# MEIC Interaction Region Beam Pipe

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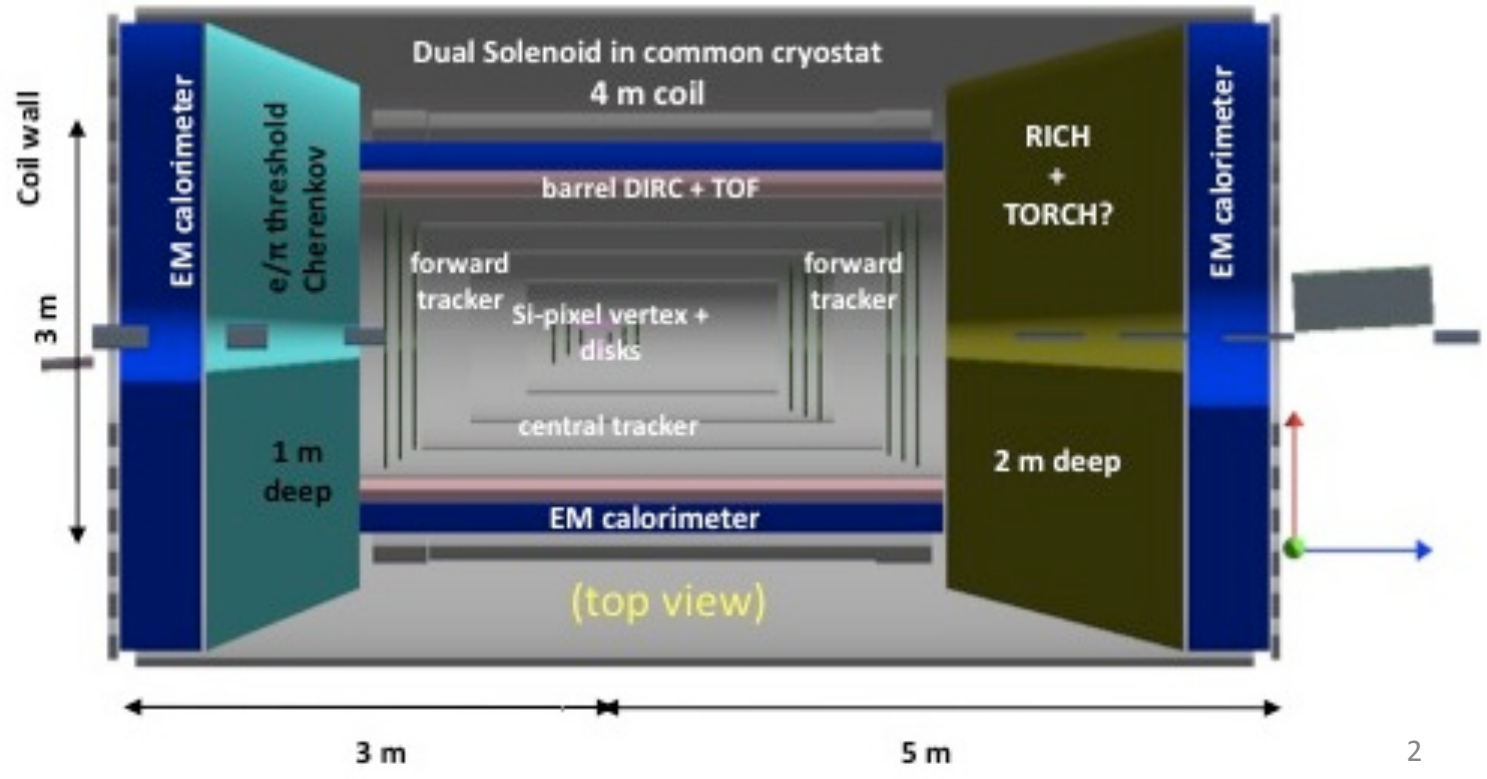
# MEIC Central Detector

- Allow all small angle particles that are outside the Lattice admittance to exit the beam pipe and be detected with minimum multiple scattering



# Beam Pipe Mechanical Requirements

- Wall Thickness of circular tube (E = Young's Modulus)

$$\frac{t}{R} \approx 2\left(\frac{4P_{atm}}{E}\right)^{1/3}$$

TABLE III. Young's Modulus $E$, Radiation Length $X_0$, Figure of Merit $X_0\sqrt[3]{E}$, and minimum wall thickness to radius ratio $t/R$ for a circular vacuum pipe, for common materials used in accelerator beam pipes.

| Material → | | Be | CFC* | Al-Be | Al | Ti | Fe** | Air |
|---|---|---|---|---|---|---|---|---|
| Parameter | Units | | | | | | | |
| $E$ | GPa | 290 | 200 | 193 | 70 | 110 | 210 | — |
| $X_0$ | cm | 35.3 | 27.1 | 25.3 | 8.9 | 3.6 | 1.8 | $3.0 \cdot 10^4$ |
| $X_0\,E^{1/3}$ | | 2.34 | 1.58 | 1.46 | 0.37 | 0.17 | 0.11 | — |
| $t/R$ | % | 2.15 | 2.43 | 2.46 | 3.45 | 2.97 | 2.39 | — |

* Carbon Fibre Composite

** Stainless Steel

# Electron/Ion Beam Parameters

- S. Abeyratne, *et al.,* arXiv:1504.07961

| Beam → | Electron | Proton | Deuteron | Helium | Carbon | Calcium | Lead |
|---|---|---|---|---|---|---|---|
| Parameter | Units | $e^-$ | $p$ | $d$ | $^3He^{++}$ | $^{12}C^{6+}$ | $^{40}Ca^{20+}$ | $^{208}Pb^{82+}$ |
| Momentum | GeV/c | 5 | 100 | 100 | 200 | 600 | 2000 | 8200 |
| Normalized Emittance | | | | | | | | |
| Horizontal | $10^{-6}$ m rad | 144 | 1 | 0.5 | 0.7 | 0.5 | 0.5 | 0.5 |
| Vertical | $10^{-6}$ m rad | 72 | 0.5 | 0.25 | 0.35 | 0.25 | 0.25 | 0.25 |
| Parameters at the Full Acceptance IP | | | | | | | | |
| $\beta^*_{\rm Horiz}/\beta^*_{\rm Vert}$ | cm | 2.6/1.3 | 4/2 | 4/2 | 4/2 | 4/2 | 4/2 | 5/2.5 |
| $\sigma(x)/\sigma(y)$ | $\mu$m | 19/9.7 | 19/9.7 | 19/9.7 | 20/9.9 | 19/9.6 | 19/9.6 | 22/11 |
| $\sigma(x') = \sigma(y')$ | mrad | 0.744 | 0.484 | 0.484 | 0.495 | 0.482 | 0.482 | 0.543 |
| Luminosity | $(\text{nb}\cdot\text{sec})^{-1}$ | | 4.6 | 9.2 | 6.6 | 9.2 | 9.2 | 7.8 |
| Beam Stay Clear at $s = 7$ m (Entrance to FF Q1). Units of $P/Z$ are GeV/c. | | | | | | | | |
| BSC ($P/Z = 100$) | cm | — | $\pm$3.4 | $\pm$3.4 | $\pm$3.5 | $\pm$3.4 | $\pm$3.4 | $\pm$3.8 |
| BSC ($P/Z = 20$) | cm | — | $\pm$7.6 | $\pm$7.6 | $\pm$7.7 | $\pm$7.5 | $\pm$7.5 | $\pm$8.5 |

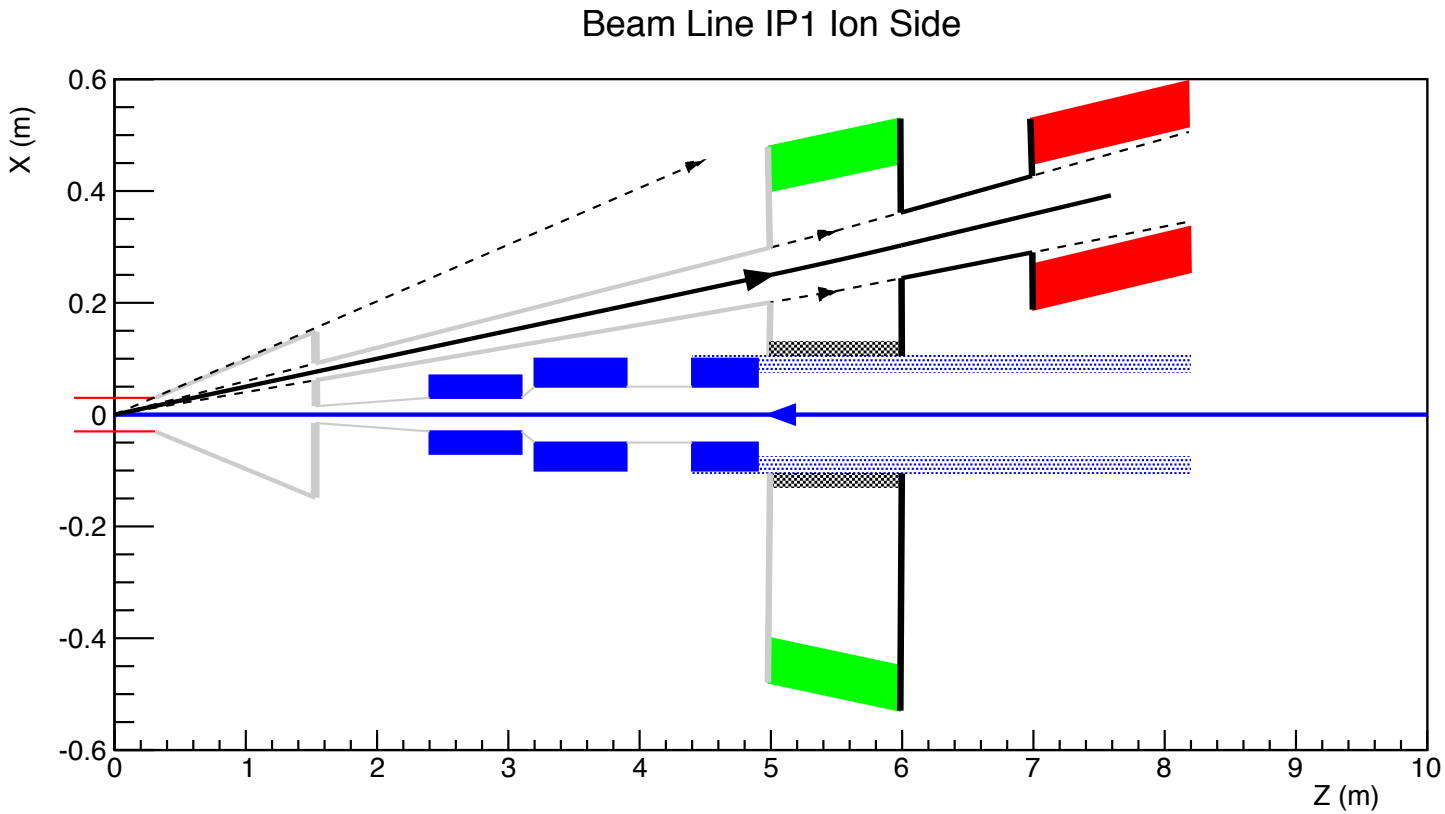
# Ion FFQ Acceptance and Beam Stay Clear

- Horizontal:
  - FFQ Acceptance ± 10 mrad
    - ± 7 cm at entrance to FFQ1 (s=7 m)
  - BSC = 10 $\sigma$ = (5 mrad) (s-$s_{IP}$) From IP to FFQ1
- Vertical
  - FFQ Acceptance ± 14 mrad
    - ± 10 cm at entrance to FFQ1
  - BSC = 10 $\sigma$ = (5 mrad) (s-$s_{IP}$) From IP to FFQ1
- Elliptical Conical Beam Pipe?

- Keep full FFQ acceptance in vacuum until exit of FFQ3
- Clean exit for particles to be detected at Dipole-1

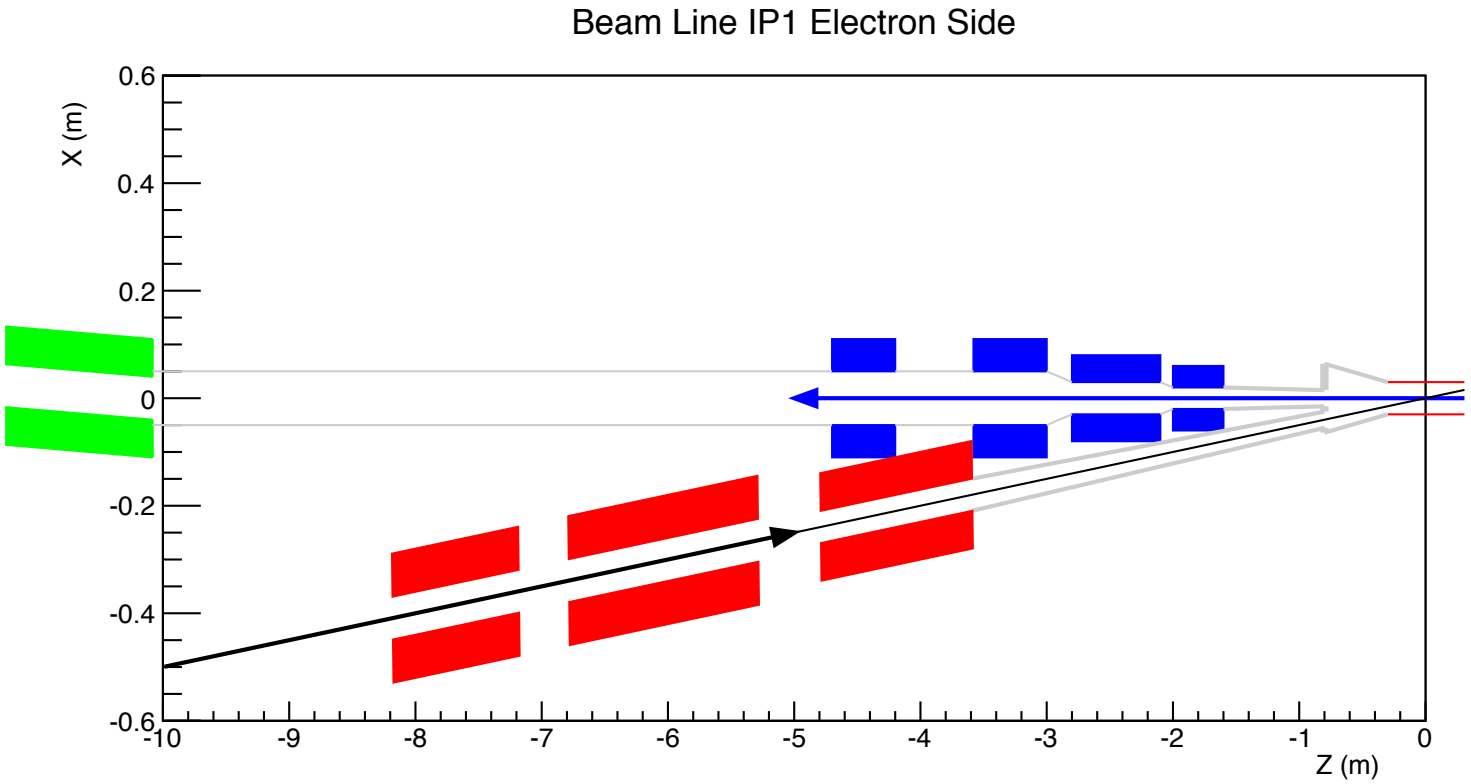
# Downstream Beam Pipe in Central Region

- Flare should match edge of Endcap detectors
  - Drawn as outer edge of Dipole-1 yoke (could be inner edge).
  - Large Dipole option, with electron Flux exclusion tube



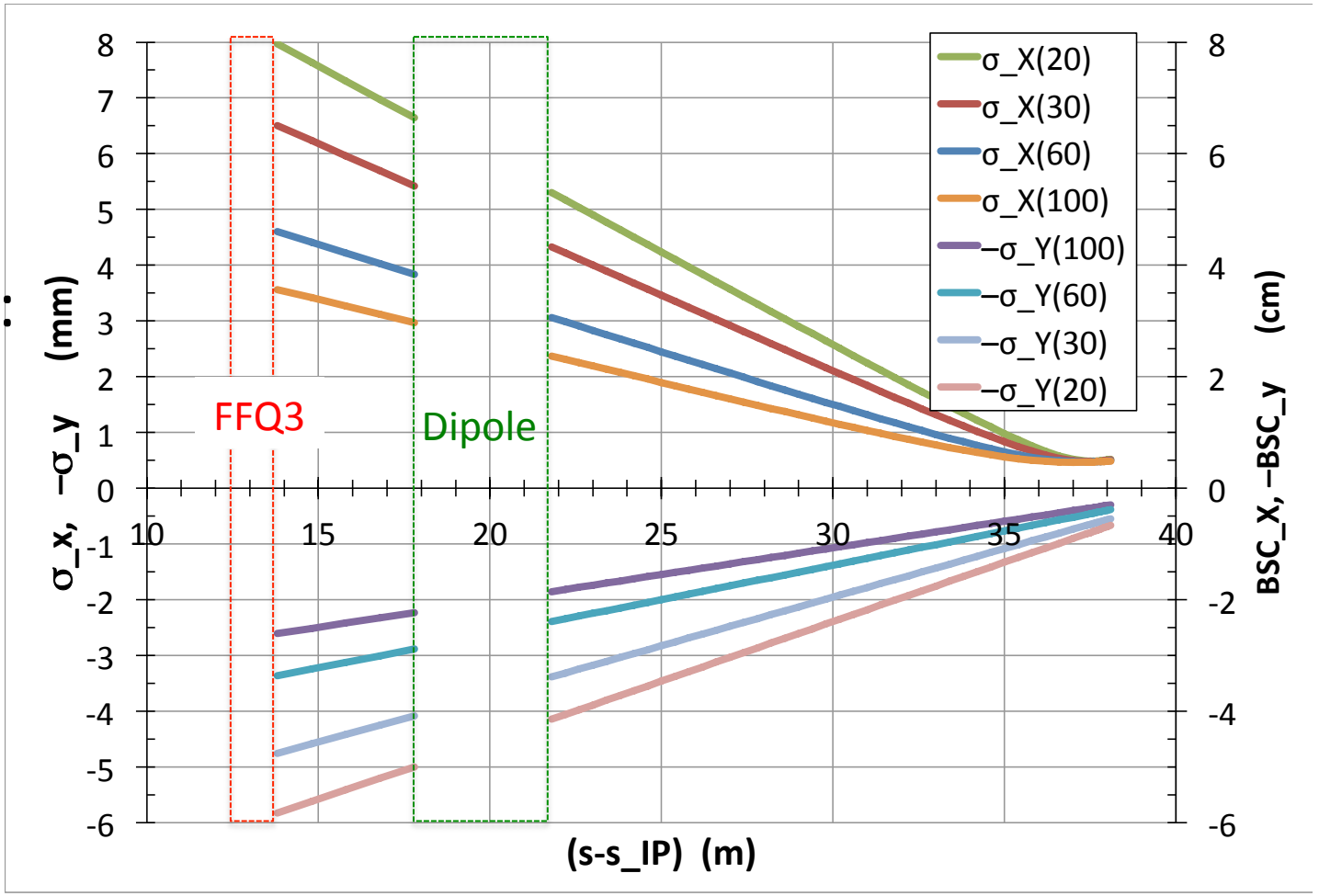
# Upstream-Ion Beam Pipe in Central Region

- Flare should match small angle high resolution EM Calorimeter ~ 150 mrad



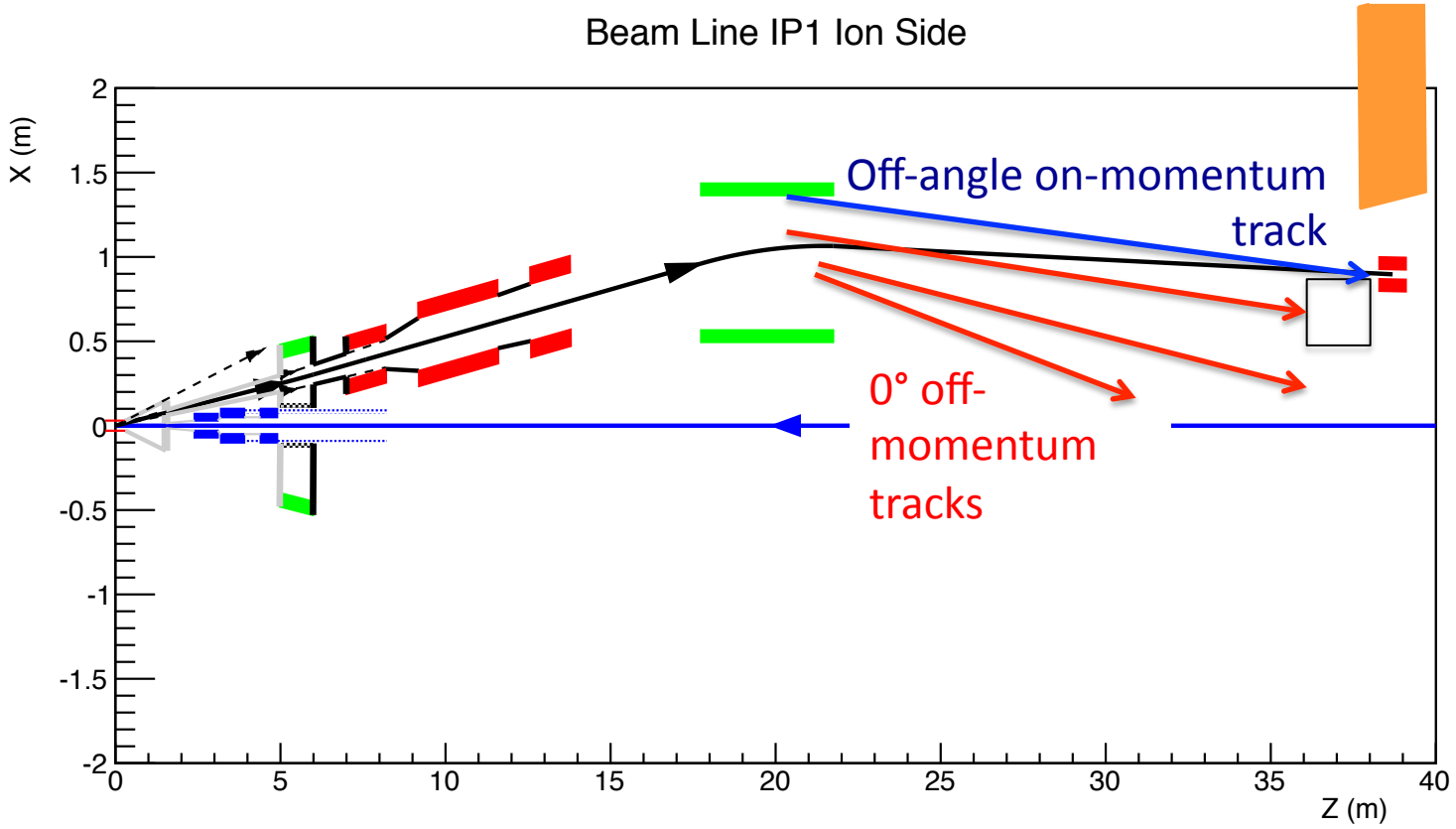
# BSC at FFQ3, Dipole-2, and Secondary Focus

- Full detection acceptance at all energies requires three Roman Pots.
- FFQ3 exit:
  *s = 13.8* m.
- Dipole-2 exit:
  *s = 21.8* m.
- Focus:
  *s = 37* m



# Full Downstream Beam Pipe

- Compromise of cost/complexity of Roman Pots and Full Acceptance at 100 GeV/c with running at 20 GeV/c



# Conclusions

- Ready (almost) to implement in GEMC and/or EICroot.
- Start simulations
  - Multiple scattering / resolution
  - Realistic acceptances
- ODU Undergrad
  - Joshua Monroe
  - Senior Thesis, Summer-Fall 2015
- Flange-free design (in acceptance regions)
  - Realistic for Al vs Be vs Carbon Fibre?
  - Possible to build CFC prototype at ODU (Tom Hartlove).
  - How would it mate to Al windows?