



Draft CERN-RRB-2003-046

# Status of the LHCb Experiment

## Resource Review Board meeting

### CERN, 16 April 2003

on behalf of the LHCb Collaboration

Tatsuya Nakada

CERN and University of Lausanne

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- 2) Status of Detector Reoptimization
- 3) Subsystem Status
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# 1) Change of organization

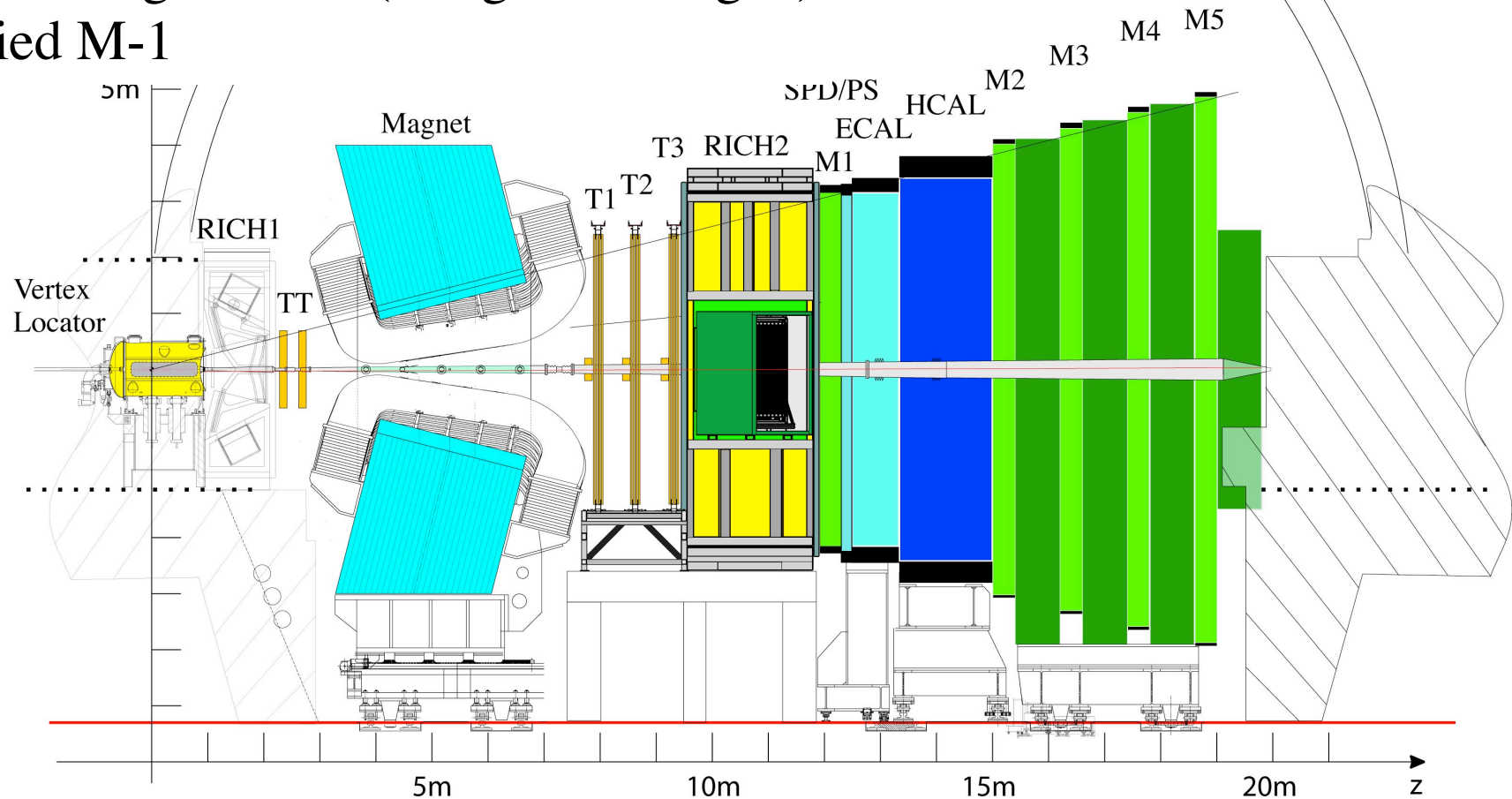
Computing project is now divided into

- 1) Online system      Project Leader: Beat Jost (CERN)
- 2) Offline software    Project Leader: Philippe Charpentier (CERN)
- 3) Offline computing   Project Leader: Nick Brook (Bristol)

NB: John Harvey who has been LHCb Computing Coordinator  
was asked to lead the EP Software Group.

## 2) Status of detector reoptimization

slightly modified VELO  
modified RICH-1  
new all Si TT  
three tracking stations (design unchanged)  
modified M-1



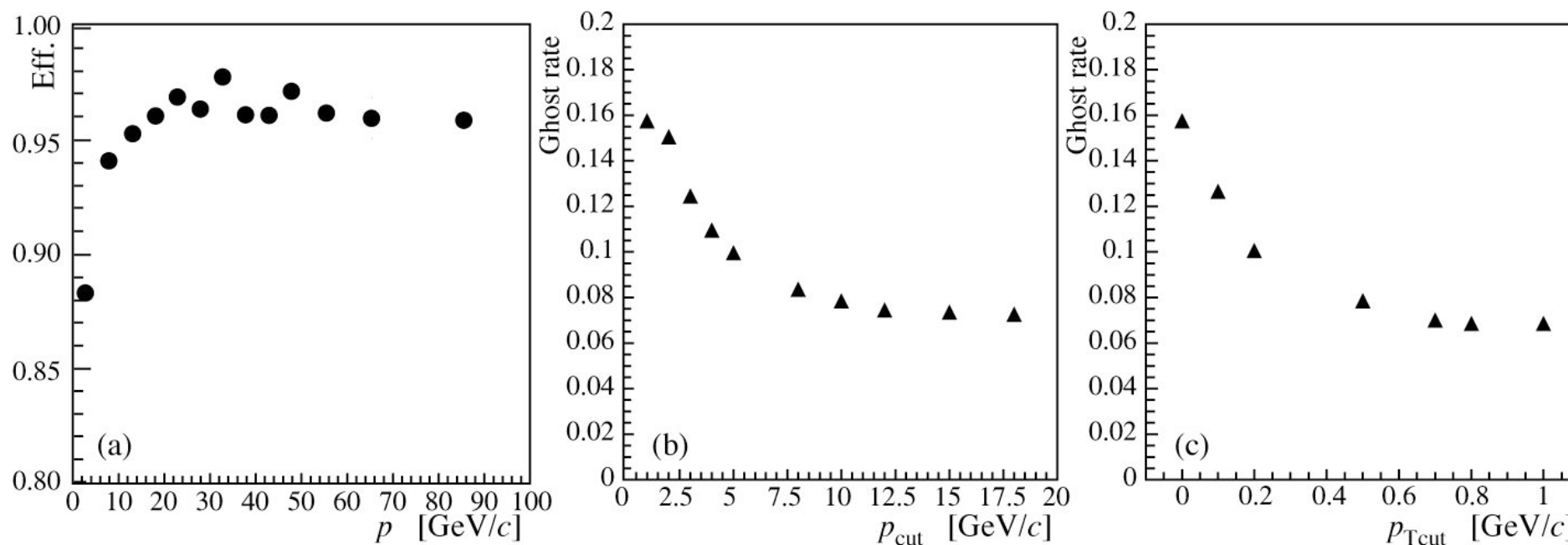


Expected detector performance has been reported to LHCC

- Written report: LHCC 2003-003/G023
- January Comprehensive Review

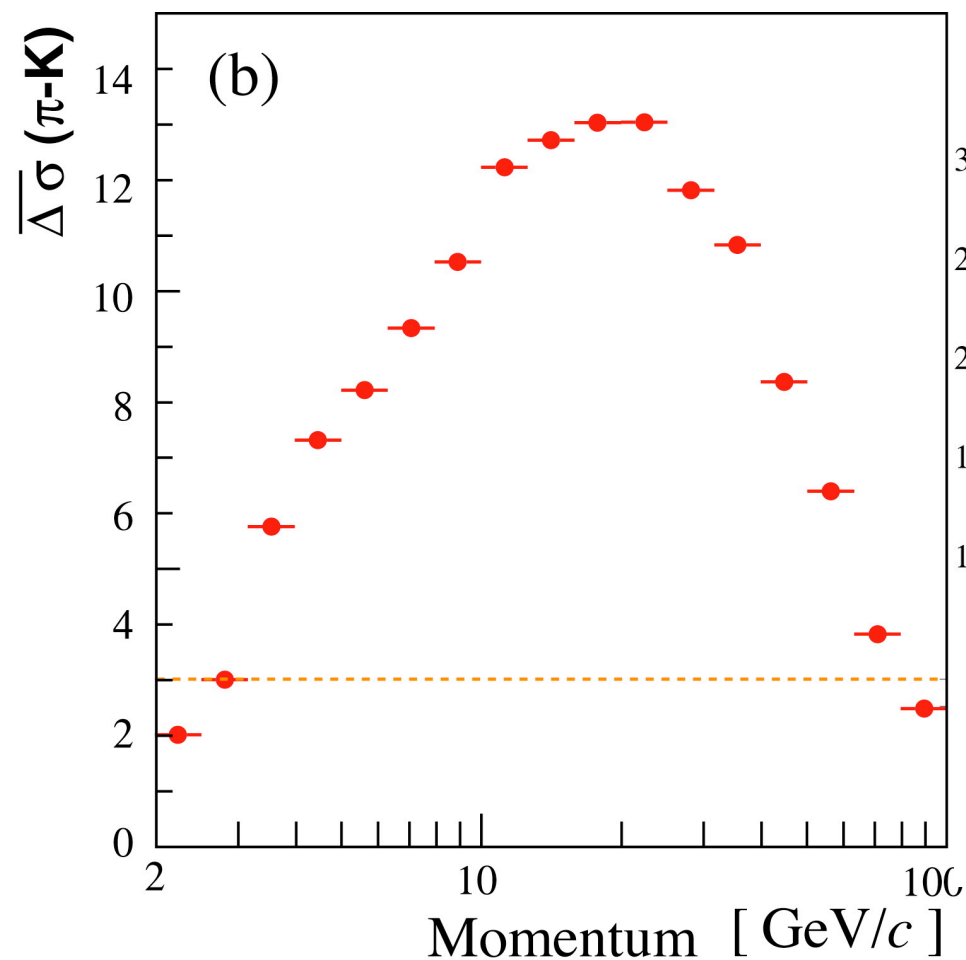
Tracking performance is good

Tracking performance for those start from VELO and go through T1-T3.



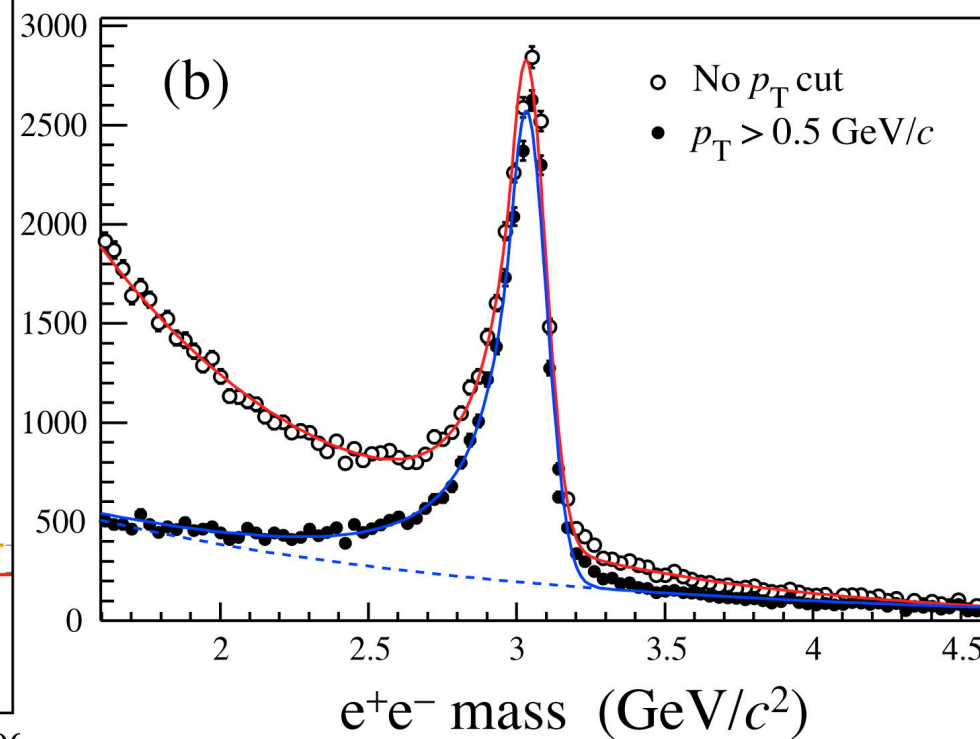
Track reconstruction efficiency 95% for  $p > 5$  GeV/c  
Ghost rate 7% for  $p_{\text{T}} > 1$  GeV/c

## K/ $\pi$ separation



Particle ID performance good

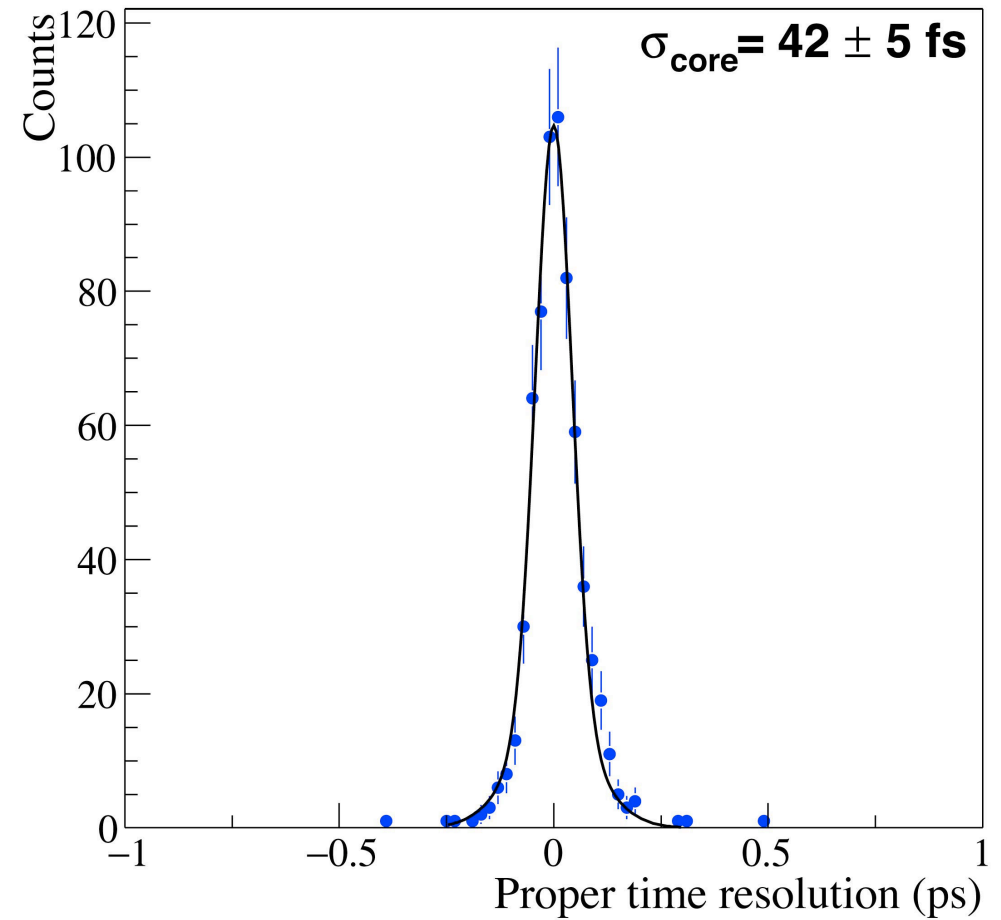
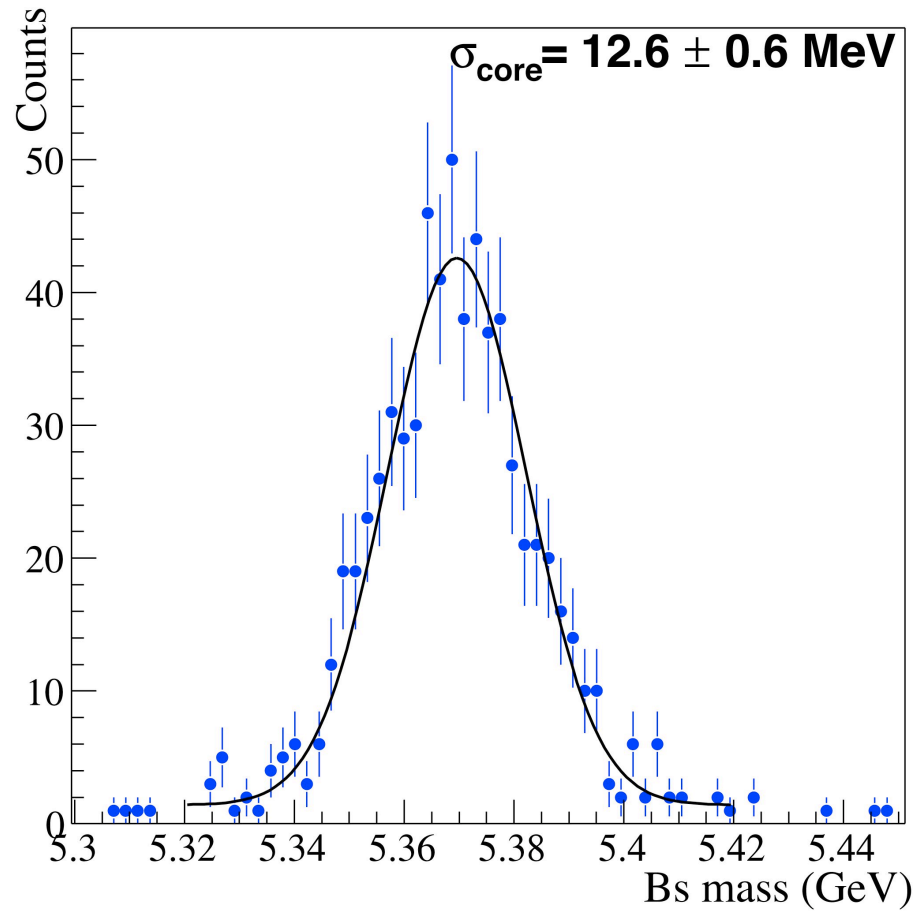
## J/ $\psi$ ( $e^+e^-$ ) peak



electron reconstruction

# Reconstruction qualities

$B_s \rightarrow D_s \pi$ : mass and decay time resolutions



## Annual yields (untagged sample)

$B_d \rightarrow \pi^+\pi^-$	27 k	$B_s \rightarrow K^+K^-$	35 k
$K^\pm\pi^\mp$	115 k	$D_s\pi$	72 k
$K^{*0}\gamma$	20 k	$D_sK$	8 k
		$J/\psi(\mu\mu)\phi$	109 k
		$J/\psi(ee)\phi$	19 k

**Results demonstrate that physics performance shown in Technical Proposal can be reached.**

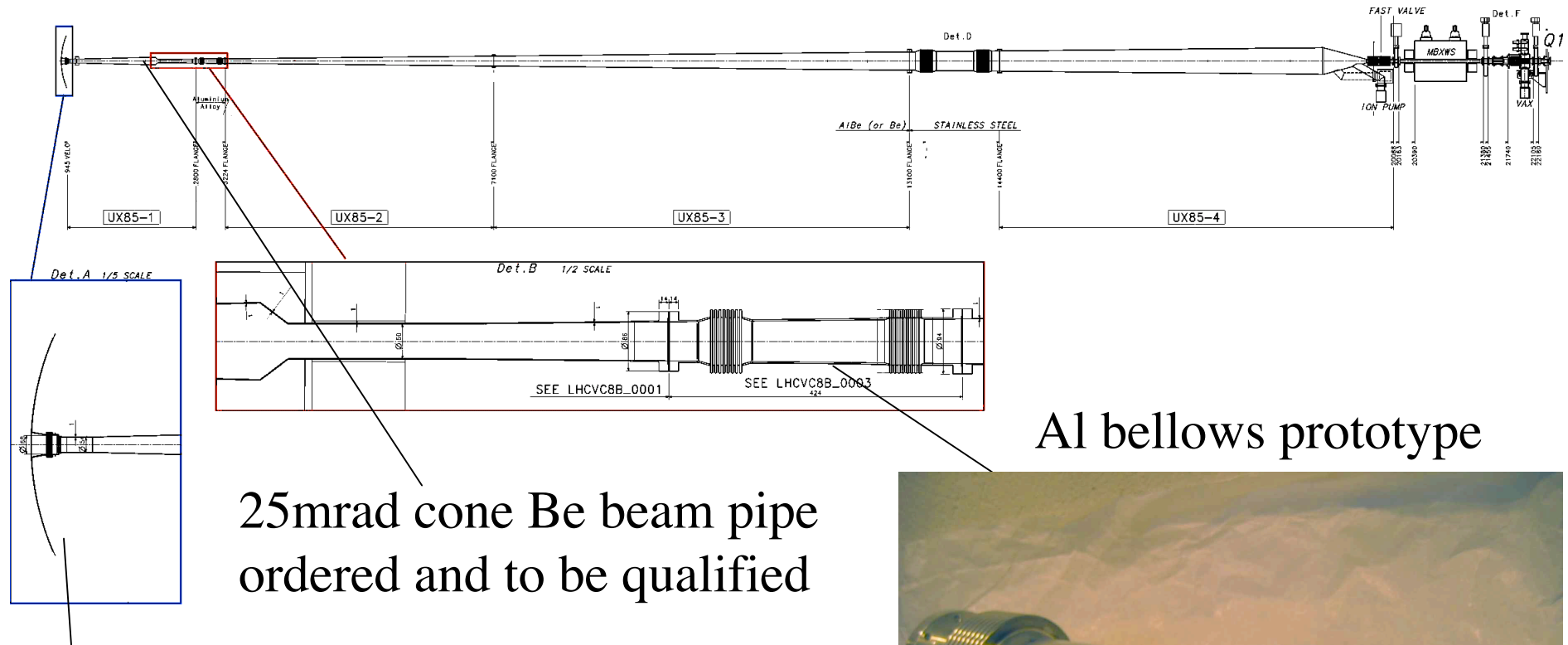
For the Reoptimization Technical Design Report in September (LHCb-light):

- more decay channels
- high statistics  $b\bar{b}$  background studies

will be included.

# 3) Subsystem Status

## a) Beam Pipe



25mrad cone Be beam pipe  
ordered and to be qualified

2mm Al exit window being made

design being finalized and prototypes  
are being made:

→ September LHCb-light TDR

Al bellows prototype



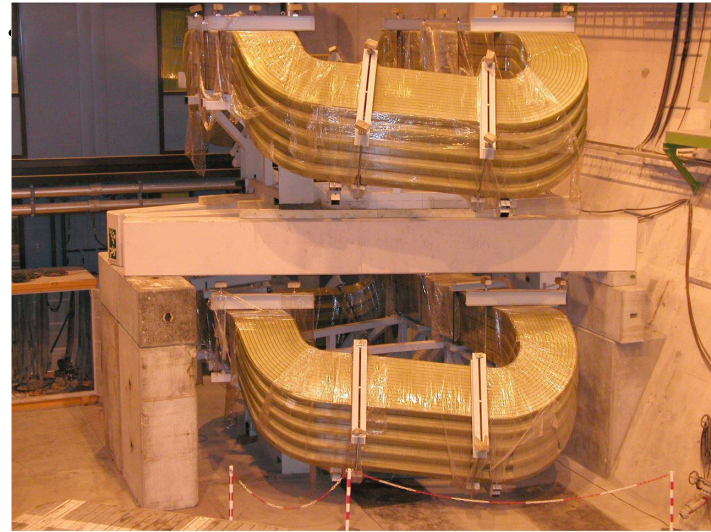


## b) Magnet

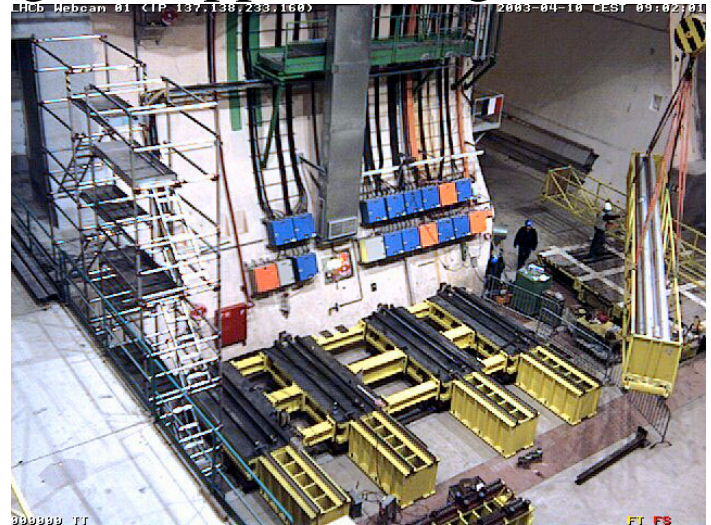
All the coils (10 triplets) have been delivered by SigmaPhi (France) to CERN and lowered to UX85.



Fe plates for the yoke are arriving from Jebens (Germany).



Magnet support being assembled

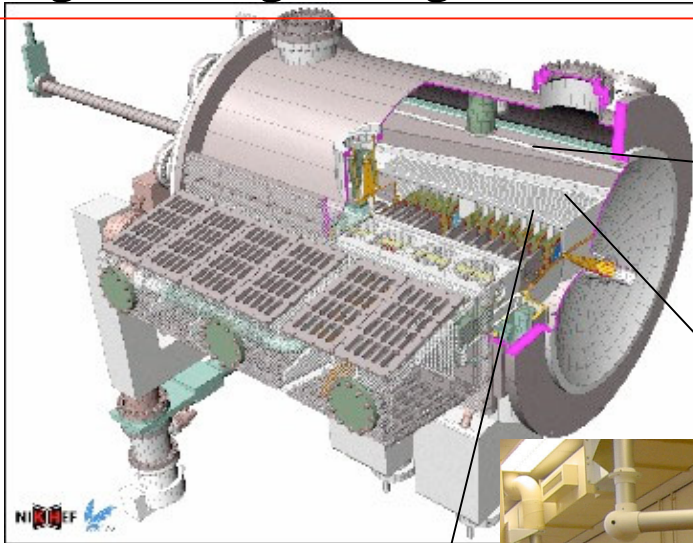


**The project is within budget so far.**



## c) Vertex Locator

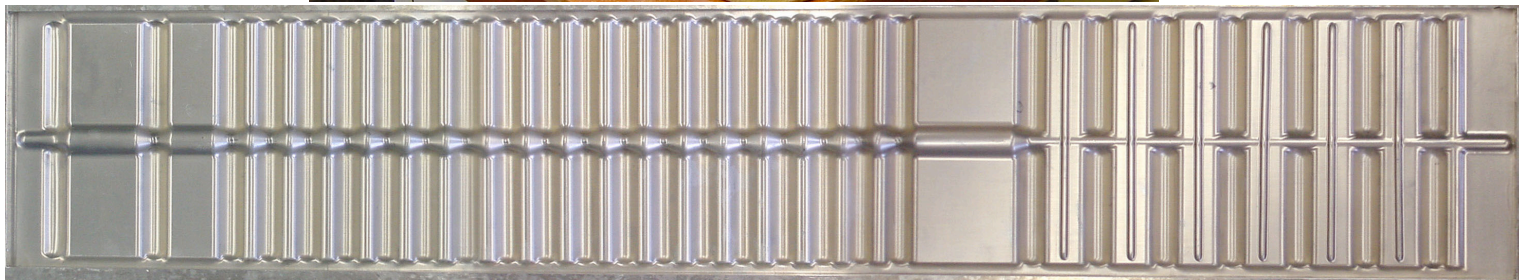
Engineering Design Review of the vacuum tank successfully completed



Al rf foil  
full scale  
prototype  
300  $\mu\text{m}$

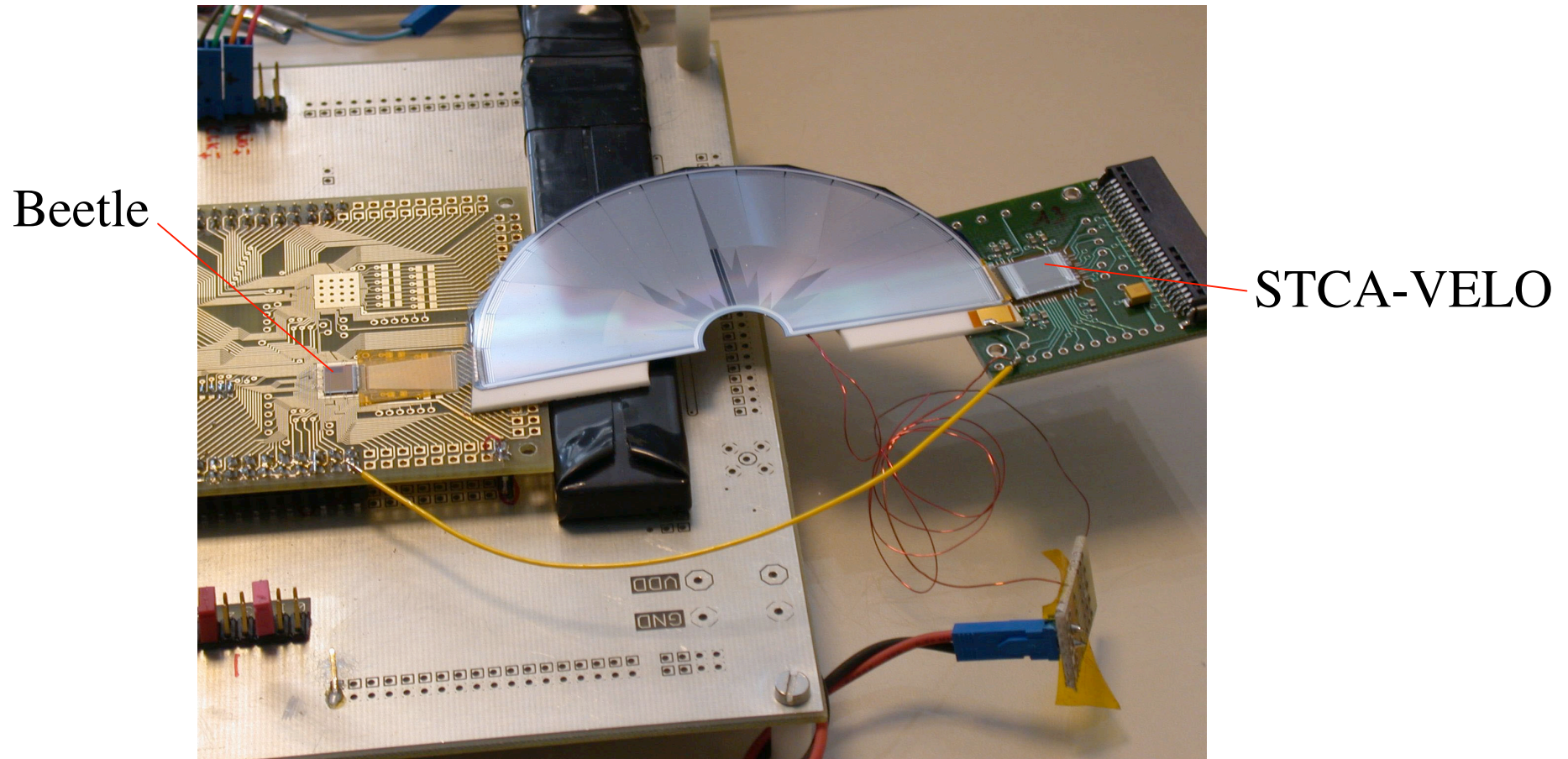


Rectangular  
bellows  
plasma welded





## Readout chip selected



- Both fulfil the LHCb requirements
- The  $1/4\mu\text{m}$  technology is a preferred technology  
→ Beetle selected

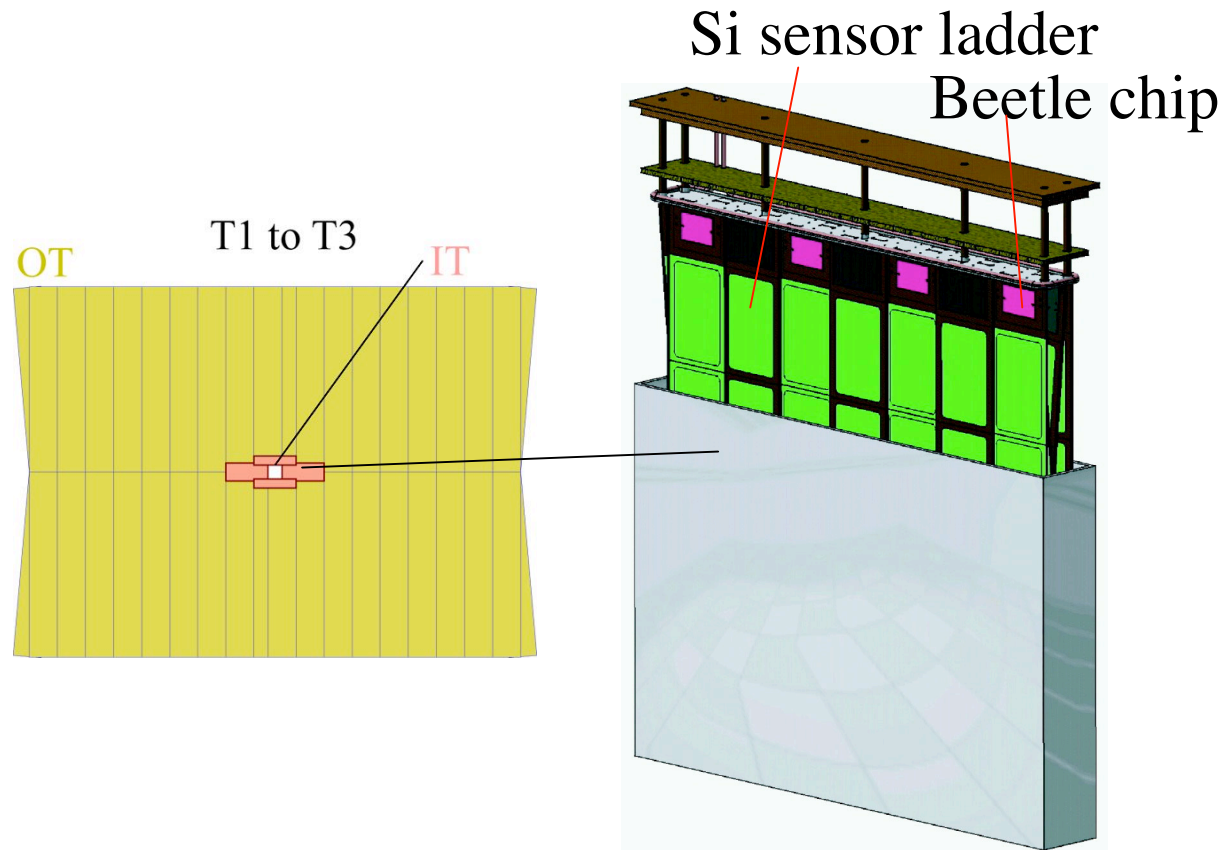
The last MPW iteration will be submitted in summer.



## d) Silicon Tracker

### Trigger Tracker and Inner Tracker

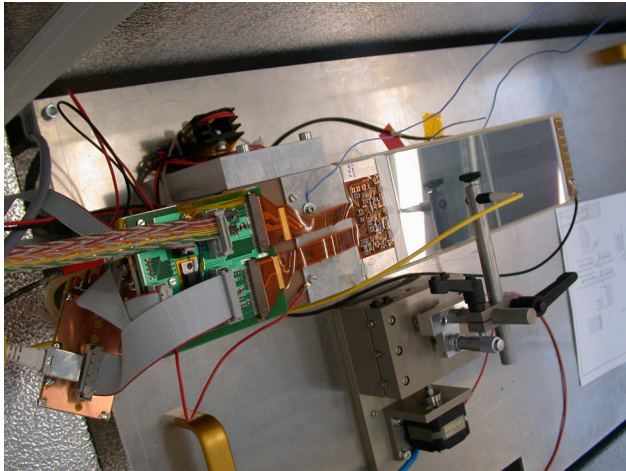
Inner Tracker TDR submitted in October 2002



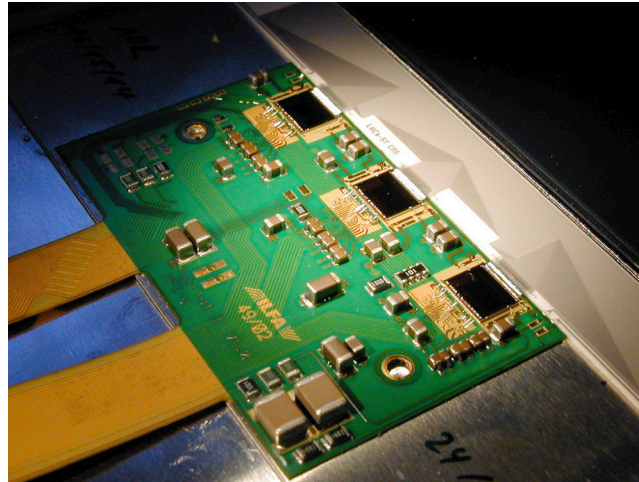
Si technology choice has been approved by the Research Board

Main effort of the ST group:  
TT design → September LHCb-light TDR

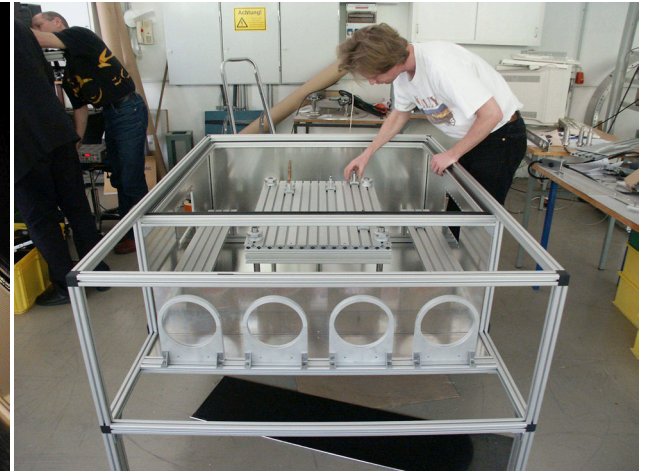
Laser test set-up



Beetle 1.2 and hybrid



Detector box for  
test beam

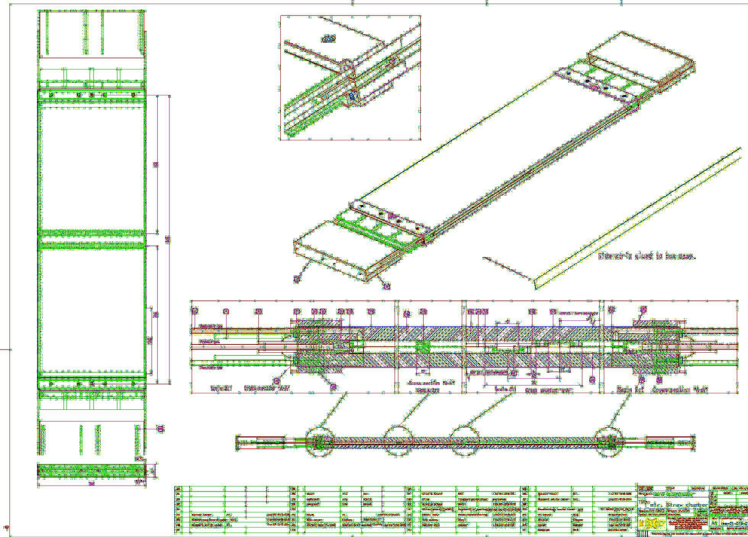


Spring test beam: verify S/N for  
the long sensor ladder and inter connect cable

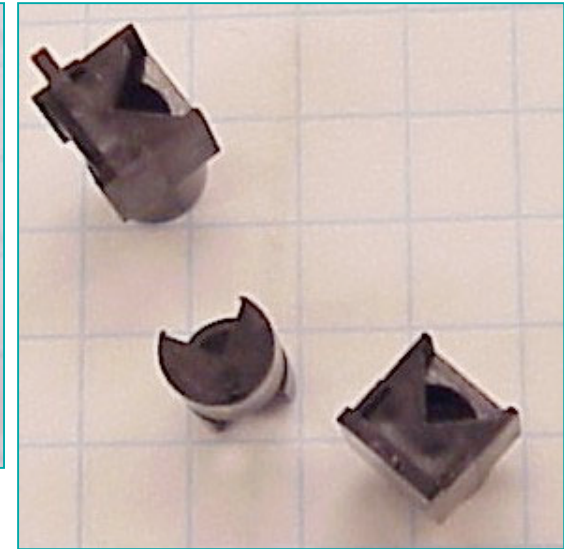


## e) Outer Tracker

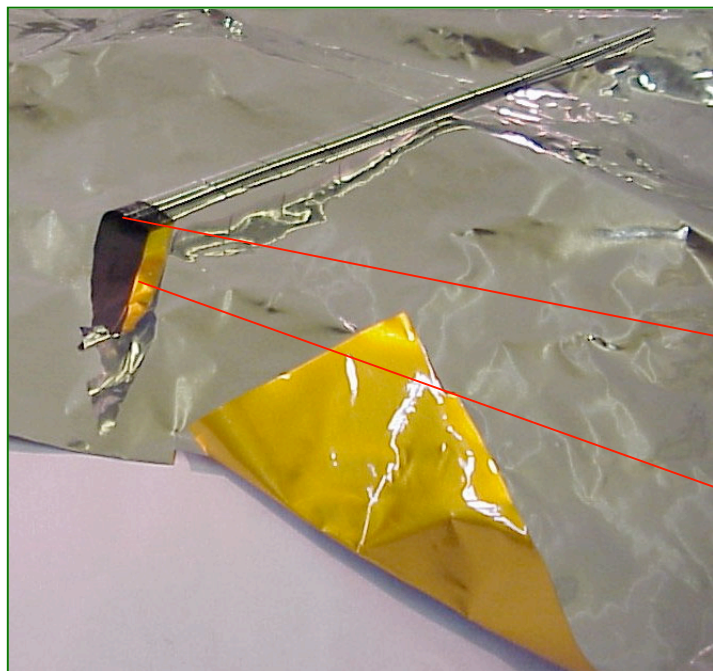
Preparation to launch the chamber mass production



Technical drawings



“small” components  
-industrial prototypes for the wire locators  
and end piece-



final straw

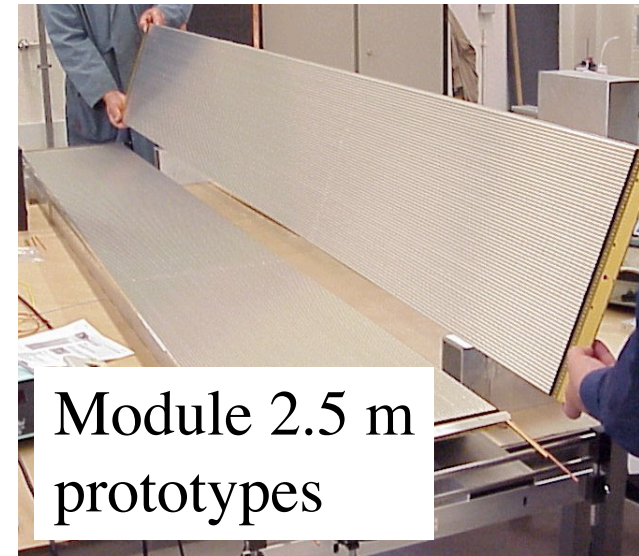
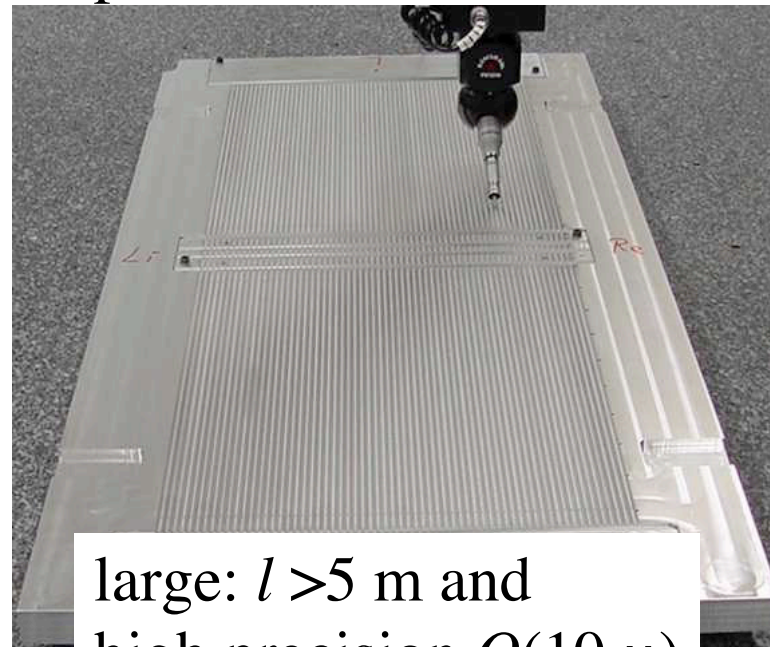
40μm Kapton XC-160

Laminated Kapton-Al

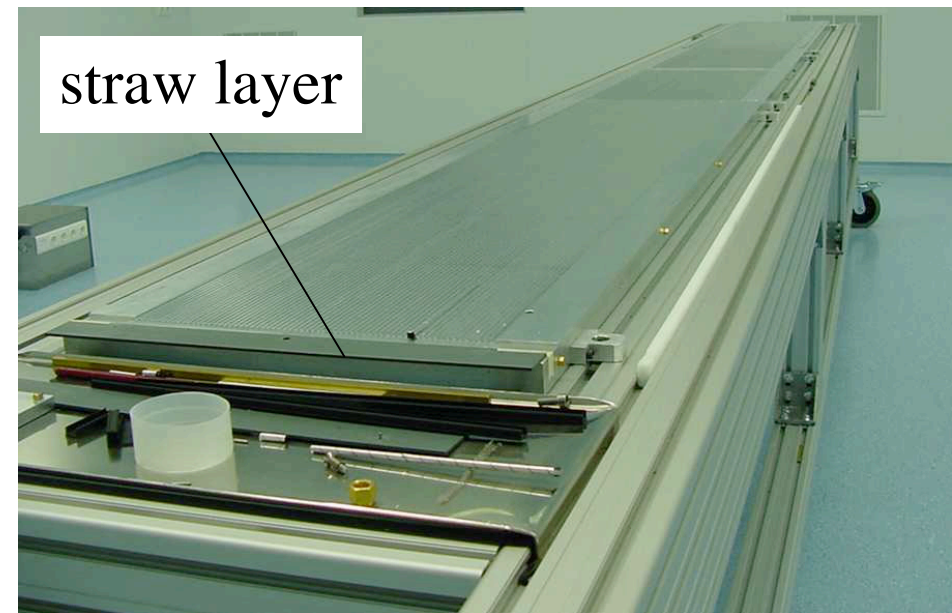




And tools are being prepared...  
template for the straw assembly



panel handling tool

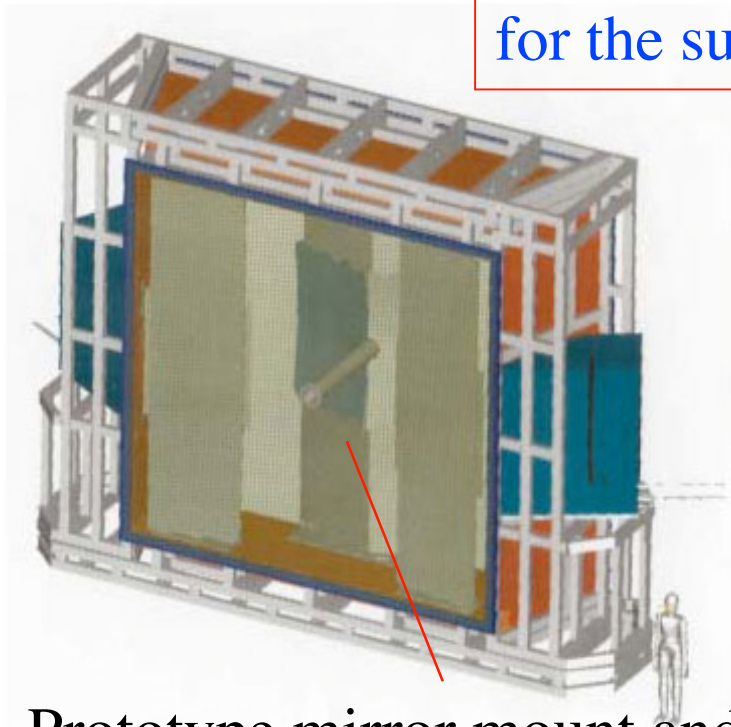


EDR expected before summer



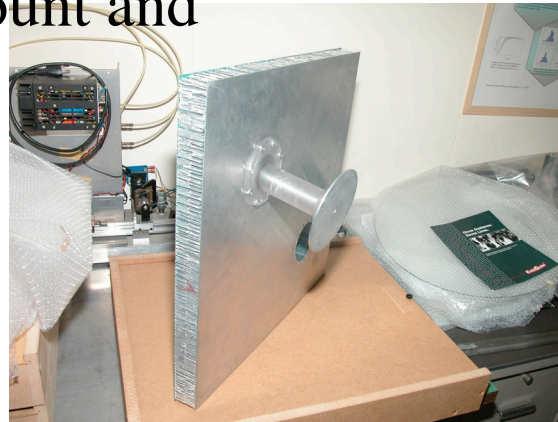
## f) RICH

RICH-2 Engineering Design Review  
for the superstructure and mirrors completed:



Prototype mirror mount and  
support panel

Spherical mirrors  
ordered.



RICH-1 design work for the LHCb-light progressing.  
→ September LHCb-light TDR

# Photon detectors

HPD R&D 40 MHz pixel chip



photocathode



tube encapsulation



initial performance



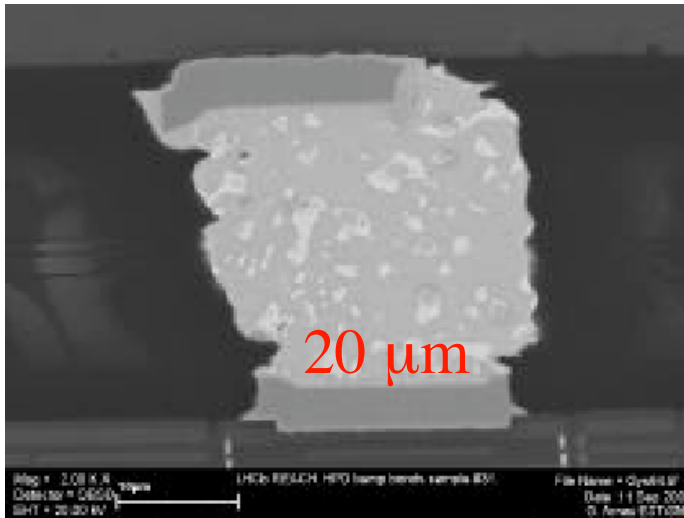
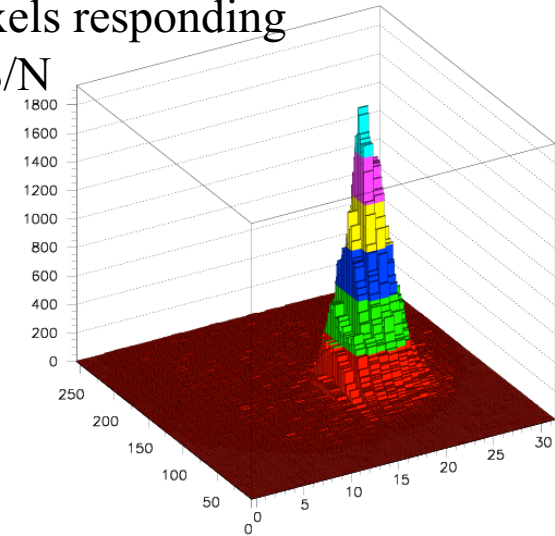
but...

long term stability

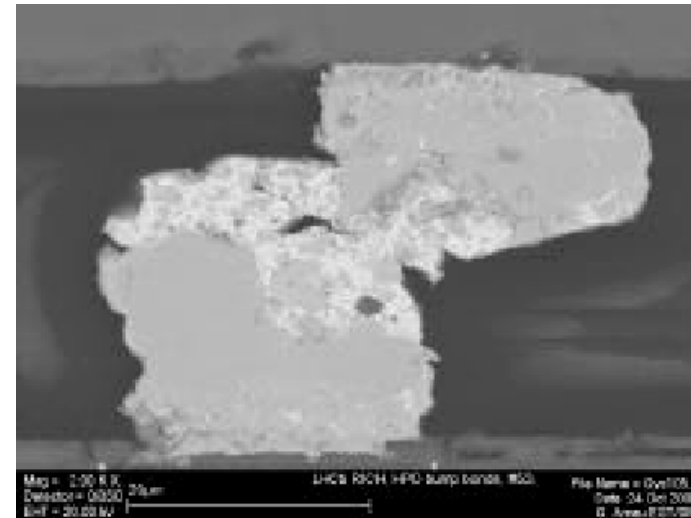


due to the bump bonding quality

> 99.9% pixels responding  
with good S/N



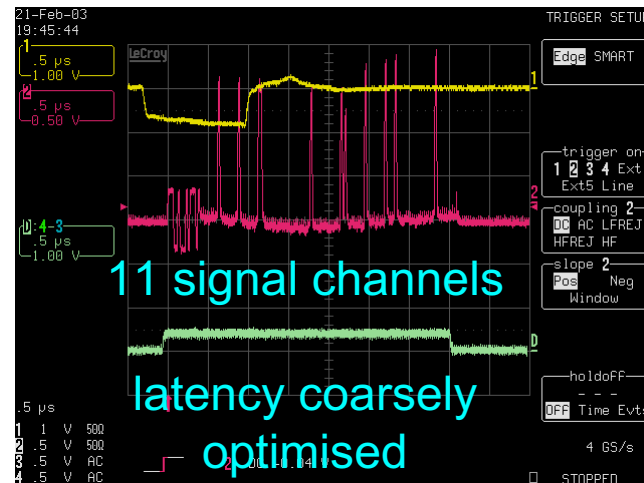
bump-bonds original state



after two bake-out cycles

New bump bonding procedure;  
soldering metal with higher melting point  
being prepared  $\Rightarrow$  must be ready by May

Effort for the multianode PMT development work increased  
readout electronics, analogue vs binary  
if analogue the cost may increase...



8-stage 64 pixel  
MaPMT readout by  
Beetle 1.2

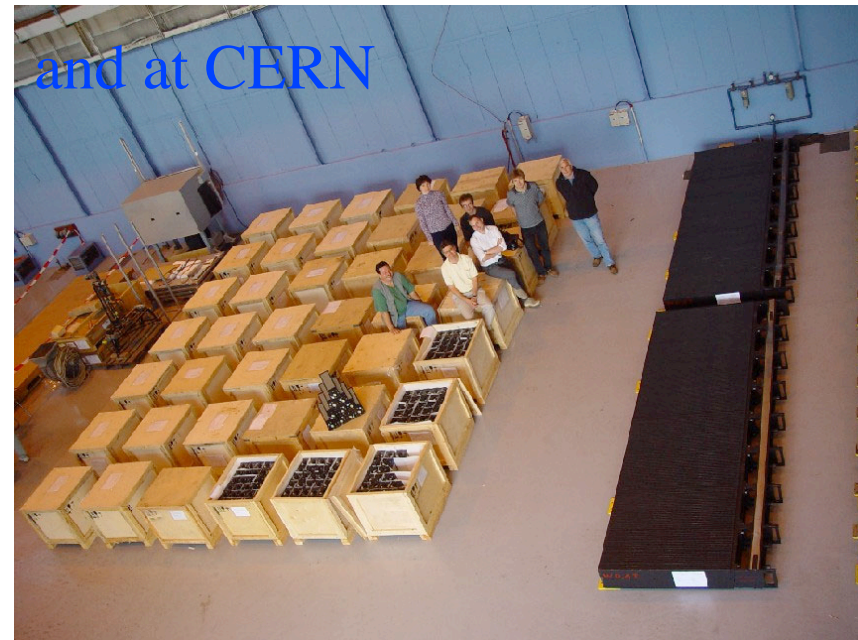
- Final decision by September
- Clear road map defined



## g) Calorimeters Ecal and Hcal mass production well advanced

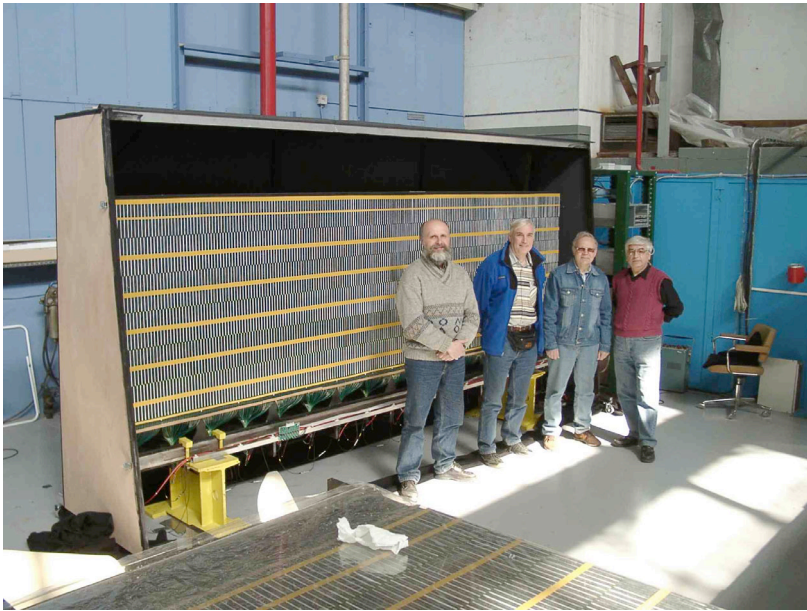


70 % of E-cal  
15 % of H-cal  
modules completed





## Preparation in progress for SPD-PS mass production at INR



Hcal optics assembly at CERN

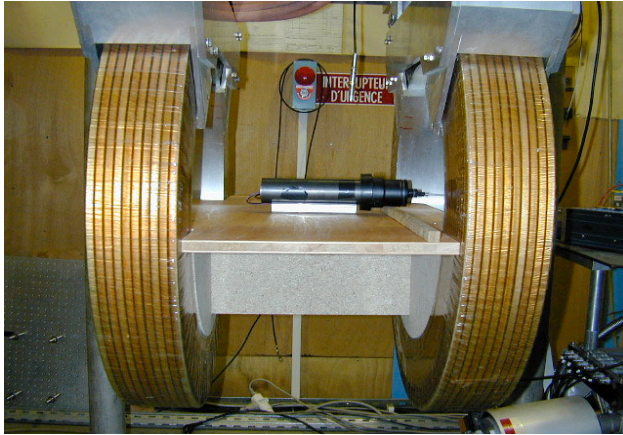


scintillator tiles

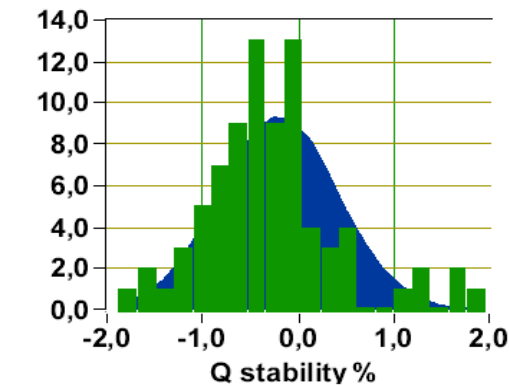
gluing of  
fibre in the  
groove of  
scintillators



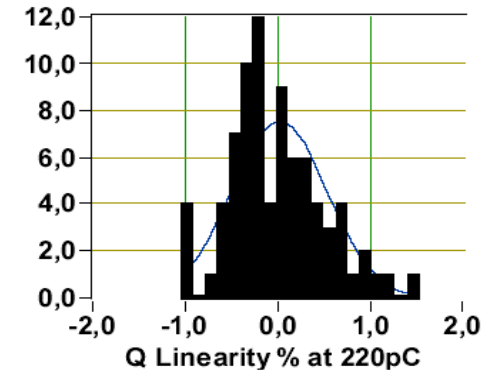
After many tests...



magnetic field property



62/80 within  $\pm 1\%$  80/80 within  $\pm 2\%$



75/80 within  $\pm 1\%$  80/80 within  $\pm 2\%$

stability and linearity measurements

PMT's for E-cal and H-cal ordered.

delivery over the next 2.5 years

first batch in May

will be tested by IHEP, ITEP and LAL-Orsay

all test benches ready by mid May

Ecal and Hcal front-end chips produced and tested with a yield of 90%.

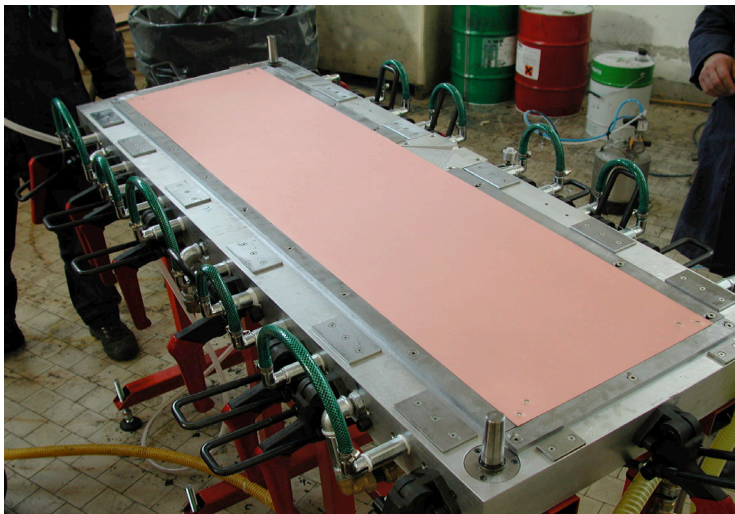
**The project is within budget so far.**



## h) Muon system

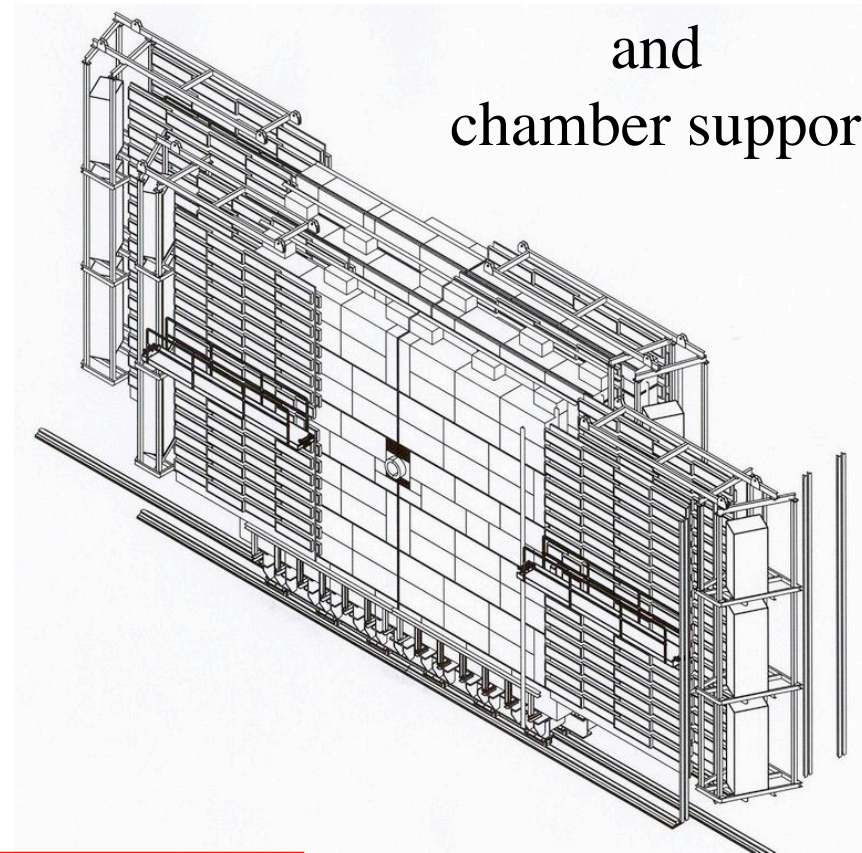
Addendum to the Muon TDR: logistics for all MWPC muon system production sites (increased number of MWPC), plan and cost  
Approved by the Research Board.

Preparation for MWPC  
mass production



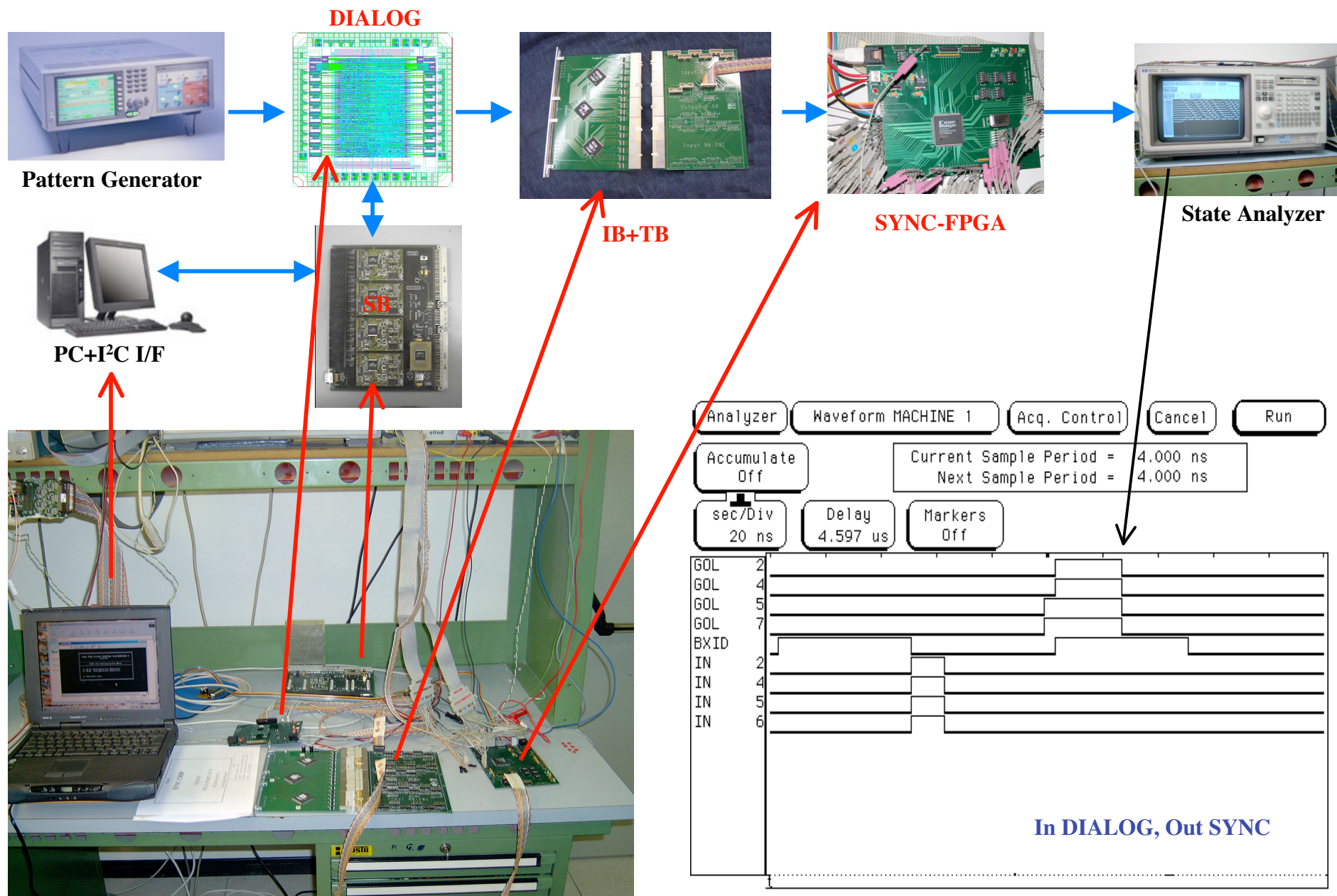
production of panel

Muon Fe filter  
and  
chamber support



EDR's soon.

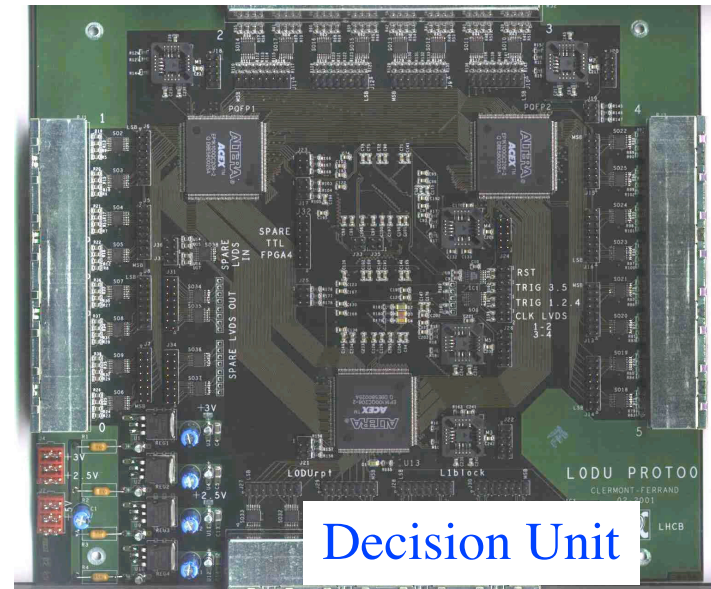
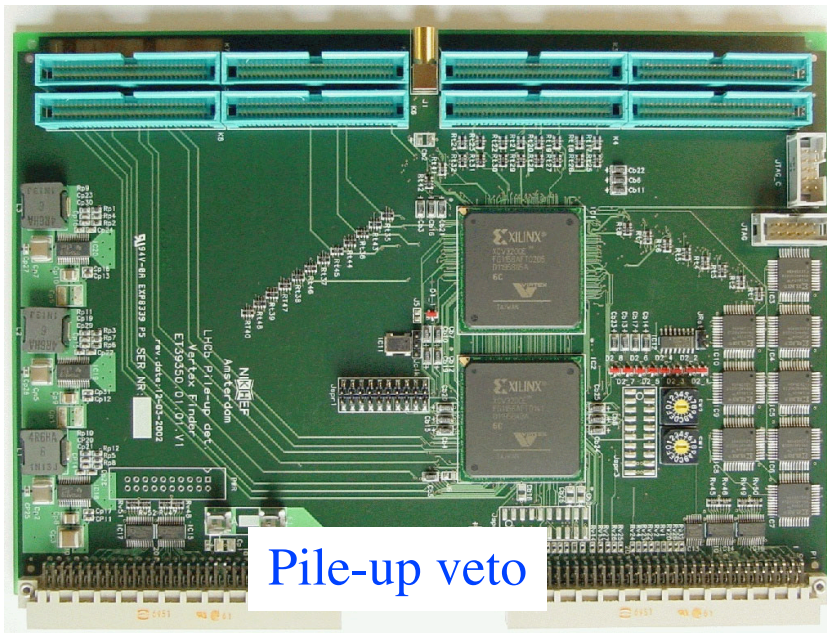
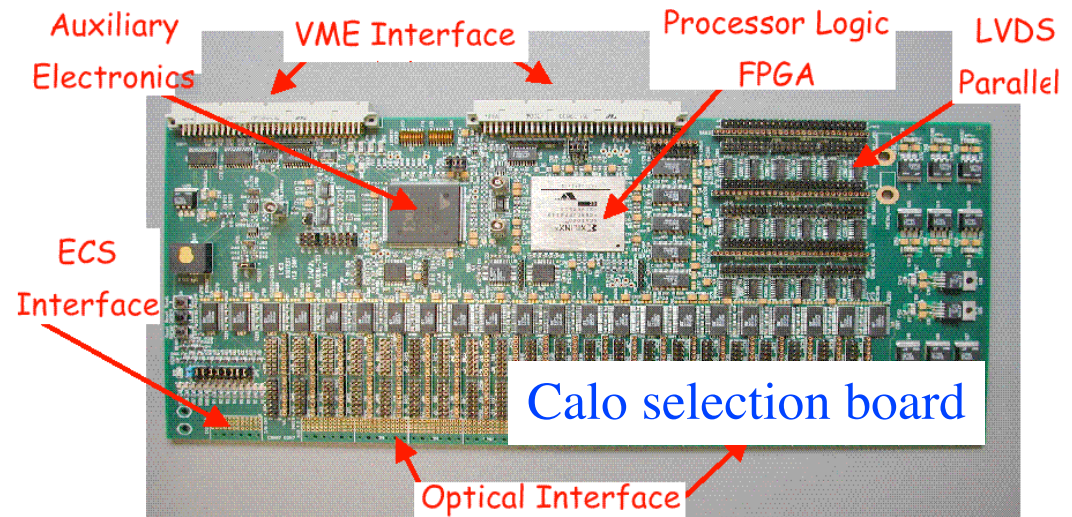
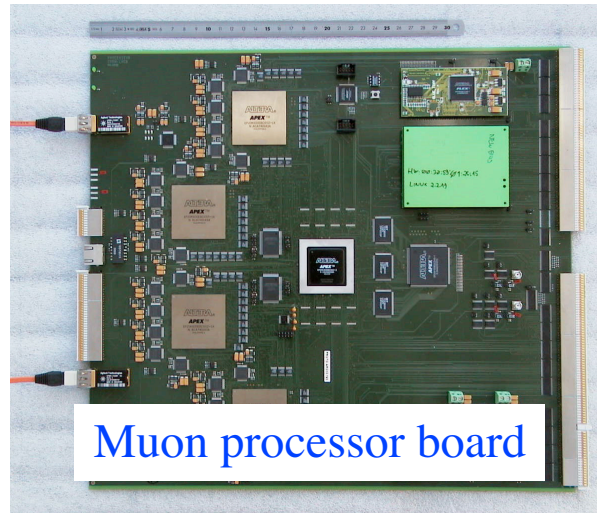
# Full chain electronics prototype test in progress





## i) Trigger

Level-0: Muon, Calorimeter ( $e$ ,  $h$ ,  $\gamma$ ,  $\pi^0$ ), Pile-up veto, Decision Unit prototype work advancing.



## Level-1

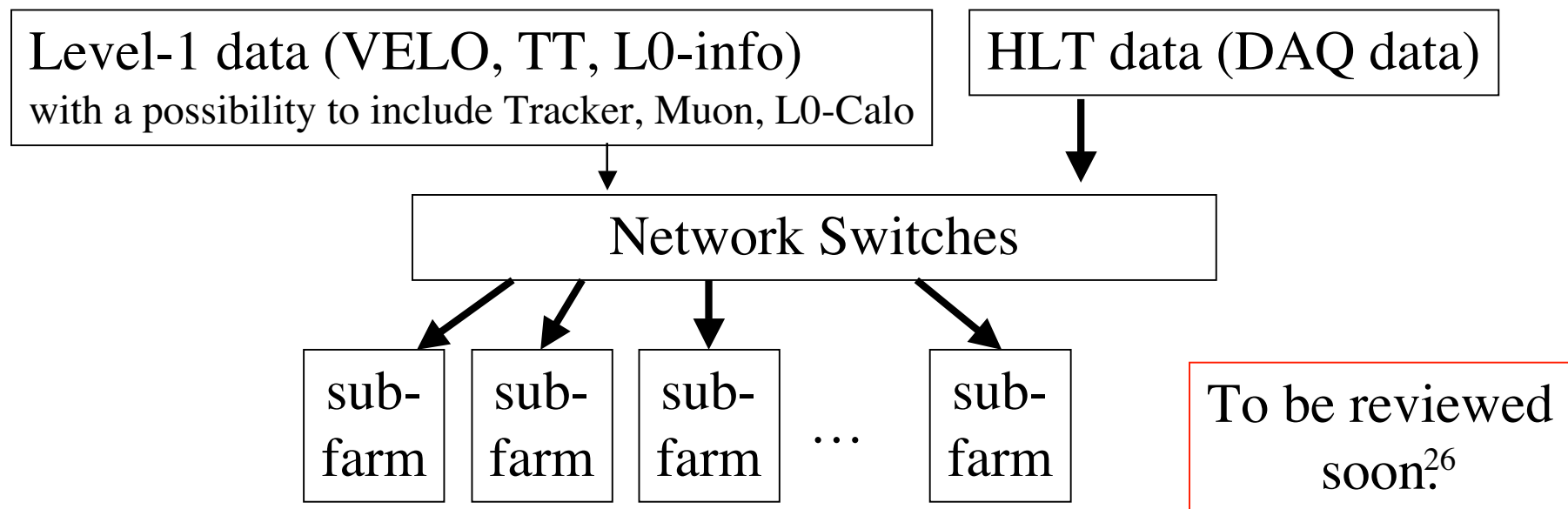
Currently data from VELO + TT + L0 Decision Unit  
Work on a dedicated Level-1 hardware implementation  
based on SCI technology completed.  
However...

more flexibility in input data and CPU power needed:  
keep **a possibility open to add**

IT+OT+Muon+Calo **in future**

**(robustness, evolving physics goal, etc.)**

**Unified Level-1/DAQ(High Level Trigger) architecture is now studied.**

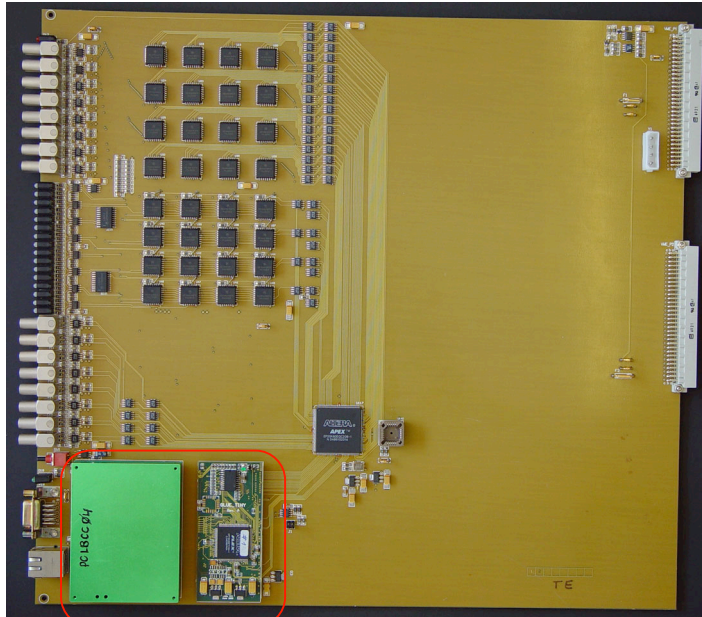




## i) Computing

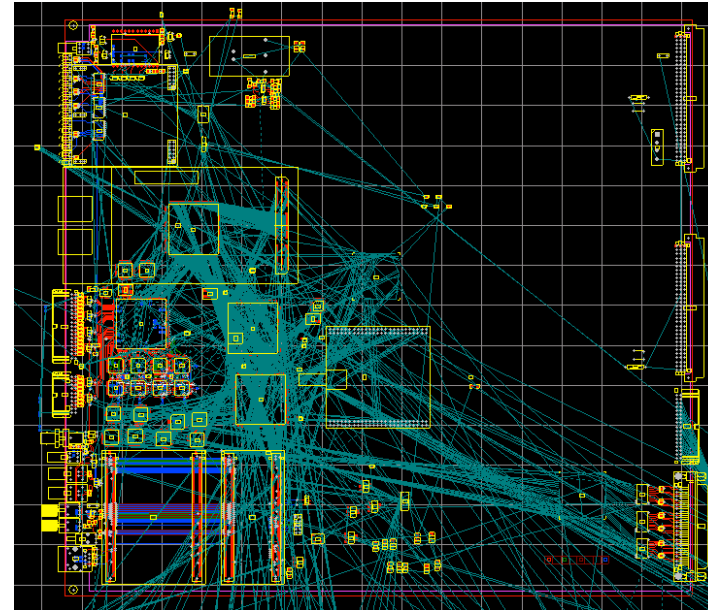
Online      Various prototypes built

Timing and Fast Control  
switch prototype board



with Interface to  
Experimental Control System

Readout Supervisor  
prototype layout



Unified L1/DAQ(HLT) architecture being investigated

## Offline software

### Stable running of

event generation  
particle tracking through the detector  
detector response simulation  
event reconstruction  
physics analysis

Pythia	}	SICBMC (Fortran)
GEANT3		
Brunel	}	almost all in C++
Brunel		
DaVinci		

### for the Trigger and LHCb-light TDR's

Close Collaboration with the **LCG** application software development  
active participation in  
general framework, persistency store, event generator...

### Current activity:

Brunel → event reconstruction only

New package for the particle tracking and detector response  
based on GEANT 4 (Gauss)



# Offline computing

## Development of the LHCb computing model

gaining experience from the large scale MC event generation

~1M events/day for the Trigger and LHCb-light TDR

using CERN + many other institutes + European Data Grid

A total of >30M events generated:

20M Minimum Bias events

+ specific B decay samples

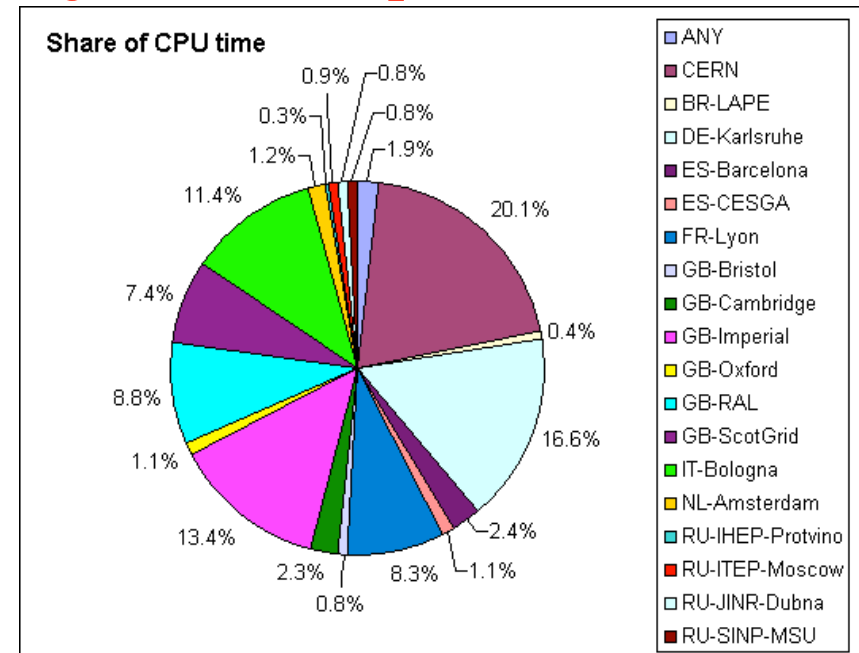
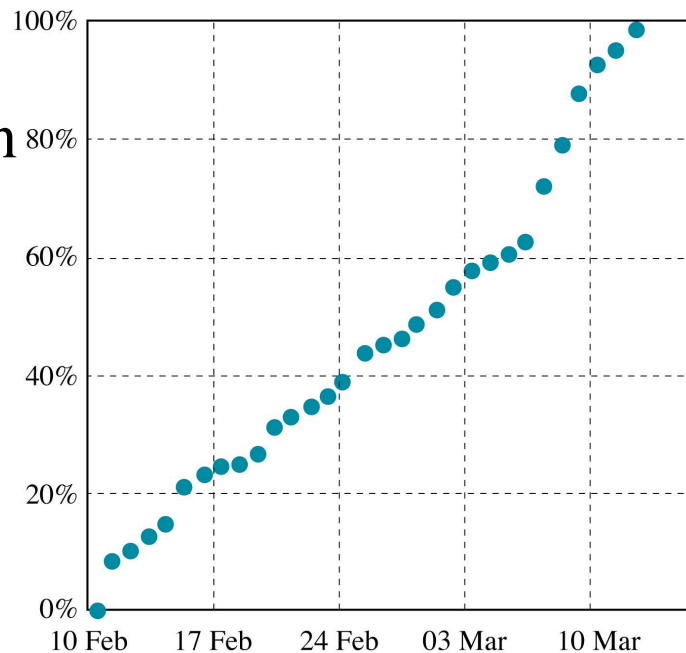
10M bb inclusive

} trigger study

} physics performance study

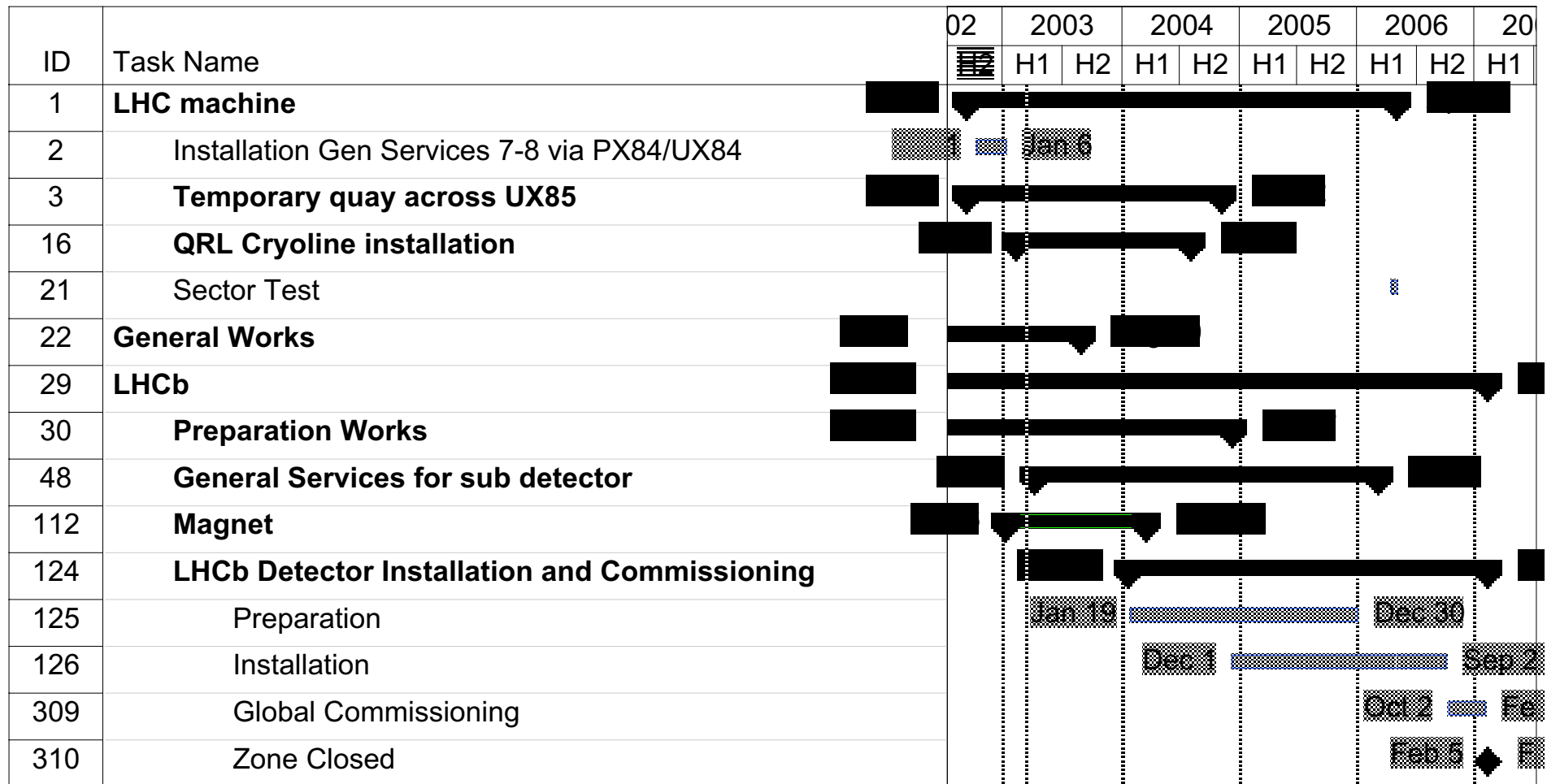
→ data reduction is being made to cope with the amount

## Status of production



# 4) Installation

First installation review took place in March



Cohabitation with machine required:  
 Construction of the cryogenic plant in UX85  
 Transportation of cryogenic component through UX85  
 LHC sector test

# GENERAL LAYOUT OF LHCb IN UX 85 AREA

TOP VIEW | UPDATED 16/01/2003 |

UX85 CAVERN  
AT POINT 8

POINT 1

CENTRE  
LHC RING

IP8

POINT 7

LHC INFRASTRUCTURE - DOT AREA - Levels - Underground			
CONTROL	NUMBER	DATE	BY
UNDERGROUND GENERAL LAYOUT	1200	2002-01-17	EGU
UX85 ARRANGEMENT - TOP VIEW		2002-01-17	EGU
DESIGN OFFICE	FOR INFORMATION	DATE	BY

CONTROL	NUMBER	DATE	BY
UNDERGROUND GENERAL LAYOUT	1200	2002-01-17	EGU
UX85 ARRANGEMENT - TOP VIEW		2002-01-17	EGU
DESIGN OFFICE	FOR INFORMATION	DATE	BY

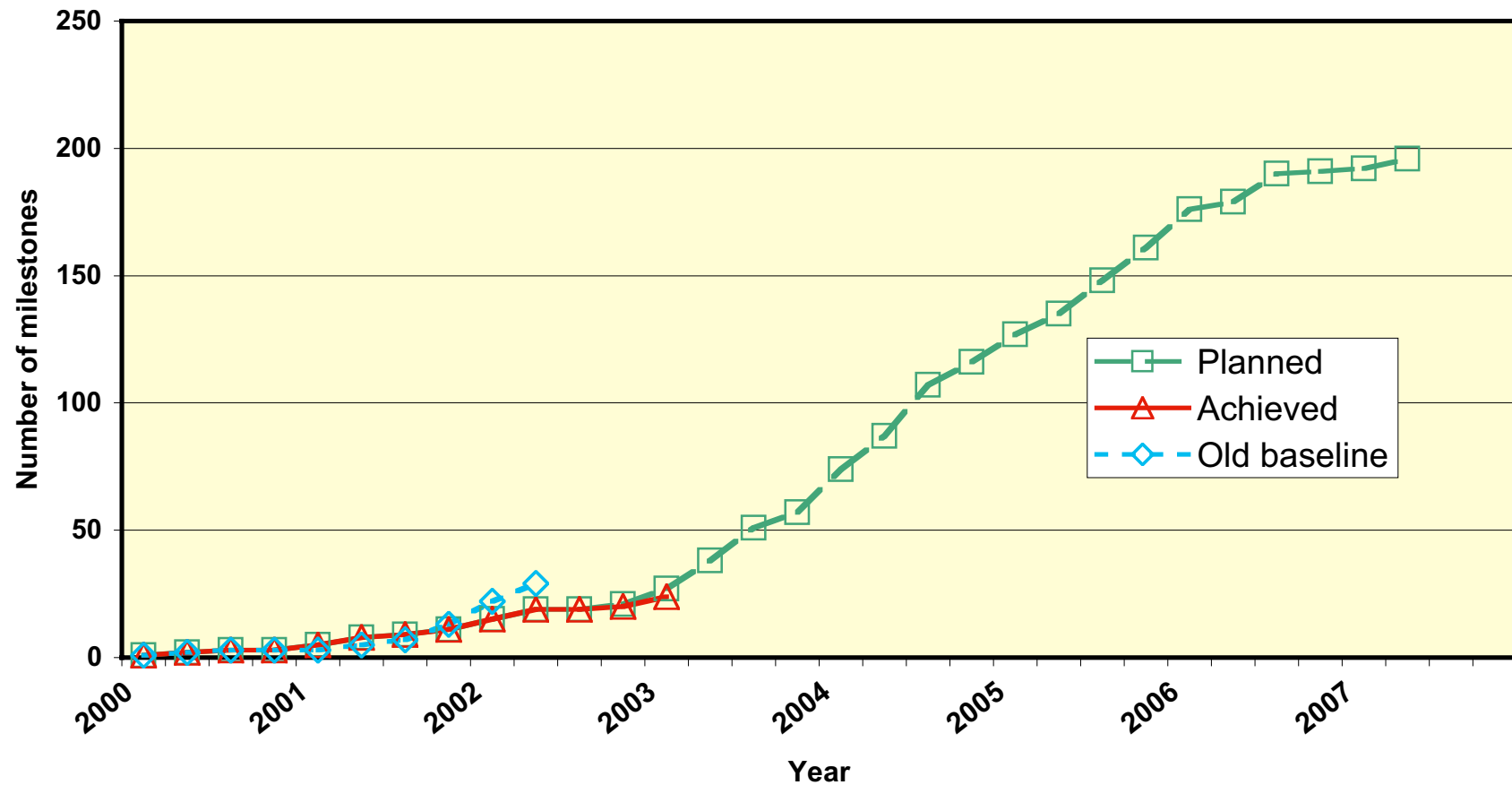


WORKSITE

January 2003

The bridge blocking the IP region<sub>31</sub> now is for the cryogenic line installation.

## LHCb Milestones



## 5) Status of Construction MoU

Countries still to sign: Brazil, Germany, Poland

7 MCHF < 10%

-Germany and Poland

Funding has been available so far for the necessary work and

Germany: a significant fraction of the core contribution secured  
application for the rest has just been made

Poland: funding for 2003 to 2005 agreed

MoU discussion in progress

→ **No real concern for the moment**

-Brazil

No funding has been allocated and will not be available in a  
foreseeable future:

Common fund	0.48 MCHF	} 1.7 MCHF $\approx$ 2%
Muon	1.22 MCHF	

Muon cost: 6.98 + 4 (Fe filter) MCHF

CERN , Italy (Frascati, Cagliari, Ferrara, Florence, Rome I and II),  
Russia (PNPI)

1.22MCHF is a sizable fraction of the muon funding

→ not trivial to absorb this...

and production of the muon chambers must start very soon.

**Collaboration has started to investigate solutions.**

Modification of the responsibility sharing in the Calo Project

-Annecy: joined after MoU and TDR

Design responsibility for the overall mechanics rearranged:

originally distributed among CERN and Russia

**→ now centred at Annecy**

(work defined and started, to be formalised soon)

-Ukraine: not totally defined at the time of TDR

In addition to H-cal iron bars, scintillator tiles for SPD/PS <sup>34</sup>

## 6) Conclusions

- Construction of the magnet and E-cal and H-cal modules are **progressing as planned within the budget** so far.
- Construction of VELO vacuum tank, RICH-2, OT, SPD/PS and Muon chambers **will start very soon**.
- First look of the installation plan. Cohabitation with the machine required. **Timely completion of the cryogenic line installation is crucial**.
- **HPD** R&D remains a **serious concern**. Effort on **MaPMT** increased.
- Good progress on the detector reoptimization. **A simpler** tracking system with **good physics performance**.
- **Shortfall in funding by 1.7 MCHF** due to Brazil. The Muon system is seriously affected.