

# Public Comment: Possibilities in Raman Amplification and Compression of High Power Light in Plasma

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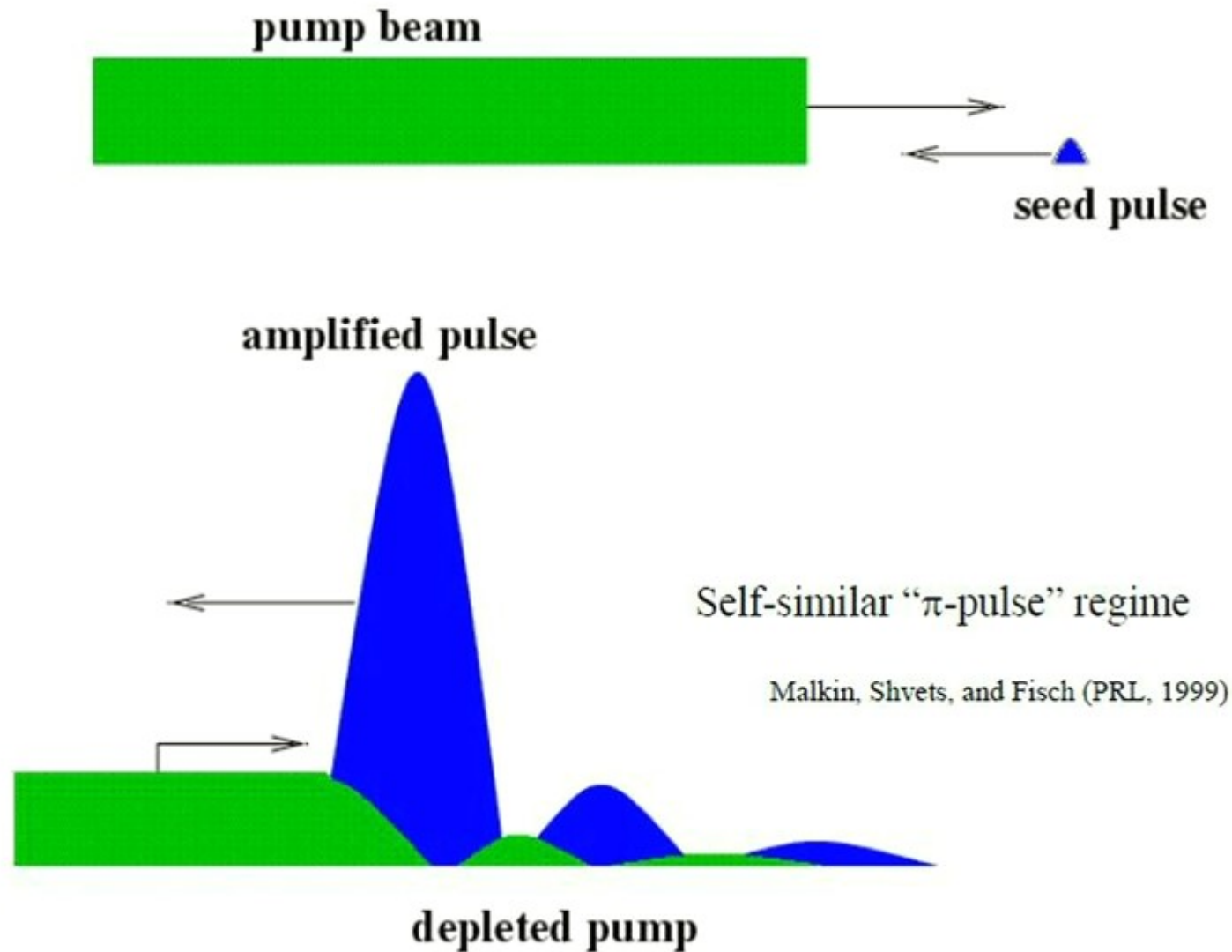
High Energy Density Physics Workshop  
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Gaithersburg, Maryland

1. What are some ideas for getting to the next generation of laser power densities?
2. What are the recent results?

7<sup>th</sup> compelling intellectual question: Note: First 6 given by Todd

How can we access the next generation of laser intensities at different frequencies?

## Amplification of Pulse by Resonant Raman Backscatter



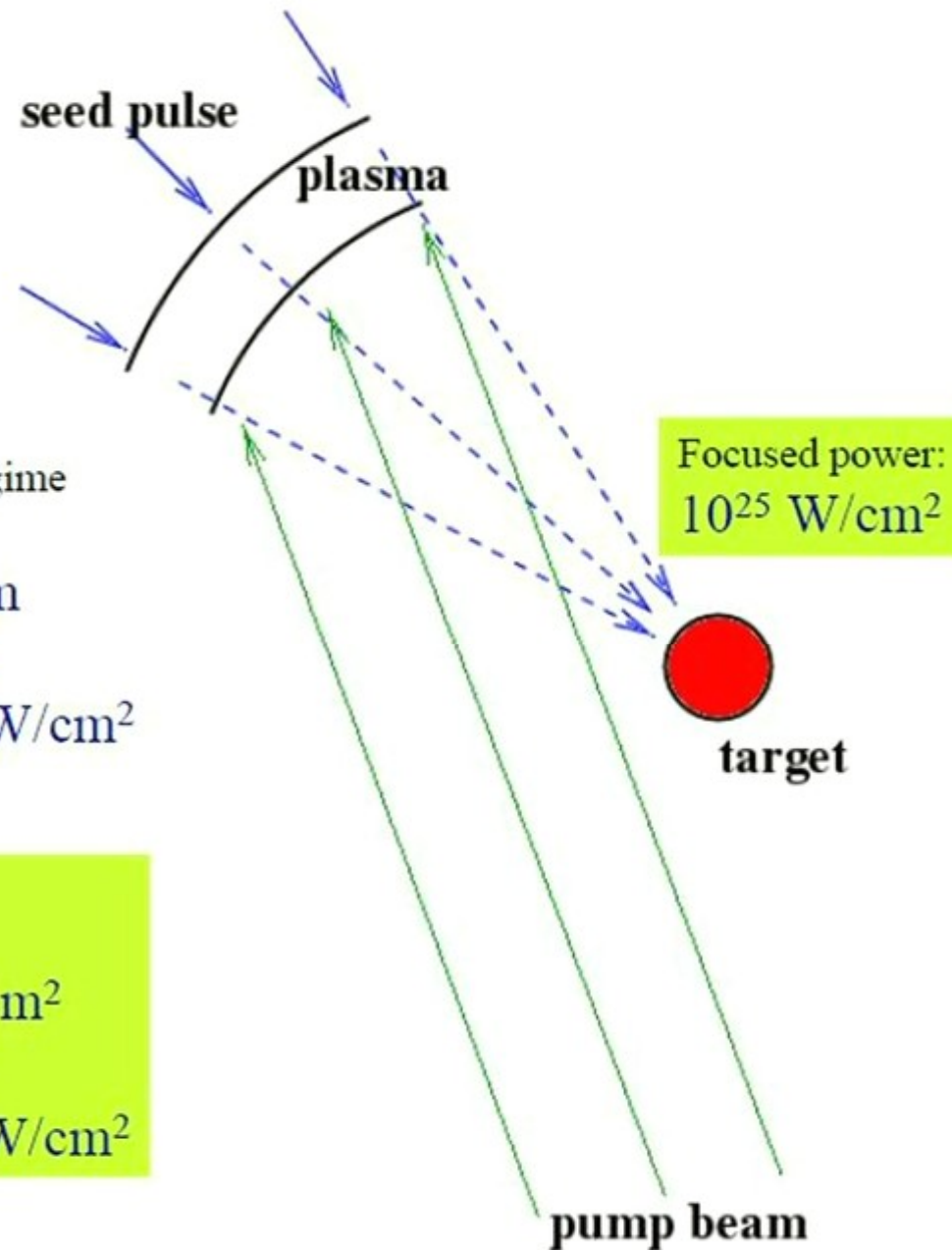
## Plasma as an Amplifier

Representative parameters  
For Resonant Raman Backscatter Regime

|                |                             |
|----------------|-----------------------------|
| Plasma width   | 0.7 cm                      |
| Pump duration  | 50 ps                       |
| Pump intensity | $10^{14}$ W/cm <sup>2</sup> |

Output parameters (unfocused)

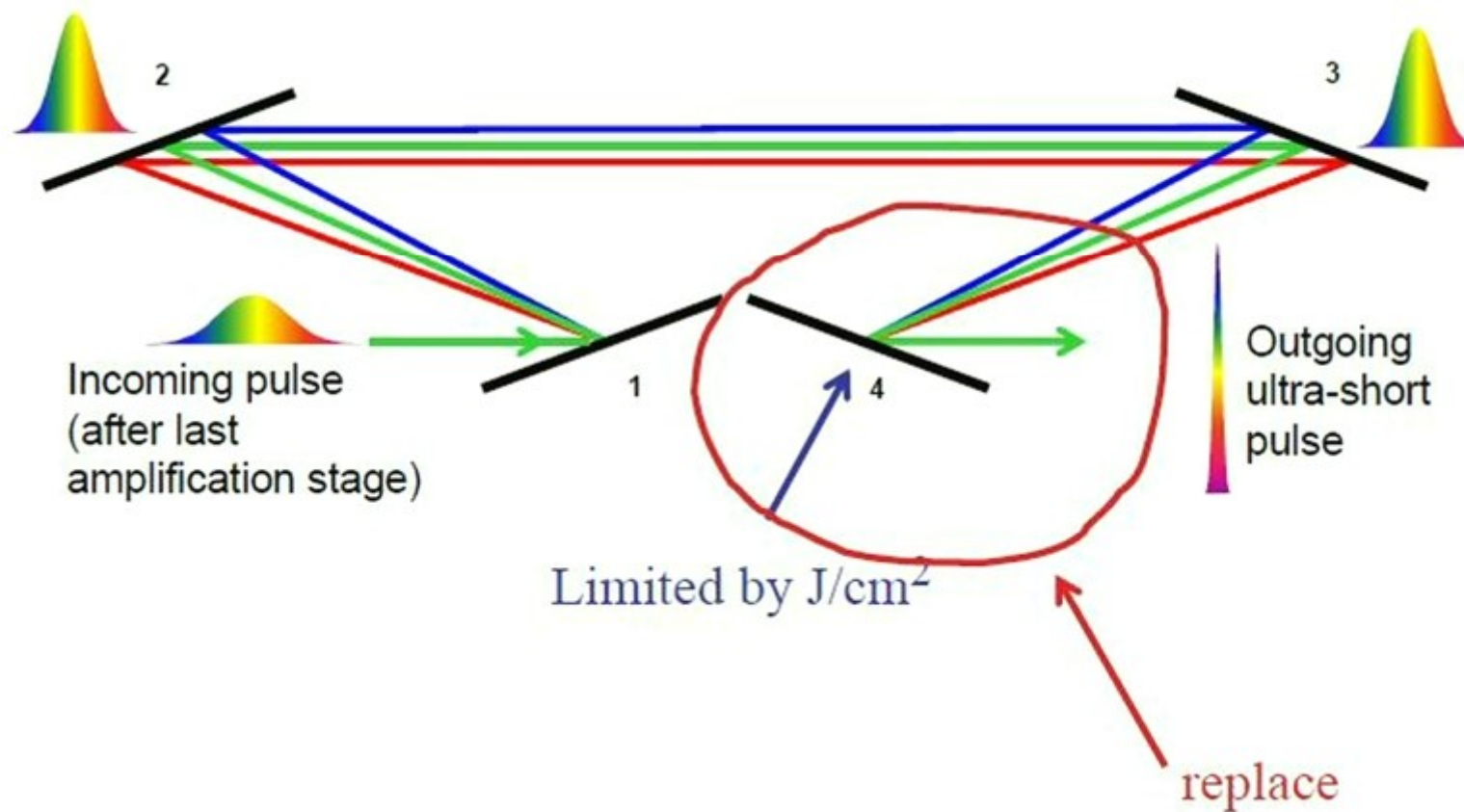
|                |                             |
|----------------|-----------------------------|
| Pulse fluence  | 4 kJ/cm <sup>2</sup>        |
| Pulse duration | 40 fs                       |
| Pulse power    | $10^{17}$ W/cm <sup>2</sup> |



## Examples

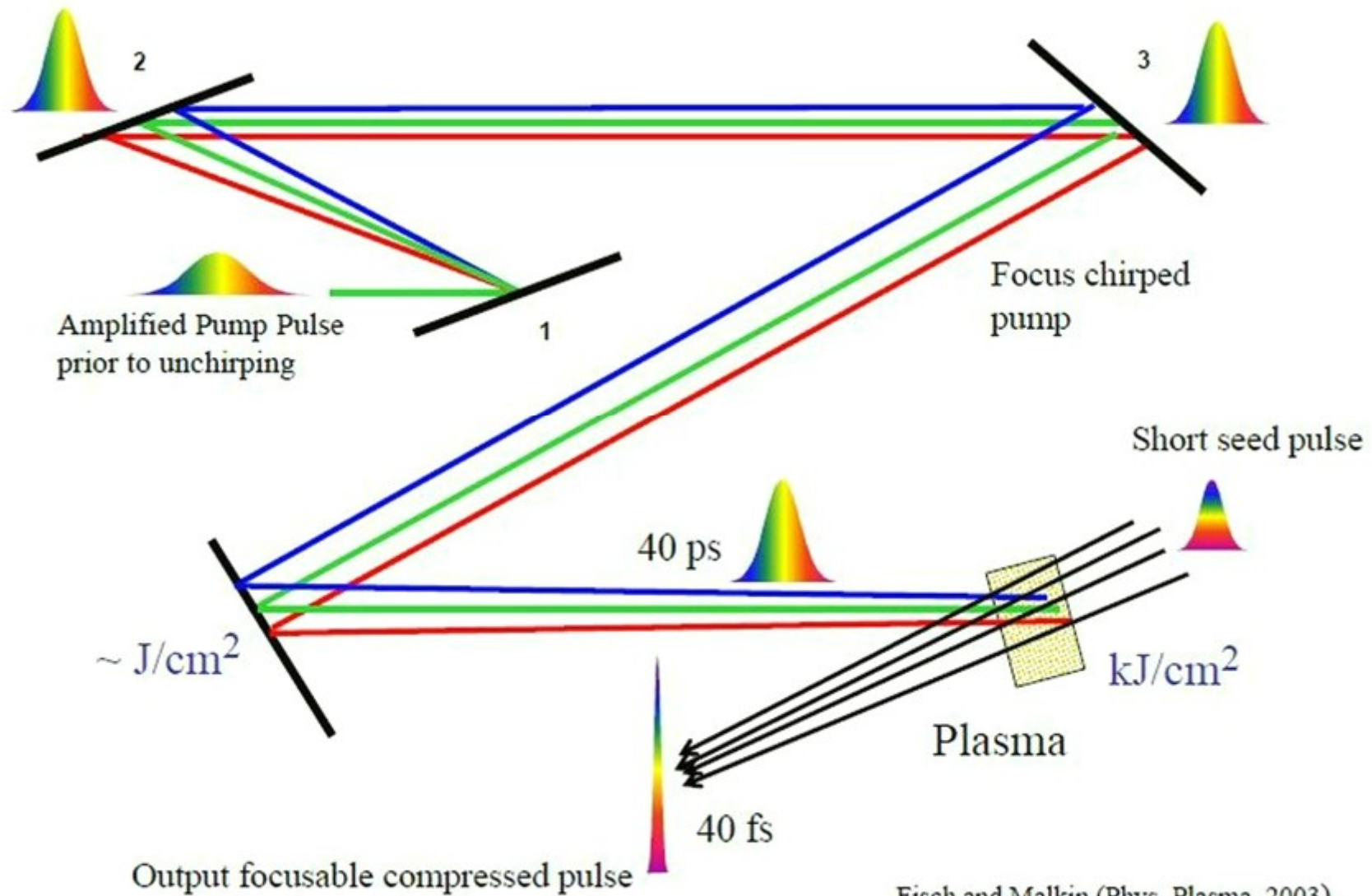
|  |                      |                      |                    |                    |
|--|----------------------|----------------------|--------------------|--------------------|
| Wavelength<br>of laser $\mu\text{m}$             | 1/40                 | 1/4                  | 1                  | 10                 |
| Duration<br>of pump ps                           | 1.25                 | 12.5                 | 50                 | 500                |
| Intensity<br>of pump $\text{W}/\text{cm}^2$      | $1.6 \times 10^{17}$ | $1.6 \times 10^{15}$ | $10^{14}$          | $10^{12}$          |
| Pump vector-<br>potential $a_0$                  | 0.006                | 0.006                | 0.006              | 0.006              |
| Laser-to-plasma<br>frequency ratio               | 12                   | 12                   | 12                 | 12                 |
| Concentration<br>of plasma $\text{cm}^{-3}$      | $1.1 \times 10^{22}$ | $1.1 \times 10^{20}$ | $7 \times 10^{18}$ | $7 \times 10^{16}$ |
| Linear $e$ -times<br>growth length cm            | .00043               | .0043                | .013               | .13                |
| Total length of<br>amplification cm              | .018                 | .18                  | .7                 | 7                  |
| Output pulse<br>duration fs                      | 1                    | 10                   | 40                 | 400                |
| Output pulse<br>fluence $\text{kJ}/\text{cm}^2$  | 160                  | 16                   | 4                  | 0.4                |
| Output pulse<br>intensity $\text{W}/\text{cm}^2$ | $1.6 \times 10^{20}$ | $1.6 \times 10^{18}$ | $10^{17}$          | $10^{15}$          |

# Modify Chirped Pulse Amplifier



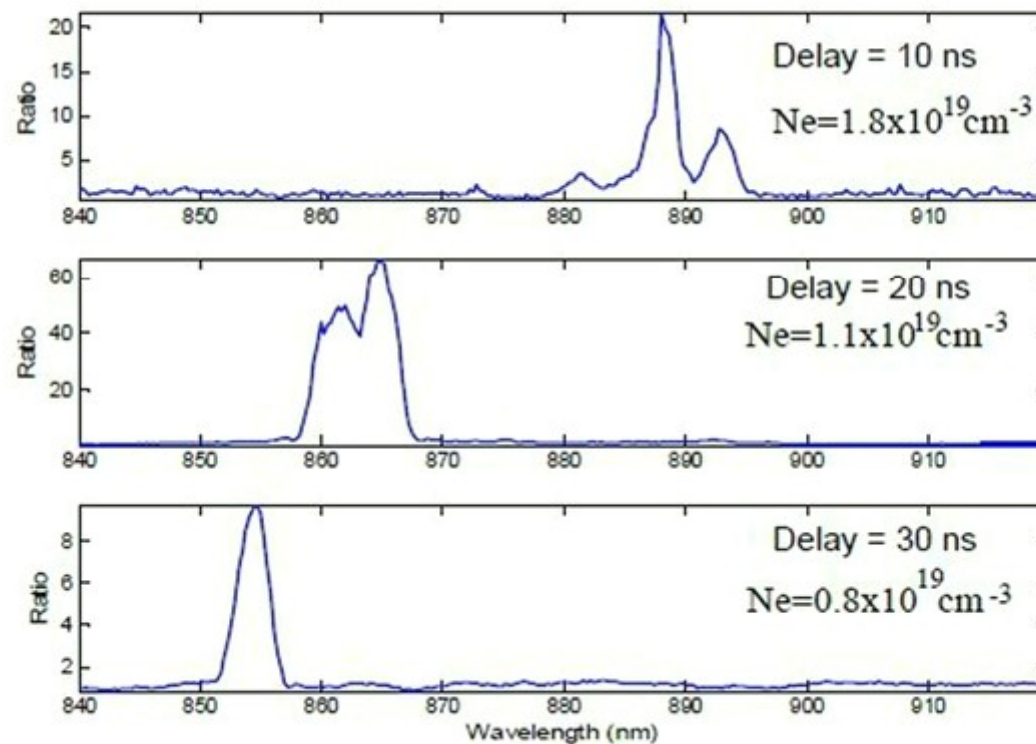


## Pulse Compression using Raman Backscattering in Plasma



Fisch and Malkin (Phys. Plasma, 2003)

## Raman Amplification in **2mm** Gas Jet Plasma at Three Densities (showing resonant effect)



Ping et al., PRL (March 2004)

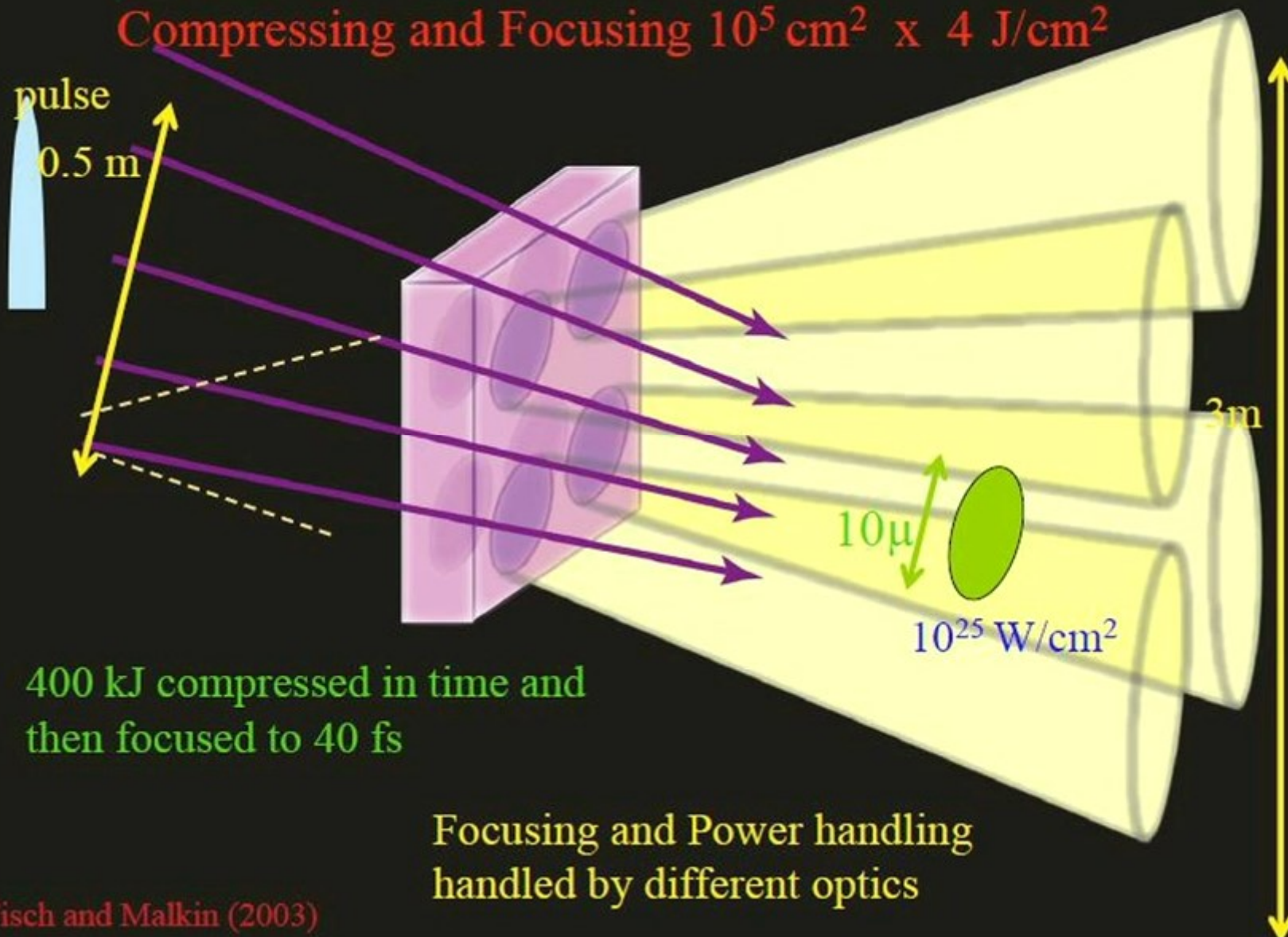
## Where do we stand today?

- A. Key experimental results
  - 1. Factor of 400 in energy amplification
  - 2. Entering nonlinear regime: pulse intensity greater than pump intensity
  - 3. Approaching shorter output pulse than linear broadening
  - 4. Validation of mechanisms and technology of RBS
    - a. Resonant interaction
    - b. control over density, frequencies and timing
    - c. Reasonable plasma target
- B. Theoretical Understanding
  - 1. Understanding Present Experiments
  - 2. Consideration of potential Showstoppers
    - a. Precursor or other instabilities of pulse
    - b. focusability of pulse in noisy plasma
    - c. Instabilities of pump, including sidescatter
- C. Multiplicity of Methods
  - 1. Detuning methods
  - 2. Multiple pumps and pump frequencies
  - 3. Amplification at ionization front
  - 4. Utilization of Compton scattering effect



# 10 Exawatt Laser: Compressing and Focusing $10^5 \text{ cm}^2 \times 4 \text{ J/cm}^2$

pulse  
0.5 m



400 kJ compressed in time and  
then focused to 40 fs

Focusing and Power handling  
handled by different optics

Fisch and Malkin (2003)