Northern Illinois University

Bright Beams Generation at AWA

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Overview

- Motivation
  - CBB collaboration
  - Bright beam generation at AWA
  - Investigate the impact of different photocathodes
- Methods and Results
- Next steps: simulation and experiment
- Conclusion

CBB integrated photocathode tests

- Integrated test of low-MTE photocathode in a photoinector; collaboration between NIU, Cornell, UCLA
- Share methods and ideas
- Test CBB photocathodes at 3 different facilities (inc. AWA)

Deliverable 1.2: low-MTE photocathodes integration in existing photoinjectors

Identification of beamlines for a potential experimental demonstration of the simultaneous generation of low-emittance and high-charge (~100 pC) bunch, using CBB low-MTE photocathodes and diagnostics, that when coupled with a bunch-compression beamline would produce beams with 5D normalized brightness $I/\varepsilon^2>10^{15}$ A/m^2.

Bright beams at AWA

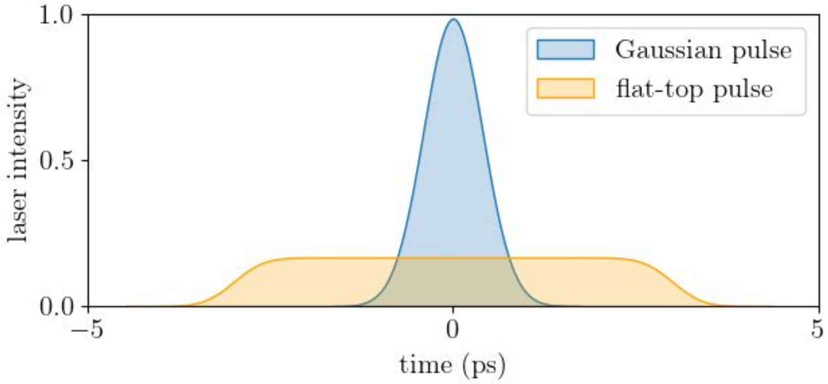
- Find optimal configurations of AWA's upgraded drive-beam photoinjector to generate bright beams
- Initial goal: produce a 100-pC beam with ~100-nm transverse emittance
- Devise a staged approach:
  - **Phase I:** minimal disruption: use current photocathode
  - **Phase II:** consider other cathodes (pending successful performances at FAST or ACT [see O. Chubenko's talk])
  - **Phase III:** (stretched goal) bunch compression for brightness increase [not discussed in detailed today; work by A. al Marzouk w/ R. Ryne (ret. LBNL)]

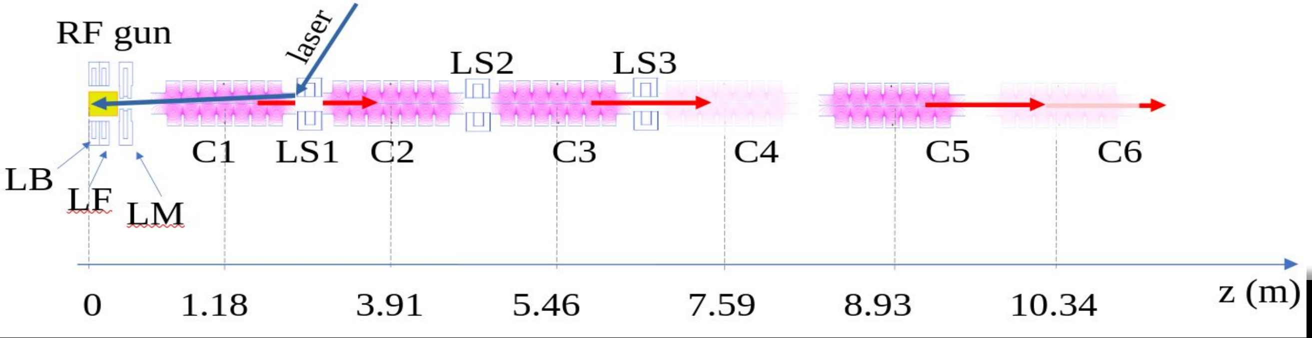
Impact of the photocathode

- Investigate the impact of the type of photocathode on emittance by varying the mean transverse energy
- Test three different photocathode MTEs:
  - 250 meV (Cs_2Te)
  - 60 meV (CsKSb)
  - ~5 meV (TBD, CBB goal)
- What is the lowest emittance we can obtain with these photocathodes?
- At what point does low MTE not further help?

The drive-beam accelerator

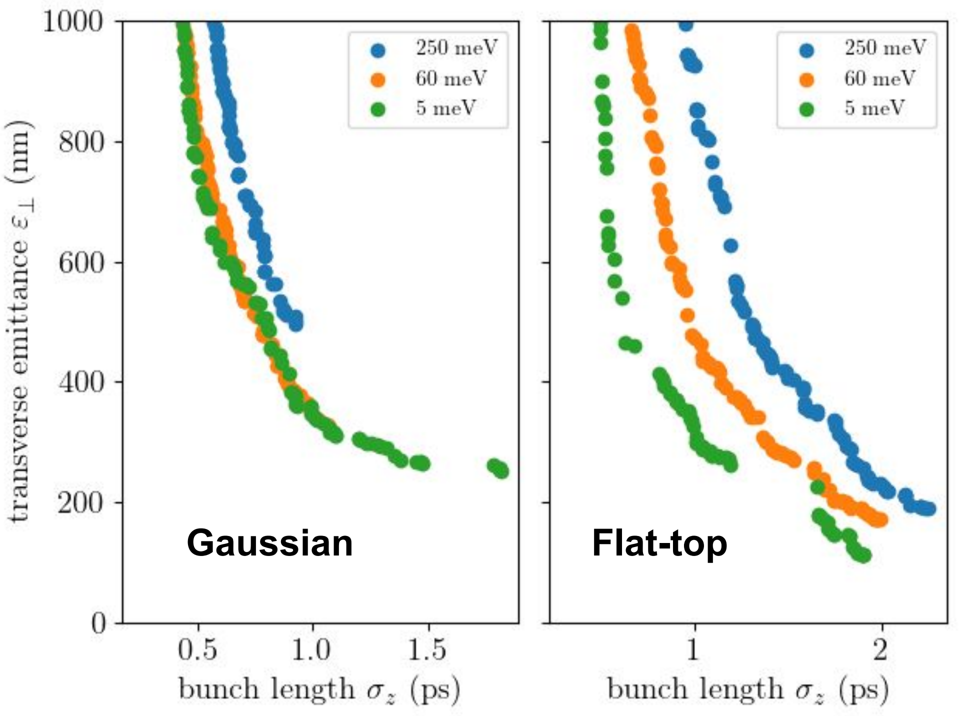
- The drive-beam accelerator operates at a wide range of charge
- Cs_2Te photocathode, 1+½ cell photoinjector operating at 1.3 GHz
- Two laser pulses: Gaussian and flat-top

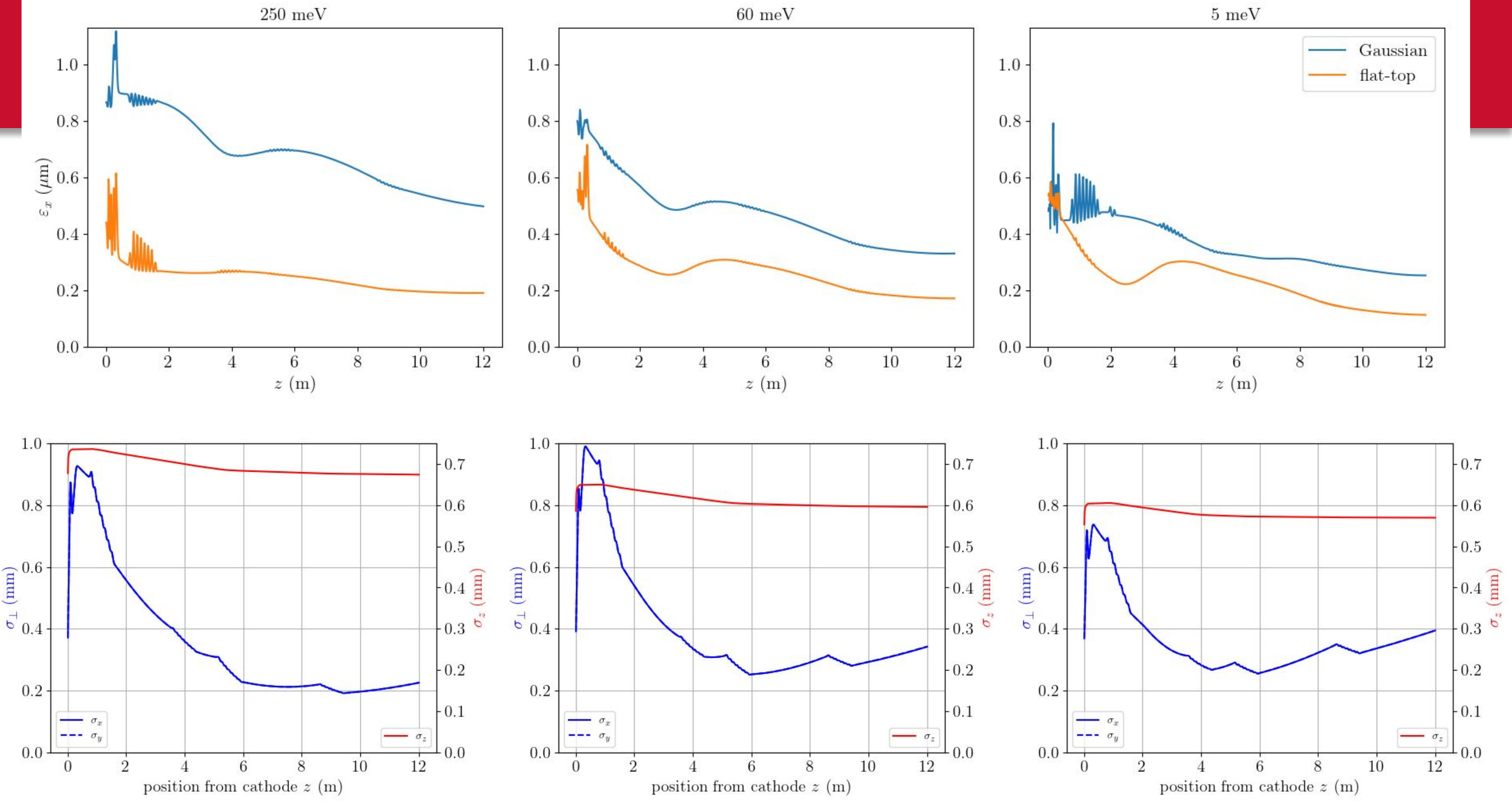




Multi-objective optimization

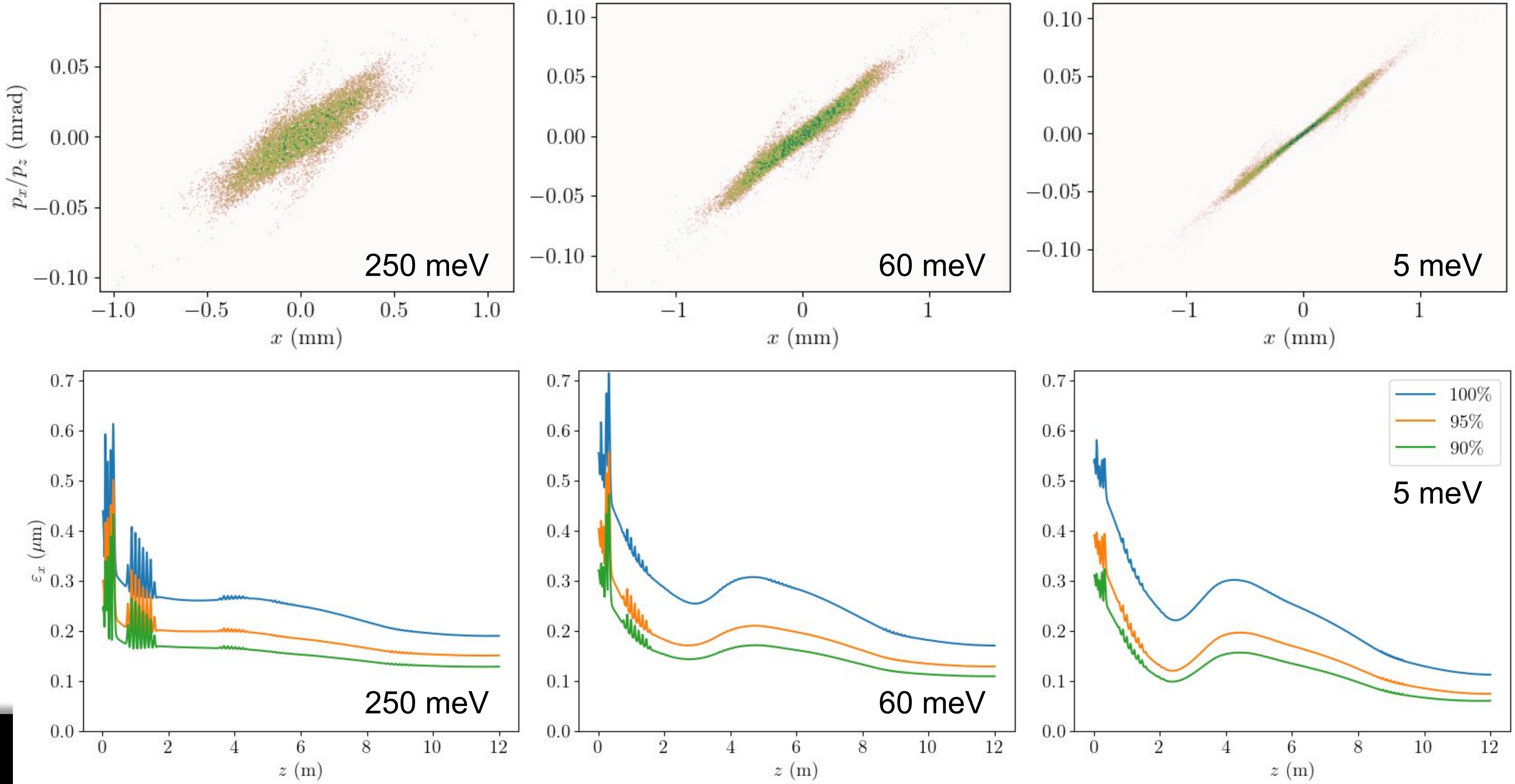
- Obtain tradeoff curves for transverse normalized emittance and bunch length
- Vary beam parameters, iterating through Astra to study the beam dynamics
- The flat-top pulse can reach lower emittance than the Gaussian pulse (< 200-nm)





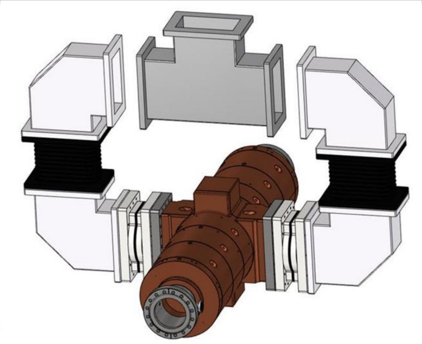
Note: beam size evolution only for flat-top

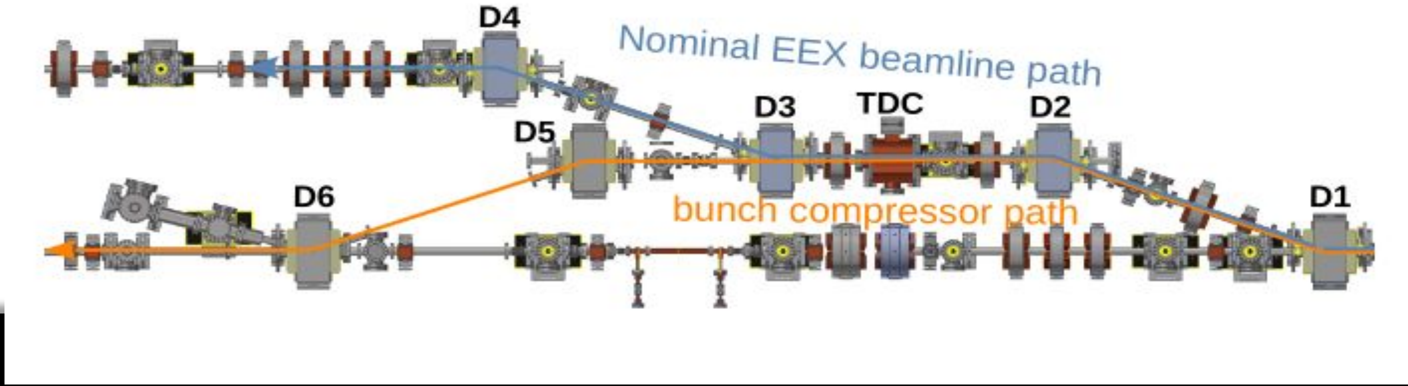
Flat-top: phase space and emittance



Simulations: next step

- Implement measured laser distribution
- Use 3D E&M fields maps (new gun, new dual-coupler linacs)
- Investigate selective collimation to improve brightness
- Explore bunch compression ("stretched" goal -- A. al Marzouk)



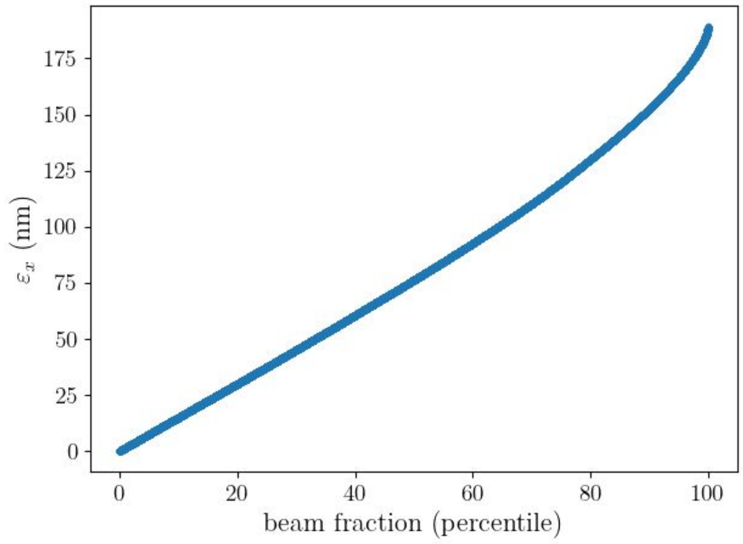


Experimental plans at AWA

- **Phase I: Cs2Te in upgraded injector**
  - Benchmark our model and validate optimum configuration:
    - Include realistic effects (measured laser distribution)
    - emittance measurement downstream of linac
    - spot size measurement along beamline
  - Measuring sub-micrometer emittances will be challenging as it will most likely rely on a multi-shot method (scanning slit or quadrupole scan)
    - Shot-to-shot stability
    - High-resolution diagnostics
  - Plan to explore the use of AIML virtual diagnostics developed by CBB and SLAC at AWA

Next steps: work at AWA

- **Phase I: Cs_2Te in upgraded injector (TBC)**
  - Explore the use of an aperture on the beamline to select brighter core (with J. Maxson)
- **Phase II: low-MTE photocathode tests**
  - Use lower-MTE CBB cathodes
  - Contingent to prior high-gradient cathodes test and characterization (see O. Chubenko's talk)



Conclusion

- Collaboration with CBB participants to demonstrate substantial emittance reduction from lower-MTE photocathodes integrated in a photoinjector
- Simulations indicate that AWA's drive-beam accelerator can achieve low emittance
- Experiments will first focus on optimizing the upgraded injector with the nominal AWA photocathode to gain experience with diagnostics and model validation
- Once ready, lower-MTE photocathode(s) will be inserted in the drive-beam RF gun.

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Thank you for listening! Questions?