

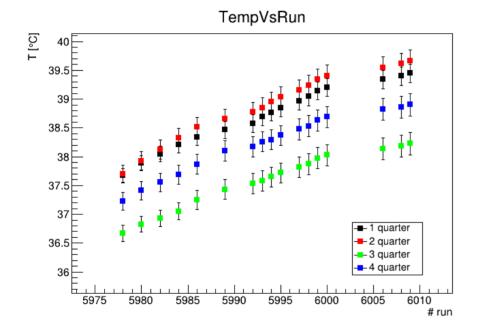


## Calo status for CNAO 2023

Benedetto Spadavecchia FOOT Physics Monthly Meeting, 06/02/2024

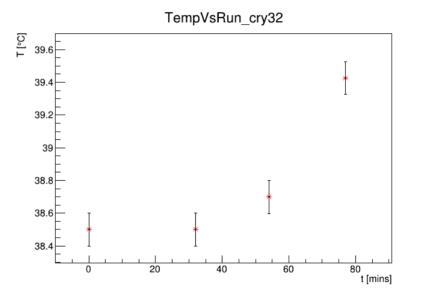






Where we stopped: no evidence of T stabilization for any quarter was found  $\rightarrow$  for next data taking: better turn on the CALO earlier.

However, for every crystal, the variation in  $T_{mean}$  was within 1°C along the 4 calibration runs  $\rightarrow 0.5\%$  variation in ADC response.



By mediating  $T_{mean}$  values among the 4 calibration runs a crystal-specific  $T_{ave}$  value was obtained and chosen as reference temperature.



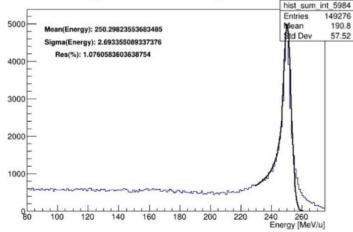


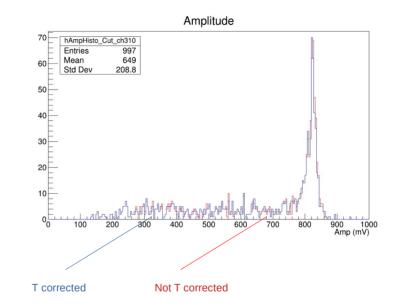
By mediating  $T_{mean}$  values among the 4 calibration runs a crystal-specific  $T_{ave}$  value was obtained and chosen as reference temperature.

$$m_{meas} = m_1 + \frac{m_2 - m_1}{T_2 - T_1} \cdot (T_{meas} - T_1)$$

$$A'_{meas} = A_{meas} + m_{meas} \cdot (T_{ref} - T_{meas})$$



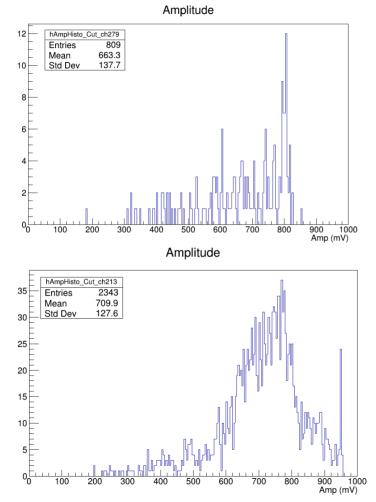


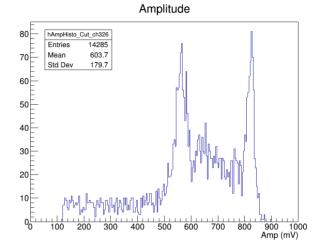


Spectra were fitted with a crystal ball function  $\rightarrow$  peak values were extracted: differently from other times, a new script was developed to perform the process automatically  $\rightarrow$  to be uploaded on *shoe*.









For some runs and crystals, energy spectra show:

- 1) scarcely populated distributions (i.e. 279)
- 2) largely distributed peaks (i.e. 213)
- 3) multiple peaks (i.e. 326).

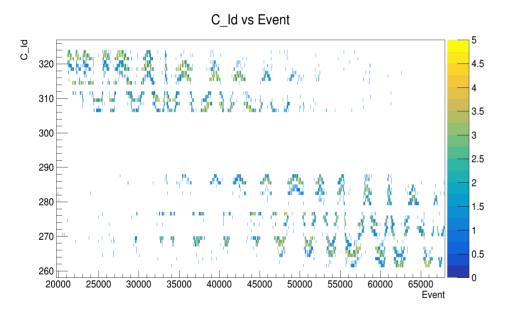
Cases (2) and (3) mainly involve crystals on border, for which discarding events with multiplicity > 1 is less efficient.





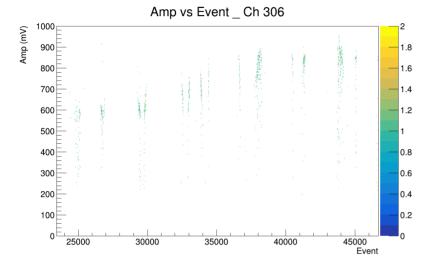
A plot of the activated channels per event was created, to obtain information upon beam scanning.

					_	_		_	_	_	_							
				0	1	2	9	10	11	18	19	20						
				3	4	5	12	13	14	21	22	23						
				6	7	8	15	16	17	24	25	26						
	27	<mark>28</mark>	29	<mark>36</mark>	37	<mark>38</mark>	<mark>45</mark>	<mark>46</mark>	47	<mark>54</mark>	<mark>55</mark>	<mark>56</mark>	<mark>63</mark>	<mark>64</mark>	65			
	30	31	<mark>32</mark>	<mark>39</mark>	<b>40</b>	<mark>41</mark>	<mark>48</mark>	<mark>49</mark>	<mark>50</mark>	<mark>57</mark>	<mark>58</mark>	<mark>59</mark>	66	67	68			
	33	<b>34</b>	<mark>35</mark>	<mark>42</mark>	<b>43</b>	44	51	<mark>52</mark>	<mark>53</mark>	<mark>60</mark>	61	62	69	70	71			
72 73 74	81	82	83	90	91	92	99	100	101	<mark>108</mark>	<mark>109</mark>	110	117	<mark>118</mark>	119	<mark>126</mark>	<mark>127</mark>	128
75 76 77	84	85	86	93	94	95	102	103	104	111	112	113	<mark>120</mark>	121	122	129	130	131
78 79 80	87	88	89	96	97	98	105	106	107	<mark>114</mark>	115	116	123	124	125	132	133	134
135136137	144	145	146	153	154	155	162	163	164	171	172	173	180	181	182	189	190	191
138139140	147	148	149	156	157	158	165	166	167	174	175	176	183	184	185	192	193	194
141142143	150	151	152	159	160	161	168	169	170	177	178	179	186	187	188	195	<b>196</b>	197
198199200							_			_	_							
201202203																	_	
201202203						_		_					- · · ·					
				_			_										259	200
	_			270	_										_			
	<mark>264</mark>	<mark>265</mark>	<mark>266</mark>	<mark>273</mark>	<mark>274</mark>	<mark>275</mark>	<mark>282</mark>	283	<mark>284</mark>	<mark>291</mark>	<mark>292</mark>	<mark>293</mark>	<mark>300</mark>	<mark>301</mark>	<mark>302</mark>			
	<mark>267</mark>	<mark>268</mark>	<mark>269</mark>	<mark>276</mark>	<mark>277</mark>	<mark>278</mark>	<mark>285</mark>	<mark>286</mark>	<mark>287</mark>	<mark>294</mark>	<mark>295</mark>	<mark>296</mark>	<mark>303</mark>	<mark>304</mark>	<mark>305</mark>			
				<mark>306</mark>	<mark>307</mark>	<mark>308</mark>	<mark>315</mark>	<mark>316</mark>	<mark>317</mark>	<mark>324</mark>	<mark>325</mark>	<mark>326</mark>						
		[		<mark>309</mark>	<mark>310</mark>	<mark>311</mark>	<mark>318</mark>	<mark>319</mark>	<mark>320</mark>	<mark>327</mark>	<mark>328</mark>	<mark>32</mark> 5						
				312	313	<mark>31</mark> 4	321	<mark>322</mark>	<mark>323</mark>	<mark>330</mark>	<mark>331</mark>	<mark>332</mark>	_					









$$A(x) = A[Re^{\alpha(L-x)} + (1-R)e^{-\alpha(L+x)}]$$

A is the normalization factor  $\alpha$  is the attenuation coefficient R is the fraction of reflected photons

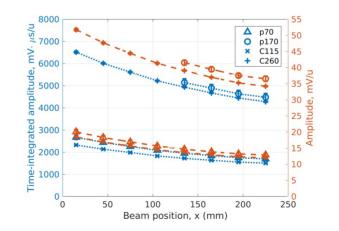
L is the crystal length.

In border crystals, sometimes energy is not fully deposited and multiplicity cut cannot be applied. In order to investigate on this issue, also a 2D plot of amplitude (mV) vs event number was created.

We already knew that if particles hit crystals closer to the SiPM, the formed signal has lower amplitude

 $\rightarrow$  hypothesis: this is more likely to happen when the beam is not perfectly centered on the crystal and at higher energies (higher particle range)

 $\rightarrow$  peaks at lower gain show up.







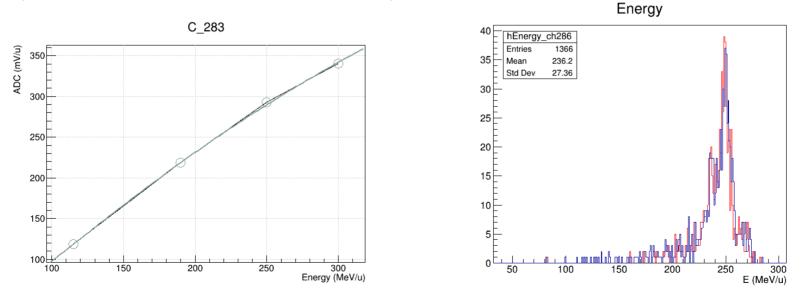
For each crystal → fit with modified Birks function on: a) not T corrected peak values; b) T corrected peak values

- $\rightarrow$  two sets of p<sub>0</sub>, p<sub>1</sub> and p<sub>2</sub> parameters
- → two hEnergy plots per crystal, one corrected for T, one not: how much do integral resolutions differ

$$ADC(E) = \frac{p_0 x^2}{1 + p_1 x + p_2 x^2}$$

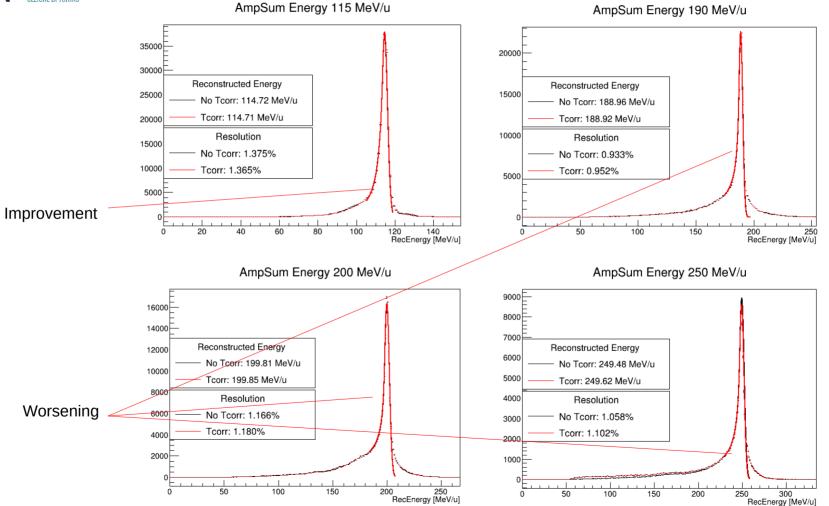
$$E(ADC) = \frac{-p_1 ADC - \sqrt{(p_1 ADC)^2 - 4ADC(p_2 ADC - p_0)}}{2(p_2 ADC - p_0)}$$

Not all the fits with Birks function lead to a correct minimization: the following results were obtained by excluding "bad Birks-fitting" crystals (37, 44, 64, 68, 71, 95, 213, 302, 304, 305, 306, 326)











## **Upcoming tasks**

**Software**: data analysis on HIT2022; to interpret CALO energy response, proper Z identification is required a) issues in reading TW tree from decode-glb output must be fixed;

- b) TW and CALO closest hits must be coupled;
- c) mass reconstruction capability from CALO to be studied.

E [MeV/u]	1	2	3	4		
115		55, 68, 71, 128	248, 295, 299, 327	312		
			1			
190		<b>55, 64, 68</b> ,	248, 295, <b>299,</b> 302	312		
		71, <mark>127</mark> , 128	304, 305, 326			
200		55, 56, 64, 68,	<b>248, 295, 299,</b> 302	306, 309, 312,		
200		71, 127	304, 305, 326	314, 321, 322		
		11, 121	304, 303, 320	514, 521, 522		
250	<b>28</b> , 46, 47,	55, 63, 64,	248, <mark>295, <b>299,</b> 3</mark> 02	207, 215, 223, 264, 269		
	82, 87, 151, 167	126, 127	304, 305, 326	274, 306, 311, 312		
300	X	Х	X	207, 215, 223, 263,		
			1	264, 265, 267, 268, 269,		
			1	271, 273, 279, 287, 306		
			1	308, 309, 311, 312, 315		
			1	319, <b>322, 323</b>		
		55	248, 295, <b>299</b>	312		
No data taking	27, 38, 39		303	225, 277, 278		
Unplugged	21,00,00	131		313		
onplaggea		101		010		
	dirty/multiple peaks		-			
	(almost) no signals		· ·			
	overflow		1			
	problems in all runs		1			
	border crystals					

**Hardware**: last spare crystals (about ten) will be glued @CERN on february-march 2024; to check whether excluded crystals need replacement or not.

