LHCb STATUS AND PHYSICS PROSPECTS

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Outline

- Introduction to the LHCb Experiment
- Detector Overview and Performance
- Detector commissioning and readiness
- Physics prospects
- Conclusions

Many thanks to V.Gibson, A.Schopper, M.Merk, M-H Schune, O.Leroy,and many others for (un)knowingly helping me!

The LHCb Experiment

- **LHCb**: dedicated b-physics experiment at LHC that will search for NP beyond the SM through the study of very rare decays of b-flavoured (and c) hadrons and precision measurements of CP-violating observables

- Enormous progress in recent years from the B factories and Tevatron, far beyond expectations.

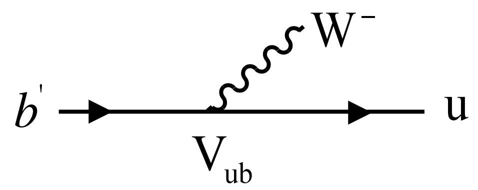
- Clear demonstration of the SM CKM mechanism as dominant source of CP violation.

CKM Matrix

- The Cabibbo-Kobayashi-Maskawa matrix $\mathbf{V_{CKM}}$ describes rotation between flavour (d',s',b') and mass (d,s,b) eigenstates

Flavour eigenstates — Mass eigenstates

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

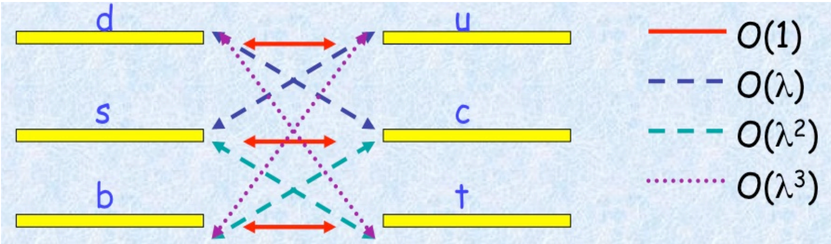


V_{ij} proportional to transition amplitude from quark i to quark j
→V_{CKM} quark mixing matrix

- V_{CKM} depends on 3 mixing angles and 1 phase, which is the only source of CP violation in SM
- Phase only present with N ≥ 3 generations (Nobel prize 2008)
  - With N=2, all phases can be removed → matrix real → no CPV
- These 4 parameters (3 angles and 1 phase) must be determined experimentally

Wolfenstein parametrization

Reflects hierarchy of strengths of quark transitions



$$V_{CKM} \approx \begin{pmatrix} 1 & \lambda & \lambda^3 \\ \lambda & 1 & \lambda^2 \\ \lambda^3 & \lambda^2 & 1 \end{pmatrix}$$

$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + O(\lambda^4)$$

- $\lambda = \sin\theta_c$
- η induces CP Violation
- $O(\lambda^4) \to (\bar{\rho},\bar{\eta}) \equiv (1-\lambda^2/2)\,(\rho,\eta)$

$A = 0.8116^{+0.0097}_{-0.0241}$

$\lambda = 0.22521 \pm 0.00082$

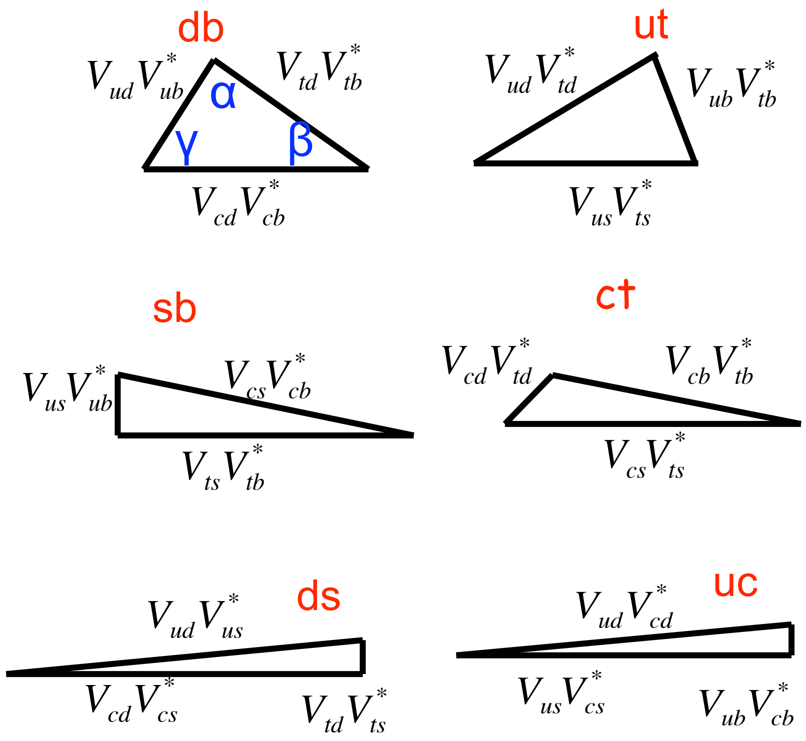
$\bar{\rho} = 0.139^{+0.025}_{-0.027}$

$\bar{\eta} = 0.341^{+0.016}_{-0.015}$

CKM fitter: Moriond 2009 (see also UTfit)

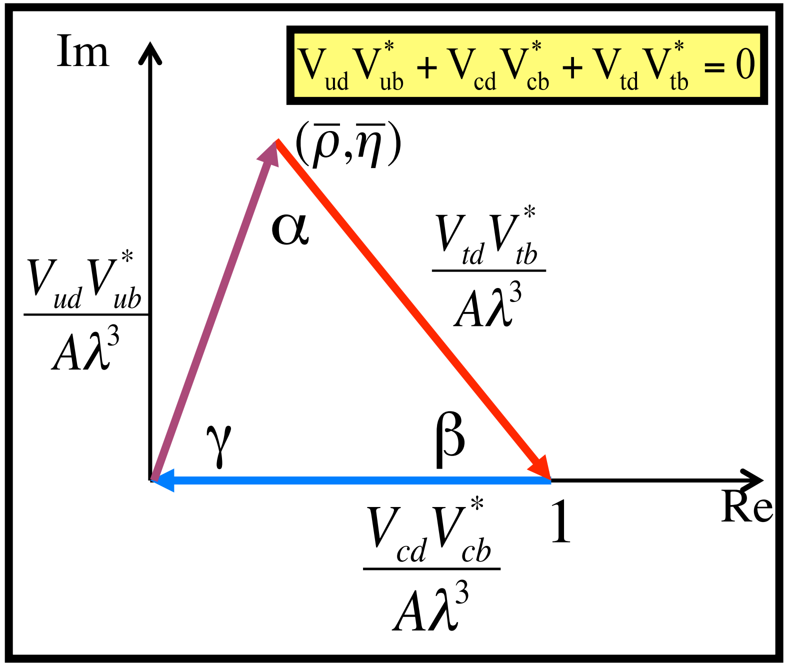
CKM Matrix

- Unitarity of CKM matrix implies $\Sigma\, V_{ij}\, V_{ik}^{*} = 0$ $(j \neq k)$
- Each of these 6 unitarity constraints can be seen as sum of 3 complex numbers closing a triangle in complex plane
- All triangles have same area a→ measure of CPV in SM $J_{CP} = 2a = \lambda^6 A^2 \eta \approx 10^{-5}$
- Only db and ut triangles have sides of same order (λ^3)
- db triangle → used to define angles α, β, γ
- ut triangle of special relevance for physics of B_s mesons

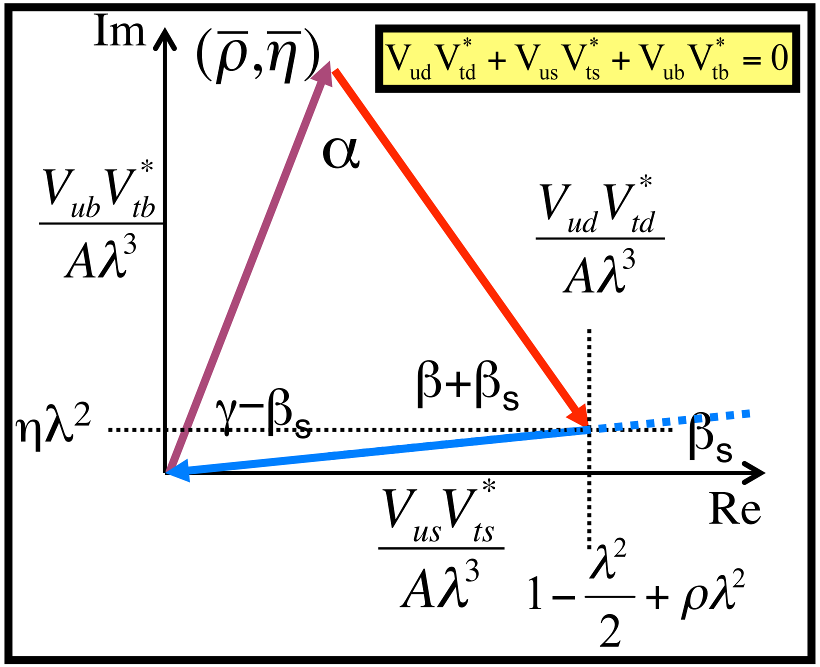


Unitarity triangles

db triangle



ut triangle



$$\gamma \equiv \arg\left[-\frac{V_{ub}^*V_{ud}}{V_{cb}^*V_{cd}}\right] = \tan^{-1}\frac{\eta}{\rho} \sim 70^{\circ}$$

$$\beta \equiv \arg\left[-\frac{V_{cb}^*V_{cd}}{V_{tb}^*V_{td}}\right] = \tan^{-1}\frac{\bar{\eta}}{1-\bar{\rho}} \sim 21^{\circ}$$

$$\alpha \equiv \pi - \beta - \gamma \sim 89^{0}$$

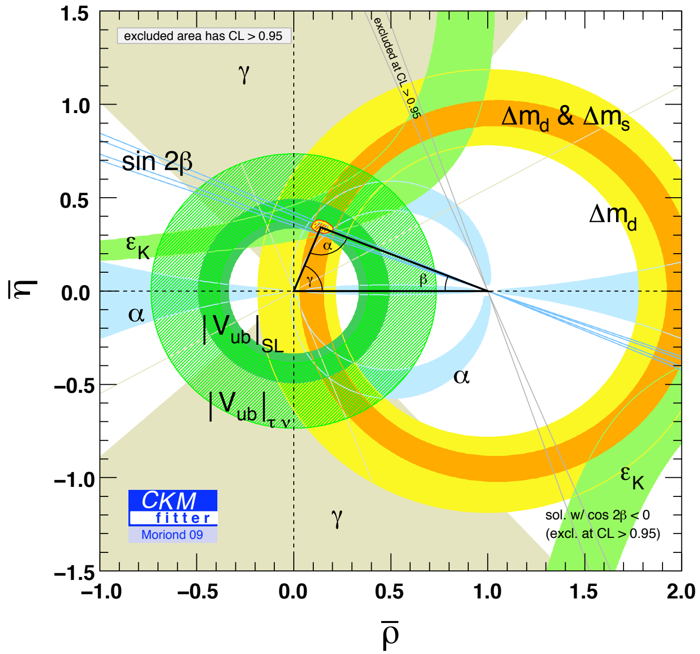
Higher λ-orders in CKM introduce small shift → $\gamma-\beta_s$ $\beta+\beta_s$

$$\beta_s \equiv \arg\left[-\frac{V_{cb}V_{cs}^*}{V_{tb}V_{ts}^*}\right] \sim \eta\lambda^2 \sim 1^{\circ}$$

Status of CKM parameters

- Measurements of many processes are consistent with the SM and fix a rather restricted domain for the CKM parameters

- Coordinates of apex of triangle:
  - $\overline{\eta} = 0$ → CP conservation
  - imaginary part $\overline{\eta}$ measured at ~5% (measurements of $\varepsilon_{K,}$ sin(2β), V_{ub} ,..)
  - real part $\overline{\rho}$ measured at ~20% (Δm_d , Δm_s, α, V_{ub}….)

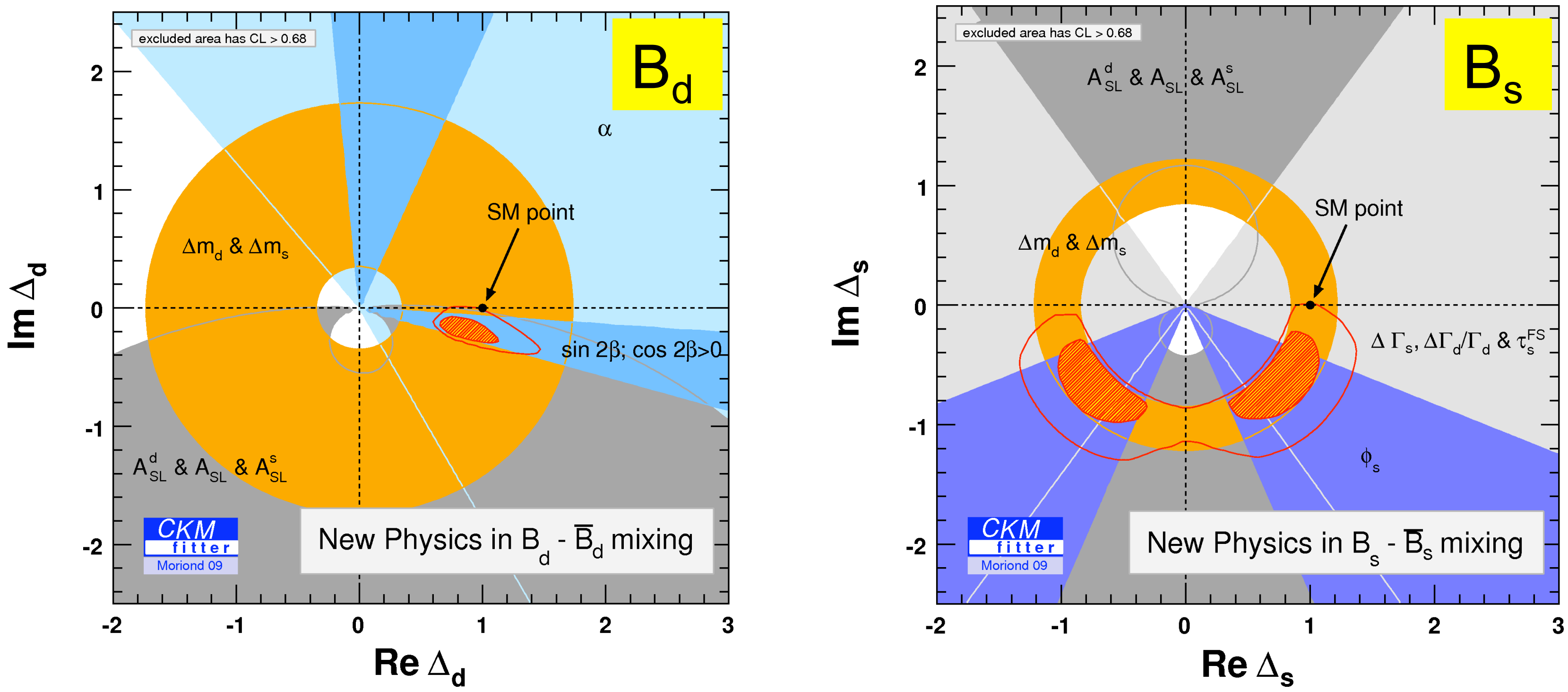


Is there still room for NP?

e.g., allowing for New Physics in B mixing in a model independent way

$$\langle B_q | H^{SM+NP}_{\Delta B=2} | \overline{B_q} \rangle \equiv \langle B_q | H^{SM}_{\Delta B=2} | \overline{B_q} \rangle \times \left[\mathrm{Re}\,\Delta_q + i\,\mathrm{Im}\,\Delta_q \right] \qquad \Delta_q = |\Delta_q| e^{2i\phi_q^{NP}}$$

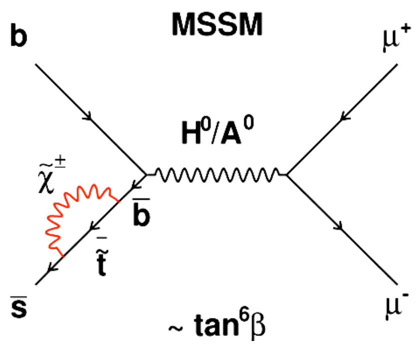
$$\text{In SM}: \mathrm{Re}\,\Delta_q = 1,\ \mathrm{Im}\,\Delta_q = 0$$

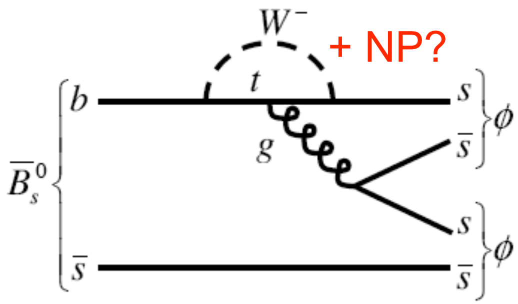


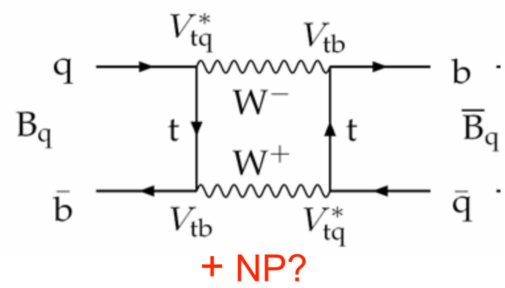
There are effects which need investigating!

The LHCb roadmap

- Focus has shifted: from seeking to verify the CKM picture to searching for signs of New Physics beyond the Standard Model in the flavour sector
- Measure processes that are strongly suppressed in the SM and poorly constrained by existing data, but that have sensitivity to new particles at high mass scales via their virtual effects in loop diagrams (complementary approach to direct searches):



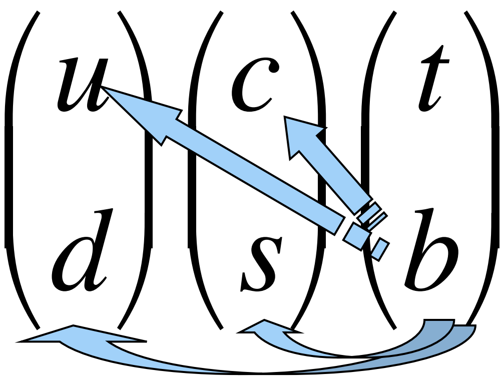




- Search for possible inconsistencies in measurements of angles and sides of the unitarity triangles: compare results from decays dominated by tree-level diagrams with those that start at loop level to probe validity of SM

Why the b quark?

- Heaviest quark that forms hadronic bound states
- All decays are CKM suppressed
  - Long lifetime (~1.6 ps)
  - Favourable experimental conditions
- High mass: many accessible final states with different expected rates
  - Dominant decay process: “tree” b→c transition
  - Very suppressed “tree” b→u transition
  - FCNC: “penguin” b→s,d transition
- CP violation – expect large CP asymmetries in some B decays
- Theoretical predictions can be precisely compared with experimental results

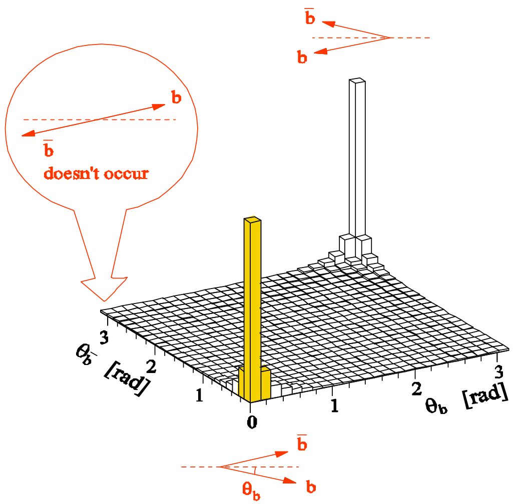


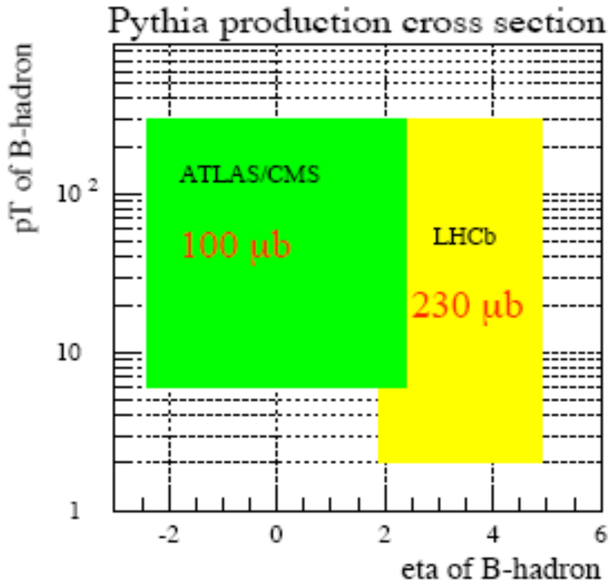
b production at LHC

- Advantages of beauty physics at hadron colliders:
  - High value of beauty cross section expected at 14 TeV:
    - σ_{bb} ~ 0.5 mb (e^+e^- cross section at Y(4s) is 1 nb)
    - σ_{cc} ~ 3.6 mb
  - Access to all b-hadrons: $B^\pm$, B^0, B_s, B_c, b-baryons
    - In particular can study the B_s (bs) system, not studied at the B factories, but measured by CDF/D0
- The challenges
  - Rate of background events: σ_{inel}~ 80 mb
    - → Trigger is essential!
  - Multiplicity of tracks (~30 tracks per rapidity unit)

LHCb Acceptance

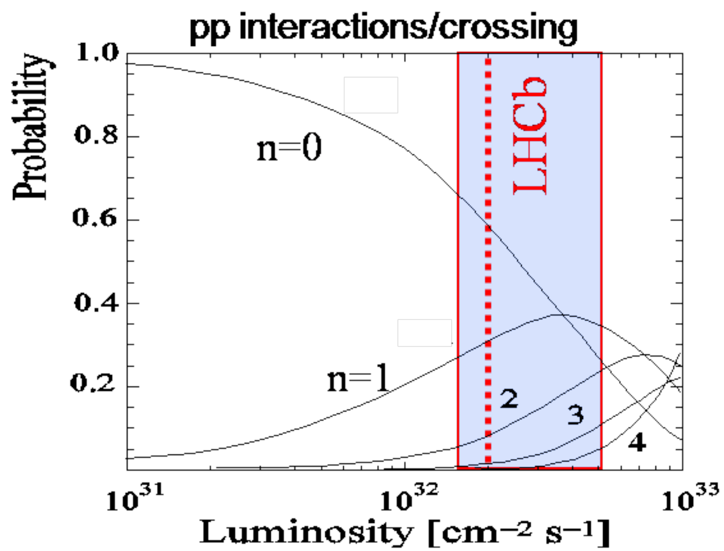
- Detector designed to maximize b acceptance (against cosθ)
- Forward spectrometer 1.9<η<4.9
  - b-hadrons produced at low angle
  - Single arm OK as b quarks are produced in same fwd or backward cone
- Rely on much softer, lower P_T triggers, efficient also for purely hadronic decays
- ATLAS/CMS: |η|<2.5
  - Will do B-physics using high P_T μ triggers, mostly with modes involving di-μ
  - Purely hadronic modes triggered by tagging μ.





LHCb running conditions

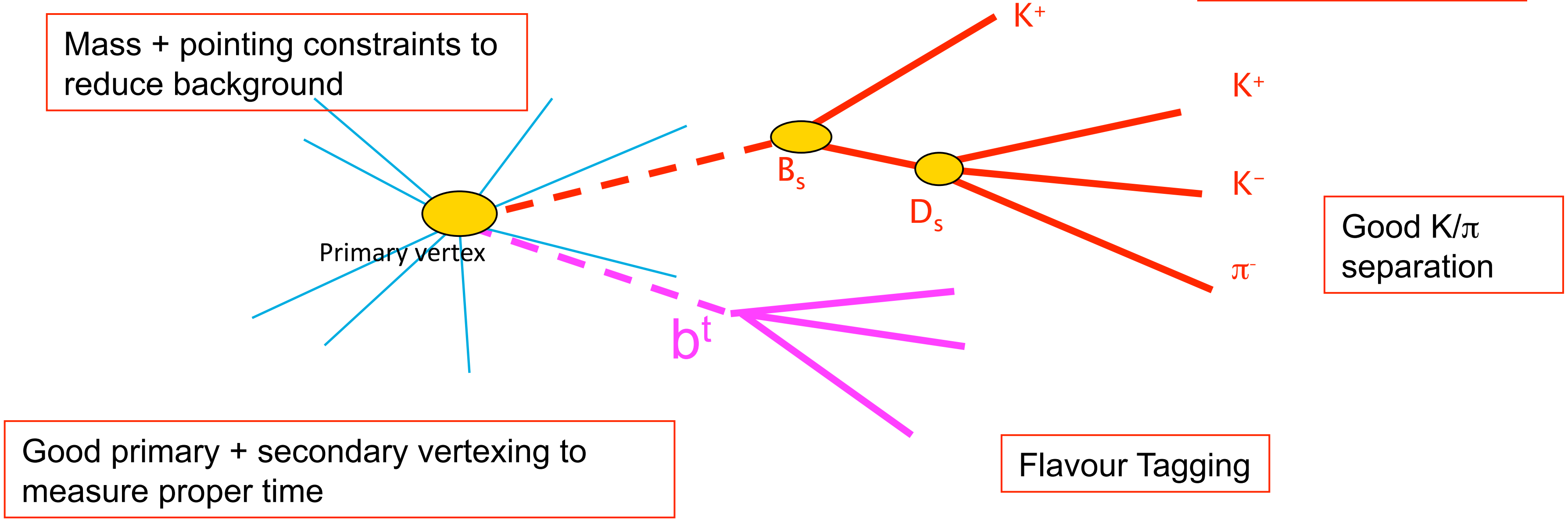
- L limited to ~2 10^{32} cm^{-2} s^{-1} by not focusing the beam as much as ATLAS and CMS (can maintain this luminosity even when ATLAS/CMS run at 10^{34} cm^{-2} s^{-1})
- Maximize the probability of single interaction per bunch crossing
  - At LHC design luminosity pile-up of >20 pp interactions/bunch crossing
  - Still 10^5 b-hadrons/sec
  - (and 7 10^5 c-hadrons/sec)
- Makes is simpler to identify B decays from their vertex structure
- Less radiation damage
- LHCb L reached soon after start-up
- 2fb^{-1} per nominal year (10^7s)
  - ~ 10^{12} bb pairs produced per year



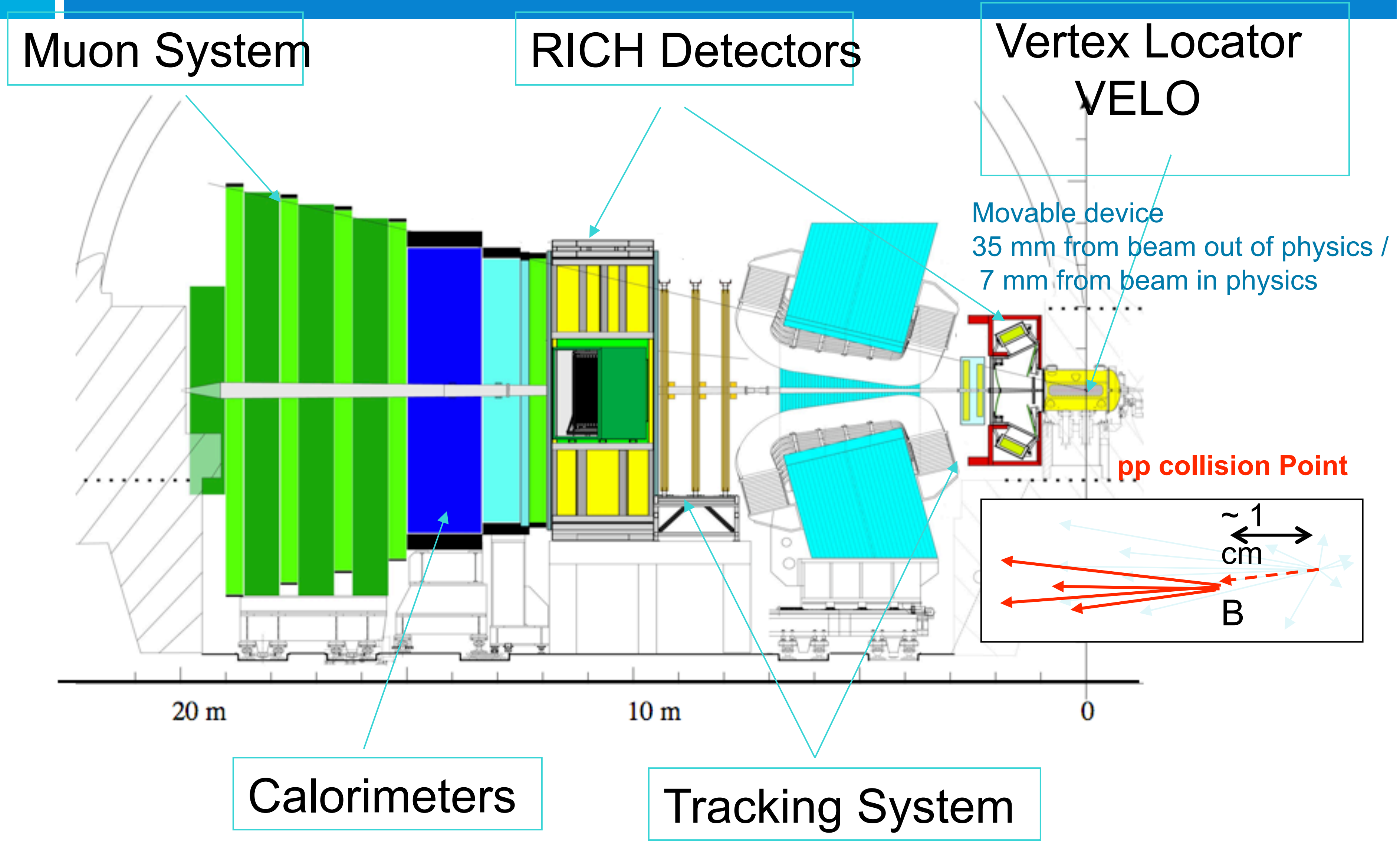
Detector Requirements

- Key features:
  - Highly efficient trigger for both hadronic and leptonic final states to enable high statistics data collection
  - Vertexing for secondary vertex identification
  - Mass resolution to reduce background
  - Particle identification

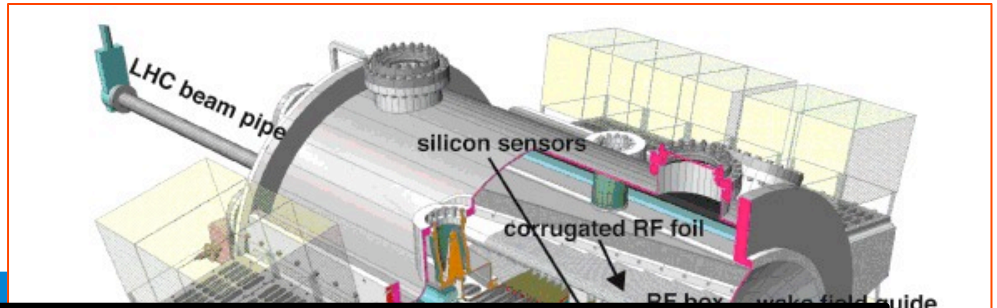
Example: $B_s \to D_s K$

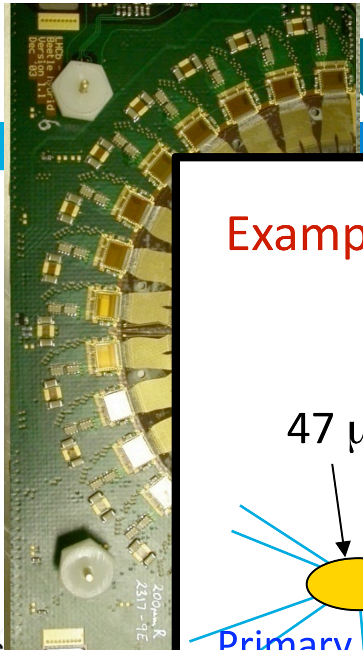


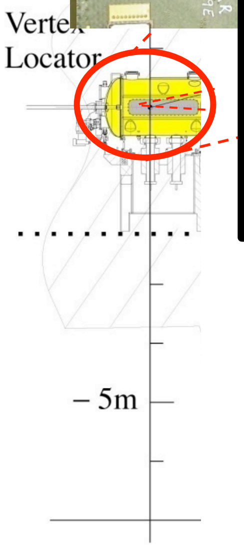
The LHCb Detector

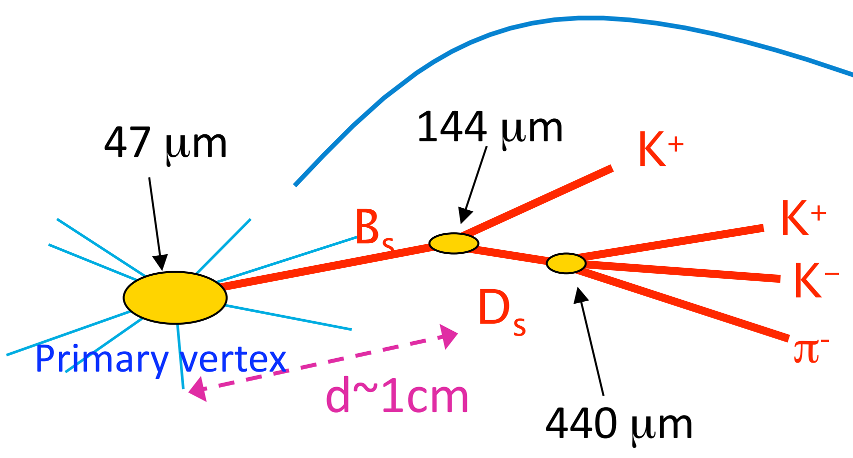


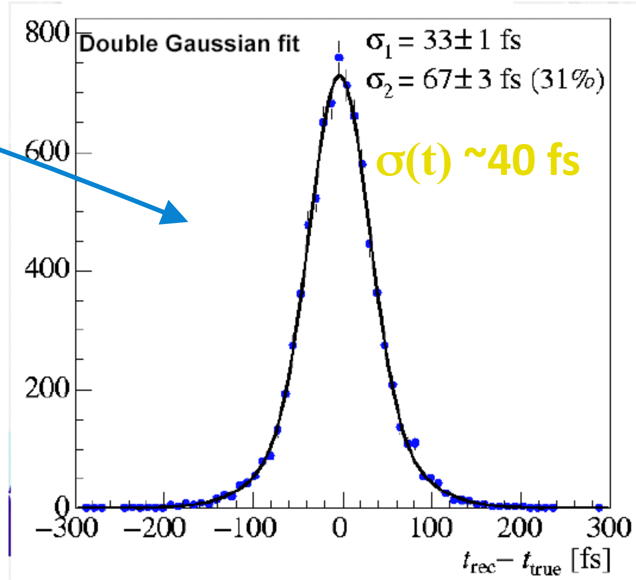
B-Vertex
urement

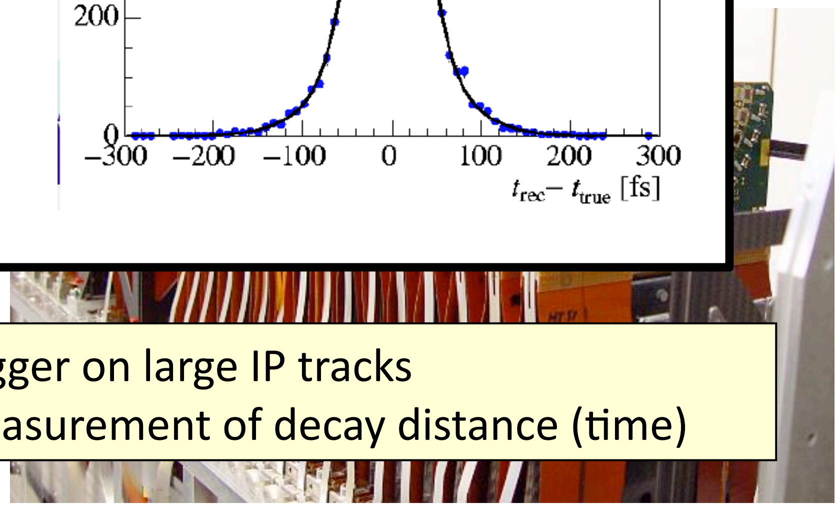












Vertex Locator (Velo)

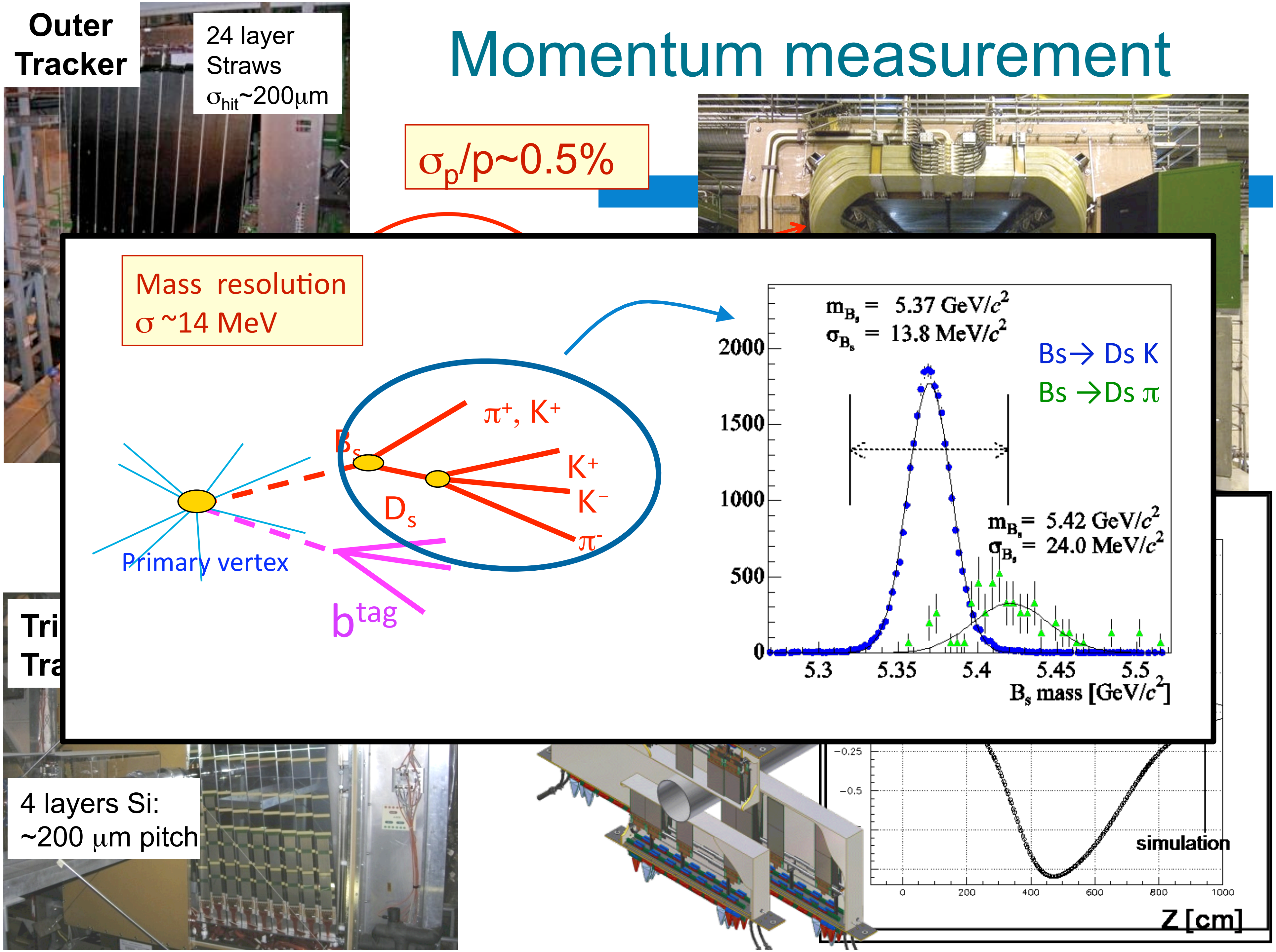
21 stations of silicon strip detectors (r-ϕ)

~ 8 μm hit resolution

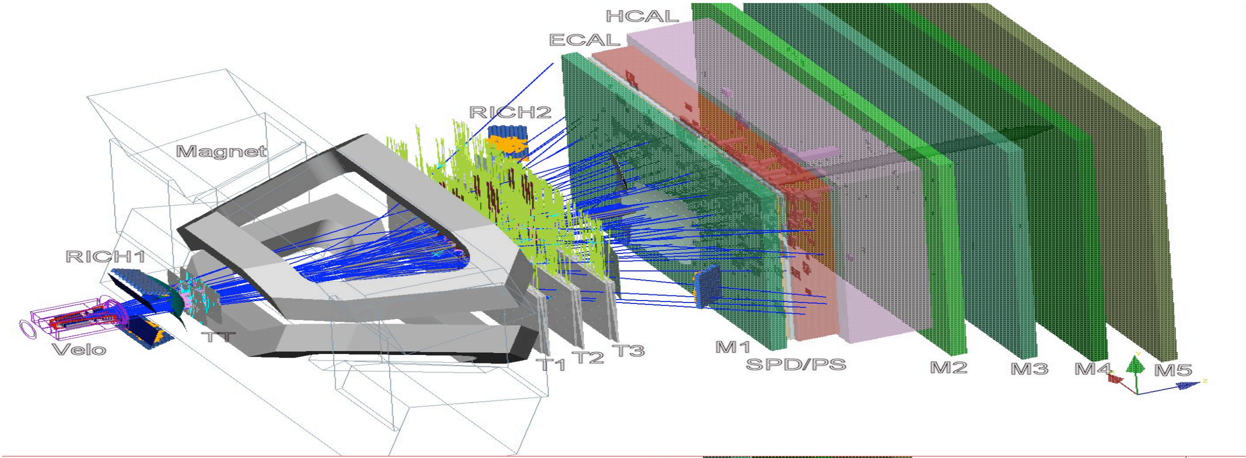
~25 μm IP resolution

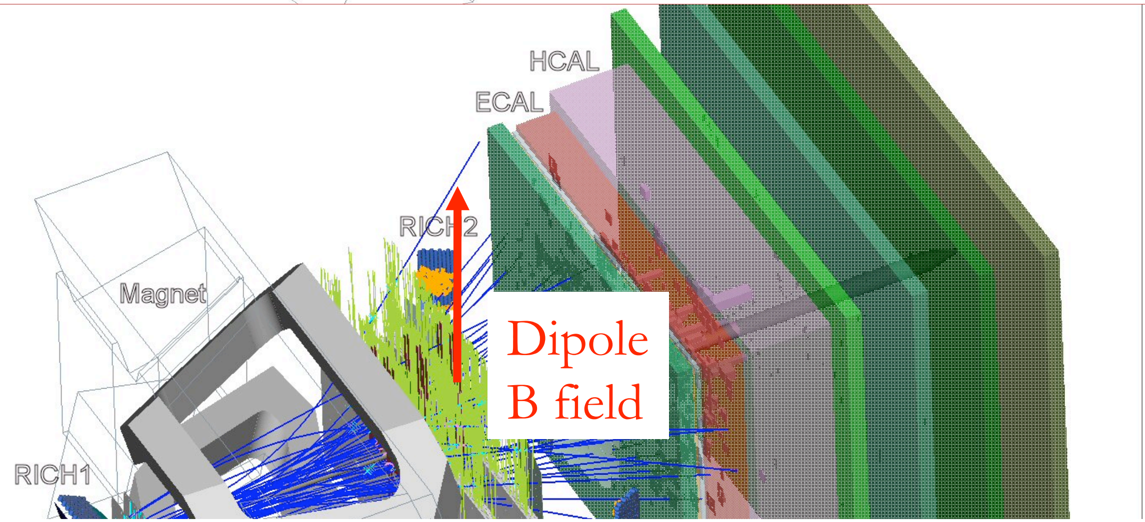
- Trigger on large IP tracks
- Measurement of decay distance (time)

Momentum measurement



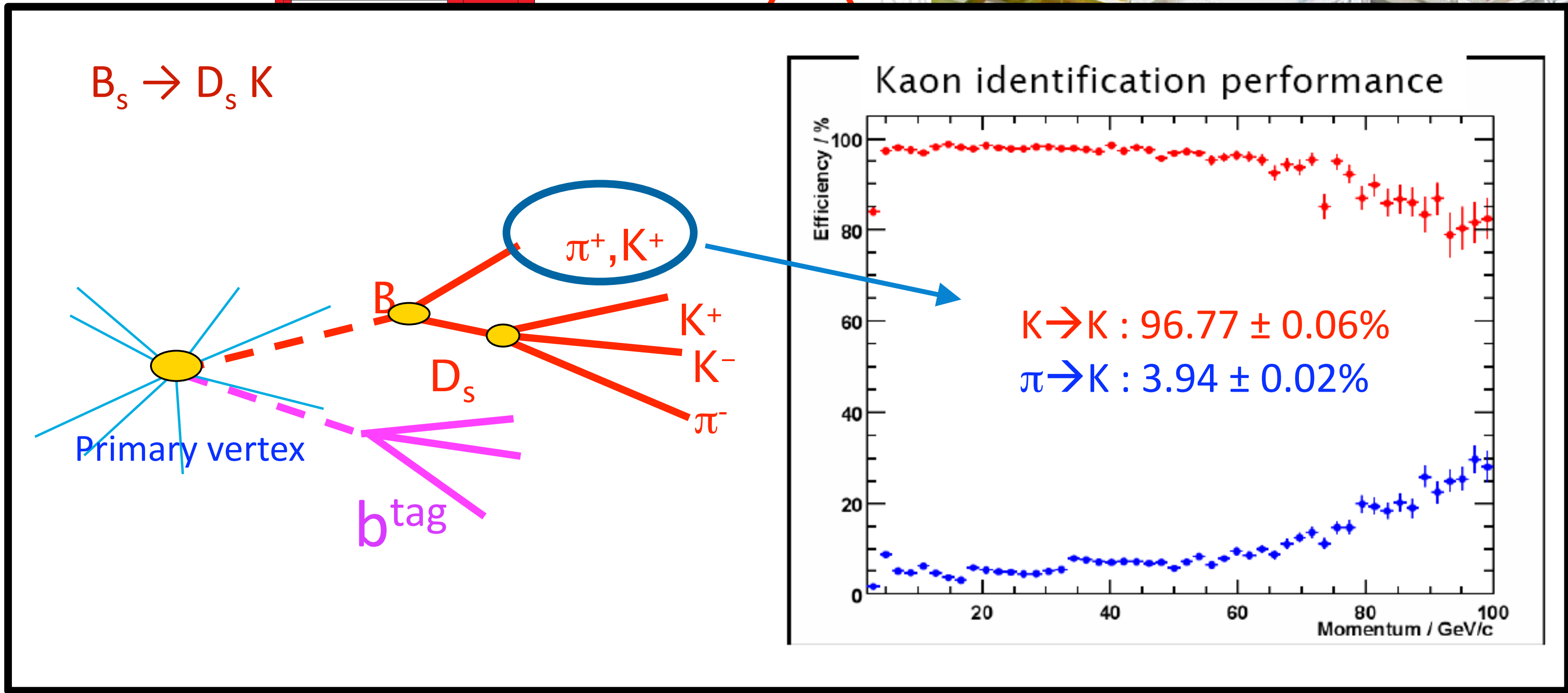
Momentum measurements





RICH Particle Identification

RICH: K/π identification using Cherenkov light emission angle

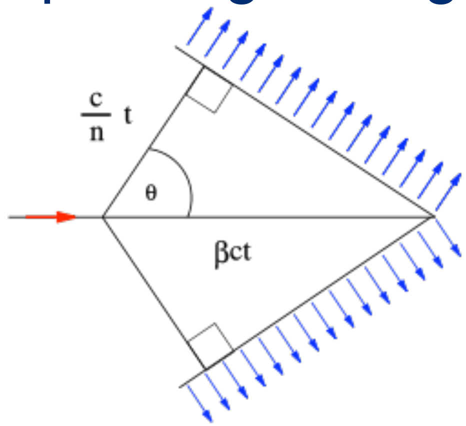


RICH1 Aerogel (2-10 GeV),
C_4F_{10} (10-60 GeV)

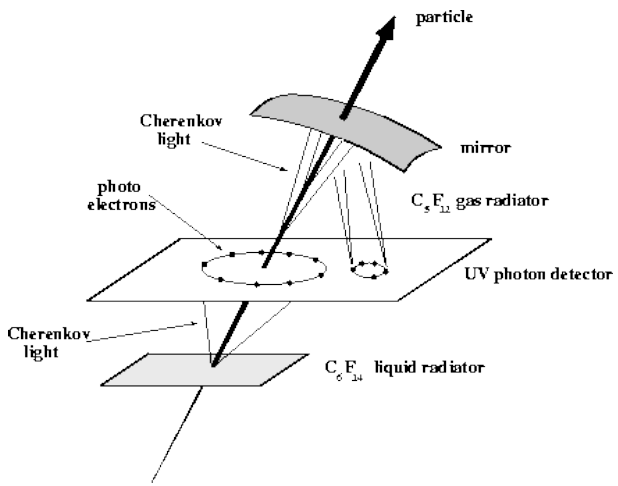
RICH2 CF_4 (16-100 GeV)

Cherenkov light

- Radiation produced when a charged particle travels faster than the speed of light in the medium it is passing through
  ($\beta c > c/n$, with n=refractive index)



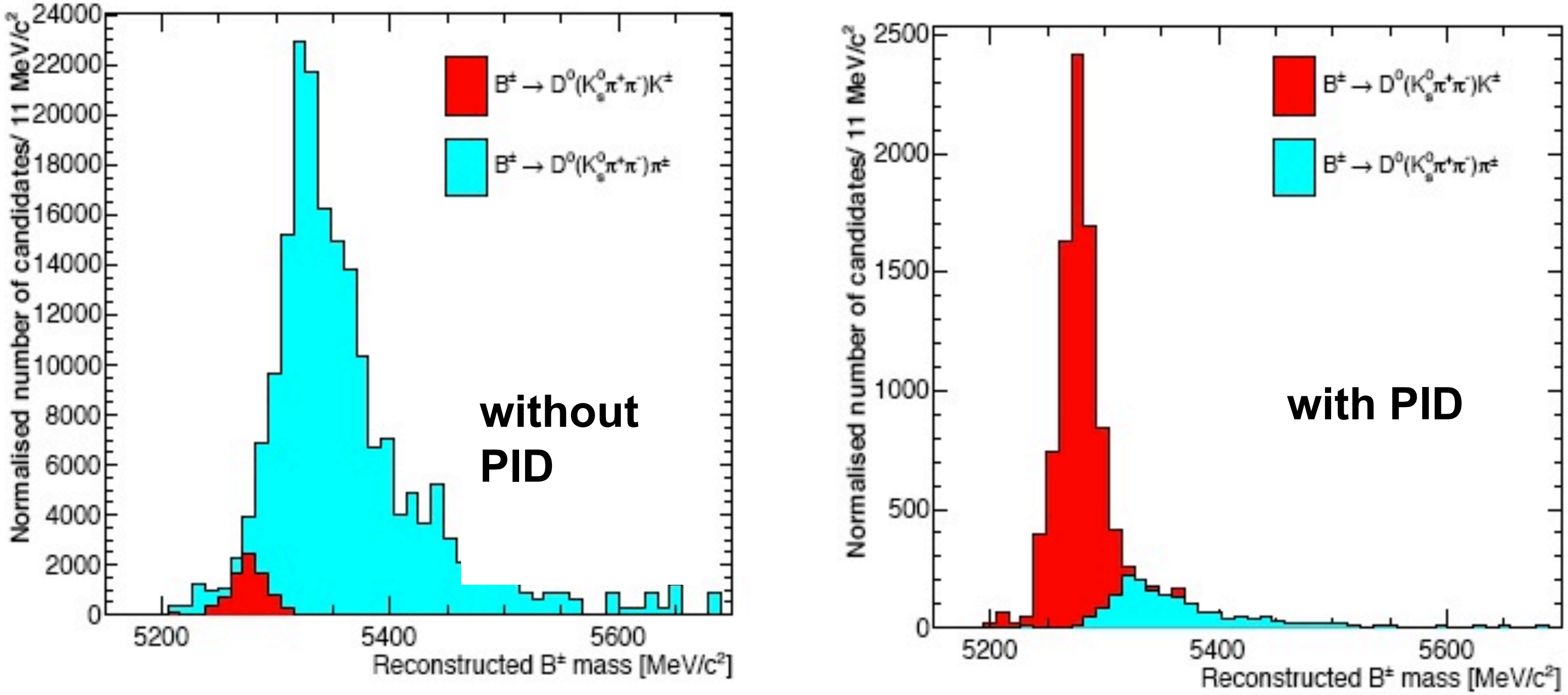
- Light produced in a cone with $\cos\theta_c = 1/\beta n$ can be detected as a ring image



- By measuring θ_c ($\propto$ radius of ring) the velocity β of the particle is found
  Then with knowledge of its momentum the mass of the particle can be found

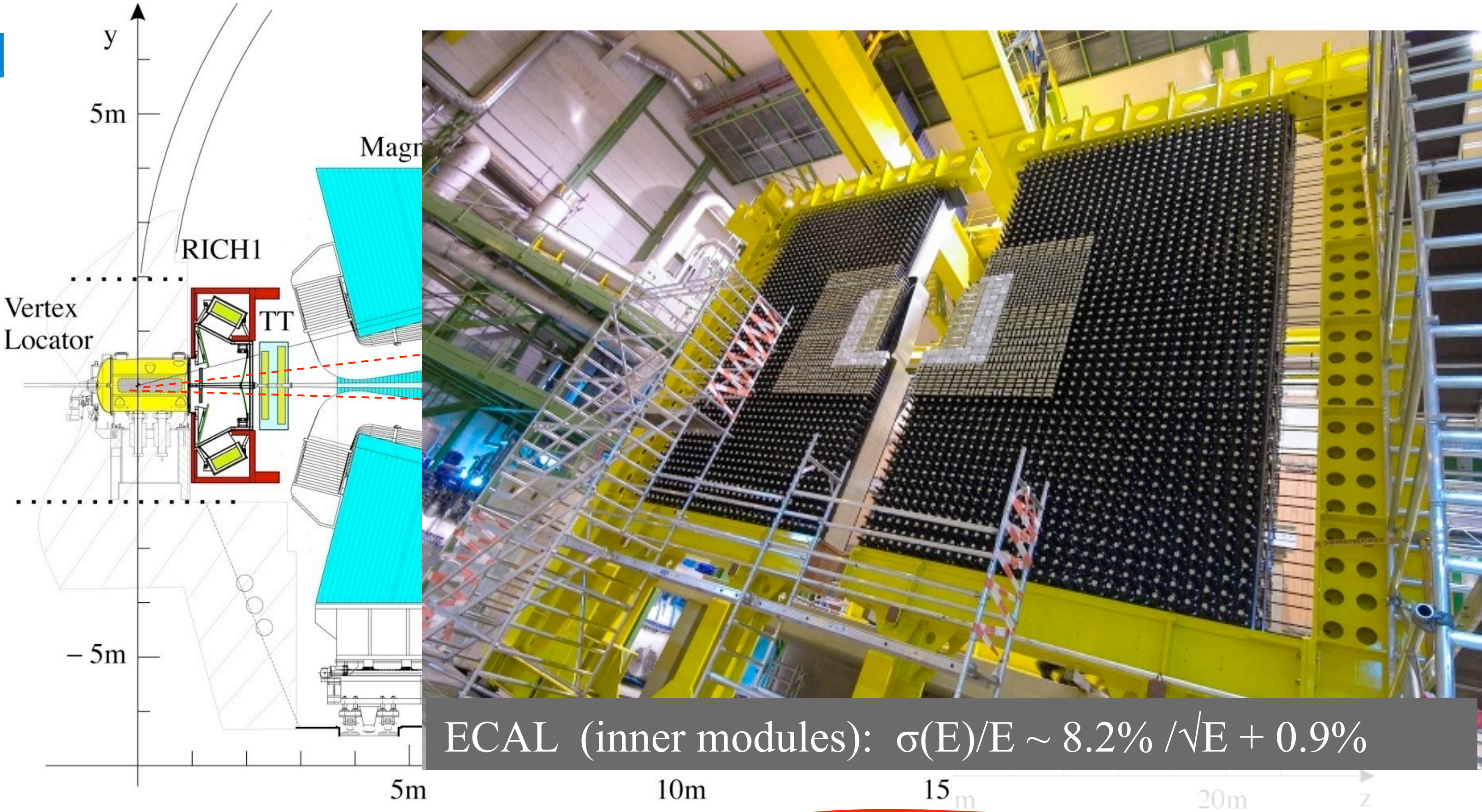
RICH PID performance

- Clean separation of $B_{d,s} \rightarrow hh$ modes



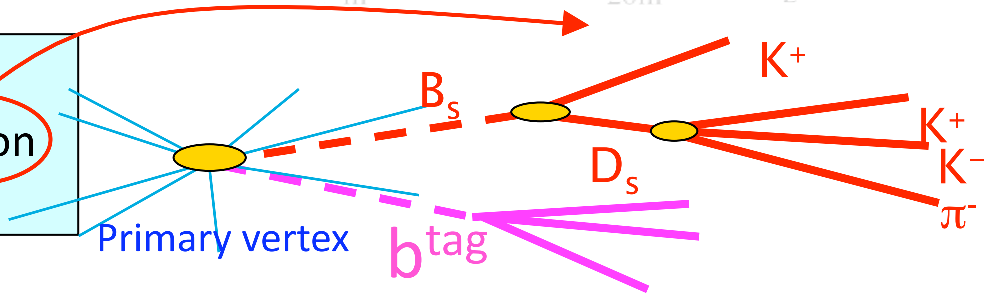
Example: reconstructed B mass for $B^+ \rightarrow D(K^0_S\pi^+\pi^-)K^+$ and $B^+ \rightarrow D(K^0_S\pi^+\pi^-)\,\pi^+$ without and with PID criteria applied to the bachelor $K^\pm$

Particle identification and L0 trigger

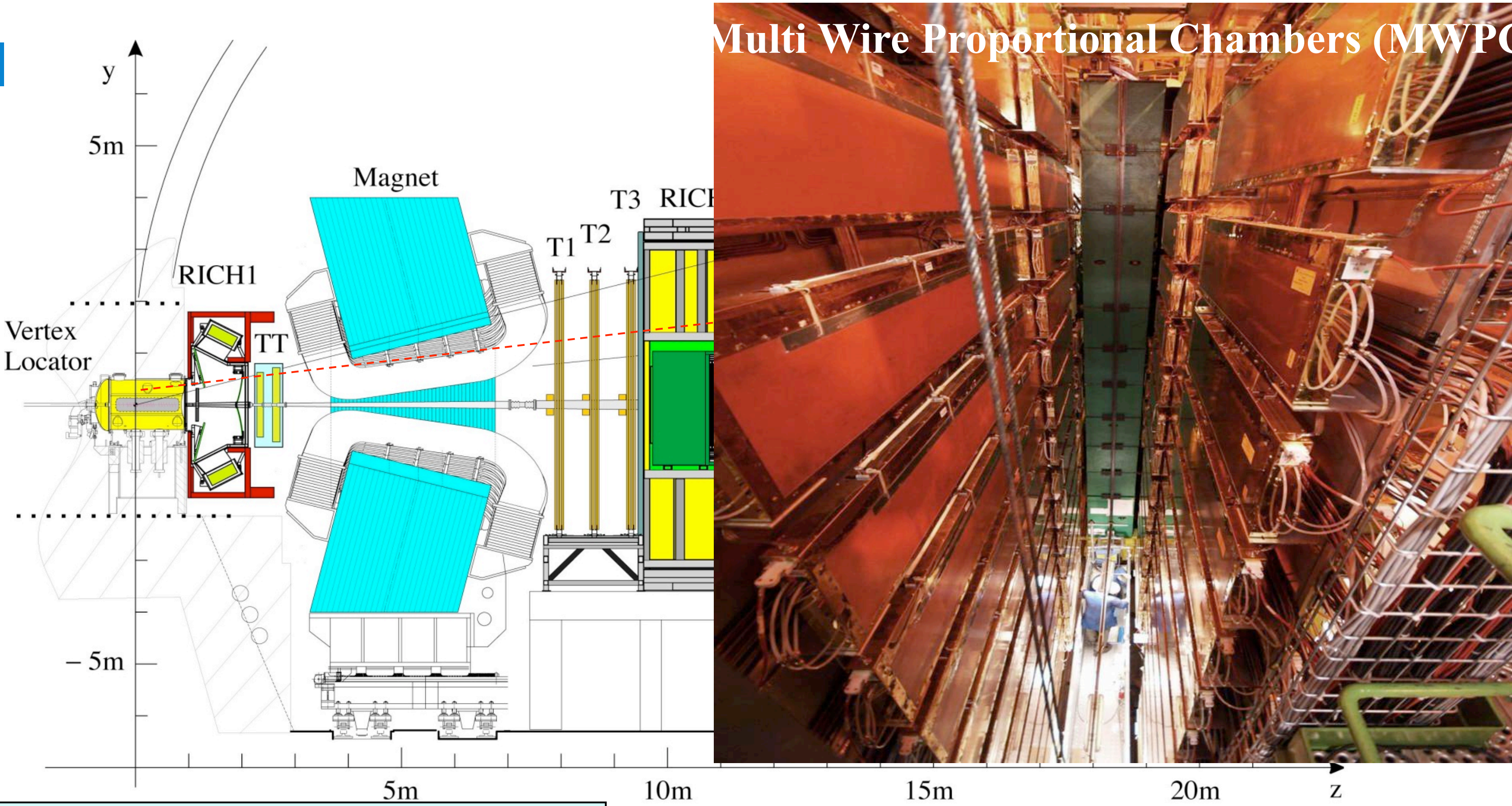


Calorimeter system :

- Level 0 trigger: high E_T electron and hadron
- Identify electrons, hadrons, π^0 ,γ

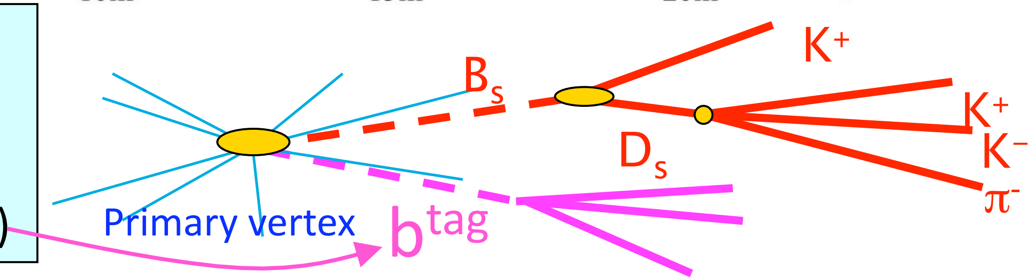


Particle identification and L0 trigger



Muon system:

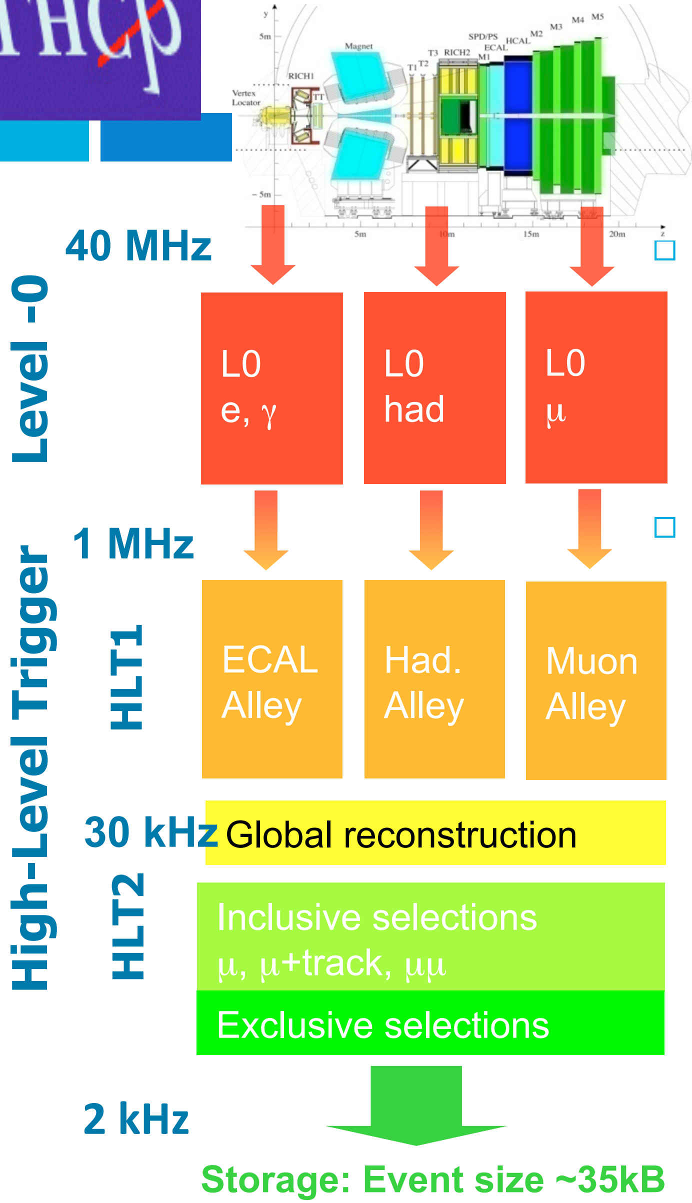
- Level 0 trigger: High P_t muons
- Identify muon
  (also important for flavour tagging)



LHCb Trigger

- **Trigger is crucial as σ_{bb} is less than 1% of total inelastic cross section and B decays of interest typically have BR < 10^{-5}**
- **b hadrons are long-lived →**
  - **well separated primary and secondary vertices**
- **have a ~large mass→**
  - **decay products with large p_T**

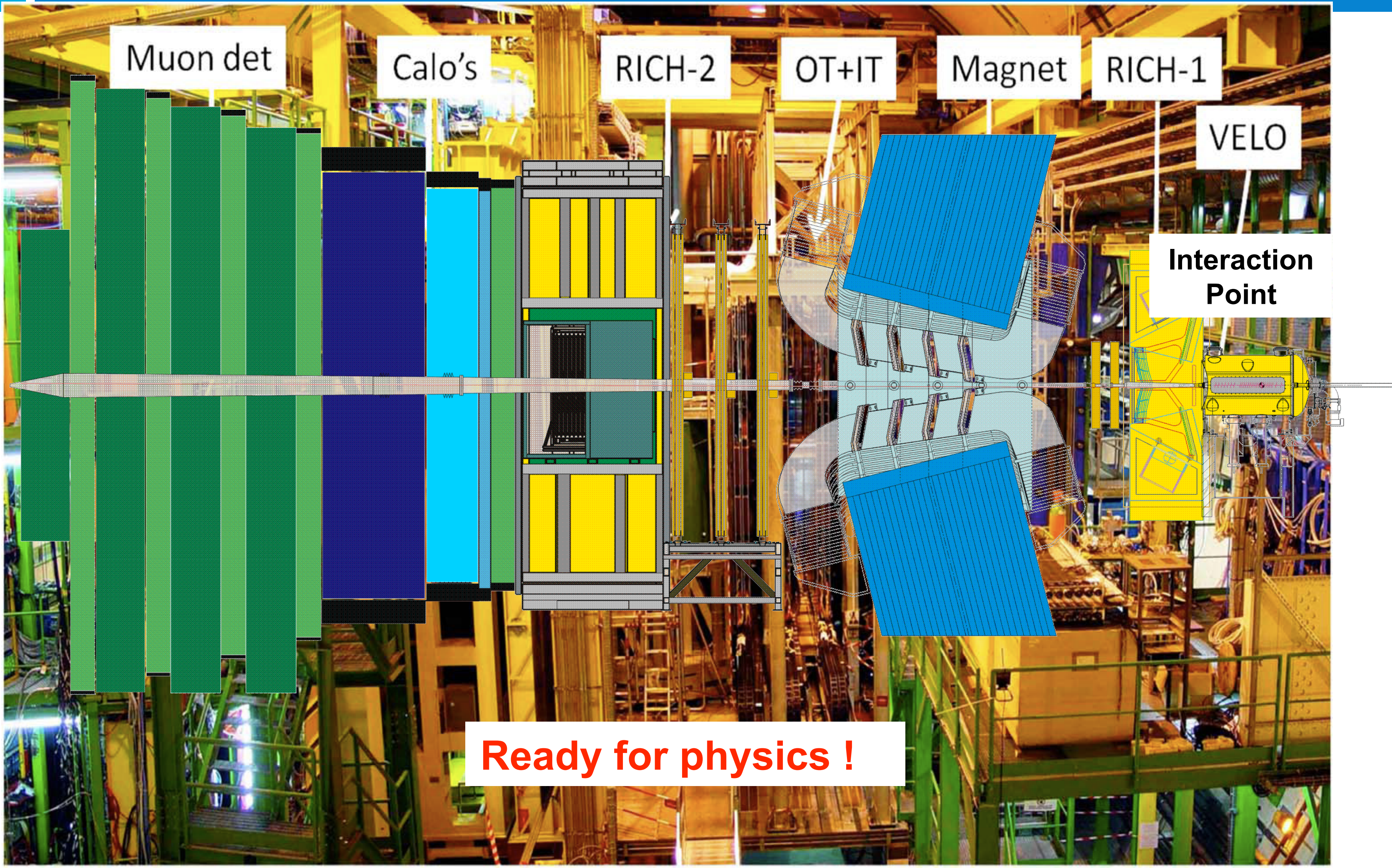
LHCb Trigger



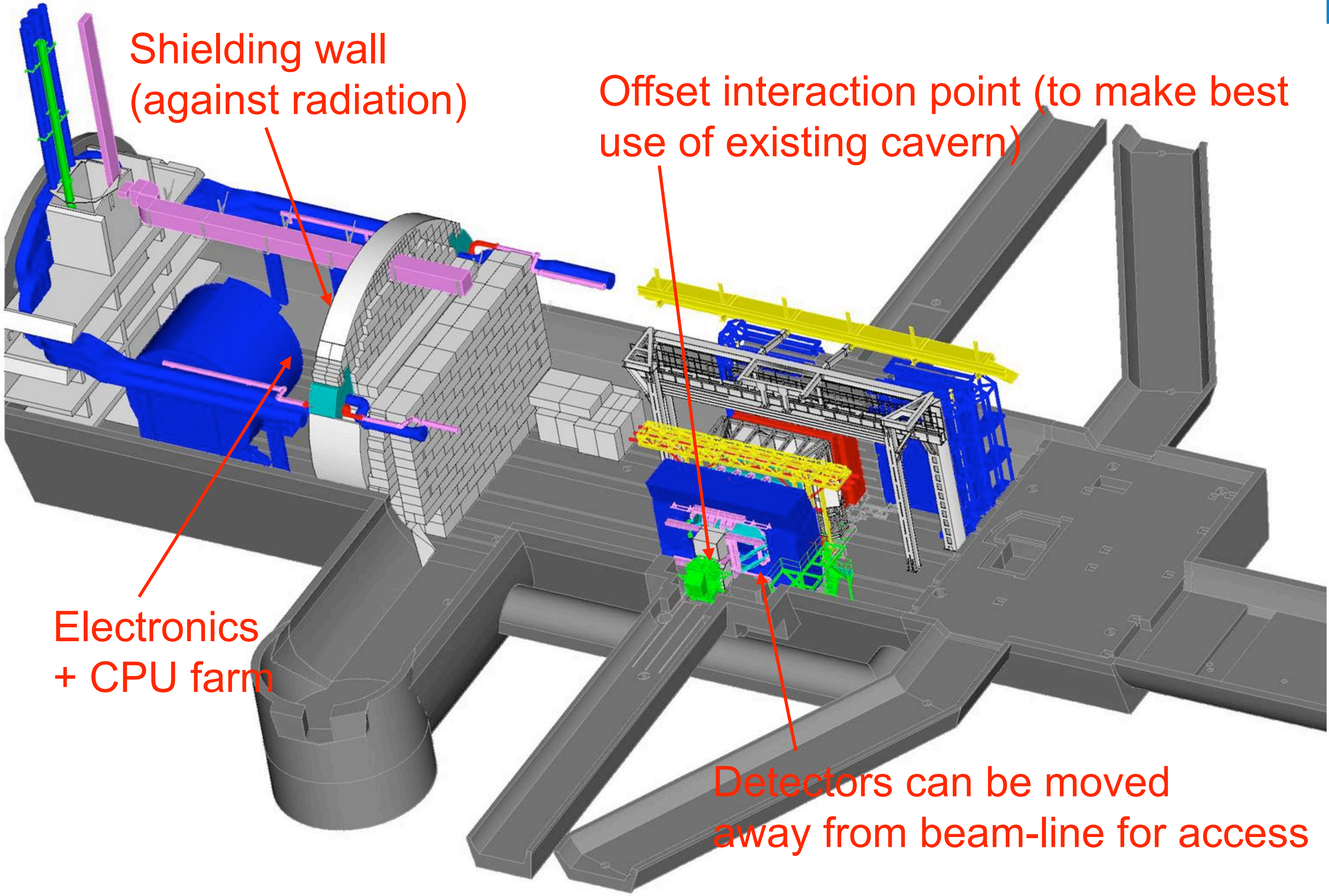
- Hardware level (L0)
  - Search for high-p_T μ, e, γ, hadron candidates (ECAL, HCAL, Muon)
  - L0 output is large!→ ~1 MHz
- Software level (**H**igh **L**evel **T**rigger, HLT)
  - Access all detector data
  - Flexible design to follow evolution of physics objectives
  - Farm with O(2000) multi-processor commodity boxes
  - HLT1: Confirm L0 candidate with more complete info, add impact parameter and lifetime cuts → ~30 kHz
  - HLT2: global event reconstruction + selections → ~2 kHz

	ε(L0)	ε(HLT1)	ε(HLT2)
Electromagnetic	70 %	> ~80 %	> ~90 %
Hadronic	50 %		
Muon	90 %		

The LHCb Detector



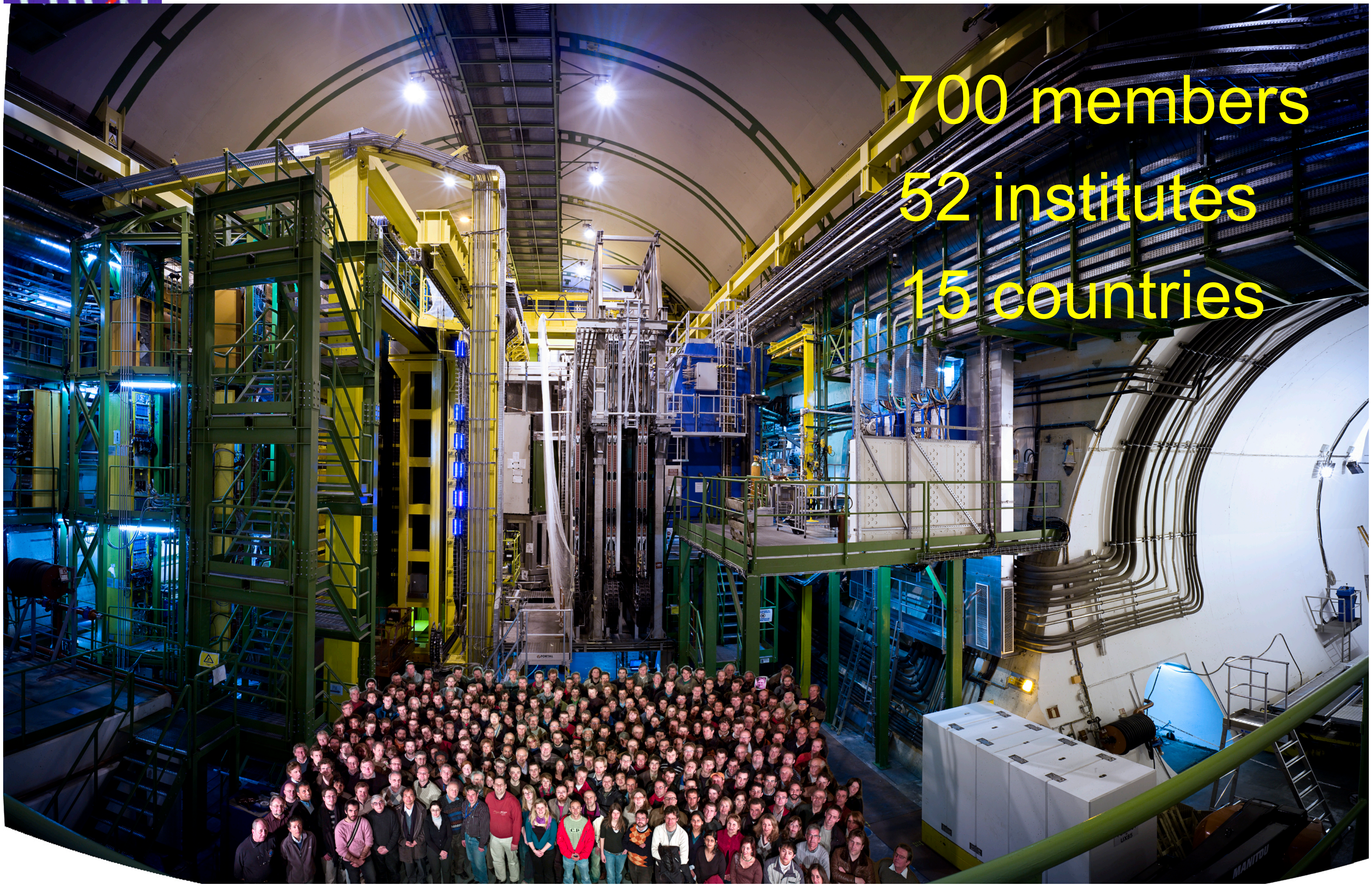
LHCb in its cavern (~100 m deep)



A lot of progress!

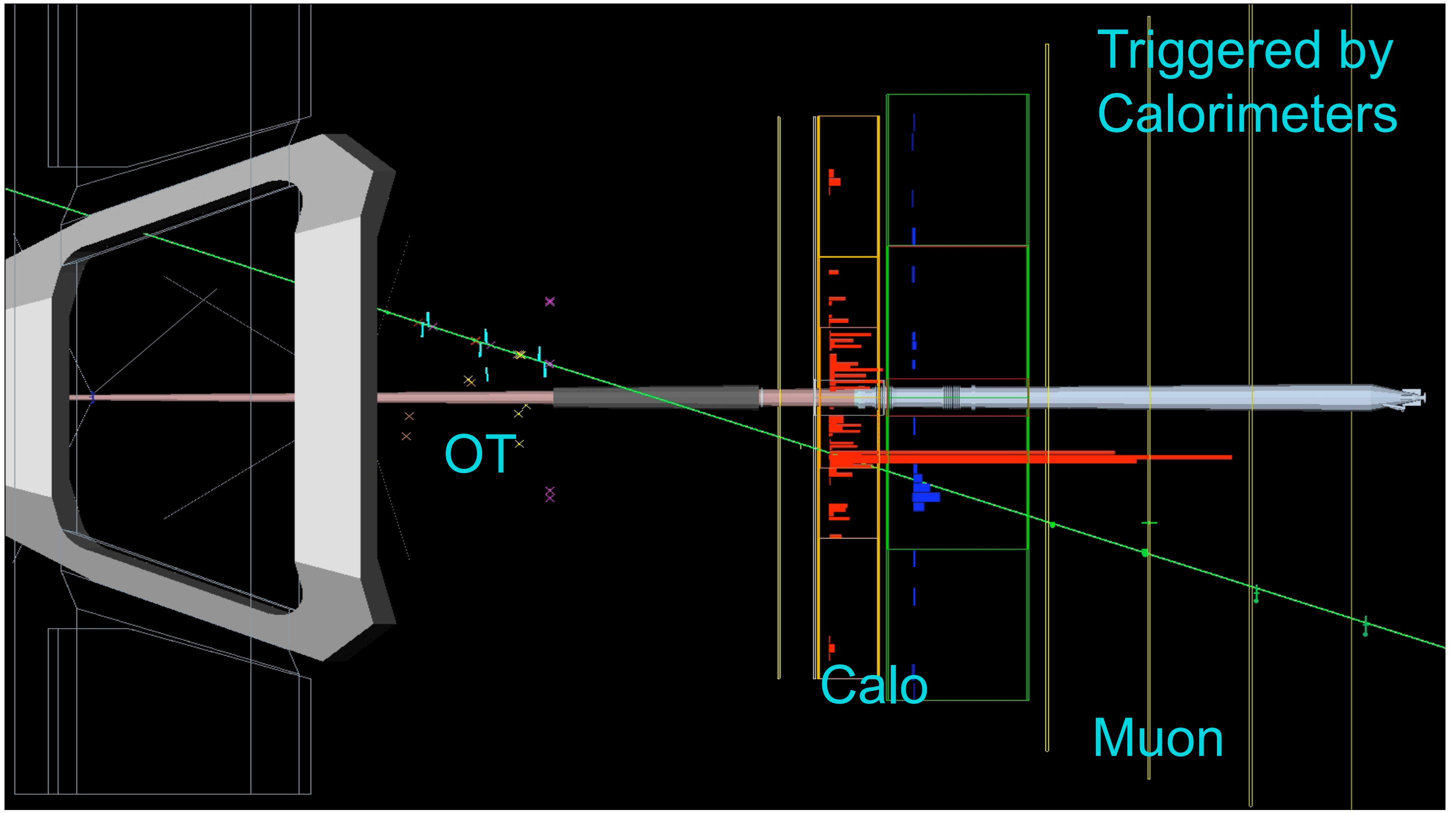
February 2002
Cavern ready for detector installation

LHCb

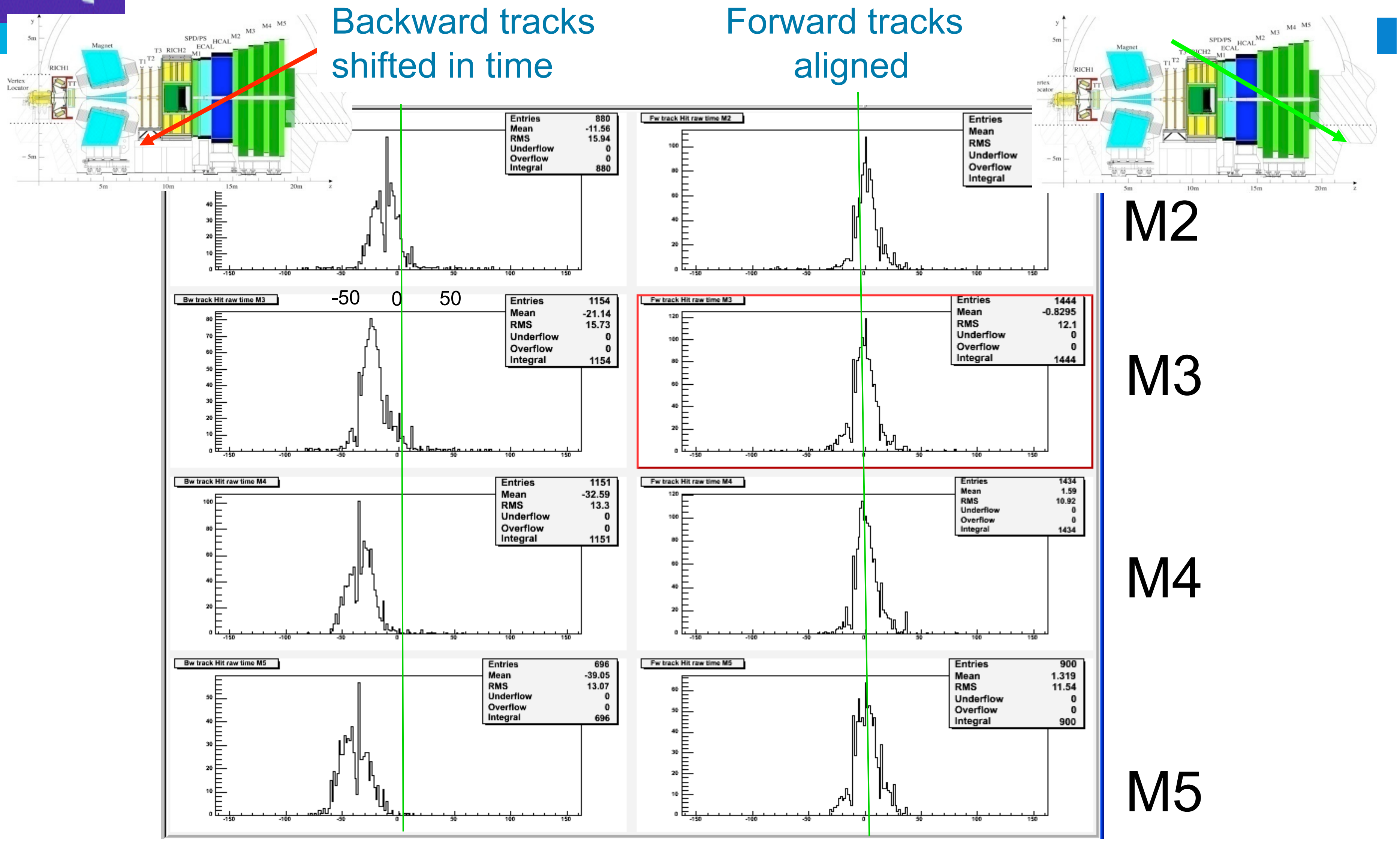


Commissioning: Cosmics

- LHCb geometry NOT well suited for cosmics… A challenge!
- Rate of ‘horizontal’ cosmics well below 1 Hz, still very useful
- Collected a total of ~ 2 Million triggers to perform initial synchronization (few nsec) and space alignment (~1 mm) of large area detectors



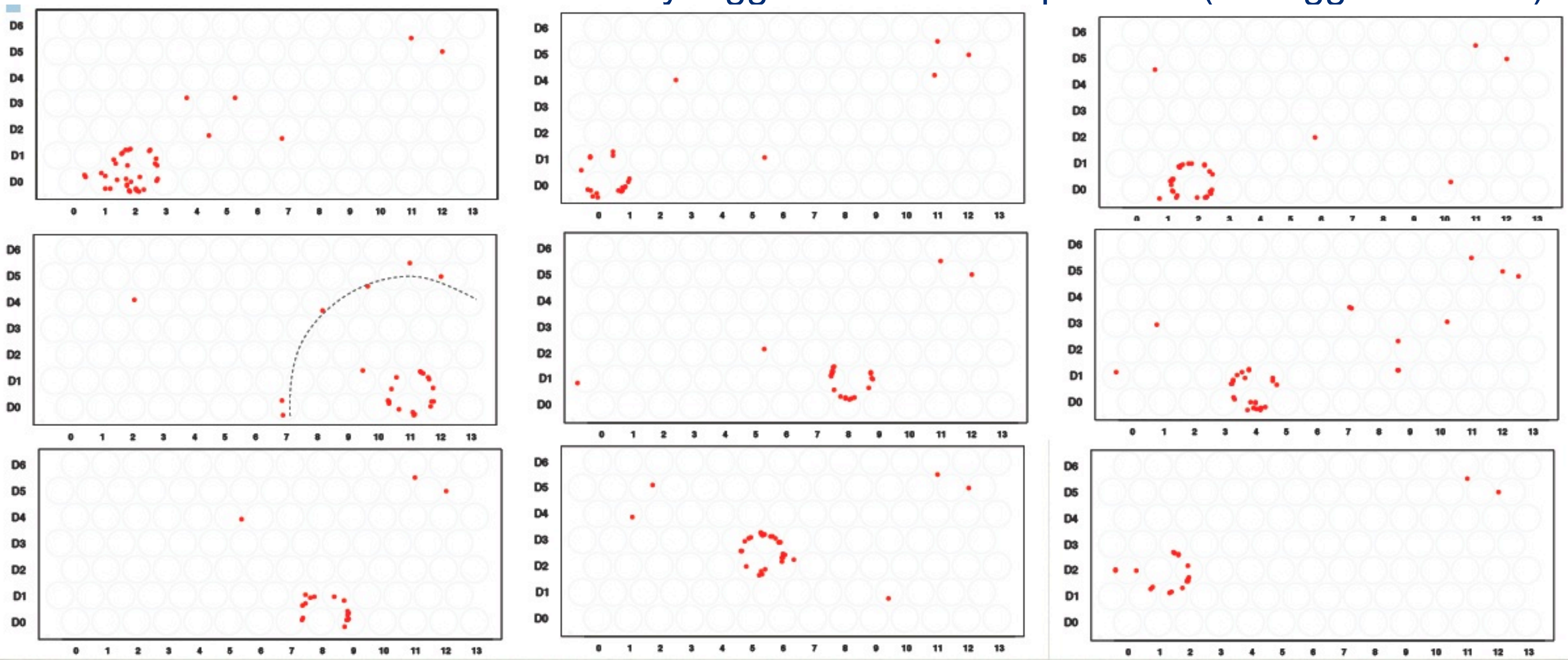
Cosmic Alignment in Time of Muon Stations



Expected arrival time wrt reference(ns)

Seeing RICH1 rings from cosmics

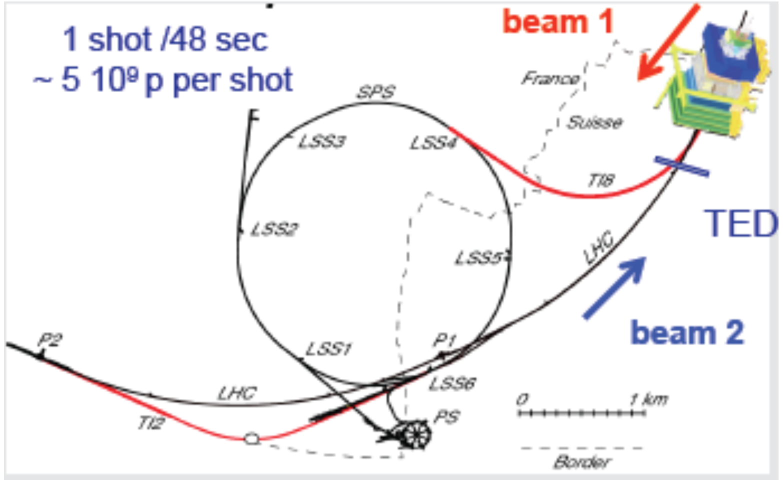
- RICH optics assumes particles ~horizontal and from IP → using cosmics is tricky!
- Solution: use scintillators as auxiliary triggers and a lot of patience (~2 triggers/minute)



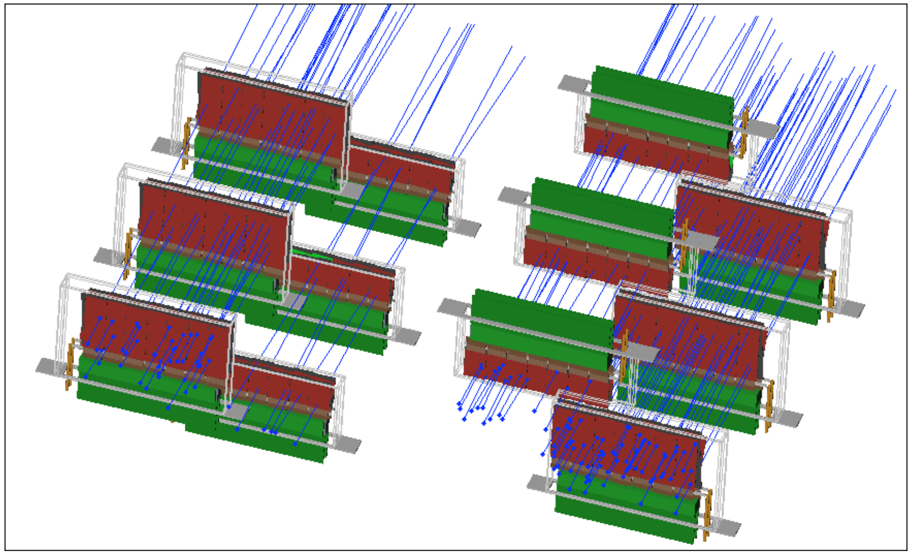
Several rings observed!

A First Glimpse of LHC Protons

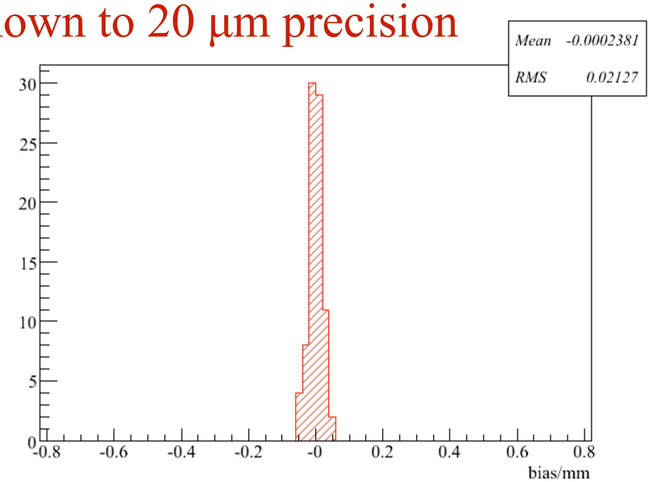
- Beam 2 dumped on injection line beam stopper (TED)
  - Located 340m before LHCb along beam 2
  - Wrong direction for LHCb
  - High flux, centre of shower O(10) particles/cm2
  - ~40 k tracks used to align VELO and IT



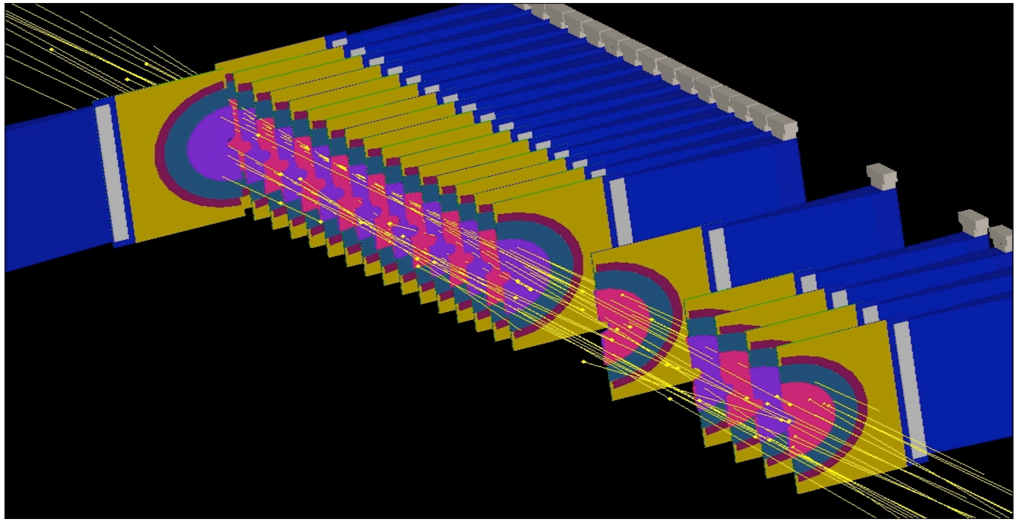
Inner Tracker

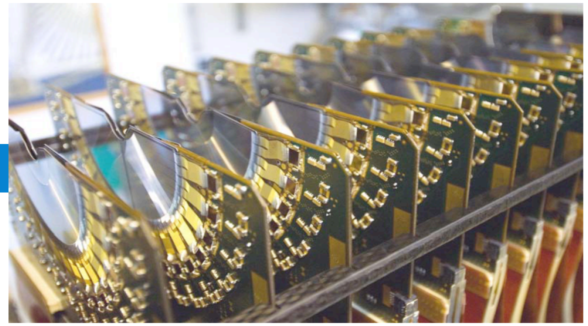


Ladder position in the Inner Tracker is known to 20 μm precision

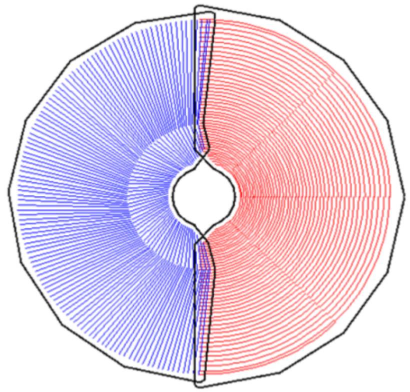


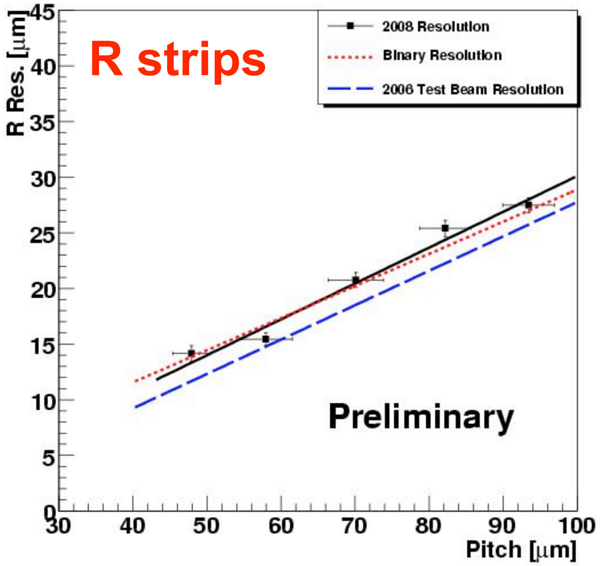
VELO Space Alignment

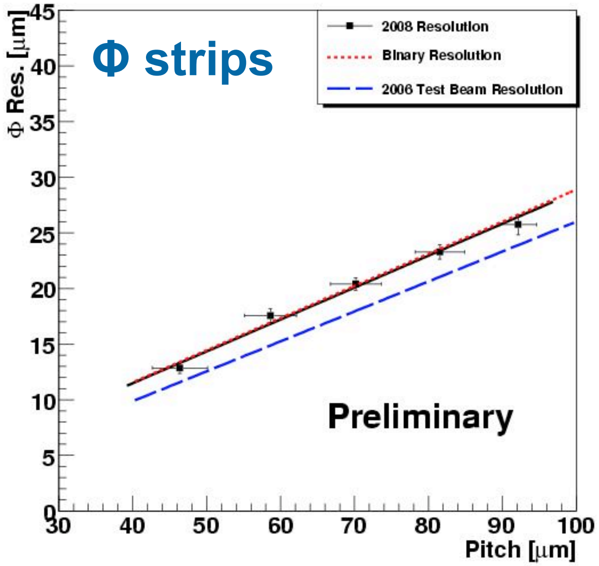




21 stations of Si
wafer pairs with
R and Φ strip readout





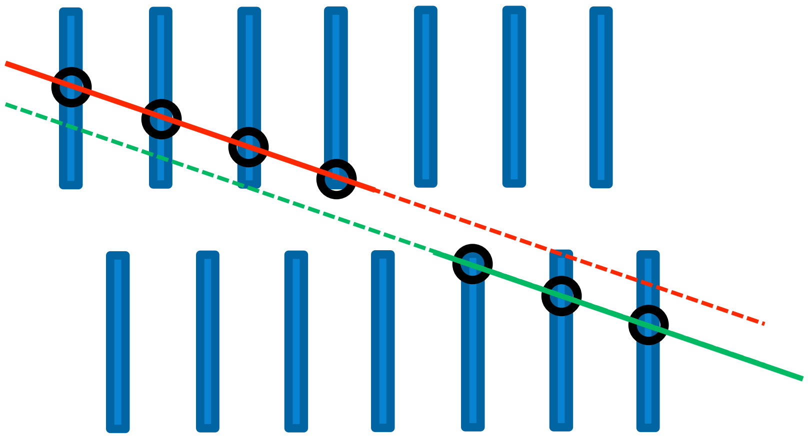


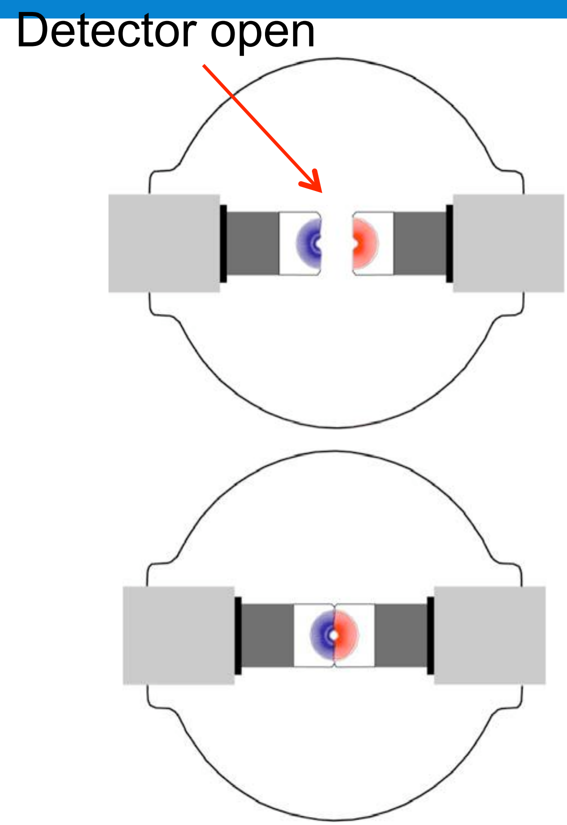
Resolution estimated from
VELO hit residuals,
agrees well with expectations

Further improvement possible

VELO Space Alignment 2009

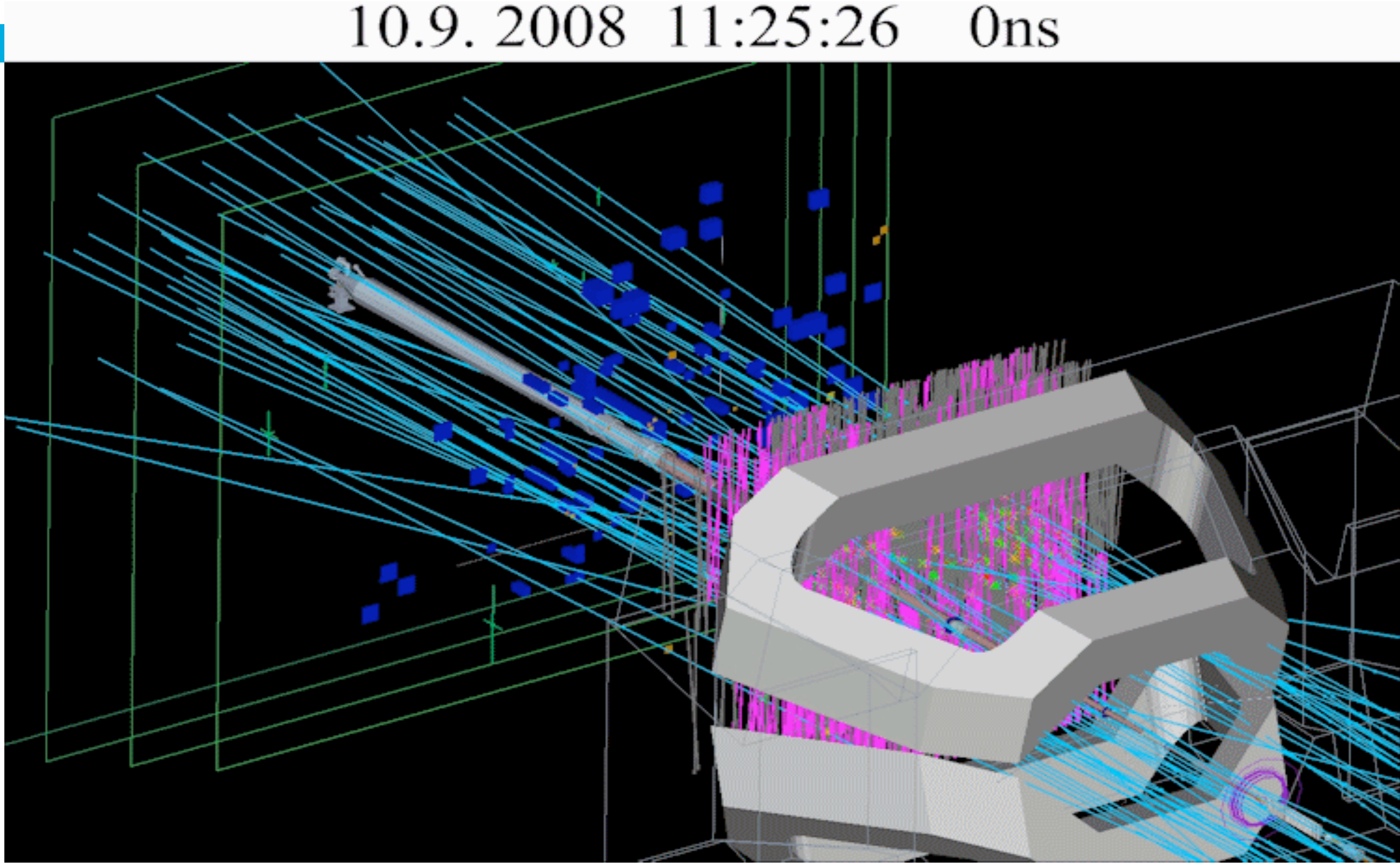
- Check how far apart the two VELO halves were using “traversing tracks”





- Detector halves separated by 2.000mm and 2.450mm i.e. Δx = 450 μm → Analysis sees Δx = 445 ±10 μm (with only 1000 tracks!)

An event from the first LHC beam



Readout of consecutive 25 ns crossings for a single trigger

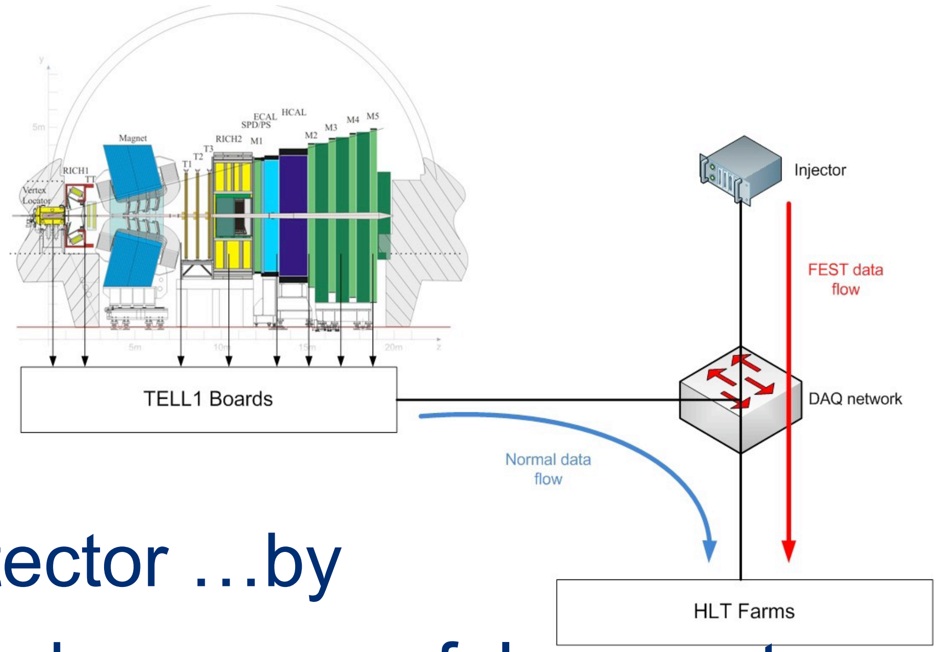
While waiting for the LHC…

New LHC Restart Schedule

- **Following substantial consolidation work, the LHC will start up in November 2009**
- **It will run for the first part of the 2009-2010 run at 3.5 TeV per beam with energy rising later in the run (to max 5 TeV per beam)**
- **LHCb expects running in 2010 with L $\leq 10^{32}$ $cm^{-2}s^{-1}$ at 7-10 TeV CM energy, with the aim to accumulate ~200 pb^{-1}**

- **LHCb:**
  - Detector consolidation
  - Adding 350 farm computing nodes to the current 200 in place
    - Farm nodes for computing power will be added as needed but infrastructure for up to 2000 in place
  - Installed last Muon station in between RICH and the Calorimeters (M1)
  - Improving
    - HV control
    - Data Monitoring → Run detector with two shifters
    - Automating global control
  - **F**ull **E**xperiment **S**ystem **T**est (FEST09)

FEST09



- Replacing a ~70M CHF detector …by
  a lot of simulated events and one powerful computer
  - HARDWARE+L0+READOUT BOARD → MonteCarlo & Event Injector
- Be ready to receive, process and analyze 7 million events in the first hour of collisions!
  - Exercise Online and Offline systems, Trigger, Monitoring, Data Quality checking and prompt (Online) reconstruction
  - Answer operational questions: e.g. "What is the best way to update alignment / calibration constants?"
  - FEST infrastructure can be used later for "dry-run" tests of various components of the system

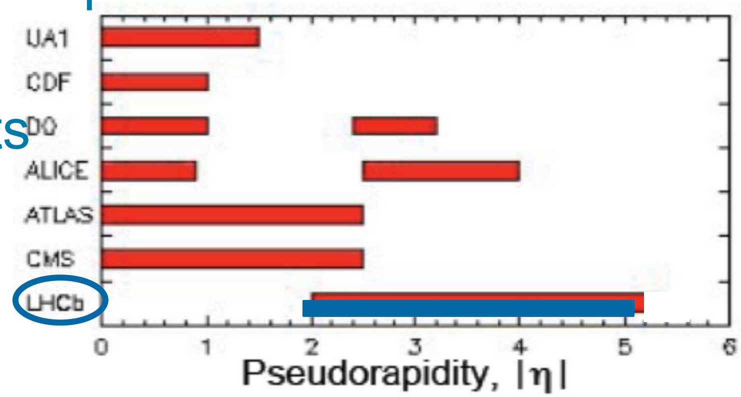
LHCb Key Measurements

Potentially sensitive to NP discovery

- In CP violation:
  - B_s-B_s mixing phase
  - weak phase γ in processes dominated by tree diagrams
  - weak phase γ in processes with large loop terms
- In rare decays:
  - BR ($B_s \rightarrow \mu\mu$)
  - Forward-Backward asymmetry in $B \rightarrow K^*\mu\mu$
  - polarization of photon in radiative penguin decays

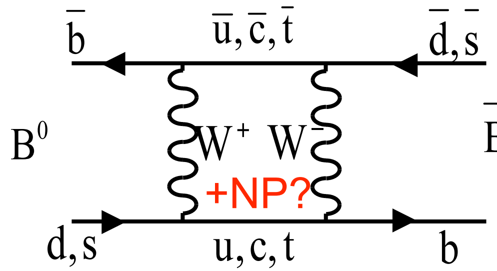
Very First Measurements
(some examples)

- Objective of very first running phase is to complete commissioning of sub-detectors and trigger
- Large Minimum Bias data samples collected as soon as the LHC delivers p-p collisions: 10^8 O(day) @ 2kHZ
  - plenty of K_s ,Λ → measure differential production distributions (η,p_T) ….
  - Clean and unbiased samples for PID studies
- p_T cut on single μ → expect ~3 10^6 $J/\psi\to\mu\mu$ with 5 pb^{-1} (8 TeV)
  - Reconstruct $J/\psi\to\mu\mu$, disentangle fraction of prompt and detached J/ψs
  - Study proper time resolution with prompt component
  - Measure prompt J/ψ and b→J/ψ in region not accessible to other collider expts

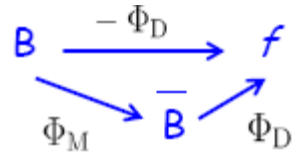


- With Full Trigger
  - Exclusive B and D decays

$\phi(J/\psi\phi)$ measurements from $B_s \rightarrow J/\psi\ \phi$

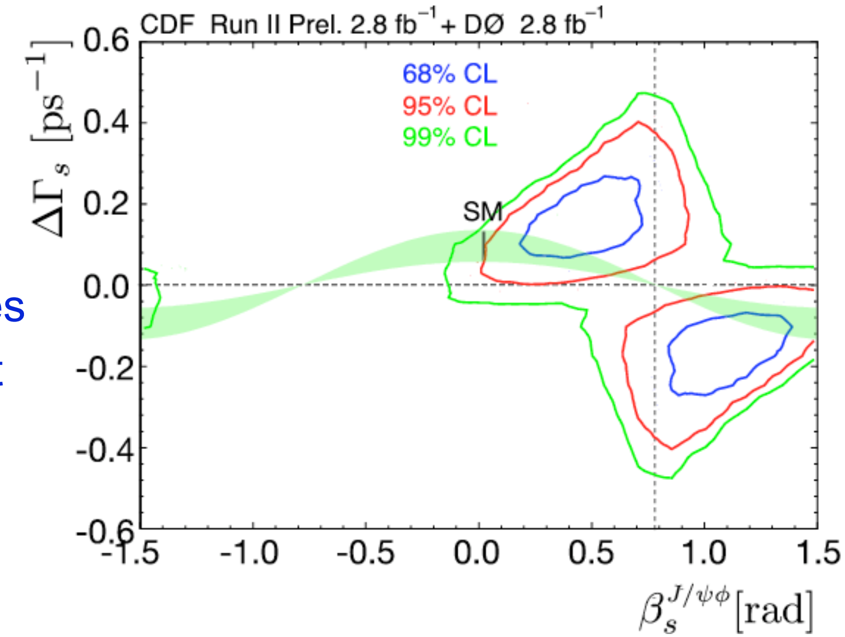


- Measure of B_s-B_s mixing phase $\phi(J/\psi\phi)$ in $B_s \rightarrow J/\psi(\mu\mu)\phi$ sensitive to NP effects in mixing
  - The phase arises from interference between B decays with and without mixing
  - $\phi^{SM}(J/\psi\phi) = -2\beta_s = -2\lambda^2\eta \sim -0.036 \pm 0.002$ rad
  - $\phi(J/\psi\phi) = -2\beta_s + \phi^{NP}$



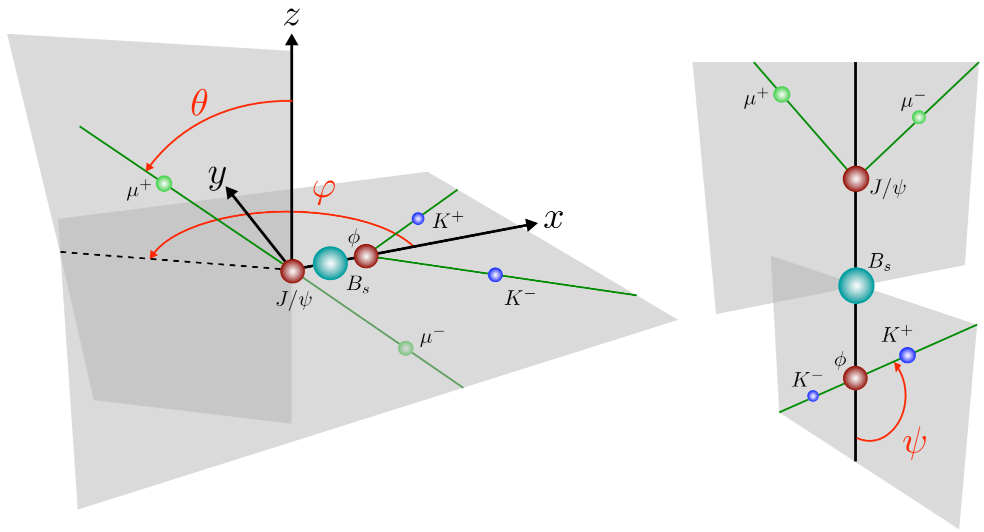
- CDF/D0 ~2.1σ from SM
  - Tantalizing small deviations in same direction
  - Both CDF/D0 currently working on 2x samples
  - Expect improved precision by simultaneous fit of CDF/D0 samples

(see EPS09, G.Punzi)



$\phi(J/\psi\phi)$ measurements from $B_s \rightarrow J/\psi\ \phi$

- P→VV decay: B_s pseudoscalar (spin=0), J/ψ and Φ vectors mesons ($J^{PC}=1^{--}$)
- Total angular momentum conservation implies ℓ=0,1,2
- $CP|J/\psi\ \phi> = (-1)^{\ell}\ |J/\psi\ \phi>$ →
  - Mixture of CP-even (ℓ=0,2) and CP odd (ℓ=1) final states.
  - Angular analysis to separate statistically the decay amplitudes
- 3 angles Ω=(θ,Φ,ψ) to describe directions of final decay products $J/\psi\rightarrow\mu\mu$, $\phi\rightarrow KK$

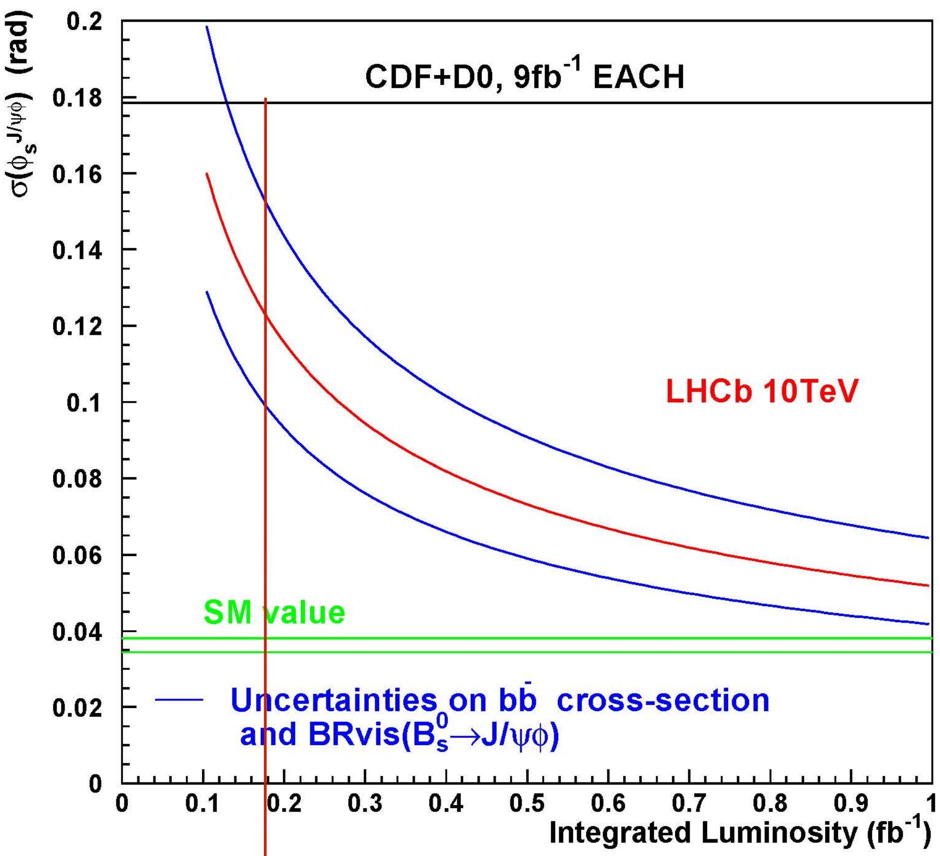


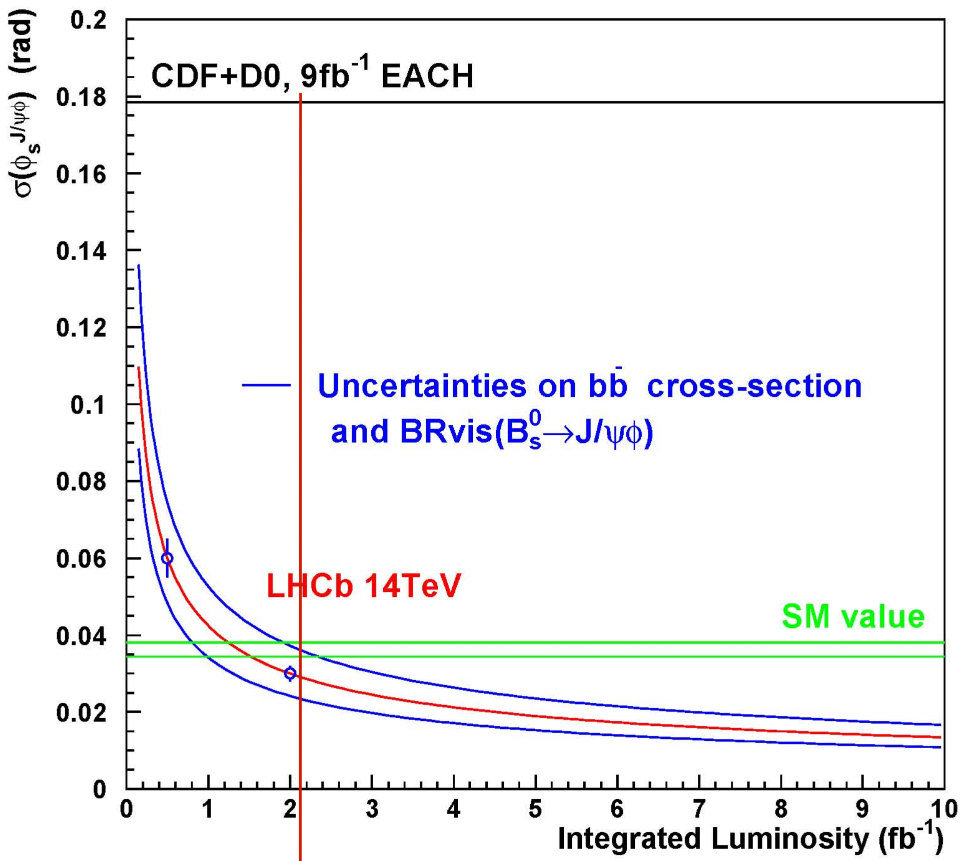
$\phi(J/\psi\phi)$ measurements from $B_s \rightarrow J/\psi\, \phi$

- Analysis strategy
  - Trigger and select $B_s \rightarrow J/\psi\phi$
  - Measure proper time
  - Measure 3 transversity angles
  - Tag initial B_s flavour
  - Likelihood fit of proper time and angular B decay rates
    - 6 observables: proper time, 3 angles, q (=0,-1,+1 for untagged, B_s, B_s) and mass
    - 8 physics parameters: Φ, $\Delta\Gamma_s$, Γ_s, Δm_s, $R_\perp$, R_0, δ_1, δ_2
    - many detector parameters (resolutions, acceptances, tagging, …)

- Key ingredients for sensitivity:
  - Large signal yield (expected 117k for 2 fb^{-1})
  - Excellent proper time resolution to resolve fast B_s oscillations: ~40 fs
  - Good tagging of initial B_s flavour with low and well known mistag rate : ~6%
  - Good control of proper time and angular acceptances
  - Crucial role of control channels to extract detector parameters without relying too heavily on MC

$\phi(J/\psi\phi)$ sensitivity as function of integrated lumi
(and comparison with Tevatron)





→ With ~0.2 fb^{-1} LHCb should improve on expected Tevatron limit: $\sigma_{LHCb} < \sigma_{Tevatron}$

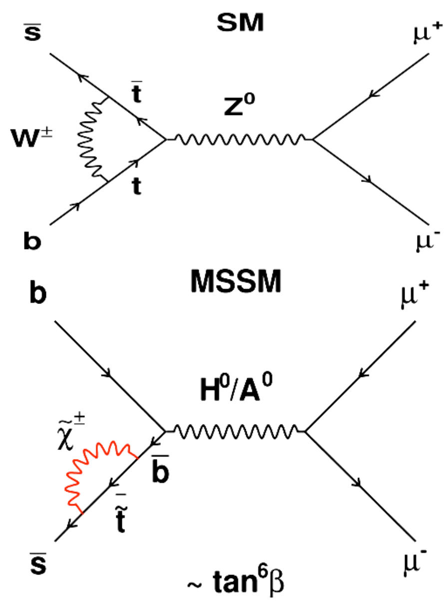
→ 5σ NP discovery if $\Phi_{true} = \Phi_{Tevatron}$ (~0.86)

→ With ~2 fb^{-1}, σ_{LHCb} ~ SM value

New Physics in $B_s \to \mu^+\mu^-$

- Small BR in SM: $(3.6 \pm 0.3) \times 10^{-9}$
  (Buras arXiv:0904.4917v1)
- Sensitive to NP
  - could be strongly enhanced in SUSY
    - In MSSM scales like $\sim\tan^6\beta$
- Current (unofficial) Tevatron limit (G.Punzi, EPS'09):

  < $\mathbf{45 \times 10^{-9}}$ with $2\,fb^{-1}$ (13xSM)
  - CDF and D0 expect ~2 SM $B_s \to \mu\mu$ events in their current samples
  - Making a dent in the final factor of 10 from the SM !



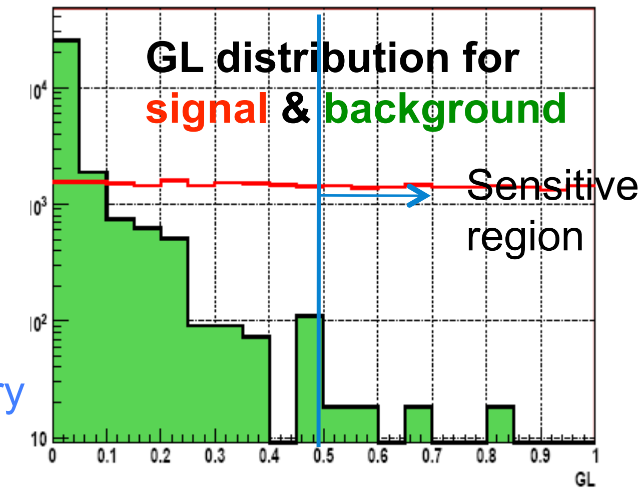
New Physics in $B_s \to \mu^+\mu^-$

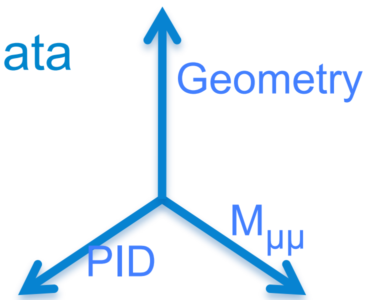
- LHCb key features
  - high stat. & high trigger efficiency for signal
  - main issue is background rejection
  - dominated by $B \to \mu^+ X$, $B \to \mu^- X$ decays
    - (two real muons fom different B decays)
  - exploits good mass resolution and vertexing, and good particle ID
  - use of control channels to minimize dependence on MC simulation

New Physics in $B_s \to \mu^+\mu^-$

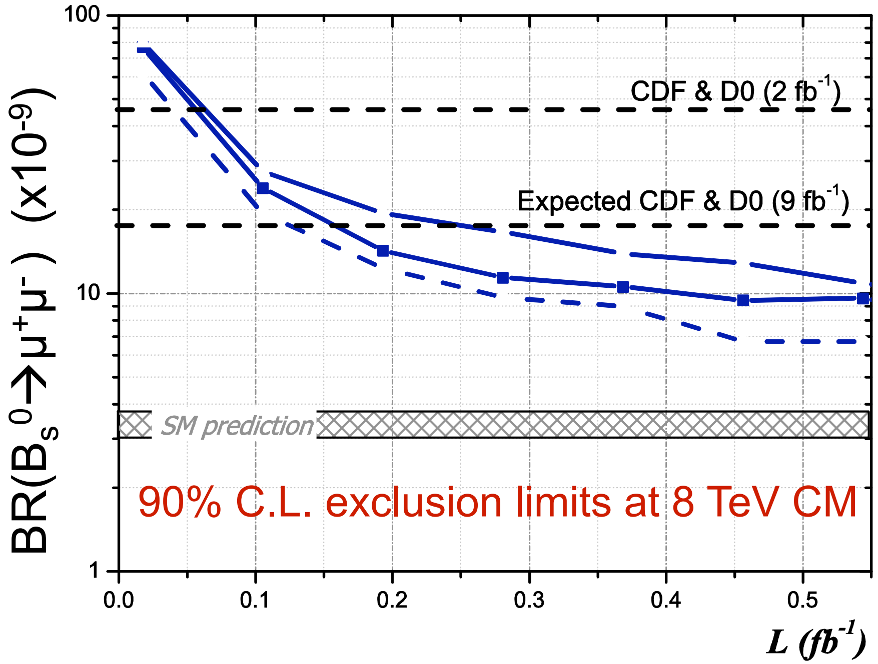
Analysis strategy

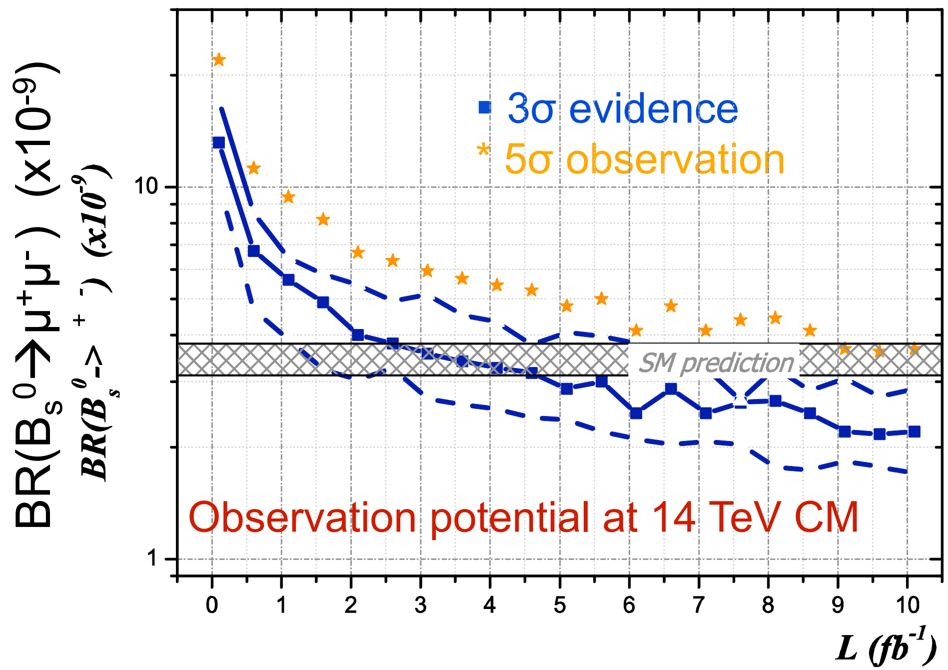
- Selection of $B_s \to \mu^+\mu^-$ as common as possible to that of control channels
  - Efficiency ratio ~1 → small corrections
  - Select B candidates with similar phase space for signal and control channels
- Each selected and triggered event is given a likelihood to be signal or background- like in a 3D space:
  - **Geometry Likelihood** (GL) based on the decay topology
  - **Invariant Mass Likelihood**: prob that event with given inv. mass is signal or background
  - **Particle ID Likelihood**: prob. that two muon candidates are indeed muons
- Axes uncorrelated → can be calibrated separately from data using control samples (B→hh)





Physics reach for BR($B_s^0 \rightarrow \mu^+\mu^-$) as function of integrated luminosity (and comparison with Tevatron)





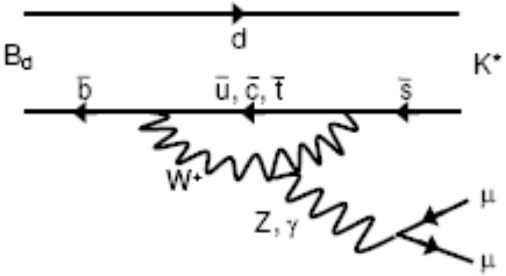
→ With ~0.3 fb^{-1} LHCb should improve on expected Tevatron limit with 9 fb^{-1}

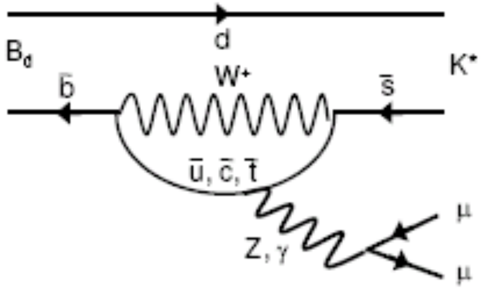
→ Collect ~3 fb^{-1} for 3σ evidence of SM value and ~10 fb^{-1} for 5σ observation of SM

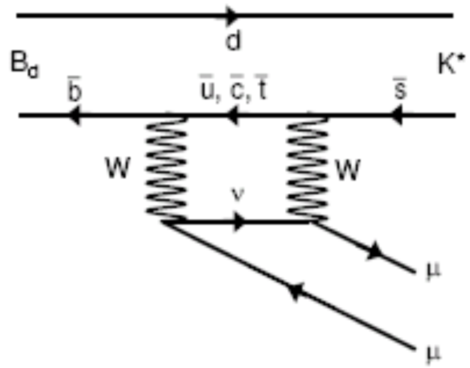
ATLAS/CMS will certainly be competitive!

$B_d \rightarrow K^{*0}$ μμ

- Potentially sensitive to NP discovery
  - FCNC b→s transition via a loop







  - First observed at Belle

$$Br(B_d \rightarrow K^{*0}\mu^+\mu^-) = (1.22^{+0.38}_{-0.32}) \times 10^{-6}$$

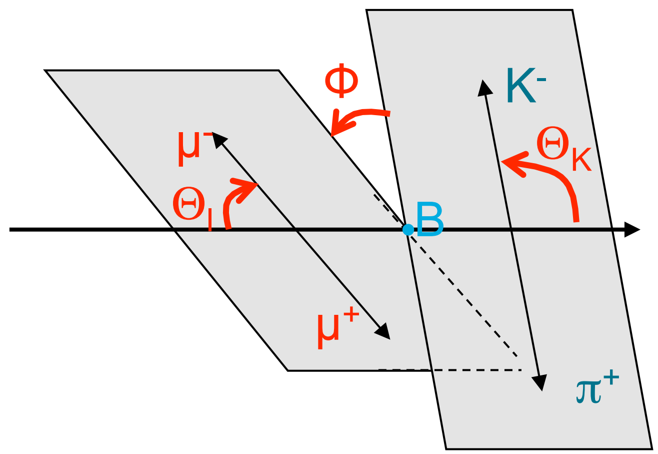
$B_d \rightarrow K^{*0}\ \mu\mu$

- Decay described by Θ_l, Φ, Θ_K and $q^2 \equiv m_{\mu\mu}{}^2$

θ_l: Angle between μ^- and $\bar{B}$ in $\mu\mu$ rest frame

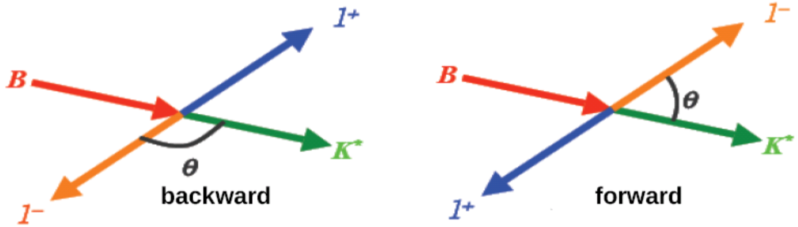
θ_K: Angle between K^- and the $\bar{B}$ in the $\bar{K}^{*0}$ rest frame

ϕ: Angle between the $\bar{K}^{*0}$ and $\mu\mu$ decay planes



- Identify variables with low theory errors
- Test for presence of NP: modified BR, modified asymmetries, polarization

$B_d \to K^{*0} \mu\mu$

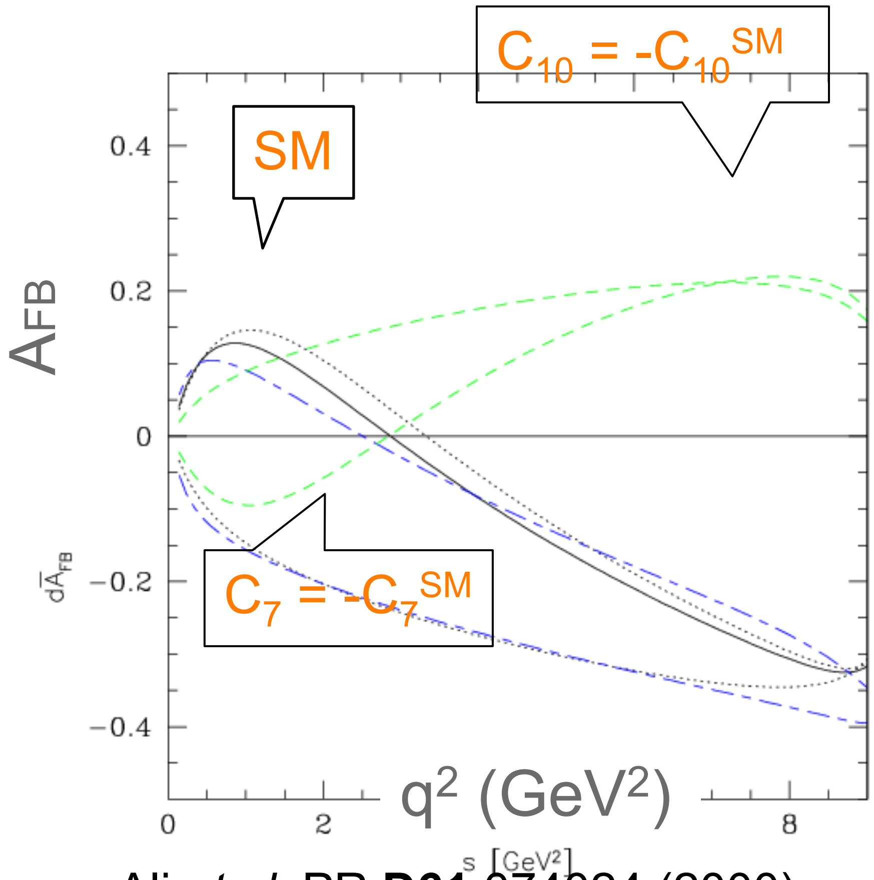


- What to measure?
  - Forward-Backward μμ asymmetry $A_{FB}(q^2)$

$$A_{FB}(q^2) = \frac{N_F - N_B}{N_F + N_B}$$

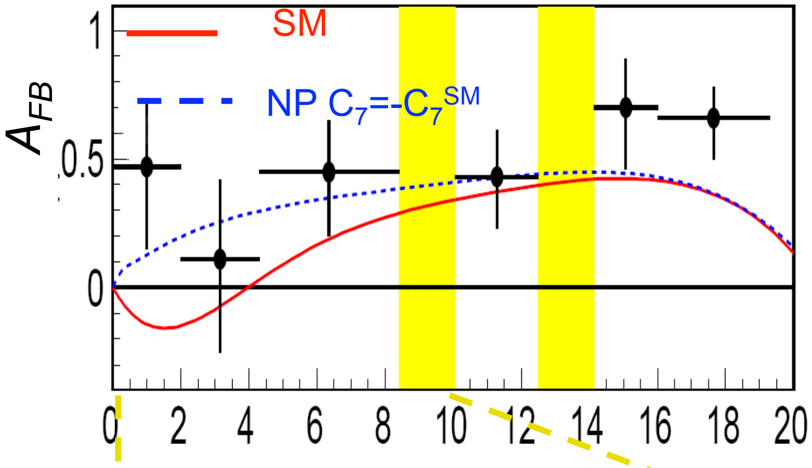
  - Zero crossing point (q_0^2)
    - Accessible with small integrated Luminosity (~0.5 fb^{-1})
    - Form factors cancel at leading order
    - Precisely predicted in SM

$$s_0^{SM} = 4.36\ ^{+0.33}_{-0.31}\ \mathrm{GeV}^2$$

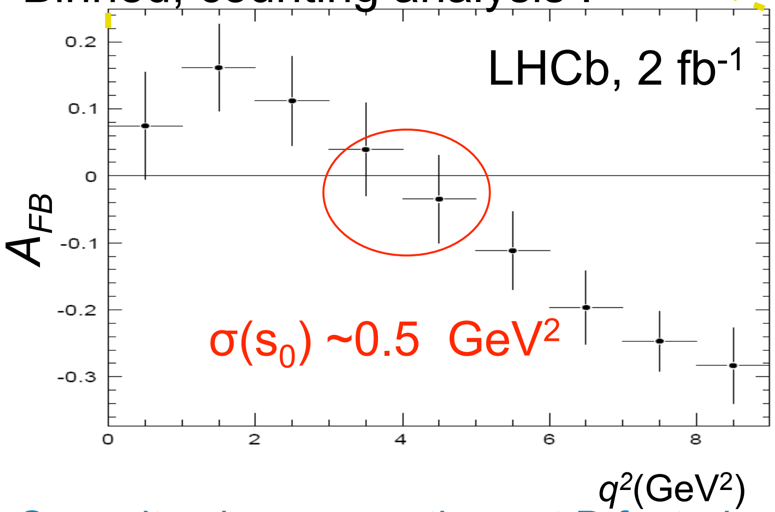


Ali *et al*, PR **D61**:074024 (2000)

$B_d \rightarrow K^{*0} \mu\mu$



Binned, counting analysis :



Opposite sign convention wrt B factories

- Example : BELLE
  - 657M BB *O*(230) events arXiv:0904.0770v1
- LHCb
  - Same number of events as all other experiments combined in 0.1fb^{-1}
  - ~7.2k per 2fb^{-1}
  - Analysis timeline:
    - A_{FB} counting experiment (0.5-2 fb^{-1})
    - Perform fits to decay angles(2-4 fb^{-1})
    - Full angular analysis
  - Key challenges:
    - Understanding biases on angular observables induced by detector and reconstruction effects

Conclusions

- LHCb is ready to take data
- Cosmics and LHC-induced tracks were very useful to commission the detector
- First LHC data will be used to calibrate the detector and the trigger and for a first exploration of low p_T physics at LHC energies
- A few observables sensitive to NP should already be accessible at the end of the 1^{st} year of data taking
- With 10 fb^{-1} LHCb has an excellent opportunity to discover NP and to elucidate its nature. Important complementary role to physics programme of ATLAS and CMS