Summary : EXC, EXS and PPC

Y. Kamada, QST

Papers: EXC 101, EXS 57, PPC 26 from 40 devices

MEDUSA (Costa Rica): R~0.14m, a~0.1cm, GLAST-III (Pakistan): R=0.2m, a=0.1 m
.... JET (EU): R~3m, a~1.2m

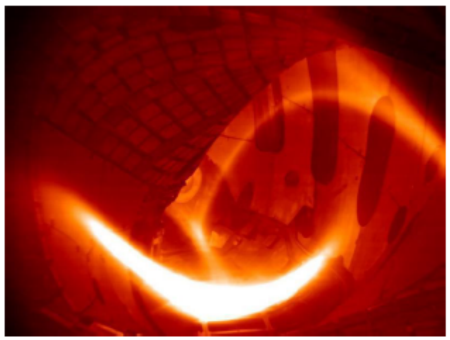
W7-X, Welcome to EX sessions !

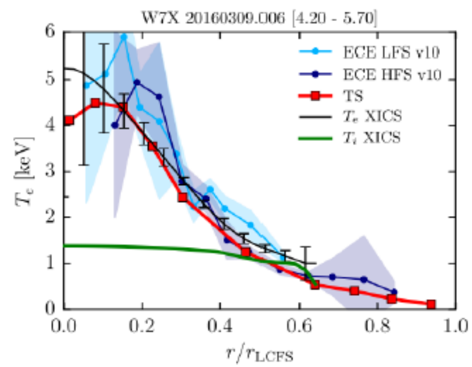
HELMHOLTZ GEMEINSCHAFT EUROfusion

IPP Max-Planck-Institut für Plasmaphysik

First plasma operation of Wendelstein 7-X

10 weeks of plasma operation from 10 Dec 2015 until 10 March 2016





Integral commissioning of superconducting stellarator, device control, plasma heating systems and diagnostics

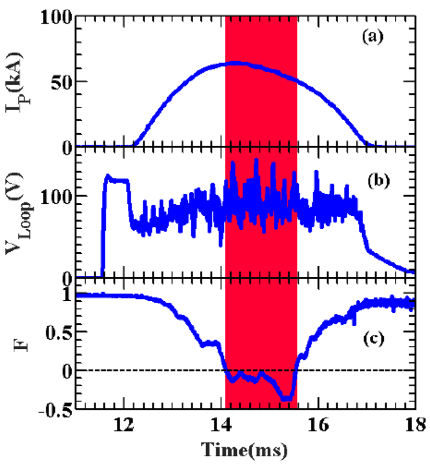
ECRH power up to 4.3 MW, $T_e \leq 8$ keV, $T_i \leq 2$ keV, $n_e \sim 3\times10^{19}$ m^{-3}, pulse durations up to 6 sec ($\int P dt \leq 4$ MJ)

Studies of plasma start-up, power balance, confinement (core electron-root conf.), bootstrap current, on-/off-axis heating, X2- and O2-ECRH, ECCD, plasma exhaust and SOL physics

Welcome to EX ! Start New Operation

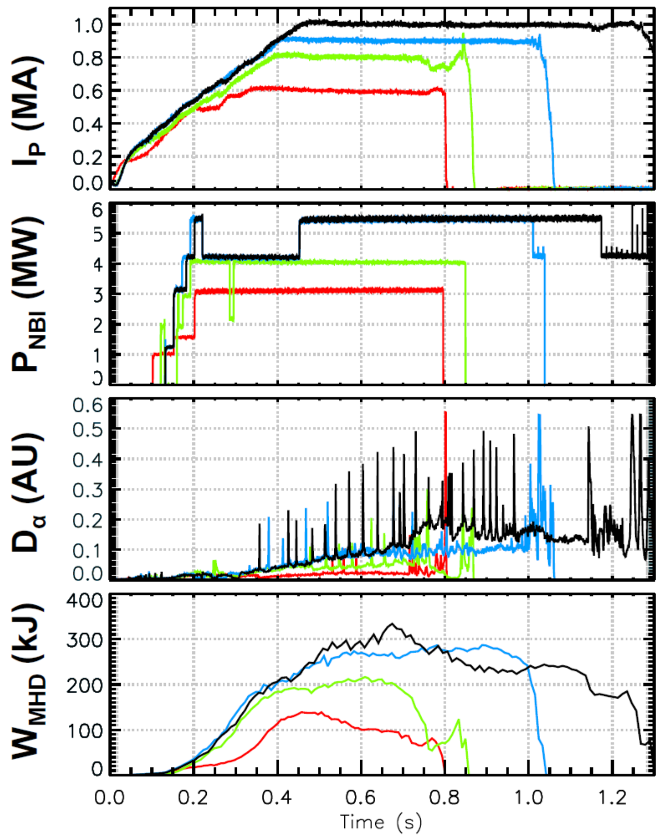
KTX

University of Science and Technology of China
RFP
R=1.4m, a=0.4m
Ip=0.5MA (=>1MA)
Bt max=0.35T (=>0.7T)



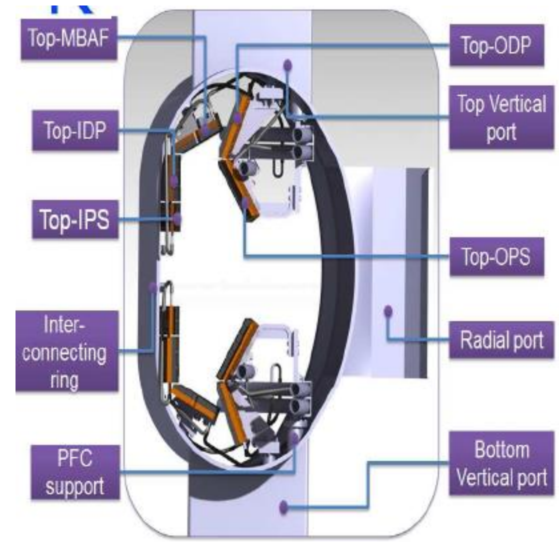
NSTX-U

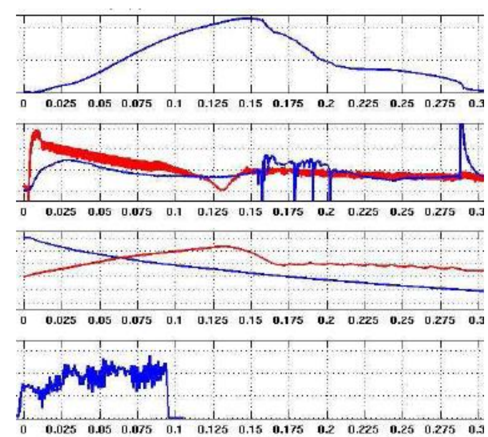
Ip~1MA H-modes,
$H_{98} \geq 1$, β_N ~4 ≥ n=1 no-wall limit
with weak/no core MHD



SST-1

Upgraded with Plasma Facing Components.



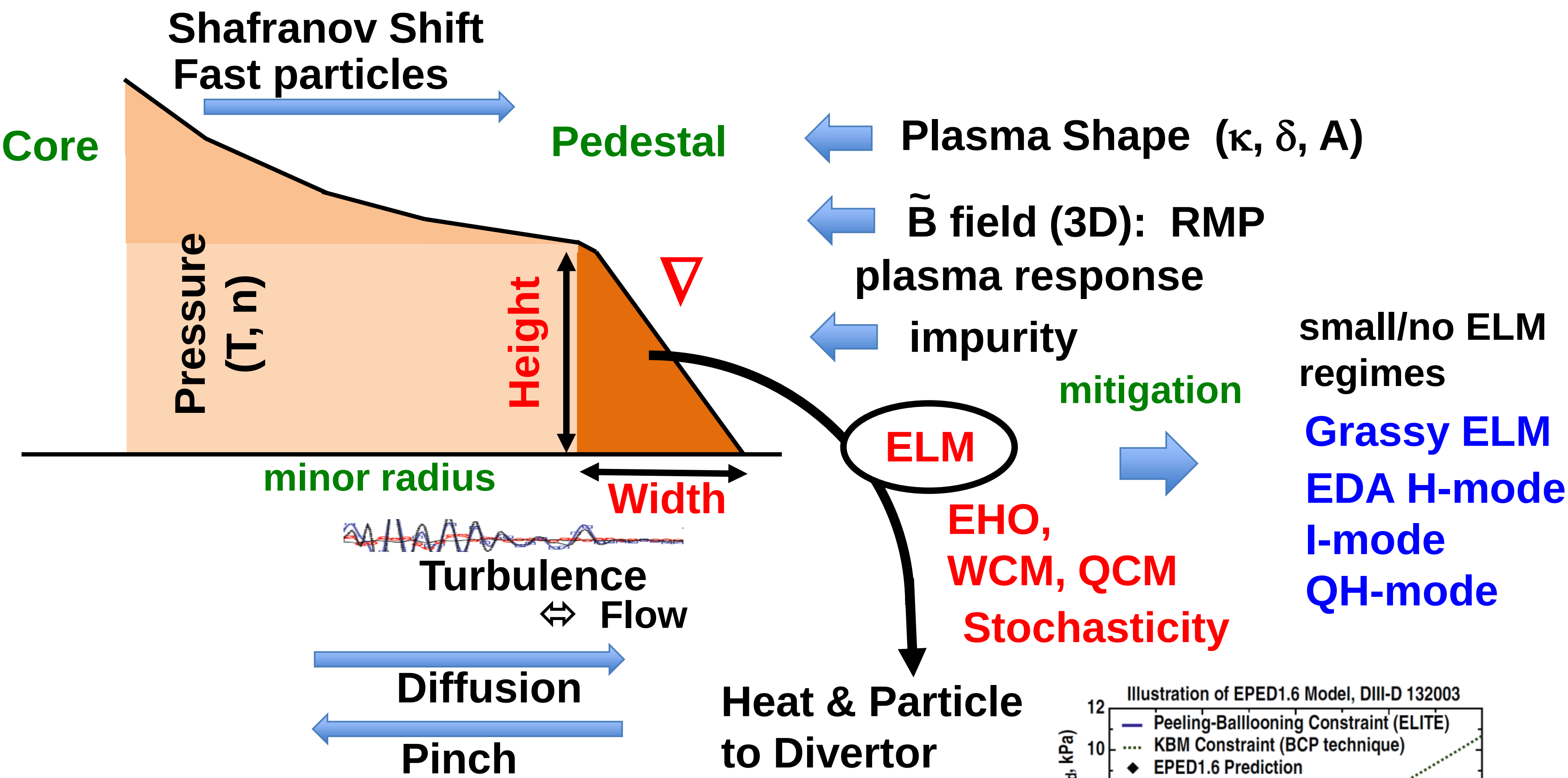


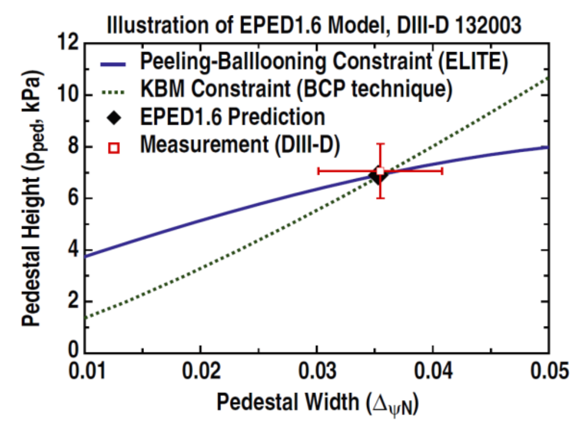
Contents

1. Edge Pedestal System
2. Core Transport
3. Core MHD Stability
4. Operation & Control

** Disruption Mitigation is treated in the next talk by Dr. D. Hill*

H-mode Pedestal Structure and Dynamics

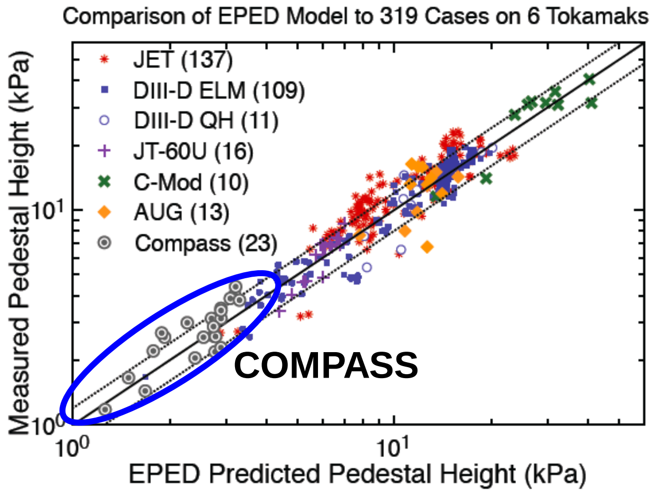




grad-p: ELM = Peeling-Ballooning modes (PBMs)
width: small-scale turbulence(KBM...)

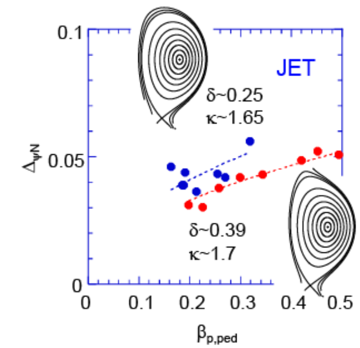
Pressure Gradient ~ Peeling Ballooning Mode

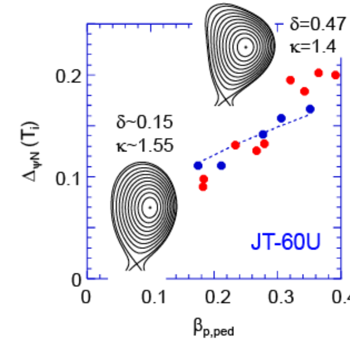
COMPASS: The experimental data are in agreement with the EPED model. **(EXP6-35, Komm)**



Shafranov shift stabilizes the pedestal gradient,

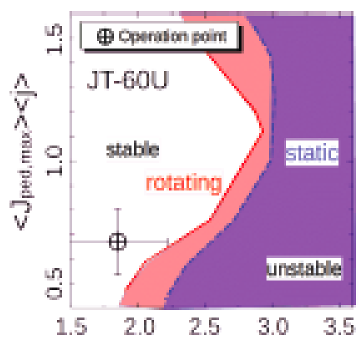
JET and JT-60U: confirmed in a wide space of (κ,δ). Low κ high δ gives lower grad-p, but wider pedestal width, then grassy ELM & good confinement. **(EX/3-4, Urano)**



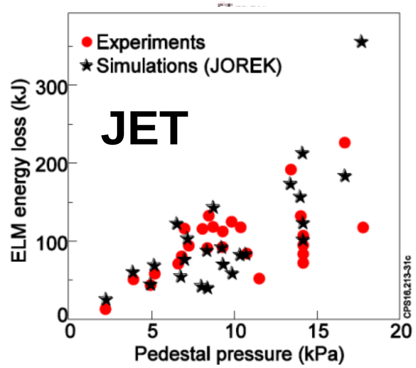


MHD simulations reproduce experiment very well.

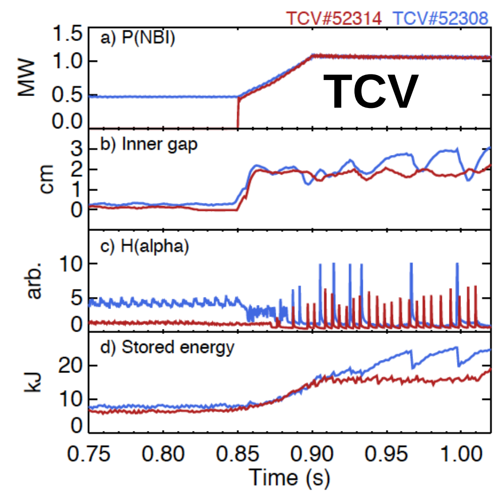
JT-60U and JET: MINERVA-DI: Rotation can destabilize PBMs due to minimizing the $\omega{*}i$ effect => better fit to exp. data**.**
(TH8-1, Aiba)



Multi-machine: JOREK simulations at low resistivity/viscosity reproduce experiment **(TH8-2, Pamela)**

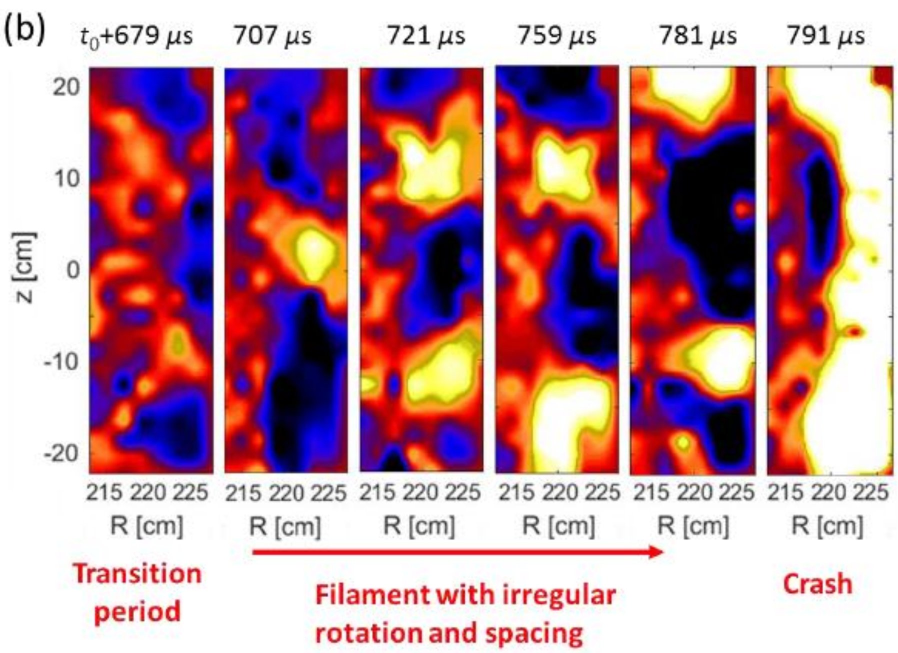


TCV, MAST and JET : The pedestal height has been significantly increased by early increase of βp-core. **(EX3-6, Chapman)**

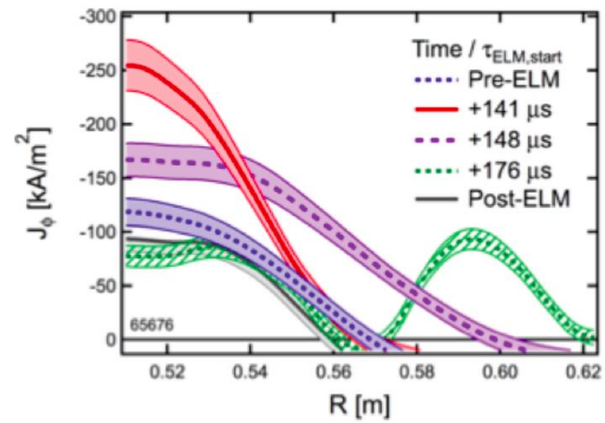


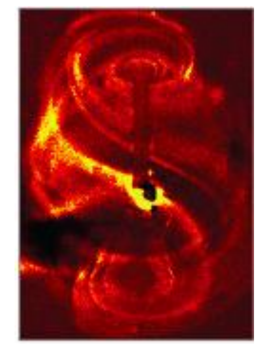
ELM crash new key findings

KSTAR: Three-stage evolution of ELM was identified using a 2D imaging: (1) quasi-steady filamentary mode with long life time n=4-15, (2) abrupt structural transformation into filaments with irregular poloidal spacing near the onset of crash, (3) and multiple filament bursts during the crash. **(EX10-3, Yun)**



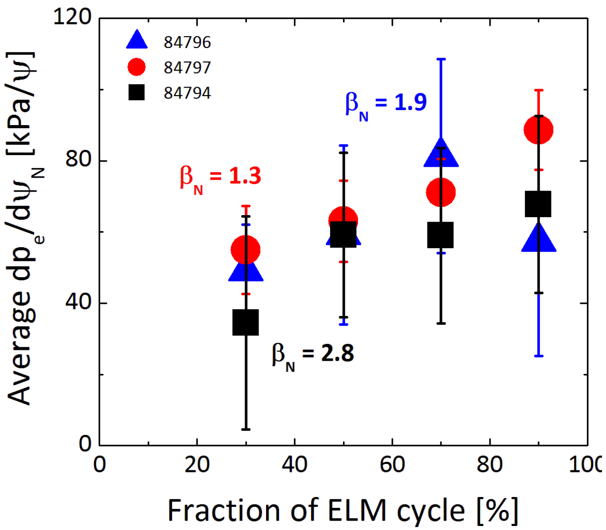
Pegasus: J-edge across single ELMs shows the nonlinear generation and expulsion of current-carrying filaments. **(EXP4-51, Bongard)**

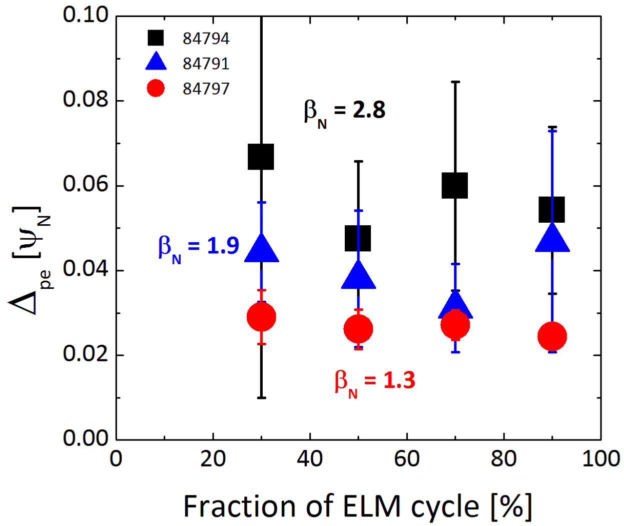


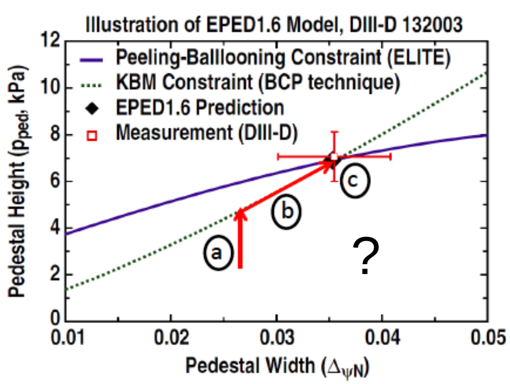


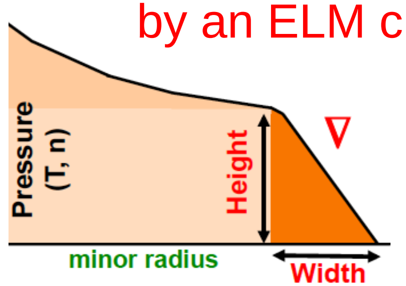
Pedestal evolution during the ELM cycle

JET: Pedestal evolution during the ELM cycle:
not always consistent with EPED **(EX3-3, Maggi)**
Low D2 Gas:
low-βN: Gradient increases and width constant:
not consistent with KBM constraint



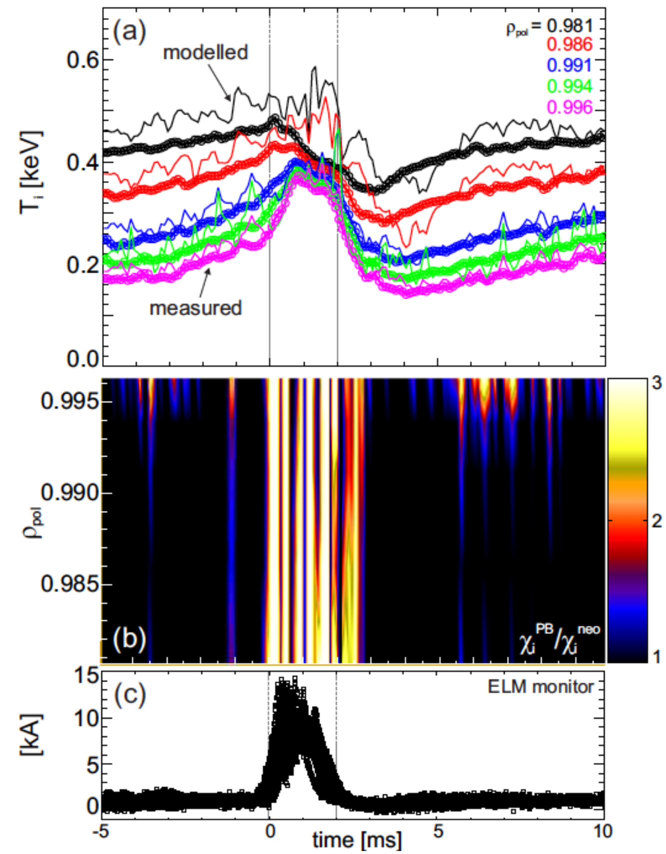






Is J-edge expelled by an ELM crash?

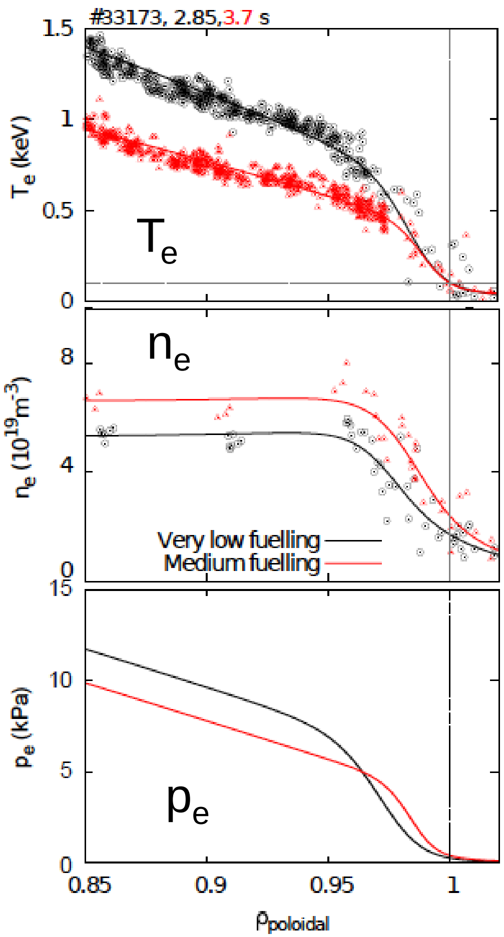
ASDEX-U: 70μs resolution Ti (r) measurement: At ELM, heat flux is first increased at the separatrix, then Ti(r) becomes flatter. χ_i comes back soon to its pre-ELM neoclassical level . **(EXP6-30, Viezzer)**

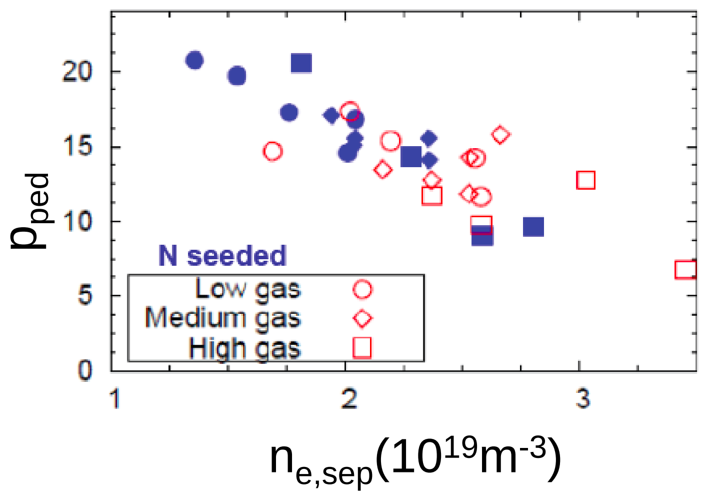


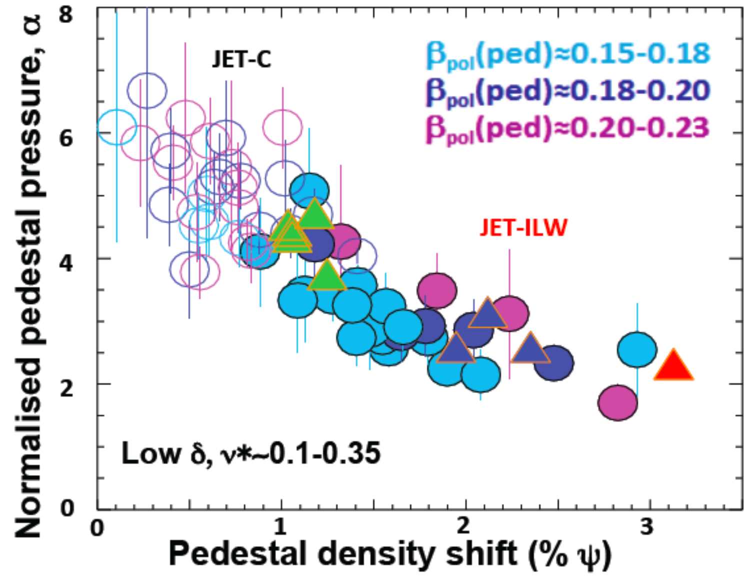
Pedestal Width: key = $n_e(r)$ relative to $T_{e,i}$ (r)

ASDEX-U: D fueling shifts density profile outward , and T profile anchored at separatrix => causes a significant degradation of the pedestal top pressure. **(EX3-5, Dunne)**

JET: Pedestal stability improves with reduced radial shift. JET-ILW tends to have larger relative shift than JET-C. **(EXP6-13, Giroud)**

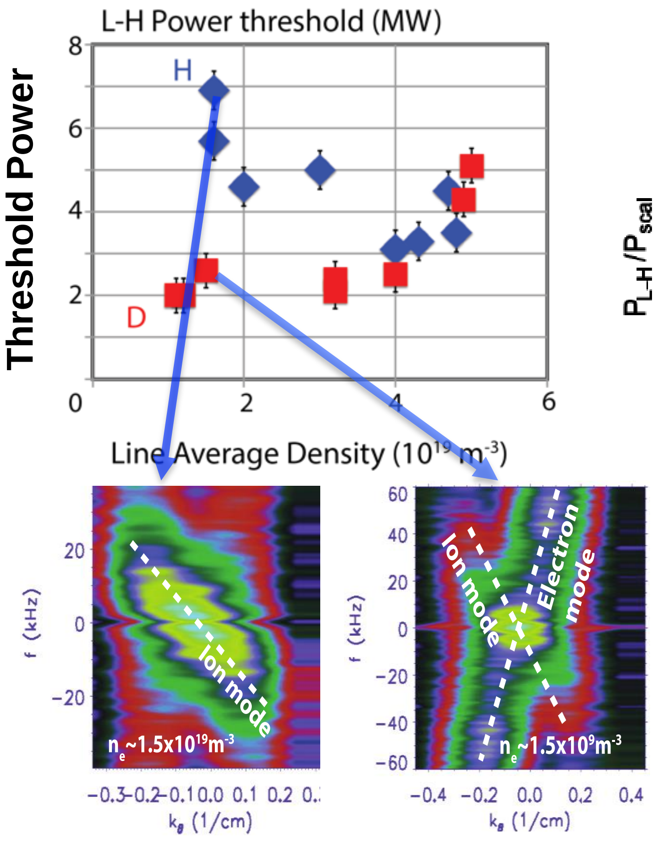




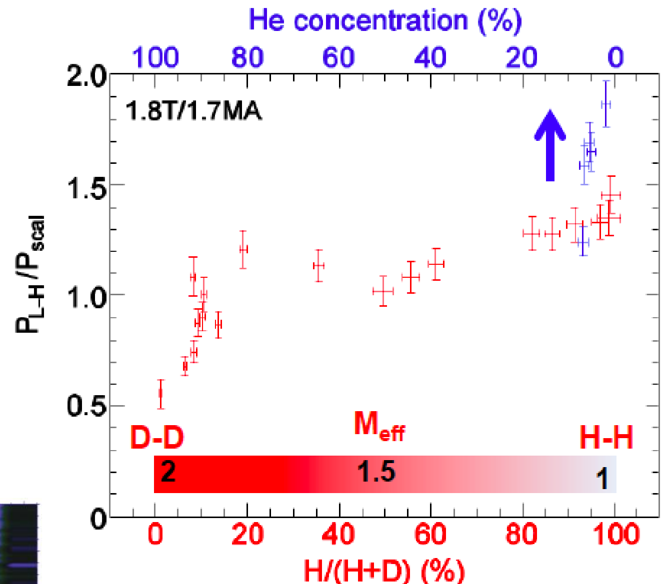


L-H Transition Threshold Power

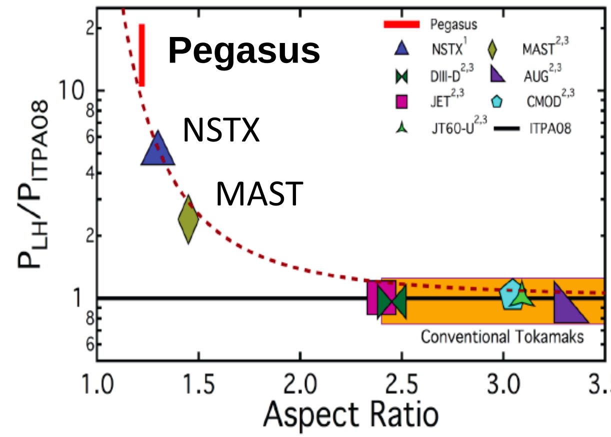
DIII-D: Dual Mode Nature of Edge Turbulence May Explain Isotope and Density Scaling of L-H Power Threshold **(EX5-1, Yan)**



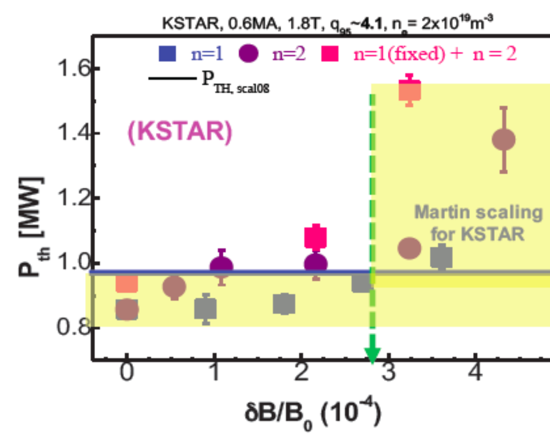
JET: Isotope Effect: Non-linear mass dependence on L-H power threshold **(EX5-2,Hillesheim) PD, Nunes)**



Pegasus: Ultralow-A
At low A(~1.2), P_{LH} >> ITPA scaling by one order of magnitude.(**OV5-4, Fonck**)



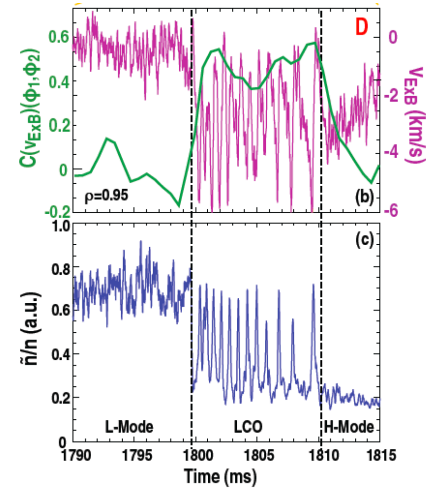
KSTAR: P_{LH} increases with δB for any cases with n=1, n=2 or mixed-n. **(EXP4-4)**

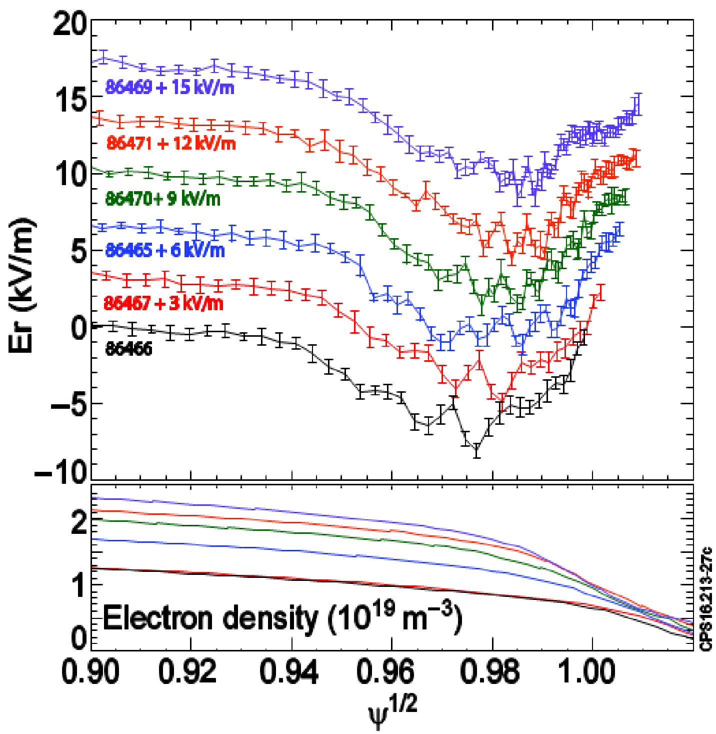


L-H transition: Behavior of turbulence

JET: Radial wavelength of Stationary Zonal Flows scales with the radial correlation length of turbulence,
~ several times smaller than the width of the edge radial electric field well.
(EX5-2, Hillesheim)

DIII-D: The main-ion poloidal flow acceleration is quantitatively consistent with Reynolds-stress-driven shear flow amplification
(**EXP3-11, Schmitz)**





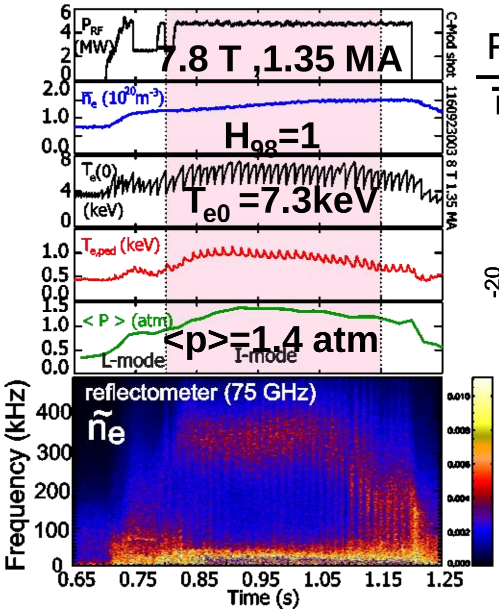
NSTX: The energy exchange between flows and turbulence was analyzed using GPI .The edge fluctuation do not vary just prior to the H-transition.
=> Turbulence depletion is probably not the mechanism of the L-H transition in NSTX. **(EX5-3, Diallo)**

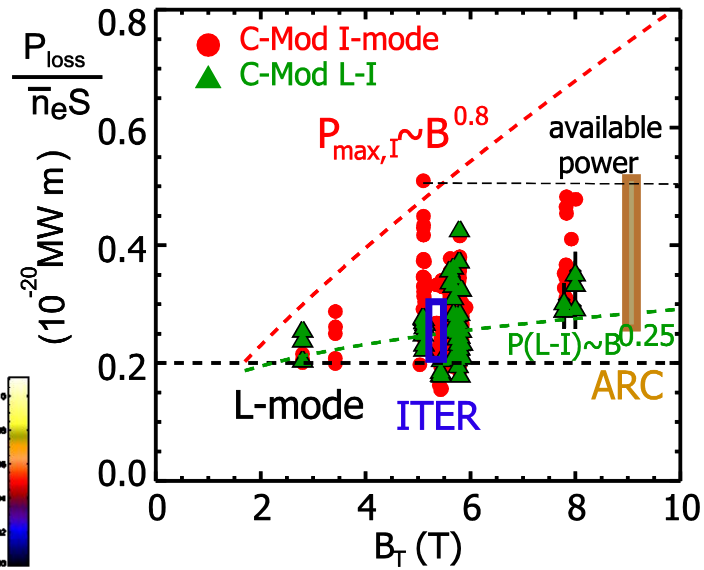
ASDEX-U: L-I Transition: Negligible contributions of ZFs. **(EXP6-29, Putterich)**

ELM-free regimes : extended remarkably

I-mode

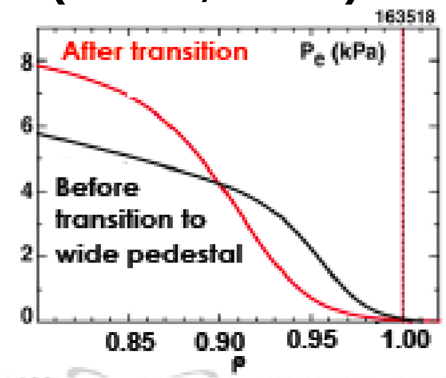
Alcator C-mod :
High energy confinement with Temperature pedestal, L-mode Density pedestal, Small impurity, Stationary and ELM-free. Extended to full field 8T and current 1.7MA. Confirms weak L-I threshold dep. on B, and wide power range at high B. **(EX3-1, Hubbard)**



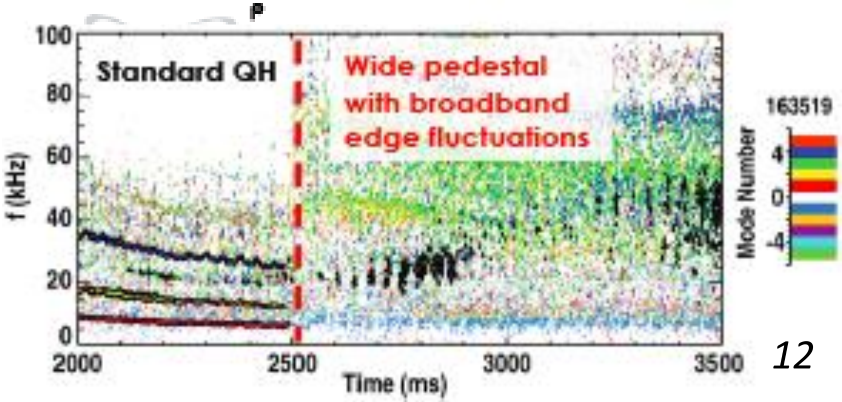


QH-mode

DIII-D: Discovered Stationary Quiescent H-mode with Zero Net NBI Torque in double-null shaped plasmas, characterized by increased pedestal height & width: sustained for $12\tau_E$ with excellent confinement (H98y2 ~ 1.5, βN ~ 2).
(EX3-2, Chen)

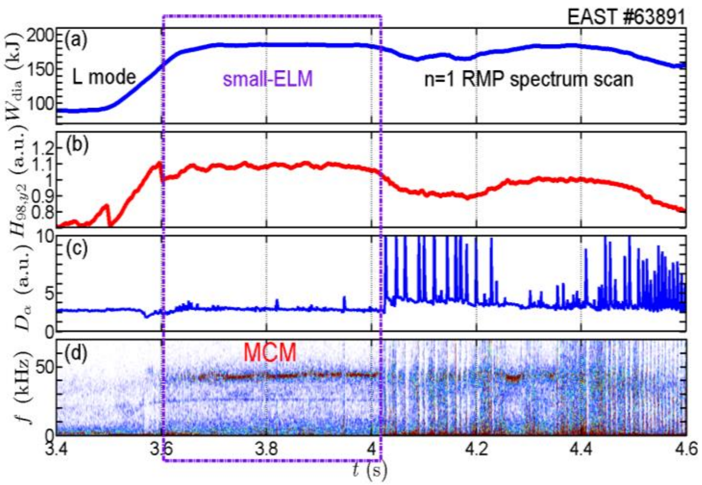


decreased edge *ExB* shear enables destabilization of broadband turbulence

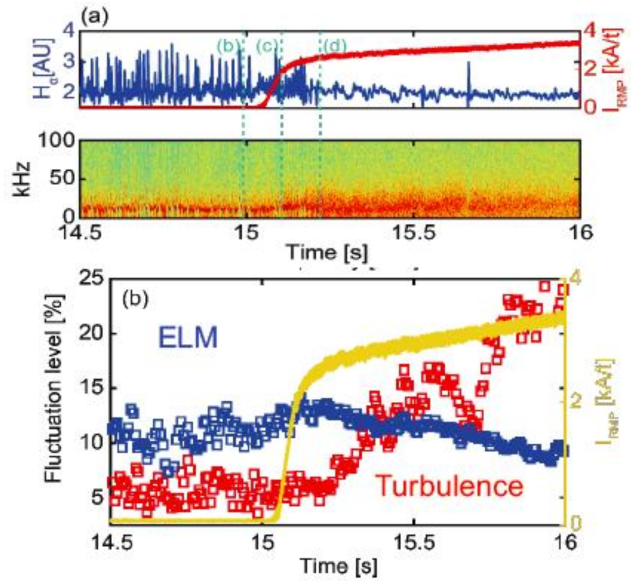


Pedestal fluctuations : variety of interplay

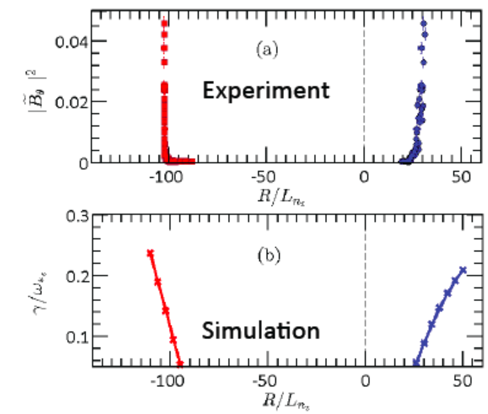
EAST: A new stationary small/no ELM H-mode was found at low $\nu e^* < 0.5$, H98 $\gtrsim$ 1.1, exhibiting a low-n electro-Magnetic Coherent Mode. It appears at the low frequency boundary of TAE gap. (+ ELM pacing)**(EX10-2, Xu)**



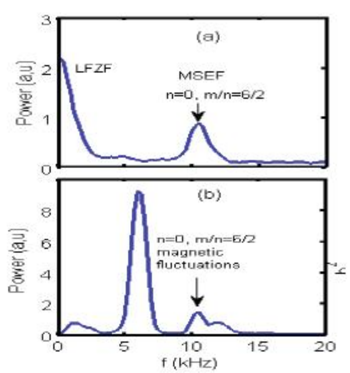
KSTAR: Broadband turbulence induced by RMP damps the ELM amplitude **(EXP4-15, Lee)**

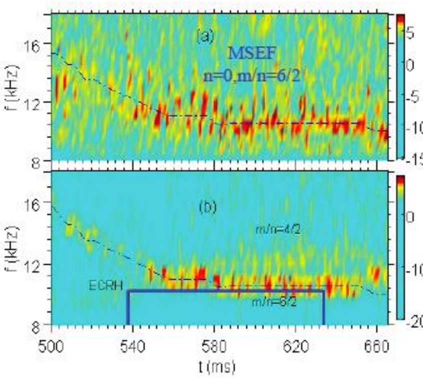


HL-2A: EM turbulence was excited by locally-accumulated impurities. Double critical gradients of impurity density were observed and reproduced by theoretical simulation. **(OV4-4, Duan)**

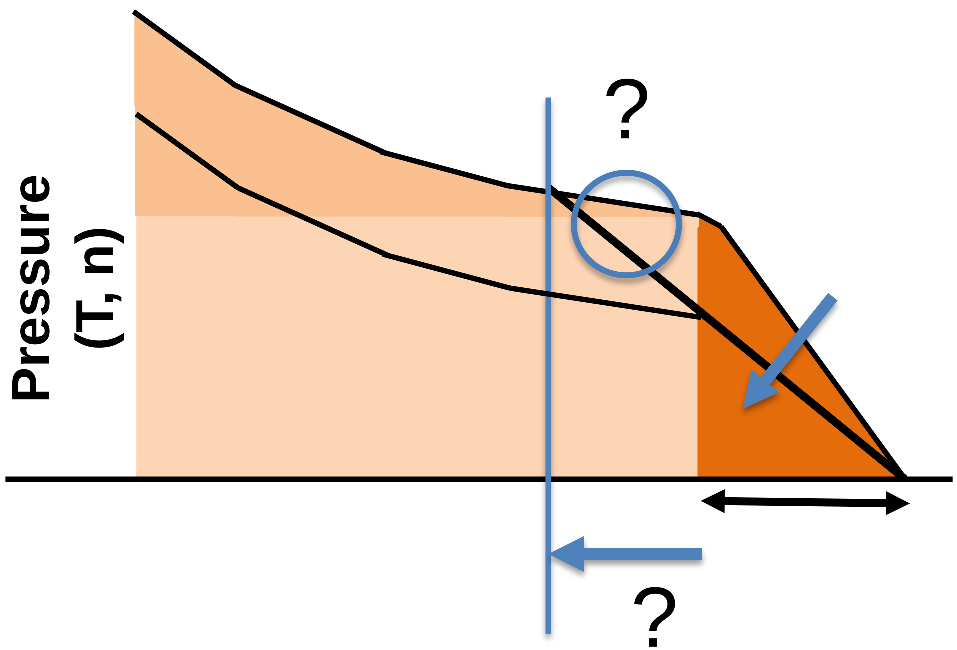


HL-2A: Synchronization of GAMs and magnetic fluctuations was observed in the edge plasmas. **(EXP7-27, Yan)**





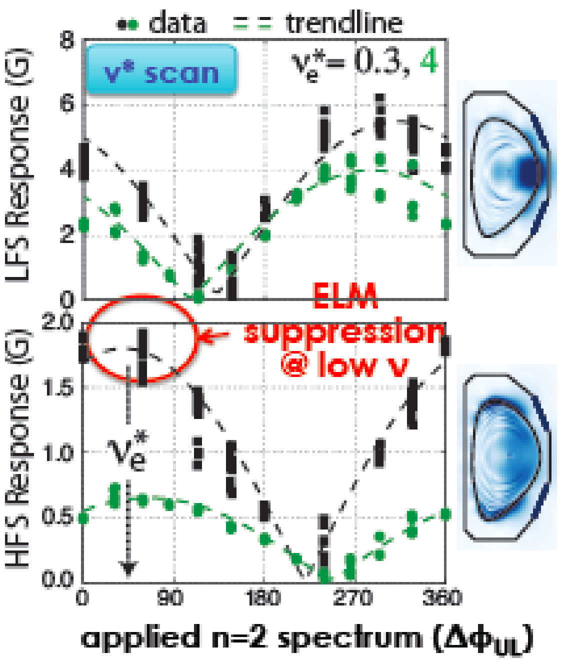
Remaining Issue:
How is the Pedestal Width determined ?



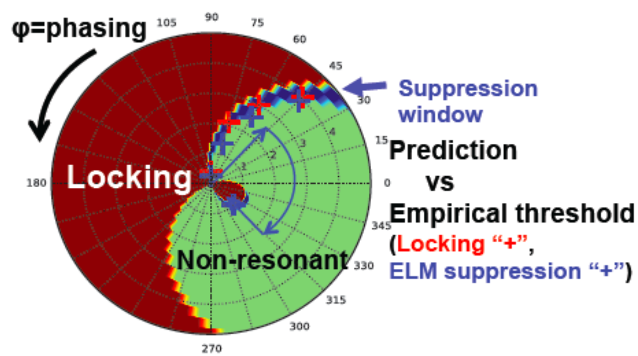
When pedestal grad-p is below Peeling-Ballooning limit,
how does the pedestal width evolve and saturate ?
During the ELM cycle?
Controllable?

Success of RMP ELM Suppression = Phase and Shape

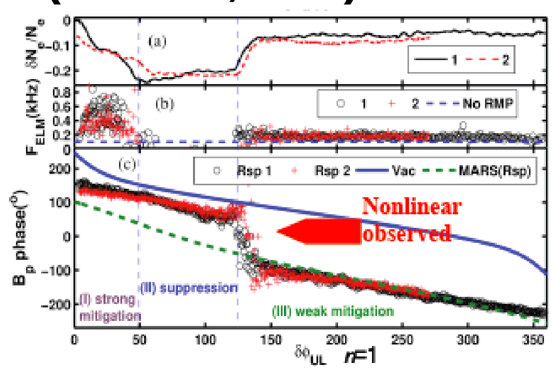
DIII-D: ELM control requires the applied field to couple to an edge stable MHD mode, directly observed on high field side. The response is inversely proportional to ν*. **(EX1-2, Paz-Soldan)**
(AUG : EXP6-25, Willensdorfer
MAST: peeling, OV5-3, Kirk)



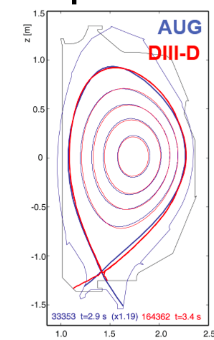
KSTAR: Optimal phasing for n=1 RMP is consistent with an ideal plasma response modeling.**(EX1-3, In)**

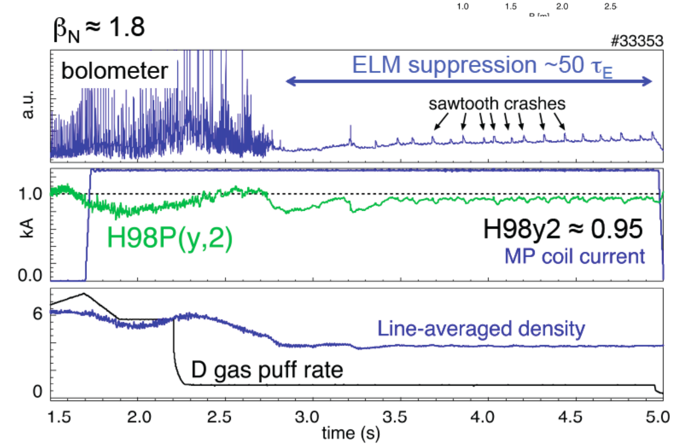


EAST: n=1 RMP, Plasma response behaves a nonlinear transition from mitigation to suppression of the ELMs **(EXP7-4, Sun)**



ASDEX + DIII-D: ELM Suppression was obtained for the first time in AUG at low ν* with a plasma shape matched to DIII-D (δ~0.3) showing the importance of stable edge kink response. **(PD, Nazikian)**



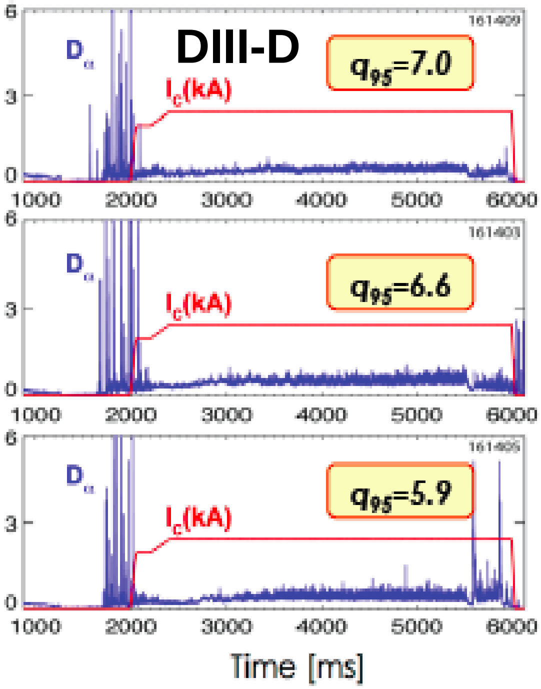


Long Pulse ELM Suppression by RMP: Big Progress

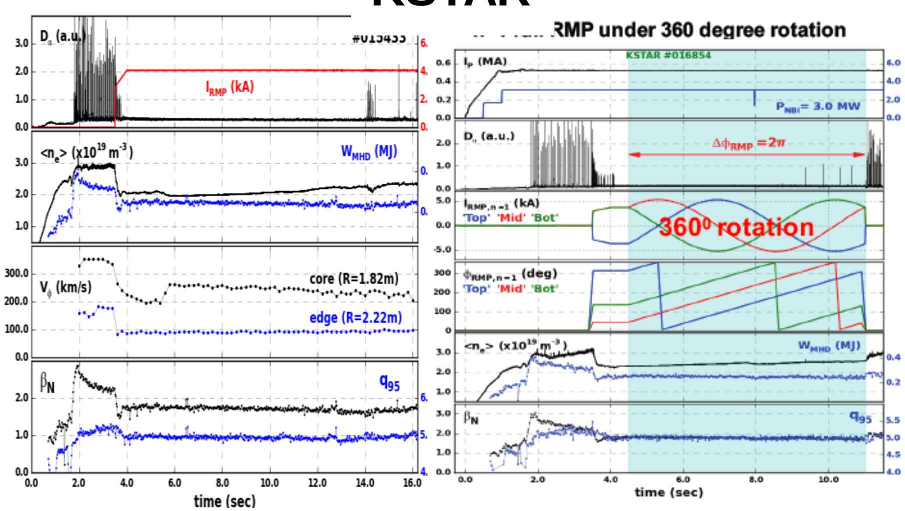
DIII-D: Fully Noninductive plasmas with high β (≤ 2.8%) and high confinement (H≤ 1.4) sustained for ≤ 2 current relaxation with ECCD and NBCD, and integrated with ELM suppression by n=3 RMP; the strong resonant interaction allows ELM suppression over a wide range of q95 **(EX4-1, Petty)**

KSTAR: *n*=1 RMP ELM suppression was sustained for more than ~90 τ_E (H89=1.5), and also confirmed to be compatible with rotating RMP, wide q95 (4.75 – 5.25) **(EX1-3, In), (PD, Jeon)**

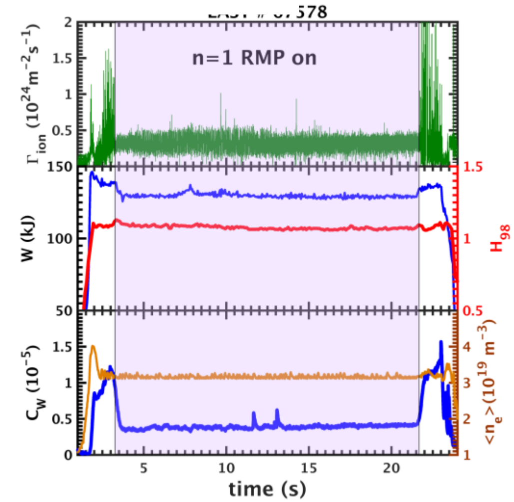
EAST: n=1 RMP ELM suppression in long-pulse (> 20s) was realized with small effect on plasma performance (H98>1) **(P7-4, Sun)**



KSTAR



EAST



Core Plasma Transport issues for ITER & DEMO

Te/Ti ~ 1 (<= electron heating (α, high energy NB, IC, ECH), high ne)

Electron Transport

Small rotation due to small external torque (=> intrinsic torque)

Small central fueling (high energy NB) => density profile ?

Confinement performance with metal divertor can be recovered?

Accumulation of heavy impurity (metal wall) ?

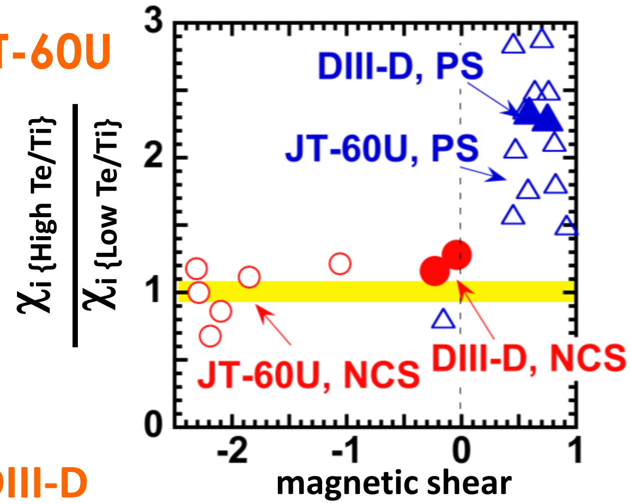
Isotope Effects on Confinement?

Thermal Transport at high Te/Ti

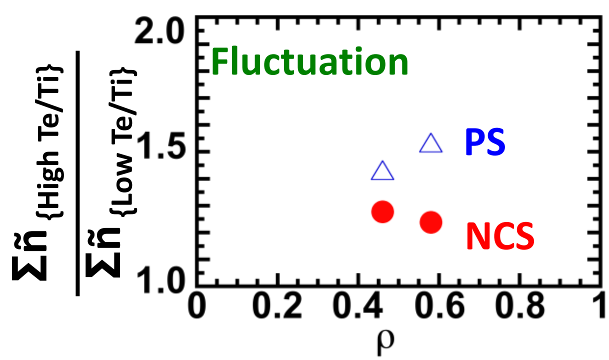
DIII-D and JT-60U: Positive Shear (PS) shows reduction in T_i when ECH is added. Negative Central Shear (NCS) minimizes confinement degradation even with increasing T_e/T_i~1. DIII-D shows smaller rise in low-k turbulent fluctuations in NCS than PS. **(EX8-1, Yoshida)**

DIII-D / JT-60U

T_e/T_i~1

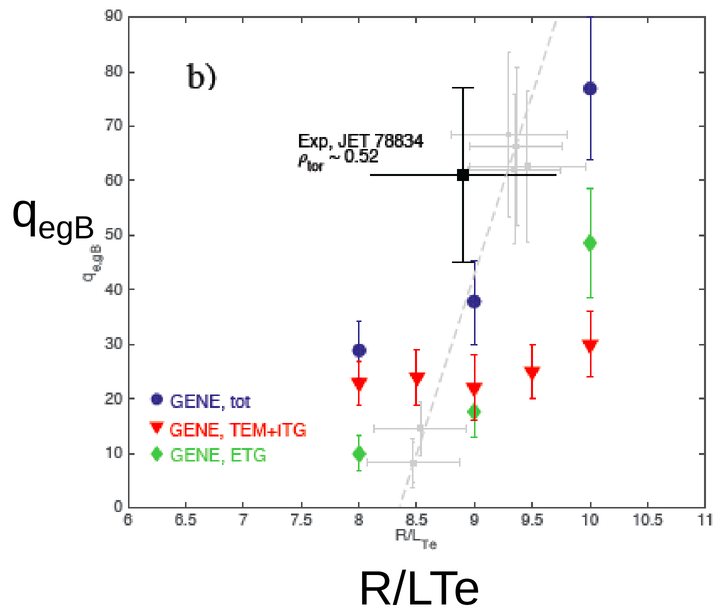


DIII-D



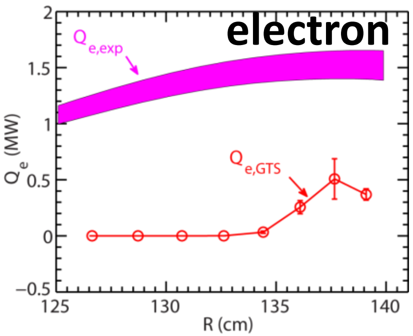
JET: High Te/Ti plasmas: Electron transport evaluated with linear gyro-kinetic simulations GENE: most consistent with (ITG/TEM) + ETG.
=> Multi-scale non-linear gyro-kinetic simulation underway.

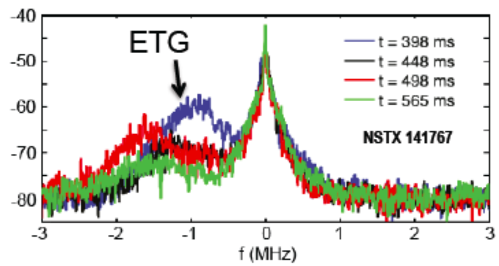
(EXP6-14, Mantica)



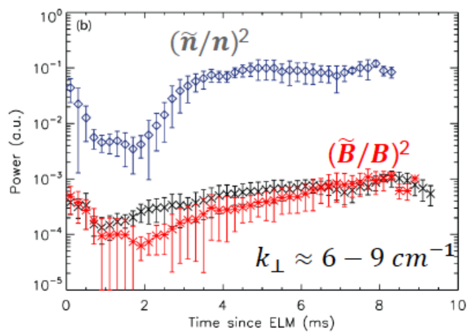
Electron thermal Transport

NSTX: Electrostatic low-k Gyrokinetic Simulation (GTS) explains ion thermal transport , but is not able to explain electron transport. => high-k ETG / EM is important for electron transport. Nonlinear GYRO simulation explains grad-n stabilization of ETG, but not enough => EM? **(EXP4-35, Ren)**

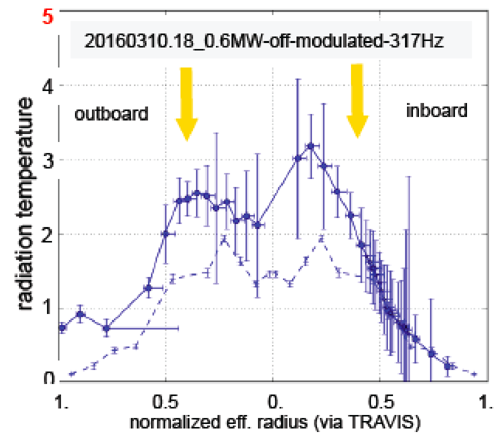




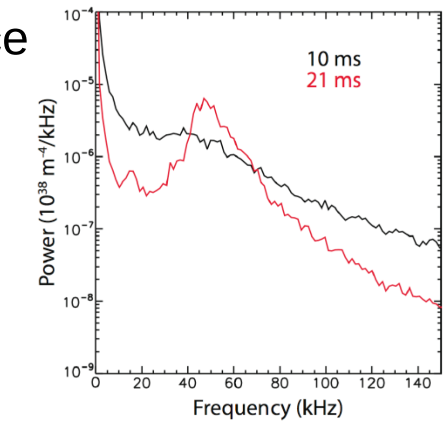
MAST: Fluctuation measured at the top of pedestal is consistent with Electron transport evaluated with linear gyro-kinetic simulations GENE: consistent with ETG. **(OV5-3, Kirk)**



W-7X: T_e profile shape follows the ECRH Power deposition
-> no indication of profile stiffness
(EX4-5, Hirsch)

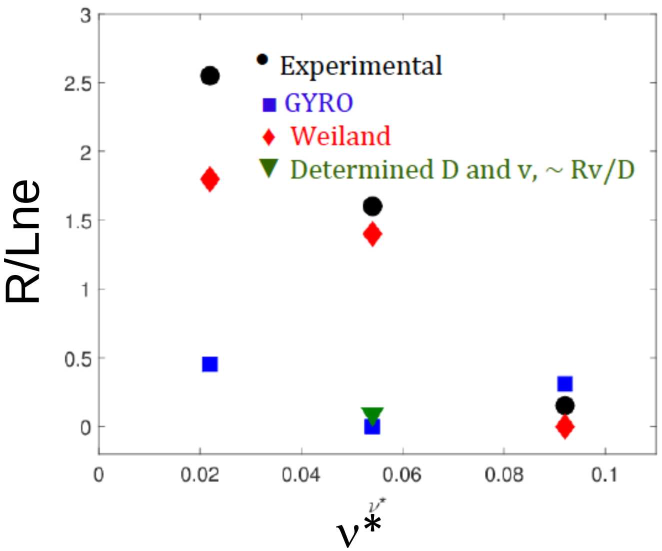


MST: Drift wave turbulence (TEM) emerges in RFP plasmas when global tearing instability is reduced by PPCD. **(EXP5-17, Brower)**



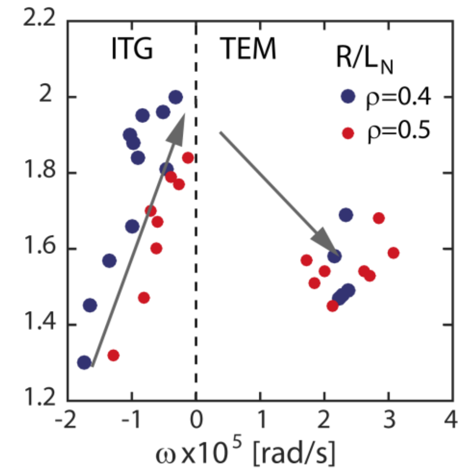
Density Profile => low ν* ITER ?

JET: Density peaks with decreasing υ* => experimentally determined particle transport coefficients. =>suggest that NBI fueling is the main contributor to the observed density peaking. **(EXP6-12, Tala)**

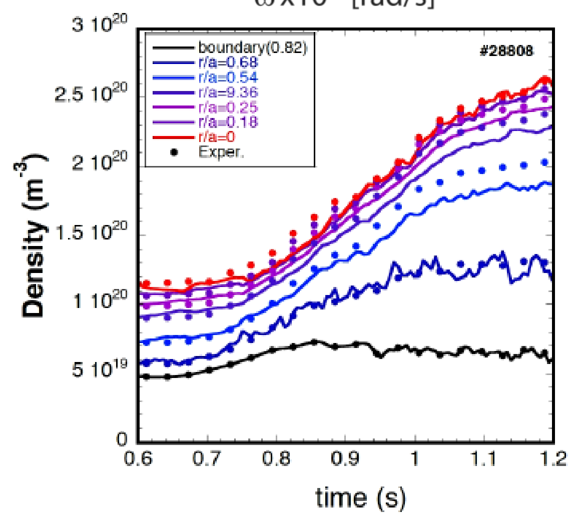


DIII-D: Change in peaking is reproduced by changes in core fueling only . **(EXP3-9, Mordijck)**

DIII-D: The density scale length R/Ln is well-correlated with the frequency of the dominant unstable mode, with the peaking when the turbulence switches from ITG to TEM.
(EXP3-9, Mordijck)



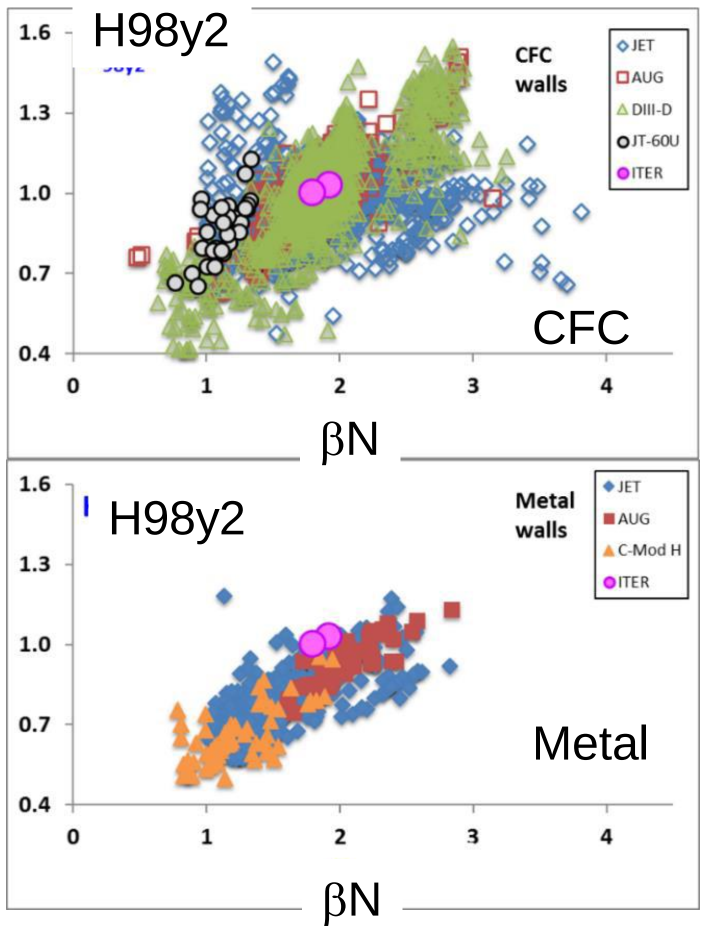
FTU: The density profile evolution in high density regime has been well reproduced using a particle pinch term with dependence on temperature gradients (U= DT /Te ∂Te/∂r) **(EXP8-24, Tudisco)**



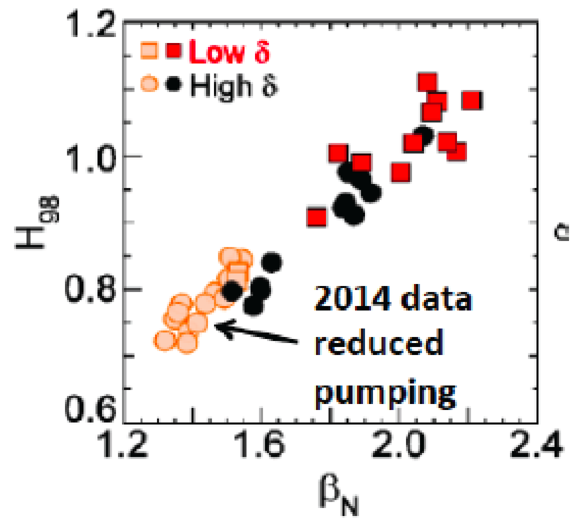
ISTTOK: Edge electrode biasing improves particle confinement by reducing radial transport via ExB shear layer formation**. (EXP7-36, Malaquias)**

Confinement towards ITER: high β_N is the key

AUG, C-Mod, DIII-D, JET and JT-60U:
Stationary H-mode discharges at q95=2.7-3.3:
1) The maximum H98 increases at lower ν*.
2) H98 increases with βN, however for metal wall H98 significantly reduced (~0.8-0.9) at βN≤1.8, H98~1 is obtained only for βN~2 or higher.
(EX6-42, Sips)

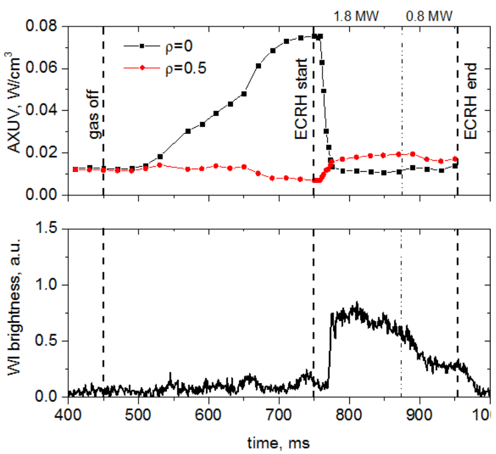


JET-ILW: stationary (5s) ITER Baseline Operation at high-δ (~0.4) achieved at 2MA/2.2T, q_{95}=3.2. New high-δ configuration optimized for pumping H=1-1.1, β_N=1.8-2.1 but n/n_{GW}~ 0.5
(EX/P6-11, De la Luna)



Avoidance of Heavy Impurity Accumulation ~ good

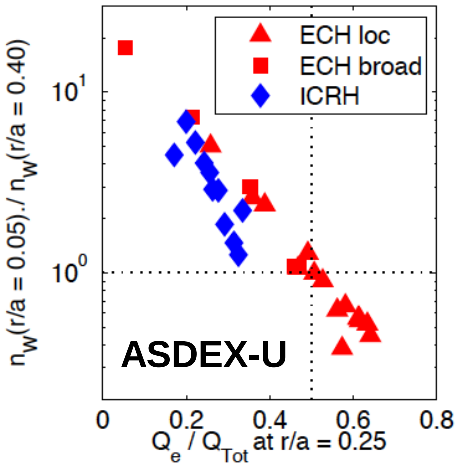
T-10: W / ECH
After ECRH start a fast decay of core radiation occurs. **(EXP8-36, Nurgaliev)**

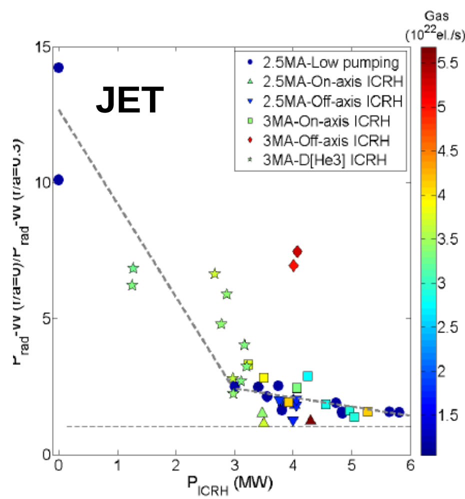


KSTAR: Ar / ECH
(EXP4-18, Hong)

HL-2A:Al / ECH
m/n=1/1
(EXP7-21, Cui)

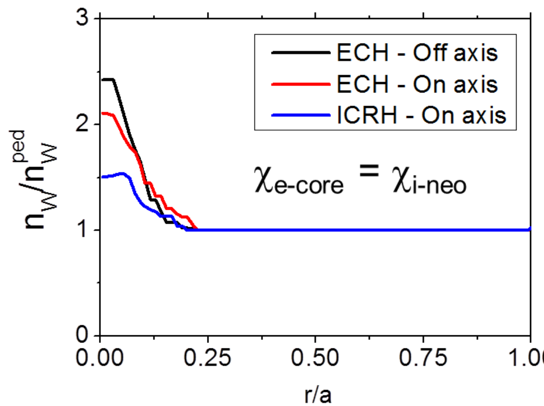
ASDEX-U: Central ECH and ICRH to NB heated H-mode shows the impact of Qe/Qi on the impurity turbulent diffusion as predicted by Nonlinear gyrokinetic simulations with GKW **(THP2-6, Angioni)**





JET: W/ ICRF minority
Central ICRH is beneficial on tungsten transport in the ITERbaseline scenario **(EXP6-16, Goniche)**

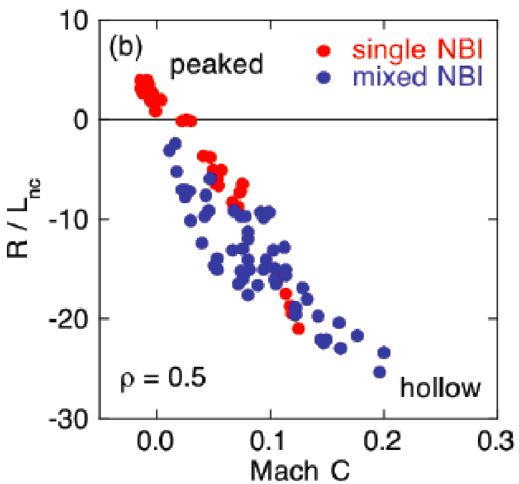
ITER Prediction: No strong W accumulation expected in ITER Q = 10 plasmas due to low NBI fueling. W accumulation in H-L transitions can take place, optimization of heating and fueling ramp-down required. **(PPC2-1, Loarte)**

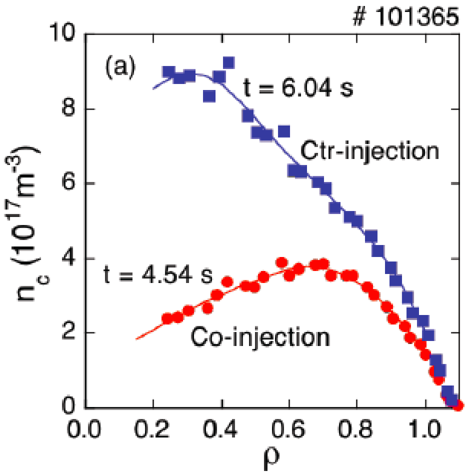


Alcator C-mod: W / ICRF minority (EXP3-3, Reinke)

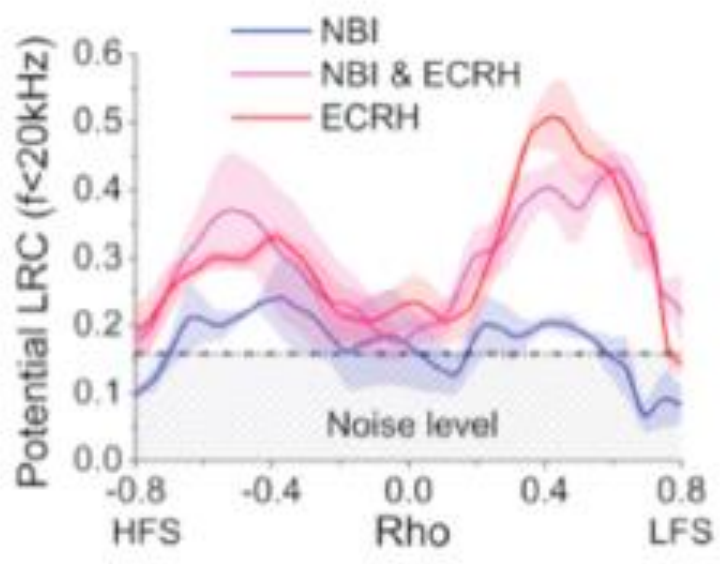
Impurity Transport in the helical system: rotation shear & turbulence drive

LHD: Carbon density profile peaks with decreasing Mach number ~ rotation gradient **(EXP8-4, Nakamura)**.



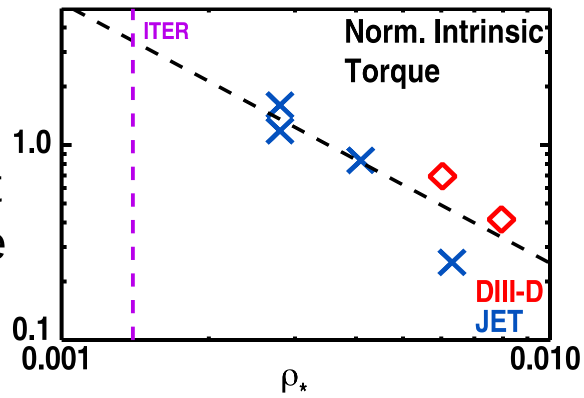


TJ-II: Dual HIBP: ECRH enhances turbulence and amplitude of Long-Range-Correlations (LRC) for potential. **(EXP7-44, Hidargo)**

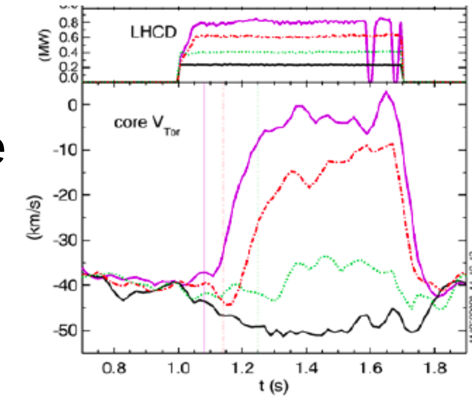


Intrinsic Torque & NTV

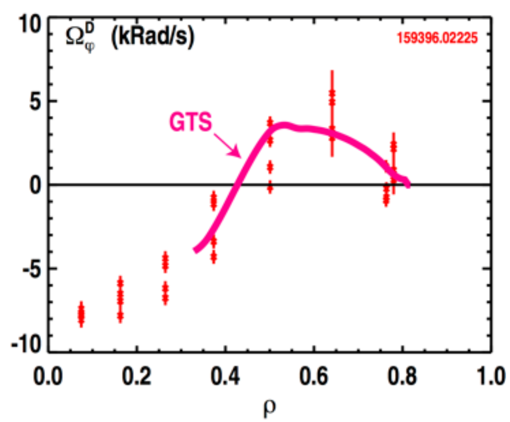
DIII-D + JET : The total intrinsic torque in the plasma is found to increase at lower ρ* (=favorable way to ITER).
(EX11-1 Grierson EXP3-13 Degrassie)



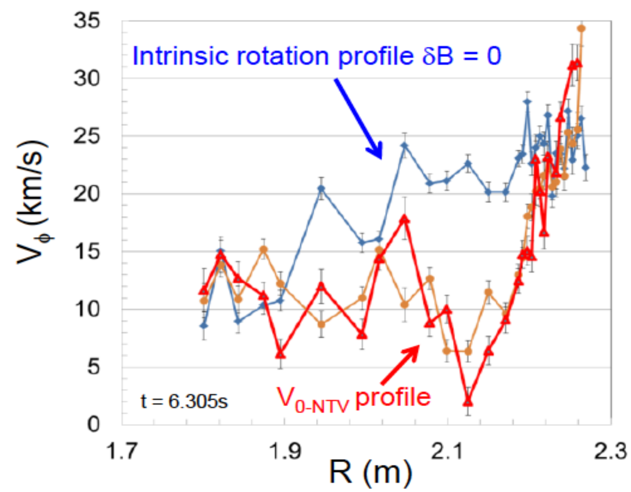
Alcator C-mod: Direction of core rotation changes in the following LHRF injection depends on the whether q0 is below or above unity.
(EXP3-2,Rice)



DIII-D : Simulations with GTS gyro-kinetic code reproduces reversal of core intrinsic rotation **(EX11-1 Grierson)**

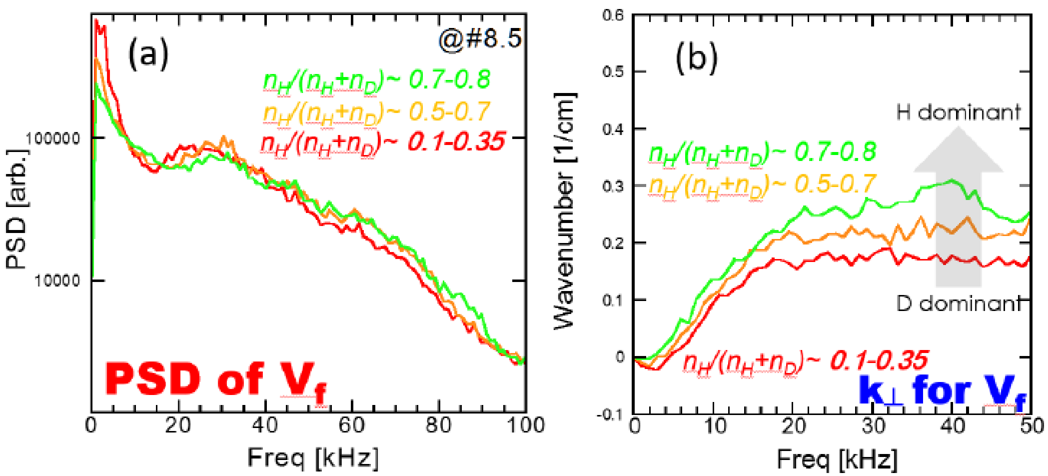


KSTAR+NSTX: Neoclassical Toroidal Viscosity (NTV) Torque: The measured rotation profile change due to the 3D field **(EXP4-33, Sabbagh)**

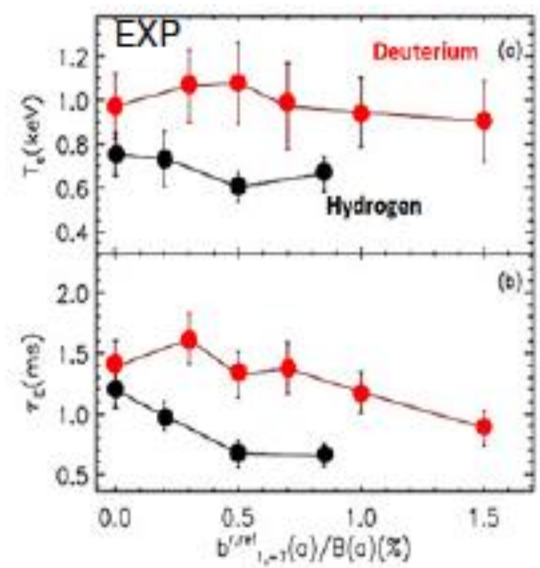


Confinement: Isotope Effects / Mass Dependence

Heliotron-J: The turbulence scale size increases as D2 gas becomes dominant. = The first evidence for the isotope effect on turbulence-zonal flow system in helical systems**. (EXP8-20: Ohshima)**

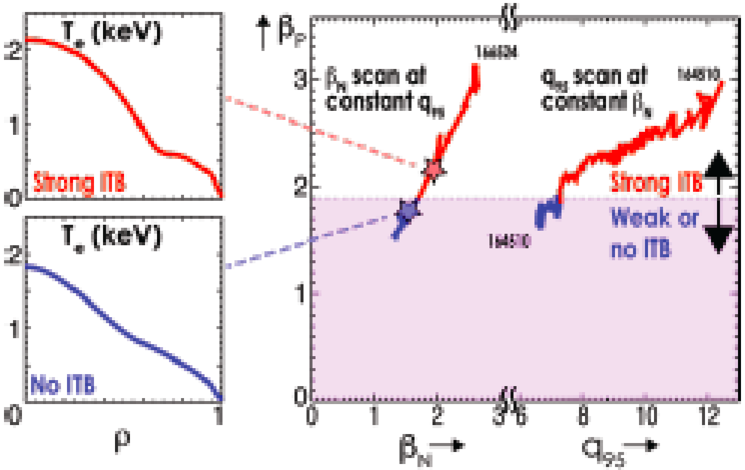


RFX-mod: 3D RFP Confinement is better for D than H **(OVP-2, Zuin)**

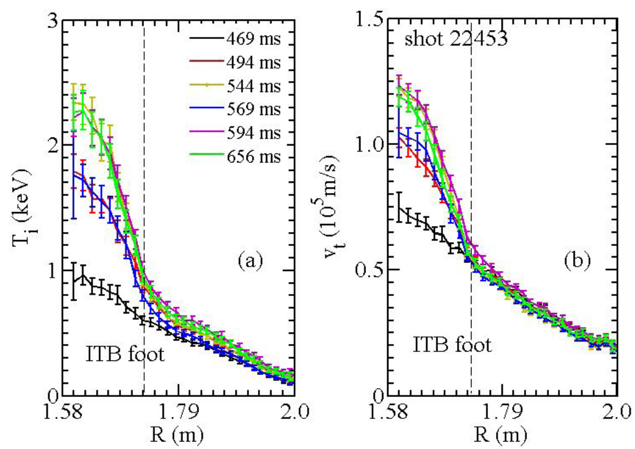


Improved Confinement Performance: ITB

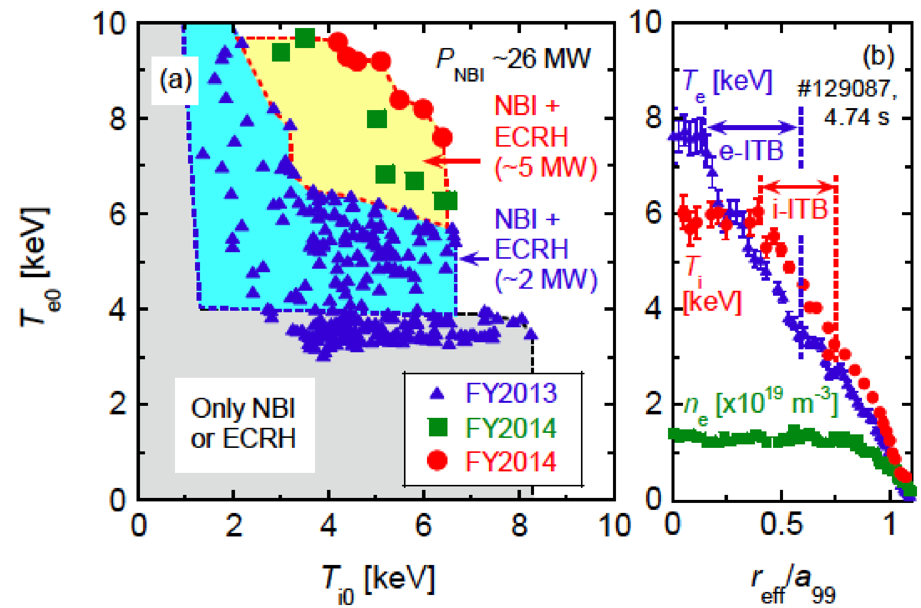
DIII-D: Large radius ITB and excellent confinement due to Shafranov Shift Stabilization. **(EX4-2, Qian)**



HL-2A: Ion ITB was observed at the q=1 surface. ITG is suppressed by the toroidal rotation shear. **(EX8-2, Yu)**



LHD: High *Ti* & *Te* > 6 keV were simultaneously achieved by high power ECH injected into NB heated plasmas characterized by simultaneous formation of electron and ion ITBs. **(PPC1-1, Takahashi)**.



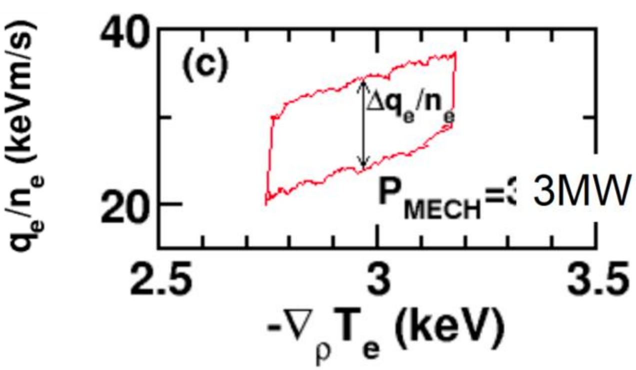
Transport hysteresis & non-localness

Multiple Machine: Transport hysteresis in core plasmas is widely observed.

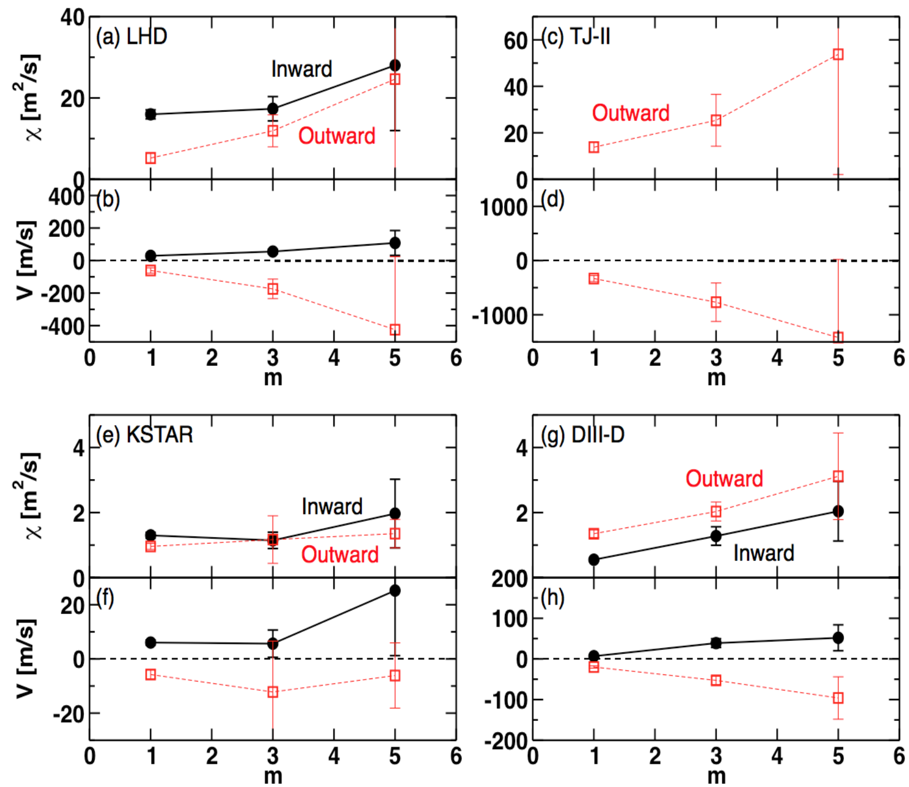
The core hysteresis involves two elements:

1. Interaction at long distance
2. Direct influence of heating on transport/fluctuations

=>‘*The heating heats turbulence*’ **(OVP-8, Itoh)**



Modulation ECH: Difference between results from the inward pulse and the outward pulse becomes larger as the harmonic number increases (**EXP8-15, Kobayashi)**

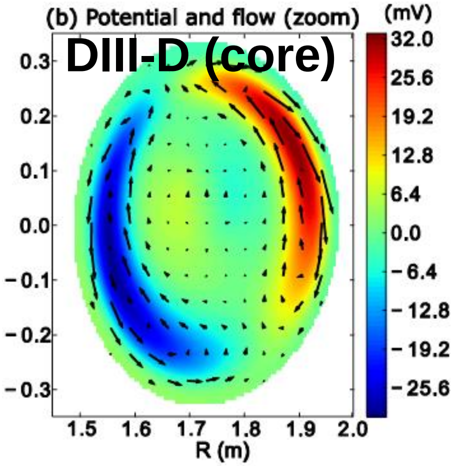


harmonic number of modulation

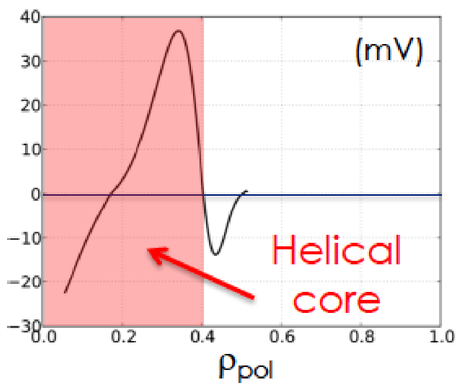
KSTAR: The non local transport (NLT) can be affected by ECH, and the intrinsic rotation direction follows the changes of NLT. **(EXP4-17, Shi)**

Effects of 3D field on equilibrium & stability

DIII-D & RFX-mod : Role of MHD dynamo in the formation of 3D equilibria.
high-β tokamak : The MHD dynamo model predicts current redistribution consistent with DIII-D experiments
(EX1-1, Piovesan)



Mean-field dynamo EMF. Consistent with expected current redistribution



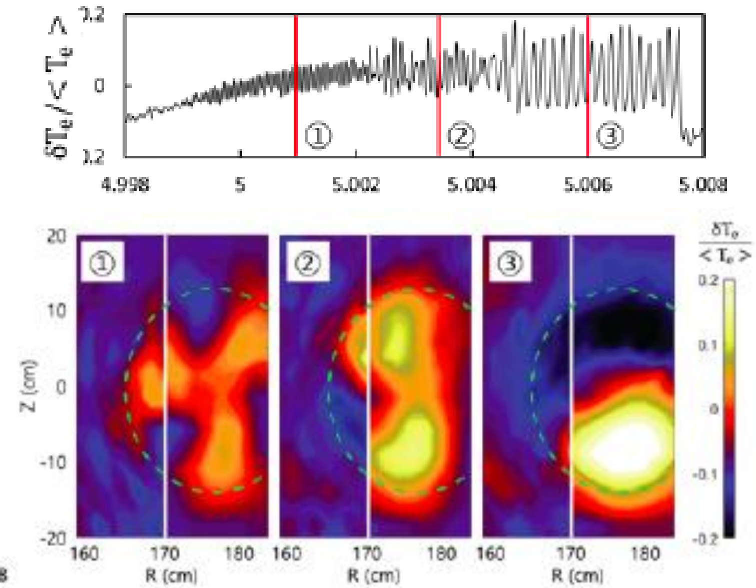
LHD: Phase shifted magnetic islands from externally imposed m/n = 1/1 RMP was obserbed **(EXP8-8, Narushima)**

J-TEXT: RMP increases the density limit from less than 0.7nG to 0.85nG and lowers the limit of the edge safety factor from 2.15 to 2.0. **(OVP-6, Zhuang)**

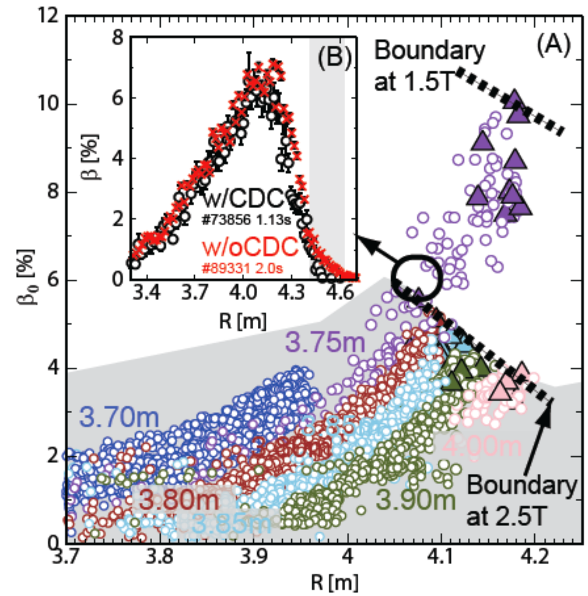
EXTRAP T2R: The resonant MP produces tearing mode braking and locking consistent with the prediction. **(EXP5-18, Frassinetti)**

Sawtooth, high β stability

KSTAR: validated q0>1 after sawtooth crash: tearing mode evolve (e.g. 3/3 to 2/2, 1/1) **(EXP4-3, Park, EXP4-27, Ko)**



LHD: Central β of the super dense core plasma is limited by "core density collapse" (CDC). A new type of ballooning mode destabilized from the 3D nature is the cause of the CDC. **(EXP8-10, Ohdachi)**



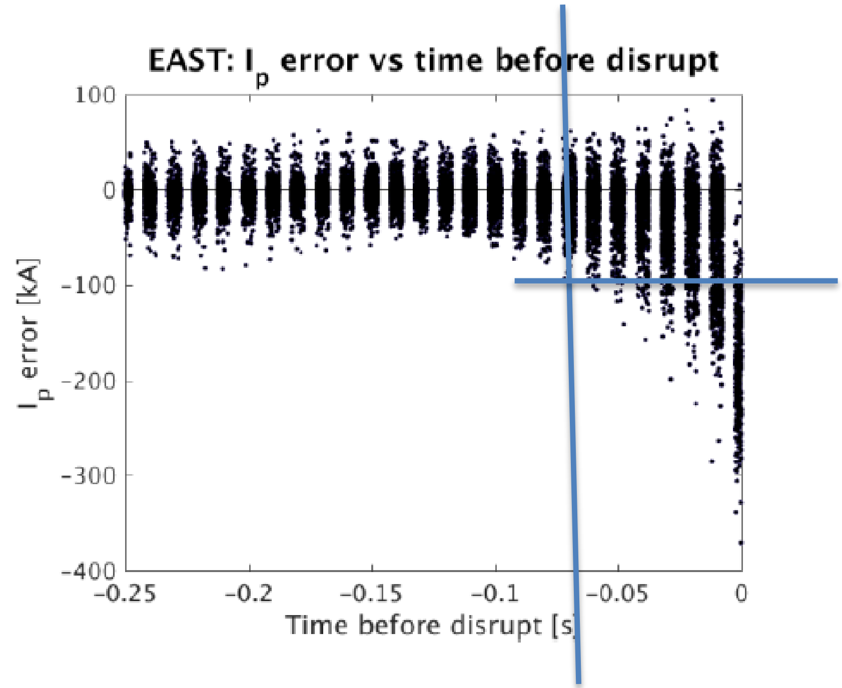
RELAX: The discharge duration is limited(RWM). The central βp~*15%* was achived in the Quasi-Single Helicity (QSH) state**.(EXP5-22, Masamune)**

Disruption Prediction/Characterization

Alcator C-mod & EAST: Developing Disruption Warning Algorithms Using Large Databases. **(EXP3-8, Granetz)**

NSTX: Disruption Event Characterization and Forecasting (DECAF) code has the potential to track RWM stability in real-time for disruption avoidance. **(Berkery, EX/P4-34)**

ADITYA: The current quench time is inversely proportional to q-edge. **(Tanna, OV/4-3Rb)**

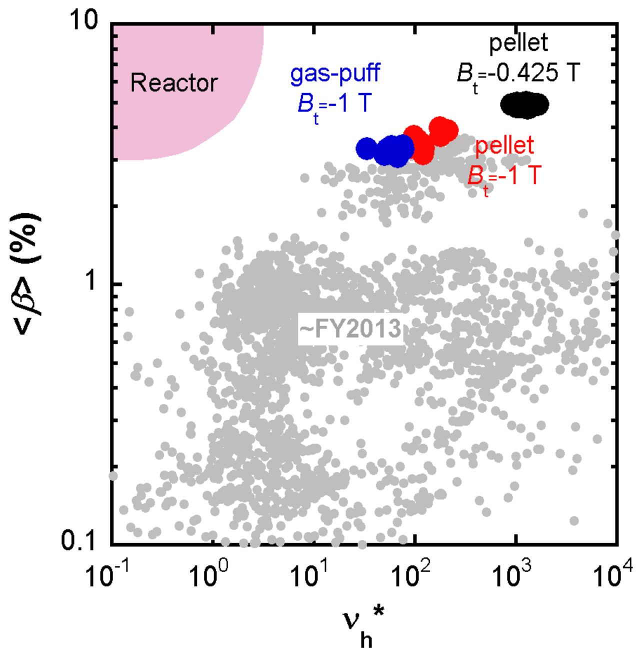


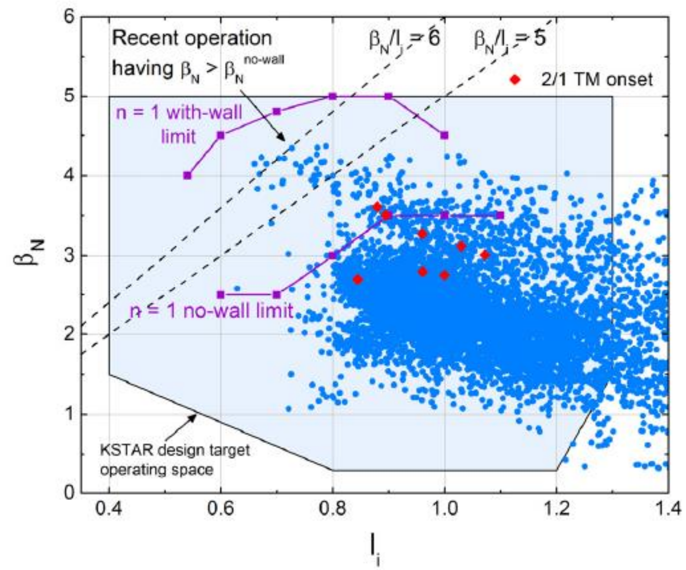
Expanded High β Regimes

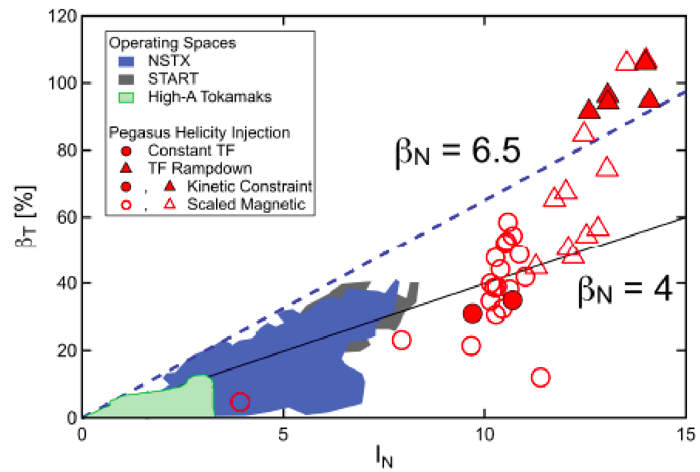
LHD: High-β ~ 4% was produced by multi-pellet injections at low ν*. Improved particle confinement was observed during a high-beta discharge produced by gas-puff.
(EX4-4, Sakakibara)

KSTAR: High β_N, up to 4.3 was achieved with high ratios of β_N/l_i up to 6.3. High β_N ~ 3.3 was sustained for 3 s, and was limited by a 2/1 tearing mode.
(EXP4-2, Park)

PEGASUS: With Local Helicity Injection (LHI), βt~100% was achieved, often terminated by disruption (n=1)
(OV5-4, Fonck)

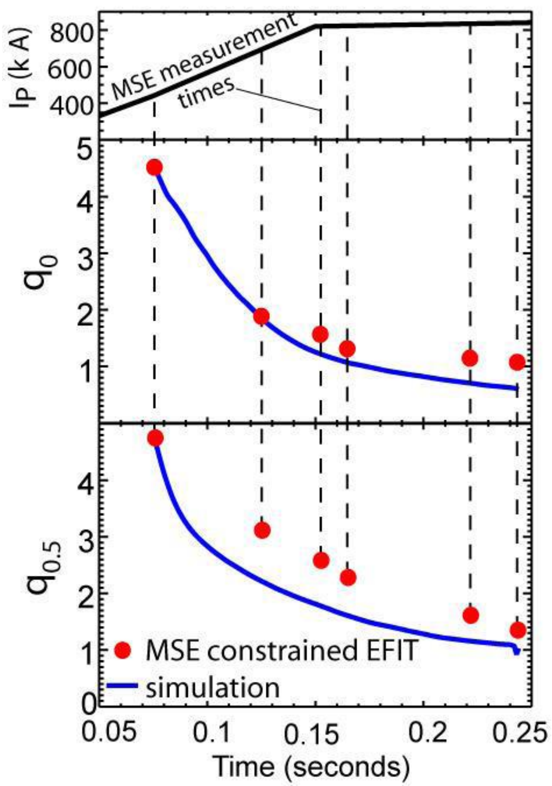




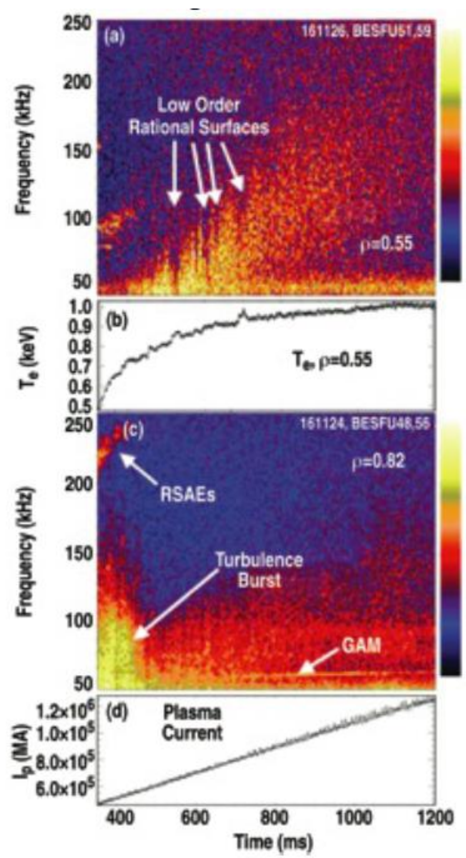


Operation: Plasma Current Rump-up → ITER & DEMO

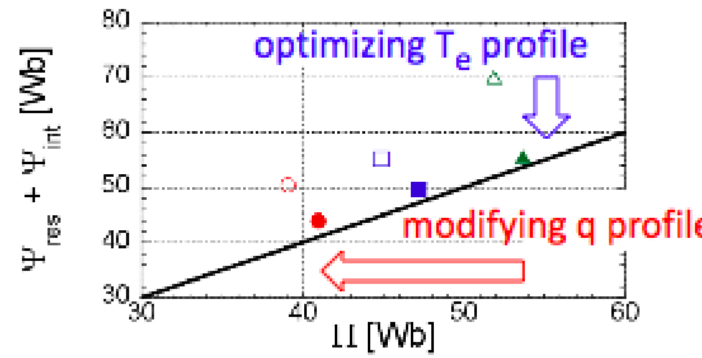
MAST: In Ip ramp-up, the real current diffusion is slower than TRANSP. But, it is well modeled during Ip flat top.**(OV5-3, Kirk)**



DIII-D: There are strong interactions between Te, fluctuation, thermal transport, safety factor, and low-order rational surfaces.
(EXP3-10, McKee)



JA-DEMO: Reduction of CS flux consumption at I_p ramp-up
(EX/P8-38, Wakatsuki)



By optimization of both Te and q profiles, ~20% reduction of flux consumption is possible.

Improved modeling
is needed for DEMO design

=> CS size
= economy of DEMO

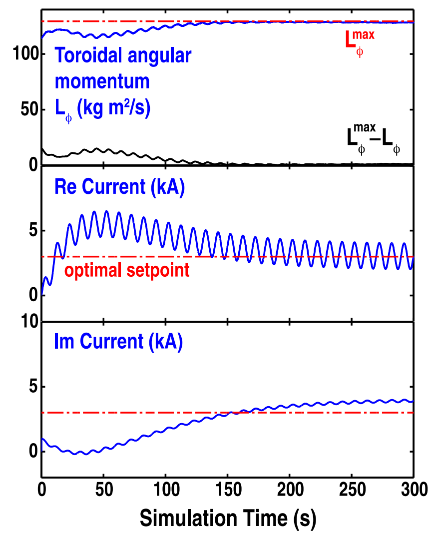
Control of ITER & SC tokamak operation

For ITER Plasms Control system (PCS)

- Preliminary design of the ITER PCS focusing on the needs for 1st and early plasmas. **(EXP6-36, Snipes)**

- Control analysis and design tools developed at DIII-D have been applied in studies supporting the ITER PCS design. **(EXP6-37, Humphreys)**

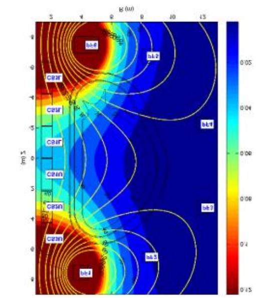
Real-time Error Field Correction: Varies correction field amplitude phase to maximize plasma rotation



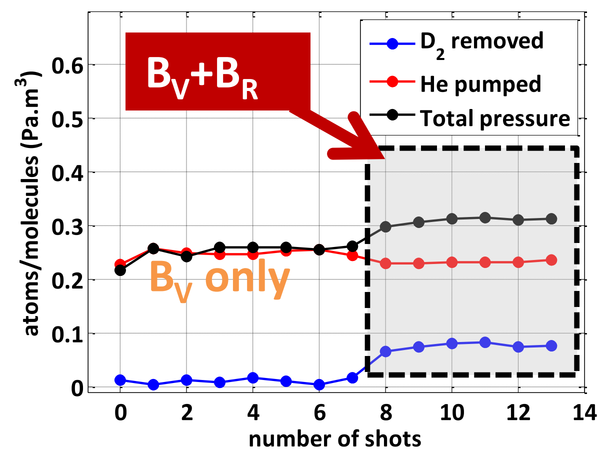
- Generation of the disruption mitigation. **(EXP6-38, Pautasso)**

KSTAR: Extending vertical stabilization controllability **(EXP4-12, Hahn)**

KSTAR: Trapped Particle Configuration for EC plasma breakdown **(EXP4-14, Lee)**

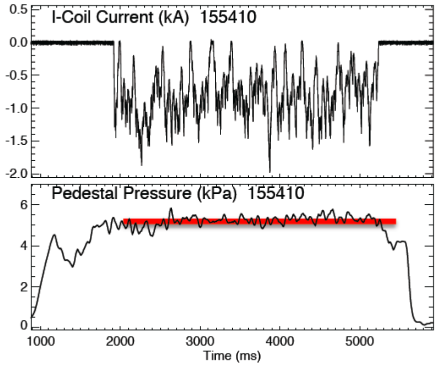


TCV: EC wall conditioning for JT-60SA **(EXP8-31, Douai)**



Advanced control

DIII-D :demonstrated Adaptive Real-Time Pedestal Control with RMP by real time stability evaluation **(EXP3-21,Kolemen)**



DIII-D : Physics-model-based q-profile Feedback Control **(EXP3-23, Schuster)**

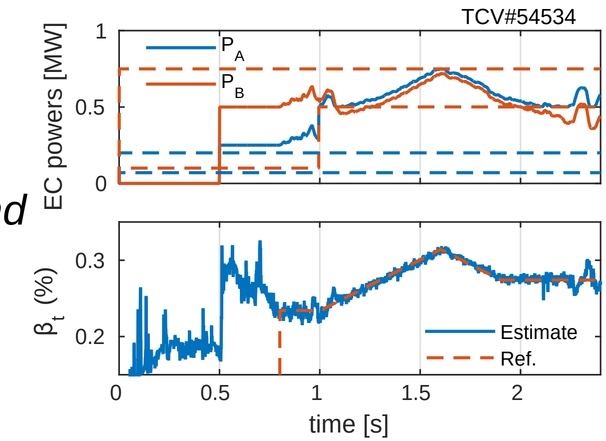
KSTAR: Physics-Based Profile Control **(EX/P4-13, Kim)**

Realtime tokamak simulation with a first-principle-based neural network turbulent transport model **(EX/P6-45, Citrin)**

NSTX-U: Feedback Control Using TRANSP for Non-inductive Scenarios **(EX/P4-43, Boyer)**

TCV, ASDEX-U & ITER: Real-time model -based plasma state estimation **(EX/P8-33, Felici)**

TCV: Beta is estimated by model-based and controlled with two gyrotrons to follow Ref.



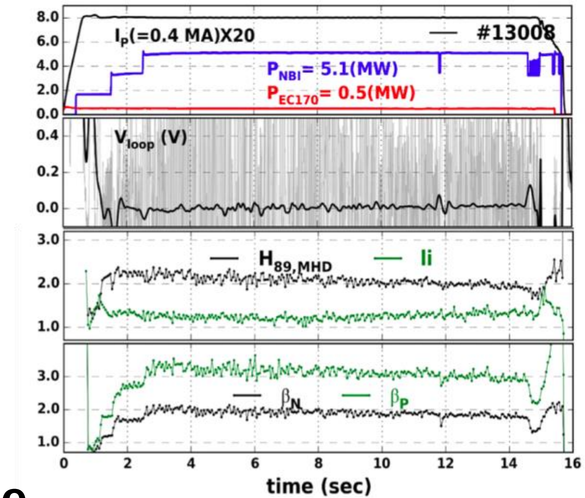
STOR-M: Toroidal Flow was modified through Momentum Injection by CT Injection **(EXP7-39, Xiao)**

FT-2: Improved Core Confinement Observed with **LHCD (EXP7-41, Lashku)**

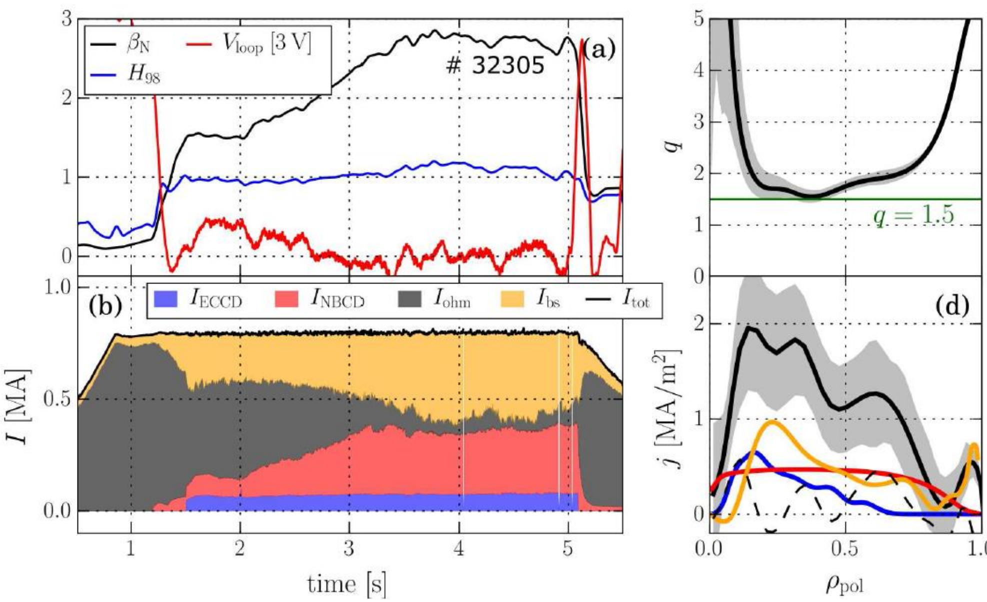
Steady-state Advanced Tokamak Operation Extended

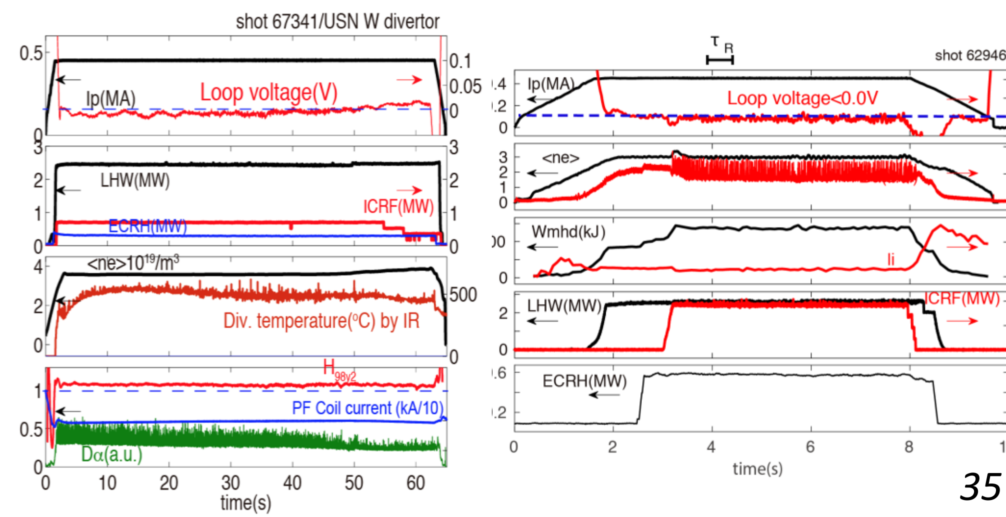
ASDEX-U: Fully non-inductive operation with W wall at I_p= 0.8 MA(40% NBCD, 50 % boostrap, 10 % ECCD). ECCD is used to tailor current profile for optimum stability and q_{min} > 1.5
(PD, Stober)

KSTAR: Fully non-inductive current drive with fBS < 0.5, βp > 3, βN ~ 2, H89 ~ 2.0 with NBCD & ECCD (Ip=0.45MA) **(EXP4-1, Yoon)**

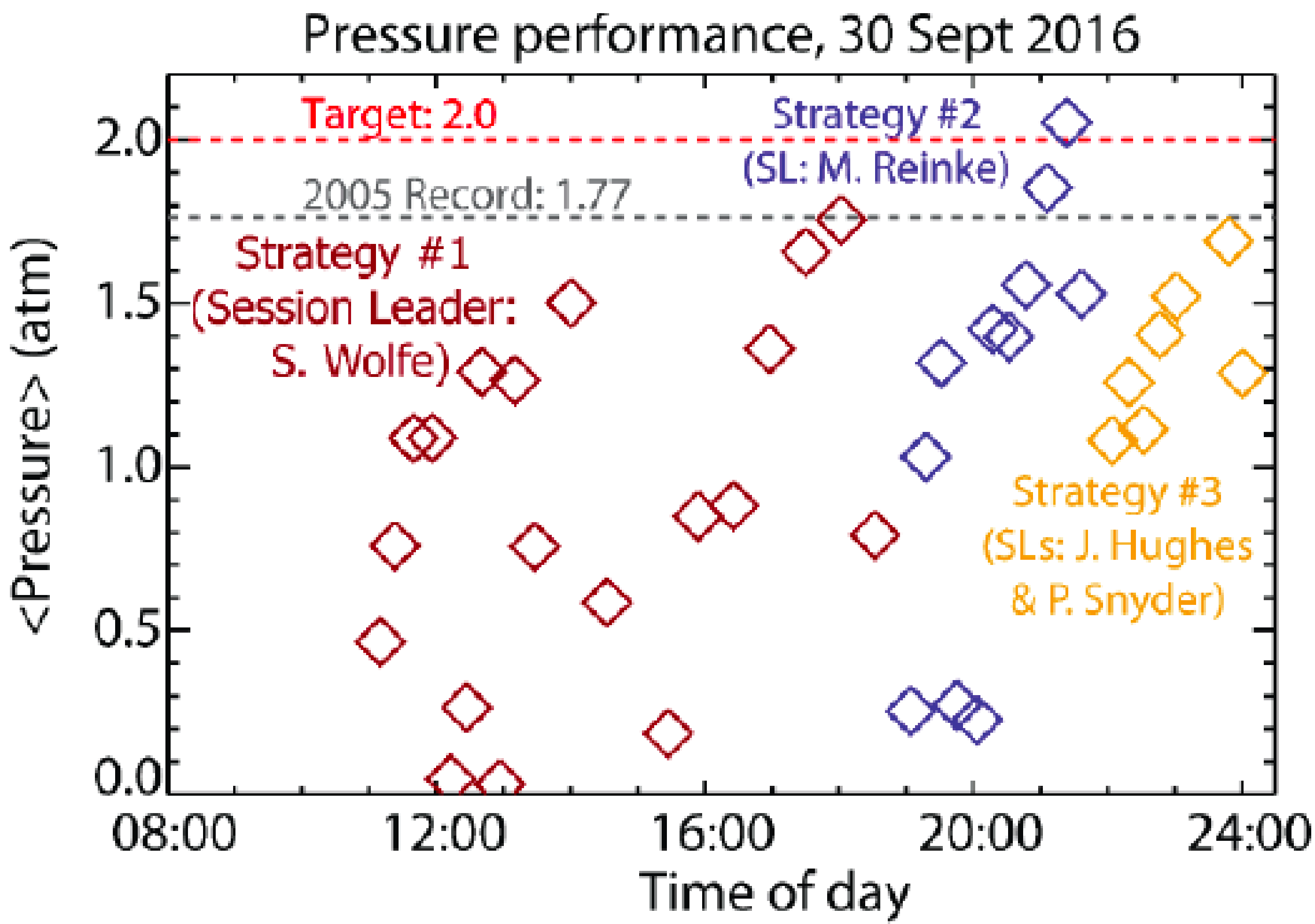


EAST: 60sec H-mode
Demonstration of full-CD (LHCD, ECCD, ICRRF) with W wall, β_P~1.1; q_{95}~6.3, t/τR~15, H98>1.1.(**EX4-3, Garofalo**)





New Tokamak World Record of volume averaged pressure 2.05atm was achieved in Alcator C-mod



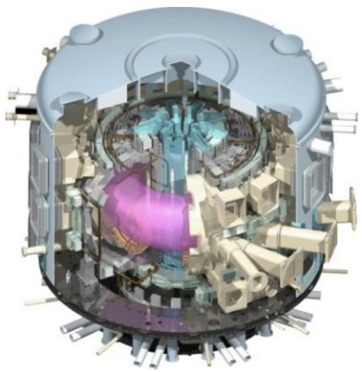
Summary: EXC, EXS and PPC

'3D' has become more common language and tool.

Understanding of H-mode & ELMs, and practical control scenarios have been progressed toward ITER.
(such as, wide applicability & steady-state ELM mitigation by RMP, understanding of confinement with W-divertor)

Transport / turbulence / instabilities are reproduced well by simulations

ITER



Encouragements towards next FEC

Width of the H-mode pedestal
Electron Transport / multiple scale transport
Disruption Prediction
Enhanced Effort towards SS tokamak operation