NSTX-U

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Discussion of magnetic sensor upgrade plan for NSTX-U

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J.W. Berkery, S. A. Sabbagh, J. Bialek, A. Diallo, S.P. Gerhardt, N. Logan, J-K Park, R. Raman, V. Soukhanovskii, et al.

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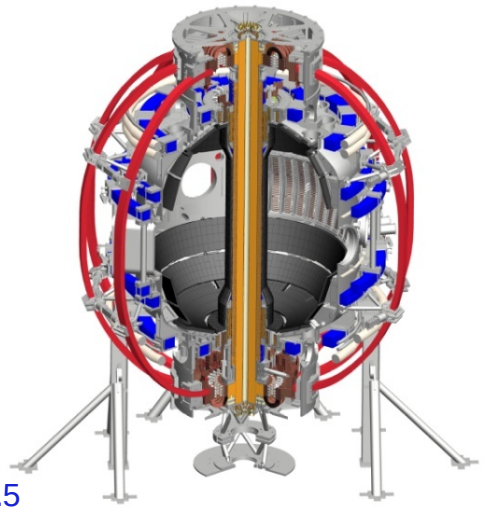
NSTX-U 5 Year Plan Meeting

January 11th, 2013

PPPL



V1.5

Upgraded magnetic sensor plan status discussed at recent meeting

- Global mode diagnosis
  - Measure theoretically expected mode alteration at high β_N
- RWM physics and control
  - Improve RWM state space active control and observer
  - Enhance input to disruption warning system

- Disruption characteristics
  - Expanded shunt tile set for halo current diagnosis, etc.
  - Do questions remain re: specs for halo current meas. / shunt tile set?
- Snowflake divertor and ELM characteristics
  - Additional requests / detail needed for probes to run snowflake?
  - Further extensions of magnetics for ELM research?
- CHI
  - Additional flux loop positions requested – what about B probes?

1) These elements to be discussed here

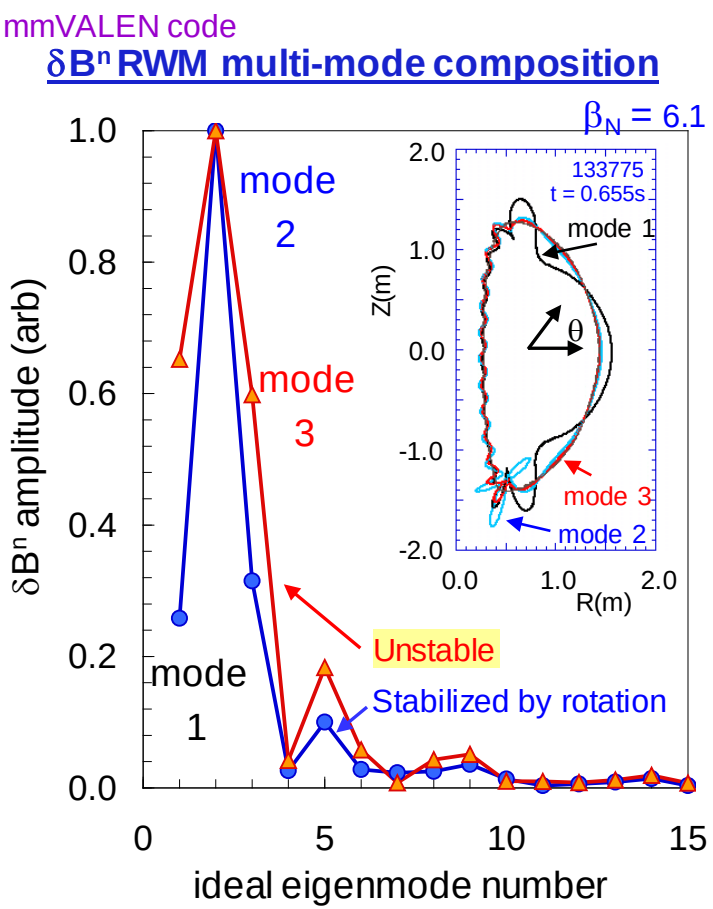
2) Further discussion on topical cross-cutting, improvements

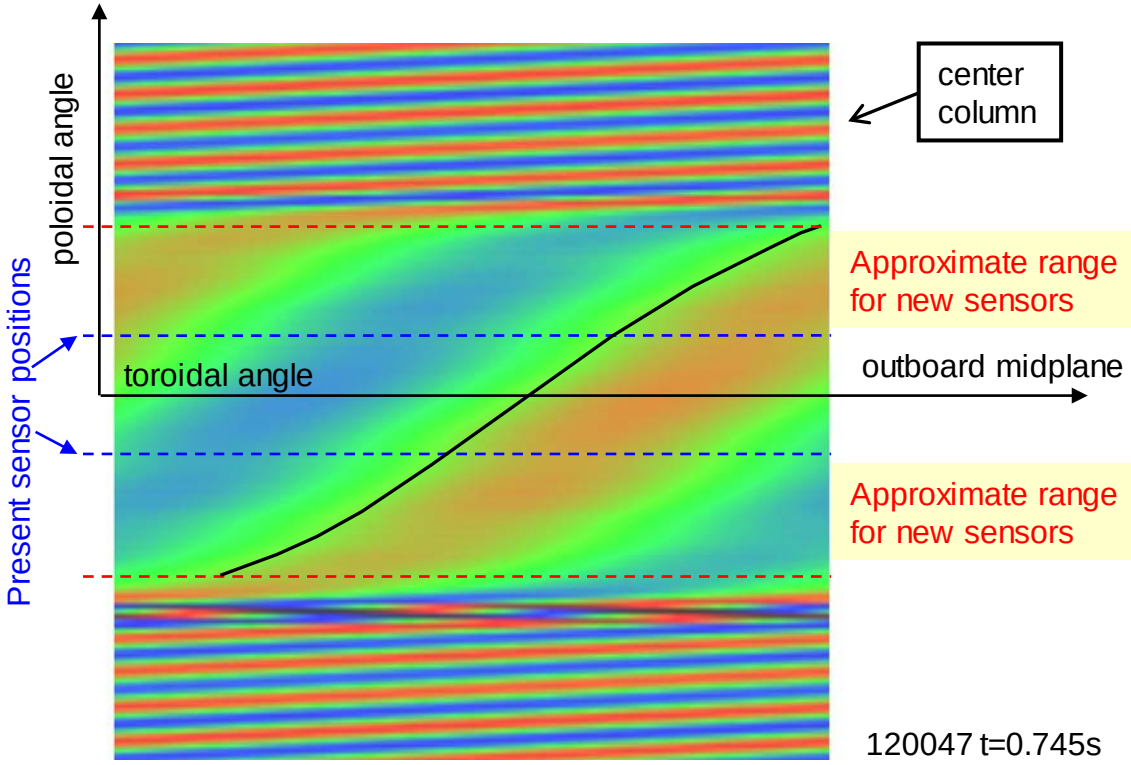
3) Status of these elements discussed yesterday

- Additional detail not needed for today's discussion

Multi-mode computation shows high amplitude near divertor, with significant change to toroidal phase

mmVALEN code





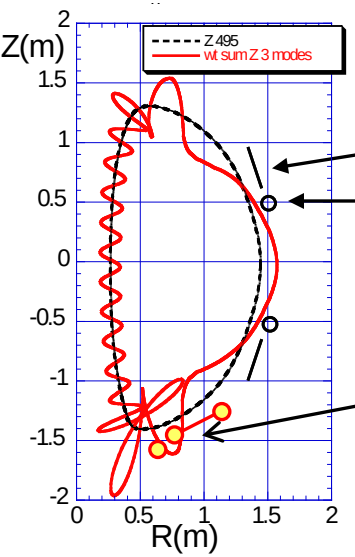
- The two primary global modes have increased amplitude in the divertor region
- This was also found theoretically for NSTX for single mode computations during the design of the present NSTX system

S. Sabbagh, et al., NF 2004

- Significant change to toroidal phase (n = 1 mode shown) would be clearly measured in new sensor location range
  - Due to significant field line pitch in this region
- Still have relatively long poloidal wavelength (vs. center column region)

Theory indicates that positioning new sensors closer to divertor will improve mode measurement

n = 1 ideal eigenfunction for fiducial plasma

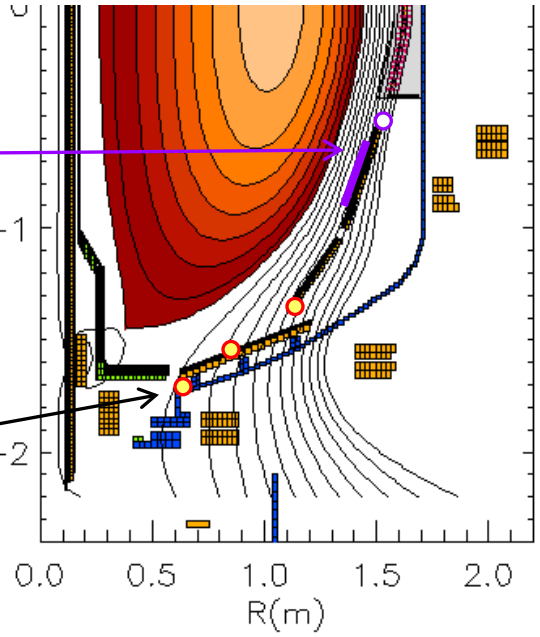


Present sensor locations

B_R sensors (nominally normal, B_{norm})

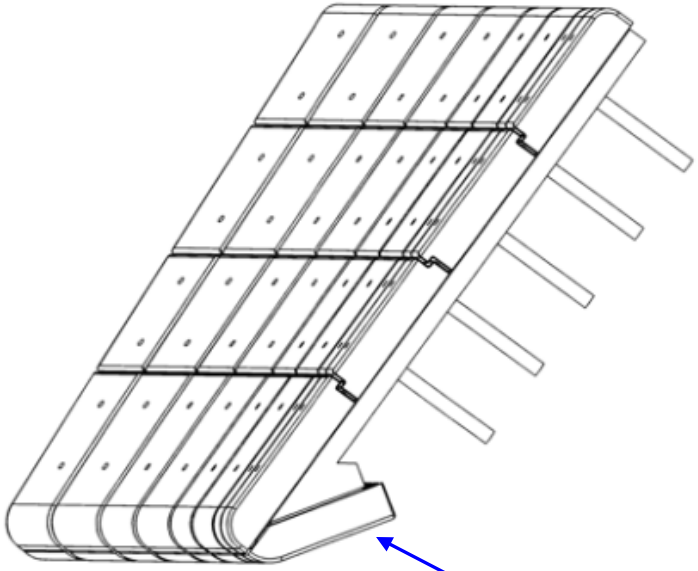
B_p sensors (nominally tangential, B_{tan})

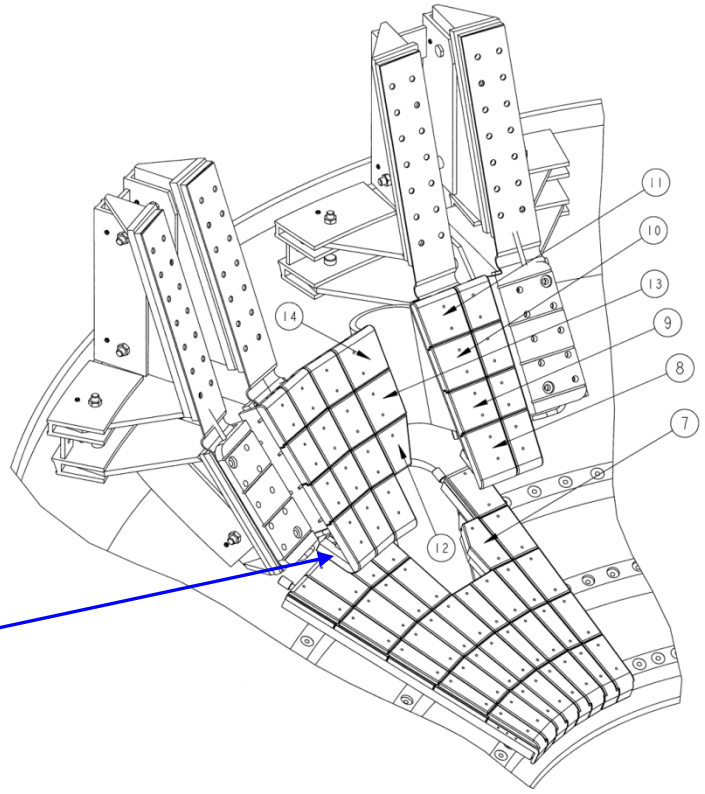
New sensor locations discussed (schematic) (includes possible locations in THIS range (+ one position above midplane)



- Present suggestions (based on recent meeting – combination of physics needs, machine hardware constraints, and budget (discussion continues):
  - Consider 12 toroidal positions, 4 arrays (48 sensors) as "baseline"
  - 1st: B_{tan} or B_{norm} at smallest R (best accessible) in outer divertor region
  - 2nd: B_{tan} just below secondary passive plate (in Z position) – (B_{norm} possible here?)
  - 3rd: B_{norm} sensors in the lower divertor tiles (R position TBD)
  - 4th: B_{norm} or B_{tan} sensors at smallest R (best accessible), opposite Z in outer divertor
  - Are other positions possible to improve higher n (higher m) detection?

SPG Idea #1: Mount them under Secondary Passive Plate Lip

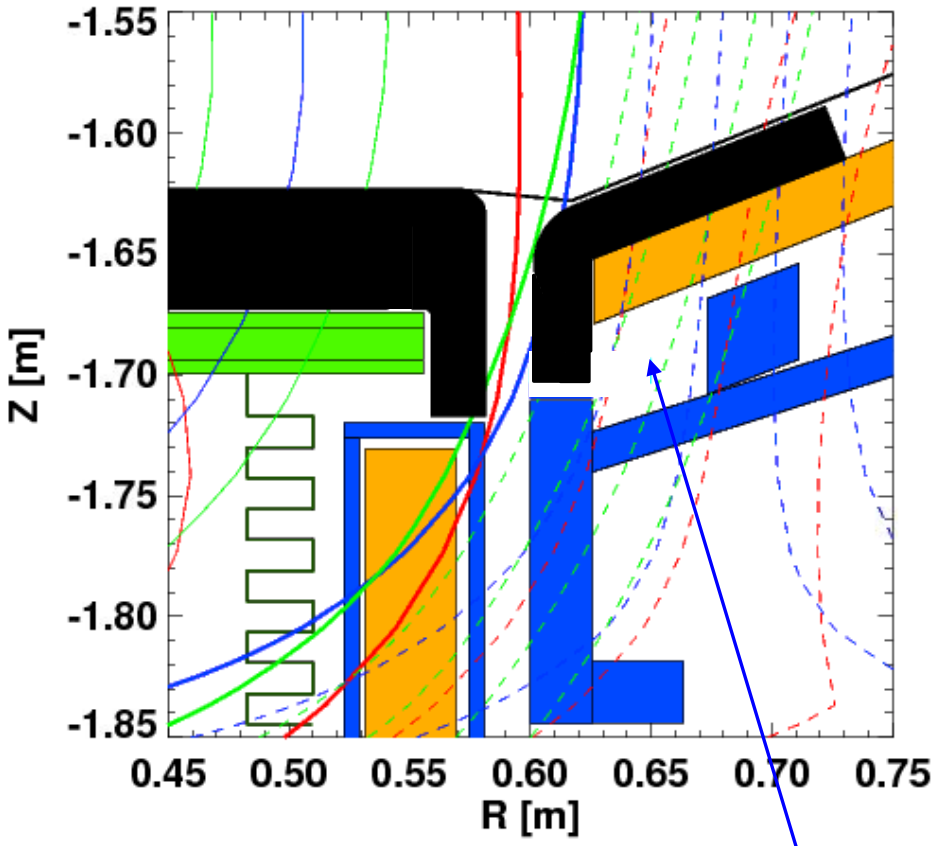


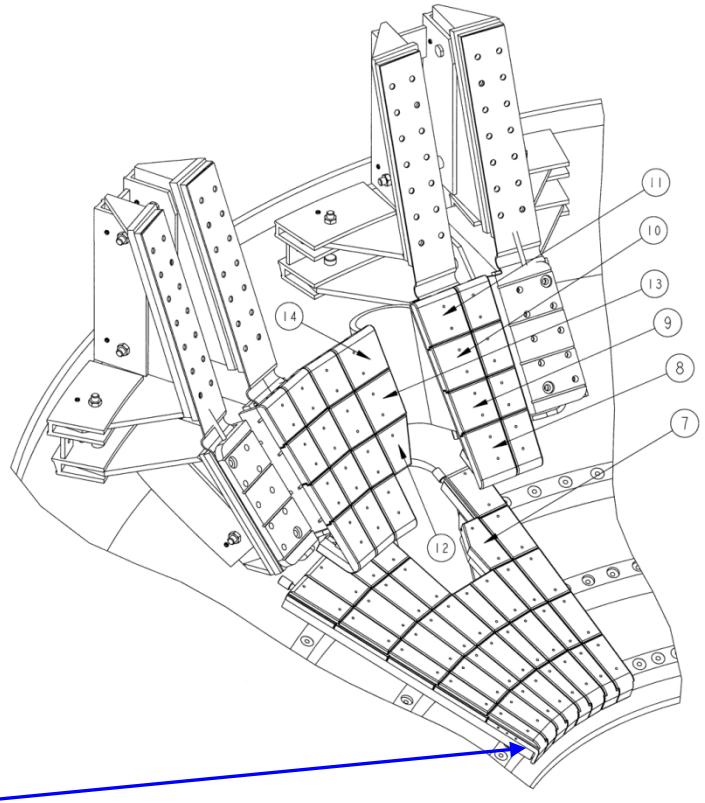


BAY "A" LOWER OPENING
DIVERTOR AND SECONDARY PASSIVE PLATE
TILE MODIFICATION ASS'Y
EXISTING HARDWARE TO BE USED
TO MOUNT TEE BARS AND TILES

- Replace this tile with sensor box.
- Would be partially shielded by SPP
- Might need to retain part of the front of the tile, but much could likely be eliminated.
- Wire extraction fairly simple.
- Boxes may need to be curved to follow outline of plate.

SPG Idea #2: Mount them under outer divertor bull nose tiles



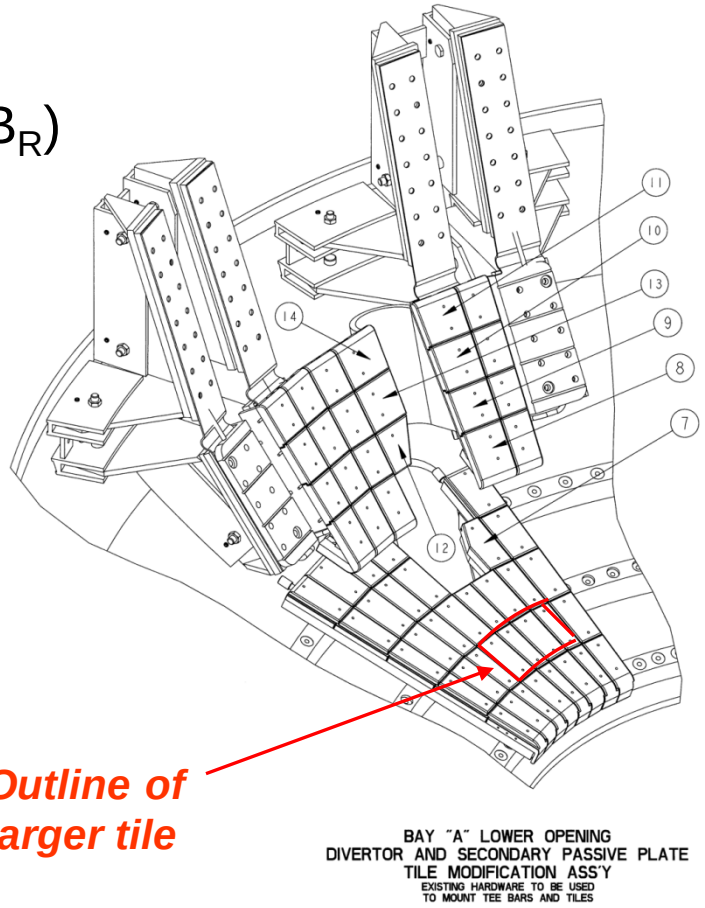


BAY "A" LOWER OPENING
DIVERTOR AND SECONDARY PASSIVE PLATE
TILE MODIFICATION ASS'Y
EXISTING HARDWARE TO BE USED
TO MOUNT TEE BARS AND TILES

- Place curved sensor box in this volume.
- Is reasonably well shielded from plasma by improved bull-nose tiles.
- Wire extraction likely to be difficult.
- Would be partially electromagnetically shielded by divertor.

SPG Idea #3: Sensors in Tiles

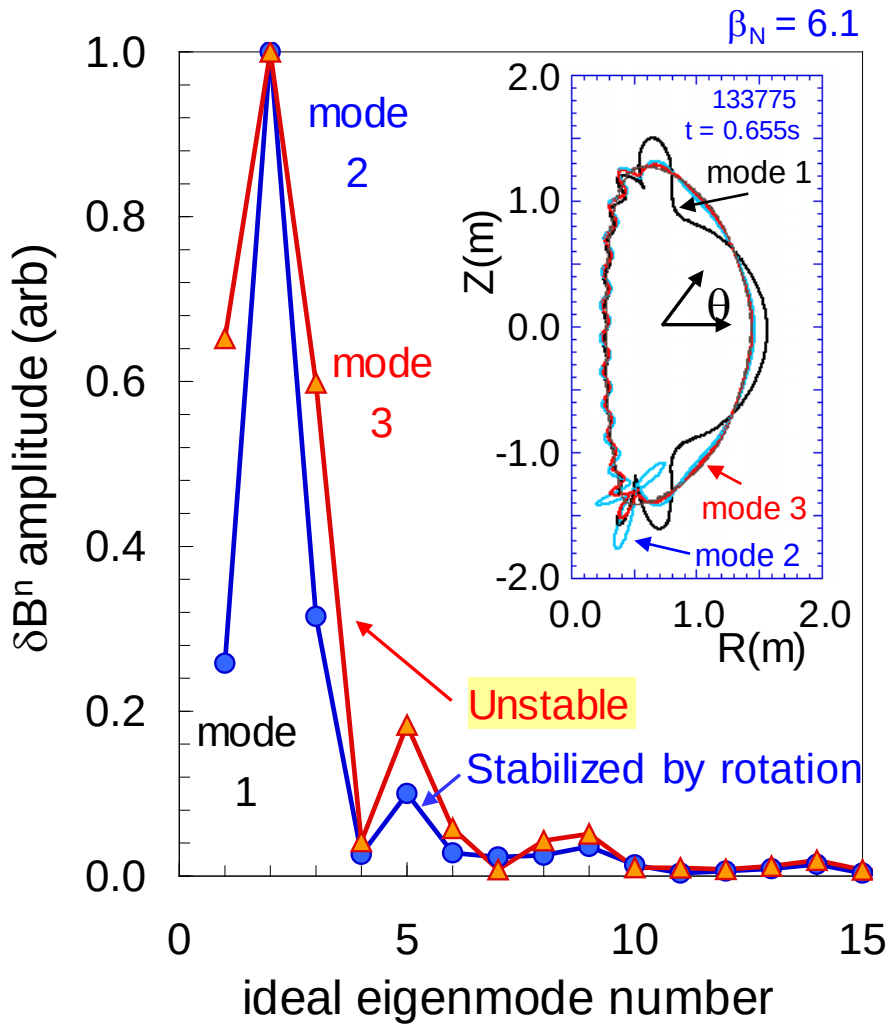
- Tiles are only about 0.9” thick, and have a T-bar right down the center.
  - Makes installation of a traditional B_P (~B_R) sensor difficult.
  - Could imagine a very thin “Hiro” sensor mounted above the T-bar.
- Could fabricate a single larger tile, taking the area of 2-4 existing tiles.
  - Wrap a B_N (~B_Z) sensor around the tile edges.
    - Sort of like how the B_R sensors are mounted to the PPPs
  - Would likely trap the t-bars
  - Are there thermal issues with larger tiles?
  - Need to check the effective area.



backup

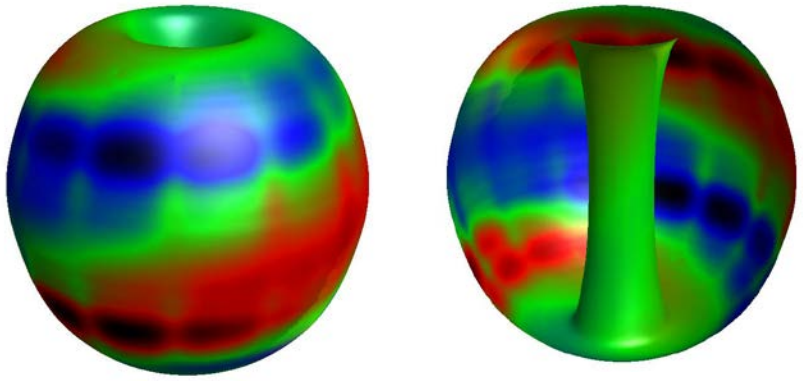
Multi-mode computation shows 2nd eigenmode component has dominant amplitude at high β_N in NSTX stabilizing structure

δB^n RWM multi-mode composition



mmVALEN code

δB^n from wall, multi-mode response



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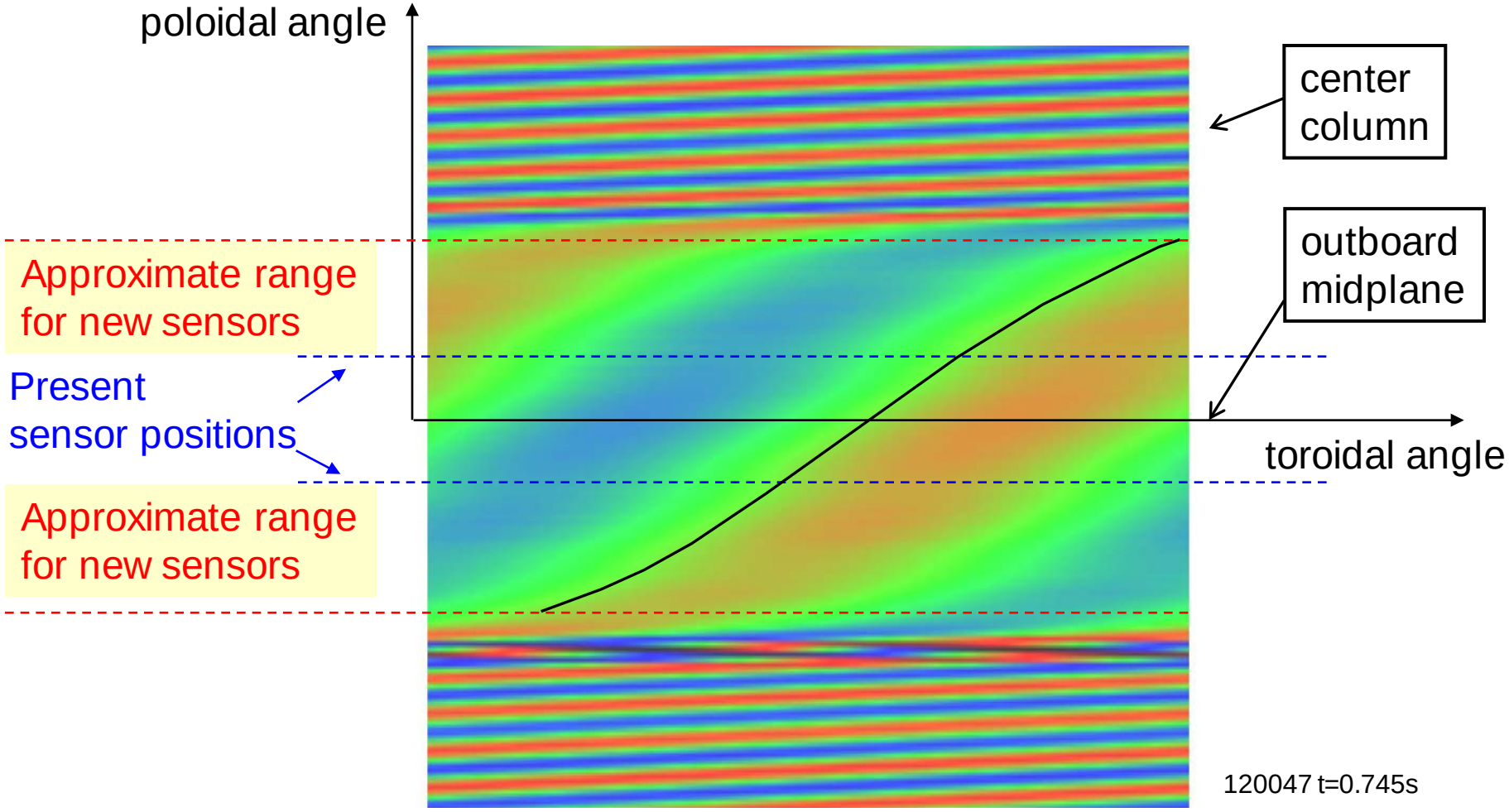

- Due to significant field line pitch in this region
- Still have relatively long poloidal wavelength (vs. center column region)

Stefan's Comments/Questions re: extended RWM sensors (+ SAS replies)

- Is it necessary that these be up/down symmetric?
  - Maybe focus on LSN discharges for the first installation?
    - SAS comment: Up/down asymmetric ok – also has advantage of higher m resolution (helps address comment by Jong-Kyu regarding higher n's)
- Is likely premature to consider the details:
  - Is lower divertor going to be modified for pumps or lithium systems?
    - Suggested locations need changes if a cryopump placed in lower divertor.
    - But, cryopump would also allow for opportunities for sensor integration
    - Reply: Sensors to be installed at same time / must be compatible w/cryo.
  - How many years of operating with these sensors is required to make them worth the effort?
    - SAS: Even one year would provide key data, and results might argue to keep them in (e.g. for improved operation of RWM state-space controller)
- Who will do this work?
  - SPG not likely to have time (if accepted in plan, person would be found)