Upgrade study of magnet BTM.BHZ 10

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ENGINEERING NOTE

Upgrade study of magnet BTM.BHZ10

ABSTRACT:

This note details the preliminary feasibility study for changes that need to be made to magnet BTM.BHZ10 for operation at 2.0 GeV.

A number of solutions are proposed: Including manufacturing additional coils for the existing magnet and building a new magnet. Power supply options, cost estimates and field quality simulations are discussed for each option.

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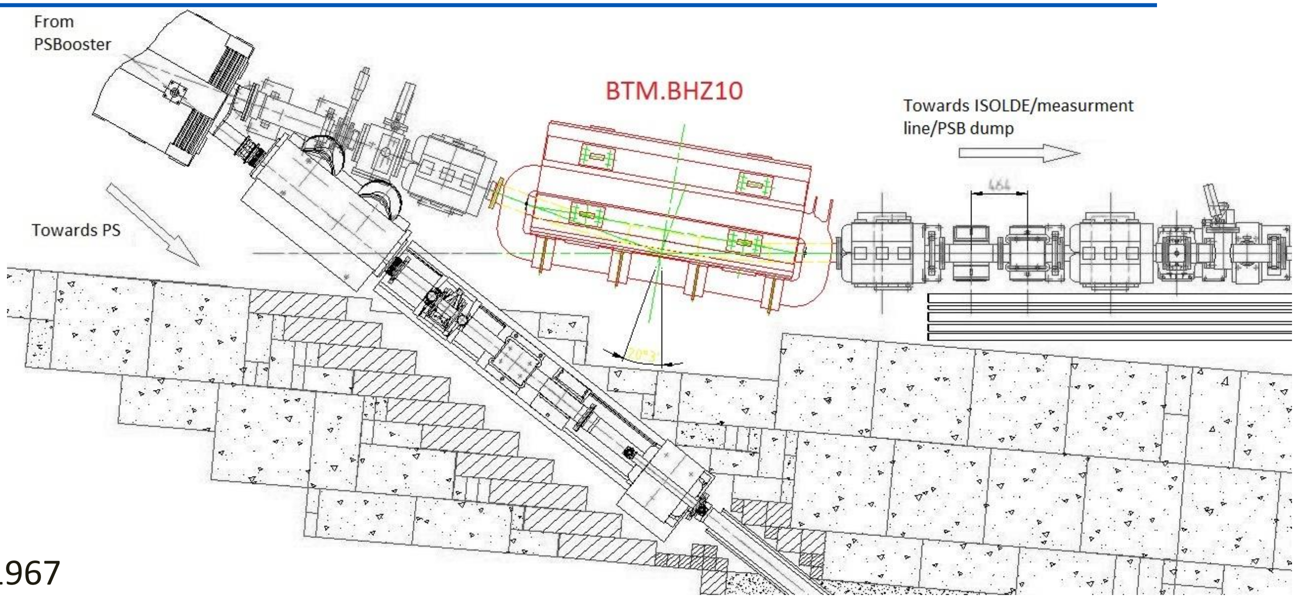
Introduction



BTM.BHZ 10

- Horizontal bending magnet
- 18 tonne total weight
- 2.8 m total length
- 204 turns
- Originally designed for ISR in 1967
- Presently operates in PPM between 1 and 1.4 GeV

Upgrade requirements

- LIU requires operation at 1.4 and 2.0 GeV
- Integrated field will increase from 2.452 to 3.188 Tm (30 %)
- Operation is required between the two fields in a 1.2 second PPM cycle
- Field homogeneity required by the measurement line at 2.0 GeV operations is not presently defined; we assume that this shall be not worse than today

Existing magnet

With no modifications

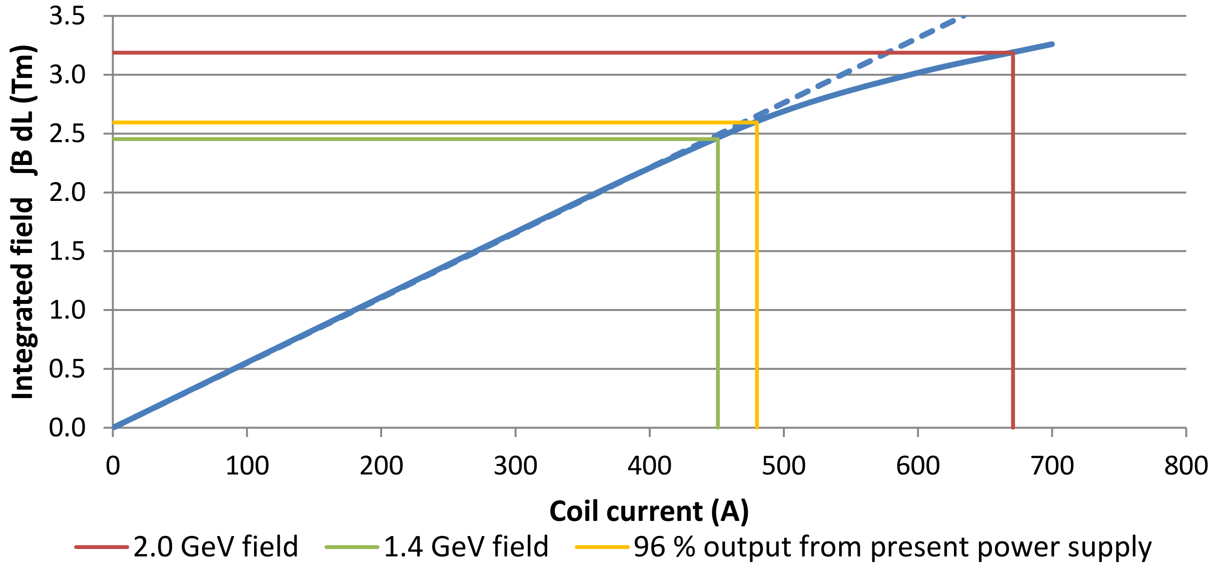
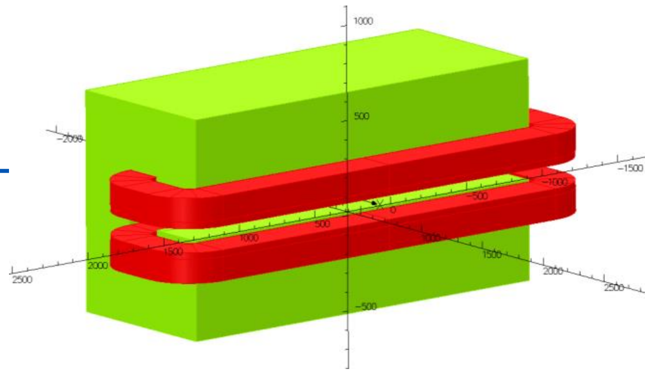


Figure 1 – Excitation curve of the present magnet using OPERA

Restrictions of present setup

- The required current will increase from 451 to 671 A requiring a new very expensive power converter
- Yoke will become saturated
- Weight currently exceeds the 10 tonne crane capabilities
- Limited additional space is available around the magnet, ~300mm can be liberated by combining a vertical and horizontal corrector magnet downstream from this magnet (study carried out by Wolfgang and Magdalena)

Existing magnet upgrade



To reduce the peak current required from the power supply a possible solution would be to add **additional coils** to the **existing magnet**.

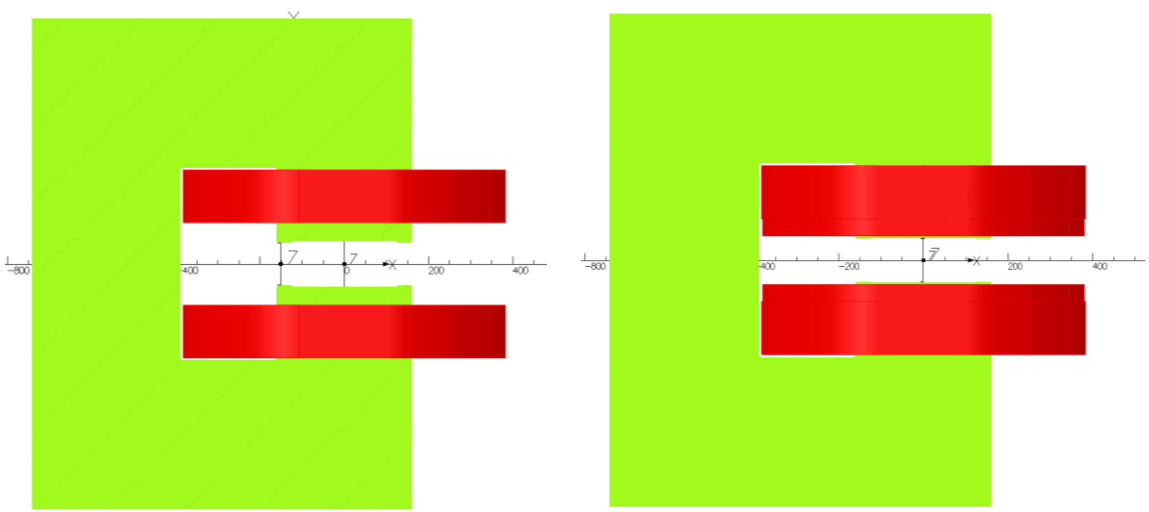


Figure 2 – Present coil configuration (left) , proposed coil configuration (right)

Existing magnet – Power supply options

	Option 1	Option 2		Option 3
	VB4 magnet with no modifications	VB4 magnet Existing coils circuit +	Additional coils circuit	VB4 magnet with additional coils series circuit
Resistance including cables (Ω)	0.163	0.163	0.101	0.301
Additional inductance (H)	0.487	0.487	0.095	1.004
Nominal current (A)	671	467	465	466
Power supply minimal voltage (V)	250	200	80	320
Power supply name	New B8 +spare	Existing B1/IEP	New S500 + spare	New model + spare
Power supply cost (kCHF)	750	0	170	*450

* Reuse of existing power supply and spare could save 240 kCHF

Specification of additional coil

- 90 additional turns
- Reduces peak current from 671 A to 466 A (44%)
- Cost estimate for manufacture of a pair of coils including a spare pair ~**120 kCHF**

Existing magnet - Field quality

As the yoke pole width will become saturated the field homogeneity with dramatically reduce.

- At the edge of the good field region the homogeneity will reduce from 8 to 94 units
- The integrated field quality may be improved with experimental end shims
- The field quality required at 2.0 GeV is dependant on the measurement line and ISOLDE down stream of the magnet

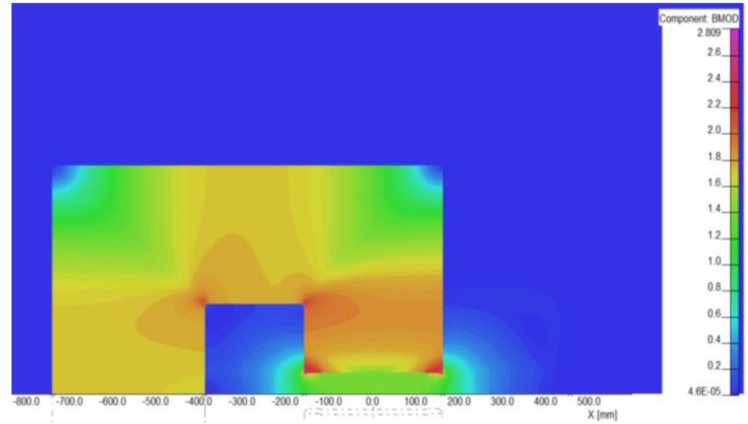


Figure 3 – 2D field modulus plot of the present yoke at 2.0 GeV operation

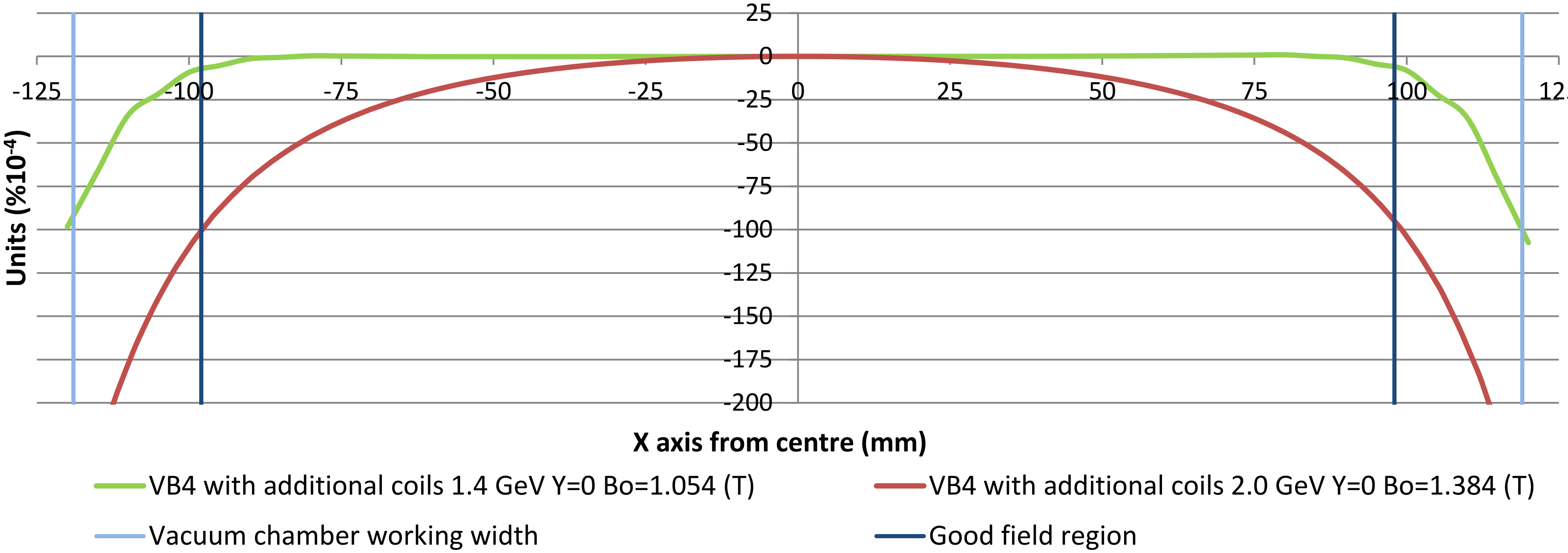
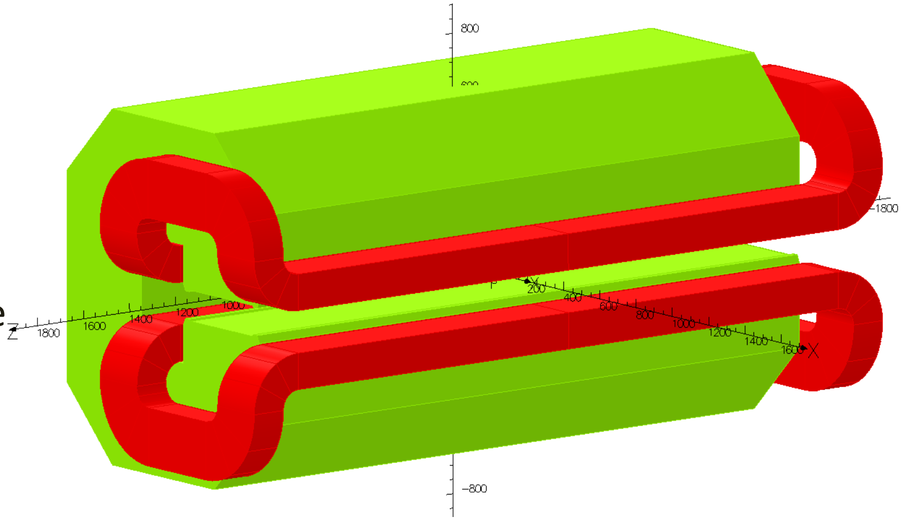


Figure 4 – Field homogeneity of B Field along X axis of present magnet [$10^4 * (\int By_{(x,0,0)} - By_{(0,0,0)}) / By_{(0,0,0)}$]

New magnet



By designing a new magnet the **pole width** and the **pole length** can be **increased**.

Key features

- Increased pole width (+100 mm)
  - Improved efficiency
- Bedstead coil used (140 mm increase in yoke length with no change in total length)
  - ~5% reduction in power supply demand
  - Increase in weight of 4 tonnes (~22 tonnes overall)
- Thinner non magnetic endplates can be used
  - Reduction in transient eddy current effects allowing faster switching between field levels
- Pole and end shims designed for purpose
  - Increase in field quality

New magnet – Field quality

Preliminary studies show that the required field quality **can** be achieved with a pole width of 420 mm, further optimisation can be made.

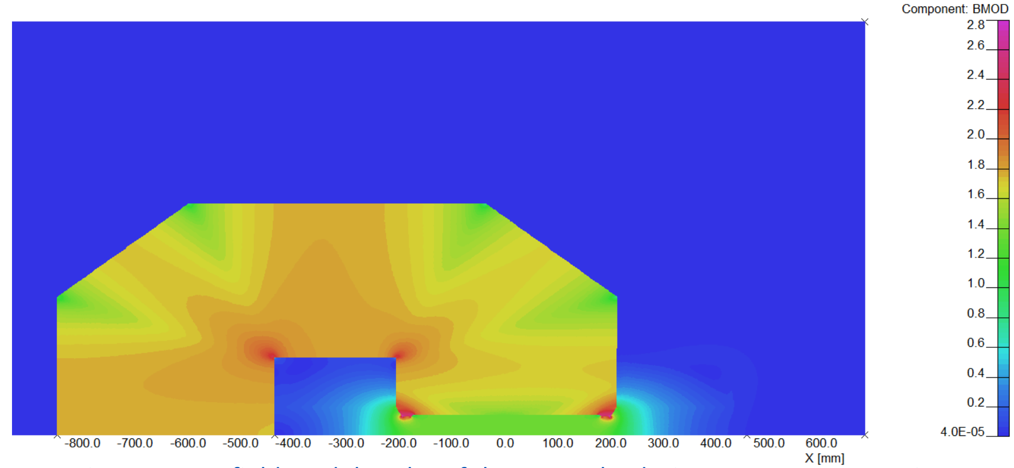


Figure 5 – 2D field modulus plot of the new yoke design at 2.0 GeV operation

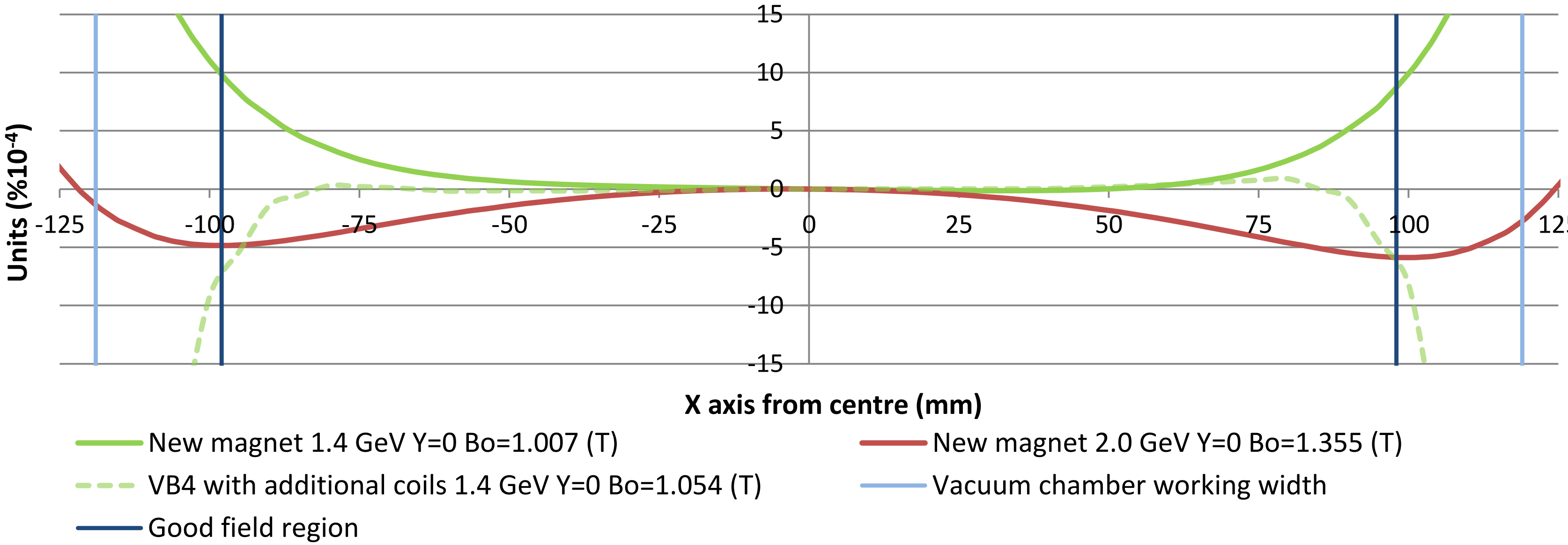


Figure 6 – Field homogeneity of B Field along X axis of the new magnet $[10^4 *(\int By_{(x,0,0)}-By_{(0,0,0)})/By_{(0,0,0)}]$

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New magnet – Power supply options

	Option 4	Option 5
	New magnet	New magnet
Resistance including cables (Ω)	0.156	0.156
Additional inductance (H)	0.875	0.875
Nominal current (A)	475	475
Power supply minimal voltage (V)	200	200
Power supply name	Existing B1/IEP with additional extraction system	New model + spare
Power supply cost (kCHF)	50	*300

* Reuse of existing power supply and spare could save 240 kCHF

Cost summary

Option 1	Present magnet with no modifications	0	kCHF
	B8 power supply + spare	750	kCHF
	Total	750	kCHF

Option 2	Present magnet with additional coils +spare	120	kCHF
	New S500 + spare	170	kCHF
	Existing B1/IEP	0	kCHF
	Total	290	kCHF

Option 3	Present magnet with additional coils + spare	120	kCHF
	New power supply + spare	450	kCHF
	Reuse of existing power supply	-240	kCHF
	Total	330	kCHF

Option 4	New magnet + spare	500	kCHF
	Existing B1/IEP with additional extraction system	50	kCHF
	Total	550	kCHF

Option 5	New magnet + spare	500	kCHF
	New power supply + spare	300	kCHF
	Reuse of existing power supply	-240	kCHF
	Total	560	kCHF

Conclusion

Currently a VB4 magnet is being liberated from the TT2 line so magnetic measurements and field quality optimisation (shimming) can be carried out. However this must be complete before the end of 2014 to allow sufficient time if unsuccessful to build a new magnet:

If the required field quality **can** be achieved with the existing magnet design **Option 3** is the preferred choice

If the required field quality **cannot** be achieved **Option 5** is the preferred choice

Considerations:

- Optics studies are needed to determine the field quality required from the BTM.BHZ 10 magnet for the measurement line operating at 2.0 GeV
- Hysteresis effects from operating the magnet in saturation and eddy current effects when switching the magnet between energies are currently unknown and need to be measured
- An integration study is required to calculate the cost of removing the existing magnet from the transfer line and the ability to install a new magnet

Additional comment:

- If ISOLDE require a 2.0 GeV beam and/or 900 ms cycle time is approved the magnet choice could be affected

Thank you for your attention