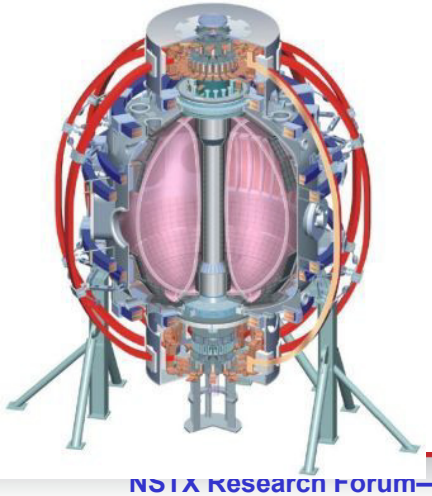
NSTX
Supported by
U.S. DEPARTMENT OF ENERGY
Office of Science

Modeling of Polarimetry for $\tilde{B}$ Measurements on NSTX

College W&M
Colorado Sch Mines
Columbia U
CompX
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Washington
U Wisconsin

Jie Zhang UCLA
W. A. Peebles, N. A. Crocker, T. A. Carter, S. Kubota *(UCLA)*
W. Guttenfelder *(PPPL)*

March, 15—18, 2011
PPPL, NJ
NSTX Research Forum



Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

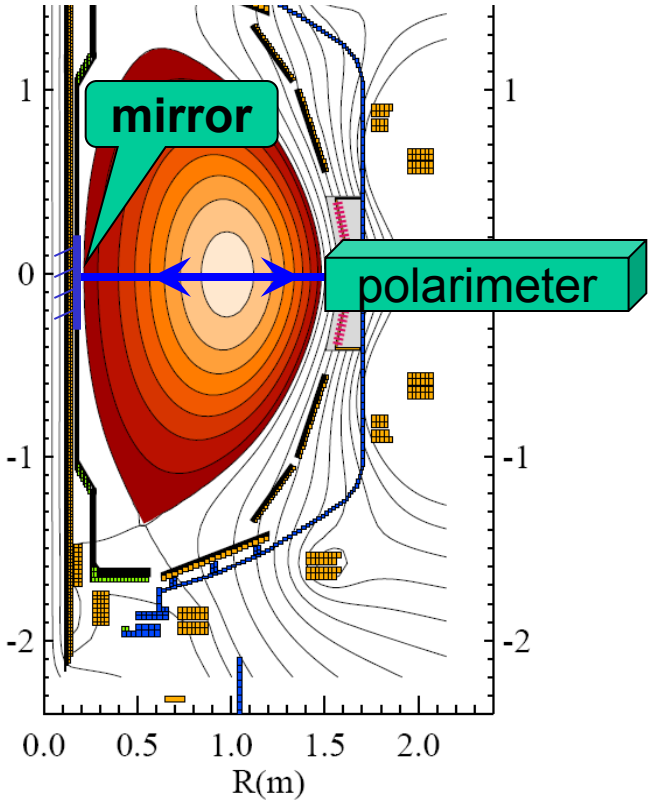
Planned polarimeter for NSTX can directly measure $\tilde{B}$

- Polarimetry measures change of wave polarization (ψ) caused by magnetized plasma
- Polarimetry on NSTX can investigate $\tilde{\boldsymbol{B}}$ of various modes
  - Microtearing modes (T&T milestone R11-1)
  - Tearing modes
  - Alfvén eigenmodes
- *288 GHz* polarimeter planned for NSTX
  - Horizontal retroreflection from Center Stack
  - Expect subdegree phase resolution at *1 MHz* sweeping rate
  - Laboratory testing underway

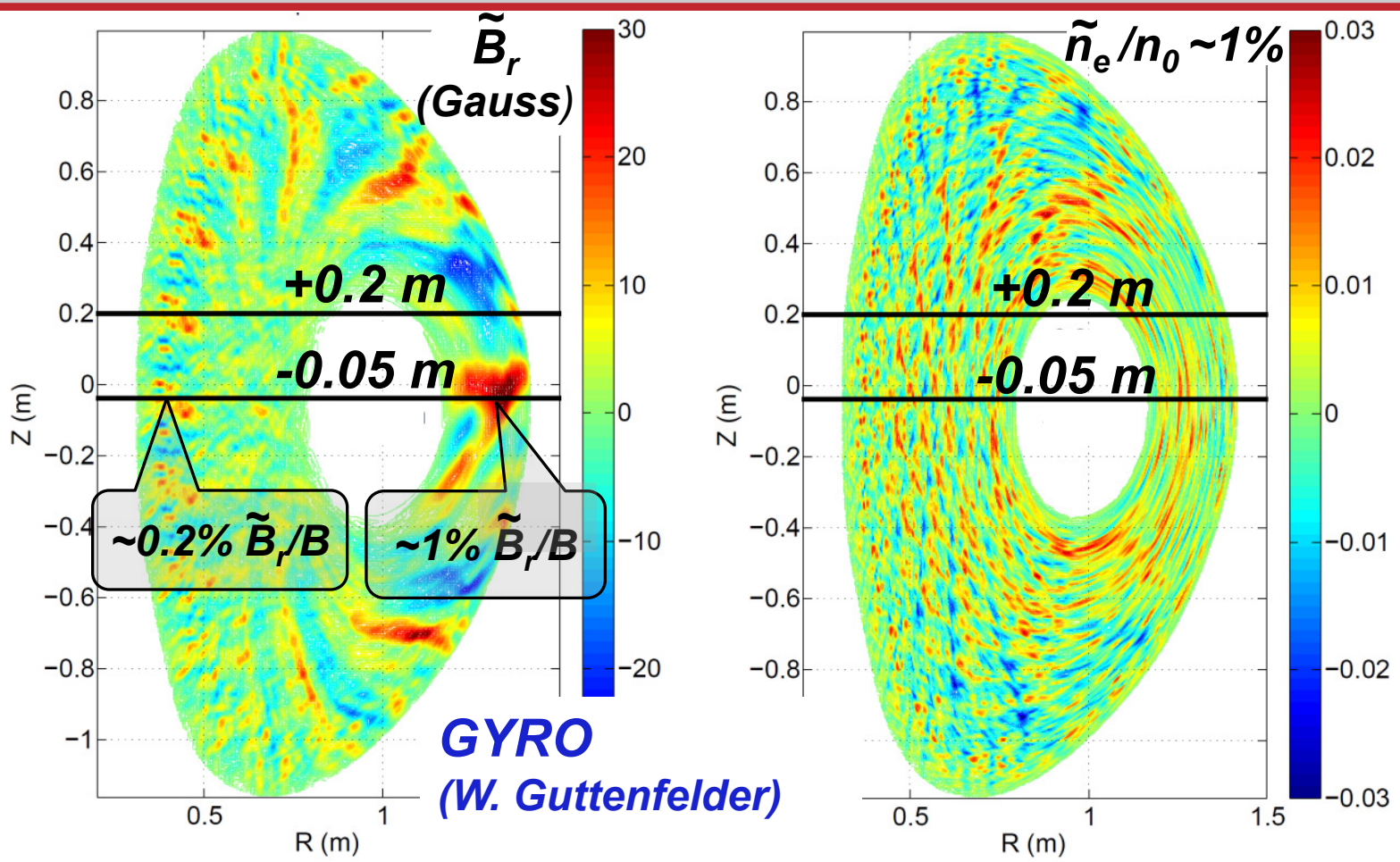
Faraday rotation:

$$\psi \propto \int n\underline{B}\cdot d\underline{l}$$

$$\tilde{\psi} \propto \int \overline{n}\tilde{\underline{B}}\cdot d\underline{l} + \int \tilde{n}\overline{\underline{B}}\cdot d\underline{l}$$

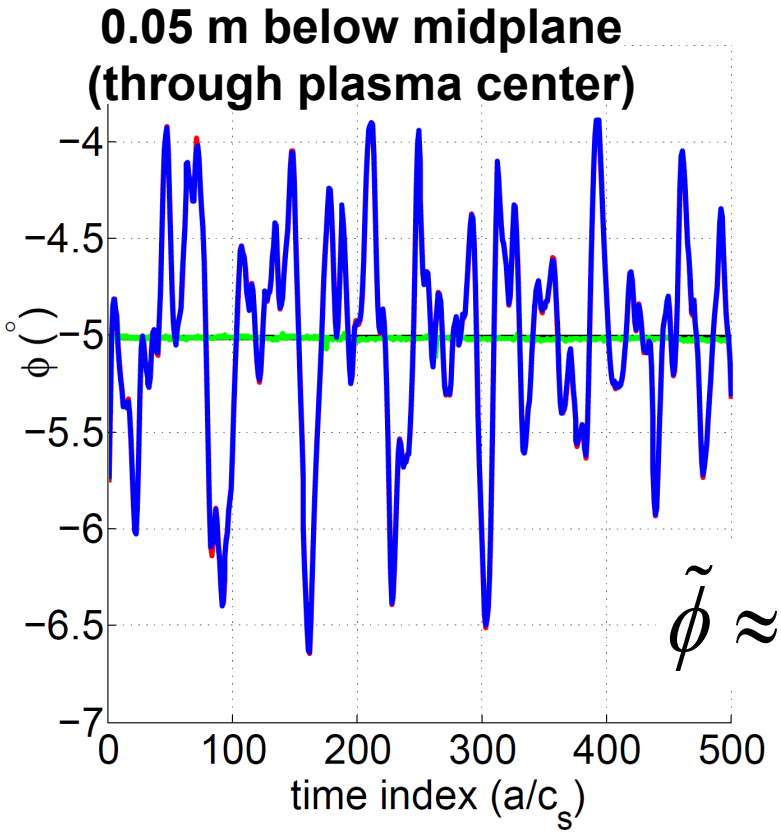


Modeling used to evaluate polarimetry sensitivity to microtearing modes

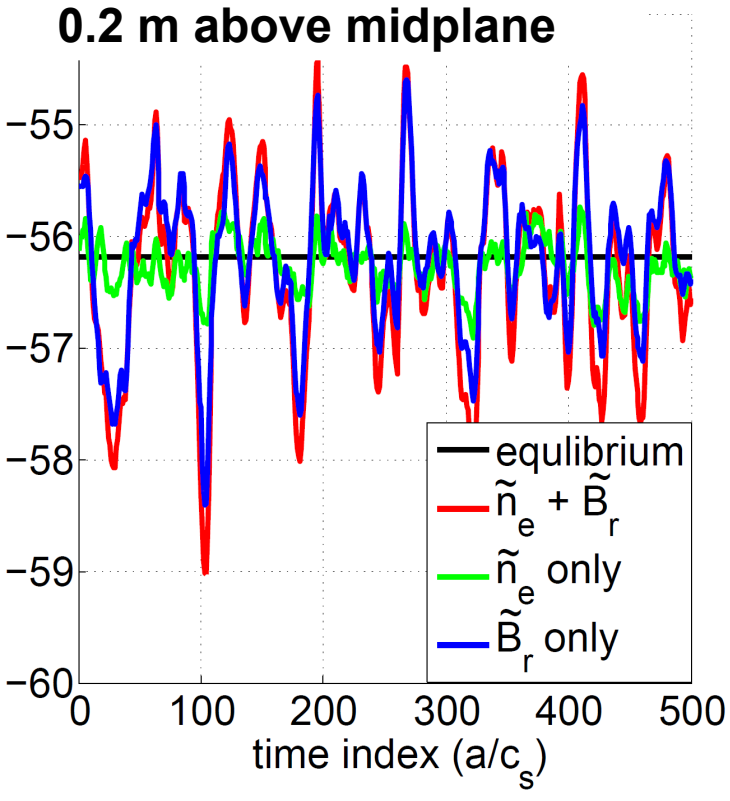


- $\tilde{B}_r$ and $\tilde{n}_e$ of microtearing modes from GYRO simulations
- Chord heights varied to evaluate polarimetry sensitivity to $\tilde{B}_r$, $\tilde{n}_e$ respectively

Polarimeter sensitive to primarily $\tilde{B}_r$ for chords near plasma center



$$\tilde{\phi} \approx 2\tilde{\psi}$$



- $\tilde{\phi}$ ~1—2°, expected to be detectable

$$\tilde{\psi} \propto \int \bar{n}\tilde{\underline{B}} \cdot d\underline{l} + \int \tilde{n}\bar{\underline{B}} \cdot d\underline{l} \quad (\tilde{n}\bar{\underline{B}} \cdot d\underline{l} \to 0)$$

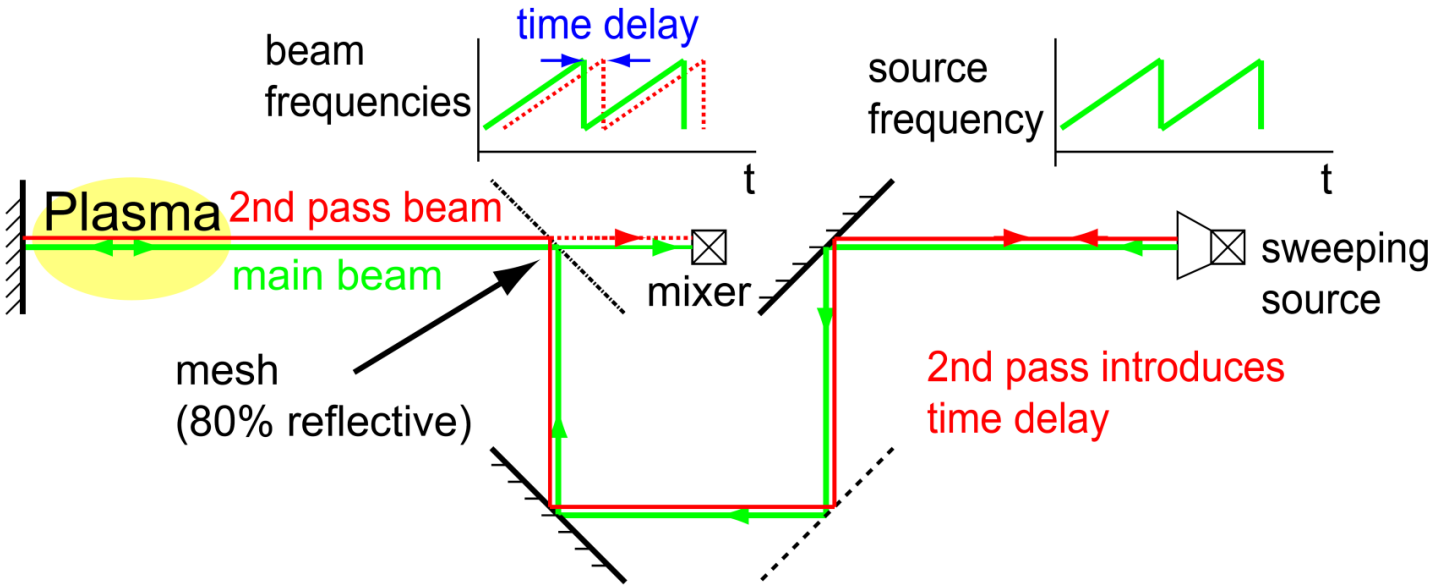
$$\bar{\underline{B}} \cdot d\underline{l} \sim 0$$

for chords near plasma center

Time-line for polarimeter installation

- Current status:
  - Phase noise too large (a few degrees)
  - Cause understood
    - Multiple reflections between millimeter-wave source and center stack
  - quasi-optical isolator components arrived
    - Faraday rotators function correctly; isolation needs detailed testing
- March/April:
  - Perform laboratory tests to reassess phase noise
  - Establish readiness for installation (sub-degree phase noise)
- May/June:
  - Install on NSTX in preparation for upcoming run

Backup#1: Multiple reflections degrade phase resolution



- Microwaves returning from plasma mostly (80%) channeled to source and partially reflected back to plasma (i.e. 2nd pass)
  - 2nd pass beam strongest among multiple reflections
- Interferometry effect is caused by 2nd pass beam
  - Phase of beating signal with main beam very sensitive to path length change ($\lambda \sim 1\ mm$)
  - Path length changes due to mechanical vibration and plasma turbulence

Backup#2: Optical isolation expected to improve phase resolution