The Photocathode Scenario and Laser Requirements

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Outline of the talk

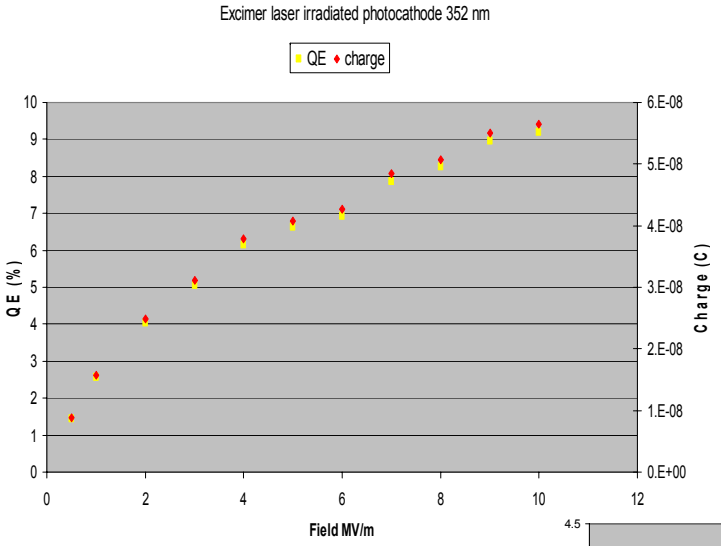
- Electron Beam Requirements
- Cathodes
  - Requirements
  - Performance
  - Research Directions
- Laser
  - Requirement
  - Research directions

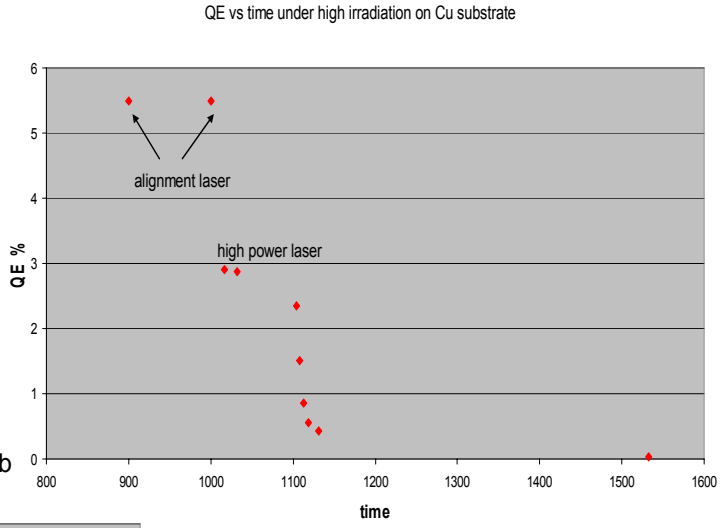
Electron Beam Parameters

Kinetic energy , MeV	54.34
Charge per bunch, nC	**5**
Rms normalized emittance, mm·mrad	**4**
Rms bunch radius, mm	**4.3**
Beta function in the cooler section, m	500
Rms momentum spread	**$3 \cdot 10^{-4}$**
Rms bunch length, cm	**1**
Repetition rate, MHz	**9.383**
Average current, mA	**47**
Relativistic factor γ	107.35

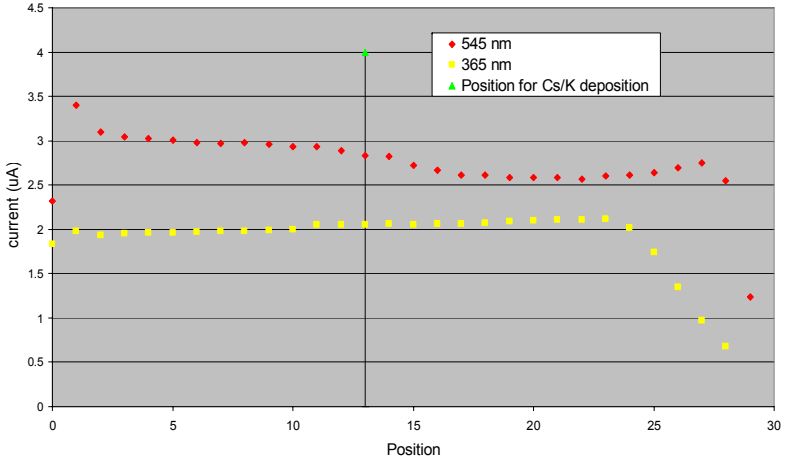
CsK_2Sb cathode

QE	Current	Current density	Charge	Uniformity	Lifetime
>10%	50 mA	0.8 mA/mm^2	5 nC	?	Days
9% @ 352 nm/ **~10%@532 nm**	2/**32** mA **@ 25% DF**	1 mA/mm^2	60 nC	System limited	Weeks/days/ Hours





Emission Uniformity Deposition 7 CsK2Sb



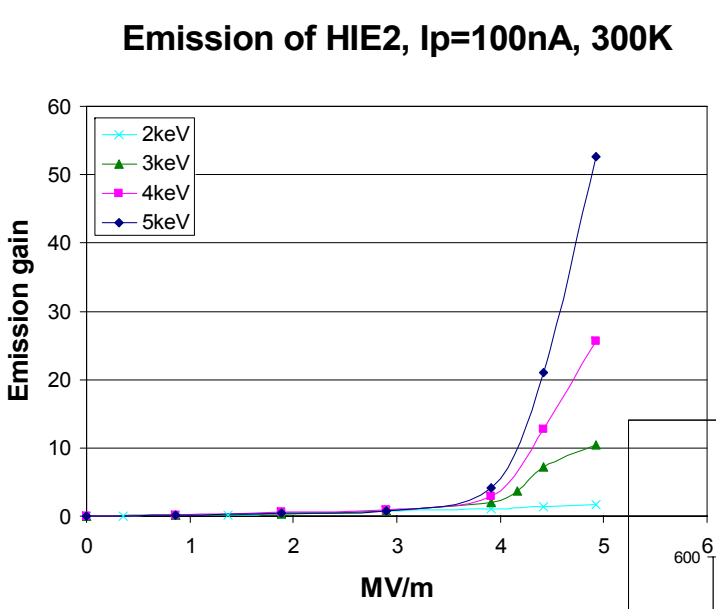
Contamination

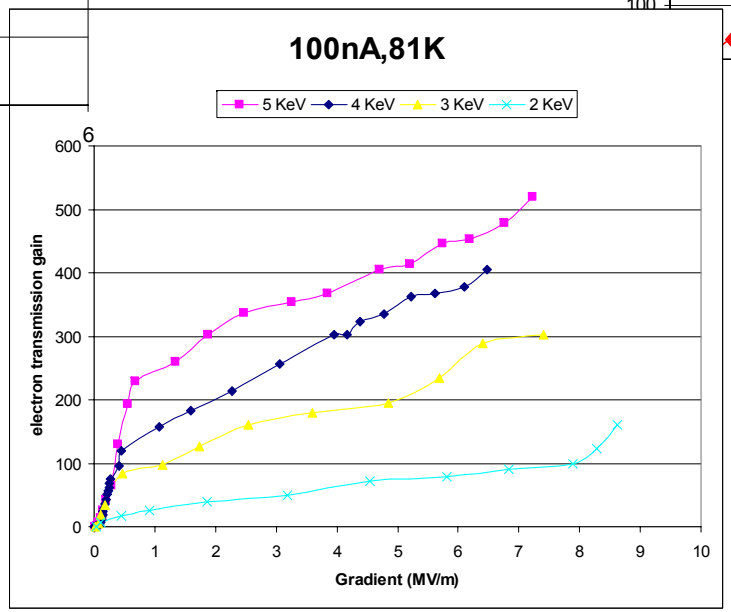
Life time

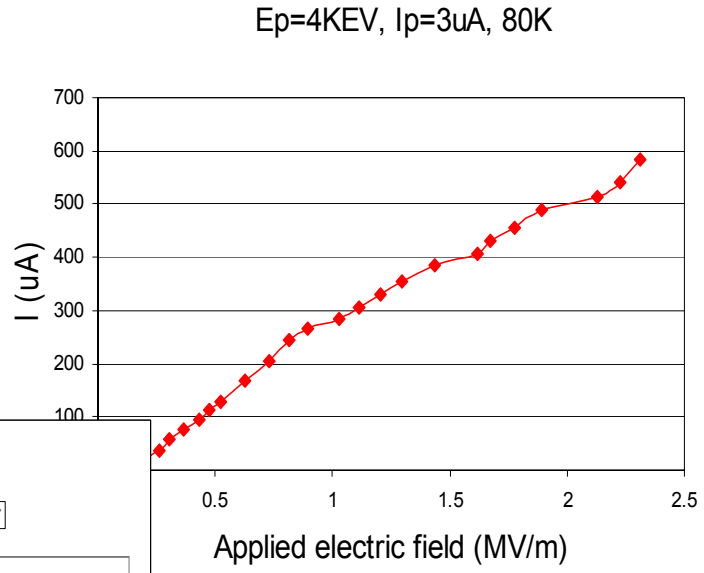
Laser

Cathode with Diamond Amplifier

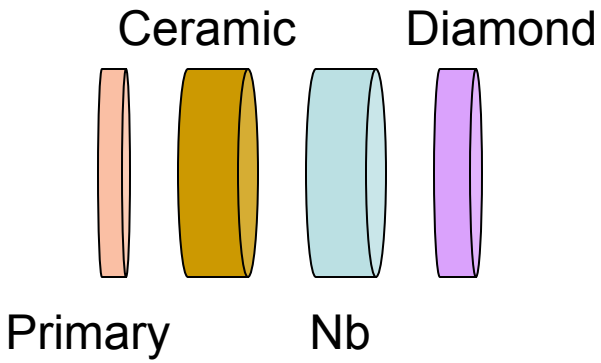
Gain	Max current	Current density	Bunch length	Energy spread
100	50 mA	1 mA/mm^2	30 ps	<0.4 ev
>50	0.6 mA	8 mA/mm^2	?	?







Diamond Capsule Fabrication



Status

- Polycrystalline diamond brazed on to Nb
- Successfully vacuum tested
- Polished from 200 to 70 micron thickness
- Chemically treated brazed Nb
- Ceramic brazed to Nb
- Cold weld in progress

Cathode Research Directions

Bialkali Cathode

- QE, Life time
- Operation at
  - High Current
  - Low Temperature
- Contamination
- Vacuum Transport

Diamond Amplifier

- Response time
- Energy spread
- Operation at
  - High Current
  - Low Temperature
- Capsule

Interface

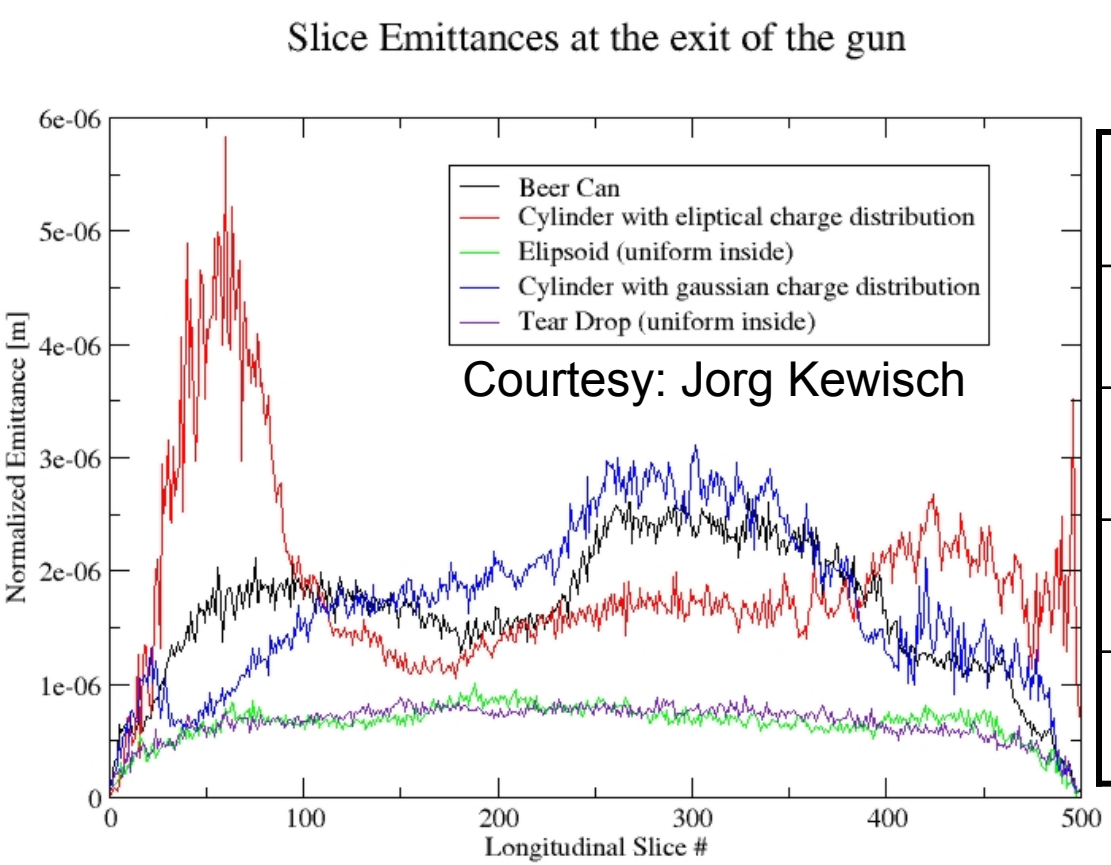
To Gun
To Diamond amplifier

Laser Specification

Ability to lock and follow master RF clock	
Master RF Repetition Rate	**703.75 MHz**
Laser PRF (Phase II for RHIC II)	**9.383 MHz**
Frequency tunability	**+/- 1 MHz**
Synchronization deviation to master oscillator	**<1 ps**
Pulse Length	**5-12 ps**
Jitter in pulse length	**0.1 ps**
Final Output wavelength	**355 nm**
Optional output wavelength	**532 nm**
Beam Quality @ 355 nm	**TEM_{00}; $M^2 \leq 1.5$**
Optimized for a required power at 355 nm	**>5 W**
Average output power stability at 355 nm	**< 1% rms**
Amplitude noise	**< 1% rms**
Centroid Position Stability	**Less than 3% of the beam radius ($1/e^2$ level)**
Pointing Stability	**Less than 25 microradian**
Pre- and post-pulses and pedestals, temporal halo	**Less than 0.5% of total UV energy within +/-100 ps of laser pulse**

Fiber laser?

Parmela Simulation Results



Courtesy: Jorg Kewisch

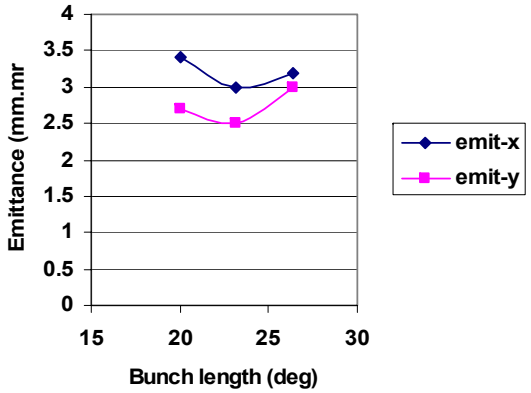
Total emittance at the end of LINAC after compensation

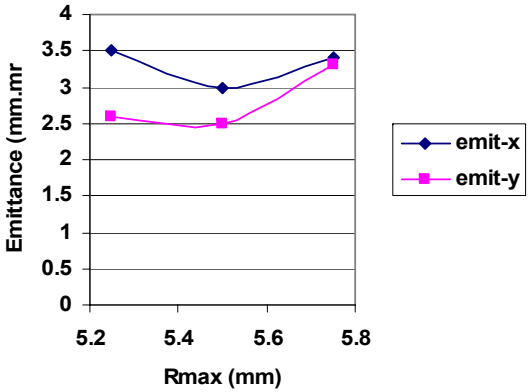
Charge / bunch = 5nC			
Laser distrib.	**$\varepsilon_{x(final)}$ (mm.mr)**	**$\varepsilon_{y(final)}$ (mm.mr)**	**Energy spread**
Elliptical	**2.5**	**2.0**	**0.18×10^{-3}**
Beer can	**3.0**	**2.5**	**0.25×10^{-3}**
Gaussian	**5.3**	**4.9**	**0.29×10^{-3}**

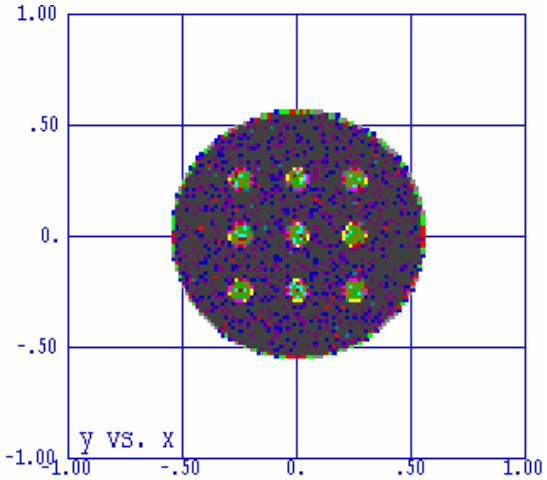
Courtesy: X. Chang

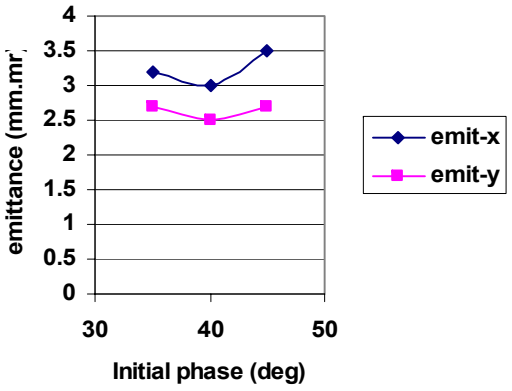
Beam shaping is highly desired, may even be needed!

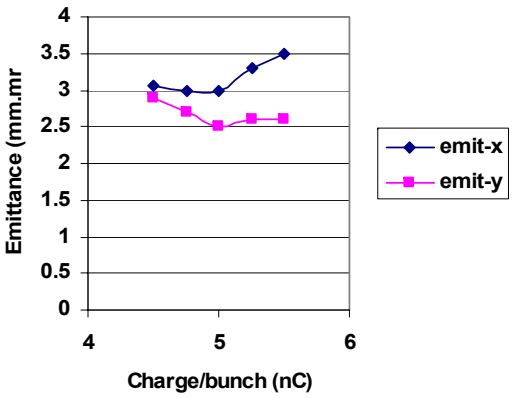
Sensitivity to laser parameters











ε_X=4.3mm.mrad

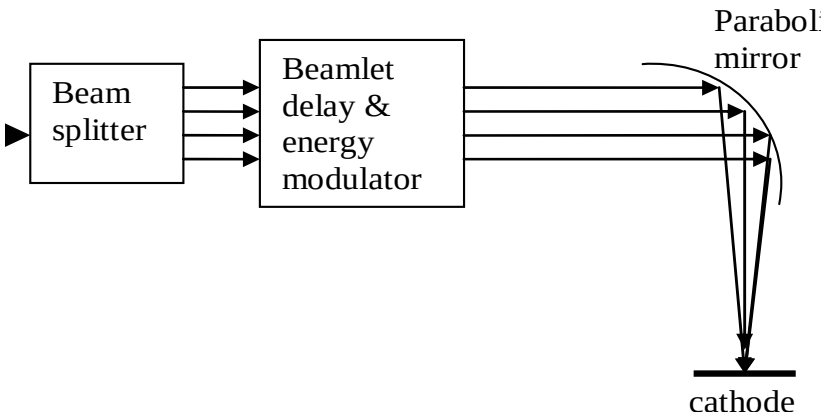
ε_Y=3.1mm.mrad

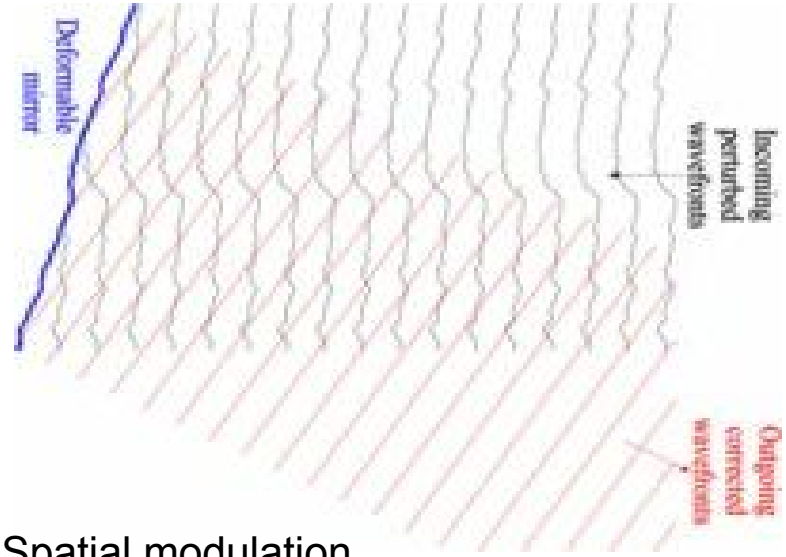
ε_{X0}=3.0mm.mrad

ε_{Y0}=2.5mm.mrad

Spectral Modulation and/or Spatial Modulation

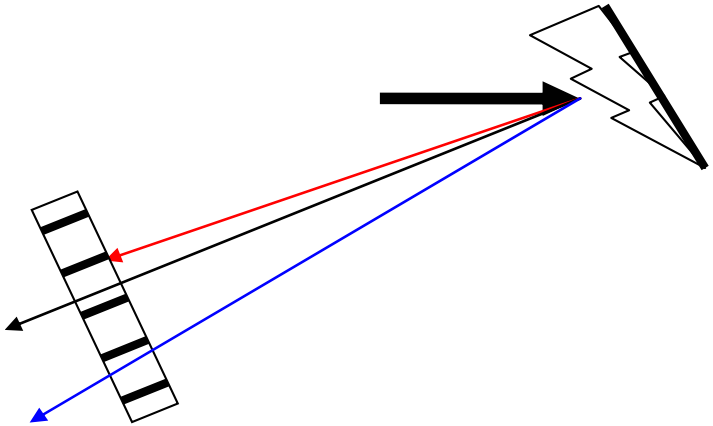
Beam stacking



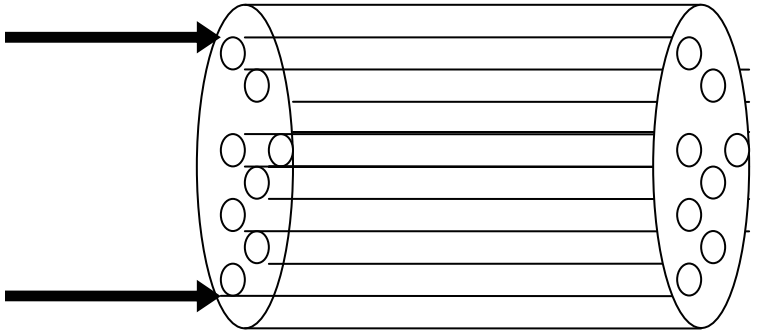


Spatial modulation

Spectral modulation



Beam stacking w/ Fiber Bundle



Laser Research Directions

- Establish tolerances
- Establish Minimum Emittance Needed-profile
- Research on Beam Shaping techniques