

# An Assessment of Phase Space Engineering

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## What does this topic mean?

With alpha particles, both their energy and position are relevant. We need to maximize the positive and minimize the negative properties associated with energetic particle confinement.

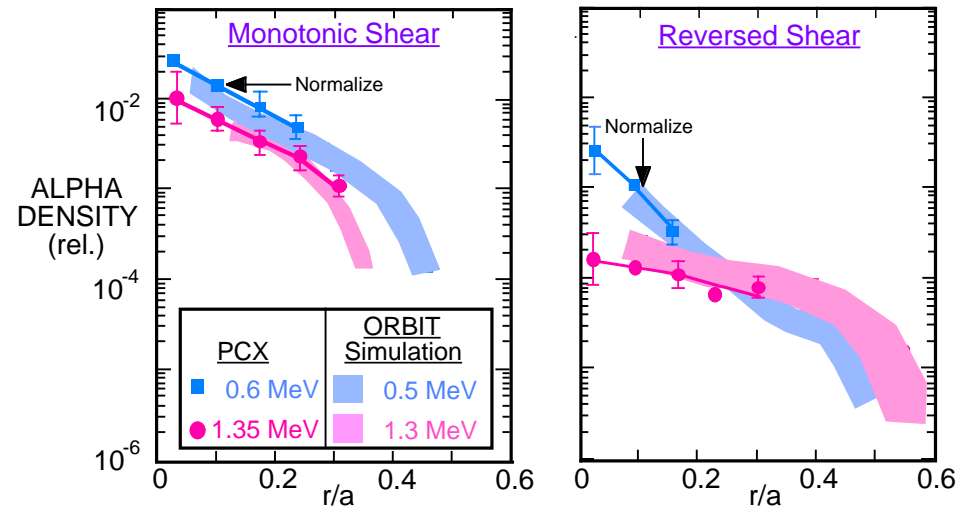
### I. We need to know where the alpha particles are to determine heating properties for ignition scenarios

*A. Classical confinement with field errors (together with plasma transport properties) gives prediction for heating and burn development.*

[see figure on control of ripple-induced loss ]

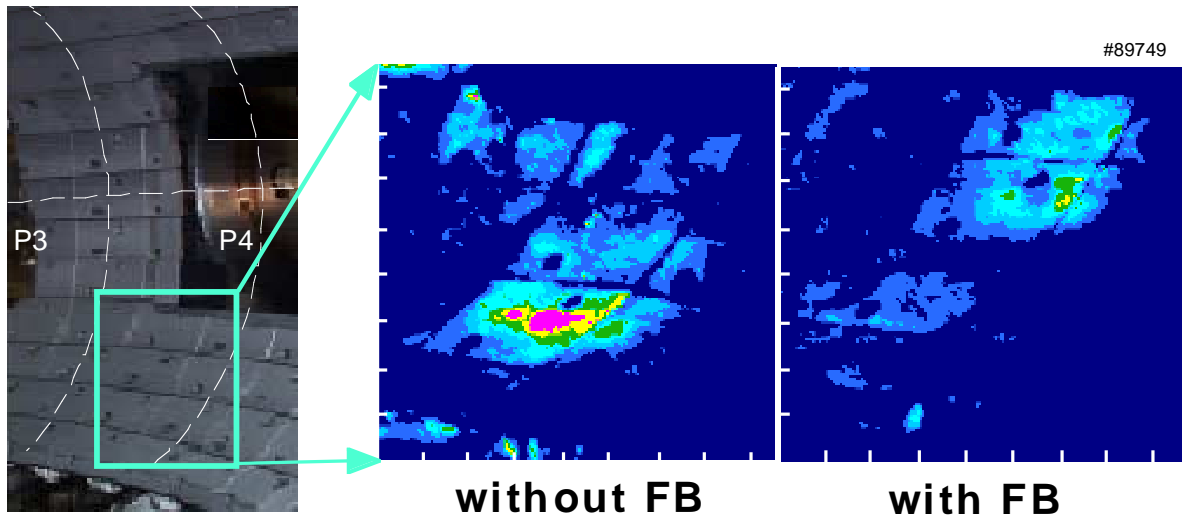
# Dramatic Progress in Detailed Understanding and the Control of Ripple Induced Loss

Depletion of 3.5 MeV confined alphas in the core of reverse shear plasmas on TFTR consistent with enhanced ripple transport for  $q(0) > 1$



Identification and control of ripple induced transport of RF ions in JFT-2M

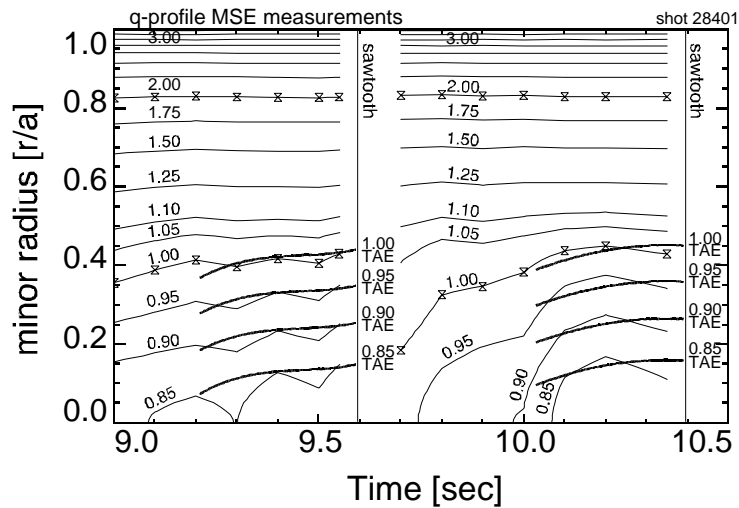
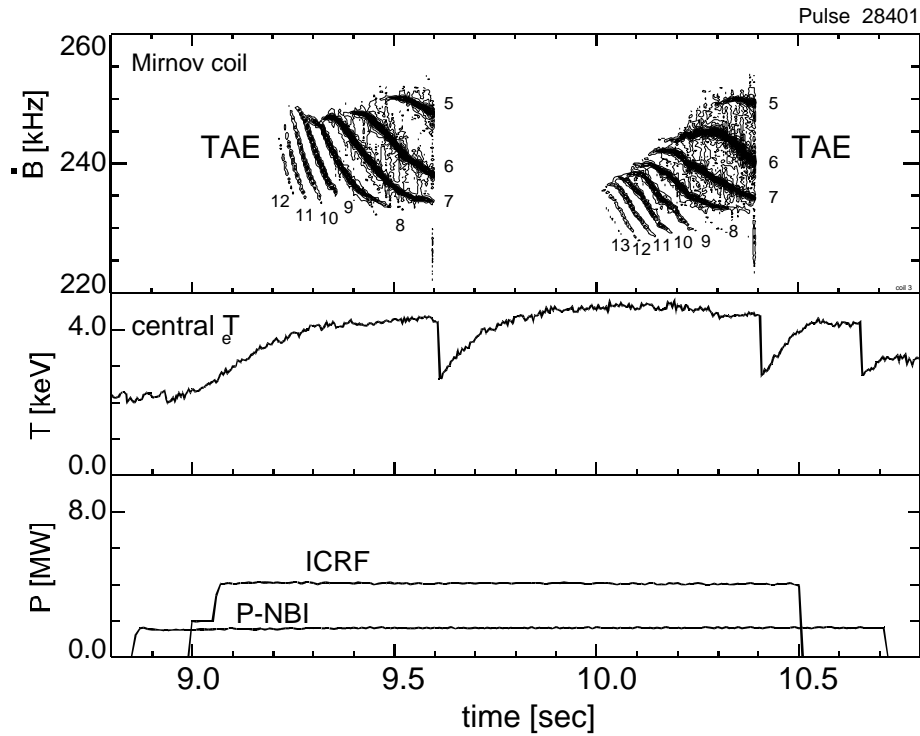
IAEA-TCM, 99, Naka



## ***B. Alpha population needs to be measured***

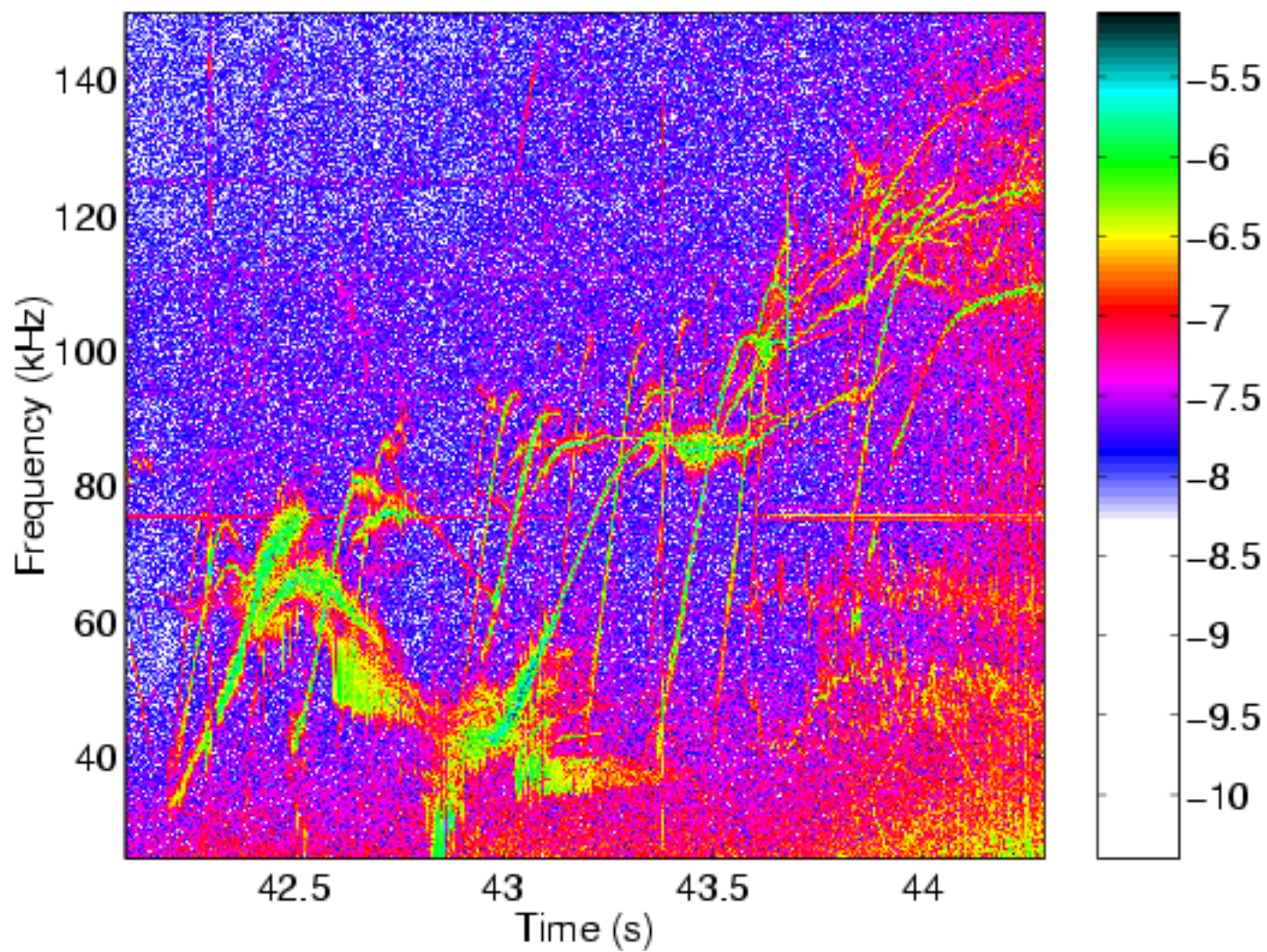
1. “Single particle effects”: e.g., knock-on effect, double charge exchange, escape spectra, etc.
  
2. Self-consistent plasma effects as a diagnostic
  - a. Ion cyclotron emission
  - b. TAE and other Alfvén signatures  
[see q-profile diagnostic figure and TAE figure]
  - c. Fishbone signatures

# Alfvén Eigenmodes as a q-profile Diagnostic on JT-60U



#49382: probe H302 via channel 131

Log(| $\delta B$ |)



## II. Active intervention using alpha particle effects

A. Suppression of saw-teeth (but what about monsters?)

[see sawtooth figure]

B. Waves and “buckets” to control He build-up, energy exchange, current drive, seed currents (highly speculative)

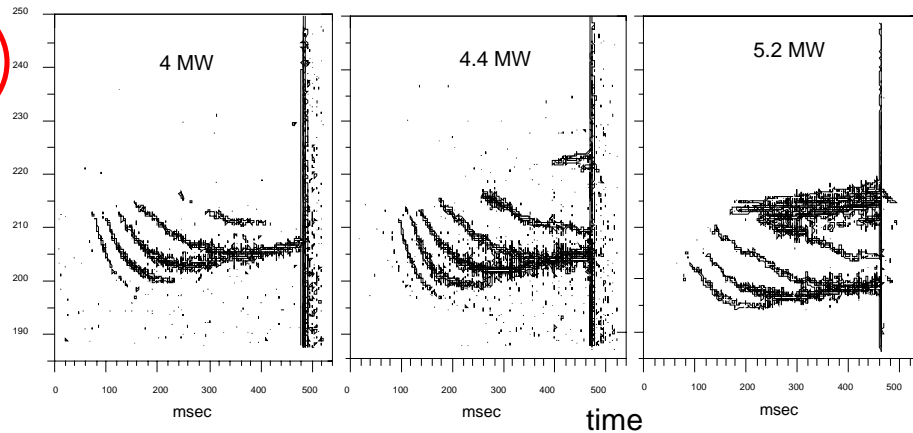
[see lost alpha probe figure and bucket transport figure]

C. Using instabilities to control burn characteristics

# SAWTOOTH STABILITY IS CLOSELY CORRELATED WITH ALFVEN MODES: CRITICAL ROLE OF AEs ON FAST ION TRANSPORT AND MACROSTABILITY

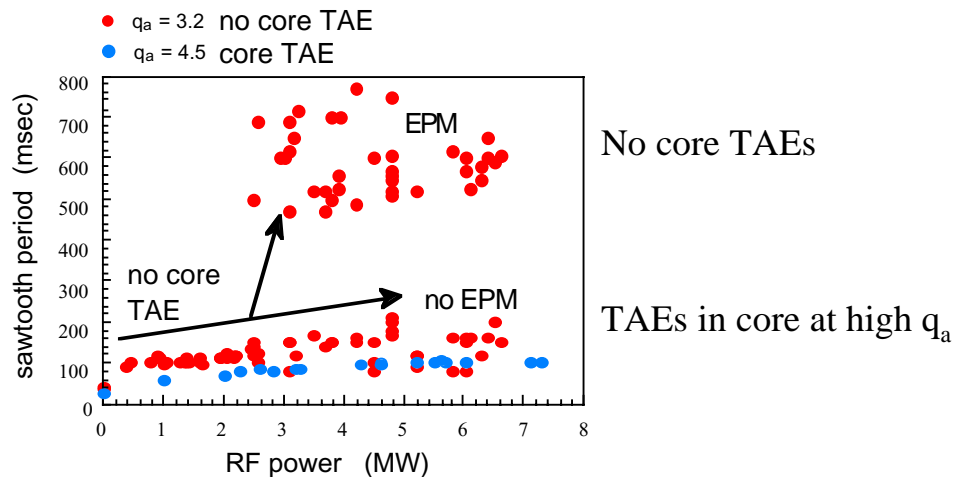
EPM always accompany  
the monster sawtooth.  
Redistribution likely  
cause of Sawtooth crash.

1



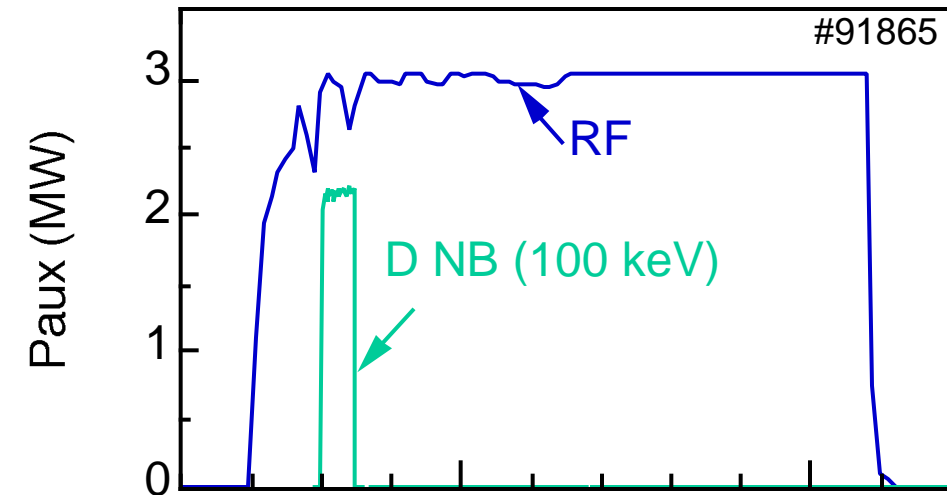
Monster sawteeth form  
ONLY at low  $q_a$ .

2



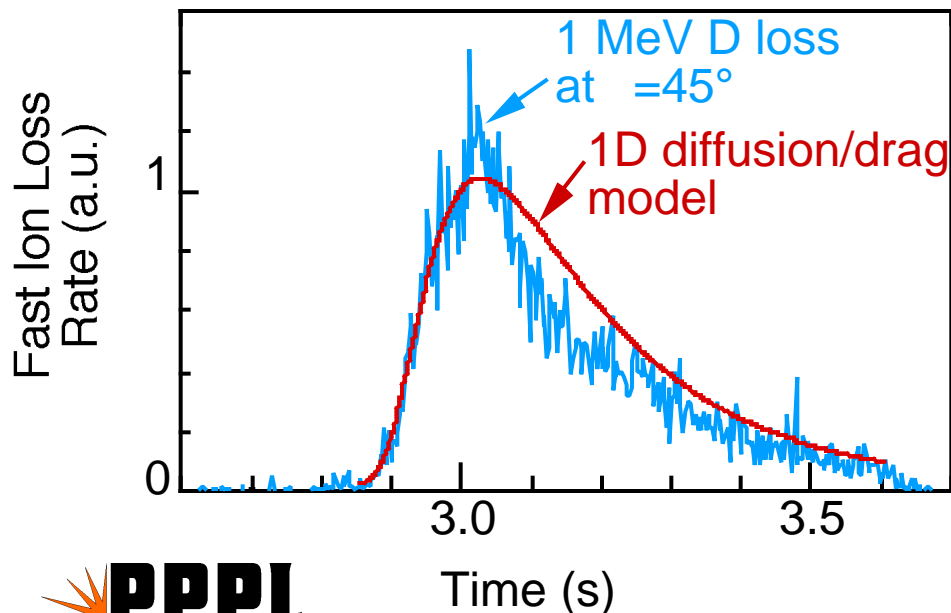
# Anomalous RF-induced Beam Ion Energy Diffusion Observed on “Lost Alpha” Probes

TFTR



- Lost Alpha probes allow direct measurement of energy diffusion (D. Darrow, PPPL)

- Energy diffusion rate of lost beam ions  $\sim 50x$  higher than quasilinear estimate



- Physics mechanism unclear
  - MC-IBW?
  - magnetosonic eigenmodes?

- Detailed & simultaneous measurement of RF field structure & lost particle spectrum required to advance physics understanding



# Radial Transport of Alpha Ash can be Manipulated using Saddle Coils: Bucket Transport

Magnetic perturbation creates drift islands for resonant particles

Frequency-sweep moves drift islands “buckets” in minor radius

Energy selective process

Experiment: Chirp saddle coil signal in order to move drift islands from inner to outer region. **[Observe transport on lost particle detectors and confined particle measurements.]**

Test if enhanced transport across H-layer alters edge  $E_r$ , i.e. use as a control tool for H-mode or edge rotation.

TFTR test case with  $m=2$

