Status of scintillator scans

CLICdp collaboration meeting
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Introduction, outline

- Goal: R&D on CLIC ScECal with tiles at CERN

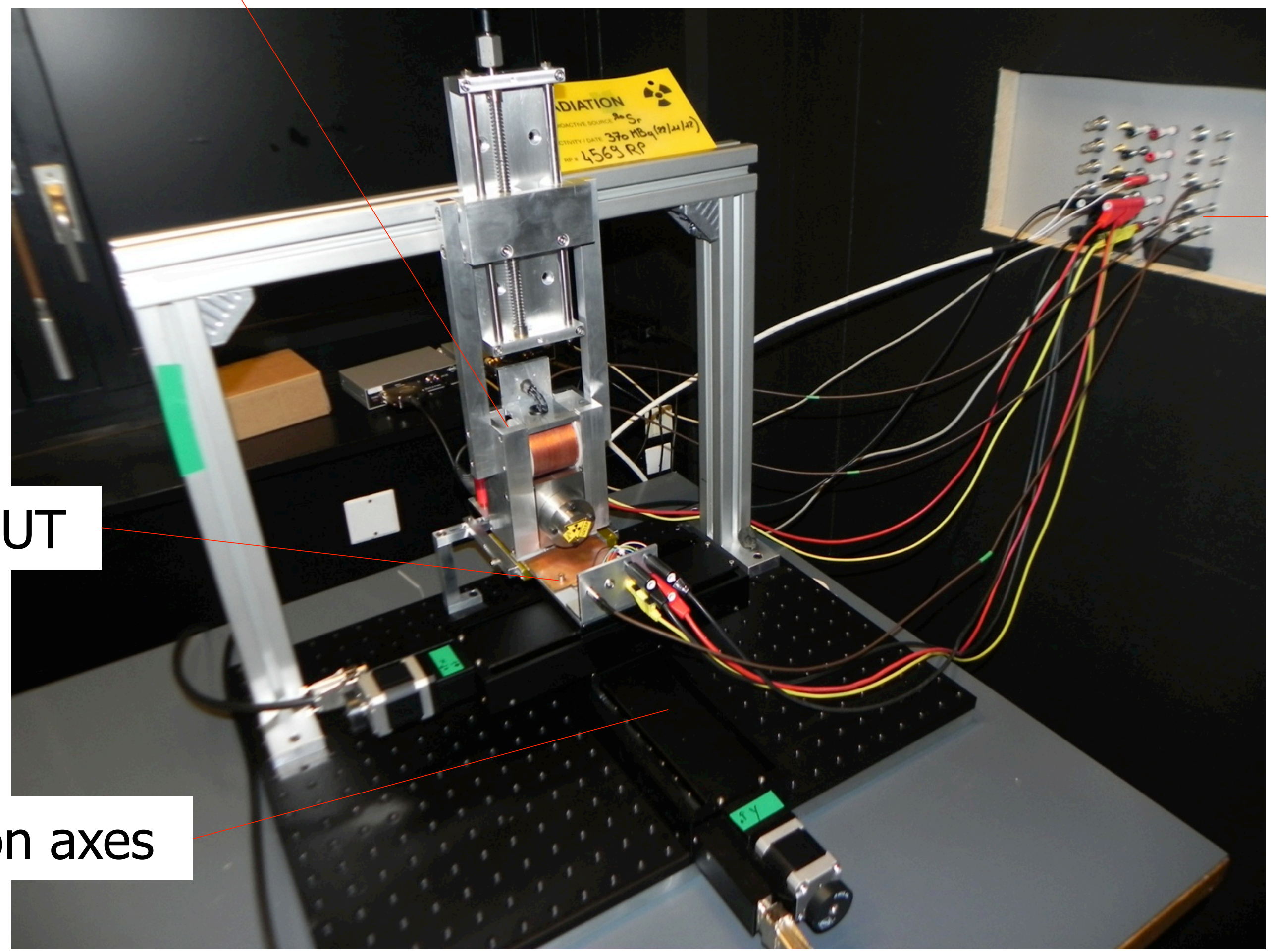
- Phase I: use scintillator scan setup to characterise various tile geometries, packaging, and SiPM couplings

- In this talk:
  - assess scintillator tiles response uniformity to MIPs
  - determine temperature correction coefficients
  - apply T-correction to full scans

Setup

Electron gun

Inside AC regulated dark room



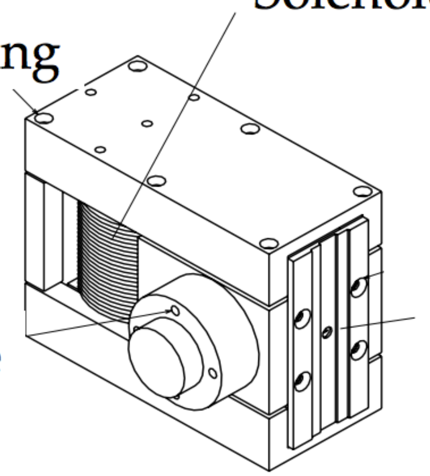
Feedthrough to lab next door

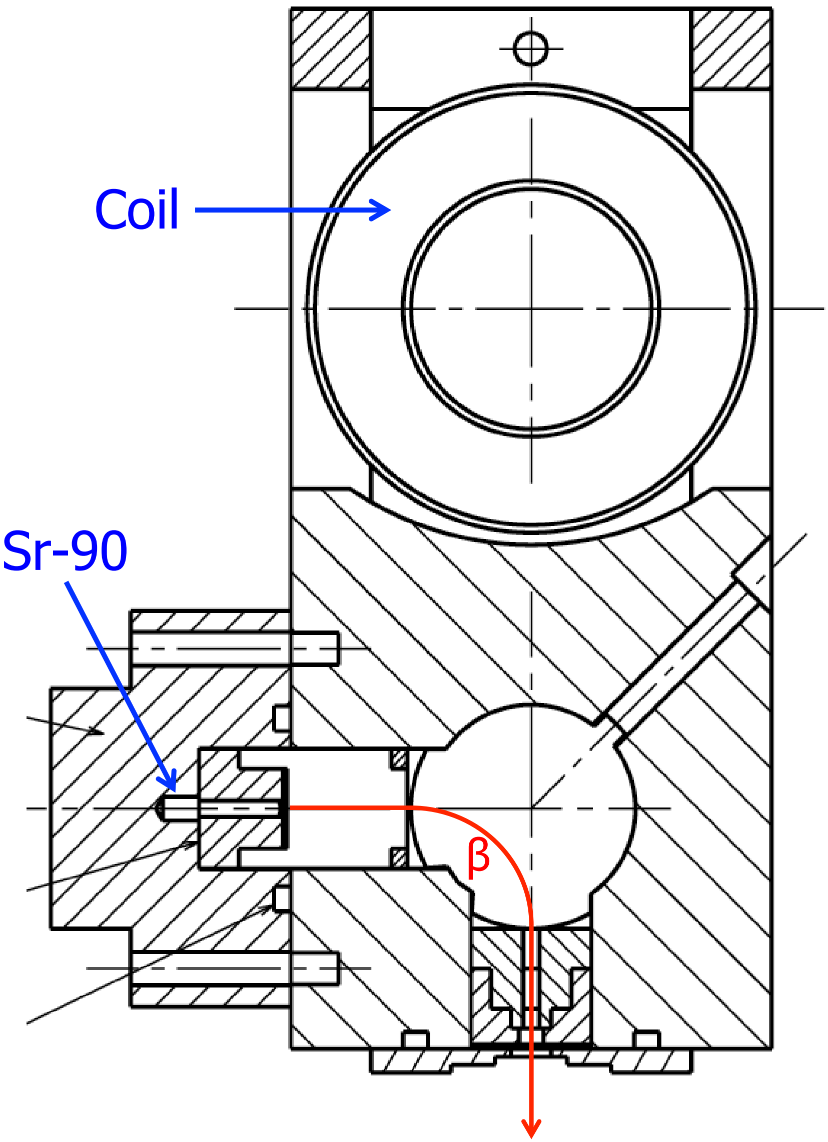
DUT

Translation axes

Electron gun

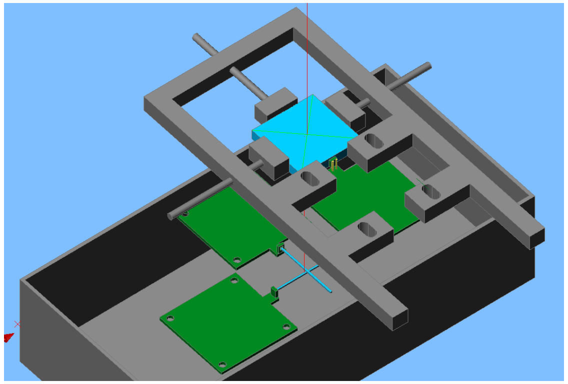
- ~350 MBq ^{90}Sr source
- Double beta emission
- Selectable energy up to ~2 MeV

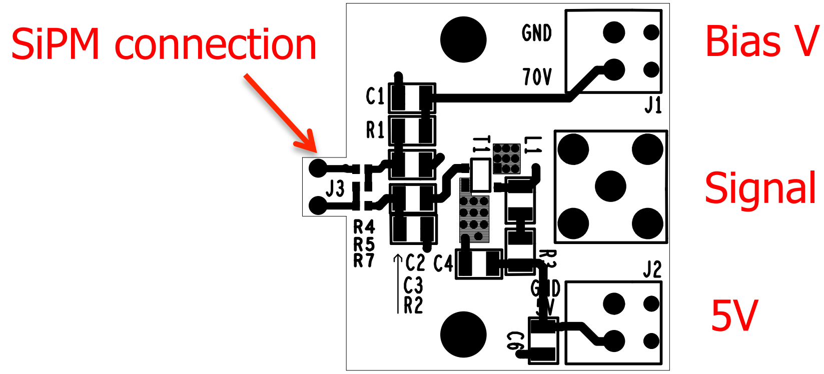




Momentum characterisation has been performed
CLICdp note under review

Readout, Trigger, and DAQ





<u>Readout</u>

- Custom-made PCB (S. Veneziano, Rome) with amplification (~10) as well as temperature monitoring with PT1000 probe. Second version in development (better PCB design, 2-stage amplification).
- DUT signal is read through USB oscilloscope (Picoscope)

<u>Trigger</u>

- Crossed scintillating fibers (20x1x1 mm^3) as trigger, fixed underneath DUT
- Hamamatsu MPPC (50 um pitch) glued to painted fibre
- Trigger signals are put in coincidence (NIM) and signal goes to Picoscope

<u>LabVIEW DAQ</u>

- Software for calibration (auto-trigger) and data-taking (with eletron source)
- Control of the step-motors for scintillator scans
- Temperature monitoring with NI DAQ Crate

Measurements performed

Two identical batches of four scintillators.
Same MPPC, same bias voltage, same electron gun current (MIPs).

Batch	Run	Size [mm^3]	Packaging	MPPC	Bias [V]	I (eGun) [A]
1	14	20x20x2	3M ESR	50µm pitch	71.3	1.4
1	13	20x20x2	Paint	50µm pitch	71.3	1.4
1	15,28	15x15x2	3M ESR	50µm pitch	71.3	1.4
1	16	15x15x2	Paint	50µm pitch	71.3	1.4
2	25,26	20x20x2	3M ESR	50µm pitch	71.3	1.4
2	27	20x20x2	Paint	50µm pitch	71.3	1.4
2	17,29	15x15x2	3M ESR	50µm pitch	71.3	1.4
2	18	15x15x2	Paint	50µm pitch	71.3	1.4

+ a series of measurements at the centre of the scintillators in order to investigate temperature sensitivity issues ==> next few slides

Old results

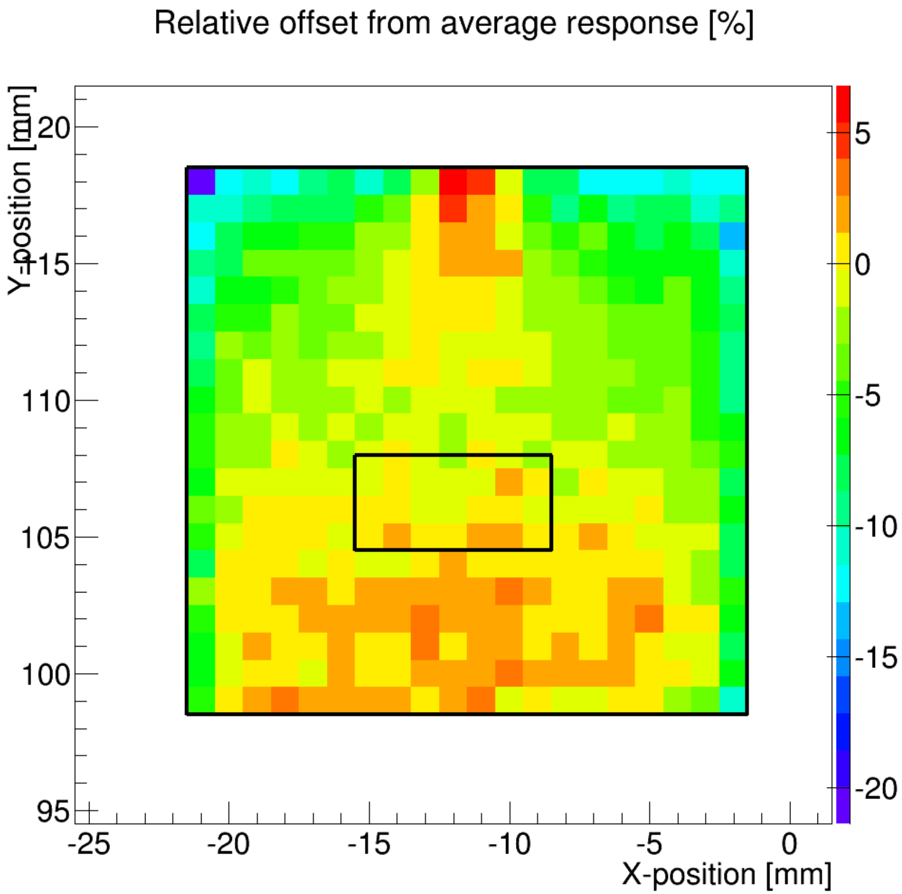
Batch	Run	Size [mm^3]	Packaging	<#p.e.>	± 5 % [%]	± 10 % [%]	± 20 % [%]
1	14	20x20x2	3M ESR	31	70.5	95	100
1	13	20x20x2	Paint	11	22.9	59.5	85.4
1	15 28	15x15x2	3M ESR	50 97	83.1 90.8	99.6 100	100 100
1	16	15x15x2	Paint	21	45.3	75.1	83.6
2	25 26	20x20x2	3M ESR	77 68	77.0 77.5	95.2 94.8	100 99.8
2	27	20x20x2	Paint	15	31.5	67.0	79.5
2	17 29	15x15x2	3M ESR	67 89	68.4 92.9	91.1 100	100 100
2	18	15x15x2	Paint	25	39.6	72.0	84.4

Large non-reproducibility observed, caused by:

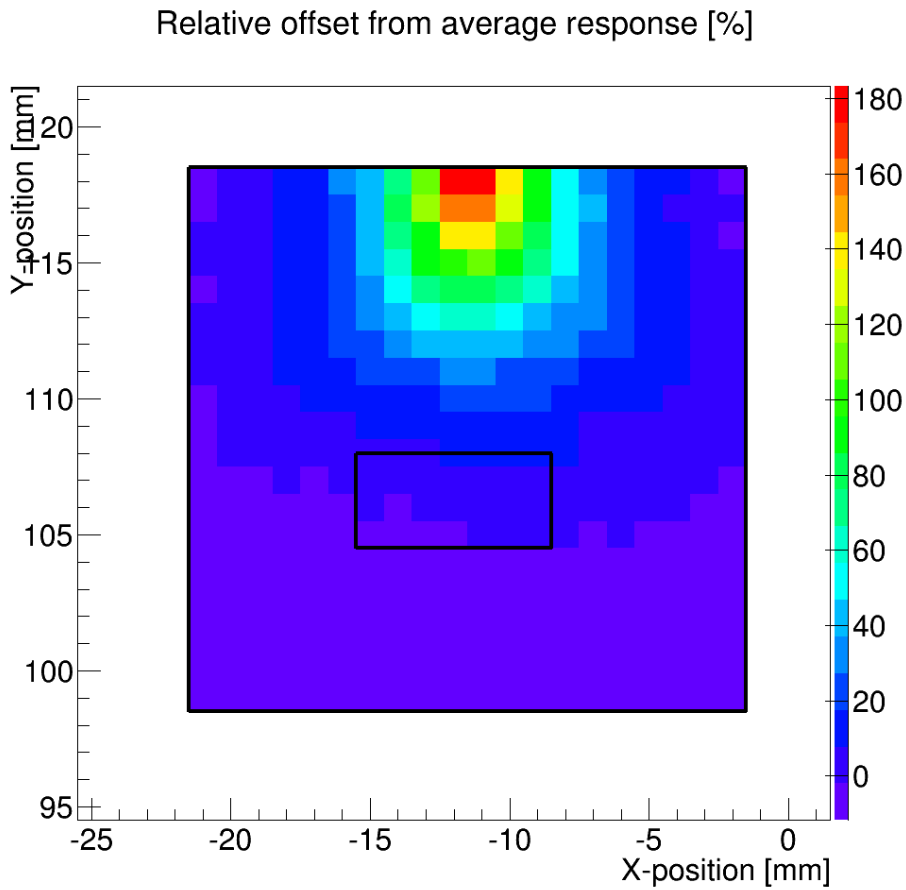
- SiPM-scintillator coupling ==> should not touch them between measurements
- ~ -4%/K temperature correction coefficient not enough ==> determine new one

What we learned: ESR vs. Paint

ESR[1]



Paint[2]

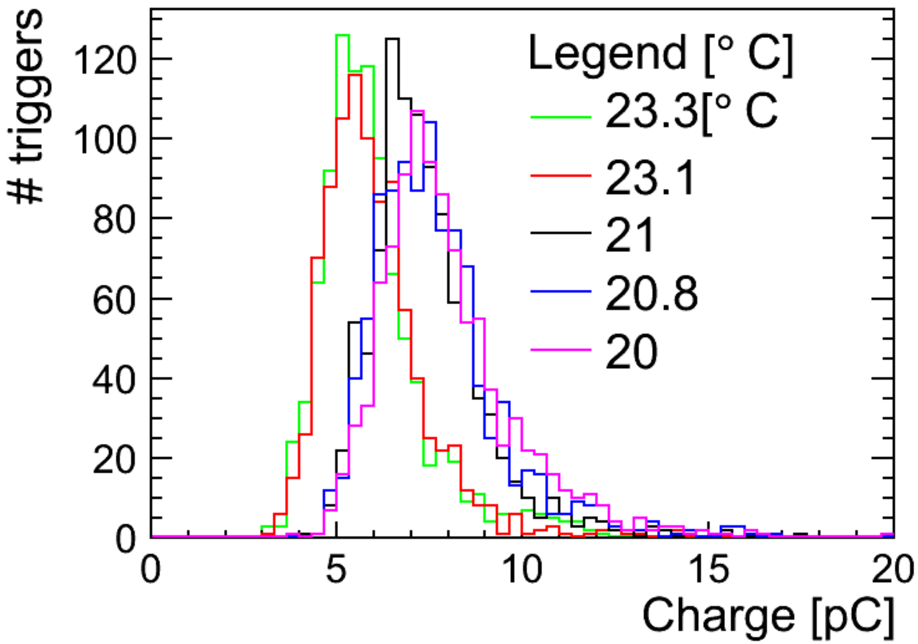


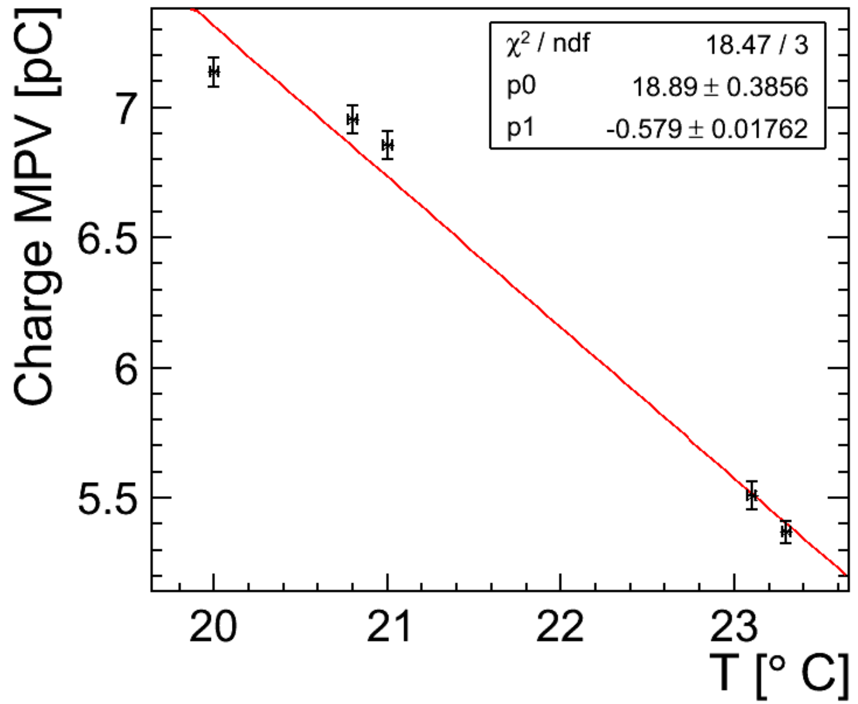
1) Reflective foil from 3M, held by teflon tape
2) Saint-Gobain BC-620 diffusive paint

Extracting T-correction (20x20)

Procedure:

- record mutiple MIP distrubtions from electron gun [left plot]
- same position (central), different temperatures
- fit each distribution with Landau-Gauss convolution
- linear fit of Landau MPV vs. T [right plot]



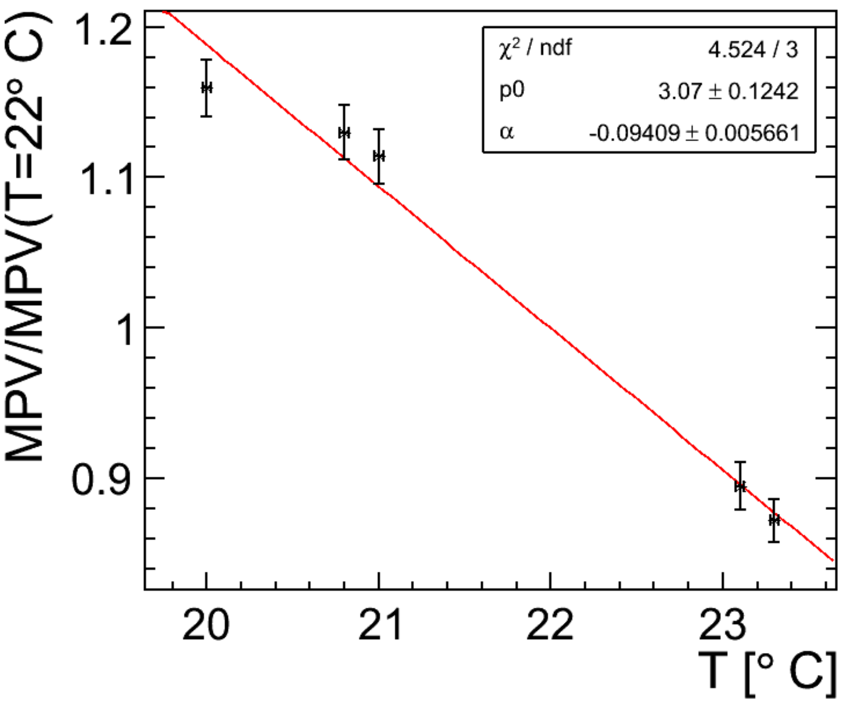


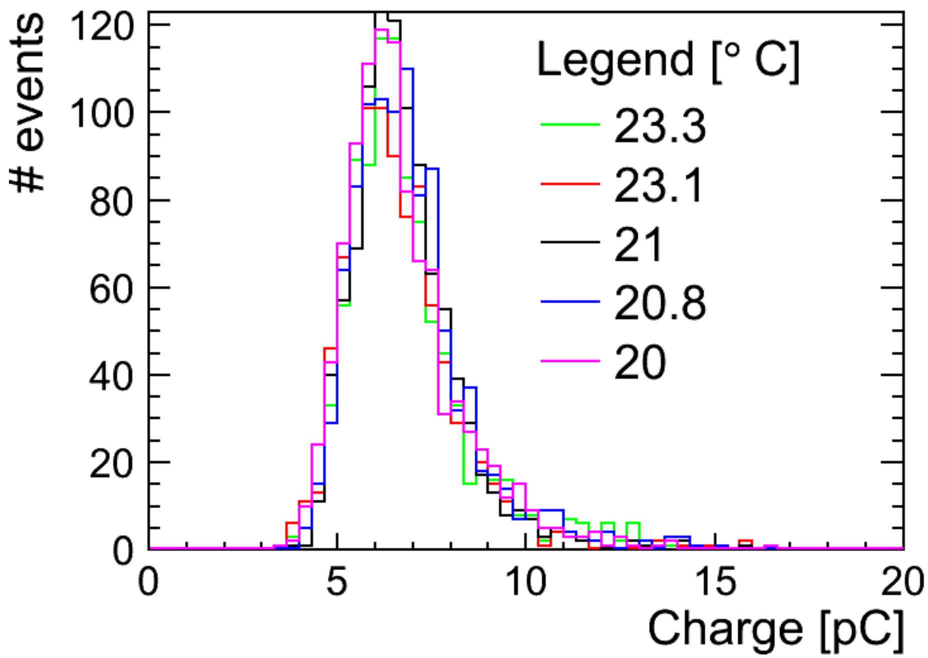
Extracting T-correction (20x20)

To extract temperature correction coefficient, need to define a reference temperature, we chose T_{ref} = 22 deg.

$$\alpha = \frac{1}{Q_{ref}} \cdot \frac{\Delta Q}{\Delta T} = -9.4\%/K$$

$$Q_{corr} = \frac{Q_{meas}}{1 + \alpha \cdot \Delta T}$$





Results after correction

	15x15 tile	20x20 tile
T_0	22°C	22°C
G_{SiPM}	43.5	43.5
α_r	-7.9 %/K	-9.4 %/K
$Mean_{ph}$	67	61
RMS_{ph}	1	2

15 x 15 mm^2 3M wrapping

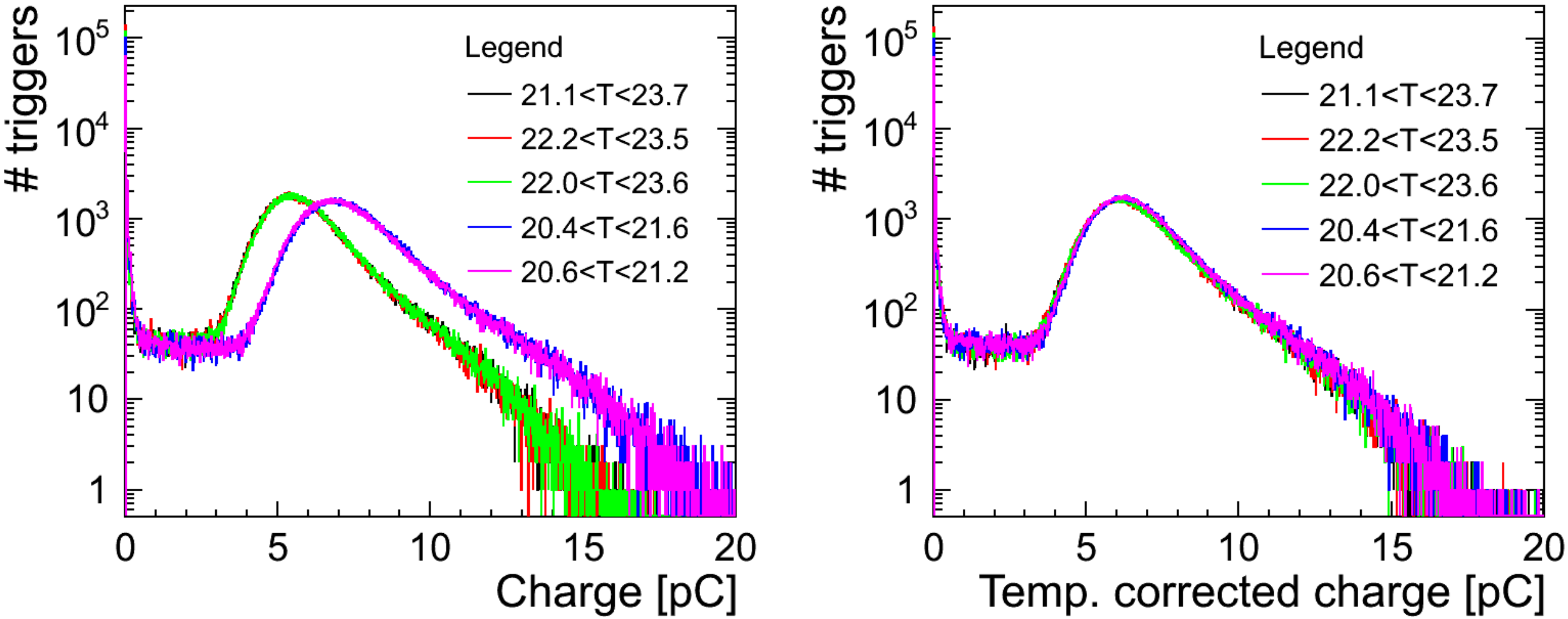
T^{meas} [°C]	Q^{meas} [pC]	Q^{corr} [pC]	Ph^{corr} [No.]
25.1	5.1	6.7	66
21.4	6.9	6.7	67
20.8	7.4	6.8	68

20 x 20 mm^2 3M wrapping

T^{meas} [°C]	Q^{meas} [pC]	Q^{corr} [pC]	Ph^{corr} [No.]
23.3	5.4	6.1	61
23.1	5.5	6.1	61
21	6.8	6.3	63
20.8	7	6.3	62
20	7.1	6	60

Testing the correction

Applied previously determined temperature correction coefficients to full scintillator scans.
Here: 20 x 20 mm^2 wrapped with 3M reflective foil



Summary

- A tile-scan setup has been assembled at CERN in view of performing scintillator and SiPM studies for the CLIC ECAL R&D
- Scintillator samples of various sizes have been scanned, their uniformity assessed
  - with reflective foil and paint
  - with direct SiPM coupling to side face
- MIP response is lower with paint, but much less uniform
- SiPM coupling to scintillator shows non-reproducibility issues
- Temperature correction coefficients have been extracted and applied to full scans, reproducibility OK if we do not touch the SiPM-scintillator coupling

- Next steps:
  - quantify light yield and uniformity for new batches of 10x10, 15x15, and 20x20 mm^2 scintillators [this summer]
  - study readout electronics for layer prototype [FCAL AGH-UST electronics, studies have started]
  - complete hardware studies with light transport simulaions in Geant4 [contributions welcome]
  - document current results as CLICdp note [ongoing]

Measurement and analysis procedures

- Measurement
  - Place selected tile in setup, coupled to the SiPM by direct contact to side face using optical grease
  - Perform self-triggered calibration run to measure gain at reference temperature
  - Switch electron gun ON, start automated tile scan with pre-selected positions
  - At each scan step (~60 sec):
    - Measure temperature (surface-mounted PT1000)
    - Record DUT SiPM waveform integral for each crossed-fibres coincidence signal
- Analysis
  - Correct each waveform integral by relative temperature offset w.r.t. calibration run
  - Convert waveform integral into #p.e.
  - Define tile area at the centre to calculate average response
  - For each scan position, compute deviation from <#p.e.>
  - Estimate effective tile areas within +/- 5, 10, and 20% of the average response to assess response non-uniformity