PCMAG without Liq. He

The LC TPC collaboration Meeting

26-27 March, 2012 at DESY

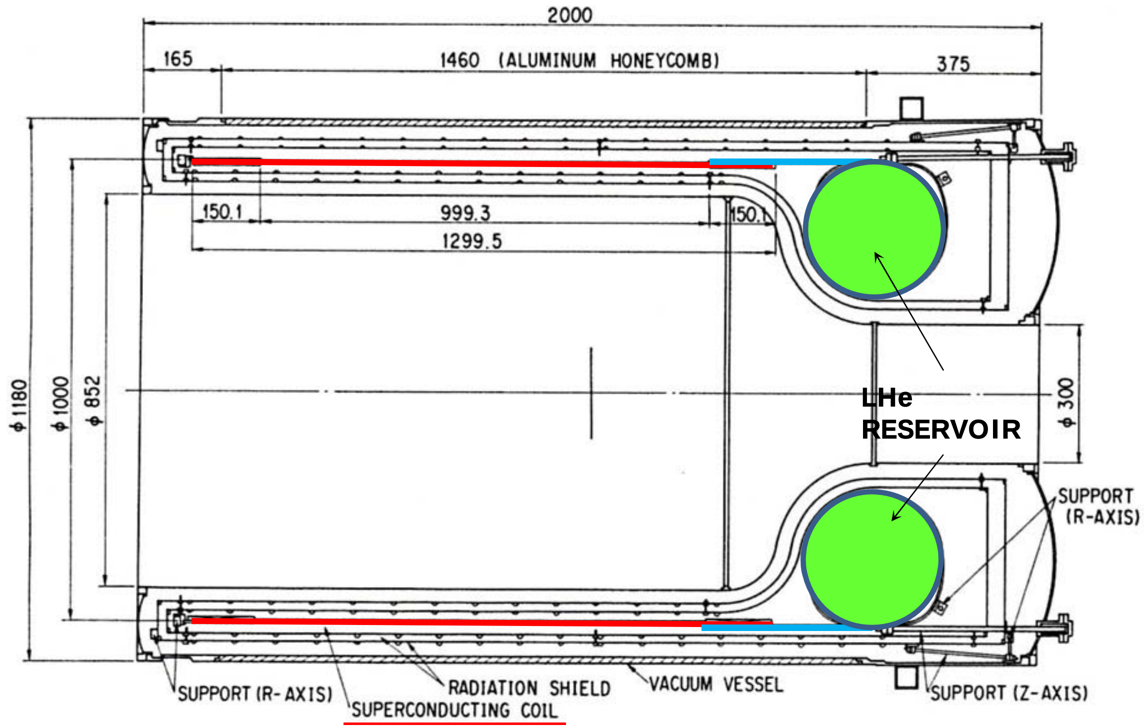
KEK/IPNS Cryogenic Group

&

LC TPC Japan

These slides were originally prepared by M. Kawai/Cryogenic group in Japanese. TM translated it in English, and modified/added with some more information.

PCMAG without Liq. He

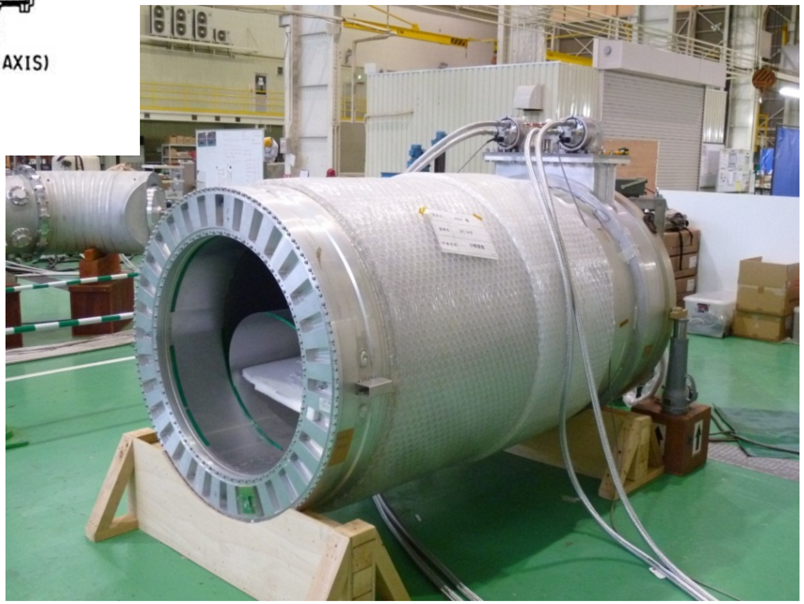


Before the modification

Conduction cooling by Liq. Cooling in the reservoir tank (in green) in PCMAG

After the modification

Conduction cooling by two GM (Gifford McMahon) crycoolers; One of two stages (4K), and another of one stage (10K). The reservoir tank remains as a heat sink.



Modification of PCMAG

Modification:

The compact GM cryo-cooler of 4K now available with an efficient regenerator of good materials.

PCMAG is based on the conduction cooling of the thin superconducting coil from the reservoir tank filled with Liq. He. It is rather easy to switch to the cooling by cryo-coolers (actually to cool the reservoir tank).

Two cryo-coolers: One two-stage 4K cryo-cooler cools the coil and the thermal shields. Another one-stage 10K cryo-cooler cools the High Tc (HTc) current leads made of a high-temperature superconductive material.

Advantages in the operation after the modification:

Simply switch-on the cryo-coolers to start cooling PCMAG.
No Liq. He fillings, no recovery of He gas, and no pre-cooling.
Safe operation without Liq. He.
Long-period, unattended-operations possible.

Some design issues:

Estimation of thermal loads, and the selection of cryo-coolers (power).
Good thermal conductivity from the cryo-cooler to coil etc.
Mechanical vibration of the GM cooler.

Thermal Loads and Selection of Cryo-coolers

Thermal loads	1st stage	2nd stage (4K)
Radiation	30W	0.5W
Thermal conduction	1W	0.02W
Current leads	42W	0.1W
Summation	73W	0.62W

Cryo-cooler	Cooling power [W]		Thermal load [W]		Expected Temperature [K]	
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
RDK-408D2	34W @ 40K	1W @ 4.2K	31	0.7	38	3.8
RDK-400B	54W @ 40K	-	42	-	30	-

RDK-408D2 : 1st radiation shield (in the 1st stag), and the coil (4K) in the 2nd stage.
RDK-400B: Current leads (high temperature side) and 2nd radiation shield.

Cryocoolers

Two-stage 4k cryo-cooler

To cool coil and the 1st -radiation shield

Sumitomo (SHI) Cryogenics 4K cryo-cooler RDK-408D2 with a compressor F-50:

1st Stage Capacity : 34W @40K @5 0Hz

2nd Stage Capacity 1.0W @4.2K @ 50Hz

One stage 10K cryocooler

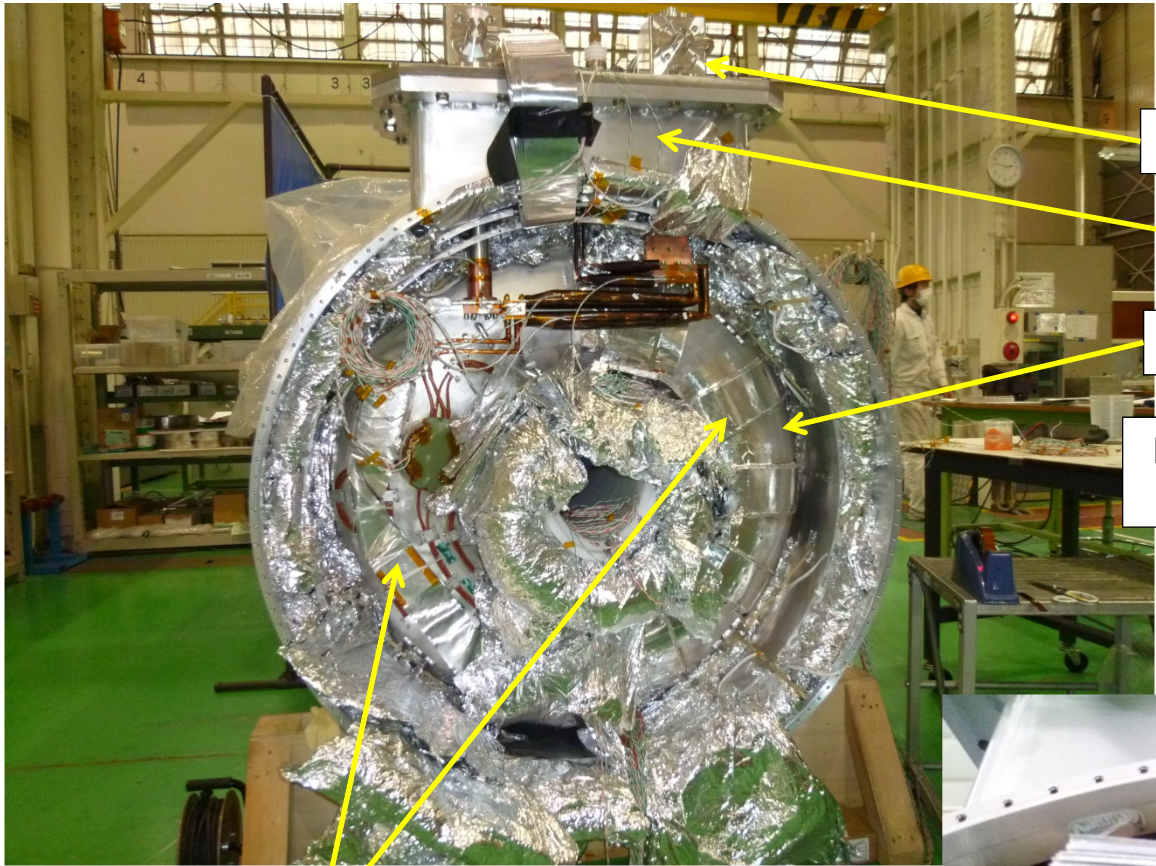
To cool HTc-superconductive current leads

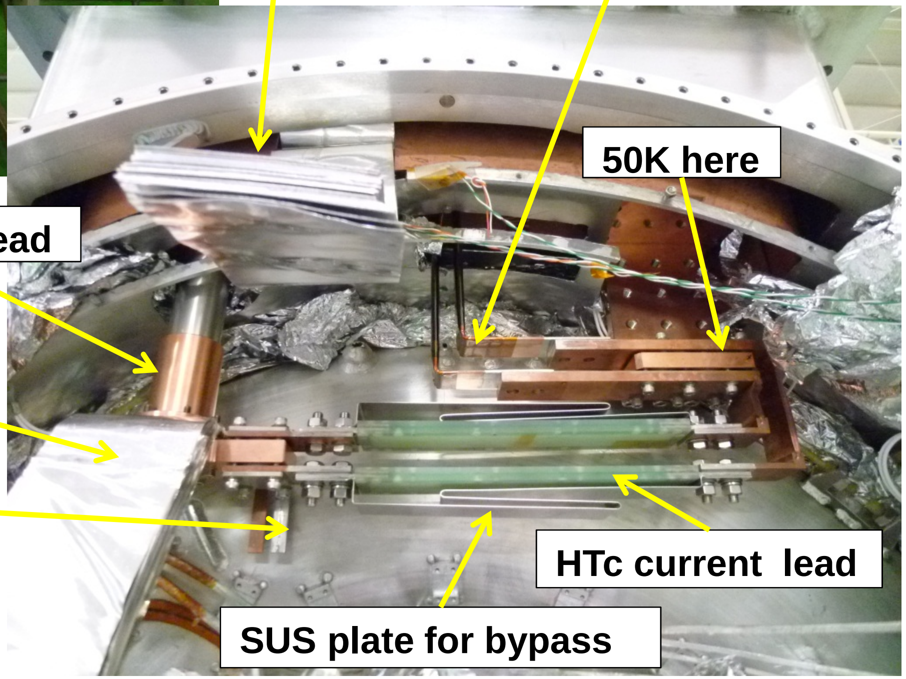
Sumitomo (SHI) Cryogenics 10K cryo-cooler RDK-400B with a compressor F-50

1st Stage Capacity : 54W@40K @ 50Hz

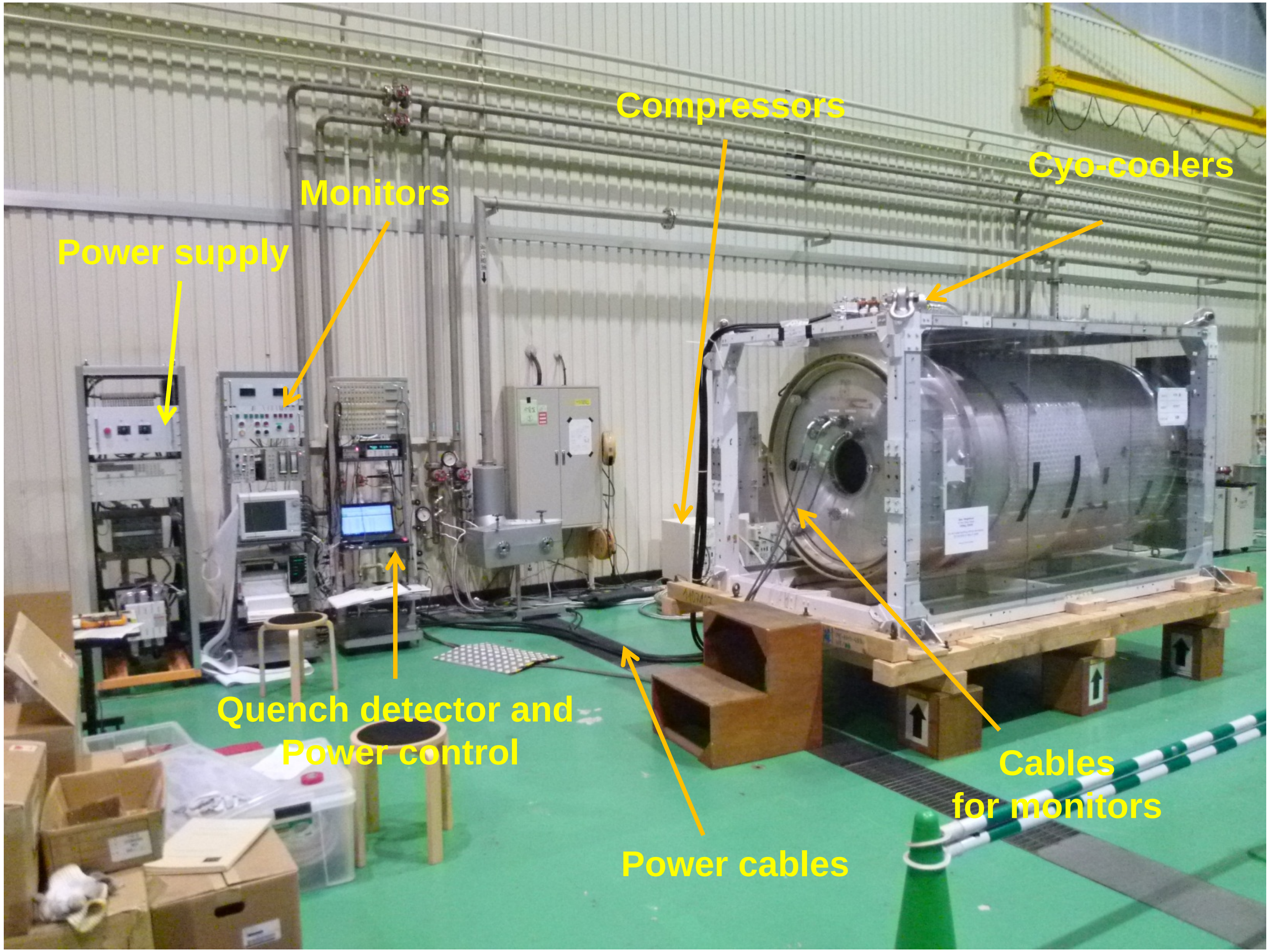
http://www.shicryogenics.com/

Some Details inside





Setup for Toshiba Test



Cooling and Excitation Tests at Toshiba

(Plots of monitor data are not yet ready. Sorry!)

10:16 Mar 10, 2012 : Start cooling

Mar 16： PCMAG delivered to KEK at Toshiba. Test continued by KEK with Toshiba at Toshiba before its shipping to DESY.

12:00 Mar 19 : The coil temperature at 5K

13:30 Test excitation in steps:

10 A→100 A→ 200A → 300A → 400A → 432A(*)

(* the nominal current for 1T)

17:50 432A（by the shunt register）/0.03V across the coil.

Power Supply output : 445.21A at 2.195V

Power supply settings: 445A and 2.5V

（Some voltage drops in the power cables and breakers)

18:50 <u>Hold the 1T excitation for one hour. No change of temperatures, the voltage and current observed.</u>

Stray field for the cryo-cooler:

Around the cryo-coolers: 600Gauss

Inside the magnetic shields of the cryo-coolers: 160Guass

18:55 Switch on the breaker to switch off magnet.

A Quench during the De-excitation

18:55 Mar 10, 2012	Switch on the breaker for de-excitation. The coil quenched during the switching-off Max coil temperature: 50K Max coil voltage: -59.572V The protection beaker functioned by the voltage (3mV) across the HTc current leads, while the setting was 1mV at the time.
00:40 Mar 20	Coil cooled down and ready for excitation. Excited PCMAG up to 200A . Confirmed no damage of PCMAG. Switch-off from 200A to 50A alright through the diode built-in the power supply. (The limiter for the voltage across the HTc current leads was set to be 4mV.) From 50A to 0A, de-excited through the current dump resistor.
01:30	Switch all off for the shipping on March 21. Remove high pressure He gas in the cryo-cooler system.
10:00 Mar 21	Shipping out from Toshiba: Coil temperature: 28K Hold the vacuum
08:00 Mar 24	PCMAG arrived at the Hamburg airport.

Possible Origin of the Quench

Need to optimization some parameters of the PS system

The coil temperature raised due to the eddy current during the switching-off process of the magnet when the cooling power of the cryo-cooler (1W at 4K) was limited. Most probably the resistance of the current dump resister (0.15 Ohm) was not proper.

→ Need to optimize the value of the current dump resistor at DESY.

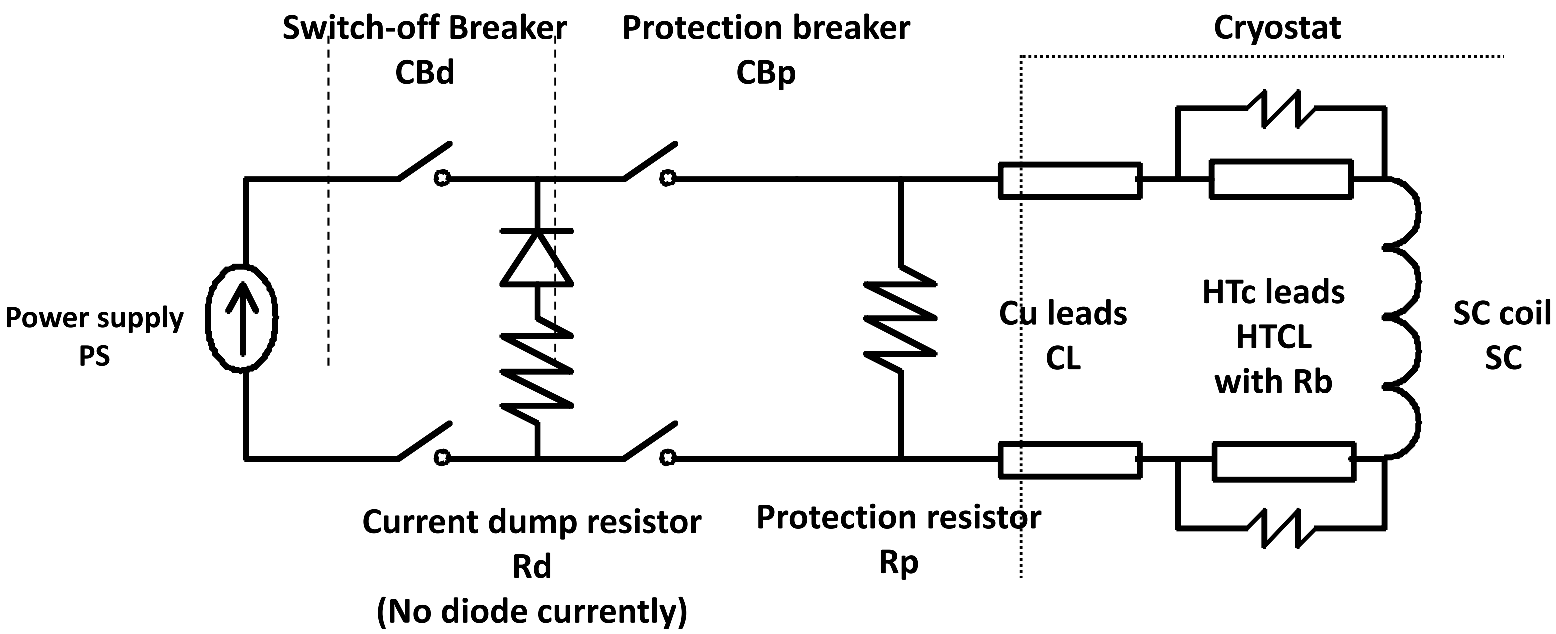
Possibly due to the quench of the coil, the temperature of the HTc current leads went up, and the limiter for the voltage across the current lead opened the protection breaker.

→ Need to optimize the limiter setting for the HTc current leads.

We <u>need to continue test excitations (probably at low excitation currents) at DESY to optimize these parameters,</u> and prepare for a safe operation by physicists for beam tests.

(KEK was responsible to prepare the PS system)

PCMAG Power Supply System



Parameters (current values)

超伝導コイル	インダクタンス	6H
	電流	430A
	エネルギー	560kJ
Rbp	抵抗値	
	熱侵入量	
高温超伝導リード	材料	
	電流容量	
	熱侵入量	
保護抵抗	抵抗値	1Ω
	吸収エネルギー	560kJ

保護抵抗	抵抗値	1Ω
	吸収エネルギー	560kJ
消磁抵抗	抵抗値	0.1Ω
	吸収エネルギー	560kJ
保護用遮断器	遮断電圧	1kV
	電流容量	500A
消磁用遮断器	遮断電圧	100V
	電流容量	500A
直流電流源	Agilent 68**	800A 5V

Proposal of a Schedule of Setup and Test of PCMAG at DESY

In April-June, 2012

24 March 2012	PCMAG arrived at the Hamburg Airport.
??	PCMAG delivered at DESY.
The second week of April:	To open and check the PCMAG, and to confirm all the preparation to setup PCMAG at T24-1, Makita and Kawai plan to visit DESY.
In April	At DESY, mounting PCMAG on its table, and probably already mount the TPC support in PCMAG. At KEK, prepare all necessary items of the PS and monitor system.
The beginning of May:	Ship out the PS and monitor system to DESY from KEK.
The end of May:	Kawai and Kondo will visit DESY to set up the PS and monitor system and to check all. Start cooling. Check if any problem of the vibration.
The beginning of June:	Makita will join to start excitation and necessary optimization.
By the end of June:	Deliver the perfect PCMAG system to the LC TPC collaboration.