A new scheme to generate magnetic field using relativistic intensity laser And its application to proton acceleration by magnetic reconnection

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Summary

- **2.3 kT was generated by using a 500 μm-snail target (P. Korneev *et al.,* PRE 2016) illuminated by a 0.5 kJ/1.5 ps LFEX laser beam.**
- **Energetic (>15 MeV) proton beam driven by an inductive electric field associated with magnetic field reconnection was observed.**
- **Energetic (>15 MeV) proton beam accelerated by Alfven wave associated with magnetic field reconnection was observed.**

Snail target

Snail target is a new scheme to generate a strong magnetic field.

The loop current produces kilo-tesla magnetic field.

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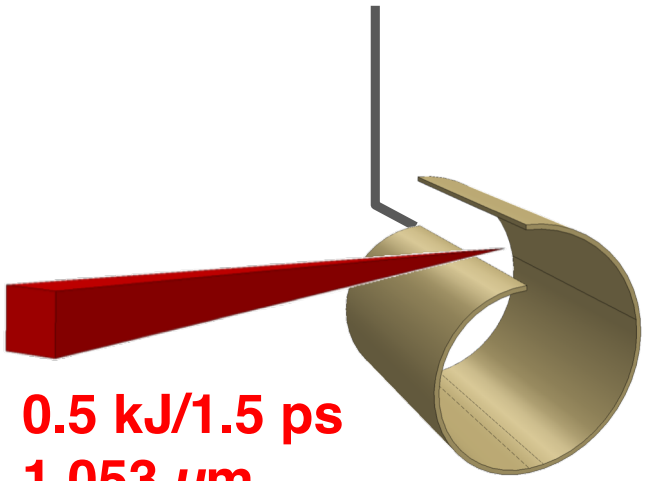
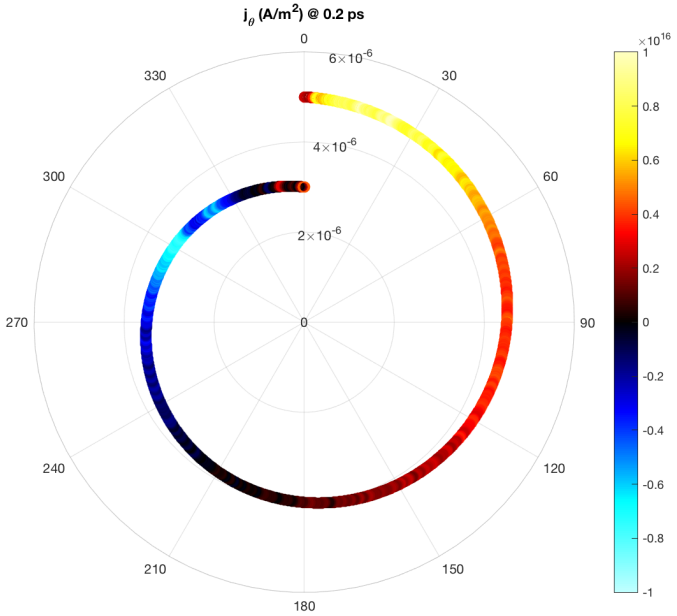
Snail target

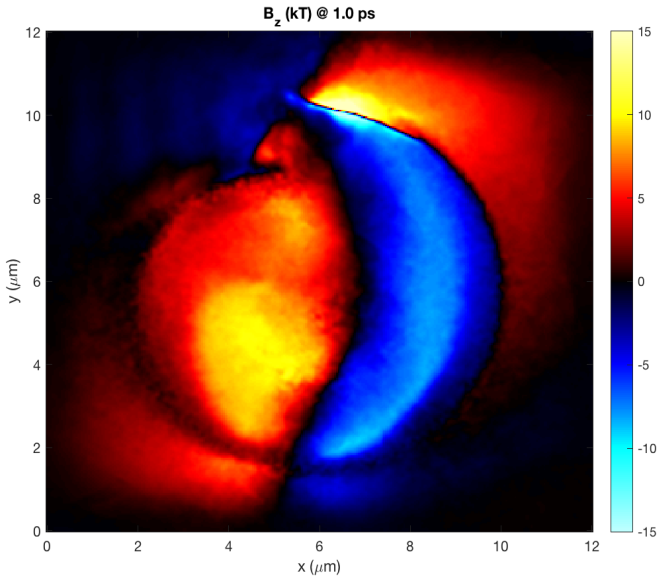


0.5 kJ/1.5 ps
1.053 μm
1 x 10^{19} W/cm^2

Current



Magnetic field Profile



Magnetic field measurement with proton beam

The large void pattern appeared in a proton probe beam.

The shape of the void corresponds to 2.3 kT of the magnetic field.

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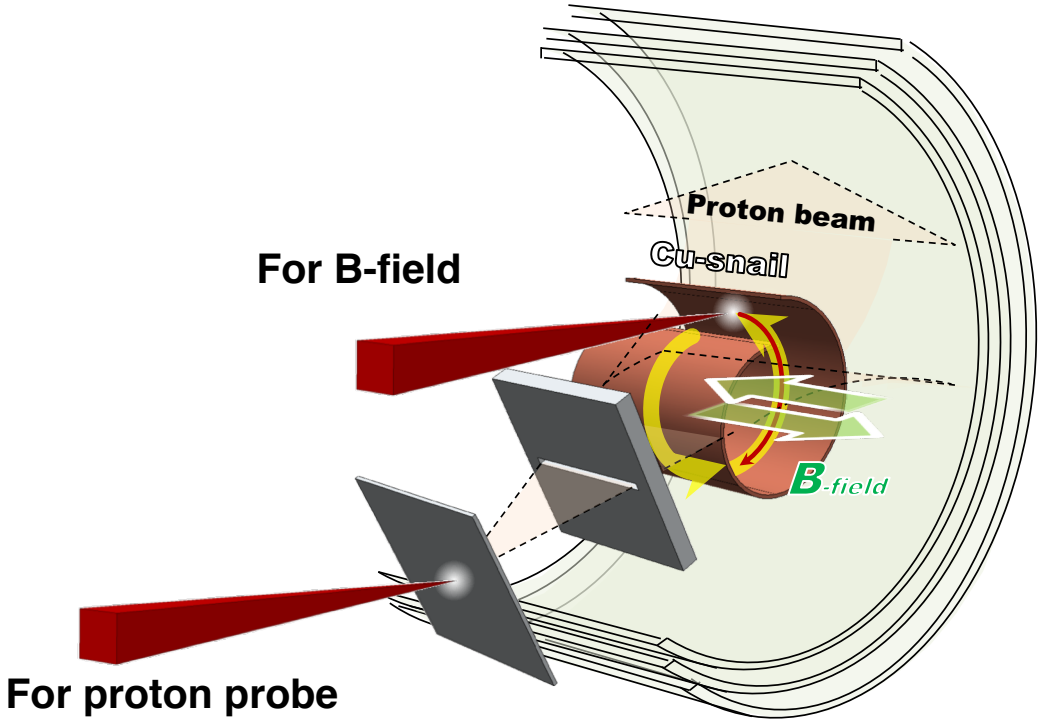
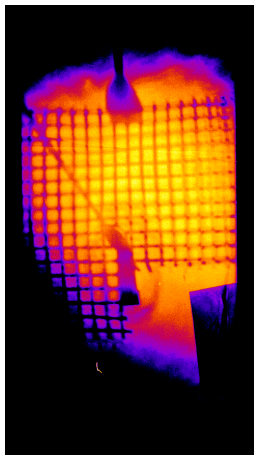
Experimental setup

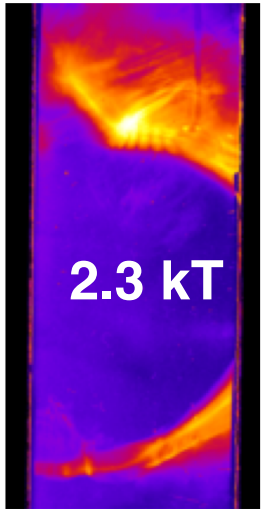


Proton radiography

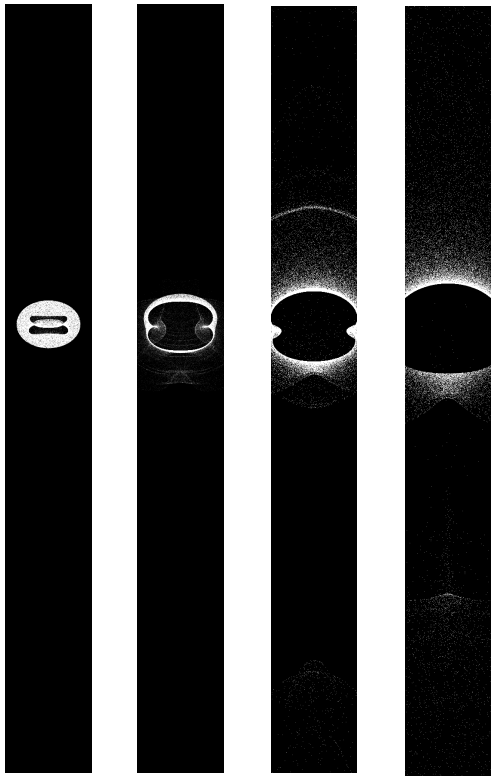
w/o B-field (cold shot)



w/ B-field



Simulation



x1 x10 x20 x30

3D-PIC simulation

Large electric current is driven at the boundary due to magnetic field anihiration.

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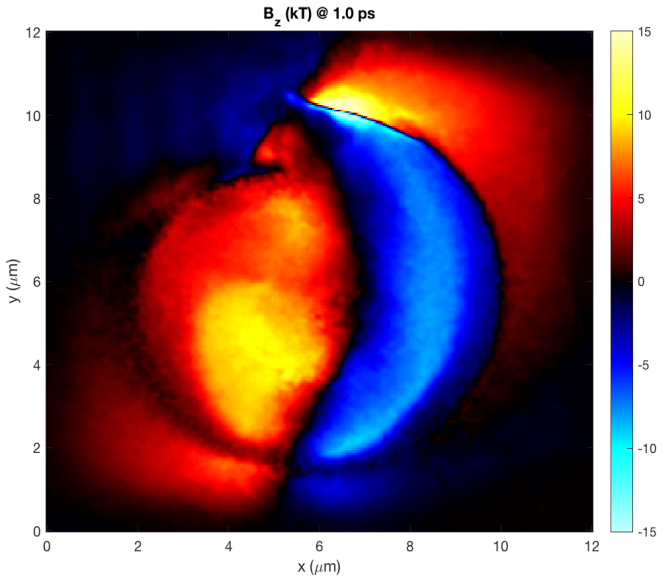
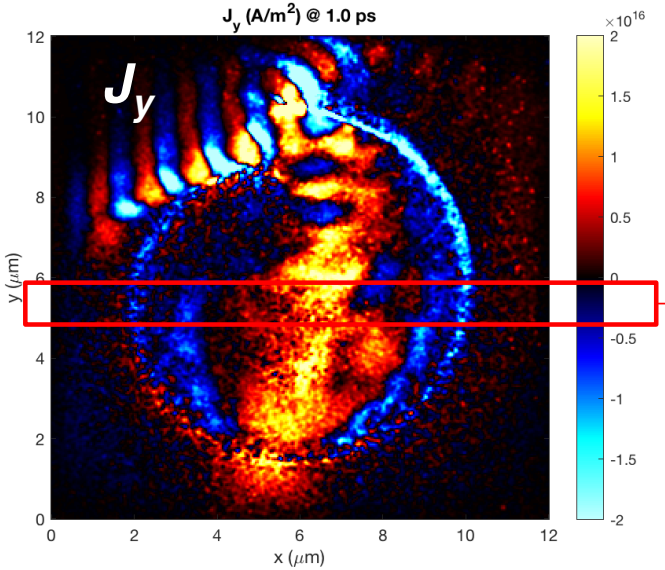
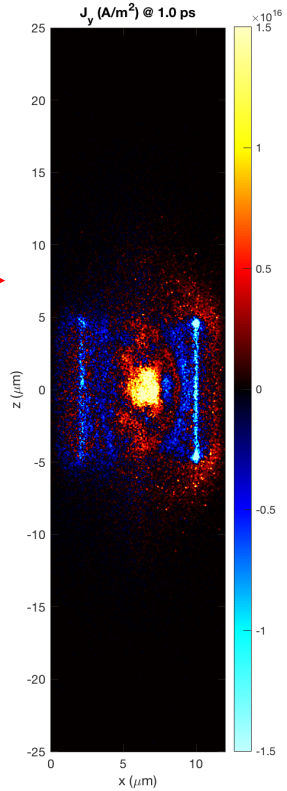
B-field profile (side-view)



Current distribution (side-view)



Current distribution (top-view)



Inductive current driven proton beam

The large current flows along the boundary produces proton beam by target normal sheath acceleration.

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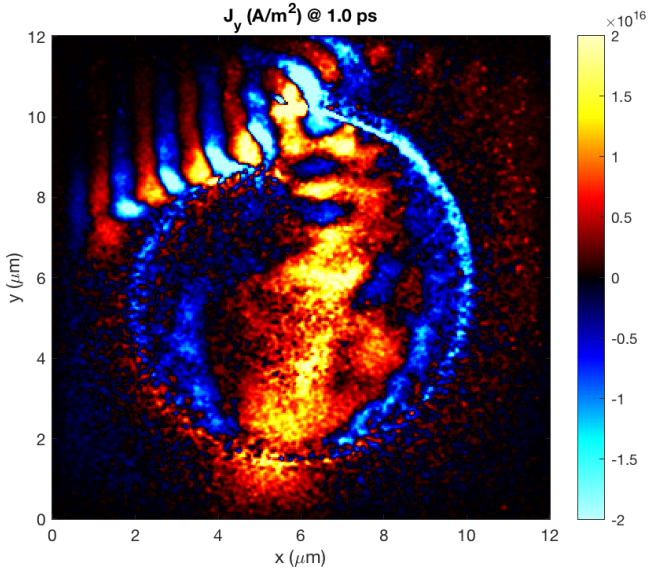
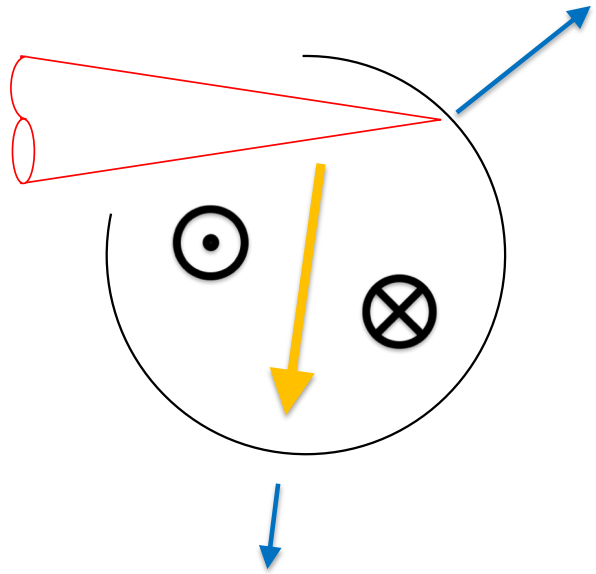
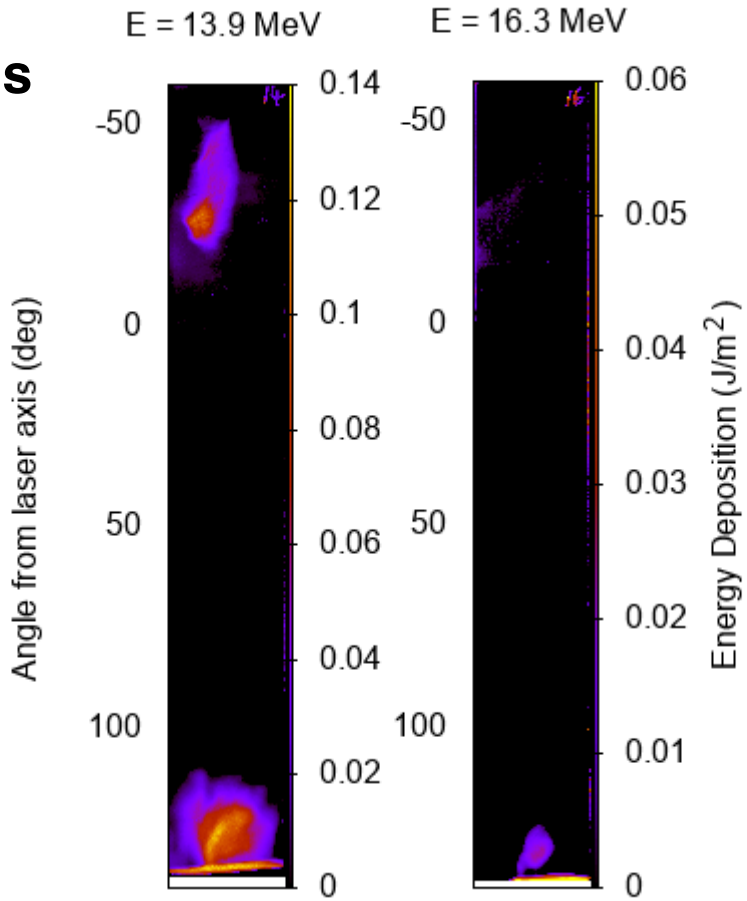


Laser-driven TNSA protons



Reconnection driven TNSA protons



Alfven wave proton

~0.18 c Alfven wave driven by magnetic reconnection produces proton beams to the side directions.

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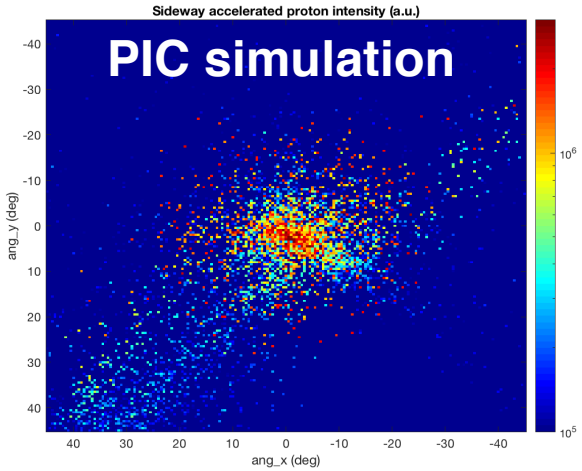
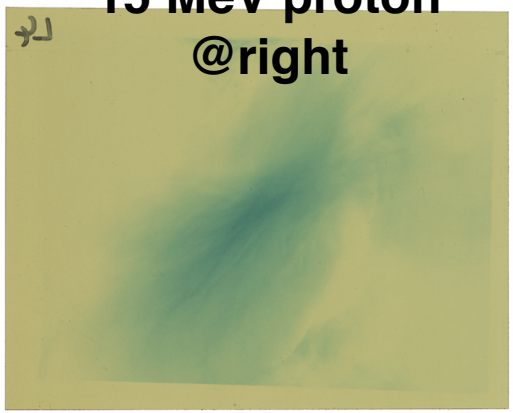
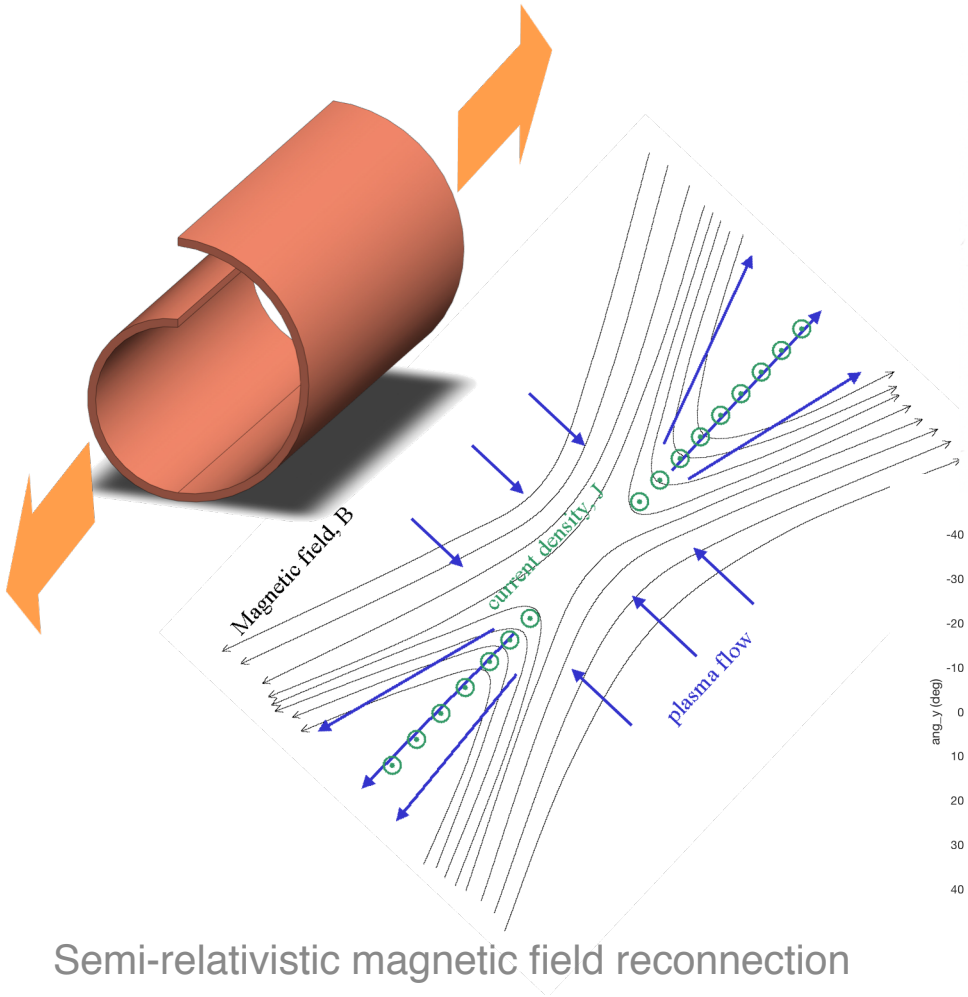
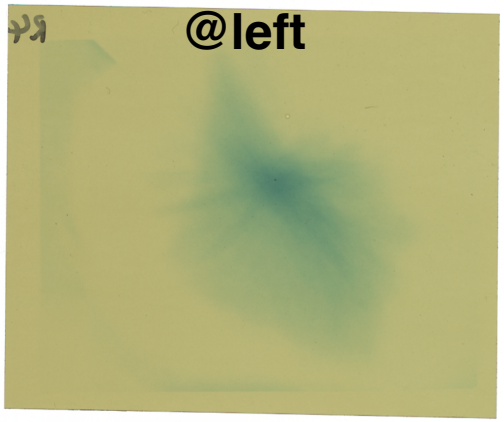


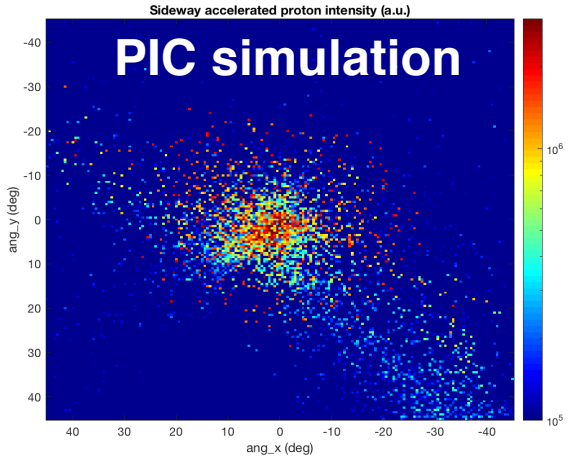
15 MeV proton @right





15 MeV proton @left





HEDP with strong magnetic field

Frontier of new plasma physics can be explored by using Kilo-tesla-level magnetic field.

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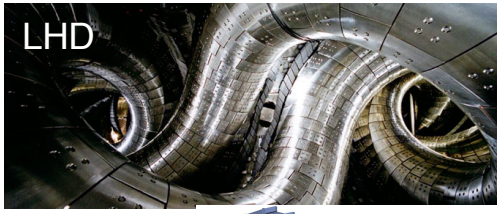

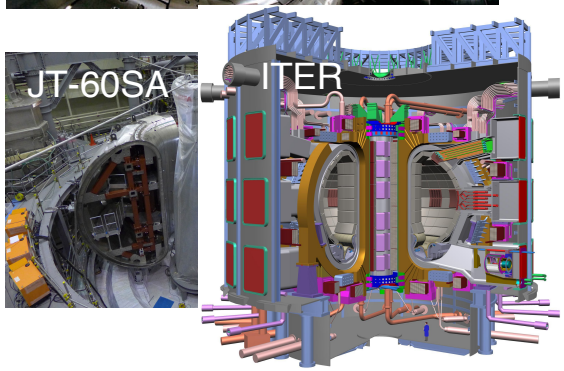

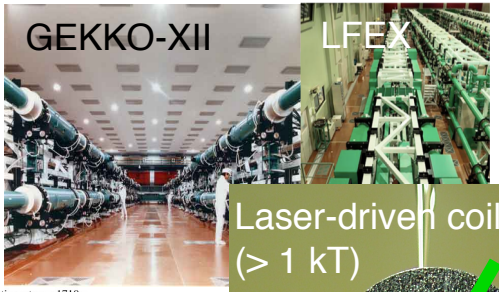

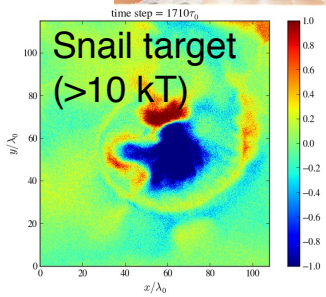

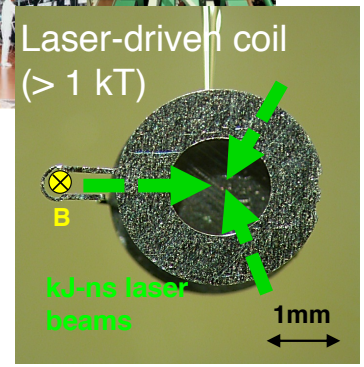

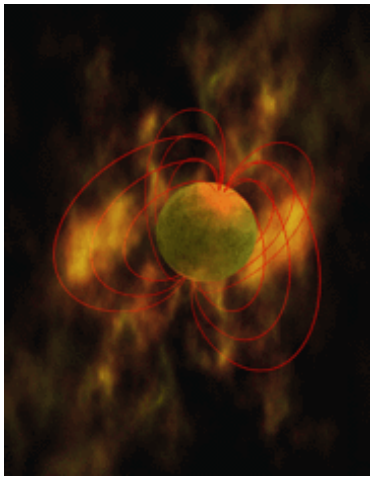

Magnetically confine fusion ~ 10 T	High Energy Density Plasma 0.1 – 100 kT	Astrophysics ~ MT
• Isotropic thermal transport • Charged particle confinement • Beam transport	• Magneto-hydrodynamics • Reconnection	• High-energy MHD phenomena • Relativistic reconnection • Nonlinear Zeeman effect	• Landau quantization • Lorenz ionization • Collisionless shock

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Future experiment

- **Zeeman spectroscopy**
- **Relativistic magnetic field reconnection**
- **Laser plasma interaction with a magnetized plasma**