中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

The Chinese Academy of Sciences

The Summary of the "FAST scintillation material workshop"

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- “FAST scintillation material workshop”

- Date: 14th. May 2021;
- Place：IHEP + Online
- AIM: ① to disscuss the possibility of using Scintillation Glass in CEPC E/HCAL;
  ② to disscuss the possibility of using Glass in TOF-PET;
- Presenter: 40 persons + 13 units

- **IHEP , USTC**
- 上海硅酸盐所：*Shanghai Institute of Ceramics, Chinese Academy of Sciences*
- 中国建筑材料研究院：*China Building Materials Research Institute Co., Ltd.*
- 井冈山大学：*Department of Physics，Jinggangshan University*
- 中国计量大学：*China Jiliang University*
- 北京玻璃研究院：*Beijing Glass Research Institute Co., Ltd.*
- 中科院福建物构所：*Fujian Institute of Research on the Structure of Matter, CAS*
- 南京大学：*Nanjing Univerisity*
- *Some company about the mass production of the Glass.*

BEPCII & BESIII Status
2021-5-14 10:36:21
KM2A - ED
KM2A - MD
Beijing Time : 2021-5-12, 13:34:50
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- There are 11 presentaions about in this workshop:
- for the physics of the CEPC: +2

①《Overview of scintillator-based calorimeters for CEPC》 by LiuYong, IHEP;

②《The Scintillating Glass AHCAL Simulation》by Yukun Shi, USTC;

- for the Scintillation Glass: +3

• 中国建筑材料研究院：China Building Materials Research Institute Co., Ltd.

③ <重闪烁体玻璃研究进展>, Research progress of heavy scintillation glass

• 井冈山大学：Department of Physics,Jinggangshan University

④ <高密度硼鍺酸盐闪烁玻璃的研究> Dense Borogermanate Glass Scintillators

• 中国计量大学：China Jiliang University

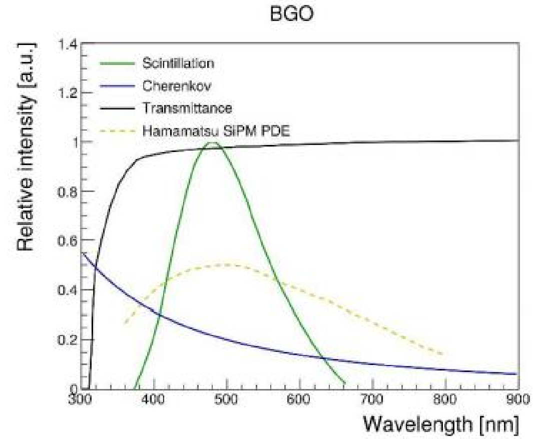
⑤ 掺杂铝硅玻璃的发光与闪烁性能初探

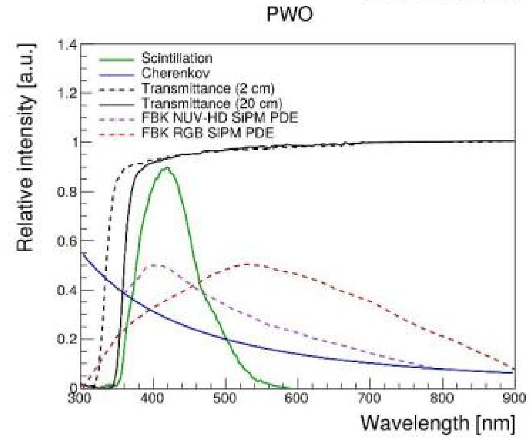
Preliminary Study on Active Ion Doped Aluminosilicate Glass

- for the Scintillation Crystal: +3;
- for the Plastic Scintillator: +1;
- for the fible, the PET: +2;

Scintillating materials: a wish list for calorimeters

- High density: preferably > 7 g/cm³ for crystals/scintillating glass
  - Compact shower profiles: good separation of near-by particles
  - Compact calorimeter design: minimum volume
- Moderate (intrinsic) light yield
  - Like o(10%) of BGO: a few thousands of photons per MeV
  - Lower calorimeter energy threshold
- Photon wavelength compatible with photosensors
  - Typical sensitive region of photosensors: 350-700 nm
  - Scintillation: emission spectrum
  - Transmittance: transparent to scintillating photons
  - Also transparent to Cherenkov photons?
- Fast timing for <=100 ps resolution
  - Particle identification, shower development along with time
- Radiation tolerance: regions near collider beam pipe, endcap



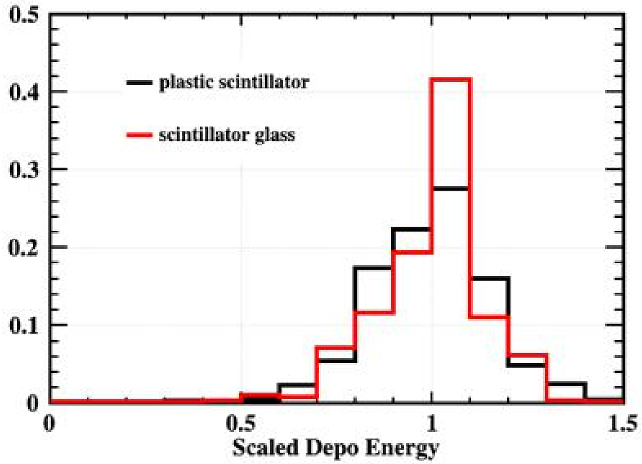


Mainly put forward the requirements for key parameters of scintillation materials for 4D calorimeters

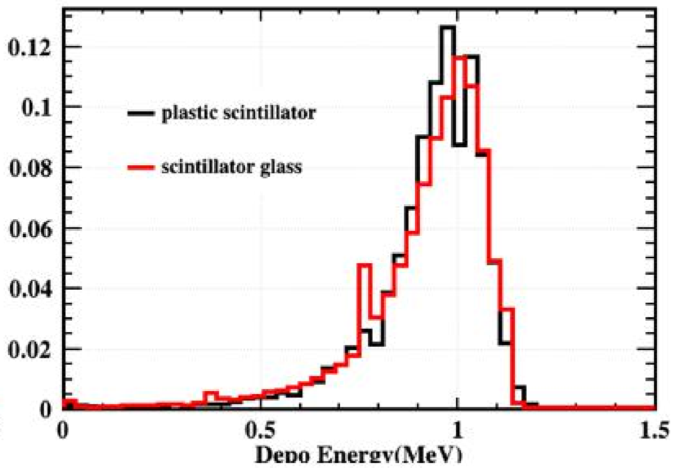
Reporter: Yong Liu, Institute of High Energy Physics, CAS

➢ ②. The Scintillating Glass HCAL Simulation

- 6mm glass + 17mm Fe VS 3mm plastic + 20mm Fe
- Energy deposition is scaled
- Scintillating glass has more advantage at low energy



10 GeV KL



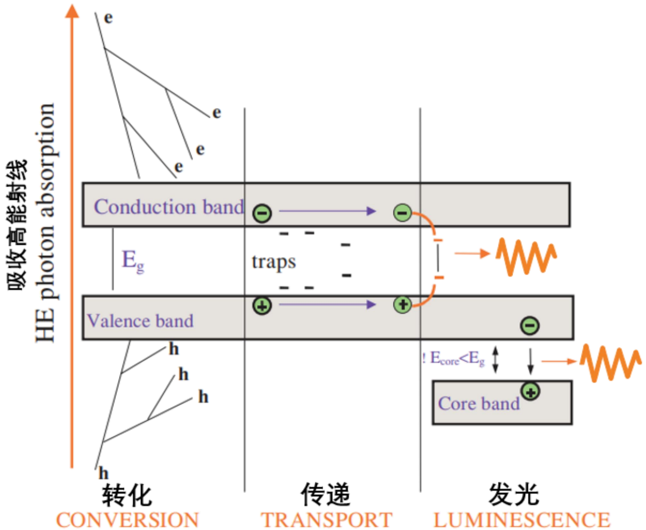
80 GeV KL

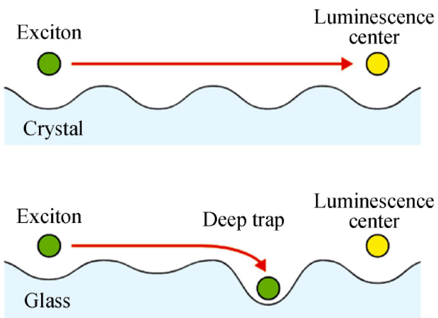
- Compare the performance of plastic scintillator and scintillation glass in HCAL
- The scintillating glass ACHAL has better resolution especially at low energy

The NEXT talk will be from YuKun for "Simulation study of the scintillation glass HCAL"

Reporter： Yukun Shi, University of Science and Technology of China

➢ ③. Research progress of heavy scintillation glass





Principle of scintillator glass luminescence

Key technologies to increase light yield:

- Luminous ion concentration
- Light alkalinity effect
- Glass transmittance
- Glass melting atmosphere
- Glass melting quality

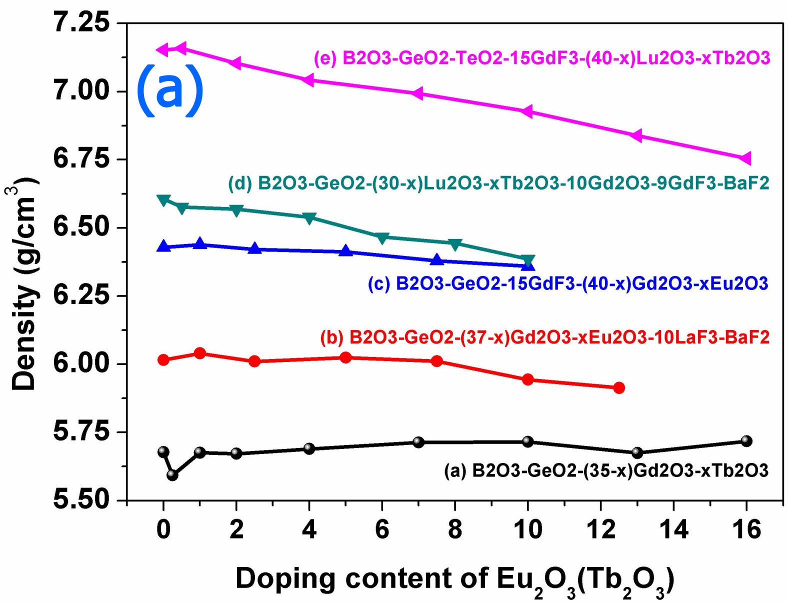
- The report introduces the main characteristics of heavy metal scintillation glass, influencing factors and several important heavy metal scintillation.

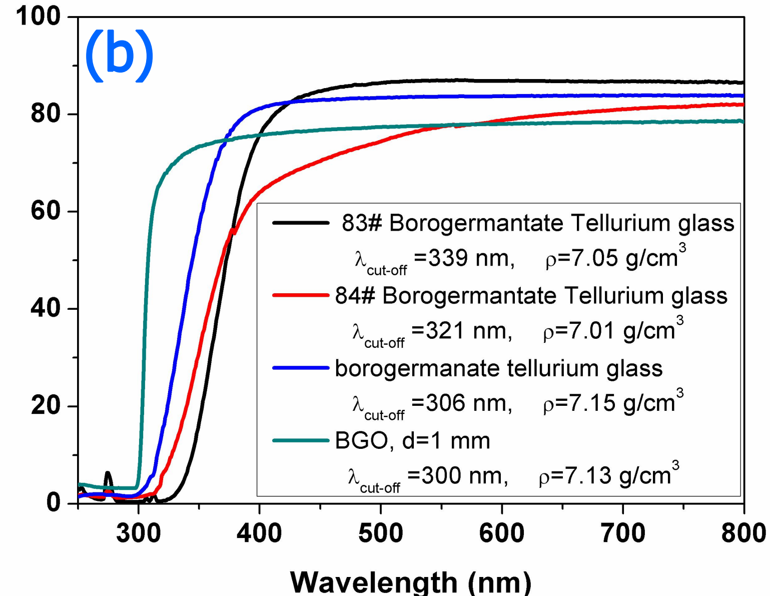
Table 1 High-density glasss cintillator

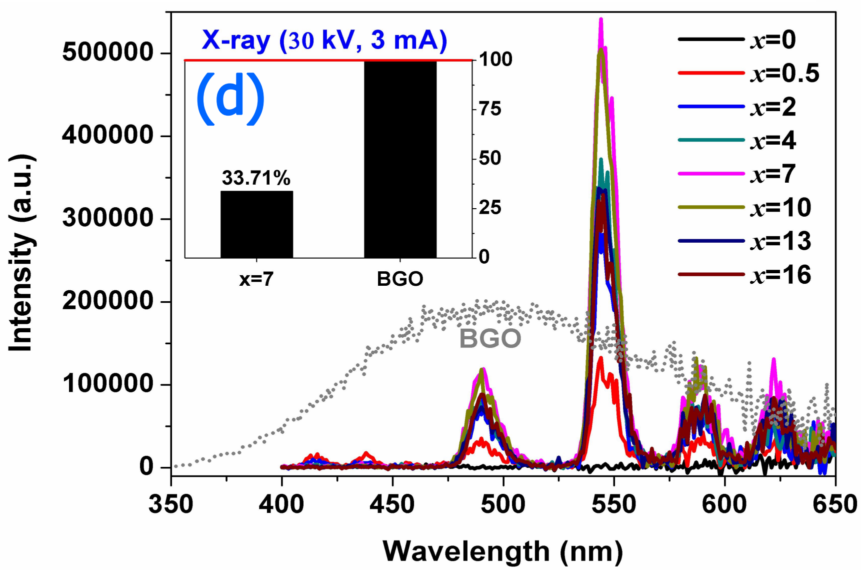
Glass composition/(mol%)	Dopant	Density/(g · cm^{-3})
$54PbO-36Bi_2O_3-10B_2O_3$		8.138
$20BaO-40Bi_2O_3-40B_2O_3$	Dy	6.67
$15SiO_2-25B_2O_3-5P_2O_5-15Ga_2O_3-38Lu_2O_3$	Tb	6.56
$20B_2O_3-40GeO_2-20Lu_2O_3-5La_2O_3-15BaF_2$	Tb	6.09
$GeO_2-Gd_2O_3-BaO$	Ce	5.75
$B_2O_3-SiO_2-Al_2O_3-Gd_2O_3$	Ce	5.51

Reporter: Hui Liu, China Building Materials Research Institute Co., Ltd.

➢ ④. Dense Borogermanate (B,Ge) Glass Scintillators







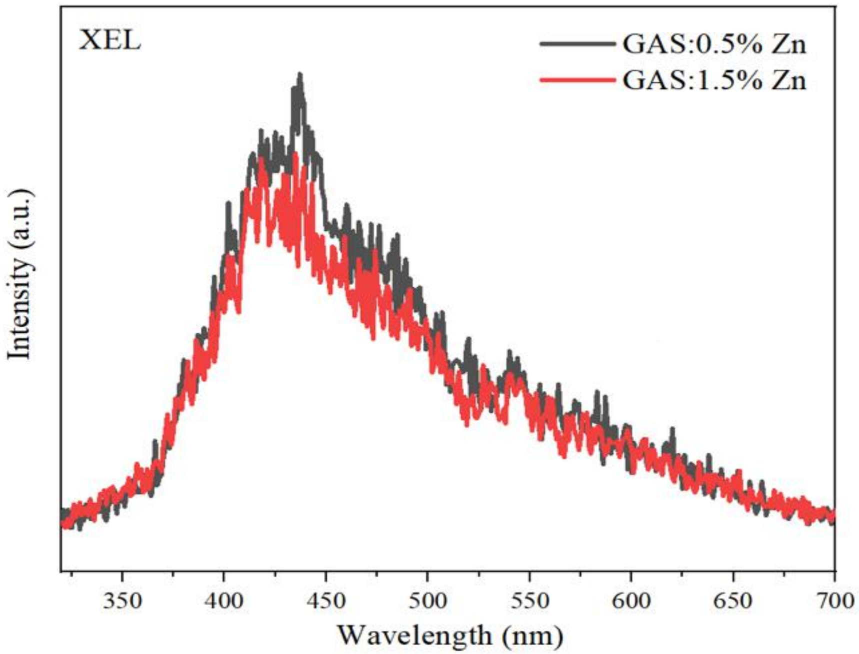
Glass density changes within 5.60-7.15 g/cm³ (a), together with the absorption edges at 306-339 nm and transmittance efficiention about 75-85% (b), which results in colorlessness (c). When doping terbium (Tb^{3+}), the borogermanate glass shows intensive RL intensity, ~33.71% BGO (d).

Reporter: Xin-Yuan Sun Department of Physics, Jinggangshan University

➢ ⑤. Preliminary Study on Active Ion Doped Aluminosilicate Glass

- Obtain a glass matrix with good thermodynamic properties and a large molding process range, which can be doped with Gd2O3, Li2O, B2O3 and other oxides in a large amount to control the luminescence properties of **non-rare earth element** activated ions: Sn2+ ions. （will be cheap!）
- X-ray excitation scintillation luminescence is located at 400-550nm

- The decay time of Zn2+ doped glass: τ1<10ns (~30%); τ2~700ns (~70%), X-ray excitation scintillation luminescence is located at 375-650nm



Reporter： Tang Gao, China Jiliang University

- scintillation crystals:due to the factors such as complex preparation process, high production cost, difficulty in mass and large-scale production
- glass scintillators: have simple preparation process, low cost, continuously adjustable composition and performance, excellent shaping and processing performance, and easy mass production and large-scale production.
- plastic scintillators: have low density (the density is only about $1g/cm^3$) and long radiation length.

Performance comparison of high-density glass scintillators with other scintillators

Composition	Density (g/cm^3)	Light yield (ph/MeV)	Decay time (ns)	Emission peak(nm)
$33.4SiO_2$-$33.3LiF$-$32.0GdBr_3$-$1.3CeBr_3$(Ce-doped high silica glass)	4.37	3460	522	431
$30B_2O_3$-$10SiO_2$-$15SiC$-$10Al_2O_3$-$34Gd_2O_3$-$1CeF_3$(Ce-doped gadolinium borosilicate glass）	4.94	1120	29.3	394
$20HfF_4$-$24YF_3$-$32ZnF_2$-$24BaF_2$-$2CeF_2$(Ce-doped fluoride glass)	6.0	2400	23.4	348
BC408	~1.0	5120	2.1	425
BC418	~1.0	5360	1.4	391
GAGG:Ce	6.6	50000	50.1	560
LYSO:Ce	7.3	25000	40	420

--> The AIM of the Scintillation Glass:

Composition: no radioactive elements;

Light Yield: > 1000p.e/MeV;

Density: > 7g/cm^3;

Transmittance Efficiention: >70%?

Radiation Length: ~20-30cm? need simulation data!

Decay time: 50ns?

Cost: 1$/c.c

1. Some Institute and University have the interesting to study the scintillation glass,
2. My Lab has the equipments and methode to test the scintillation glass sample,
3. The Company has the interesting and the equipments to do the mass production work.