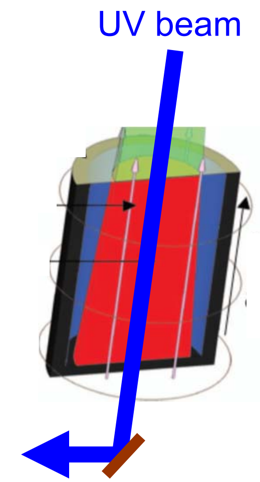
UV and Deep UV Diagnostics for Dense Plasma (V. Ivanov, UNR)

Laser wavelength for UV and deep UV:



λ/4 = 266nm - available for commercial Nd lasers, **η** = 10-30%

λ/5 = 211nm - available for commercial Nd lasers, **η** = 5-10%

λ/6 = 176nm - at the experimental stage, crystals exist

λ = 157nm - excimer F2 laser, available (Coherent, 50mJ, 10ns, $200)

Critical plasma density:

$$n_c = \frac{\varepsilon_o m_e}{e^2}\omega^2 = 1.12\cdot10^{13}\cdot\lambda^{-2}\ \text{cm}^{-3}.$$

$n_c=4\cdot10^{21}$ cm^{-3} at 532nm, **$n_c=1.6\cdot10^{22}$ cm^{-3} at 266nm**, $3.6\cdot10^{22}$ cm^{-3} at 176nm, and **$4.5\cdot10^{22}$ cm^{-3} at 157nm**.

Inversed bremsstrahlung absorption:

$$\gamma = 8.73\cdot10^{-30}\cdot\lambda^2\cdot\frac{n_e^2\cdot Z\cdot\Lambda}{T_e^{3/2}\cdot\left(1-\frac{n_e}{n_c(\lambda)}\right)^{1/2}}$$

where λ is the wavelength, n_e is the electron density, T_e is the electron temperature, Λ is the Coulomb logarithm, Z is the ion charge, and $n_c(\lambda)$ is the critical density (T. Johnson and J. Dawson, *Phys. Fluids* 1973).

$I = I_0 exp(-\gamma L)$, *L* is a length of plasma

UV Faraday rotation diagnostic:

Faraday rotation angle: $\beta = 2.62\cdot10^{-17}\lambda^2\int n_e B_{II} dl$

Simulations of the liner (S. Slutz, Phys. Plasmas 2010)

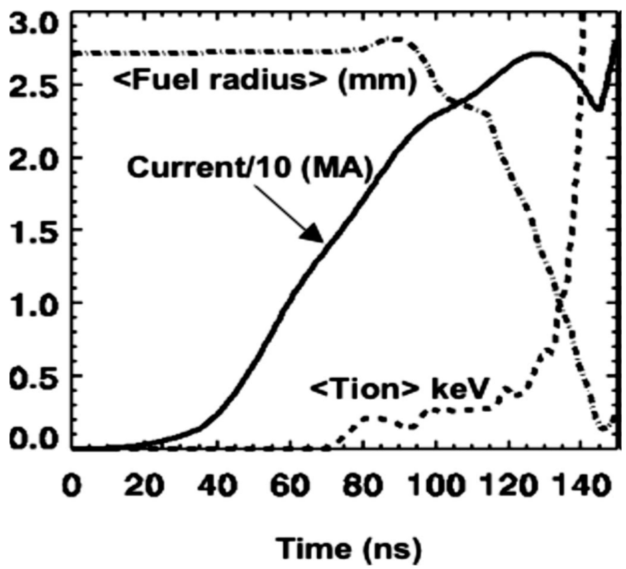
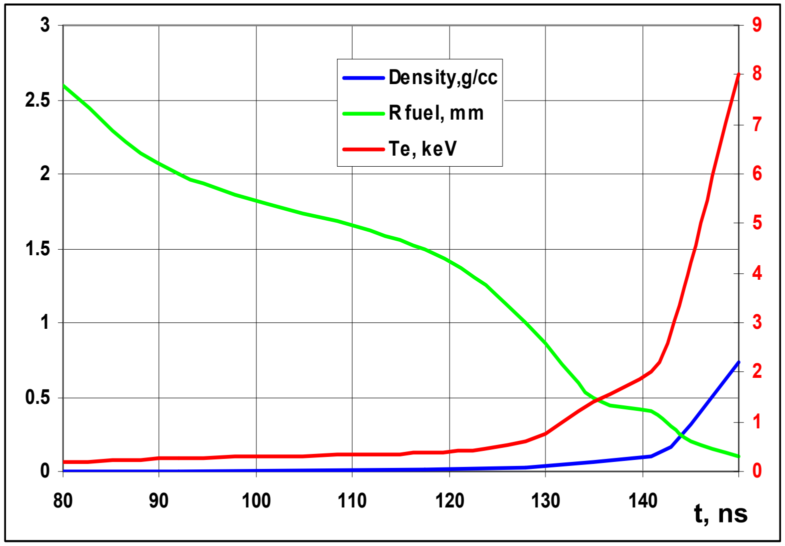


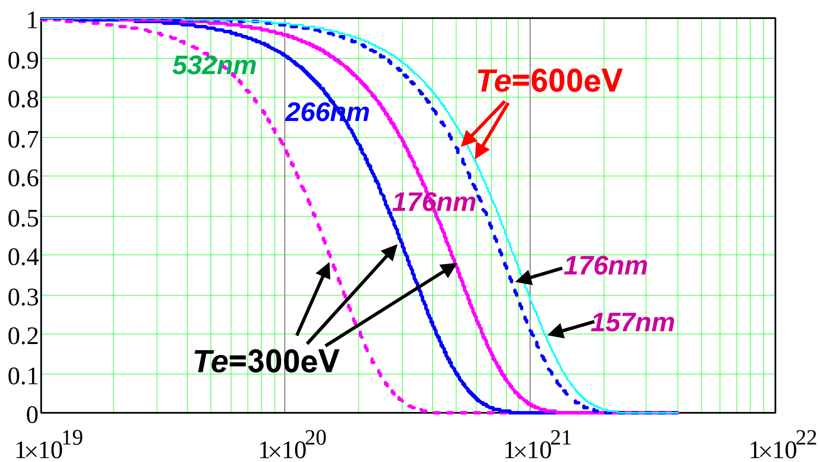
FIG. 4. The results are from a Lasnex simulation of a beryllium liner with an aspect ratio of 6, an initial magnetic field of 30 T, an initial fuel density of 3 mg/cc, and an initial fuel temperature of 250 eV.

t, ns	R fuel, mm	Density,g /cc	Te	B, MG	N_e, cm-3
80	2.6	0.003	200	0.3	9.033E+20
92	2	0.0044	270	0.45	1.325E+21
118	1.5	0.0078	380	0.77	2.349E+21
128	1	0.02	600	1.7	6.022E+21
135	0.5	0.06	1400	5.8	1.807E+22
141	0.4	0.1	2000	10	3.011E+22
143	0.3	0.17	2800	17	5.119E+22
145	0.2	0.32	4200	33.8	9.635E+22
150	0.1	0.74	8000	78	2.228E+23

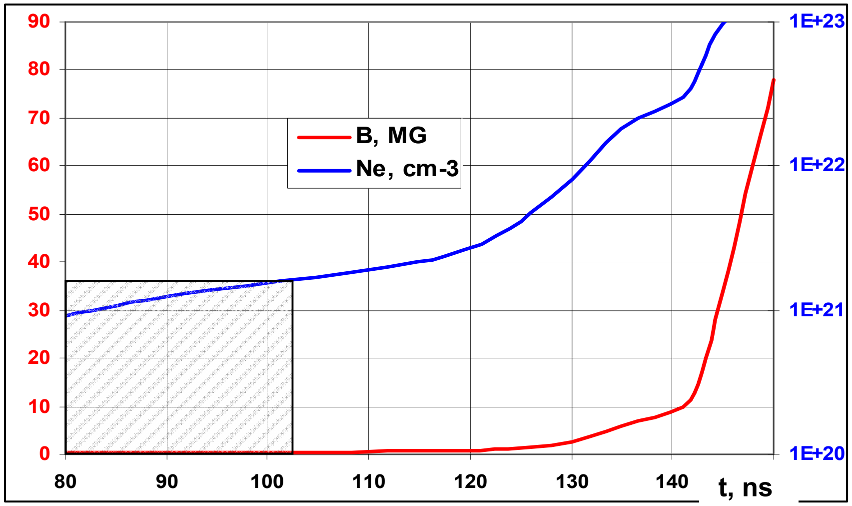


Absorption in a 1-cm liner

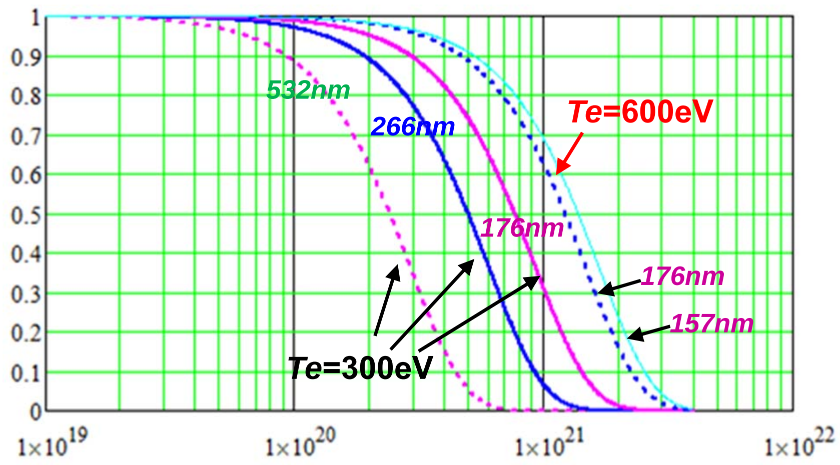
L = 1cm of D



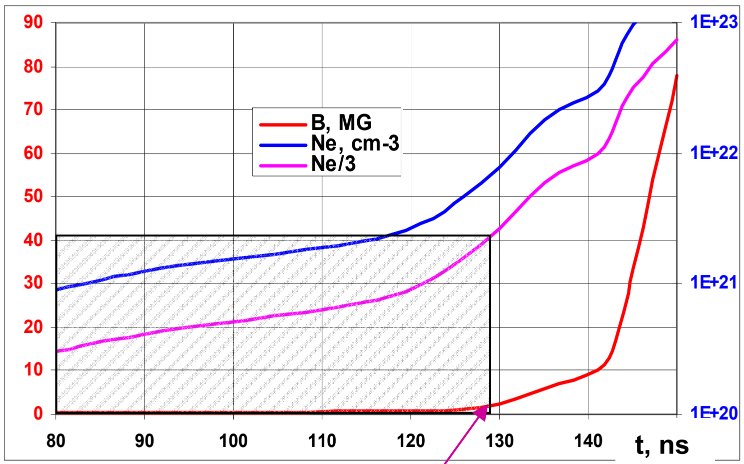
$$\gamma = 8.73 \cdot 10^{-30} \cdot \lambda^2 \cdot \frac{n_e^2 \cdot Z \cdot \Lambda}{T_e^{3/2} \cdot \left(1 - \frac{n_e}{n_c(\lambda)}\right)^{1/2}}$$



Probing of the light 3-mm liner

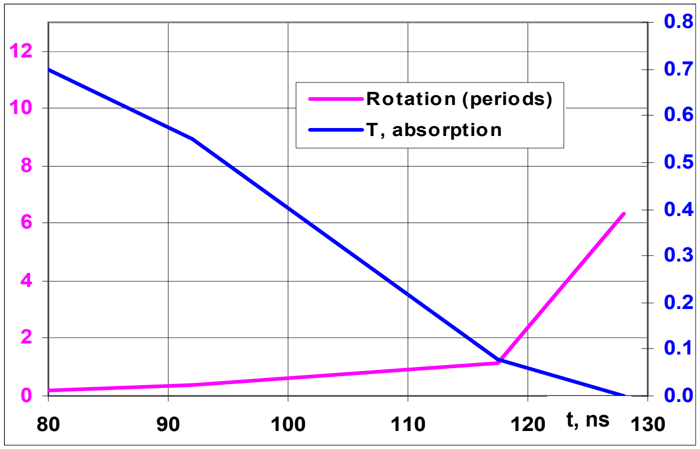


Short liner, L = 3 mm



B=2-3 MG

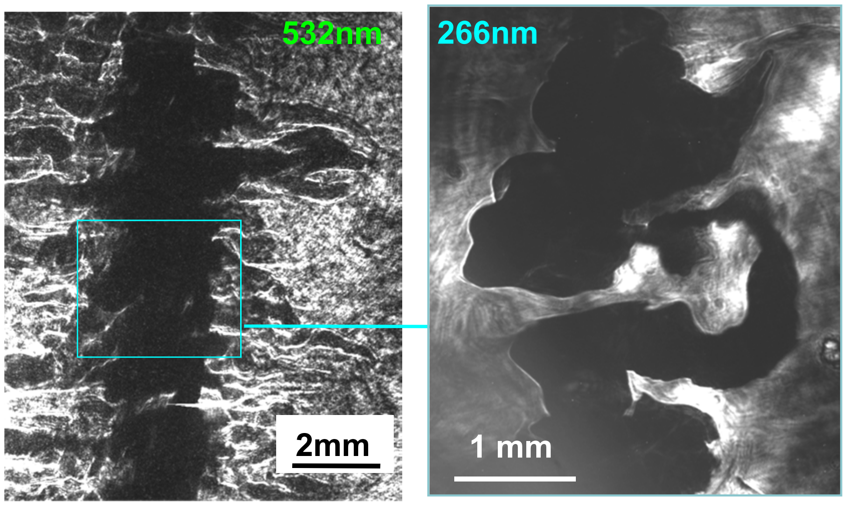
No-imaging diagnostic



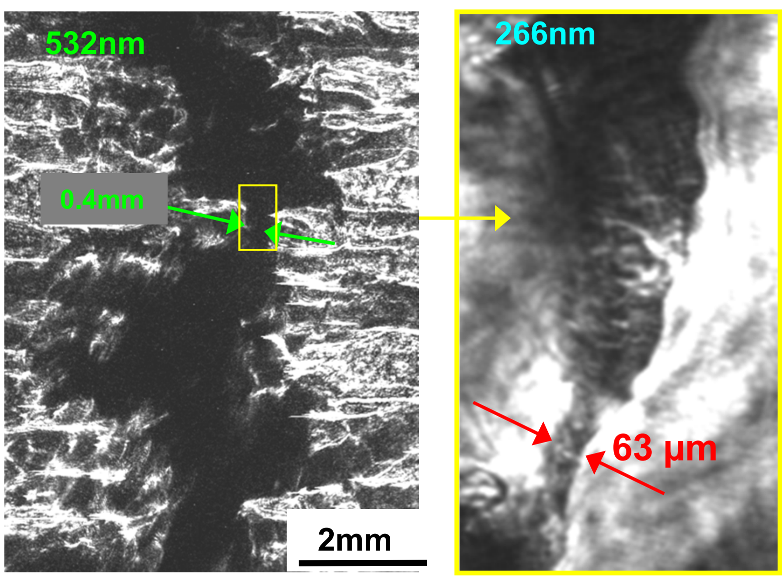
1. Long DUV laser pulse
2. Radiation from the liner
3. Damage of mirrors by X-ray

UV diagnostics show a structure of the dense Z pinch

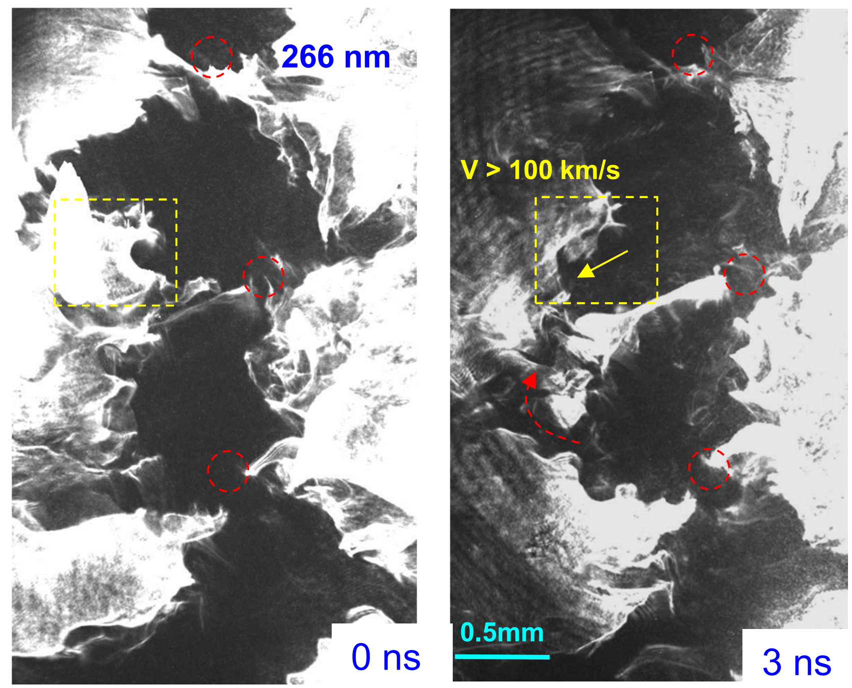
#2373, Al cyl. Ø8mm, 16 wires *



#2357, Al cyl. Ø16mm, 8 wires

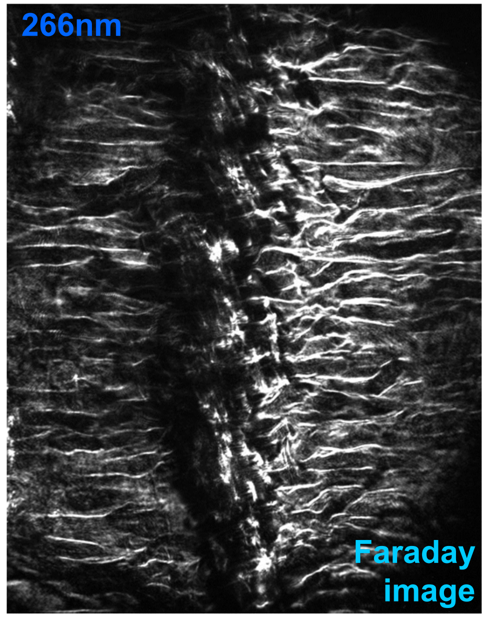


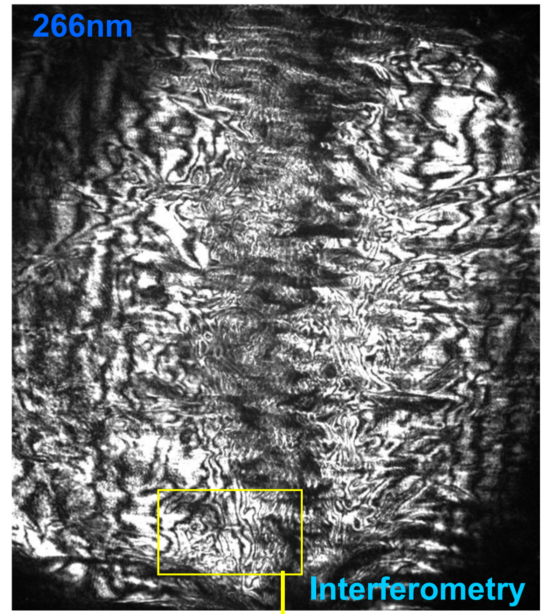
#2544, Al planar 10 wires

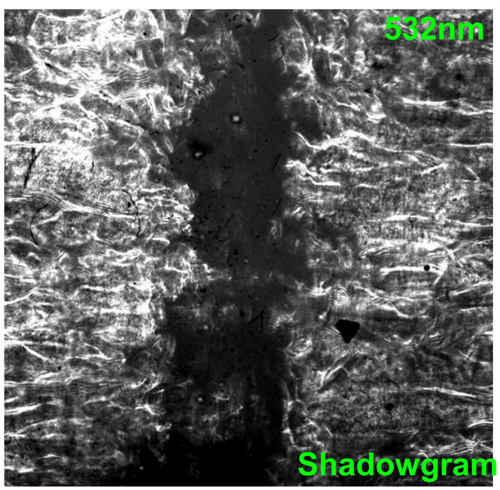


* V. Ivanov et al., PRL 107, 165002 (2011)

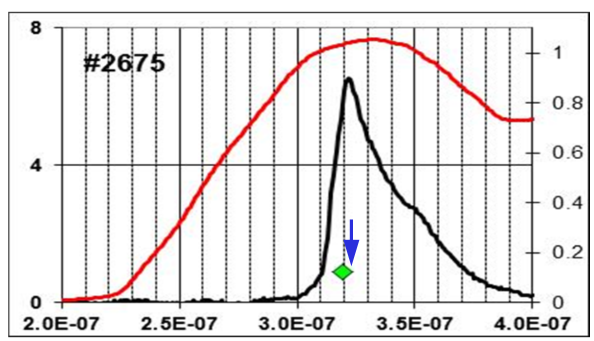
A UV Faraday diagnostic shows a structure of magnetic fields

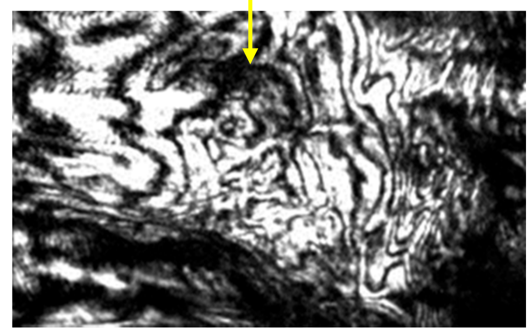






#2675. Al Ø16mm, 8 wires,
m = 54 µg, α = 5.6º

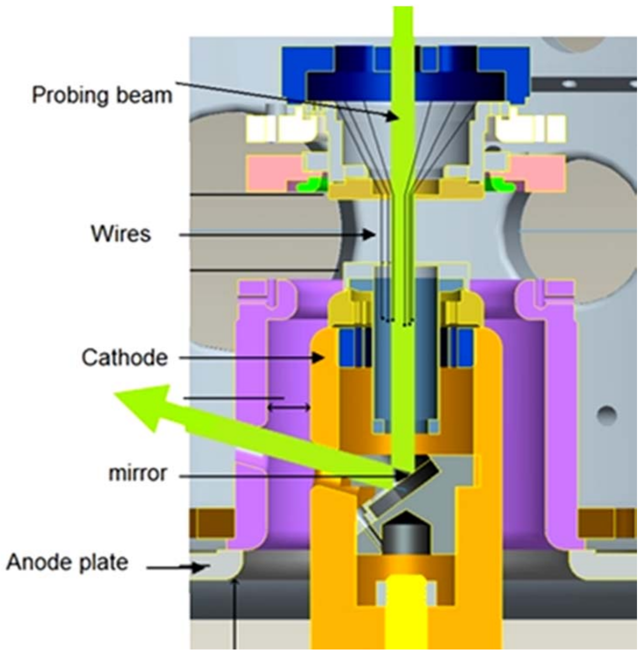




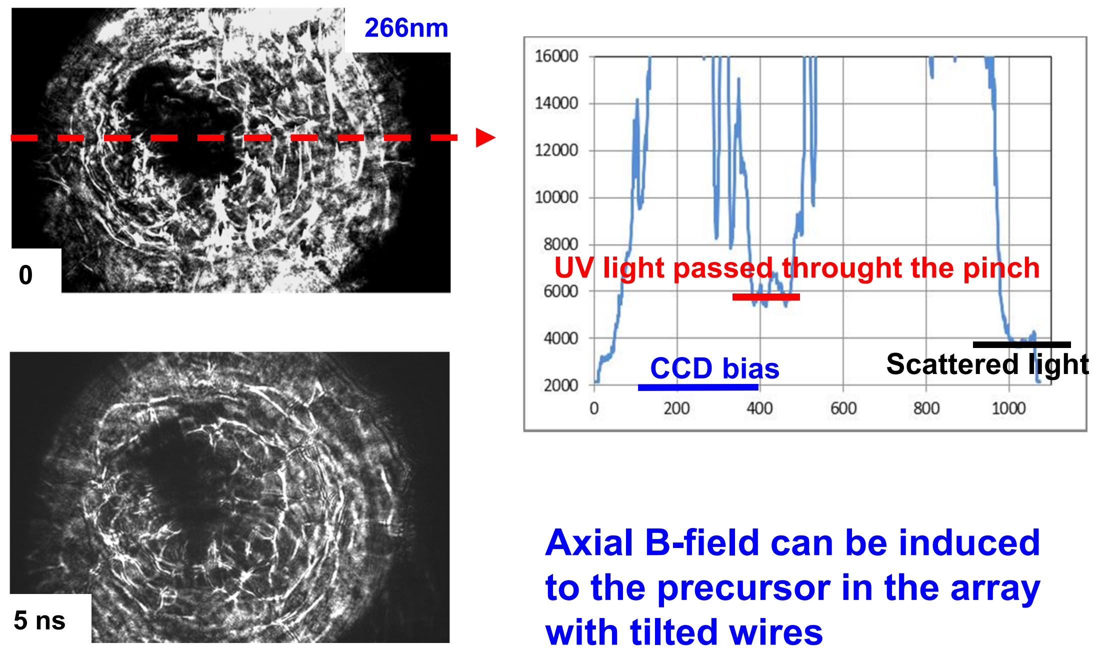
January 2012

Preliminary experiments with axial Faraday diagnostics can be carried out at the Zebra generator

Two-frame UV 266nm axial shadowgraphy is available at Zebra (D. Papp, UNR)



Two-frame axial shadowgram. #2723. Cylindrical wire array, h=1cm, m=27μg



Axial B-field can be induced to the precursor in the array with tilted wires

February 2012

λ = 266nm, 0.2ns, 50mJ – available for preliminary experiments at Zebra. Quartz optics, cost X (2-3).
λ = 157nm - excimer laser, Coherent, 50mJ, 10ns, $200. Small energy?
λ = 176nm – 6^{th} harmonic of the neodymium laser. Needs a research.
MgF_2 and CaF_2 optics, cost X (5-10). Vacuum beampath. Polarizers, narrowband filters?