Relativistic electron injection acceleration in laser-driven magnetic reconnection plasmas

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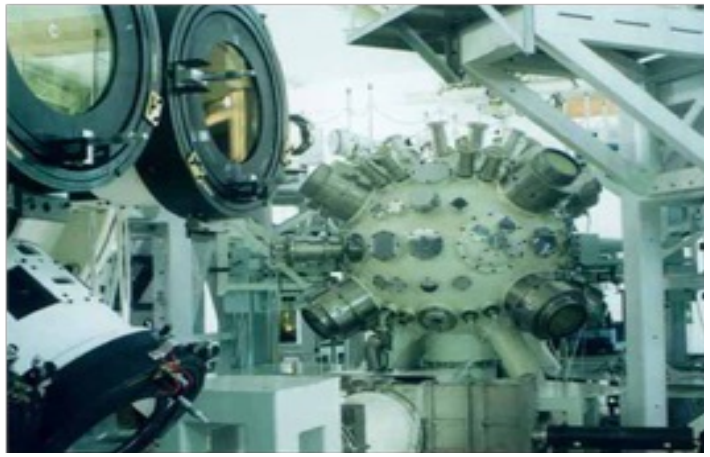
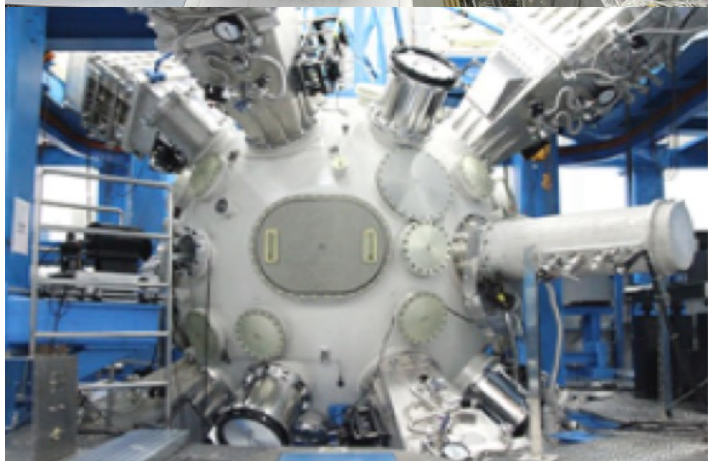
Shenguang (SG) II laser facilities

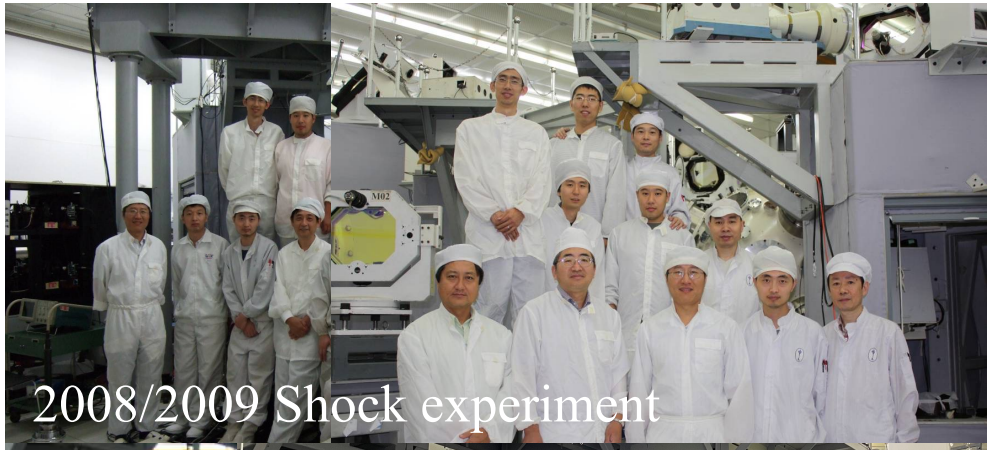
SG II Lasers
Beams:8
Pulse:1 ns
Energy: 260J/beam for 3w
The 9th laser 25J/100ps

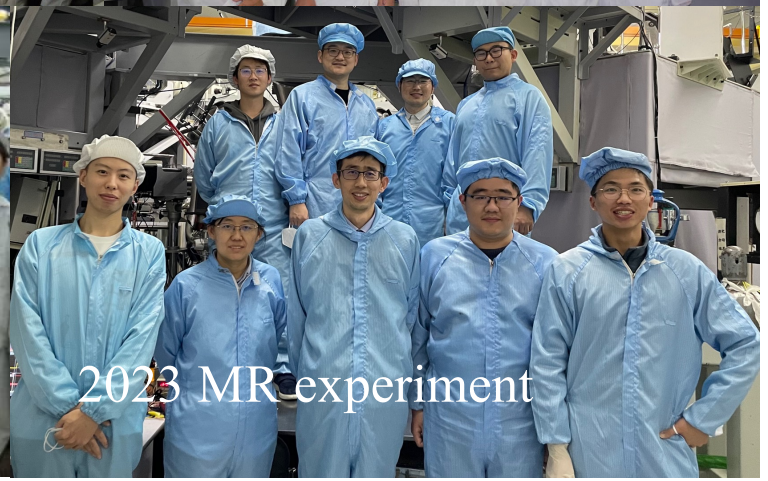


SG II - Upgrade Lasers
Beams:8
Pulse:1 ns
Energy: 800J/beam for 3w
PW laser:(1.053 μm, 350 J, 1 ps)

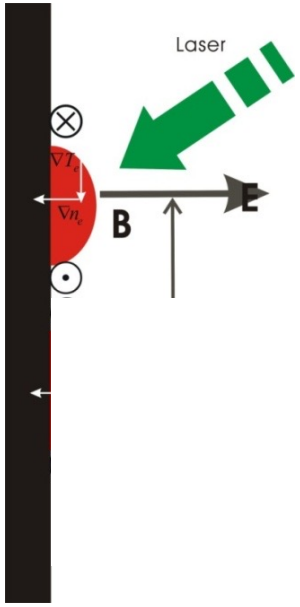


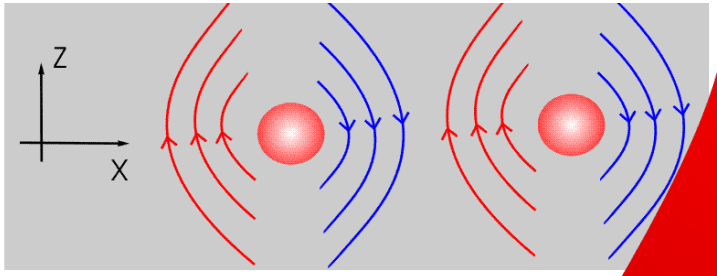
The SG II facilities provide open users with more than 100 shots per year to conduct high energy density physics studies, including LA. It has been available for more than 15 years. Most important LA experiments in China are performed on these facilities, esp. SG II lasers.

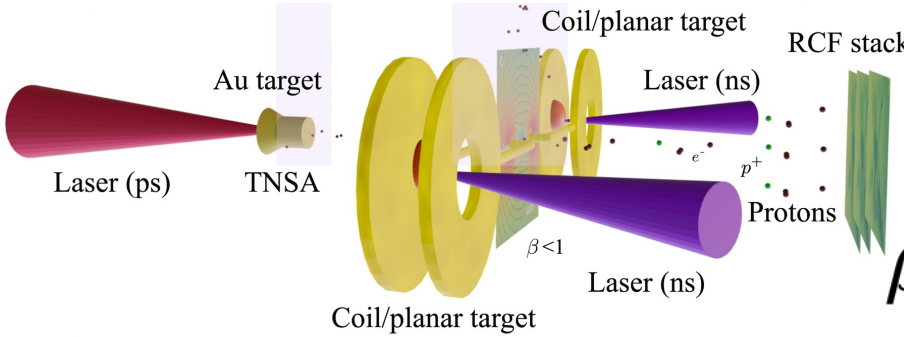




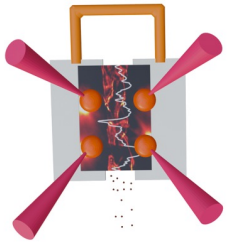
Laser driven magnetic reconnection(LDMR)on SG II

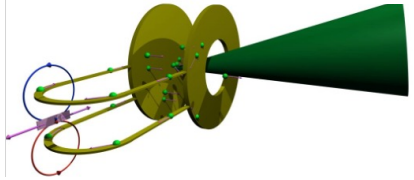


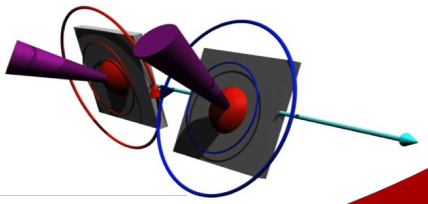


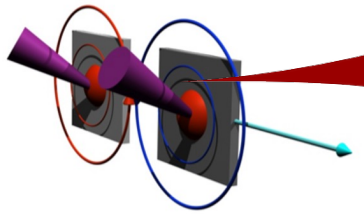


$$\beta = \frac{P}{B^2/2\mu_0}$$









Relativistic Electron Injection Acceleration in LDMR

J Y Zhong, et al, (2023);

High beta Turbulent Magnetic Reconnection

*Y L Ping, et al, Nature Physics, **19**, 263 (2023);*

Low beta Magnetic Reconnection with a Helmholtz Target

*X X Pei, et al, PoP, **23**, 032125 (2016);*

High beta Laminar Magnetic Reconnection with a Guide Field

*J Zhong, et al ApJS, **225**, 30 (2016)*

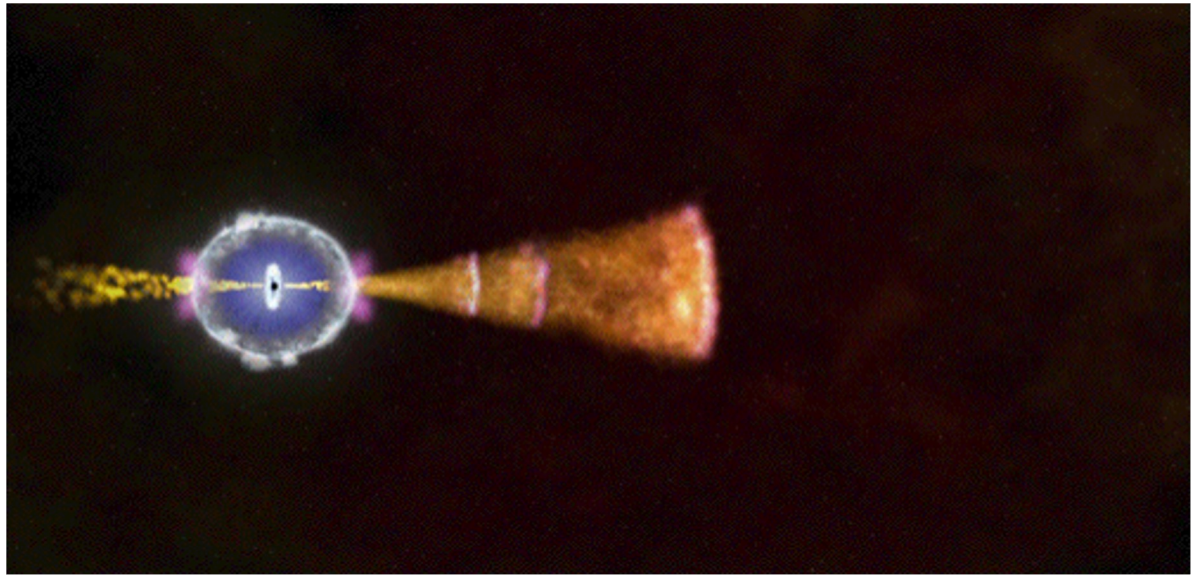
High beta Laminar Magnetic Reconnection for simulation of solar flares

*J Zhong, et al, Nature Physics, **6**, 984 (2010);*

Outline

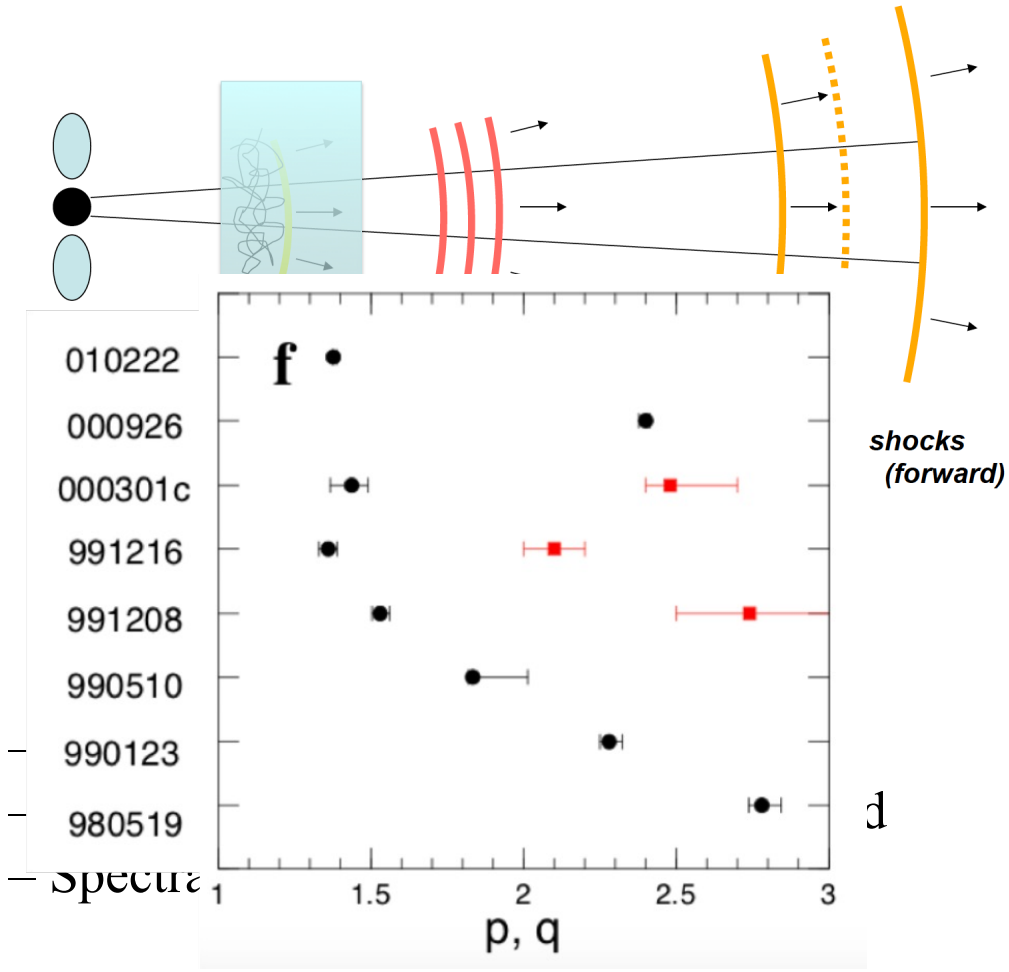
- Motivation
- Internal Collision-induced MAgnetic Reconnection & Turbulence (ICMART) model
- Experiments and Results
- Summary

Motivation



Gamma-ray bursts (GRBs)

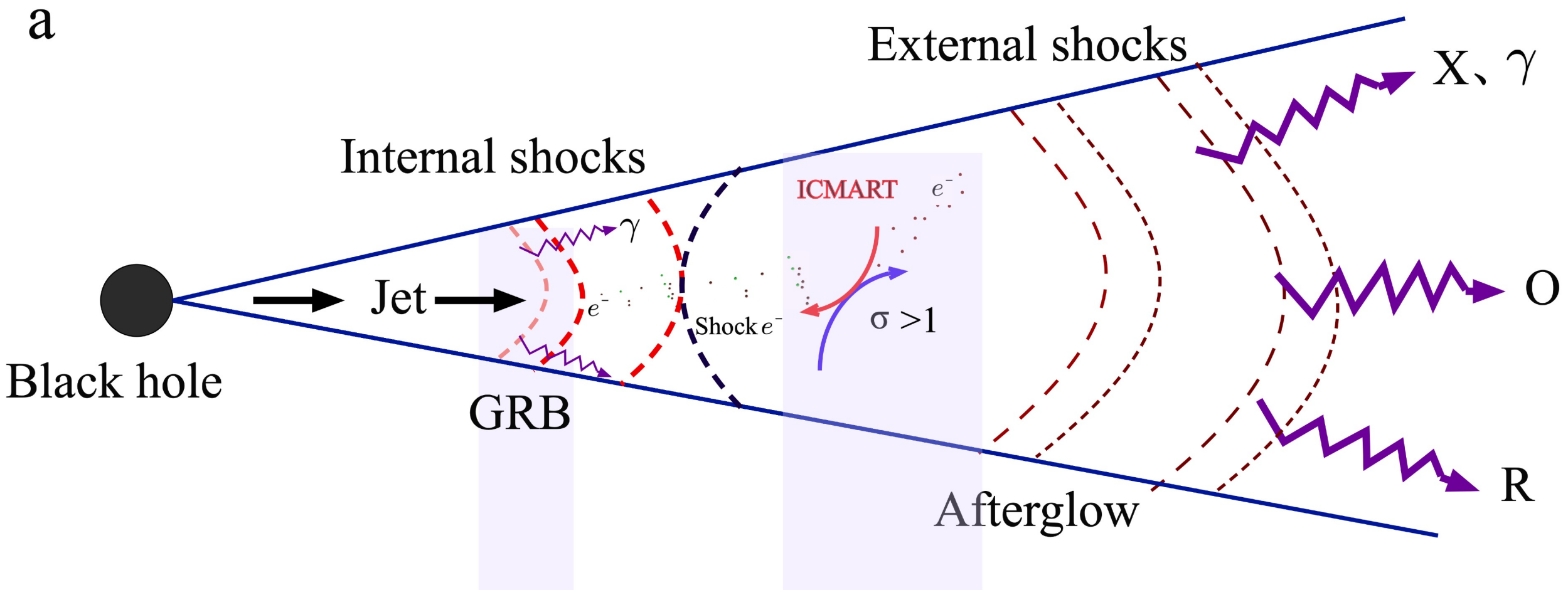
Gamma-ray bursts (GRBs) are the strongest and brightest explosions in the universe and are leading candidates for the origin of ultrahigh-energy cosmic rays (UHECRs)



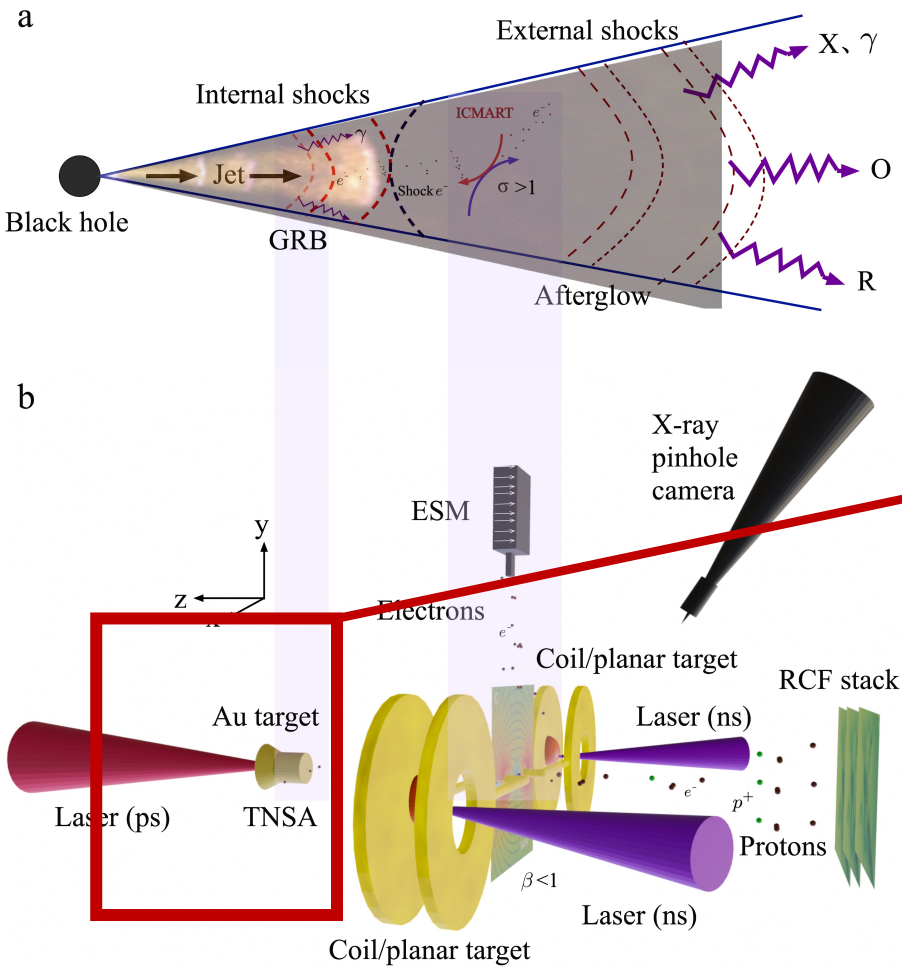
(Bednarz & Ostrowski 1998;Kirk et al. 2000; Achterberg et al. 2001; Lemoine & Pelletier2003).

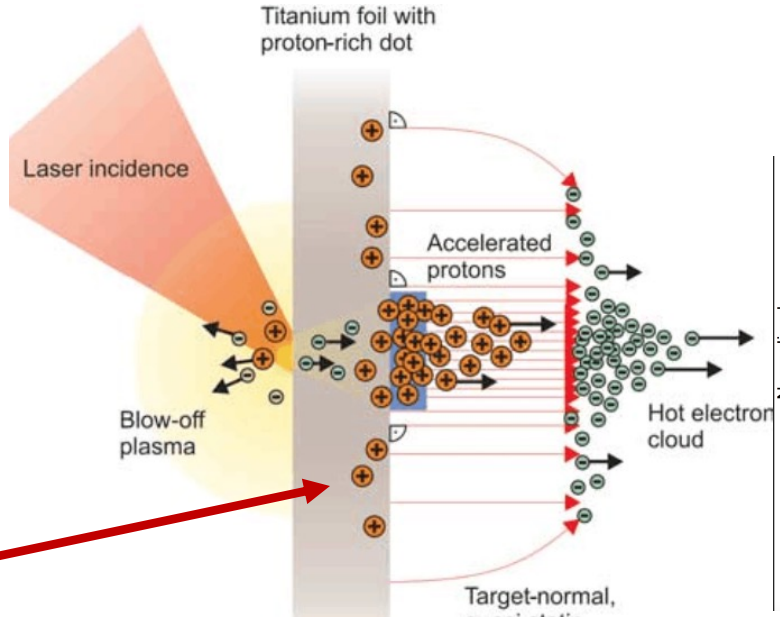
The ICMART Model

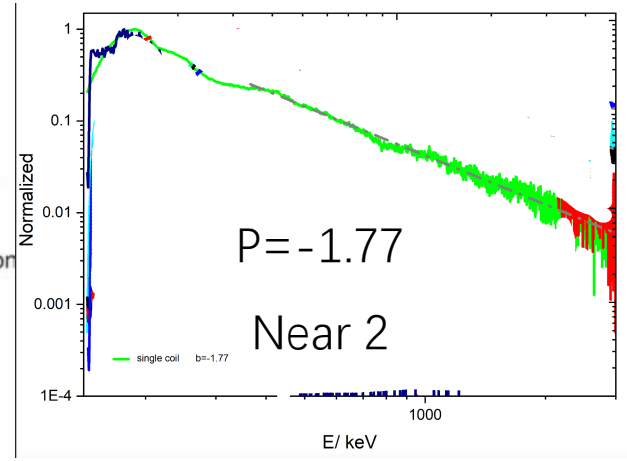
Internal Collision-induced Magnetic Reconnection&Turbulence



Goal: Checking the acc. efficiency of MR, positive or not







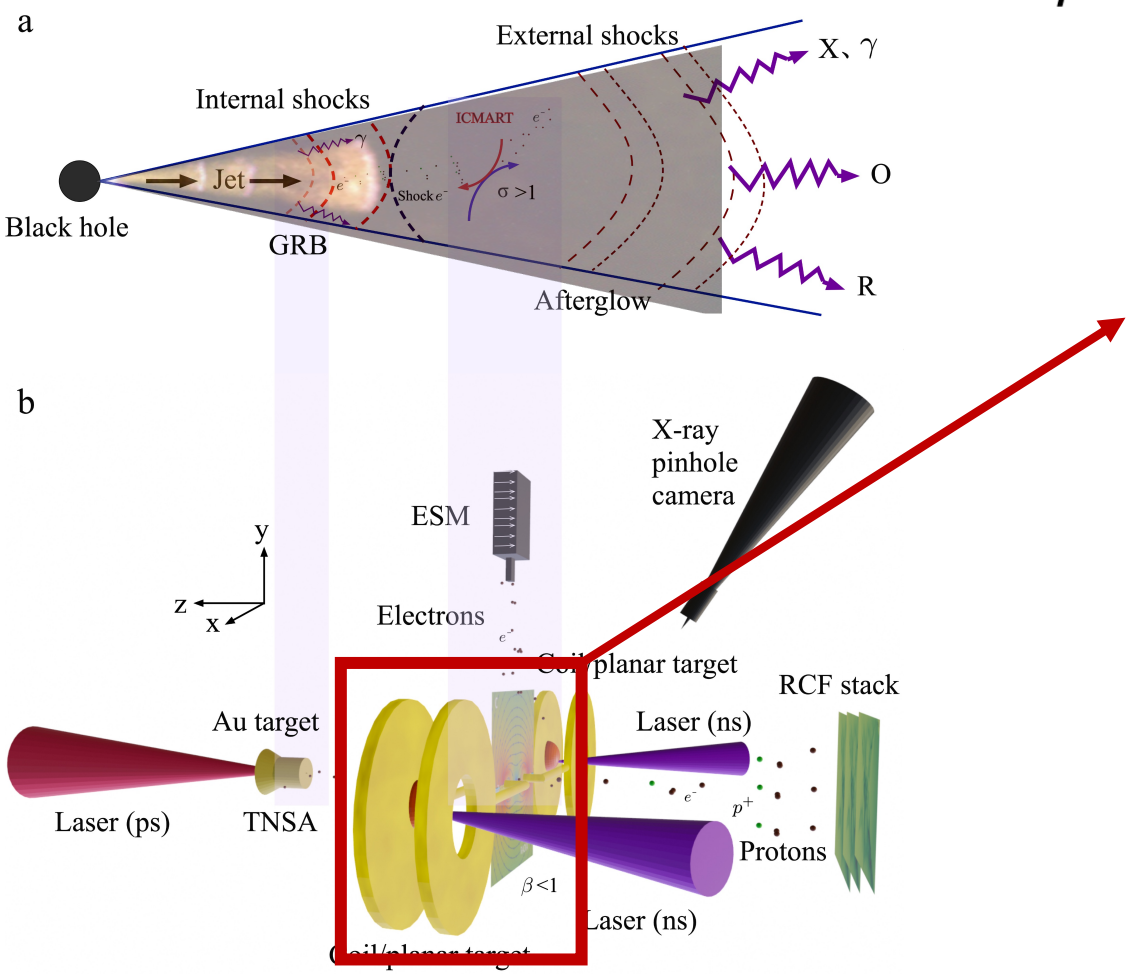
lativistic injection electrons

-Target normal sheath acceleration (TNSA) mechanism for quasi-shocked e⁻

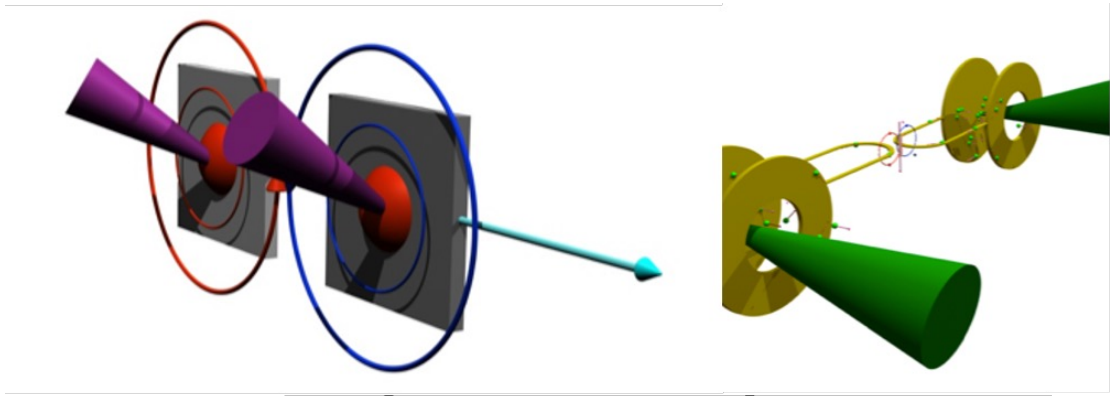
Acceleration regions of injection electrons

$$\beta = \frac{P}{B^2/2\mu_0}$$

- Ratio between pressure of thermal or kinetic and magnetic

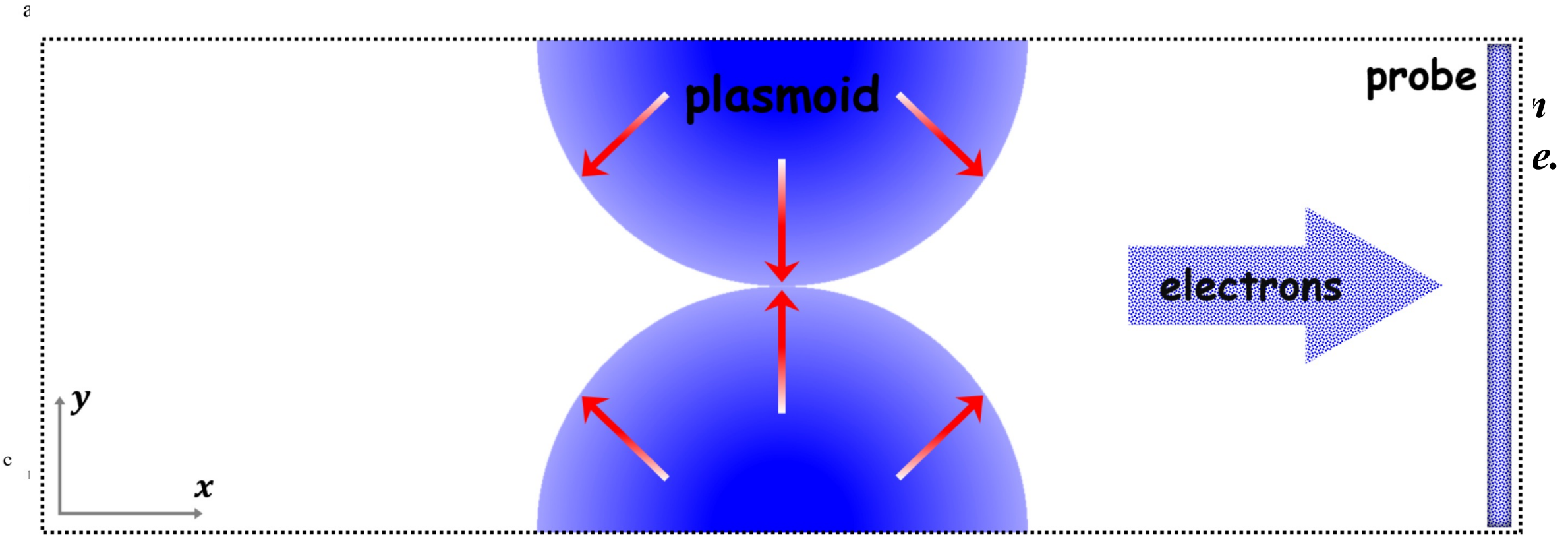


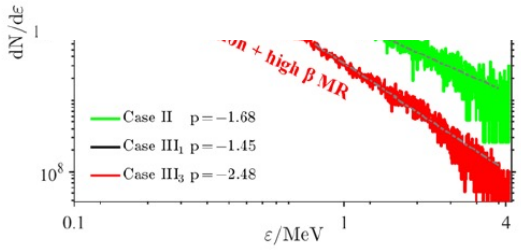
High beta MR Low beta MR

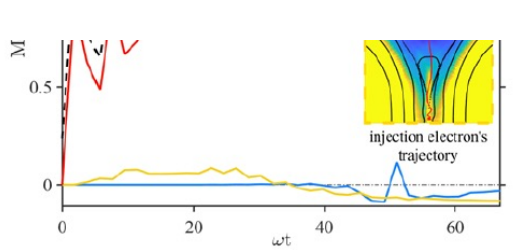


B	0.1-1MG	1-10MG
Te	keV	100 eV
Ne	$10^{20}/cm^3$	$<10^{17}/cm^3$
β	4-40	<<1

PIC Simulation for the acceleration of injection electrons







bubble density with magnetic field lines

Summary

- Motivated by the GRB spectral index problem, considering the acc efficiency of Magnetic reconnection
- Initail relativistic injection electrons: produced with short pulse lasers
- Acceleration region: High and Low Magnetic reconnection are made in the laser-produced plasmas
- Low-beta MR can flatten the energy spectra even with a striking electron bump. In contrast, high-beta MR softens the energy spectra,
- The structure of current sheet and cooling effect are different contribution to the acc. ,which benefits a deeper understanding of GRB emissions

Thank you very much for your attention