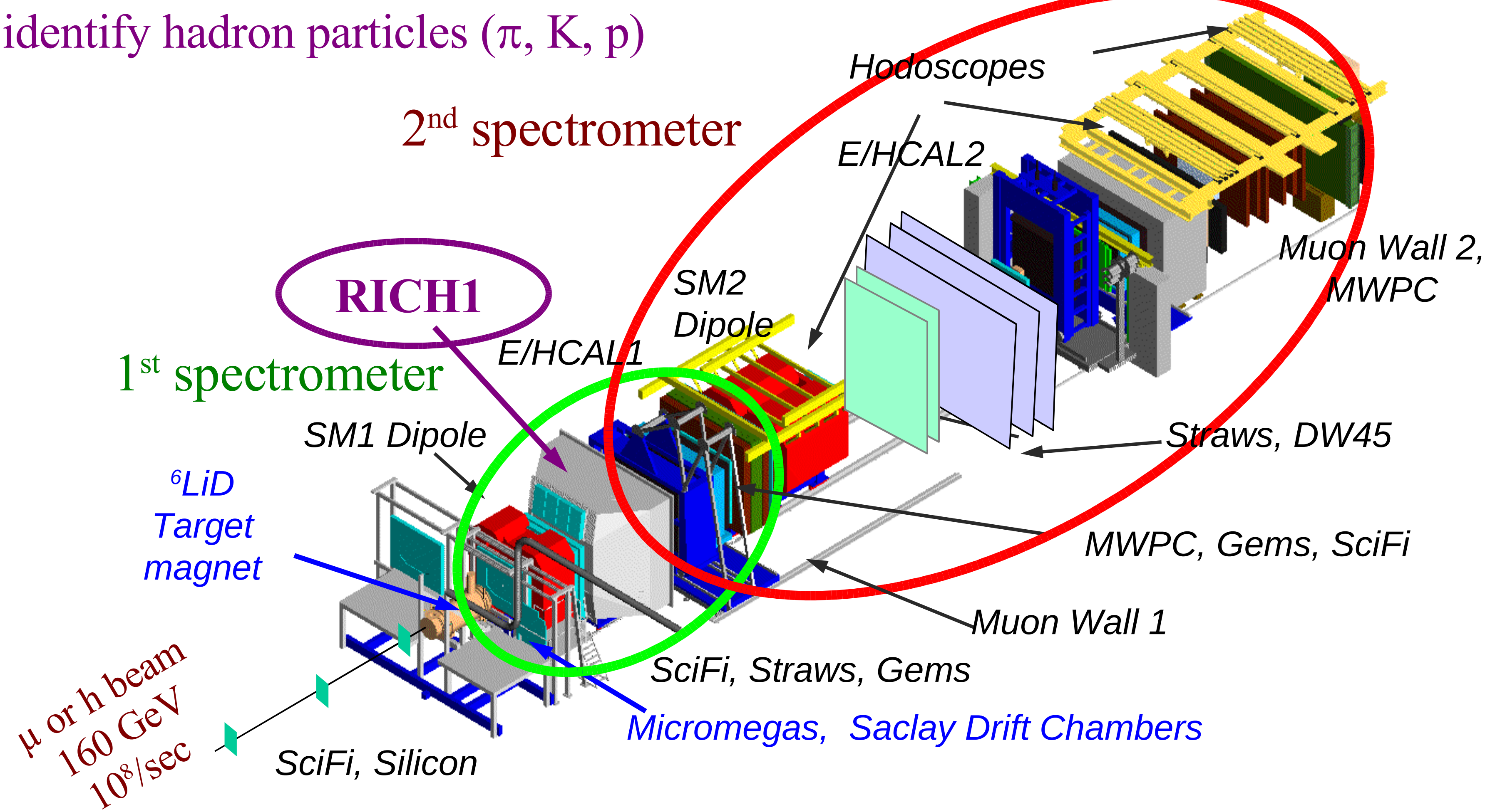
Fast read-out of the COMPASS RICH CsI-MWPC chambers

D. Neyret
CEA-Saclay
DSM/DAPNIA/SPhN

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

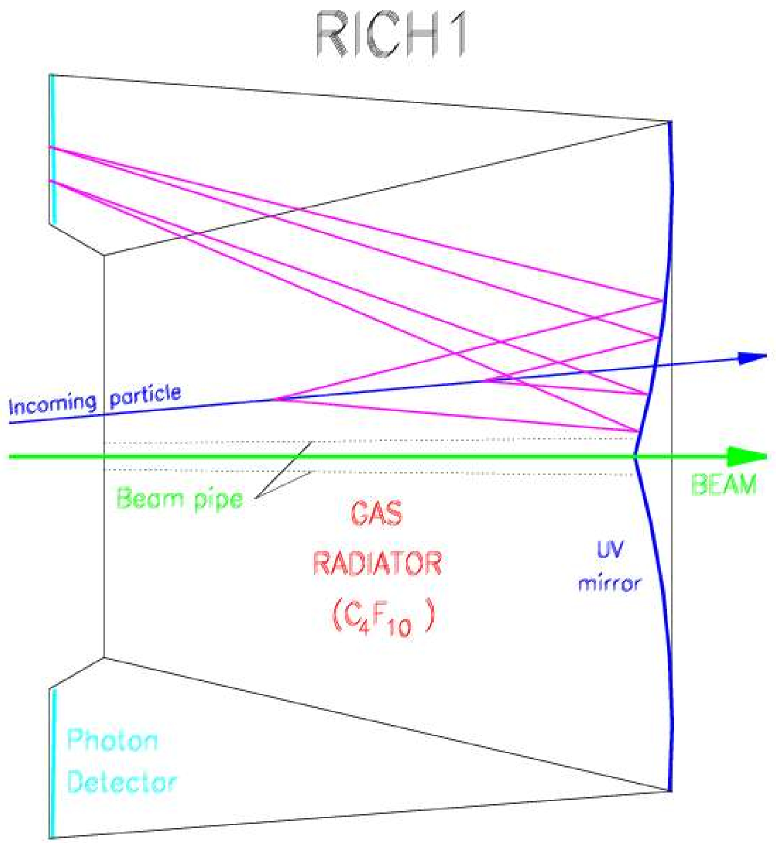
The COMPASS experiment

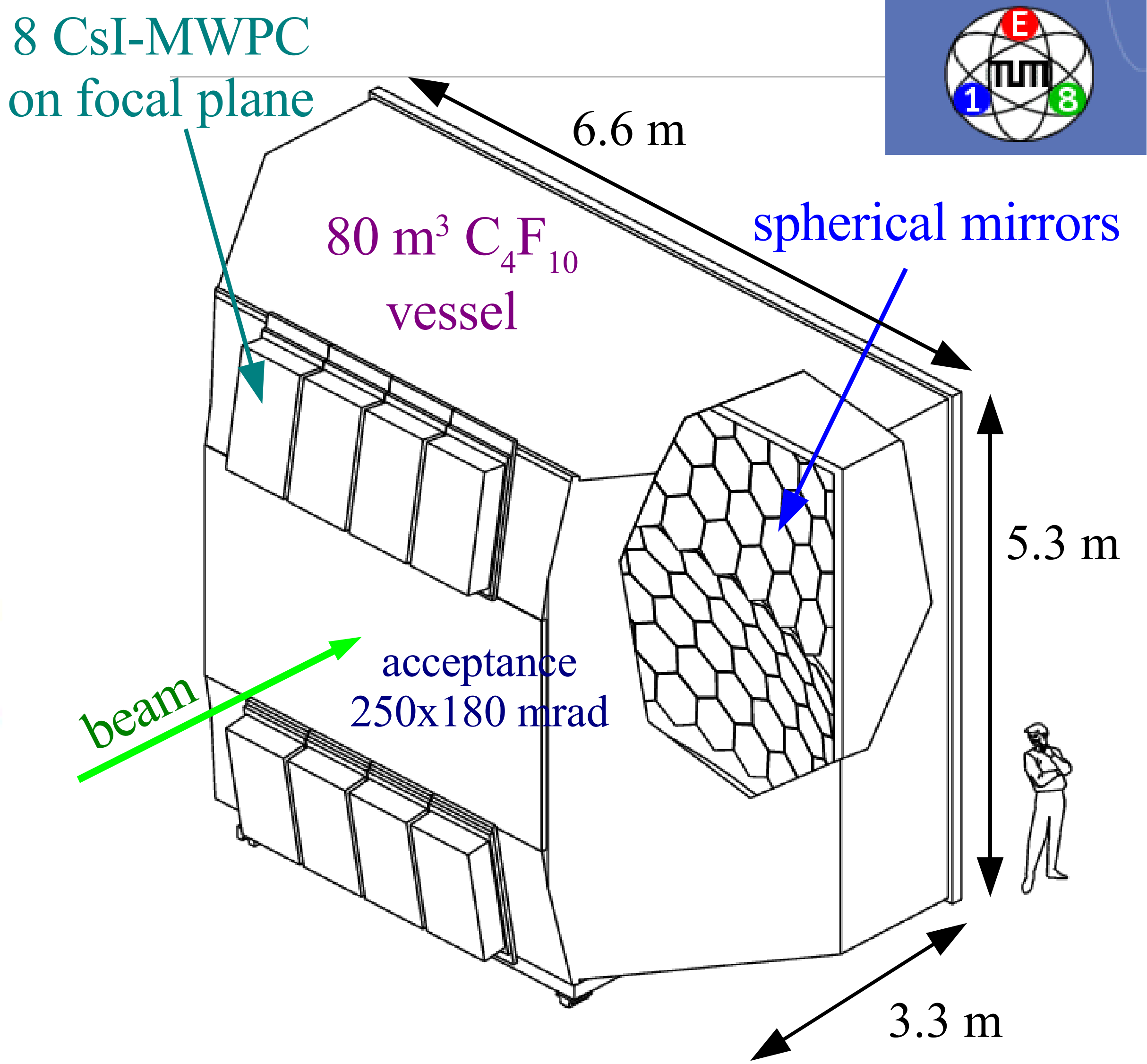
Dedicated to nucleon structure and spectroscopy studies
On CERN-SPS 160 GeV μ and h beam (Prévessin site)
Need to identify hadron particles (π, K, p)



The COMPASS RICH detector

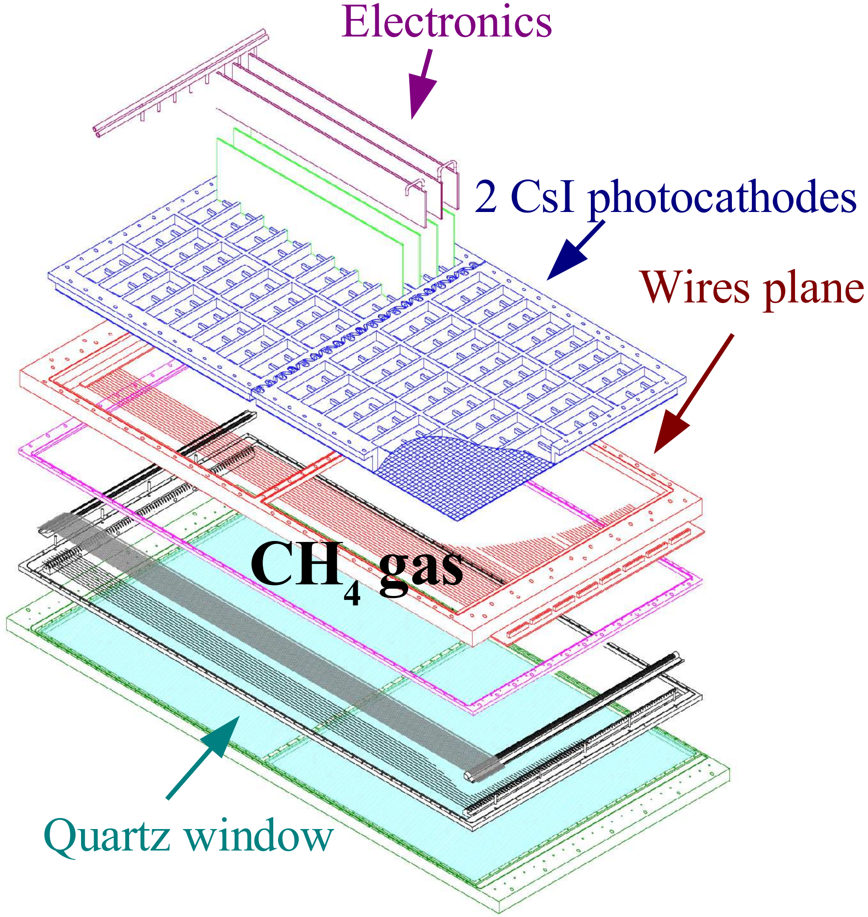
- built by INFN (Trieste and Torino), ICTP, CERN and Bielefeld
- designed to identify particles between 5 to 50 GeV

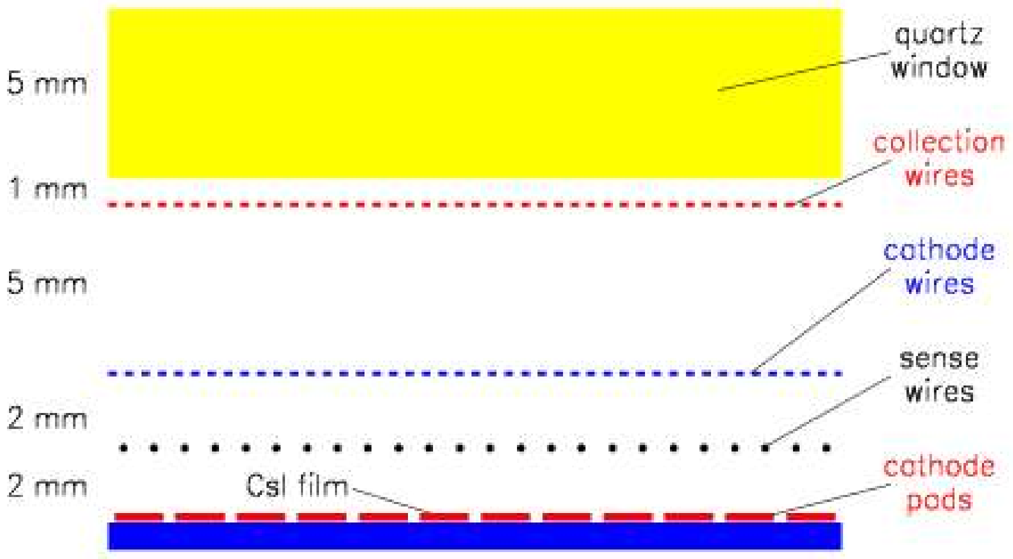




The RICH MWPCs

8 chambers with 2 photocathodes each, methane gas





photocathode: 72x72 pads of 8x8 mm²

γ detection range 160-200 nm

gas gain ~ 3.10^4 at 2000V

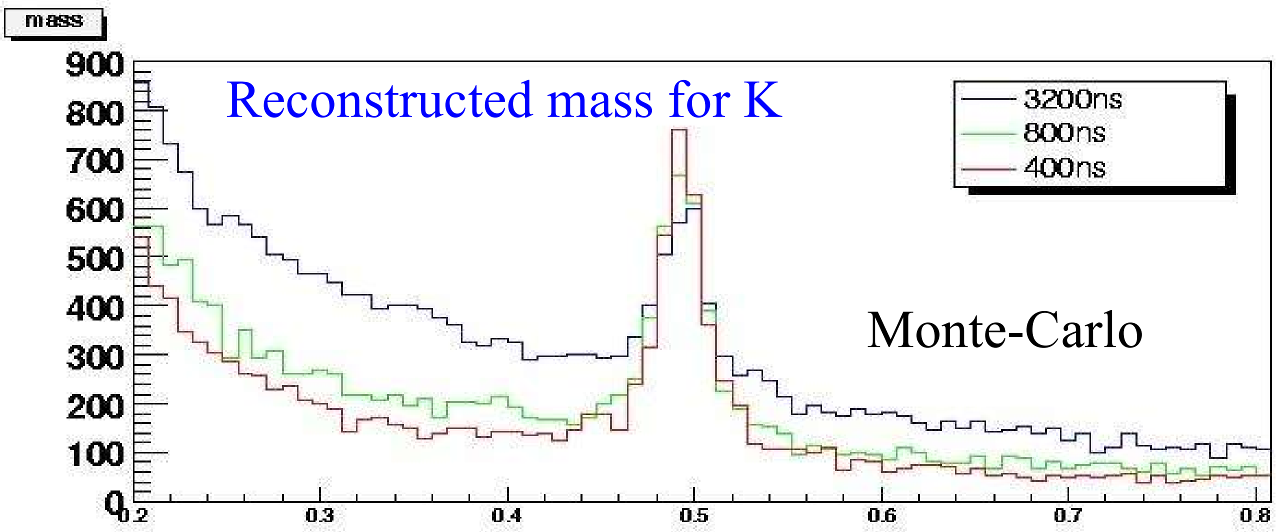
The RICH MWPC read-out

Present electronics based on Gassiplex amplifier

- electronics noise ~1000 e^-
- large integration time (~3 µs, compared to up to 1 Mhz hit rate in central region)
- long dead time needed by amplifier to restore the base line (~5 µs)

Features to improve

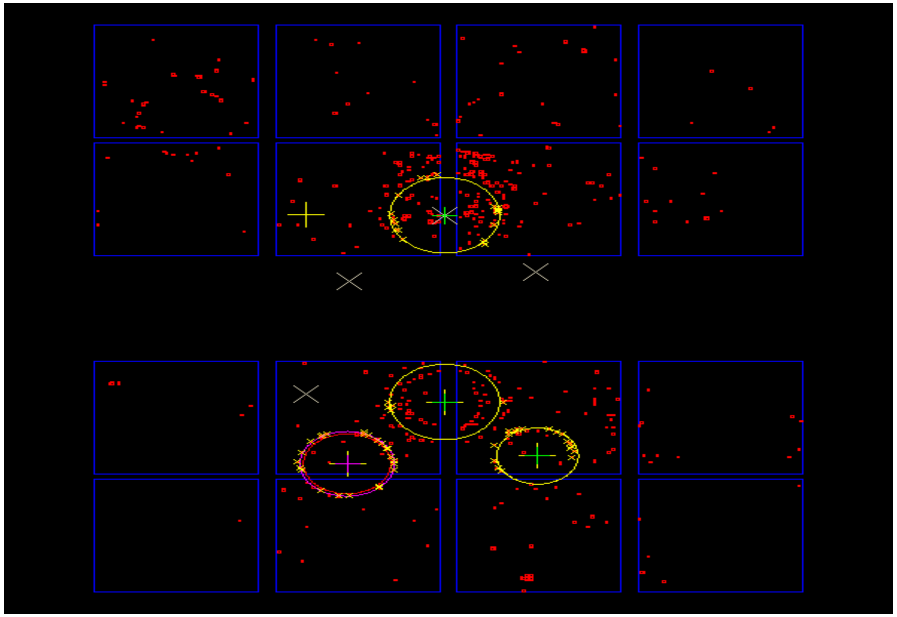
- signal over background improvement by reducing integration gate
- dead time reduction to stand higher trigger rate (up to 80 kHz)



Upgrade of the COMPASS RICH

2 complementary projects:

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



The APV25-S1 chip read-out

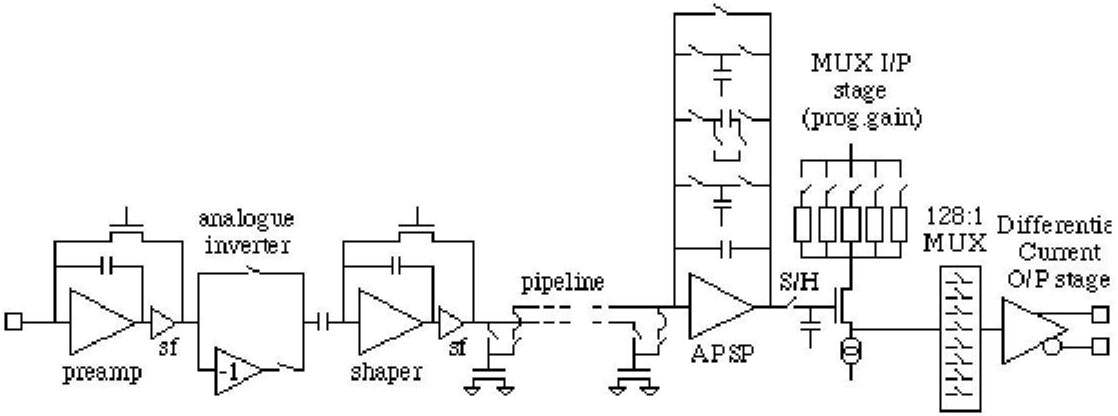
APV25-S1 chips amplifies, shapes, samples and multiplexes analog signals, which are then read by flash ADCs

Main characteristics of the APV25-S1:

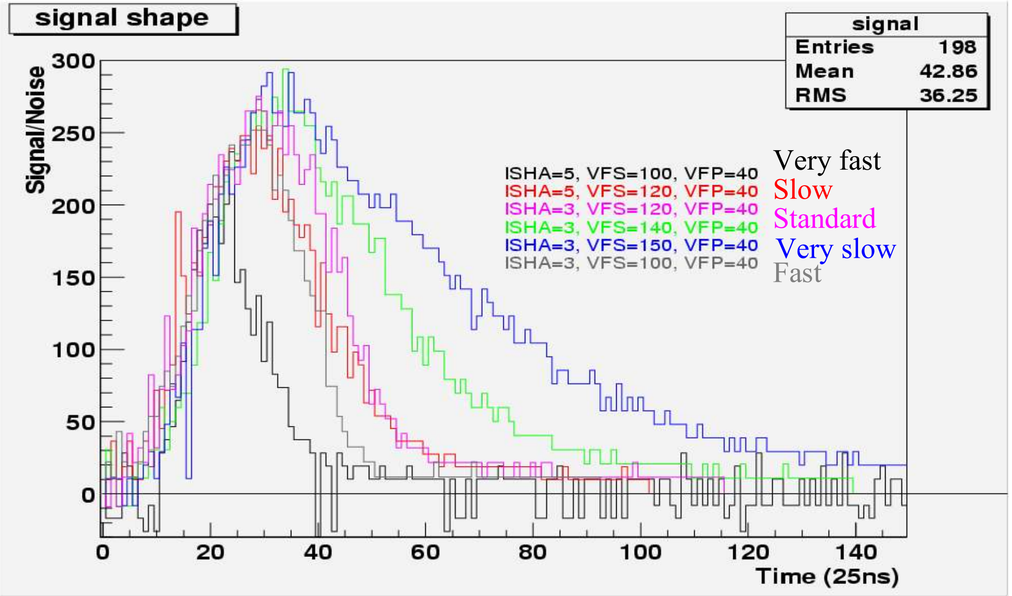
- designed for CMS silicon microstrip tracker
- CMOS 25 µm
- fast analog signal pre-amplifier, shaper and multiplexer, adjustable time constants
- 128 channels / chip, low cost
- 40 MHz sampling on 192 cells analog pipeline
- already used on other COMPASS detectors (GEM, Silicon tracking detectors)

Joint project between TUM Munich and CEA Saclay COMPASS groups

APV25 functional schematic



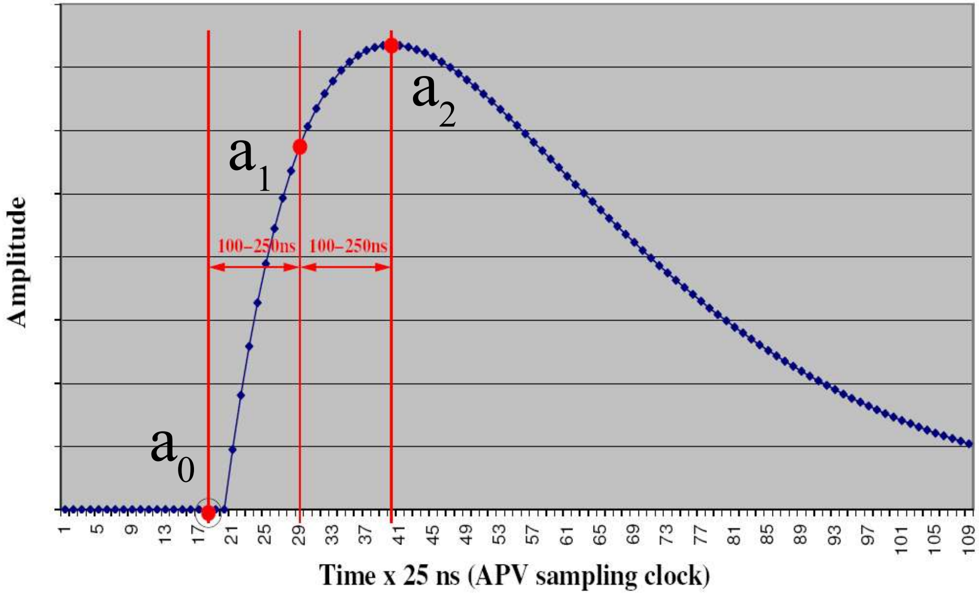
Characteristics of the read-out



Signal shapes for different sets of APV parameters

peaking time from 50 to 500 ns

gate time from 400 to 2 µs



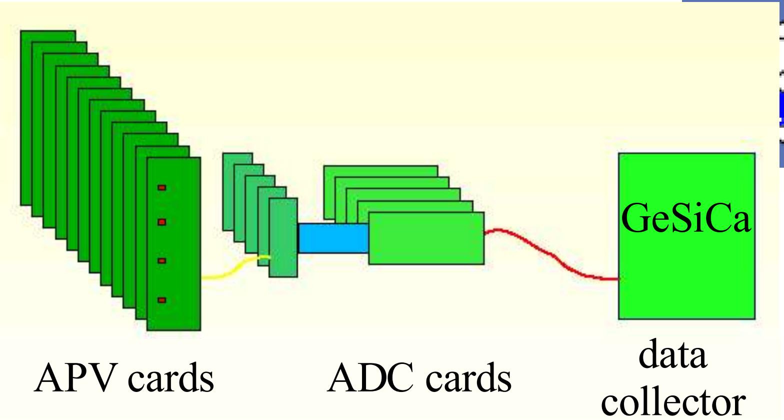
3 samples read for each hit to get informations on signal shape and timing

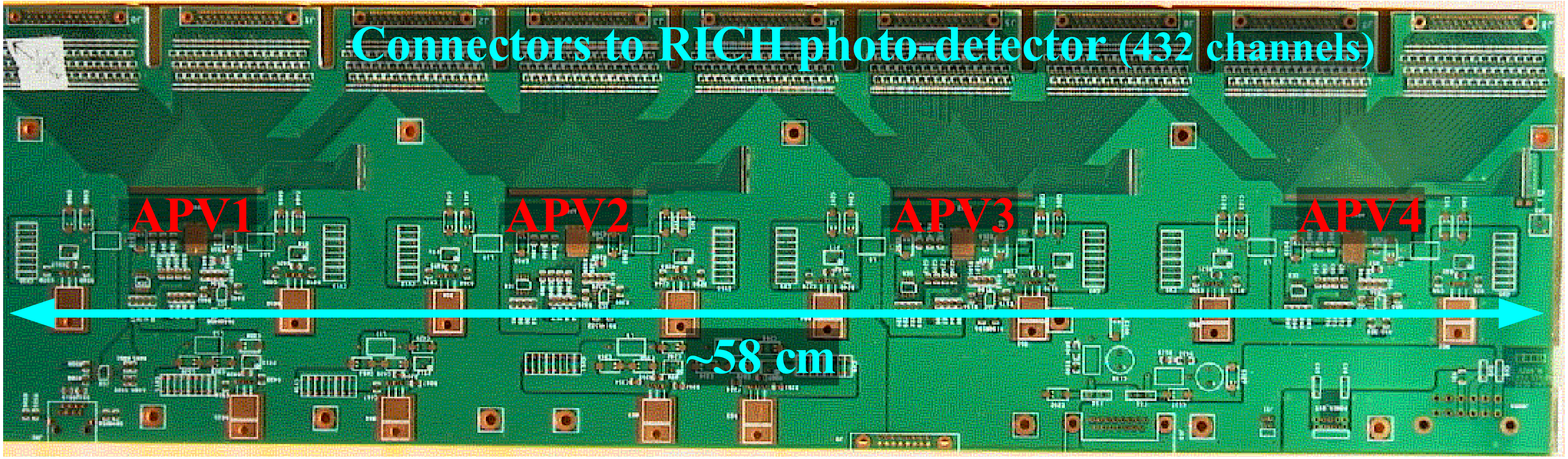
Low dead time up to 80 kHz

Tests in real conditions

12 front-end cards (432 ch. each) built to equip a whole photocathode in RICH central region

Tested with μ and h beam in ~ nominal conditions



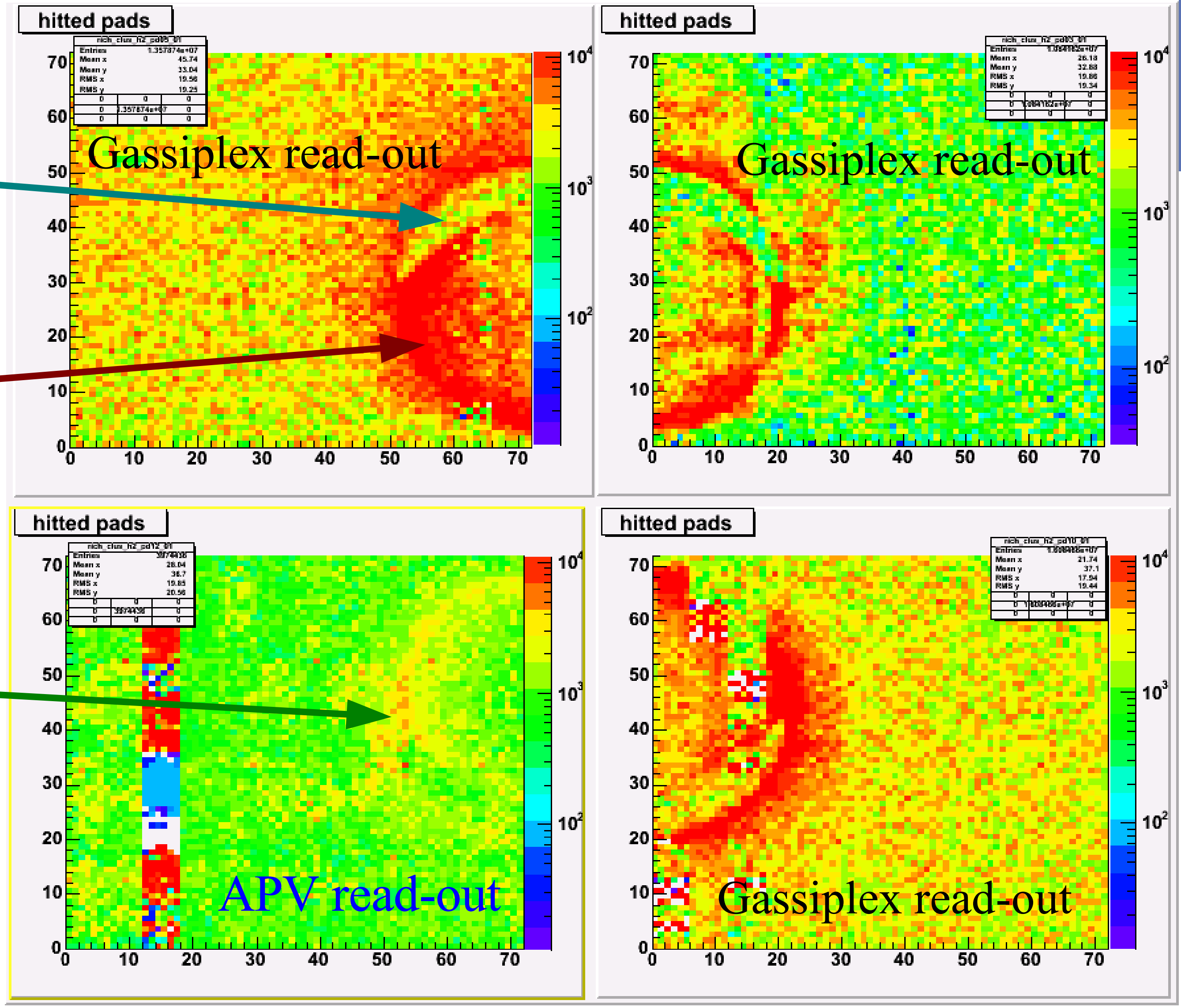


2D profiles of the RICH central chambers

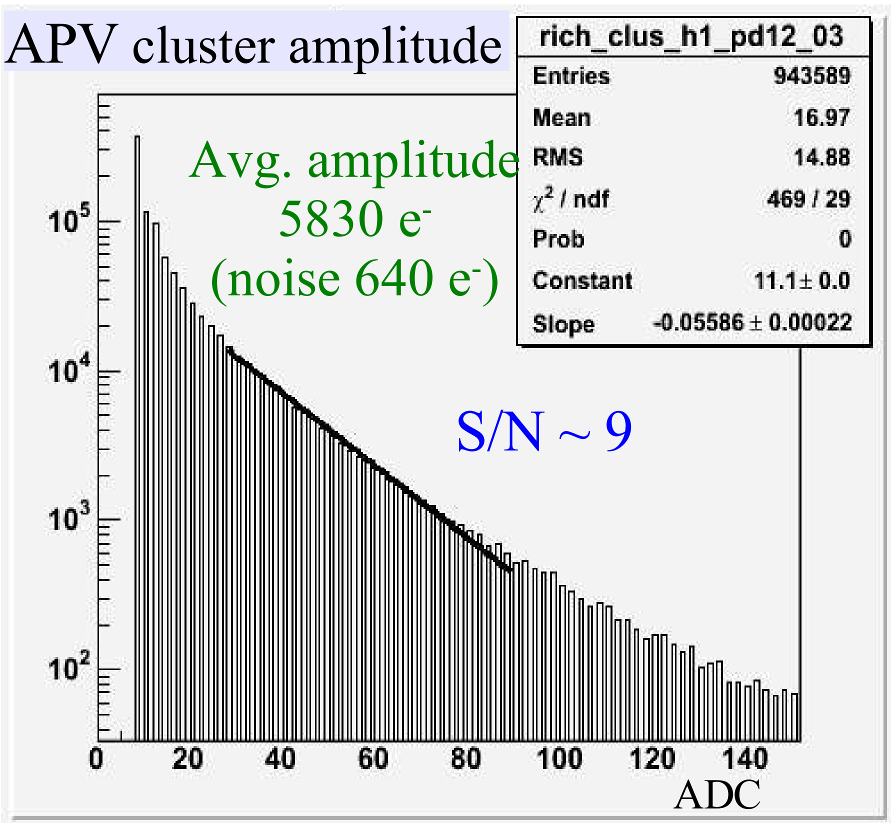
Halo mask
(“lunettes”)

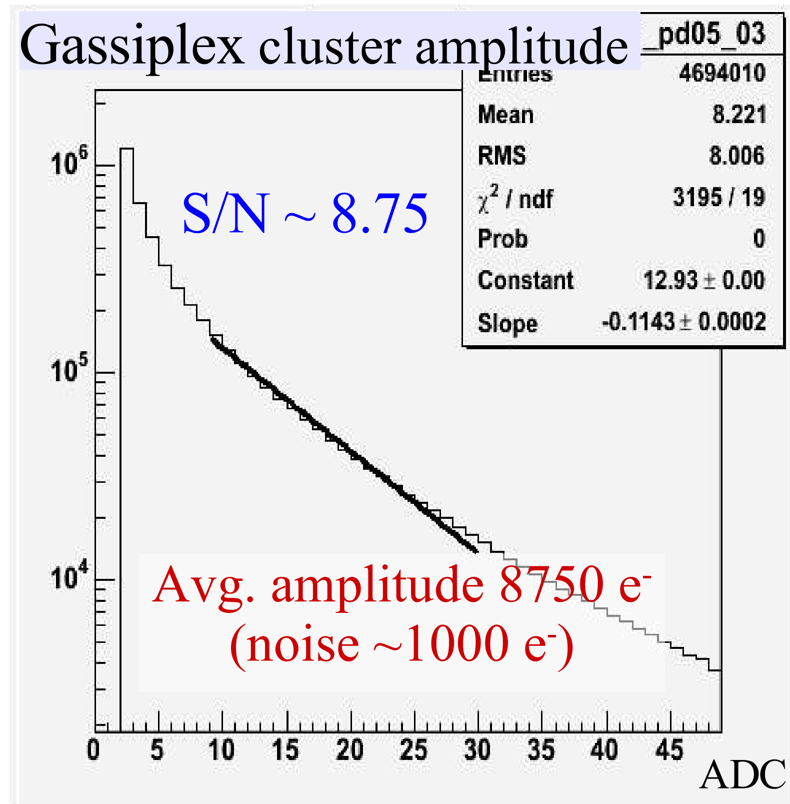
Beam halo

Reduced
occupancy from
beam halo



Amplitude spectrum



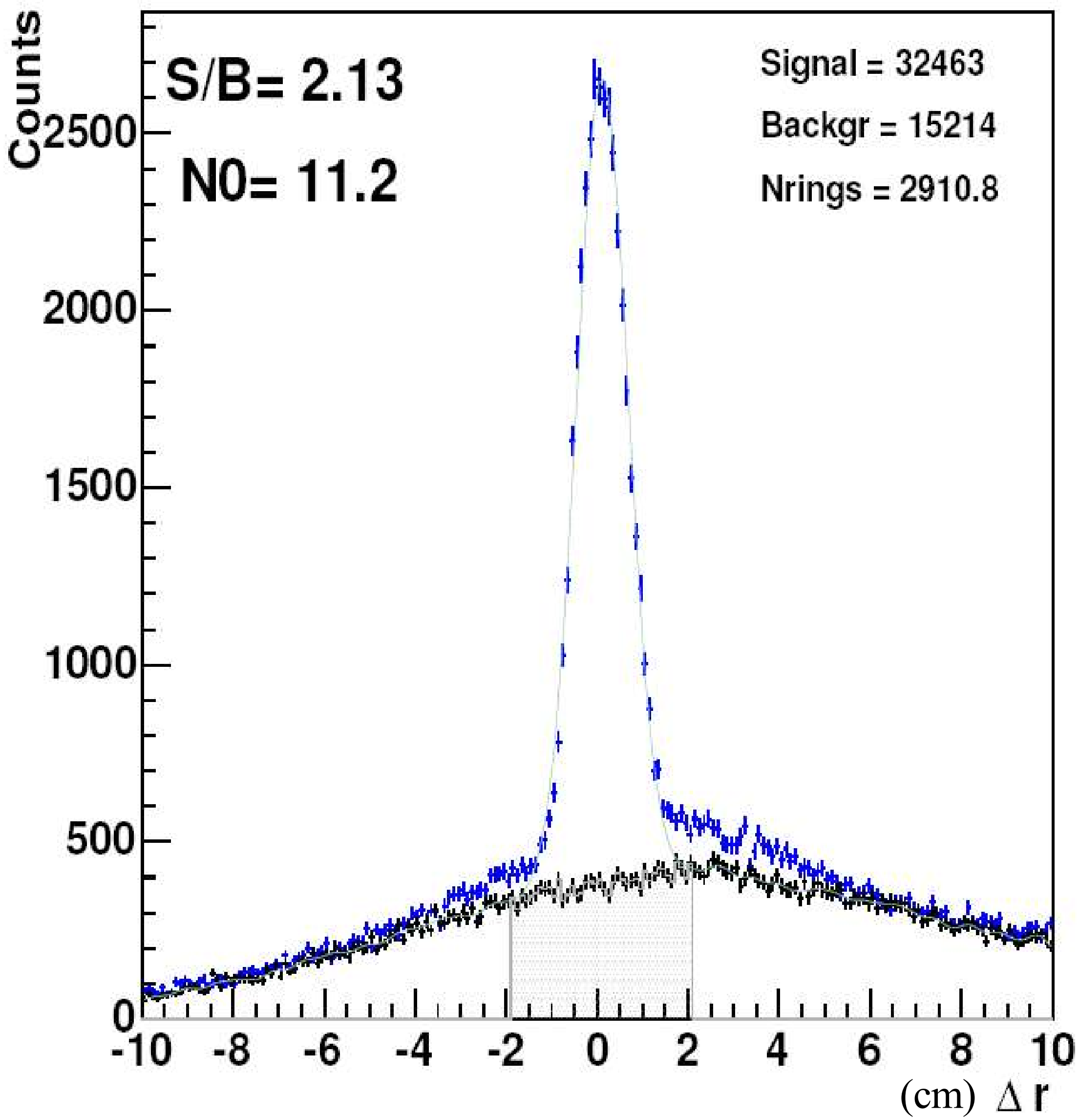


Higher ballistic deficit due to shorter integration time

As expected by simulation

Deficit compensated by lower threshold (better noise figure)

Ring reconstruction with APV



$$\Delta r = r_{hit} - r_{\pi}$$

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

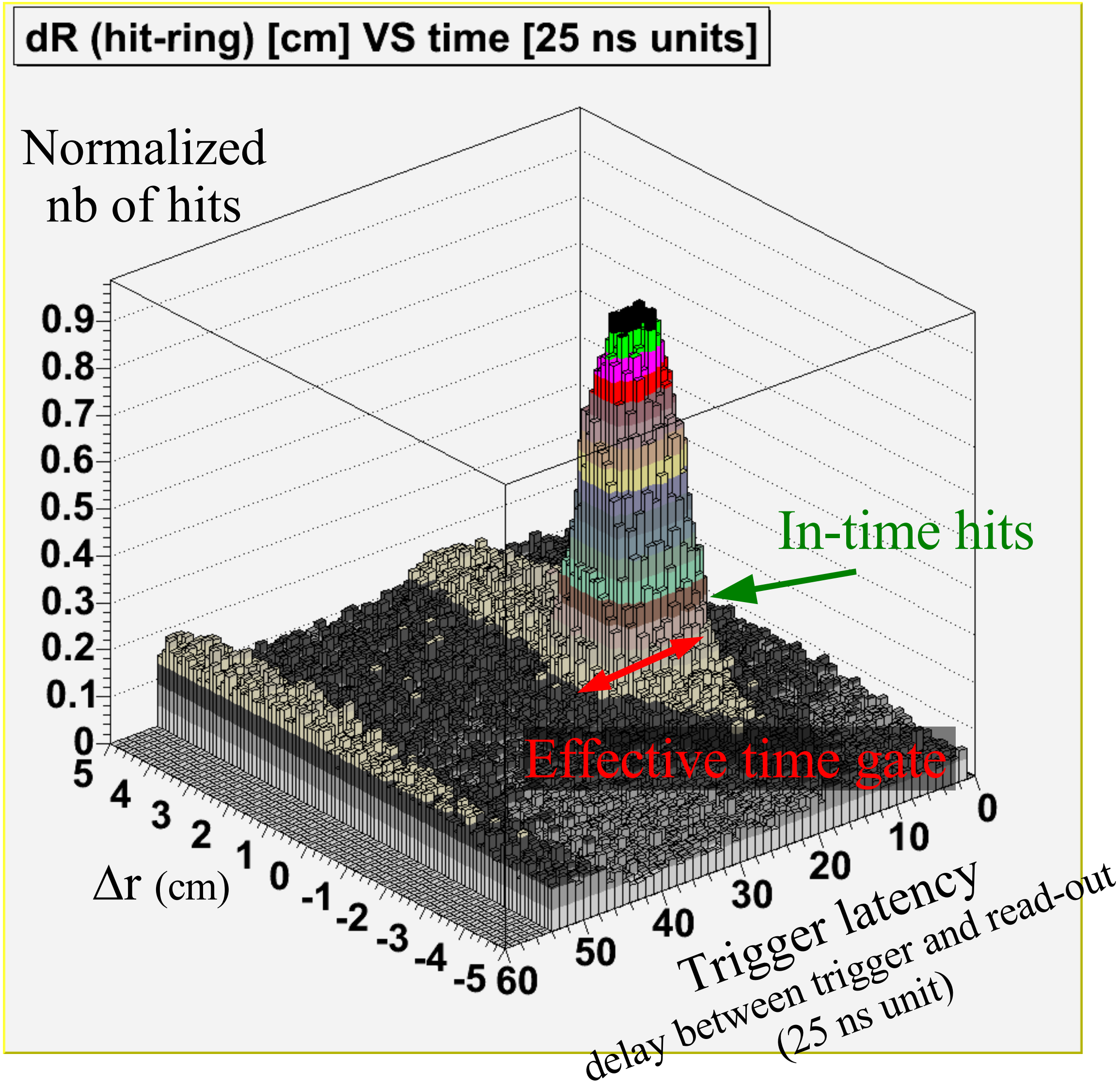
Cuts:

- $a_2 > a_1$
- $a_2 > a_0$
- $a_{cluster} > 2400\ e^-$ (~ 3 σ)

Number of clusters = 11.2 similar to Gassiplex

S/B = 2.13 compared to 0.35 with Gassiplex

Effective time gate



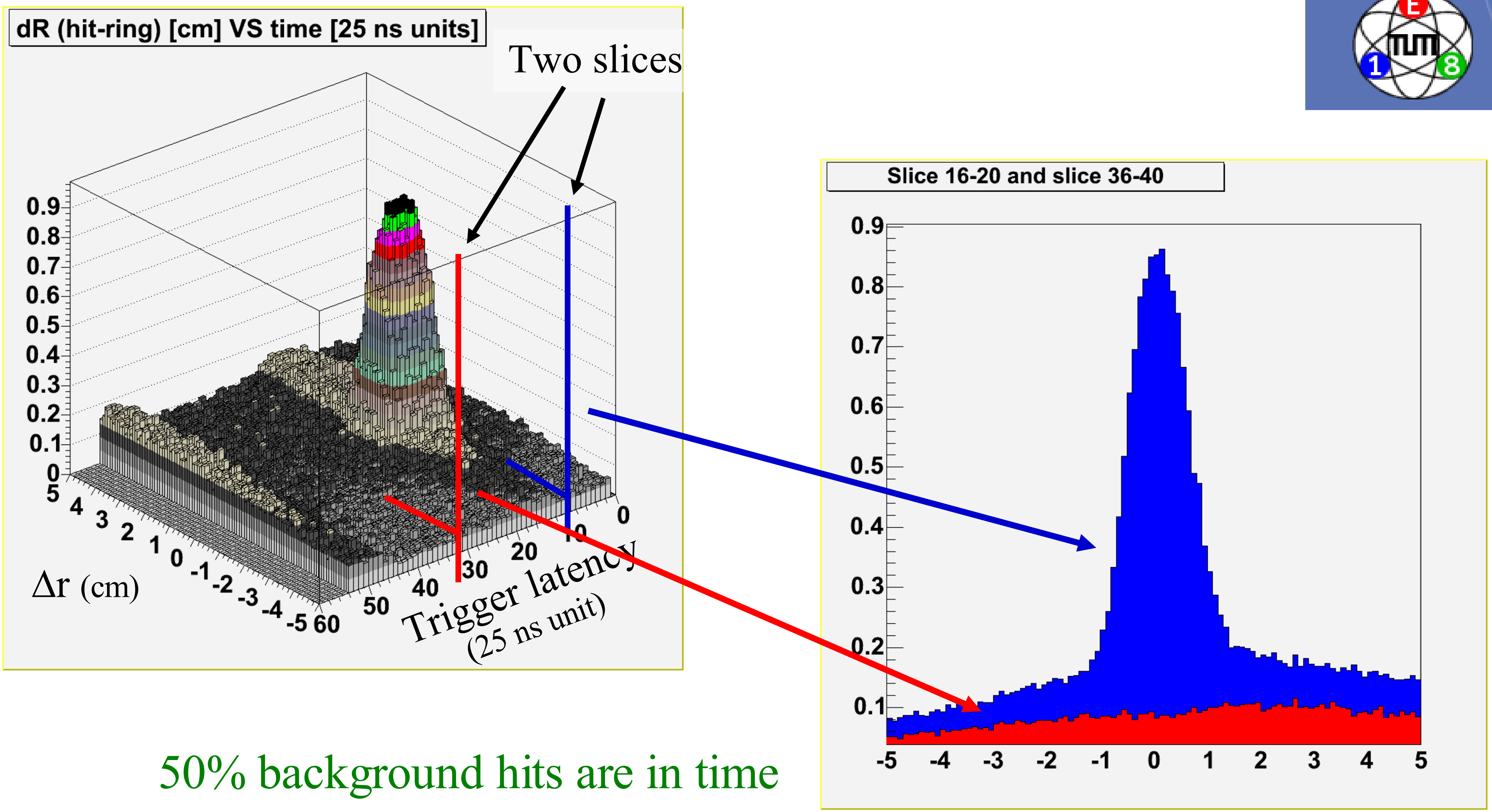
Normalization by the number of rings

Measured effective time gate

full width: 375 ns

at half maximum: 250 ns

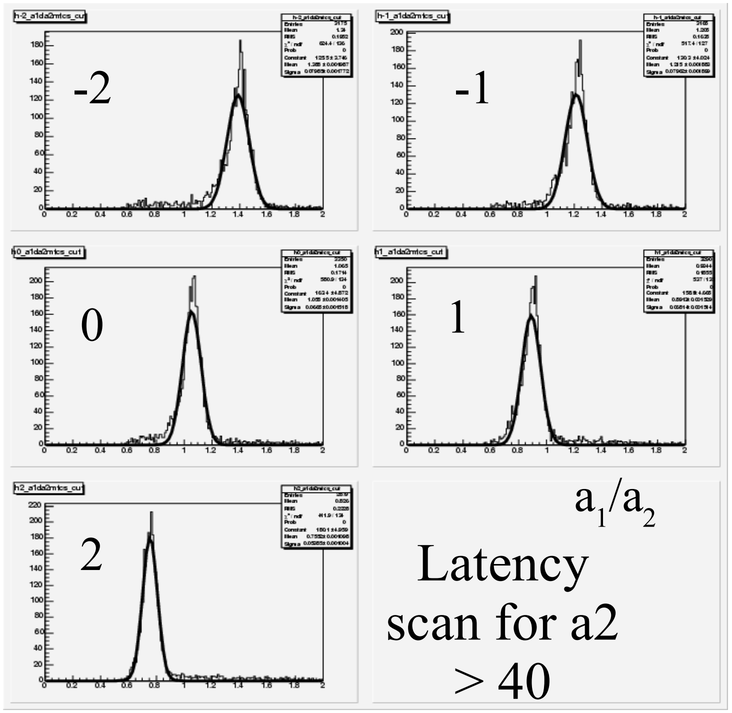
Signal – background comparison

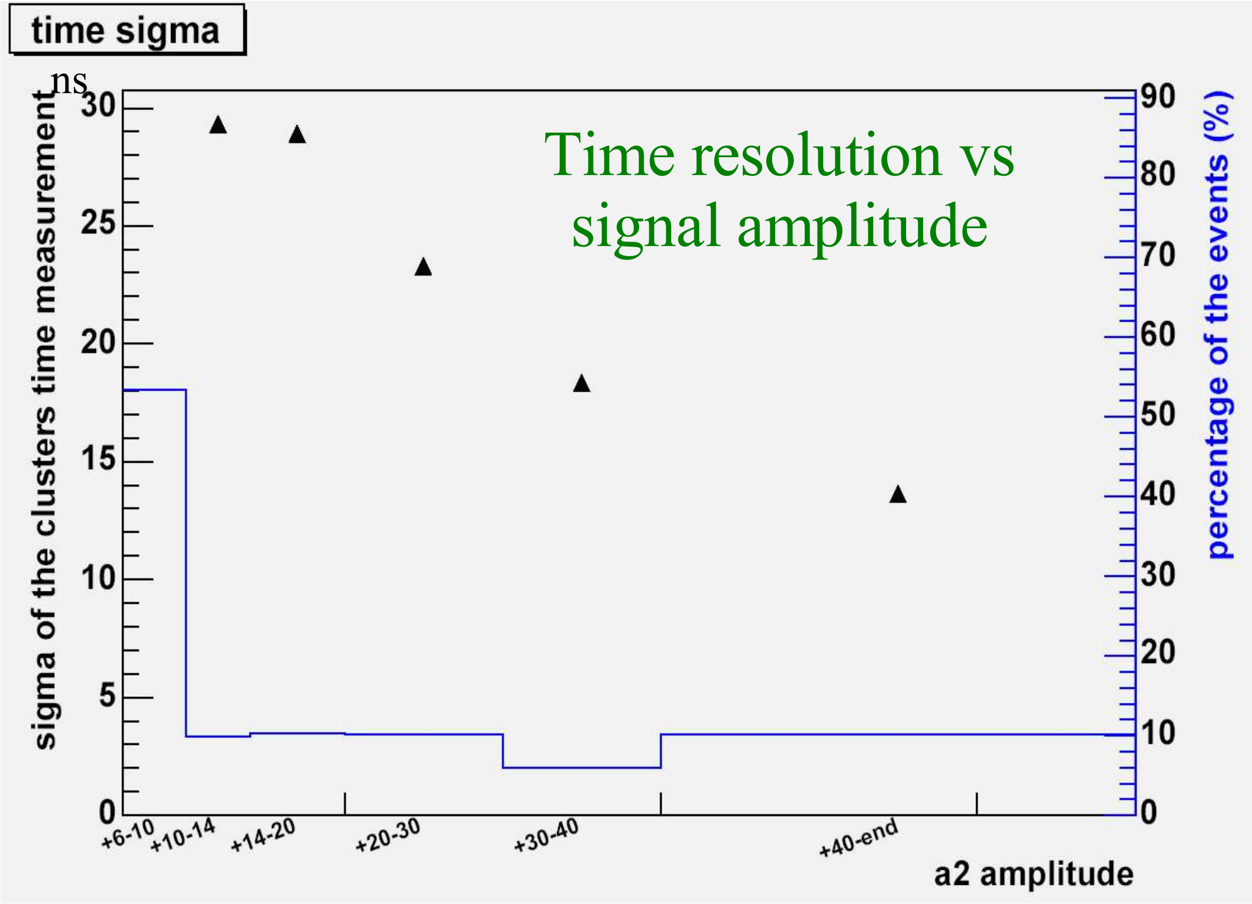


50% background hits are in time

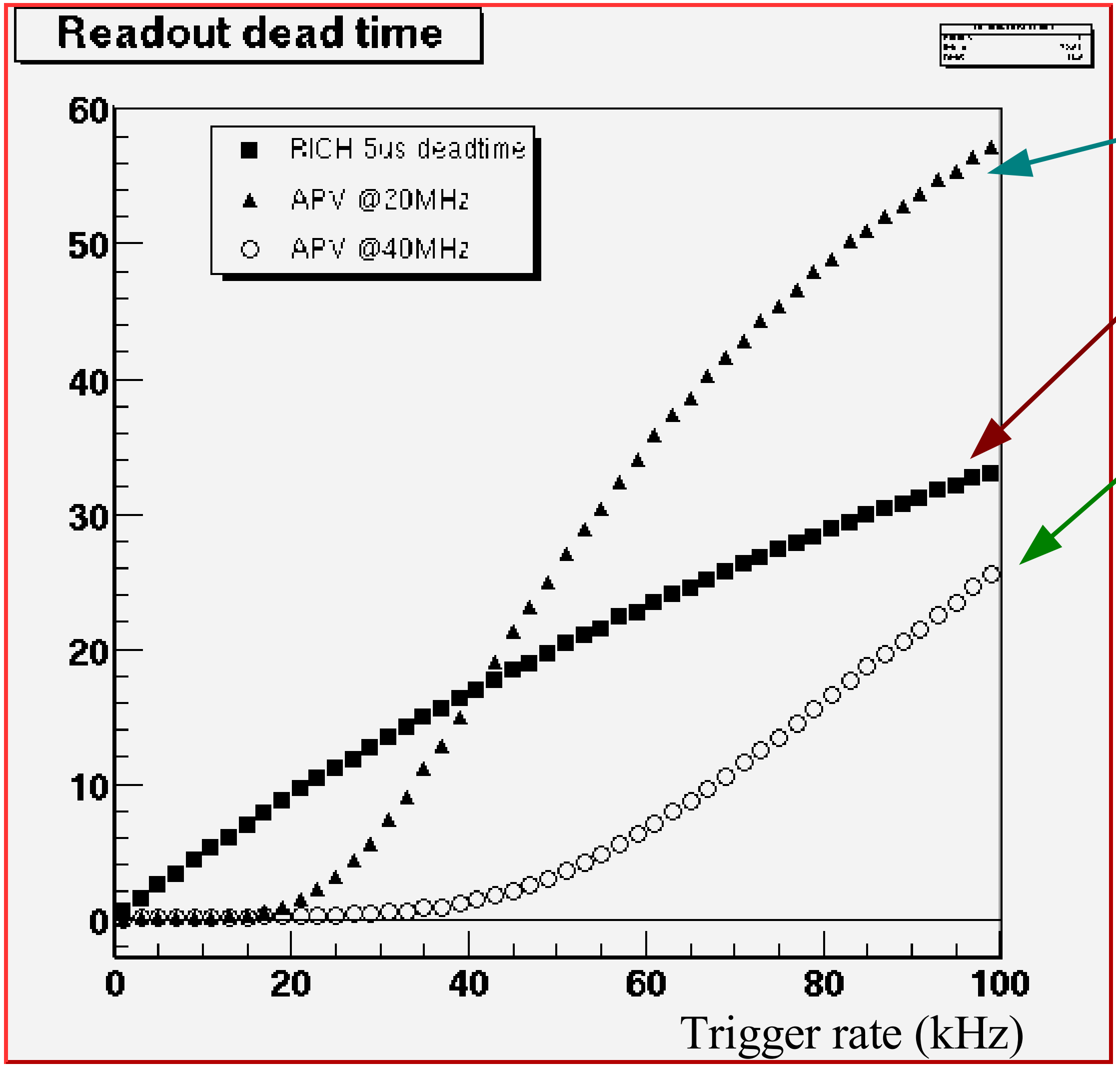
Time measurement resolution

Time measurement with a_1/a_2 ratio





Dead-time improvement



APV 20 Mhz read-out

Old Gassiplex electronics

APV 40 Mhz read-out

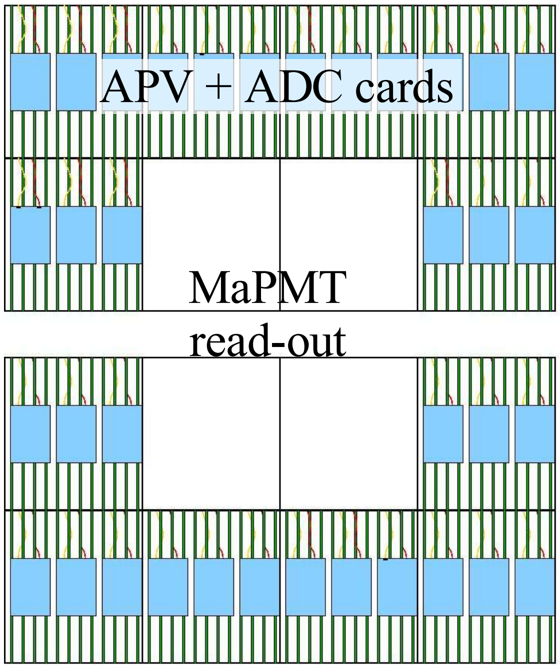
Almost no dead time up to
40 kHz trigger rate
Low dead time up to 80 kHz

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)