PROGRESS OF DELHI LIGHT SOURCE (DLS) AT IUAC, NEW DELHI*

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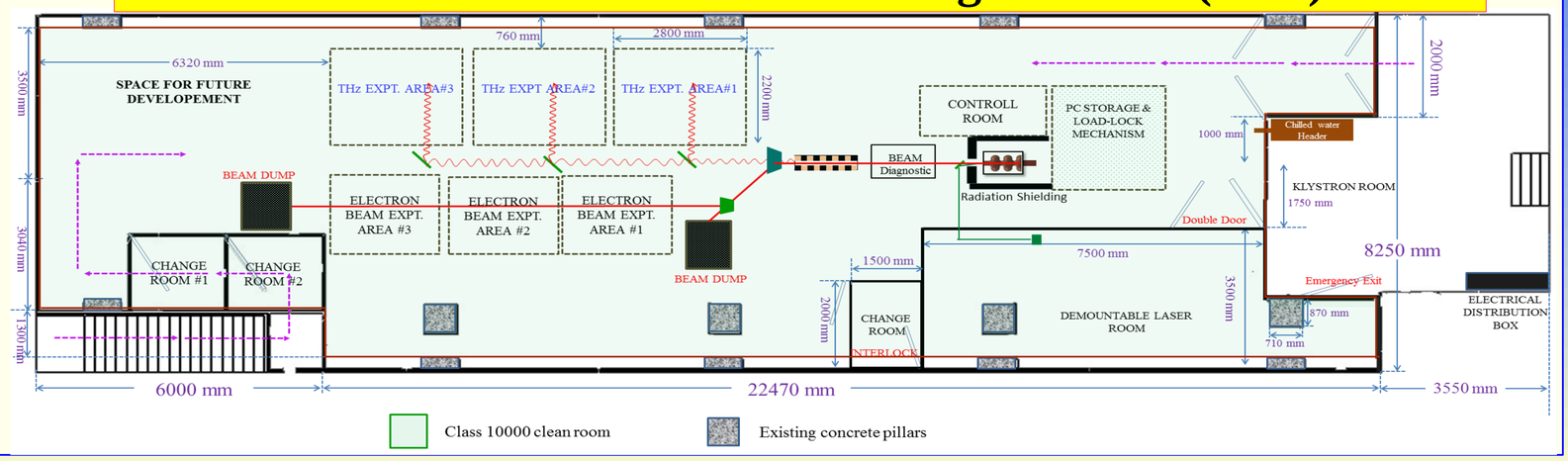
Introduction

- Delhi Light Source (DLS) project has 3 phases:
  - Phase-I: NC RF electron gun, Prebunched FEL, ~ 8 MeV, 0.15 – 2 THz, λ = 2 mm -150 μm.
  - Phase-II: SC RF electron gun: Terahertz (high av. power) radiation
  - Phase-III: A few 9 cells Tesla type cavities, Energy boost up: 8 – 40 MeV, IR by undulator, Soft X-rays by Inverse Compton Scattering
- Estimated time to complete Phase-I: by 2018

Schematic of Phase-I of Delhi Light Source (DLS)



Various development of Phase-I of DLS

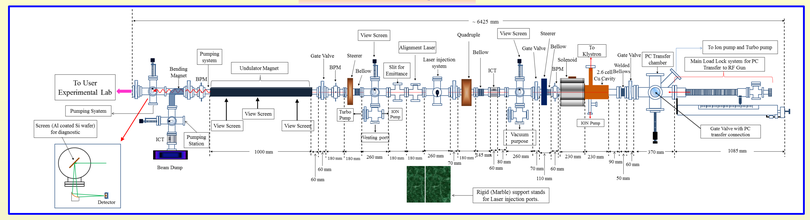
Major Components

- NC copper cavity. Klystron and Modulator
- Photocathode deposition /transfer mechanism
- Devices – Laser, Undualtor, other magnets
- Beam diagnostic / radiation detection devices

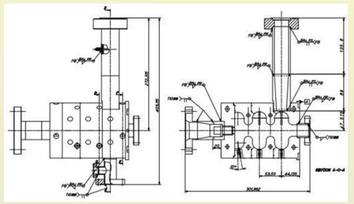
Uniqueness of the facility

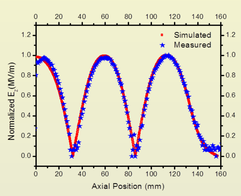
- Prebunched FEL by splitting a laser pulse in 16
- Tunability - varying laser pulse separatn
- Compactness of the facility ~ a few metres
- Very low emittance – use of photocathde

Beam Line layout



Copper cavity as electron gun





- Central frequency = 2859.795 MHz @ 24.8C
- β = 0.904, Metal bead dia ~ 1.89 mm

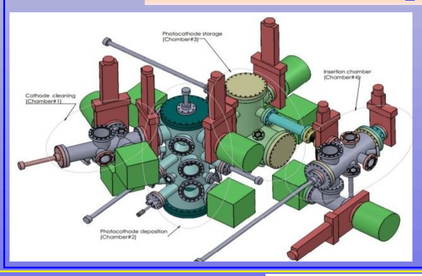
$$\frac{1}{Q_0} = \frac{1}{Q_L} - \frac{1}{Q_{ext}} = \frac{1}{7988} - \frac{1}{16822}$$

$$Q_0 = 15211$$

Klystron and Modulator Parameters

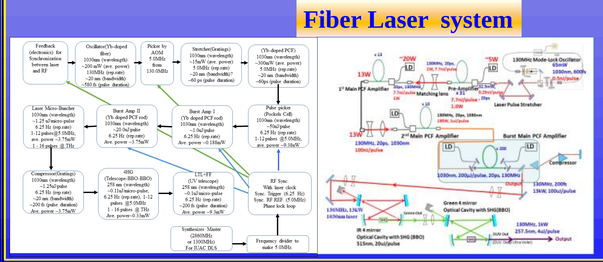
Sr. No.	Parameter – RF system	Value
1	Peak Output power	≥ 25 MW
2	Average Output power	≥ 5 kW
3	Operating frequency	2860 MHz
4	Bandwidth (-1 dB)	± 1MHz
5	RF pulse duration	0.2 μs to 4 μs
6	Pulse repetition rate	1-50 Hz
7	Pulse top flatness	±0.3%
8	Rate of rise and fall of modulator output voltage	200-250 kV/μs
9	Long term stability	±0.05 %

Photocathode deposition system

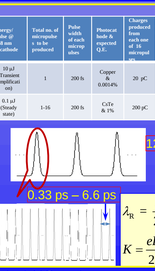


- Steps to be followed:
  - Clean Mo substrate – chamber 1.
  - Transfer the plug to PC deposition chamber.
  - Deposit Te @ 1nm/min (up to ~10 nm).
  - Evaporate Cs at the same rate likeTellurium.
  - Monitor QE by illuminating UV light.
  - Continue till QE peaks
  - Typically max QE is recorded for ~100 nm.
  - State of the art, Performance varies,

Fiber Laser system

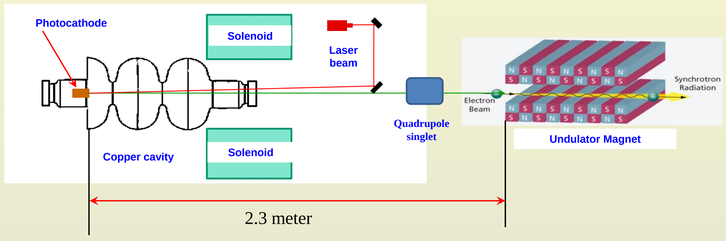


Energy/ Pulse @ 258 nm @Cathode	Total no. of micropulse s to be produced	Pulse width of each micro-p ulses	Photocat hode & expected Q.E.	Charges produced from each use of 16 micropul ses	Max Average Current (15x16 bunch structure @12.5 Hz rep rate)
10 μJ (Transient amplificati on)	1	200 fs	Copper & 0.001-4%	20 pC	3.8 nA
0.1 uJ (Steady state)	1-16	200 fs	CsTe & 1%	200 pC	600 nA

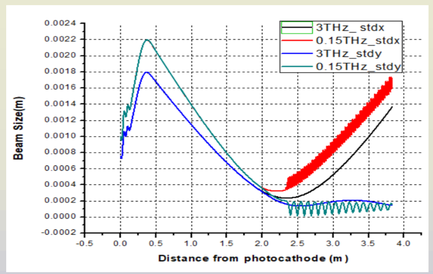


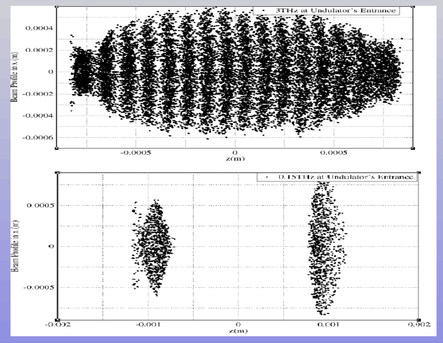
$$\lambda_R = \frac{\lambda_U}{2\gamma^2}[1+K^2] \qquad K = \frac{eB_1\lambda_U}{2\pi mc}$$

Beam Optics Simulation

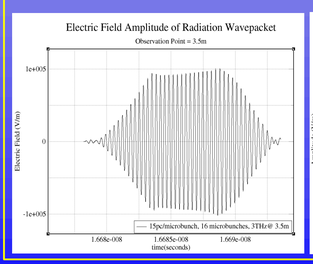


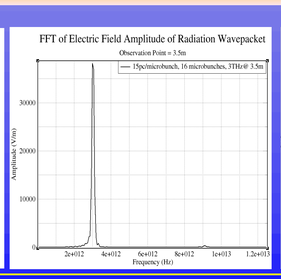
Range of Radiation Frequency (THz)	0.15	3
Accelerating field (MV/m)	58.5	110
Launching Phase (deg)	30	30
Electron Energy (MeV)	4.1	8.1
Energy spread (%)	1.1	0.43
e-beam FWHM @ Cathode (fs)	200	200
Total Charge (pC)/microbunch	15	15
Number of microbunches	2	16
Av. Microbunch separation @ Undulator's entrance	6.6	0.345
Peak Current (A) at undulator entrance	20	75
$\sigma_{x,y}$ (mm) at undulator's entrance	0.25, 0.19	0.27, 0.17
Emittance (x, y) mm-mrad at undulator's entrance	3.7, 0.04	0.2, 0.01

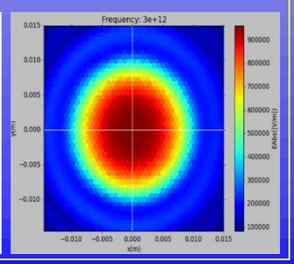




Simulation calculation on THz radiation

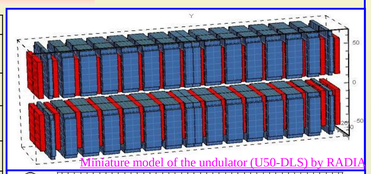




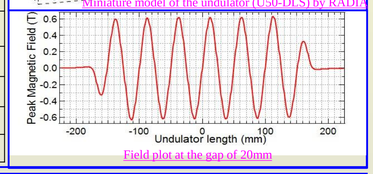


Design of Undulator

Technology	Hybrid planer Anti-symmetric
Magnet	Permanent NdFeB magnet (B_r =1.21T)
Pole	Vanadium permendur
Magnetic gap	20-45 (mm)
Period length	50 mm
No of Periods	28 (Full)
Magnetic field	0.62 -0.11 (T)
Undulator parameter (K)	2.89-0.61
Radiation Frequency	0.18 - 2.85 THz
Device length	~1.5 m



Miniature model of the undulator (U50-DLS) by RADIA

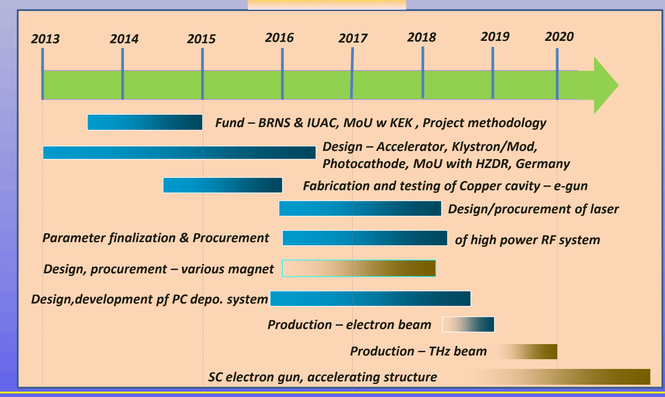


Field plot at the gap of 20mm

Present Status

- Class 10000 clean room to accommodate the complete facility was installed
- Copper resonator was fabricated, tested w low power, to be installed beginning of 2018
- Beam optics calculation is finalized. Radiaion simulation is going on
- Parameter finalization for Klystron/Modulator was over, order was, device to be delivered at the beginning of 2018
- Parameter finalization for Laser is done. Detail design of the fiber laser is going on. Development will start - end of this year, to be operational at IUAC by Summer, 2018
- Basic design of Photocathode deposition system is done, fabrication will start - next 6 months
- Various beam optics components and electromagnet are being designed or procured.

Time Chart



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