Plan for SBL simulation
- energy scale investigation for positron measurement at single baseline experiment -

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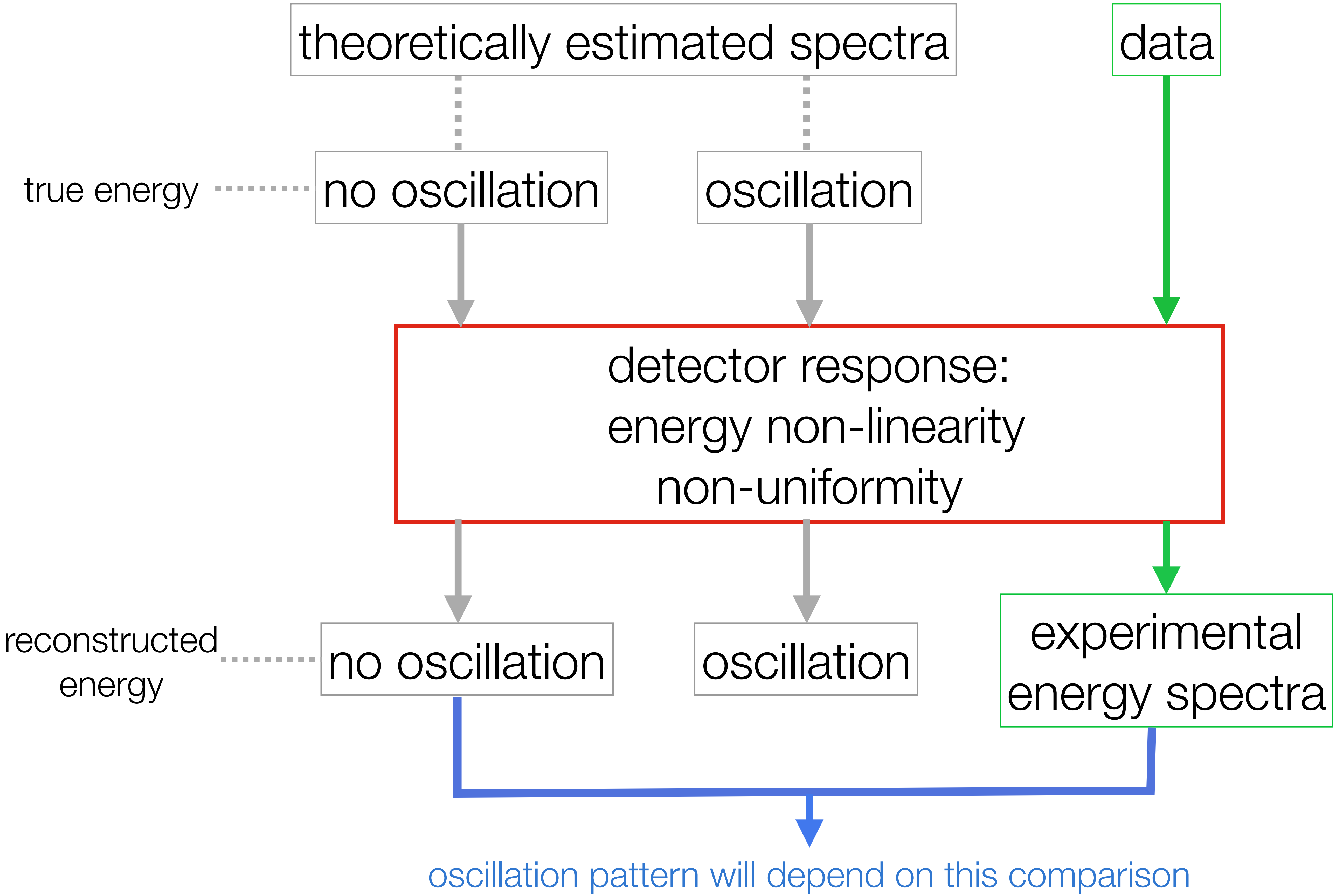
- Our goal is to observe the energy dependent oscillation pattern
  - the best way is to locate two identical detectors at different baselines
- But, at tendon gallery it would be single baseline experiment
  - oscillation pattern will depend on the comparison between experimental energy spectrum and theoretically estimated spectrum


theoretically estimated spectra
data
true energy
no oscillation
oscillation
detector response:
energy non-linearity
non-uniformity
reconstructed energy
no oscillation
oscillation
experimental energy spectra
oscillation pattern will depend on this comparison

- Inverse beta decay

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

- prompt energy spectra
  - E_prompt = e+ kinetic energy + 2 gammas (from annihilation)
    - e+ losses kinetic energy via ionization
    - gamma interaction with matter results in e+, e-
      - Compton electrons
      - photoelectron
      - e- from pair production
      - e+ from pair production
    - e- deposits energy in LS via ionization
    - the ionization energy of e+ and e- can be assumed to have the same nonlinearity
- It is not easy to calibrate the detector with e+ or e- of given energy

- total number of photons generated in the simulation, N_{tot}

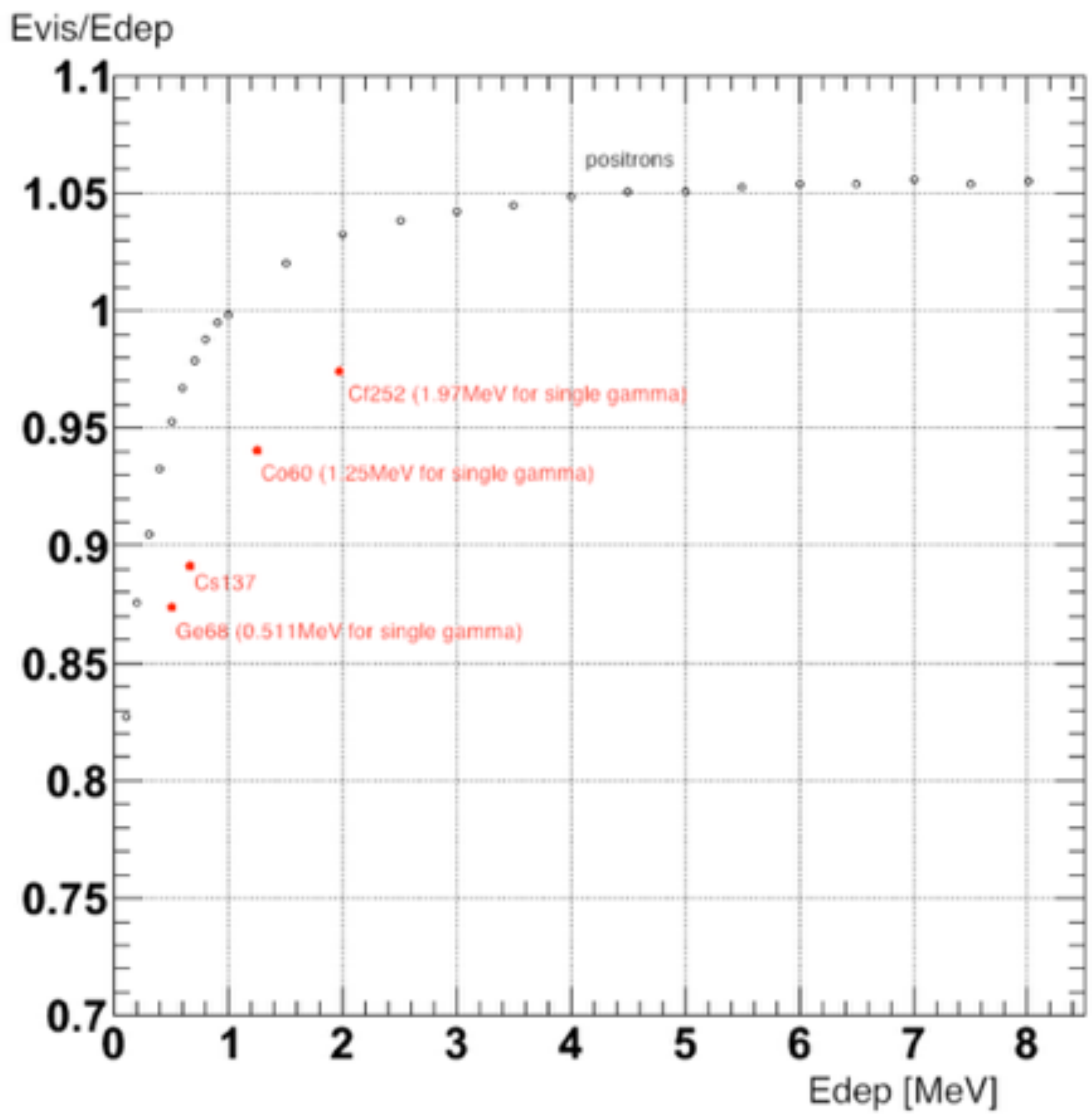
$$N_{tot} = N_{qc} + N_{Ckov}$$

$$N_{qc} = L0 \cdot \left(\frac{E_{dep}}{1.0 + kB \cdot \left(\frac{E_{dep}}{x_{step}} \right)} \right)$$

$$\frac{d^2 N_{Ckov}}{dx_{step} d\lambda} = \frac{2\pi\alpha z^2}{\lambda^2} \left(1 - \frac{1}{\beta^2 n^2(\lambda)} \right)$$

$$E_{vis} = K \cdot N_{PE}$$

- energy scale

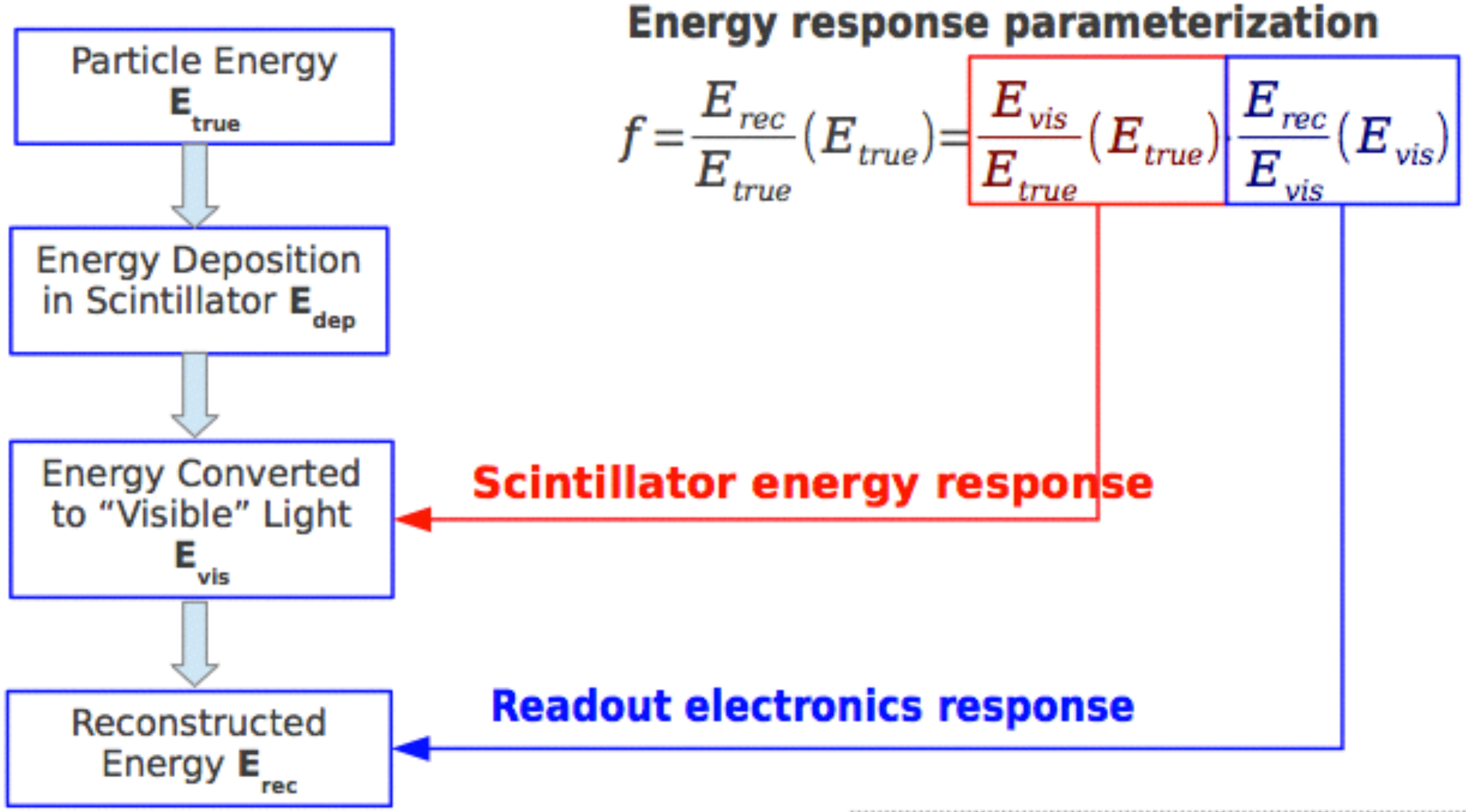


- Cherenkov photons
  - it ranges in wavelengths from ~100-300nm
  - reemission of absorbed cherenkov photons will increase the light yield
  - refractive index n as a function of wavelength
  - reemission probability of the photon with wavelength below 200nm is not known
  - …
- Double Chooz …

Energy Response Model

Energy response parameterization

$$f = \frac{E_{rec}}{E_{true}}(E_{true}) = \frac{E_{vis}}{E_{true}}(E_{true}) \frac{E_{rec}}{E_{vis}}(E_{vis})$$



Scintillator energy response
- **Scintillator quenching effect**
- **Cerenkov radiation**

Readout electronics response
- **Charge collection efficiency**
- **PMT signal shaping**
- **Others**

Detector energy response model converts particle true kinetic energy to the reconstructed energy

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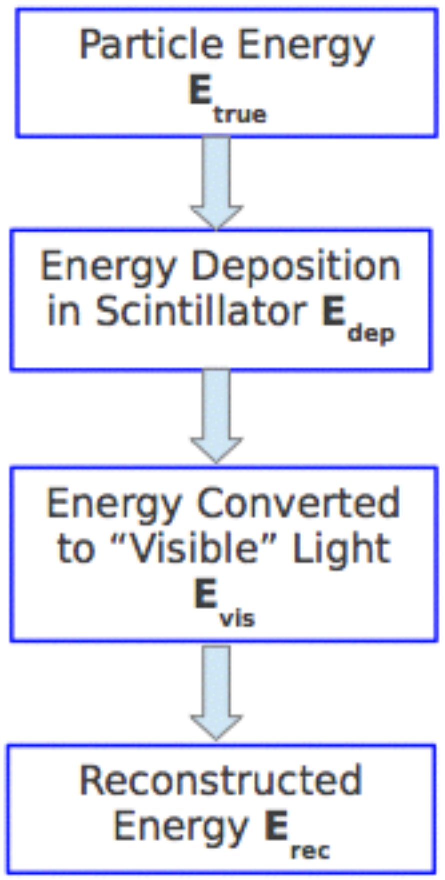
Jiajie Ling(Daya Bay), TAUP 2013

Electron Energy Response Model



Energy Response Parameterization

$$f = \frac{E_{rec}}{E_{true}}(E_{true}) = \frac{E_{vis}}{E_{true}}(E_{true}) \frac{E_{rec}}{E_{vis}}(E_{vis})$$

Scintillator energy response

- **Electrons**
  - 2 parameterizations to model electron scintillator response

$$\frac{E_{vis}}{E_{true}}(E_{true}) = \frac{1 + p3 \cdot E_{true}}{1 + p1 \cdot e^{-p2 \cdot E_{true}}}$$

$$\frac{E_{vis}}{E_{true}}(E_{true}) = f_q(E_{true}; k_B) + k_C \cdot f_C(E_{true})$$

k_B: Birk's constant

k_C: Cherenkov contribution

Readout electronics response

- Empirical parameterization: exponential

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Gamma and Positron Energy Response Model

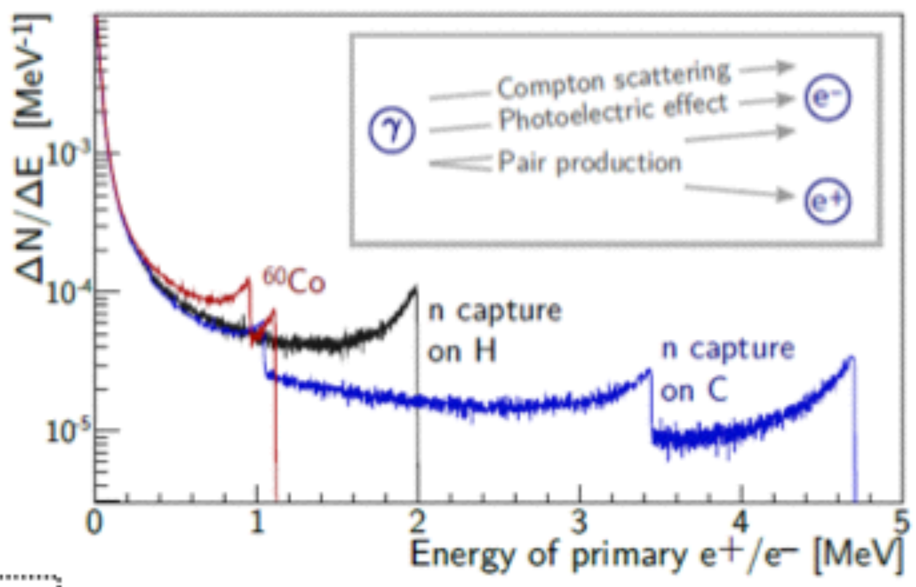
Energy response parameterization

$$f=\frac{E_{rec}}{E_{true}}(E_{true})=\frac{E_{vis}}{E_{true}}(E_{true})\cdot\frac{E_{rec}}{E_{vis}}(E_{vis})$$

Scintillator energy response

- **Gamma and Positron Response**
  - Gamma connected electron model through MC
  - Positron assumed to interact with the scintillator in the same way as electrons:

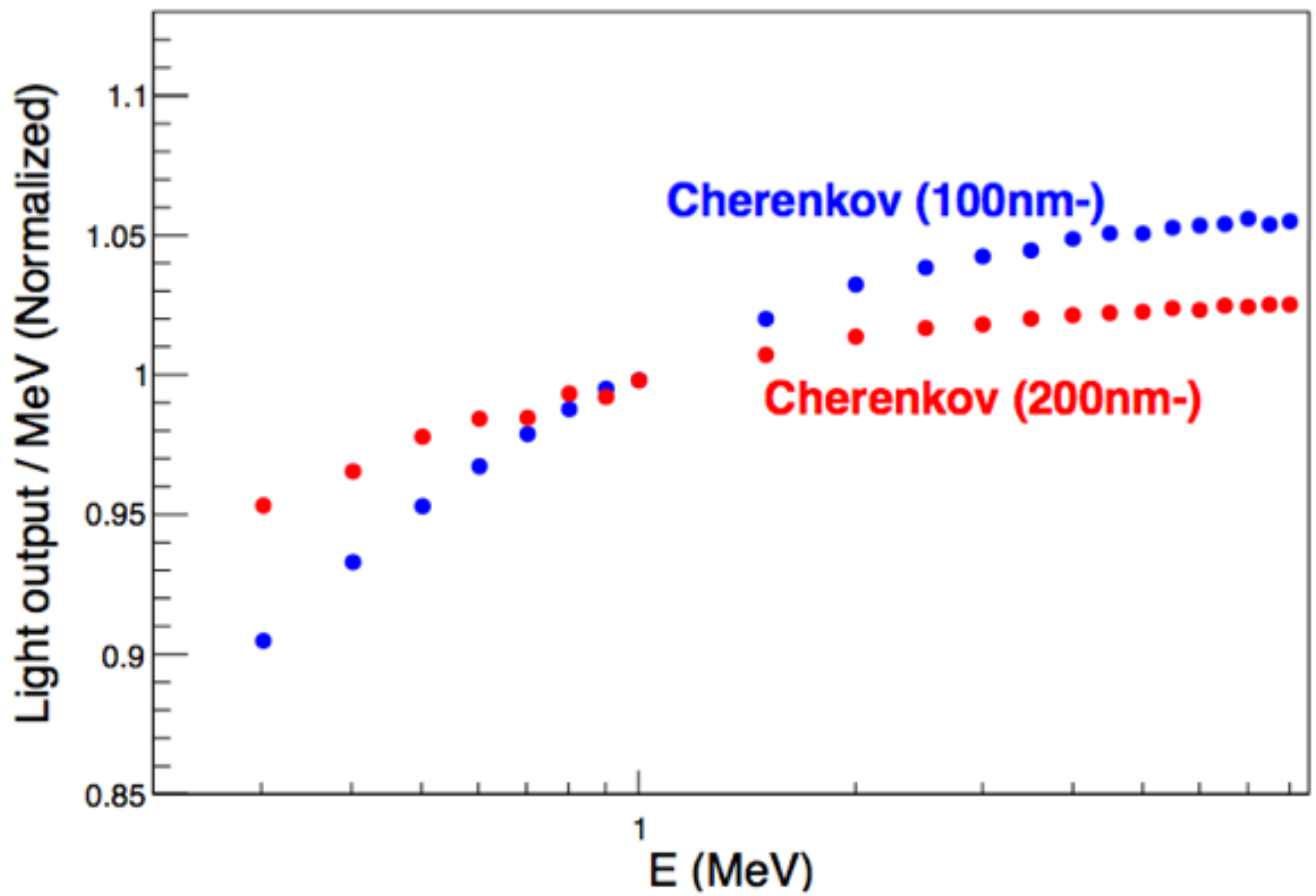
$$E_{vis}^{e+}=E_{vis}^{e-}+2\cdot E_{vis}^{\gamma}(0.511\,MeV)$$



Readout electronics response

- Same response as electrons

Backup


Cherenkov (100nm-)
Cherenkov (200nm-)
Light output / MeV (Normalized)
E (MeV)
1.1
1.05
1
0.95
0.9
0.85
1