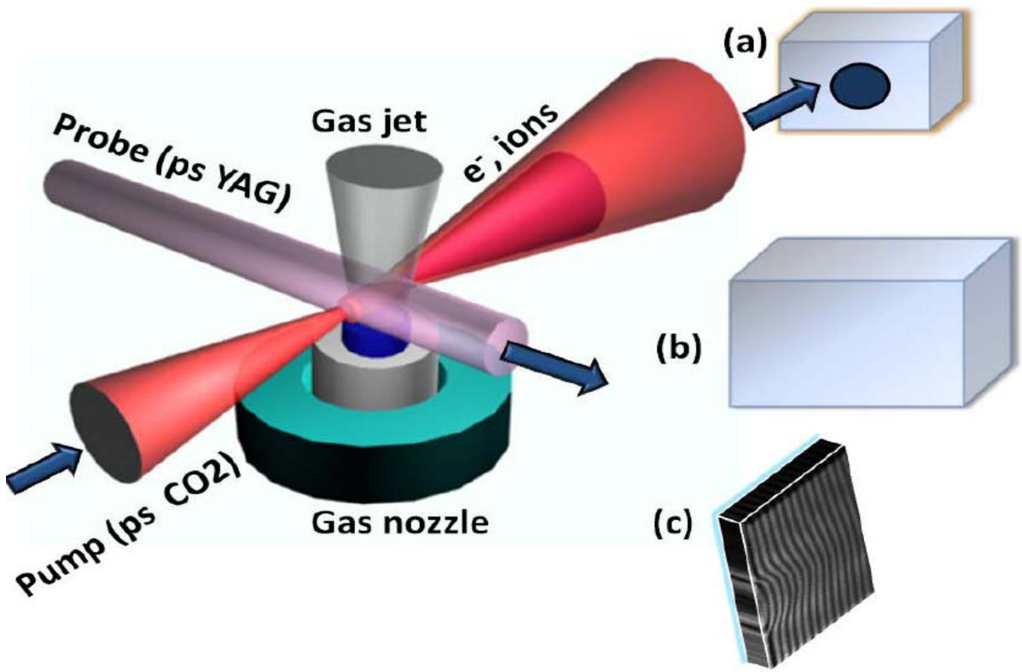
Proposed project: Study of Hot Electron Transport and Subsequent Ion Acceleration using Overdense Gas Jet Target and Ultrafast TW CO2 Laser System

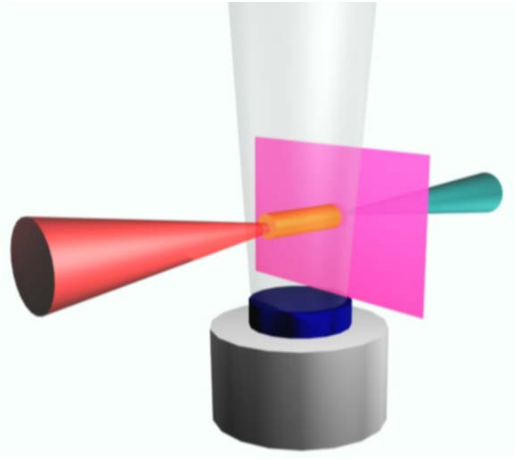
Subhendu Kahaly, F.Sylla, A. Flacco, V. Malka
Laboratoire d' Optique Applique (LOA), Ecole Polytechnique, France

Vitaly Yakimenko, Igor Pogorelsky
ATF, Brookhaven National Laboratory, USA

Planned experiments at BNL



(a) Ion detection, (b) Magnetic field detection, (c) Diagnostics for interferometry



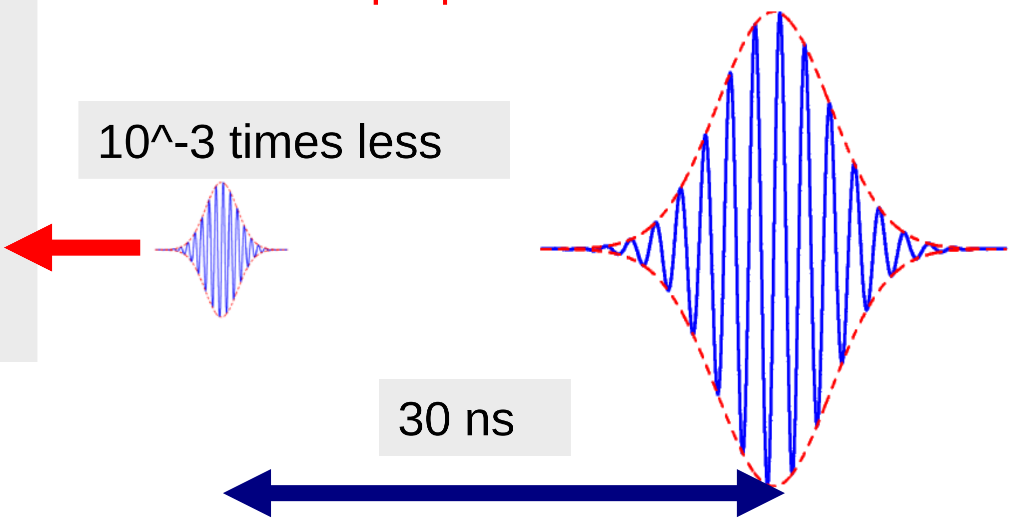
1.Alpha	He+, He++ in forward direction
2.B field	Faraday rotation + Interferometry
3.Al ion	Gasjet + Al foil target

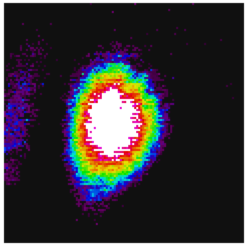
Main pulse characteristics

<u>Pulse parameters</u>

- Wavelength (10.2 um)
- Pulse duration (3~6 ps FWHM)
- Pulse energy (3~4 J)
- Polarisation (circular)
- Beam diameter (2 inch)
- Has a 30 ns replica prepulse

No visible preplasma
Due to the prepulse





Laser intensity 10^16 W/cm2 (@1 TW)

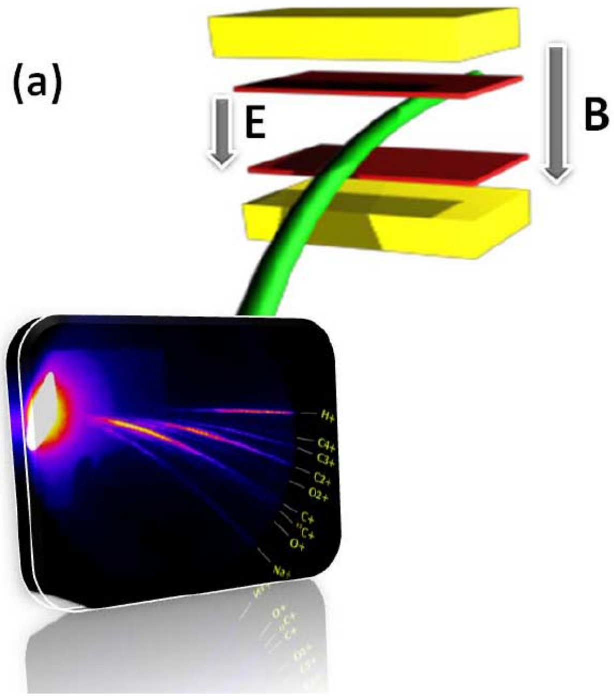
a_0 = 1.4 ~ 0.85

<u>Focal conditions</u>

- Parabola f = 150 mm
- f/# = f/3
- W_0 ~ 70 um

Forward ion spectra with Thomson parabola+MCP

1.Alpha



Typical ion traces from Al foil due to TNSA

Motivation

- Accessing 3 orders in density from strongly underdense to highly overdense
- Signature of RPA? (1,2)
- To settle the issue charge resolved measurement is a must
- Effect of nozzle geometry and gas jet size controlling propagation

1. ***Laser energy conversion to solitons and monoenergetic proton in near-critical hydrogen plasma***, V. Pogorelsky *et al.* Proceedings of IPAC’10, Kyoto, Japan

2. ***Monoenergetic proton beams accelerated by a radiation pressure driven shock***, Charlotte A. J. Palmer, http://arxiv.org/pdf/1006.3163

Probe beam option

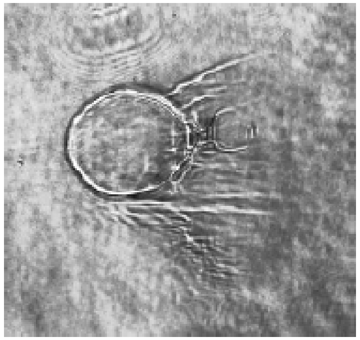
<u>Pulse parameters</u>

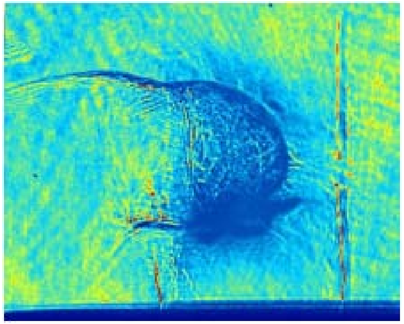
- SHG of the YAG pulse
- Wavelength (0.532 um)
- Pulse duration (14 ps FWHM for the YAG)
- Pulse energy (~ sufficient)
- Arrival time w.r.t CO_2 beam (jitter less than 1~2 ps)

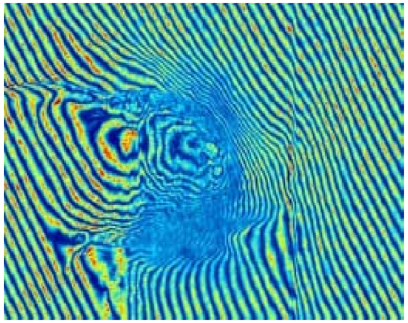
☹ Duration longer than the main pulse

☺ Probed plasma is strongly Underdence refraction effects less

☺ This probe has already been used for shadowgraphy and interferometry

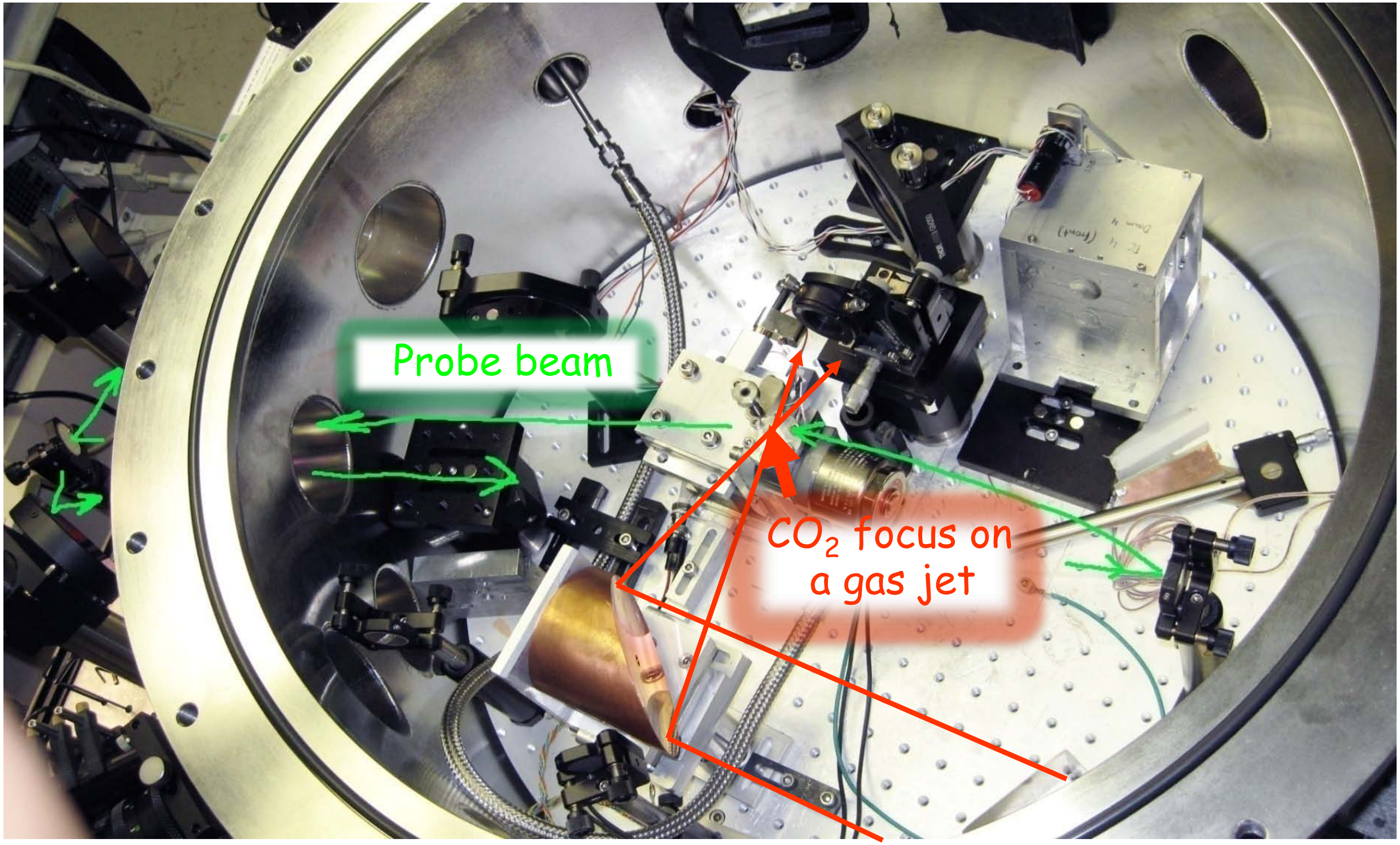






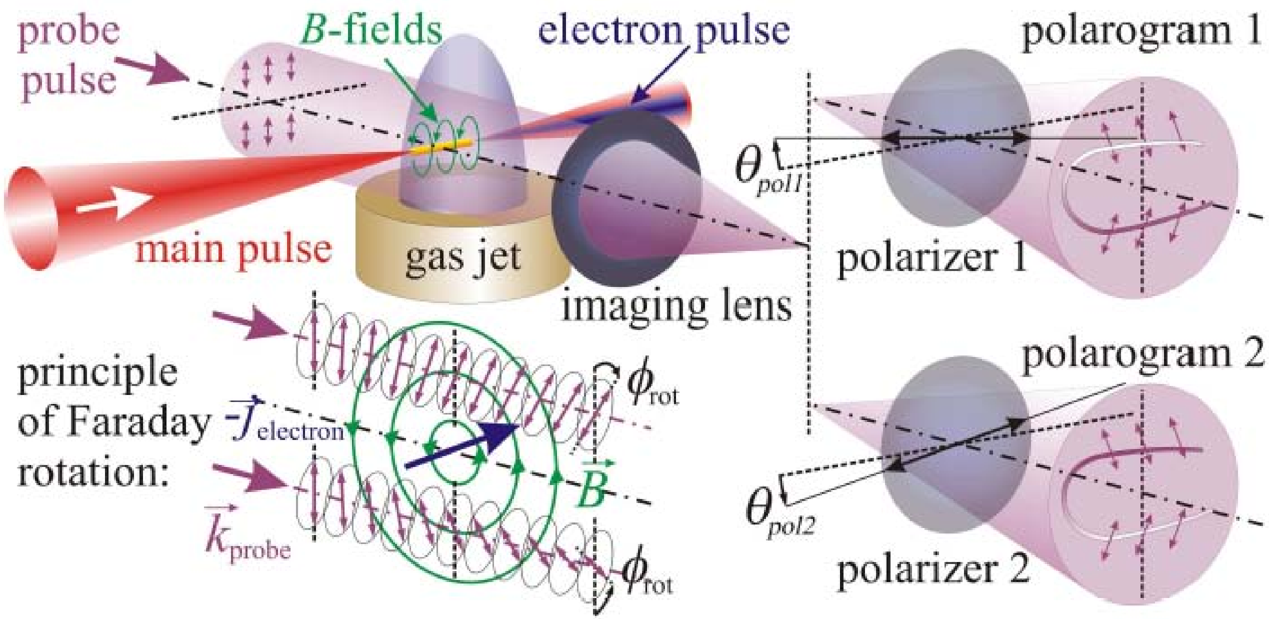
Laser energy conversion to solitons and monoenergetic proton in near-critical hydrogen plasma,
V. Pogorelsky *et al.* Proceedings of IPAC'10, Kyoto, Japan

BNL pump-probe set up with gas jet



Measuring the azimuthal magnetic field

2.B field



Motivation

- Capturing the rich physics of transport in *overdense* laser plasma
- Correlation of self generated B field with forward ion acceleration
- Space resolved time evolution of B field over a wide density range

Measurement technique has already been successfully applied to *underdense* laser plasma interaction

Measurement of Magnetic-Field Structures in a Laser-Wakefield Accelerator
M. C. Kaluza *et al.* http://arxiv.org/abs/1007.3241

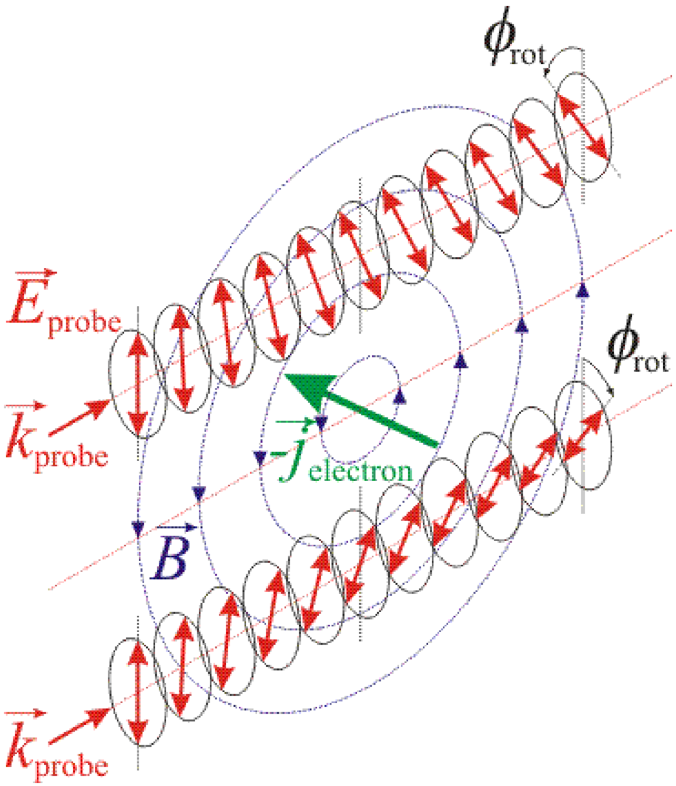
Faraday-Rotation Principle

- Probing of magnetic fields in plasma with linearly-polarized pulse:

⇒ Probe polarization rotation:

$$\phi_{\text{rot}} = \frac{e}{2m_e c}\int \frac{n_e(\vec{r})}{n_{\text{cr}}}\vec{B}(\vec{r})\cdot\frac{\vec{k}_{\text{probe}}}{k_{\text{probe}}}\,\mathrm{d}s$$

⇒ For *B*-field distribution we need to measure ϕ_{rot} and n_e all over the plasma space!!



http://arxiv.org/abs/1007.3241

Target configuration

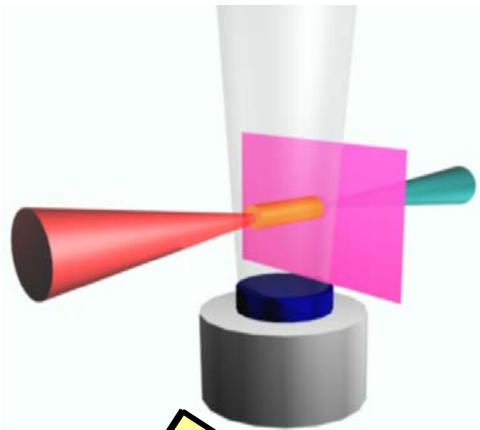
3.Al ion

Motivation

- Taking advantage of self focussing to reach high intensity
- Tuning gas density to control interaction and hot electron source
- Look at the ion emission from foil back surface while the gas jet controls propagation

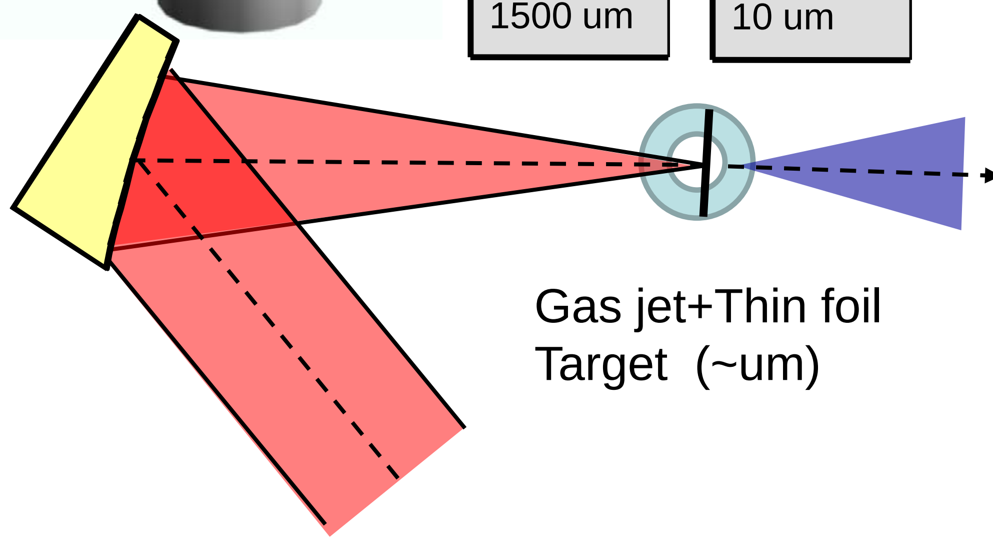
Gas jet target
- Of different nozzle diameters

Thin foil target
- Of varying thickness



He JET
diameter
200 um
400 um
1000 um
1500 um

Al FOIL
thickness
400 nm
2 um
6 um
10 um



Gas jet+Thin foil
Target (~um)