

Title: Particle Acceleration and Non-thermal Emission in Radiatively Inefficient Accretion Flows

Date: Nov 10, 2014 12:00 PM

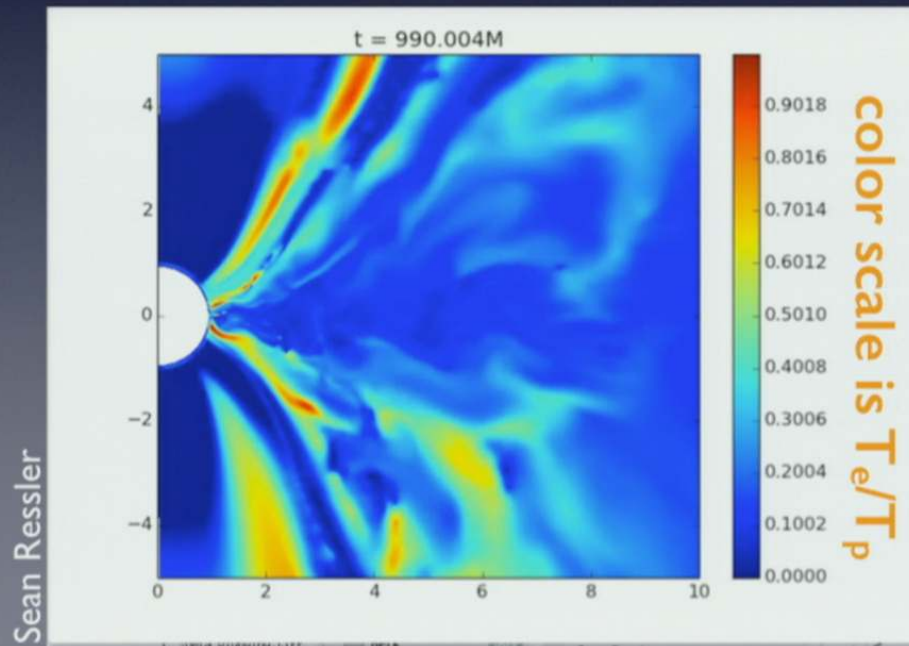
URL: <http://pirsa.org/14110069>

Abstract: I summarize several physical processes that can produce efficient particle acceleration in radiatively inefficient accretion flows. I then describe the implications for non-thermal emission and EHT observations of Sgr A*.

Particle Acceleration & Non-thermal Emission in Radiatively Inefficient Accretion Flows

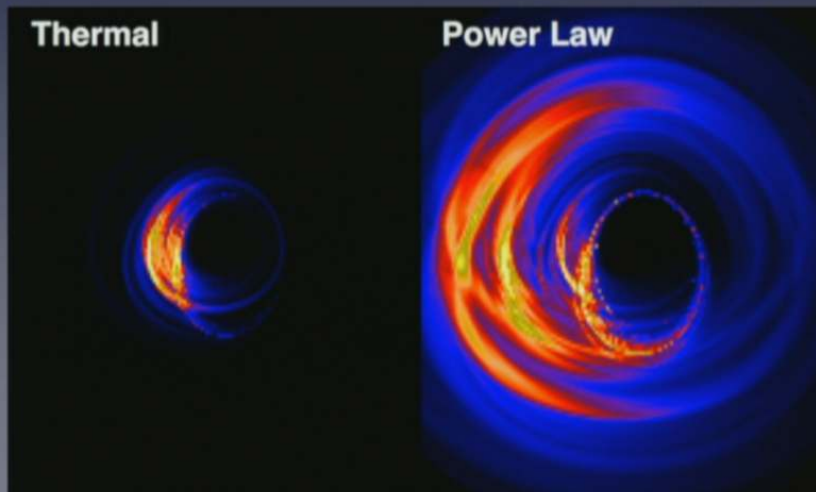
Eliot Quataert (UC Berkeley)

w/ Jacob Lynn, Mario Riquelme, Sean Ressler, Sasha Tchekhovskoy,
Jason Dexter, Ian Parrish, Charles Gammie



Sgr A*: Accretion at \sim the Horizon

- $\dot{M}_{\text{BH}} \sim 10^{-8.5} M_{\odot} \text{ yr}^{-1} \ll \dot{M}_{\text{Bondi}}$ $L \sim 10^{-2} \dot{M}_{\text{BH}} c^2$
- 'Known' at $\sim R_S$: $T_e \sim 10^{11} \text{ K}$ $B \sim 30 \text{ G}$ $n \sim 10^6 \text{ cm}^{-3}$
 - $\text{mfp} \gg \gg \gg R_S!$ (collisionless)

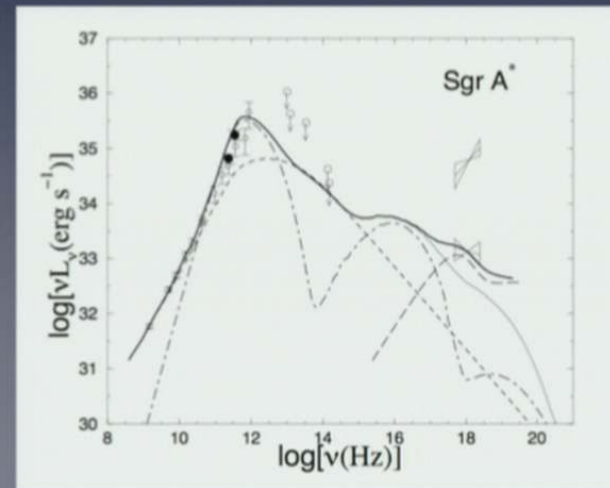
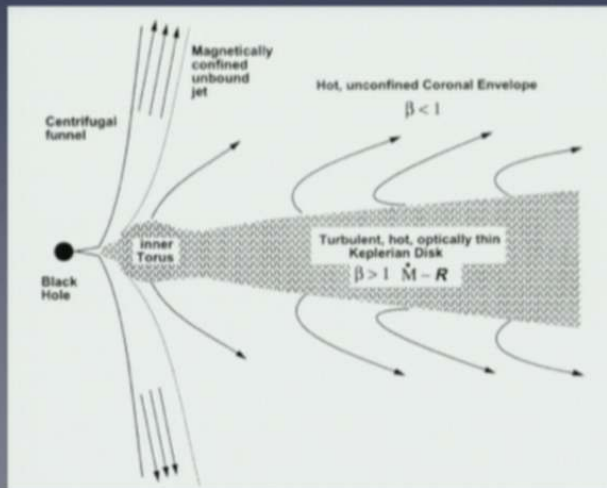


Alwin Mao & Jason Dexter

Not in Thermal Equil:
Emission Sensitive
to Electron Physics
and Distribution
Function

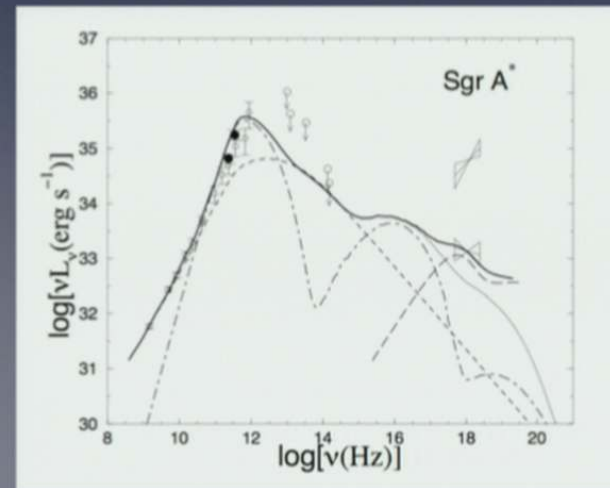
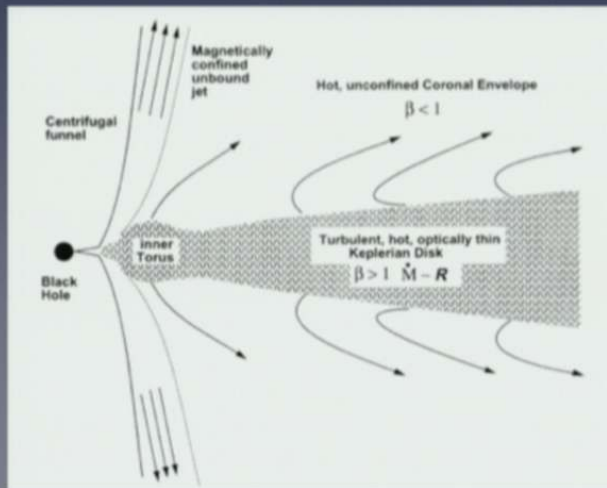
Electron Physics

- Need a model for electron thermodynamics to calculate emission from simulations or semi-analytic models
- Numerical sims are well behind analytic theory: $T_p/T_e = \text{const}$, jet handled in ad hoc way, mostly thermal models
- Largest systematic uncertainty in interpreting EHT observations



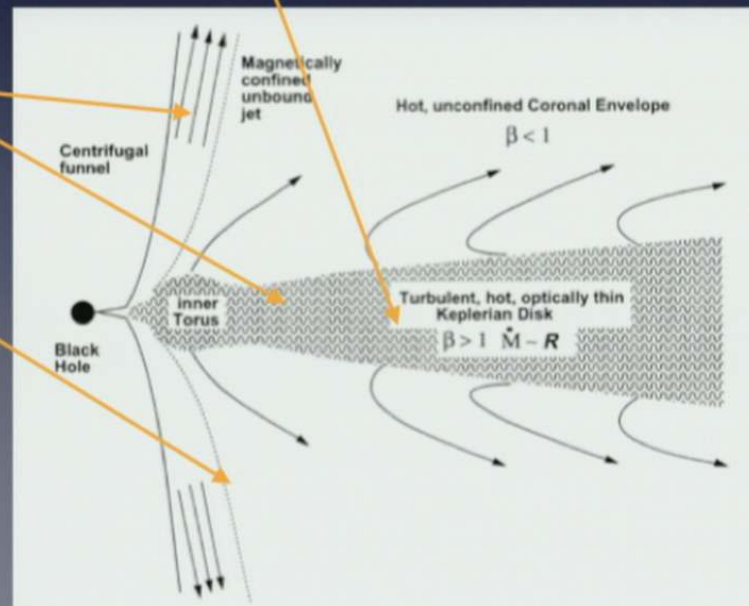
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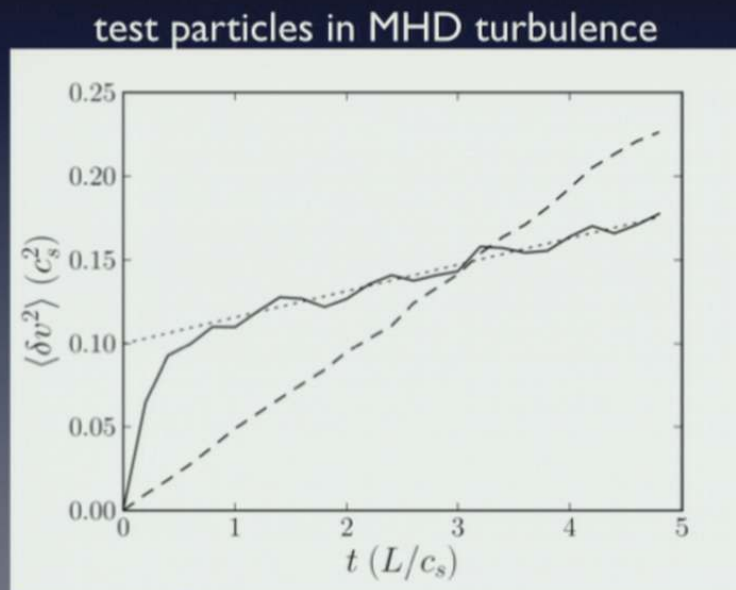


Electron Acceleration

- Accretion Disk Turbulence
- Reconnection
- Shocks



Particle Acceleration by MHD Turbulence

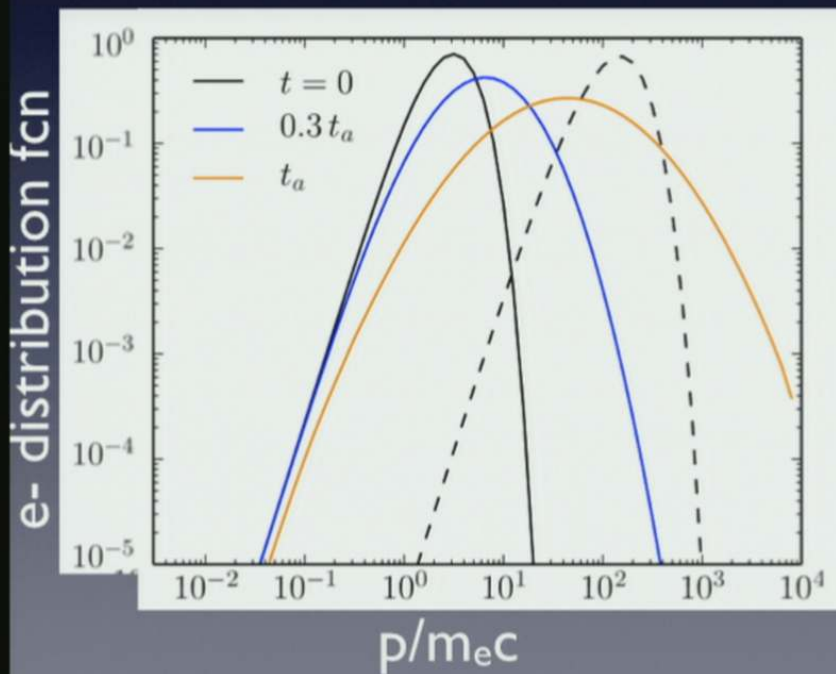


Lynn+ 2013, 2014



Vorticity in Turbulence Sim by Jonathan Zrake

Particle Acceleration by MHD Turbulence



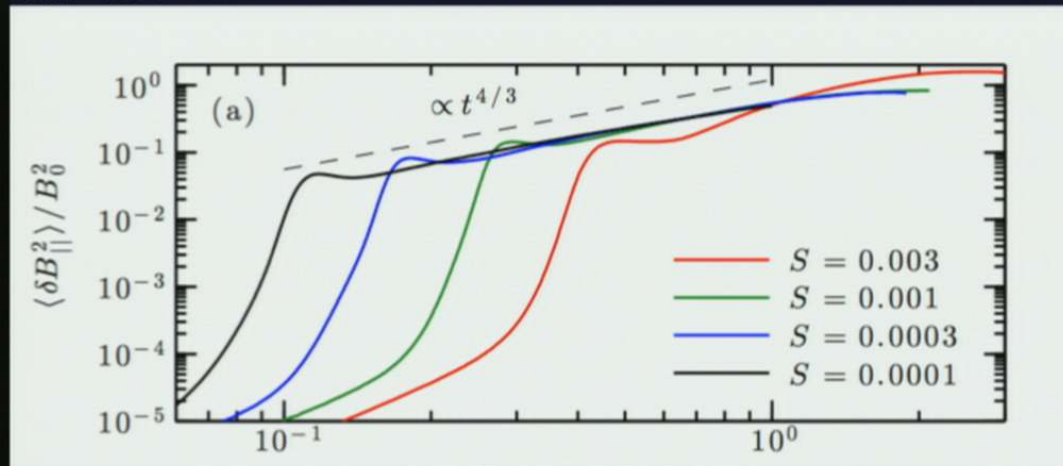
$$\dot{E} \sim E \frac{v_A^2}{Lc} \left(\frac{\delta|B|}{B} \right)^2$$

$$\gamma_{max} \sim 100 \left(\frac{\tau_T}{10^{-6}} \right)^{-1}$$

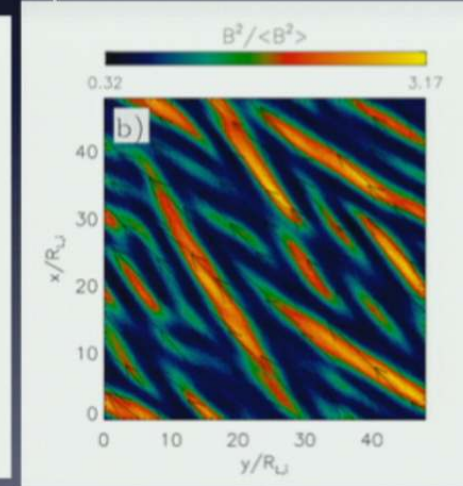
likely important for mm & infrared emission in Sgr A*

Mirrors Self-Generated in Collisionless Turbulence

Kunz+ 2014



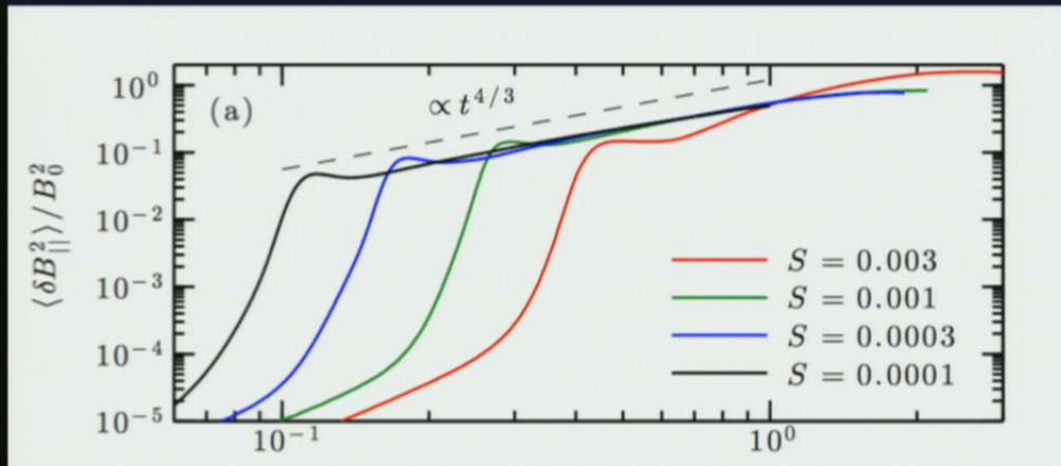
Riquelme+ 2014



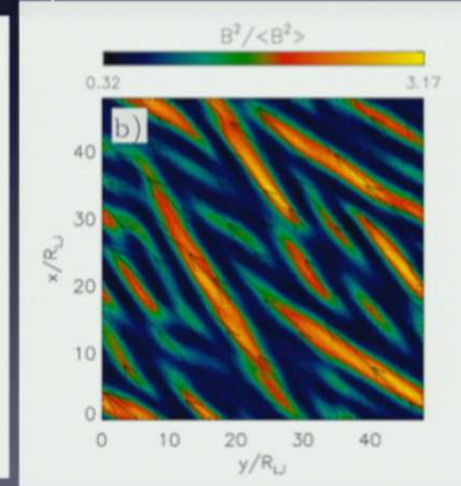
kinetic simulations of shear flows with shear rates \ll cyclotron freq.: magnetic mirrors with $\delta B/B \sim 1$ generated likely strongly affects particle propagation: e.g., Fermi acceleration & e- conduction

Mirrors Self-Generated in Collisionless Turbulence

Kunz+ 2014



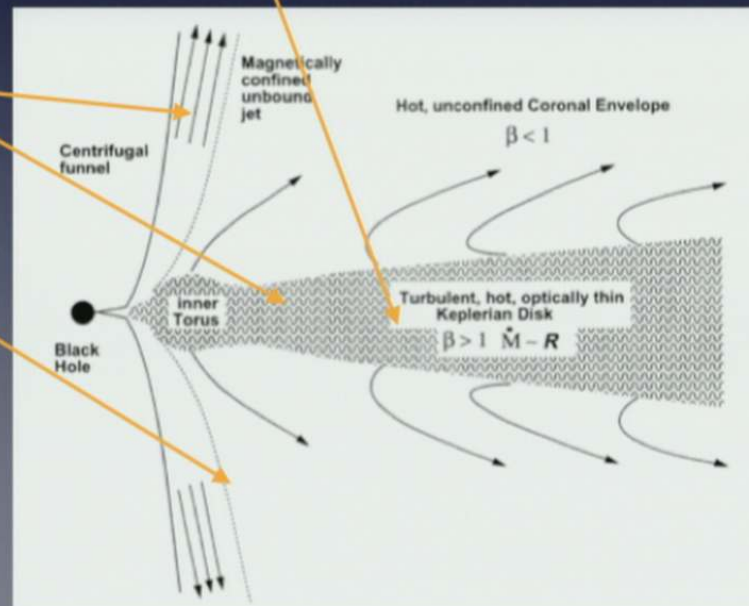
Riquelme+ 2014



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Electron Acceleration

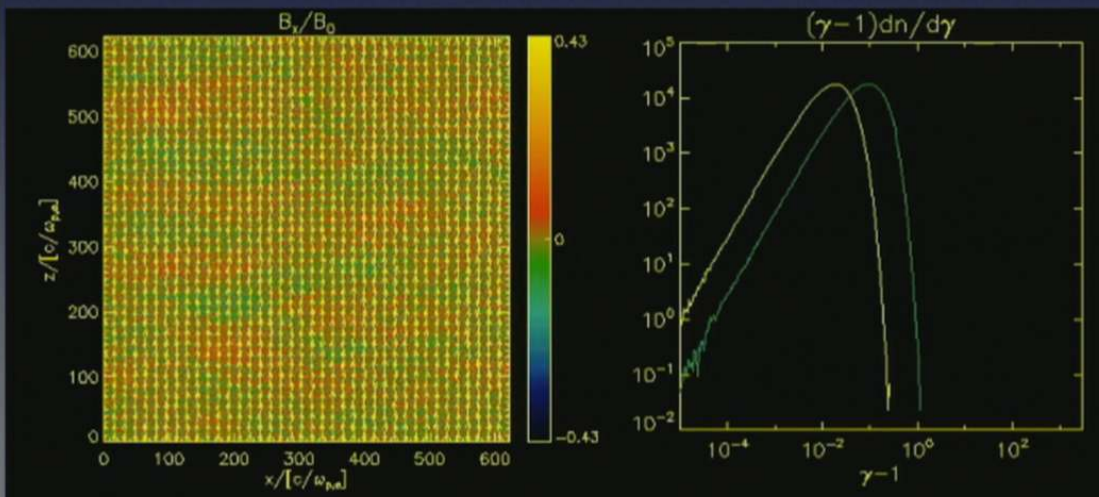
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Particle-in-Cell Simulations of Accretion Disk Turbulence

- solve for full e- and p distribution functions + MRI +
- downside is limited spatial resolution; thusfar restricted to local sims

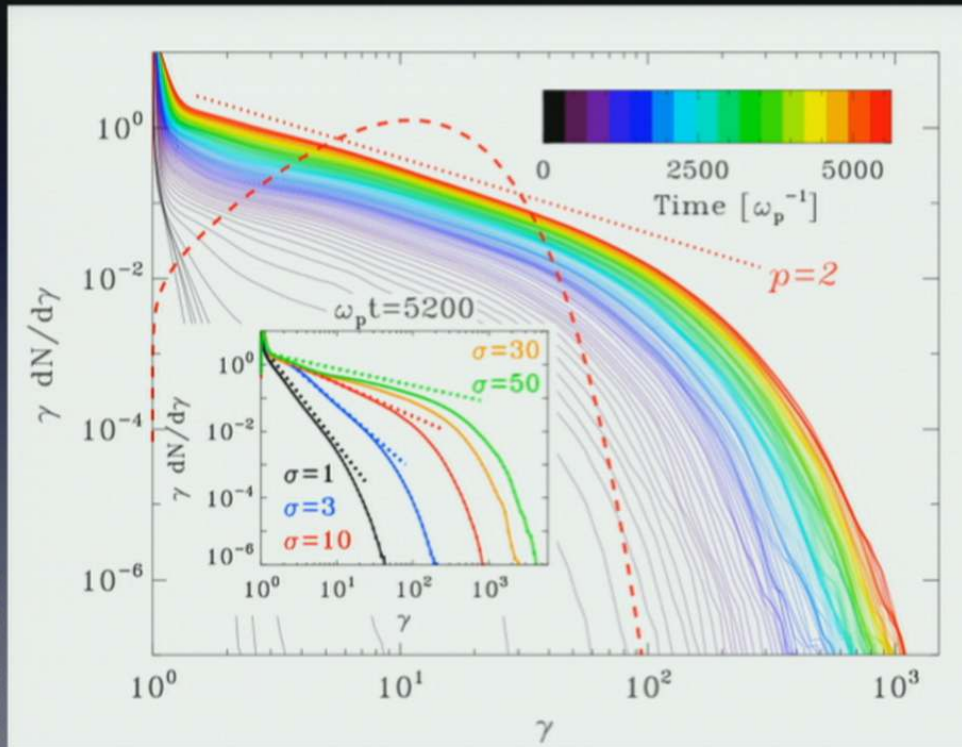
B_{radial} (color) + B vectors



Transient Power-law
Tail to Dist. Fcn
created during
reconnection

Mario Riquelme

Relativistic Reconnection

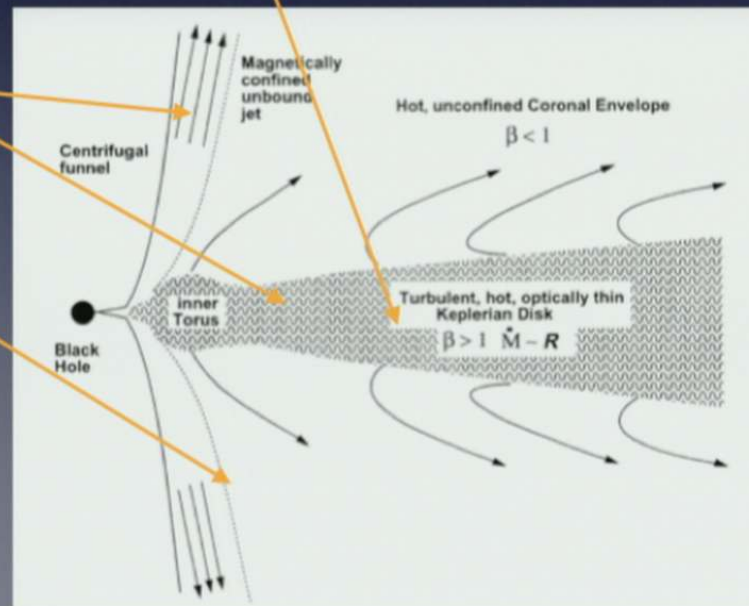


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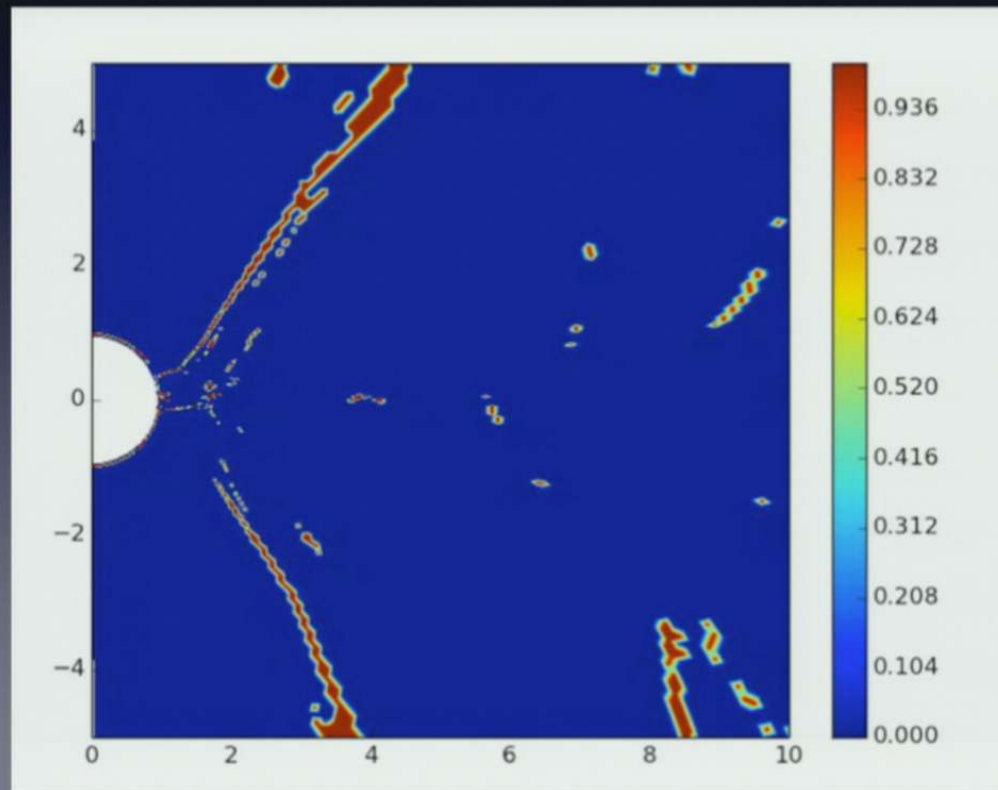
acceleration much more efficient for $\sigma \sim B^2/\rho c^2 \gg 1$
 \rightarrow may be particularly important in the jet
 (e.g., Moscibrodzka+ models)

Electron Acceleration

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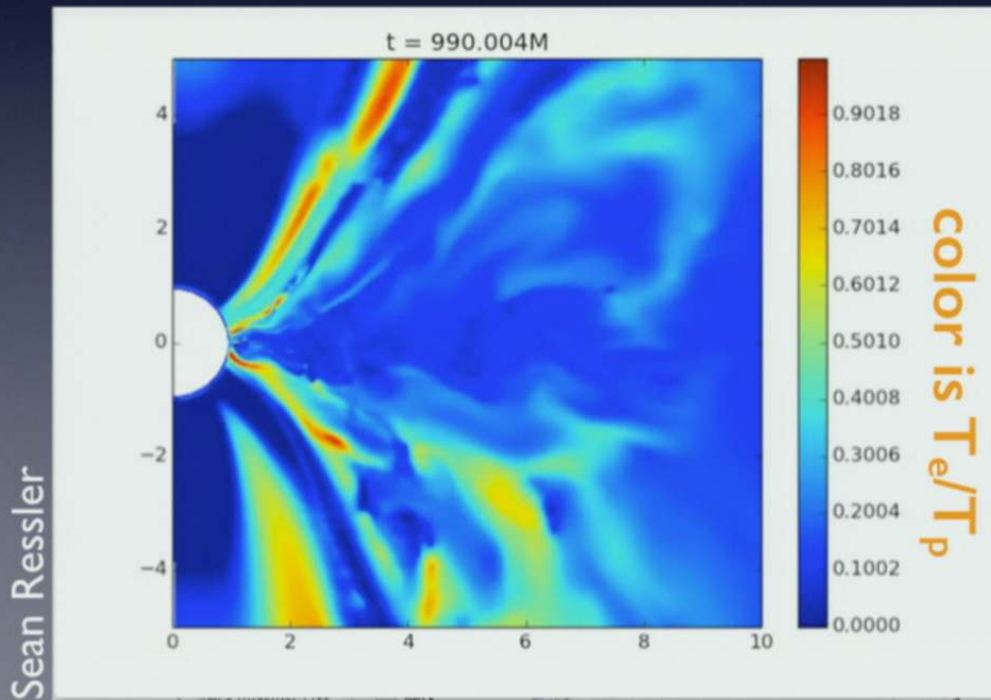


Shock Detection in HARM Simulations: Funnel Wall Boundary 'Lights Up'



Approach: Explore Range of Plausible
Electron Physics, Emission Regions, ...
Figure out How to 'Marginalize' over
Uncertainties in Interpreting EHT Data

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electrons are
evolved as a separate
fluid with $htg(\beta)$
based on theories
of turbulent htg