Characterization of the MPGD-based Photon detectors for COMPASS RICH-1 analysis

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Outline

- COMPASS Experiment at CERN and Upgrade of COMPASS RICH
- Hadron identification
- Post upgrade characterization of RICH1
    - APV Header error
    - Noise estimation
- Understanding of RICH-1 the analysis framework
- Participation in Hardware maintanence

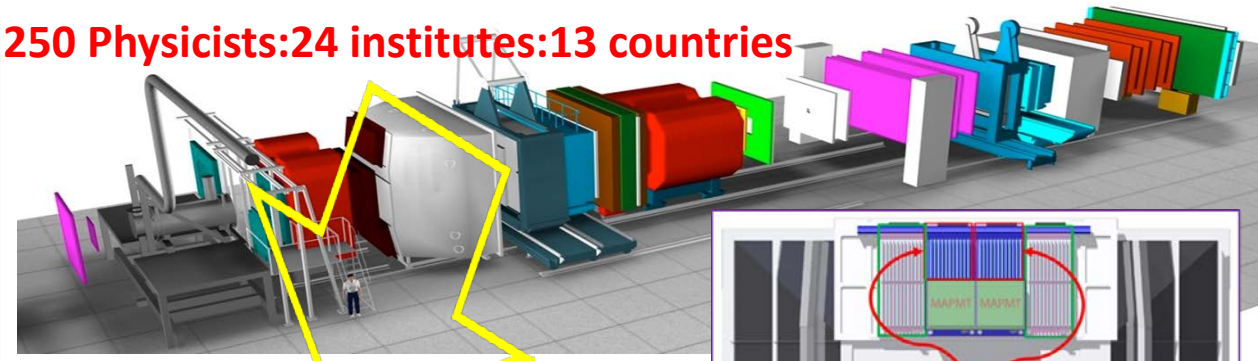
COMPASS Experiment at CERN and Upgrade of RICH1

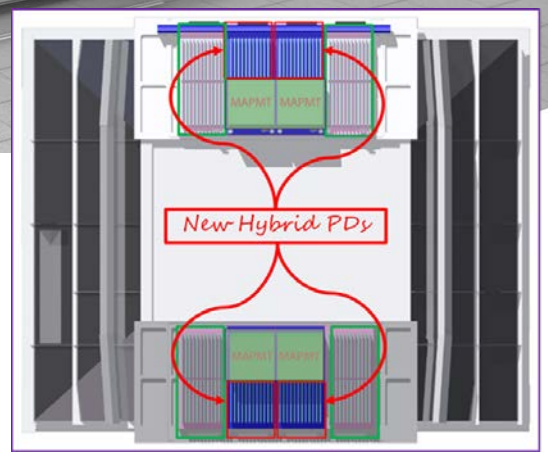
- **CO**mmon **M**uon **P**roton **A**pparatus **S**tructure **S**pectroscopy Fixed target experiment at CERN, SPS

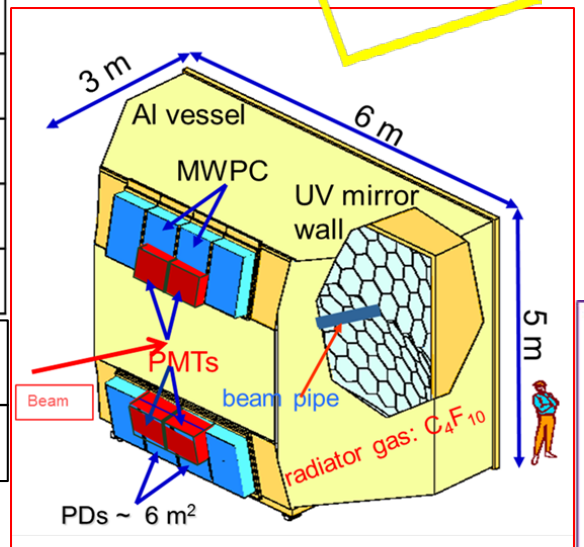
50 mt. long spectrometer 2 Stages. Each with ECAL, HCAL and Muon walls, Several trackers.

Measurements with muon beam:	Measurements with hadron beams:
COMPASS - I (2002 – 2011)	
Spin Structure, Gluon Polarization	Pion Polarizability
Flavor Decomposition	Diffractive and Central Production
Transversity	Light Meson Spectroscopy
Transverse Momentum Dependent PDFs	Baryon Spectroscopy
COMPASS - II (2012 – 2018)	
DVCS and DVMP	Pion and Kaon Polarizabilities
Unpolarized SIDIS and TMDs	Drell-Yan Studies
LoI in preparation (2020 - ...)	
SIDIS with deuteron (One extra year of data taking)	
Measurement of Proton radius	

250 Physicists:24 institutes:13 countries





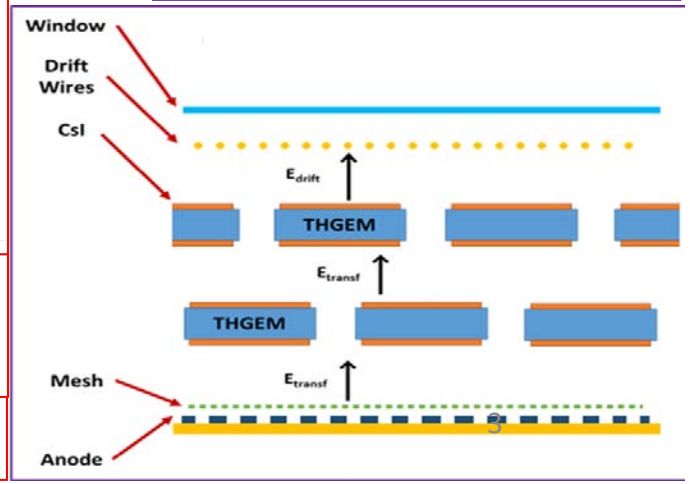


hadron PID from 3 to 60 GeV/c

acceptance: H: 500 mrad V: 400 mrad

trigger rates: up to ~50 KHz, beam rates up to ~10^8 Hz,

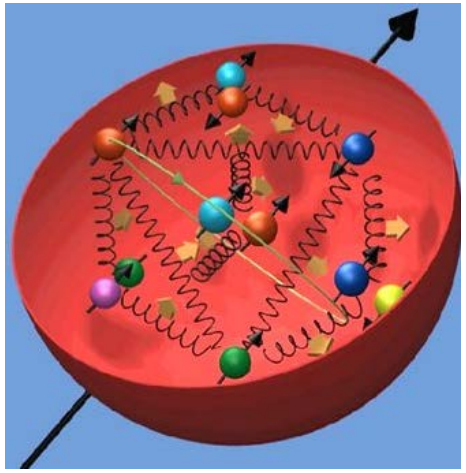
Detector designed in 1996 In operation since 2002
MAPMT based upgrade in 2006 A new upgrade with Hybrid MPGD is done in 2016



The new PDs have to be capable of :

A small time resolution ≤$\mathbf{10}\ \boldsymbol{ns}$.
A closed geometry to avoid photon feedback.
A large gain (~$\mathbf{10^5}$).
A reduced Ion Back – Flow (IBF) to the CsI photocathode (≤3 %).

Requirement of Hadron Identification



quark polarization \ nucleon polarization	U	L	T
U	f_1 number density		$f_{1T}^{\perp}$
L		g_1 helicity	g_{1T}
T	$h_1^{\perp}$	$h_{1L}^{\perp}$	h_1 transversity, $h_{1T}^{\perp}$

$$\Delta_T q \equiv \int dx\, \Delta_T q(x)$$

A fundamental quantity of nucleons.
Not easy to access!!
Can not be accessed by Standard Deep Inelastic Scattering.
This distribution is "Chiral odd" in nature.
We need "Another" Chiral odd function to access Physics.
Fragmentation Function is the other Chiral odd function
Semi Inclusive DIS is the key to access
TRANSVERSITY

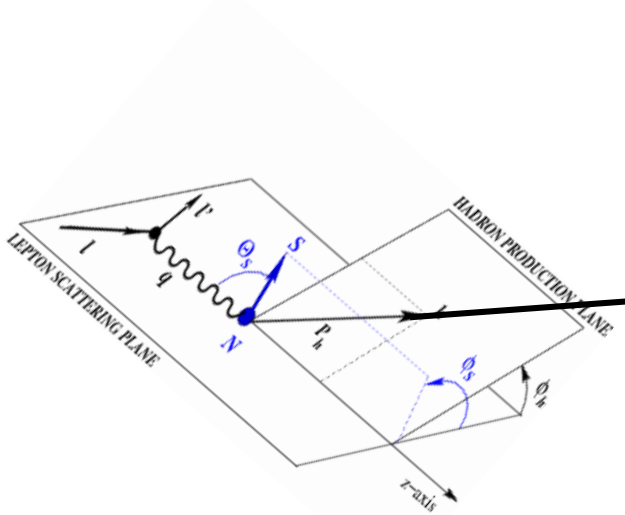
Tags the struck quark of the vir. Gamma interaction.
(Flavor tagging).
Therefore AT LEAST ONE HADRON DETECTION IS ESSENTIAL **IN COINCIDENCE** with the scattered lepton

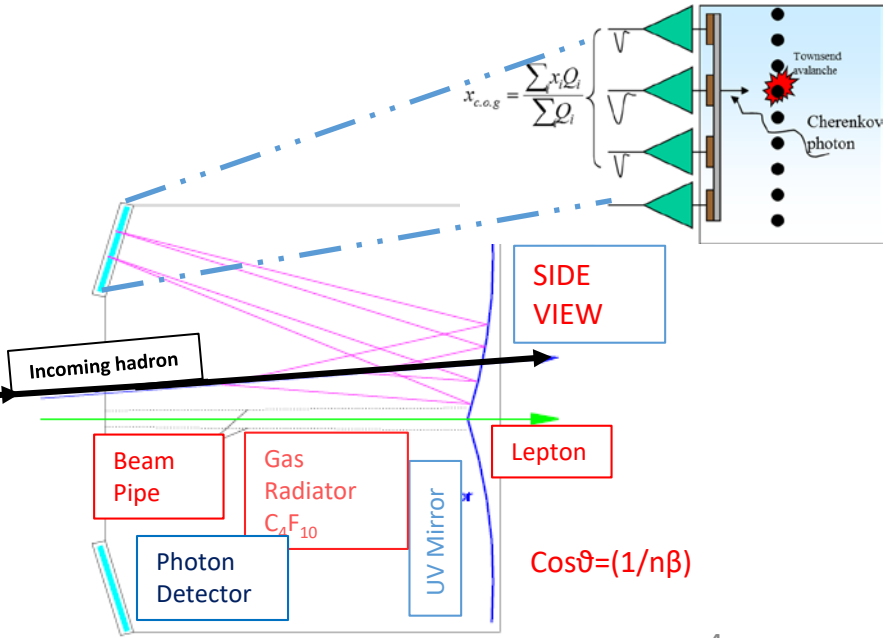
$$\left(\frac{d\sigma}{dxdQ^2\,dz}\right) = \frac{\sum_f e_f^2 q_f(x,Q^2) D_f^h(z\cdot Q^2)}{\Sigma_f e^2 q_f(x\cdot Q^2)} \left(\frac{d\sigma}{dxdQ^2}\right)$$

Quark distribution

Fragmentation Function (probability of finding quark of flavor 'f' in hadron h)

Q^2= 4-mom transfer,
x= fraction of proton's mom carried by quark
z= fraction of energy transfer carried by outgoing hadron





Post Upgrade Characterization

- Performance of photon detectors is essential to optimize RICH performance.
- Characterization of PDs is therefore essential.
- Need to understand the noise level of the detector.
- Detectors have ~80K Channels

3 types of photon detectors of two classes (MAPMT and Gaseous) in use.

MAPMTs

MWPCs and Thick Gas Electron Multiplier-Micromegas based on MPGD technology

Characterization requires ->Stable Condition

All errors (Front end electronics etc. to be minimized)

Post Upgrade Characterization

APV header error

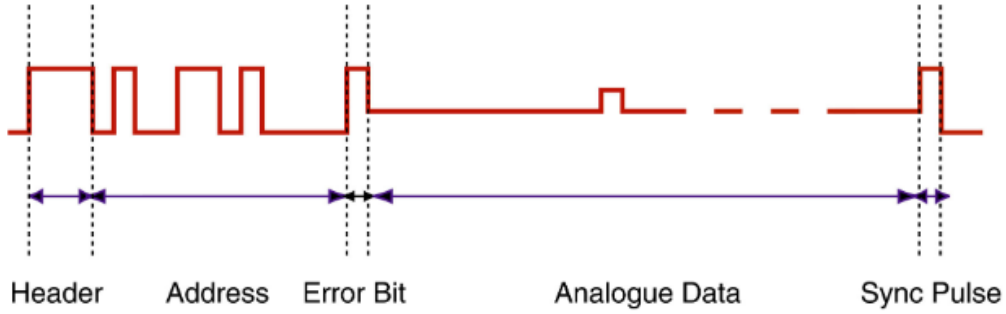
RICH photon detectors are read out in Two different way

CMAD (MAPMTs)

Based on APV25 (Gaseous detector: MWPCs and Hybrids)

APV25 is an Analogue pipeline Application Specific Integrated Circuit read-out implemented for gaseous detectors of RICH1.

The Data output Format is :



The data acquisition system in 2016: several times an error appearing called APV header error.

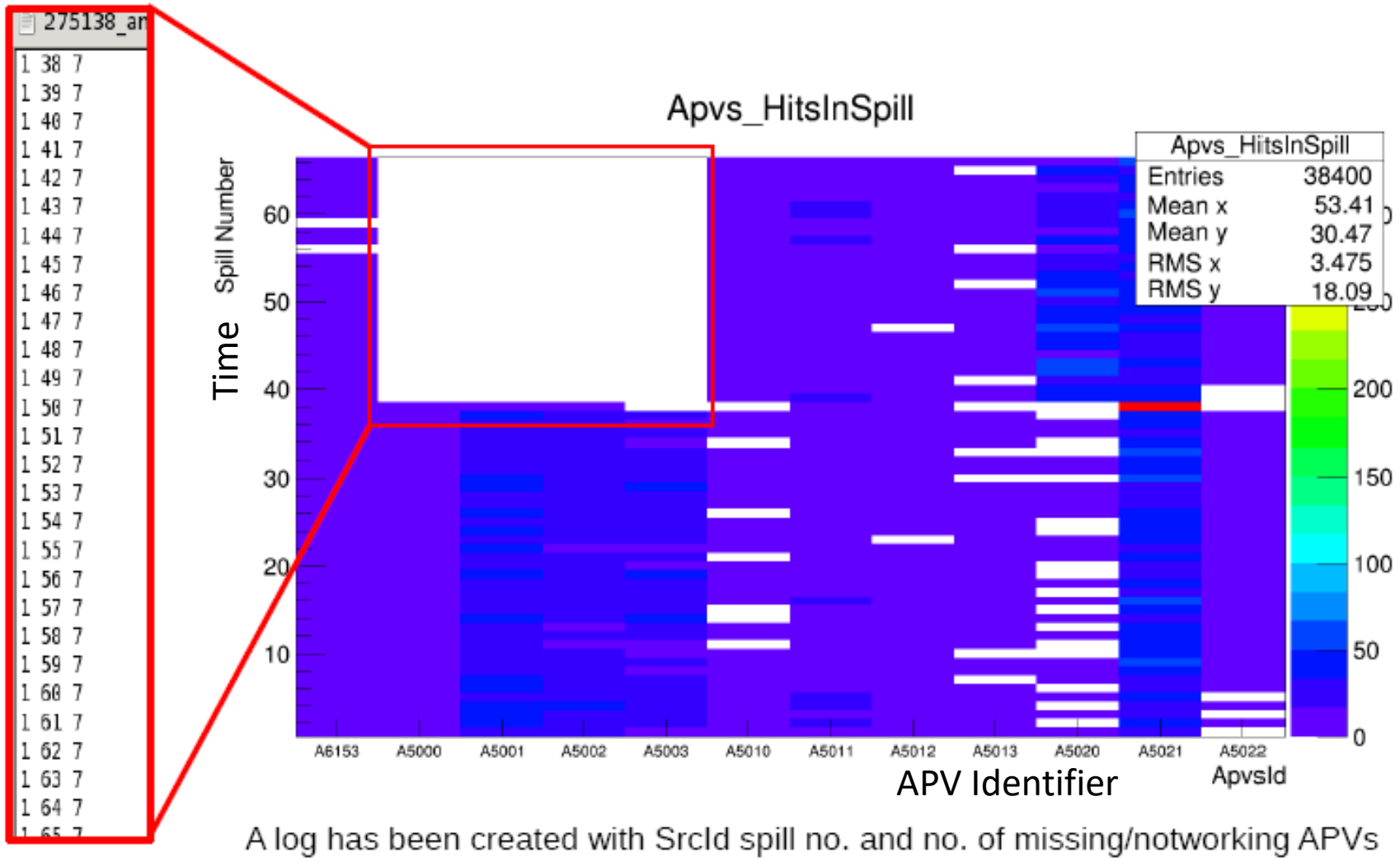
The source IDs of the detectors in the Online monitor showed this error

APV header Error:

After hit level reconstruction we found, this error paralyzes the APVs for the rest of the run. That disappears after reload.

The possible explanation was:

Discharge within the detector level which gives a wrong address to the readout



A log has been created with SrcId spill no. and no. of missing/notworking APVs

APV header Error:

21 runs were analyzed.

Nevents>100,000

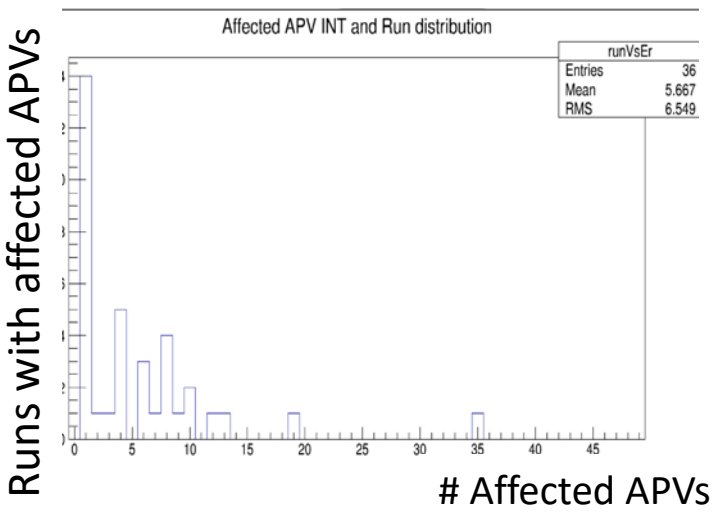
Run types: μ+andμ-

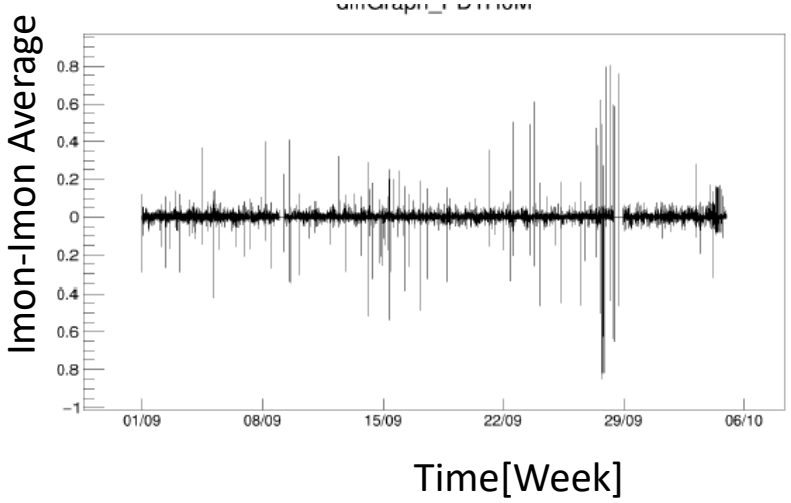
Runs where sum of Errors appeared in the source ids are between 2% to 40%

-To Ensure observation of appearance of header errors.

Entire corrupted runs have errors ranging between 45-50 %

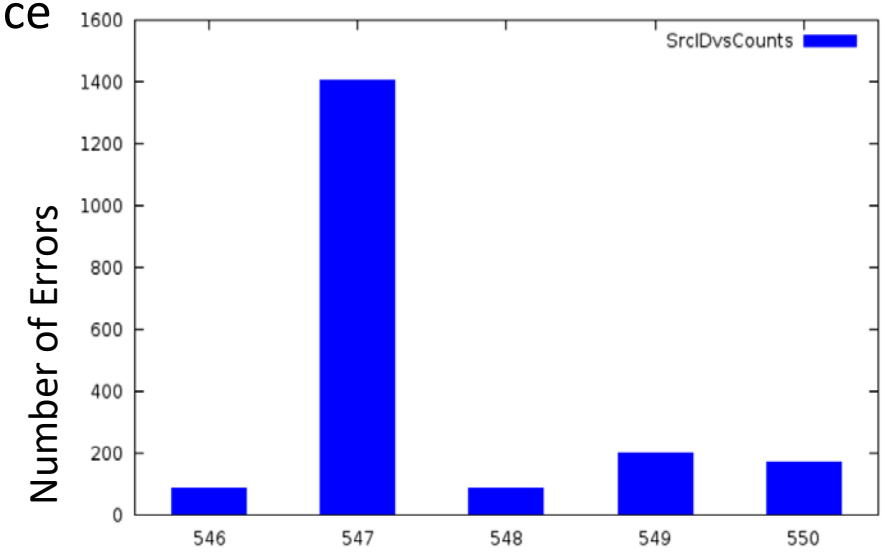
I took from the spill time information the time of the APV header error appearance





Collected Information of Sparks from Spark Log of the detectors and The APV header. Checked the simultaneity

```
# DetId ApvInt  NSp SpT SpTFormatted
4 0 37 1471113041 2016-08-13_20:30:41
4 0 38 1471113059 2016-08-13_20:30:59
4 0 39 1471113077 2016-08-13_20:31:17
4 0 40 1471113095 2016-08-13_20:31:35
4 0 41 1471113113 2016-08-13_20:31:53
4 0 42 1471113131 2016-08-13_20:32:11
```

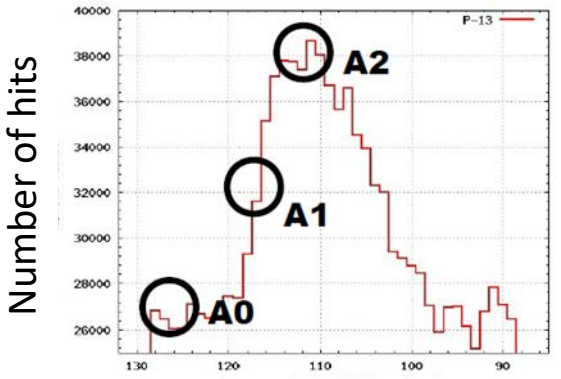


Conclusion Part 1:

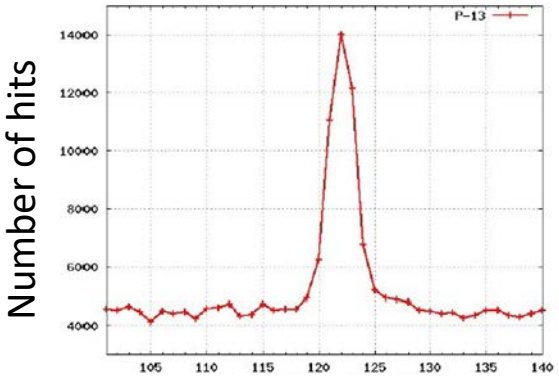
1. The direct correlation of Spark and APV header error is observed.
2. Based on the analysis an OffSpill reload option is added for the shift crews.
3. In 2017 we are having no such data loss so far.

Noise Issue:

The APV25 chips record 3 samples of pulse known as A0,A1,A2 in 150 ns intervals.
A0 is the Baseline, A1 is the rising edge and A2 is the peak
The APVunits of time is 25 ns.

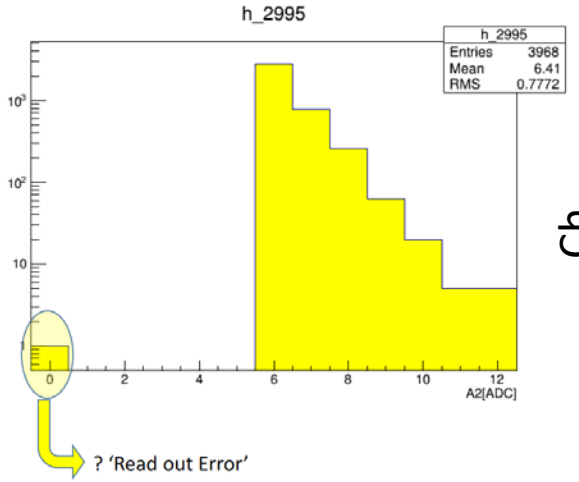


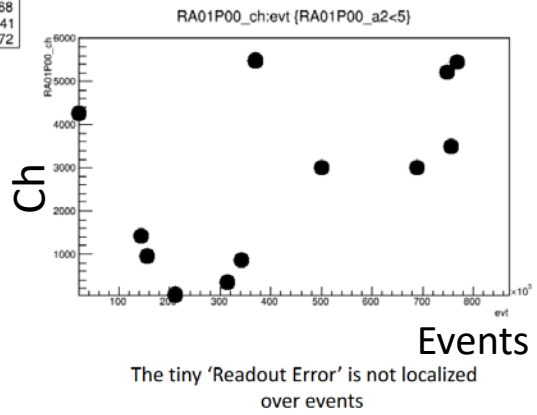
Latency of A2 in 25 nS units



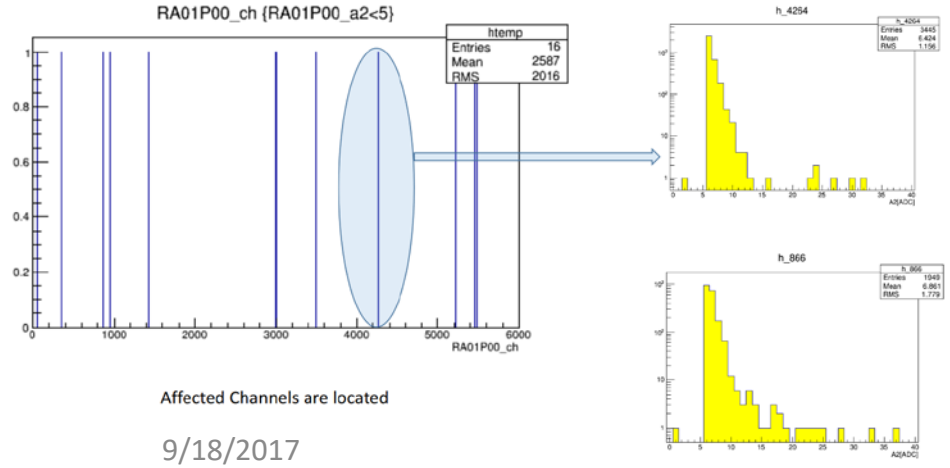
Latency of A0 in 25 nS units

Appearance of Readout Error:
The pedestal is applied to the detectors.
The A2 distribution shouldn't have any value below the set threshold.
The MWPCs had a rare but different behavior some time.





The tiny 'Readout Error' is not localized over events



Affected Channels are located

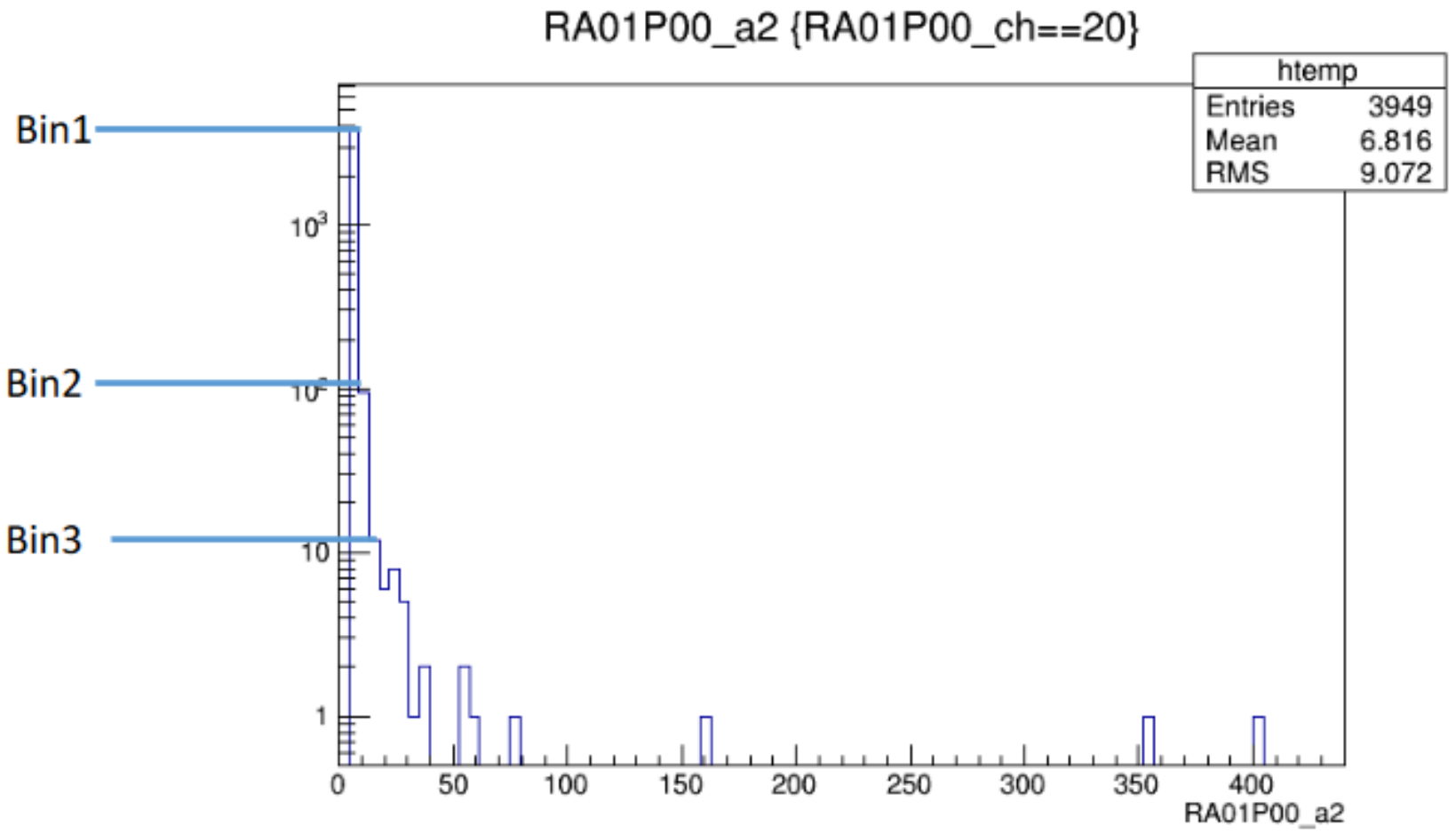
Conclusion part3:

1. Reported to FE meeting
2. Reason not well understood
3. So far not observed in the 2017 Data. More investigation will be done in future.

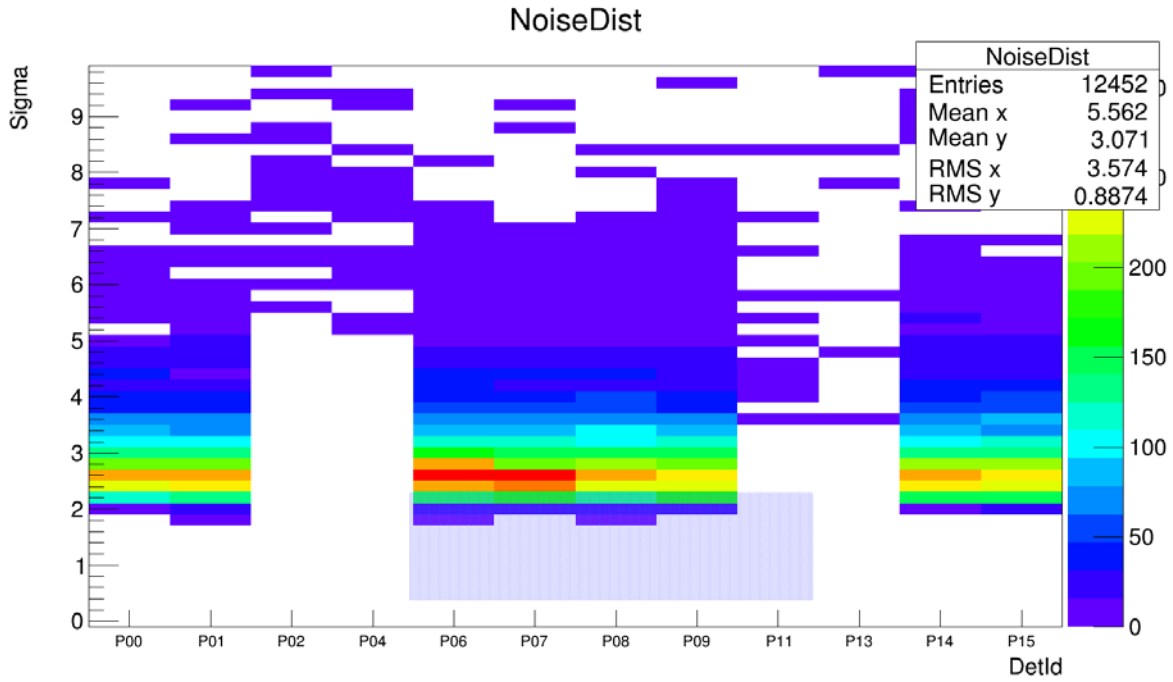
Noise Issue:

- Assumption to estimate Noise :
  - $\sigma_{12} = \sqrt{0.5 \frac{2 \cdot TH + 1}{\ln\left(\frac{B_1}{B_2}\right)}}$
  - $\sigma_{23} = \sqrt{0.5 \frac{2 \cdot TH + 3}{\ln\left(\frac{B_2}{B_3}\right)}}$

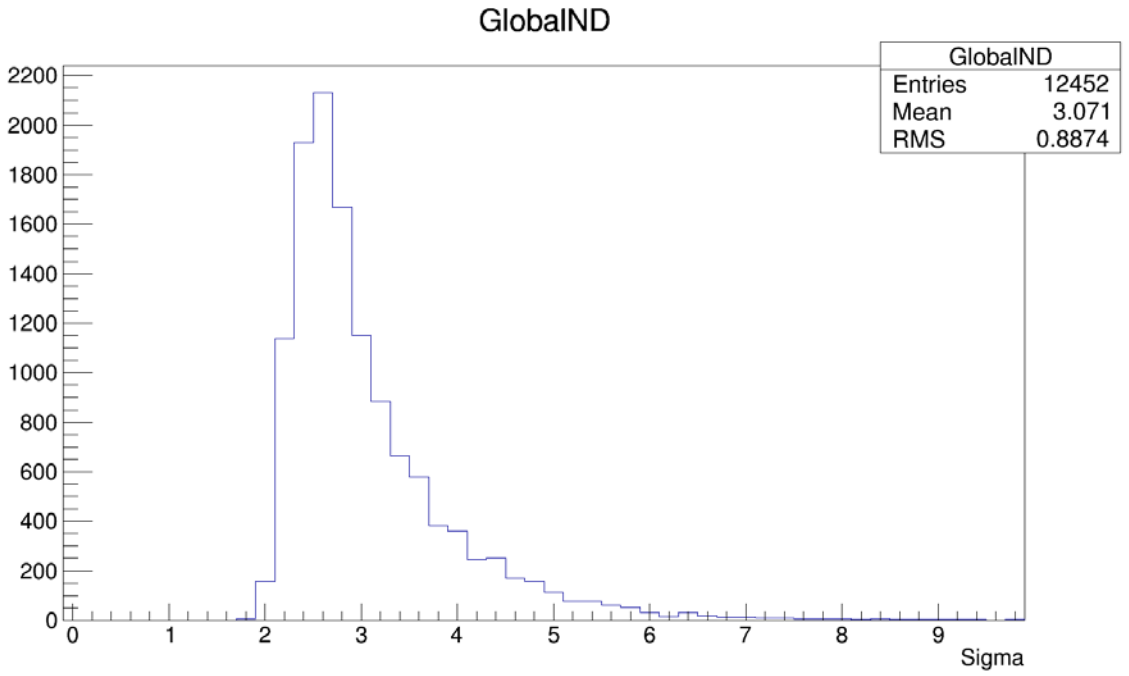
After checking compatibility we are taking the average Noise



Noise Issue:



Noise is 600-900 electron equivalent.



Noise Issue:

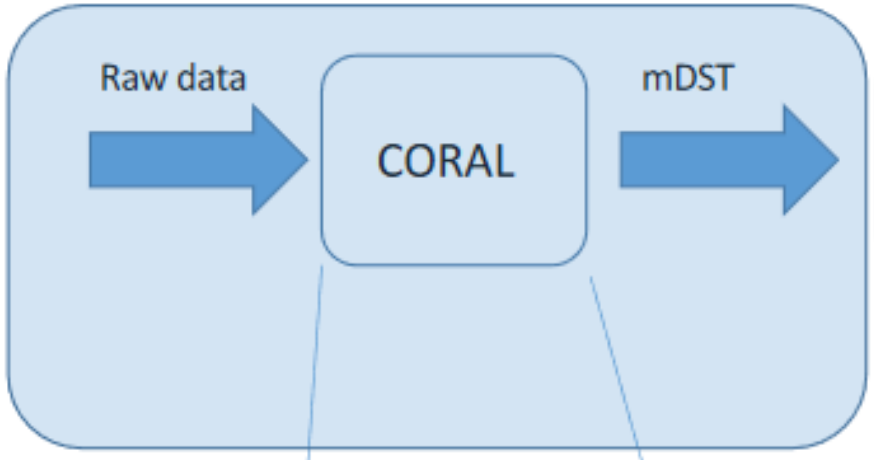
Summary Plots:

MWPC stat is intentionally low, to check goodness of Code

Conclusion part 3:
The c++ Code to estimate the Noise and to monitor the detectors in Channel level is present.
2017 data are still under scrutiny.

Hand-made mismatch in the input file to check
goodness of code.

RICHONE Code: Understanding the code



mDST: mini Data Summary Tape
µDST: micro Data Summary Tape

RICH recon. and HPID: RICHONE package

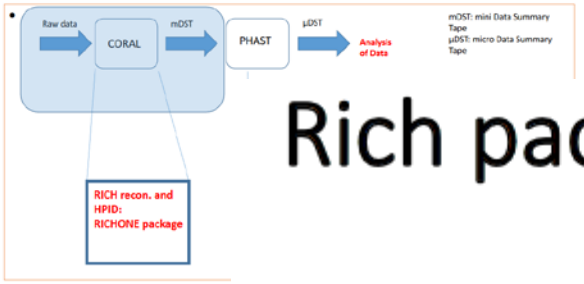
Task done and to be done with CORAL:

Level 0 : Installation and running in interactive mode
> Done, following web page any user can do that http://thgem.ts.infn.it/

Level 1&2: Understanding the RICHONE package and play with it.
> We want to do it in parallel.
> Personal CORAL (in case of problems with generic) in back up

Level 3 and higher: Full scale analysis requires full knowledge of mDST and µDST, that requires understanding of PHAST.. (**future plan**.)

RICHONE Code: Understanding the code



Rich package in CORAL

Still working on understanding the code!

RichOne

- Particles ← Track info input
- pads
- clusters
- Photons

with hits information on RICH

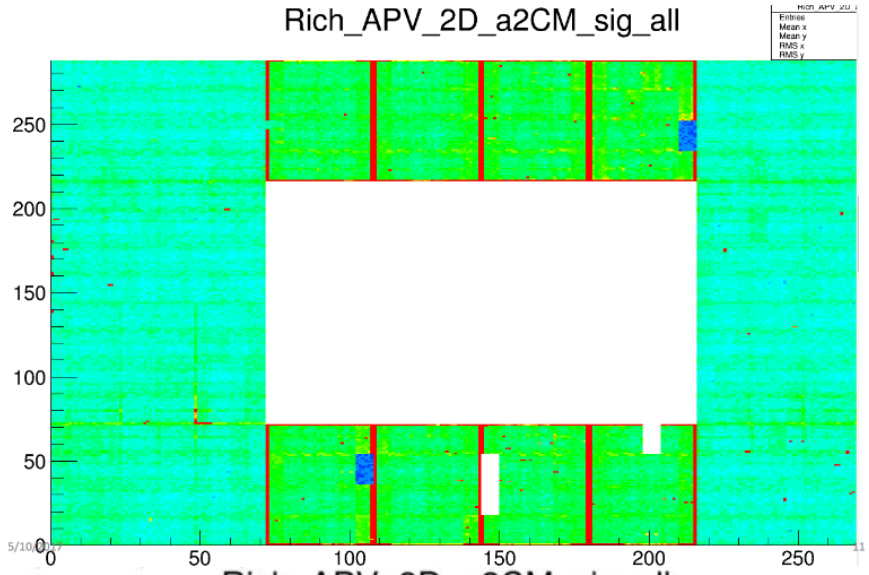
- Rings
- Analysis, Likelihood,chi2, etc. ← Track info input, Background file

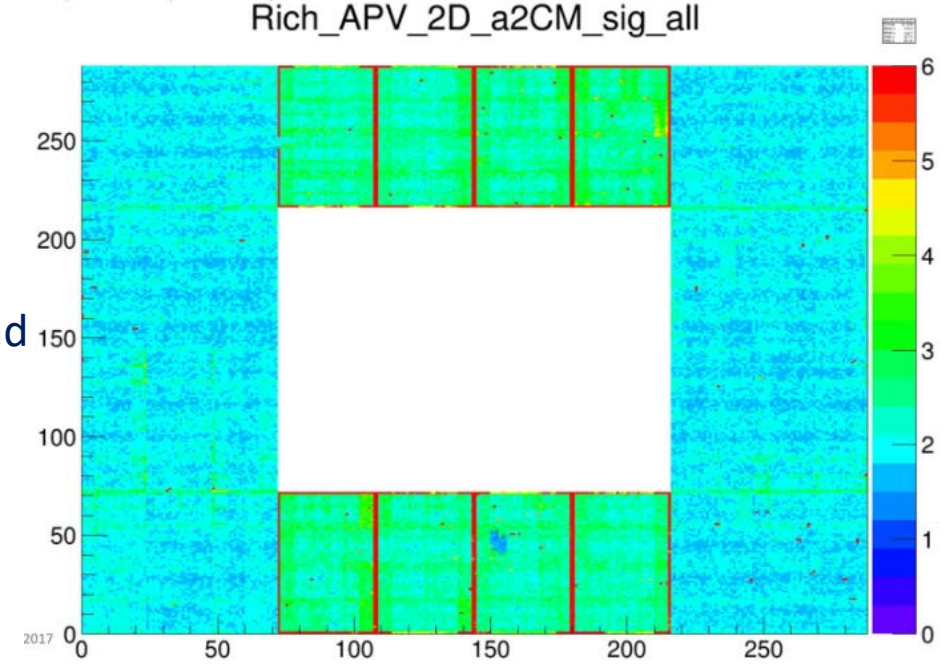
Each box is realized by a class

Conclusion part 4:
The analysis framework is complex. Looking into each class to realize the functions and switches.

Task for hardware maintenance and Lab activity

- I took part in the RICH hardware maintenance at CERN. To have optimize RICH performance.
- I contributed in the lab activities.





Concluding :

1. I also took part in hardware maintenance and lab activities as was foreseen in the beginning.
2. Realized the complexity of the ongoing project.
3. Looking forward for more adventures.

THANKS FOR YOUR ATTENTION

Spare Transversity.

- **properties:**
- $\Delta_T q(x) \neq \Delta q(x)$
- **probes the relativistic nature of quark dynamics**
- **no contribution from the gluons → simple Q^2 evolution**
- **positivity (Soffer) bound** $2|\Delta_T q| \leq q + \Delta q$
- **first moments: tensor charge** $\Delta_T q \equiv \int dx\, \Delta_T q(x)$
- **sum rule for transverse spin in Parton Model framework** $\frac{1}{2} = \frac{1}{2}\sum \Delta_T q + L_q + L_g$

Spare Sigma Analysis.

Comparison of Different Sigma Cut