Studio dei cristalli e confronto dati-simulazione

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09/05/2025

BGO: μ^+ 120 GeV

Confronto: CH1, μ^+ 120 GeV

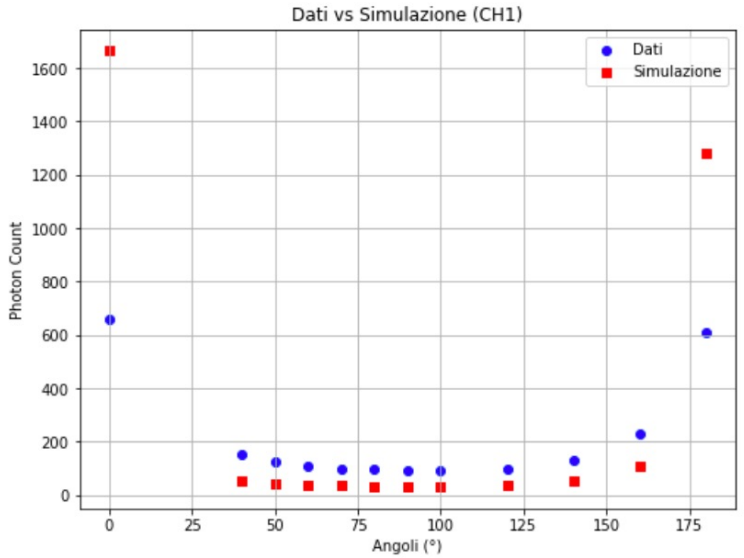
Pre- Amp Gain: 18

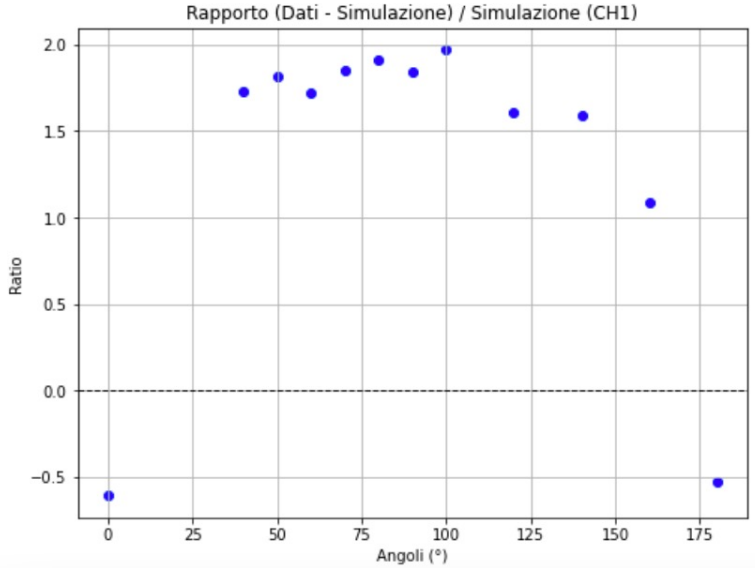
Simulazione

Nph	0°	20°	40°	50°	60°	70°	80°	90°	100°	120°	140°	160°	180°
N_{tot}	1664	-	55	44	39	34	33	32	31	38	51	109	1281

Dati

N_{CH1}	656	274	150	124	106	97	96	91	92	99	132	227	610





Confronto: CH2, μ^+ 120 GeV

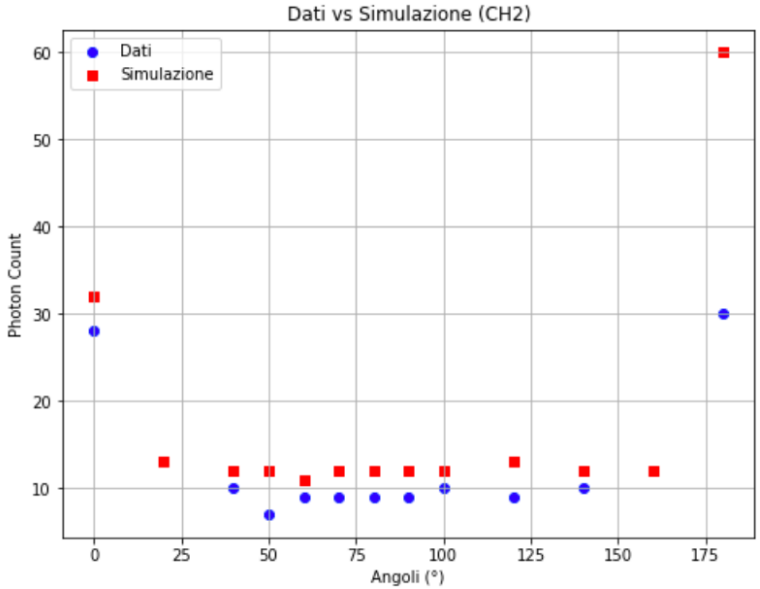
Pre- Amp Gain: 28

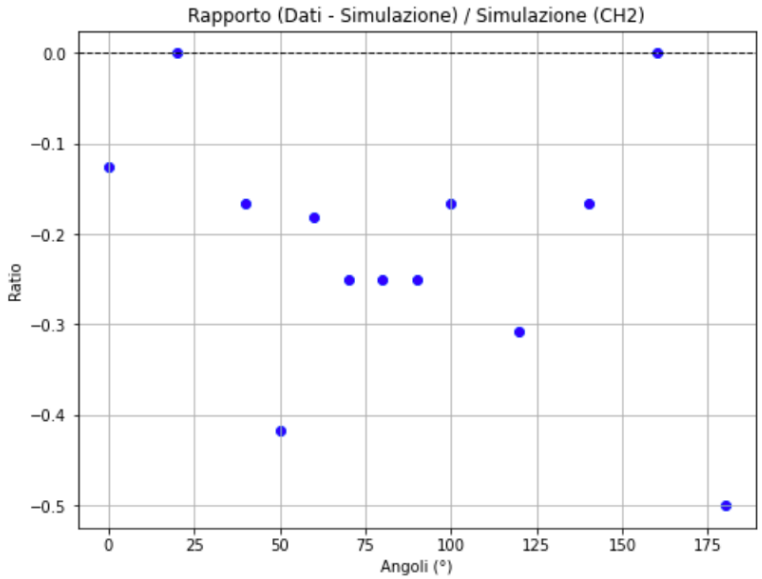
Simulazione

Nph	0°	20°	40°	50°	60°	70°	80°	90°	100°	120°	140°	160°	180°
N_{tot}	32	13	12	12	11	12	12	12	12	13	12	12	60

Dati

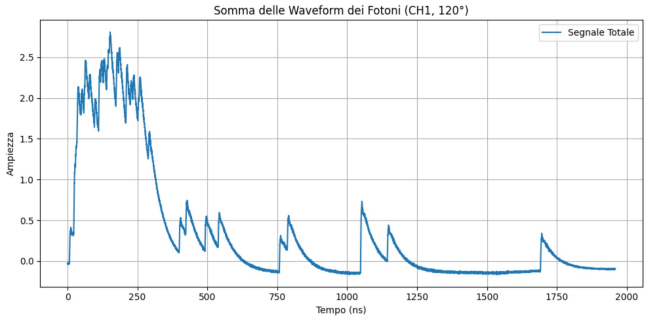
N_{CH2}	28	13	10	7	9	9	9	9	10	9	10	12	30



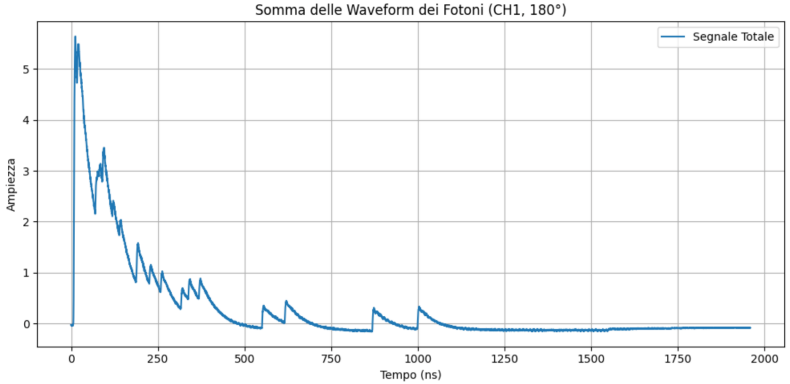


Waveforms simulate: CH1

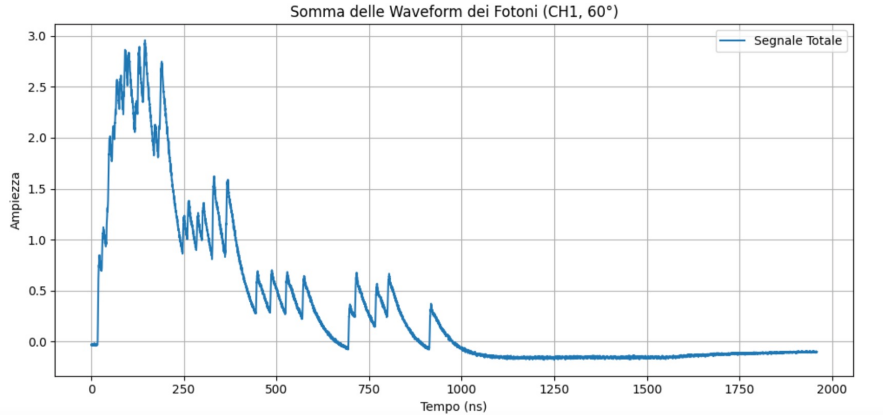
120°
Scintillazione:37
Dark:1



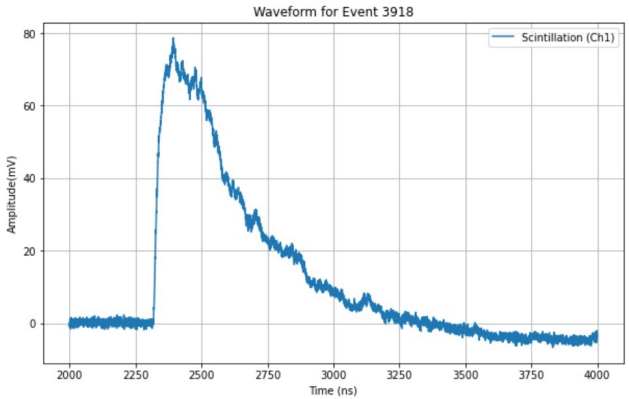
180°
Scintillazione: 77
XT:3



60°
Cherenkov :1
Scintillazione:38

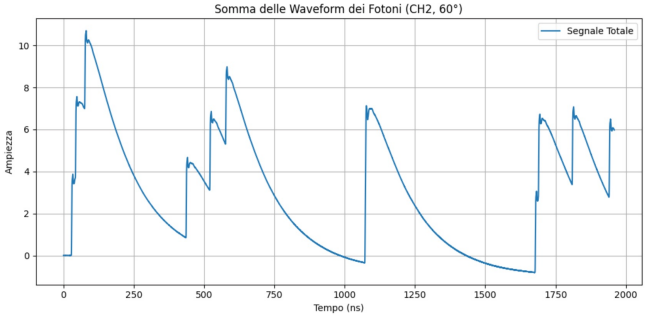


Wf dati

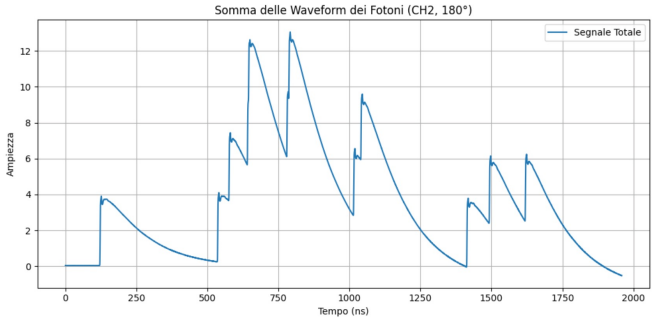


Waveforms simulate: CH2

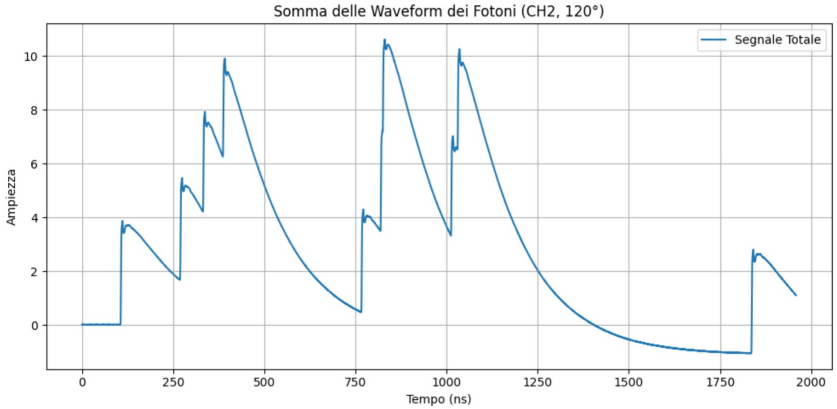
60°
Dark:12



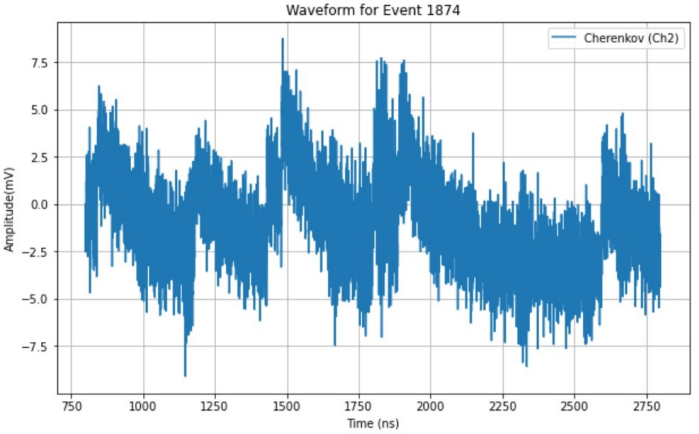
180°
Cherenkov: 2
Scintillazione. 19
Dark:13



120°
Dark:11



Wf dati



BSO: μ^+ 120 GeV

Confronto: CH1, μ^+ 120 GeV

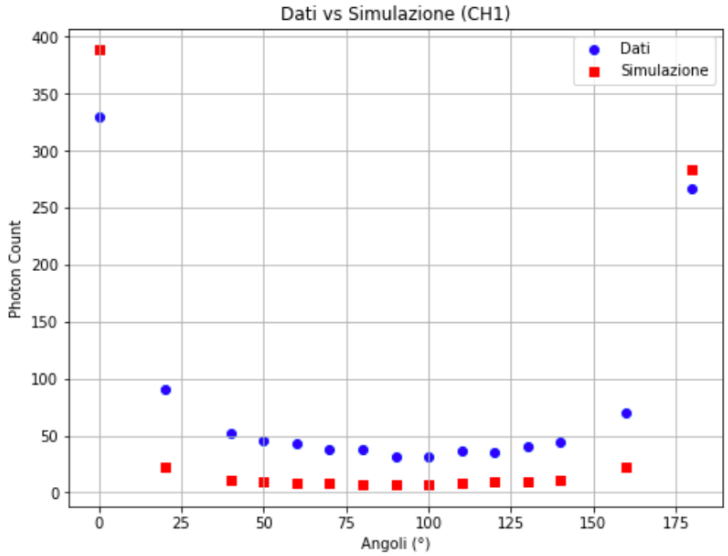
Pre- Amp Gain: 18

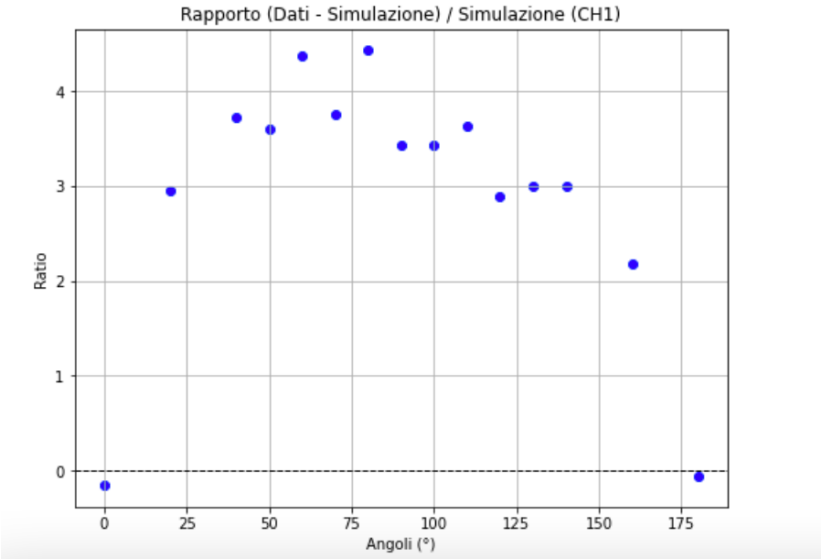
Simulazione

Nph	0°	20°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	160°	180°
N_{tot}	388	23	11	10	8	8	7	7	7	8	9	10	11	22	283

Dati

N_{CH1}	329	91	52	46	43	38	38	31	31	37	35	40	44	70	285





Fotoni totali generati

Numero di fotoni **totali generati** (media su tutti gli eventi)

BGO

N_{TOT}	Scintillazione	Cherenkov
0°	1809465	18944
20°	343695	3647
90°	109757	1164
120°	127438	1356
160°	363301	3842
180°	1996531	20875

BSO

N_{TOT}	Scintillazione	Cherenkov
0°	344171	20151
20°	62712	3730
90°	20390	1220
120°	23595	1414
160°	65549	3904
180°	445009	25824

Confronto: CH2, μ^+ 120 GeV

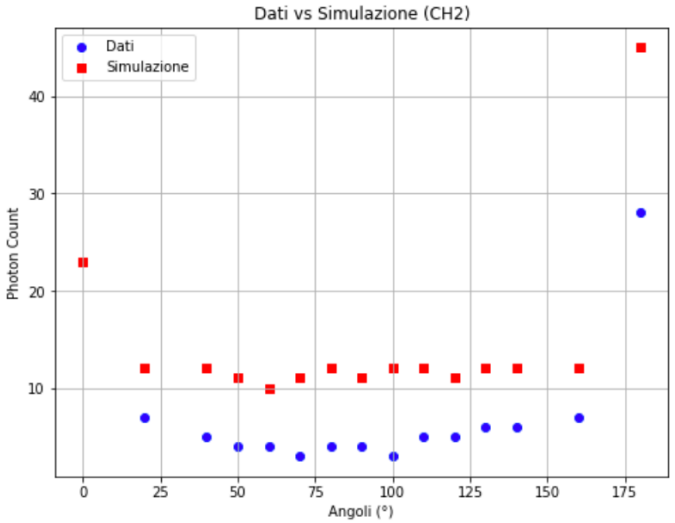
Pre- Amp Gain: 28

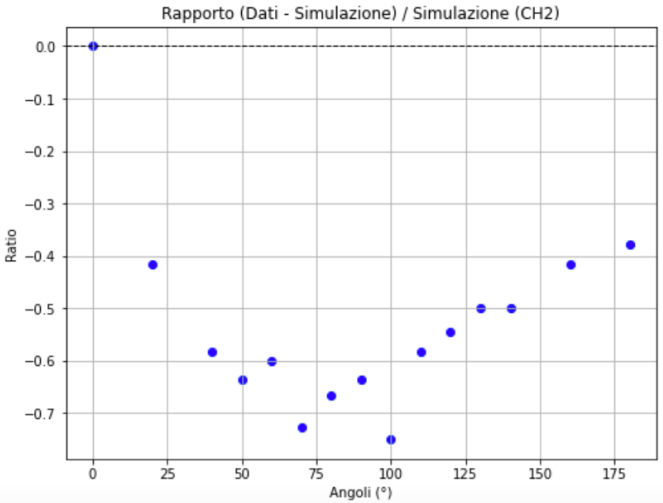
Simulazione

Nph	0°	20°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	160°	180°
N_{tot}	23	12	12	11	10	11	12	11	12	12	11	12	12	12	45

Dati

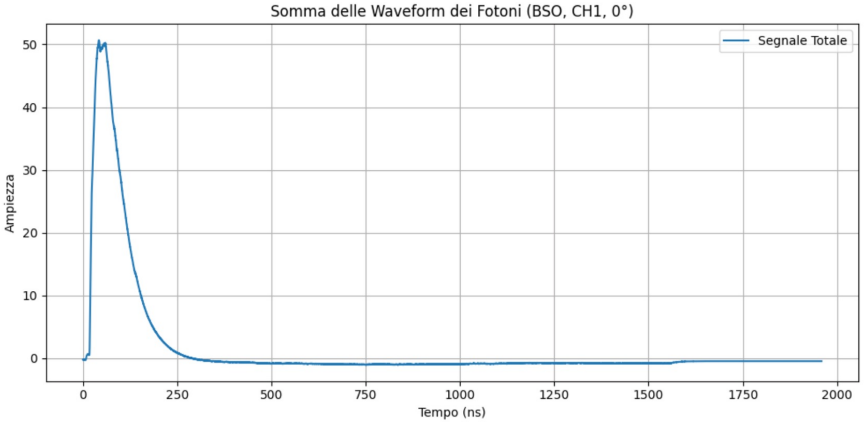
N_{CH2}	23	7	5	4	4	3	4	4	3	5	5	6	6	7	30



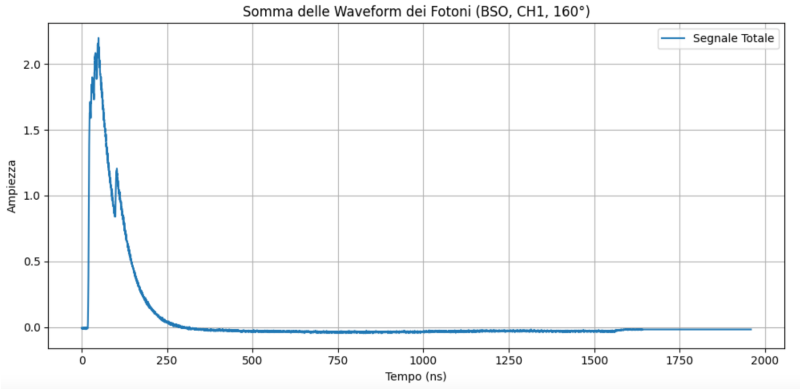


Work in progress: l'integrale dei dati è sottostimato.
Sto correggendo il calcolo dei fotoni

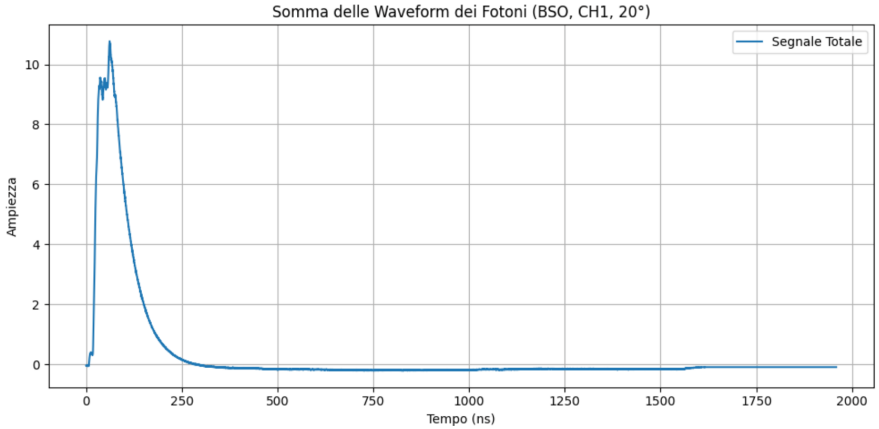
Waveforms simulate: CH1



S: 178
C: 23
D: 2

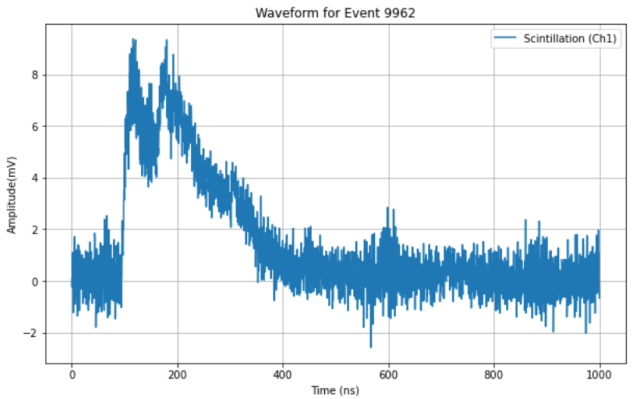


S: 8



S: 37
C: 3
D: 1

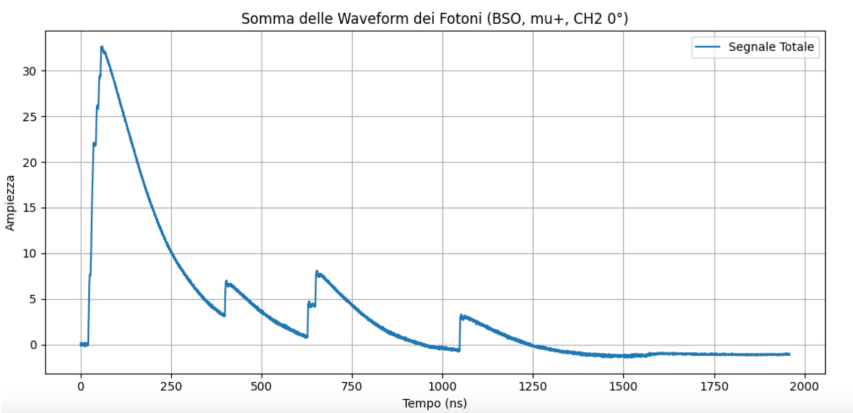
Wf dati

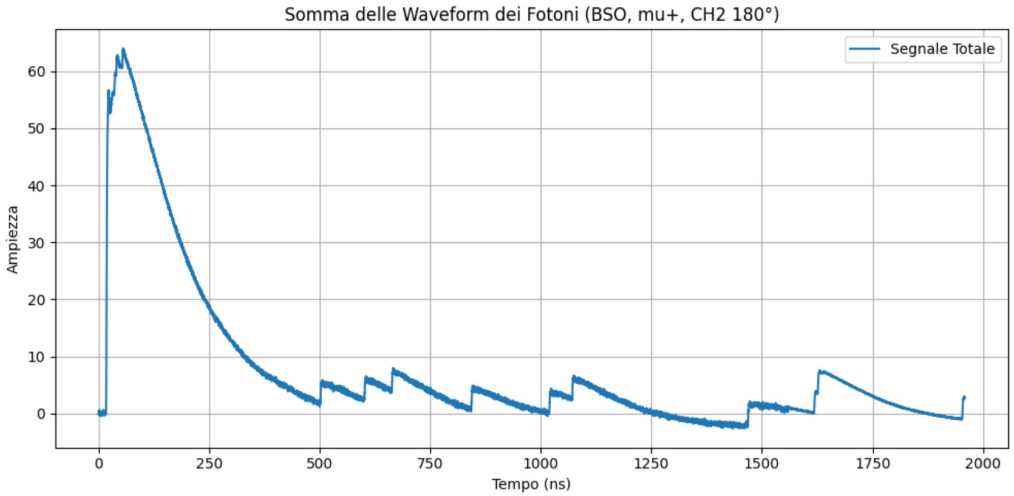


Waveforms simulate: CH2

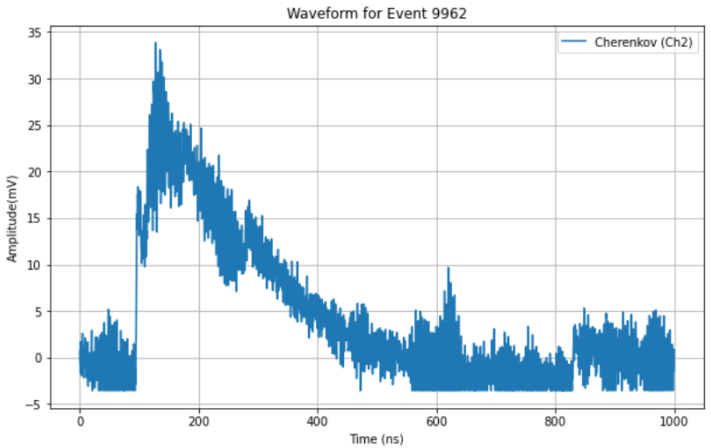
S: 6
C: 11
D: 11

S: 9
D: 4





Wf dati



Energia depositata vs Numero di fotoni

Frazione di fotoni incidenti

$\frac{N_{inc_{CH1,2}}}{N_{tot}}$ Frazione dei fotoni originati nel cristallo al passaggio del muone che incidono sui SiPM

BGO

	CH1	CH2
0°	0.005	$2.95 \cdot 10^{-5}$
20°	0.002	$1 \cdot 10^{-5}$
90°	0.002	$9 \cdot 10^{-6}$
120°	0.002	$2.30 \cdot 10^{-5}$
160°	0.002	$1 \cdot 10^{-5}$
180°	0.004	$6.5 \cdot 10^{-5}$

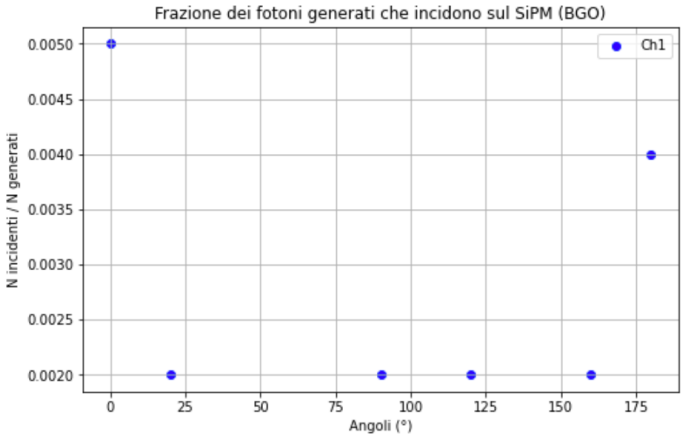
BSO

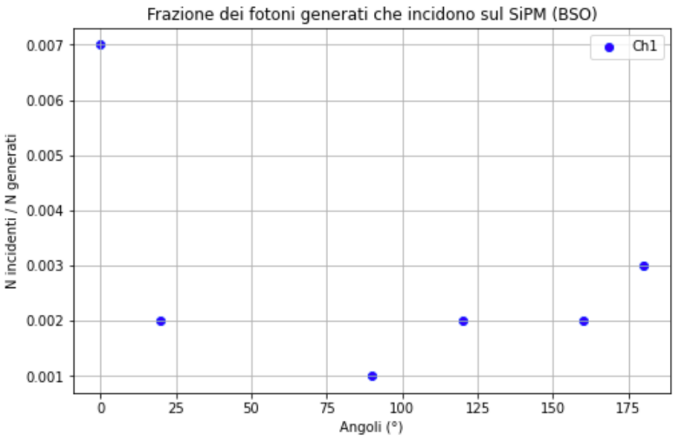
	CH1	CH2
0°	0.007	$6.8 \cdot 10^{-5}$
20°	0.002	$3 \cdot 10^{-5}$
90°	0.001	0.0001
120°	0.002	0.0001
160°	0.002	$4 \cdot 10^{-5}$
180°	0.003	0.0002

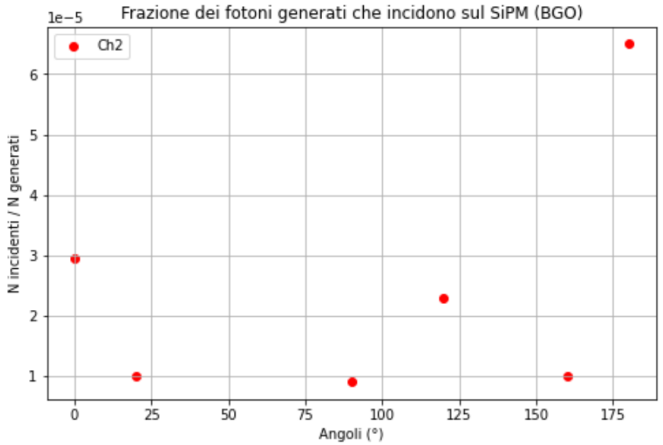
Frazione di fotoni incidenti

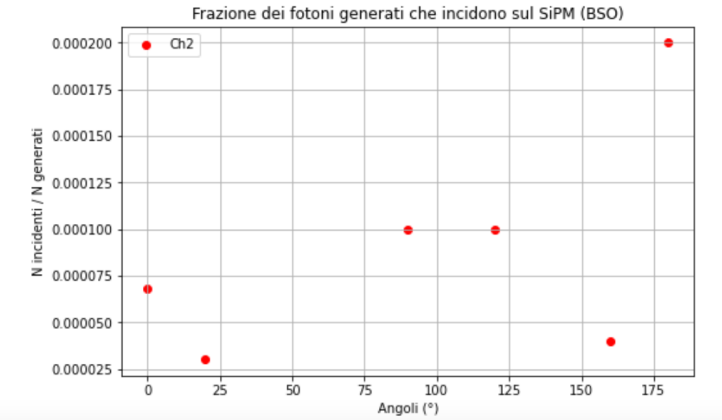
$$\frac{N_{inc_{CH1,2}}}{N_{tot}}$$

Frazione dei fotoni originati nel cristallo al passaggio del muone che incidono sui due SiPM (CH1 e CH2)









Frazione di fotoni rivelati

$$\frac{N_{riv_{CH1,2}}}{N_{inc\ CH1,2}}$$

Frazione dei fotoni incidenti sul SiPM che vengono rivelati dai due SiPM

Pde media 3x3: 0.2
Pde media 6x6: 0.4

* Non ho considerato il dark count

BGO

	CH1	CH2*
0°	0.16	0.37
20°	0.16	0.4
90°	0.17	0.36
120°	0.17	0.30
160°	0.16	0.36
180°	0.16	0.36

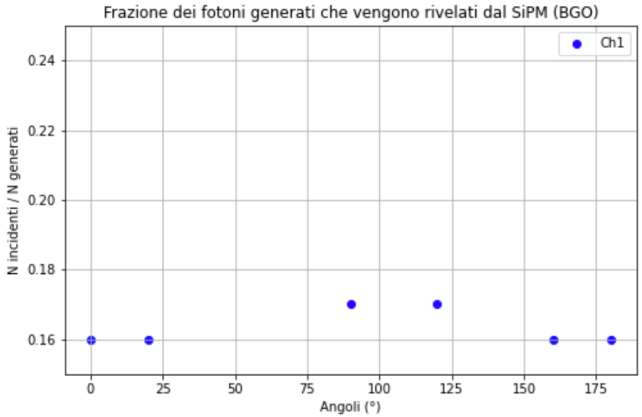
BSO

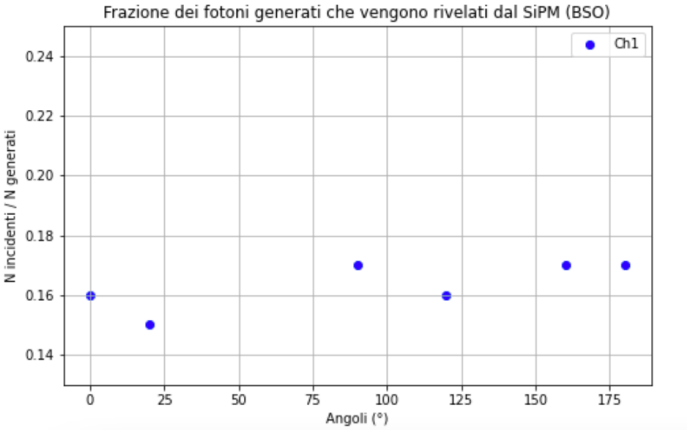
	CH1	CH2
0°	0.16	0.36
20°	0.15	0.3
90°	0.17	0.3
120°	0.16	0.3
160°	0.17	0.3
180°	0.17	0.3

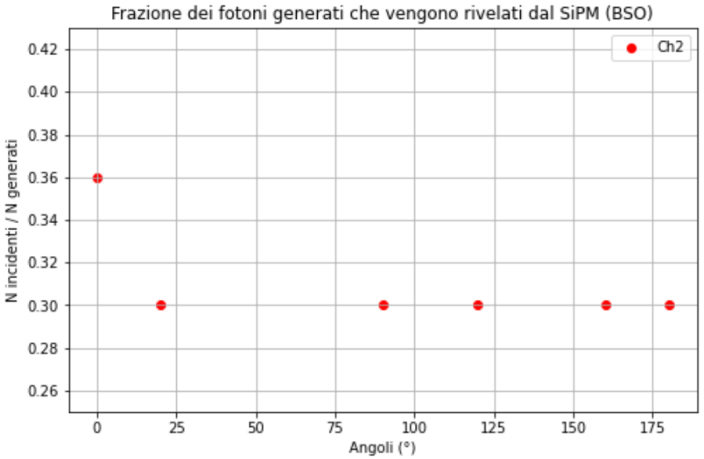
Frazione di fotoni rivelati

$$\frac{N_{riv_{CH1,2}}}{N_{inc\ CH1,2}}$$

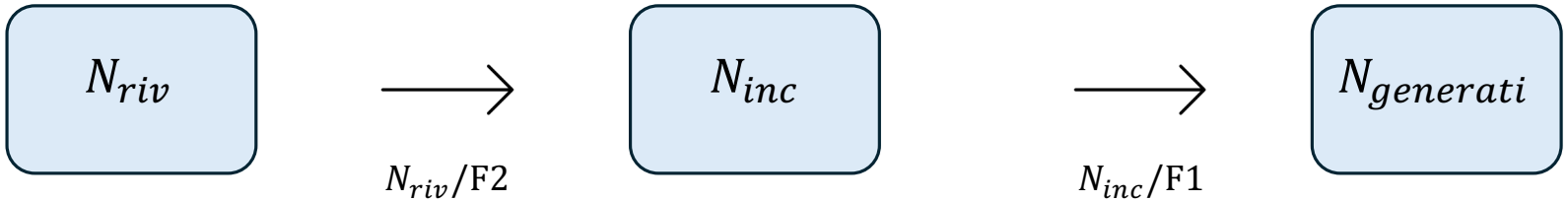
Frazione dei fotoni incidenti sul SiPM che vengono rivelati dai due SiPM







Dati: dai fotoni rivelati ai fotoni generati



- $F1 = N_{inc}/N_{tot}$ Frazione di fotoni incidenti
- $F2 = N_{riv}/N_{inc}$ Frazione di fotoni rivelati

Dati: dai fotoni incidenti ad Energia totale incidente

BGO: Fotoni incidenti

	CH1	CH2
0°	4100	47
20°	1712	5
90°	568	2
120°	582	2
160°	1418	2
180°	3812	53

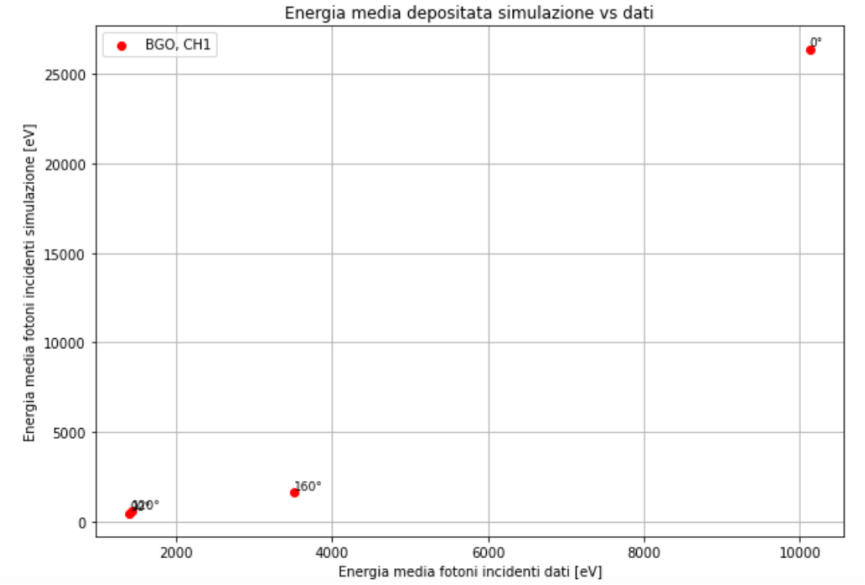
$$N_{inc}^{data} \cdot \left(\frac{E_{inc}^{sim}}{N_{inc}^{sim}}\right)^{*}$$

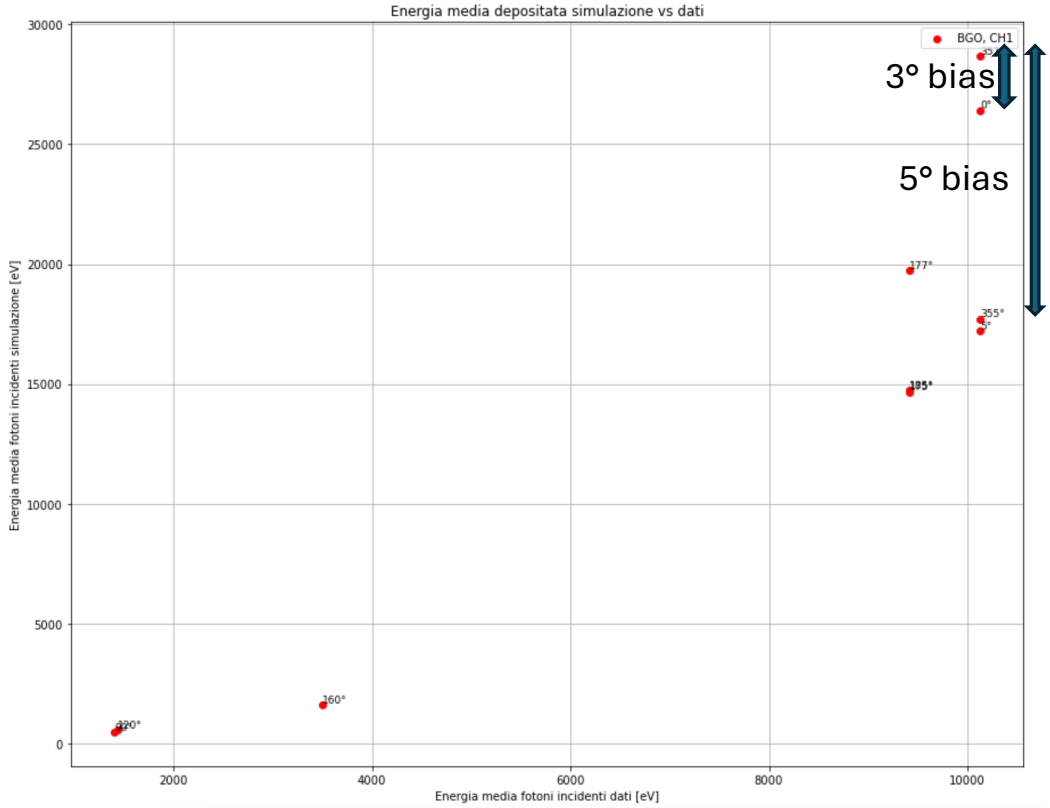
BGO: Energia fotoni incidenti

E_{inc}[eV]	CH1	CH2
0°	10127.0	160
20°	4228.6	17
90°	1402.9	7
120°	1437.5	7
160°	3502.4	7
180°	9415.6	180

$*$: $CH1: 2.47, CH2: 3.4$

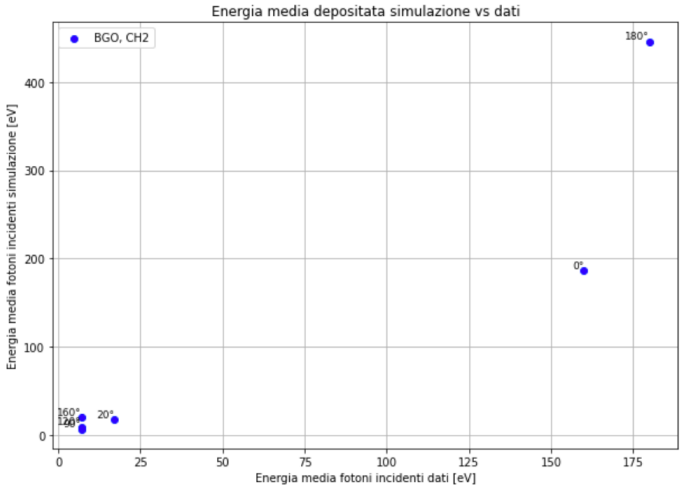
Energia fotoni incidenti: Simulazione Vs Dati

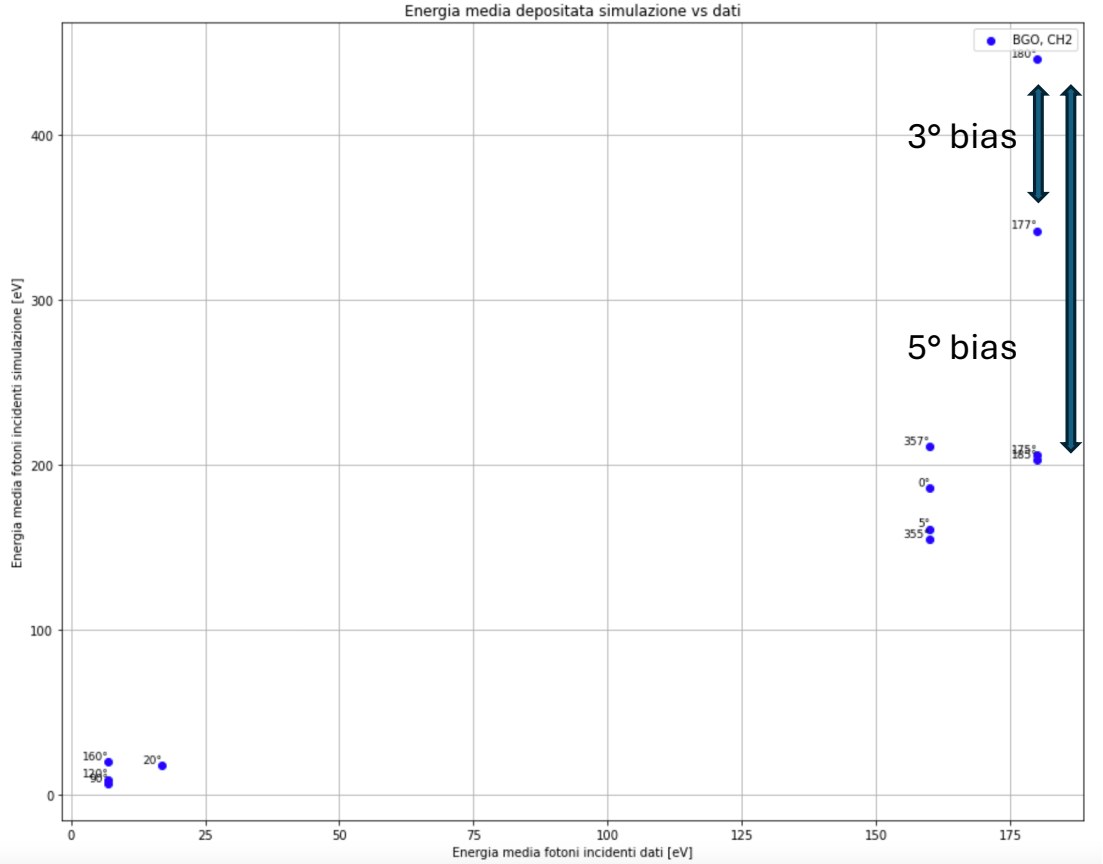




=> Considerando il bias angolare (U plot) i punti si abbassano =>
da fare il cross-check sulla calibrazione di energia

Energia fotoni incidenti: Simulazione Vs Dati





=> Considerando il bias angolare (U plot) i punti si abbassano =>
da fare il cross-check sulla calibrazione di energia

backup

BGO e BSO: e+ 10 GeV

BGO: e+ 10 GeV

Simulazione: CH1

Nph	0°	120°	180°
N_{tot}	12621	897	27800

Dati: CH1

N_{CH1}	1028	212	16333

Pre- Amp Gain: 18

Simulazione:CH2

Nph	0°	120°	180°
N_{tot}	659	38	336

Dati:CH2

N_{CH2}	155	36	885

Pre- Amp Gain: 28

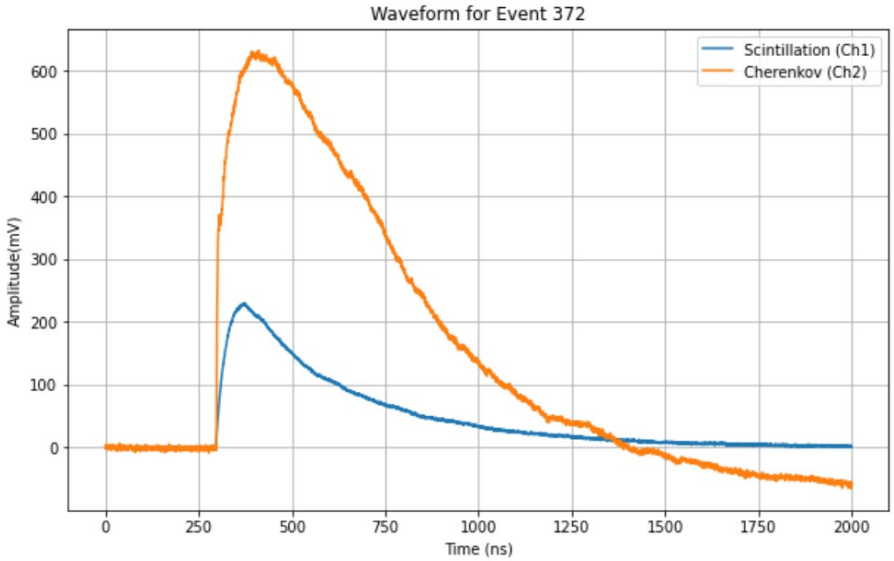
BGO: e+ 10 GeV

Dati: 0°

N_{CH1}	1028
N_{CH2}	155

Simulazione: 0°

N_{CH1}	12621
N_{CH2}	659

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Integrale ch1 scintillation:  85372.39755182451
Integrale ch2 cherenkov:  286067.6409807802
Npe CH1 (integrale):  3414.8959020729803
Npe CH2 (integrale):  515.4371909563607
```

È il massimo dei dati che corrisponde a 3414, quindi la media non raggiungerà mai i 12mila fotoni che invece ha la simulazione

BSO: e+ 10 GeV

CH1: Simulazione

Nph	0°	40°	120°	160°	180°
N_{tot}	978	354	175	851	6587

CH1: Dati

N_{CH2}	1986	670	402	1195	1697

Pre- Amp Gain: 18

CH2: Simulazione

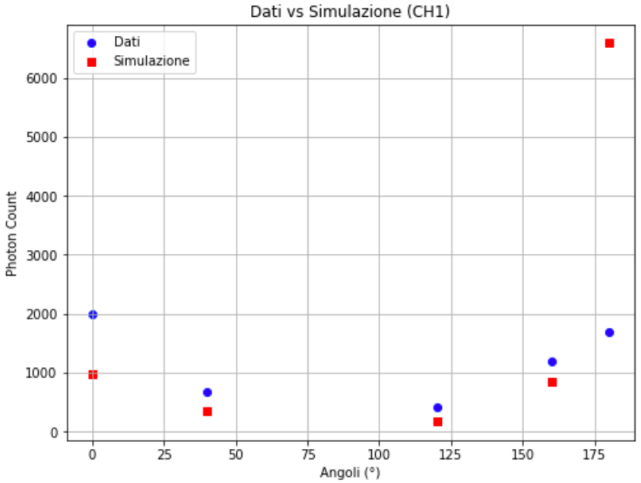
Nph	0°	40°	120°	160°	180°
N_{tot}	91	26	28	91	81

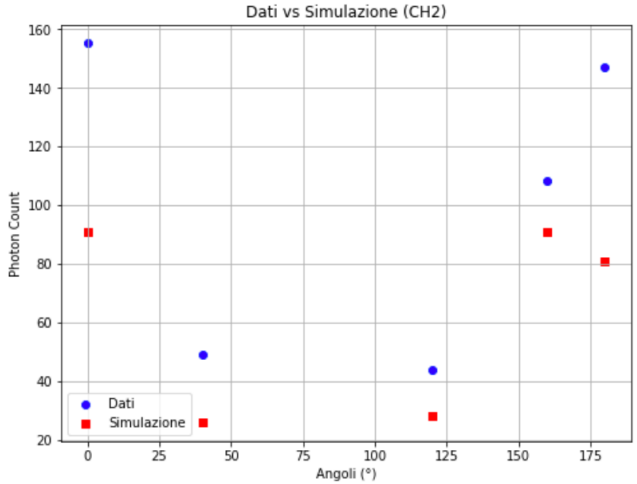
CH2: Dati

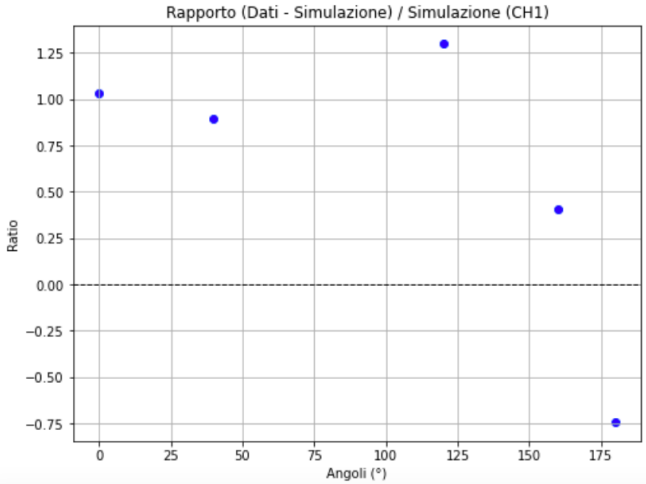
N_{CH2}	155	49	44	108	147

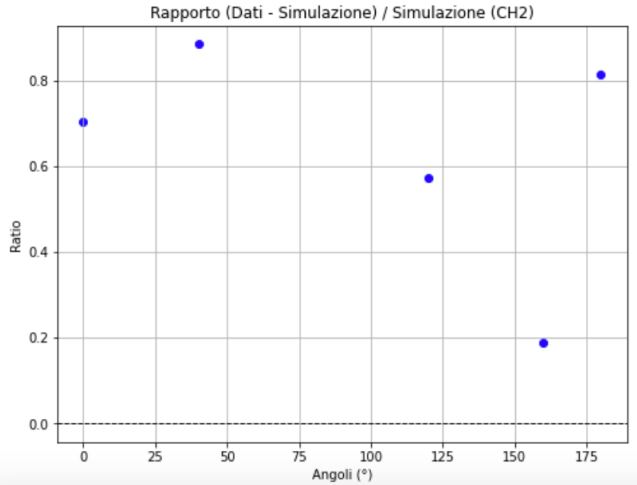
Pre- Amp Gain: 18

BSO: e+ 10 GeV


Dati vs Simulazione (CH1)
Dati
Simulazione
Photon Count
Angoli (°)

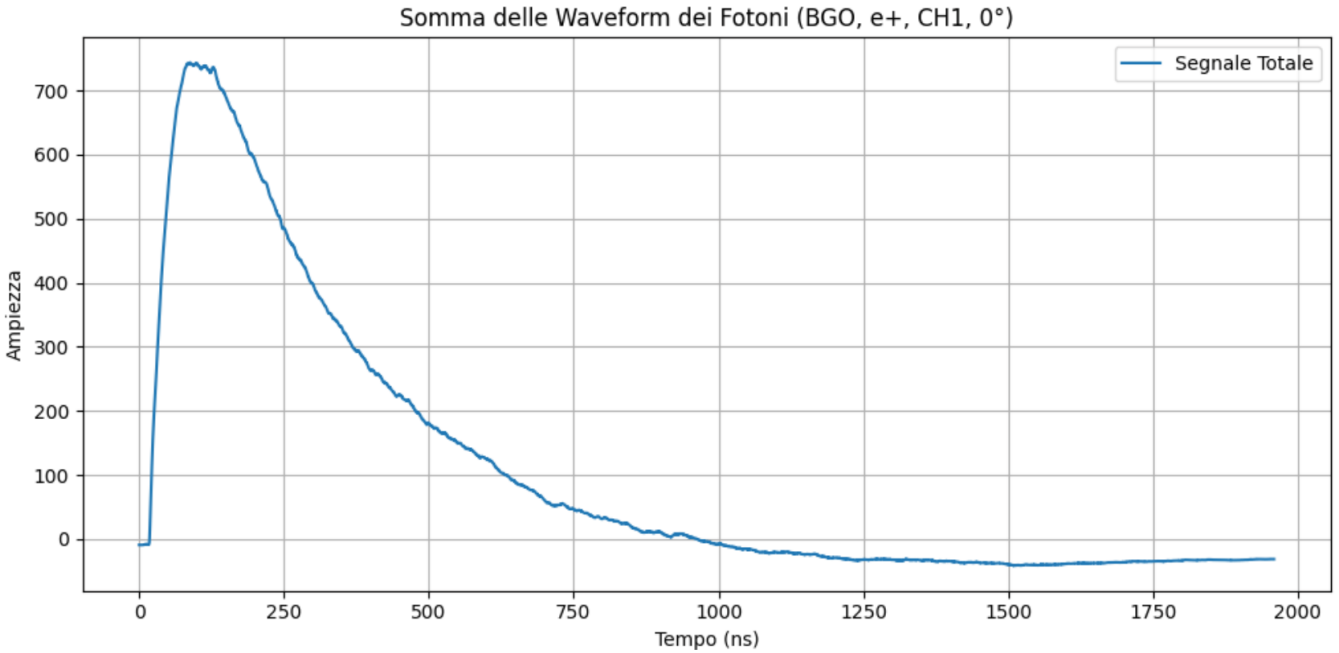

Dati vs Simulazione (CH2)
Dati
Simulazione
Photon Count
Angoli (°)


Rapporto (Dati - Simulazione) / Simulazione (CH1)
Ratio
Angoli (°)


Rapporto (Dati - Simulazione) / Simulazione (CH2)
Ratio
Angoli (°)

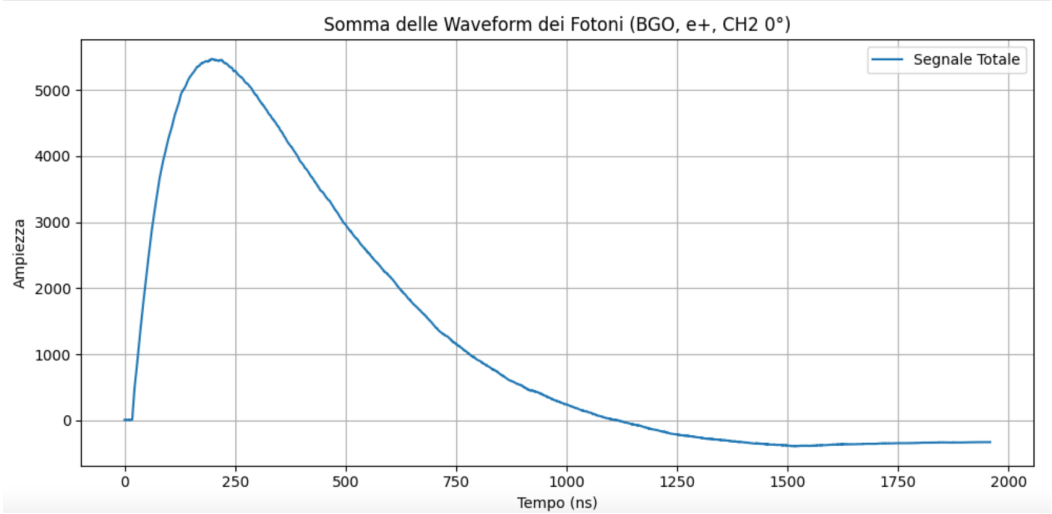
Waveform simulate: BGO CH1

S: 12334
C: 118
D: 2
OC: 123

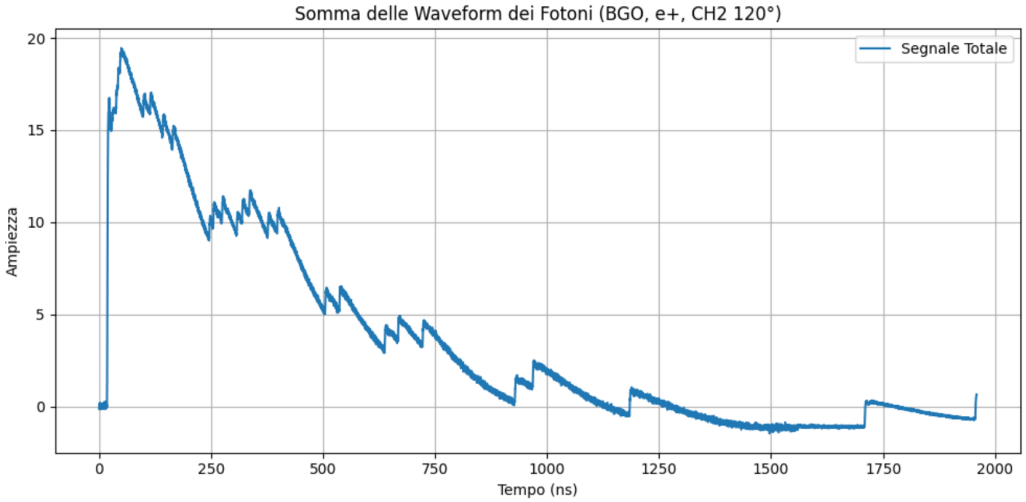


Waveform simulate: BGO CH2

S: 576
C: 35
OC: 19
D: 8

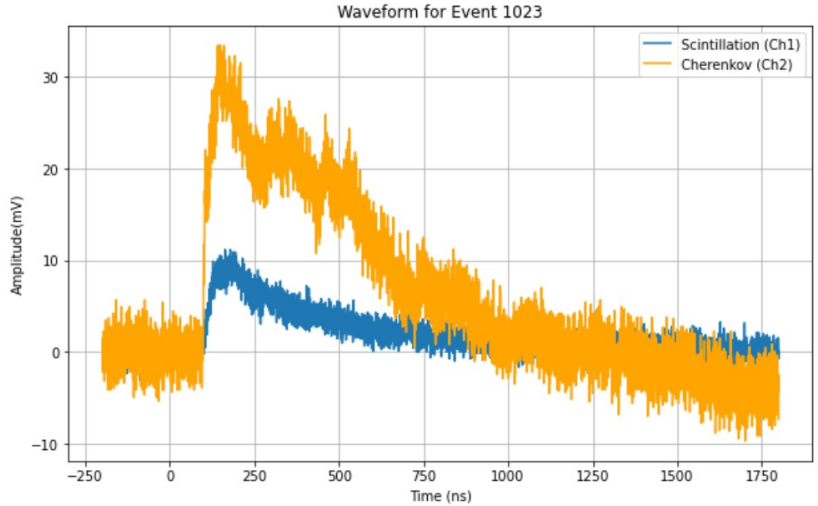


S: 21
C: 12
OC: 1
D: 3

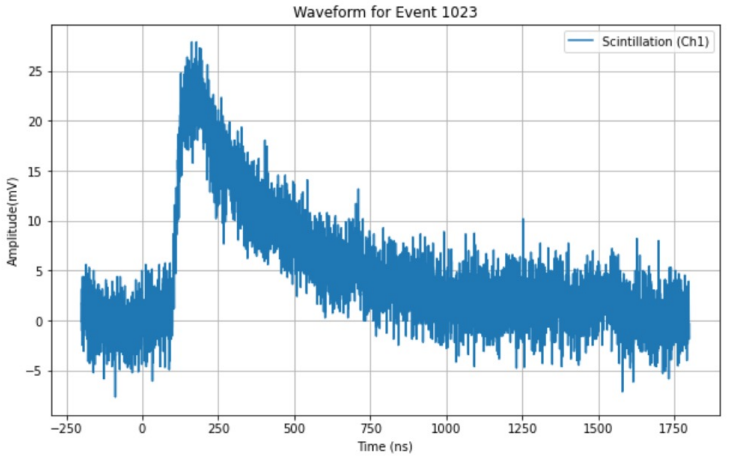


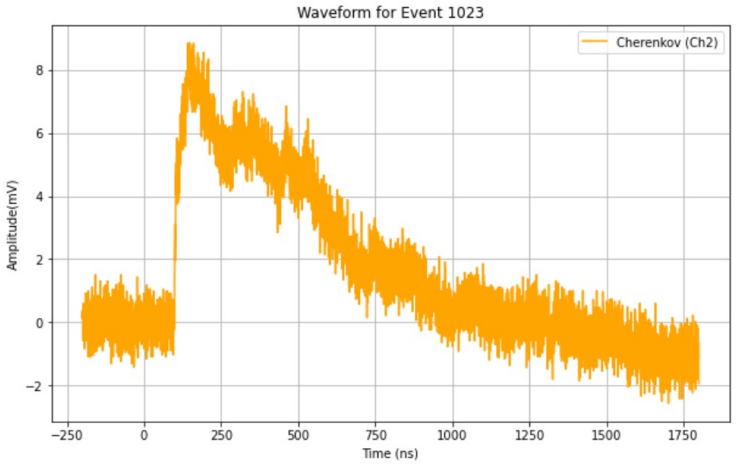
Analisi pochi fotoni: 0°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$



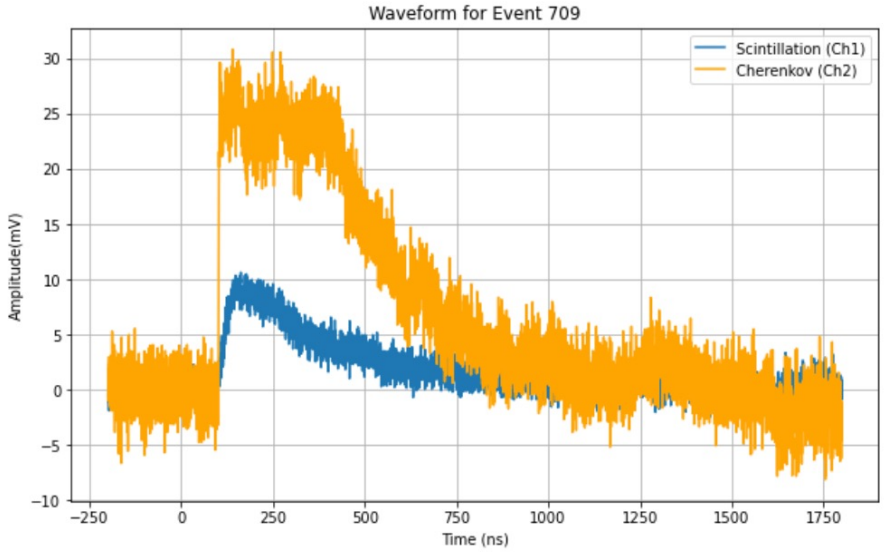

```
Integrale ch1 scintillation:  3649.8039050094617
Integrale ch2 cherenkov:  11822.260198895909
Npe CH1 (integrale):  145.99215620037847
Npe CH2 (integrale):  21.301369727740376
```

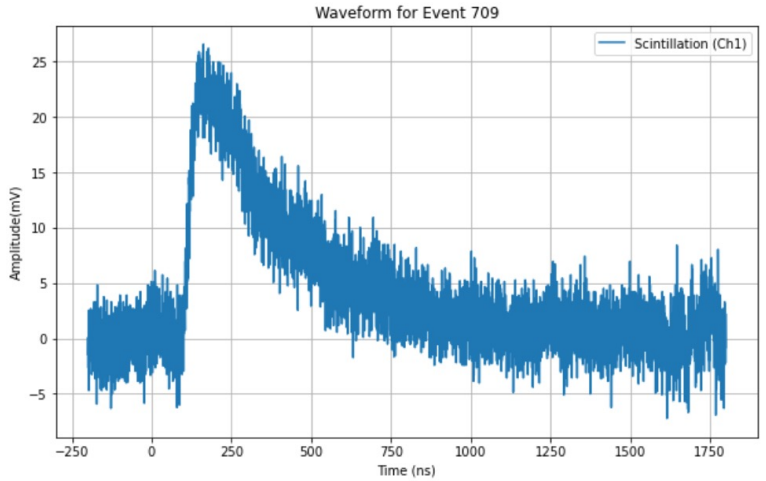


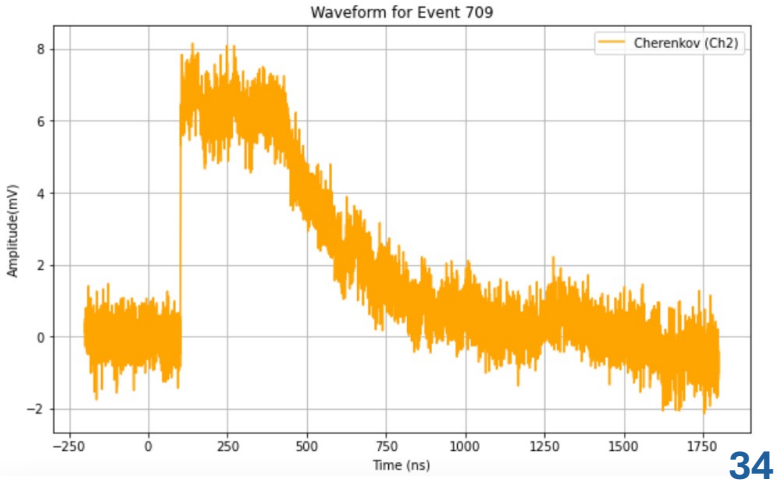


Analisi pochi fotoni: 120°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$



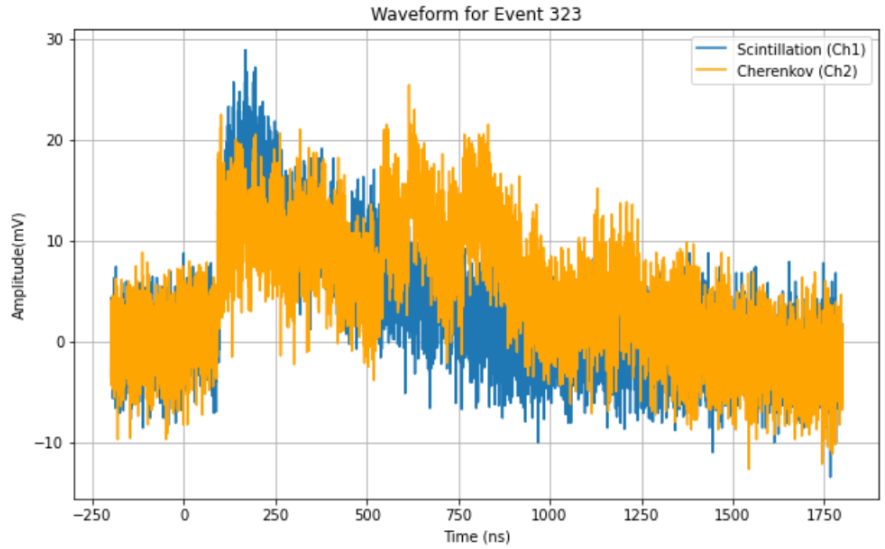




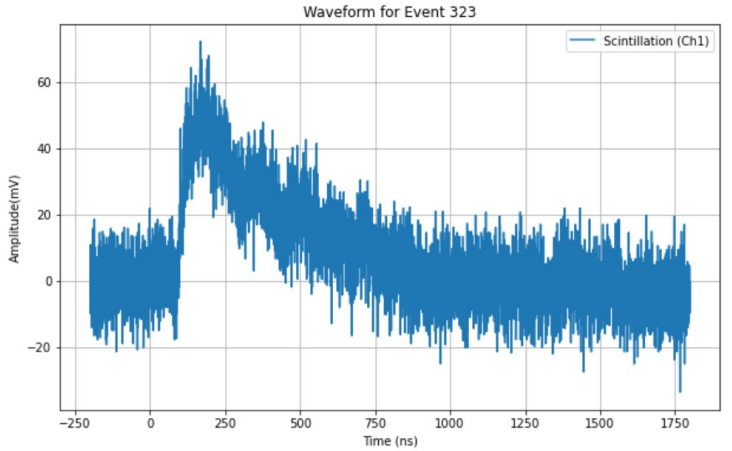

```
Integrale ch1 scintillation:  3314.547439343351
Integrale ch2 cherenkov:  12671.843179322781
Npe CH1 (integrale):  132.58189757373404
Npe CH2 (integrale):  22.83214987265366
```

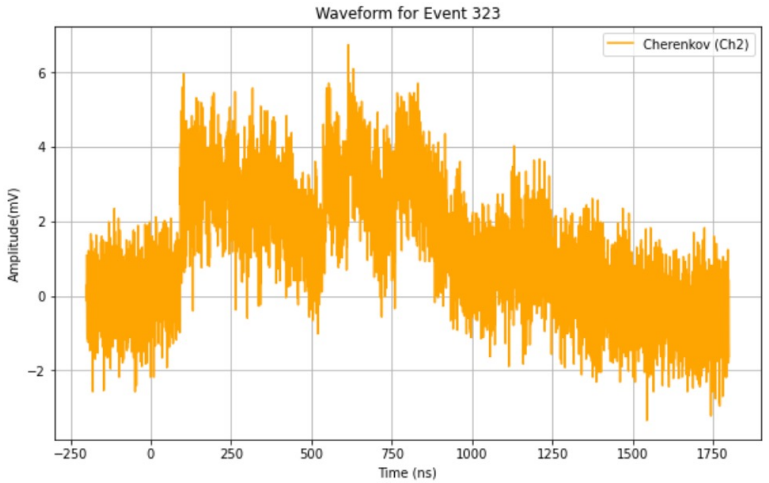
Analisi pochi fotoni: 180°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$



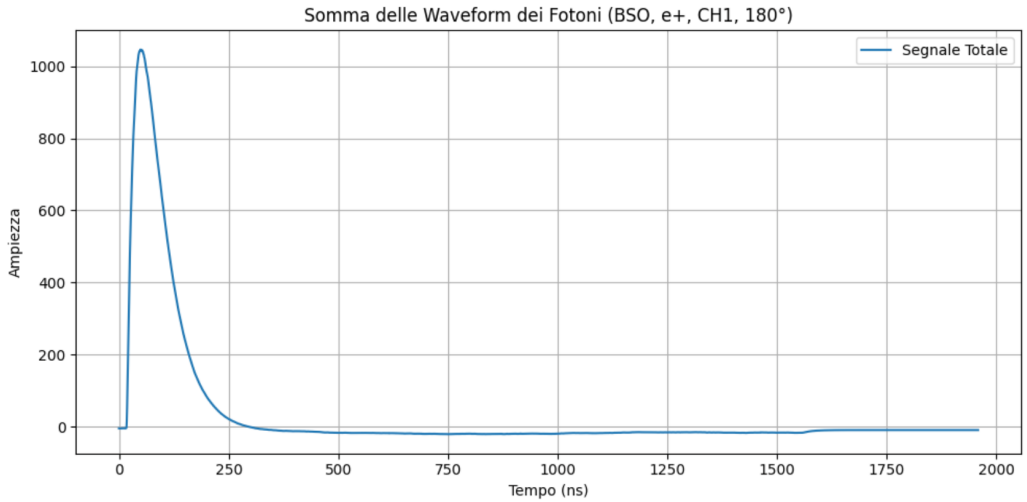

```
Integrale ch1 scintillation:  6174.626776969311
Integrale ch2 cherenkov:  9349.502708513653
Npe CH1 (integrale):  246.98507107877245
Npe CH2 (integrale):  16.845950826150727
```



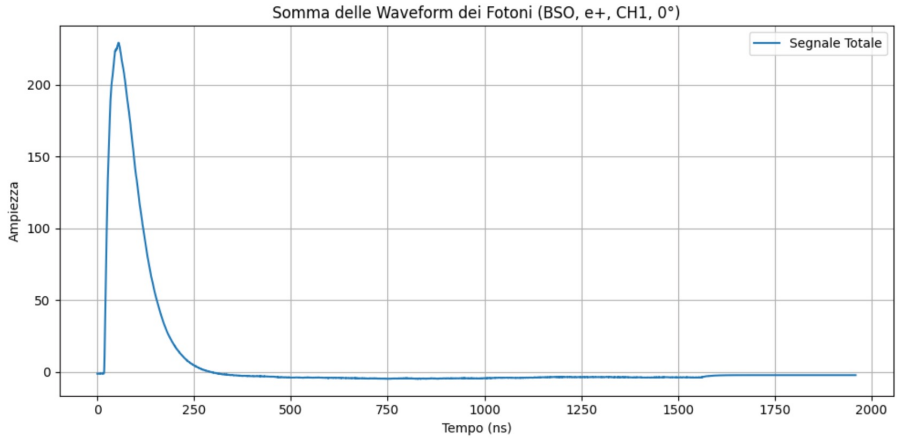


Waveform simulate: BSO CH1

S: 4242
C: 63
OC: 38

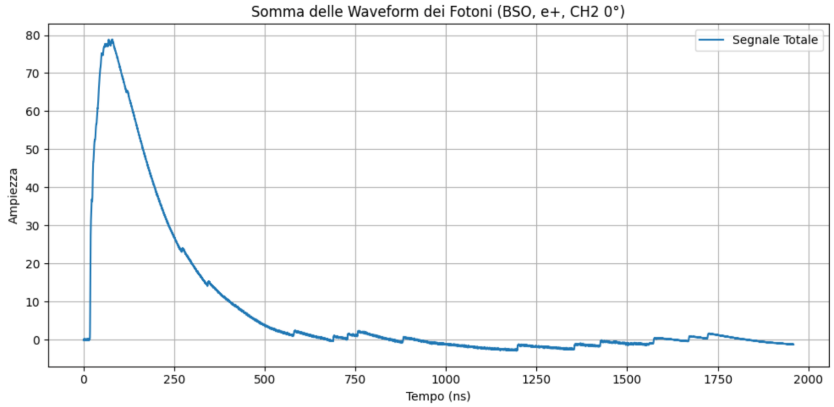


S: 898
C: 44

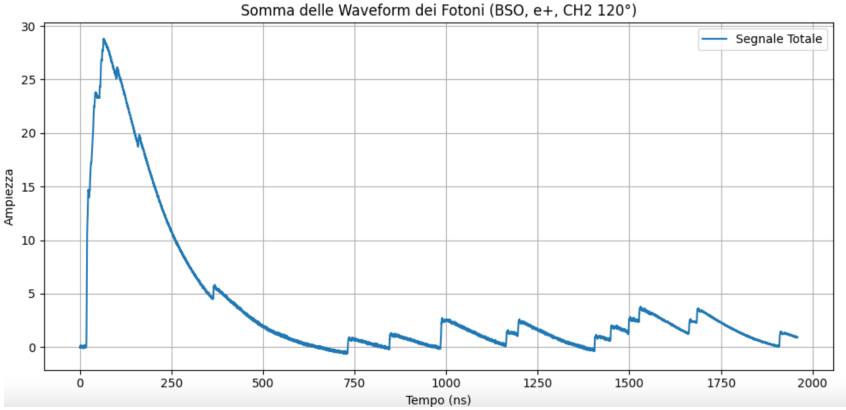


Waveform simulate: BSO CH2

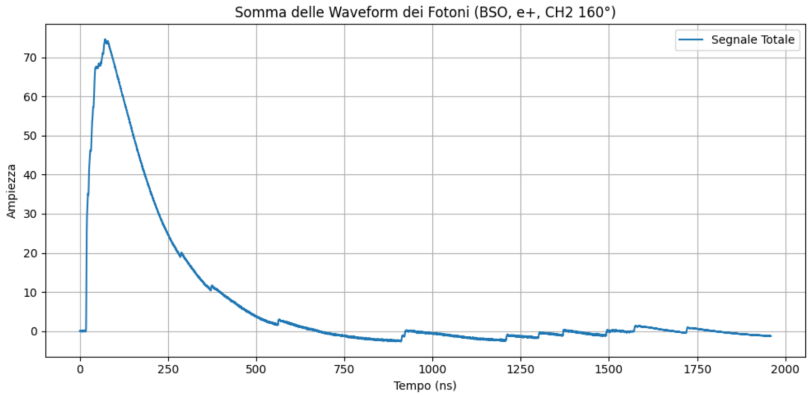
S: 41
C: 22
D: 13
OC: 4



S: 14
C: 9
D: 15

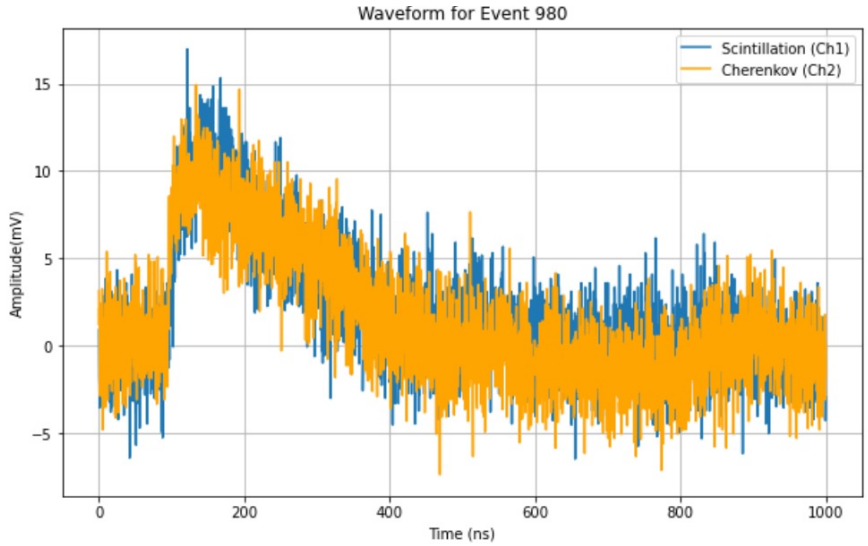


S: 38
C: 21
D: 13
OC: 2

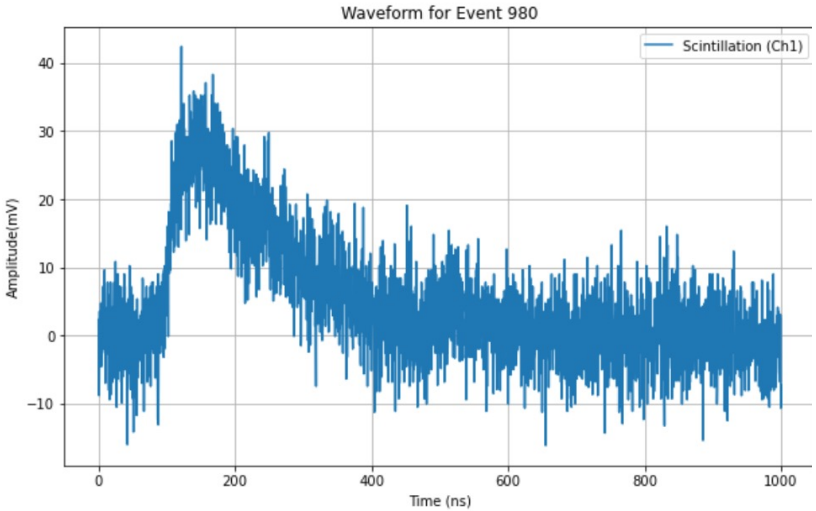


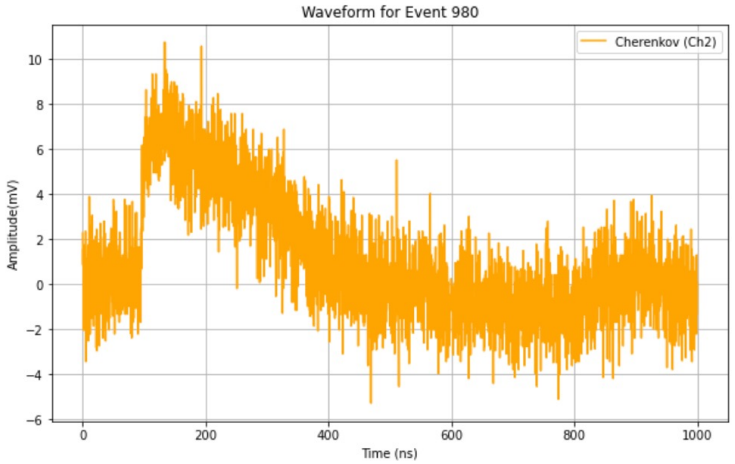
Analisi pochi fotoni: 0°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$



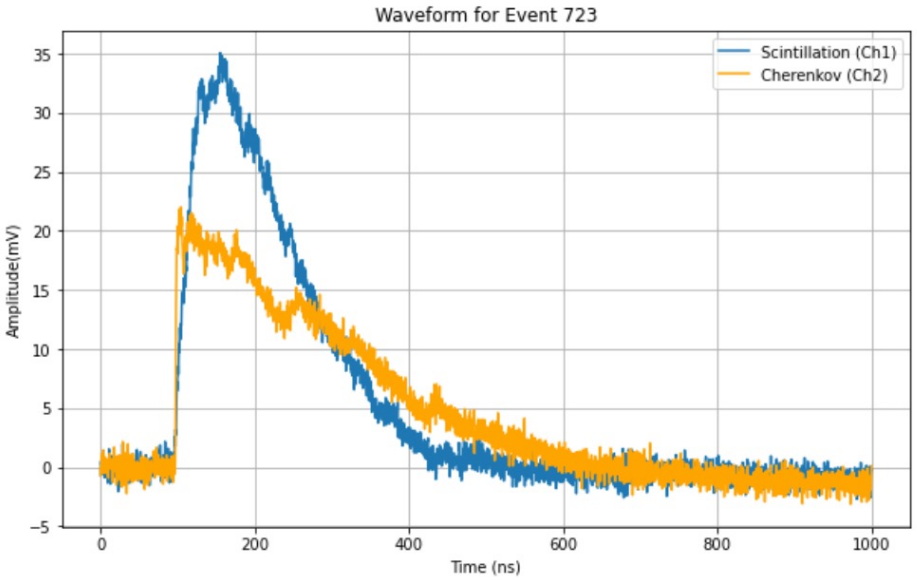

```
Integrale ch1 scintillation:  2008.773023401543
Integrale ch2 cherenkov:  1501.7963061209662
Npe CH1 (integrale):  80.35092093606173
Npe CH2 (integrale):  6.764848225770118
```



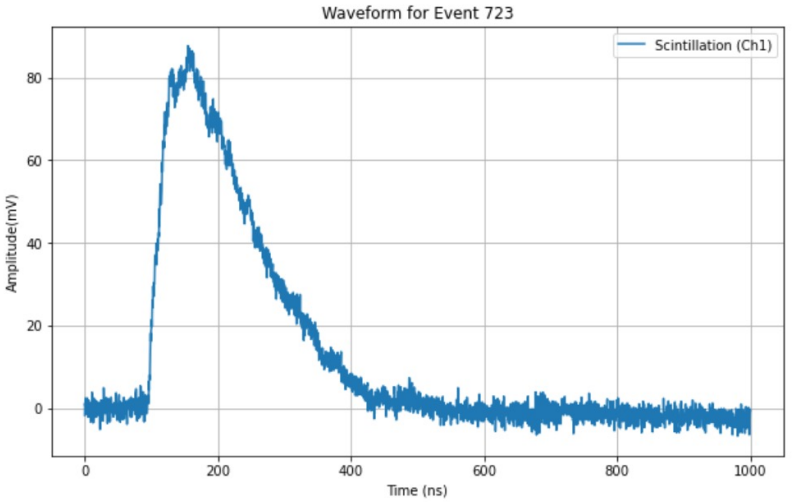


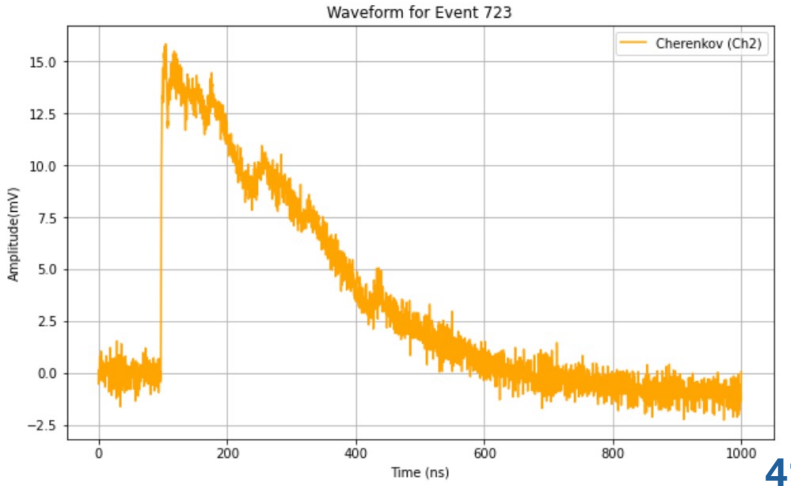
Analisi pochi fotoni: 120°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$



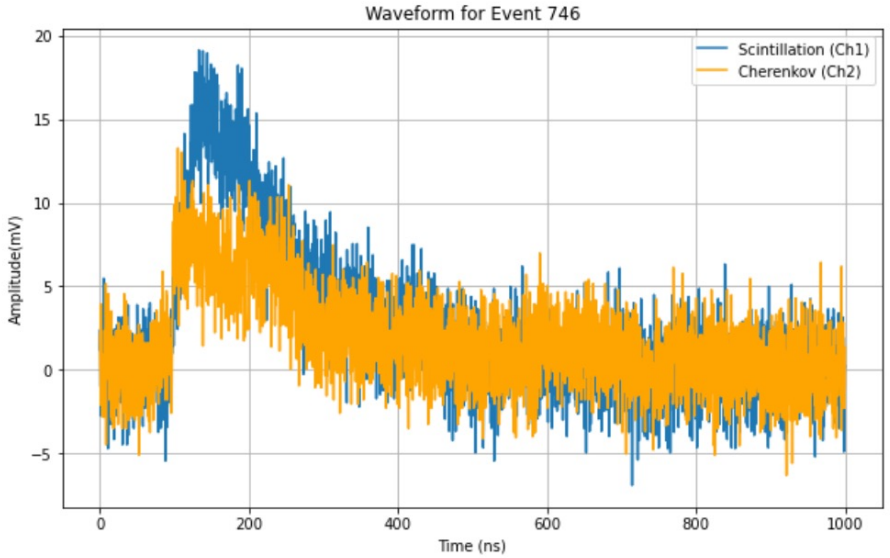

```
Integrale ch1 scintillation:  5154.8931034086945
Integrale ch2 cherenkov:  4397.076350249107
Npe CH1 (integrale):  206.1957241363478
Npe CH2 (integrale):  19.80665022634733
```



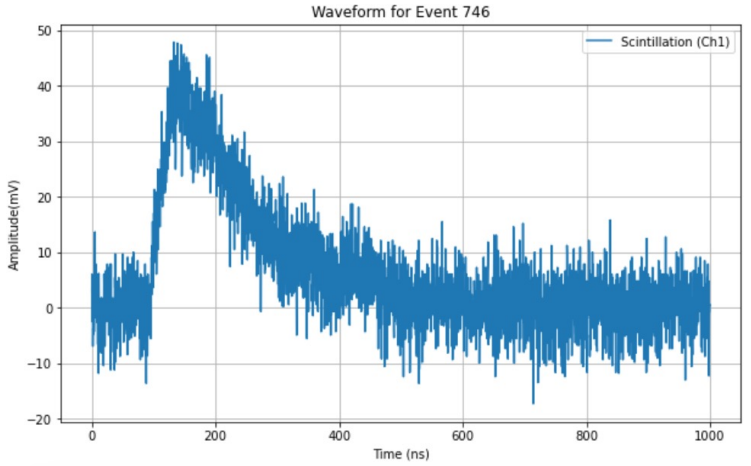


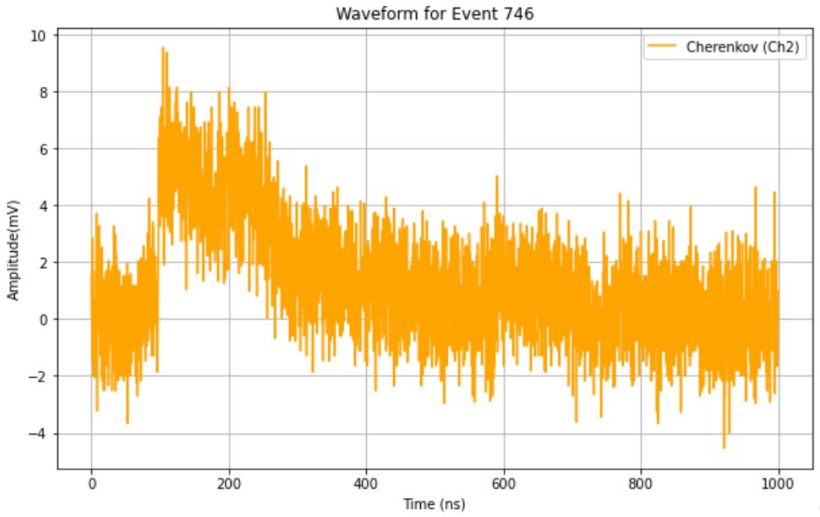
Analisi pochi fotoni: 180°

Wf riscalate con il fattore di ampiezza p_1: $\frac{A[mV]}{p_1\left[\frac{mV}{n_{pe}}\right]} = n_{pe}$




```
Integrale ch1 scintillation:  2667.665425794333
Integrale ch2 cherenkov:  1814.2584987049
Npe CH1 (integrale):  106.7066170317733
Npe CH2 (integrale):  8.1723355797518
```





PWO: μ^+ 120 GeV

PWO: μ^+ 120 GeV

Simulazione: CH1

Nph	0°	1°	2°	3°	4°	5°	175°	177°	180°	183°	185°
N_{tot}	68	53	66	56	42	32	19	29	32	26	19

Dati: CH1

N_{CH1}	55	45	47	47	48	47	34	40	54	50	46

Pre- Amp Gain: 28

Simulazione: CH2

Nph	0°	1°	2°	3°	4°	5°	175°	177°	180°	183°	185°
N_{tot}	13	13	13	13	13	13	16	18	22	17	14

Dati: CH2

N_{CH1}	1	0.6	0.6	1	1	1	0.6	0.6	1	1	1

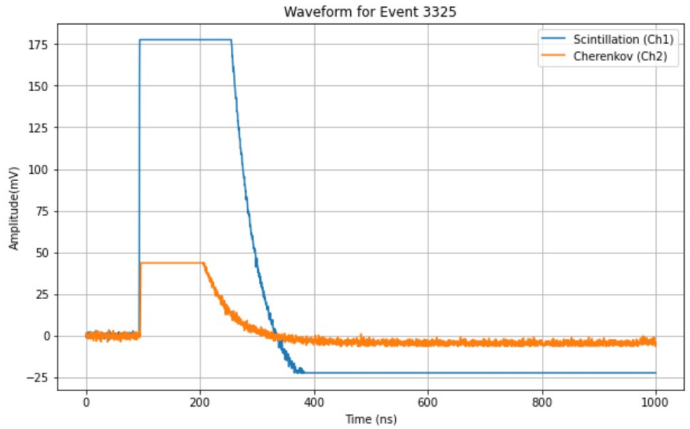
Pre- Amp Gain: 28

PWO: μ^+ 120 GeV, CH2

Nph	0°	1°	2°	3°	4°	5°	175°	177°	180°	183°	185°
N_{DATI}	1	0.6	0.6	1	1	1	0.6	0.6	1	1	1

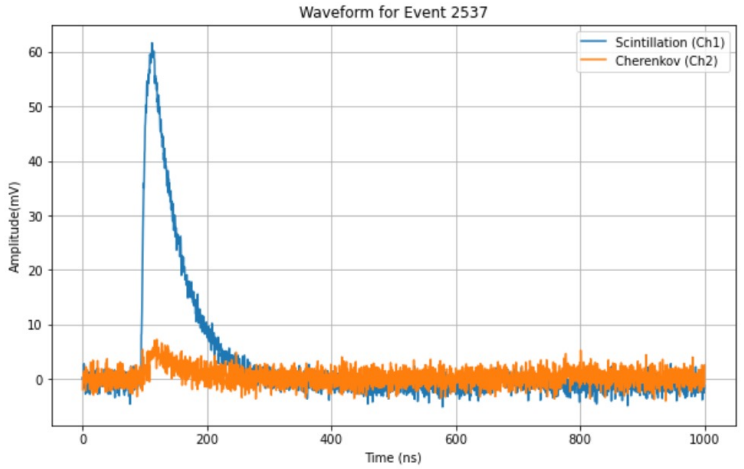
Il motivo per cui sono così pochi i fotoni nel canale 2 misurati sta nel fatto che le wf relative ad un maggior numero di fotoni nel CH2 corrispondono ad eventi che saturano il CH1, e che quindi vengono scartati.
Esempi:

Evento scartato




```
Integrale ch1 scintillation:  19288.139970407992
Integrale ch2 cherenkov:  3654.0089612595993
Npe CH1 (integrale):  771.5255988163196
Npe CH2 (integrale):  6.583799930197476
```

Evento preso (4mila su 5mila sono eventi così)




```
Integrale ch1 scintillation:  2951.0678330180294
Integrale ch2 cherenkov:  473.53665275949487
Npe CH1 (integrale):  118.04271332072118
Npe CH2 (integrale):  0.853219194161252
```

Grafici, PWO: μ^+ 120 GeV