# The LHCb Silicon Tracker Project

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# introduction

- The LHCb Spectrometer
- Why Use Silicon?
- Trigger Tracker
- Inner Tracker
- Readout Chip
- Testbeam Results
- Outlook

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# Why LHCb?

- CP-violation used to explain matter over anti-matter dominance in universe.
- But, current CP-violation data insufficient to explain matter abundance
- new experiments needed to measure CP-violation in $B_s$ system
- Hence LHCb...

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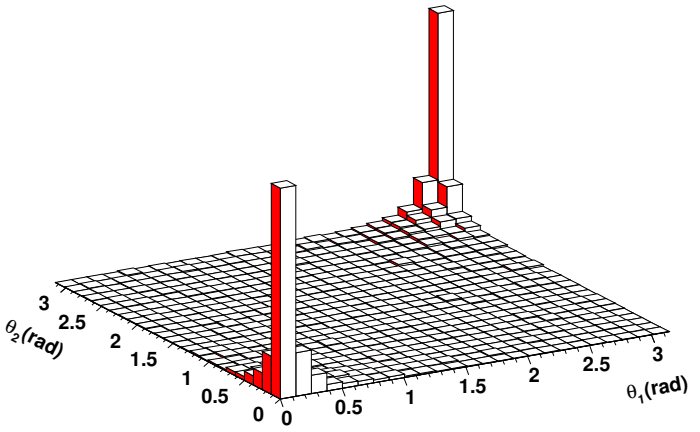
# Why LHCb?

- At LHC, $b\bar{b}$ pairs produced at forward and backward angles $\longrightarrow$




- construct a forward-angle spectrometer

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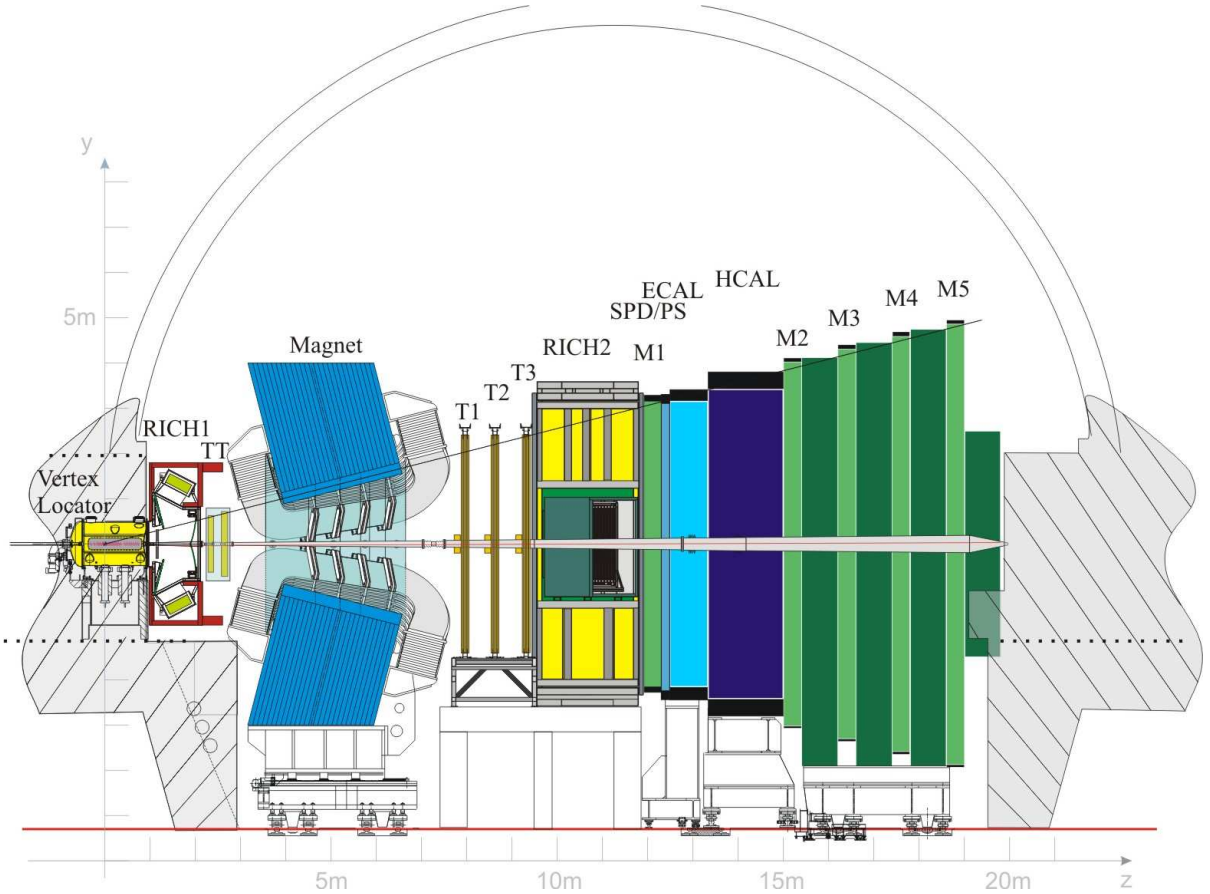
# Why LHCb?

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# Why use silicon?

- At high luminosity ($1.5 \times 10^{32} \mathrm{cm}^{-2} \mathrm{s}^{-1}$), high trigger rate ($1\ \mathrm{MHz}$) $\rightarrow$ good event rejection needed.
- Use tracking station (Trigger Tracker) to measure $\mathrm{P_T}$ of tracks and apply in L1 trigger.
- high particle density ($5 \times 10^5\ \mathrm{cm}^{-2} \mathrm{s}^{-1}$) around beam-pipe $\rightarrow$
- employ silicon-strip technology for inner part of spectrometer

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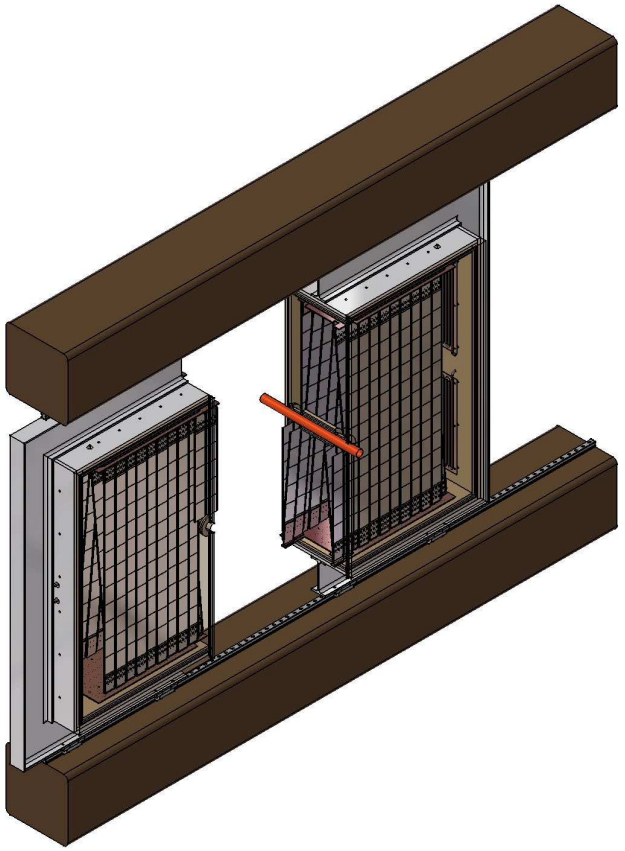
# Trigger Tracker



- cover large area with silicon (total of $8.3\ \mathrm{m}^2$)
- located in fringe-field in front of dipole magnet

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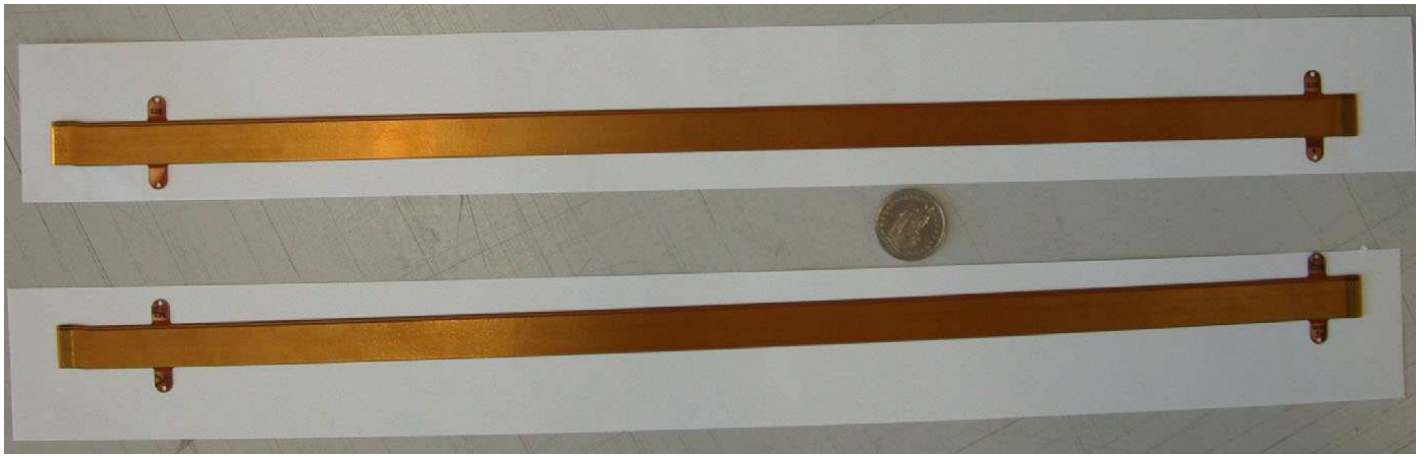
# Trigger Tracker

- need many sensors glued together to cover acceptance
- front-end needs to be outside acceptance $\longrightarrow$
- signal transport may be a problem



- use Kapton cables to connect lower sensors to front-end

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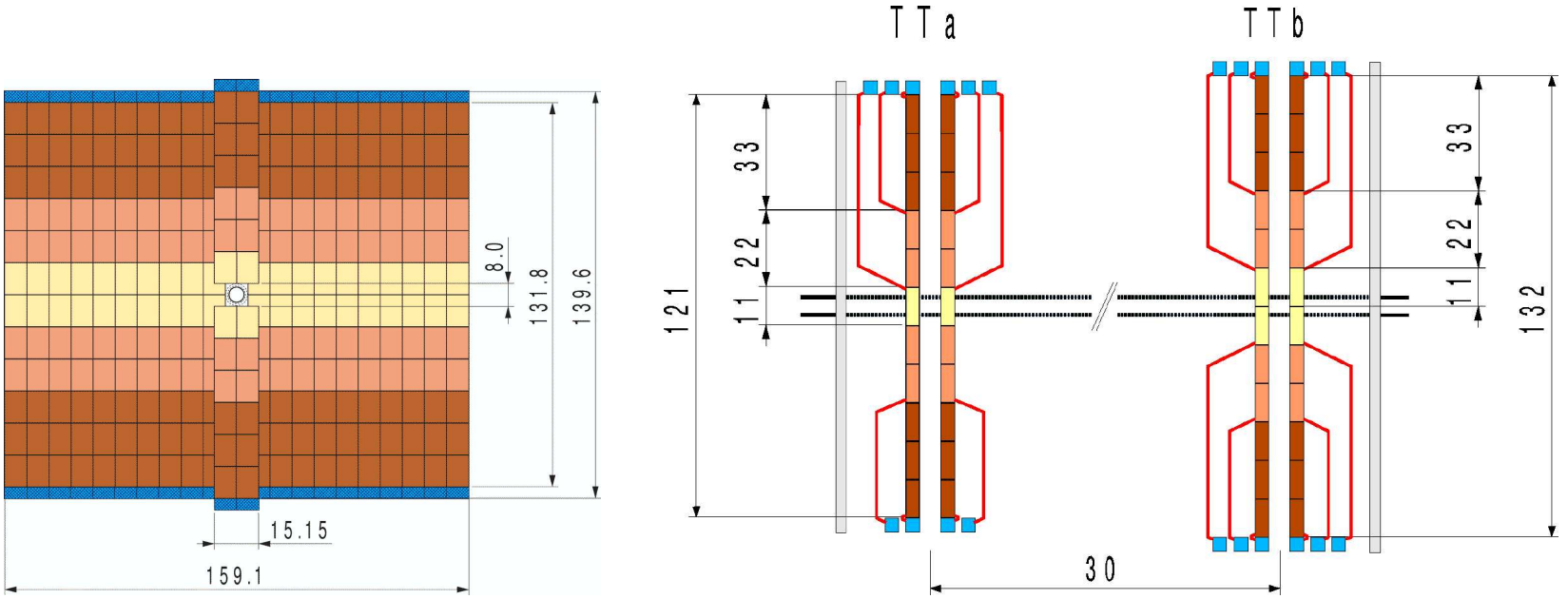
# Trigger Tracker




- two stations with each two planes in an $(x, x')$ and $(u, v\ 5^\circ$ stereo-angle) configuration
- connect inner substrates with flexible Kapton cable to read-out frontends

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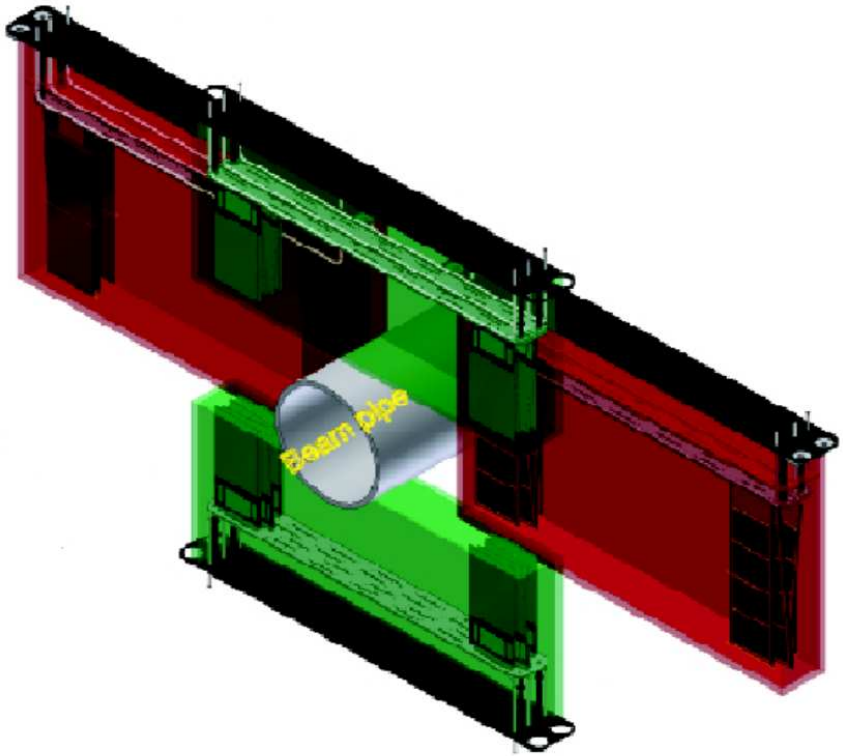
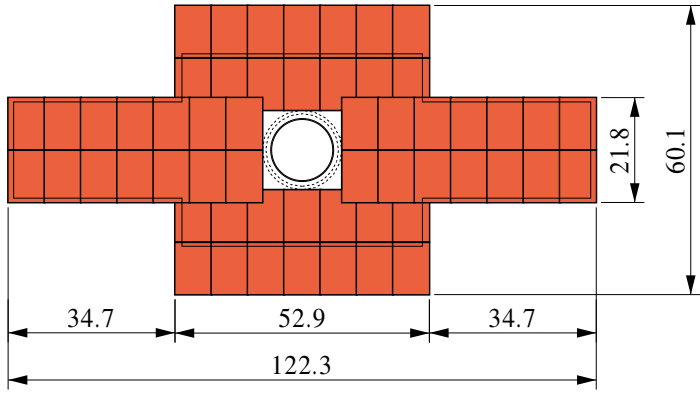
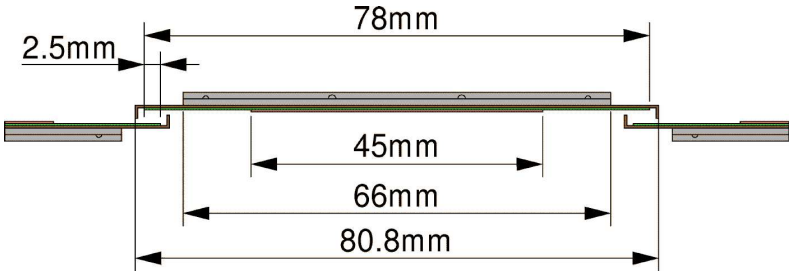
# Inner Tracker

- located in proximity of beampipe behind magnet
- 1.3% areal size, 20% of tracks
- two station, four boxes of four layers each



# Inner Tracker




- overlap between layers
- 197 $\mu$m pitch
- $110 \times 78$ mm$^2$ size sensors

- operating temperature $5^\circ$ C
- close to 100% hit finding efficiency
- 1-and 2-sensor ladders

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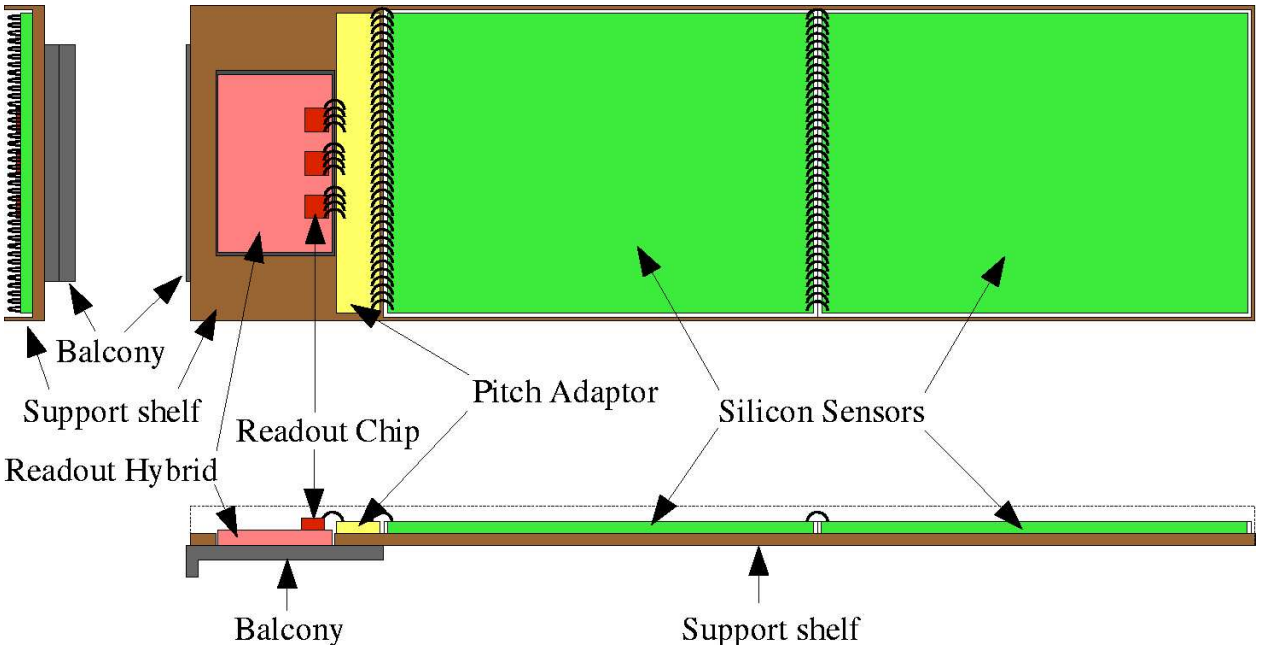
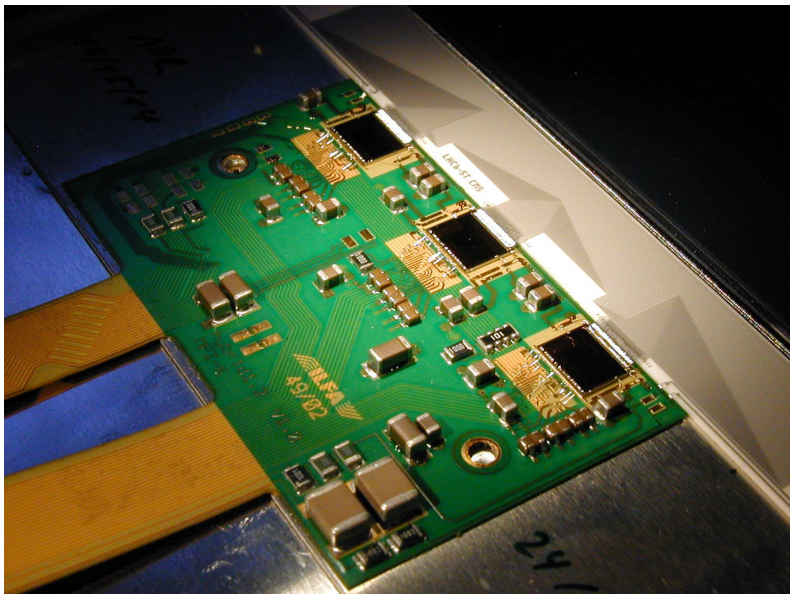
# Sensor Design

- different sensor types used in test beam
- various geometrical designs (pitch, width, thickness)




- study signal-over-noise behaviour for
- different substrate thicknesses

# Front-end



- Beetle chip developed by Asic lab in Heidelberg
- 64 channel, fast readout (40 MHz)

- three Beetle front-end chips per hybrid
- study pulseshapes on different loads
- signal remainder
- tracking efficiency

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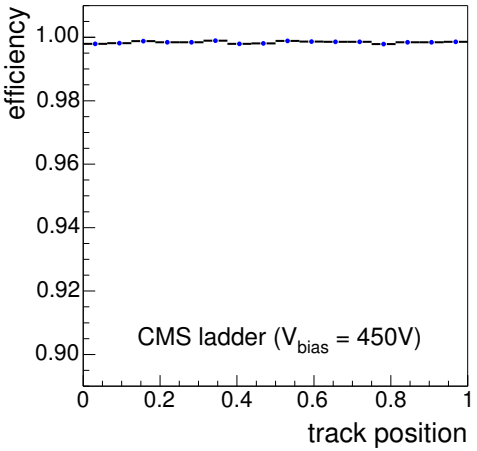
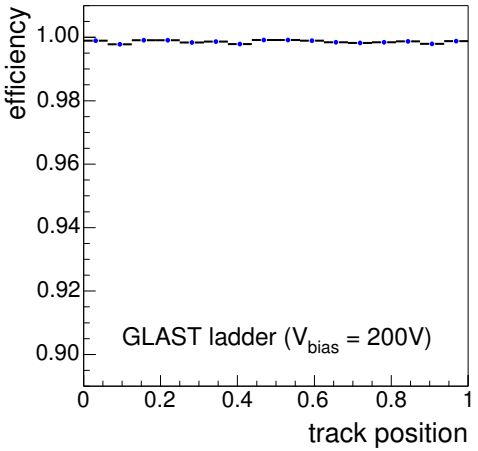
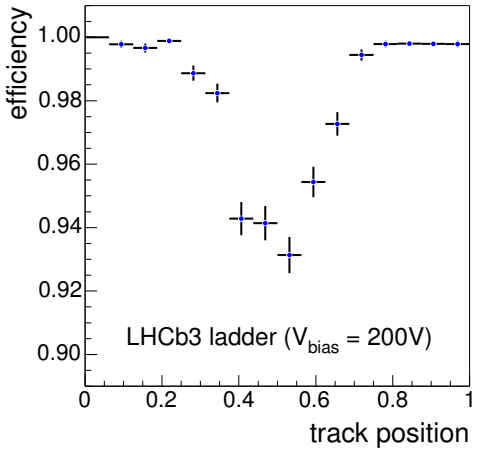
# Test Beam Results




500 $\mu$m thick
180 $\mu$m pitch

410 $\mu$m thick
228 $\mu$m pitch

320 $\mu$m thick
198 $\mu$m pitch

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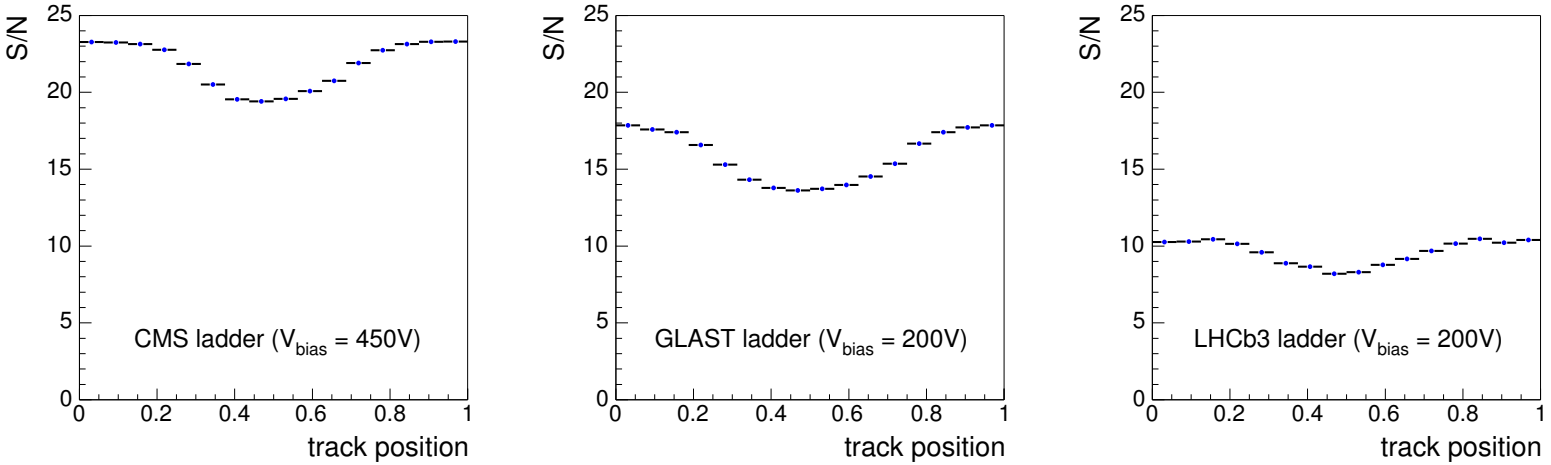
# Test Beam Results




- signal drop in between two strips due to charge loss
- impact on efficiency for $\mathrm{S/N} < 10$
- signal drop largest for thinner substrates

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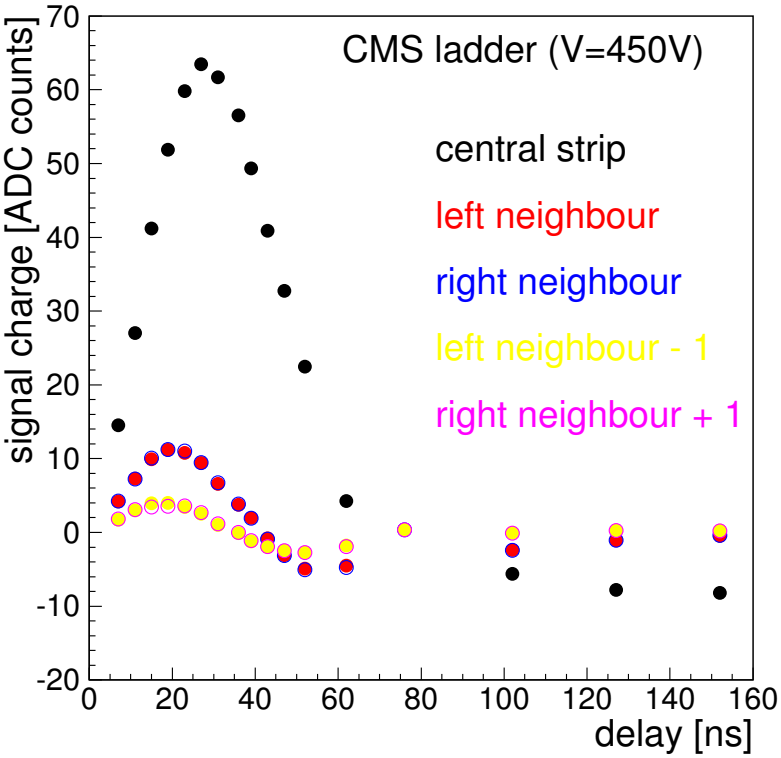
# Test Beam Results




- fast read-out: signal remainder after 25 ns $< 50\%$ of peaking time
- mirror charge arrives quicker
- Beetle chip fullfills LHC requirements
- sufficient tuning possible to accomodate various load capacities

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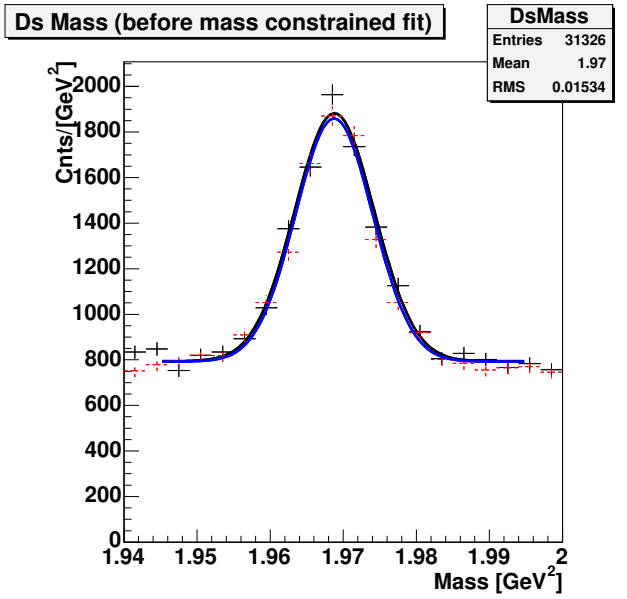
# Outlook




- minimal substrate thickness: $400\ \mu\mathrm{m}$
- no adverse effect on tracking and physics performance:
- large pitch: $200\ \mu\mathrm{m}$
- long strips: $10 - 30\ \mathrm{cm}$
- fast read-out: $O(25\ \mathrm{ns})$

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