Backward endcap EMC digitization in PandaRoot

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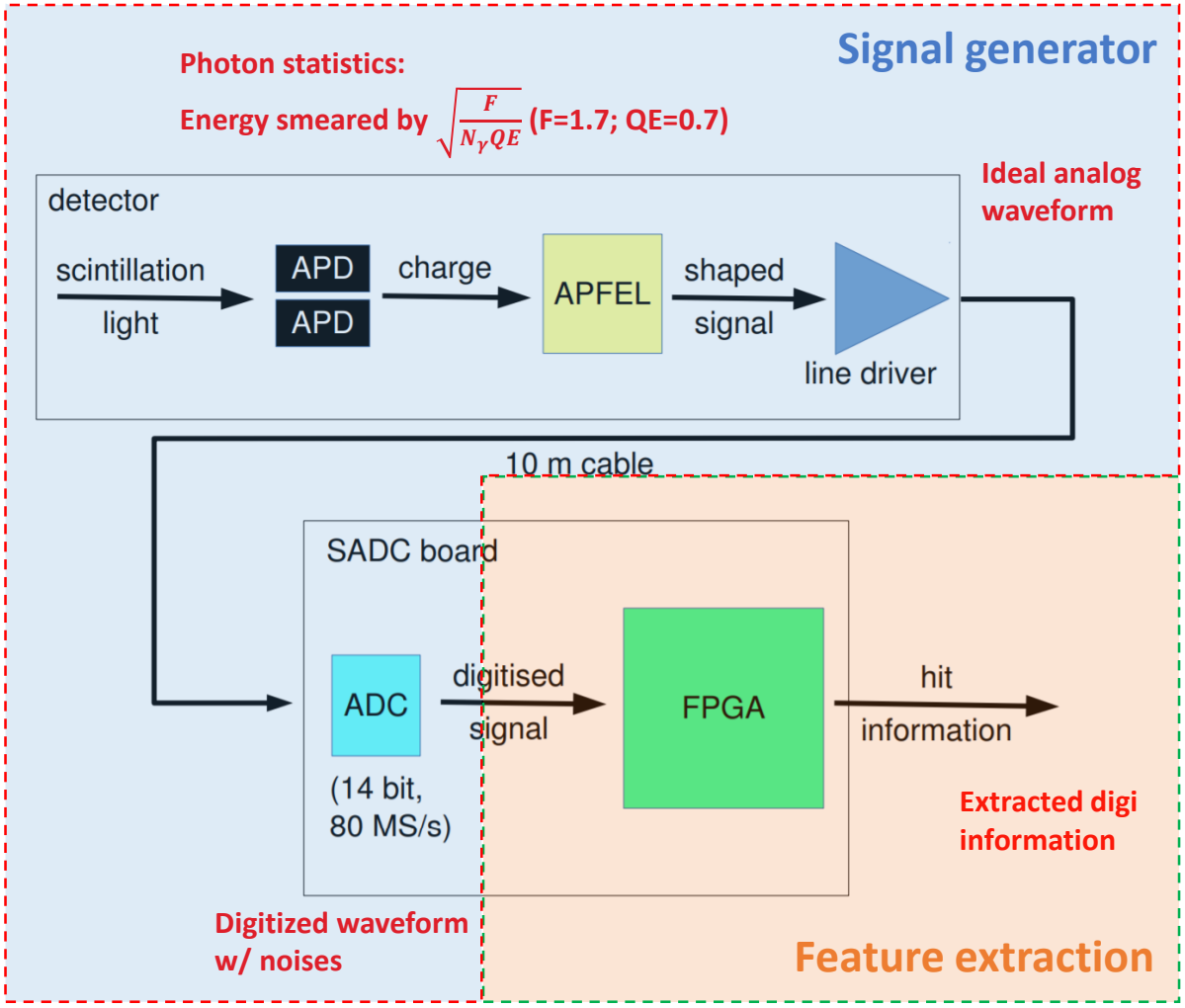
Outline

- **Backward endcap EMC digitization update**
- **A proposal about EMC digitization combination**

BWEC readout

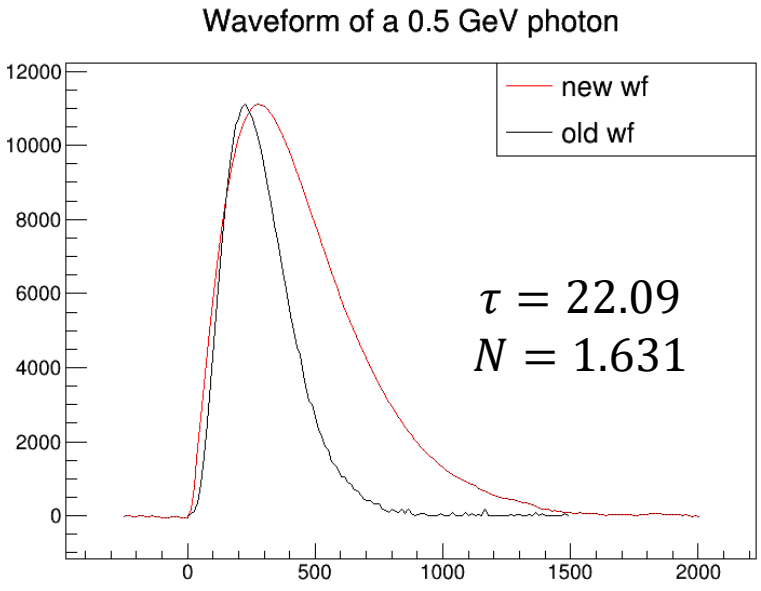


Pulse shape

$$f(x) = -A \cdot e^{\frac{-N(x-\delta)}{\tau}} \cdot \left(\frac{x-\delta}{\tau}\right)^N \tag{2.1}$$

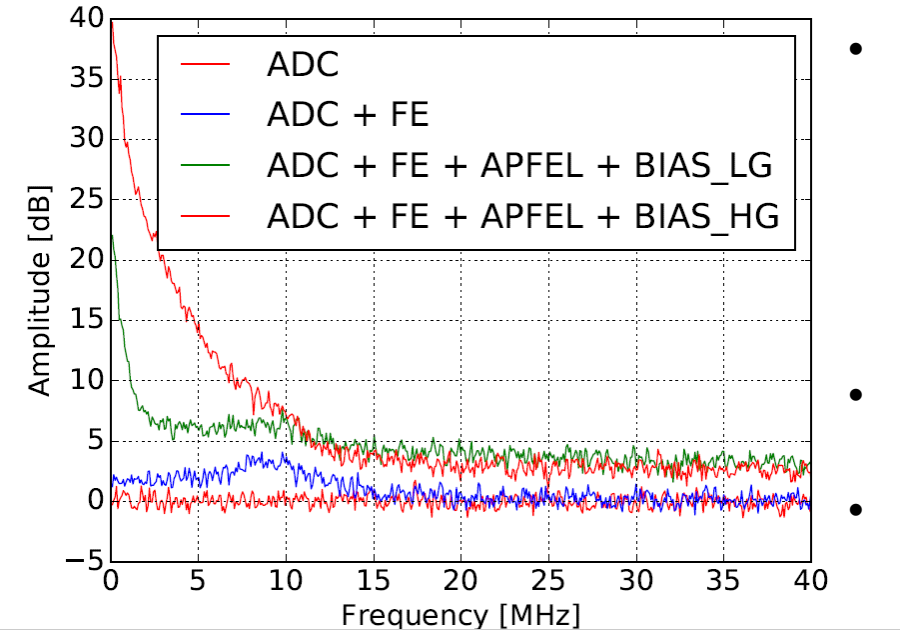
Whereby τ is describing the decay behavior. N has an impact on the rising and decay ratio. δ shifts the pulse in time. A is proportional to the pulse hight H:

$$A = H \cdot e^N \tag{2.2}$$



- APFEL ASIC pulse digitized by the SADC
- Two gains: HG/LG = 10.5
- Full pulse width: ~1700 ns
- Rising time: ~300 ns

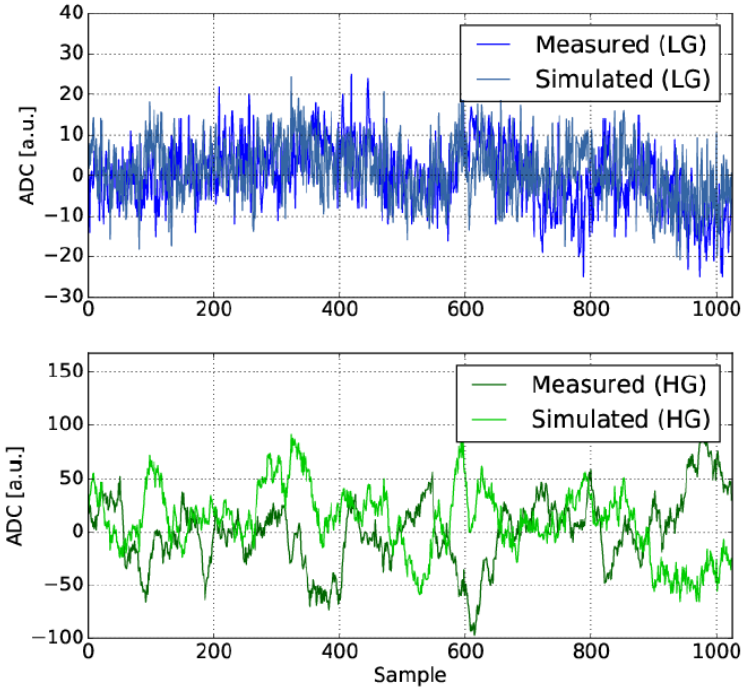
Noise

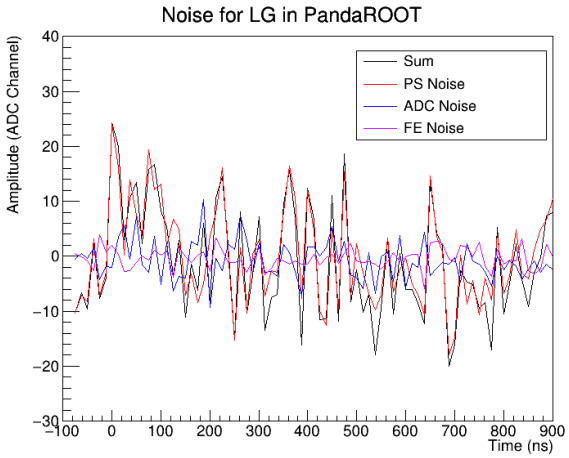


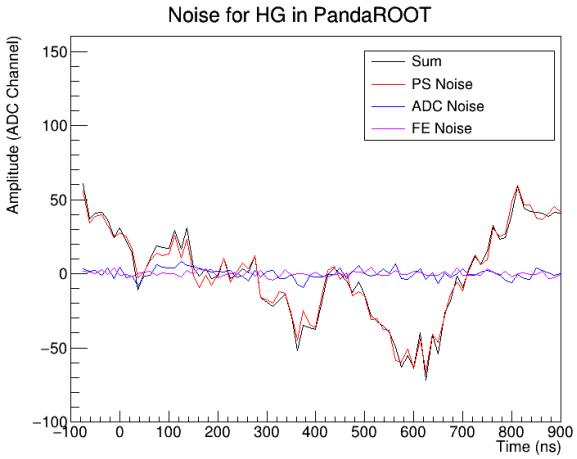
- Noise components
  - Biased APD, APFEL preamplifier at low/high gain
  - Open ADC entrance
  - Front-end electronics transmission
- FTT analysis of the noises
- IFFT of the power spectrum to obtain time-domain noises

Noise (II)

Biased APD, APFEL preamplifier at low/high gain (updated)

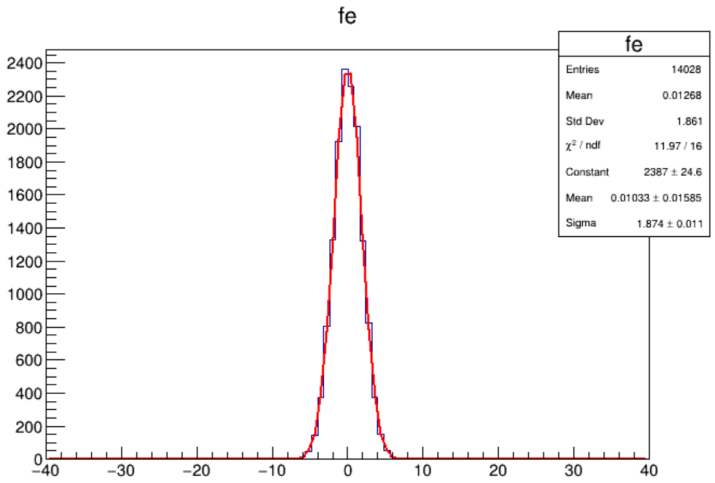




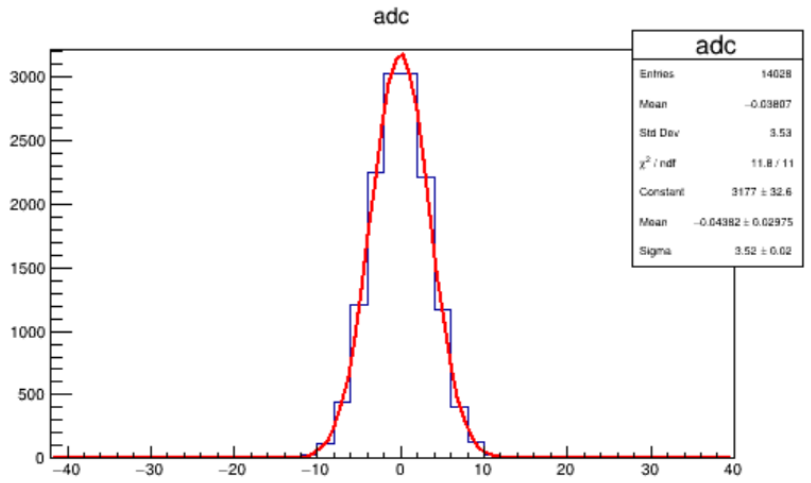


Noise (III)

- **ADC noise: 3.5 [ADC] (measured)**
- **FEE transmission noise: 1.89 [ADC] (measured)**

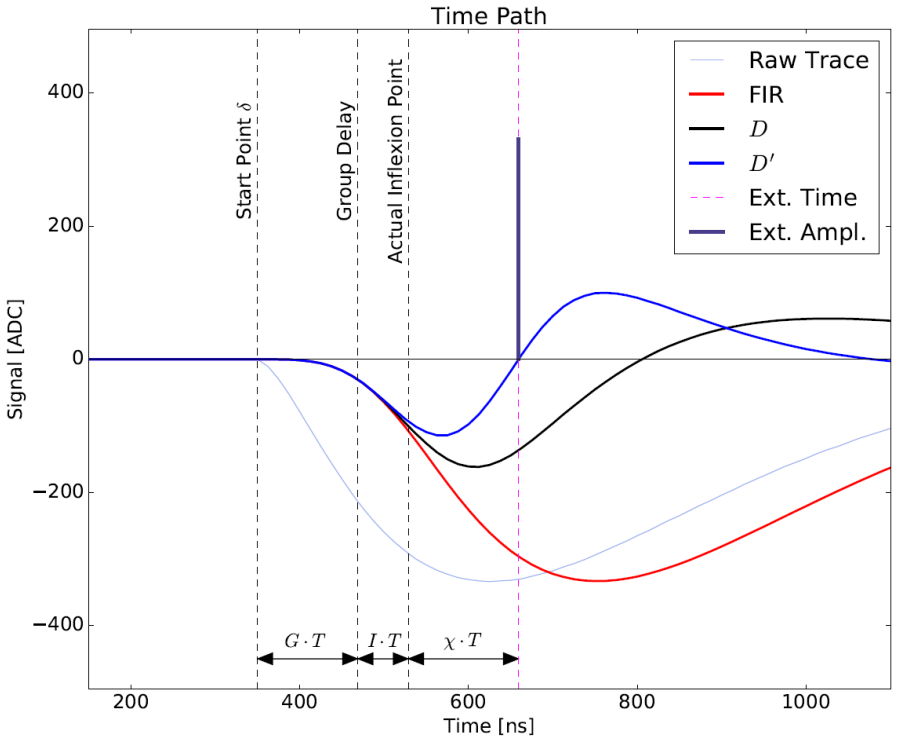


Simulated value: 1.874 +/- 0.011



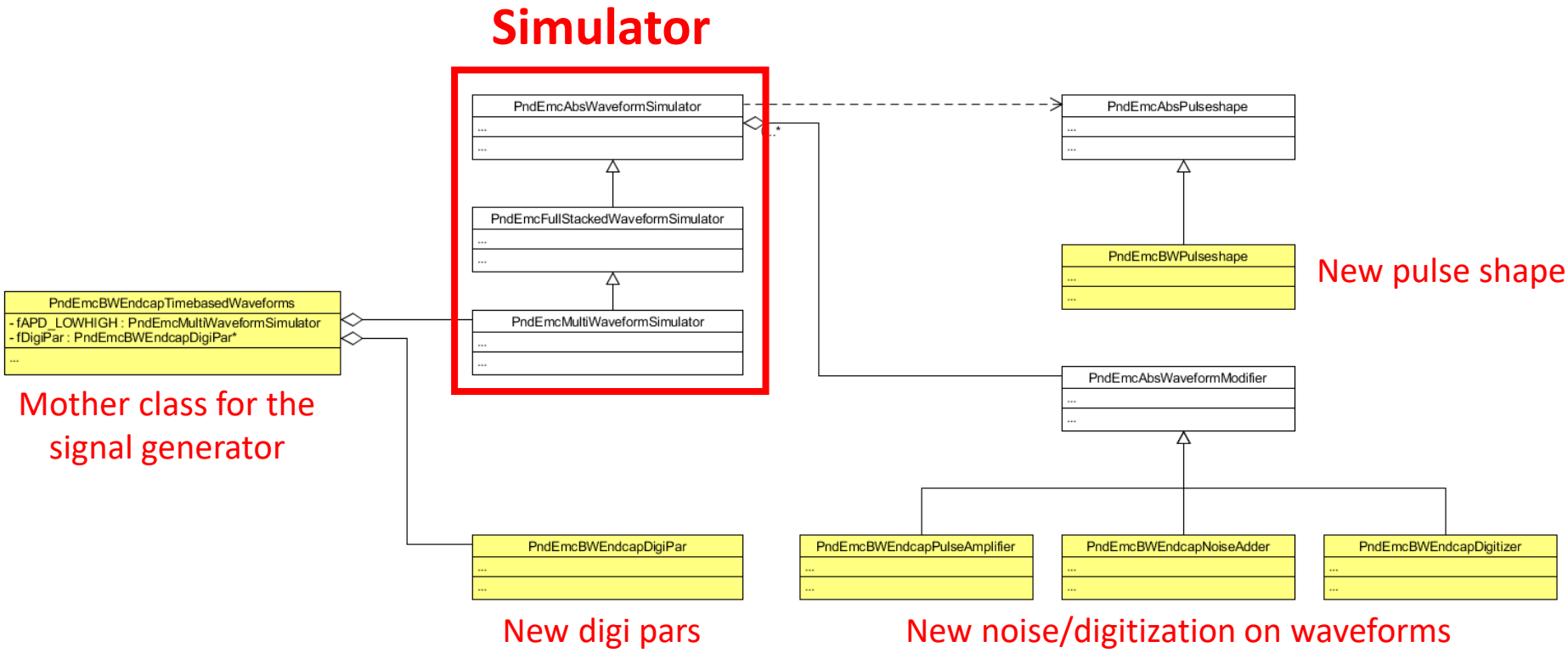
Simulated value: 3.52 +/- 0.02

Time extraction (updated)



- Extracted T_0
  - Second derivative of the FIR smoothed signal
  - Linear interpolation between samples
- T_0 shift
  - Group delay G caused by the FIR filtering
  - Distance between the start point and the first inflexion point of the pulse
  - Numeric error

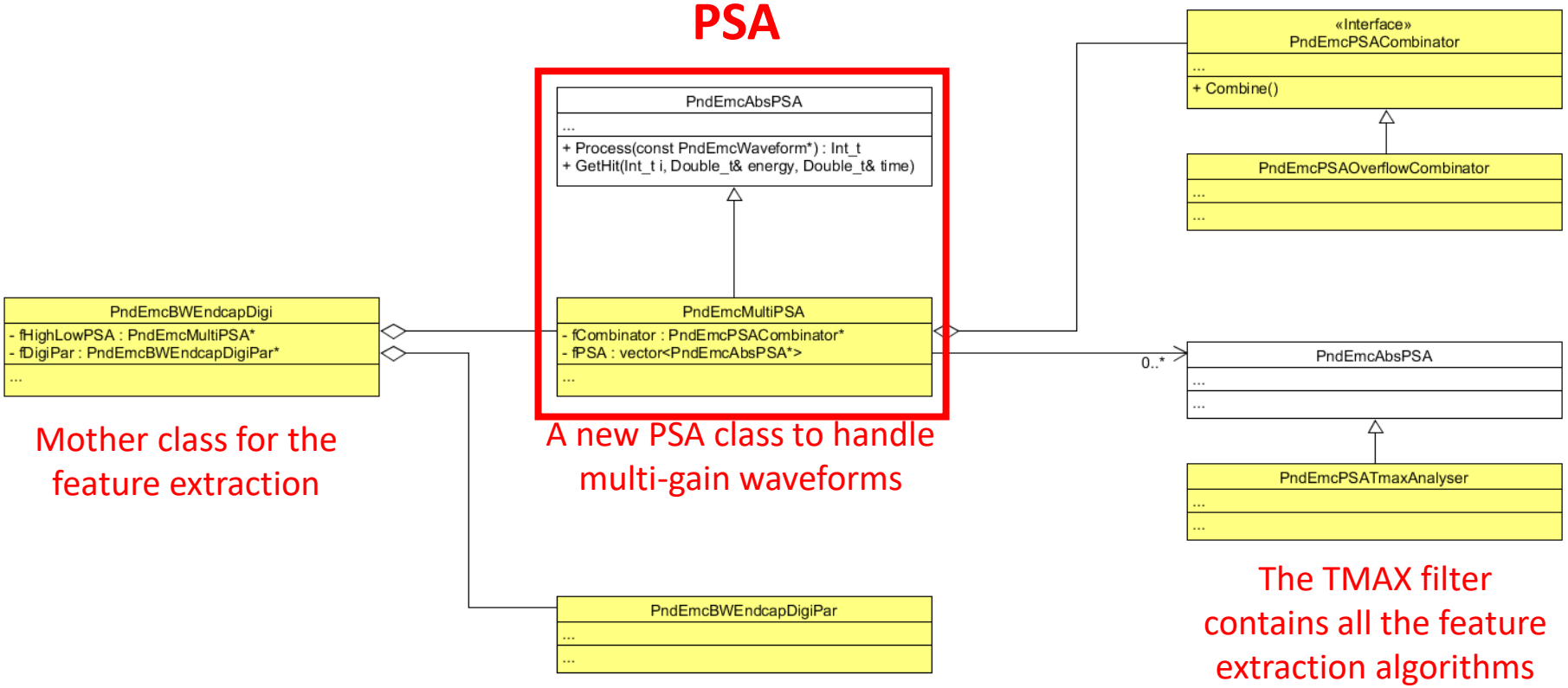
PandaRoot implementation (I): Signal generator



Newly added for BW

PandaRoot implementation (II): Feature extraction

The combinator combines the multi-waveform input to a single output digi. Now we always use the high-gain waveform unless it is overflowed



Mother class for the feature extraction

A new PSA class to handle multi-gain waveforms

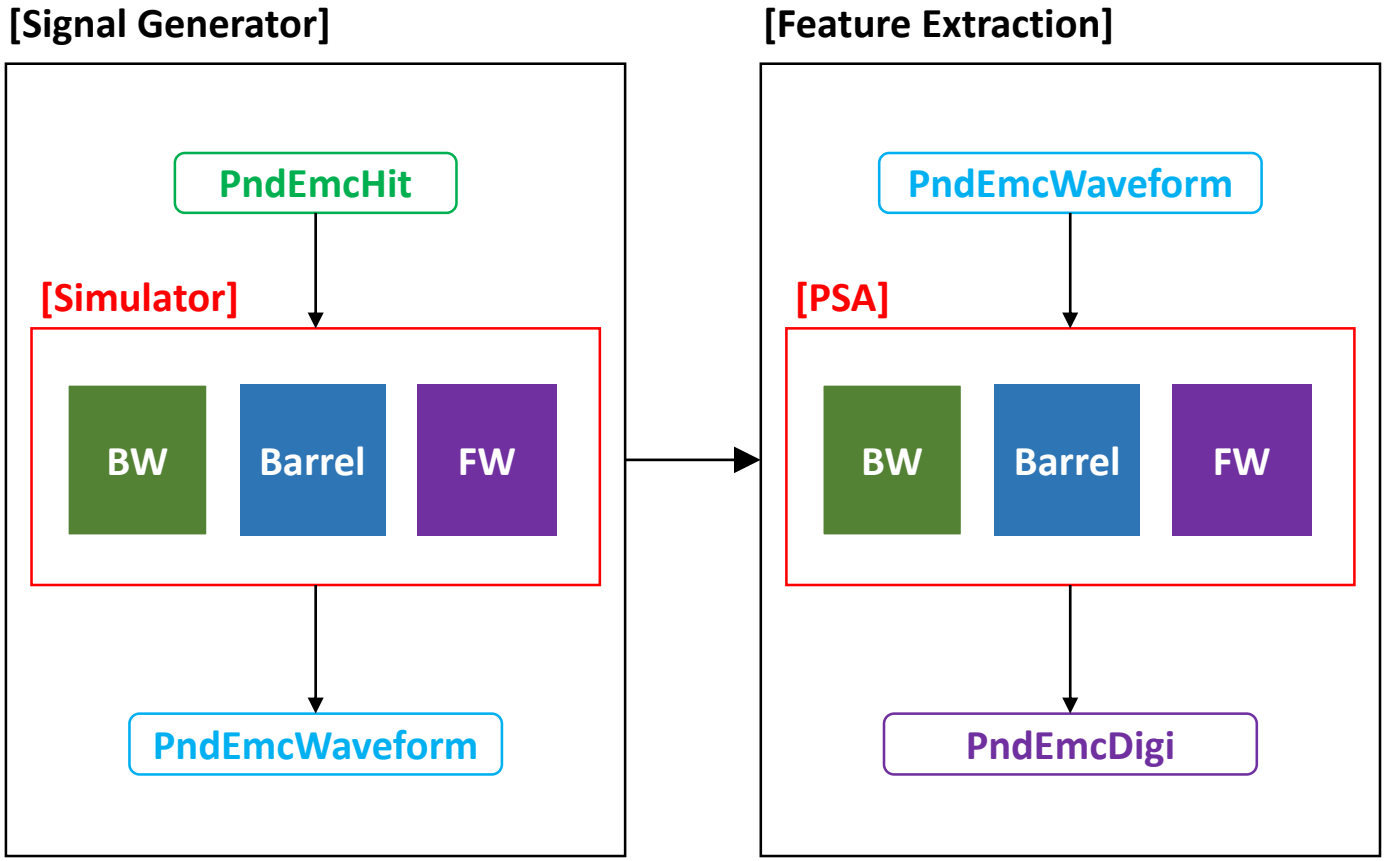
The TMAX filter contains all the feature extraction algorithms

Digi pars (the same to the signal generator)

Newly added for BW

A general digitization framework

A combined package?



- ✓ Implement simulator/psa for other EMC modules
- ✓ Runtime choose the needed one based on detector ID

Combined signal generator package

```
for (Int_t iHit=0; iHit<nHits; iHit++) {

    theHit = dynamic_cast<PndEmcHit*>(fHitArray->At(iHit));

    if(theHit->GetModule() > 5 ) continue;    //tackles invalid PndEmcHit i

    PndEmcAbsWaveformSimulator* wfSimulator = NULL;

    /* Selection of simulators for different EMC modules */
    // select wf Simulator.
    // TODO Add realistic description for other emc modules and make simula
    switch(theHit->GetModule() {
    //      case 1: wfSimulator = ...
    //      case 2: wfSimulator = ...
    //      case 3: wfSimulator = ...
          case 4: wfSimulator = fAPD_LOWHIGH; break;
    //      case 5: wfSimulator = ...
          default: wfSimulator = fAPD_LOWHIGH;
    }
```

- A new class for signal generator: “PndEmcTimebasedWaveform”
- Define simulators for all EMC modules
- Runtime determine the correct simulator according the detector ID

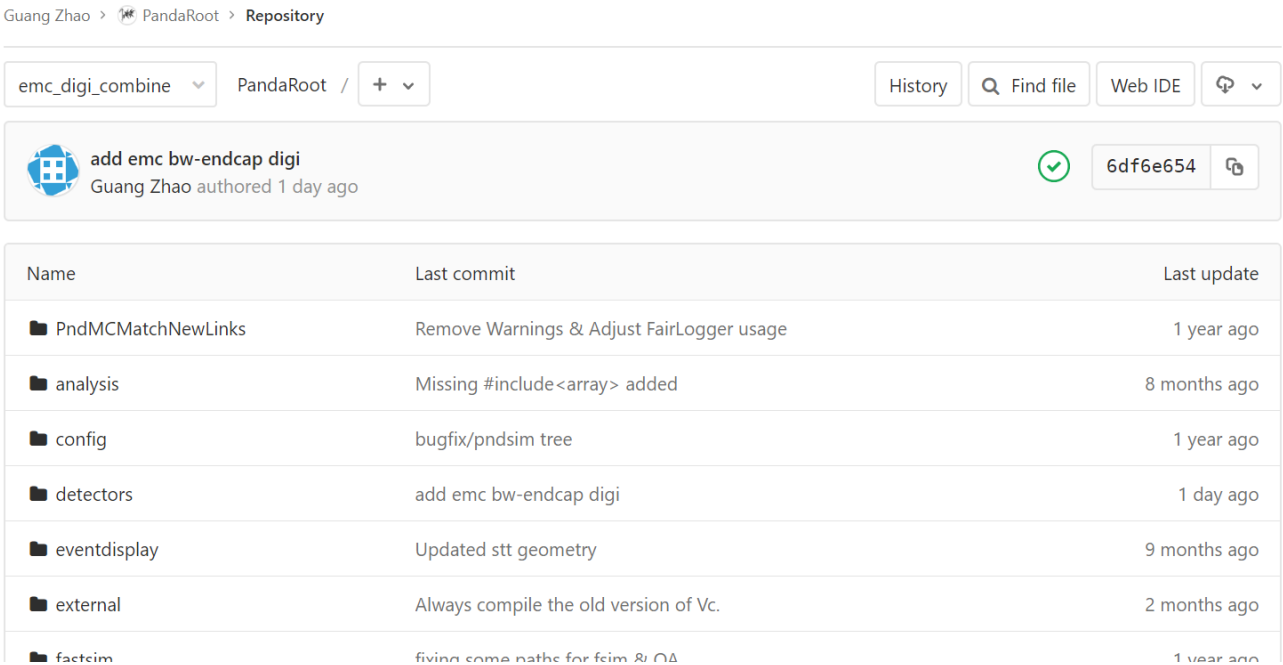
Combined feature extraction package

```
for (Int_t iWaveform = 0; iWaveform < nWaveforms; iWaveform++)
{

    theWaveform = (PndEmcWaveform *)fWaveformArray->At(iWaveform);
    hitIndex = theWaveform->GetHitIndex();
    detId = theWaveform->GetDetectorId();
    trackId = theWaveform->GetTrackId();

    //Double_t timeshift; // how maximum is shifted //[R.K. 01/2017] unus
    switch (theWaveform->GetModule()) {
        case 1: break;
        case 2: break;
        case 3: break;
        case 4: fPSA = fHighgainPSA;
        case 5: break;
        default: fPSA = fHighgainPSA;
    }

    nHits = fPSA->Process(theWaveform);

    for (Int_t iHit = 0; iHit < nHits; ++iHit)
    {
        fPSA->GetHit(iHit, energy, digi_time);
        //PndEmcAbsCrystalCalibrator::CalibrationStatus_t CalS //[R.K. 03
```

- A new class for signal generator: “PndEmcTimebasedDigi”
- Define PSAs for all EMC modules
- Runtime determine the correct PSA according the detector ID

Create a branch for combination in GIT

- https://git.panda.gsi.de/zhaog/PandaRoot/tree/emc_digi_combine



Template classes PndEmcTimebasedWaveforms/PndEmcTimebasedDigi are defined

Summary and Questions

- **BWEC digitization is updated since CM. Final tests are ongoing.**
- **A combination of the digitization is proposed. Need input from hardware experts and software developers.**
- **Questions about the digitization**
  - For barrel EMC, the readout system is similar to BWEC. Can we use the same parameters? Or which parameters need to be modified?
  - For Shashlyk, from whom we can get more information?