Local Trigger Electronics for the CMS Drift Tubes Muon Detector

Presented by R. Travaglini
INFN-Bologna
Italy
CMS Drift Tubes Muon Detector

CMS Barrel: 5 wheels
Wheel: Azimuthal sectors with 4 chambers
Chamber: staggered layers of drift tubes
Drift Tubes L1 Trigger

• CMS Muon Trigger
  ➢ Muon identification
  ➢ Transvers momentum ($P_t$) measurement
  ➢ Assignment to the correct Bunch Crossing

• Drift Tubes Level 1 Trigger (custom electronics)
  ➢ DTBX : Local muon identification
  ➢ Regional Trigger : correlates chamber information

• DTBX:
  ➢ Selects 2 track segments with higher $P_t$
    ✓ Reliability
    ✓ Radiation tolerance

Electronics directly installed on the DT chambers
DT local trigger electronics

- Synchronous pipelined system (40 MHz)
- Processing stages organized in a logical tree structure
Track Sorter Slave - TSS (1200 ASIC, Alcatel 0.5 μm):
- selects 2 best muons in a portion of the chamber

Track Sorter Master - TSM (250 x 3 pASIC, Actel, 0.35 μm):
- selects 2 best muons in the whole chamber
Track Sorter Slave test system

TSS Asic
Alcatel 0.5 μm CMOS
16000 gates – 210 pins
Product by Europractice

Piggy board mounted on a VME
Pattern unit emulating Traco input
and receiving output

4.5 mm
Software for tests

Developed under Win2000 with Visual C++

SW controls all test options:
✓ Generates, transmits and receives pattern
✓ Checks output with emulation
✓ Finds better setup conditions
✓ Provides monitoring and configuring

*) interfaces Power supply and clock generator through GPIB protocol
*) interfaces mySQL database for bookeeping
We developed a screening system which checks:

- chip bonding
- sorting with different setups (clock frequency, supply voltages, reg.s configurations)
- monitor and control logic
- current drawing

We need to screen 1200 (spares included) perfectly working devices to be installed on the Trigger Boards (so that TRB rejection rate could be lower)

30 sept.:

1200 accepted / 1290 tested

Performance of the screening system: 2 min/chip
Server Board

Front side

9.5 cm

20.6 cm

PCB
16 layers!

TSM side

TSMS

National serializer
10-to-1 DS92LV1021

TSMDs

Reminder: TSM is implemented with 3 pASIC Actel A54SX32 0.35 μm CMOS

NB: Backside contains most of the control logic electronics for the minicrate
Server Board test system

Pattern Units (pattern generator and readout module)

Crate VME

Vme board with CPU Pentium II

Rs232
PC serial port

Server Board

Adapter Board

Trigger Link Rx

232 bits @ 40 MHz

2 copper cables FTP class 6– 40 m

LVDS link – data serialized @ 480 MHz

80 bits @ 40 MHz

232 bits @ 40 MHz
Server Board production

TSM
(3 x 250 pASIC, Actel, 0.35 µm):
- 1000 device in hands and fused accordingly to the Server Board production rate
- System tested with “surgical” and random pattern (about $10^9$)

Server Board:
- pre-production delivered in March 03 (5 SB)
  ⇒ successfully tested ⇒ design validated!

- 1 SB installed into the minicrate used at the test beam (see last slides..)
  - Valid integration test!

- Pre-series production (35 SB for '03 minicrate production) delivered
  ⇒ test will start very soon;

- tender for full production going on
Irradiation Tests

- TSS - ASIC Alcatel 0.5 μm
  $\sigma_{SEU} = 8.4 \times 10^{-15}$ cm$^2$/bit
  for 60 MeV protons
- $R \approx 2$ SEU/1200 chips
  in 10 LHC years

- TSM - Actel A54SX32-3PQ208
  $\sigma_{SEU} < 2.9 \times 10^{-12}$ cm$^2$/chip
  90% c.l., for 59 MeV protons
- $R < 2.2$ SEU/chip
  in 10 LHC years

Performed at CRC in Louvain with 60 MeV energy protons
Transmission between Server Boards (on chambers) and Sector Collector (first stage of the regional trigger, located on the towers)

LVDS technology - 80 bits @ 480 MHz through 2 copper cables (FTP- Cat6) of about 30 m length.

Tested with ad-hoc setup (Tx + Rx) with different conditions: supply voltages, temperature, cables length, clock jitter.

Result: expected to work in DT minicrate environment
Test at Cern SPS with muon beam having 120 GeV of energy
Beam structure: bunches 25 ns spaced

Setup: one DT muon chamber equipped with a complete minicrate

(pictures by M. Bontenackels)
Test beam result: analysis is on going

~ 9 million events acquired with several different configurations of the trigger system

A dedicated sample of di-muon events has been acquired!

Data quality seems to be good!

Preliminary analysis shows high BX tag efficiency ( > 95 %) and trigger timing distribution very similar to the simulation

But: analysis still going on…
Summary

- Devices composing the Trigger Server system (TSS and TSM) have been successfully checked with ad-hoc test jig and they fulfill requirements for working in CMS environment.

- On-chamber trigger electronics production has been started. Concerning the Trigger Server system:
  - TSS: 1200 chip perfectly working have been screened for producing the trigger boards
  - TSM and SB: pre-production for ’03 has been delivered and full production will start soon in accordance with the minicrate production rate

- The full Trigger Electronics System for a DT muon chamber was integrated for a test with bunched beam and preliminary analysis confirm that it works according to the expectations