THE ORION PHOTOINJECTOR: STATUS and RESULTS

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5. Laser System
    1. Oscillator Subsystem
    2. Amplifier Subsystem
6. Phase Noise
7. Photocathode Material
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General Design Parameters of the ORION Facility

Beam Energies	7 MeV (Source); 7-67 MeV (LE Hall); 67-350 MeV (HE Hall)
Charge per Bunch	0.25 nC optimum, adjustable up to a nominal maximum of 1 nC
Number of Bunches	1 or 2 (split charge)
Transverse Emittance	$< 2 \times 10^{-6}$ m , normalized rms (0.25 nC)
Bunch Length	1.8 psec, rms (0.25 nC)
Charge Stability	2.5% pulse-to-pulse
Bunch Timing Jitter	500 fsec, rms
Repetition Rate	10 Hz
Average Beam Power	0.67 W at 67 MeV; 3.5 W at 350 MeV (1 nC bunches)
Electron Source	1.6 cell, S-band (2.856 GHz) Photoinjector , Mg cathode
Drive Laser	Commercial Ti:Sapphire, 266 nm wavelength, 1 mJ output
Source RF System	SLAC 5045 Klystron; Solid-State, NLC-type Modulator
Injector Linac	Two X-band (11.4 GHz), 0.9 m, 30 MV, NLC structures
High-Energy Linac	Four X-band, 1.8 m, 72 MV, NLC structures

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FFTB

NLCTA

http://www-project.slac.stanford.edu/orion/

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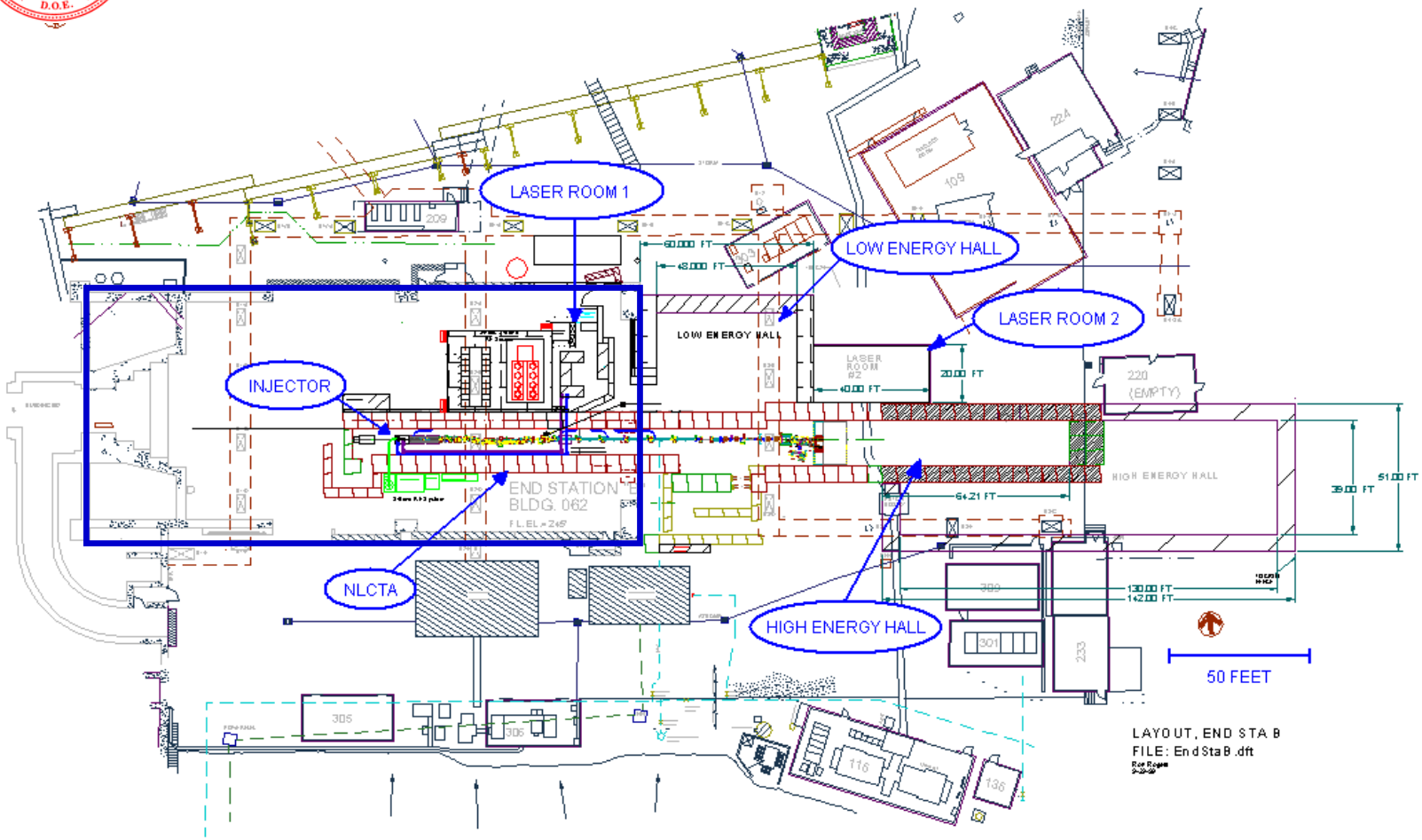
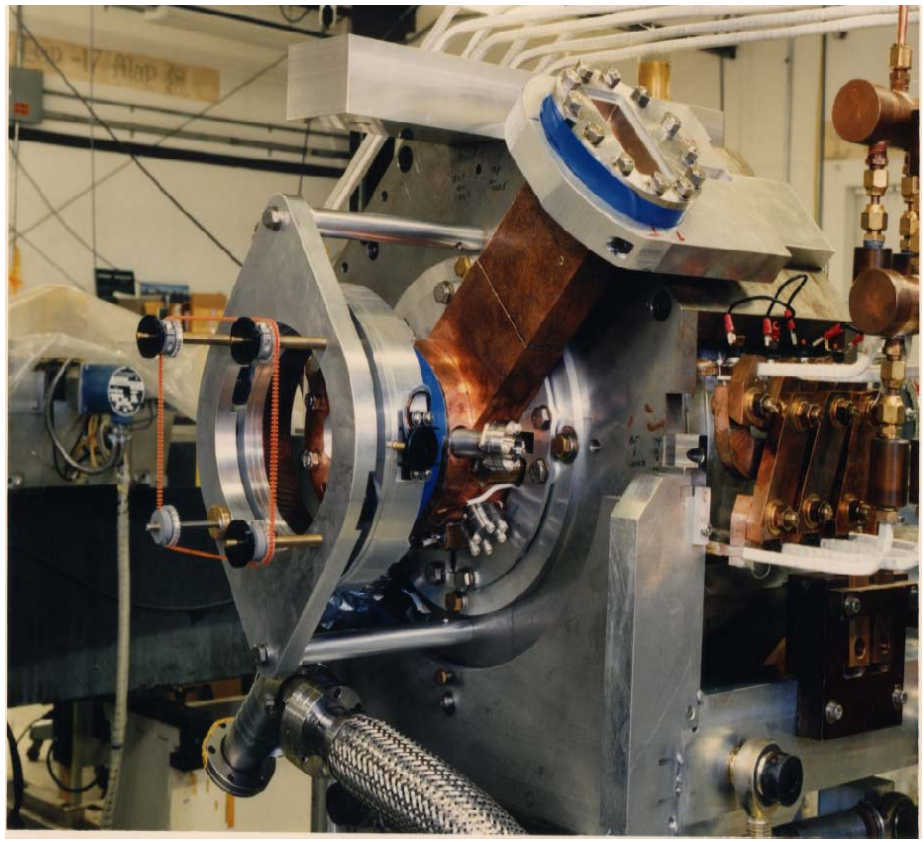
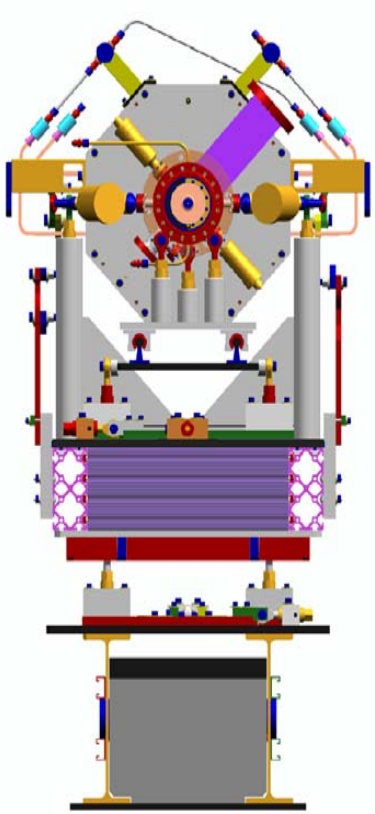
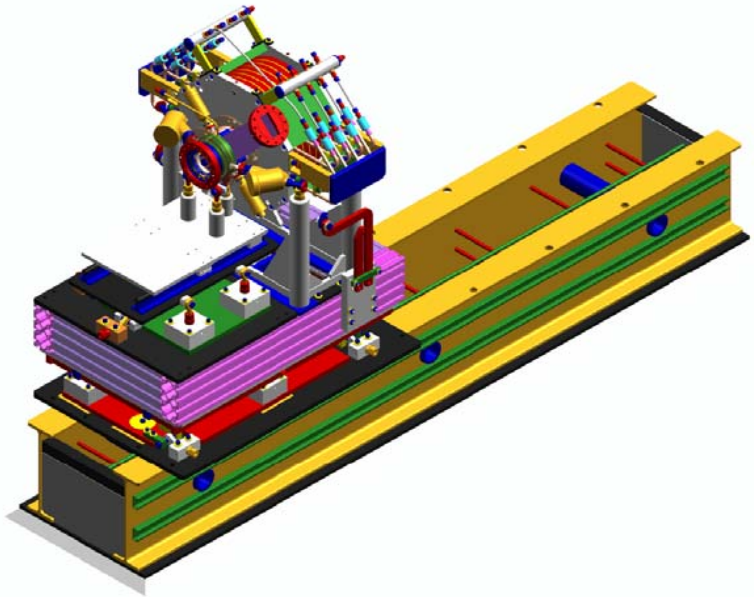
ORION FACILITY @ NLCTA

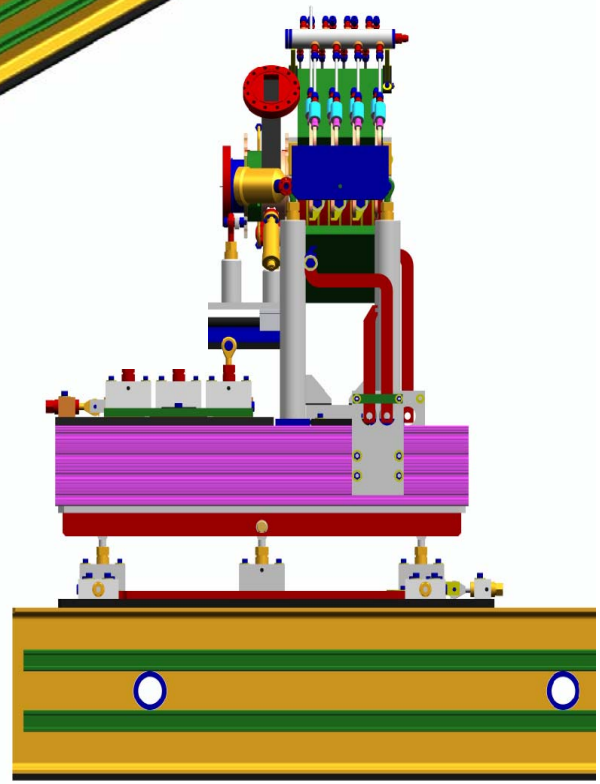


Next Generation Photoinjector









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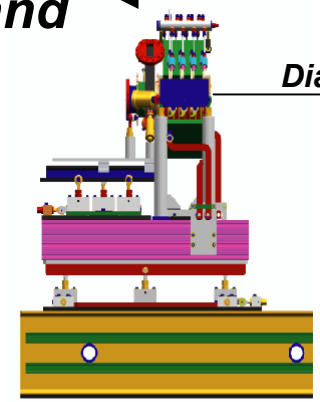
Photoinjector Layout

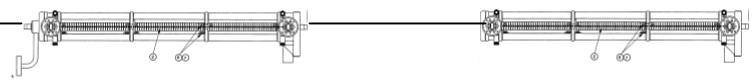
S-Band

150 cm

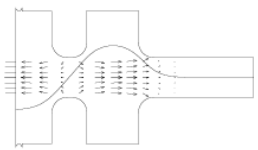
X-Band

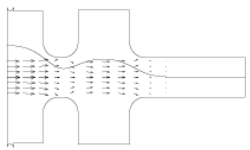


Diagnostics



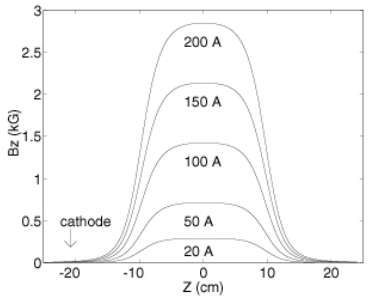
111.4 cm

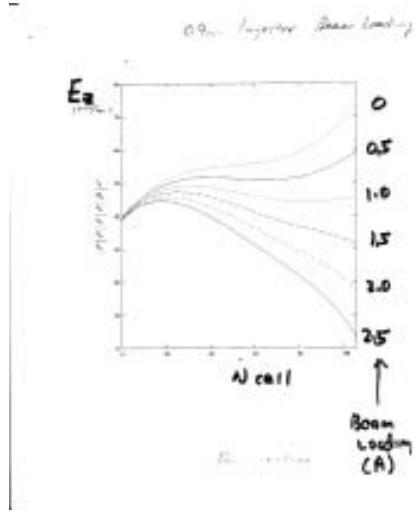




f_π = 2856.050 MHz

f_o = 2852.586 MHz





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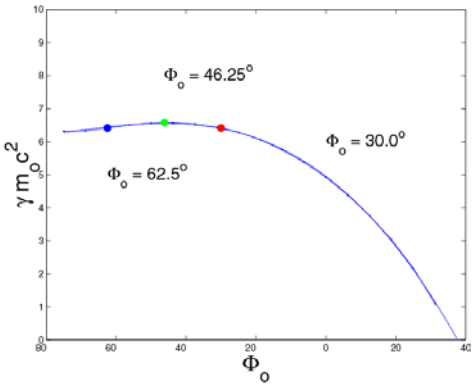
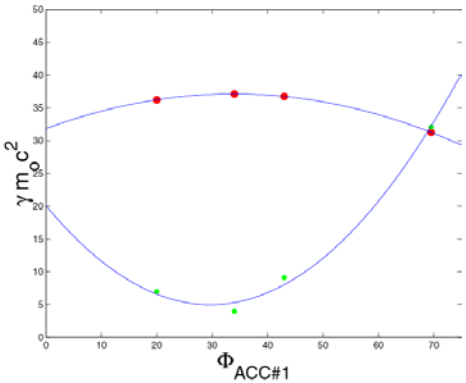
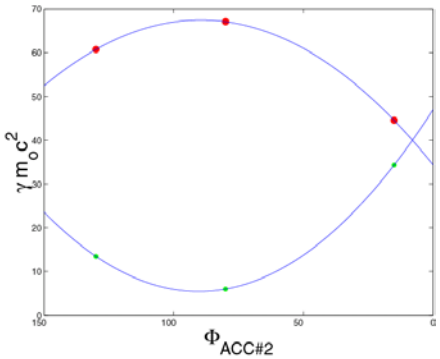
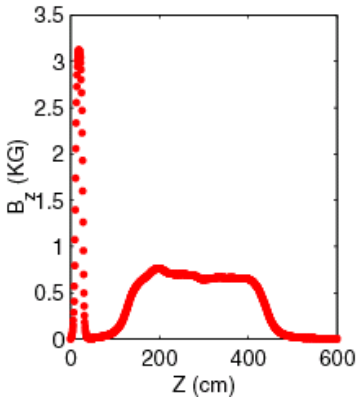
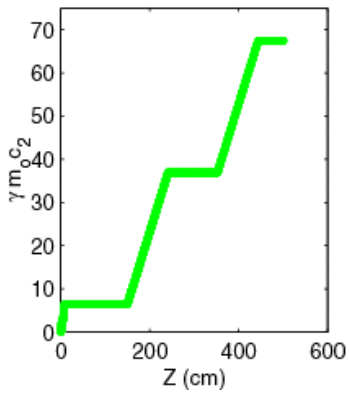
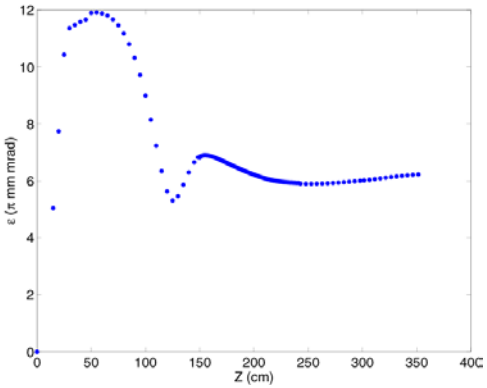






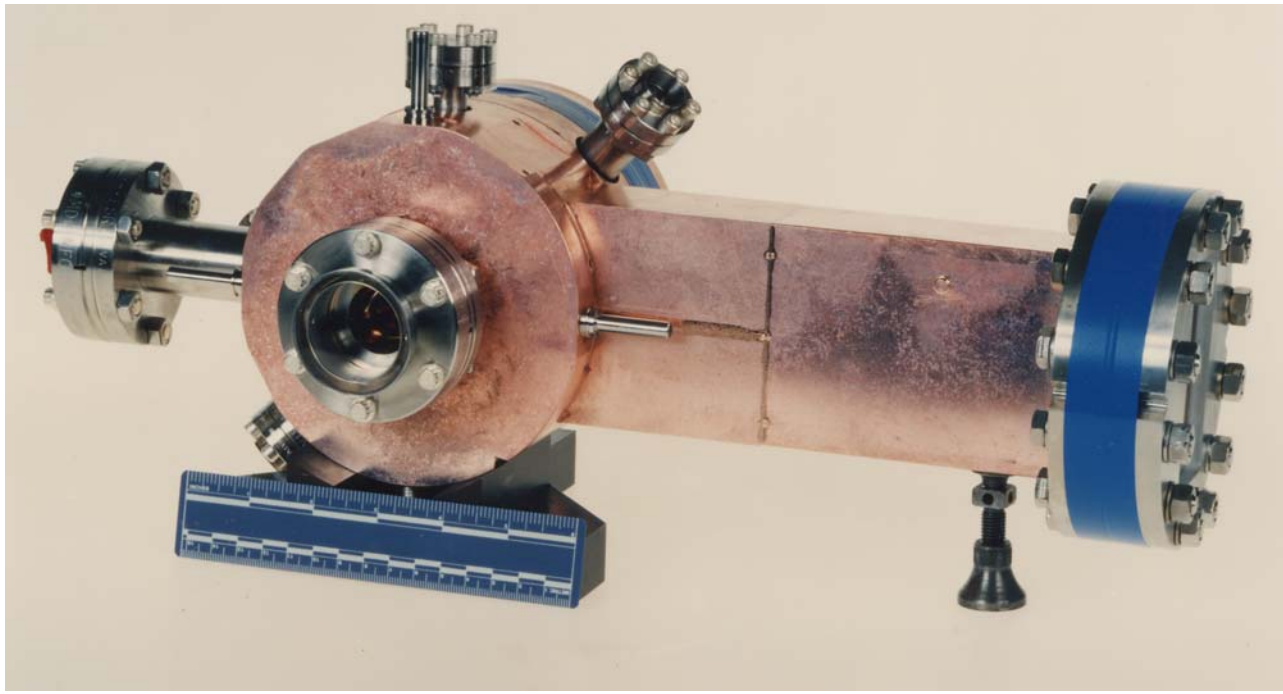






R = 1 mm
Q = 1 nC
σ_z = 500 fsec
N = 10K
Quiet Start

BNL/SLAC/UCLA 1.6 cell S-Band RF GUN



Mechanical Improvements

Cathode Enclosure

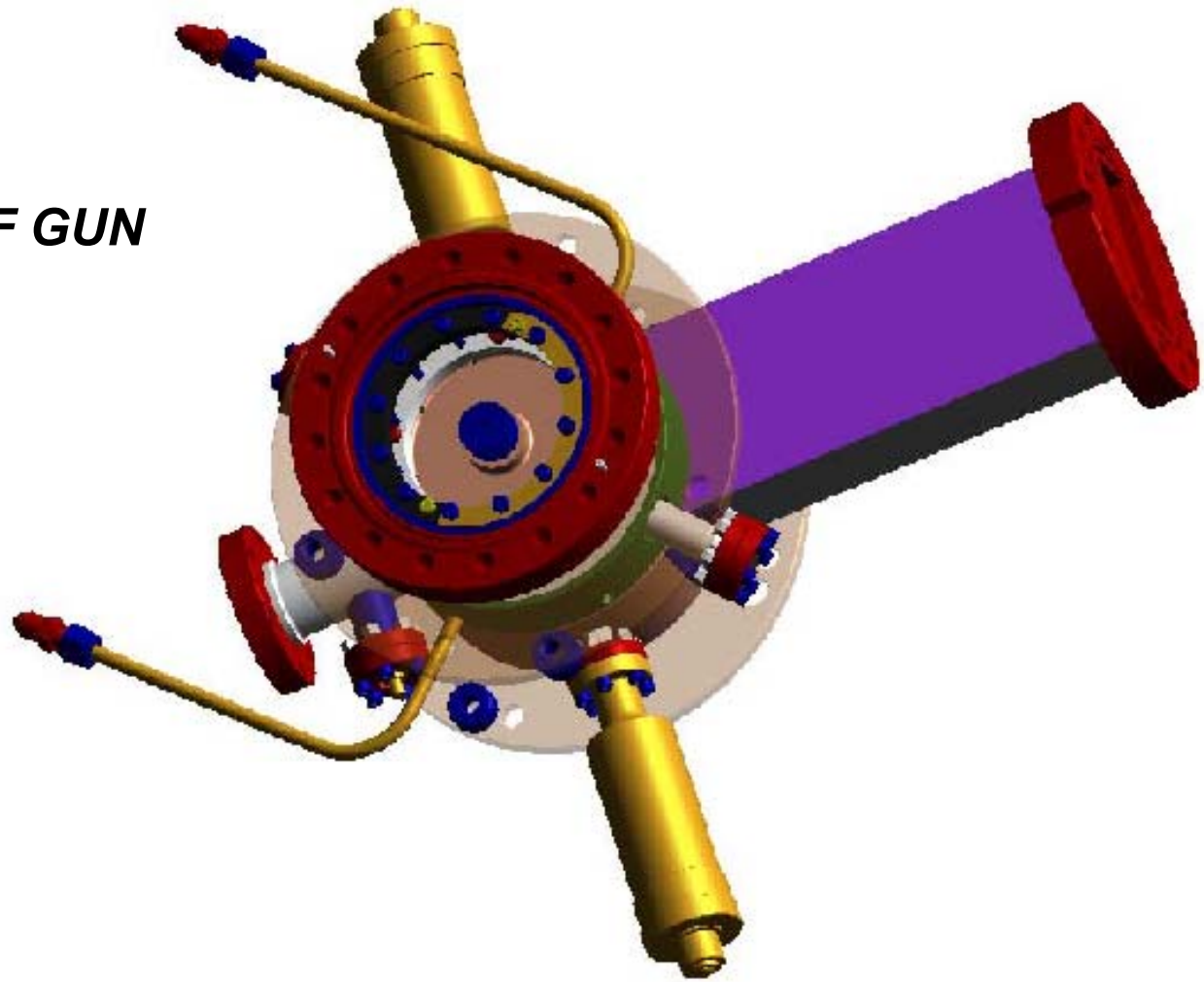
ONE OF A KIND

Exit Port

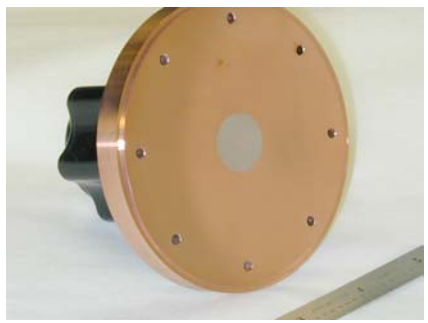
Vacuum Port / RF Probe

MDC HIGH TEMP

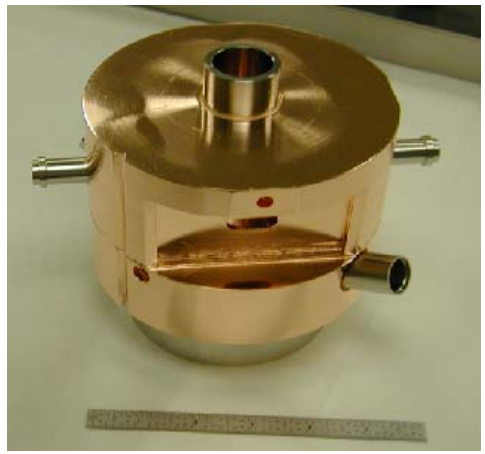
ORION RF GUN



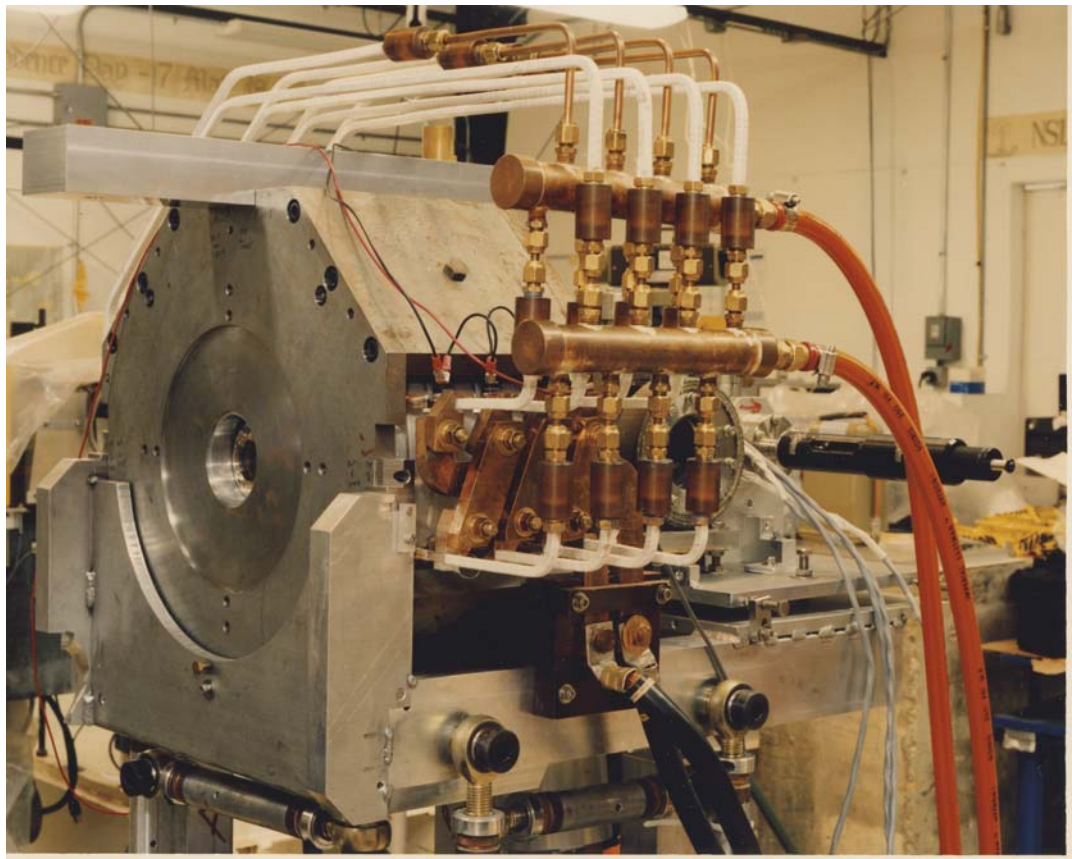
ORION/Neptune RF GUN

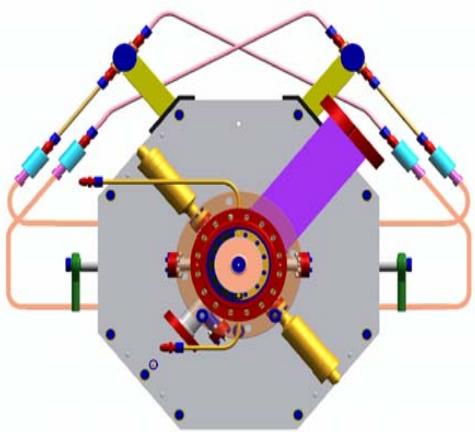


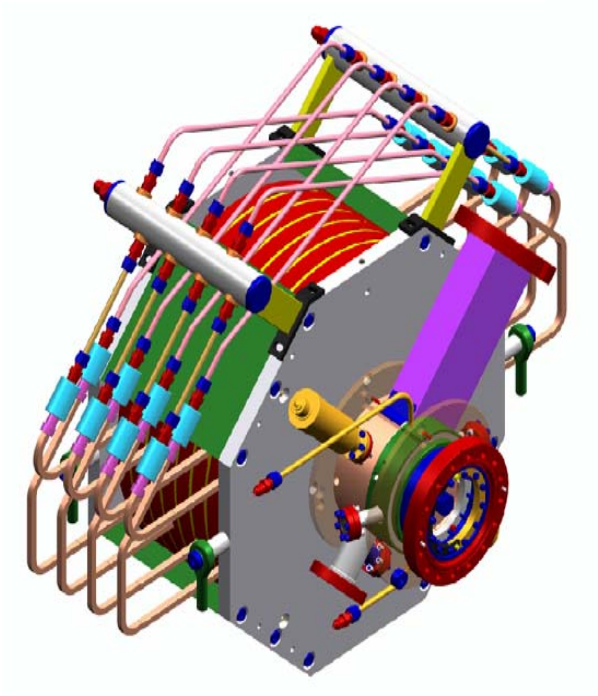
Spare Neptune 1.6 cell RF Gun
After 1st Braze

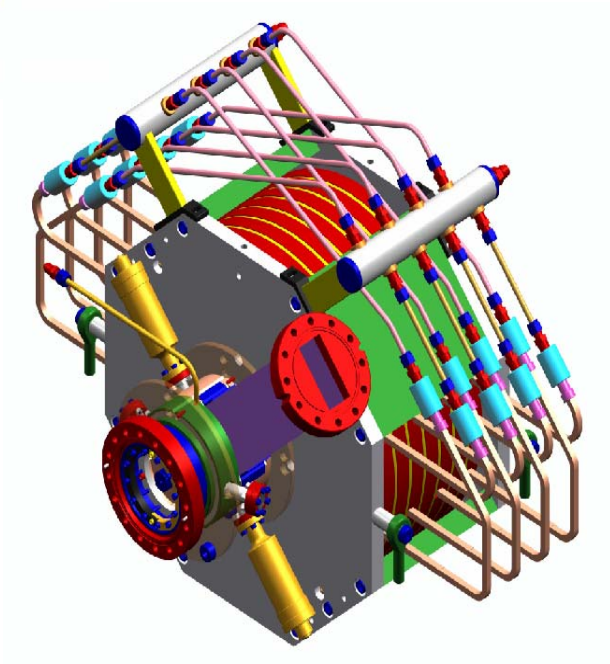


Solenoidal Magnet

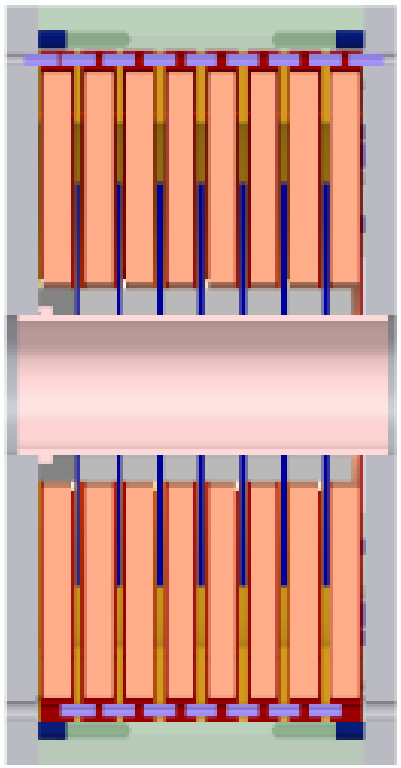






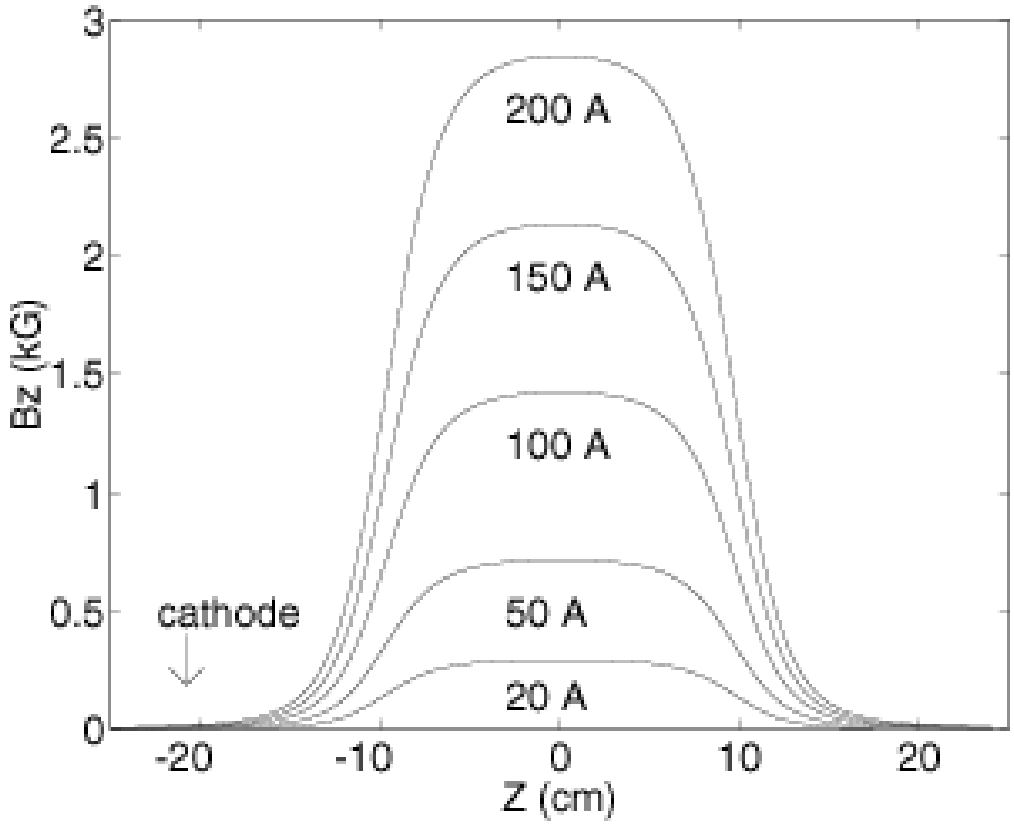


Solenoidal Magnet



Magnet Material	1006 Steel
Conductor	Hollow
Length	200 m
Cross Section	0.39477 cm^2
Resistance	0.08613 Ω
Voltage	18.95 V
Current	220 A
Power	3445 W
J	557.3 A/cm^2

Magnetic Field Versus Current



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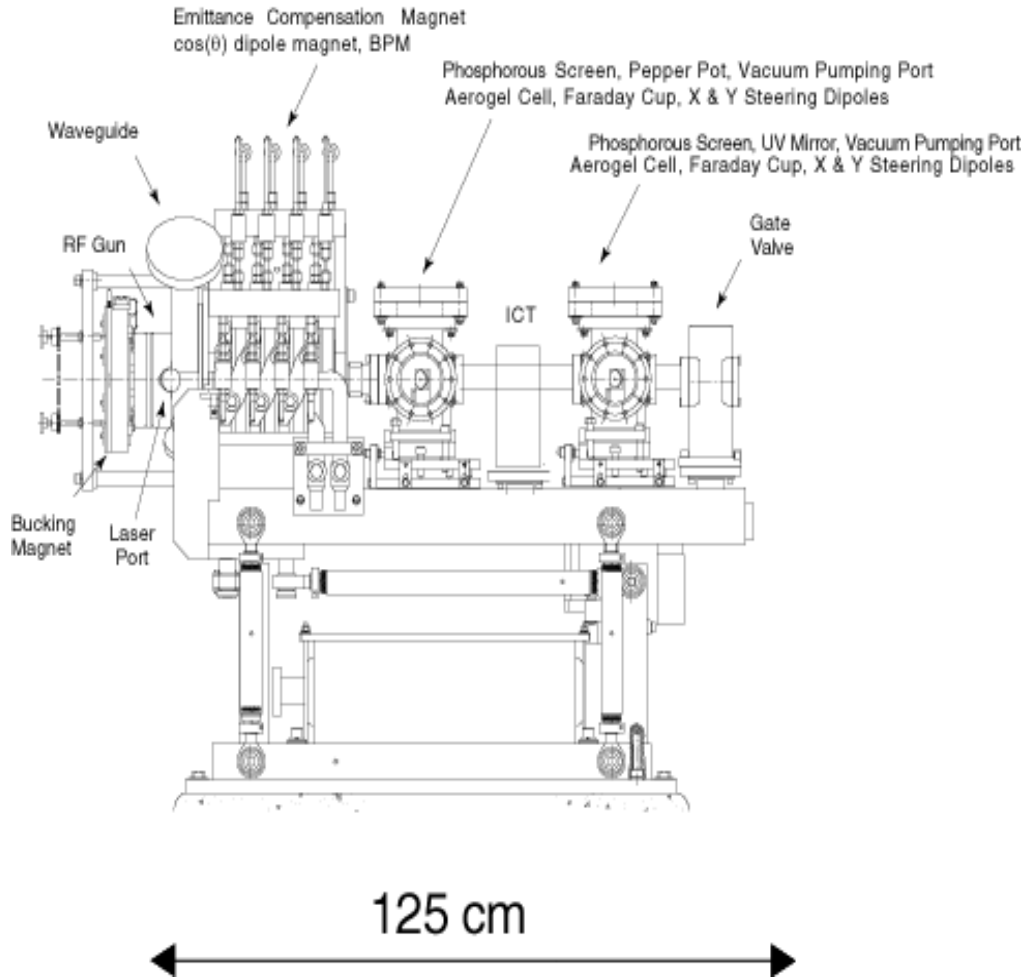

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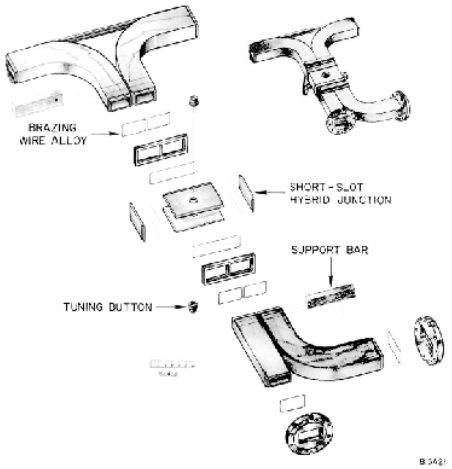
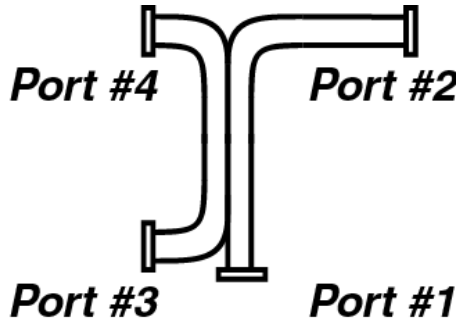
S-Band Power 5045 + Modulator

SLAC Type I Coupler Under Test





Theory

$$S = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{12} & 0 & S_{14} & 0 \\ 0 & S_{14} & 0 & S_{12} \\ S_{14} & 0 & S_{12} & 0 \end{bmatrix}$$

Exp.

$$|S| = \begin{bmatrix} -32.7 & -3.15 & -39.5 & -3.00 \\ -3.15 & -30.1 & -3.05 & -31.5 \\ -39.5 & -3.04 & -24.7 & -3.26 \\ -3.01 & -31.5 & -3.24 & -29.5 \end{bmatrix}$$

All units in dBm

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Drive Laser Minimum System Requirements and Performance Enhancements

Parameter	Minimum System Requirement	Performance Enhancements
Pulse Repetition Frequency	10 Hz	
Laser Energy [1]	> 1 mJ	
Laser Energy Jitter	< 5% rms	Best Effort
UV Timing Jitter [2]	< 500 fs, rms	Best Effort
Pulse Length (FWHM)	300 fs – 10 ps	
Temporal Amplitude Profile	Gaussian	Uniform [3]
Radial Amplitude Profile	Approx. Uniform	Best Effort [4]
MTBF	5000 hours	

Footnotes:

1) Measured on a Gaussian temporal and radial profile beam.
2) Measured with respect to a 79 1/3 MHz external master RF clock
3) ≤ 5% ripple, peak to peak, 1 ps rise/fall times on 10% - 90% of full amplitude.
4) ≤ 10% ripple, peak to peak

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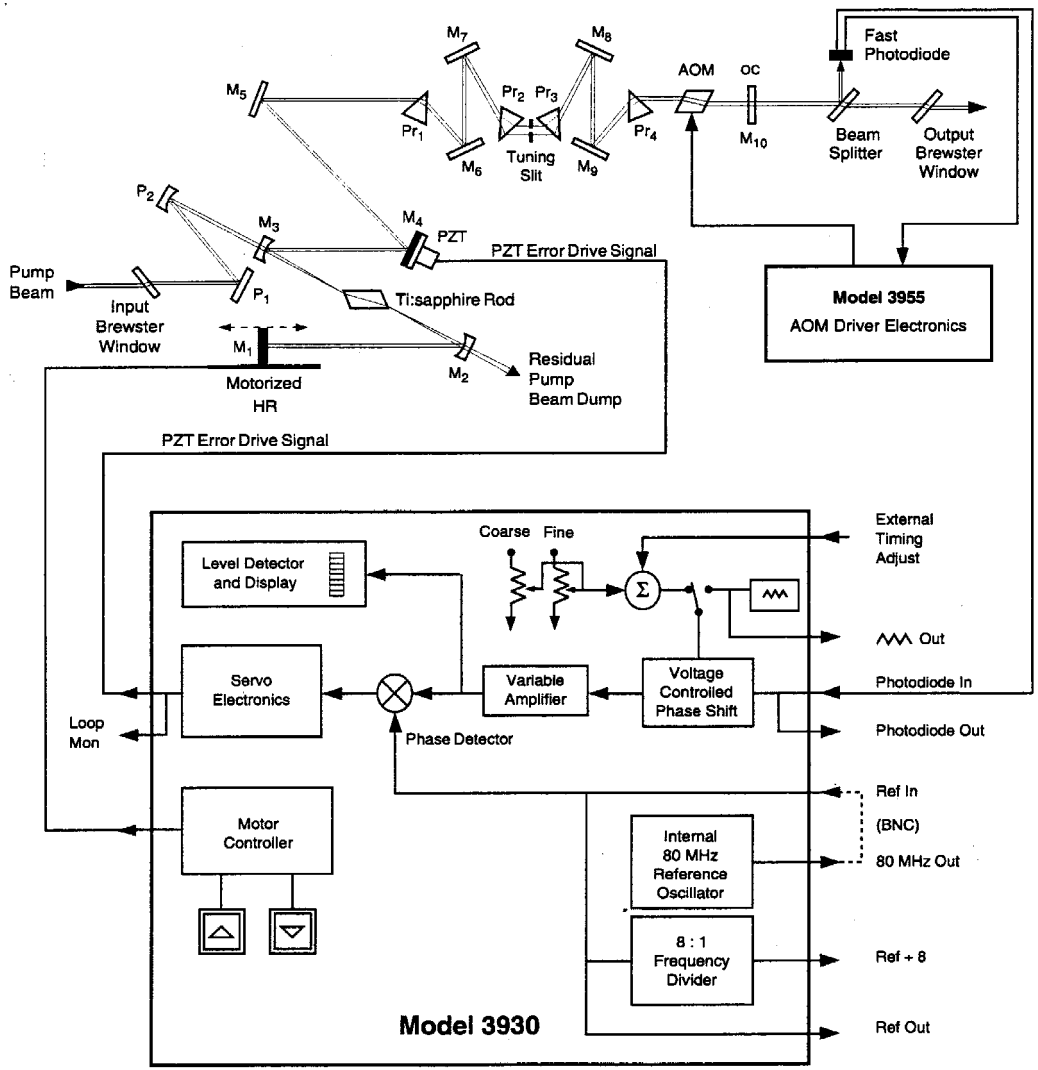
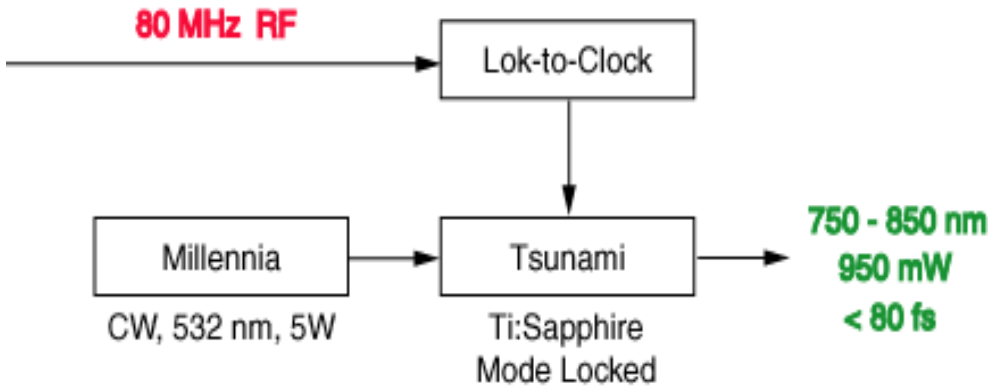
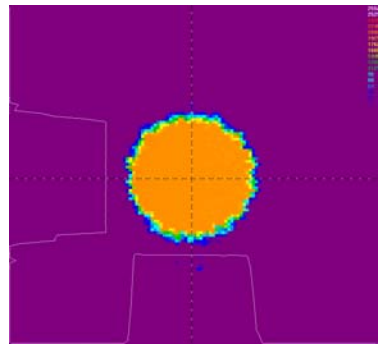
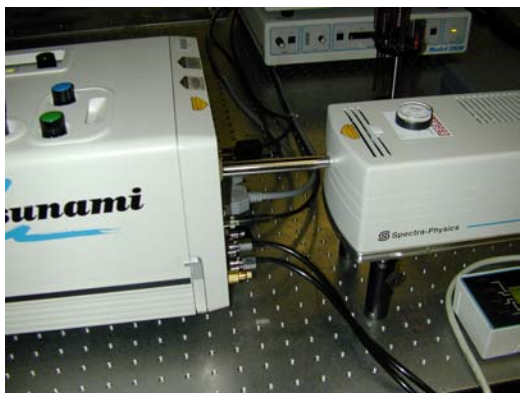


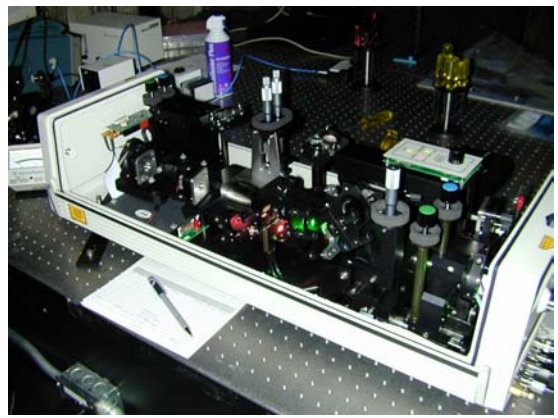
ORION LASER OSCILLATOR





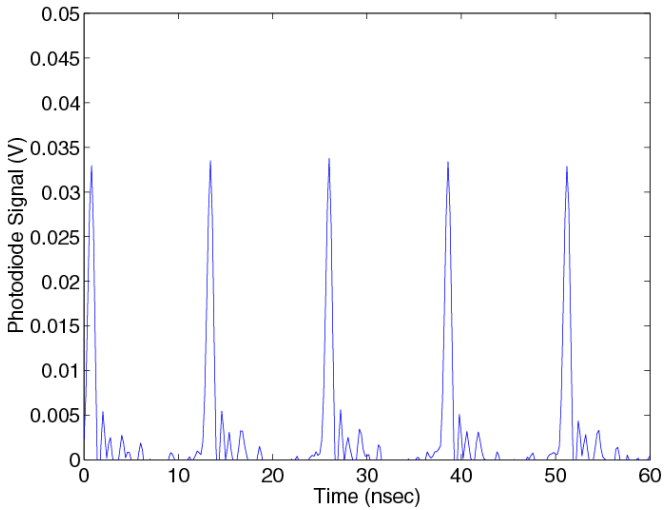
FIRST LIGHT @ 800 nm





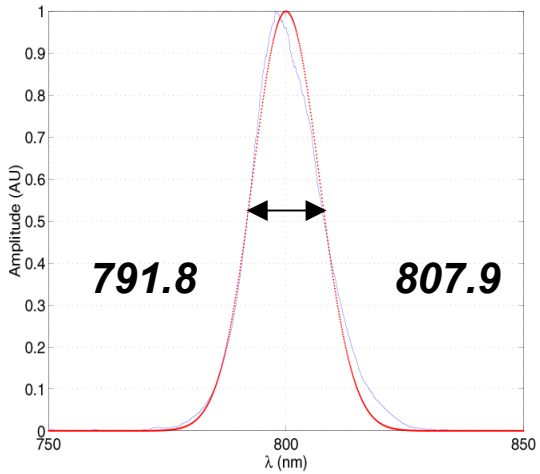
ORION LASER OSCILLATOR

Photodiode Signal



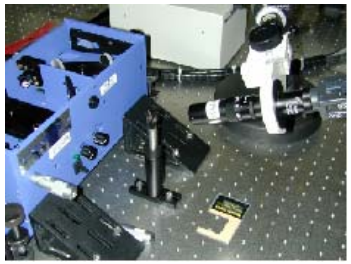
79.3333 MHz → ***12.61 nsec***

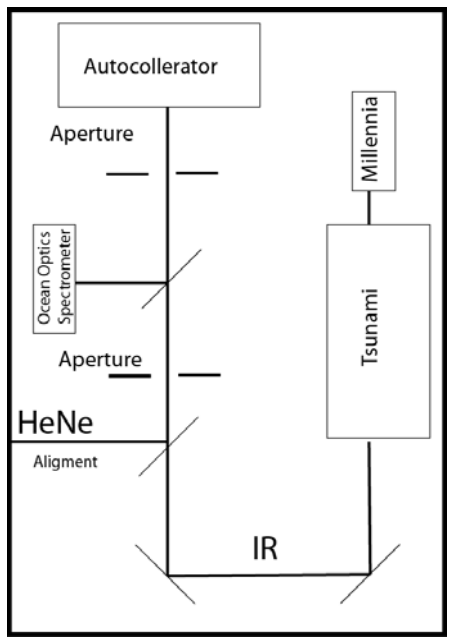
Spectral Measurement

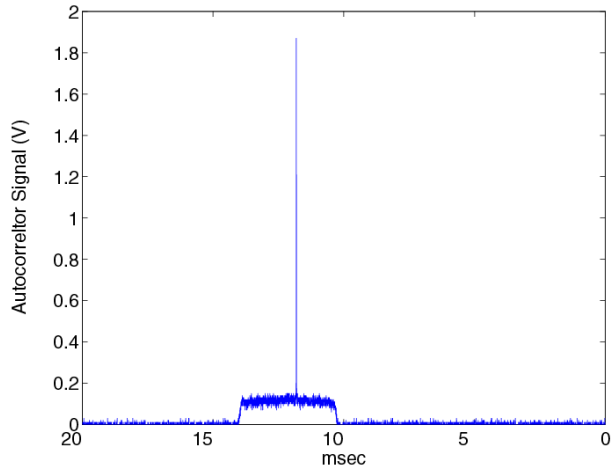


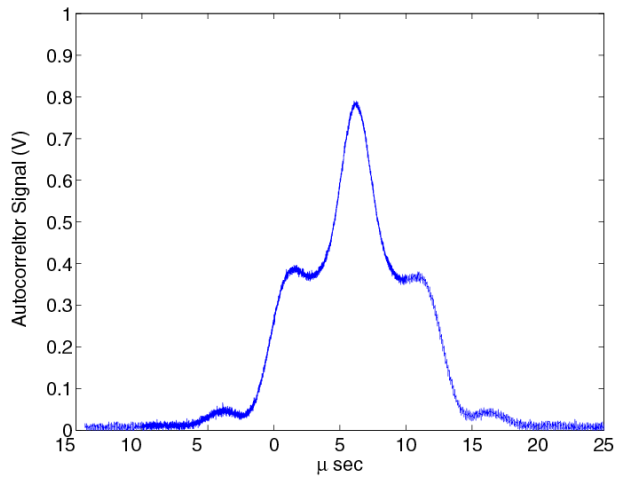
$\Delta\lambda$ = 16.1 nm

Autocorrelation Measurement









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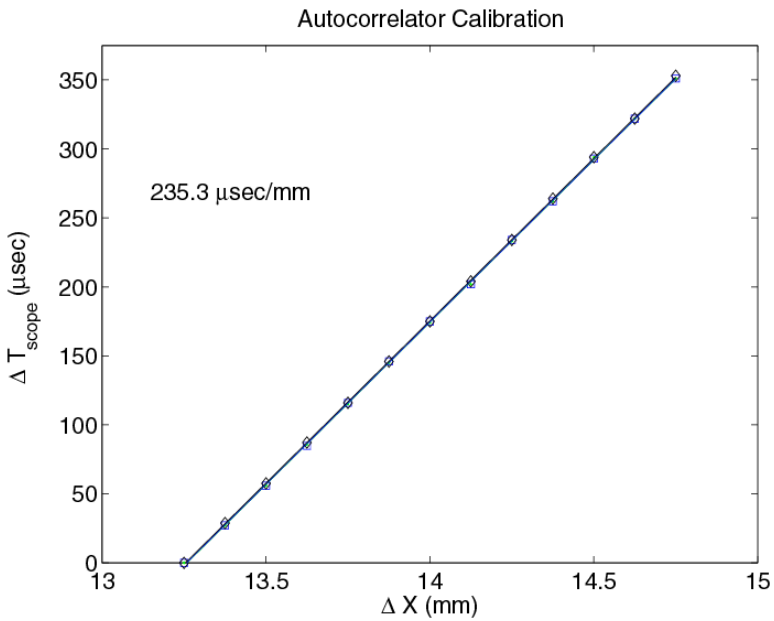
$32 \frac{psec}{msec}$

Autocorrelation Calibration



$$\frac{T}{t} = 28.33 \frac{psec}{msec}$$

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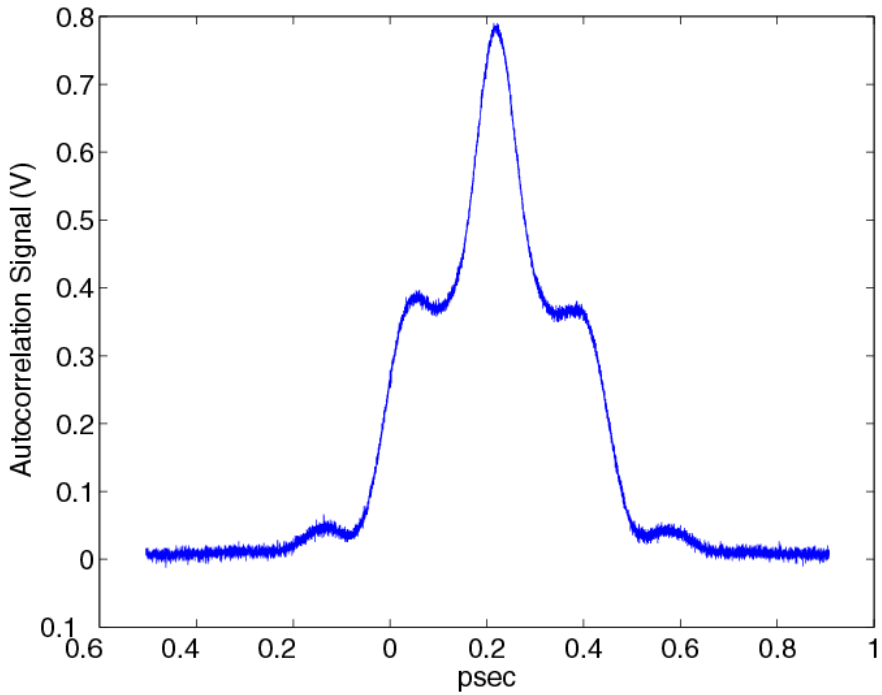
Autocorrelation Measurement



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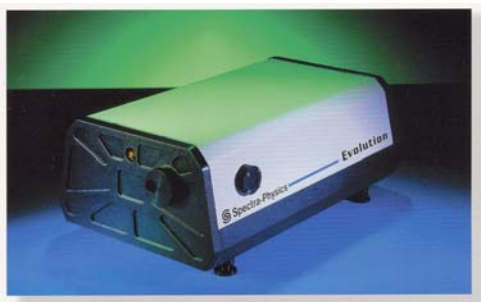
TSA – 25

Regenerative Amp + Multi-pass Stage + future upgrades

Evolution X



Diode Pumped Nd:YLF
10 mJ @527 nm 1KHz

LAB-170-10

Nd:YAG pump 400 mJ 10 Hz
for Multi-pass Amplifier

Phase Noise Circuit Diagram

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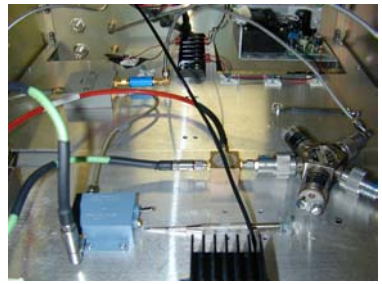

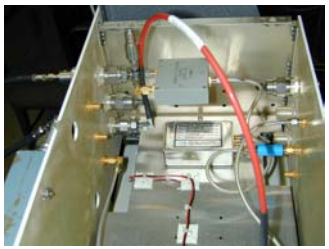

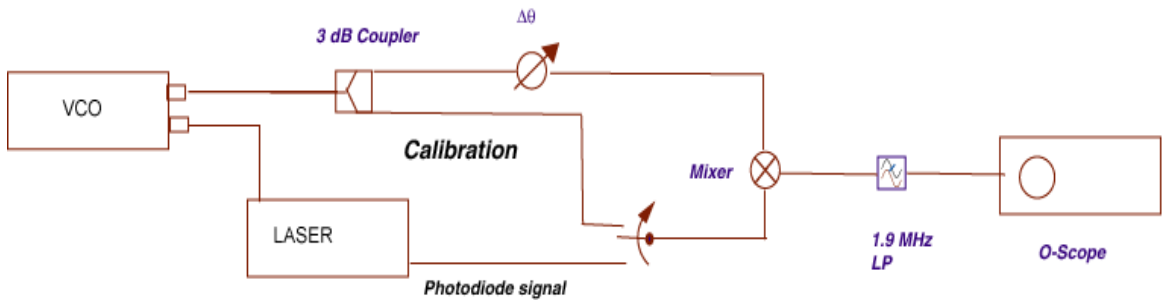

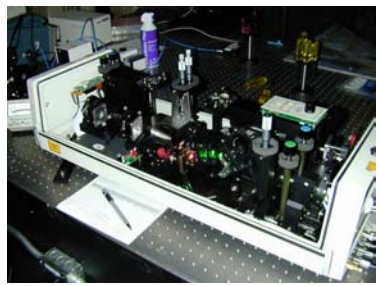

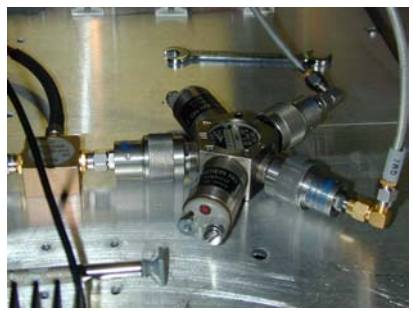

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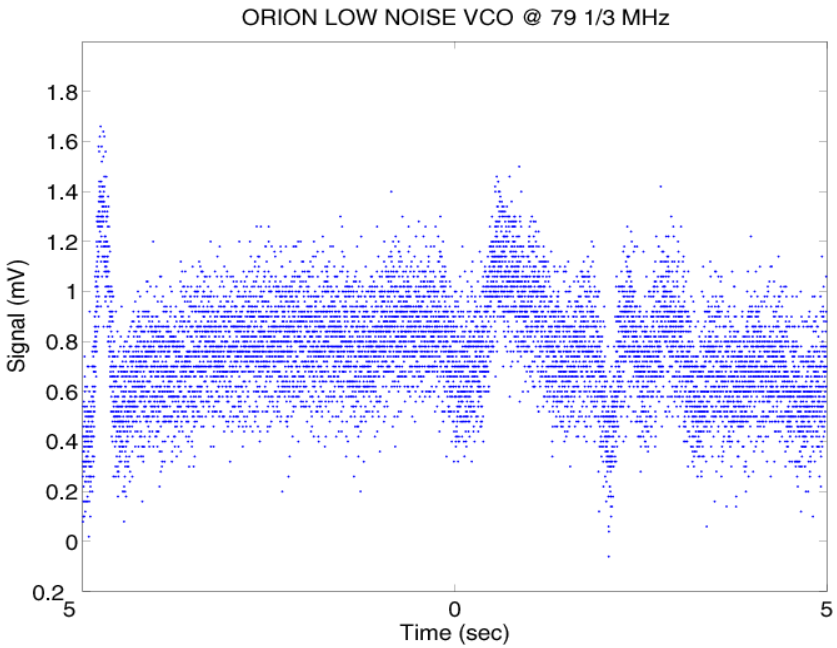
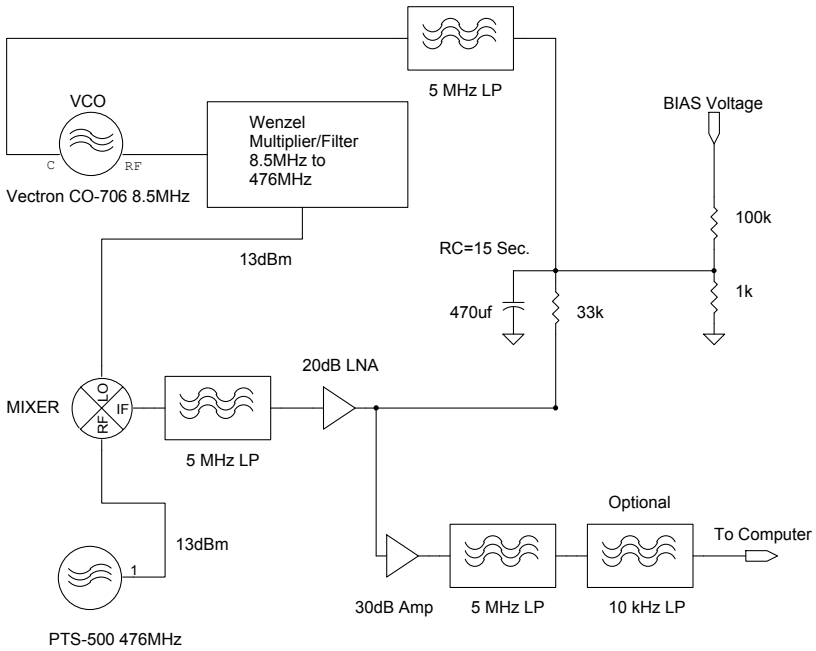
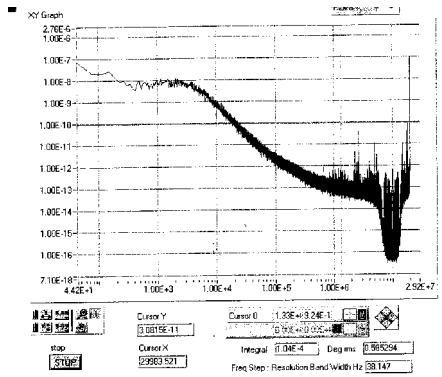


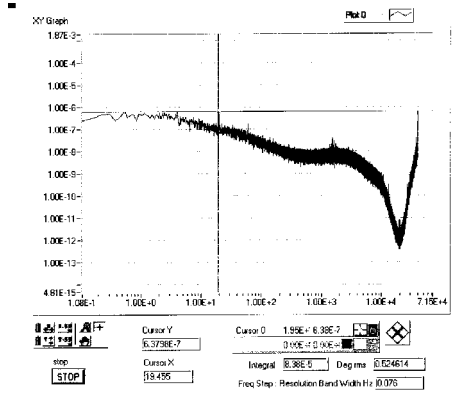
0.142 ^{o} = 1 mV

0.035 ^{o} @ 79 1/3 MHz

1.28 psec @ 2856 MHz





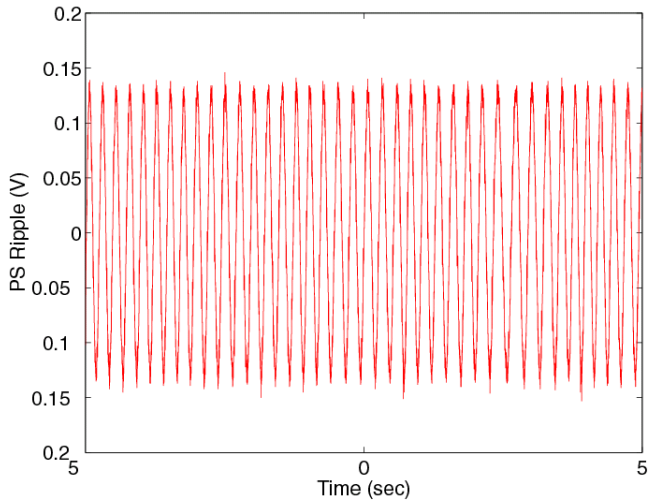


Jitter ~ 500 fsec

R. Akre et al.

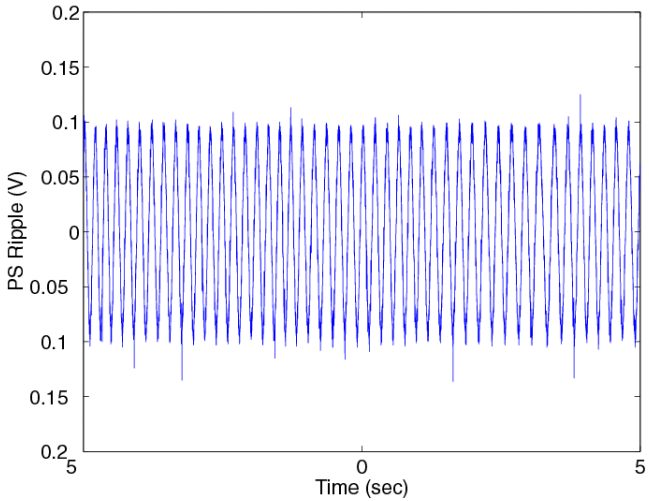
Power Supply Noise

Unregulated P.S.



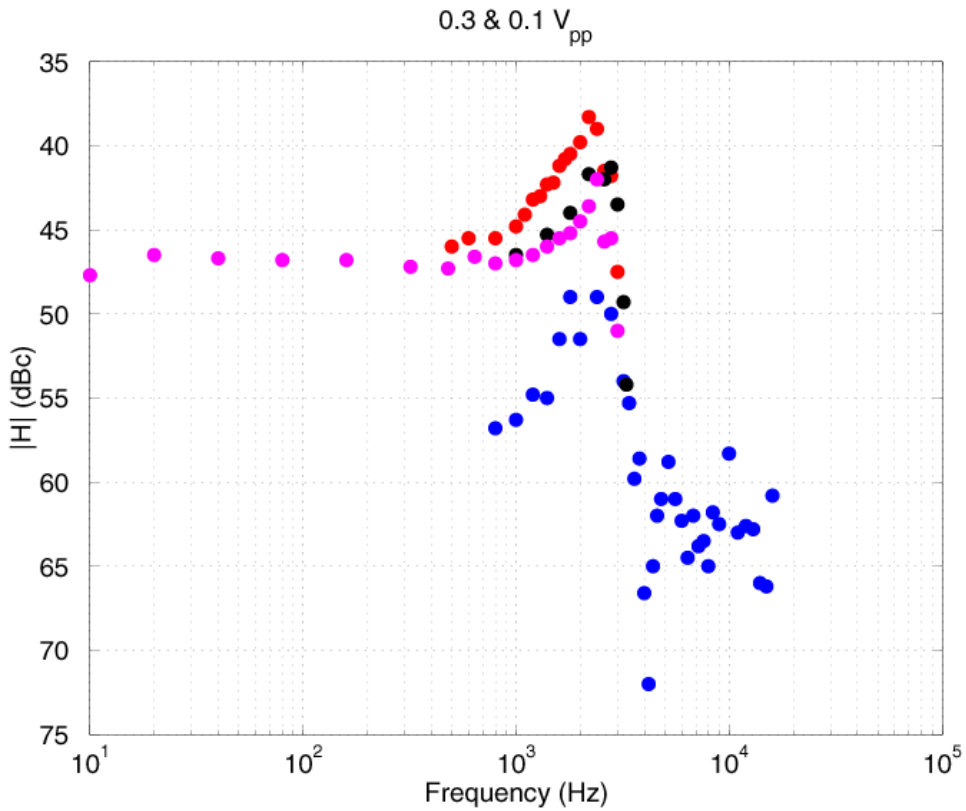
RMS = 90 mV

Regulated P.S.



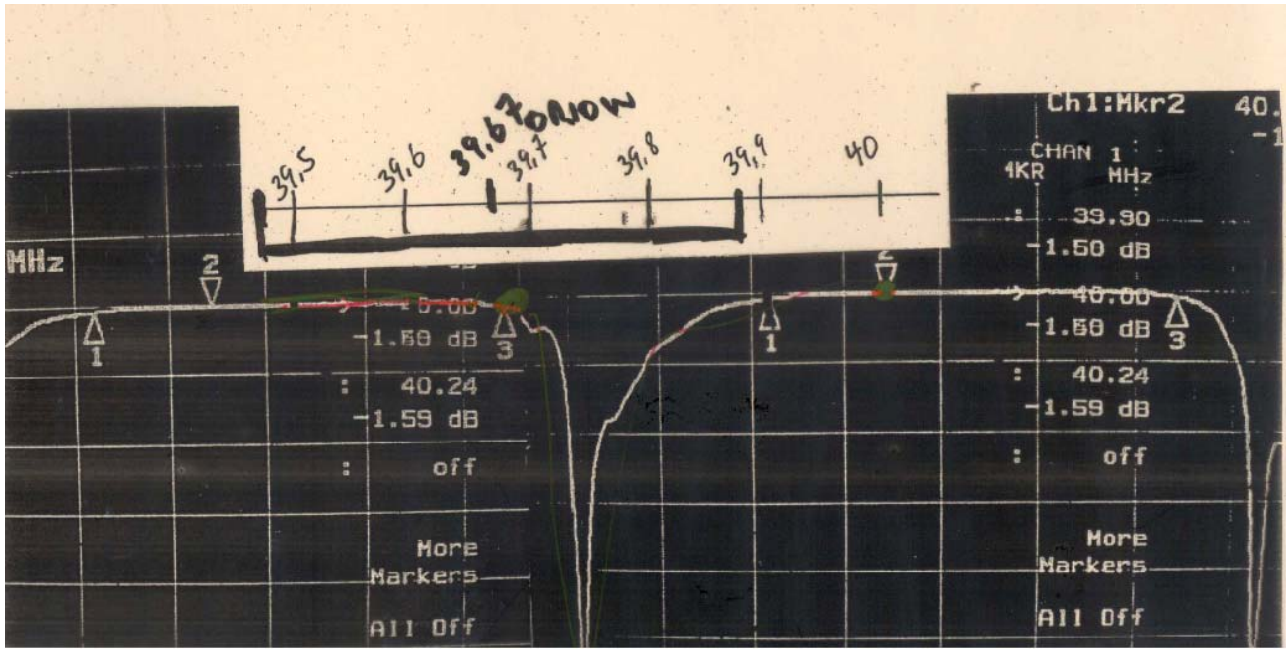
RMS = 64 mV

Bode Plot


0.3 & 0.1 V_pp
35
40
45
50
55
60
65
70
75
|H| (dBc)
10^1
10^2
10^3
10^4
10^5
Frequency (Hz)

Replace AOM for 79 1/3 MHz

Accelerator Research Department B



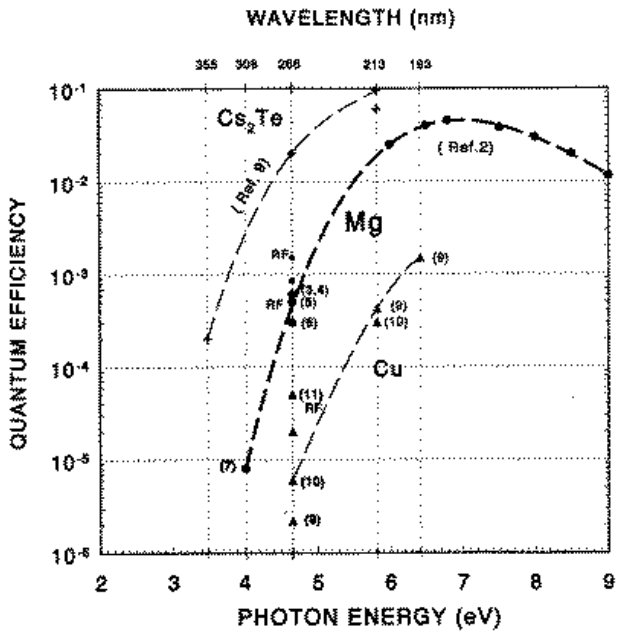
Courtesy of SP Laser Corp

CU_{100}

Mg

????

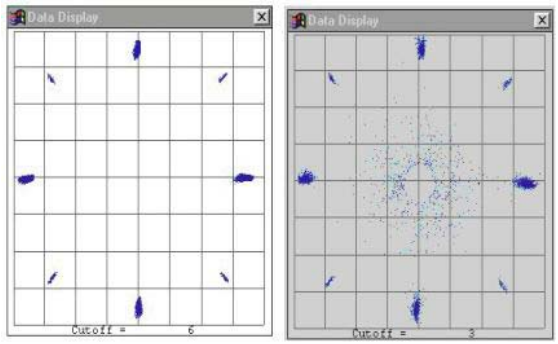
MAGNESIUM PHOTOCATHODE EFFICIENCIES
VS. PHOTON ENERGY
COMPARED TO Cu AND Cs_2Te



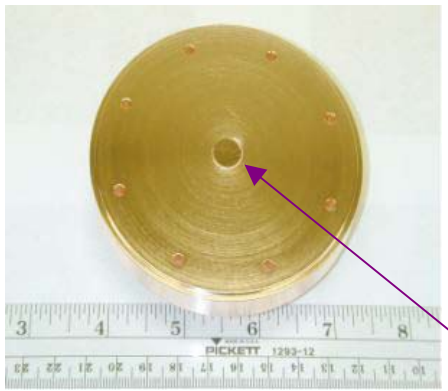
Laboratories: Oak Ridge Ref. 2; CERN Ref. 9; BNL Ref. 3,4,5,6,10,11
Nuc. Res. Ctr. (Israel) Ref. 7

Single Crystal Copper Photocathode

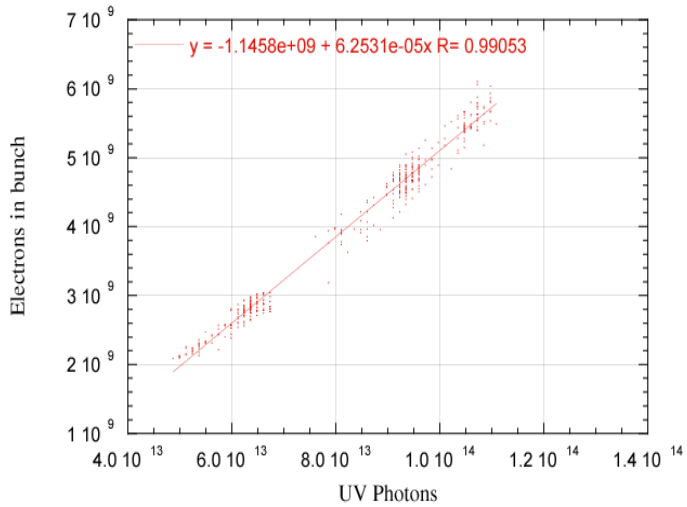
Before **After**



Ez ~ 90 MV/m
Q = 90°



CU 100



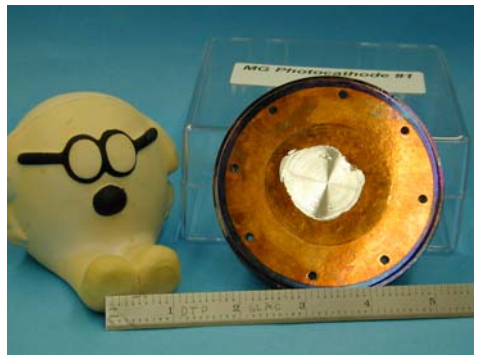
QE = 6.2 x10^{-5}

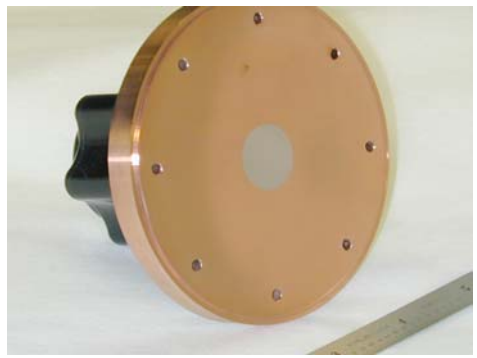
Mg Photocathode Development

NCT, Inc. Friction Welding

Mg Rod 99.97%

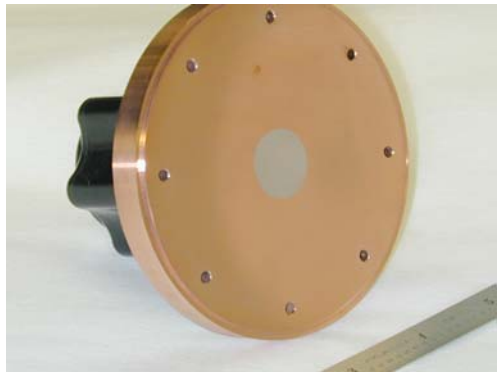
Element	Concentration (ppm)
Mo	Major
Al	30
Zn	50
Mn	31
Fe	34
Ni	4
Cu	2
Si	30
Pb	10
Ca	10
Sn	<10
Cd	<1



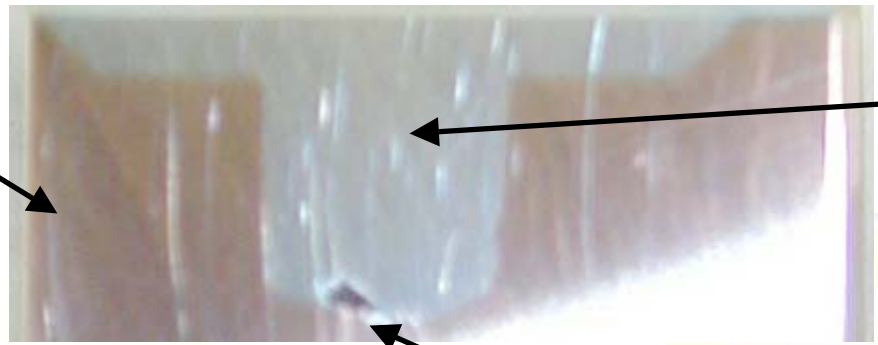


D.T. Palmer x4611

Friction Welded Mg Photocathode



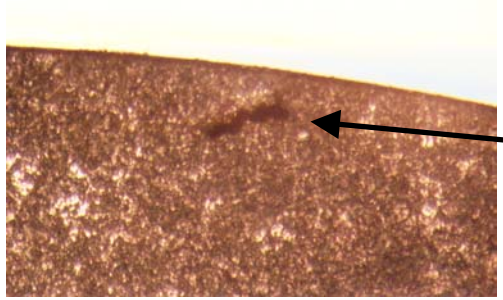
OFHC Grade II copper

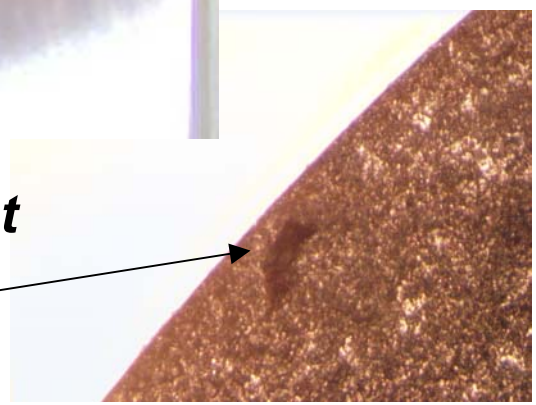


Mg

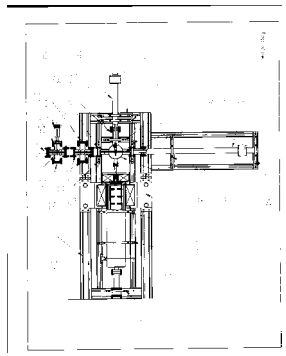
Vent

1 μm

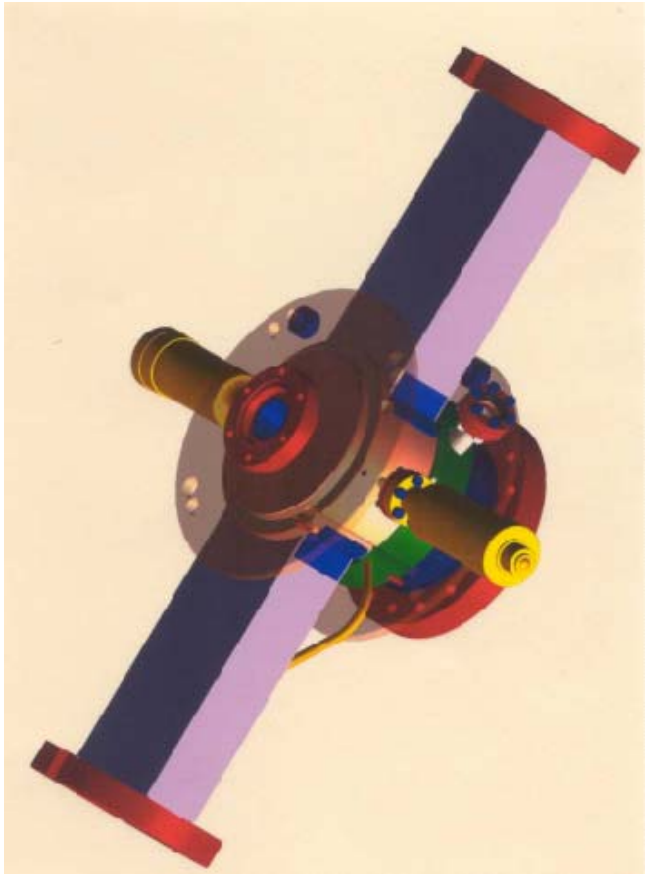




Next Steps…..



Possible Prototype LCLS RF Gun



THE ORION GROUP

1) Robert Noble
2) Ben Cowan
3) Patrick Muggli
4) Mark Hogan
5) Robert H. Siemann
6) Brent Blue
7) Dennis T. Palmer
8) Caolionn O'Connell
9) Eric Colby

14 Nov 2001

Photo by K. Jobe

Whose missing????