Synergies for Near-Term Colliders and Advanced Accelerator R&D

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SLAC National Accelerator Laboratory
AAC WG7
July 27, 2026

Advanced Accelerator R&D and Near-Term Colliders

Advanced Accelerator R&D

- Blue sky - consider all possibilities
- Invention of new methods
- Failure is ok
- Publications are a measure of success.

Near-Term Colliders

- Shovel-ready
- Established methods
- Low technical risk
- “We publish in concrete and steel” - Sir John Adams

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Advanced Accelerator R&D and Near-Term Colliders

Are there opportunities for AAC concepts to make an impact on near-term collider projects?

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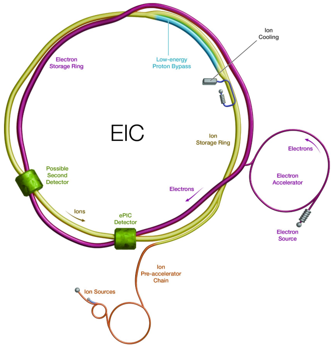
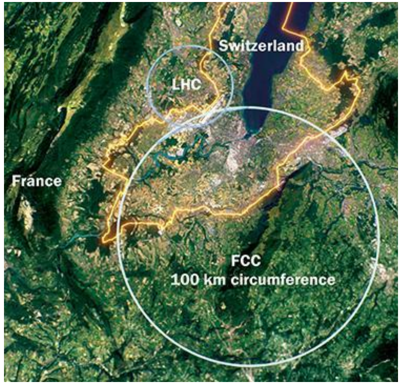
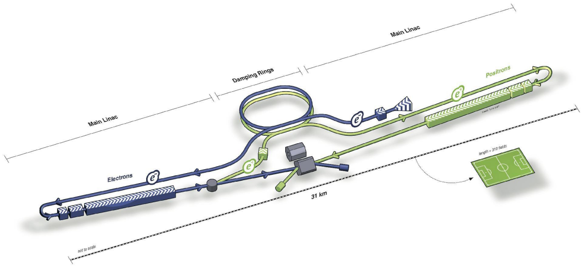
Colliders of the future

EIC @ BNL

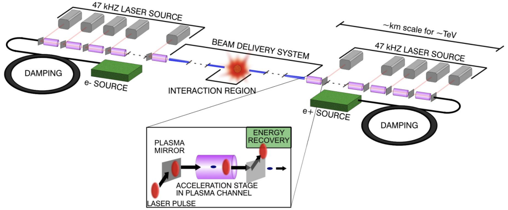


FCC @ CERN

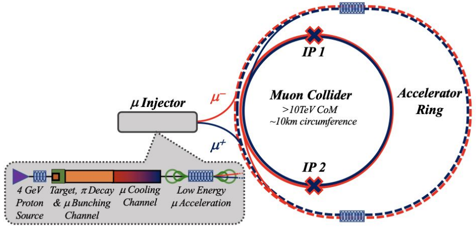




Linear Collider



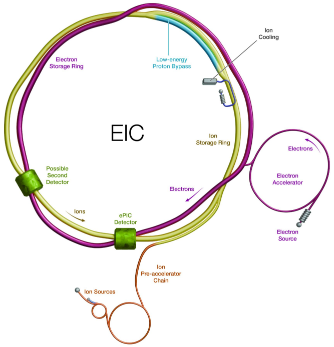
Wakefield Collider



Muon Collider

Colliders of the future

EIC @ BNL



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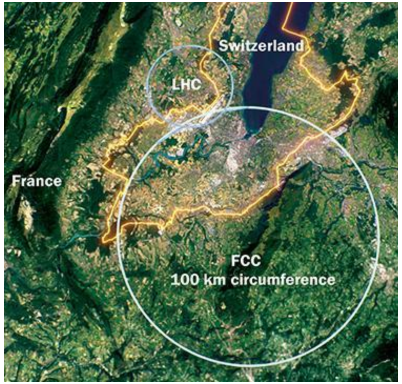

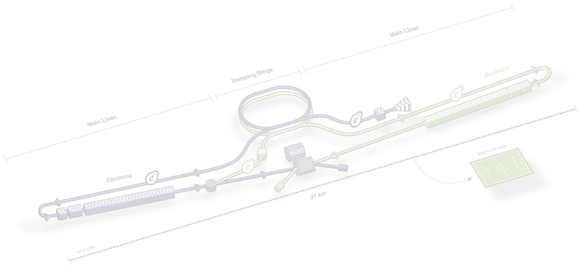

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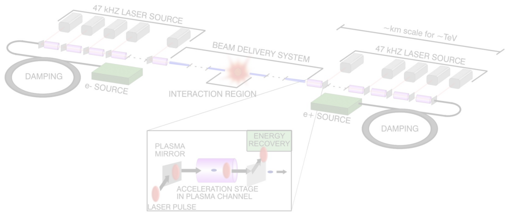
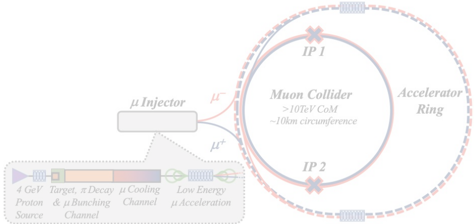


Wakefield Collider



Muon Collider

How can AAC make an impact?

DON'T ask "How can we add a plasma accelerator to your collider?"

DO ask "What are the challenges for your project?"

Beam Physics Challenges for EIC

- Generation and acceleration of polarized electron beams.
- Preservation of electron beam polarization in the injector chain.
- Preservation of electron beam polarization in the collider ring.
- Beam-beam effects on hadron beam emittance.
- Swap-out injection.
- Collimation.
- High-energy hadron cooling.

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Opportunity for AAC modeling tools

- WarpX for beam-beam (Arianna Formenti)
- Material wakefield calculations

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Opportunity for AAC methods
- Laser collimation (Ching-En Lin)
- Beam dynamics and microbunching

Beam Physics Challenges for FCC

- Generation and acceleration of electron beams with dynamic charge.
- Beam-beam limitations and detector backgrounds.
- Impedance effects.
- Electron cloud effects.
- Top-up injection.
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- Intensity control with Compton Backscatter.

Opportunity for AAC facilities

- Emittance preservation studies at FACET (Brendan O'Shea)
- Shot-to-shot charge variation at the photocathode.

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Opportunity for AAC modeling tools

- WarpX for beam-beam
- Material wakefield calculations
- PIC for electron cloud studies

- Top-up injection.
- Collimation.
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Beam Physics Challenges for FCC

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Opportunity for AAC methods

- Laser collimation (Ching-En Lin)
- Pulse-by-pulse Compton scattering with Joule-class laser.

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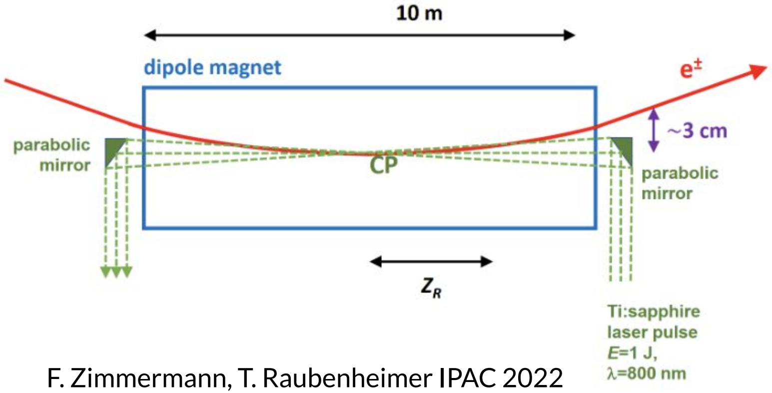
Laser Control of Beam Intensity at FCC

A beam-beam flip-flop instability occurs when colliding bunches have asymmetric charge-per-bunch.

If the instability grows faster than the top-up rate, a new method must be used to control bunch charge.

Zimmermann and Raubenheimer proposed a charge feedback system based on Compton backscattering.



F. Zimmermann, T. Raubenheimer IPAC 2022
https://accelconf.web.cern.ch/ipac2022/papers/wepost010.pdf

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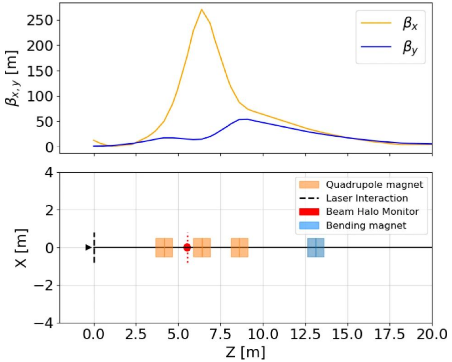
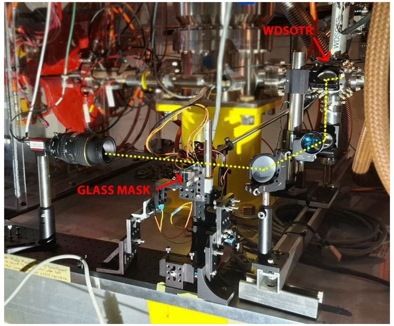
We are executing a proof-of-concept demonstration at FACET using the E320 experimental platform.





Experimental layout and AWAKE-style beam halo monitor.

Eur. Phys. J. Plus (2026) 141:568
https://doi.org/10.1140/epjp/s13360-026-07754-x

THE EUROPEAN PHYSICAL JOURNAL PLUS

Regular Article

Check for updates

Laboratory tests of laser control of electron beams for future colliders

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Received: 12 February 2026 / Accepted: 25 April 2026

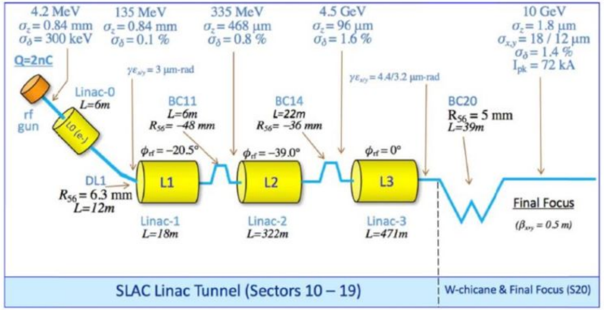
https://doi.org/10.1140/epjp/s13360-026-07754-x

FCC Injector R&D @ FACET-II

S. Bettoni, PSI
A. Latina, CERN
B. O'Shea, SLAC

Measurements at FACET-II

PSI

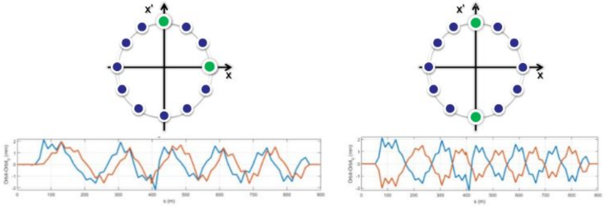


Damping at FACET-II

FACET-II linac is shorter than the HE linac. It has a different lattice, wakefield

Tuned the machine settings to observe the jitter damping: bunch length at BC14 using L2 and charge and observe the JA along L3

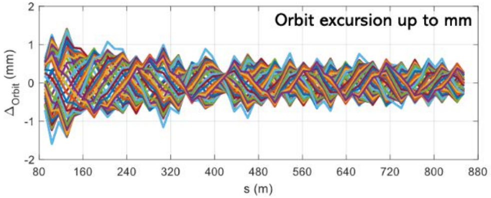
2D painting in the real world



Beam kicked using a combination of 90 degrees apart phase advance correctors pairs

Machine settings

- Bunch charge: 0.5-2 nC
- Bunch length: up to 4.5 mm (L2 phase >45 deg)
- Nshots: 30-100



Deploying WarpX Beam-Beam to the HEP Community

Fourth US FCC meeting

8–11 Sept 2026
SLAC
America/Los_Angeles timezone

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Tutorials

Tutorials will be held on Tuesday morning from 9:00AM-12:30PM.

Machine-Detector Interface Tutorial, John Seeman (SLAC):

The Interaction Region IR in a high-current high-luminosity e^+e^- collider is compact and complex, combining many of the most difficult aspects of the accelerator and detector. MDI helps coordinate plans for the highly interconnected interface between detector and accelerator to facilitate that both are successful even at the highest luminosities, often at several center-of-mass energies, for example from the Z pole to the t-tbar threshold. The accelerator and detector layouts integrate accelerator components such as lightweight and actively cooled beampipes, superconducting IR-magnets, bellows, and remote vacuum connections with detector components of inner detectors, vertex chamber, diagnostics, luminosity detectors, and utilities (cables, cooling, power, supports). This tutorial will cover more than thirty interface topics (from SC magnets, shielding solenoids, vacuum chamber masks, and inner detector elements to IR beam physics, beam loss sources, various beam backgrounds, and irradiation protection shielding). Examples from past and present colliders (KEKB, PEP-II, SuperKEKB) and future colliders under design (FCCee, ILC) will be used.

Beam-Beam Physics and Modeling Tutorial, Arianna Formenti (LBNL) and Peter Kicsiny (SLAC):

Beam-Beam physics is an important consideration for both accelerator performance and detector backgrounds. This tutorial will introduce the WarpX Particle-in-Cell (PIC) code for beam-beam modeling. The tutorial will provide a hands-on introduction to the simulation code with examples relevant to accelerator and detector physics:

- Beamstrahlung
- Incoherent pair generation
- Hand-off to detector simulations
- Beam-beam effects for turn-by-turn simulations

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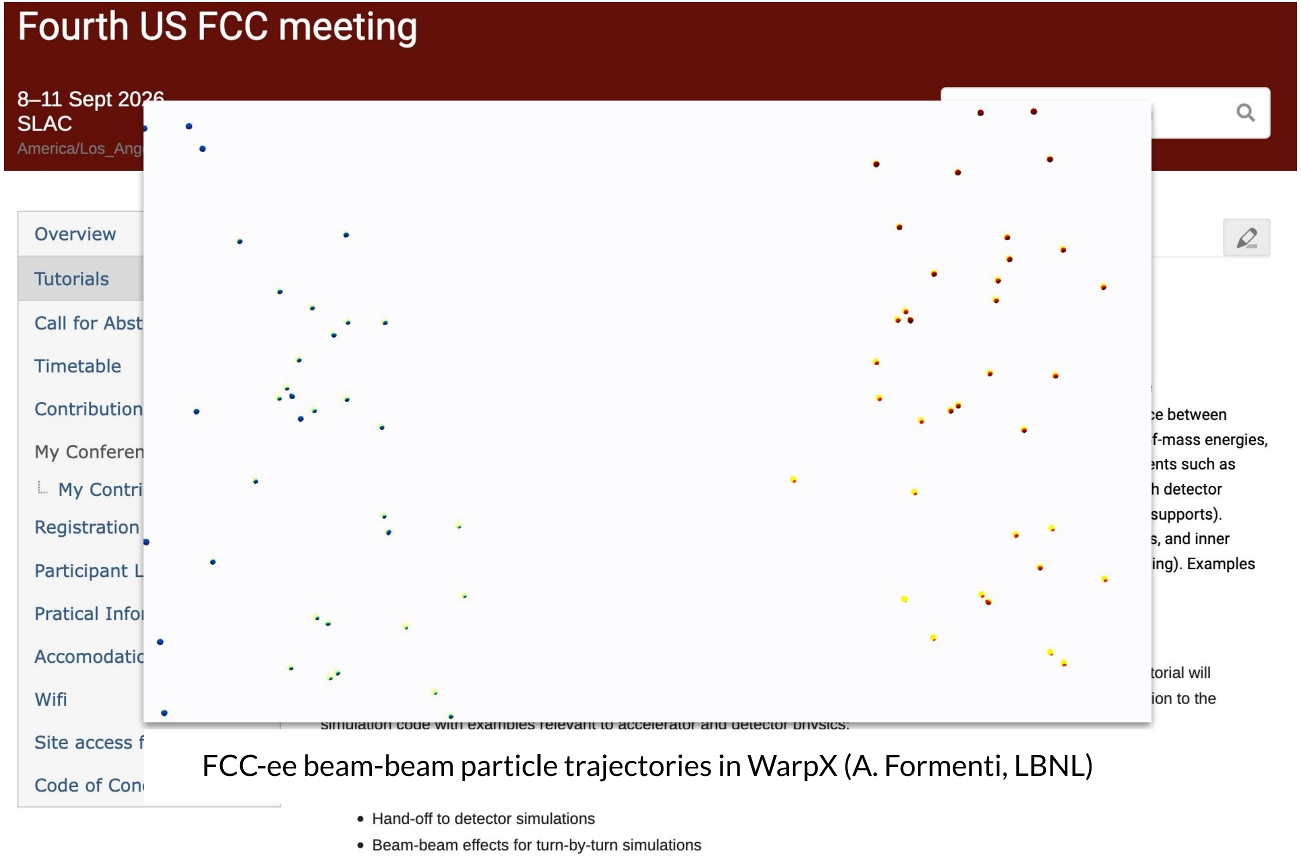
Deploying WarpX Beam-Beam to the HEP Community



FCC-ee beam-beam particle trajectories in WarpX (A. Formenti, LBNL)

Conclusion

- The AAC community has developed novel technologies and techniques that may benefit near-term projects.

- We must be honest about technical risks when presenting the upside of new ideas for reducing collider costs and improving collider performance.

- The leaders of upcoming collider projects need our help! There are excellent examples of AAC contributions in this session:
  - Laser-based collimation, Ching-En Lin, SLAC/Stanford
  - Self-consistent simulations of colliders, Arianna Formenti, LBNL

- Their support and endorsement will benefit the AAC community in the long-term when HEP is ready to support accelerator R&D.