Q2Q3D Specifications, Requirements and Scope

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Q2Q3D Outline

- Q2Q3 and Dipole Contracts
- Q2Q3 and Dipole Specifications
- Scope of Work JLAB
- Scope of Work SigmaPhi
- Contract Reviews
- Contract Documentation

SHMS 11 GeV/c Spectrometer Hall C- June 2016

New companion to the 25 Year old HMS 7.4 GeV/c spectrometer

- 11 GeV/c
- 5 x 10^-4 dP/P resolution
- 4 mStr. Acceptance
- 5.5 to 40 degrees
- Momentum bite 20%

SHMS Spectrometer- June 2016

detectors and magnet yokes

SHMS Magnets and Systems

•Cryo-Control Reservoirs
•Cryogenics Infrastructure

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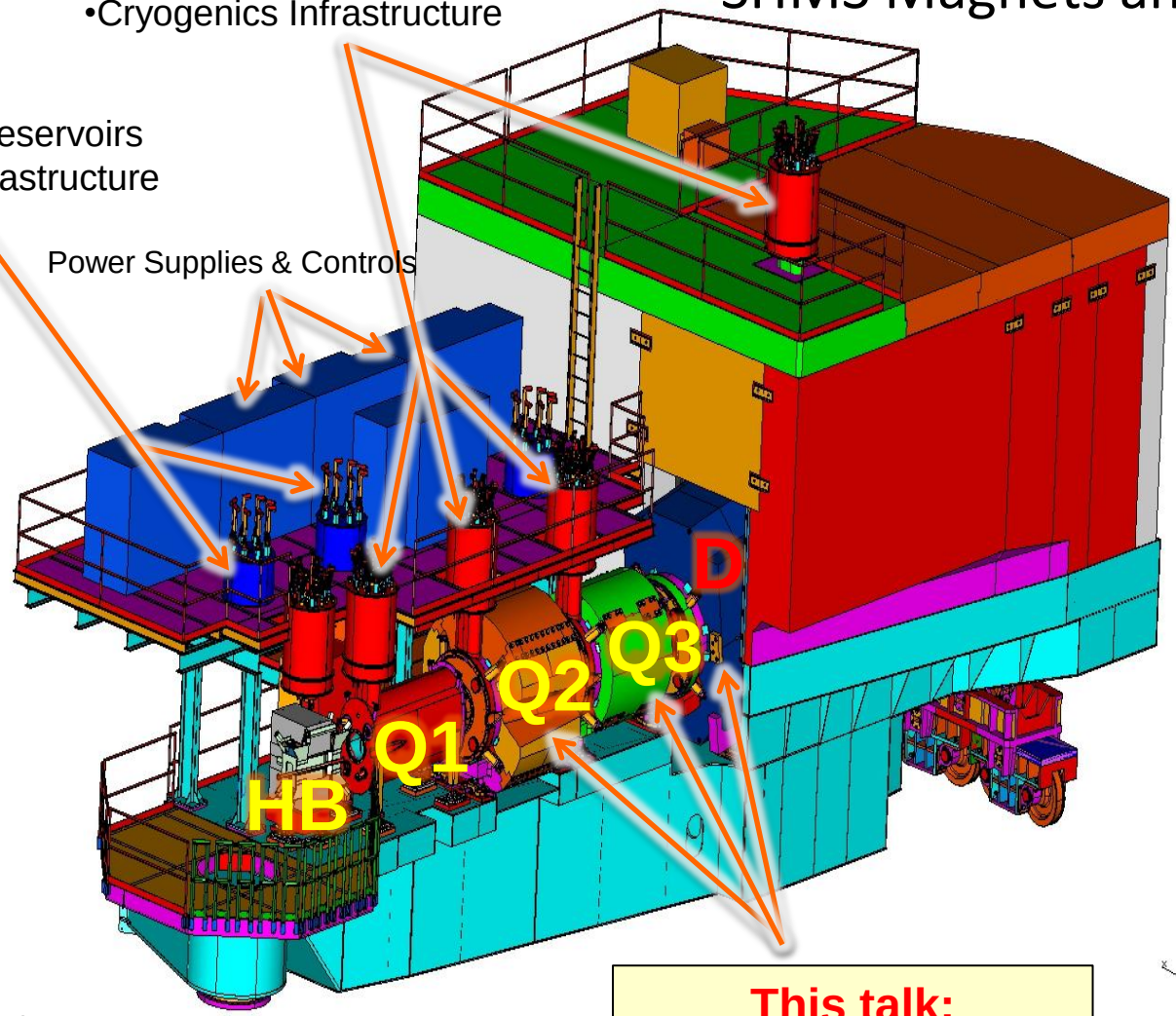
•Cryogenics Infrastructure

Power Supplies & Controls



1 x 10^{-3} dP/P Resolution

4 mSr Acceptance

1 to 11 GeV/c

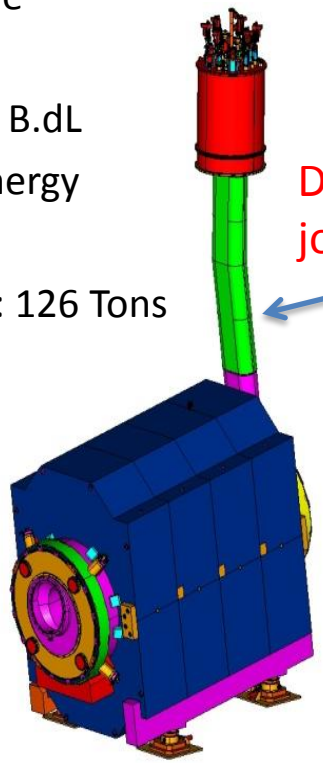
Warm Yoke steel Magnet Supports

This talk:
Q2, Q3 & Dipole
Vendor = Sigma Phi

SHMS Dipole/Q2/Q3

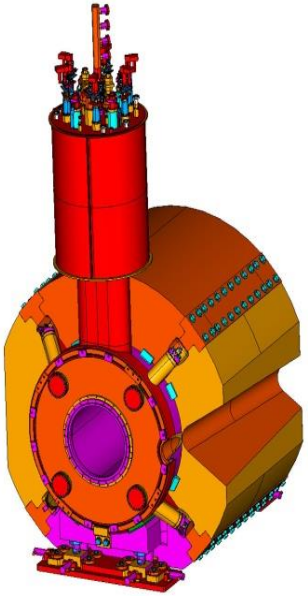
DIPOLE:

- 3.86 Tesla Cosine(Θ) dipole
- Bath Cooled 1.2 Atm, 4.42K
- 60 cm warm bore
- 2.85 m EFL
- 11.2 Tm Integral B.dL
- 17 MJ stored Energy
- 11 GeV/c
- Warm Iron Yoke: 126 Tons



Q2 (shown):

- 11.8 T/m cos(2Θ) Quad
- Bath Cooled
- 1.2 Atm., 4.42K
- 60 cm. warm bore
- 1.64 m EFL
- 7.6 MJ stored Energy
- Warm Iron Yoke: 72 Tons



Q3:

- Identical to Q2 but runs at 7.9 T/m
- Warm Iron Yoke: 18 Tons
- Both use same conductor as dipole (Cu + SSC outer)

SHMS Dipole Q2/Q3 Specifications @ 11 GeV/c

	Q2	Q3	Dipole
Type	Cos 2θ	Cos 2θ	Cos θ
Field/grad	11.8 T/M	7.9 T/M	3.9 T
EFL	1.64 M	1.64 M	2.85 M
Energy	7.6 MJ	3.5 MJ	17 MJ
Inductance	1.14 H	1.14 H	2.86 H
Current	3660 A	2480 A	3450 A
NI	6.3 MAT	4.2 MAT	4.2 MAT
aperture	60 cm Φ	60 cm Φ	60 cm Φ
Dump Volts	270 V	180 V	240 V
Dump R	0.075	0.075	0.075
Conductor Soldered cable in channel	0.3x1.9 cm^2+ SSC outer	0.3x1.9 cm^2+ SSC outer	0.3x1.9 cm^2+ SSC outer
AHS Temp	45 K	34 K	70 K

SHMS Dipole and Quad Magnet Coils

SHMS Quad 2/3

- 8 Layer, 4 Dbl. Pancake
- 2 sector Cos. 2 Theta coil
- Constant Perimeter ends
- 427 Turns/pole

SHMS Dipole

- 6 Layer, 3 Dbl. Pancake
- 2 sector Cos. Theta coil
- Constant Perimeter ends
- 606 Turns/pole

Q2Q3D Interface Specifications

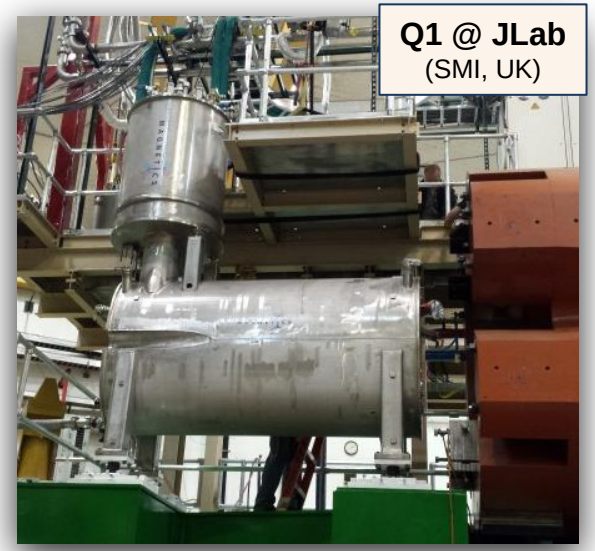
- JLAB Specified and provided the interface for:
  - Cryogenics- Cryo Control Reservoir
  - DC Power Supply- Danfysik (6 V, 4000 Amps)
  - QD/QP- DF quench detector and energy dump
  - Controls – Hall C PLC
  - External Instrumentation- Pressure, LL, Vac, lead flow
  - Internal sensors- detailed spec and wiring in Tech Spec
  - Magnet operating conditions- 4.4 K 1.2 Bar

ASME, Pressure, Leak, VCL and Cryo Spec's

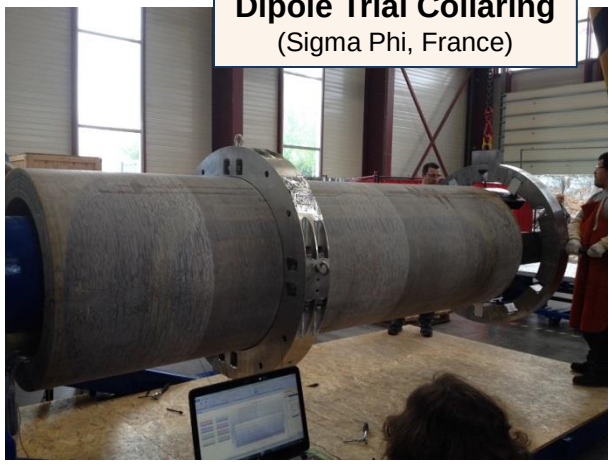
- ASME BPV Section VIII design, fab, test, material certs, welders certs and documentation required- No U Stamp
- Pressure Max HE 75 PSIG, Max LN2 75 PSIG
- Pressure test – 90 PSIG He & LN2
- Leak Test Spec- none at 1 x 10^-9 Atm cc/sec
- Cryogenic QHe < 40 W, QN2 < 100 W
- VCL 5 KA burnout resistant (1.8 LL/Hr/KA, 80mV)
- VCL TESTED conduction limit ~ 3700 A > Q2Q3D Iop

Hall C SHMS Magnets a Year Ago – June 2015

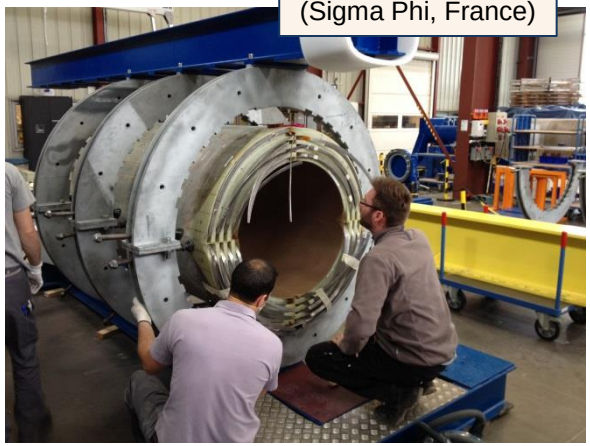
HB @ JLab
(MSU/FRIB)



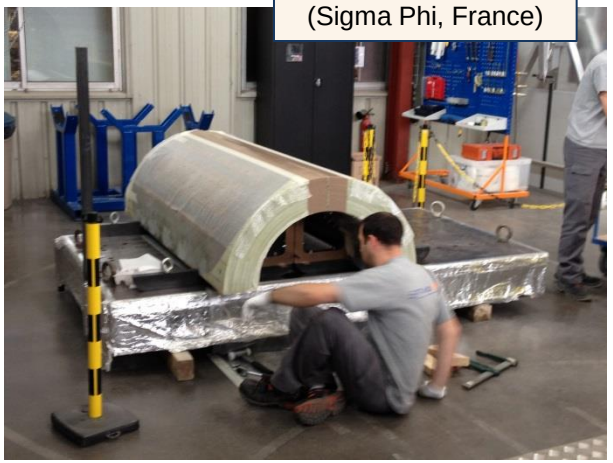
Q1 @ JLab
(SMI, UK)



Dipole Trial Collaring
(Sigma Phi, France)

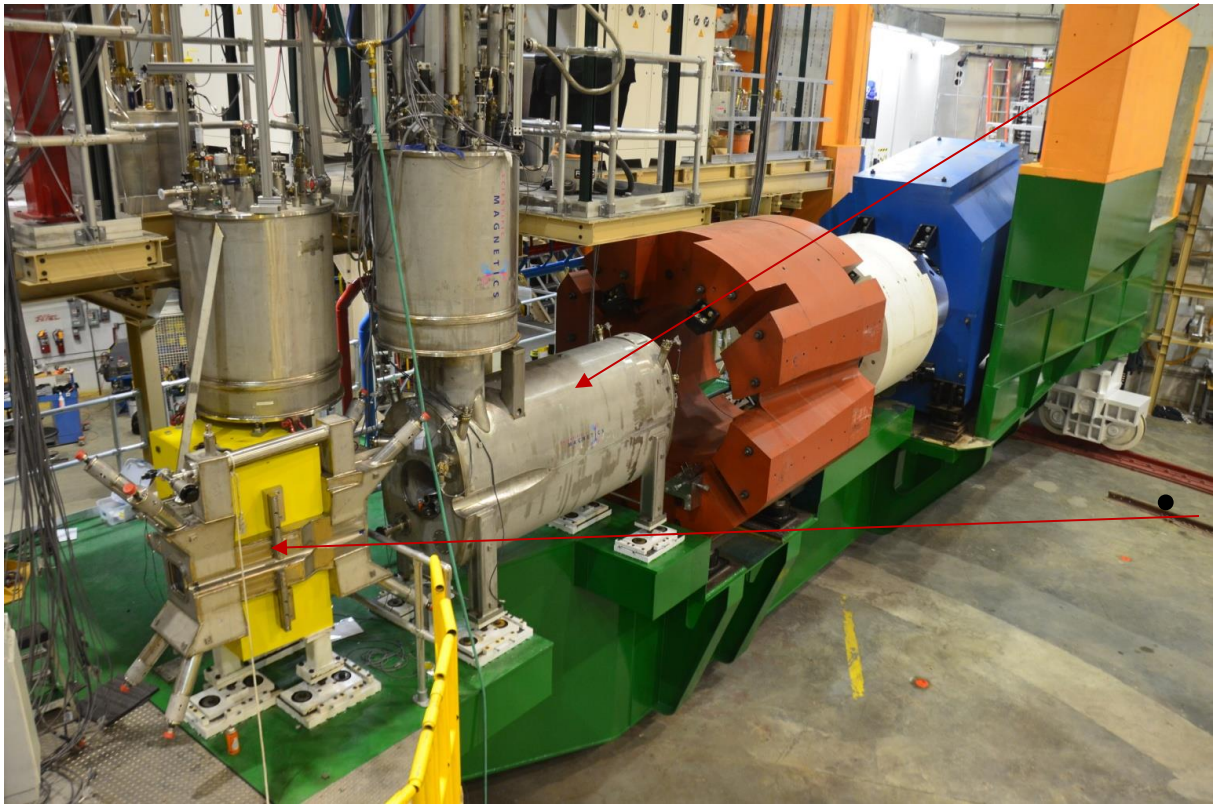


Q2 splicing
(Sigma Phi, France)



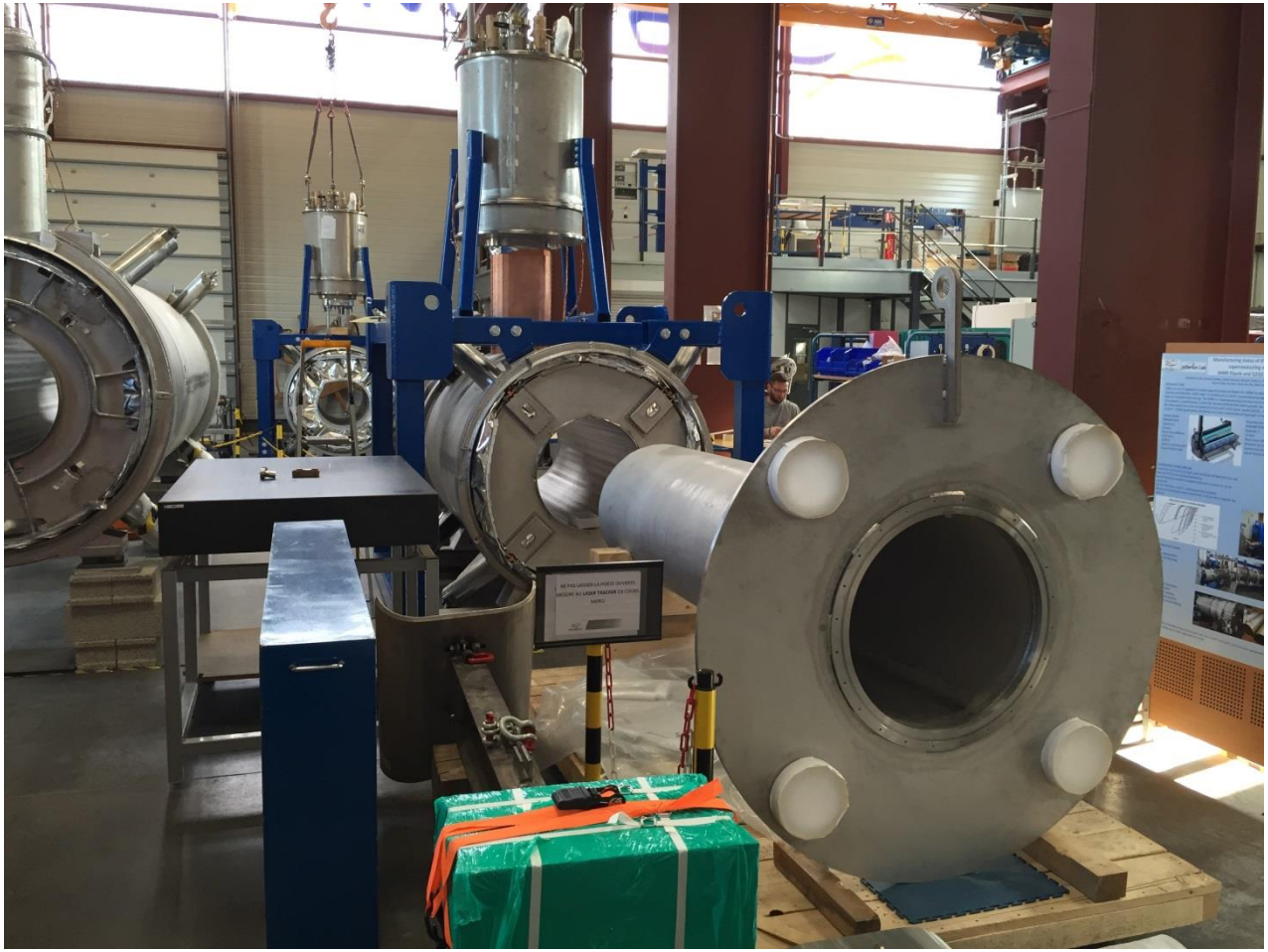
Q3 coil assembly
(Sigma Phi, France)

SHMS Q1 and HB Status



- **Q1:**
  - **Installed on SHMS**
  - **Cooled down**
  - **Power test to 3000 Amps or 110% of operational current**
  - **Accepted 2015**
- **HB:**
  - **Installed on SHMS**
  - **Cooled down**
  - **Power test to 4000 Amps or 102% of operational current**
  - **Accepted 2016**

Dipole , Q2 & Q3 April 2016



Q3 & Dipole June 2016

Q2 July & August 2016

Q2 has landed! Norfolk VA 10/5/16

Q2 in JLAB Hall C 10/8/16

Q2 Mounted on the SHMS 10/9/16

Q2Q3 and Dipole Contracts

- Two Fixed price Design Build Contracts placed with SigmaPhi as a result of a competitive “Best Vaaue” award process- world bidders list- Buy America Act
- Bid documents included a JLAB Reference Conceptual Design(RCD) for both magnets including CAD models, TOSCA models, FEA, models, drawings, reports, test results
- Dipole Contract awarded Aug 2010
- Q2Q3 Contract awarded Oct 2010

Q2Q3Dipole Contracts

- Q2Q3D were 4 year contracts now about 6 years
- Q2Q3D fixed price contracts ~ 20% delta
  - Extra scope items- consolidation and tests
  - Productivity investments- extra tooling and shifts
  - Storage of JLAB excess conductor and tooling
  - Negotiated costs for extra work and problems

Q2Q3Dipole Status

- Q2 is in JLAB Hall C installed on SHMS and under vacuum- Yoke assembly underway
- Dipole is in Antwerp waiting for its ship- ETA Virginia is 10/26/16
- Q3 is complete, leak tested and final welding underway –ship date is 10/31/16
- Documentation
  - FDR Drawings, analysis, reports- Complete
  - Dipole manufacturing Doc. - 90 % complete
  - Q2Q3 manufacturing Doc.- 90 % complete

Scope of Work - JLAB

- RCD provided by JLAB
- Conductor
  - Superconductor(surplus SSC outer 32 strand cable)
  - Copper Stabilizer(copper channel extrusion - FreeportMcMoran
  - Soldering(AES, Allentown PA)
- Cryo-Control Reservoir(CCR)- Meyer Tool & Mfg.
- Burnout Resistant Vapor Cooled Leads, Mfg. & Testing (AMI)
- DC Power Supply (DCPSU)- Danfysik
- Quench protection and Detection- Danfysik
- PLC controls, instrumentation read out, logging-JLAB Hall C
- Warm Yoke- Ningbao-Jensen & Craft Machine
- All on site installation and assembly except soldering dipole SC bus-Hall C
- All on site services for Acceptance Testing (labor, cryogenics, AC power)
- Plus all the free advice the contractor can stand!

Scope of Work - SigmaPhi

- Q2Q3 and Dipole Design and Analysis thru manufacturing drawings including ASME
- Design & build all manufacturing tooling
- Design all manufacturing processes
- Design and perform all QA,QC, Inspections and Tests
- Host Preliminary, Intermediate and Final Design reviews
- Q2Q3D Documentation
- Attend and present at ERR review (today)
- Integrate JLAB items (SC, CCR, VCL's) into Q2Q3D
- Attend Magnet Arrival Tests and Acceptance tests

Scope of Work SigmaPhi II

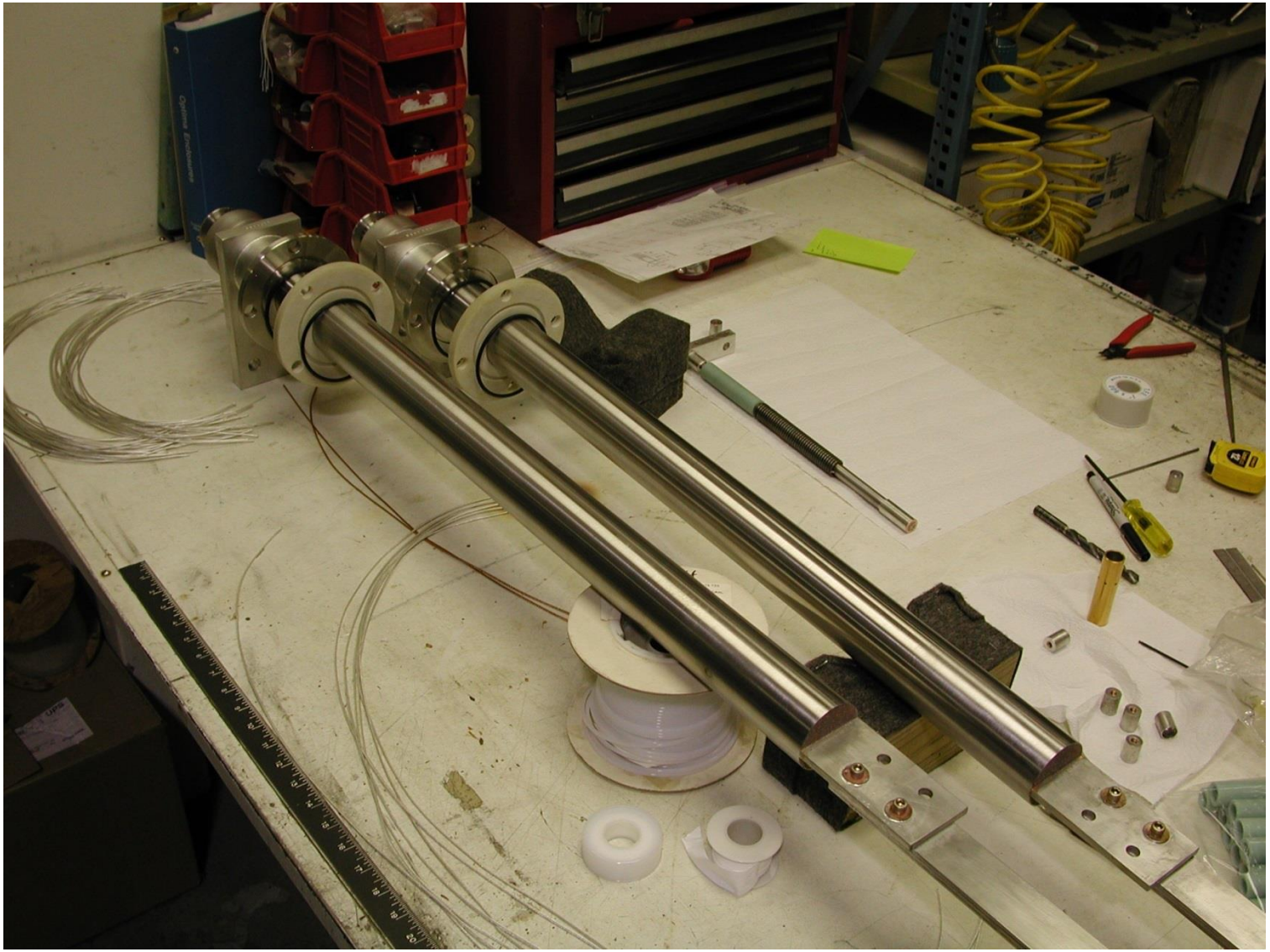
- Manufacture Q2Q3D SC magnets
  - Consolidate conductor (contract mod)
  - Wind coils
  - Vacuum impregnate coils
  - Assemble coils into cold masses
  - Collar coils
  - Magnet instrumentation(Volt Taps, LHE&LN2 Temp. sensors, strain gauges)
  - ASME Code test and documentation- Apave
  - Fabricate cryostats- SDMS
  - Final magnet assembly
  - Pack and ship to JLAB Hall C

Summary

- Fixed price contracts for Q2Q3 and Dipole have born fruit!
- Magnet installation has begun for Q2
- Dipole is on its way and Q3 is ready to ship
- Q2 Cool Down begins in ~ four weeks
- Q2 Low Power Testing begins in ~ 6 weeks
- Q3 Testing Jan 2017
- Dipole testing Feb 2017

Appendix VCL test results

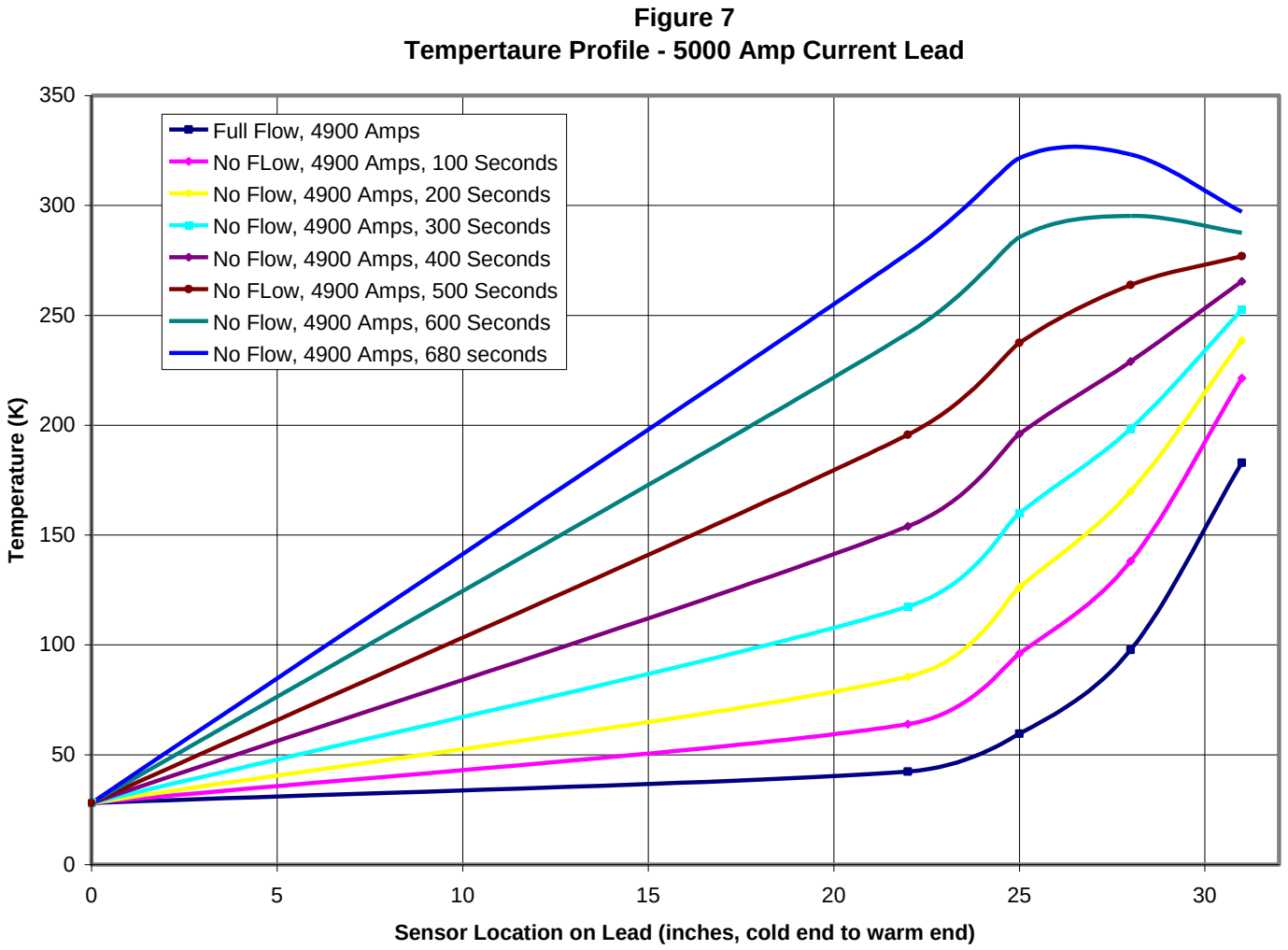
PIX of Burnout proof VCL's



Development of Burnout Proof Current Leads for SHMS Magnets

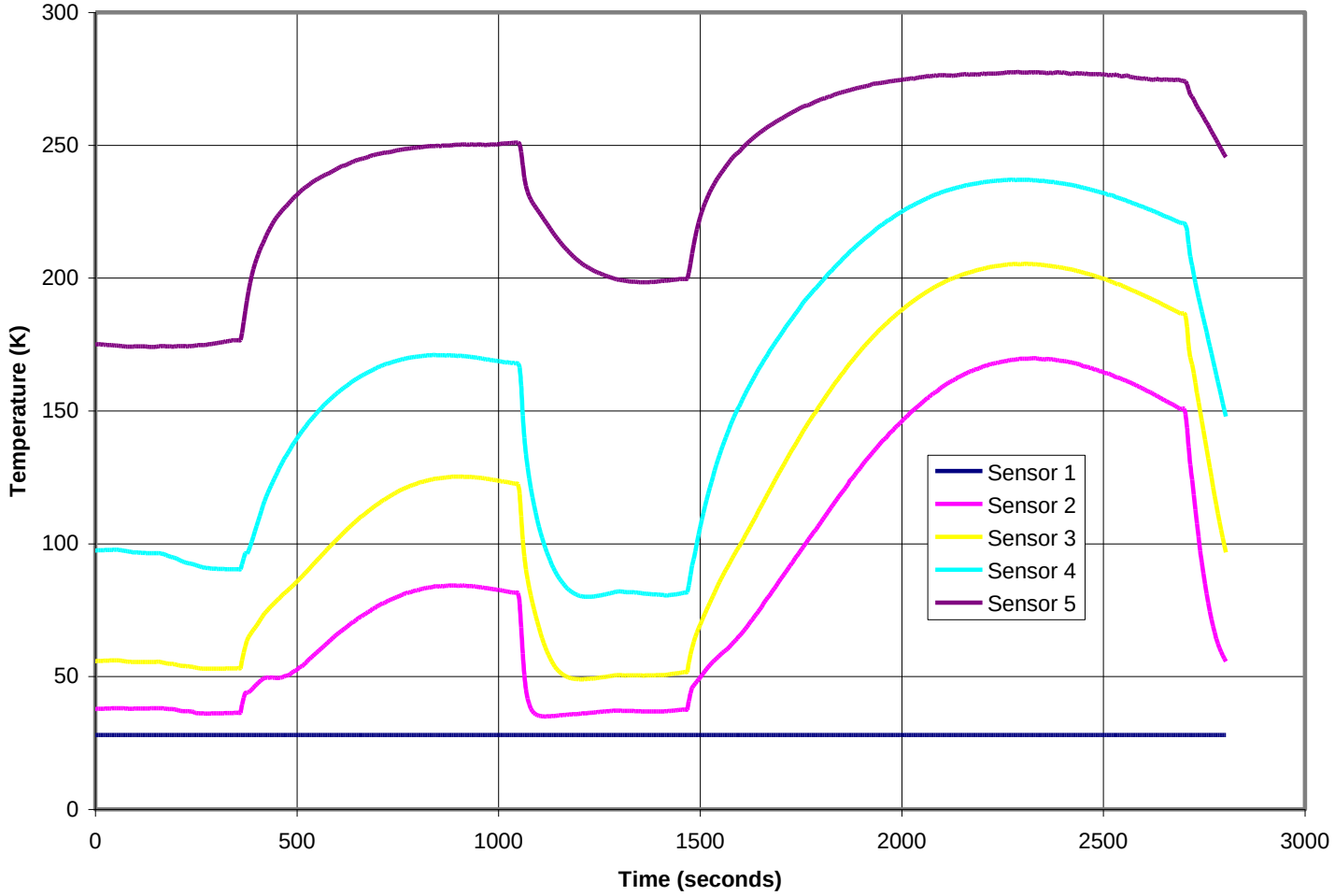
- AMI/JLAB 5000 AMP burnout proof re-optimized vapor cooled current lead (1.63 L/Hr/KA)
- 5 KA lead pair designed, built and tested by AMI
- 5000 A DC No Cooling for 11.3 minutes Safe
- 3700 A DC No Cooling Safe forever
- 33 minute (2.5 A/sec)slow dump no cooling safe
- We required a safe 15 Minute slow dump non cooled discharge!

No burnout VCL 5 KA no coolant 11 min. test results



No burnout VCL discharge test results

Figure 9
Temperature Profiles vs. Time for Decreasing Current

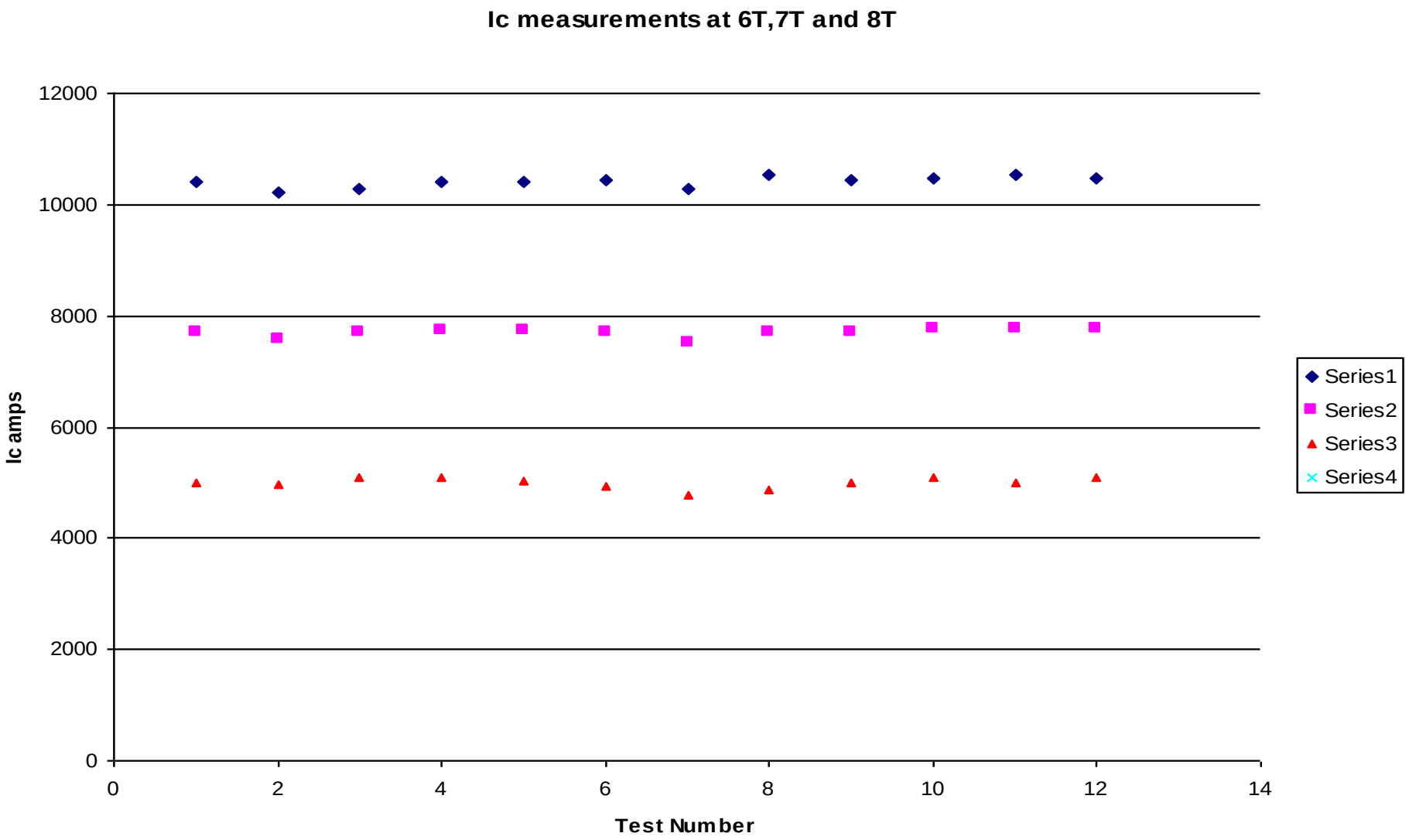


Appendix 2 SSC Cable tests

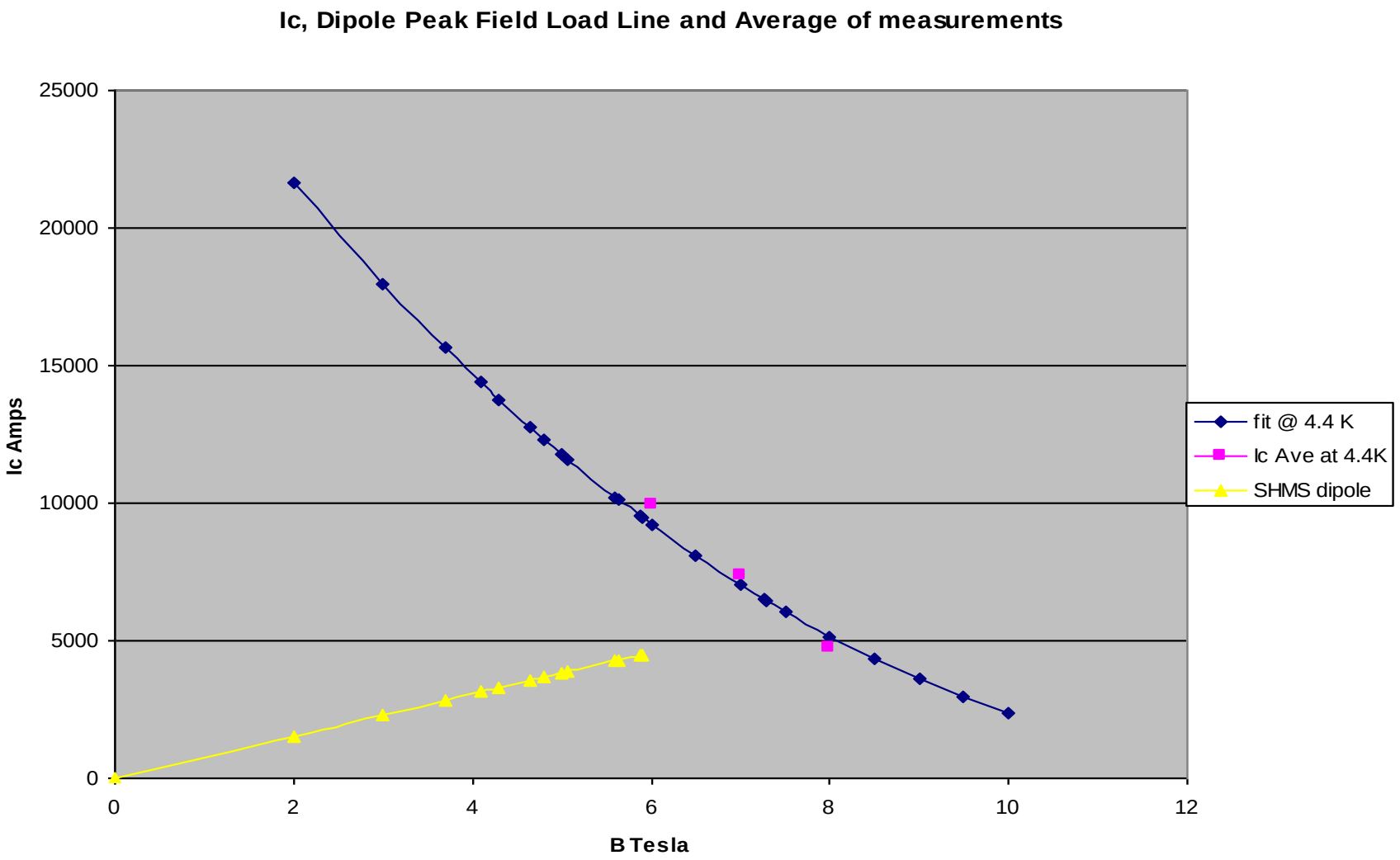
SSC Outer Cable Tests

- 12 samples of SSC outer cable tested at BNL
- Test Conditions ~ SHMS Magnets
- Field Range B (6T, 7T, 8T)
- Current $0 < I < 11{,}000$
- Tests at 4.2 K
- Results compare favorably to nominal short sample curve Ic=31532(1-B/15)^2.315 L. Dresner
- Typical Ic twice (or thrice) Io at constant B

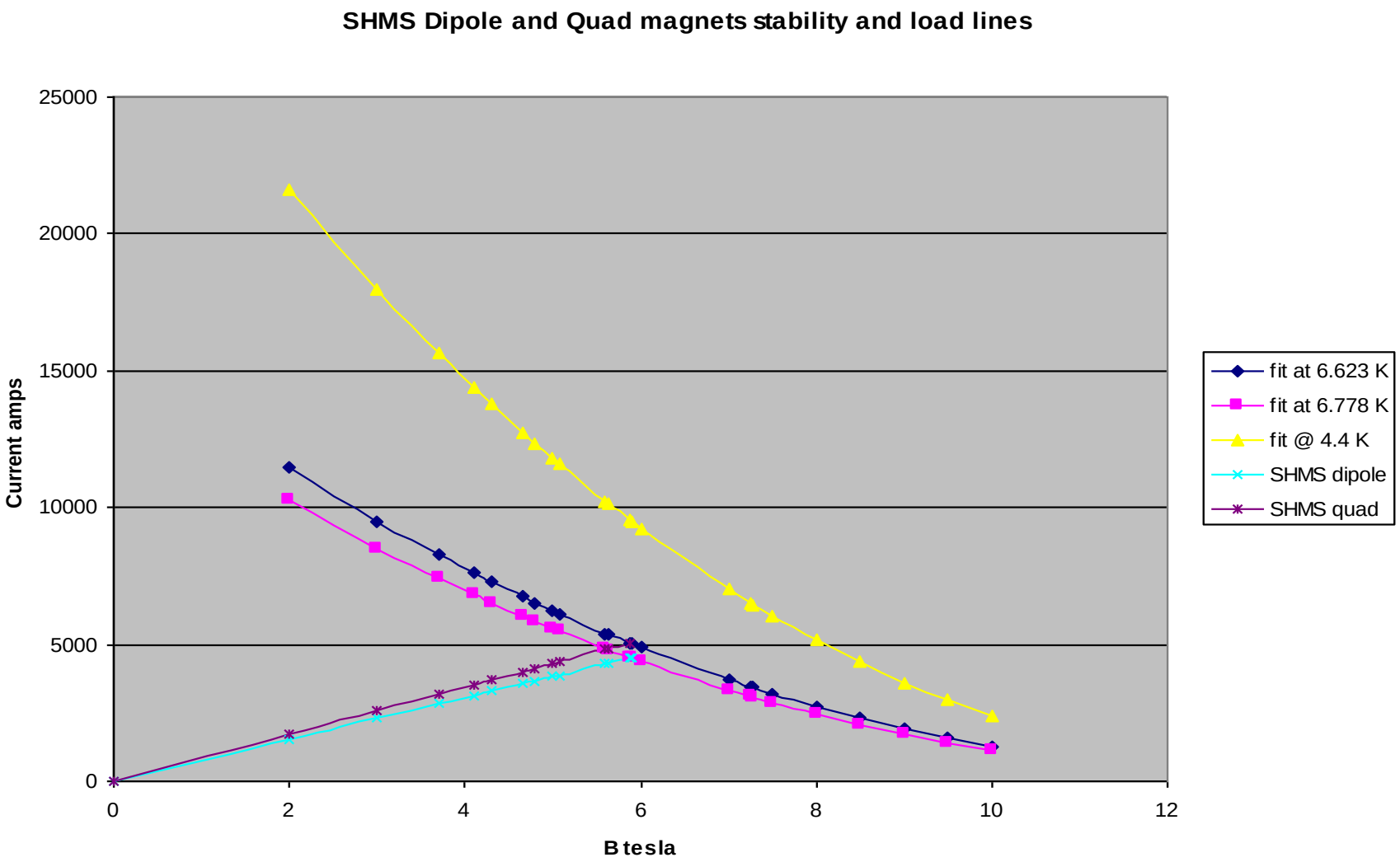
SSC Outer Cable Measurements at 4.2 K



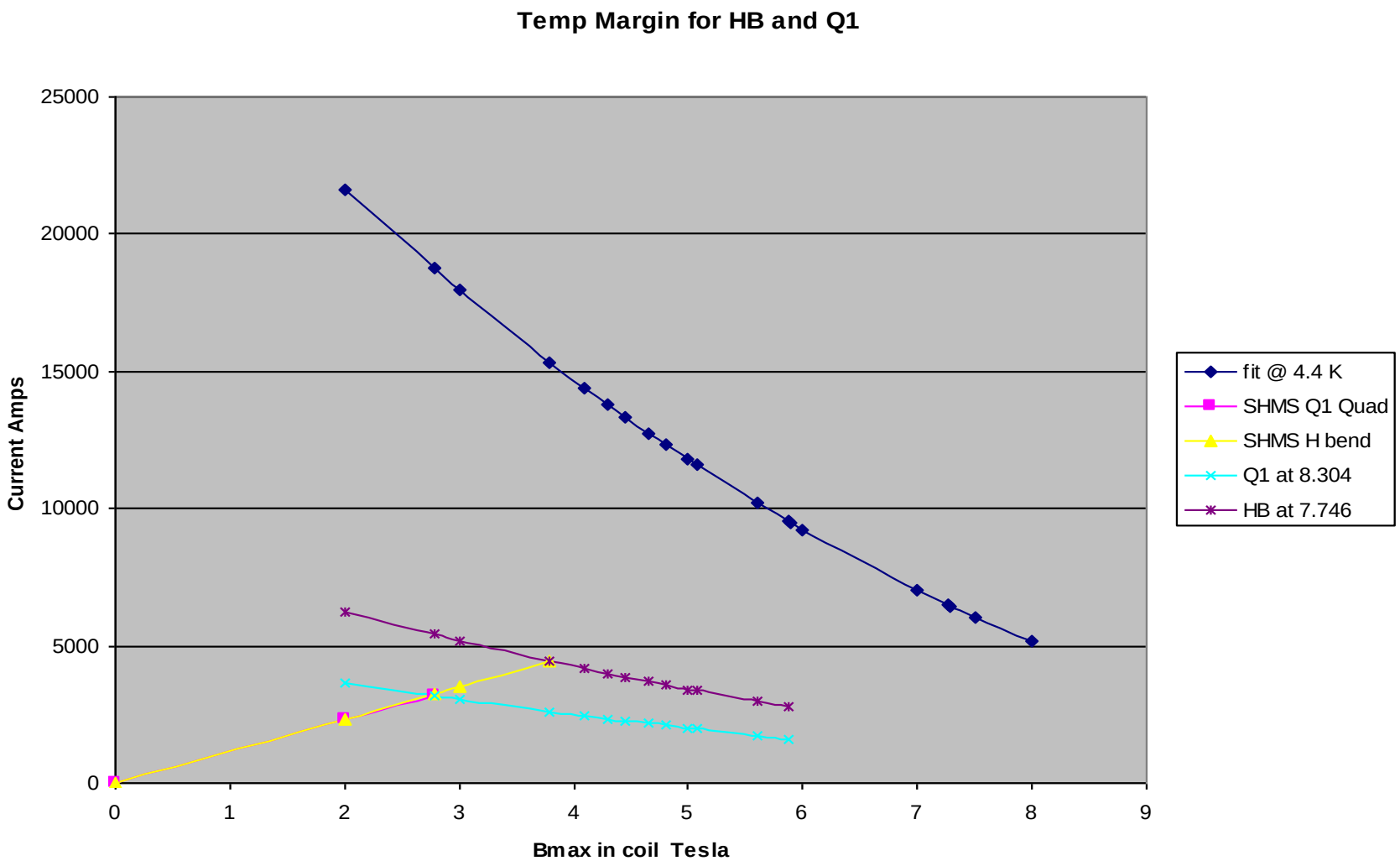
Cable Tests, Nominal SSC Outer Short Sample Curve & SHMS Dipole Peak Field Load line



SHMS Dipole and Q23 temp margins



SHMS Q1' and HB Temp margins



SHMS Operating Margins on Peak Field Load Line

	Temp K	Current A	Ratio Ic/Io	Field T	Energy J/M
HB	3.31	3408	(1.77)	2.91	0.088
Q1'	3.86	4659	(1.46)	3.92	0.213
Q23	2.18	1217	(1.24)	1.43	0.480
Dip	2.34	1552	(1.35)	1.68	0.528