A Charged Fusion Product Diagnostic for NSTX

W.U Boeglin and R. Valenzuela-Perez

Department of Physics, Florida International University [a)]

D. Darrow

Princeton Plasma Physics Laboratory [b)]

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 ms
- Provide new information on fast ion transport
- Has the potential for other ion detection: ^{3}He, ^{3}H
- Rev. Sci. Instrum. **81**, 10D301 (2010)

Principle

detect protons from:

$$d + d \rightarrow p + {}^{3}H$$

dominated by neutral beam and plasma ion interactions

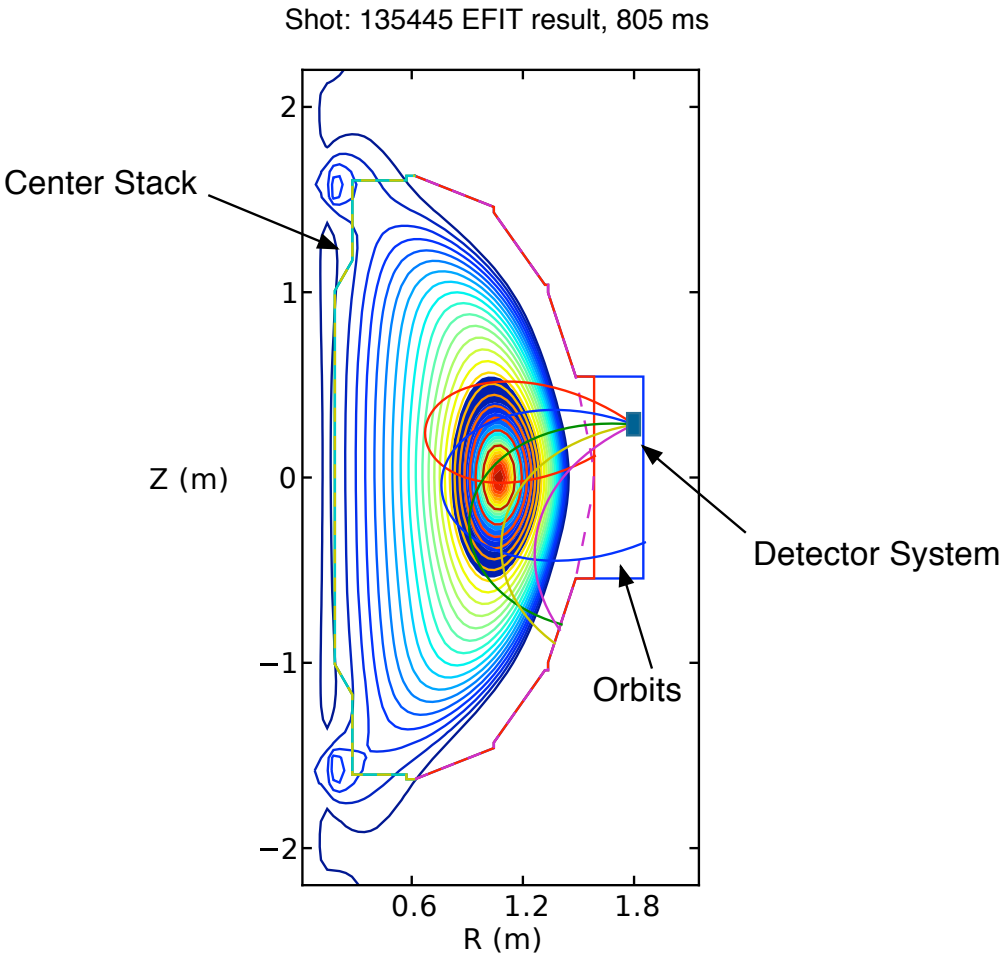
Kinematics:

T_p = 3.02 MeV
T_T = 1.01 MeV
p = 75 MeV/c

Advantage at NSTX:

- proton is not confined in the magnetic field of NSTX
- 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

Measurement technique:



- array of proton detectors views different parts of the plasma
- each detector-collimator system defines a phase space volume
- proton orbits conserve phase space
- every proton emitted in the corresponding phase space volume is detected
- view path is determined by calculating the time-reversed proton orbit for a proton entering along the collimator-detector center line
- observed proton rate is a measure of the integrated emissivity along the view path

Proton measurements have been carried out previously:

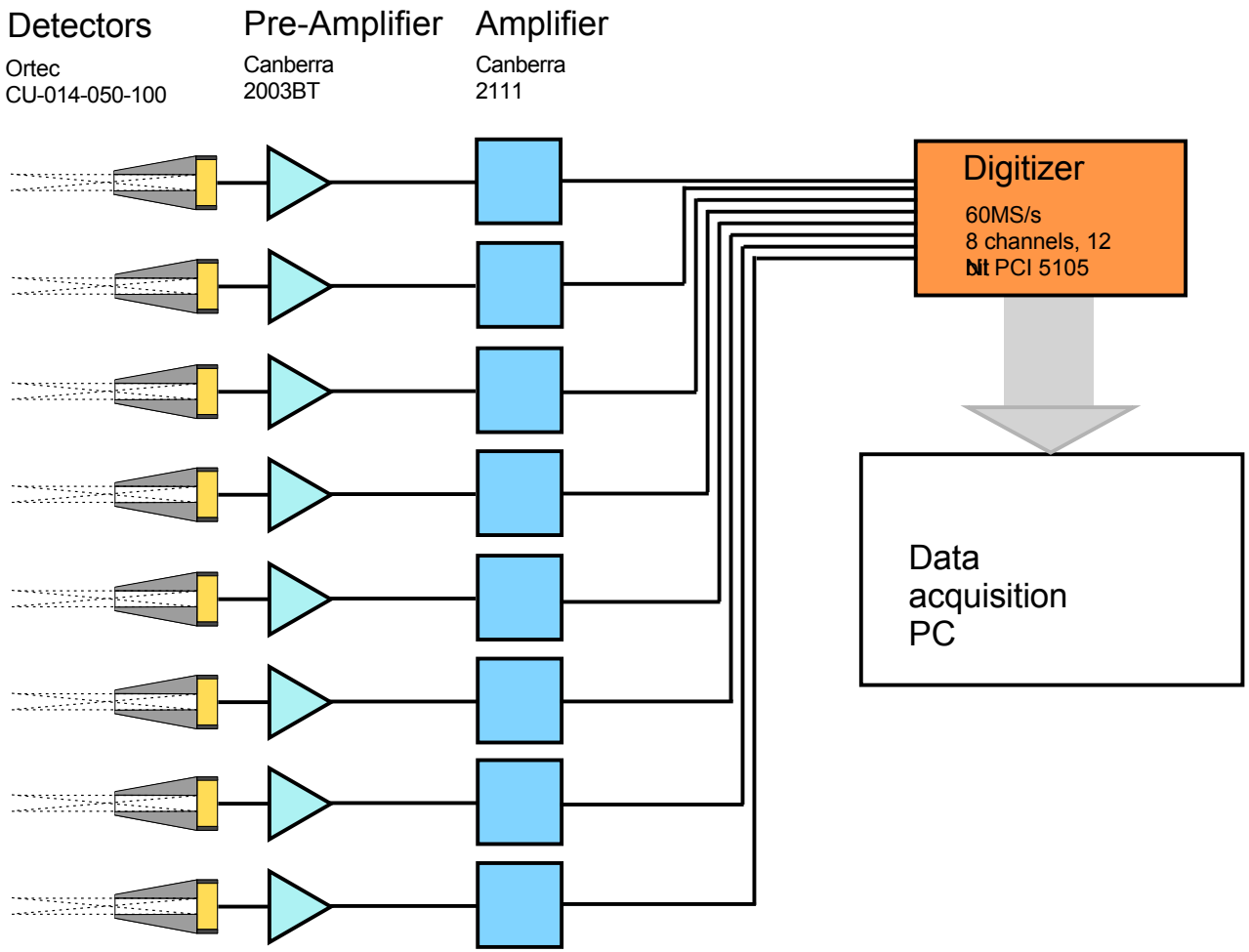
- W.W.Heidbrink, J.D.Strachan, Rev. Sci. Instrum, **56**, 501 (1985)
- J.D. Strachan, Rev. Sci. Instrum., **57**, 1771 (1986)

Reconstruction of Emission Profile

Principle

- assume emissivity *S*, is constant on surfaces of constant flux (y_{rel})
- use a parametric expression for $S(y_{rel})$
- fit parameters to the observed efficiency (data yield)

Data Acquisition



First Step

- Prototype: 1 – 2 detectors (Presentation by Ramona)
- Flexible orientation
- Study signals and rates
- Optimize detector arrangement and location

Second Step

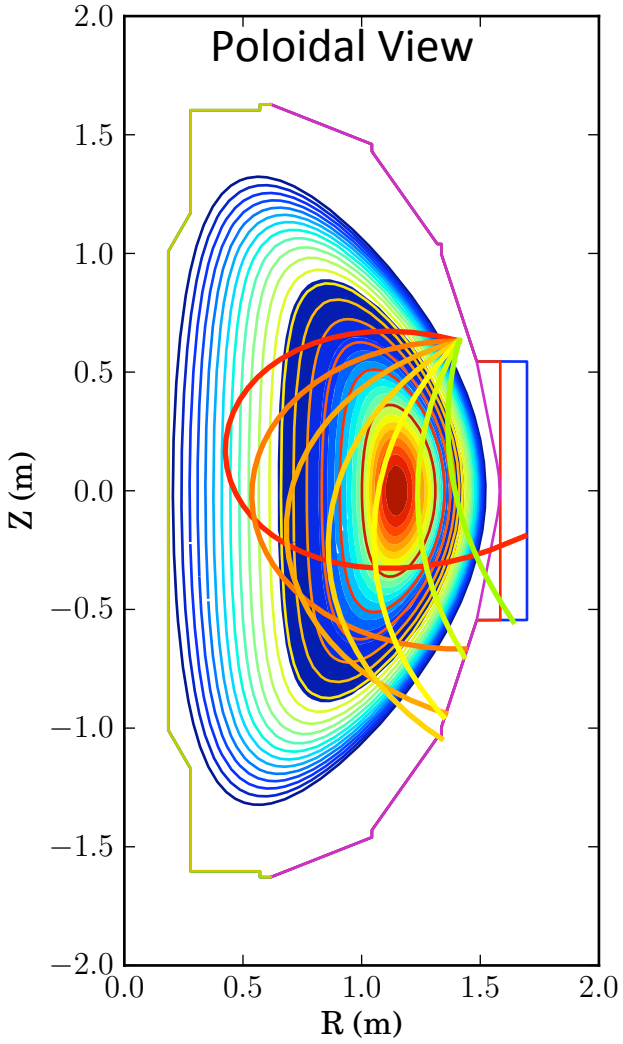
- Build full array
- Compact design
- Orientations fixed

Simulations with Lorentz Orbit Code (based on ORBIT205)

- For full array of 8 detectors
- Use a standard field configuration
- Acceptance for rectangular collimator and detector
- Use counting statistics as error source
- Emissivity as a function of relative flux used:

$$S_{Orbit}(\psi_{rel}) = \psi_{rel}^{11.45}$$

View C



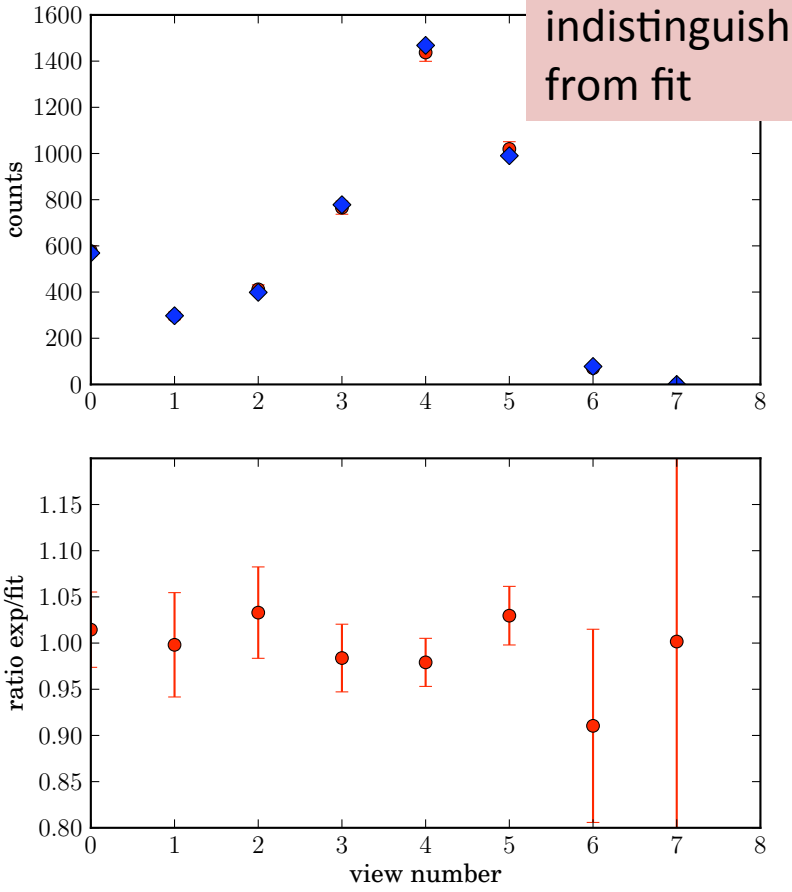
view 0
view 1
view 2
view 3
view 4
view 5
view 6

Total Reaction Rate: $2 \cdot 10^{14}$/s

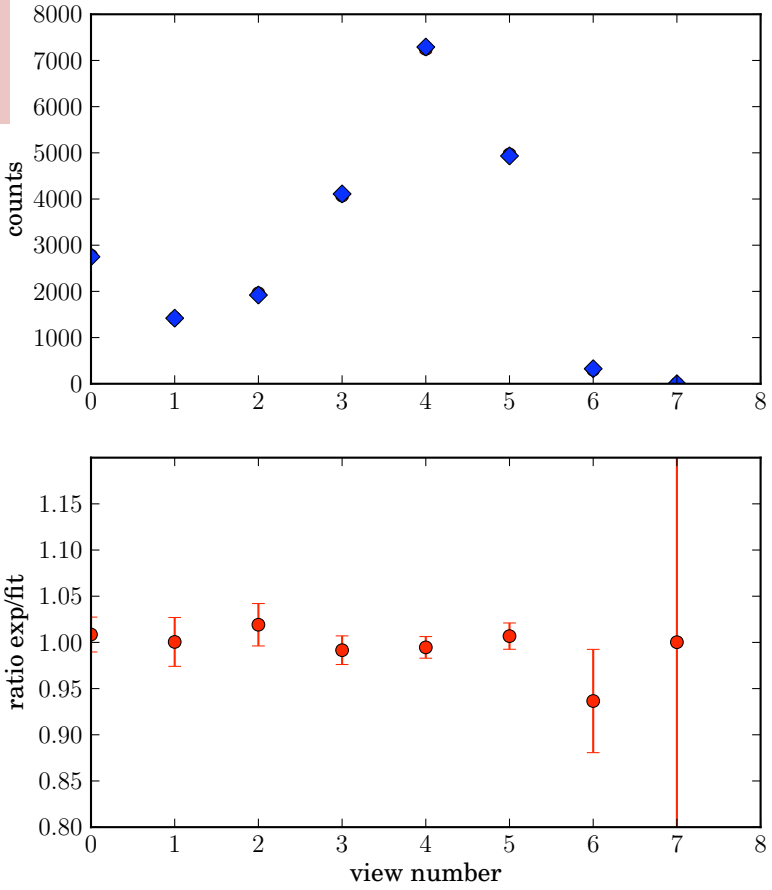
Red Points: expected counts
Blue Points: Fit

Integration time : 1ms

'experiment' almost indistinguishable from fit

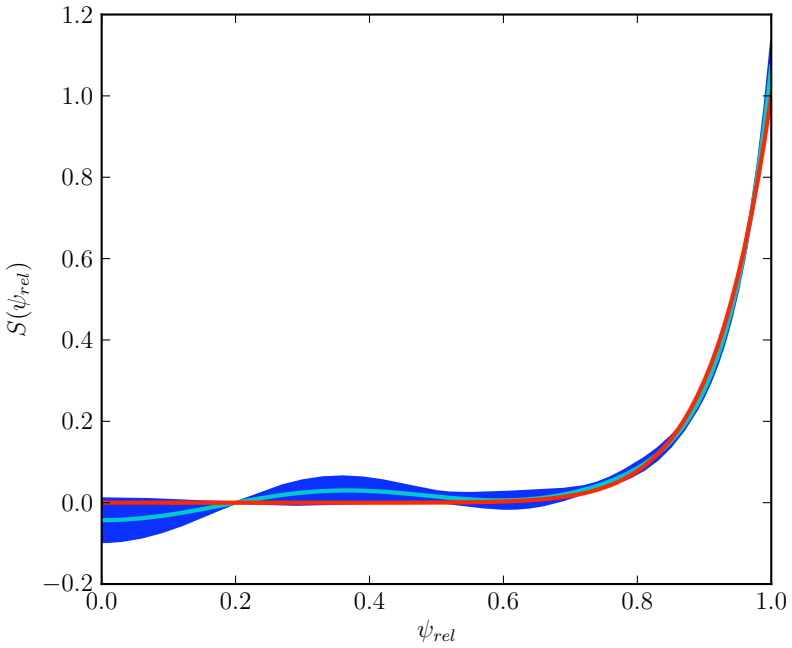


Integration time : 5ms

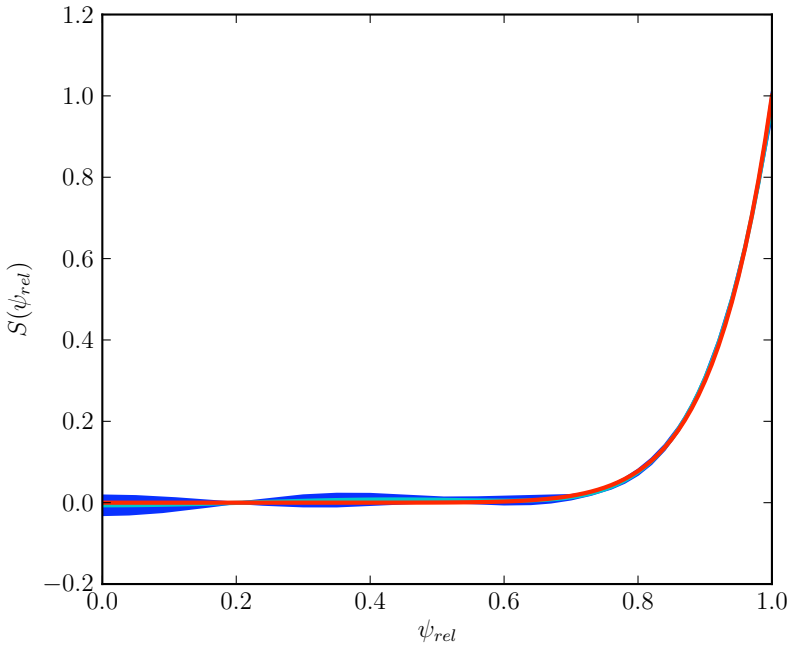


Zernike Polynomial Fit up to 5th order

Integration time : 1ms



Integration time : 5ms



Red Line: $S(y_{rel})$ used in ORBIT
Cyan Line: fitted $S(y_{rel})$
Blue Band: Error Band