NSTX-U

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Fast-Ion-D-Alpha and Solid-State NPA Diagnostics for NSTX-U

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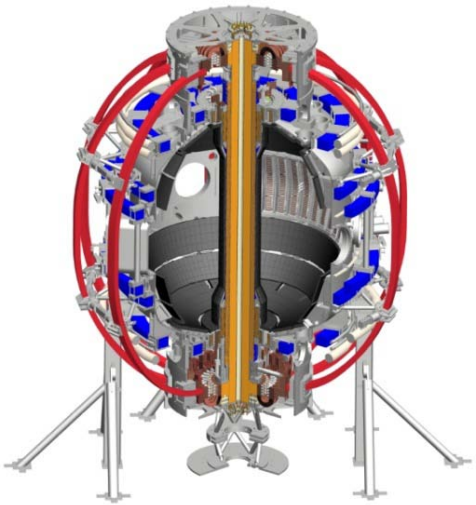


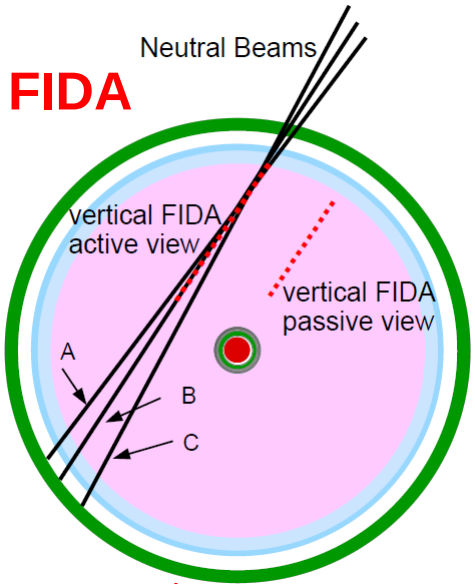
Multiple Fast Ion Diagnostics are Needed to Constrain/Invert Fast Ion Distribution Function

- **Goal: measure beam ion distribution in NSTX-U**
  - → transport of beam ions due to MHD and Alfven eigenmode activity
  - → interaction between high-harmonic fast waves and beam ions
  - → neutral beam current drive

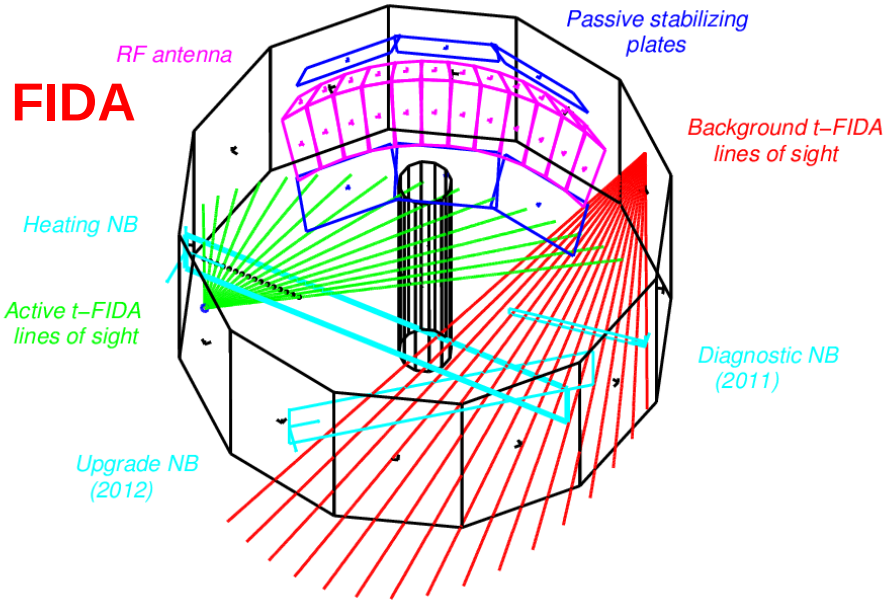
- **Different fast ion diagnostics weight phase space differently**
  - FIDA: sensitive to a **swath** in velocity space
  - NPA: very **localized** in pitch;
    - ssNPA: measure **trapped** fast ions at different radii; **fast time resolution,** no energy resolution
    - E||B NPA: diagnose **co-passing** fast ions; **excellent energy resolution**
  - Neutron: strongly weighted toward **high energy** fast ions; insensitive to pitch angle; **volume averaged**
  - Charged fusion product diagnostic: strongly weighted toward **high energy** fast ions; **spatial profile**
  - Fast ion loss detector: **lost fast ions**; narrow in pitch

Both Vertical and Tangential FIDA Diagnostics are Nearly Ready for Operation in NSTX-U

Vertical FIDA



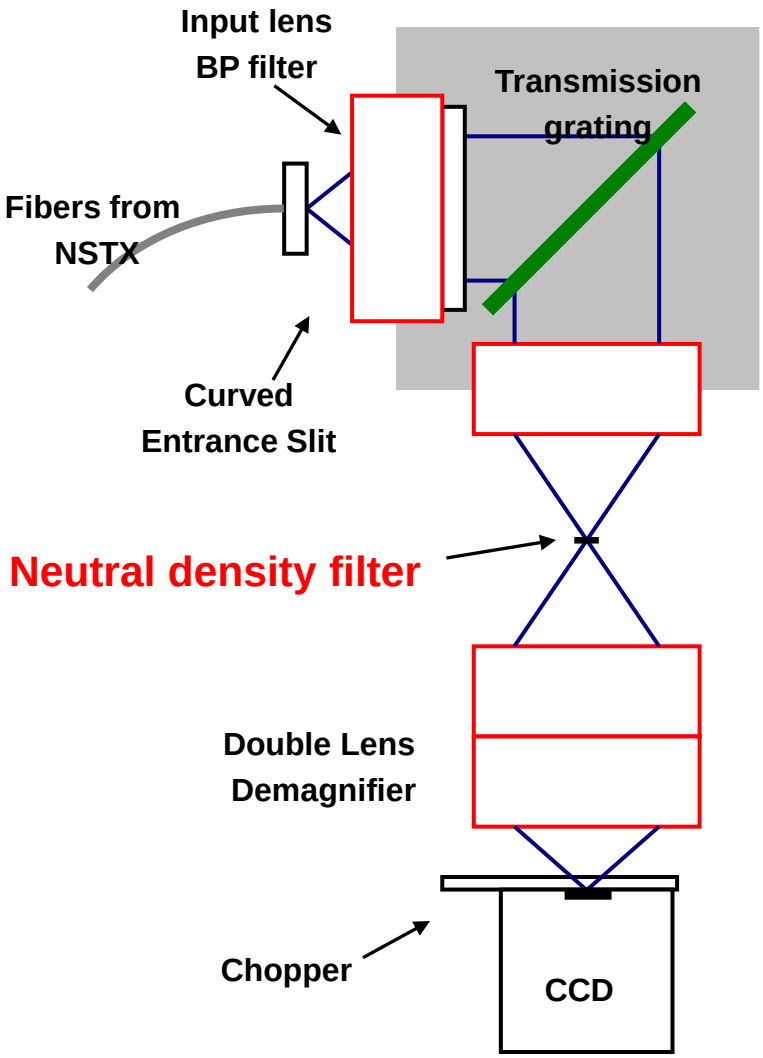
Tangential FIDA



- Vertical and tangential FIDA diagnostics consist of two systems
  - spectrometer-FIDA, full Dα spectrum , 16 channels R=0.86-1.66m, 100Hz
  - band-pass filter-FIDA, 3 channels at R=1.0, 1.2, 1.4m, 50kHz
- The vertical FIDA diagnostic has worked routinely since 2008.
- The new tangential FIDA diagnostic was installed in 2011, but didn't collect any data due to the failure of toroidal field coil.
- During the NSTX upgrade construction, FIDA fibers & optics are protected and secured.

Minor Improvements Needed for FIDA Diagnostics

- Acquire a shutter for the camera in the tangential FIDA system; (Liu, 2013)
- Install a fiber patch panel for the vertical FIDA system; (Liu, 2013)
- Reduce strayed cold D-alpha light by replacing the neutral density filter with a narrow band (~2nm) notch filter?
  Depending on the availability and cost.
  (Liu, 2012, do a survey of such notch filter and purchase it if affordable)



Pre-design of New Solid-State Neutral Particle Analyzer

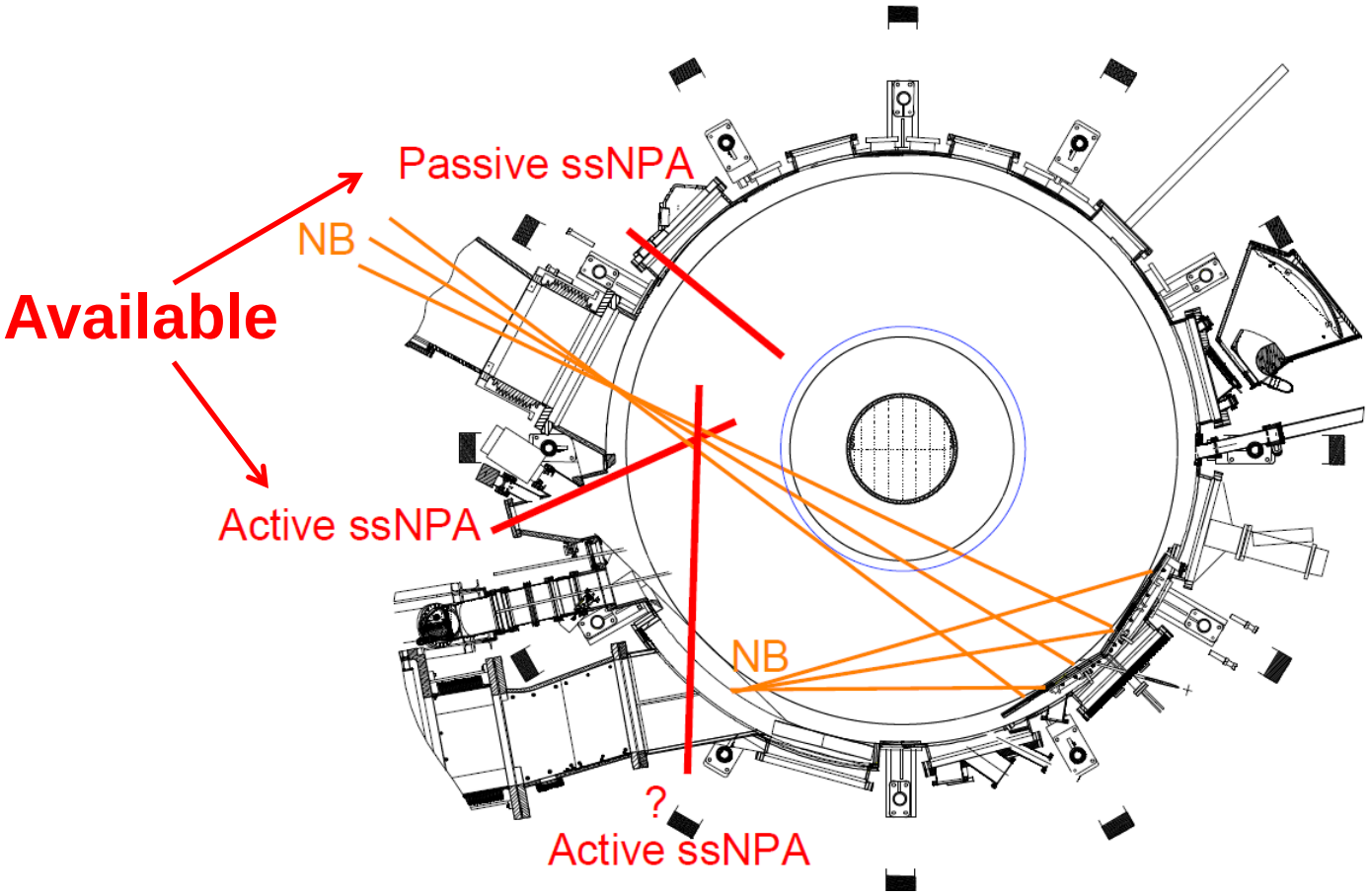
- **Goal: Measure trapped fast ions at several radial locations**
- Same concept as the ssNPA in NSTX and DIII-D (i.e. using silicon photodiode to detect CX neutrals directly)
- Work in current mode

  → fast time response (>100kHz), but no energy resolution
- Could incorporate pulse-counting mode to get some energy resolution
- Select radial viewlines on the mid-plane

  → minimize path length of escaping CX neutrals
- 5 chords intersect a NB at different radii, 2 chords miss any NBs

  → separate active and passive CX signals and obtain spatial profile
- Use pair of “active” and “blind” detectors for EM noise subtraction

Ports Identified for Solid-State Neutral Particle Analyzer



If possible, another chord measures co-passing beam ions.

Overall Schedule

- **Vertical and tangential FIDA diagnostics**

2013 minor improvements i.e. shutter, fiber patch panel , notch filter

2014 reinstallation of fibers on NSTX-U; calibration;
data acquisition and data analysis tool

- **solid-state NPA**

2012-2013 Spring ports selection, concept design

2013 Spring-2014 fabrication and testing;

2014 installation;
data acquisition and data analysis tool

- **Modeling**

2012 conversion of synthetic diagnostic code FIDAsim from IDL to Fortran

2013-2014 a reduced model for FIDA emission analysis (Heidbrink and Grierson)

2012-2014 fast ion distribution inversion project (Heidbrink, Salewski, Stagner)