Femtosecond Probing of Solid Density Plasmas with Coherent High Harmonic Radiation

Rainer Hörlein

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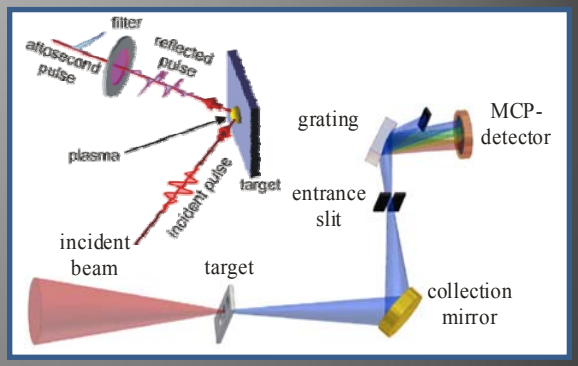
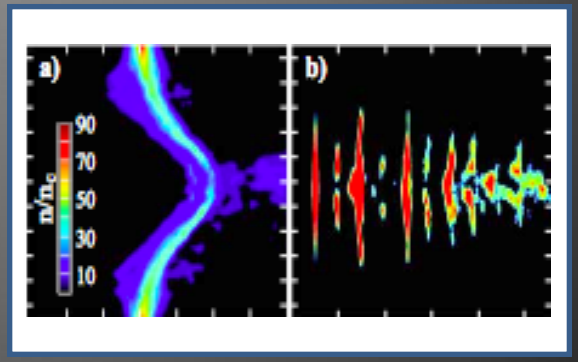
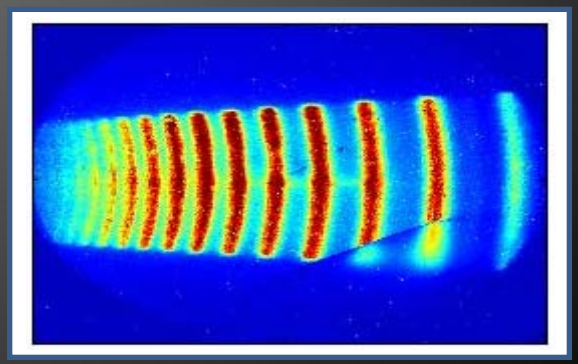
Overview

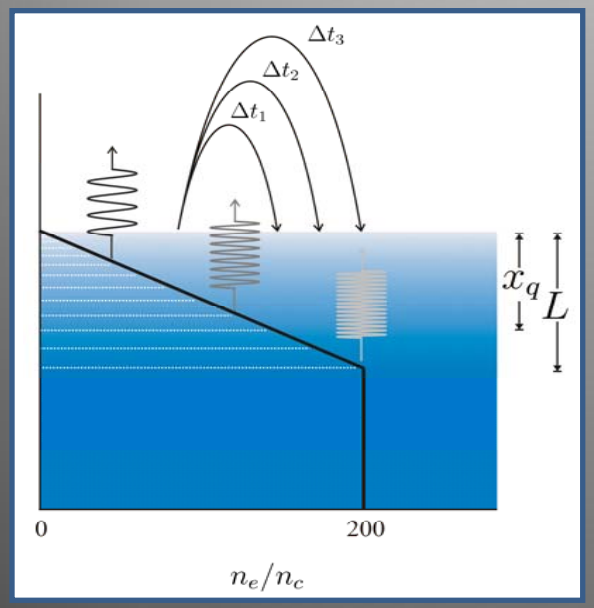
1. Introduction
2. Dynamics of nm-Scale Foils
3. Plasma Probing using SHHG
4. Conclusions and Outlook

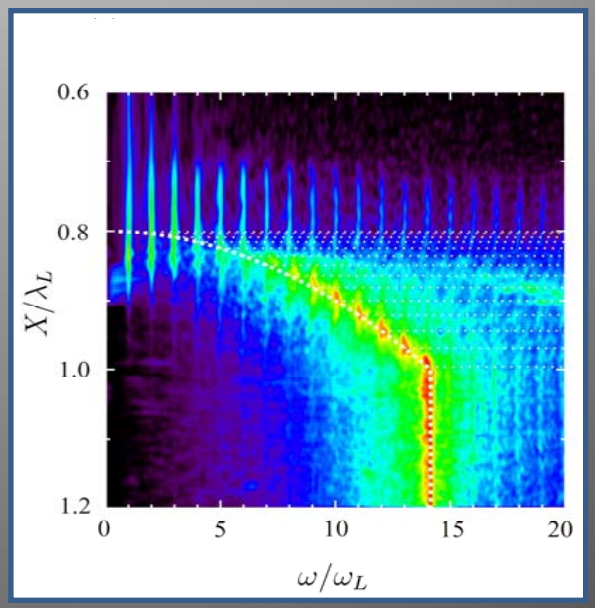




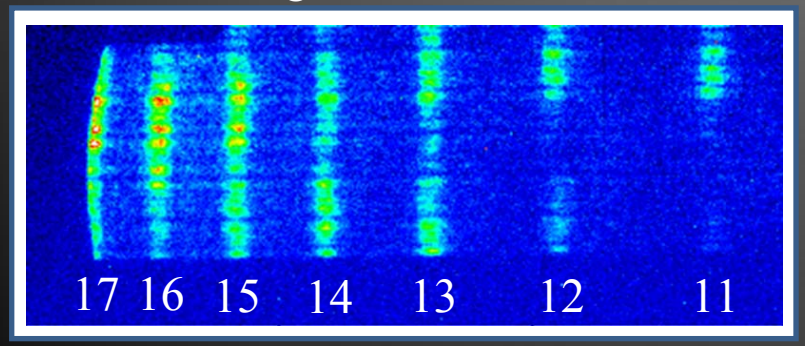


1.1 Coherent Wake Emission

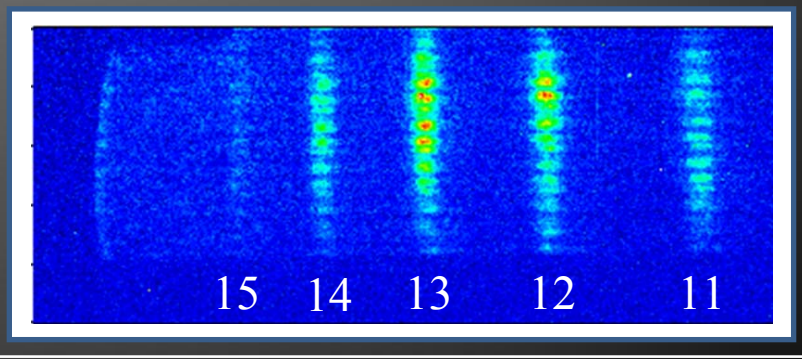




Glass Target (Density ≈2.6 g/cm^3):

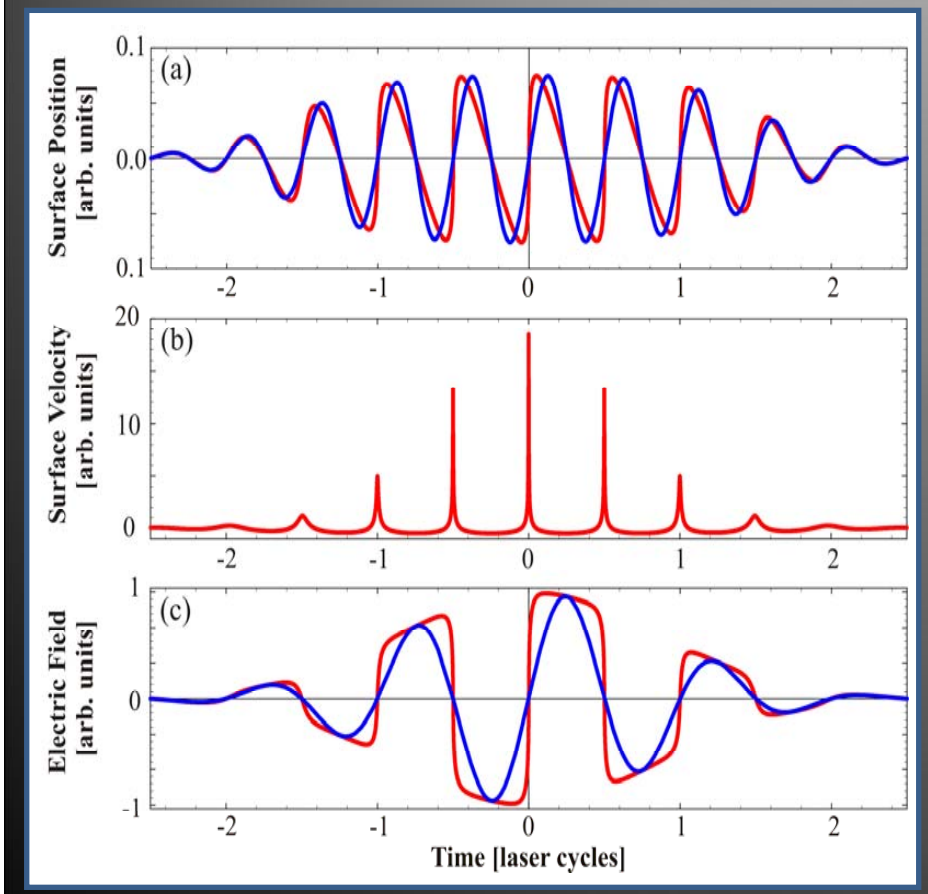


Plexiglass Target (Density ≈ 1.3 g/cm^3):

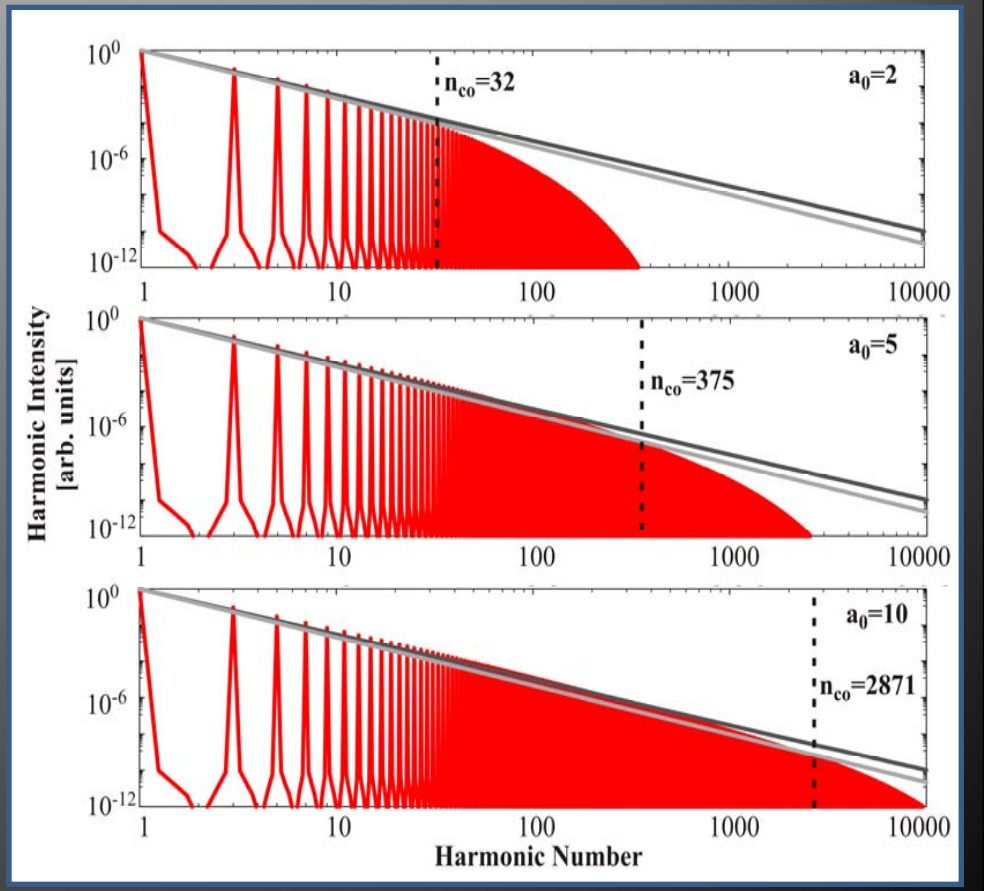


1.2 Relativistic Harmonics

Mirror Motion:

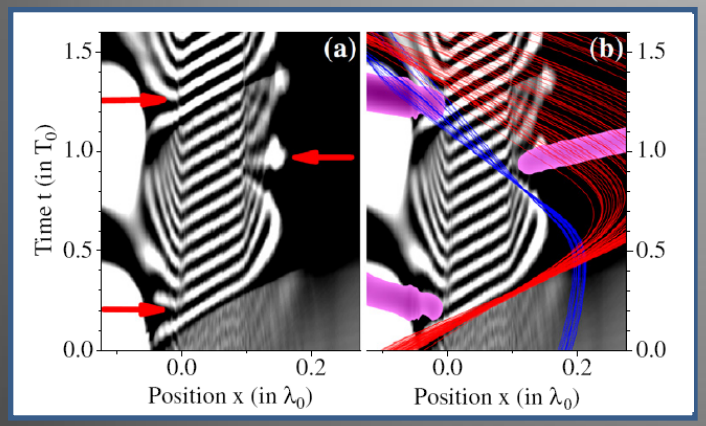


Harmonic Spectra:

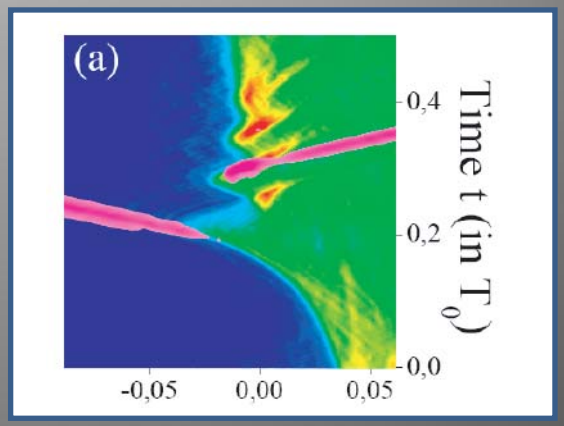


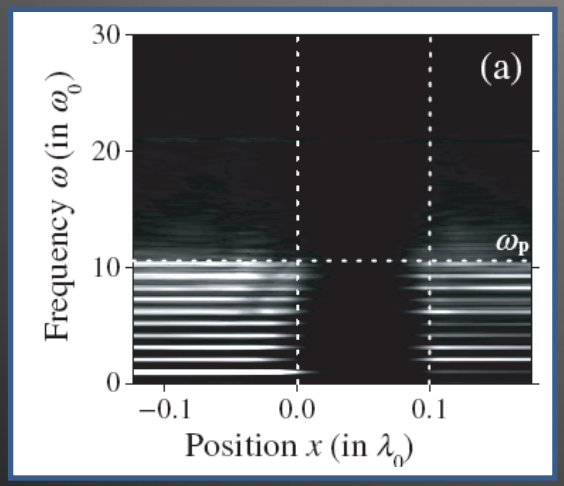
1.3 Thin Foils

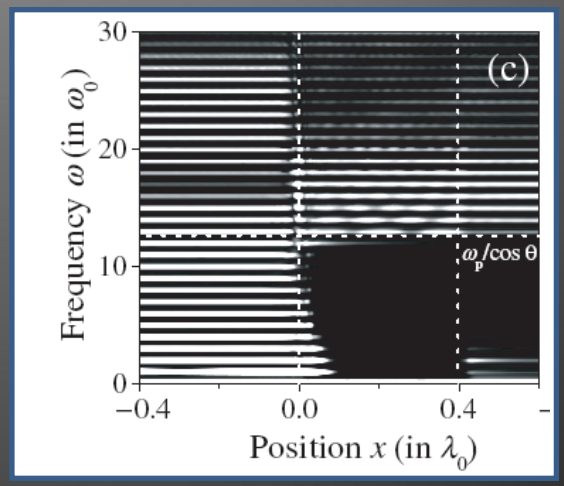
CWE in transmission:



ROM in transmission:







H. George, *et al.*, NJP, 11, 113028 (2009)

Experiments:

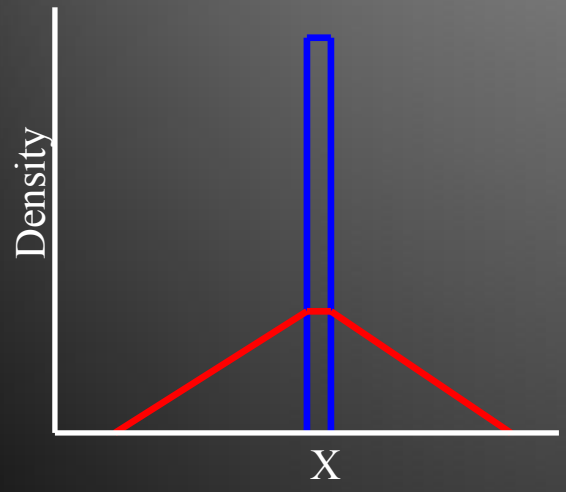
U. Teubner, *et al.*, PRL, 92, 185001, (2004).

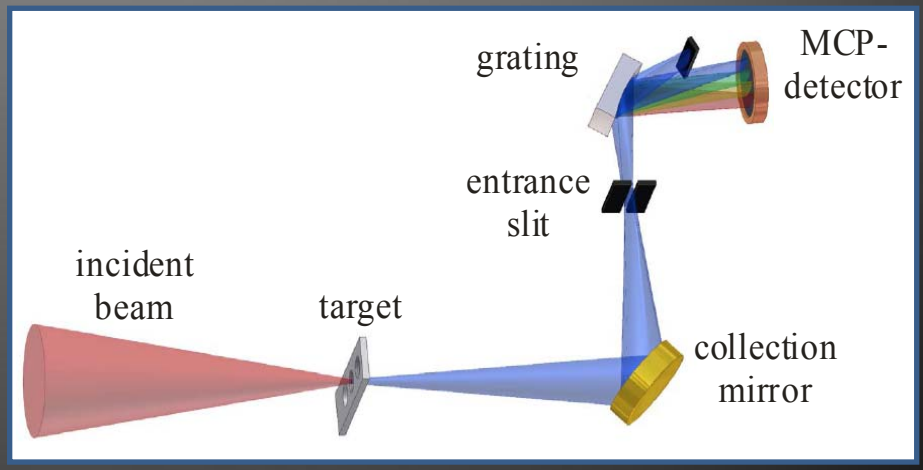
K. Krushelnick, *et al.*, PRL, 100, 125005, (2008).

2. Dynamics of nm-Scale Foils

nm-scale diamond-like carbon foils promise access to new regimes for efficient ion acceleration

S.G. Rykovanov et al., NJP. 10, 113005 (2008).
O. Klimo et al., PR ST AB 11, 031301 (2008).
A.Henig et al., PRL 103, 245003 (2009)
and many others

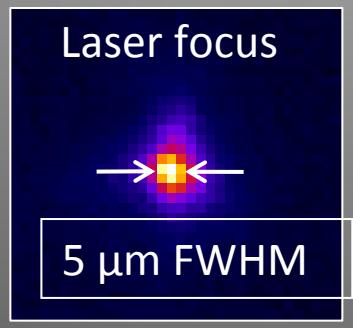


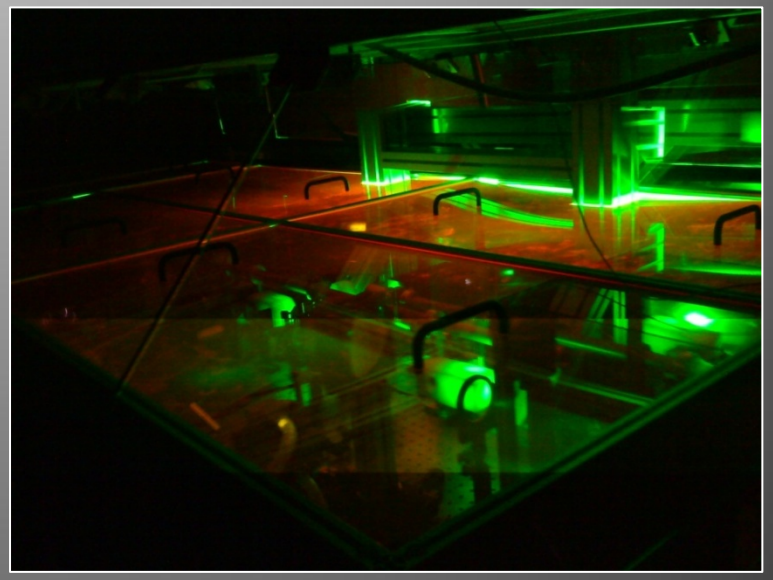


2.1 The Berlin Laser System

Berlin 30 TW CPA Ti:Sa system

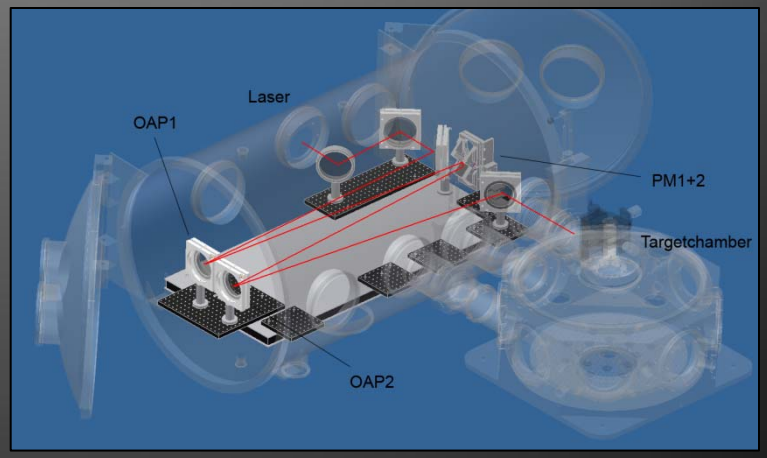
- Pulse energy 1.2 J (0.7 J with PM)
- Pulse duration 40 fs
- Rep. rate10 Hz
- F/2.5 focusing
- Adaptive mirror
- Focused intensity $5x10^{19}$ Wcm^{-2}





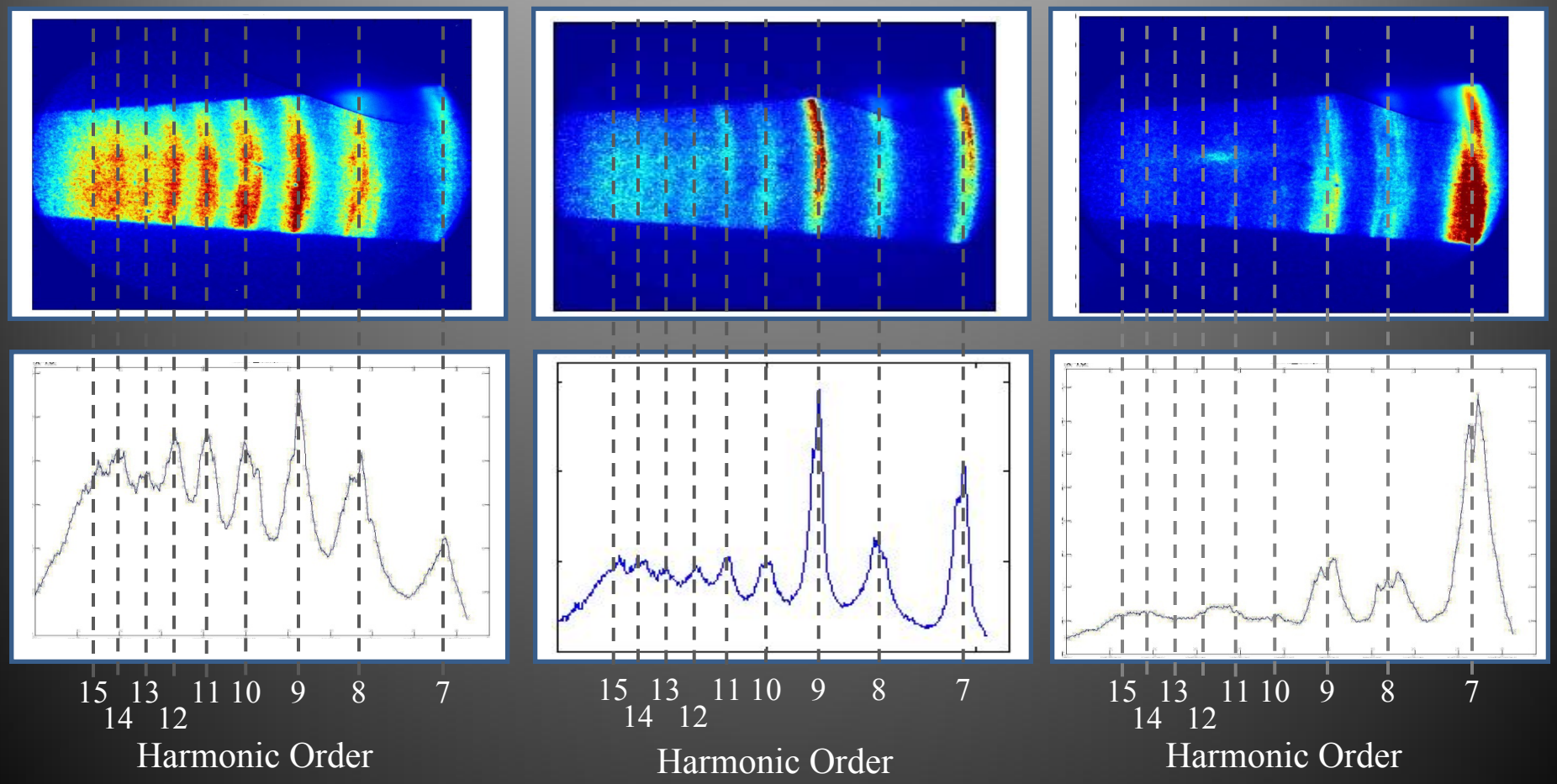
Double Plasma – Mirror (DPM)

- energy throughput ~65%
- contrast enhancement 10^3 to 10^4
- no decrease in focusability



2.2 Probing nm-Foil Targets

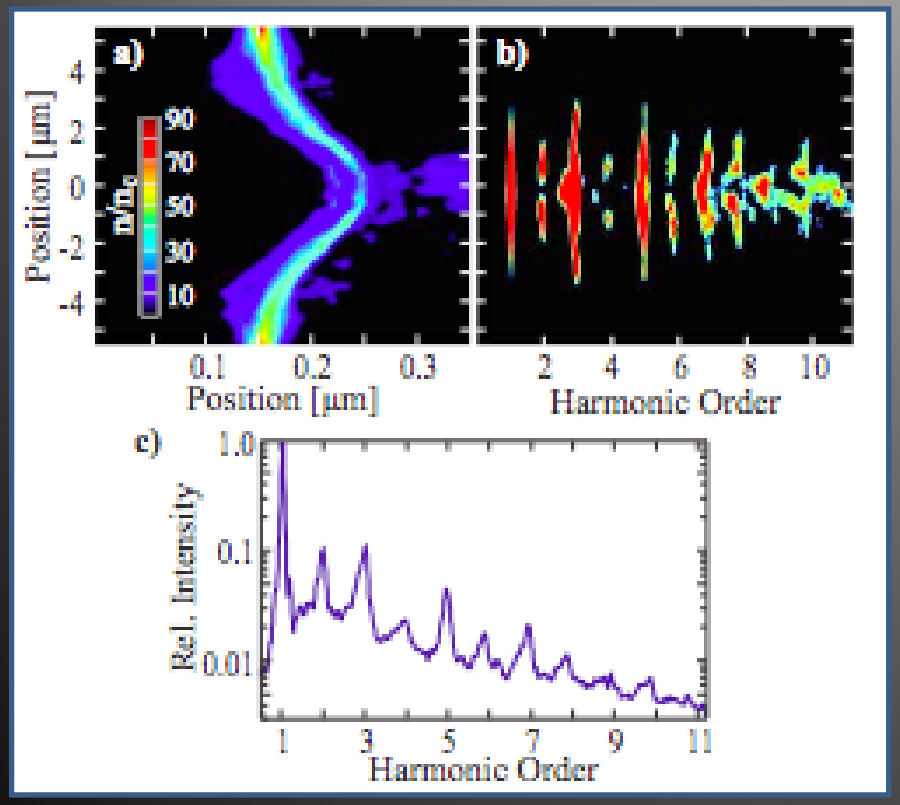
32 nm DLC | 17 nm DLC | 5 nm DLC



2.2 Probing nm-Foil Targets

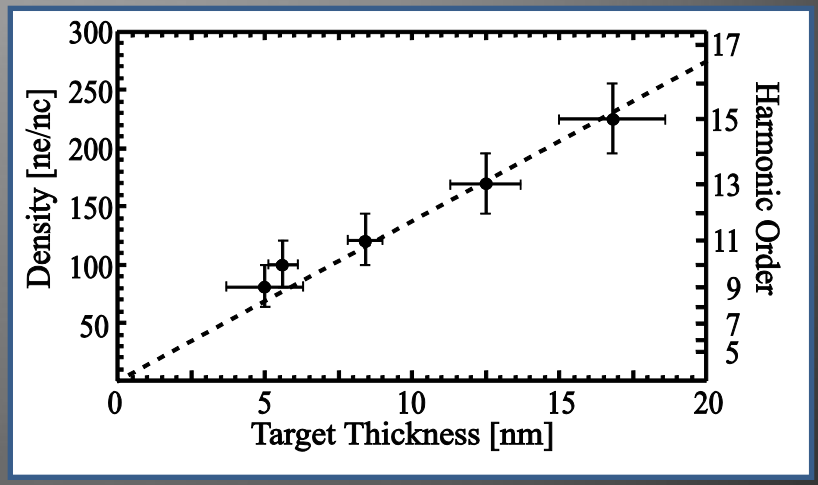
2D-PIC Simulation

a_0=3.6, n_{max}=100n_c, 25nm ramp, τ=10 cycles



Measured Density

Density during relativistic interaction



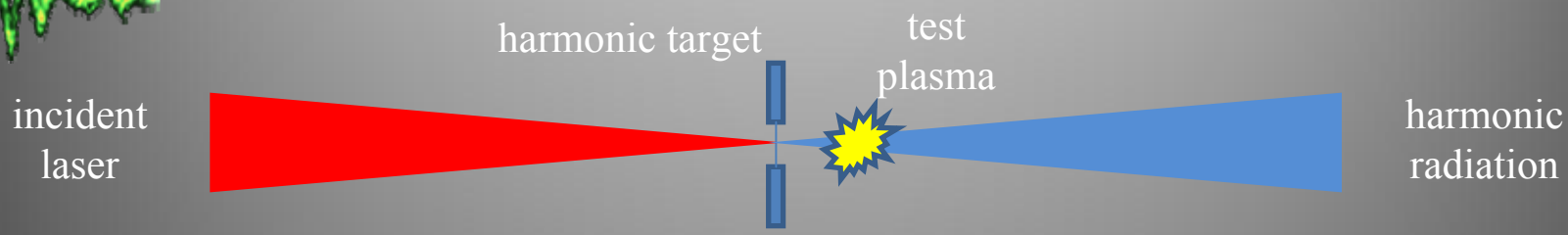
Consistent with 1D expansion of the foil target ionized on the leading edge of the 45fs laser pulse

$C_{s,av} \approx 2.2 \times 10^7$cm/s

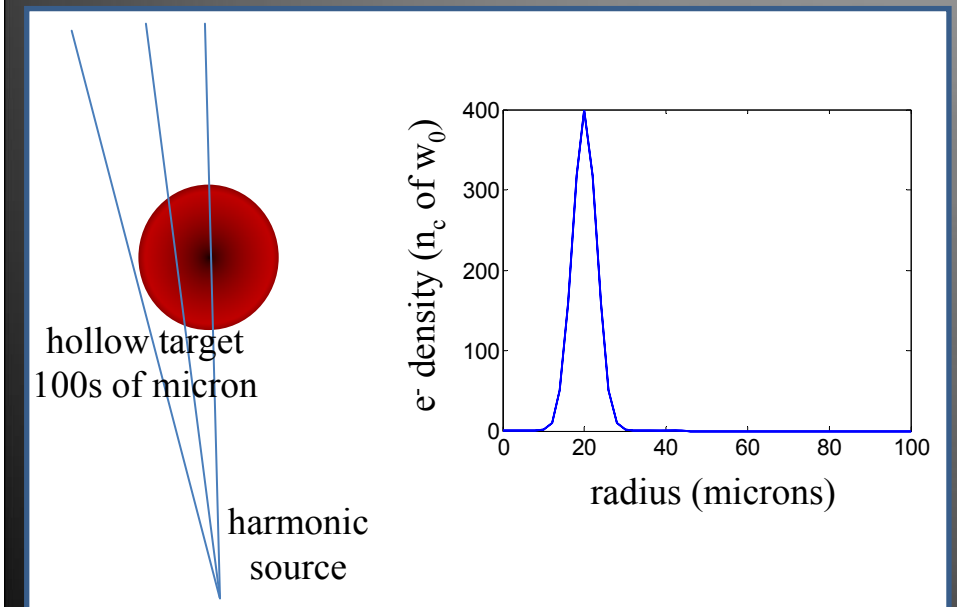
$T_{Exp} \approx 70$fs

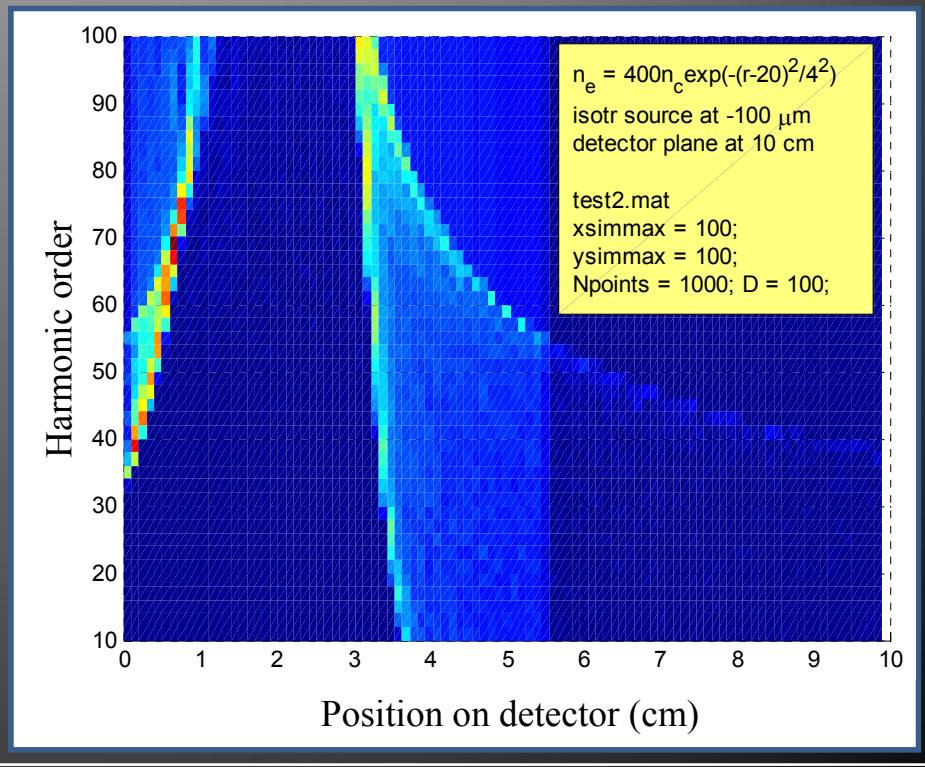
R. Hörlein et al., arXiv:1009.1582 (2010)

3. Plasma Probing using SHHG



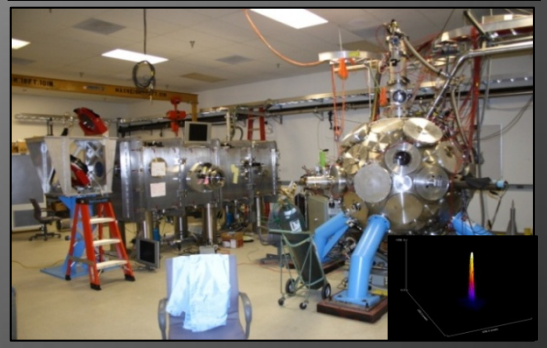
(very) preliminary Simulations

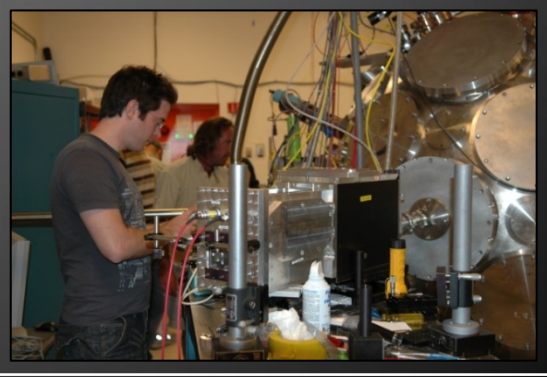




previous work using gas harmonics for example:
W. Theobald et al., PRL 77, 298 (1996).
S. Dobosz et al., PRL 95, 025001 (2005).

3.1 The TRIDENT Laser





TRIDENT short pulse beam:

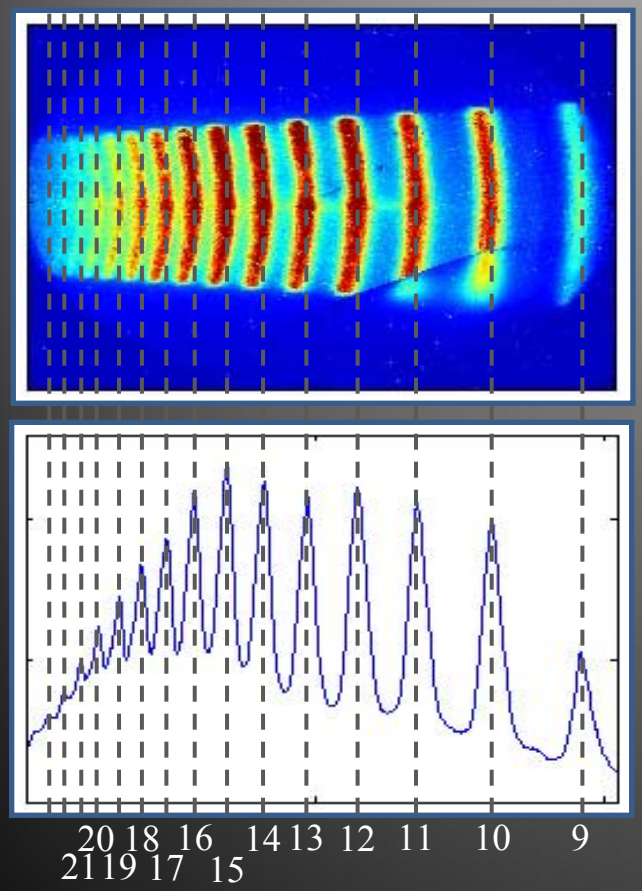
- Pulse energy 80 J
- 1 shot/45 min.
- F/3 focusing
- Pulse duration 500 fs
- Wavelength 1054 nm
- Adaptive mirror
- Focused intensity 5×10^{20} Wcm^{-2}

TRIDENT has ~10x longer pulse than MBI
but ~100x more pulse energy
i.e. 10x higher intensity on target

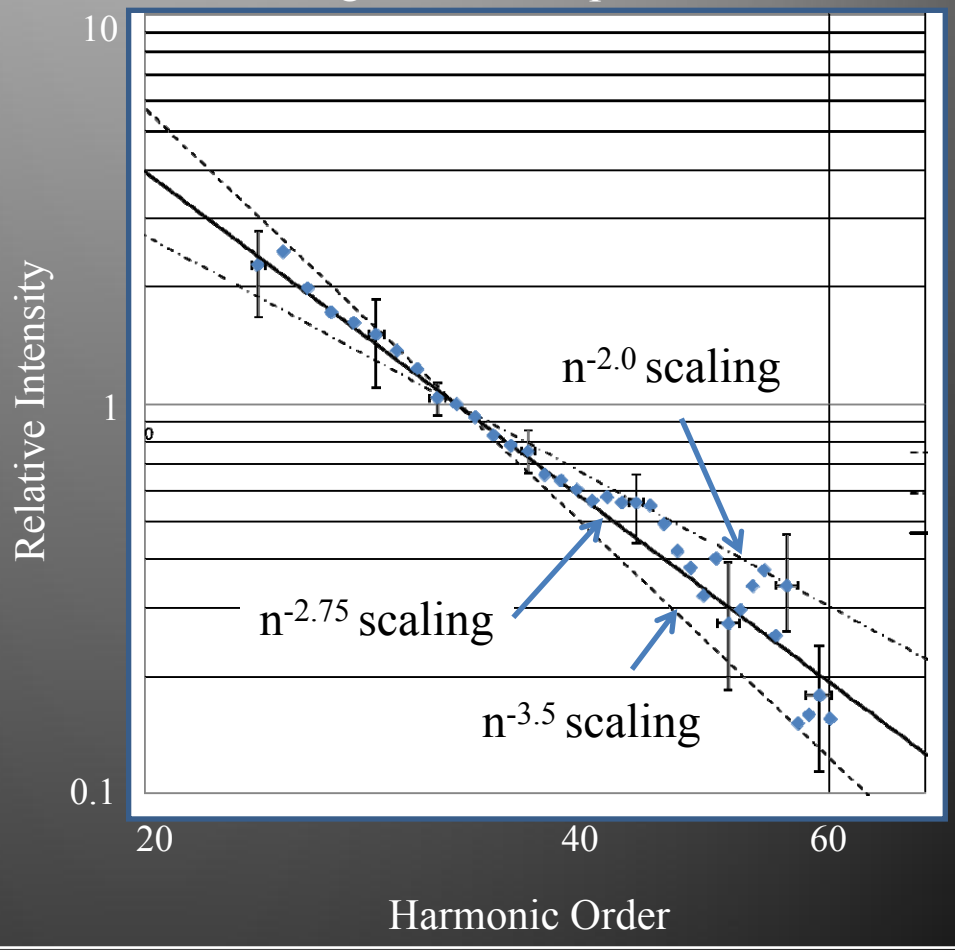
3.2 Relativistic Forward Harmonics

Harmonic radiation from 200 nm DLC Targets

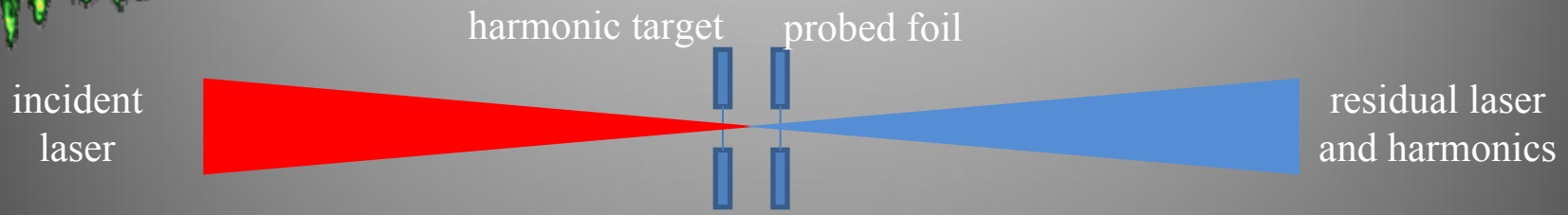
Normal incidence spectrometer

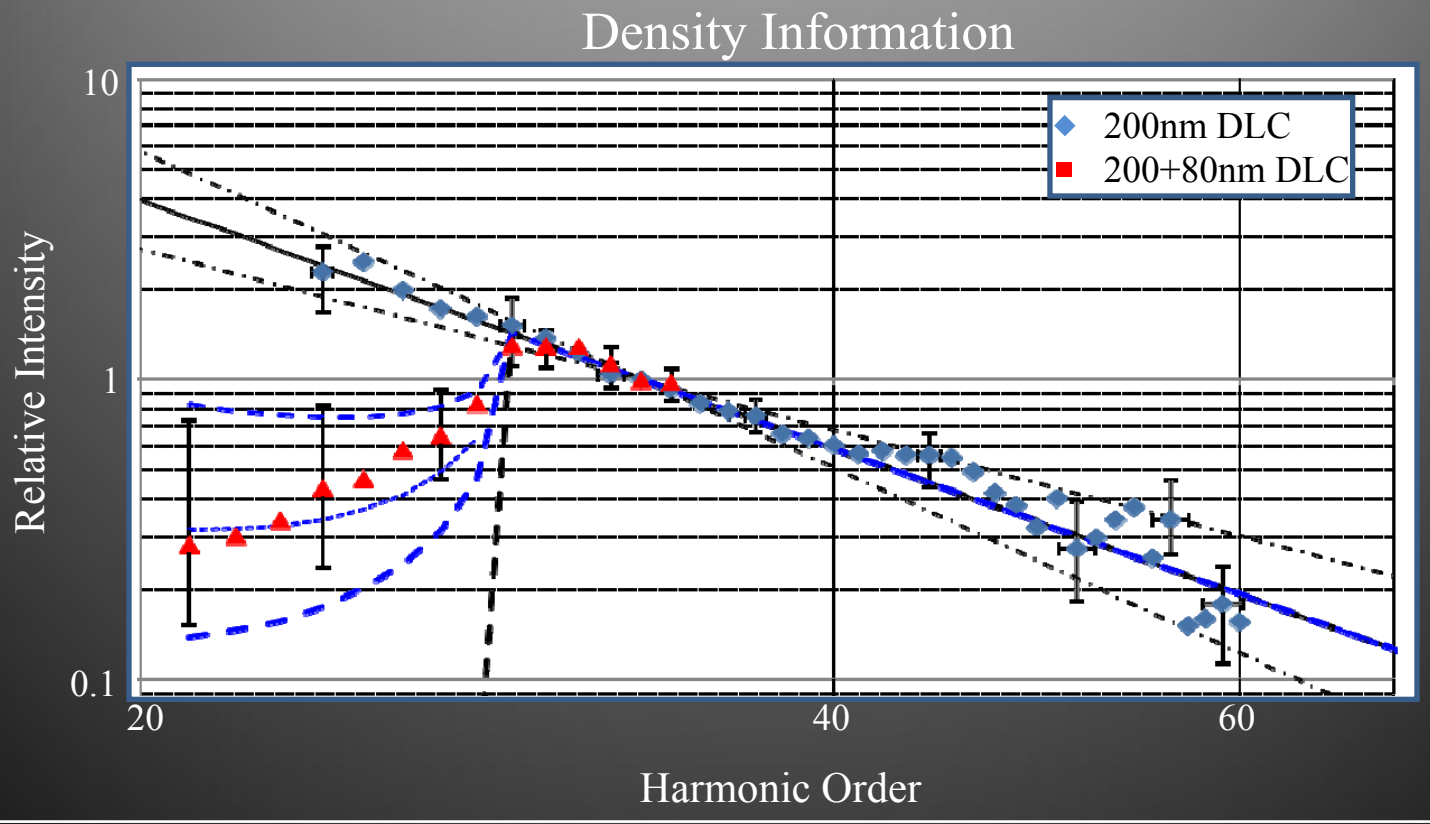


Grazing incidence spectrometer

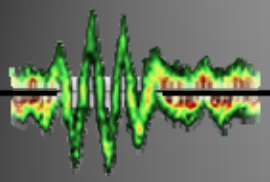


3.3 Plasma Probing: First Results





Conclusions and Outlook



- High harmonics generated on solid surfaces are a very versatile source of intense coherent XUV radiation
- High harmonics can be used to probe and monitor the interaction of intense femtosecond laser pulses with nm-scale foil targets
- Direct measurement of target density during relativistic interaction
- First clear observation of only odd-numbered relativistic harmonics in normal incidence geometry
- High harmonics generated with PW-scale short-pulse lasers could serve as unique backlighting sources for a wide range experiments