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

Pre-Forum Discussion on the Low-Density Startup Milestone (R12-3)

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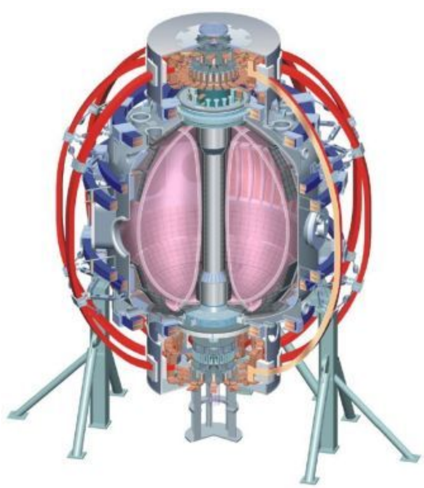

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Agenda

- SPG organizational comments as the (ir)responsible TSG leader.
- SPG technical comments on the milestone.
- D. Mueller proposals.
- K. C. Lee presentation.
- E. Fredrickson slide.

Note on Likely ASC Run Time

- No official guidance yet.
- FY10 run had 15 run weeks
  - ASC has 8 days 1st + 2nd priority XPs at time of forum
- FY2011/12 run will be about 20 weeks.
  - New TSG will take run-time…but don't have the LLD commissioning.
  - Assume ASC will get a 10 days
- Propose that at ~3-3.5 ASC days be allocated to this milestone at the time of the forum.
  - Is equal to this being the dominant activity for ½ the total run.
  - But may also be insufficient due to the complexity of the problem.
- Other days for other priorities:
  - Plasma control development, especially in support of R(11-2), R(11-3)
  - ST scenario development.
  - Upgrade prep.

SPG Questions for Today

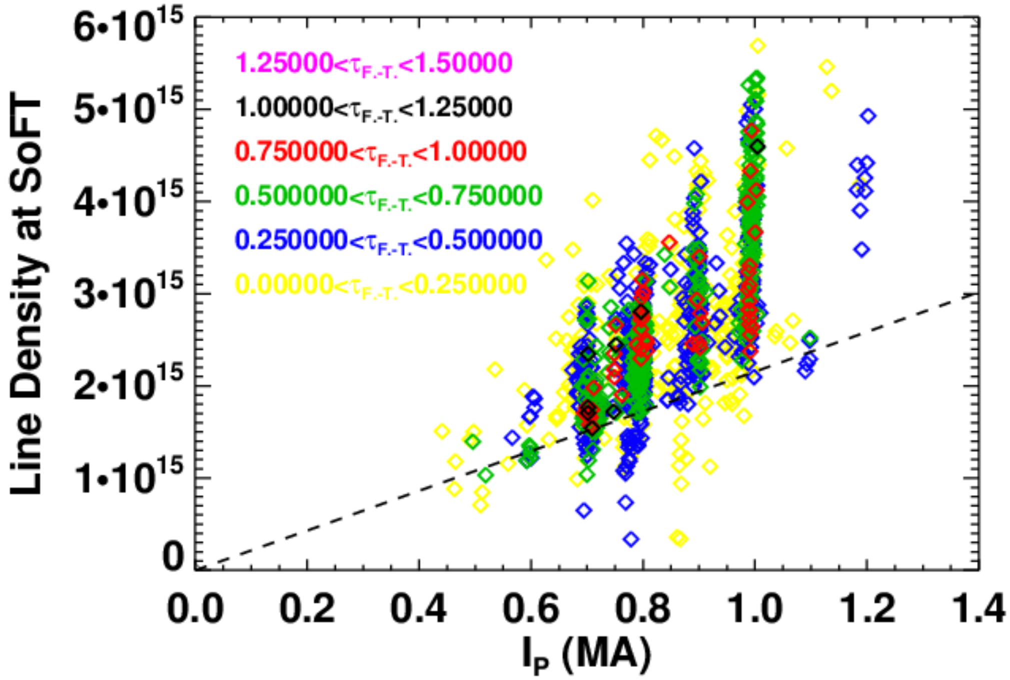
- Will we have 1 or 2 "group-XPs", or 3-4 XPs with individual primary authors?
- What are the MHD and BP TSG contributions? For instance:
  - MHD XPs on the physics of mode penetration, EF correction, …?
  - BP TSGs on fuelling and/or pumping?
- How low a density is low enough? When will we know we succeeded?
  - How will we know when to give up?
- Are the correct tools available at the correct times?
  - And what machine conditions are required? How good must the performance be?
  - What is the role of HHFW?

R(12-3): Assess access to reduced density and collisionality in high-performance scenarios

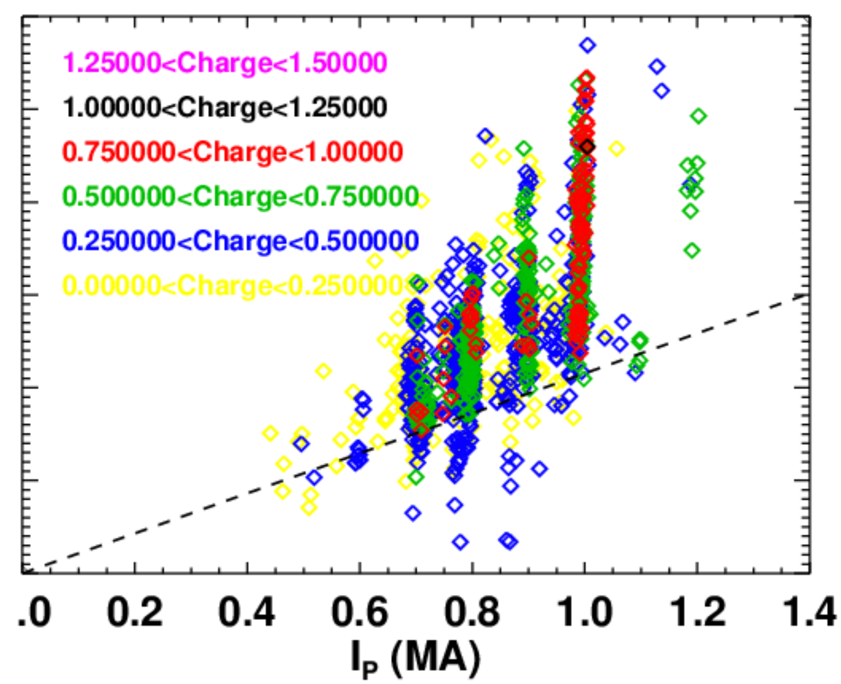
The high performance scenarios targeted in NSTX Upgrade and next-step ST devices are based on operating at lower Greenwald density fraction and/or lower collisionality than routinely accessed in NSTX. Collisionality plays a key role in ST energy confinement, non-inductive current drive, pedestal stability, RWM stability, and NTV rotation damping. Lower density and/or higher temperature is required to access lower ν^*. HHFW is a potential means of increasing electron temperature and reducing ν^*, and reduced fueling and/or Li pumping are effective and readily available tools for lowering ν^* through lower density. However, while D pumping from lithium has been observed, additional gas fueling is typically required to avoid plasma disruption during the current ramp and/or in the high β phase of the highest performance (i.e. highest confinement, beta, non-inductive fraction, etc) plasmas of NSTX . The goal of this milestone is to identify the stability boundaries, characterize the underlying instabilities responsible for disruption at reduced density, and to develop means to avoid these disruptions. Possible methods for stability improvement include changes in current ramp-rate (li and q(r) evolution), H-mode transition timing, shape evolution, heating/beta evolution and control, optimized RWM control and error field correction, fueling control (SGI, shoulder injector), and optimized Li pumping. This milestone will also aid development of MISK and VALEN stability models and TRANSP and TSC integrated predictive models for NSTX Upgrade and next-step STs.

What Density at SoFT Is Required For a "Good Shot"? Data From 2006 & 2007

Color Indicates Flat-Top-Duration (seconds)



Color Indicates Integral Charge (MC)

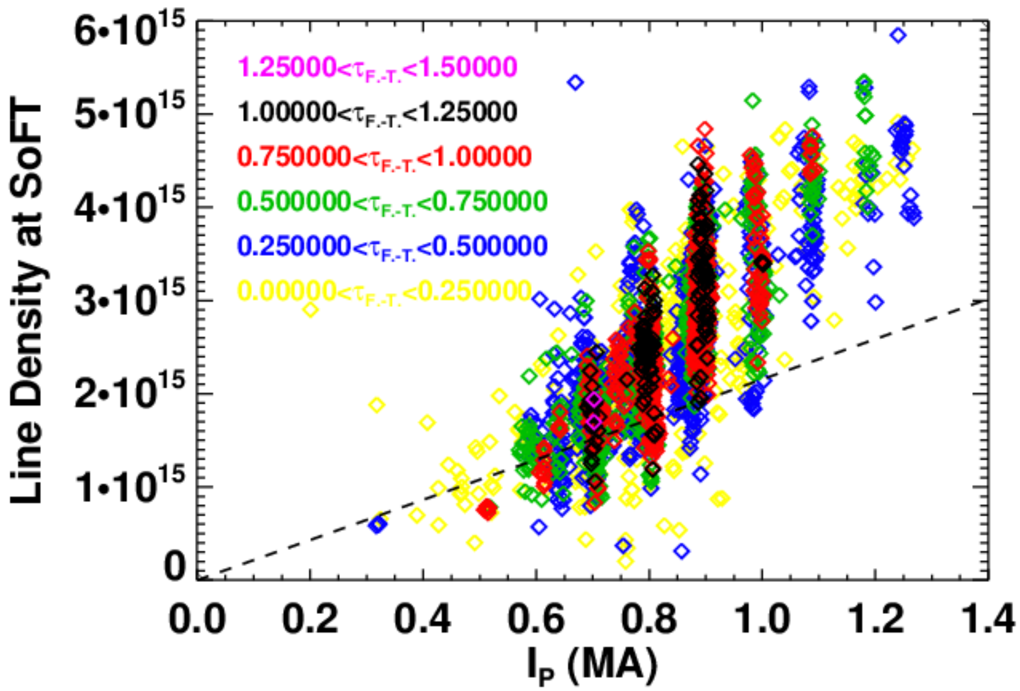


Shots with f_{GW}<0.2 at SoFT are typically poor (points below the line).

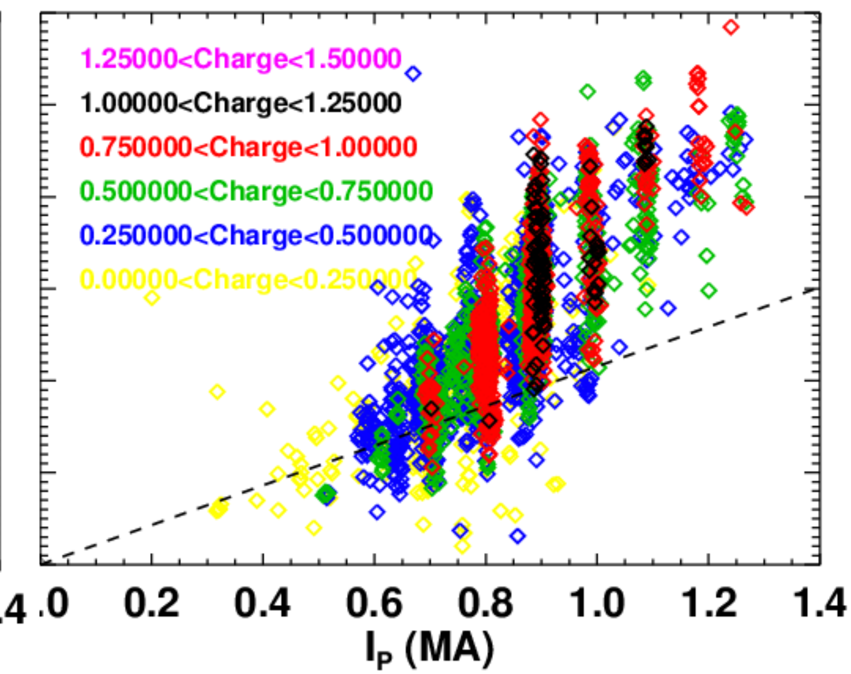
For f_{GW}>0.2 at SoFT, many other things determine the performance.

What Density at SoFT Is Required For a "Good Shot"? Data From 2009 & 2010

Color Indicates Flat-Top-Duration (seconds)



Color Indicates Integral Charge (MC)

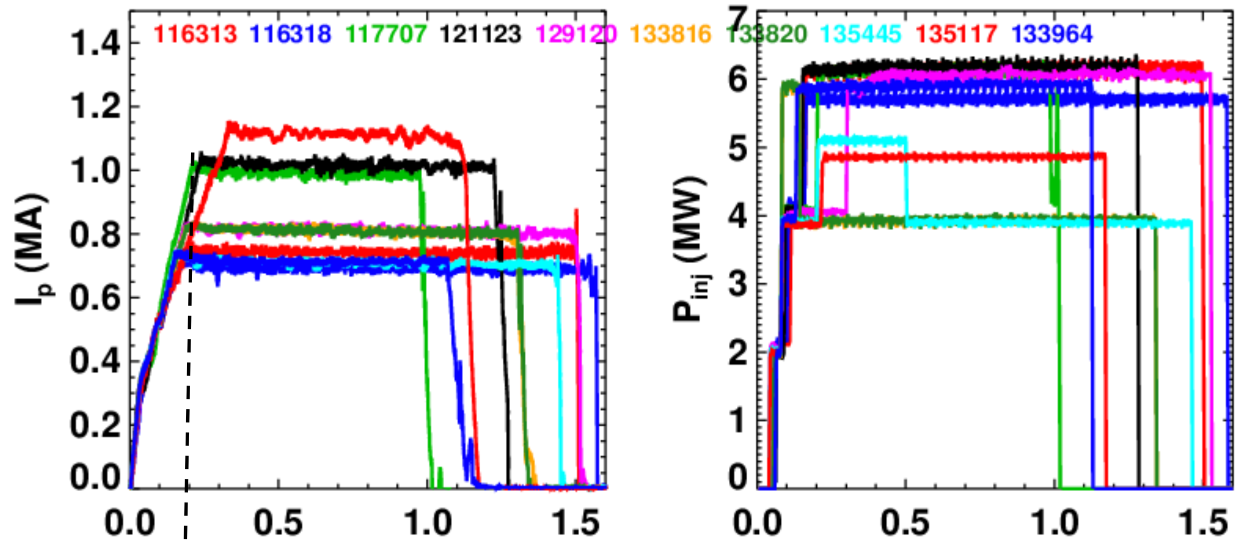


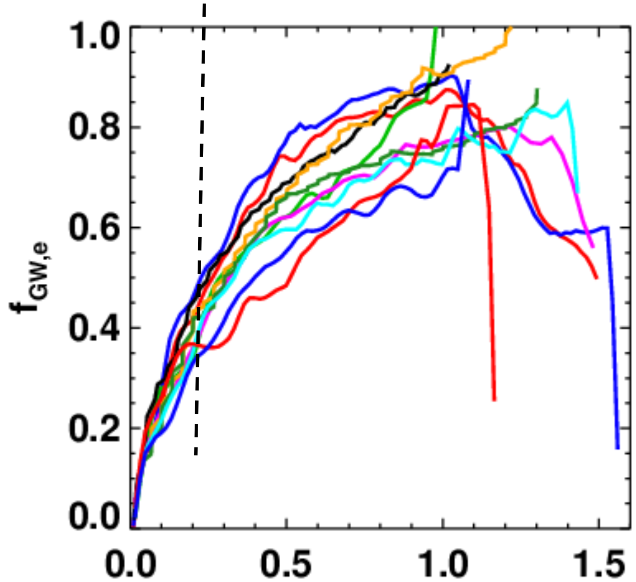
Same trends:

Shots with f_{GW}<0.2 at SoFT are typically poor (points below the line).

For f_{GW}>0.2 at SoFT, many other things determine the performance.

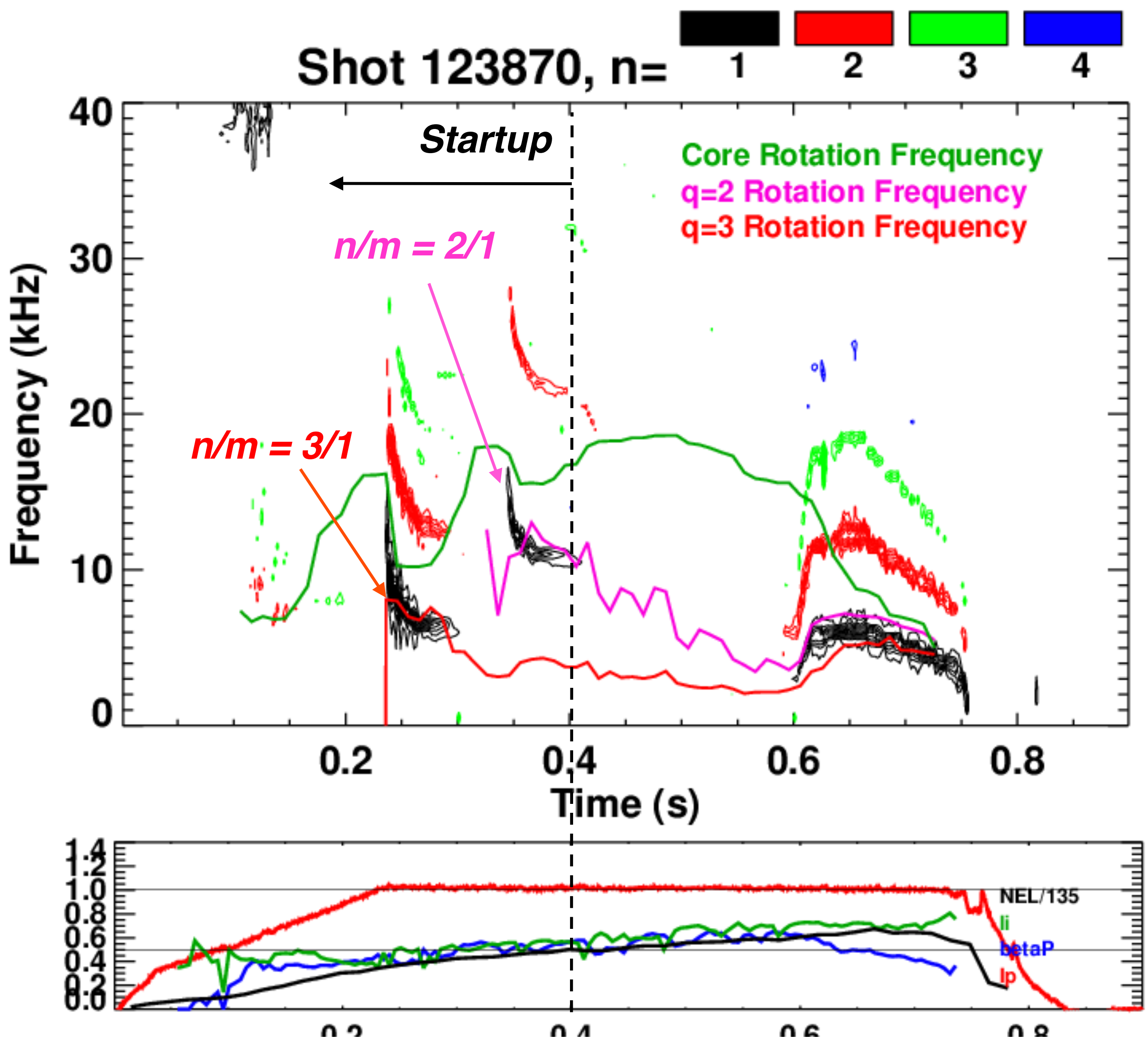
Greenwald Fractions of 0.2-0.3 at SoFT May be a Reasonable Target





- A bunch of shots designed to target high-performance…f_{GW}=0.3-0.5 at SOFT
- Propose that we make reliable operation at 0.3 @ SOFT a target.
- *Reliable=Routinely survives through the q=2 surface entering the plasma & MHD associated with that rational dying away.*

The "Startup" Ends When the q=2 Surface is Fully in the Plasma



Mode that rotates with the q=2 surface often locks to the wall, leading to β collapse or disruption.

Once q=2 is safely in the plasma, the "startup" is accomplished.

Disruptions after this are typically high-β (RWM) or n=1 core kink/tearing.

Both out of scope!

SPG Suggestion For Strategy Based on Suggestions From Many People

- Both strong gas fuelling and observation of beneficial “plasma scraping” may indicate the current profile is too hollow.
  - These things help to cool the edge.
- Rapid current ramp makes error field correction more difficult.
  - For instance, uncompensated pickup of toroidal eddy currents.
- Our H-mode access techniques (strong HFS gas, source C blips) tend to increase the density.
  - We can use Lithium, loop-voltage transients, fuelling tricks to get into H-mode with leaning as hard on these?
- Reduced density will likely lead to faster rotation, which will help avoid disruptive mhd.
- Suggestion:
  - Use a standard (900 kA?) fiducial as the reference.
  - Use slower ramp-rate after breakdown/current channel is established. Maybe less heating power.
  - Transition to H-mode during ramp, using above tricks to get in if necessary.
  - Test error field correction methods (n=1 and n=3).
  - *See D. Mueller’s talk for more.*