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Emittance and photocathodes

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- **Where we are today**
  - Injector performance
  - Ongoing work
  - Venues for improvements
- **Next generation gun**
  - Achieving ultralow emittances
- **Photocathode research**
  - Newman lab and Phillips Hall

Cornell ERL photoinjector highlights

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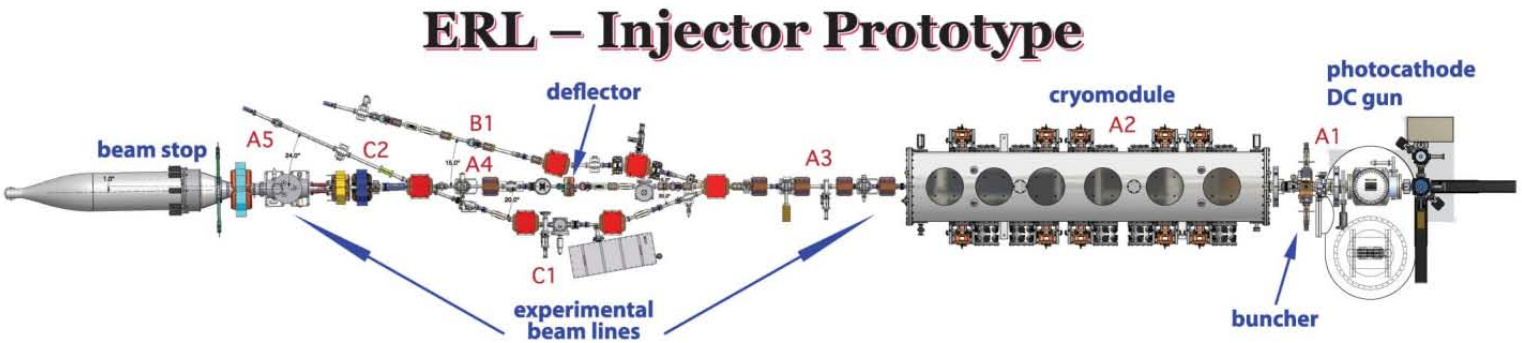
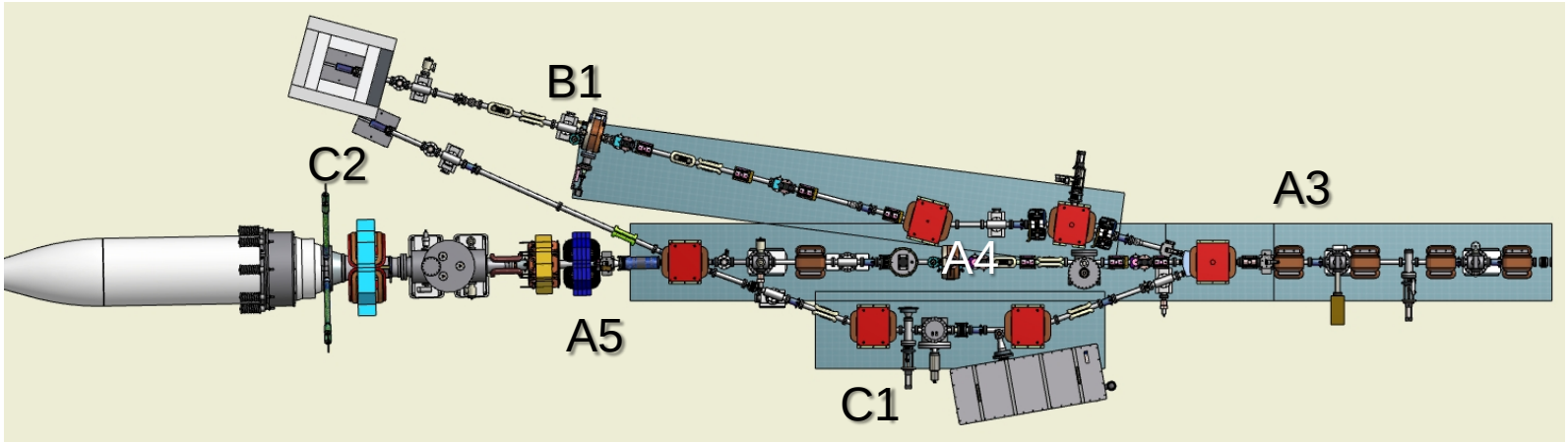
- **Over the last year:**
  - **Maximum average current of 52 mA from a photoinjector demonstrated**
  - **Demonstrated feasibility of high current operation (~ kiloCoulomb extracted with no noticeable QE at the laser spot)**
  - **Original emittance spec achieved: now getting x1.6-1.8 the thermal emittance values (0.35 mm-mrad) at full 80pC charge (= 100mA at 1.3GHz)**
  - **Would surpass best of existing storage rings if this quality beam were to be accelerated to 5 GeV (~5 better than PETRA3 today!)**

Emittance work



- **5 MeV operation**
  - Initially limited to 5 MeV energy due to potential radiation hazards
  - Extensive studies of emittance in A4 section, getting 0.8 mm-mrad 100% rms emittance at 80 pC (simulated values 0.6 mm-mrad)
  - Longish bunch length 12 ps rms (simulated 8 ps rms)
  - Some issues with a non-round beam (cause of asymmetry is unclear, likely due to SRF cavities & alignment)
  - New diagnostics capabilities developed: slice emittance measurements (PhD thesis, Heng Li)

Ongoing emittance work



- **~8 MeV operation (merger studies)**
  - **Now cleared to run the injector up to 10 MeV**
  - **Rebuilt B1 section (merger) by adding RF deflecting cavity for slice emittance measurements**
  - **Finally commissioned THz interferometer (alternative bunch length diagnostics)**
  - **Now bunch length is 2-3 ps rms with 0.3 mm-mrad 70% core vertical emittance in the merger (matches simulations well)**
  - **Still discrepancy with the horizontal (x1.5-2 bigger)**

Measured merger phase space at 80 pC (bunch length 2.3 ps rms)

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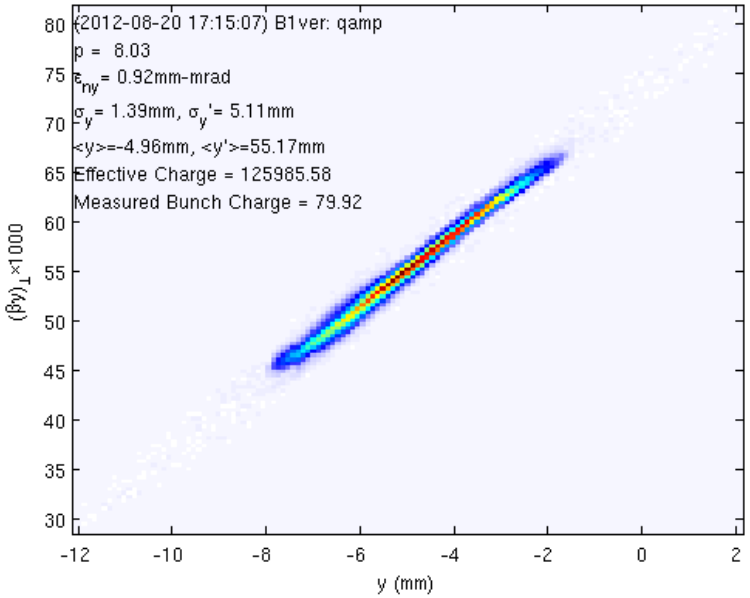
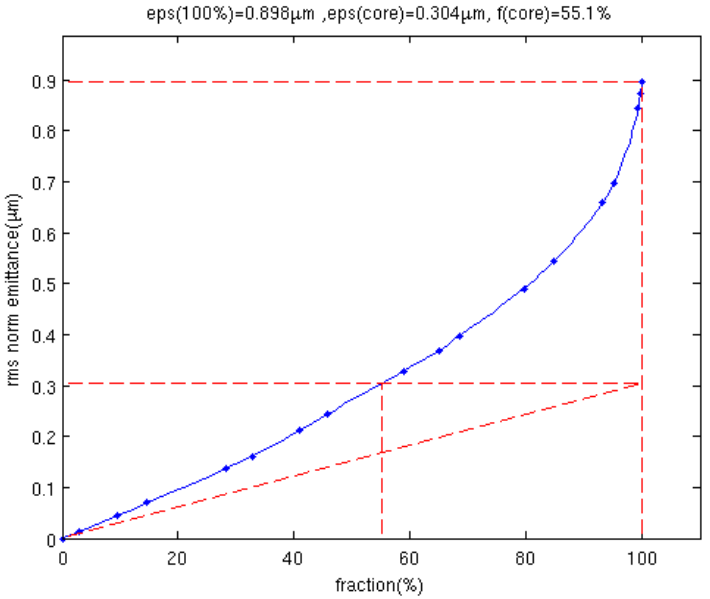
0.9 mm-mrad 100% vertical emittance, 0.3 mm-mrad core (60% fraction)





Simulated emittance is 0.8 mm-mrad 100% rms emittance

For proper description of beam brightness of non-Gaussian beams refer to

PSRTAB 15 (2012) 050703

Good agreement between THz interferometer and RF deflector

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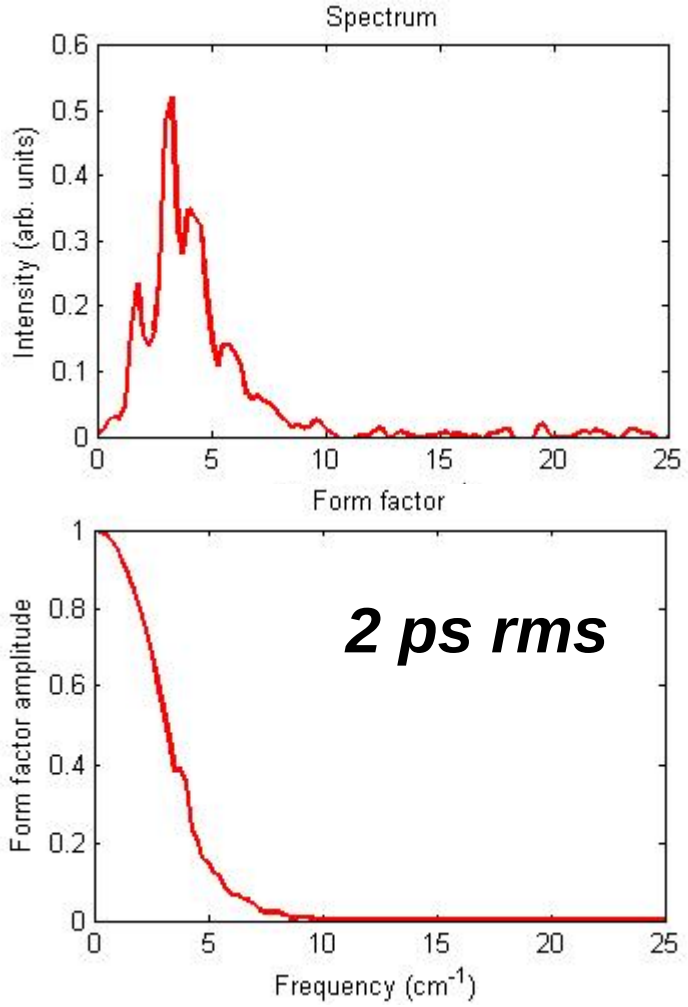
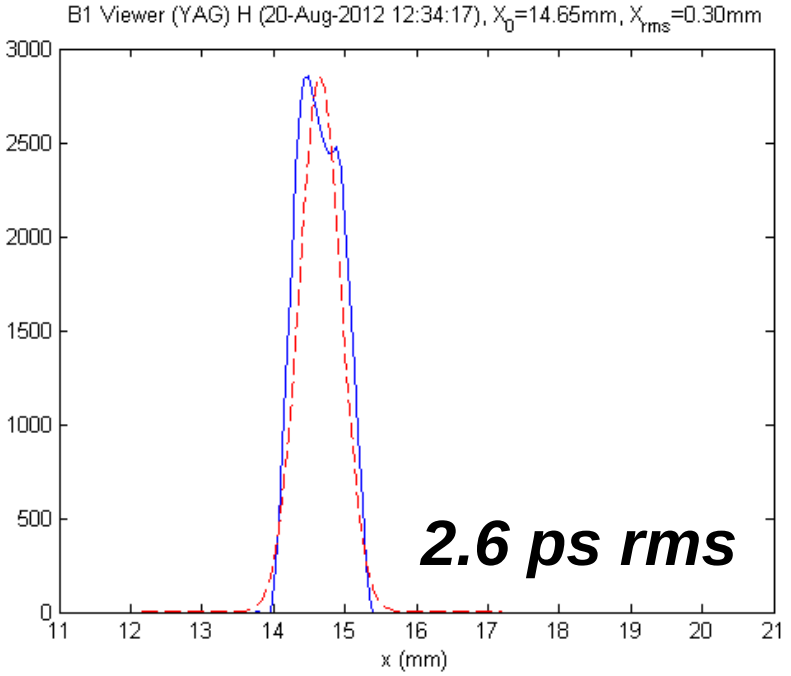
THz diagnostics



RF deflector (central slice)



Linear optics characterization (response matrix measurements)

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- **Horizontal emittance**
  - Initial loading of optimized optics quite successful (agrees well)
  - Horizontal emittance is still larger (simulated values should be about the same)
- **Approach: make linear optics to agree**
  - Characterize response matrices for optics by measuring $M_{11,33}$ $M_{12,34}$, coupling, and $M_{55,56}$ along the beamline and check with detailed simulations (3D field maps)
- **Result so far:**
  - Very good agreement of longitudinal elements $M_{55,56}$ (bunch compression, energy); very good agreement of the transverse for static elements (solenoids, gun, quads, etc.); good agreement for $M_{11,33}$ and $M_{12,34}$ for first SRF cavity on and off-crest (last Fri!)

Emittance work plan & improvements

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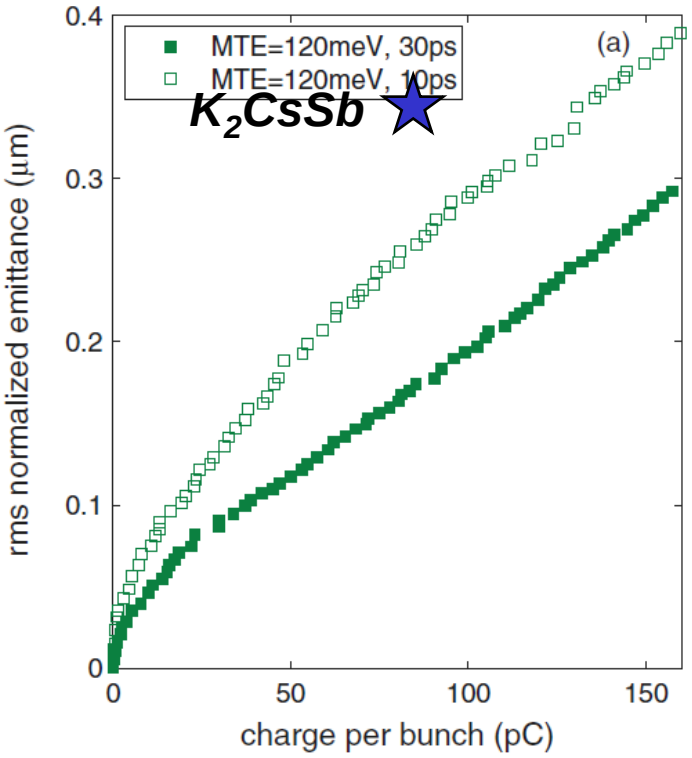
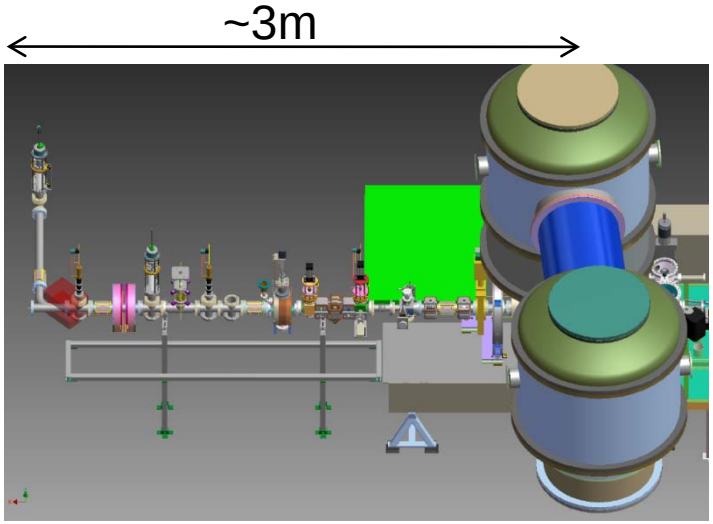
- **Finalize measurements of the low emittance in the merger and publish a detailed study**
  - **PhD student thesis (Colwyn Gulliford)**
  - **Planning to finish this or early next year (summer 2013 at the latest)**

- **Smaller emittance improvement venues**
  - **Better cathodes**
  - **Better laser shape**
  - **Better gun**

The new gun for ultralow emittances (coming online this year)

- **New gun & better laser shaping**
  - **Improved gun will give < 0.4 mm-mrad 100% 80pC emittance;**
  - **This will be first demonstrated in W128 (photogun devel. lab);**
  - **Adaptive laser shaping is acquired, the lab is being set up**





Developing advanced photocathodes for accelerators

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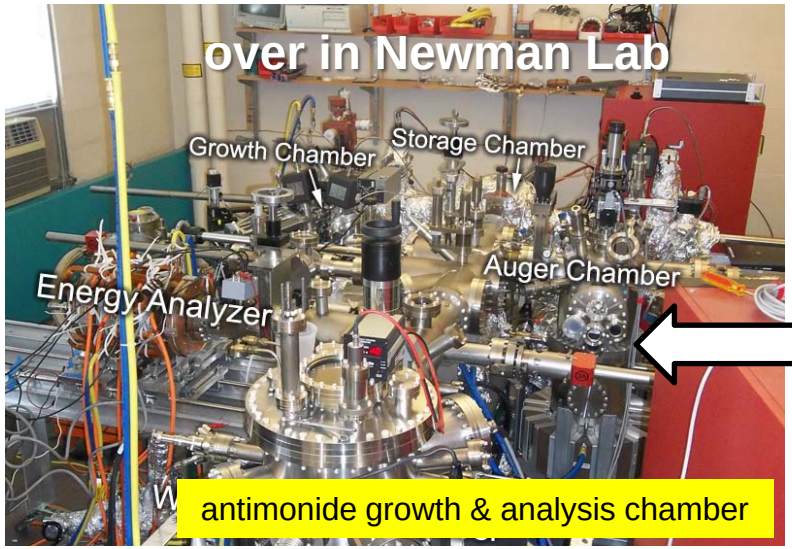
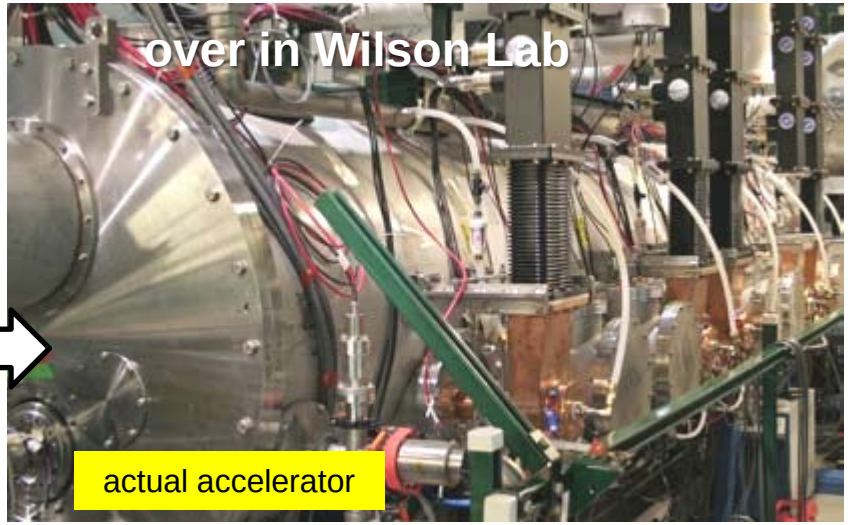
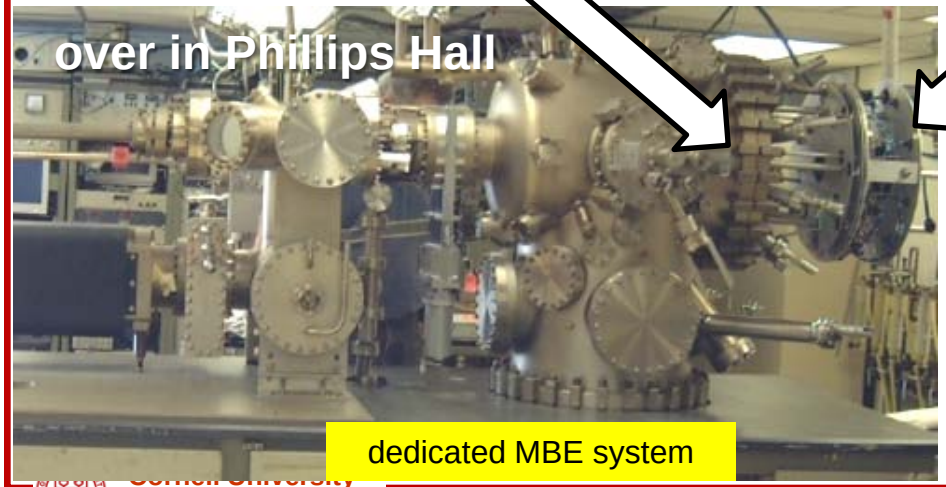
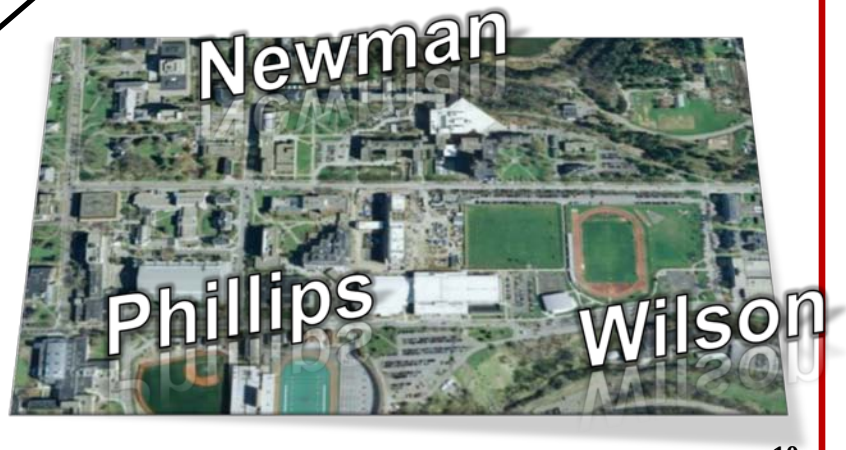


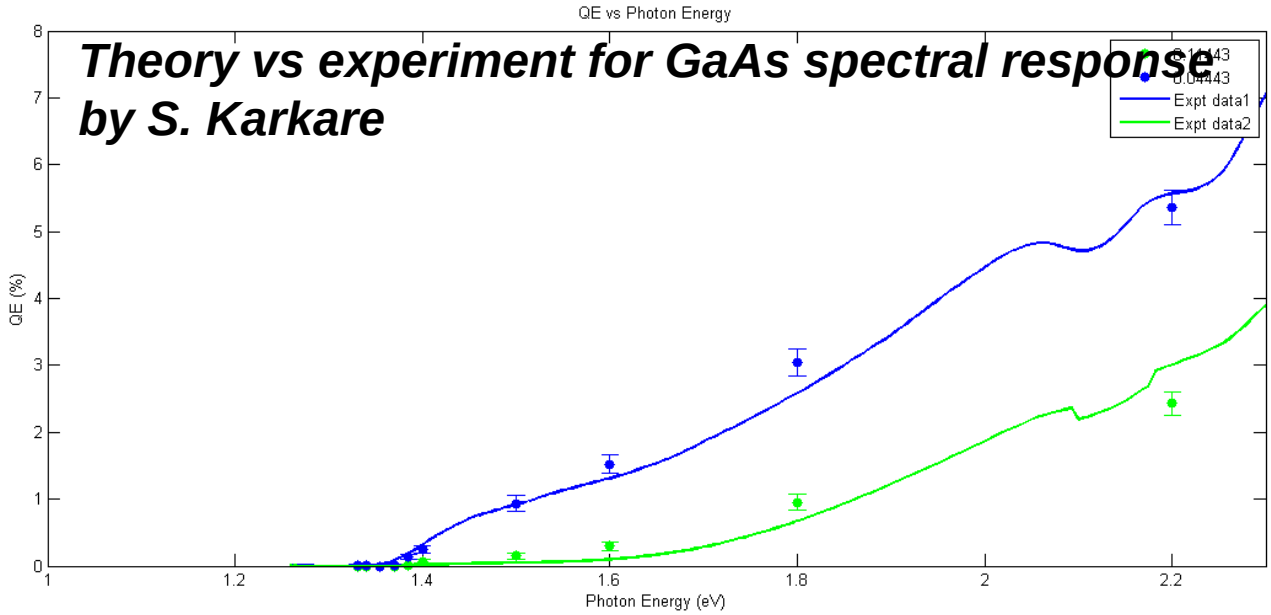






Photocathode research

- **Much progress over the last year**
  - **New photocathode lab set up in Newman lab (in-situ Auger/LEED, RHEED, spectral response, work-function measurements)**
  - **New MBE photocathodes grown and characterized**
  - **Now effort in modeling existing photocathodes to guide us in engineering of the new material**



“Easiest” brightness improvement

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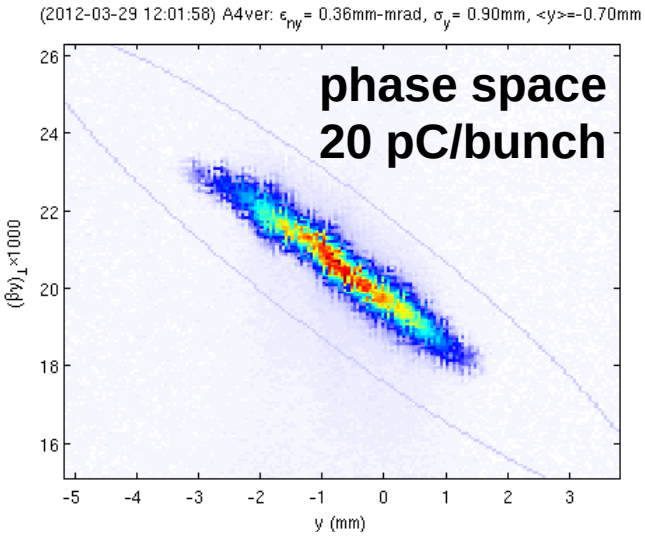
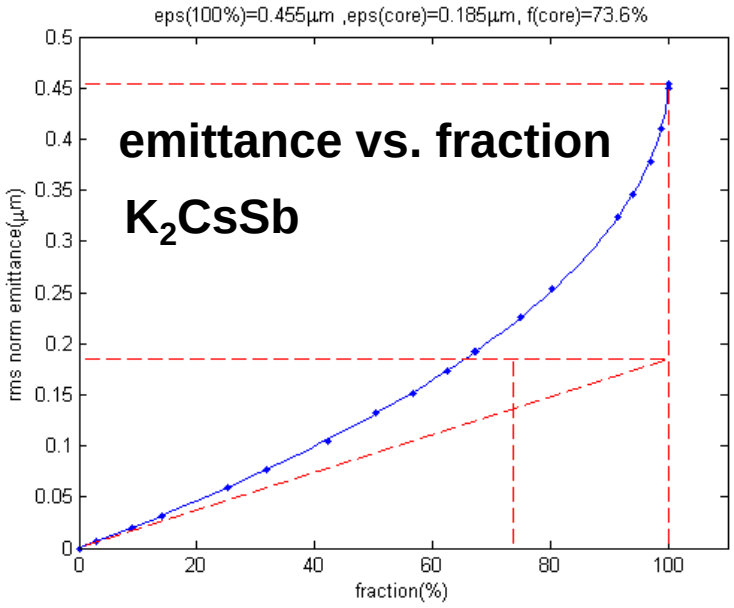
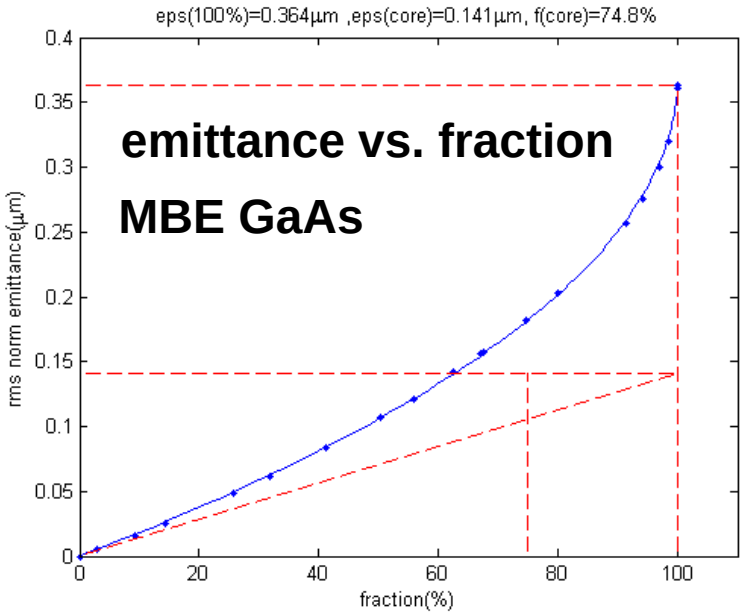
- **x2 brightness increase after swapping the cathodes (0.14 mm-mrad core emittance at 75% core fraction for 20pC/bunch)**







PPP workshop at Cornell (Ithaca, October 2012)

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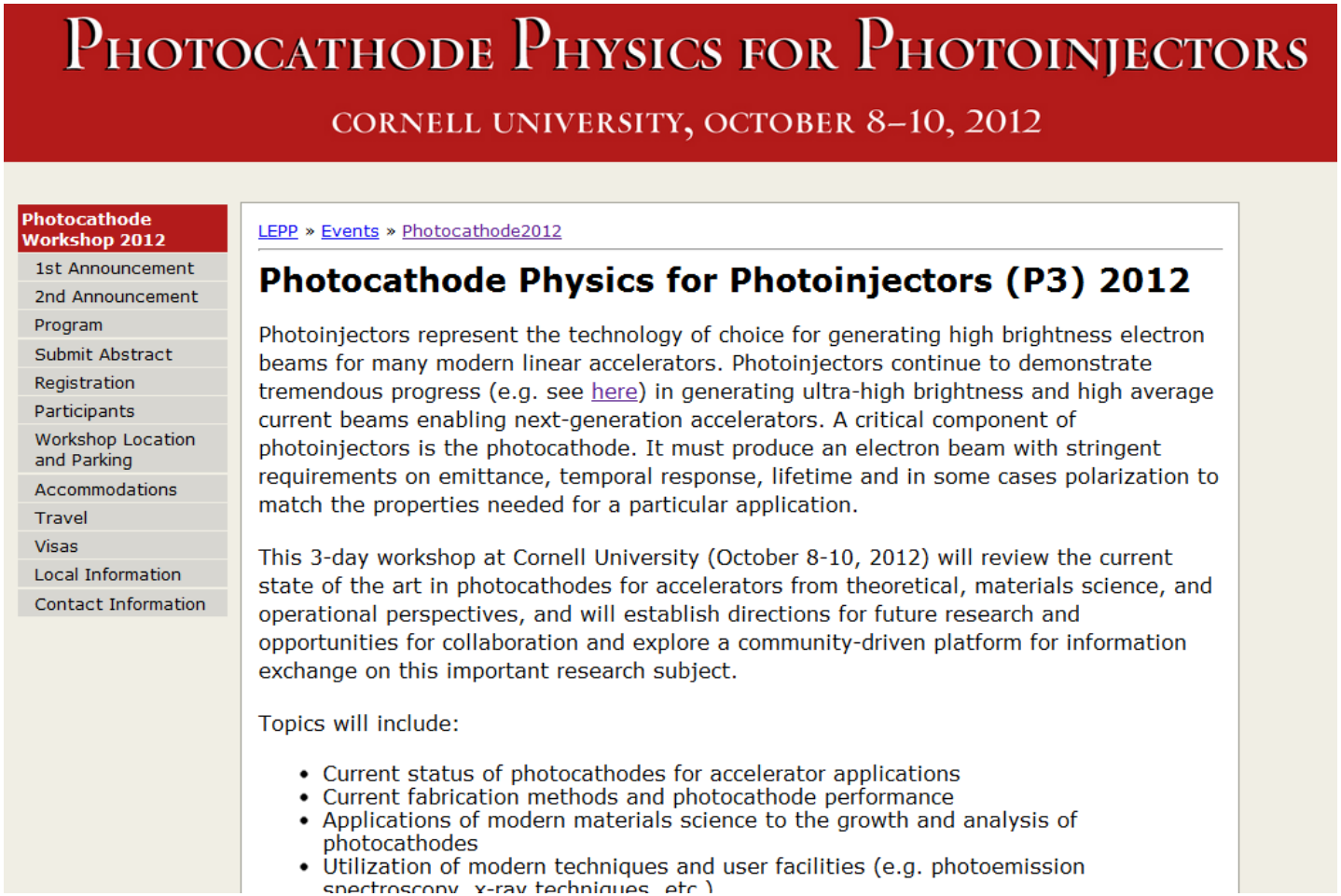
http://www.lepp.cornell.edu/Events/Photocathode2012/WebHome.html



PHOTOCATHODE PHYSICS FOR PHOTOINJECTORS

CORNELL UNIVERSITY, OCTOBER 8–10, 2012

Photocathode Workshop 2012

- 1st Announcement
- 2nd Announcement
- Program
- Submit Abstract
- Registration
- Participants
- Workshop Location and Parking
- Accommodations
- Travel
- Visas
- Local Information
- Contact Information

LEPP » Events » Photocathode2012

Photocathode Physics for Photoinjectors (P3) 2012

Photoinjectors represent the technology of choice for generating high brightness electron beams for many modern linear accelerators. Photoinjectors continue to demonstrate tremendous progress (e.g. see here) in generating ultra-high brightness and high average current beams enabling next-generation accelerators. A critical component of photoinjectors is the photocathode. It must produce an electron beam with stringent requirements on emittance, temporal response, lifetime and in some cases polarization to match the properties needed for a particular application.

This 3-day workshop at Cornell University (October 8-10, 2012) will review the current state of the art in photocathodes for accelerators from theoretical, materials science, and operational perspectives, and will establish directions for future research and opportunities for collaboration and explore a community-driven platform for information exchange on this important research subject.

Topics will include:

- Current status of photocathodes for accelerator applications
- Current fabrication methods and photocathode performance
- Applications of modern materials science to the growth and analysis of photocathodes
- Utilization of modern techniques and user facilities (e.g. photoemission spectroscopy, x-ray techniques, etc.)

Conclusions

- **Emittance performance today is in good agreement with simulations**
- **Work underway to finalize emittance measurements for the present injector setup in L0**
- **Further emittance improvements will be realized in a short beamline with the new photoemission gun & adaptive laser shaping**
- **Novel photocathodes can improve emittance beyond what is achievable today; aggressive program underway**