

RPC 2012 - XI Workshop on
Resistive Plate Chambers and
Related Detectors,
INFN Frascati



A Free-Streaming Readout for the CBM Time of Flight wall

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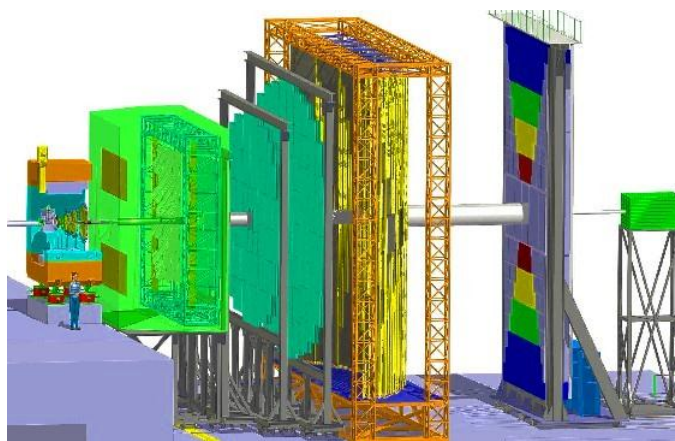
Outline

1. CBM, Time of Flight wall
2. Free-streaming readout, prototypes
3. Beam Time in COSY, November 2011
4. Results

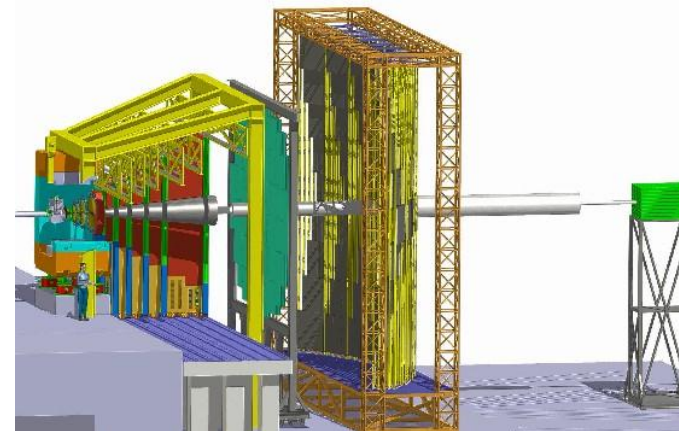
1. CBM

CBM = Compressed Baryonic Matter

- Heavy Ion spectrometer, fixed target
- Installed at the new FAIR facility in Darmstadt, Germany, new synchrotron: SIS100 / SIS300
- Au beams up to 35 AGeV (11 AGeV) with SIS300 (SIS100), typical being 25 AGeV
- Proton beams up to 89 GeV (29 GeV)
- Investigation of the properties of strongly interacting matter under extreme conditions
- High statistics measurement of rare probes => **High rate + High resolution!**



Standard setup



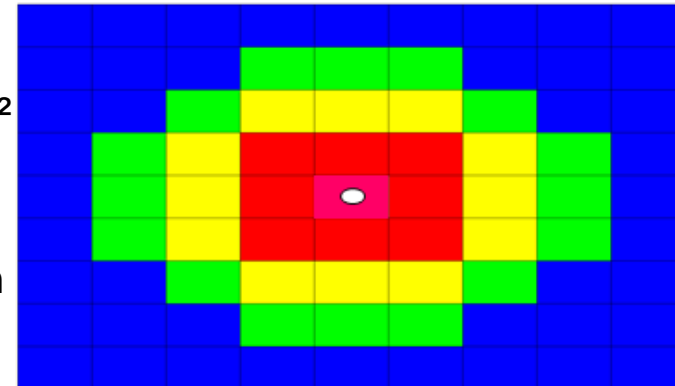
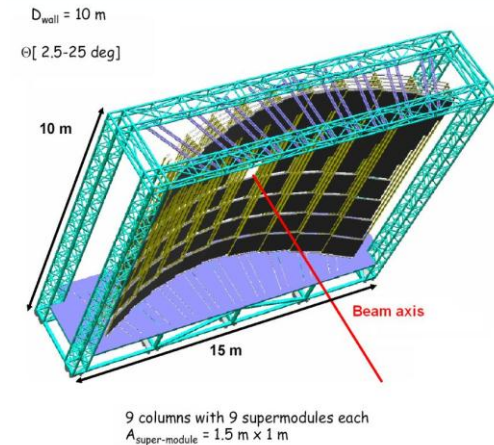
Muon setup

1. Time of Flight wall

- Provides charged hadron identification to CBM
- Based on Multi-Gaps Resistive Plate Chambers
- Number of channels: Between 70k and 100k, in 80 SuperModules

Requirements:

- Full system time resolution: 80ps to separate Kaons/Pions up to 3.5 GeV/c @ 25AGeV
=> 40ps for electronics
- Efficiency > 95 %
- Hit rate: 0.5 kHz/cm² to 25 kHz/cm², could go to 35 kHz/cm²
=> up to 200 kHz per electronic channel
- Double hit capability better than 10ns, if possible better than 5ns
- **Self triggered electronics, Free-streaming readout**



Cf I. Deppner, J. Wang,
M.Petrovici for designs

2. Free-streaming readout

Motivation:

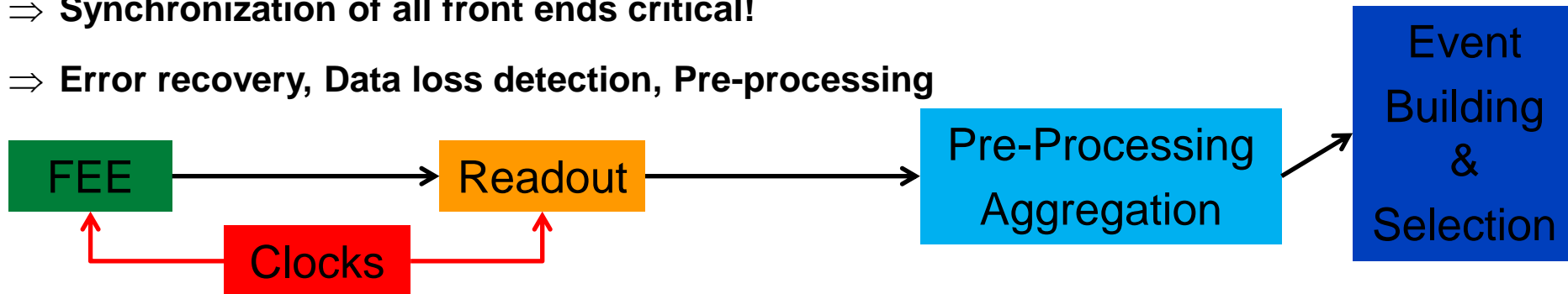
- CBM interaction rate: up to **10^7 Hz** Au+Au @ 25AGeV
- Rate + need to inspect full event for decision => free streaming!

Principle:

- 1) Each front-end chip must detect hits and timestamp them
- 2) The data are pushed through the readout chain toward the First Level Event Selector
- 3) Data pre-processing as soon as possible => Bandwidth!

⇒ **Synchronization of all front ends critical!**

⇒ **Error recovery, Data loss detection, Pre-processing**



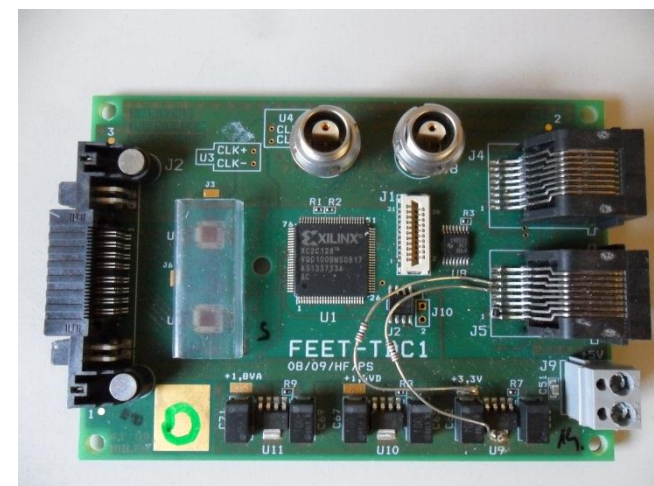
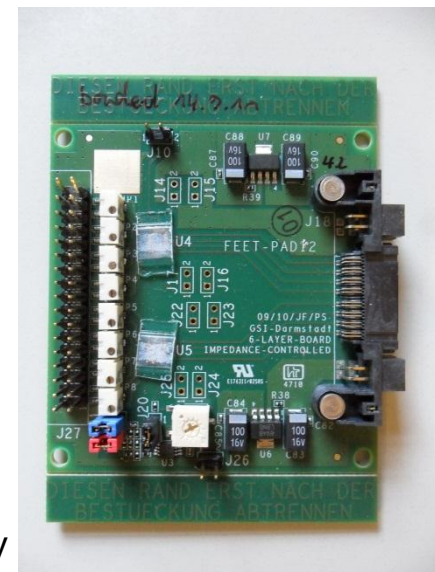
Goal = build a full readout chain for each sub-detector working at the full rate

2. The PADI-GET4-ROC readout chain

Components: custom designs

- Clock System: CLOSY2 board and distribution tree
- Pre- amplifier and discriminator: PADI III
 - Fully differential design
 - Impedance matching with strip RPCs
 - 1-100mV signals standard operating range

=> Adapted to detector developed in Heidelberg, cf Ingo Deppner talk Tuesday
- Free-running digitizer: GET4 proto
 - ASIC = Radiation tolerant!
 - 50 ps bin size for 25ps resolution (RMS, with pulser)
 - Free streaming readout
 - Synchronization error detection
 - 3.2ns double hit capability



2. The PADI-GET4-ROC readout chain

Components:

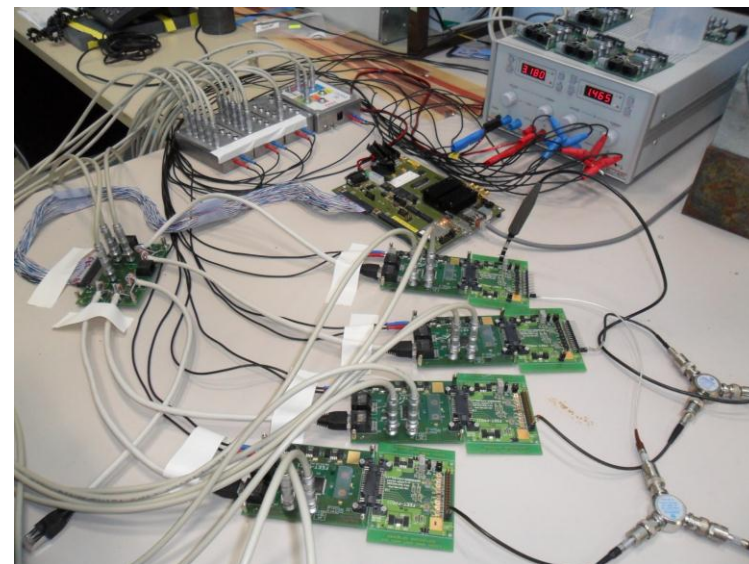
- ReadOut Controller: ROC
 - DAQ: DABC software
- ⇒ Compatible with both triggered and free-streaming systems

Lab pulser results	σ [ps]
chip level	36.94
PCB level	38.94
PCB-PCB level	40.22

Test by J. Frühauf, GSI

Characteristics:

- 4 channels/chip, 8 channels/board
- Free streaming
- Achieved ~40ps in lab setup
- Time Over Threshold (ToT) capability
- Known problems on both chips
- Main goal: Data quality/system test



2. COSY Beam Time: Setup

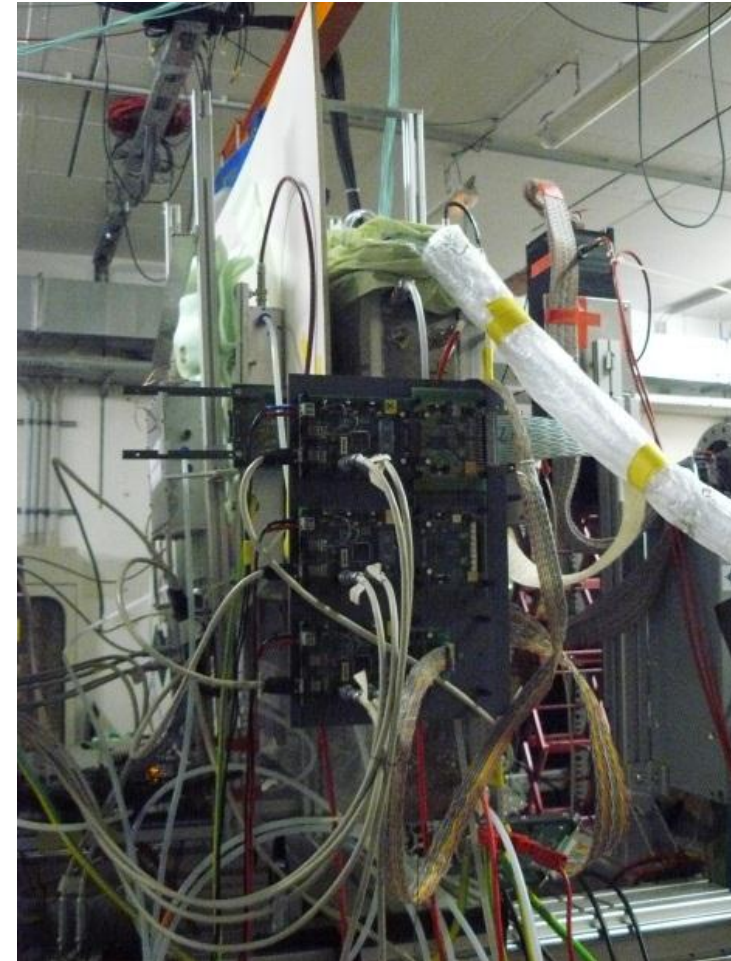
COSY:

- Synchrotron in Jülich, Germany
- 2.5 GeV proton beam
- Control on rate: Hz to MHz

Characteristics:

- Hybrid measurement:
 - Time reference in triggered VME system
 - Detector data in free streaming system
- 16 detector channels readout (8 strips)
- Reference system build with 3 plastic scintillators

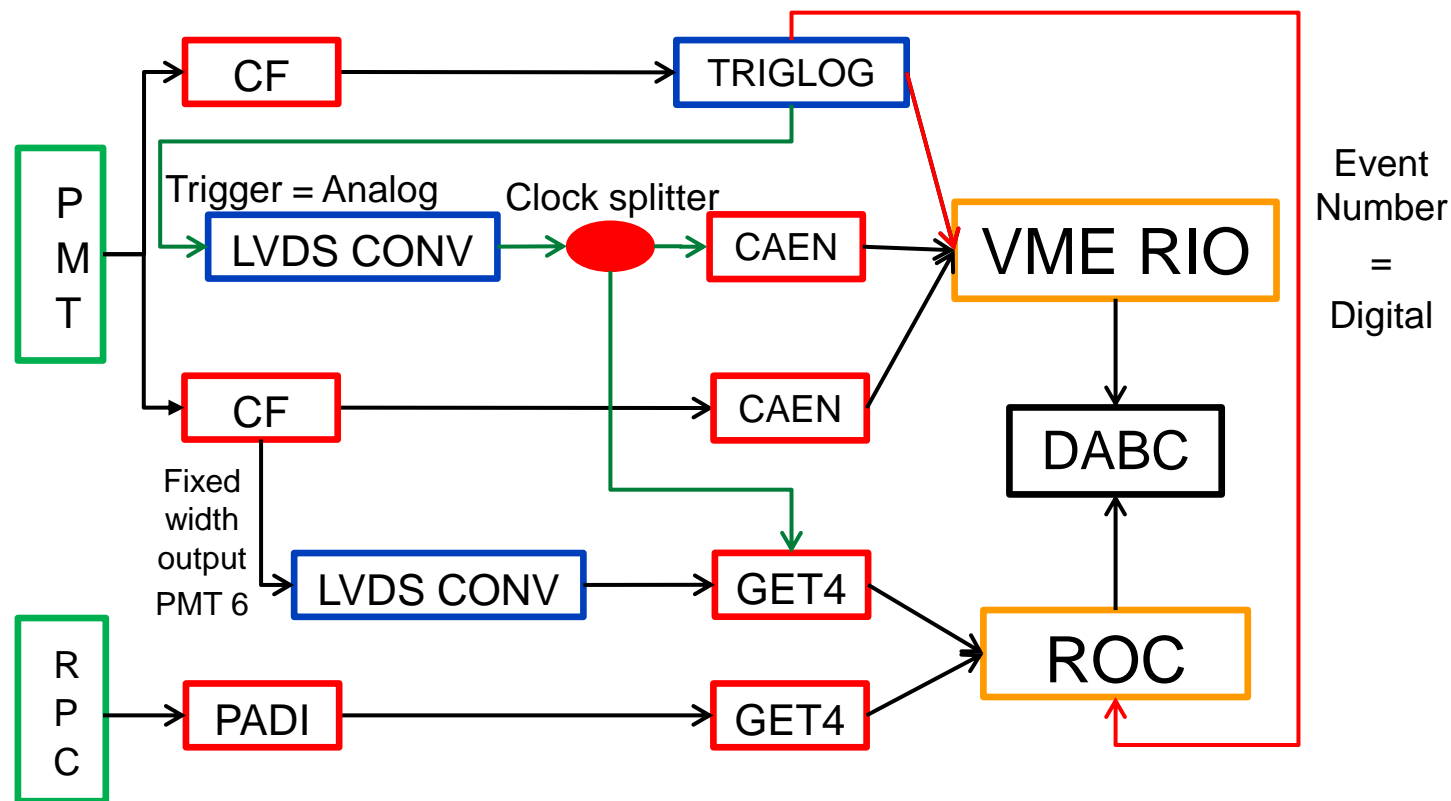
(Setup description see I. Deppner talk last Tuesday)



2. COSY Beam Time: Hybrid system

Hybrid system constraints:

- Data synchronization at DAQ level = **event nb** generated in VME trigger logic, transmitted to all free-streaming parts, there **time stamped**
- Time synchronization by measuring **same signals in both systems**
 - PM 6
 - Trigger



3. Analysis status: Reference & synchronization

Reference:

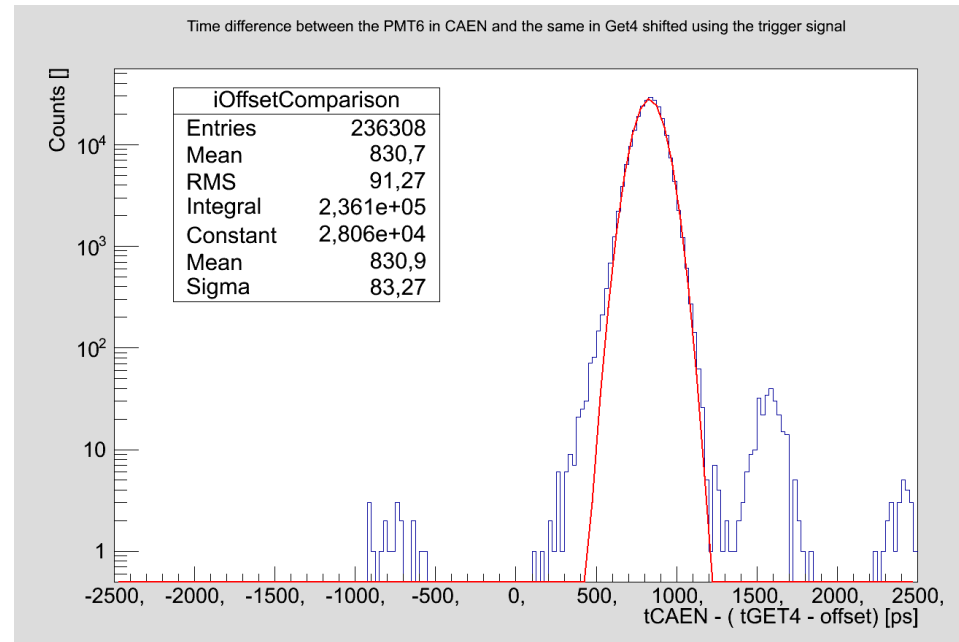
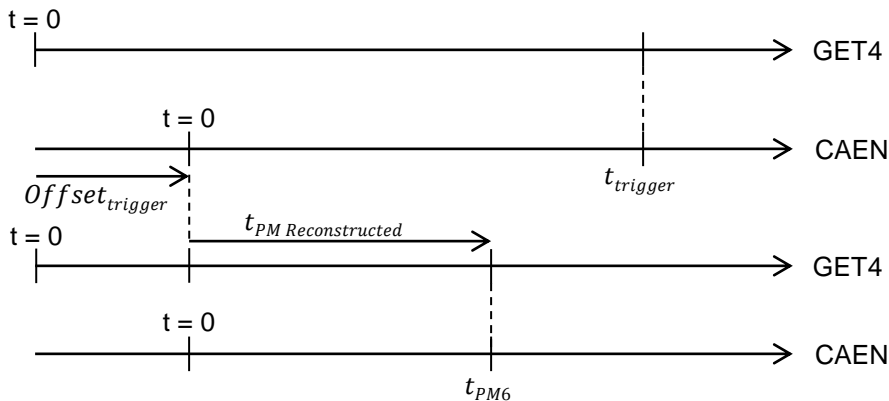
- Same as for fully triggered test with CAEN TDC => ~45ps time resolution

Time synchronization:

- Test:

$$Offset_{trigger} = [t_{trigger}]_{GET4} - [t_{trigger}]_{CAEN}$$

$$t_{PM\ Reconstructed} = [t_{PM6}]_{GET4} - Offset_{trigger}$$



$$\Delta t = [t_{PM6}]_{CAEN} - t_{PM\ Reconstructed} = [t_{PM6}]_{CAEN} - ([t_{PM6}]_{GET4} - Offset_{trigger})$$

- Resolution of the time offset between GET4 and CAEN: 80 to 85ps
- In tested runs: 99% of events with correlation

Conclusion

- A first free-streaming readout chain specially designed for Multi-Gap Multi-strips RPC timing detectors was assembled and tested
- Free-streaming implies new constraints, like synchronization
- Require a mix of triggered and non-triggered electronics for first tests
- Hybrid setup synchronization principle is working
- Time stability of this synchronization for now around 80ps
⇒ Goal is 40ps
- Analysis under development to process free-streaming and hybrid data

Outlook

- Analysis will continue to extract time resolution/efficiency and compare to triggered system performances
- New version of each component coming this year, closer to final version
 - Pre-amplifier: PADI VI
 - TDC: GET4 v1.0 and new FPGAs
 - Readout controller: SYSCORE v3
- The setup will be improved by steps in prevision of this new generation:
 - Cleaner with reduced clocks/power cables
- Goal: decision on main components and alternatives for TDR end 2013



Thank you for your attention



CBM-TOF Group

Contributing institutions:

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- GSI Darmstadt,
- USTC Hefei,
- PI Heidelberg,
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