ADVANCES IN PHOTOCATHODE TECHNOLOGY AT CORNELL UNIVERSITY

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(For ERL team)

OUTLINE

- Motivation and requirements
- Photocathode experimental facilities at Cornell
- Alkali-antimonide cathodes
- Photoemission simulations
- Layered GaAs based photocathodes

Why photocathodes?

4th generation light sources powered by **photoinjectors**

Photoinjector beam brightness – **limited by photcathode**

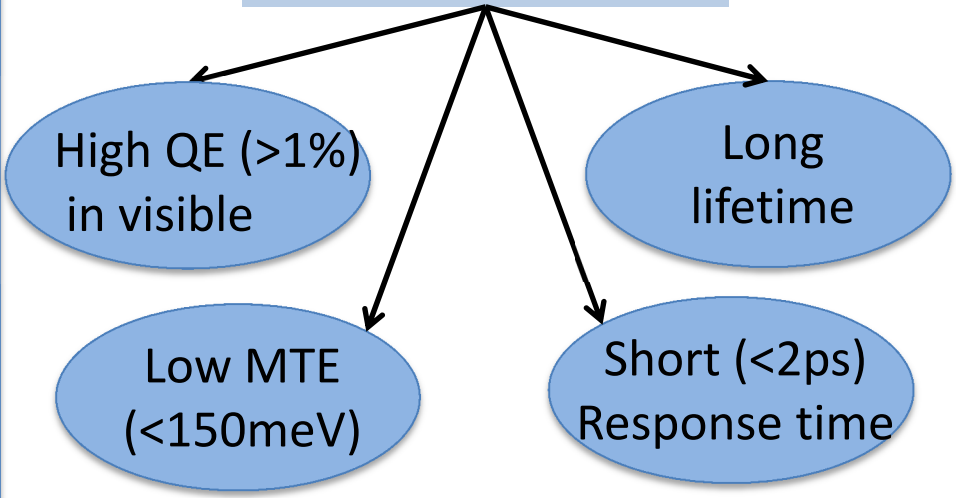
Better photcathodes→brighter x-rays

Other applications –
- Ultrafast Electron Diffraction
- Night vision
- Photon detection

Process of photoemission **not very well understood**

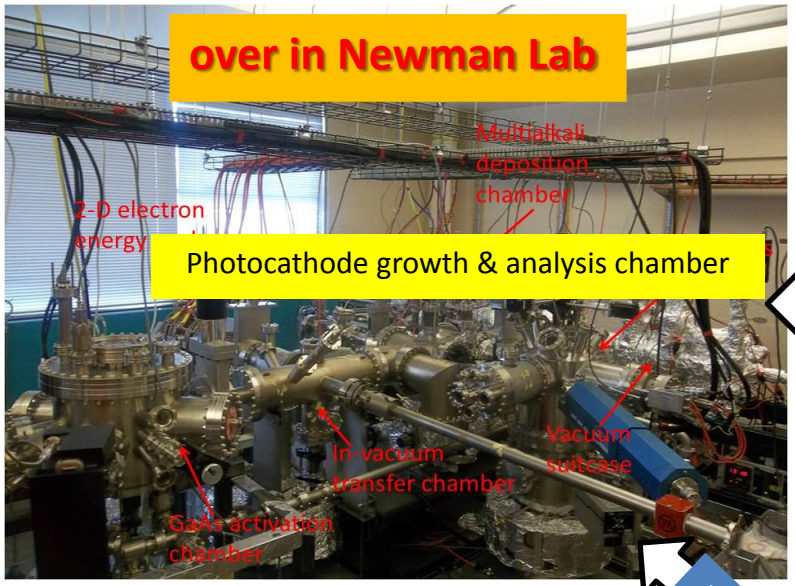
What we need from them?

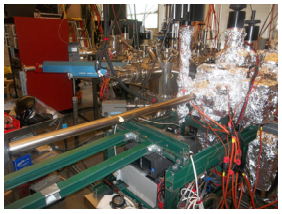
ERL photoinjector photocathode



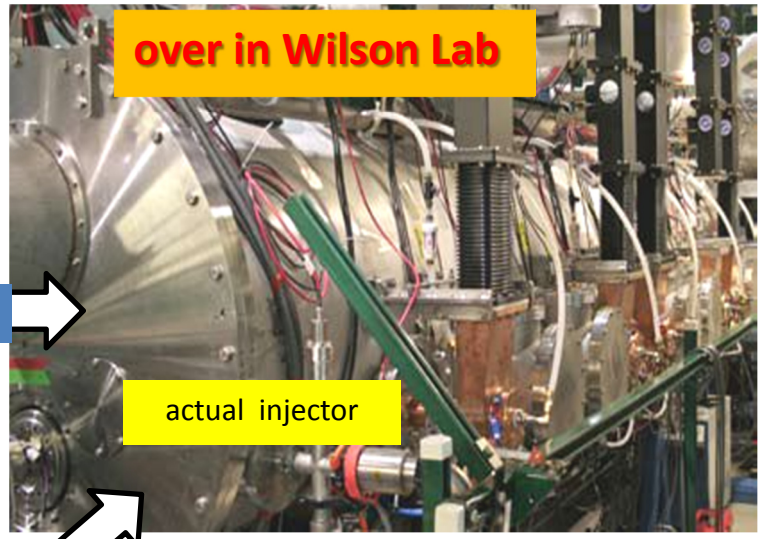
Good photocathodes –
- Alkali-antimonide
- NEA GaAs cathodes

Photocathode Facilities at Cornell





Vacuum Suitcase



Arsenic Cap

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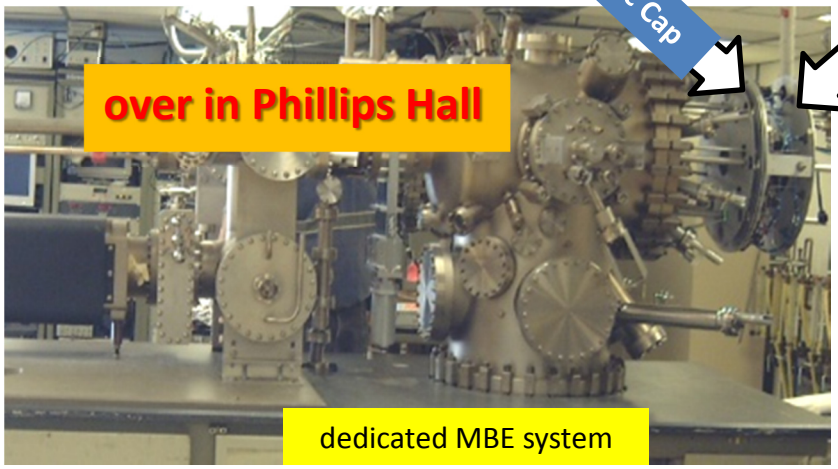
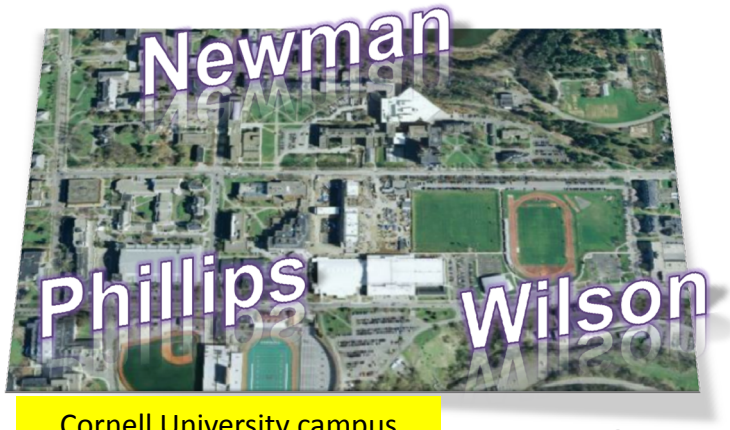
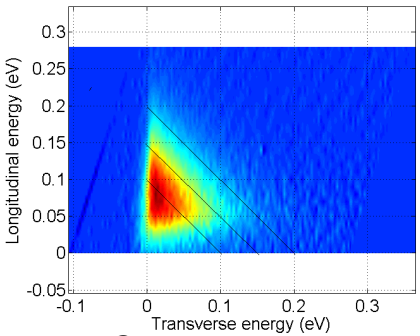
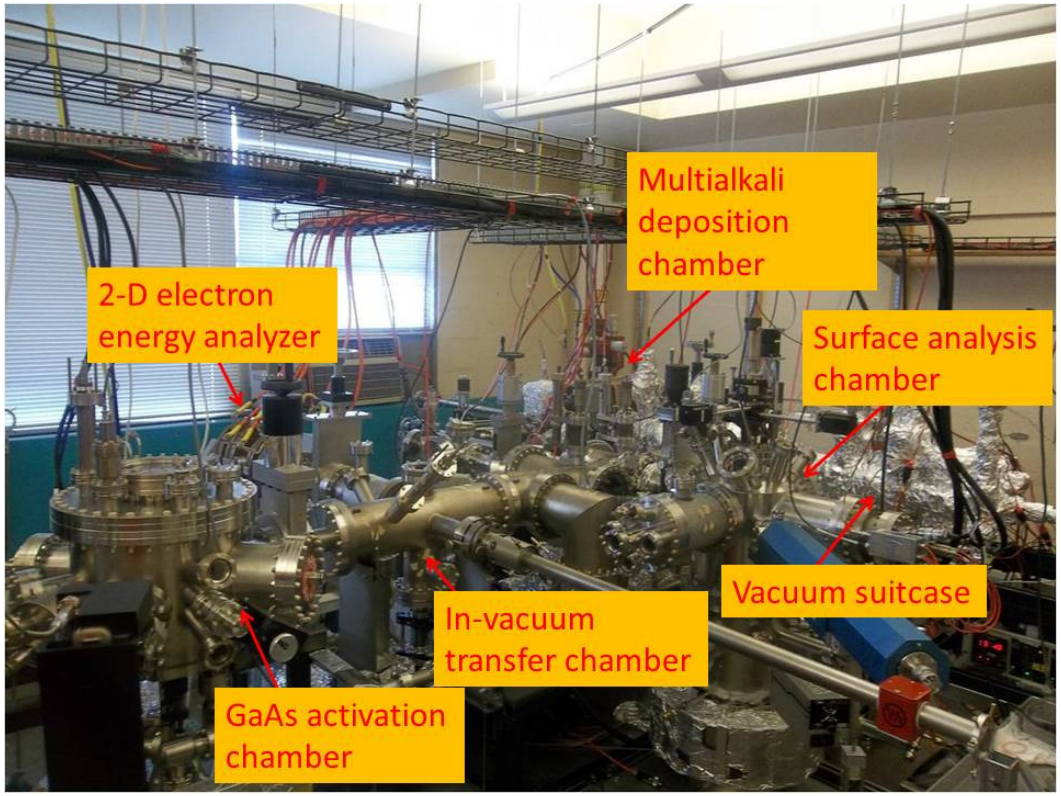


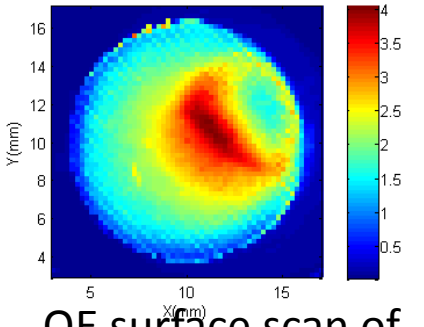


Photocathode diagnostics lab

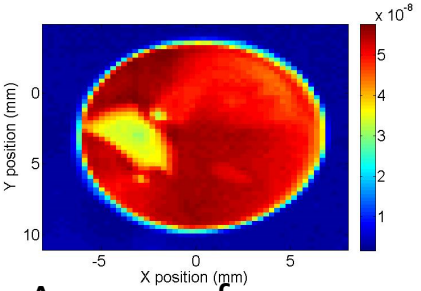


2-D energy distribution from GaAs at 780nm

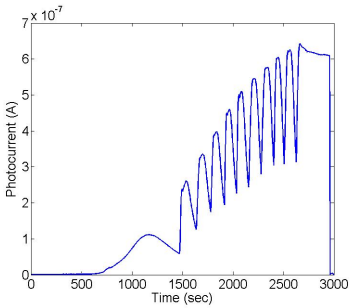




QE surface scan of NaKSb cathode

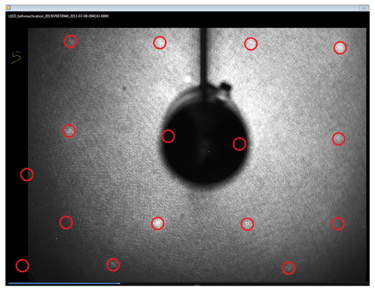


Auger surface scan of K on a NaKSb cathode



Yo-Yo activation of GaAs

All connected in vacuum of less than 10^{-10} torr

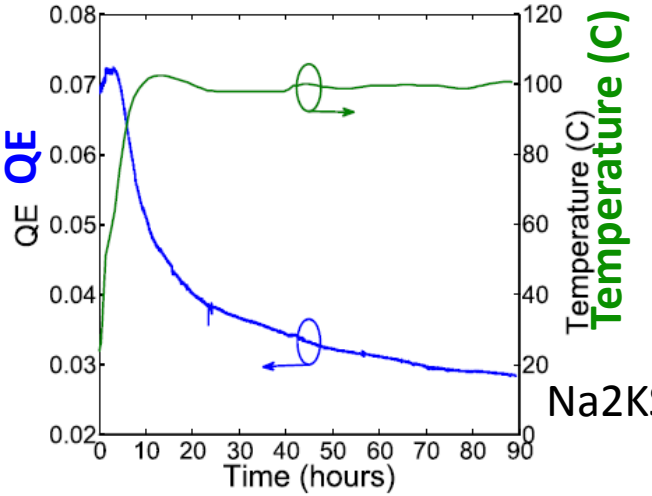


LEED pattern from GaAs

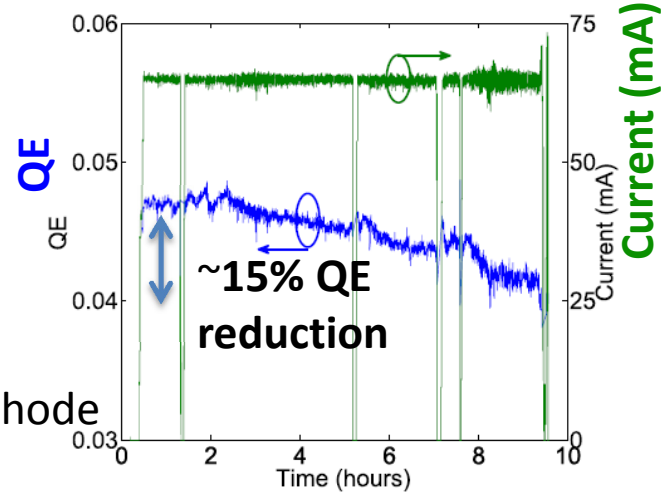
Alkali-antimonides Exploring new materials

Cathode	QE @ 532nm	MTE @ 532nm	Response time
Cs_3Sb	4-5%	160meV	< 2ps
K_2CsSb	7-10%	160meV	< 2ps
Na_2KSb	4-7%	120meV	< 2ps

elevated temperature, lifetime 90hrs

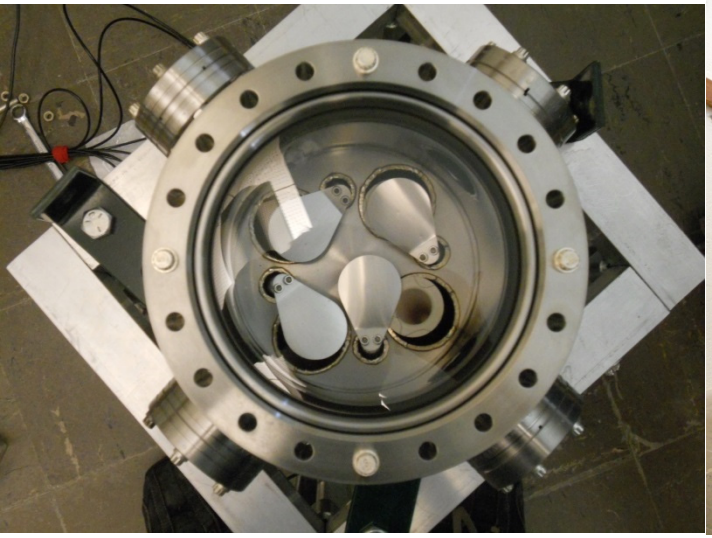


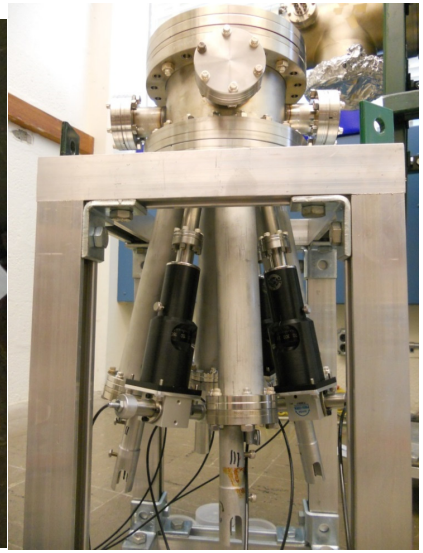
high current operation lifetime 66hrs



Na2KSb cathode

Experimental Alkali-antimonide test chamber





Use of MBE like effusion cells and pneumatically controlled shutters

New alkali-antimonide growth test chamber for testing various alkali metal sources

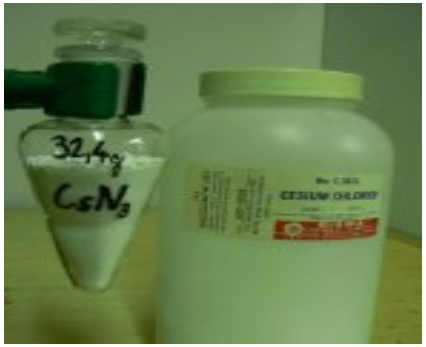
Alkali-antimonides – Exploring new sources

Source	Capacity	Stability	Thermal load on substrate	Effect on vacuum	Handling outside vacuum
SAES	Poor	Good	Significant	Negligible	Stable in air
ALVATEC	Good	Poor	Not measurable	Negligible	Stable when unused
Azides	Good	Poor	Not measurable	Rises to 10^{-5} Torr	Stable in air
Pure metal	Good	Good	Not measurable	Negligible	Needs inert gas environment

SAES dispensers

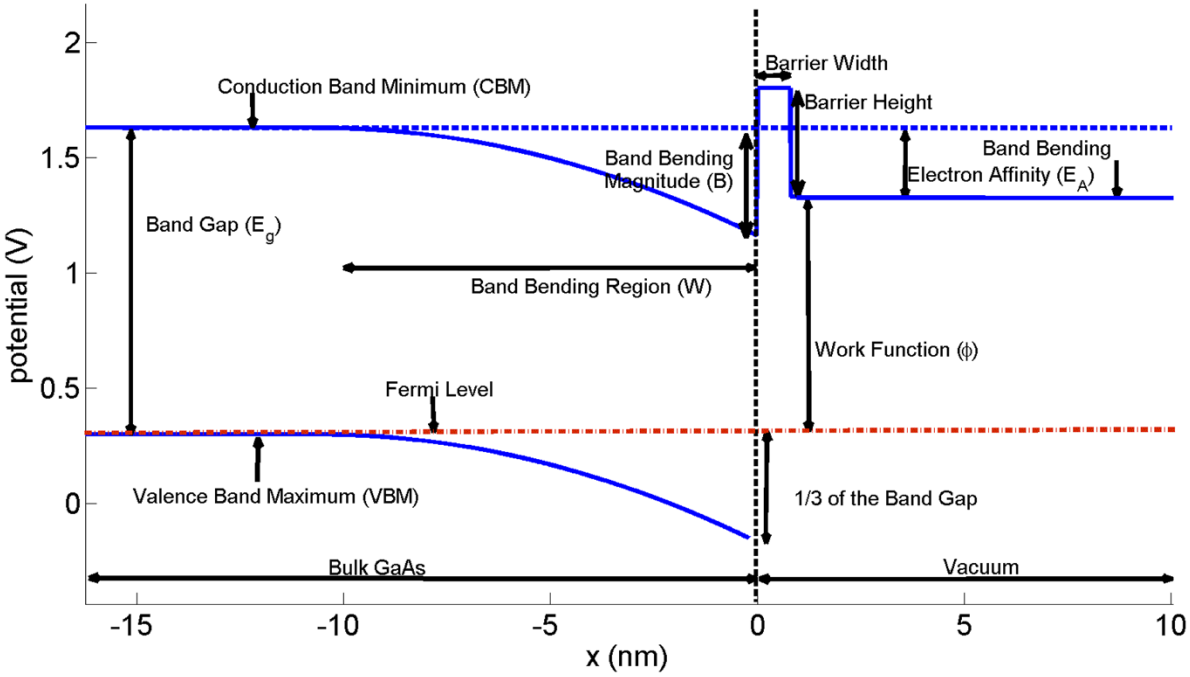
ALVATEC sources

Alkali Azide (AN_3)



Pure metal alkali sources

GaAs cathodes – Monte-Carlo simulations



3-Step photoemission model

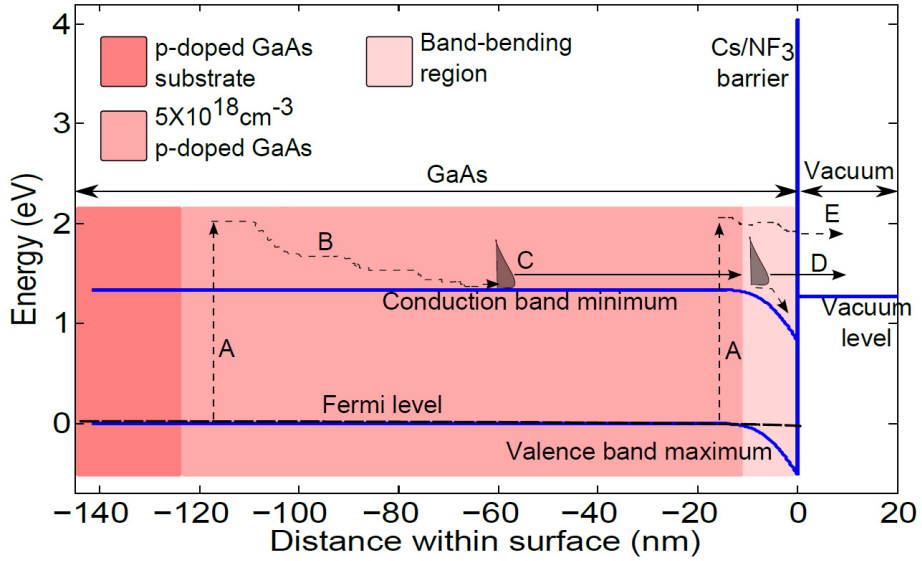
Excite electrons.

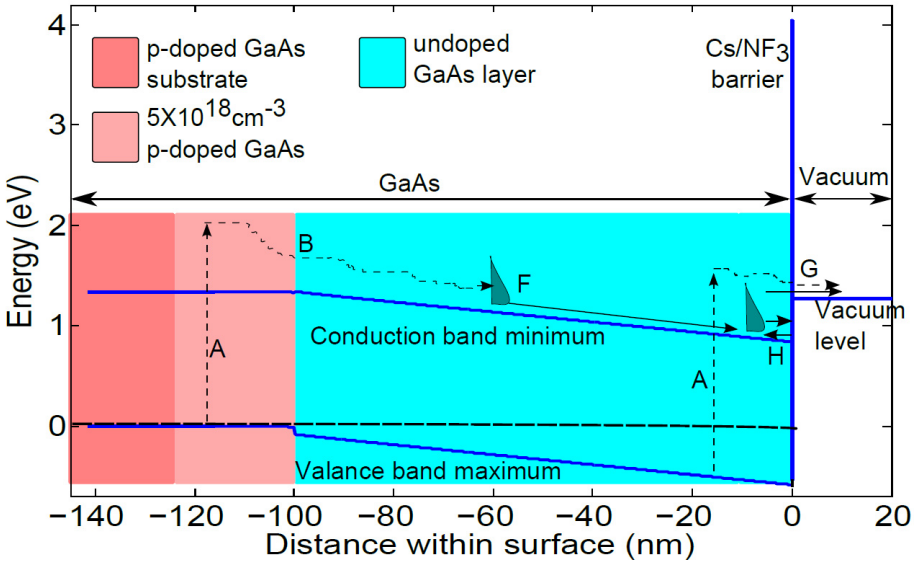
Transport to surface – includes Monte-Carlo scattering with phonons, holes etc.

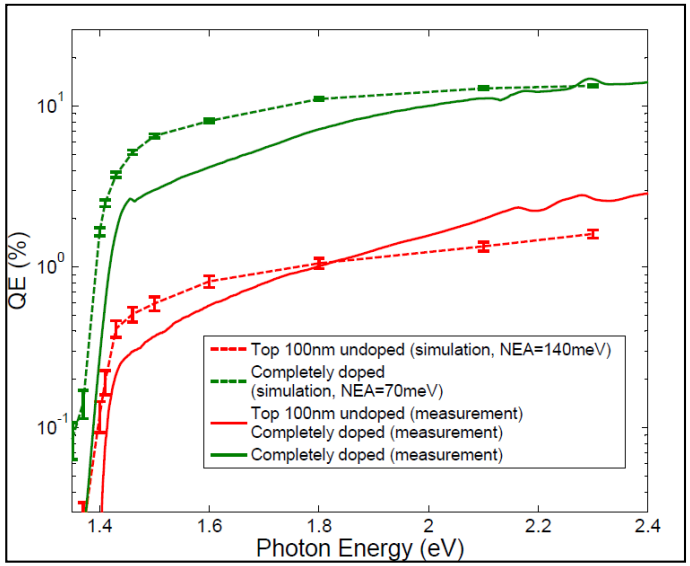
Emission from surface.

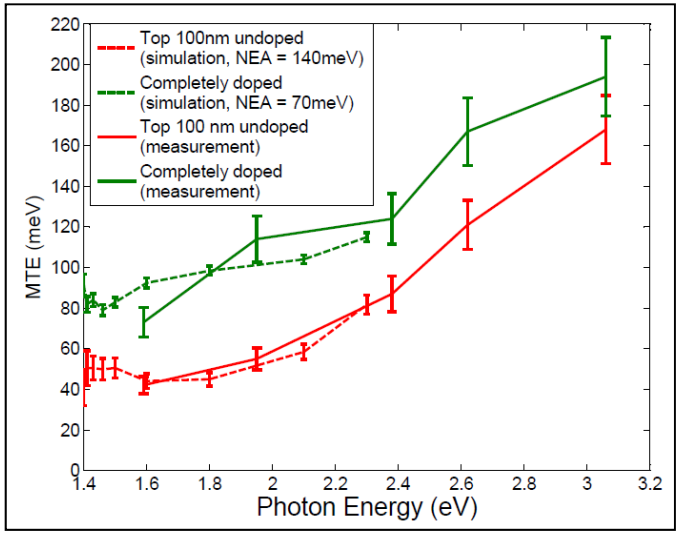
Gives accurate QE and MTE results without use of any ad hoc parameters

Low MTE layered cathodes









Work in progress

Alkali-antimonides

Automate cathode growth using more reliable sources

Develop and characterize other materials like the S-20 photocathode

III-V semiconductors

Use simulation to predict complex structures using AlGaAs/GaAs

Grow them in MBE and characterize them

Activate within MBE chamber to ensure surface cleanliness and quality

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