# Overview of Recent Progress on High Repetition Rate, High Brightness Electron Guns


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# Outline

- Why are high-brightness high-repetition rate electron guns necessary?

- Requirements for high-repetition rate high-brightness electron guns.

- Advantages and challenges of available gun technologies.

- Recent progress of and results from high brightness high-repetition rate guns.
(probably an incomplete list!).

# What Is Driving the Need for High Brightness Electron Guns?

• Major linear collider proposals all include damping rings where the final beam quality (brightness, emittance) is set.

• X- ray light sources are the driving force!

• $4^{th}$ generation light sources require electron beams with extremely low emittance in both transverse planes.

• Such beams cannot be generated in damping rings and linear accelerators are required.

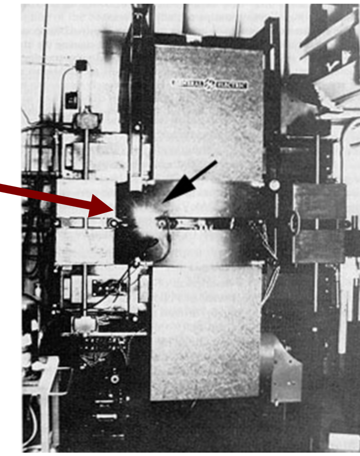
• In linear accelerators the ultimate quality of the beam is defined at the electron gun.

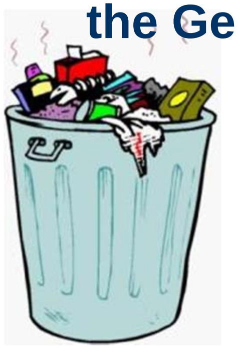
# The Early Times of Accelerator Based Light Sources



- Electron accelerators were initially developed to probe **(subnuclear) particles** in fundamental particle physics.

- The first time **synchrotron radiation (SR)** was observed in an accelerator was in 1947 from a 70 MeV electron beam at the General Electric Synchrotron in New York State.





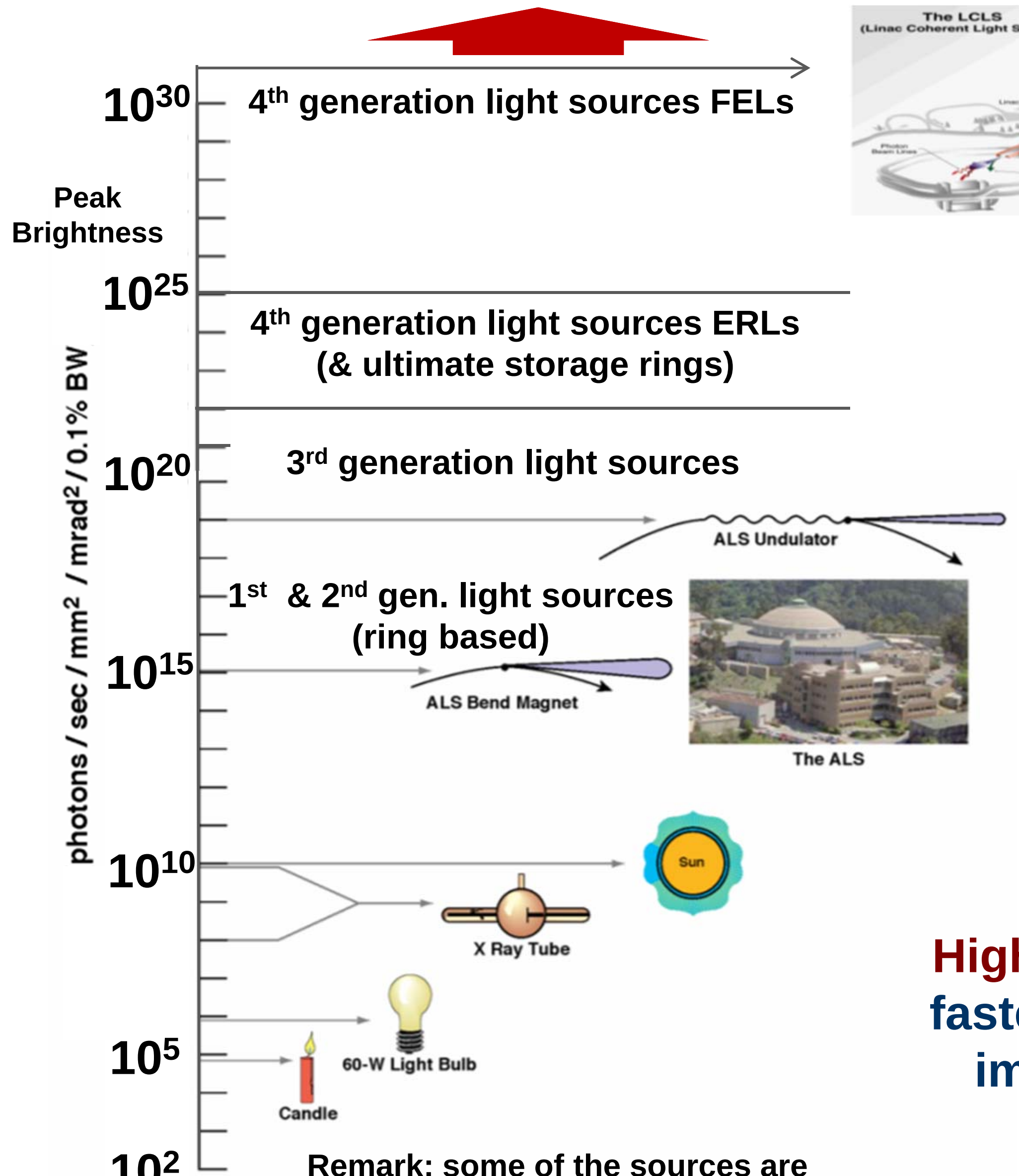
- Initially, synchrotron radiation was just considered as a **waste product** draining energy and limiting the performance achievable by lepton colliders.

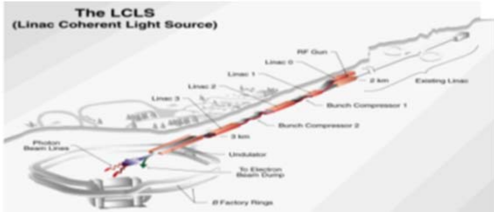
- However, it was soon realized that **synchrotron radiation represented the brightest source of light from infrared to x-rays**, and that it could be very useful in a large variety of scientific applications.

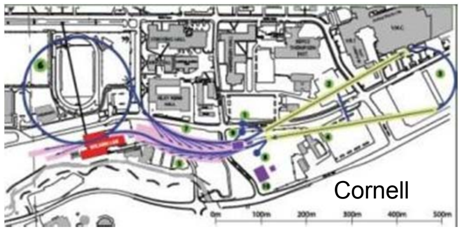
- **Light sources were born and in ~ 60 years would undergo a dramatic evolution:**
  - *1st generation*: "parasitic" SR sources from dipoles in colliders.
  - *2nd generation*: dedicated storage rings with light ports in dipoles
  - *3rd generation*: dedicated storage rings with insertion devices
  - *4th generation*: free electron lasers, energy recovery linacs, …

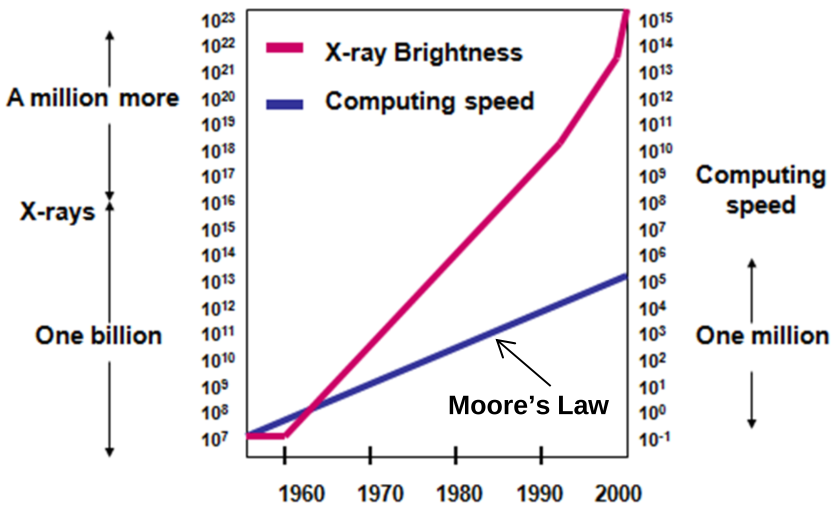
# Light Source Photon Brightness

High repetition rate, high brightness e- guns (F. Sannibale)




Remark: some of the sources are compared at different wavelengths!

**High brightness is strongly desirable: faster experiments, higher coherence, improved spatial, time and energy resolutions in experiments, …**

# New Science Opportunities

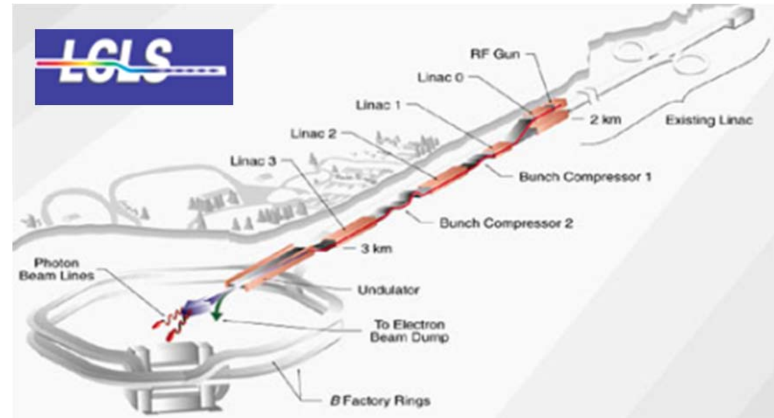
High repetition rate, high brightness e- guns (F. Sannibale)


- Medicine
- Biology
- Chemistry
- Material Science
- Environmental Science
- Atomic Physics
- ...

# 4th Generation Light Sources Already Exists!

High repetition rate, high brightness e- guns (F. Sannibale)

## A number of X-ray FELs are already in operation:

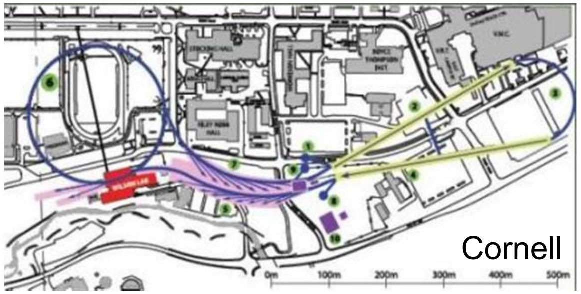



**Their spectacular results represent a revolutionary opportunity for science!**

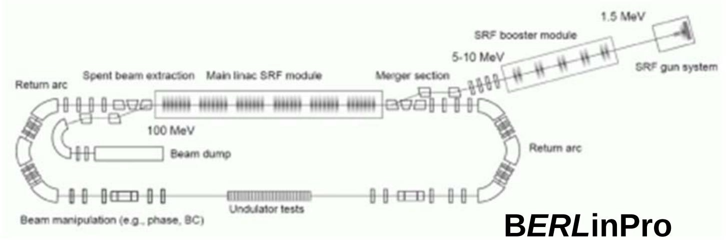
# What Is Next?



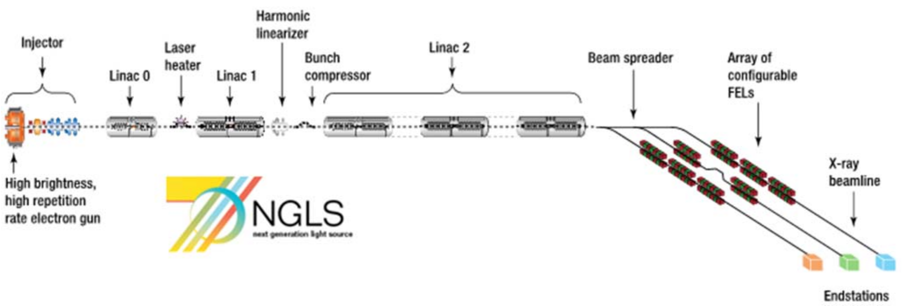
## All operating 4th generation light sources are low repetition rate (< 120 Hz)

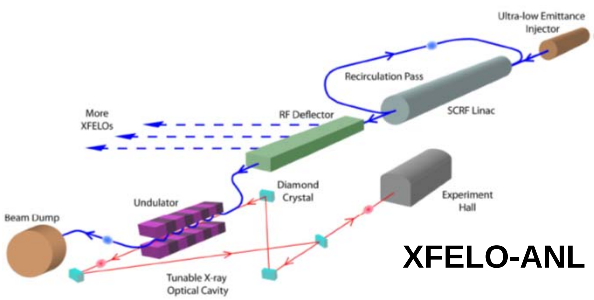



**But proposed X-ray ERLs require the same beam quality at GHz repetition rates.**




## And proposed high average photon brightness X-ray FELs And X-FEL oscillators require the same beam quality at MHz repetition rates.




## High-repetition rates high-brightness electron guns are now required

# Electron Gun Requirements



**To achieve the goals of these high-repetition rate, high-brightness applications, the electron source should allow for:**

- Repetition rates from ~ 1 MHz up to ~ 1 GHz
- Charge per bunch from few tens of pC to ~ 1 nC
- ~ $10^{-7}$ (low charge) ~ $10^{-6}$ m normalized beam emittance
- Beam energy at the gun exit greater than ~ 500 keV (space charge)
- Electric field at the cathode greater than ~ 10 MV/m (space charge limit)
- Bunch length control from tens of fs to tens of ps for handling space charge effects, and for allowing the different modes of operation
- Compatibility with magnetic fields in the cathode and gun regions (mainly for emittance compensation)
- Acceptable dark current (SRF linac quenching, high radiation doses, …)
- Operating high QE photocathodes (to generate with the required charge with available laser technology)
- $10^{-9}$ - $10^{-11}$ Torr operation vacuum pressure (high QE photo-cathodes)
- "Easy" installation and conditioning of different kind of cathodes
- High reliability compatible with the operation of a user facility

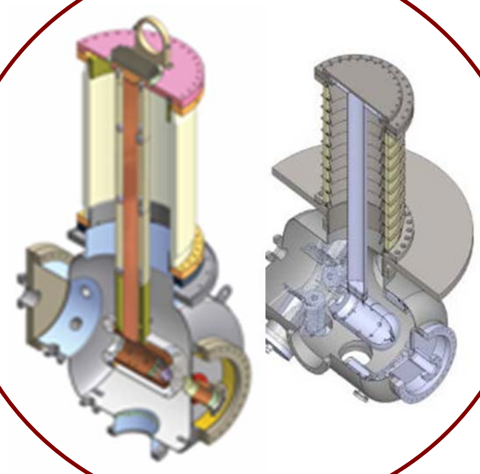
**Injector cost is typically a small fraction of a 4th generation light source total cost. Minimizing cost is usually not a top-priority requirement.**

# Problem…

**Successful low repetition rate NC high frequency (> 1.3 GHz) RF guns cannot run at repetition rates >~ 10 kHz**

## A high repetition rate high brightness source presently does not exist!

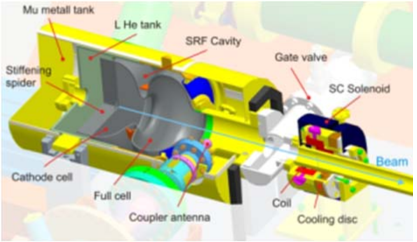
# Candidate Electron Gun Technologies



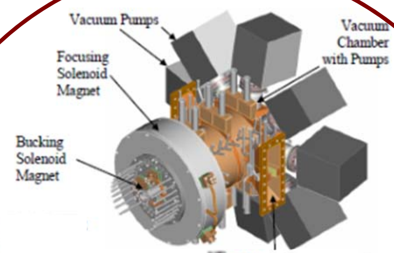
**DC guns**

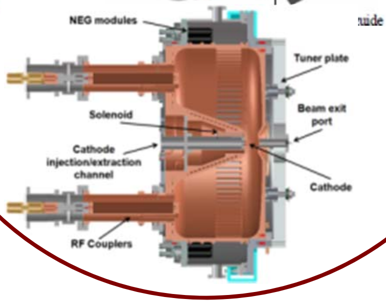
**+**

**Hybrid Schemes**




**SC RF guns**



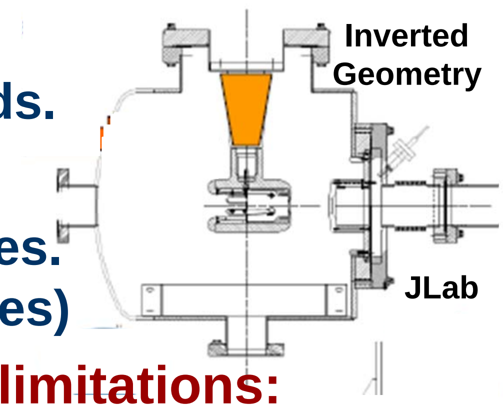

**Low freq. (<~ 700 MHz) NC CW RF guns**

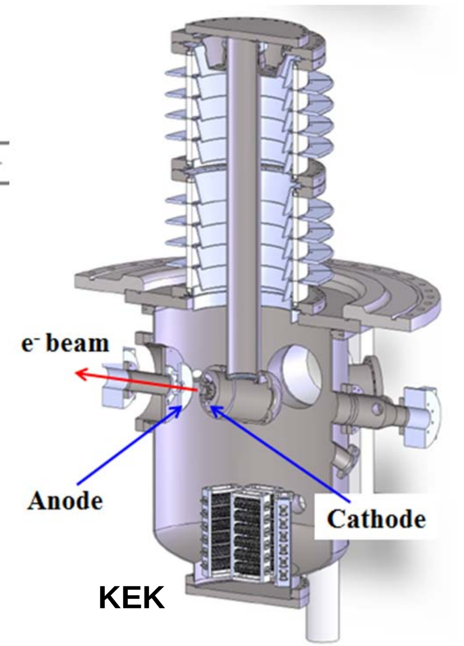
# DC Guns



## Pros:

- DC operation
- DC guns reliably operated at 350 kV in several labs since many years, ongoing effort to increase the final energy (Cornell, JAEA, Jlab, KEK …).
- Extensive simulation work by several groups "demonstrated" the capability of sub-micron emittances at hundreds of pC, if a sufficient beam energy is achieved
- Full compatibility with magnetic fields.
- Excellent vacuum performance
- Compatible with most photo-cathodes. (The only one operating GaAs cathodes)




## Areas for improvement and potential limitations:

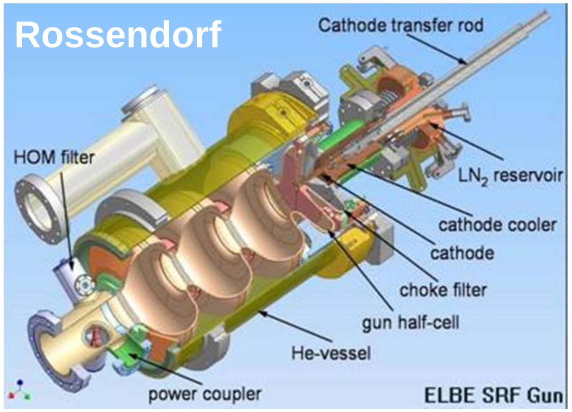
- Higher energies require further R&D and technology improvement.
- In particular, improvement of the high voltage breakdown ceramic design and fabrication.
- Minimizing field emission for higher gradients (>~ 10 MV/m)
- Developing and test new gun geometries (inverted geometry, SLAC, JLab).

# Super-Conducting RF Guns

High repetition rate, high brightness e- guns (F. Sannibale)

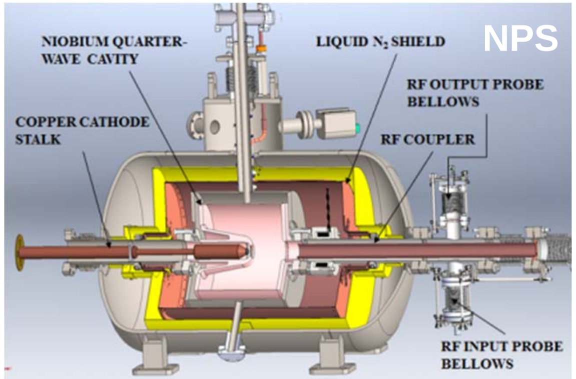
## Pros:

- Potential for relatively high cathode gradients (several tens of MV/m)
- CW operation
- Excellent vacuum performance.




## Areas for improvement and potential limitations:

- Control of multipacting (mainly in RF couplers)
- Control field emission at higher gradients
- Performance reproducibility. (vertical/ horizontal performance)
- Evaluate and experimentally verify high QE cathode compatibility (promising results with $Cs_2Te$ at Rossendorf)
- Compatibility with emittance compensation (“cohabitation” with magnetic fields, HOM schemes, SC Solenoid…).

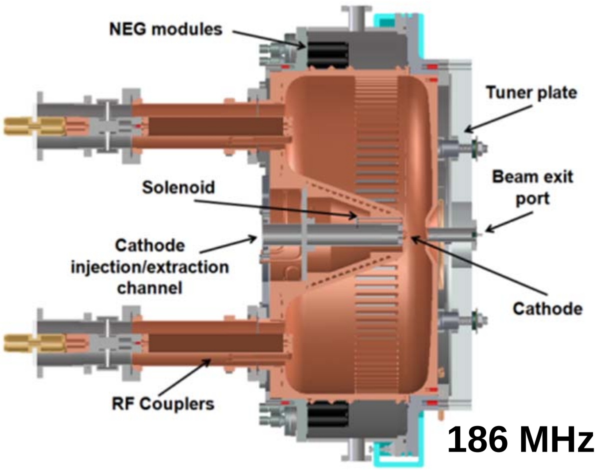


# Normal Conducting Low Frequency (<~700 MHz) CW RF Guns

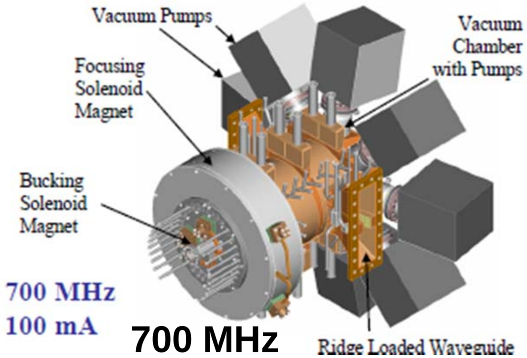
High repetition rate, high brightness e- guns (F. Sannibale)

## Pros:

- Operate in CW mode
- Beam dynamics similar to DC but with higher gradients and energies
- Based on mature RF and mechanical technology (especially in the VHF range).
- Full compatibility with magnetic fields.
- Compatible with most photo-cathodes
- Potential for excellent vacuum performance.




186 MHz LBNL gun

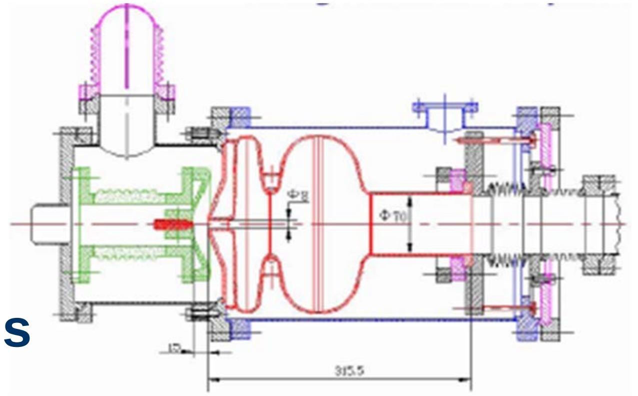



700 MHz LANL gun

## Areas for improvement and potential limitations:

- Gradient and energy increase limited by heat load in the structure
- Higher frequency range requires state of the art cooling techniques.
- Repetition rates > ~ 700 MHz (required by ERLs) not achievable

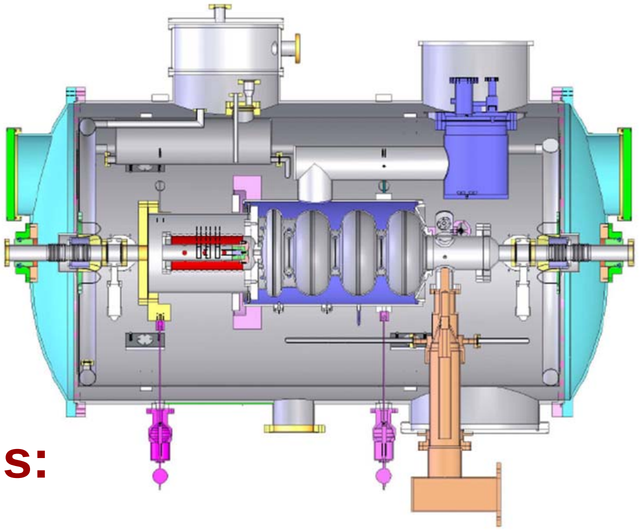
# DC-SRF Hybrid Gun



**Pros:**

- **DC gun advantages:**
  - **potential for magnetic field in the cathode area**
  - **better cathode compatibility than in SRF guns**
  - **Excellent vacuum**

- **SRF gun advantages:**
  - **CW operation**
  - **High energy beam at the exit**
  - **Excellent vacuum**



**Areas for improvement and potential limitations:**

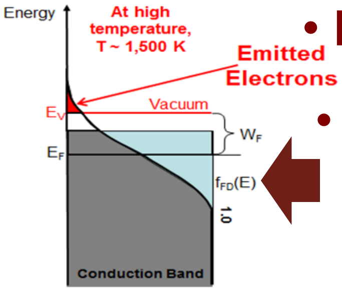
- **Low gradient at the cathode to avoid challenging the DC technology**
- **System complexity**

# Cathodes

- **Cathodes are obviously a fundamental part of electron sources. The gun performance heavily depends on cathodes**

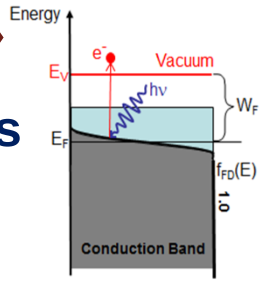
- **In the low charge regime (tens of pC/bunch) the ultimate emittance performance is set by the cathode thermal/intrinsic emittance**

- **The ideal cathode should allow for:**
  - **high brightness (low thermal/intrinsic normalized emittance, low energy spread, high current density, …)**
  - **full control of the 6D bunch distribution**
  - **long lifetimes.**




- **Photo-cathodes (most of present injector schemes)**

- **Thermionic cathodes can offer low thermal emittances but require sophisticate compression schemes. ($CeB_6$ at SCSS-Spring 8, XFELO-ANL)**




**Other cathodes under study (photo-assisted field emission, needle arrays, photo-thermionic, diamond amplifiers, …).**

**In high-repetition rates photo-guns high quantum efficiency photo-cathodes (QE>~ 1 %) are required to operate with present laser technology.**

# Examples of Photo-Cathodes

**PEA Semiconductor: Cesium Telluride $Cs_2Te$ (used at FLASH for example)**

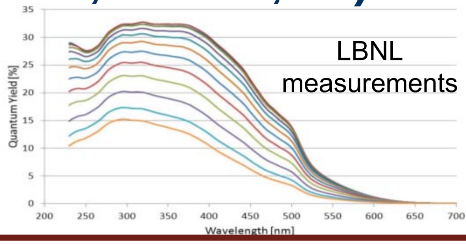
- <~ps pulse capability
- relatively robust and un-reactive (operates at ~ $10^{-9}$ Torr)
- successfully tested in NC RF and SRF guns
- high QE > 1% over long periods
- photo-emits in the UV ~250 nm (3rd or 4th harm. IR conversion)
- for 1 MHz repetition rate, 1 nC, ~ 10 W IR required


**NEA Semiconductor: Gallium Arsenide GaAs (used at Jlab for example)**

- ~ps (green), tens of ps (IR) pulse capability
- reactive; requires UHV <~ $10^{-10}$ Torr pressure
- high QE >1%
- photo-emits already in the NIR (tens of ps pulses)
- low emittance due to phonon scattering, allow for polarized $e^-$
- for nC, 1 MHz, hundreds of mW of IR required

**PEA Semiconductor: Alkali Antimonides eg. $SbNa_2KCs$, $CsK_2Sb$, …**

- <~ps pulse capability (studied at BOING, INFN-LASA, BNL, LBNL, Cornell, ….)
- reactive; requires ~ $10^{-10}$ Torr pressure
- high QE > 1%
- requires green/blue light (eg. 2nd harm. Nd:YVO4 = 532nm)
- for nC, 1 MHz repetition rate, ~ 1 W of IR required




**Complete cathode review in:** D. Dowell, *et al.*, NIMA **622**, 685, 2010

# Beam Dynamics in High Repetition Rate High Brightness Electron Guns



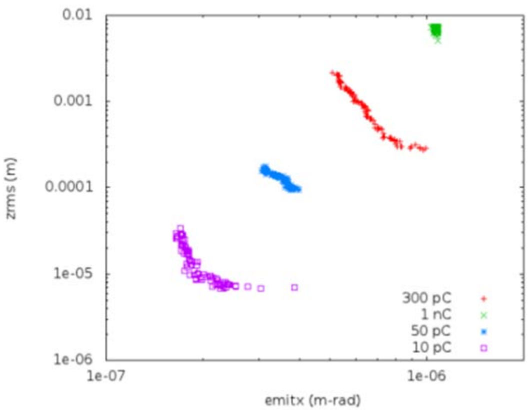
Technology limitations

Acceptable dark current

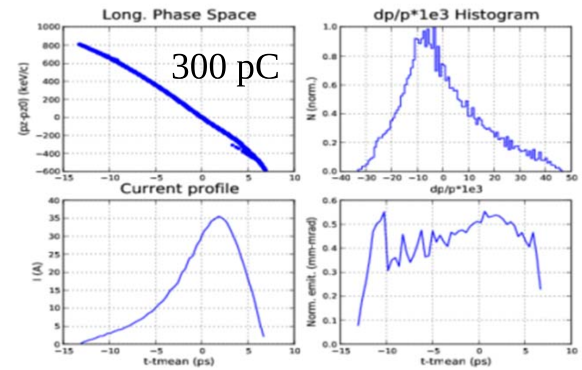
Relatively low gradients at the cathode at emission (~ 10 – 20 MV/m)

• Different regime respect to low repetition rate injector (~30-60 MV/m at emission) **longer bunches** to keep space charge forces under control.

• **Compression** already in the injector usually required ("zero crossing" buncher, velocity bunching).




• Simulations and early experimental results indicate that the desired beam parameters can be achieved.




• **A full experimental demonstration still required.**

• **Beam "blow-up" regime**. Wisconsin is pursuing this regime.
Very short (tens of fs) laser pulses and high gradients (~40 MV/m) required.
Excellent longitudinal phase space quality and reasonable transverse emittance.

# Present Status and Future Perspective

**Numerous groups around the world are pursuing the development of high-brightness high-repetition rate electron guns.**

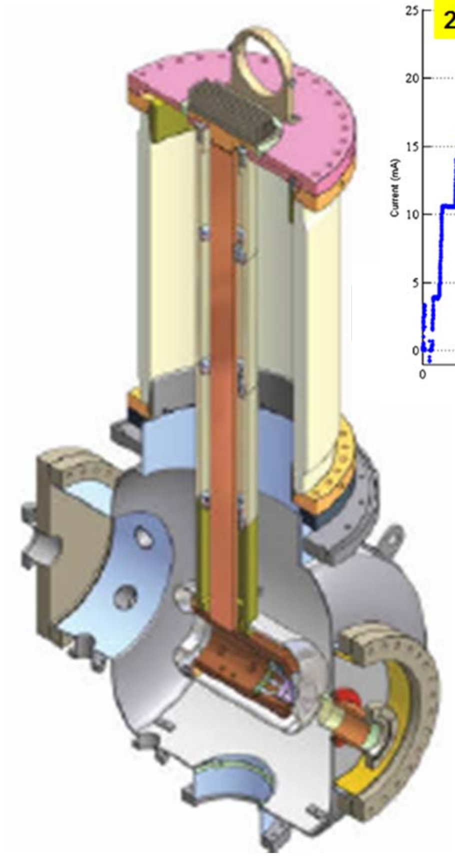
**Although none of the adopted technologies has demonstrated all requirements yet, significant steps forward have been achieved with the promise for success in the near future.**

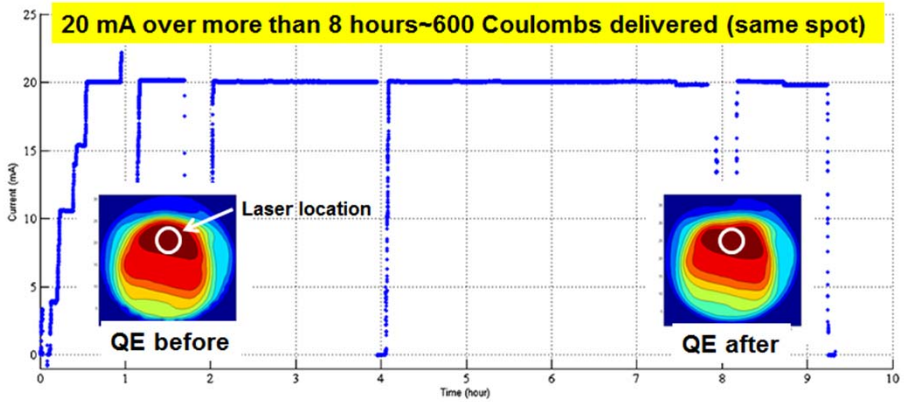

**In what follows an overview of the field activities is presented.**

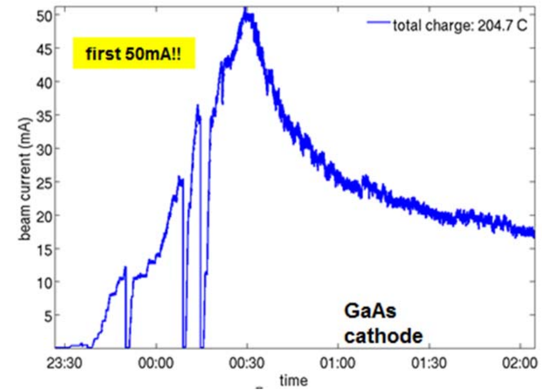
# Cornell DC Gun

ERL

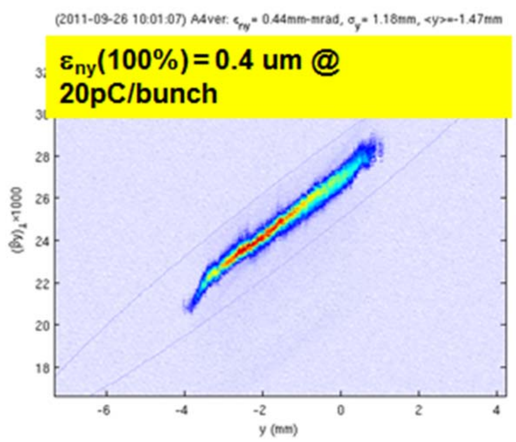
- Present beam energy: 350 kV
- New gun to be tested this summer designed for 500kV
- Operation gun pressure ~$10^{-11}$ Torr during beam operations.

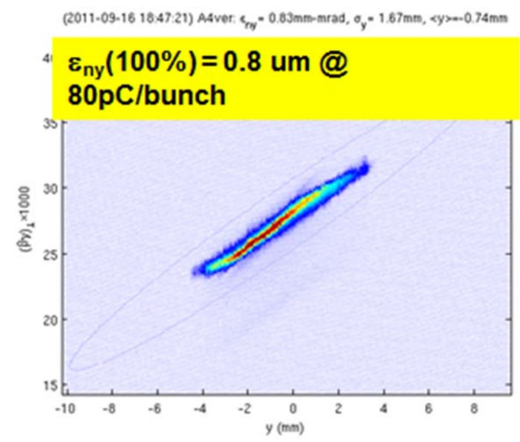




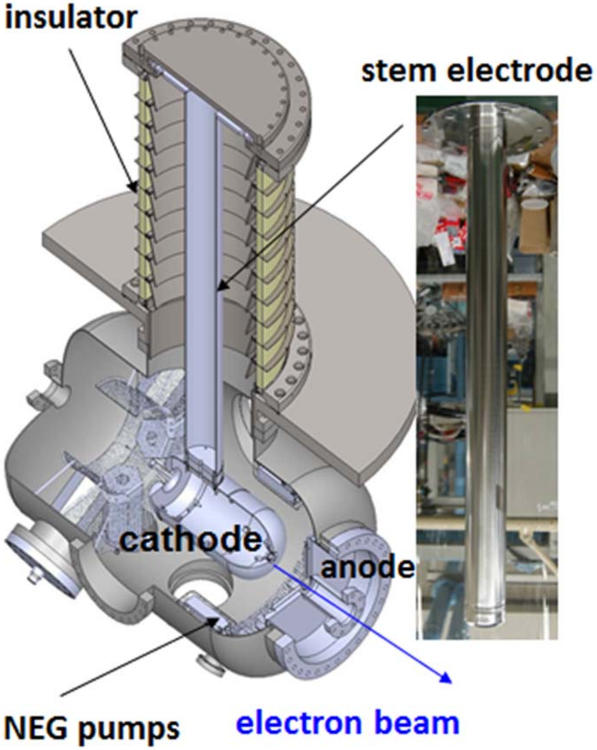

•Great cathode results achieved!




Courtesy of Bruce Dunham

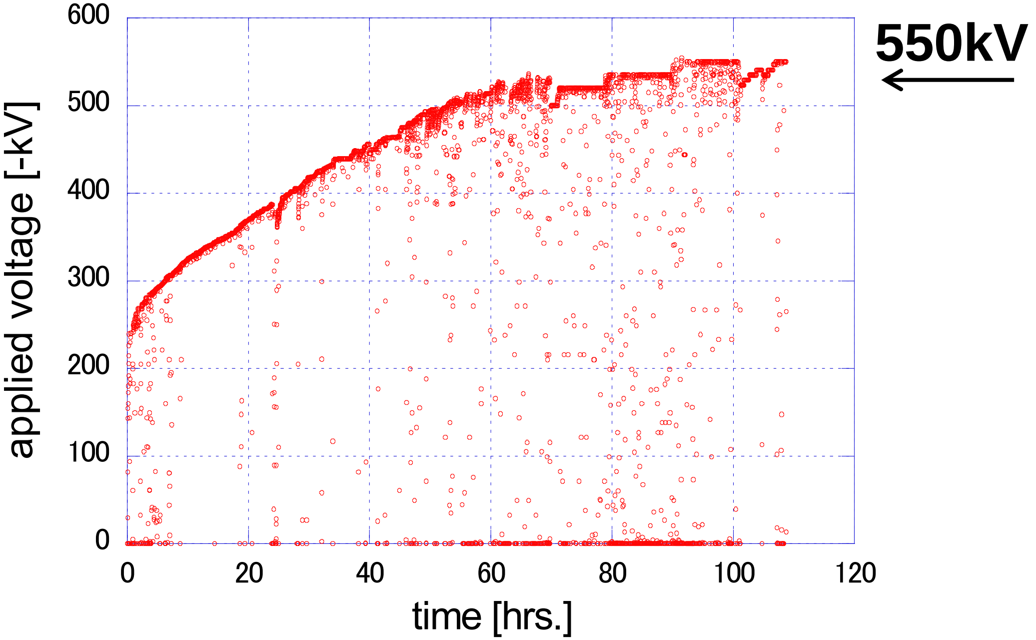
## HV testing of segmented ceramics with a stem electrode




Courtesy of Nobuyuki Nishimori

- HV processing up to 550 kV
- 500 kV for eight hours without any discharge

ERL

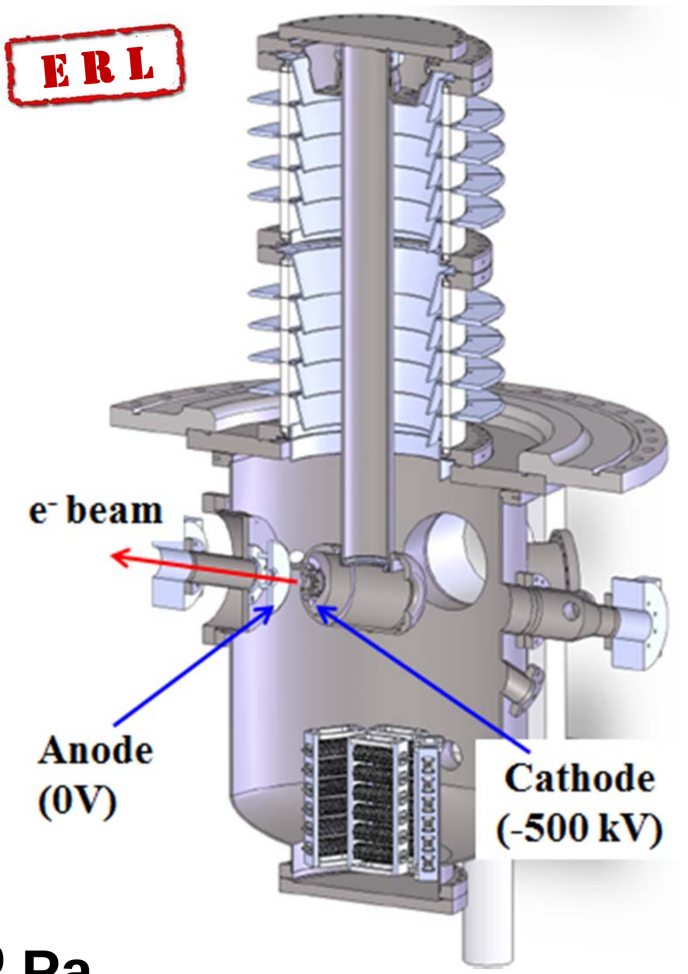



R. Nagai et al., RSI 81 033304 (2010).

- Conditioning with the cathode assembly under way. 526 kV achieved. Some field emission starting at ~ 449 kV. Issue to be solved.

# KEK DC Gun

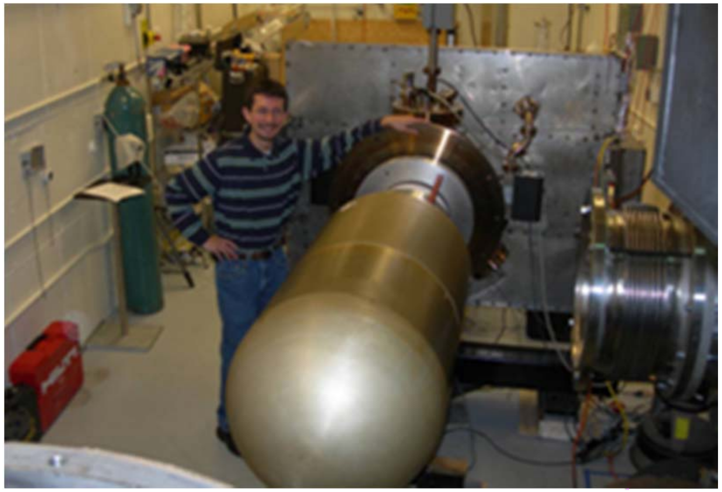
- **High voltage insulator**
  - Segmented structure
  - Special $Al_2O_3$ material (TA010, Kyocera)
- **Low outgassing system**
  - Titanium chamber, electrode, guard rings
  - Total outgassing rate: ~$1 \times 10^{-10}$ Pa.$m^3$/s (actual measurement)
- **Main vacuum pump system**
  - 4K Bakeable cryopump
    > 1000 L/s, for $CH_4$, $N_2$, CO, $CO_2$ @$1 \times 10^{-9}$ Pa (actual measurement )
  - NEG pump
    > $1 \times 10^4$ L/s, for $H_2$ (design value)




**Goal :<u>Ultimate pressure : $1 \times 10^{-10}$ Pa</u>**

**Courtesy of Masahiro Yamamoto**

# JLab DC Guns



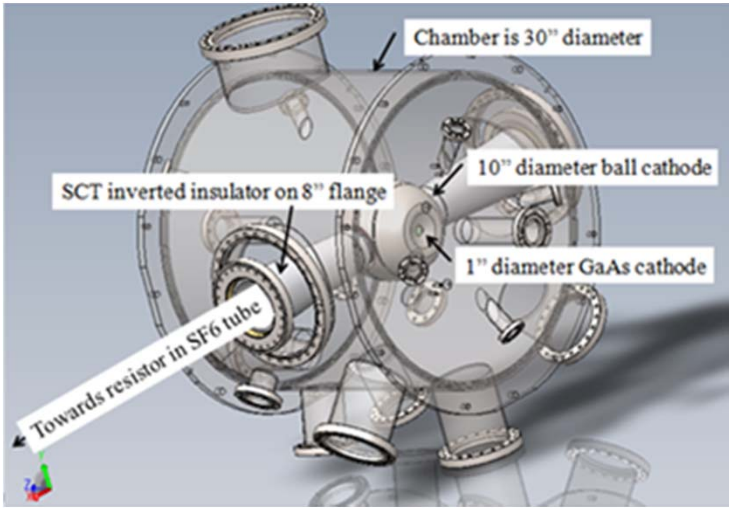
Jefferson Lab
Thomas Jefferson National Accelerator Facility

Photocathode: Cs:GaAs
Pt-implanted alumina insulators. No load-lock.
Operating voltage: 350kV
Charge: 135 pC for IR FEL, and 60 pC for UV FEL
Typical current at 135pC: 1.2 mA CW
Highest current at 135pC: 9 mA CW
Operating vacuum conditions: $10^{-11}$ to 5 $10^{-11}$ Torr.
Typical photocathode QE: 5%
Laser pulse: 50 ps FWHM, 532 nm
max rep rate: 75MHz
Typical rep rate: 4.67 MHz

FEL

**More than 10,000 C delivered!**

**“Inverted” geometry**
**DC gun under consideration**



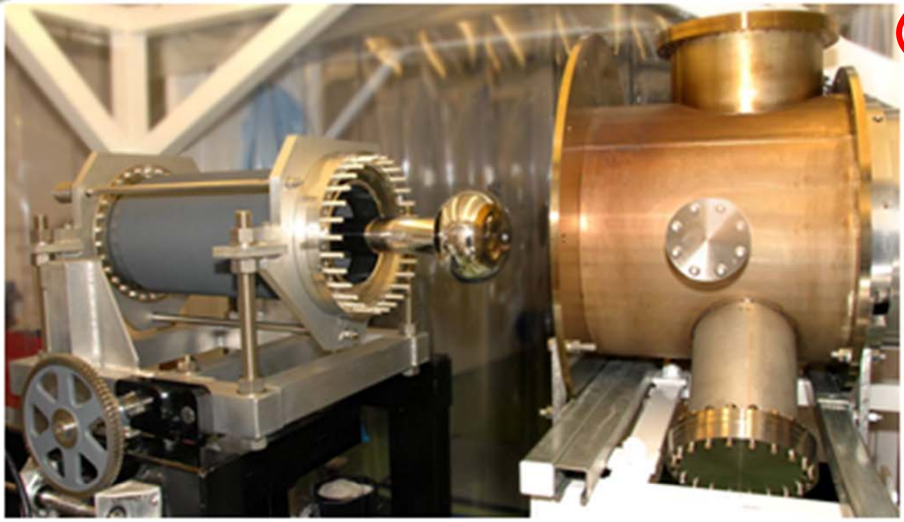

Courtesy of Carlos Hernandez-Garcia

# Alice DC Gun

Science & Technology Facilities Council ASTeC

ERL

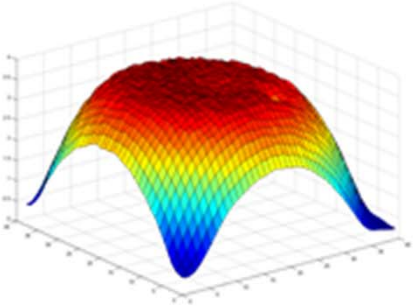
## ALICE ERL Photocathode gun Current status



- *The ALICE high voltage DC photocathode gun is a modified version of the GaAs gun developed at TJNAF for the IR-FEL. The main modification to the original design is the use of a single large ceramic for high voltage insulation which uses bulk-doped to control resistivity*
- *Because of the problem with insulator brazing since 2008 the gun was operated with temporary double ceramic insulator with reduced high voltage of 230 kV with different operation mode*
- *During recent shutdown the insulator has been replaced with a newly brazed single ceramic unit after that the operation voltage of 325 kV (restricted by the field emission of current photocathode) has been reached*
- *Further gun upgrade, involving development of new photocathodes, a "load-lock" photocathode preparation facility has been designed and delivered but its installation has been postponed*

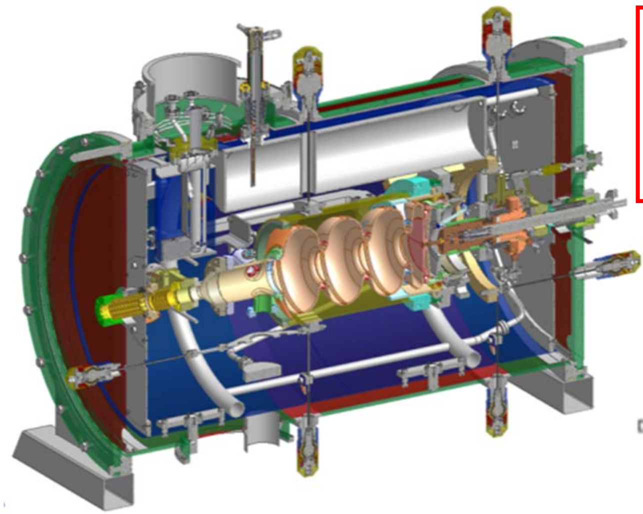
*QE map of a photocathode activated with $O_2$-$NF_3$ "Yo-Yo" procedure. Peak value of QE is 3.9% at a wavelength of 532 nm*

*See also Yu. Saveliev et al. MOPPP023*



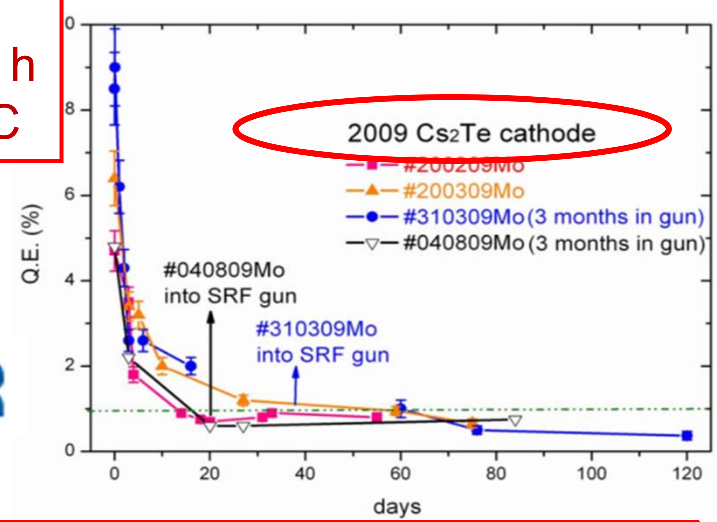
Courtesy of Boris Militsyn

# Rossendorf SRF Gun



- QE in gun 1%
- total beam time 1013 h
- extracted charge 35 C

FEL




STATUS

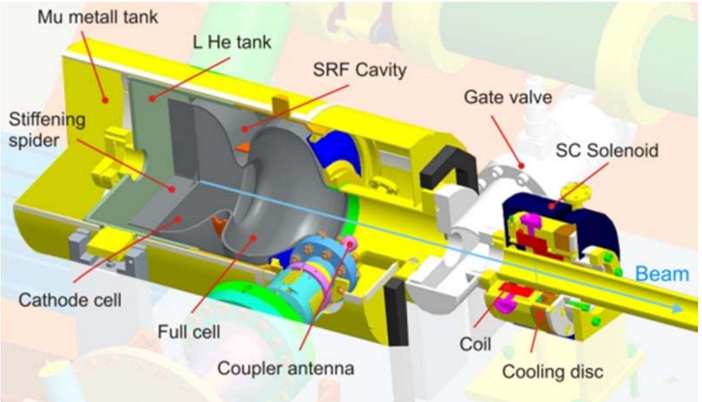
- Long lifetime of NC $Cs_2Te$ photo cathodes in SRF gun (>1 yr, total charge 35 C @ QE = 1%)
- No Q degradation since 4 years (RF operation ≈ 2500 h, beam time ≈ 1400 h)
- Strong MP at cathodes defeated by DC bias and grooves, further improvement needed
- First successful use of SRF injector at the ELBE accelerator
- But gun performance limited by low RF-field ($E_{pk} \leq$ 18MV/m and $Q_0 \leq 3x10^9$)

FUTURE

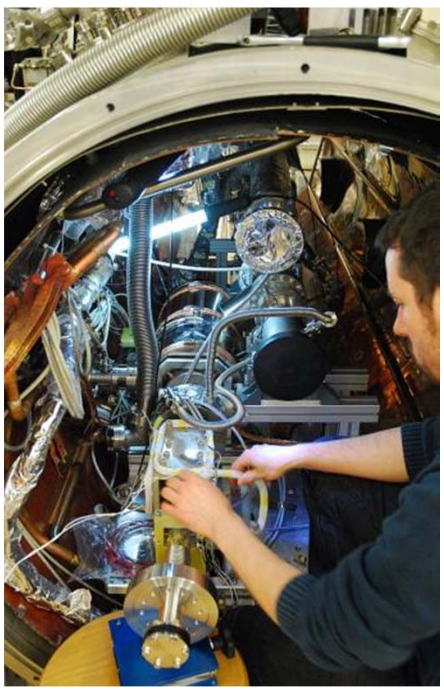
- On new upgrade cavity built at JLab (Peter Kneisel) with $E_{pk}$ = 43 MV/m (8 MeV) is ready
- Assembly of cold mass at JLab and installation in new cryomodule with SC solenoid
- 13 MHz / 500 kHz UV-laser upgrade will allow high-average current operation (1mA)

Courtesy of Jochen Teicher

# HoBiCaT SRF Gun




| | Gun0 (HoBiCaT) | Gun1 | Gun2 |
|---|---|---|---|
| Goal | Beam Demonstration (1st beam April 2011) | High brightness R&D gun (2014) | High average current production gun (2015) |
| Cathode material | Pb (SC) | $CsK_2Sb$ (NC) | |
| Cathode $QE_{max}$ | 1*10^-4@258 nm* | 1*10^-2@532 nm | |
| Drive laser wavelength | 258 nm | 532 nm | |
| Drive laser pulse length and shape | 2.5 ps fwhm Gaussian | ≤ 20 ps fwhm Gaussian | ≤ 20 ps fwhm Gauss./Flat-top |
| Repetition rate | 8 kHz | 54 MHz/25 Hz | 1.3 GHz |
| Electric peak field in cavity | 20 MV/m* | ≥ 10 MV/m | |
| Operation launch field on cathode | 5 MV/m* | ≥ 10 MV/m | |
| Electron exit energy | 1.8 MeV* | ≥ 1.5 MeV | |
| Bunch charge | 6 pC* | 77 pC | |
| Electron pulse length | 2...4 ps rms*° | ≤ 10 ps rms | |
| Average current | 50 nA* | 4 mA/40 µA | 100 mA |
| Normalized emittance | 2 mm mrad* | 1 mm mrad | |



ERL

**Solenoid sits close to cavity. Both cavity and solenoid are shielded. No performance degradation with respect to Q of cavity found, OK.**

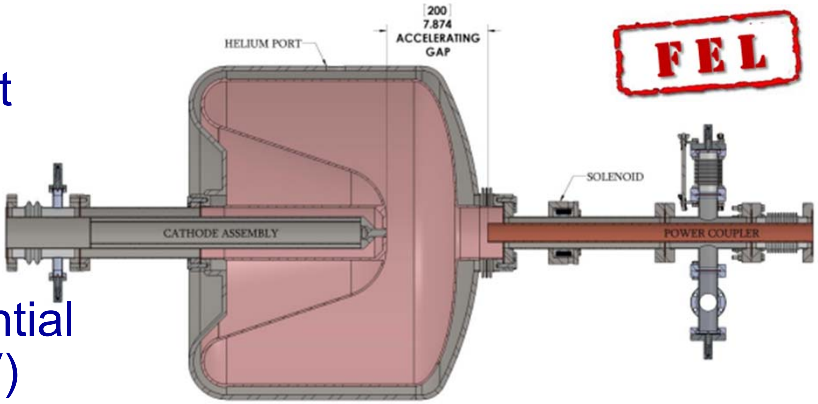
**First beam April 2011**

**New cavity with tuner assembly, cathode plug and movable solenoid under way. Showed gradient > 20 MV/m. Expect to run with Gun0 in Autumn 2012.**

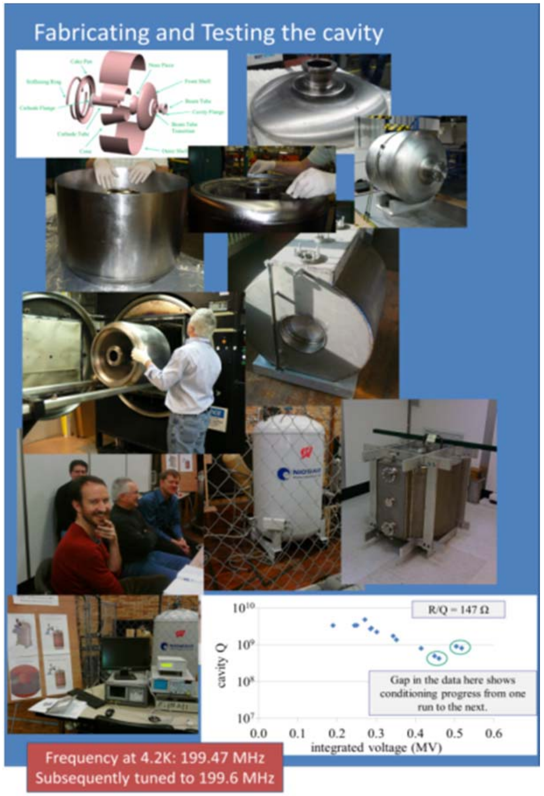
Courtesy of Thorsten Kamps

# Wisconsin SRF Gun

- SRF offers advantages for high average current electron gun
  - Higher gradients at cathode (~40 MV/m)
  - Without need to optimize for heat load, integrated field in gap can be large, substantial increase in output beam energy (to ~4 MeV)
- Lower freq. for temporal field flatness (quasi-DC)
- High gradient allows "blow out" mode




| PARAMETER | UNITS | |
|---|---|---|
| Temperature | K | 4.2 |
| Cavity frequency @ 4.2 K | MHz | 199.6 |
| Bunch charge, nominal | pC | 200 |
| Unloaded Q (Q0), nominal at nominal E Acc | | 2.5E9 |
| Peak surface electric field, nominal | MV/m | 53 |
| Integrated electric field, at nominal Q0 | MeV | 3.96 |
| Normalized $\varepsilon_{Transverse}$ | mm-mr | <1 |
| R/Q | Ω | 147.9 |
| Max transverse dimension | m | 0.6 |
| Cathode Aperture | cm | 1.2 |
| Cavity Mass (Nb) | kg | 63.9 |
| Dynamic heat loss at Peak surface electric field | W | 39.2 |
| Static Heat loss of cavity and dewar | W | 15 |



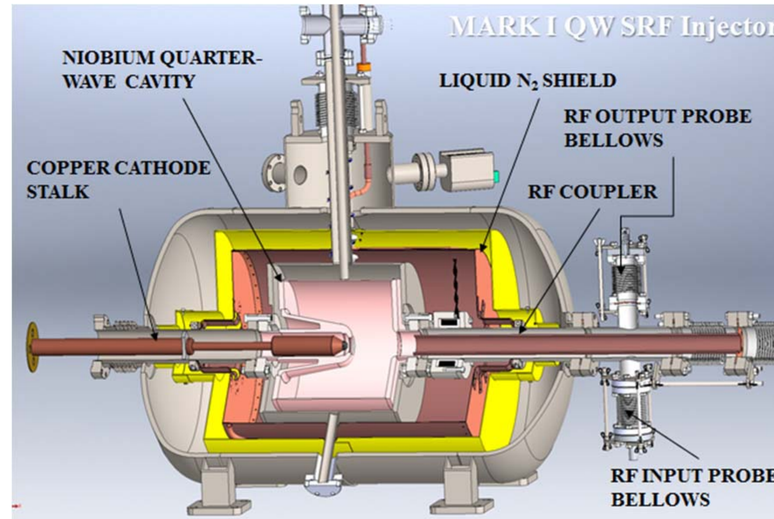

Courtesy of Bob Legg

DOE Award # DE-SC0005264

# NPS/Niowave/Boeing SRF Gun

- Research funded by Office of Naval Research

- Team approach:
  - NPS: beam dynamics, cavity simulation
  - Niowave: Fabrication, test facility
  - Boeing: Drive laser design
  - Joint: Operation & testing




- Guns based on rotated quarter-wave RF cavity
  - small gap: high gradients for modest voltage
  - compact, but low frequency: 4.2 K operation
  - cathode on stalk: thermal isolation, simple design

- Mark I successfully tested at Niowave; moved to NPS last summer

- Mark II initial tests are currently underway at Niowave

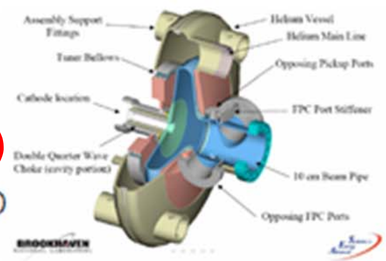
Courtesy of John Lewellen

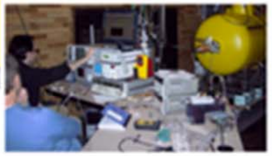
# BNL SRF Guns

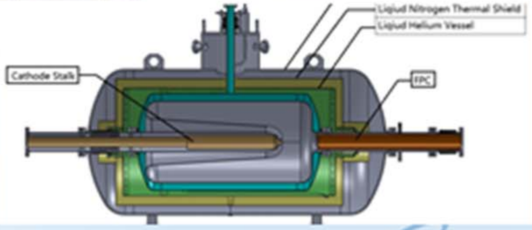
ERL+

## Status of BNL SRF guns

- Two SRF guns are under active development at BNL.
- The first gun, ½-cell elliptical shape, belongs to the first generation of SRF guns. It operates at 703.75 MHz and is designed to produce high average current (up to 500 mA), high bunch charge (up to 5 nC) electron beams for the R&D ERL at BNL.
- The gun cavity has been tested vertically several times and ins now in the process of being assembled into its cryomodule. The first cold test of the gun and subsequent beam generation are scheduled for second half of 2012.
- The gun will operate with a high-QE multi-alkali photocathode.
- The second gun, of a Quarter-Wave Resonator (QWR) type, operates at 112 MHz. This gun is designed to generate high charge, low repetition rate beam for the Coherent electron Cooling (CeC) experiment as well as to be used for photocathodes studies.
- The gun has been cold tested successfully last year. It is now being modified to be compatible with use in the CeC proof-of-principle experiment. Multi-alkali cathodes will be used in this experiment.



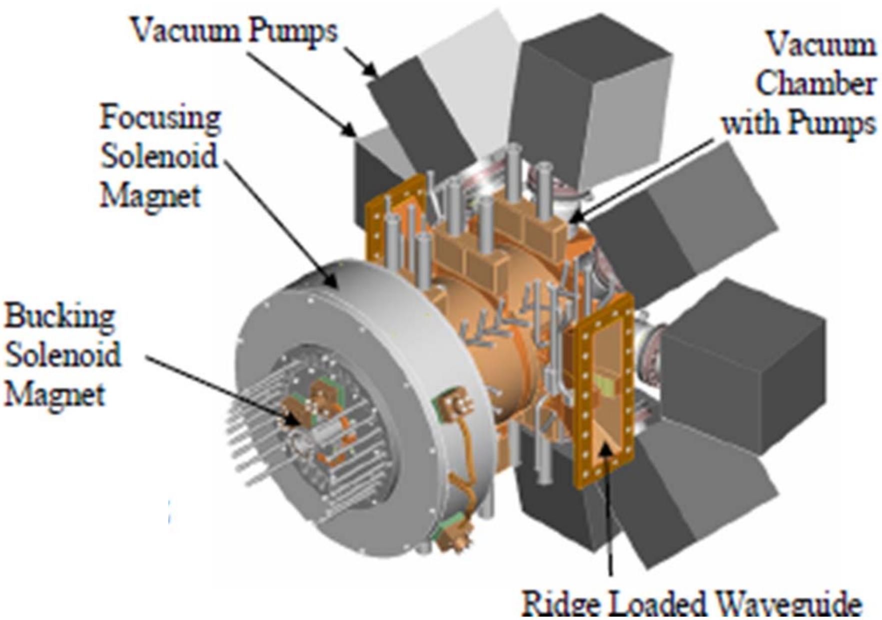



Brookhaven Science Associates

BROOKHAVEN NATIONAL LABORATORY

Courtesy of Sergey Belomestnykh and Ilan Benz-Vi

# LANL/AES
# NC CW 700 MHz Gun




| | | |
|---|---|---|
| Frequency | 700 | MHz |
| Energy | 2.54 | MeV |
| Current @ 33.3 MHz* | 100 | mA |
| Bunch Charge* | 3 | nC |
| Transverse Emittance | 6 | mm-mrad rms normalized |
| Longitudinal Emittance | 145 | keV-psec rms |
| Energy Spread | 0.5 | % |
| Bunch Length | | psec rms |

F E L

**700 MHz CW normal-conducting gun.**

**Many hundreds of kW dissipated in the glidcop structure.**

**Part of a 100 mA injector for ~ 100kW IR FEL**

**RF conditioning successfully completed.**

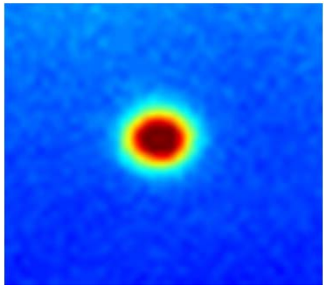
**Beam tests under way**

Courtesy of D. Nguyen and B. Carsten

# The LBNL CW NC VHF gun

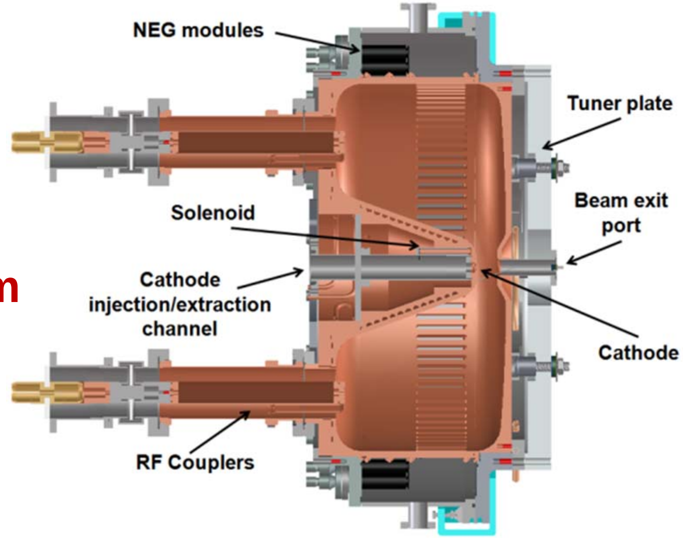
High repetition rate, high brightness e- guns (F. Sannibale)

FEL

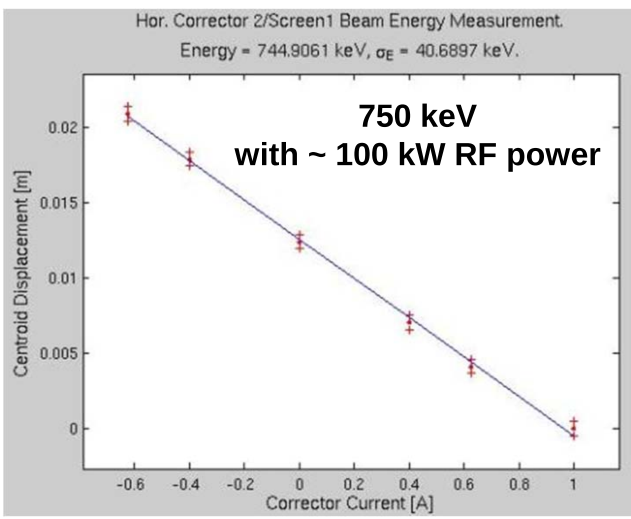


1st photo-emitted beam from a “dummy” moly cathode: 10 nA (10 fC @ 1 MHz).

Nominal operation energy achieved.




| | |
|---|---|
| Frequency | 186 MHz |
| Operation mode | CW |
| Gap voltage | 750 kV |
| Field at the cathode | 19.47 MV/m |
| $Q_0$ (ideal copper) | 30887 |
| Shunt impedance | 6.5 MΩ |
| RF Power | 87.5 kW |
| Stored energy | 2.3 J |
| Peak surface field | 24.1 MV/m |
| Peak wall power density | 25.0 W/cm$^2$ |
| Accelerating gap | 4 cm |
| Diameter/Length | 69.4/35.0 cm |
| Operating pressure | ~ $10^{-11}$ Torr |

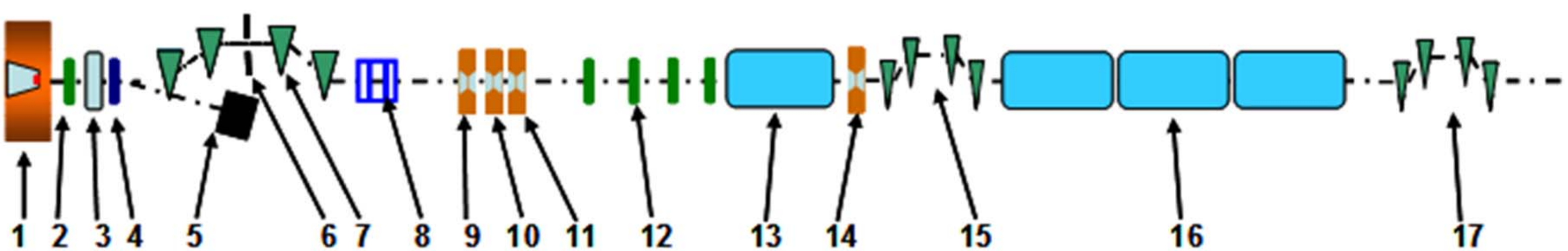



• Next: “real” cathode tests ($Cs_2Te$, $CsK_2Sb$, diamond amplifier, …)

## A Novel Injector Concept for XFELO

FEL

- Current paradigm of injector design: laser driven rf photocathode
- For low intensity & ultra-low emittance → thermionic cathode inside VHF band cavity
- Inspired by the SCSS/Spring-8 success of pulsed DC gun (T. Shintake, K. Togawa,..) but employ low frequency RF cavity for high, constant rep rate
- Performance
  - Normalized rms emittance < 0.2 **(0.3)** mm-mr
  - Bunch length (rms) ≲ 1 **(0.1 ps)**
  - Peak current 20 **(100)** A
  - A constant bunch rep rate @ ~1 MHz



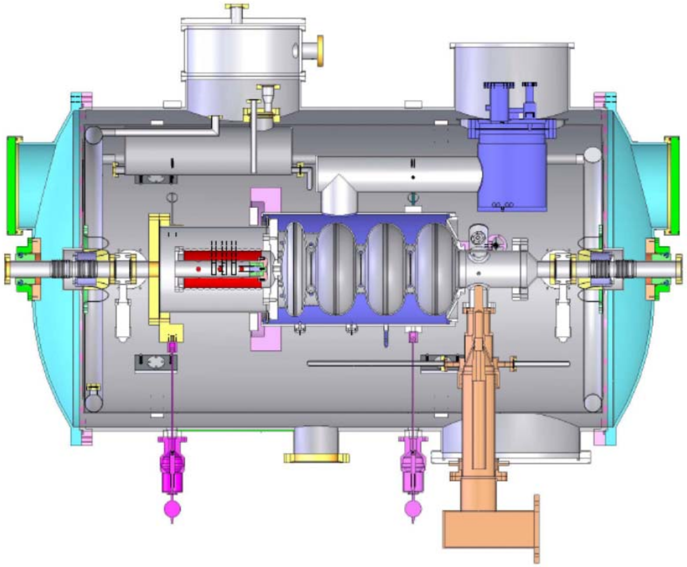

Courtesy of Kwan-Je Kim

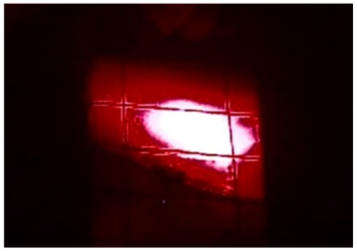
KJK, for Fernando

2

# Peking University DC-SRF Gun

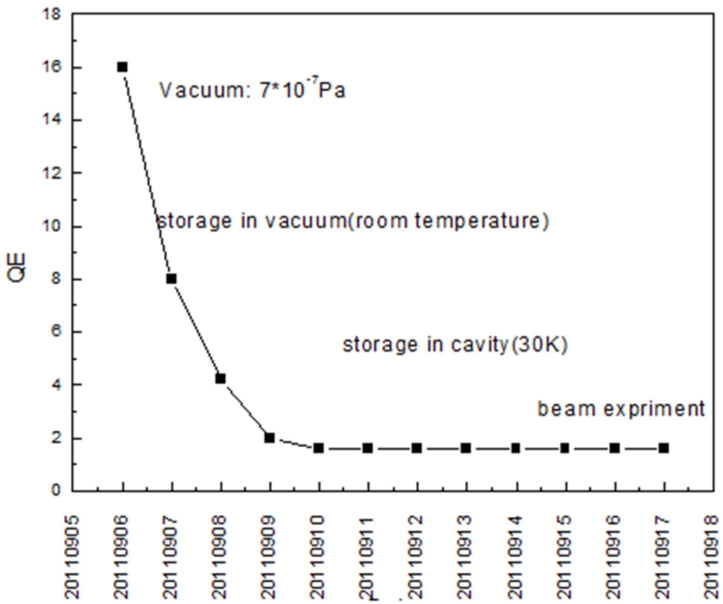
- **100 KV Pierce DC gun with $Cs_2Te$ cathode matched with SRF cavity**





ERL

- **Eacc~6MV/m**
- **Nominal charge/bunch: 60 pC**
- **Beam energy~2.5MeV, current~50μA**
- **Aperture diaphragm was used to reduce laser power**




Courtesy of Jiankui Hao

# Acknowledgements

**A sincere "thanks!" to the colleagues that shared their work information and allowed to put together this talk.**

# Additional Viewgraphs

# Gun - 4th Generation Light Source Matching

High repetition rate, high brightness e- guns (F. Sannibale)

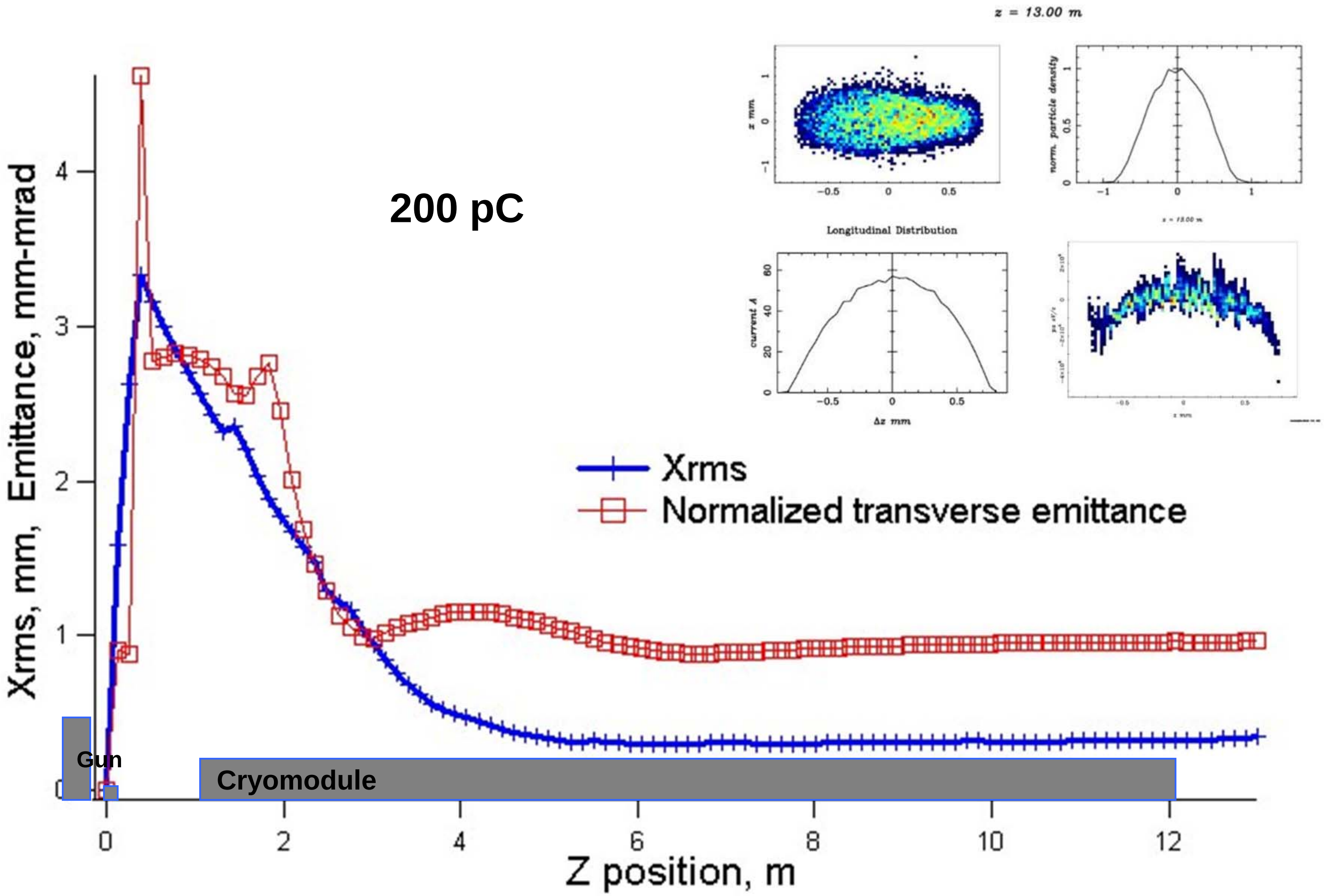
BERKELEY LAB

**ERL**
- Up to hundreds of MHz reprate → DC, SRF and DC-SRF gun, low freq. NC RF Gun
- >~ 700 MHz reprate → DC, SRF and DC-SRF Gun

**FEL**
- Reprate < ~ 10kHz → High freq. NC RF gun, pulsed DC gun
- Up to hundreds of MHz reprate → DC, SRF and DC-SRF gun, low freq. NC RF gun

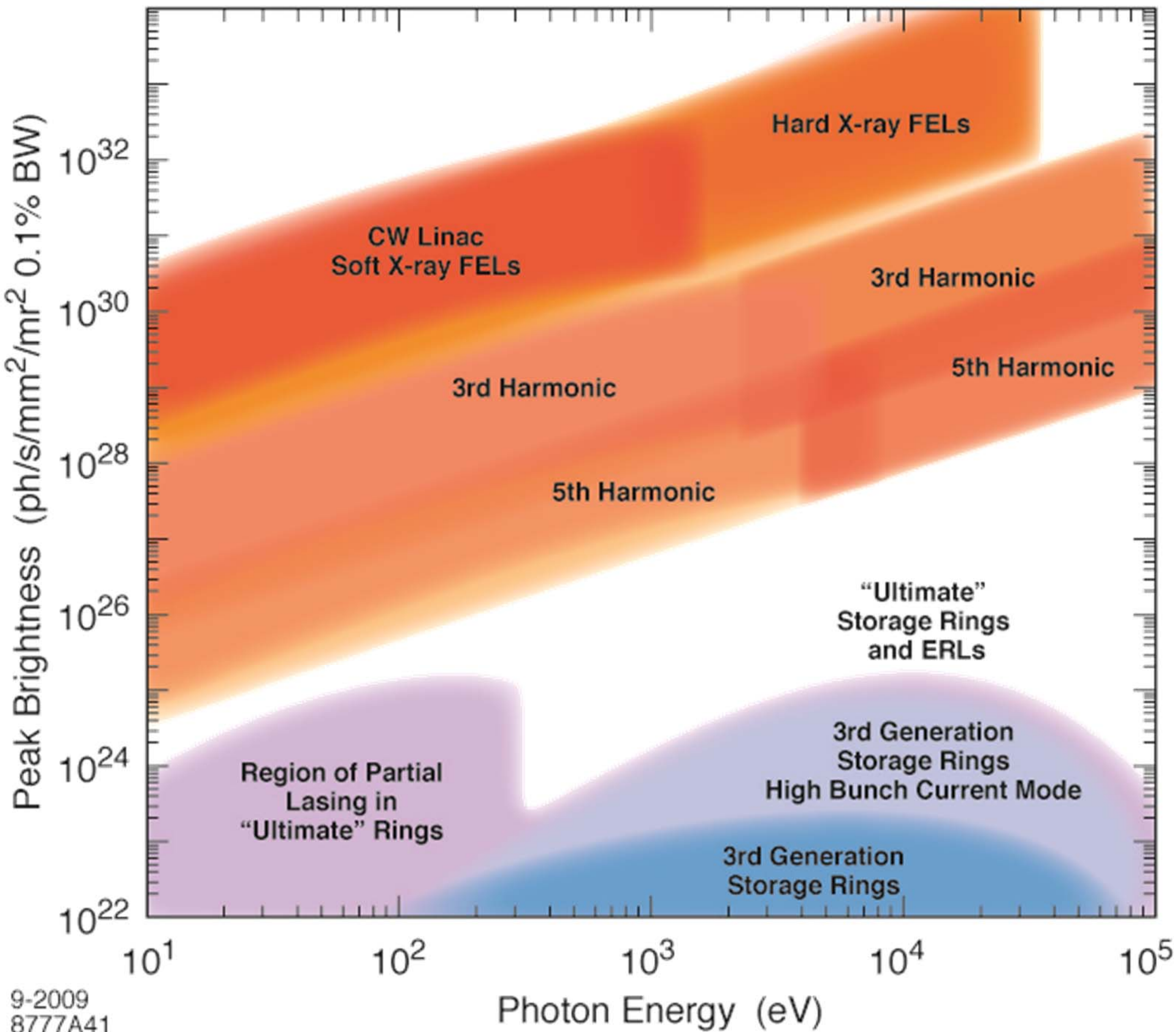
**XFELO**
- Few MHz reprate → DC, SRF and DC-SRF gun, low freq. NC RF gun

# Beam Dynamics Simulations of Injector using Blow Out Bunches



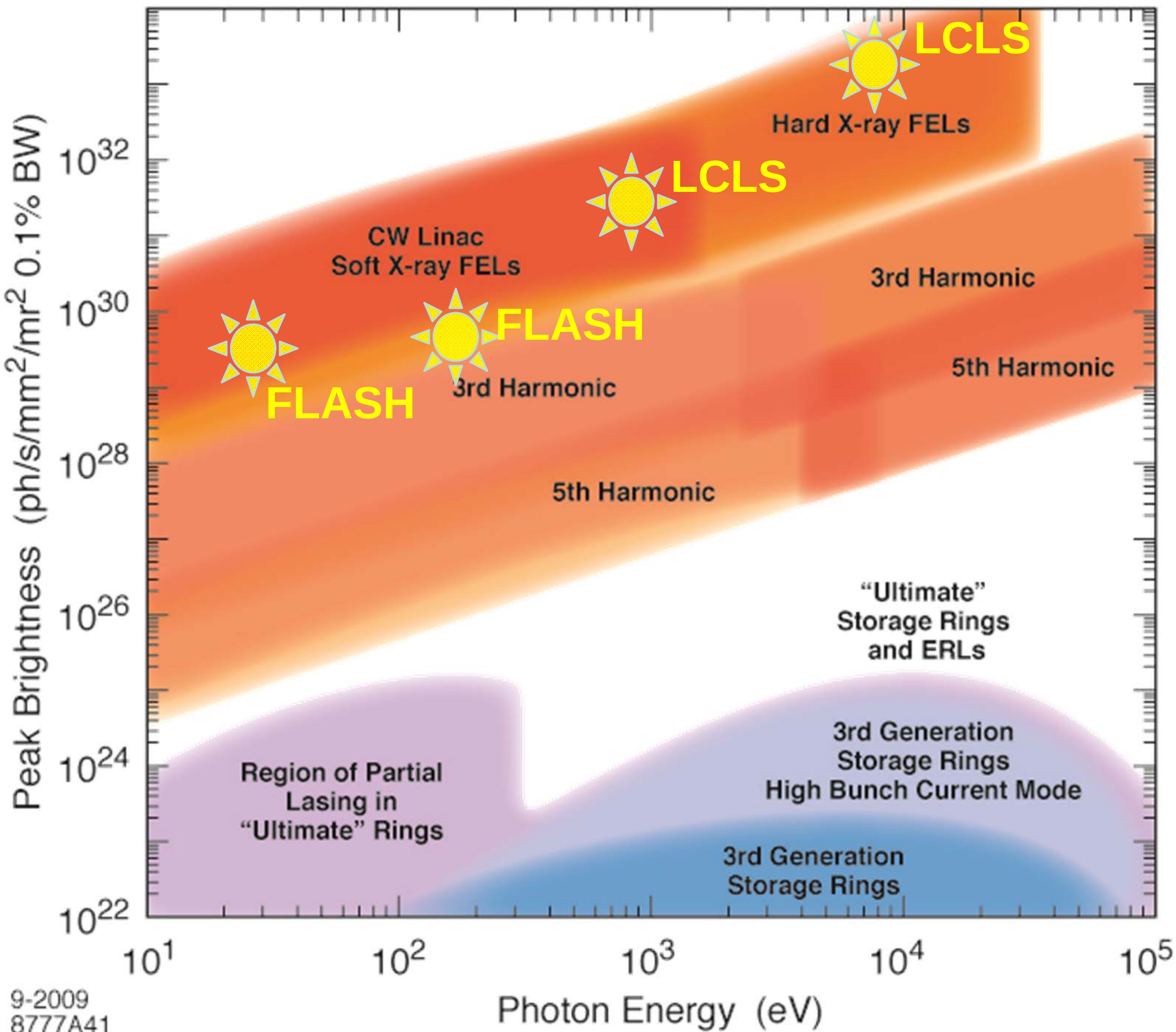

Courtesy of Robert Legg

# Peak Brightness



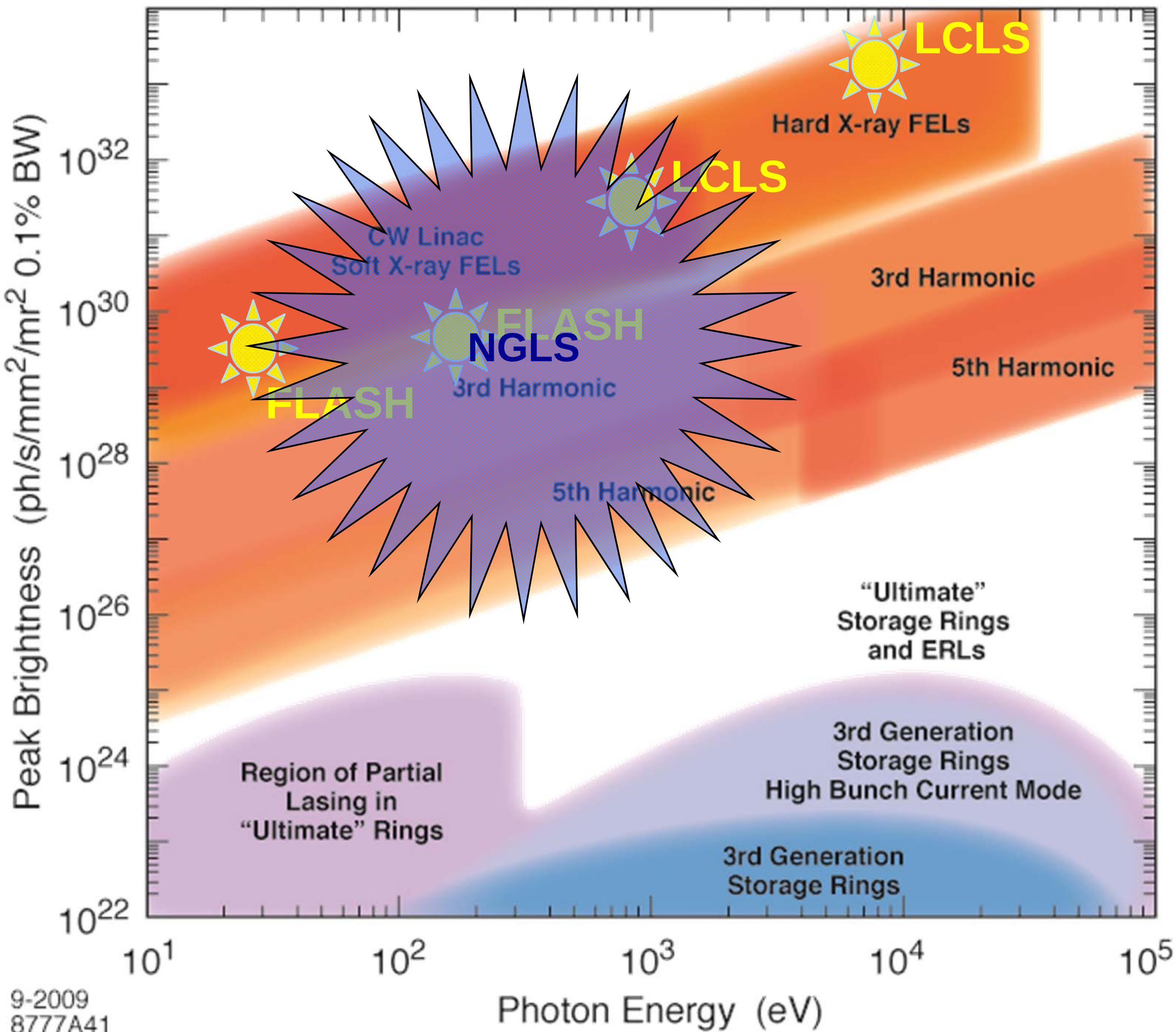

ANL-08/39
BNL-81895-2008
LBNL-1090E-2009
SLAC-R-917

# Peak Brightness

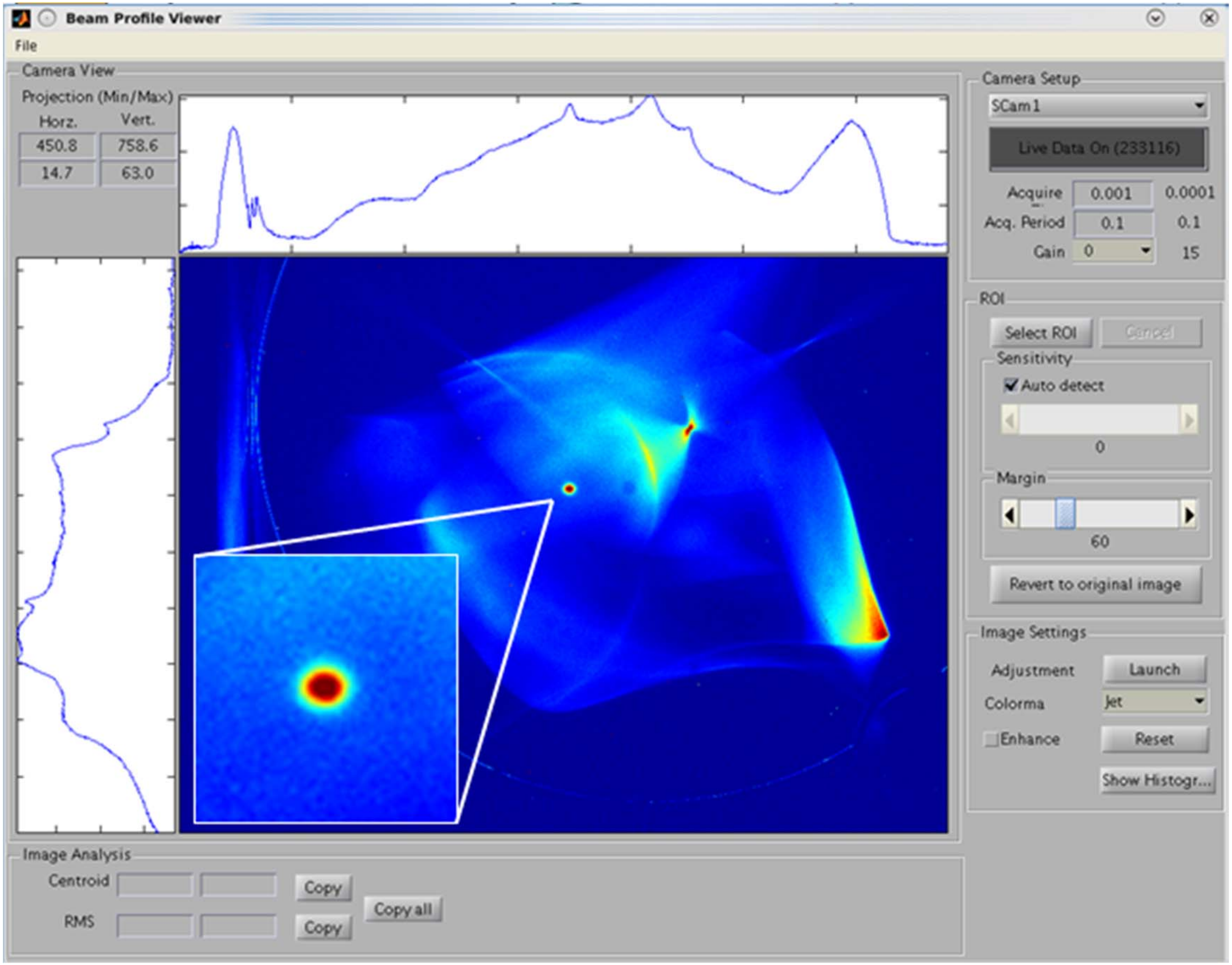



ANL-08/39
BNL-81895-2008
LBNL-1090E-2009
SLAC-R-917

# Peak Brightness




ANL-08/39
BNL-81895-2008
LBNL-1090E-2009
SLAC-R-917


Beam Profile Viewer
File
Camera View
Projection (Min/Max)
Horz.
Vert.
450.8
758.6
14.7
63.0
Camera Setup
SCam1
Live Data On (233116)
Acquire
0.001
0.0001
Acq. Period
0.1
0.1
Gain
0
15
ROI
Select ROI
Cancel
Sensitivity
Auto detect
0
Margin
60
Revert to original image
Image Settings
Adjustment
Launch
Colorma
Jet
Enhance
Reset
Show Histogr...
Image Analysis
Centroid
Copy
Copy all
RMS
Copy