

# Towards digitization on the SiW ECAL for ILD

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# Outline

The SiW ECAL prototype – Test Beam

Digitization

Simulated hits

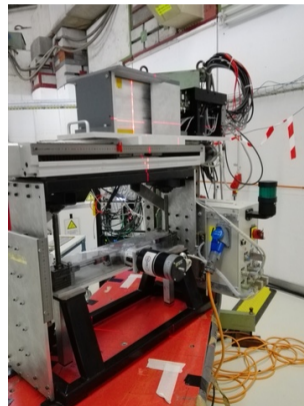
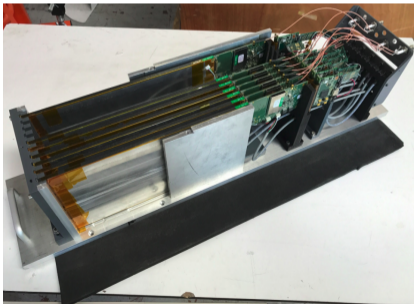
Conversion to MIP

Signal shaping

# The prototype

A technological prototype for the Silicon Tungsten (SiW) ECAL is under development.  
(See slides by Roman Pöschl from Wednesday.)

- Test beam data taken in 2017 (then 7 layers)
- Use this setup to implement Digitization



# Test Beam

The 2017 setup: three configurations with varying amounts of  $W$  in front of each slab,

- Configuration 1: 0.6, 1.2, 1.8, 2.4, 3.6, 4.8 and 6.6  $X_0$ ,
- Configuration 2: 1.2, 1.8, 2.4, 3.6, 4.8, 6.6 and 8.4  $X_0$ ,
- Configuration 3: 1.8, 2.4, 3.6, 4.8, 6.6, 8.4 and 10.2  $X_0$ .

Positron beams of 1, 2, 3, 4, 5 and 5.8 GeV.

A study of this data demands a comparison with simulations,  
that include digitization effects

# Simulations

- Simulation code of this detector prototype with beam tests are in place  
→ Daniel Jeans @ cern gitlab, [calice\\_dd4hepTestBeamSim](#)
- We generated samples for the following setups:
  - The 2017 test beam ( $e^+$ ) as in previous slides, same for  $e^-$ .
  - No Tungsten (configuration 0) for  $e^-$  and  $e^+$  @ 3 GeV, and  $\mu$  @ 40 GeV.

After this, we need to add digitization effects

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**Digitization**

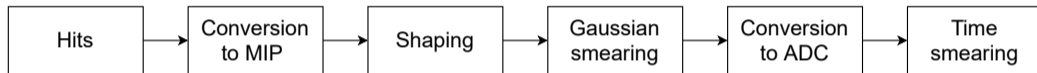
Simulated hits

Conversion to MIP

Signal shaping

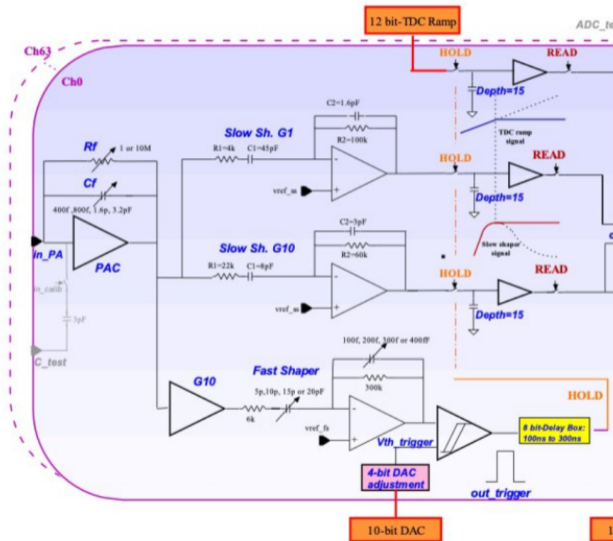
# Digitization

**Raw simulation  $\Rightarrow$  info. resembling detector output, including readout effects**



- Hits: starting point from raw simulation.
- Map energy deposited to MIP scale.
- Simulate pulse shaping in the readout electronics + saturation effects.
- Add smearing: noise term in detector cells/readout.
- Conversion to ADC, time smearing

# Skiroc2 readout (from datasheet)



Two signal paths after pre-amp:

- One Fast Shaper  
→ Trigger threshold
- Two Slow Shapers  
→ Measure energy, time



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Digitization

**Simulated hits**

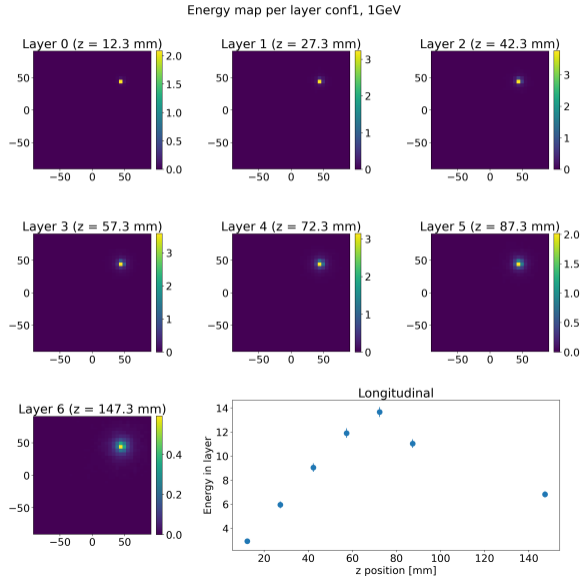
Conversion to MIP

Signal shaping

# Simulated Raw Hits. Configuration 1, $e^+$ @ 1 GeV

- Example: 10k events.
- $\Sigma$  cell energy (all hits in all evts).
- Longitudinal: total e. / layer.
- EM Shower develops in W.
- Conf1: initial part of shower.

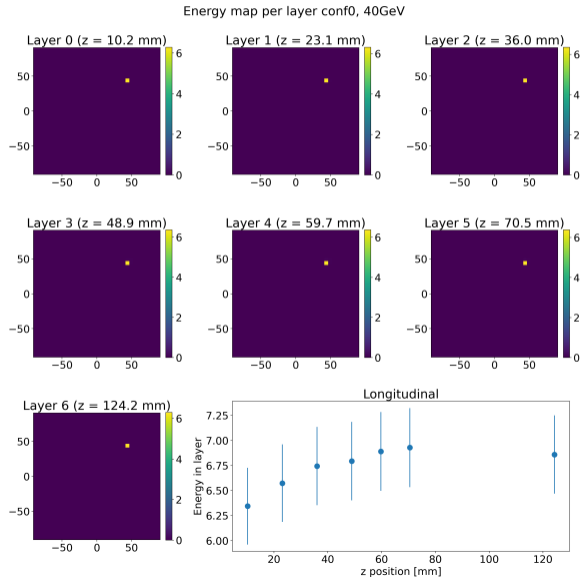
More control plots in backup.



# Simulated Raw Hits. No Tungsten, $\mu$ @ 40 GeV

MIP: mean response to  $\mu$  crossing at normal incidence

- Use this as a reference
- 🙌 Have muons in next TB (?)
- Understand longitudinal ( $>10\%$ ) trend



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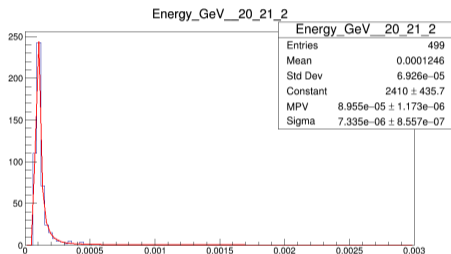
Simulated hits

Conversion to MIP

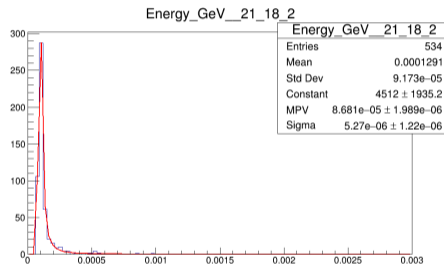
Signal shaping

# Cell energy of hits. No Tungsten, positrons and muons

Take cells with  $>200$  hits (out of 10k events)  $\Rightarrow$  100-200 cells  
 $\rightarrow$  fit Landau distribution



Positrons @ 3 GeV

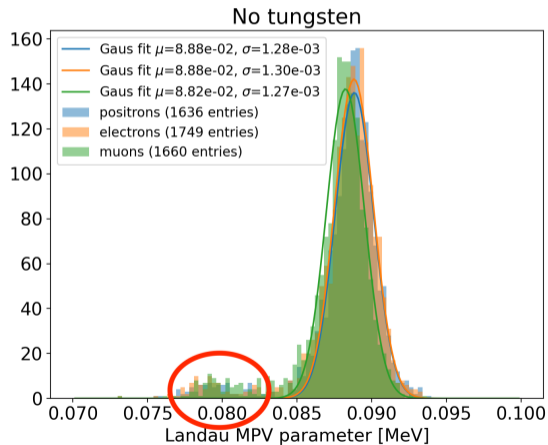


Muons @ 40 GeV

Use Landau location (MPV) as reference for calibration.

# Conversion to MIP - No Tungsten

Landau localization parameter distribution on cell energy fits (20\*10k evts)



- Electrons and positrons @ 3 GeV, muons @ 40 GeV
- Map muons - electrons:  $0.0882 \rightarrow 0.0888$  MeV ( $\sim 7\%$ )
- Expected: electrons  $\sim$  positrons
- Calibrate with electrons?
- Identify lower energy bump?

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Simulated hits

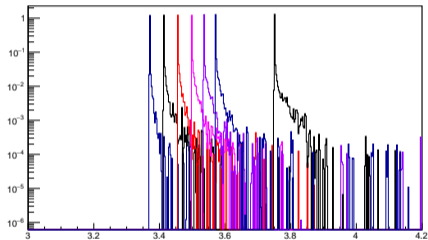
Conversion to MIP

Signal shaping

# Subhit timing

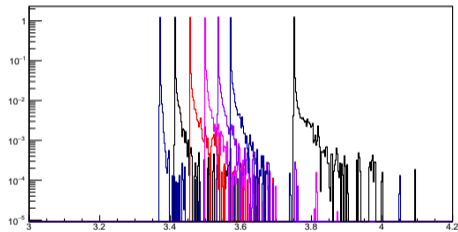
Subhit energy for layers (No Tungsten)

Electrons



Time [ns]

Muons



Time [ns]

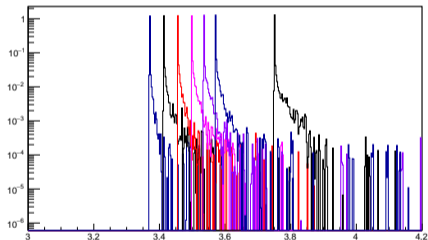
Preliminary, but we need to understand time dispersion



# Subhit timing

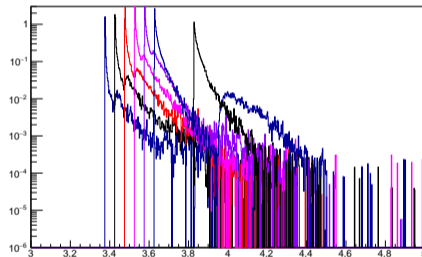
Subhit energy for layers electrons

No Tungsten



Time [ns]

Tungsten



Time [ns]

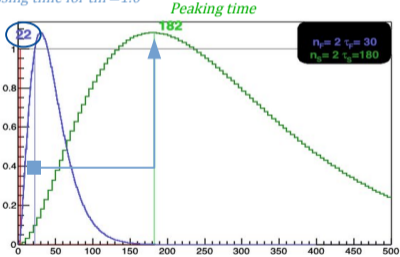
Delayed hits on layers with Tungsten (6th layer, right plot)

# Signal shaping

## Shaping by histograms:

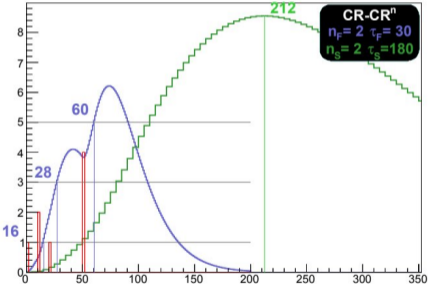
- bin  $\sim$  time resolution
  - 1 ns ns for FS
  - 5 ns for SS

Crossing time for  $thr=1.0$



## Multiple hits

- Time slew effect
- Peaking time



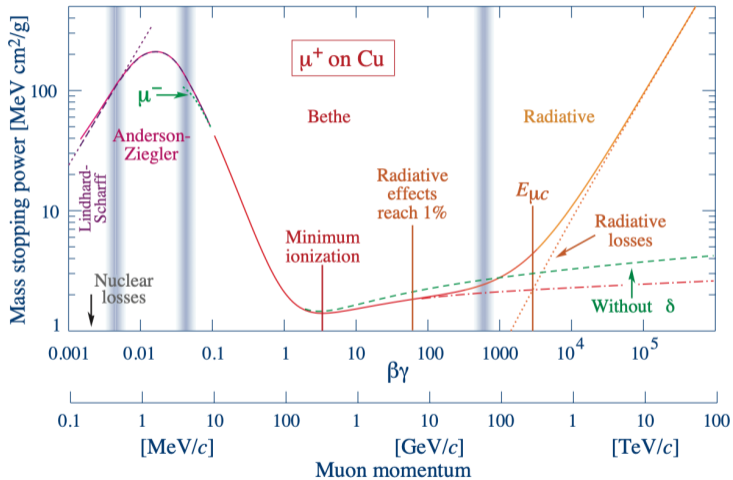
(Slide from V. Boudry)

## Summary, plans

- Simulations of prototype in place for digitization.
- Further developments in simulations include:
  - Configuration 0: Muons @ 0.4, 4 GeV.
  - Sim settings: lowering interaction threshold, checking physics lists.
  - Including beam profile (atm localized particle gun).
  - Thinking on how to simulate cosmics.
- Preliminary studies on MIP conversion.
- Shaping to be implemented in the near future.
- This framework is being organized to function within Calice Soft.

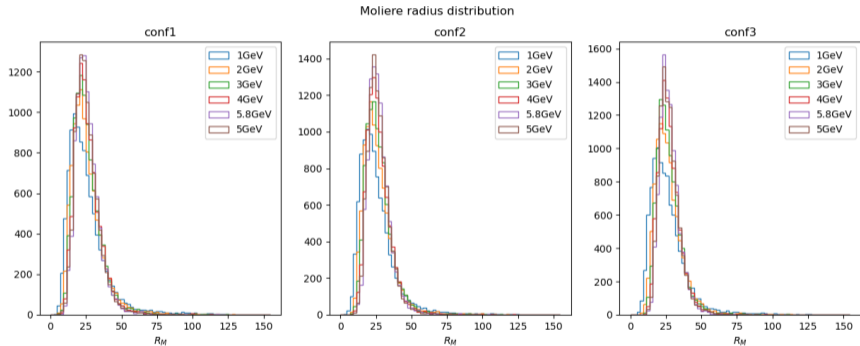
Backup

# Mass stopping power for positive muons (PDG)



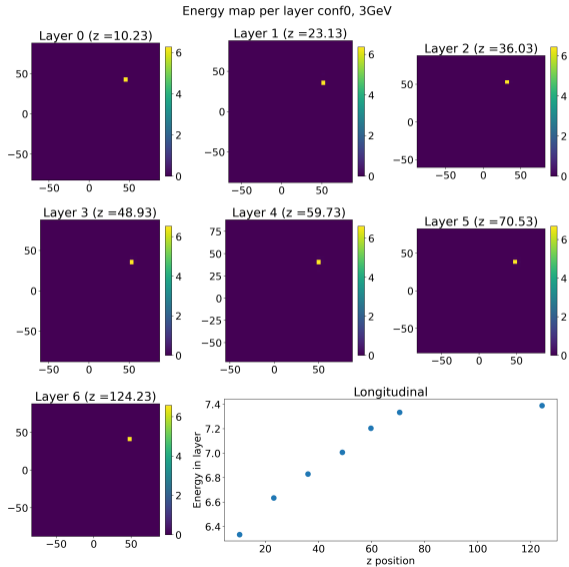
Muon minimum ionization occurs at  $\sim 0.4$  GeV

# Moliere Radius distribution, e-, all confs with Tungsten



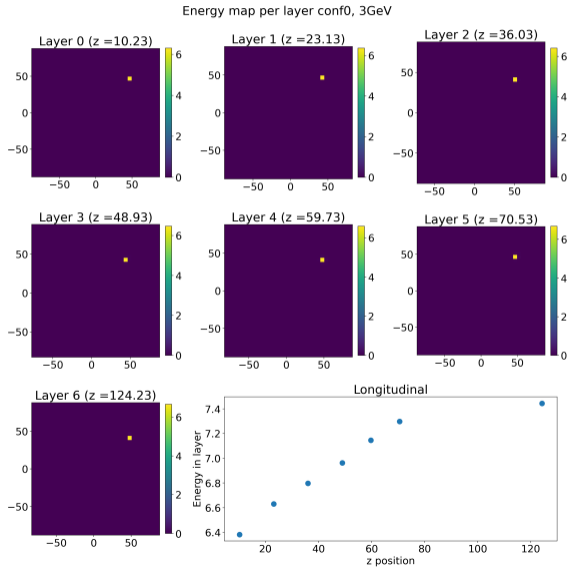
# Before digitization (e-, No Tungsten)

This plot: e- 3GeV, without Tungsten



# Before digitization (e+, No Tungsten)

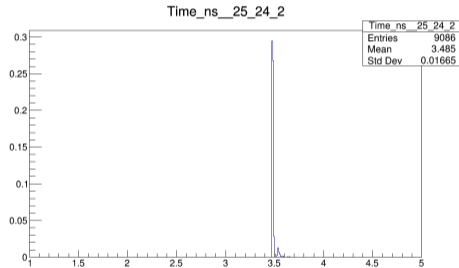
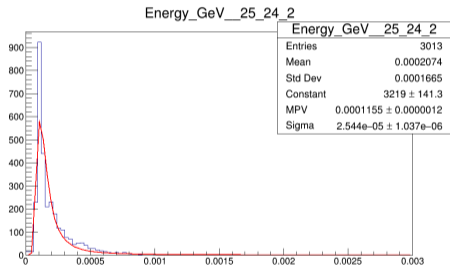
This plot: e+ 3GeV, without Tungsten





## Cell energy of hits (e-, conf1)

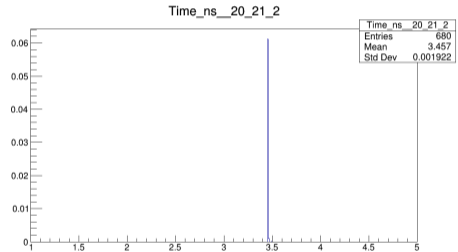
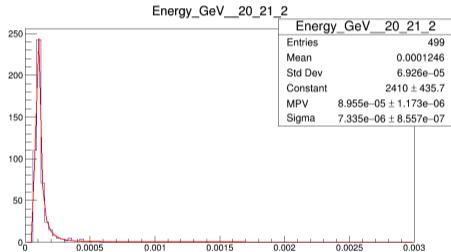
For each event, take cells with  $>200$  hits, fit Landau distribution (subhit time on right plot)



Here Landau fit not appropriate (?)

## Cell energy of hits (e-, no tungsten)

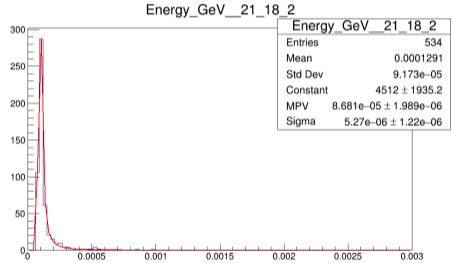
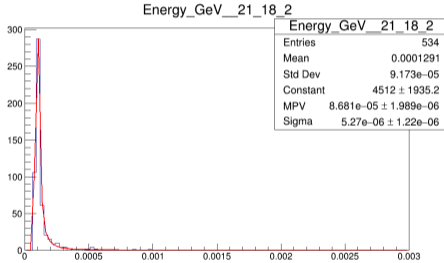
For each event, take cells with  $>200$  hits, fit Landau distribution (subhit time on right plot)



TO-DO: Use langaus for fit

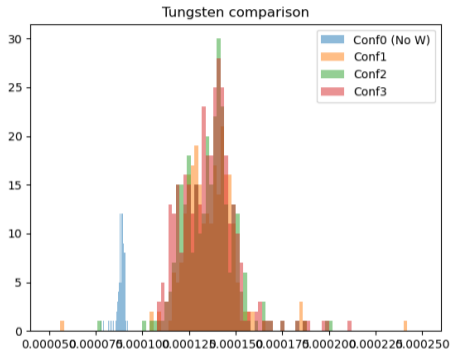
# Cell energy of hits (muons, no tungsten)

For each event, take cells with  $>200$  hits, fit Landau distribution (subhit time on right plot)



TO-DO: Use langaus for fit

## Compare confs (electrons)



Here using 10k events on each sample (not more on conf0 for consistency).

- (Fix x axis)

Fitting Landau in electrons with W: not a good idea?

# AHCAL Digi

## AHCAL Digitization CaliceSoft

