RF Diagnostics for Ecloud measurement

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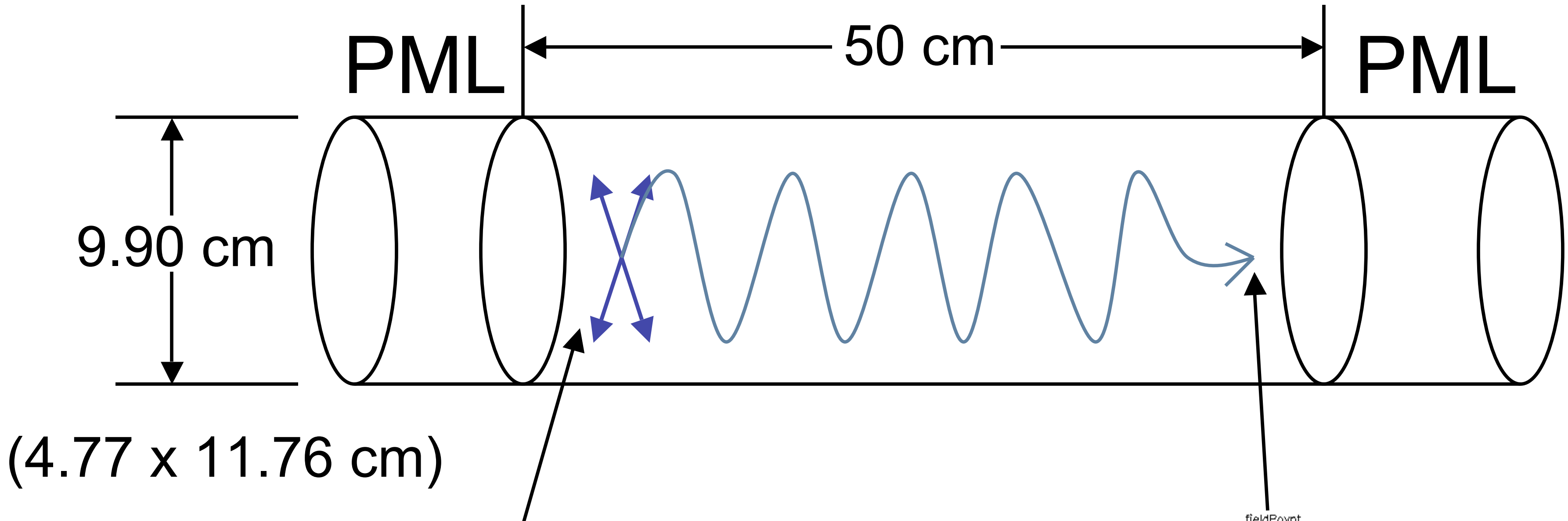
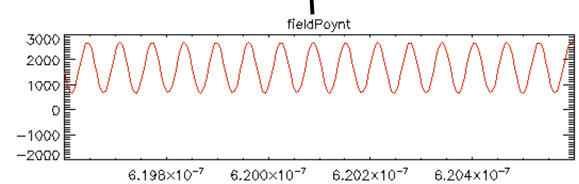
Detailed Simulations Provide Tests of RF Diagnostic Methods



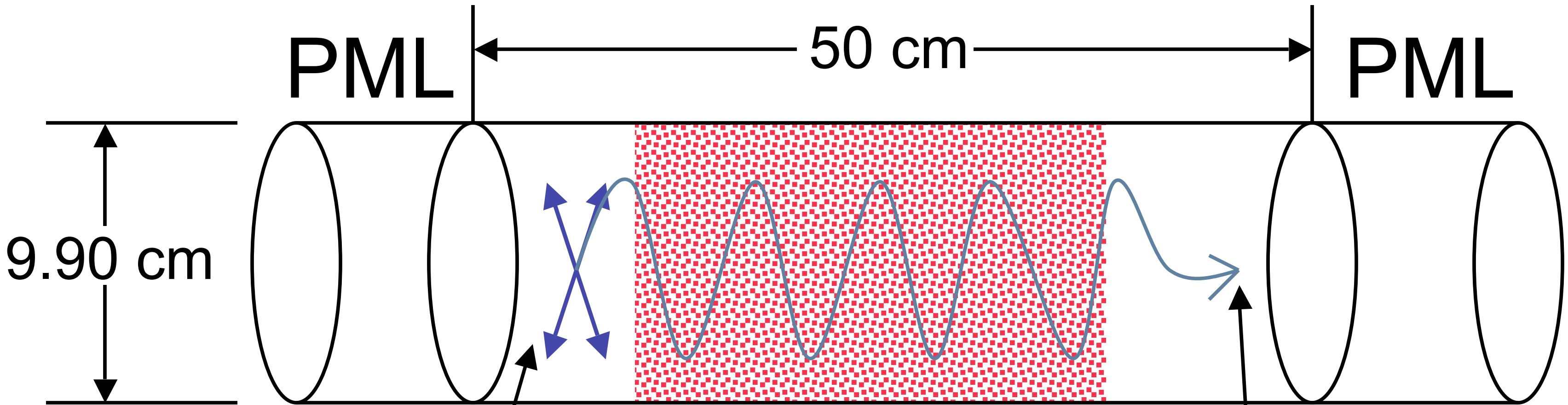
Current Source



Driving frequency is
10% above cutoff frequency

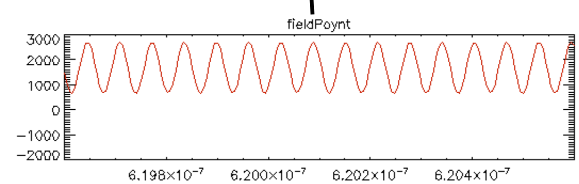
2.17 GHz for TE_{11} circular cross section
2.84 GHz for TM_{01} circular cross section

Detailed Simulations Provide Tests of RF Diagnostic Methods



(4.77 x 11.76 cm)

Current Source



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Phase Shifts Can Easily be Extracted from RF Time Series’

- Microwaves propagating in a beam pipe experience a phase shift in the presence of a plasma
- Phase shifts can be experimentally measured
- Phase shifts can be extracted from simulations

$$A\sin(\omega t+\varphi_1)-A\sin(\omega t+\varphi_2)=2A\sin[(\varphi_1-\varphi_2)/2]\cos[\omega t+[(\varphi_1+\varphi_2)/2]]$$

$$\cong A(\phi_1-\phi_2)\cos[\omega t+(\phi_1+\phi_2)/2]$$

$$\left\langle\left(\sin(\omega t+\phi_1)-\sin(\omega t+\phi_2)\right)^2\right\rangle\cong\tfrac{1}{2}(\phi_1-\phi_2)^2$$

- However, accurate simulations require the inclusion of lots of physics, at different scales
  - EM propagation
  - Cut-cell geometry
  - Self-consistent electron orbits and surface emission

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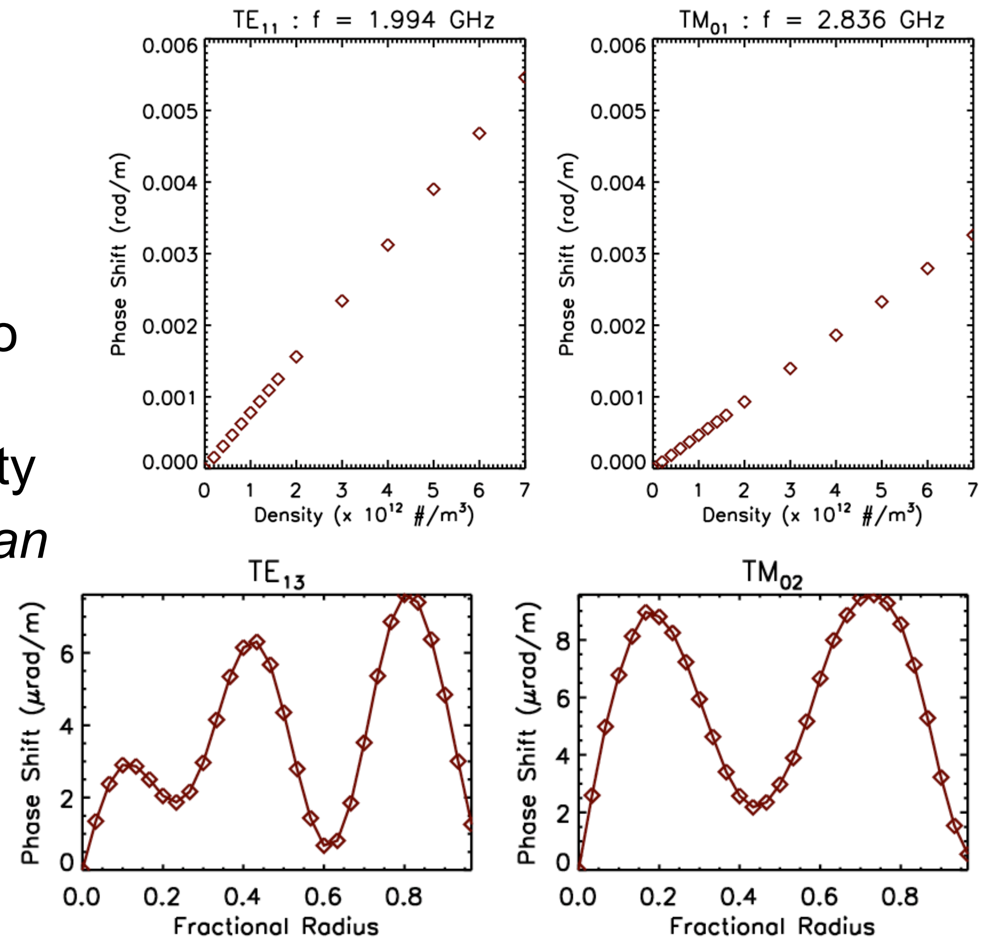
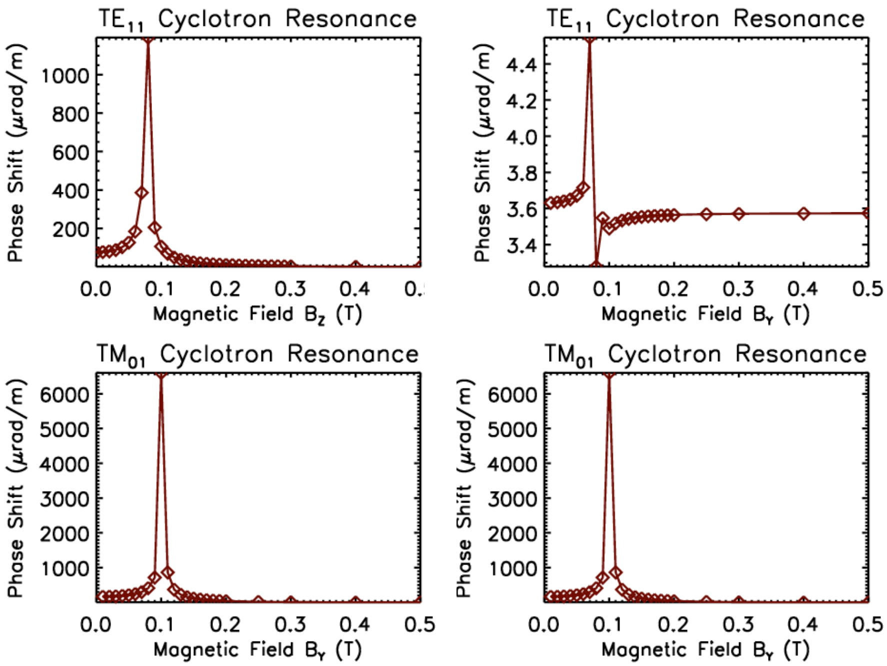
Plasma-induced phase shifts are linear in cloud density*

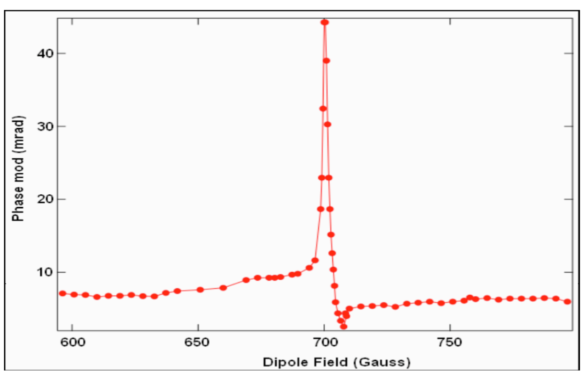
- Phase shift magnitude depends on many things
  - Electron cloud density
  - RF mode
  - Proximity of RF frequency to cutoff frequency
  - Electron cloud non-uniformity
  - *Strength and orientation of an applied magnetic field*



*…to first order

We Have Measured the Cyclotron Resonance in Phase Shift





From Pivi et. al., *Proc. EPAC08*

- A dipole B field normal to the RF electric field creates an *extraordinary wave*, that produces a resonance in the phase shift when the upper hybrid frequency aproaches the wave frequency
- When the B field is parallel to the RF electric field, an *ordinary wave* is created, and there is no resonance
- Since the cloud density is low here (small plasma frequency), the upper hybrid frequency is approximately equal to the cyclotron frequency
- This effect has been observed experimentally