CP Violation Prospects at the LHC

- CPV Introduction
  - The CKM-matrix
  - Unitarity Triangle(s)
  - Selected B-factory measurements
- B's at the LHC
  - $\mathrm{b\bar{b}}$ production at the LHC
  - Experiments at the LHC
  - LHCb in detail
    - Tracking environment and detectors
    - Vertex detector and proper time resolution
    - Particle identification
    - Calorimetry
    - Triggering
    - Expected event yields
  - Expected performance illustration
- Conclusions

CP Violation

- Charge conjugation: particle$\rightarrow$anti-particle
- Parity: reflection in the origin of the space coordinates of a particle.

CP violation distinguishes matter from anti-matter: baryogenesis.

The CPV in the standard model too small to explain our existence:

- Leptogenesis? Since ν's have mass, they mix and they will probably have CPV.
- New physics $\longrightarrow$ new source(s) of CPV

Studying CPV can reveal new physics, beyond the reach of "direct searches".

The observation of CPV in the K-system, led Kobayashi and Maskawa to the prediction of the third generation. Hence....

But: no smoking gun....

The Cabibbo-Kobayashi-Maskawa Matrix

CKM-matrix describes the charged current interactions of quarks: $\longrightarrow$ couplings of W^+-boson to up-down quark pairs:

$$V = \begin{pmatrix} V_{\rm ud} & V_{\rm us} & V_{\rm ub} \\ V_{\rm cd} & V_{\rm cs} & V_{\rm cb} \\ V_{\rm td} & V_{\rm ts} & V_{\rm tb} \end{pmatrix} .$$

The matrix can be parametrized with four independent parameters, including one phase, which introduces CP violation.

Wolfenstein parametrization: $\lambda (= \sin\theta_{\rm Cabibbo})$, A, ρ and η parameters.

$$V \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\,\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\,\eta) & -A\lambda^2 & 1 \end{pmatrix} + \delta V ,$$

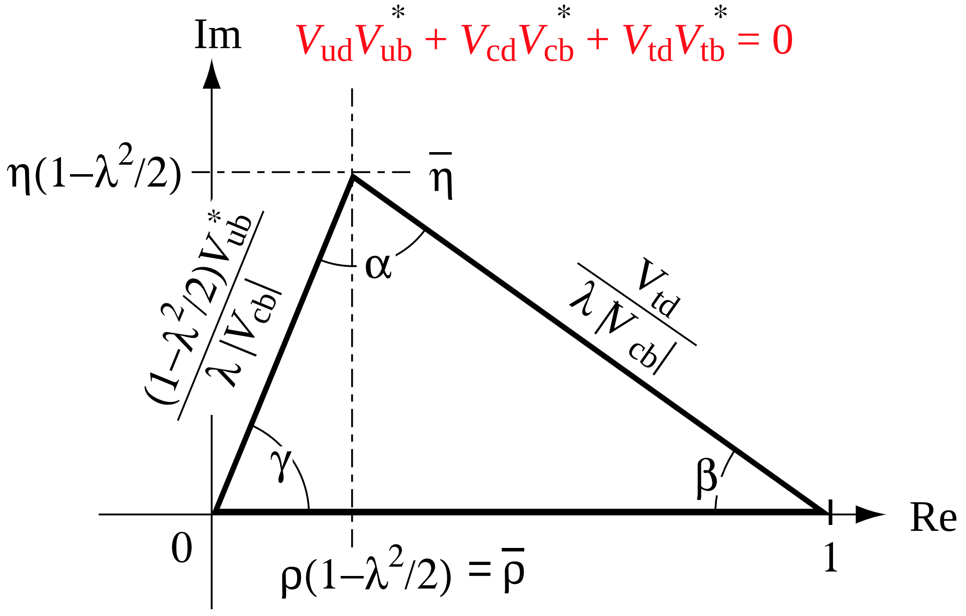
δV contains $\lambda^{\geq 4}$ terms

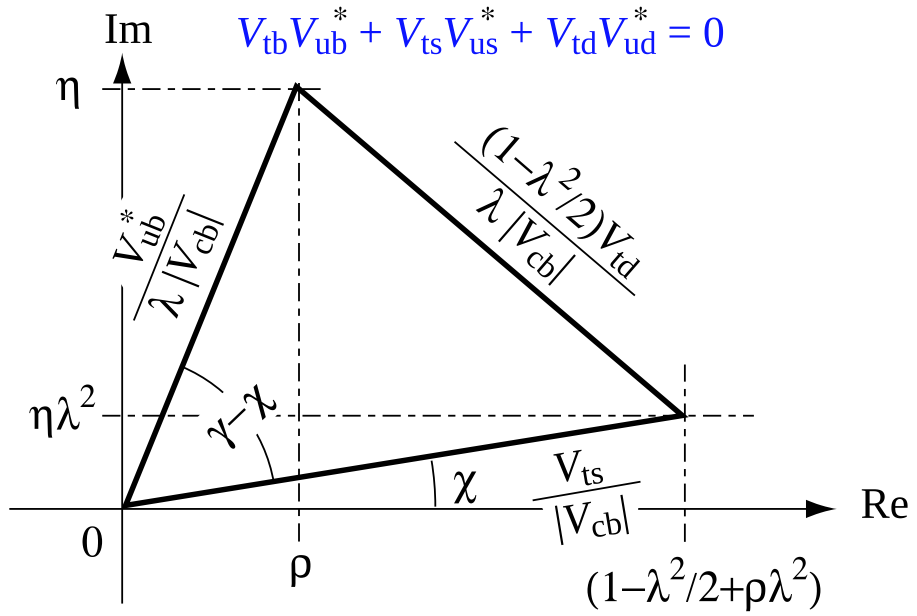
There are nine unitarity relations in the matrix: $\longrightarrow$ triangles.

Triangles (B-physics)

Two "most relevant" unitarity relations:

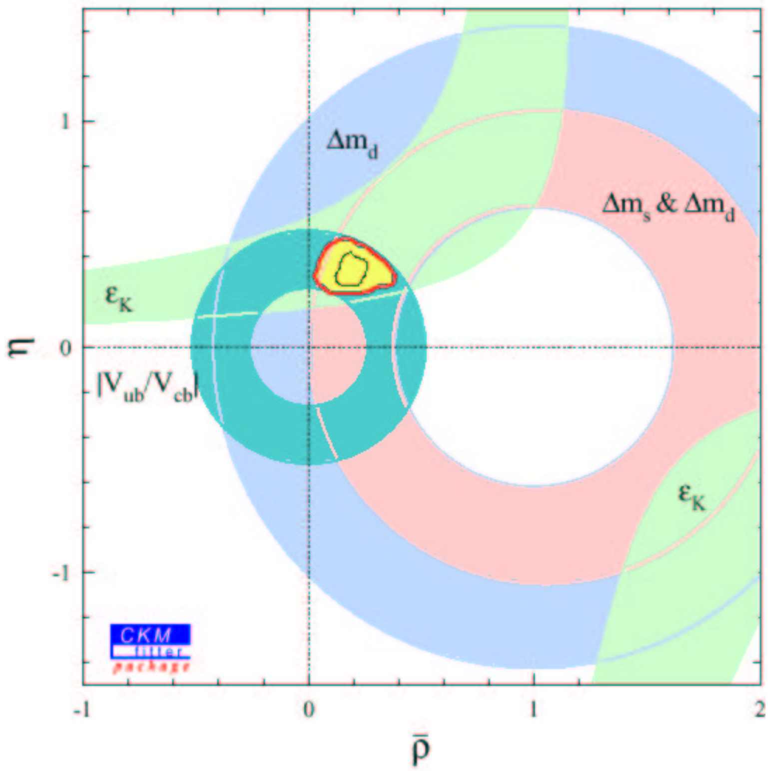
$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$
$$V_{tb}V_{ub}^* + V_{ts}V_{us}^* + V_{td}V_{ud}^* = 0$$





Triangle without CPV$_{\mathrm{B-system}}$

- $|V_{\mathrm{ud}}|$ and $|V_{\mathrm{cs}}|$ from nuclear β-decay and $\mathrm{K} \to \pi l \nu$ resp: fixes λ.
- $|V_{\mathrm{ub}}|$ and $|V_{\mathrm{cb}}|$: from tree diagram B-decays at LEP/CLEO: fixes A.
- Δm_d: dominated by B-factories (0.503$\pm$0.006 ps^{-1}), but dominated by theoretical uncertainty.
- Δm_s: lower limit only(LEP,SLD), if measured (Tevatron?, but LHC for certain) will reduce theory contribution to error significantly.
- ϵ_{K}: CPV in K$\to \pi\pi$.



Fit tip if the triangle $[\bar{\eta}, \bar{\rho}]$, and extract prediction:

sin2β=0.695$\pm$0.055

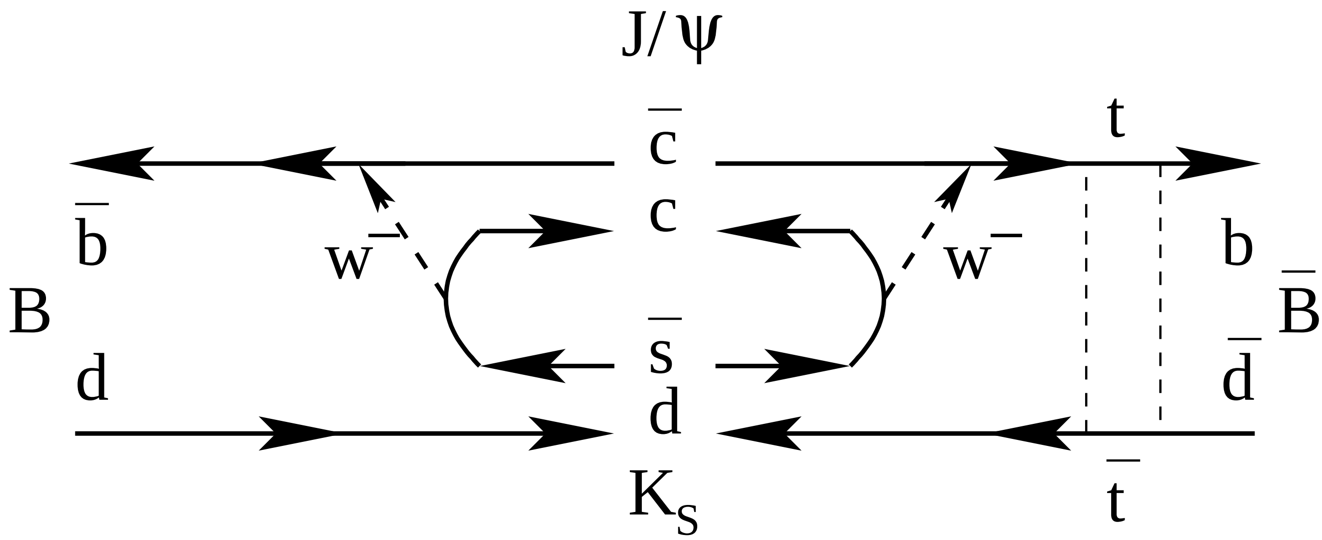
sin2β can be measured in CPV in the B-system....

The Golden Channel: $\mathrm{B_d} \to \mathrm{J}/\psi \mathrm{K_S^0}$

In general (with some approximations though):

$$\frac{\Gamma_{\bar{\mathrm{B}}\to \mathrm{f}}(t) - \Gamma_{\mathrm{B}\to \mathrm{f}}(t)}{\Gamma_{\bar{\mathrm{B}}\to \mathrm{f}}(t) + \Gamma_{\mathrm{B}\to \mathrm{f}}(t)} =$$

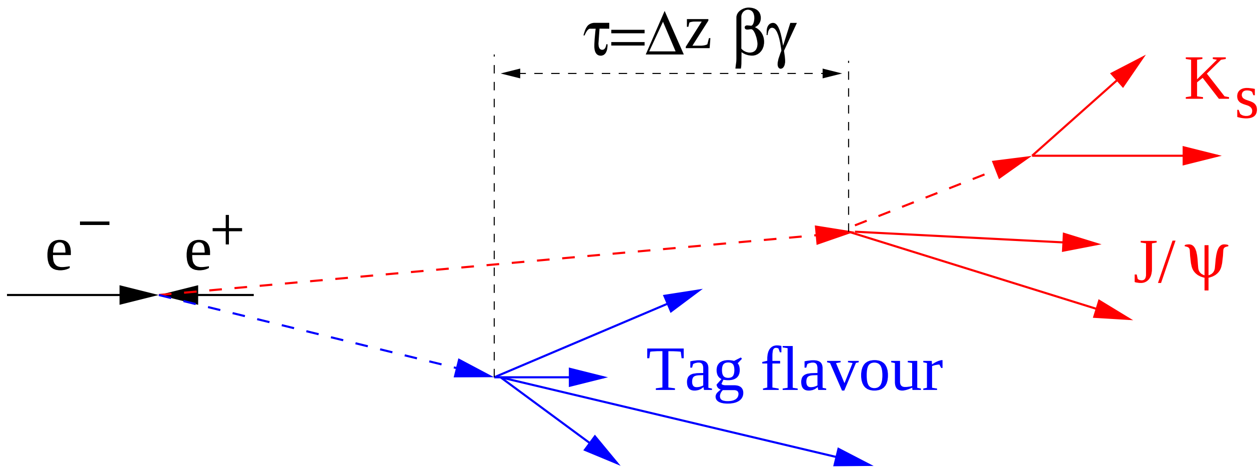
$$= \mathrm{A_f^{dir}} \cos(\Delta \mathrm{m t}) + \mathrm{A_f^{mix}} \sin(\Delta \mathrm{m t})$$



- Theoretically "clean" case:
  - Small penguin with a phase close to tree
  - Standard Model expectations are: $\mathrm{A^{dir}} = 0$ and $\mathrm{A^{mix}} = \sin(2\beta)$
- Experimentally: nature has been 'kind' to us
  - BR $\mathrm{B_d} \to \mathrm{J}/\psi(\mu\mu)\mathrm{K_S^0}(\pi^+\pi^-)$= 2.10^{-5}.
  - Two resonances: good Signal/Background

Extract sin(2β) at B-factories

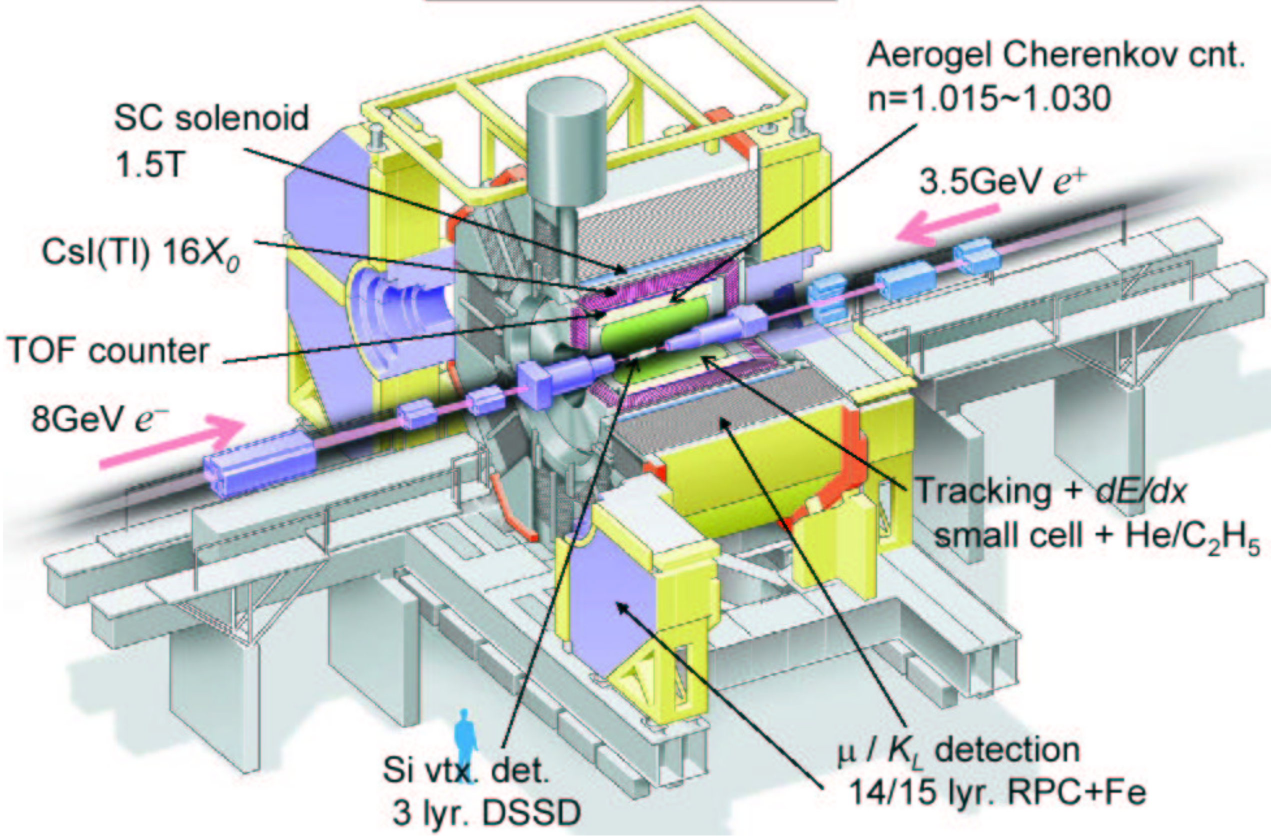
- Asymmetric $e^+e^- \rightarrow \Upsilon(4s) \rightarrow B^0\bar{B}^0$
- $B^0\bar{B}^0$-pair evolves coherently, hence have opposite flavour at decay →tagging.
- Measure $\frac{N_{\bar{B}}-N_B}{N_{\bar{B}}+N_B}$ as a function of τ.
- Likelihood fit to extract A^{mix} and A^{dir}



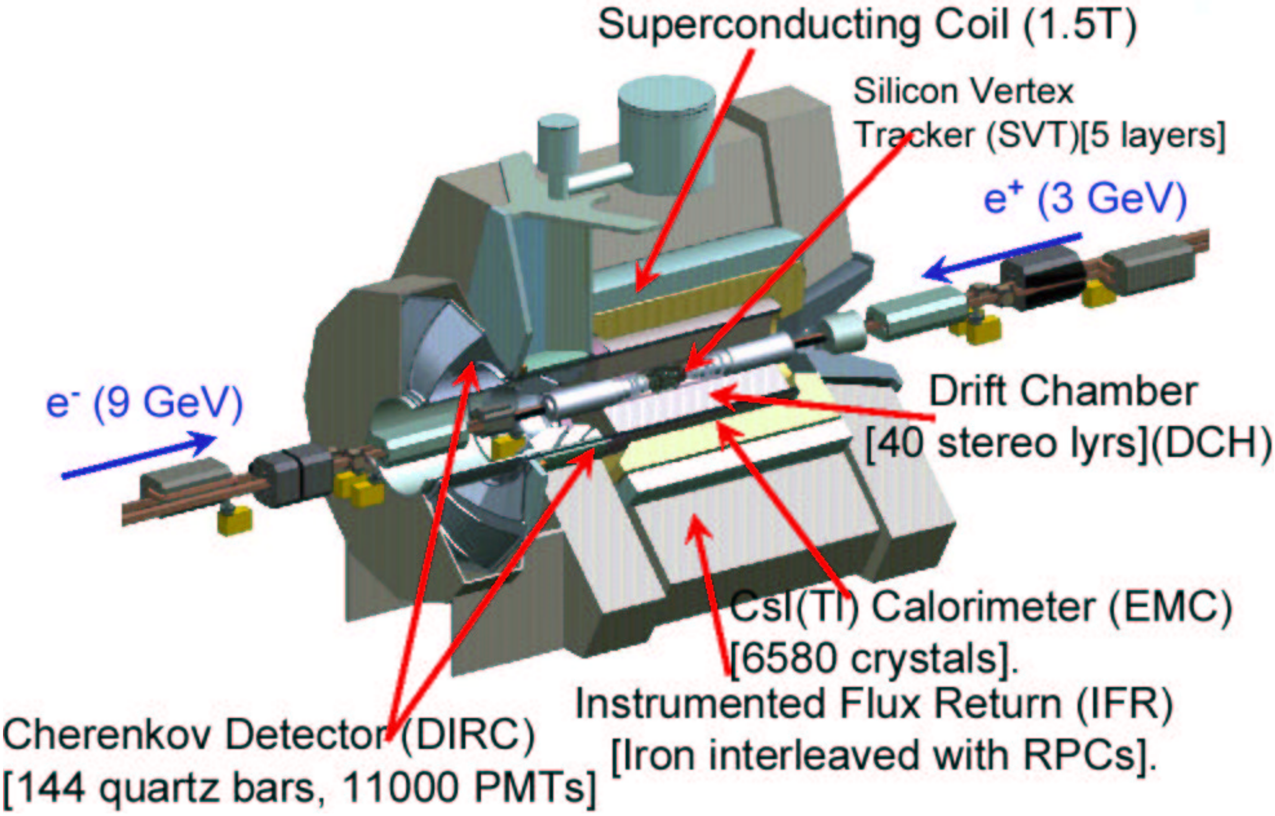
B-Factories

	KEKB	PEP II
$\int L dt$ (2003)	158 fb^{-1}	131 fb^{-1}
$\int L dt$ on peak	140 fb^{-1}	113 fb^{-1}
Detectors	Belle	Babar
Nr $B\bar{B}$-pairs	152×10^6	123×10^6

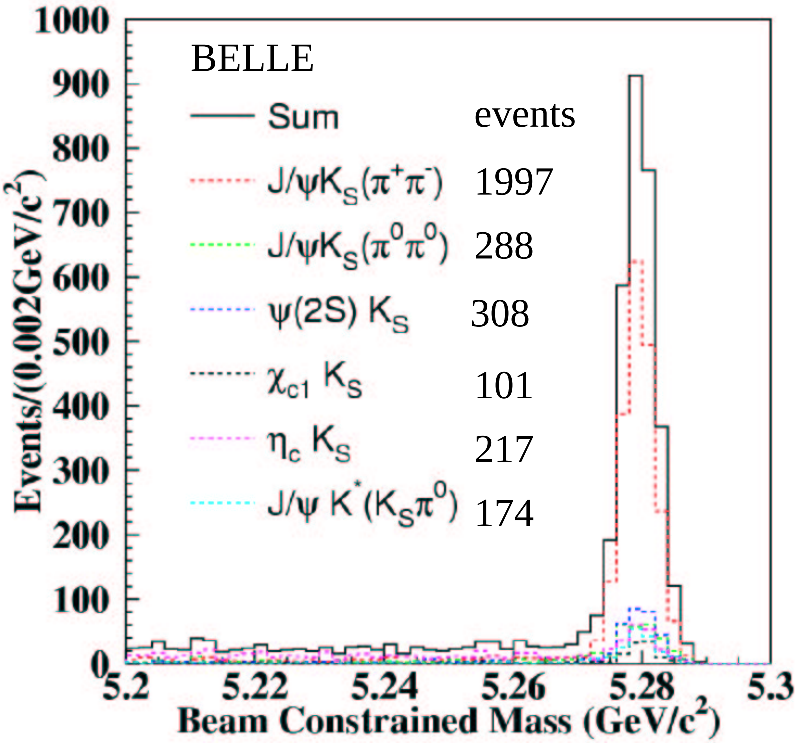
Belle Detector



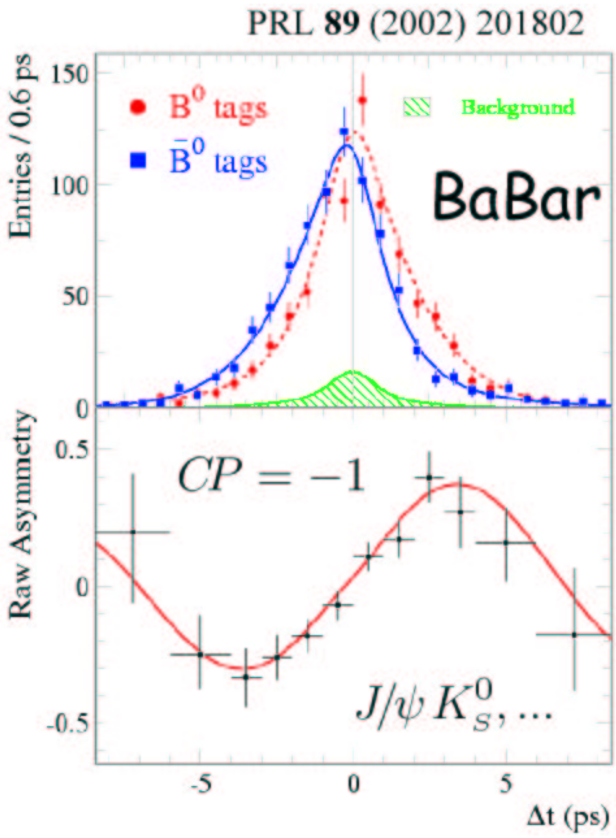
The BaBar Detector



Extract sin(2β) at B-factories



$\sqrt{(E_{CM}/2)^2 - (\vec{p}_{J/\psi} + \vec{p}_{K_S})^2}$



Belle(2003): sin$(2\beta) = 0.733 \pm 0.057 \pm 0.028$

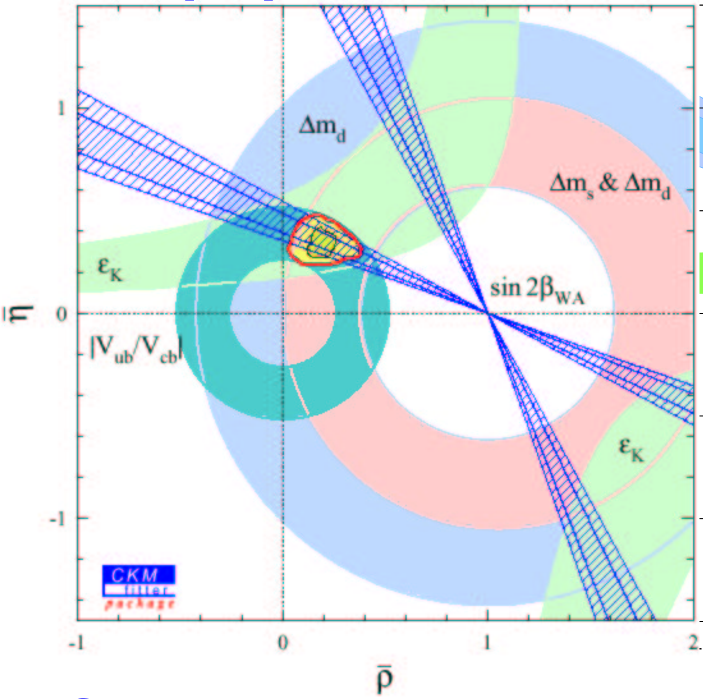
Babar(2002): sin$(2\beta) = 0.741 \pm 0.067 \pm 0.033$

CKM-fit prediction: sin$(2\beta) = 0.695 \pm 0.055$

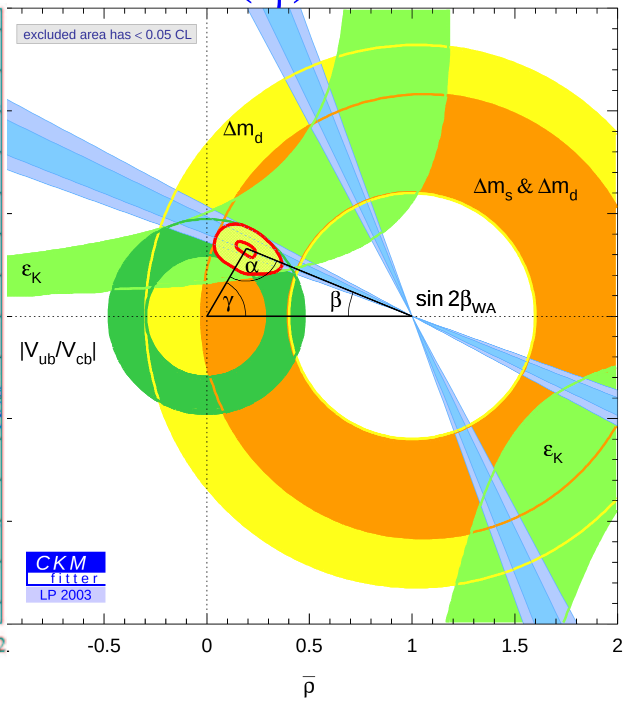
Excellent agreement!

Back to the Unitarity Triangle

Compare prediction/measurement



Include sin(2β) in the fit



Conclusion:

- KM mechanism can explain the CPV in flavour changing processes!
- CPV in B-system better constraint than any other observable.

But:

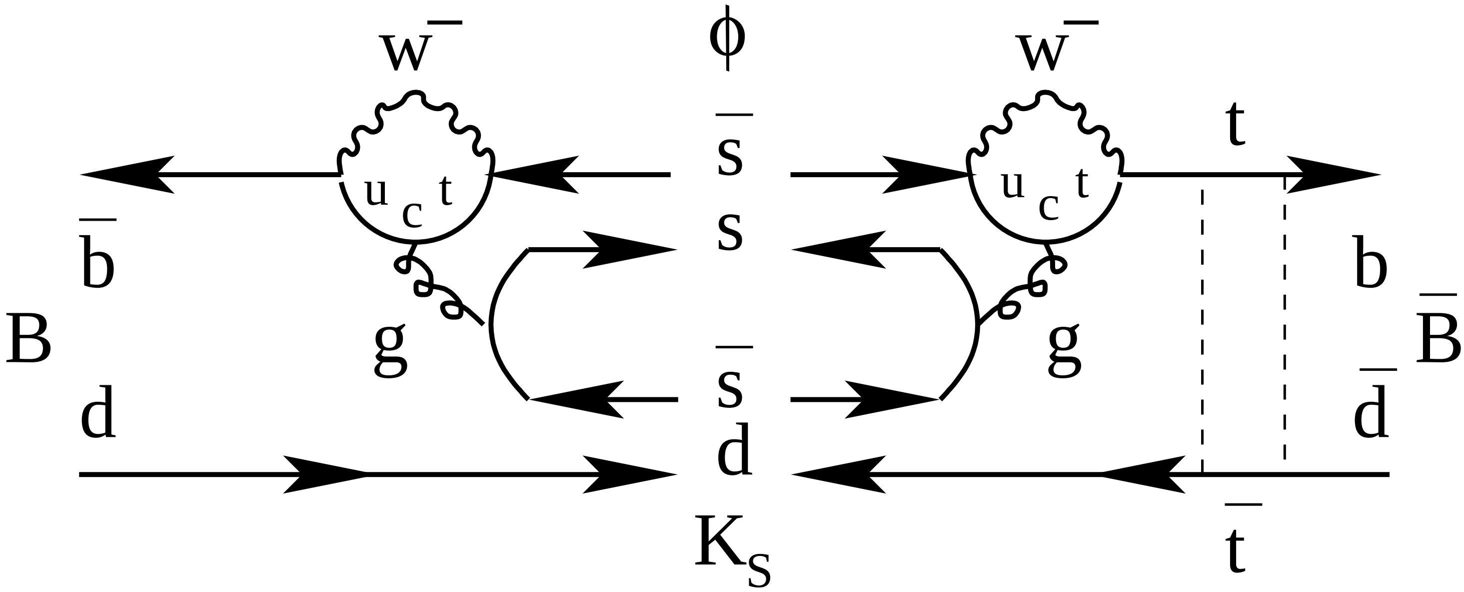
- Coincidence? A combination of SM contribution and new physics?

Bottom line:

- Need to check CPV in many B-decays.
- Especially look for decays sensitive to new physics.

New Physics Searches in Rare B-decays

Theoretically cleanest example: ϕK_S



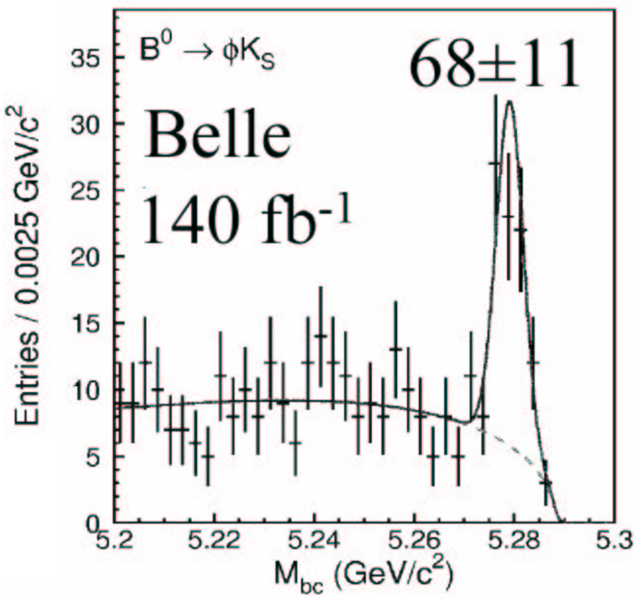
In the Standard Model:

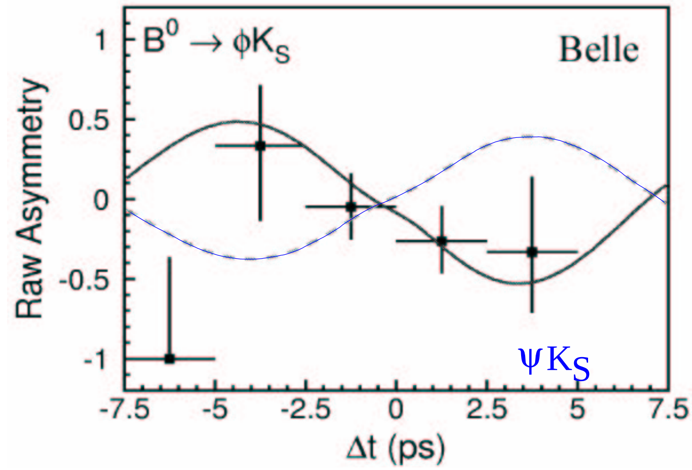
$$\sin(2\beta)_{\psi K_S} = \sin(2\beta)_{\phi K_S}$$

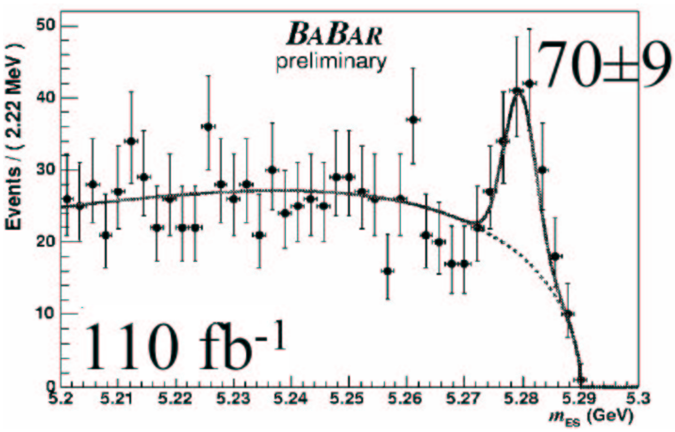
But the hope is that CPV probes other penguin diagram with new particles in their loop (squarks and gluinos?).

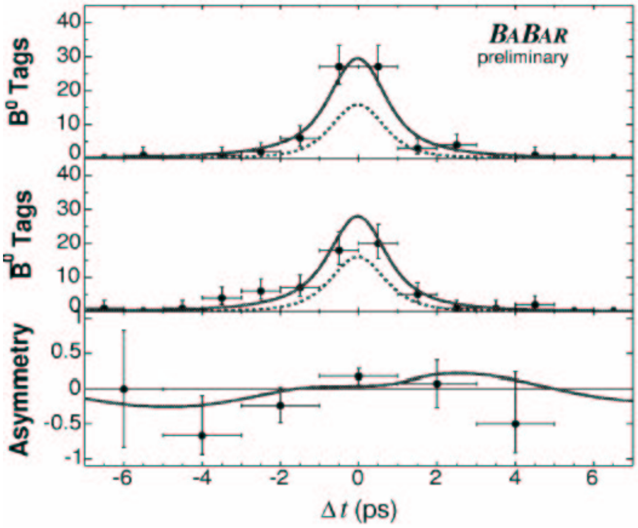
Experimentally:
$BR(B \to \phi(K^+K^-)K_S(\pi^+\pi^-) = 1.4 \times 10^{-6})$.
Compare: $J/\psi(\mu\mu)K_S$: 20×10^{-6}.

Experiments and ϕK_S







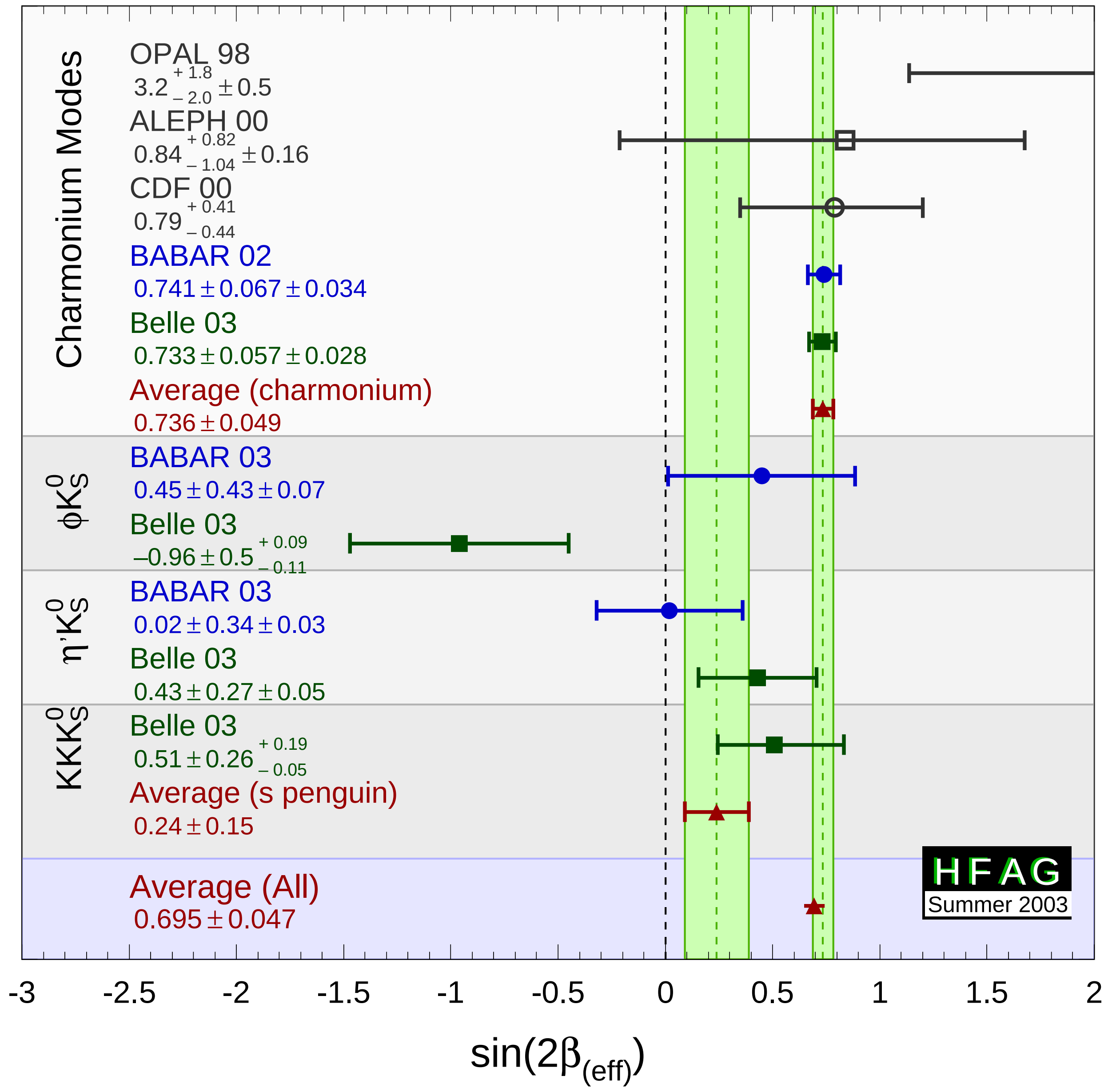


Belle: $\sin(2\beta)_{\phi K_S} = -0.96 \pm 0.50^{+0.09}_{-0.11}$

Babar $\sin(2\beta)_{\phi K_S} = +0.45 \pm 0.43 \pm 0.07$

World average: $\sin(2\beta)_{\psi K_S} = +0.736 \pm 0.049$

Comparison of Tree/Penguin Measurements



Based on $\sim 250\ \mathrm{fb}^{-1}$ (Babar+Belle)

Expected: $\sim 1000\ \mathrm{fb}^{-1}$ in 2006

(LHC starts in 2007!)

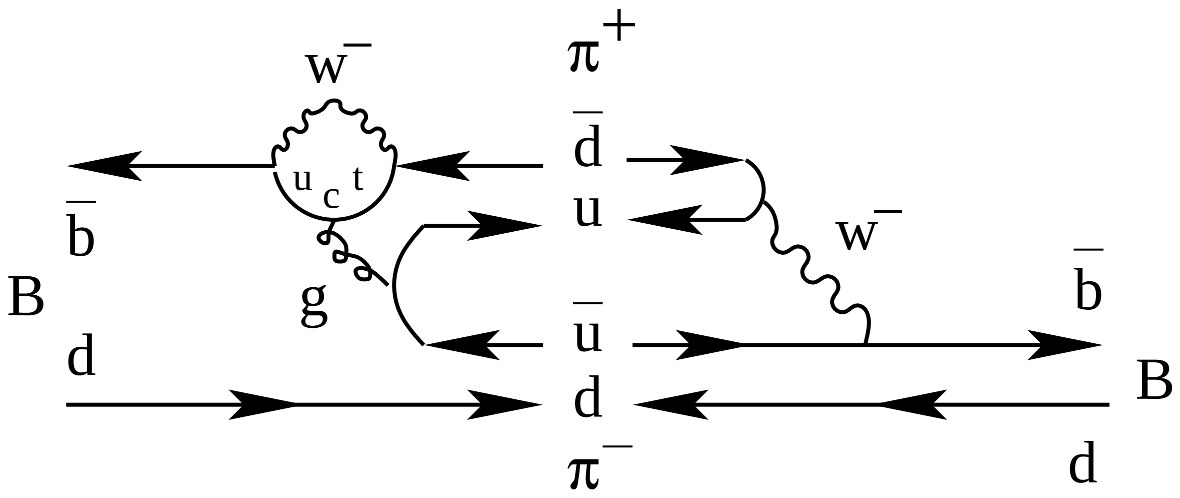
What about α and γ?

- Constraints from CKM fit "weak": while $\Delta\beta \sim \pm 3^\circ$, $\Delta\alpha(\gamma) \sim \pm 20^\circ$
- no golden channels accessible to B-factories.

But fruitful ground to check deviations from Standard Model:

- Do the angles agree with CKM-fit ranges?
- $\alpha + \beta + \gamma = \pi$?

To probe α take a charmless CP eigenstate:



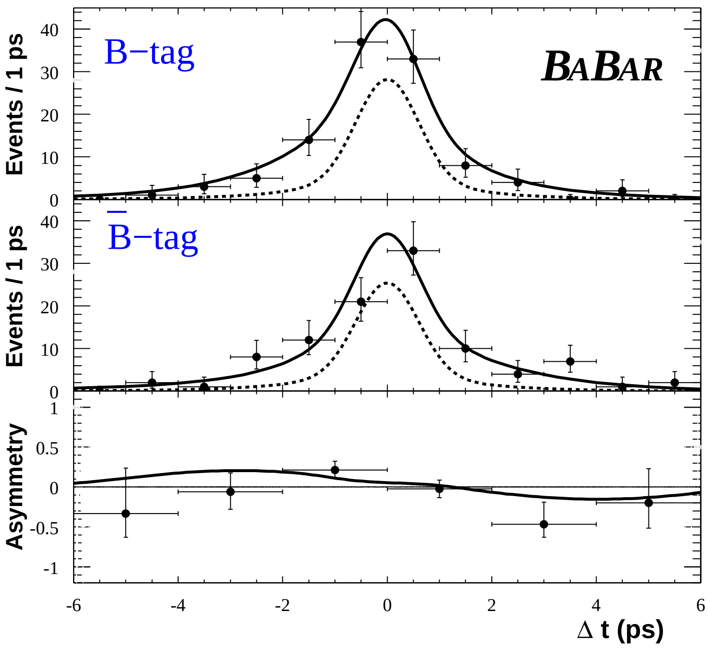
- P/T~ 0.3 from BR($\pi\pi/K\pi$).
- P&T not the same weak phase!

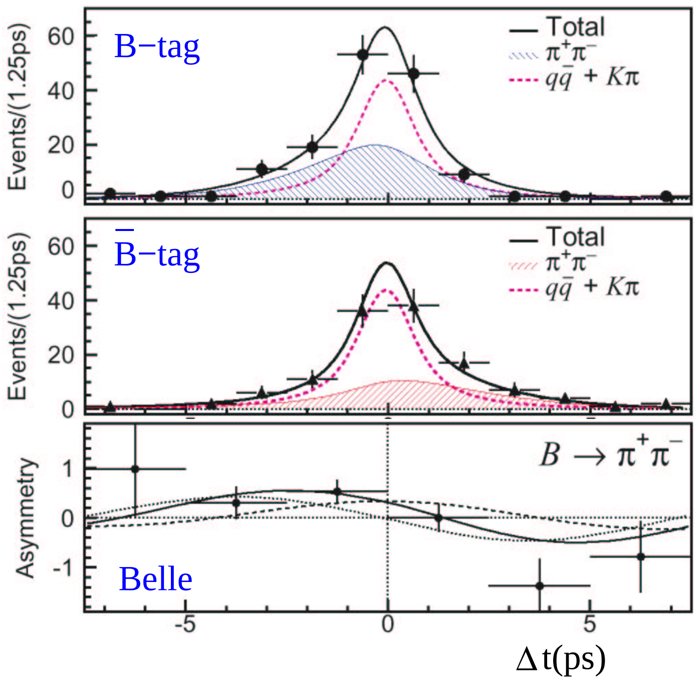
Large penguin effects (in B_d-decays), hence:

Measurements+symmetries+theory$\rightarrow \alpha, \gamma$

CPV in $\mathrm{B} \to \pi\pi$ (BR=5$\times 10^{-6}$)

Belle and Babar reconstruct $\sim 200\ \pi^+\pi^-$:





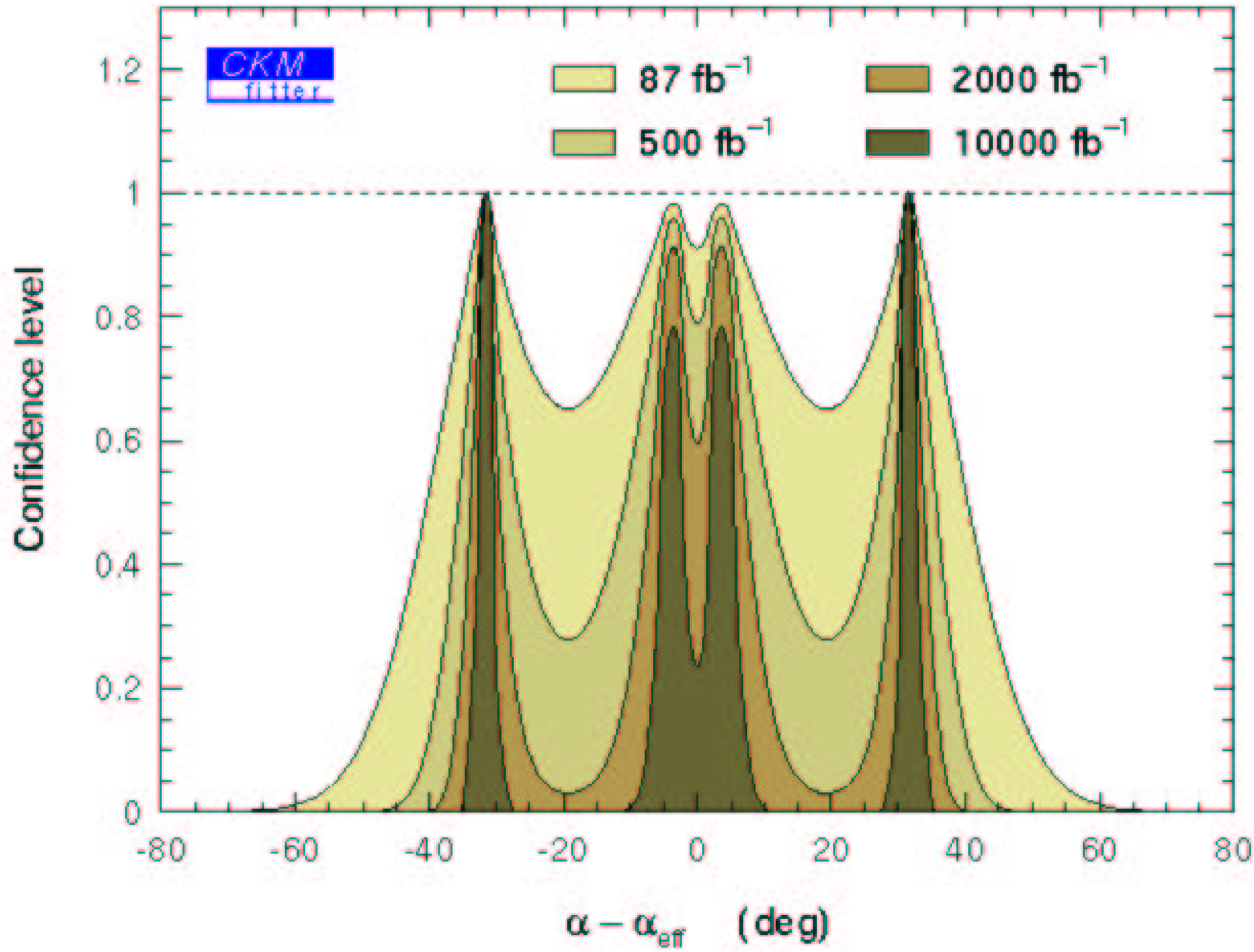
Extracted asymmetries:

	Babar	Belle
$\int L$	113 fb^{-1}	78 fb^{-1}
$\mathrm{A}^{\mathrm{mix}}$	$-0.40 \pm 0.22 \pm 0.03$	$-1.23 \pm 0.41^{+0.08}_{-0.07}$
$\mathrm{A}^{\mathrm{dir}}$	$0.19 \pm 0.19 \pm 0.05$	$0.77 \pm 0.27 \pm 0.08$

- $\mathrm{A}^{\mathrm{mix}}\&\mathrm{A}^{\mathrm{dir}} \to\ \sin(2\alpha_{\mathrm{eff}})$: $\Delta\alpha = \alpha_{eff} - \alpha$
- New measurement of BR($\mathrm{B} \to \pi^0\pi^0$):
  $|\Delta\alpha| < 48^\circ$, hence not constraining...

Full Isospin Analysis to Constrain $\Delta\alpha$

Use Babar central values, increase statistics...



Even with 2000 fb^{-1} $\Delta\alpha$ cannot be pinned down!

What will we know in $<$2007?

Babar and Belle together will have accumulated $\sim 1000\ \mathrm{fb}^{-1}$, hence roughly $10^9\ \mathrm{b\bar{b}}$-pairs :

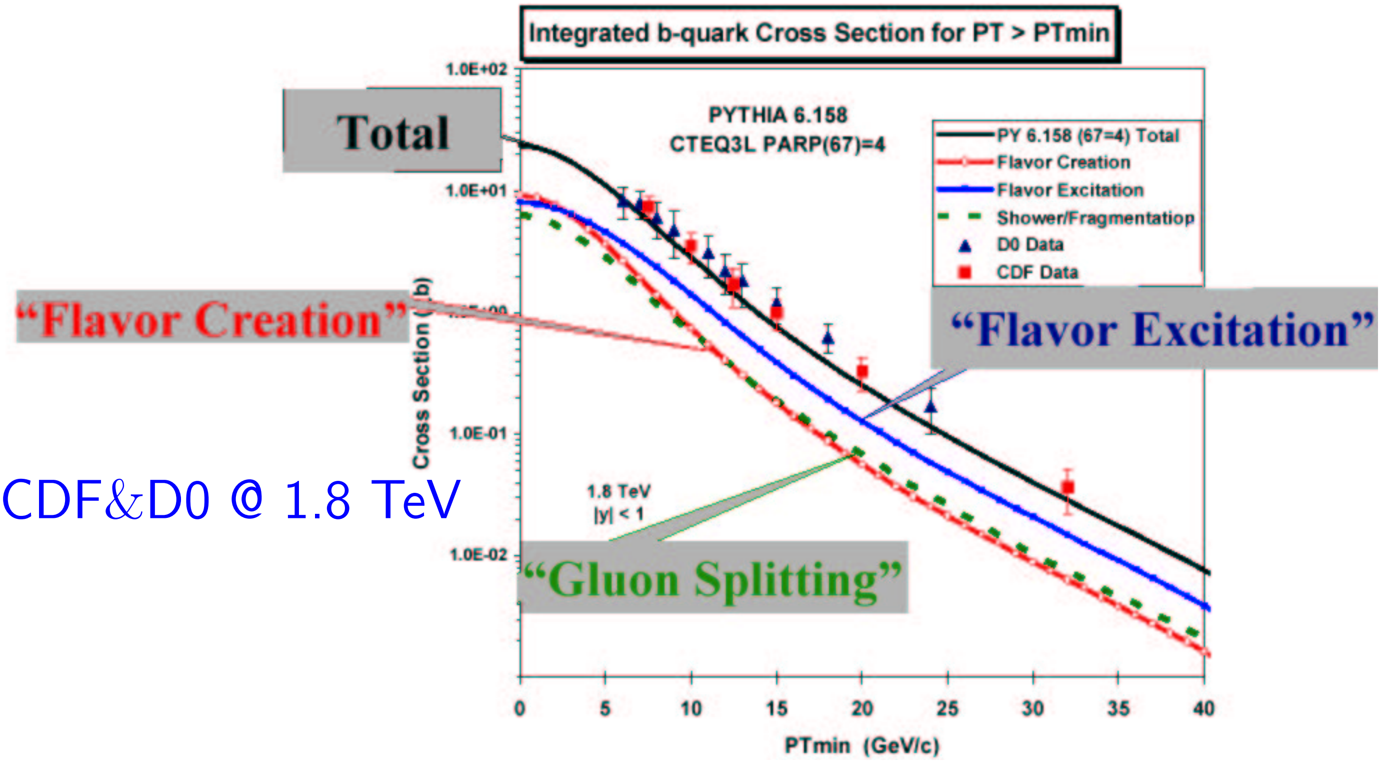
- $\sin(2\beta)$ will be know to ∼0.025 from $\mathrm{J}/\psi\mathrm{K_S}$.
  But probably not even enough increase in statistics to reconcile $\phi\mathrm{K_S}$ discrepancy between two experiments, let alone establish a signal for new physics.
- α, γ: No precise measurement of either of these angles.

What is needed?

Increase Statistics
AND
Study ALL B-hadrons

The Large Hadron Collider allows both.

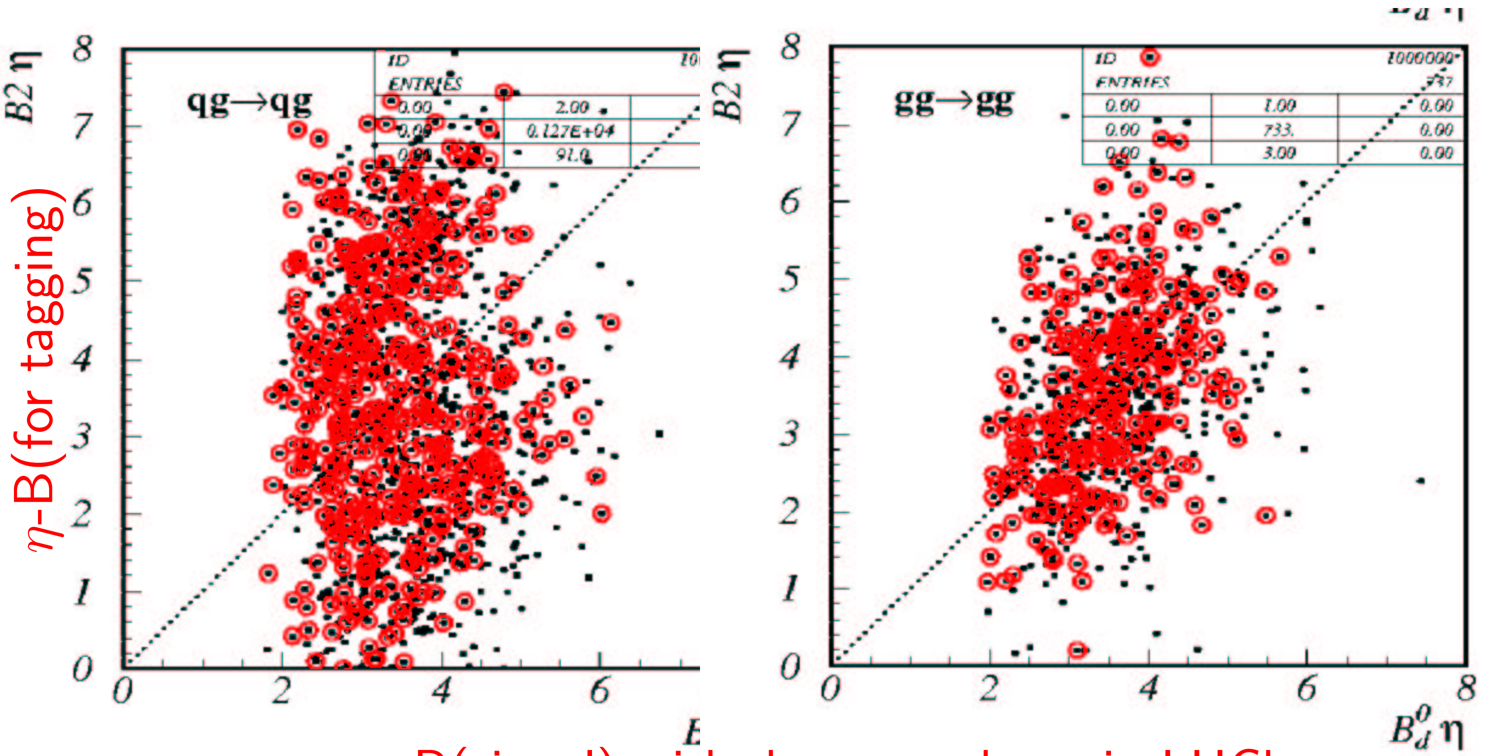
$b\bar{b}$ production at the LHC



CDF&D0 @ 1.8 TeV

PYTHIA at 14 TeV predicts $\sigma_{b\bar{b}} = 633\ \mu$b, with flat η-distribution up to $\eta = 4-5$ (down to ~ 15 mrad)

But also need to "tag" the b-flavour:



η-B(signal) with decay products in LHCb

Comparison B-factory⇔LHC

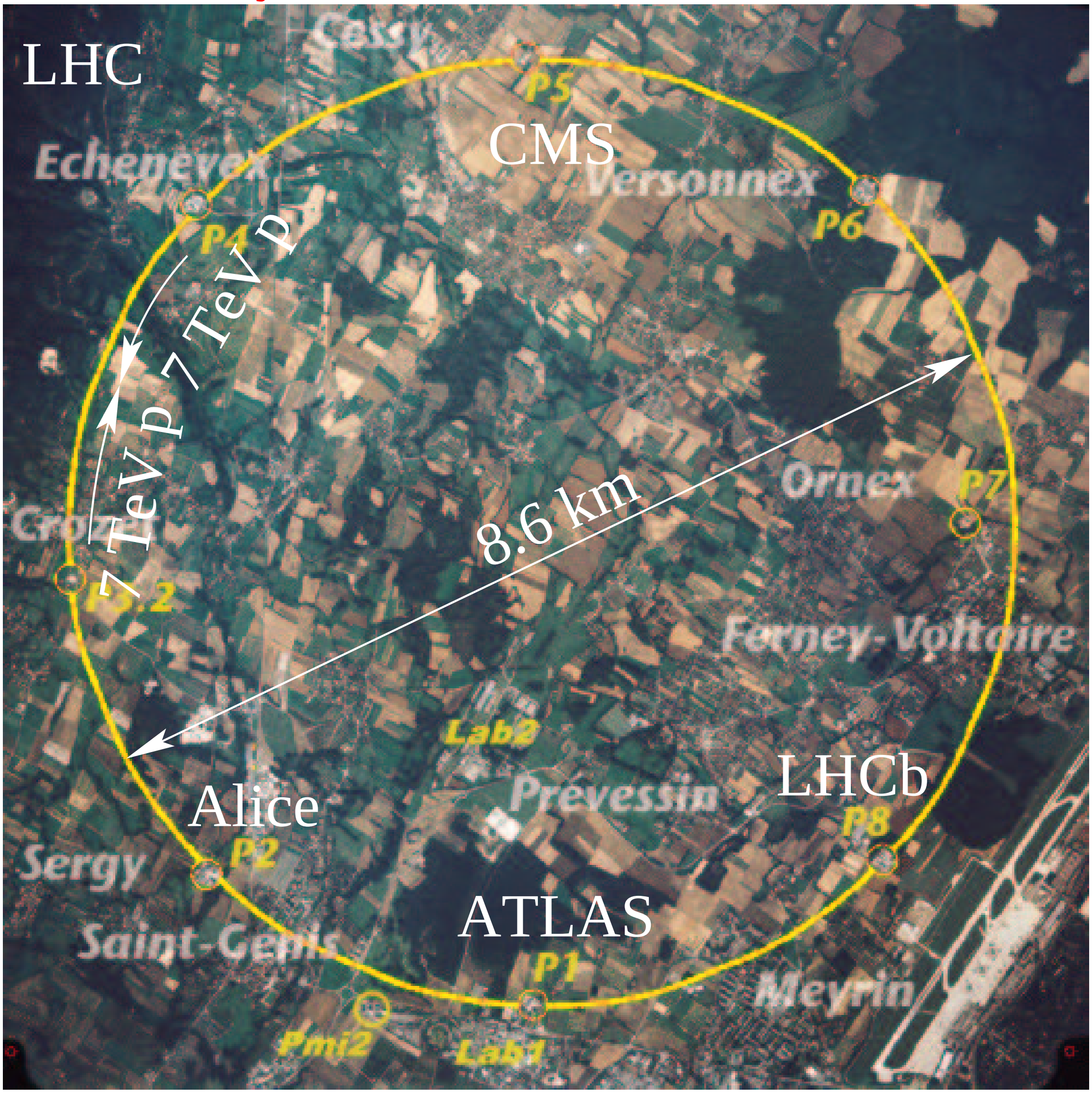
☺ $L \times \sigma(b\bar{b})$ 10000 times larger at LHC(b).

☺ At LHC produce also $\mathrm{B_s}$, $\mathrm{B_c}$ and baryons.

☹ $\sigma(b\bar{b})/\sigma_{total} = 30\times$ larger at the LHC.

☹ LHC: radiation damage issues.

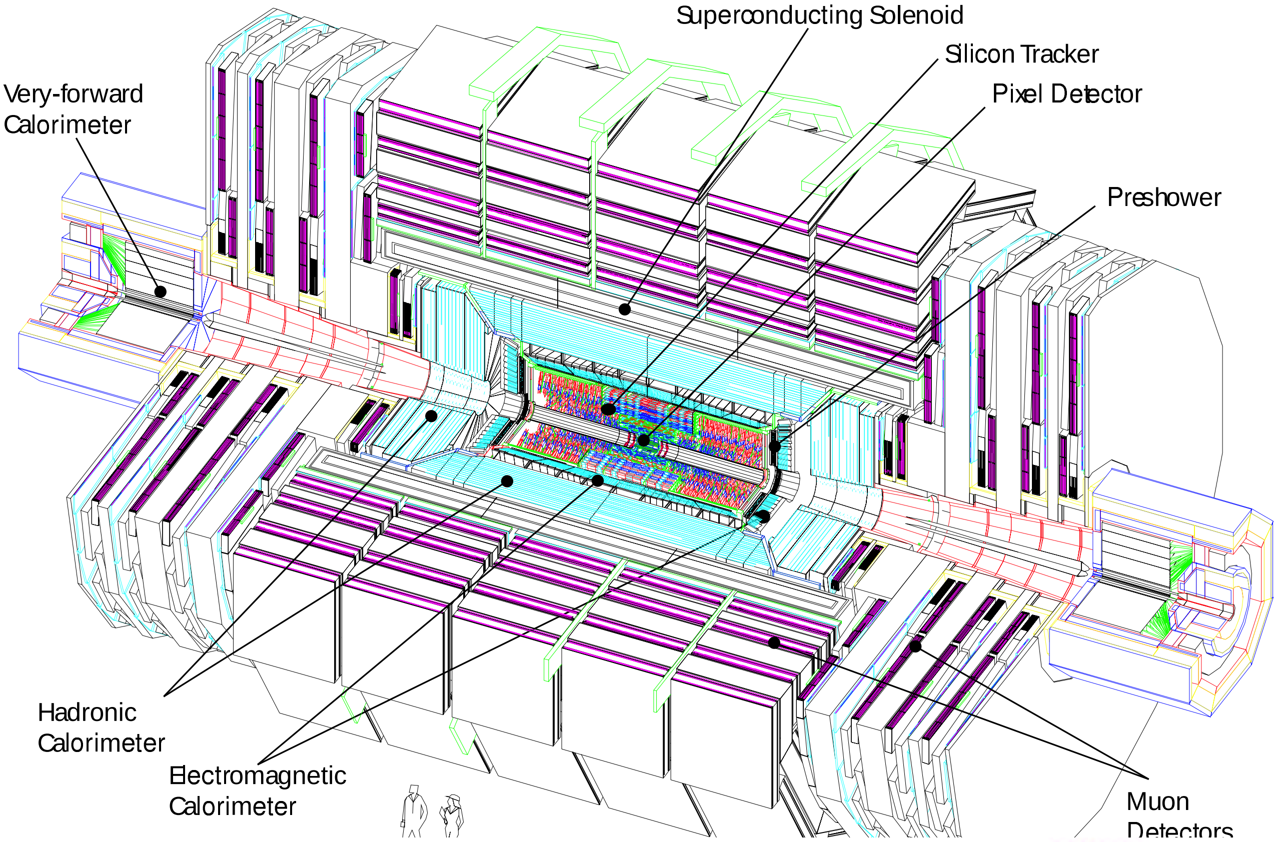
☹ Tagging at LHC more diluted: more particles and $\mathrm{b\bar{b}}$-pairs do not evolve coherently.



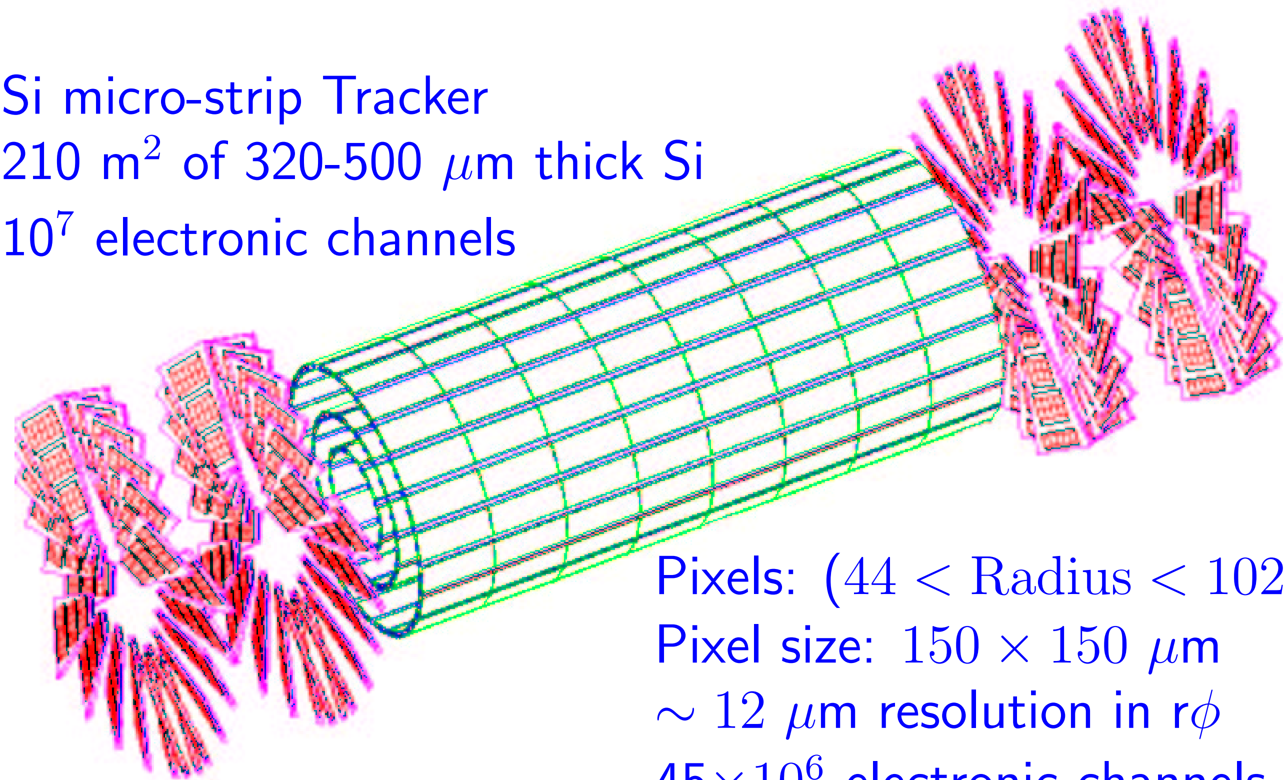
LHC B-Physics Experiments

- High p_T central detectors: ATLAS and CMS
  - Coverage -2.5$< \eta < 2.5$
  - Optimized for "direct searches" of Higgs and SuSy.
  - During LHC startup phase ($L \sim 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$) can trigger on "low" p_T leptons.
  - No π/K/p identification.
- Dedicated B-physics experiment: LHCb
  - Coverage $1.9 < \eta < 4.9$
  - Optimized for low p_T physics
  - Beam optics allow running at $L \sim 2 \times 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, even when Atlas/CMS run at $L \sim 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
  - RICHes for PID
  - Dedicated B-trigger including hadrons.

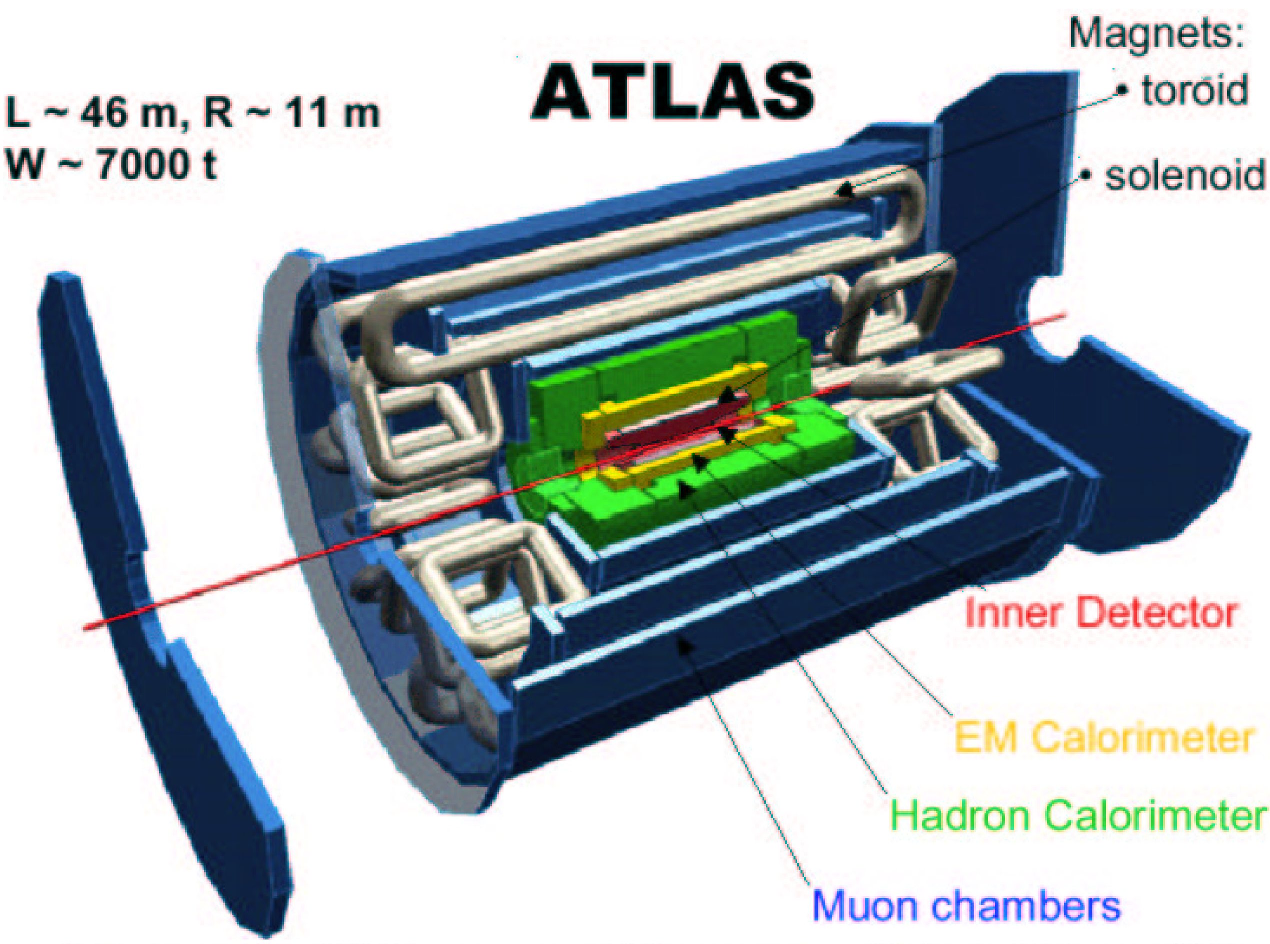
Compact Muon Solenoid

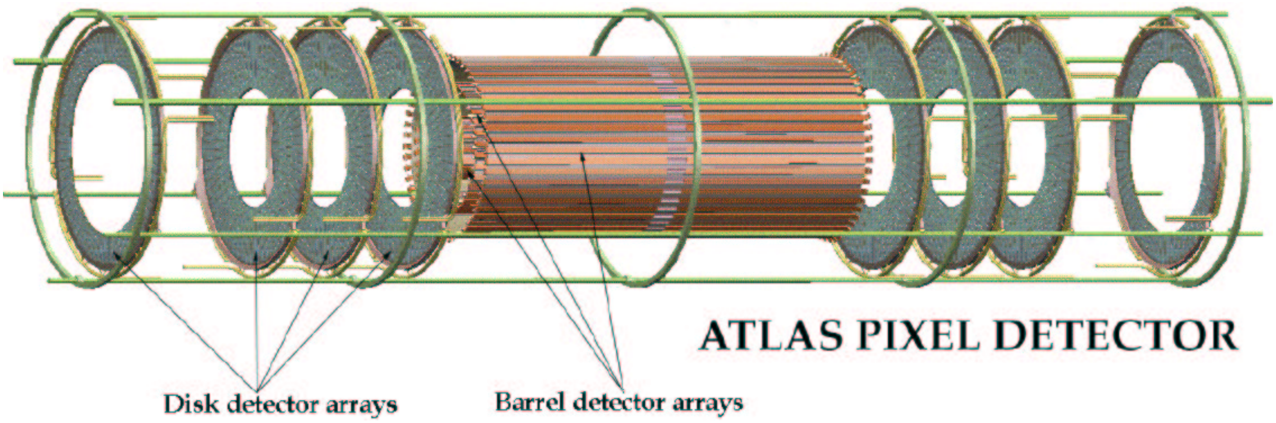


Si micro-strip Tracker
210 m^2 of 320-500 μm thick Si
10^7 electronic channels

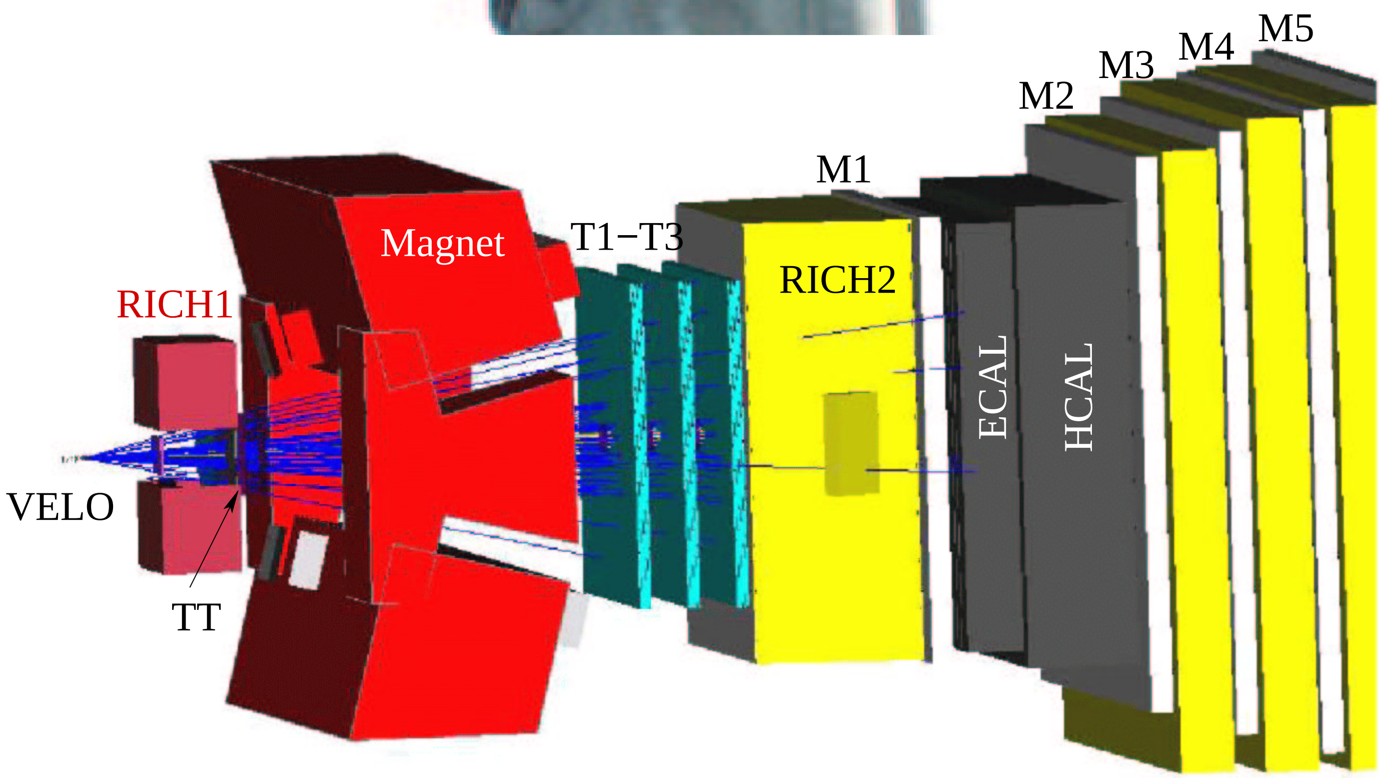


Pixels: $(44 < \mathrm{Radius} < 102$ mm)
Pixel size: 150×150 μm
~ 12 μm resolution in rϕ
$45{\times}10^6$ electronic channels
Three barrel layers (2 at startup?)

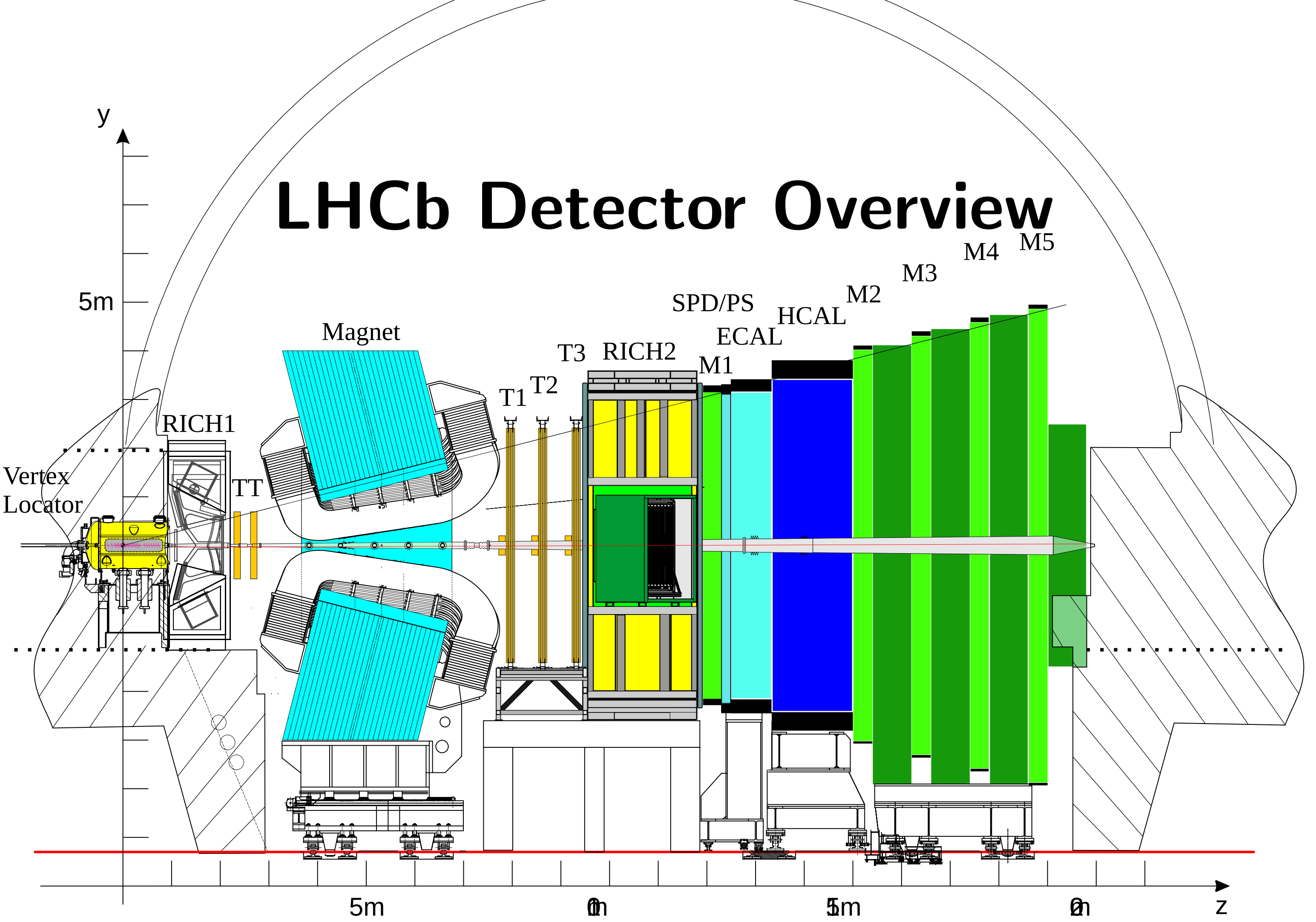




- Pixels (5$<$ Radius $<$ 13 cm): 50×300 μm
- Three barrel pixel layers, $2\ \mathrm{m}^2$, again 2 at startup?
- $80{\times}10^6$ channels
- ~ 12 μm resolution in rϕ
- Si-strips: 65 m^2, 6×10^6 channels

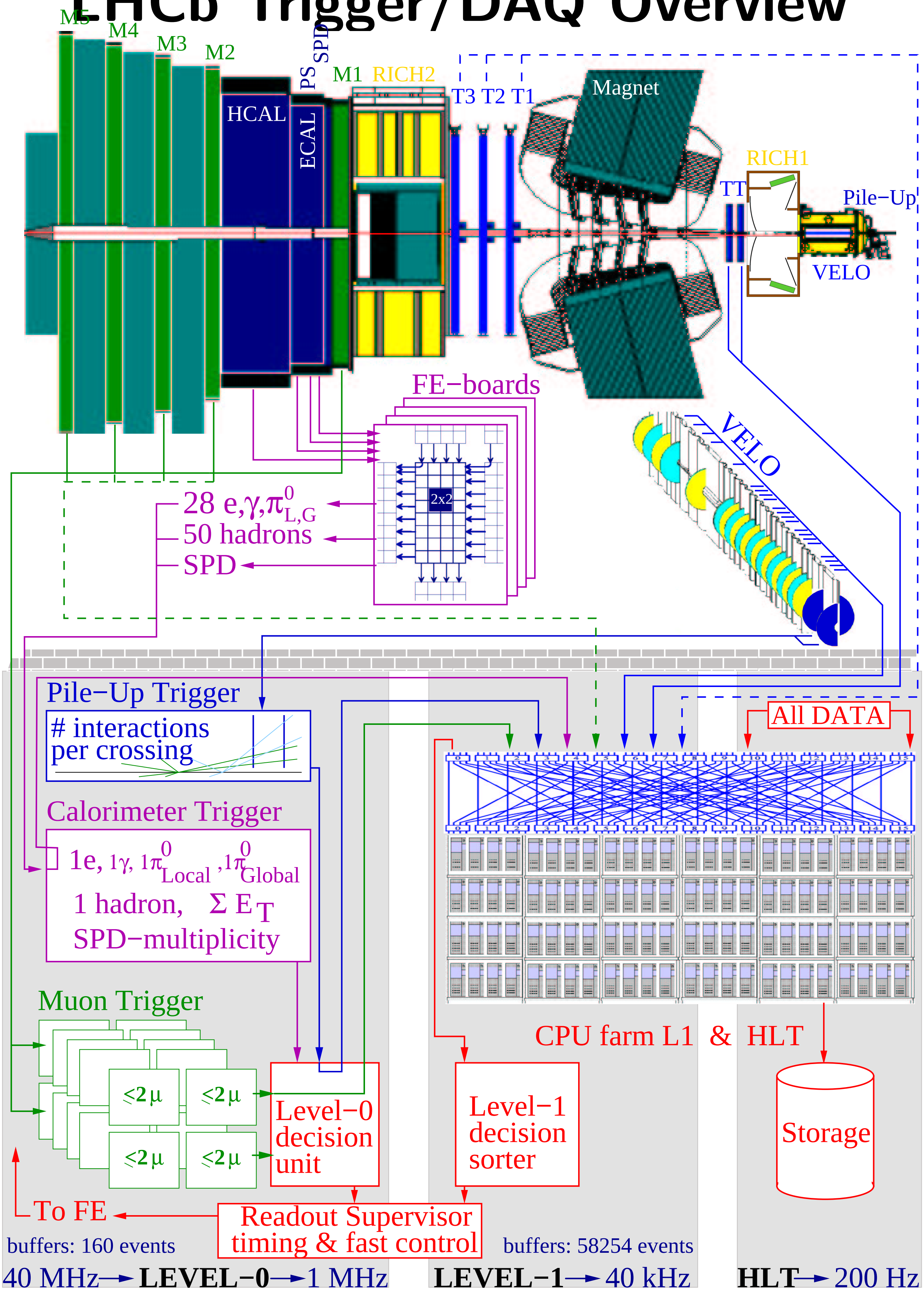

M5
M4
M3
M2
M1
Magnet
T1−T3
RICH2
RICH1
ECAL
HCAL
VELO
TT

LHCb Detector Overview

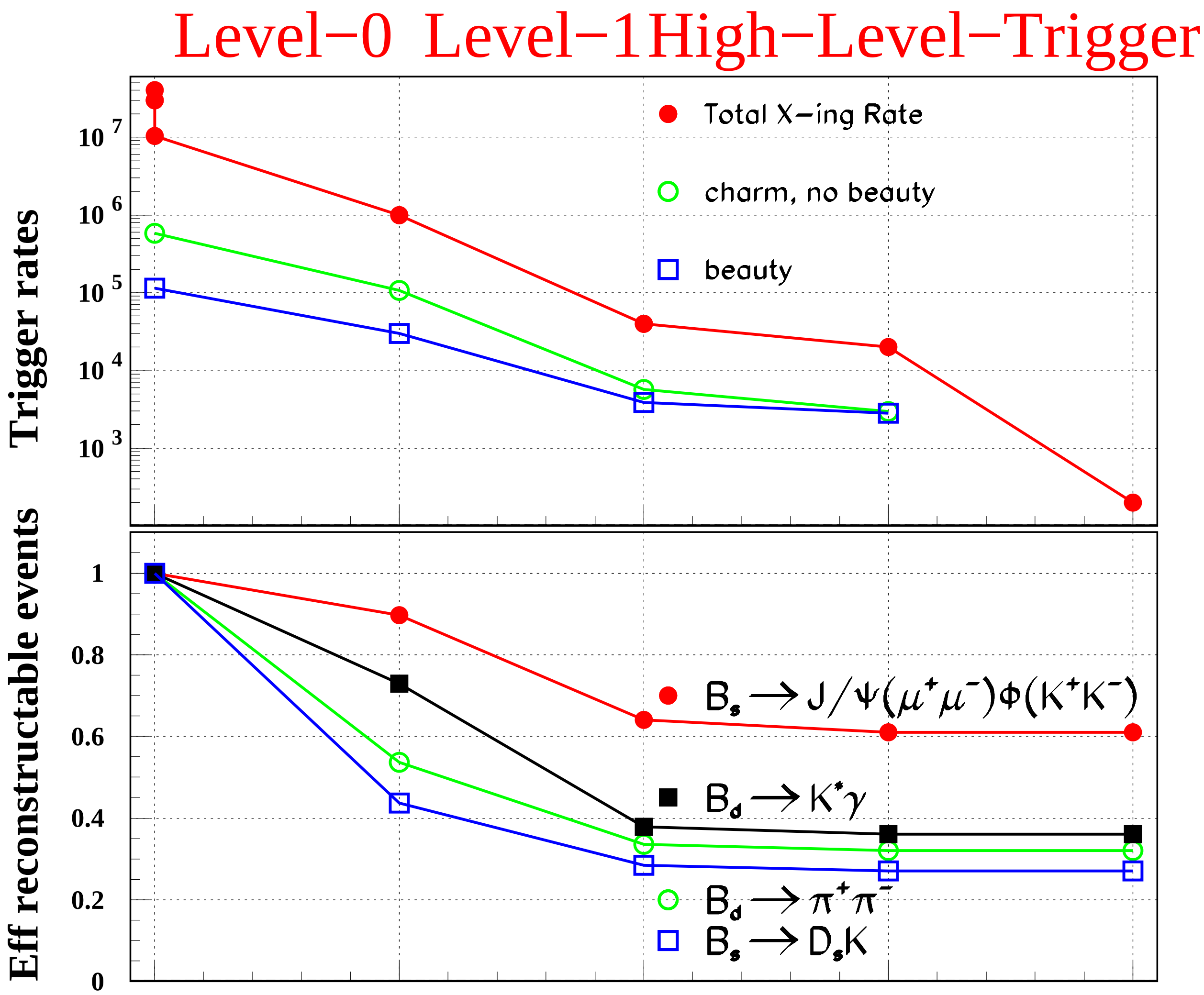


- VELO: Si-vertex detector.
- Two RICH detectors to separate $\pi/K/p$
- Dipole magnet: 4 Tm.
- Trigger Tracker: Si-planes for tracking.
- T1-T3: Tracking stations, Straws/Si.
- M1-M5: MWP Muon Chambers.
- Calorimetry: Scintillating Pad detector (SPD), Pre-Shower (PS), ECAL and HCAL.
- and the Trigger and DAQ →

LHCb Trigger/DAQ Overview

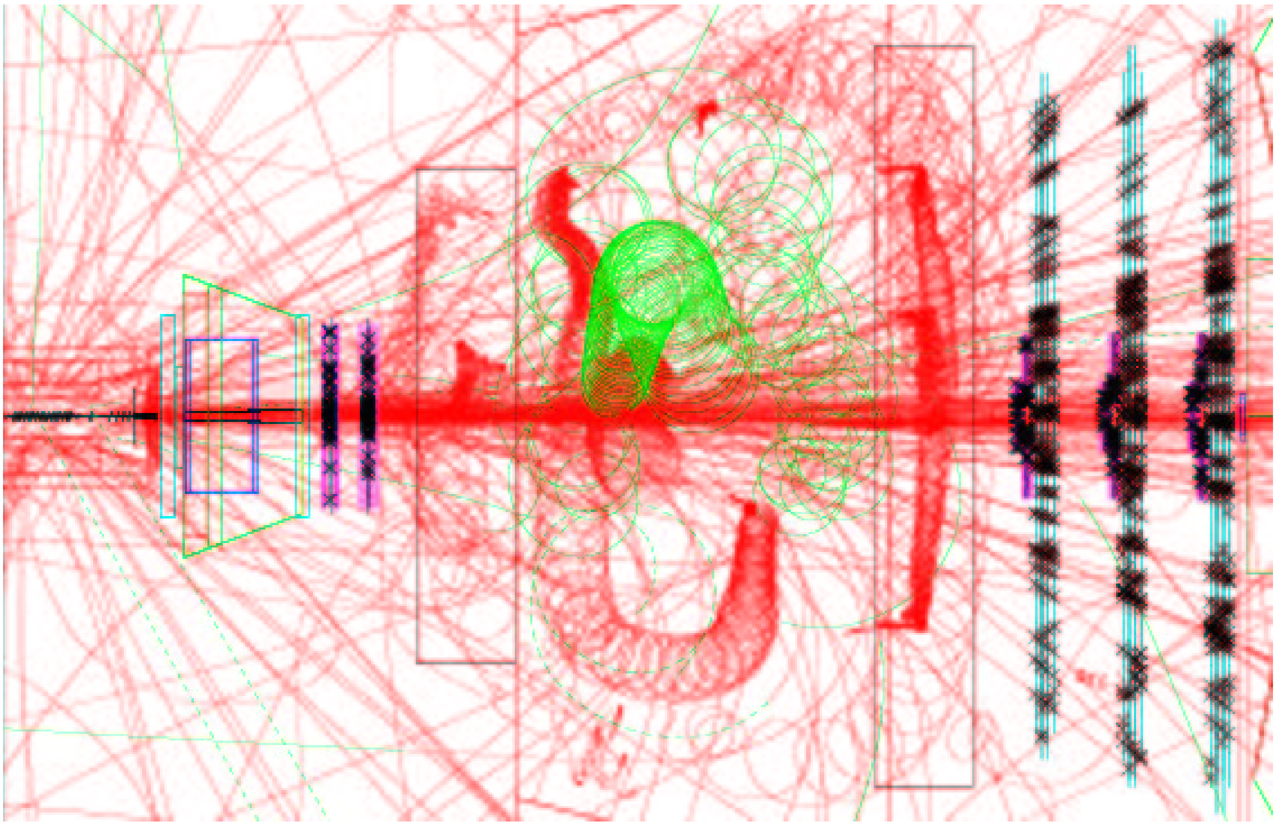


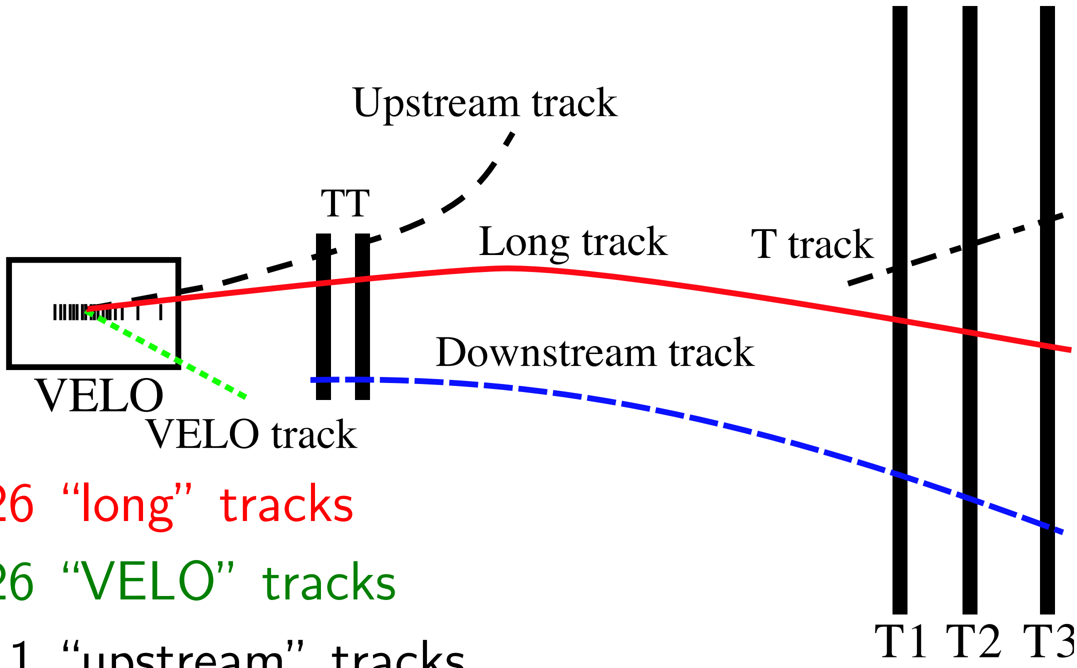
LHCb Rates Overview



- 40 MHz, but 30 MHz of x-ings with $\mathrm{p} \rightarrow\leftarrow \mathrm{p}$
- LHCb runs at $L{=}2{\times}10^{32}$ cm^{-2}s^{-1}.
- $\sigma_{\mathrm{pp}}^{\mathrm{visible}}$ ~60 mb: →~10 MHz of “visible” x-ings.
- Pile-Up, multiplicity: rate to ~8 MHz
- L0 highest E$_T$ μ,e,γ,π^0 and h: →1 MHz
- L1→40 kHz: finite lifetime and $\mathrm{p_T}$
- HLT→~ 200 kHz using “all” info.

A Typical B-event in LHCb

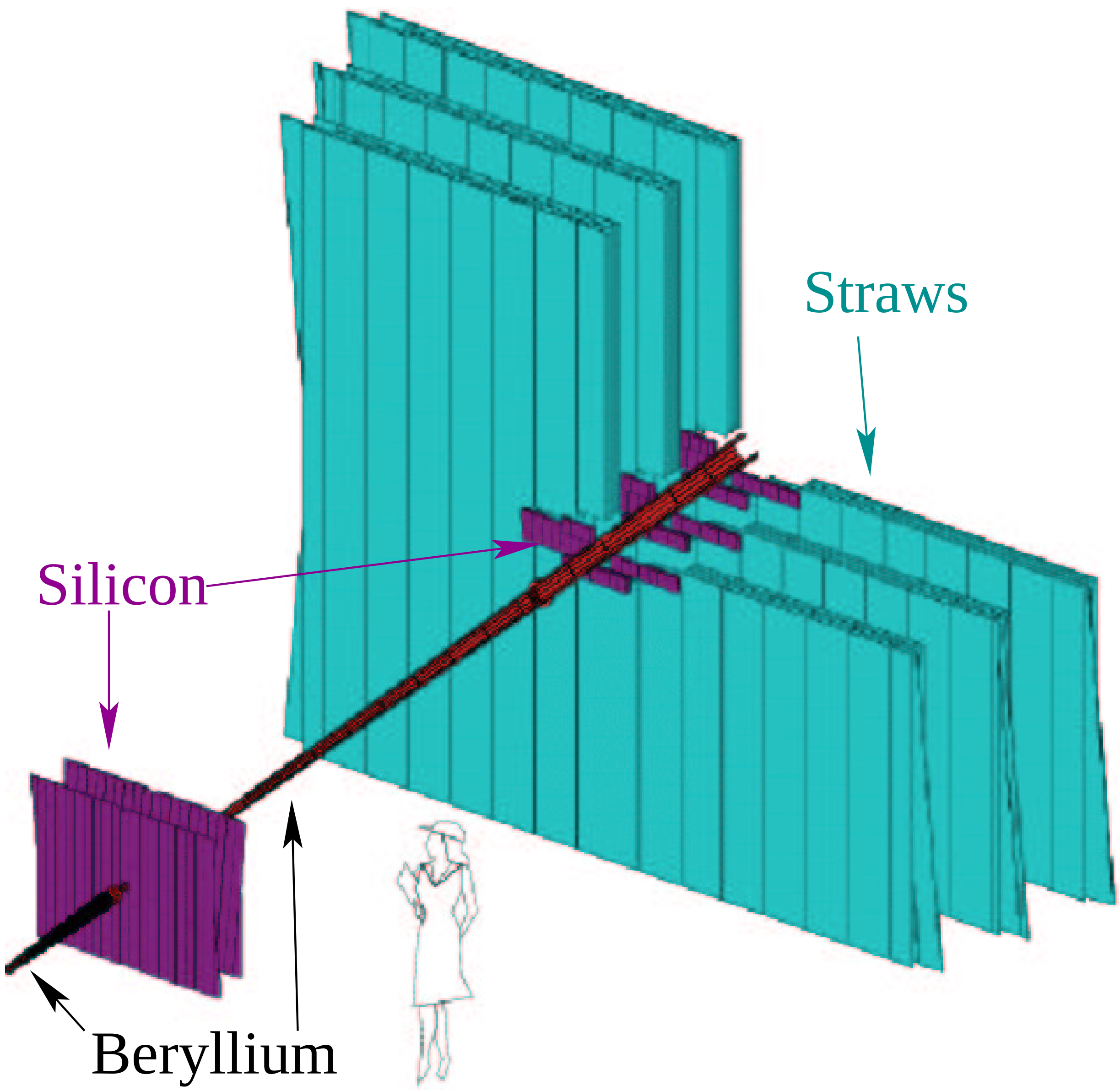




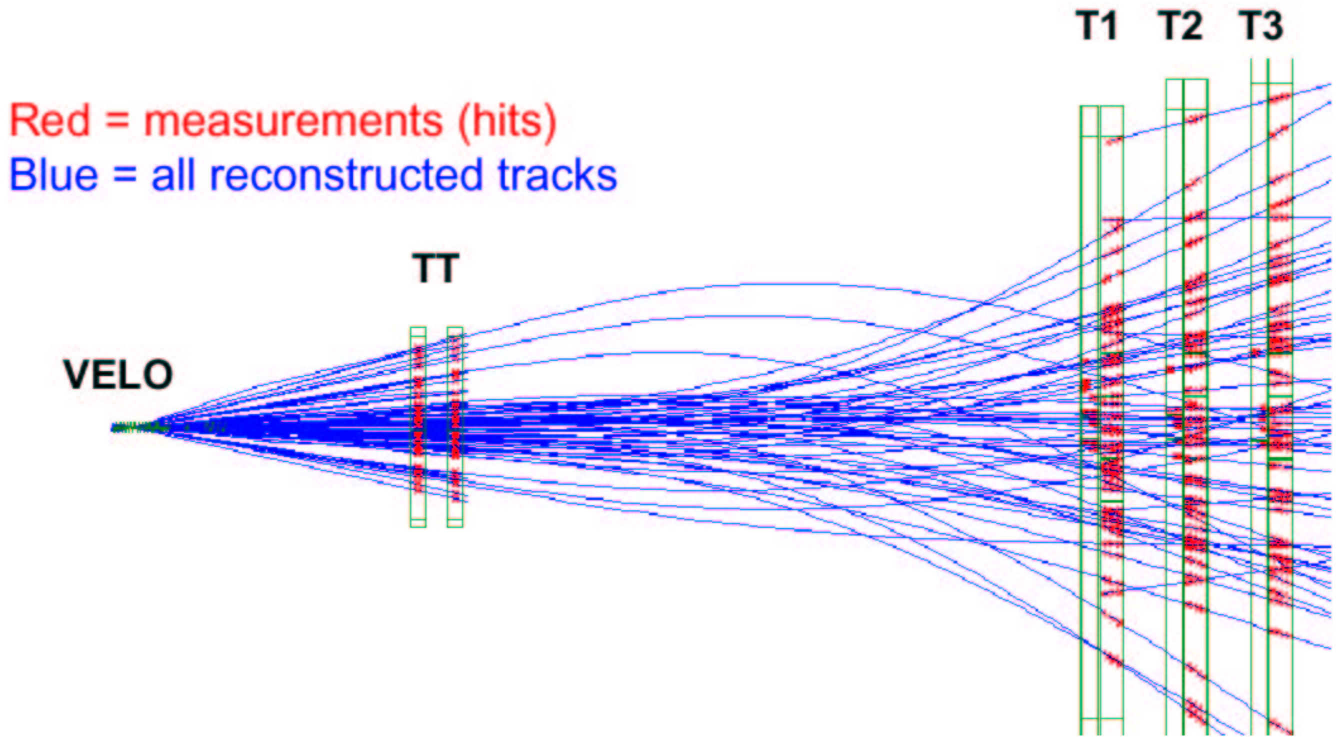
- 26 “long” tracks
- 26 “VELO” tracks
- 11 “upstream” tracks
- 4 “downstream” tracks

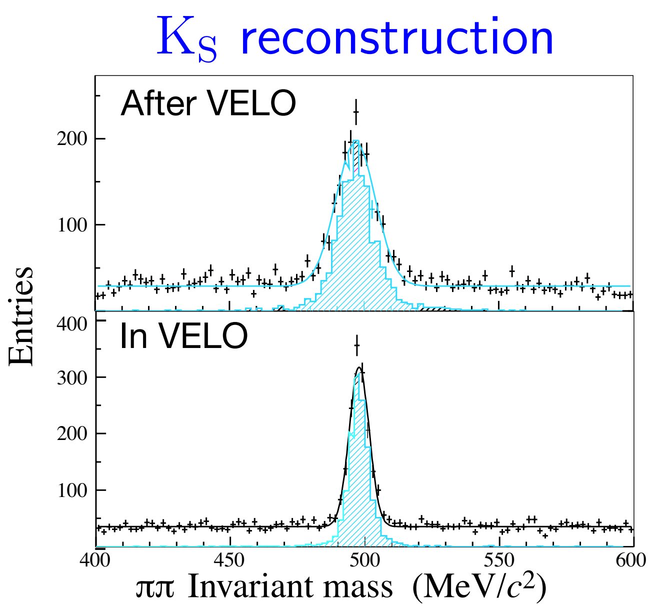
Tracking Stations

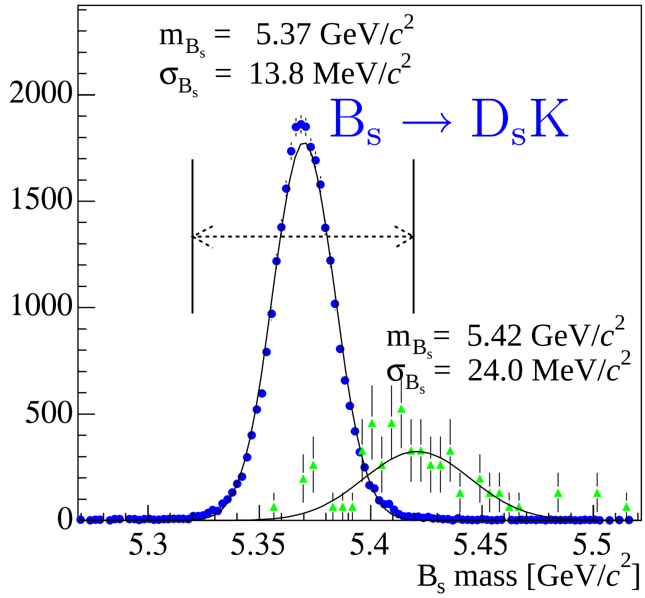
- Beryllium conical beam-pipe to avoid too many secondaries.
- 3×8 layers of 5 mm $\oslash$, 5 m long, straws, 0°, 5° stereo.
- $200\ \mu$m pitch Silicon, 0°, 5° stereo. $\sim 14\ \mathrm{m}^2$ of Si.



Tracking in LHCb



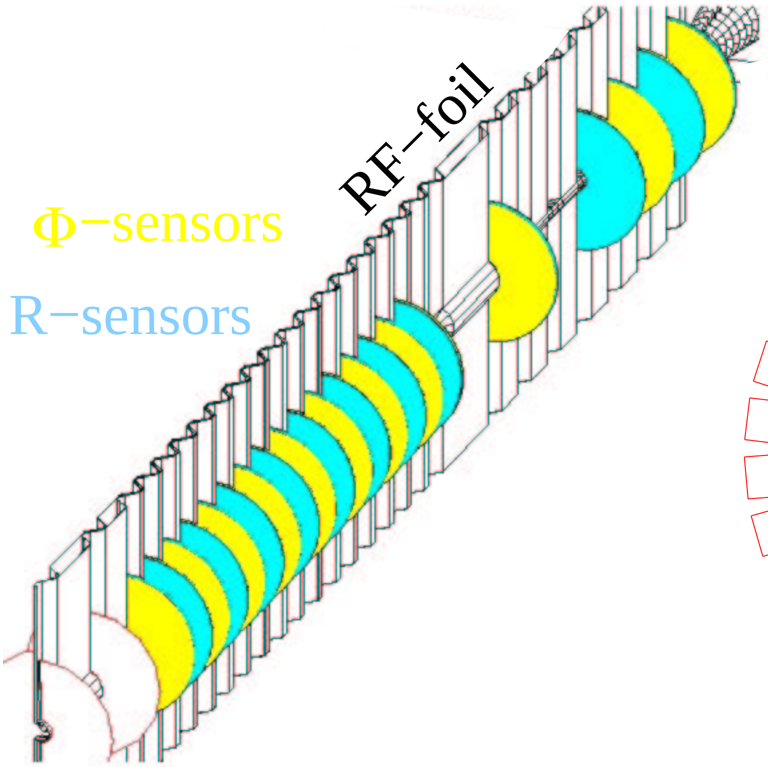


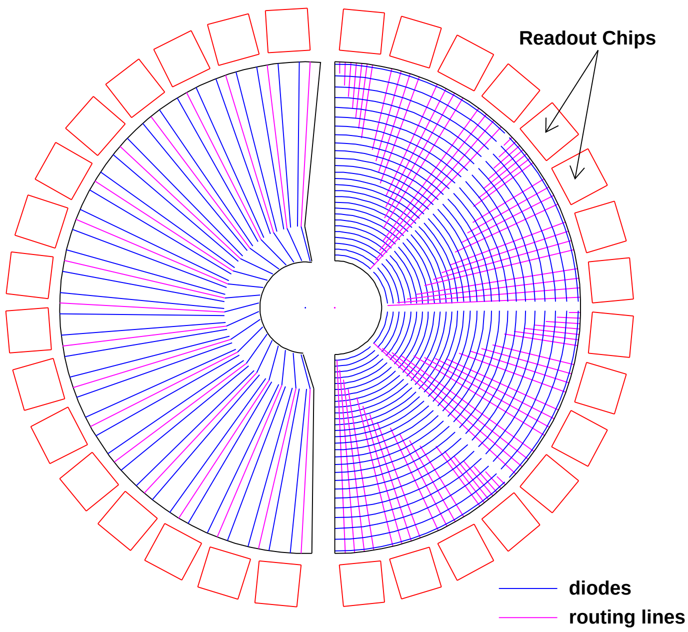


LHCb VELO

VELO "tasks":

- Provide precise tracking close to the B-vertex
- Stand-alone tracking capability
- Contribute to L1 and HLT triggers



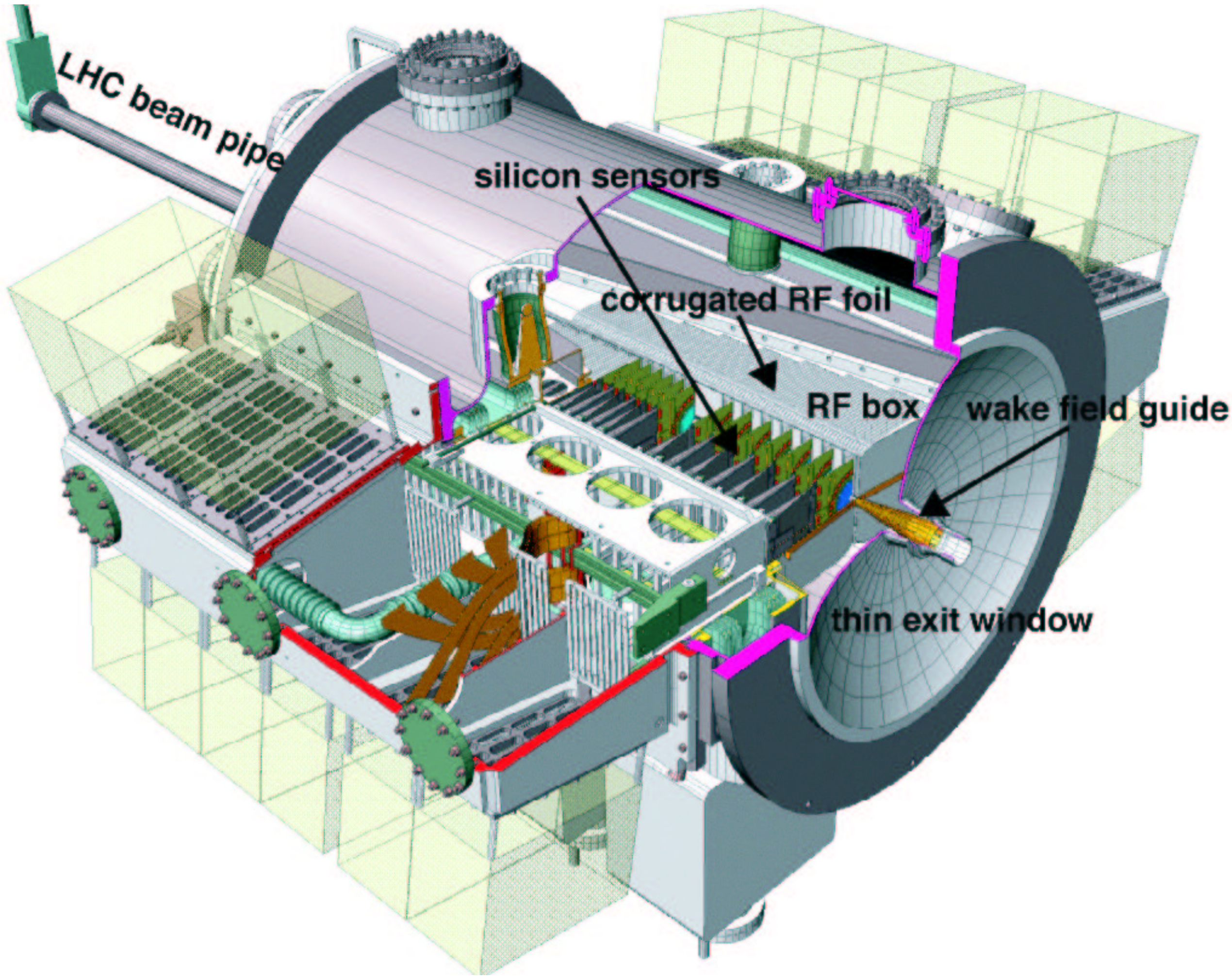


- VELO: 220μm thick Si, $40 - 100$ μm pitch, 170k channels, 0.23 m^2 of Si,
- Each station is a sandwich of a R and Φ-sensor.
- Φ-sensors have a 10-20° stereo angle.
- Sensitive Si-area: 8 mm from LHC beams
- But: during LHC injection 3 cm away from beam.
- VELO on XY-table to centre on beam-line.

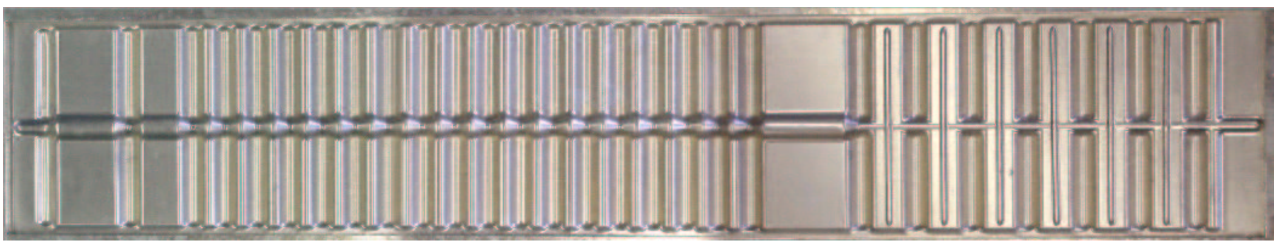
Critical issues: Roman-pot mounting, radiation damage.

VELO roles

VELO: two halves in a "Roman-pot".

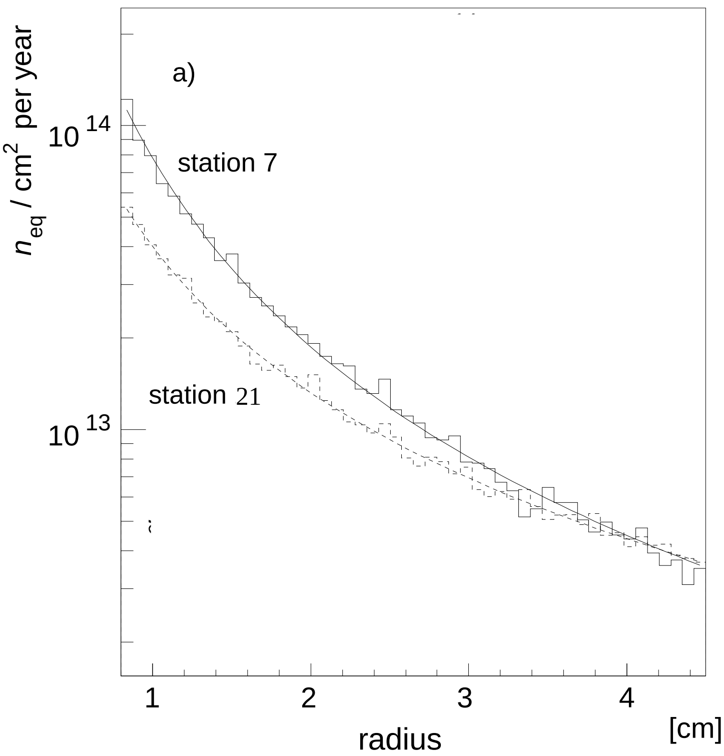


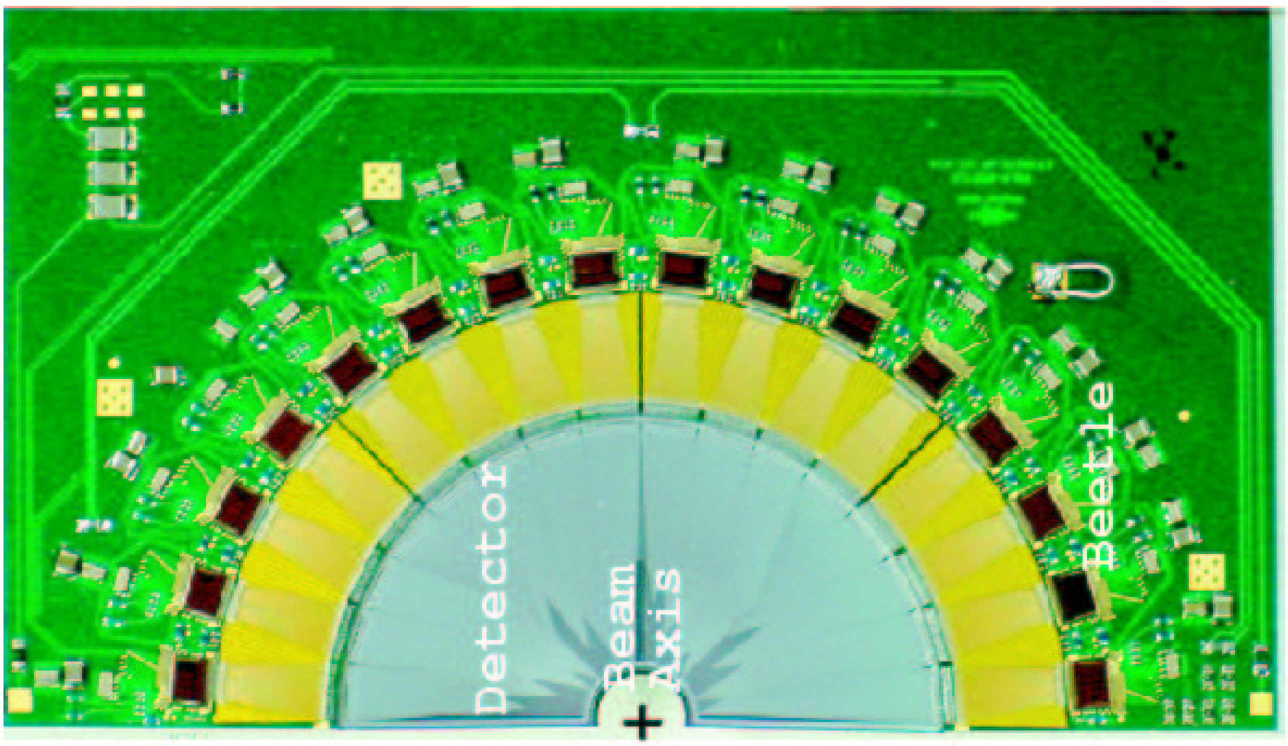
- Retractable by 3 cm left/right.
- Separated from LHC vacuum by $250\ \mu\mathrm{m}$ AlMg$_3$ corrugated foil.



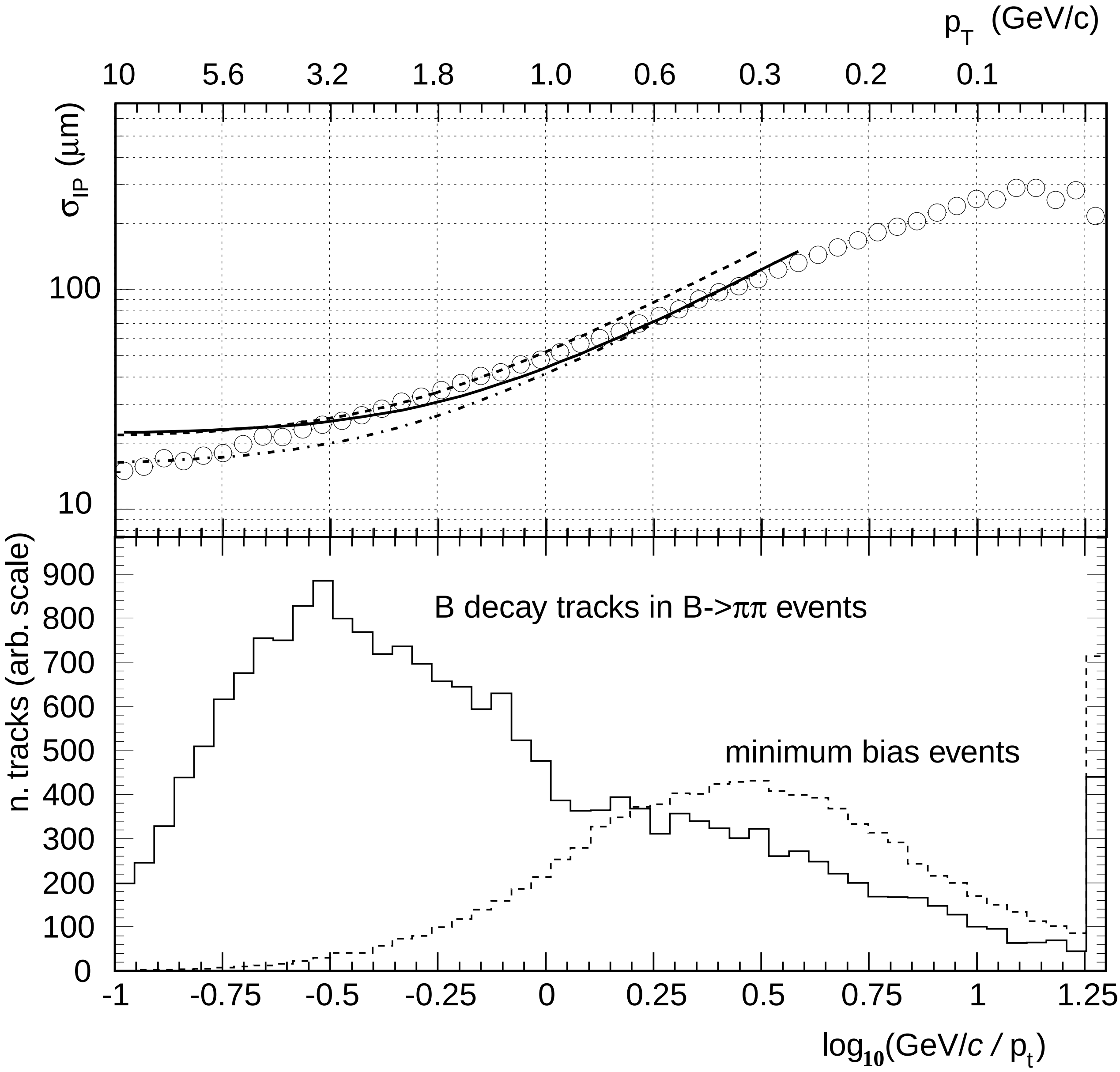
Radiation damage

- Close to beam: $\sim 10^{14}$ n/cm^2/year
- Dislocations in Si-cristal
- $< 0°$ C to freeze damage
- Survives 3-4 years
- Hence: replace (but small surface area)





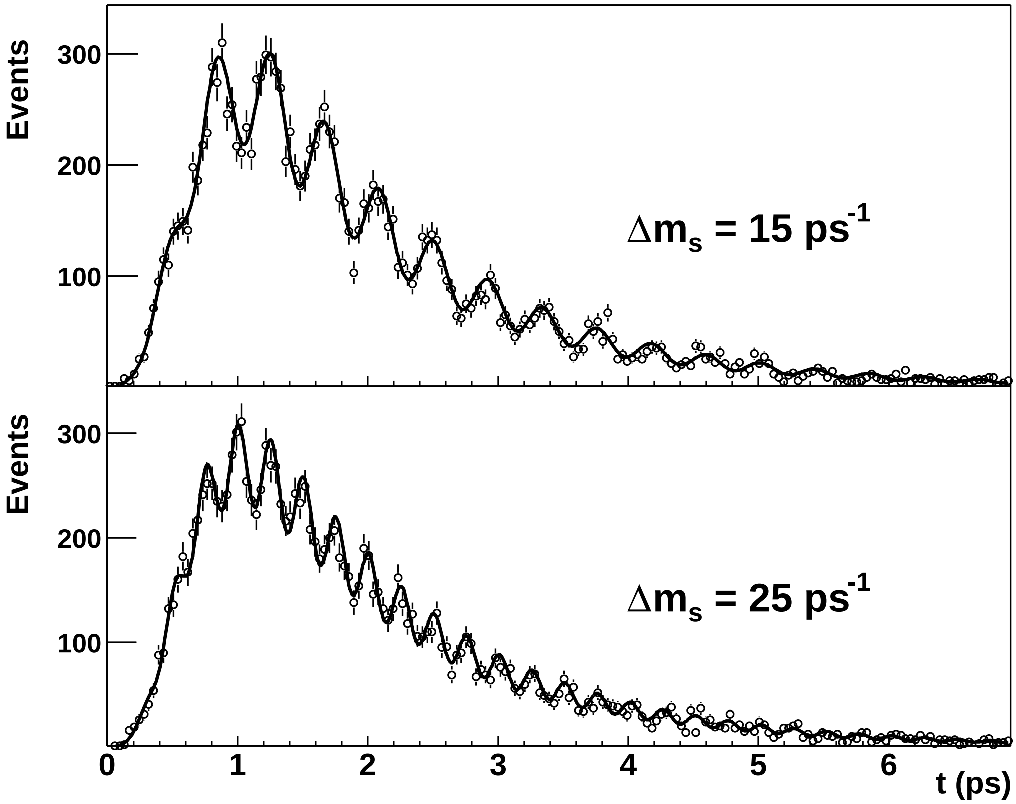
VELO performance

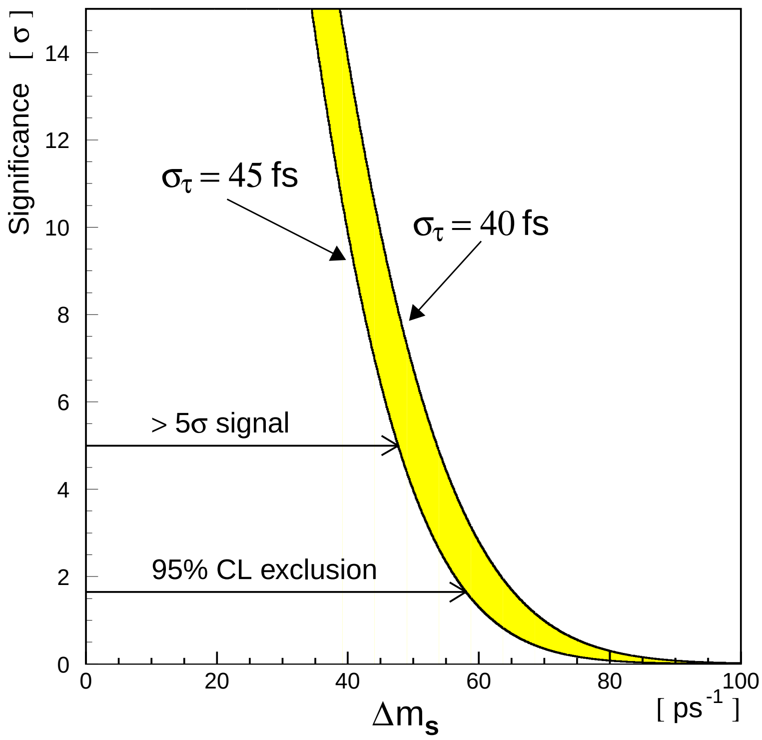


Working at the LHC (7 TeV beams!), still see multiple scattering effects!.
But for "most" B-tracks: $20 - 40$ μm impact parameter resolution
Typical B-vertex resolution 40 fs ($\tau_B = 1.5$ ps), hence:

LHCb Δm_s sensitivity

One year of running (10^7 s): Δm_s from 44 k $B_s \to D_s \pi$



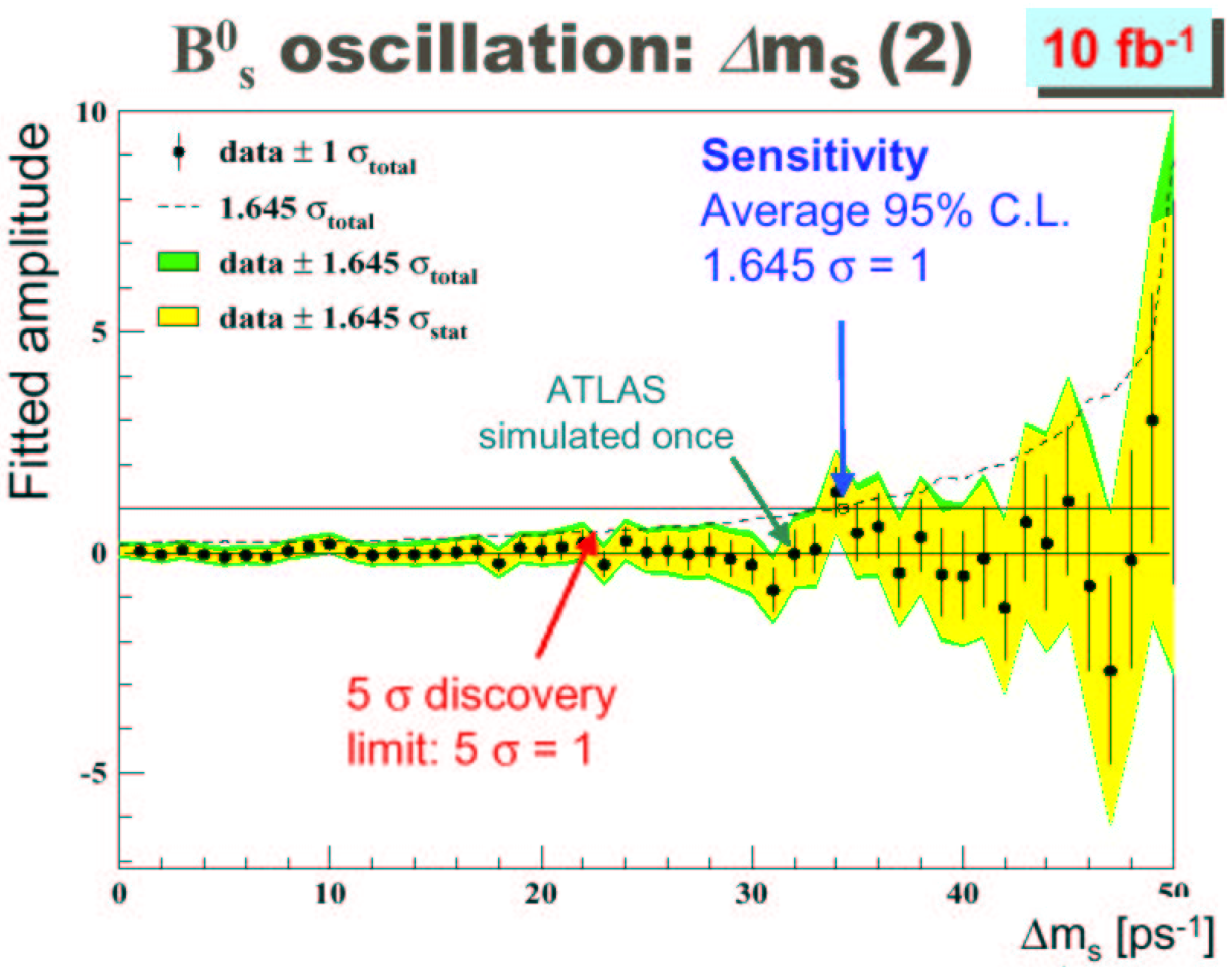


CMK-fit: expect $\sim 20\ \mathrm{ps}^{-1}$

ATLAS & CMS Δm_s sensitivity

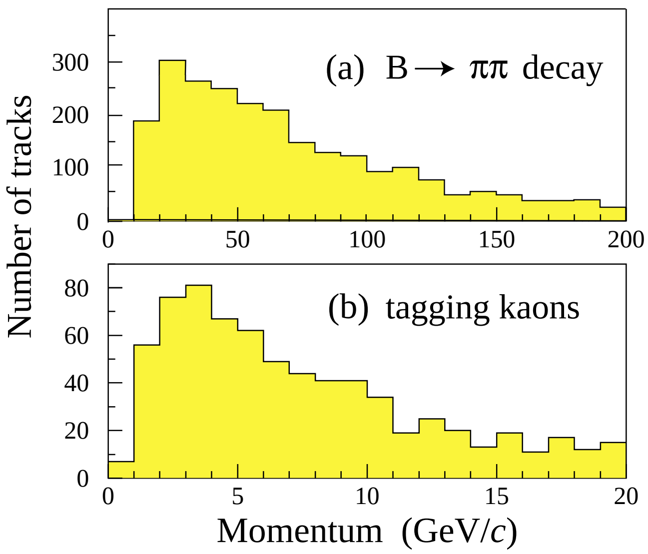
One year at $L = 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$

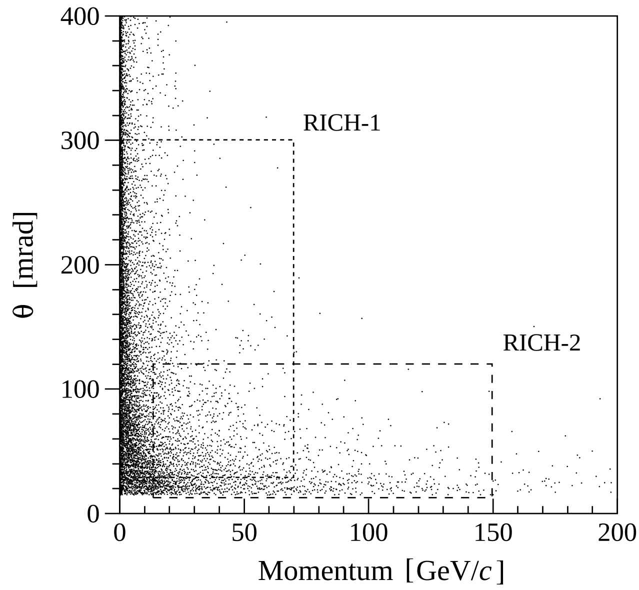
- Atlas
  - Tagged events/year: few k
  - Proper time resolution: $\sim\ 70\mathrm{ps}^{-1}$
- CMS:
  - Tagged events/year: few k
  - Proper time resolution: $\sim\ 65\mathrm{ps}^{-1}$



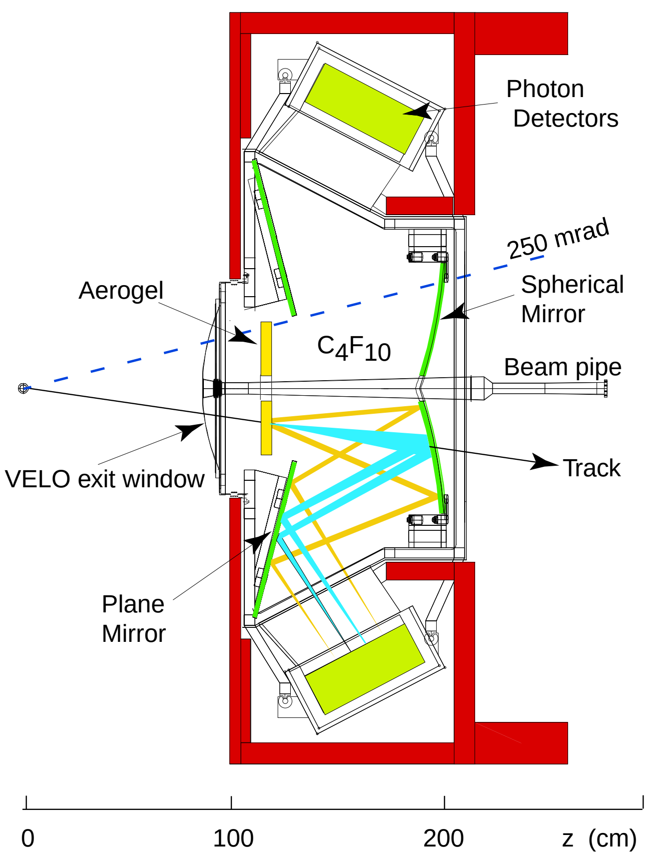
LHCb Particle Identification

What is the relevant momentum range?

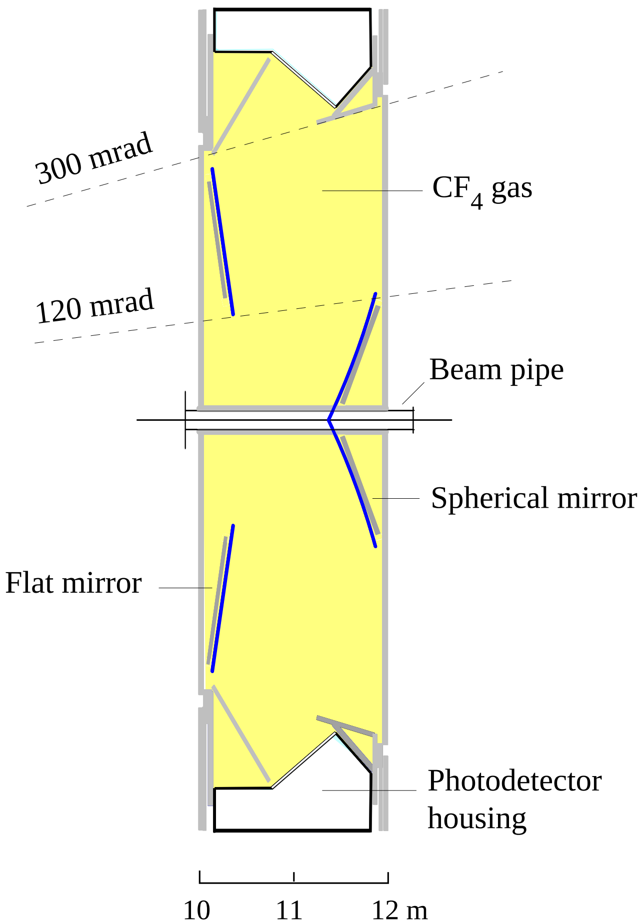




RICH1



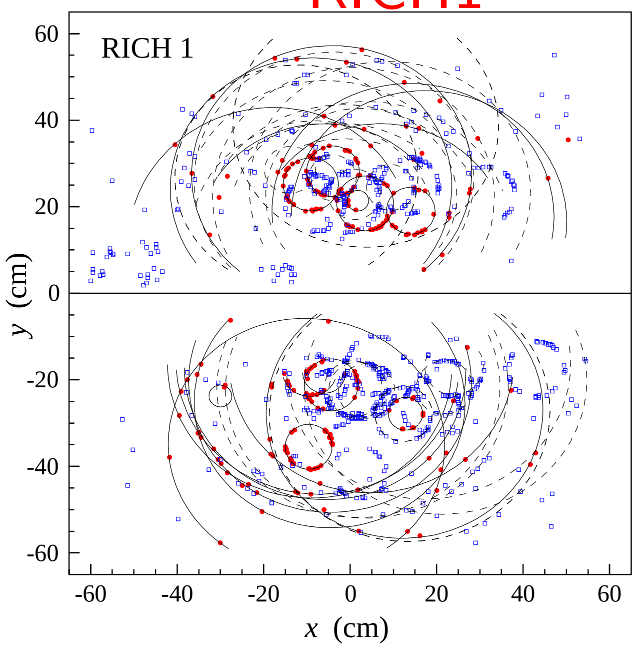
RICH2



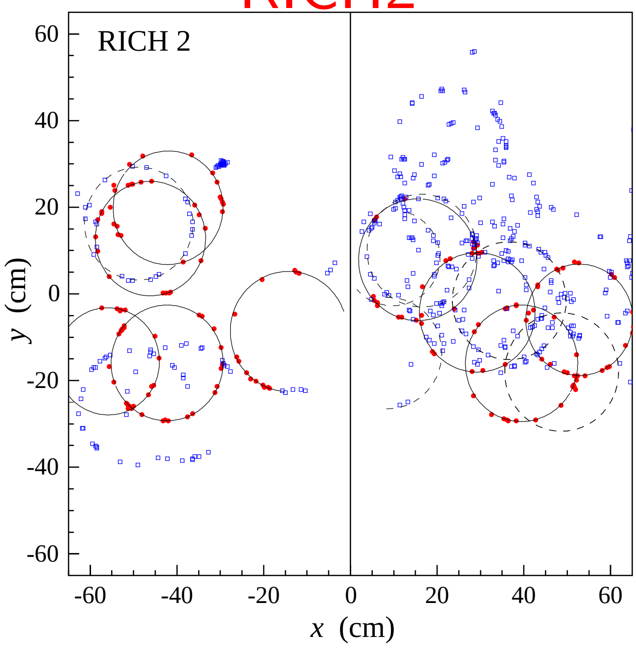
Photon Detections and Ring reconstruction

- cover 2.6 m^2 with segmented photon detectors
- Typical resolution required corresponds to pads of 2.5×2.5 mm^2
- Hybrid Photon Detectors (Si-pixel detectors incapsulated in photo-tube), or
- Multi-anode Photo Multipliers

RICH1



RICH2

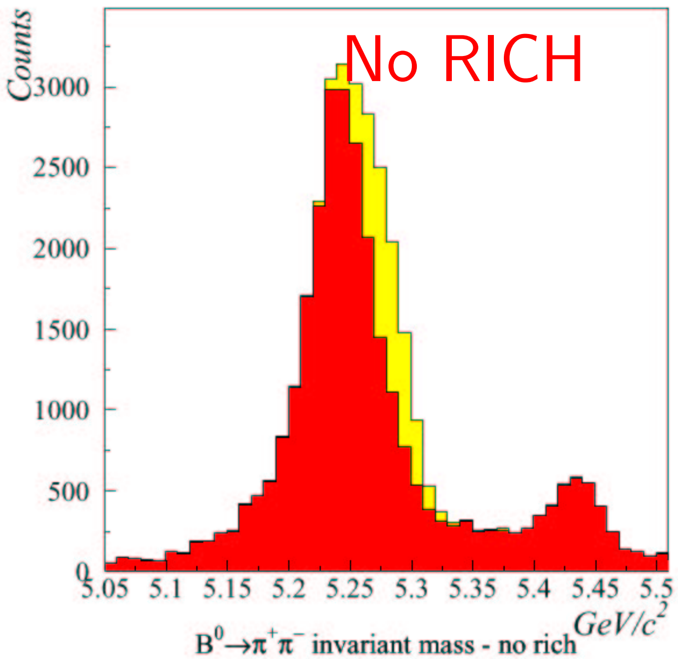


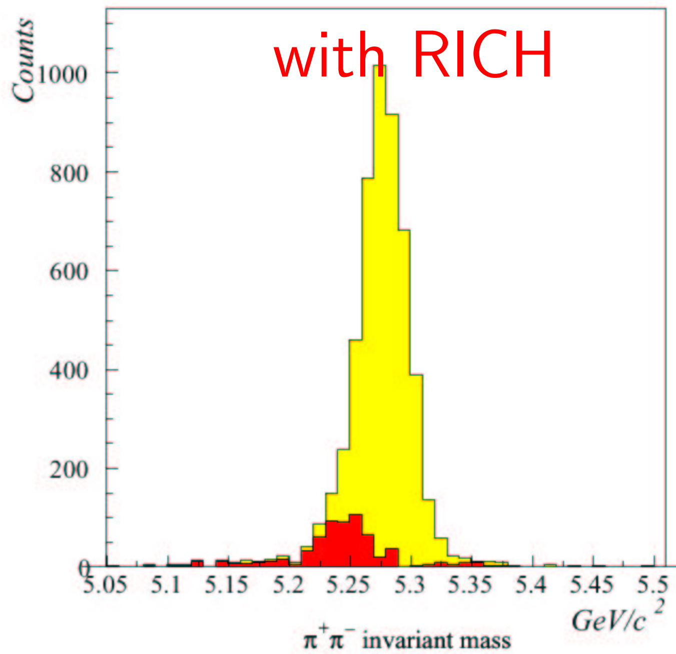
Rings obtained with “global” likelihood fit using all reconstructed tracks.

π/K **Separation**

$B_d^0 \to K^+\pi^-$, $B_s^0 \to K^+\pi^-$, $B_s^0 \to K^+K^-$,
$\Lambda_b \to pK$, $\Lambda_b \to p\pi$

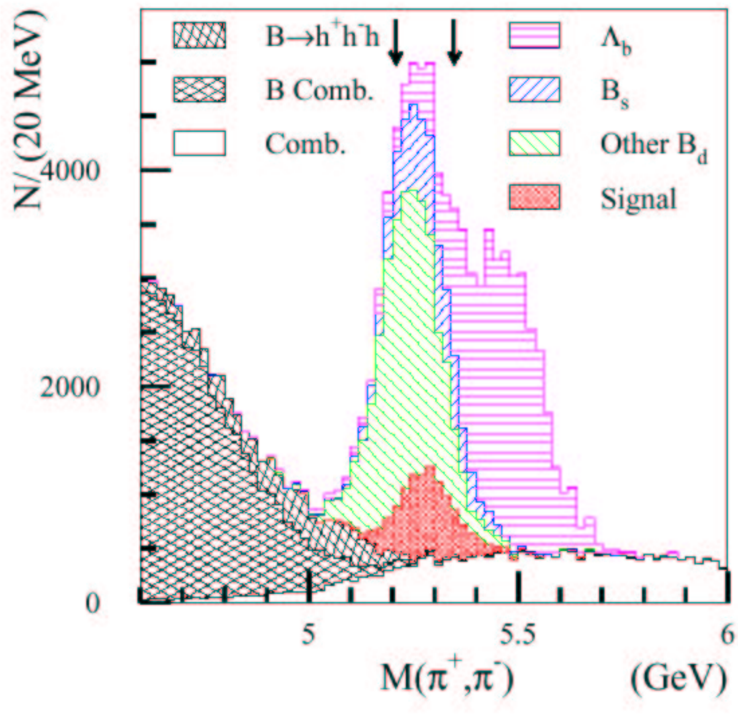
LHCb





ATLAS (no PID!)

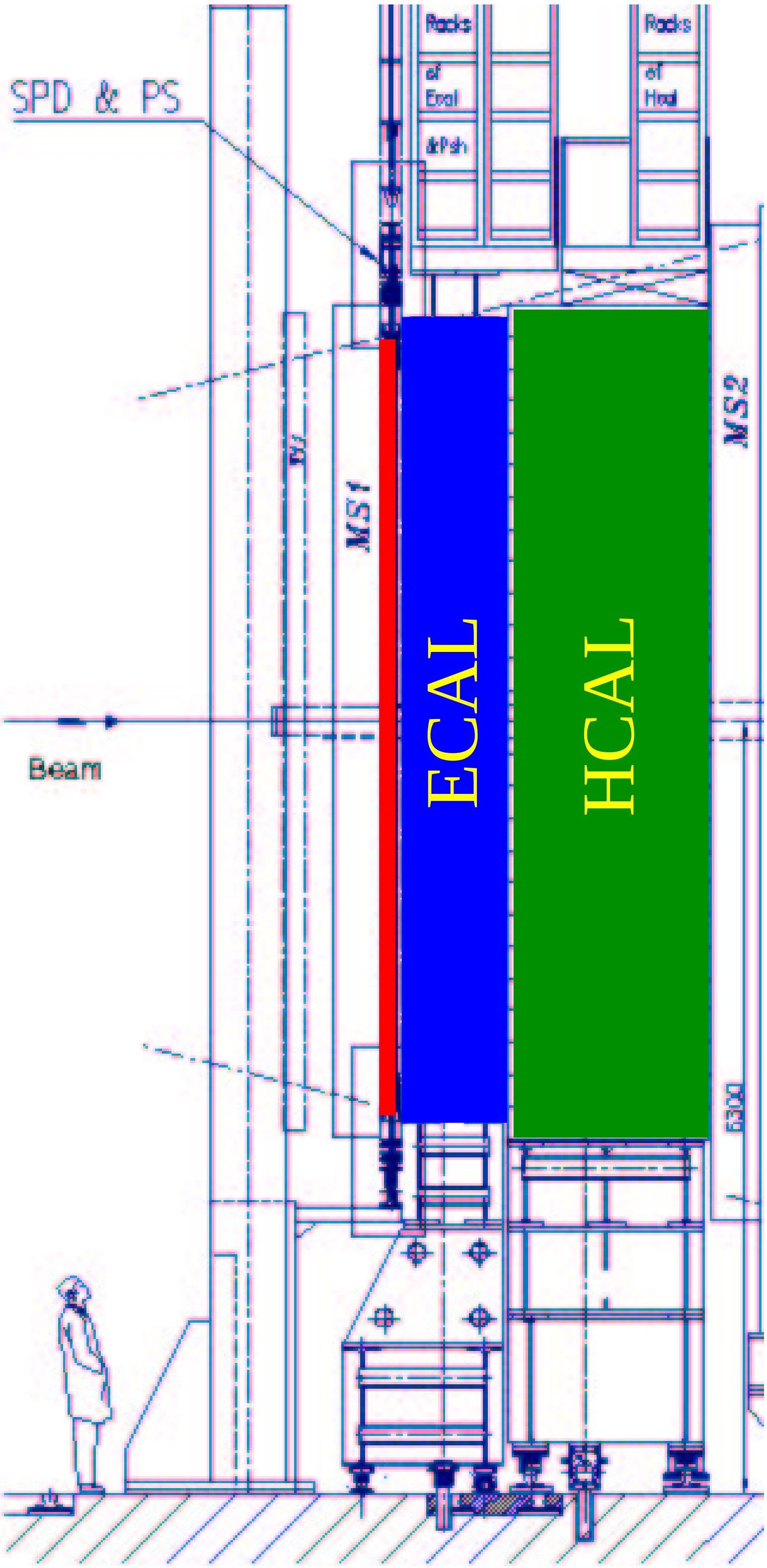
Mass resolution:
LHCb: 17 MeV
ATLAS: 70 MeV



Calorimetry

- Scintillating Pad Detector: 5984 cells Level-0 Trigger.
- Preshower: scintillator, 5984 cells, 2.5 X_0
- Electromagnetic-Cal.: shashlik, 5984 cells, 25 X_0
  $\frac{\sigma_E}{E} = \frac{9.5\%}{\sqrt{E}} \oplus 1\%$
- Hadron-Cal.: iron/scintillating tiles, 1468 cells, $5.6\lambda_I$ Level-0 Trigger.
  $\frac{\sigma_E}{E} = 80\%$

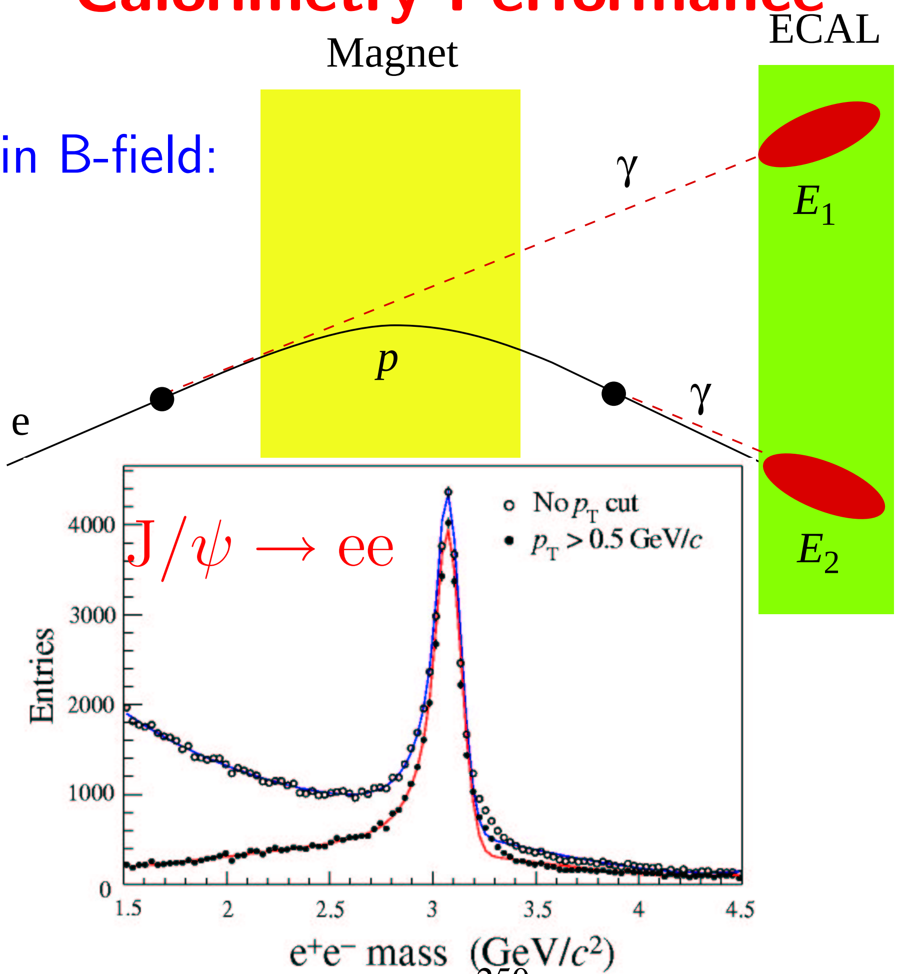
Cell-size from
$4 \times 4 \rightarrow 26 \times 26 \text{ cm}^2$



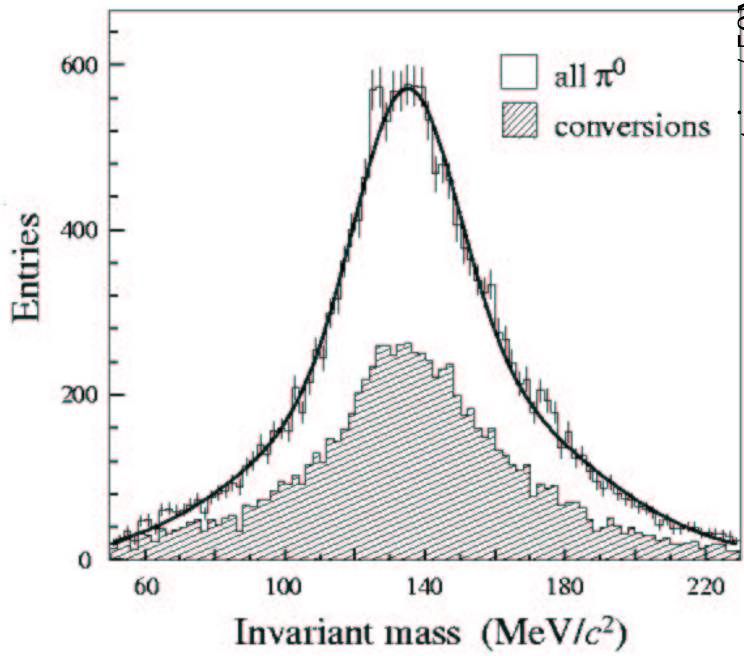
Calorimetry Performance

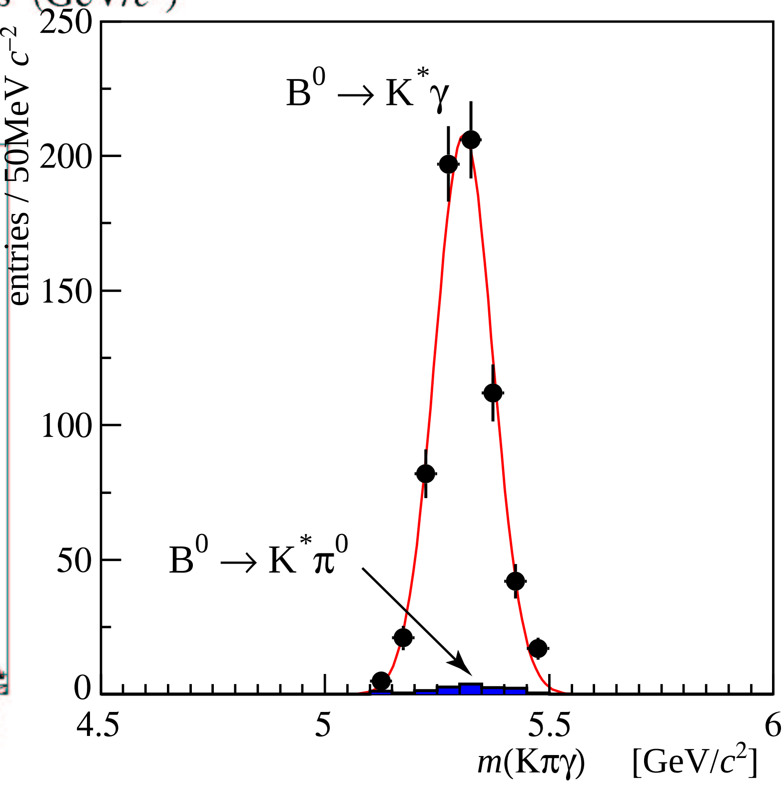
Note:

only air in B-field:



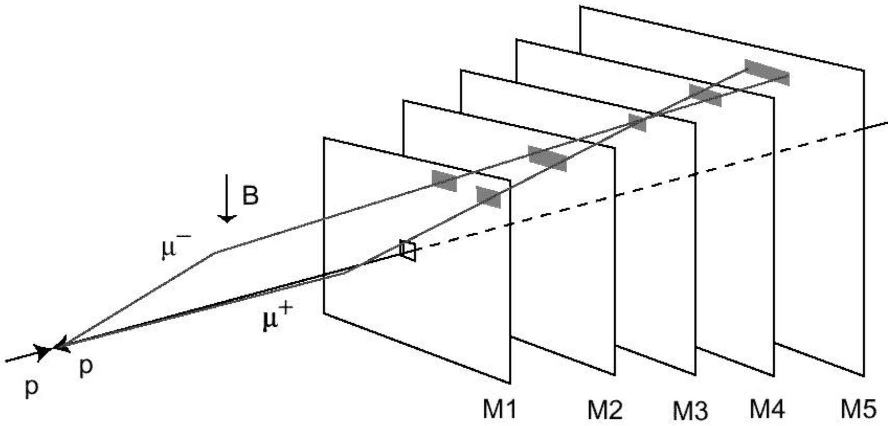
$\pi^0 \to \gamma\gamma$



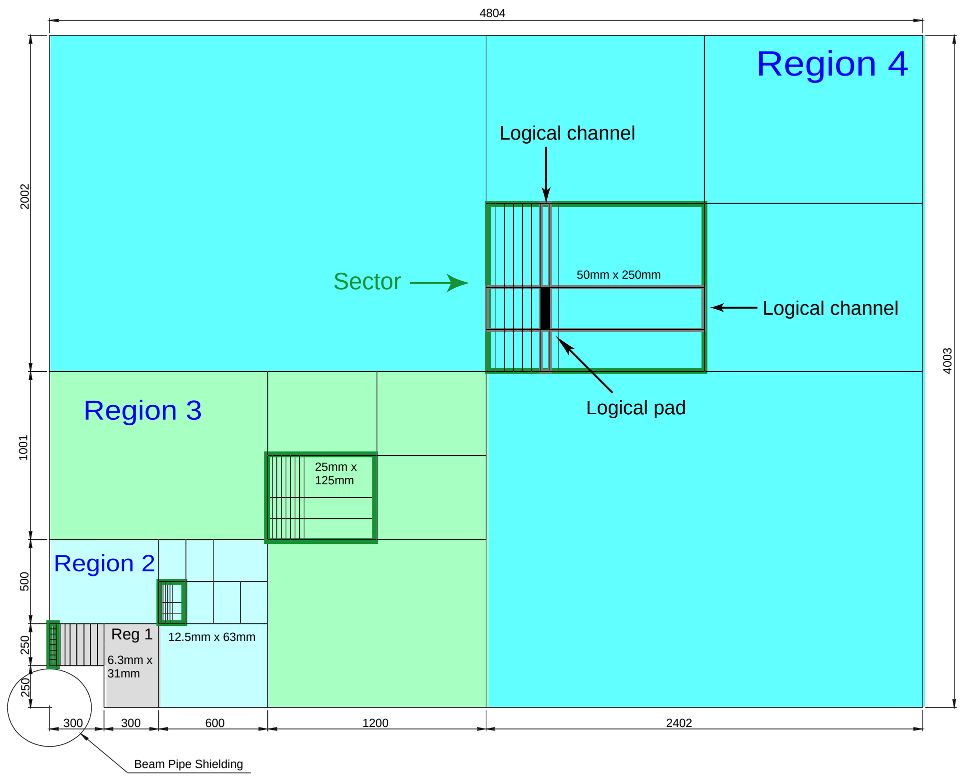


Muon System

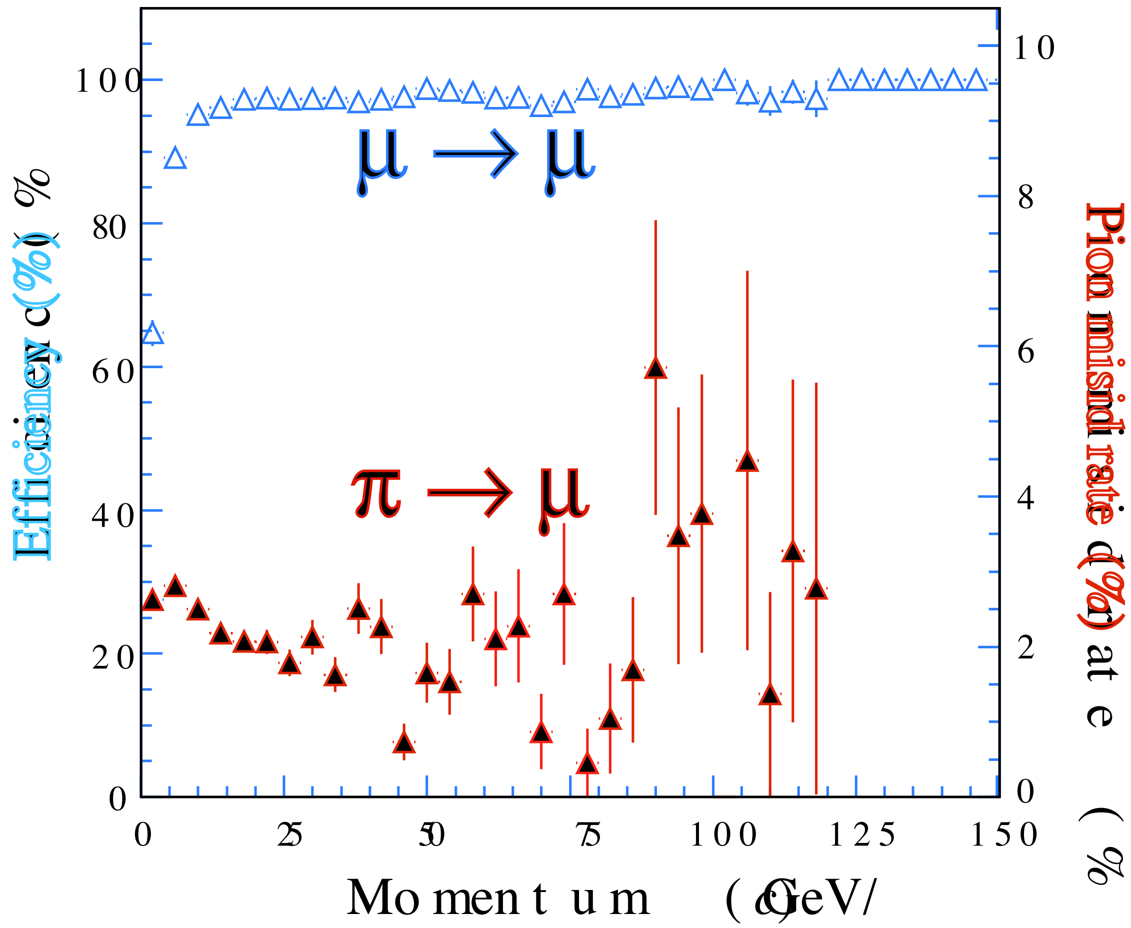
Look for straight lines in pads in the μ-chambers

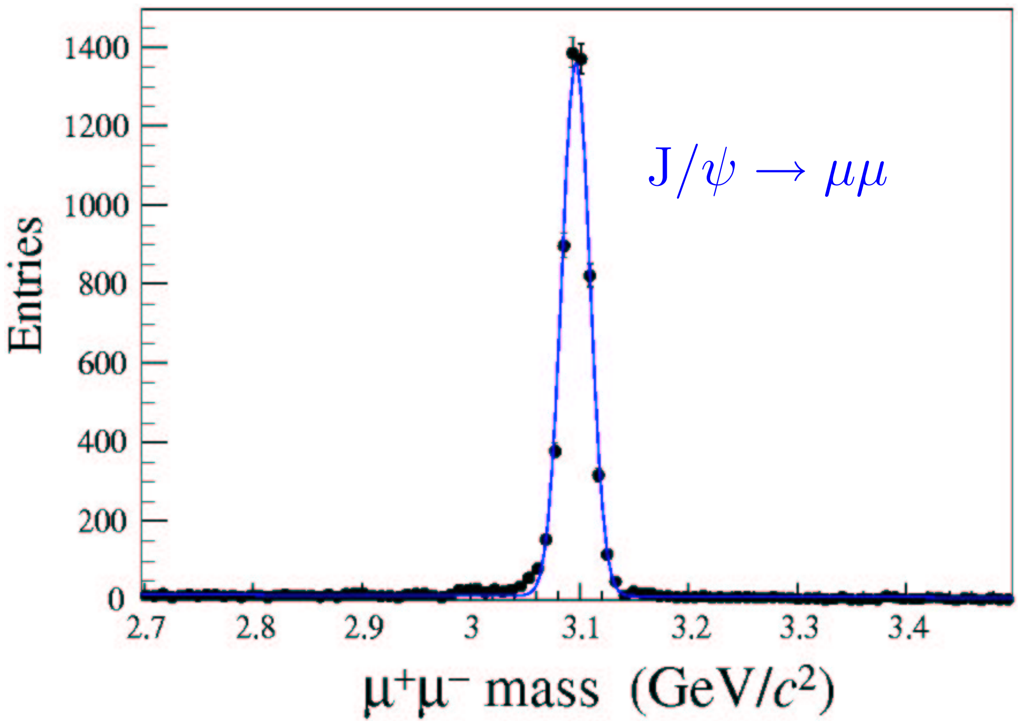


- Technology: MWPC, projective in Y for L0-trigger.
- 120k pads and strips. Eff$> 99\%$ by .OR. 2 layers per station.
- Combined strips$\rightarrow$ 26k pads. Size: 1×2.5 cm^2 (M1-inner) to 16×20 cm^2 (M5-outer)



Muon Performance





Triggering on B's @ LHC

ATLAS&CMS:

- Only lepton triggers to reduce 40 MHz rate to 50-100 kHz.
- Need to apply "large" p_{T} cuts: $> 6 - 7$ GeV.
- Physics: yields large statistics in B-decays involving J/ψ and rare decays like $\mathrm{B_s} \to \mu\mu$. Or trigger on tagging lepton.
- From 50 kHz $\to$ "Hz":
  - ATLAS: FOI search to confirm L1 μ trigger, define cones of interest (and PV, pile-up) to look for hadrons.
  - CMS: CPU farm with full detector information. Algorithms: similar strategy.

LHCb three trigger levels:

L0 μ&e&γ and HADRON trigger

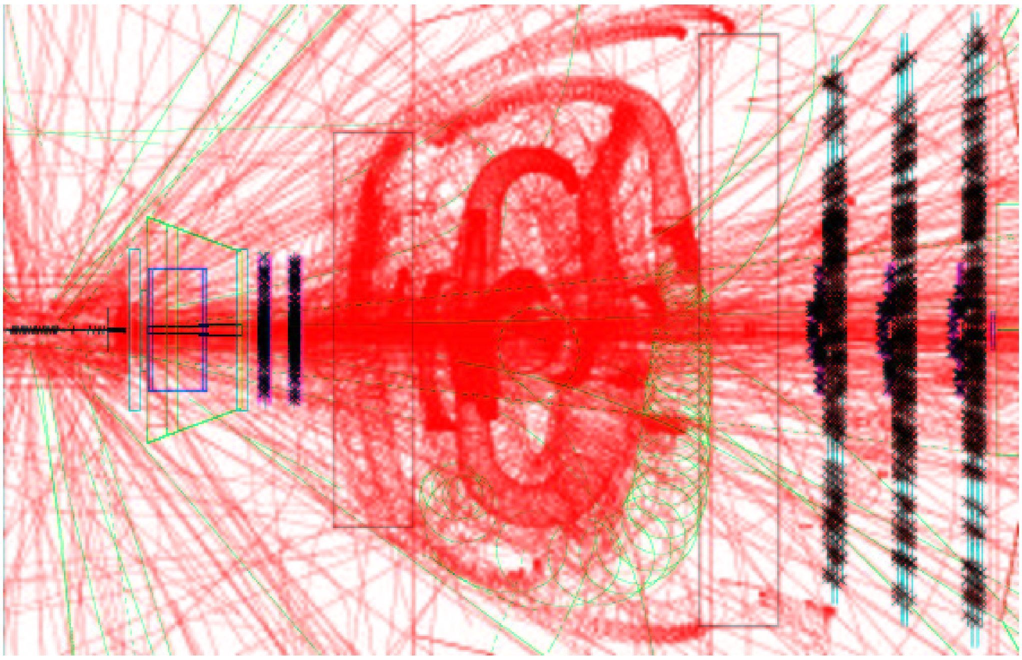
L1 Input rate: 1 MHz: "full" tracking in VELO + rough momentum

HLT Input rate: 40 kHz: "off-line" quality tracking

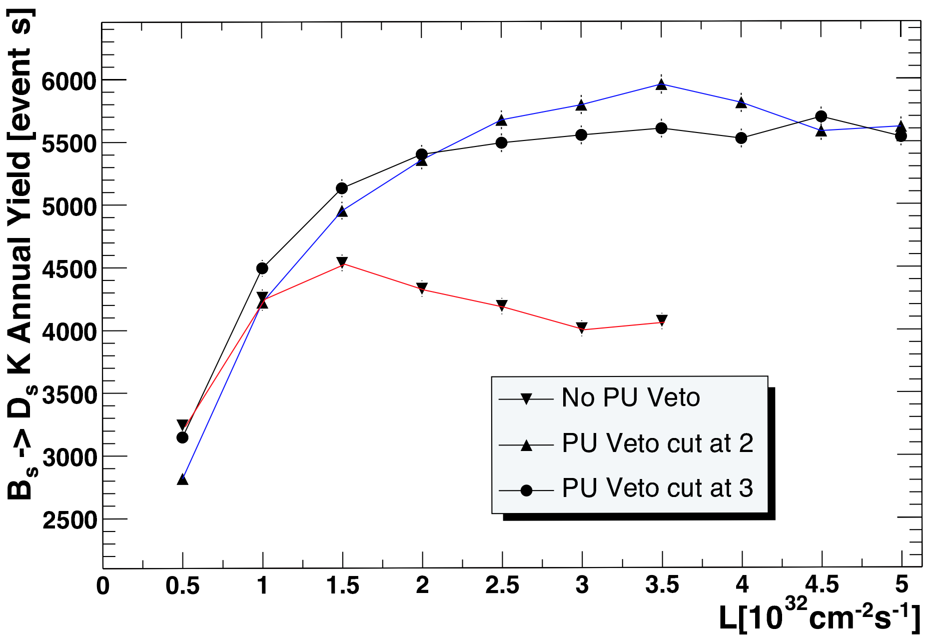
One year (10^7 s):

	ATLAS	CMS	LHCb
Luminosity	10^{33}	10^{33}	2×10^{32}
$\mathrm{J}/\psi(\mu\mu)\phi$	~100 k	84 k	100k
$\mathrm{D_s}\pi$+tagged	few k	few k	44 k

LHCb-L0: Special Complex Events Veto



LHCb uses combination of detecting Pile-Up and charged track multiplicity to Veto these events:

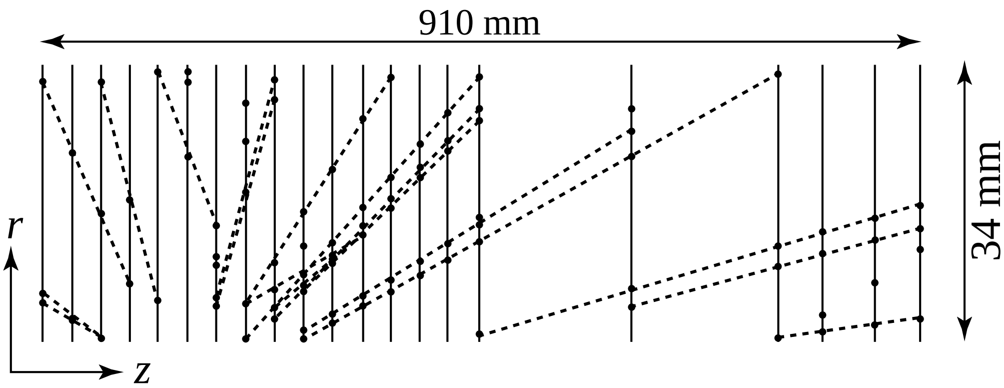


Pile-Up veto

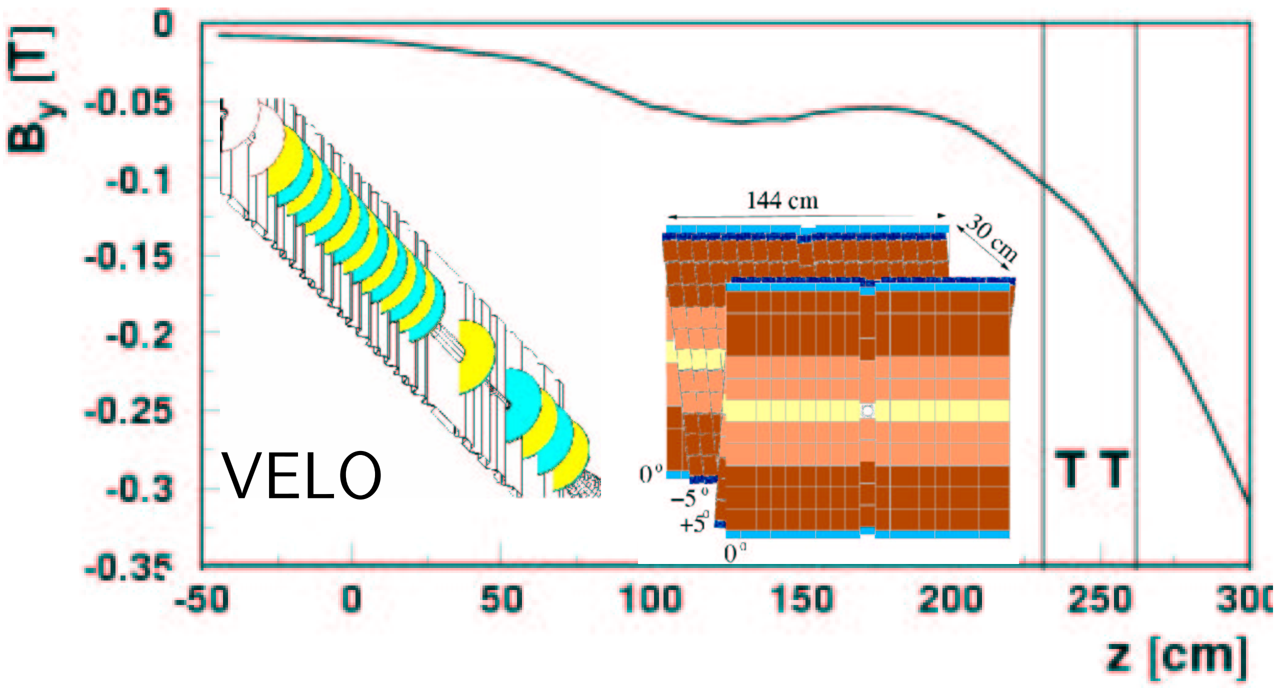
No Pile-Up veto

LHCb-L1: tracking @ 1 MHz event rate

- Reconstruct all tracks in VELO: 1 event/μs, 1000 CPUs: 1 ms/event.
- 45° sectors: busy event "slice":

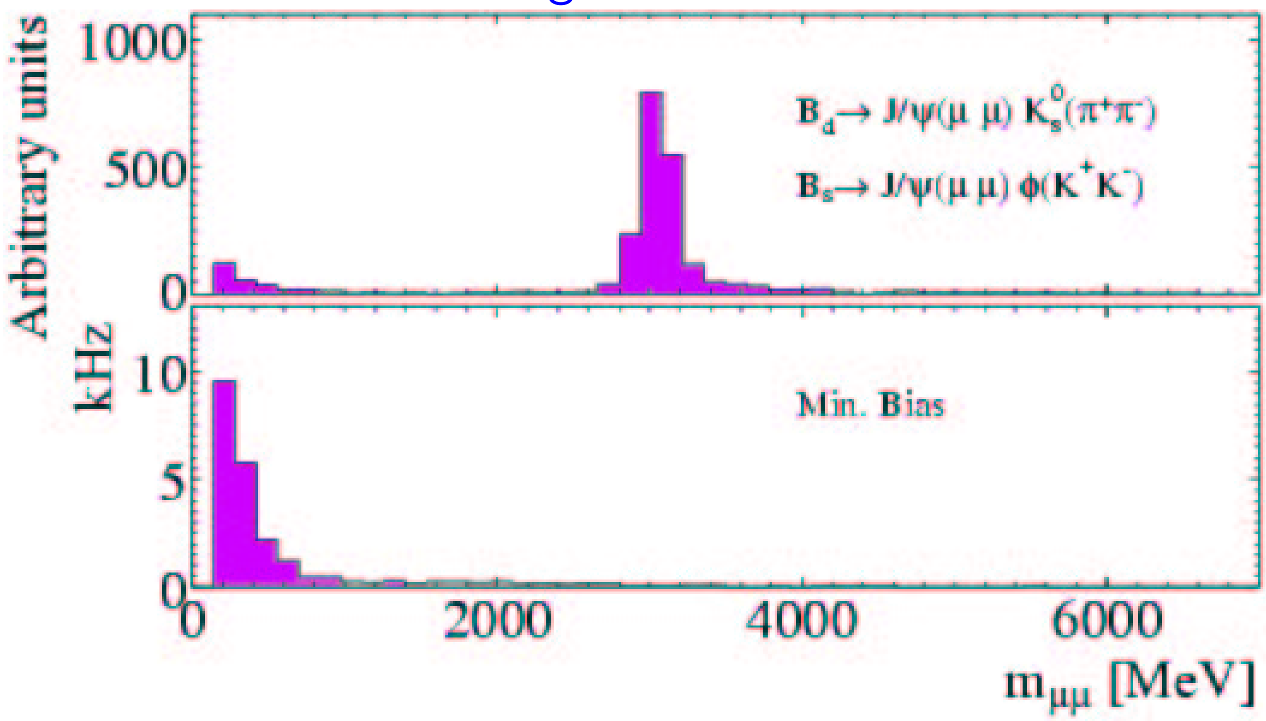


- Determine primary vertex using all VELO tracks
- Add momentum to "large impact" tracks using TT:

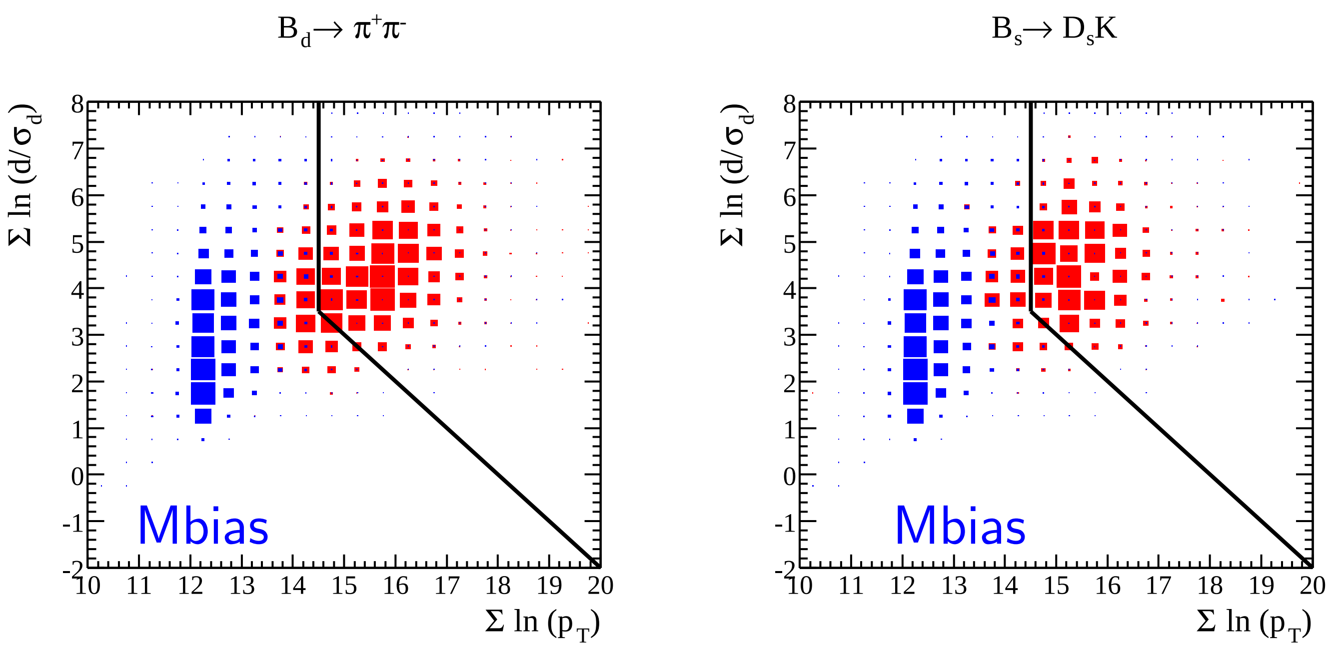


LHCb L1-Performance

Using L0-muons:

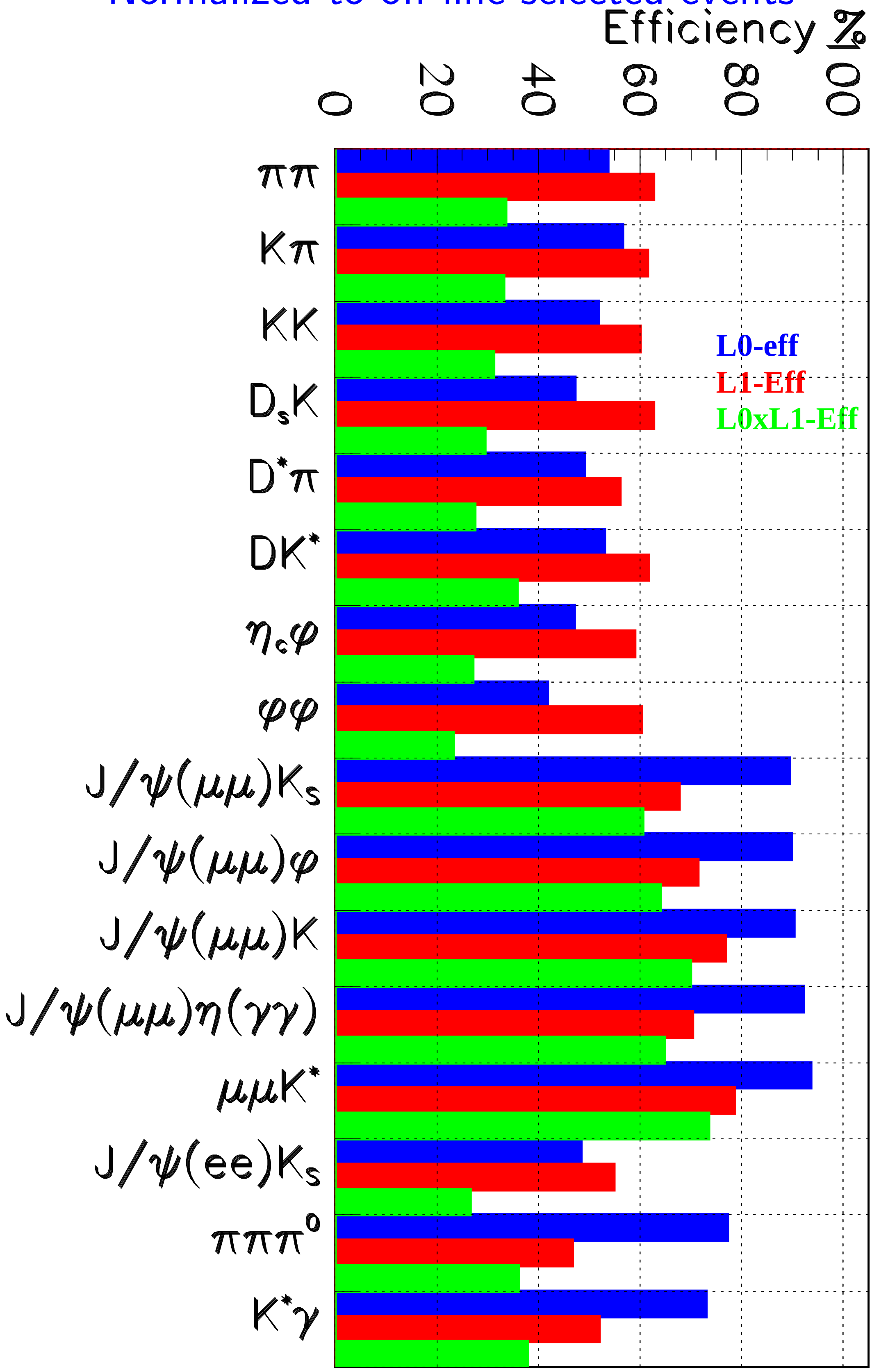


Select hadronic channels with combined impact/p_T cut:

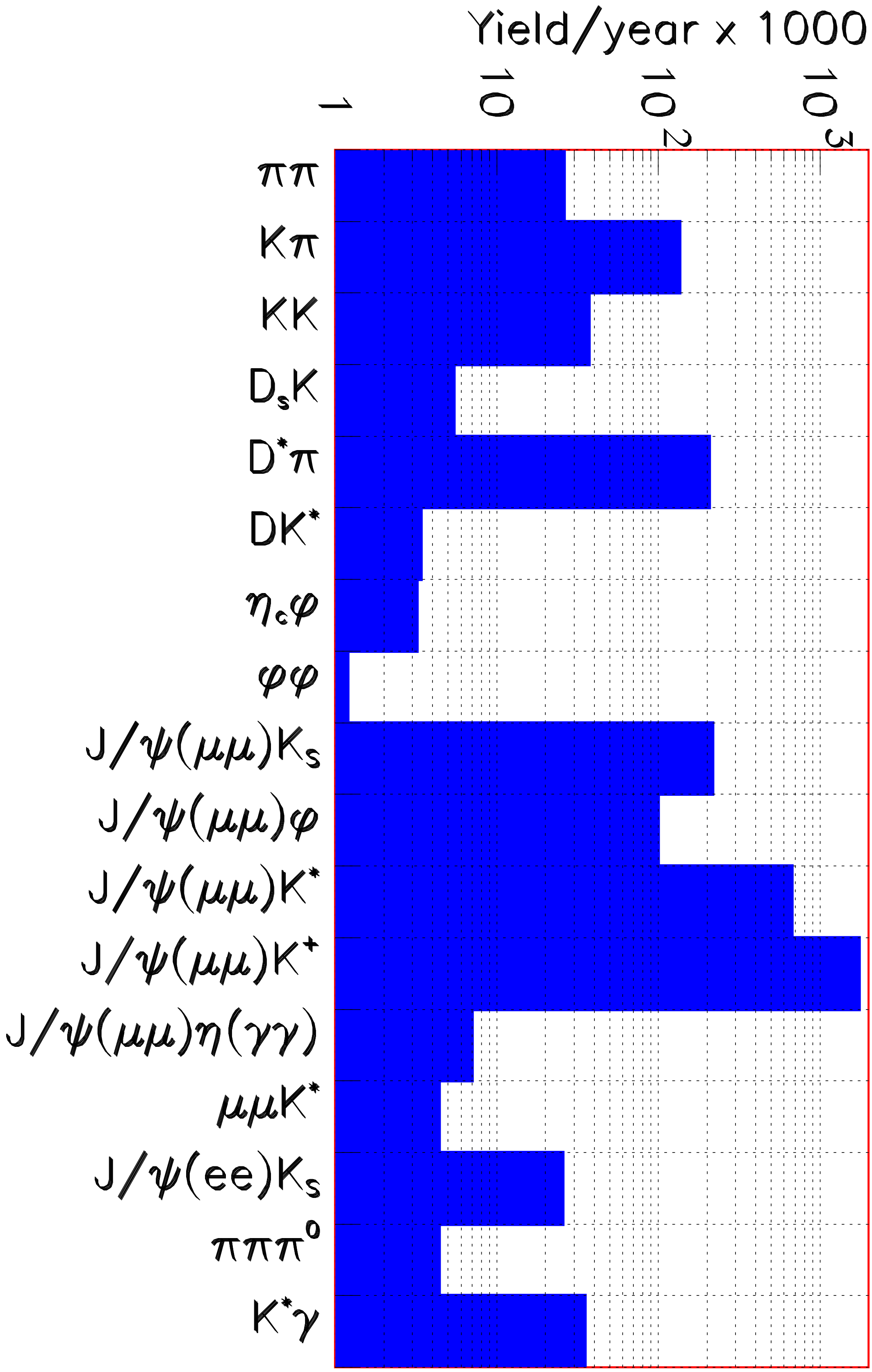


Expected Trigger Performance

Normalized to off-line selected events



LHCb: Expected Event Yield



Compare to B-factories?

Yield comparison, after trigger/background rejection:

channel	B-factory ≤ 2003	LHCb (1 year)
$J/\psi K_S$	2000	220,000
$\pi\pi$	200	26,000
ϕK_S	60	1000

And LHCb has large yields in many interesting B_s decays...

But comparison is "not fare", need to include the tagging and Signal/Background.

$\epsilon_{tagging}(1-2\omega)^2$	B-factory	LHCb
B_d	28%	4%
B_s	-	6%

Hence B-factory (B's evolve coherently, no "spectator" background) a factor 7 better.

On top of that at LHC more background, typically: B/S~ 1, looses a factor $\sim \sqrt{2}$ in sensitivity:

Bottom line: loose a factor 10 in sensitivety at LHCb compared to B-factories per event. Hence effective yields comparison looks like

channel	B-factory ≤ 2003	LHCb (1 year)
$J/\psi K_S$	560	6200
$\pi\pi$	56	740
ϕK_S	17	30

Example: LHCb precision on γ (in one year):

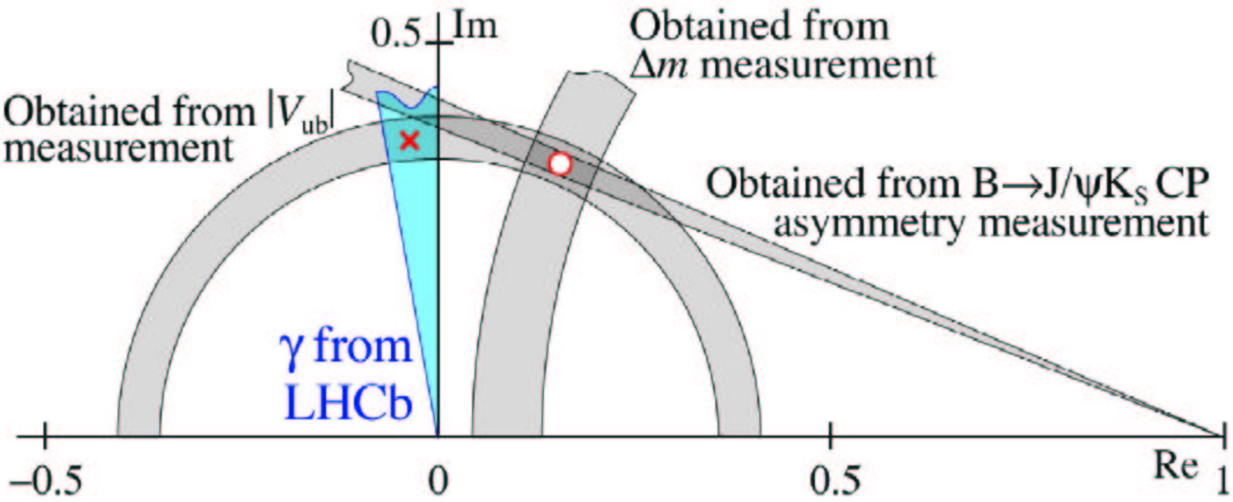
- 5.4k $B_s \to D_s^{\pm} K^{\mp}$ combined with 100k $B_s \to J/\psi(\mu\mu)\phi(K^+K^-)$ will yield theoretically clean measurement with $\sigma(\gamma) = 14 - 15^\circ$.
- 26k $B^0 \to \pi^+\pi^-$ and 37k $B_s \to K^+K^-$, combined with 216k $B^0 \to J/\psi(\mu\mu)K_S$ and 100k $B_s \to J/\psi(\mu\mu)\phi(K^+K^-)$ allows $\sigma(\gamma) = 4 - 6^\circ$ assuming U-spin symmetry.
- 3.4k $B^0 \to \bar{D}^0(K\pi)K^\star$ and 600 $B^0 \to D_{CP}(K^+K^-)K^\star$ gives $\sigma(\gamma) = 7 - 8^\circ$.

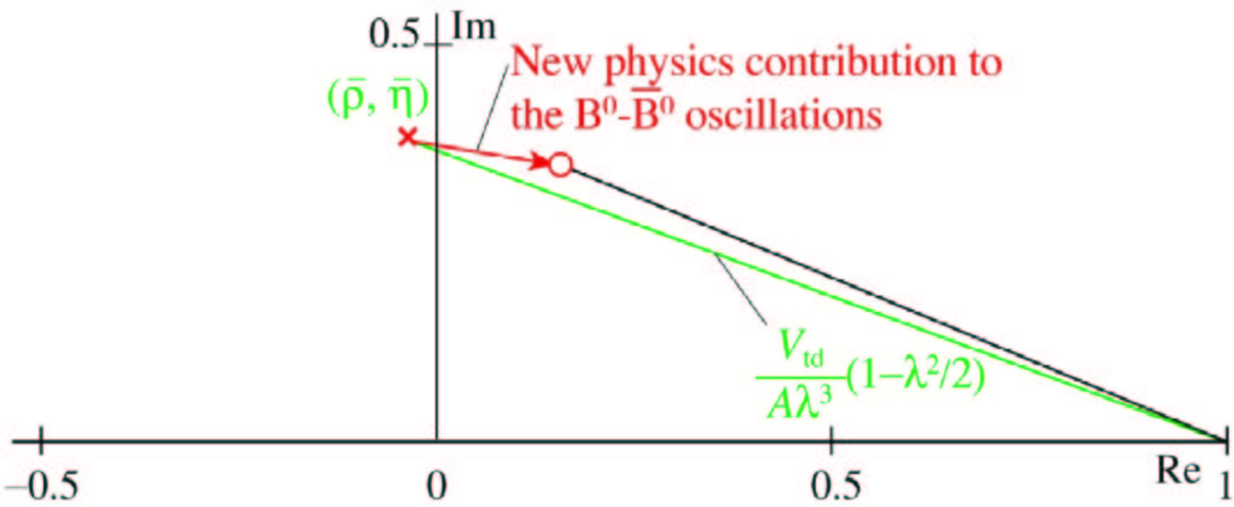
LHCb will run for at least 10 years: hence eventually $\sigma(\gamma) <$ few degrees in at least three independent ways!

How could new physics manifest itself?

New Physics?

Lemma: there are more NP-models than theoreticians...
But suppose in 2008 LHCb measures γ to be:





- Before 2007: Δm is thought to measure $\mathrm{V_{td}}$
- But in 2008 we find γ, which really measured $[\bar{\eta}, \bar{\rho}]$.
- Concluson: NP in $\mathrm{B^0 - \bar{B}^0}$ oscillations.

Bottom line:
extract CKM and NP contributions by measuring CPV in many decays.

Conclusions

- The first generation CPV experiments at the B-factories have achieved precise measurements already.
- However, to look beyond the SM predictions, need $\mathrm{B_s}$ and larger statistics.
- The LHC offers large statistics, and all B-flavours, at an "experimental" cost.
- ATLAS and CMS can contribute to channels with leptons in the final state at the start-up luminosities of the LHC.
- LHCb is "made to measure" to exploit CPV in the B-system by:
  - a dedicated trigger,
  - excellent proper time resolution,
  - good tracking ,
  - ability to reconstruct and identify charged and neutral hadrons, muons, electrons and photons,
  - acceptabel background rejection, and
  - adequate flavour tagging.

LHC and its experiments under construction.
First collision expected on April 1, 2007
First hints of NP: Caxambu October 2007?