

FOCUS COIL STATUS

OXFORD

V. Blackmore

J. Cobb

W. Lau

RAL

V. Bayliss

T. Bradshaw

M. Courthold

R. Preece

J. Tarrant

M. Tucker

S. Watson

DARESBUURY

T. Hartnett

S. Griffiths

I. Mullacrane

A. Oates

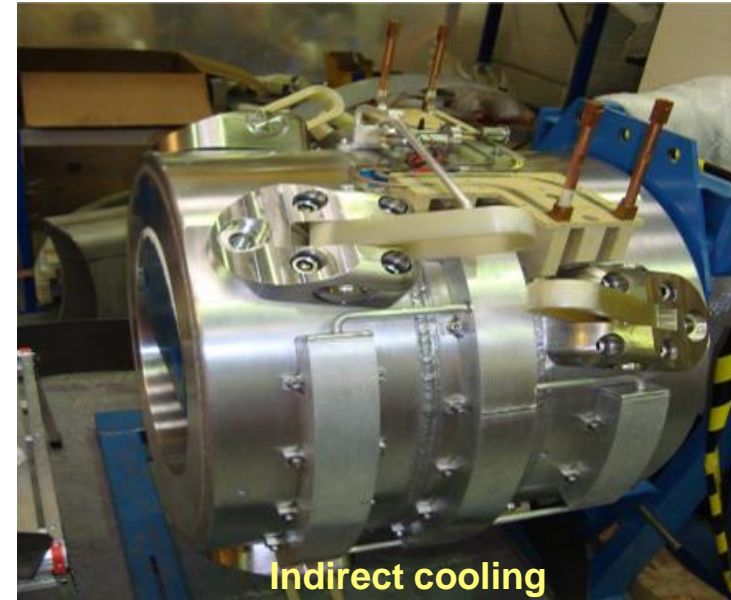
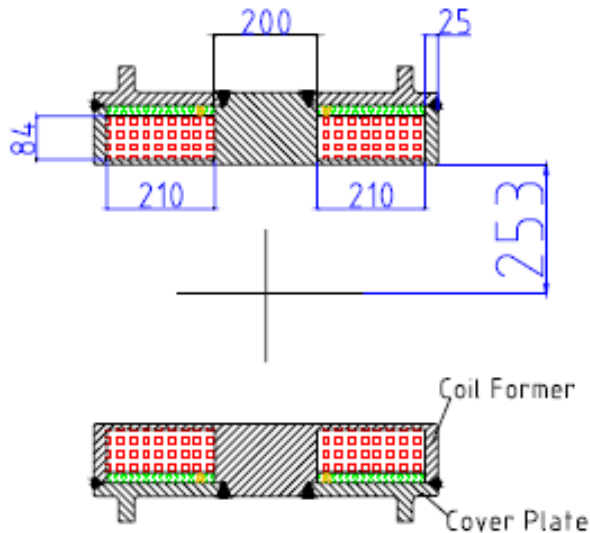
P. Owens

C. White

OUTLINE

- **FC 1 training history 2013**
- **FC 2 status**
- **FC 1 rides again in 2014**
- **De-rating for MICE Step IV**
- **Plans**

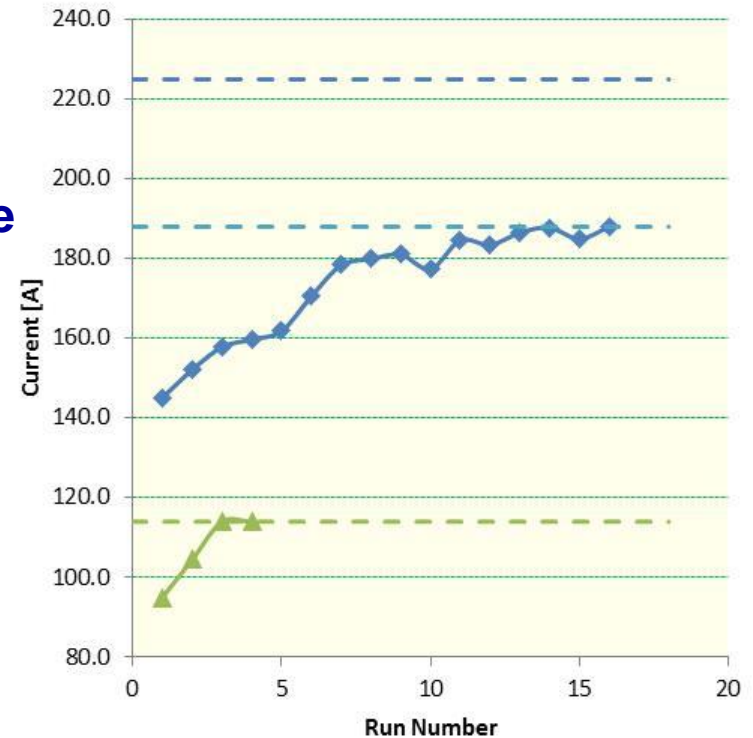
REMINDER



- **FC Modules contain two coils operated in:**
 - ‘Solenoid mode’ = same polarity
 - ‘Flip mode’ = opposite polarity
 - More demanding:
 - 2 x higher currents
 - 2 x higher fields at conductors
 - 4 x higher forces and stored energy
- **Still responsibility of manufacturers**

FC 1 HISTORY

- **Trained Feb – Oct 2013**
 - Full current – 114 Amp – Solenoid mode
 - 188 Amps Flip mode – *just*
 - 200 MeV/c ‘baseline’
 - *No overhead*
 - Stability not tested at that time
- **Known faults**
 - Insufficient tension on CM supports
 - Lack of excess cooling at 4K
 - Insulation between stages of cryocoolers omitted
- Training stopped when FC 2 arrived
 - *Fate of FC 1 to depend on performance of FC 2*



ENTER FC 2

- **FC 2 arrived end October 2013**
- **FC 1 disconnected & moved**
- **FC 2**
 - **Connected**
 - **Pumped down**
 - **Started to cool with cryocoolers**



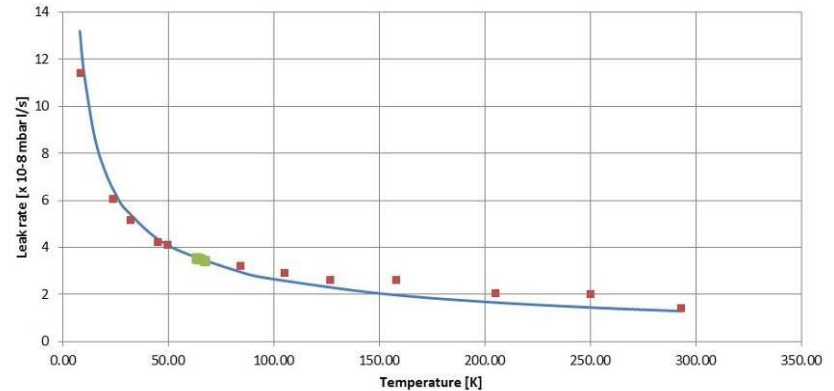
THREE STRIKES & YOU'RE OUT...

1. Fault with temp sensor on cold mass

- Just liveable with

2. Leak in He system

- *Just* outside spec. at 293K
- Increasing with decrease in T
 - Suggests on cold mass



3. Could not cool cold mass < 9K

- Rad shield ~120K *cf* 60K
- Condensation on warm bore
 - One spot at one end
 - Thermal shorts

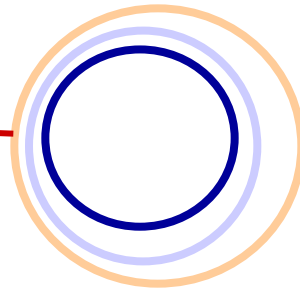
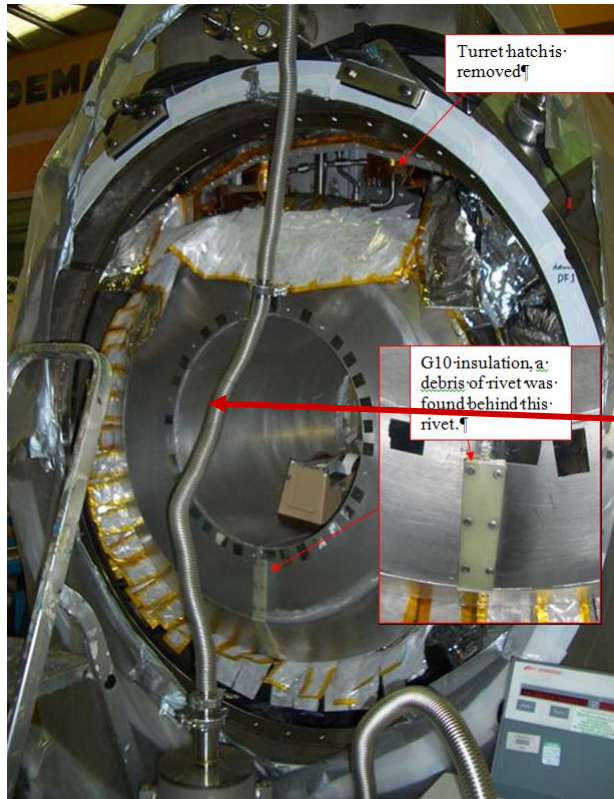
➔ Warm up and...

FC 2 GOES BACK TO MEET ITS MAKER



First week in January 2014

FC 2 INVESTIGATIONS



- Forensic disassembly established source of thermal shorts:
 1. Cold mass / rad. shield / warm bore tube not concentric
6mm clearance reduced to 3mm → compressed MLI
 2. Debris of pop-rivet on radiation shield impinging on cold mass
- Calculations agree with observed thermal loads

FC 2 REPAIR & PLAN

- He leak is somewhere on cold mass
- Decide – with manufacturer – *not* to remove cold mass to fix it
 - Like brain surgery
 - Risk to connections to cold mass, leads...
 - Almost impossible to test *cold* at manufacturers
 - May have to pump fairly hard?
 - We don't know
 - **Want to assess *electrical* performance of FC 2**
 - **To inform FC 1 decisions**
- **Manufacturer will:**
 1. Replace thermal sensor & wiring
 2. Add spare sensor
 3. Reassemble *carefully*
 - Alignment of CM / Rad. shield / bore tube
- **Expect delivery mid / late May**

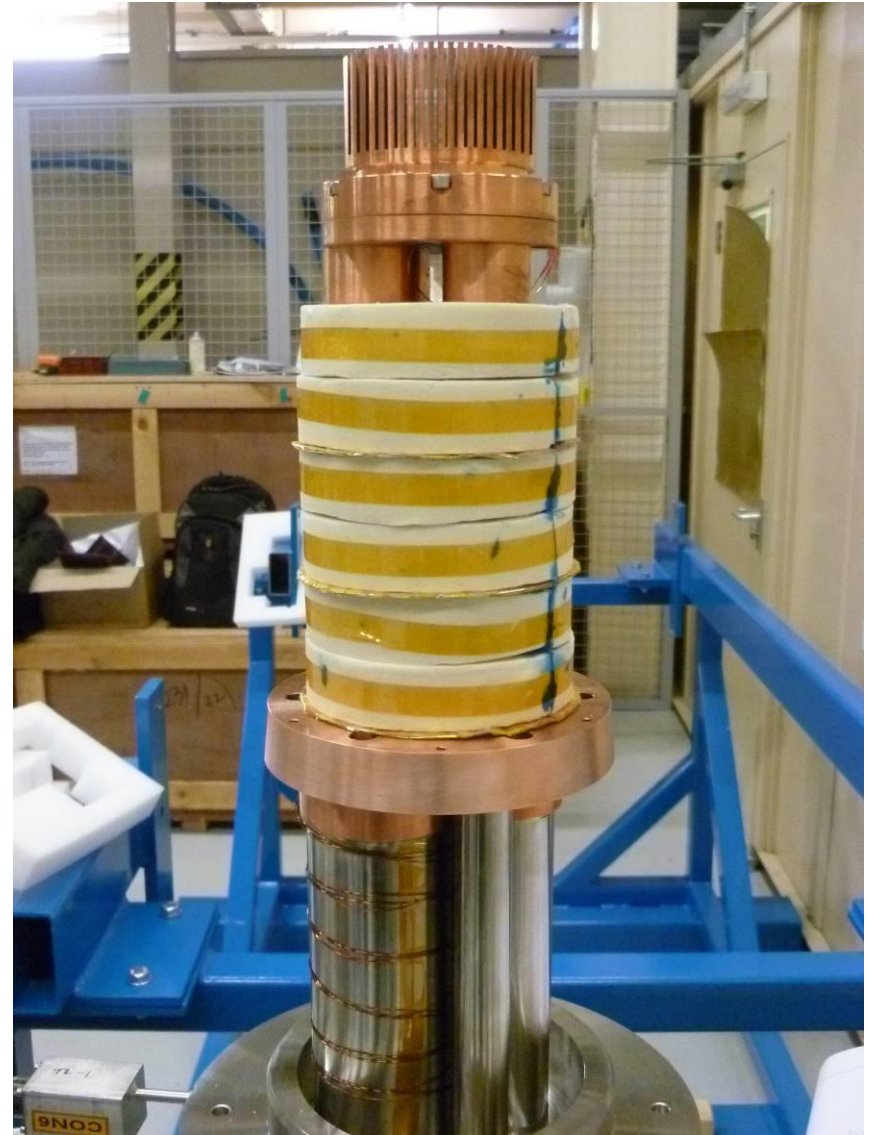
ABSORBER FIT CHECK



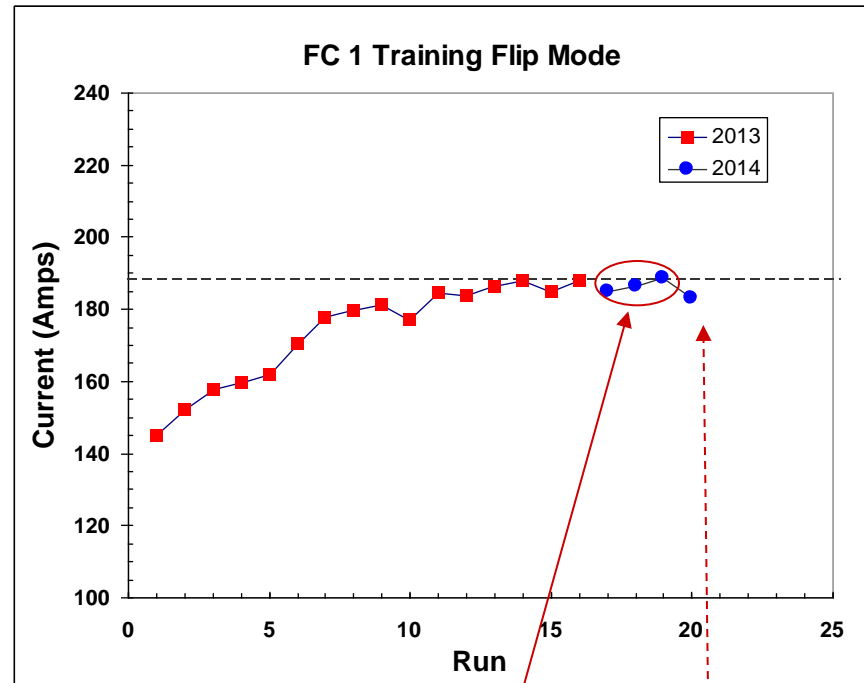
- **It fits**

FC 1 RIDES AGAIN

- **First two weeks of January**
 - Cryocooler insulation added
 - CM support tensions increased
- **Start cool down**
 - Lost some time due to damaged pressure relief valve
- **Start training again**

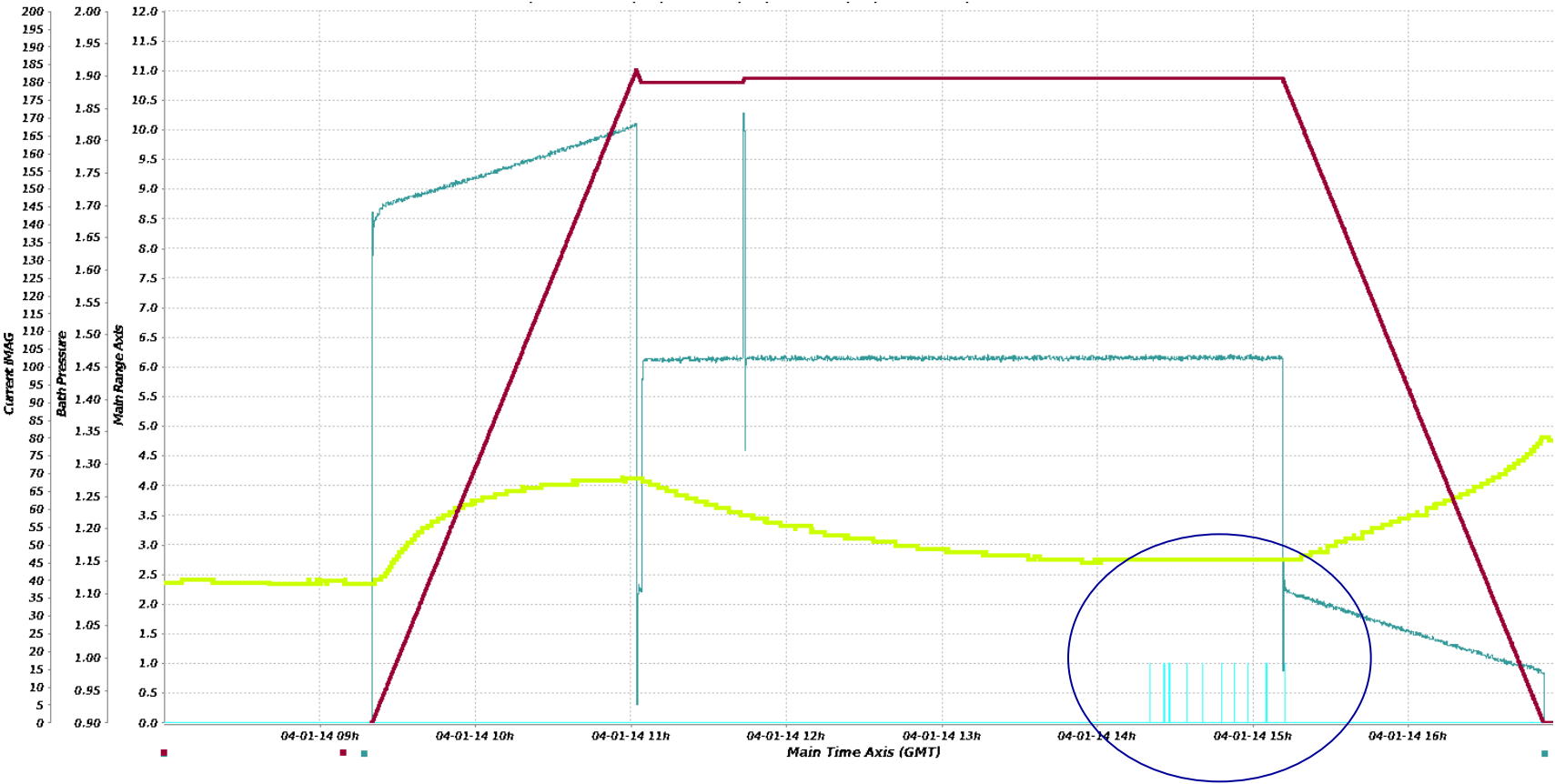


FC 1 QUENCH HISTORY 2014



- **Three training runs after warm-up**
 - **Module remembered its training !**
- **First estimate of stable operating current was 185 Amps**
 - **Two stable 4-hour runs at 185 Amps**
 - ***Quenched at 183 Amps on third attempt***
- **Stable at 180 Amps for ~20 hours night of 24 – 25 April**

CRYOCOOLER PERFORMANCE IMPROVED

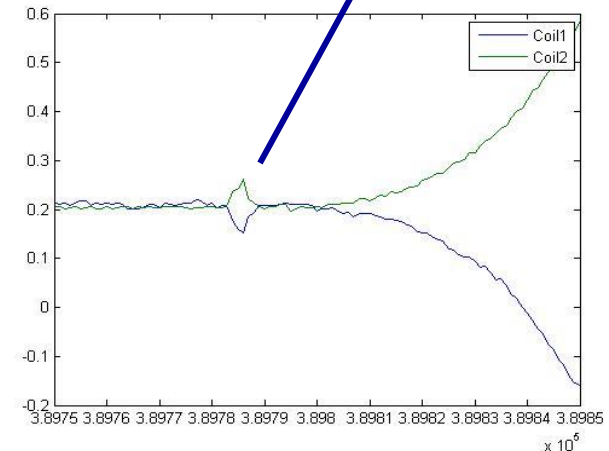
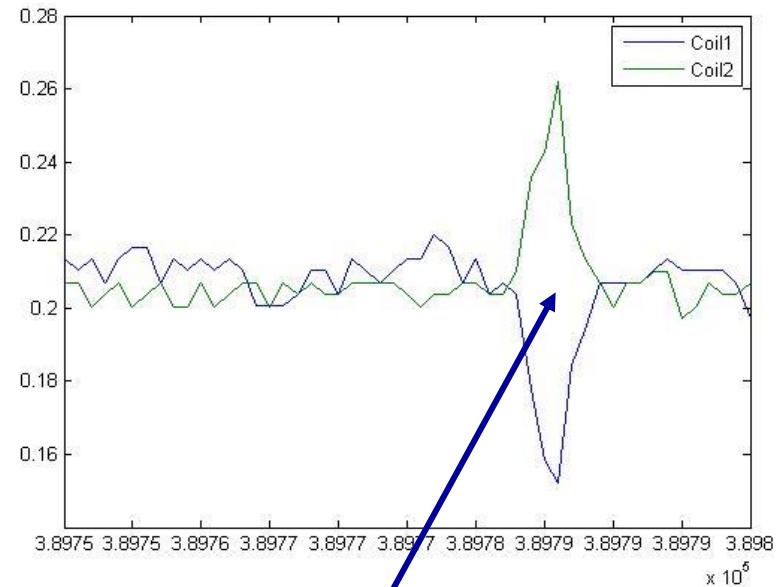


He bath heater activating at full current → excess cooling capacity

Cryocooler performance increased by > 50%

QUENCH DIAGNOSTICS

- **New fast voltage logging system commissioned**
- **Coil voltages build up as expected**
 - Not noise triggers of QP system
- **No longer see ‘stick-slip’ precursors but ‘event’ always precedes quench**
 - Quenches not due to slow build up of heat in coils
- **Possible conductor movement?**



USING FC 1 IN STEP IV

- *May have to use FC 1 in Step IV*
- Assume it's stable at 180 A maximum *in isolation*
- In Step IV it must work in presence of Spectrometer Solenoids
 - Will change the local environment (fields & forces)
- Must de-rate for two reasons:
 1. Technical
 - Must be stable, i.e. not quench
 2. Operational
 - Need headroom for tuning
 - e.g. beam momentum known to only 1 – 2 %
 - Would need this headroom in any case
 - Expected ~ 20%
- *De-rate based on forces...*

FORCES IN STEP IV

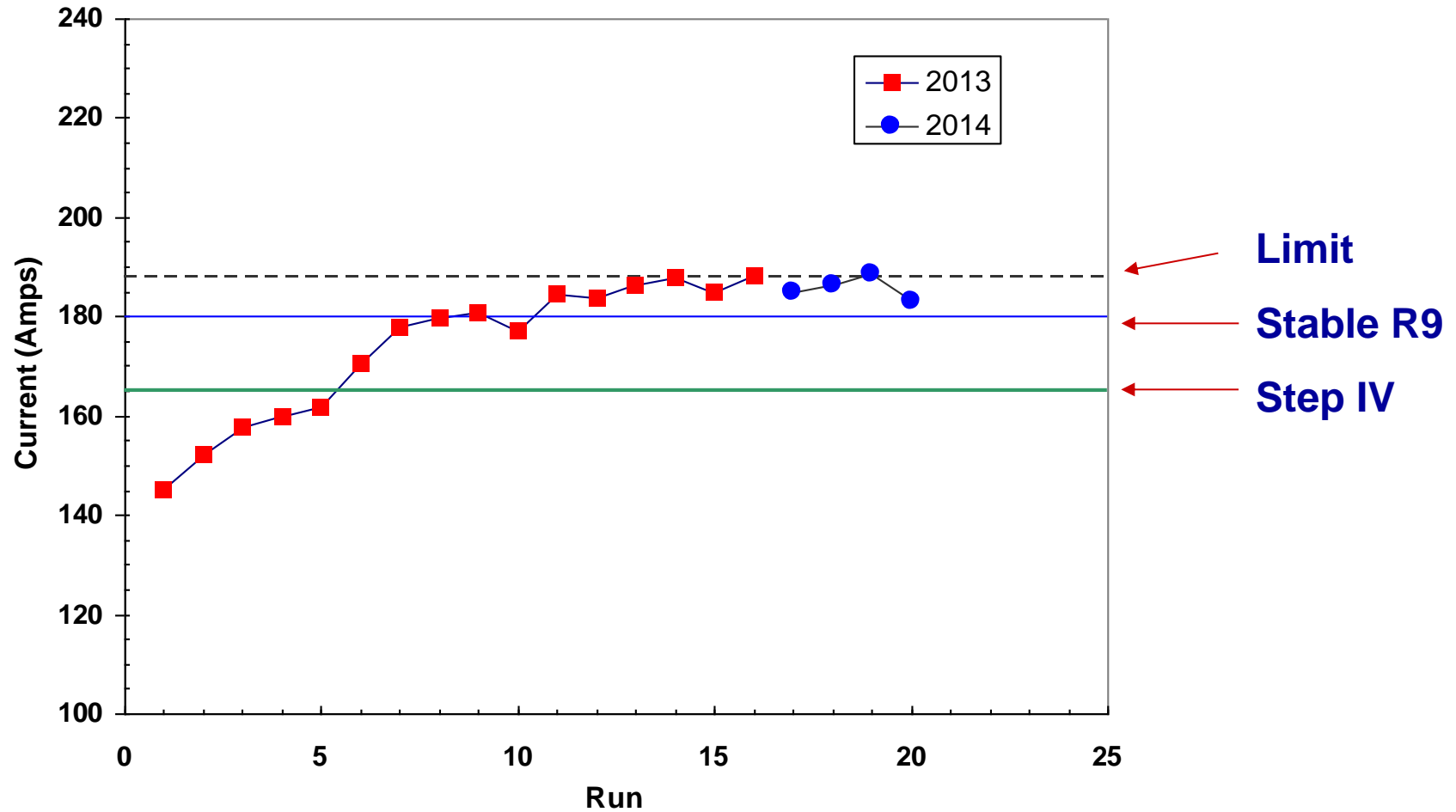
	E	C	E	M	M	FC	FC	M	M	E	C	E	
Abs(J)	135.18	152.44	127.37	137.13	118.56	104.92	104.92	118.56	137.13	127.37	152.44	135.18	
E 135.18	0.0	141.6	0.7	0.2	0.2	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	142.6
C 152.44	-142.4	0.0	120.8	12.5	3.6	1.8	-1.0	-0.2	0.0	0.0	-0.2	0.0	-5.1
E 127.37	-0.5	-120.2	0.0	26.4	4.5	1.5	-0.7	0.0	0.0	0.0	0.0	0.0	-89.0
M 137.13	-0.2	-12.8	-26.4	0.0	27.2	4.0	-1.3	-0.2	0.0	0.0	0.0	0.0	-9.6
M 118.56	-0.2	-3.6	-4.5	-27.3	0.0	28.2	-6.1	-0.4	-0.2	-0.2	-0.2	0.0	-14.4
FC 104.92	-0.1	-1.9	-1.5	-4.0	-28.2	0.0	-220.9	-6.1	-1.3	-0.7	-1.0	-0.1	-265.9
FC 104.92	0.1	1.0	0.7	1.3	6.1	221.0	0.0	28.2	4.0	1.5	1.9	0.1	266.0
M 118.56	0.0	0.2	0.2	0.2	0.4	6.1	-28.4	0.0	27.3	4.7	3.6	0.2	14.4
M 137.13	0.0	0.0	0.0	0.0	0.2	1.3	-4.0	-27.3	0.0	27.4	12.5	0.2	10.3
E 127.37	0.0	0.0	0.0	0.0	0.2	0.7	-1.5	-4.7	-27.1	0.0	115.5	0.5	83.6
C 152.44	0.0	0.2	0.0	0.0	0.2	1.0	-1.9	-3.6	-12.5	-114.2	0.0	140.3	9.5
E 135.18	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.2	-0.2	-0.5	-141.6	0.0	-142.4
	-143.3	4.5	89.9	9.2	14.2	265.8	-266.0	-14.4	-9.9	-81.9	-9.3	141.2	0.008

Force Matrix for Step IV at nominal baseline operating currents, I(FC) = 188 Amps

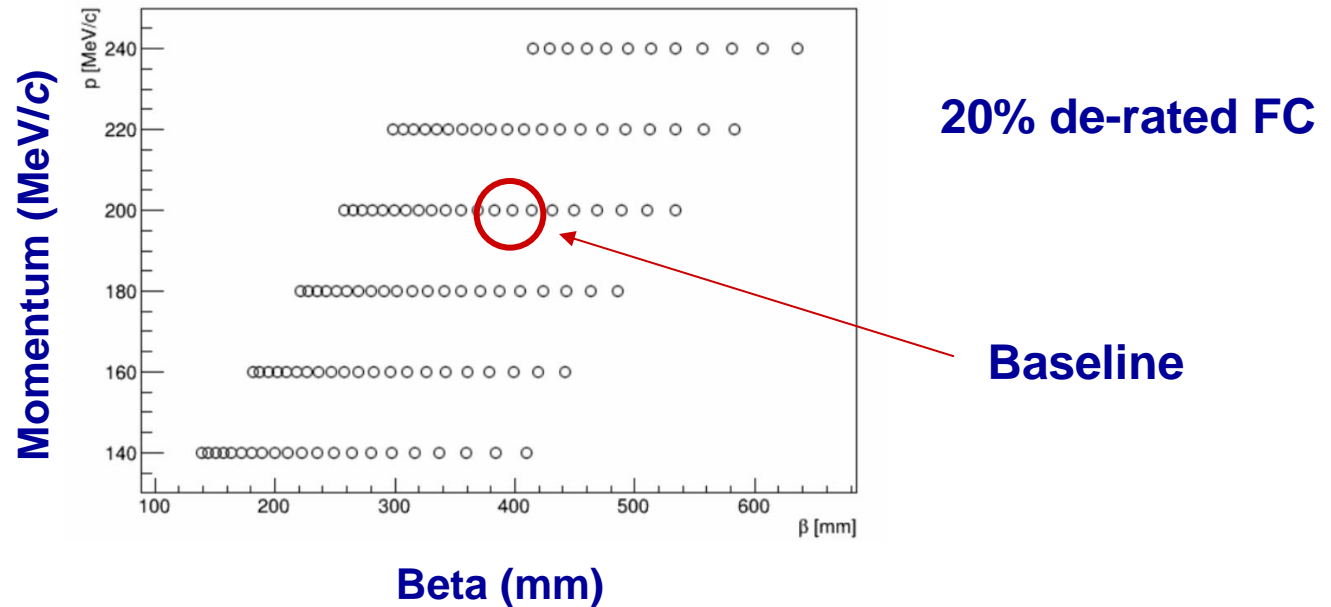
- **Force on a single FC coil increases from**
 - 203 tons in isolation at 180 A → 246 tons in STEP IV
 - i.e. + 43 tons in presence of SS
- **Assume quench occurs at same force on FC coil**
 - Reduce current to 170 Amps → same force
 - Allow 3% headroom 170 A → 165 Amps = 88% of 'baseline'

DE-RATED OPERATION

FC 1 Training Flip Mode



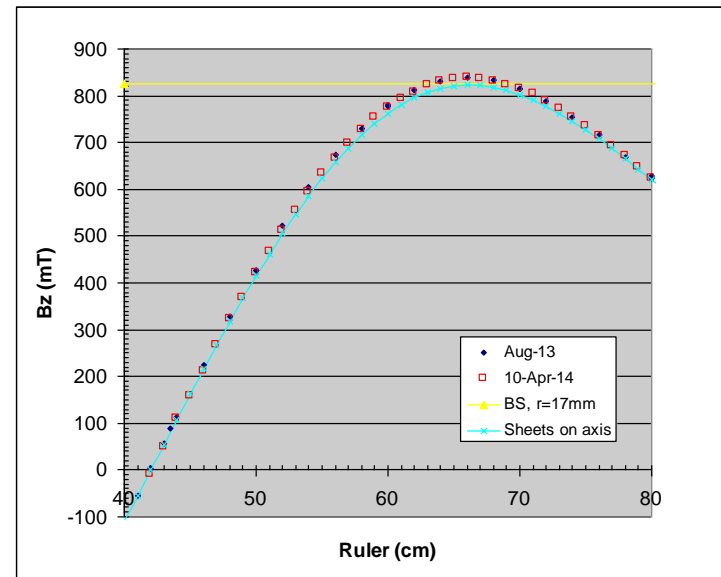
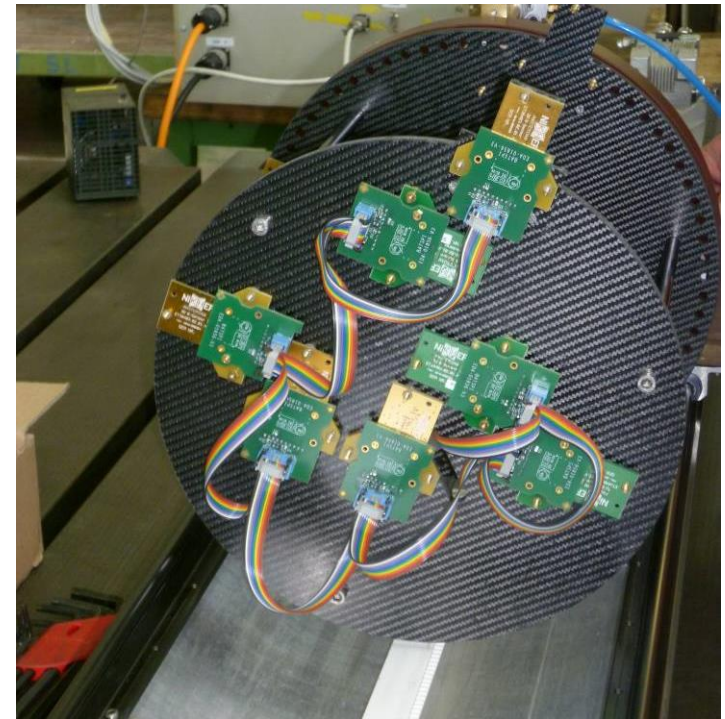
BEAM OPTICS WITH DE-RATED FC

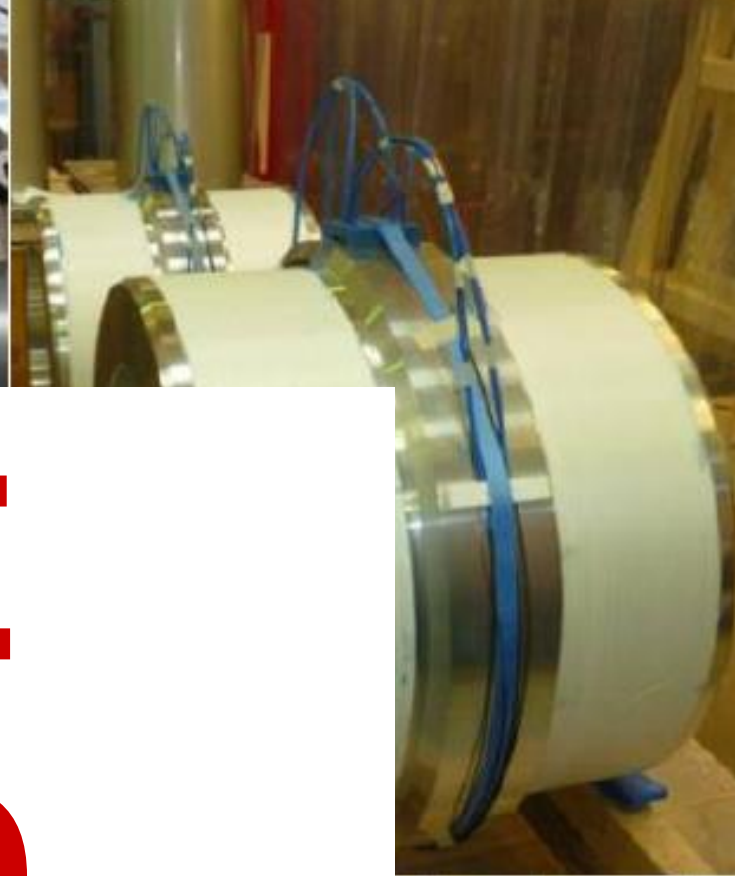


- **Matched optics possible even with 20% de-rated FC**
 - Discussed at last MPB & in other talks

PLANS

- **Need to see how FC 2 behaves asap**
 - Informs what we do with FC 1 & how we interact with manufacturer
- **Have ~ 3 – 4 weeks to work with FC 1**
 - Before instrumentation needed for FC 2
- **Devote ~ two weeks to mapping FC 1**
 - CERN-built mapper
 - Infinite data...
 - Confirm position of coils
 - Also is stability test
 - May solve puzzle of why measured field $\sim 1.5\%$ > calculated field
- **Then start cool down of FC 2**
 - Assess He leak cold
 - Power & test





**THE
END**

