Update of ECAL barrel beam background simulation

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Update of **Input Rate**

Background	Rate/Hz	$N_{MCParticle}$ / 0.5 μs time window
Pair production	---	~ 150
Beam-Gas Bremsstrahlung (BGB)	**49,181,897.5**	~ 25
Beam-Gas Coulomb (BGC)	**636,290,798.6**	~ 318
Beam Thermal Photon Scattering (BTH)	**200,960,378.6**	~ 100
Synchrotron Radiation	---	---
Radiative Bhabha	---	---
Touschek	---	---

Background	Rate/Hz	$N_{MCParticle}$ / 0.5 μs time window
Pair production	---	~ 150
Beam-Gas Bremsstrahlung (BGB)	**83,280.65**	~ 0.04
Beam-Gas Coulomb (BGC)	**884,002.12**	~ 0.44
Beam Thermal Photon Scattering (BTH)	**623,520.09**	~ 0.31
Synchrotron Radiation	---	---
Radiative Bhabha	---	---
Touschek	---	---

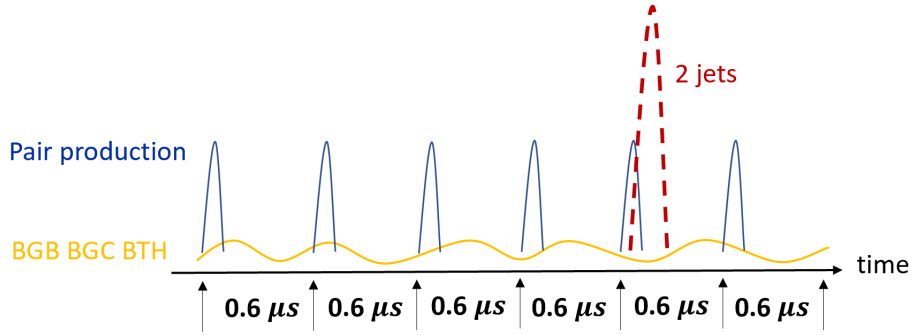
- Update of **Input Rate**:
  - missing interaction region loss
    - lost rate in old version is full ring (100km)
    - lost rate in new version is IR (+-7m)
  - update of beam lifetime
- Pair production is dominant

Update of **Time Window**

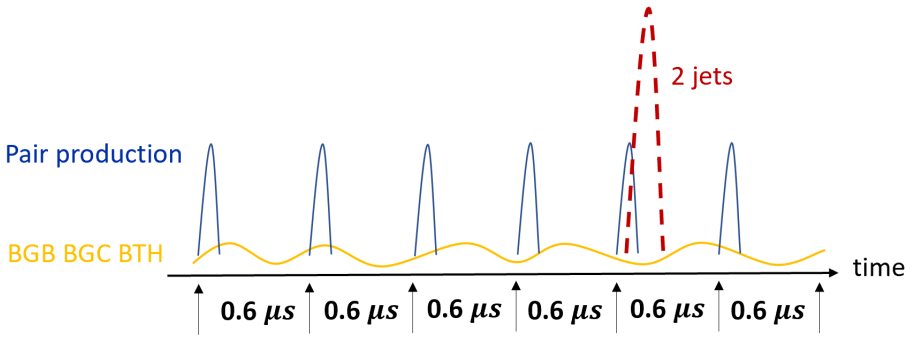
Background	Rate/Hz	$N_{MCParticle}$ / 0.5 μs time window
Pair production	---	~ 150
Beam-Gas Bremsstrahlung (BGB)	**83,280.65**	~ 0.04
Beam-Gas Coulomb (BGC)	**884,002.12**	~ 0.44
Beam Thermal Photon Scattering (BTH)	**623,520.09**	~ 0.31
Synchrotron Radiation	---	---
Radiative Bhabha	---	---
Touschek	---	---

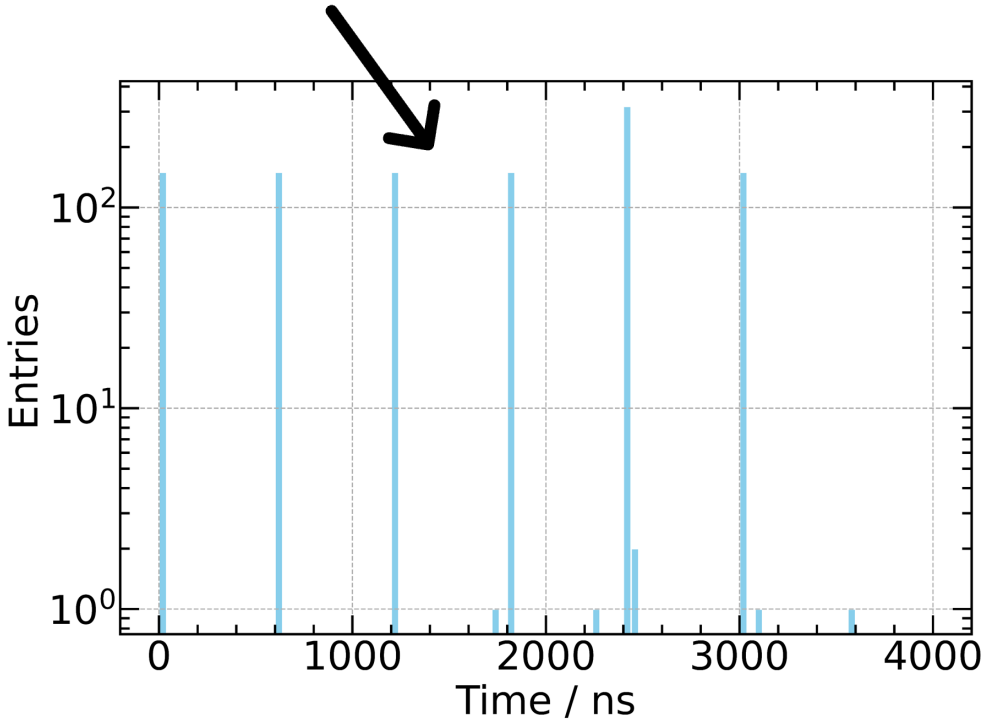
Background	Rate/Hz	$N_{MCParticle}$ / 3.6 μs time window
Pair production	---	~ 900
Beam-Gas Bremsstrahlung (BGB)	**83,280.65**	~ 0.30
Beam-Gas Coulomb (BGC)	**884,002.12**	~ 3.18
Beam Thermal Photon Scattering (BTH)	**623,520.09**	~ 2.24
Synchrotron Radiation	---	---
Radiative Bhabha	---	---
Touschek	---	---

- **Use 6 bunches as a unit to study the time structure:**
  - 1 physics event ee->ZH->vvjj
  - 6 pair production events
  - BGB+BGC+BTH with rate x time (3.6 us).



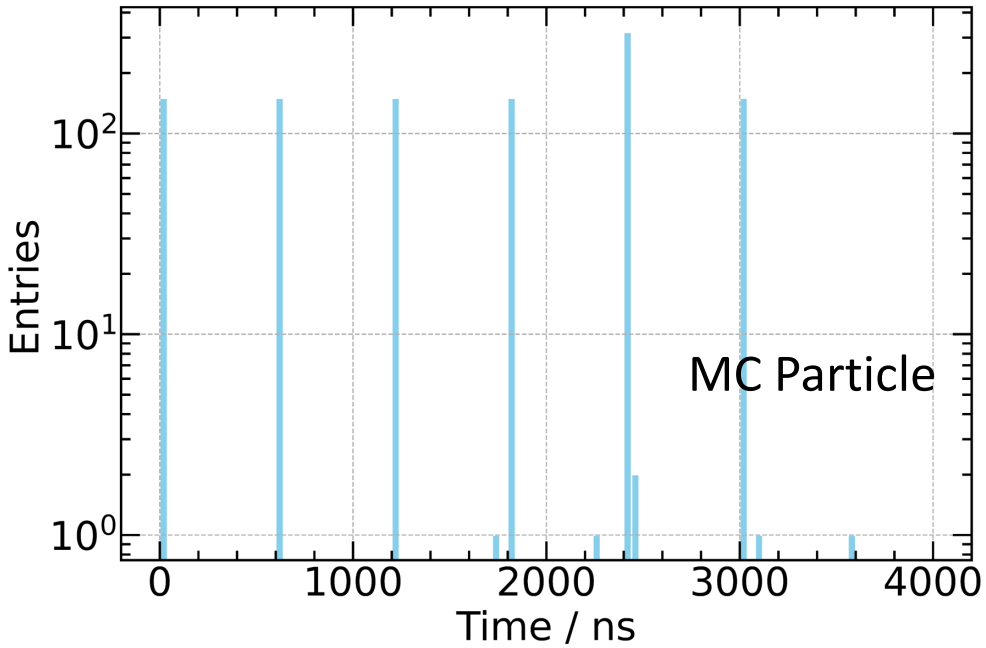
Beam background simulation



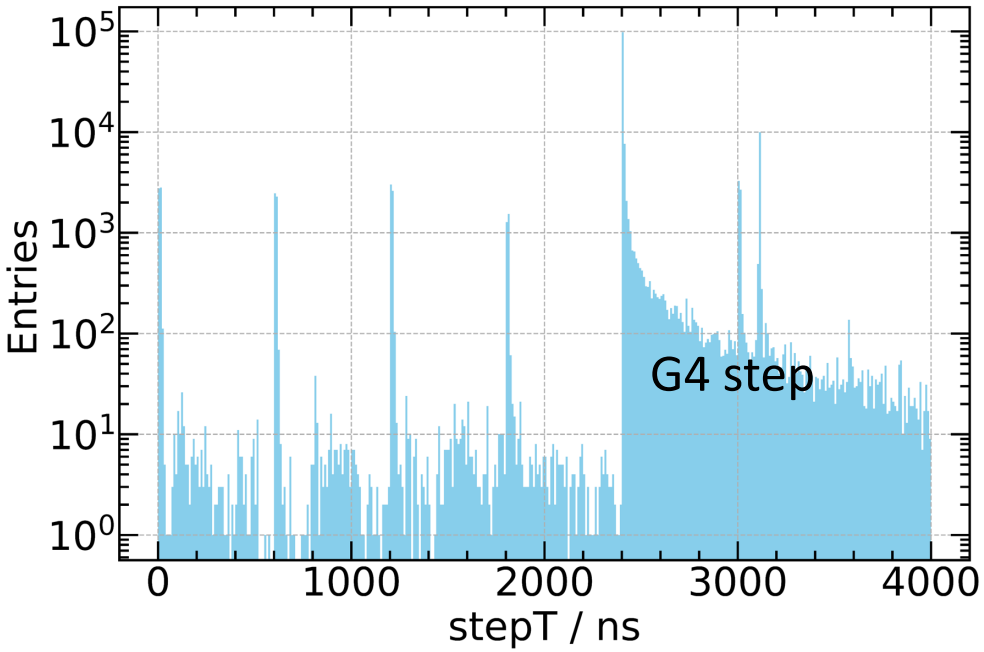


- **Higgs mode**:
  - pair production: double beams, but all e-
  - BG: single beam
- Using **4 types** of beam backgrounds.
- 1 event: **3.6 us** time window.
- Simulation of **barrel** long crystal bar ECAL.

Time structure study



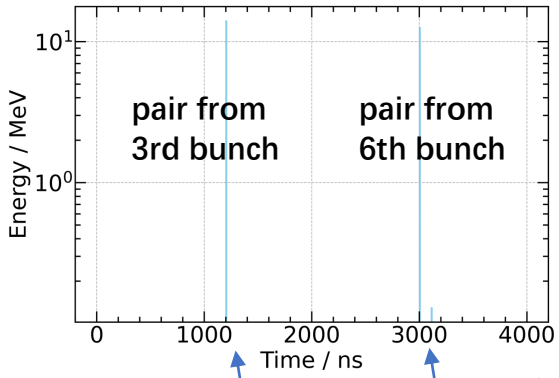
detector simulation



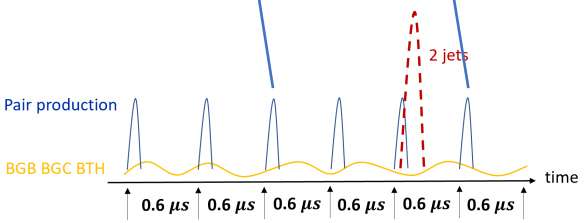
Time structure study

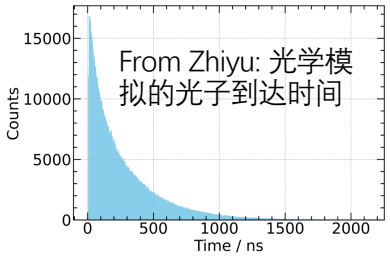
single crystal bar

step (E, T)

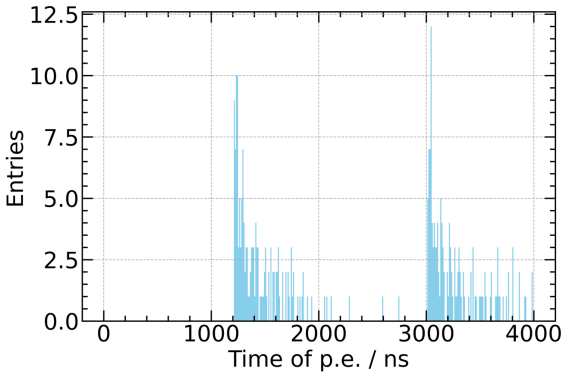


step (E, T)





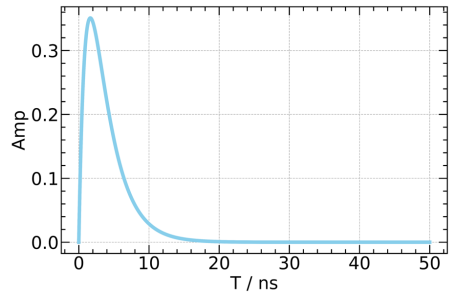
对每个p.e.：抽样得到BGO发光+传输时间



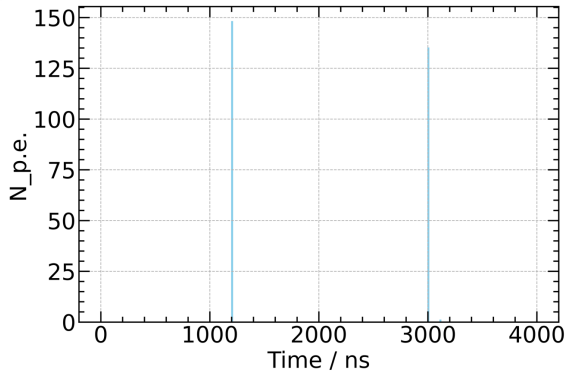
$$A(t) = A_0 \cdot (1 - e^{-\frac{t}{\tau_{dis}}}) \cdot e^{-\frac{t}{\tau_{rec}}}$$

Table 6. Waveform parameters for various SiPMs

SiPM	HPK S13360-6025PE	HPK S14160-3010PS	NDL EQR06 11-3030D-S
τ_1 (ns)	1.91	1.58	1.66
τ_2 (ns)	74.64	34.22	2.82

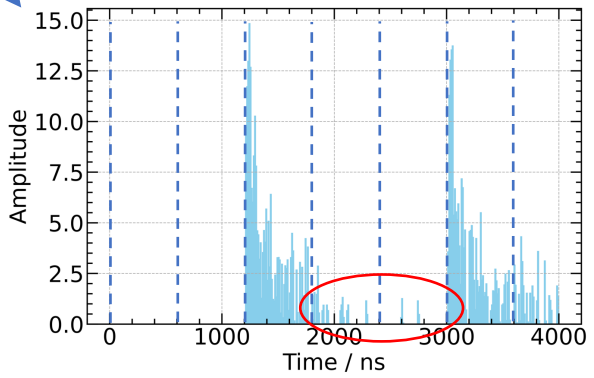


考虑电子学响应时间：
激光实测+参数化



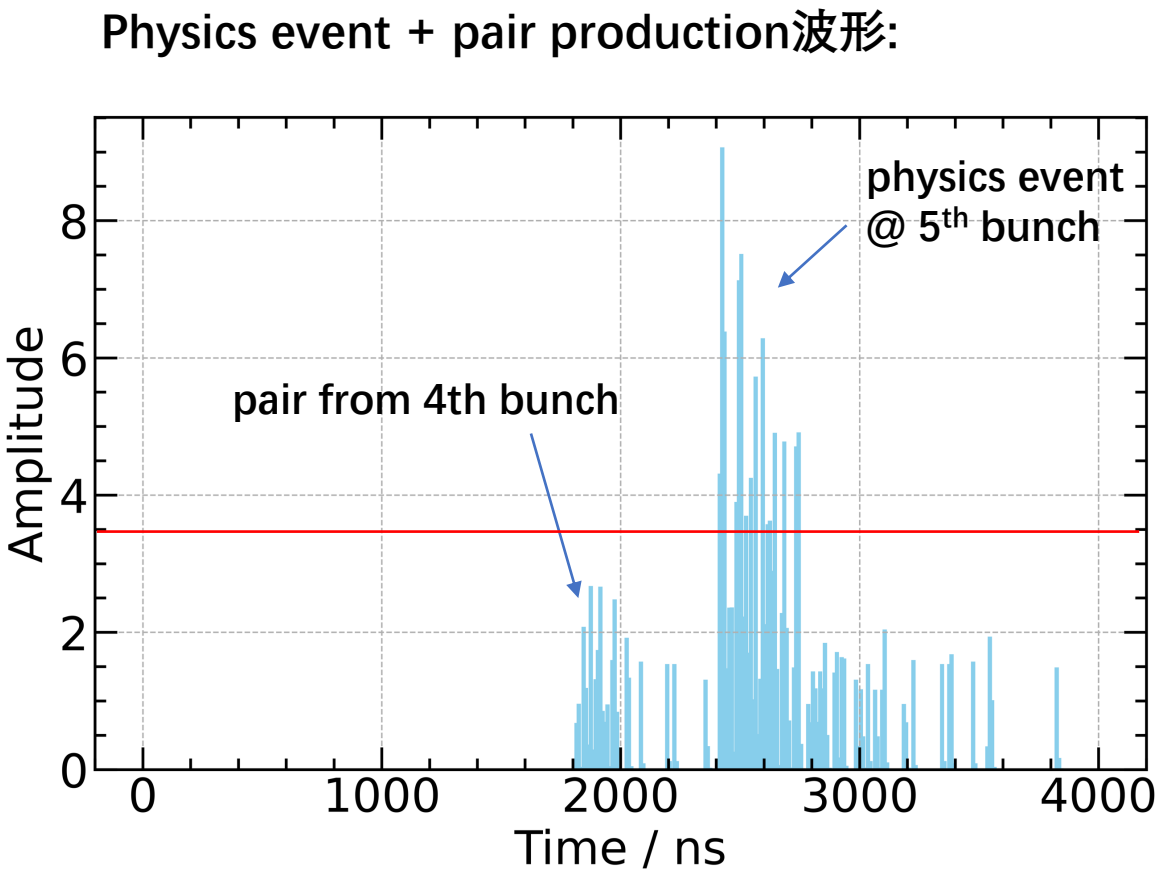
Detected Np.e. in SiPM
1 MIP ~ 100 p.e.

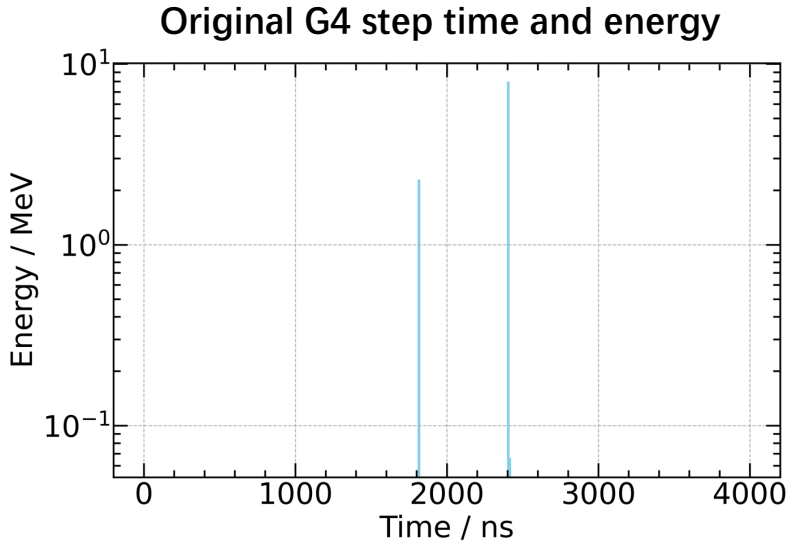
单晶体条波形模拟
2 pair production事例



minor pile up exist

Time structure study

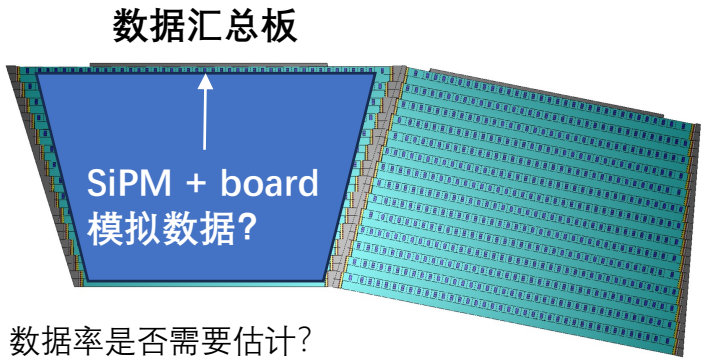




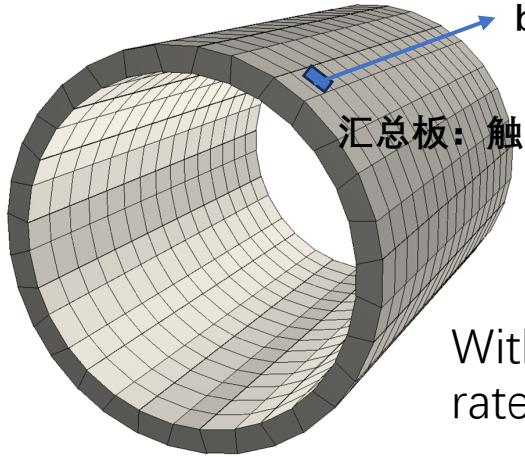
trigger threshold? -> readout unit design?

Event rate estimation

- SiPM ⟶ Readout unit + ASIC ⟶ back end



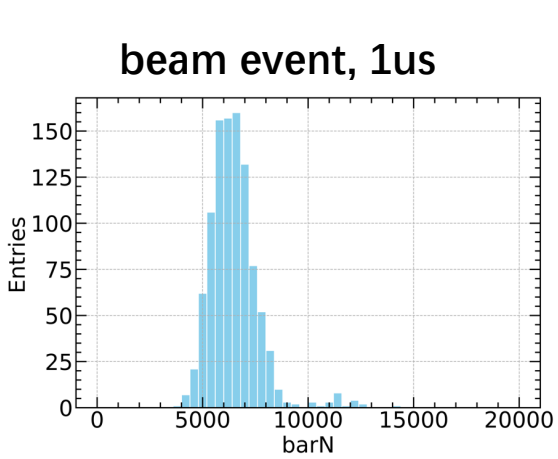
数据率是否需要估计?

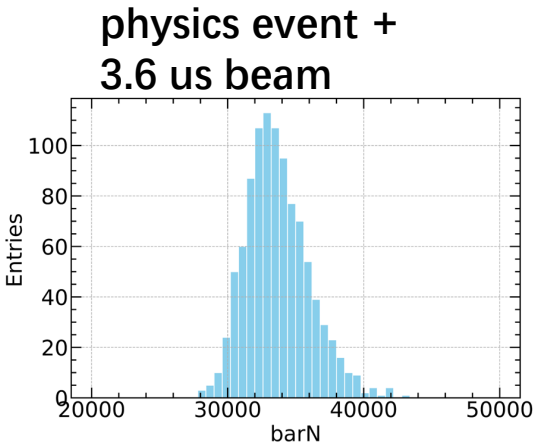


With reasonable trigger threshold:
rate ~ physics rate (<100 Hz)

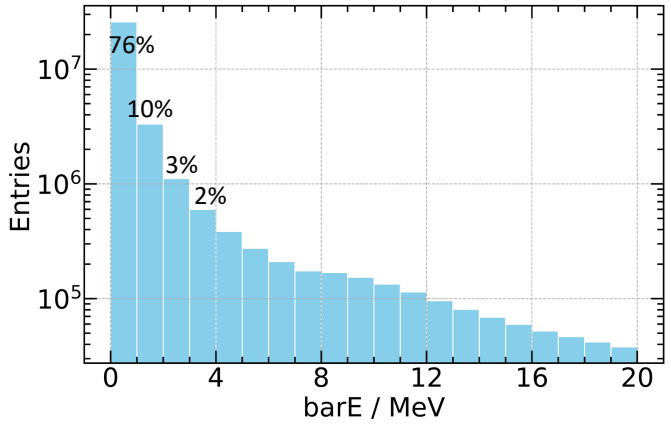
Event rate estimation

- No threshold + 1 us readout time window:
  - Rate = 1 MHz, Nbars < 10k,
  - data size 10 MHz * 10k bar * 2 ch/bar * 32 bit/ch = 80 GB/s.





- Threshold ~2 MIP:
  - Rate = 1 MHz, Nbar ~ 1k,
  - data size 8 GB/s



- With high enough threshold:
  - Rate < 100 Hz, Nbars < 50k,
  - data size 40 MB/s

Backup

Count

- There are 1000 events in total.