Magnetization of the Hadron Stopper

Collaboration meeting June 2017

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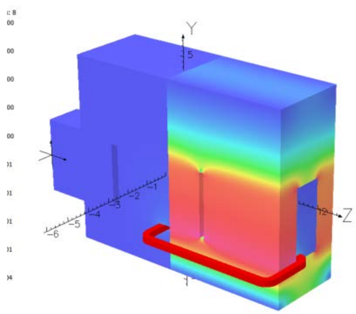
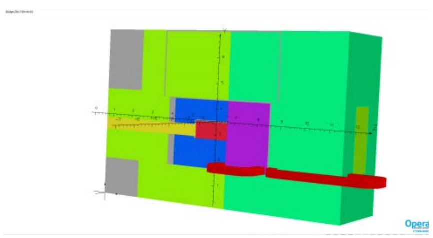
Evolution of Architecture



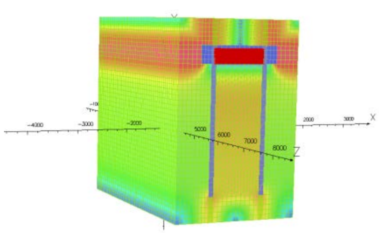
Jan-2017
One coil beneath the facility

Single coil but…
Mechanical integration issues ✗



April-2017
Two coil beneath the facility
(on Mobile trolley)

Complex to implement
Large forces ✗



May-2017
One coil above beam axis

Retains benefits of previous design

+ Elegant & accessible ✓

Reasons for rejecting 2-Coil architecture

Mechanical Forces

- Trolley assembly introduced several magnetic gaps. Across these large force develop which could not be mitigated

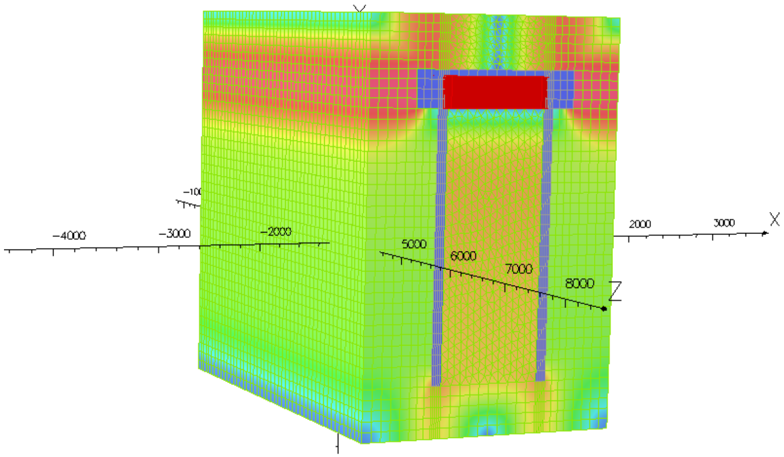
Modelling uncertainty

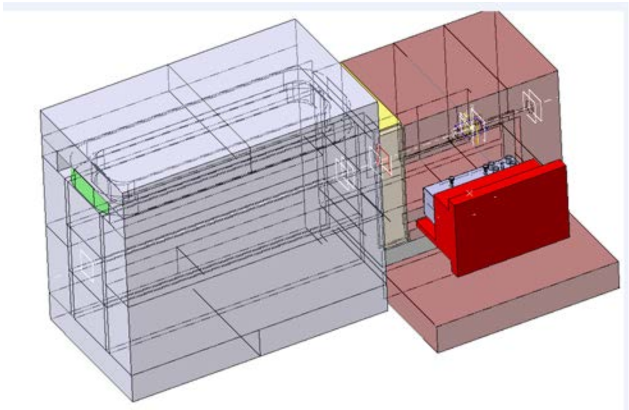
- The magnetic circuit can be considered like an electric circuit.
- Uncertainty in the mechanical design added large and unpredictable “reluctances” into the model making it hard to predict where the flux would flow.
- Hysteresis in iron may cause the trolley to stick to the US1010, after the coil is powered off.

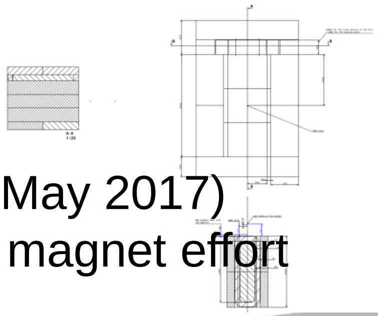
Thermal management

- Cooling is likely to be an integral part of the coil.
- The cooling complexity became unreasonable using the trolley concept.

May-2017 Baseline

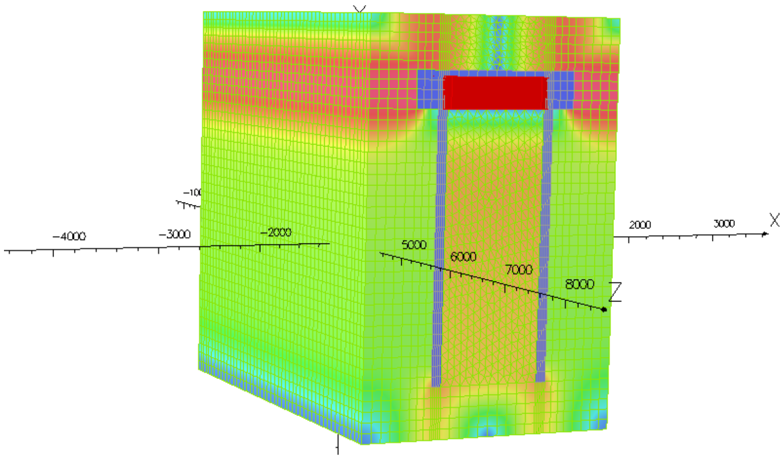






- Single coil (down stream of target)
- Coil above beam axis
- Dimensions given by Target and Target Complex team (25th May 2017)
- “Similar” to Jan-17 design, allowing continuation of previous magnet effort
- Thermal and mechanical management will be simplified
- Magnetic circuit has fewer assumptions

May-2017 Baseline



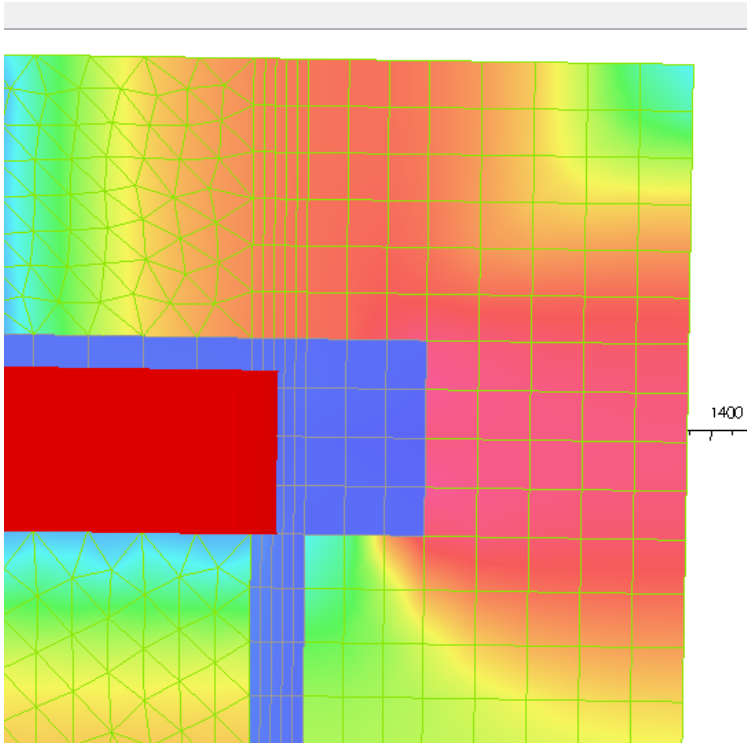
Initial modelling

- Low current densities required to produce significant field on axis
- 1A/mm2 (J_{eng}) ~ 1.5 Tesla on axis.
- Higher field possible (awaiting results)

J_{eng} up to 10A/mm2 *conceivable* with convective cooling alone.
Thermal management is unlike to limit this magnet ☺

Science & Technology Facilities Council

May-2017 Baseline



Viewed on axis

- Corners near the coil are saturated.
- Beyond saturation field increases similar to air (i.e.. No further benefit of using iron).
- Chamfering, additional yoking and coil current optimisation will improve this.
- This work will reduce stray fields and input power.

Science & Technology Facilities Council

May-2017 Baseline

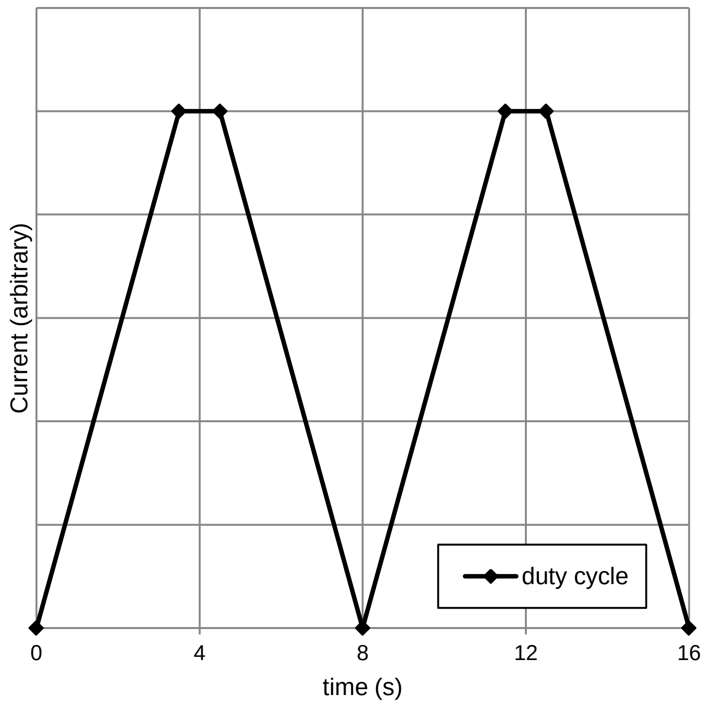
Coil configuration

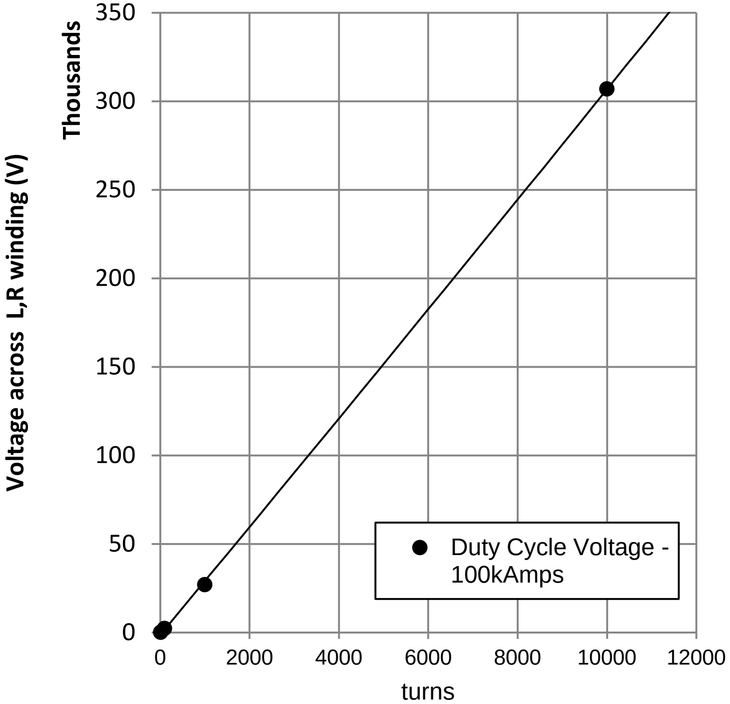
- 100 kA-turns (rough order of magnitude)
- 1< Jeng <<10 : require a resistive magnet
  (large volume and field rule out permanent magnets)
- Coil solutions found for copper and aluminium between 1000 and 10000 turns. Aluminium favoured by STFC.
- Fill factor sensitivity analysis suggests power consumption likely to be between: 30 & 80 kW (subject to coil selection)

May-2017 Baseline

Operation

- Pulsing the magnet in time with beam's duty cycle not feasible due to considerable inductance and induced forces.





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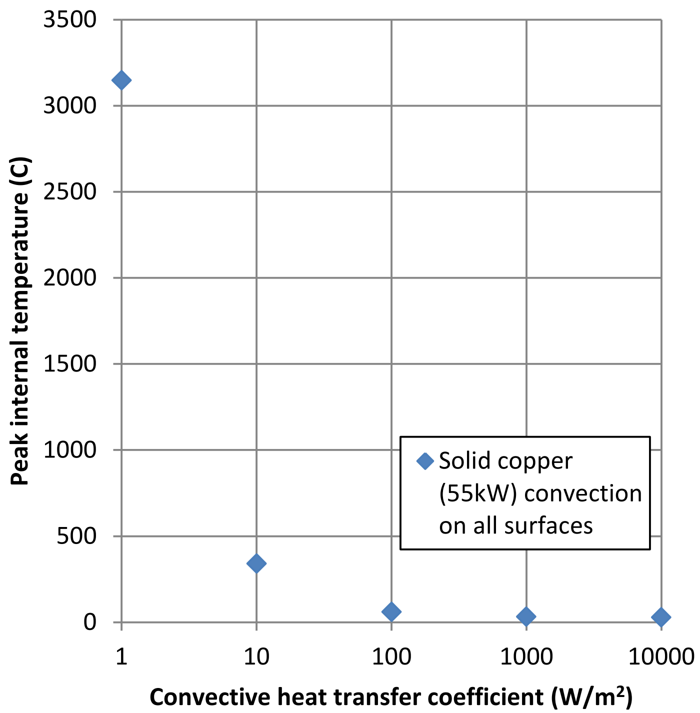
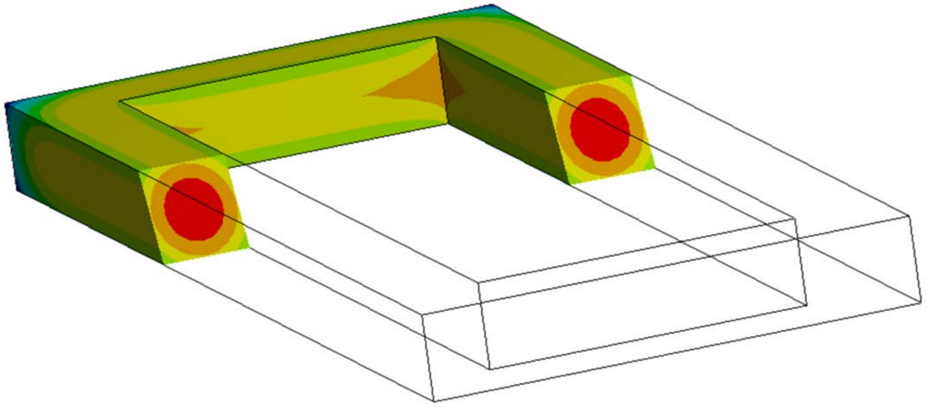
May-2017 Baseline

Very basic thermal management

- Peak internal temperature manageable with believable heat transfer coefficients. (simplistic assumptions but building confidence)
- More work to do once coil is defined.





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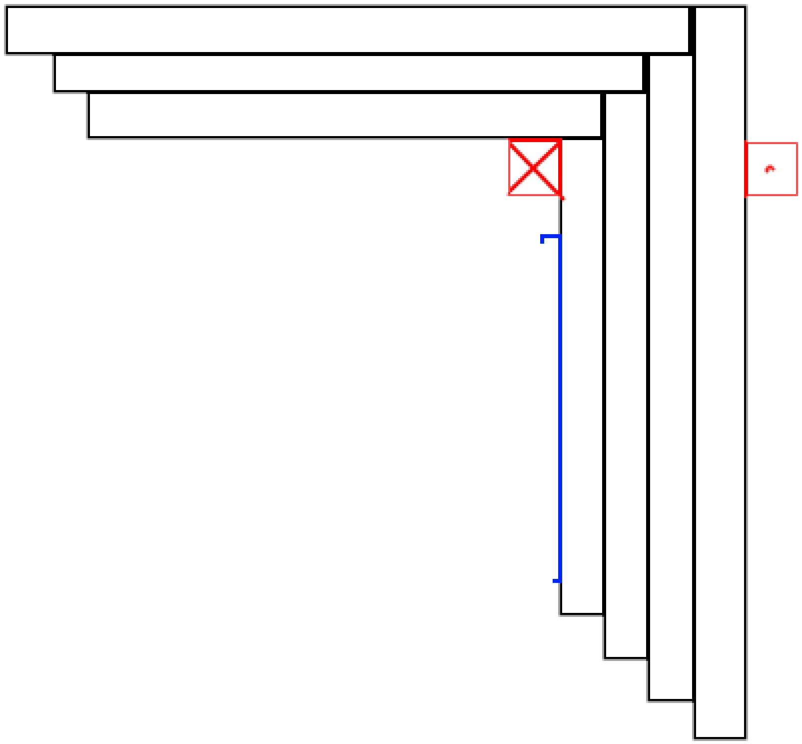
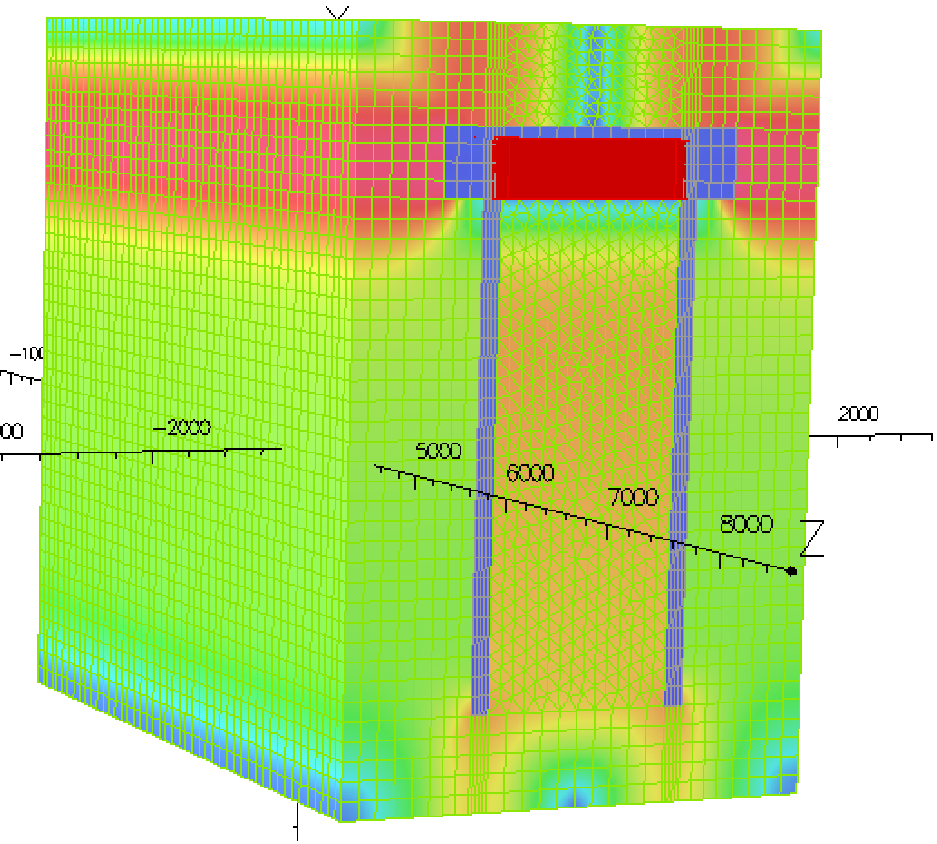
May-2017 Baseline



- The magnetic return path will be made from US1010.
- The image shows a concept for how to assemble the iron.
- This method minimises high reluctance gaps in the steel.
- Resulting in reduced power consumption.

Our Opinion

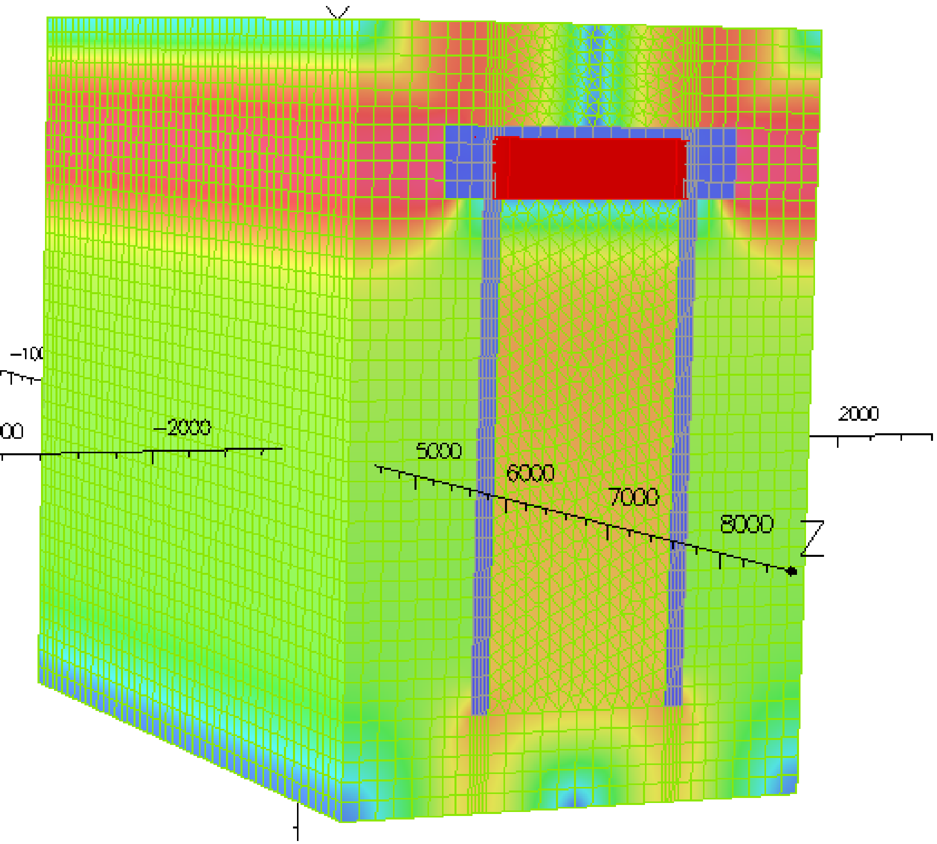


The May-2017 magnetic-architecture concept is superior to all predecessors in regards to:

- Modelling uncertainty
- Thermal management
- Accessibility

It should also be possible to produce the same on axis field as previous models (1.6 – 1.8 Tesla)

Soon we will report…



Sensitivity analysis of:

- Coil configuration
- Operating temperature
- Input power
- Yoke geometry