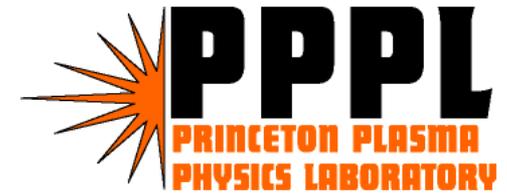




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A Charged Fusion Product Diagnostic for NSTX

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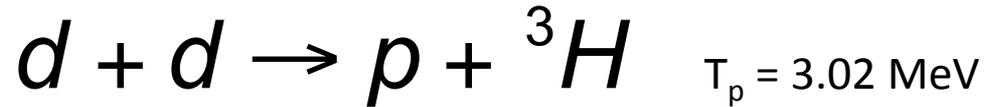
This work is supported by US Department of Energy contract numbers (a) DE-SC0001157 and (b) DE-AC02-09CH11466

Goal of the Diagnostic:

- Obtain time-dependent information on the proton emission profile
- Achieve a time resolution down to 1-2 ms
- Extract neutral beam ion density profile
- New data on fast ion transport
- New data on instabilities driven by NB/plasma interaction
- Complementary data for other fast ion loss diagnostics
- Explore the potential for other ion detection:
 ^3He , ^3H
- Rev. Sci. Instrum. **81**, 10D301 (2010)

Principle

detect protons from:

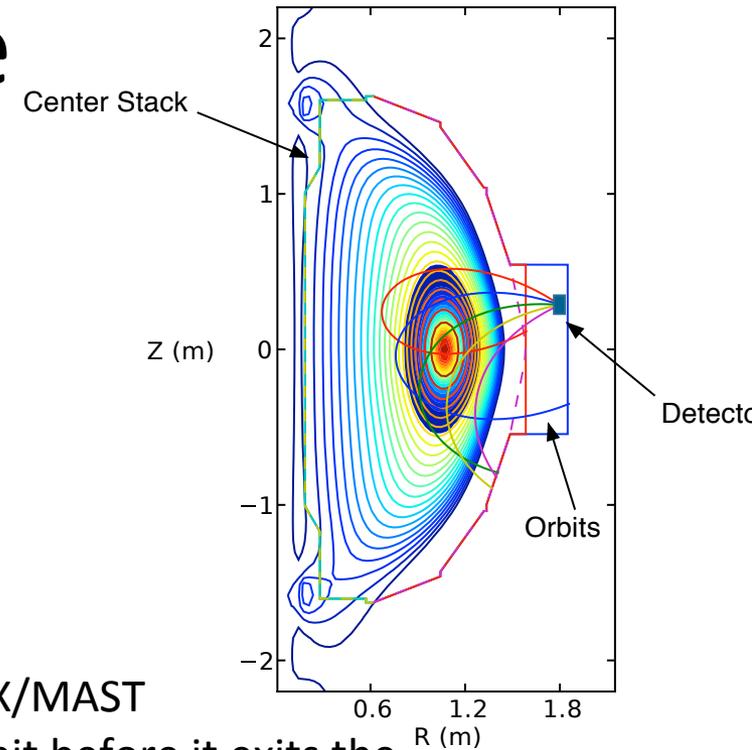


$$T_p = 3.02 \text{ MeV}$$

$$T_T = 1.01 \text{ MeV}$$

$$p = 75 \text{ MeV}/c$$

dominated by neutral beam and
plasma ion interactions



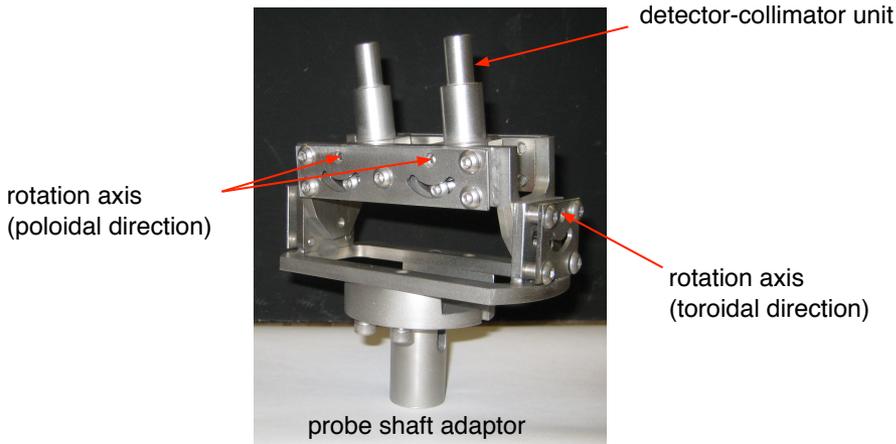
Advantage at NSTX and MAST:

- proton is not confined in the magnetic field of NSTX/MAST
- proton frequently does not complete a full gyro orbit before it exits the plasma
- proton trajectory similar to a view chord of an X-ray camera
- observed proton rate is a measure of the integrated emissivity along the view path

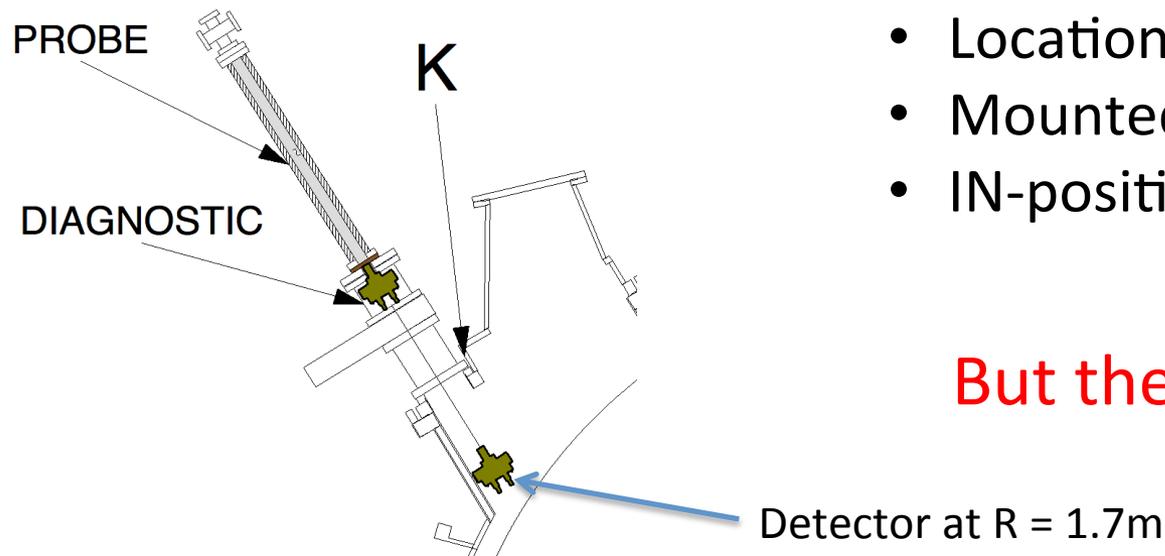
Proton measurements have been carried out previously:

- W.W.Heidbrink, J.D.Strachan, Rev. Sci. Instrum, **56**, 501 (1985)
- J.D. Strachan, Rev. Sci. Instrum., **57**, 1771 (1986)

Original Prototype



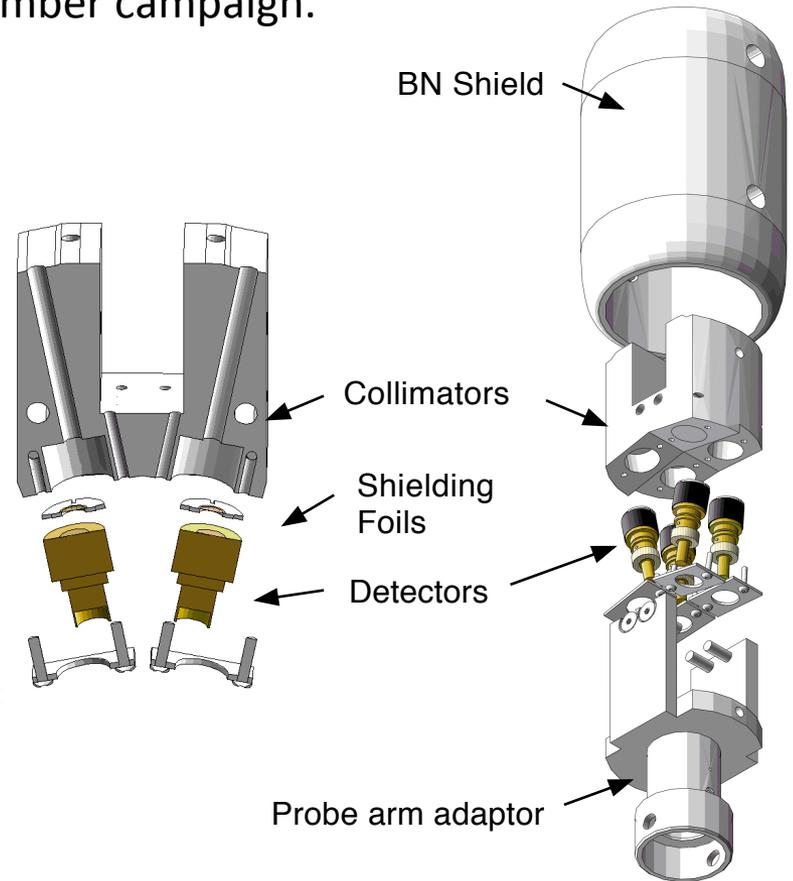
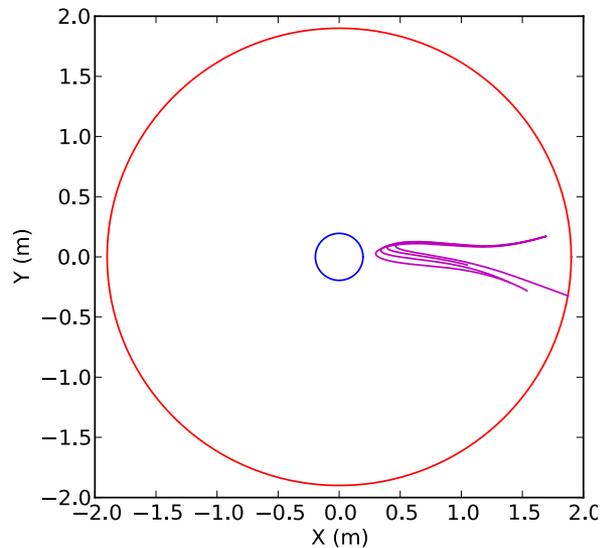
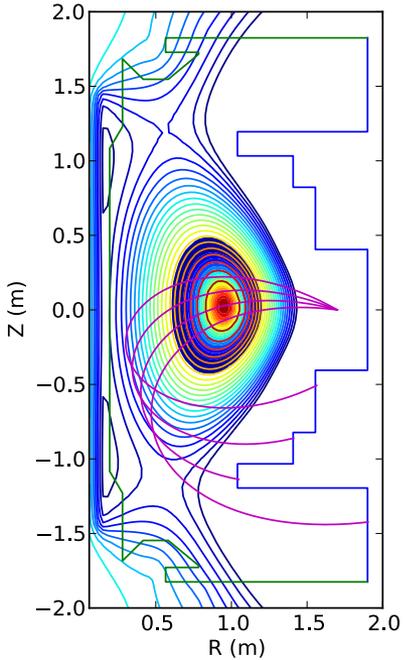
- Prototype: 2 detectors
- Flexible orientation around 3 axes
- Study signals and rates
- Optimize detector arrangement and location for full array of 8 detectors
- Location: Bay K
- Mounted on moveable probe shaft
- IN-position: $R=1.7\text{m}$, $Z = 0.286\text{m}$



But then NSTX broke

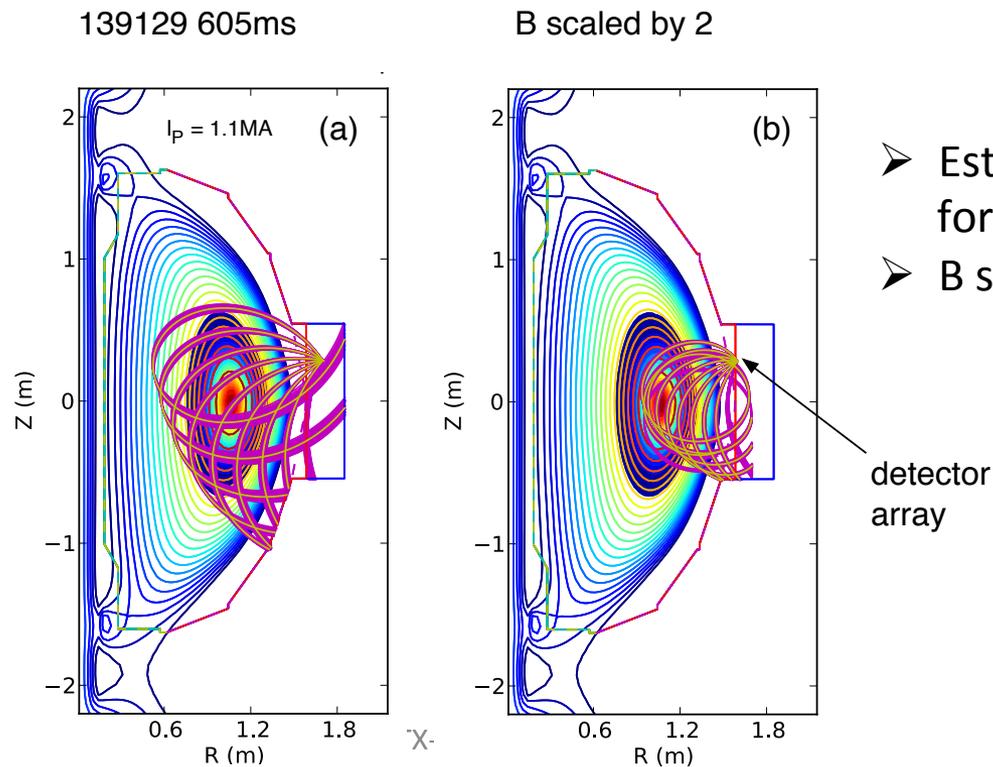
Test at MAST

- 4 channel system
- Detector fixed, array can be moved radially
- To be tested in the November campaign.



16 Channel System for NSTX-U/MAST

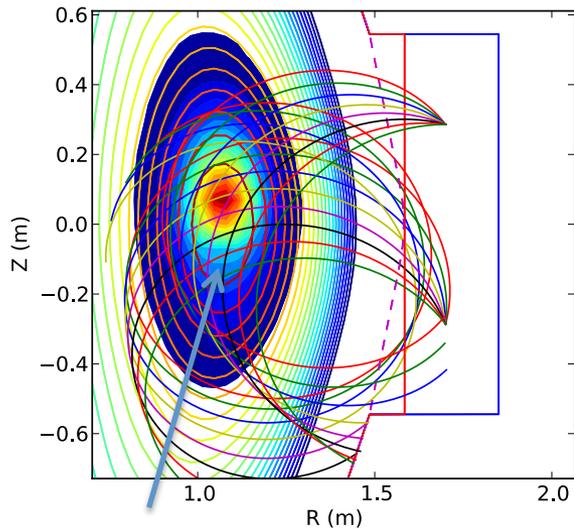
- 2 units of 8 channels each
- 2 fixed units
- One fixed, one on probe drive (with axial rotation)
- Various collimator arrays possible, can be optimized for specific experiments
- Allows for determination of shifts of the profile in 2 dimensions



- Estimated orbit bundles for NSTX-U
- B scaled by a factor of 2

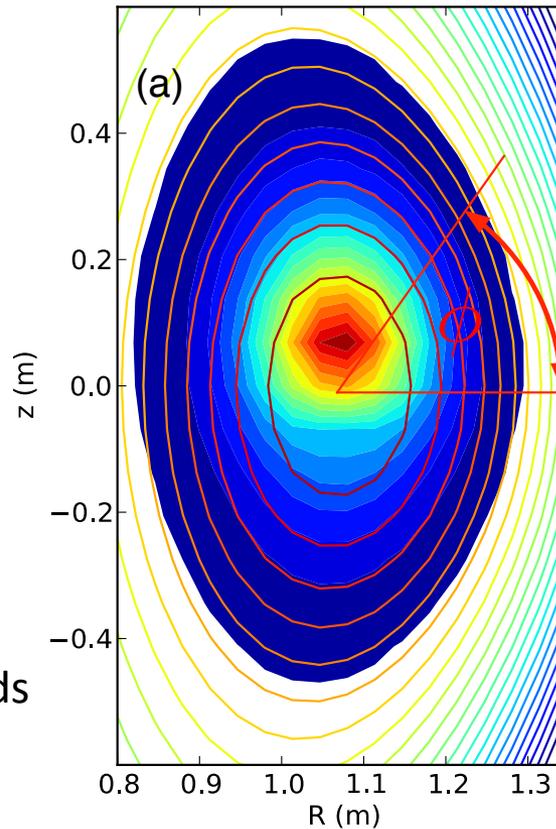
Profile Reconstruction

Central Orbits

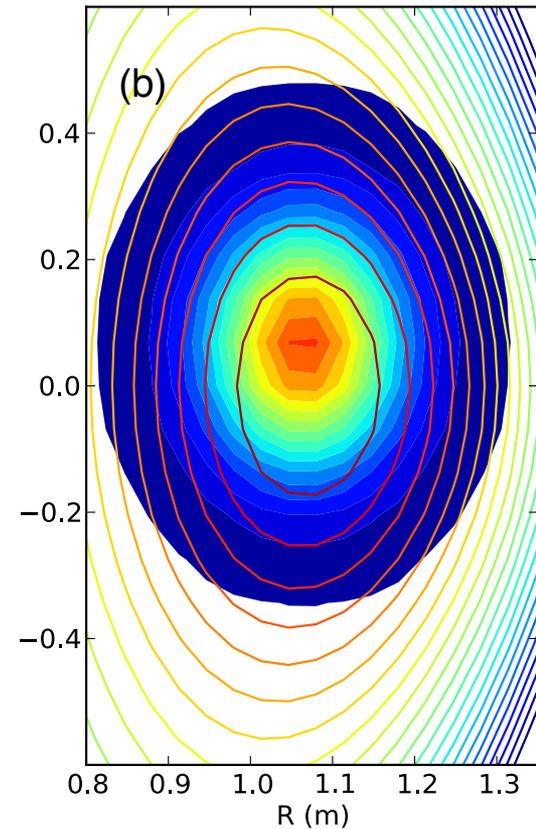


- Orbits cross central plasma region
- Act like 'curved' sight chords in X-ray tomography

Simulation



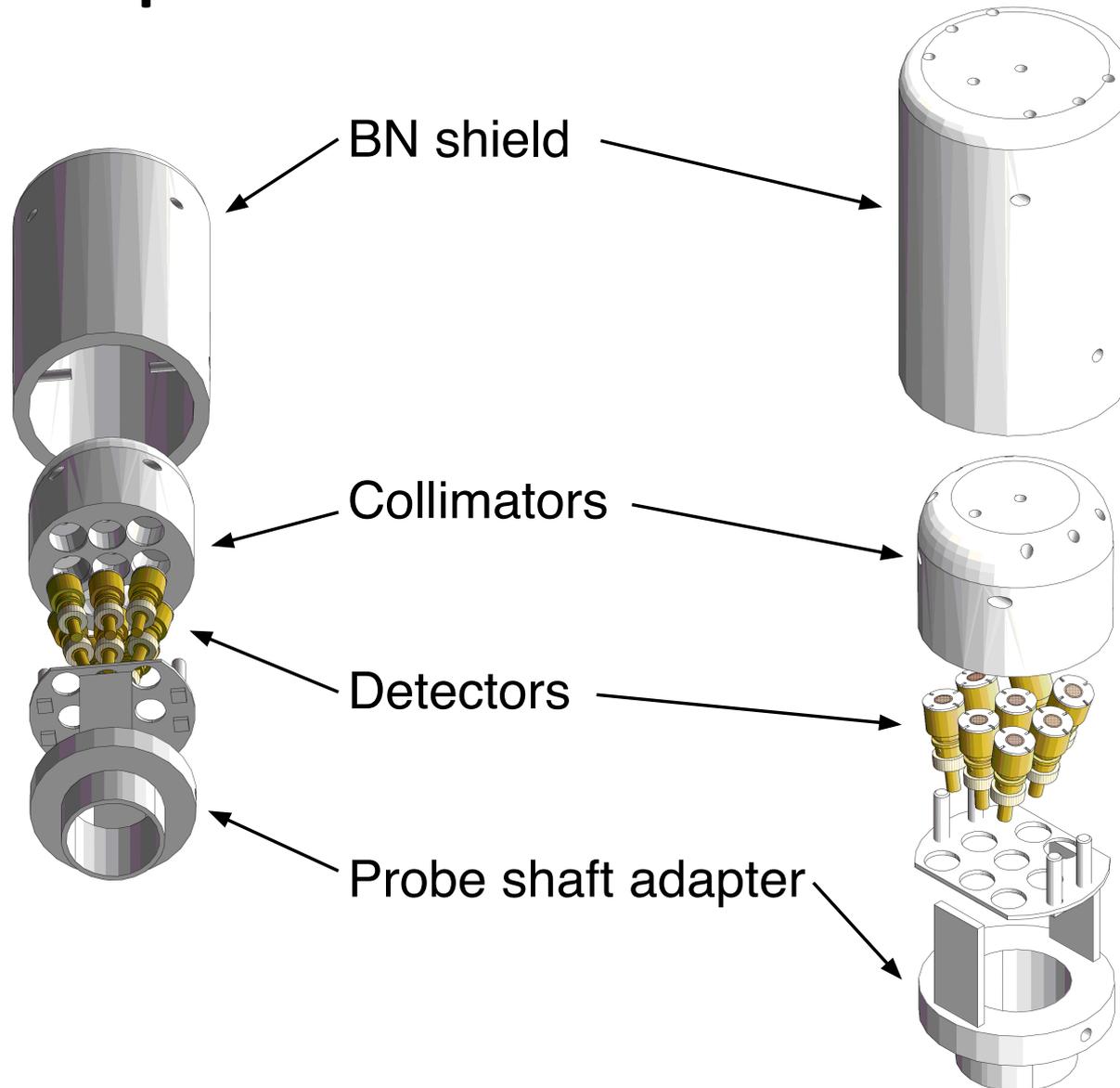
Fit



Simulation: $S(\psi) = \psi^\lambda (1. + A \sin(\phi)), \lambda = 11.45, A = 0.5$

Fit function: $S_{fit}(R, z) = A e^{-\frac{1}{2} \left(\frac{R-R_0}{\sigma_R} \right)^2} e^{-\frac{1}{2} \left(\frac{z-z_0}{\sigma_z} \right)^2}$

Compact 8 channel module



Summary

- New data on proton emissivity profile (similar to neutron detector)
- 2D information accessible
- Good time resolution
- Access to the plasma core at high density and large current
- Complements current fast ion diagnostics
- Will be applying via:
Diagnostic Systems for Magnetic Fusion Energy Sciences
Funding Opportunity Number: DE-FOA-0000744
- Practical experience this Fall at MAST (hopefully)

Backup: DAQ setup

