Measurement of Current Fluctuations and Charge Transport During Reconnection

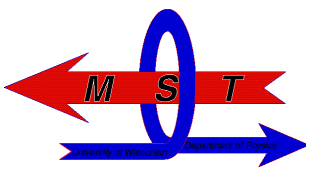
by N. A. Crocker, G. Fiksel and S.C Prager

RFP Workshop

February 28, 2000 - March 1, 2000

Madison Symmetric Torus

Dept. of Physics, Univ. of Wisconsin - Madison



Introduction

Reconnection associated with resistive tearing mode activity is frequent in edge plasma of RFP:

What is spatial structure of current and magnetic perturbation (current “sheet” and magnetic island of tearing mode)?

Is particle transport from reconnection ambipolar?

Current and Magnetic Spatial Spectra

Using a pair of insertable probes, measure simultaneously at same location:

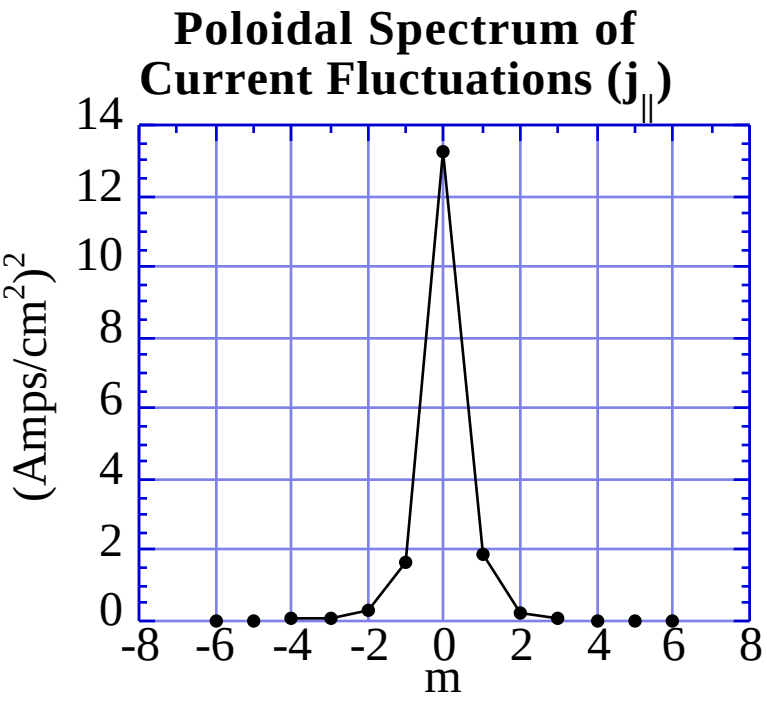
- **parallel current density (Rogowskii coil)**
- **various components of magnetic field (multiple magnetic field sensing coils)**

Separation of probe pair gives estimate of poloidal or toroidal wave number spectra.

Correlation with magnetic toroidal spectrum from surface coil array estimates toroidal spectrum inside plasma.

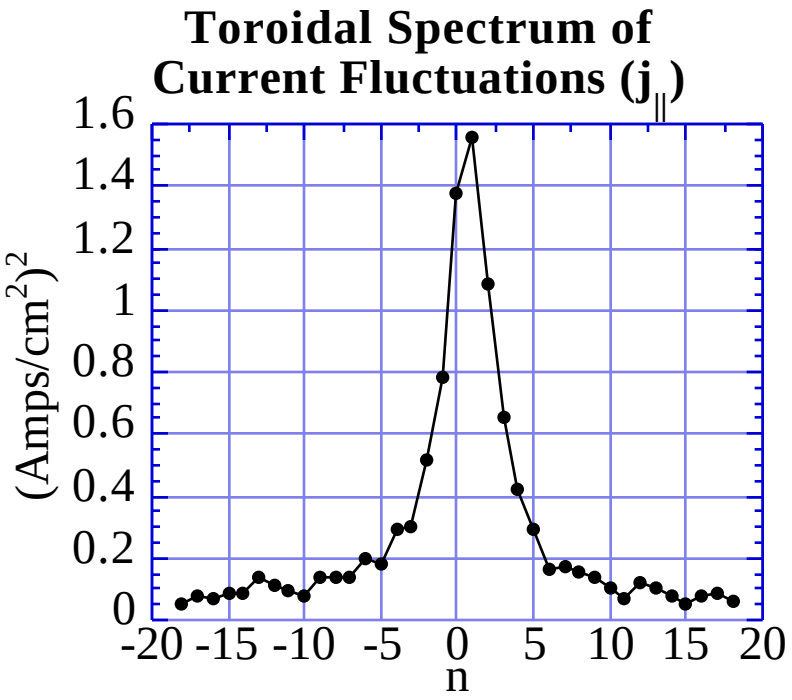

M S T
University of Wisconsin
Department of Physics

Current Fluctuations are Mostly from Edge Resonant Modes

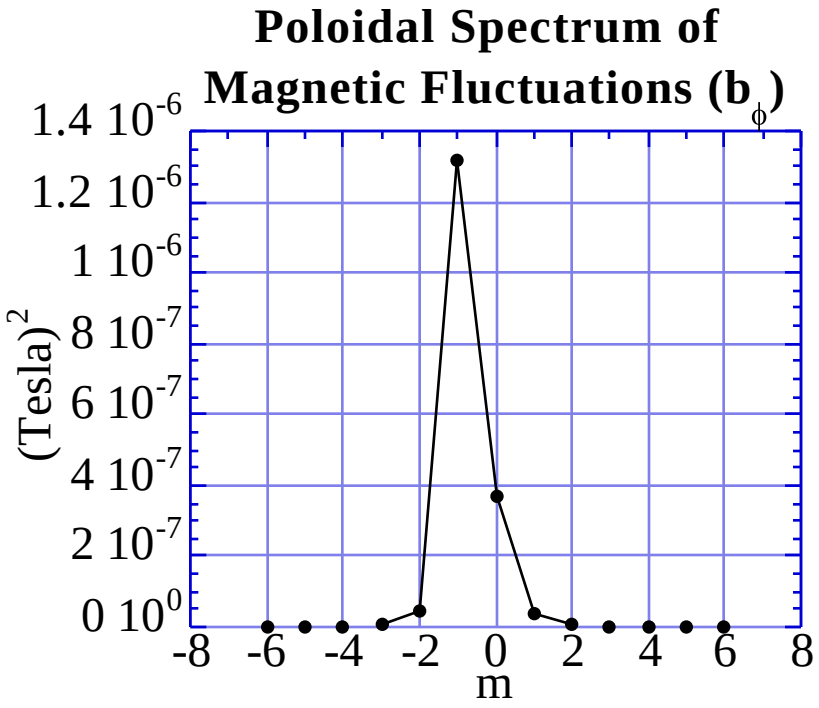


Toroidal and Poloidal Spectra are measured at

Edge resonant current perturbation is reconnection

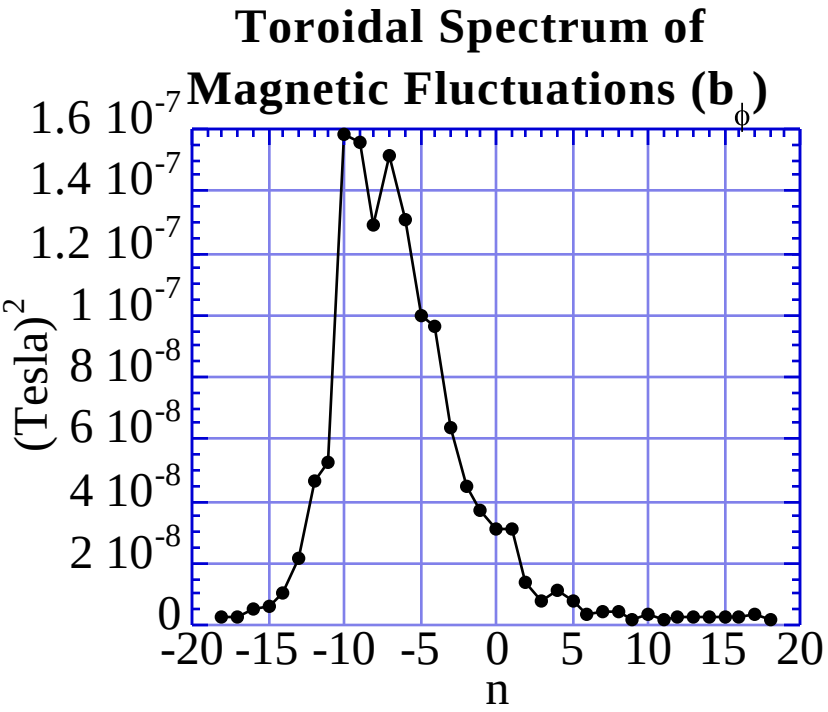


Magnetic Fluctuations are Mostly from Core Resonant Modes

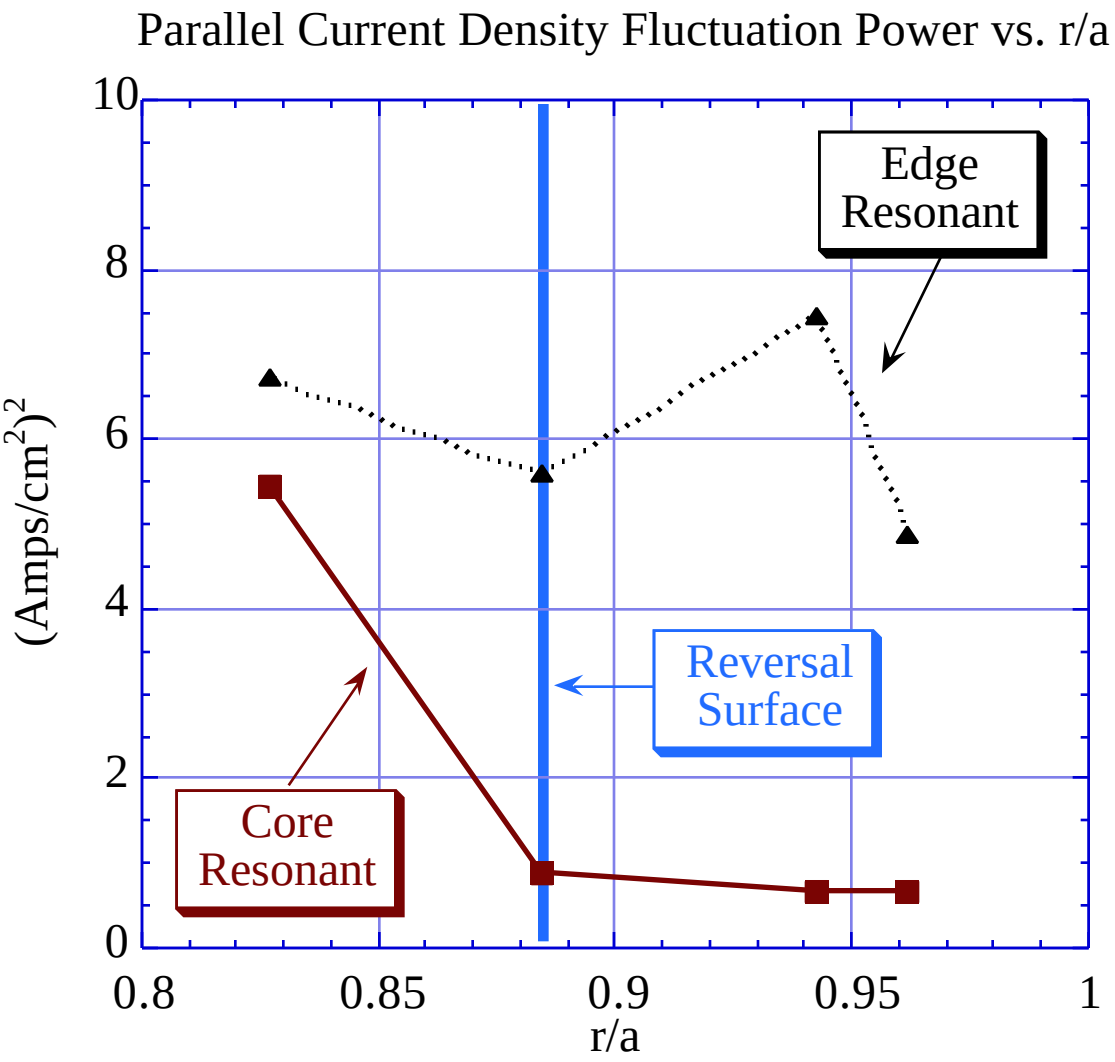


Toroidal and Poloidal Spectra are measured at

Edge resonant magnetic perturbation is relatively small.



Current “Sheet” of Edge Reconnection is



Magnetic Fluctuation Driven Radial Charge Flux Measured in Plasma Edge

Magnetic fluctuation driven radial charge flux is the flux surface average of parallel current density and radial magnetic field fluctuations:

$$\Gamma_q = \left\langle \tilde{j}_{\parallel} \tilde{b}_r \right\rangle / B_0$$

Plasmas are rotating: correlation of current and radial magnetic field fluctuation gives flux surface average.

Magnetic Fluctuation Driven Radial Charge Flux is Small Except During Sawteeth

Total particle transport:

$$\Gamma_{total} \sim 25 \times 10^{20}\ (m^2 sec)^{-1}$$

Between Sawteeth:

$$\left|\left\langle \tilde{j}_{||} \tilde{b}_r \right\rangle / eB_0\right| \lesssim 4 \times 10^{20}\ (m^2 sec)^{-1}$$

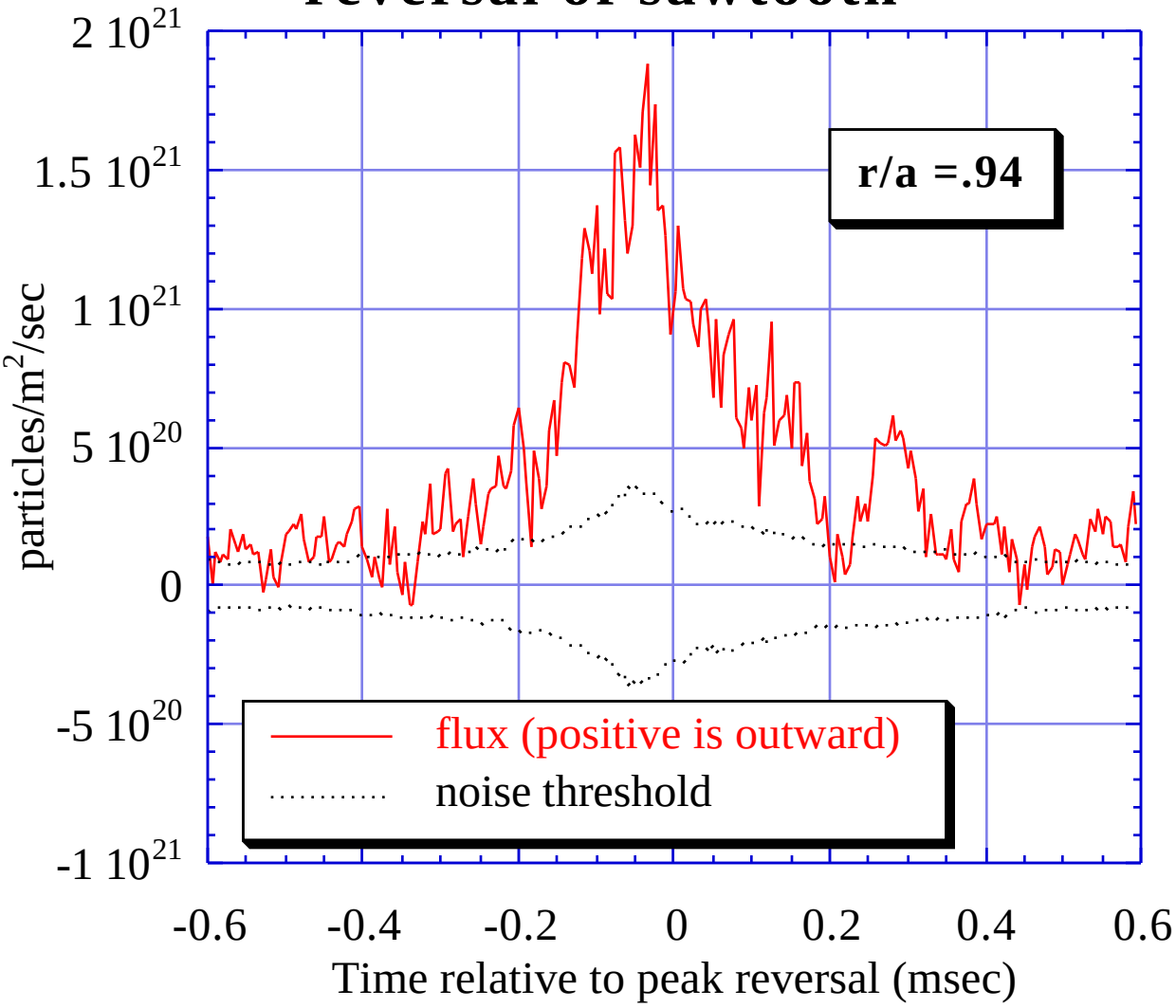
Relatively small: physical cause of small varies with depth

During Sawteeth
at extreme edge (outer 10%):

$$\left|\left\langle \tilde{j}_{||} \tilde{b}_r \right\rangle / eB_0\right| \sim 20 \times 10^{20}\ (m^2 sec)^{-1}$$

Magnetic Fluctuation Driven Charge Transport in MST Edge is Large During

$\left\langle \tilde{j}_{\parallel} \tilde{b}_r \right\rangle / (eB)$ vs. time relative to peak reversal of sawtooth



Caveat: Plasmas decelerate during crash. Is time average of $\tilde{j}_{\parallel} \tilde{b}_r$ product still a valid flux surface average?

Cause of Small Magnetic Fluctuation Driven Radial Charge Flux Varies with Depth

Outside Reversal Surface, $\tilde{j}_{||}$ and $\tilde{b}_r$ have small amplitude.

Near Reversal Surface, $\tilde{j}_{||}$ and $\tilde{b}_r$ are relatively incoherent

- **incoherence is consistent with difference in wave number spectra.**

Inside Reversal Surface $\tilde{j}_{||}$ and $\tilde{b}_r$ are out of phase, but relatively coherent.

- **consistent with theoretical expectation for resistive tearing modes**
- **coherence and phase are consistent with increased contribution of core modes to $\tilde{j}_{||}$**

Conclusions

Reconnection current perturbation is not sheetlike.

- **Cause is unknown.**
- **Radial extent comparable to island width.**

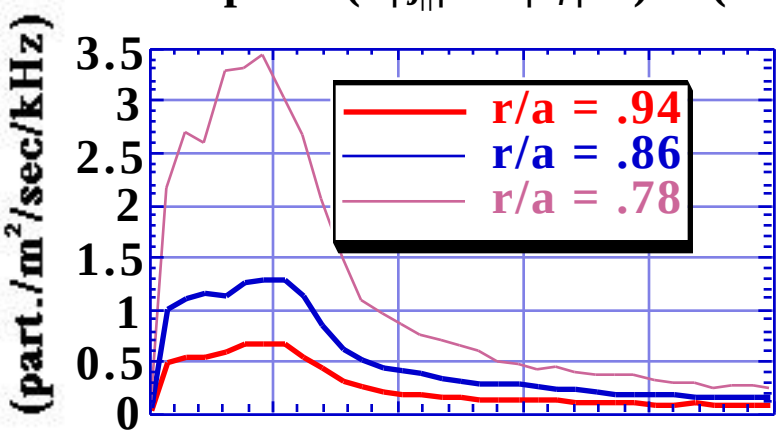
Reconnection magnetic perturbation is relatively small.

Current and magnetic perturbation amplitudes consistent with traditional resistive tearing mode picture.

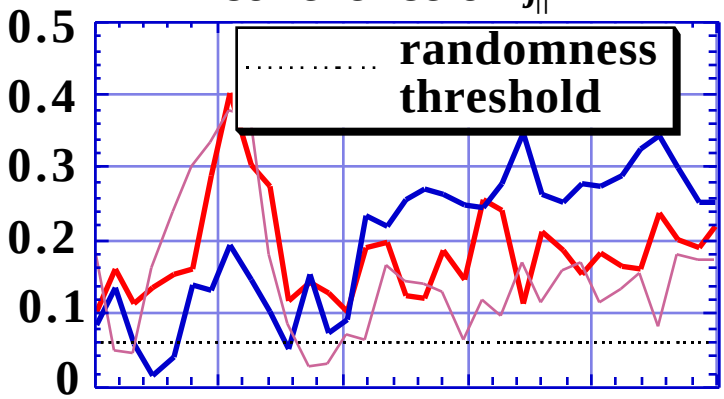
Magnetic flucuation driven radial charge flux associated with reconnection small except during sawteeth.

Cause of Small Magnetic Fluctuation Driven Radial Charge Flux Varies with Depth

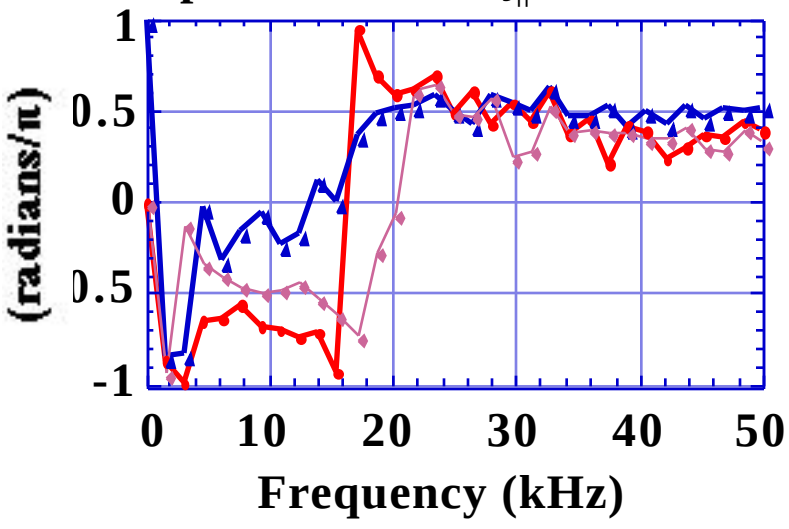
Maximum Possible Charge Transport: $(<|\tilde{j}_{||}|^2><|\tilde{b}_r|^2>)^{1/2}/(eB_0)$



coherence of $\tilde{j}_{||}$

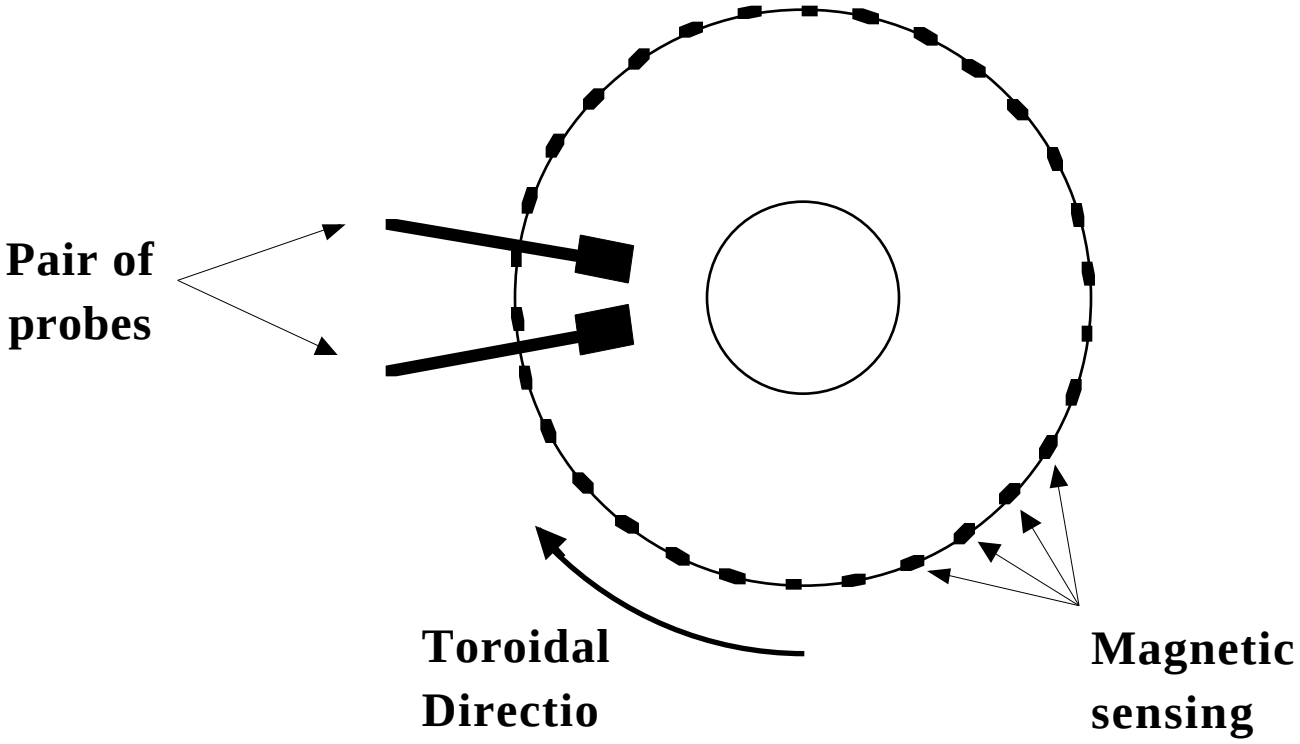


phase between $\tilde{j}_{||}$ and $\tilde{b}_r$



Experimental Setup

Top View of MST




M S T
University of Wisconsin
Department of Physics


M S T
University of Wisconsin
Department of Physics