DSS system performance and interface

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DSS Review

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Outline

- Requirements
- DSS loads from the TPC
- Motion of the TPC and cryostat
  - Thermal contraction of the TPC and the impact on the DSS
  - Cryostat roof deflection
- Summary

Positional requirements

- No absolute TPC position accuracy is required.
- Wire position on the APAs has a limit of +/- 5 mm.
- Maintain the drift distance +/- 10 mm.
- Control the detector volume to 1% during cooldown.
- Minimize the motion of the beam plug with respect to the membrane.

Charge question #1

Mechanical requirements

- Support the loads of the TPC.
- Allow for possible reconfiguration of drift distance from 3.6 to 2.5 m.
- Materials do not contaminate the LAr.
- Materials qualified for cryogenic use.
- Provide vibration isolation between the warm structure and TPC.
- Provide vertical adjustments of each of the TPC planes.
- Accommodate the contraction of the TPC.
- Accommodate the movement of the cryostat roof during various stages of operation.

Charge question #1

Electrical requirements

- DSS must be electrically connected to the detector ground. All elements of the DSS must be connected (no floating electrically conductive parts).
- TPC components must be isolated from the DSS. (Provided by TPC)

Charge question #1

DSS loads from the TPC

- During the TPC installation.
  - Dead loads of the TPC.
  - Dynamic loads of moving TPC elements on beams.
  - Moment loads from translation of the TPC on the runway beams.
- From the contraction of the TPC during gaseous cooldown.
  - Rolling friction loads from trolleys on beams.
  - Loads from the angular changes of the TPC support rods.
  - Loads from angular changes of the APA and CPA hangers.
- During liquid fill, the deformation of the cryostat, the effects of the moving LAr and the reduction in dead loads due to buoyancy.
- During detector operations
  - Affects from the convective flow of the liquid.
  - Potential vertical adjustments of the TPC.
  - Dampening of vibrations from outside sources.

Charge question #6

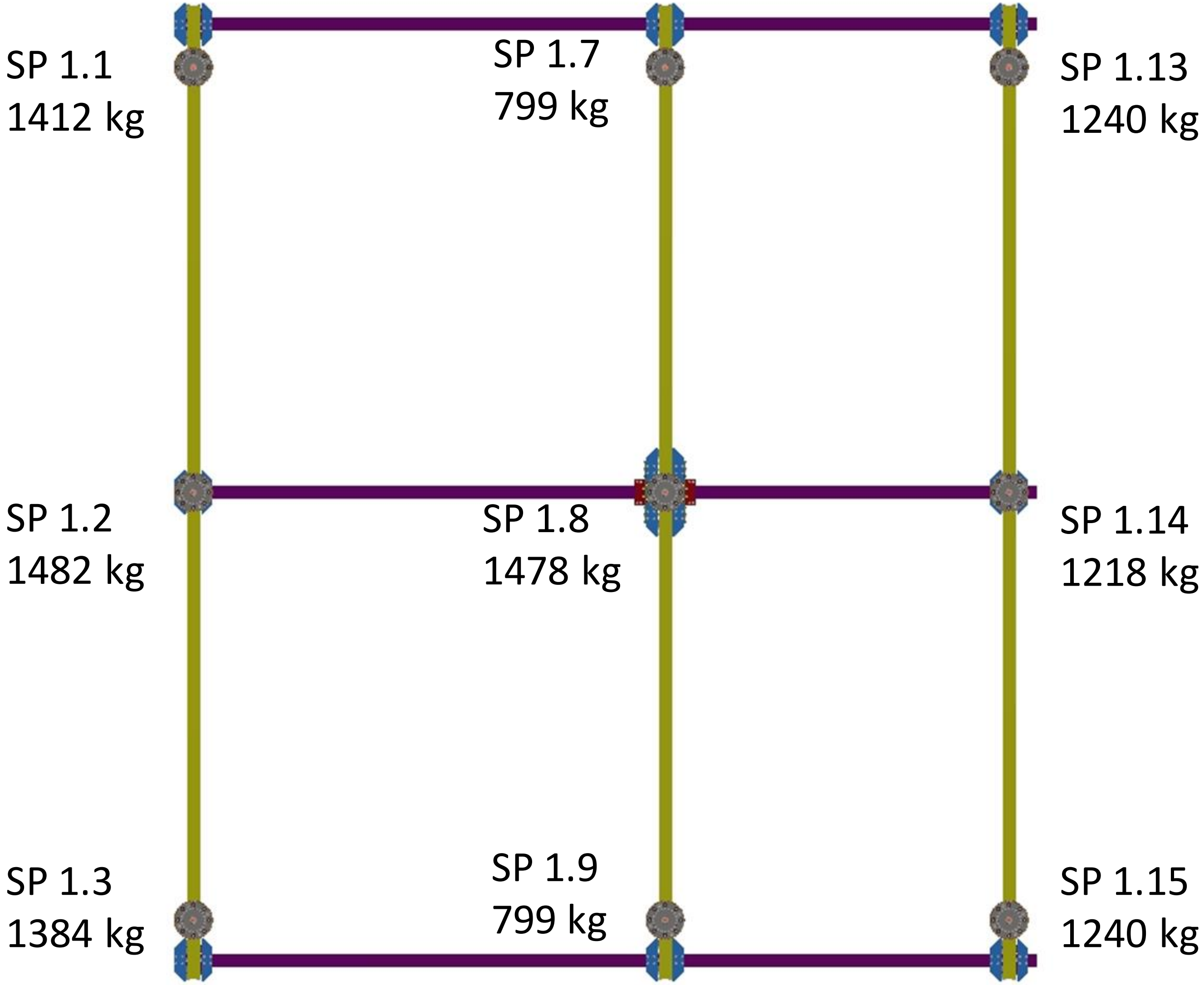
Total detector mass support by TPC

- The total mass of all subsystem components is shown below:

Part		WGT-TOT (lbs)		WGT-TOT (kg)
CPA panel		948		430
FC Top Panel		2640		1197
FC Bottom panel		2640		1197
FC End Wall panel		5600		2540
Beam Plug		100		45
APA panel		4745		2152
Support structure		4397		1995
GRAND TOTAL		**21071**		**9557**

Load distribution to the support points from TPC

(Static loads after installation of the TPC is complete, without liquid)



Charge question #6

TPC requirements for cryogenic system

- The cryostat / TPC cooldown will be done by injecting a mix of GAr and LAr via sprayers to generate a mist of small liquid droplets that are moved around by another set of sprayers flowing GAr only.
- The TPC requires a maximum cooldown rate of 40°K/hr and 10°K/min.
- The TPC requires a maximum delta T between any two points of 50°K.

Charge question #3

Thermal properties of materials

- The temperature of the TPC will change from 293°K to 88°K.
- The motion/contraction of the TPC is driven by the coefficient of thermal expansion (CTE) for the various materials. The values for CTE come from the National Institute of Standards and Technology (NIST) Cryogenics Technologies Group.
  - *http://cryogenics.nist.gov/MPropsMAY/materialproperties.htm*
- From 293°K to 88°K
  - The CTE for SS is 0.27%.
  - The CTE of G10/FR4 is 0.21% in the warp direction and 0.62% in the normal direction.
  - The CTE for FRP is 0.23%.
- With the exception of the normal direction in the fiber reinforced material, all of these values are very similar. The contraction of the various elements, should be very close to the same value.

Detector motion during cooldown (X and Y directions)

- In the X direction (beam), the contraction of the APAs is dominated by SS material. We expect the APA row to contract in X ~ 19 mm.
- In the X direction, the contraction of the CPAs is dominated by FR4. We expect the CPA row to contract in X ~ 15 mm.
- The current plan is to leave small gaps between the CPA panel during installation that will close during cooldown. The gap size is calculated such that the overall CPA row length will be equal to the overall APA row length when cold.
- In the Y direction (drift), the contraction is dominated by FR4/FRP. We expect the TPC to contract in Y ~ 8.3 mm per drift or ~ 17 mm total.
- Horizontally the position of the TPC elements is controlled by the stationary hangers to the bridge beam. All of these beams are SS and will contract the same.

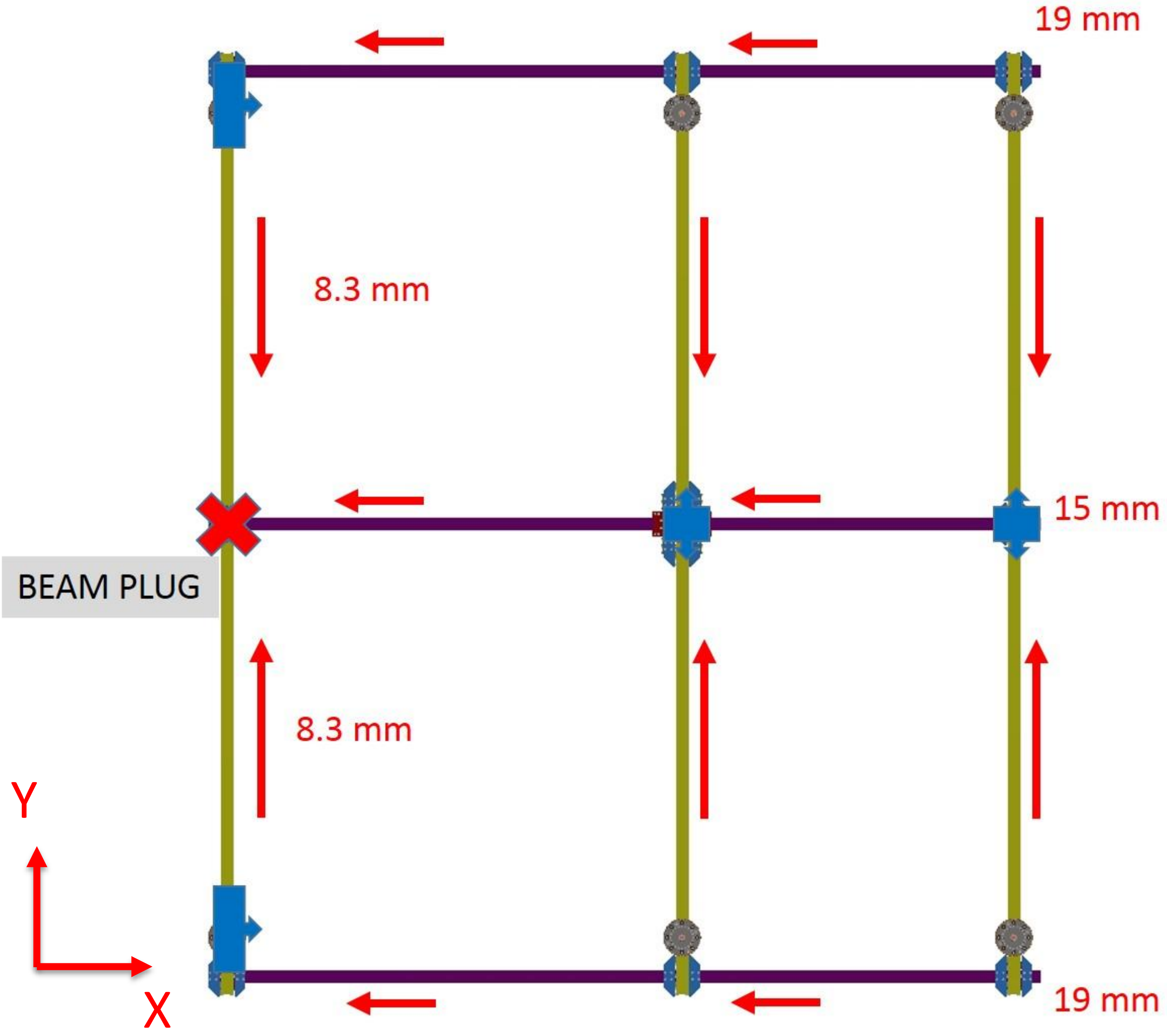
Charge question #6 & 9

Detector motion during cooldown (Z direction)

- In the Z direction (vertically), the APA planes are dominated by SS material. Over the ~7 m height these contraction is ~19 mm.
- The CPA plane is dominated by FR4/FRP material. The estimated contraction is ~ 15 mm.
- The differential contraction vertically is anticipated to be only ~ 4 mm. This is well within the dimensional requirements of the TPC. However, there is vertical adjustment in the DSS hanger assembly to compensate for this if necessary.
- The height of the planes has been designed to be equal for all three rows when cold.
- The installed vertical position of the CPA will be slightly different from that of the APAs. This delta will be computed so that the final position of the three rows is the same when cold.

Charge question #6 & 9

Motion/Contraction in X and Y



- The TPC is constrained in X and Y at the center support point near the beam plug side of the cryostat.
- Some of the other support points will be constrained to force the TPC to contract in controlled directions.
- The arrows show the directions that the TPC is to predicted move.
- The dimensions are the amounts we predict the overall TPC will contract .

Cryostat roof deflection analysis

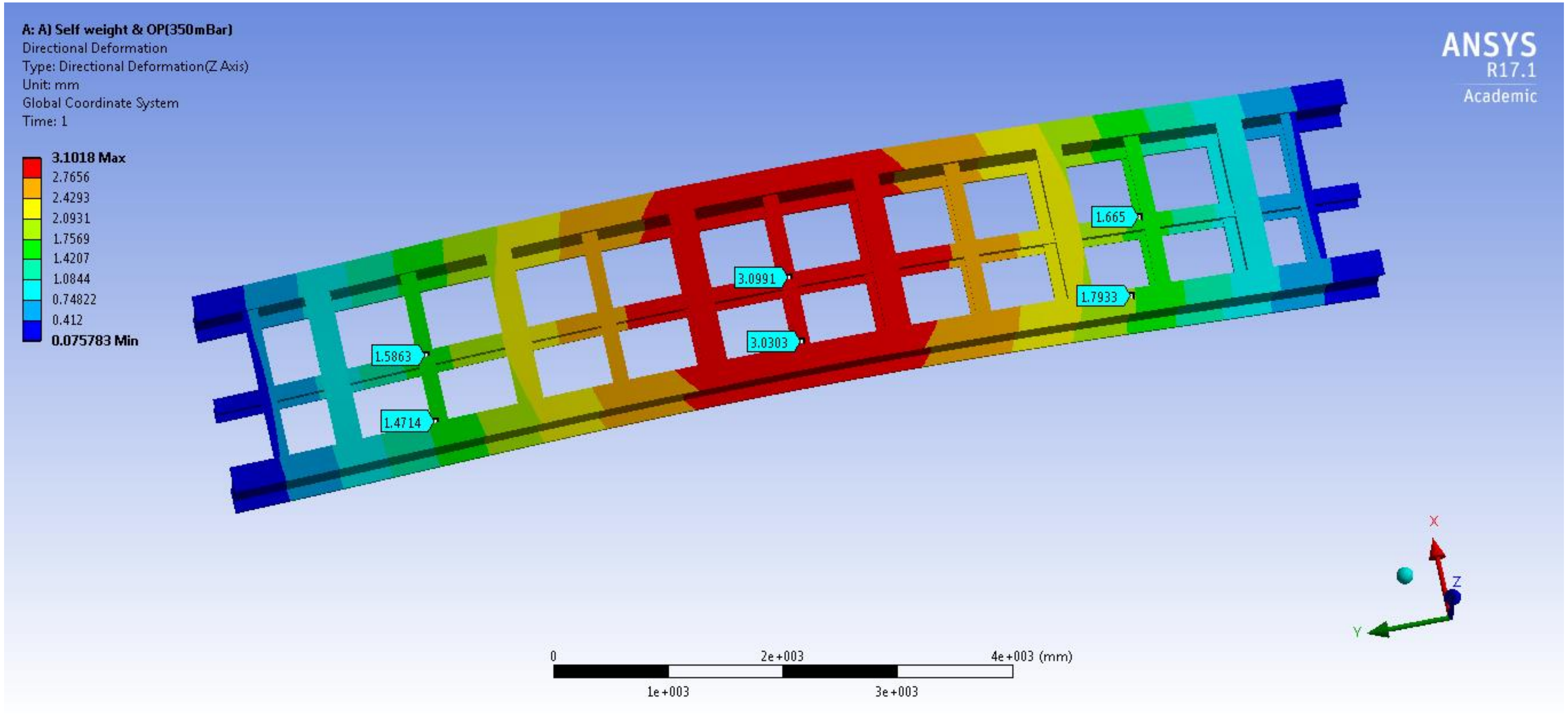
- A comprehensive deformation analysis of the cryostat roof was performed by CERN.
- The technical report for this can be found at
  - https://edms.cern.ch/document/1531441
- The deflection analysis was performed for a slice of the cryostat at the center line of the cryostat in X (beam) direction and at three points in Y (drift). The points in Y are listed below:
  - The center line of the cryostat above the CPA plane.
  - A distance of 2700 mm out from the center line.
  - A distance of 3600 mm out from the center line.

Cryostat roof deformation

- In the analysis, four different load cases were evaluated. These are listed below:
  1. 350 mBar, gas pressure only. This is only possible at the beginning of the LAr fill after the gaseous cooldown.
  2. LAr only.
  3. LAr & 350 mBar. This is an accidental load condition and is considered the worst case scenario.
  4. LAr & 75 mBar: This is considered the normal operational mode.

Charge question #3

Example of analysis (load case 1)



Roof deflection calculations

	ΔZ at 0 mm	ΔZ at 2600 mm	ΔZ at 3600 mm
Load case 1	3.10 mm	1.80 mm	1.60 mm
Load case 2	-2.60 mm	-1.69 mm	-1.63 mm
Load case 3	1.37 mm	0.56 mm	0.46 mm
Load case 4	-1.75 mm	-1.22 mm	-1.15 mm

- The worst case deflections are at the center of the cryostat over the CPA plane.
- The total range of deflection is only ~6 mm (-2.6 mm / 3.1 mm). This number is well within the positional tolerances of the TPC.
- Independent vertical adjustment of the TPC support points has been added to the DSS design to compensate for this deflection if necessary.

Summary

- Detector tolerances are on the order of 10 mm as long as the planes are not distorted.
- Thermal contraction dominates the movement of the TPC. This is 10 to 20 mm for each of the three directions.
- Roof deflection range is only 6 mm.
- The DSS can accommodate all of this motion and be adjusted vertically if issues are found after the detector is filled and operating.

Back up slides

Show various load conditions/deflections for the rails

- APA at long mid span.
- All three APAs
- CPA/FC at long mid span
- All CPA FC
- EW at long mid span
- EW applied to all APA
- EW applied to all CPA FC