

## Analysis of RICH Assembly Rotation Forces

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After analysis of forces on lifting components during rotation of the fully-assembled RICH support, it was determined that the pulley and winch do not have an adequate load rating.

The Ring Imaging Cherenkov (RICH) detector is a new detector for Hall B that will improve particle identification capabilities of the CLAS12 spectrometer. INFN collaborators and the Detector Support Group (DSG) will be assembling RICH in the EEL 124 cleanroom.

During RICH assembly, an extruded aluminum structure supports the detector shell and allows RICH to be rotated from

a horizontal to vertical position (Figs. 1 and 2). In March 2017, DSG and INFN rotated RICH both from horizontal to vertical and from vertical to horizontal. For the rotations, the cleanroom’s gantry crane and the assembly structure’s winch system (Figs. 3–5) shared the lifting load because of uncertainty in the winch system’s load rating.

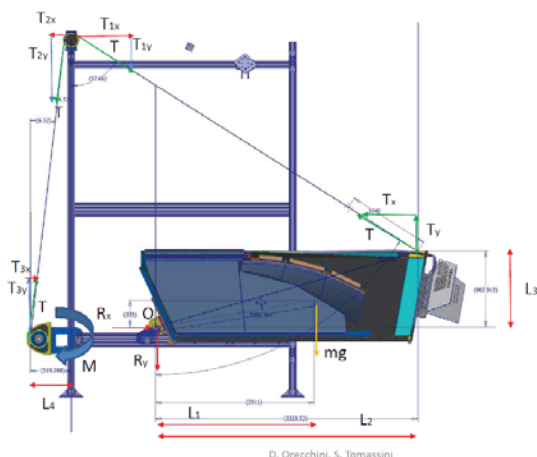


FIG. 1. RICH in horizontal position on assembly structure. Diagram also shows forces and parameters calculated using Python script.

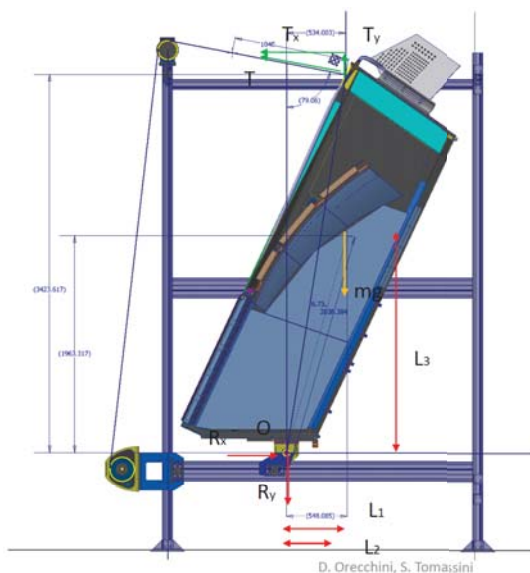


FIG. 2. RICH in vertical position on assembly structure.

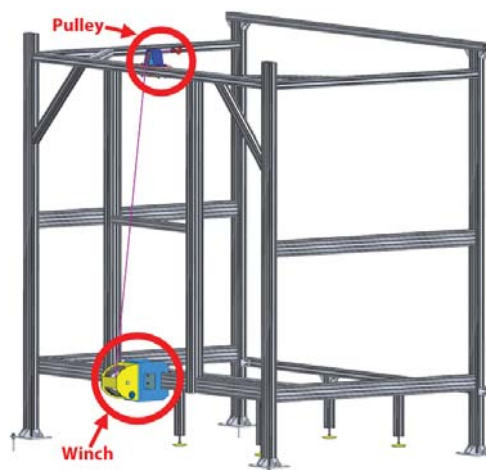


FIG. 3. RICH assembly structure model with winch system.



FIG. 4. Huchez Manibox GR1000 winch provided to rotate RICH.

While rotating from vertical to horizontal, there was a small, sudden drop of the detector, thought to have been caused by the shifting of the load from the winch to the gantry. To prevent a similar drop from occurring when RICH is fully assembled, DSG proposed placing the lifting load of the

rotation only on the winch. Before finalizing a lift plan that uses only the winch, the lift forces during RICH rotation required analysis to ensure that forces do not exceed the rating of the installed winch system.



FIG. 5. Gebuwin KB1000 pulley provided for RICH rotation. The pulley has a maximum load capacity of 1000 kg. Maximum wire rope diameter allowed is 10 mm.

DSG developed a Python script to calculate lift forces and generated plots of the results (Figs. 6 and 7). In the Python script, RICH’s mass was set to 1500 kg, which includes 1000 kg for the fully-assembled RICH, 200 kg for the stiffening frame, and 300 kg for a 25% safety margin.

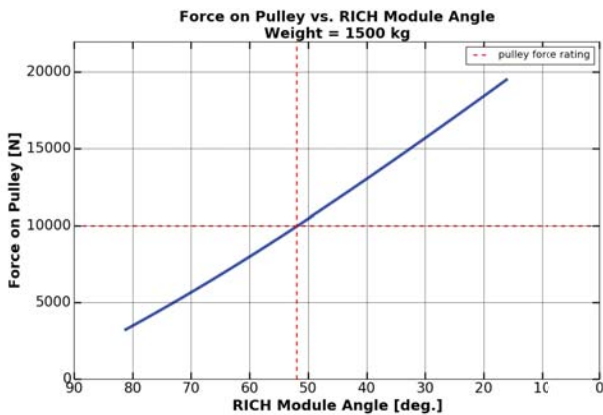


FIG. 6. Plot generated in Python showing relationship between force on pulley and RICH module angle. The red, dashed lines indicate the pulley’s force rating.

To confirm the Python script results, DSG created simplified lift diagrams in AutoCAD. The lift diagrams generated showed RICH in the horizontal position, an intermediate position, and the vertical position (Figs. 8–10).

Results show that the force on the pulley increases as RICH rotates from vertical to horizontal. When nearing horizontal, the force on the pulley is ~2,040 kg which is greater than the rating of the provided pulley. Therefore, a more suitable pulley must be procured.

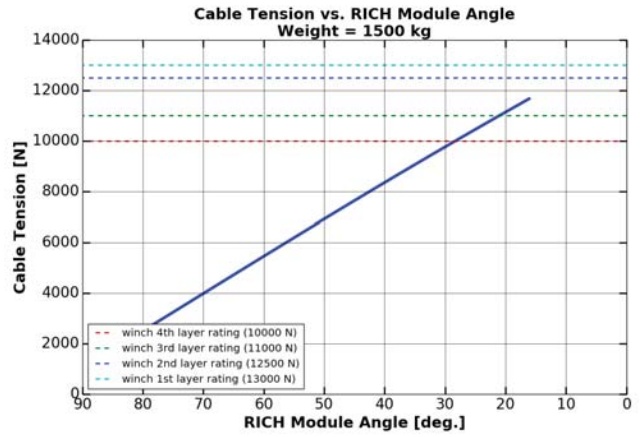


FIG. 7. Plot generated in Python showing relationship between cable tension and RICH module angle. The colored, dashed lines indicate force rating of each of the winch’s layers.

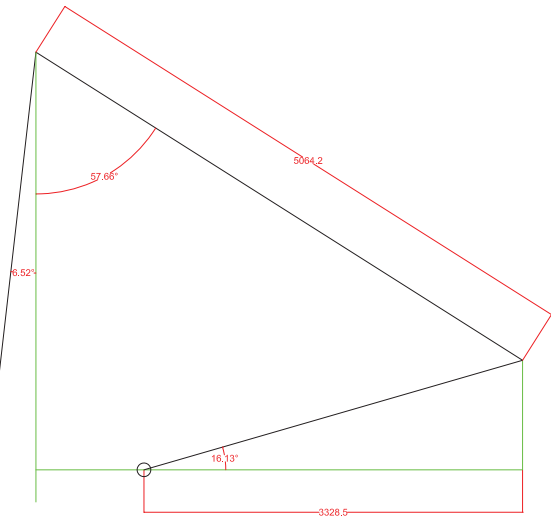


FIG. 8. Simplified AutoCAD diagram of RICH in horizontal position.

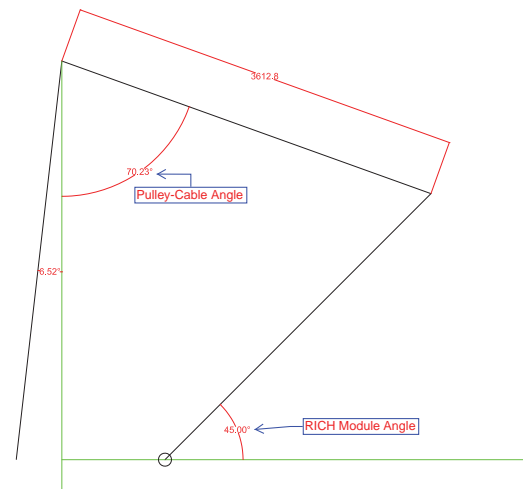


FIG. 9. Simplified AutoCAD diagram of RICH in an intermediate (45°) position between horizontal and vertical.

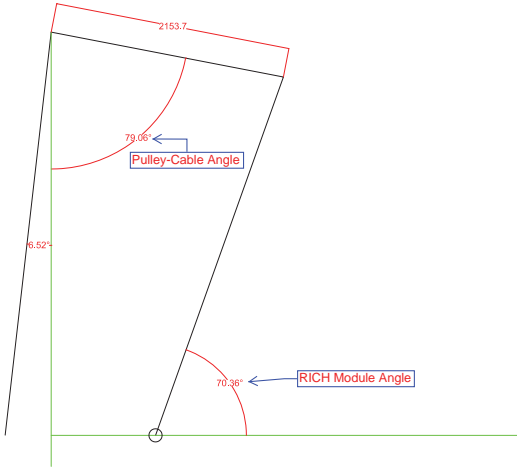


FIG. 10. Simplified AutoCAD diagram of RICH in vertical position.

Results also show that as RICH rotates from vertical to horizontal, tension on the winch cable increases. The tension on the cable directly relates to the force on the winch. The maximum force on the winch is  $\sim 1,193$  kg, which exceeds the maximum lift rating of the fourth and third winding layer of the provided winch, Table I.

Because the load on the winch exceeds the safety rating of two layers, DSG's proposed lift plan for fully-assembled RICH rotation required modification. The lift plan was amended to only use the gantry when RICH nears its final horizontal position. The gantry should be positioned at the lo-

Layer	Maximum load [kg]
1	1300
2	1250
3	1100
4	1000

TABLE I. Winch GR1000 lifting capacity by layer.

cation where the tension on the cable will exceed the winch's rating. This positioning will prevent any load on the winch greater than its safety rating and allow a gradual transfer of load from the winch to the gantry.

In conclusion, the winch cannot be used alone to rotate the RICH due to force on the winch exceeding the present winch's safety rating when RICH nears horizontal. To avoid the need to procure a new winch, the gantry will still be used to share the load during the rotation, positioned over the point where the force on the winch begins to exceed the winch's safety rating. This should prevent any load on the winch greater than the rating.

Due to the load on the pulley, a new pulley should be procured that is rated for a higher load. A pulley with an adequate weight rating of  $\sim 3,000$  kg has been identified, Jeamar Winches' VB7000. For this pulley, the sheave diameter is specified at 152 mm and the rope size at 10 mm.

With the new proposed lift plan and pulley, the rotation of fully-assembled RICH should not include any sudden drops of the detector caused by transfer of load.