Accelerator R&D Overview

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Director's Review of Accelerator R&D
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Outline

- Long-Term Accelerator Facility Vision
- R&D Portfolio
- External Partnerships
- Education
- Challenge

Long-Term Accelerator Facility Vision

Future Accelerator Options at JLab

- The top choice for a future facility at JLab is ELIC, an ELectron Ion Collider
  - Provides a long-term future for Nuclear Physics at JLab
  - Recently, a staged approach was worked out (MEIC)
- Positron option for CEBAF
  - Working with IAC (Idaho Accelerator Center) to develop the technology for a positron pre-burner for CEBAF
- 4th Generation Light Source
  - Good match to our technology
  - JLab plans based on development of the FEL
  - Hoping for BES R&D investment
    - Trying to be the "recipient of choice" by initiating relevant R&D on other money so we have a head start

R&D Directions

- All of these options build on our core competencies

R&D aims to further improve our core competencies and to be applicable to most options

- Today's presentation will showcase the R&D carried out by the Accelerator Division in support of these long-term accelerator options

R&D Portfolio

R&D Strengths

- Accelerator Division contains the core competencies in accelerator science and technology
  - SRF (SRF Institute) led by Bob Rimmer
  - Cryogenics R&D led by Dana Arenius and Rao Ganni
    - Matrixed from Engineering
  - Center for Injectors and Sources led by Matt Poelker
  - Accelerator Physics (CASA) led by Geoff Krafft
- The FEL Division is also tightly coupled
- These core competencies define JLab accelerator science

High current, CW, superconducting, multi-pass linacs
this explicitly includes energy recovery linacs

Accelerator Division R&D Goals

- Our goal is World Leadership in all our core competencies
  - SRF with particular focus on CW applications
  - High-efficiency cryogenics
  - Accelerator physics (special focus on ELIC and ERLs)
  - Electron injectors (high current, CW, polarized and unpolarized)

- Goals have been established for each R&D area which support the Accelerator Division Goals
  - Aiming for total alignment of the different R&D areas
    - Not there yet!

SRF Institute

- The SRF Institute has fabricated and/or processed a wider variety of multi-cell SRF cavities than anyone else
- 608 multi-cell cavities fabricated / processed (was 549)
  - 25 different cavity types, including:
    - 9 different frequencies
    - 6 different beta values
    - Both CW and pulsed
- In addition a large number of single cell test cavities have been fabricated and/or processed
  - So many, we do not even have an exact count!
- Total number of cavity tests in VTA is now at 2945
  - Nearest competitor is DESY ~800!

Project	# of Cavities built @ Jlab	# of Cavities processed / tested	Frequency (MHz)	Beta	# of Cells	Duty Factor
CEBAF (OC cell shape)	20	358	1497	1	5	CW
CEBAF (OC) - C50 rework		74 +20	1497	1	5	CW
CEBAF Upgrade Style (OC)	8	8	1497	1	7	CW
CEBAF Upgrade Style (LL)	5	5	1497	1	7	CW
CEBAF Upgrade Style (HG)	9	9 + 2	1497	1	7	CW
C100 - (LL)	2	2	1497	1	7	CW
FEL IR DEMO (OC)	10	10	1497	1	5	CW
FEL 10 kW Upgrade (OC)	8	8	1497	1	7	CW
FEL HCCM (HC)	3	1	1497	1	5	CW
FEL HCCM (HC)	1		750	1	5	CW
AES HC Inj		3	750	1	1	CW
AES HC Inj		1	1500	1	1	CW
APT	2	2	700	0.64	3	CW
APT		3	700	0.64	5	CW
SNS	4	37 +7	805	0.61	6	Pulsed
SNS	1	52	805	0.81	6	Pulsed
RIA	2	2	805	0.47	6	Pulsed
INFN Legnaro - seamless		1	1500	1	5	CW
INFN Milan - TRASCO		1	703	0.5	5	CW
DESY - seamless		3	1300	1	2	CW
KEK	1	1	1300	1	10	Pulsed
ILC-like - superstructure	1	1	1497	1	10	Pulsed
BNL		1	704	1	5	CW
FLASH - FNAL/DESY	5		3900	1	9	Pulsed
ILC - (TESLA)		9 +5	1300	1	9	Pulsed
ILC - (LL)	1	1	1300	1	7	Pulsed
ILC - (Japan LL)		1	1300	1	9	Pulsed
ILC - (TESLA)	4	4	1300	1	9	Pulsed
Total	**87**	**632**				

Six SRF Goals

1. Increase the maximum gradient to > 50 MV/m
2. Develop cavities for high currents (~1Amp)
3. Increase Q at 25 MV/m
4. Reduce cost per MV
5. Develop new structures
6. Develop a solution for operation at 4.5K

More from Bob Rimmer, Rongli Geng and Charlie Reece

Collins Cryogenics Institute

- R+D centered on both large and small helium refrigeration system operational efficiencies and system cost
- Advanced degree thesis work integrated into the R&D activities
- FY2008 focus areas included improvements to the warm helium compression systems and helium purification
- Substantial funding from external sources for common development interests
  - JLab projects have benefited
    - E.g. the JLab 12 GeV helium refrigeration system

Five Cryogenic Goals

1. Increase cryogenic efficiency of ~5 kW systems
2. Increase cryogenic efficiency of ~1 kW systems
3. Design CTF Upgrade as ~1 kW demonstration project
4. Evaluate efficiency-temperature performance
5. Develop 4.5K plant for ~10 MeV CW SRF accelerator

More from Dana Arenius

Center for Injectors and Sources

- JLab leads the world in delivery of CW beams
  - At CEBAF, world record polarized beams
    - > 85% polarization measured by the Users at the Hall
    - 16 Coulombs delivered in one 24 hr period
      - An average of 185 μA for 24 hours
    - Load-lock gun has operated at 1 mA in test stand
      - Nearest competitors – Bates 120 μA, Mainz 50 μA
    - Test Cave research to support new initiatives like EIC and ILC
  - At the FEL, world record unpolarized beams
    - > 9 mA achieved daily for months at a time
      - Nearest competitor - Cornell ERL test stand 5 mA

Six Injector and Source Goals

1. Improve **performance** of CEBAF photoinjector
2. Prepare for **parity violation** experiments
3. Demonstrate high **average current** (EIC, FEL)
4. Demonstrate high **bunch charge** (FEL, ILC, CLIC)
5. Demonstrate high **peak current** (ILC, CLIC, light sources)
6. Make **positrons** at CEBAF

More from Matt Poelker

Center for Advanced Studies of Accelerators

- 10 professional staff, 7 graduate students
- Specializing in:
  - Multi-pass linacs
  - Energy recovery linacs
  - Superconducting cavity interactions with electron beam
  - Transport optics
  - Electron Ion Collider design
  - Simulations
- Same group provides optics support to 12 GeV Upgrade, will commission the 12 GeV machine and actively supports the 6 GeV Physics program

Five CASA Goals

1. Design a future Electron Ion Collider appropriate for JLab

2. Study current limiting phenomena in SRF Linacs and Energy Recovery Linacs (ERLs), including mitigation techniques

3. Develop instrumentation and beam-based measurement procedures for SRF Linacs

4. Develop, in collaboration with the FEL Dept, a design for a 4th Generation Light Source based on an SRF Linac

5. Study large-aperture Recirculating Linear Accelerators (RLAs) based on SRF Linacs

More from Geoff Krafft, Mike Tiefenback and Alex Bogacz

External Partnerships

Cross-Project R&D Funding

- We seek R&D funding from any project that needs our core competencies
  - We can be a cost-effective R&D partner because of our present experience
  - But carrying out the R&D will reinforce our leadership in our core competencies
    - Will make us even more cost-effective in the future
- Examples
  - Digital RF controls funded jointly by 12 GeV and RIA
  - High efficiency cryogenics funded by NASA (12 GeV)
  - High current cavities funded by ONR (electron cooling)
  - High voltage guns funded by ILC (6 GeV)
  - Crab cavities funded by APS (ELIC)

Partnerships Being Negotiated

- In all cases, JLab participation is based on SRF technology and cryogenics, backed by accelerator theory, diagnostics and, in two cases, injectors
  1. ILC
  2. Japan-USA Cooperation Agreement
  3. FRIB at MSU
  4. PUP (Power Upgrade Project) at SNS
  5. Project X at Fermilab
  6. APS at ANL
  7. FEL at LBNL

SRF Business Plan

- We have developed a business plan based on estimated future needs for manufacturing (~75%) and R&D (~25%)
- Production capacity equivalent to:
  - 2 cryomodules per month
  - 16 multi-cell cavities per month
- New TEDF Building is designed around this capacity

Education

FY08 Accelerator Education Activities at JLab

- Staff with University Affiliation 11
- Staff who taught at USPAS 3
- Staff who mentor graduate students 9
- Staff who taught abroad 2
- Graduate students *Present* Graduated '0*1- '08*
  - PhD 21+4* 8
  - Masters 1+3* 3
- In addition,
  - 1 ODU undergraduate thesis was completed in 2008
  - High school students are mentored in special topics during the school year

*Staff Members

Education - Accelerator Physics at ODU

- The Accelerator Division continues to promote Accelerator Physics at ODU
  - Teaching one graduate level course in Low Temperature Physics (Jean Delayen) and one Introduction to Accelerator Physics to senior undergraduate/graduates (Geoff Krafft)
  - Serve on Graduate Program Committee and Condensed Matter Search Committee (Jean Delayen)
  - Serve on Graduate Recruitment and Admissions Committee (Geoff Krafft)

Education Activities, continued

- We have created an Accelerator Science Center at Old Dominion University (ODU)
  - The Director of the Center is a jointly funded by JLab and ODU
    - Excellent candidates, now in final stages of the selection process
  - JLab/ODU has already received a grant from NSF (REU) for undergraduate research opportunities
    - First students already on site

Idaho Accelerator Center

We have established the first ever joint appointment in accelerator physics

- Jointly funded by JLab Accelerator Division and Idaho State University
- Based at the Idaho Accelerator Center

- Dr. Giulio Stancari was selected and has started at IAC
- Initial priority is the development of a 10 MeV positron source

Accelerator Division Students

Student's Name	Univ.	JLab Mentor	Univ. Adviser	CurrentGrad Year	Funded by
Serkan Golge	ODU	Arne Freyberger	Charles Hyde-Wright	2010	Acc. Div.
Ahmed, Eman	ODU	Geoff Krafft	Charles Sukenik	2009	Acc. Div.
Gambhir , Ranjit	ODU	Geoff Krafft/Michael Kelley	Charles Sukenik	2010	Acc. Div.
Sayed, Hisham	ODU	Alex Bogacz	Geoff Krafft	2011	Muons Inc.
Senthilraja, Singaravelu	ODU	Geoff Krafft	Mark Havey	2011	Acc. Div.
Liu, Chuyu	Peking	Geoff Krafft	Xiangyang Lu	2010	Acc. Div./Peking U.
Shin, Ilkyoung	U. Conn	Byung Yunn	Kyungseon Joo	2011	Acc. Div.
Bodenstein, Ryan	UVA	Michael Tiefenback	Blaine Norum	2010	Acc. Div.
McCarter, James	UVA	Matt Poelker	Blaine Norum	2010	Acc. Div.
Snyder, Ryan	UVA	Matt Poelker	Gordon Cates	2009	Acc. Div.
Dumas, Jonathan	Univ. Joseph Fornier	Joe Grames	Eric Voutier (Hall A User)	2012	Acc. Div./Grenoble
Jayaprakash, Ashwini	ODU	Joes Grames/Matt Poelker	R.P. Joshi	2013	ILC
Xiao, Binping	W&M	Charlie Reece	Michael Kelley	2009	Acc. Div.
Upadhyay, Janardan	ODU	Anne-Marie Valente	Lepsova Vuskovic	??	Acc. Div.
Bowring, Daniel	UVA	Larry Phillips	Blaine Norum	2010	Acc. Div.
Zhao*, Liang	W&M	Charlie Reece	Michael Kelley		Acc. Div.
Xu*, Chen	W&M	Charlie Reece	Michael Kelley		Acc. Div.
Niroula, Megh	ODU	Hari Areti	Larry Weinstein	2009	Acc. Div.
DeSilva, Payagalage	ODU	Jean Delayen	Jean Delayen		Acc. Div.

From Steven Chu's confirmation speech:

- President Obama's plan builds on the good work of this committee in recent years: a greater commitment to wind, solar, geothermal, and other renewable energy sources; aggressive efforts to increase energy efficiency of our appliances and buildings; more fuel efficient cars and trucks, and a push to develop plug-in hybrids; greater investment in technology to capture and store carbon emissions from coal-fired power plants; a continued commitment to nuclear power and a long-term plan for waste management and disposal; responsible development of domestic oil and natural gas; increased commitment to research and development of new energy technologies; a smarter, more robust transmission and distribution system; and a cap-and-trade system to reduce our greenhouse gas emissions.

Andrew's Challenge

- What do we do for energy and climate change problems?
- The honest answer is probably not very much right now, so the next step is to look at our capabilities and see if we can find applications outside of Nuclear or Particle Physics
- Can I challenge you all (as I am challenging myself) to come up with creative ways to use our technologies outside our field in ways that help the country
  - To be clear, finding ways to do our own research using less energy, while good, is not sufficient