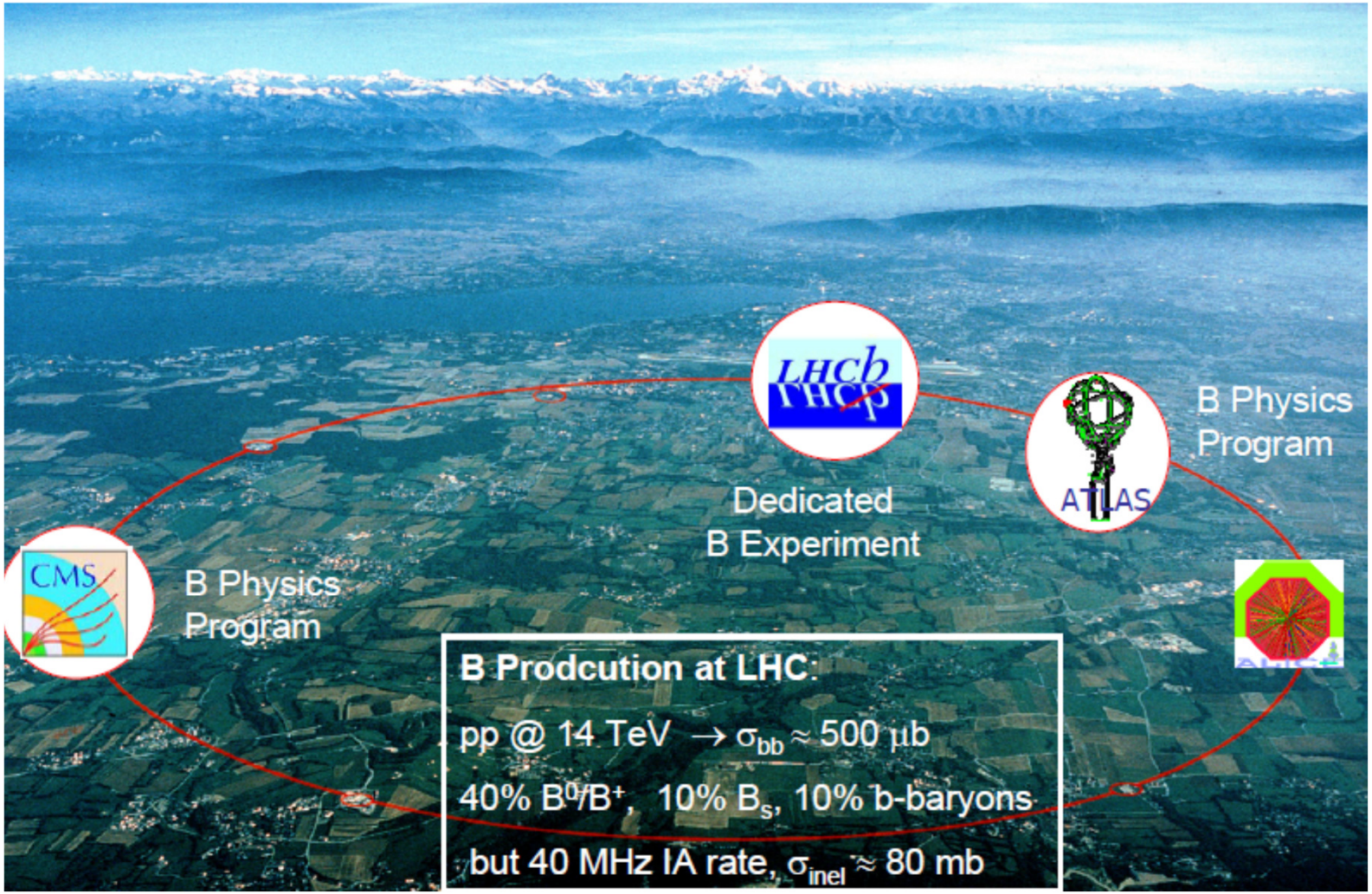
LHCb Detector

Flavor Physics at LHC

LHCb at LHC


LHCb
Dedicated
B Experiment
ATLAS
B Physics
Program
CMS
B Physics
Program
B Prodcution at LHC:
pp @ 14 TeV → $\sigma_{bb} \approx 500$ μb
40% B^0/B^+, 10% B_s, 10% b-baryons
but 40 MHz IA rate, $\sigma_{inel} \approx 80$ mb

Machine

LHC

- pp collisions at $\sqrt{s}$ = 14 TeV

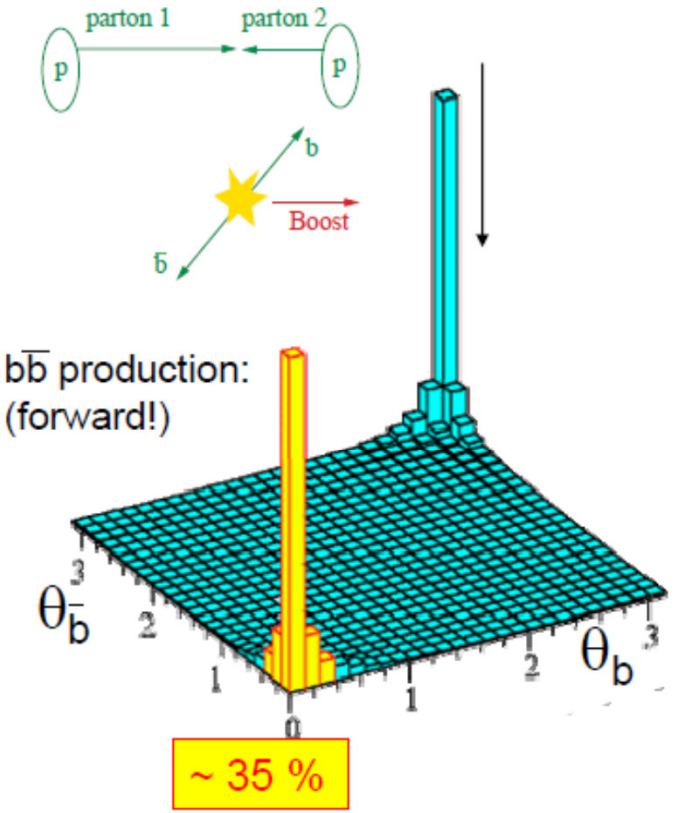
$$\begin{cases} \sigma_{inel} \sim 80\ mb \\ \sigma_{b\bar{b}} \sim 500\ \mu b \end{cases}$$

- Forward production of bb, correlated
- for L ~ 2 x 10^{32} $cm^{-2}s^{-1}$ (defocused beams at LHCb IP)

~10^{12} b $\bar{b}$ events/yr produced

LHCb

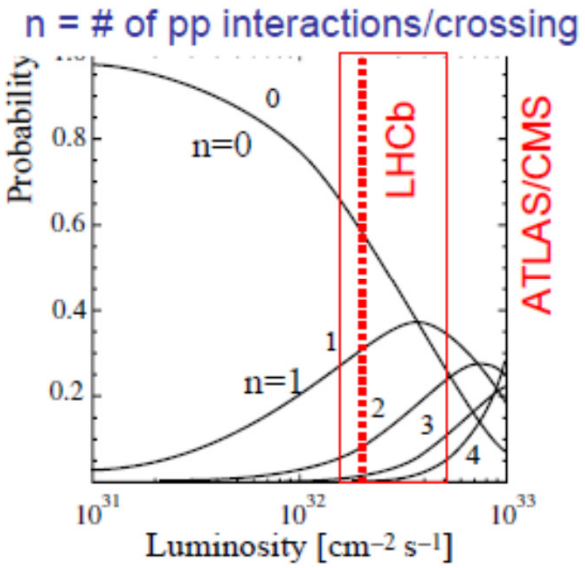
- Single arm forward spectrometer
  12 mrad < θ < 300 mrad(1.8<η<4.9)



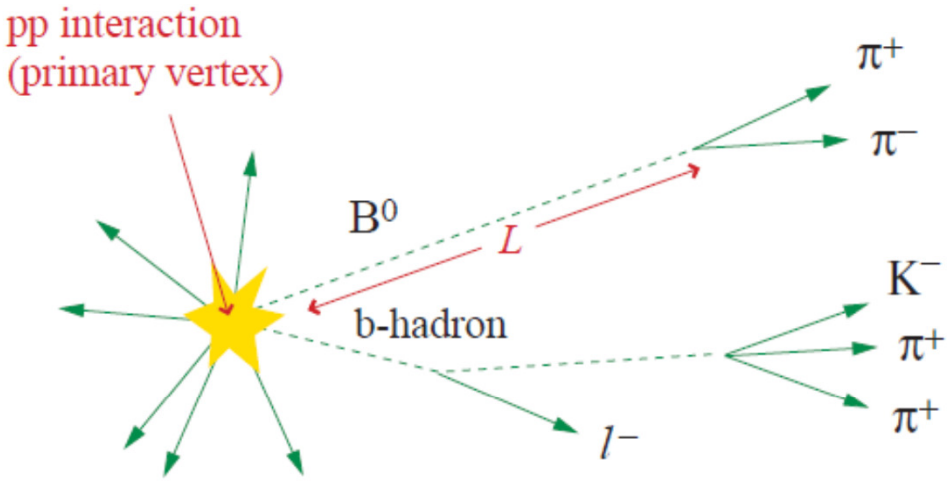
Design guidelines

LHCb:

- designed to maximize B acceptance
- Forward, single arm spectrometer, $1.9 < \eta < 4.9$ (bb pairs correlated, mainly forward)
- Excellent vertexing and particle ID (K/π separation)
- "lower" pT triggers, including purely hadronic modes, very flexible
- Luminosity tuneable by adjusting beam focus: run at $L \sim 2\times10^{32}\,cm^{-2}s^{-1} \rightarrow n\approx0.5$

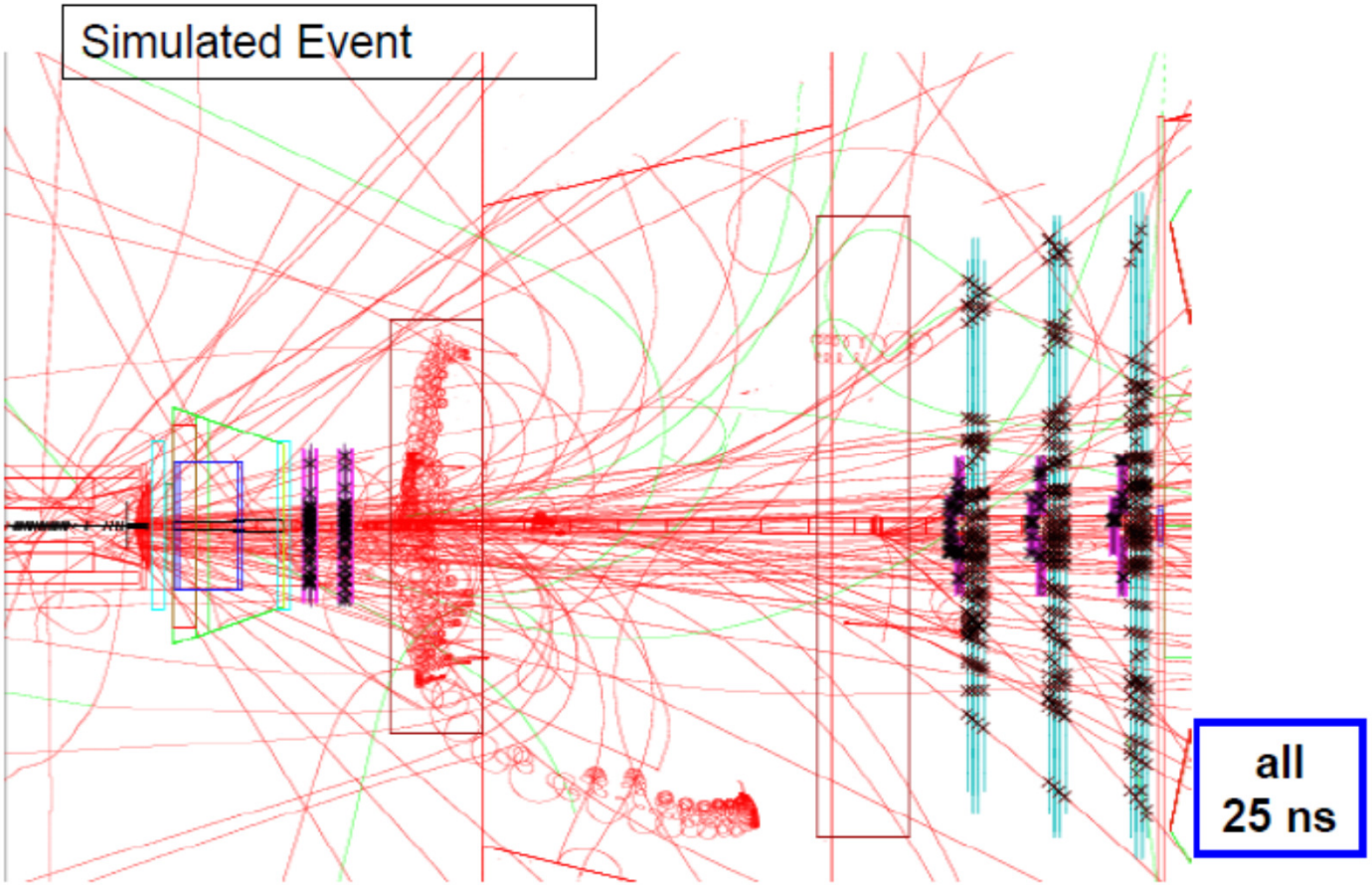


B Tagging

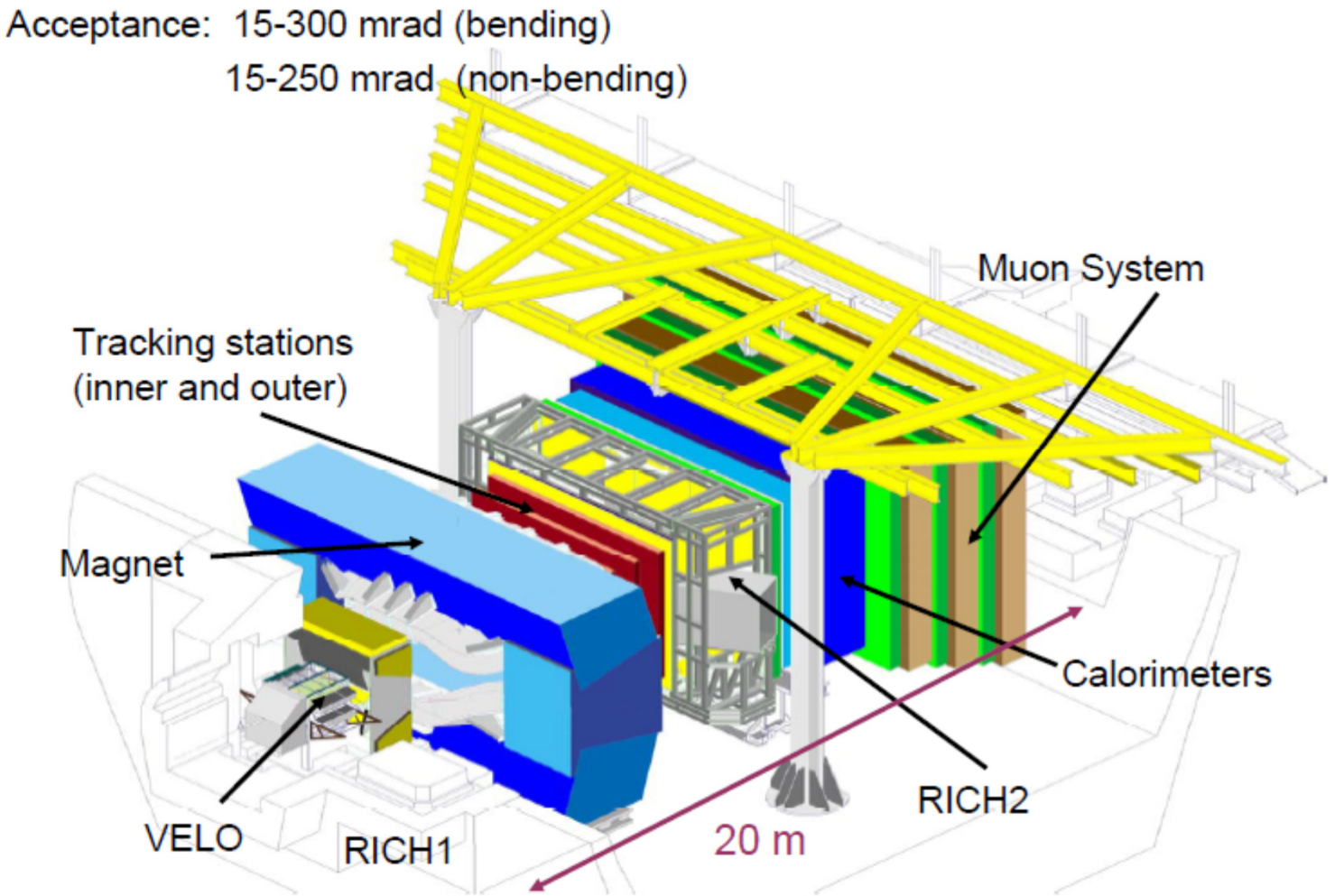


- Decay length *L* typical ~ 7 mm
- Decay products with p ~ 1–100 GeV
- Trigger on "low p_t" particles (similar to backgr)

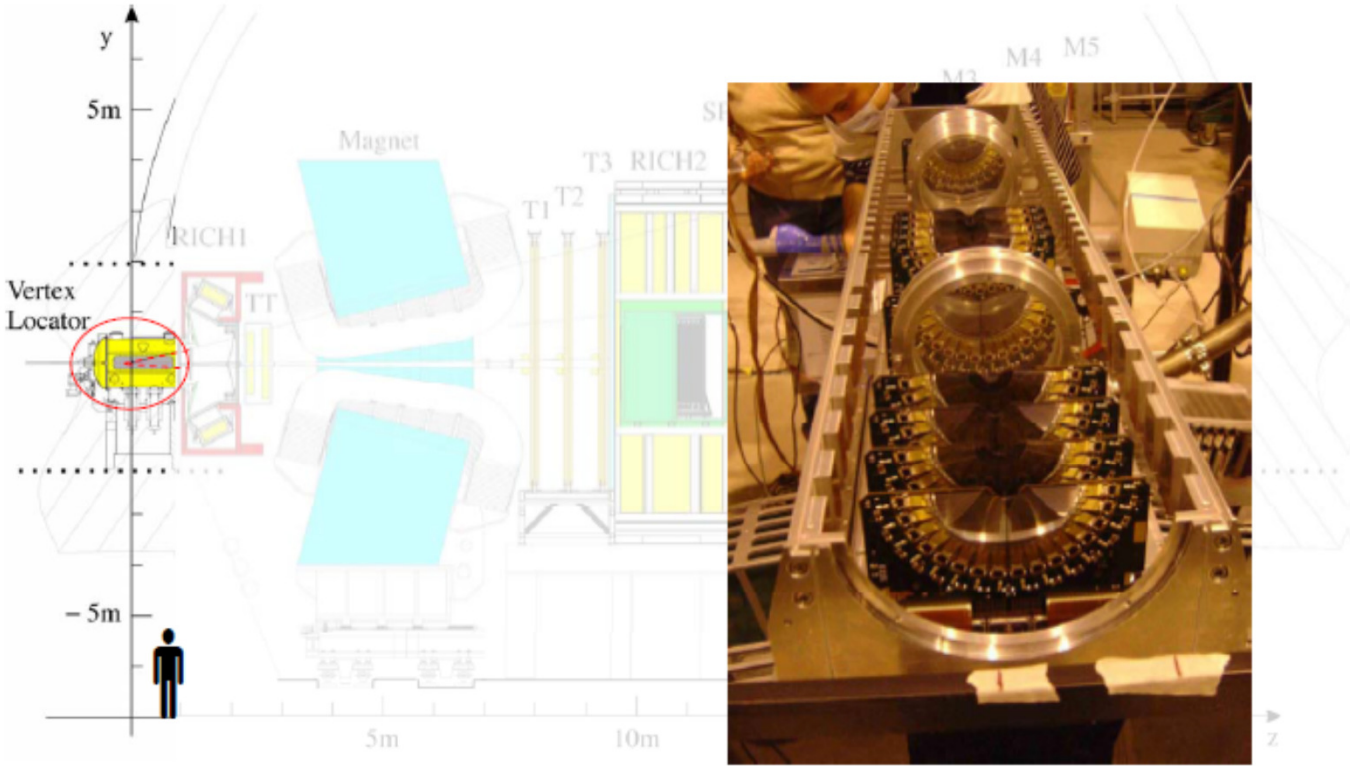
LHCb Event



Detector


Acceptance: 15-300 mrad (bending)
15-250 mrad (non-bending)
Muon System
Tracking stations
(inner and outer)
Magnet
Calorimeters
RICH2
VELO
RICH1
20 m

Vertex Detector

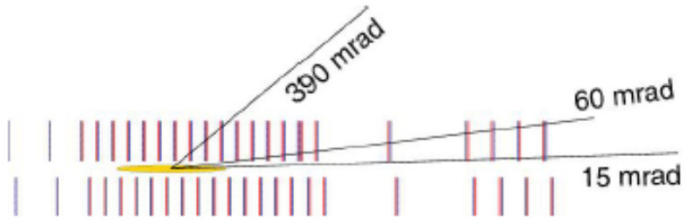


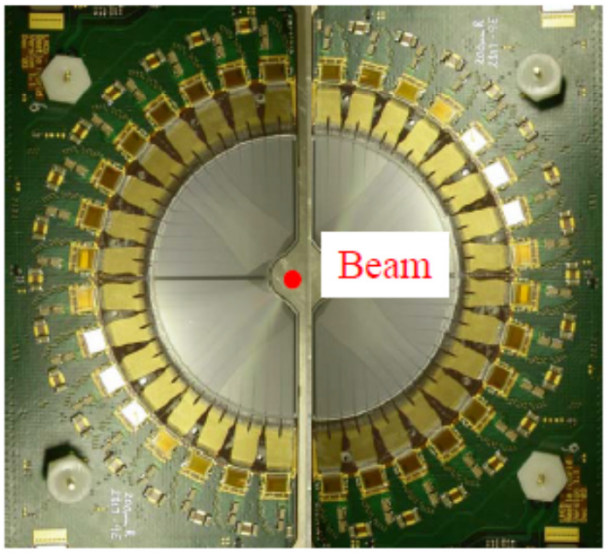
Vertex locator around the interaction region

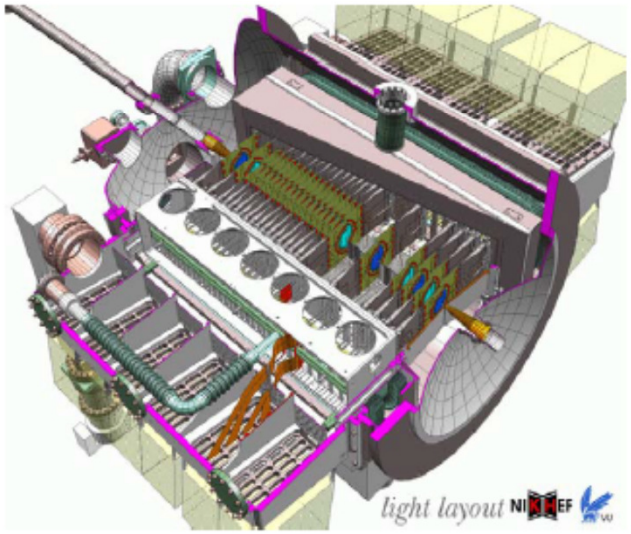
Silicon strip detector with ~ 30 μm impact-parameter resolution

Silicon Tracker

- 21 stations w/ double sided silicon sensors
- micro-strip sensors with $r\phi$ geometry,
- approach to 8 mm from beam
  (inside complex secondary vacuum system)

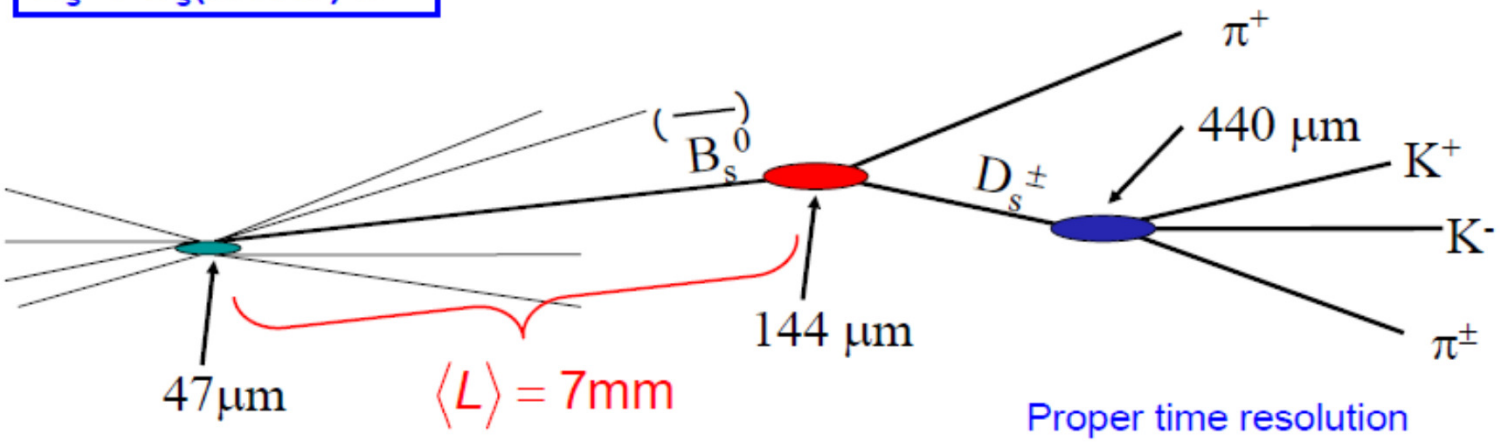






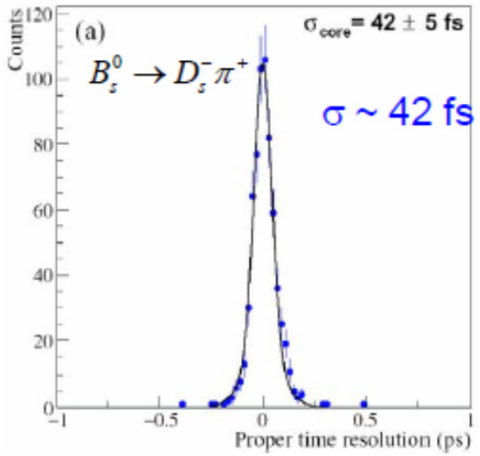
Typical Vertex Resolutions

$B_s \to D_s(K\,K\,\pi)\,\pi$



$L = c\beta\gamma t$ ➡

Proper time resolution



Life time information is used in the trigger !

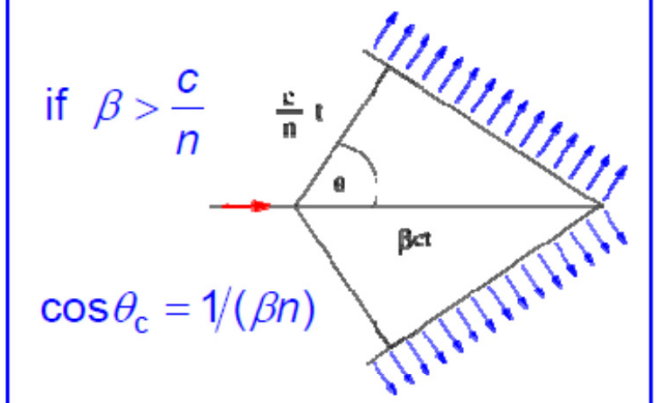
Particle ID

RICH detectors are the specialized detectors to allow charged hadron (π, K, p) identification.

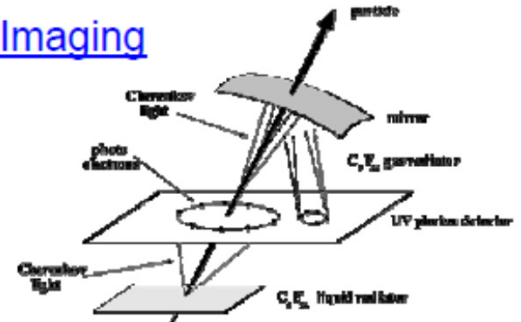
Important for B physics, as there are many hadronic decay modes
e.g.: $B_s \rightarrow D_s^- K^+ \rightarrow (K^+ K^- \pi^-) K^+$

Since ~7× more π than K are produced in pp events, making the mass combinations would give rise to large ***combinatorial background*** unless K and π tracks can be separated

Cherenkov Radiation

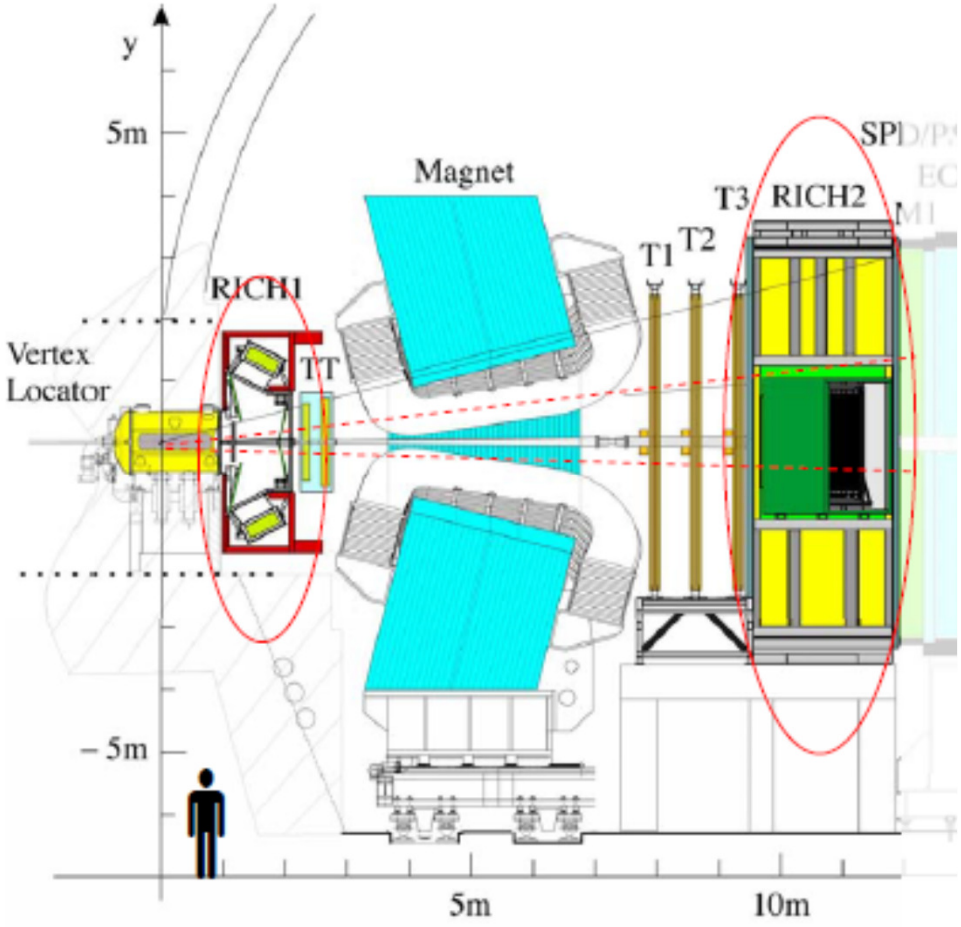


Ring Imaging

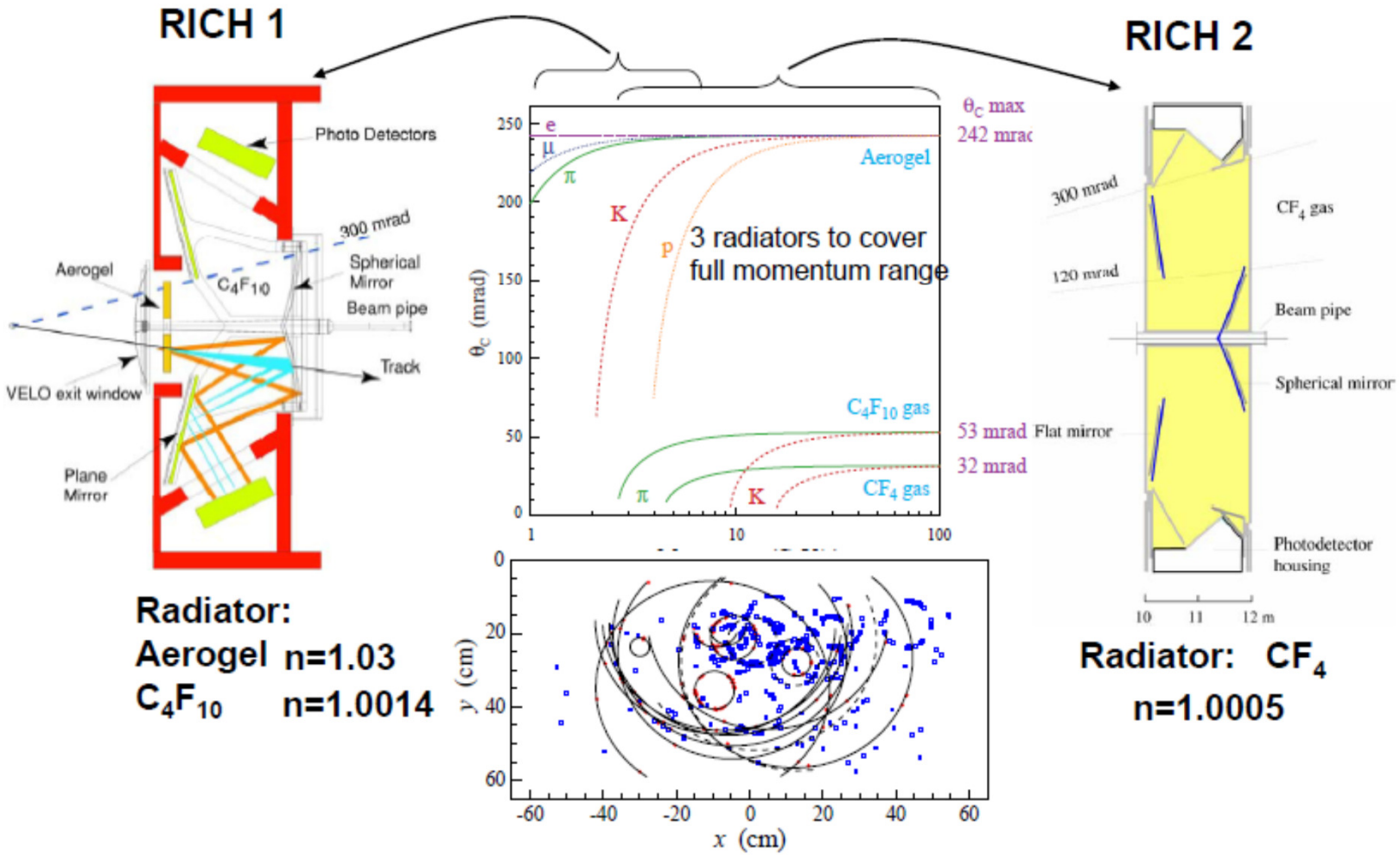


Ring radius $\rightarrow \theta_c \rightarrow \beta$

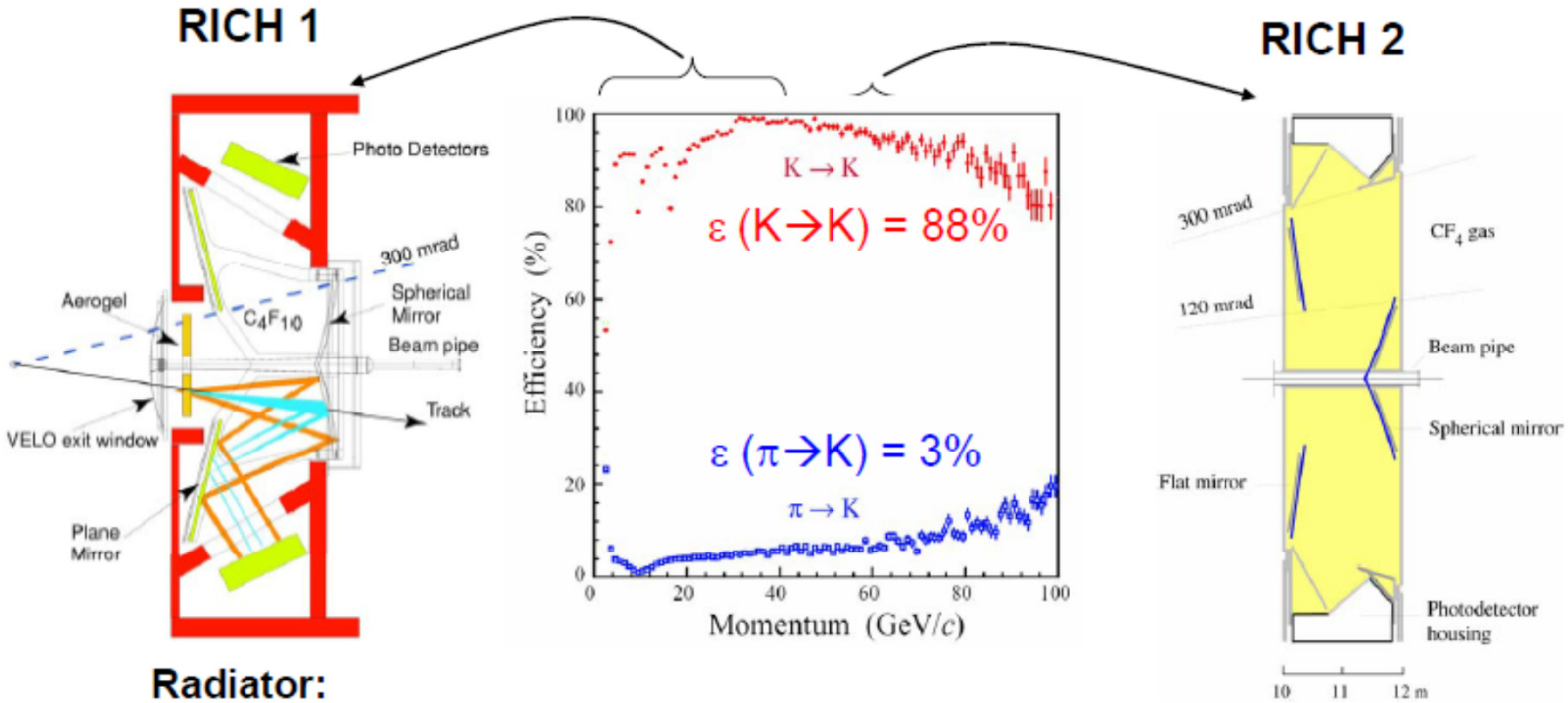
RICH



RICH


RICH 1
Photo Detectors
300 mrad
Aerogel
C_4F_{10}
Spherical Mirror
Beam pipe
Track
VELO exit window
Plane Mirror
Radiator:
Aerogel n=1.03
C_4F_{10} n=1.0014
e
μ
π
K
p
3 radiators to cover full momentum range
Aerogel
C_4F_{10} gas
CF_4 gas
θ_C (mrad)
θ_C max 242 mrad
53 mrad
32 mrad
Flat mirror
y (cm)
x (cm)
RICH 2
300 mrad
120 mrad
CF_4 gas
Beam pipe
Spherical mirror
Photodetector housing
10
11
12 m
Radiator: CF_4
n=1.0005

RICH



Radiator:
Aerogel n=1.03
C_4F_{10} n=1.0014

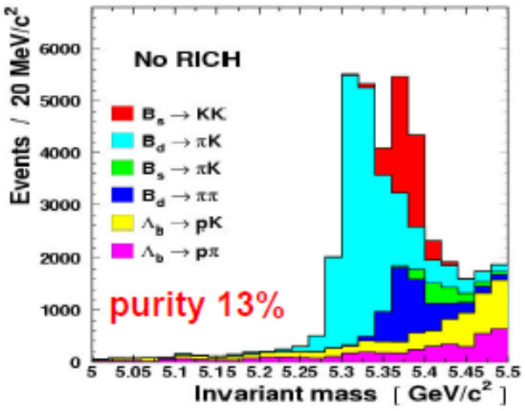
Radiator: CF_4
n=1.0005

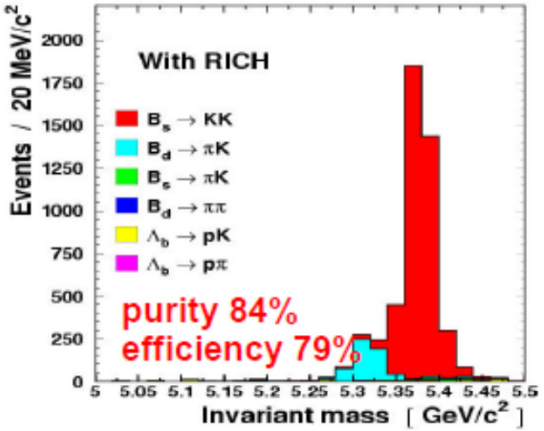
RICH

No RICH

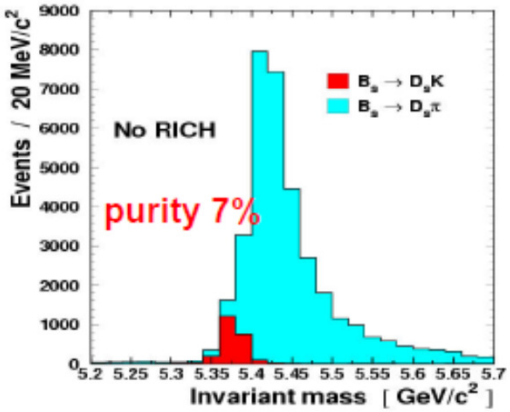
With RICH

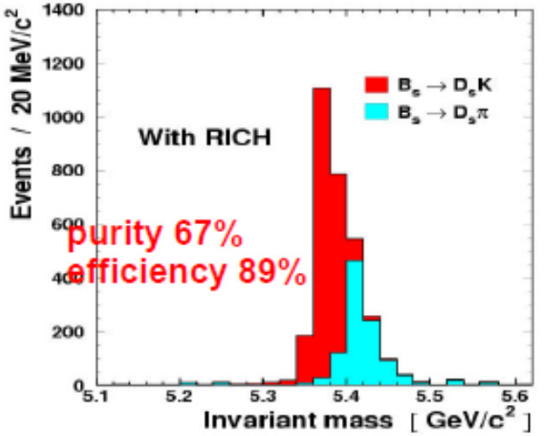
$B_s \rightarrow KK$



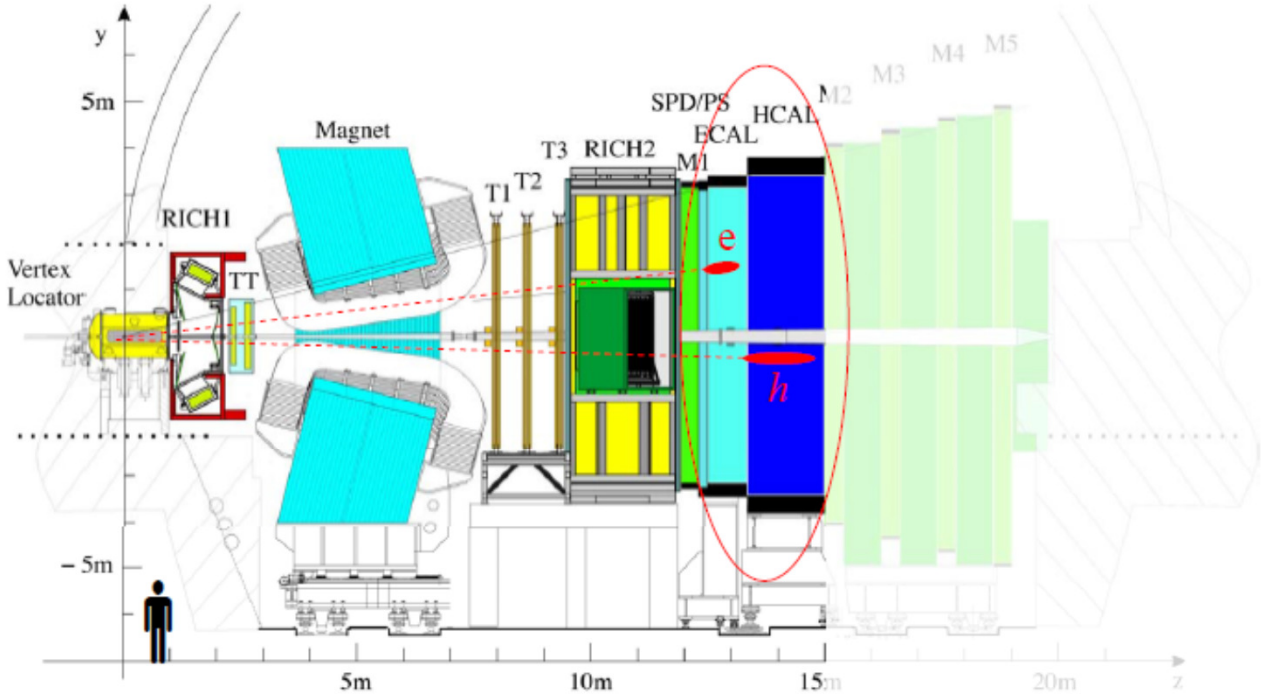


$B_s \rightarrow D_s K$



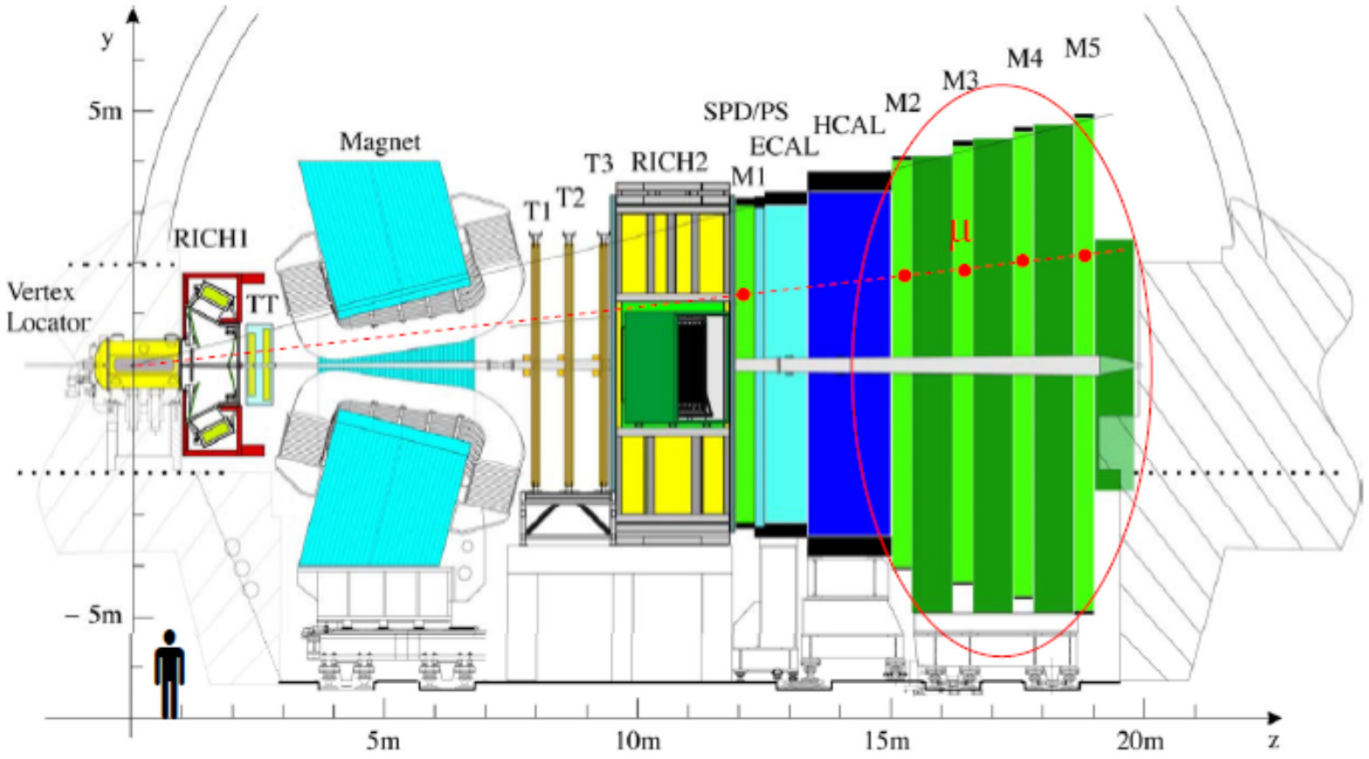


Calorimetry



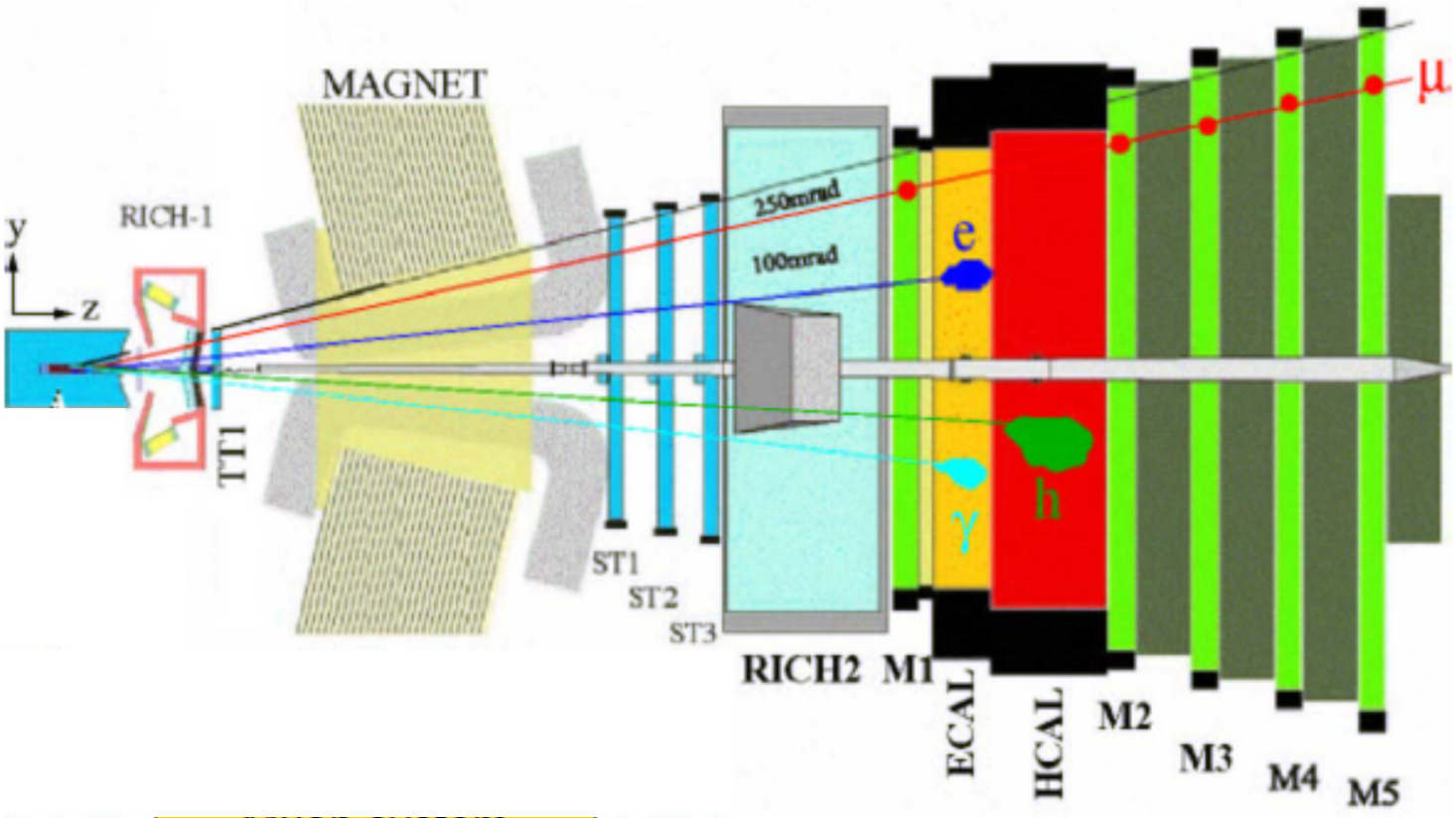
Calorimeter system to identify electrons, hadrons and neutrals
Important for the first level (Level 0) of the trigger.

Muon Detector

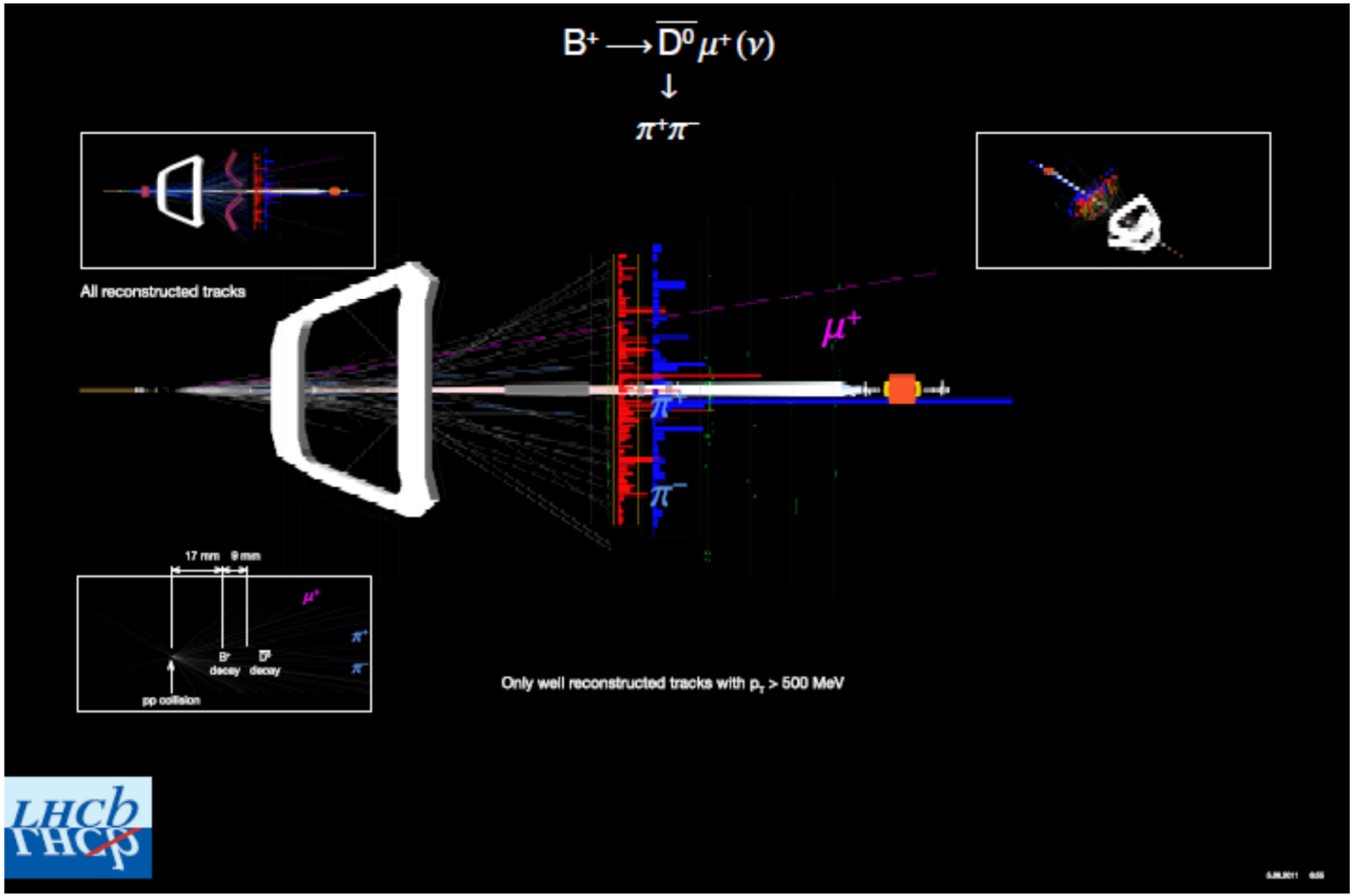


Muon system to identify muons, also used in first level (L0) of the trigger

Layout


MAGNET
RICH-1
y
z
TT
250mrad
100mrad
e
γ
h
μ
ST1
ST2
ST3
RICH2
M1
ECAL
HCAL
M2
M3
M4
M5

Charged B Decay



B_s Decay and Oscillations