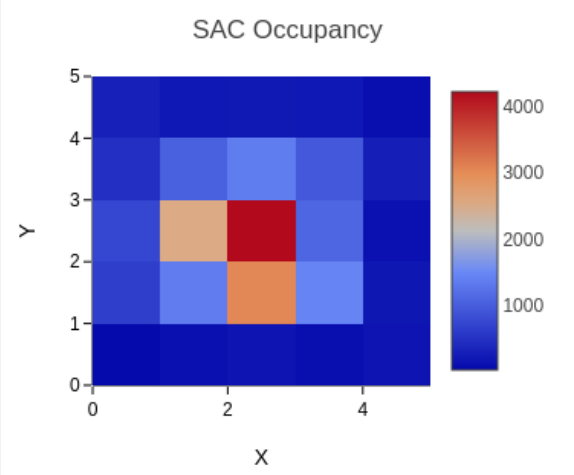
SAC CALIBRATION

C. Taruggi - PADME General Meeting 8-9/01/19

THE PROBLEM

- Since the reliability of Hamamatsu PMTs, we thought that SAC would not have needed a dedicated calibration, like the one we performed on ECAL.



Nevertheless, in standard condition (E_0 = 545 MeV, DHSTB001/002/102 on) we expect a smoother energy distribution in the central cross, instead it looks like the units in the upper/right central part count less than the others.

A POSSIBLE SOLUTION

- S. Baunack et al., *"Real-time calibration of the A4 electromagnetic lead fluoride (PbF_2) calorimeter"*, Nuclear Instruments and Methods in Physics Research Section A, Vol. 640, 1(2011) 58-68 (thanks to A. Sterenberg Frankenthal).
- Cluster calibration: instead of using single crystals at different HV, we can point the beam to one of the SAC crystal, take into exam the cluster made of 8 crystals enclosing the reference crystal, and study the lateral energy distribution of the cluster crystals.

THE PATH TO CALIBRATION: STEP 1

4 μ_d	3 μ_n	2 μ_d
5 μ_n	0 μ_c	1 μ_n
6 μ_d	7 μ_n	8 μ_d

- Crystal 0 is the one hit by the beam.
- The energy is deposited in the crystals of the cluster according to:

$$E_{deposit} = (\mu_c + 4\mu_n + 4\mu_d)\, E_{incident}$$

with μ_i denoted as distribution parameters.

- μ_i can be determined by averaging the energy deposition over all possible impact positions on the central crystal's surface.
- Theoretical values for μ_i are: μ_c = 65.3%, μ_n = 6.2%, μ_d = 1.2%.

THE PATH TO CALIBRATION: STEP 2

If the calorimeter is not calibrated, the signal strenght S_i of each 3 × 3 cluster i caused by events of energy E_0 depends on the amplification factors k_{ij} of the central crystal and the nearby 8 crystals:

$$S_i = [\mu_c k_{i0} + \mu_n (k_{i1} + k_{i3} + k_{i5} + k_{i7}) + \\ + \mu_d (k_{i2} + k_{i4} + k_{i6} + k_{i8})]E_0$$

4 μ_d	3 μ_n	2 μ_d
5 μ_n	0 μ_c	1 μ_n
6 μ_d	7 μ_n	8 μ_d

THE PATH TO CALIBRATION: STEP 3

The notation can be eased by dropping the *i* cluster index:

$$S_1 = [\mu_c k_1 + \mu_n(k_2 + k_6) + \mu_d k_7]E_0$$

$$S_2 = [\mu_c k_2 + \mu_n(k_1 + k_3 + k_7) + \mu_d(k_6 + k_8)]E_0$$

$$S_3 = [\mu_c k_3 + \mu_n(k_2 + k_4 + k_8) + \mu_d(k_7 + k_9)]E_0$$

…

k_{25}	k_{24}	k_{23}	k_{22}	k_{21}
k_{20}	k_{19}	k_{18}	k_{17}	k_{16}
k_{15}	k_{14}	k_{13}	k_{12}	k_{11}
k_{10}	k_9	k_8	k_7	k_6
k_5	k_4	k_3	k_2	k_1

THE PATH TO CALIBRATION: STEP 4

If we use a matrix notation, we can write:

$$\vec{S} = \begin{pmatrix} S_1 \\ S_2 \\ S_3 \\ \dots \\ S_{25} \end{pmatrix} \qquad \vec{k} = \begin{pmatrix} k_1 \\ k_2 \\ k_3 \\ \dots \\ k_{25} \end{pmatrix} \qquad \boldsymbol{A} = \begin{pmatrix} \mu_c & \mu_n & 0 & \dots \\ \mu_n & \mu_c & \mu_n & \dots \\ 0 & \mu_n & \mu_c & \dots \\ 0 & 0 & \mu_n & \dots \\ \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\vec{S} = \boldsymbol{A}\vec{k}E_0$$

The amplification factors can then be calculated as:

$$\vec{k} = \frac{1}{E_0}\boldsymbol{A}^{-1}\vec{S}$$

EQUALIZED HV

- For every channel *i*, the charge Q_i for a fixed number of incident photons at the photocathode is a power function of the applied voltage *V*:

$$Q_i \sim V^{\beta i}$$

- If we find the amplification factors, it is possible to calculate the equalized HV V_{eq} to reach the desired amplification factor k_{req}:

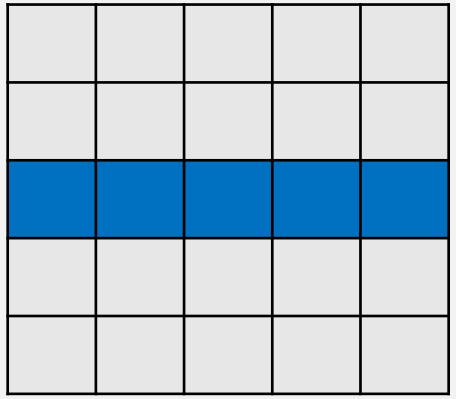
$$V_{eq} = \sqrt[\beta_i]{\frac{k_{req}}{k_i}} \; V_{i,old}$$

WHAT WE HAVE/ WHAT WE NEED

To fasten the process, we may think to consider only the central 9 crystals of the SAC: it's very unlikely to have particles in the external ones.

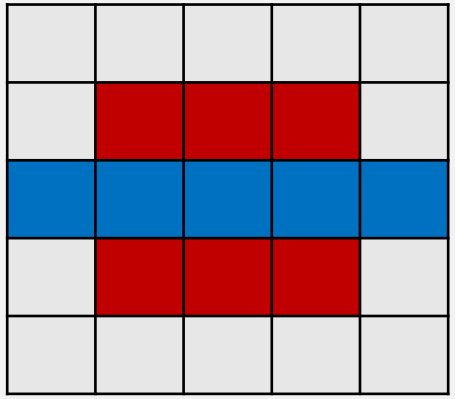
HAVE

Runs with beam into the crystals of the central line of the SAC



NEED

Runs with beam into the crystals of the other 6 crystals



CONCLUSIONS

- A SAC calibration is needed
- This method offers a quicker solution than the changing HV method, which can give saturation problems (already seen)
- We only need taking data for 6 crystals, if we settle for calibration of the 9 central crystals