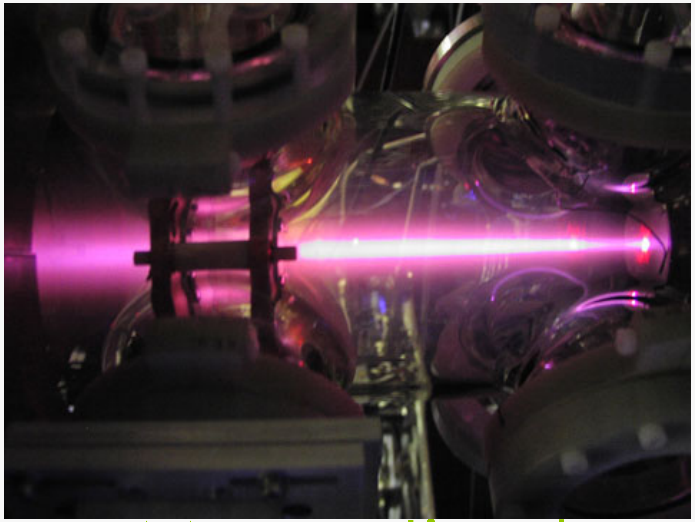
Summer of Learning 2012

Matthew Chu Cheong

Sponsored by PEI

Internship at PPPL

- PPPL:
  - "The Future of Fusion Energy"
  - fusion energy for practical power
- Worked under Professor Samuel Cohen
  - Research focus: smaller, ***cleaner*** less expensive fusion devices



Magnetized Nozzle Experiment

Plasma in Professor Cohen's lab

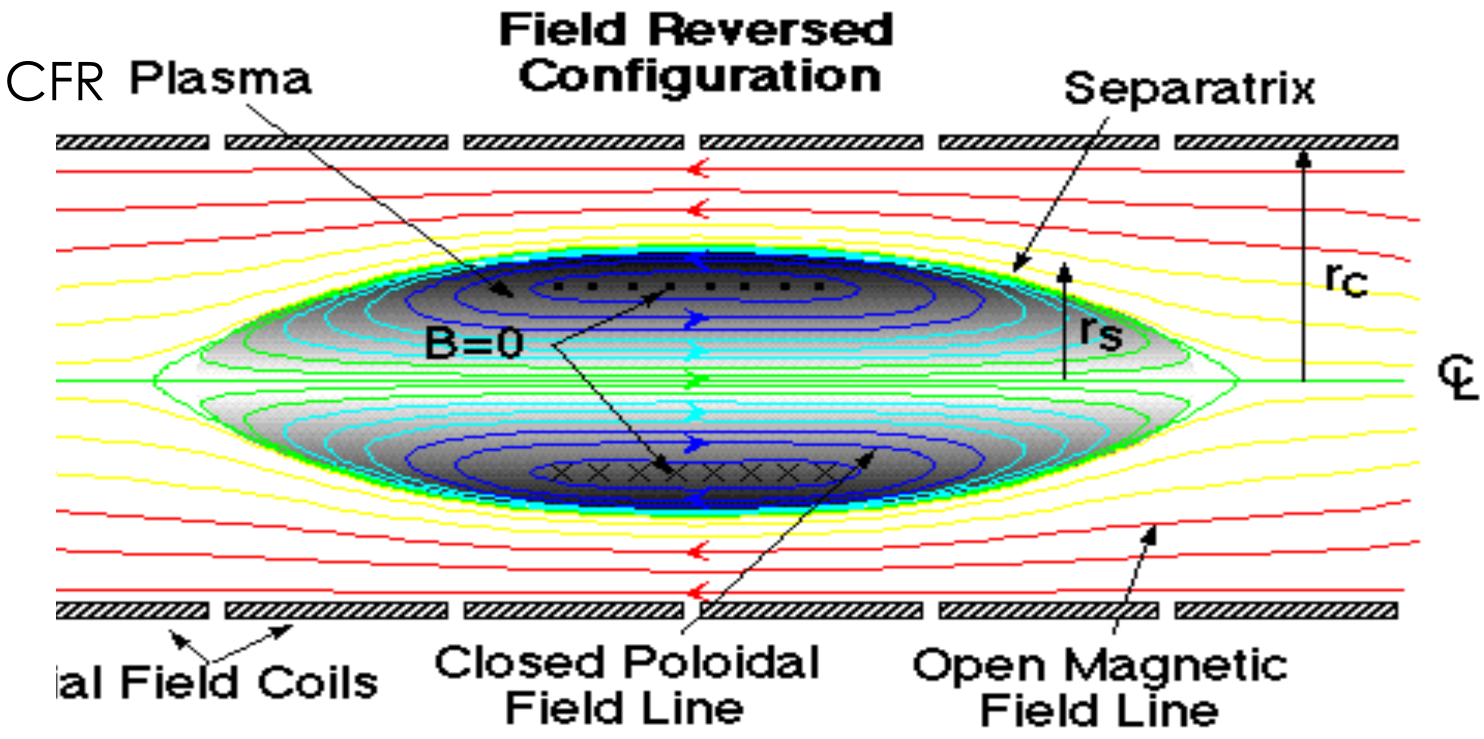
FYI – the image shows a thin stream of plasma flowing from the right into the region where we make FRCs. This tenuous plasma serves as a seed for making the hotter denser larger FRC plasma

Project Goals

- Researching the "Field Reversed Configuration"
  - Specific magnetic field that is potentially capable of confining a hot, dense, plasma core
  - "Closed" magnetic field lines serve as insulators, confining the plasma and separating it from material walls
- Sought to determine behavior of plasma at the outer edges of the hot core (scrape-off-layer) FOUND- a **New** way to exhaust fusion ash and extract power from the fusion reaction products (FPs, mostly protons and alpha particles)

Unique magnetic field shape: FRC

We studied hot plasma which crosses the green boundary from the blue (confined) to the yellow (unconfined) regions



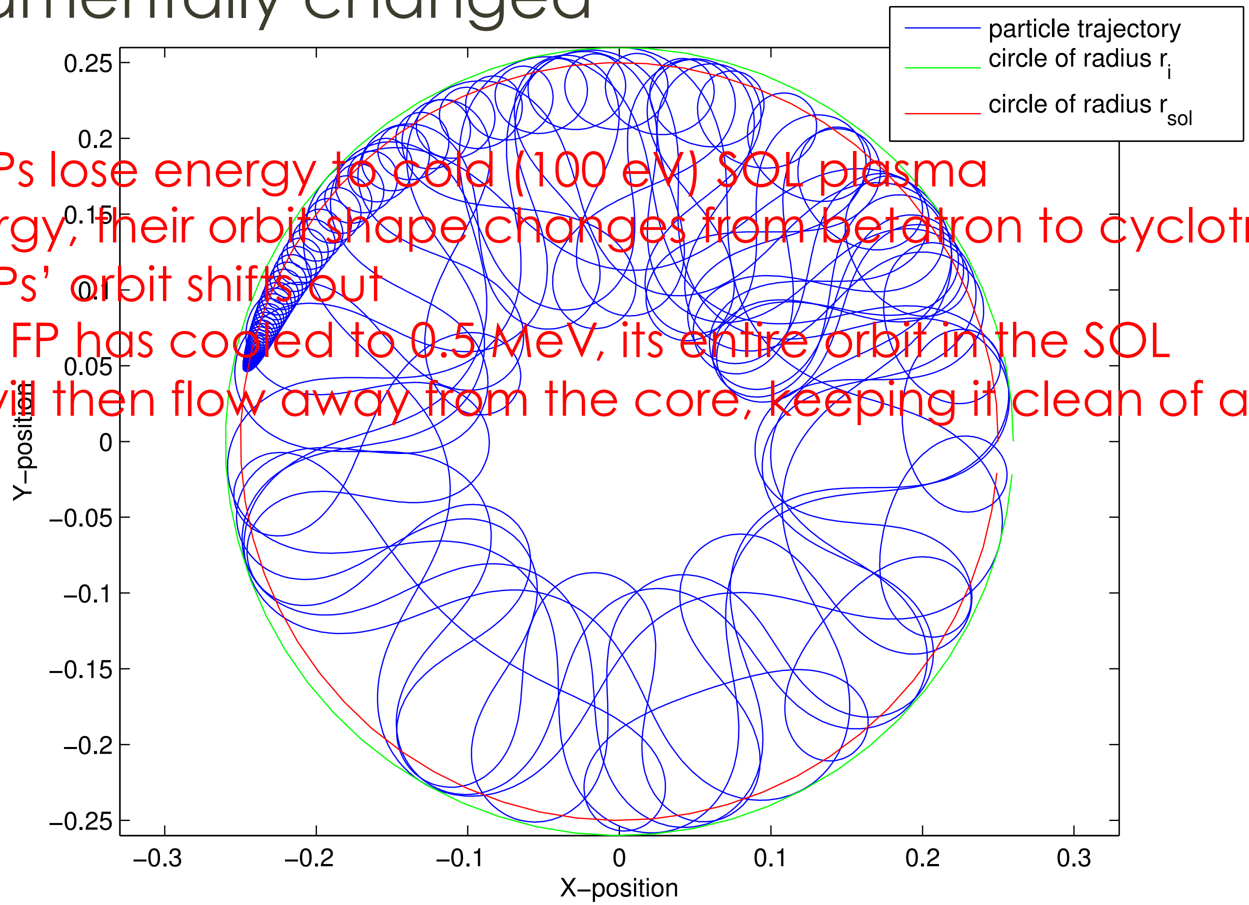
Part 1: Building a Model

- Developed a 2D model of the behavior of energetic particles interacting with the cooler boundary plasma
  - Studied the effect of energy loss on fundamental features of the trajectory

- Dynamics modeled as a system of nonlinear differential equations
  - Numerical solutions for equations of motion required high precision: Runge-Kutta method was adapted

Results: Fusion reaction product orbit Behavior

- As fusion product (FP) particle loses energy, orbit is fundamentally changed



Hot (14 MeV) FPs lose energy to cold (100 eV) SOL plasma

As FPs lose energy, their orbit shape changes from betatron to cyclotron

The center of FPs' orbit shifts out

By the time the FP has cooled to 0.5 MeV, its entire orbit in the SOL

The cooler FP will then flow away from the core, keeping it clean of ash

Part 2: Using a Simulation

- Used an established simulation code, based on fluid equations, to examine different features of the plasma behavior at the boundary with the heating provided by the FP slowing down.
- Examined a potential method, using neutral gases, to lower plasma temperature at the confining wall
  - Significant aspect of fusion confinement!

Results: Plasma Temperature

- The neutral-gas "blanket" can lead to a temperature drop of up to 97% at the boundary
- Observed a nonlinear relationship between the input power and input neutral gas
  - For higher power inputs, proportionally less gas was required for an appreciable temperature drop at the boundary

“Other” advances

- A perspective into what it means to research physics, not just study it
- Experience working in a field I would have never otherwise seen
- Insight into the attitudes and mindsets necessary to improve as a researcher

Thanks!

- Professor Samuel Cohen and Dr. Eric Meier, for their invaluable guidance and mentorship
- PEI, for acknowledging the significance of such research, and funding this work
- PPPL, for fighting the good fight, and continuing the mission for fusion power