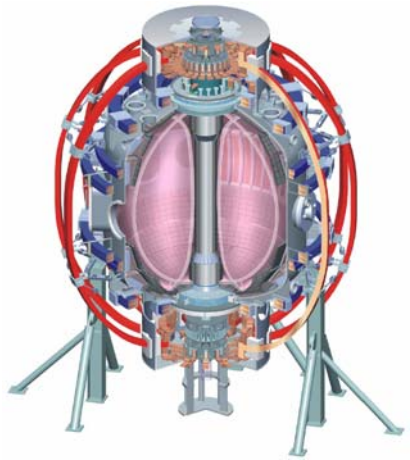
Supported by

XP832: Profile of Fast Ions that are Accelerated by HHFW

D. Liu, W. W. Heidbrink, M. Podestà
University of California, Irvine

R. Bell, S. S. Medley, E. D. Fredrickson, J. Hosea
Princeton Plasma Physics Laboratory

R. Harvey
CompX



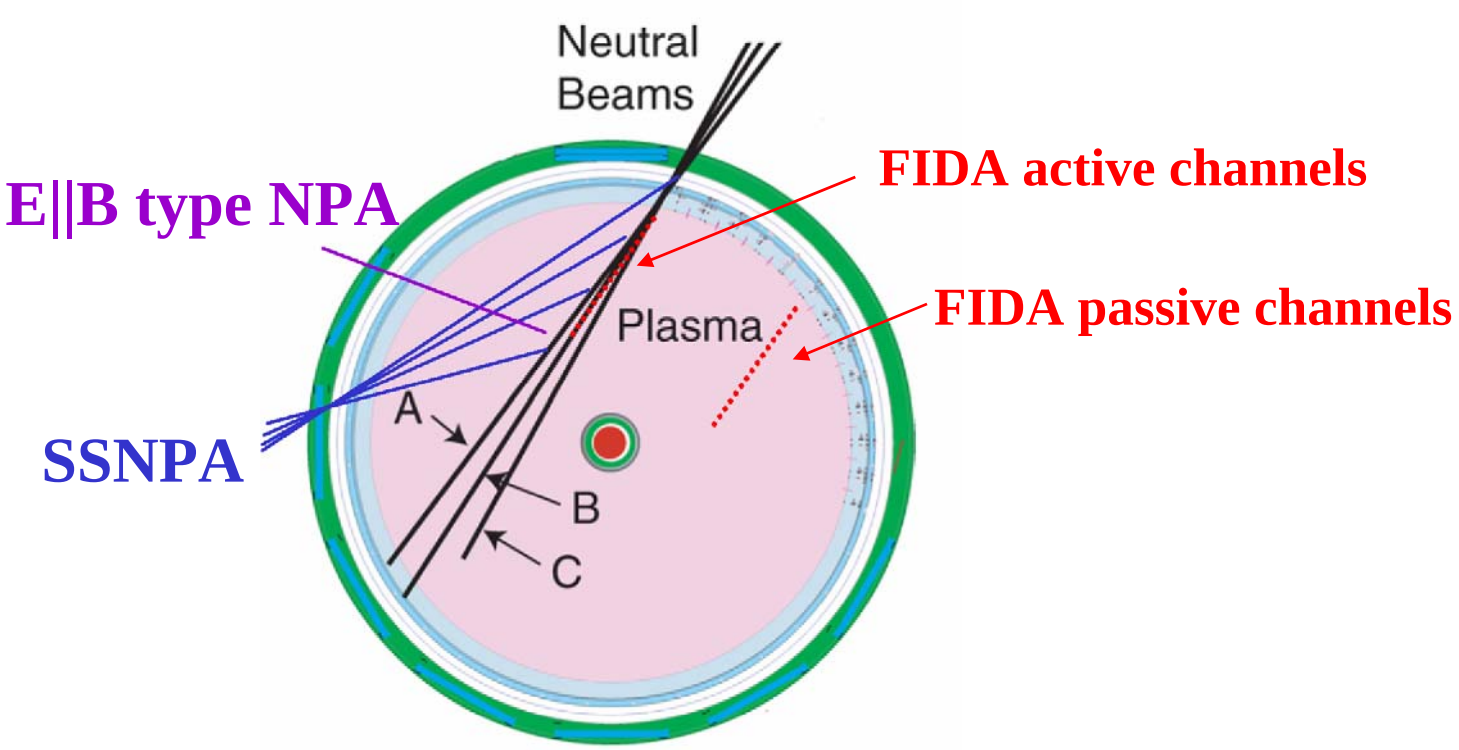
NSTX 2008 Results Review

PPPL PRINCETON PLASMA PHYSICS LABORATORY

UCIrvine University of California, Irvine

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UC Irvine
UCLA
UCSD
U Maryland
U New Mexico
U Rochester
U Washington
U Wisconsin
Culham Sci Ctr
Hiroshima U
HIST
Kyushu Tokai U
Niigata U
Tsukuba U
U Tokyo
JAERI
Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
U Quebec

The Spatial Profile of Fast Ion is Measured by FIDA and NPA Diagnostics



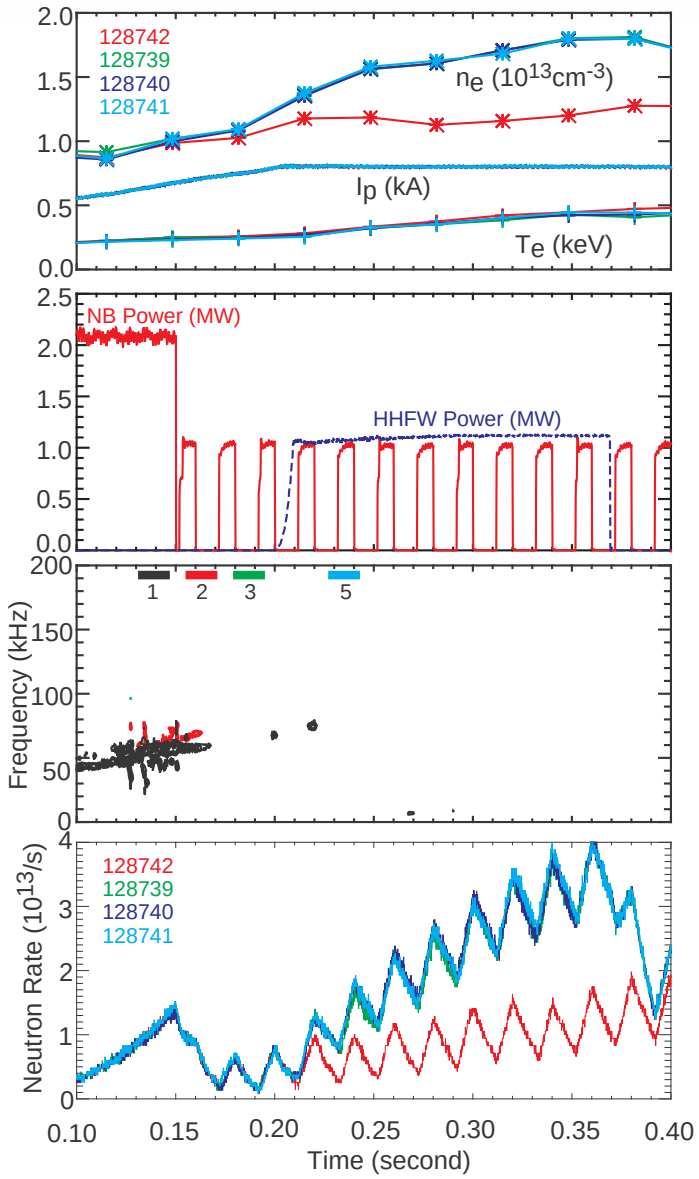
Goal: **Use new built FIDA and NPA diagnostics to measure the spatial profile of accelerated beam ions.**

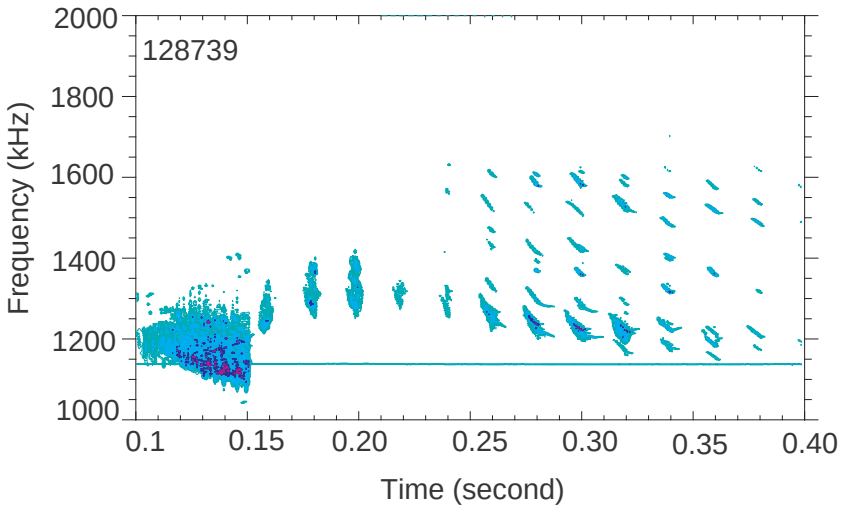
Motivation: **NSTX is in a novel regime for fast-wave heating.**

Super-Alfvenic fast ions, very large values of $k_{perp}\rho_{fast}$, multiple resonance layers

Tools: **FIDA, NPA, SSNPA and neutron detectors**

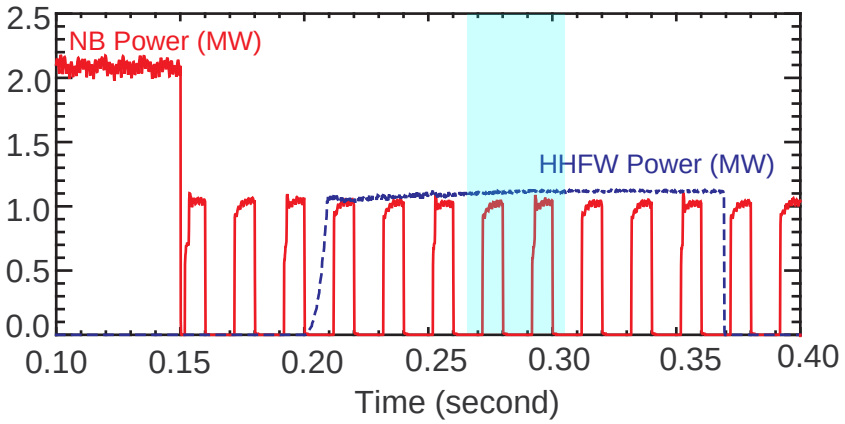
HHFW Enhances Neutron Rates in Quiet Plasmas

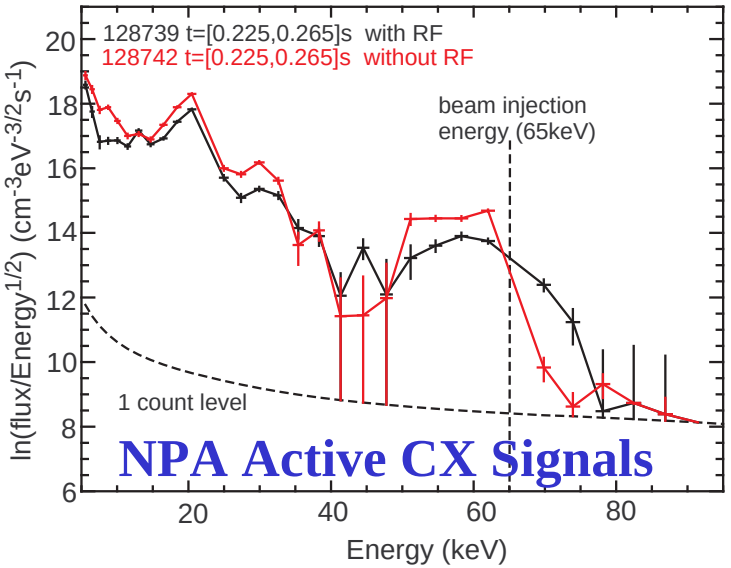




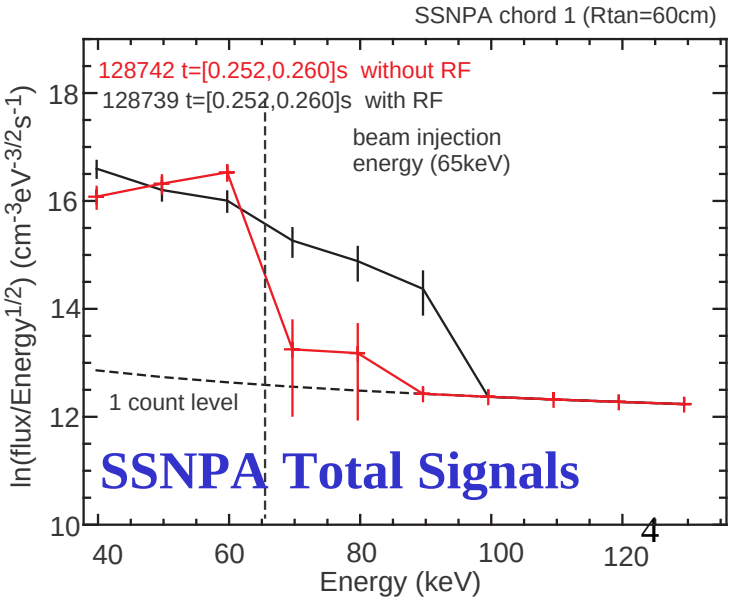
- **Similar plasma profiles in the repeated RF shots and the no-RF reference shot except that n_e in the reference shot is lower.**
- **No low frequency MHD instabilities, but weak chirping CAEs in frequency range 1100~1800 kHz during RF heating period.**
- **HHFW enhances neutron rate significantly.**

Fast Ion Tails Generated by HHFW are Observed on SSNPA Energy Spectra



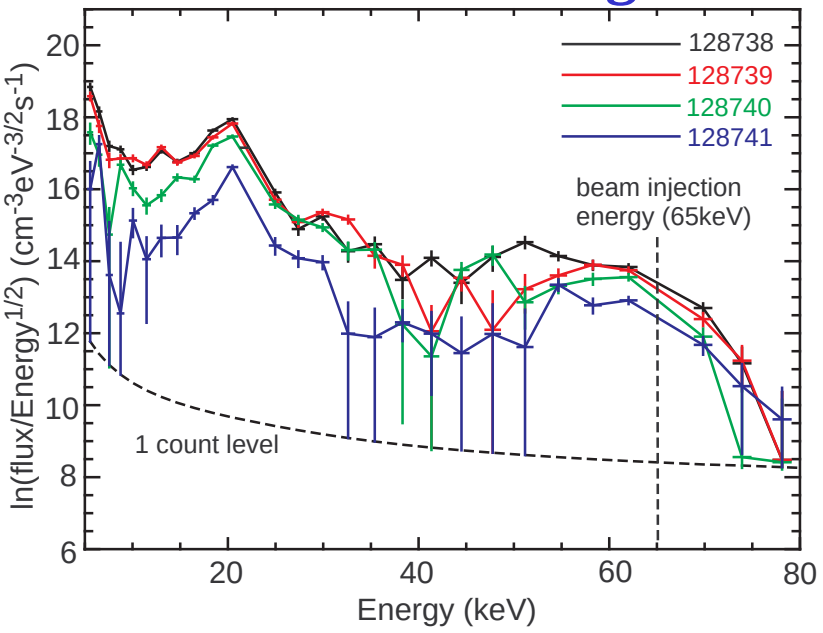


- Neutral beam source B @65 keV
- RF-induced noise contaminated NPA energy spectra.
- Active CX signals of NPA are obtained by "beam modulation" technique.
- The active CX energy spectra on NPA and SSNPA don't show high energy tail.
- D^+ tail extends to ~100 keV on the energy spectra of chord 1 of SSNPA, which is mainly from passive charge exchange.

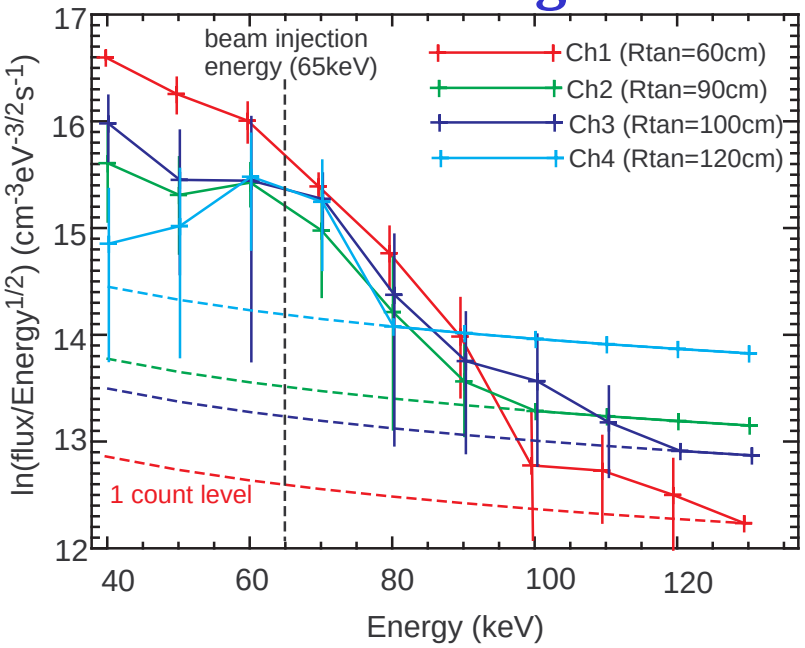


Acceleration of Fast Ions is Strong in the Perpendicular Direction

NPA Active CX Signals

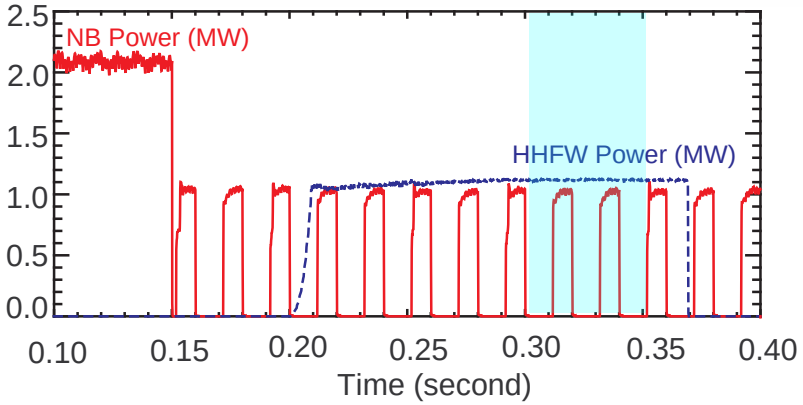


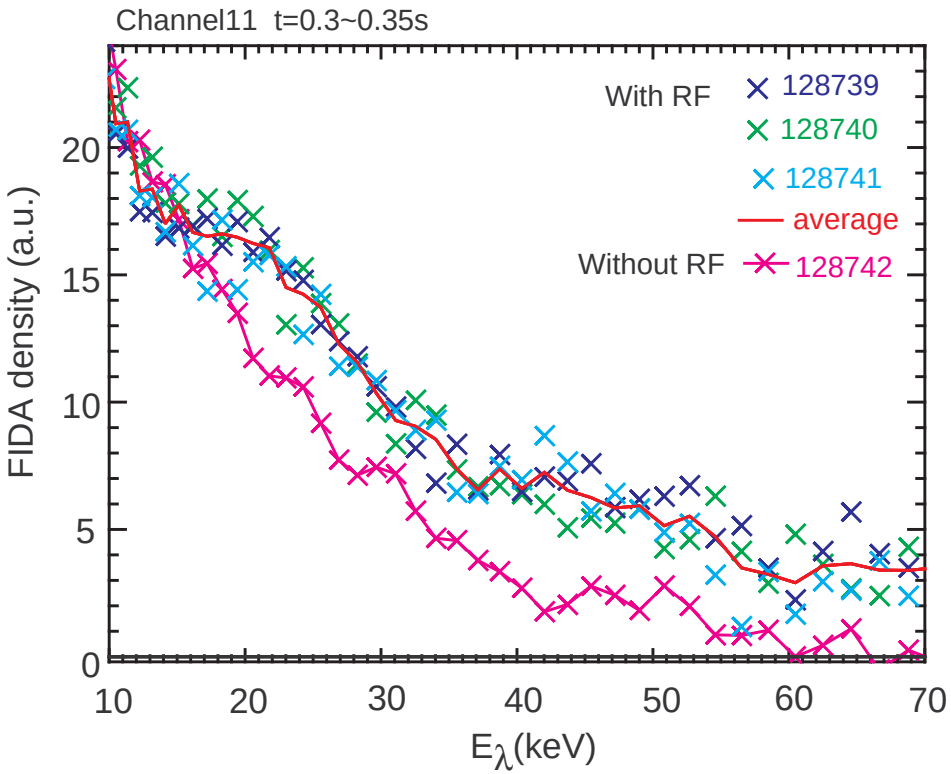
SSNPA Total Signals



- **Neutral beam source B @65 keV**
- **Little acceleration detected in NPA vertical scan → this portion of phase space weakly affected by RF.**
- **For SSNPA, the acceleration of fast ion tail is strongest in chord 1 and 3 whose pitch at the edge are 0.3 and 0.5.**

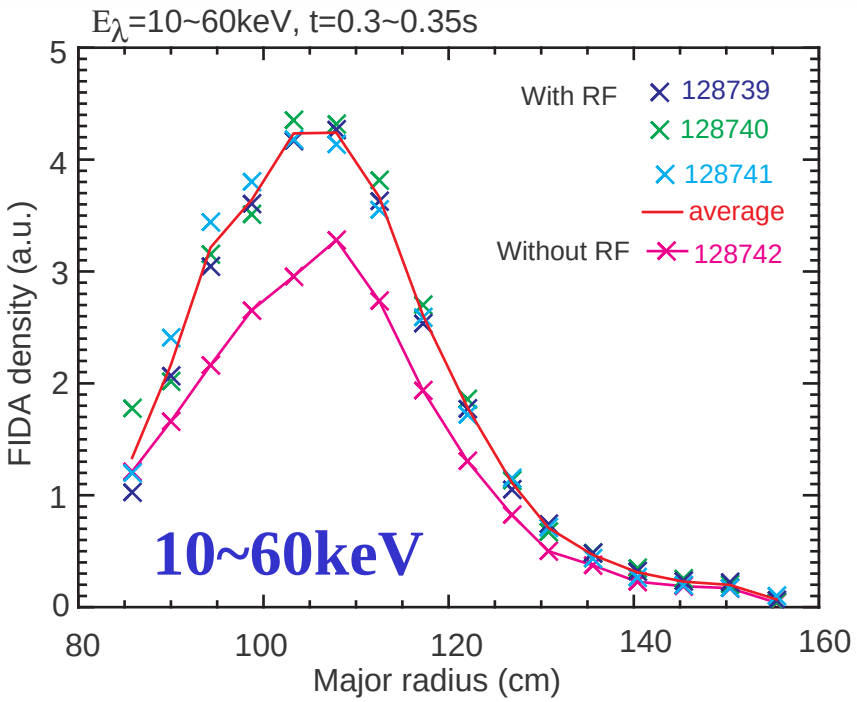
Fast Ion Tails Generated by HHFW is also Observed on FIDA Energy Spectra

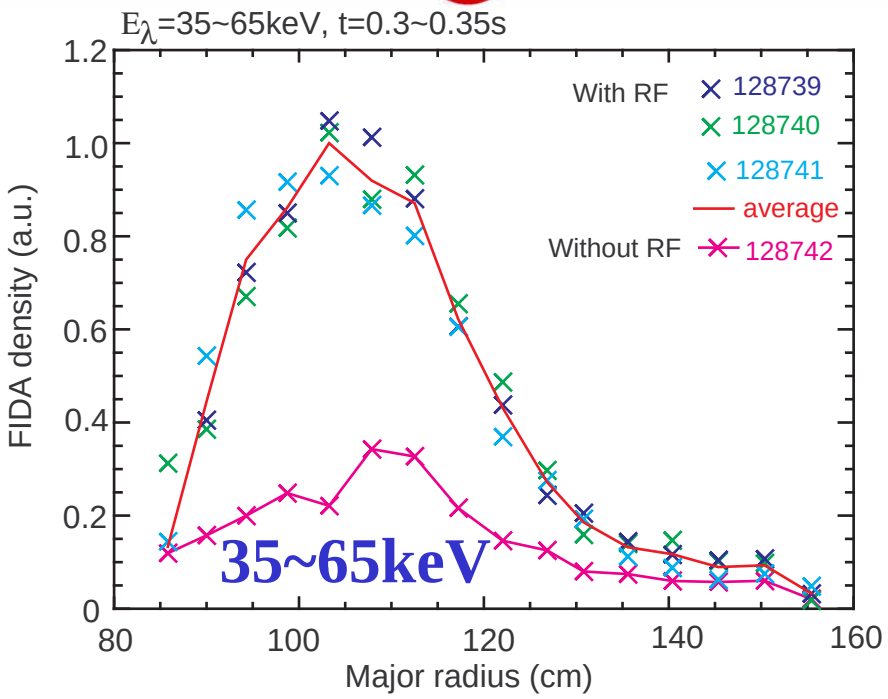




- **Neutral beam source B @65 keV**
- **For FIDA diagnostic, "beam modulation" technique is used to remove the background.**
- **A fast ion tail is clearly seen is in FIDA energy spectra during RF heating.**

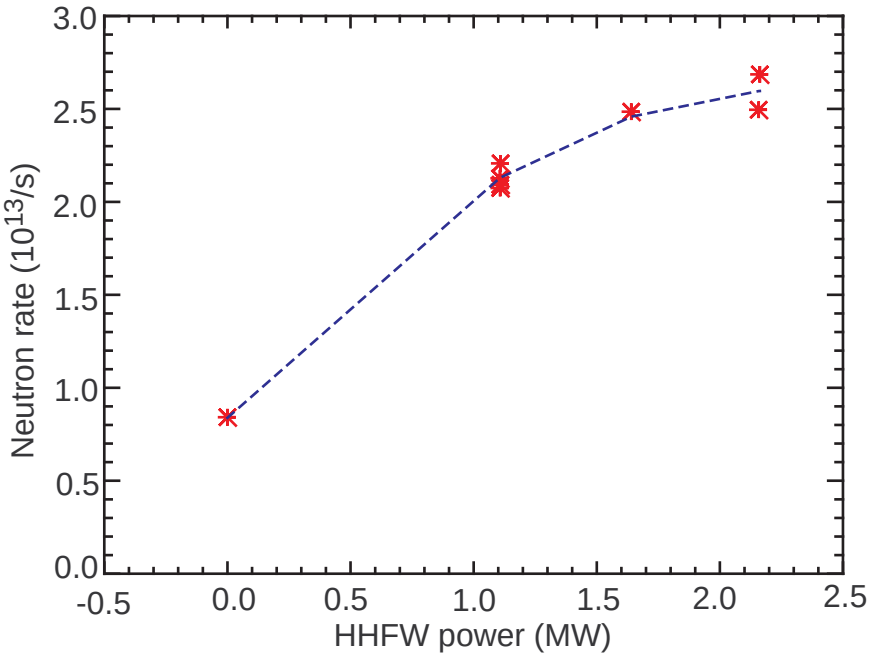
The Acceleration of Fast Ions is Greatest for Energies near or above the Injection Energy

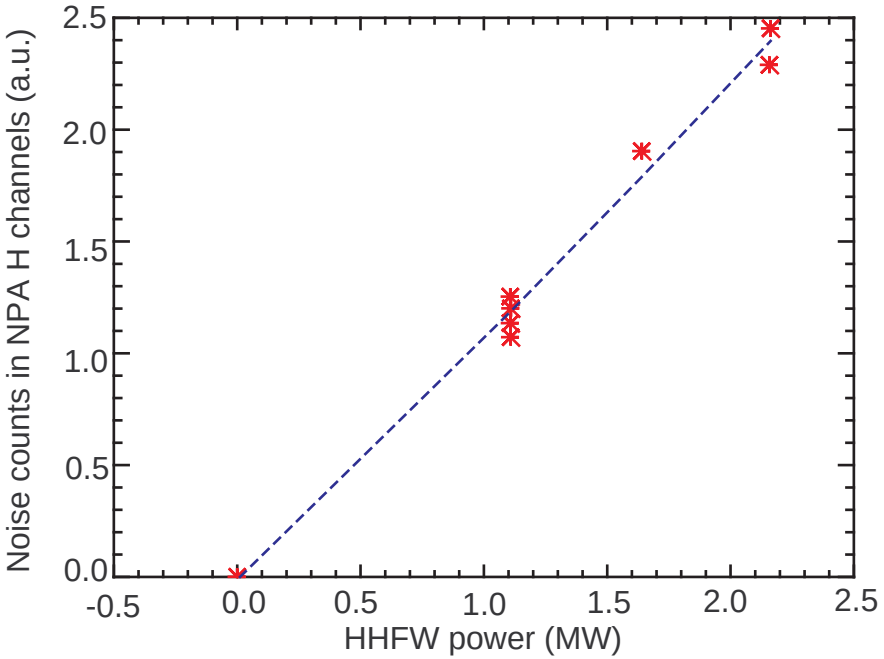




- **The "FIDA density" in the energy range of E_λ=10~60 keV didn't vary much in RF shots compared with the reference shot.**
- **The "FIDA density" in the high energy range E_λ=35~65 keV increased significantly.**
- **The accelerated tail extended up to 30 cm in FWHM, which is much broader than that in DIII-D.**

Efficiency of HHFW Heating Decreases with HHFW Power

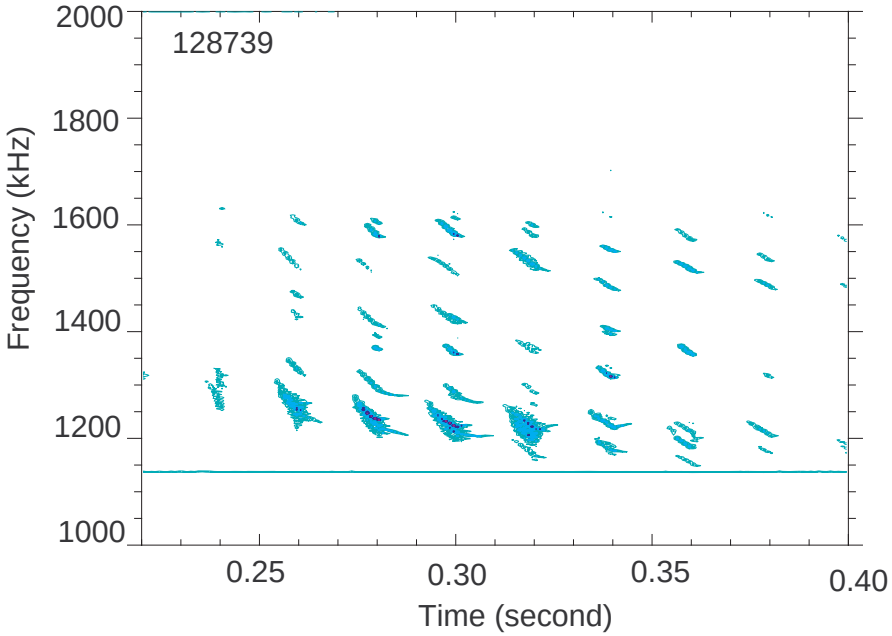




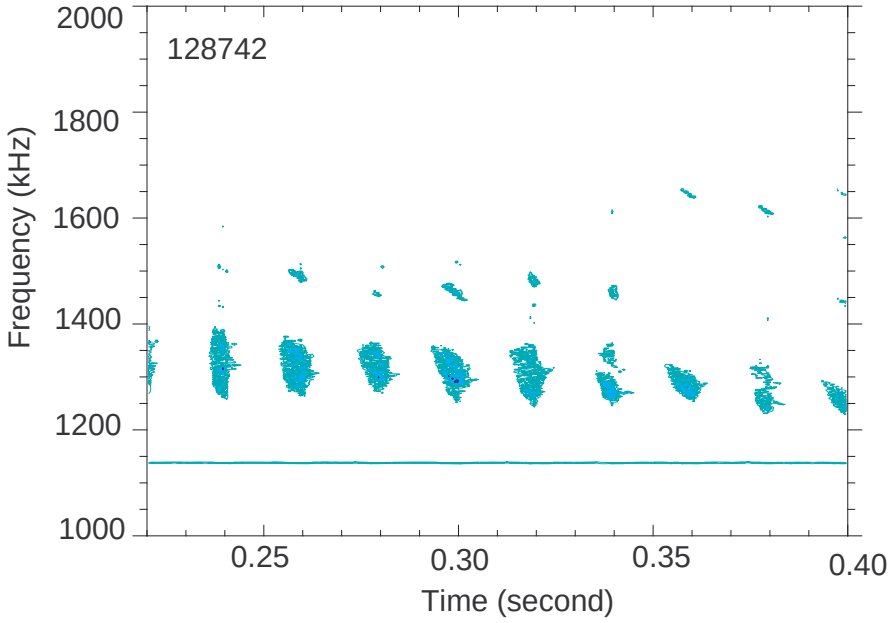
- **Neutron rate doesn't increase linearly with HHFW power.**
- **The noise counts in NPA hydrogen channels increase linearly with HHFW power.**
- **More impurity lines in FIDA spectra during high power HHFW shots.**

CAEs Behaves Different During RF Heating

0.8MW HHFW



No HHFW



Weak CAEs in RF heating shots and the no-RF reference shot.

CAEs have chirping feature in RF heating shots, but not in the reference shot.

Summary and Future Work

- **Neutron rate is significantly enhanced by RF heating**
- **A RF-induced fast ion tail above the injection energy is clearly observed on SSNPA and FIDA diagnostics.**
- **The acceleration of fast ions is strong in the perpendicular direction.**
- **The acceleration of fast ions is greatest near or above the injection energy**
- **The spatial profile of high energy ions is much broader than conventional Tokamaks.**

- **Simulate the NPA, SSNPA, FIDA spectra with fast ion distribution calculated from CQL3D Fokker-Planck code and compare with experimental measurements.**
- **Want to compare with other theoretical predictions too**
- **Understand whether the chirping CAEs affect the interaction between HHFW and fast ions.**