Status of the Nonlinear ICS Experiment at UCLA

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Erice, Sicily
October 9-14 2005

Why do we care about nonlinear?

- Desire maximum photon production via:
  - High laser power ($P_L \geq 1$ TW)
  - Long laser wavelength (e.g. CO_2--10.6 _m)
  - Tight laser and electron beam focusing
- Creates condition of high laser intensity, $a_o \geq 1$

$$a_o = 0.85\times10^{-7}\lambda_o[m]\sqrt{I_o[W/cm^2]}$$

- Theory predicts nonlinear effects in form of harmonics in ICS photon spectrum, giving it even greater tuning range
- If nonlinear ICS to be effectively used as an inexpensive 3rd generation x-ray or polarized positron source, need to verify expected frequency and angular spread and degree of laser polarization preserved

Beam Parameters

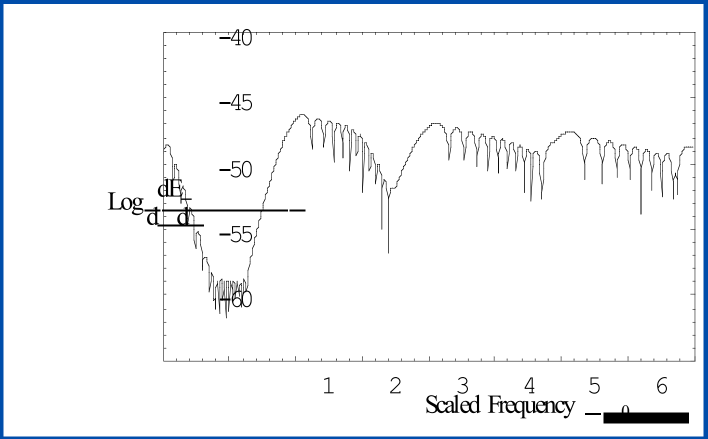
Parameter	Value
Electron Beam Energy	14 MeV
Beam Emmittance	5 mm-mrad
*Electron Beam Spot Size (RMS)	25 _m
Beam Charge	300 pC
Bunch Length (RMS)	4 ps
*CO_2 Laser beam waist at IP	25 _m
*Laser wavelength	10.6 _m
*Laser Rayleigh Range	0.75 mm
*Laser Power	500 GW
Laser Pulse Length	200 ps

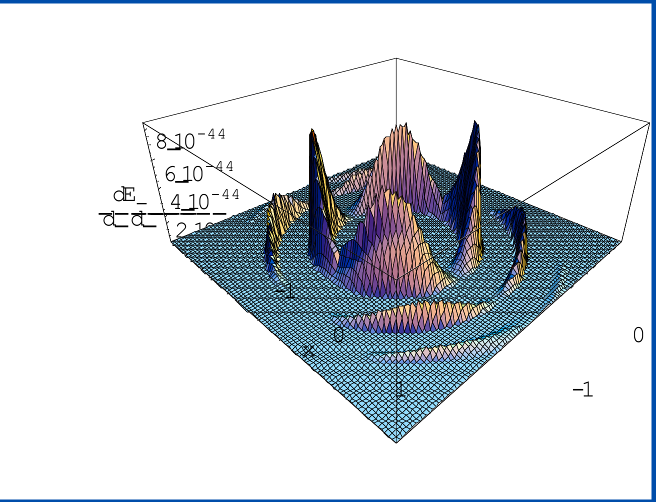
Laser guiding in plasma might be an option to increase interaction time and hence ICS photon flux (see talk by R. Yoder)

TABLE 2: Scattered Photon Parameters		
Parameter	**Head-on**	**Transverse**
Scattered photon wavelength	5.3 nm	10.7 nm
Scattered photon energy	235.3 eV	117.7 eV
Scattered photon pulse duration (FWHM)	10 ps	10 ps
Interaction time	5 ps	0.33 ps
# of periods electrons see	283	10
# of photons emitted per electron	3.34	0.11
Total # of photons	$6.3x10^9$	$2x10^8$
Half Opening Angle (?)	2.7 mrad	15 mrad
Bandwidth	0.35%	10 %

Expected Spectrum and Intensity Distributions

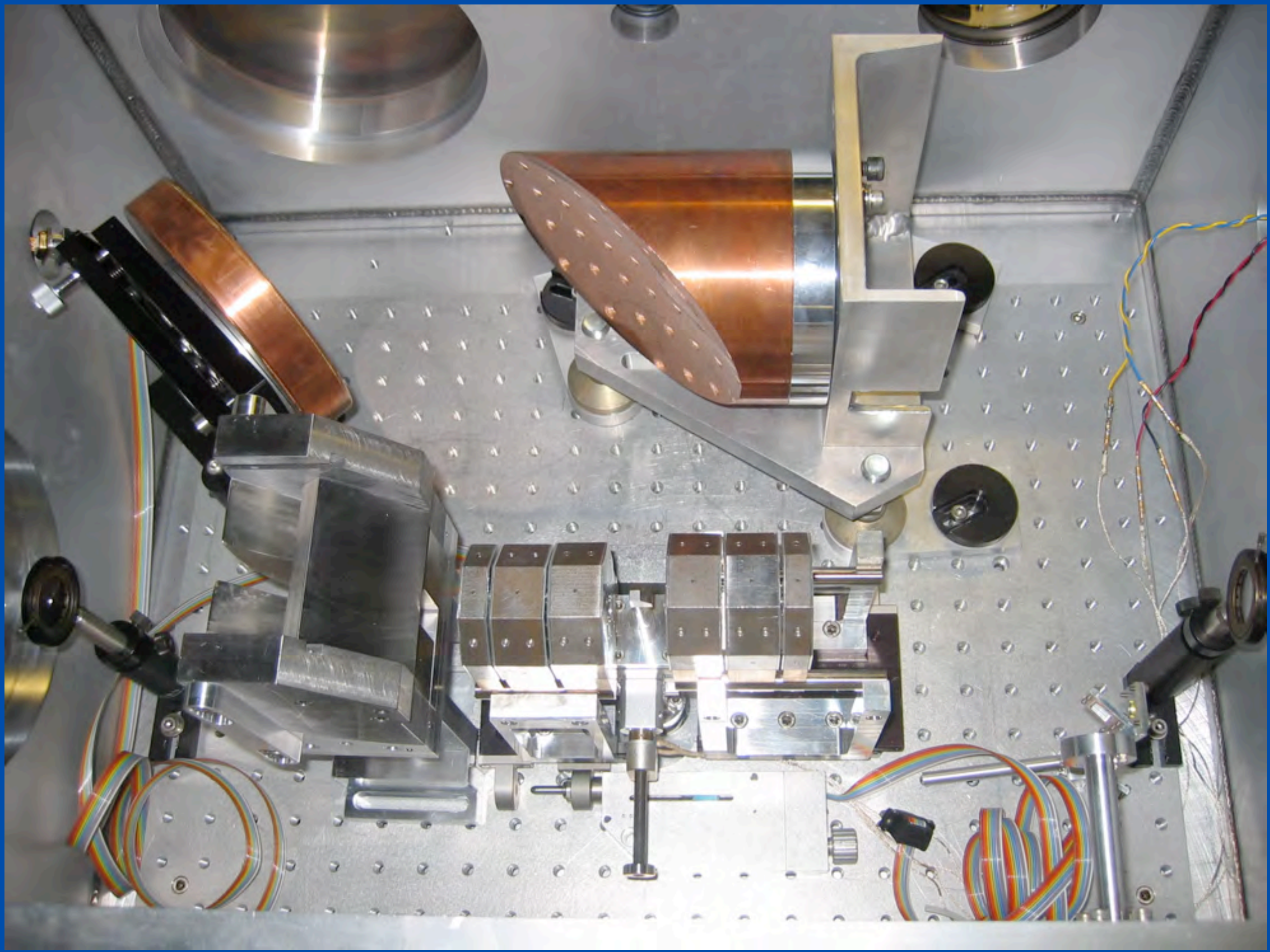
- Spectral broadening of the ICS photons is expected due to the ponderomotive scattering of the electrons from high laser field
- Even AND odd harmonics are expected to be prevalent off-axis
- Shown are frequency and intensity (2nd harmonic) distributions seen on axis of the ICS photons for a _-polarized, incident gaussian laser profile





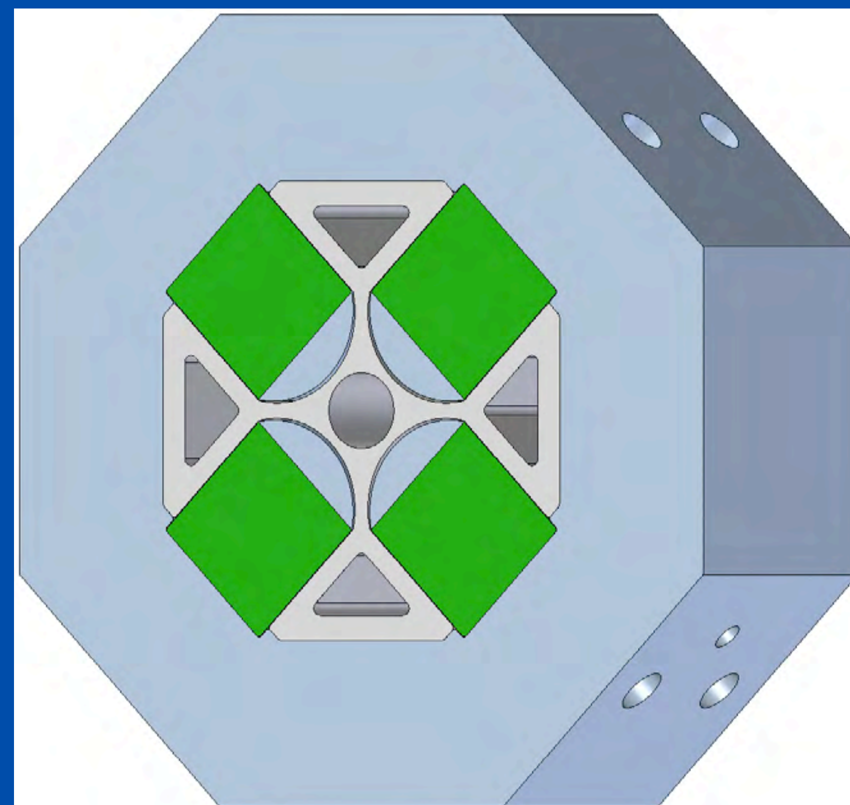
Courtesy of A. Doyuran and G. Krafft

Experimental Layout



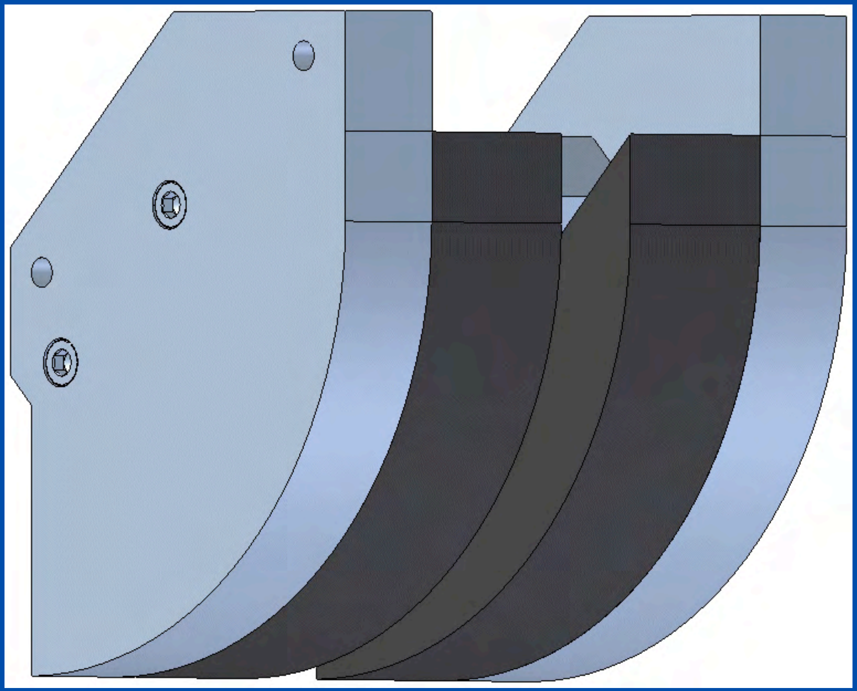
PMQ Performance

- Measured ~110 T/m focusing gradient of PMQ's
- Obtained a 40-50 _m _$_{x,y}$ RMS beam at the IP
- Measurements at only 38.5 kV in the modulator, corresponding to a ~12.5 MeV beam
- Emittance expected to be less than optimal due to low field on cathode and asymmetric laser profile
- PMQ spacing and gradient optimized for 14 MeV beam, therefore smaller spots expected in future with emittance improvement and higher energy electrons



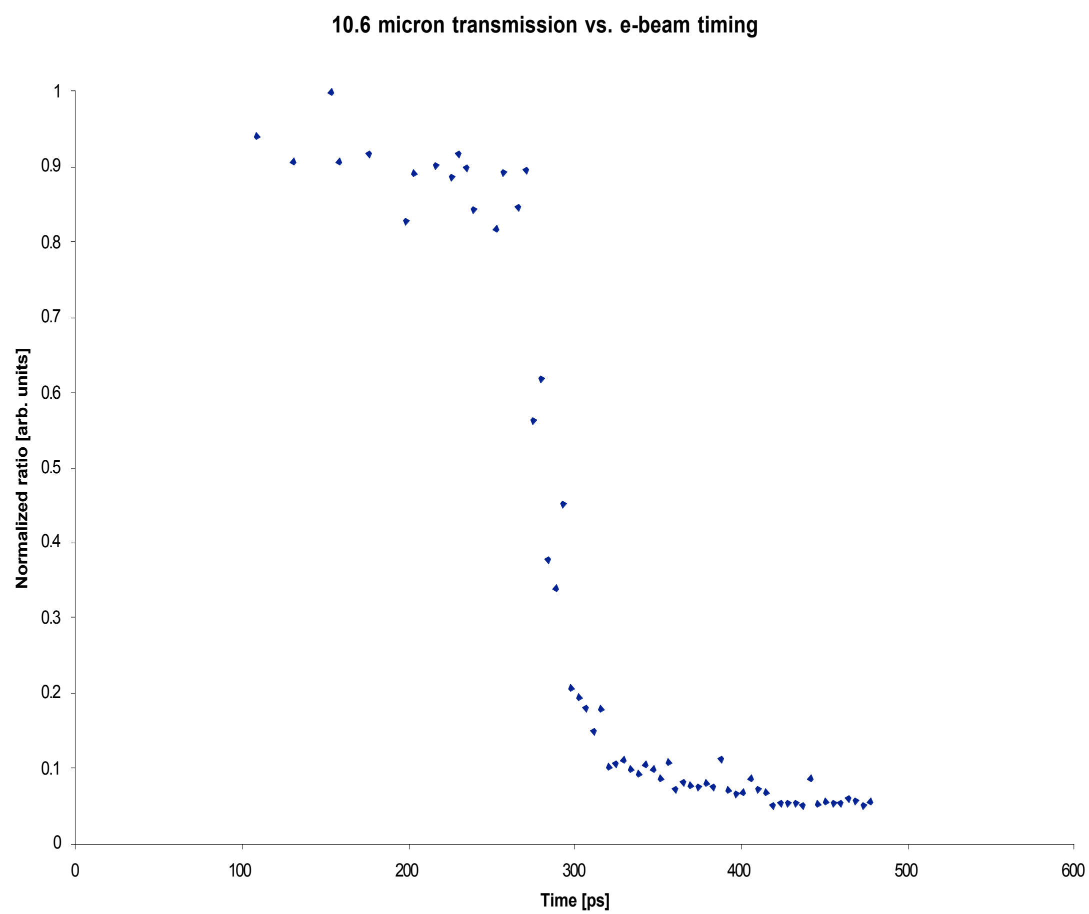
Necessity of PM Dipole

- The compactness of the experiment created by the low energy e-beam (14 MeV) and hence large divergence angle of ICS photons required the immediate recollimation and dumping of the beam following the interaction with the laser pulse
- NdFeB, M=1.32 T, 16 mm gap yields a bend radius of 60 mm for 14 MeV electrons
- Exit trajectory adjusted by entrance position into PMD via in-vacuum heavy load actuator allowing for acceptance of 12-14 MeV beams with up to few mm offsets



Initial Alignment/Synchronization Results

- Initial alignment done using graphite-coated phosphor
- Synchronization achieved using Ge crystal acting as a "gate" to 10.6 _m radiation, where e-beam is the "key"
- 10.6 _m absorbing semiconductor plasma created with formation length approx. e-beam bunch length
- Limits resolution to ~10 ps (but have 200 ps laser pulse)
- This method requires spatial overlap, therefore confident beams are "seeing" each other



Future Work

- Upon set-up of x-ray CCD and acquisition software, shots for ICS photons will begin
- Initial verification of harmonic creation will be achieved using thin filters (e.g Al and Ti) to cut-off the fundamental (~110 eV)
- Angular and frequency spectrum to eventually be imaged using diffraction grating coupled with high resolution x-ray CCD
- Methods of polarization analysis still being researched (transmissive multilayer optics are an option)