Event Reconstruction in IceCube

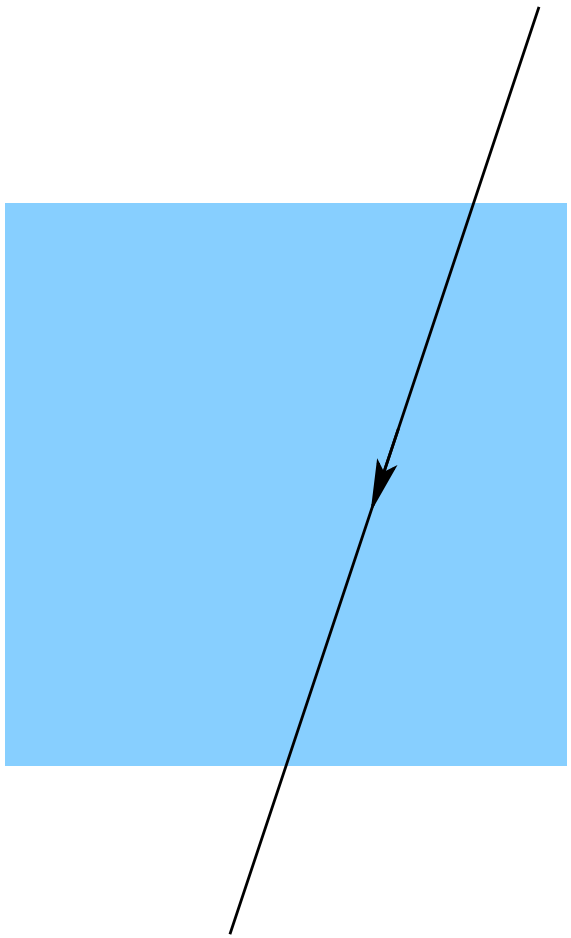
David J. Boersma

The IceCube Project

July 30 MMX, Aachen

Outline

Event Types (1): cosmic ray muons



- $\mathrm{CR} \rightarrow \mu$
- $\mathrm{CR} \rightarrow \mu$ (LE)
- $\mathrm{CR} \rightarrow \mu$ bundle
- $\mathrm{CR} \rightarrow \mu$ (high p_T)
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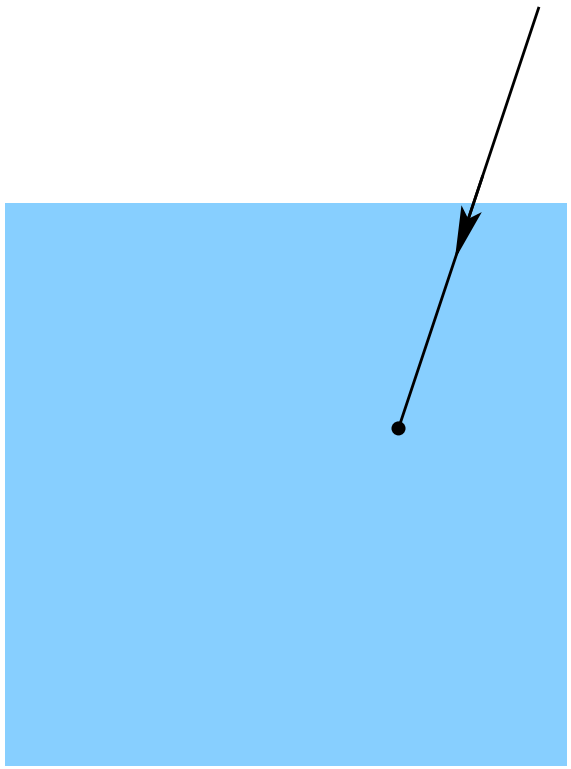

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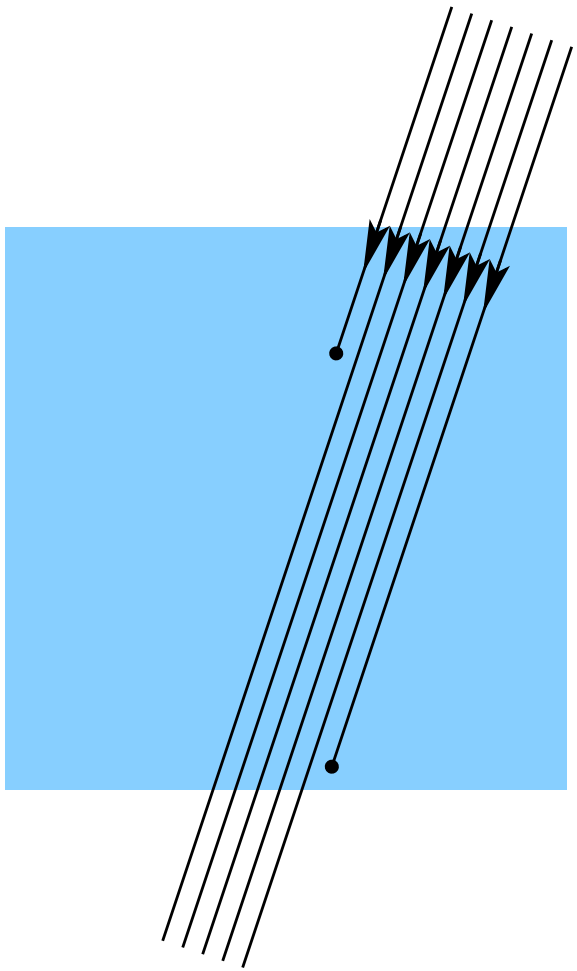

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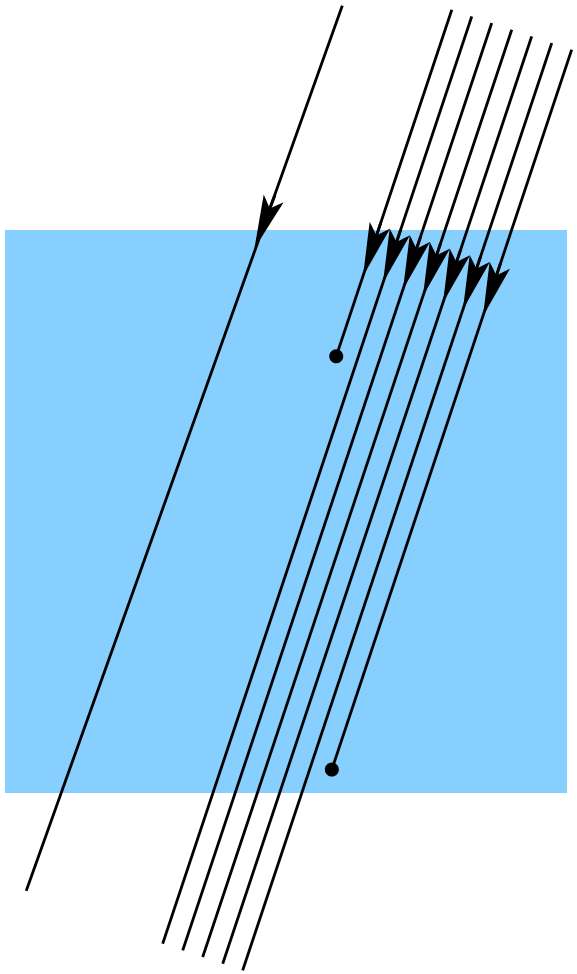

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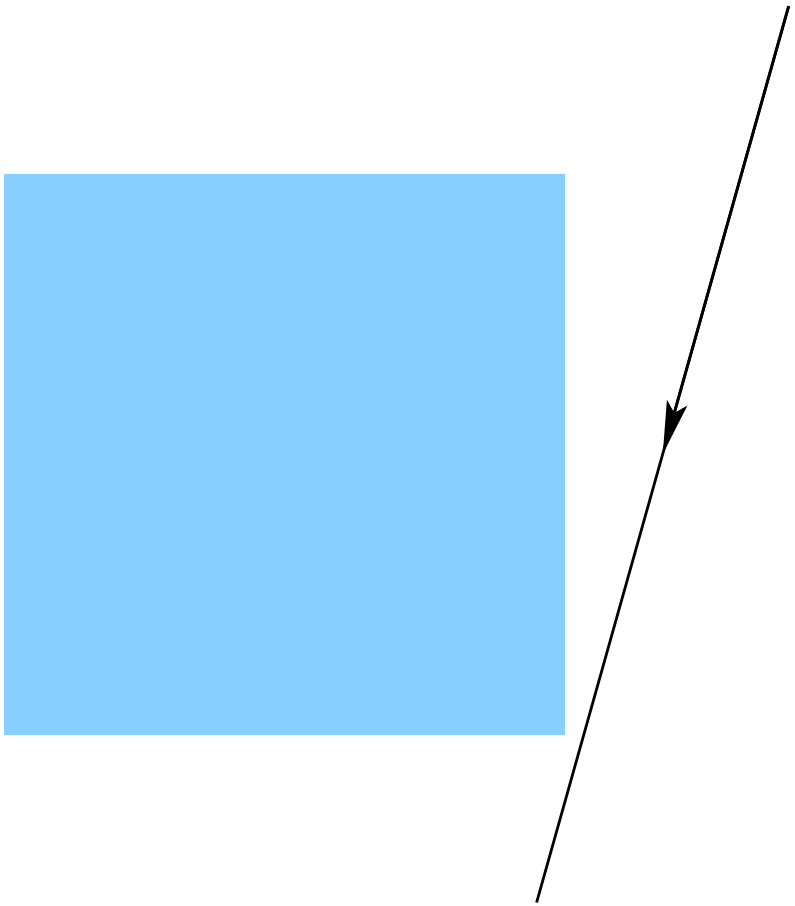

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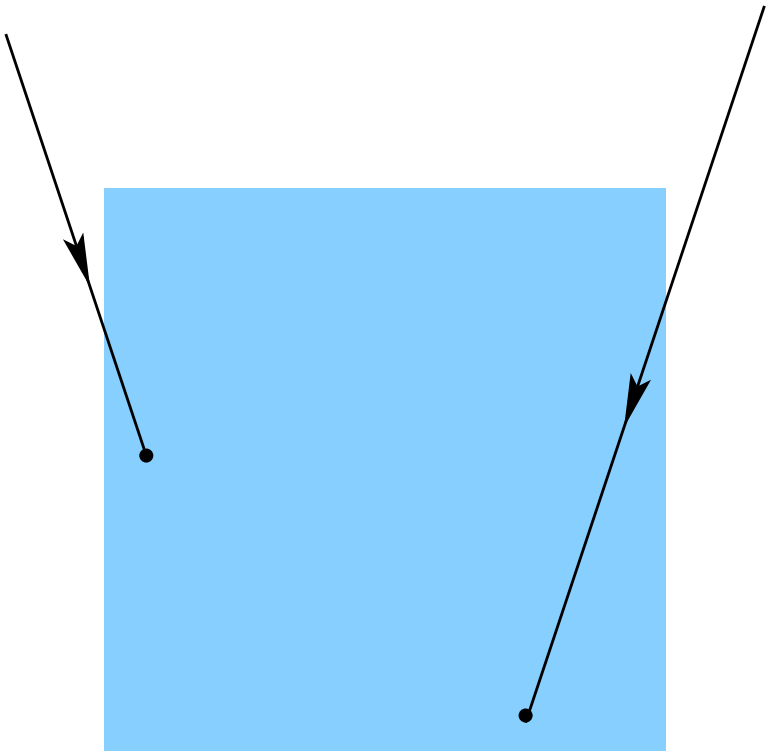

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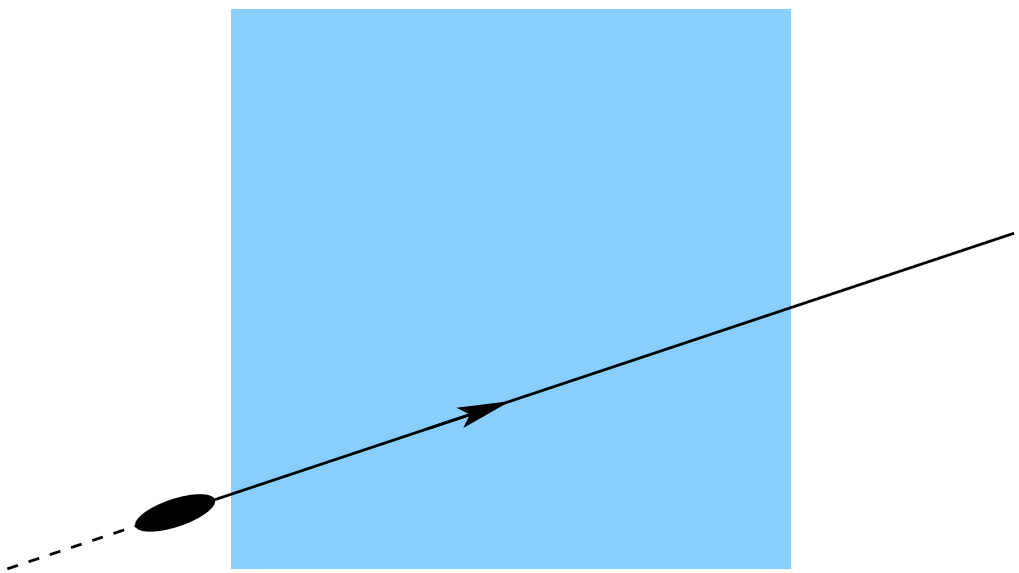

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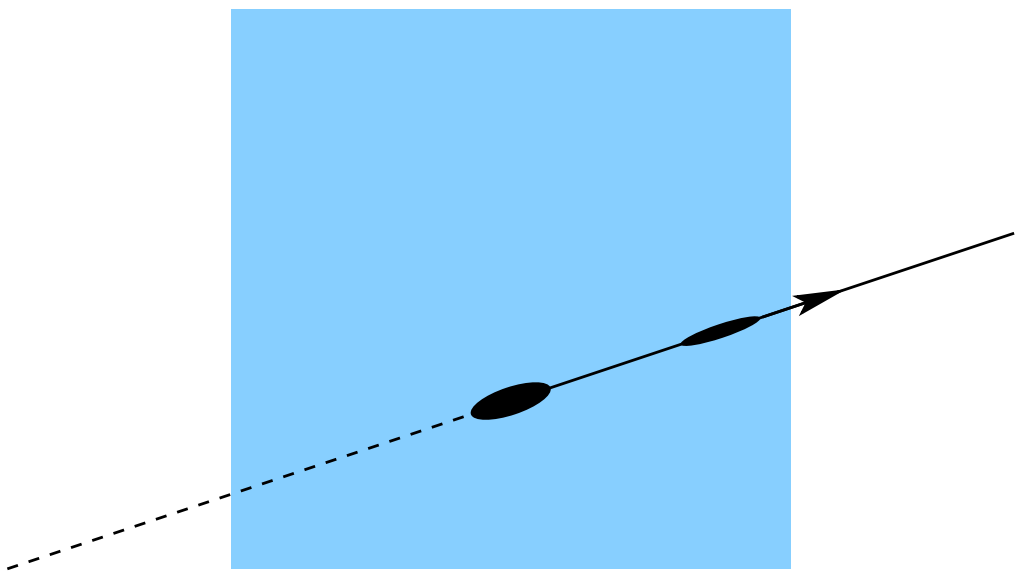

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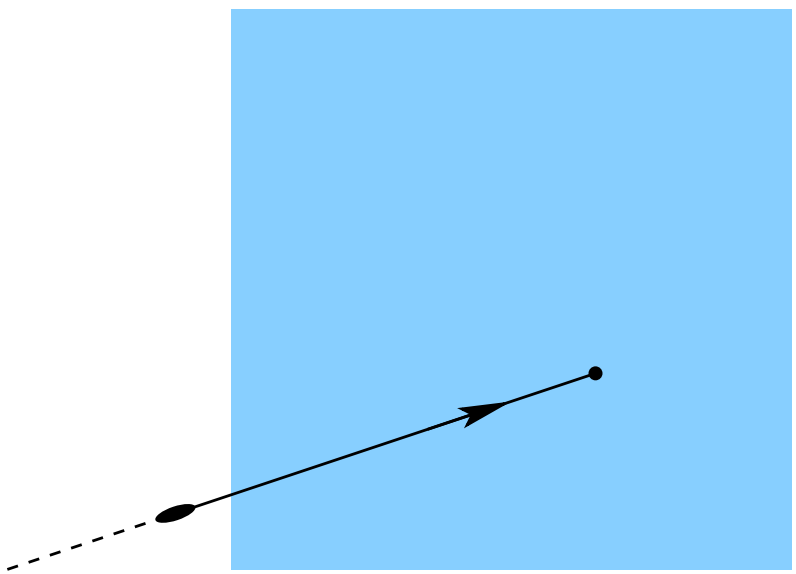

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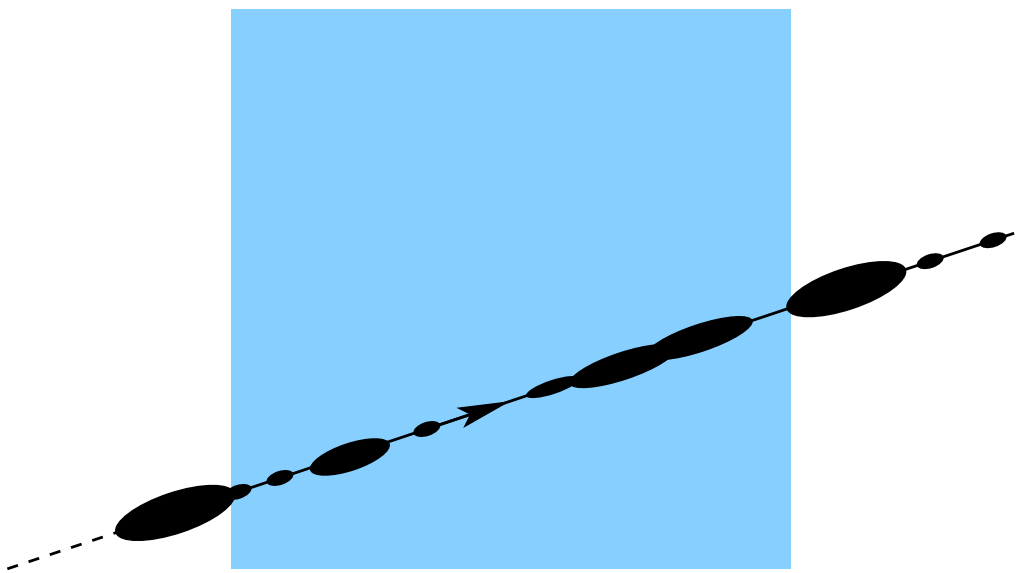

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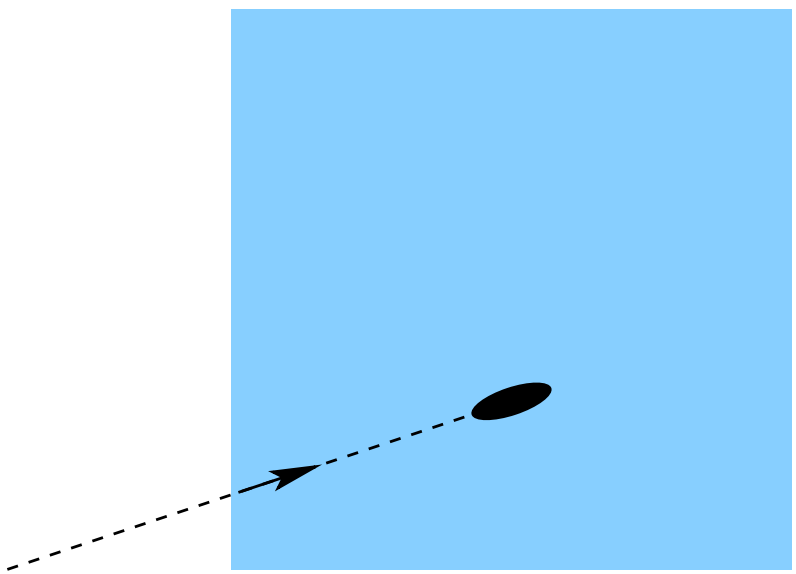

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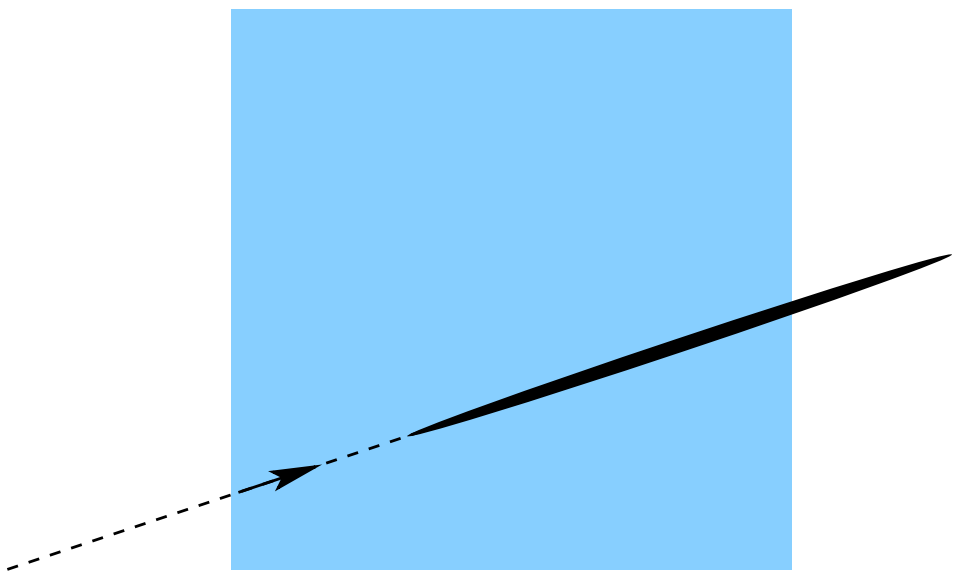

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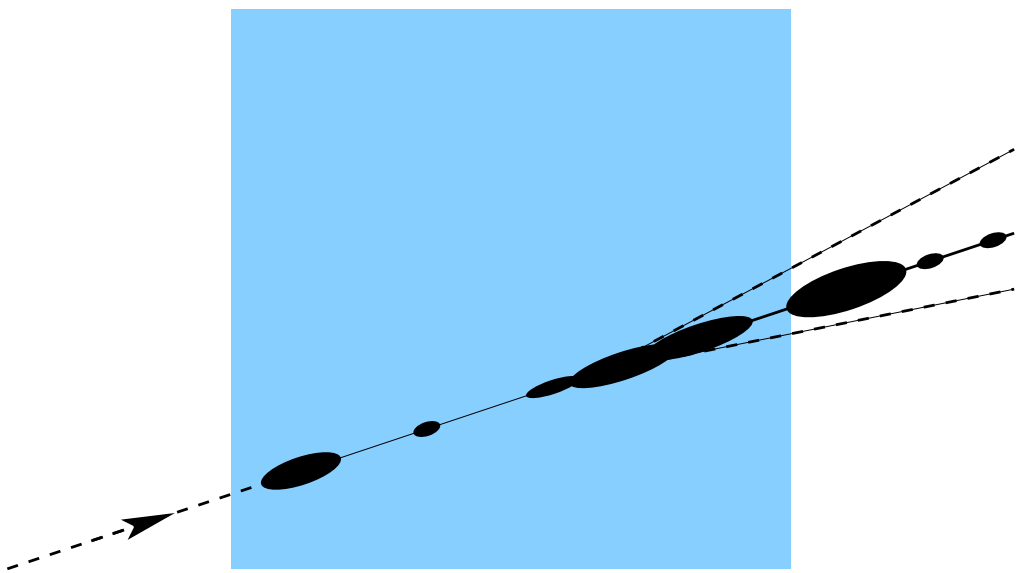

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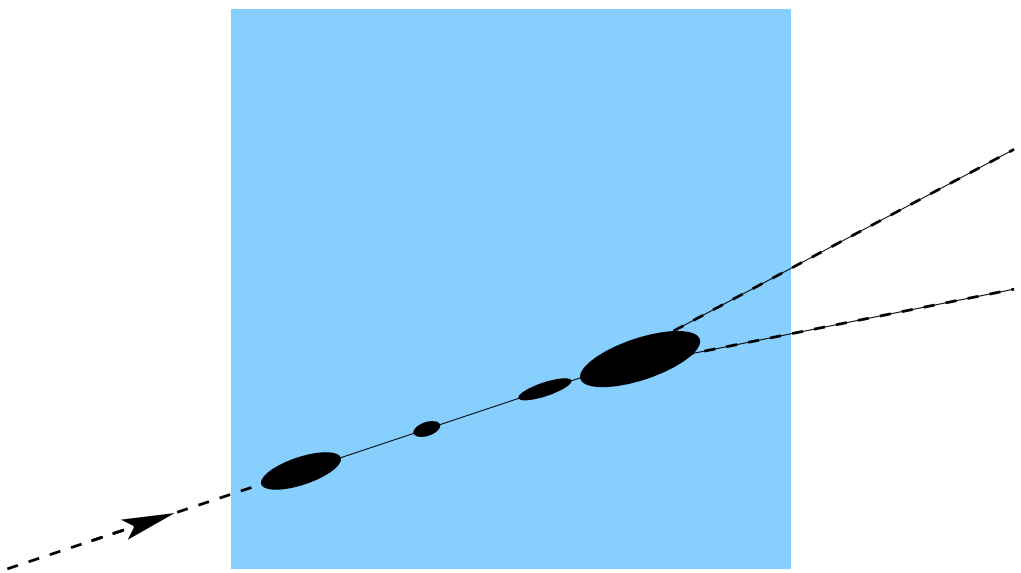

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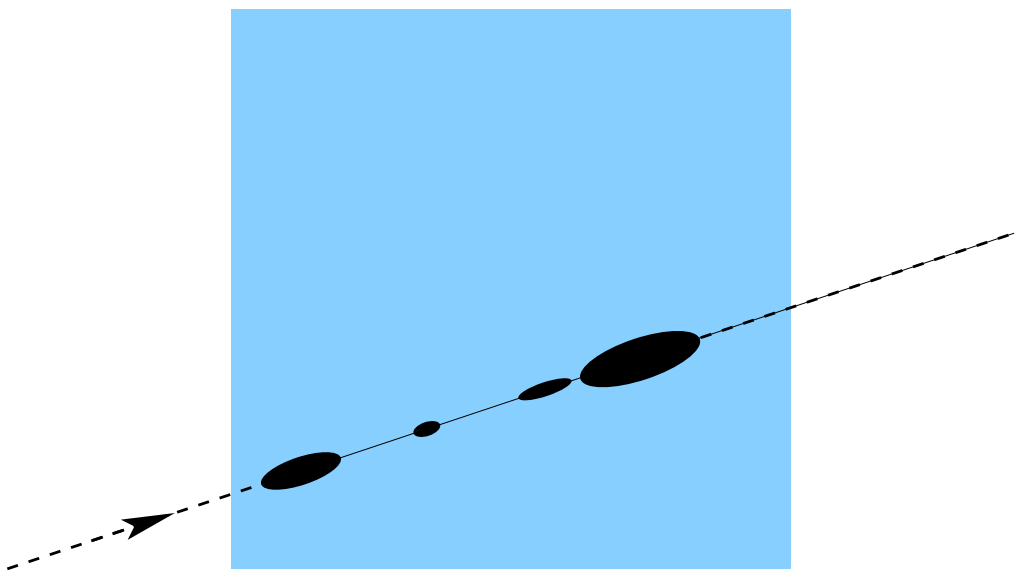

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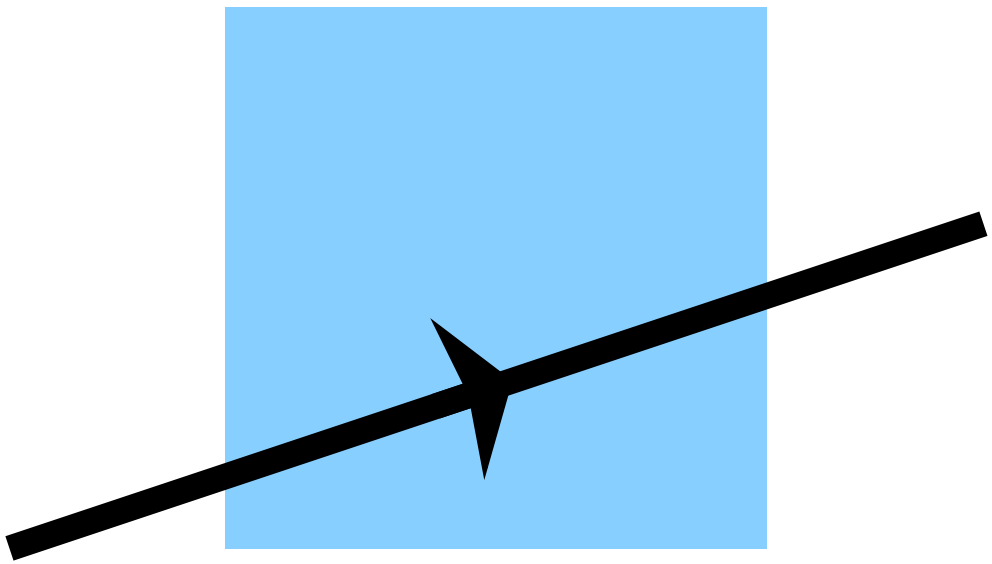

- relativistic magnetic monopoles
- slow magnetic monopoles
- microscopic black holes
- . . .

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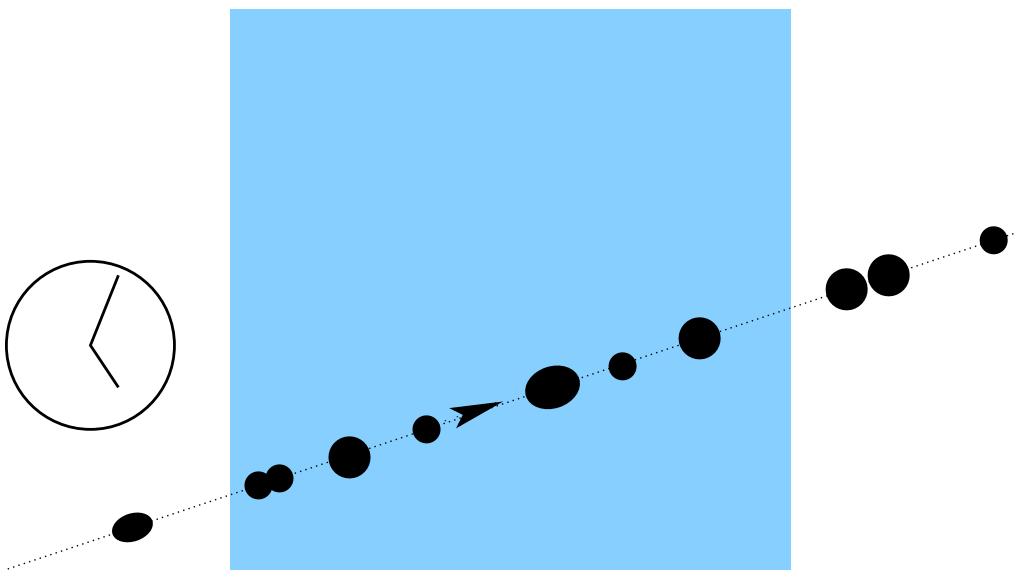

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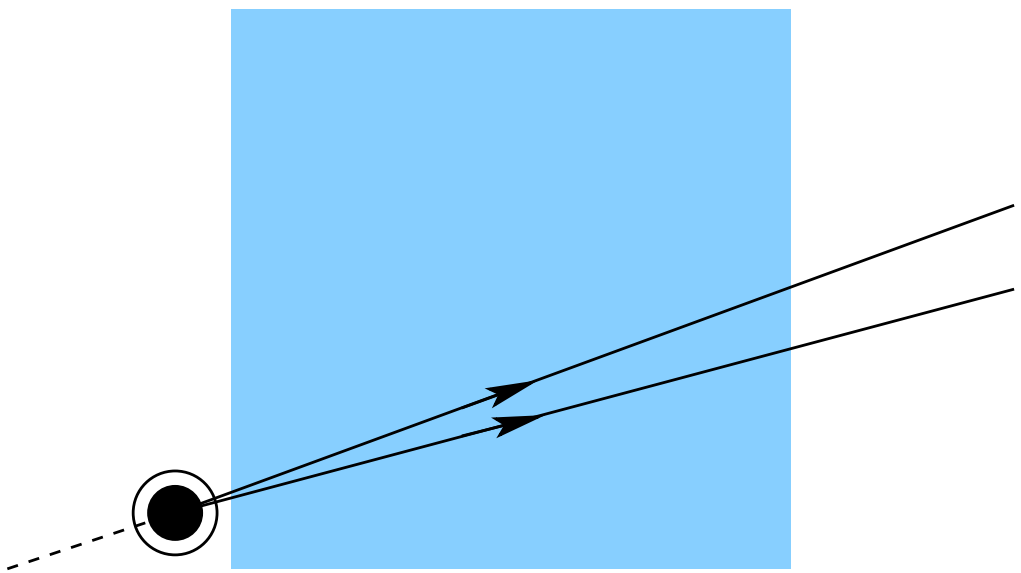

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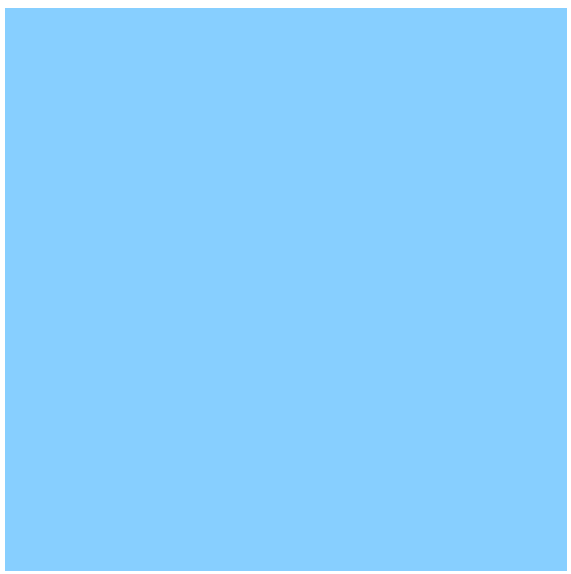

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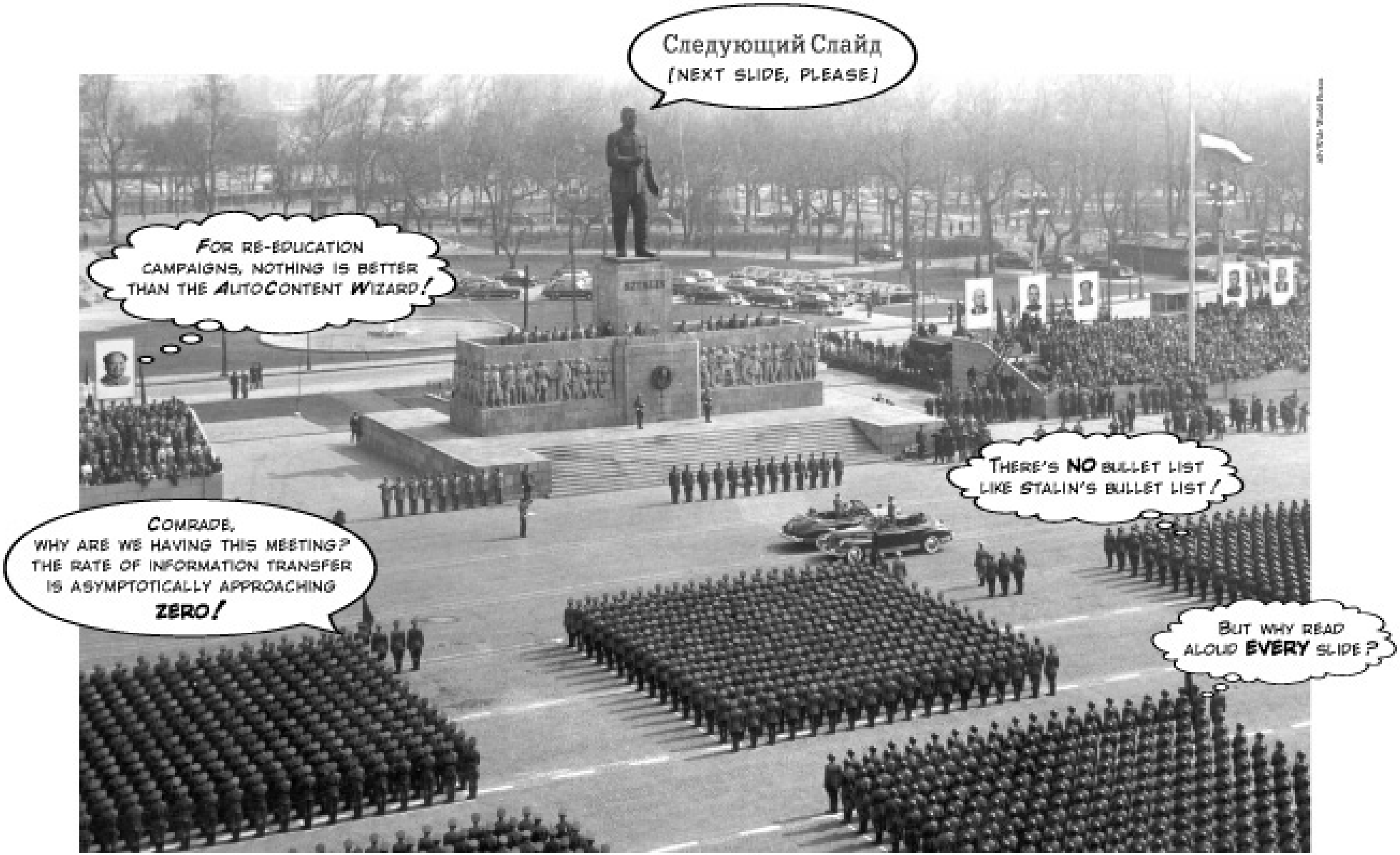


Edward Tufte, *The Cognitive Style of PowerPoint*

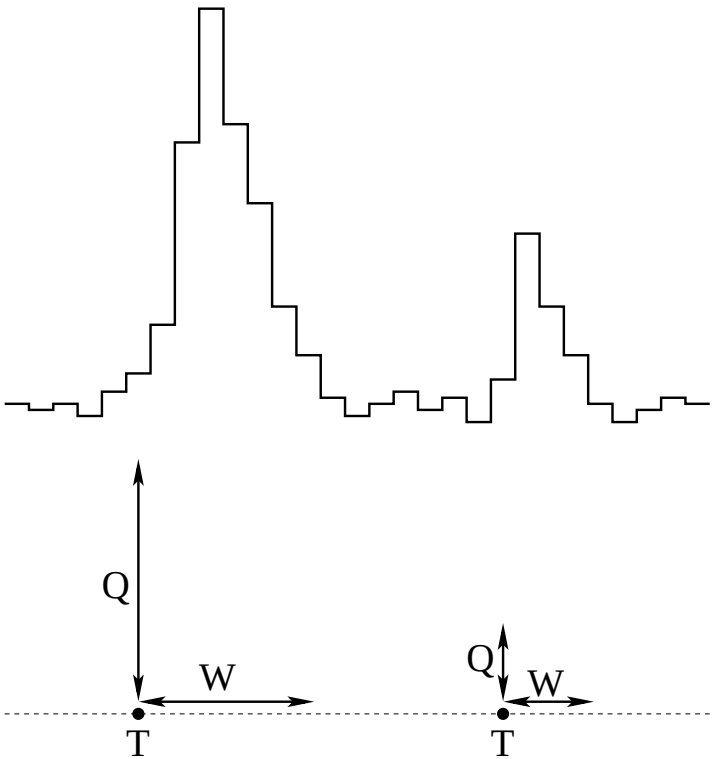
Triggers (recap)

- SMT: *Simple Multiplicity Trigger*, or a minimum number of HLC hits within some time
  - SMT8 (all strings)
  - SMT3 (IC79: DeepCore, IC86: extended DeepCore)
  - IceTop (?)
- Cylinder Trigger (a.k.a. "Volume Trigger"): low energy horizontal events (solar WIMP analysis)
- Slow Monopole trigger (can be milliseconds long!)

Filters (recap)

- Track Engine Prescale
- LowUp
- DeepCore
- EHE
- Vertical Event
- DST
- IceTop
- Muon
- Galactic Center
- Slow Monopole
- Cascade
- Sun and Moon
- MinBias

From raw data to pulses



- Waveforms
  - ATWD (128 $\times$ 3.6ns)
  - FADC (256 $\times$ 25.0ns)
- "Extracted" pulses

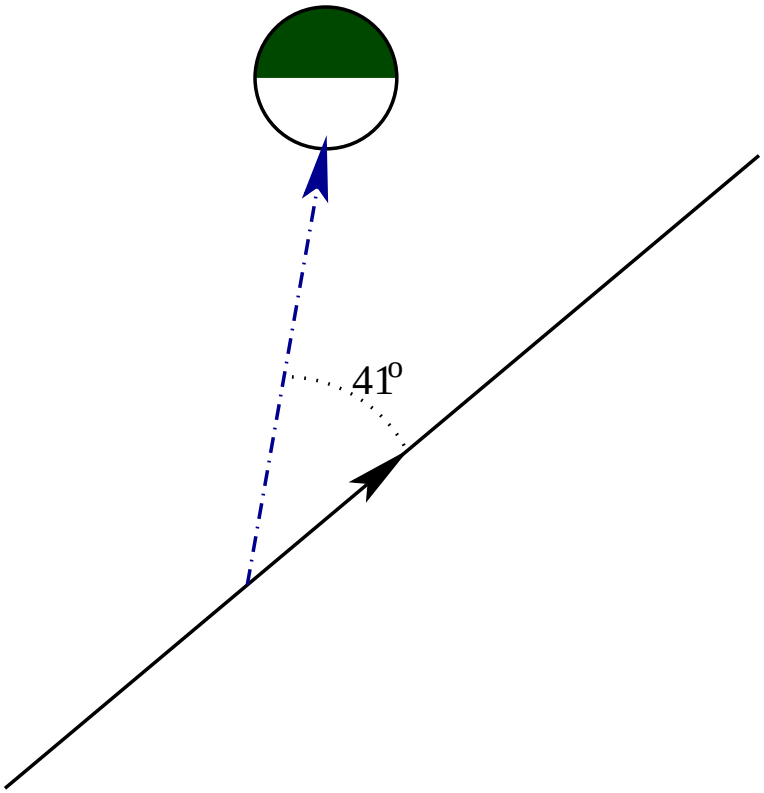
Processing Steps: calibration and feature extraction

- Read the data
- DOM cleaning: remove data from known bad DOMs
- Calibration of waveforms. This involves:
  - Estimate baseline
  - Correct for "droop"
  - Linear transformation from digital "units" to mV.
- Feature Extraction
  - Convert calibrated ATWD/FADC waveforms to pulses
  - Convert SLC charge stamps to pulses
  - Merge all these into one "I3RecoPulseSeriesMap"

Hit cleaning

- Time window cleaning (TWC)
  - Static window w.r.t. a trigger time
  - Dynamic window
- Seeded RT cleaning (SRT)
  - "Seed" can be:
    - Center of Gravity (COG) of HLC pulses
    - all HLC pulses
    - most HLC pulses (excluding obvious outliers)
  - Add to seed pulses that are within a certain distance (R) and time (T) of the pulses we already have
  - Repeat the previous step a few times

Light & Photoelectrons



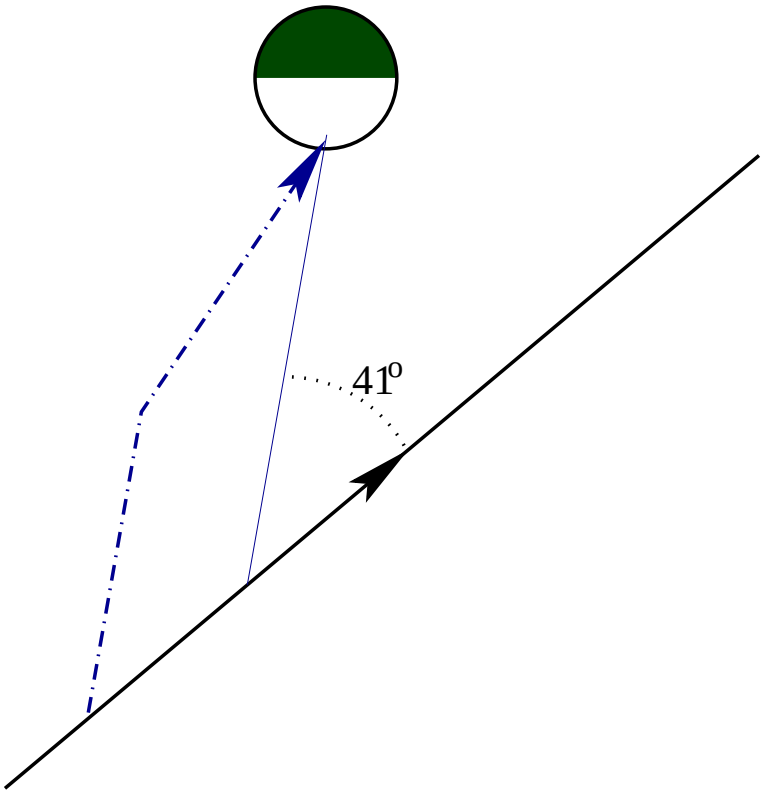
To be modeled:

- Light Emission
- Scattering, absorption
- Time residual
- Arrival time distribution
- Jitter, noise
- Expected total number of PE

Available solutions:

- Analytic: Pandel
- Table: Photonics

Light & Photoelectrons



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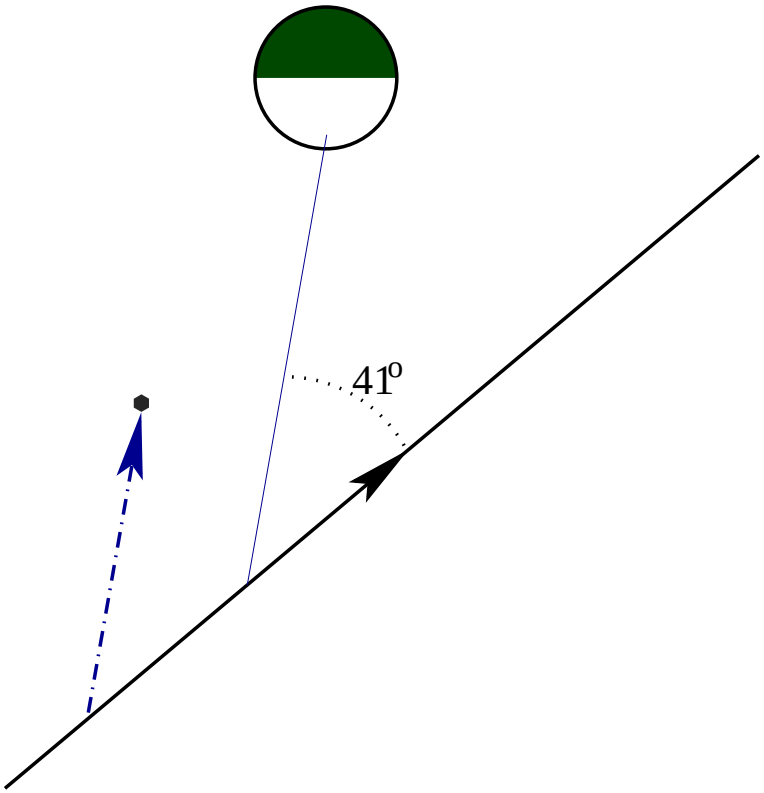

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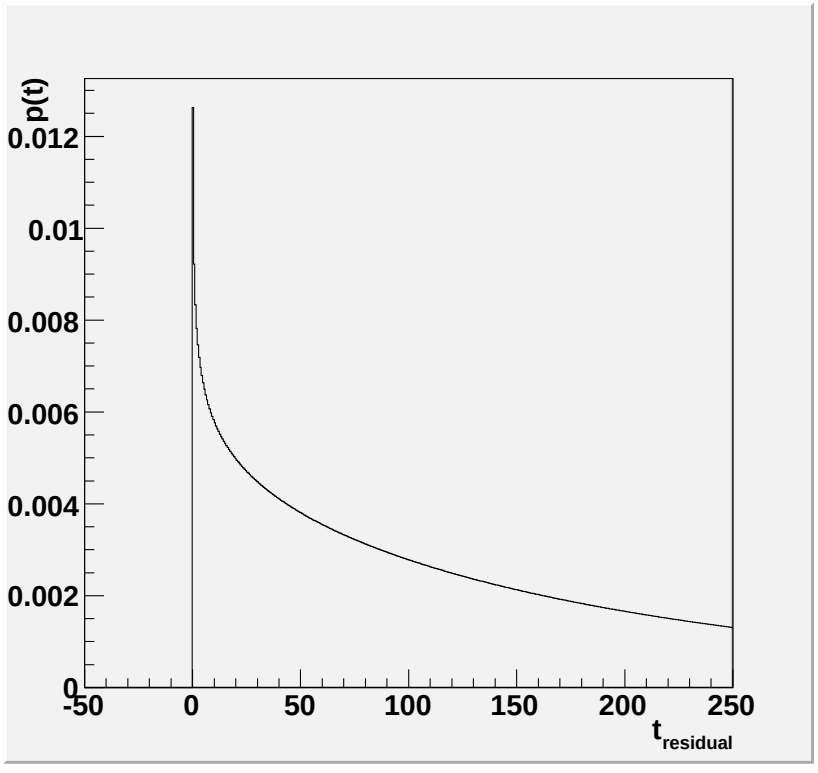

$$t_{residual} = t_{pulse} - t_{direct}$$

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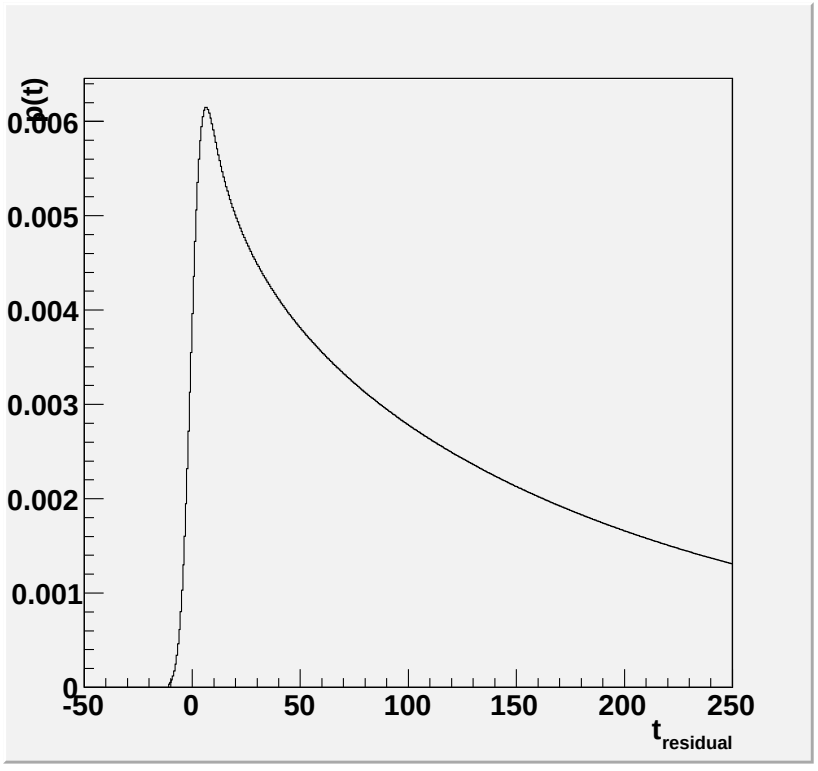

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Light & Photoelectrons

$$p(\xi, \rho, t) = \frac{\rho^{\xi} t^{\xi-1}}{\Gamma(\xi)} e^{-\rho t}$$

$\xi = R/\lambda$

$\rho = \frac{1}{\tau} + \frac{c}{\lambda a}$

$$\mathcal{F}_{\sigma}(\xi, \rho, t) = \int_{-\infty}^{+\infty} p(\xi, \rho, t') g_{\sigma}(t' - t, \sigma) dt'$$

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Light & Photoelectrons

(photonics movie)

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