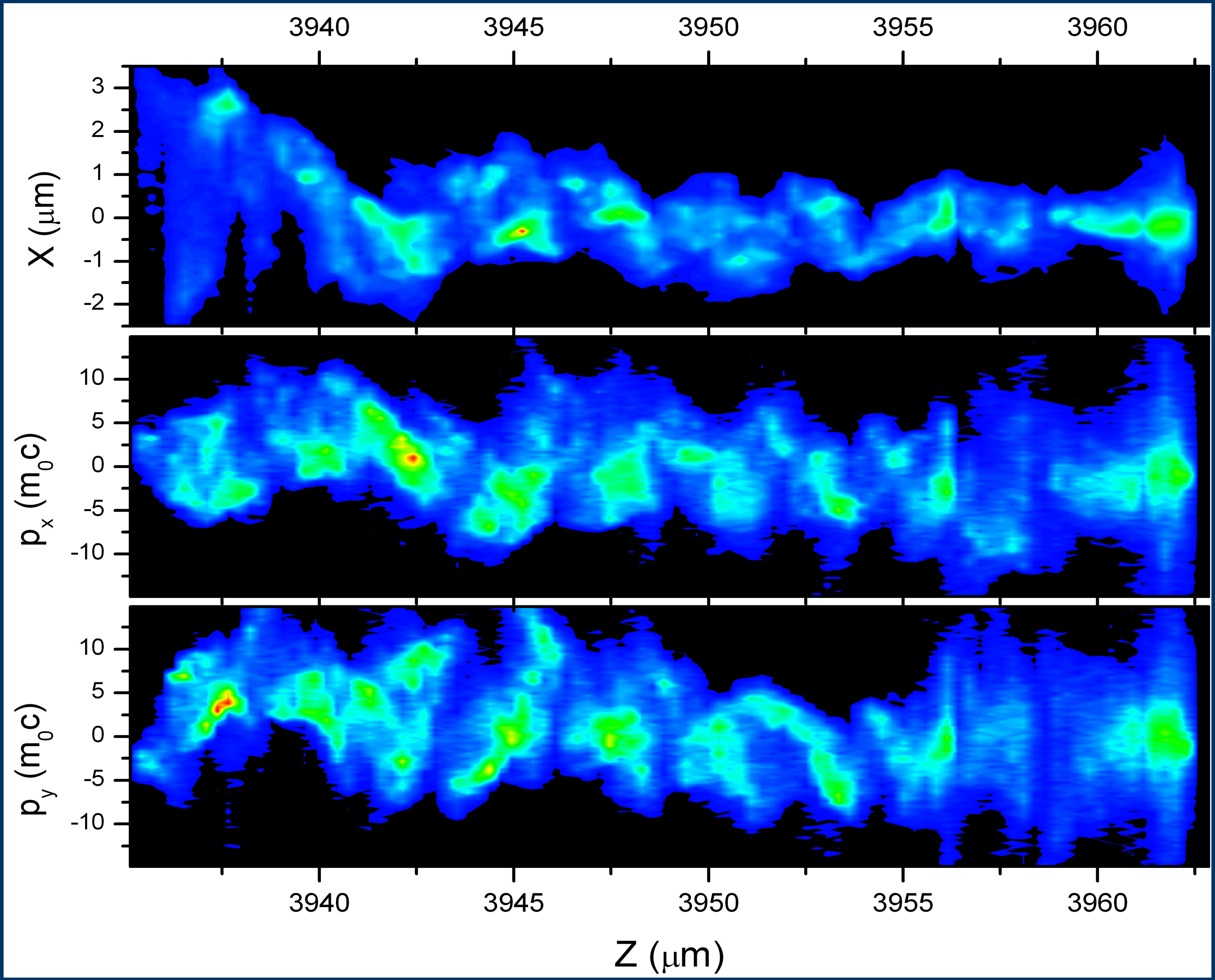
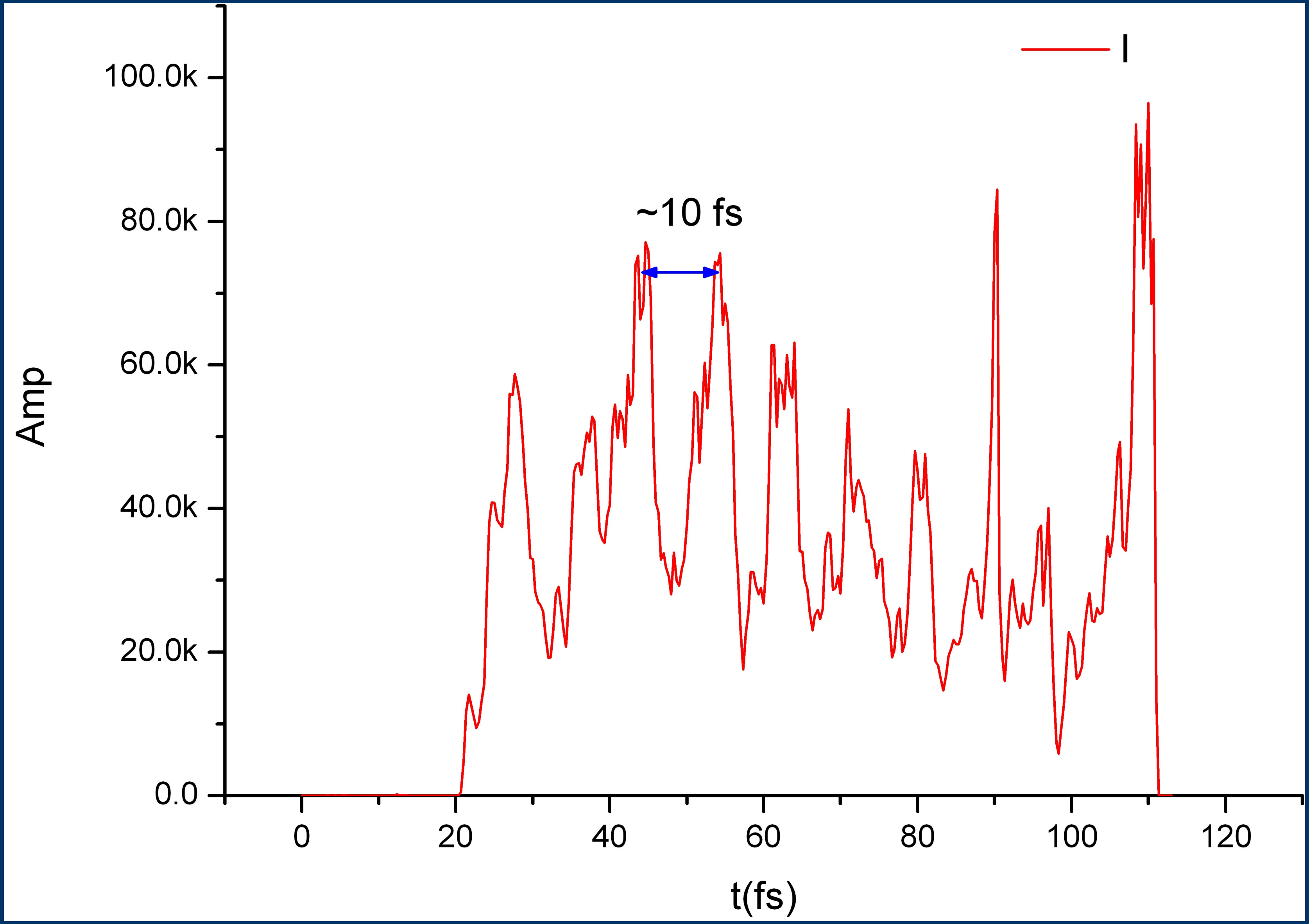
Exploiting CTR to perform beam dignostics @ SITE

- The self injected bunch displays a high degree of current modulation due to the diode effect.



- The self injected bunch displays a high degree of current modulation due to the diode effect.

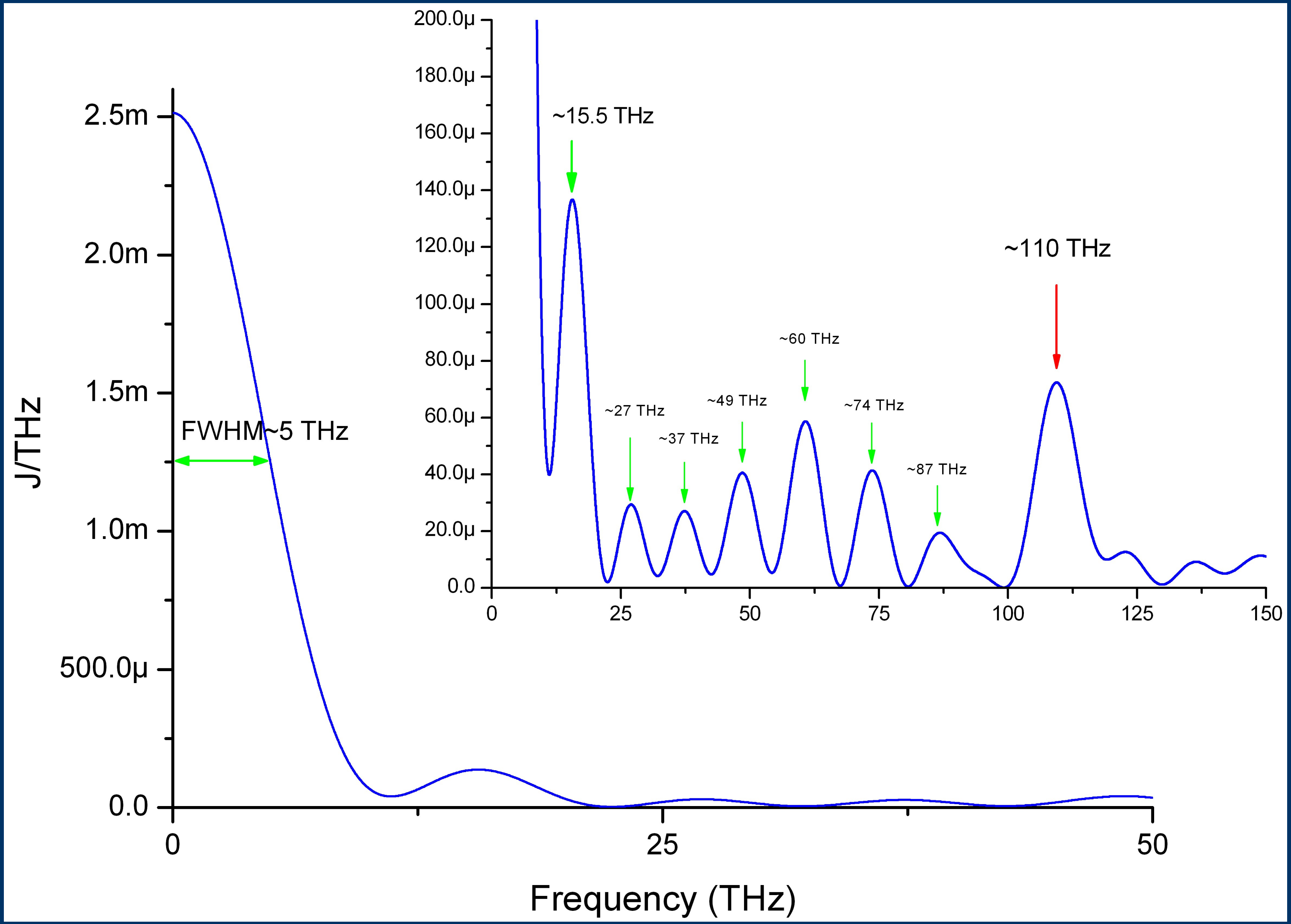


Assuming:

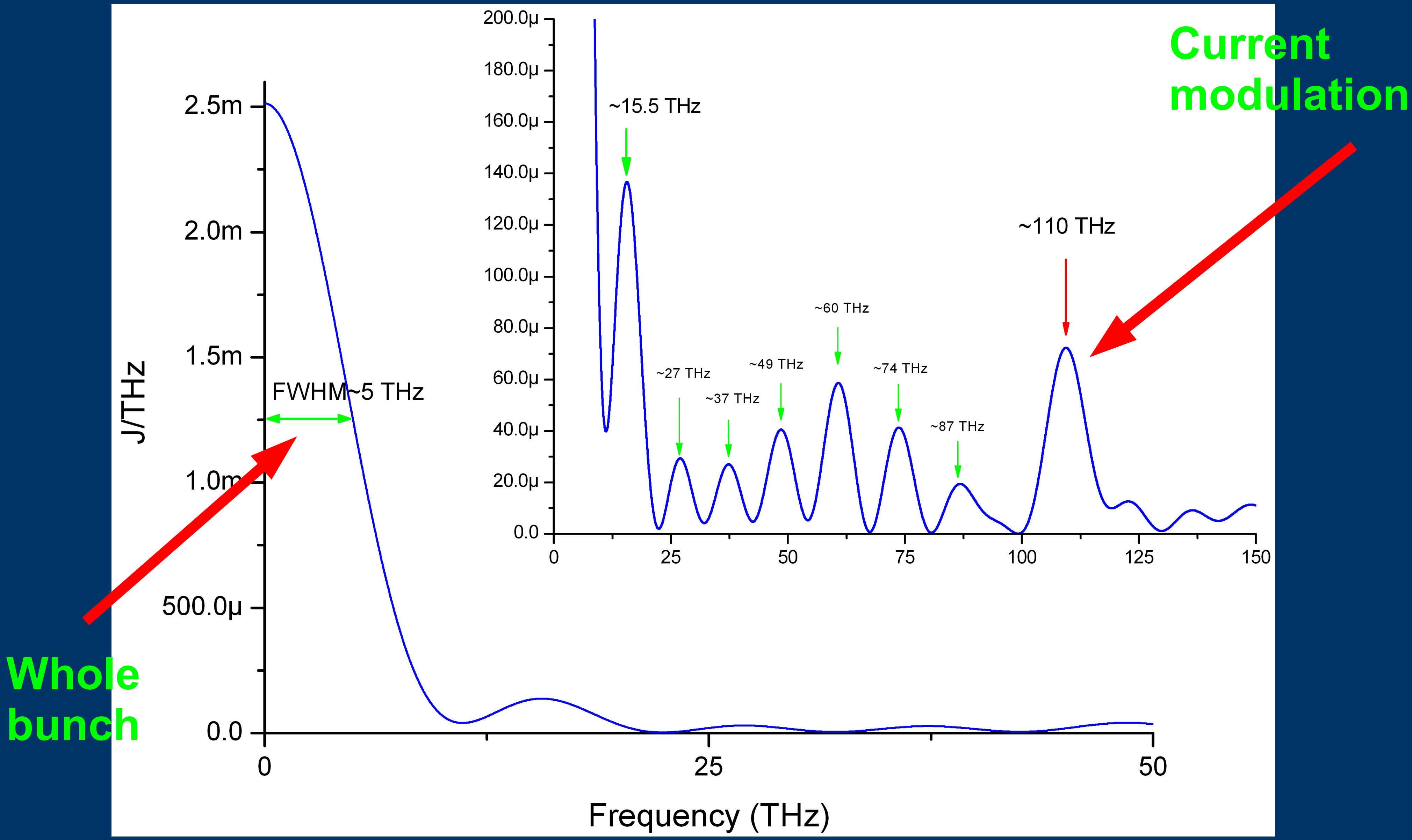
- sharp transition between plasma and vacuum;
- the plasma is a perfect conductor;
- the plasma has infinite transverse dimensions;

then ...

- … this current modulation produces CTR at plasma vacuum interface



- … this current modulation produces CTR at plasma vacuum interface



Beam spotsize determination.

Core assumptions:

- The number of current oscillations n is:

$$n = \frac{\omega_\mathrm{b}}{\omega_\mathrm{p}} \quad \text{or} \quad n^2 = \frac{n_\mathrm{b}(1 - f_\mathrm{e})}{n_\mathrm{p}} = \frac{n_\mathrm{b}}{n_\mathrm{p}} - 1$$

- The beam length L_b is:

$$L_\mathrm{b} = n\lambda_\mathrm{peak}$$

- $\sigma_x = \sigma_y = \sigma_\mathrm{b}$

Core assumptions:

- $$n = \frac{\omega_\mathrm{b}}{\omega_\mathrm{p}}$$

  Could possibly be

  $$n = \alpha \frac{\omega_\mathrm{b}}{\omega \mathrm{p}} \text{ with } \alpha \neq 1$$

  as well, but $\alpha = 1$ yields very good results !

Core assumptions:

- $\sigma_x = \sigma_y = \sigma_\mathrm{b}$

Not a problem, depends on laser transverse shape.

Main result

$$\sigma_{\mathrm{b}}^2 = \frac{Q_{\mathrm{b}}}{\pi e \lambda_{\mathrm{peak}} n(1+n^2) n_{\mathrm{p}}}$$

Main result

Indipendent measure (e.g. toroid) or from spectrum

$$\sigma_{\mathrm{b}}^2 = \frac{Q_{\mathrm{b}}}{\pi e \lambda_{\mathrm{peak}} n (1 + n^2) n_{\mathrm{p}}}$$

By spectroscopic means

Depend on laser – gasjet parame-ters only

Main result

Simulation

- Charge = 3.4 nC
- $\sigma_x = 0.91\ \mu m$
- $\sigma_y = 1.00\ \mu m$
- $L_b = 27\ \mu m$
- $\omega_0 = 0.75\pi\ 10^{15}$ Hz
- $w_0 = 14\ \mu m$
- $n_p = 3\ 10^{18}\ cm^{-3}$
- $n_b = 2.5\ 10^{20}\ cm^{-3}$

Our results

- Charge = 3.4 nC (assumed)
- $\sigma_b = 0.89\ \mu m$
- $\sigma_x = \sigma_y$
- $L_b = 28\ \mu m$
- $\omega_0 = 0.75\pi\ 10^{15}$ Hz (known)
- $w_0 = 14\ \mu m$ (known)
- $n_p = 3\ 10^{18}\ cm^{-3}$ (known)
- $n_b = 2.46\ 10^{20}\ cm^{-3}$
- $n = L_b/\lambda_{peak} = 10$

Side results

- Since the different sub-bunches have different energies, if the detection device can discriminate in θ, we can perform longitudinal energy – density diagnostics;

- Since the different sub-bunches have different average transverse momenta, if the detection device can discriminate in φ, we can perform transverse phase space diagnostics;

- The working point is $L_{gasjet}=L_d$ so that $L_{bubble}\sim 2L_b$ is an estimate of the bubble length.

Work in progress

1) evaluate the effects due to the smooth plasma-vacuum transition and to its finite conductivity;

2) evaluate the effects due to the finite transverse extent of the plasma (coherent diffraction radiation);

3) use the three dimensional form factor for radiation production since $\lambda_{peak} \sim \sigma_b$;

4) evaluate possible effects of CTR emission on lower energy portion of the bunch;

5) evaluate effects of the transverse momentum modulation on emission;

6) estimate the radiation produced by the bubble itself.