Scintillation: Uses and Mechanisms

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Scintillator: detecting ionizing radiations

Basics

- Ionizing radiations: x-ray; γ -ray, α , neutrons, ions, electrons...
- Detection requires electric pulse
- \bullet Interaction radiation-matter: ionizing \rightarrow electron and holes



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Indirect detection Charges to light conversion ↓ Light detection (PMT,CCD, SiPM...) ↓ Scintillation

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Scintillators in general

Detection of ionizing radiation: Old style



Detection of ionizing radiation: Modern one



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About the processes



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About the processes



1 high energy photon (keV-MeV) \rightarrow thousands of IR-Vis photons (eV)

Multiscale Physics

- As cutting a 10km string in pieces of a few cm!
- First steps in the ps range, last ones can be in the s time range
- Energy deposition is structured at the nm and mm scale

Scintillation mechanisms



The number of photons is supposed to be linear with the energy...

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Scintillation mechanisms

As a summary

Energy sharing during the relaxation process \rightarrow light, heat & storage



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Several scintillator classes



Kamiokande (neutrino)

Organic solids



Plastics @ Saint Gobain

Inorganic solids



PbWO₄ @ CERN

Why so many materials and researches?

It does not exist universal scintillators!

• Requirements in terms of performances and shapes depend on the application

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First rank parameters

- Density & Z_{eff} (host selection): Stopping power, photoelectric effect
- Scintillation yield: Easier to detect, energy resolution, timing
- Scintillation decay: Countin rate, coincidence gate, time of flight ...
- $\bullet \rightarrow$ cerium doped Lutetium based compounds were very popular (LSO)

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Second rank parameters

Mechanical and chemical stability, emission wavelength, cost, mass production capability, radio-isotopes purity, thermal stability, shaping possibilities ...

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Why so many materials and researches?

2 main uses: counting and integration



Various applications using scintillators

- High energy calorimetry
- Medical imaging (PET-Dosimetry-X-ray CT...)
- Homeland security
- Oil drilling

...

- Space exploration
- Dark Matter search
- Industrial control
- Nuclear industry
- Nuclear waste survey

Research on new compositions \rightarrow Light production

It doesn't exist universal scintillator and each application has its own requirements

- host
- doping
- codoping
- defects
- synthesis protocols
- in connection with the theory of processes

see SCINT conference series (since 1992)

http://Scint.univ-lyon1.fr

2019 - Sendai - Japan

2022 - Santa Fe - USA

2024 - Milano - Italy

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or / and shapes \rightarrow Light collection

Single Crystal



Many applications

Inorganic Fibers



Calorimetry?

ZnS:Mn NP in PMMA



http://chm.tu-dresden.de





Medical x-ray imaging

Csl-NaCl eutectic



@Canon, Adv. Mat. 2012

Thin films



High resolution x-ray imaging

Phosphor powder



x-ray imaging

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