Science & Technology Facilities Council

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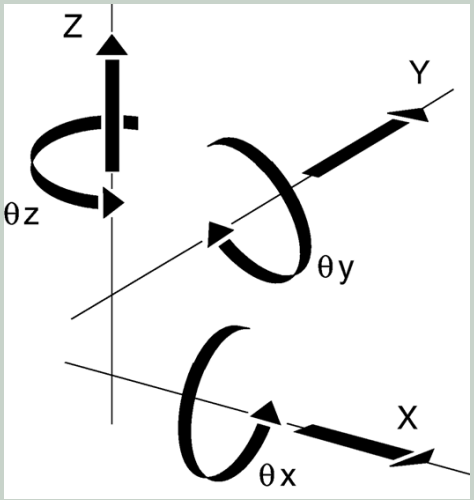
FETS meeting

12th January 2011

CMM Measurement Plan

by Peter Savage

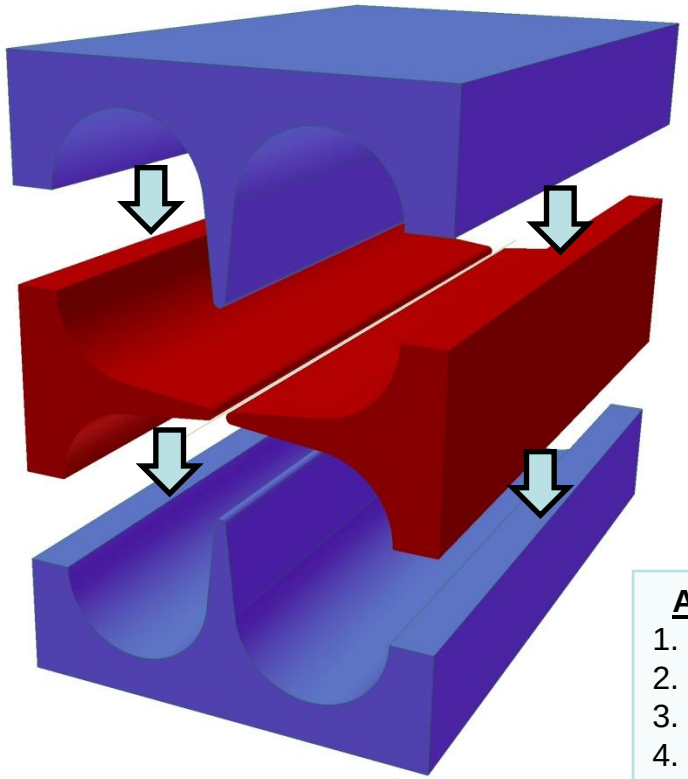


Why measure the RFQ components?

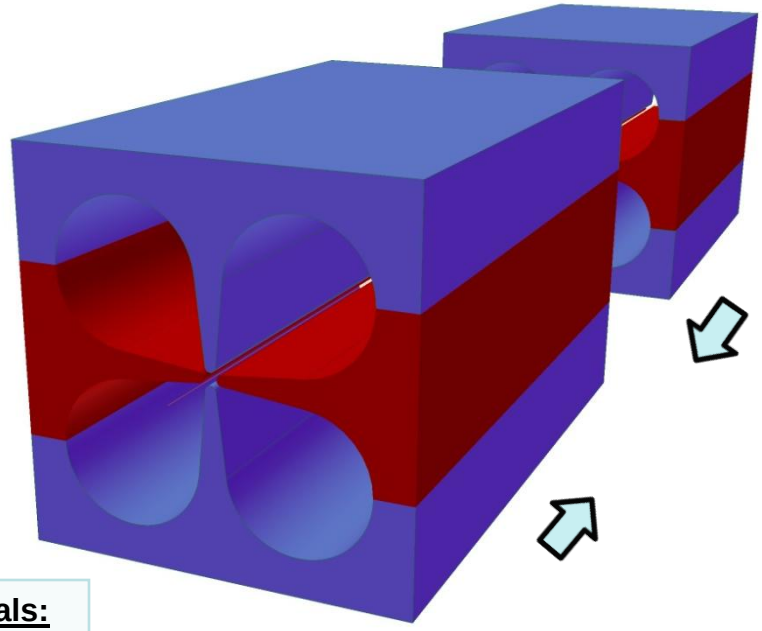
- We will need to measure the manufactured RFQ components to make sure that they will perform to the designed specification.
- FEA modelling has shown the sensitivity of the performance to the size and shape of the structure.
- Need to measure the individual parts and the assembled structure to assess the effect of cumulative errors.
- Need a sensible set of measurements that tells us enough about the components without flooding us with data.
- Acts as check on movements due to joining process (if heat is involved).
- Allows us to develop the system ready for use on the real RFQ.

RFQ assembly interfaces

2 major vanes (blue) +
2 minor vanes (red) to make one 1m section



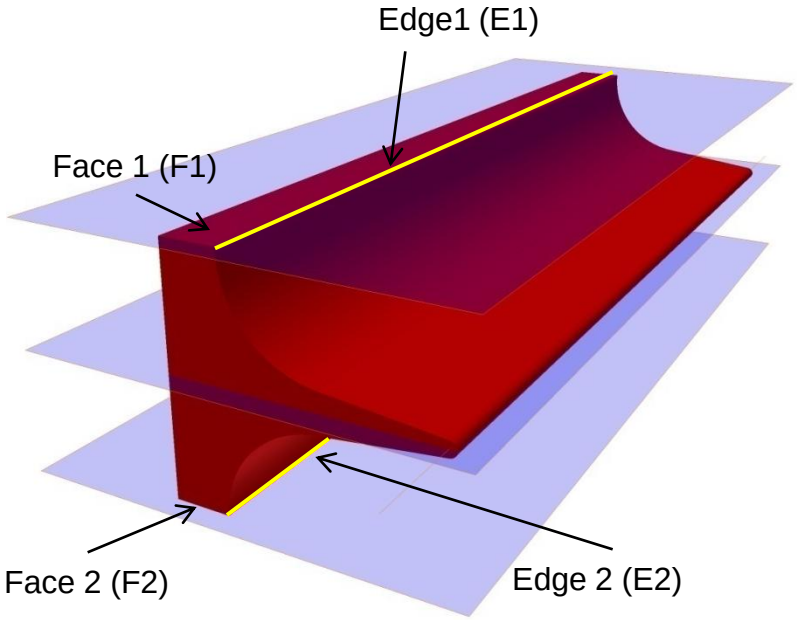
Section to section assembly

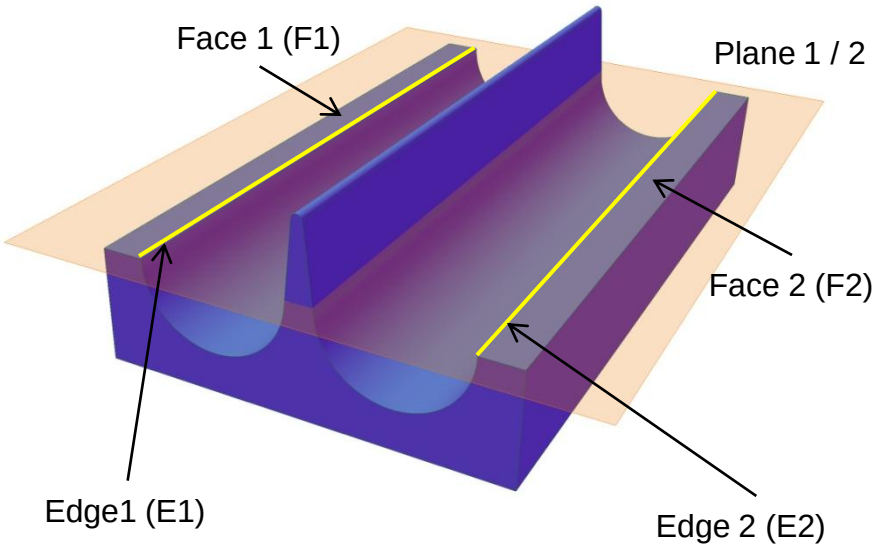


Assembly goals:

1. Vacuum seal
2. RF seal
3. High Q value
4. Alignment
5. Dismantle

Alignment





Minor vane machining tolerances

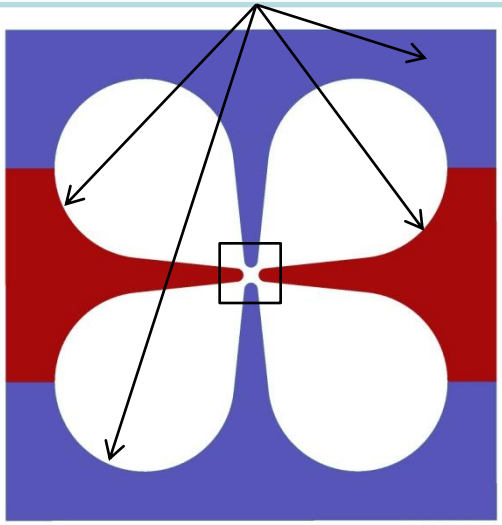
Property	Where?	Tolerance
Planarity	Face 1 & Face 2	+/- 0.01mm
Parallelism	Face 1 to face 2	+/- 0.01mm
Dimension	Between Face 1 & Face 2	+/- 0.01mm
Dimension	Vane tip radius (R)	+/- 0.01mm
Dimension	Vane tip centre of R from F1 or F2	+/- 0.01mm
Dimension	Vane tip centre of R from E1 or E2	+/- 0.02mm

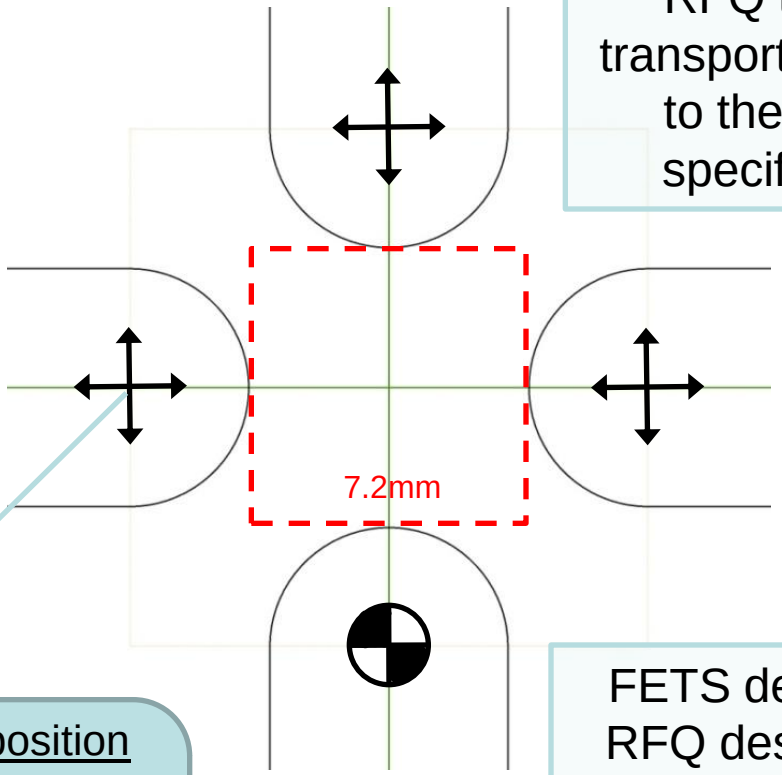
Major vane machining tolerances

Property	Where?	Tolerance
Coplanarity	Face 1 & Face 2	+/- 0.01mm
Dimension	Vane tip radius (R)	+/- 0.01mm
Dimension	Vane tip centre of R from P1 / 2	+/- 0.01mm
Dimension	Vane tip centre of R from E1	+/- 0.02mm
Dimension	Vane tip centre of R from E2	+/- 0.02mm

Alignment

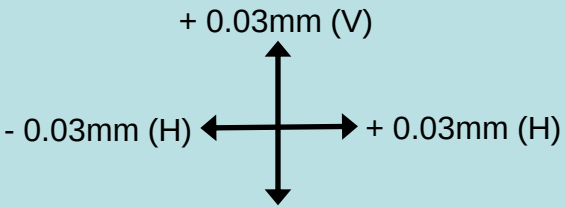
Bringing those high tolerance machined parts together....





.....to produce an RFQ that will transport the beam to the design specification.

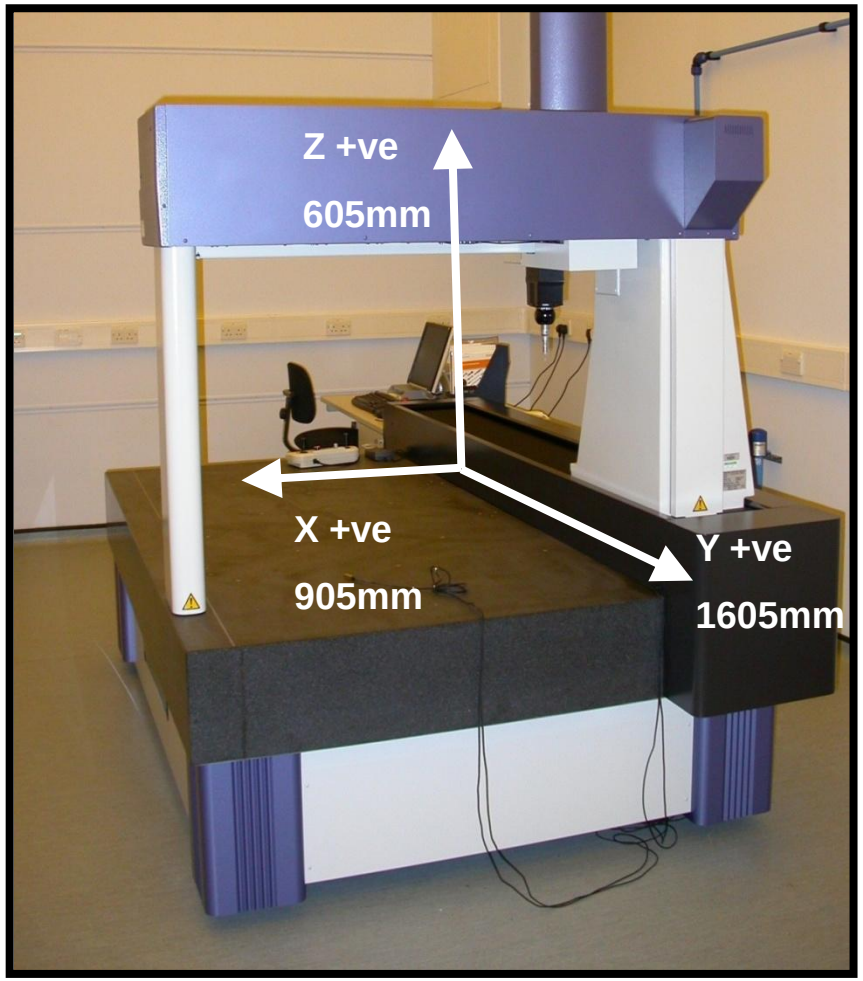
Vane tip centre of radius position



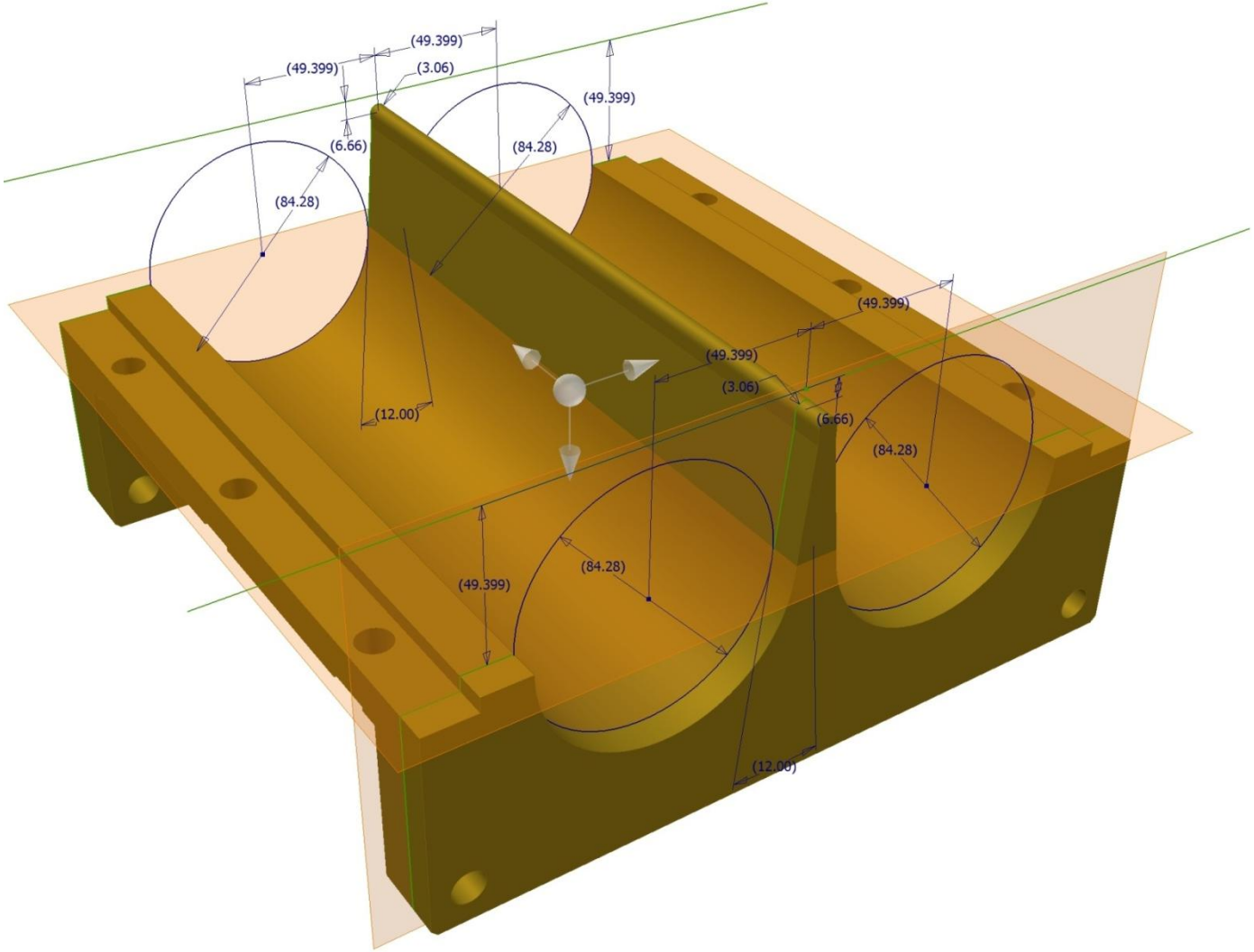
Estimated values

FETS developed RFQ design path will allow us to feed in real displacement data to see effect on particle tracking.

Mitutoyo CRYSTA APEX C9166
Coordinate-Measuring Machine (CMM) at Imperial College

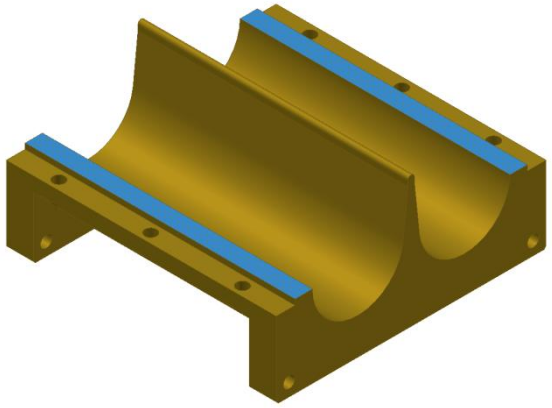


We know what dimensions we need....



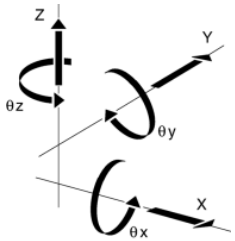
.... and we can simulate the performance effect due to deviations from the target dimensions

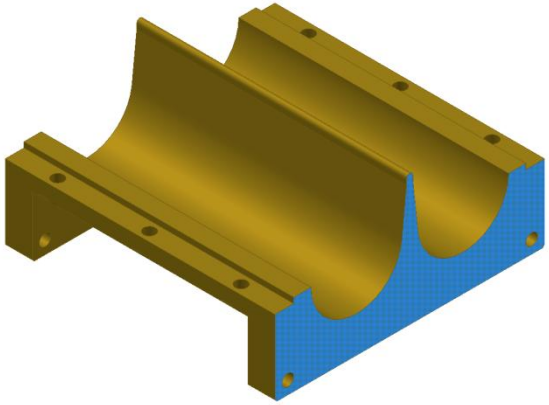
First step: aligning coordinate system to work-piece. 3 measurements are required



Measurement **1**: Interface plane XY

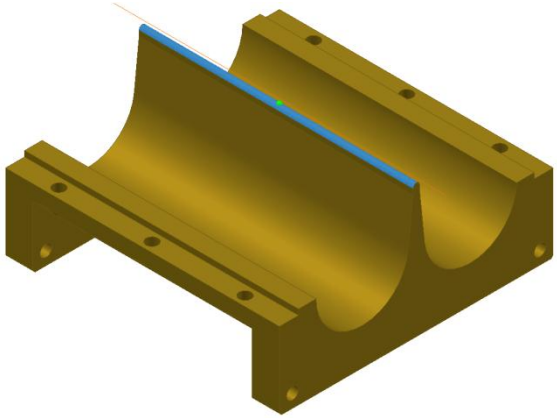
Why here?
Because this is where vanes are joined. The vane tip location is important relative to this plane.





Measurement **2** : End plane YZ

Why here?
Because this is where the RFQ sections join to each other. The beam axis must lie perpendicular to this face



Measurement **3**: Beam axis

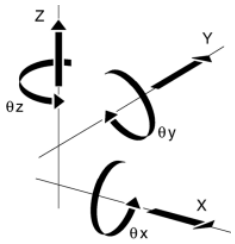
How?
Measure vane tip radius at one end to define vane tip radius centre. Offset (perpendicular to Interface plane XY) by 6.66mm

Why here?
We need to check the location of the quadrant radii relative to the beam axis.

Aligning coordinate system to work-piece. - quick check

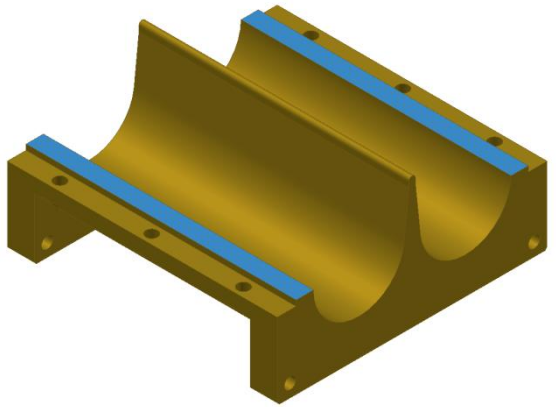
C = constrained		Degrees of freedom					
		Linear movement			Rotation		
Measurement	Type	X	Y	Z	θX	θY	θZ
1	Interface plane XY			C	C	C	
2	End plane YZ	C				C	C
3	Beam axis		C			C	C

When the coordinate system alignment is complete all six degrees of freedom should be constrained.



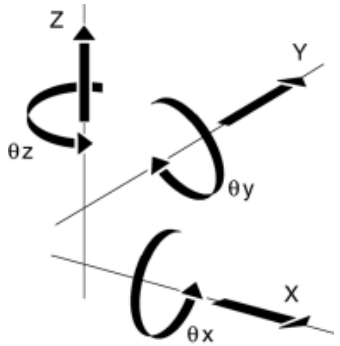
Features to be measured

1. **Vane to vane interfaces**
    1. Planarity



2. **Section to section end faces**
    1. Planarity (individually at either end)
    2. Parallelism between ends
    3. Distance between ends
    4. Perpendicularity to vane to vane interfaces

3. **Vane tip**
    1. Radius (3 places along length)
    2. (Provides) centre of radius at those 3 places (creates a vane tip axis)
    3. Parallelism of vane tip axis to vane to vane interface
    4. Perpendicularity of vane tip axis to end face (part of measurement 2.4)
    5. Distance to vane tip axis from vane to vane interface



4. **Quadrant radii**
    1. Radius (3 locations along length) on each side of vane
    2. (Provides) centre of radius at those 3 locations (creates a cylinder axis)
    3. Parallelism of cylinder axis to vane to vane interface
    4. Perpendicularity of vane tip axis to end face (part of measurement 2.4)
    5. Location of cylinder axis w.r.t. beam axis

What to do next?

- Phil to speak to RAL inspection people?
- Finish measurement plan. Really could benefit from first measurement pass to see whether the measurements are useful / meaningful.
- Include plan for minor vane – very similar.
- Work-pieces to be labelled so that measurements can be repeated.
- Measurements must be repeatable once components are assembled – access will be restricted.