RECONSTRUCTION OF CURRENT PROFILES IN DIII-D ECCD DISCHARGES

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GENERAL ATOMICS

MOTIVATION

- Use of ECCD to control and sustain the current profile for AT study is a key element of DIII-D research program
- Determination of ECCD profiles for current profile control and for testing against theoretical models is an important issue
- Previous results from analysis based on a time series of EFIT reconstructions with smooth basis functions using MSE data show that the widths of the ECCD profiles are generally broader than those predicted theoretically[1]
- ECCD simulations indicate that the narrower predicted ECCD profiles are consistent with MSE data and the discrepancy is due to the finite spatial resolution and the smooth basis functions used in the reconstruction

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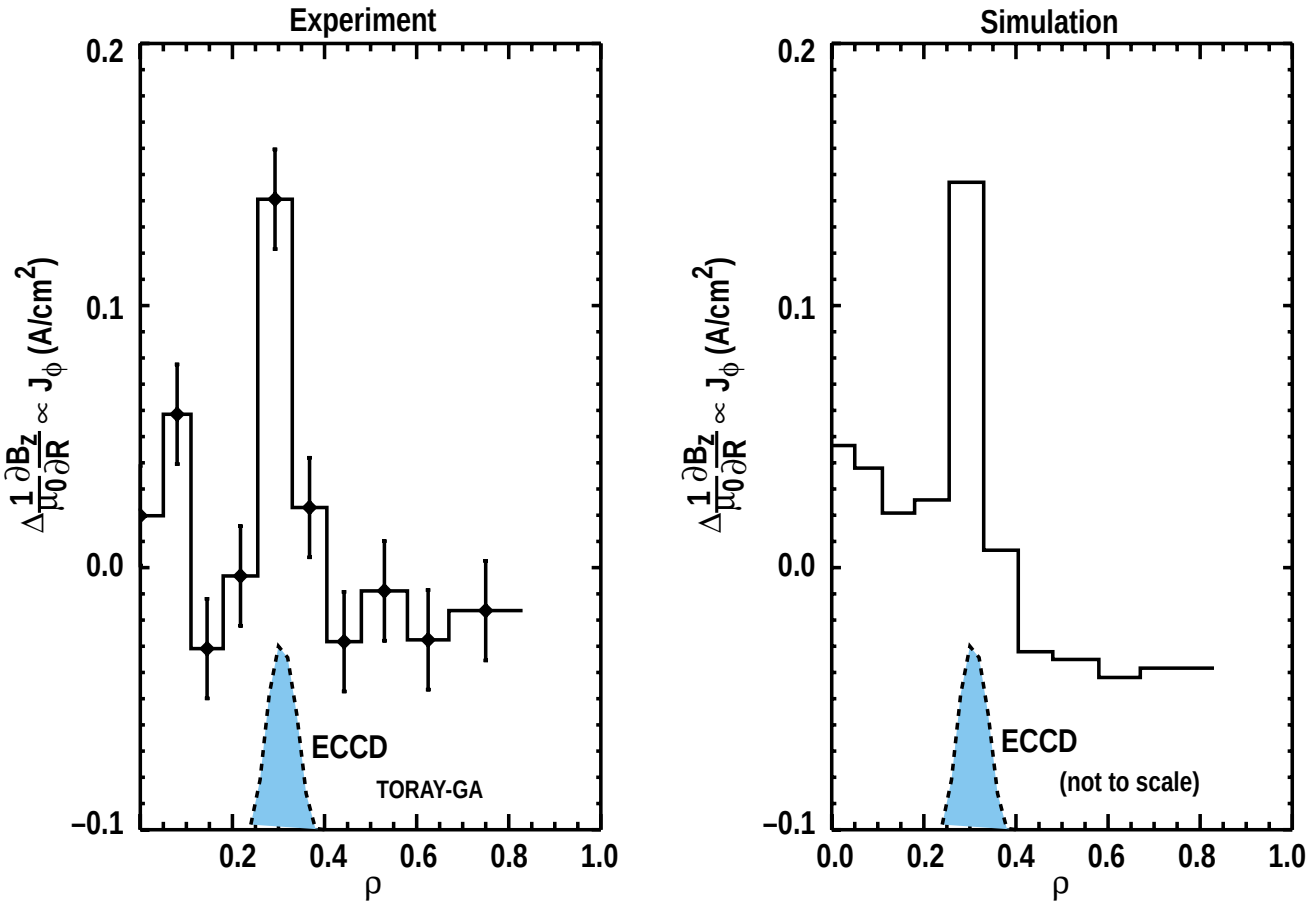
[1]Luce, et al, Phys. Rev. Lett. 83, 4550 (1999)

GENERAL ATOMICS

MSE MEASUREMENTS SHOW THAT THE INCREASE IN CURRENT DENSITY FROM ECCD IS VERY LOCALIZED

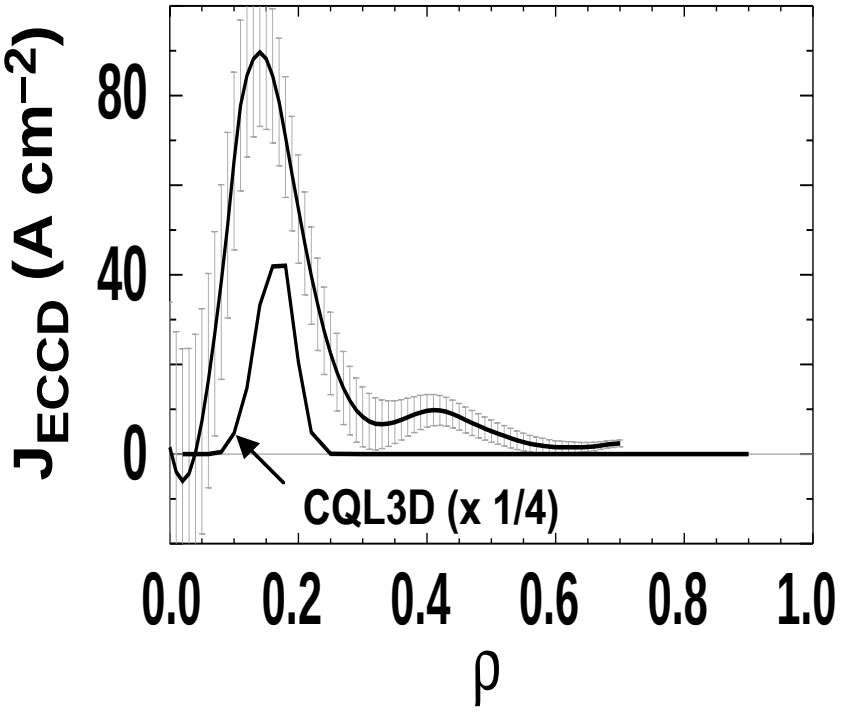
- Measurements consistent with ray tracing calculations

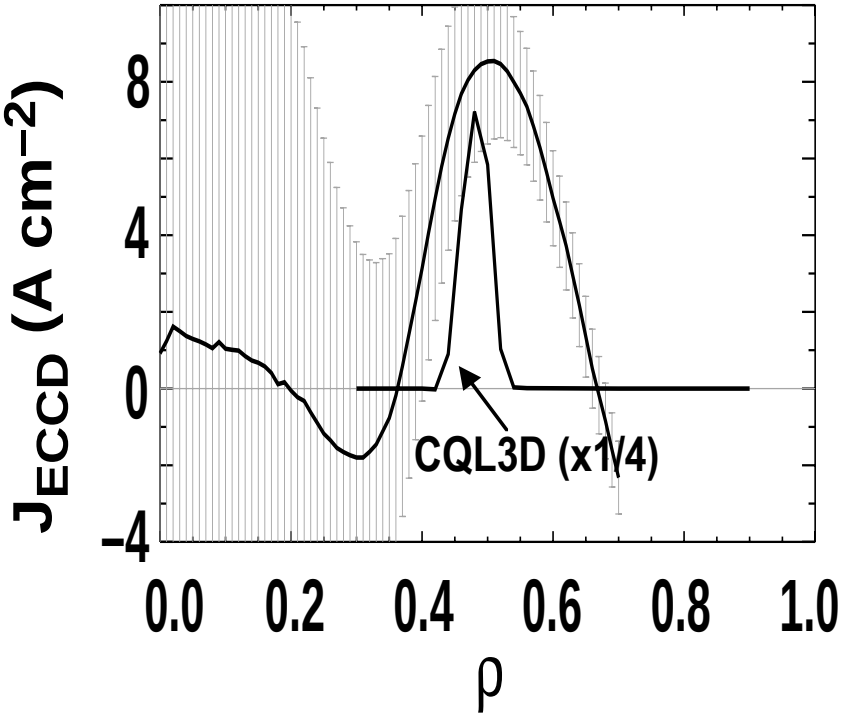


Petty, et al, GA-A23388 (2000)

PREVIOUS EFIT ANALYSIS USING SMOOTH BASIS FUNCTIONS SHOWS VERY BROAD ECCD PROFILES

- ECCD profiles from a time series of EFIT reconstruction using MSE data
- Inconsistent with quasi-linear Fokker-Planck results from CQL3D





Luce, et al, Phys. Rev. Lett. 83, 4550 (1999)

QUESTIONS TO ANSWER

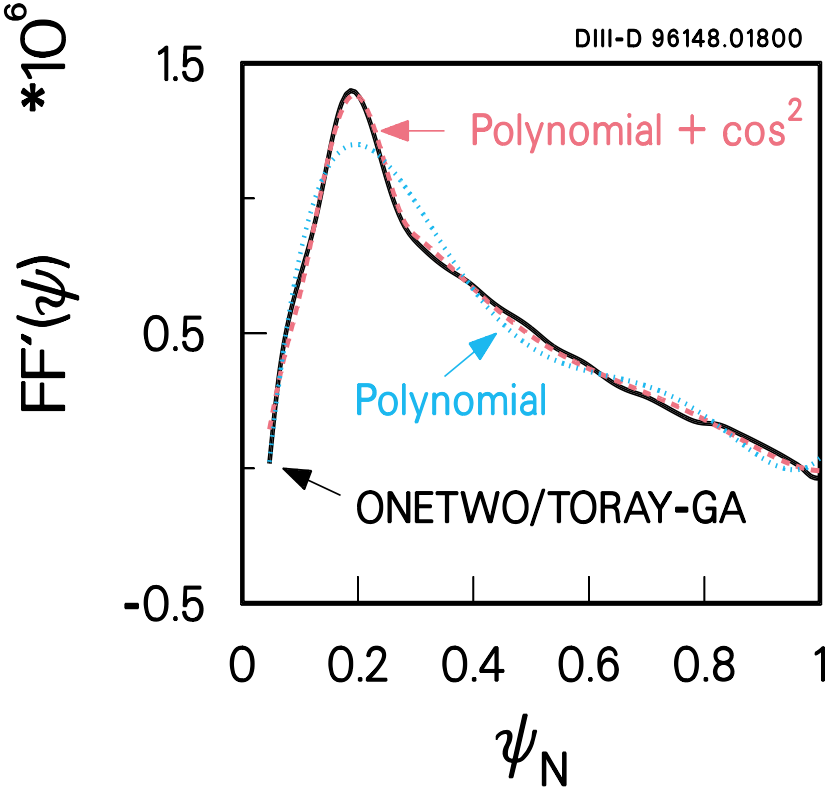
- Can a local basis function be used to improve the reconstruction of the very localized ECCD profiles ?
- What measurements are crucial for an accurate determination ?
- What other techniques can be used to improve the reconstruction ?

OUTLINE / KEY RESULTS

- ECCD profiles can be conveniently represented and reconstructed using a local cosine square basis function
- Reconstructed ECCD profiles from MSE data are consistent with the very narrow computed current drive profiles from the quasi-linear Fokker-Planck code CQL3D
- Accurate measurements of the core MSE channels are crucial for the determination of the ECCD profiles

ECCD PROFILES CAN BE CONVENIENTLY REPRESENTED USING A LOCAL COSINE SQUARE BASIS FUNCTION

- $J_\phi(R,Z) = J_{\phi 0}(R,Z) + J_{local}(R,Z)$
  - $J_{local} = FF'_{local}(\psi) / R$
  - $FF'_{local} = C \cos^2 kx \quad |x| \le \Delta\psi_0$
    $0 \quad$ otherwise
  - $x = \psi_n - \psi_0$
  - $k = \pi / (2\,\Delta\psi_0)$
  - ψ_0: local current peak location
  - $\Delta\psi_0$: current channel half width
  - $J_{\phi 0}$: smooth background current



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NUMERICAL IMPLEMENTATION

$$J_{local} = C \cos^2 kx / R \qquad |x| \le \Delta\psi_0 \qquad x = \psi_n - \psi_0 \,,\; k = \pi / (2\,\Delta\psi_0)$$

$$0 \qquad \text{otherwise}$$

- The amplitude C is determined similarly as other current profile parameters by directly inverting the response matrix *A* at each iteration using the singular value decomposition method[1]

$$\alpha = A^{-1} M$$

α : current profile parameter vector

M : measurement vector

- The local current peak location and current channel half width ψ_0 and $\Delta\psi_0$ are driven externally as done for the spline knot optimization

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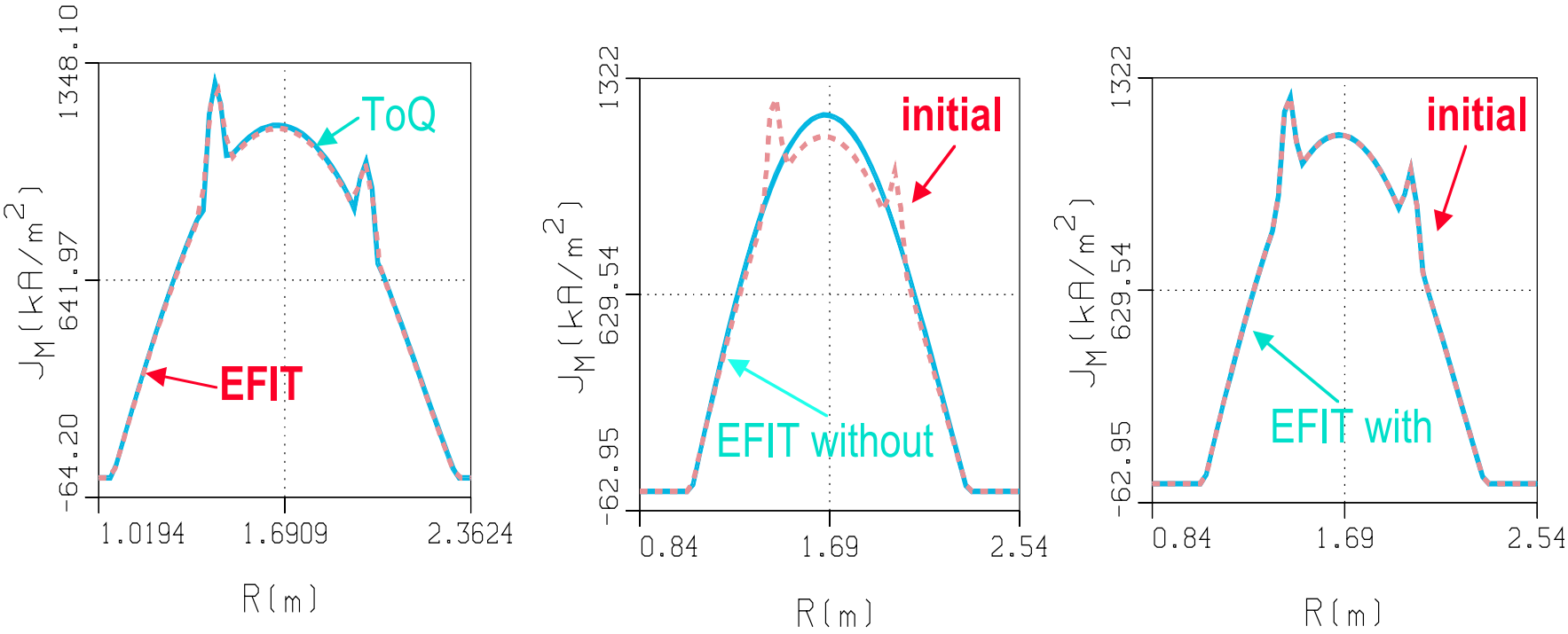
Lao, et al, Nuc. Fusion 25, 1611 (1985)

GENERAL ATOMICS

EFIT LOCAL REPRESENTATION HAS BEEN BENCHMARKED USING SIMULATED DATA AND AGAINST TOQ

- EFIT equilibrium with local cosine square representation agrees well with ToQ
- Reconstructed equilibrium using simulated data agrees well with initial equilibrium



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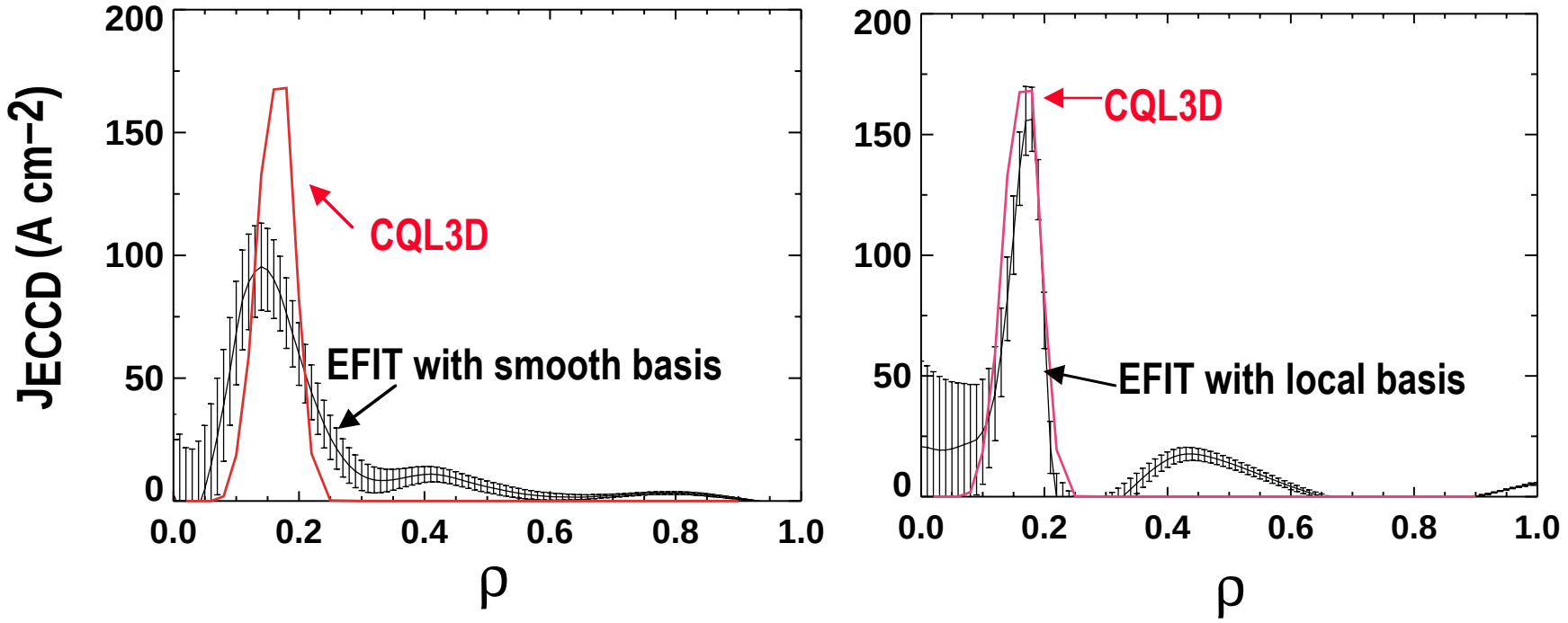
GENERAL ATOMICS

INITIAL RESULTS INDICATE RECONSTRUCTIONS USING A LOCAL BASIS FUNCTION CAN RESOLVE VERY PEAKED J

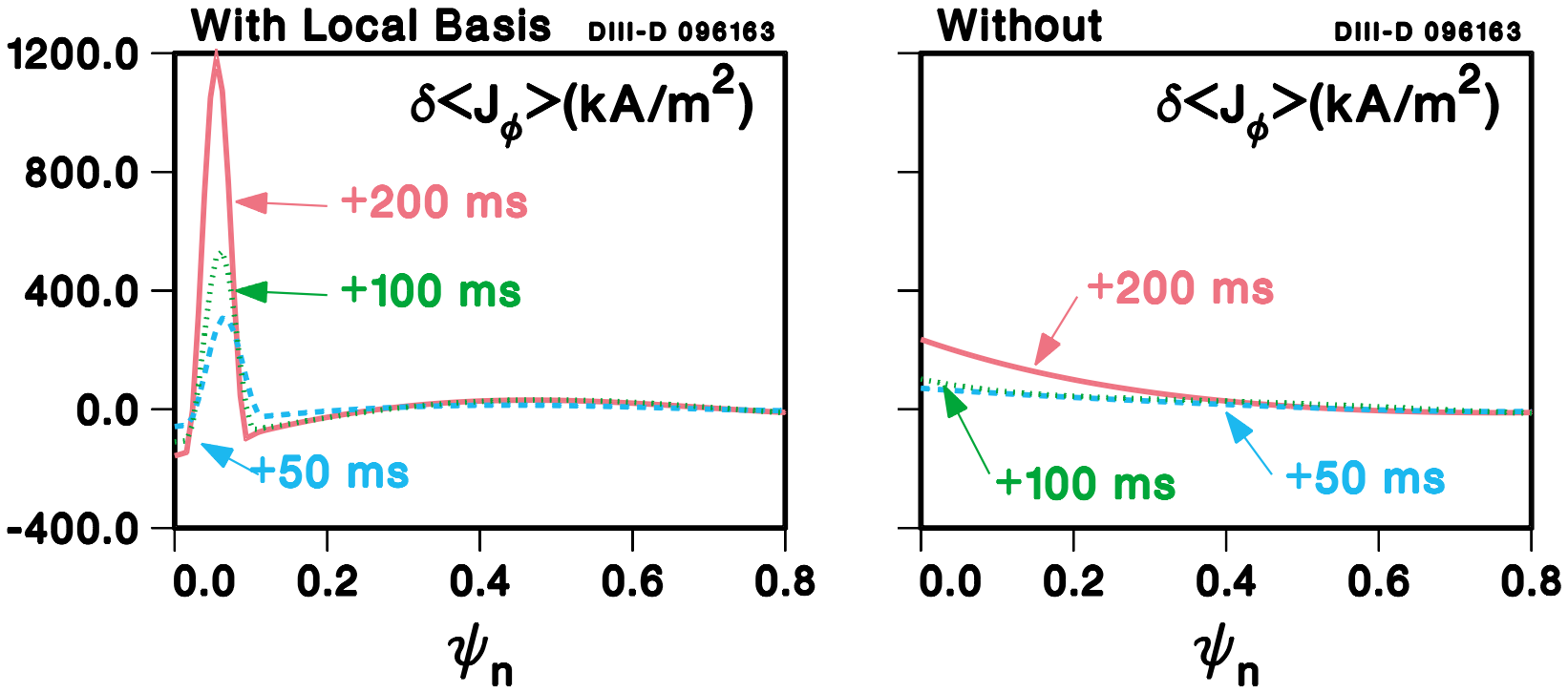
- ECCD profile determined from a time series of 129 x 129 EFIT reconstruction with a local cosine square basis function using MSE data, ψ_0=0.055, $\Delta\psi_0$=0.04
- Consistent with quasi-linear Fokker-Planck results from CQL3D



Lao, et al, poster NP1.079, Wednesday PM

EFIT WITH A LOCAL BASIS FUNCTION CAN DETECT LOCAL CHANGES IN CURRENT PROFILE

- ECCD profiles are reconstructed from MSE and magnetic data using 129 x129 EFIT with a local cosine square basis function



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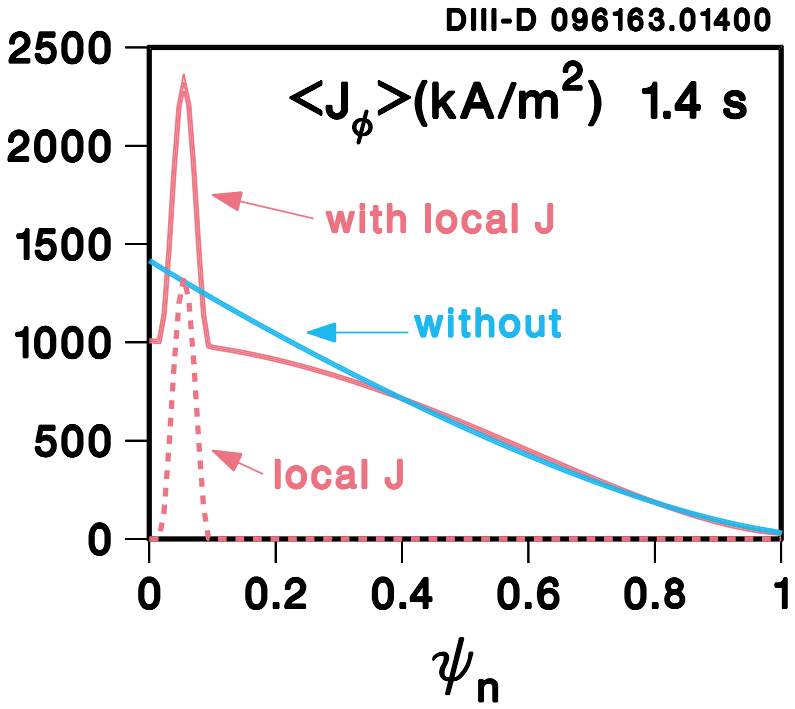
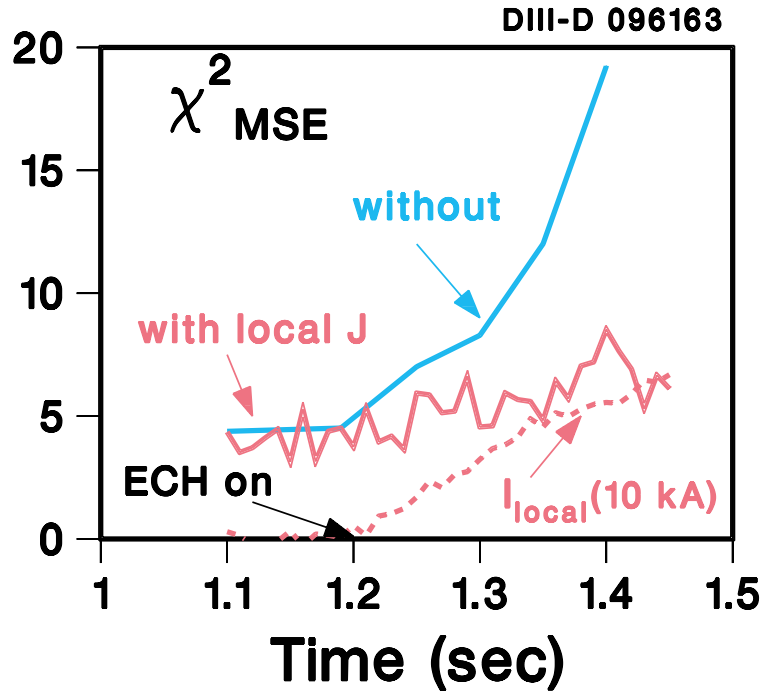
A LOCAL CURRENT COMPONENT IS ESSENTIAL TO MATCH MSE MEASUREMENTS IN ECCD DISCHARGES

- Similar magnetic χ^2 ~ 12 - 13, ψ_0 = 0.055, $\Delta\psi_0$ = 0.040
- EFIT reconstruction with a local cosine square representation, 129 x 129 grid





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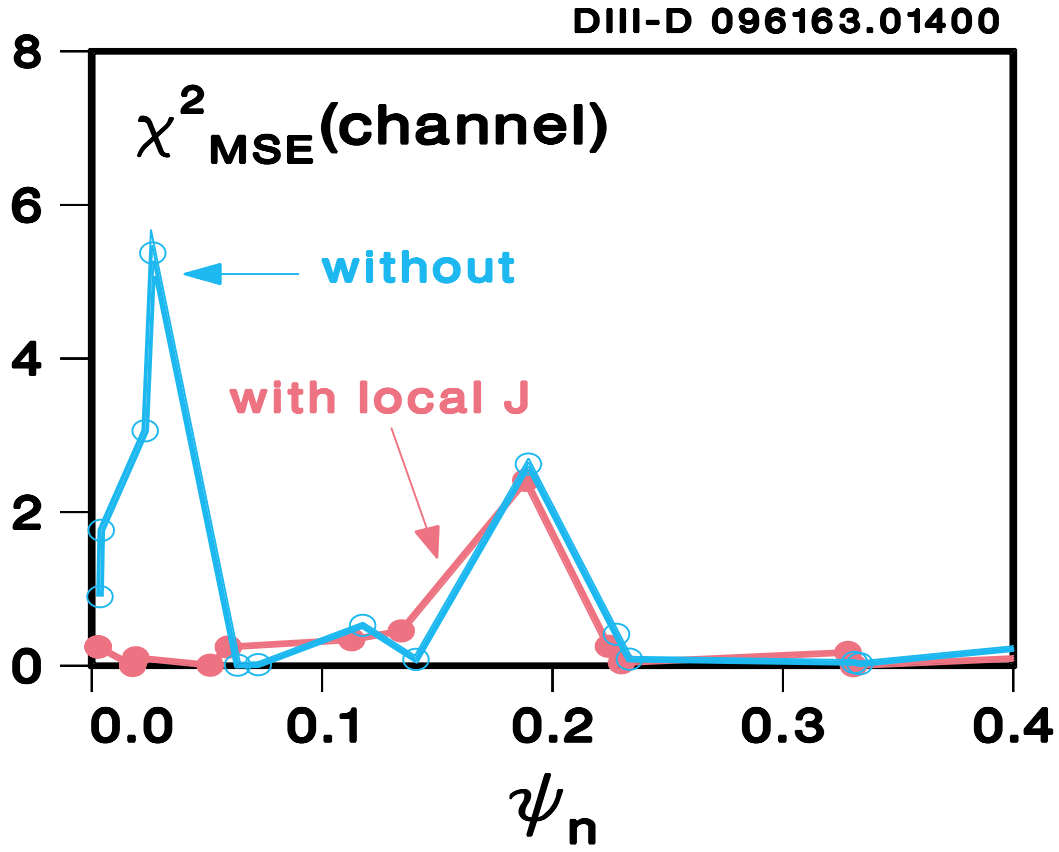
GENERAL ATOMICS

CENTRAL MSE MEASUREMENTS ARE CRUCIAL FOR DETERMINATION OF ECCD PROFILES

- Similar magnetic $\chi^2 \sim 12 - 13$, $\psi_0 = 0.055$, $\Delta\psi_0 = 0.040$
- EFIT reconstruction with a local cosine square representation, 129 x 129 grid



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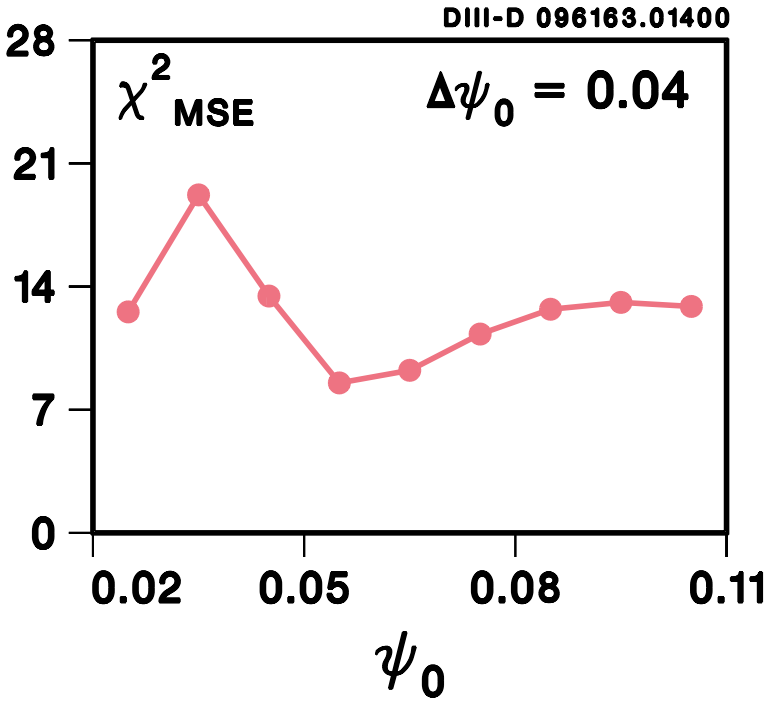
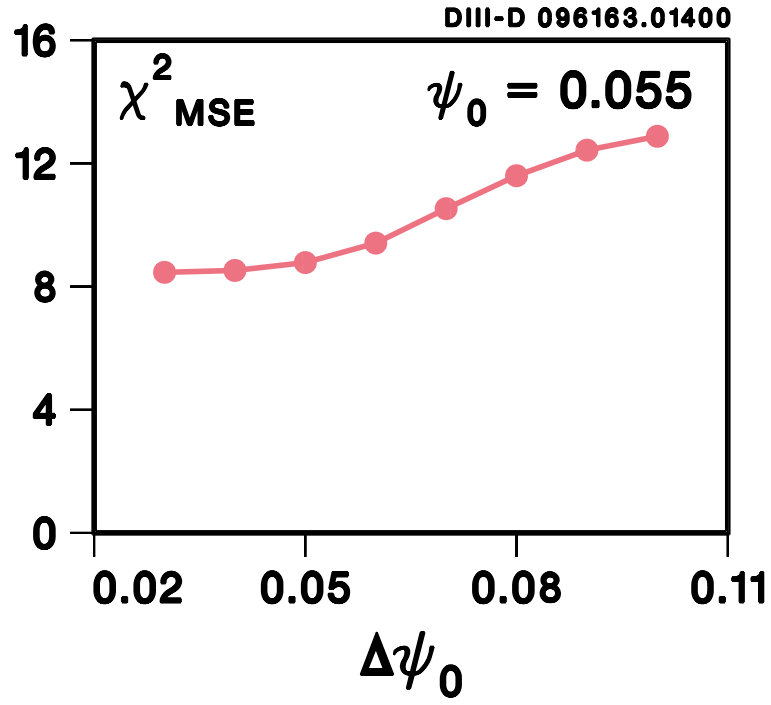
MSE MEASUREMENTS CAN DETECT CHANGES IN ECCD PROFILE LOCATION AND WIDTH

- ECCD profiles are reconstructed from MSE and magnetic data using 129x129 EFIT with a local cosine square basis function
- Similar magnetic χ^2 ~ 12 - 13





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SUMMARY

- ECCD profiles can be conveniently represented and reconstructed using a local cosine square basis function
- Although more works need to be done to further test and improve the ECCD current profile reconstruction technique, initial results indicate that the reconstructed ECCD profiles from MSE data are consistent with the very peaked computed current drive profiles from Fokker-Planck calculations using CQL3D
- Accurate core MSE measurements are crucial for the determination of the ECCD profiles