The Center for BRIGHTBEAMS
A National Science Foundation Science & Technology Center

Testing CBB-developed Low-MTE Photocathodes in Accelerators

Motivation

Beam Production

Deliverable 2.1 (Priority): Photocathode that can operate for >1 week with MTE <35 meV at 50 mJ/cm^2 laser fluence and high field (>100 MV/m) for high peak current applications such as XFELs (**Summer 2025**)

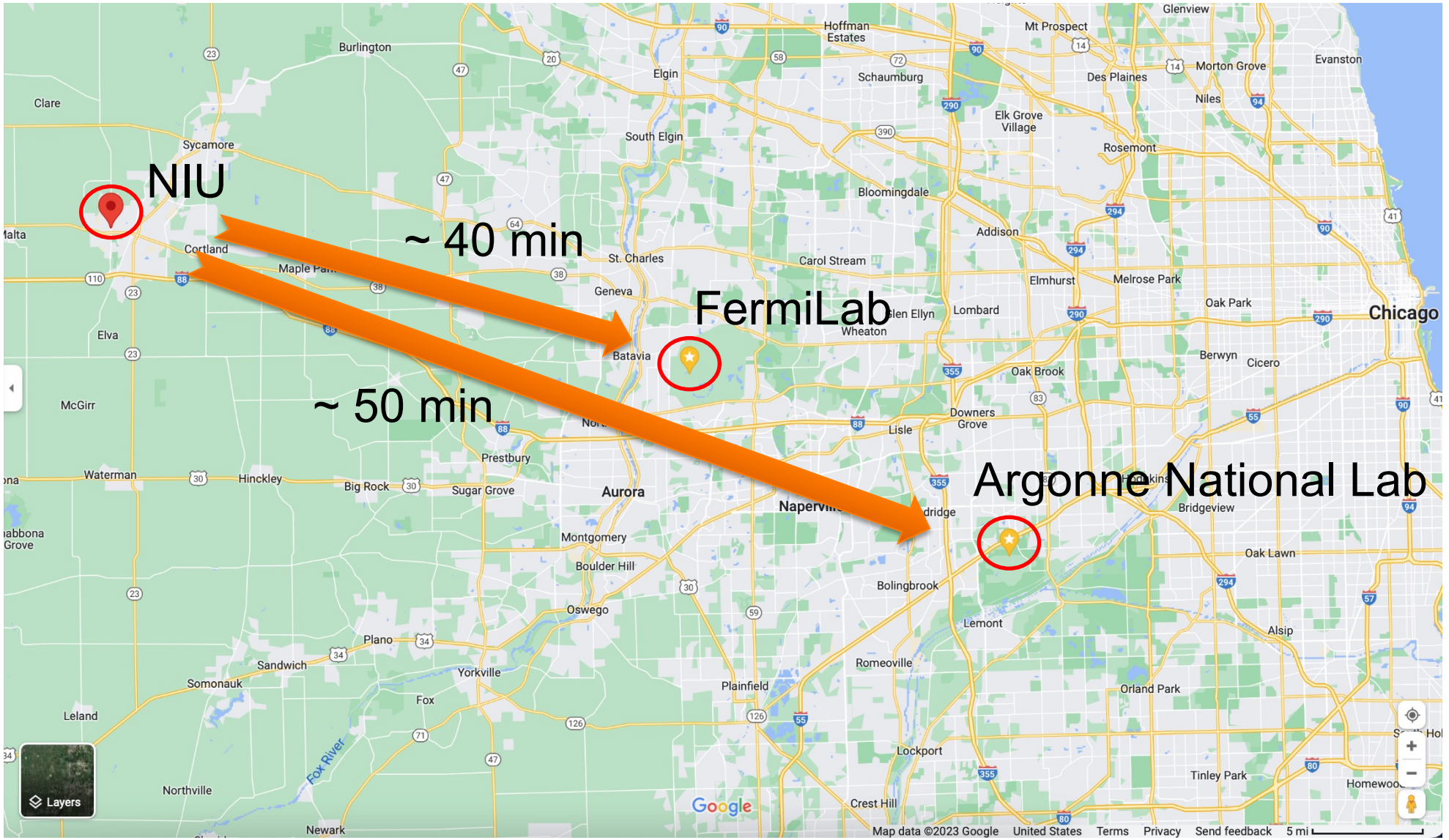
Deliverable 2.2 (Priority): Photocathode that can operate for >1 week with MTE <100 meV and QE>1% under high average current (>50 mA) conditions (**Summer 2026**)

Beam Dynamics and Control

Deliverable 1.2: Identification of beamlines for a potential experimental demonstration of the simultaneous generation of low emittance and high bunch charge, using CBB low-MTE photocathodes and diagnostics, and the development of possible experimental plans for identified beamlines (**Spring 2023**)

Deliverable 1.3: Characterization of the performance of photocathodes in either high field or high current conditions as needed to complete *PHC Deliverables 2.1* and *2.2* (**Annual, starting 2023**)

Motivation



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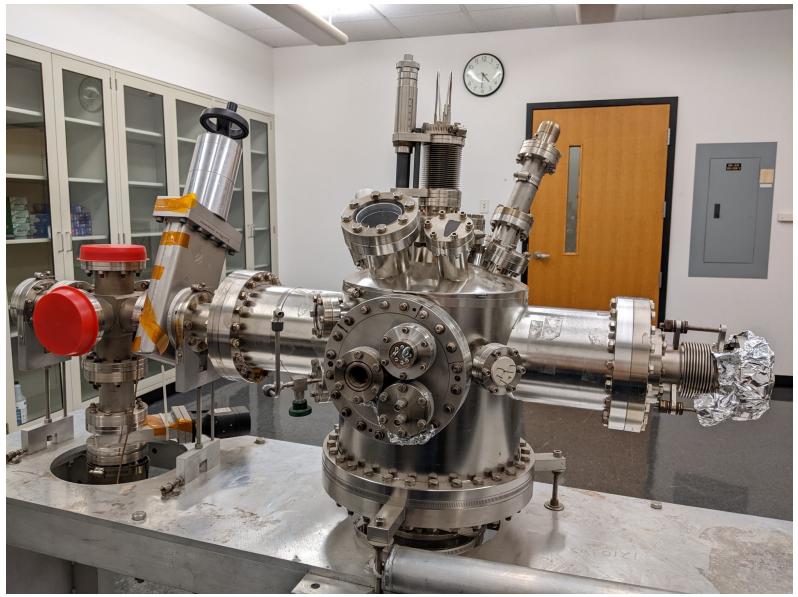
NIU Photoemission Research Lab



Growth system previously used to grow Cs-Te at Fermilab

Old INFN-type photocathode plug

NIU Photoemission Research Lab

Minimal updates required for the growth system operation:

- Clean the chamber to remove Te residuals
- Replace broken parts
- Update the pump system

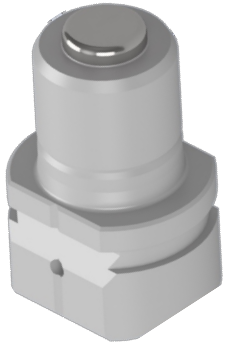
Further future updates

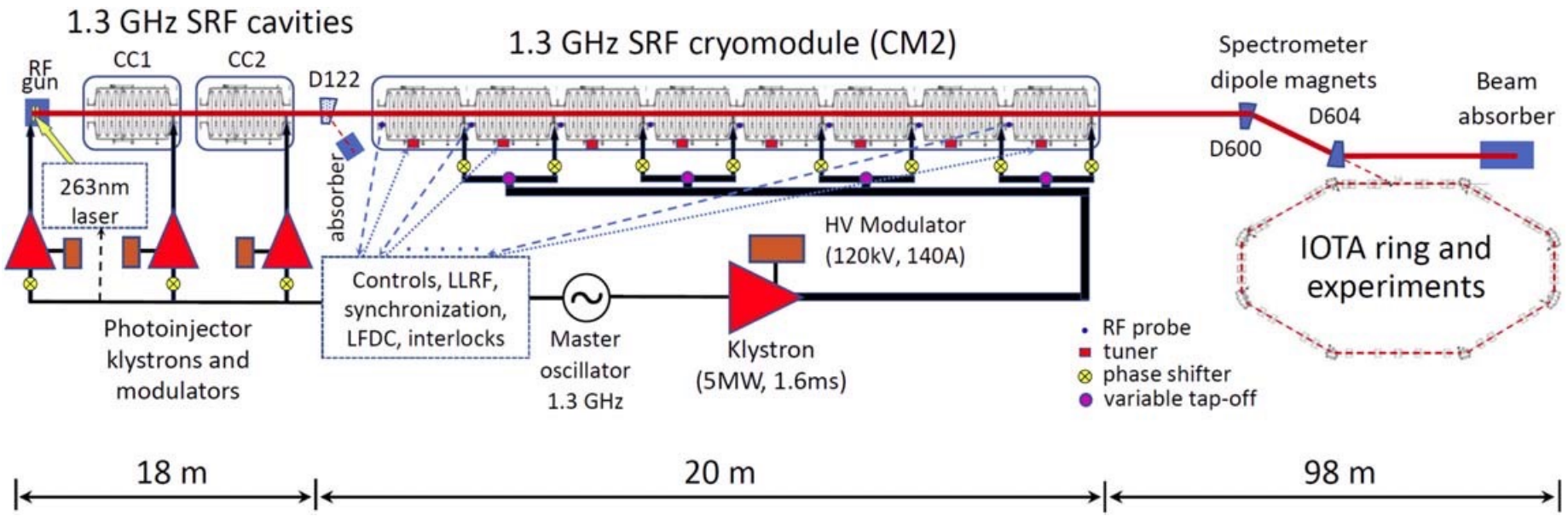
- Replace SAES strip sources with long-lasting effusion cells
- In situ/operando characterization with the RHEED system

Fermilab Accelerator Science and Technology (FAST) facility

FAST electron injector:

- photoinjector-based 1.3 GHz SRF linear accelerator
- Cs_2Te-coated Mo photocathode
- INFN-type photocathode plug
- production of 150 MeV electrons for IOTA ring
- main facility electron gun



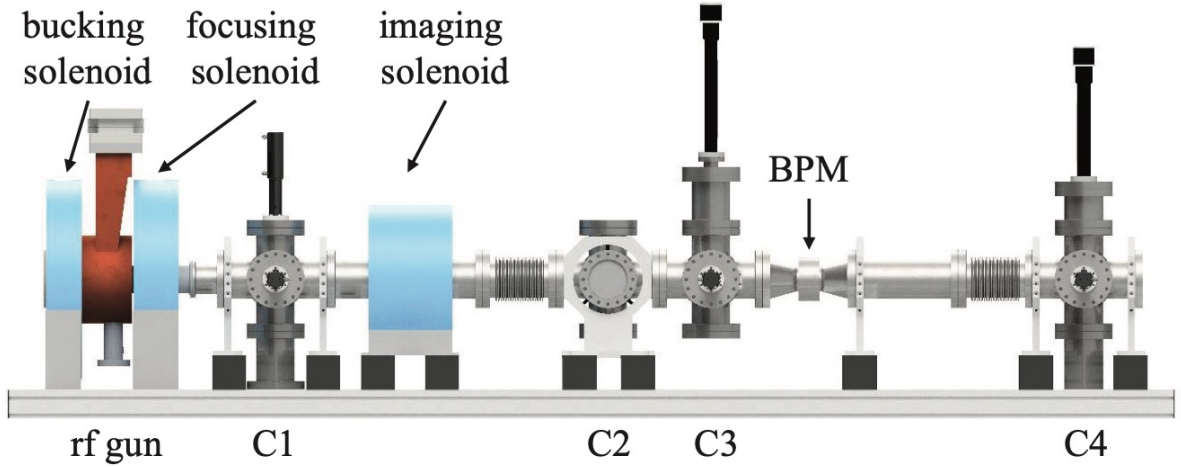


Broemmelsiek et al, New J. Phys. 20, 113018 (2018) https://doi.org/10.1088/1367-2630/aaec57

Argonne Wakefield Accelerator (AWA) Facility

Option 1: Argonne Cathode Teststand (ACT) beamline:

- L-band 1.3 GHz single-cell photocathode RF gun
- includes field emission (FE) imaging system to locate emitters with a resolution of ~20 μm
- currently suitable for testing air-stable materials only
- not in often use
- photocathode plug is suitable for testing different photocathode substrates
- intention of adding a load-lock system for testing Cs-containing photocathodes
- intention to update the pump system for ~10^{-10} Torr
- intention of adding the deflecting cavity for photocathode response time measurements



Shao et al, IPAC 2018 https://accelconf.web.cern.ch/ipac2018/papers/tupml006.pdf

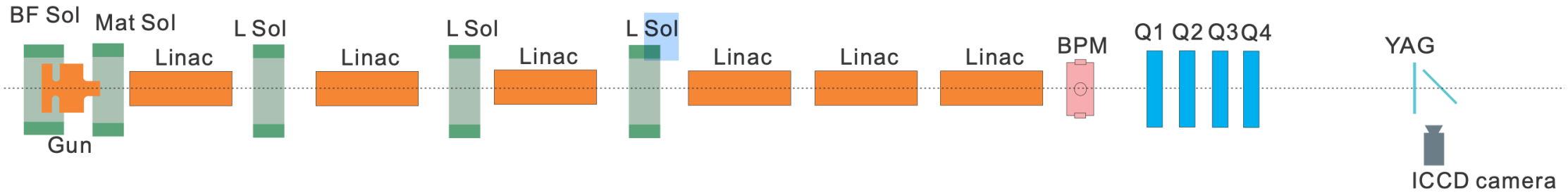
Argonne Wakefield Accelerator (AWA) Facility

Option 2: AWA drive gun

- L-band 1.3 GHz 1.5-cell photocathode RF gun
- Cs_2Te photocathodes
- quadrupole-scan method for measuring thermal emittance

$$\varepsilon_{T,x} = \sigma_x \frac{\sqrt{\langle p_\perp^2 \rangle}}{m_e c} = \sigma_x \frac{\sqrt{MTE}}{m_e c^2}$$

- has a load-lock system for testing Cs-containing photocathodes
- seems to be suitable to demonstrate CBB deliverables
- main facility gun = busy + concern regarding inserting new photocathodes



Zheng et all, IPAC 2017 https://accelconf.web.cern.ch/ipac2017/papers/tupab074.pdf

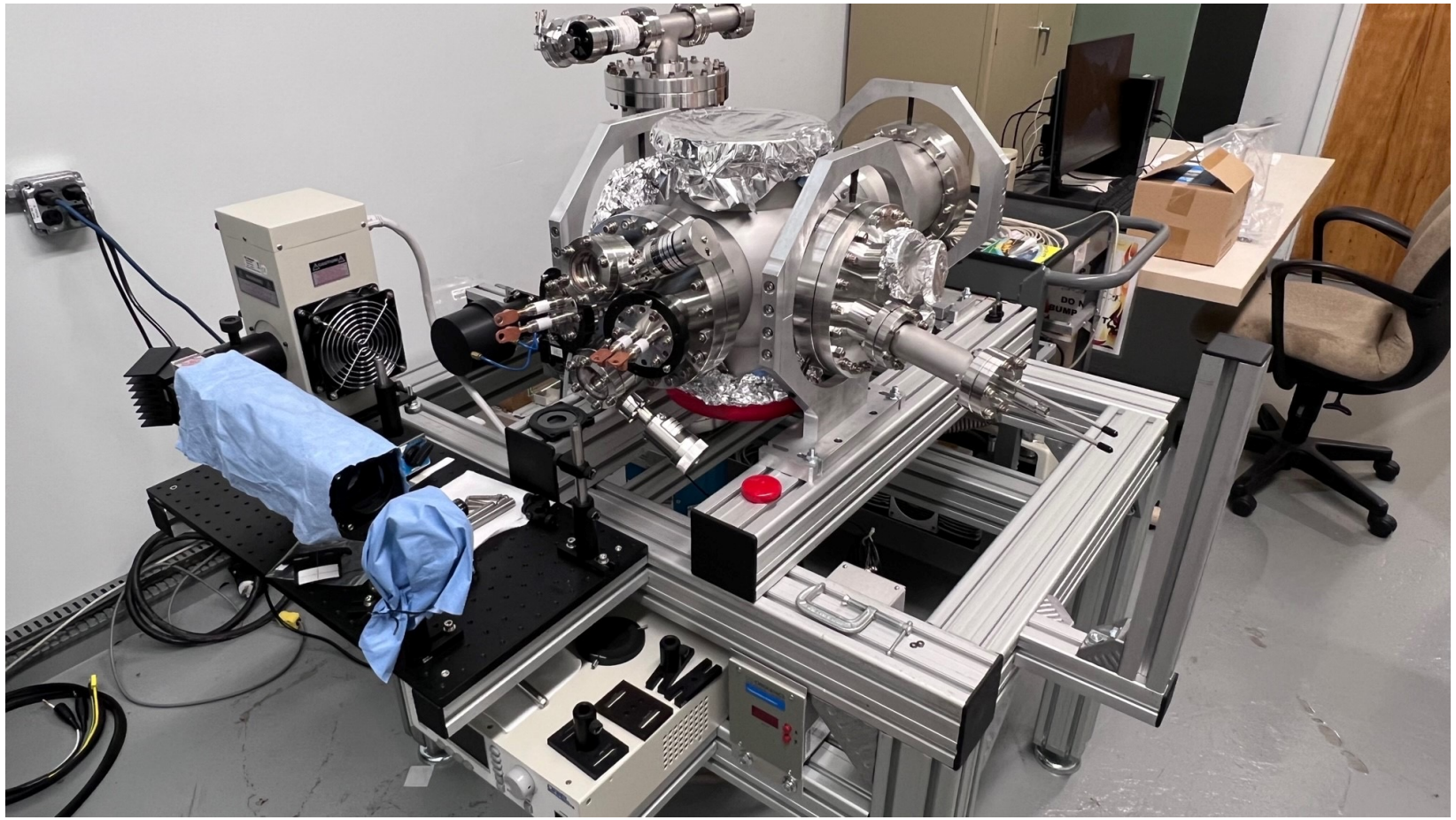
Argonne Wakefield Accelerator (AWA) Facility

Option 3: AWA witness gun

- RF gun, prototype of the new AWA drive gun
- provides more flexibility
- some modifications are required to perform our tests

Argonne Wakefield Accelerator (AWA) Facility

Brand-new, unused (but unfinished) cathode deposition system.



Tasks:

- Decide on the beamline, which is the most suitable for our purposes
- Complete the growth system so that it is compatible with the selected beamline