An attempt to summarize the mechanical constraints for modules and stations of the OTR

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General considerations

To guarantee the position of all wires within one half station to the necessary accuracy by construction is essentially impossible. This accuracy has to be obtained by an alignment procedure using real data. Such an alignment program has the following requirements:
- the positions of the individual modules should not vary with time outside the required accuracy e.g. on time scales of less than about 1 month. Shorter term variations would else require an active alignment system which is a major complication and hard to realise.
- in order to keep the number of alignment constants small enough the wire positions within one module has to be guaranteed by construction to the final accuracy. This then leaves about 4 constants to be determined for each module.
- the position of a module in the x-y plane within one half station will have to be determined with data. Considering the size of the frames it is excluded to guarantee the position by construction to an accuracy of better than 100 microns. The mechanical constraints on the support structure should therefore be reduced to a 'reasonable' value of about 500 microns which would allow a good start of the alignment procedure.
- within one half station we have to prevent independent movements of modules along z. It is therefore proposed to couple all modules of one half station in z also near the height of the beamline. Ways to do that are discussed below. This will then allow only a common bend of the front surface in z which can be measured optically but also determined from data and described by few alignment constants. In addition this reduces the risk of short term variations of module positions. Note: the modules will never have enough rigidity to remain flat in z – we have to allow for bends outside the required accuracy. This is no problem unless this bends changes with time.

- half stations can be treated as independent. There is no need to align them by construction to better than 1 to 2 mm. – the support of the inner tracker has to be guaranteed by the OTR support structure. It makes no sense to build independent supports for the ITR.

OTR modules

1. The position of all wires in the direction perpendicular to the wires has to be guaranteed by construction. The position acccuracy in this direction relative to the support pins has to be $\leq$ 100 μm.
2. The position of all wires in a module along the beam (z) direction relative to a line connecting the two support pins on one surface of the module has to be fixed by construction to $\leq$ 300 μm.

This has the following consequences for the module production:

- The distance between straws has to be fixed over the whole length of the module to better than 100 micron by the jig.
- the twisters have to be well positioned and must guarantee this accuracy.
- The accuracy in z requires that the gluing surface of each panel during gluing of the straws has to be flat to better than about 300 microns over the length of one wire. This accuracy has to be transferred to the last step- the gluing of the two panels to one module.
- the distance between the two straw layers has to be guaranteed to better than 300 micron over the full length during the gluing of the two half modules.

Half stations:

1. the relative positions of modules in the x-y plane are not allowed to vary with time in x more than 70 microns, in y more than 400 microns.

2. It would be desirable to fix the relative position of the modules in x by construction to better than 500 micron over the width of the station.This looks reasonable– it would however be not dramatic if this accuracy would only be 1 mm.

3. we have to know the position of the wires in z to better than 500 micron, they are therefore also not allowed to vary by more than about 400 micron with time. It is not required that the modules are flat to this accuracy in z. Global bendig of modules is allowed and unavoidable because the modules have not enough bending strength and they will have internal stresses.

4. The maximum allowed global module bending is defined by the maximum accepted gas gain variation along the wires and by the maximum accepted sagitta of the wire (off-center position of the wire in z direction). Assuming that the latter should be less than 200 microns would restrict the maximum module bending to be less than 5 mm (for wire locator distances of about 80 cm) - a comfortable value.

This has the following consequences for the construction of half stations:

- the modules which end near the beam line have to be fixed in (x,y,z)

- It is proposed to fix all 4 layers of one half station in z relative to each other such that the relative distances of their front faces (or equivalent their absolute position in z relative to the front face of the half station) are known over the whole half station to better than 500 micron. A rough guess indicates that this can be acheived by coupling them at both ends via the support structure and only one additional coupling near the beam height. If this is not sufficient then more couplings in y can be forseen.

- the height (distance) between the upper and lower support bar of a half station has to be fixed to an accuracy of better than 400 micron independent of temperature.

- the inner tracker has to be supported using the support bars of the OTR. Any support structure for the ITR can then also be used to guarantee the distance between upper and lower support bar.

note: The only strict requirements exist for the wire positions inside one module. The requirements on a half station can be debated and should be done to an accuracy which is doable without very special and expensive measures. The numbers given above are estimates of what we think is doable. There would be no cathastrophy if we would relax them somewhat.

Possible solution for the construction of a half station:
The principle requirements as outlined above could be realised in the following way:
The half station is covered by one large honeycomb plate of sufficient stiffness (height about 2.5 cm) over the full area including the area of the ITR sensors. In principle one could reduce the area by using a plate of only about 1.5 m at the beam line but there is no real reason to do so. This plate serves several purposes:
1) it guarantees the distance of upper to lower support bar of the half station
2) it allows to fix the half modules at their free ends
3) it serves as a surface plane which is used to align and fix all modules of a station in z.
4) it supports the ITR and its infrastructure (cables, cooling,..)

The support honeycomb plate could in principle be replaced by a support structure for the ITR using at least two thick vertical carbon fibre bars locally which are supported from the horizontal support bars of the OTR. Such a solution is used for HERAB. These bars could serve as a reference to fix the half modules and they would also guarantee the distance of the support bars. The main question here is how dead material should be distributed-homogeneously or in lumps. The plate might be easier to realise and serves all purposes.
Additional thickness is unavoidable , the plate will only add something like 0.3% of a radiation length per station – this is certainly tolerable, every other solution will add similar amounts but in a less well defined way.