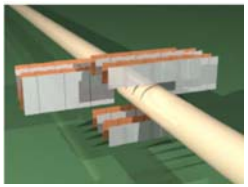


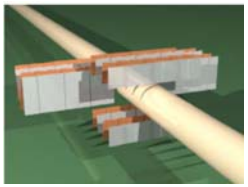
The LHCb Silicon Tracker

Helge Voss

for the LHCb Si-Tracker

- Introduction
- Inner Tracker design
- TT-Station design
- Test results

LHCb Introduction



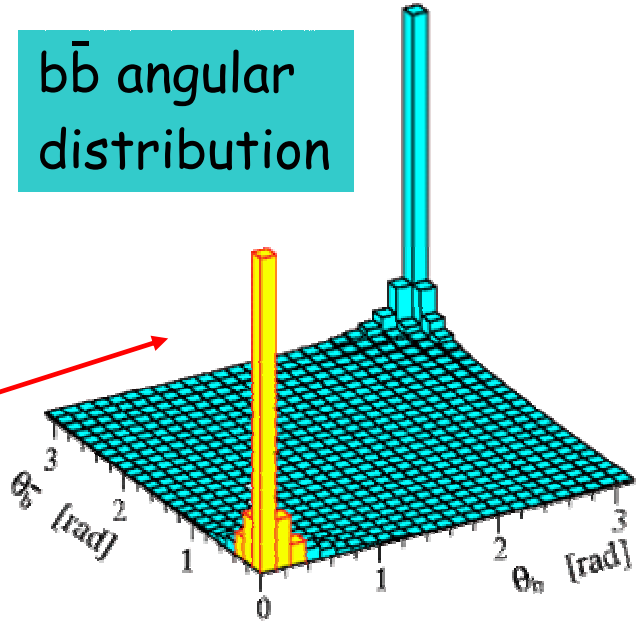
LHC: "b-factory" with 10^{12} $b\bar{b}$/year

pp@14 TeV, lumi=$2 \bullet 10^{32}$ $cm^{-2}s^{-1}$

(compared to 10^{7} at $\Psi(4S)$)

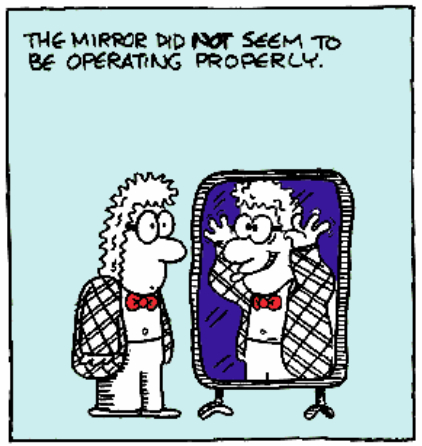
access to full B spectrum B_d, B_s

$b\bar{b}$ angular distribution

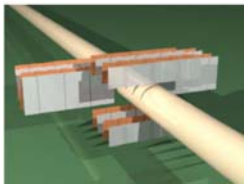


LHCb: single-arm forward spectrometer dedicated to B-physics acceptance: 15-300(250)mrad:

CP violation and other rare phenomena in the B-system

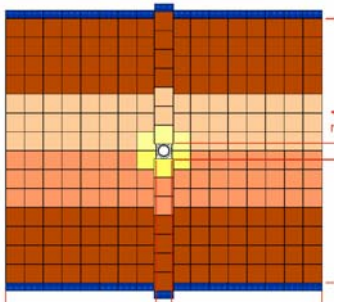


The LHCb Experiment



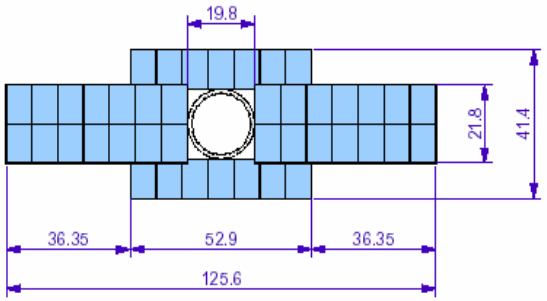
Silicon Tracker

TT-Station

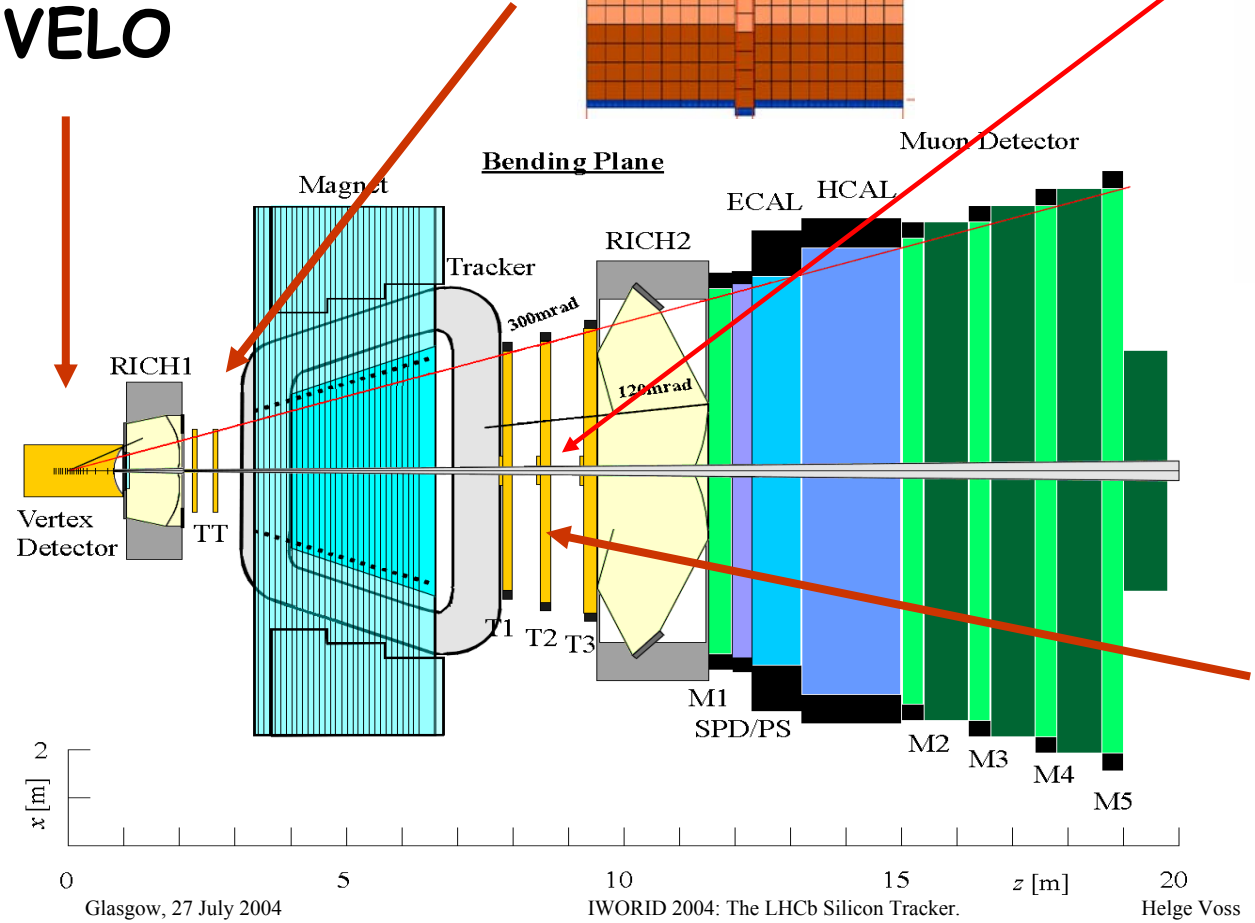


tracking detectors:

Inner Tracker

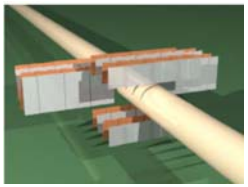


VELO

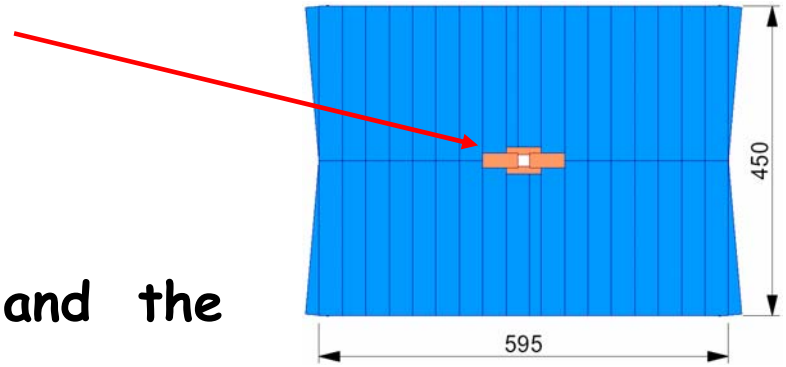


Outer Tracker

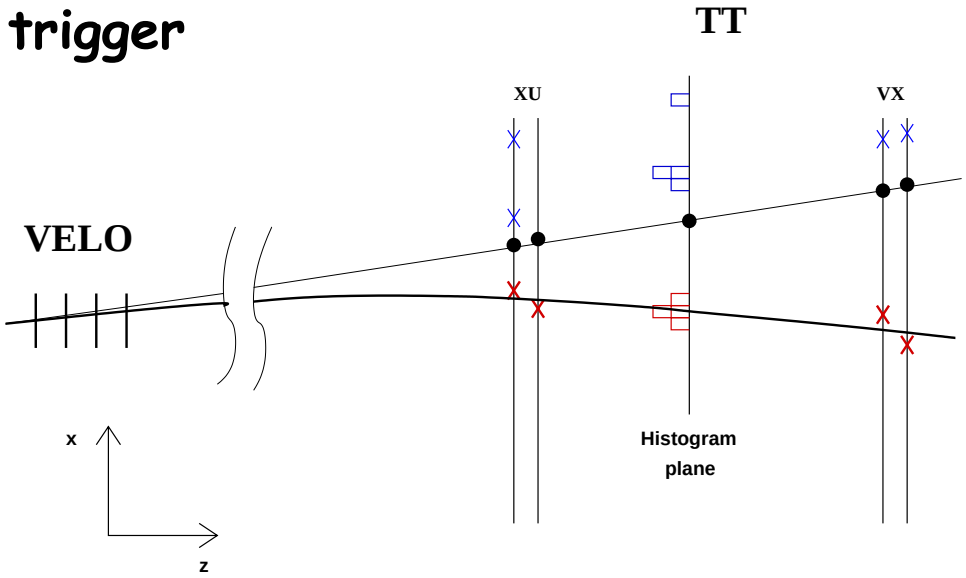
Why Silicon Detectors ?



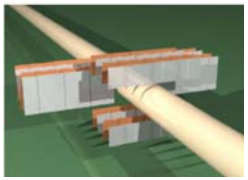
- high track density near the beam pipe



- good spatial resolution
  - → good hit matching between VELO and the two TT half stations
  - →good minimum bias retention in second level trigger



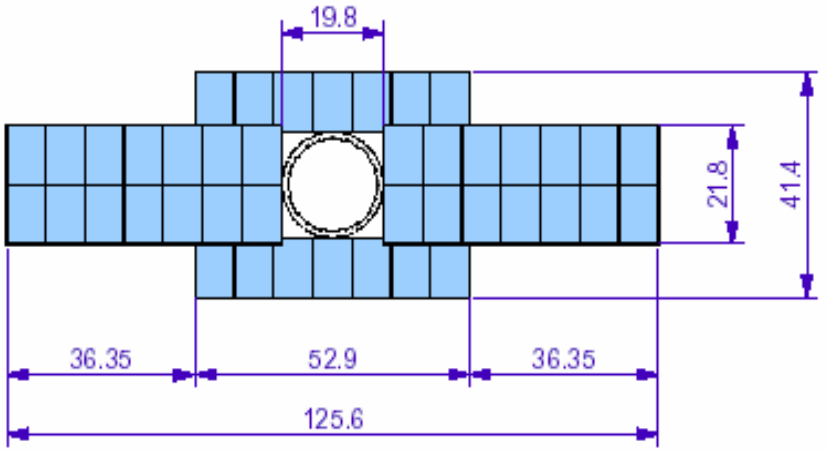
Inner Tracker

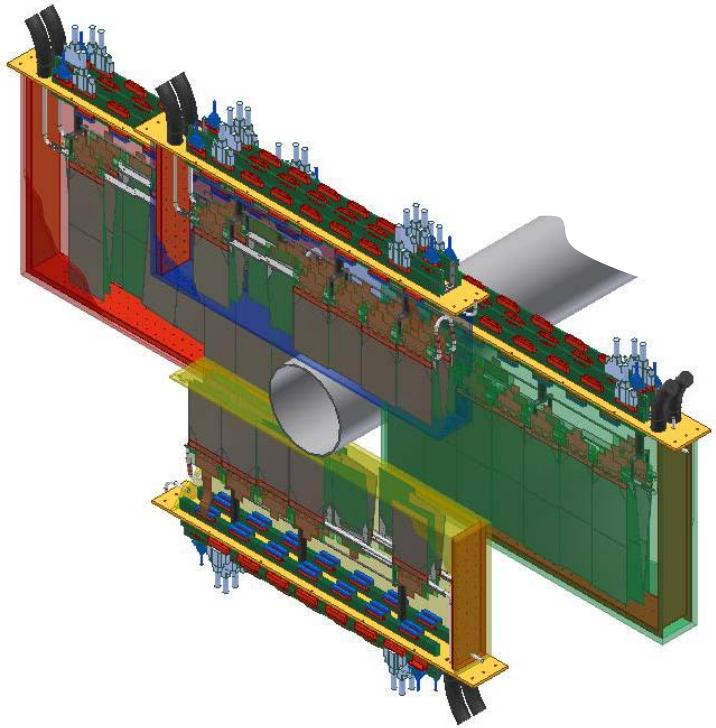


- 4 individual boxes per station
- 4 layers per station:(2 stereo layers)

➔336 modules: 11 and 22cm long

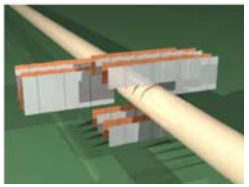
129k readout channels on 4.3m² silicon



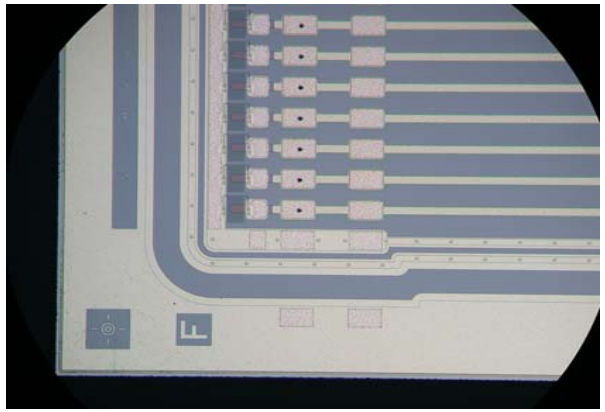


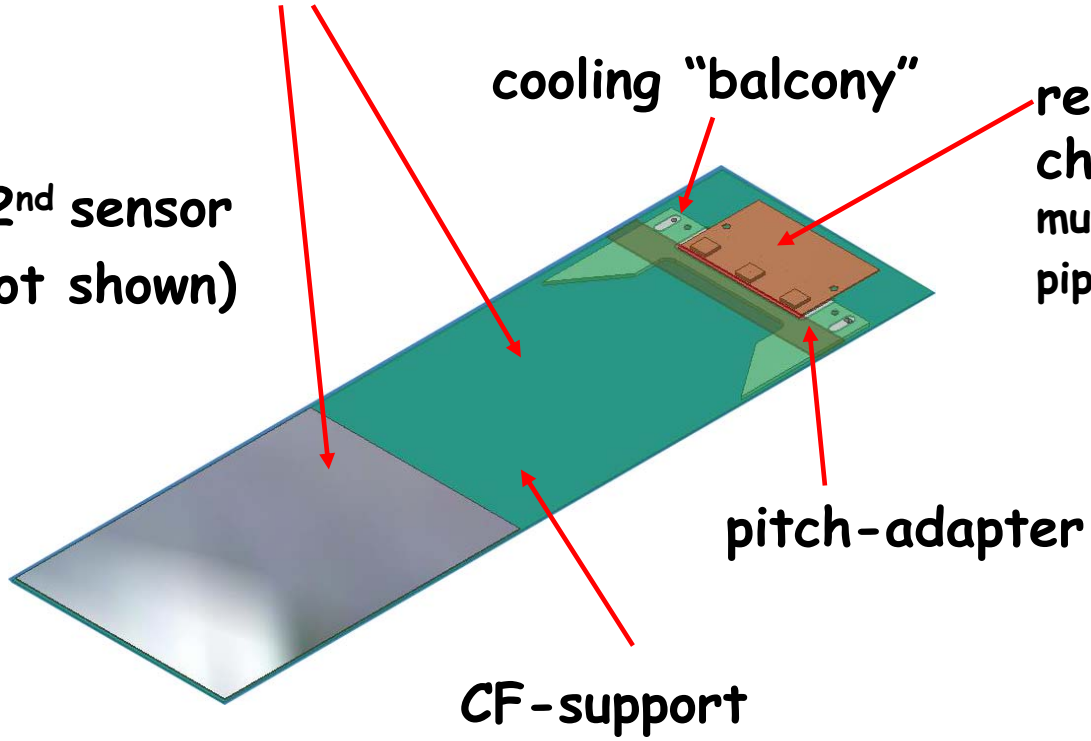
- operation at ~5°C
  - liquid cooling system for cooling hybrid and sensors
  - thermally conductive CF support
- box enclosure lightweight isolation foam + Al foil for electrical shielding

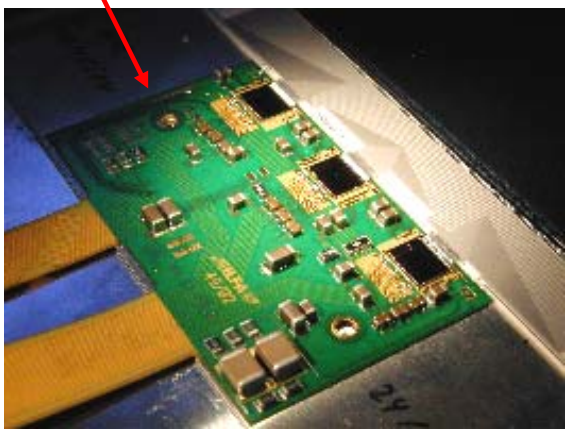
Inner Tracker Modules



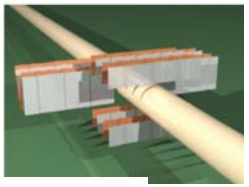
p-n silicon micro-strip sensors (HPK)
108 mm long strips, 384 readout strips
197μm pitch, w/p=0.25,
320 (410) μm thickness

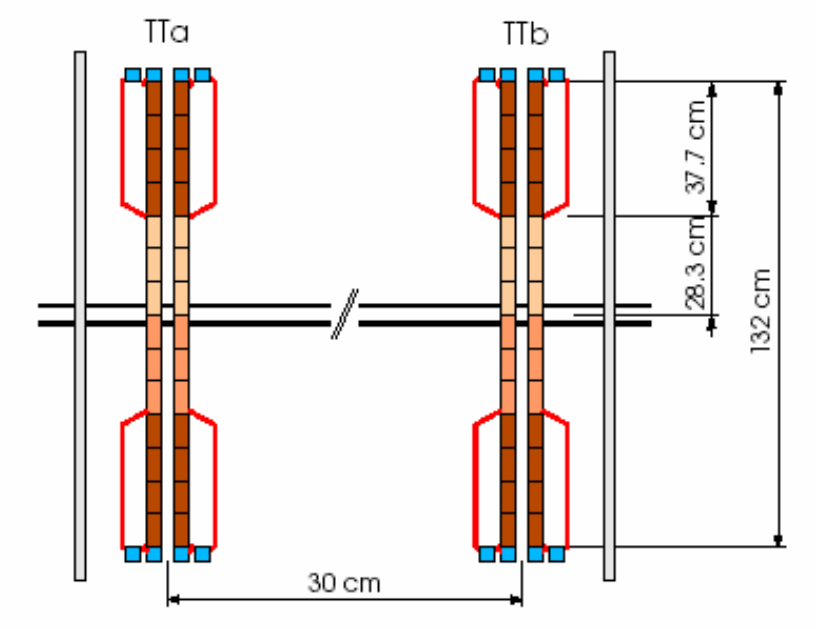


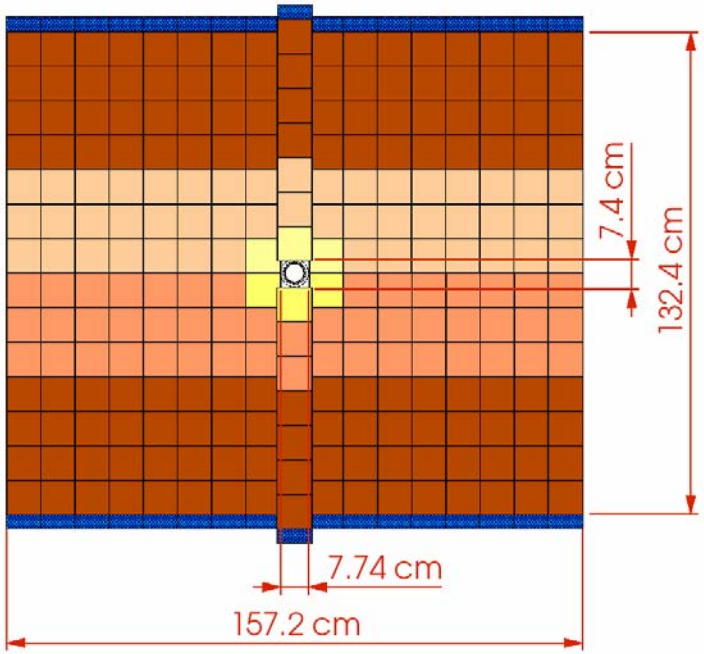




TT-Station Layout

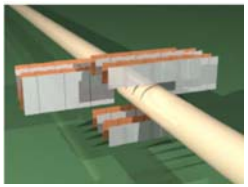




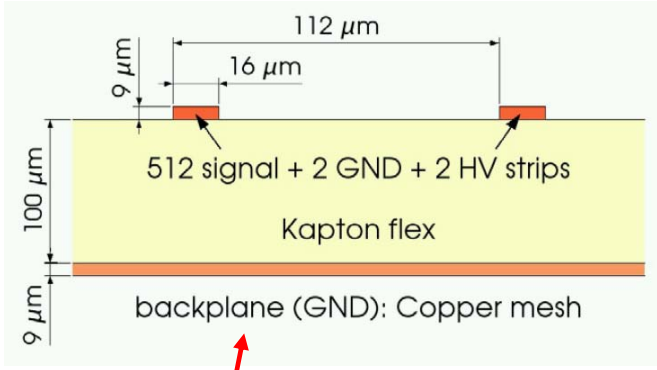


- 4 layers in 2 half stations, 2 layers ±5° stereo angle
- 280 readout sectors, 143k readout channels on 7.9m² silicon
- readout sectors with 1,2,3 and 4 sensors
- all readout hybrids at the edge outside of the acceptance
- inner modules connected via Kapton interconnect cables
- both stations enclosed in one box, operated at ~5°C

TT-Station Modules



TT: CMS-OB2 sensors (HPK)
p-n silicon micro-strip sensors
91.6 mm long strips,
512 readout strips
183μm pitch, w/p=0.25,
500 μm thickness

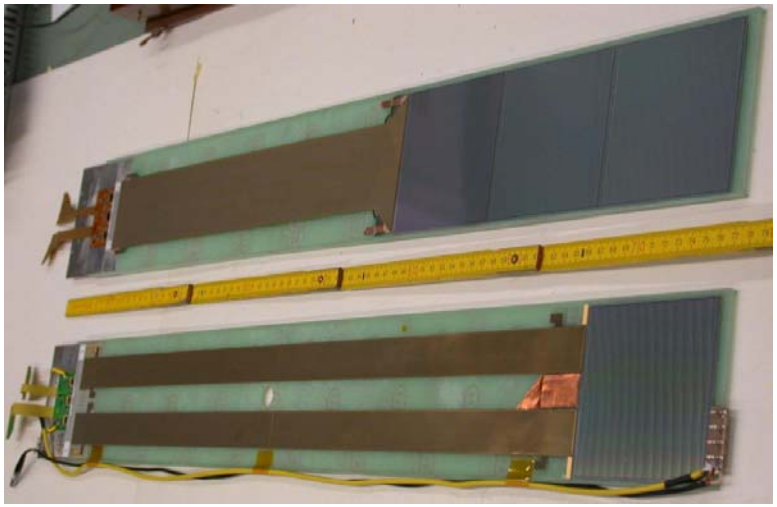


readout hybrids
(4 Beetle chips)

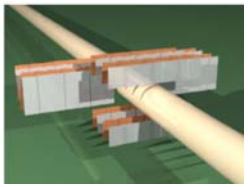
Kapton interconnects

CF rails

silicon
sensors



The Challenges



- moderate spatial resolution requirement (~60μm)
- moderate radiation environment. After 10 years: 1 (5) Mrad or $9 \cdot 10^{12}$ ($4.5 \cdot 10^{13}$)cm^{-2} of 1-MeV Neut.equiv. in IT (TT)

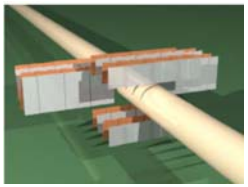
But:

minimize: R/O channels ⇒ large pitch O(200μm) (charge collection)
⇒ long strips 38cm (55pF) or
(28cm+40cm Kapton, 57pF) (noise)

40MHz, fast readout ⇒ (noise)

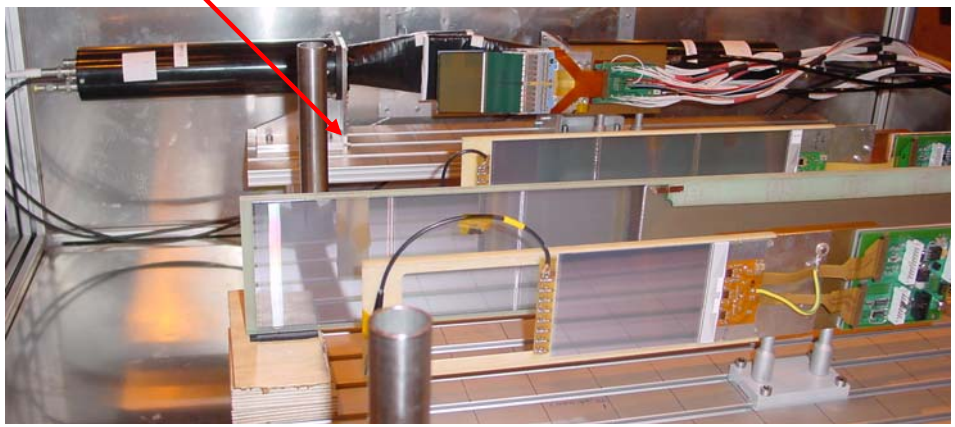
choose minimal material ⇒ "thin" sensors (little charge)

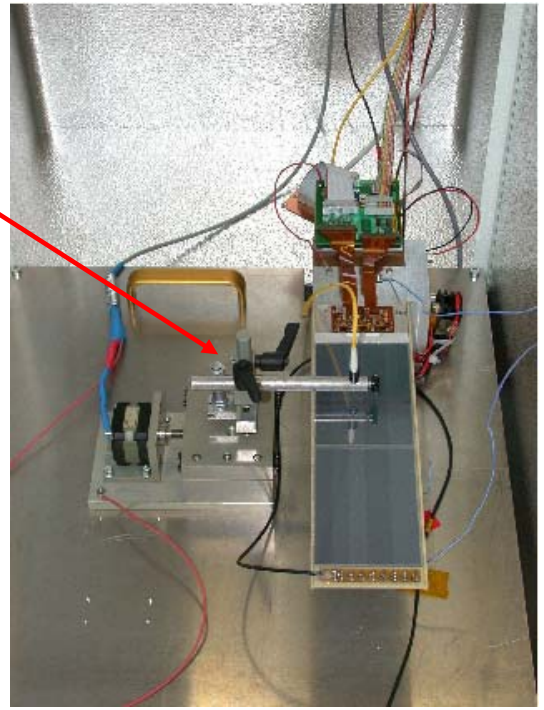
Test Setup



CERN test-beam and IR-laser

120GeV pions

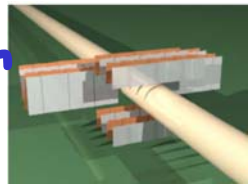


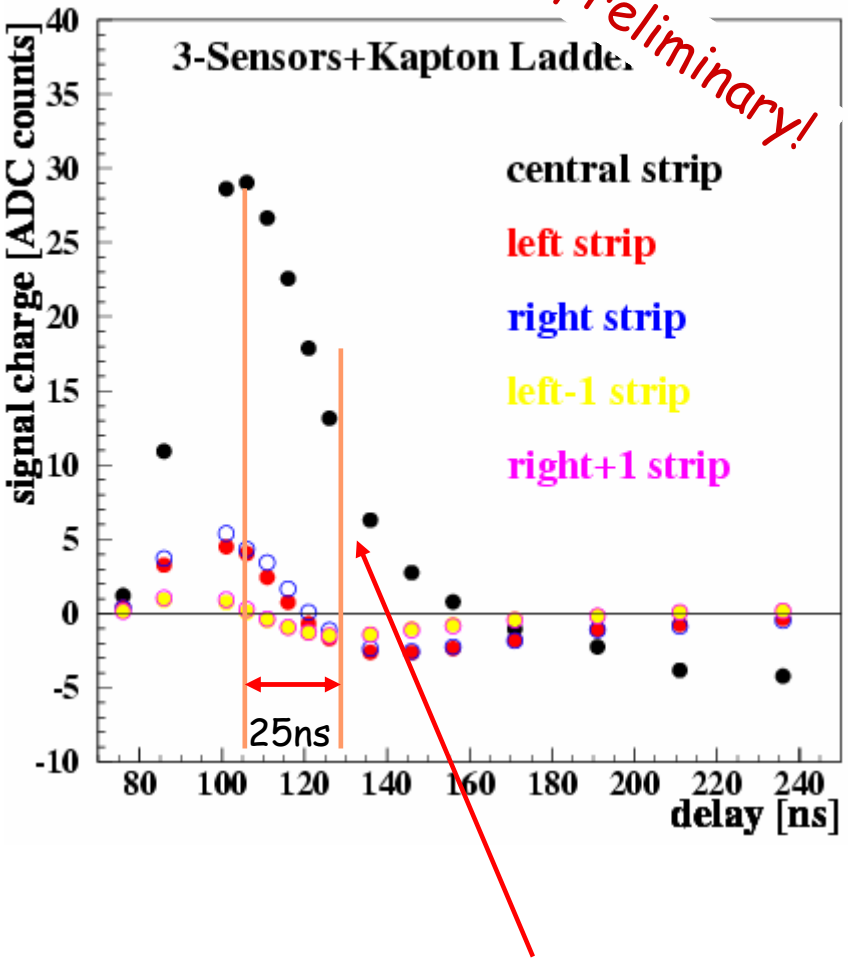


testing of:

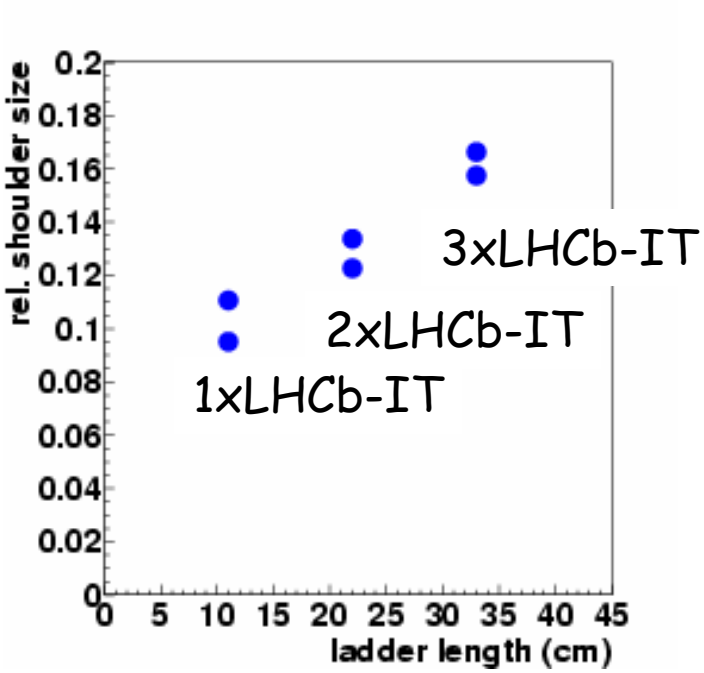
- ladders with 3 TT(CMS-OB2), GLAST and LHCb-IT sensors (~30 cm)
- 2, 1 sensor ladders with LHCb-IT sensors
- 1 LHCb-IT sensor irradiated to equiv. of 10year LHCb running
- 1 TT (CMS-OB2) sensor + 60cm Kapton flex cable (→ laser only)
- 3 TT (CMS-OB2) sensors + 40cm Kapton flex cable

Pulse-shape + Signal Remainder





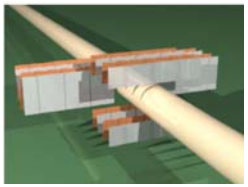
- charge in neighbouring strips due to capacitive coupling has different time structure compared to central strip

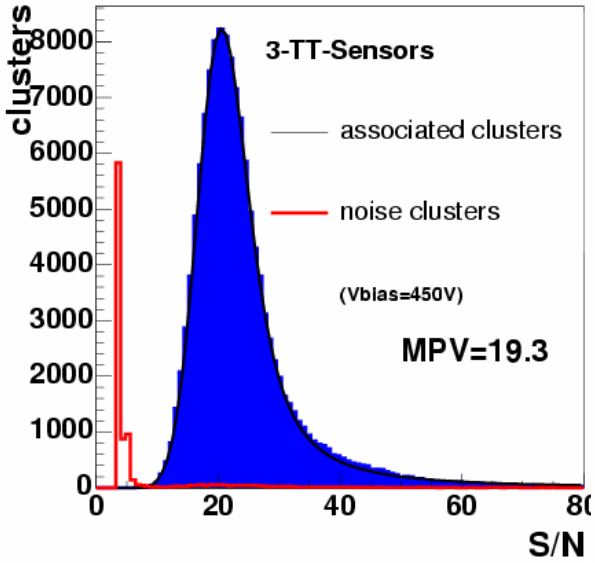


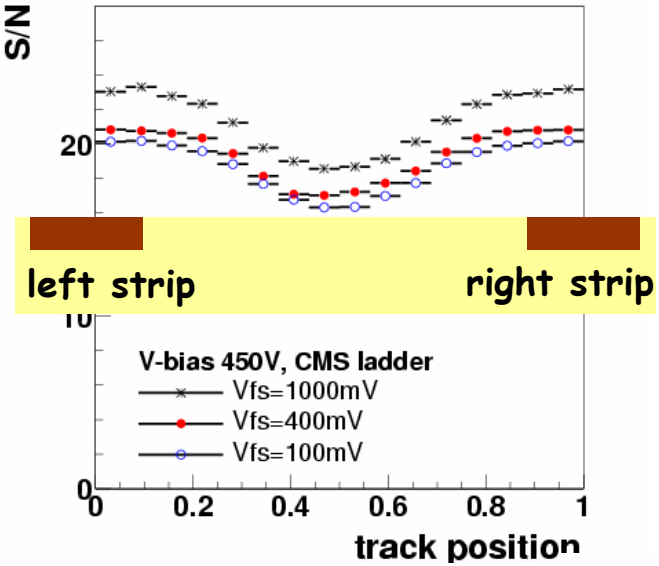
signal remainder 25ns after peak (BX every 25ns)

→ specification: remainder < 0.5 (0.3) TT (IT) o.k.

Spatially resolved S/N



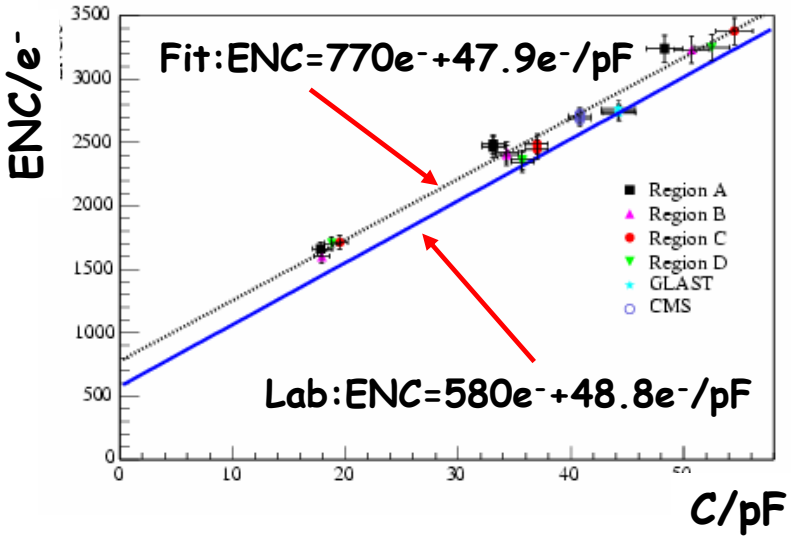




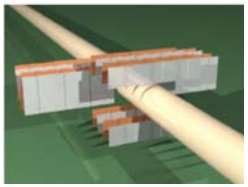
- MPV S/N from fit Landau ⊗ Gaussian
- charge loss in inter-strip region
- ensure sufficient S/N over the whole sensor →thickness

- good understanding of noise behaviour w.r.t. load capacitance, thickness, pitch and w/p
- extrapolation to 4 sensor ladder and 3 sensor + Kapton flex ladder

→ comparison with this year's test-beam data look promising



Summary



- LHCb Si-Tracker uses silicon strip detectors with
  - large pitch of ~200μm
  - long strips up to 38cm or 28cm+40cm Kapton cable
  - fast readout O(25ns)

- presented the current design of the TT – station and the Inner Tracker

- (preliminary) test results show
  - modules fully meet our expectations
  - sufficiently fast signal → pulse-shape
  - sufficient signal → S/N in inter-strip region
  - results on irradiated sensors are still to come