## Nonlinear Compton scattering

Long wavelength $\mathrm{CO}_{2}$ laser effectively induce nonlinear motion

Relativistic e-beam


Nonlinear ICS: $a_{L}>1$ : Transverse motion induce nontrivial longitudinal oscillation (Multi photon process in dense photon field)
7.6 keV < Fe k-edge Off-axis component



Redshifting (mass shift) to $5-6 \mathrm{keV}$

$$
0.5<a_{\mathrm{L}, 0}<0.7
$$

## Harmonics emitted from

 the Figure of 8 motion(linear) or Helical motion(Circular)Al $250 \mu \mathrm{~m}: \quad$ Linear, $2^{\text {nd }}$
Two peak


Elliptical, $\mathbf{2 n d}^{\text {nd }}$ rotation


Circular, $2^{\text {nd }}$
Off axis


OAM ?

Al $1000 \boldsymbol{\mu m}$
Linear, $3^{\text {rd }}$ Three peak


Circular, $3^{\text {rd }}$
off axis


OAM ?

## Mo/Si curved Multi-layer spectrometer





Single shot, double differential spectral measurements of inverse Compton scattering in the nonlinear regime, Phys. Rev. ST Accel. Beams in press

Complete AE70: nonlinear Compton, @ 10keV X-ray


Extend nonlinear ICS, @ 100 keV , X to $\gamma$-ray regime (For Medical, Nuclear Photonics application etc.)

## Compton interaction in multi photon fields

> High frequency laser (VAG, Ti: Sapphire )
> electron
> Infra-red Long wavelength laser $\left(\mathrm{CO}_{2}\right)$
> Non-linear figure-8 motion
> Hybrid motion
> Modulated $\gamma$-ray
> $=$
> is under investigation.

## Controlling radiation kinetics at $\boldsymbol{h} \boldsymbol{\nu}=100 \mathrm{~s} \mathbf{k e V}$

Bi-Harmonics case (Two wavelengths mixing)

## Pulsed waveform modulation <br> at < as time scale



Harmonic spectrum:

$$
h v_{\mathrm{ICS}}=4 \gamma^{2} h\left(v_{\mathrm{L}, \text { Short }}+n v_{\mathrm{L}, \mathrm{Long}}\right)
$$

(b)


Numerically calculated Lienard-Wiechert potential $E_{\mathrm{LW}, x}\left(t_{\text {screen }}\right)$ on $(x, y, z)=(0,0,0)$
@ X to Gamma ray regime, in ATF II

