NSTX-U

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NSTX-U Collaboration Status and Plans for: UC Irvine Group on Beam Ion Studies

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University of California, Irvine

NSTX-U Collaborator Research Plan Meetings
PPPL – LSB B318
April 24th, 2014

Coll of Wm & Mary
Columbia U
CompX
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FIU
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LANL
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Lodestar
MIT
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Nova Photonics
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U Colorado
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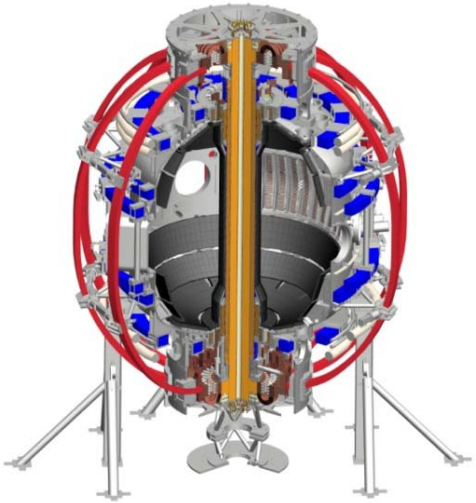
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC



Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
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TRINITI
Chonbuk Natl U
NFRI
KAIST
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Seoul Natl U
ASIPP
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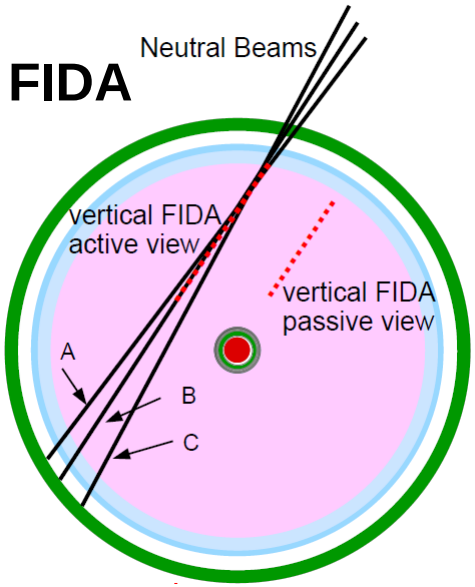
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

Overview of UC Irvine Collaboration at NSTX-U

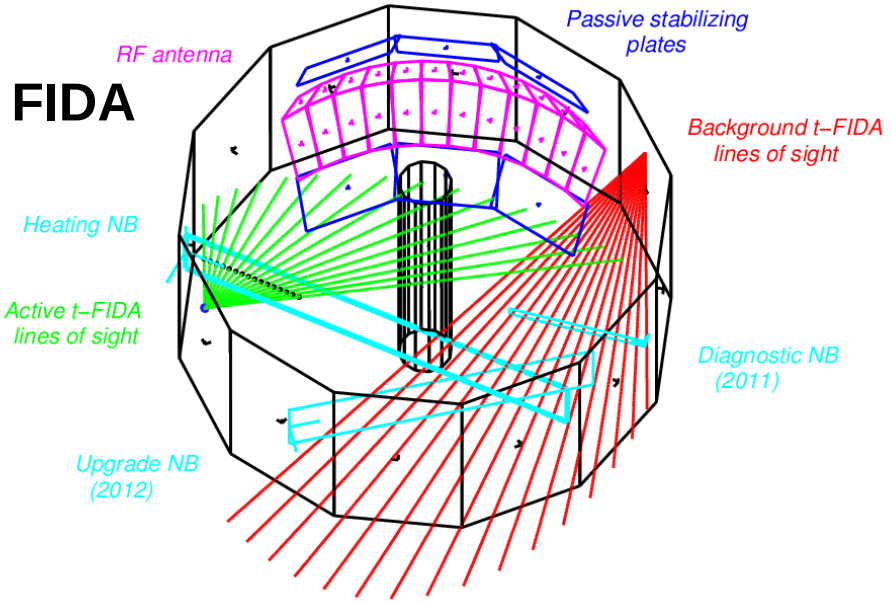
- **Goal: measure and infer beam ion distribution; characterize and understand the behavior of beam ions and associated instabilities.**
  - Separate diagnostic & physics grants
  - Deyong Liu & postdoc full time at PPPL
  - Luke Stagner (PhD student) & Heidbrink at Irvine
- **Hardware: active beam ion diagnostics**
  - Vertical Fast-Ion D-alpha (v-FIDA)
  - Tangential FIDA (t-FIDA)
  - solid state Neutral Particle Analyzer (ssNPA)
- **Modeling & Physics**
  - Synthetic diagnostic code FIDASIM
  - Reconstruction of fast-ion distribution function from measurement data
  - Simulation of TAE on NSTX with MHD/kinetic hybrid code M3D-K

Vertical and Tangential FIDA are Ready for Installation and Calibration in NSTX-U

Vertical FIDA

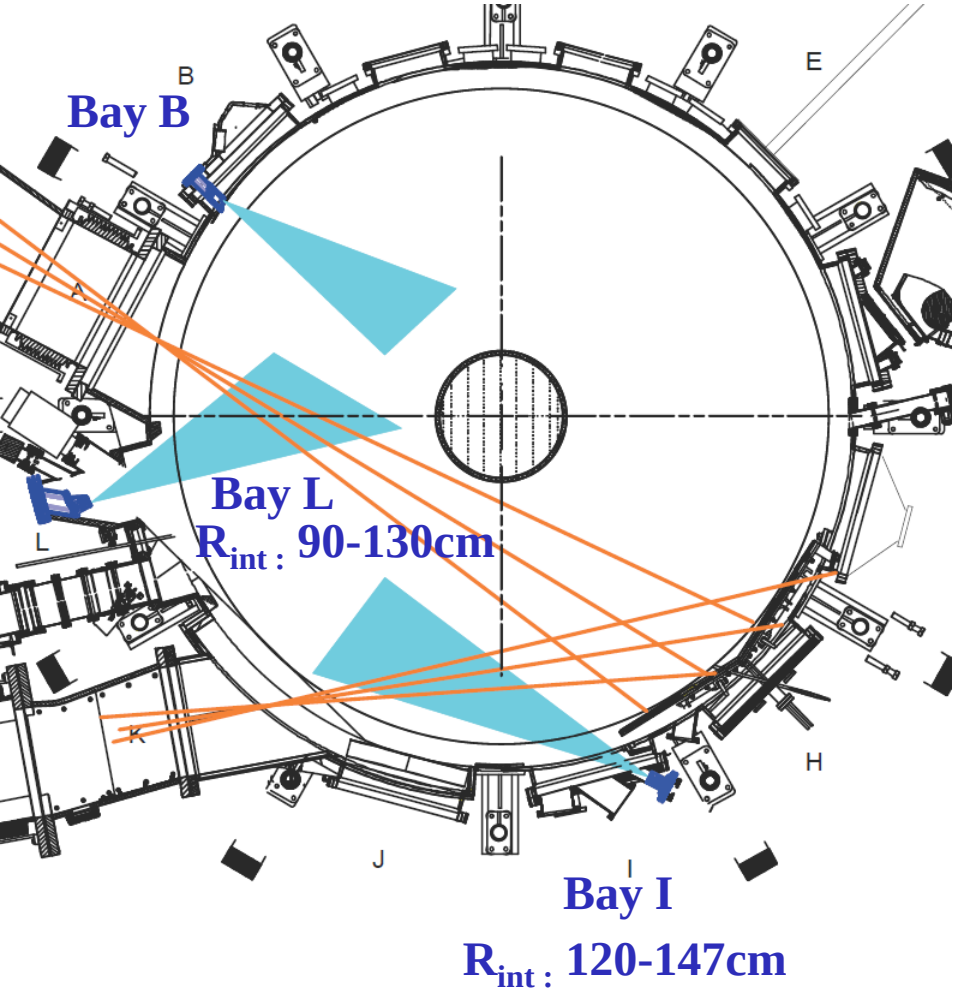


Tangential FIDA



- **Each FIDA system consists of**
  - spectrometer-FIDA, full D_α spectrum , 16 channels R=0.86-1.66m, 100Hz
  - band-pass filter-FIDA, 3 channels at R=1.0, 1.2, 1.4m, 50kHz
- **Minor change**
  - Lens holder at Bay L is modified to accommodate thicker re-entrant tube (done)

New ssNPA is Nearly Ready for Installation on NSTX-U



- **Final design review in Sept. 2013**
  Bay I: passing beam ions
  Bay L: trapped beam ions
  15 ch, [>25,>45,>65] keV, 120kHz
  Bay B: reference view
  15 ch, energy:>25keV, 120kHz
  Fabrication is nearly completed, to be assembled and tested
- **Amplifiers:** design is completed; currently under fabrication, **to be shipped by May-June 2014.**
- Detectors, digitizers and cables have been ordered and received.
- G. Smalley (PPPL) will help design a PCB module that provides power and gain control to amps

The Fortran 90 Version of FIDASIM Simulates Active FIDA & NPA Signals

- Runs quickly on PPPL cluster
- Same physics as predecessor IDL version but better halo model & atomic physics
- New efficient NPA simulation
- Velocity-space “weight functions” are standard output
- Source code and documentation available on Github www.github.com/D3DEnergetic/FIDASIM

Near-term plans

- Accommodate NSTX input
- Graphical user interface

The Distribution Function has been Inferred From Real Data

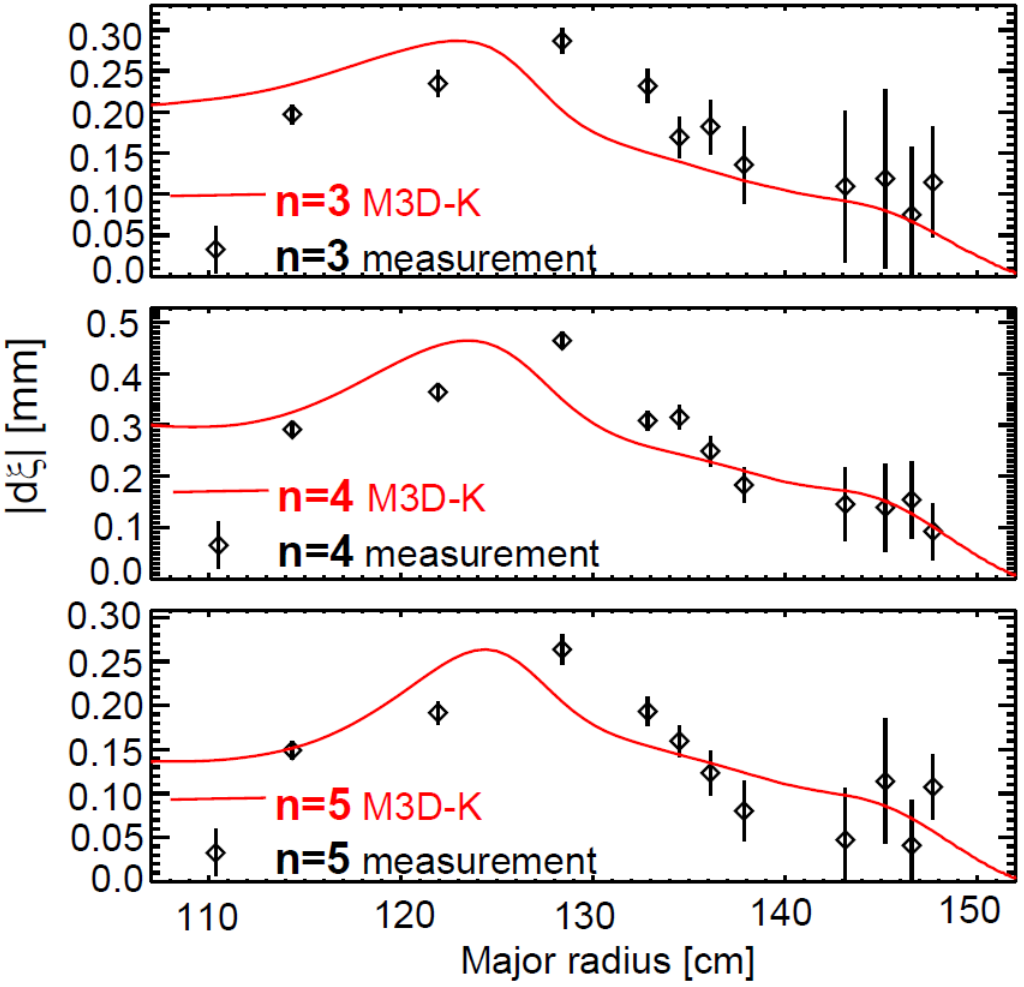
Velocity-space reconstructions

- ASDEX-Upgrade FIDA data: M. Salewski et al., "Measurement of a 2D fast-ion velocity distribution function by tomographic inversion of FIDA data", Nucl. Fusion **54** (2014) 023005
- DIII-D FIDA data: L. Stagner et al., "Progress on Bayesian inference of the fast-ion distribution function," Bull. APS **58** (2013).

Improved weight functions facilitate inversions

- M. Salewski et al., "On velocity space sensitivity of FIDA spectroscopy"

M3D-K Simulated TAE Mode Structure and Mode Frequency are Similar to Measurements



	n=3	n=4	n=5
f_{exp} (kHz)	**100**	**120**	**140**
f_{M3D-K} (kHz)	**106**	**130**	**149**

Black: reflectometer measurements

Red: M3D-K synthetic reflectometer signal

Short Term Plans (FY14)

Hardware

- 05/2014 Reinstall v-FIDA, t-FIDA; perform spatial & intensity calibrations
- 06/2014 Assemble ssNPA and test electronics on bench
- 07/2014 Install ssNPA

Modeling

- 05/2014 Submit paper on linear simulation of TAE
- 05-06/2014 Adapt Fortran 90 version of FIDASIM for NSTX-U; benchmark halo calculation with TRANSP code
- 07-09/2014 Complete the NUBEAM and M3D-K interface

Long Term Plans (FY15 and beyond)

Hardware

- Operate and maintain FIDA and ssNPA diagnostics
- Develop electronics for ssNPA in pulse-counting mode
- Improve FIDA (a fiber patch panel for v-FIDA, a shutter for the CCD camera of t-FIDA, narrow band notch filter)

Modeling

- Non-linear simulation of multiple TAEs on NSTX and comparison between experiments and simulations
- Reduced model for FIDA/ssNPA signals, modeling of passive signals
- Fast-ion-distribution inversion with experimental data

Physics

- Validation of classical TRANSP prediction for 2nd NBI
- Interaction of beam ions and high harmonic fast wave
- Fast ion transport due to Alfvén eigenmodes

Ideas to enhance participation in NSTX-U research/program by U.S. Universities, early-career researchers, and students

- More technical support from PPPL machine shop and electronics shop
- Lab space or workbench is needed for diagnostic development and testing