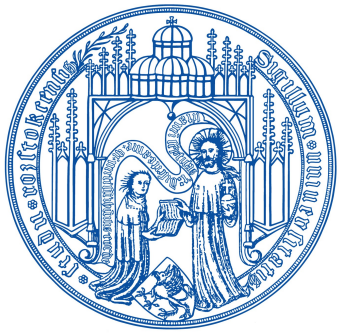
TPC readout electronics with Time-to-Digital Converters



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LCWS 2008
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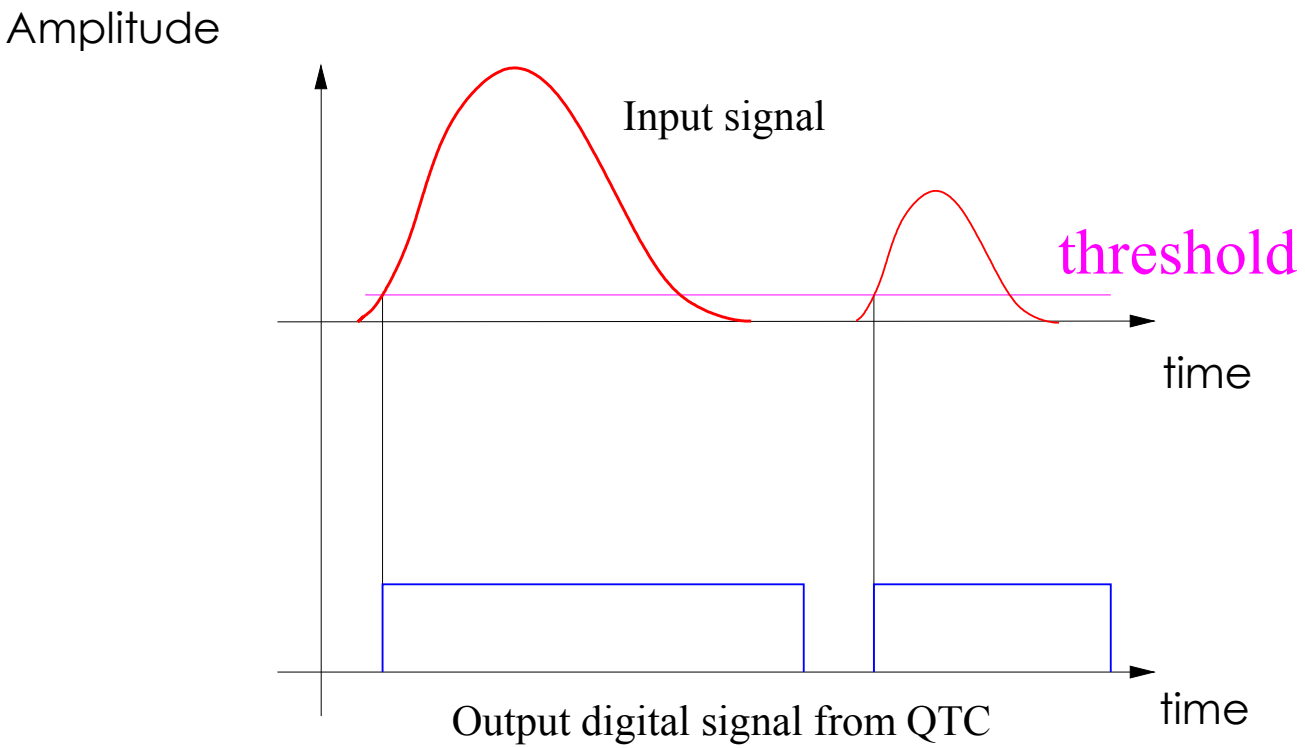
TPC signal processing with Time-to-Digital converter



Data zero suppression by analogue data processing.

Here example with threshold timing and charge-to-time conversion.

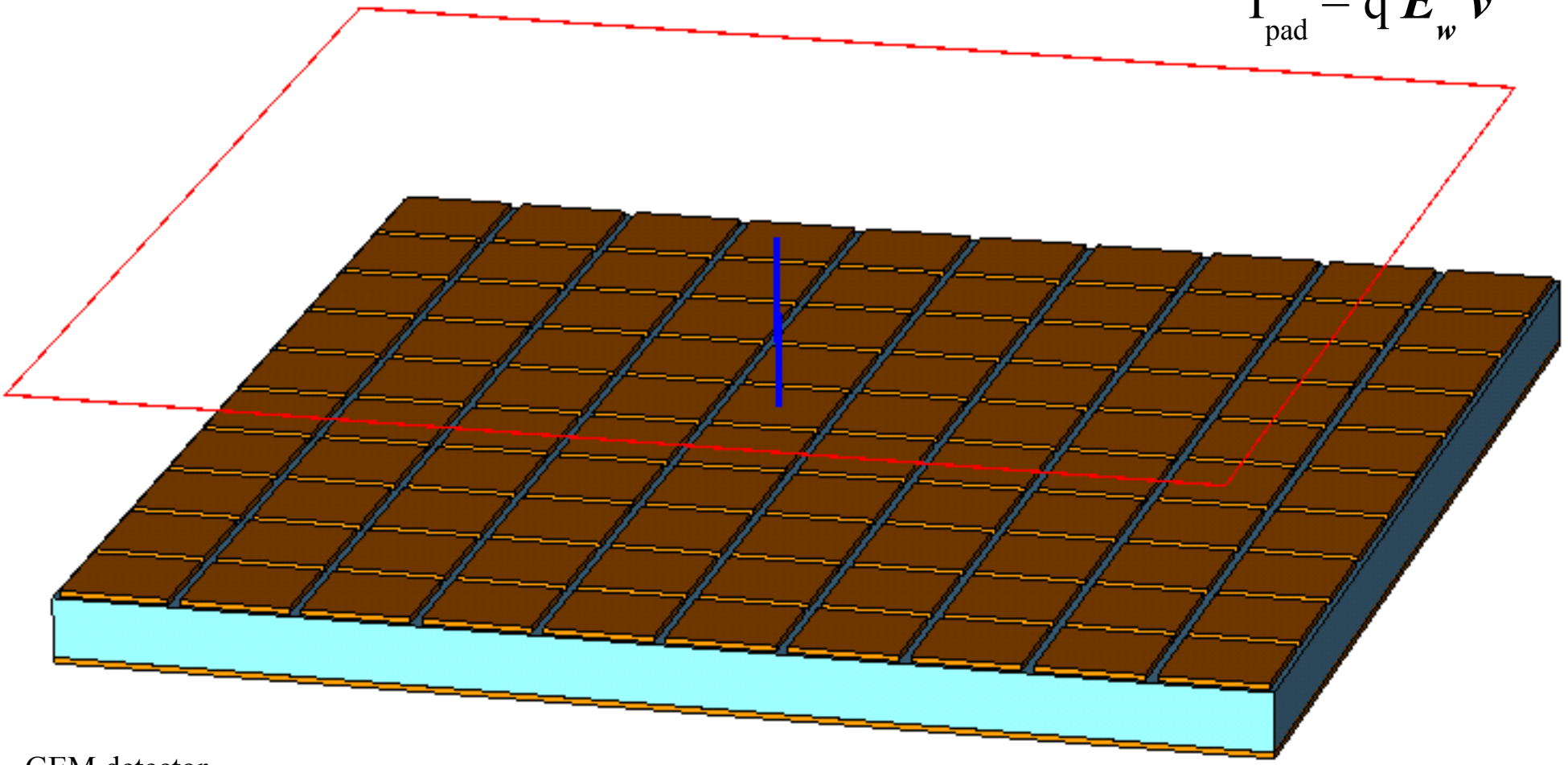
- The time of arrival is derived using the leading edge discriminator.
- The charge of the input signal is encoded into the width of output digital pulse.

The method has several advantages, but optimization is needed.

GEM signal simulation

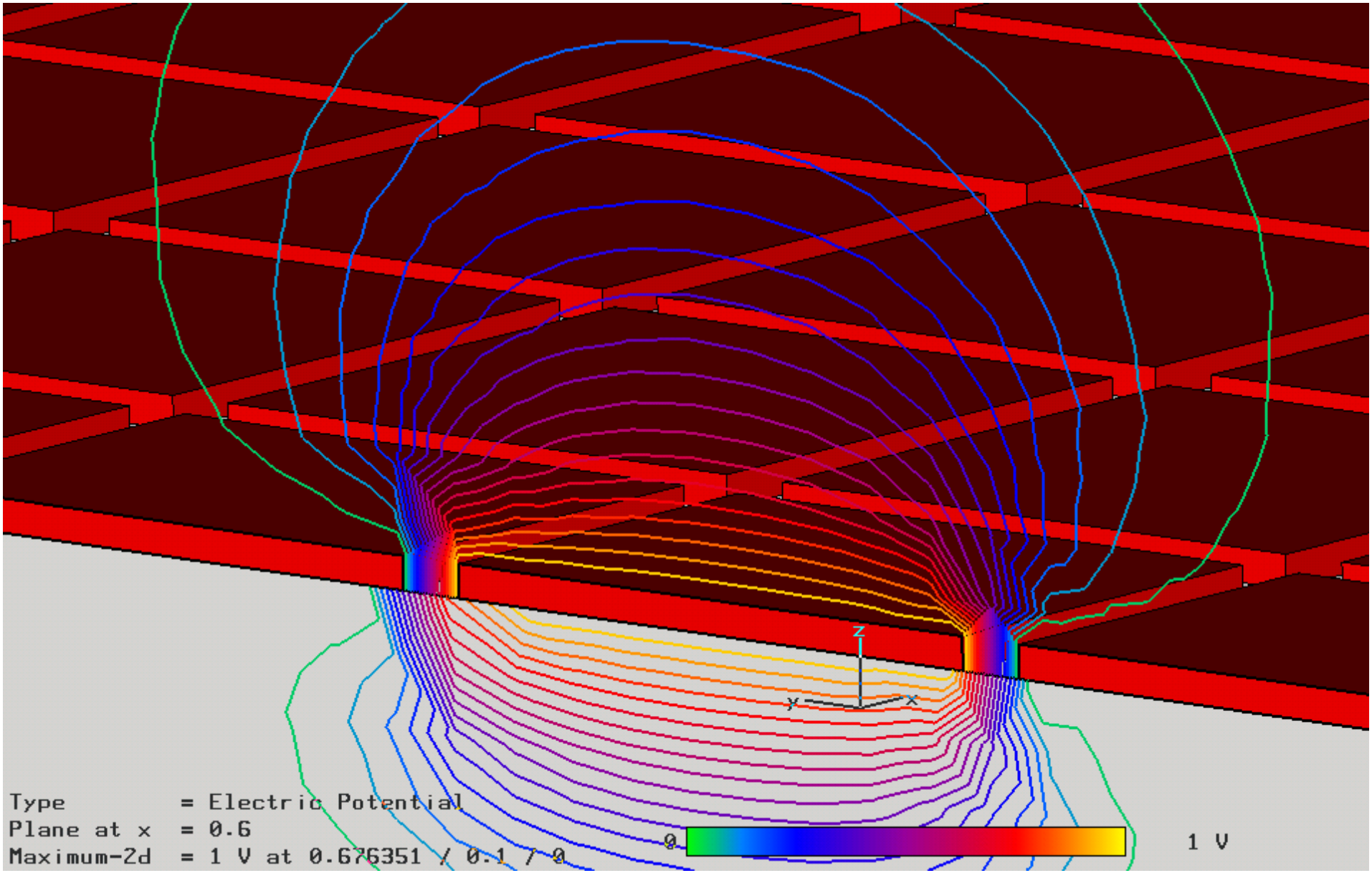
Using Ramo theorem and FEM electrostatic calculation with *CST Studio*, signals from a single electron can be calculated.

$$I_{pad} = q \boldsymbol{E}_{w} \boldsymbol{v}$$



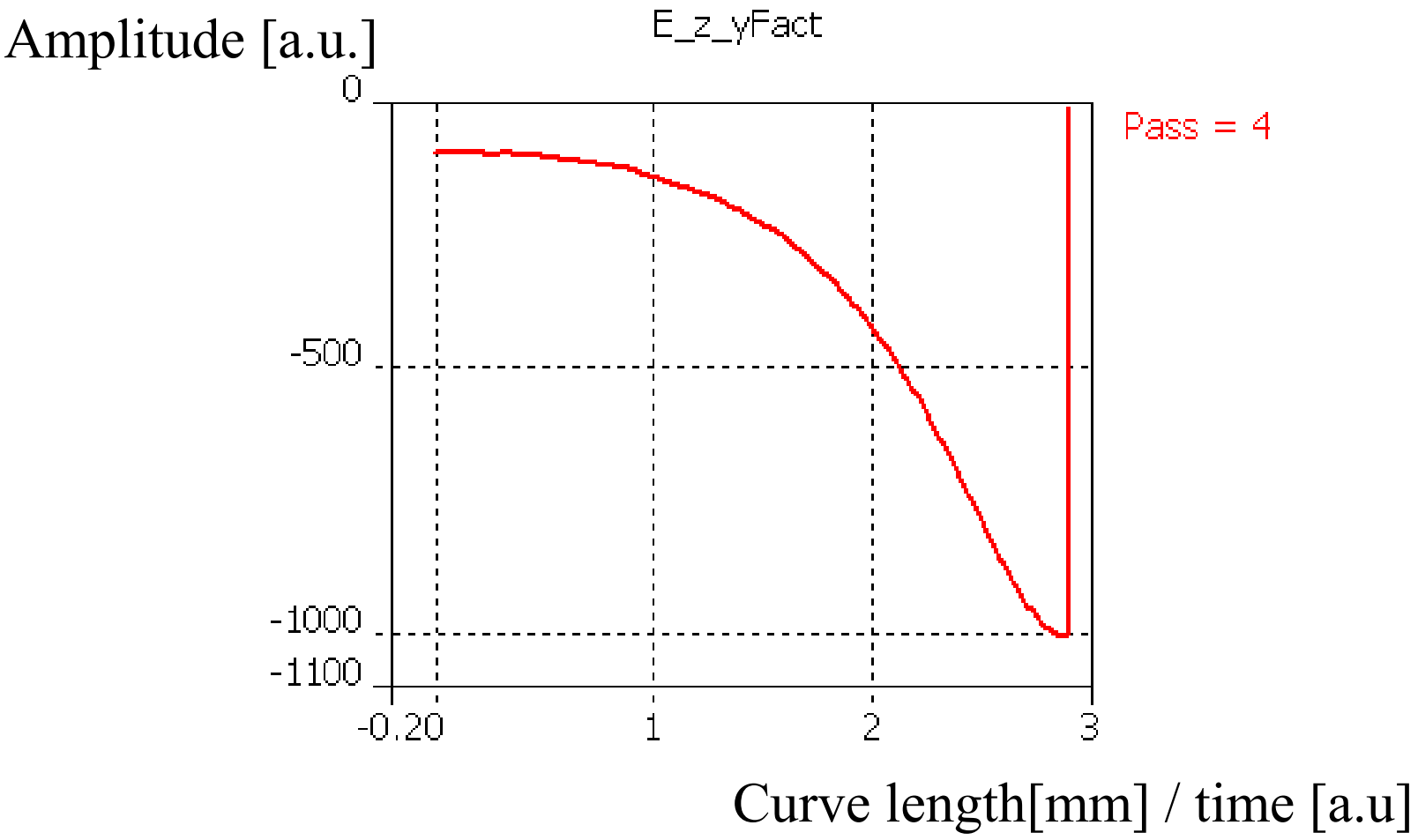
GEM detector,
2 mm square pads,
3 mm induction gap

Weighting field calculation



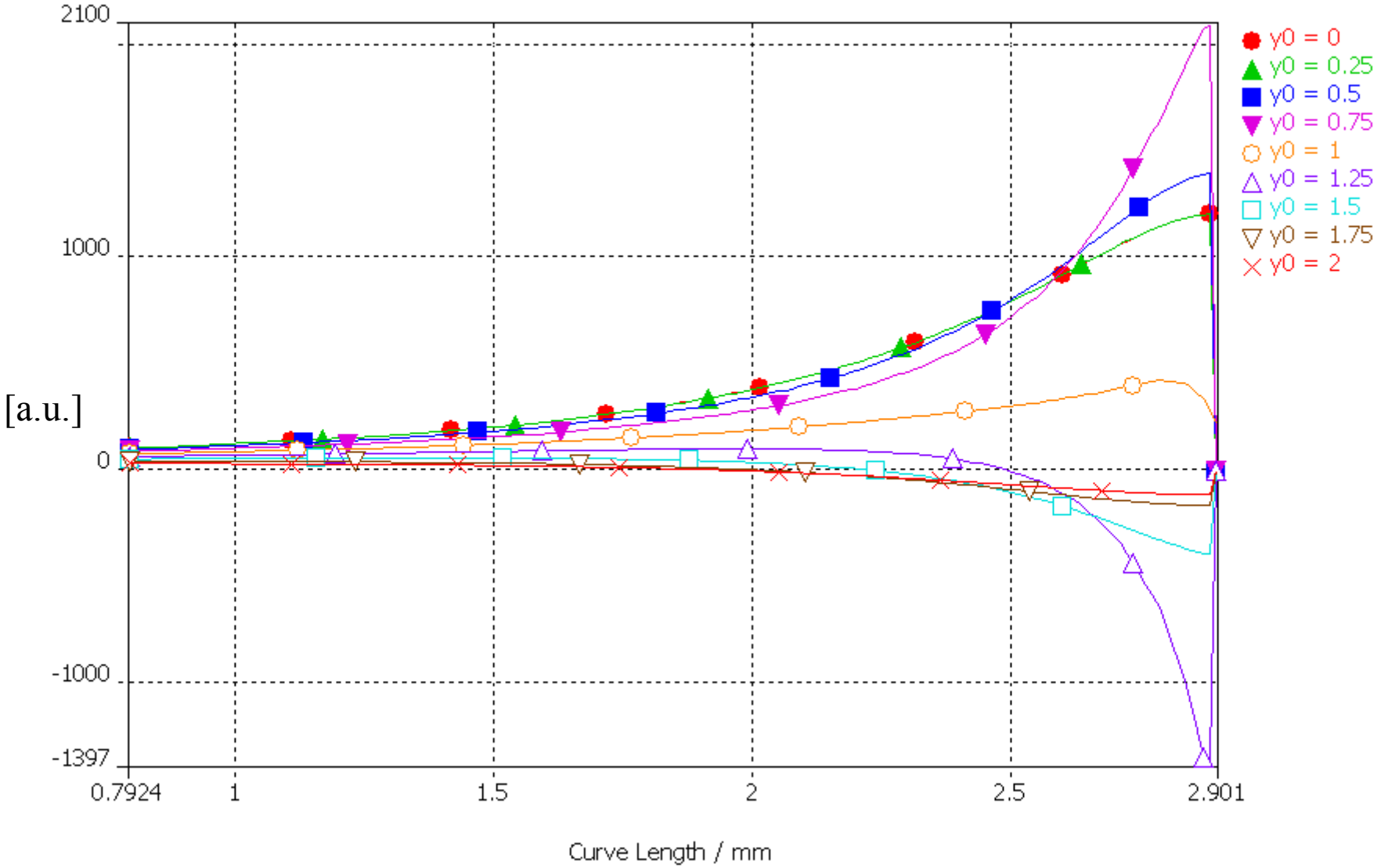
An example: weighting field is visualized in form of potential lines on a cutting plane.

Shape of the signal from a single electron



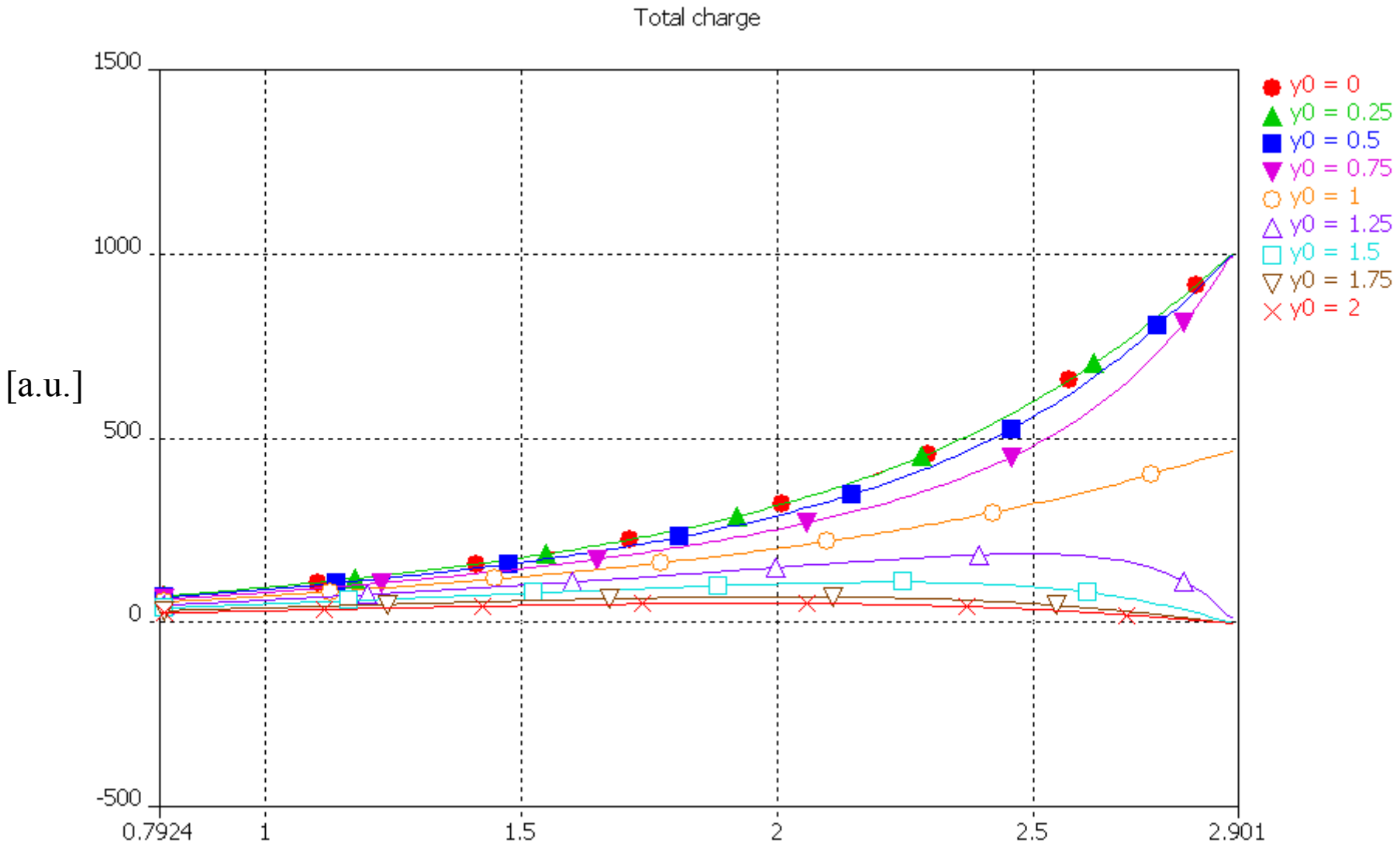
E_z component of the weighting field = shape of the signal

Shape of the signals from a single electron



Different positions of the drifting electron with respect to the center of the pad

Total charge accumulated on the pad



Pad response function can be also obtained from such calculation

Simulation of signals from a GEM detector

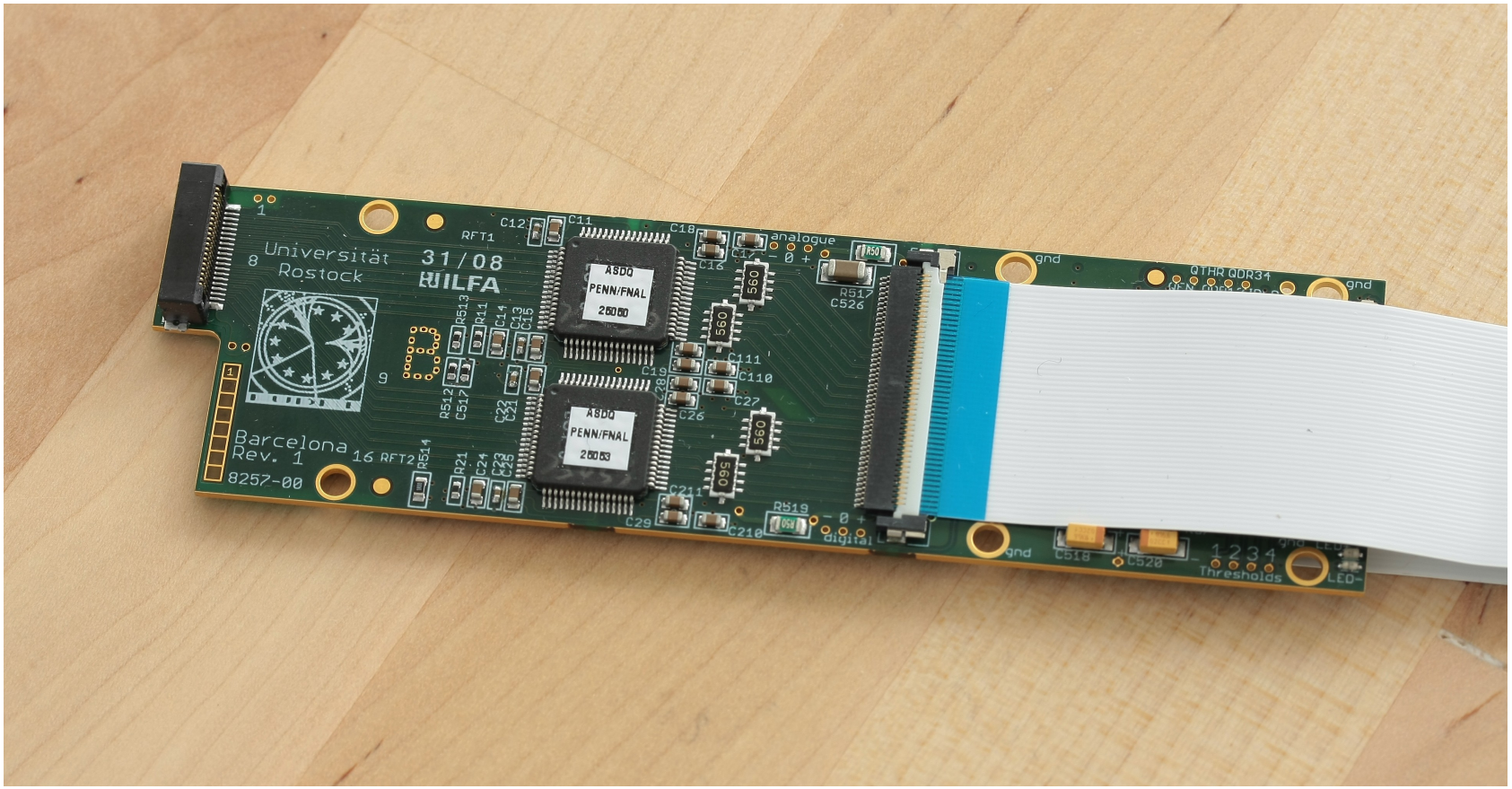
Optimization of the readout electronics shall be done for:

- z-timing (new methods of triggering: peak detector ?)
- Double pulse capabilities.
- Log-like QT characteristic.

Verification of the simulation:

Using new PCA16 preamplifier and fast flash-ADC (scope?)

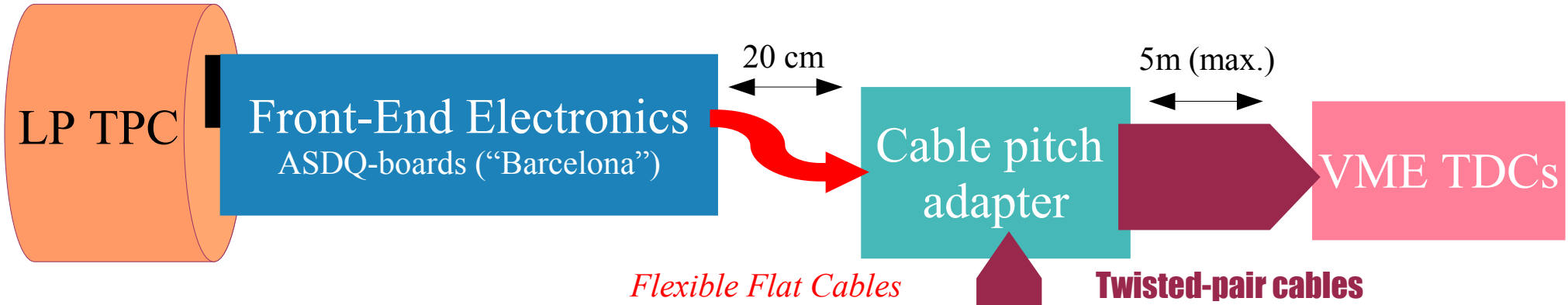
“Barcelona” board



32 channels (4 ASDQ chips) in 30 mm * 106 mm
Top-to-bottom thickness: 4.4 mm

28 boards available, 20 boards will be used (640 channels)

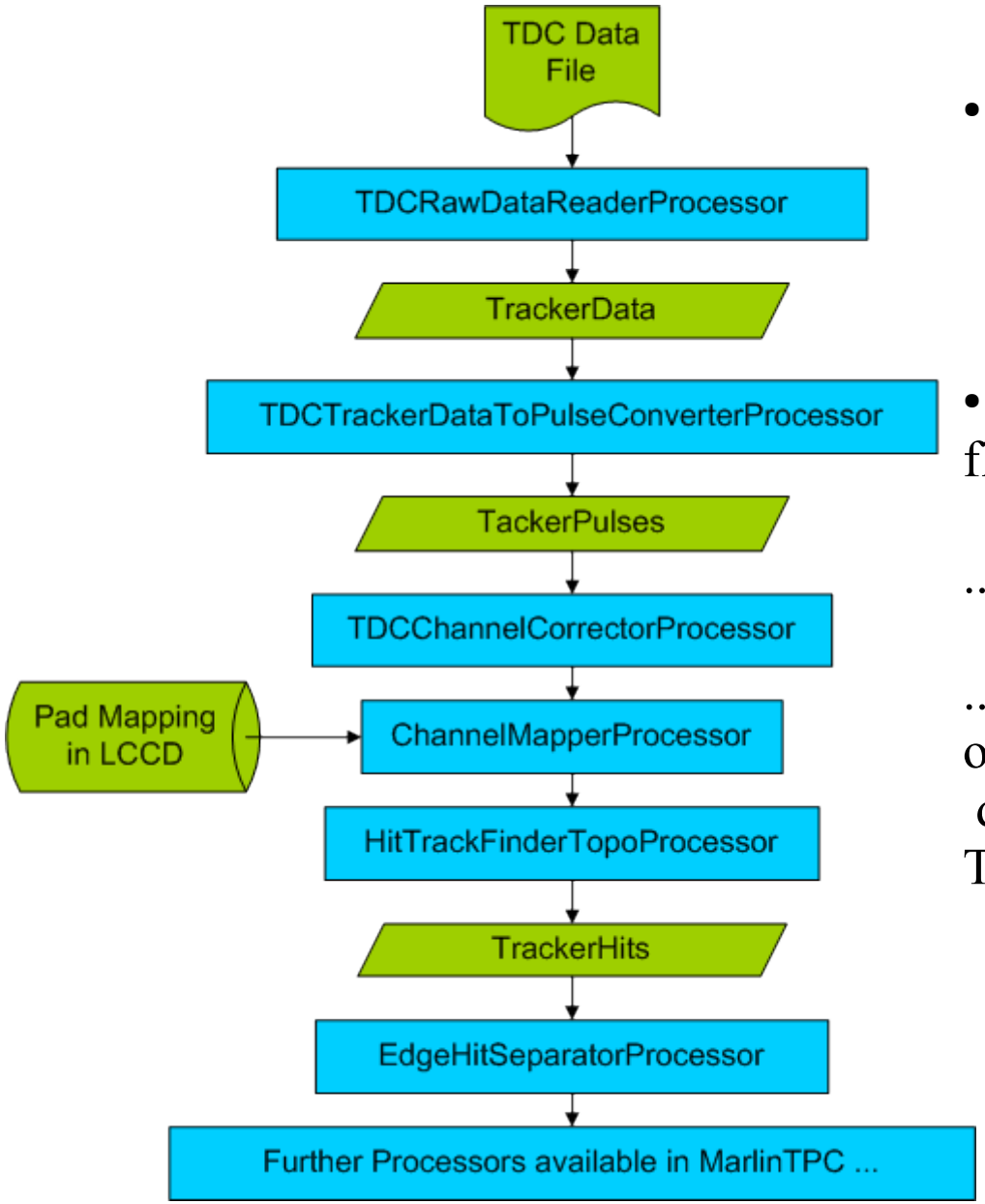
Tests of the TDC-based electronics with LP TPC



Boards will be installed directly onto the LP TPC endplate.

No custom made components used(yet).

Data analysis chain



- A chain of processors is available:
  - Input - proprietary binary files(TDC v767)
  - Output - data in LCIO format

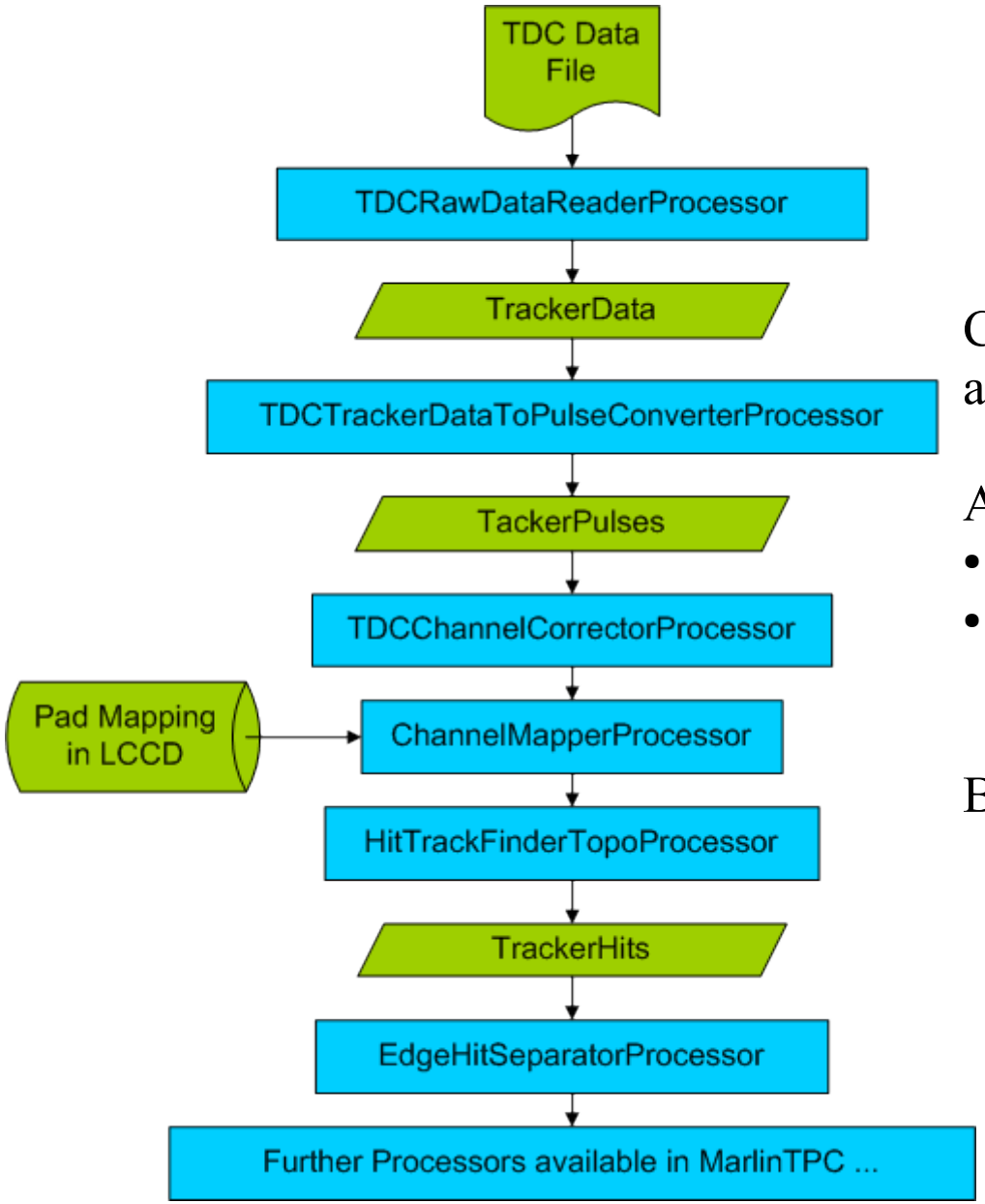
- Representation of raw data in LCIO is based on a flash-ADC approach. **TrackerRawData** skipped...

... it can be used for monitoring.

... it can be useful when TDC electronics is operated under EUDAQ, where data from different detectors will have to be combined on the level of TrackerRawData.

Work of Oliver Schäfer

Raw data or LCIO format



Could one send data in LCIO format already from detector ?

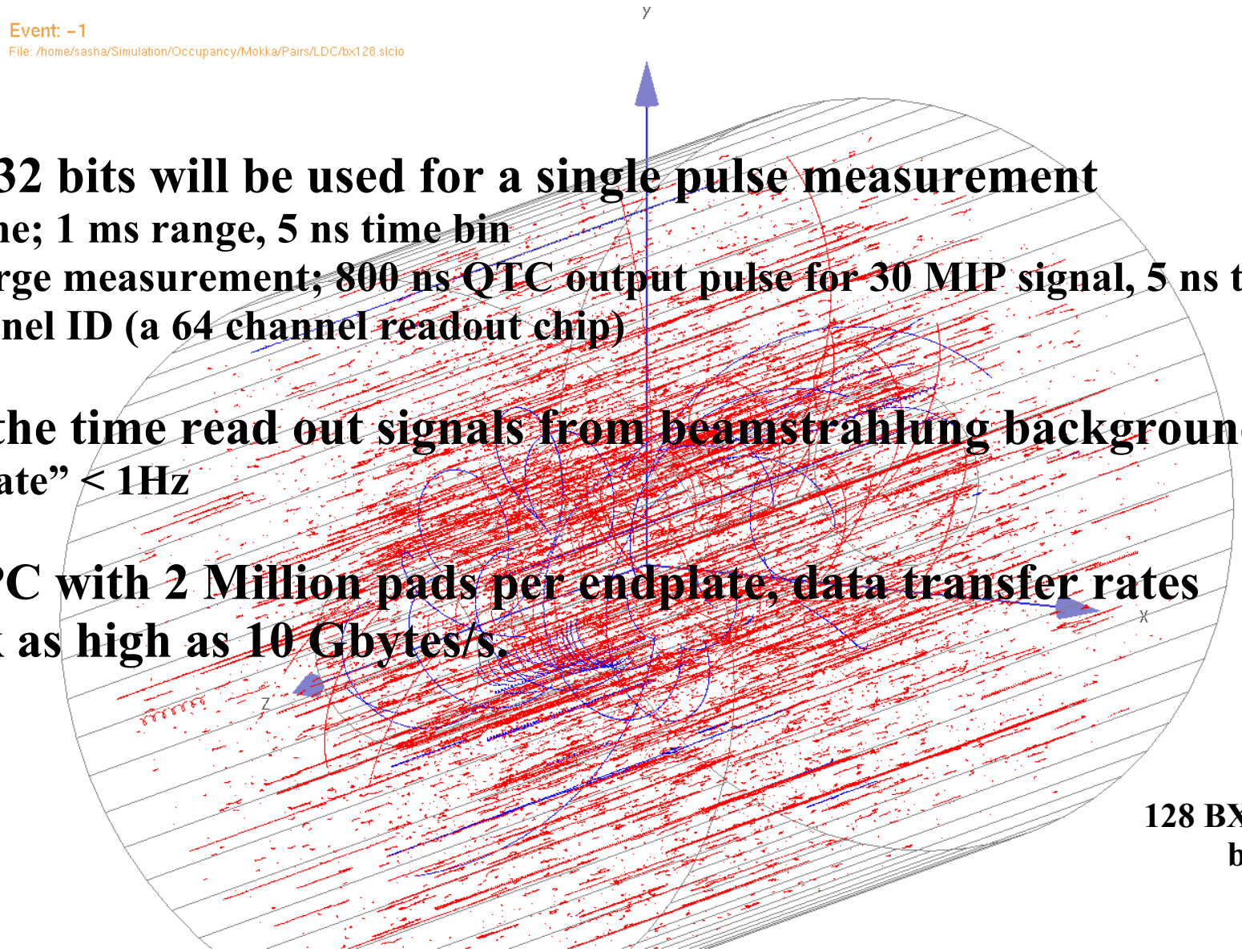
An example:

- raw data (***Fe55_1.tdc***) from TDC: 1 100 544 bytes
- raw data packed in LCIO: 27 985 328 bytes
  ~26 times larger

But: *Data compression in LCIO enabled ?*

Work of Oliver Schäfer

Data collection from many readout modules in LC TPC



Assume 32 bits will be used for a single pulse measurement

- **18 bit time; 1 ms range, 5 ns time bin**
- **8 bit charge measurement; 800 ns QTC output pulse for 30 MIP signal, 5 ns time bin)**

6 bit channel ID (a 64 channel readout chip)

Most of the time read out signals from beamstrahlung background

"physics rate" < 1Hz

For a TPC with 2 Million pads per endplate, data transfer rates can peak as high as 10 Gbytes/s.

128 BX beamstrahlung background

- **Combine data from many readout modules into single optical fiber ?**

Summary and Outlook

- Simulation of the signals from GEM structure is being prepared.
Will need to be combined with TPC simulation package(s).

- Test TDC based electronics with small TPC chamber, integrate with EUDAQ.

- Study of GEM signals with “Barcelona” boards and new PCA16 preamplifier.

- Compact electronics (amplifier with QTC and a TDC) on the same board to mimic functionality of a readout chip for LC TPC.