Fusion source profile measurements with a charged particle detector

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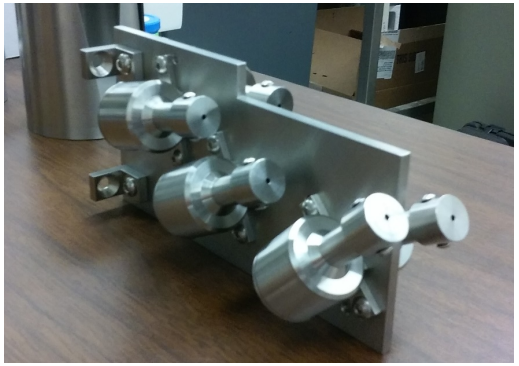
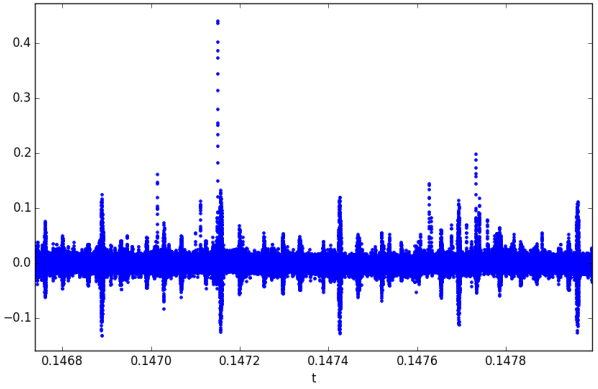
New probe head



Noise & Particles

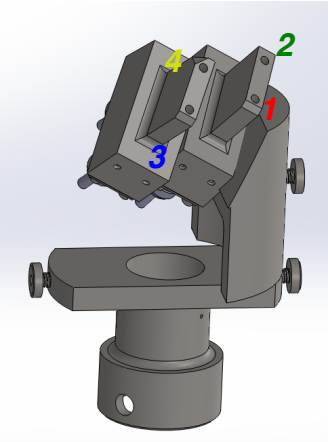


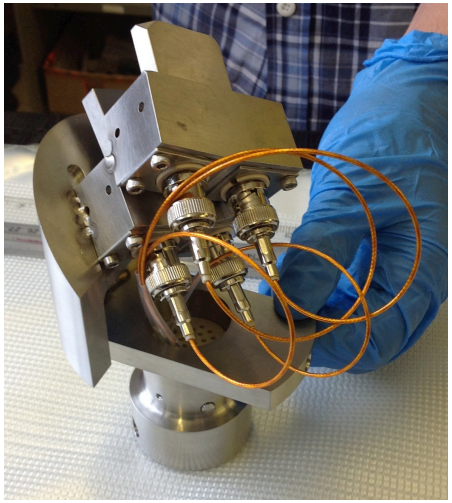
Overview

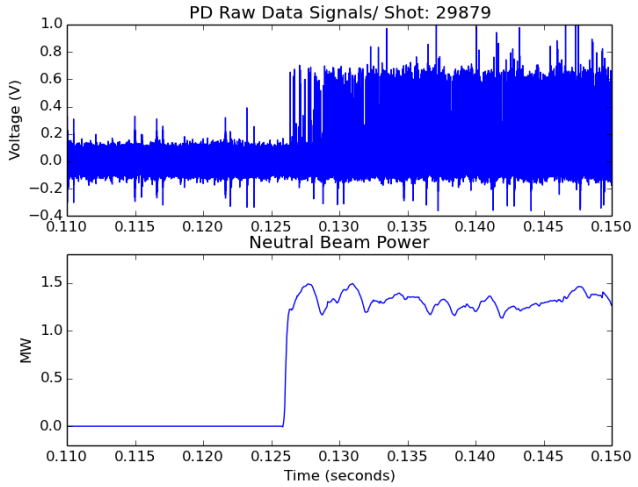
- Goal
  - Determine neutral beam ion density profile with minimal model dependency
  - Provide new data on beam ion transport by plasma activities (MHD, TAE, NTM, ELM, IRE etc.)
- Method
  - Measure d(d,p)t products with good time, position and energy resolution
- FIU group
  - 1 Faculty, 1 current Ph.D. student (A. Netepenko) support for additional student starting this Fall.

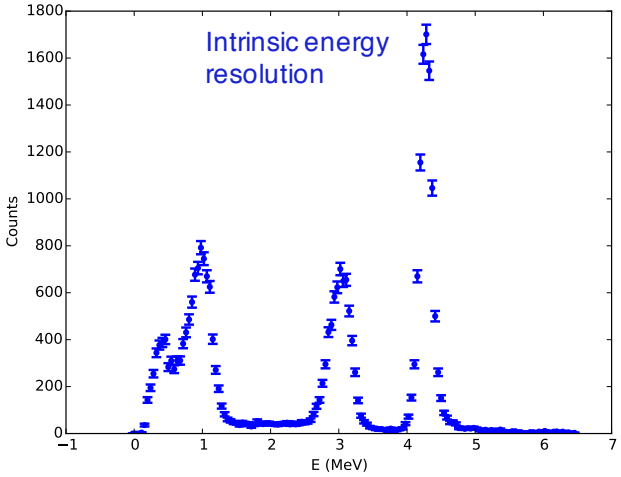
Based on First 3 MeV Proton Results from MAST 2013

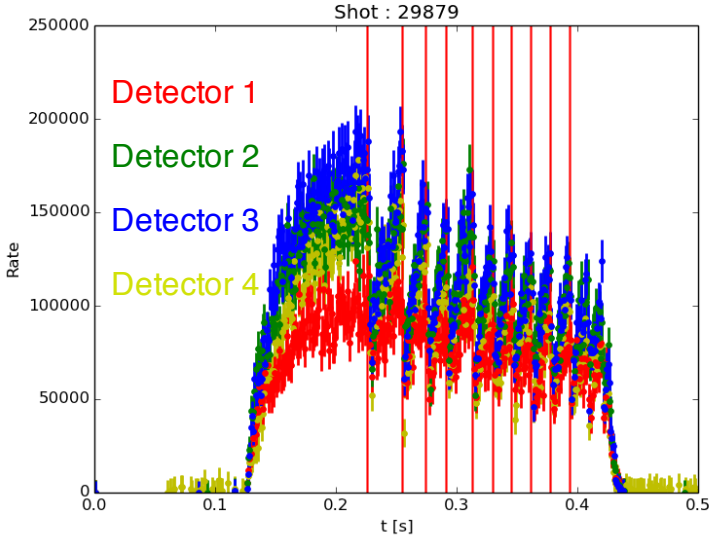
SAW TOOTH





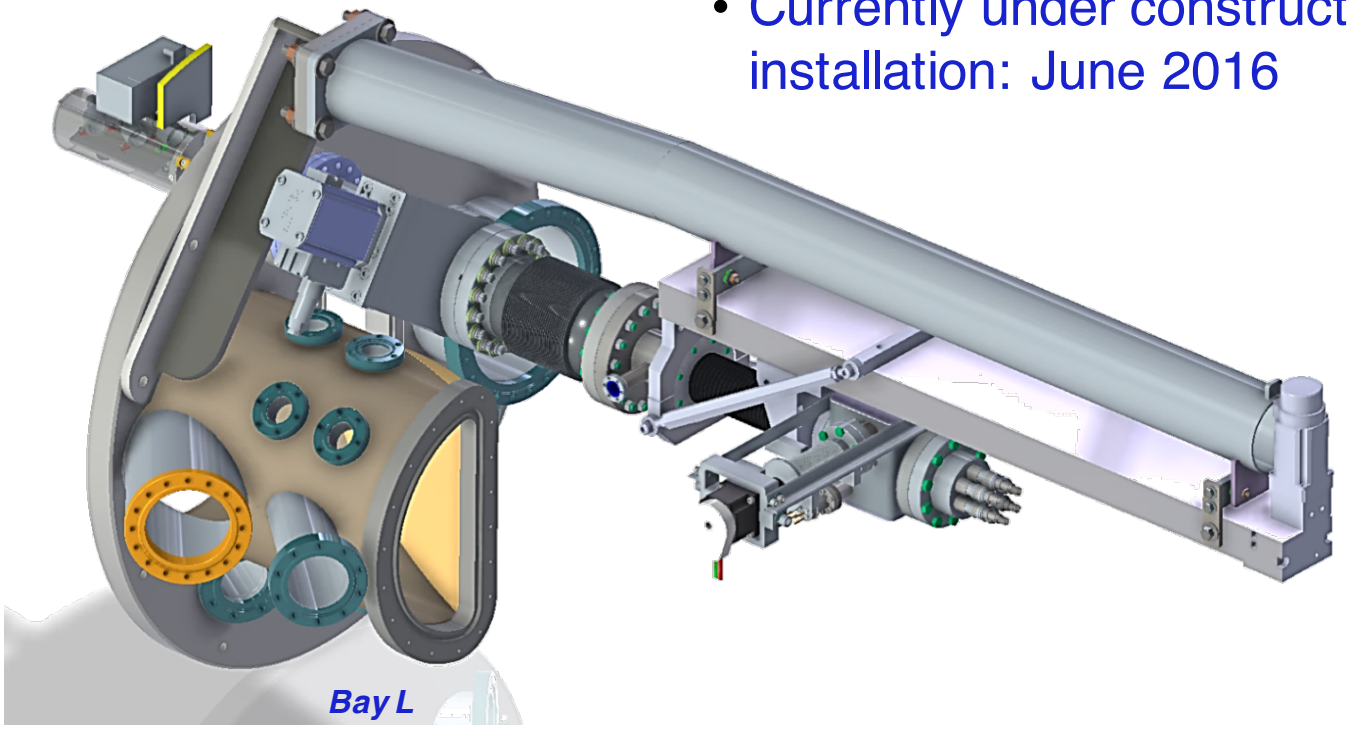






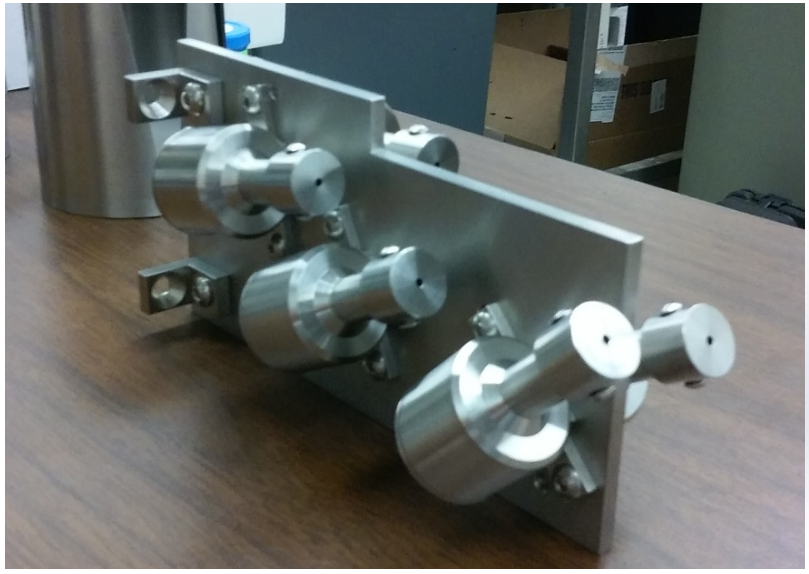
Plans 2016

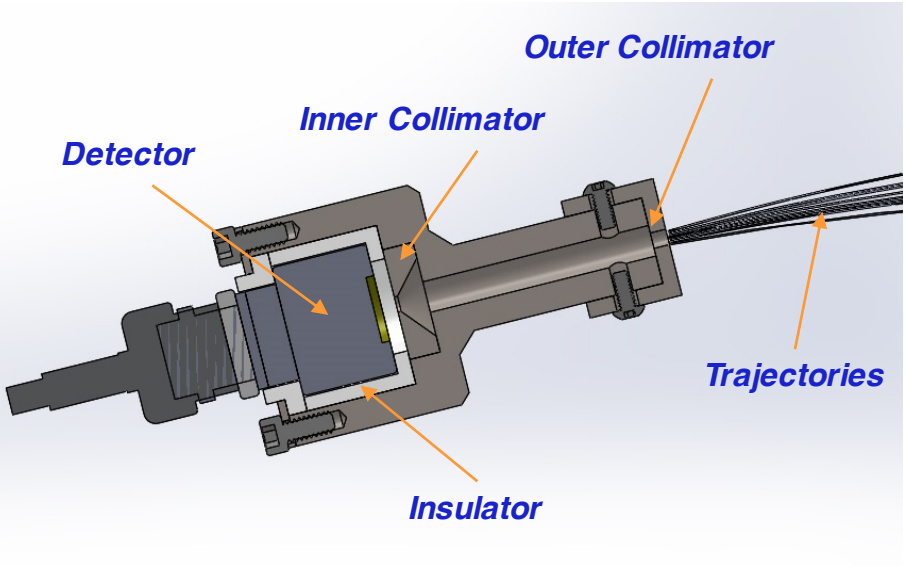
- Complete Installation of new proton detector array
  - Currently under construction, expected installation: June 2016



New Probe Head

- 6 collimated detectors



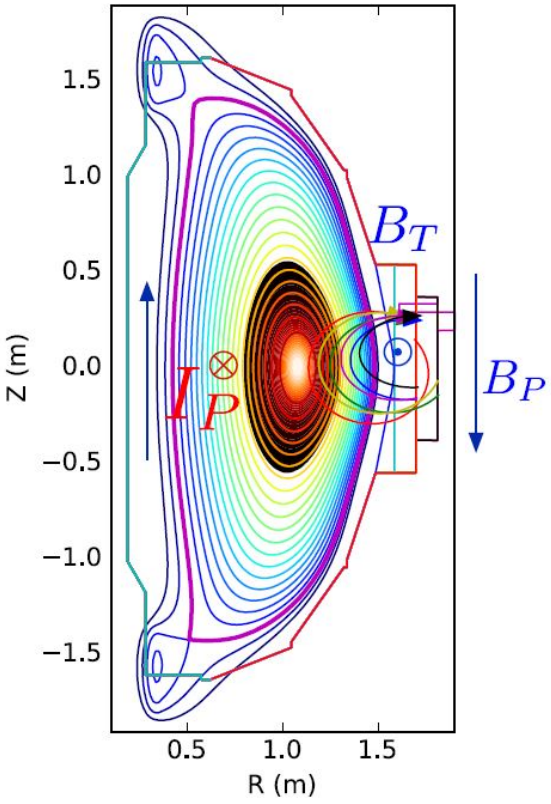


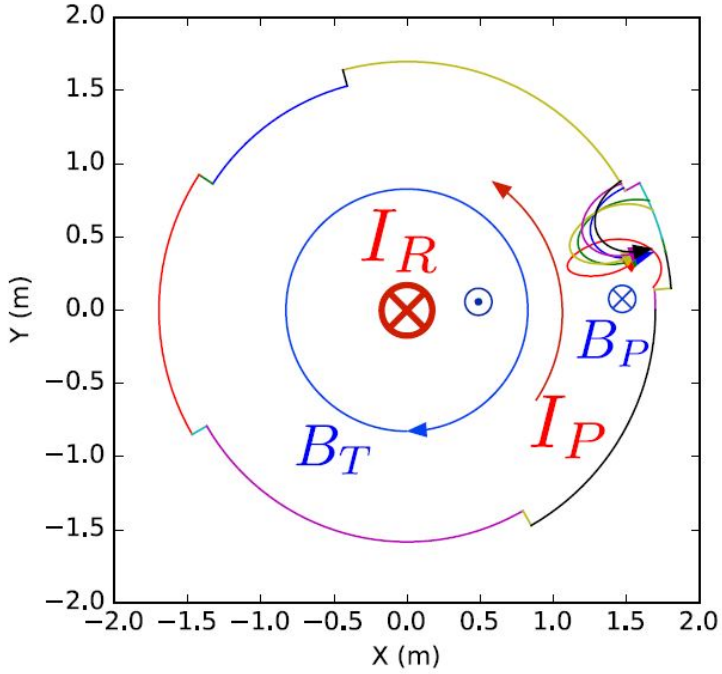
- Radial and axial motion remote controlled

Particle Trajectories

Case 3 Detector positions switched

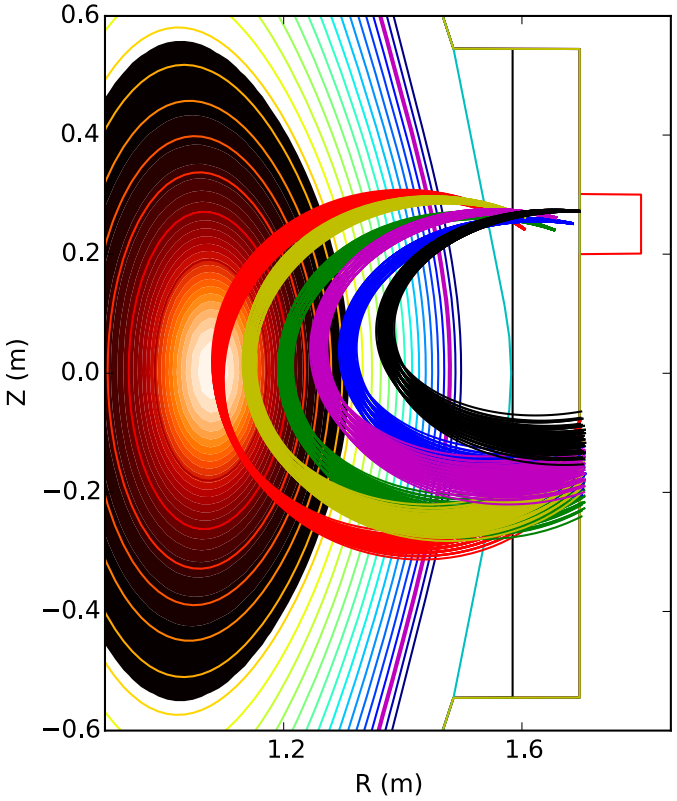
$$I_P = 2\ MA \quad B_T = 1\ T \quad \phi_R = -47.5$$

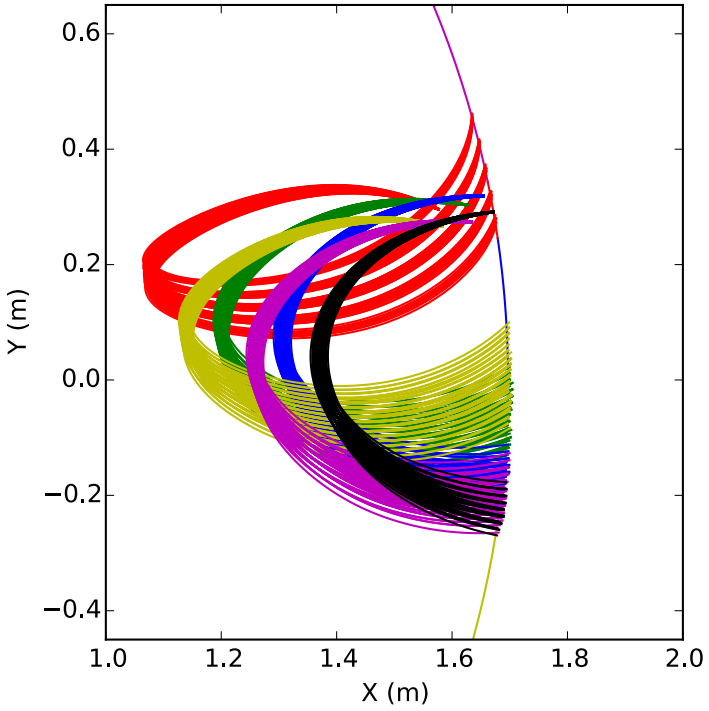




Trajectory Acceptances

$B_T = 1T \;\; I_P = 2\ MA$



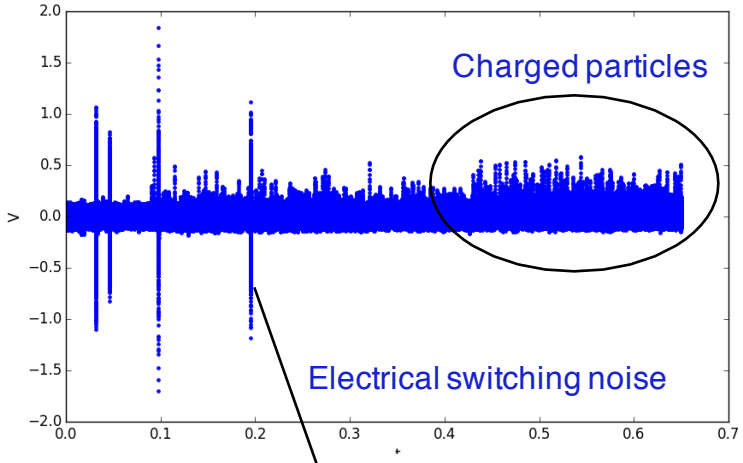


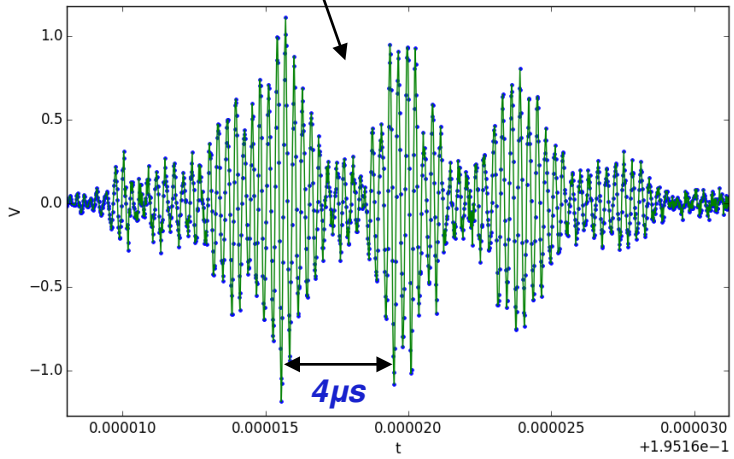
Mid-plane resolution ~2cm

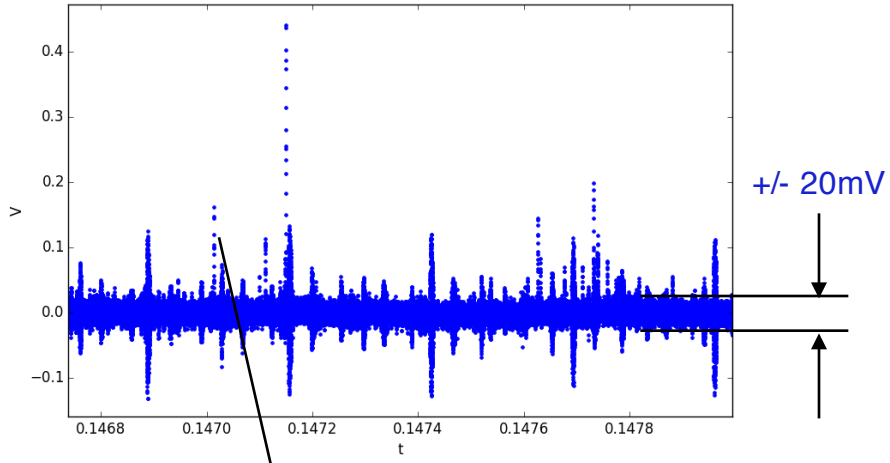
Plans for 2016

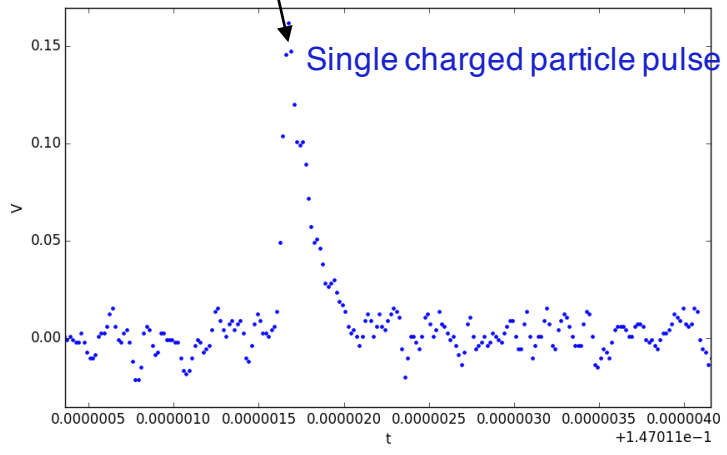
- Proton Detector Commissioning
  - Objective : extract first fusion rate profile data.
  - Need a range of plasma currents, toroidal fields, NB power and detector orientations
  - Preferably quiescent plasmas, with as many other fast ion diagnostics as possible also taking data.
  - Repeated shots for probe scans.
  - Comparison to Neutron data other FI data and TRANSP predictions
  - Measurement during MHD activity
  - Determine potential cooling needs (will complicate things)

First Noise Results from NSTX-U



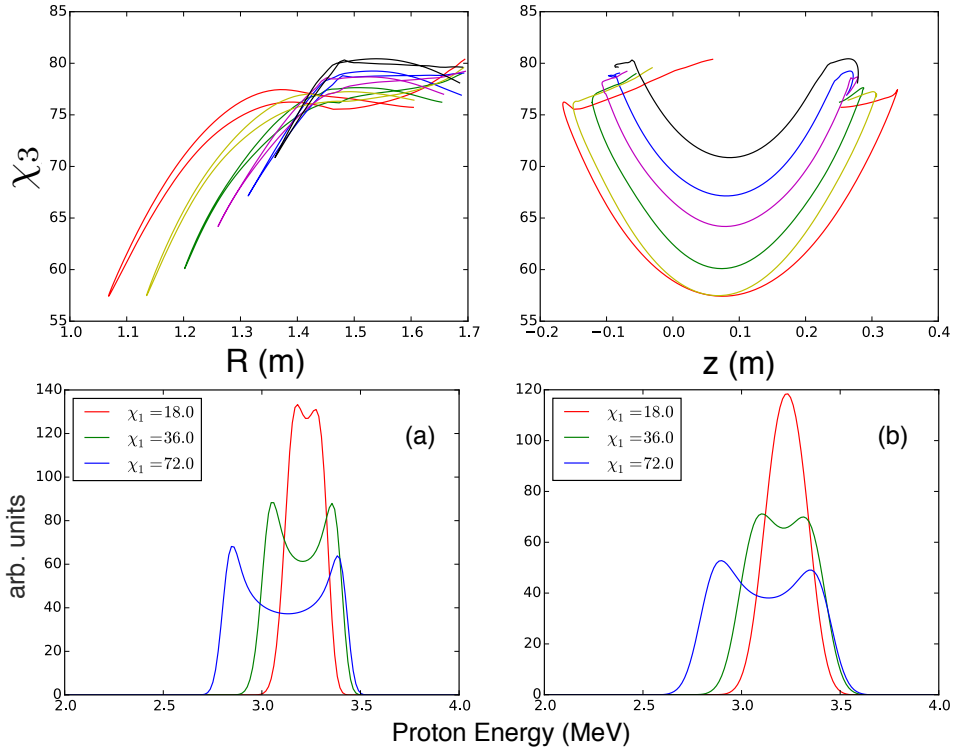






Plans 2016 continued

- Energy resolution, rate capabilities
  - Perform signal noise studies, optimize energy resolution (100keV should be feasible)
  - Perform rate studies: tested with accelerator: practical limit 450kHz with reduced energy resolution



χ_3 Pitch angle of outgoing particle

χ_1 Pitch angle of beam particle

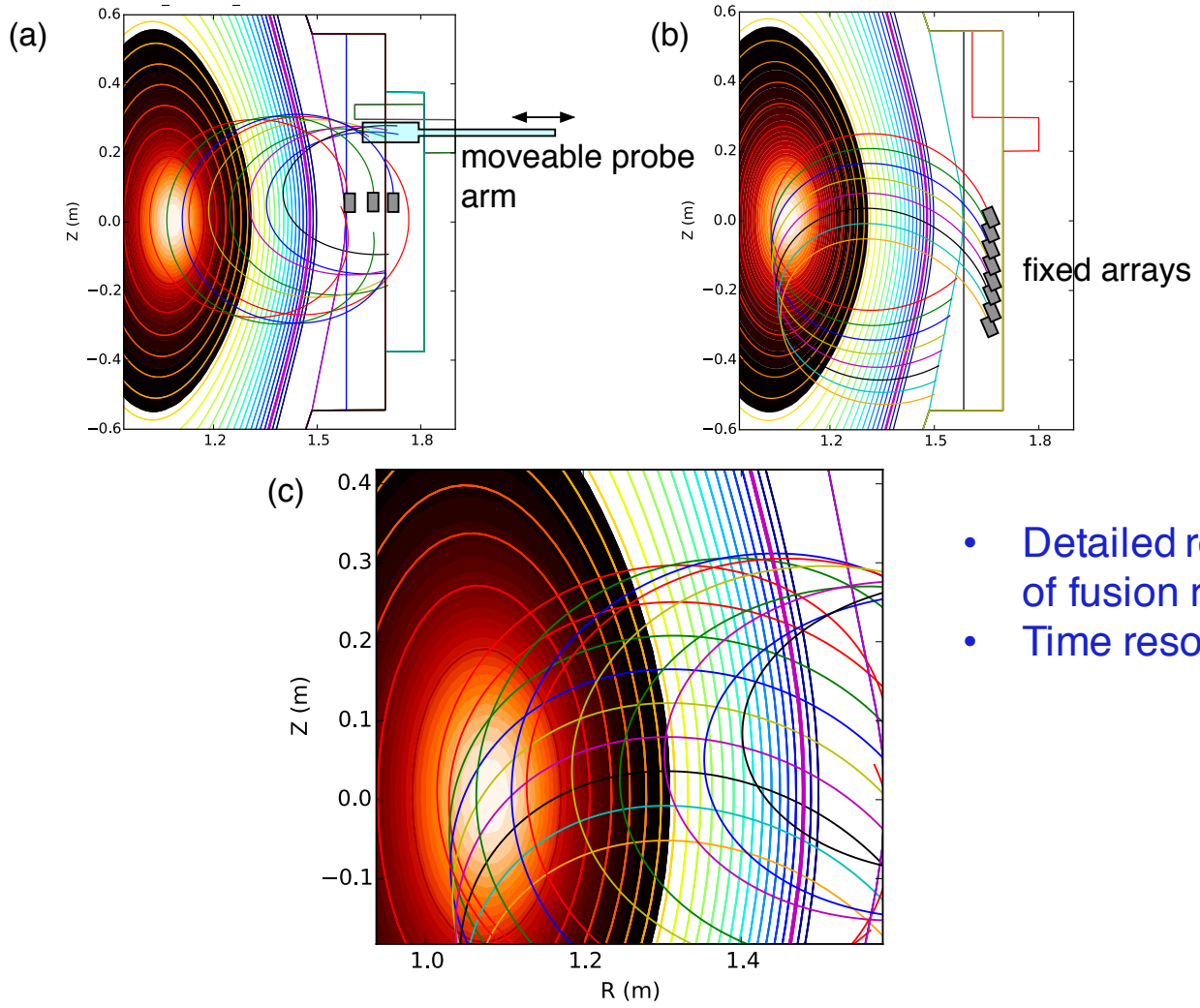
a) $\Delta E_{\mathrm{FWHM}} = 100\ \mathrm{keV}$

b) $\Delta E_{\mathrm{FWHM}} = 170\ \mathrm{keV}$

Plans 2016 - 2018

- Upgrade system to 16 detectors
- 6 – 8 detectors on (thermionics drive)
- Remaining detectors installed at fixed locations inside the vessel (exact locations to be determined)
- Upgrade digitizer to 16 channels (100 MS/s)
- Memory upgrade to store 16 channels for 5 s.
- Upgrade LabView acquisition code
- Upgrade raw analysis for new large data sets
- Run TRANSP simulations

Coverage with 16 detectors

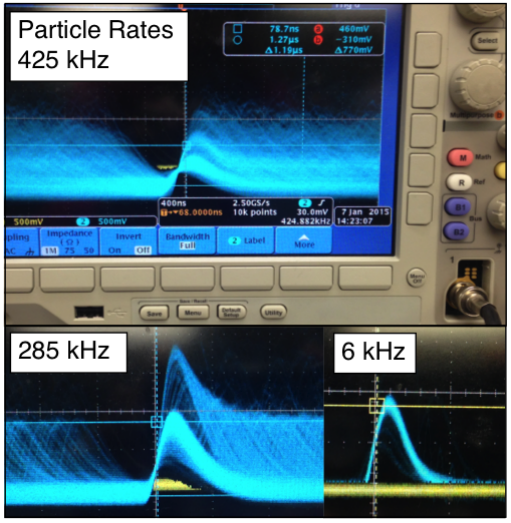


- Detailed reconstruction of fusion rate profile
- Time resolution ~1ms

Estimated Time Line

- 2016 – 2017
  - 6 channel data analyzed
  - Design of 16 channel system
  - Pass design reviews
  - TRANSP simulations
- 2017-2018
  - New detectors
  - New electronics
  - New DAQ hardware
  - DAQ installed in NSTX-U tested with 6 channel system
  - Construction of remaining detector channels
- 2018-2019
  - Installation of 16 channel system
  - First data at maximal pulse length

Rate Behavior of Detector



Particle pulses as a function of rate

300 kHz