

# **Solenoid-Free Startup: Plans and New Capabilities for FY'05**

## **Pre-ionization improvements**

- Installing additional ports in lower divertor chamber to inject gas and ECPi power

## **Investigating requirements and possibilities for operating at 2kV**

- Hipot test injector and absorber insulators to required levels during present outage
  - Replace the bolt insulating sleeves if necessary.
- Change MOVs and snubber capacitor at injector gap

## **Make preparations for nulling field in absorber to suppress arcs**

- Power supplies available from UW but local services and control development needed

## **Soukhanovskii: Supersonic gas jet fuelling for SFSU plasmas**

- Good collimation of gas jet; fast response (5ms); 20Torr.l/s
- Possibility for injecting different gases (*e.g.* CD<sub>4</sub>)
- Need modeling to investigate whether this nozzle can create a locally increased pressure for improving breakdown and minimizing inventory.

# Solenoid-Free Startup: Proposals for FY'05

## Transient CHI (Raman)

- Continuation of previous experiment XP-406 using capacitor bank (4 days in FY'04)
  - Demonstrated operation of bank  $C = 5 - 35 \text{ mF @ } 1\text{kV}$
  - Breakdown at 1/3 of previous prefill pressure at low injector fluxes
    - Power input per particle is still marginal
  - Current multiplication factors up to 40,  $I_p$  up to 140kA, but no persistence beyond  $I_{\text{CHI}}$
- Desirable to operate at higher injector voltage and lower gas pressure
- Improve pre-ionization by injecting gas and ECPi power into lower divertor chamber
- Assess need for nulling poloidal field in absorber to suppress absorber arcs
  - Absorber arcs were not fatal to CHI in FY-04 experiments
- Propose using PF4 coils to pull the evolving CHI discharge onto the outboard PPs
  - Would need to commission PF4 operation with reversed polarity at low current
- **1 commissioning day; 2 days followed by analysis period; 2 days**

# Solenoid-Free Startup: Proposals for FY'05

## Mueller: CHI added to Inductive Discharge

- Investigated in HIT-II in 2004: characterized scaling limitations
- Previous experiments in NSTX were hampered by noise on magnetic diagnostics
  - Have made improvements in RF noise immunity but effect on CHI noise unknown
  - $I_p$  Rogowski coil is being upgraded during this outage
- Propose using CHI capacitor bank for fast rise of injector current
  - Also desirable to have fast switch-off to resolve persistence
- Use OH target plasma initially, then preheat with NBI
  - Compatibility of NBI with CHI cap. bank has been established
- **1 day (after assessing noise during CHI commissioning day)**

# Solenoid-Free Startup: Proposals for FY'05

## Ono: Outer-PF only Startup

- Started experiments at end of FY'04 run: no significant current produced
- Cross-section inside vessel where Lloyd criterion ( $E_T B_T / B_\perp > 0.1 \text{ kV/m}$ ) is satisfied is rather small in scenarios investigated
  - Trend is that making more flux available creates smaller region satisfying criterion
- Need to reduce prefill pressure to raise  $T_e$  and, thereby, reduce the resistive flux loss
  - More HHFW power, mixed phasing – in-phase for breakdown, out-of-phase to heat
  - $\text{CD}_4$  prefill; use SSGI to produce local pressure enhancement – modeling needed?
  - 8 – 10 GHz would be more appropriate for ECPI
  - CT injection would provide a good “seed”
- Propose to use PF4, PF5 in opposite polarity from previous experiment
  - May need to beef-up supports
- Experiment would benefit from higher TF
- **1 day plus commissioning time**

# Solenoid-Free Startup: Proposals for FY'05

## Menard: Outer-PF only Startup

- Continue experiment started in FY'04 run: produced  $I_p \approx 20\text{kA}$ 
  - Increase HHFW power 0.5 → 1.5 MW – use all straps
  - Optimize vertical field profile to keep plasma off inner wall
    - Expect some guidance from DINA modeling
- Study null quality required for breakdown
  - Reduce TF or add stray fields
- **1.5 days**

# Solenoid-Free Startup: Proposals for FY'05

## Reed: Low-TF Steady-State CHI Discharges in NSTX

- CHI discharges on HIT-II with  $I_p$  up to 350kA at  $I_{inj} \approx 20$ kA
- Developed and tested criteria for reconnection to overcome resistive flux consumption
- Calculations for NSTX show  $I_p = 0.79$ MA for  $I_{TF} = 0.85$ MA,  $I_{inj} = 45$ kA or  $I_p = 0.78$ MA for  $I_{TF} = 1.00$ MA,  $I_{inj} = 37$ kA.
- Would need rectifier power supply plus absorber field nulling capability
- **2 days**

# SF Startup: Supporting Experiments, Theory & Analysis

## Redd: HIT-II

- Summarized HIT-II results and possible contributions to NSTX CHI
  - Scalings, *e.g.*  $\lambda$  scaling of threshold for adding CHI to induction
  - Scenario development, *e.g.* transient CHI and CHI plus induction

## Tang: MHD Modeling of CHI Plasmas

- 3D MHD including helicity transport by instabilities generated by current gradient
- Analysis for transient CHI case shows importance of narrow footprint for flux closure
- Limited by funding for NSTX-related work

## Sovinec: NIMROD Modeling of CHI Plasmas

- 2D dynamics as CHI is applied in STs with and without induction (Transient CHI)
- Investigate CHI-driven MHD activity and poloidal flux amplification and determine whether it is important/desirable for startup (Steady-State CHI)
- Optimization studies