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Level-1 Calorimeter Trigger Calibration

Birmingham, Heidelberg, Mainz, Queen Mary, RAL, Stockholm

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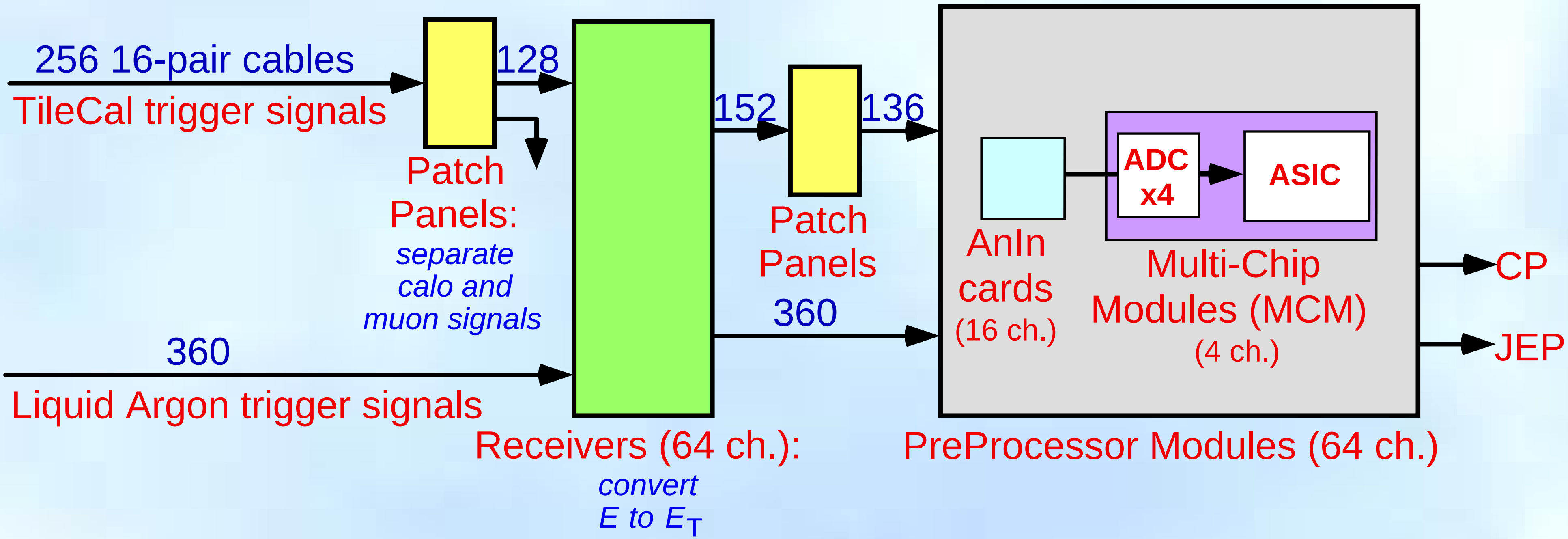
Outline

- **Reminder of Trigger Architecture**
  - Analogue & Digital functionality
- **List of areas to calibrate**
  - Including some not discussed here
- **Short refresher on Bunch Crossing Identification**
- **Calibration of BCID timing and filter**
- **Calibration of E_T scale (Receivers & LUT)**
- **Calibration Procedure**
- **Next Steps**

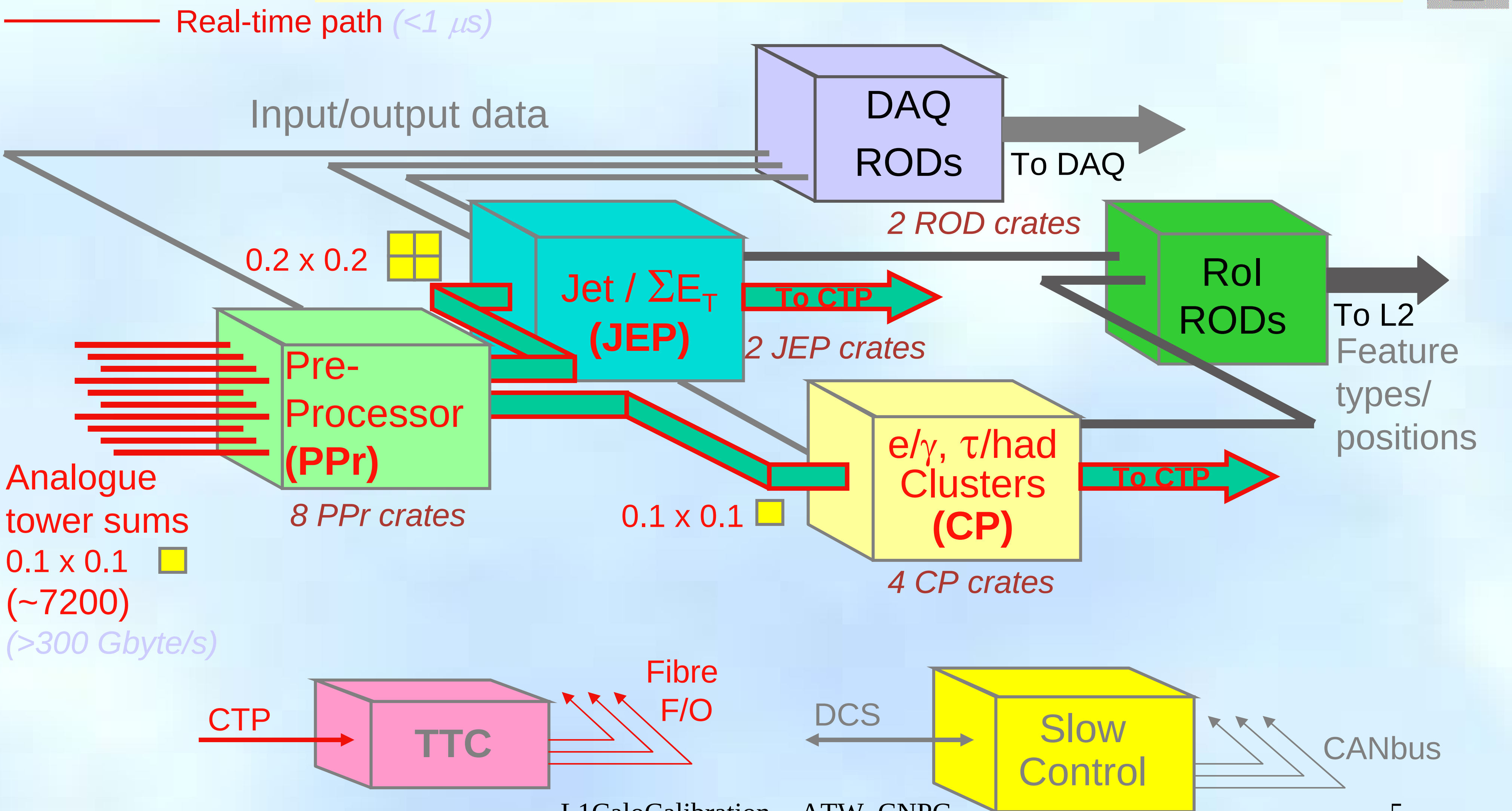
Analogue data path into L1Calo



Analogue functionality

- **TileCal patch panels**
  - Separate calo and muon trig signals sent together on the same long cables
  - TileCal long cables use 50-way connectors, but short cables from patch panels to receivers use 37-way
- **Receivers** ***(8 crates, 128 modules, 64 channels./module)***
  - Convert E to E_T *(variable-gain amplifiers) (LAr TBs deliver* E_T*)*
  - Rearrange trigger tower signals *(remapping cards)*
  - Sum some signals to form trigger towers *(e.m. barrel–endcap, FCAL)*
  - Monitor analogue signals
- **Receiver–PreProcessor patch panels**
  - Rearrange signals in 'transition' regions *(e.m. barrel–endcap, Tile–HEC, etc.)*

Digital data path inside L1Calo



Preprocessor functionality

- **Digitisation at 40 MHz**
  - 10-bit precision: 2.56 V = 256 GeV *(0.25 GeV/count)*
- **Bunch-crossing identification**
  - Finite-Impulse-Response filters using 5 bunch-crossings
- **Timing**
  - FIFOs *(25 ns steps)* to align all signals to same bunch-crossing
  - ADC strobes on pulse peaks adjustable in 1 ns steps
- **Final calibration via look-up table**
  - Remove pedestal
  - Adjust E_T value: 8-bit outputs for trigger algorithms *(~ 1 GeV/count)*
  - Apply noise filter *(~1 GeV)*
  - Suppress problem trigger towers
- **Sum 0.1 × 0.1 trigger towers into 0.2 × 0.2 jet elements**

Preprocessor FADC Output

10-bit 40Mhz Digitisation

(12-bit FADC, 2 bits dropped)

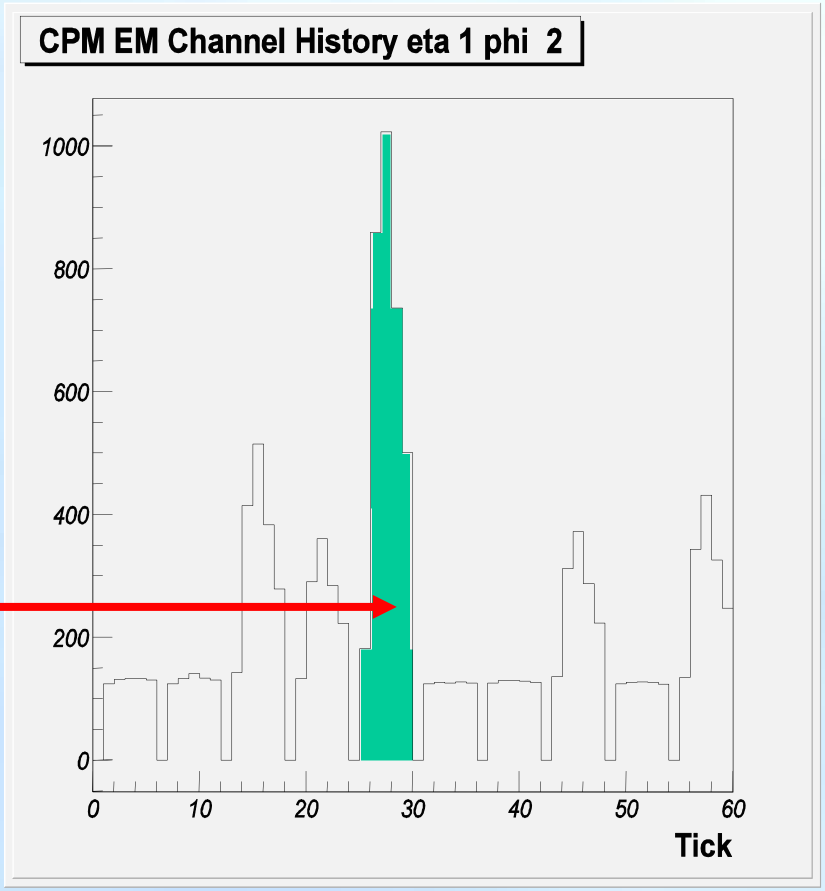
Scale: ~0.25 GeV/count

350 GeV 25 ns

recorded at test Beam

Data from one L1A

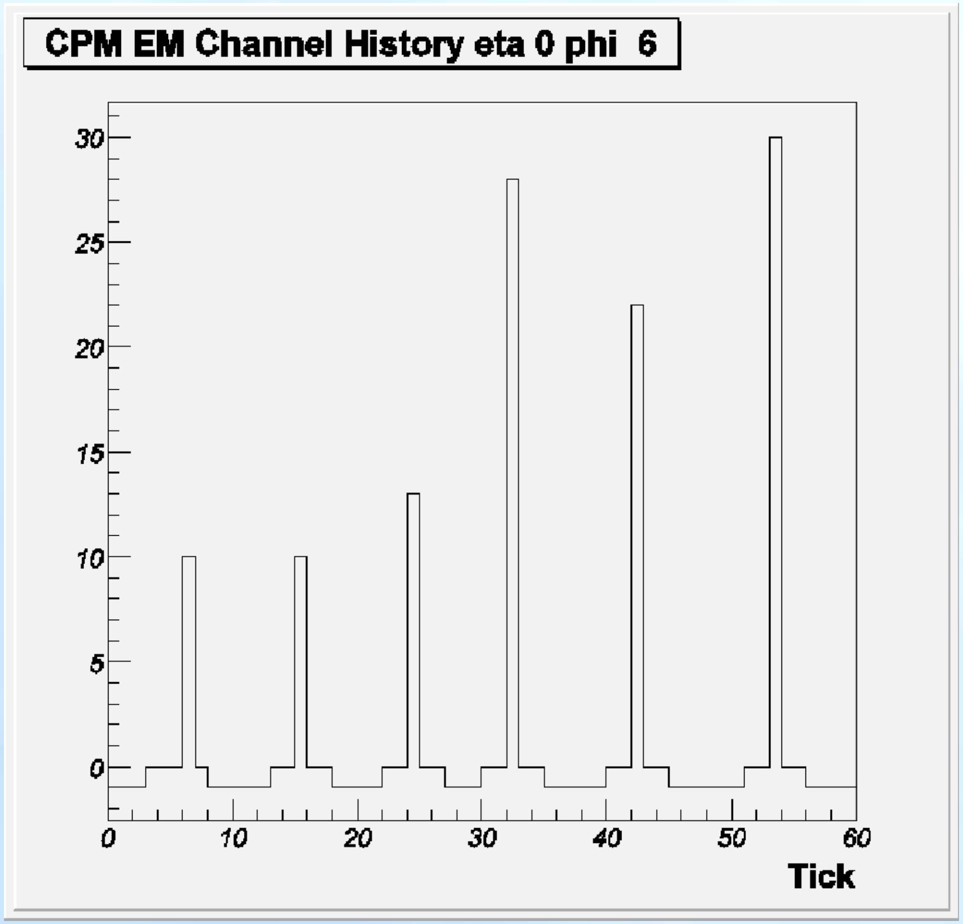
Pedestal ~ 120 counts



PPM – Bunch Crossing Identification

- **Digitised pulse is converted to a single 8-bit E_T value, phased to enter the trigger pipeline at the correct time (correct bunch number) for all calorimeter towers.**

- **Most of the calibration is ultimately incorporated into this process.**



Areas requiring Calibration

- **1. Analogue Pulse shapes and timing:**
  - compensated by BCID coefficients + coarse and fine timing
- **2. ET extraction from calorimeters via detector electronics chain, cables, receivers, & L1Calo FADCs**
  - variable gain amplifiers, final tuning by LUT Contents
  - This also requires measurement of noise/pedestal levels
- **3. Trigger threshold settings to manage efficiency & rate**
  - Adjustable in steps across eta and phi

Not discussed here

- **Internal digital timing settings are important for us, they are another type of calibration and use many similar tools…**
  - Digital timing settings for correct operation of the digital links;
  - Readout parameters related to sampling the triggered slice to Daq.

- **When to do which types of calibration, and how often.**
  - i.e. during running, at end of fills, between fills, during long shutdowns
  - during installation, commissioning, cosmic running.
  - We have to be flexible, depending on system stability, beams, …..

- **Verifying Connectivity during installation**
  - Presumably using calibration systems. Needs planning (see later).

Calibrating BCID coefficients

- **This relies on charge injection calibration pulses**
  - of constant (say 100 GeV equivalent) amplitude, shaped as for particles
  - locked to the common ATLAS 40.08 MHz clock,
  - preferably timed as beam relative to L1A (at least within one calo)
- **We measure the pulse shape by FADC, varying the timing of the strobe.**
  - these data provide the BCID filter coefficients for each trigger tower
  - and the coarse and fine timing delays needed.
- **We will measure both complete trigger towers AND the precise timing for each raw calorimeter cell**
  - to check that they all line up within the required +- 2ns
- **With these settings, the BCID mechanism will convert time-extended, unsynchronised analogue pulse to single digital values.**
  - by looking for the peaks in the FIR filter output.
  - The digital values are used by the Lookup Table (LUT), which follows.

ET Extraction

- **This also relies on charge injection calibration pulses, like the BCID**
  - but with adjustable amplitudes, of known equivalent energy.
  - together with map of good/bad/hot… cells, dead material,….
    - ***Both of these measured and provided by the calo groups, please.***

- **The LUT tunes the E_T energy scale. Eta-dependent conversion is done**
  - in receivers (hec, fcal, tile). L1Calo will set and monitor the gains.
  - in the tower builders and receivers (LAr em). Who sets the gains?

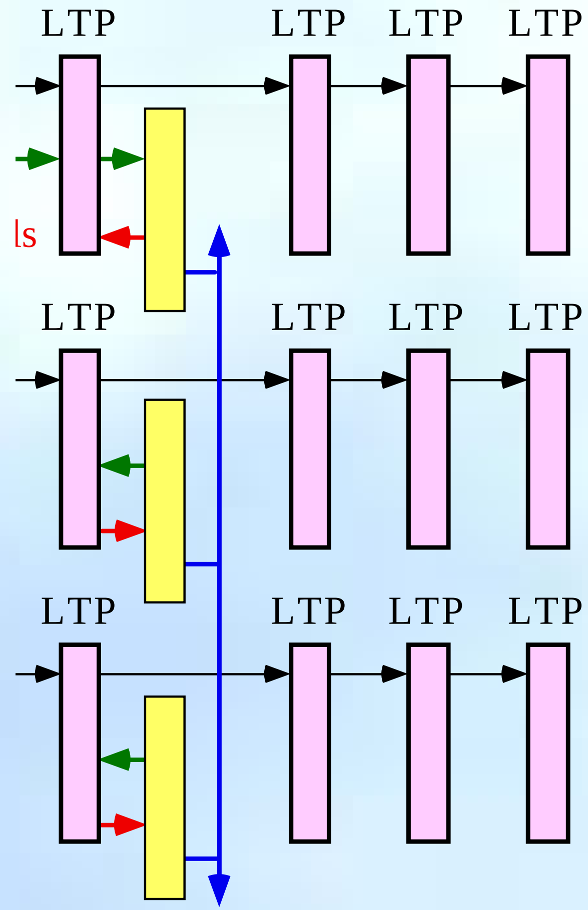
- **We will measure both complete trigger towers AND each raw calo cell**
  - to check that the gains are all equal (precision required is a few percent).

- **Measurement needs each calorimeter to inject calibration pulses with**
  - Common timing; controllable patterns; different raw cells summed; and..
  - Energy values chosen to span the range 0-250 GeV in ET.

Calibration Procedure

- **Calibration runs have to be able to use LTPs without CTP**
- **There are (at least) two types of calibration run:**
  - 1. Fast - measurements concentrate on complete trigger towers:
    - ***calculations are done online, based on e.g. 100 pulses of known energy.***
    - ***possibly no need to see precision calorimeter readout.***
  - 2. More detailed – looking at raw cells
    - ***event-building trigger and calorimeter data,***
    - ***looking at instrumental effects and systematics***

- **There were some initial discussions (before the testbeam). There are many details to sort out.**



Some random Bits & Pieces

- **Database. We'll be storing all parameters in conditionsDb.**
  - and we'll need to read some info from calo conditionsdb.
- **Will need some tools to compare trigger & Calo measurements.**
- **How/who sets the switches enabling/disabling raw cells, etc?**
  - hot towers, dead cells,…
- **Who sets, records and monitors the LAr receiver gains?**
- **How will we use cosmics to check timing…**
- **Frequency of measurements like pedestal (drift,…)**
- **Data volumes to database, and organisation of data.**
- **Checks of linearity using physics data.**

Next steps…

- **L1Calo had planned to explore calibration after the test beam.**
  - but we had exhausted ourselves and no-one was available.

- **We need to resume discussions.**
- **Our installation and testing should match calo sequence.**
  - and we need to agree how/when to test calo trigger outputs.
- **L1Calo would like to set up a meeting with calo groups and DAQ to understand together the joint commissioning procedure and some of the questions raised here. We will try to organise this at an agreed time probably in January.**

End

- **Thank you for inviting us**

Background Material

Calibration Procedure – Fast run

- Decide to do a calibration run (by hand? Automatically?)
- Create appropriate partition (by hand? Automatically?)
- Start run

L1Calo Calorimeter

"Send me e.g. 100 events at 25 GeV"

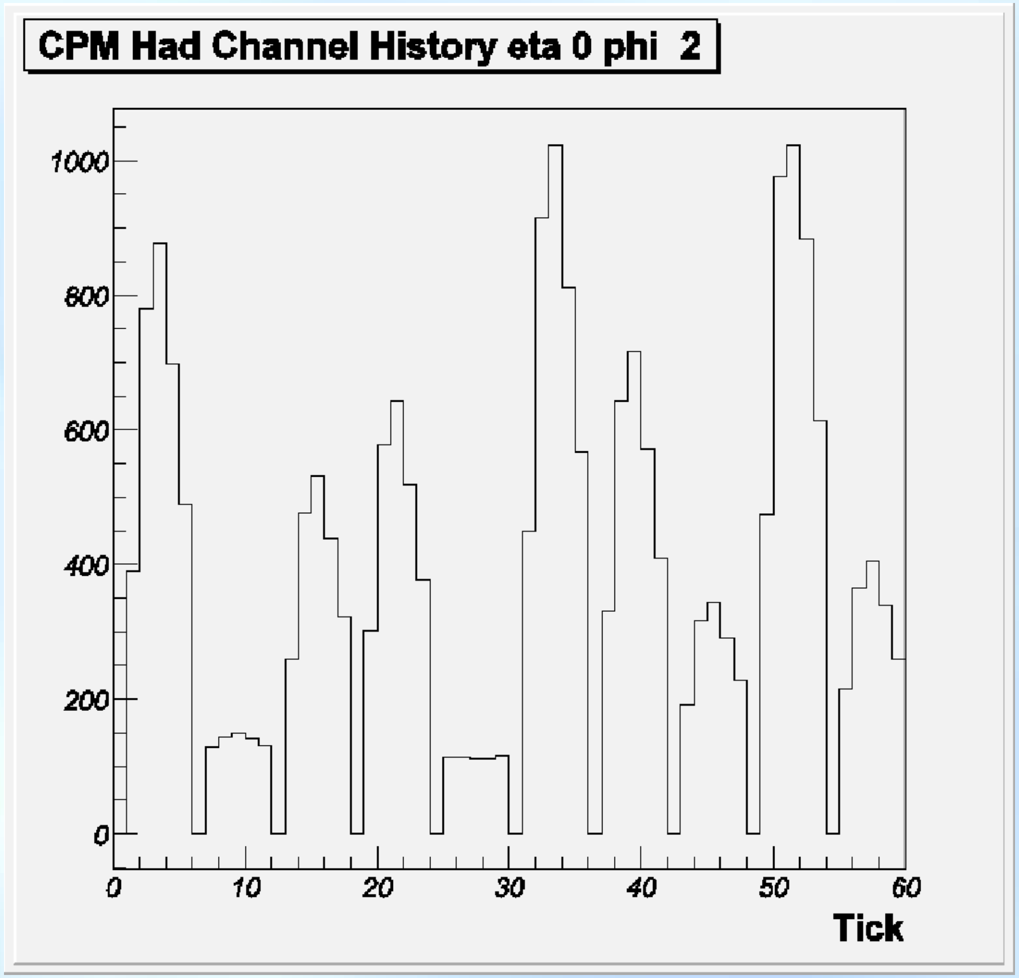
Generates 100 L1As + Pulses

"Done. The analysis results were…"

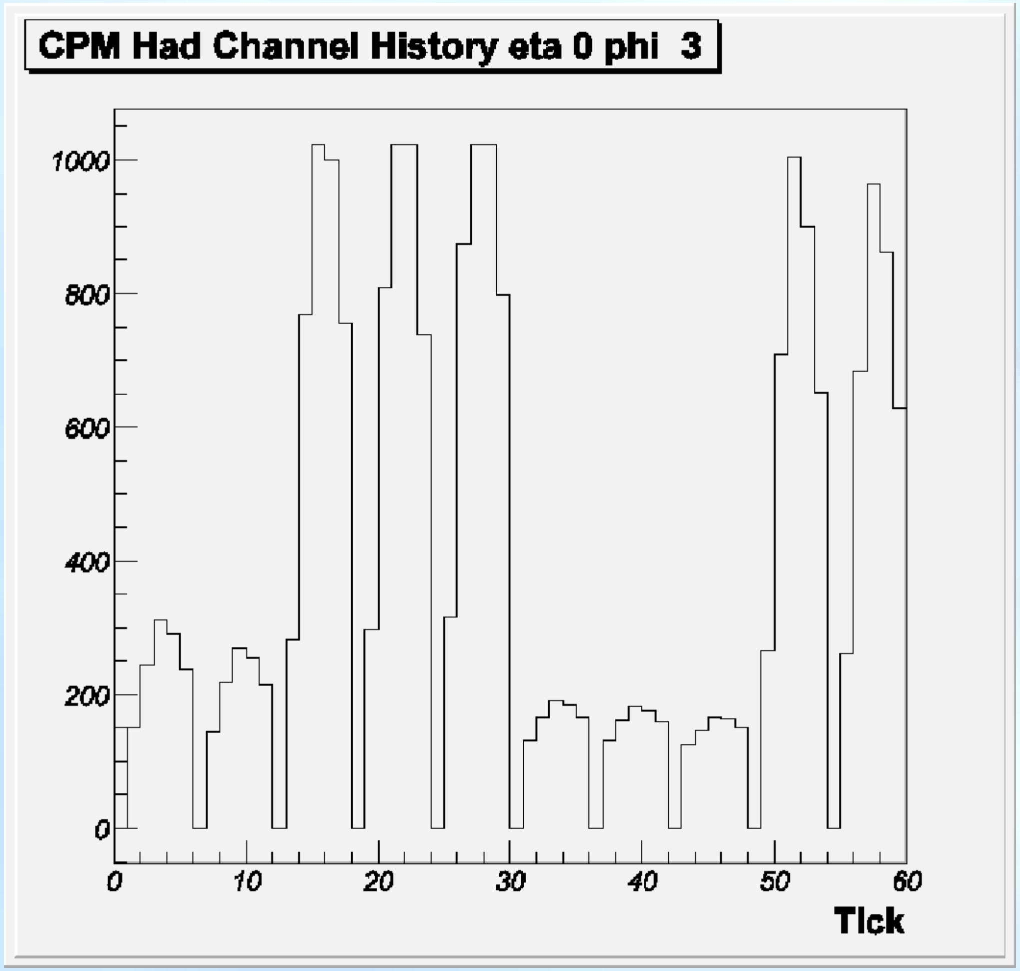
Analyse these events (includes compute Et)

- Iterate
- End run
- Compute final results, store in database, compare with reference…

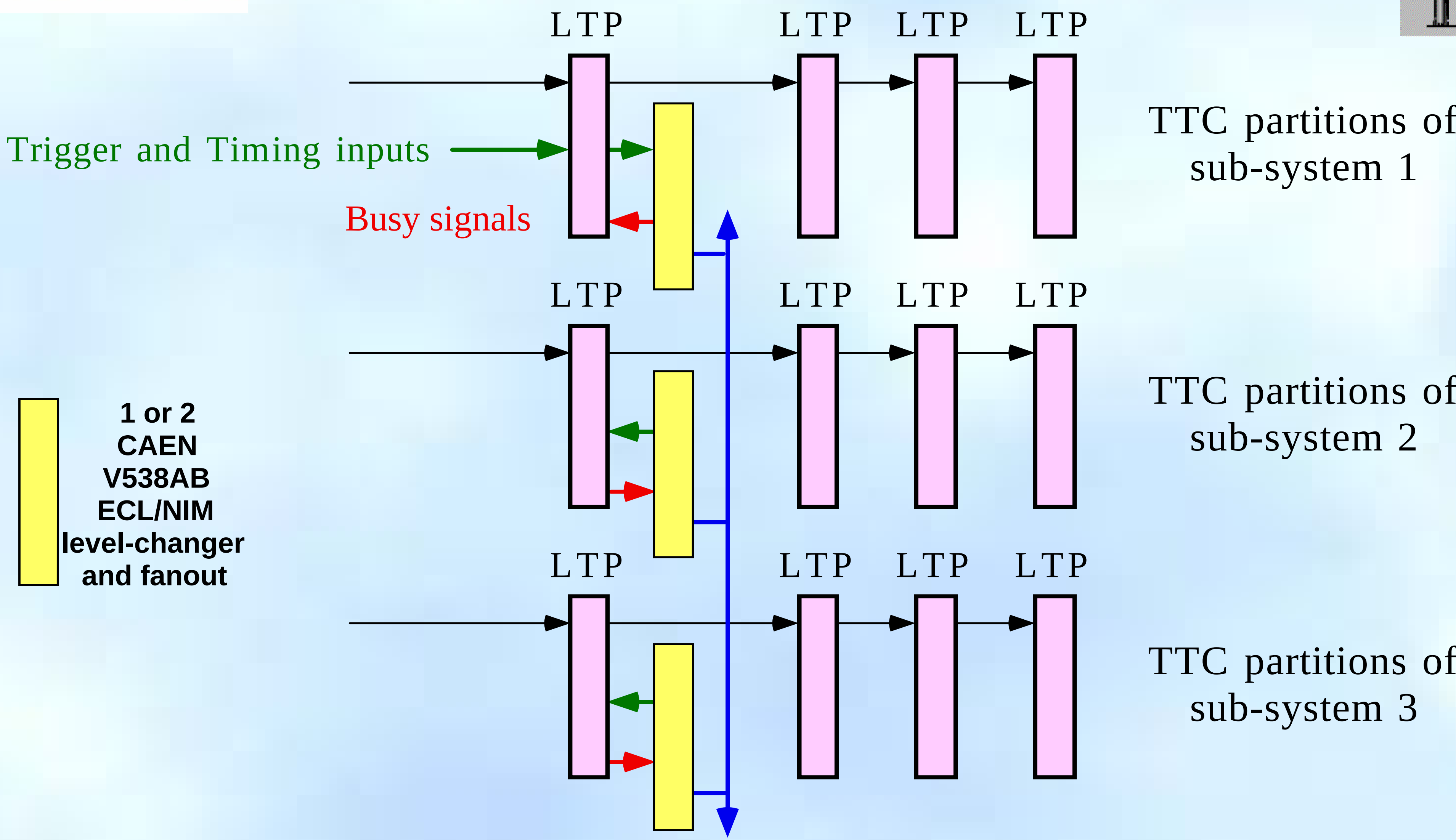
FADC Data –Hadronic



Saturated



LTP: LVL1 + LAr + Tile, no CTP



(Drawing based on P. Farthouat)