Gamma-ray Induced Radiation Damage up to 100 Mrad in Scintillation Crystals

Ren-Yuan Zhu
California Institute of Technology
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The Total Absorption Dose Facility of JPL

Two high intensity $^{60}$Co sources provide variable dose rate up to 1 Mrad/h in a opening throat of 10” x 10” x 13.5”
Samples Irradiated at JPL

ID | Dimension (mm)
---|----------------
Shashlik (LYSO/W) | 14x14x150
LYSO SIC Plate | 14x14x1.5
CeF3 SIC | 33x32x191
BaF2 SIC2012 | 20x20x250
PWO SIC | 28.5²x220x30²
BGO SIC2011 | 25x25x200
LYSO SIC L2 | 25x25x200
CsI SIC2013 | 50x50x200

ID | Dimension (mm)
---|----------------
Shashlik (LYSO/W) | 14x14x150
LYSO SIC Plate | 14x14x1.5
LYSO SIC Plate | 14x14x2
LYSO CPI Plate | 14x14x2
CeF3 SIC | 33x32x191
BaF2 SIC2012 | 20x20x250
PWO SIC | 28.5²x220x30²
LYSO SIC L2 | 25x25x200
BGO SIC2011 | 25x25x200
LYSO SG L2 | 25x25x200
BGO NIIC | 25x25x200

10 Mrad @ 180 krad/h

90 Mrad @ 1 Mrad/h
Radiation Induced Absorption Coefficient (RIAC)

Crystals with no recovery

Crystals with recovery

~2 m\(^{-1}\) measured in LYSO after 100 Mrad
RIAC as a Function of Integrated Dose

- CeF$_3$ ($\lambda_{em} = 300$nm)
- CMS PWO ($\lambda_{em} = 424$nm)
- SIC BGO ($\lambda_{em} = 480$nm)
- NIIC BGO ($\lambda_{em} = 480$nm)
- LYSO ($\lambda_{em} = 420$nm)
- BaF$_2$ ($\lambda_{em} = 220$nm)
- CsI ($\lambda_{em} = 310$nm)

Caltech HEP Crystal Laboratory

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Shashlik Uniformity with Y-11 Readout
CMS Uniformity Specification

D. Graham & C. Seez, CMS Note 1996-002

Optimum slope in rear 100mm is 8% rise

Slope < 0.3%/X₀ where most of the energy is

Can tolerate almost any slope at front

Beam
1%/12% light output loss after 10/100 Mrad

No change in LRU caused by 100 Mrad to LYSO
Light Output with Direct PMT Readout

LYSO CPI-1402 14×14×2 mm³
PMT: R1306, Cs-137 source, Tyvek wrapping

Testbeam LYSO SIC-275 14×14×1.5 mm³
PMT: R1306, Cs-137 source, Tyvek wrapping

$L.O = A_0 + A_1 (1 - e^{-t/\tau})$

- Before IR: $A_0 = 0$, $A_1 = 3623$, $\tau = 43$
- $9 \times 10^7$ rad: $A_0 = 0$, $A_1 = 3392$, $\tau = 43$
- $1 \times 10^8$ rad: $A_0 = 0$, $A_1 = 3090$, $\tau = 46$

6% loss after 100 Mrad consists with Y-11 readout
1\textsuperscript{st} round irradiation with $^{60}\text{Co}$ source up to 100 Mrad was carried out at the total absorption dose facility of JPL.

Radiation induced absorption coefficient of $\sim 2 \text{ m}^{-1}$ was measured for 20 cm LYSO:Ce sample after 100 Mrad.

Light output loss of a Shashlik cell with Y-11 readout due to LYSO was measured to be 1%/12% after 10/100 Mrad.

Light response uniformity of the Shashlik cell with Y-11 readout is not changed after 100 Mrad applied to LYSO.

2\textsuperscript{nd} round of 100 Mrad irradiation will be carried out at JPL during the labor day weekend. Y-11 fibers and wrapping materials will also be investigated.

Irradiation with 800 MeV protons will be carried in October at the Weapons Neutron Research facility of the Los Alamos Neutron Science Center.
25 x 25 x 200 mm LYSO Crystals

Both samples were grown about ten year ago

Photo-Luminescence
Summary of LYSO Crystals

All samples were grown about ten years ago.
Both samples were grown about twenty years ago.
Sample L3 was grown about thirty years ago.
Summary of BaF$_2$ Crystals

**Fast Component**

**Slow Component**

Sample S302 was grown about twenty year ago
Kharkov samples were grown about twenty years ago.