NEW DETECTING CELLS FOR «SHASLIK» TYPE calorimeter based on GaGG crystals.

REQUIREMENTS FOR SPD CALORIMETER

-TO MINIMIZE THE MOLIERE RADIUS < 15mm and CELL LENGTH

if Xo < 5mm ⇒ size of detecting cell (20 Xo) ~ 15x15x 100 mm3 !!!

- FAST RESPONSE < 50 ns

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-TO USE RADIATION-HARD MATERIALS > 100 MRAD

- TO USE WLS or TRANSPORT CAPILLARIES FOR WAVELENTGH SHIFTING to data collection boxes

Suggested solution

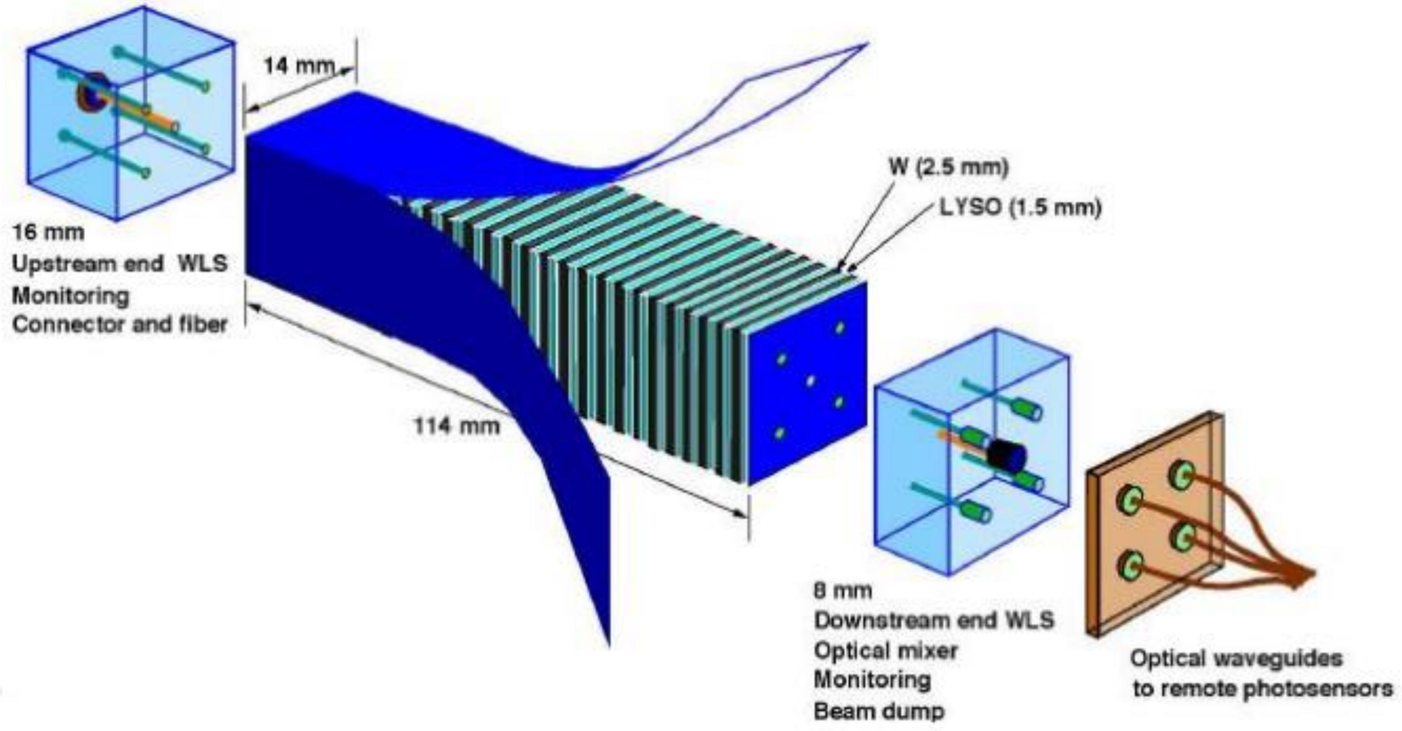
Shashlik configuration

based upon interleaved **W and GaGG crystals** plates

TOTALLY (50 -60) PIECES PER CELL

Test setup W- LYSO(Ce) cell for upgrade CMS calorimeter

R&D DOE grant
29 plates LYSO(Ce) & 28 W



SPD prototype

29 plates **GaGG(Ce)**

$Gd_3Al_2Ga_3O_{12}$

20X 20X2 mm3

& **28 W** powder plates

20x20 x2 mm3

all plates **2 mm**

Table 1. Comparison of LYSO/W Shashlik Module with conventional Lead Tungstate Crystal

	W/LYSO:Ce Module	$PbWO_4$ Crystal
Length (mm)	114	220
Transverse size (mm)	14	28.6
Average Molière Radius (mm)	13.7	21
Average Radiation Length X_o(mm)	5.1	8.9
Crystal Light Yield (relative to NaI = 100)	85	0.3
Emission Wavelength	425	425
Decay time (ns)	40	25
Light Output (p.e./MeV)	6-8	2
Temp Dependence (%/C)	-0.2	-2.2

Optical electromagnetic calorimetry for high energy experimental app…. (draft)

Why GaGG

Material	LY, Ph/MeV	dE/dx @ e^-, MeV/mm	Yield, ph per 1 mm per MIP	Radiation hardness to protons
Plastic scintillator (vinyltoluene based)	10 000	0.154	1 540	-
$Y_3Al_5O_{12}$ (YAG)	11 000	0.591	6 500	+
$(Lu\text{-}Y)AlO_3$	30 000	0.614	18 420	-
$YAlO_3$ (YAP)	16 000	0.708	11 350	-
$Gd_3Al_2Ga_3O_{12}$ (GAGG)	46 000	0.808	37 200	+
Lu_2SiO_5 (LSO)	27 000	0.879	23 700	+
$(Lu_{0.8}\text{-}Y_{0.2})_2SiO_5$ (LYSO)	30 000	0.85	25 500	+

In general:

GAGG shows the best yield per MIP- 37200 Ph/mm,

RADHARD& ROBUST similar to diamond ,

Energy resolution ~ 4 % on 662 keV with SiPM

Energy deposit per MIP for different crystal

Ionization losses per 1 mm of the media for 10GeV e^- and 50Gev π^-

Material	Density ρ, g/cm^3	dE/dx @ e^-, MeV/mm	dE/dx @ π^-, MeV/mm
Plastic scintillator (vinyltoluene based)	1.032	0.154	0.154
$Y_3Al_5O_{12}$ (YAG)	4.55	0.591	0.589
$Y_3(Al_{0.5}\text{-}Ga_{0.5})_5O_{12}$	4.80	0.614	0.612
$YAlO_3$ (YAP)	5.50	0.708	0.705
$Gd_3Al_2Ga_3O_{12}$ (GAGG)	6.63	0.808	0.804
Lu_2SiO_5 (LSO)	7.4	0.879	0.873
$(Lu_{0.8}\text{-}Y_{0.2})_2SiO_5$ (LYSO)	7.2	0.85	0.85

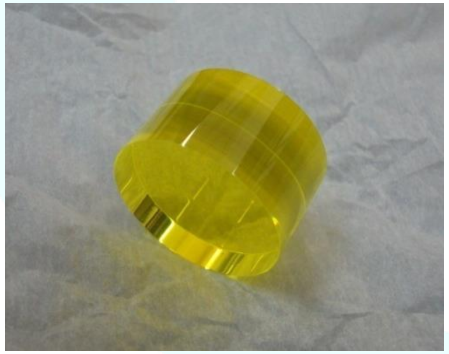
Light output per MIP (10GeV e^-) per 1 mm in different scintillation materials

Material	LY, Ph/MeV	dE/dx @ e^-, MeV/mm	Yield, ph per 1 mm per MIP
Plastic scintillator (vinyltoluene based)	10 000	0.154	1 540
$Y_3Al_5O_{12}$ (YAG)	11 000	0.591	6 500
$Y_3(Al_{0.5}\text{-}Ga_{0.5})_5O_{12}$	30 000	0.614	18 420
$YAlO_3$ (YAP)	16 000	0.708	11 350
$Gd_3Al_2Ga_3O_{12}$ (GAGG)	46 000	0.808	37 200
Lu_2SiO_5 (LSO)	27 000	0.879	23 700
$(Lu_{0.8}\text{-}Y_{0.2})_2SiO_5$ (LYSO)	30 000	0.85	25 500

Already Grown GGAG Crystals

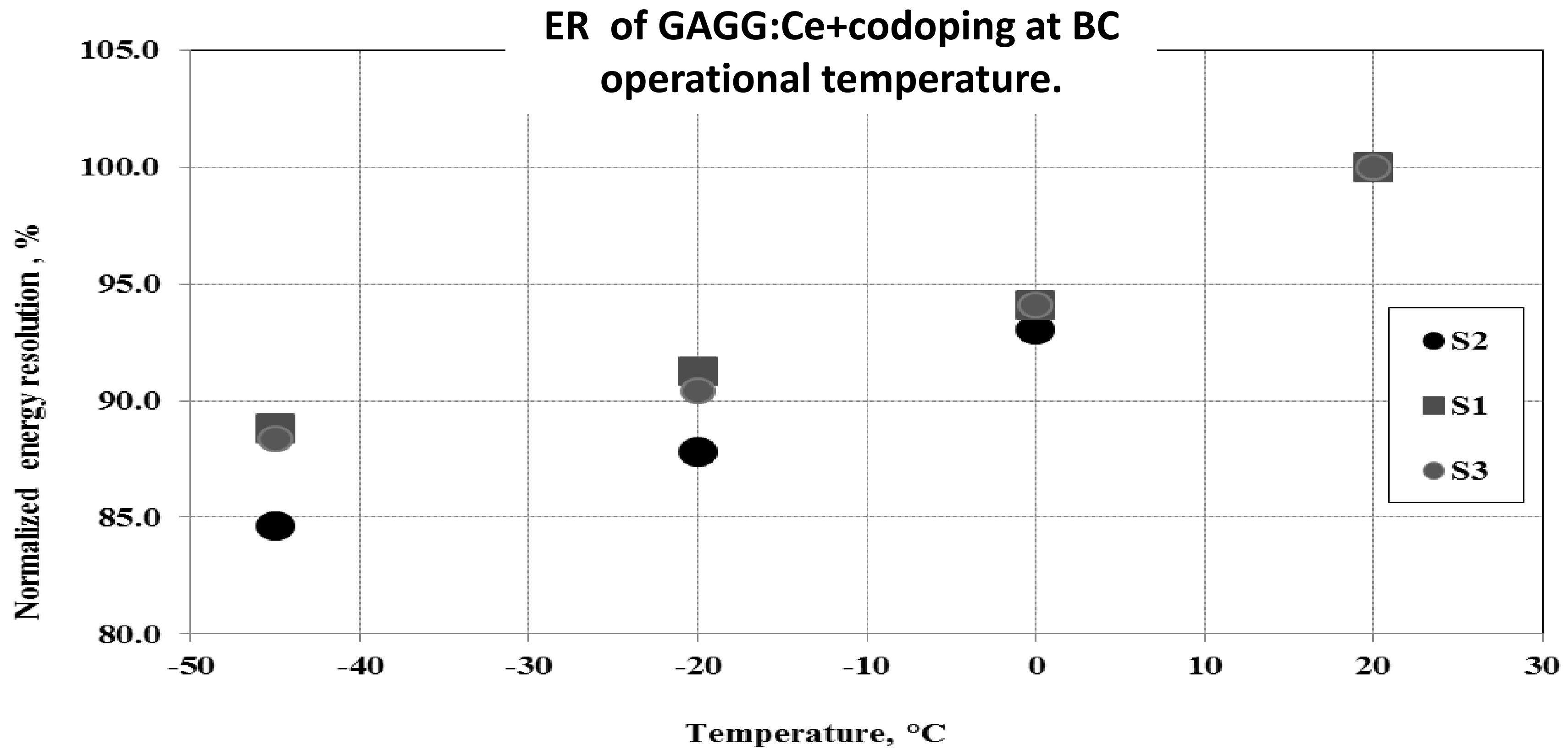
Up to now JSC Fomos-Materials grew GGAG crystals with following compositions:

- GGAG:Ce with different cerium concentrations
- GGAG:Ce with different Ga/Al ratio
- GGAG:Ce with codoping of:
  - Magnesium
  - Calcium
  - Strontium
  - Barium
  - Scandium
  - Zirconium
  - Titanium
- GGAG:Ce with pair and triple codoping of above listed elements



A favorable decision of the Federal Service for Intellectual Property (Rospatent) concerning the issuance of the patent has been received. Application 2017119423/05(033718))

Modern trend : to operate at temperature below 0^{o}C to reduce noise while operating with SiPM

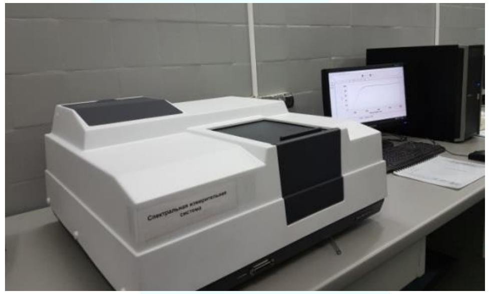


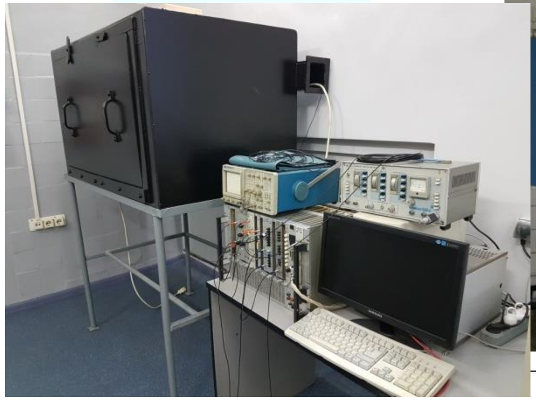
Temperature change of energy resolution FWHM at 662 keV normalized to result room temperature. Measurements have been performed with 1000 ns time gate.

Radiation Instruments and New Components LLC

Full Technological Circle

- *Initial Charge Synthesis*
- *Crystal Growing*
- *High Temperature Heat Treatment*
- *Cutting, Grinding, Drilling, Polishing.*





THANK YOU FOR YOUR ATTENTION