ASC Milestones and Research Priorities in 2011 & 2012

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Colorado Sch Mines
Columbia U
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General Atomics
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
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UC Davis
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U Colorado
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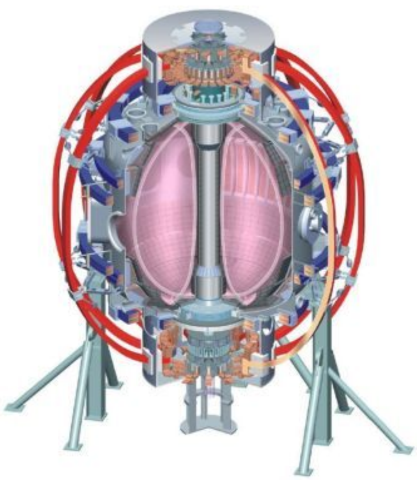
U Rochester
U Washington
U Wisconsin



Culham Sci Ctr
U St. Andrews
York U
Chubu U
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Kyoto U
Kyushu U
Kyushu Tokai U
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RRC Kurchatov Inst
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POSTECH
ASIPP
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

To Be Discussed

- Milestones
  - Do we want any last minute changes?
    - (SPG: my feeling is to leave them alone)
  - Some discussions on how to approach them.
    - Brainstorming about low-n_e startup approaches.
- ITPA
- 2011/2012 run priorities proposals
  - These go on the forum web-site.
  - These will be told to the PAC
  - These will be used to guide XP prioritization.

R(11-2): Assess impact of varied aspect ratio and boundary shaping on ST stability

Next-step ST conceptual designs assume aspect ratio A ≥ 1.6 and/or high elongation (κ = 3-3.5) to maximize projected fusion performance. These aspect ratio and elongation values are higher than commonly accessed on NSTX (A < 1.5 and κ = 2.4-2.8), and to narrow this gap, NSTX Upgrade is designed to overlap next-step configurations by operating with higher aspect ratio (A=1.6-1.7) and κ up to 3. *This combination of increased aspect ratio and higher elongation is projected to increase vertical instability growth rates by up to a factor of 3* and degrade kink marginal stability normalized beta by -0.5 to -1 relative to present NSTX performance. In this milestone, the integrated plasma scenarios previously developed in NSTX will be extended to plasma geometries much closer to those of the Upgrade and next-steps and the stability properties systematically explored. The maximum sustainable normalized beta will be determined versus aspect ratio (up to A=1.7) and elongation (up to 3) and compared to ideal stability theory using codes such as DCON and PEST. Both passive and actively-controlled RWM stability will be assessed both experimentally and theoretically using codes such as VALEN and MISK, and the viability of previously developed control techniques will be tested. *The vertical stability margin will also be determined, and vertical motion detection and control improvements will be implemented. Boundary shape variations – in particular squareness – will be varied to assess the impact of shaping and plasma-wall coupling on global stability.* Edge NTV rotation damping is also expected to vary with aspect ratio and will be investigated. *Plasma profile modifications and the impact on NSTX integrated performance (confinement, non-inductive fraction, pedestal stability) will also be documented*. Overall, these results will help guide stability control development for both NSTX Upgrade and next-step STs.

ASC Role in this Milestone…

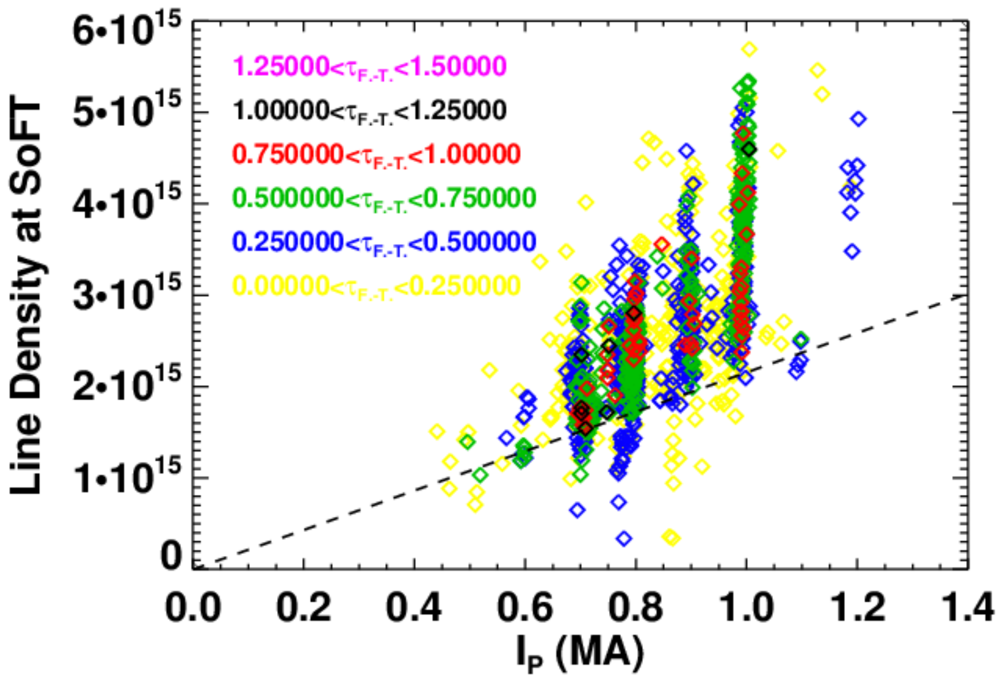
- n=1 research is part of the M.S. TSG responsibility.
  - n=0 equilibrium and stability control is ASC responsibility.
- We should consider research and XPs in the following:
  - More fully populated controller matrices.
  - Use of PF-2 as a pushing coil for top/bottom gap control.
    - Opposite polarity as when used as a divertor coil.
  - Squareness control with large inner gap and high-κ.
  - Better detection and actuators for n=0 VDE control.
    - Use of RWM coils for simultaneous n=0 and 1 control.
      - PCS spec. finished.
    - Better dZ/dt detectors for fast derivative control.
      - PCS spec. finished.
  - Better algorithms for n=0 VDE control?

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

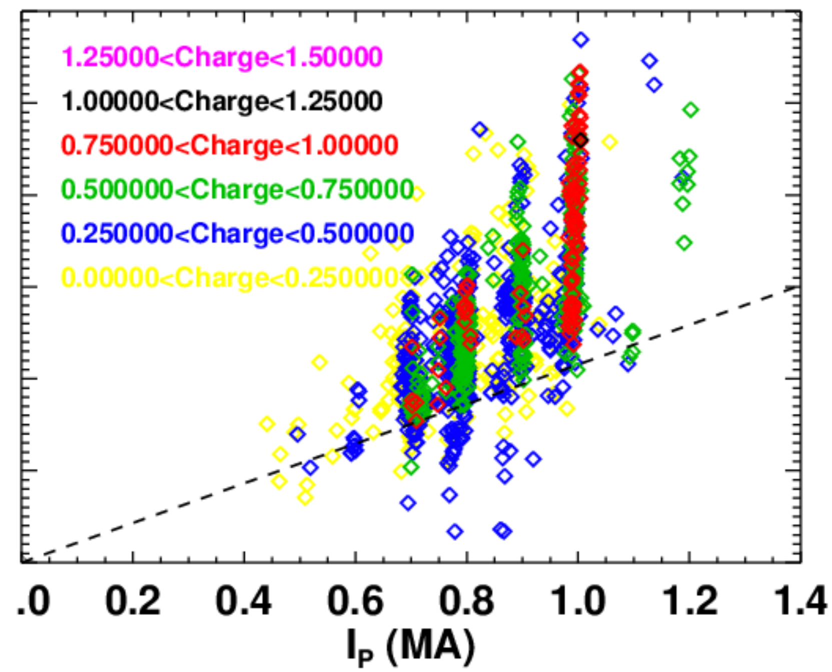
The high performance scenarios targeted in NSTX Upgrade and next-step ST devices are based on operating at lower Greenwald density fraction and/or lower collisionality than routinely accessed in NSTX. Collisionality plays a key role in ST energy confinement, non-inductive current drive, pedestal stability, and RWM stability and NTV rotation damping. Lower density and/or higher temperature is required to access lower n*. HHFW is a potential means of increasing electron temperature and reducing n*, and reduced fueling and/or Li pumping are effective and readily available tools for lowering n* 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 (l_i 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 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)

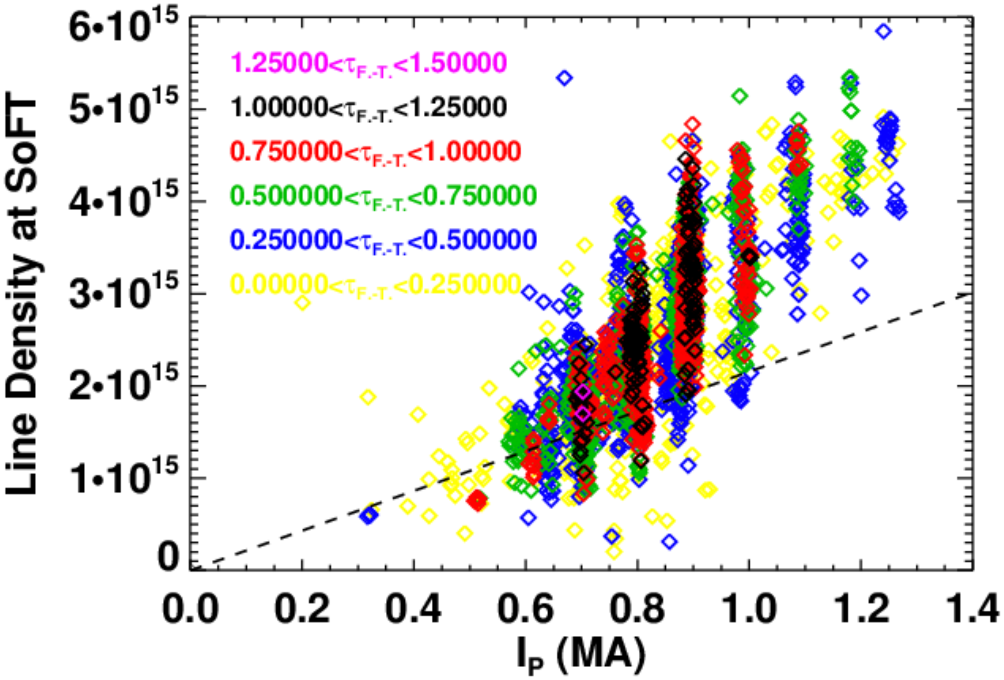


Shots with f_{GW}<0.2 at SoFT are typically poor (points below the line).

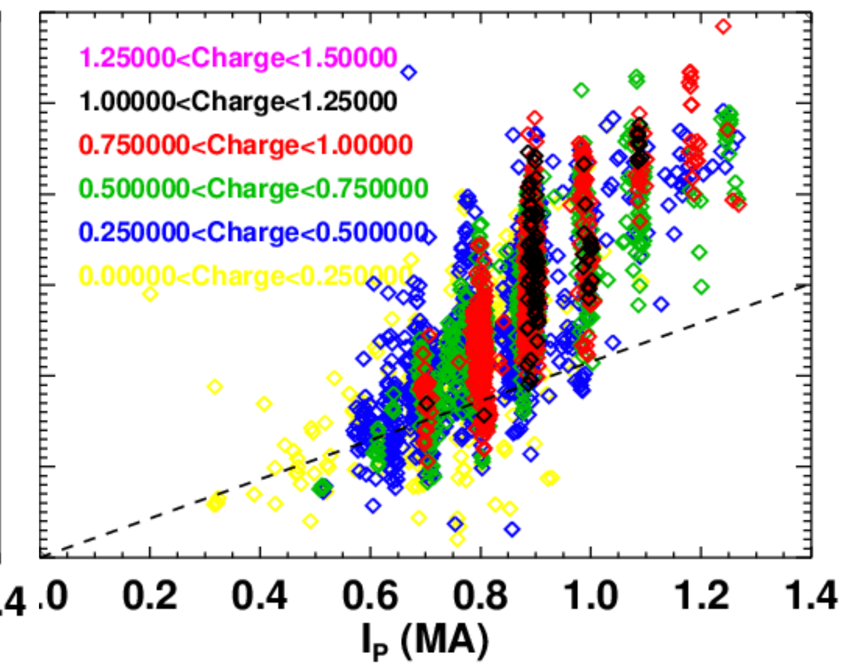
For f_{GW}>0.2 at SoFT, many other things determine the performance.

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)



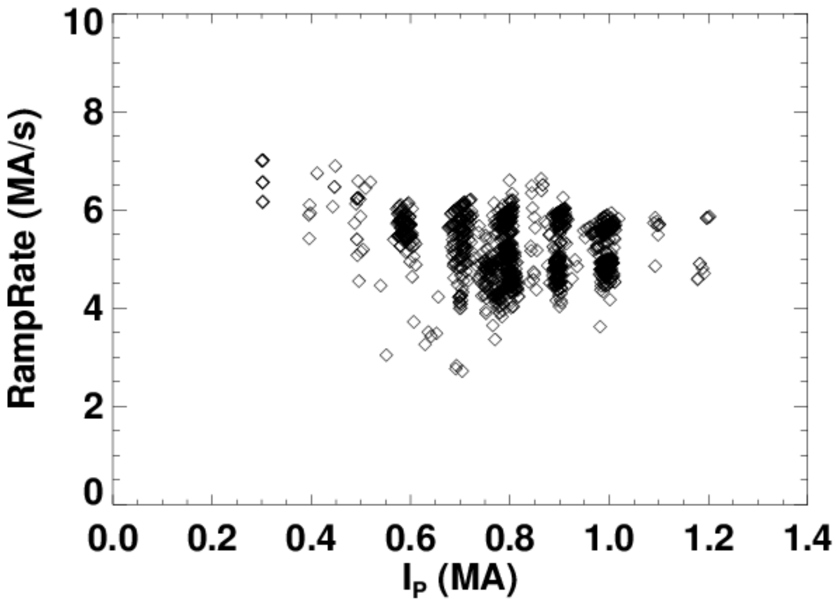
Same trends:

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

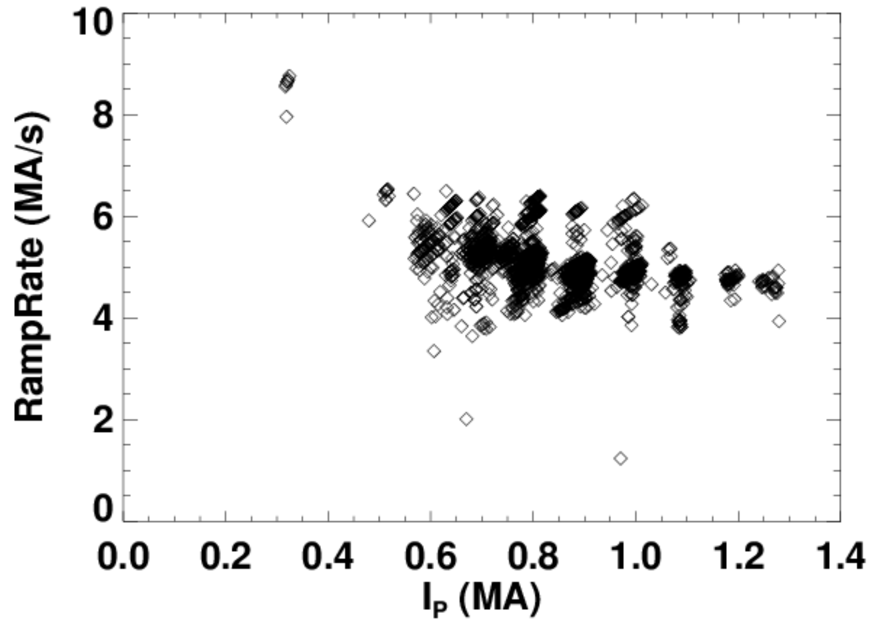
For f_{GW}>0.2 at SoFT, many other things determine the performance.

I_P Ramp Rate Is Seldom Changed

2005, 2006, 2007



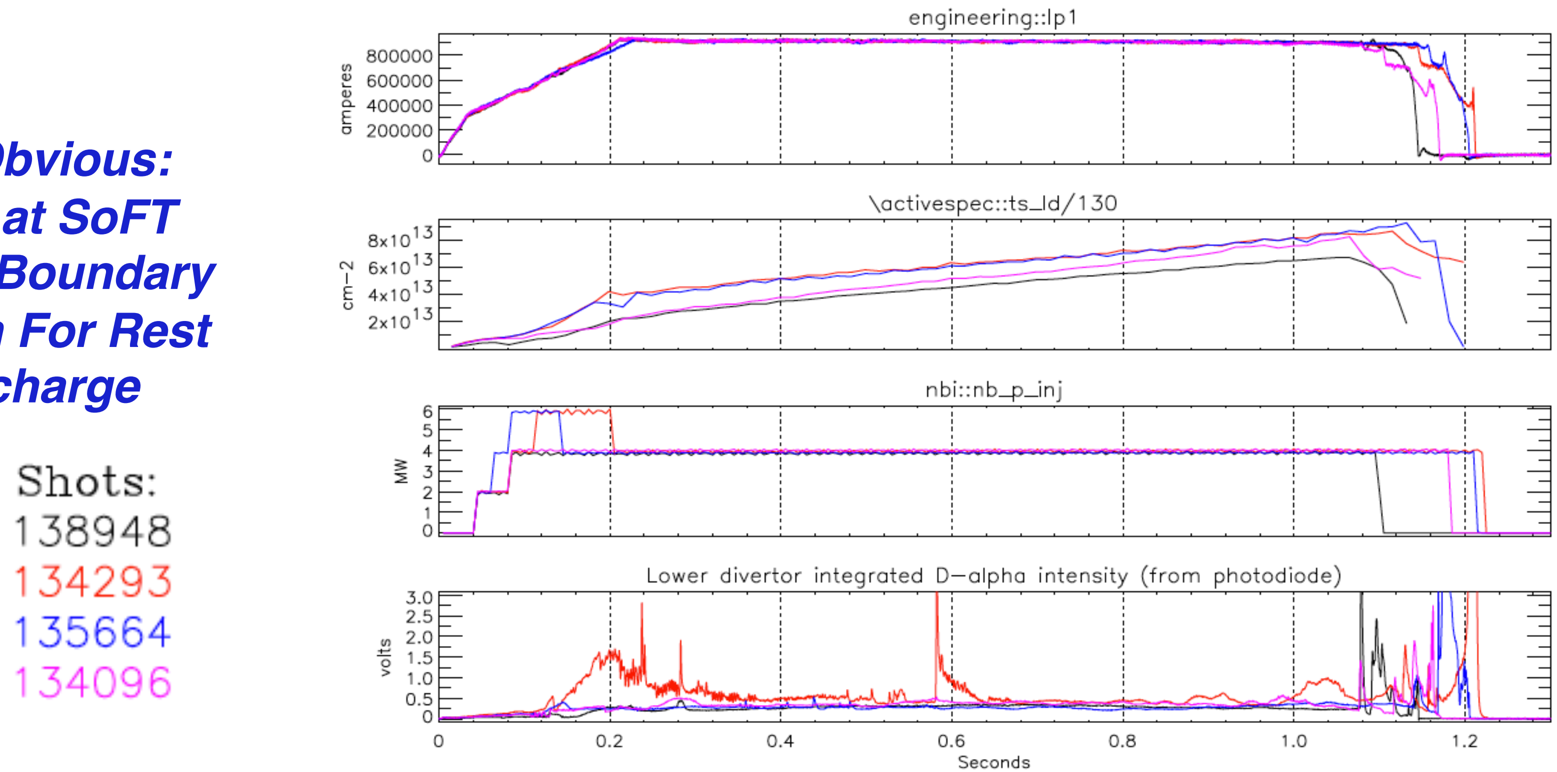
2009, 2010



- Rapid I_P-ramp helps preserve flat-top duration.
- Evidence that we may be ramping too fast:
  - Lots of gas to cool the edge?
  - E. Kolemen observation that shots which limit on the bottom early are often quite good afterwards.

Examples Dicharges With Large Density Range: 4 MW, 900 kA, Fiducial-Like Configuration

Kinda Obvious: Density at SoFT Provides Boundary Condition For Rest of Discharge



- H-mode triggering techniques:
  - HFS Gas: Would like to cut it down, replace with shoulder?
  - 3rd Source: Appears to be a correlation between 3rd source and higher SoFT density.
- Should we revisit alternative H-mode access techniques?
  - Loop voltage transients. Shaping tricks (transient low X-point?).
  - Reduced ramp rate may allow easier access with less HFS and P_{inj}.

Language is Fine (you agree?); Milestone Is Hard…

- Will need to define clear metrics & goals…examples might include
  - "Use ~1/2 the total gas input of shot XXXXXX while maintaining long pulse"
  - "Reduce the D_2 inventory at start of flat-top (or maybe t=0.4 sec) by 50%"
  - "Diagnose and optimize scenarios with f_{GW}=0.25 at SoFT"
- Must ensure that appropriate control tools are available:
  - Density feedback should be developed (if possible).
  - MHD: β_N control should be improved (if possible), optimized early EFC.
  - Other?
- Early discharge MHD is often hard to diagnose. New tools might include:
  - D. Battaglia camera? Edge USXR? MSE-LIF when heating is delayed? Other?
- Need to understand how to navigate n-dimensional space:
  - diverting time, ramp rate, heating profile, EFC, fuelling (LFS, SGI, HFS, Shoulder), lithium…will be temping to pour the gas in and declare victory.
- Start by carefully looking at the existing data.
  - XP-838 for instance, SAS no-prefill shots, database searches for interesting trends.
  - ***Would help if lithium rates & gas injection amounts were easily accessible in the tree.***
- Will need additional discussion next year to work out research plan.

ITPA-IOS Obligations

- IOS-1.2: Study seeding effects on ITER demo discharges
  - Contact: V. Soukhanovskii
- IOS-4.1: Access conditions for hybrid with ITER-relevant restrictions.
  - Contact: S.P. Gerhardt
  - Mainly data mining for now: what conditions (ramp rate, density, heating) lead to best high-performance scenarios?
  - Unlikely to request dedicated run time.
- IOS-4.3: Collisionality scaling of confinement in advanced inductive plasmas.
  - Contact: S. Kaye
  - Mostly database studies for now.
- IOS-5.2: Maintaining ICRH Coupling in expected ITER regime.
  - Contact: J. Hosea.
  - Run-time covered in HHFW.

Suggested Priorities for 2011/12

- *Propose that we do the most important things at the beginning of the run period, regardless of the year in which the results are promised.*
- **Group #1: Milestone support**
  - Improved n=0 stability control and understanding (R11-2).
  - Improved boundary and divertor control in NSTX-U and large-A/κ scenarios (R11-2, R11-3).
  - Development/understanding of reliable scenarios with reduced fuelling and lower density (R12-4).
- **Group #2: If applicable, rotation control**
  - Diagnostic and control algorithm commissioning?
- **Group #3a: High-performance scenarios w/ reduced impurities.**
  - HHFW for impurity "ejection"? Divertor modifications? USN? dr_{sep}?
- **Group #3b: ITPA support XPs**
- **Group #4: Generic high performance scenario development**
  - Scenario extension to high(er)-β / long(er)-pulse / high(er)-τ/ …
  - HHFW H&CD

This prioritization is a proposal…do you agree?