Fast method for measuring the ^{90}Sr activity with Cherenkov radiation in silica aerogel

S.Korpar, P.Križan, R.Pestotnik, A.Stanovnik, M.Starič, L. Benedik

Institut
Jozef Stefan
Ljubljana
Slovenia

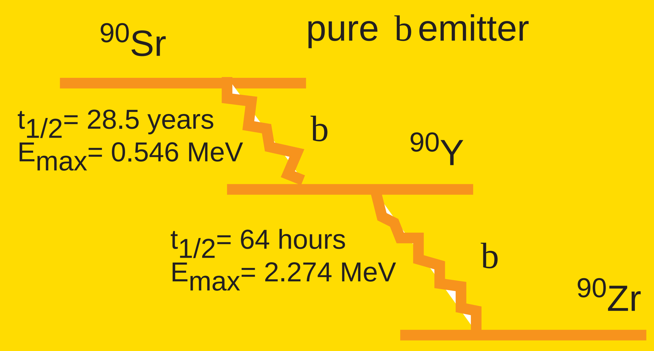
Scientific background:

Fast and easy method for identification of ^{90}Sr is needed.

Identification of ^{90}Sr using standard b-spectrometry is complicated:

b-spectrum is continuous,
many overlapping contributions from different radionuclides in the sample.

Idea: Only electrons with high enough energy radiate Cherenkov photons



Cherenkov radiation

Charged particles with velocity b radiate photons under specific Cherenkov angle in a medium with refractive index n :

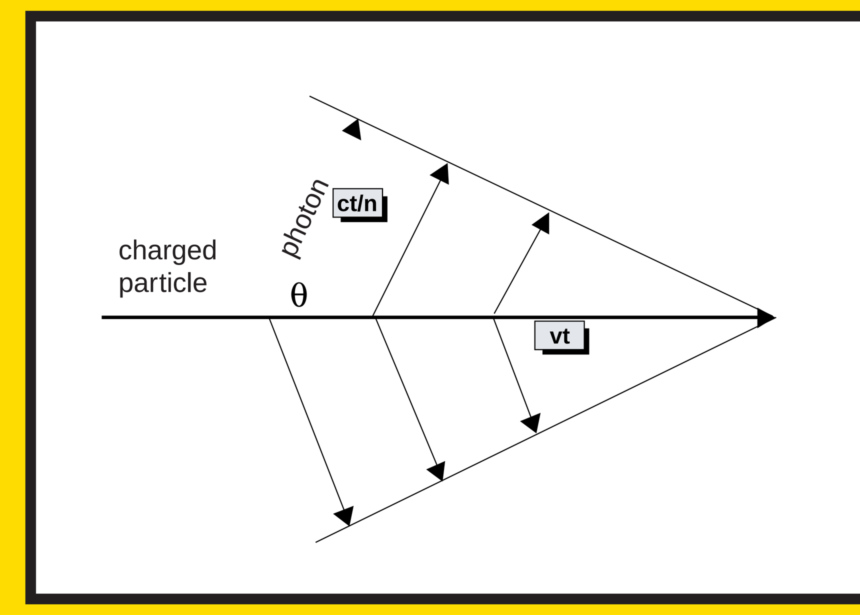
cos q = 1 / b n

Threshold for radiation: b > b_t =1 / n

Detected number of photons:

$N=N_0$ L <$\sin^2$ q>

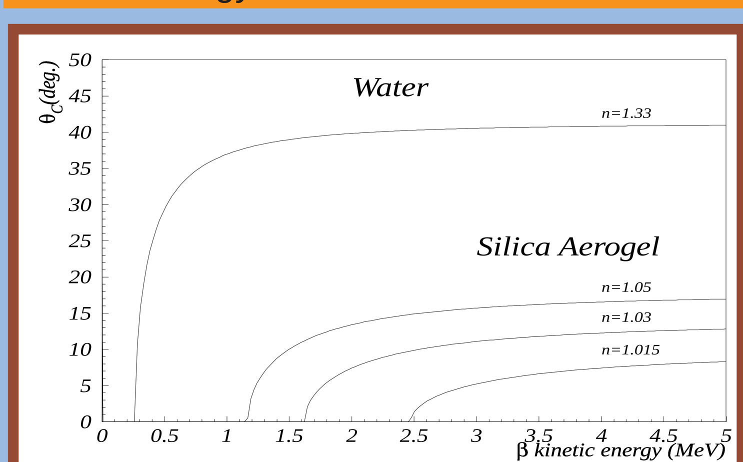
N_0 detector properties, L radiator length



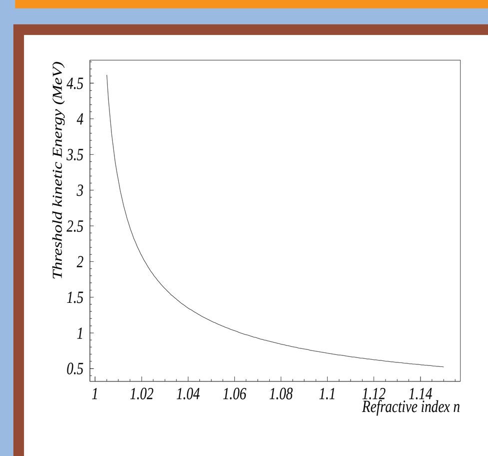
Cherenkov radiator: Silica Aerogel

refractive index 1.01 - 1.05
mean pore diameter 20 nm
density 0.1g/cm^3

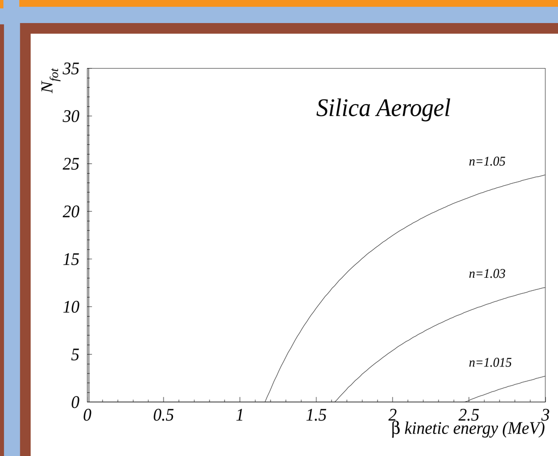
Cherenkov angle as a function of electron kinetic energy for different refractive indices



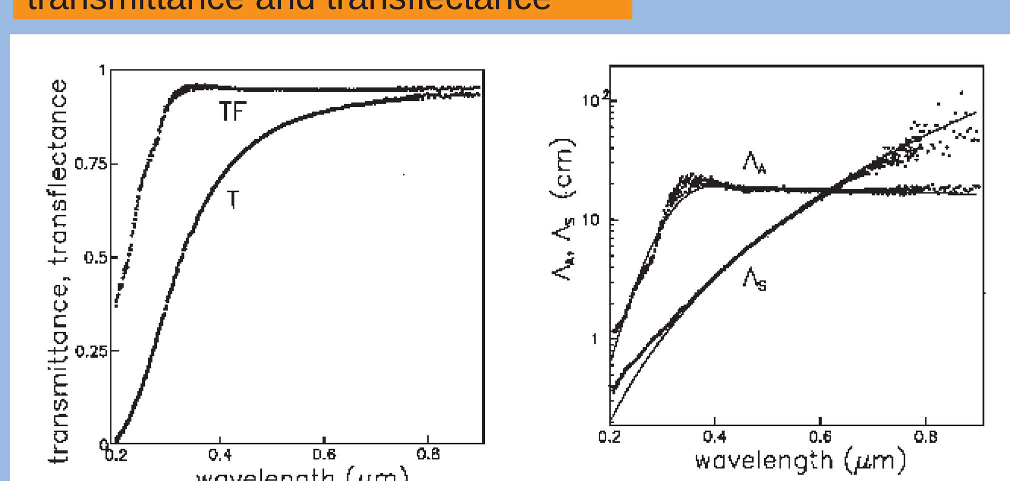
Energy threshold as a function of refractive index



Number of photons detected in full solid angle:



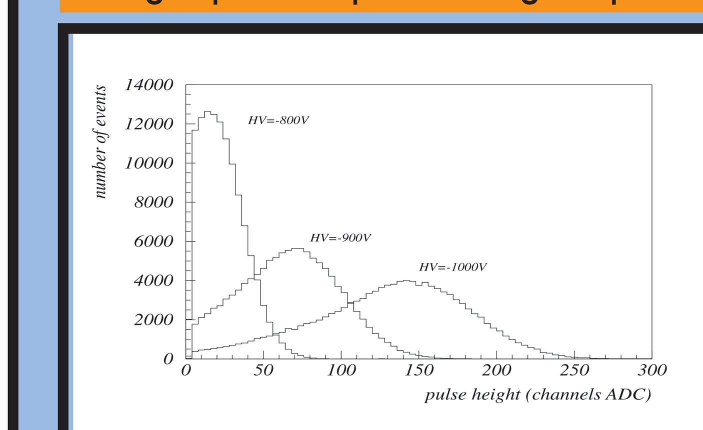
Photon wavelength dependence of transmittance and transflectance



References:
E.Aschenauer et al., Nucl.Inst. and Meth. A440 (2000) 338-347

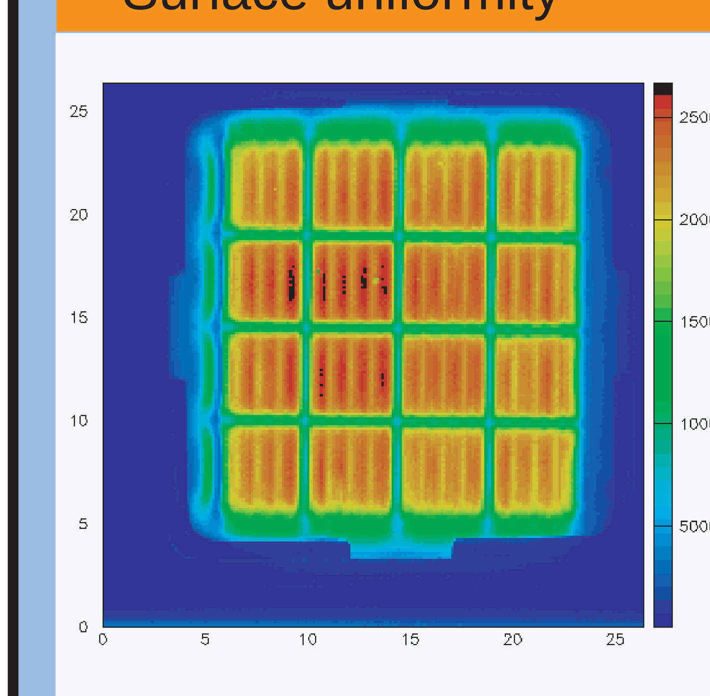
Photon detector: Hamamatsu R5900 multianode photomultiplier

Single photon pulse height spectra



Spectral response: 280 to 650 nm
Quantum efficiency at peak : 22%
Photocathode : Bialkali
Effective area : 18mm x 18 mm
Anode divisions : 2x2 M4, 4x4 M16
Operational voltage: 600-1000 V
Surface uniformity: better than 10%

Surface uniformity

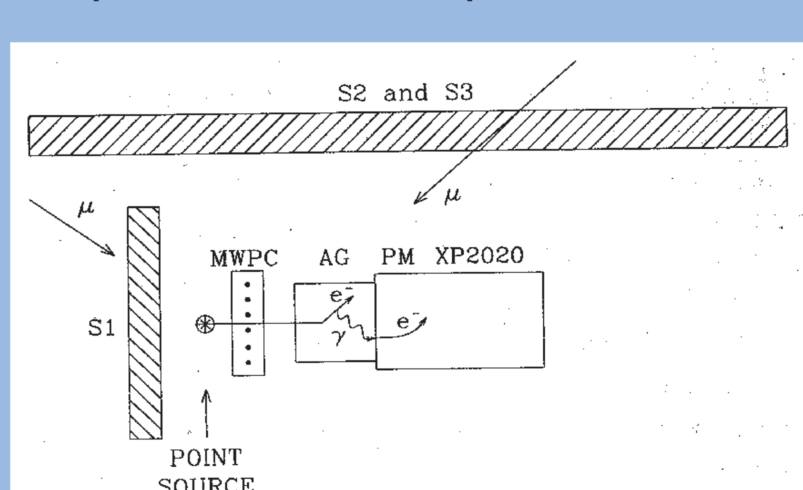


A sample of 2250 PMTs of this type was tested in HERA-B RICH as a large position sensitive photon detector

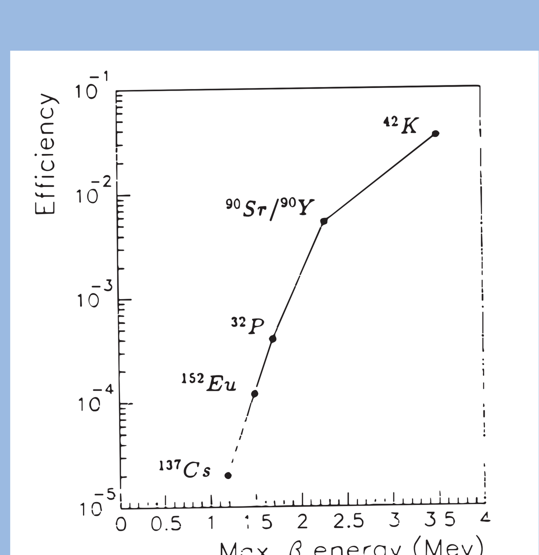
References:
S.Korpar et al.,
Nucl. Instr. and Meth. A442 (2000) 316-321
I.Arinyo et al.,
Nucl. Instr. and Meth. A453 (2000) 289-295

Previous study:

Experimental setup

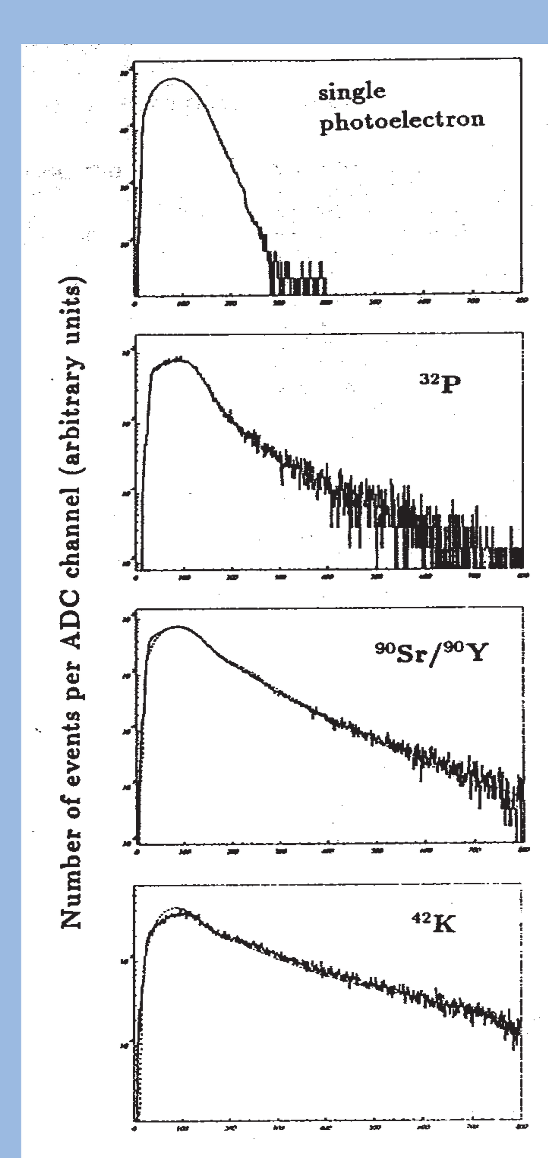


Efficiency for detection of the higher energy b decay of the radionuclides ^{137}Cs,^{152}Eu,^{32}P,^{90}Sr / ^{90}Y and ^{42}K



References:
* D.Brajnik et al.,
Nucl. Instr. and Meth.
A353(1994)217-221
* K.Walter et al.,
Radio.Acta 62 (1993) 207-212

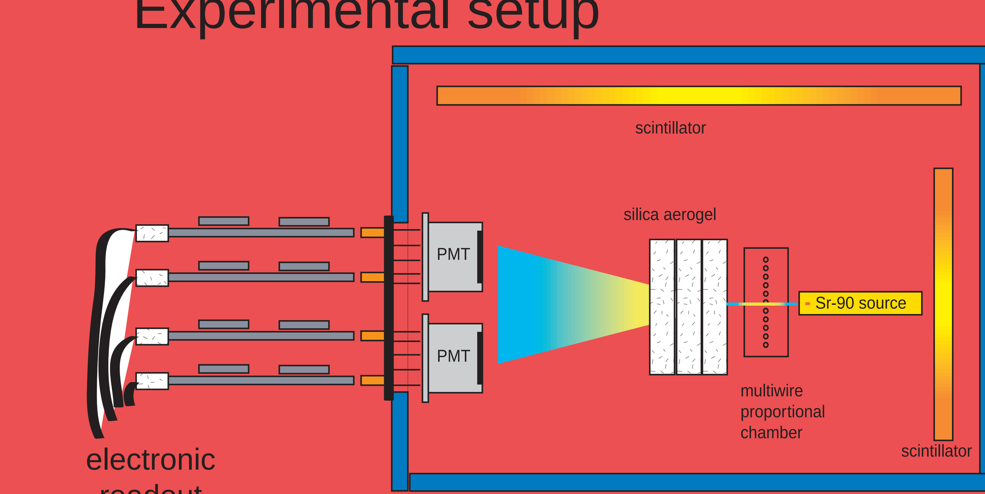
Pulse height spectra



Current study:

New components used:
- aerogel with a better transparency
- low noise multianode PMTs

Experimental setup



Tasks:
* optimize radiator thickness and refractive index
* optimize active detector area and detector distances
* optimize sample preparation
* design apparatus: power supplies, electronics, mechanical layout

Final apparatus:

Features:
-fast measurement of ^{90}Sr concentration in thin samples
-easy to handle
-available for final user in the field

Detector unit:
- photomultiplier with high quantum efficiency
- radiator of low refractive index (silica aerogel)
- multiwire proportional chamber

Electronics:
-Internal amplifier, shaper and discriminator
-Internal counter with LED display

Power supplies:
-220V AC
-Internal low voltage PS unit
-Internal high voltage PS unit

Optional:
-Direct analog pulse output for pulse height measurements
-Internal ADC