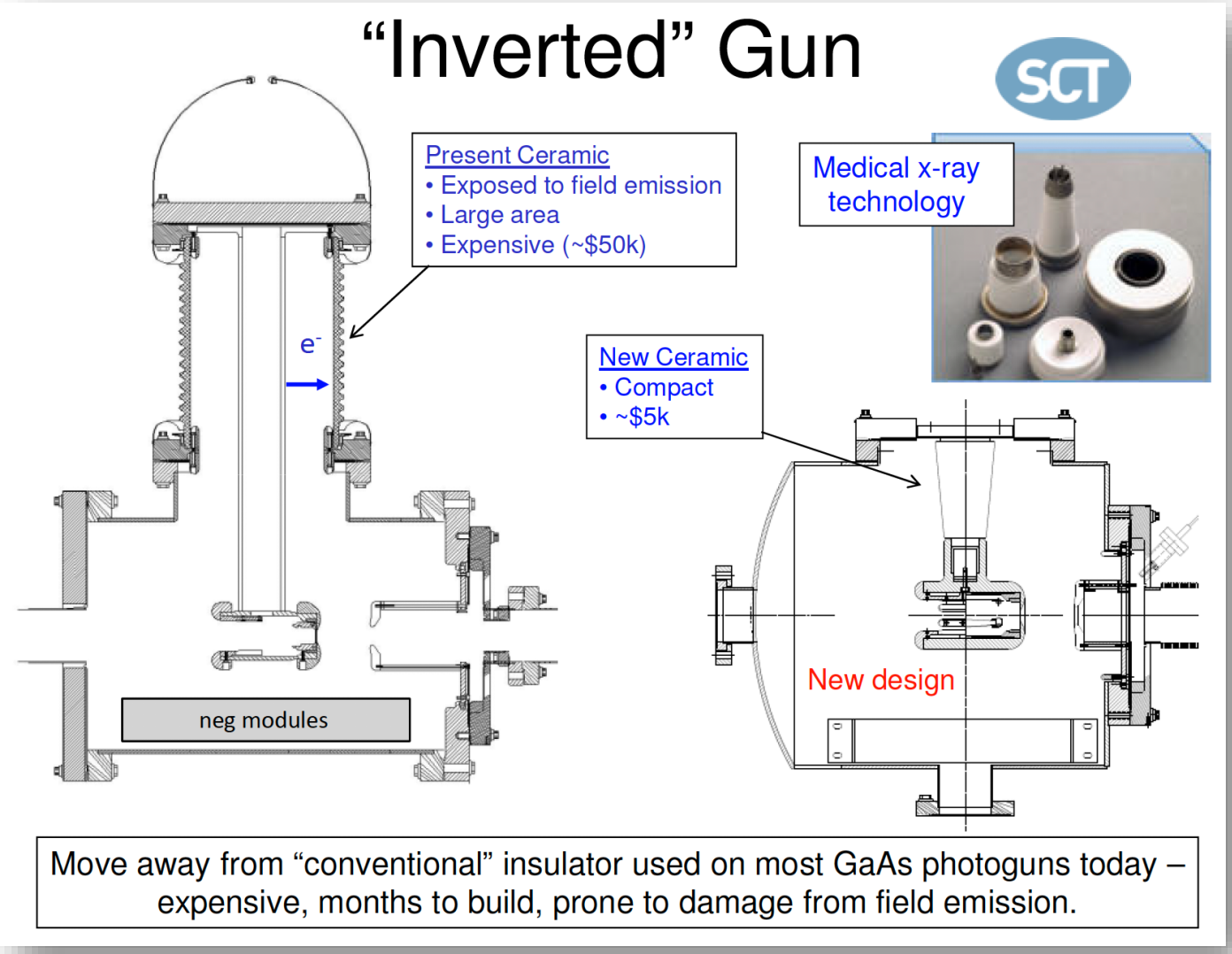
Jefferson Lab

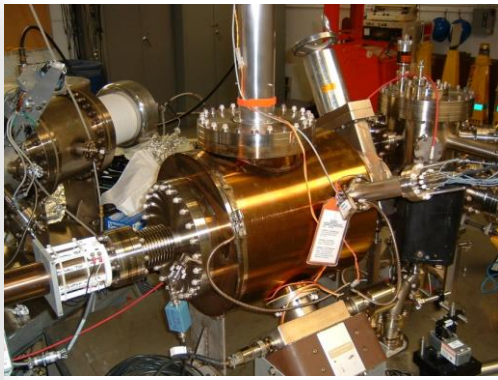
# CEBAF load-lock polarized gun – installed in 2007



100kV gun. Lifetime limited to 30C.  Path to higher lifetime and beam quality – higher voltage

# New CEBAF/ILC "Inverted" gun ~2007-2009



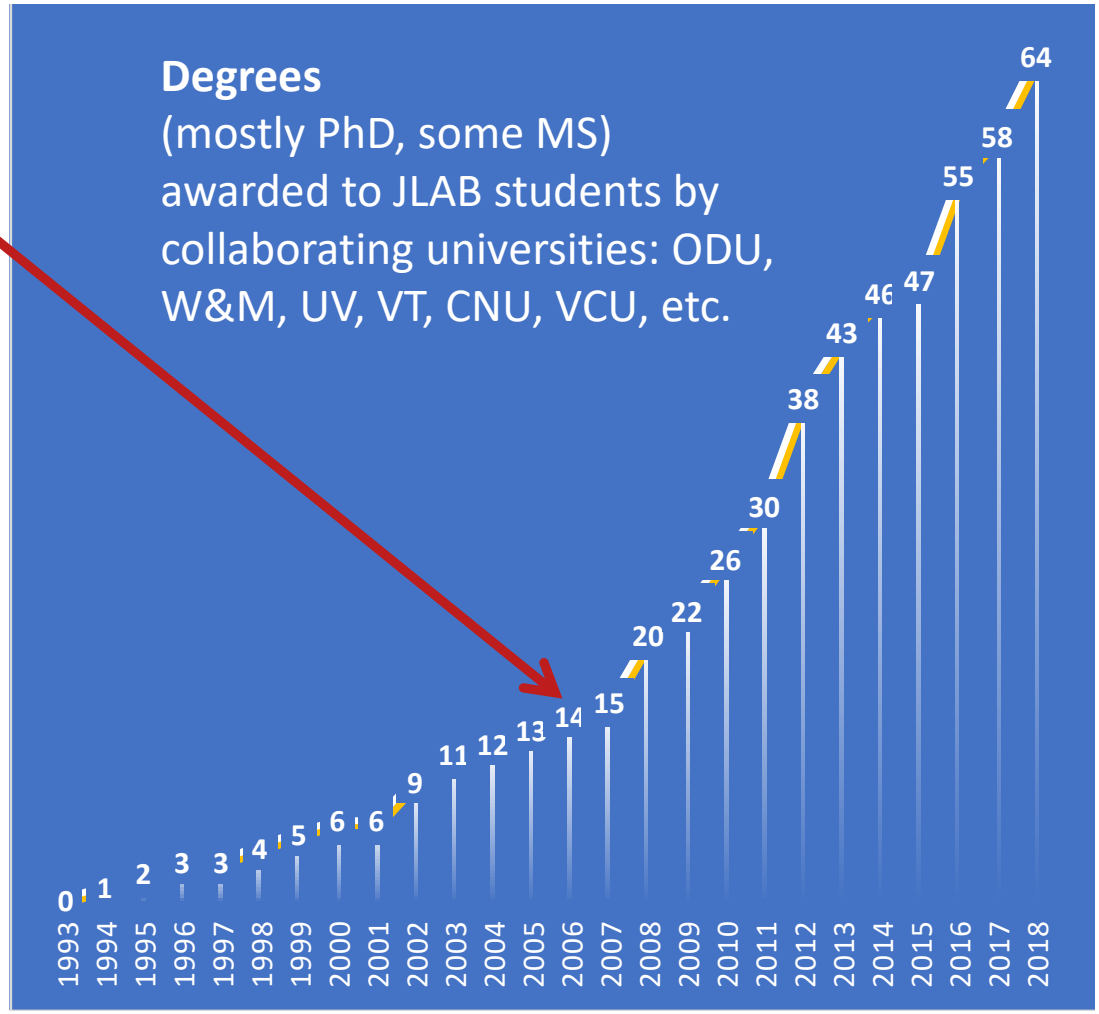
Inverted CEBAF/ILC Gun#1 installed at CEBAF, July 2009

Higher voltage, higher lifetime

200 kV for CEBAF, 350 kV for ILC

# Efforts to boost accelerator education

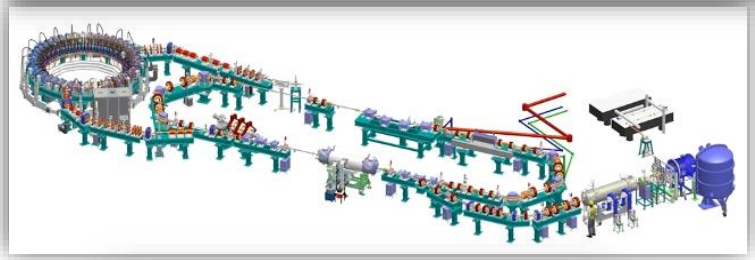
- In ~2006 the Old Dominion University (ODU) has launched an institutional program in accelerator physics with the help of JLAB – Swapan's efforts
- In 2008 JLAB and ODU joined forces to create CAS – Center for Accelerator Science at ODU

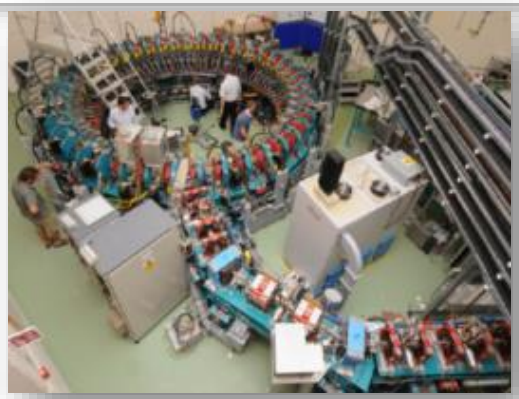


# Cockcroft Institute era

*2007-2014*

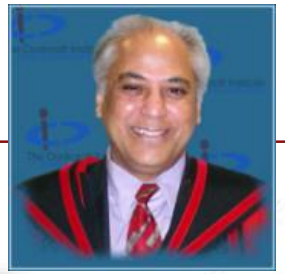
Daresbury Lab & Cockcroft Institute





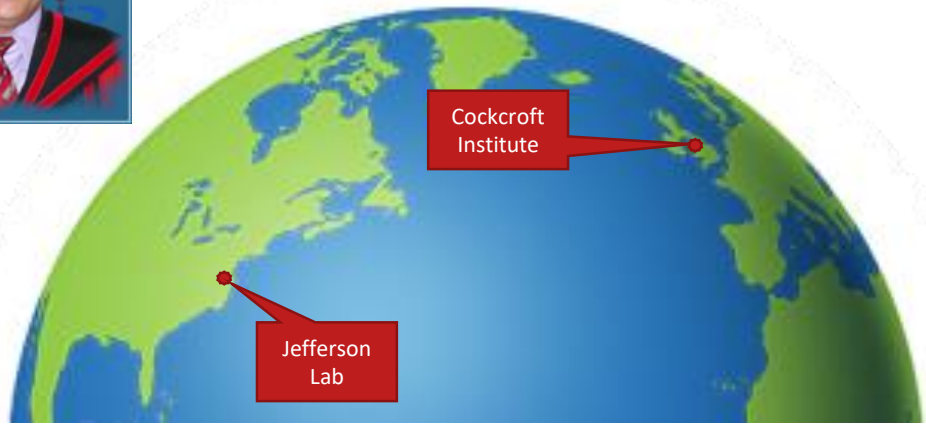
The Cockcroft Institute of Accelerator Science and Technology

Lancaster University



MANCHESTER 1824 The University of Manchester

UNIVERSITY OF LIVERPOOL



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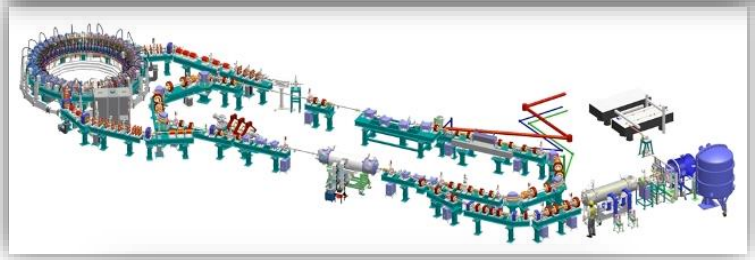

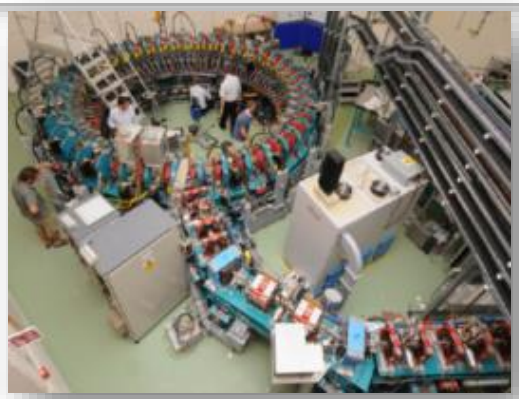

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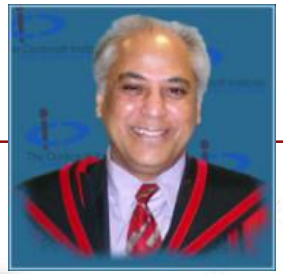

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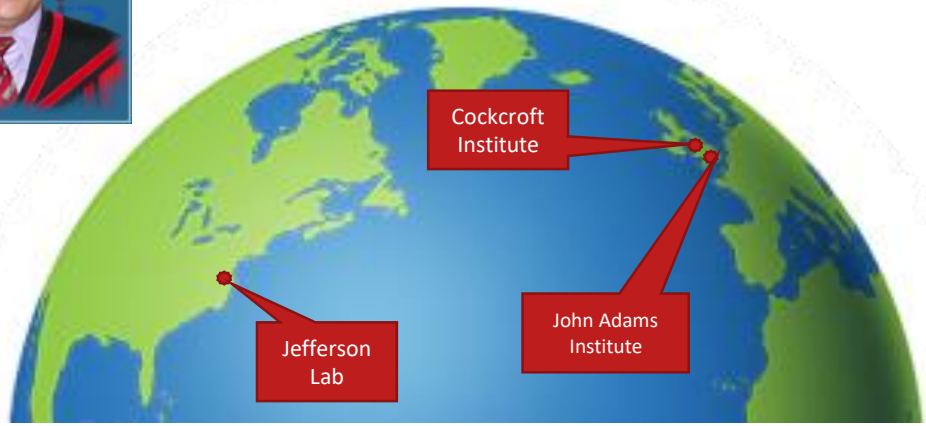


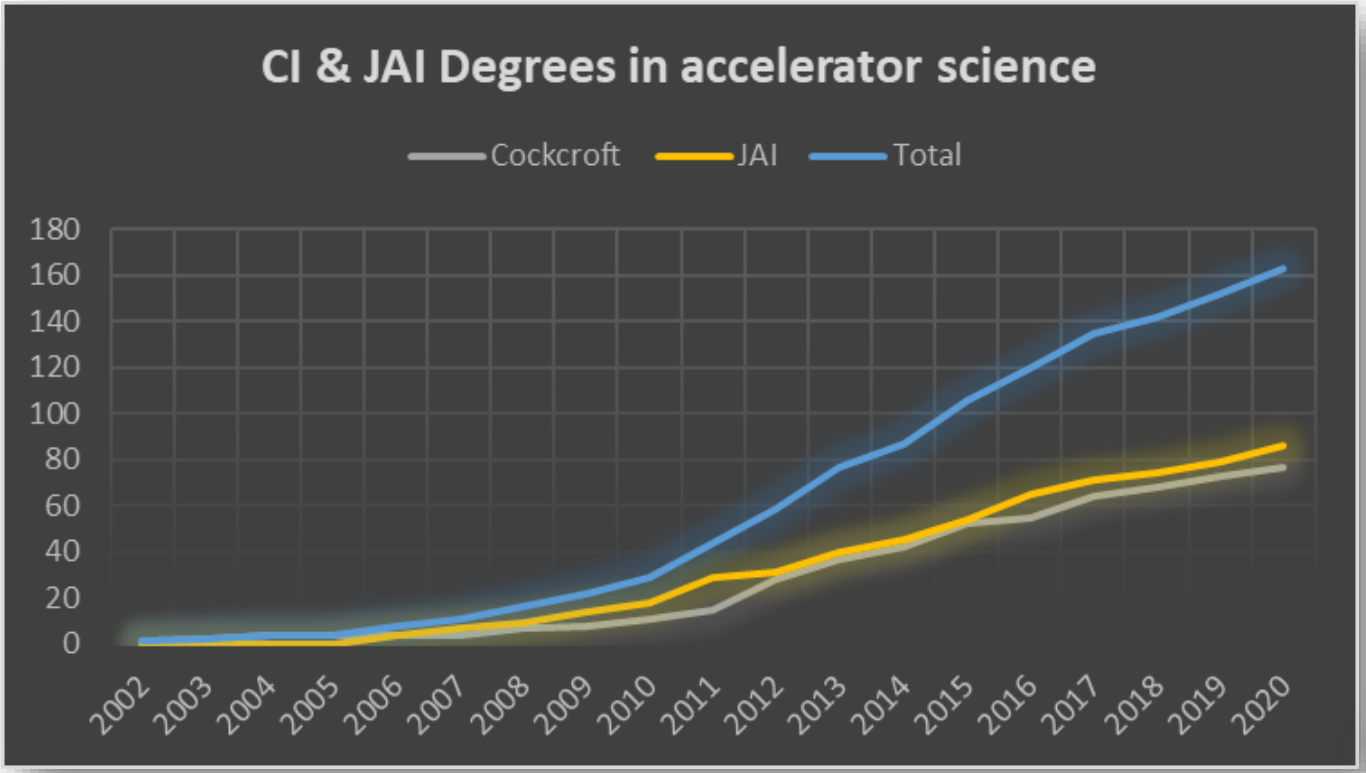

JAI John Adams Institute for Accelerator Science

ROYAL HOLLOWAY UNIVERSITY OF LONDON

UNIVERSITY OF OXFORD

Imperial College London

# “Integrated luminosity” measured in PhDs




The Cockcroft Institute of Accelerator Science and Technology

https://www.cockcroft.ac.uk/dissemination/theses

JAI John Adams Institute for Accelerator Science

https://www.adams-institute.ac.uk/thesis

**“EDUCATING AND TRAINING ACCELERATOR SCIENTISTS AND TECHNOLOGISTS FOR TOMORROW”**
**William Barletta**, United States Particle Accelerator School and Department of Physics, Massachusetts Institute of Technology, USA
**Swapan Chattopadhyay**, Cockcroft Institute, Universities of Liverpool, Manchester and Lancaster and Daresbury Science & Innovation Campus, UK
**Andrei Seryi**, John Adams Institute, University of Oxford, Royal Holloway University of London and Imperial College London, UK

EDUCATING AND TRAINING ACCELERATOR SCIENTISTS AND TECHNOLOGISTS FOR TOMORROW

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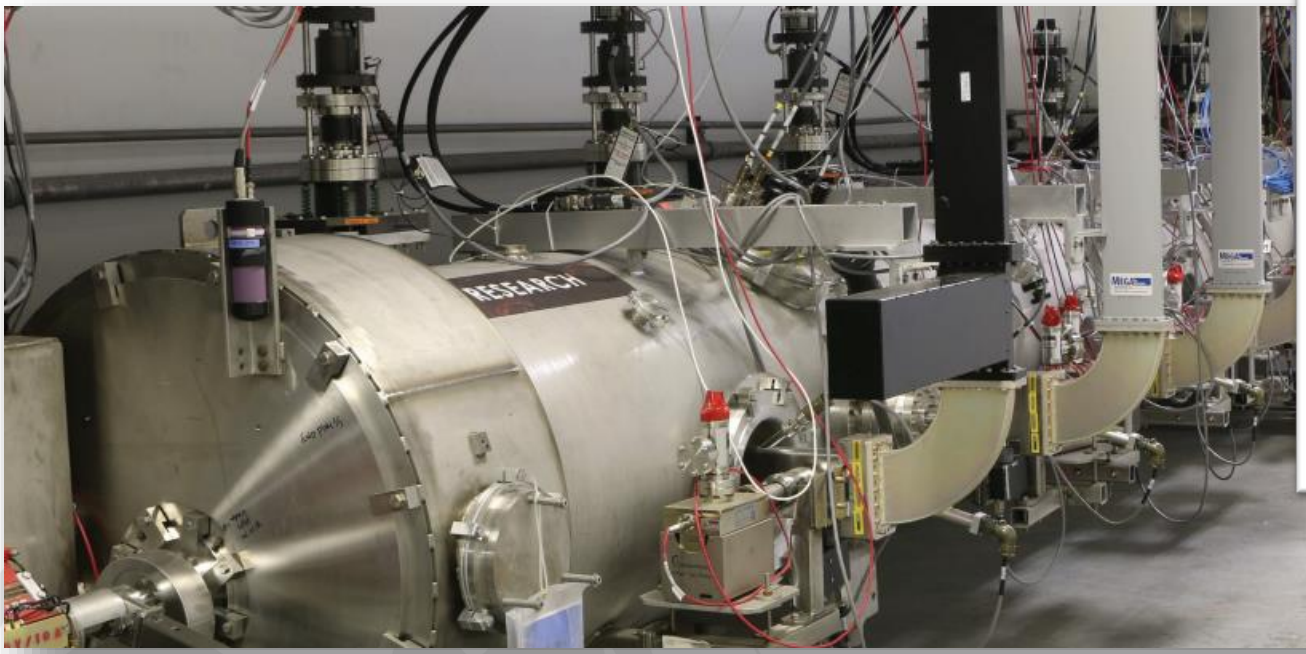
Accelerator science and technology is inherently an integrative discipline that combines aspects of physics, computational science, electrical and mechanical engineering. As few universities offer full academic programs, the education of accelerator physicists and engineers for the future has primarily relied on a combination of on-the-job training supplemented with intense courses at regional accelerator schools. This paper describes the approaches being used to satisfy the educational interests of a growing number of interested physicists and engineers.

https://www.worldscientific.com/doi/abs/10.1142/S1793626812300125 https://arxiv.org/abs/1207.3065

# Thanks & best wishes!



*Andrei Seryi, Associate Director, Accelerator Operations and R&D, Jefferson Lab*

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