Matched Filter for Real-time RWM ID & Control in NSTX

NSTX Research Opportunities Forum,

Nov. 12-14, 2003

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Matched Filter Rejects Patterns Not Matching Sensor Basis Vectors

- **Matched Filter $\mathbf{M}=[[\mathbf{WV}]^{-1}\mathbf{W}]$: Pattern matching between measured and modeled sensor signals**
  - *constructed from generalized inverse of weighted ($\mathbf{W}$) basis vectors* $\mathbf{V}$
- **MHD stability code calculates pair of sensor basis vectors**
  - *EFIT→GATO/DCON→FARVAC→* $\left[\vec{V}_1 \quad \vec{V}_2\right] = \mathbf{V}$
- **Combines multiple sensors into single fast real-time analysis**
  - *B_p, B_t, B_r magnetic sensors*
  - *different poloidal/toroidal locations*

$$\mathbf{M}\, y(t) = a(t)$$

$$\left[\vec{V}_1 \quad \vec{V}_2\right] \begin{bmatrix} a_1(t) \\ a_2(t) \end{bmatrix} = \mathbf{V}\, a = y(t)$$

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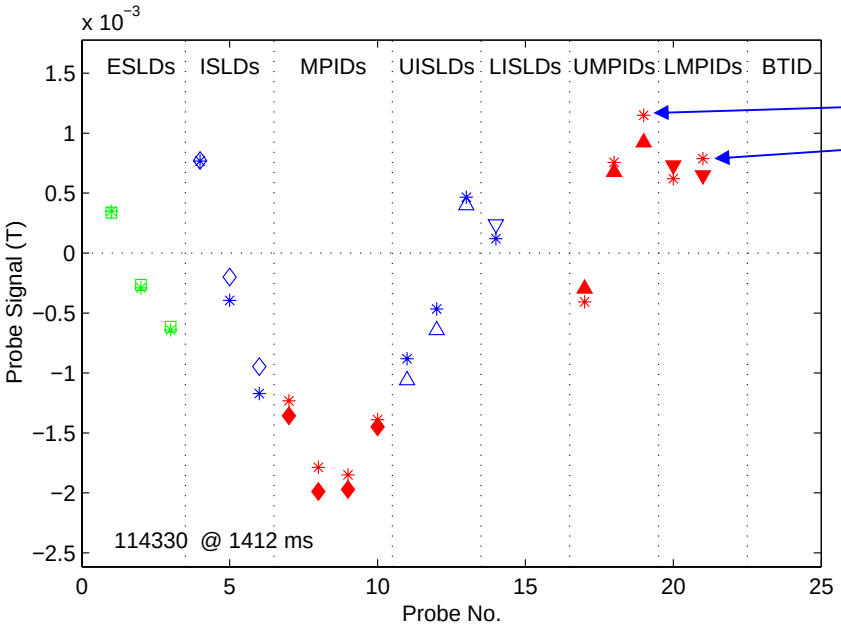
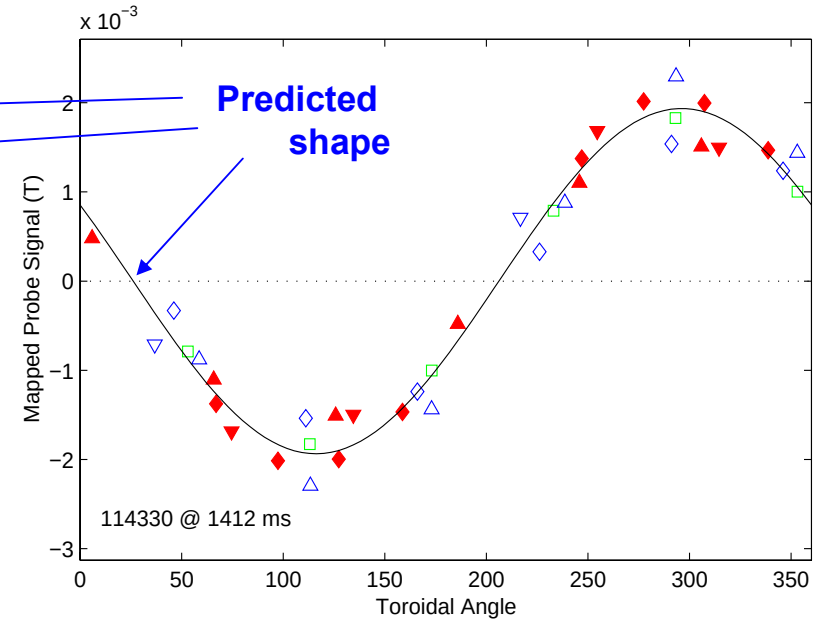
Matched Filter RWM ID in DIII-D Successfully Combines Many Sensors





- **Measured sensor pattern similar to matched filter calculations**
- **Implemented in real-time plasma control system (PCS)**
  - *processing time <1 μs*

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Propose Creating a RWM Matched Filter for NSTX's Entire New Internal Sensor Set, B_r & B_z

- **High-β_N plasmas with typical RWMs required to validate matched filter**
  - *No dedicated time, strictly piggy-back*
- **Results will benefit future NSTX active RWM control experiments**
  - *Using multiple sensors improves reliability & noise reduction*
  - *Matched filter reduces multiple inputs into two outputs characterizing the RWM amplitude and phase*
  - *Simplifies creating a fully populated MIMO (multiple-input/multiple-output) controller matrix*