Integrating Enhancements in Plasma Performance

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NSTX Ideas Forum

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Ambitious Goals Are Being Set for NSTX

- IPPA and FESAC goals for ST research

  "Integrate high confinement and high beta" (IPPA 3.2.1.6)

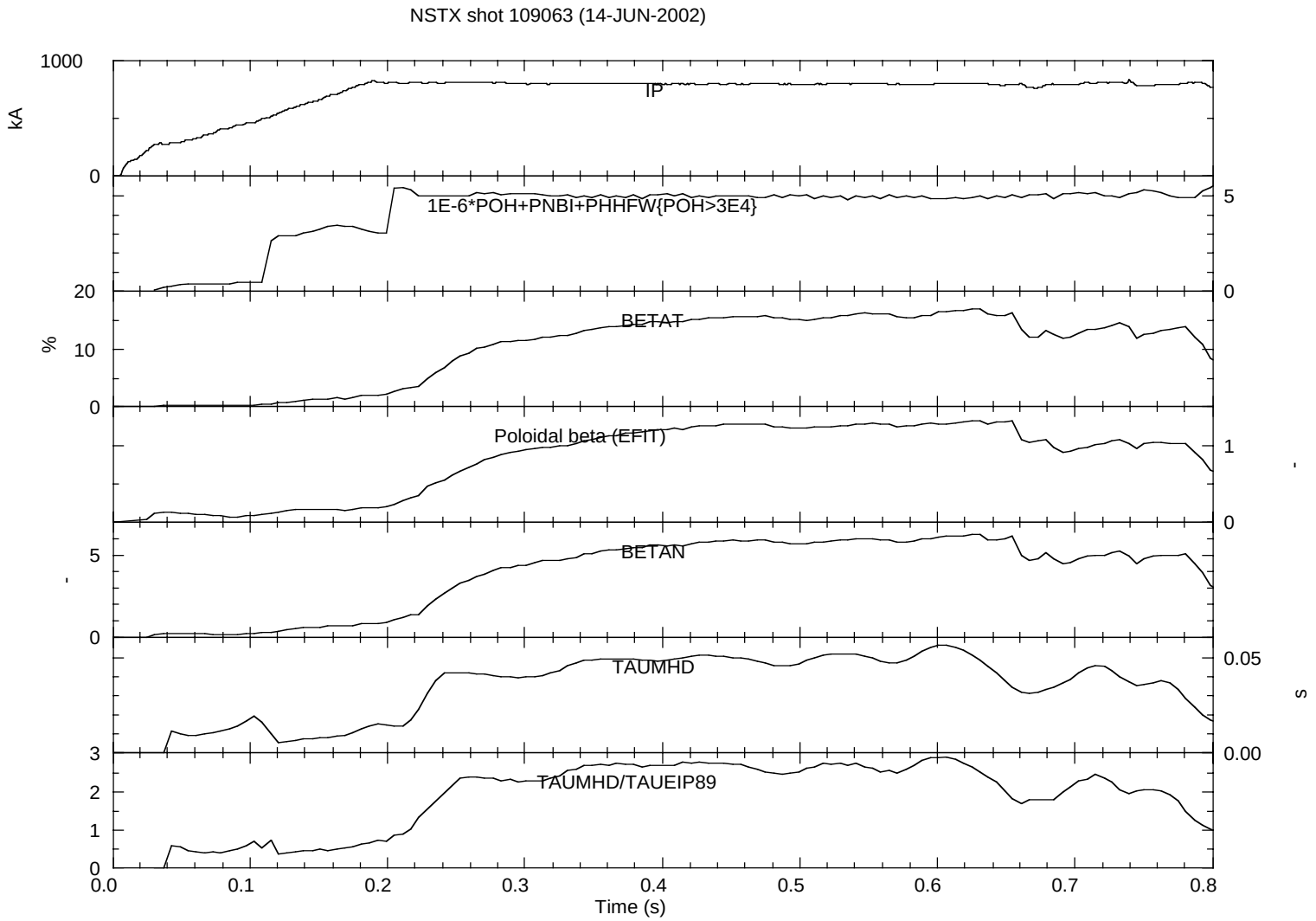
  "...assessing high-beta stability, confinement, self-consistent high-bootstrap operation, and acceptable divertor heat flux, for pulse lengths much greater than energy confinement times" (FESAC 5-year Objective #2.1)

- Already have Milestone FY03-2:

  "... beta near the "no-wall" limit simultaneously with high energy confinement for durations >> τ_E"

  - Can argue that we are close to meeting this:
    - $\beta_N \approx 6\% \cdot m \cdot .T/MA$ *(closeness to "no-wall" limit defined by β_N)*
    - $H_{89P} \sim 2.5$
    - $\tau_E \approx 50ms$ for duration $t \sim 200ms$

Long Duration "Milestone" Shot



J. Menard (XP-229)

Future Milestones Likely to Extend Pulse Length Requirements

- t_{pulse} to several seconds (> current penetration time)
  - Can only be achieved at $B_T \leq 0.4T$ with present CS
- Higher absolute β required: $\beta_T \sim 30 – 40$ %
  - Lower q_{edge}, same or higher I_p required
- Inductive limitation adds requirement for current drive
  - High bootstrap fraction $\Rightarrow$ high $\beta_P > 1$
  - Efficient RF current drive needed
    - Power counts against τ_E
- Energy input will become an issue
  - Divertor tile temperature is increasing

Suitable Tools ("Actuators") Needed

- Stabilization
  - Ideal modes – p(r), q(r)
    - wall influence appears adequate at high β
  - RWM
    - Error field reduction has helped
    - First attempts at control next year
    - Stabilization requires rotation
  - NTM
    - Not a serious issue yet at $\beta_P \sim 1.5$ but may develop
    - Control of q_{min} may be sufficient
    - Control of local j, p' more problematic: localization

Current Drive and Non-Inductive Startup

- Can HHFW be made efficient?
  - Parasitic interaction with fast ions
  - Localization and ability to control
    - Absorption $\propto \beta$ - tendency to develop in center
- EBW
  - Development schedule is tight
  - Coupling and efficiency major issues
    - compatibility of edge with mode, power handling
- Role of CHI
  - Controllability and reproducibility
  - Transition to RF-CD phase

Density Control and Fueling

- Pellets
  - Size of perturbation *vs*. penetration
- Compact Toroid injection
  - Potential match to STs (size, high B-field gradient)
  - Timing of, space for installation
  - Development of repetition rate
- Wall material changes
  - Coatings: Li, B, other?
- Edge pumping
  - Cryo-pump – controllability
  - Lithium module – dominating system

Power Handling

- Enhanced edge radiation
  - Intrinsic impurities
  - Recycling gases
    - Localization in NSTX conditions
- Strike point sweeping
  - Possibility for feedback on local surface temperature
  - Possible need for additional localized coils
- Edge ergodization or segmented biasing
  - MAST example
  - Major change to divertor mounting
    - Effect on CHI capability