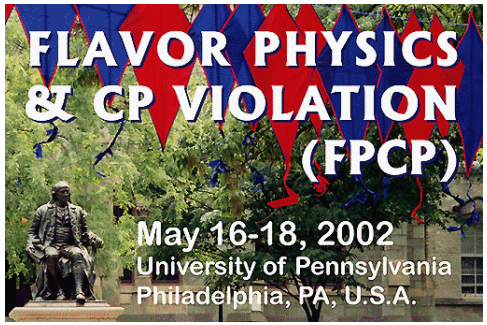
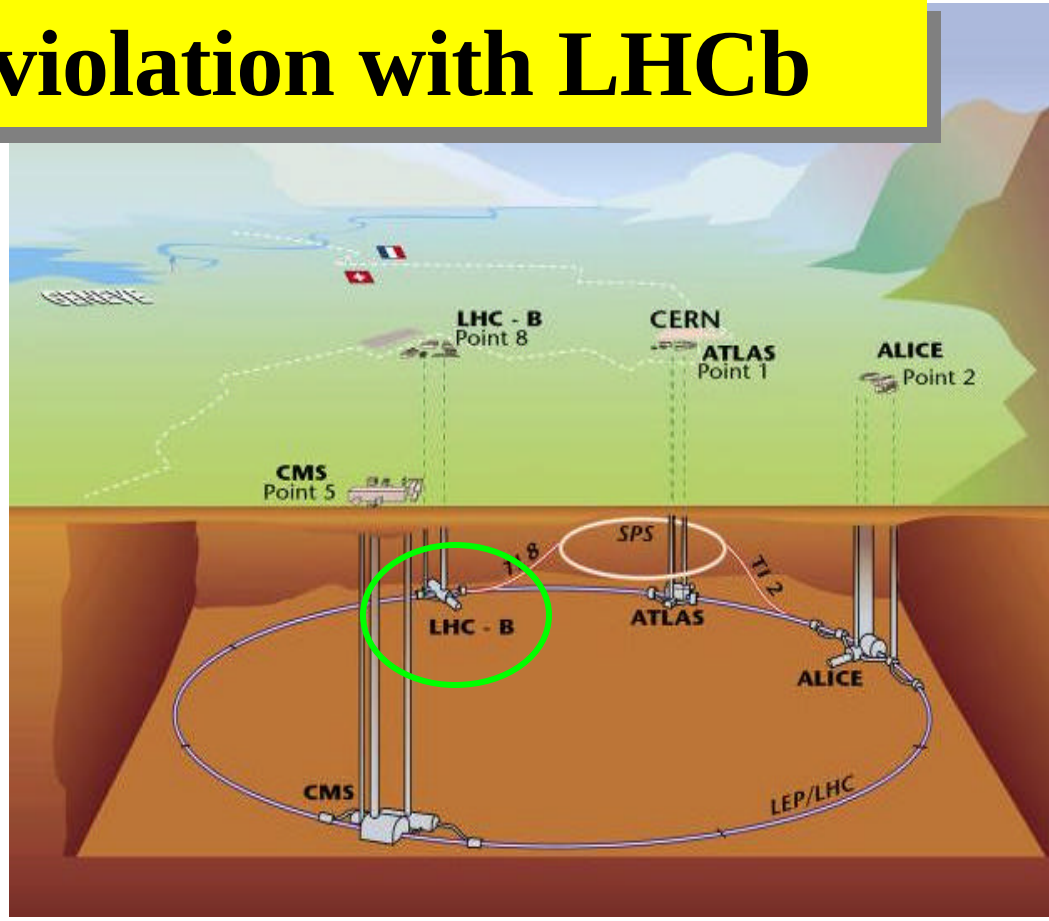


Giovanni Carboni
Roma 2 and CERN

B-Physics and CP violation with LHCb



> 400 participants
> from 48 Institutes

B-physics from LHC startup

The future at LHC:

- the machine will switch on in April 2007
  - 10^{12} b-anti b pairs/year at modest luminosity of $2\ 10^{32}\ cm^{-2}\ s^{-1}$
- LHCb is the only dedicated b experiment on LHC
  - ~ 0.5 events/crossing (low *L*, special optics)
  - specialized trigger
  - particle ID
  - vertex detector at trigger level
- Huge statistics:

  ~ 100,000 reconstructed J/y K_s per year

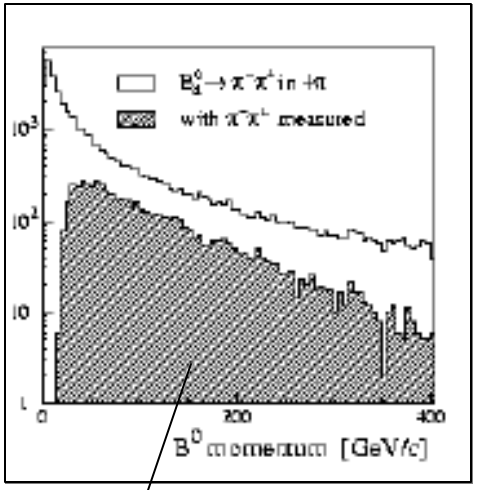
  All b hadrons produced:

  $B^0, B^{\pm}, B_s, B_c, \Lambda_b$,……
- A broad spectrum of precision studies on many channels will be possible:
  - CP violation
  - rare decays
  - B_s oscillations
  - search for new physics

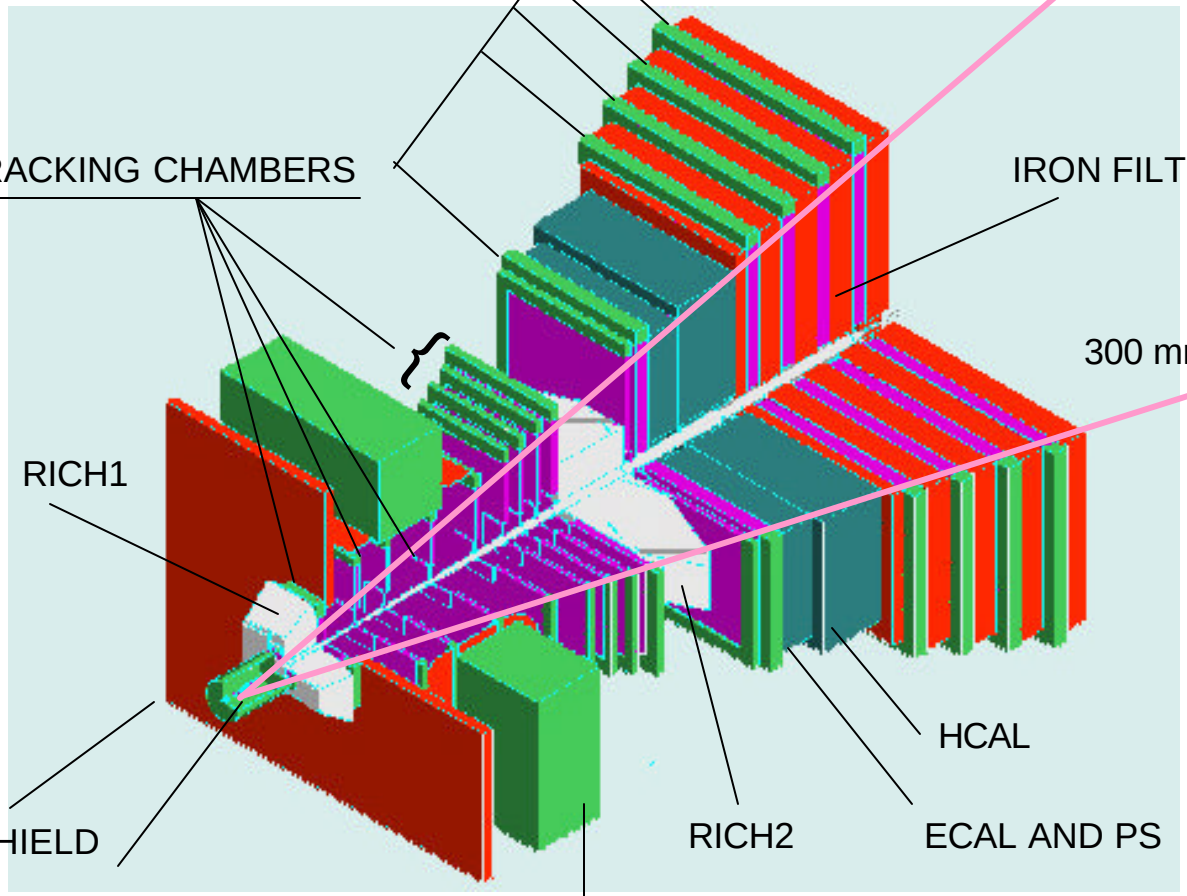
The present:

- most TDRs approved (pending: Trigger, Inner Tracker)
- construction has started
- we are within budget and ~ on schedule

$1.9 < \eta < 4.9$



inside acceptance



Re-optimization ➔ LHCb-light (reduced material budget)

Improving

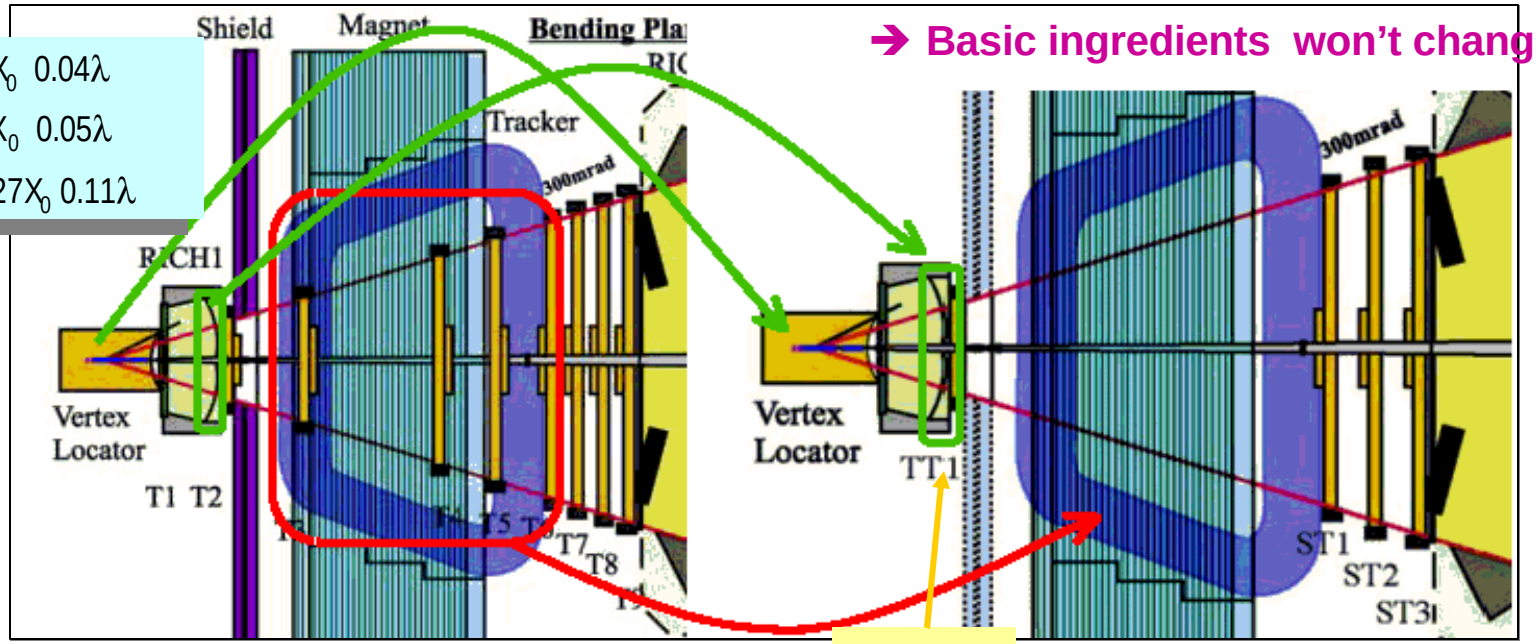
- VELO (↘ # stations, thinner Si sensors)
- RICH 1 (lighter mirror & support)
- remove tracking stations in magnet (➔ new tracking strategy)
- trigger
- Al-Be beam pipe

Expect finalization by end 2002

VELO $0.19X_0$ 0.04λ

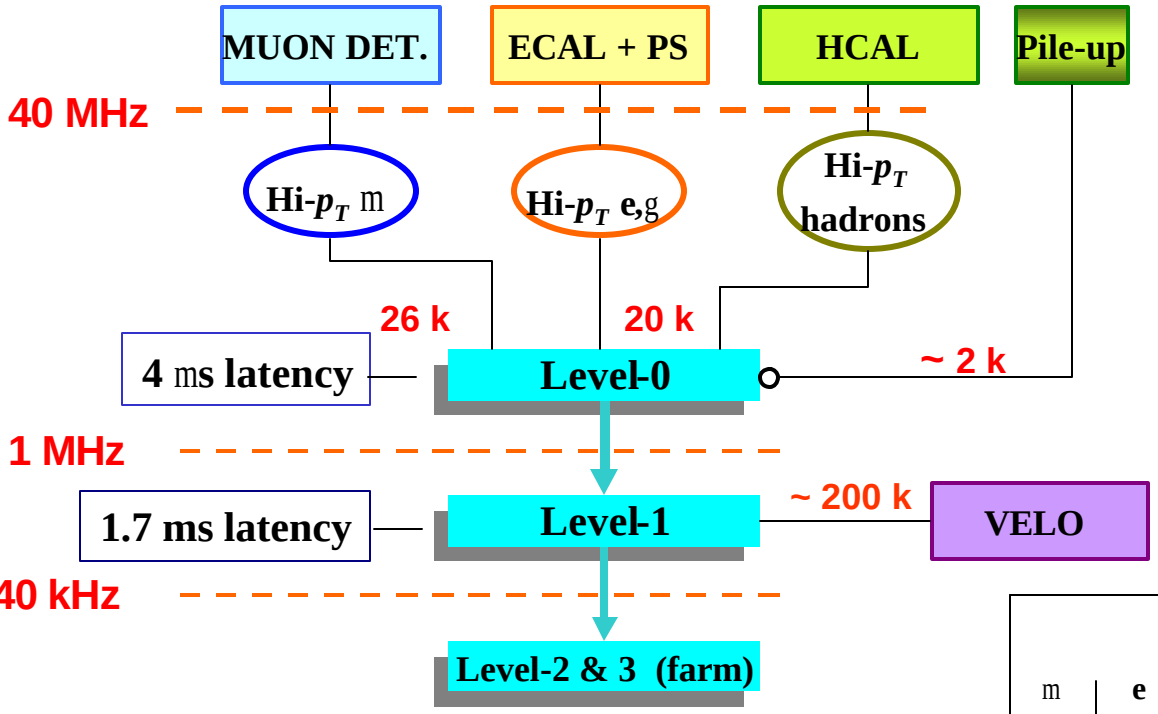
RICH1 $0.14X_0$ 0.05λ

Tracking $0.27X_0$ 0.11λ



➔ **Basic ingredients won't change**

LHCb Trigger Scheme



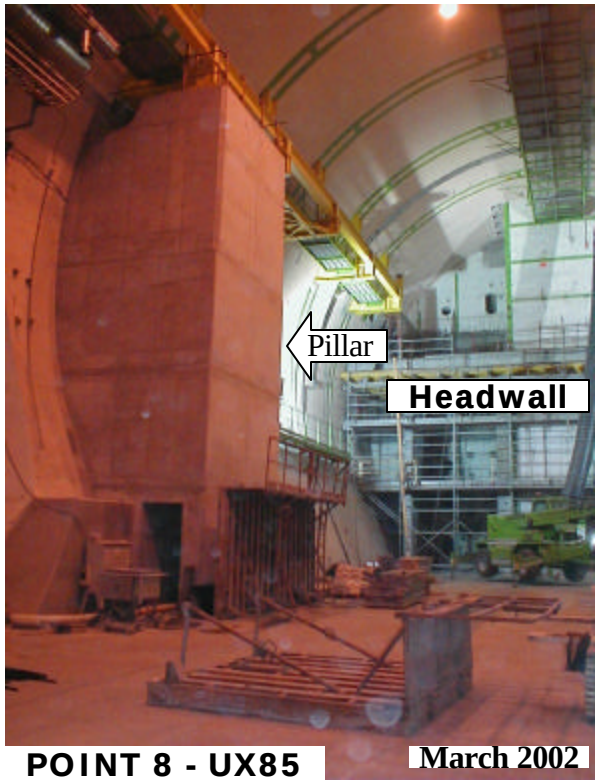
Match of L1 VELO tracks with L0 clusters

Super-L1 algorithm

Improved efficiency

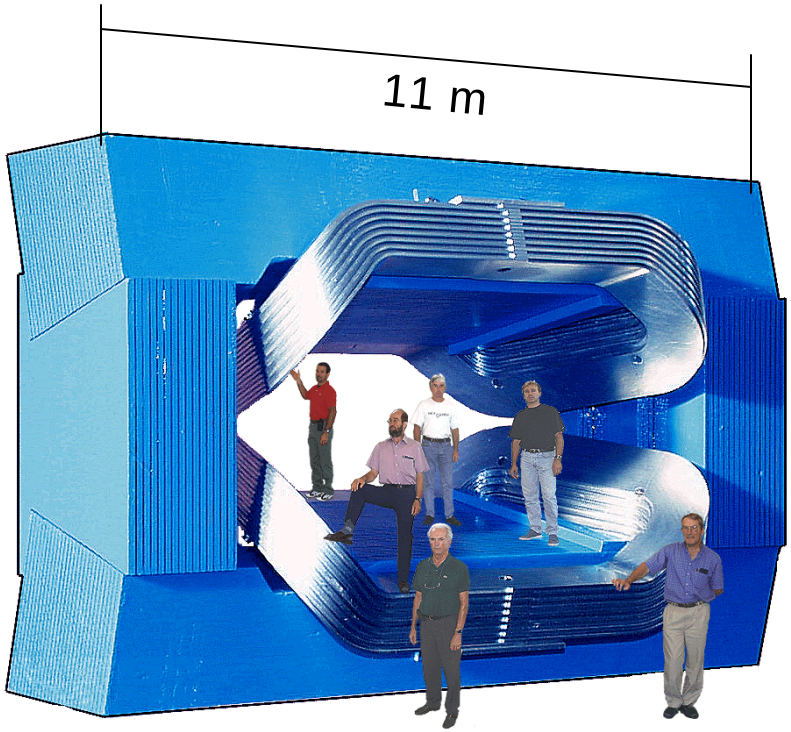
	L0 (%)				L1 (%)	L2(%)	Tot (%)
	m	e	h	all			
B_d ® J/y(mm)K_s + tag	87	6	16	88	50 ® 90	81	36 ® 64
B_d ® J/y(ee)K_s + tag	17	63	17	72	42 ® ...	61	24 ® ...
B_s ® D_sK + tag	15	9	45	54	56 ® 70	92	28 ® 35
B_d ® pp + tag	14	8	70	76	48 ® 72	83	30 ® 45

Experimental area: the DELPHI dismantling is completed



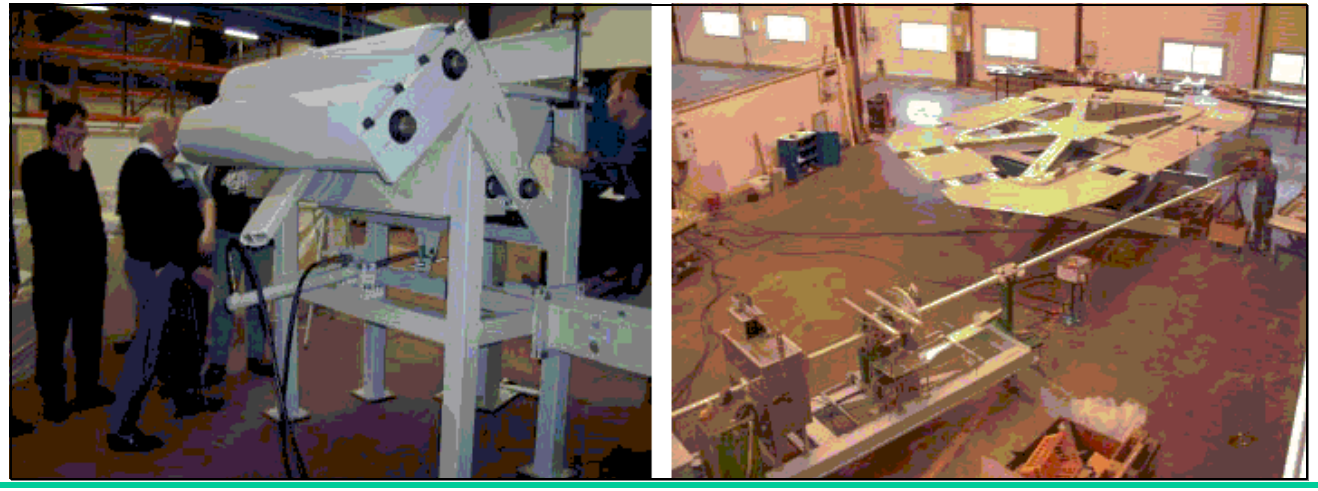
Iron blocks from the neutrino beam line are recuperated for the muon filter

$$\int Bdl = 4\ \mathrm{Tm}$$



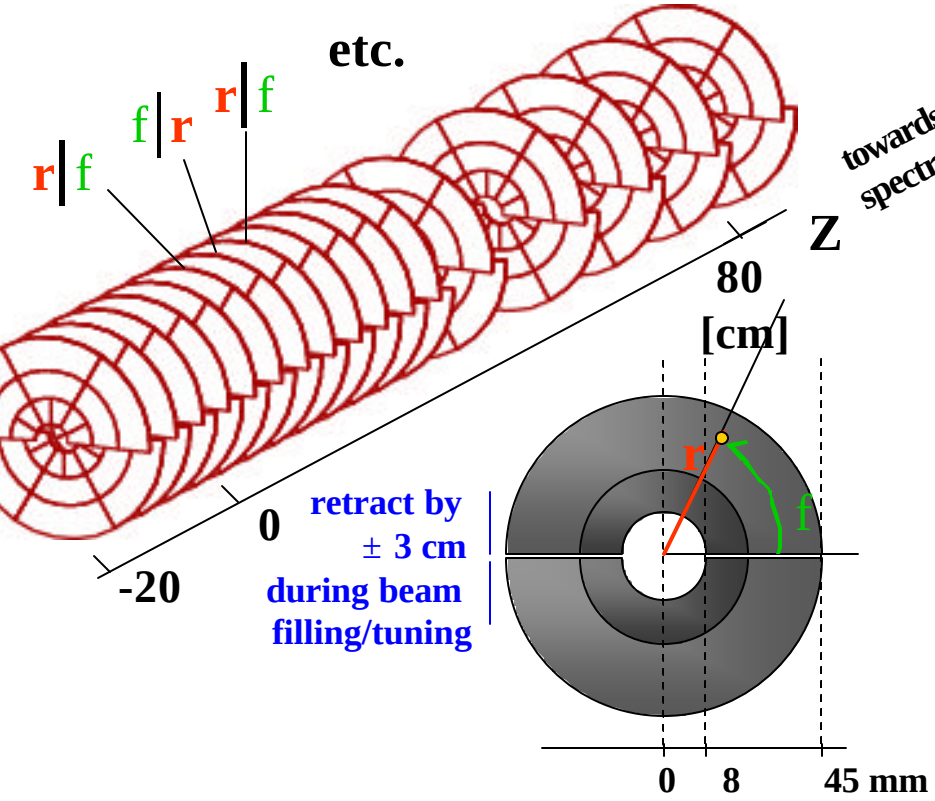
- Ramps with LHC
- Yoke: 1450 T
- P: 4200 kW
- Reversible field

All contracts awarded
Production has started

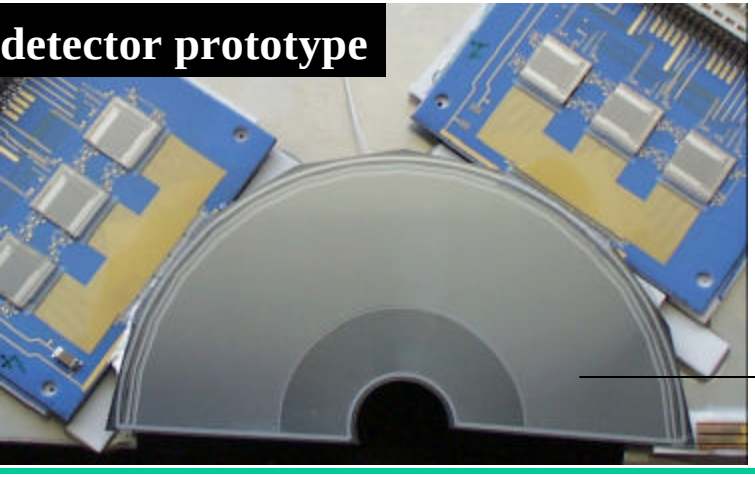


Bending the Al conductor

Vertex Locator

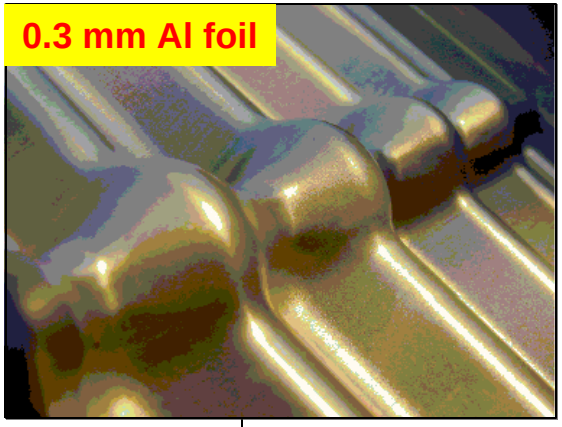


- 25 stations, 2 sensors each (r and f), with stereo angle
- come as close as possible to LHC beams
- total of 220 k channels, analog, S/N=15
- small overlap between opposite halves for alignment and acceptance
- cool down: $-25 < T_{operate} < +10\ ^{o}C$
- minimise material between vertex and first hit on Si ® put detectors in vacuum
- Design work ongoing for front-end chip (DMILL and 0.25mm technologies)

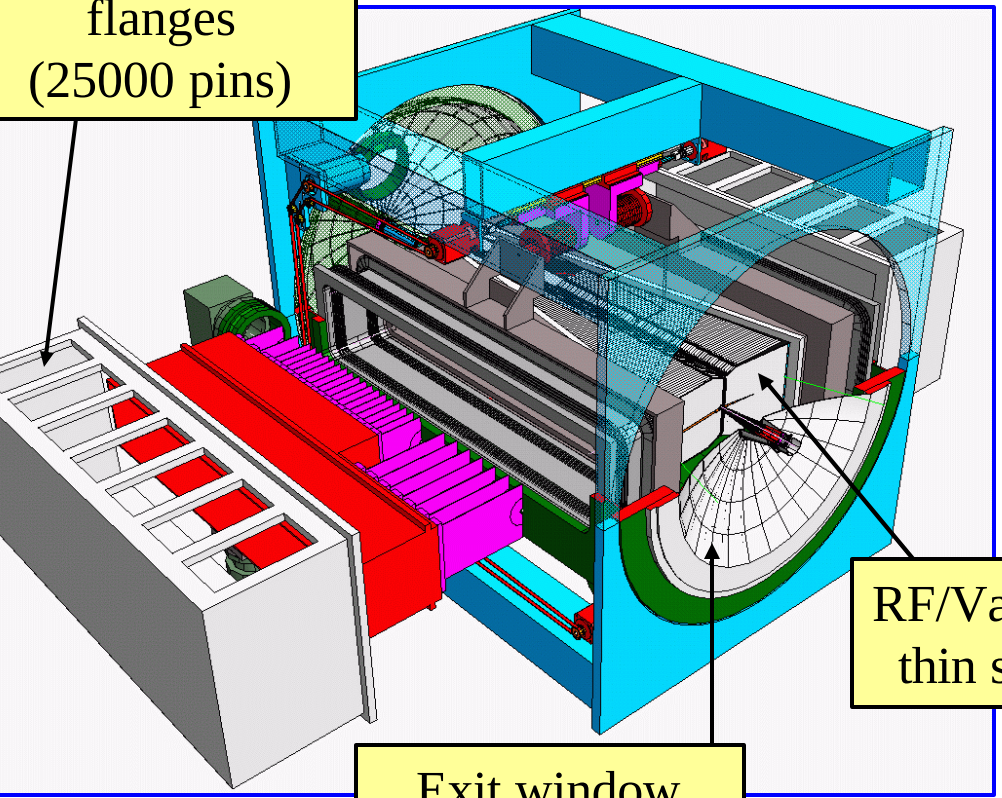


300 mm thick Si single-side *n*-on-*n*
(↘ 220 mm in light version)

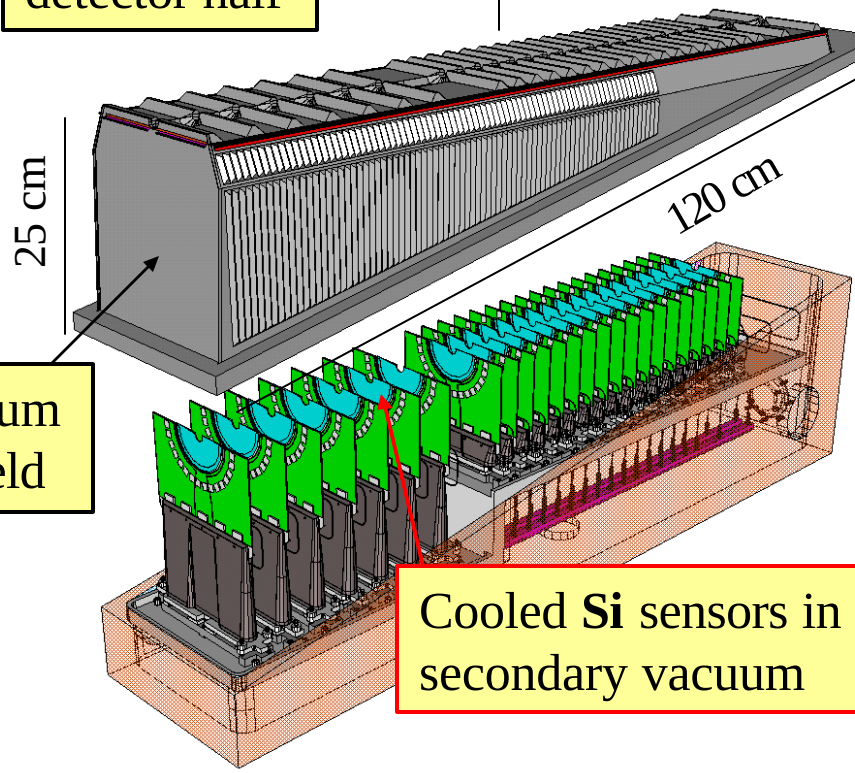
VELO mechanical design



Openings for feedthrough flanges (25000 pins)



Vertex detector half

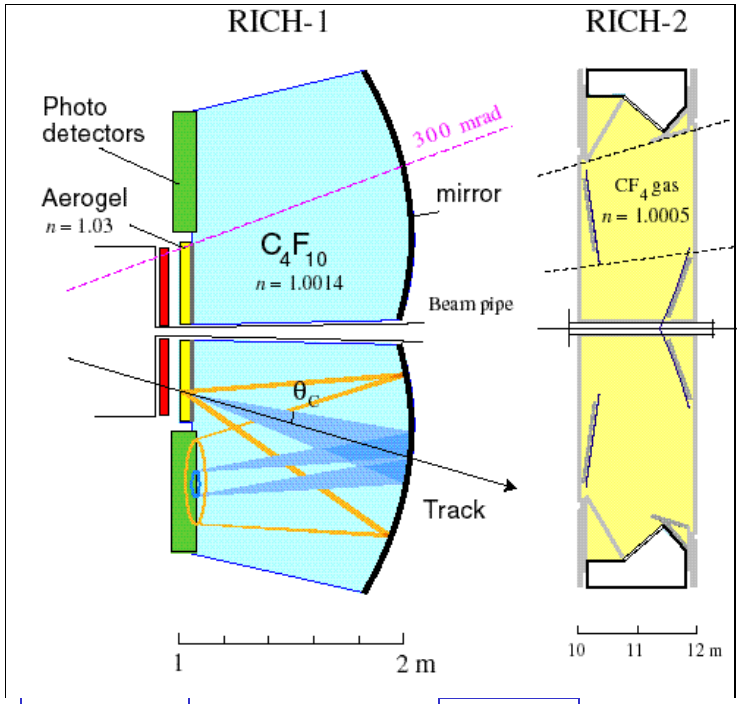


RF/Vacuum thin shield

Exit window 1.5-2 mm thick Al

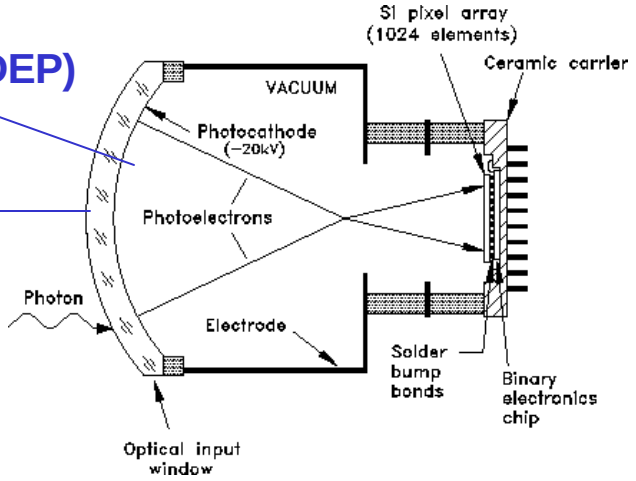
Cooled **Si** sensors in secondary vacuum

RICH Detector



HPD Tube (DEP)

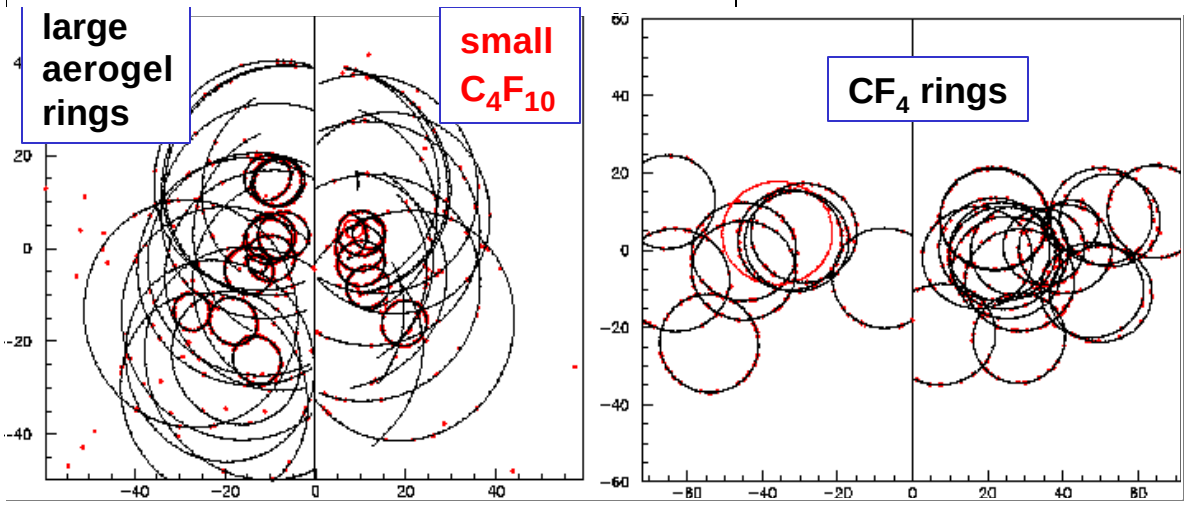
quartz window with S20 photocatode

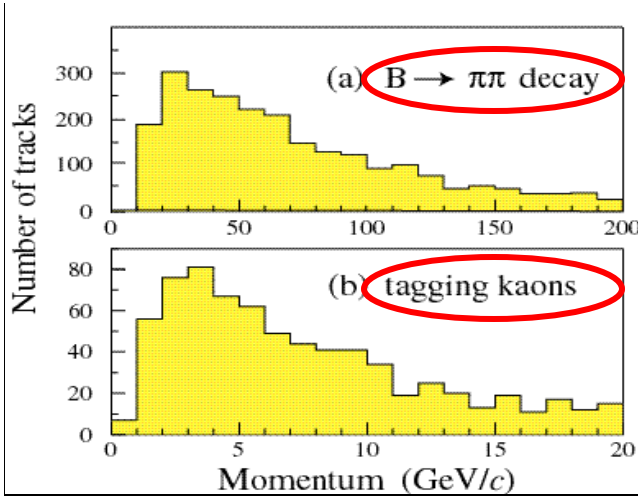


400k channels

Readout:

- HPD (baseline)
- MPMT (backup)

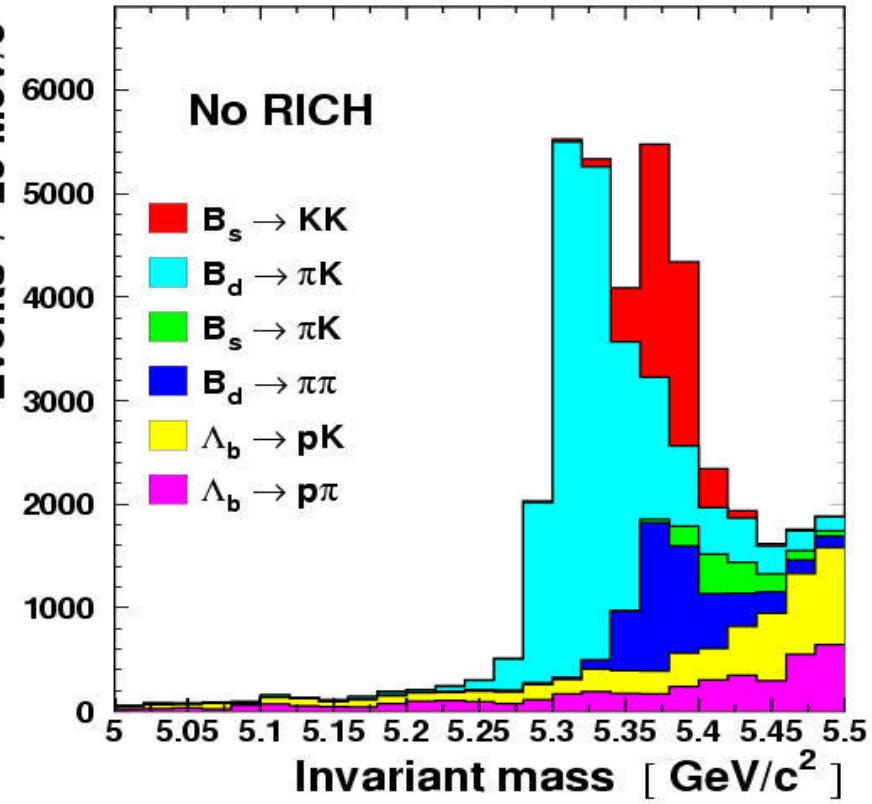




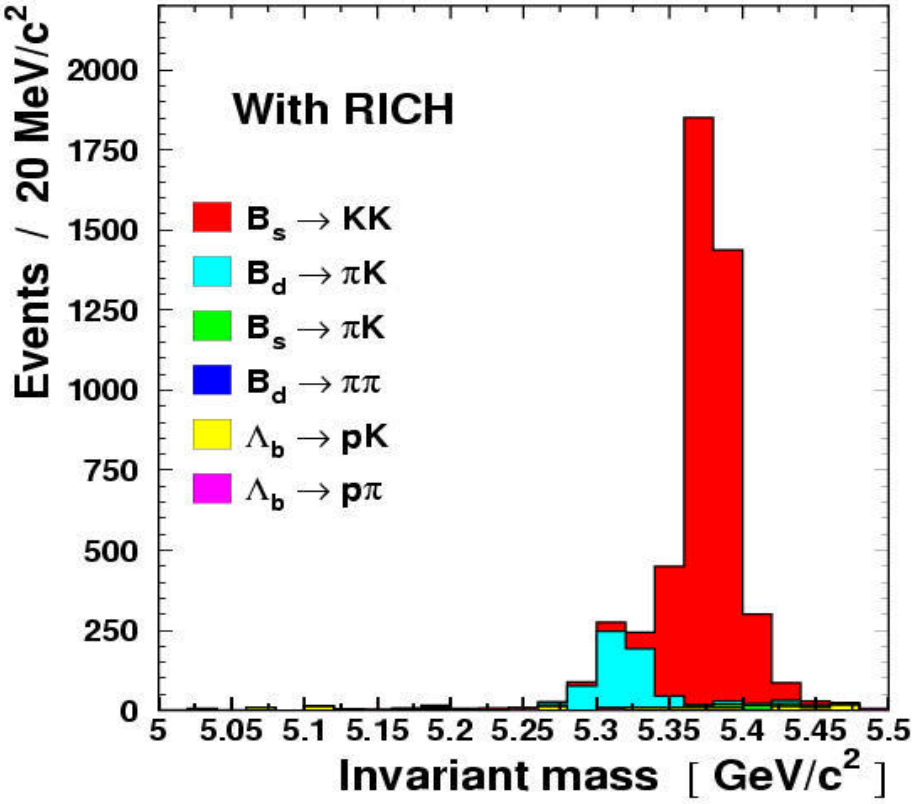
Occupancy: average < 1%, max < 13%

Physics with Particle Identification

$B_s \rightarrow K^+K^-$

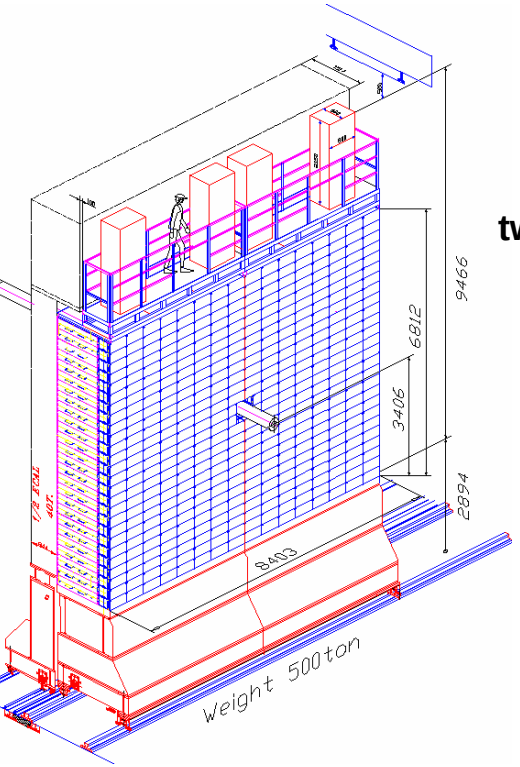


Purity=13%



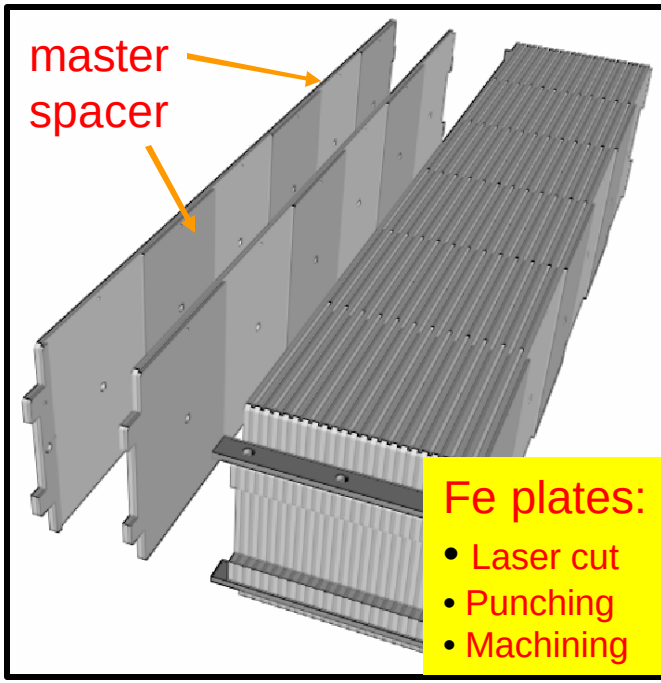
Purity=84%
Efficiency=79%

Hadron Tile Calorimeter



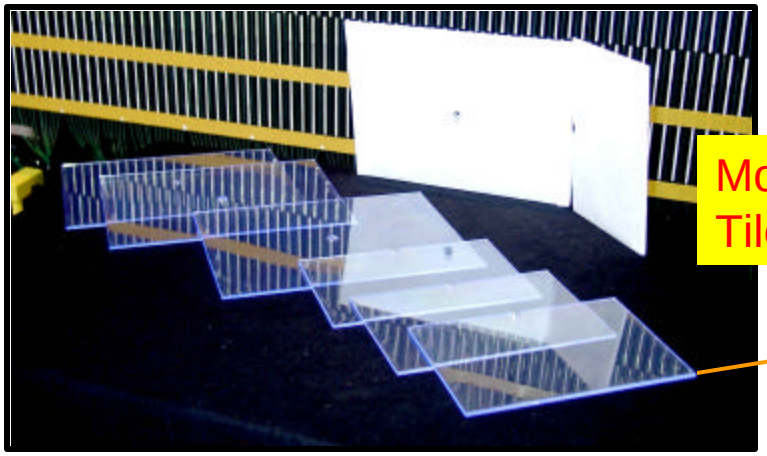
two separate movable halves:

- **stack of 26 modules in each half**
- **5.6 l instrumented depth**
- **read-out electronics on detector**
- **built-in Cs137 calibrator**
- **s/E = 0.80/ÖE Å 0.1**



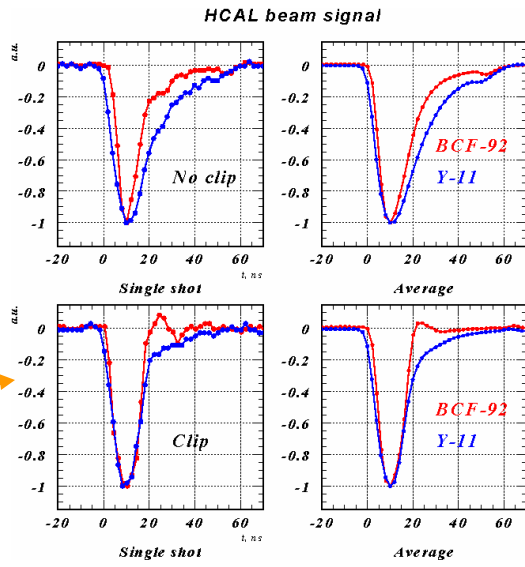
- Module-0 built and tested
- Mass production started

Max dose: 5 kGy/10 y

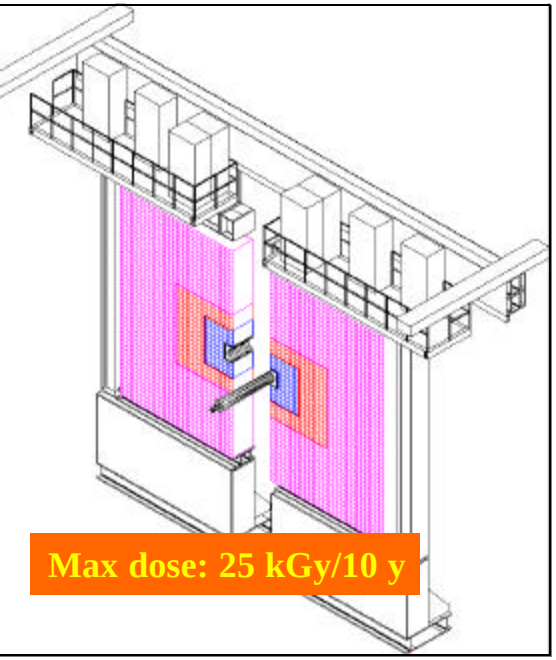


Molded Scintillator Tiles (3 mm thick)

WLS fiber readout

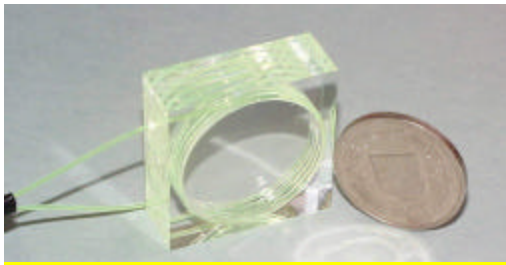


EM Calorimeter and Preshower



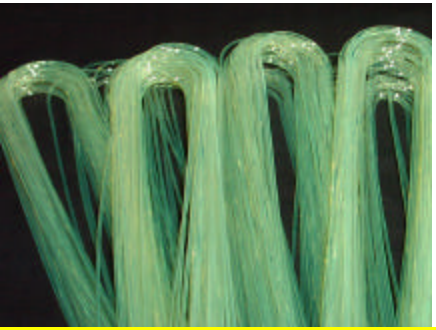
Max dose: 25 kGy/10 y

- **Shashlyk type**
- **3300 modules**
- **25 X_0, 1.1 l_I**
- **s /E = 0.09/ÖE Å 0.01**
- **Radiation hard**
- **Intercalibration: LEDs**
- **Preshower: 2 pad planes, 11.9 k channels**



Preshower tile with WLS fiber

- Mass production of ECAL started
- 490 modules already produced

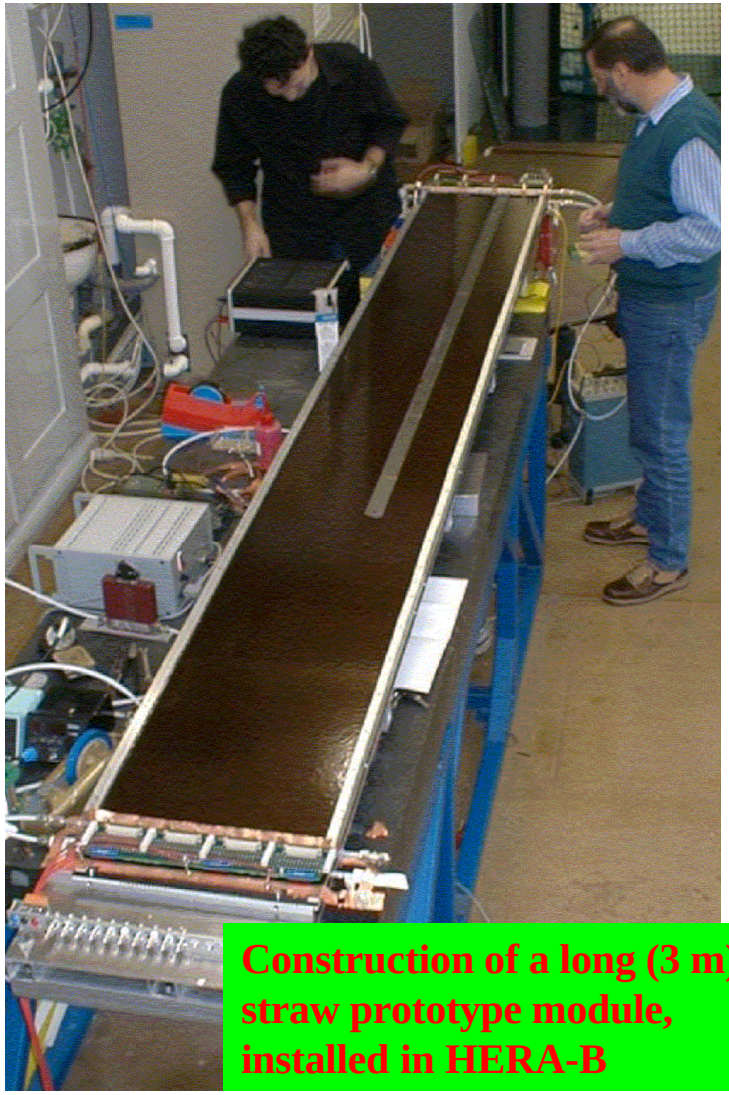


LS fiber readout: Kuraray Y11

Preshower fiber gluing machine

10 modules/day production

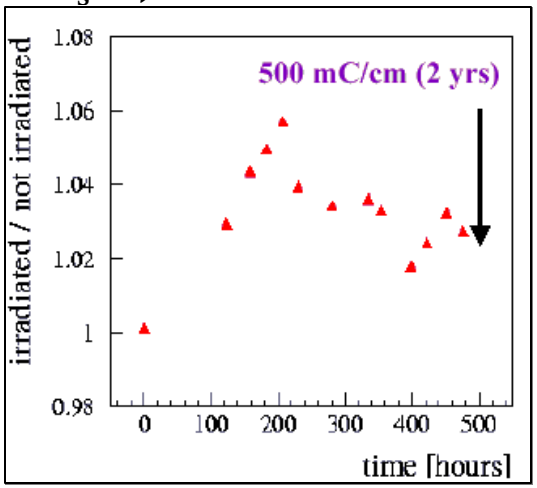
Outer Tracker



Construction of a long (3 m) straw prototype module, installed in HERA-B

- ~100k channels
- 5 mm dia. straw tubes, occupancy < 10%
- 200 mm resolution
- XUVX (2 staggered planes/coord., 5° stereo)
- drift time: 40 ns ($Ar/CF_4/CO_2$)
- readout: ASDBLR or ASDQ
- custom rad-hard TDC chip (OTIS)
- dp/p = 0.4 – 0.8 %
- Dm
  - 21.8 MeV (B ® pp)
  - 4.3 MeV (B_s ® D_s K)

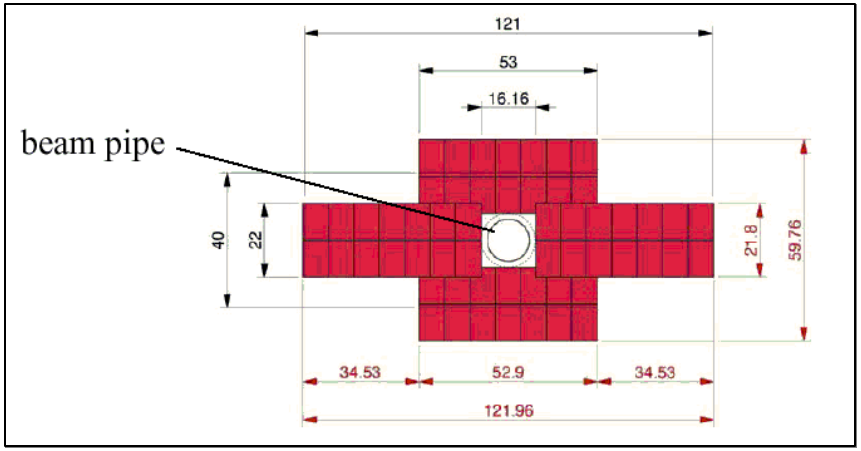
Max rate: 2 MHz

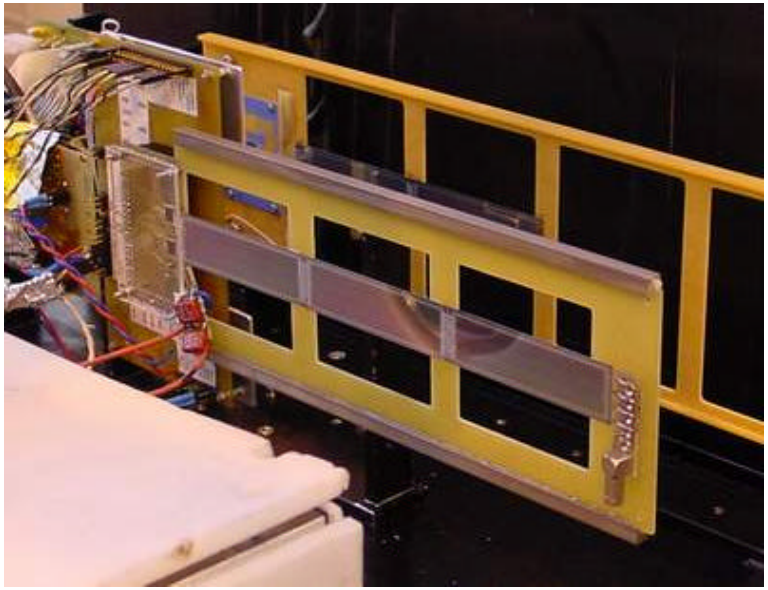


X-ray aging test

Inner Tracker

- **Technolgy: full Silicon**
- **Readout: Beetle chip**
- **Several tests done**
- **TDR: in preparation**



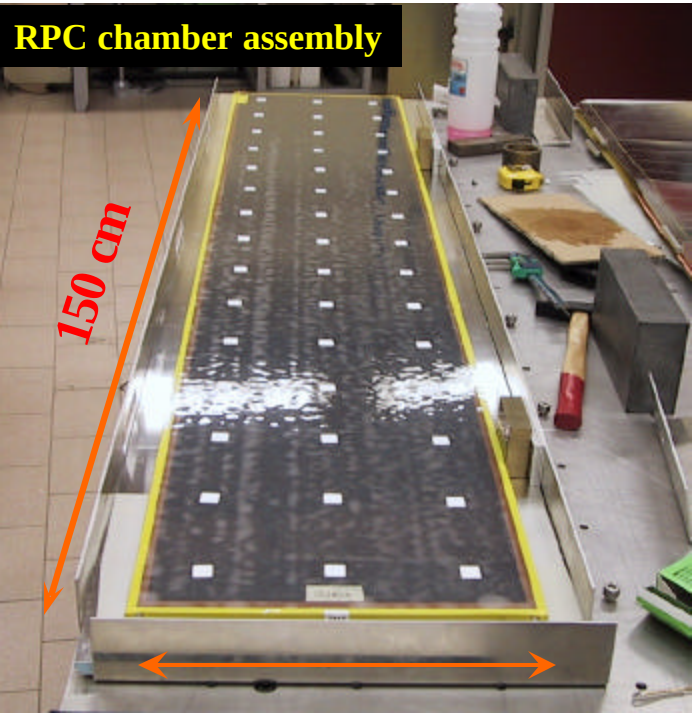


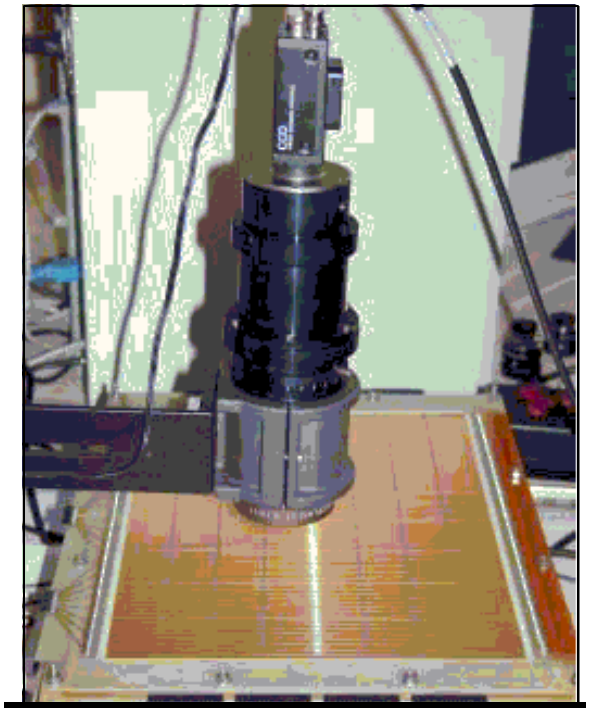
Muon detector

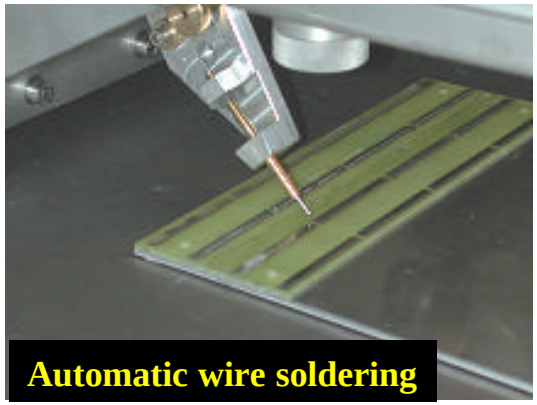
- 5 stations
- 900 wire chambers
- 480 RPC chambers

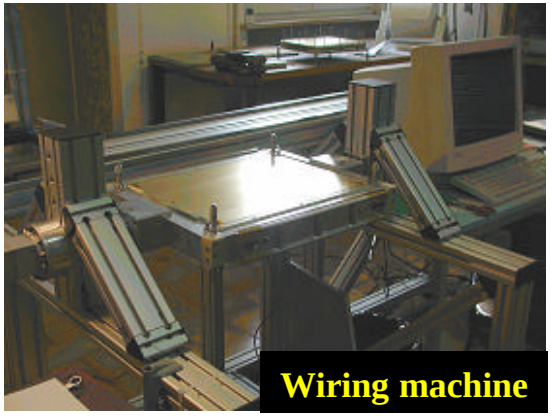
} Aging test: > 5 LHCb years

- 120k FE channels (26 k logic)
- highly automated construction
- custom rad-hard chips developed




Automatic wire pitch measurement


Automatic wire soldering

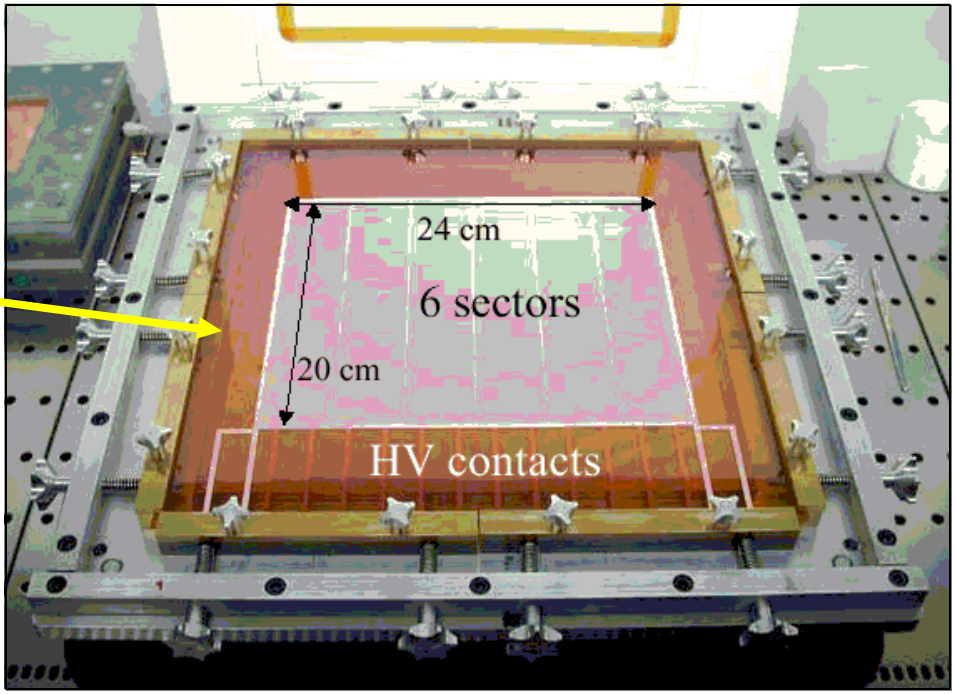

Wiring machine

R&D for the "hot" region of the first Muon chamber, M1
3-GEM prototype

- **Main issue: eff. in 20 ns gate**

- **Encouraging results from 10x10 prototype**
  - **No rate problems**
  - **Aging tests with X-rays OK**

- **New full-size prototype to be tested soon**

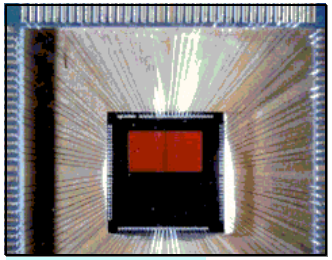


Alternative:

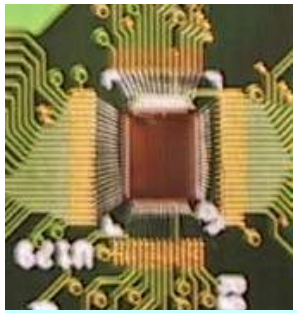
MWPC with "optimized" layout

Rad-hard chip development in LHCb

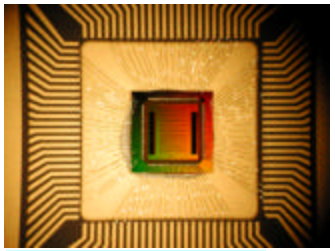
Name	Laboratory	Detector	Process	Use
CARIOCA	CERN	Muon	IBM 0.25 mm	8 ch ASD
DIALOG	Cagliari	Muon	IBM 0.25 mm	16 ch Delay & Logic
BEETLE	HD/Nikhef/OX	VELO+IT	IBM 0.25 mm	128 ch pipelined AS
SCTA_VELO	CERN	VELO	DMILL	128 ch pipelined AS
Pixel chip	CERN(ED)	RICH	IBM 0.25 mm	1024* ch pipelined ASD
OTIS	Heidelberg	OT	IBM 0.25 mm	32 ch pipelined 1ns TDC



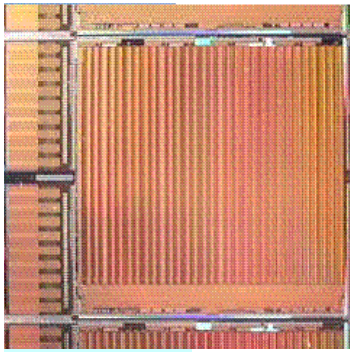
OTIS chip



CARIOCA FE chip



DIALOG chip



Pixel chip

Performances: summary

Observable	Channel	Annual Yield (* : tagged)	Physics Performance
b	$B_d \to J/\psi K_s$	> 40k *	$\sigma(b) = 0.6^o$
g	$B_d \to D^*\pi$	530k *	$\sigma(\gamma) = O(10^o)$
	$B_s \to D_s K$	2.4k *	$\sigma(\gamma) = O(10^o)$
a	$B_d \to \pi\pi$	4.9k *	Theory dependent
	$B_d \to \rho\pi$	1.3k *	$\sigma(\alpha) = 5^o$-10^o
$\Delta\Gamma$	$B_s \to J/\psi \phi$	370k	$\sigma(\Delta\Gamma) \sim 2^o$
	$B_s \to J/\psi \eta$		
$\lvert V_{td}/V_{ts}\rvert$	$B \to \mu\mu X$	17k	11% rel. error
Δm_s	$B_s \to D_s\pi$	34k	$\sigma(\Delta m_s) = 0.01$ ps^{-1}

Tagging (lepton + K): $\varepsilon = 0.4$; $D = 0.4$

Conclusions

- LHC: new scenario for B physics
  - large statistics
  - rare channels
  - ➢ a probe for physics beyond SM
- LHCb will be ready on “day one”
  - dedicated experiment
  - ➢ specialized trigger, particle ID
  - ➢ excellent mass and proper time resolution
- Good mix of advanced and proven technologies
- Preparation progressing well