# HGC Module Production Line Requirements

Updated February 2018

## Analysis

Based on CMS TOB/TEC module production experience, we estimate that HGC module production centers could sustain a rate of 21-24 modules per 8 hour day. The following is a brief overview of our analysis:

-HGC module size is roughly the same as an R-phi TOB module.

-There is one 8-inch sensor per module

-Copper/Tungsten base plate could be purchased with Kapton insulator already applied. This would be similar to the TOB frame.

-2 glue steps would be required, 1st gluing the sensors to the base plate and 2nd gluing the PCB to the sensor. To produce 21-24 modules a day, 21-24 baseplate to sensor glue steps and 21-24 sensor to PCS glue steps would need to be done per day.

-4 single modules will fit on an assembly plate in a .75m x .75m gantry.

-6 single modules would fit on an assembly plate in a 1m x 1m gantry.

-Assembly on the gantry should take ~3/4 hour.

- 7-8 assembly plates per 8h day (21-24 modules) seems reasonable on a 1m x 1m gantry. In this model 4 plates could be assembled in the morning with some time for initial set-up and 4 plates in the afternoon with some time for clean-up and maintenance afterward.

Using 247 work days per year, total module production would be 5187 to 5928/y. There would need to be some contingency added to this for equipment failures, maintenance, etc. but a careful analysis of potential failures and recovery times was done for the TOB assembly to assure deadtime would be minimal. TOB module production at UCSB took place in a period of 13 months with negligible deadtime.

With 4 major HGC module production centers for the high multiplicity module types (and possibly 1-2 small centers for the odd-shaped modules which are low multiplicity), all modules can be produced in one year if necessary. Note that even this 1 year schedule has contingency if one considers a slightly extended workday of 10 hours or working on weekends. For the construction of CDF and DZero silicon detectors for Run 2 of the Tevatron, a 10h workday was maintained by offsetting start and finish times of production line workers.

## Personnel

Assuming 21-14 modules/day is the gantry production rate, the next question is: How many FTE’s are required to carry out all of the other associated steps? The steps we considered, based on the TOB experience are: Receiving of components, surveying, wire bonding and rework, testing and rework, burn-in and thermal cycling, encapsulation to protect wirebonds and finally, shipment to cassette assembly centers. The estimated manpower needs are the following:

* 1 FTE (tech) for receiving, inspection, stocking of parts, who can also do the after-cure module surveys.
* 2 FTE (tech) for module assembly on the gantry. One person monitors the gantry while the other prepares for the next assembly plate.
* 2 FTE (tech) for wire bonding modules
* 1 FTE (tech) for testing, thermo-cycling, who supervises a team of about 3-5 students carrying out the testing
* 1 FTE (tech) for encapsulation and shipping
* 1.5 FTE (engr) for supervising technicians, students and overall production of modules.

This is a total of 7 FTE technicians and 1.5 FTE engineers during module production. This does not included grad and undergrad student support which will mainly be needed in the module testing area and is relatively low cost in the case of undergrads.

There would be a ~1.5-2 year research and development time for the full production and testing process that would include the production of mechanical grade modules, the first functional prototype modules, and preparation for a high throughput pre-production test. The R&D would be led by UCSB which will involve:

* 2 FTE engineers
* 1 FTE technician

## Space considerations

For CMS we used 120 m2 for module production. This was a bit tight. For HGC module production lines, it would be prudent to have more like 150 m2 for the modules production.

## Major Equipment and Tooling Needs

Basic equipment and tooling needs:

Aerotech 1 x 1m gantry system ~$150-$175k

Hesse BJ820 automatic wedge bonder w/45° bondhead ~230k[[1]](#footnote-1)

Royce 610 pull tester ~15k

Optical measurement device (OGP) ~110k

Small glue gantry for gluing protective covers (I&J2200) ~15k

Module assembly plates (12 minimum per center) ~2.5k ea

Wirebonder tooling (5 per site – assumes 2 bonders per site) ~5k ea

NB: 1-2 centers (doing odd-shaped modules with small multiplicities) would need of order 30 assembly plates in total.

Electronic test stands and thermal cycling equipment ~50k

Module shipping boxes (24modules/box, 12min per center) ~1k ea

## Electronic test stands and thermal cycling equipment

Test stand types and quantities are based on 8 inch, single sensor modules.

* PCB test and thermal cycle box and readout – capacity 4 PCBs
  + All PCBs are tested and thermal cycled before being qualified for use in modules.
* Single module test stands with full readout and laser diode array for stimulation of all channels (3 stands)
  + These are used to test modules just after manufacture to assure no damage occurs in module production. Modules are tested again before being installed on rods.
* Module test and thermal cycle box (“Wien box”) – capacity 10 modules
  + Initially, all modules were thermal cycled and tested continuously for 48 hours. This was cut back to 24 hours.

## Production center layout

The production center layout document (floorplan) shows the layout that UCSB will use for production, labeling equipment and rooms / zones. The floorplan does not need to be repeated exactly at other production centers, but serves as a guide for organizing floor space and grouping equipment by purpose and to create smooth workflow.

## Equipment details

The equipment details file contains more detailed information about the equipment needs for production centers. It includes information such as weights, footprints, model numbers, required software, and other details about equipment and equipment purposes.

1. \* Note: Hesse sells a few machines each year to research institutions for a reduced price of ~130k [↑](#footnote-ref-1)