COPL Centre d'optique, photonique et laser

Ultrafast Intense Laser Science Lab

UNIVERSITÉ LAVAL

Lasing action in air induced by ultrafast laser filamentation

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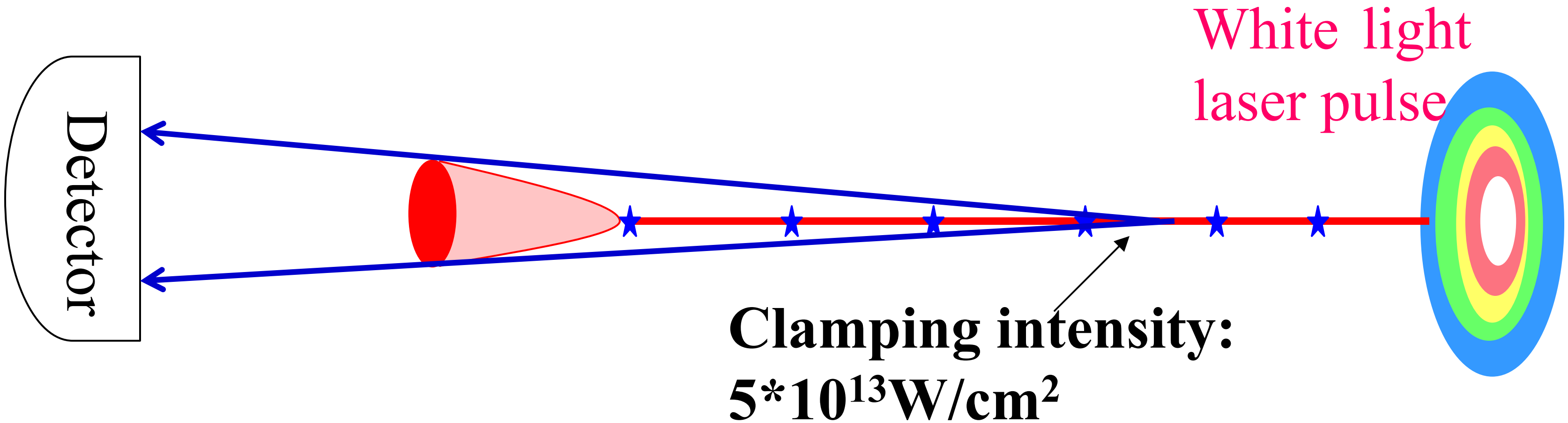
Filamentation



Balance between self-focusing and defocusing effect of the plasma → Intensity clamped inside filaments :

J. Kasparian et al,Appl. Phys. B **71**, 877 (2000).
A. Becker et al, Appl. Phys. B **73**, 287 (2001).
H.R. Lange et al, Phys. Rev. Lett. **81**, 1611 (1998)

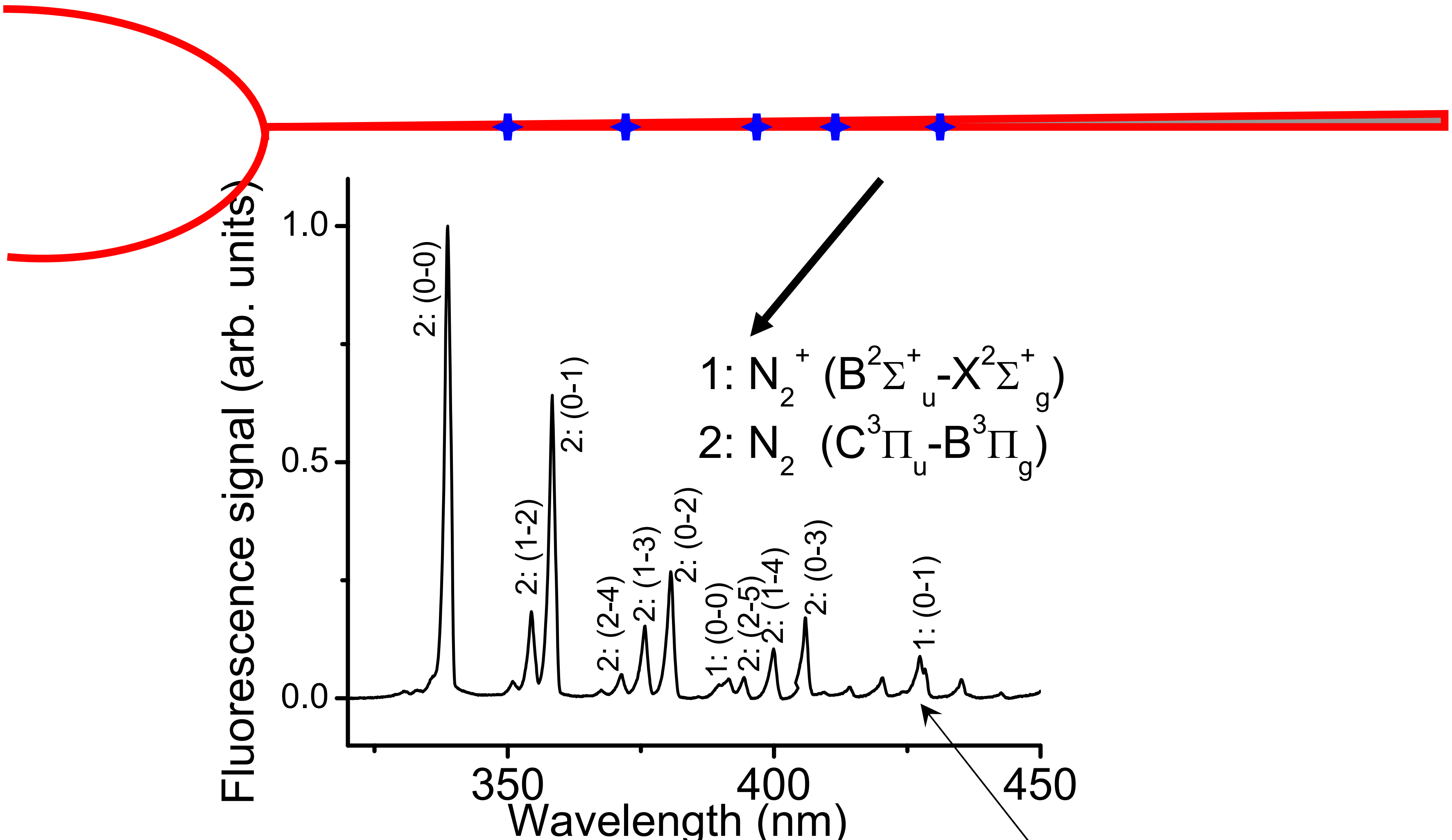
W.Liu, Opt. Commun. 202, 1897(2002).

Potential application: remote sensing------Lidar technique:

Backscattered linear absorption spectra of white light

P. Rairoux et al (Teramobile group), Appl. Phys. B 71, 573 (2001)

The fluorescence spectrum of air (from the side)

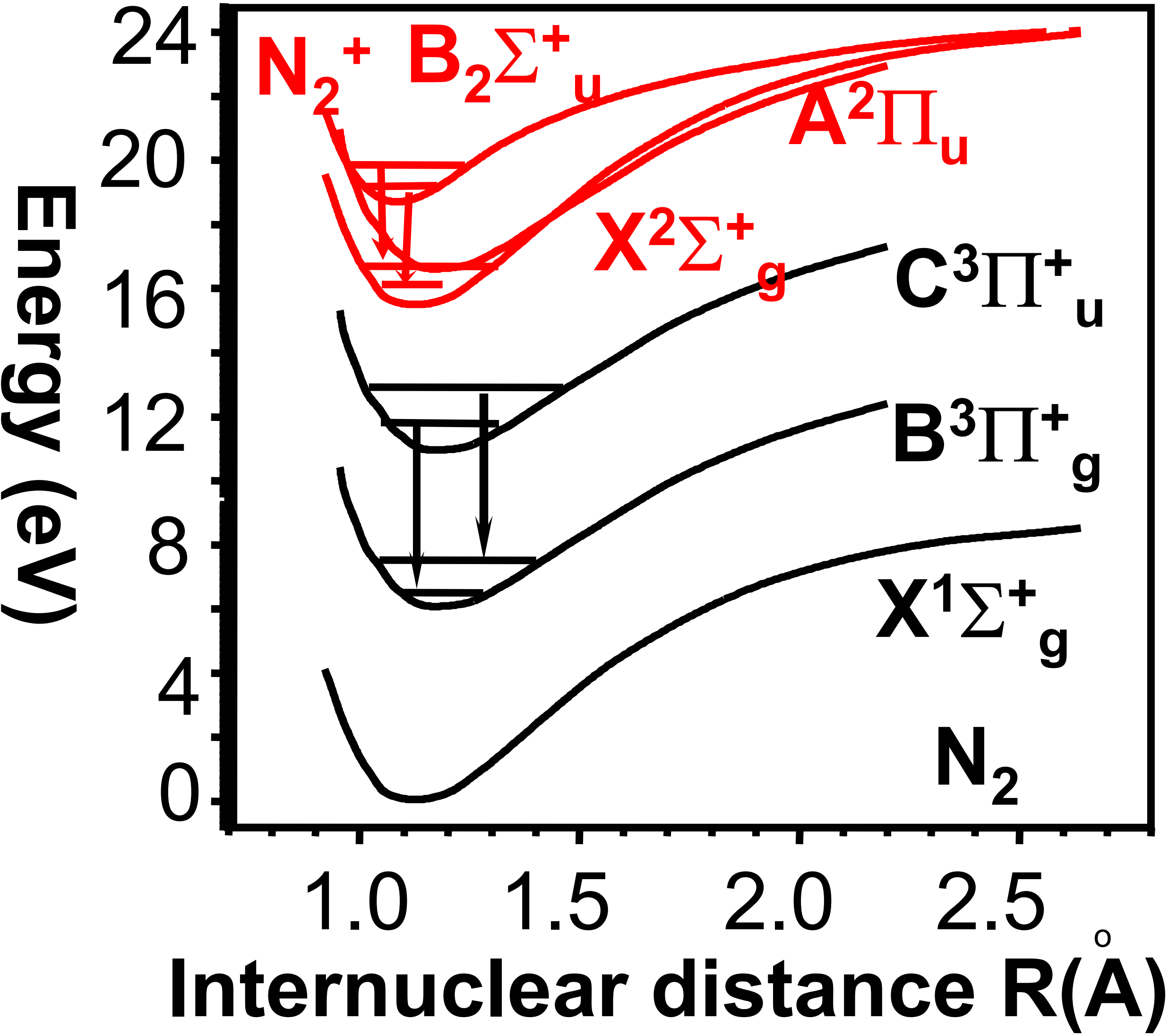


Free of plasma continuum

A. Talebpour et al, Opt. Comm. 183, 479 (2000)

Laser Physics 11, 68 (2001)

The schematic potential energy diagram of N_2 and N_2^+



$N_2 \rightarrow N_2^+$:

multiphoton ionization of inner valence electron

N_2^*

e-ion recombination

— ASE

A Talebpour et al, Chem. Phys. Lett. **313** (1999).
A. Becker et al, Chem. Phys. Lett. **343** (2001).

Is there amplification for the N_2 fluorescence?

In this work, backscattered fluorescence is studied:

– Spectra

– Intensity dependence

– Angular distribution

Time-resolved backscattered fluorescence spectra with ICCD)

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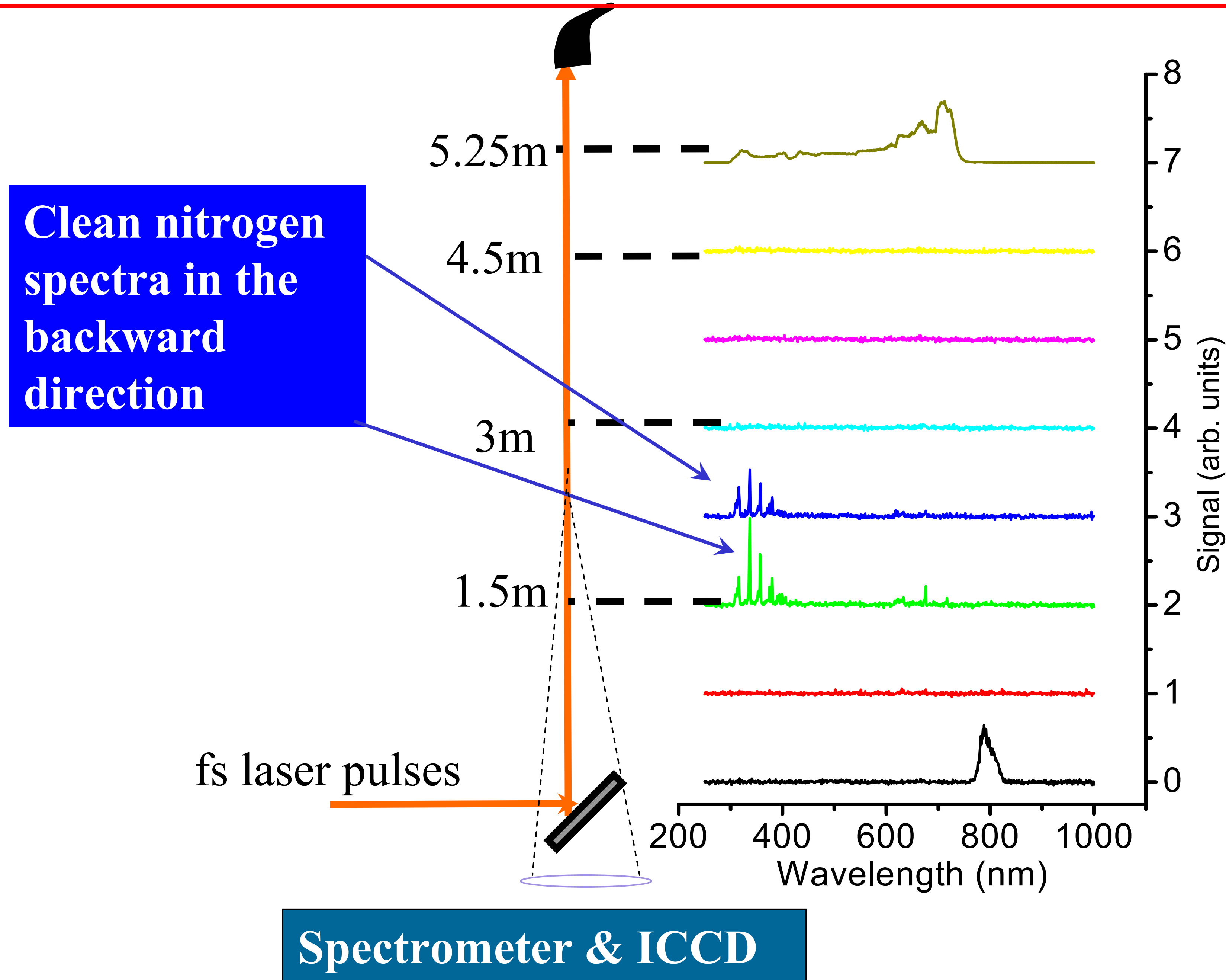
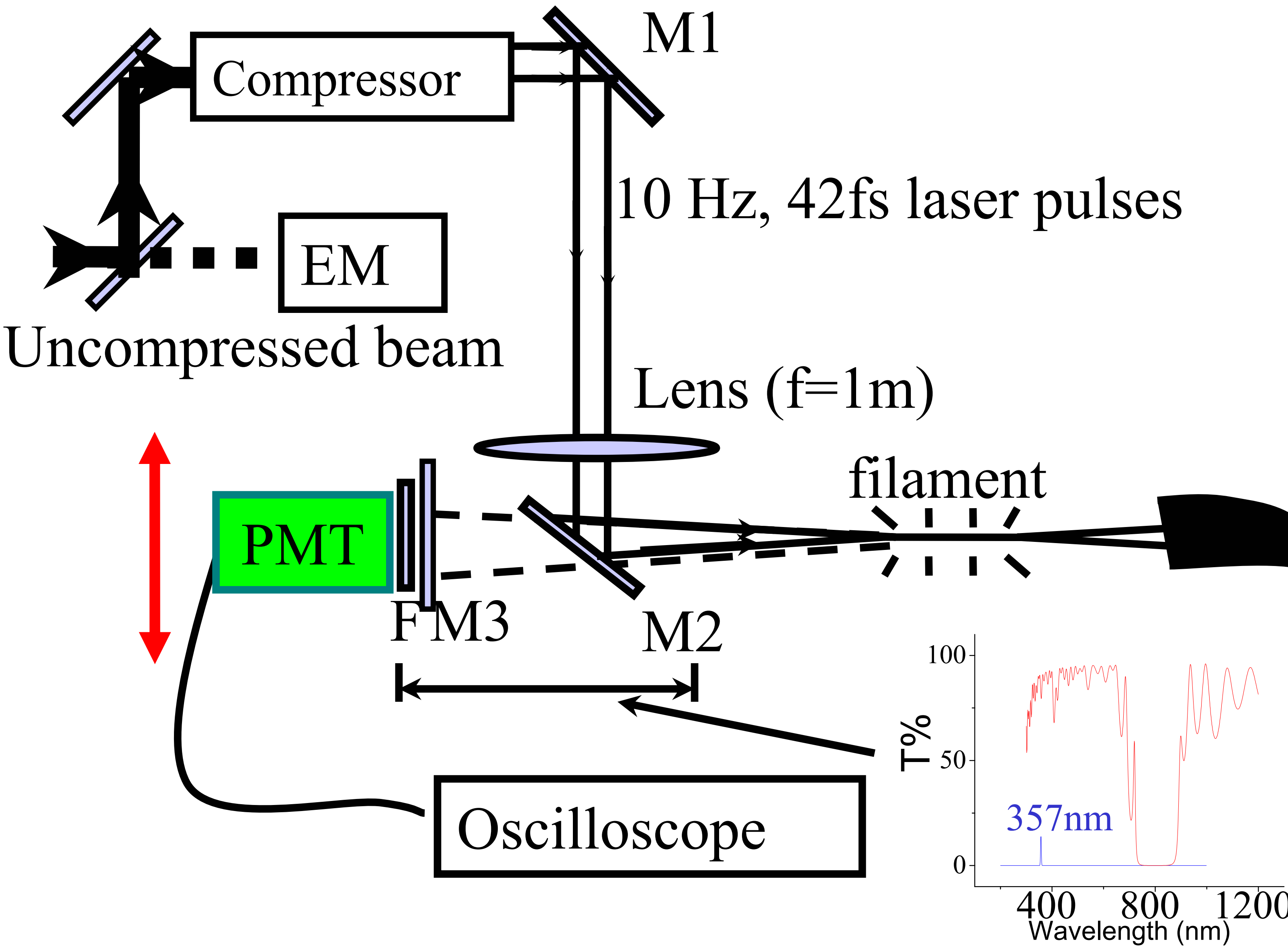
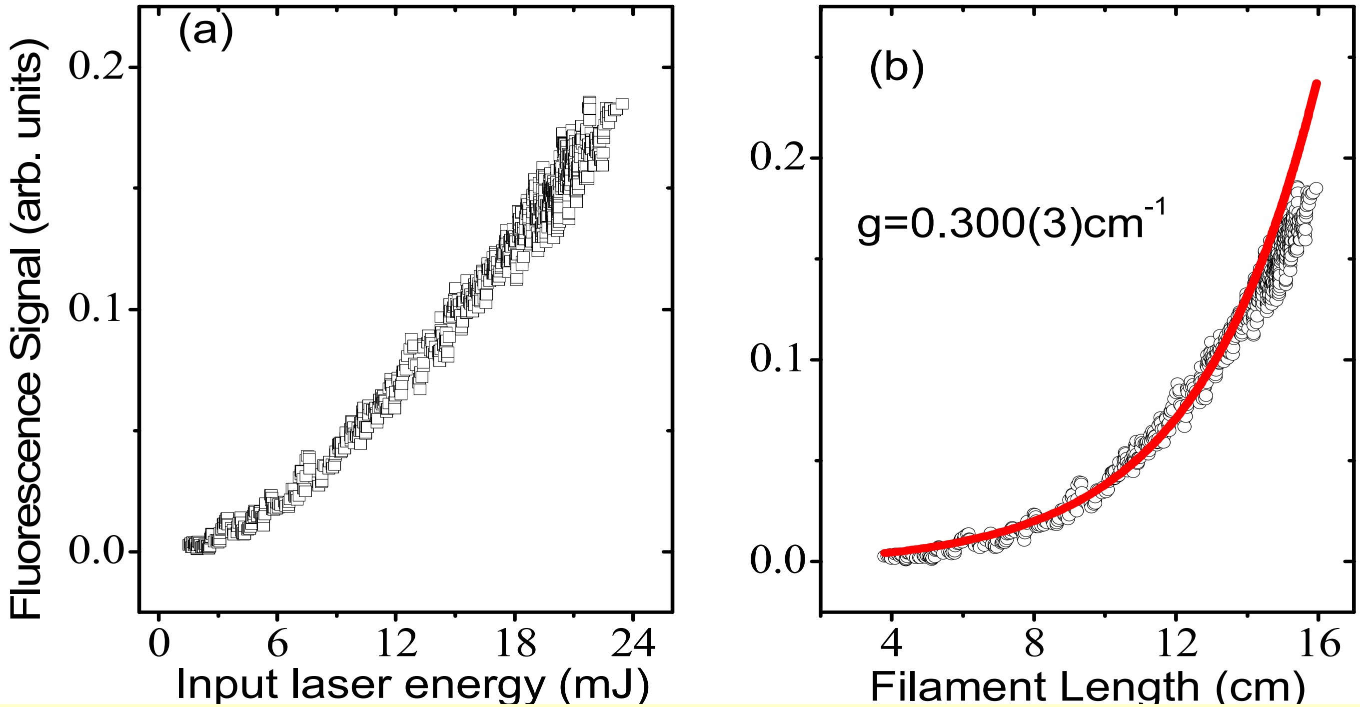


Experimental setup



Intensity dependence of the backscattered fluorescence

With external focusing lens (f=1m)



Filament length L : $L=f-z'_f$

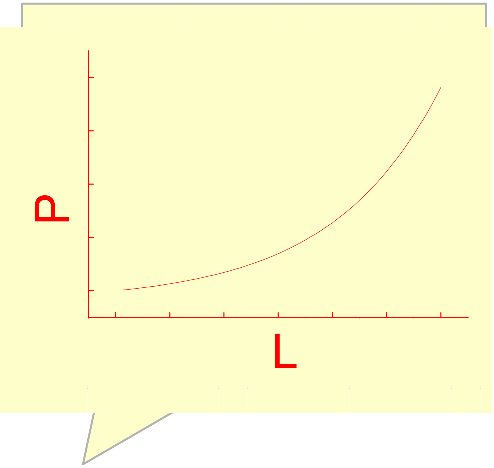
$$z_f = \frac{0.367ka^2}{\left\{\left[\left(\frac{P}{P_{crit}}\right)^{1/2} - 0.852\right]^2 - 0.0219\right\}^{1/2}}$$

$$z_f' = \frac{z_f f}{z_f + f}$$

Q.Luo et al, Appl. Phys. B 76 (2003)

Calculation for the ASE signal

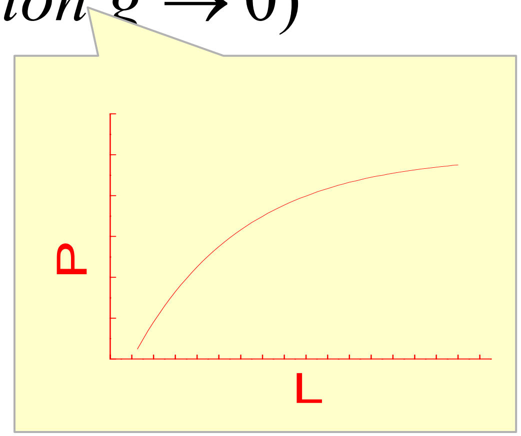
Consider filament as a line source emitting fluorescence:



$$I \propto P$$

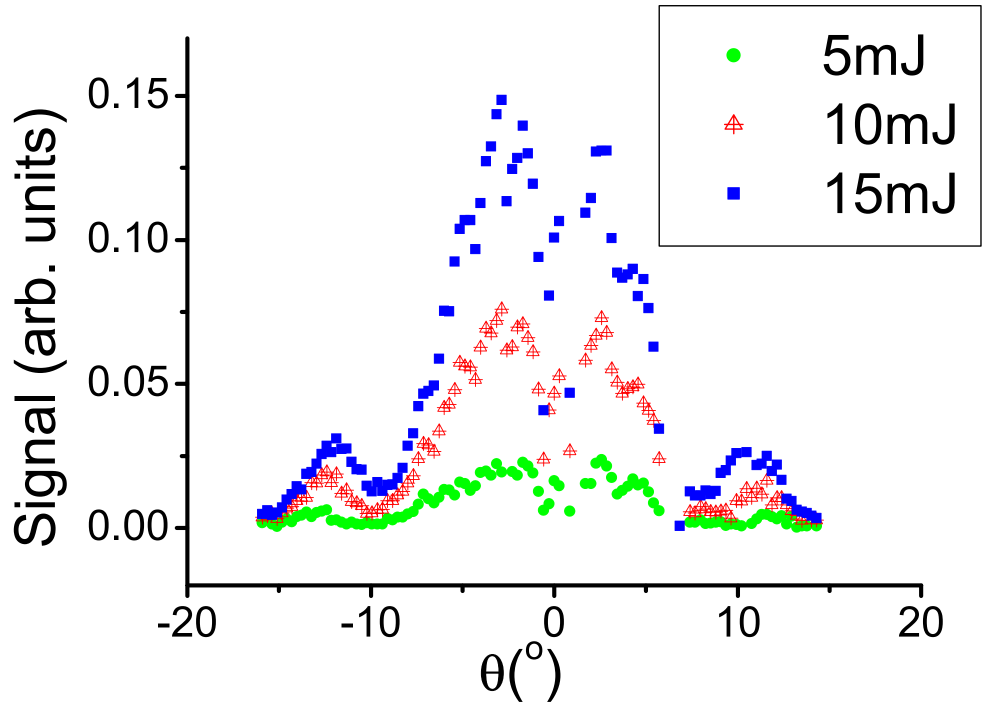
$$= \int_0^L P_s e^{(G-\alpha)l} dl$$

$$= \begin{cases} \dfrac{P_s}{G-\alpha}\left(e^{(G-\alpha)L} - 1\right) = \dfrac{P_s}{g}\left(e^{gL} - 1\right)(\textit{with amplification}) & (a) \\ \dfrac{P_s}{\alpha}\cdot\left(1 - e^{-\alpha L}\right)\ (\textit{without amplification } g \to 0) & (b) \end{cases}$$

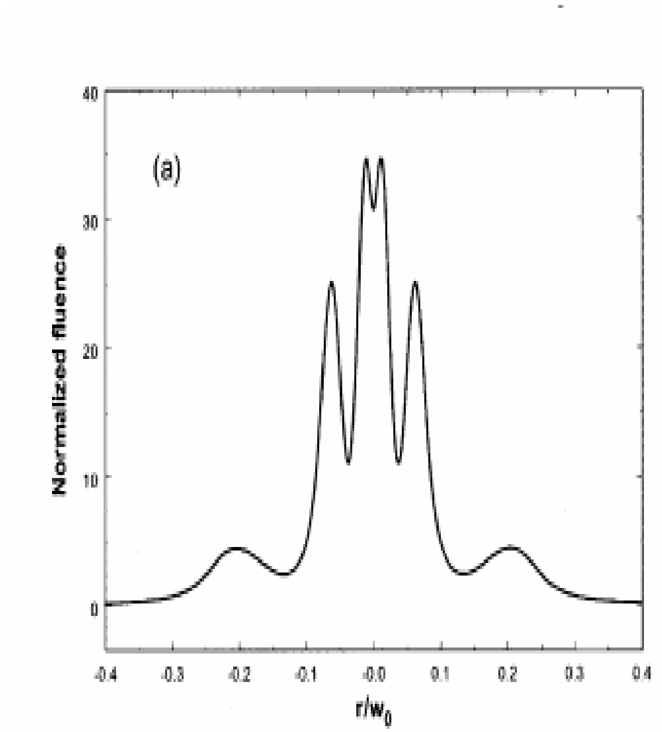


Effective gain : $g = G - \alpha$

Angular distribution of fluorescence signal



Experimental results



Calculated fluence distribution inside filament

S.L. Chin et al, Optics Communications 188, 181-186 (2001)

The gain curves at different angles

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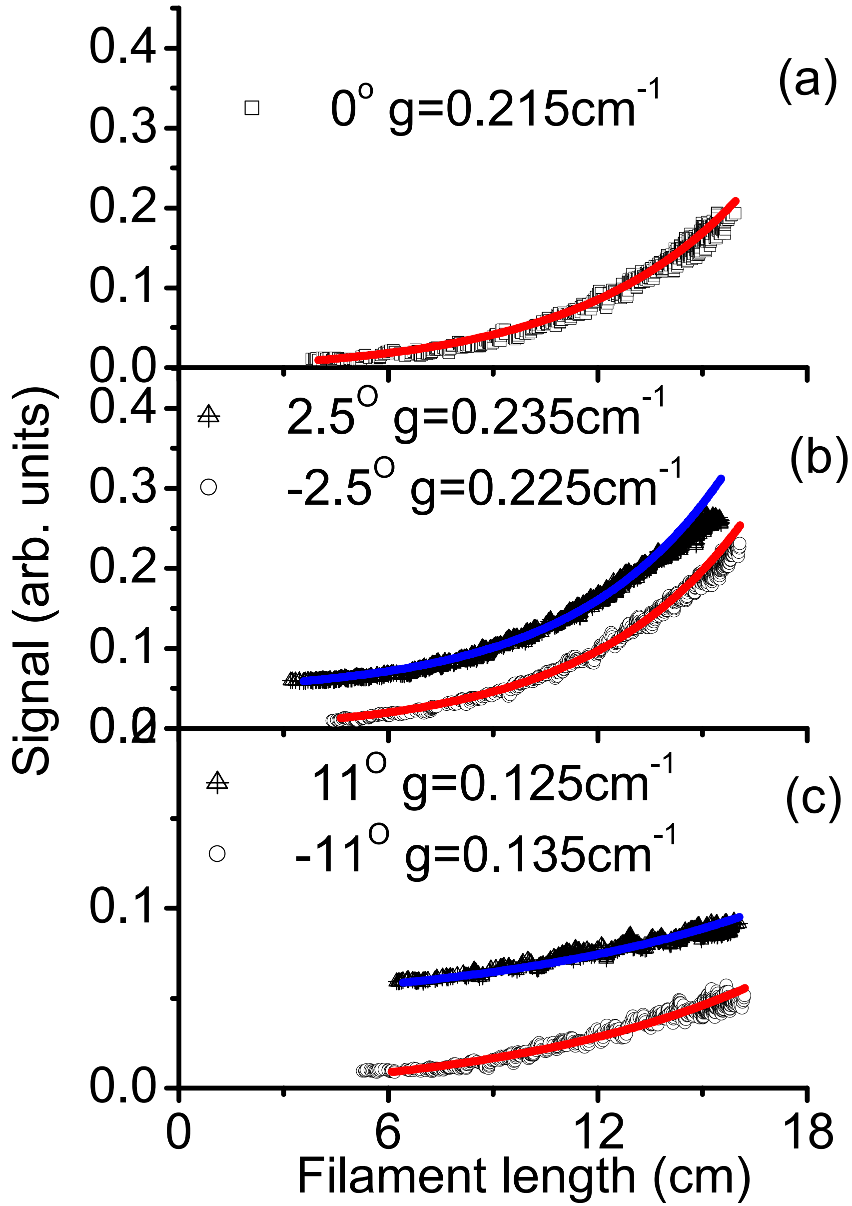

Conclusion

- Clean time-resolved fluorescence spectra in backward direction.

- The backscattered fluorescence from filament in air is amplified.

- The angular distribution of the fluorescence shows ring structure which is consistent with the fluence distribution inside filament.

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