



Detector Construction & Integration

For more details, see “Status report” document CMS RRB-D 2001-111

v 31 baseline schedule and milestones

frozen & approved by LHCC: takes into account all known sub-detector delays

Subdetector construction progress :

(including standard production monitoring charts)

Tracker

Electromagnetic calorimeter

Hadron calorimeter

Muon system

Trigger, DAQ & CPT

Integration & coordination progress (examples)

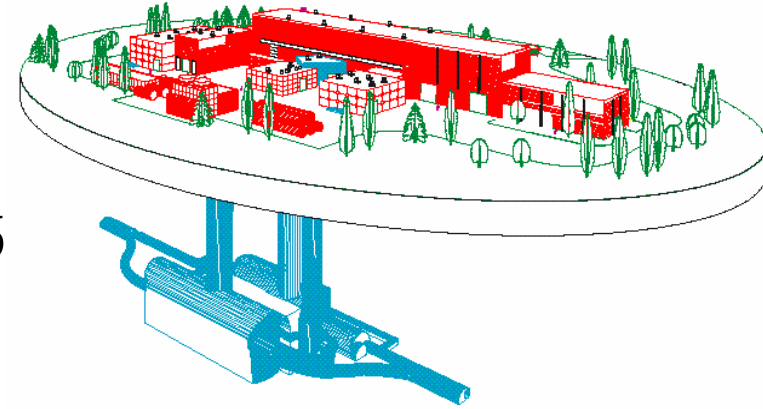
Conclusion



Schedule & Milestones v31

- Reminder of v31 boundary conditions

- * UX Civil Engineering complete: April 04
- * CMS closed for LHC commissioning : Feb 06
- * pilot run: April 06 : 1 month
- * shutdown of ≥ 3 months after pilot run.
- * both em endcaps (EE) + pixel tracker installed in shutdown after pilot run
- * 10 fb^{-1} physics run starts Aug 06

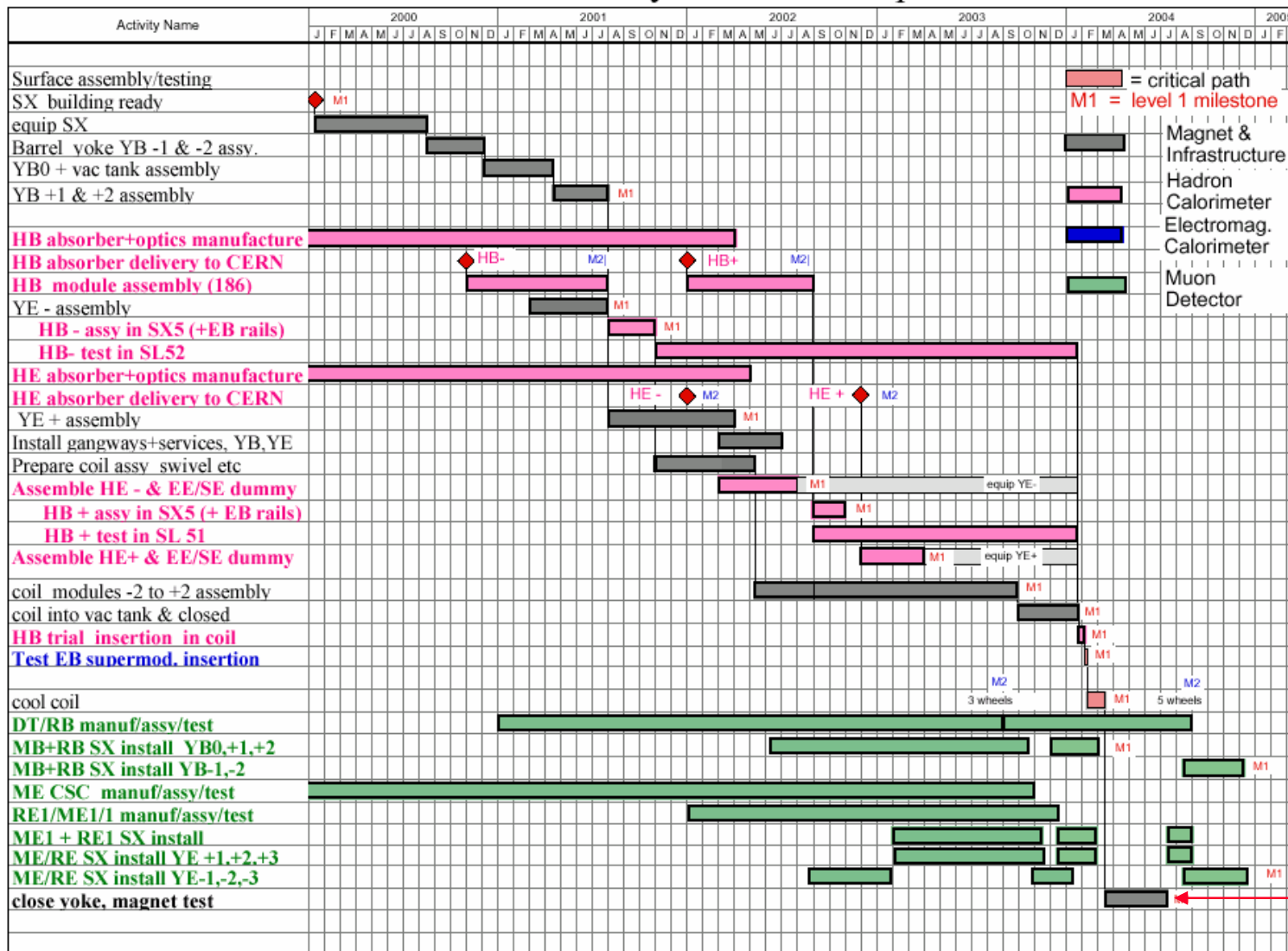


- Actions to respond **flexibly** to Civil Engineering delays

- * pit head cover constructed by main contractor
- * start UXC and USC preparation before Civ. Eng complete
- * SCX building delivered ~ 3 months early (autumn 04)
- * pre-cable & pre-test subsystems on the surface (extra SX infrastructure)
- * install EB in HB on the surface (after magnet test)



v31 schedule up to end of magnet test



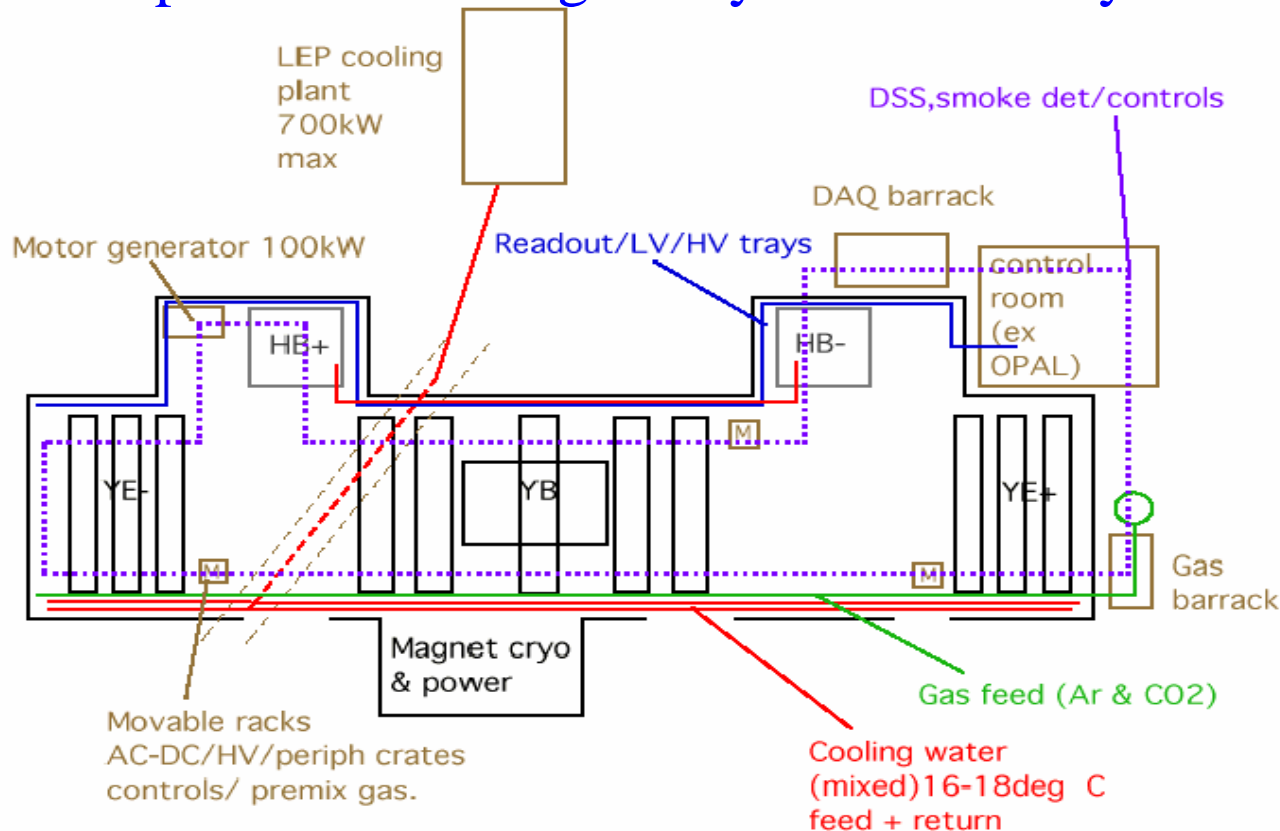
Civ Eng delays do not affect this part of the schedule

End magnet test



SX: extra infrastructure

Compensate Civ. Eng. delays & efficiently conclude part of installation.



Objectives:

channel test of HV/LV

burn-in of electronics

flushing gas

readout test of $\geq 10\%$ of any subdet (MB, ME, RB etc)

eg vertical slice tests

with test-beam DAQ

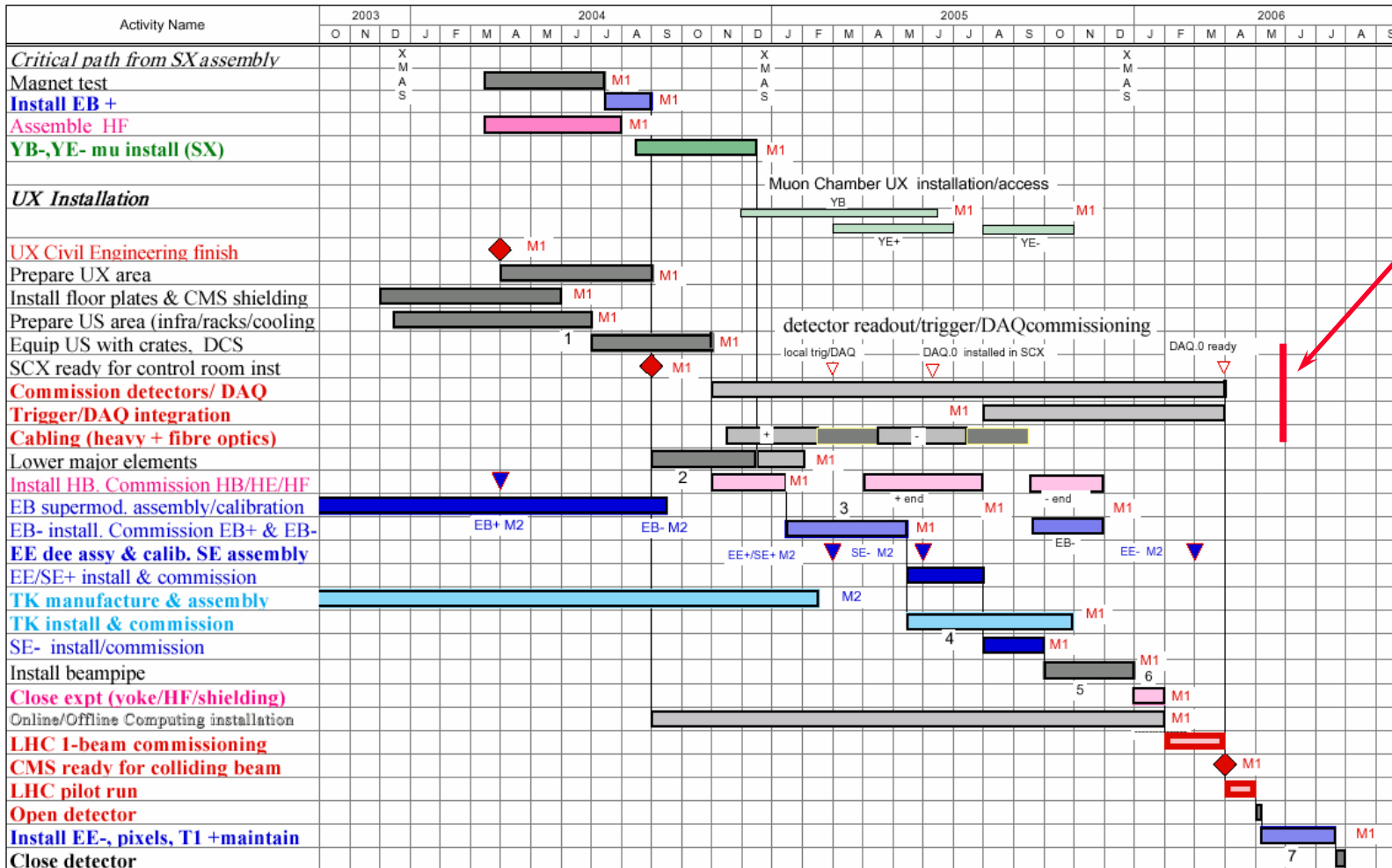
- complete + endcap before mag test \rightarrow full understanding of LV and cabling
- endcap and barrel central wheel pre-cabling after magnet test

This increased activity in SX requires additional resources (C & I)



v31 schedule: after magnet test

16 Jun 2001 Austin Ball



Critical path
(cabling &
TRIDAS integr)
under study
in case u/g phase
is further
compressed



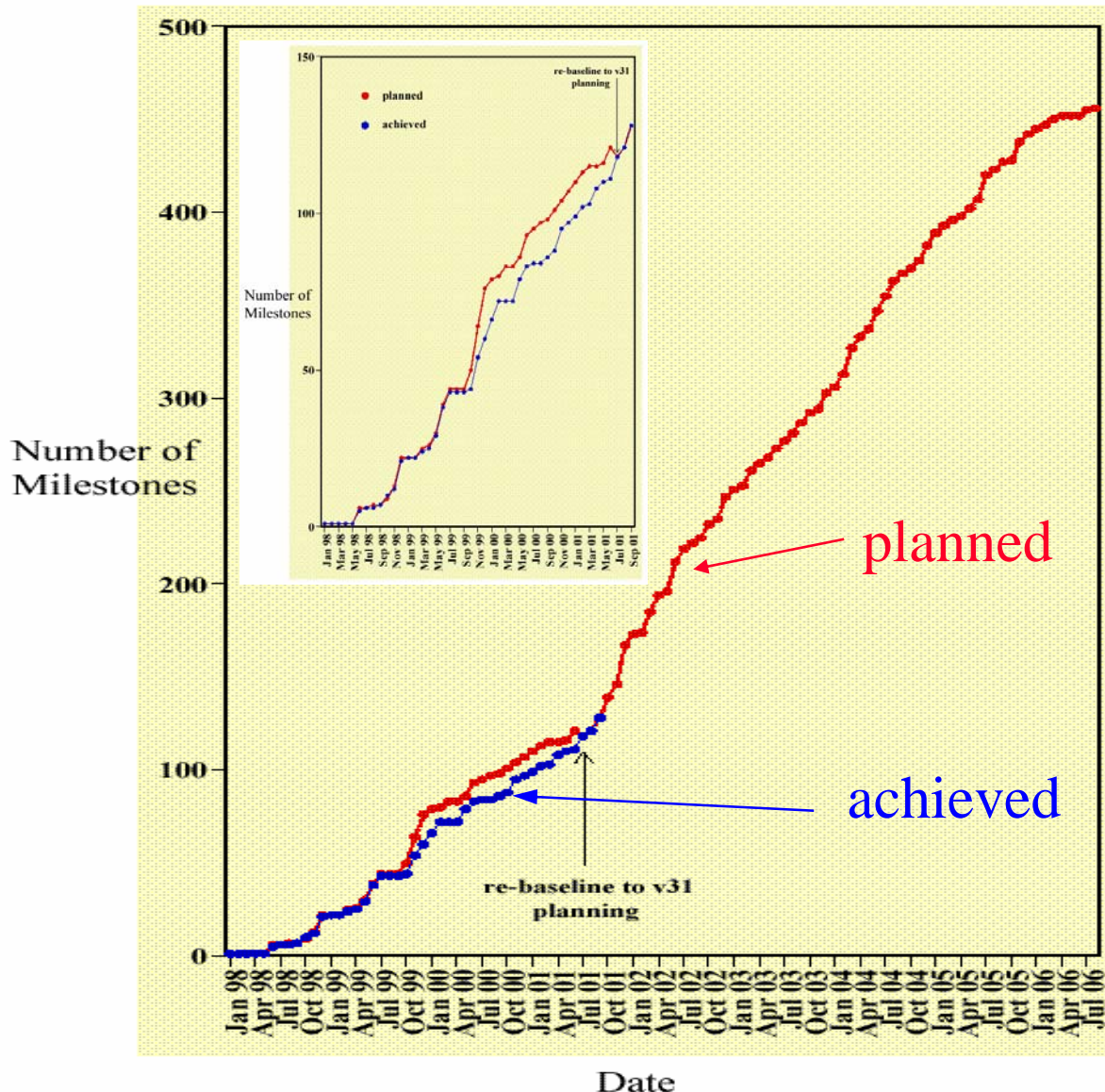
Milestones (monitored by LHCC)

baseline v31 frozen (890 milestones, 460 at Level 1 & Level 2)
(LHCC 2001-030)

	v26 Aug 99	v31 Oct 01		
Surface Hall (SX5) Civ. Eng. finished	<u>01/00</u>		Underground Hall (UX5) Civ. Eng. finished	04/03 04/04
Submit Trigger TDR	<u>11/00</u>	<u>12/00</u>	UX area floor plates and CMS shielding installed	05/04
End Assembly of Barrel Yoke	06/01	<u>08/01</u>	US infrastructure & racks installed	06/04
End Assembly of Endcap yoke YE-		10/01	SCX building ready for control room installation	08/04
End Assembly of HB- ½ barrel in SX5		10/01	UX ready: start lowering Magnet parts	01/04 09/04
End Assembly of Endcap Yoke YE+	01/02	04/02	DSS/DCS & local DAQ in USC ready for use	10/04
HE- absorber mech assembly complete		07/02	End mechanical installation of HB in UX5	05/04 01/05
End Assembly of HB+ ½ barrel in SX5	07/02	10/02	All major elements lowered, dismantle gantry	01/05
Submit DAQ TDR	12/01	11/02	End mechanical installation of EB in UX5	10/04 05/05
HE+ absorber mech assembly complete		03/03	End Installation of DT+RB chambers in UX5	06/05
End Assembly of Coil Modules	02/03	10/03	Coil ready to be powered in SX5	06/05
Core Computing & Software TDR submission		12/03	End mechanical installation of SE+	05/05 07/05
Coil inserted in Vac-tank and closed	04/03	01/04	End Cabling and Test of + side HB/EB/HE/SE/MU	07/05
HE Optics & HE/EE/SE cabling installed on endcaps		02/04	Start sub-detector Trigger/DAQ integration	07/05
End Trial Insertion of HB in Vac Tank	07/03	02/04	End Mechanical Installation of SE-	05/05 09/05
End Trial Mounting of EB Super Module on HB	08/03	02/04	End Installation and cabling of Tracker in UX5	10/05
End muon cham. SX installation on YE+, YB+2,+1, 0		03/04	Alignment system installed and tested	10/05
Coil cold, close yoke.	08/03	03/04	End cabling & test of -side HB/EB/HE/SE/MU	11/05
End Magnet Test in SX5	09/03	07/04	HF installation and testing in UX5 complete	11/05
End assembly of HF in SX5		07/04	End beampipe installation and bake-out	12/05
End mechanical installation of EB+ in HB+		08/04	Fully operational computing & reg. centres (20% capac)	12/05
End muon system SX installation on YE-, YB-		12/04	CMS ready for circulating beam (Yoke/HF/shielding)	01/06
20% data challenge complete		12/04	Working CMS closed, DAQ.0 ready for colliding beam	03/06
Physics TDR submission		12/04	End Installation, Test & Debug of EE+ & EE_- in UX5	07/06
			End installation, test & debug of pixel tracker in UX5	07/06
			Complete CMS closed, ready for extended physics run	08/06
			Fully operational computing & reg. centres (100% capac)	12/07
			DAQ.1 ready (100% capacity)	12/07



Milestone progress :update Oct 01



92% of milestones then scheduled were complete at re-baselining (Jul 01)

v31 is a revised plan to complete CMS by Aug 06 taking into account latest sub-project planning and all known (Jul01) delays .

Expect to use v31 set of milestones to monitor CMS progress until at least mid 04 (after magnet test)



Pixel tracker

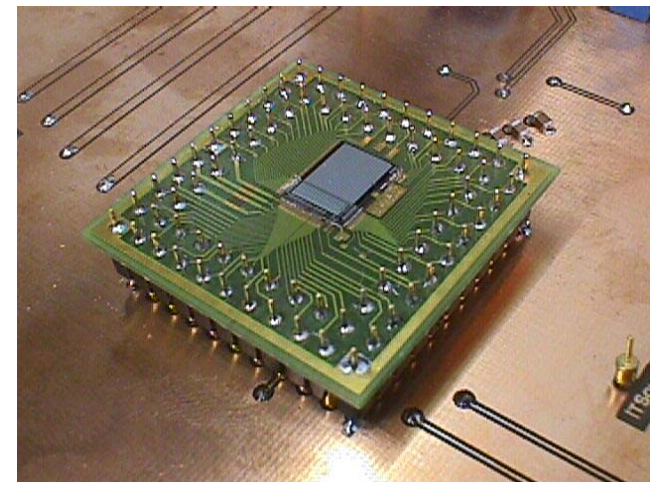
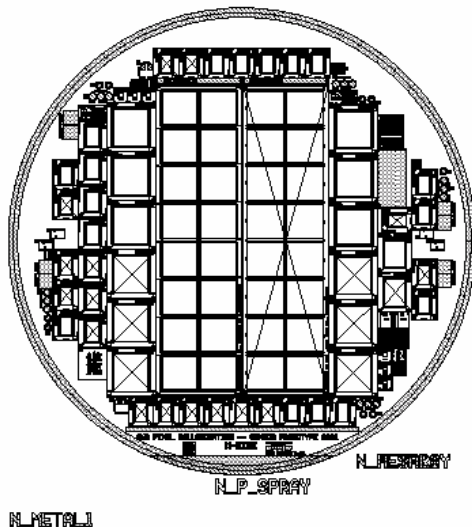
Still in development phase : first complete modules by mid-2002

EDR Jun 02, ESR 12/03

Full size sensor submitted Aug 01.

150 x 150 μm & 150 x 100 μm

Prototype DMILL ROC April 01
(column drain architecture): OK!



Pixel concerns: none

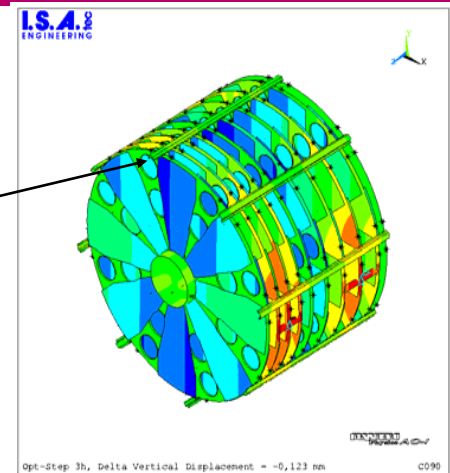
Full size DMILL r/o chip: submit Oct 01



Tracker

Mechanics: procurements imminent.

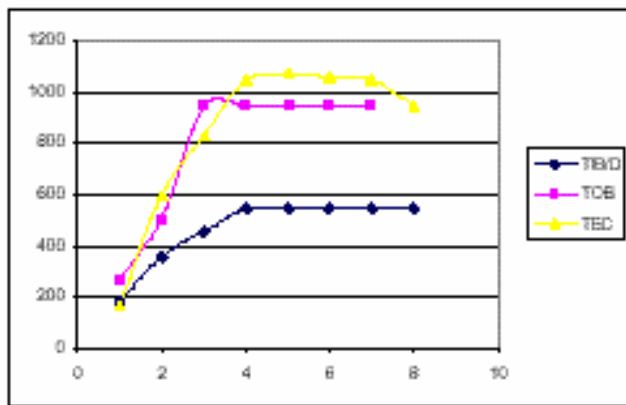
TEC structure: holes to reduce material



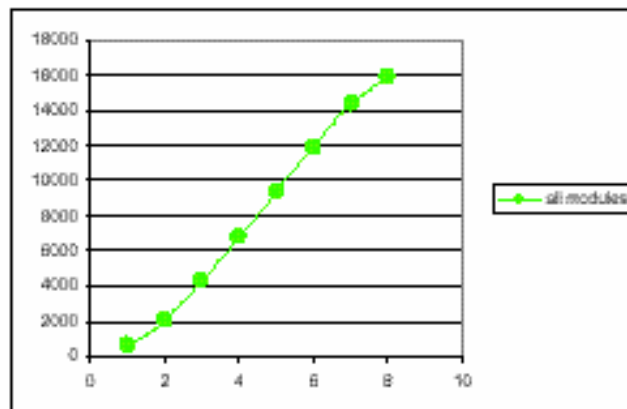
Si sensors: 2 vendors: Hamamatsu & ST :

M200 sensors meet specs
mass manufacture starting end 01

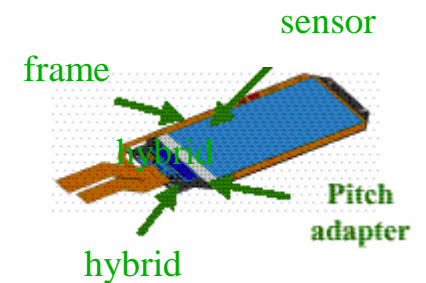
Modules: M200 completion early 2002 (4 mo late due to hybrids),



Quarters



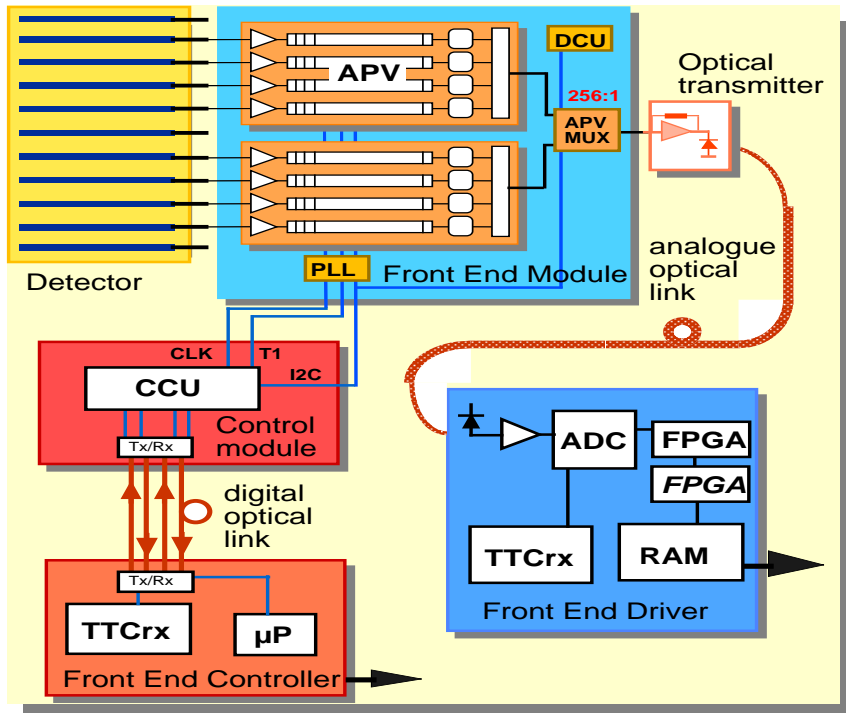
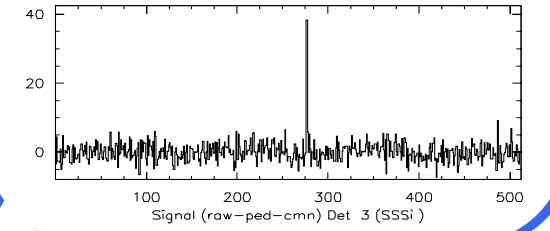
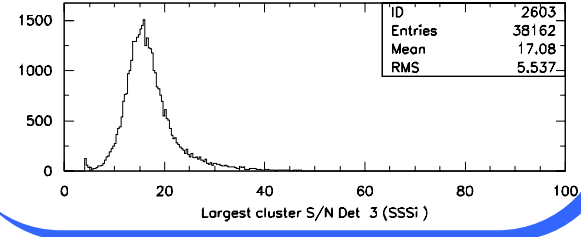
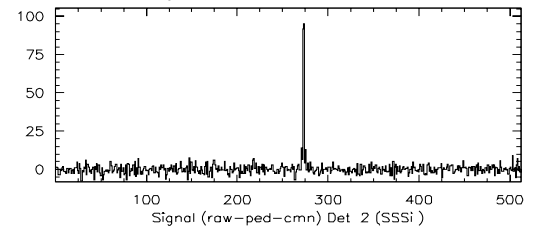
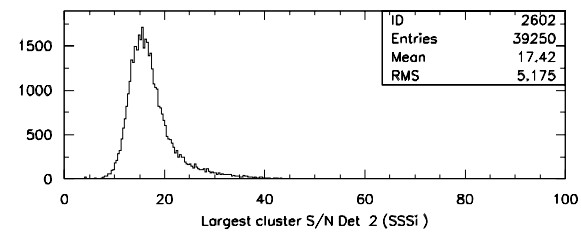
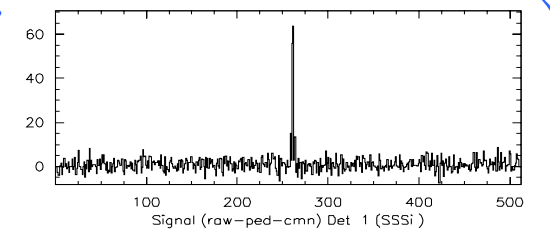
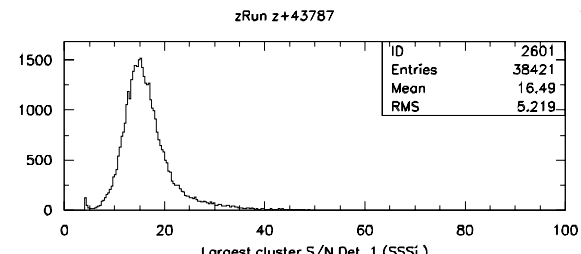
Quarters





Tracker: 2001 beam test of 3 modules

Important validation of sensor+ front end
 S/N ratio: ~16 (26) in deconvolution (peak) mode



Next steps: test fully equipped rod (6 mods)
 order optical links by end 01
 ESR early 02



Tracker: module production :v31

Camera support

optics

Base plate system

I/O box

Bare gantry

Glue control box

Vacuum system

Pickup tools

Final assembly system

Assembly & supply plates

Glue disp. Tool

Centres: ready to go or commissioning test complex logistics during M200.

Concerns: shortfall in funding, ramp-up of module production



Electromagnetic calorimeter

Barrel Crystals:

9000 (10 tons!) produced with $\leq 2\%$ rejection
 all crystals for barrel now under contract
 continuing development of ≥ 2 crystals per boule
 (difficulties: Pt procurement for crucibles
 infrastructure costs)



Barrel Mechanics:

grid re-designed, orders placed
 power cooling circuit re-designed
 module manufacturing centres ready
 module 0 (400 crystals) complete
 EDR 11/01 for “bare” supermodule production.





Electromagnetic calorimeter

Endcap crystals: offers in hand,
assessing schedule/funds for ordering

Endcap mechanics:

40% of alveolar units delivered by end 01

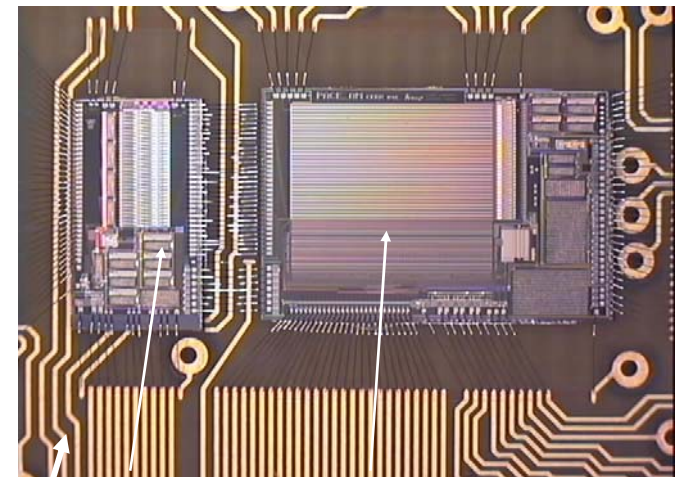
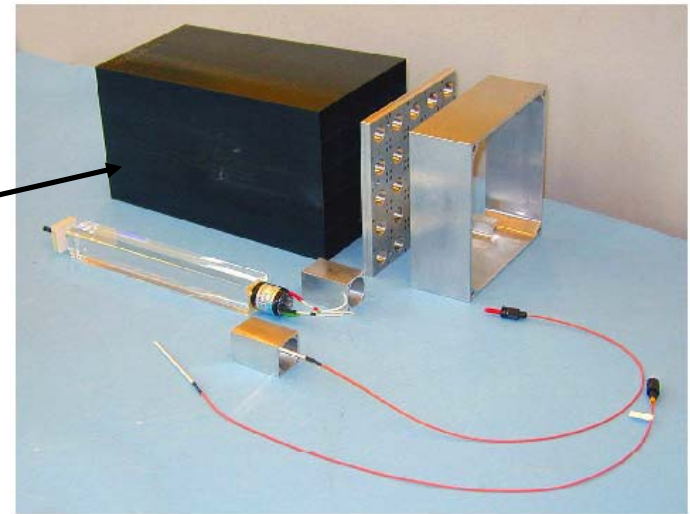
EDR for full mechanics: mid 02

Preshower:

Steady progress: Si sensors & mechanics
proceeding towards manufacture

DMILL readout chips look good,

launch 0.25 μm version as backup



DELTA and PACE-AM chips



Electromagnetic calorimeter

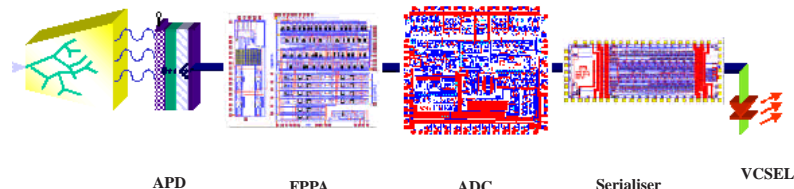
Electronics for crystal barrel & endcap:

11,000 APD's delivered. Full screening effective (3.8% rejected)

Pre-production of 500 VPT's successful: order placed.

front-end preamplifier noise being corrected, design back in Mar02

LIGHT to LIGHT



optical links: use $0.25\mu\text{m}$ and at double intended speed (reduce cost)

Loss of 3 key personnel

→ electronics chain ready only in 2003

→ modify SM construction/calibration strategy

Organisation: consolidate barrel & endcap projects.

concentrate first on barrel manufacture & endcap prototypes

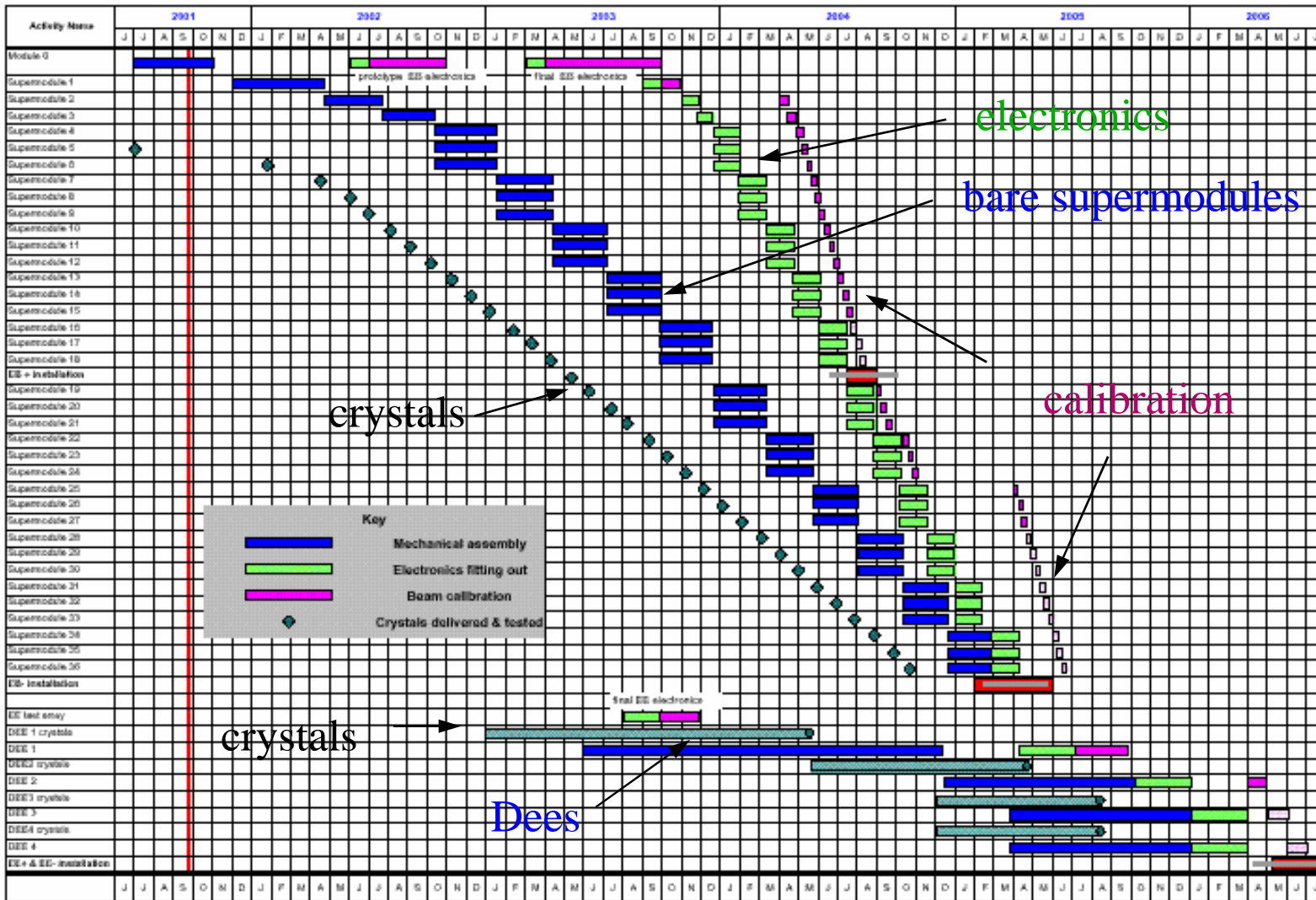
ECAL Concerns:

Electronics delays & personnel. Cost containment measures eg optical links

Assurance of funding for critical orders. Sensitivity to \$/CHF exchange rate.



ECAL crystal & module production: v31



Start “bare” SM assembly without Electronics.

Electronics is on critical path
Action taken

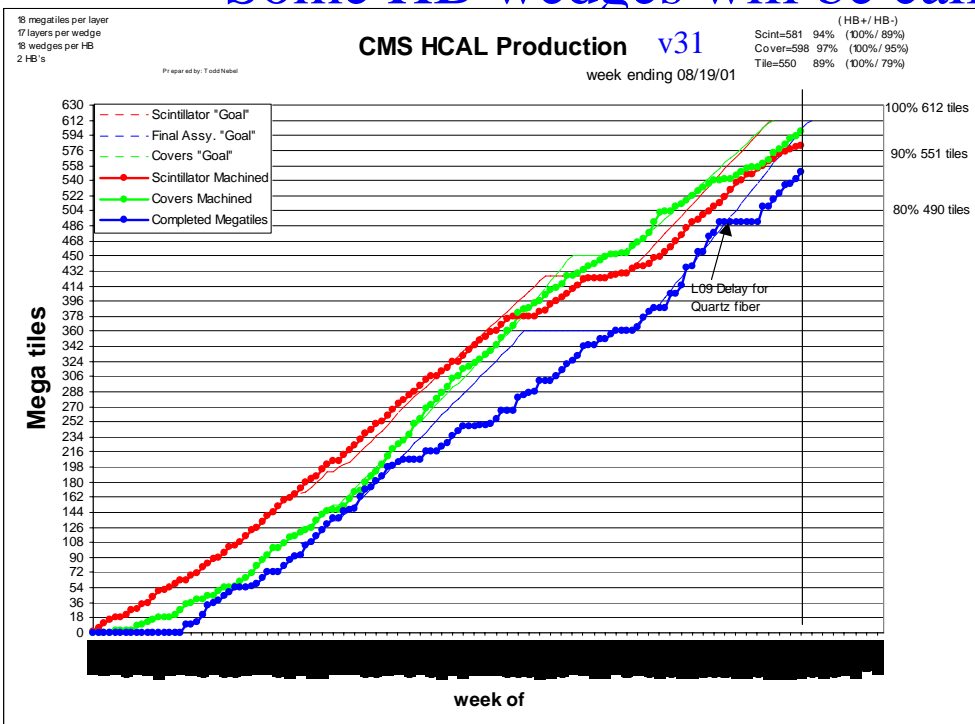
Not all SM’s and Dees can be calibrated.

Most endcap assembly takes place after barrel complete.



Hadron calorimeter

Barrel: all HB absorber delivered to CERN, optics complete by end 01
 HB- assembly near completion in SX5, HB+ complete by end 02.
 Some HB wedges will be calibrated in beam during 02.



Endcap: HE-1 absorber (here!) and optics expected at CERN by end 01
 HE+1 absorber and optics expected at CERN by end 02



Hadron Calorimeter

Forward (HF):

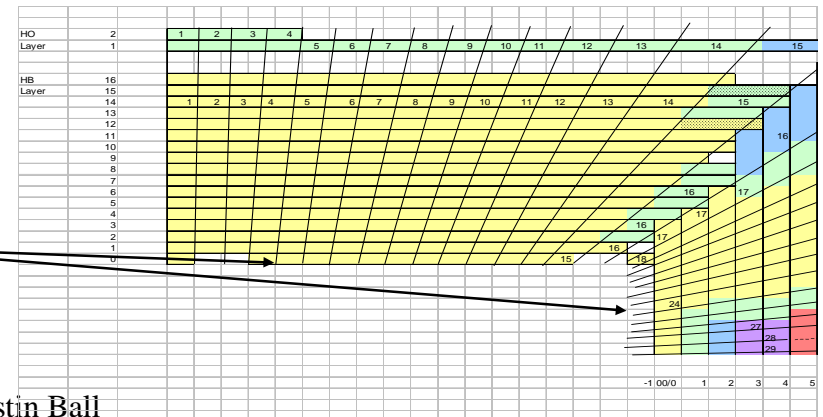
1'st production wedge a success(VNIITF)
Bulk manufacture authorised.

9 wedges expected at CERN by end 2001!
Fibre + phototubes reviewed → order.
Organisation & responsibilities
of HF project defined



Missing funds covered :

2 --> 1 longitudinal samples
in most of HB/HE
(effect on physics performance acceptable)





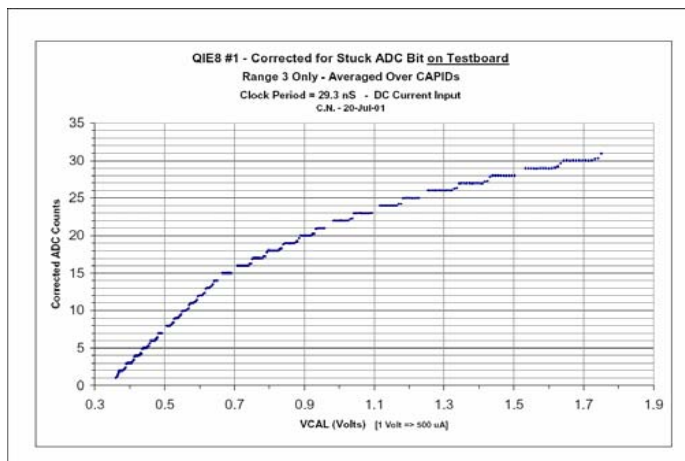
Hadron Calorimeter

Outer: Approx 1/3 of scintillator tiles machined.
Target “ready for installation” in barrel yoke in mid 03

Electronics:

QIE works & is off the critical path

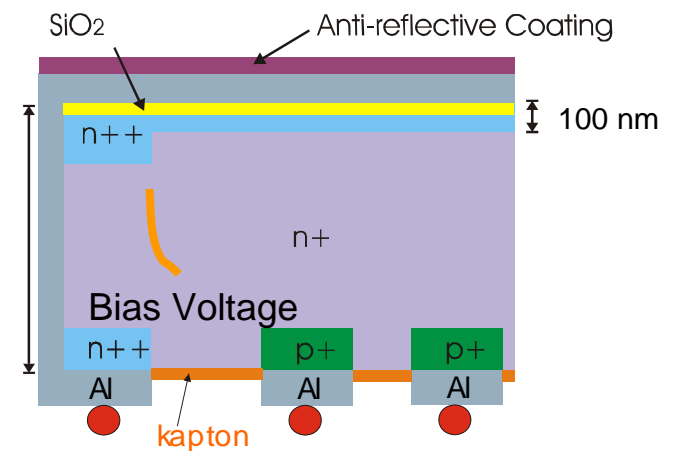
- needs small changes for 40 MHz
- 1 more submission



HCAL Concerns: none at present

HPD: correcting remaining faults
expect to order soon

New Diode Structure





Muon drift tube manufacture



3 sites
operational

~30 superlayers
assembled at
CIEMAT
Legnaro
Aachen

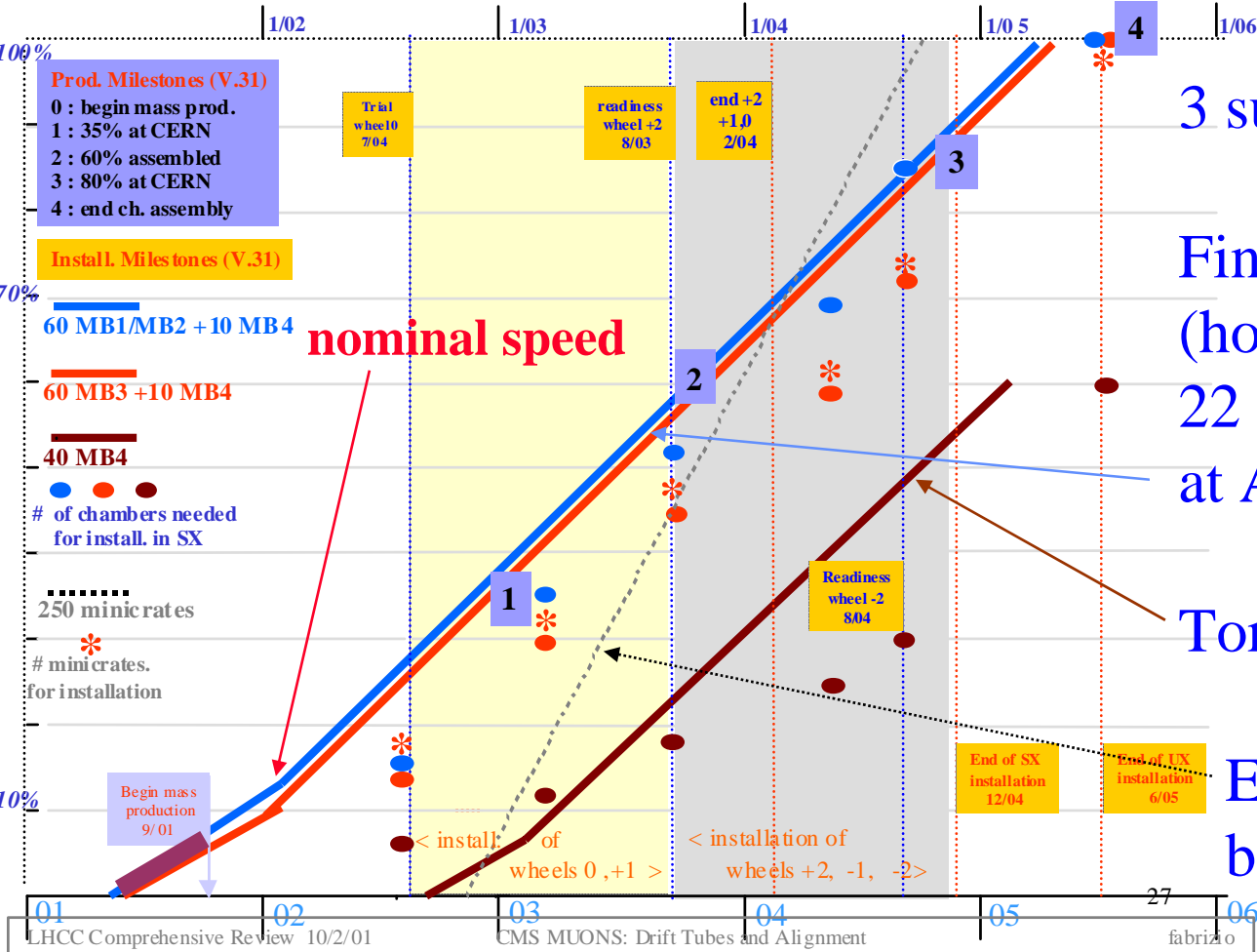


electrode
manufacture
being transferred
to Russia





Muon drift tube production:v31



3 superlayers/9days achievable!

Final chamber assembly delayed (honeycombs) but on target for 22 chambers (66 sl) by end 01. at Aachen +Legnaro+CIEMAT

Torino line starting in Oct 02

Electronics: minicrate delivery by end of 2002



CSC panel & chamber manufacture

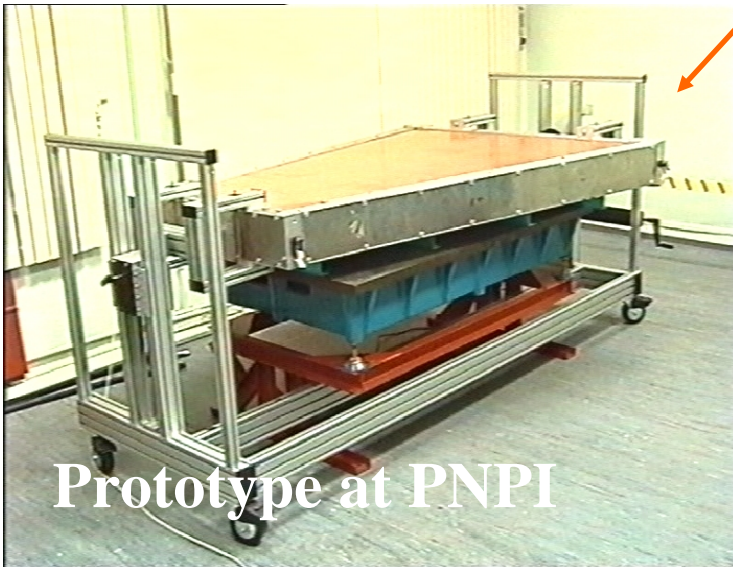


Prototype at IHEP

FNAL
46/148 CSC's made
38 delivered to
FAST sites



U.Florida FAST site



Prototype at PNPI

IHEP & PNPI
2 prototypes done
prod.start in Nov.

Dubna
ME1/1 panels
near complete
9 CSC's by end 01.

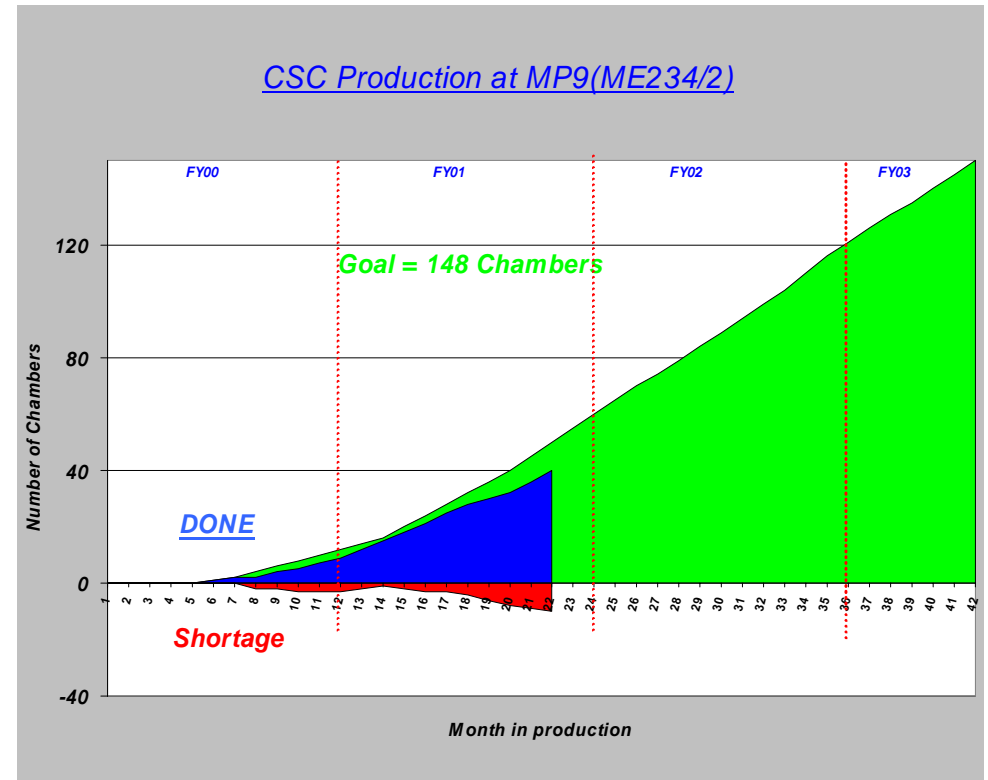
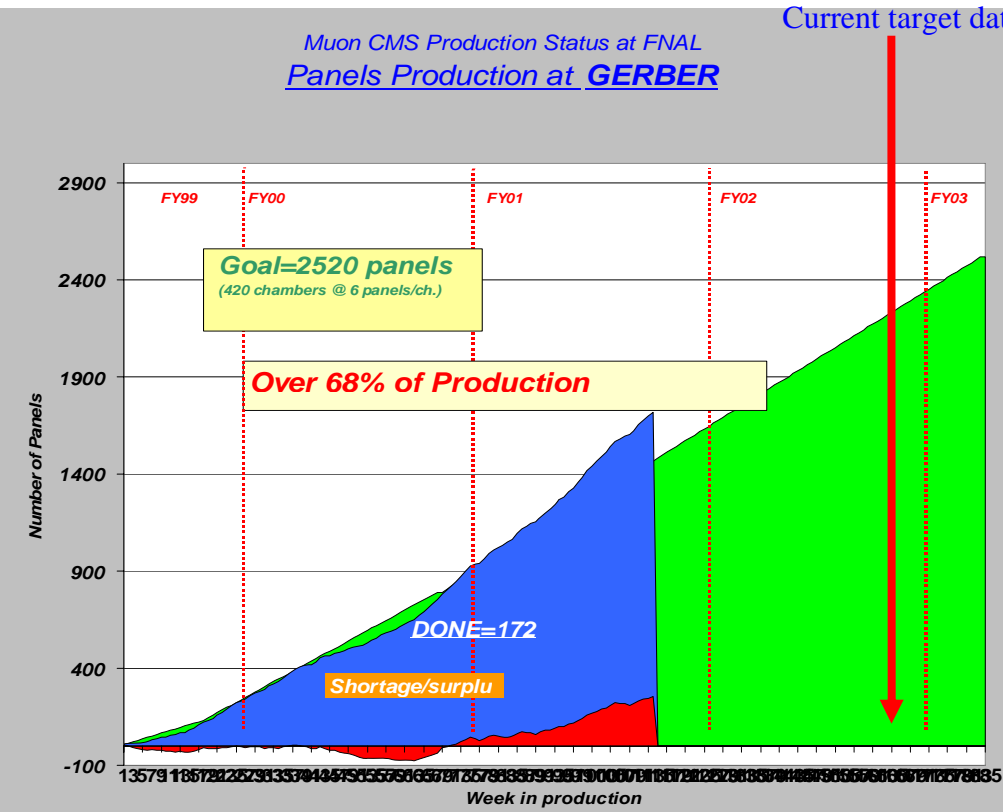


Dubna

470 CSC panels



CSC panel & chamber production:v31



Electronics:

Anode and cathode front-end electronics in production

ALCT (trigger) board re-design complete (on critical path) : ESR in Dec 01



Muon System

Barrel RPC : production starting : oiled bakelite + improved QC procedures.

Endcap RPC: latest prototypes have excellent characteristics.

1 more prototyping round (low noise w/o oil?) → EDR in Jan 02.
design of 1'st station converging (on CMS critical path).

RPC electronics : progressing well, on schedule.

Alignment: delayed MAB prototype due for delivery Dec 01.

Muon System Concerns:

DT's: electrode pre-production in Protvino & Dubna.

achieving target manufacturing rate in 02. Electronics delays (TRACO)

CSC's: funds for electronics & cables for ME1/1

RPC's: world capacity for gap production, chamber assembly start-up.

funds for services, particularly for endcap.



Trigger, data acquisition & CPT

- Trigger:** Final, full-function prototypes being constructed & tested
 Moving towards integration & system tests with sub-det front ends
 Enhanced processor to be produced for more robust RPC trigger
- DAQ:** Results from prototypes & demonstrators have validated design.
 Modularity introduced for easier upgrading.

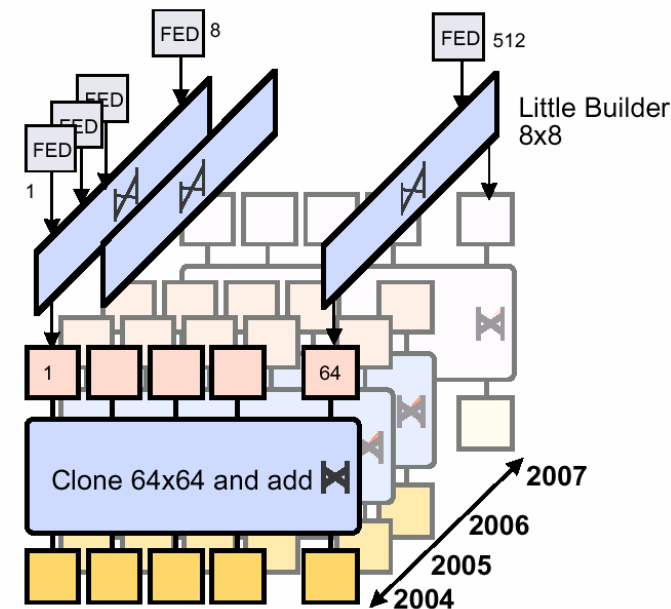
EVB staging by event multiplexing and DAQ slices

- 64 8x8^(*) switches (FED builders. FB) group FED fragments by 8 and divide the time (events) into 8 domains (NoEv Modulo 8). The result is a DAQ made of 8 independent systems (slices).

Each slice consists of 64 RU, a 64x64 EVB, 64 BU and associated FUs. A slice can read up to 12.5 kHz

- Allow easy staging (e.g. in 8 steps) each step runs as an independent system and it may be implemented with a different technology
- Use the 64x64 preseries as basic unit

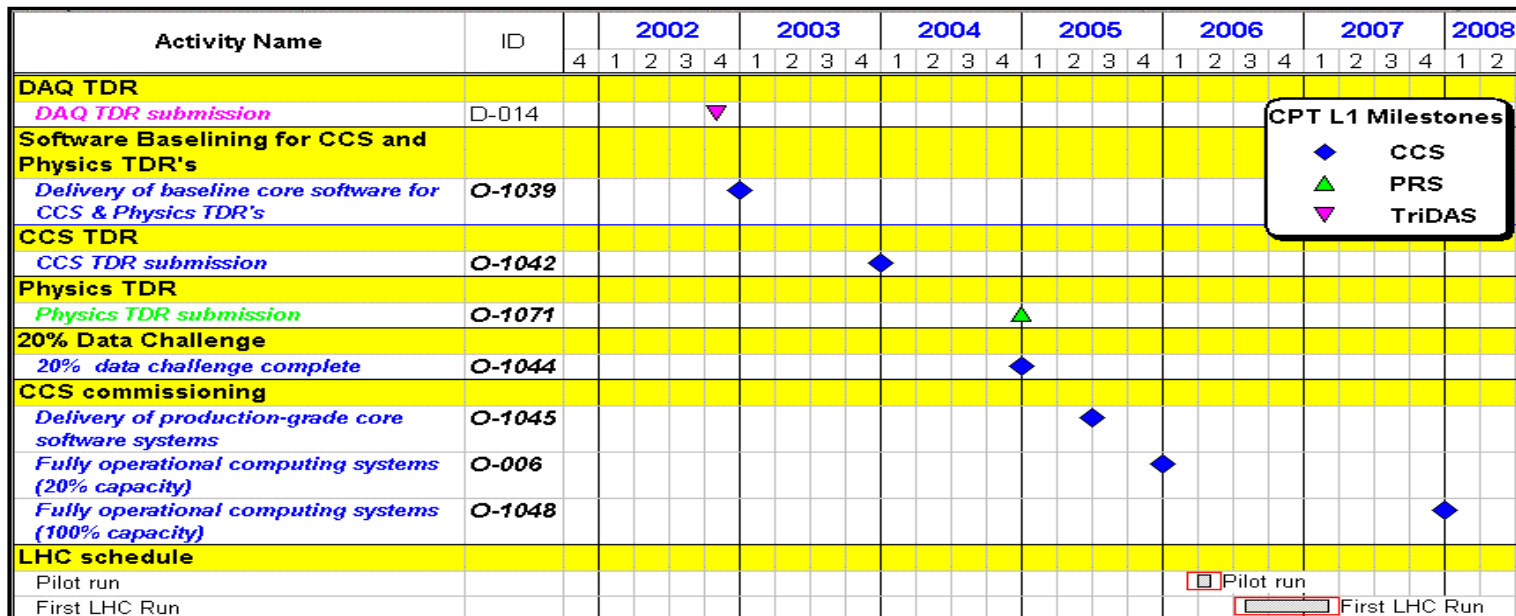
^(*) 8x8 FB is a simplification it is NxM where M is the number of slices
 S. Citroni EP/CMD





Trigger, data acquisition & CPT

CPT: Large scale event generation exercised with 11 proto regional centres
 Reconstruction software well advanced & used for HLT studies
 Effect of staging some sub-detector elements studied.
 Will investigate backup technologies for Objectivity event store



TRIDAS Concerns: Trigger + online system commissioning underground
CPT Concerns: Lack of software engineers



Integration progress & examples

Detector periphery

Metal frameworks, cabling & piping
 Crates & racks, LV system.
 Access devices

Outer gap

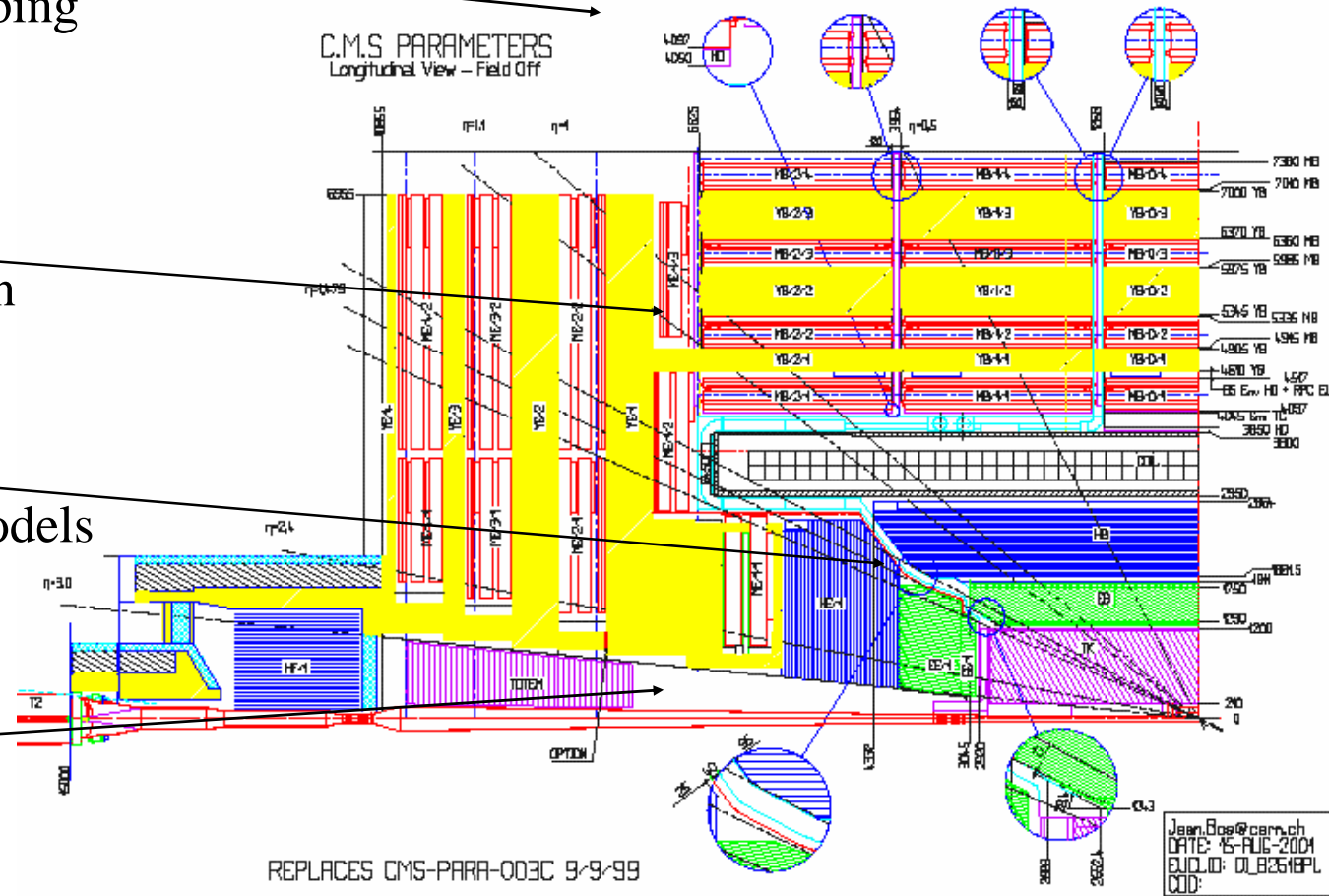
Alignment, CSC/RPC integration
 LV & readout units

Inner gap

Services: starting mm precise models
 Proximity opening system

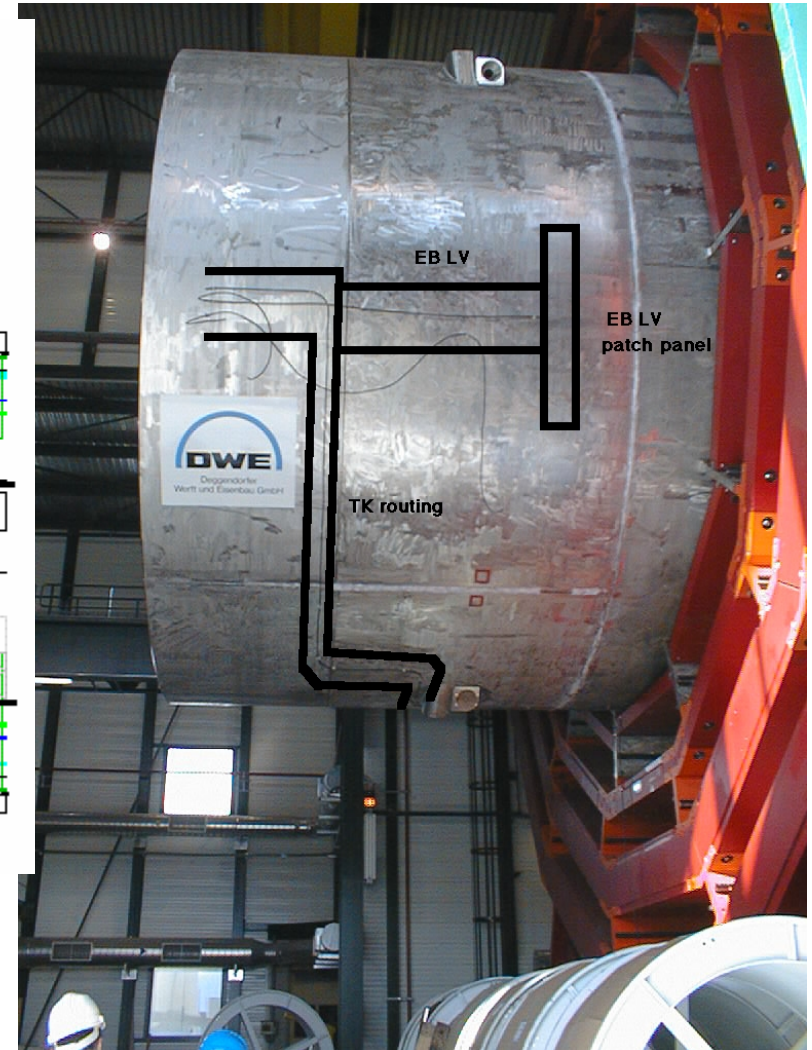
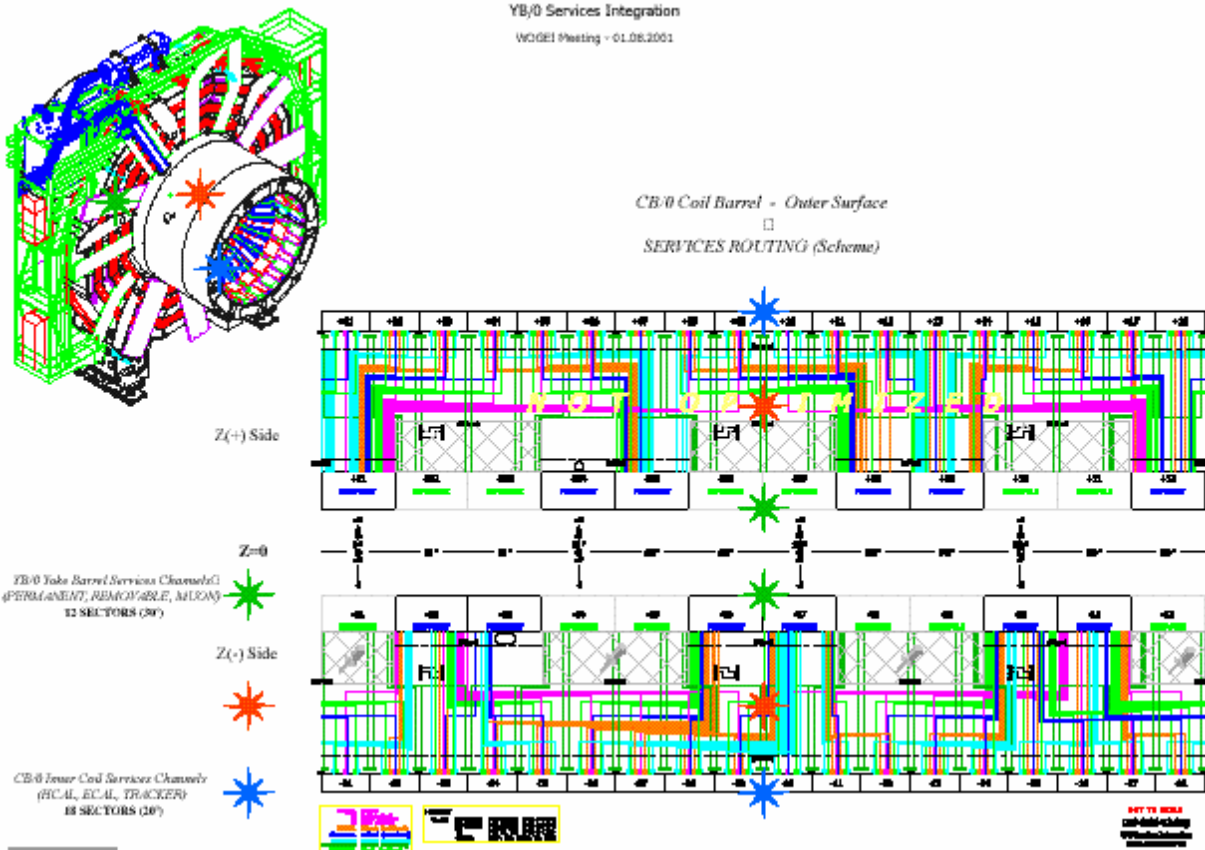
$$\eta \geq 3$$

Detector inner edge
 Beampipe design
 10m opening system





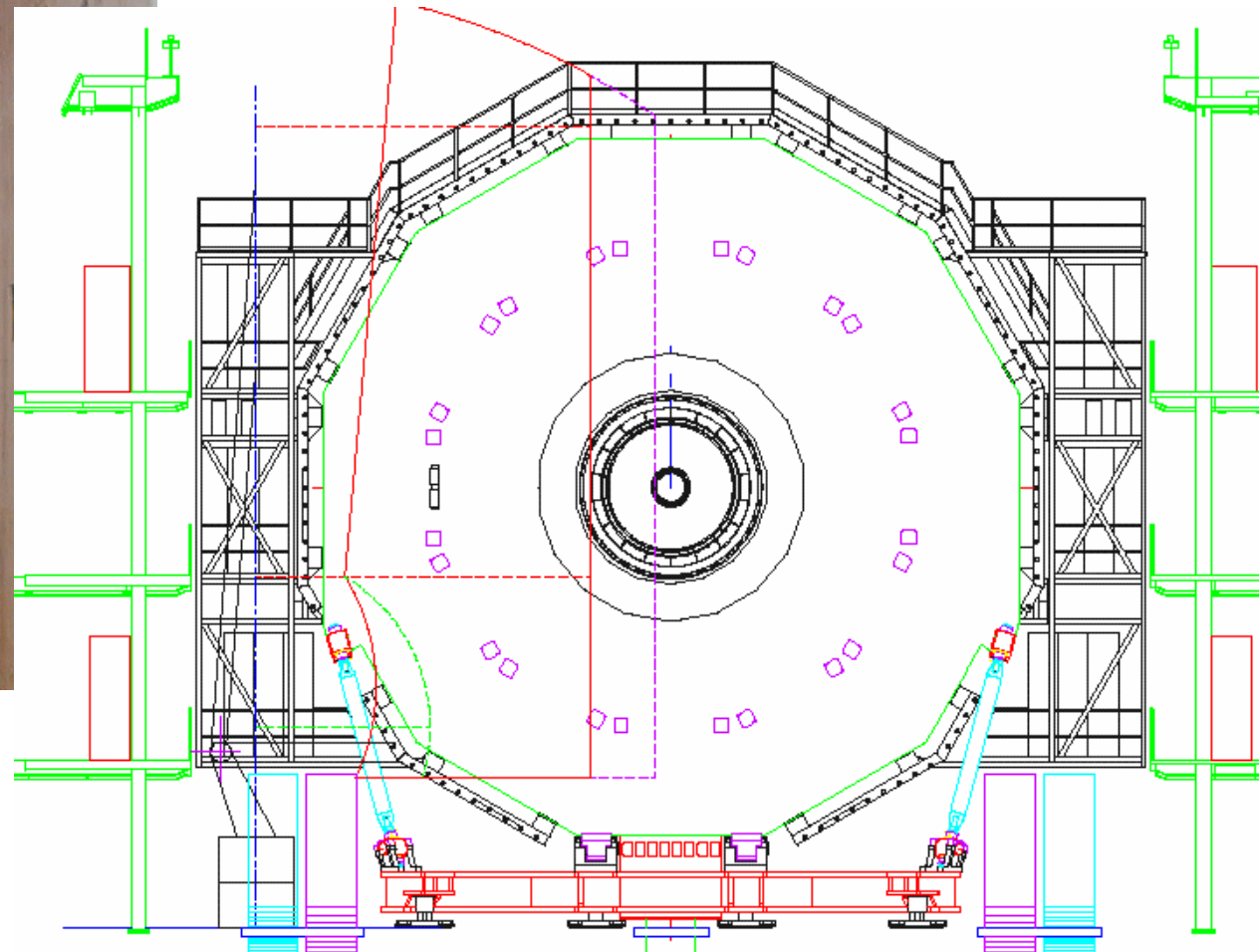
Integration : YB0 cabling



CAD layout verified on actual objects in SX5
layout of peripheral crates is a critical issue!



Integration: access devices



- cherry-picker selected
- 4 to be acquired
- reach on YB/YE understood.



Scheduled Reviews: TDR's/EDR's/ESR's

EDR

EB (supermods)	November 01
RPC (endcap)	January 02
Beampipe	February 02
EE (dee's)	June 02
Pixel	June 02
INFRA	Dec 01/ Jun 02

TDR

DAQ TDR	November 02
CCS TDR	December 03
PRS TDR	December 04

- Manufacturing Progress EDR's (MPR's) can be anticipated following Muon Barrel pattern
- PRR's and EDR subcommittees as necessary

ESR

Pixel	December 03
Tracker	March 02
ECAL (VFE)	October 01
ECAL	October 02
HCAL	March 02
Muon Barrel	March 02
Muon Endcap	June 02
RPC's	June 02
Alignment	December 02

Other system reviews:

DCS/DSS	March 03
Safety	Sept 02



Conclusion

- Subdetector manufacture: **proceeding at optimum speed** towards :
(providing shortfalls covered) working detector by Feb 06
 complete detector by Aug 06

In general, progress is encouraging: several concerns remain:

ECAL: electronics delays and personnel, orders awaiting funding.

Muon : DT assembly rate, funding for ME1/1 electronics, RPC services.

TRIDAS,CPT: commissioning timescale, lack of software engineers.

- **Schedule & Milestones:** new milestone baseline frozen: linked to v31 schedule
 monitoring of critical sub-system items is in place
 - flexibility to respond to & recover from Civ Eng delays included in plan
 - increased activities on surface are essential. (more resources)
- **Integration**
 - reasonable progress in major integration hotspots
 - subdetectors are entering critical assembly sequence.