RWM active control performance analysis – Impact of number of turns

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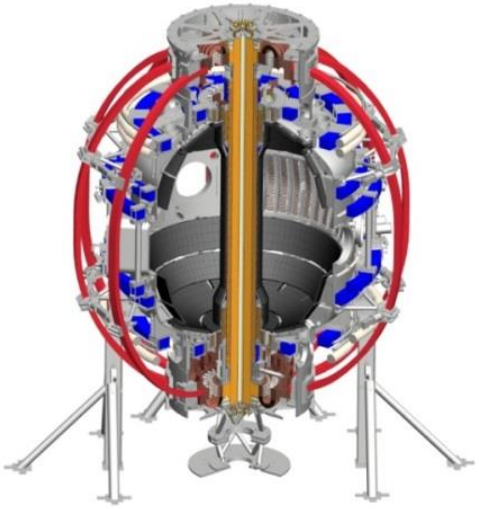
PPPL



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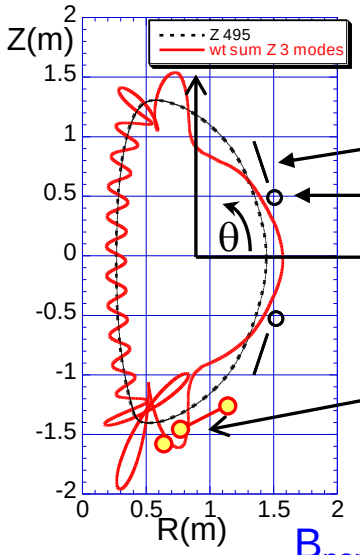
RWM active control performance analysis examined to determine impact of a 1 or 2 turn NCC

- Motivation
  - A 2 turn coil may be difficult for engineering to implement, so examine the performance of a 1 turn coil for RWM active control
- Outline
  - Reminder of realistic sensor use, and examination of a new sensor position
  - Enhanced control performance of NCC using 2 turns
  - Control performance of NCC using 1 turn

Review: 3D analysis of extended MHD sensors show significant mode amplitude off-midplane, incl. divertor region

n = 1 ideal eigenfunction for high beta plasma

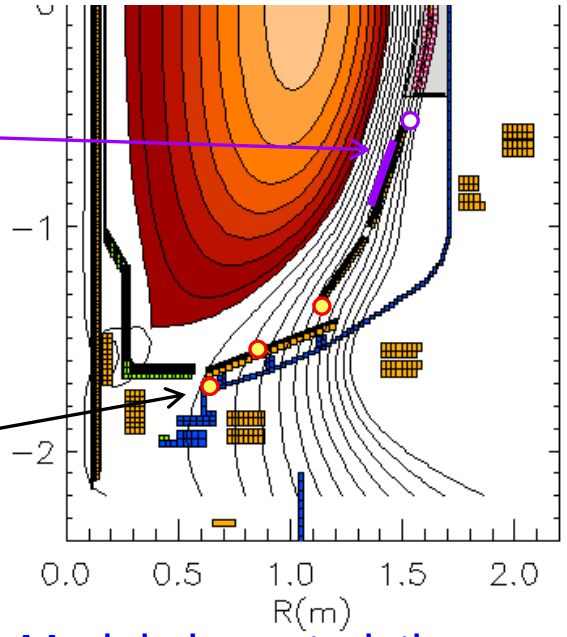


Present sensor locations

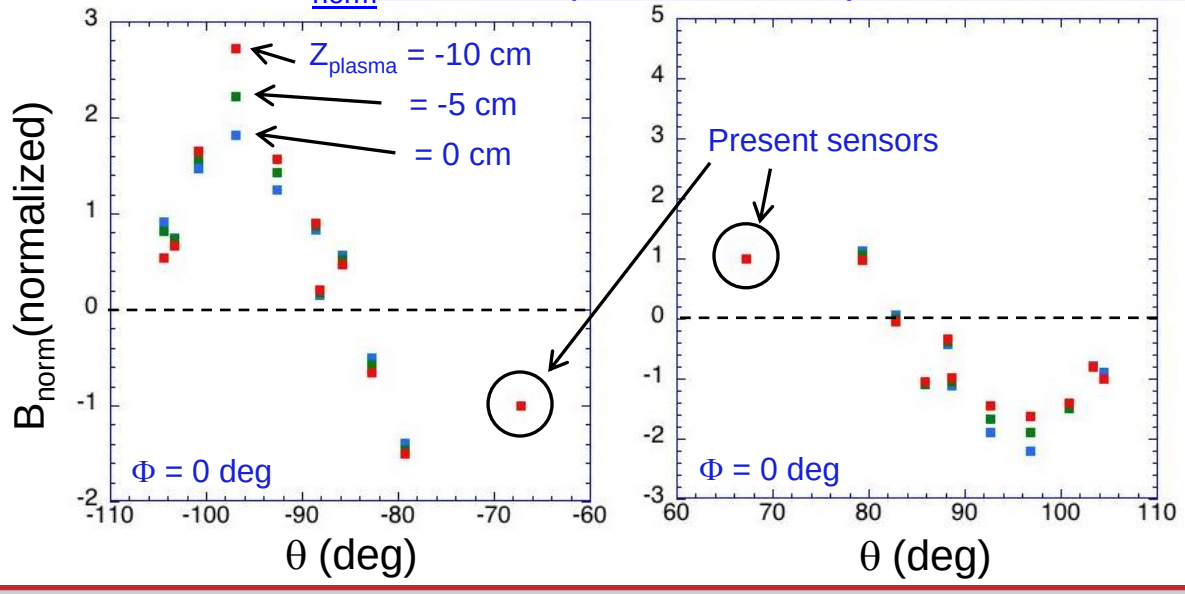
B_R sensors (nominally normal, B_{norm})

B_p sensors (nominally tangential, B_{tan})

New sensor locations (includes one new location above midplane)



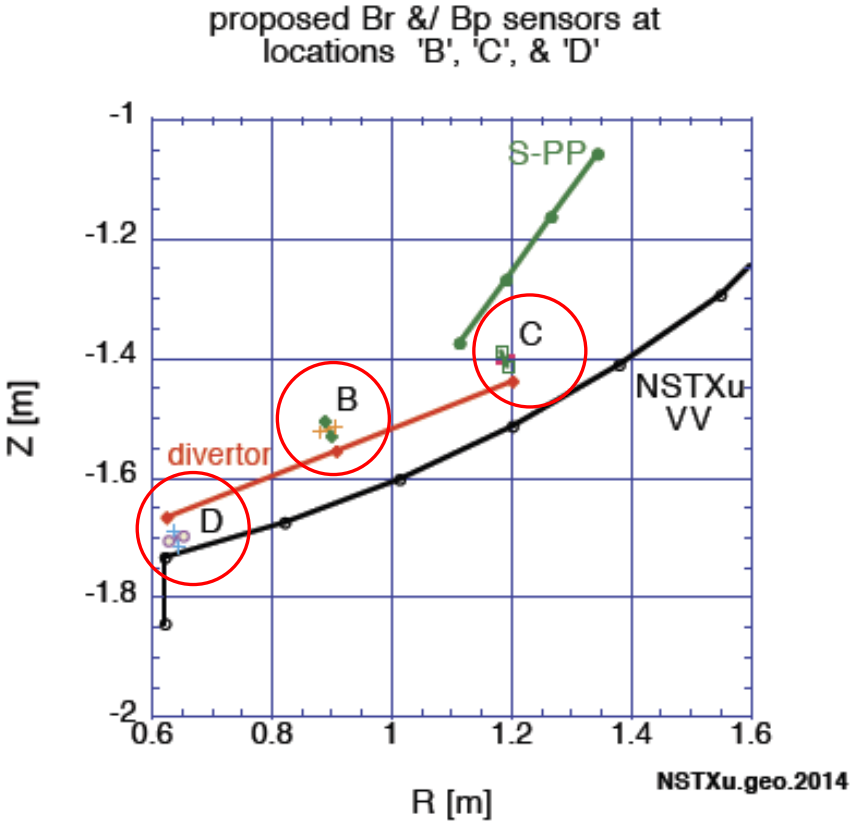
B_{norm} vs. theta (normalized to present Br sensors)

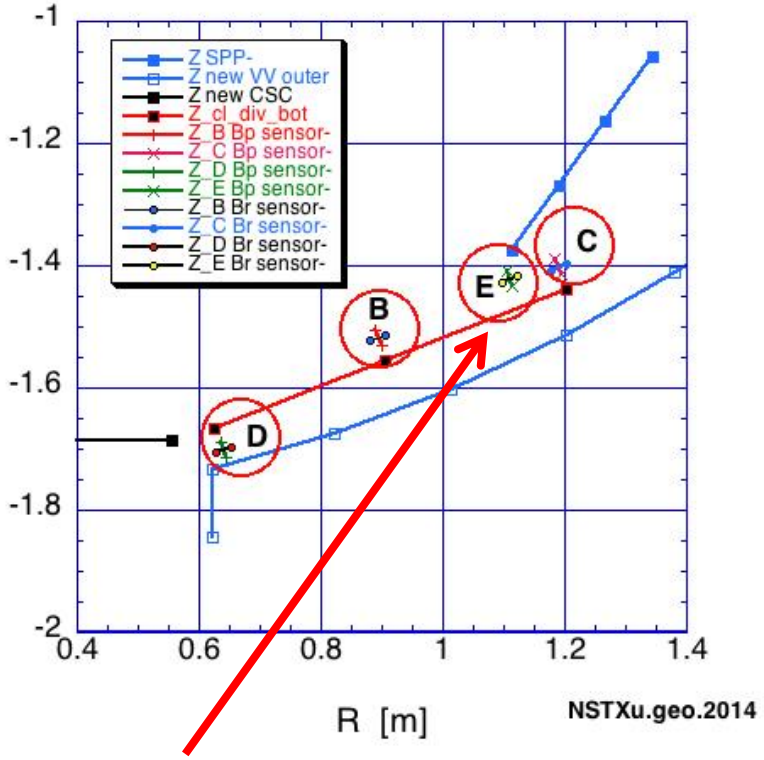


- Model characteristics
  - New 3D model of divertor plate
  - 3D sensors with finite toroidal extent; n*A of existing sensors
- Results summary
  - Field amplitude up to factor of 6 larger with new sensors
  - Perturbed field reversals observed with new sensors
  - Signals sufficient with plasma shifted off-midplane

New realistic RWM sensor positions proposed for greater NCC performance – would a further new position be better?

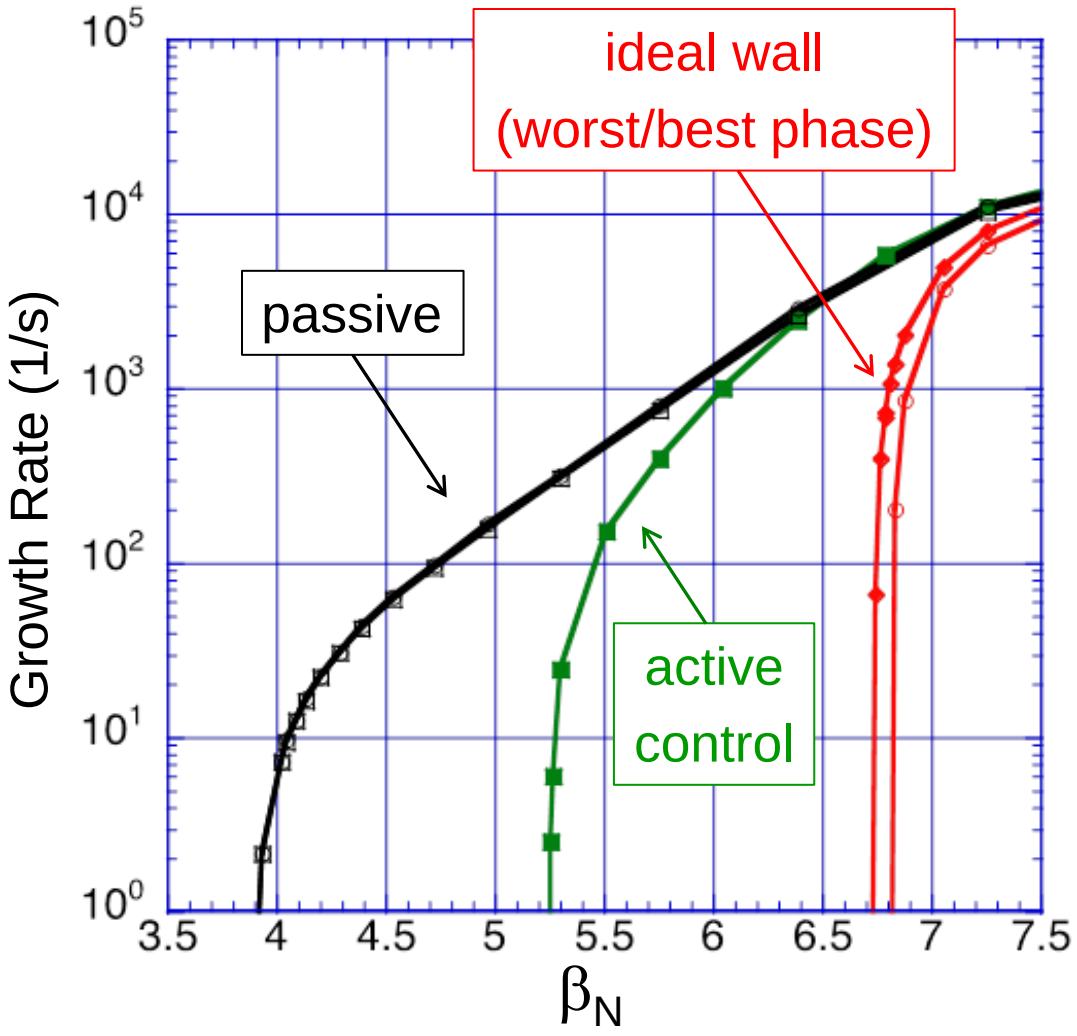
- Review: Initial calculations using existing RWM sensors and NCC yielded inferior performance to idealized sensors; superior new locations found





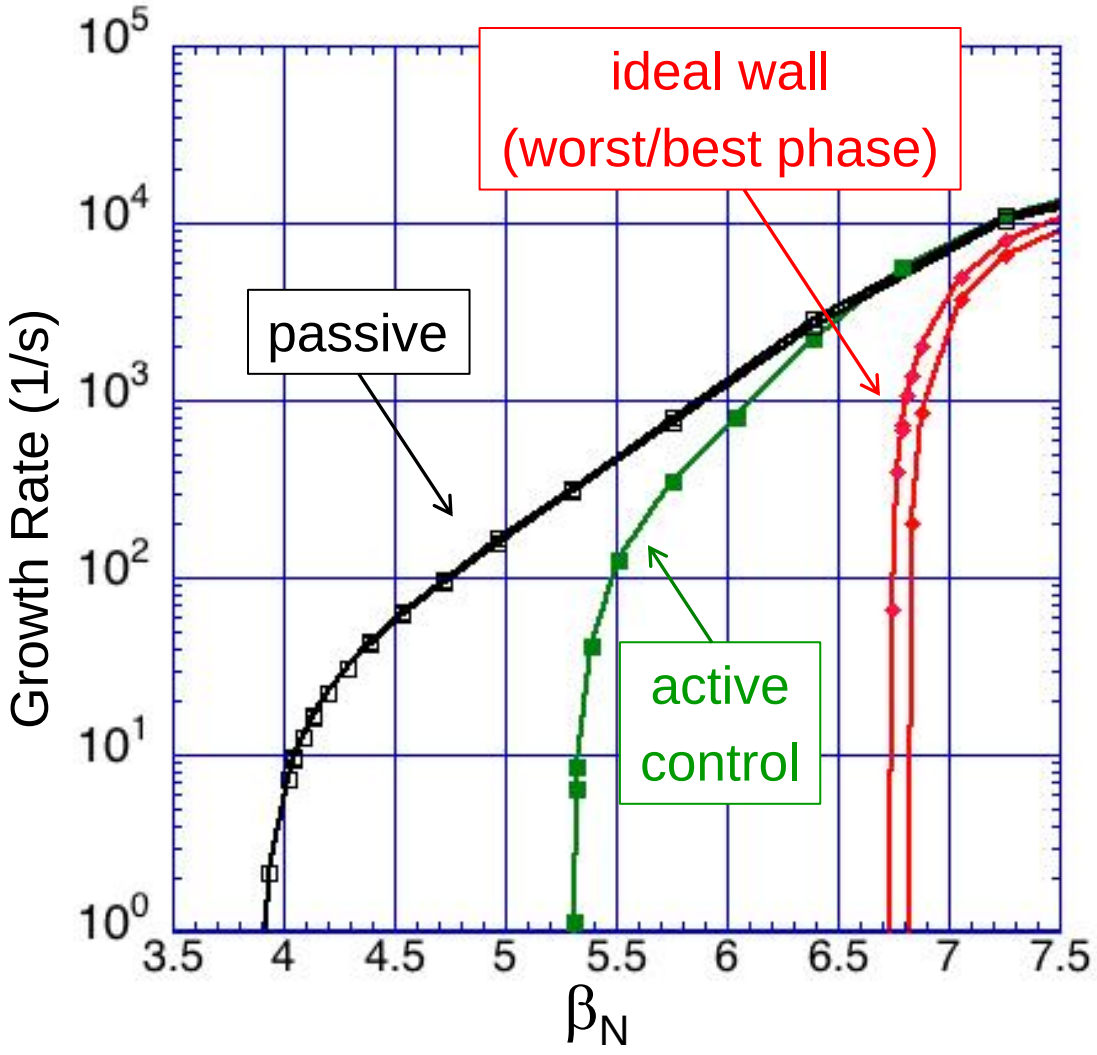
- New result: "E" positioned sensor does not increase control performance
  - Sensor at position "B" still yields superior performance (used in the next calculations)

Review: The other potential "new" sensors (e.g. Position C) tested are inferior to the "B position" sensor results



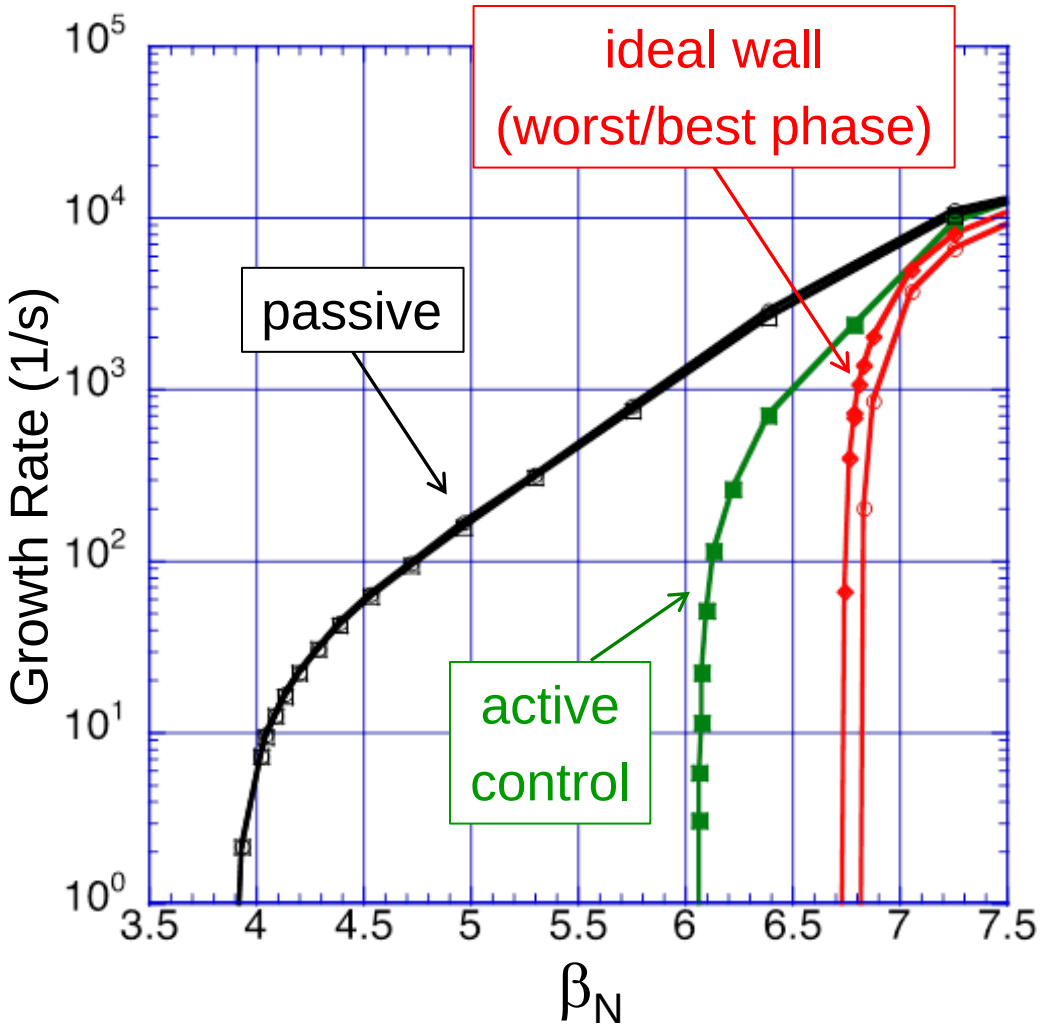
- Sensors
  - Top B_p, position C, compensated
- Actuators
  - Bottom NCC (1x12)
- Performance
  - Inferior to "Position B" sensor results by $\Delta\beta_N \sim -0.85$

Performance with potential new sensors in Position "E" equivalent to the "C position" sensor results



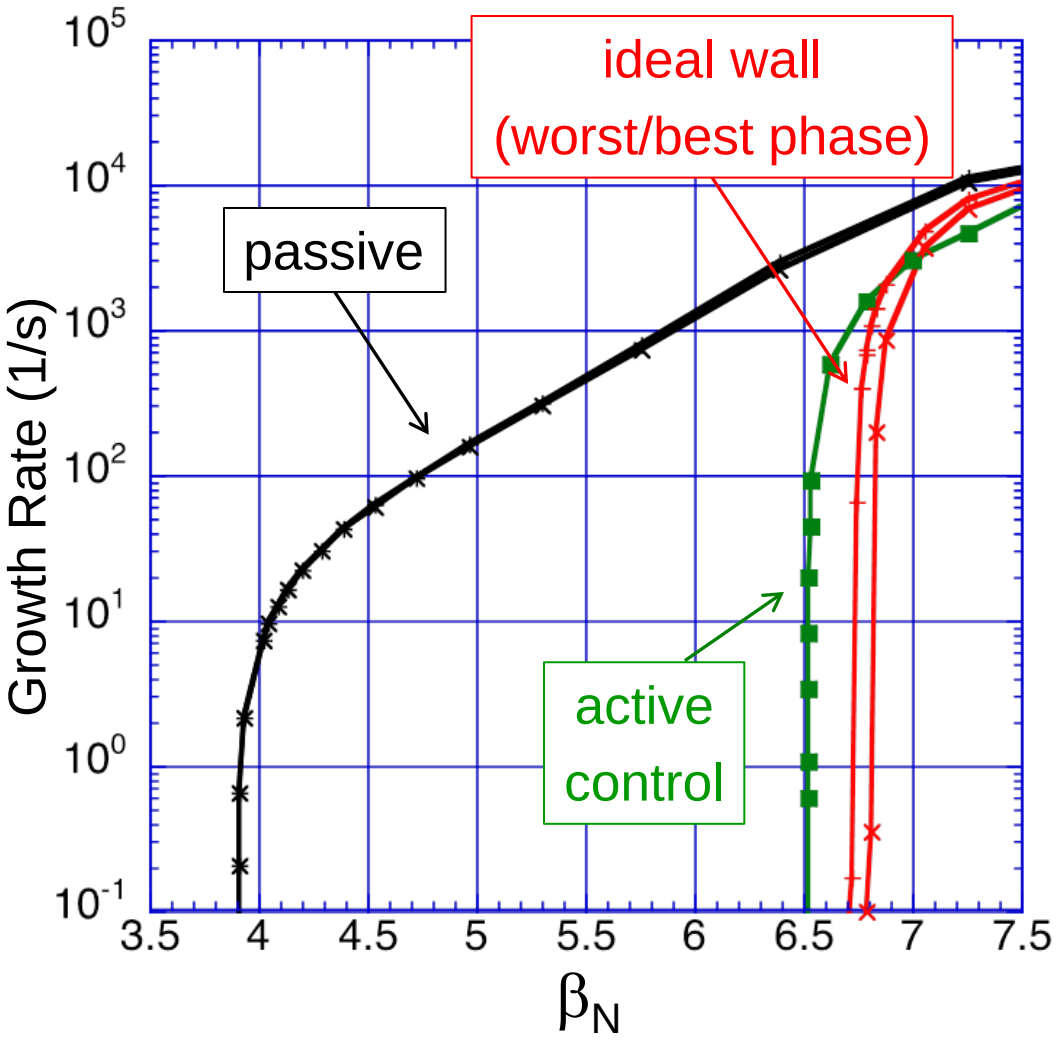
- Sensors
  - Bottom B_p, position E, compensated
- Actuators
  - Top NCC (1x12)
- Performance
  - Equivalent to "Position C" sensors: $\Delta\beta_N \sim +0.05$
  - Inferior to "Position B" sensor results by $\Delta\beta_N \sim -0.8$

Review: Proposed "B position" sensors in upper divertor driving upper & lower NCC yields high performance



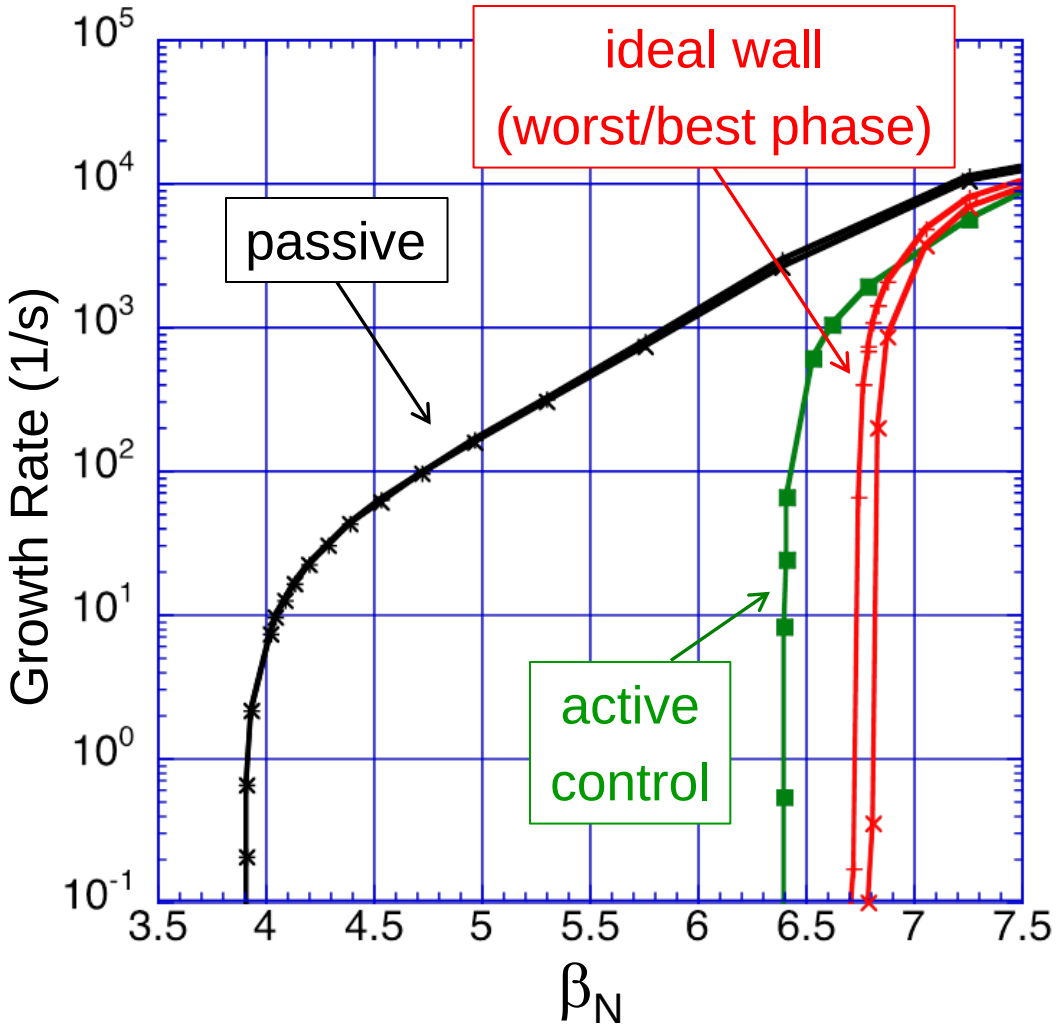
- Sensors
  - Top B_p, position B; compensated
- Actuators
  - Top and bottom NCC (2x12) – 2 turns
- Performance
  - Uncompensated sensor results similar
  - Significantly superior performance to existing sensors/coils ($\Delta\beta_N$ ~ 1.25)

New: Further gain optimization yields higher performance when using "B position" sensors driving upper & lower NCC



- Sensors
  - Top B_p, position B; compensated
- Actuators
  - Top and bottom NCC (2x12) – 2 turns
- Performance
  - Increased gain factor of 4
  - Significantly superior performance to existing sensors/coils ($\Delta\beta_N$ ~ 1.67) – close to with-wall limit

New: Control performance is slightly reduced with 1 turn NCC, but is still very high, when using "B position" sensors



- Sensors
  - Top B_p, position B; compensated
- Actuators
  - Top and bottom NCC (2x12) – 1 turn
- Performance
  - Slightly reduced, but still great performance compared to existing sensors/coils ($\Delta\beta_N \sim 1.57$) – close to with-wall limit

High performance active RWM feedback performance possible with 1 turn NCC and new RWM sensor positions

- Past result: Active RWM control calculations showed superior performance to RWM coils with NCC and idealized sensors
- Issue: Further calculations showed existing RWM B_p sensors driving neighboring NCC coils yielded relatively poor performance
- Present calculations (latest results)
  - Existing RWM B_p sensors driving NCC on the opposite side of the midplane can improve feedback performance ($\Delta\beta_N$ ~ +0.5)
  - Sensors in correct positions near the divertor plates driving the full 2x12 NCC yield significant performance improvement ($\Delta\beta_N$ ~ +1.25)
  - Partial NCC (2x6) also show significant performance improvements: (odd, or even parity options yield $\Delta\beta_N$ ~ +0.9)
  - New: “E” sensor position not superior to “B”, equivalent to “C” position
  - New: a 1 turn NCC has only slightly reduced performance vs. 2 turn