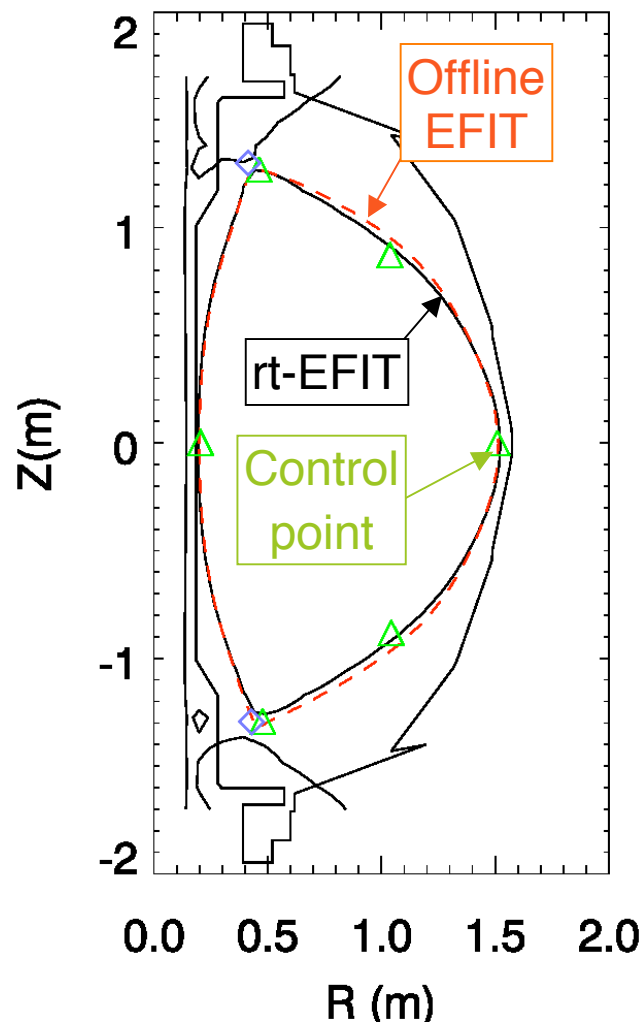
Advanced shape control development

J. Ferron, D. Humphreys, J. Leuer, M. Walker (GA), D. Gates (PPPL)

- Demonstration of shape control with real time equilibrium reconstruction (rtEFIT) and the isoflux control method was performed in 2002-2003.
  - Real time equilibrium reconstruction is working.
  - Control of a double-null shape was demonstrated.
  - Initial attempt completed: improvement of control needed.
- Work proposed for 2004:
  - Improve control of double-null shapes by refining the X point control technique and outer gap control gains.
  - Implement control of the single-null divertor shape.
  - Develop a high elongation discharge.
- Key components of capability for higher elongation:
  - Reduction of latency of commands to the power supplies. (PPPL)
  - Modeling of the NSTX plasma/vessel/power supply system to allow development and testing of an optimal controller for vertical position. (General Atomics)

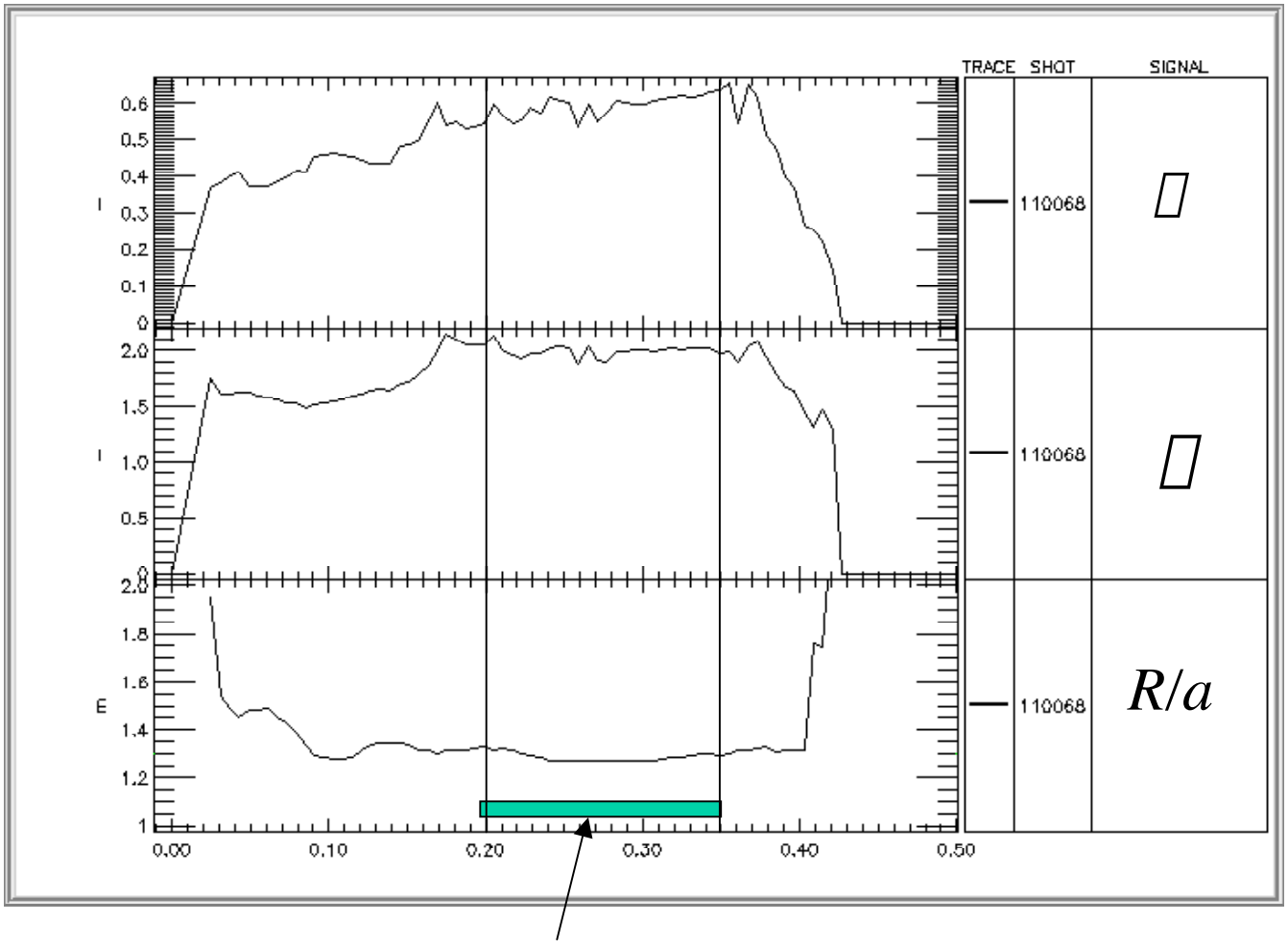
rtEFIT/isoflux control implementation

- Real-time analysis on 8 333MHz G4 processors
  - Data acquisition at 5kHz
    - 75 magnetic data points,
    - 11 coil currents,
    - 8 loop voltages (□ vessel eddy currents)
  - Reconstruction every 12ms
  - Currents calculated on grid every 0.4ms
- Controlled boundary at 5 points using all PF coil currents for I_p flattop (~300ms)



rtEFIT/isoflux performance

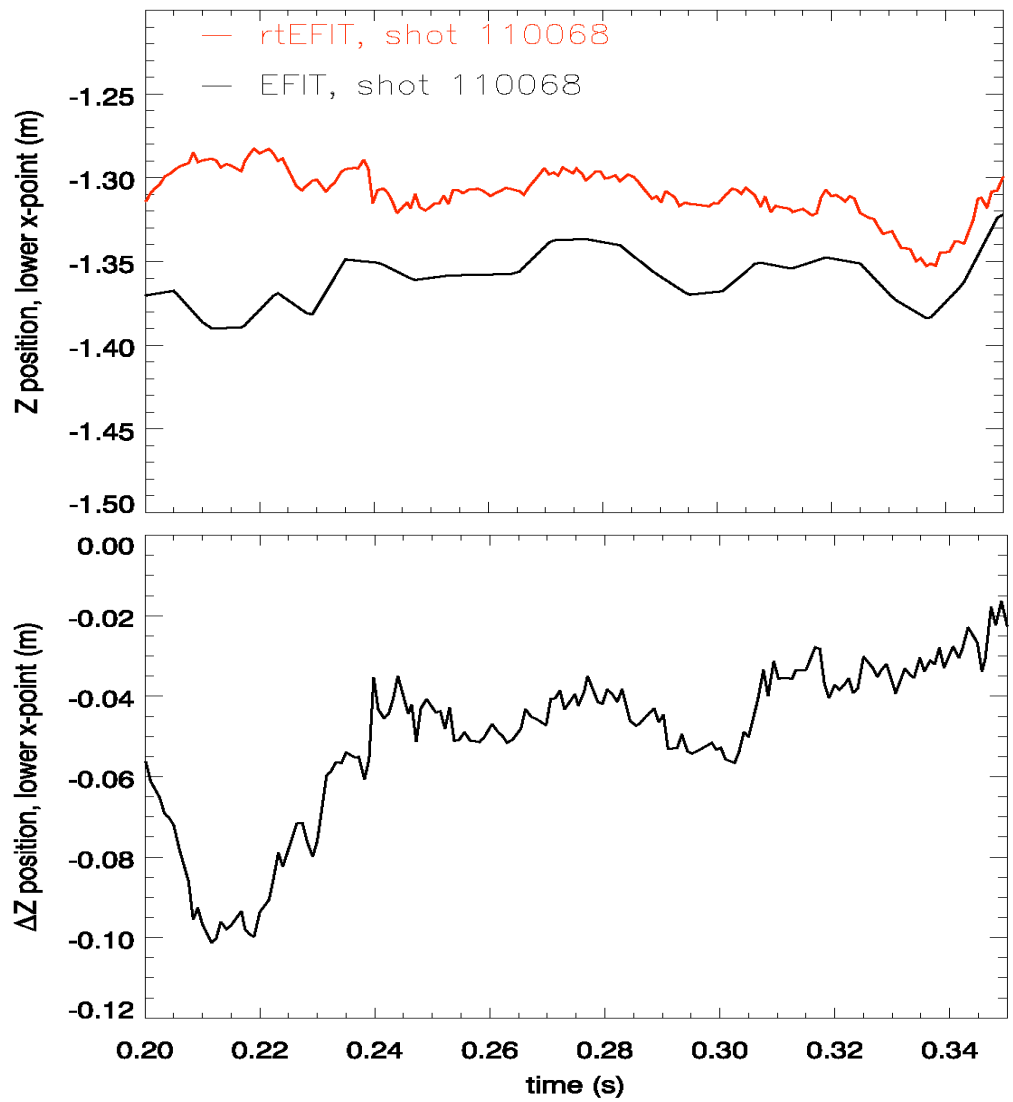
- Plasma shape control w/ isoflux improved compared to manual shape control
- Gains need optimization
- Initial condition for exchange between flux expansion and isofluxbased algorithm needs optimization
- Differences between rtEFIT and EFIT are understood (below)



rtEFIT control window

Comparison of EFIT/rtEFIT

- Biggest difference between rtEFIT and EFIT is between location of the z position of the x-point (~3-5cm)
- Several differences exist between code parameters
  - Different grid resolutions
    - rtEFIT 33x33, EFIT 65x65
  - Different current profile parameterizations
  - Different EFIT options ("fitdelz" on in rtEFIT)
- All parameter differences contribute to differences in boundary - when differences eliminated codes agree
- Better divertor magnetics measurements may help reduce discrepancy



rtEFIT development plans

- Improve gains and phase transitions
- Develop repertoire of “standard” shots for quick restore (LSN, DND, limited)
- Incorporate with improved vertical position control
- Start to include kinetic profiles into equilibrium reconstruction (profile control)