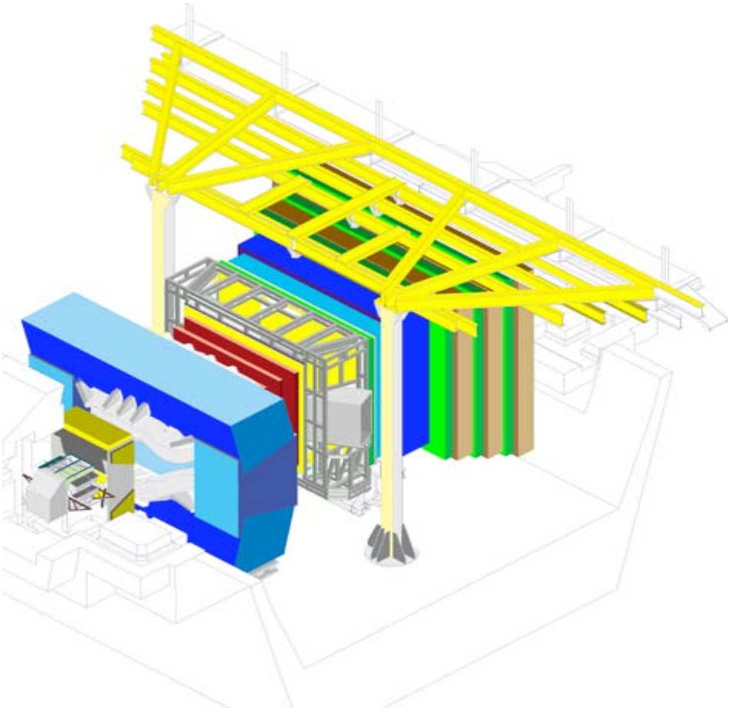
# Status of the LHCb Experiment



M. Needham

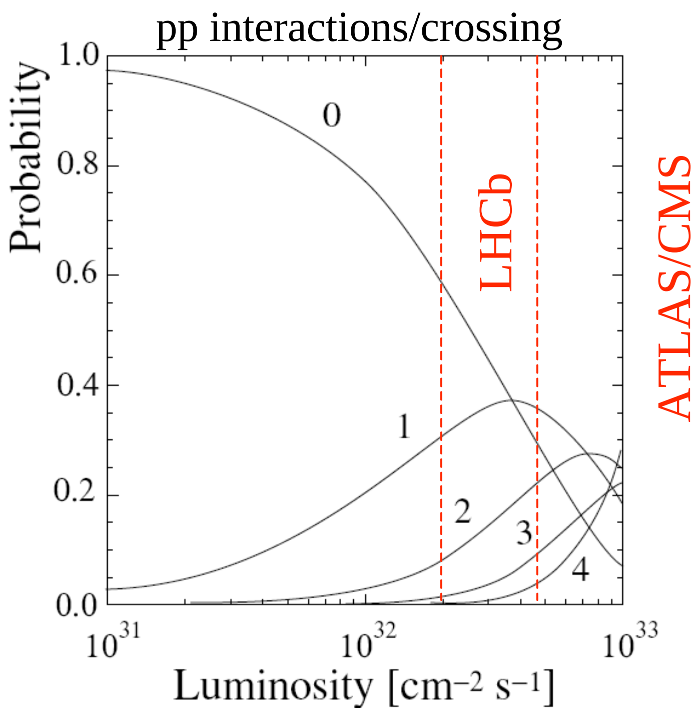
EPFL

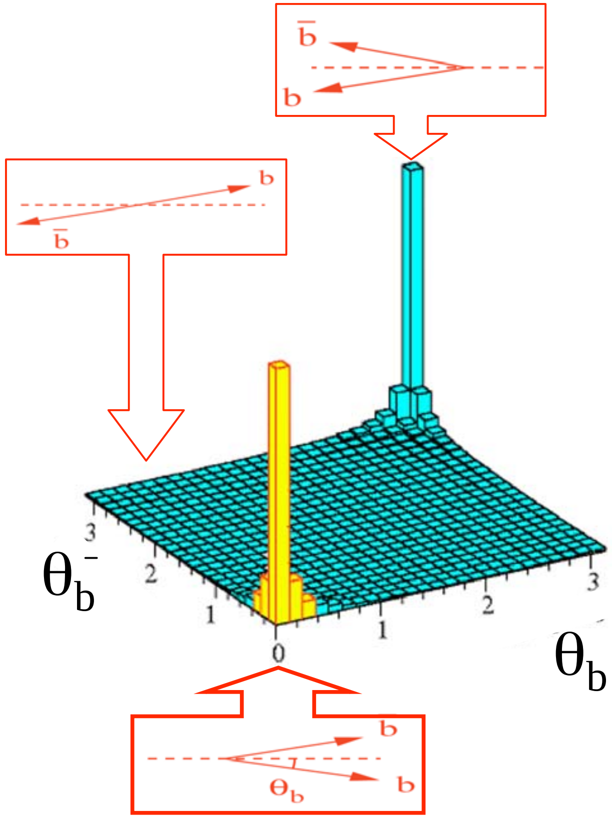
CHIPP Meeting 15th October 2007

# LHCb

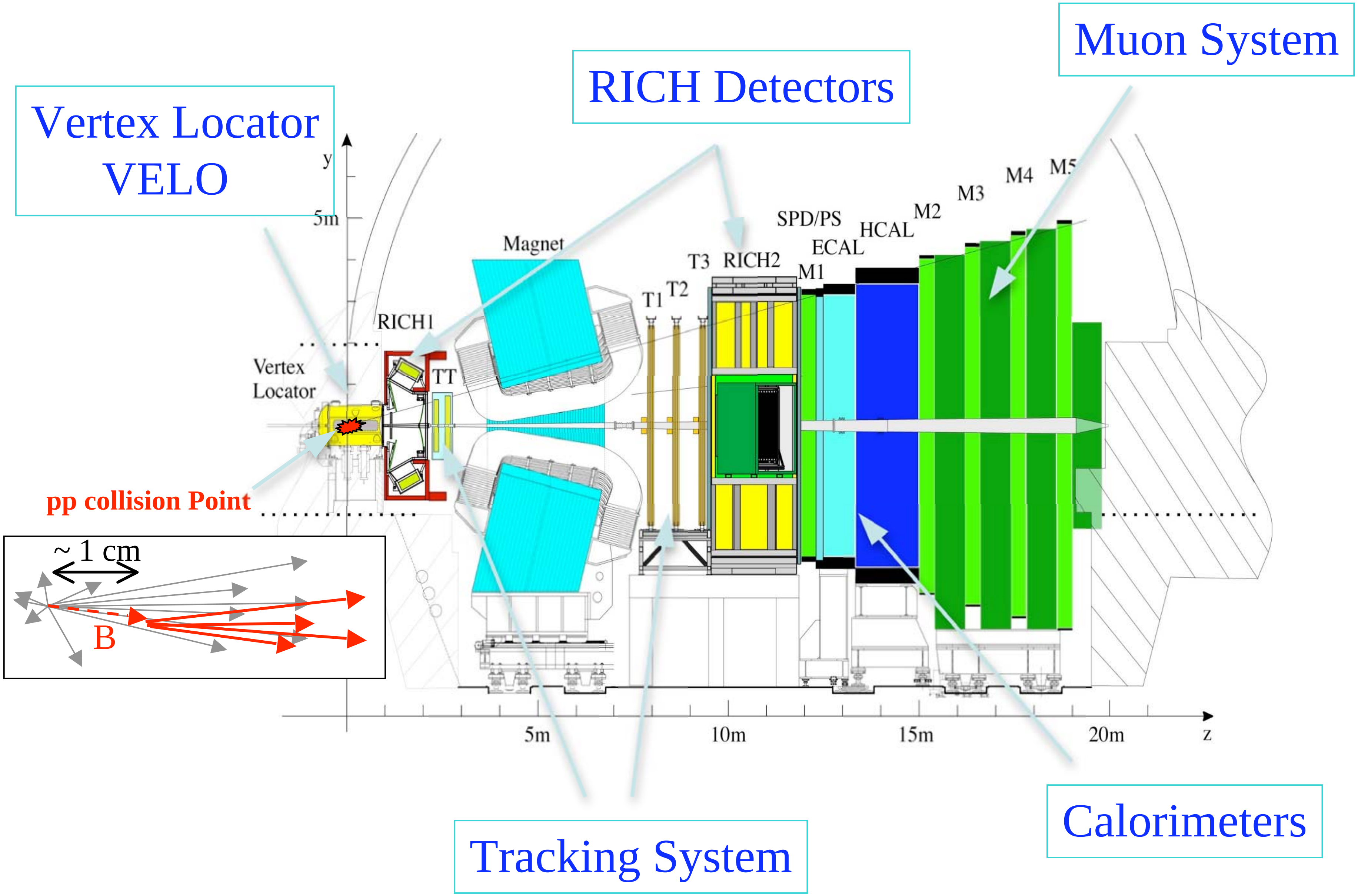
Dedicated B physics experiment at the LHC: 700 participants from 15 countries

- At the LHC B production correlated and peaked in the forward direction
- LHCb single arm spectrometer covering 15 - 300 mrad
- LHCb runs at luminosity of $2 \times 10^{32}$ $cm^{-2}s^{-1}$ by focussing the beam less
- Maximizes probability of one interaction per crossing
- Design luminosity from machine startup

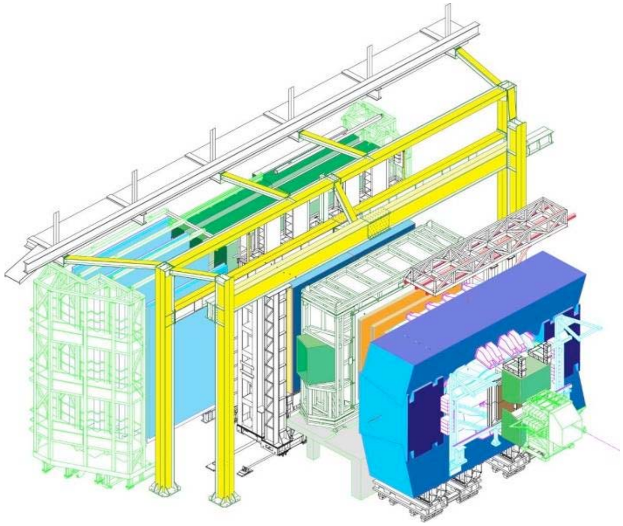


# The LHCb Detector



# LHCb Status




2007: Complete installation + begin commissioning

- LHCb is confident that the experiment will be ready for data-taking in spring 2008

2008: Start-up phase

- Complete commissioning of detector and trigger at 14 TeV
- Calibrate momentum, energy and particle ID
- First physics data taking, assume ~ 0.2 $fb^{-1}$

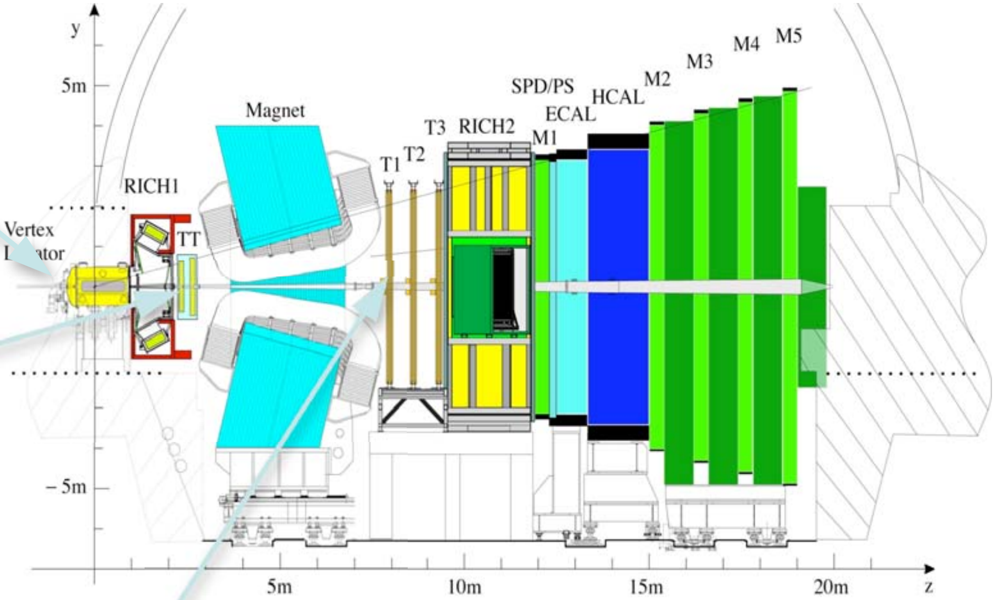
2009 onwards: stable running

- Collect ~ 2 $fb^{-1}$/year
- Develop full physics program

# Swiss Involvement

• VELO readout link + LV (EPFL)

• Construction of Trigger Tracker (Uni Zürich)




• Inner Tracker Construction (EPFL)

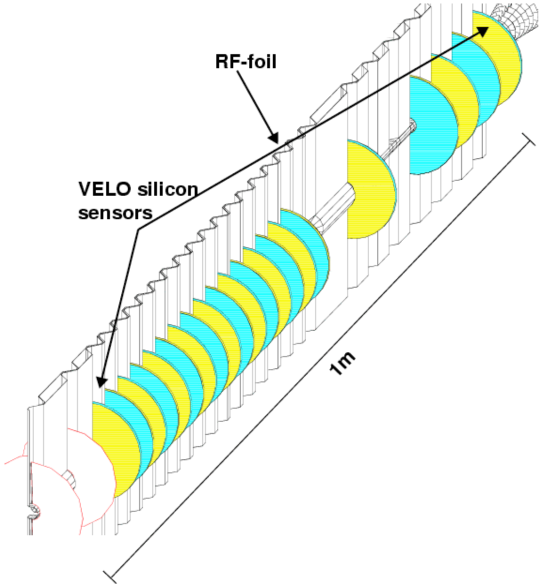
IT + TT = Silicon Tracker (Project leaders O. Steinkamp, U. Straumann)
Common software, electronics, infrastructure

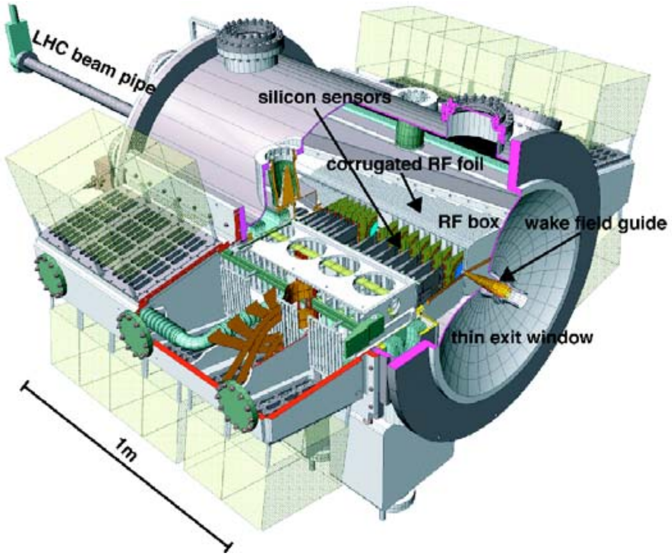
- TELL1 boards common off-detector readout electronics (EPFL)
- Higher Level Trigger studies (EPFL)
- Physics studies (Physics coordinator O. Schneider): $\phi_s$, jets, …
- Spokesperson: T. Nakada

Total 40 participants from EPFL, Uni Zurich

# Vertex Locator

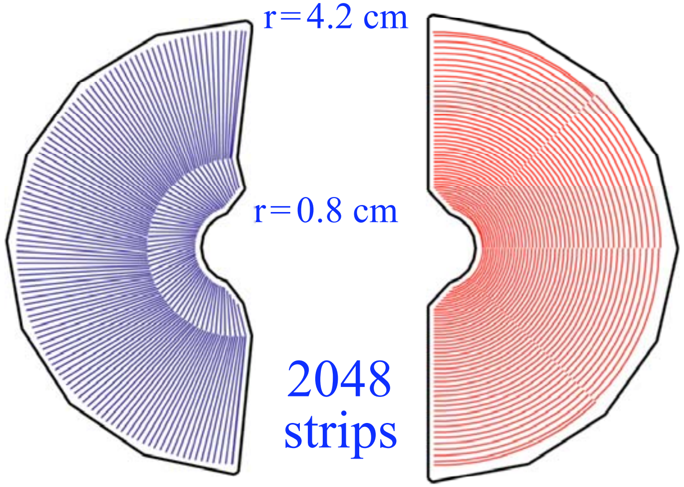
- 21 stations measuring r and phi
- 300 μm thick n-on-n Silicon




$\phi$-sensor

- divided into short and long strip region
- pitch: 35 - 100 μm




r-sensor

- divided into quadrants
- pitch: 40 - 100 μm

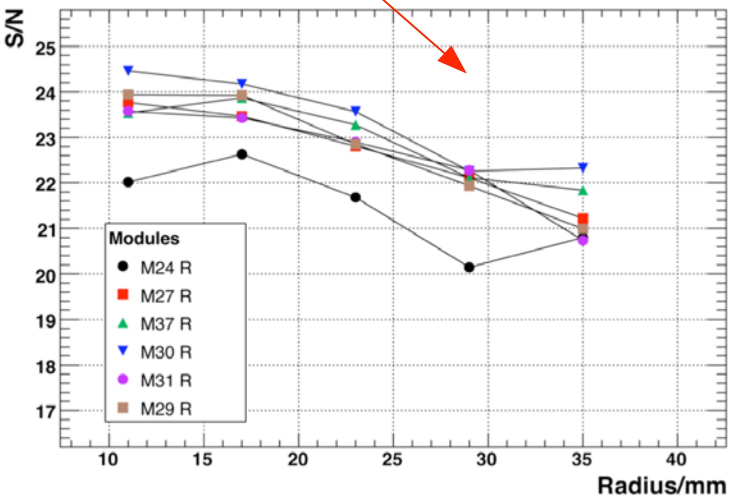
# Vertex Locator

Velo Half in testbeam November 2006

- Full readout chain + final electronics
- Including analogue link + Tell1
- Excellent performance
- Demonstrated software alignment procedure works
- Exercise software (DAQ, ECS, offline, monitoring)

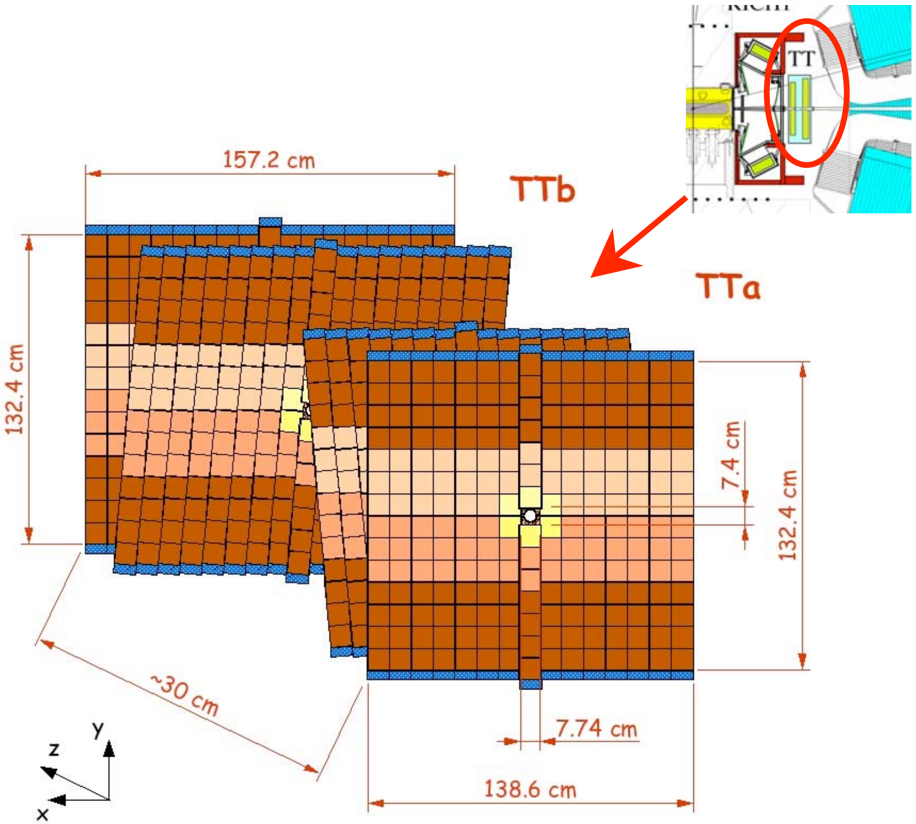
## Status:

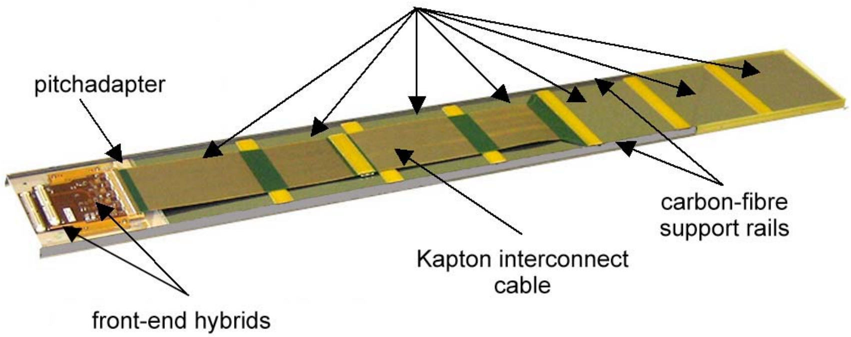
- Module production and burn-in: completed March 2007
- Module assembly on detector halves: completed March 2007
- Vacuum detector positioning system installed
- Cooling System + readout being commissioned
- Installation of first VELO half in the pit: end October



# Trigger Tracker

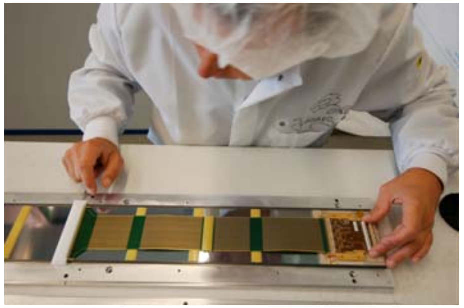
- Four planes of Silicon (0°, +5°, -5°,0°)
- 7-sensor long ladders.
- All Hybrids outside active area.
- Kapton interconnects to take signal out
- 500 µm thick,  CMS-OB2 sensors
- Pitch 183 µm
- Strip length ups to 37 cm
- Area of 8.2 $m^2$ covered by Silicon
- 143 k strips

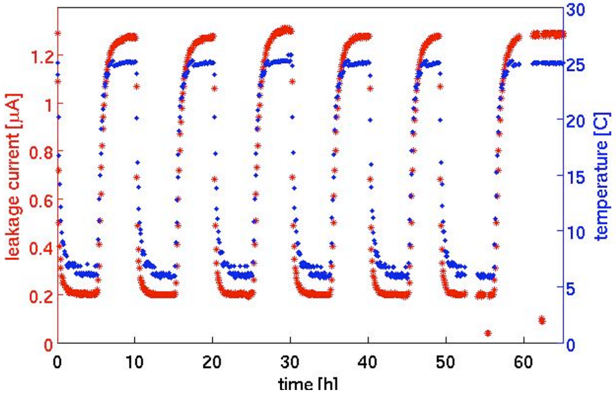


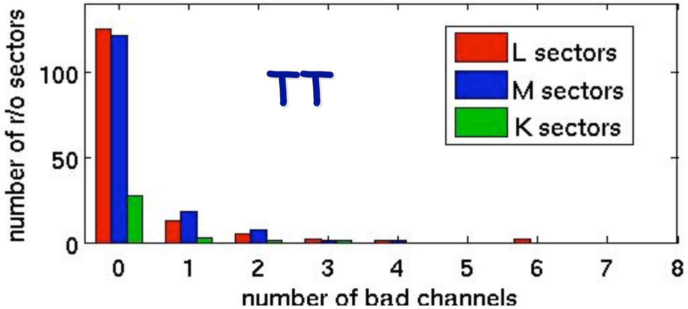



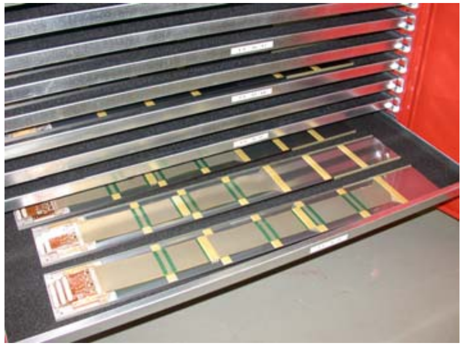
# TT: Module Production

- 147 modules produced (including 15% spares)
- Three modules "lost" during production
- All modules tested in burn-in setup
- 109 bad strips out of ~ 158 k tested
- Leakage currents typically < 500 nA per sensor



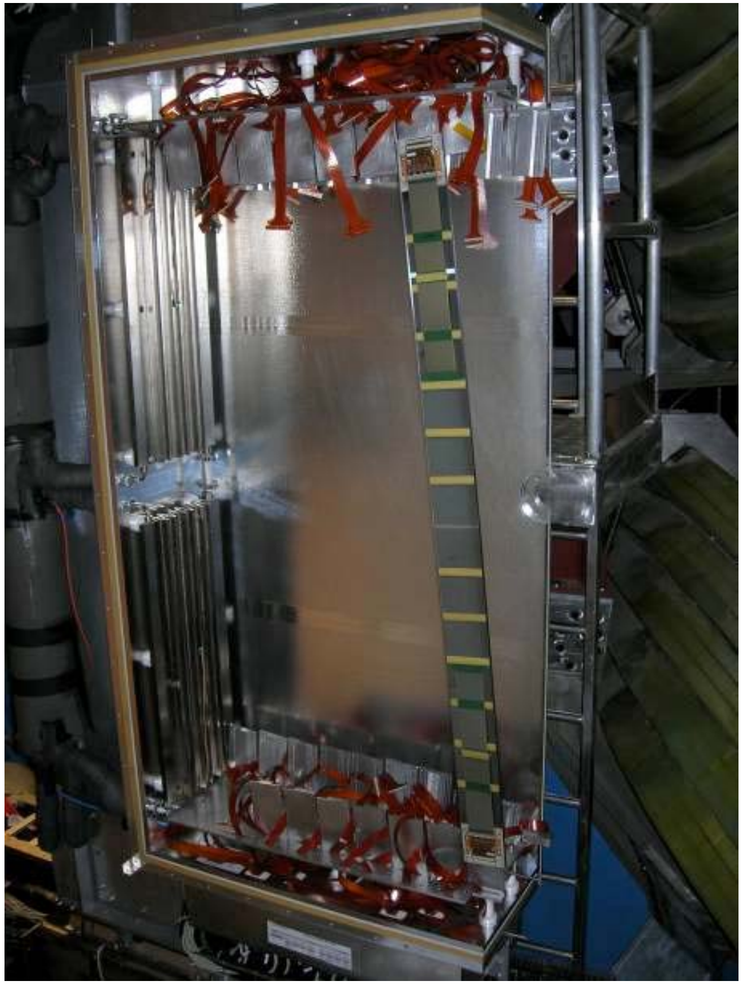


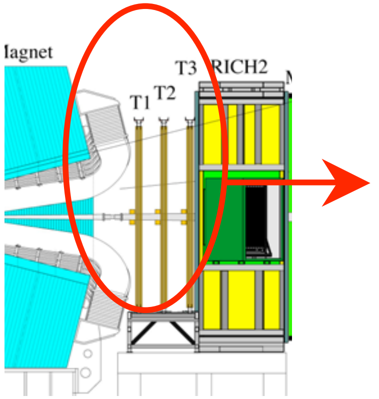



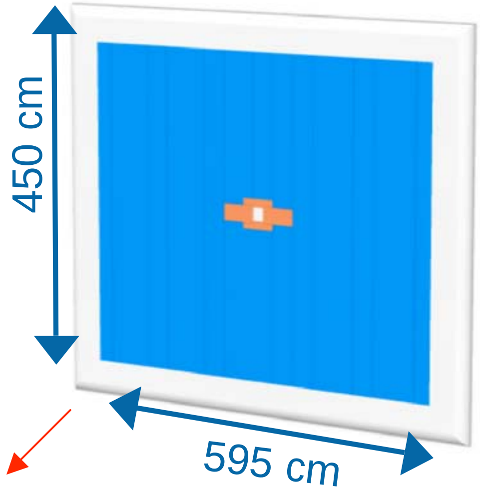
# TT: Status

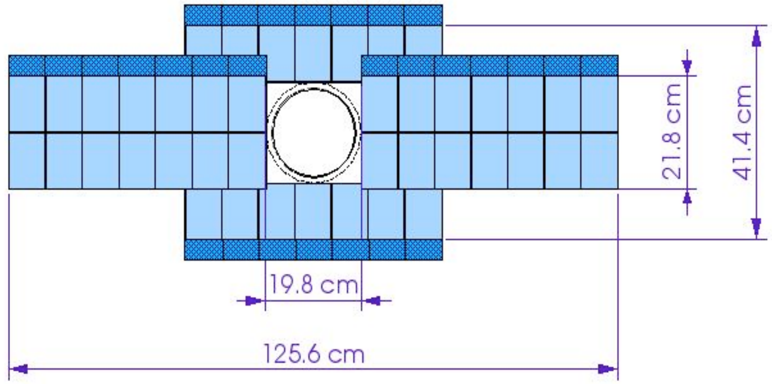
- Detector box installed in the pit
- First module installed for mechanical/cooling tests
- Cabling in progress
- End October: electronics service boxes installed
- Mid November: installation of first half station
- December: Remaining modules installed



# Inner Tracker



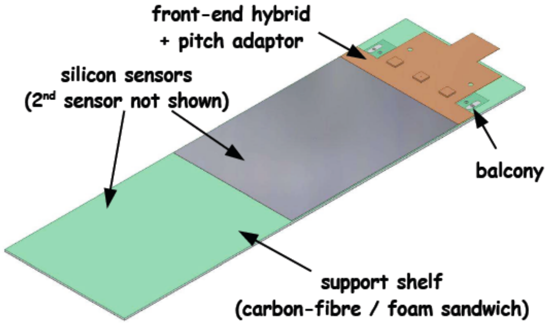



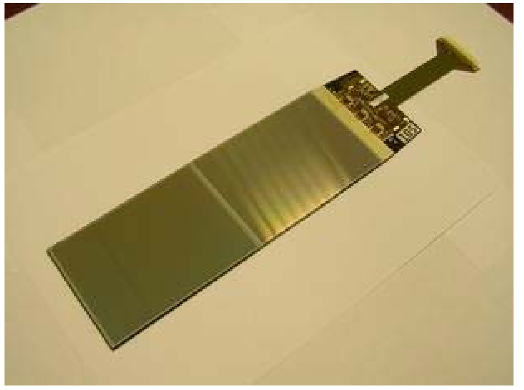



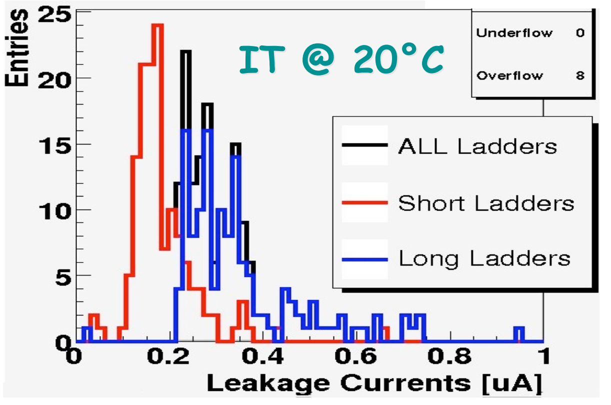

- Innermost part of 3 tracking stations after the magnet
- Outer part straws
- 2 % of the surface area but 20 % of the tracks
- Each station consists of 4 boxes
- Box contains 4 layers (0, 5,- 5, 0 degrees)
- 320/410 μm thick 11 cm long p-on n sensors
- Readout pitch 198 μm
- 1 sensor + 2 sensor ladders
- 336 ladders, 130 k readout strips

# IT: Module Production

- Module production recently finished
- 336 modules + ~ 15 % spare
- Fraction of bad strips « 1 %
- Leakage currents typically < 400 nA per sensor

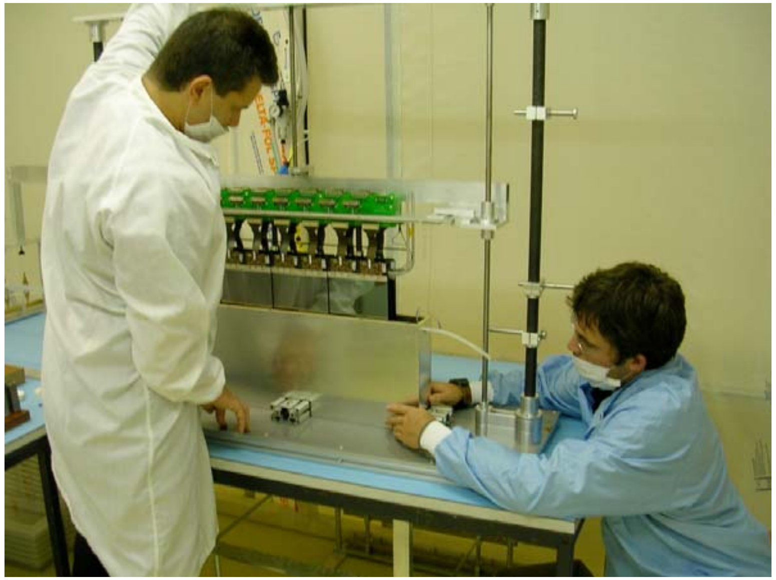




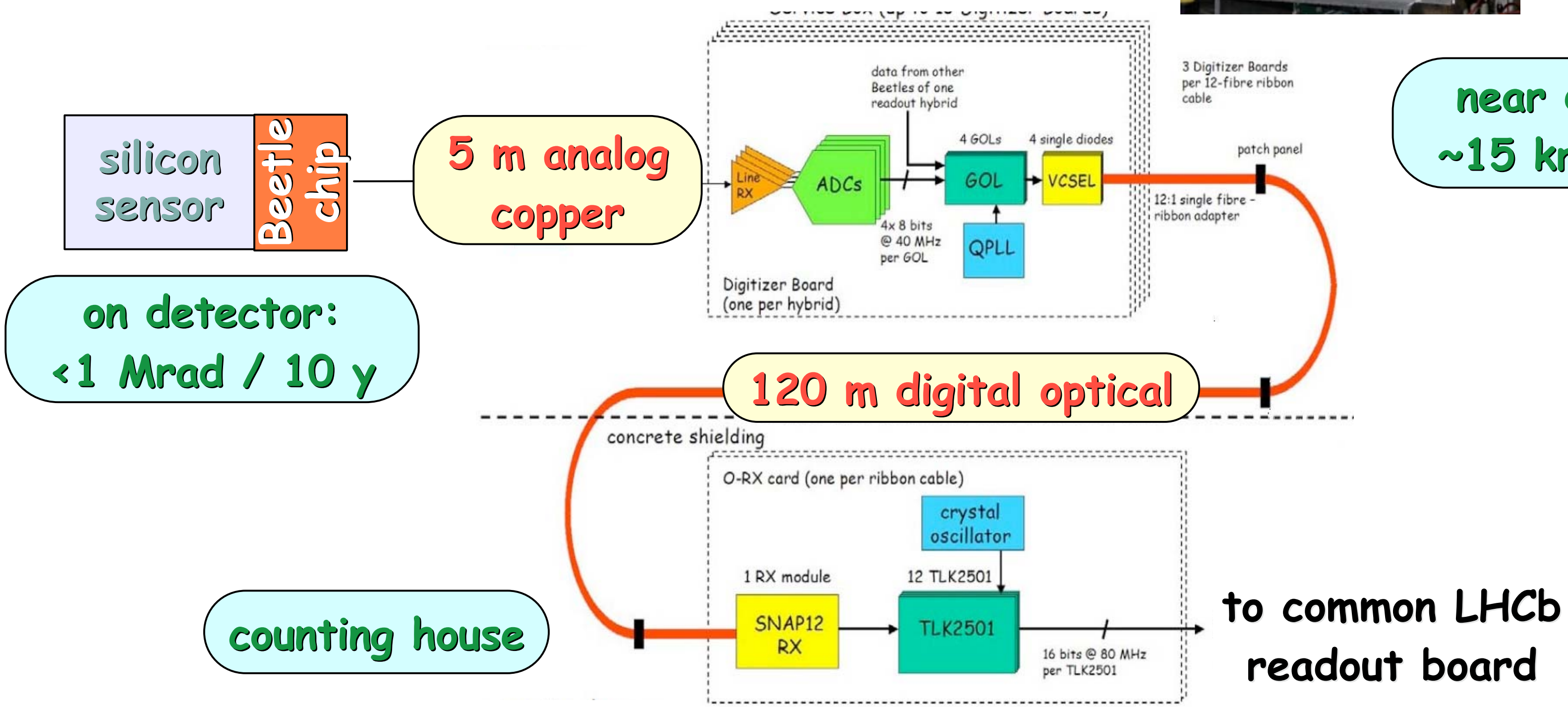
# IT: Status

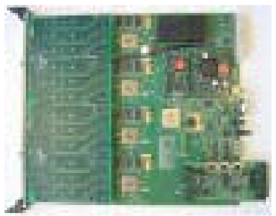
- 5 (out of 12) detector boxes assembled
- First electronics service boxes in the pit
- End of October 2 service boxes tested in lab + installed in the pit
- Infrastructure in the pit ready for the service boxes
- Plan to install remaining service + detector boxes by the end of the year



# ST Readout

Service Box



Tell1

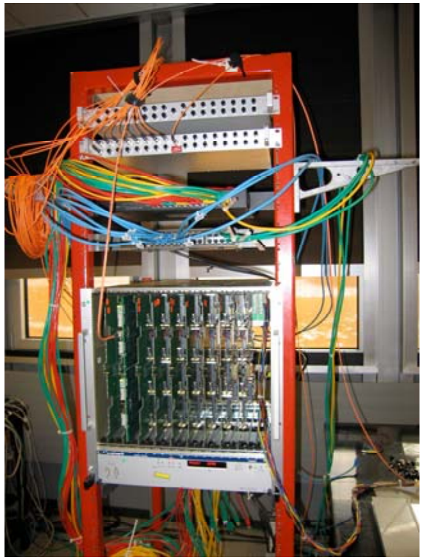
# ST Readout

## Service boxes

- Digitizer boards/service boxes assembled
- Burn in tests performed in Zurich
- Few small problems found + fixed

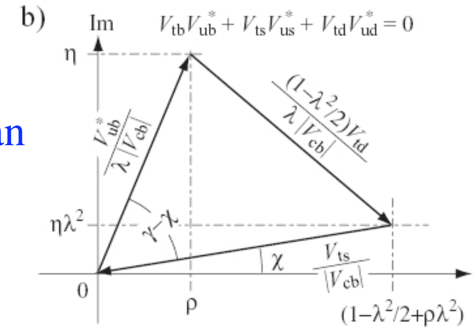
## Tell1 boards

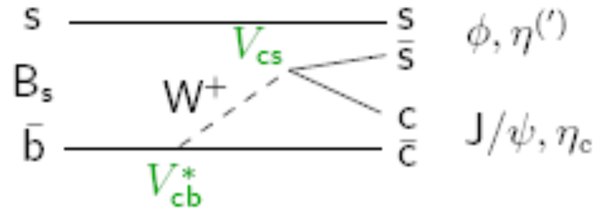
- Produced, tested + installed in the pit
- Sucessfully used in IT/TT burn-in stands
- [And also in Velo testbeam]
- Algorithms (CM, ZS) being developed/validated
- Slow control + monitoring being developed

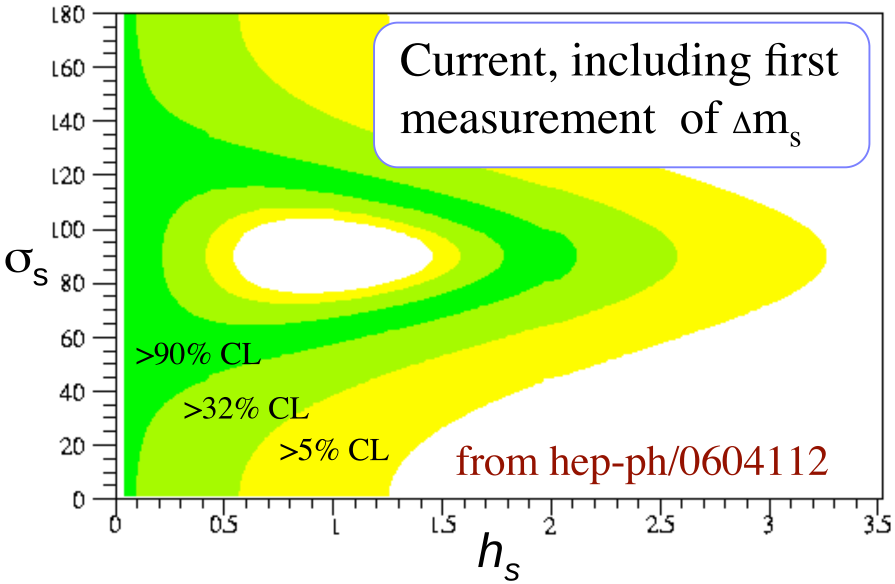


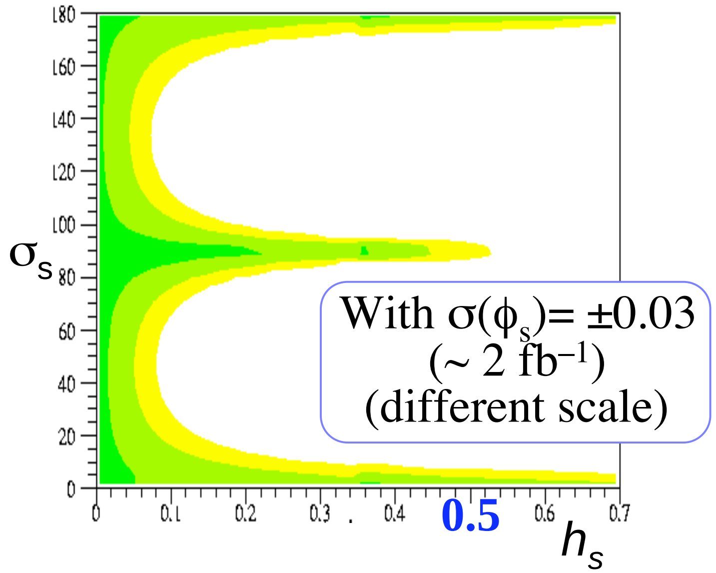
# $B_s$ mixing phase

- $\phi_s$ , Bs oscillation mixing phase
- $\phi_s$ is small in the standard model: $\phi_s = -\arg(V_{ts}^2) = -2\lambda^2\eta \sim -0.04$ radian
- Sensitive probe for new physics: $\phi_s = \phi_s^{SM} + \phi_s^{NP}$
- Unconstrained even with $\Delta m_s$ measurement from CDF
- Measure from time dependent asymmetry in b →ccs transitions
- For this measurement need $\Delta m_s$ as input



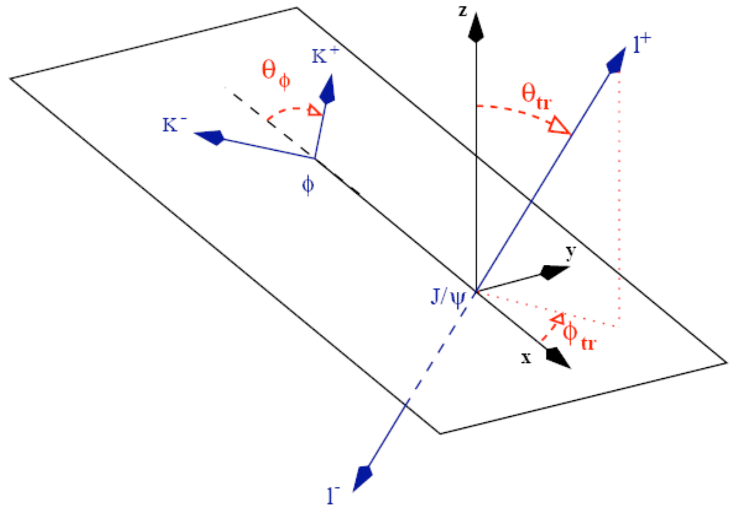




- Parameterize new physics in $B_s$ mixing: $M_{NP} = M_{SM}(1+h_s e^{is})$)

# $B_s$ mixing phase

- $B_S \to J/\psi\ \phi$ is the counter part of the golden mode $B_d \to J/\psi\ K_s$
- High yield: 125 k signal events per year (before tagging)
- Vector-Vector final state: Admixture of CP eigenstates
  - Angular analysis needed




- Pure CP eigenstates (e.g. $B_S \to J/\psi\ \eta$) can also be added
- No angular analysis needed but total statistics low

# $B_s$ mixing phase

Physics reach

| Channel | Yield [2 $fb^{-1}$] | B/S | $\sigma_t$ [fs] | $\sigma(\phi_s)$ [rad] |
|---|---|---|---|---|
| $B_s \to J/\psi\ \eta\ (\pi^+ \pi^- \pi^0)$ | 3k | 3 | 26 | 0.142 |
| $B_s \to J/\psi\ \eta(\gamma\gamma)$ | 8.5k | 2 | 30 | 0.109 |
| $B_s \to J/\psi\ \eta'(\pi^+ \pi^- \eta)$ | 2.2k | 1 | 19 | 0.154 |
| $B_s \to J/\psi\ \eta'(\rho\gamma)$ | 4.2k | 0.4 | 25 | 0.08 |
| $B_s \to J/\psi\ \eta_c\phi$ | 3k | 0.6 | 26 | 0.108 |
| $B_s \to D_s\ D_s$ | 4k | 0.3 | 44 | 0.133 |
| $B_s \to J/\psi\ \phi$ | 131k | 0.12 | 29 | 0.023 |

Sensitivity with 2$fb^{-1}$, $\Delta m_s = 17.5\ ps^{-1}$, $\phi_s = -0.04$ ,$\Delta\Gamma_s/\Gamma_s = 0.15$

CP eigenstates: $\sigma(\phi_s)$ 0.046, combined with Bs $\to J/\psi\ \phi$, $\sigma(\phi_s) = 0.021$

With 0.2 $fb^{-1}$ in 2008: $\sigma(\phi_s) = 0.07$

# Possible Upgrade Scenarios

Interest within the collaboration of detector upgrade ~ 2015

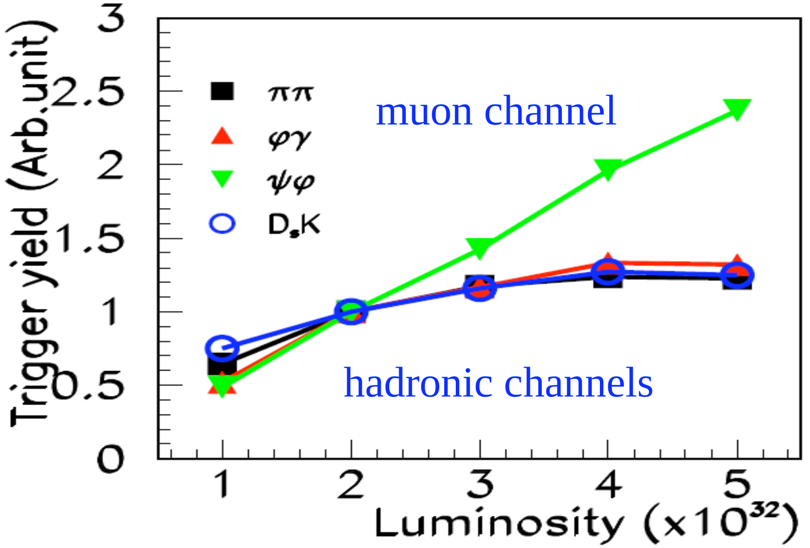
- LHCb luminosity is limited by the detector not by the machine
- Upgrade compatible with but independent of SLHC
- Extend physics reach collect 100 $fb^{-1}$ of data

Physics Goals:

Measure $\gamma$ with $1^o$ accuracy in $B_s \to D_s K$, $B \to DK$
Precision measurement of all observables in $B_d \to K^*\mu\mu$
Precision measurement of $B_s \to \mu\mu$
Precision measurement of the mixing phase in $B_s \to \phi\phi$

Key issues:

- Occupancies in the tracking detectors
- Radiation hardness of vertex detector
  - Pixels versus strips
- Radiation hardness of inner part of Calo
- Hadron Trigger limited by pile-up veto @ L0
  - First level displaced vertex trigger
  - Readout of the detector at 40 MHz



# Summary

- LHCB will be ready to collect data with its full detector in 2008
- Even with 0.2 $fb^{-1}$ significant measurements can be made
- Velo modules performed well in testbeam in 2006 together with final electronics
- Module production for both IT and TT complete
- Installation and Commissioning of Velo, IT and TT in the pit in coming months
- Possible upgrade scenarios to run at 10 times higher luminosity being investigated

LHCb will contribute significantly to the search for NP via precise measurements of the CKM angles and the study of loop decays