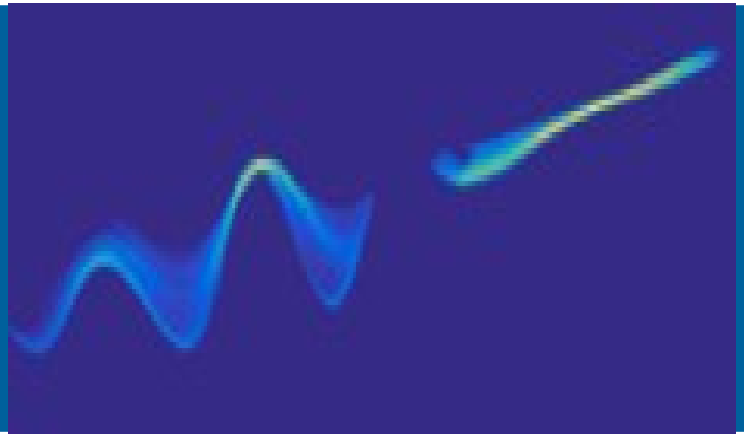
Theme 2: Beam Manipulation & Diagnostics



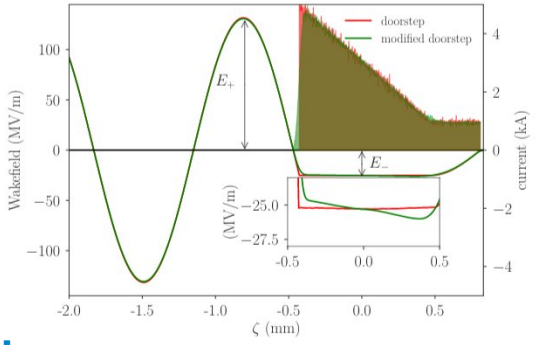
P. Piot
August 10th, 2023

Overview Beam Manipulations & Diagnostics

Optimal outcomes of beam manipulation

- Optimize particle-wave interactions toward efficient high-gradient acceleration → **building compact colliders**
- Study new techniques to control particle distributions in beams → **improving electromagnetic coherence**
- Investigate new electron-sources for generation of bright electron beams → **reaching quantum degeneracy**

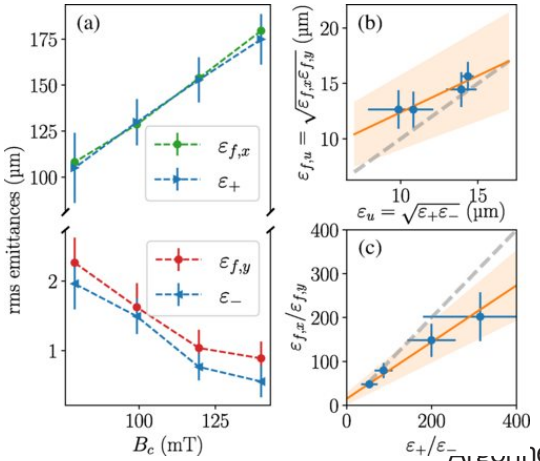
W. Tan, et al. PRAB 24, 051303 (2021)



Integrating role: Matching sources to front-end applications

T. Xu, et al. PRAB 25, 044001 (2022)

- Temporal beam shaping: enabling “super-radiance”, improving wakefield-accelerator efficiency
- Conserving/Controlling brightness (emittance preservation, phase space redistributions, coupled beams, halo-control,...)



Needs “in-sync” development of diagnostics

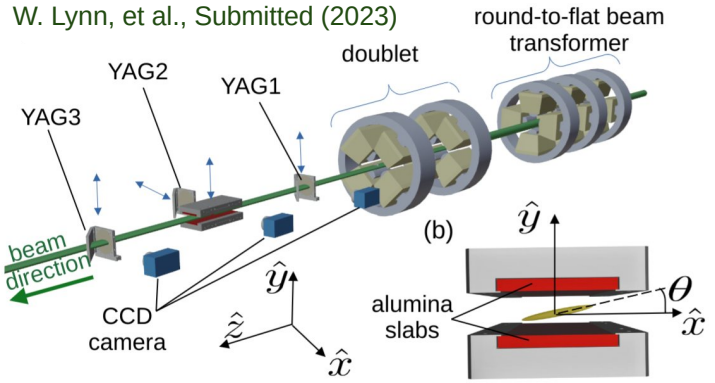
- Developing diagnostics with advanced capabilities (3D charge distribution, halo)
- Deploying AIML-based virtual diagnostics + controls

Collaborator-driven vs in-house R&D: synergies

In-house research: ecosystem of beam-manipulation infrastructures

- Emittance exchange (EEX) beamline: two cascaded EEX beamlines (or DEEX) available
- Round-to-flat beam generation
- in principle x/y/z phase-space partitioning possible (e.g. for damping-ring-free e+ injector; see T.Xu's talk)
- Laser shaping (nominal train of UV pulses)

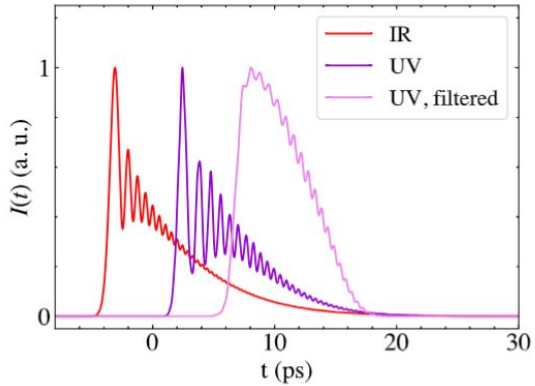
W. Lynn, et al., Submitted (2023)



Collaborator-driven R&D on beam manipulation

- Multi-leaf collimator (UCLA, see N. Majernik's talk)
- Laser-shaper (ANL/NIU/SLAC/UCLA in progress)
- Multi-TDC beamline (LANL proposed)

T, Xu, et al. Proc. NAPAC22 (2022)

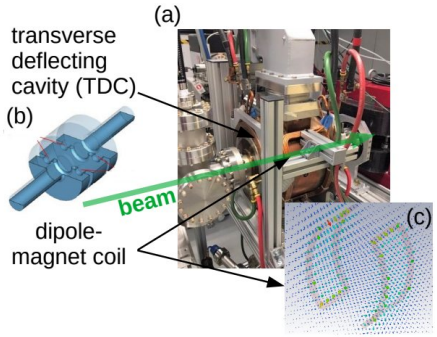


Synergies

- AWA capabilities enable "discovery" research (e.g. flat beam use to unveil skew wake)
- Manipulation experiment by collaborator sometime morph into an added capability at AWA available to the other collaborator

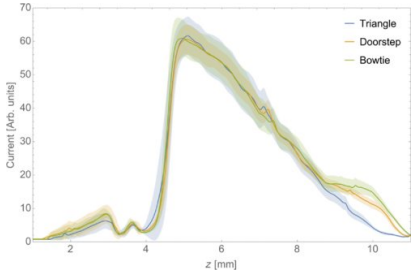
Highlight of Recent (~2 year) Achievements

Straight-Merger for ERL



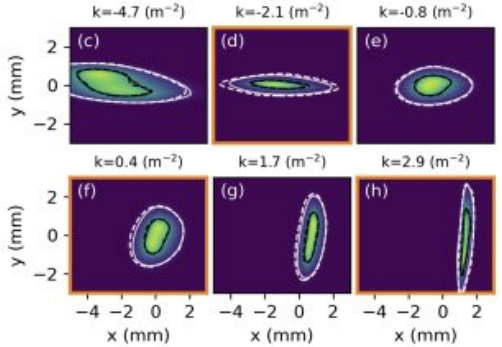
A. al Marzouk, et al., NAPAC22 (2022)

Multi-Leaf collimator combined with EEX



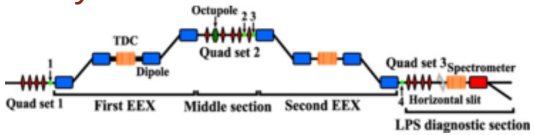
N. Majernik, et al., PRAB 26, 022801 (2023)

Virtual diagnostics (AIML)



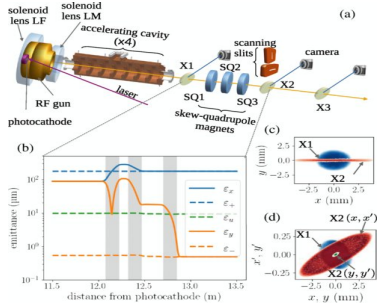
R. Roussel, et al. PRL 130, 145001 (2023).

Double EEX: a versatile shaping with no local coupling only



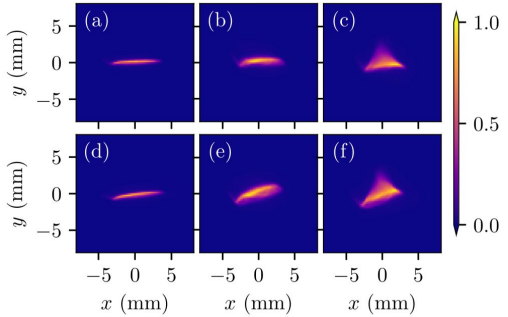
J. Seok, et al., PRL 129, 224802 (2023)

Eigen-emittance repartition



T. Xu, et al. PRAB 25, 044001 (2022)

Skew wake driven by tilted flat beams



W. Lynn, et al. submitted (2023)

Ongoing local (AWA) manipulation study

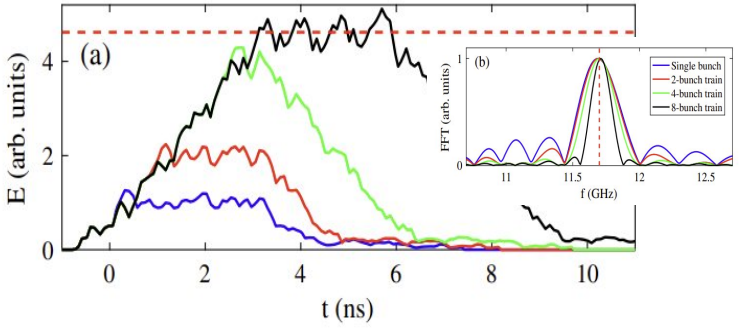
Motivation for AAC

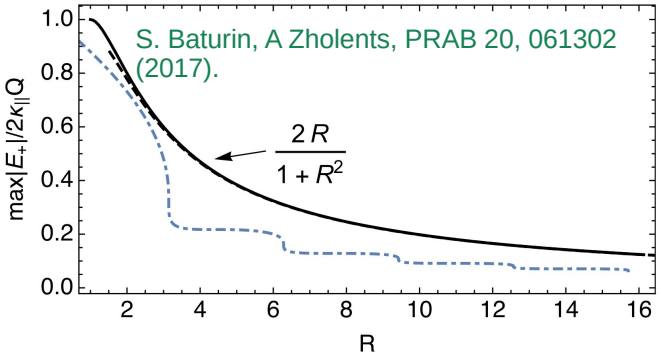
- Beam control to mitigate instability during high-charge transport of bunch train in cascaded PETS
  → **optimizing a X/K-band TBA @ 500-MeV**
- Compromise between transformer ratio and accelerating field
  → **toward a high-efficiency high-gradient CWA**
- Transport of coupled/flat beams for collider & cooling (see SY Kim's talk)

Exploring new capabilities

- Laser-shaping upgrade to produce ramped bunches (could be more versatile w/ some effort)
- Bunch compressor
- Deflecting-cavity-based bunch shaper

J. Shao, et al., PRAB 23, 011301 (2020).





Concluding remarks

This session:

- 10 talks on beam controls & diagnostics (a couple already occurred)
- 2 of the talks focus on AIML (AWA is very active thanks to CBB (UChi/SLAC) & PSI

Establishing an AWA Community

- Many of us are doing the same thing: run simulations, perform analysis, write acquisition scripts
- Let's share resources! Started on GitLab w/ public access.

Share you idea on desired features

- They will help us bolster our case for future upgrade.