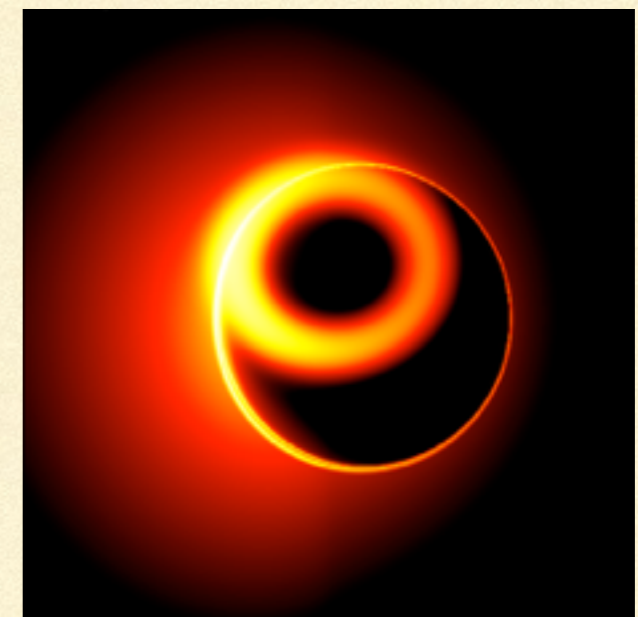


$$G_{\mu\nu} - \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

# MHD SHOCKS IN ACCRETION ONTO A ROTATING BLACK HOLE

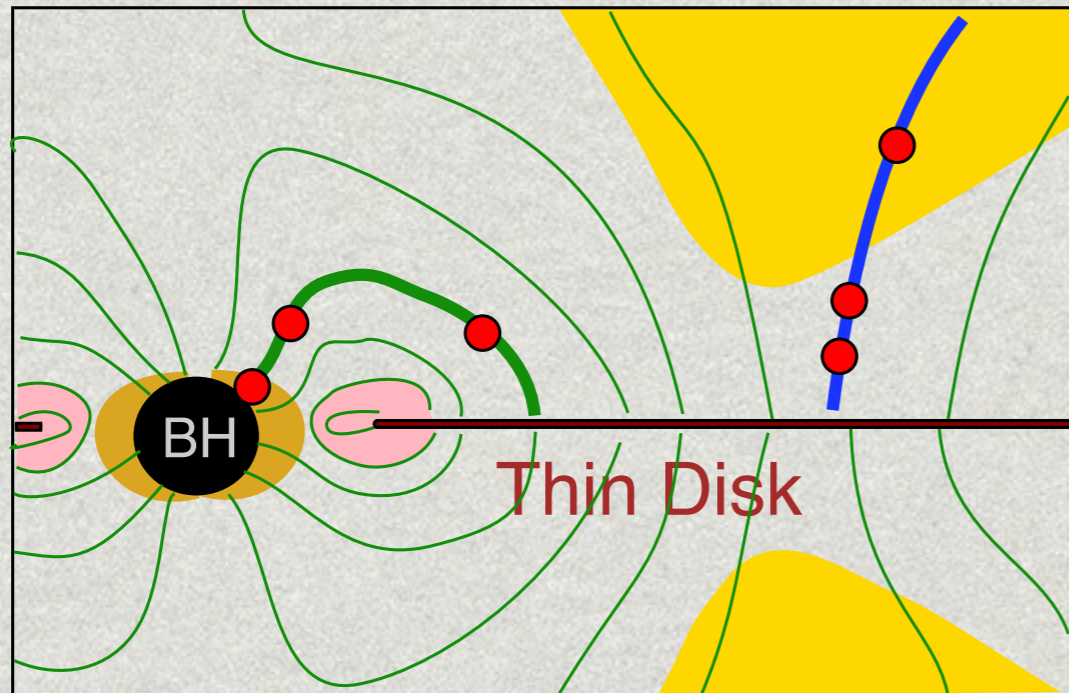
Masaaki TAKAHASHI

Aichi University of Education



# BLACK HOLE MAGNETOSPHERE

## INFLOWS & OUTFLOWS



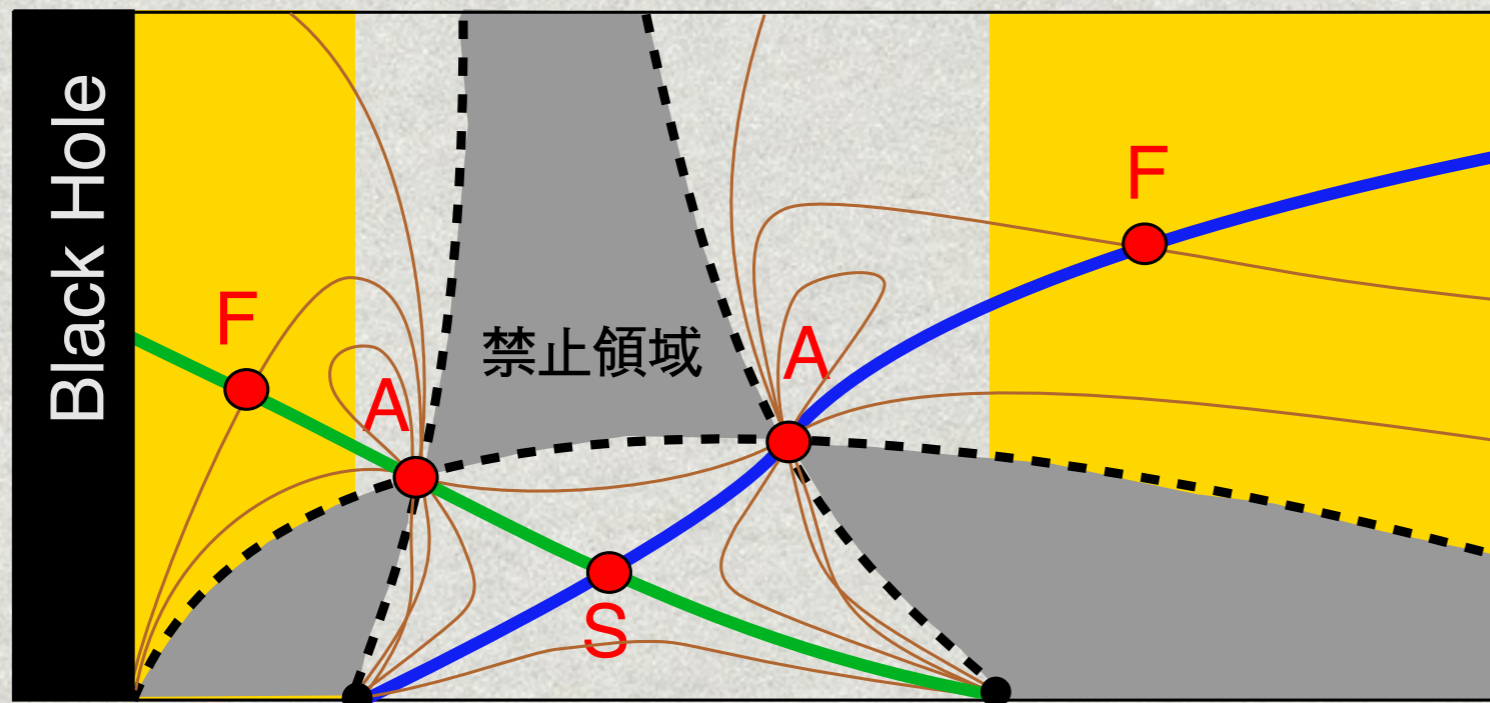
What are Relativistic Effects?

**LIGHT SURFACE**

**FORBIDDEN REGION ( $E^2 < 0$ )**

ALFVEN MACH NUMBER

$M^2$

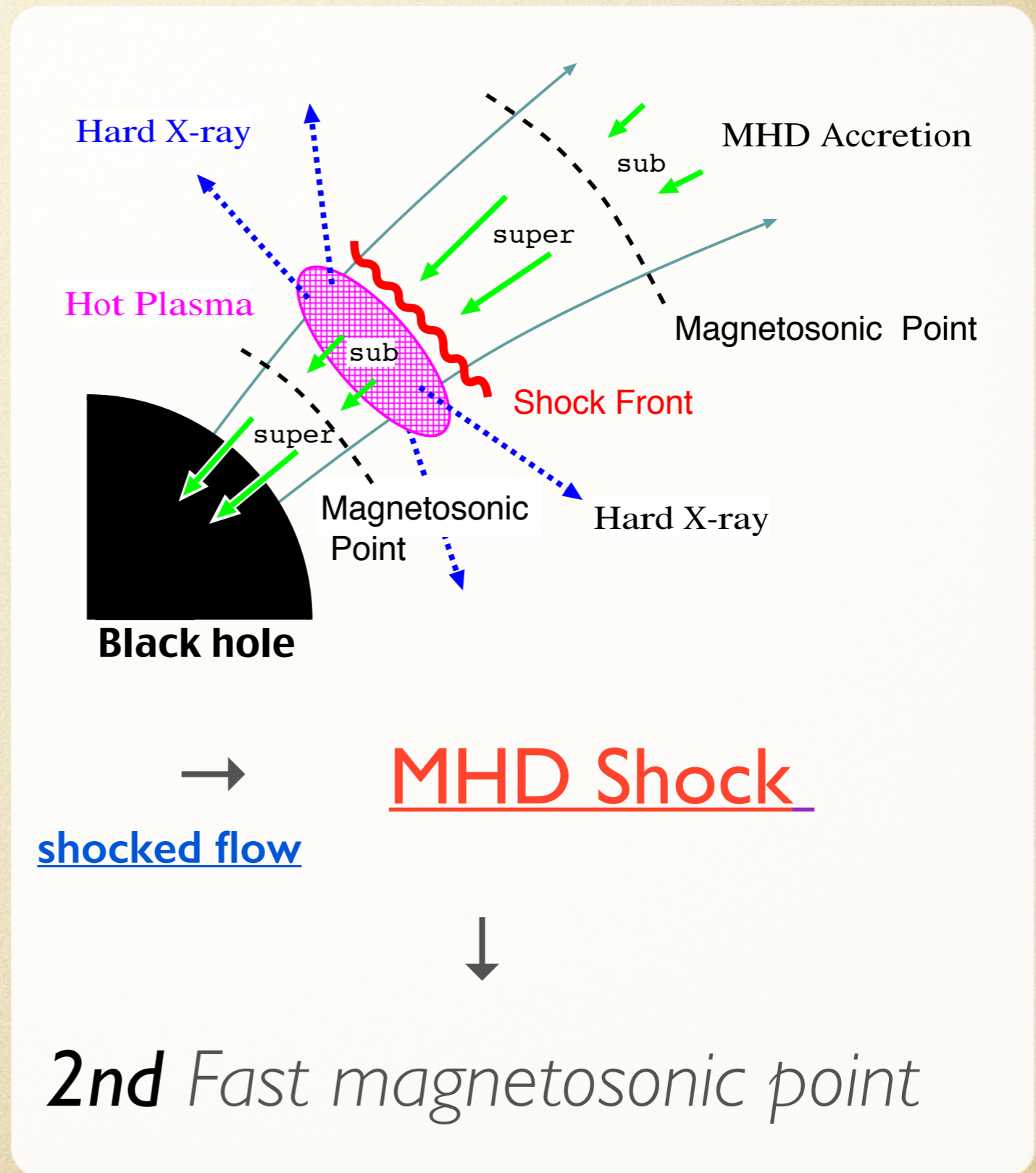
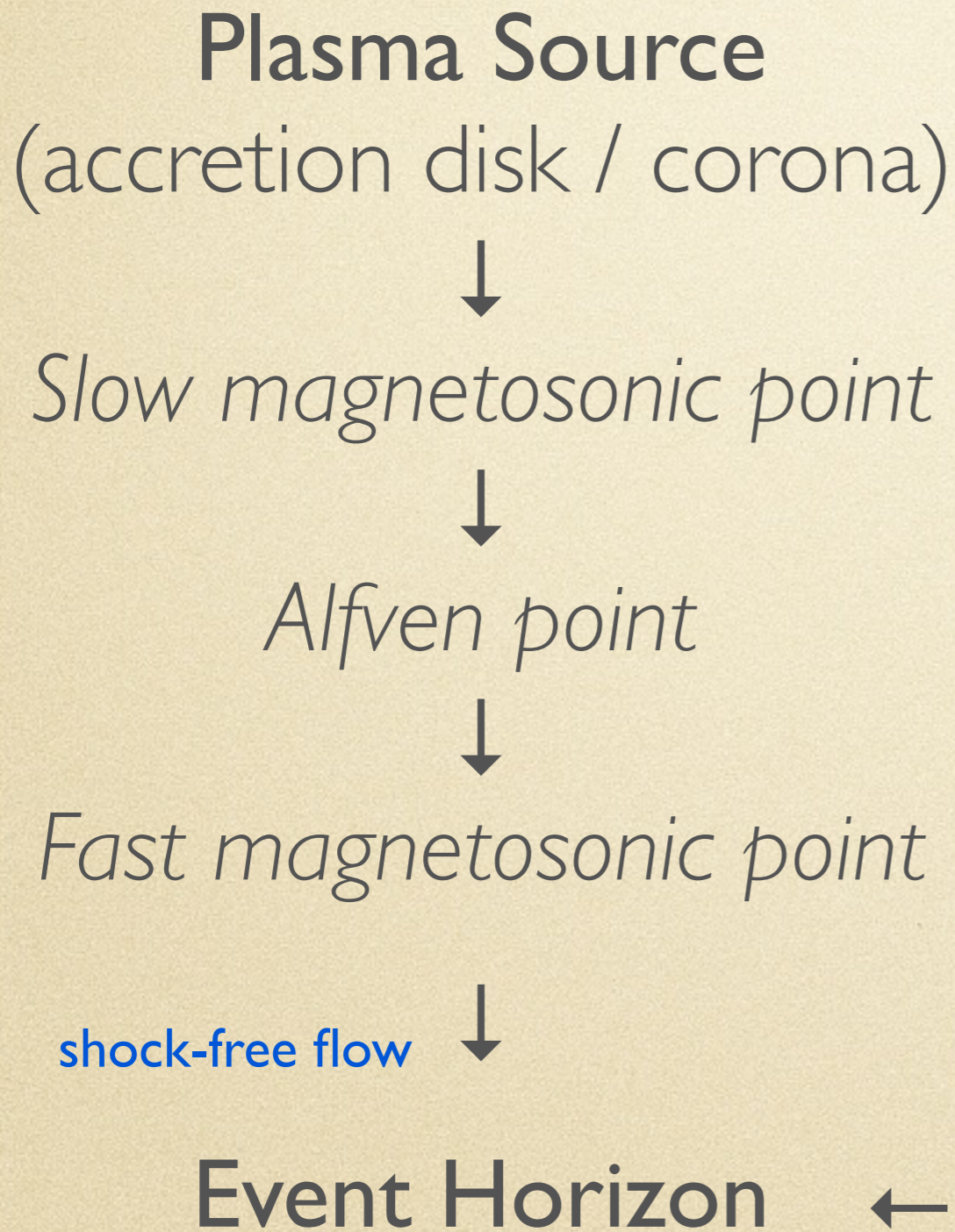


$R$   
RADIUS

Characteristic radii

- Plasma spurce
- Slow point
- Alfven point
- Fast point
- Event Horizon

# Shock Heating : High-energy emission from the vicinity of BH (observable)



# Black Hole MHD Shock

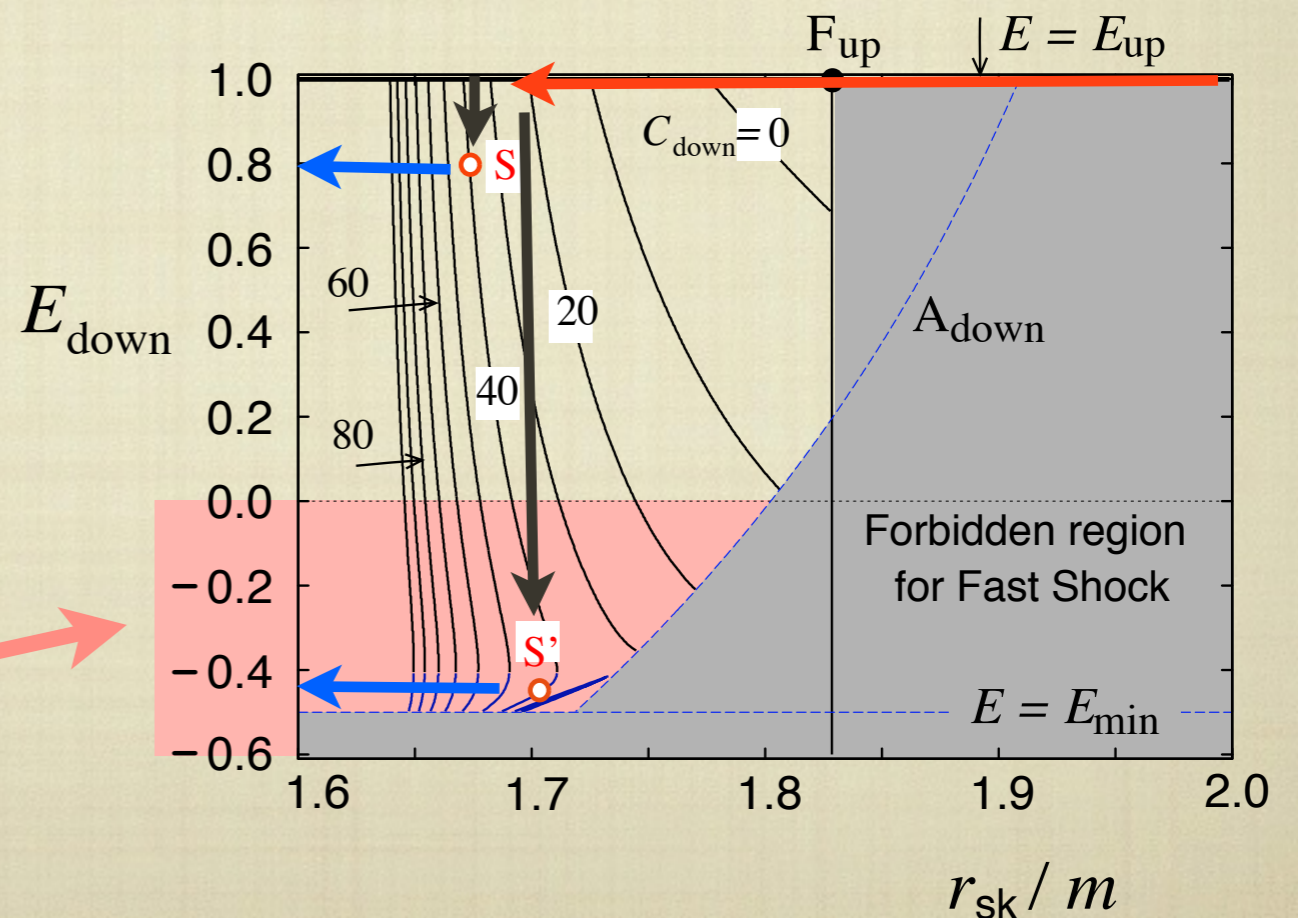
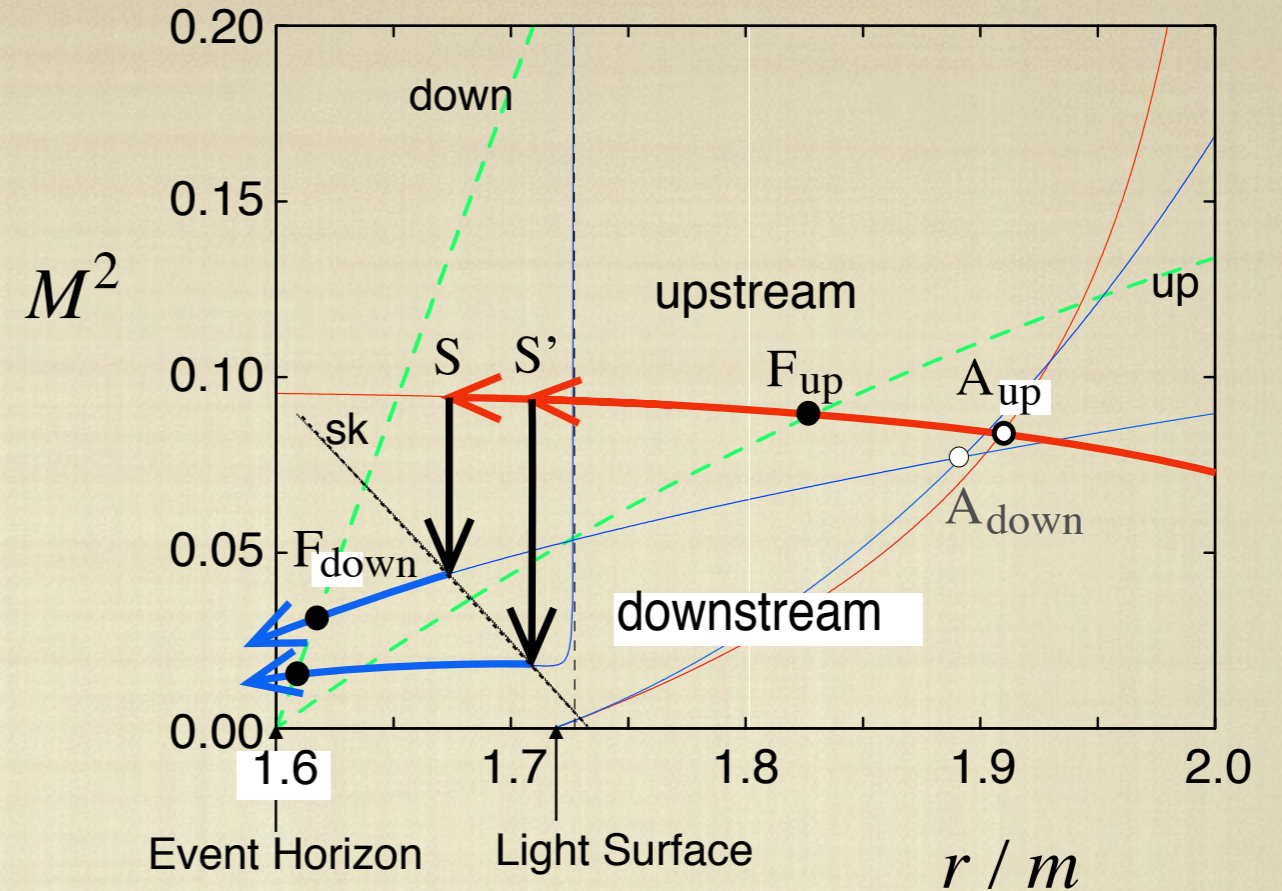
■ FAST MAGNETOSONIC SHOCK IN ERGOSPHERE

■ COLD UPSTREAM → COLD DOWNSTREAM

■  $S'$  :  $\Delta E > mc^2$

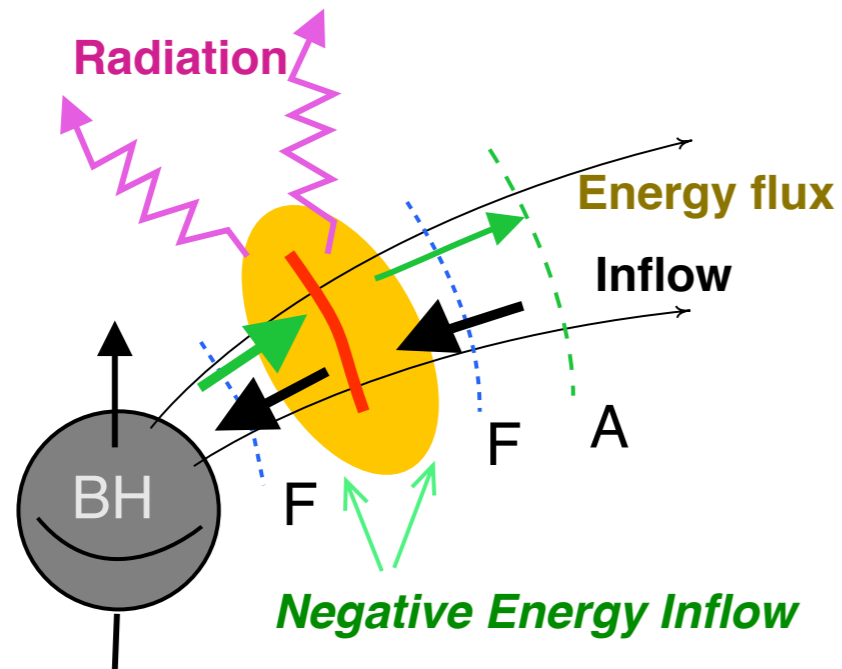
NEGATIVE ENERGY INFLOW

MT & TAKAHASHI . 2010

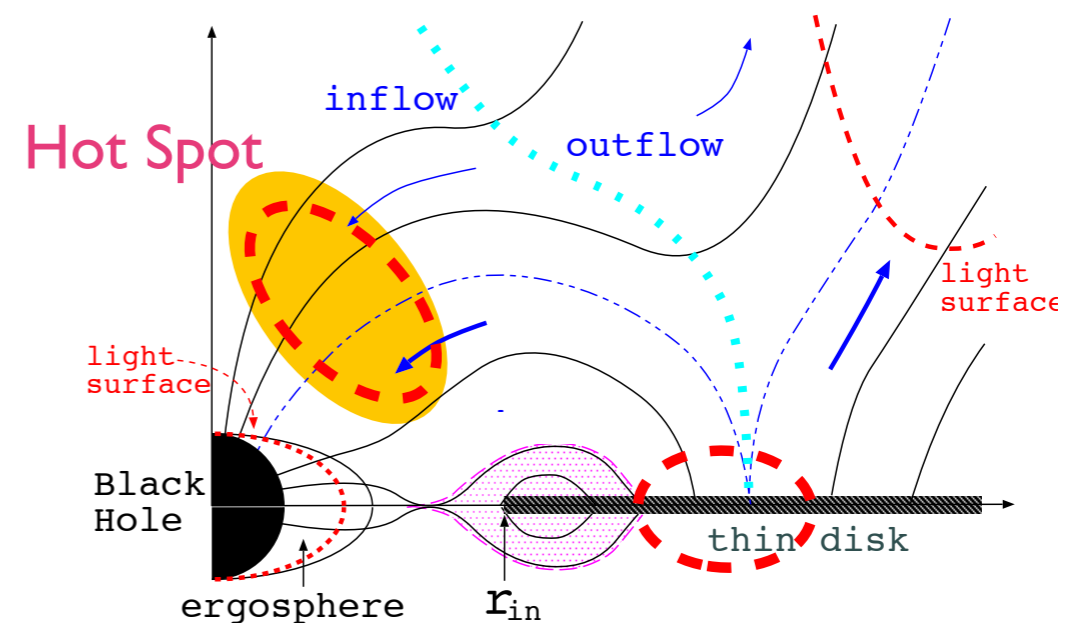
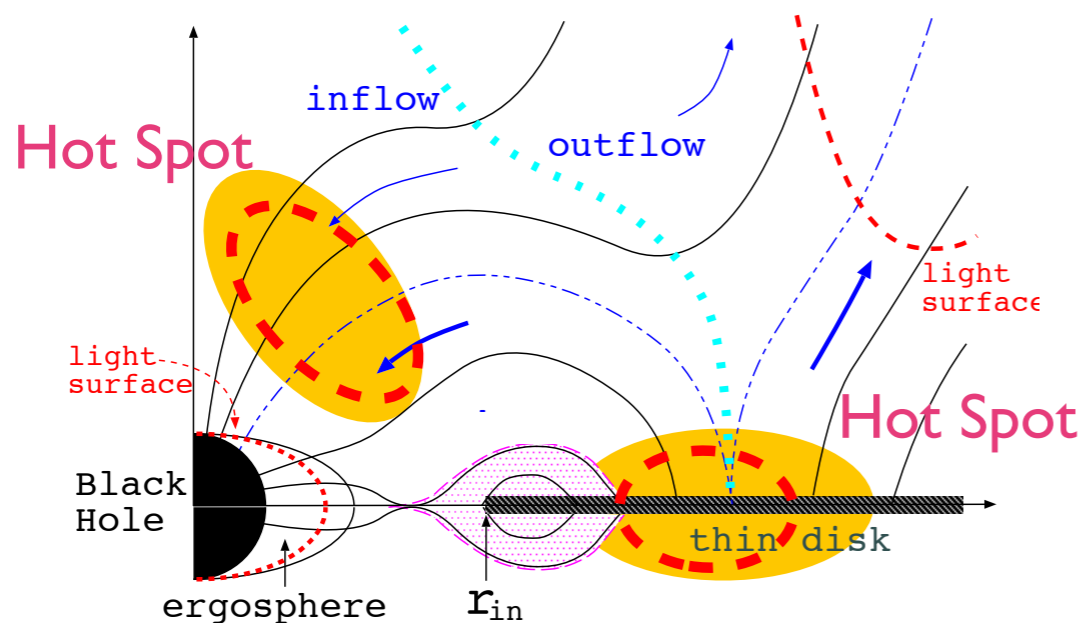
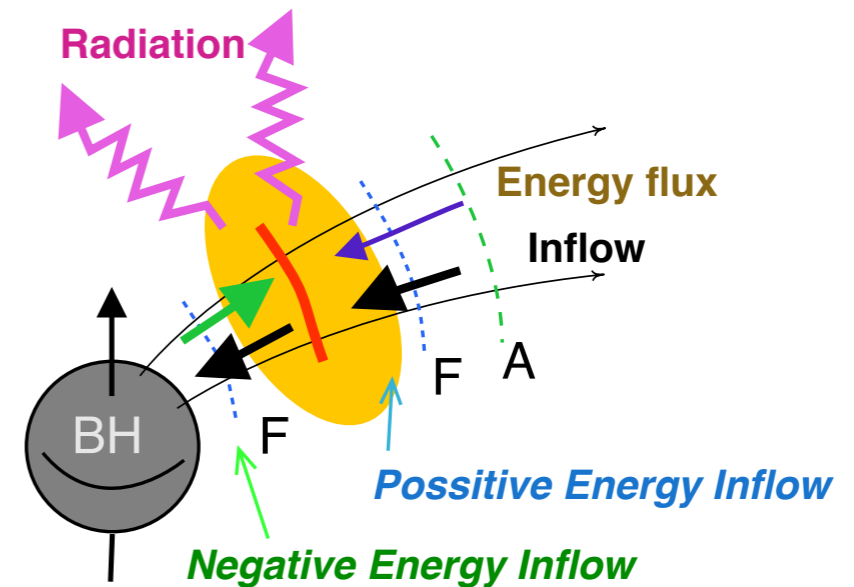


# Hot Spot powered by Rotating BH

High-energy radiation including the information of space-time.



The extracted energy from BH can radiate at Shock front.



# SOURCE - REFLECTOR

Theoretical Toy-Model

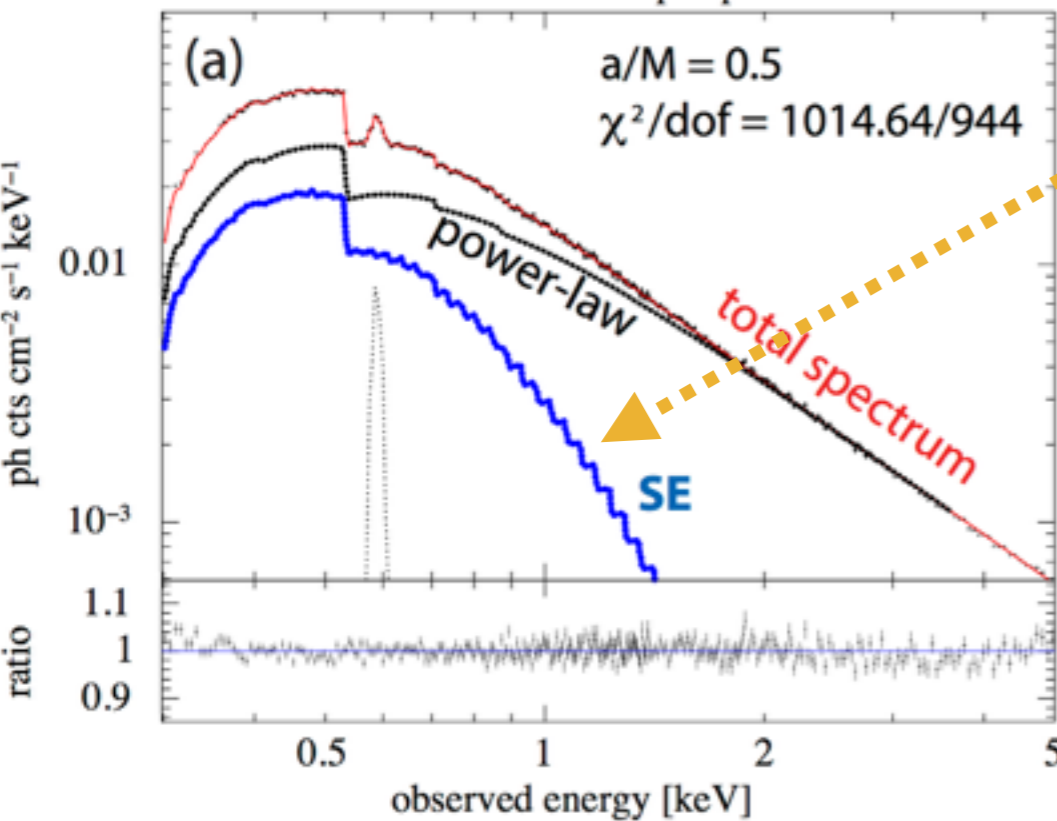
Near the BH Horizon...

Source : MHD Shock

Hot plasma region = BH Aurora

Seyfert 1 (NLS1) : Arc 120

60 ks XMM-Newton/EPIC-pn spectrum of Ark120



Soft X-ray Excess !?

continuum

Fe-line

Fe-line

Reflector :  
Equatorial thin disk

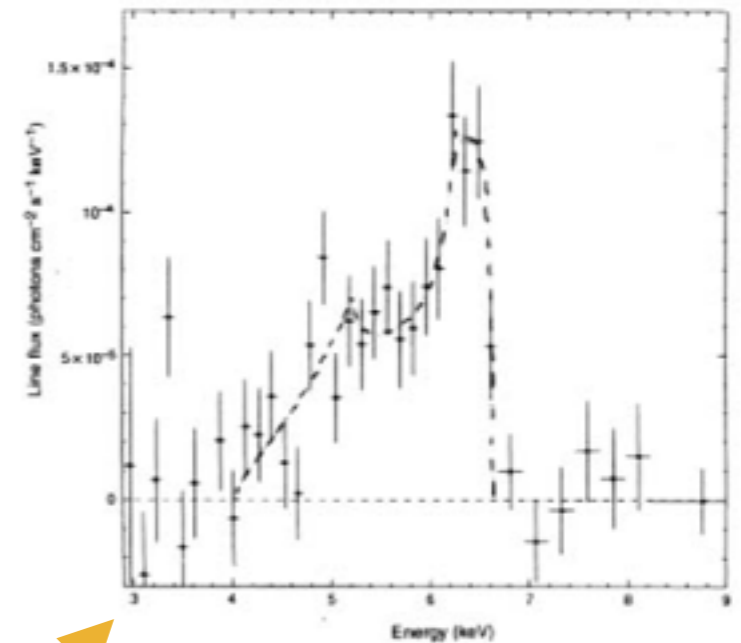
cloud

Fukumura, MT +  
2016

Haba2013

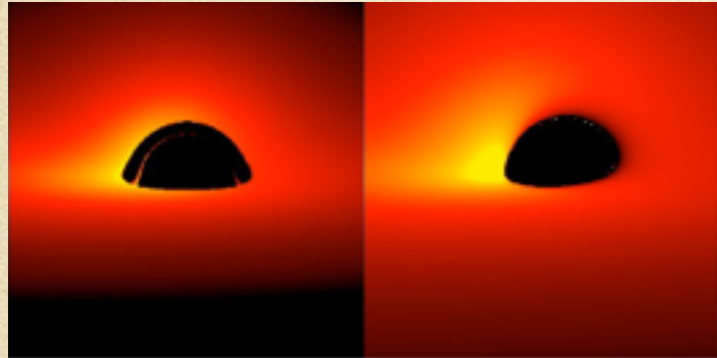
Black Hole

Accretion Disk



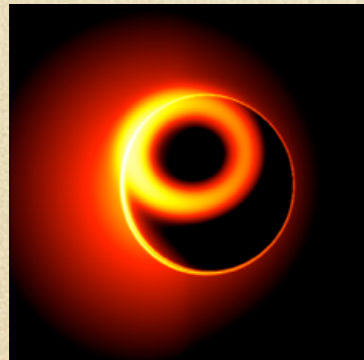
# Information of the black hole spacetime

Accretion Disk



--- **Image** of the Black Hole Shadow and Accretion Plasma ( sub-mm VLBI)

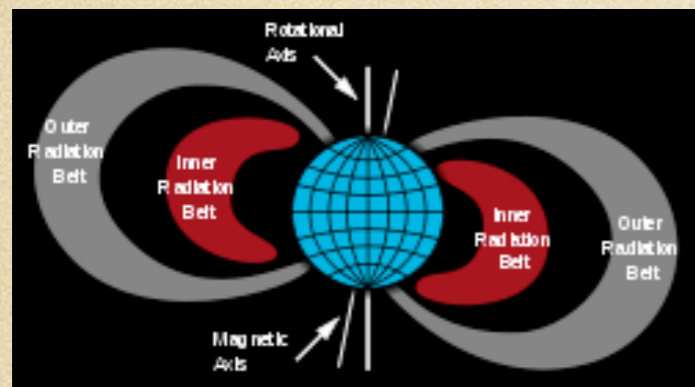
BH - Aurora



--- **HE-emission** from very close to the Event Horizon ( X-ray,  $\gamma$ -ray)

MT & R.TAKAHASHI 2010

BH - Van Allen radiation belt



--- The plasma can be

trapped in this zone, which may be related to a **cosmic ray** .

MT & H.KOYAMA 2009