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 scintillator materials mini workshop”

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- “FAST scintillation materials mini 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: 28 persons + 11 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
Beijing Time : 2021-5-12, 13:34:50
KM2A - ED
KM2A - MD
KM2A
STOPPED
WCDA
RUNNING
WFCTA
STOPPED

- There are 11 presentaions about in this mimi 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

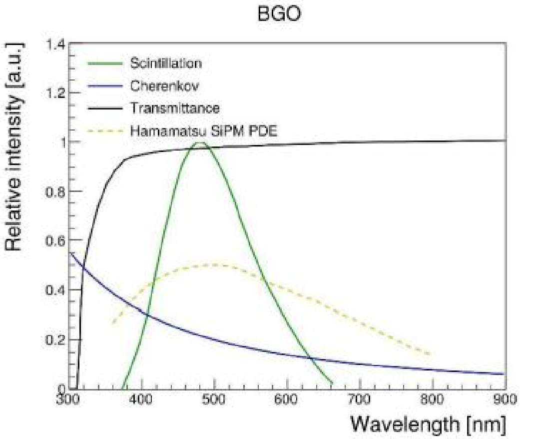
⑤ 掺杂铝硅玻璃的发光与闪烁性能初探

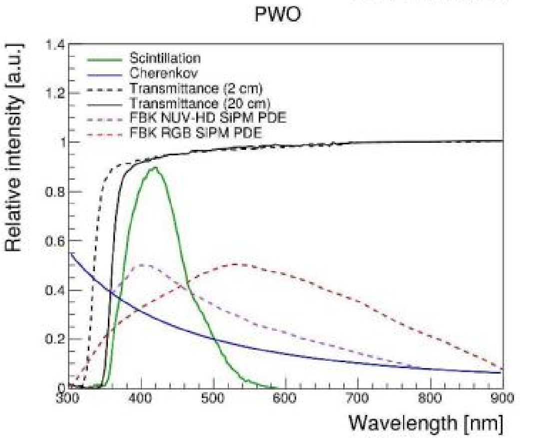
Preliminary Study on Active Ion Doped Aluminosilicate Glass

- 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/cm^3 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



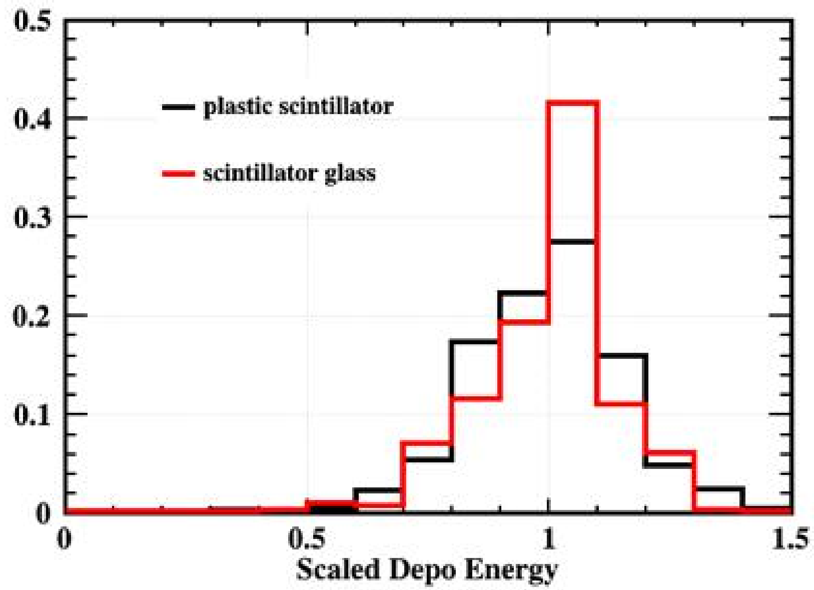


Mainly put forward the requirements for key parameters of scintillation materials for 4D calorimeters

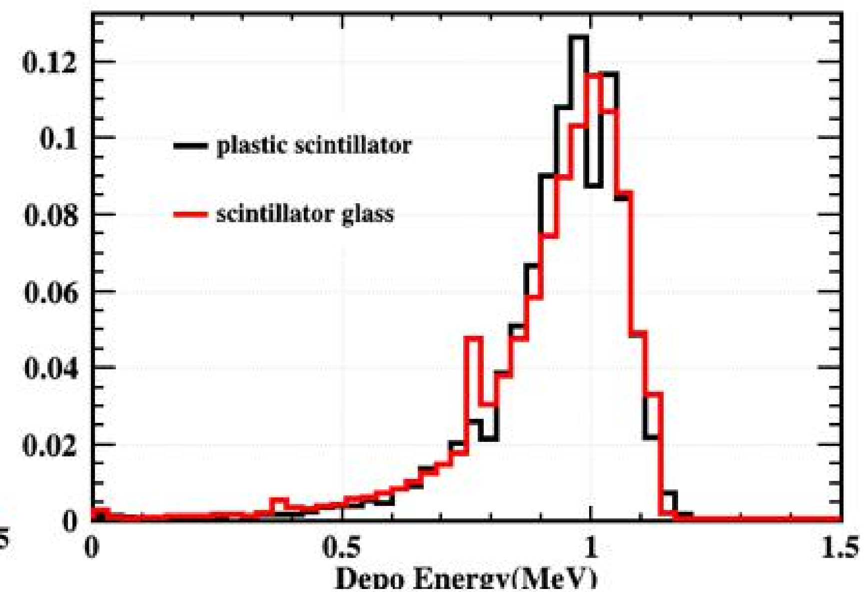
Reporter: Yong Liu, Institute of High Energy Physics, CAS

➢ ②. The Scintillating Glass AHCAL 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

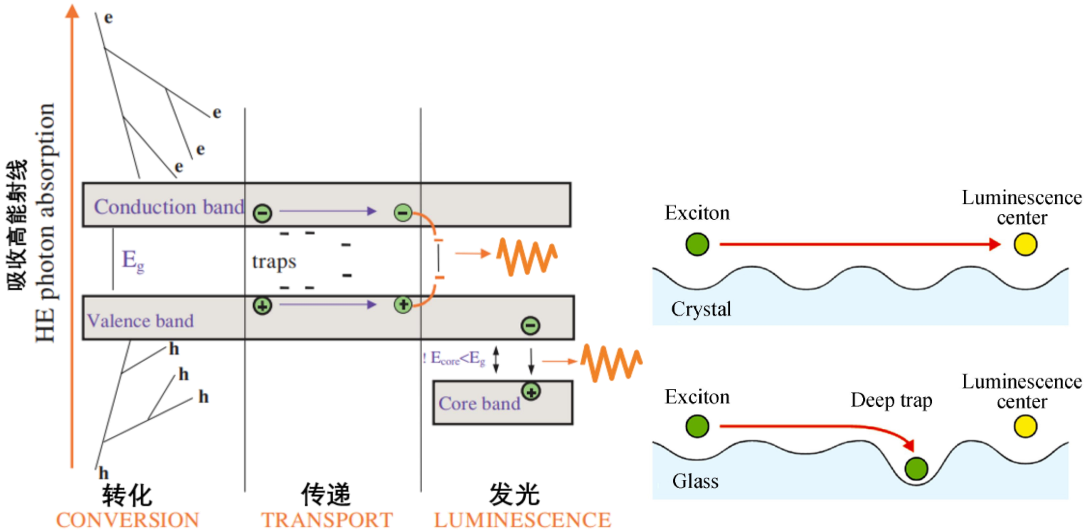


80 GeV KL

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

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

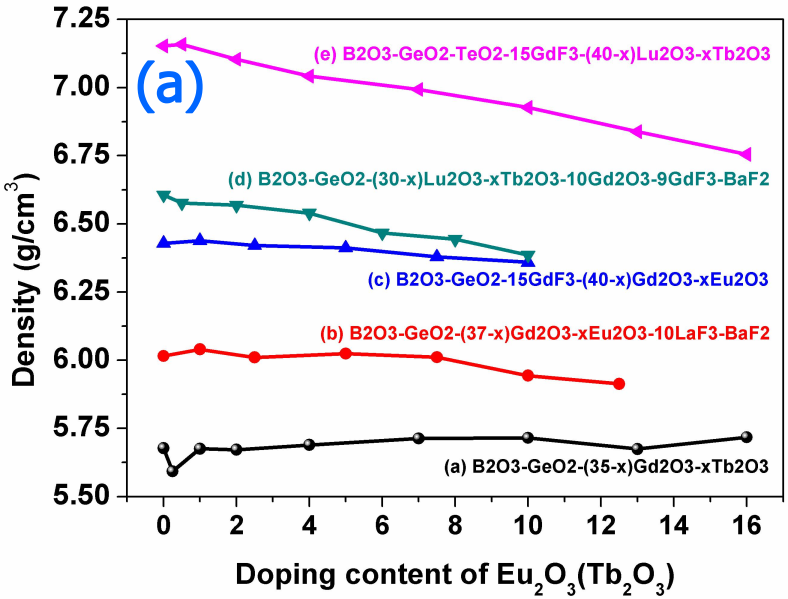
- The report introduces the main characteristics of heavy metal scintillation glass, influencing factors and several important heavy metal scintillation

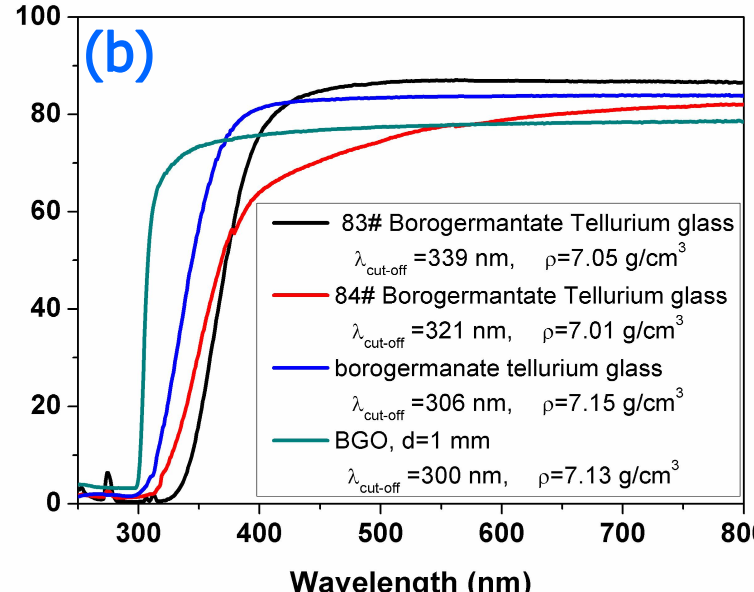
Table 1 High-density glasss cintillator

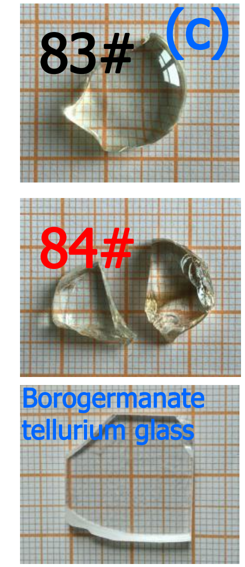
No.	Glass composition/(mol%)	Dopant	Density/($g \cdot cm^{-3}$)
1	$54PbO-36Bi_2O_3-10B_2O_3$		8.138
2	$20BaO-40Bi_2O_3-40B_2O_3$	Dy	6.67
3	$15SiO_2-25B_2O_3-5P_2O_5-15Ga_2O_3-38Lu_2O_3$	Tb	6.56
4	$20B_2O_3-40GeO_2-20Lu_2O_3-5La_2O_3-15BaF_2$	Tb	6.09
5	$GeO_2-Gd_2O_3-BaO$	Ce	5.75
6	$B_2O_3-SiO_2-Al_2O_3-Gd_2O_3$	Ce	5.51

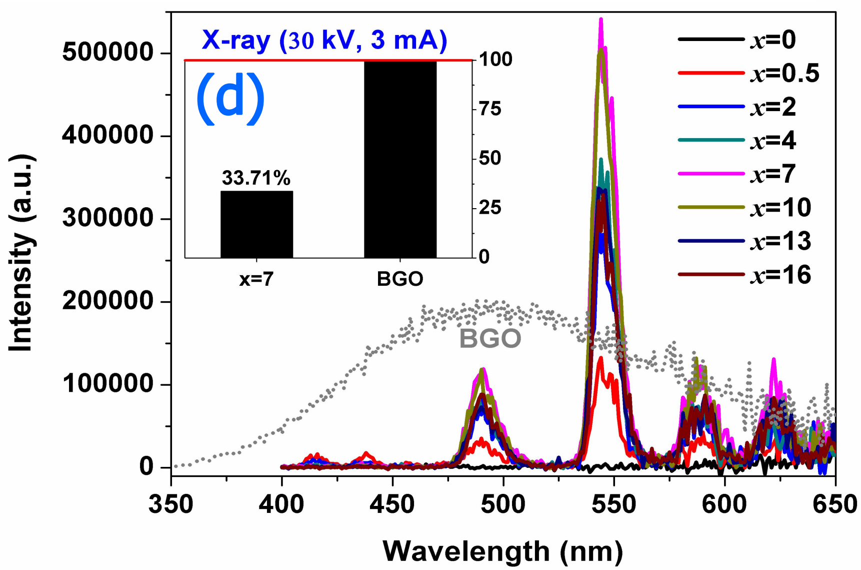
Reporter： Hui Liu, China Building Materials Research Institute Co., Ltd.

➢ ④. Dense Borogermanate Glass Scintillators









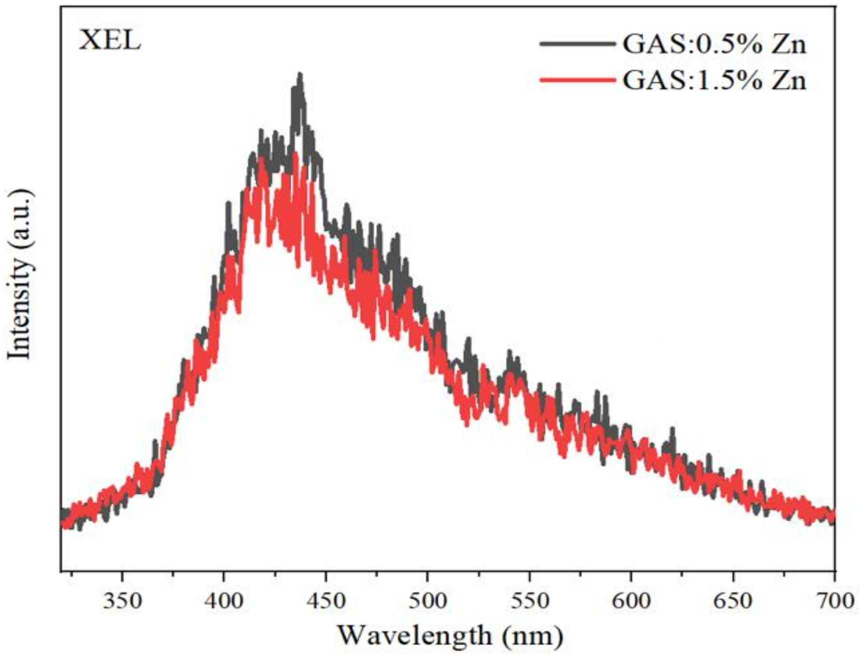
Glass density changes within 5.60-7.15 g/cm³ (a), together with the absorption edges at 306-339 nm and transmittance coefficient about 75-85% (b), which results in colorlessness (c). When doping terbium (Tb^{3+}), the borogermanate glass shows intensive RL intensity, ~33.71% BGO (d).

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 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 materials

- 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 $1 g/cm^3$) 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)
AIM	>7	>1000	?	?
$33.4SiO_2$-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