Search for magnetic monopoles in IceCube via luminescence light

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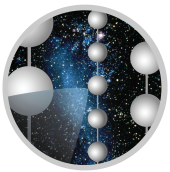
October 10th, 2016



IceCube
South Pole Neutrino Observatory

BERGISCHE
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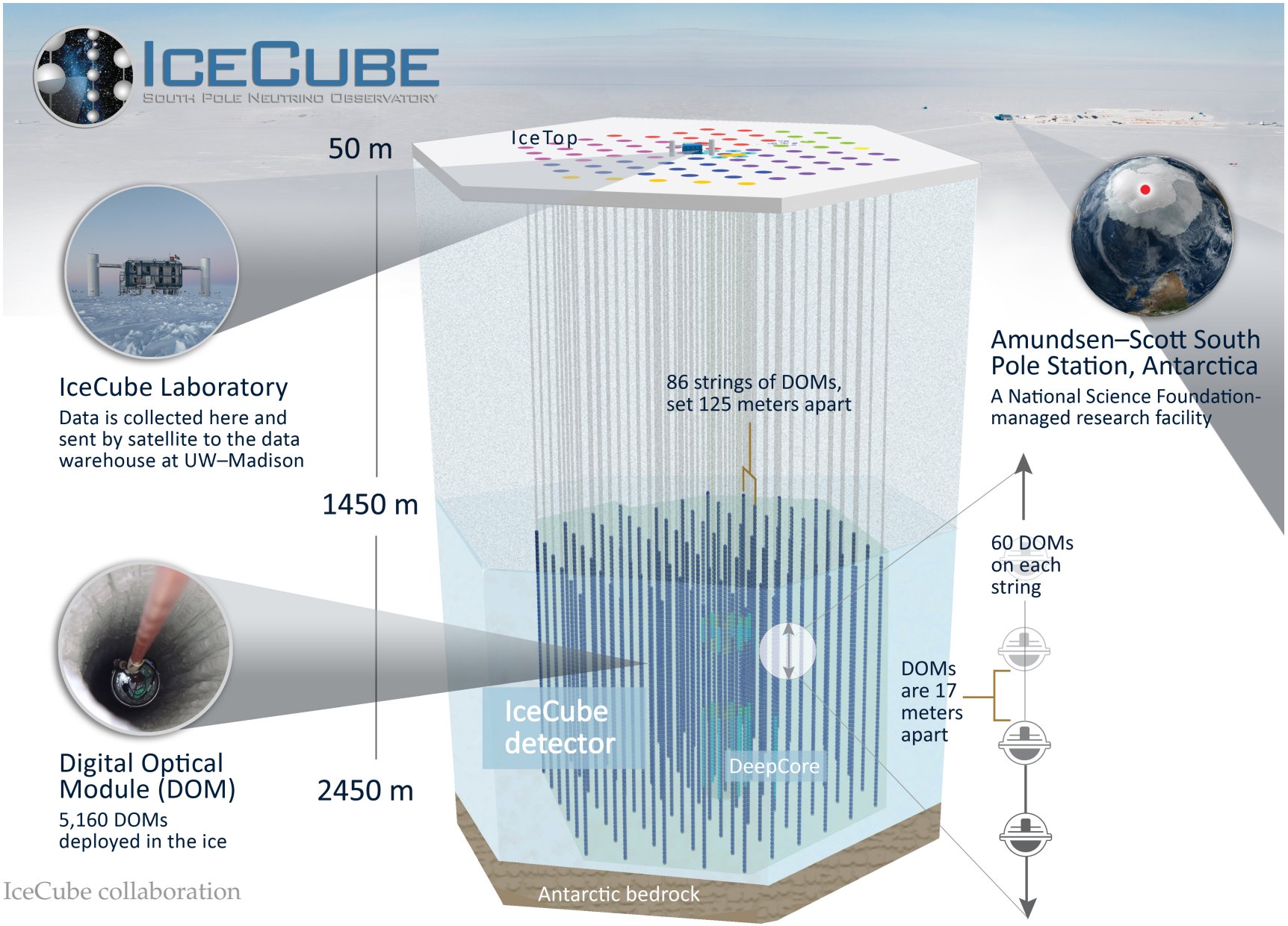
bmb+f - Förderschwerpunkt
Astroteilchenphysik
Großgeräte der physikalischen Grundlagenforschung

IceCube



IceCube collaboration

Monopoles

Maxwell: 1864

$$\vec{\nabla} \cdot \vec{D} = \rho_e$$
$$\vec{\nabla} \cdot \vec{B} = \rho_m$$
$$-\vec{\nabla} \times \vec{E} = \vec{j}_m + \frac{\partial \vec{B}}{\partial t}$$
$$\vec{\nabla} \times \vec{H} = \vec{j}_e + \frac{\partial \vec{D}}{\partial t}$$

Dirac: 1931

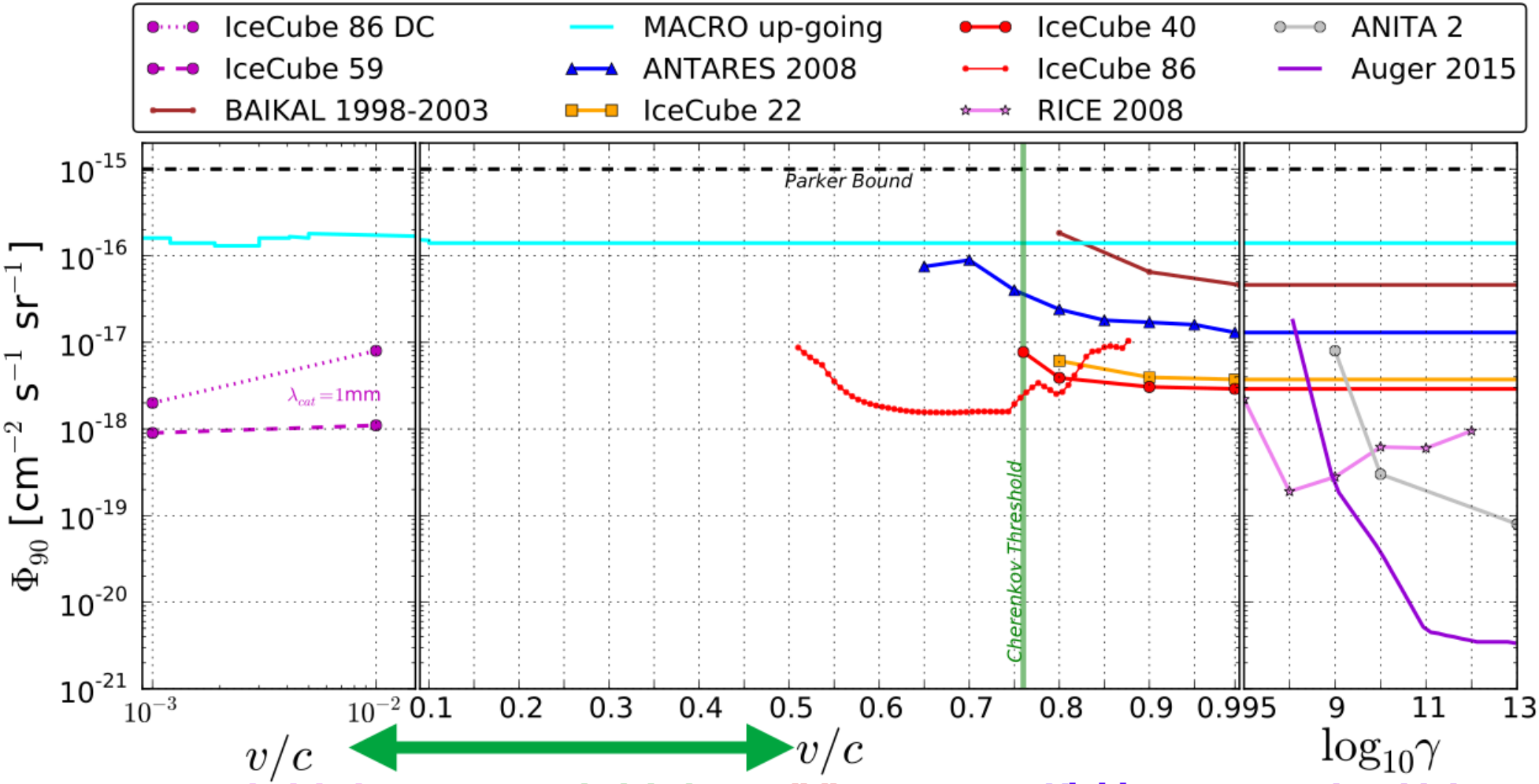
Electric charge quantization

$$e = \sqrt{\hbar c \alpha}$$

results in a magnetic charge g

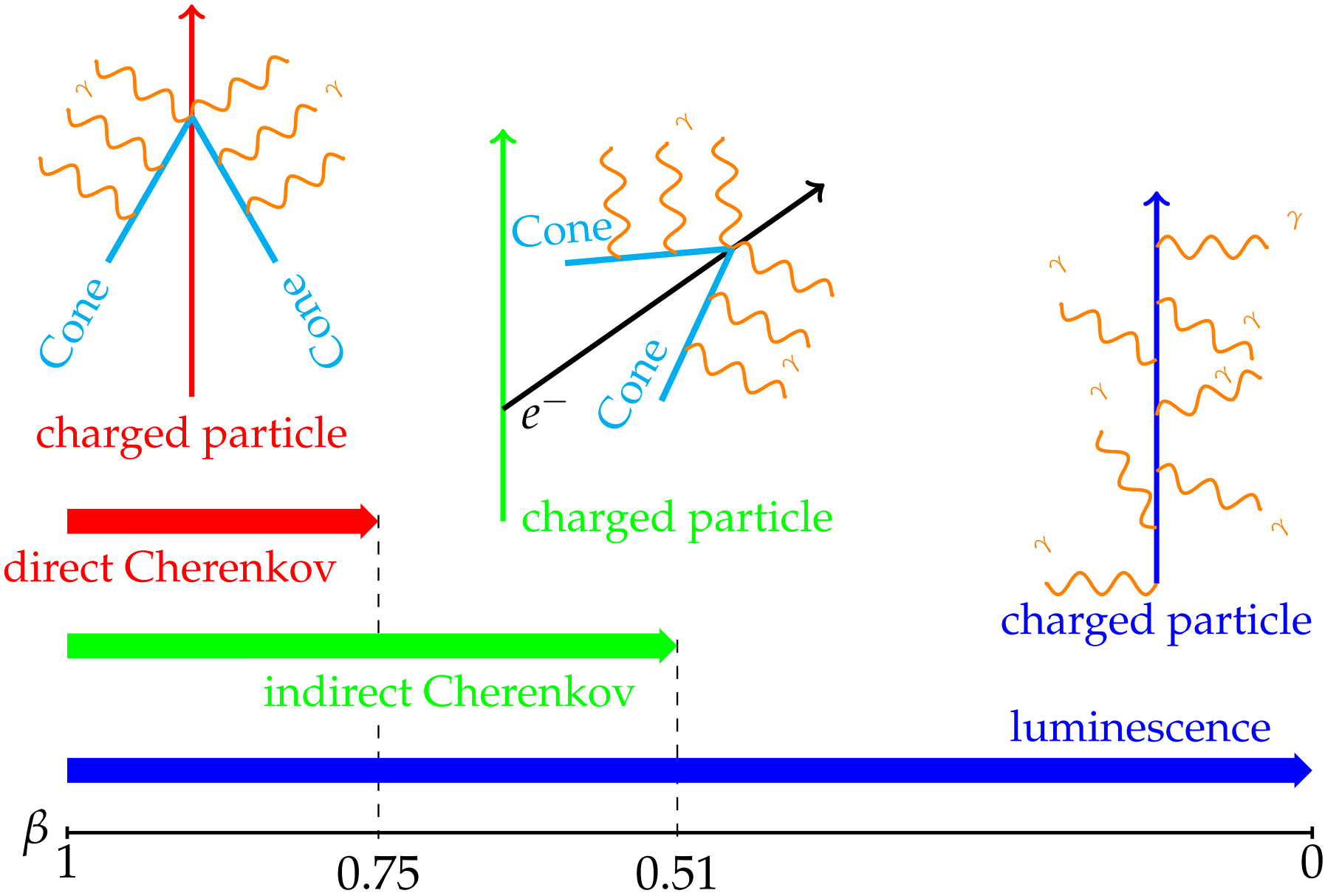
$$g = k\frac{e}{2\alpha} \approx 68 \cdot e$$

Previous searches



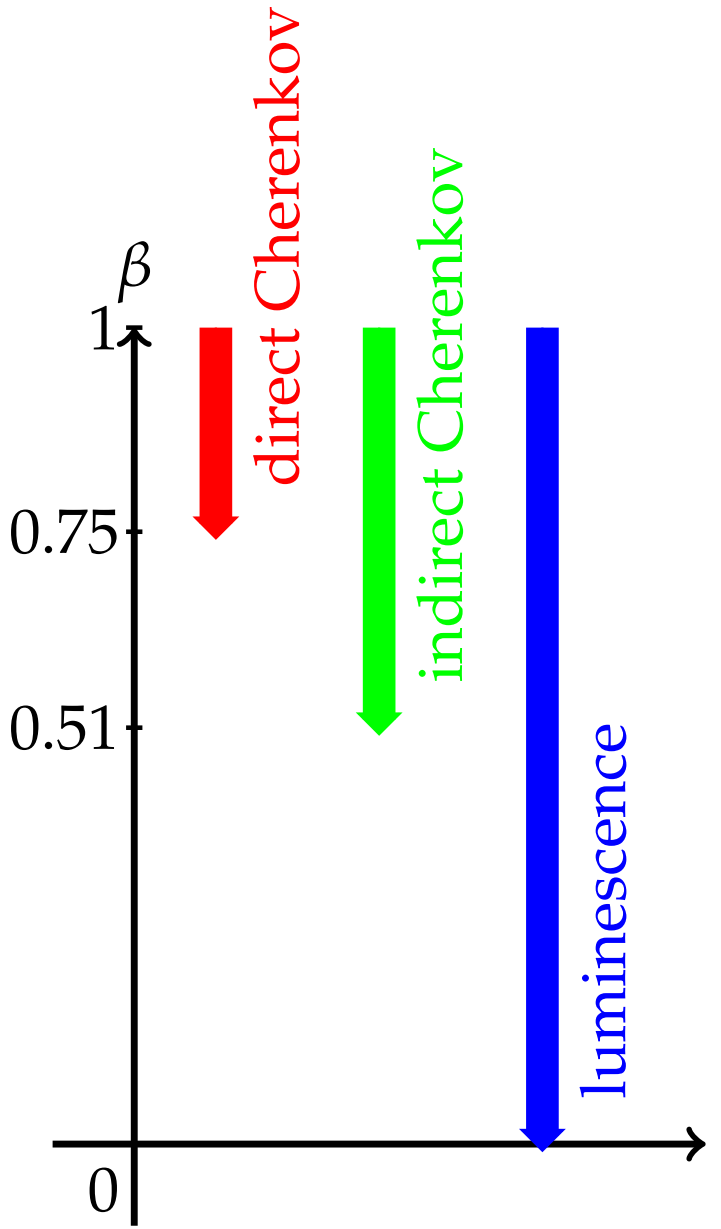
A. Pollmann (born Obertacke)

Light production mechanisms



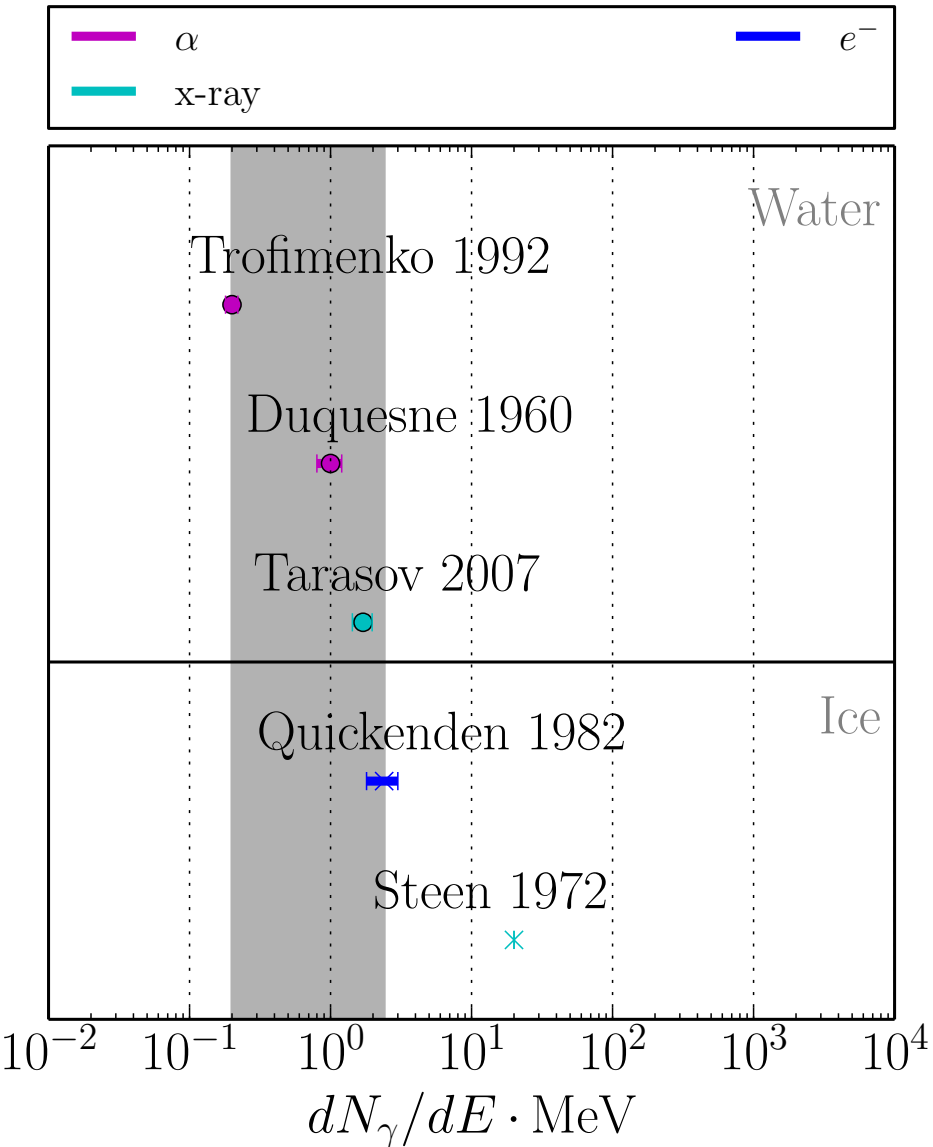
Why luminescence?

- light emission due to excitation of medium
- light yield $\propto \frac{dE}{dx} \propto Z^2 \Rightarrow$ good for high charge particles like monopoles!
- new detection method for particles with $\beta < 0.51\,c$ for IceCube!



Problems?

- wide range of efficiencies
  $\frac{dN_\gamma}{dE} = 0.2\,/\mathrm{MeV} \ldots 2.4\,/\mathrm{MeV}$
- multiple decay times
  $\tau = 1\,\mathrm{ns} \ldots 2000\,\mathrm{ns}$
- temperature dependent
- highly impurity dependent



based on A. Pollmann (born Obertacke)

Luminescence in simulation

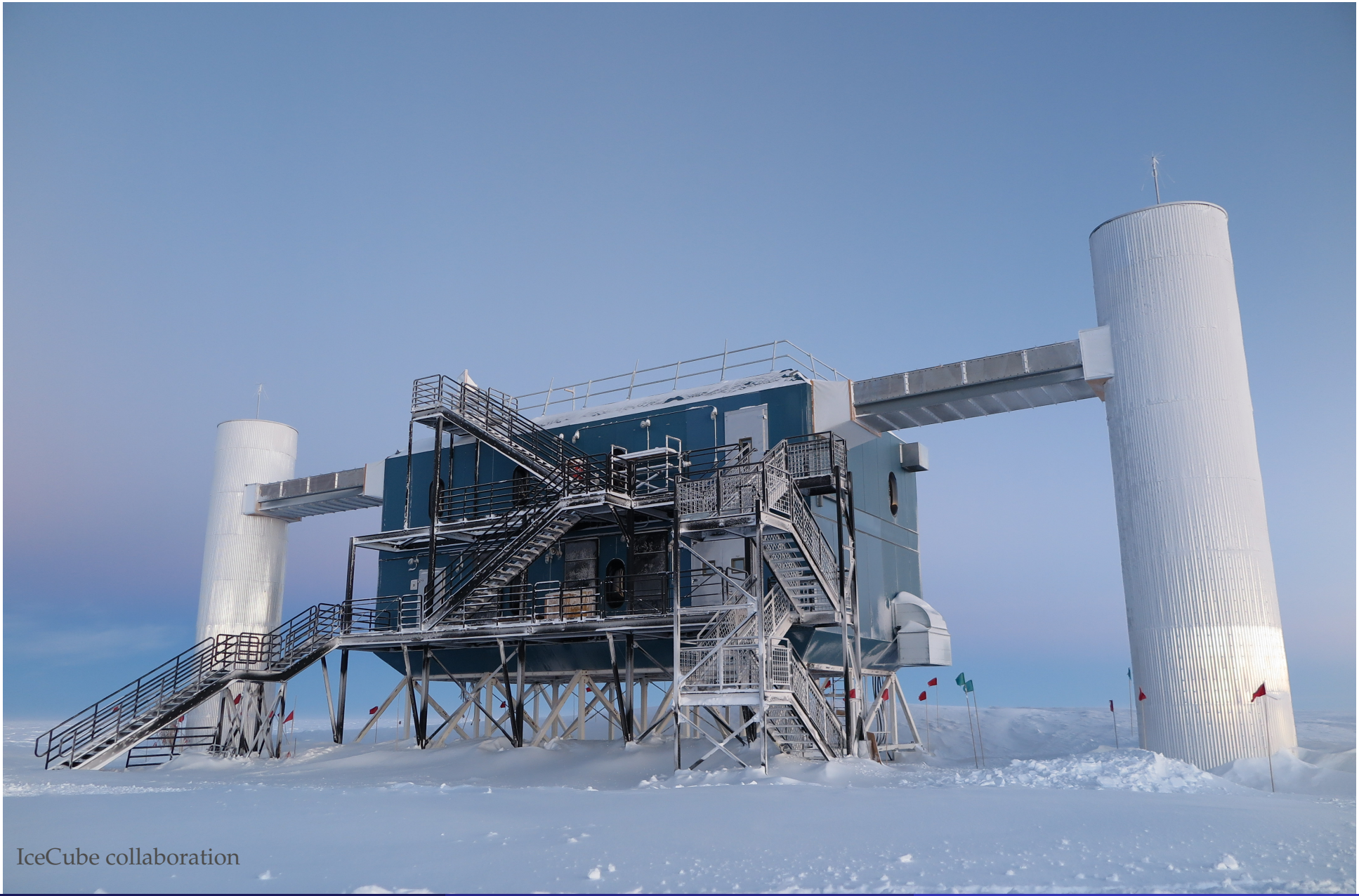
Summary

- luminescence as a new detection mechanism for monopoles!
- implemented in simulation chain
- experiment in development to measure variables

Backup Slides

Backup Slides

IceCube



IceCube collaboration

Simulation production

Settings:

- Monopolmass: 10^{11} GeV
- Disk_dist: 1000 m
- Disk_rad: 850 m
- only one τ and one $\frac{dN_\gamma}{dE}$
  - $\frac{dN_\gamma}{dE} = 0.2\,/\mathrm{MeV}$
  - $\tau = 500\,\mathrm{ns}$

Simulation Chain (Module/Segment):

- I3SPRNGRandomServiceFactory
- I3InfiniteSource
- I3MonopoleGenerator
- I3MonopolePropagator
- i3ppc
- I3Writer $\Rightarrow$ before trigger
- DetectorSim (without adding noise)
- Calibration
- I3Writer $\Rightarrow$ after trigger

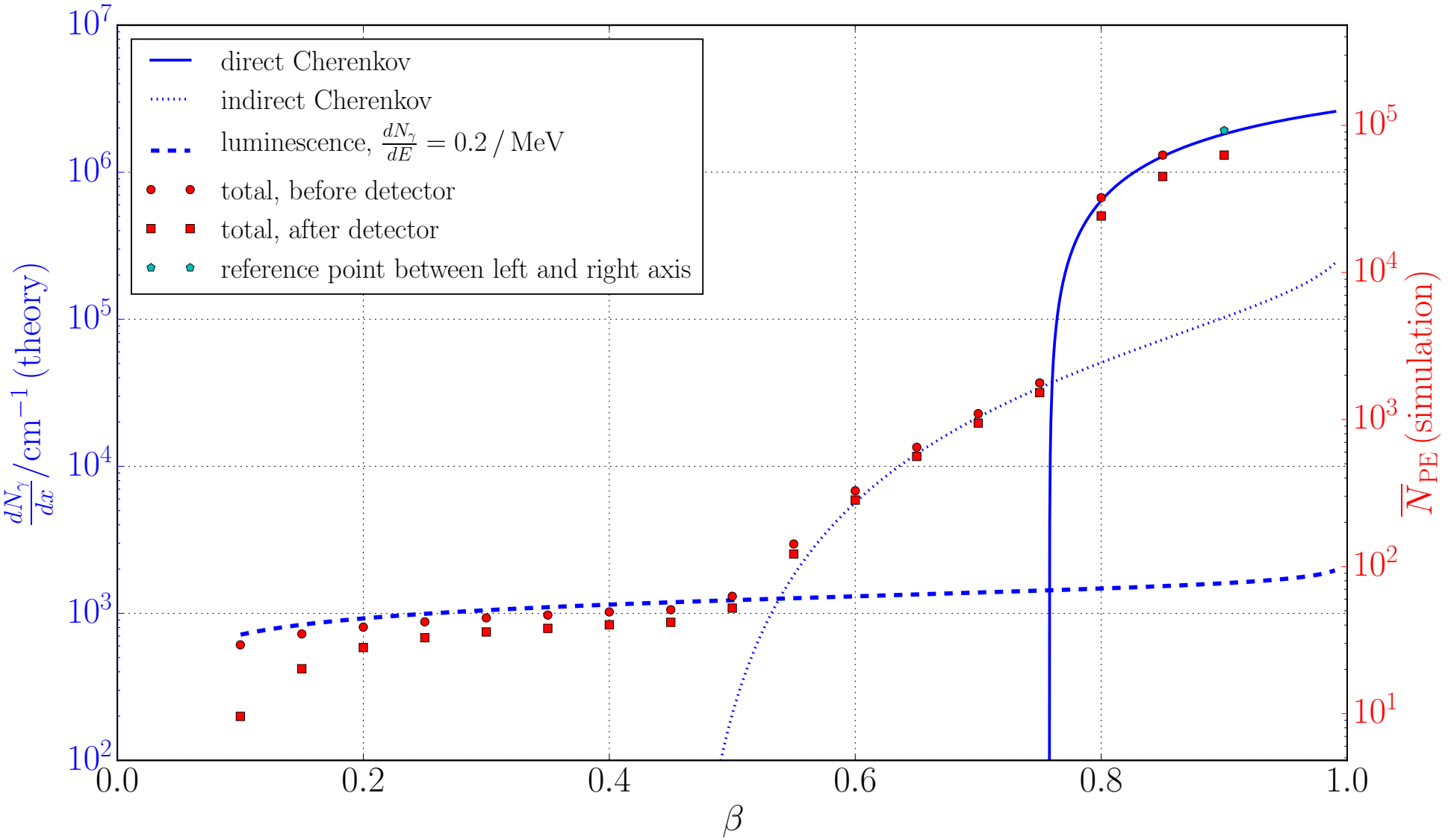
Luminescence in ppc

- only depend on τ and dN_γ/dE
- add probability parameter to photon:pbuf
- roll dice on each photon
- only differences to Cherenkov:
  - uniform directional emission
  - add time delay to emission
- qualitative check with steamshovel

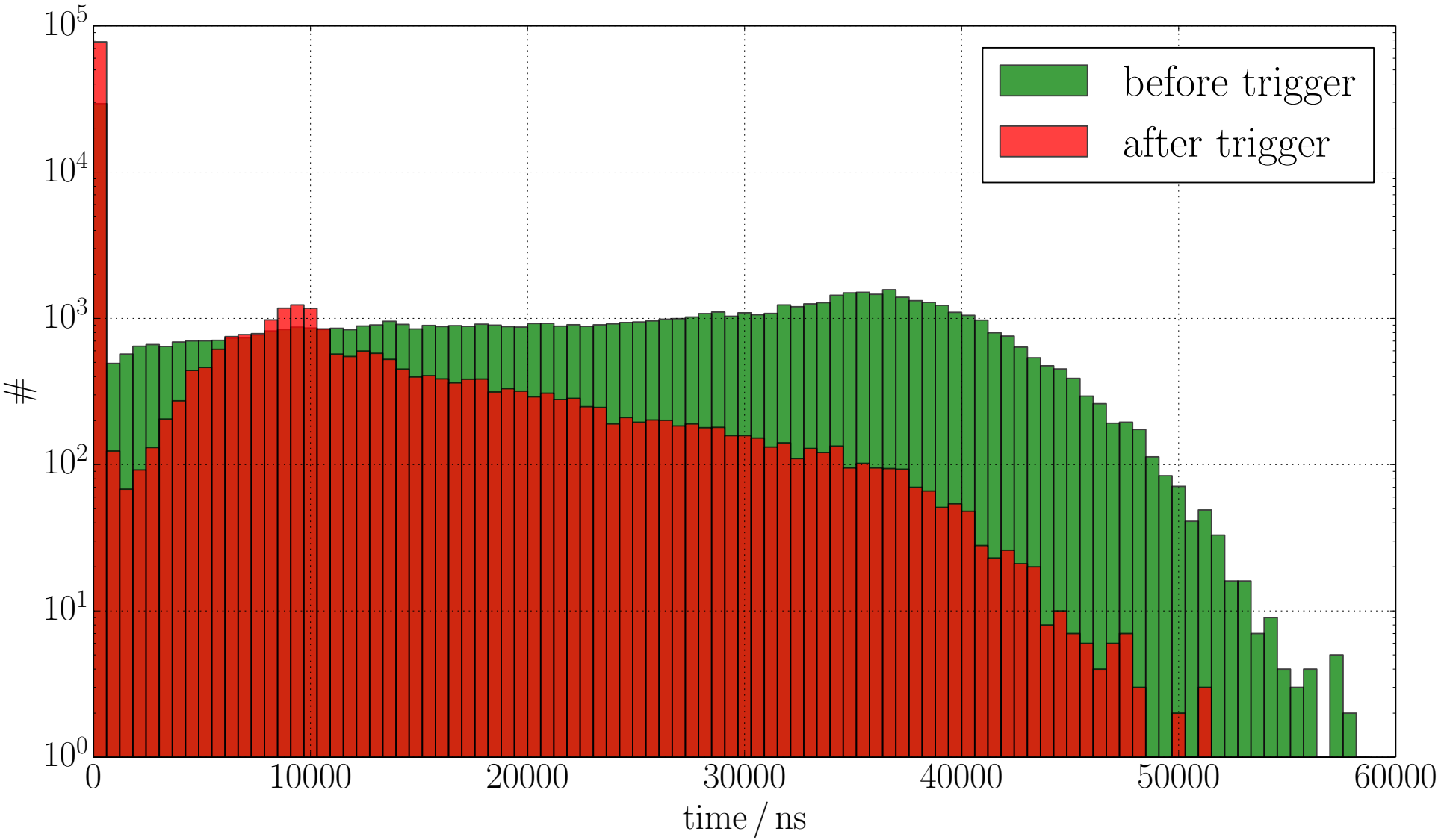
pro.cu

```
luminescenceCase = p.p_l >= xrnd(s);
//dice toss -> cherenkov or luminescence
if (! luminescenceCase){
    //standard Cherenkov
    w=1*e.ocv/p.beta;
}else{
    //luminescence
    w=1*e.ocv/p.beta
    w-= p.tau * log(xrnd(s));
}
```

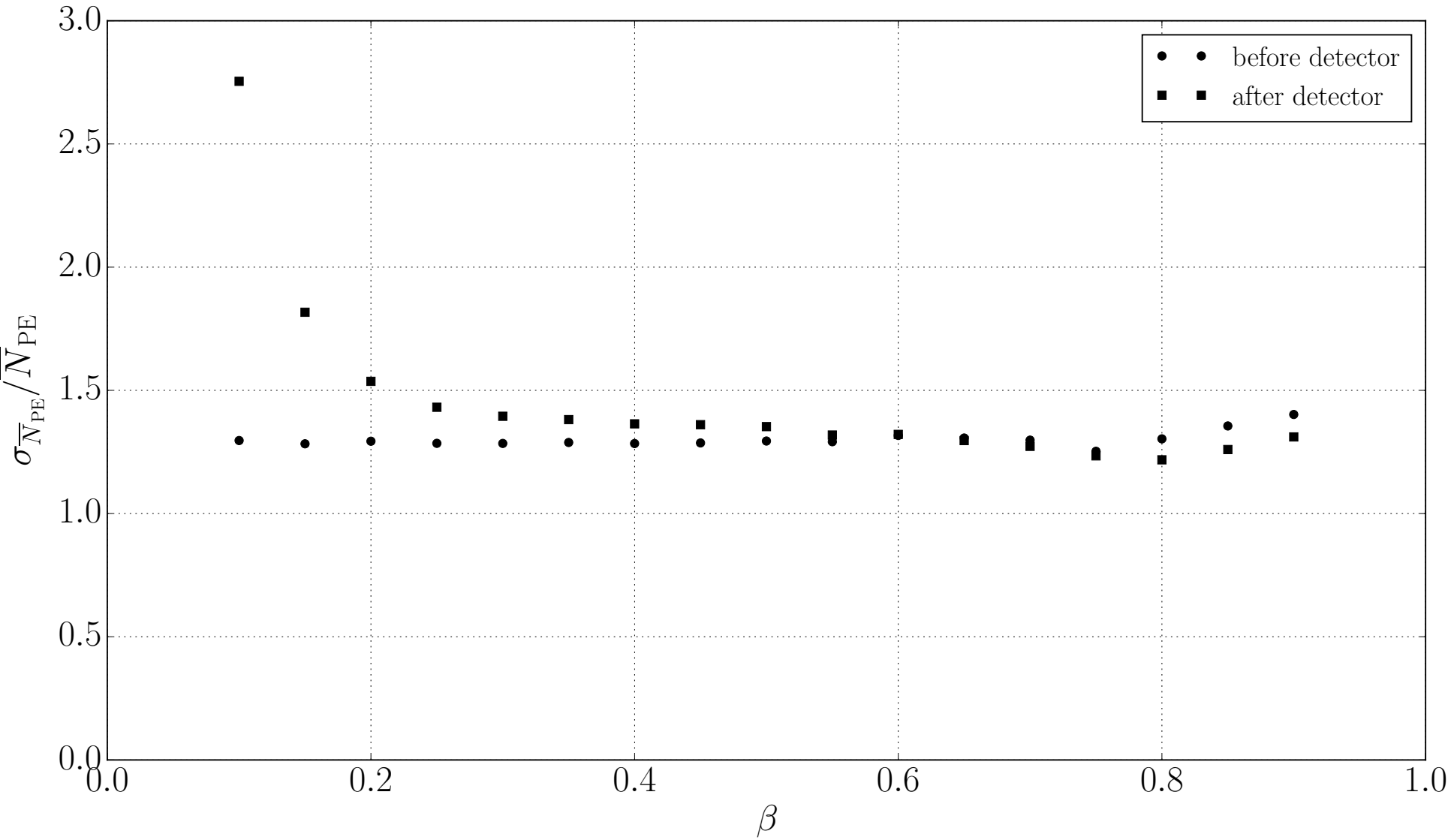
Quantitative Check



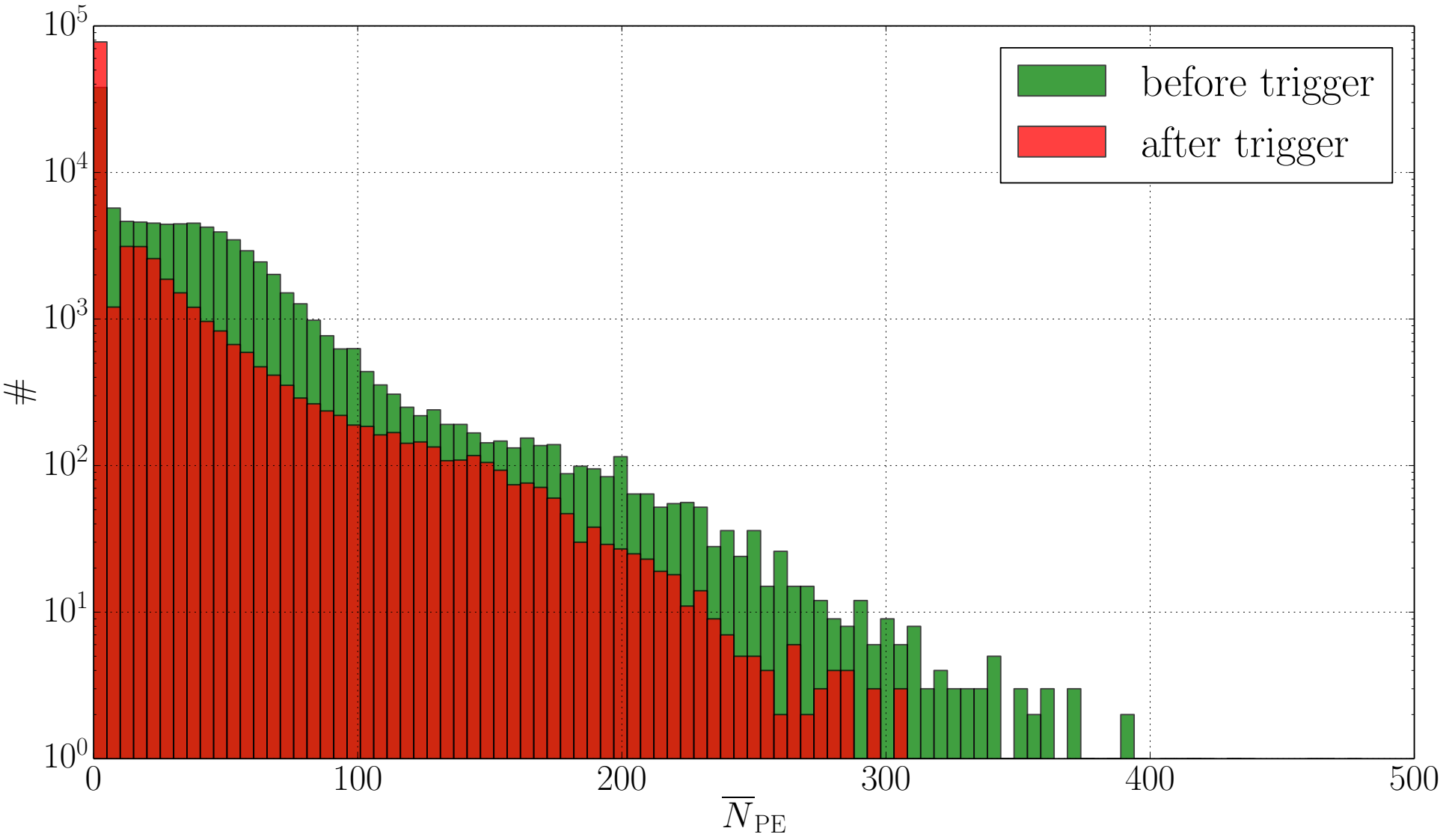
Length of events at $\beta = 0.1$



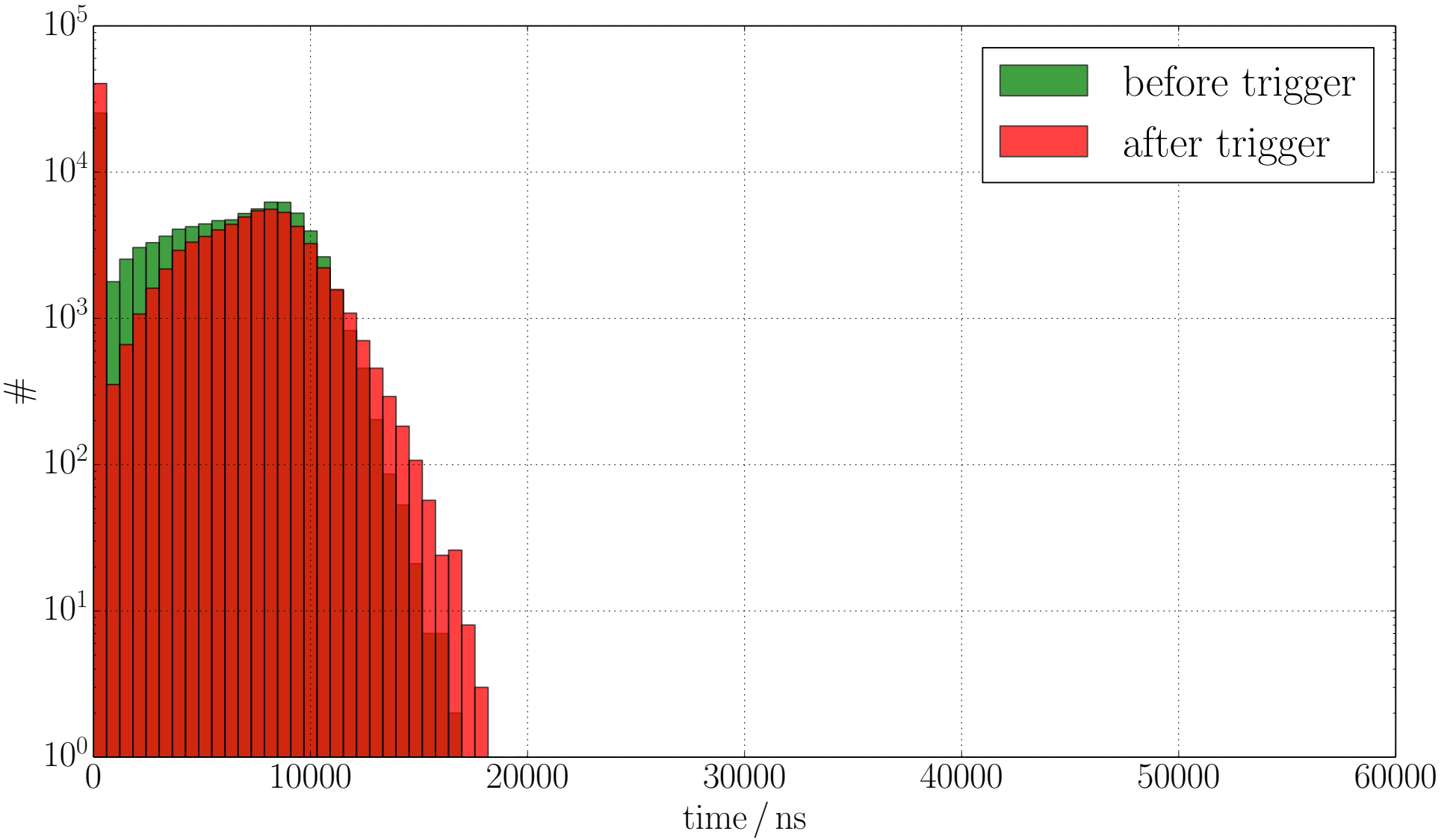
Closer look at low betas



$\overline{N}_{\mathrm{PE}}$ of events at $\beta = 0.1$



Time of events at $\beta = 0.5$



$\overline{N}_{\mathrm{PE}}$ of events at $\beta = 0.5$