Color test

I just want to be

sure

that all my favourite colors

are

being displayed correctly on this

new

device. If not I'll modify them.

Inferring cosmic particles

TEST seminar

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LAL, LRI, University of Paris-Sud XI

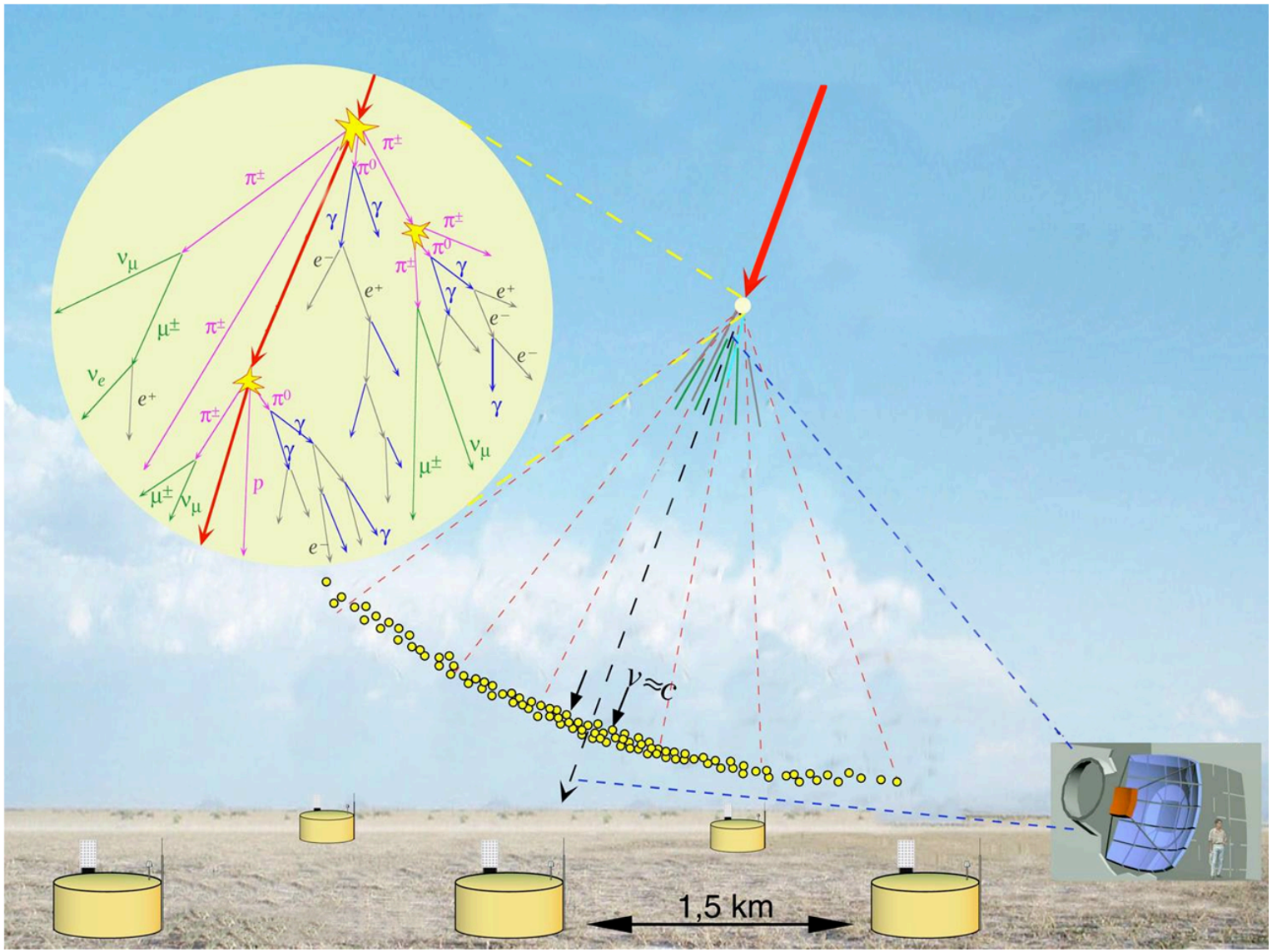
February 23rd, 2012

Contents

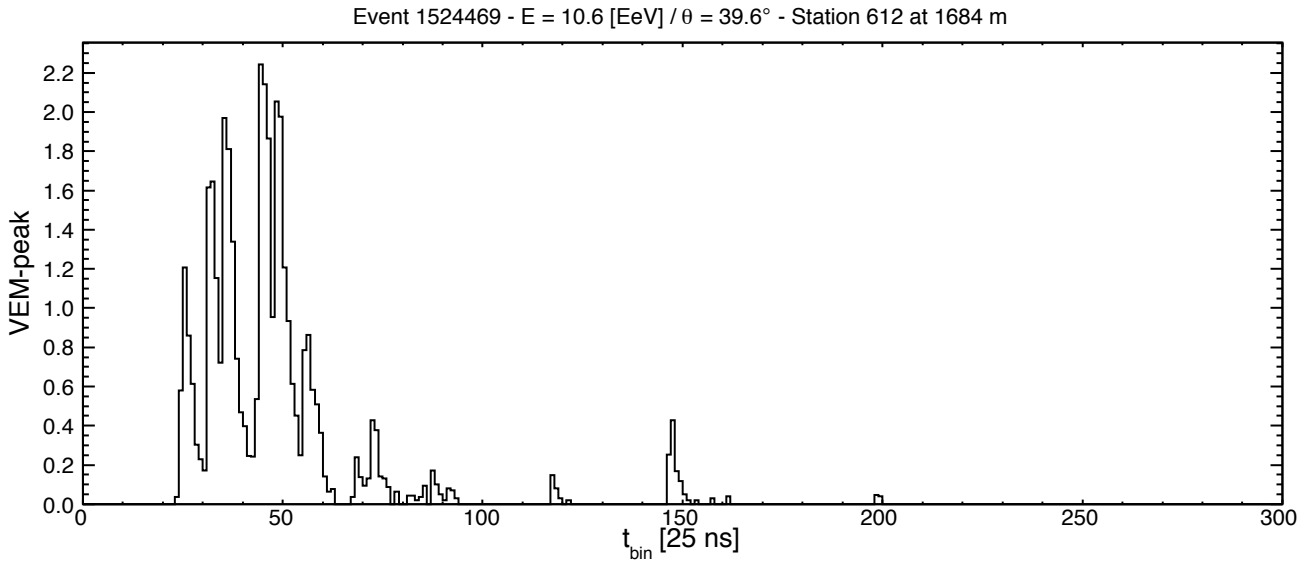
A cosmic shower

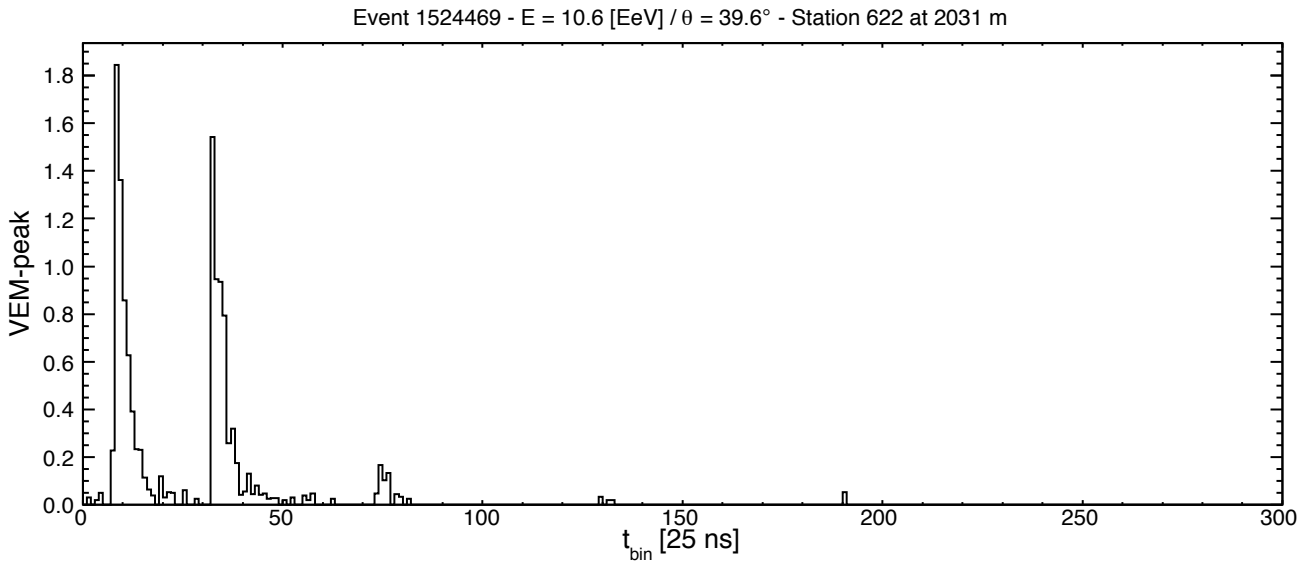
Google Earth tour

A cosmic shower (aka flying Greek letters)



A glance at tank signals





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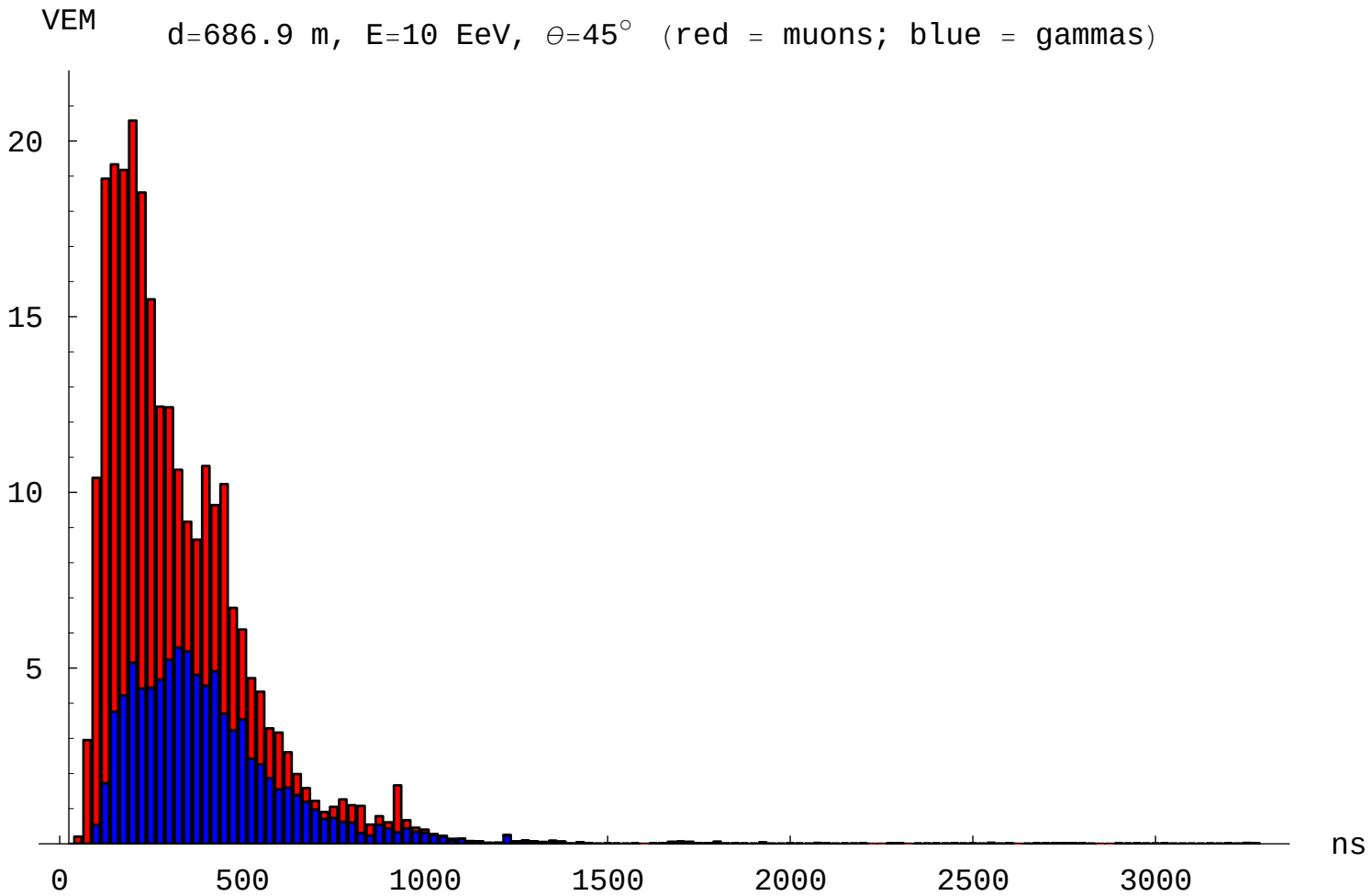

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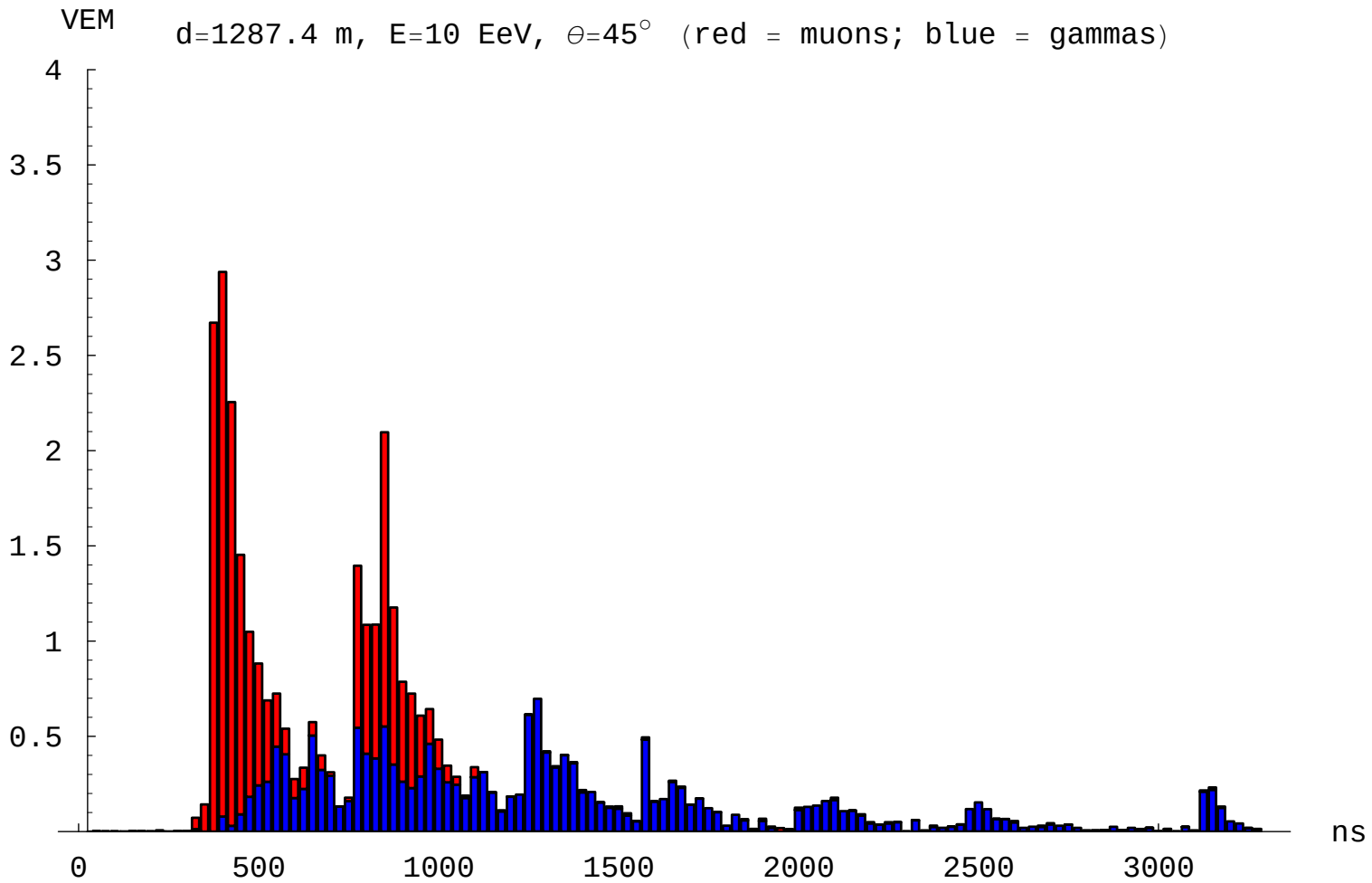
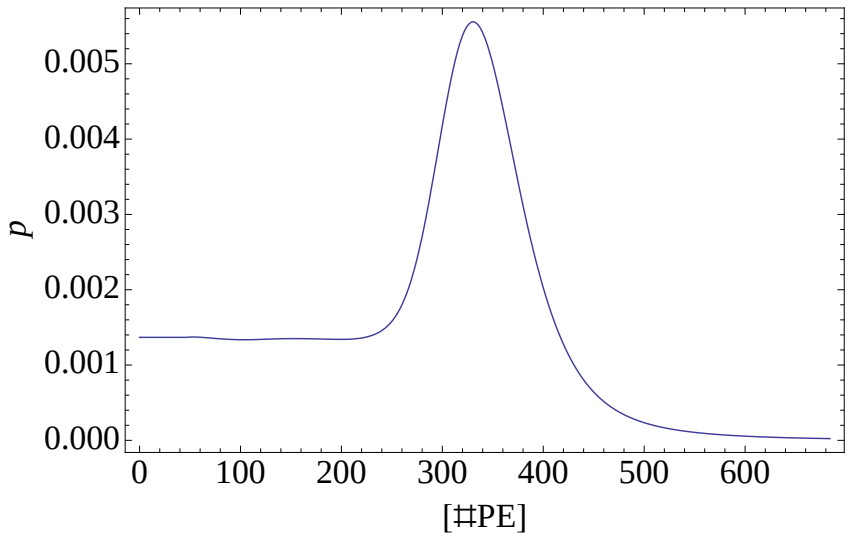
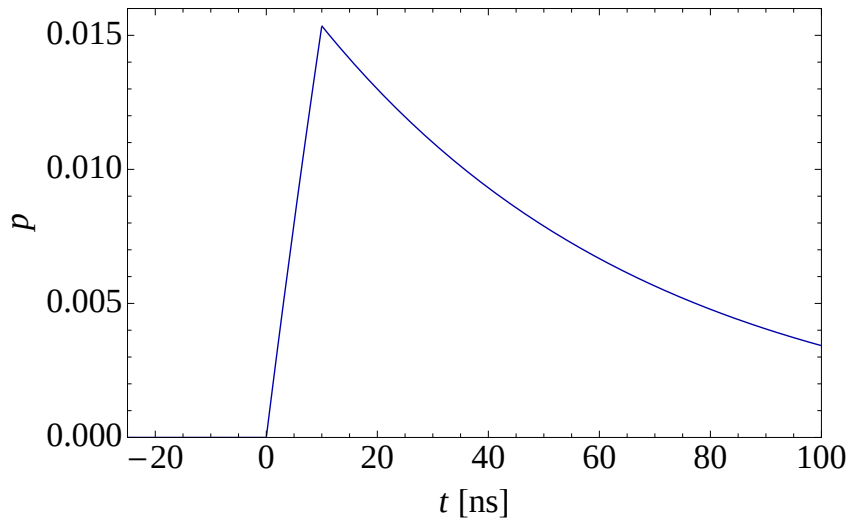




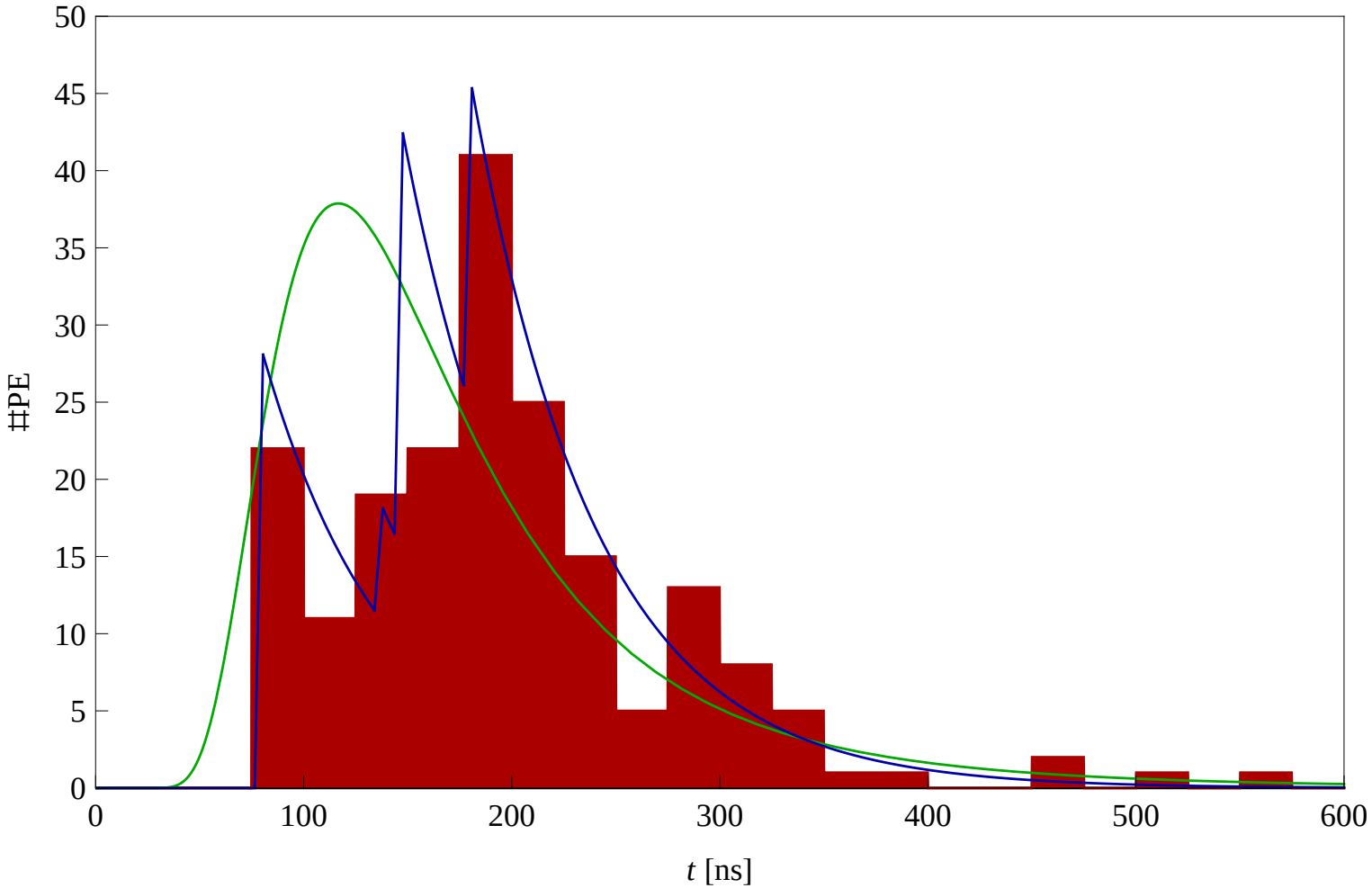
(a) Muonic signal amplitude distribution



(b) Muonic time response model p_{τ,t_d}

Mean number of Photo-electrons per bin & per muon

$$\bar{n}_i(A_\mu, t_\mu) = A_\mu \int_{t_{i-1}}^{t_i} p_{\tau,t_d}(t - t_\mu)dt.$$



$$n_i \text{ Poisson with mean } \bar{n}_i(\mathbf{A}_{\boldsymbol{\mu}}, \mathbf{t}_{\boldsymbol{\mu}}) = \sum_{j=1}^{N_\mu} \bar{n}_i(A_{\boldsymbol{\mu}_j}, t_{\boldsymbol{\mu}_j}),$$

MCMC issues

- Possibly high dimensions but also highly correlated model.
  - Use adaptive proposals.
- The number of muons N_μ is unknown.
  - Use a nonparametric prior or
  - use a Reversible Jump sampler.
- Likelihood $\mathcal{P}(\mathbf{n}|\mathbf{A}_\mu, \mathbf{t}_\mu)$ is permutation invariant.
  - Marginals are useless, a problem known as label-switching.

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Adaptive Metropolis

- When the target $\pi(x)$ is multivariate Gaussian with covariance Σ_π, the optimal choice of Σ is of the order of $(2.38)^2\Sigma_\pi/d$
  See Roberts et al. 07
- You can approximate this with proposals

$$q(.|X_t) = \mathcal{N}\big(\,\cdot\,|X_t, c\Sigma_t\big)$$

with

$$\Sigma_t = \frac{1}{T}\sum_{i=1}^{T}(X_i - \bar{X})(X_i - \bar{X})^T.$$

See Haario et al. 01

- Wake up, audience: Is the new chain Markovian ?

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Reversible Jump MCMC

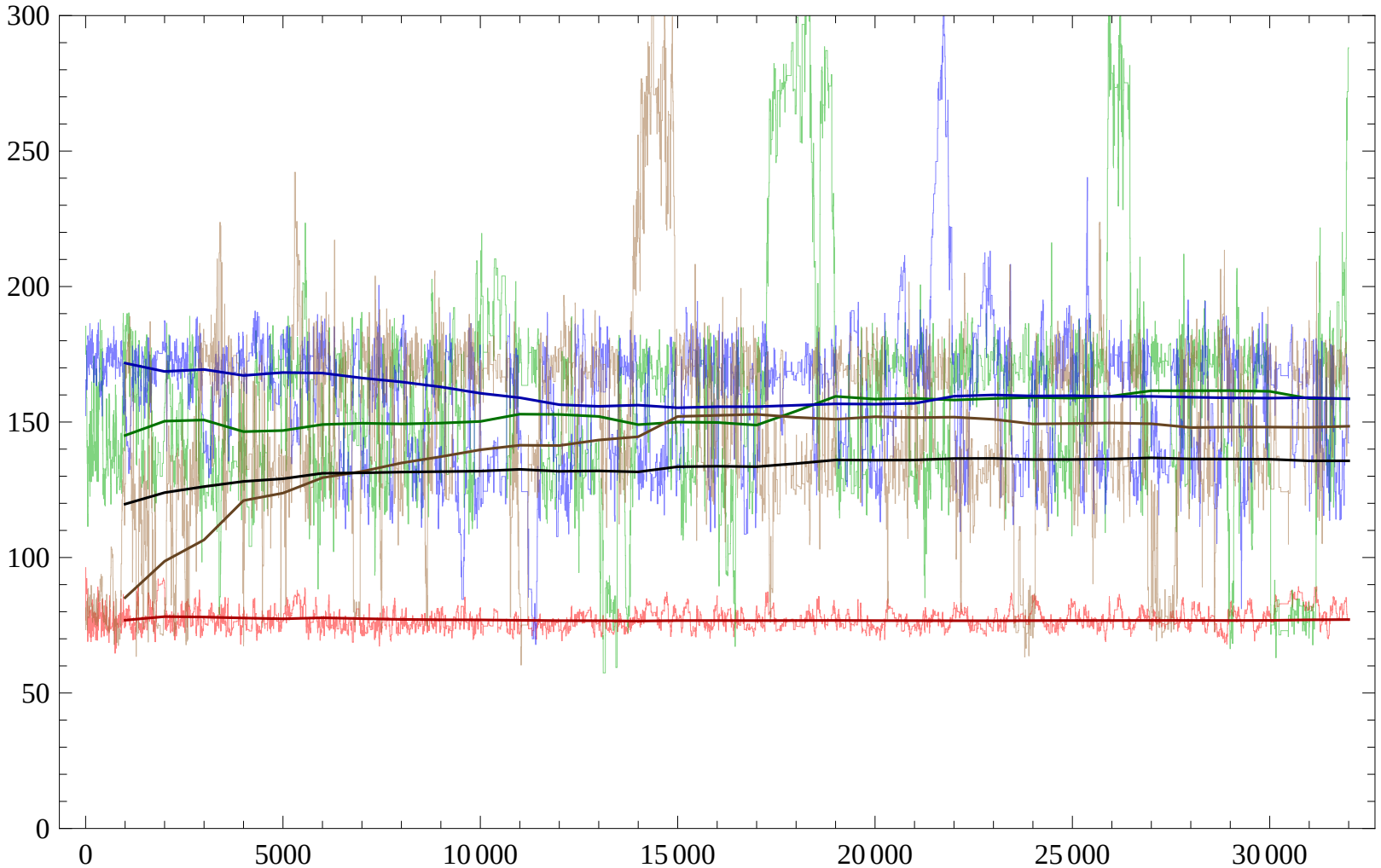
- Nonparametric prior: needs simple model with conjugacy properties for easy sampling, Neal 00.
- RJMCMC Green 05: MCMC kernel on

$$\bigcup_{N_\mu=1}^{N_\mu^{\max}} \{N_\mu\} \times \{ \text{ Parameter space for } N_\mu \text{ muons } \}.$$

- RJMCMC needs careful design of transdimensional moves.

Label-Switching

- If the prior is exchangeable, then $\pi(\mathbf{A}_\mu, \mathbf{t}_\mu)$ is permutation-invariant.



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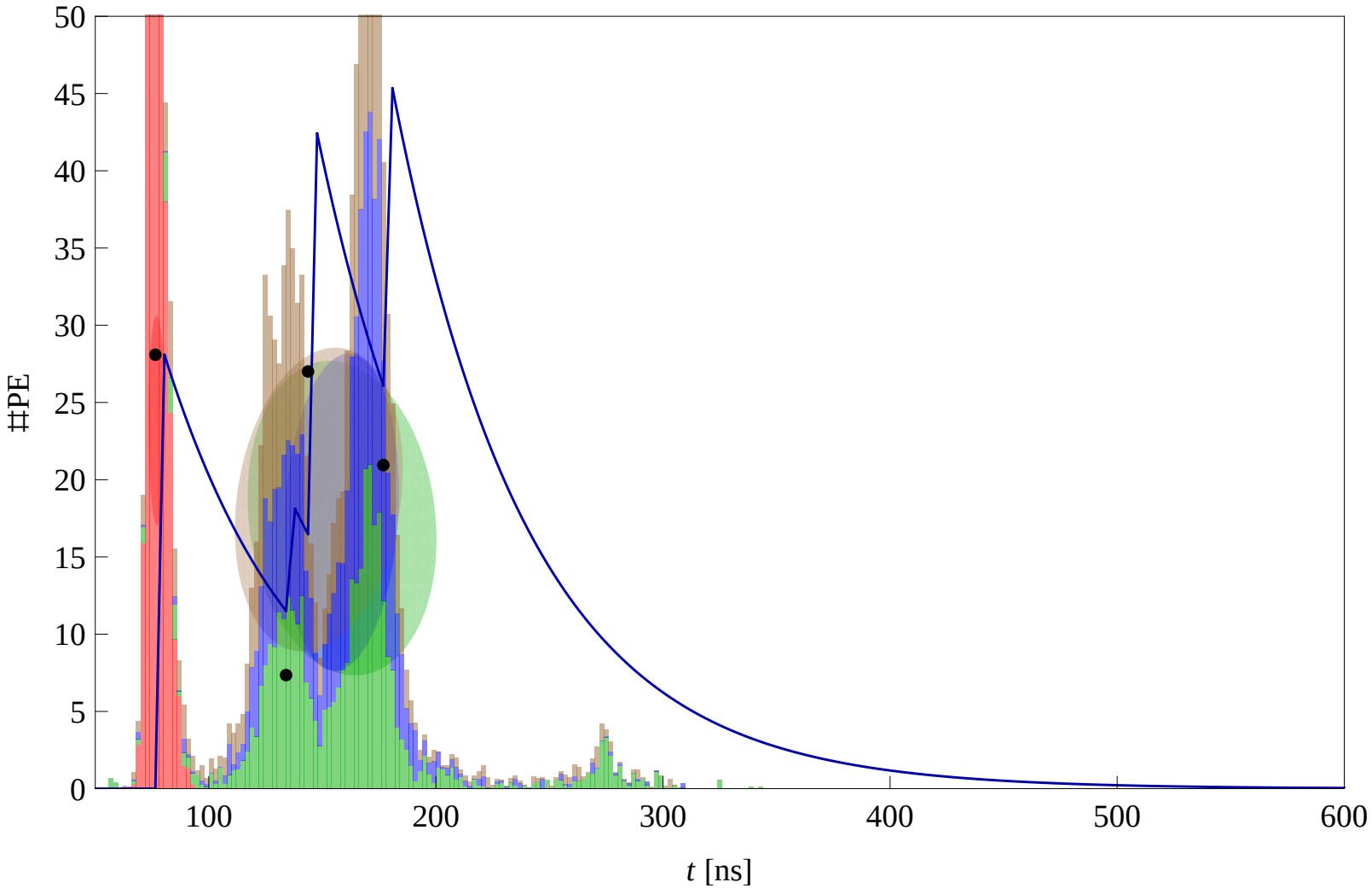

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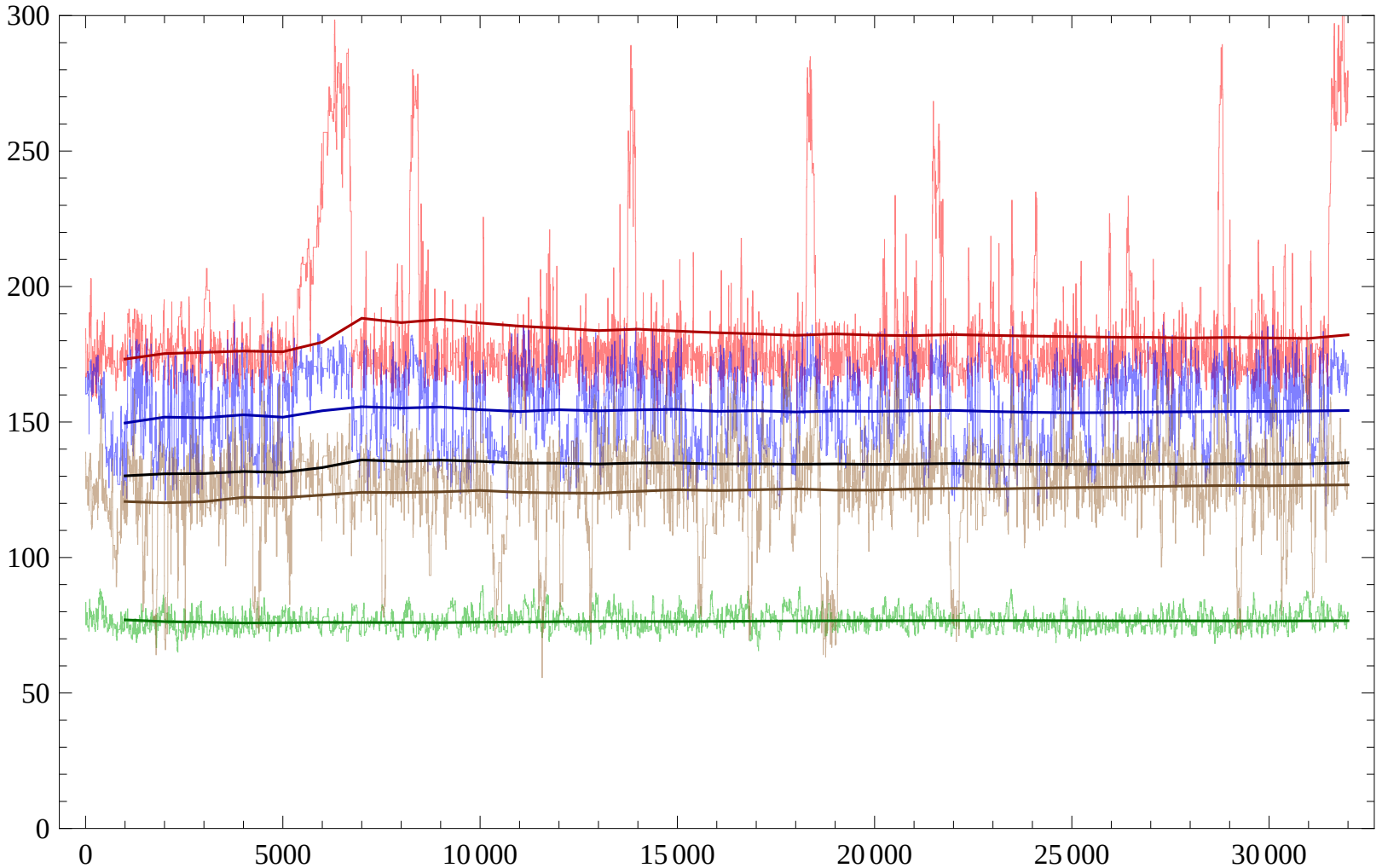

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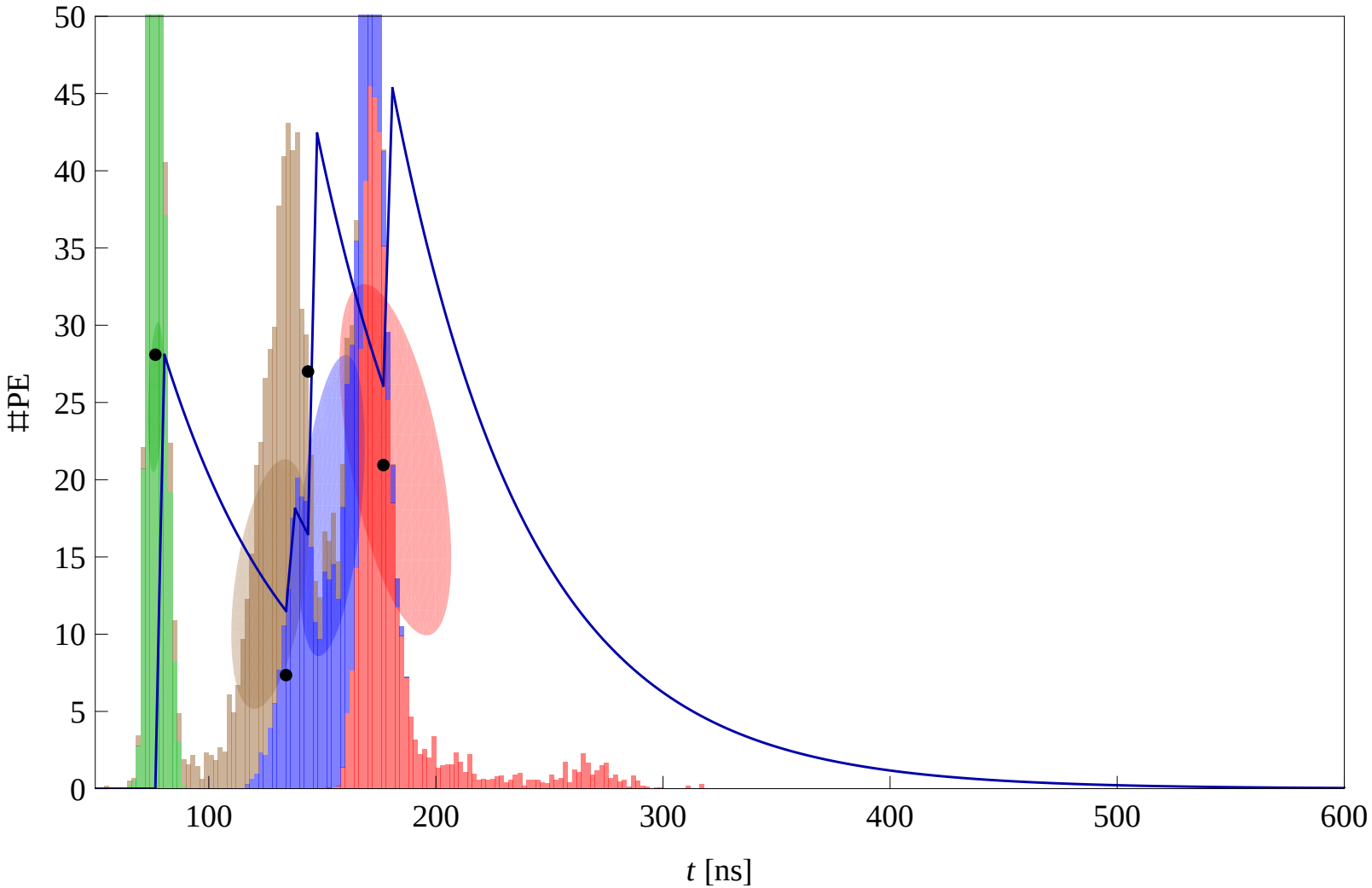

The AMOR sampler

AMOR$(\pi(x), X_0, T, \mu_0, \Sigma_0, c)$

1 $\mathcal{S} \leftarrow \emptyset$

2 **for** $t \leftarrow 1$ **to** T

3 $\Sigma \leftarrow c\Sigma_{t-1}$ ▷ *scaled adaptive covariance*

4 $\widetilde{X} \sim \mathcal{N}(\,\cdot\,|X_{t-1}, \Sigma)$ ▷ *proposal*

5 $\widetilde{P} \sim \underset{P\in\mathfrak{P}}{\arg\min}\, L_{(\mu_{t-1},\Sigma_{t-1})}(P\widetilde{X})$ ▷ *pick an optimal permutation*

6 $\widetilde{X} \leftarrow \widetilde{P}\widetilde{X}$ ▷ *permute*

7 **if** $\dfrac{\pi(\widetilde{X})\sum_{P\in\mathfrak{P}}\mathcal{N}(PX_{t-1}|X,\Sigma)}{\pi(X_{t-1})\sum_{P\in\mathfrak{P}}\mathcal{N}(PX|X_{t-1},\Sigma)} > \mathcal{U}[0,1]$ **then**

8 $X_t \leftarrow X$ ▷ *accept*

9 **else**

10 $X_t \leftarrow X_{t-1}$ ▷ *reject*

11 $\mathcal{S} \leftarrow \mathcal{S} \cup \{X_t\}$ ▷ *update posterior sample*

12 $\mu_t \leftarrow \mu_{t-1} + \frac{1}{t}(X_t - \mu_{t-1})$ ▷ *update running mean and covariance*

13 $\Sigma_t \leftarrow \Sigma_{t-1} + \frac{1}{t}\left((X_t - \mu_{t-1})(X_t - \mu_{t-1})^\intercal - \Sigma_{t-1}\right)$

14 **return** $\mathcal{S}$

(Scientific) conclusion (and ads)

- Particle Physics is cool,
- MCMC is neat,
- Mixing the two is great.
- To learn more on cosmic rays and Auger: Karim Louedec's thesis (link).
- On the model & AMOR: our last AISTATS paper (link) and a submitted Physics paper I can probably send you.
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