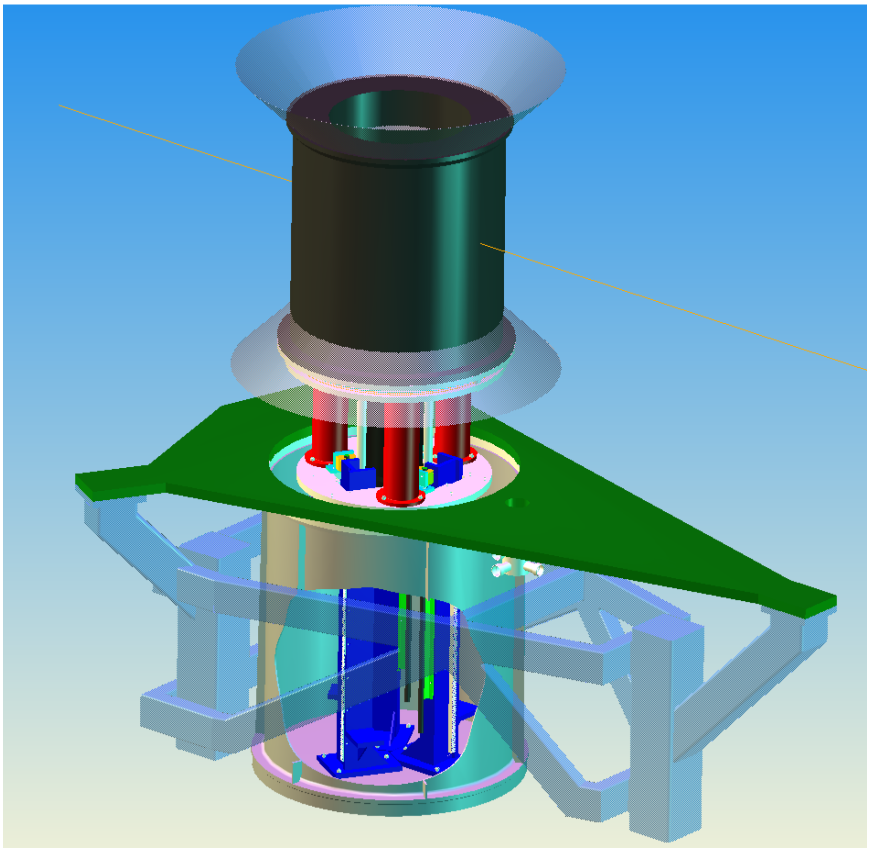
GEM ORC LIFTING MECHANISM, by Chris Benson, Dennis Cowdery and Peter Galsworthy

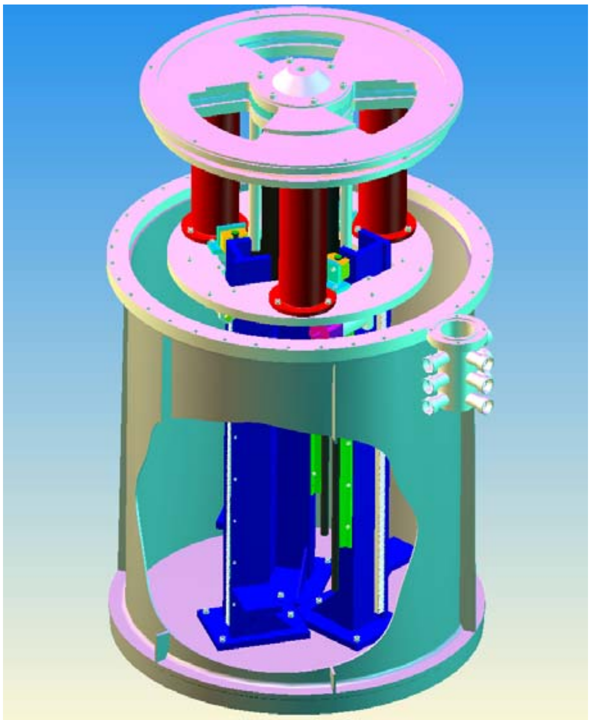
Project Overview:-

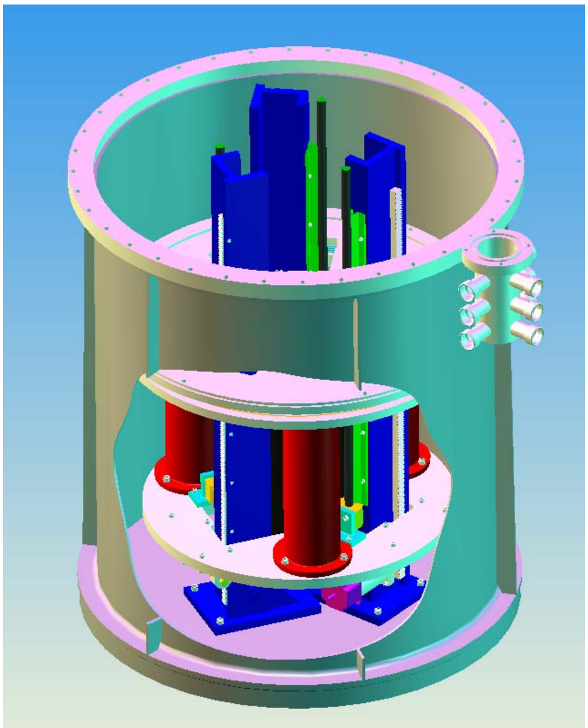
Gem's oscillating radial collimator is permanently in the beam, however a recent requirement has been to allow the removal of the collimator from the beam, without having to shut gem down and strip it apart. There were no provisions for this requirement and so there have been many constraints with the design, the main one being space. This means the final design is a one off solution specific to gems situation, a more radical approach than if you had a blank canvas. A non tried and tested method carries its own problems.

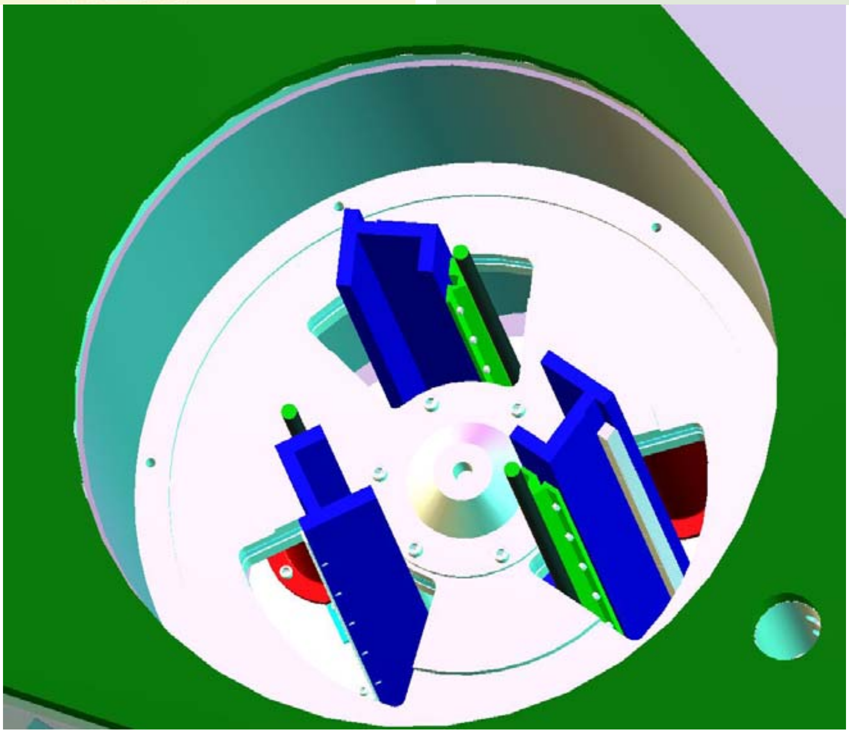
The final design consists of a large tank under gem, with its own adaptor ring to allow the current bore and PCD in the base plate to be reduced to allow the tank to fit in the space underneath.



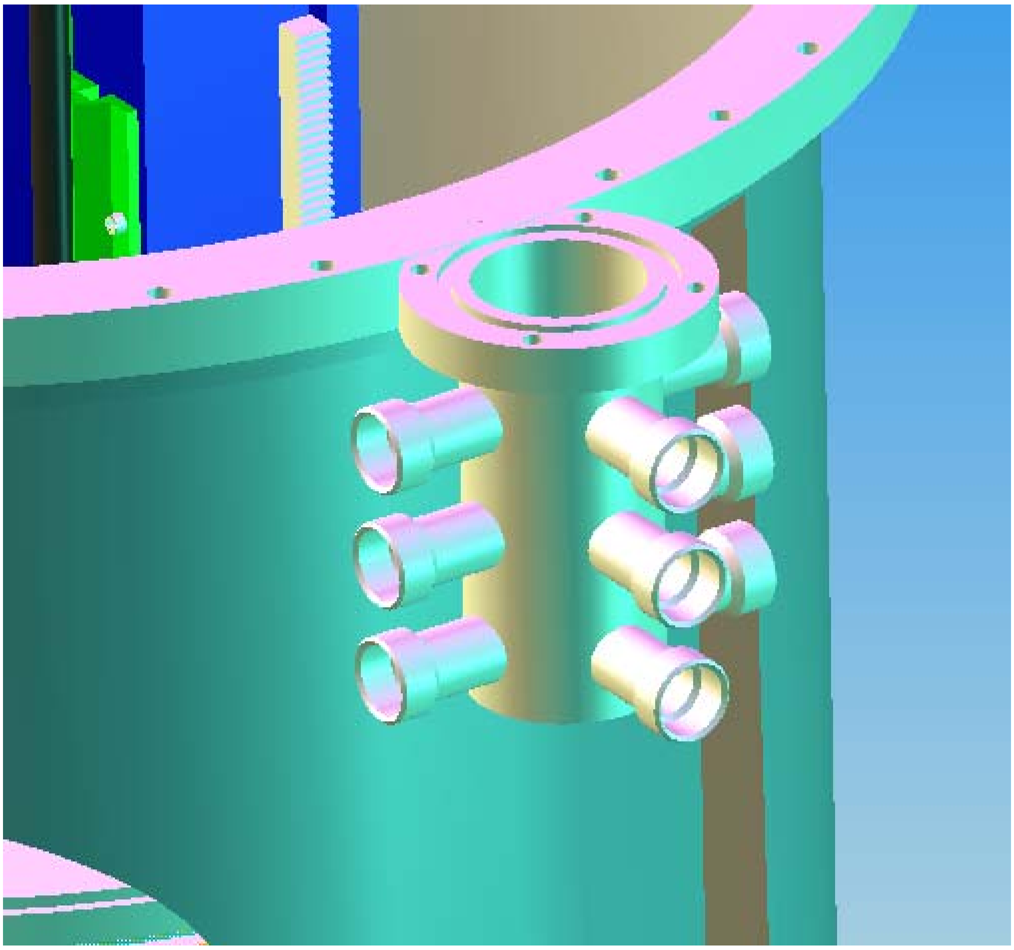
Most of the orc mechanism itself has had to be redesigned to fit the lifting mechanism. Now standing on only 3 legs, its base plate carries 3 motor/gearbox units with a pinion on each and a linear bearing. These will ride up and down 3 specially designed J-section pillars, which have a rack and a linear bearing rail (for guidance). They are positioned close enough together to allow the collimator to lower down over them yet still retain rigidity. Each plate has specially cut holes also to allow the pillars to pass through (space constraints).







The numerous electrics can only come out of an existing 70mm diameter hole on the gem base plate (not enough room for the required 9 jaeger fittings!) and so a special jaeger fitting feed-through manifold (like a traffic light box) was designed.

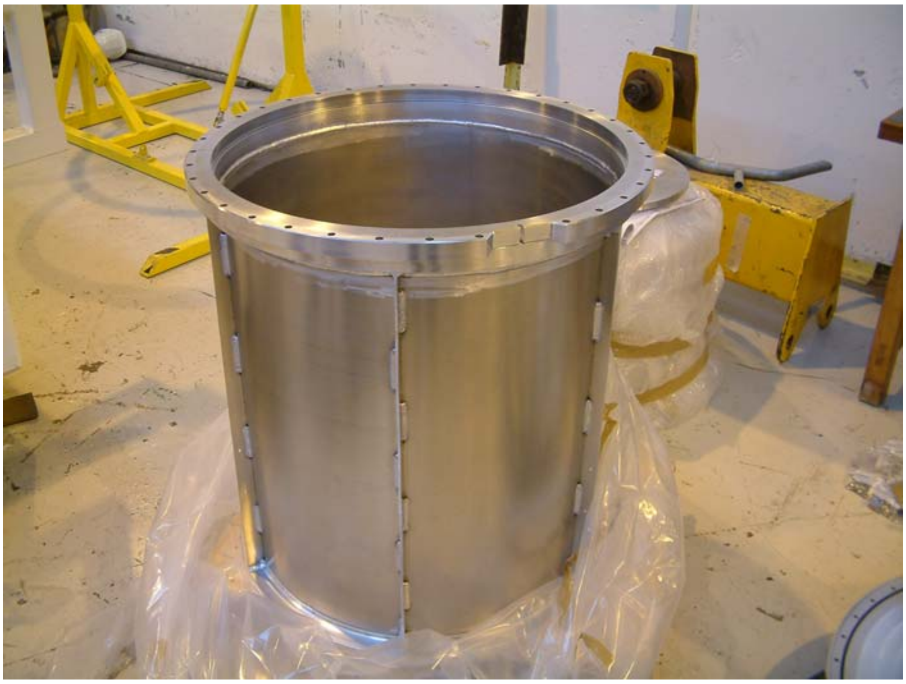


ASSEMBLY:

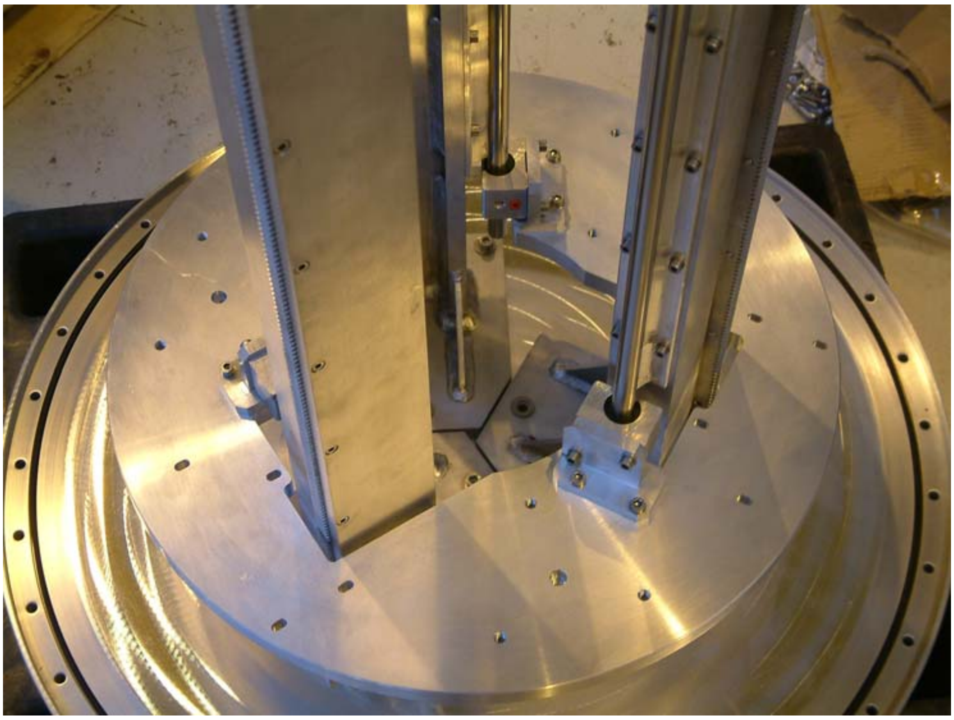
Assembly of the many components of this complex design was started in January 2004 in R6 (feel free to visit). Being a non tried and tested method, it is very important to adjust and test at each stage of assembly, so any possible flaws can be identified and ironed out prior to installation.

On go the J-pillars, fixed to the base plate

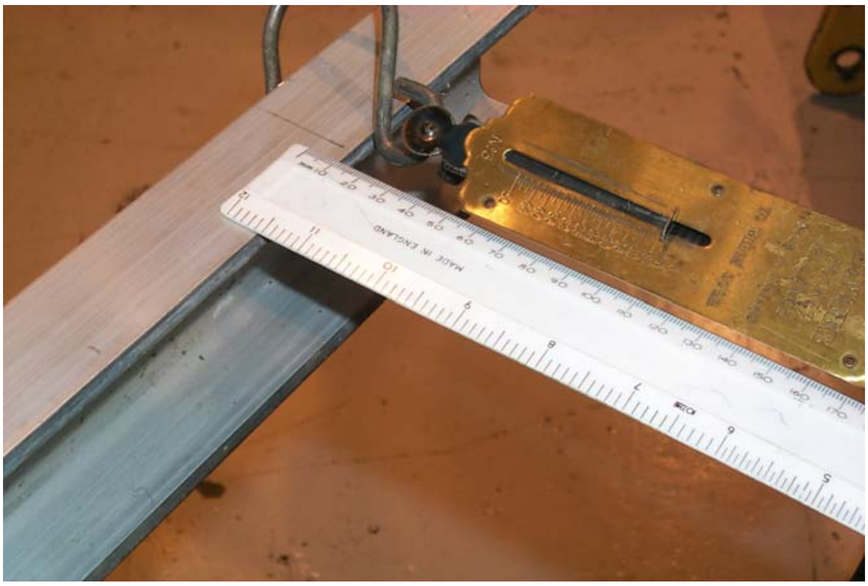
Here is the large vacuum tank (700mm bore), plus adaptor ring.



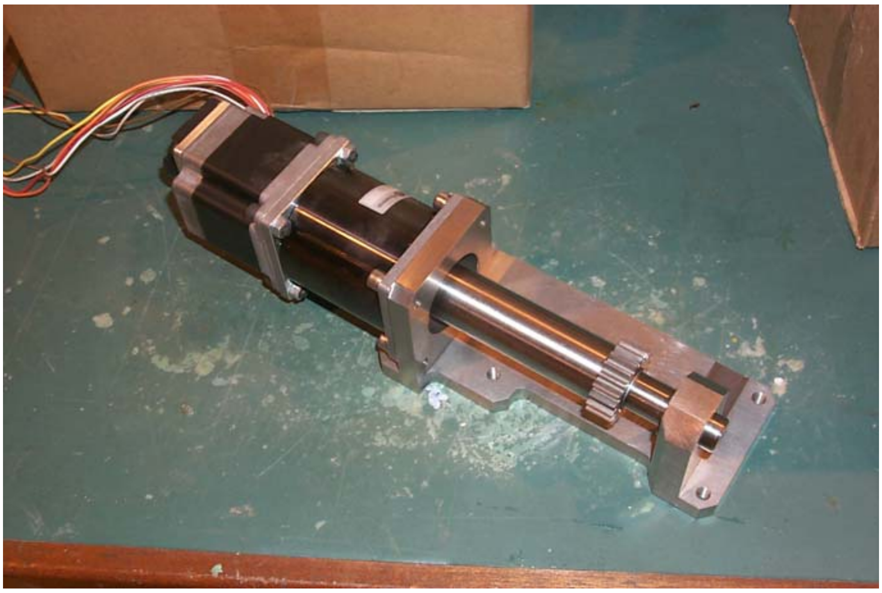
The linear bearings are fitted to the lifting base plate, which is then slid over the pillars to check the alignment and freedom of movement

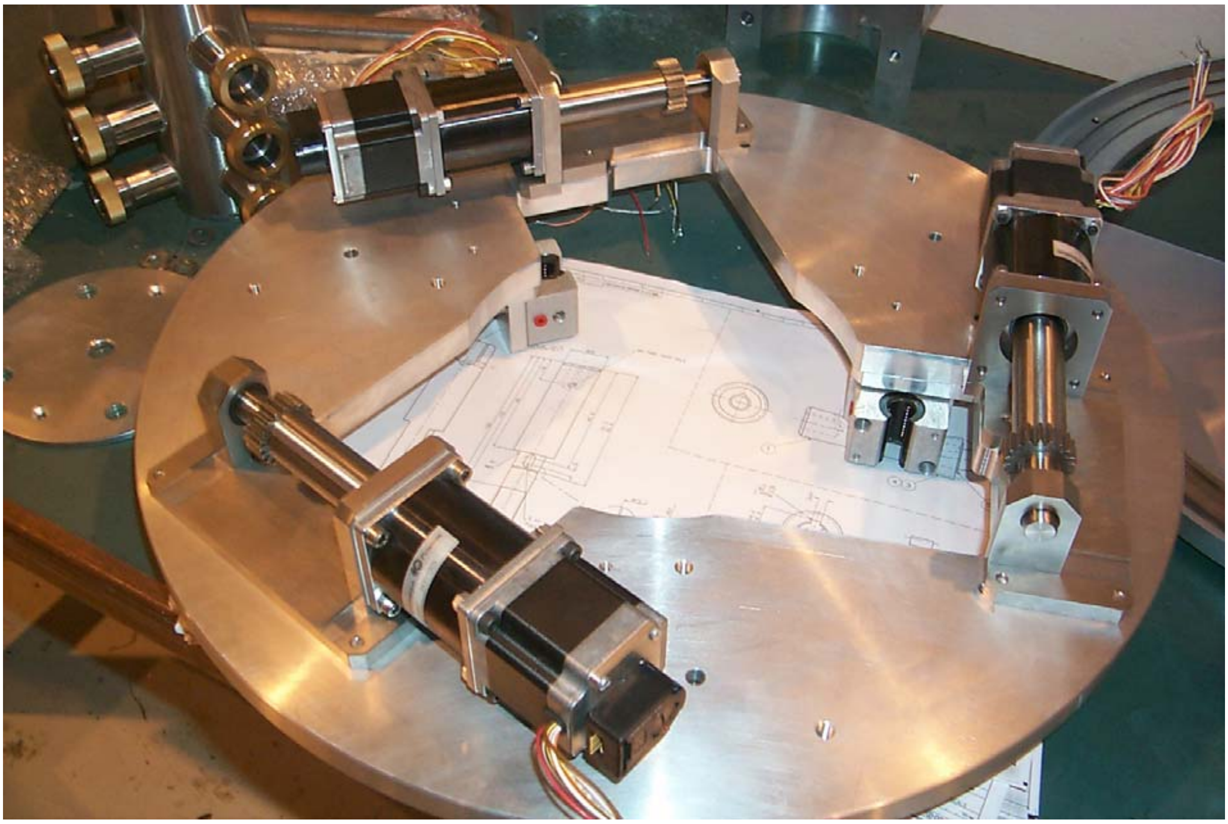


We were concerned about possible twisting of the pillars and therefore disengagement of the pinion when the orc would be in its top postion. The pillars are free at one end due to the design constraints and so can flex, but the shape was designed to give good rigidity. So we performed a crude torsion test, by clamping an aluminium beam to the top of the pillars and applying a moment measured with a spring balance. A 50Nm force (twice what would be applied in reality) resulted in only 10mm deflection a metre from the pillars. We decided this was acceptable and the teeth shouldn’t jump.

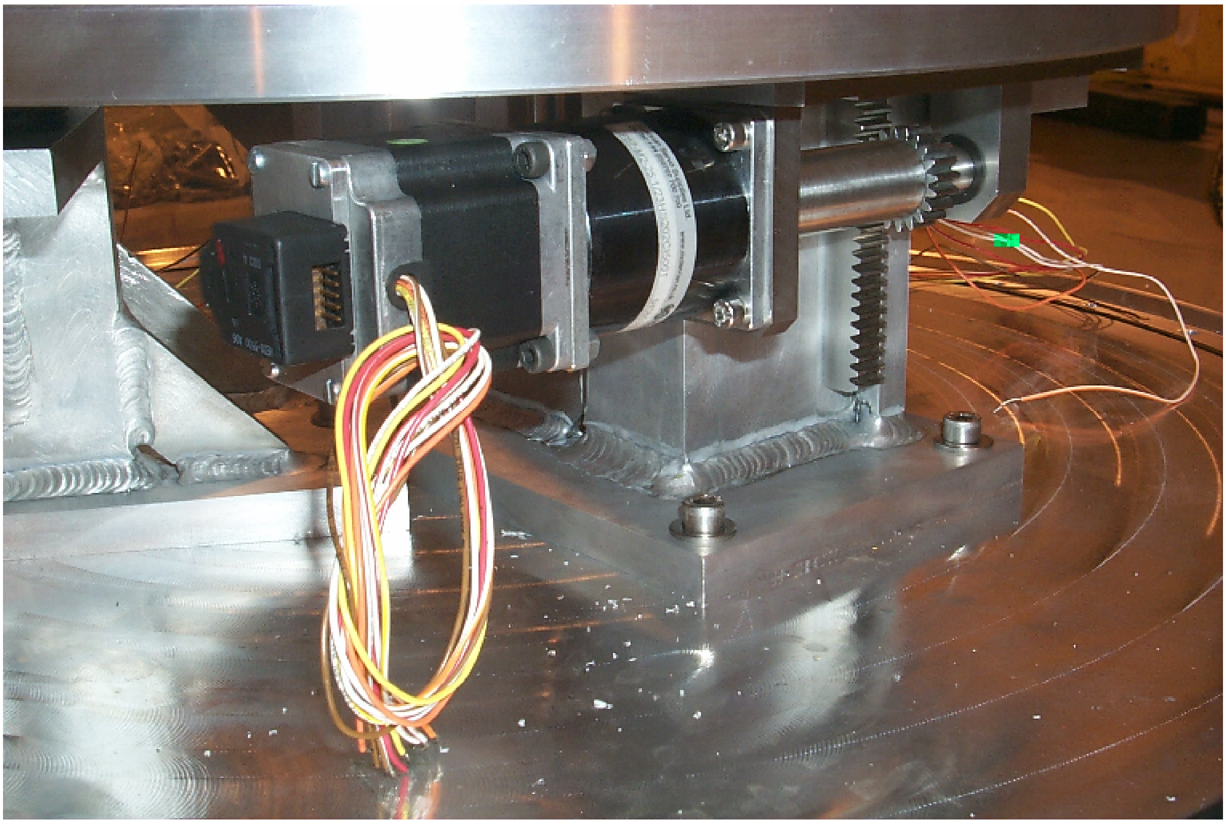


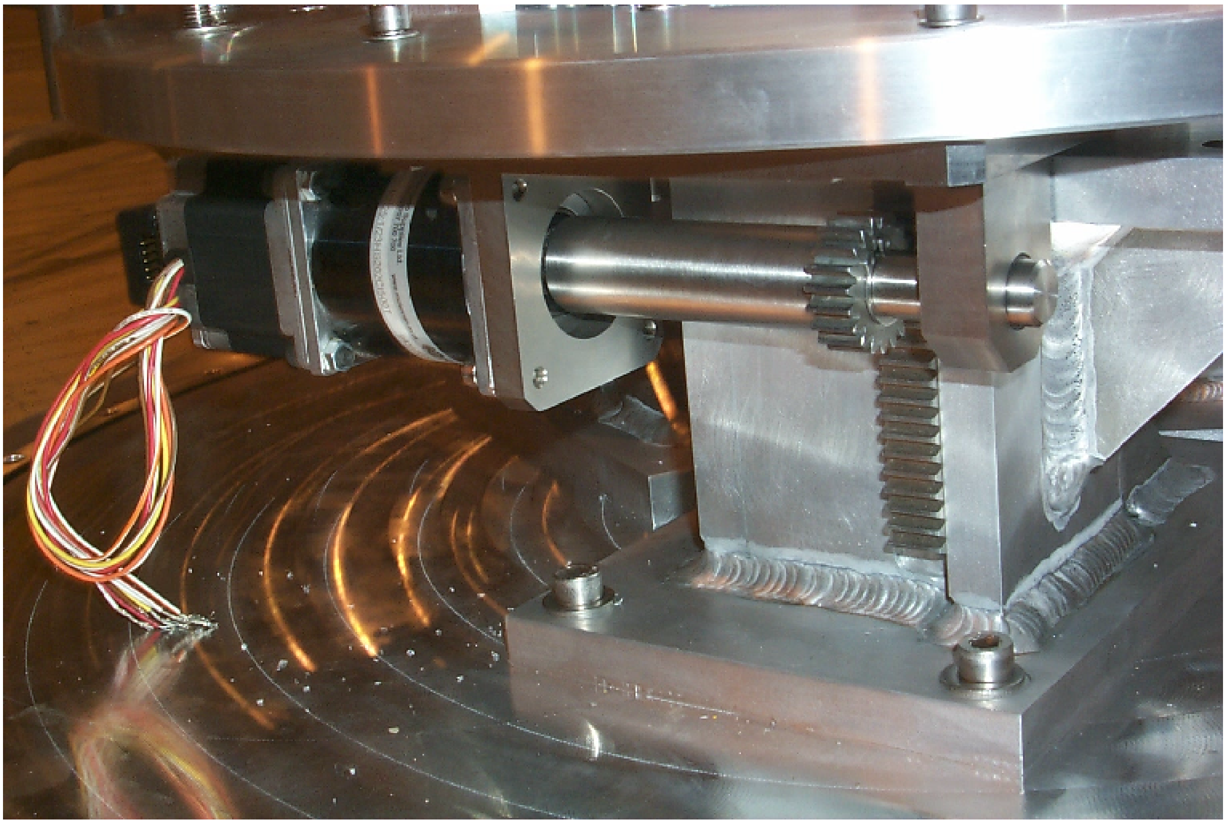
The motor/shaft/pinion sub assemblies are completed, then fitted to the underside of the lifting base plate.



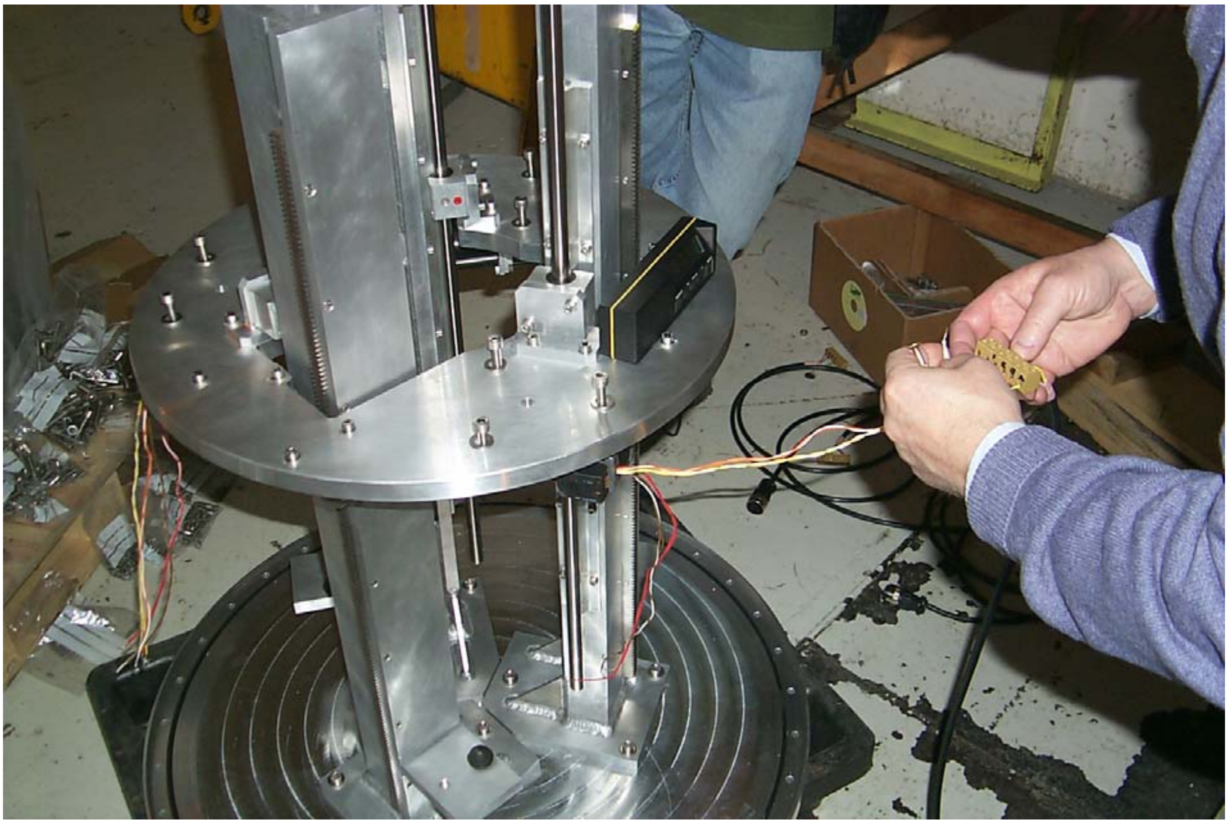


The plate can be put back over the pillars and the engagement of the teeth is checked.





The motors were then roughly connected up to the lifting control crate (designed by Dennis Cowdery). The problem of synchronising 3 motors at once to give a stable lift is a complex one and required some complicated programming by Dennis. The crate can allow each motor to be controlled manually using the box shown below or it can automatically synchronise all 3 (very smoothly)



We adjusted the speed and acceleration of the motors by changing the program through a laptop. This allowed us to get the peak torque out of the motors, thus giving a strong yet steady lift. The next test will be seeing what the actual weight limit is, the calculations have been done on 200kg. Quick tests using people before we adjusted the torque (Dave Maxwell, myself, Dennis Cowdery and even Alex Hannon) showed it was very forgiving of non-equally distributed loads and that it could carry 3 men of around 12 stone, which is more than adequate.

The load testing was successful, using lead blocks (each weighing 11.8 kg) we loaded the mechanism with 210kg! . This was then ran to its top position and back down again. For safety, we tied slings round the lifting plate and attached them to the electric stacker truck, this was not to aid the mechanism, but to catch it if the motors gave up (210kg falling that distance would make quite an impact). Despite the success of the lift, we are considering the design of a shot bolt mechanism for when the device is in its top position, thus taking the strain off the motors.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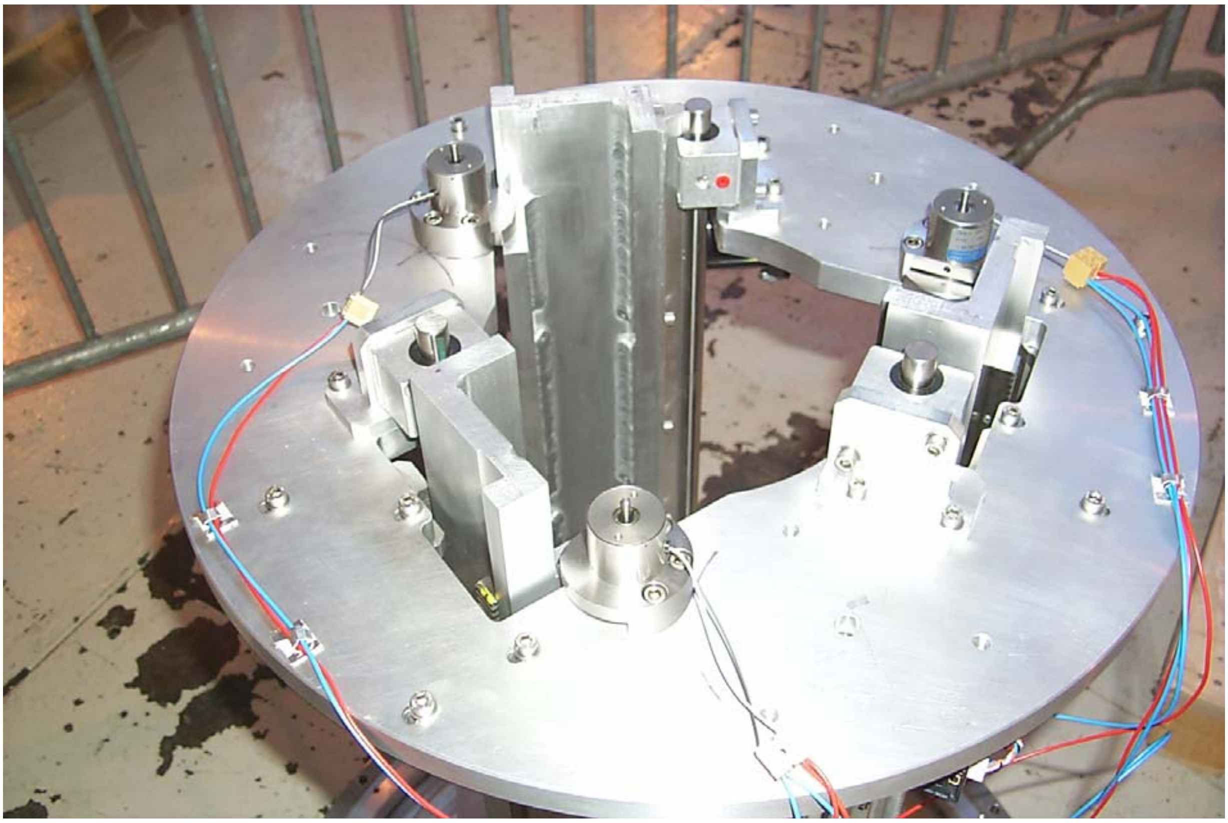
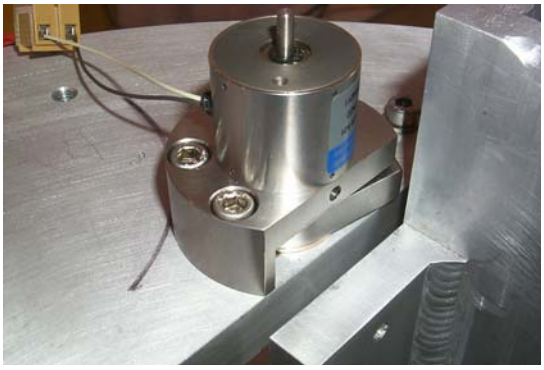
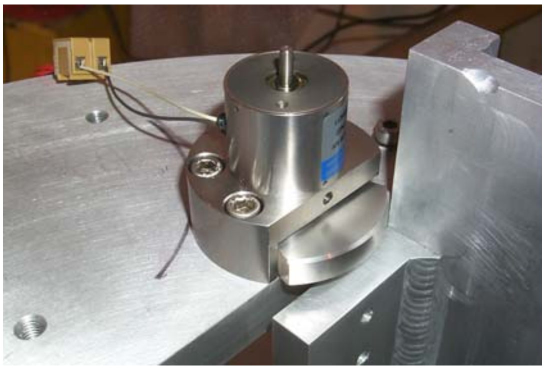
The shot latch mechanisms have arrived and now the motor plate and j-pillars need modifying to include them. Here are some pics of the finished results.

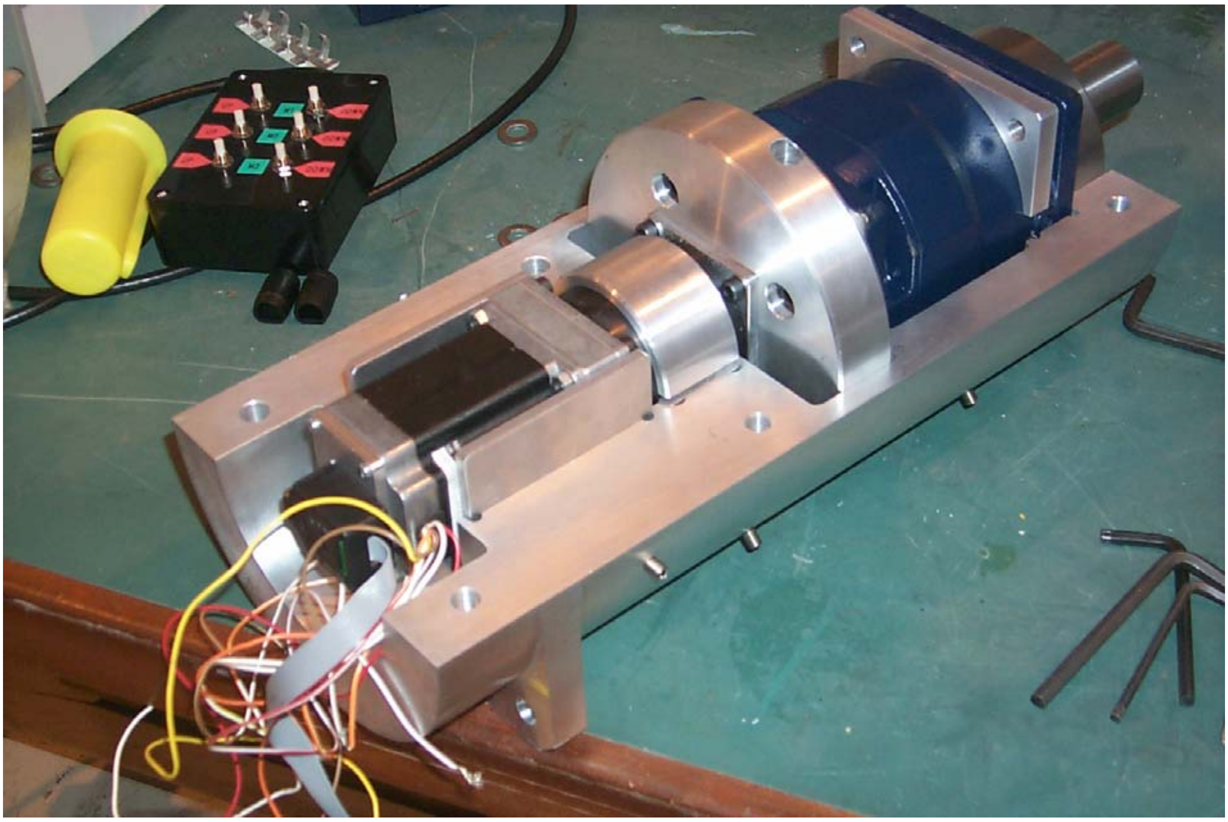


Above the 3 installed shot latch mechanisms. Below, the action of the latch is shown.





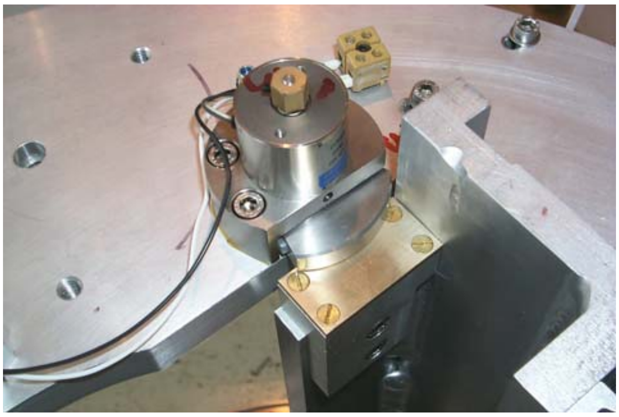
Concurrent with the lifting mechanism we started building up the ORC itself.

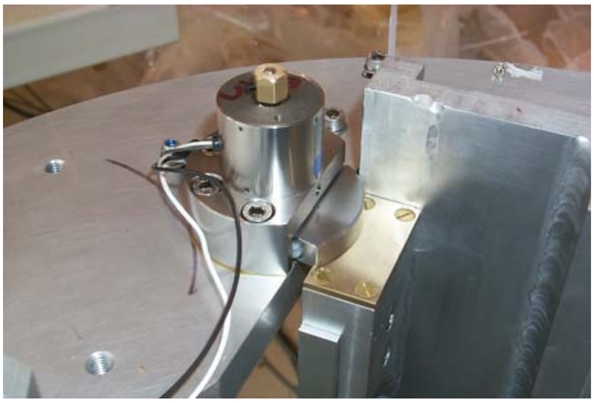


Here is the gear box being assembled.

Here the gearbox is fitted to the main bearing plate.

Next special brass shims were manufactured. These are what the shot latches rest upon (to stop wear on the j-pillars) and can be re machined to allow fine adjustment of the top height of the mechanism (important for collimator accuracy).





The connector brackets and the addition of a power chain allow the cables to be managed properly and tidied up.

It was decided that the idea of attaching the multi-jaeger can to an existing port in the GEM base plate would lead to complicated wiring and assembly/disassembly problems. So the vacuum vessel itself was modified to include a port for the can, thus making it integral with the rest of the system and making the ORC lifting mechanism a single self-contained unit.

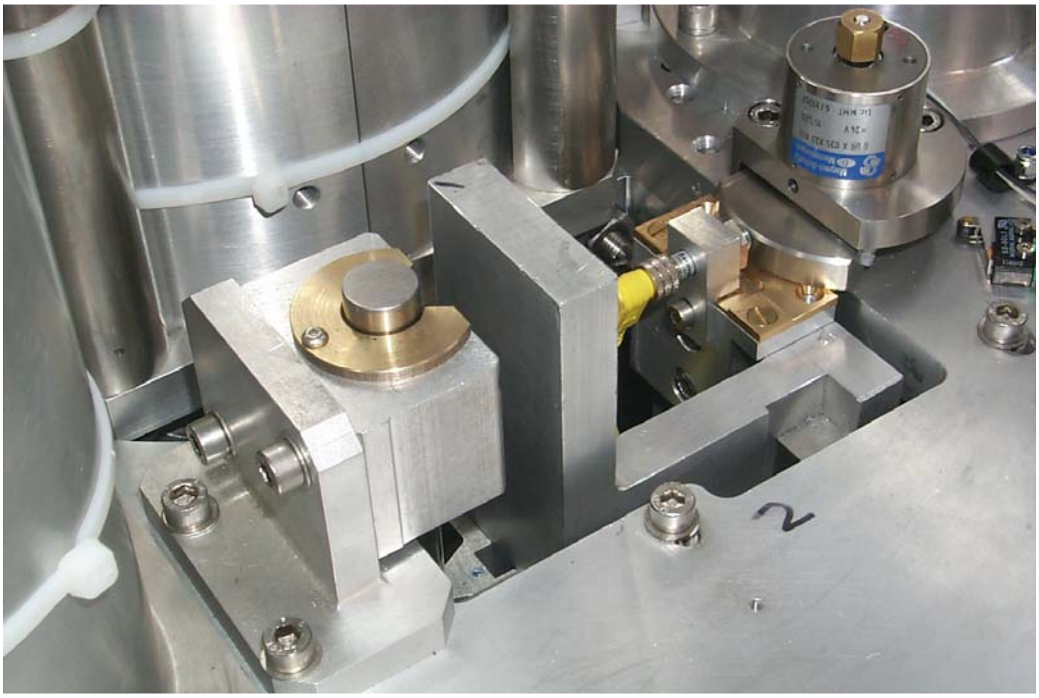
Here is the unique ‘jaeger tree’ attached to the new port on the main tank. This will allow the many cables to be fed through the vacuum.

Here are the stilts that will raise the GEM frame up so that the tank can be installed.

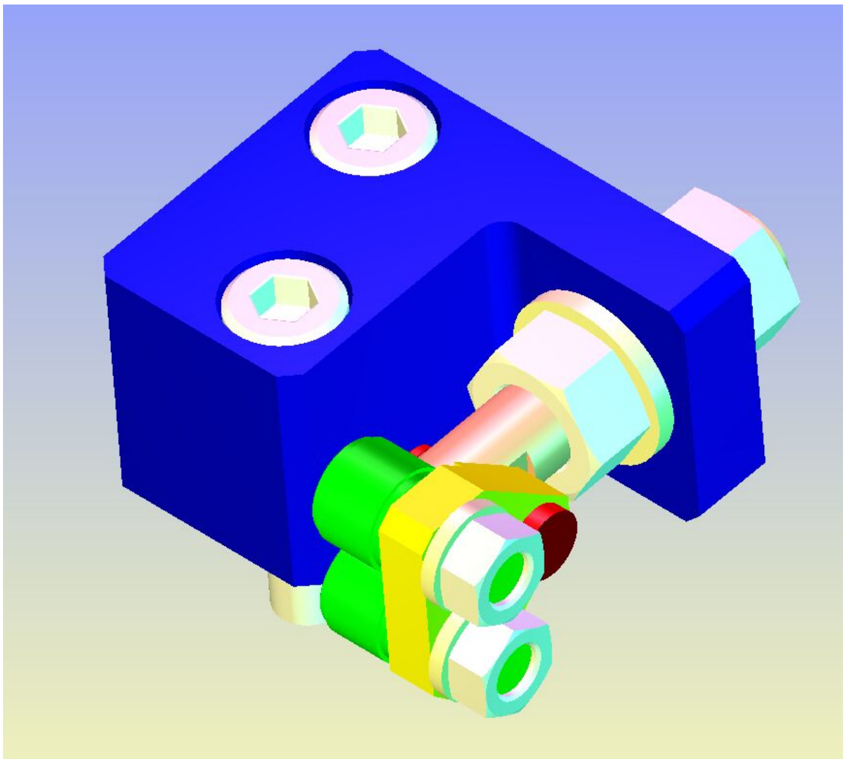
Once GEM was extracted from its beamline, the original ORC equipment was stripped off.

The tank was then attached to the original port using the specially designed adaptor ring, which reduces the diameter of the hole to allow the tank to fit under the frame.

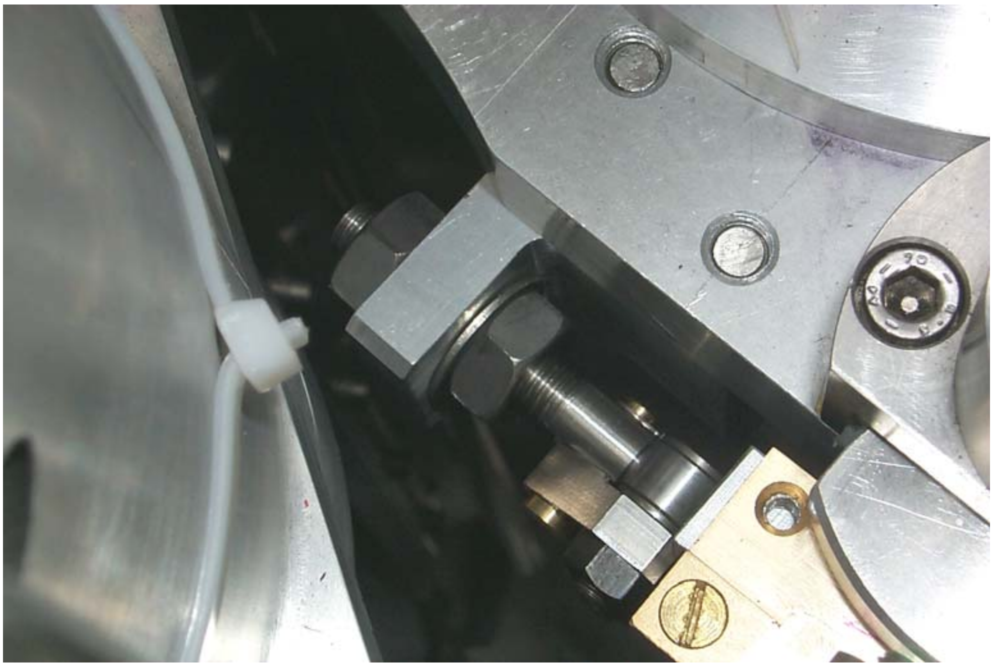
It was decided that to further stiffen the system, the linear bearings should be replaced by aluminium bronze bushes and that a thrust roller system should be designed to prevent the gears from jumping teeth as they travel up the legs. Here is the bush installed.



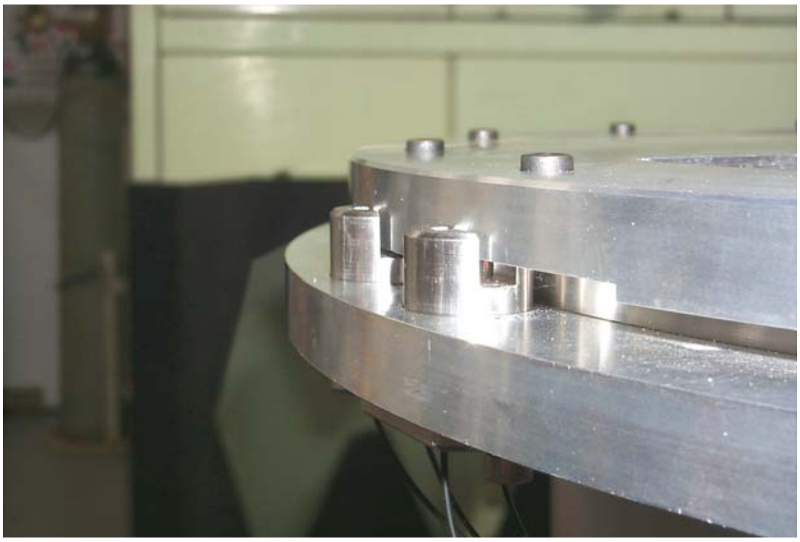
Here is a ProE model of the thrust roller.

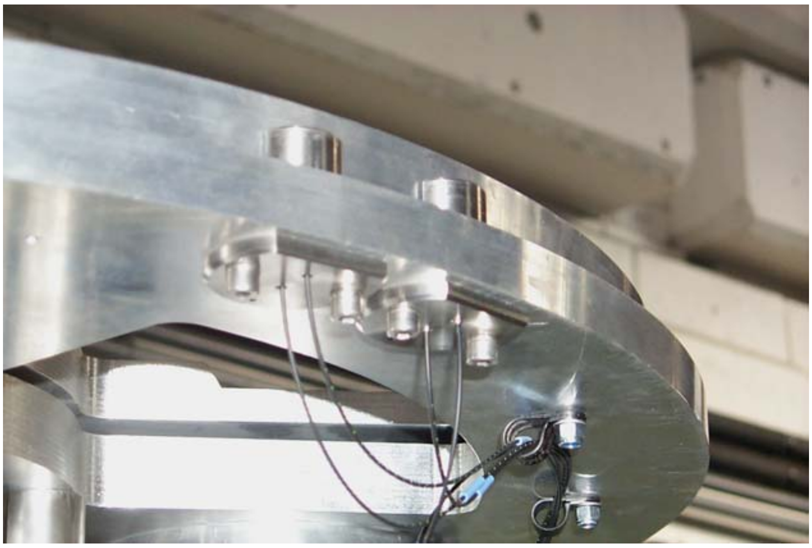


The placement of the roller is so that it can roll up and down a section of the j-pillars opposite the motor assembly, thus preventing the gear from leaving the rack.



With these modifications complete, the diagnostic components (fibre optics, optical strip reader) of the oscillating system could be installed and checked.





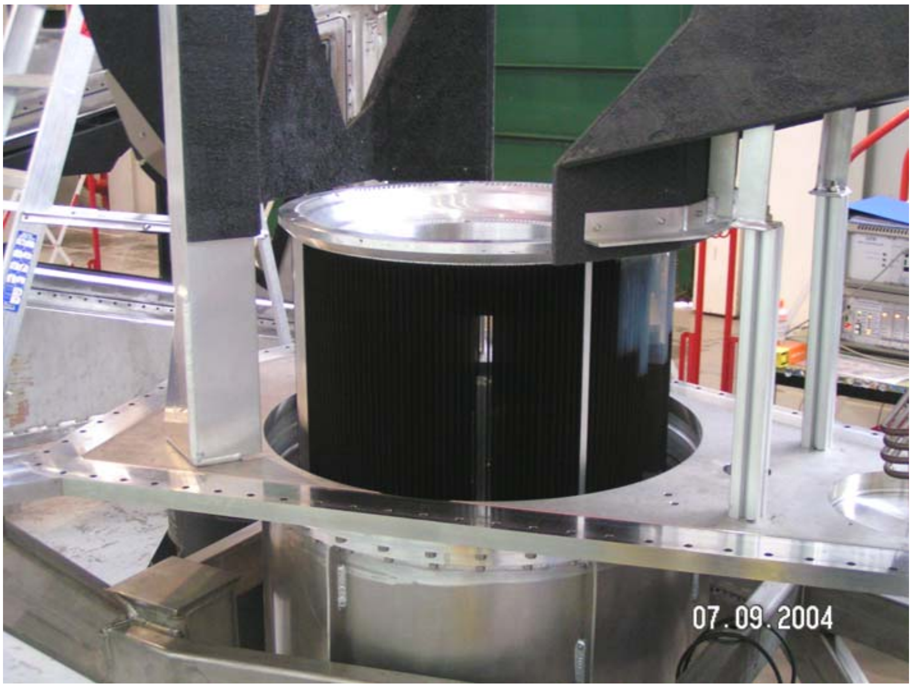
Above the fibre optic position sensors. Below the Renishaw strip reader.

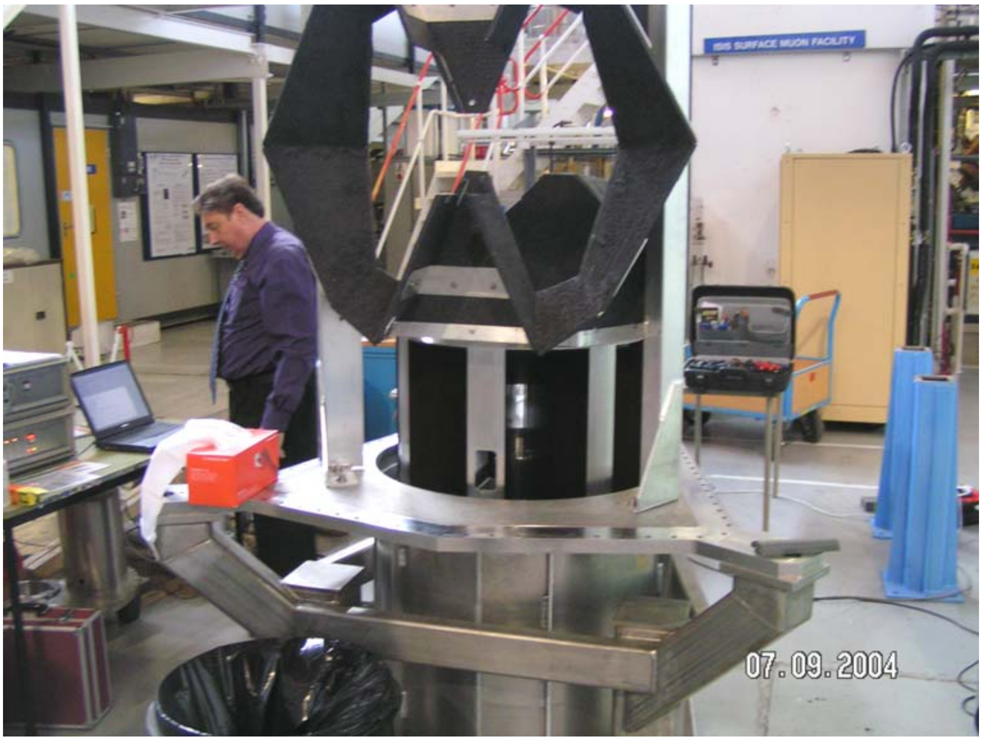
Finally work could begin on sorting the mass of wiring through the multi-jaeger can. Firstly the frame was lifted back onto the stilts.

Then the wires were soldered up to their correct connecters.

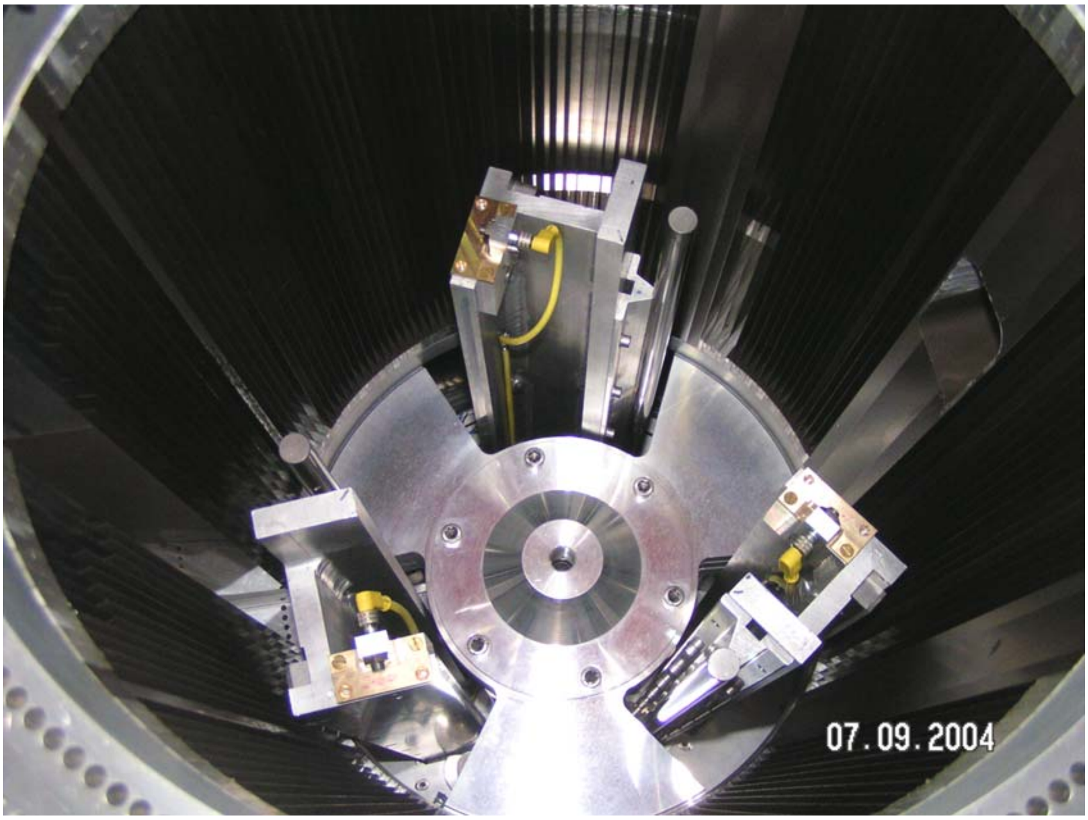
The system is now ready for vacuum testing before final installation. A few checks were carried out before the GEM tank went back on. Here it is in its top position with some of the B4C shielding reassembled.

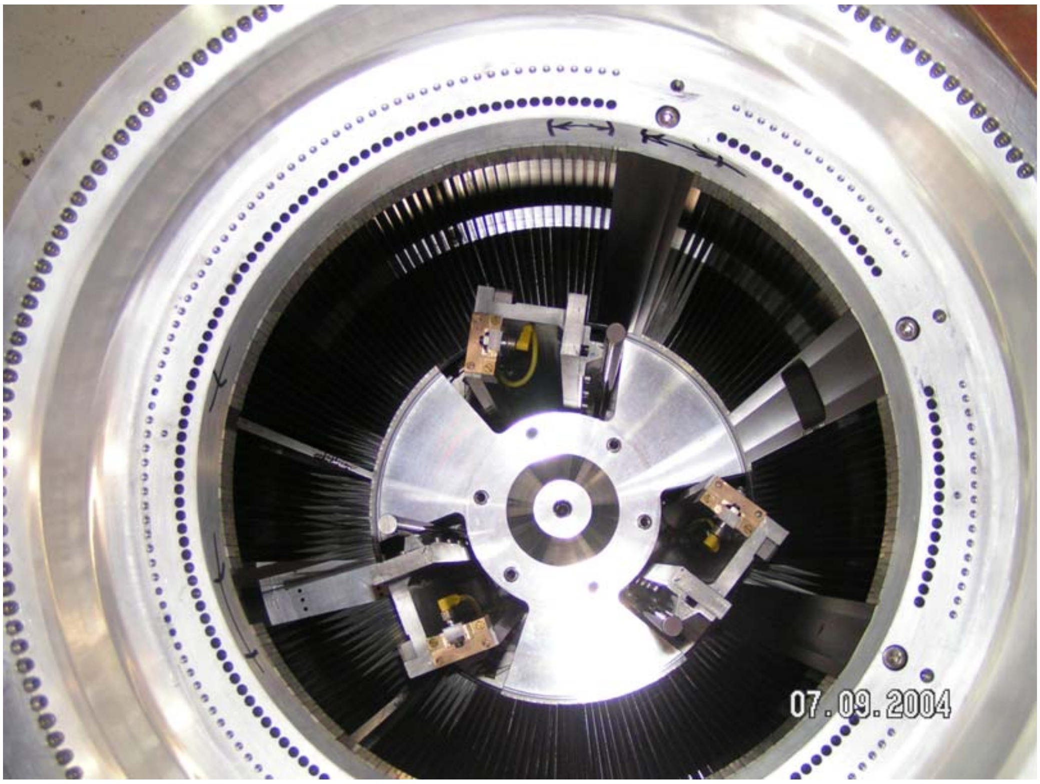
Now in its bottom position, which takes the ORC out of the beam scatter path.





Here we can see how the mechanism lowers itself over the j-pillars like in the 3d model shown previously. This also indicates how little room there was to play with for the initial design, almost no room for error.





The GEM tank was then reattached to the frame, this is a very tricky operation as there is virtually no room between the brittle B4C shielding and the tank.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Tank back on and the ORC lifting mechanism neatly inside ready for vacuum testing