

# Electron-Muon Ranger (EMR)

## Construction and Tests

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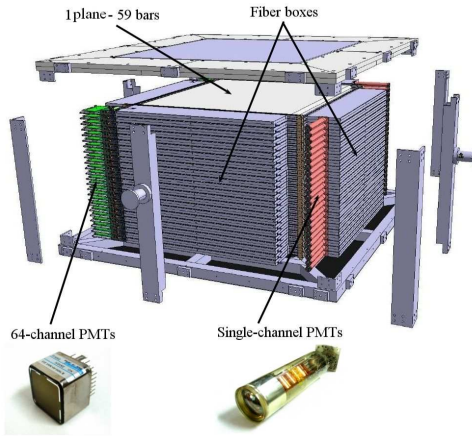
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MICE Collaboration Meeting 29, February 15-18, 2011

# Characteristics

## Horizontal View



### Characteristics

- 24 modules (X-Y planes)
- 48 planes
- 59 bars per plane
- 2832 bars
- 3m WLS fibers per bar
- 8.5 km WLS fibers
- single and 64-channel PMTs per plane
- 3072 + 48 channels

# Application

## Physics Goals

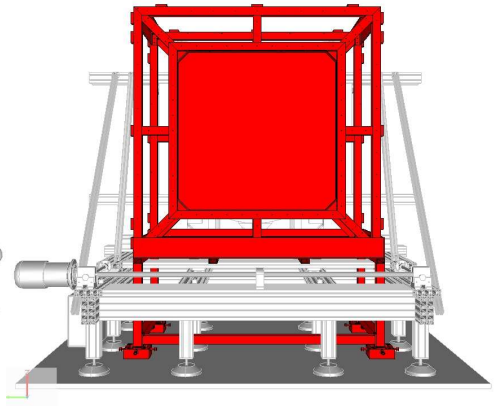
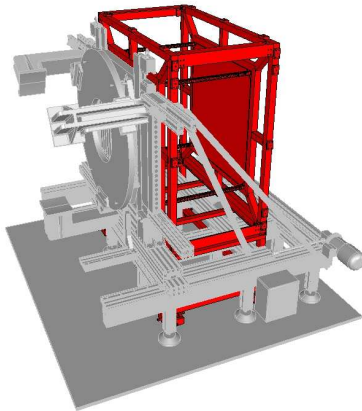
- Almost  $1\text{m}^2$  of active volume allows to stop electrons and muons with momentum up to 280 MeV/c.
- Different behavior of muons and electrons gives very distinct identification signatures.
- Granularity of the detector allows to reconstruct individual tracks and measure energy deposition in every bar.

## Future Applications

Because of the modularity and relatively low cost, this detector can be extended to cover big area and be used in large scale neutrino experiments.

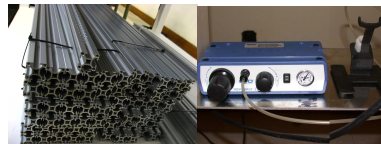
# EMR at RAL

## Integration with KL and Supporting Frame



## Production Status. Bars

All supporting metal bars manufactured, all fiber boxes produced, more than 1000 bars glued with fibers, 18 planes assembled, 2 modules (4 planes) are fully equipped with fiber boxes and PMT connectors (see EMR Test Setup).



In order to speed up gluing of WLS fibers into scintillator bars a special device is being employed.

## Production Status. Fiber connectors

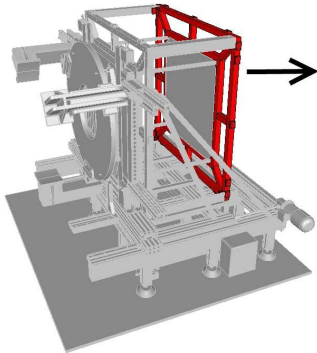
It is crucial to have very good optical contact between fibers and PMTs window in order to reduce light loss. After fibers are glued into connectors they are polished.



A dedicated polishing machine is being used.

## Outer Box. Bottom Frame

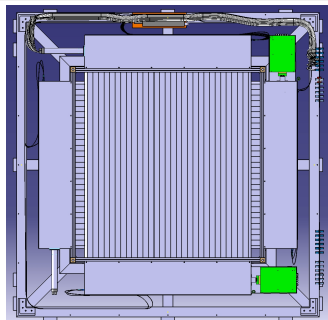
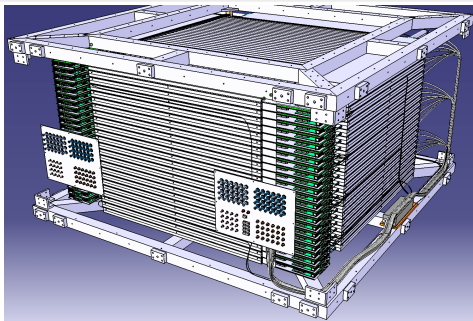
The Outer box will house the EMR planes and patch panels and will be used for transportation



the bottom frame has been manufactured and will be used to store completed modules

# Outer Box. Patch Panels

work in progress



- there will be 4 patch panels located on the sidewall of the outer box (more than 200 connections)
- cables tightly attached to supporting frames and walls
- all patch panels will be detachable for easy access
- protection will be put on low voltage power cables



## Issues

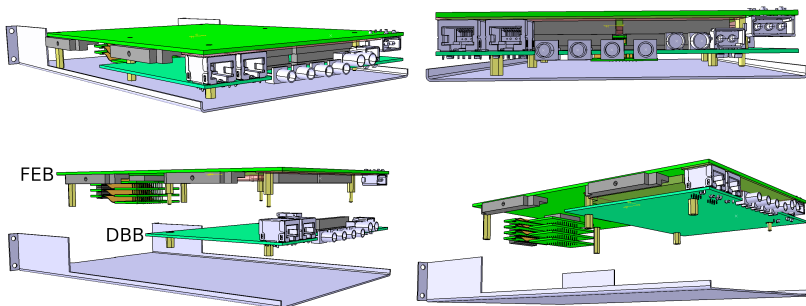
- 1-2 scintillator bars are usually replaced during assembly due to broken fibers (we keep the bars for future use)
- 16 low voltage power supplies should be ordered:
  - each should provide 5V and 15A
  - will power 48 DBBs and 48 FEBs
  - separate digital and analog lines

## Production Schedule

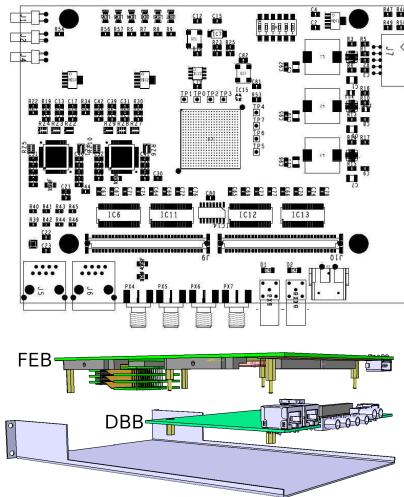
- 1 module (2 planes) can be completed within a week (if 118 bars were glued with fibers and assembled earlier)
- production of all the modules will be finished in September-October this year (see EMR Schedule)
- the outer box will be produced by May to be used for transportation and tests in June

# New Electronic Boards for 64-channel PMT

A new Front-End-Board (FEB) and Digitizer-Buffer-Board (DBB) were developed in order to read 64-channel PMT and store data during the MICE spill and subsequently transfer it to a dedicated VME board.

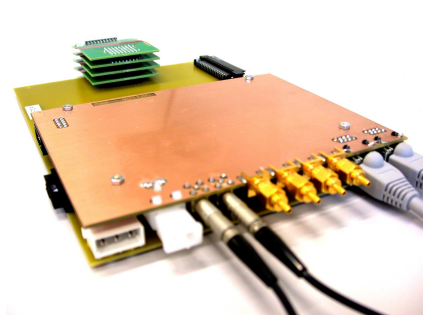
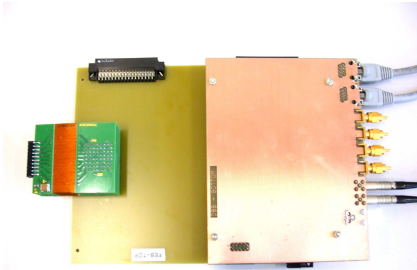


# Digitizer-Buffer-Board

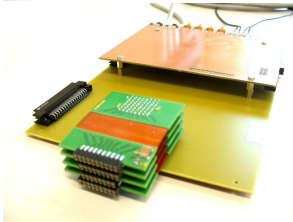


The DBB samples the 64 channels coming from FEB and transmits the event data upon request of the acquisition system. FPGA performs the sampling, data buffering, and data-flow control functions of the board. Internal memory of the FPGA is used to store data which is a collection of rising/falling edge timestamps which occurred on each channel during a spill. Six DBB are daisy-chained together with upstream and downstream links. The first DBB in each group is directly connected to the acquisition system.

# Mechanical Model of DBB and FEB

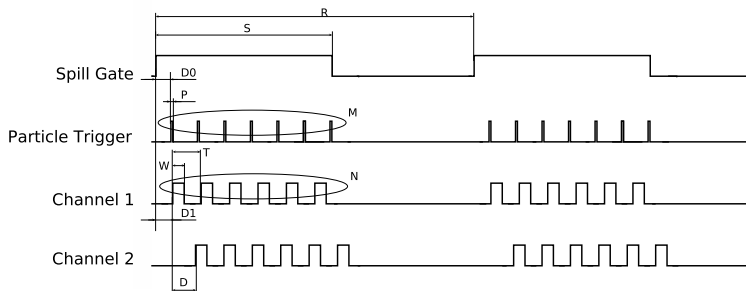


A full mechanical model of DBB and FEB was produced in order to test the assembly and accessibility of different connectors.

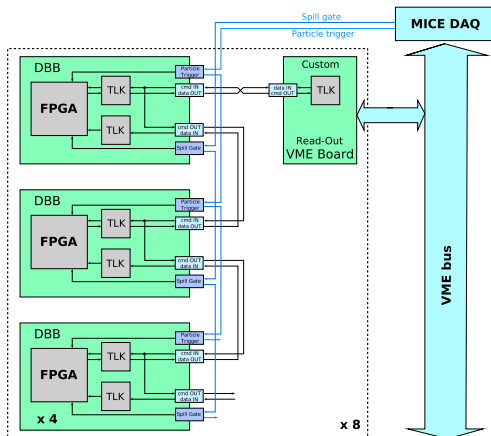


# Test Signal Generator for DBB

- In order to check the functionality of the DBB independently from the FEB (since DBB might be produced earlier), a special Test Signal Generator (TSG) has been proposed.
- The TSG should be able to generate a limited set of well defined signal patterns that could be used to check that the DBB is doing what it is supposed to do.



# Communication of DBB with VME Board



- 1 at the end of MICE spill a command is sent to 8 VME read-out boards to start reading data simultaneously
- 2 the VME boards send commands to six DBB requesting data in sequential order
- 3 MICE DAQ waits until all VME boards finish receiving data from DBB and then reads the data from VME boards in sequential order

# EMR Data Format

work in progress

## Data format

### Header

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Header type				0	0	0	0	0	0	Board ID						Spill Number															
0	0	0	0	0	0	Trigger count										0	0	0	Hit count												

### Data Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data type				Channel ID						Hit time																					

### Trailer

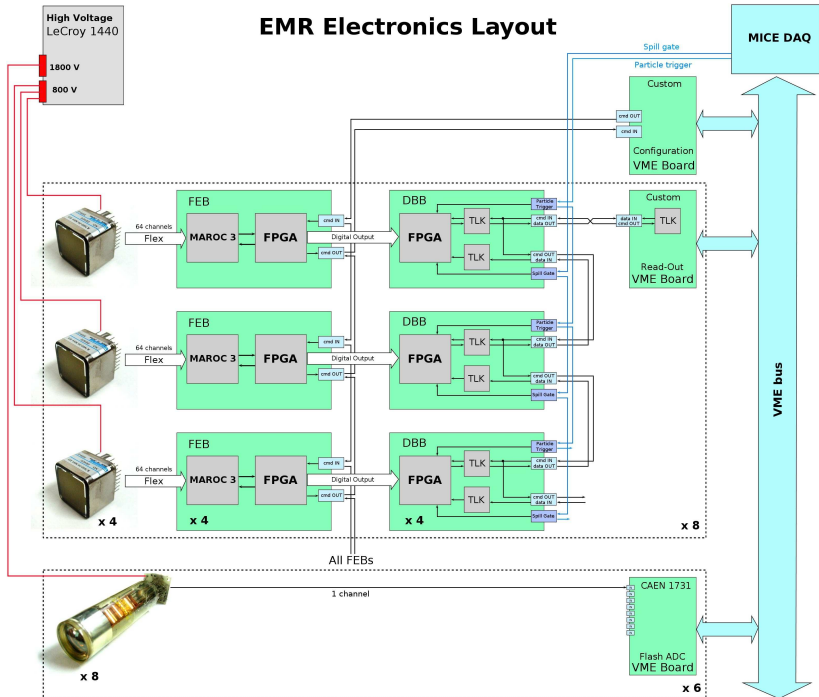
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Trailer type				Status						Board ID						Spill Number															

## Format of control commands

### Command

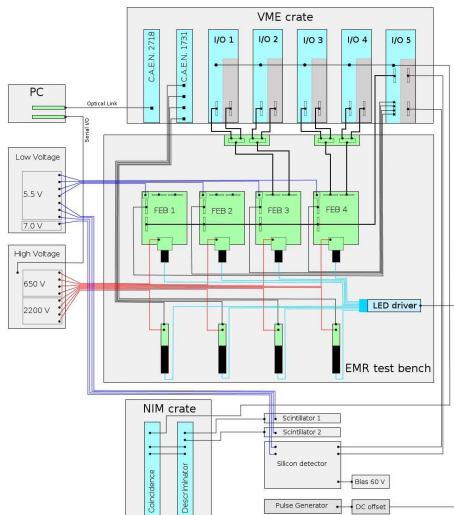
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Cmd type				Command						Board ID						Arguments															

# EMR Electronics Layout



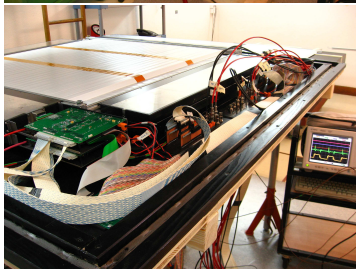


# Block Diagram of the Test Setup at UNIGE



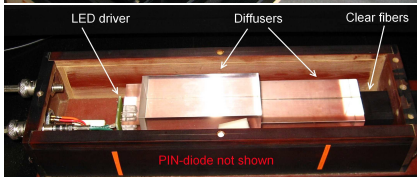
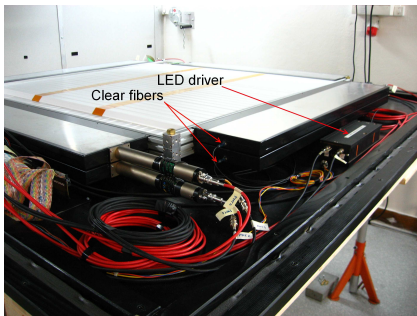
- the test setup is used to setup DAQ system and test modules before transportation to RAL
- 2 modules are installed inside light tight box
- lower module is kept as a reference, upper one is exchanged
- analog signal from 64-ch. PMT is read from all boards, digital - only from the upper two

# EMR Test Setup



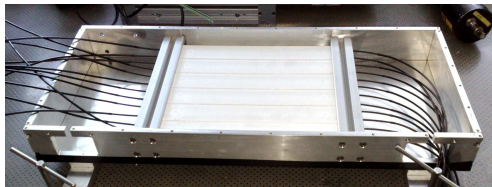
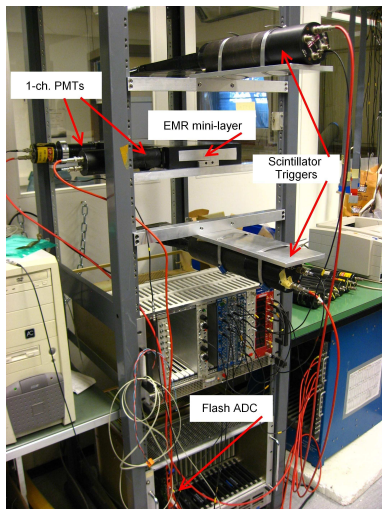
- all set up to perform tests with cosmics
- 2 CPUs, VME (read-out boards) and NIM (coincidence unit) crates
- LeCroy-1440 high voltage power supply for single- and 64-ch. PMTs
- scintillator triggers and silicon micro-strip detectors for track reconstruction and efficiency measurements (silicon detector is being repaired)
- LED pulser system for PMTs

# LED Pulser System for PMTs



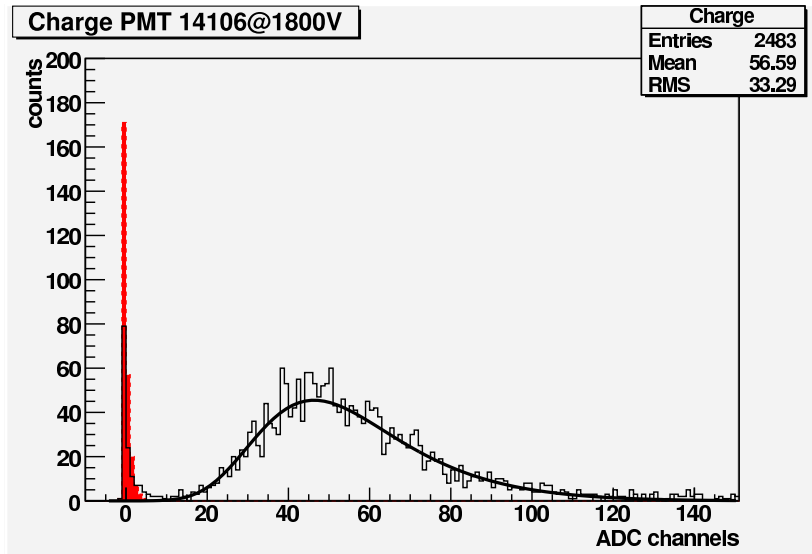
- the LED Pulser system (provided by P.Hanlet, D0 experiment, Fermilab, US) is used to monitor the performance of PMTs
- short pulses are feed into LED driver attached to light diffusers
- light is distributed through clear fibers directly to all PMTs
- PIN-diode is used in order to monitor light intensity (not operational yet)
- similar system but with 98 fibers will be used in the final setup

# EMR mini-layer for testing 1-ch. PMTs

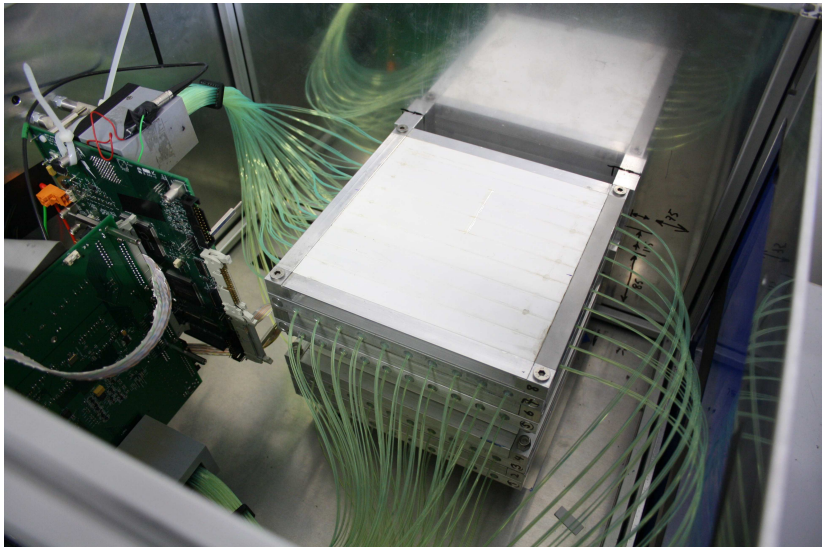


- EMR mini-layer: short EMR scintillator bars with fibers fed into two 1-ch. PMTs
- purpose: to test 1-ch. PMTs and study their performance
- two scintillators in coincidence are used for the trigger
- signals from PMTs are analyzed by flash ADC (C.A.E.N. v1731)
- MIPs are used for calibration

# Cosmics Spectrum at 1800 V



# Small EMR Prototype at Trieste

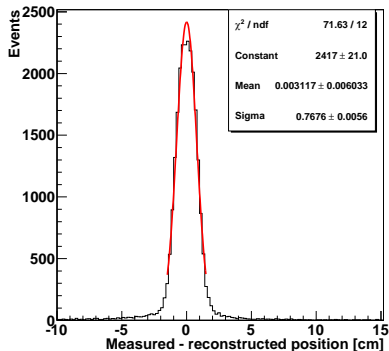
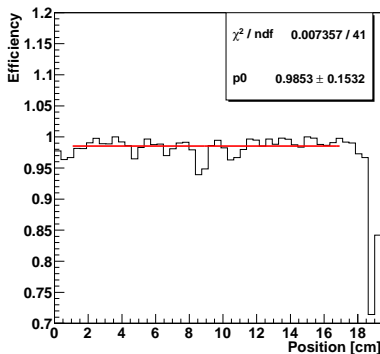


# Small EMR Prototype at Trieste

- it was used in order to test prototypes of front-end boards
- it consists of 8 planes of plastic scintillator bars arranged in two blocks and in a x-y geometry
- each plane has ten 19 cm long scintillating bars with a rectangular shape ( $1.9 \times 1.5 \text{ cm}^2$ )
- the light is carried out by four 0.8 mm WLS fibers two 64-ch. PMTs directly plugged on FEB
- the setup to test the system with cosmic rays consists of a couple of  $20 \times 20 \text{ cm}^2$  plastic scintillators for the trigger, a couple of  $9.5 \times 9.5 \text{ cm}^2$  micro-strip silicon detectors for the particle tracking and the EMR prototype.

# Small EMR Prototype at Trieste

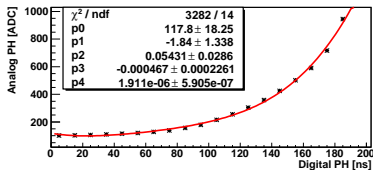
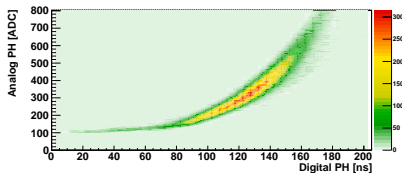
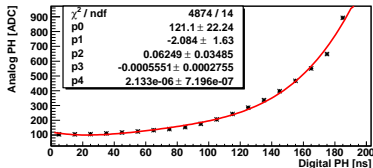
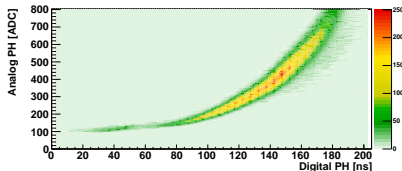
- spatial resolution is around 7mm for all bars
- efficiency has a value of the order of 99%





# Small EMR Prototype at Trieste

There is a clear correlation between analog and digital signals. Analog pulse high versus time over threshold is shown. This can be fitted by 4<sup>th</sup> order polynomial. **Digital signal can be used in order to estimate energy deposited in every bar.**



# Summary

- Construction and assembly of EMR modules has been resumed and should be finished in September/October this year.
- New electron boards (FEB and DBB) for 64-ch. PMTs are in production. Firmware needs to be written. Testing should be done in May.
- 4 new FEB (without buffer board) for cosmic tests will be equipped with MAROC-3 chips
- new boards will be tested with cosmic test setup at UNIGE

	2011											
	February	March	April	May	June	July	August	September	October	November	December	
EMR construction and assembly	8 modules		16 modules + Outer box for transportation		24 modules			Complets EMR assembly				
Electronics	Production of 6 FEB+DBB And 1 VME board			DBB+VME Tests	Production of 48 FEB+DBB and 8 VME boards			Further tests of electronics				
Tests	Tests	Cosmic tests and calibration 8 modules	Cosmic tests and calibration 16 modules					Cosmic tests and calibration 24 modules				
Transportation					Delivery and installation of 3 modules at RAL					Delivery and installation of full EMR at RAL		
At RAL		CM 29				Test run at RAL 5 July – 5 August			Physics run at RAL 15 November – 23 December			