SIMULATION CALCULATION OF COMPACT THZ FACILITY AT IUAC, NEW DELHI

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Type: Poster
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Overview and work objective

- **System**: Delhi light source (DLS) at IUAC, New Delhi:
- Compact pre-bunched FEL THz facility under commissioning (THz range: ~ 0.2 – 3 THz).
- Will use 2, 4, 8, 16 micb with adjustable micb seperation to obtain coherence and tunability.

RF gun:

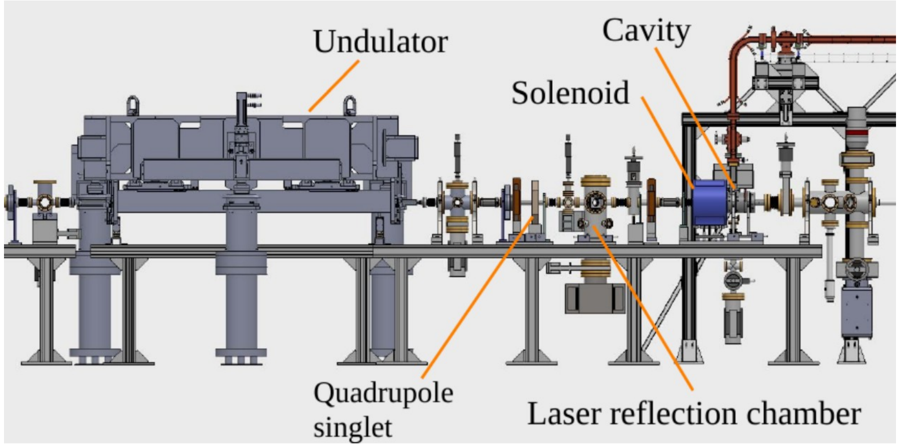
- 2860 MHz,
- 2.6 cell Cu cavity.

Max peak field: 115 MV/m

Energy range: 4 – 8 MeV

Und field : 0.12 T – 0.61 T

Und period : 33 (48mm)



Beamline

Present status : RF gun conditioning and dark current studies ongoing. [*Proc of IPAC 21 ; ID: TUPAB105*]

Objective: Optimize beam optics simulations for optimizing radiation output (presented for ~ 0.5 & 2 THz).

Beam optics simulations

Optimizations aimed to :

achieved by

Minimize line width

- beam matching at undulator entrance (to minimize betatron amplitude) → tuning solenoid + quad singlet.
- keep energy spread to as min possible → proper selection of cavity field & RF phase, no of micb, micb charge, transverse & temporal size at PC.
- ***Increase spectral intensity***
- Intensity (I) : → micb separation and charge, use quad singlet.

$$I \propto N_m N_b^2 B_0^2$$

N_m : no of micb

N_b : e^- s in a micb

N : no of e^- s in macro-bunch

ω : frequency of interest

t_j : temporal position of j^{th} particle

- Bunching factor:

$$B_0 = \frac{1}{N}\sum_{j=1}^{N} e^{i\omega t_j}$$

- maximizing BF through undulator.

Optimized parameters

Parameter	~ 0.5 THz	~ 2.0 THz
Charge/micb	15 pC	15 pC
No. of micb	4	8
rms transverse size @PC	9 mm	11 mm
rms temporal size @PC	85 fs	85 fs
micb separation @PC	2350 fs	626 fs
particles/micro-bunch	10000	10000
Beam energy	6.44 MeV	8 MeV
rms energy spread @ und.	36.5 keV	30 keV
Cavity field	88 MV/m	110 MV/m
Injection phase	30^o	30^o
undulator field	0.6 T	0.273 T

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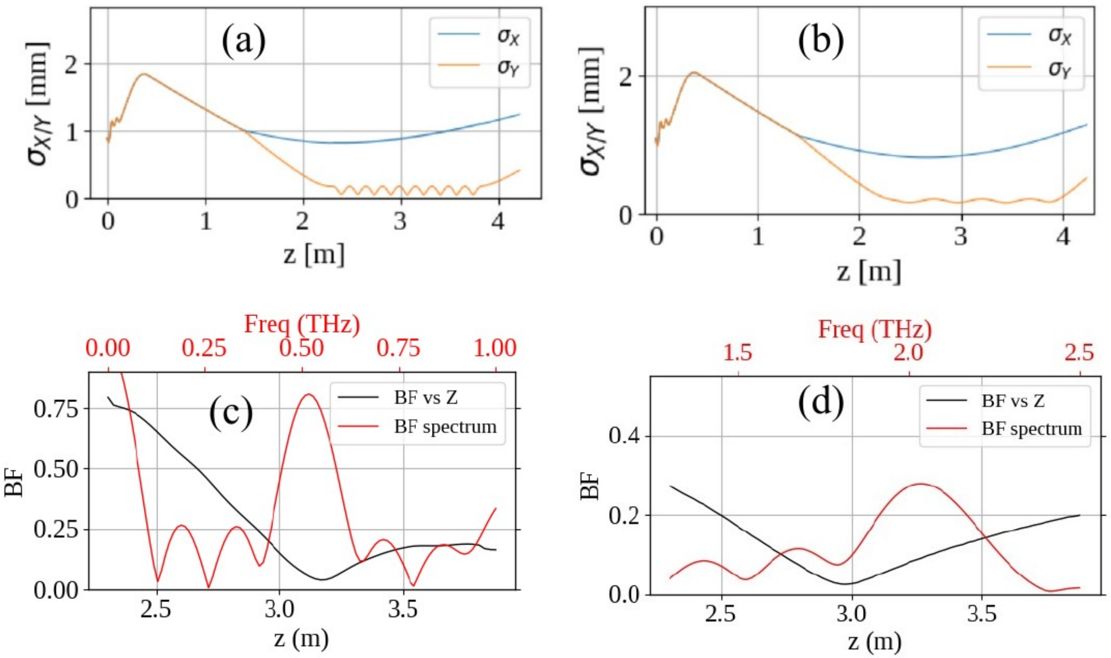
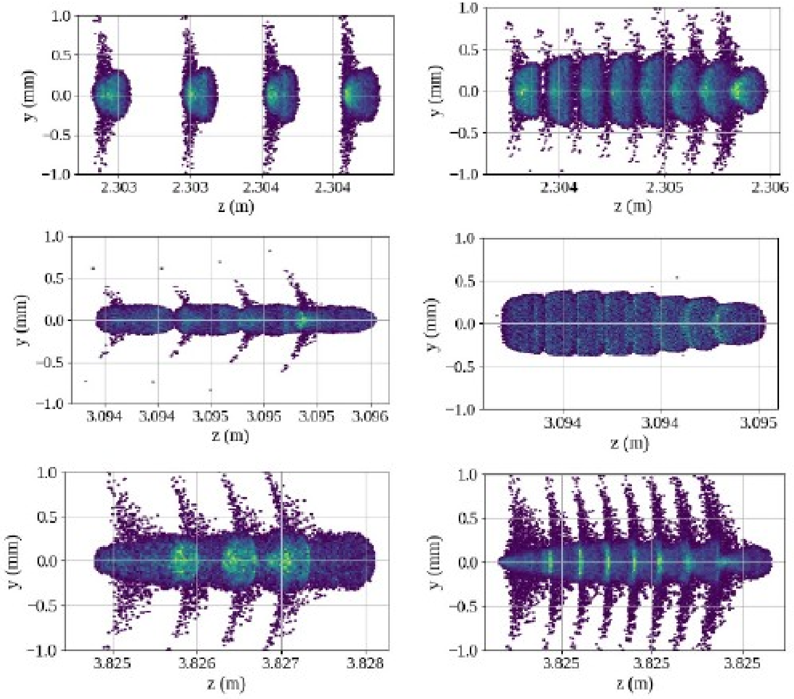
Beam optics simulations

Simulation results for 0.5 THz & 2 THz:



0.5 THz

2 THz



0.5 THz

2.0 THz

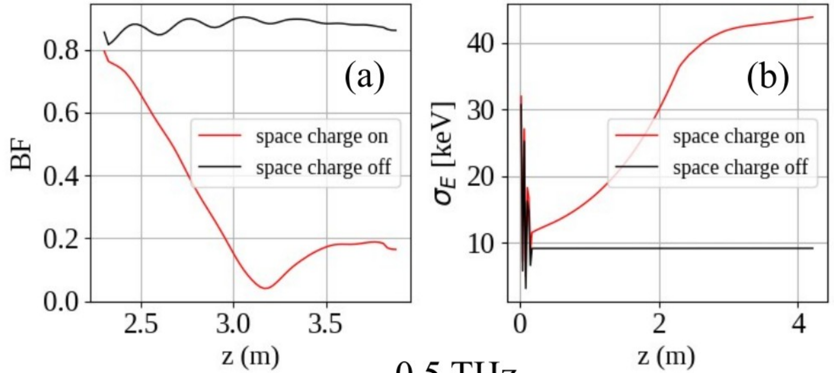
$\sigma_y \leq 0.2$ mm for both frequencies.

varying micb sep, BF is maximized

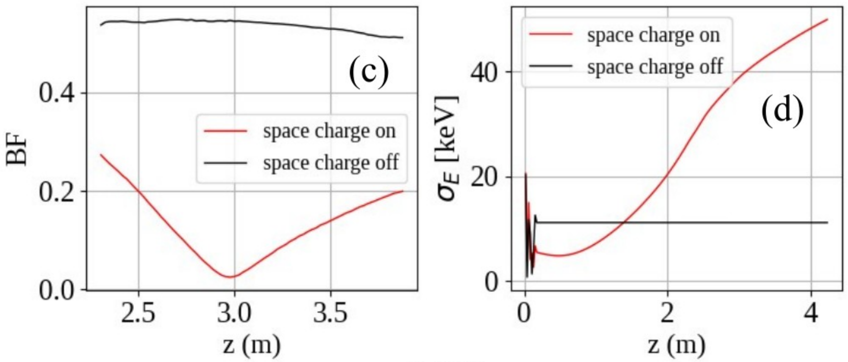
Long distb through und start, mid & exit.
(explains dip in the BF curve)

Beam optics simulations

Analyzing bunch behaviour inside undulator



0.5 THz



2 THz

Compared results with and without space charge.

➔ No dip observed for w/o space charge

➔ Energy spread factor of 4 lower w/o space charge.

Inference:

- Space charge introduces dynamic energy spread in micbs & macro bunch structure.
- Energy spread cause dispersive motion of micbs in undulator causing longitudinal expansion of micb.
- the outward moving particles of adjacent micb repel when very close, slowing down the relative motion of opposite moving particles and thus forming ordered cluster again.

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Radiation calculation:

Computation of radiation field and intensity

- Used the simulated trajectory data

$$\vec{r}_e(x, y, z, t) \qquad \vec{\beta}(\beta_x, \beta_y, \beta_z, t)$$

- to compute E field in advanced time steps

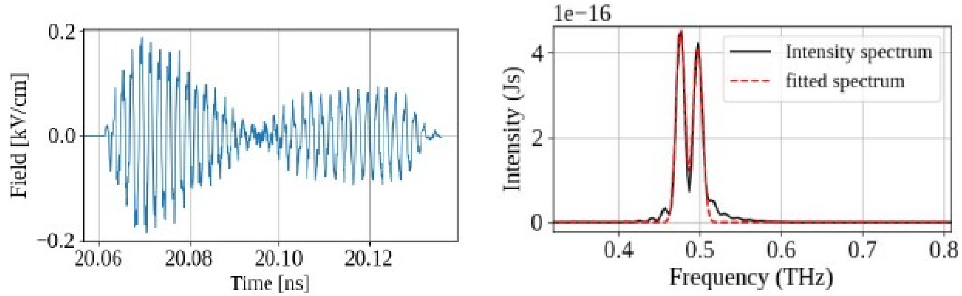
$$\vec{E}(\vec{r}_{ob}, t_{ad}) = \frac{q}{4\pi\varepsilon_0}\left[\frac{(\vec{n}-\vec{\beta})}{R^2\gamma^2(1-\vec{\beta}.\vec{n})^3} + \frac{\vec{n}\times\left[(\vec{n}-\vec{\beta})\times\dot{\vec{\beta}}\right]}{cR(1-\vec{\beta}.\vec{n})}\right]$$

where, $t_{ad} = t + \frac{|\vec{r}_{ob}-\vec{r}_e(t)|}{c}$, $\vec{R}(t) = \vec{r}_{ob} - \vec{r}_e(t)$ and $\vec{n} = \frac{\vec{R}}{|\vec{R}|}$.

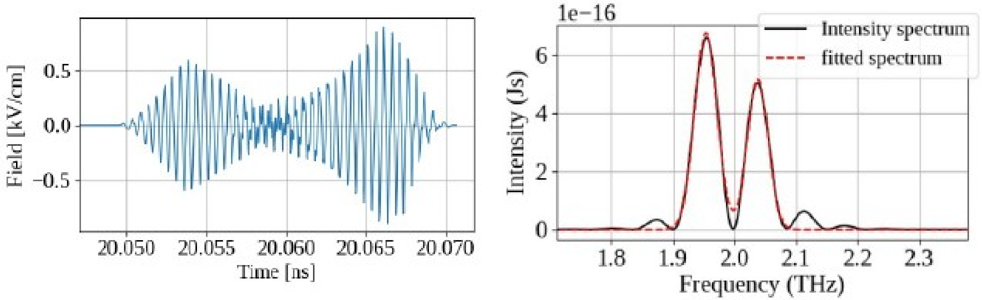
- Field in frequency domain $\vec{\varepsilon}(\omega)$ computed by fourier transform.
- finally computed spectral intensity using:

$$\frac{d^2I}{d\Omega d\omega} = 2.|\vec{\varepsilon}(\omega)|^2$$

Simulation results:

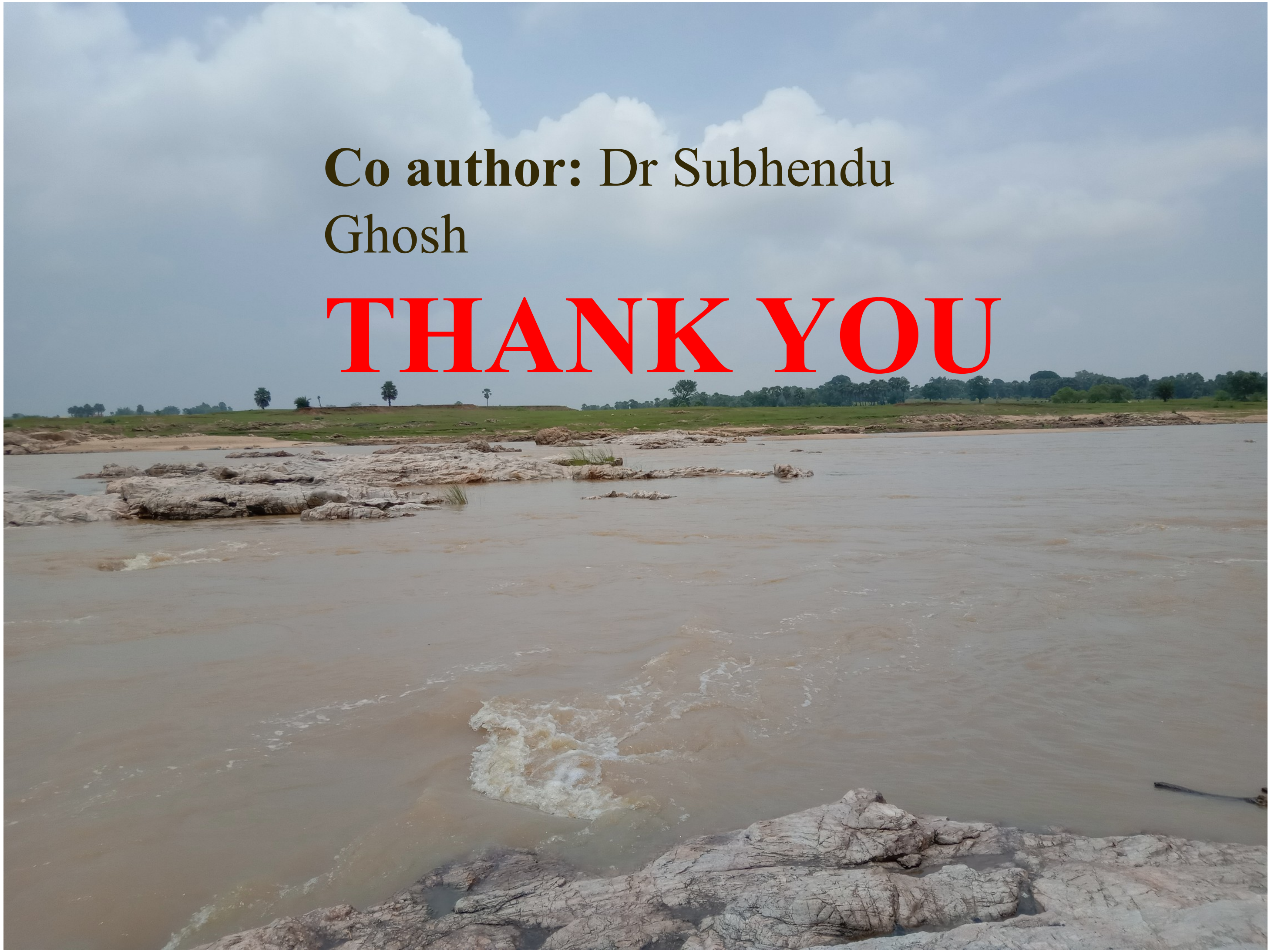


0.5 THz



2.0 THz

Two peaks corresponding to micb structure before and after diffusion.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THANK YOU