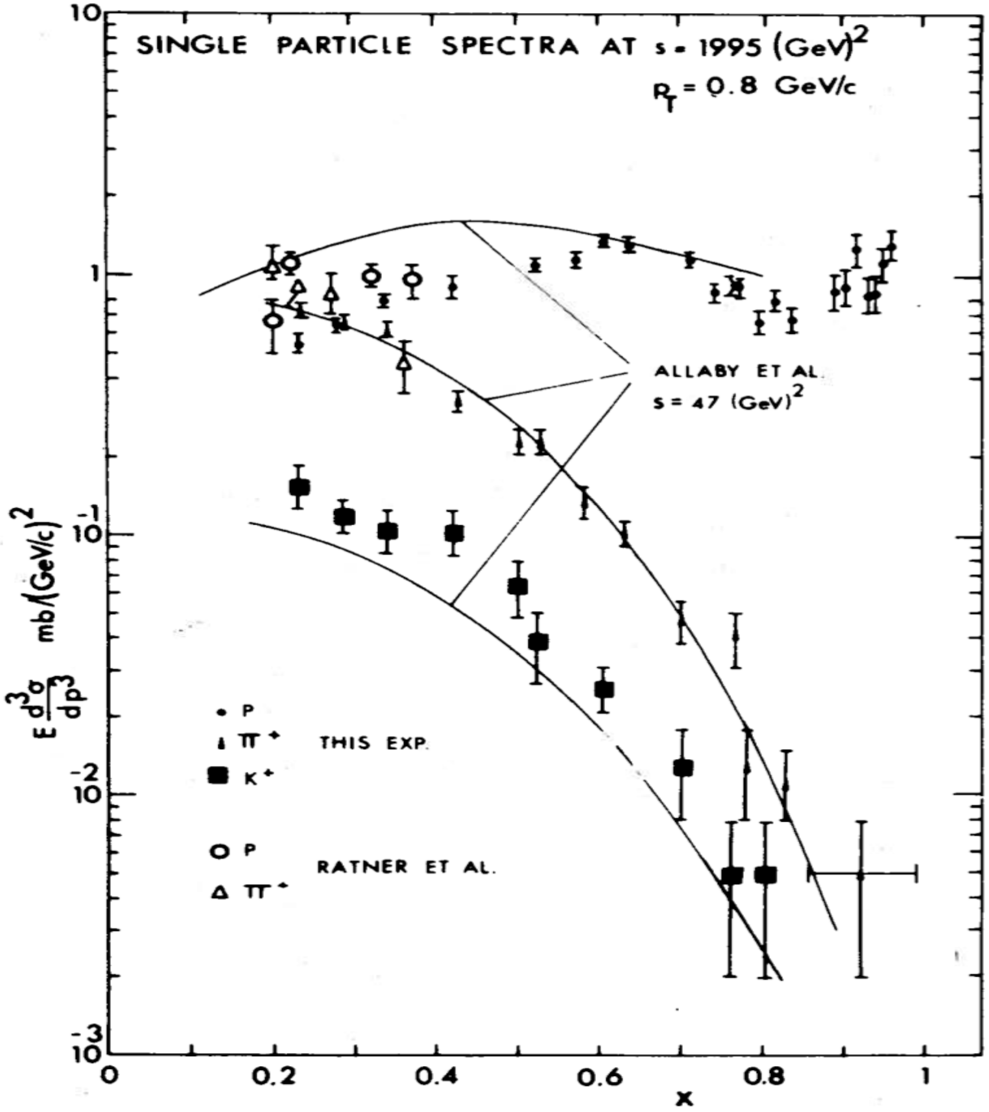
TRDs for SAS@LHC

Notes on the back of envelope.

A. Romaniouk

Some useful numbers



$x_F = p_z/p_{beam}$

Energy range 1 – 5(6) TeV

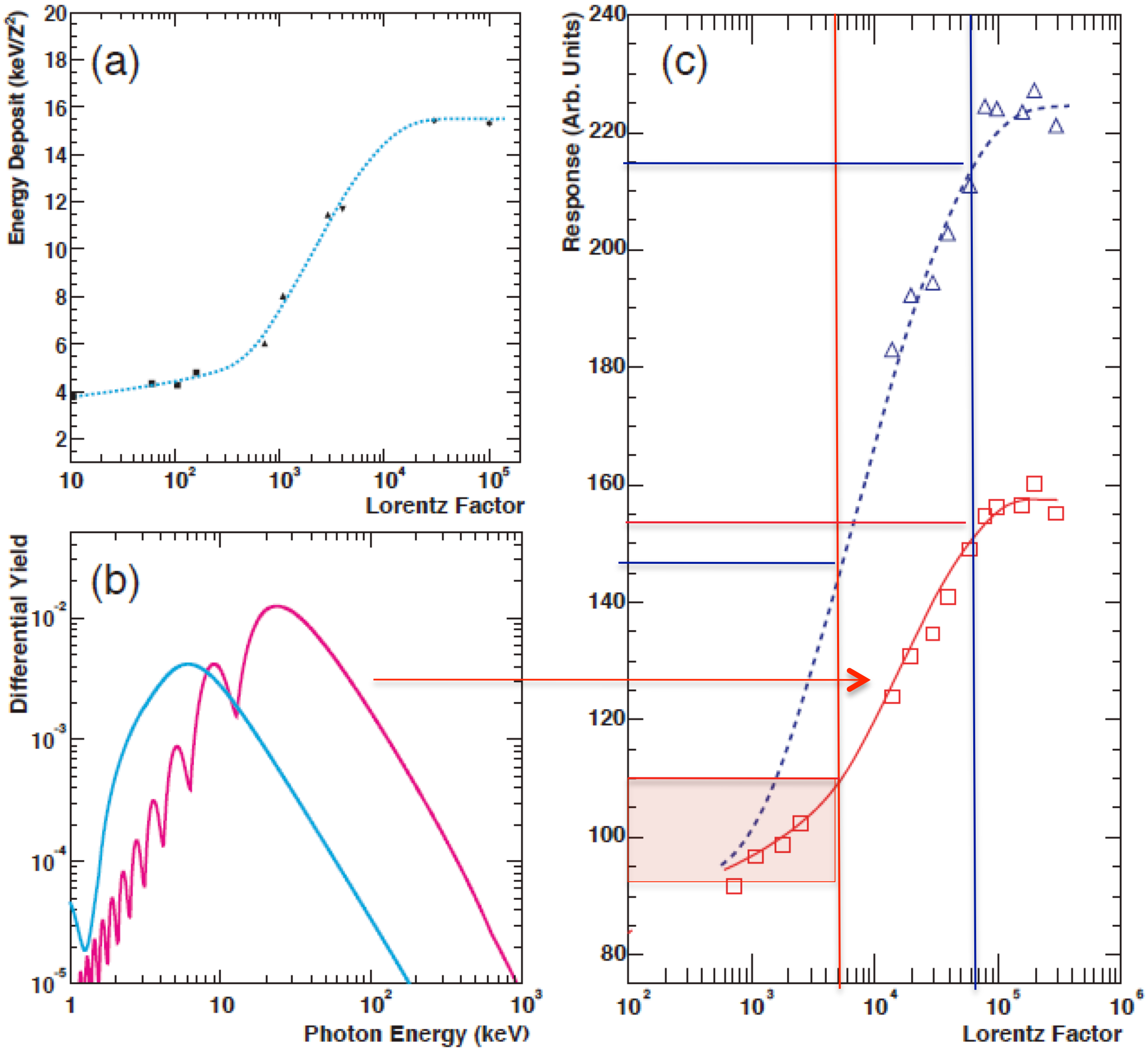
Gamma factor range:

Protons (938 MeV): **$1.1 \cdot 10^3$-$6.6 \cdot 10^3$**
Kaons (493.7 MeV): 2.***10^3-10^4**
Pions (139.6 MeV) : **$7 \cdot 10^3$-$3.5 \cdot 10^4$**

Separation requirements:

- Protons is dominating background everywhere This means it would be great to have a proton “blind” detector means TR turn on starts at gamma factor of ~6*10^3.
- Another difficult problem is to separate Pions and Kaons in different gamma ranges.
- Both the radiator optimization and the detector choice are critical.

Proton blind or proton gamma measurement



Combination of radiators

76 μm
spaced by 15 mm

What is the most interesting TR energy range?

The largest dependence on the gamma factor is in the area close to the cut-off frequency.

Cut-off frequency

$$\omega_c = \omega_p * \gamma$$

90% of energy in the range of

$0.1\omega_c < \omega < \omega_c$

Low number of photons can be compensated by the length of the detector. Radiators with low ω_p are preferable!

$\gamma_{sat} = 0.6\ \omega_p \sqrt{l_1 l_2}/c.$

At low ω_p we can push γ_{sat} up using l_1 nd l_2

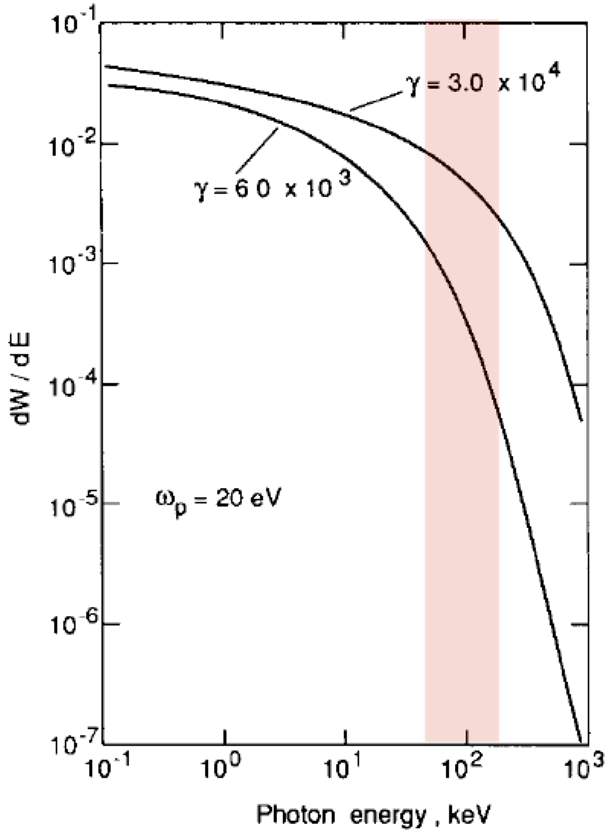


Fig. 3. The radiated TR spectrum from a polyethylene surface.

Detectors for photon energies 20-60 keV energy range

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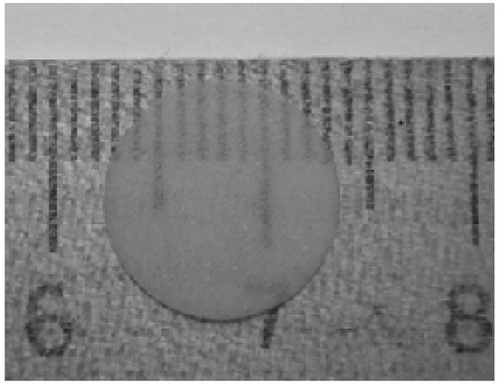
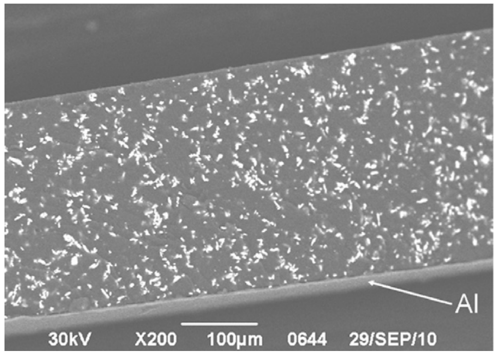
Transition radiation detector based on the usage of thin scintillators

V.V. Berdnikov [a], B.A. Dolgoshein [a,1], V.A. Kantserov [a], A.P. Shmeleva [b], V.V. Sosnovtsev [c], V.O. Tikhomirov [b,*], B.I. Zadneprovski [c]





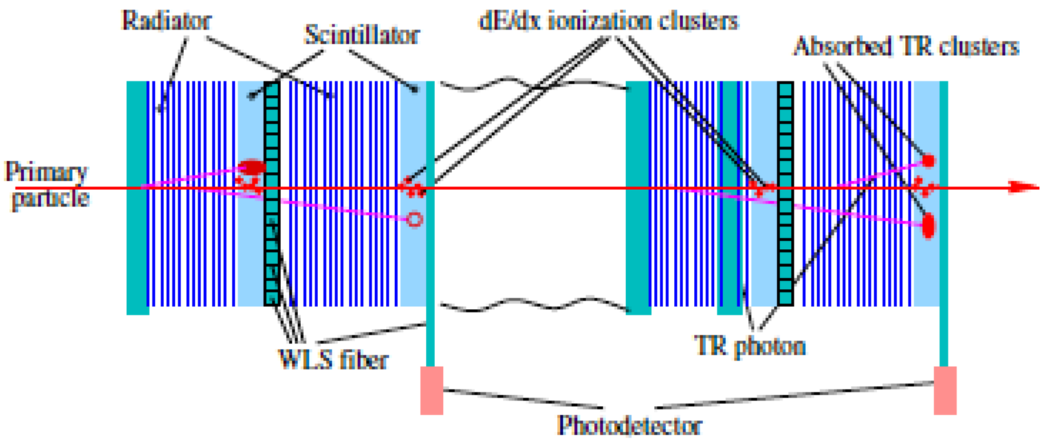
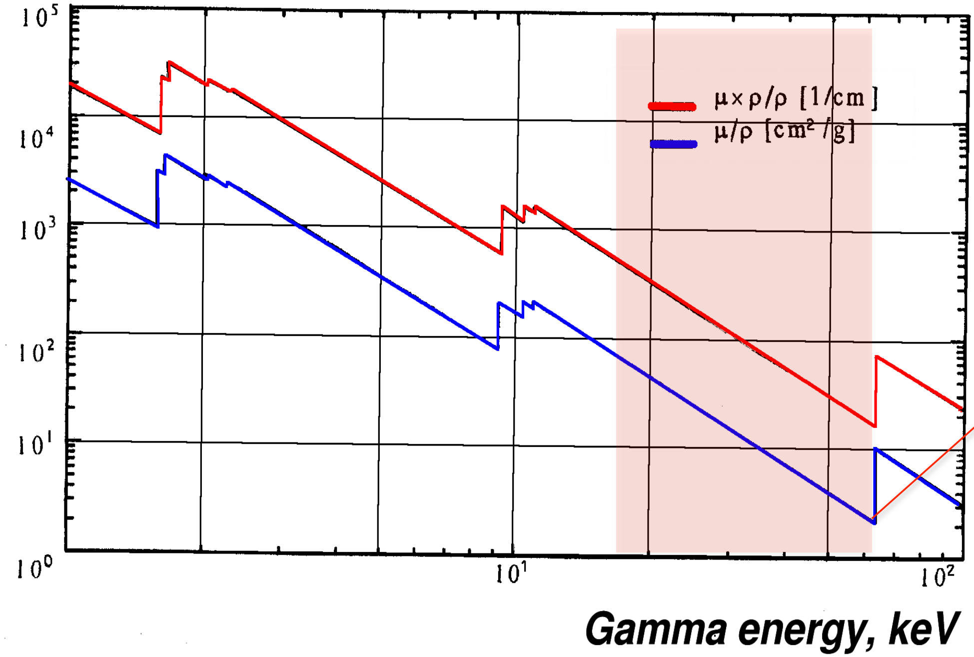
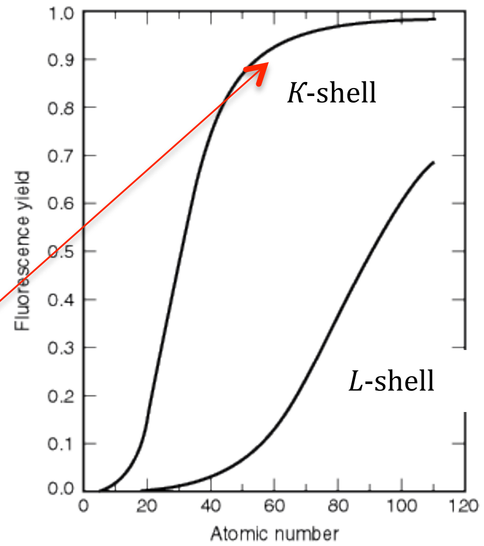


Fig. 1. Layout of proposed Sci-TRD.

Why 20-60 keV energy range?





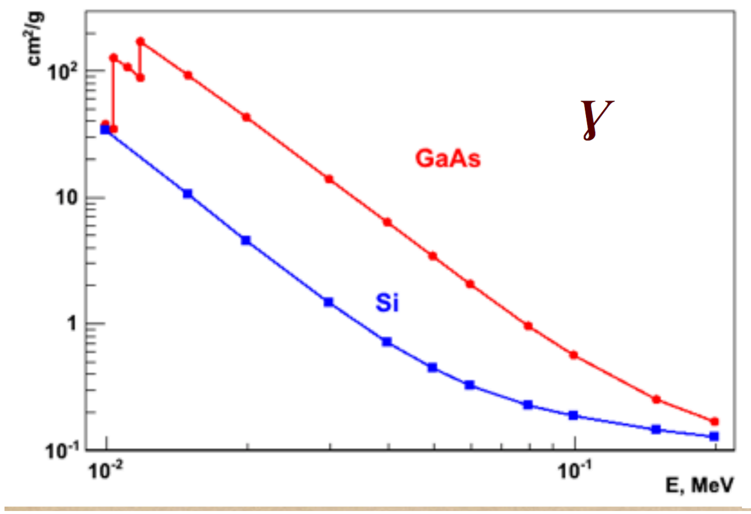
LSO: $Lu_2SiO_5:Ce^{3+}$:

- Density -7,41 г/см3
- Effective Z 66
- Light yield 30 photons=keV
- Fast response 40 ns
- Emission spectrum with lmax 440 nm
- Typical dE/dx loss in10 μm of LSO is 10 keV

Thin Layer of plastic (100 – 400 μm) with $Lu_2SiO_5:Ce^{3+}$ powder (granules 0.3-0.8 μm), LSO thickness 4.0 - 21.0 mg/cm², LSO

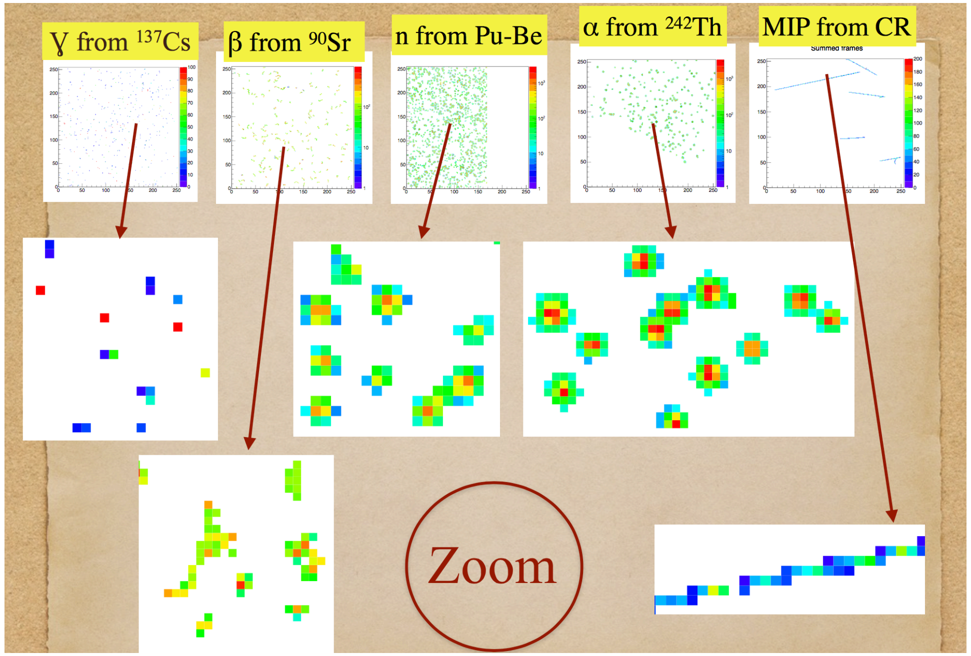
GaAs detectors

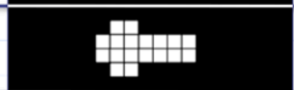
Parameter	Si	GaAs
Density, g/cm^3	2,33	5,31
Effective atomic number	14	32
Nuclear interaction length, cm	46,5	26,9
Radiation length, cm	21,8	12,2
Electron mobility, cm^{2}V^{-1}s^{-1}	1500	8500
Electron diffusion constant, cm^{2}s^{-1}	39	220



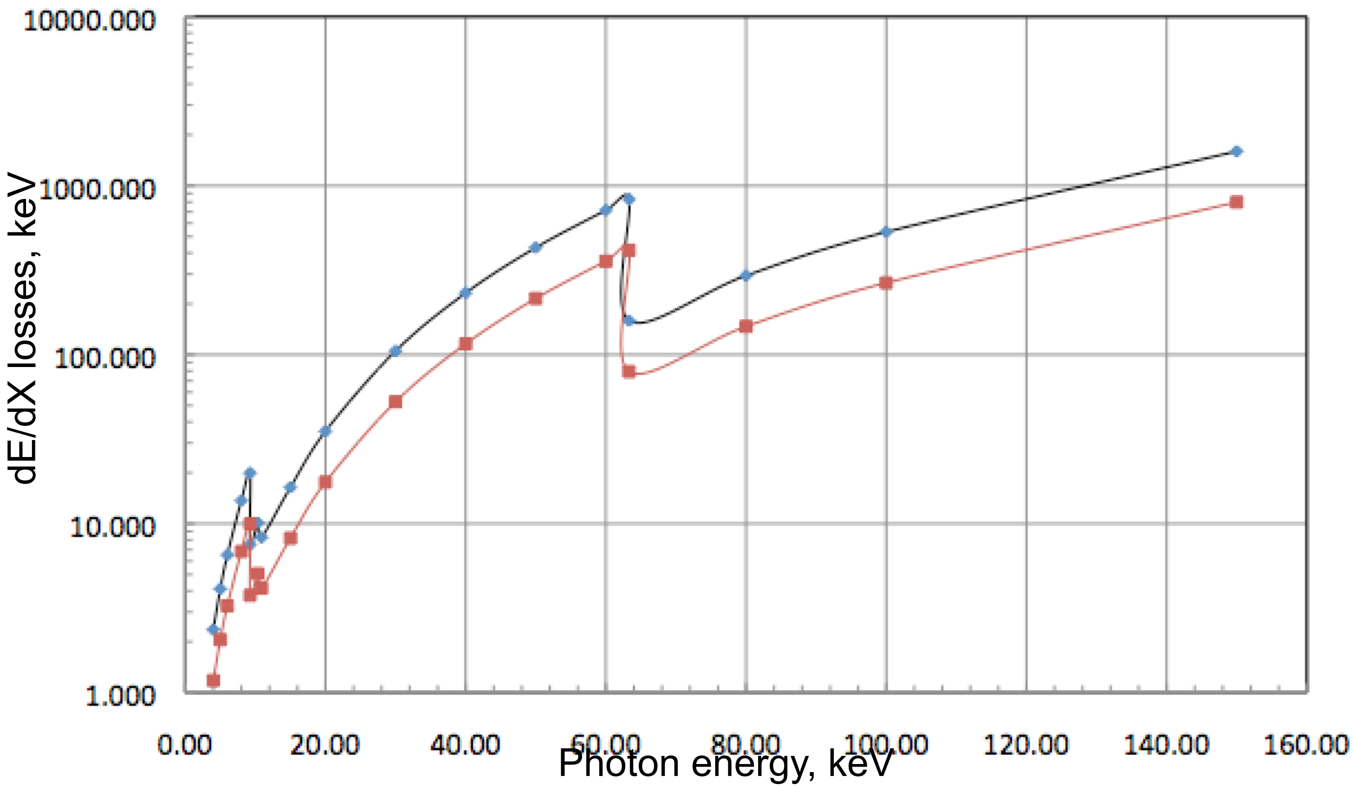
Material	main charge carriers	electron drift length	bulk resistivity	active sensor thickness	intrinsic noise
LEC SI-GaAs	holes	0.3-0.5 mm	$<2*10^8\ \Omega*$cm	<300 μm	high
GaAs:Cr	electrons	0.7 – 2 mm	$\sim10^9\ \Omega*$cm	up to 1 mm	low

Event patterns of GaAs detectors



1) Dot		Photons and electrons (10keV)
2) Small blob		Photons and electrons
3) Curly track		Electrons (MeV range)
4) Heavy blob		Heavy ionizing particles with low range (alpha particles,...)
5) Heavy track		Heavy ionizing particles (protons,...)
6) Straight track		Energetic light charged particles (MIP, Muons,...)

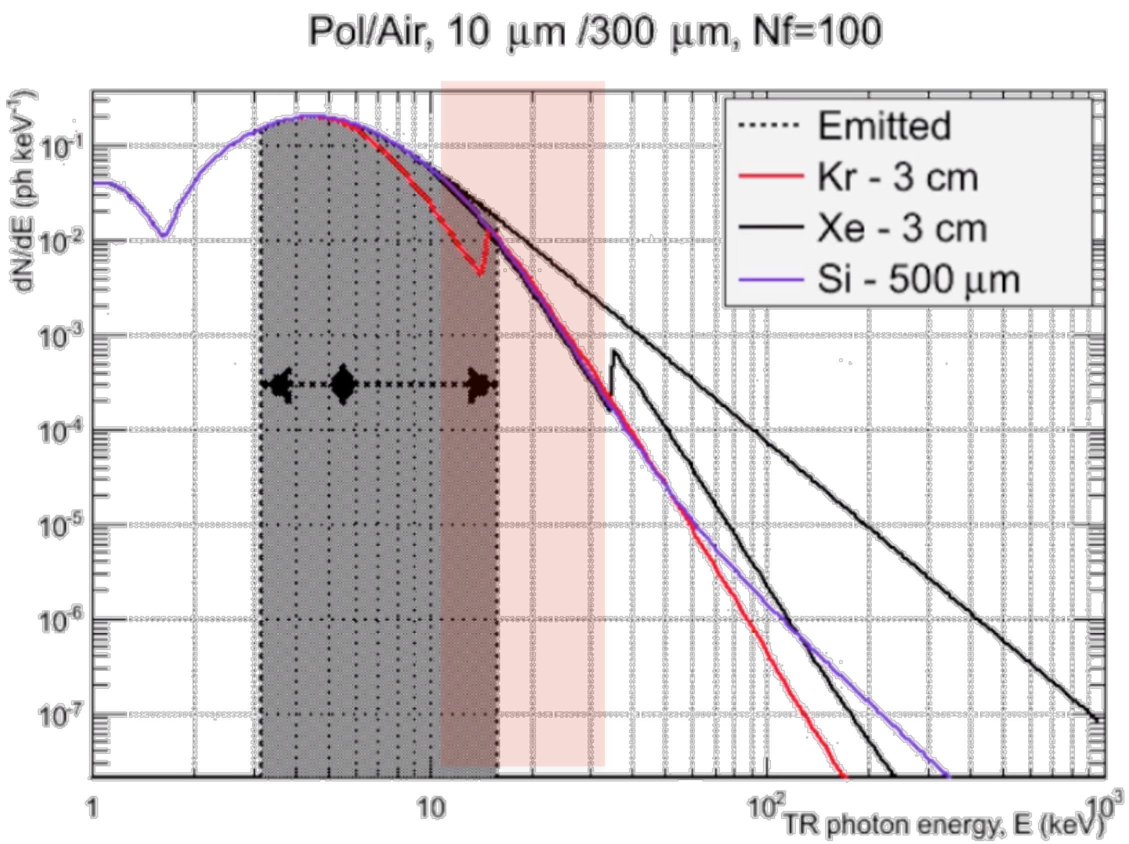
Huge contribution from dE/dX in this range



Ionization losses in the LSO with a thickness required to absorb 60% (black line and 40 % (red line) of photons

Push spectrum below 30 keV!?
Than gas detectors?

Kr is the best detector material for energy range > 15 keV?



Another possibility is a Compton based TRD: -> too few photons!