The LHCb Experiment II Detector

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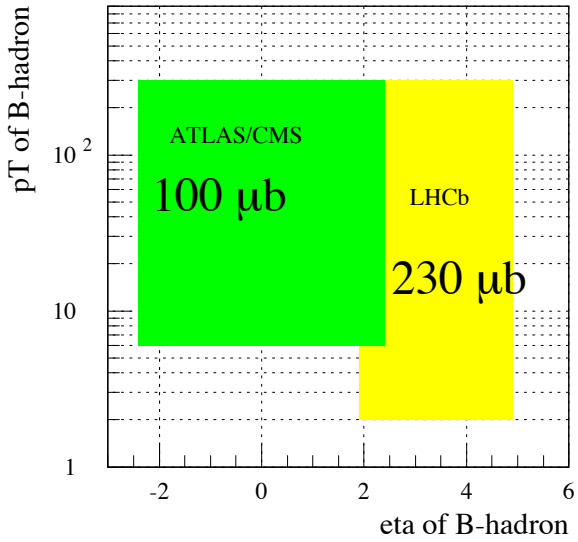
Tatsuya NAKADA
CERN
and
Ecole Polytechnique Fédérale de Lausanne (EPFL)

1) Introduction

Physics requirements for the detector

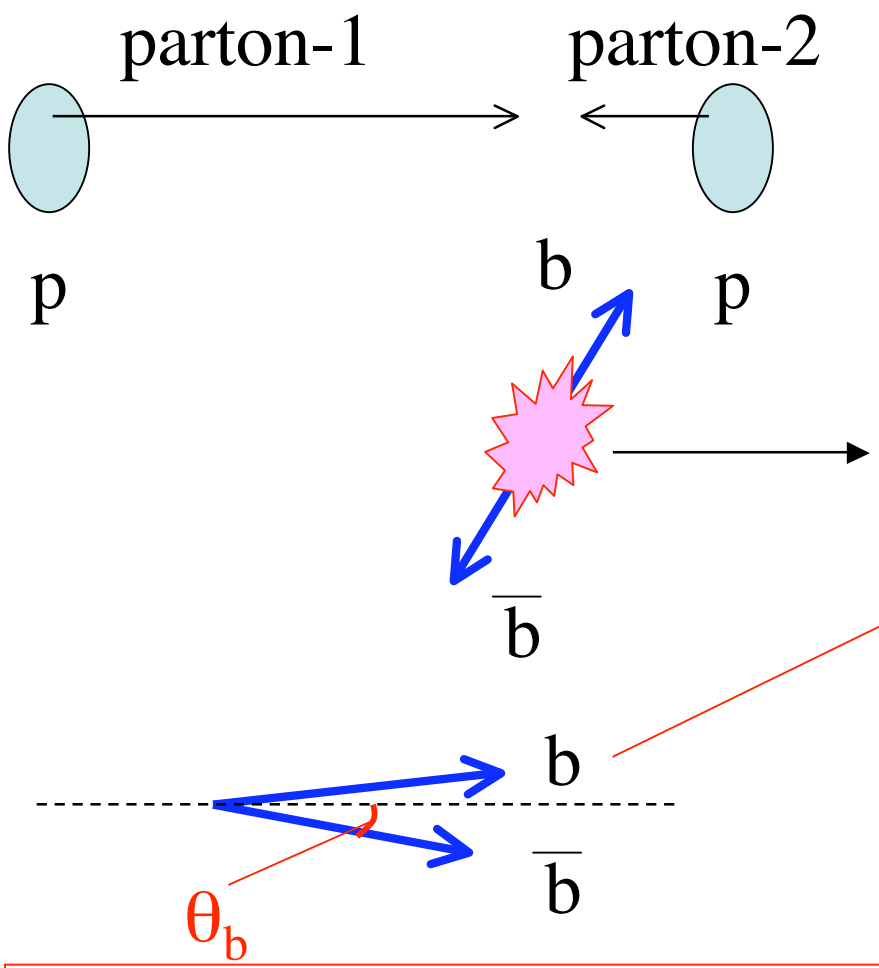
- large acceptance for the both b and $\bar{b}$ final states
- trigger sensitive on
  hadronic, semileptonic and leptonic final states
- efficient, flexible and robust trigger
- lepton and hadron particle identification
  e/μ/γ/π/K/p
- good propertime resolution
- good mass resolution

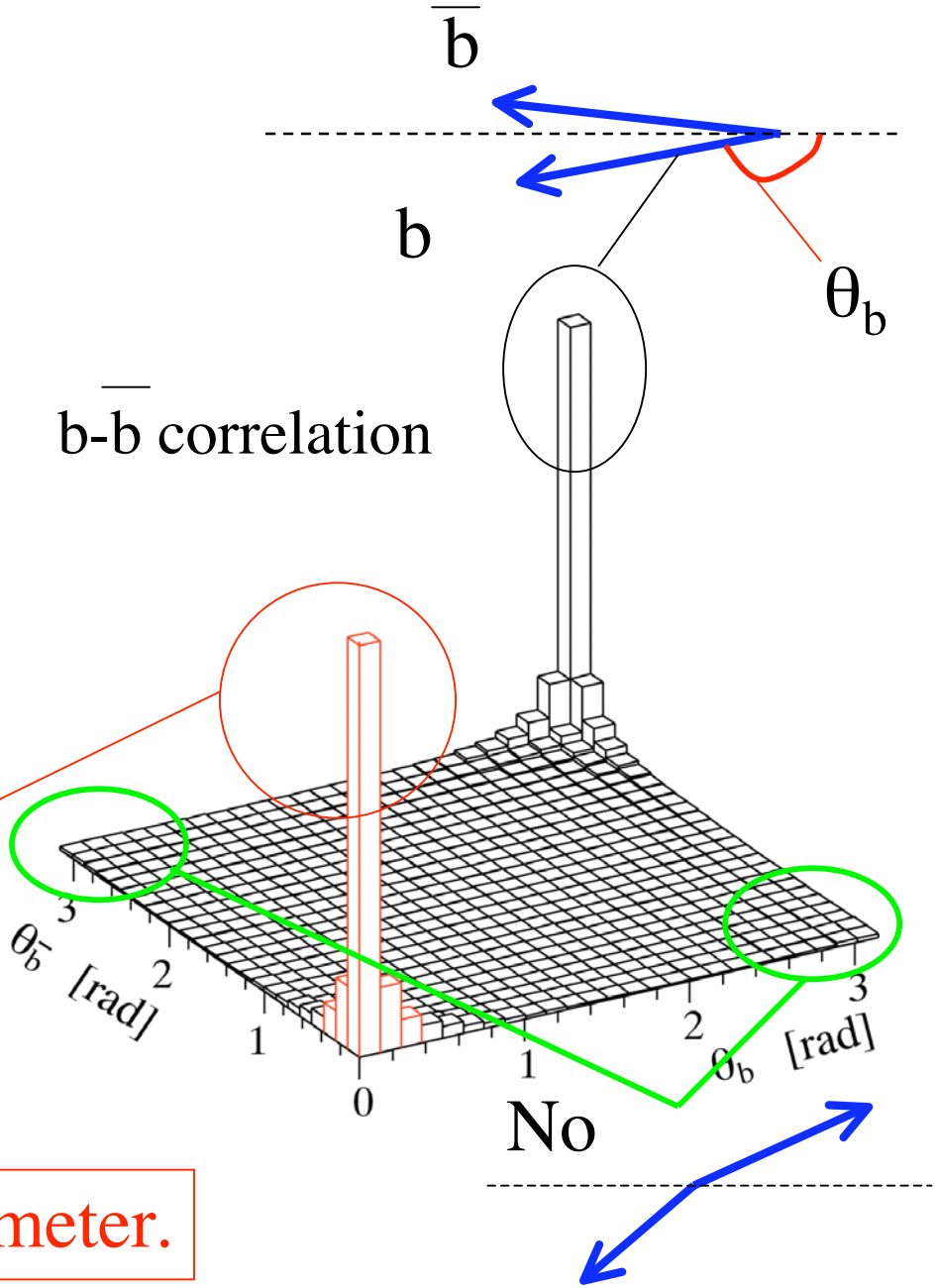
LHCb Spectrometer



Good mass and eigentime resolution: VELO + tracking system
Hadron identification: RICH system
L0 Lepton and Hadron p_T trigger: Calorimeter and muon system

$b\bar{b}$ pair production kinematics

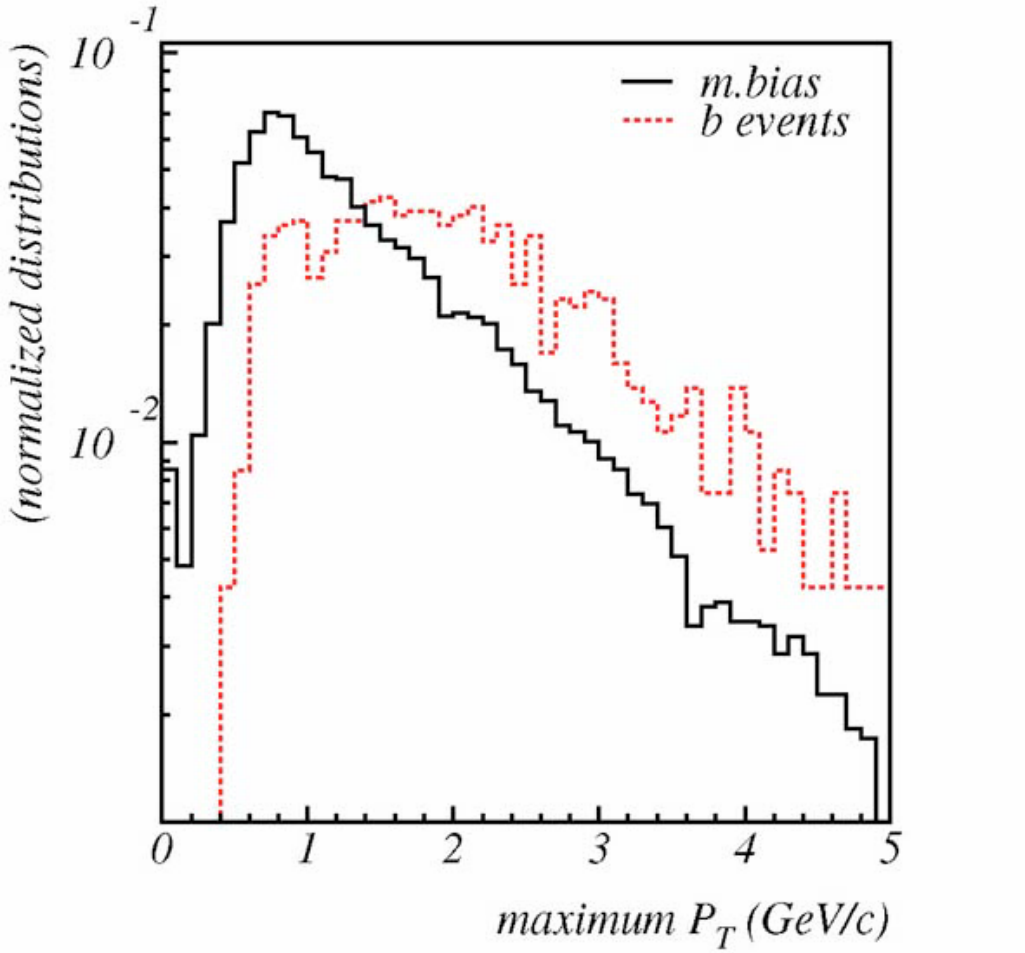


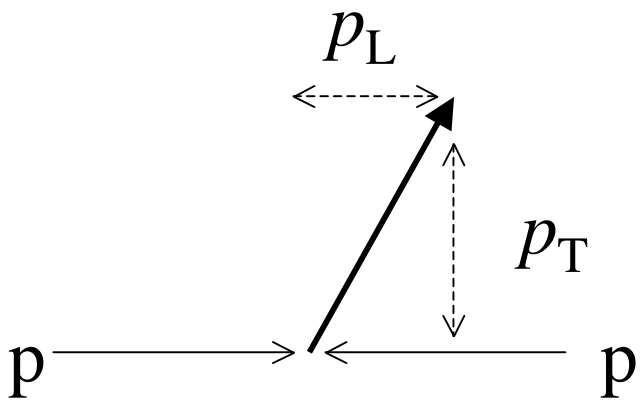


Both b and $\bar{b}$ are in the spectrometer.

f_{pp} @ LHC = 40 MHz → simple first level trigger needed

Single p_T trigger for μ, e, h

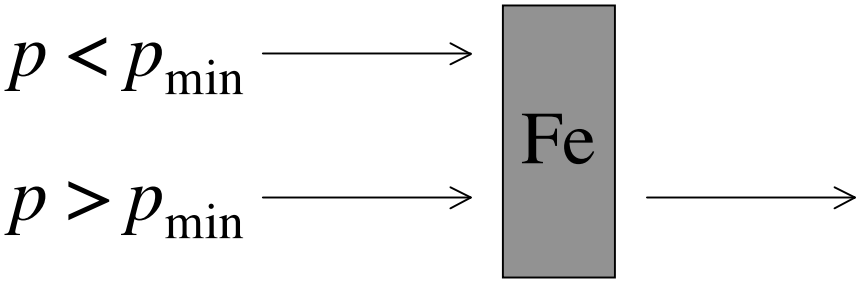




muon system:
low track density
e and h:
calorimeter
E_T measurements

However…. $p > p_{\min}$

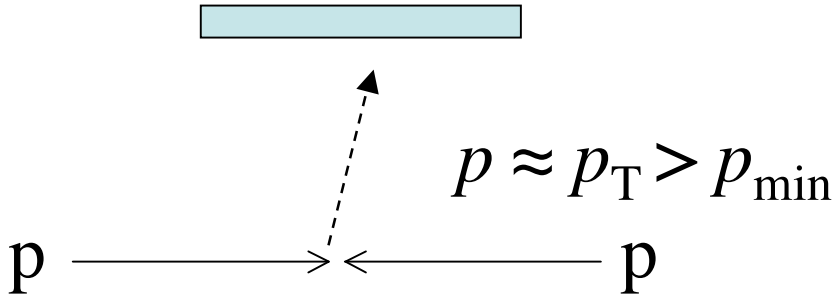
muon:
identification



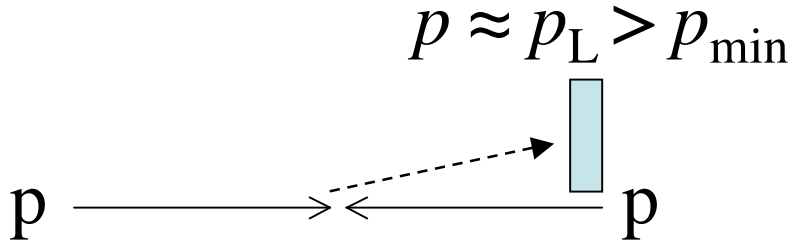
hadron:
energy resolution

$\sigma_E/E \approx \sqrt{}\,70\%/\sqrt{}\,E$

central detector

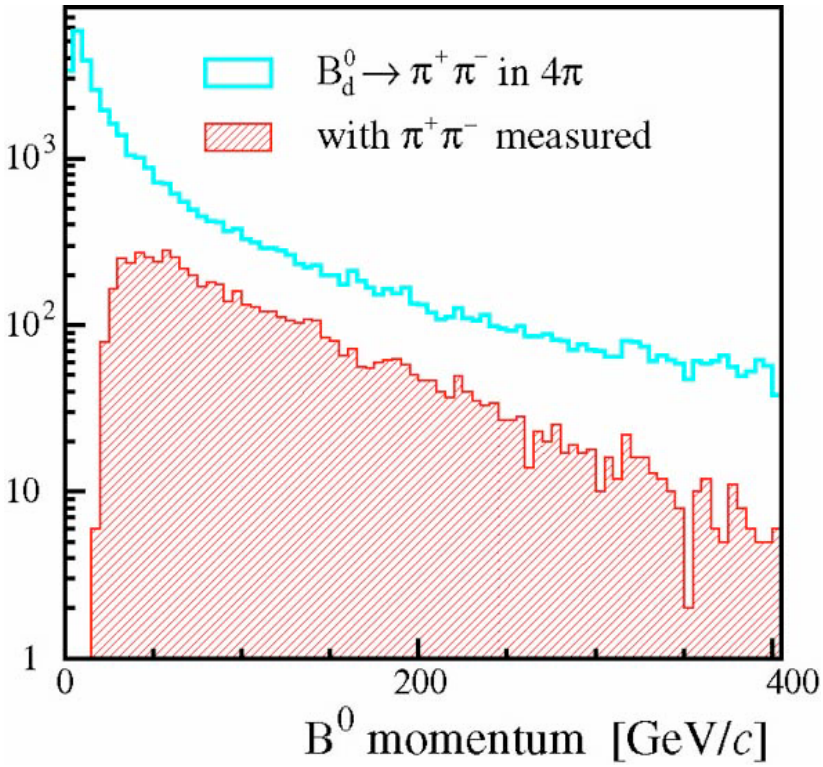


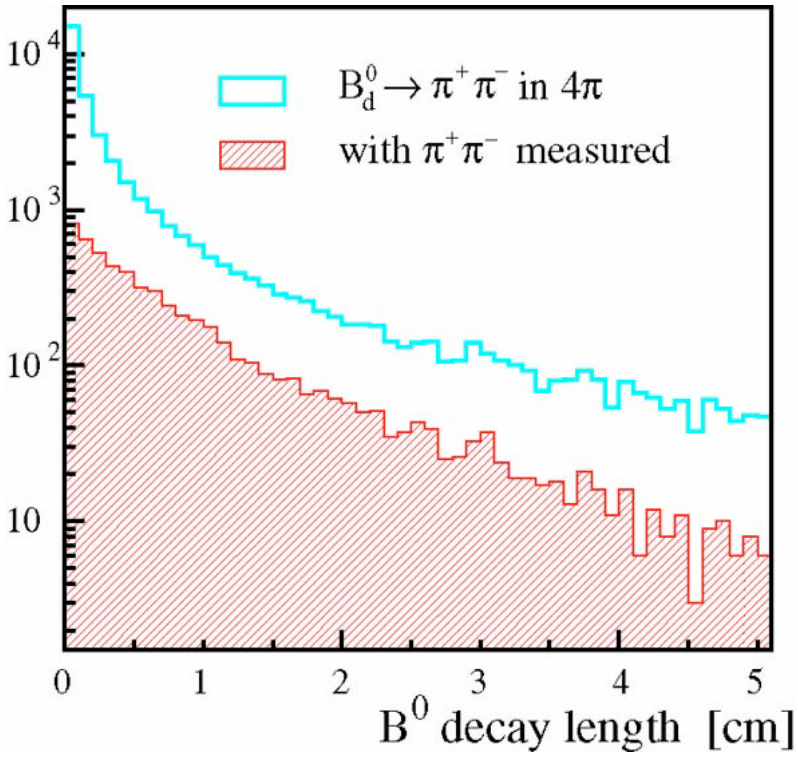
forward detector



p_T threshold can be set low:
→ high b efficiency

Momentum spectrum and decay distance for B mesons



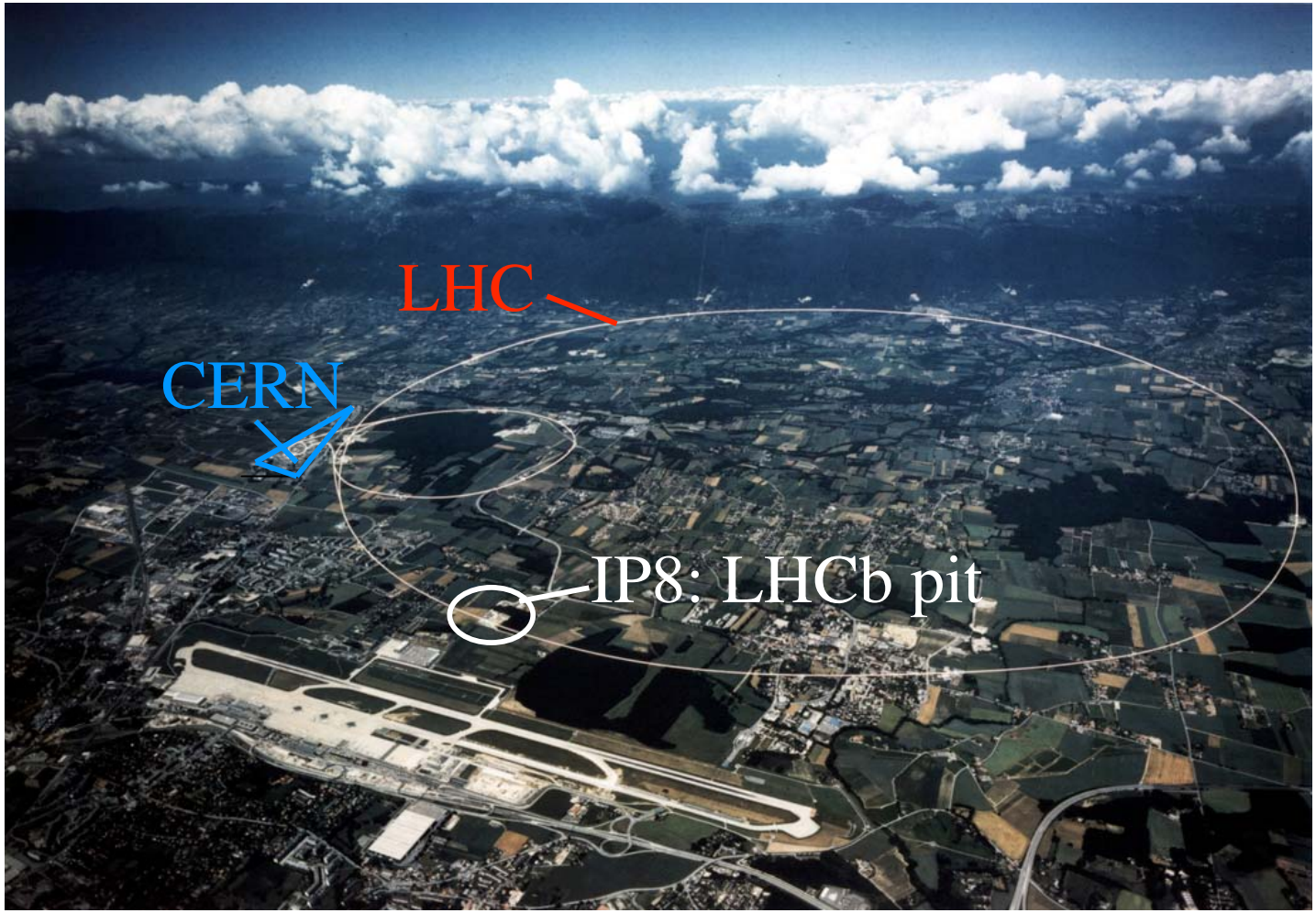


are larger in the forward region.

→ average B decay distance in the detector ~1cm

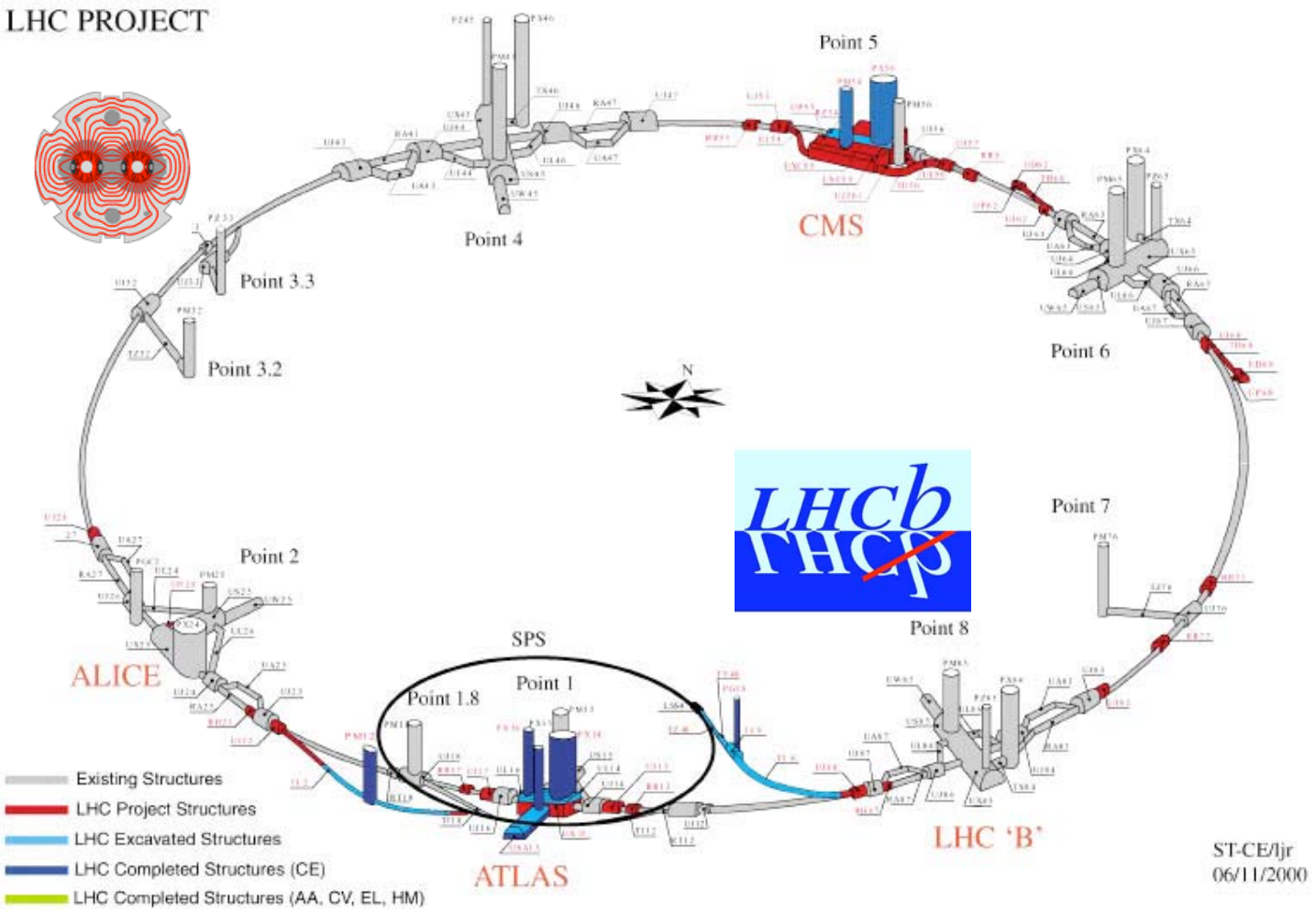
Good proper time resolution.

2) Status of the Experiment



Brazil, China, France, Germany, Italy, Netherlands, Poland,
Romania, Russia, Spain, Switzerland, UK, Ukraine, USA
600 people, 75 MCHF

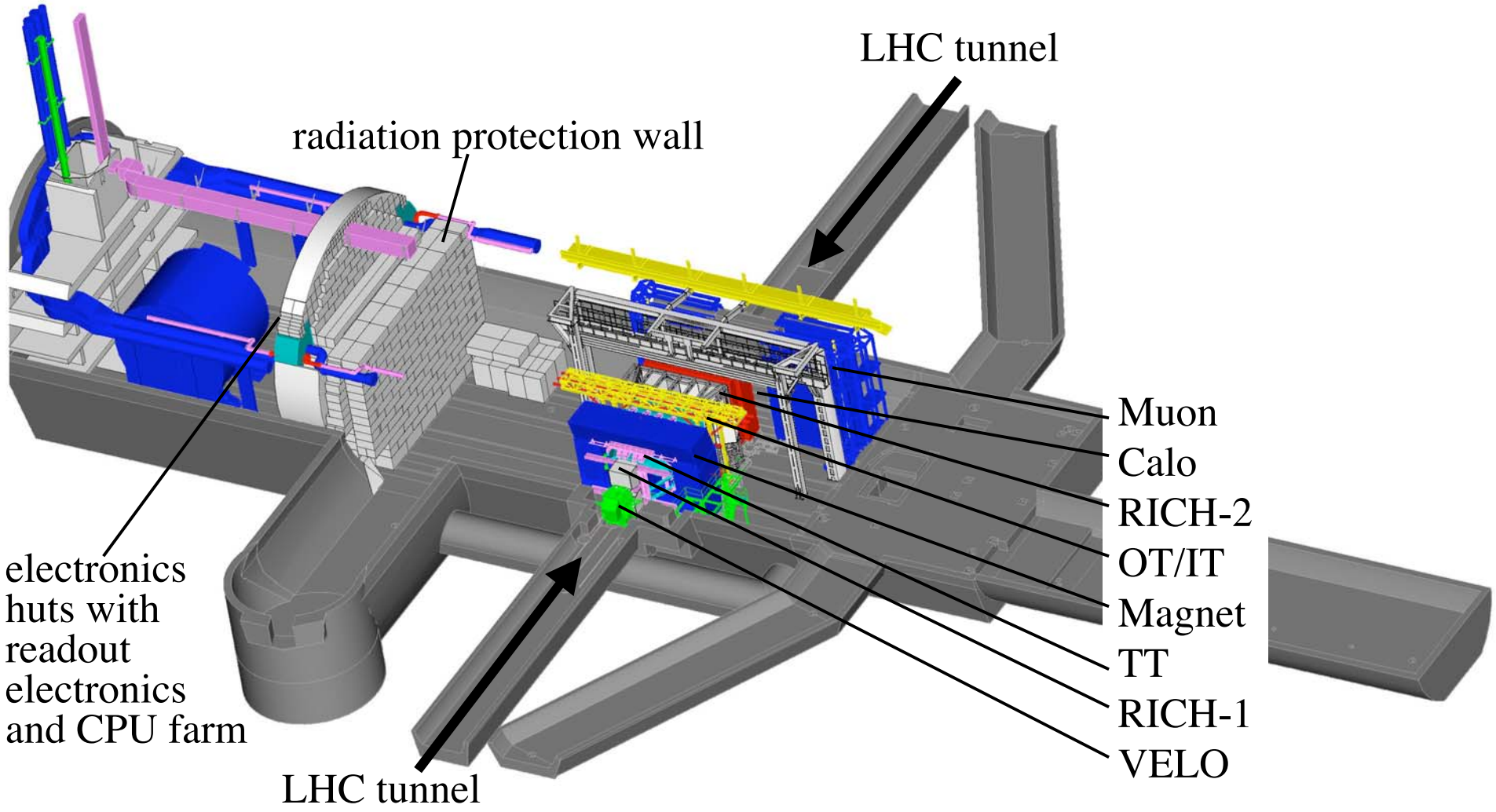
LHC



$\langle L \rangle \sim 2\times10^{32}$ ($L_{\text{nominal}} = 10^{34}$), $\sigma_b = 500$ μb ($\sigma_{\text{inelastic}} = 80$ mb),

10^{12} $b\bar{b}/10^{7}$ sec

$B_{u,d,s,c}$, Λ_b, Σ_b, and other b-hadrons



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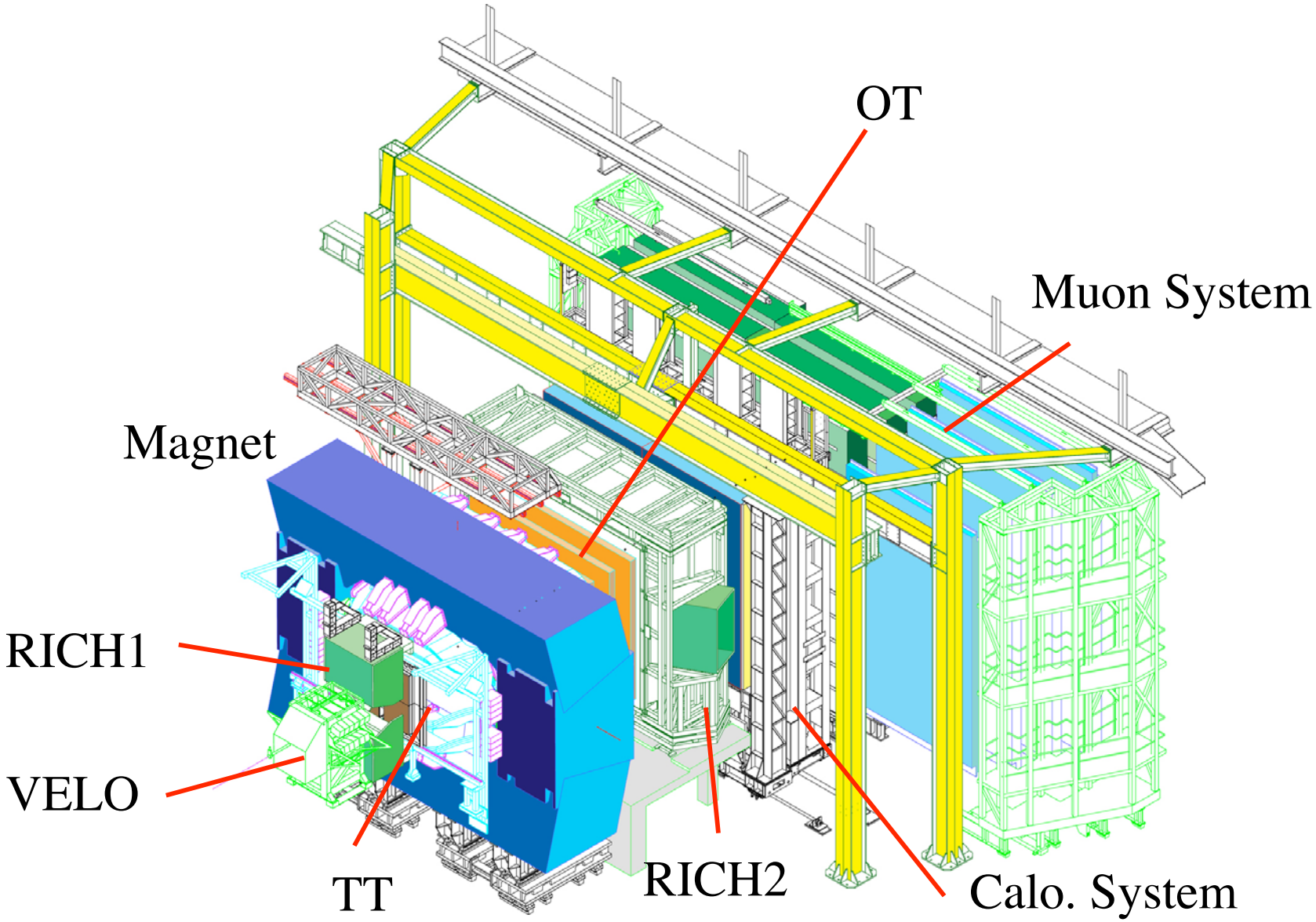
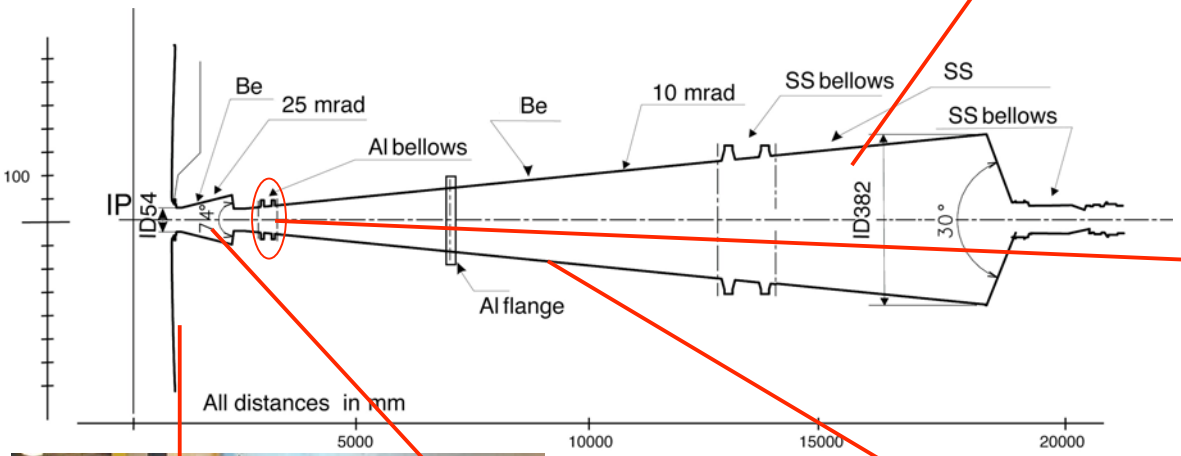
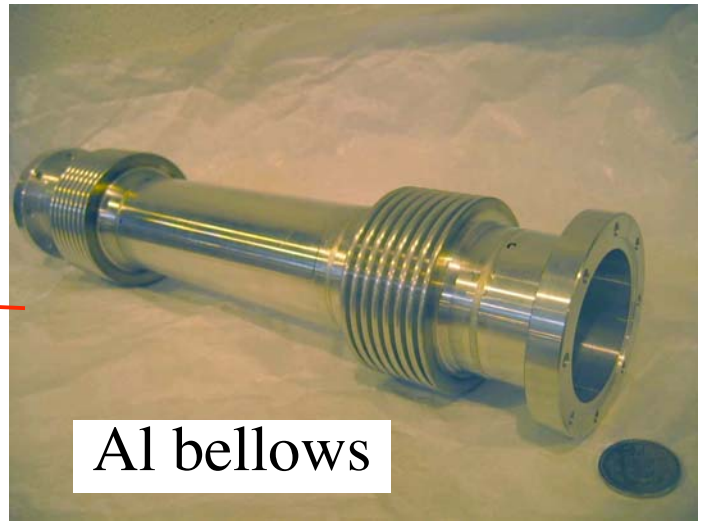
LHCb Spectrometer

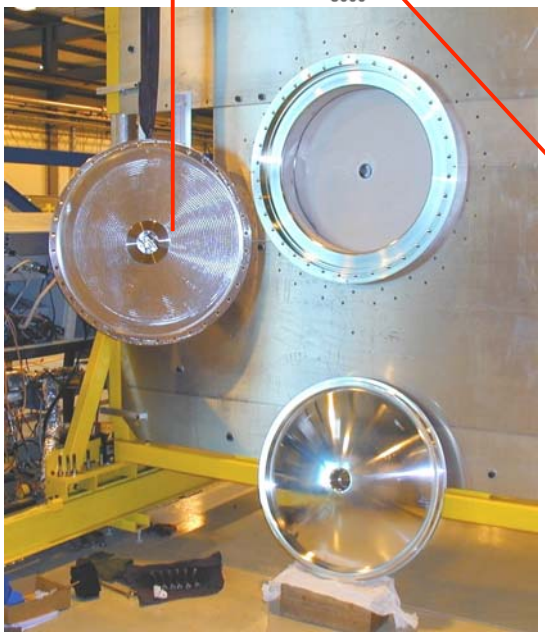


Beam pipe



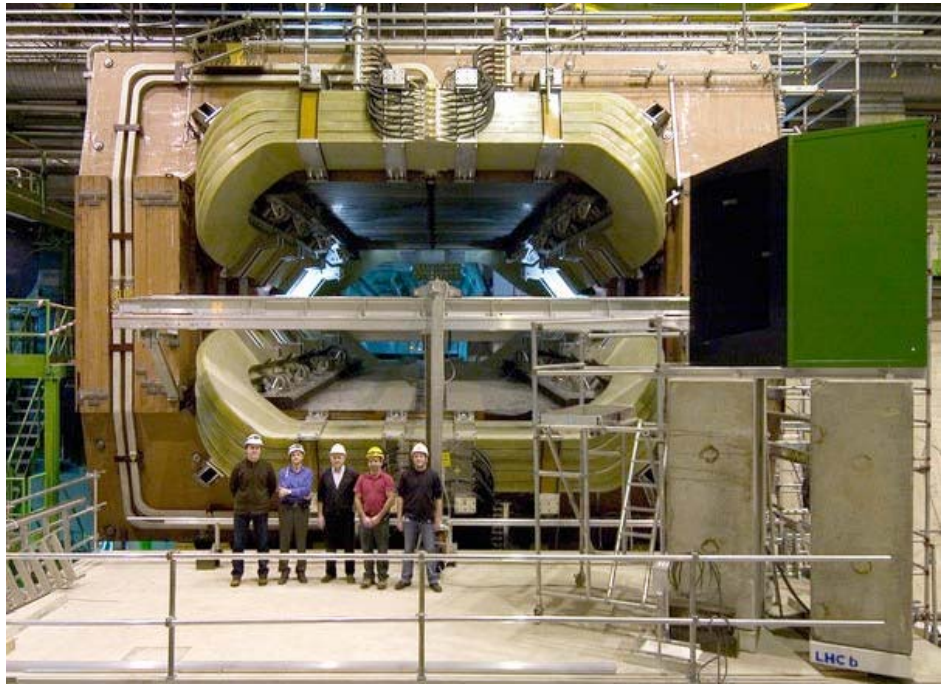
10mrad stainless steel cone

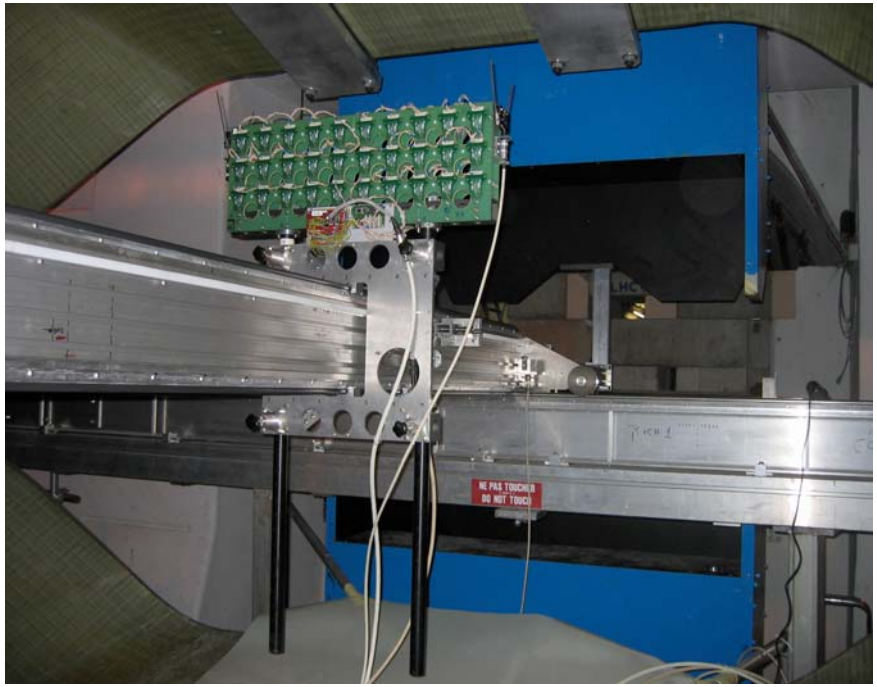




Al exit window of VELO tank

Magnet



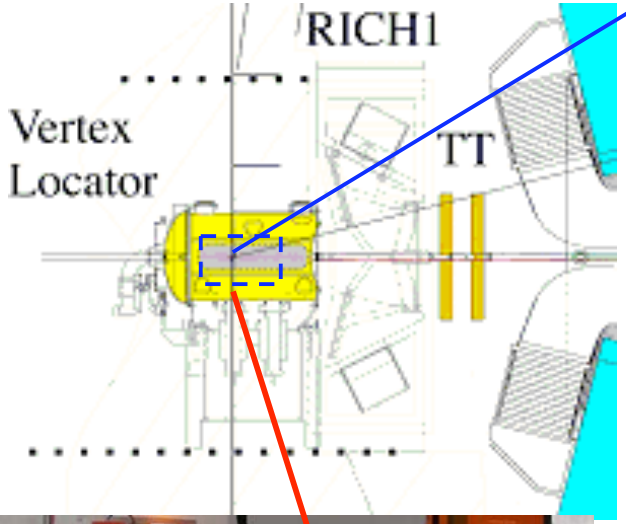


assembled, positioned, aligned, and field map measured

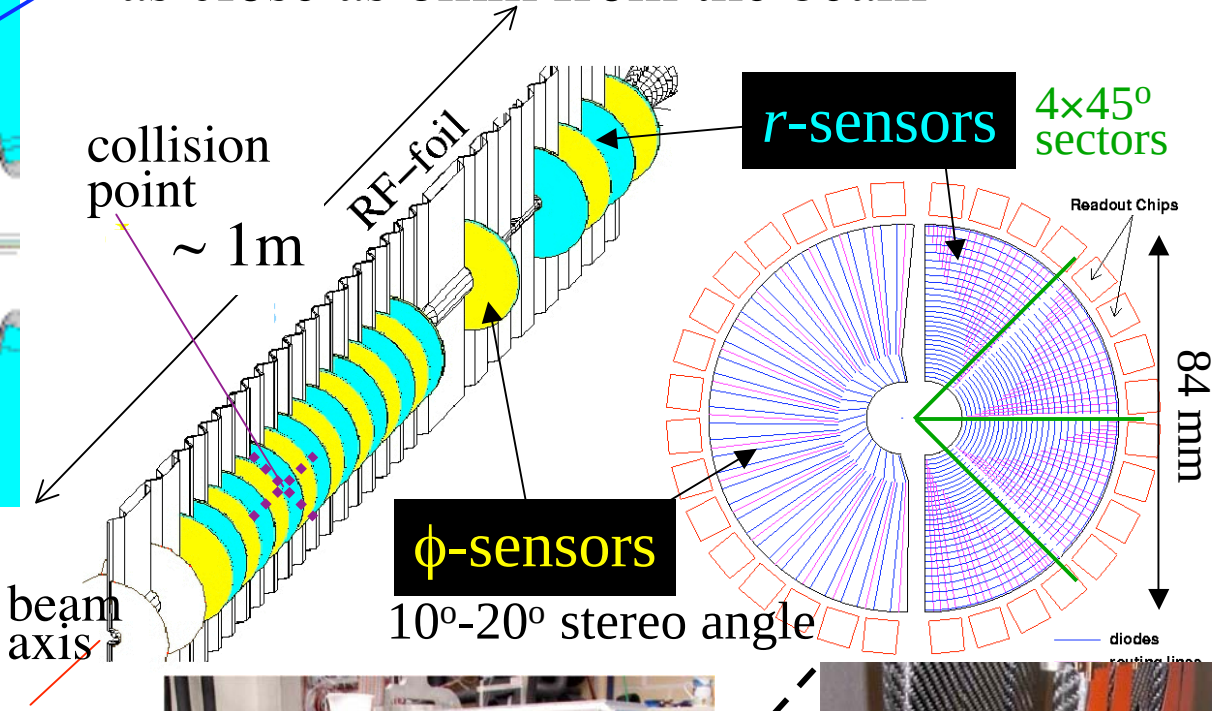
- the field was measured with a precision of 3×10^{-4} →fulfils the requirement
- good symmetry between the two polarities: $\Delta B/\langle B\rangle \sim 3\times10^{-4}$ →small "fake" P violation

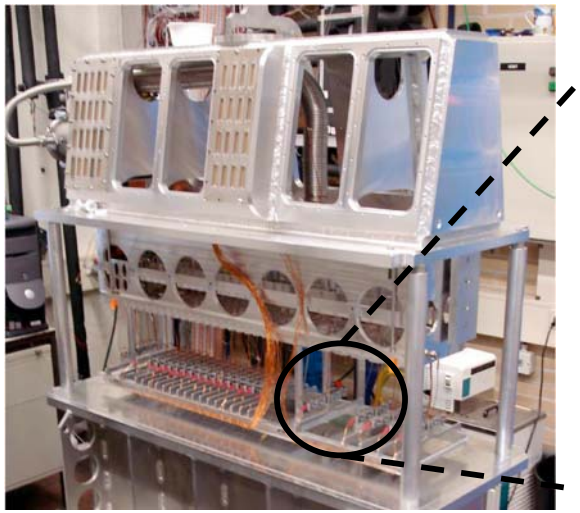
Magnet is now operational

VErtex LOcator

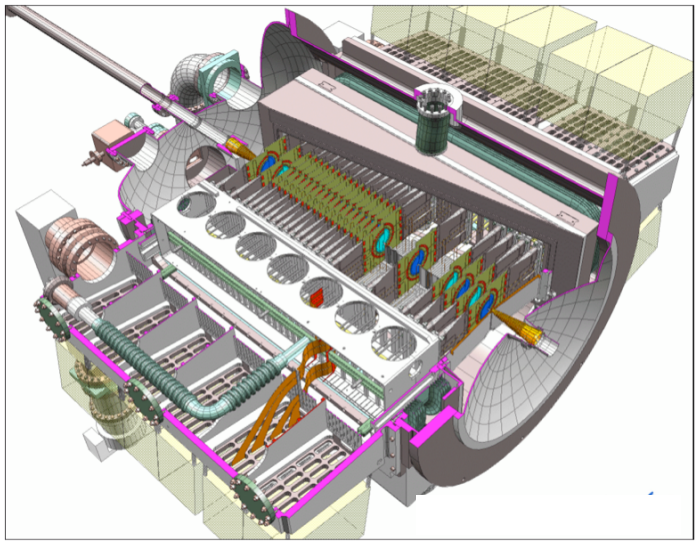


300 μm Si sensor
as close as 8mm from the beam





Si in secondary vacuum with the Roman pot technology

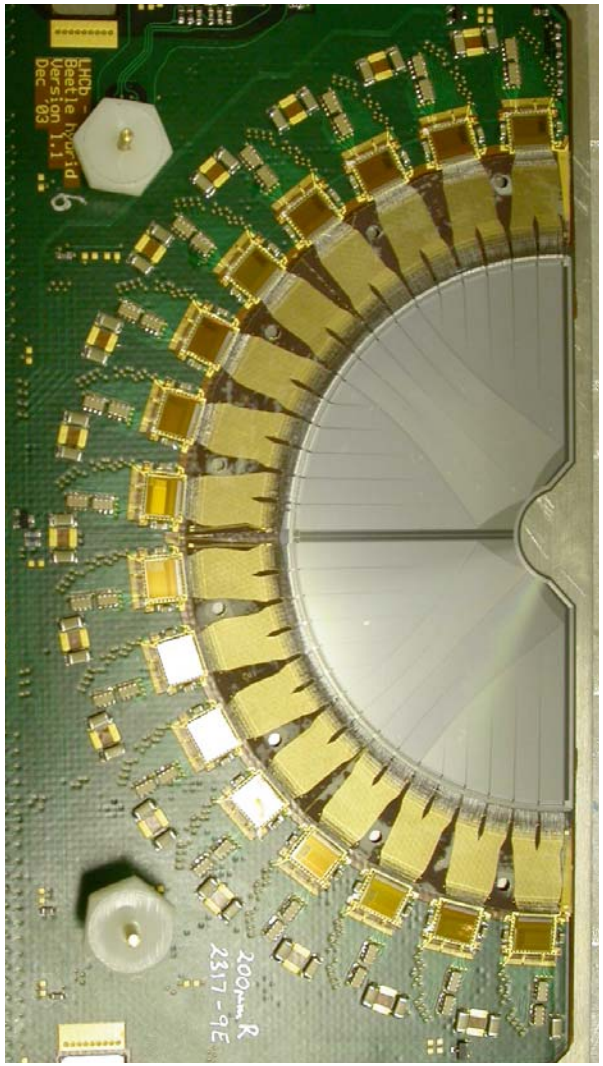


vacuum vessel in its support

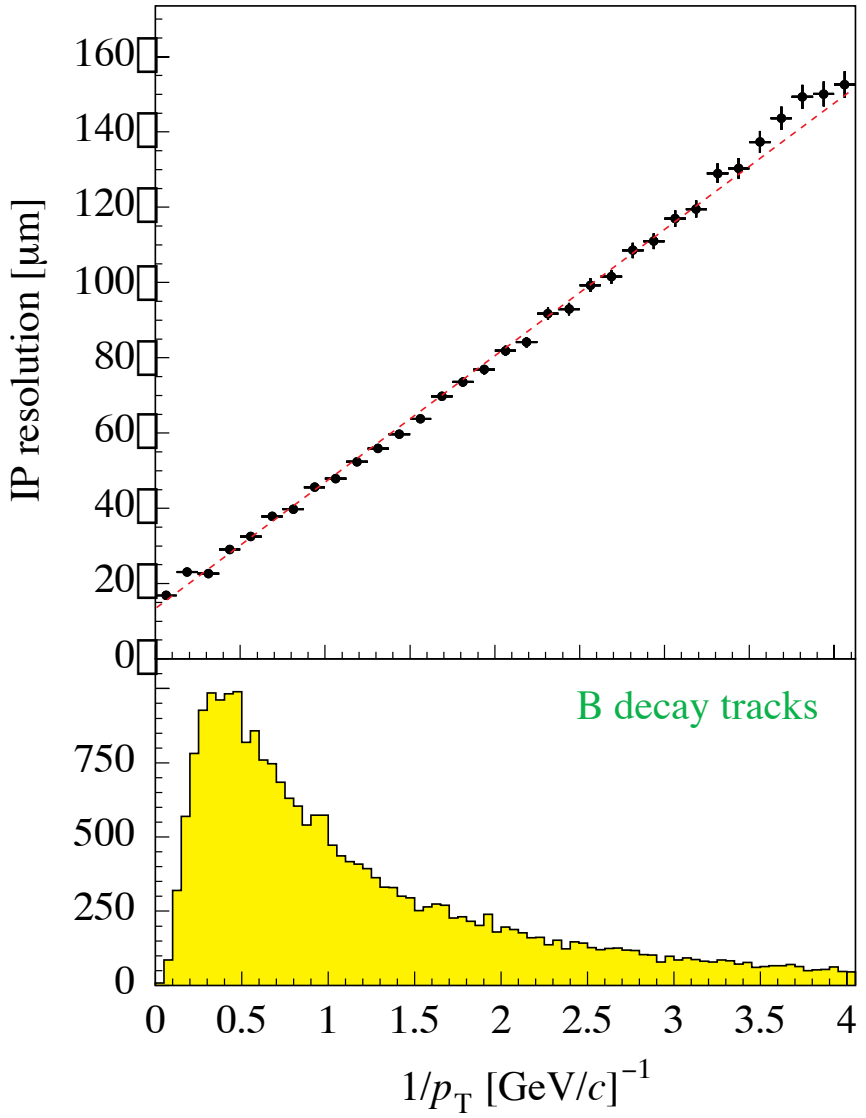
Being lowered and

Installed at final position

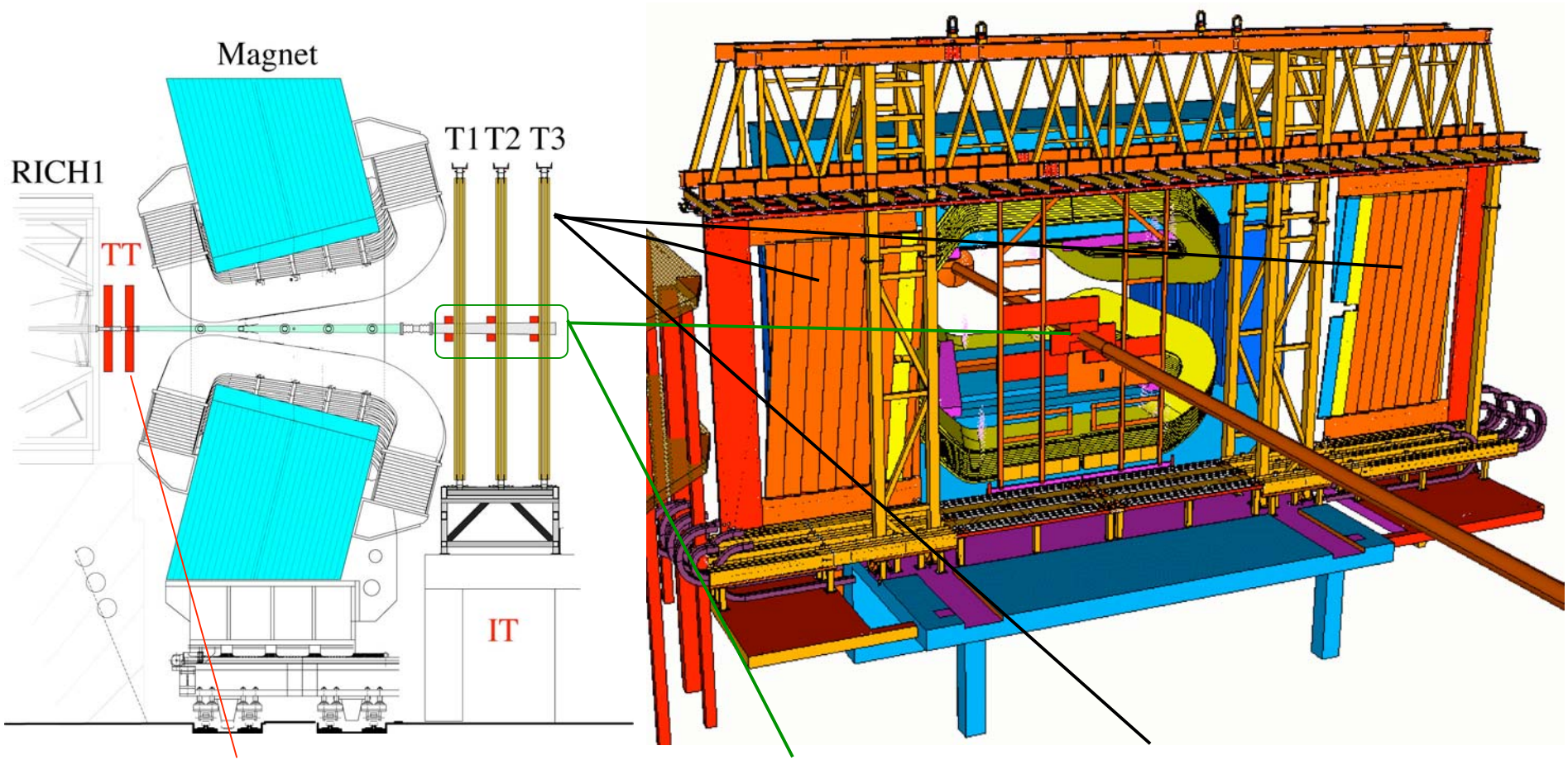
Detector Module



Impact parameter resolution



Outer Tracker and Silicon Tracker



Trigger Tracker Inner Tracker Outer Tracker

~1.4×1.2 m^2

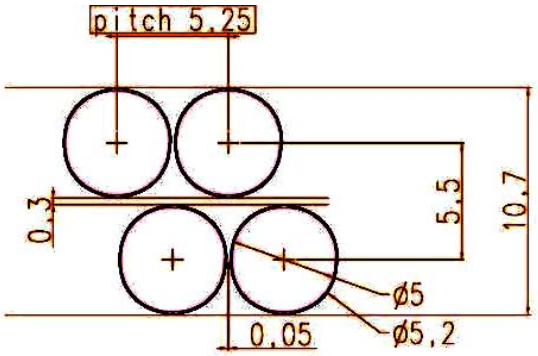
Silicon Tracker

Outer Tracker

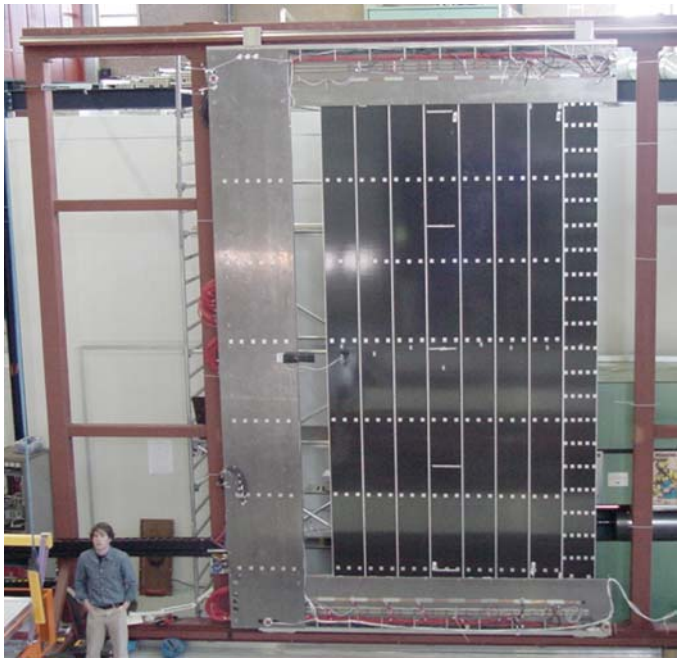
Straw drift chambers

40μm Kapton XC-160
+ Laminated Kapton-Al

connecting two small modules
around the beam pipe



All the detector module
construction completed



Module Support C-frame

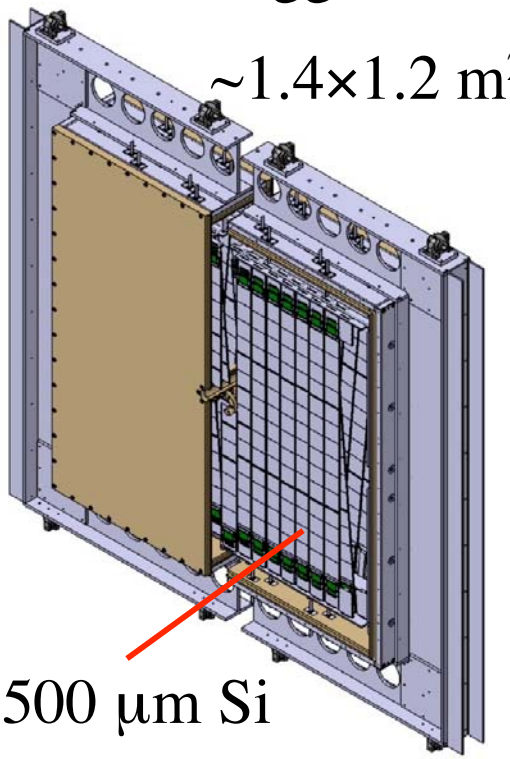
-prototype tested
-all produced and delivered at CERN
-ready for loading the modules

OT support
hanging structure
installed

Silicon Tracker

Trigger Tracker

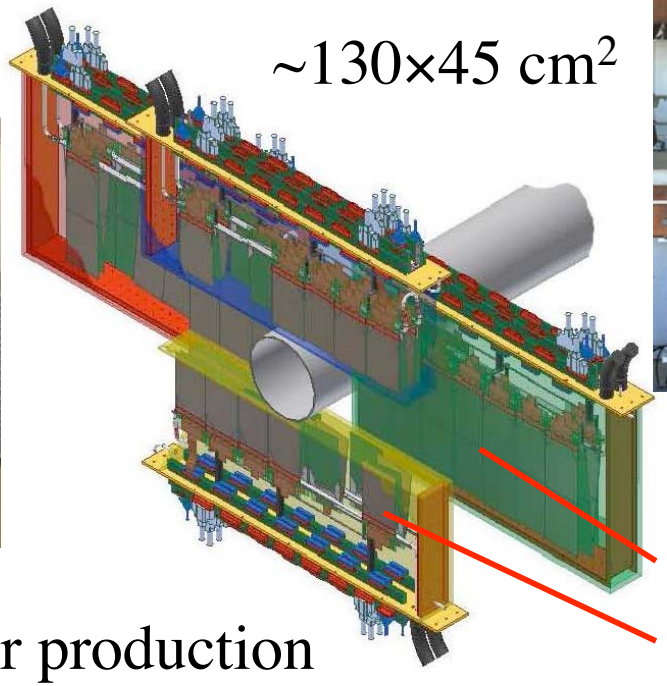
~1.4×1.2 m^2



500 μm Si

Inner Tracker

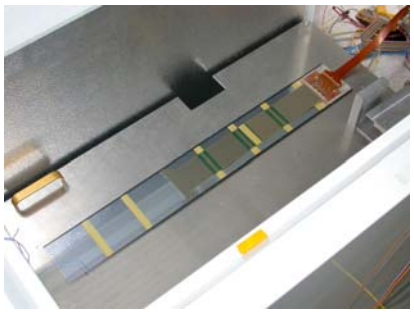
~130×45 cm^2

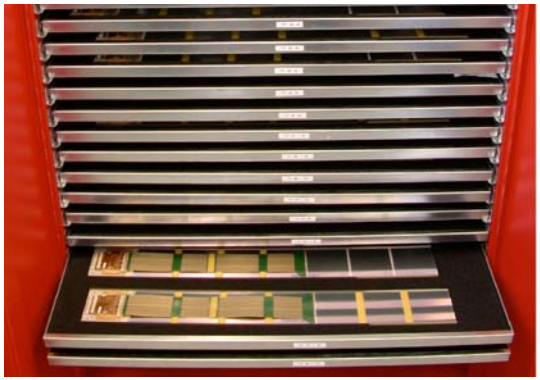


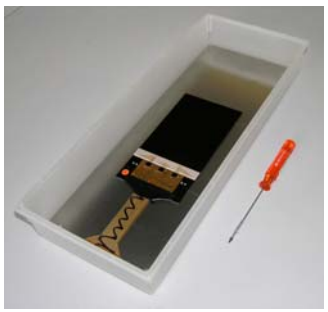
410 μm Si

320 μm Si

Si ladder production in progress



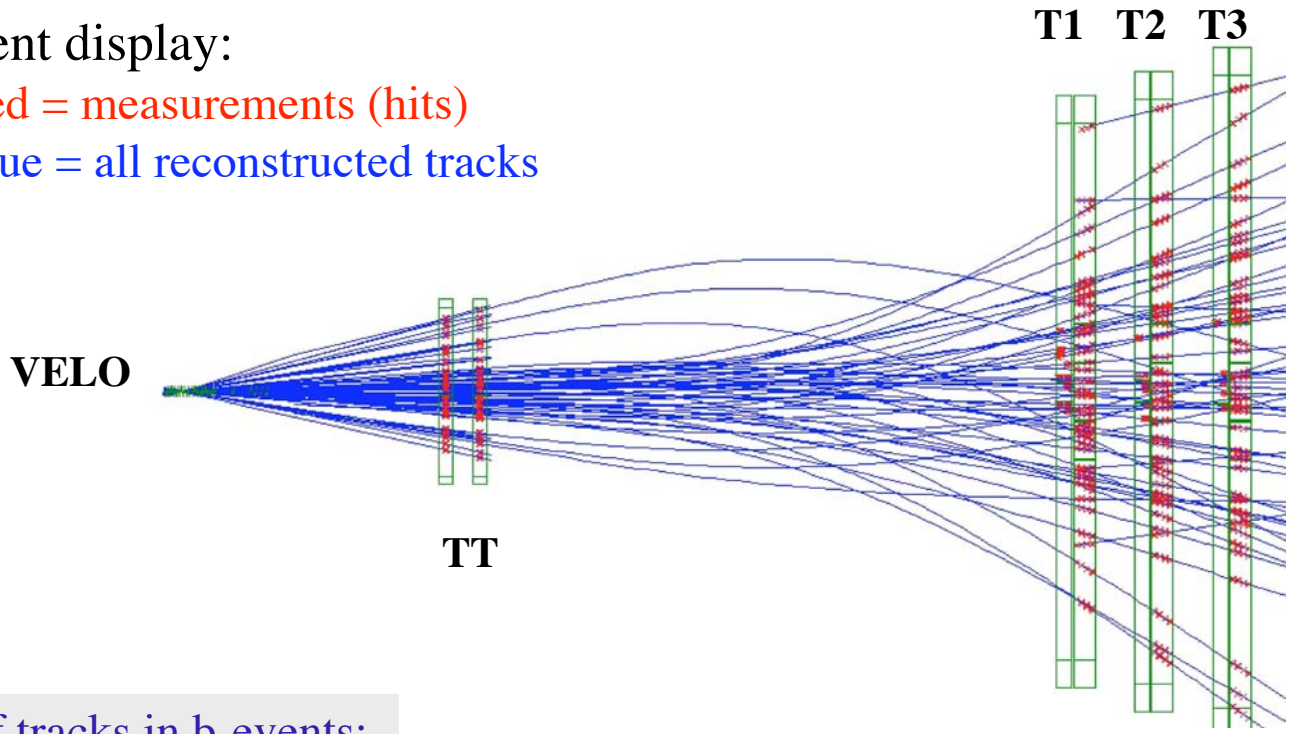




Typical event display:

Red = measurements (hits)

Blue = all reconstructed tracks

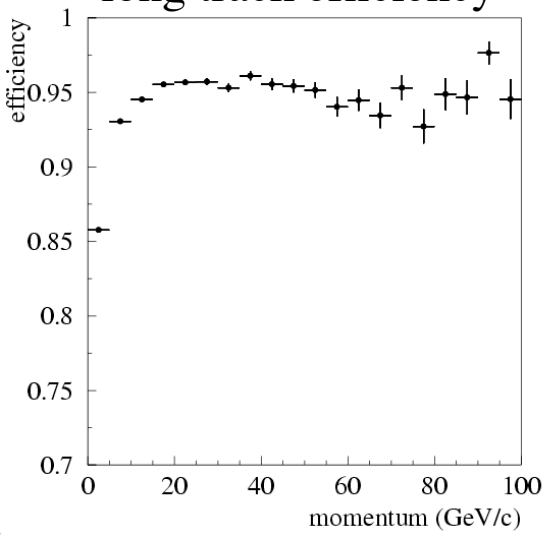


Average # of tracks in b-events:

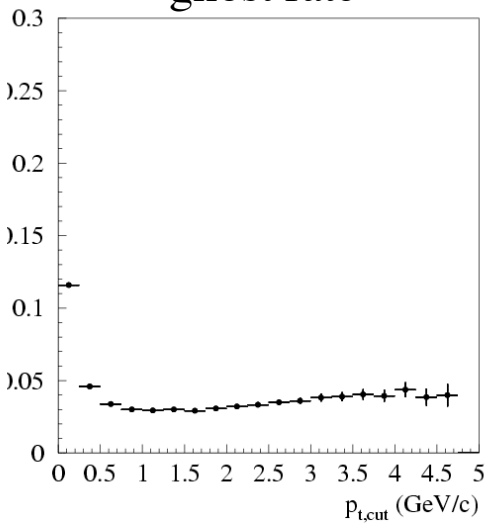
34	VELO,
33	long,
19	T tracks,
6	upstream,
14	downstream
Total	106 reconstructed tracks

~ 20 to 50 hits assigned to each long track
98.7% correctly assigned

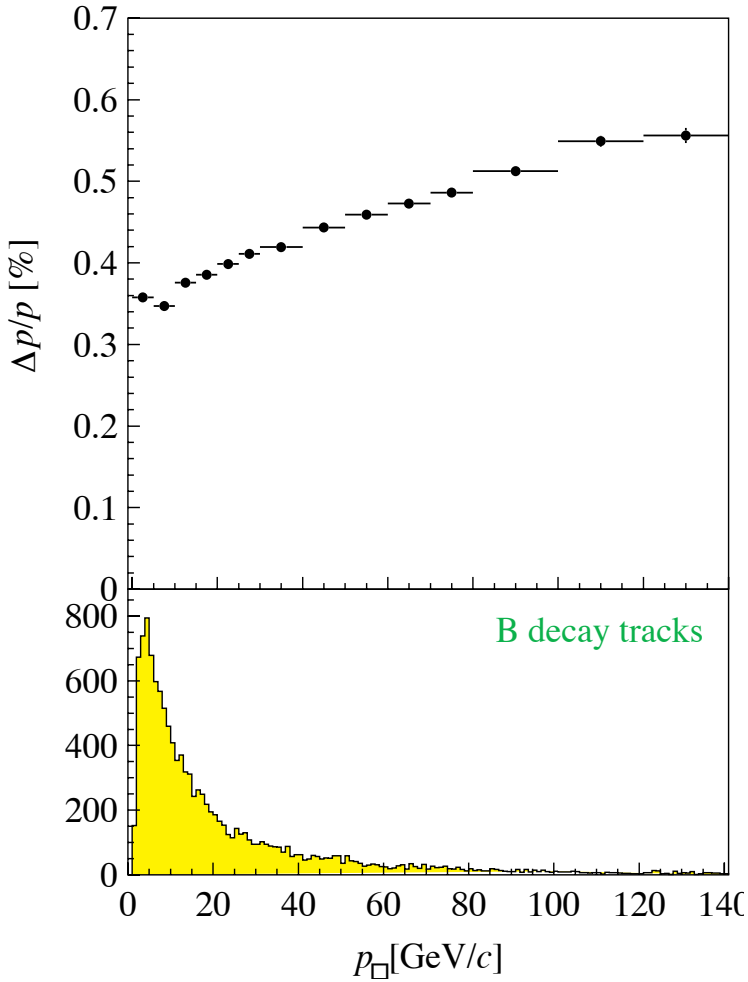
long track efficiency



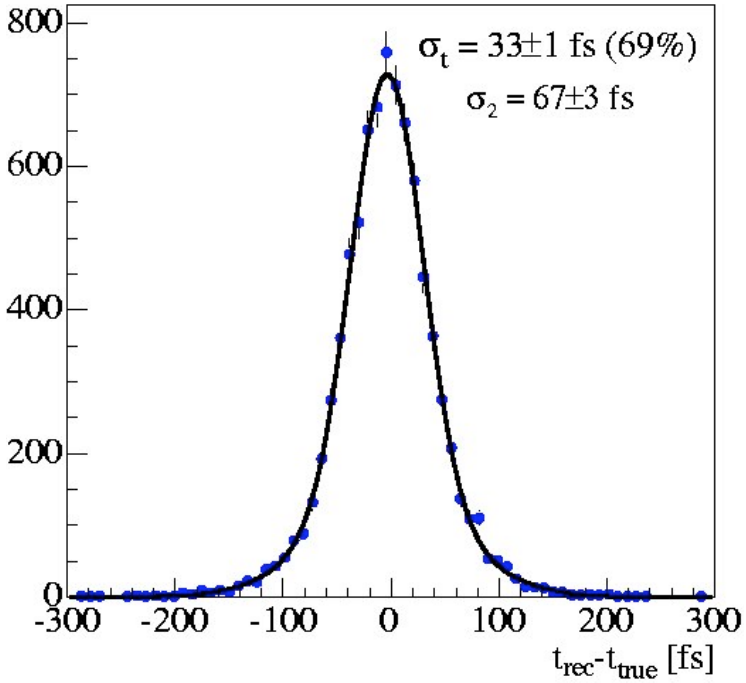
ghost rate



VELO + ST + OT + Magnet



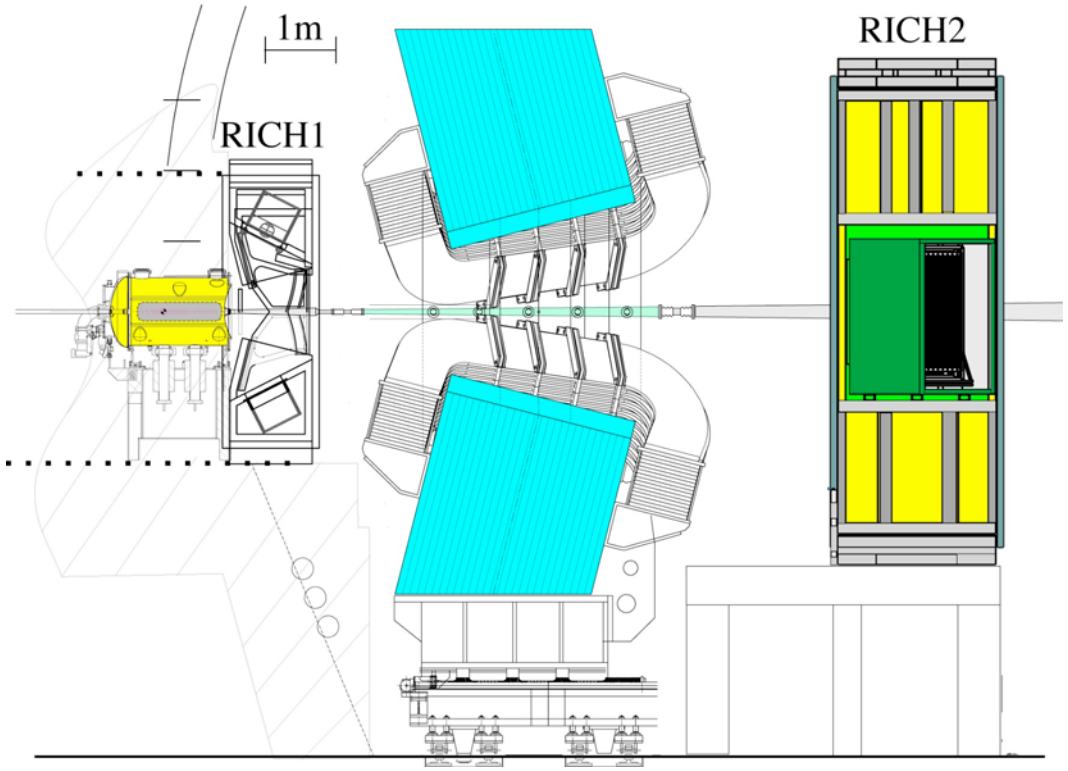
momentum resolution

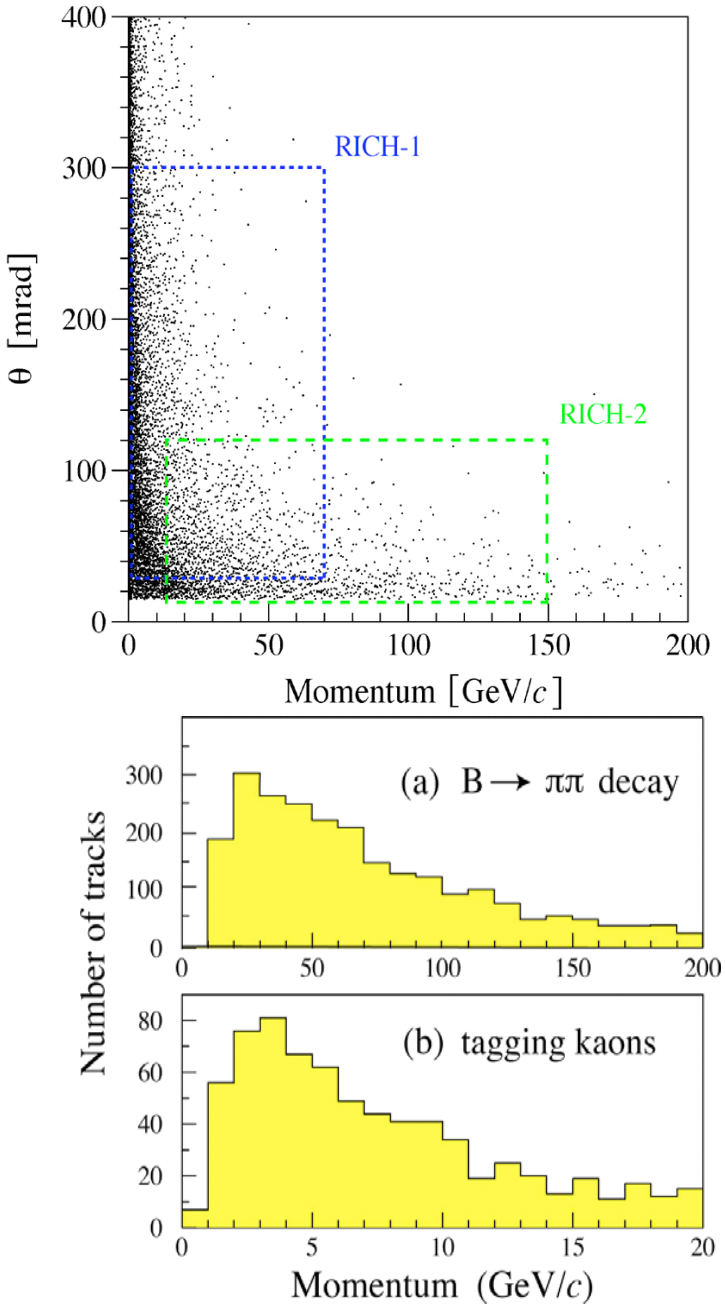


Proper time resolution ~ 40 fs

$B_s \rightarrow D_s^- \pi^+$

RICH



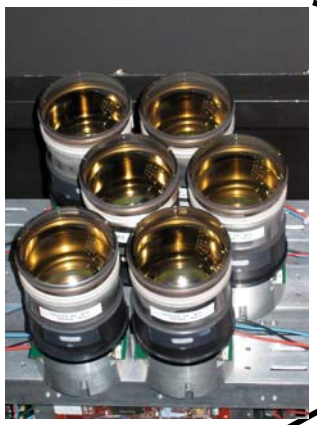


Two RICH with three radiators

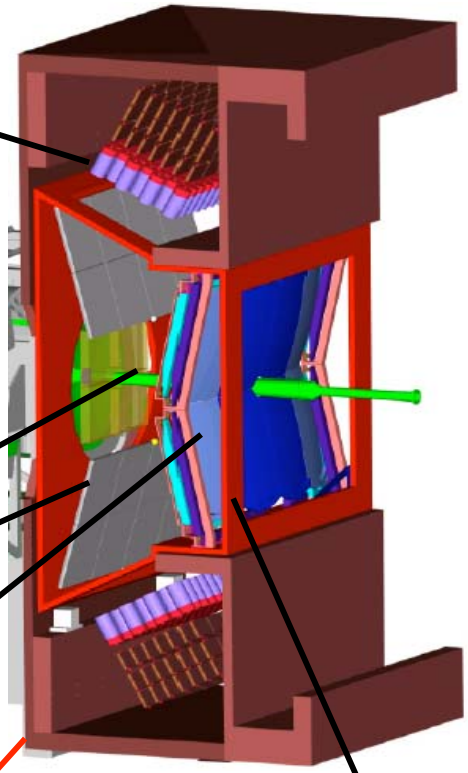
Aerogel, C_4F_{10} } RICH1 (25-300 mrad)

CF_4 RICH2 (15-120 mrad)

HPD
Photodetectors



RICH1



Beam Pipe

Flat Mirror

Spherical Mirror

Magnetic Shield

Gas Enclosure

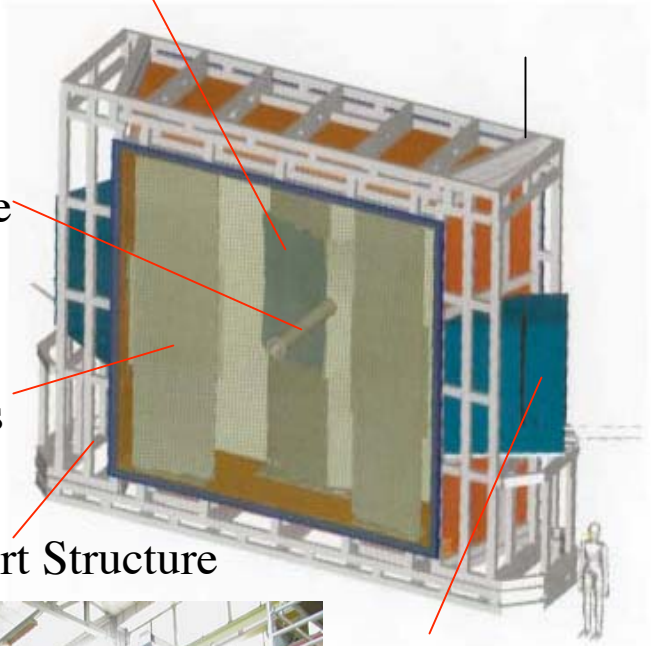
RICH2

Spherical Mirrors

Central Tube

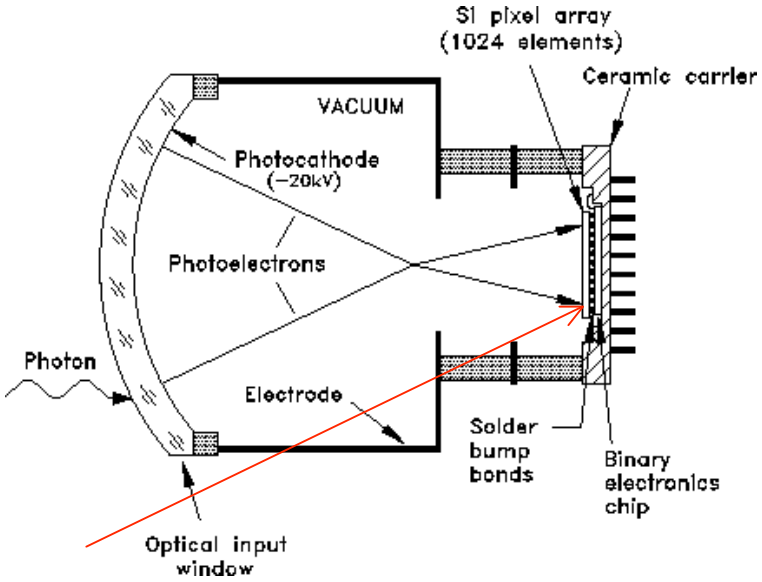
Flat mirrors

Support Structure

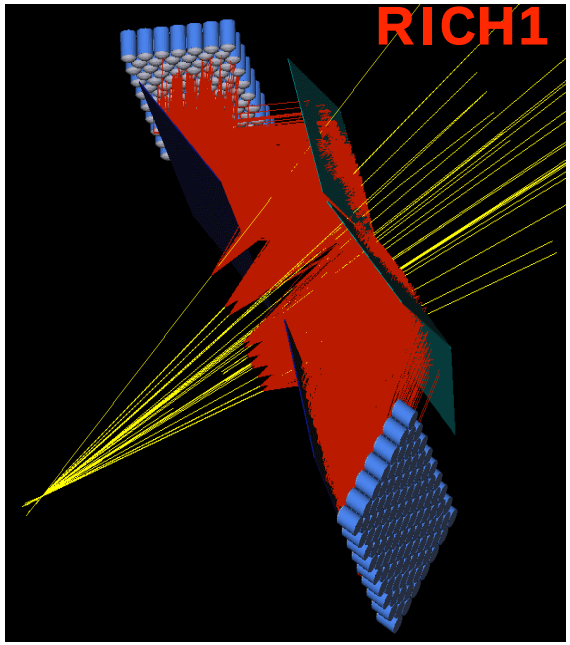


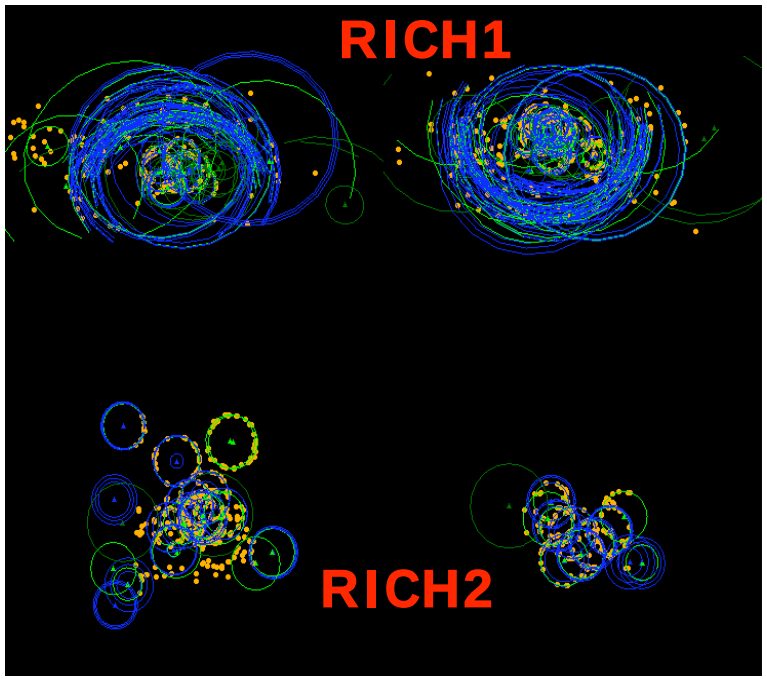
Photon Funnel
+ Shielding

HPD



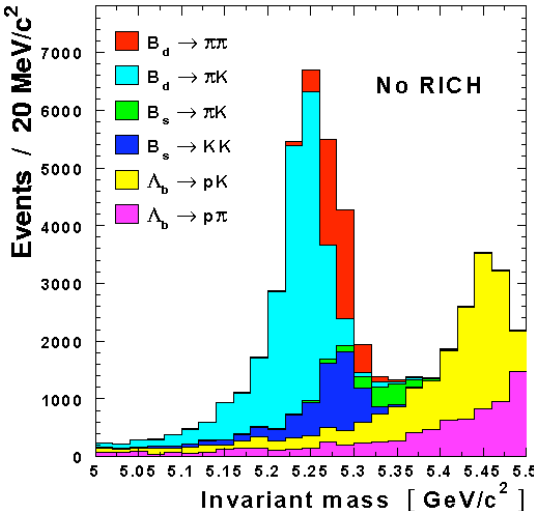
1024 pixel (500μm×500μm) detector and bump bonded pixel readout electronics.

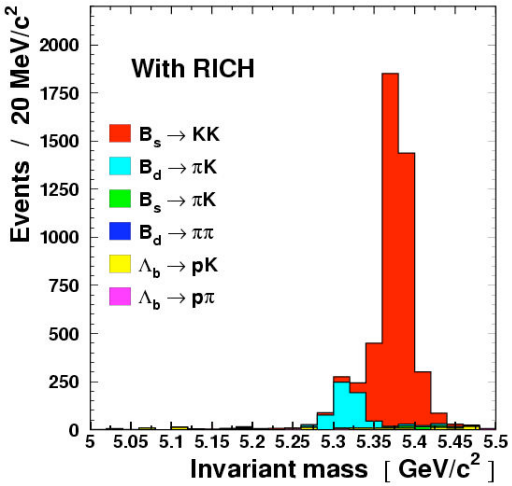


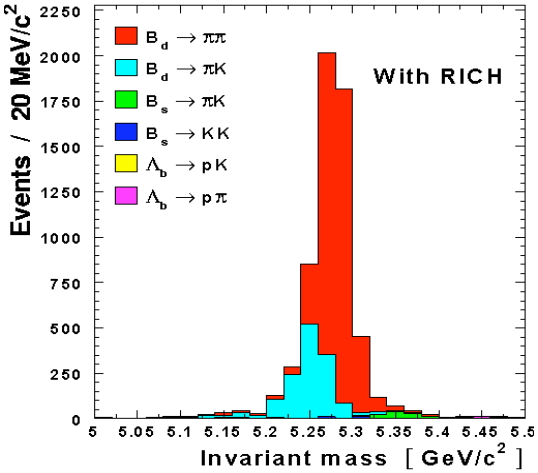


RICH-2 transport to IP8

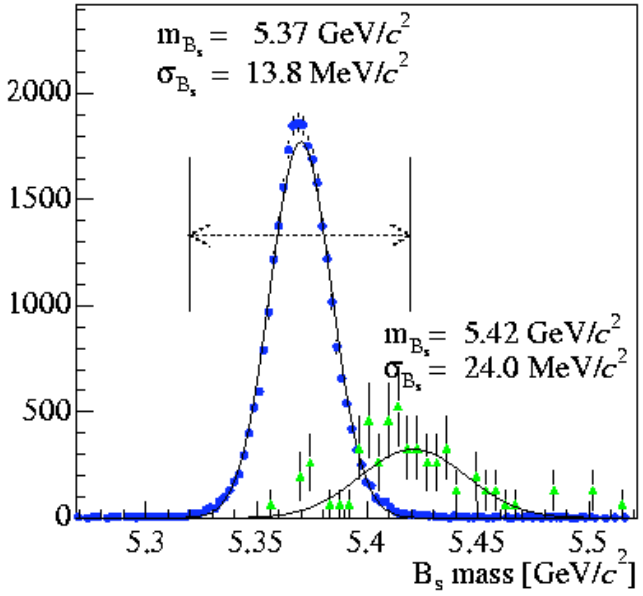
PID for $B \to \pi\pi$ and $B_s \to KK$ reconstruction



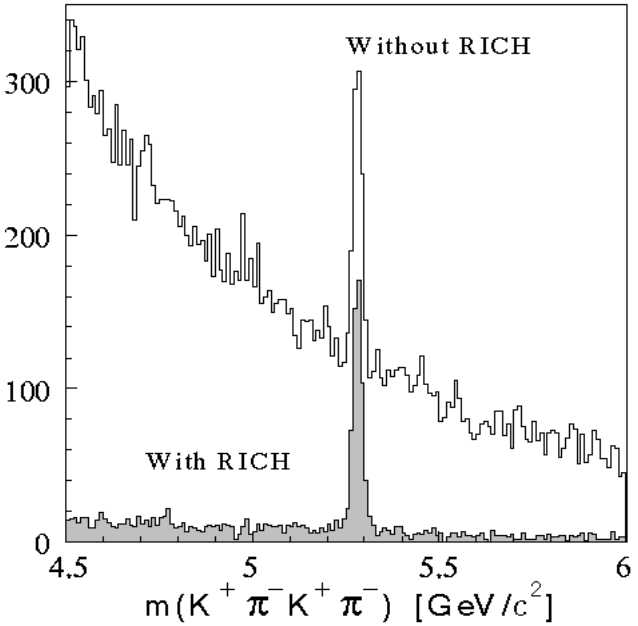




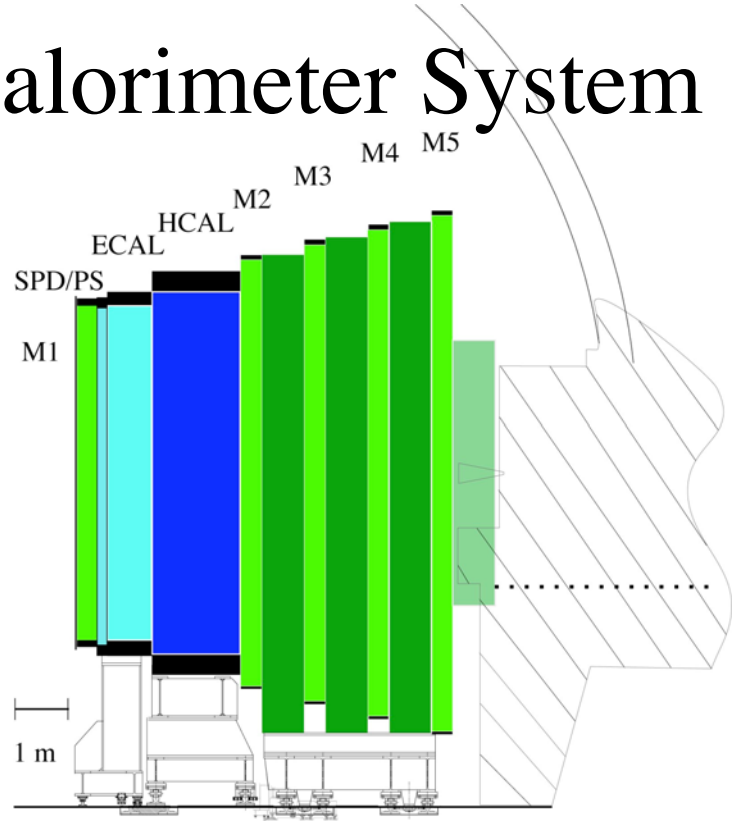
$B_s \to D_s\pi$ suppression with PID for $B_s \to D_sK$



Comb. suppression with PID for $B \to DK^{*0}$



Calorimeter System

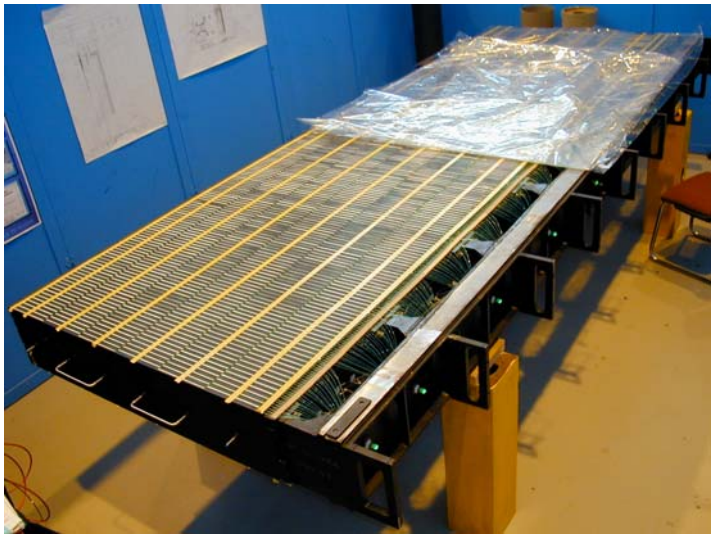


Ecal
Shashlik

$25X_0$

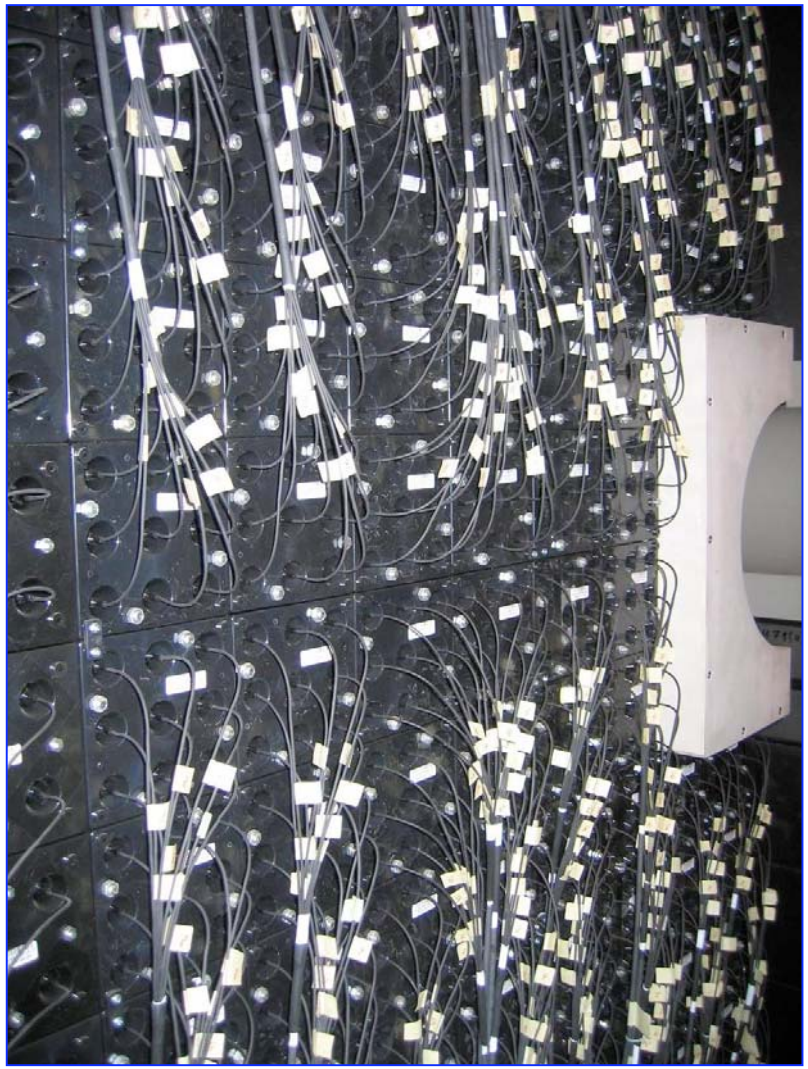
Hcal
Fe-Scintillator tile

5.6λ



SPD/PS
Scintillator-Pb-Scintillator

Production completed

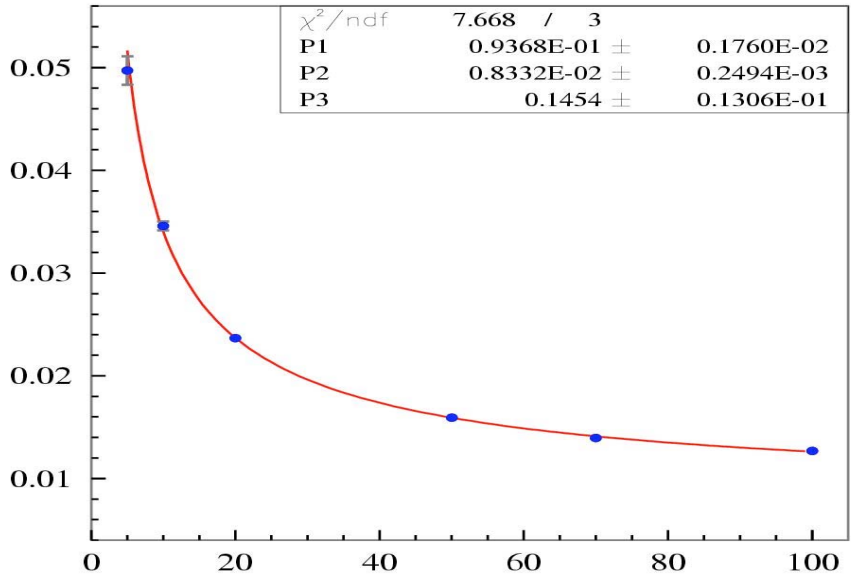


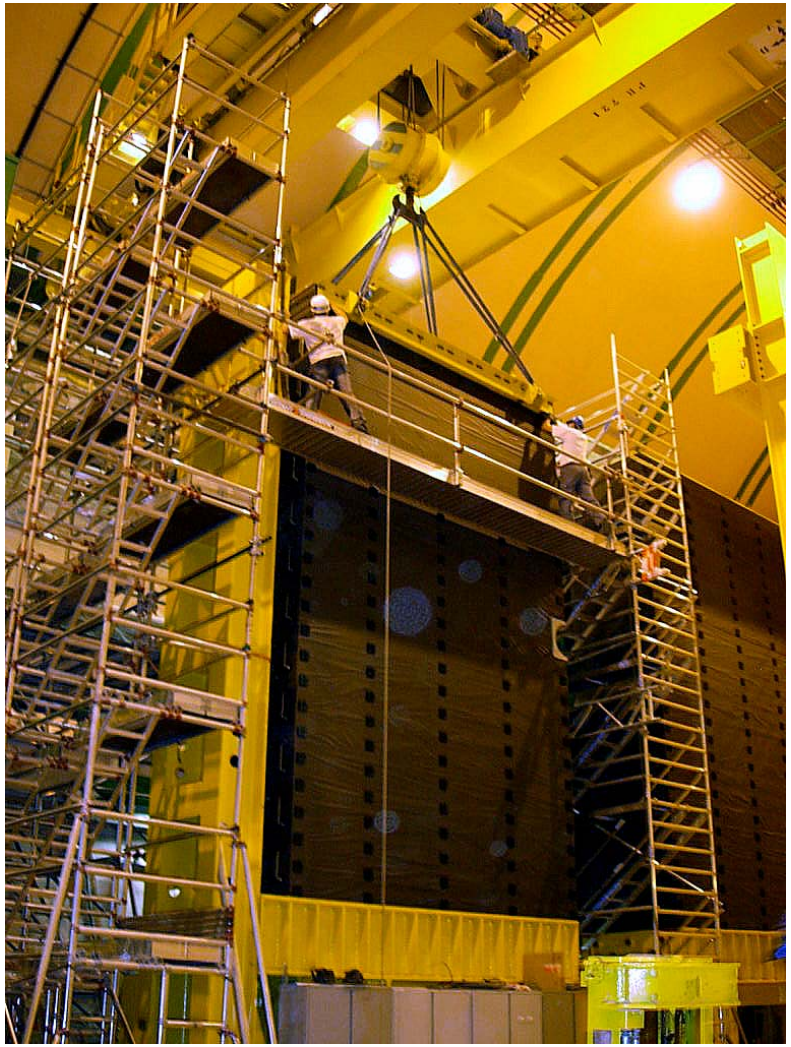
front

E-cal installation completed

E-cal measured in test beam

$$\frac{9.4\%}{\sqrt{E}} \oplus (0.83 \pm 0.02)\% \oplus \frac{(0.145\text{GeV})}{E}$$

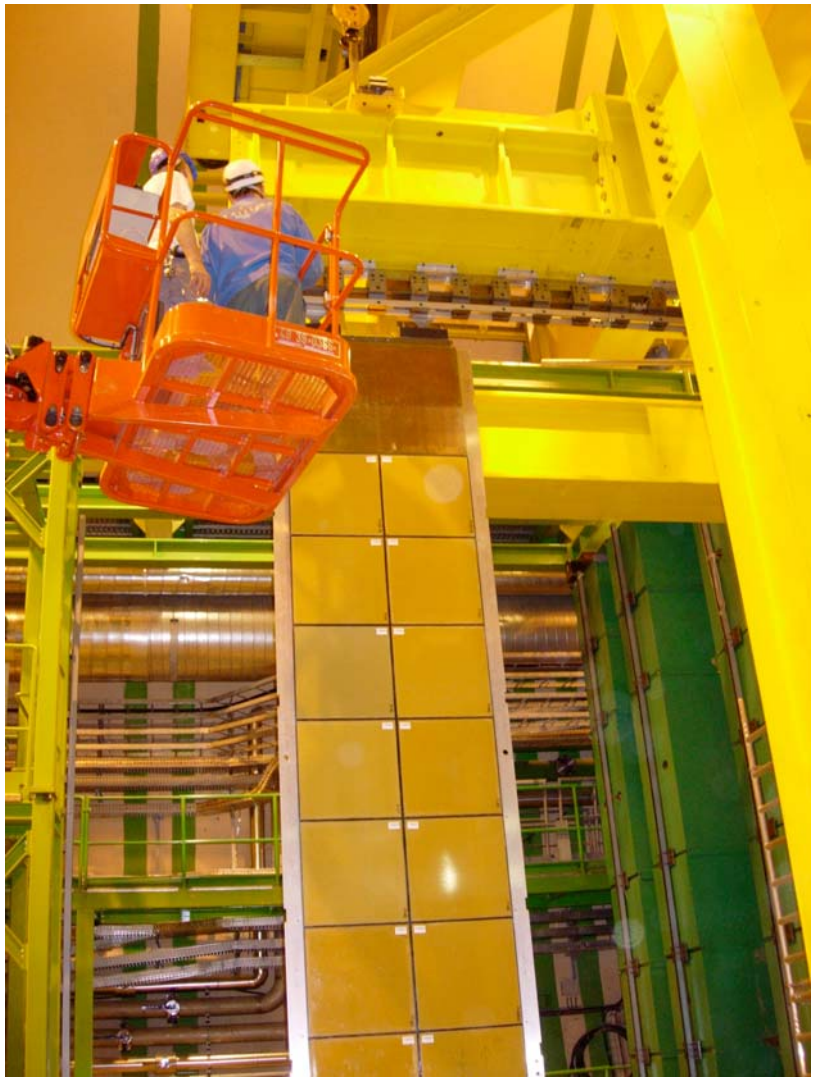




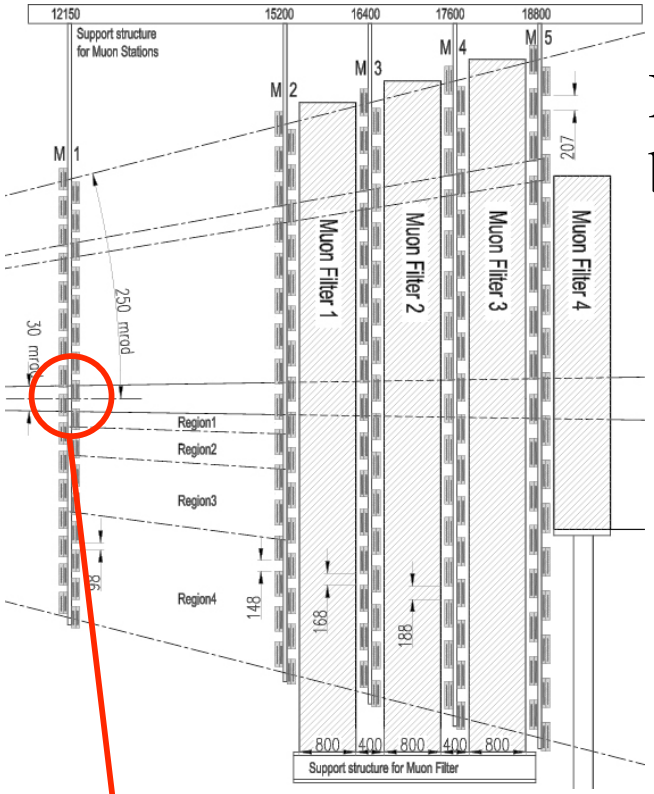
Hcal installation completed

PS/SPD
fibre connections

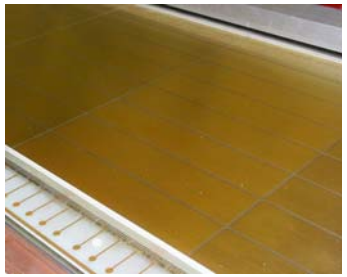
and being installed



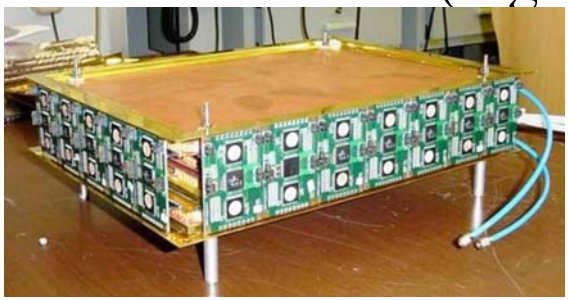
Muon System



Projective readout based on MWPC's



except 3-GEM at M1R1(high occupancy)



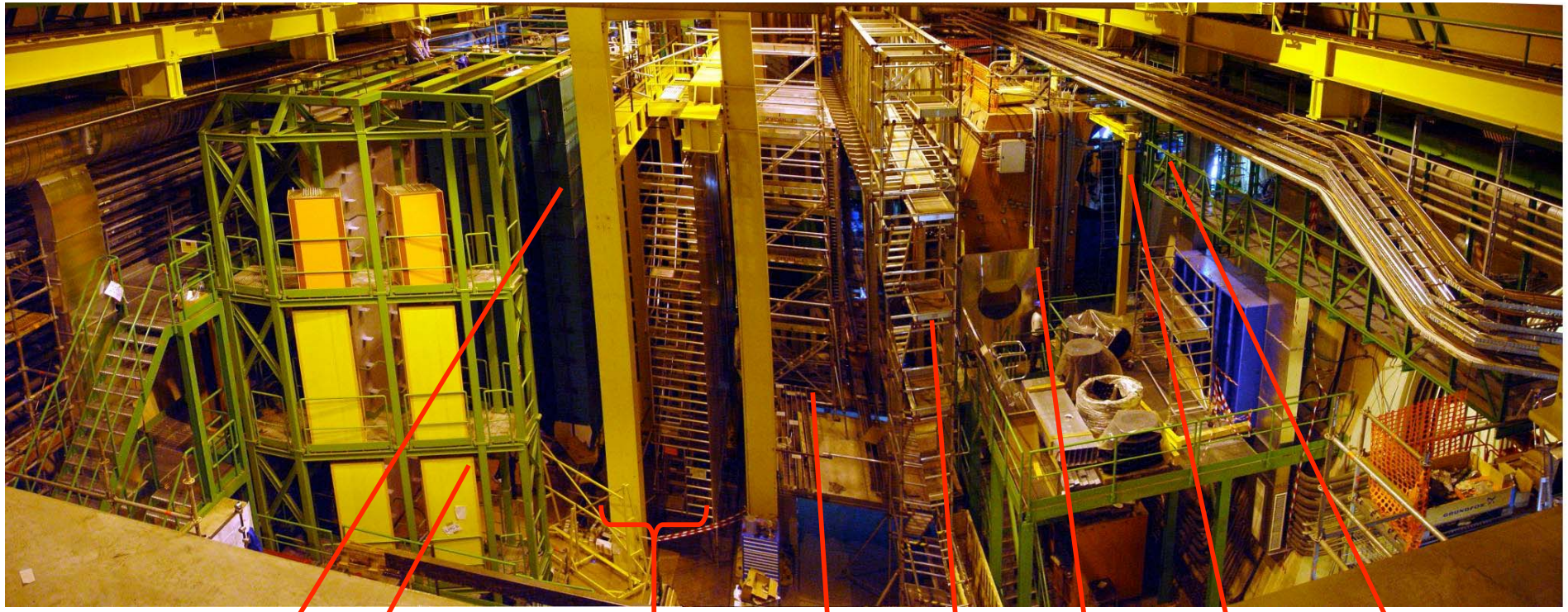
MWPC production

Infrastructure at the pit

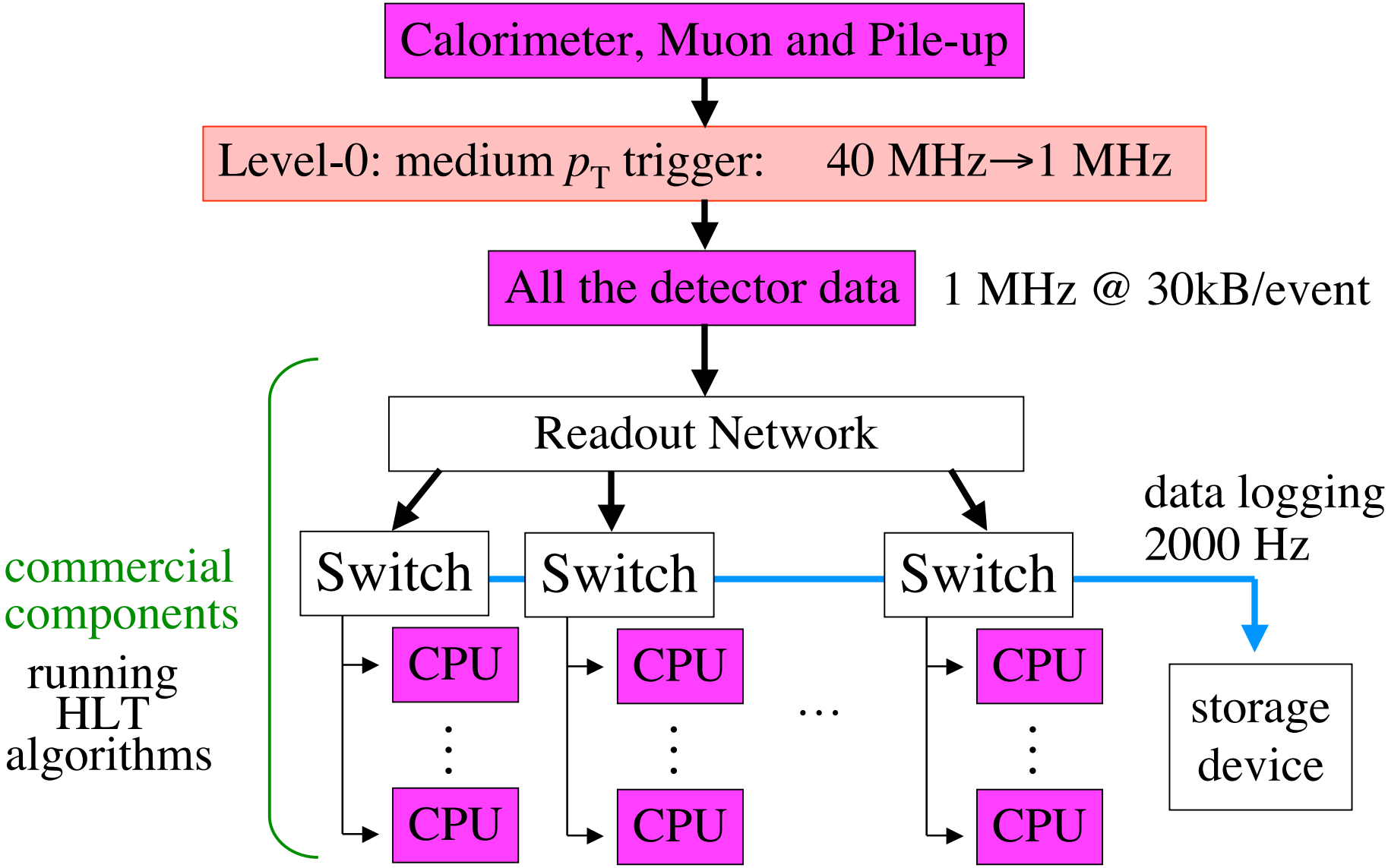
construction of the chamber mounting wall >50% completed

Fe filter and electronics tower ready

Current status of the pit (IP8)

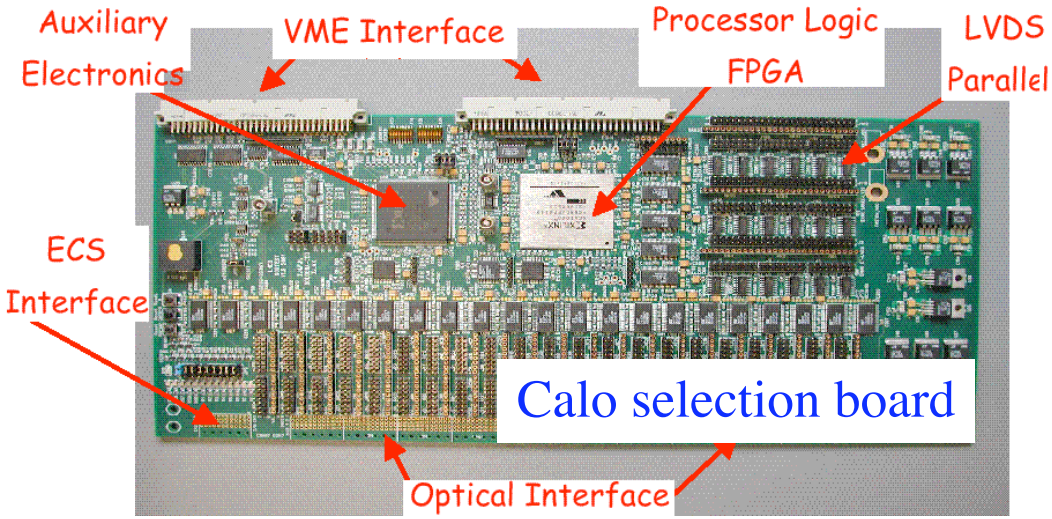


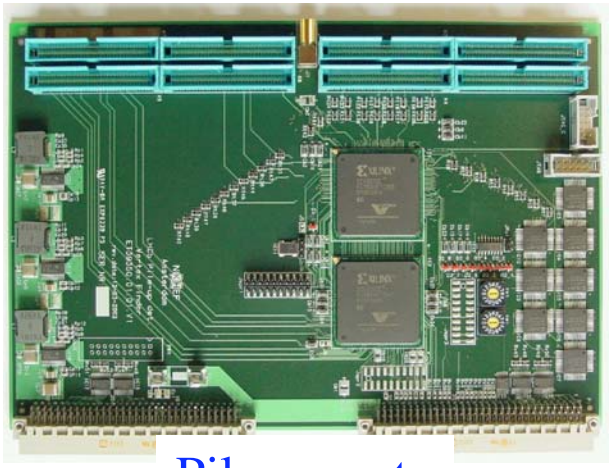
Trigger and Online



Level-0: Muon, Calorimeter (e, h, γ, π^0), Pile-up veto, Decision Unit prototypes.

Muon processor board



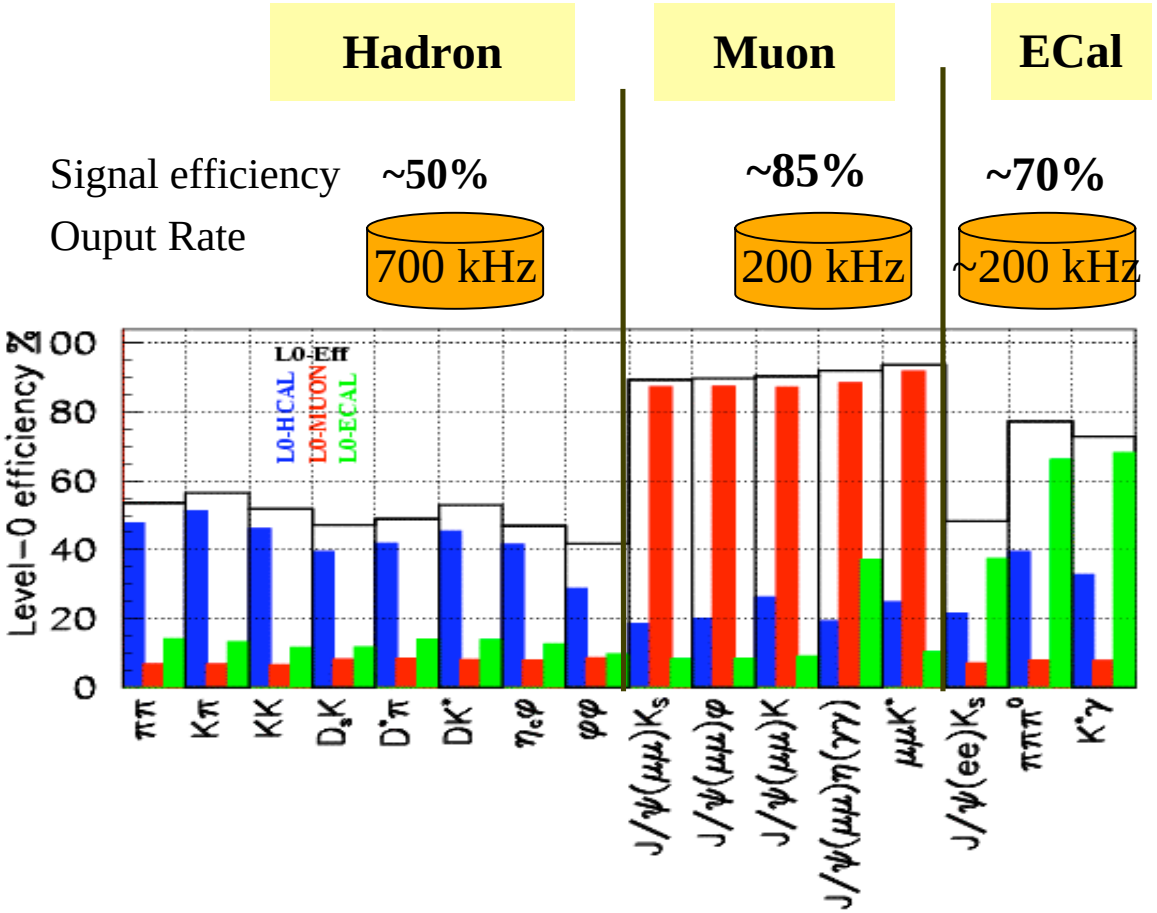


Pile-up veto

Decision Unit

Level-0

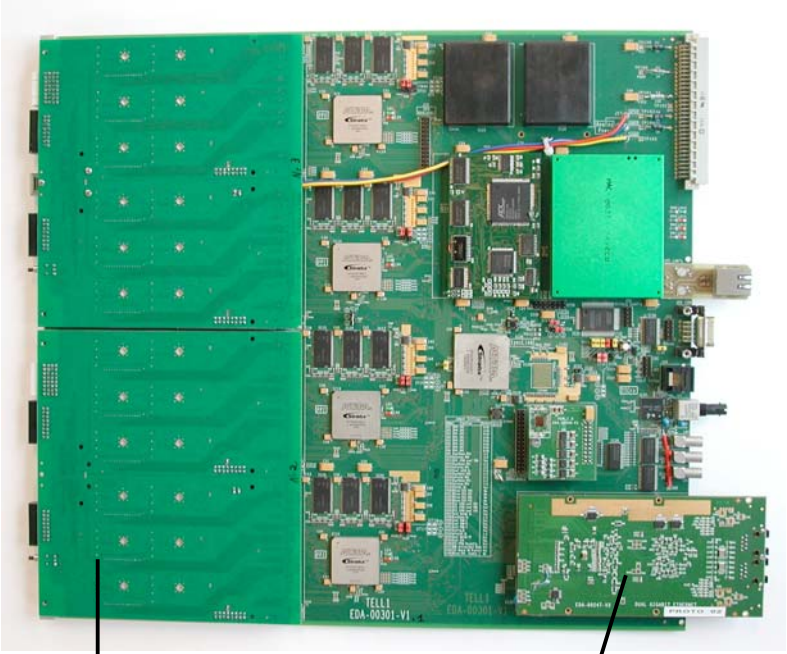
efficiencies for offline selected events



L0 setting

Type	Thresh (GeV)
Hadron	**3.6**
Electron	**2.8**
Photon	**2.6**
π^0 local	**4.5**
π^0 global	**4.0**
Muon	**1.1**
Di-muon Σ p_T^{μ}	**1.3**

Tell1:
LHCb **common**
readout board



Optical receiver card

Giga-bit Ethernet transmitter card

350 boards

Force10 E1200
network switch

CPU farm
prototype

~1800 “boxes”
≈ 3600 CPU’s

CPU farm: 1800 “boxes” = 3600 CPU’s

Start with L0-info, VELO, TT, T and Muon

look for events with

medium p_T tracks with large impact parameters

high p_T muon tracks

di-muon

high p_T photon

Reject events as soon as possible.

Later include Calorimeters and RICH

exclusive reconstruction of B decays

semi-inclusive reconstruction of B decays

exclusive D reconstruction

etc.

On tape:

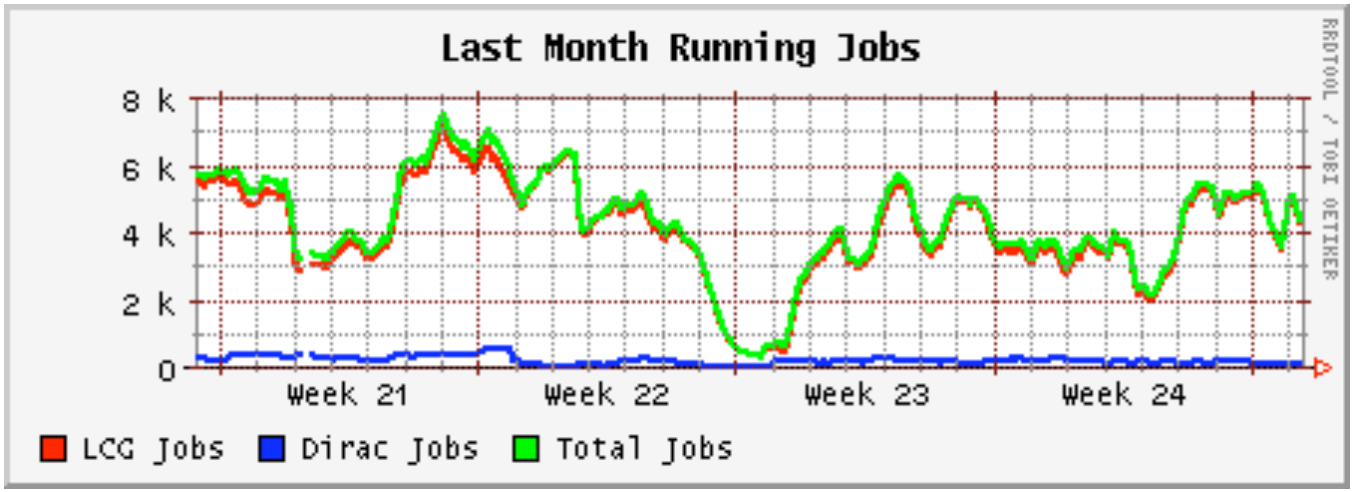
200 Hz B exclusive, 1.8 kHz D*+di-muon+single-muon

Computing

C++ based LHCb complete software suite for simulation, reconstruction, analysis, alignment and calibration, and high level trigger are running under the uniform framework "GAUDI"

LHCb computing model based on
- reconstruction, pre-selection and analysis at Tier-1
- simulation at Tier-2

All the computing aspects are periodically tested through "Data Challenges"



simulation and reconstruction jobs running at WLCG sites in DC2006

On going!

Preparation for the first data

In order to be ready for

1) pilot run @900 GeV in November 2007

2) first physics run @14 TeV in Spring 2008

we have

Commissioning Task Force

- Defining the mode of operation for data taking, and identifying, producing, implementing and testing all the tools necessary for this operation;
- Coordinating the commissioning the sub-systems;
- Preparing the detector for steady data taking, through global commissioning, including the pilot run

Physics Planning Group

- Optimizing physics output for a given running scenario and preparing necessary tools

4) Conclusions

- LHCb expects to take B physics a significant step further than the B factories:
  - access to other b hadron species + high statistics
  - excellent vertexing and particle ID
  - flexible and efficient trigger, dedicated to B physics

  Many channels with different sensitivities to new physics
- Construction of the LHCb detector is advancing well
- Low luminosity (~10^{32}) required for the LHCb experiment will allow to exploit full physics potential from the beginning of the LHC operation, and we will be ready for the pilot run in 2007 and the start of physics exploitation in Spring 2008