First simulation studies for LATTES

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LIP

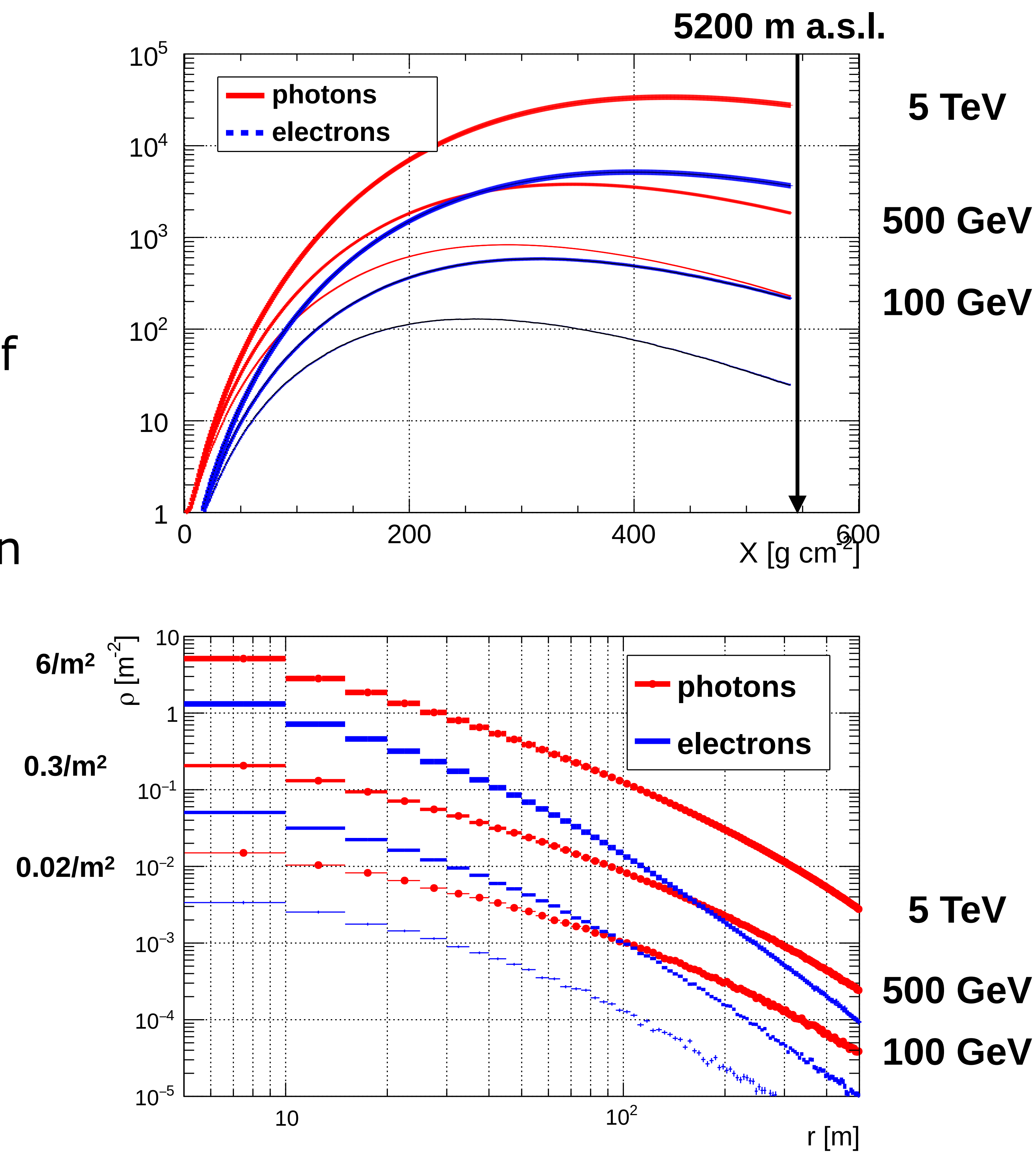
LATTES aims to detect gamma air-showers by fulfilling the following requirements:

(see Ronald Shellard's talk)

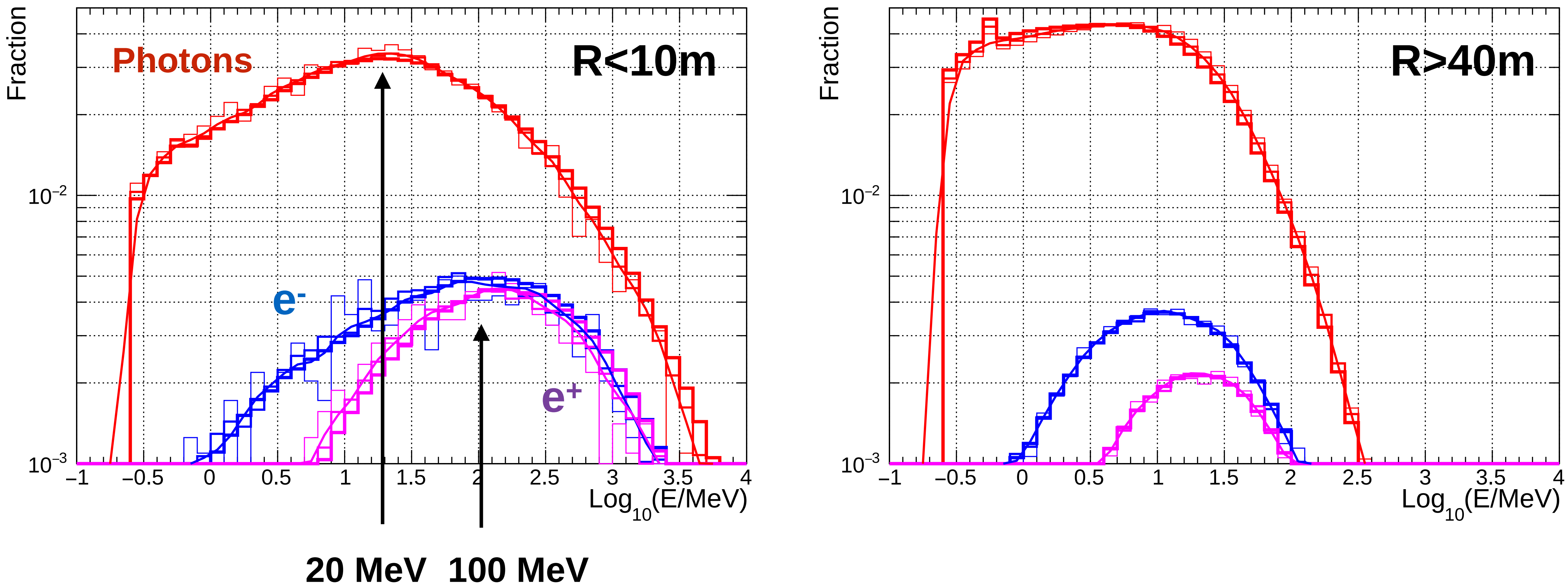
- Attain a low energy threshold and good background rejection
- Large FoV coverage
- Large area + low cost
- Reliability and good control of systematics
- Explore particle physics capabilities ?

Shower longitudinal and lateral profiles

- Photons are the main component of the shower (4 x more than e^+/e^-)
- At low energies few particles within 10 m^2
- Single particle detection using RPC



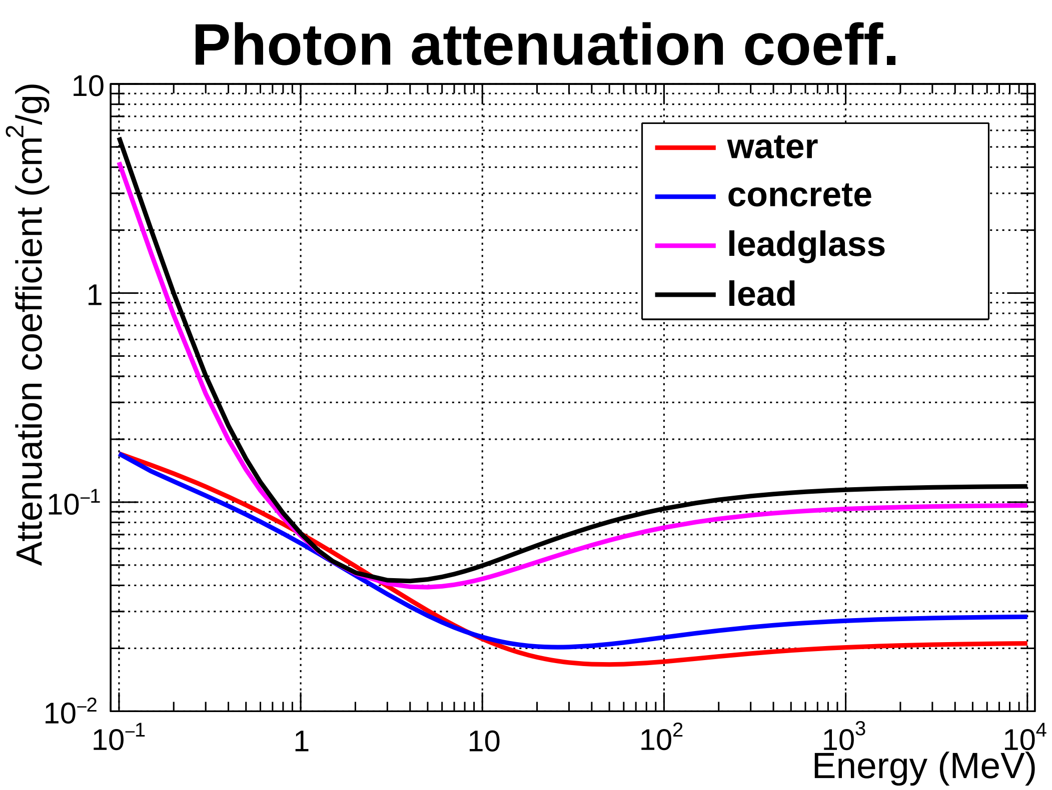
Shower particle spectra @ ground

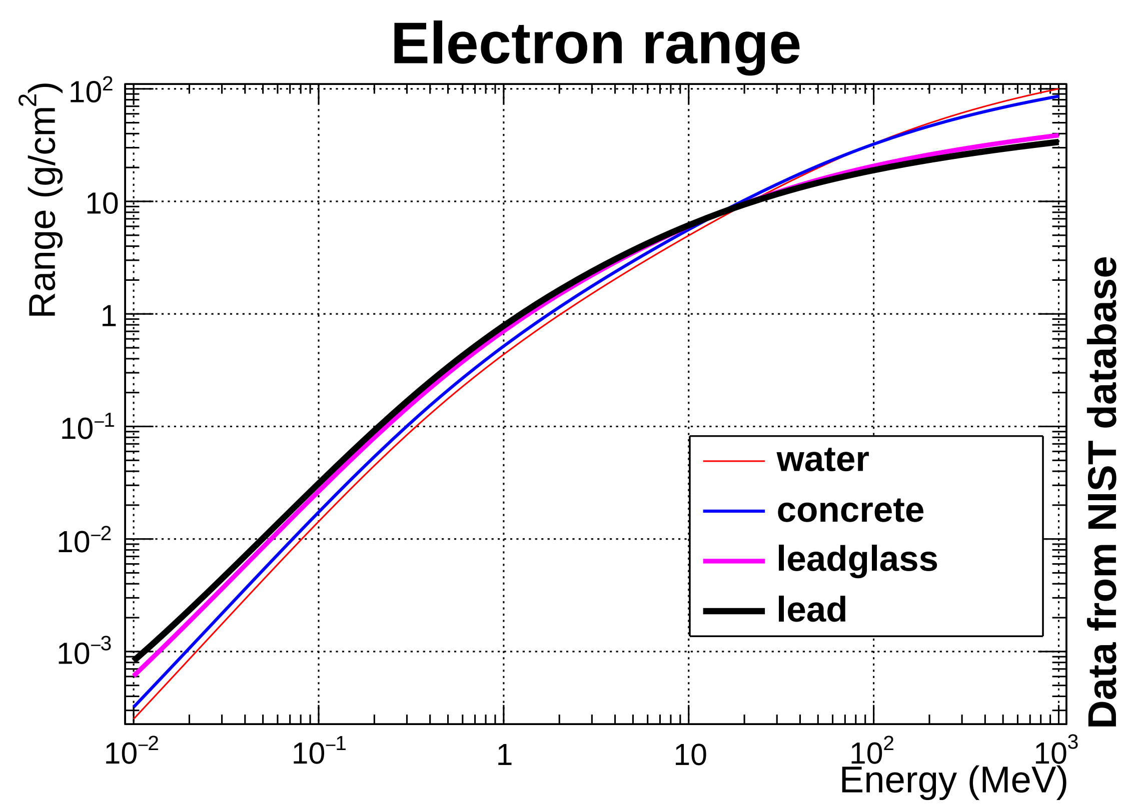


Normalized spectra for primary photons of 100 GeV, 500 GeV and 5 TeV

To convert or not to convert photons

- “Game” between photon energy, photon absorption length and e^+/e^- range





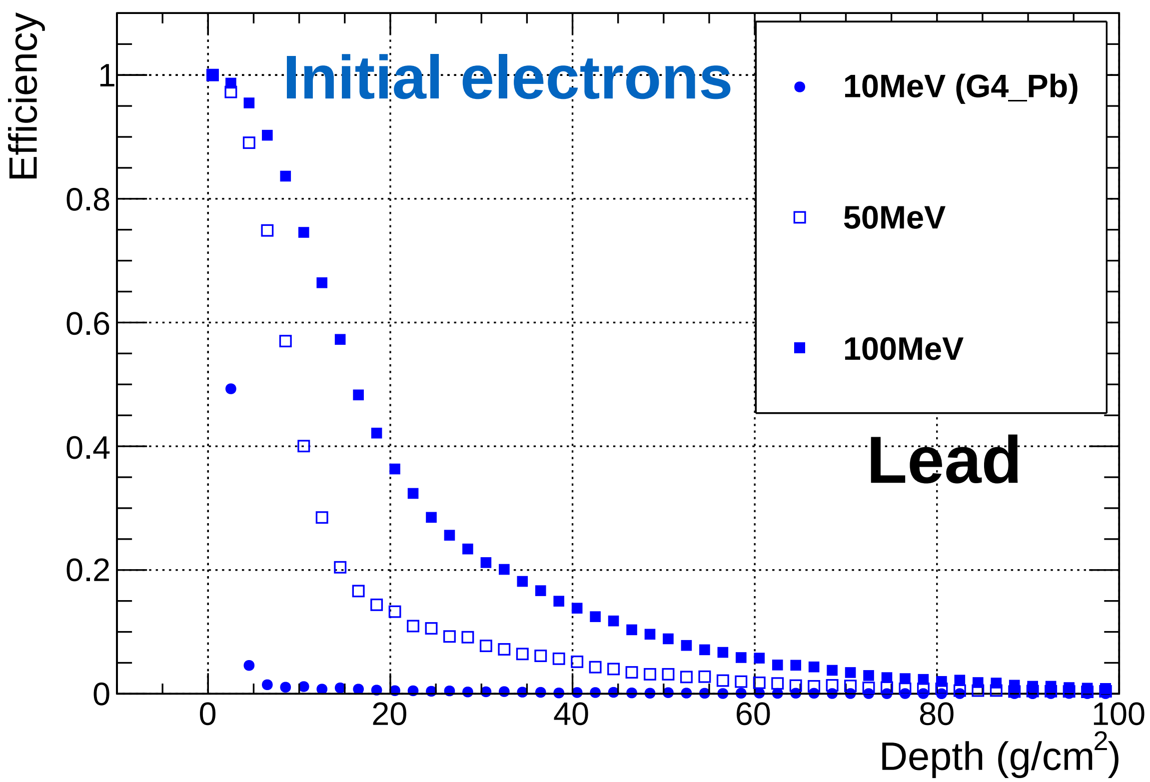
20 MeV photons in Pb : **L_{abs} ~ 20 g/cm²**

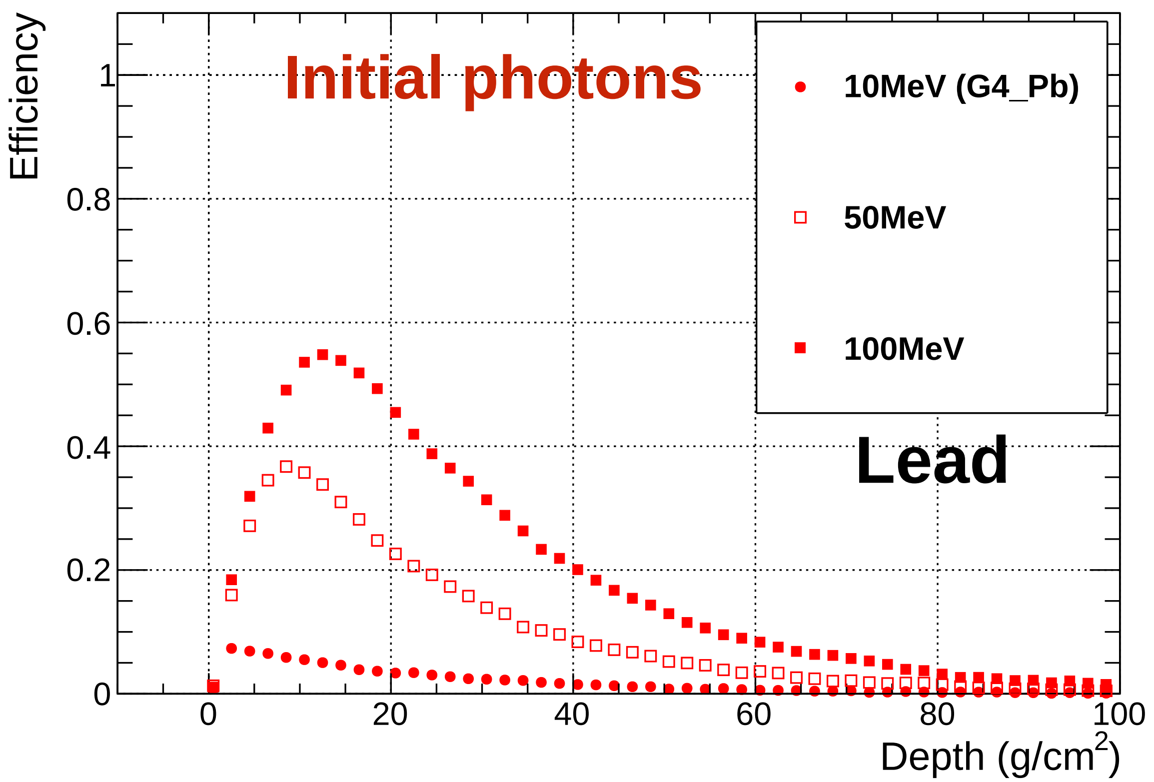
10 MeV e^- in Pb : **Range ~ 7 g/cm²**

Lead thickness required to convert 63% of 20 MeV photons is 2-3 times the typical range of the produced charged particles

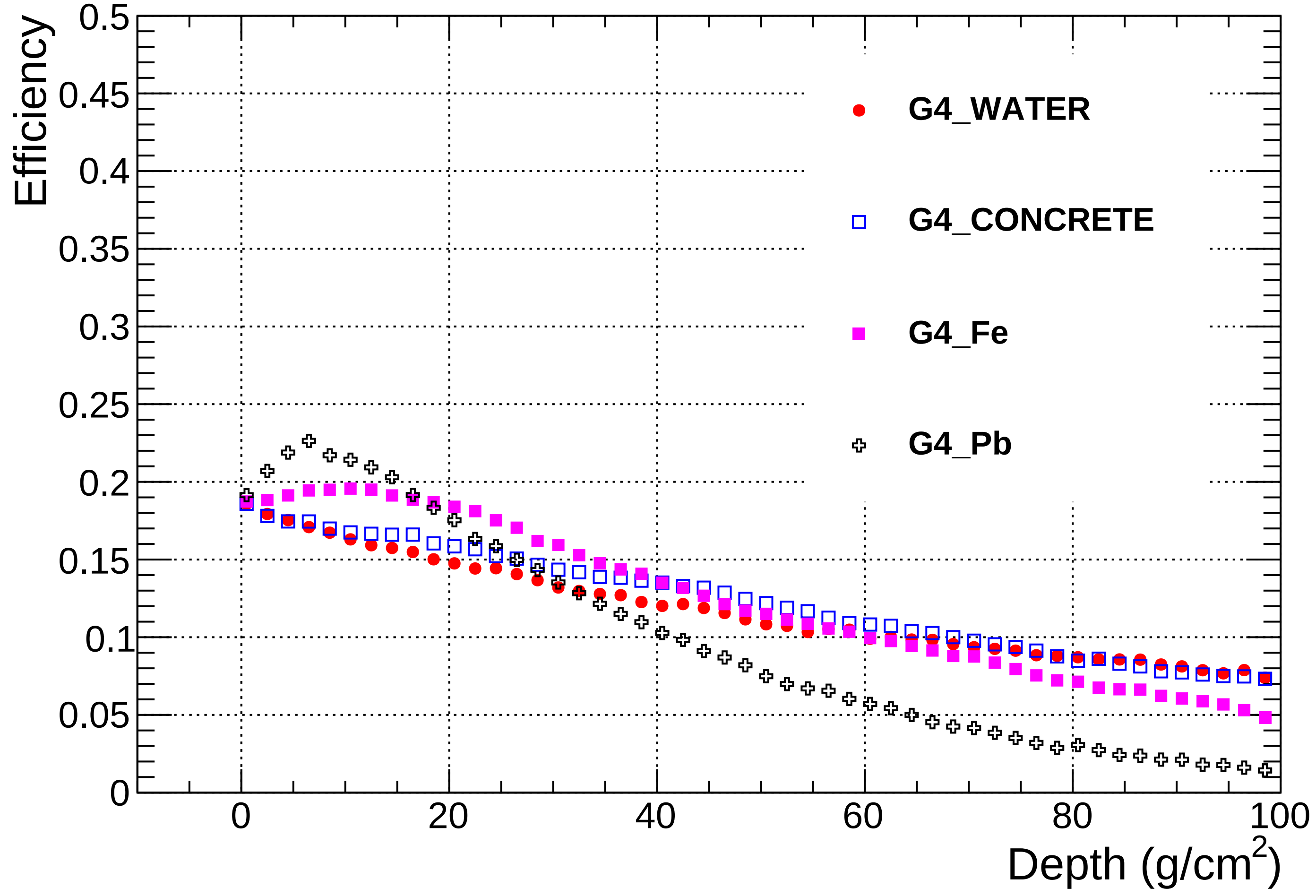
Geant4 simulation

Probability of finding > 0 charged particles vs depth in lead



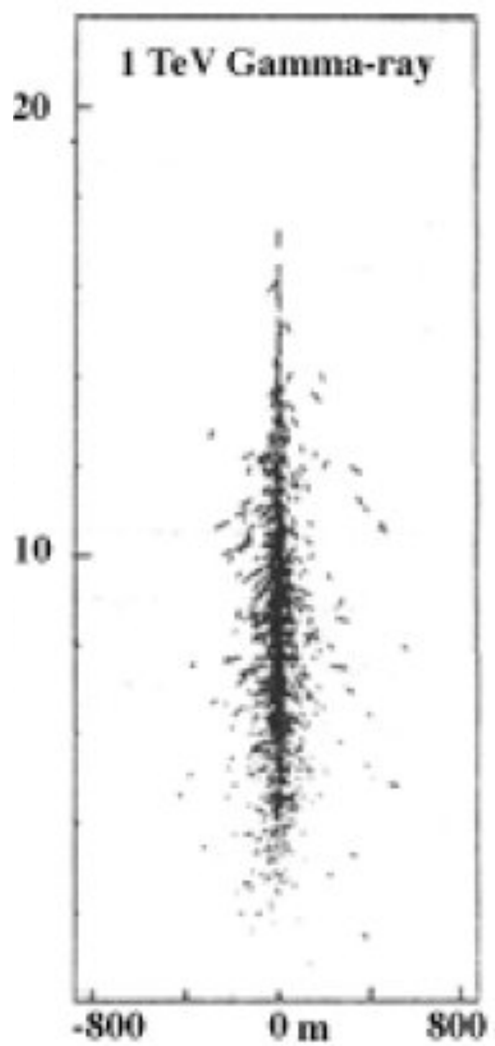


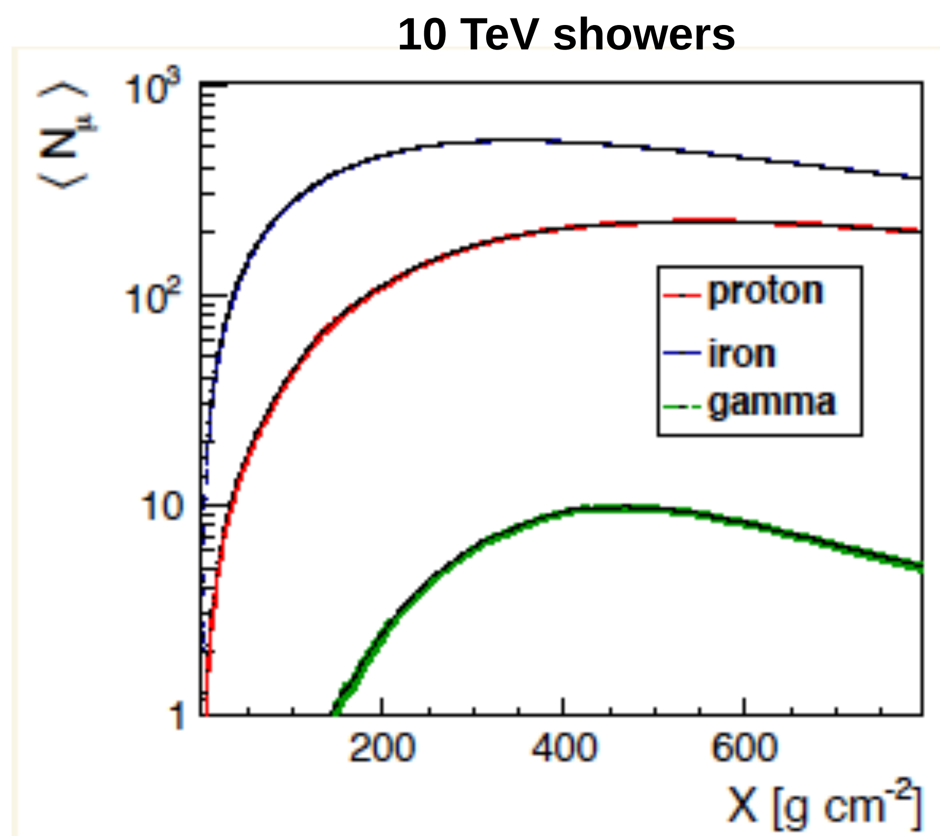
Conversion efficiency for full shower particle spectrum

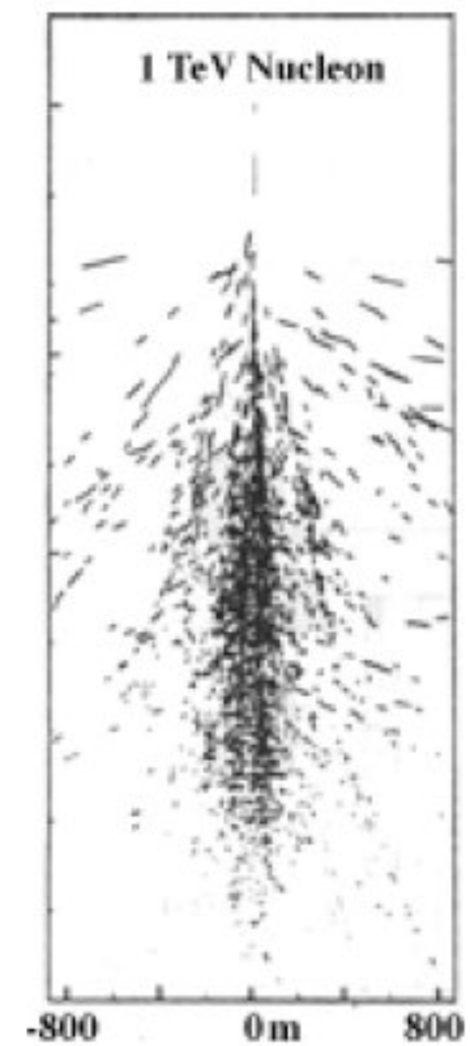


The overall efficiency for getting a charged particle after a lead converter is only 5% greater than the fraction of e^+/e^- in the shower

gamma/proton discrimination







Thanks to Ronald Shellard

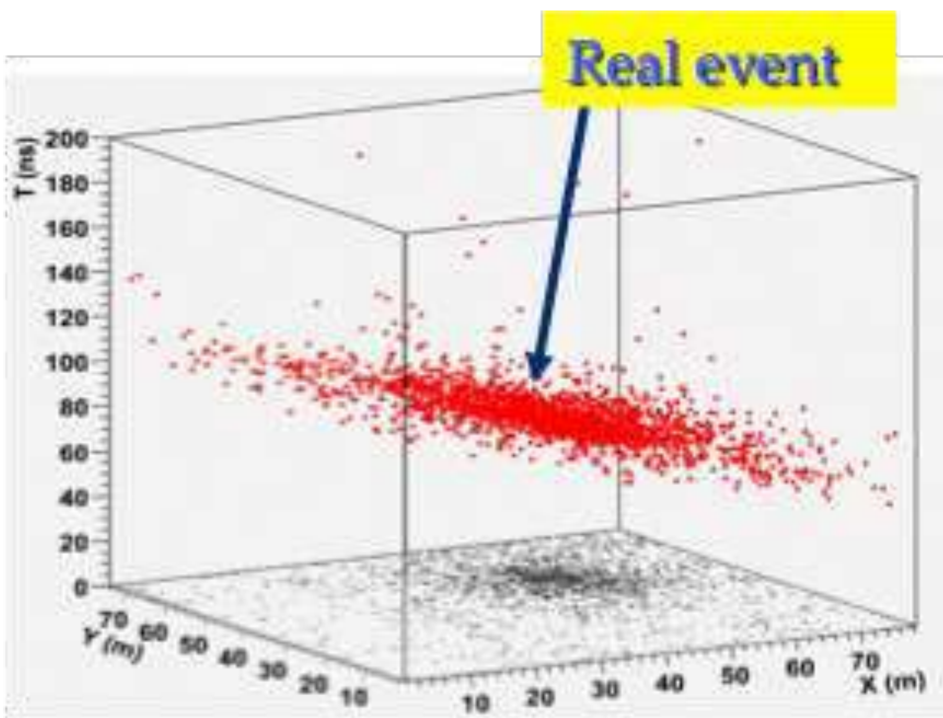
- Dense imprint of particles on ground
- Low muon content

- Sparse imprint on ground
- Muon content ~10x larger
- Energetic muons away from the shower core

The best of the worlds ?

ARGO

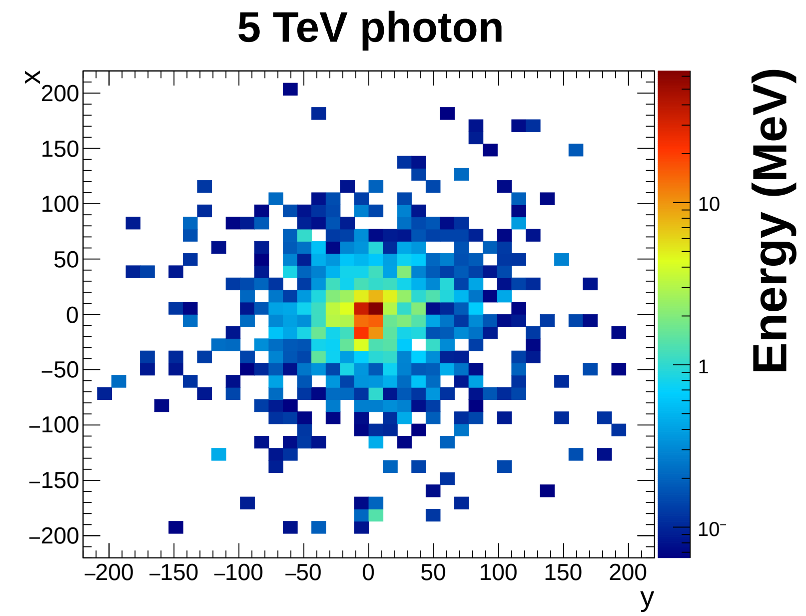
A detailed 3D reconstruction of the shower particles

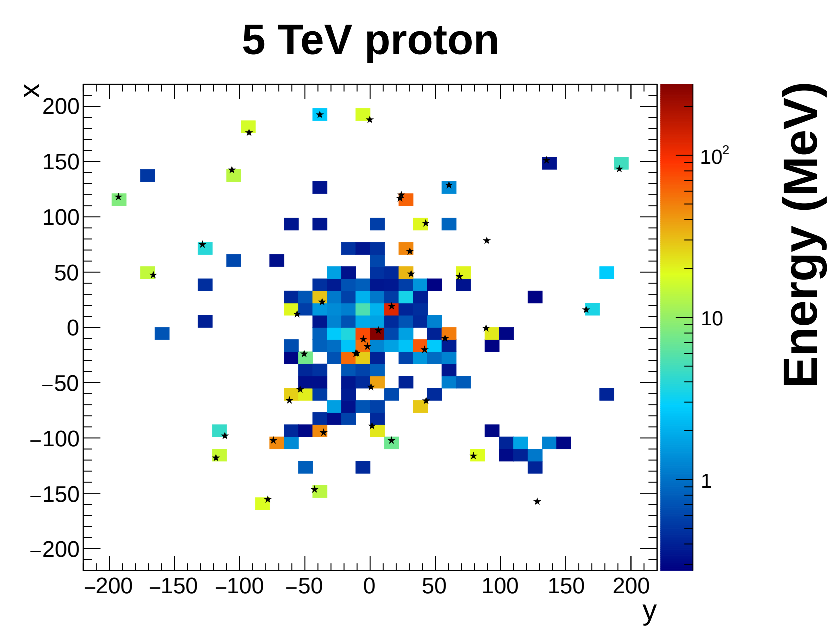


High segmentation of the readout
Very good time resolution
Low energy threshold for transients ?

HAWC

Explore the energy pattern of the shower





Gamma/proton discrimination

Two alternative strategies (or maybe complementary)

ARGO-YBJ

- Detailed study of the shower pattern over a large area
- Spatial correlations among shower particles

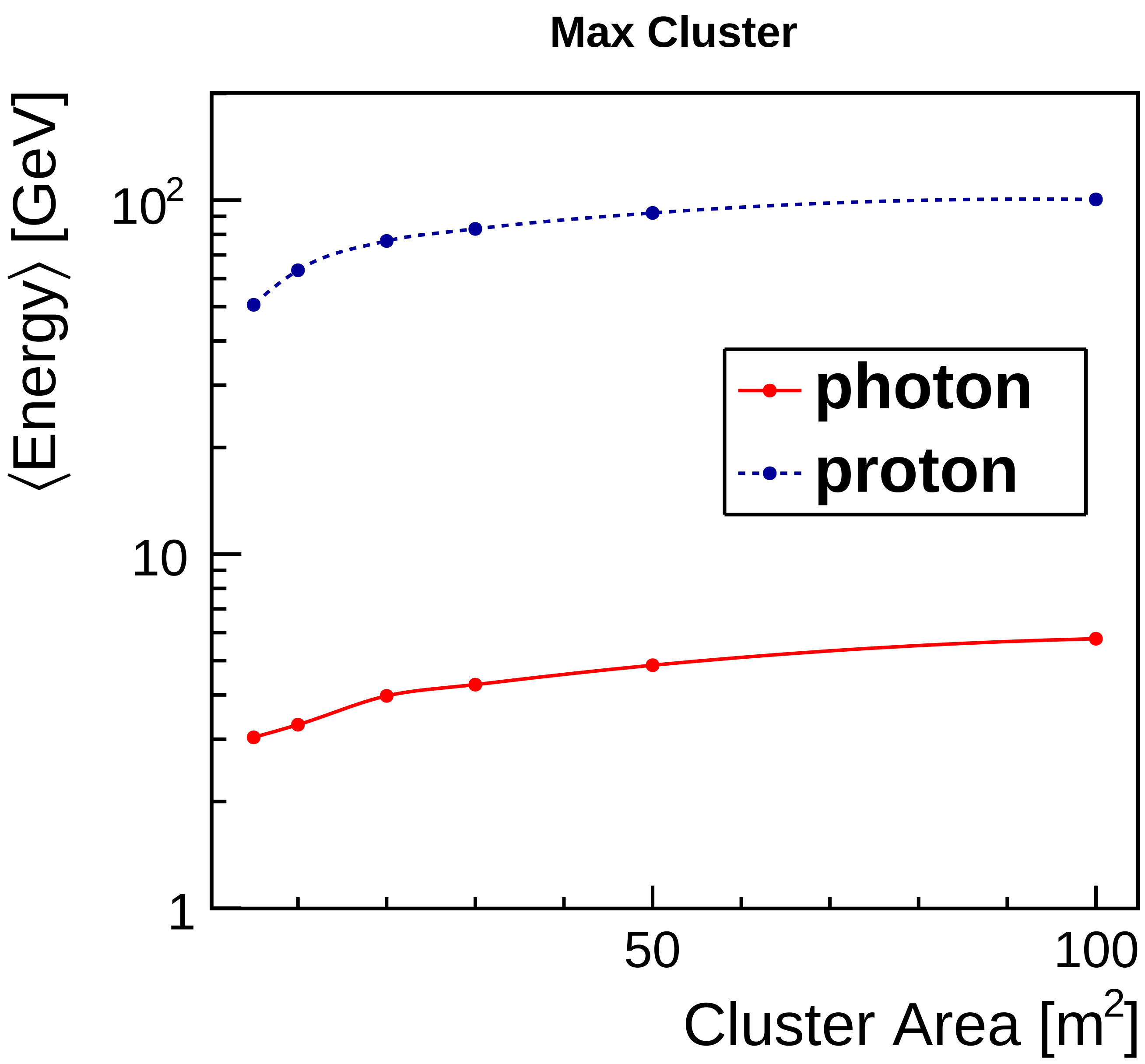
HAWC

- Look for large energy depositions away from the core

Ongoing work for LATTES:

- Study the ARGO approach in the proposed RPC configuration for LATTES.
- Explore the potential of HAWC strategy in dimensioning a compact detector for muons.

Mean energy in hottest cluster



- Measuring the energy is crucial to identify (energetic) muons in an event
- Provides efficient gamma/proton discrimination

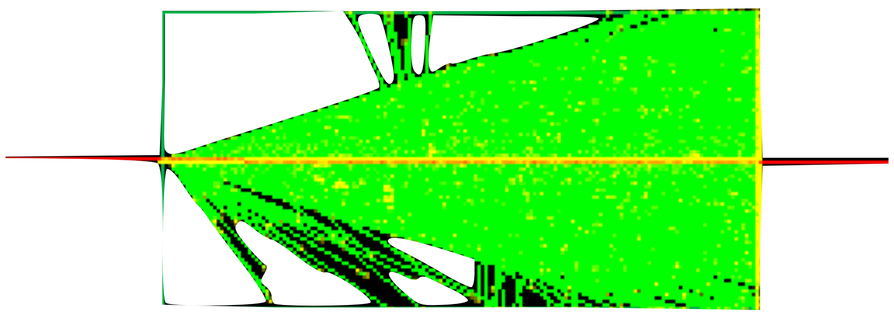
A simple exercise

Geant4 simulation of glass Cherenkov detector

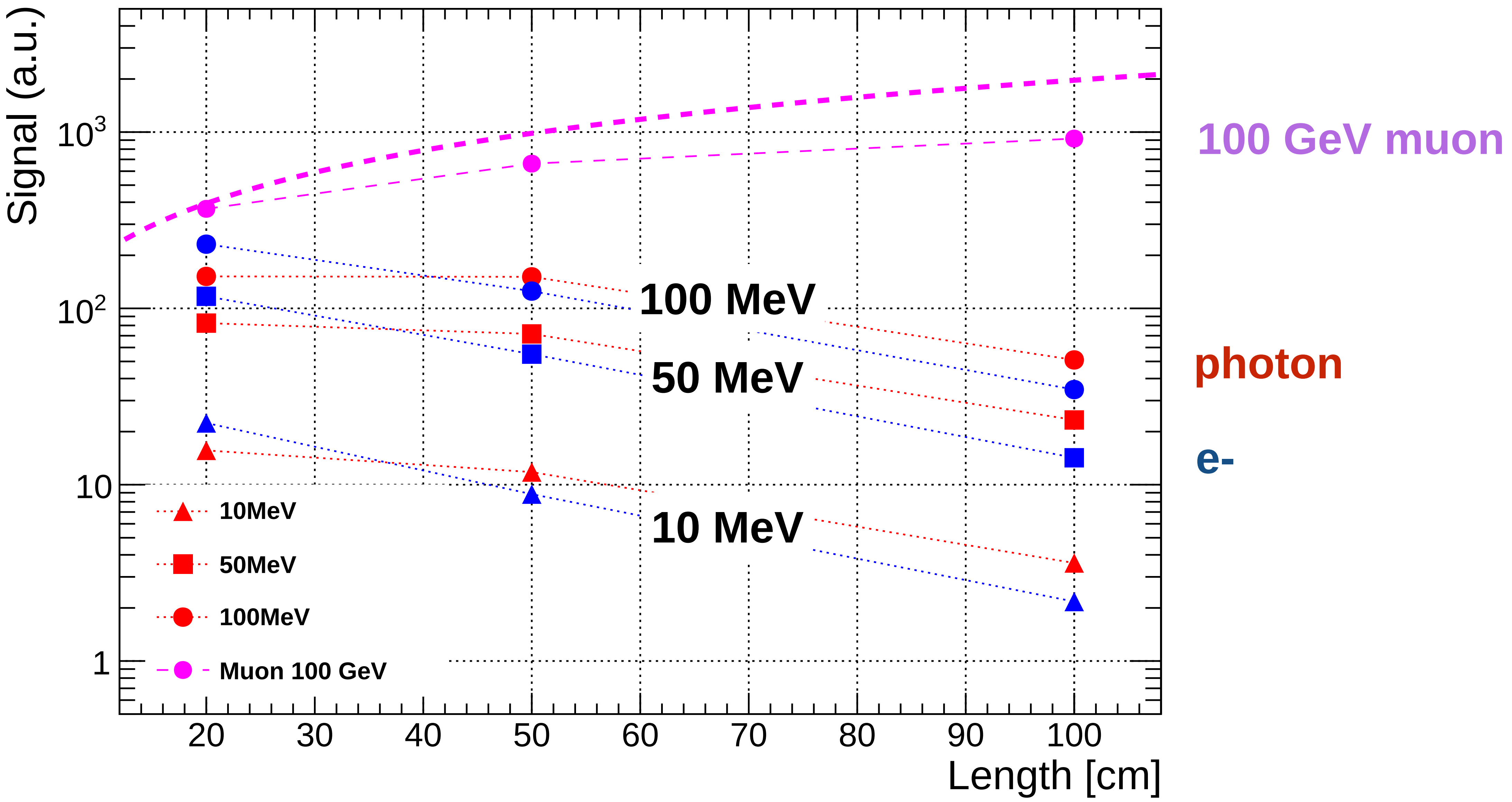
- Compact detector (density = 2.5 g/cm^3)
- Refractive index n = 1.5
- Light yield grows with $(n^2-1)/n^2$
- But light attenuation length small …(0.5m vs 80 m in water)

50 MeV electron

100 GeV muon



Signal vs Glass Length



Towards a next-generation gamma air-shower detector

- Low energy threshold (~100 GeV)
- Explore shower particle patterns with good spatial resolution
- Measure energy flow
- Assess the potential of combining particle detection with good spatial resolution using RPCs with a calorimetric measurement to boost :
    - Sensitivity to low energy showers
    - photon/proton discrimination