Fast read-out of the COMPASS RICH CsI-MWPC chambers

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- The COMPASS experiment and its RICH detector
- A new electronics using APV25-S1 chips
- Tests in real conditions
- Conclusion
The COMPASS experiment

Dedicated to nucleon structure and spectroscopy studies
On CERN-SPS 160 GeV $\mu$ and $h$ beam (Prévessin site)
Need to identify hadron particles ($\pi$, $K$, $p$)

$1^{\text{st}}$ spectrometer

$2^{\text{nd}}$ spectrometer
The COMPASS RICH detector

- built by INFN (Trieste and Torino), ICTP, CERN and Bielefeld
- designed to identify particles between 5 to 50 GeV

8 CsI-MWPC on focal plane

80 m$^3$ $C_4F_{10}$ vessel

spherical mirrors

acceptance 250x180 mrad

3.3 m

6.6 m

5.3 m
The RICH MWPCs

8 chambers with 2 photocathodes each, methane gas

- **Electronics**
- **2 CsI photocathodes**
- **Wires plane**
- **CH₄ gas**
- **Quartz window**

**Photocathode:** 72x72 pads of 8x8 mm²
**γ detection range:** 160-200 nm
**Gas gain:** $3 \times 10^4$ at 2000V
The RICH MWPC read-out

Present electronics based on Gassiplex amplifier
- electronics noise \( \approx 1000 \, \text{e}^- \)
- large integration time (\(~3 \, \mu\text{s}, \text{compared to up to 1 Mhz hit rate in central region}\) 
- long dead time needed by amplifier to restore the base line (\(~5 \, \mu\text{s}\) 

Features to improve
- signal over background improvement by reducing integration gate
- dead time reduction to stand higher trigger rate (up to 80 kHz)
Upgrade of the COMPASS RICH

2 complementary projects:

- replace MWPC by MaPMT in the central region (cf. A. Ferrero's talk)
- replace read-out electronics by a new one using APV25-S1 amplifier in external region
The APV25-S1 chip read-out

APV25-S1 chips amplifies, shapes, samples and multiplexes analog signals, which are then read by flash ADCs

Main characteristics of the APV25-S1:
- designed for CMS silicon microstrip tracker
- CMOS 25 μm
- fast analog signal pre-amplifier, shaper and multiplexer, adjustable time constants
- 128 channels / chip, low cost
- 40 MHz sampling on 192 cells analog pipeline
- already used on other COMPASS detectors (GEM, Silicon tracking detectors)

Joint project between TUM Munich and CEA Saclay COMPASS groups
Characteristics of the read-out

Signal shapes for different sets of APV parameters
peaking time from 50 to 500 ns
gate time from 400 to 2 µs

3 samples read for each hit to
get informations on signal shape
and timing

Low dead time up to 80 kHz
Tests in real conditions

12 front-end cards (432 ch. each) built to equip a whole photocathode in RICH central region
Tested with $\mu$ and $h$ beam in $\sim$ nominal conditions
2D profiles of the RICH central chambers

Halo mask ("lunettes")

Beam halo

Reduced occupancy from beam halo

Gassiplex read-out

APV read-out
Amplitude spectrum

**APV cluster amplitude**

- Avg. amplitude: \(5830 \text{ e}^-\) (noise: \(640 \text{ e}^-\))
- \(S/N \sim 9\)

**Gassiplex cluster amplitude**

- Avg. amplitude: \(8750 \text{ e}^-\) (noise: \(\sim 1000 \text{ e}^-\))
- \(S/N \sim 8.75\)

**Results and Analysis**

- Higher ballistic deficit due to shorter integration time
- As expected by simulation
- Deficit compensated by lower threshold (better noise figure)
Ring reconstruction with APV

\[ \Delta r = r_{\text{hit}} - r_{\pi} \]

where \( r_{\pi} \) is the radius expected if the particle is a pion (ring center given by tracking system)

Cuts:
- \( a_2 > a_1 \)
- \( a_2 > a_0 \)
- \( a_{\text{cluster}} > 2400 \ \text{e}^{-} \ (\sim 3 \ \sigma) \)

Number of clusters = 11.2
similar to Gassiplex

S/B = 2.13 compared to 0.35 with Gassiplex
Effective time gate

Normalization by the number of rings

Measured effective time gate
full width: 375 ns
at half maximum: 250 ns

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Signal – background comparison

50% background hits are in time
Time measurement resolution

Time measurement with $a_1/a_2$ ratio

Latency scan for $a_2 > 40$

Time resolution vs signal amplitude
Dead-time improvement

- APV 20 MHz read-out
- Old Gassiplex electronics
- APV 40 MHz read-out

Almost no dead time up to 40 kHz trigger rate
Low dead time up to 80 kHz

Graph showing readout dead time vs. trigger rate (kHz)
Conclusions

Project to read gaseous CsI-MWPC photo-detector with fast electronics using APV

APV more efficient than classical slow electronics:
  • Same signal / noise ratio
  • Small effective time gate (< 375 ns) → factor 6 gain on signal/background ratio
  • Time resolution < 30 ns for 50% of the clusters
  • Low dead time
  • Highly integrated and cost effective

This electronics will be installed on COMPASS RICH detector for the 2006 data taking period (~62000 channels)