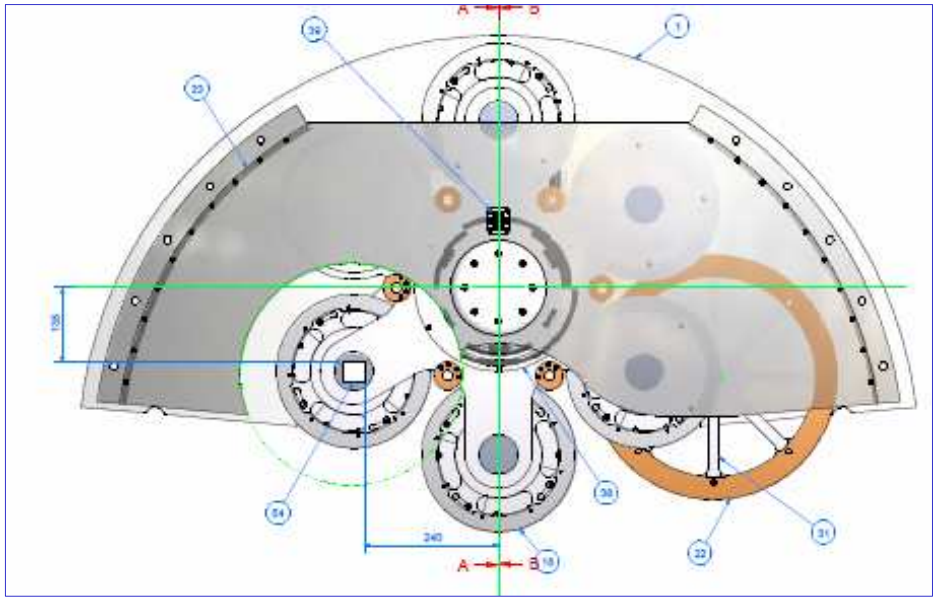
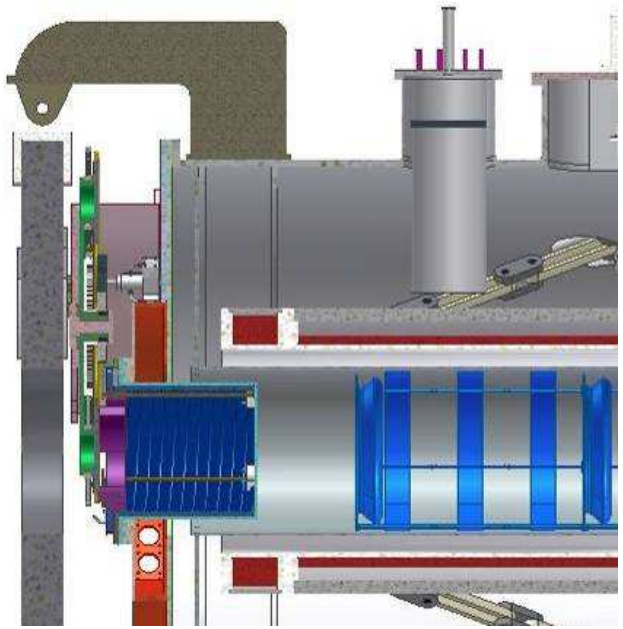
THE DIFFUSER

- **The Progress**
- **The Problems**
- **The Proposal**

DIFFUSER

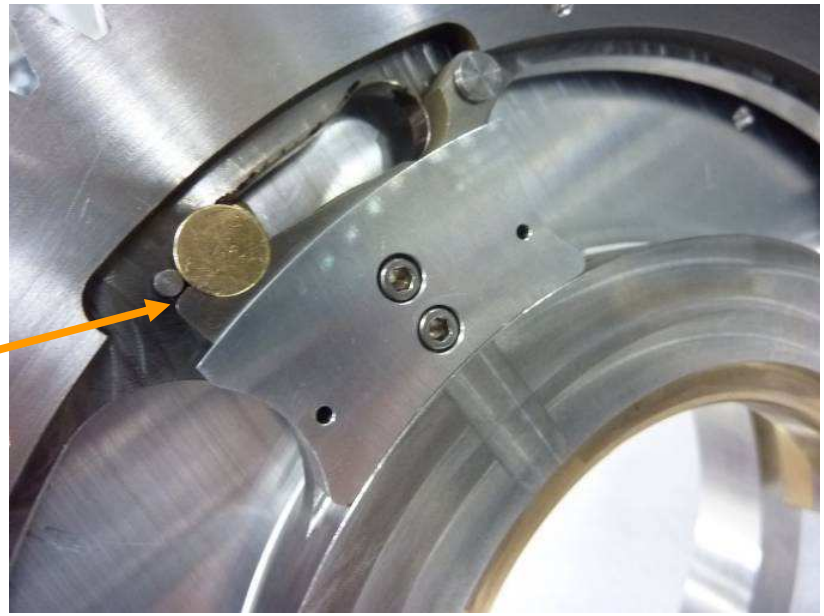




- **Lead discs carried on *Disc holders* on a five-armed *Carousel***
- **Selected disc transferred to or from *Carrier* and carried into solenoid bore**
- **Magnetic field precludes many normal engineering components**
- **Driven by three *air motors***
- **Space is very limited – must fit in ~20cm or less**

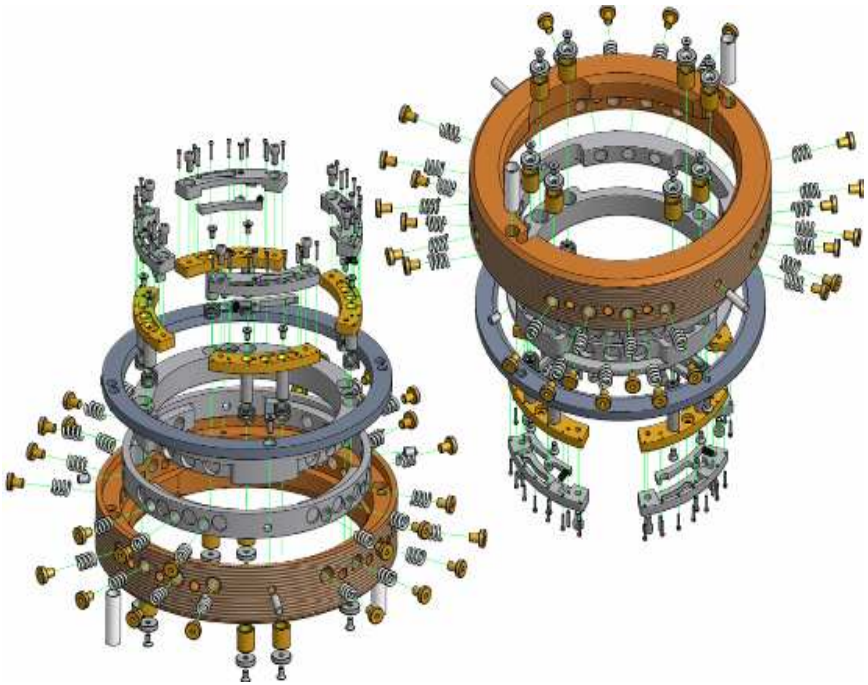
PROGRESS SINCE CM26

- **Design modifications made, in particular:**
  - **New *disc-holders* in SS**
  - **New *pins* for the discs**
  - **Locking catches for discs**



  - ***Floating carrier front plate* to accommodate misalignments**

FLOATING CARRIER FRONT PLATES

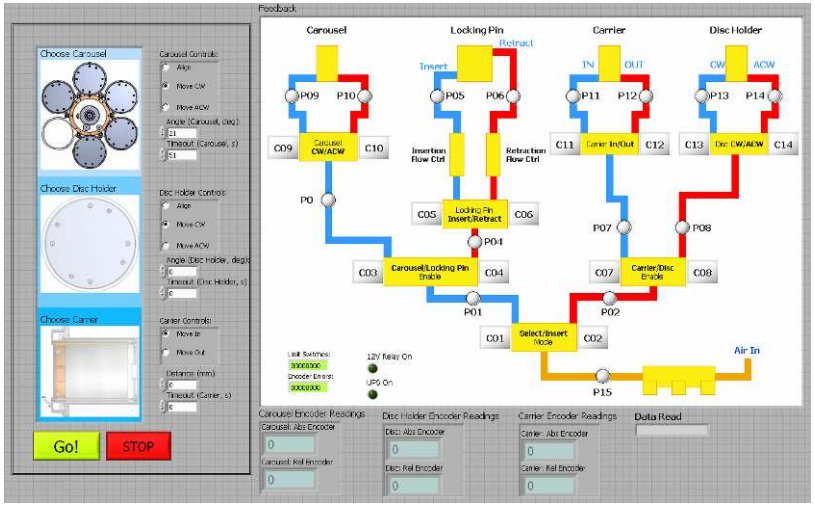


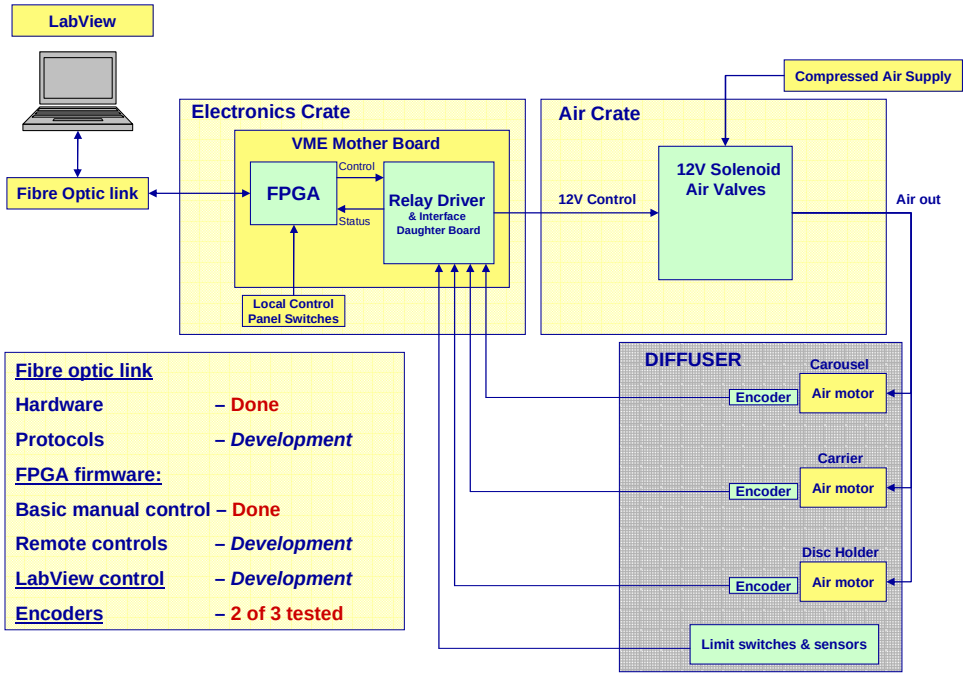
(about) 40 springs allow Left/Right, Up/Down & Fore/Aft floats of 0.5 – 1mm to accommodate alignment errors between disc-holders & carrier

Works on bench – nice piece of engineering

CONTROLS

- **FPGA in *electronics crate* controls air motors via valves in *air crate* and receives signals from encoders and microswitches**
- **FPGA controlled by LabView**
- **Air & electronics crates complete**
- **Firmware and software being developed**
  - **Versions exist for tests**





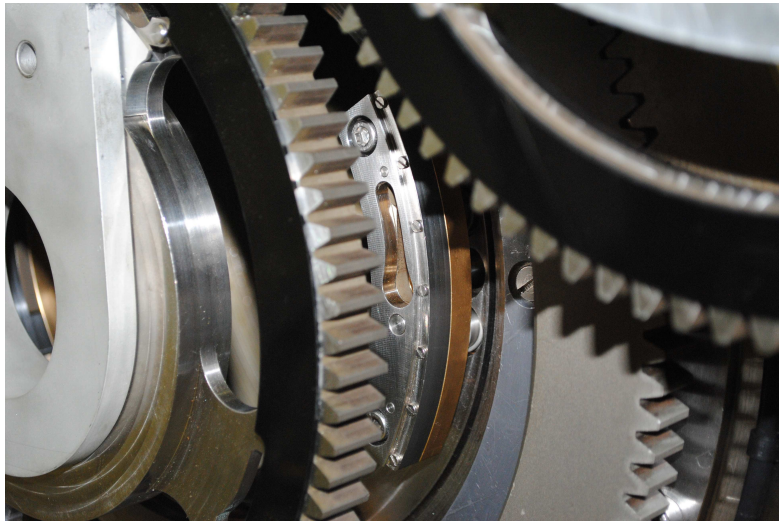
Fibre optic link

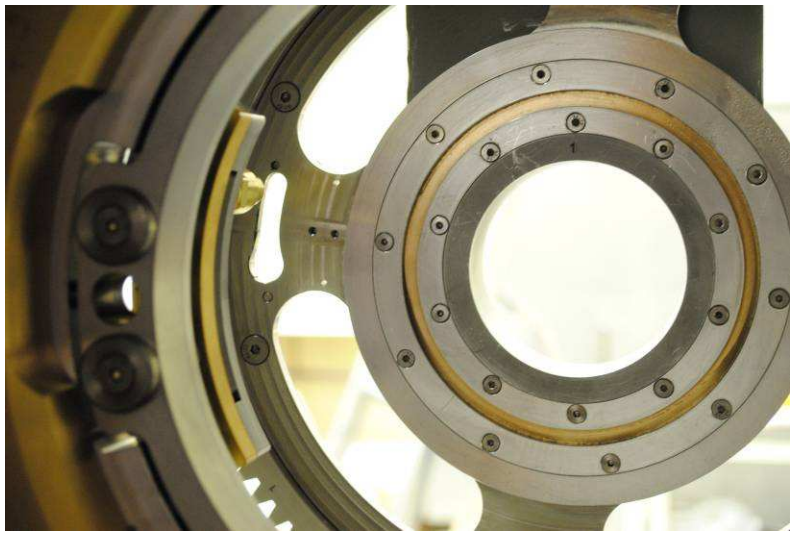
Hardware	– Done
Protocols	– *Development*

FPGA firmware:

Basic manual control	– Done
Remote controls	– *Development*
LabView control	– *Development*
Encoders	– 2 of 3 tested

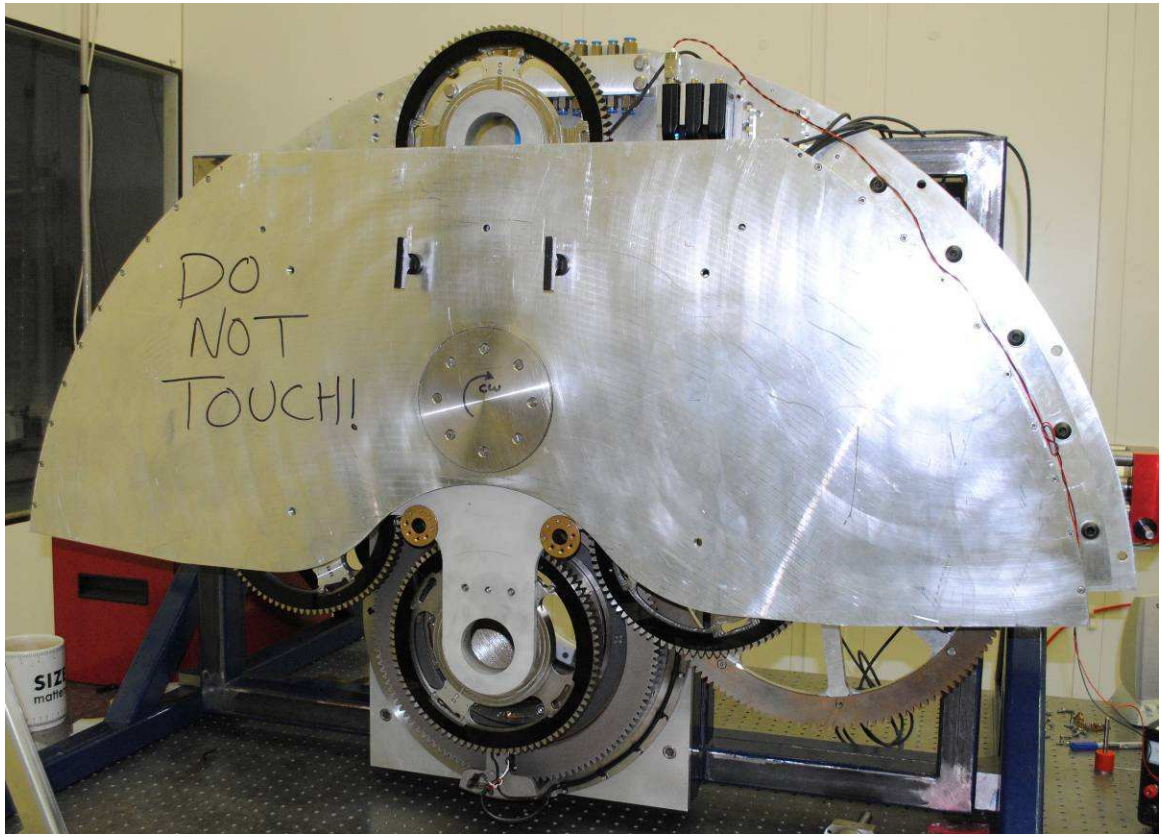
REASSEMBLY – END OF MAY



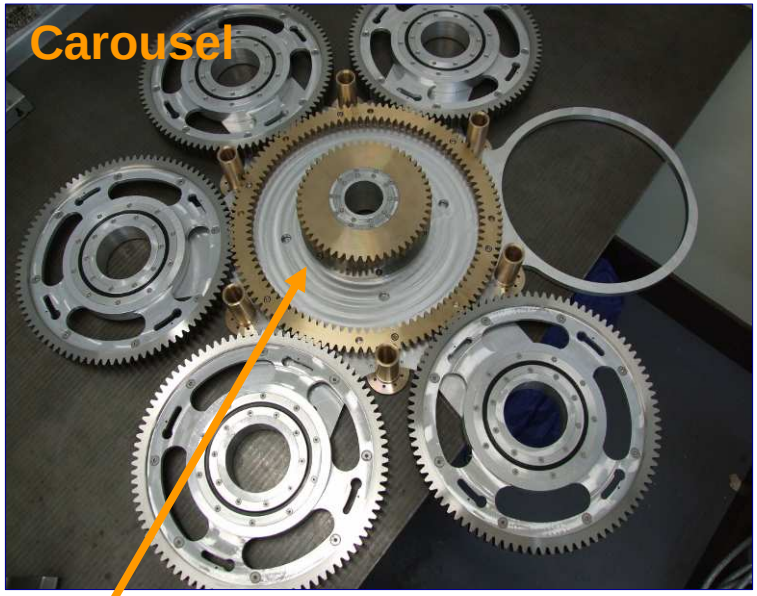


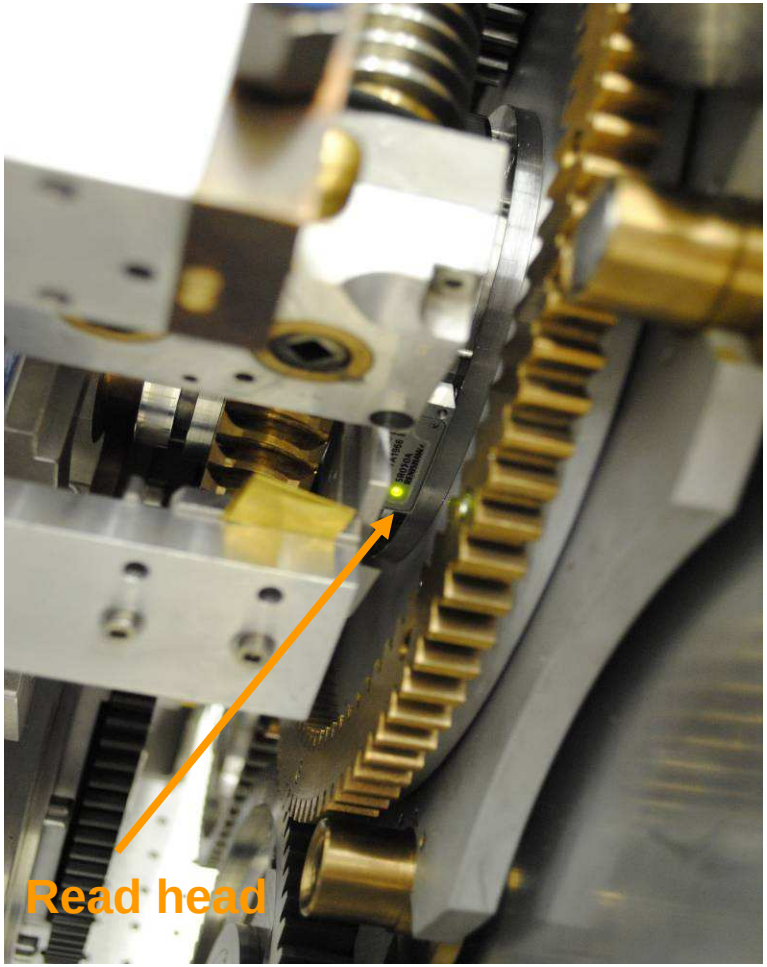
- **Beginning of June:**

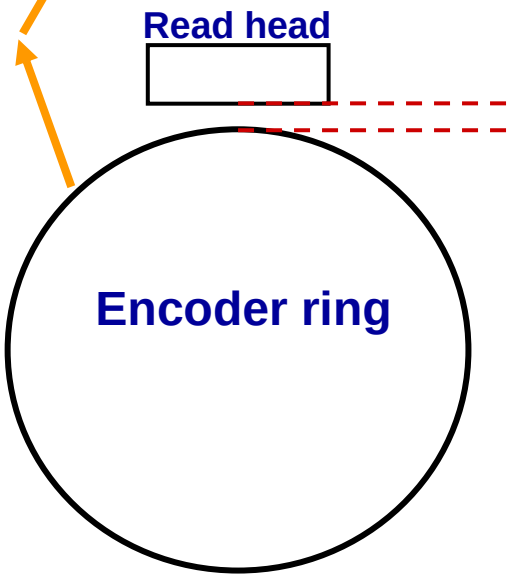
  Started to test the ability to drive the carousel and disc-holders to the correct positions



- **Accurate alignment of disc-holders with carrier is crucial to allow transfer of disc**
- **Controlled by high-precision shaft-encoders**
  - ***Require fractional mm alignment themselves***
  - **Difficult to access**
    - **Buried inside mechanism ➔**







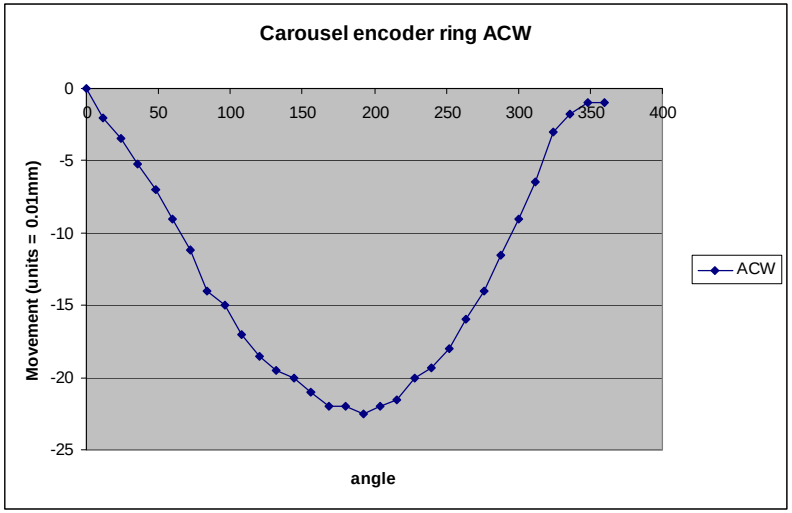
Ride height =
0.8 +/- 0.08 mm

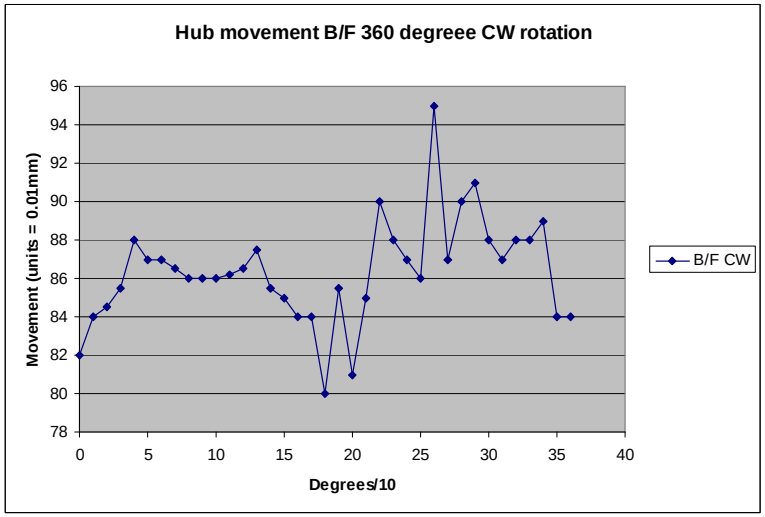
Pitch, roll, yaw
0.0 +/- 0.5 degrees

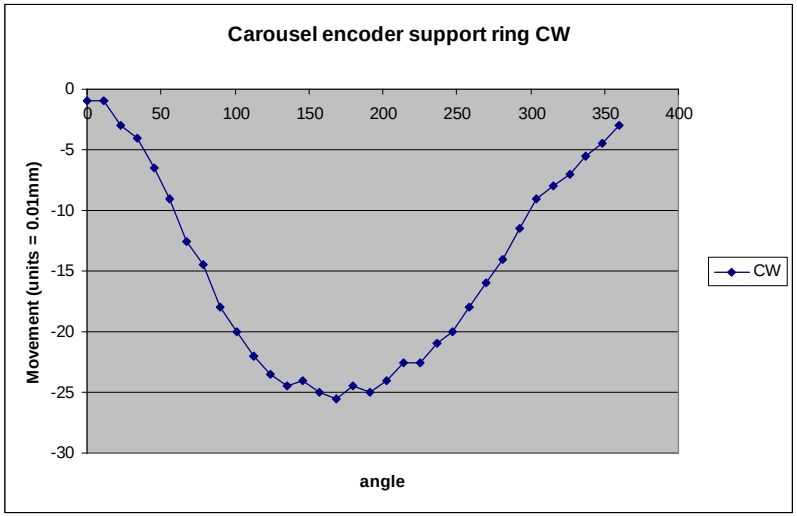
THE PROBLEMS (1.i)

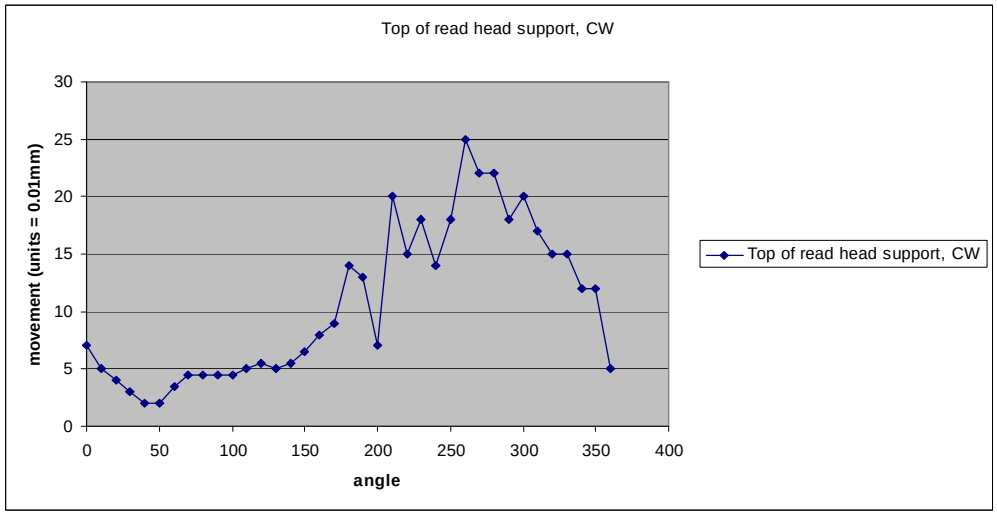
- **Proved impossible to get stable signals from encoders**
  - **Obtained software from Renishaw (mfrs) giving signal size**
    - **Signal varies from < 30 % to > 100% of acceptable**
    - **Signal depends on position of carousel and movement**
  - **Made series of measurements at various places**
    - ***Hard to get to where we really want to measure***

SOME MEASUREMENTS









Components move by ~250 microns during one rotation of Carousel – too much

THE PROBLEMS (1.ii)

- **Movements of 0 – 0.25 mm during 360 degree rotation**
  - **Compare with +/– 80 microns in encoder spec.**
  - **Also some visible roll >> 0.5 degreees**

- **Carousel is unbalanced load**
  - **Whole assembly flexes**
    - **Significant forces (~500N) generated during rotation**
  - **Central 'shaft' not running true**
    - **Actually several pieces**
      - **Independent support each end**
      - **'Hub' on front plate & 'Inner hub' supported by drum**
        - » **Not tied together – unit comprises two pieces**

THE PROBLEMS (2)

- **Tried Disc-Transfer by hand**
  - **Floating plate tends to jam**
    - **Some misalignment forces pins outwards (??)**
      - **Possibly fixable by modifying pin profiles (??)**
  - **Carousel arms flex by ~1.5 mm when compressing springs of floating plate on carrier**
    - **Quite moderate force (few x 10N)**
    - **Much too much flex**
    - **Flexing of arms changes encoder signals !**
- **Too add to our woes…**
  - **Vital pin in carrier came loose**
    - ***Would require complete strip-down & rebuild to fix***
      - ***2 weeks for that!***
- **Moderate despair….**

POSSIBLE SOLUTIONS

- **Strengthen mechanics**
  - **But space very limited**
  - **One (~30mm) SS shaft for Carousel &c.**
  - **Beef-up Carousel**
    - **Use disc rather than 'pentapus'**
    - **Little (~2mm) space to make it thicker**
    - ***How thick is thick enough?***
    - ***What material ?***
  - **Would still be difficult to align the encoders**
    - **Space limited**
    - **Access difficult**
- **Some ground-up re-design needed**
  - ***Not guaranteed to work***
  - ***A lot of time, £££ and effort***

OTHER CONSIDERATIONS

- Current design could (perhaps) be made to work in lab
  - Critical alignments < = 0.1mm
- Would have to repeat on Spectr. Solenoid eventually
  - Magnetic or quench forces could upset alignments
- Magnetic field
  - Unknown risks
    - Behaviour of components in fringe field unknown
      - Even with SS there will be some magnetic forces
      - There are a few unavoidable small ferromagnetic components
      - Cannot guarantee (e.g.) that encoders would work
- *Current design not converging*
  - *Haven't passed first base*
- Need a Plan B
  - Head scratching (*Why are we doing it like this?)*
  - 'Plan T' (Tacon & Tunnell)

PLAN T

Q. What do we really want to do ?

A. Place *up to ~ 3 X_0* of dense material in beam to cover a diameter of *up to 300mm* depending on ε, p

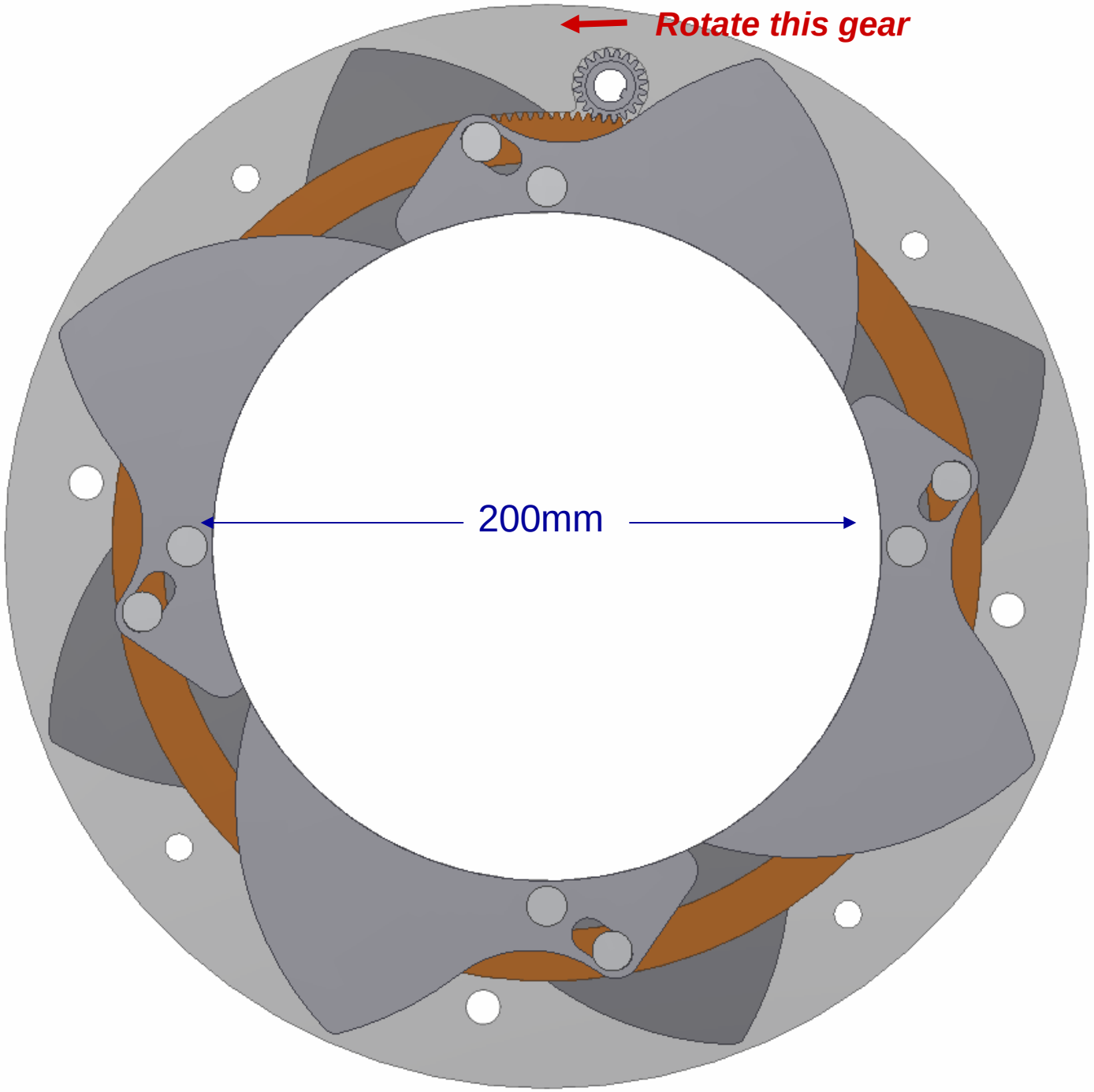
Do this as simply and reliably as possible

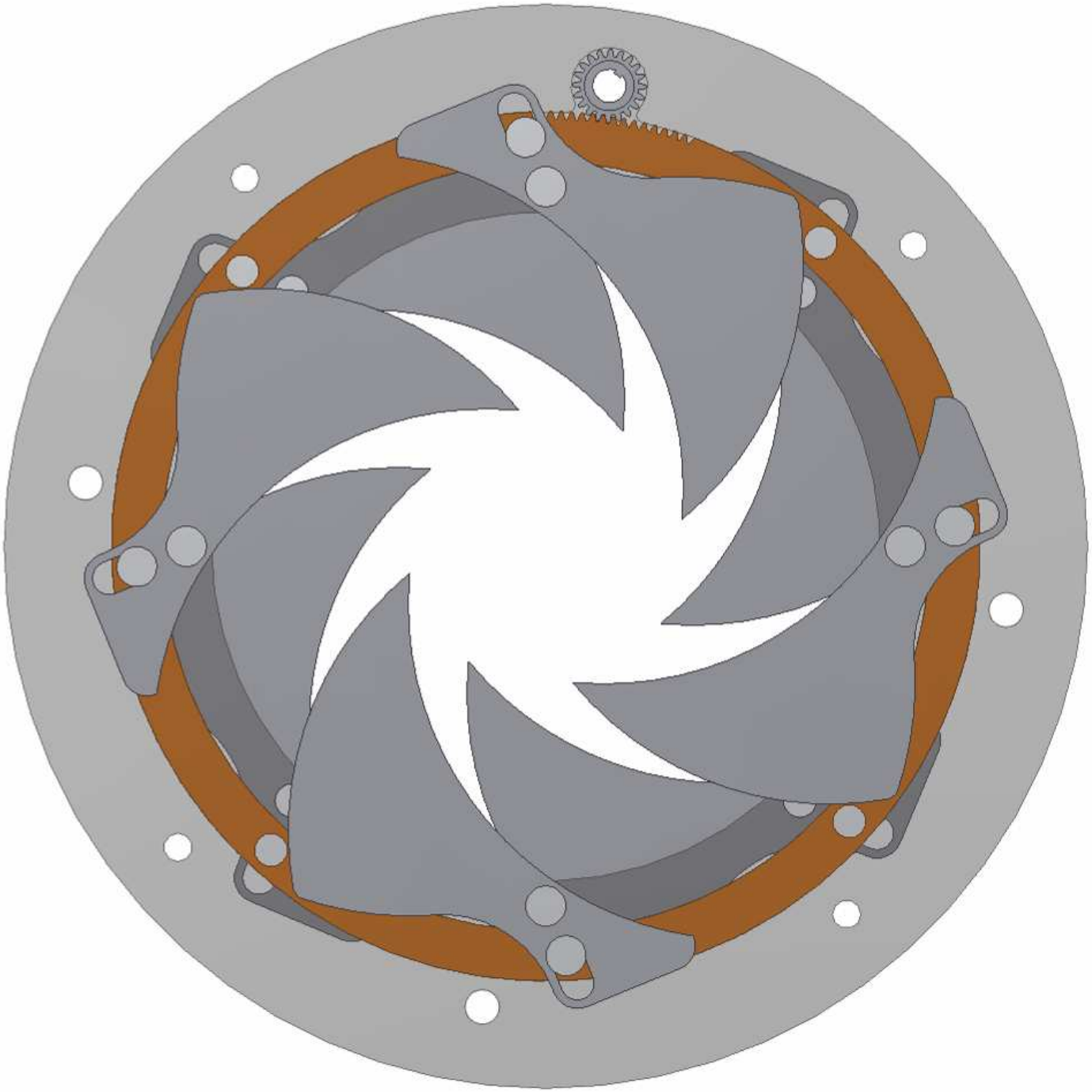
No need for complicated machinery – better without it

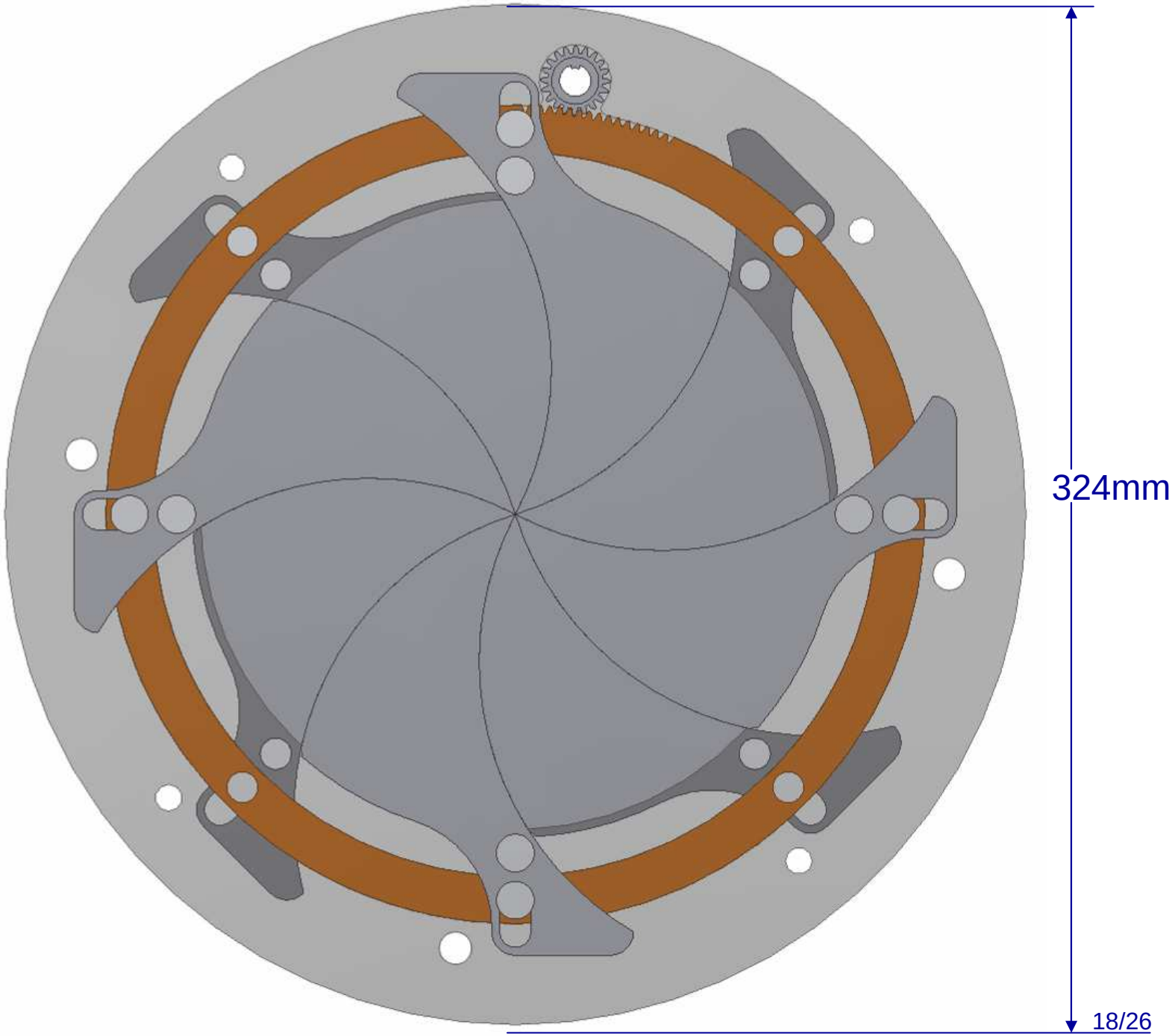
➔ **Use simple iris, or set of irises**

Suggested by J. Tacon ~ 2 weeks ago

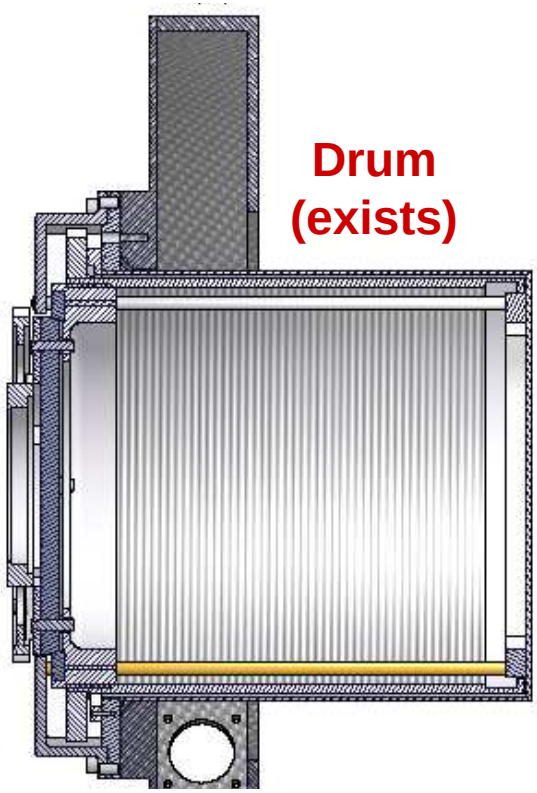
(also C. Tunnell)


Rotate this gear
200mm

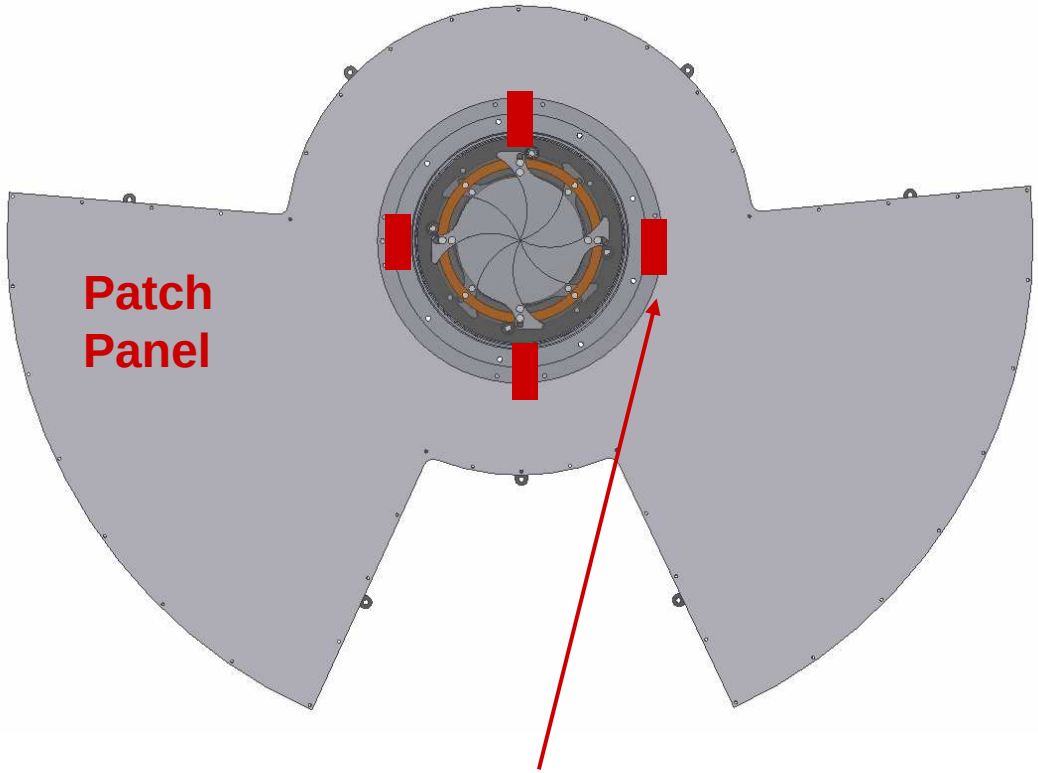




CM27



Drum
(exists)

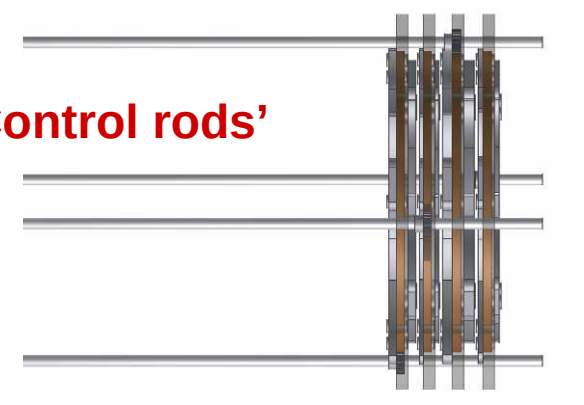


Patch
Panel

Pneumatic actuators (4)

Details being worked out

Must be non-magnetic



4 'Control rods'

4 Irises

4 Irises:

Double-sided with 4 petals / side
(max is 6 /side)

16 combinations of thickness

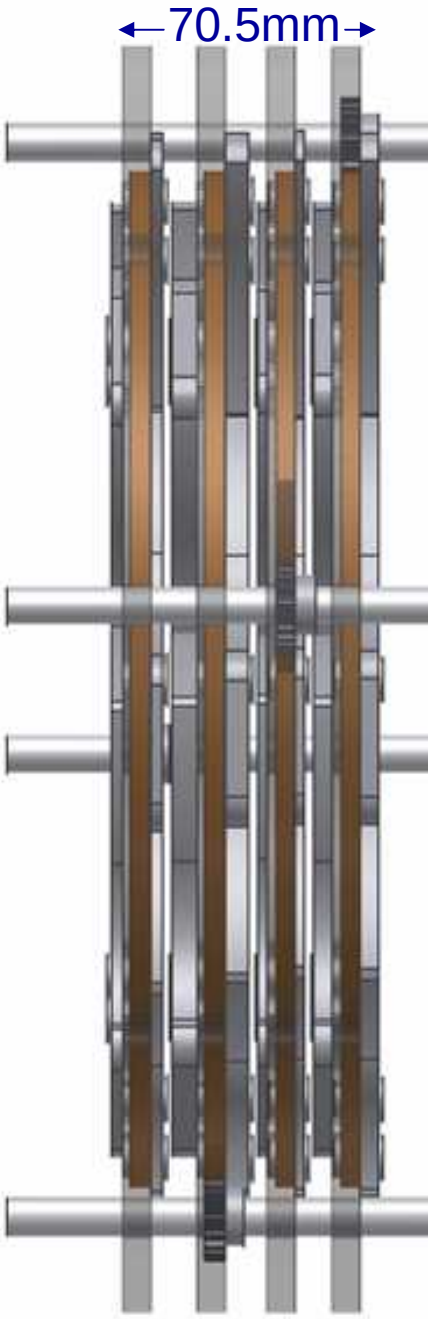
Provisionally (needs bit of work):

3.14 mm SS
6.28 mm SS
2.35 mm tungsten
4.70 mm tungsten (or SS/Pb/SS sandwich)
Total of 2.7 X_0 in 15 steps of 0.18 X_0

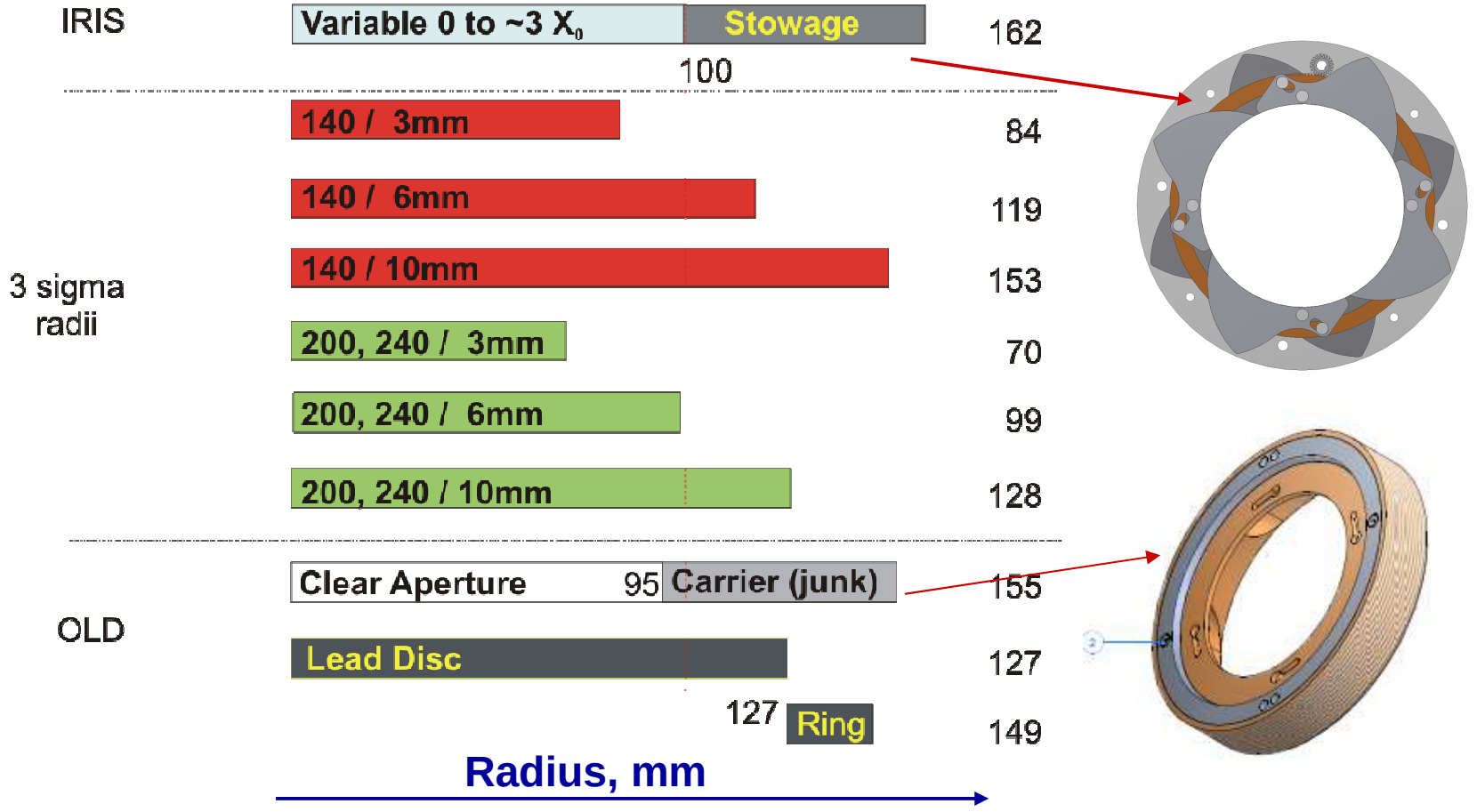
Operated by rotating 4 'control rods' 120 degrees

Will fit in existing 'Drum'

Somewhat longer than old version but initial MC says OK



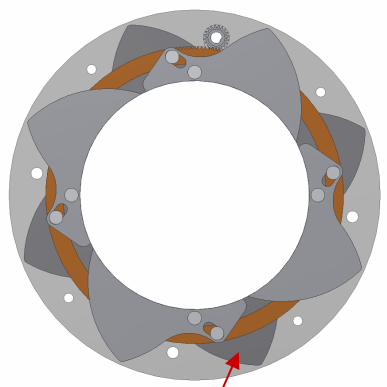
APERTURES & BEAM RADII



Increasing variable area ➔ more petals ➔ 3 or 4 layers per iris – may be possible but would make it longer by 50 – 100 %

LONGITUDINAL MATERIAL BUDGET

Emittance (mm)	Momentum (MeV/c)	Thickness required (X0)	3 sigma radius (mm)	Setting	In Aperture	Outside r = 100 mm	Outside + Supports
					(Radiation Lengths)		
				0	0	1.73	3.72
				1	0.18	1.62	3.60
				2	0.36	1.50	3.49
				3	0.54	1.38	3.37
				4	0.72	1.27	3.26
6	**140**	**0.88**	**119**	**5**	**0.9**	1.15	**3.14**
				6	1.08	1.04	3.03
				7	1.26	0.92	2.91
				8	1.44	0.81	2.80
10	**140**	**1.66**	**153**	**9**	**1.62**	0.69	**2.68**
				10	1.8	0.58	2.57
				11	1.98	0.46	2.45
				12	2.16	0.35	2.33
				13	2.34	0.23	2.22
				14	2.52	0.12	2.10
10	**200 & 240**	**2.71**	**128**	**15**	**2.7**	0.00	**1.99**



Last column = Average material outside r = 100mm aperture
= Average over area of retracted petals
+ 5 x 7mm SS supports (to check)

Not obviously worse than old design – which was accumulating various bits of junk on Carrier, r > 95mm

WHAT WOULD IT TAKE ?

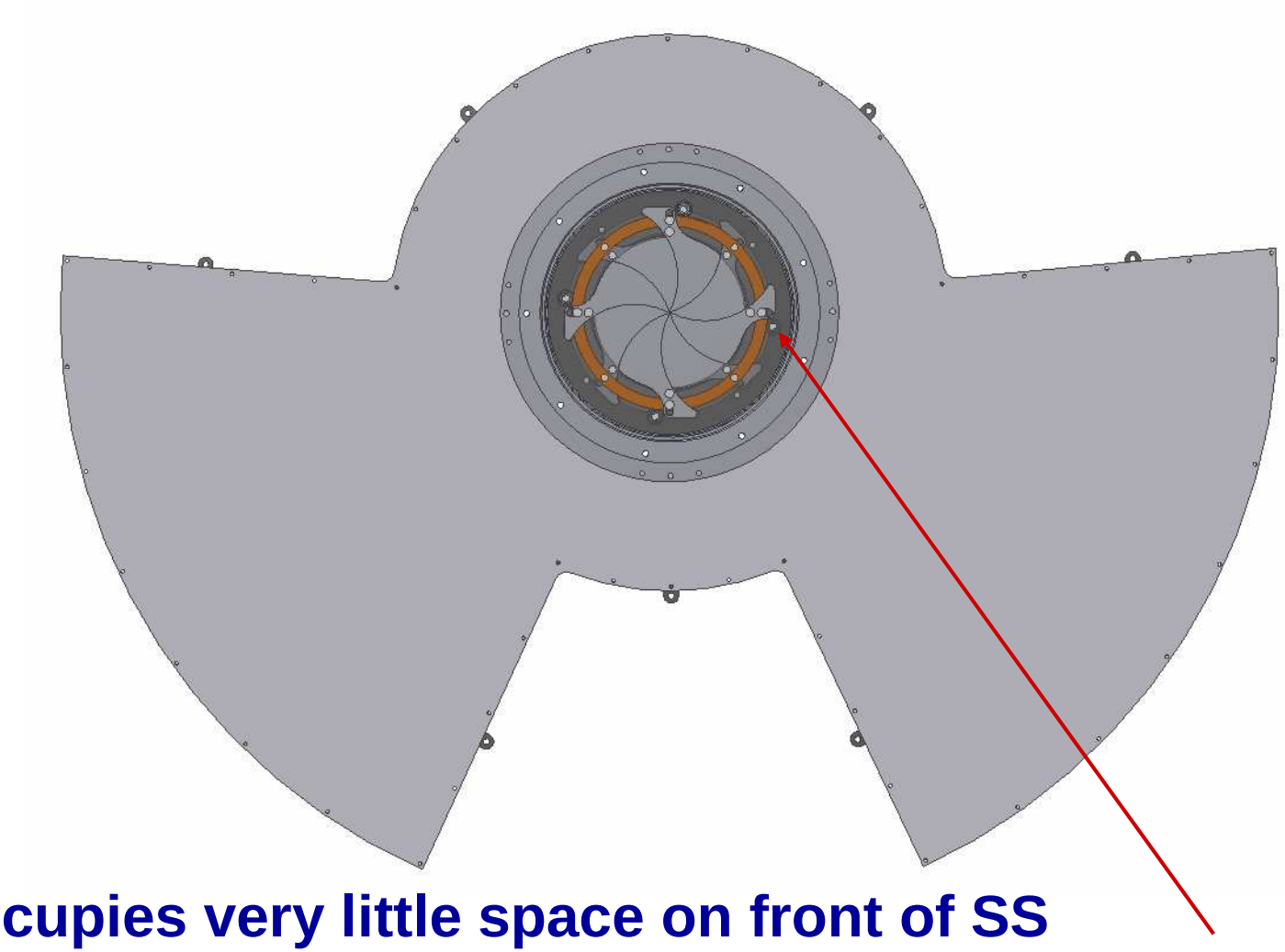
- Some consideration of Physics requirements
  - Choice of 15 thicknesses probably advantageous
  - Can't easily do wedge (for dispersion)
    - But never in original plan
- Mechanics
  - Very simple
    - A few weeks to design & manufacture
      - Say 12 weeks
- Controls
  - Modify (rebuild) air crate
    - Re-use components (solenoid valves)
  - Modify electronics crate
    - Re-program FPGA
      - No big deal
- Approval by MICE TB (presumably)

CONCLUSION

- **Hoped to demonstrate a working diffuser by now but *'The best laid plans of MICE and Men oft gang agla'*.**
- **Have seen enough of the problems of the 'flying wheel' design to be convinced that it will be very difficult to make it work, even on the bench**
  - **Have not passed first base after (too) much time & effort.**
- **Would be very nervous about the design in high field**
  - **Fixing problems would be a nightmare for everyone**
- **It's been fun but…. *Tant pis, il faut en finir!***

- **Though I don't like tempting providence…**
  - **New design is simple**
  - **Quick to manufacture**
  - **Quick to install**
  - **Rugged in operation**

THE END



Occupies very little space on front of SS
Use simple pneumatic actuators to rotate ‘control rods’ (~120 degrees to open / close)