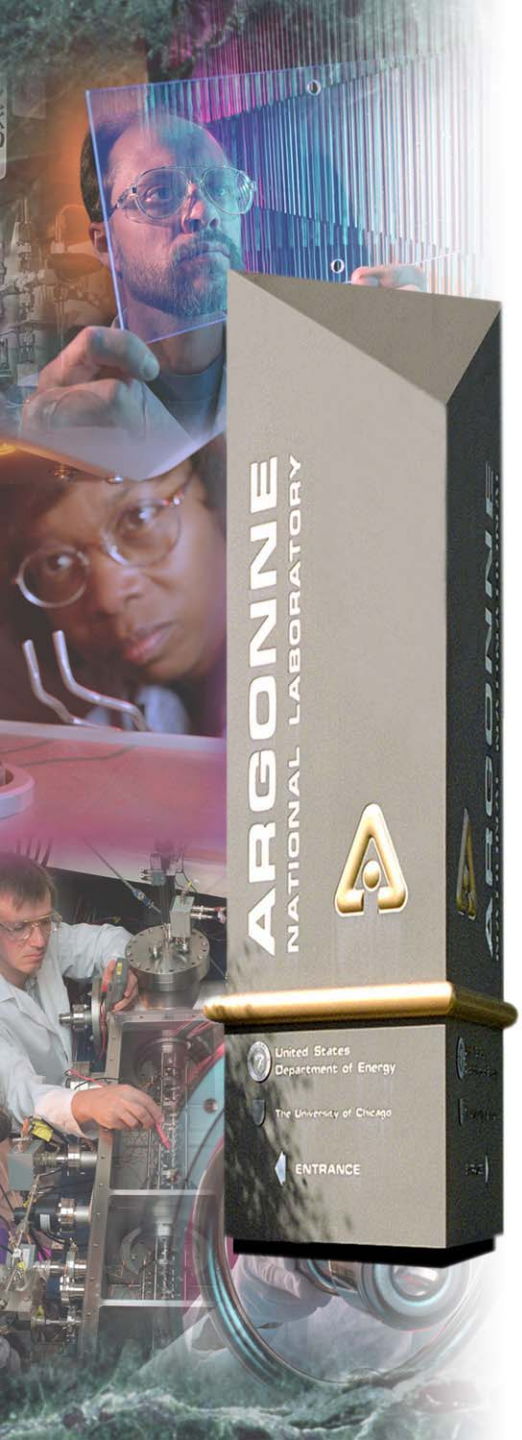

Accelerator Research at Argonne and Beyond

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Introduction – APS Accelerator Research

- **Accelerator Physics R&D at the APS is conducted by both AOD and ASD**
  - AOD: Operations Analysis Group, Diagnostics Group
  - ASD: Accelerator Physics Group, Division Office
  -
- **Accelerator Engineering R&D is done by all APS divisions**

Introduction – APS Accelerator Research

- **This talk will first highlight the work of accelerator physicists on the APS facility itself**
  - Daily support of machine operation
  - Evaluation and development of near-term enhancements
  - R&D for long-term “far reaching” enhancements
- **APS accelerator R&D support for other programs at ANL**
  - Physics and engineering involvement
- **APS accelerator R&D involvement beyond ANL**
  - Universities
  - Fermilab
  - Collaborative Organization

Accelerator Research at APS

Guiding factors:

- **Source brightness**
- **Beam stability**
- **Beam quality**

Source Brightness

- **Low emittance (8.0 nm → 2.5 nm)**
  - Simulation tools and techniques allow efficient lattice development
    - *Direct emittance optimization*
    - *Accelerator geometry optimization*
  - Developed tools – Orbit Response Matrix analysis – to measure and correct particle beam optics, improving symmetry and lifetime

- **Higher beam current**
  - Studied machine performance up to 200 mA
  - Demonstrated user operation up to 110 mA
- **Investigating options for special optics**
  - Longer straight sections (~11 m)
  - Various exotic single-sector lattices

Beam Stability

- **World-class orbit stability**
  - ID x-ray BPM feedback
  - Fast DC orbit correction

- **Overcome effects of beam-induced wakefields**
  - Understand single-bunch intensity limitations
  - Develop and benchmark complete and accurate model of machine impedance
  - Raise intensity-dependent instability thresholds
  - Study and test passive (e.g., rf cavity HOM dampers) ← and active (e.g., feedback) options

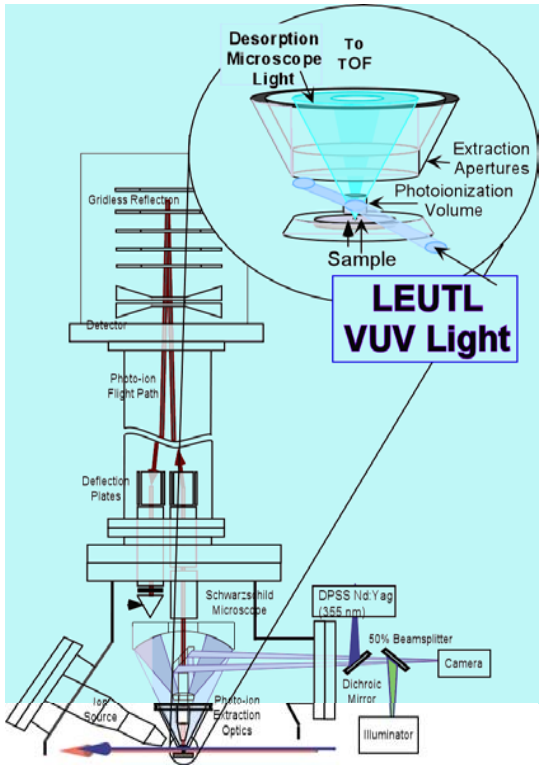
Beam Quality

- **Bunch purity to a part in 10^6 or 10^7**
  - Bunch cleaning
- **Injection efficiency and transparency to fully exploit advantages of top-up operation**
  - Booster low emittance
  - Off-energy injection

Long-Term Topics

- **To ensure APS remains competitive and viable in 20 years: possible future upgrades**
  - Ultra-low emittance storage rings
  - Options for energy-recovering linacs (ERLs)
  - Interleaved linac and ring-based sources
  - Ultrafast x-rays (ultra short e- bunches)
  - Linac-based free-electron lasers (FELs)
    - *LEUTL R&D success extended to developing user facility capability*
- **General beam dynamics**
  - Model independent analysis
  - Electron cloud effects
  - Ionization cooling

FEL R&D at APS



Single Photon Ionization / Resonant Ionization to Threshold

J. Moore and M. Pellin MSD/ANL

- **LEUTL has SPIRIT**
- **Presently LDRD funded: Preparing proposal to DOE to upgrade to VUV user capability: Argonne Linear FEL Facility (ALFF)**

- **SASE FEL-related R&D**
  - Time-resolved radiation analysis using FROG
  - High-brightness e- source development

  - Comprehensive start-to-end simulation
    - *Coherent synchrotron radiation (CSR) instability and longitudinal space-charge instability*

    - *Static and dynamic error sources*
- OTR diagnostics

Accelerator Research at ANL

Coordination of Accelerator Research at ANL (CARA)

- **A new cross-divisional activity started in April 2002 by Kwang-Je Kim to coordinate accelerator R&D at ANL that had been pursued independently by several divisions**

- **Participation from three ALD areas:**
  - Physical, Biological, and Computing Sciences (PBCS)
    - *Involves HEP, CHEM, PHY, IPNS divisions*
  - Advanced Photon Source (APS)
    - *Involves ASD, AOD, XFD divisions*
  - Energy & Environmental Science and Technology (EEST)
    - *Involves ET Division*

CARA: Accelerator Research at ANL

- **Benefits of CARA:**
  - Increased research efficiency by sharing resources and manpower
  - Strengthened accelerator science at ANL on existing program and new initiatives
  - A body to respond to collaboration and other opportunities from outside

- **CARA activities are supported by LDRD**

CARA: ANL Accelerator R&D Expertise

- **APS**
  - High-brightness storage ring study
  - ID design
  - Injector test stand for high-brightness linac study
  - Engineering resources
- **Argonne Wakefield Accelerator (AWA)**
  - High-brightness and high-Q sources
  - Wakefields and wakefield acceleration
- **ATLAS/Rare Isotope Accelerator (RIA)**
  - Low- and medium-beta SCRF
  - Multi-Q ion beam transport
- **Terawatt tabletop (T3) lasers**
  - Femtosecond techniques
  - Laser-plasma interaction for extreme high gradient
- **Materials science and surface physics**
  - Accelerating structure development

CARA: Basic Accelerator R&D Wish List

- **Higher acceleration gradient by a factor >10**
  - Multi-TeV collider
  - Material limits, advanced accelerator concepts
- **Higher electron beam brightness by a factor >10**
  - Sub-angstrom x-ray lasers
- **Femtosecond-attosecond timing control**
  - Combine with, learn from, laser techniques
- **CW accelerators for high-average output**
  - Superconducting rf
- **Test accelerators, e.g., LC damping rings**

CARA: Present Activities

- **Monthly meetings**
- **“Beams and Applications Seminar” series**
- **Cross-divisional, cross-ALD LDRD research**
  - Linear collider LDRD
    - *SCRF processing lab (ANL/RIA, FNAL)*
    - *High-brightness beams (HEP and ASD)*
  - VUV FEL user facility development (AOD, ASD, XFD)
  - Engineering for RIA
  - Fermilab collider run II collaboration initiated

Benefits realized to date of the CARA initiative

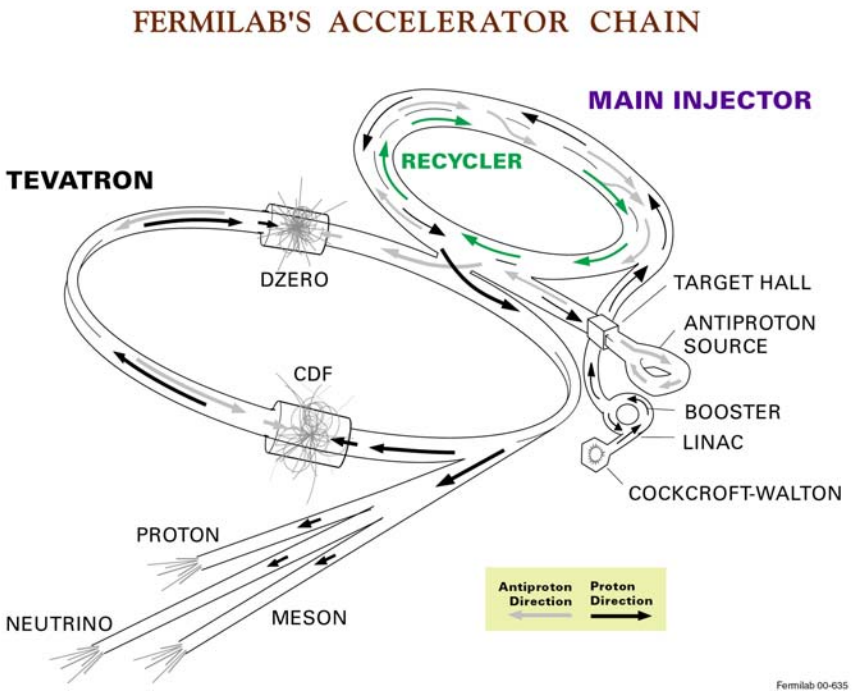
- *Wide support by both scientific staff and the lab management*
- *A positive impact on ANL accelerator research*
- *Noticed and praised by scientists and management from other national laboratories*

CARA: Future Activities

- **Continue present R&D and add new topics**
  - High-brightness e-beams
  - VUV FEL
  - High-gradient SCRF
  - Damping ring studies
  - Ultra-fast laser techniques
  - Rf cavity breakdown
  - EPICS for emerging platform
  - Second harmonic cavity for Rapid Cycling Synchrotron (IPNS)

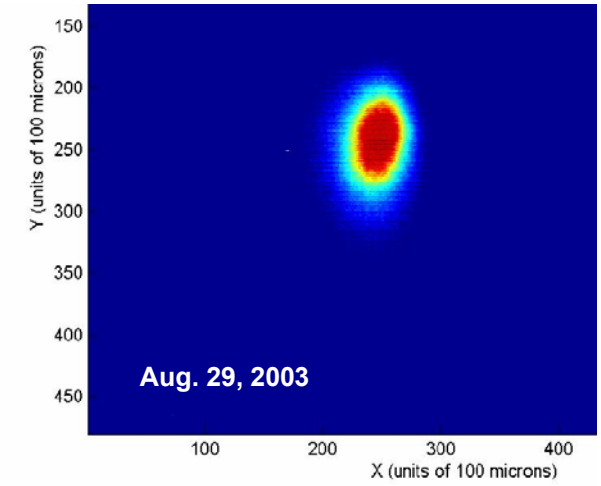
- **Expand coordination/collaboration outside ANL, to neighboring institutions**
  - SCRF collaboration with FNAL
  - New collaborative projects with FNAL to improve Tevatron run II luminosity
  - Joint faculty position with NIU for advanced heavy-ion beam dynamics
  - Provide opportunities for graduate student placement at ANL

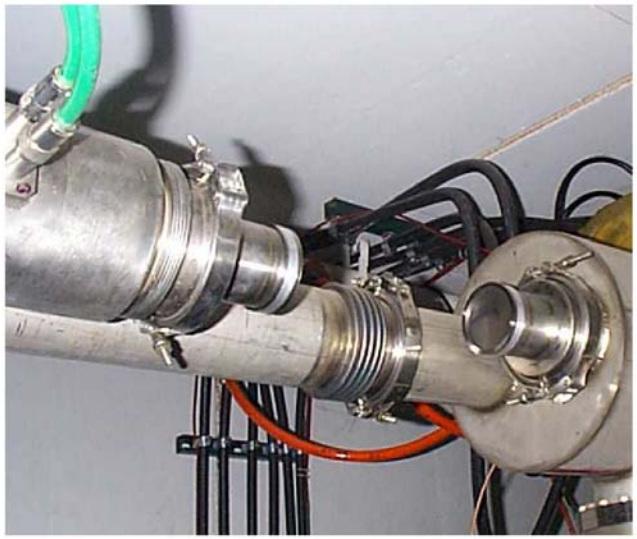
Collaboration on Fermilab Run II

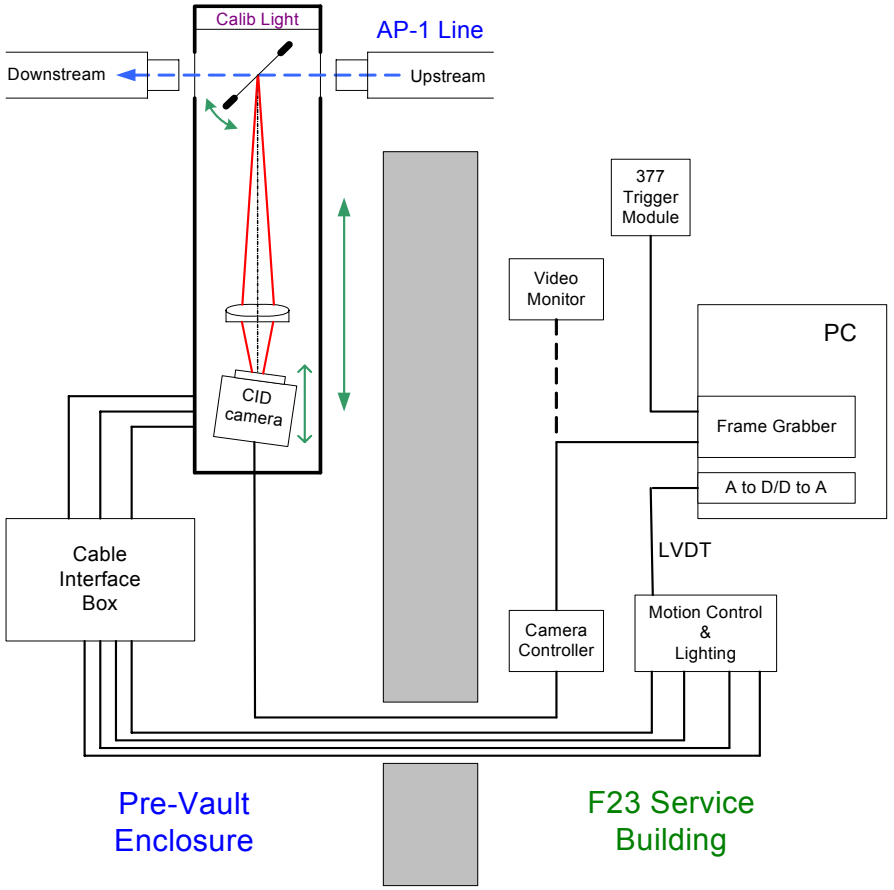


- Booster beam dynamics
- Recycler vacuum
- Tevatron optics modeling
- OTR imaging for p and p-bar
- Electron cooling

First OTR Light, 120-GeV Protons at FNAL







V. Scarpine, FNAL

A. Lumpkin, ANL

Towards Forming Institute for Advanced Accelerator Physics (IAAP)

Vision:

- **Chicago area has strong accelerator research capabilities spread over ANL, FNAL, and nearby university groups**
- **Advances in basic accelerator physics limited since activities are scattered and usually subordinate to other research programs**
- **A broad, coordinated research program in fundamental accelerator physics will enhance regional capability required to participate in major future projects (e.g., linear collider, 4^{th}-generation light source)**
- **Approach:**
  - Invite and consolidate participating groups/institutions
  - Secure funding prospects
  - Launch a few pilot collaborative projects with a high probability of success

Summary

- APS accelerator R&D program is balanced and directly focused on both near-term APS user needs and long-term evolution of facility to maintain world-class capabilities
- APS accelerator scientists and engineers pursuing productive collaborations with colleagues in other ANL divisions, leveraging expertise
- Vision of forming IAAP to strengthen accelerator R&D capability beyond ANL for future growth