U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

NSTX-U halo current sensors: FY16 status and FY17 enhancements

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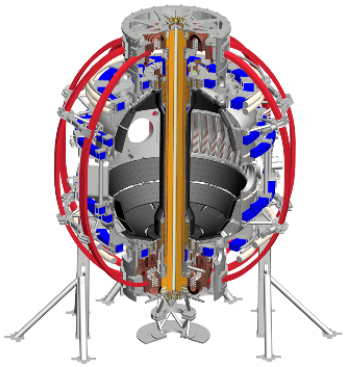
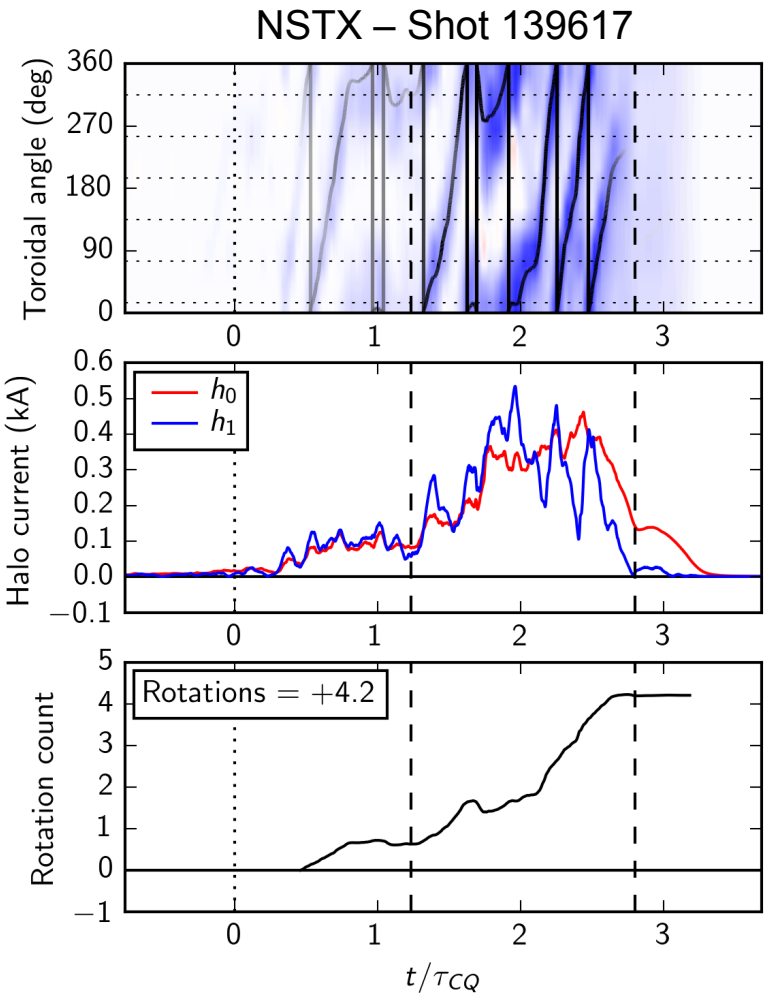
NSTX-U Diagnostic Research Plans, Part II
May 27, 2016

PPPL



Motivation and summary

- Non-axisymmetric + rotating halo currents pose a substantial hazard to tokamaks
  - Asymmetries can generate radial shift forces, especially on the centerstack
  - Rotation can resonate with the vessel and dynamically amplify the halo forces
  - This is a major concern for ITER (ITPA WG)
  - NSTX observed very high halo current rotation when compared to other devices



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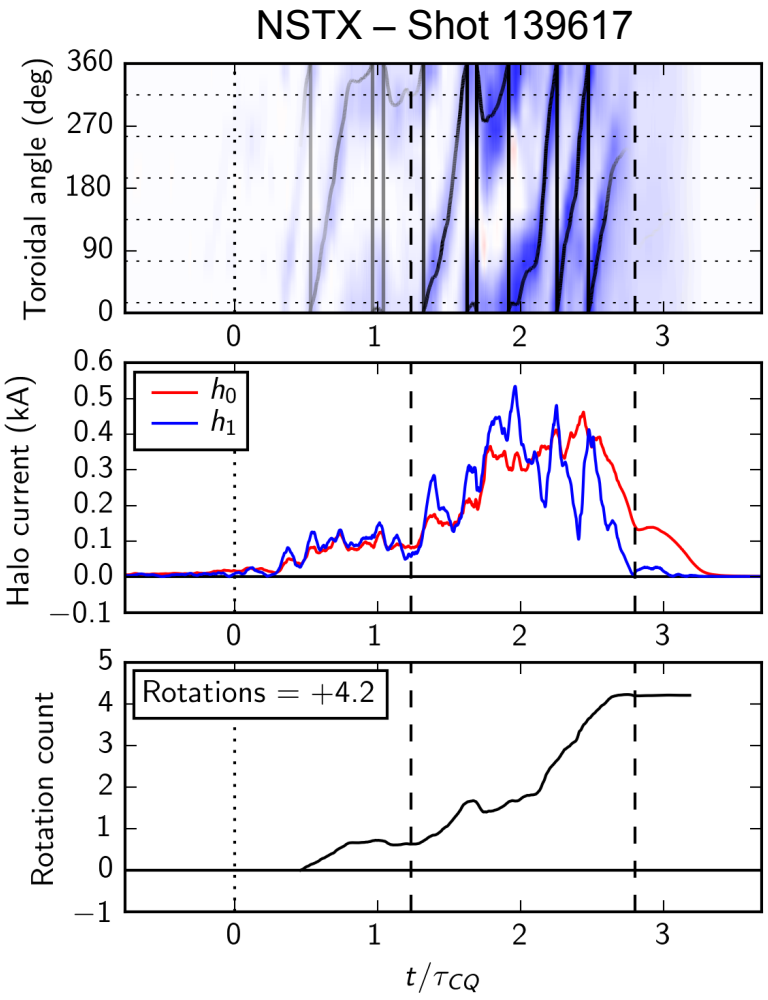
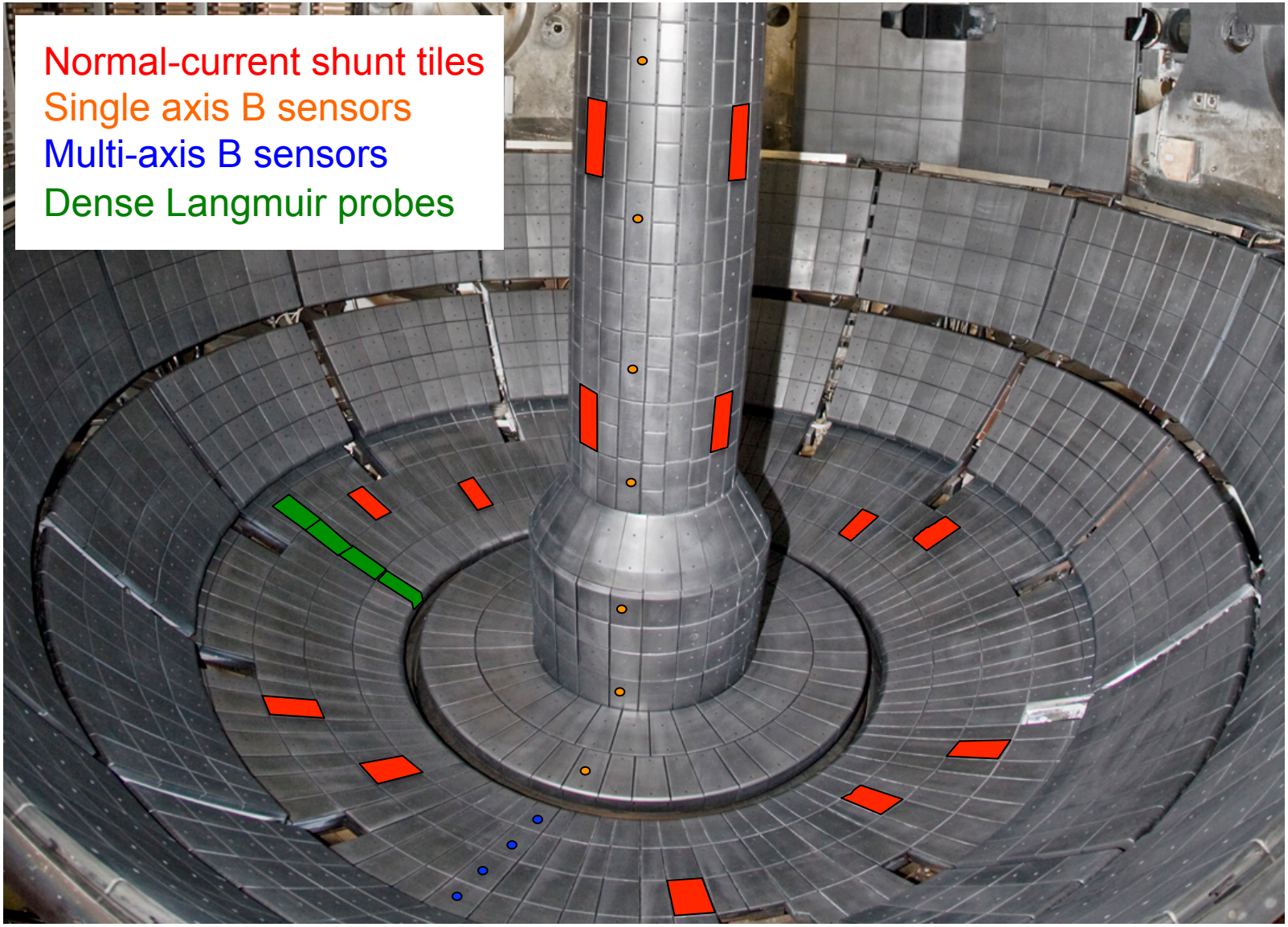
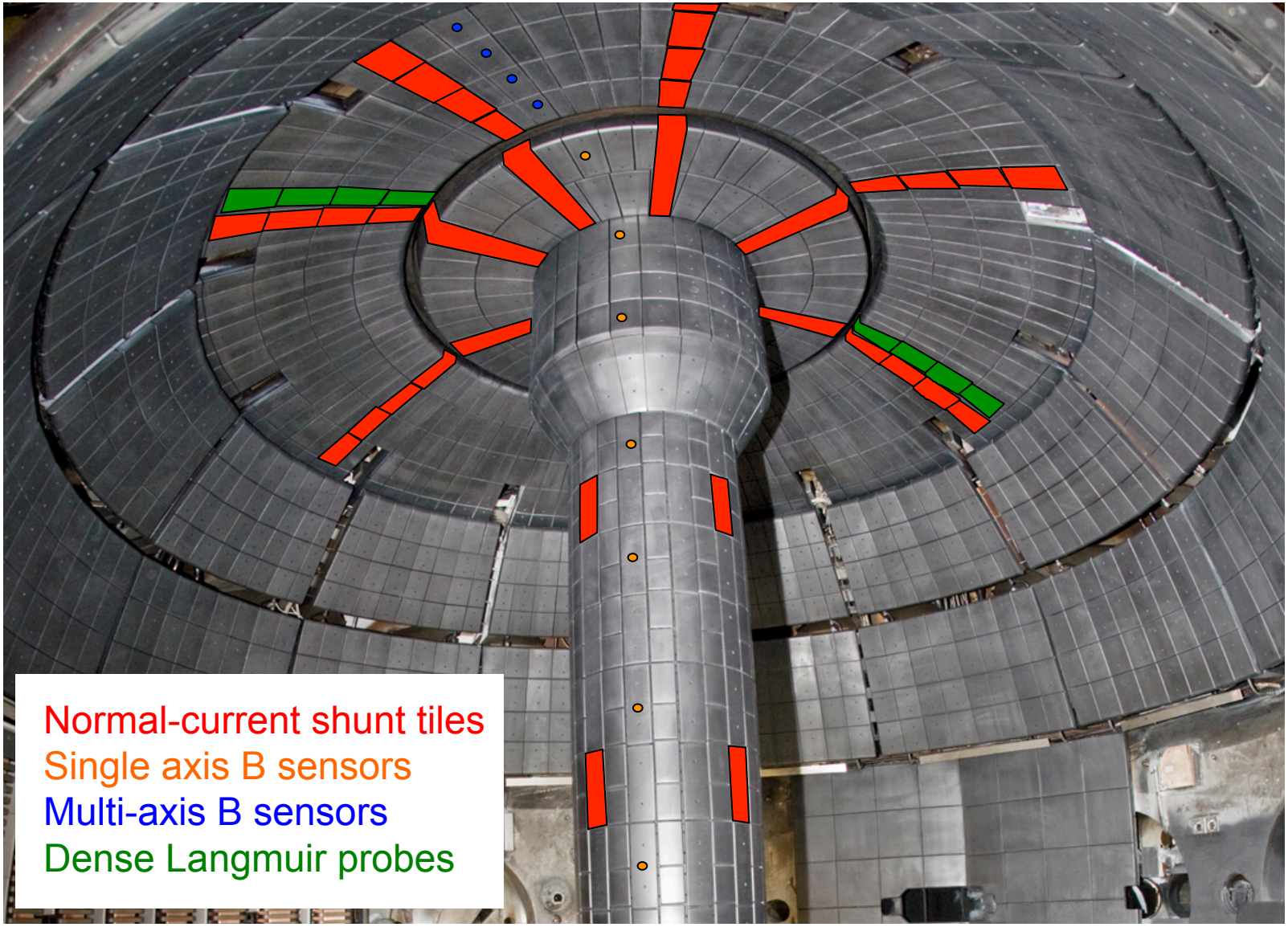
  - Rotation can resonate with the vessel and dynamically amplify the halo forces
  - This is a major concern for ITER (ITPA WG)
  - NSTX observed very high halo current rotation when compared to other devices
- The path forward on NSTX-U
  - FY16: Partial shunt tile array in lower divertor
  - FY16: First shunt tile measurements on the center column of an ST
  - FY16: Rogowski measurements of inner-to-outer vessel currents through CHI buswork
  - **FY17: New, fully resolved array of shunt tiles in the upper divertor**
  - FY17 (incremental): Enhanced 2D Mirnov arrays for studying I_p asymmetries



Sketch of present NSTX-U configuration (FY16)

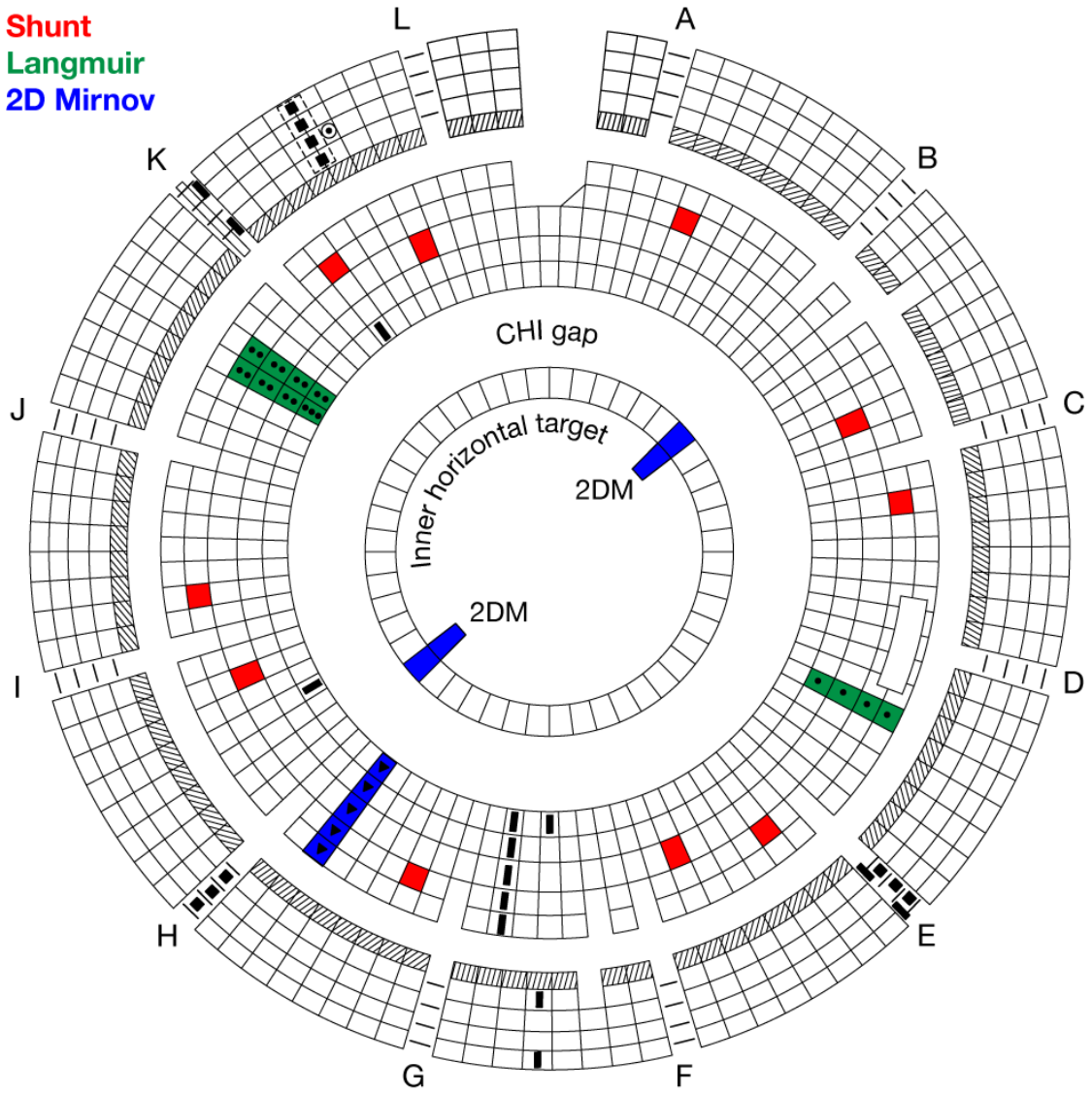


Sketch of planned enhancements (FY17)



Existing lower divertor configuration (FY16)

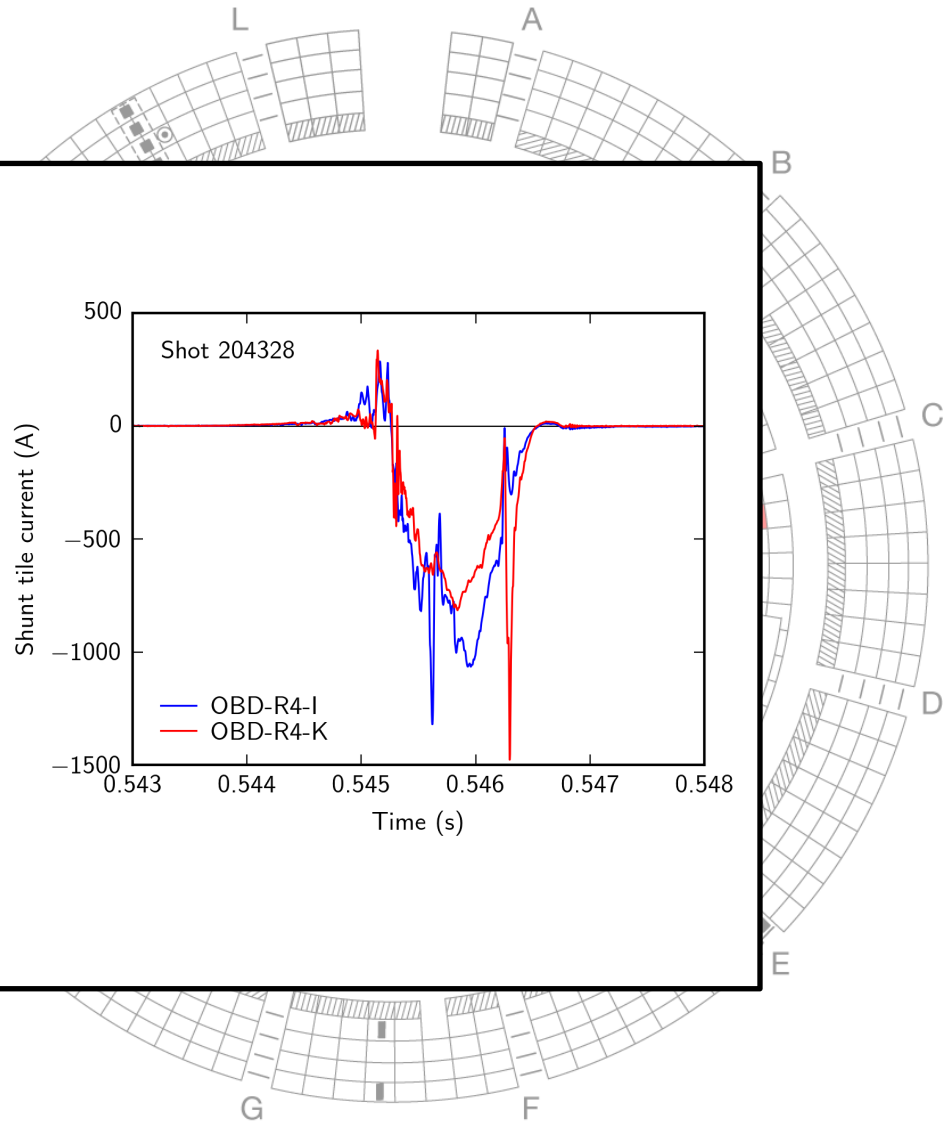
- Shunt tiles
  - Instrumented tiles with a shunt resistor to measure wall-normal halo currents
  - Six shunt tiles in OBD Row 4 and four tiles in Row 3
- Langmuir probes
  - Legacy cassette at D-E
  - New 17 channel high-density cassette at J-K
  - Can measure halo currents with higher spatial resolution if grounded to vessel
- 2D Mirnovs
  - OBD Mirnovs near Bay H
  - Two vertical columns of Mirnovs on opposite sides of the center stack (2D+1D)



Existing lower divertor configuration (FY16)

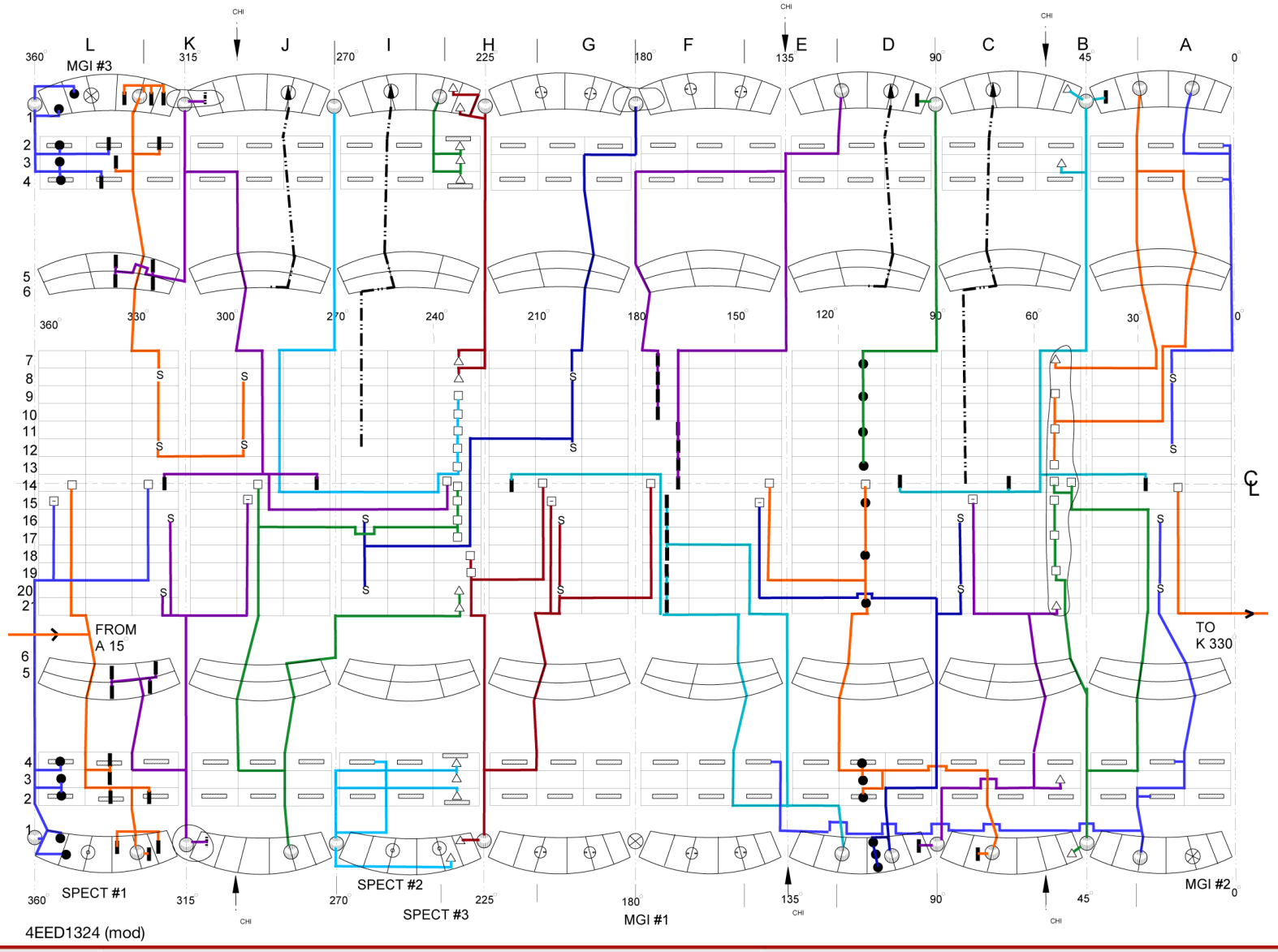
- Shunt tiles
  - Instrumented tiles with a shu… wal…
  - Six… and…
- Langr…
  - Leg…
  - Nev… cas…
  - Car… with… if gr…
- 2D M…
  - OB…
  - Two… Mir… the center stack (2D+1D)

Shunt
Langmuir
2D Mirnov



- The NSTX-U lower divertor shunt tiles are up and running
- Will be able to connect back to the NSTX data set from the SPG halo current papers [*NF* 2012, *NF* 2013]
- Data stored in the LANGMUIR tree (finalizing the structure now)
- Data acquisition at 500 kHz (set by LP requirements)

Existing center stack configuration (FY16)



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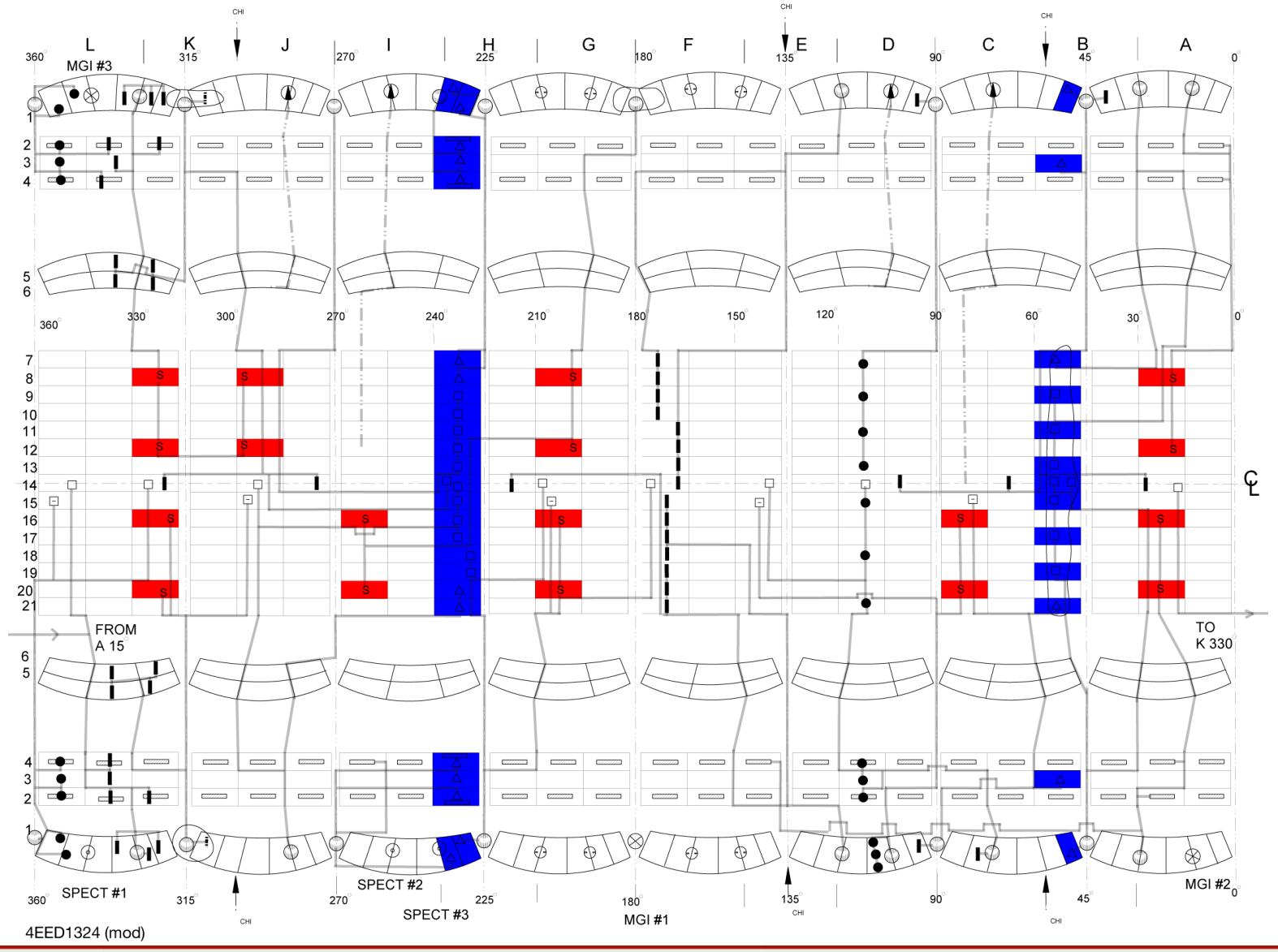
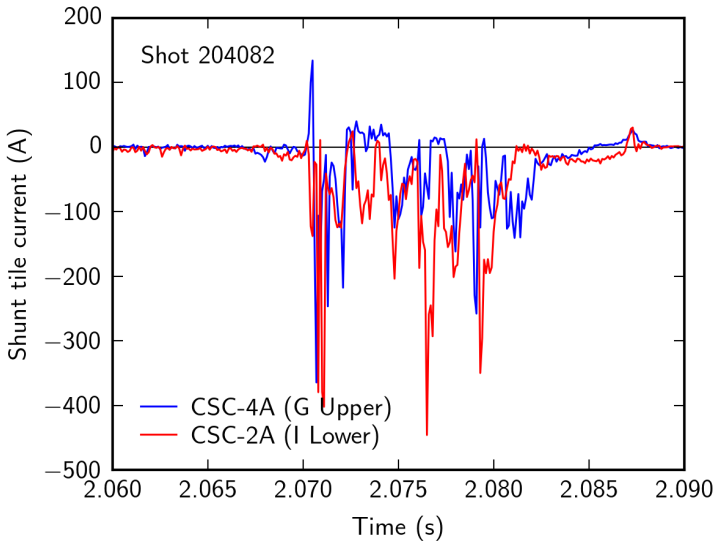


4EED1324 (mod)

Existing center stack configuration (FY16)

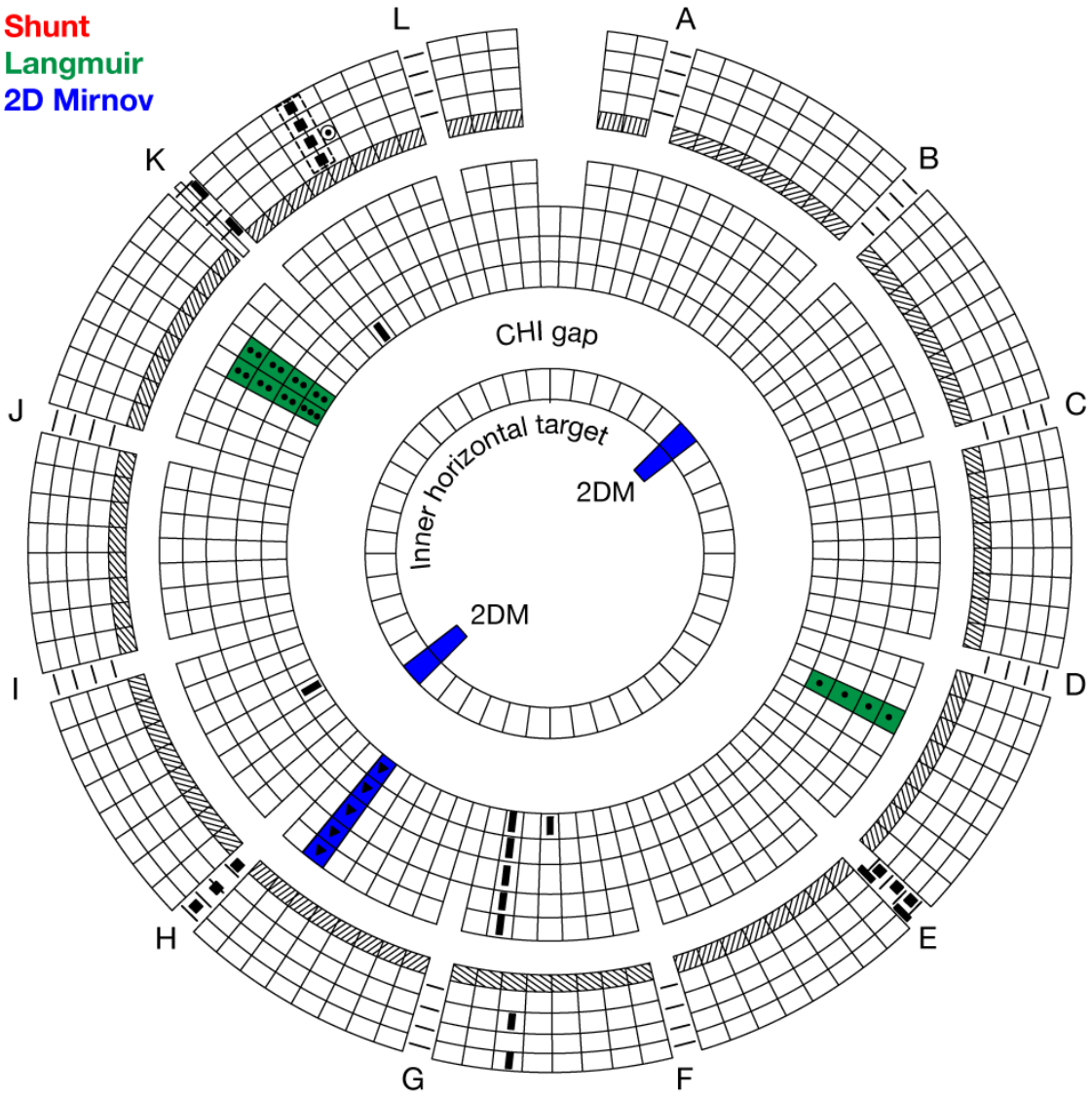
- The NSTX-U center stack shunt tiles are up and running
- The PCS shutdown handler often forces inner-wall-limited ramp-downs that terminate in modest halo current pulses
- Data stored in the LANGMUIR tree (finalizing the structure now)
- Data acquisition at 500 kHz (set by LP requirements)



4EED1324 (mod)

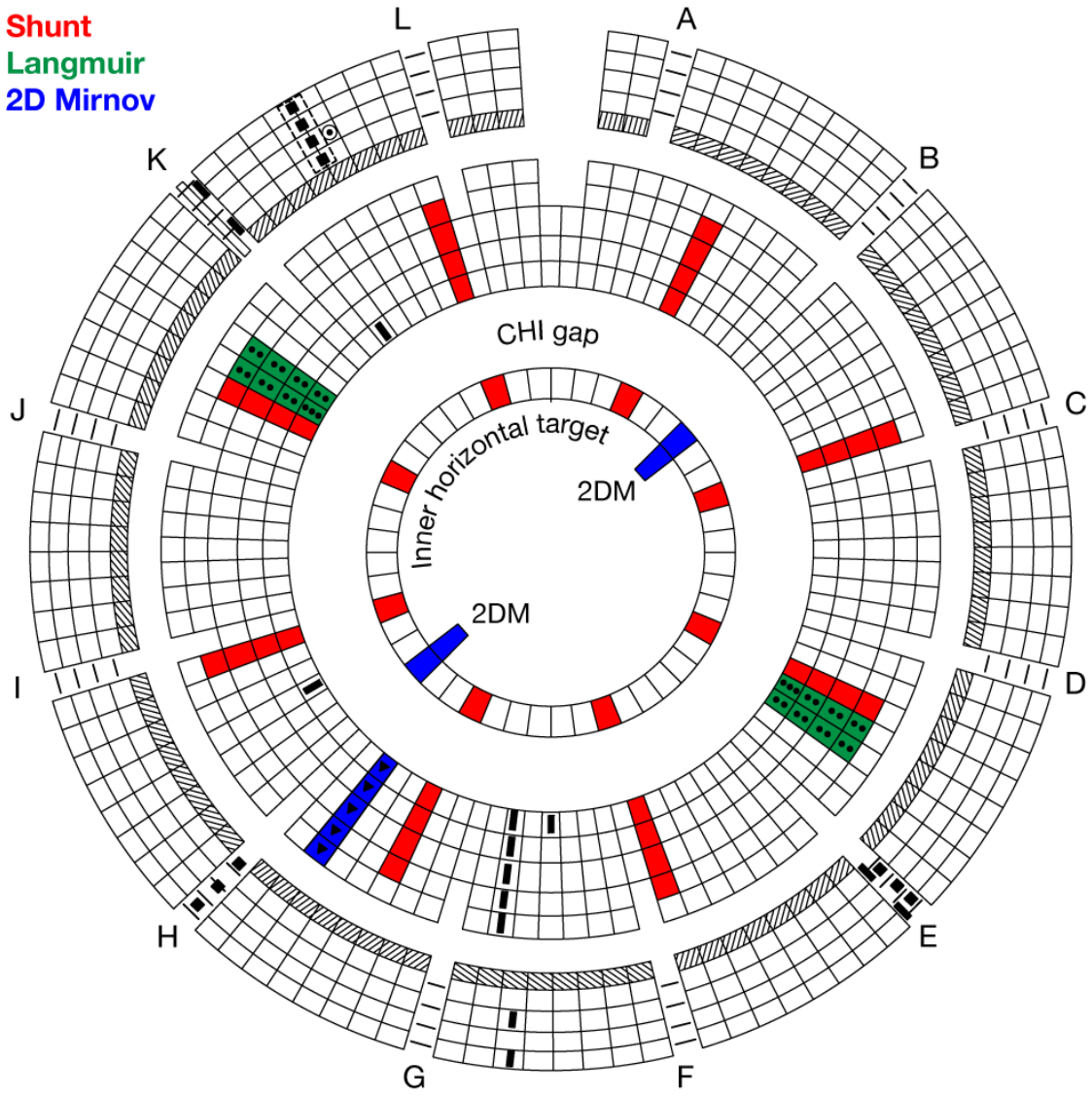
Existing upper divertor configuration (FY16)

- Why the upper divertor?
  - Avoid metal and/or lithium tile installations and cryo-pump



Enhanced upper divertor configuration (FY17)

- Why the upper divertor?
  - Avoid metal and/or lithium tile installations and cryo-pump
- Shunt tiles
  - Install 8 spokes of shunt tiles spanning OBD and IBDH
  - Utilize new stainless steel mesh insulation on the IBDH tiles?
- Langmuir probes
  - Add second high-density cassette near D-E
  - Initially run grounded
  - Compare directly with adjacent shunt tiles



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  - Add second high-density cassette near D-E
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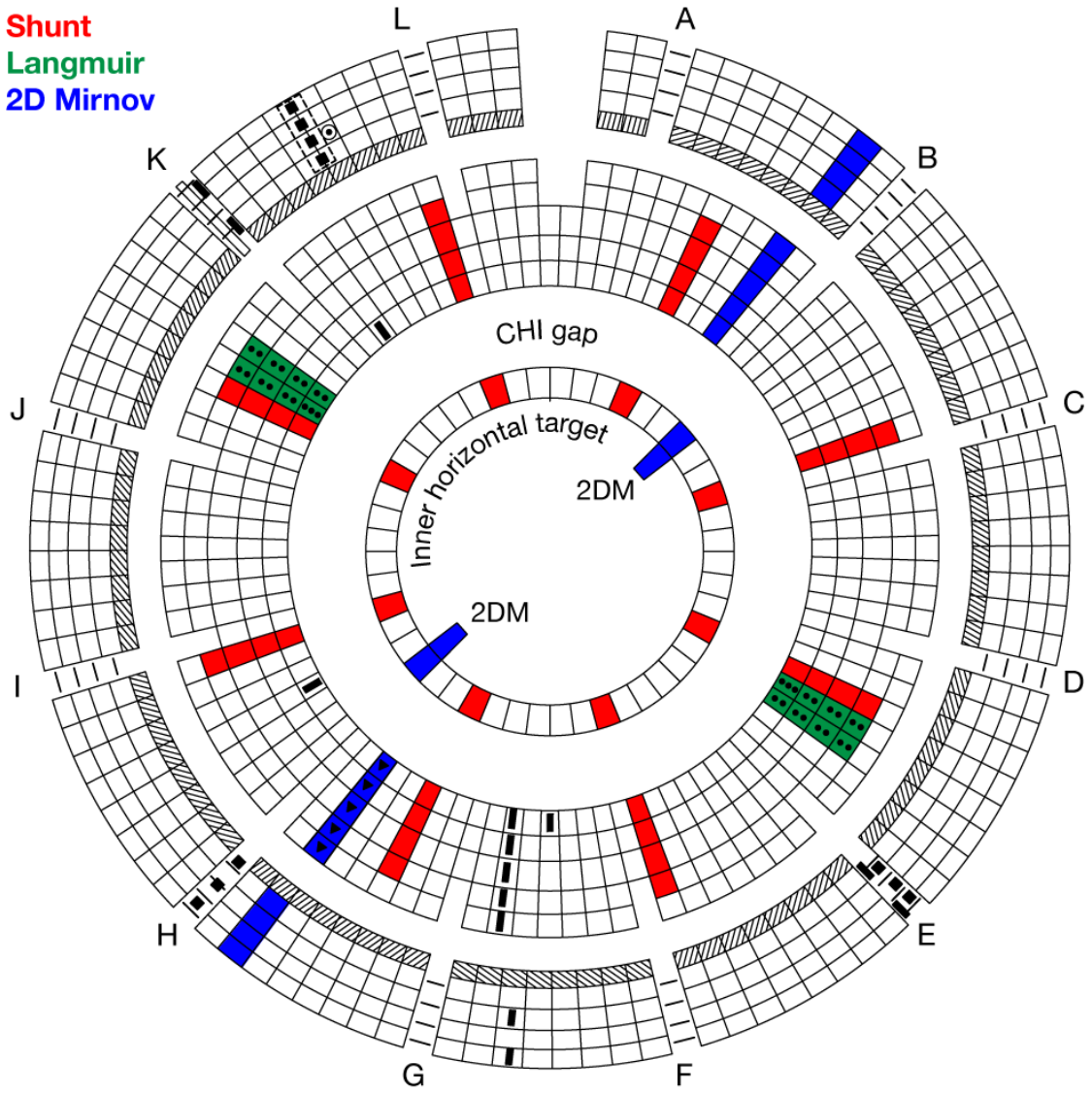
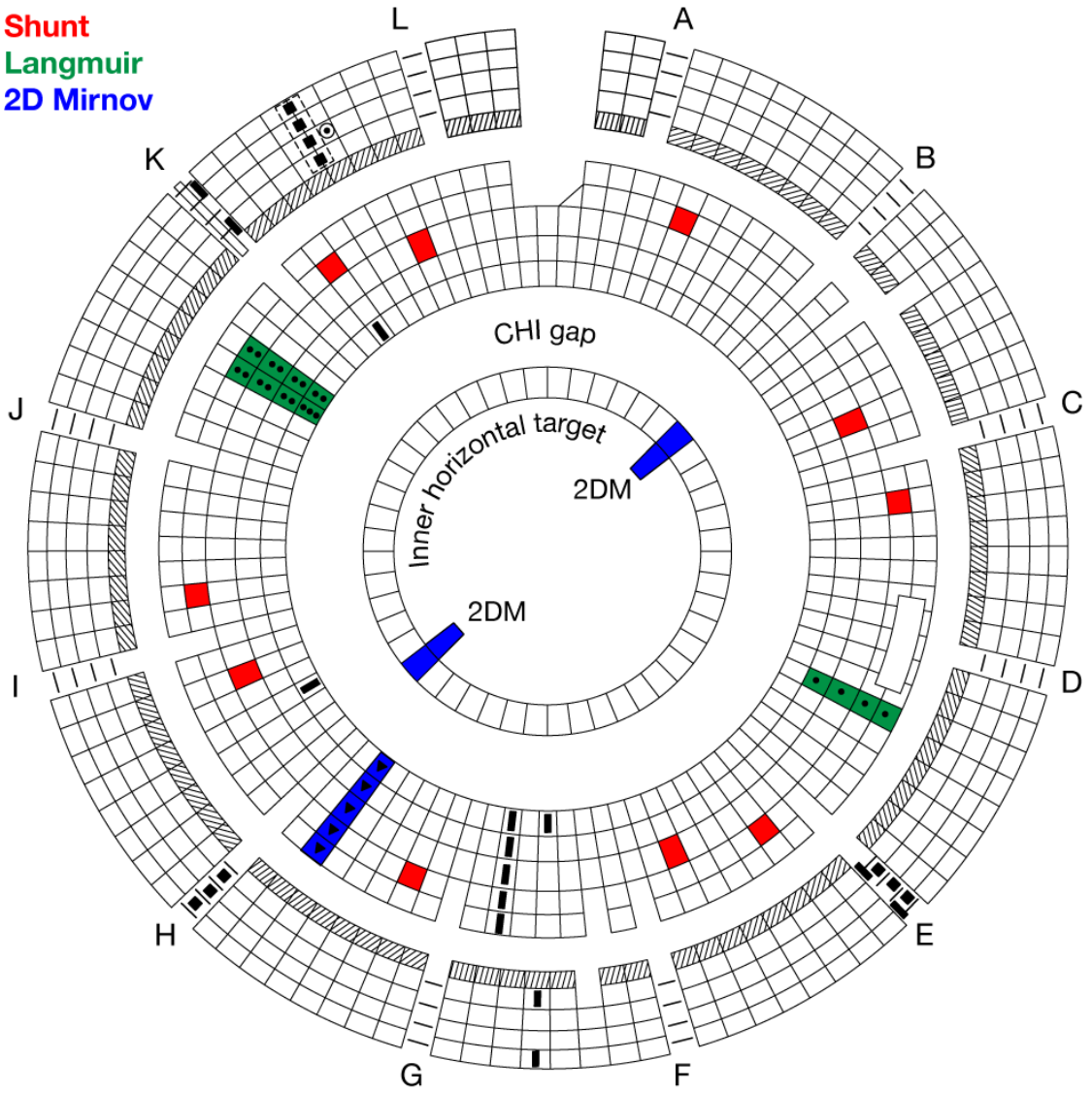
  - Compare directly with adjacent shunt tiles
- 2D Mirnovs
  - Extend OBD mirnov arrays to passive plates
  - Measure 180° I_p asymmetries



Existing lower divertor configuration (FY16)

- Why the lower divertor?
  - Most tiles already exist
  - Combine with other diagnostic coverage



Enhanced lower divertor configuration (FY17)

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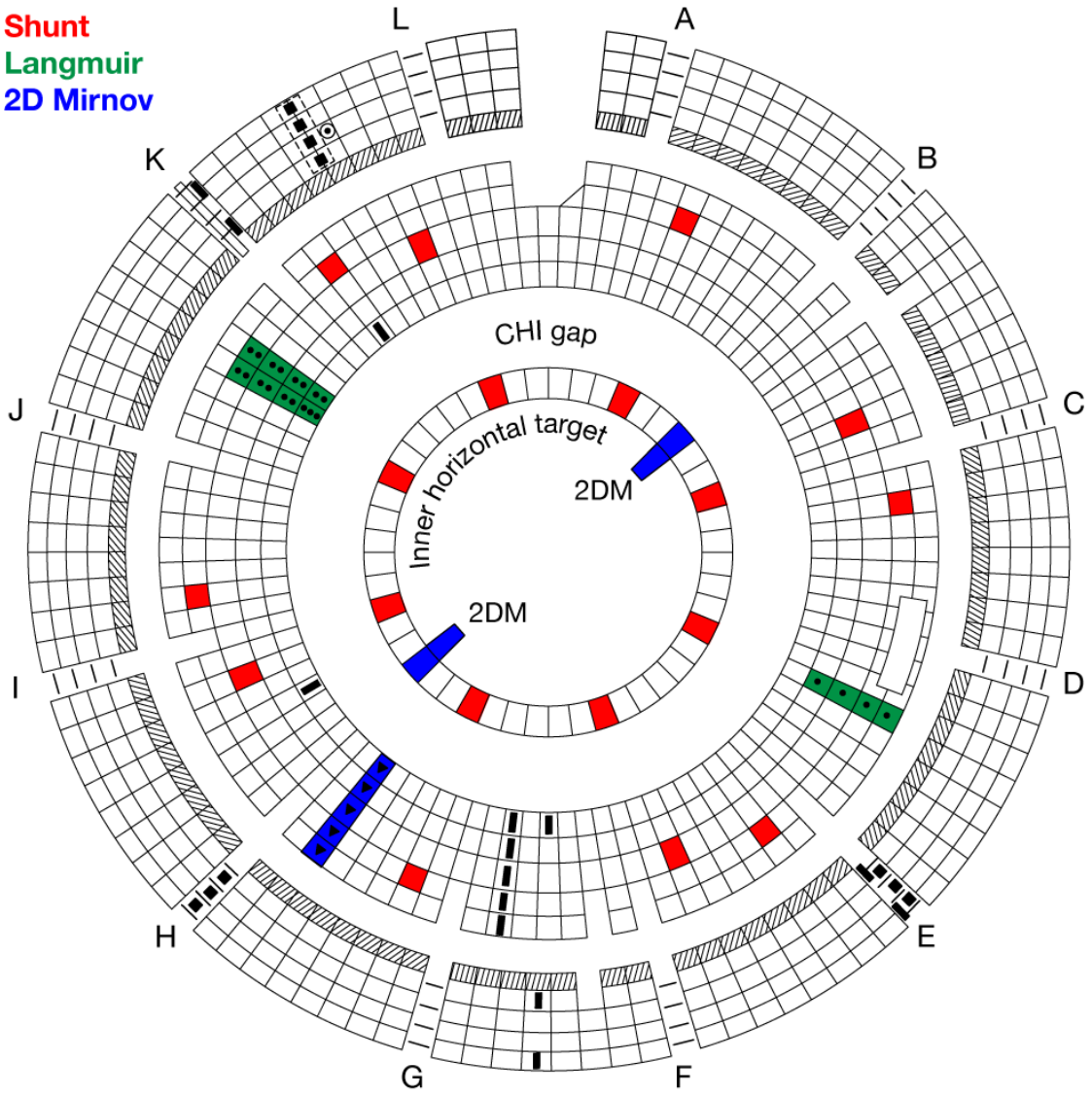
- Shunt tiles
  - Add IBDH (inner target) ring to match the upper divertor
  - Fields and forces are high at that location



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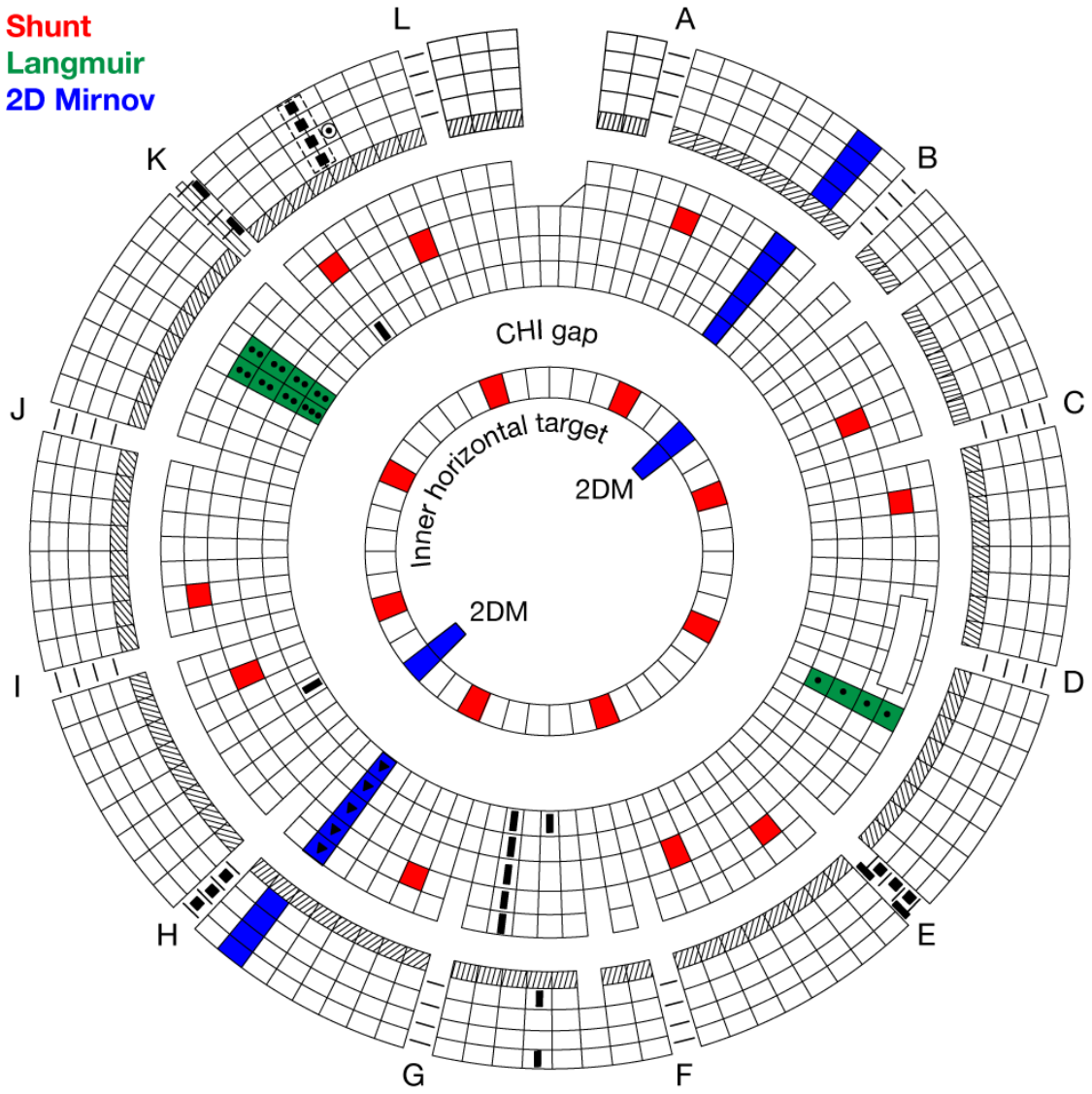
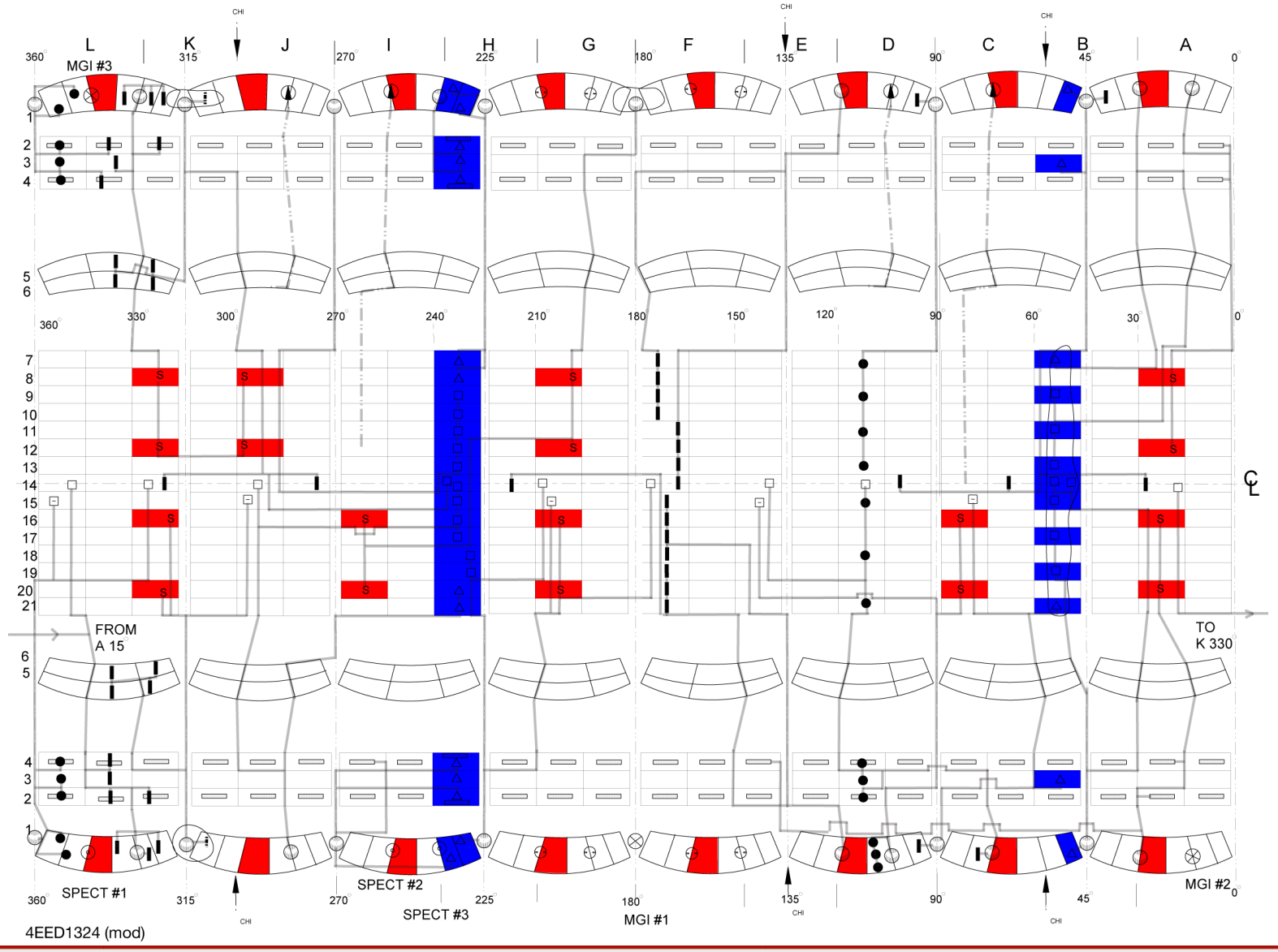
  - Extend OBD mirnov arrays to passive plates
  - Measure 180° I_p asymmetries
  - This upgrade must be done both on the upper and the lower to measure I_p



Center stack configuration (FY17)



Channel accounting and prioritization

- Priority 1 upgrades (40 channels):
  - Upper divertor shunt tiles (OBD) = 8×4 = 32 channels
  - Upper divertor shunt tiles (IBDH) = 8 channels
- Priority 2 upgrades (25 channels):
  - Lower divertor shunt tiles (IBDH) = 8 channels
  - Upper divertor Langmuir probe cassette = 17 channels
- Priority 3 upgrades (32 channels):
  - Lower passive plate Mirnovs = 4×4 = 16 channels
  - Upper passive plate Mirnovs = 4×4 = 16 channels

- CHI buswork rogowskis (machine protection):
  - Measure inner-to-outer current during disruptions
  - 6 rogowskis in-place and operational on the lower CHI buswork (credit to SPG)
  - Additional rogowskis will be added if the upper buswork is used to connect the inner VV to the outer VV at the top of the machine