# 5 Year Review Panel Questions – Day 1

*Coll of Wm & Mary*
*Columbia U*
*CompX*
*General Atomics*
*FIU*
*INL*
*Johns Hopkins U*
*LANL*
*LLNL*
*Lodestar*
*MIT*
*Lehigh U*
*Nova Photonics*
*ORNL*
*PPPL*
*Princeton U*
*Purdue U*
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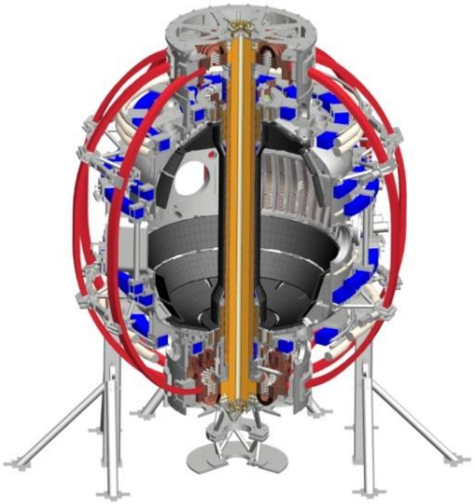
*U Maryland*
*U Rochester*
*U Tennessee*
*U Tulsa*
*U Washington*
*U Wisconsin*
*X Science LLC*

## NSTX-U Team

**NSTX-U 5 Year Plan Review**
**LSB B318, PPPL**
**May 21-23, 2013**



*Culham Sci Ctr*
*York U*
*Chubu U*
*Fukui U*
*Hiroshima U*
*Hyogo U*
*Kyoto U*
*Kyushu U*
*Kyushu Tokai U*
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*JAEA*
*Inst for Nucl Res, Kiev*
*Ioffe Inst*
*TRINITI*
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*FOM Inst DIFFER*
*ENEA, Frascati*
*CEA, Cadarache*
*IPP, Jülich*
*IPP, Garching*
*ASCR, Czech Rep*

# Questions from Panel – 1-4 of 7

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   - What are the complementary research objectives?
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   - ➢ Addressed by J. Menard

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   - ➢ Addressed by M. Ono

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   Is MGI compatible with divertor cryopump and NB operation?
   - ➢ Divertor cryo – Addressed by J. Canik / R. Maingi
   - ➢ NBI cryo – Addressed by: R. Raman / S. Gerhardt

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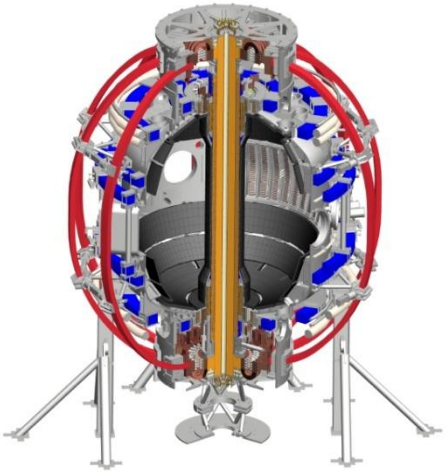
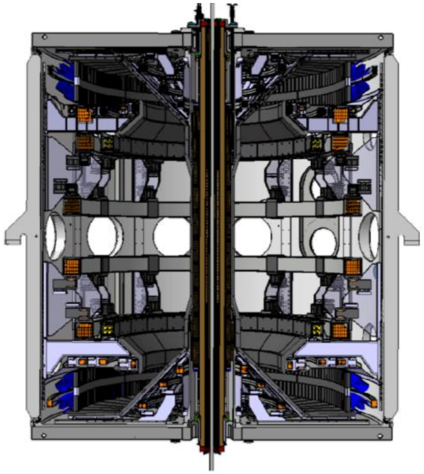
# NSTX-U and MAST-U share common mission elements with complementary physics capabilities





**Mission elements:**

- **Establish knowledge-base for an ST-based FNSF**
- **Extend physics understanding of tokamak, ITER**
- **Develop innovative PMI solutions for next-steps**

**NSTX-U**

- High $\beta$ up to ideal-wall limit at low $\nu^*$
- BES, high-k, polarimetry for e & i-transport
- HHFW electron heating and CD
- High $f_{BS}$ + co-NBI for high $f_{NI}$
- CHI/plasma gun, ECH, HHFW, NBI ramp-up
- LiTER+paced ELMs for ion control (until cryo)
- Snowflake, detachment, Li vapor shielding
- J(r) control via large $R_{tan}$ co-NBI
- Long-term: transition to high-Z + flowing LM

**MAST-U**

- MHD studies near no-wall limit at low $\nu^*$
- BES, high-res Thomson for NTM, boundary
- EBW electron heating and CD
- High co-NBI CD fraction + BS for high $f_{NI}$
- Merging-compression, EBW for ramp-up
- Divertor cryo-panels for D pumping
- Long line-length Super-X divertor, detachment
- Vertically-shifted off-axis co-NBI
- Graphite PFCs

# NSTX-U and MAST-U devices have similar current and field capability goals, but target complementary scenarios

## NSTX → NSTX-U

- $I_P$ = 1MA (1.4MA max) → 2MA
- $B_T$ = 0.55 → 1T
- $\tau_{pulse}$ = 1s → 5s
- $P_{NBI}$ = 5, 7.5MW → 10,15MW (5s,1.5s)

## MAST → MAST-U

- $I_P$ = 1MA (1.2MA max) → 2MA
- $B_T$ = 0.55 → 0.84T
- $\tau_{pulse}$ = 1s → 4s
- $P_{NBI}$ = 5MW → 7.5MW (4s) (Phase 1)

**NSTX-U will have leading PMI capability: ITER-level P/R, P/S up to 24MW/m, 0.5MW/$m^2$ from 15+6=21MW NBI+FW vs. MAST-U 7.5MW**

**Passive structure + MHD control differences motivate complementary scenarios:**

- **Conformal close-fitting Cu plates**
- Mid-plane coils for RMP and **active RWM/EF control** (unless/until NCC)

- **Far conducting wall**
- Mid + off-mid-plane EF/RMP coils (MAST-U may not have off-midplane coils – TBD)

- **Impact on elongation and beta**
  - ➢ NSTX-U: w/ wall-stabilization → **$\kappa$ = 2.5-3, $\beta_N$ = 4.5-6 → $f_{BS}$ = 60-80%** → access lower $l_i$ → higher $\kappa$
  - ➢ MAST-U: w/o wall stabilization → **$\kappa$ = 2-2.5, $\beta_N$ = 3-4.5 → $f_{BS}$ = 30-50%**
- **100% non-inductive sustainment**
  - ➢ NSTX-U: Moderate-to-high $f_{GW}$ = 0.4-1.0 → 20-40% NBI-CD → J(r) controllability challenging?
  - ➢ MAST-U: Low to moderate $f_{GW}$ = 0.25-0.5 → 50-75% NBI-CD → AE, low-n kink stability problematic?

# NSTX-U researchers will be playing active role in MAST 2013 run campaign

| Number | Title | Person in charge |
|---|---|---|
| FPP-001 | Time-resolved measurements of DD fusion products using proton detector & neutron camera/fission chamber during short timescale MHD activity & NBI blips | D. Darrow<br>M. Cecconello |
| FPP-006 | Identification & study of TAE avalanches | E. Fredrickson |
| MHD-011 | Effect of $I_P$ and $\beta_P$ on pedestal | A. Diallo |
| TC-014 | Measure perturbative particle transport in MAST | Y. Ren |
| TC-011 | Momentum transport | W. Guttenfelder |

- Thanks to MAST team for strong outreach/accomodation to NSTX team
- Gary Taylor assisting coordination of NSTX collaboration on MAST
- Experiments to start very soon - will benefit MAST/MAST-U and NSTX-U

**NSTX-U will accommodate MAST researchers during MAST-U outage**

# Expected joint research, confirmatory experiments

Nucl. Fusion **51** (2011) 073045

**MAST**

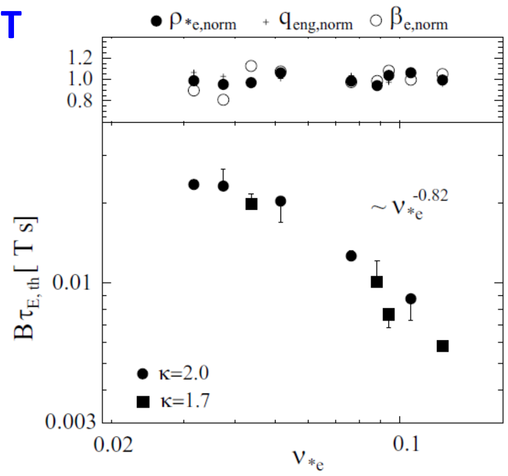
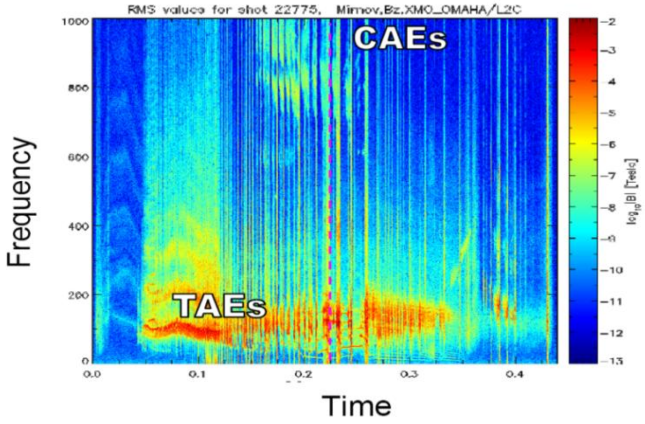


**Figure 3.** Collisionality scan of thermal energy confinement time. Vertical bars show the size of the correction due to variations in $\rho_{*e}$, assuming gyro-Bohm scaling. $\nu_{*e} \propto \bar{n}_e \langle T_e \rangle^{-2} R$,

- Underlying physics of collisionality scaling of thermal confinement
  - NSTX + MAST observation of 1/ν scaling of confinement confirmed scaling as ST trend rather than device-specific trend
  - Confinement scaling critical issue for projecting to next-step STs – data from both devices will be essential

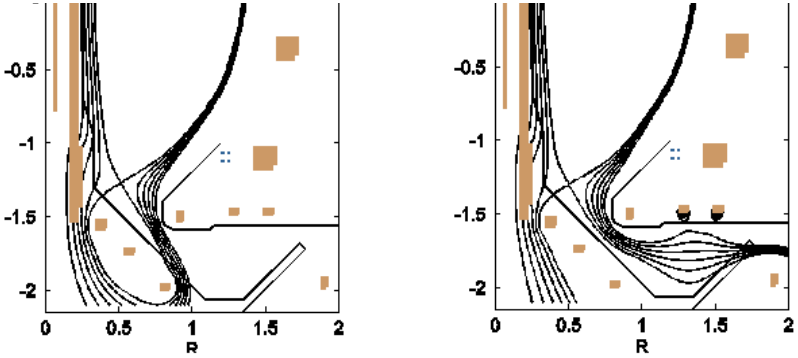
**MAST**



- Physics & impact of fast-ion instabilities
  - Chirping/bursting TAE/EPM modes
  - EP-induced modes
  - Exploitation of active MHD spectroscopy (AE antenna) in ST geometry
  - Fast-ion transport from *AE critical issue for NBI-CD in NSTX-U, MAST-U, FNSF

# Expect substantial joint research on advanced divertors

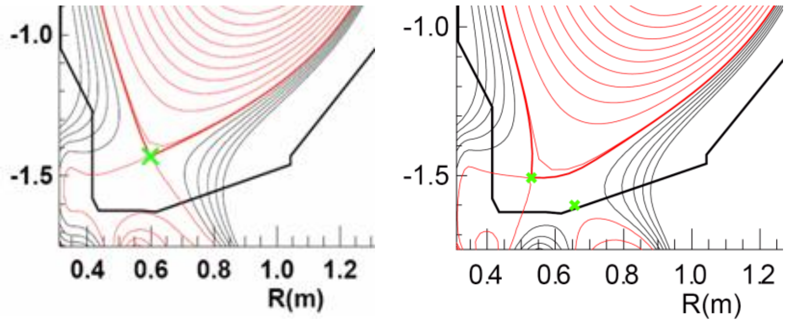
## MAST Upgrade



Conventional

Super-X

## NSTX Upgrade



Conventional

Snowflake

- MAST-U: Super-X + cryos NSTX-U: snowflake + lithium
  - Both will access high flux expansion, variation of line-length, pumping
  - Complementary: open vs. closed divertor, different pumping techniques
  - Both will require advanced boundary control
    - Example: control of multiple X-points/flux expansion
  - Divertor requirements and optimization are critical issues for FNSF

**Joint super-X and snowflake research on MAST-U, NSTX-U, DIII-D, TCV recently proposed by H. Wilson (University of York + many others) – unfortunately this proposal was not funded by UK EPSRC**

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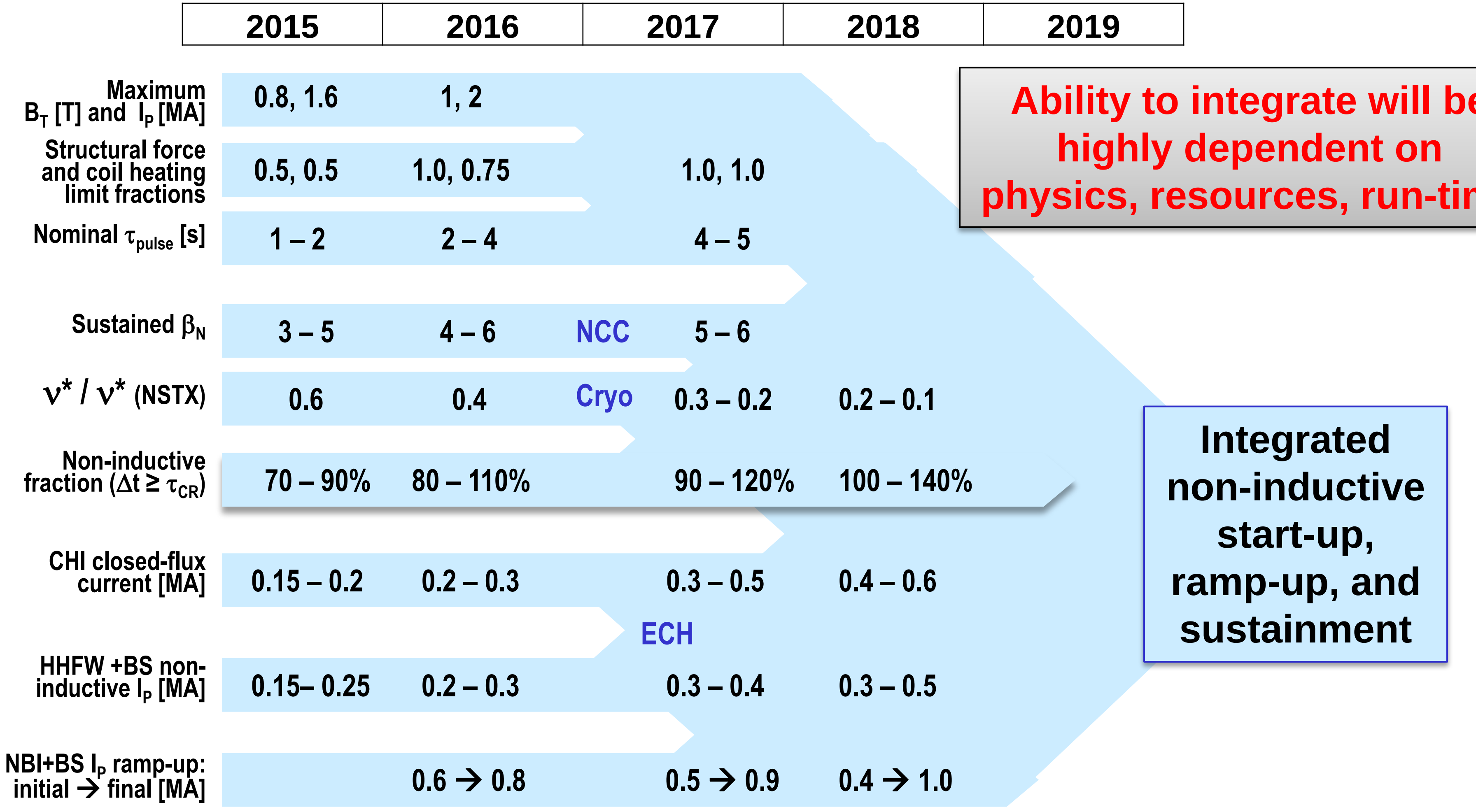
# Aim to demonstrate and understand integrated non-inductive start-up and ramp-up for ST-FNSF near end of 5 year plan



| | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|
| Maximum $B_T$ [T] and $I_P$ [MA] | 0.8, 1.6 | 1, 2 | | | |
| Structural force and coil heating limit fractions | 0.5, 0.5 | 1.0, 0.75 | 1.0, 1.0 | | |
| Nominal $\tau_{pulse}$ [s] | 1 – 2 | 2 – 4 | 4 – 5 | | |
| Sustained $\beta_N$ | 3 – 5 | 4 – 6 | NCC<br>5 – 6 | | |
| $\nu^* / \nu^*$ (NSTX) | 0.6 | 0.4 | Cryo<br>0.3 – 0.2 | 0.2 – 0.1 | |
| Non-inductive fraction ($\Delta t \geq \tau_{CR}$) | 70 – 90% | 80 – 110% | 90 – 120% | 100 – 140% | |
| CHI closed-flux current [MA] | 0.15 – 0.2 | 0.2 – 0.3 | 0.3 – 0.5 | 0.4 – 0.6 | |
| | | | ECH | | |
| HHFW +BS non-inductive $I_P$ [MA] | 0.15– 0.25 | 0.2 – 0.3 | 0.3 – 0.4 | 0.3 – 0.5 | |
| NBI+BS $I_P$ ramp-up: initial → final [MA] | | 0.6 → 0.8 | 0.5 → 0.9 | 0.4 → 1.0 | |

**Ability to integrate will be highly dependent on physics, resources, run-time**

**Integrated non-inductive start-up, ramp-up, and sustainment**

- Model, interpret, understand in NSTX-U with TSC, TRANSP, NIMROD, NOVA-K, AORSA, GENRAY, …
- Extend models to FNSF → assess implications for FNSF design: coils, NBI, ECH/EBW, FW, …

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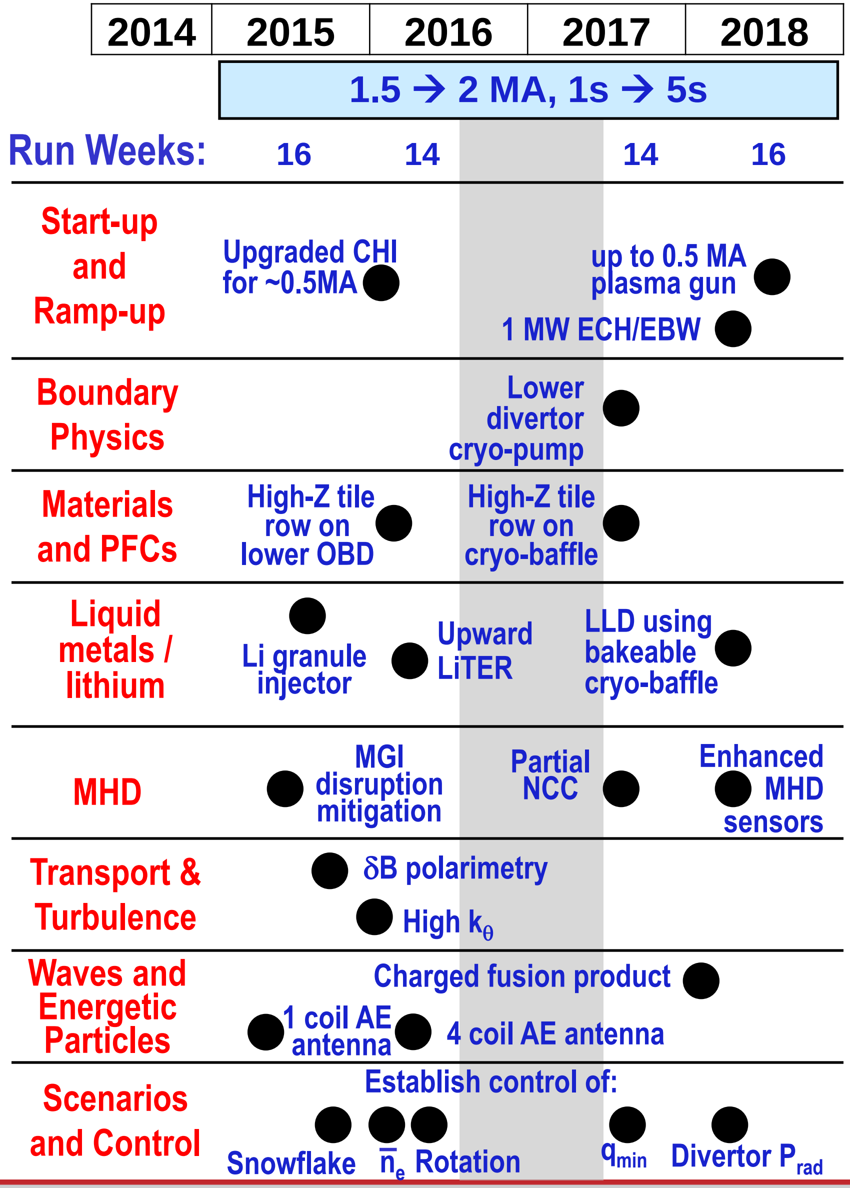
# Prioritization of 5 year plan tools with 5YP base funding

## Ranked according to programmatic impact, cross-TSG linkages, cost



**2014** **2015** **2016** **2017** **2018**

1.5 → 2 MA, 1s → 5s

**Run Weeks:** 16 14 14 16

**Start-up and Ramp-up**
- Upgraded CHI for ~0.5MA ●
- up to 0.5 MA plasma gun ●
- 1 MW ECH/EBW ●

**Boundary Physics**
- Lower divertor cryo-pump ●

**Materials and PFCs**
- High-Z tile row on lower OBD ●
- High-Z tile row on cryo-baffle ●

**Liquid metals / lithium**
- ● Li granule injector
- ● Upward LiTER
- LLD using bakeable cryo-baffle ●

**MHD**
- ● MGI disruption mitigation
- Partial NCC ●
- ● Enhanced MHD sensors

**Transport & Turbulence**
- ● $\delta$B polarimetry
- ● High $k_\theta$

**Waves and Energetic Particles**
- Charged fusion product ●
- ● 1 coil AE antenna
- ● 4 coil AE antenna

**Scenarios and Control**

Establish control of:
- ● Snowflake
- ● $\bar{n}_e$
- ● Rotation
- ● $q_{min}$
- ● Divertor $P_{rad}$

- Plasma control development
  - Highly cross-cutting, modest cost
- Density control, access to low $\nu^*$ and $Z_{eff}$ cross-cutting for all 5YP goals
  - Modest cost: upward LiTER, LGI
  - Higher cost: divertor cryo-pump
- Turbulence diagnostics (high-k, $\delta$B) critical for understanding transport at low $\nu$, high b
  - Modest cost, collaborator supported
- Start-up/ramp-up critical ST issue
  - Upgraded CHI: high impact, modest cost
- *AE important for sustainment, ramp-up
  - AE antenna, charged FPD: low/modest cost
- MHD tools vital for high $\beta$, FNSF control
  - MHD sensors, MGI/EPI - modest cost
  - NCC: cross-cutting, but higher cost
- FNSF start-up: bridging $T_e$ gap important
  - ECH: higher cost, a bit less cross-cutting
  - Plasma guns: moderate cost, technically ready?
- Begin high-Z studies, cryo-baffle LLD
  - Longer-term goal, modest/moderate cost

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# NSTX-U Research Manpower Summary

## (#s are based on the recent count)

### PPPL Science / Operations FTEs

| | NSTX | NSTX-U Construction | | NSTX-U | |
|---|---|---|---|---|---|
| | FY 2010 | FY2014 | | FY 2015-2018 | |
| | Actual | Base | Incrementals | Base | Incrementals |
| Run Weeks | 15 | 0 | 0 | 14 - 16 | 16 - 20 |
| Science | 36.2 | 31.3 | 31.3 | 36.8 | 39.3 |
| Operations | 71.1 | 42.3 | 42.3 | 72.2 | 74.2 |
| Total FTEs | 107.3 | 73.6 | 73.6 | 109 | 113.5 |

- NSTX-U research and operations staffing level is similar to that of NSTX. Incremental funding will enable research staff enhancement to support increased research output.
- Collaborating FTE#s are not accurately known since the grant is managed directly by OFES. We estimate that 16.6 FTE non-lab collaborators and 5.4 lab collaborators are directly supported by the NSTX-U collaboration grant.
- There are other sources of funding for our collaborating researchers including advanced diagnostic initiative and theory related funding.
- International collaborators are generally funded by home institutions.
- 17 NSTX-U collaborating researchers are presently residing at PPPL.
- In addition, there are 33 students presently associated with NSTX-U research program.

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# NSTX Rep. Rates and NSTX-U TF Limitations

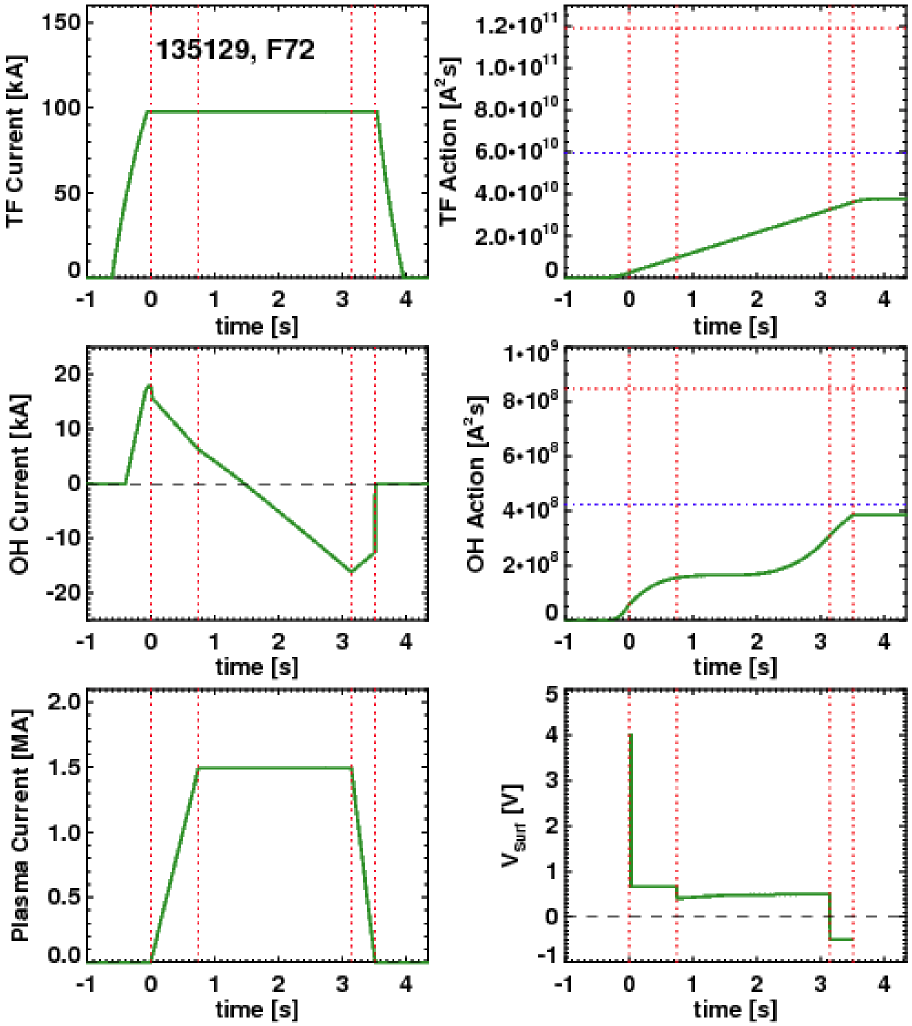
- NSTX Rep. Rates:
  - W/ boronization and He glow, 15-20 minutes was standard for high performance plasmas.
  - W/ Lithium conditioning, 10 minutes was possible (though borderline too fast: ~4 minutes for data to arrive + 2 minutes to set up shot left only 4 minutes for thinking.)
- NSTX-U: TF $I^2t$ increased a factor of 20, OH increased a factor of 3.5.
- Basic spec. for NSTX-U is a $\tau_P$=2400 s rep rate at full field and current, upgradable to $\tau_P$=1200 s.
  - Key point: CS systems themselves are qualified at $\tau_P$=1200 s @ full performance
- Key Constraint: TF bus work is presently sized for $\tau_P$=2400 s, with an equivalent square wave of $\tau_{ESW}$=7 seconds @ $I_{TF}$=130 kA, ($I_{RMS}$=7 kA).
  - Year 1 max: $\tau_{ESW}$=4.5 s @ $I_{TF}$=100 kA, then rep. rate is 15 minutes.
  - Year 2 max: $\tau_{ESW}$=5.5 s @ $I_{TF}$=125 kA, then rep. rate is 30 minutes.
  - Year 3 max: $\tau_{ESW}$=7.0 s @ $I_{TF}$=125 kA, then rep. rate is ~ 38 minutes.
- 1200 s upgrade for the TF involves increasing the cable runs between the rectifiers and the TF coils, increasing the RMS current to 10 kA:
  - Year 3 max: $\tau_{ESW}$=7.0 s @ $I_{TF}$=125 kA, then rep. rate is 16 minutes.

# Other Coils Will Not Be Near As Limiting

## Solenoid and Vertical Field Coil Already Designed for 1200 s at full capability (24 kA on VF coil).

- Use OH pre-charge that causes the OH coils to maximize the time near zero.
  - Proper pre-charge will be a function of the target plasma current and non-inductive level.
  - In general, OH heating likely to provide pulse duration constraint in year 1 of NSTX-U (limiting heating to ½ the design point).
- For year 1 example with 19 kA pre-charge with $I_{RMS}$=0.9 kA (1200 sec configuration), OH rep rate is 9 minutes.
  - TF cools in 15 minutes for this case.
  - Even most aggressive year 1 scenarios will not have cycle times longer than NSTX standards.

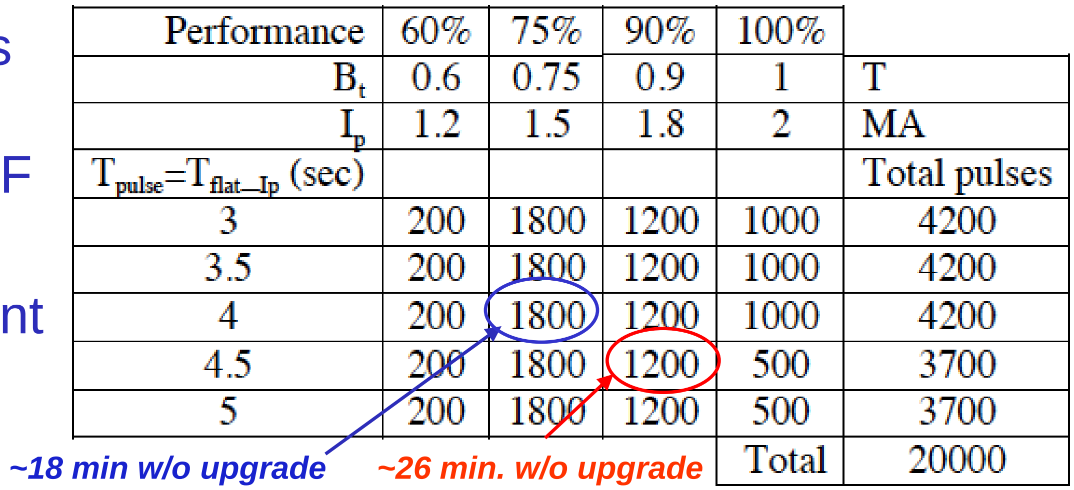
Example Year 1 Scenario at 1.5 MA and 0.75 T



# Anticipated Pulse Spectrum of NSTX-U Limits the Number of Full Field Long Pulse

- For engineering design purposes, a distribution of pulses was assumed in the General Requirements Document.
  - Based on the distribution of NSTX discharges
  - 20000 pulses = 10 years x 16 weeks x 5 days x 25 shots
    - This implies a 20 minute rep rate for an 8.5 hour day.
- Limited number of 1 T, 5 second discharges anticipated.
  - Majority of research program anticipated to be ~0.75 T -> 23 minute rep rate for 7.0 second TF flat-tops.
  - Limitation to 500-1000 shots ***very*** conservative with regard important fatigue limits.
- Other mitigating effects:
  - New PCS code that automates the TF rampdown after a disruption eliminates wasted TF heating/lifetime.
  - Will monitor the TF RMS current to stay near, but beneath, the limits.

**Table 2-4 - NSTX CSU Pulse Spectrum**



| Performance | 60% | 75% | 90% | 100% | |
|---|---|---|---|---|---|
| $B_t$ | 0.6 | 0.75 | 0.9 | 1 | T |
| $I_p$ | 1.2 | 1.5 | 1.8 | 2 | MA |
| $T_{pulse}=T_{flat\_Ip}$ (sec) | | | | | Total pulses |
| 3 | 200 | 1800 | 1200 | 1000 | 4200 |
| 3.5 | 200 | 1800 | 1200 | 1000 | 4200 |
| 4 | 200 | 1800 | 1200 | 1000 | 4200 |
| 4.5 | 200 | 1800 | 1200 | 500 | 3700 |
| 5 | 200 | 1800 | 1200 | 500 | 3700 |
| | | | | Total | 20000 |

*~18 min w/o upgrade*

*~26 min. w/o upgrade*

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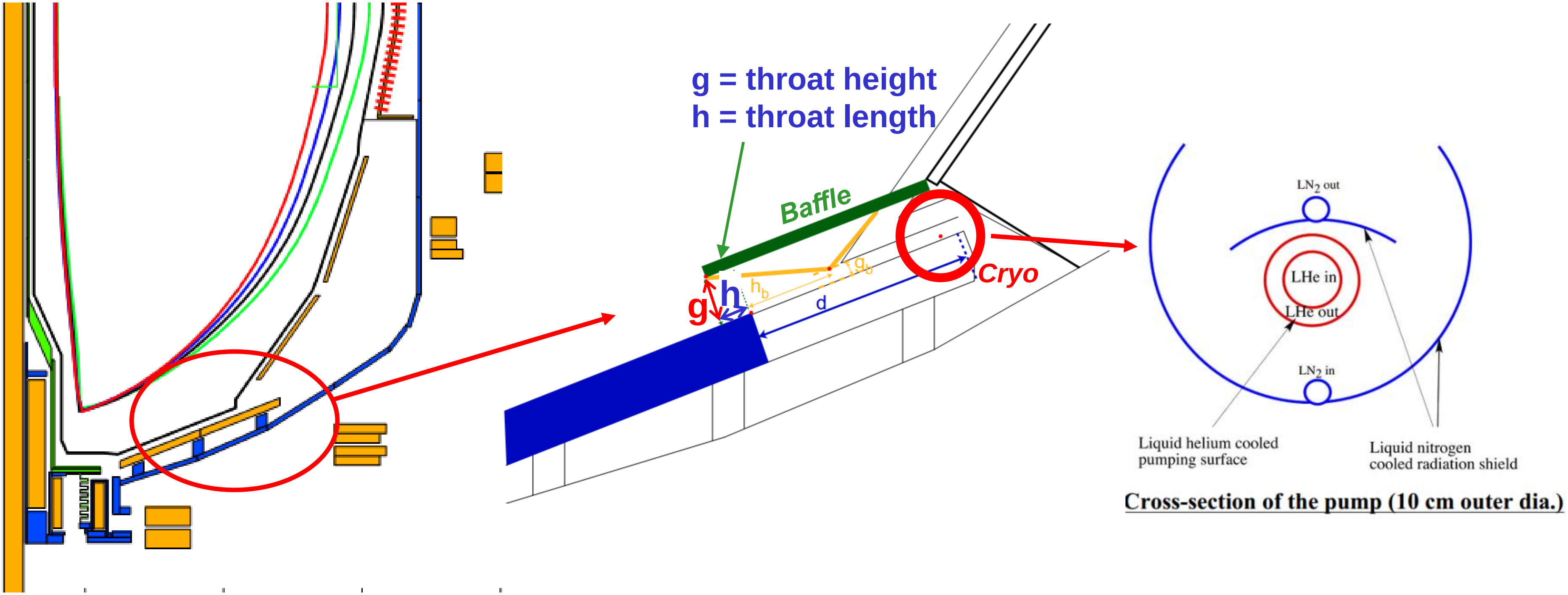
# NSTX-U cryo-pumping design based on DIII-D system

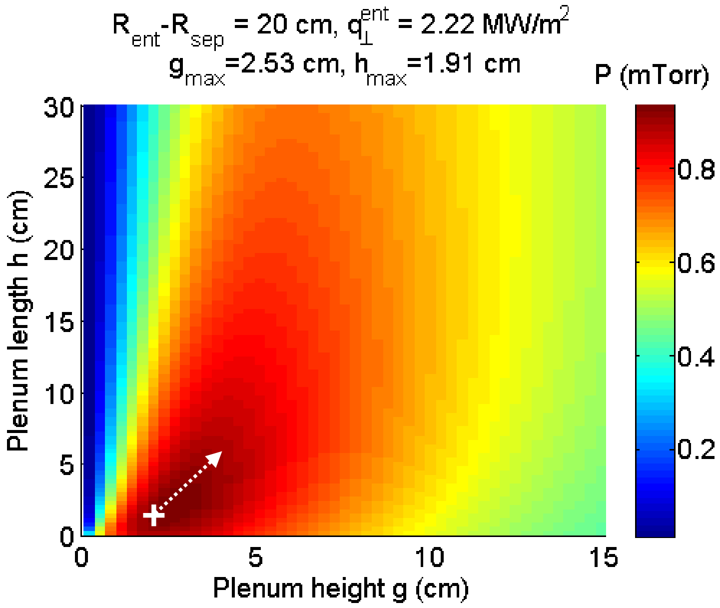
- Cryo-pump is proven technology for plasma density control
  - More conventional pumped ELMy H-mode scenario
- NSTX-U design is similar to DIII-D outer lower pump
  - Plenum located under new baffling structure near secondary passive plates
  - Pumping capacity of a toroidal liquid He cooled loop
    - S=24,000 l/s @ R=1.2m (Menon, NSTX Ideas Forum 2002)
  - Need plenum pressure of 0.6 mTorr to pump beam input (TRANSP)

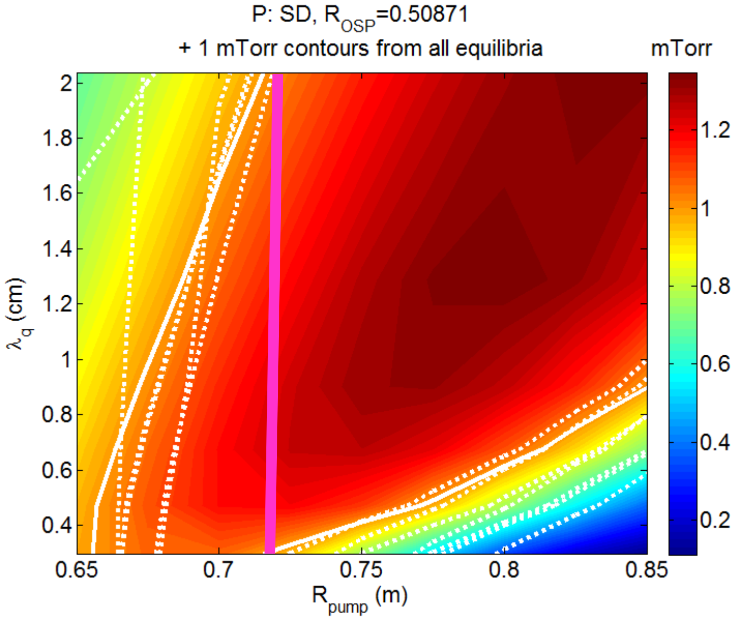


Cross-section of the pump (10 cm outer dia.)

# Semi-analytic pumping model used to optimize plenum geometry

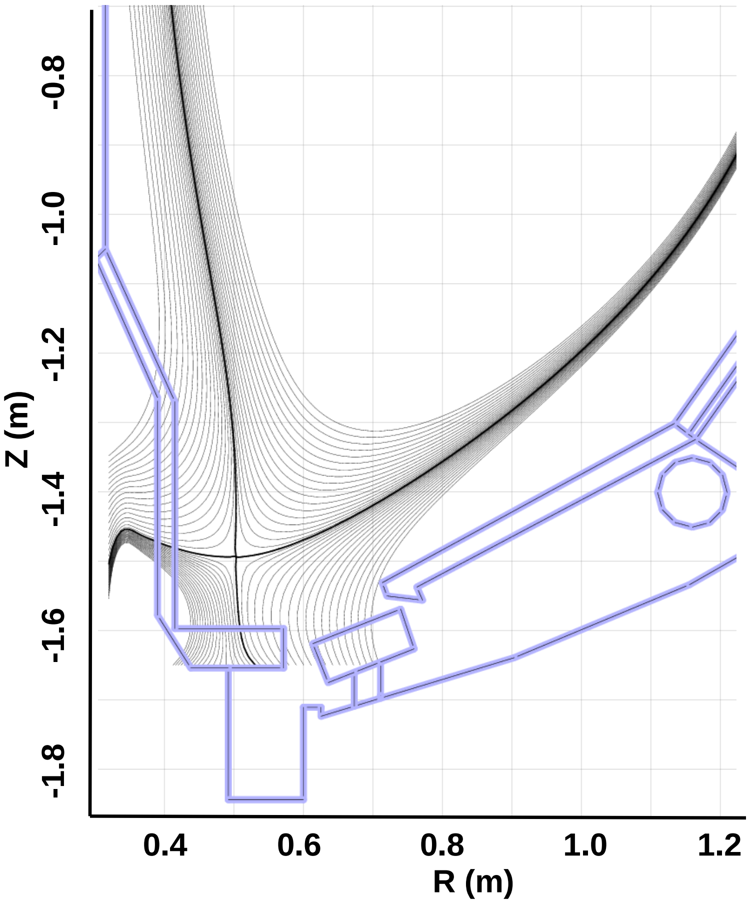
- Model developed for DIII-D pumping studies (Maingi, NF ‘99)
  - Predicts plenum pressure, validated with DIII-D data
  - Projected NSTX-U heat flux ($I_p$ scaling) and divertor $T_e$ (~15 eV) used as input
  - Uses first-flight neutral model (insufficient for detached divertor)
- Pressure is maximum for duct height g~2.5 cm, length h~2 cm
  - But is only weakly reduced if these are increased together
- With pump entrance at R=0.72m, pressures >1 mTorr can be reached over wide range of plasma shapes and SOL widths
  - Comparable to pressures in DIII-D plenum
  - Well above that needed to pump NBI particle input



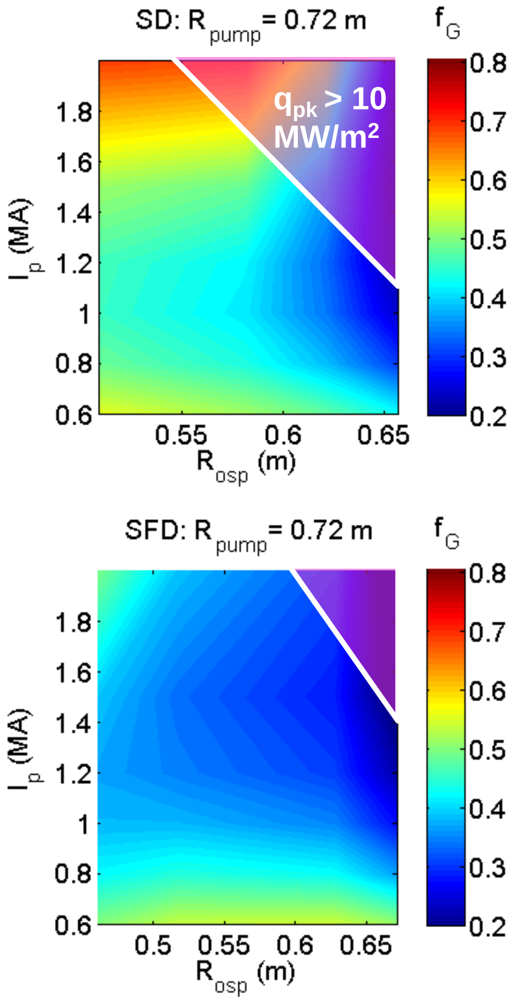


# Optimized plenum geometry can pump to low density for conventional and snowflake divertors over a range of $R_{OSP}$, $I_p$

***$R_{OSP}$: outer strike point radius***
***$R_{pump}$: plenum entrance radius***
***SD: standard divertor***
***SFD: snowflake divertor***
***$f_G$: $n_e/n_G$***

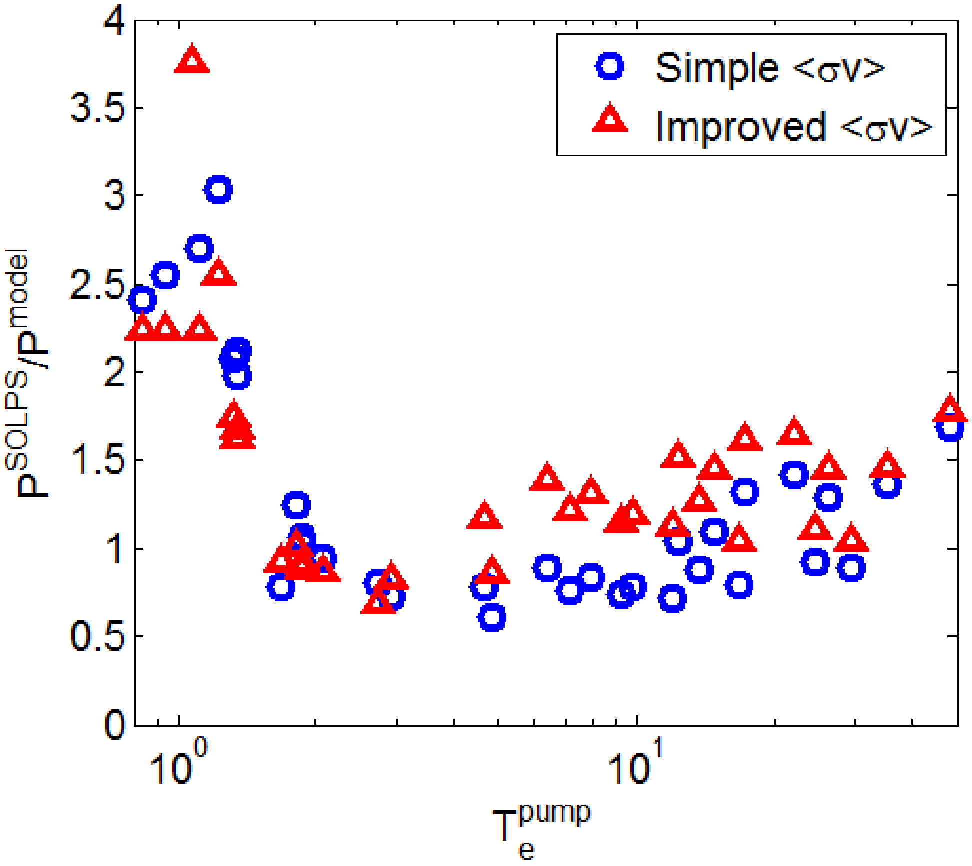


- Core density estimated assuming pumped flux=NBI input
  - 2-pt model used to estimate upstream density
  - Assume $n_e/n_e^{sep}$~3
- Can pump to $f_G$<0.5
  - $f_G$~0.7 desirable for all scenarios, lower provides more flexibility
  - Moving $R_{OSP}$ closer to pump allows lower $n_e$, but limited by power handling
- High flux expansion in SFD gives better pumping with SOL-side configuration
  - More plasma in far SOL near pump
  - More room to increase $R_{OSP}$ at high $I_p$



# SOLPS calculations confirm optimization approach based on analytic model

- SOLPS: 2D fluid plasma/neutral transport
  - Plasma transport classical parallel to B (+kinetic corrections), ad-hoc cross-field transport coefficients
  - Kinetic neutral transport using MC code EIRENE
    - More comprehensive treatment of neutral transport (beyond first-flight)
    - Can treat radiative/detached divertor
- Range of divertor conditions have been produced using standard and snowflake equilibria
- SOLPS-calculated plenum pressure agrees with analytic model for $T_e^{div}$>2 eV, factor of ~3 higher in detached regimes



***⇒ Optimization of design presented here is conservative***

- ***Pumping likely to be stronger for realistic conditions***

# Questions from Panel – 5-7 of 7

5. What are the rep-rate limitations for high field operation?
   - What arises first, second, third?
   - How do you plan deal with them?
   - ➢ Addressed by S. Gerhardt

6. What is the physics basis for the cryopump and the expected particle exhaust rates as compared to lithium coatings?
   - ➢ Addressed by J. Canik

7. Is the cryopump compatible with MGI or NB operation? (… but we will answer a slightly different question):

   Is MGI compatible with divertor cryopump and NB operation?
   - ➢ NBI cryo – Addressed by: S. Gerhardt / R. Raman
   - ➢ Divertor cryo – Addressed by J. Canik / R. Maingi

# MGI Experiments on NSTX-Upgrade are Primarily For Scientific Purposes

- NSTX-U is designed to tolerate 2 MA disruptions.
  - MGI is not anticipated to be a machine protection system
- Experiments on other devices show that the leading edge of the gas front is most critical for mitigation
  - NSTX-U experiments will aim at understanding the minimum required gas loading by varying the poloidal injection location
  - Will use fast-opening electromagnetic valves of a design similar to JET and ITER, located close to the vessel, to minimize the gas input.
- Anticipated MGI levels are up to 500-700 torrL at most
  - $D_2$ or He, with smaller fractions of Ne or Ar.
  - Values are ~5000 torr @ ~100 cc-> 500 torrL.
  - Leads to ~6 mtorr vessel w/ one beam box, 4 mtorr w/ two beams boxes.
  - NSTX-U TMP systems significantly upgraded, will help with He pumping.

- Beams: Very desirable to use NBI + MGI to test penetration into H-mode pedestal.
- Cryopump: May very well be possible to run MGI experiments with divertor cryopump not at liquid He temp, as it is not needed for experiments

# Two Significant Issues Have Been Identified for NBI+MGI

- Beam Reionization: Beam is "reionized" in the duct by the higher pressure, bent to the duct wall as it enters the TF.
  - Can avalanche: sputtered/ejected material from beam strike can increase the duct pressure.
  - Solution: Interlocks and procedures will be implemented to turn beams off before MGI. Experiment would be conducted within the beam slowing time.
    - Updated Gas Injection PCS Spec. for NSTX-U has an explicit test of the beam power before firing MGI valves.

- Beamline Cryopump Regen
  - Helium provides a conduction path from panels to the hotter components.
  - NB Group does regenerations by applying 5 mtorr of He to a closed box.

- Experiments with NB valves open will need to maintain the pressure in the box beneath this level with some safety margin. 90 Torr.L He is acceptable (previously tested on NSTX)

☐ 2015: 100 Torr.L D2, and gradually increase to 500-700 Torr.L D2 (understand assimilation efficiencies)
☐ 2015: 500-700 Torr.L D2 + Neon
☐ 2015: 500-700 Torr.L He + Neon (should be sufficient for full mitigation studies)
☐ 2016: Determine minimum levels of He + Neon to achieve full mitigation
☐ 2017: Determine minimum levels of He + Argon to achieve full mitigation

# Heat load on the divertor cryo-pump during MGI needs assessment

- As previously noted, beam cryo-pump already provides a significant constraint on the maximum He pressure for cases with beams:
  - Divertor cryopump will only be needed for long-pulse examples, all of which will require beams.
- Acceptable heat load on NSTX-U divertor cryo-pump has not yet been assessed
  - DIII-D design maximum cryo heat load was ~ 10 W
  - DIII-D tests were conducted with heat loads up to 25 W, with no spontaneous re-gen
  - DIII-D cryo can pump large amounts of *deuterium* gas > 2500 torr-l, without re-gen
- Reiterate: For scientific exploration of MGI physics, likely not necessary to utilize divertor cryo-pumps at all.

# Backup

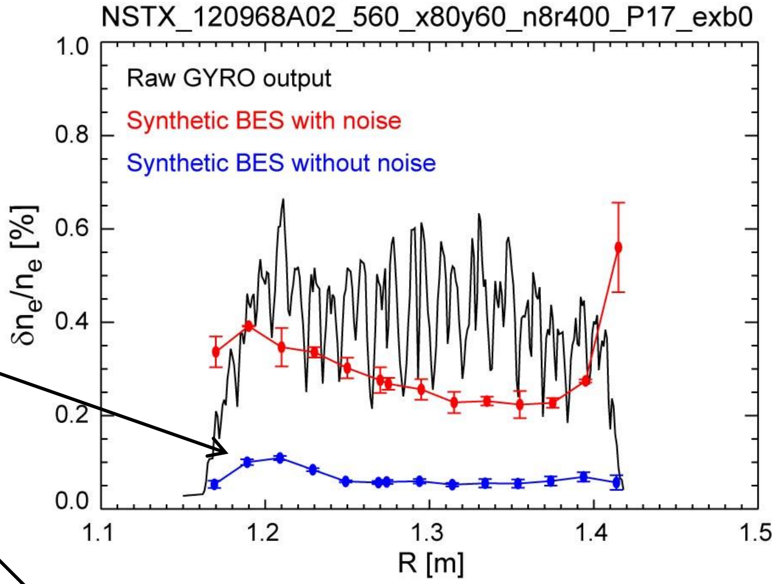
# MAST-NSTX collaboration testing sensitivity of BES to microtearing turbulence through synthetic diagnostics

- Using nonlinear NSTX microtearing simulations from GYRO with synthetic diagnostic for MAST BES
  - Difficult to detect MT with expected signal-to-noise ratio (uncorrelated noise dominates)
  - If S/N can be increased (e.g. significant time averaging) MT features may be measurable, such as:

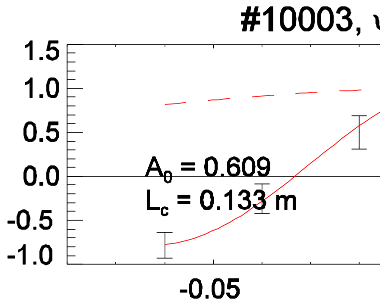
    detectable correlated fluctuation levels (δn/n~0.1%)

    large poloidal correlation lengths ($L_p$~15-20 cm)

**Density fluctuation (rms)**



**Poloidal correlation from synthetic diagnostic**



Future plans:

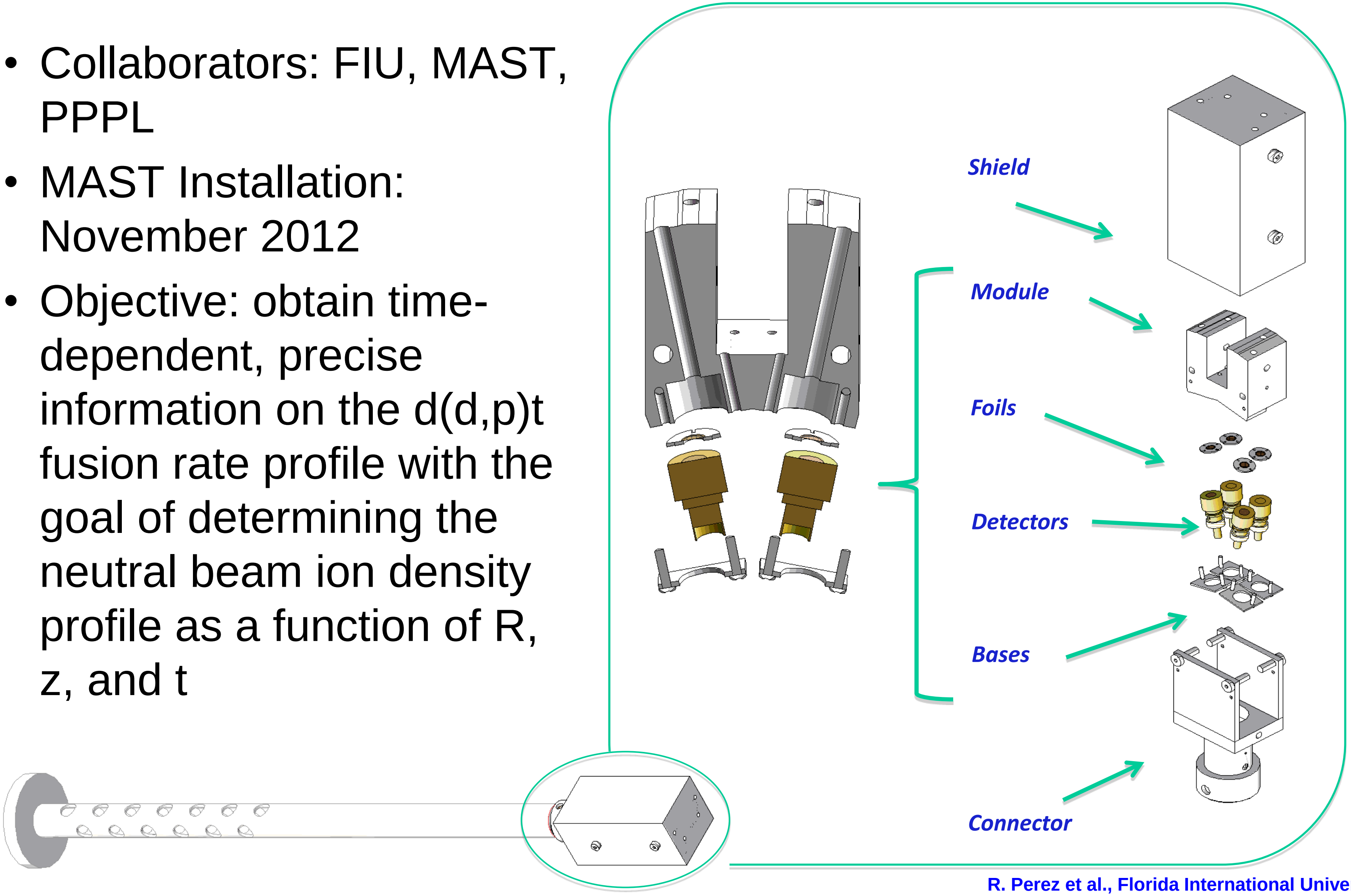
- Pursue non-linear simulations for MAST discharges with available BES data
- Propose experiments for FY13 at next MAST research forum (Dec 2012) to focus on relationship between collisionality scaling and microtearing turbulence

**W. Guttenfelder, et al. PPPL**

# NSTX-U Charged Fusion Products Diagnostic on MAST

## Provides fusion reactivity profile due to MHD and other phernomena

- Collaborators: FIU, MAST, PPPL
- MAST Installation: November 2012
- Objective: obtain time-dependent, precise information on the d(d,p)t fusion rate profile with the goal of determining the neutral beam ion density profile as a function of R, z, and t



**R. Perez et al., Florida International University**

# Data Acquisition Will Be Upgraded to Support Increased Data Load

- Extension of pulse length to 5 seconds increases the data load considerably, and steps have been taken to bring down the data transfer time.
  - Network upgrades
  - Elimination of CAMAC
- Expected times:
  - 3.5 minutes for MDS+ physics data.
  - 5 minutes for EPICS engineering data (mostly NB, MG, and rectifier signals)