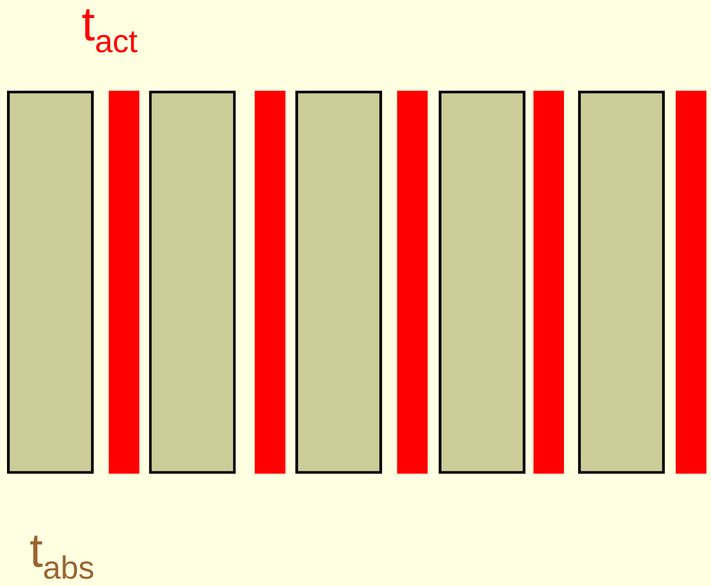
Study of Sampling Fractions

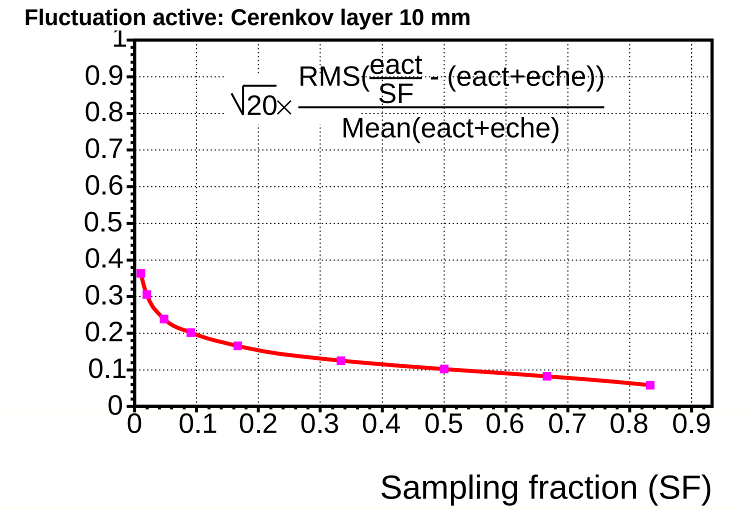
Shin-Shan Yu, A P, Hans Wenzel,
October 18, 2006

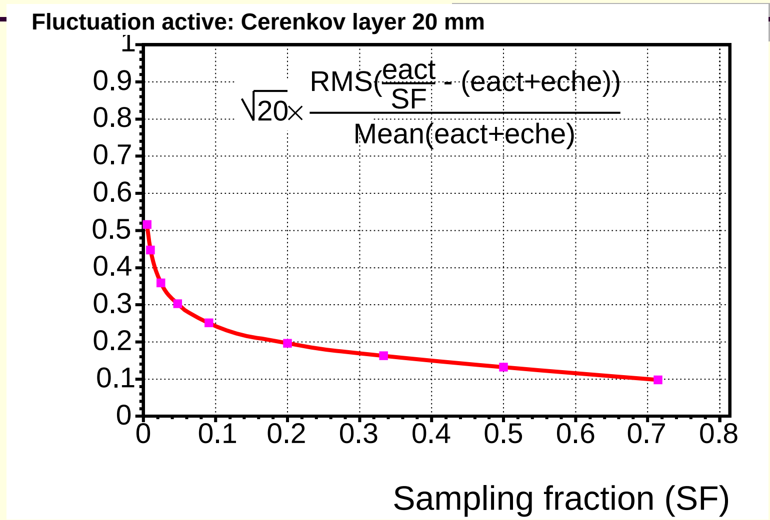
Definitions

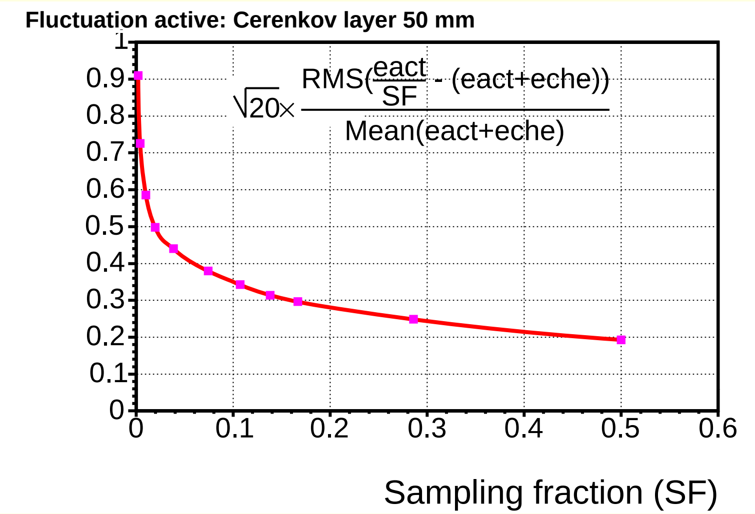
- Construct a sampling calorimeter from alternating layers of 'absorber', thickness t_{abs} and 'active' material, thickness t_{act}. Both active and absorber are made of the same material (lead glass)
- Sampling fraction SF = $t_{act} /(t_{abs} + t_{act})$ represents the fraction of the total energy deposition (on average) deposited in the active layers.
- Estimate of the total energy deposition from the corrected observed energy in the active layers has an additional contribution due to 'sampling fluctuations': fluctuations of the sharing of total energy between the absorber and active layers
- 20 GeV pion beam

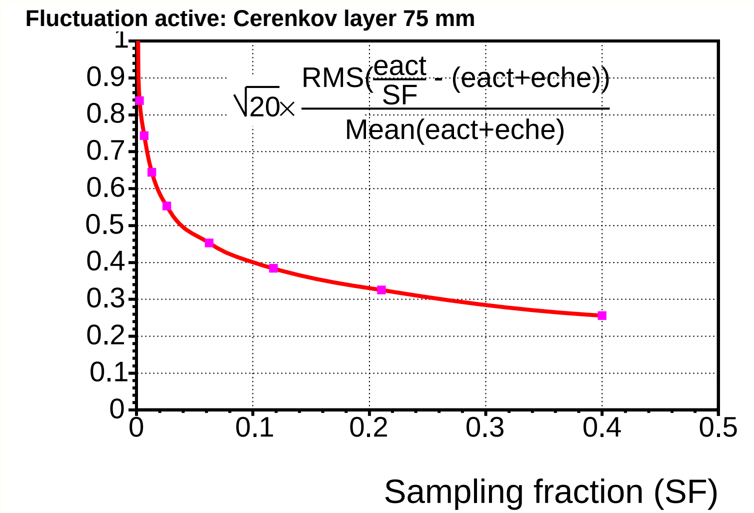


Fluctuations of the energy deposition in the active layer – Sampling Fluctuations

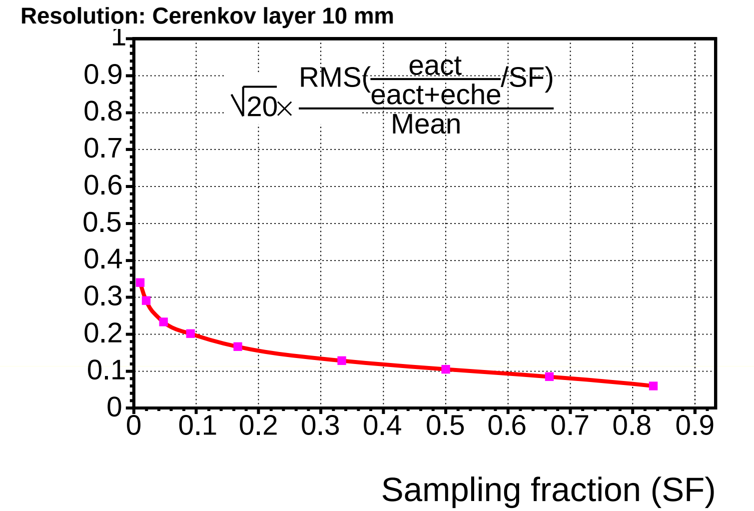


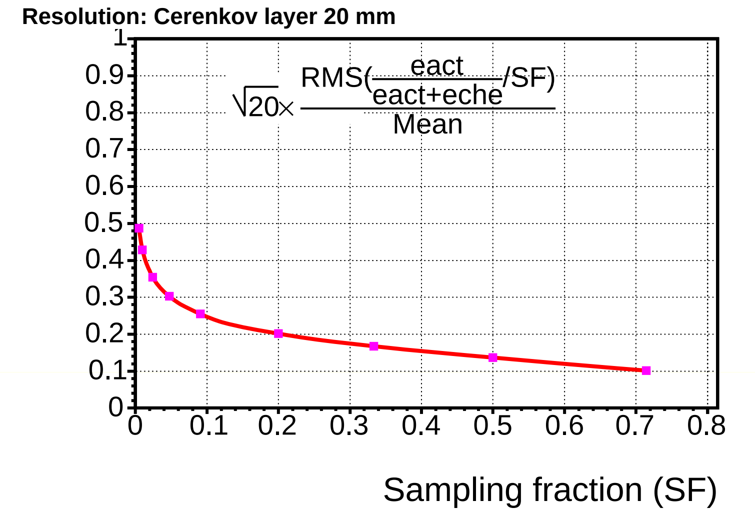


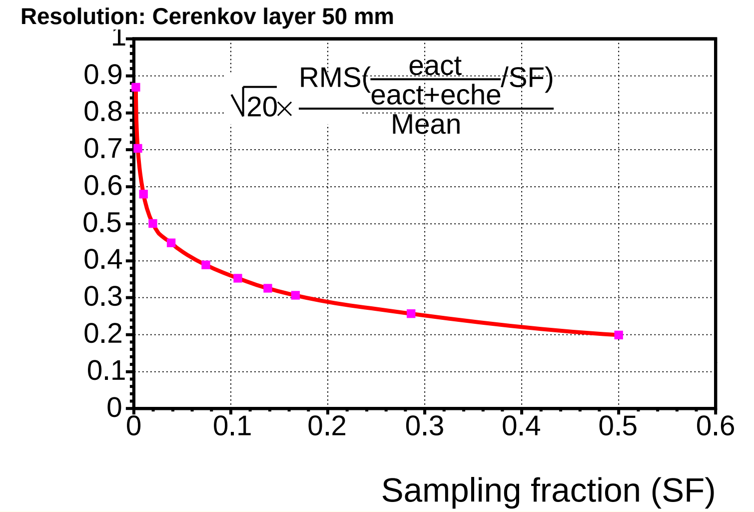


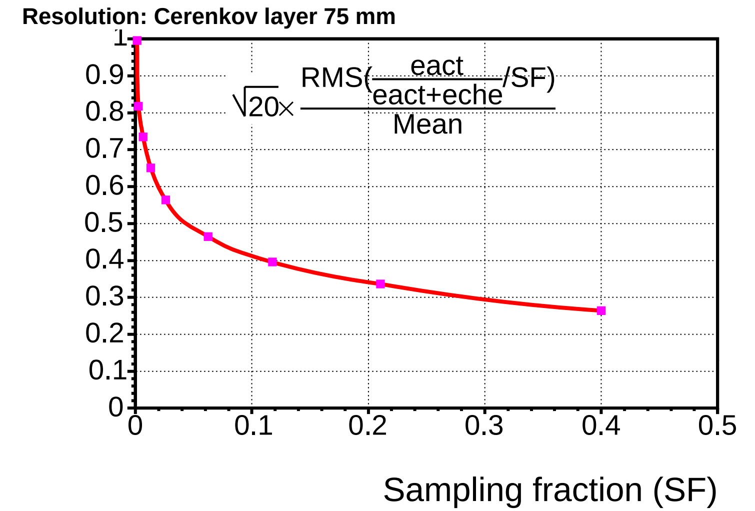


Sampling Fluctuations Contribution to Energy Resolution

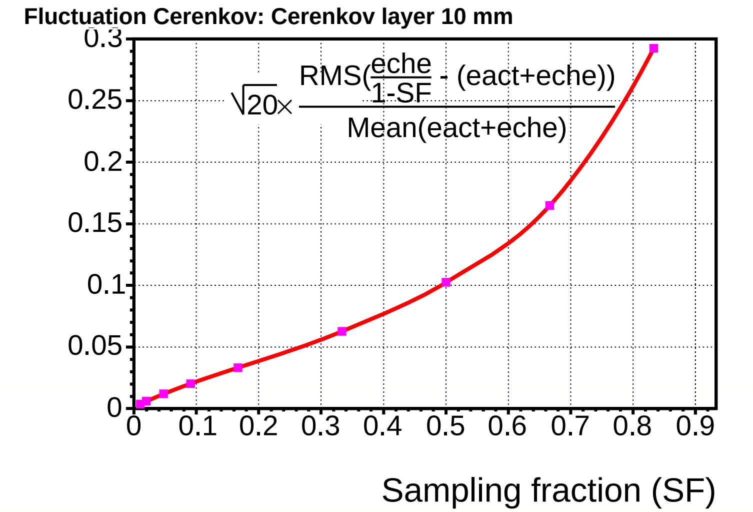


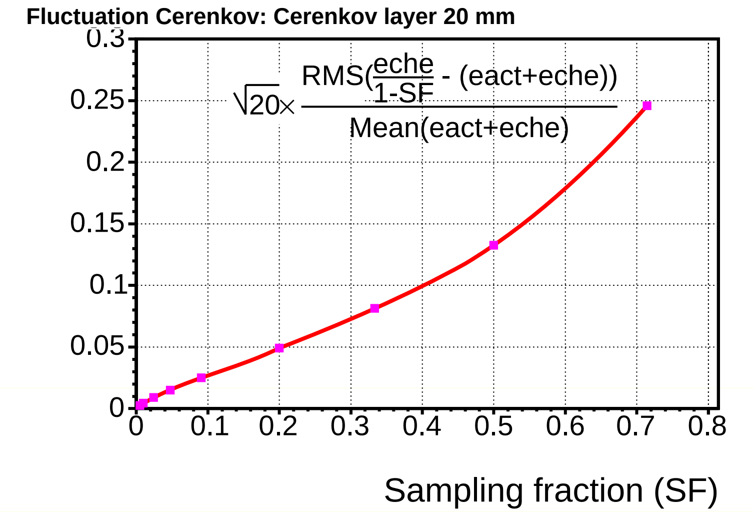


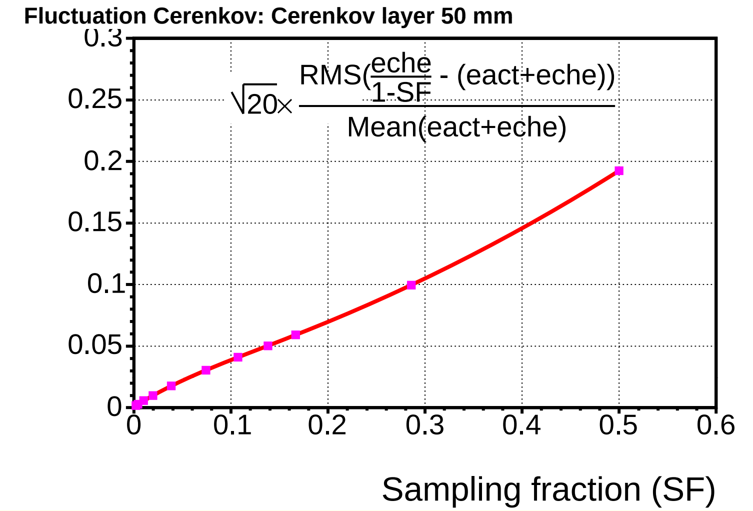


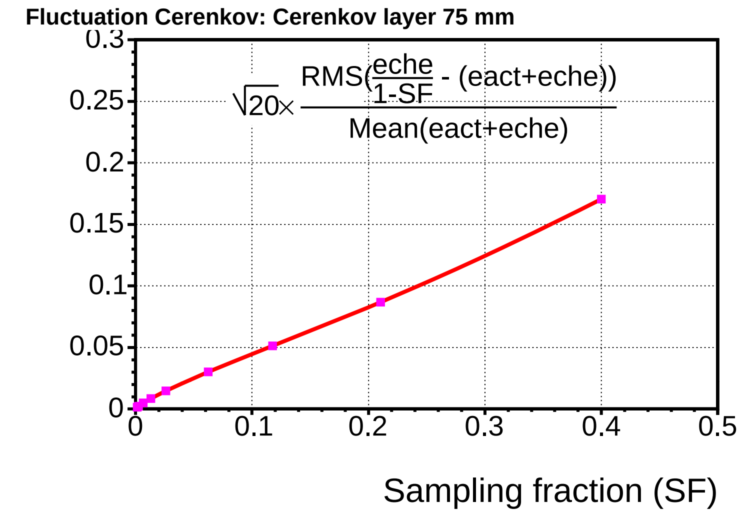


Fluctuations of the energy deposition in the Cherenkov radiator – Sampling Fluctuations

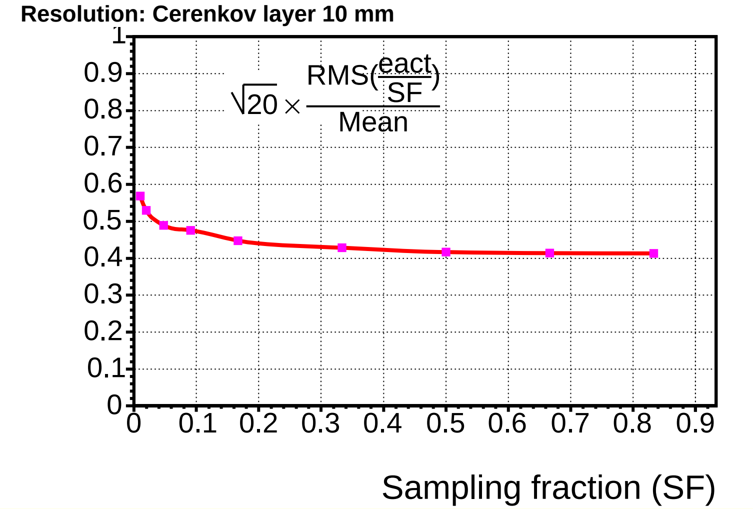


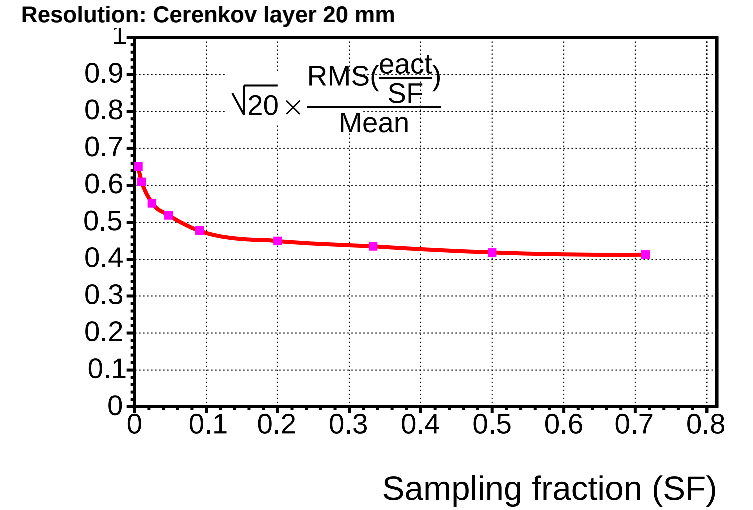


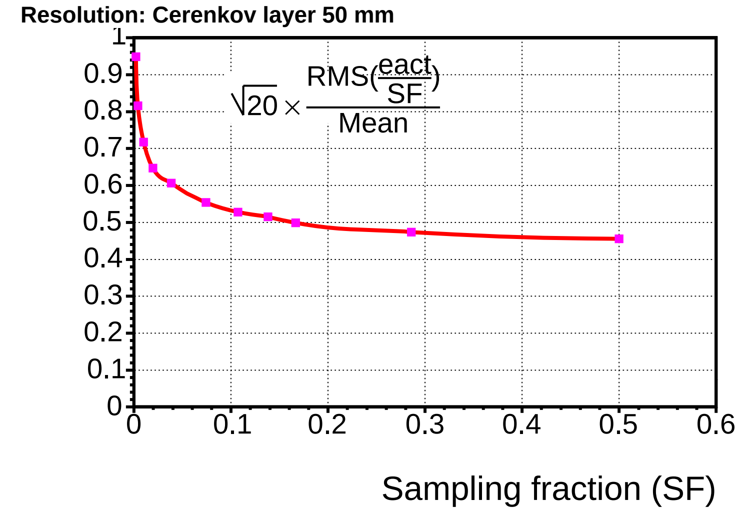


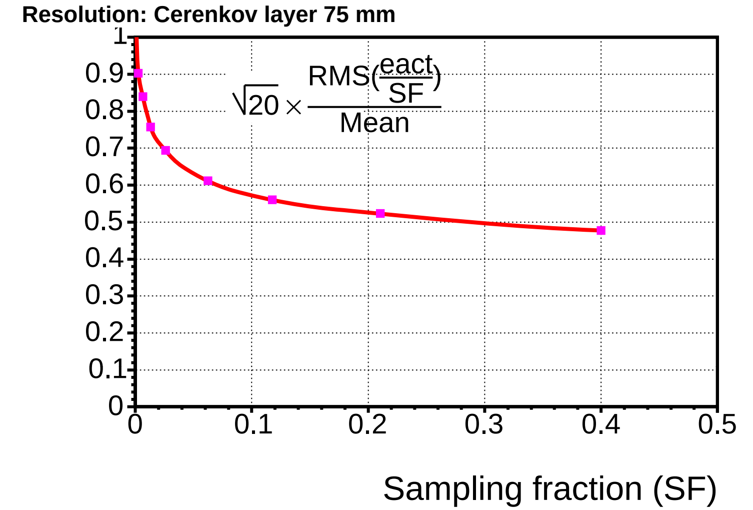


Energy Resolution

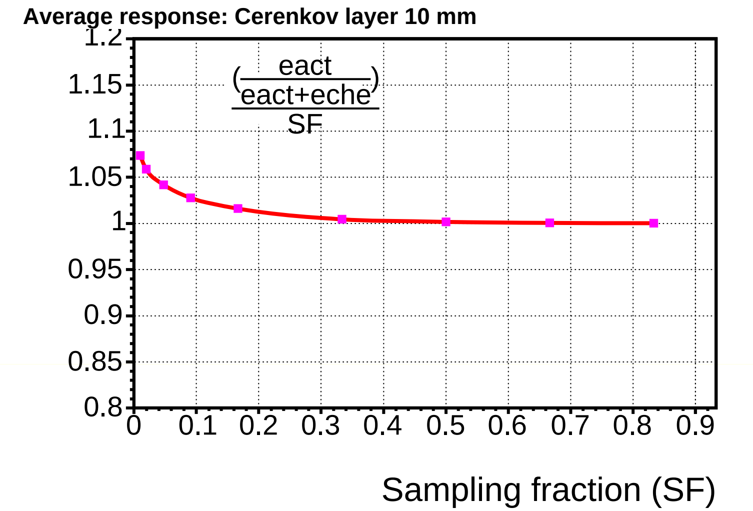


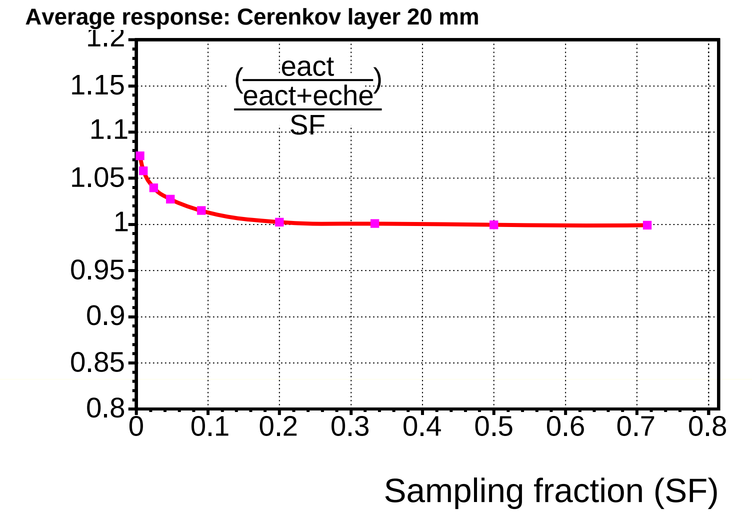


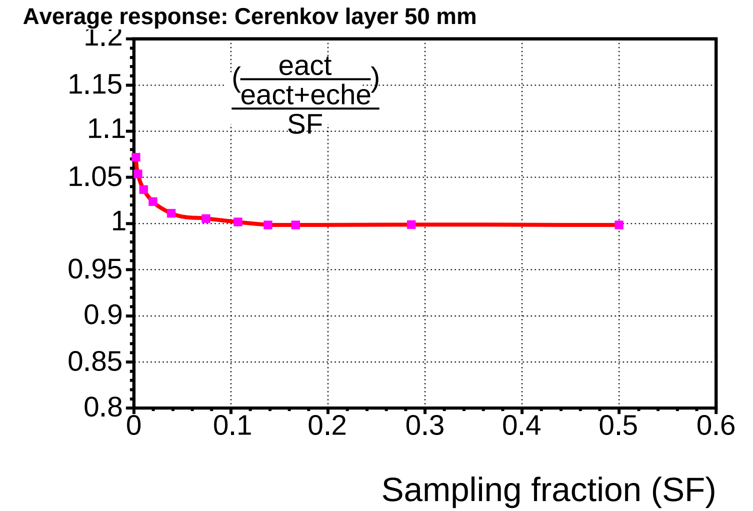


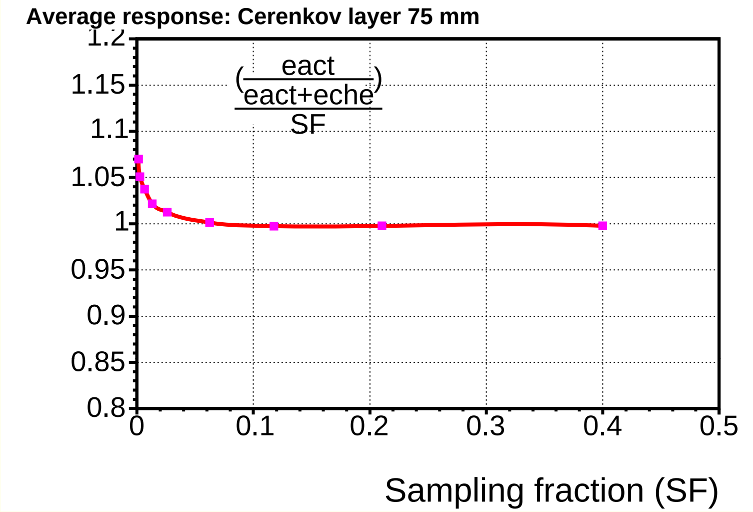


Corrected response

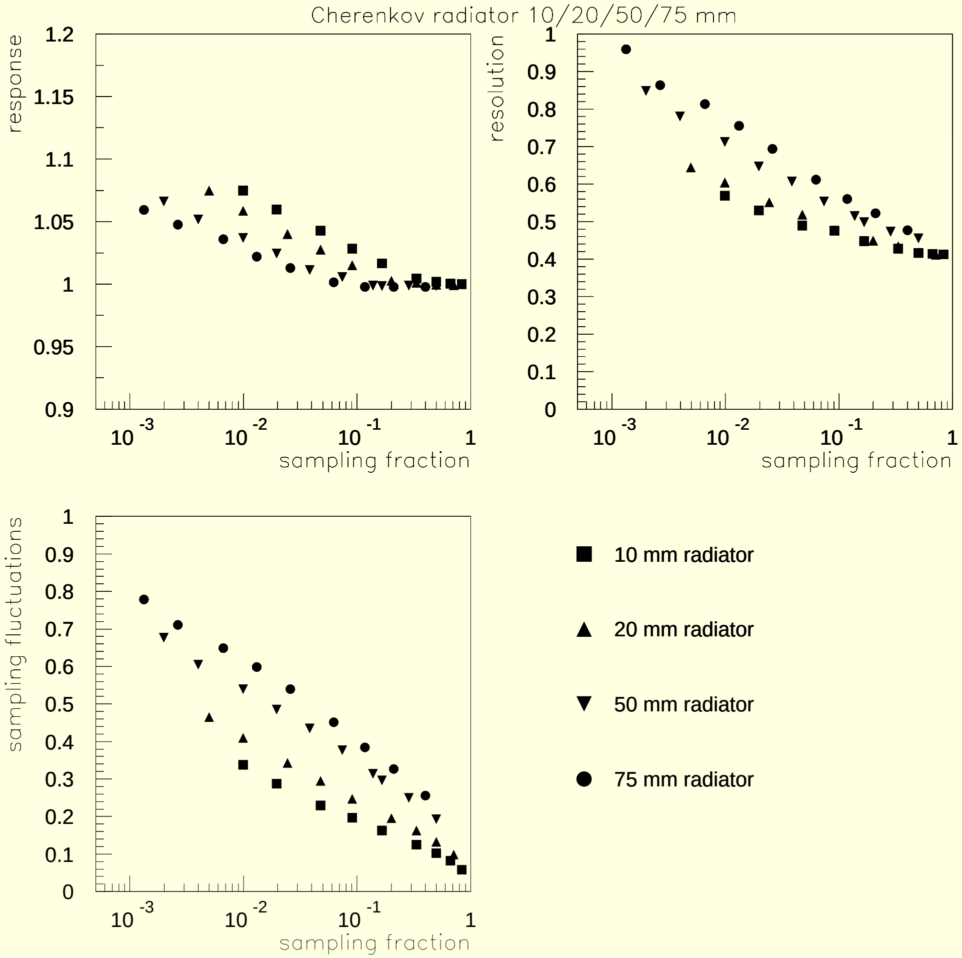






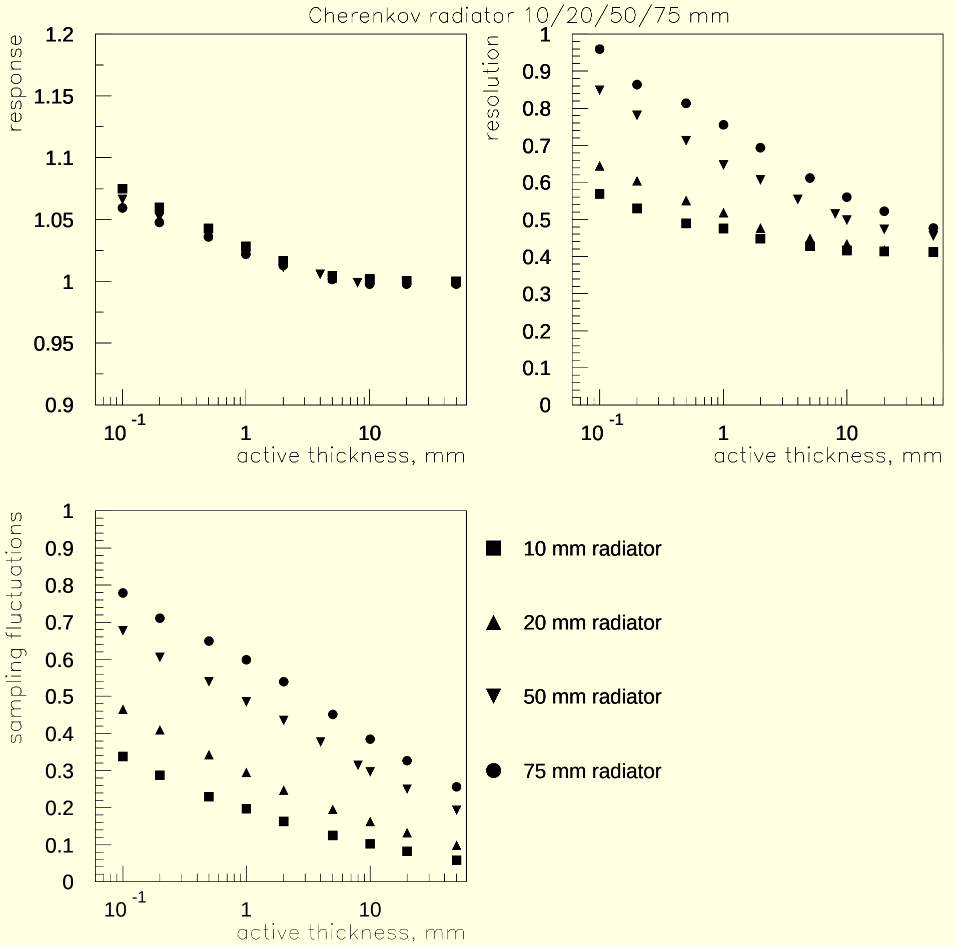


Response and Resolution as a Function of Sampling Fraction



- Corrected response is not a simple function of the sampling fraction, when active layer is small
  - Physics??
  - GEANT4 feature?
- Sampling fraction represent a significant contribution to the energy resolution when the cherenkov radiator thickness is ‘large’ (>2.5 cm or so)

Response and Resolution as a Function of the Active Layer Thickness



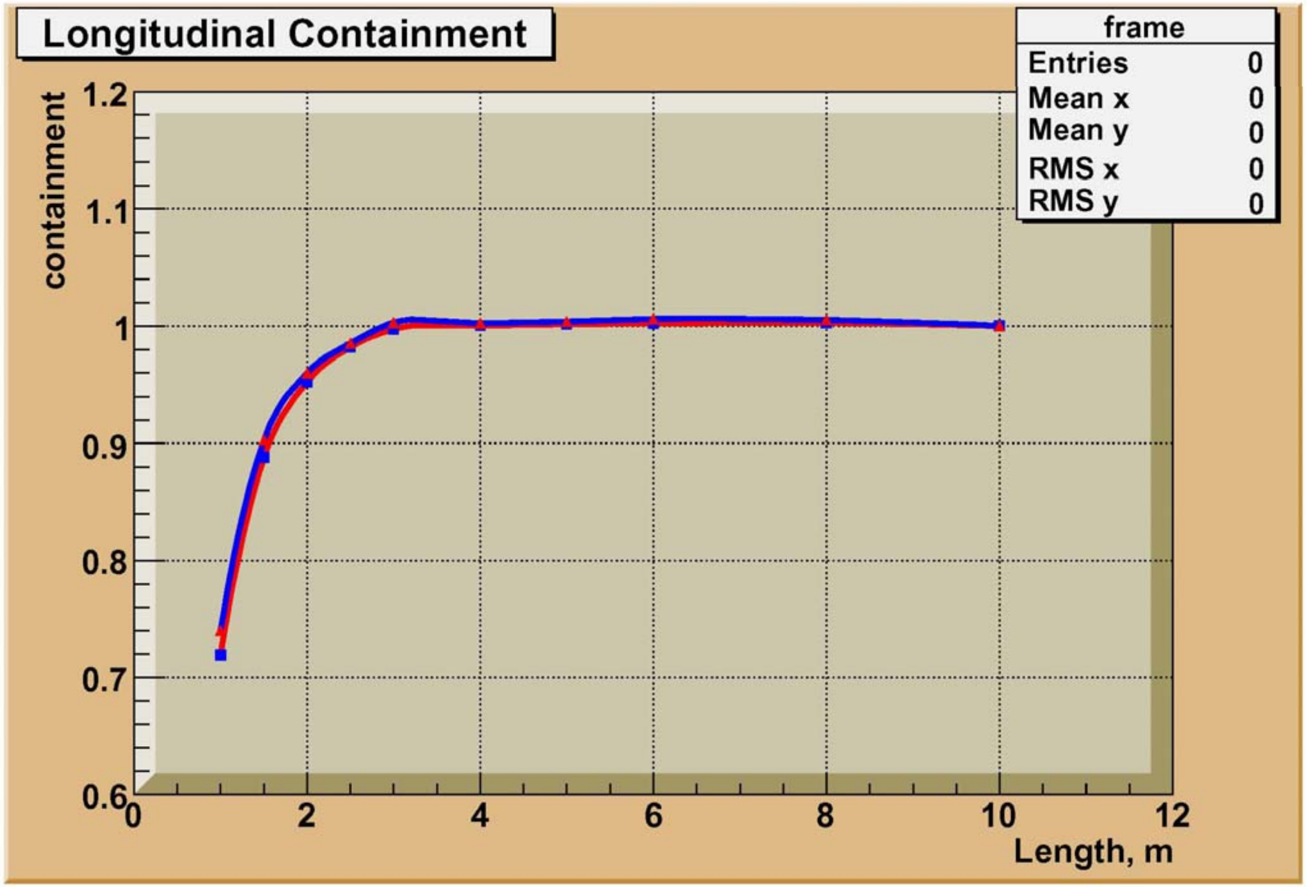
- Corrected response problem at small active layer thickness seems to be related to the absolute thickness of the active layer and not to the sampling fraction

How Big a Test Calorimeter?

- Hadron calorimeters are large (m^3), hence expensive. Can't afford to be bigger than necessary.

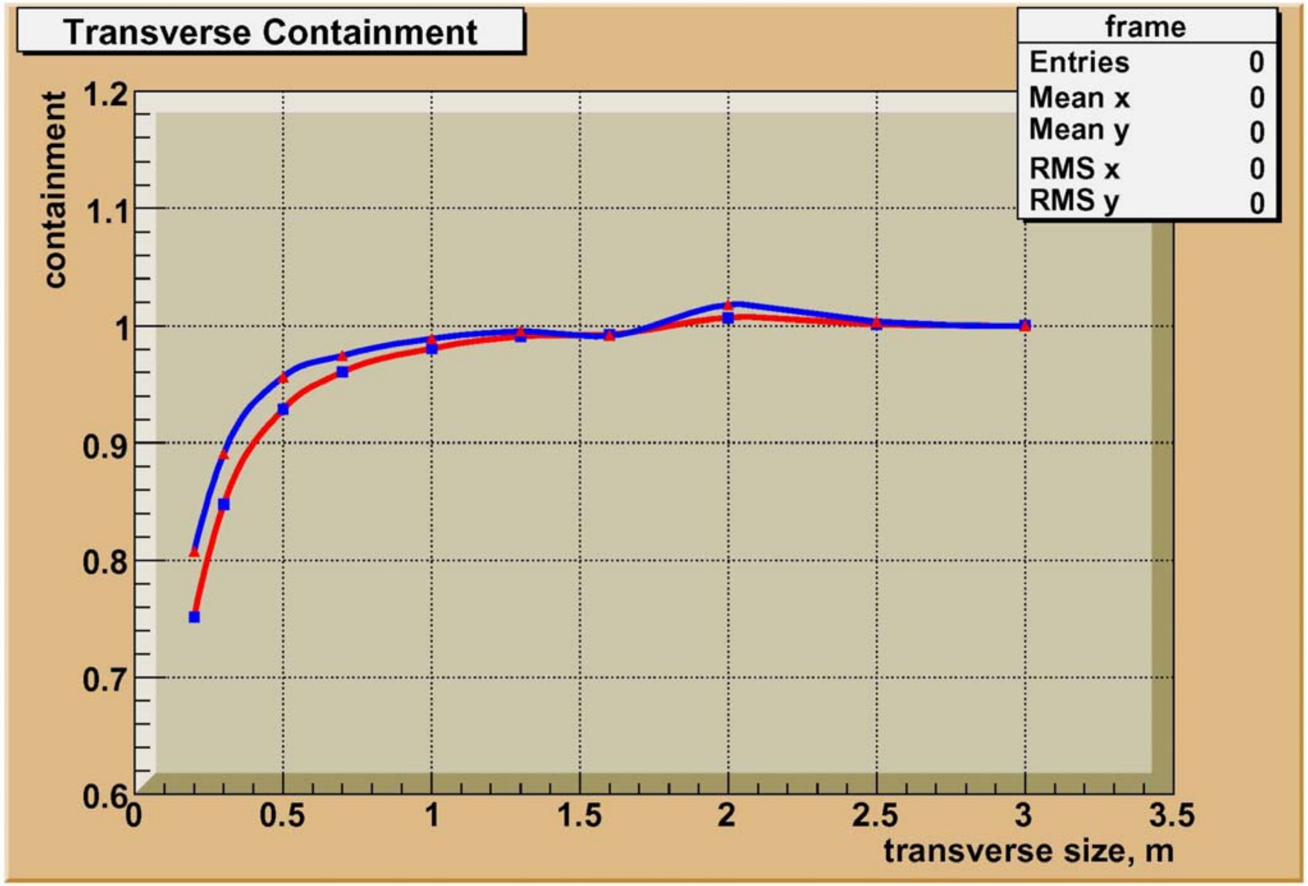
- (if we build it) we want to demonstrate good energy resolution ~(20-30)%/sqrt(E), that is ~2-3% energy resolution at 100 GeV. If the calorimeter is not long/wide enough there will be some energy leakage from the calorimeter and its fluctuations will contribute to the energy resolution. Need containment ~98% or better.

How Long a Calorimeter



- Need 2.5-3 m long lead glass
- Blue = Cherenkov
- Red = ionization

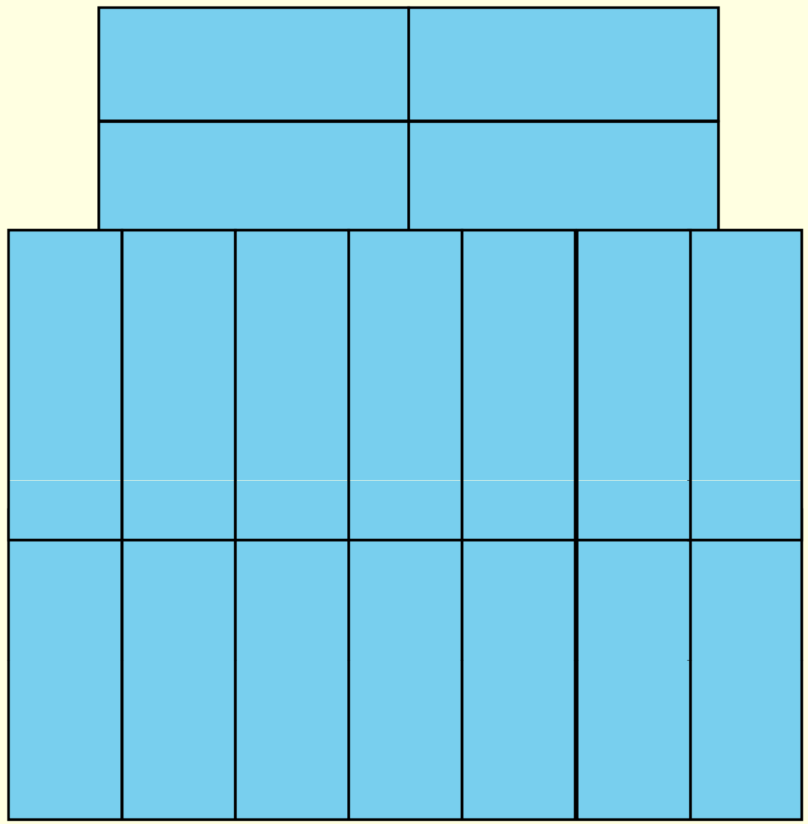
How Wide a Calorimeter?



- Need ~ 1m wide test module
- Red = ionization
- Blue = Cherenkov

Available Building Blocks

- E70 experiment (Lederman, upsilon): SF5 lead glass blocks 6”x6”x16”
- 6” is far too thick. Optimal absorber thickness needs study (sampling fluctuations): 3” (thick)? 2”(thin)? Options
- 3 m = 120”:
  - 40 thick planes
  - 60 thin planes
- 7 x 6” = 105 cm wide
- 32”+12” = 110 cm tall
- 18 ‘pixels’ per plane
- Fundamental unit: lead glass
  + scintillator plate
- Transverse segmentation:
  - Common LG and scintillator
  - Is 6”x16” sufficient?
  -



Readout?

- Assume: LG block and the scintillator plates are read out via a single waveshifting fiber (light collection efficiency and uniformity to be demonstrated)
- Channel count: 18 x 2 x 40 (60) = 1440 (2160)
- Assume Hamamatsu 5800-M64 phototube (?) ➔ need 25(35) tubes
- Electronics?
- DAQ?

Cutting the Lead Glass Blocks

- Cut along the long axis:
  - Diamond band saw
  - Water-jet (with abrasives)
- Initial vendor contacts: promising
- Surface quality: do cut surfaces need to be polished (manpower = cost)
  - Need to find out what the surface quality is
  - Need to find out what is the acceptable surface quality