Crystal Research at SIC

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About SIC: History

Since 1928 SICCAS

1928 — Engineering Institute of Academia Sinica

1959 — Institute of Ceramic Chemistry and Engineering, Chinese Academy of Sciences

1984 — Shanghai Institute of Ceramics, Chinese Academy of Sciences

- Shanghai Institute of Ceramics (SIC), CAS traces its origins back to the Engineering Institute of Academia Sinica established in 1928, which was designated as the Institute of Metallurgy and Ceramics under the auspices of the Chinese Academy of Sciences in 1953, and then was divided to two branches in 1959. The ceramic branch evolved into the Shanghai Institute of Ceramic Chemistry and Technology, subsequently rechristened the Shanghai Institute of Ceramics in 1984.

About SIC: Campus and location

CAMPUS

JIADING (140,000 m^2):
Headquarters
Basic research
New material discovery

CHANGNING (16,000 m^2):
Basic research
Academic exchange center

TAICANG (120,000 m^2):
Pilot plant
Small production

- SIC has three campus: Headquarter campus in Jiading District (Shanghai), Academic exchange center campus in Changning District (Shanghai), and Pilot plant campus in Taicang city (Jiangsu Province).

About SIC: Research areas

Research areas

- Structural ceramics
- Functional ceramics
- Transparent ceramics
- Artificial crystals
- Inorganic coatings
- Bio-medical materials
- Analysis and testing

■SIC is focused on the inorganic non-metallic materials science and engineering

About SIC: Research organization

SICCAS Since 1928

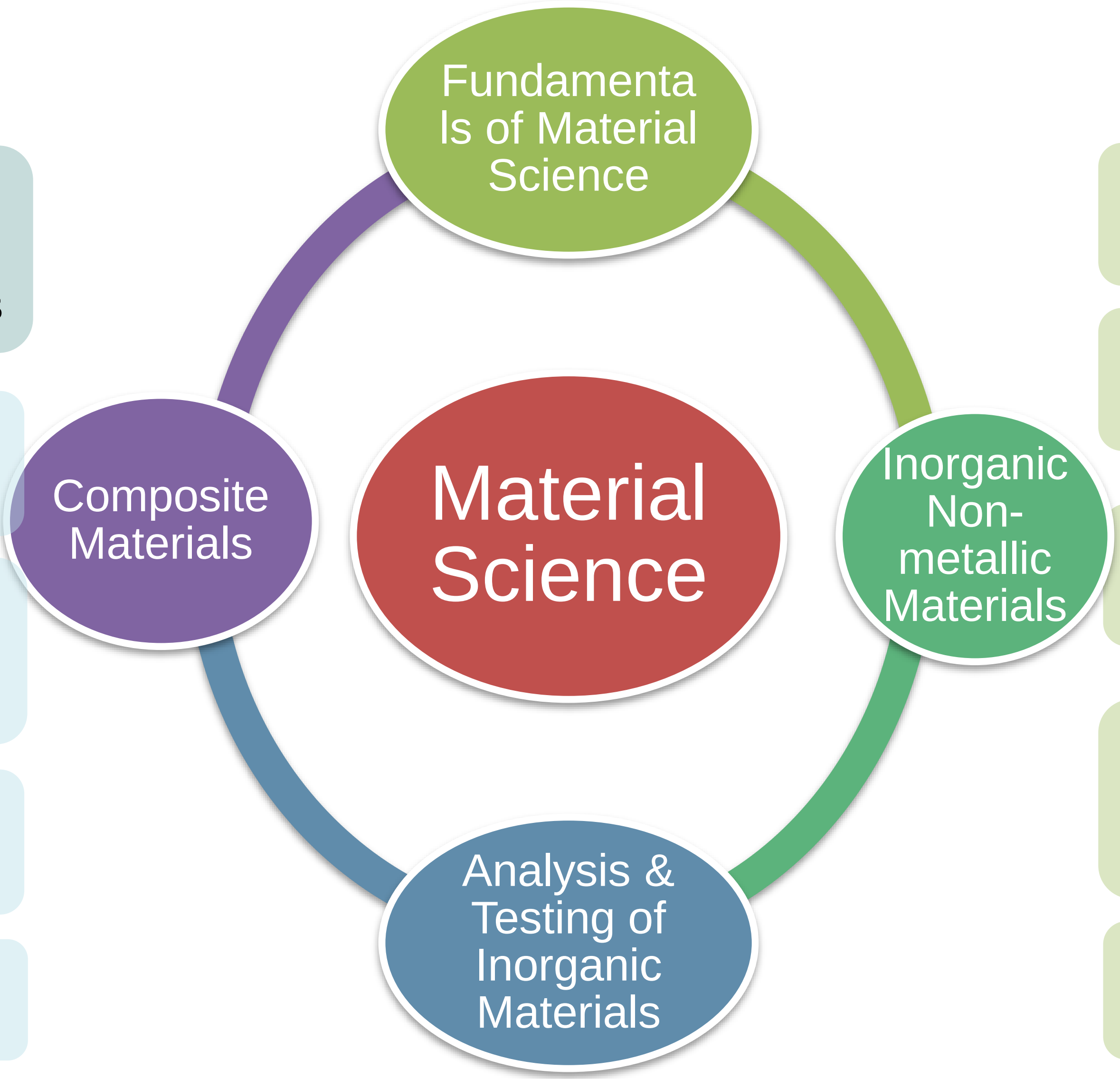
Key Labs

1

- State Key Lab of High Performance Ceramics & Superfine Microstructures

4

- CAS Key Lab of Inorganic Coating Materials
- CAS Key Lab of Transparent & Opto-functional Advanced Inorganic Materials
- CAS Key Lab of Materials for Energy Conversion
- CAS Key Lab of Inorganic Functional Materials & Devices



Research Centers

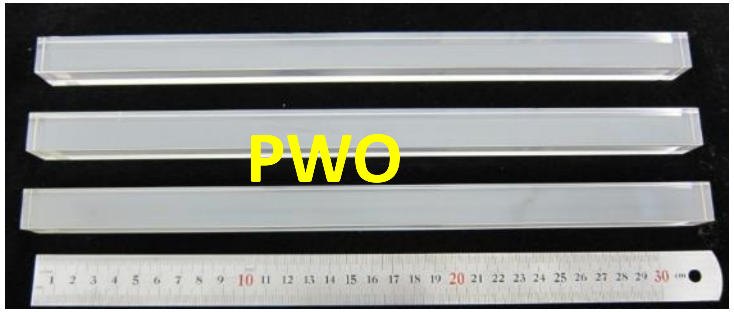
5

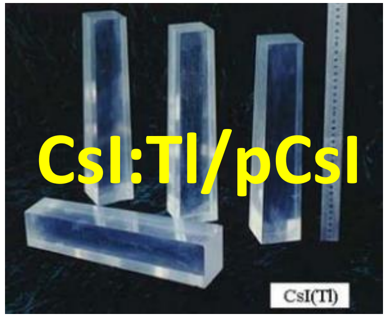
- Structural Ceramics Eng. Research Center
- Ancient Ceramics Research Center
- Bio-Mater. & Tissue Eng. Research Center
- Inorganic Mater. Analysis & Testing Center
- R&D Center for Novel Materials

R&D activities on inorganic functional crystals at SIC

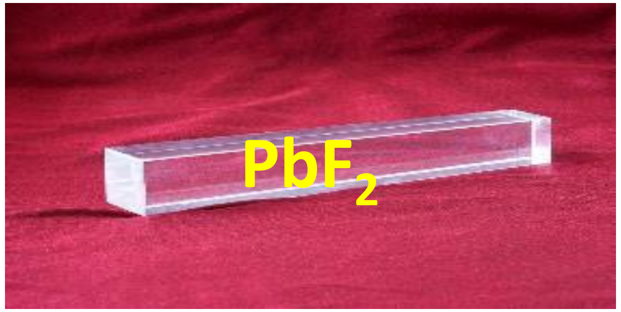
Since 1928 SICCAS

◆ *Scintillation crystals*



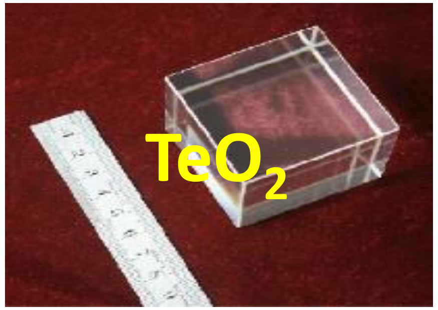


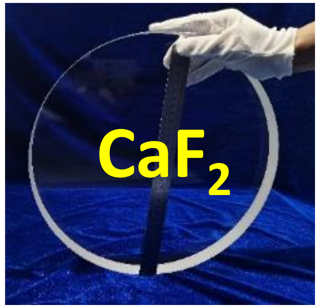
◆ *Cherenkov crystals*



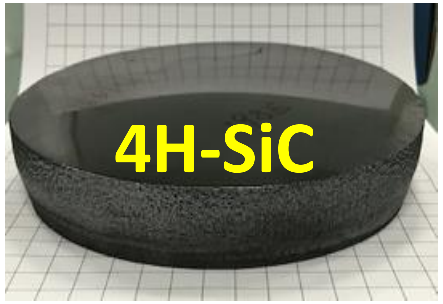
◆ *Piezoelectric and ferroelectric crystals*

◆ *Optic crystals*





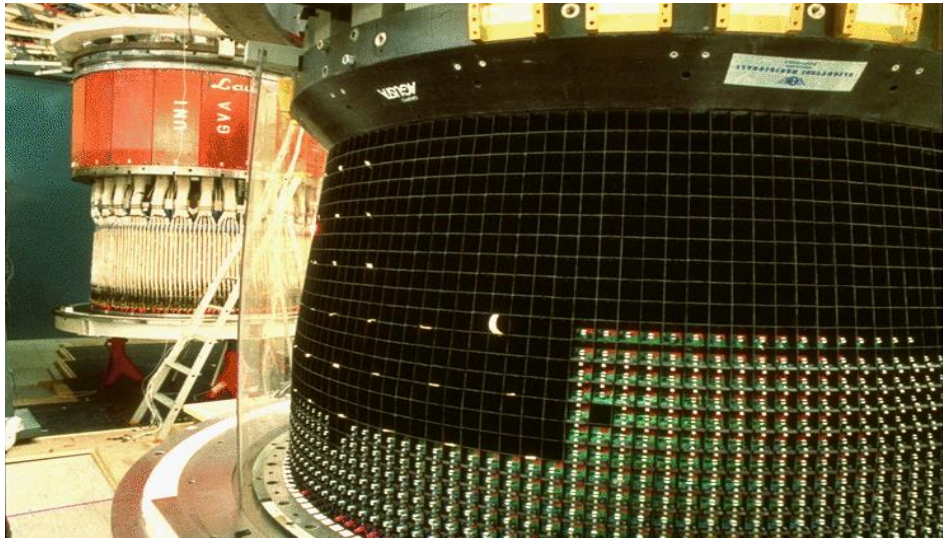
◆ *semiconductor crystals*



R&D activities on crystals for particle physics at SIC

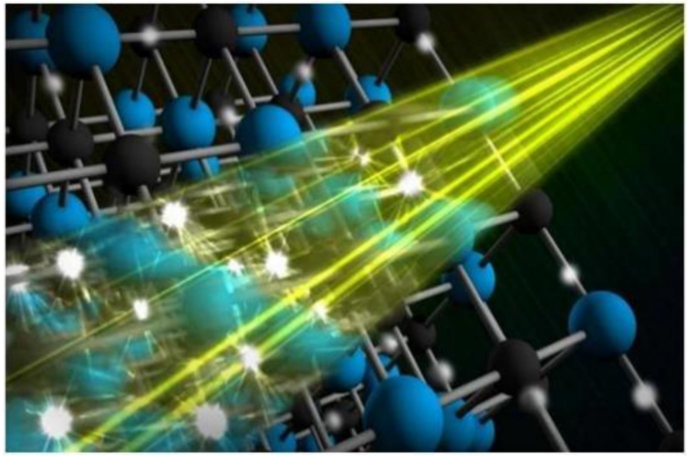
Since 1928 SICCAS

1980s

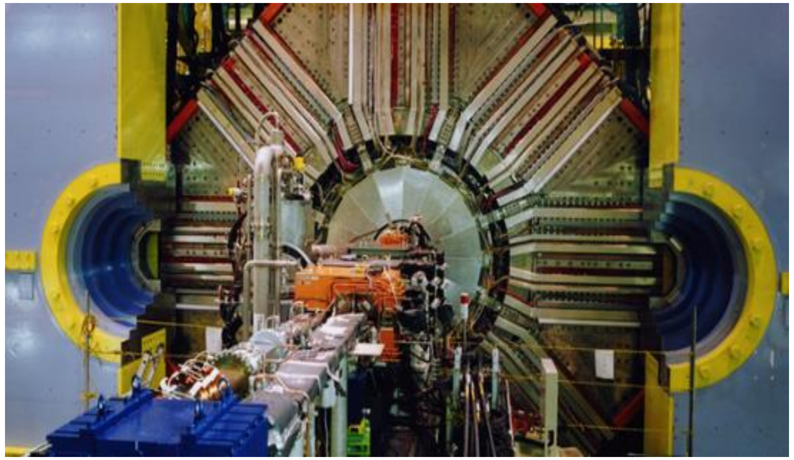


24cm-long BGO crystals for LEP L3 experiment（CERN, 11,000 kg)

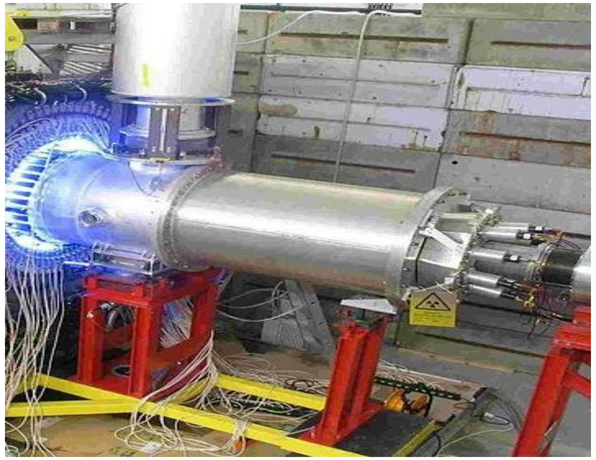
1990s



SLAC ECAL (CsI:Tl)



Belle ECAL (CsI:Tl)

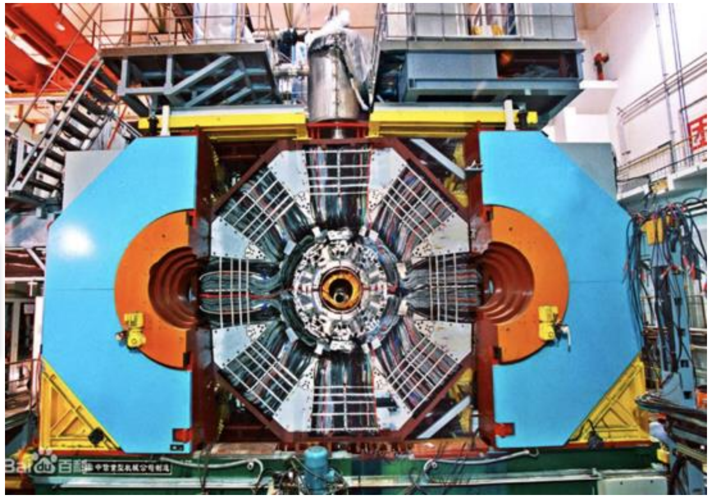


MAMI (PbF_2)

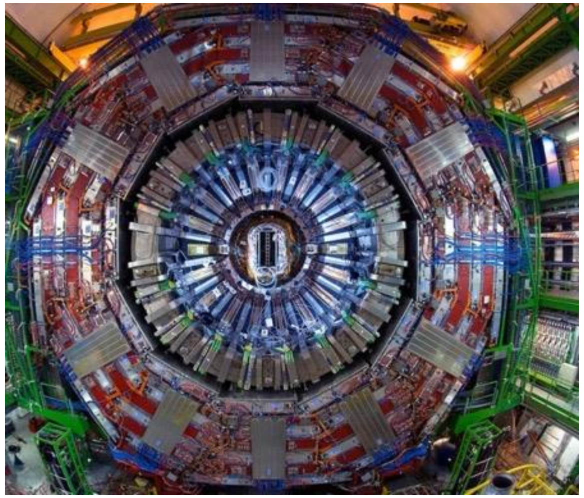
R&D activities on crystals for particle physics at SIC

Since 1928 SICCAS

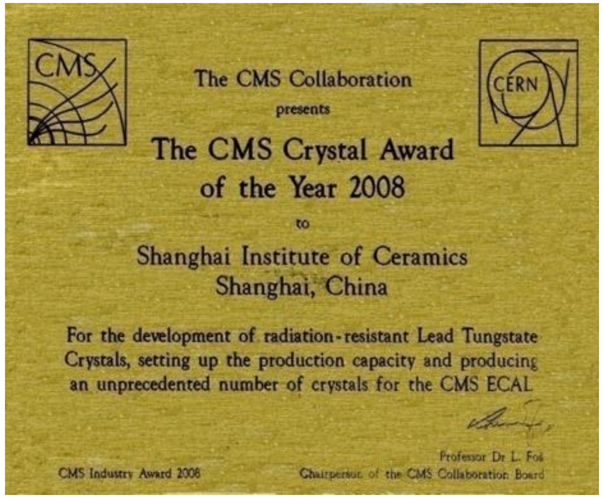
2000s



BEPC-II (BESIII) (CsI:Tl)

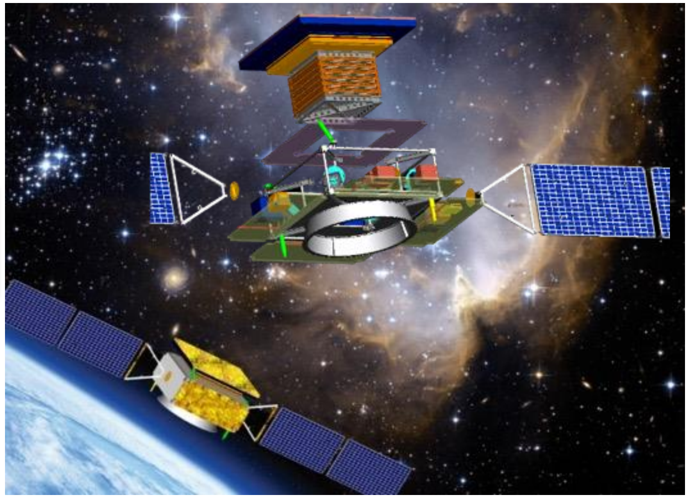


CEBAF/PANDA/CMS (PWO)

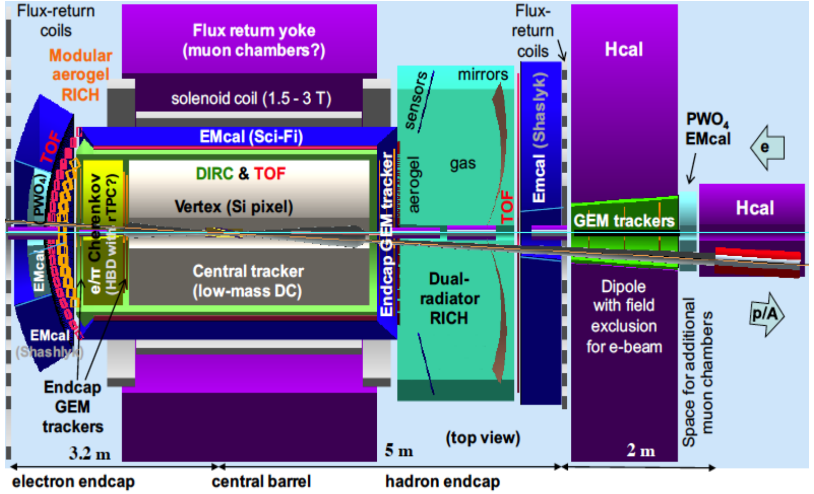


CMS Crystal Award

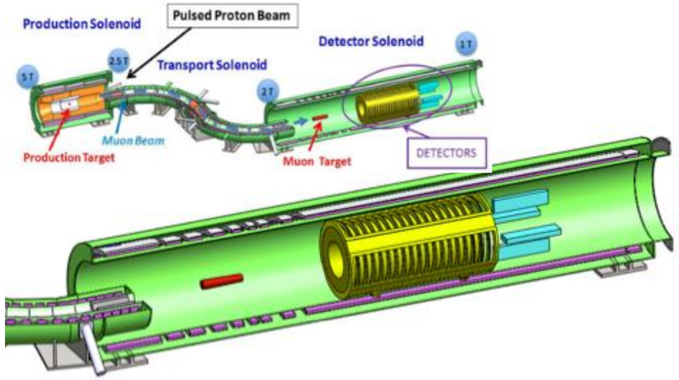
2010s



DAMPE (BGO)



Jefferson Lab (PWO)



Fermi Lab Mu2e (pCsI)

R&D activities on crystals for particle physics at SIC

Story begin from BGO crystal

A scintillator community exists since 1992

International Conference on Scintillating Materials and their Applications (SCINT)

- **Crystal2000, 22th-26th September 1992, Chamonix (France, 1st)**
- MRS94, San Francisco (USA)
- SCINT95, 28th August-1st September 1995, Delft (The Netherlands)
- **SCINT97, 22th-25th September 1997, Shanghai (China)**
- Scint99 16th-20th August 1999, Moscow (Russia)
- Scint01, 16th-21th September 2001, Chamonix (France)
- Scint03, 8th-12th September 2003, Valencia (Spain)
- Scint05, 19th-23th September 2005, Kharkov (Ukraine)
- Scint07, 4th-8th June 2007, Winston-Salem (USA)
- Scint09, 8th-12th June 2009, Jeju (Korea)
- Scint11, 12th-16th September 2011, Giessen (Germany)
- **Scint13, 15th-19th April 2013, Shanghai (China)**
- Scint15, 7th-12th June 2015, Berkeley (USA)
- Scint17, 18th-22th September 2017, Chamonix (France)
- Scint19, 29th September -4th October , 2019, Sendai (Japan)
- Scint22, 18th-23th September , 2022, Santa Fe (USA)
- Scint24, 8th-12th July 2024, Milan (Italy, 17th, coming)

17 times
3 times in France
2 times at SIC

R&D activities on crystals for particle physics at SIC

Properties of Heavy Crystals With Mass Production Capability

Crystal	NaI(Tl)	CsI(Tl)	CsI	BaF_2	CeF_3	BGO	$PbWO_4$	LSO/LYSO(Ce)	PbF_2
Density (g/cm^3)	3.67	4.51	4.51	4.89	6.16	7.13	8.3	7.40	7.77
Melting Point (°C)	651	621	621	1280	1460	1050	1123	2050	824
Radiation Length (cm)	2.59	1.86	1.86	2.03	1.70	1.12	0.89	1.14	0.93
Molière Radius (cm)	4.13	3.57	3.57	3.10	2.41	2.23	2.00	2.07	2.21
Interaction Length (cm)	42.9	39.3	39.3	30.7	23.2	22.7	20.7	20.9	21.0
Refractive Index[a]	1.85	1.79	1.95	1.50	1.62	2.15	2.20	1.82	1.82
Hygroscopicity	Yes	Slight	Slight	No	No	No	No	No	No
Luminescence[b] (nm) (at Peak)	410	560	420 310	300 220	340 300	480	425 420	420	?
Decay Time[b] (ns)	245	1220	30 6	650 0.9	30	300	30 10	40	?
Light Yield[b,c]	100	165	3.6 1.1	36 4.1	7.3	21	0.30 0.077	85	?
d(LY)/dT[b,d] (%/°C)	-0.2	0.4	-1.4	-1.9 0.1	~0	-0.9	-2.5	-0.2	?
Experiment	Crystal Ball	CLEO *BaBar* BELLE BES III	KTeV	TAPS	-	L3 BELLE	CMS ALICE PrimEx **Panda**	**Mu2e** **SuperB** **HL-LHC?**	A4 **HHCAL?**

a At the wavelength of the emission maximum.; b Top line: slow component, bottom line: fast component.

c Relative light yield of samples of 1.5 X and with the PMT quantum efficiency taken out.; d At room temperature.

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 59 (5), 2012: 2229-2236.

- SIC is deeply involved in growing the above heavy crystals with mass production capability

R&D activities on crystals for particle physics at SIC

Inorganic crystals for present and future HEP optical calorimeter concepts

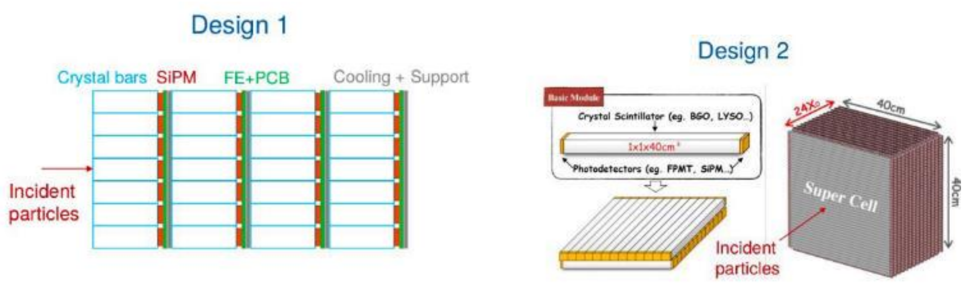
Project	Scintillator/WLS	Photodetector	DRDTs	Target
Task 3.1: Homogeneous and quasi-homogeneous EM calorimeters				
HGCCAL	BGO, LYSO	SiPMs	6.1, 6.2	e^+e^-
MAXICC	PWO, BGO, BSO	SiPMs	6.1, 6.2	e^+e^-
Crilin	PbF_2, PWO-UF	SiPMs	6.2, 6.3	$\mu^+\mu^-$
Task 3.2: Innovative Sampling EM calorimeters				
GRAiNITA	$ZnWO_4$, BGO	SiPMs	6.1, 6.2	e^+e^-
SpaCal	GAGG, organic	MCD-PMTs,SiPMs	6.1, 6.3	e^+e^-/hh
RADiCAL	LYSO, LuAG	SiPMs	6.1, 6.2, 6.3	e^+e^-/hh
Task 3.3: (EM+)Hadronic sampling calorimeters				
DRCal	PMMA, plastic	SiPMs, MCP	6.2	e^+e^-
TileCal	PEN, PET	SiPMs	6.2, 6.3	e^+e^-/hh
Task 3.4: Materials				
ScintCal	-	-	6.1, 6.2, 6.3	$e^+e^-/\mu^+\mu^-$/hh
CryoDBD Cal	TeO, ZnSe, LiMoO NaMoO, ZnMoO	n.a.	-	DBD experiments

https://indico.cern.ch/event/1386879/

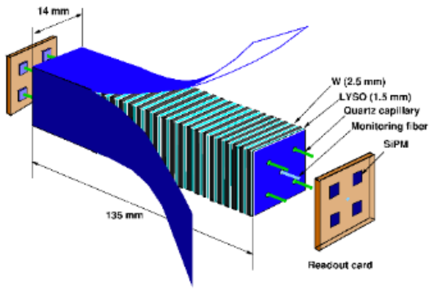
- High-granularity crystal calorimeter (HGCCAL)
- Homogeneous and quasi-homogeneous calorimeters (MAXICC)
- Sampling calorimeter: RADiCAL(Shashlik), GRAiNITA (CRystal), SpaCal (Single crystal fiber+W/Pb absorber)
- Hadronic Dual-readout sampling calorimeter: Scintillating and Cherenkov fibres, SiPM or MCP-PMT

■ Various crystals for present and future HEP optical calorimeter concepts are grown in SIC

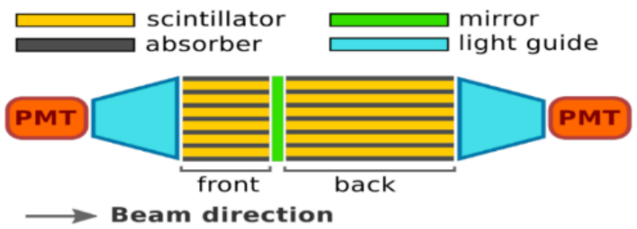
R&D activities on crystals for particle physics at SIC



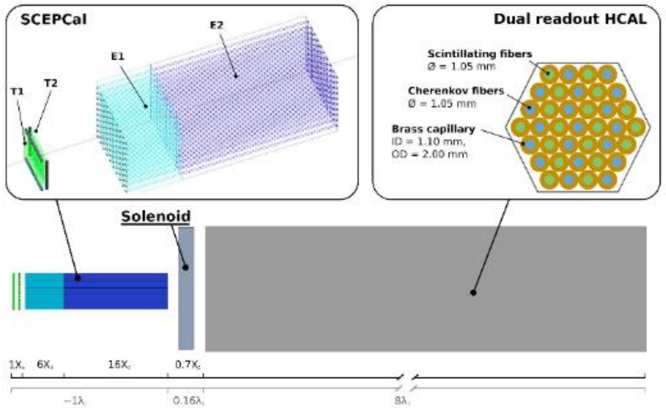
HGCCAL



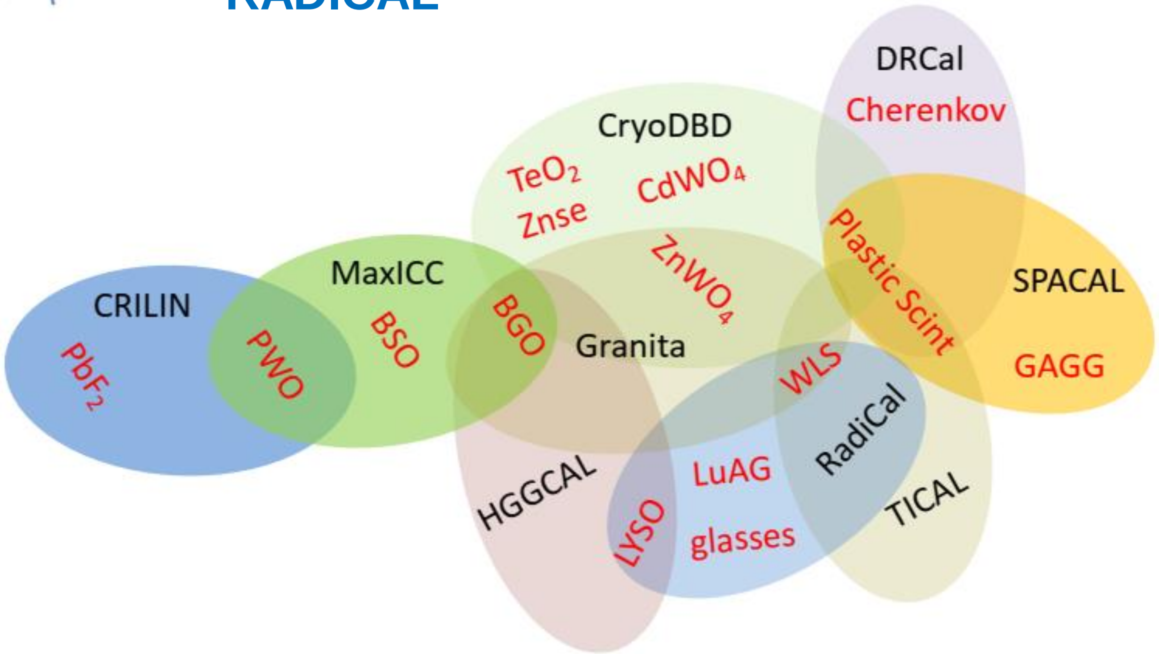
RADICAL



SPACAL



MAXICC

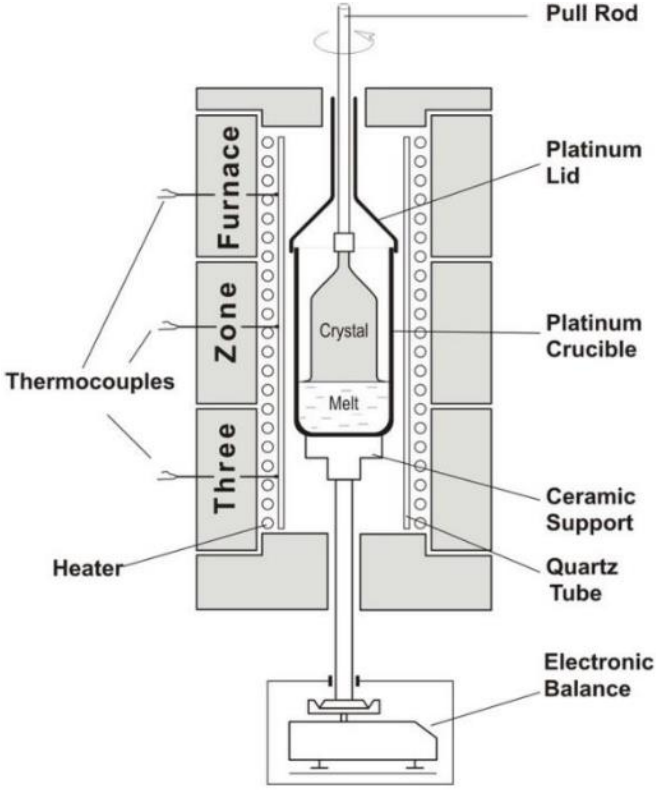


- Cost-effective and fast/ultrafast scintillation crystals, including single crystal scintillator fibers;
- Cherenkov radiator, and low radioactive background crystals.

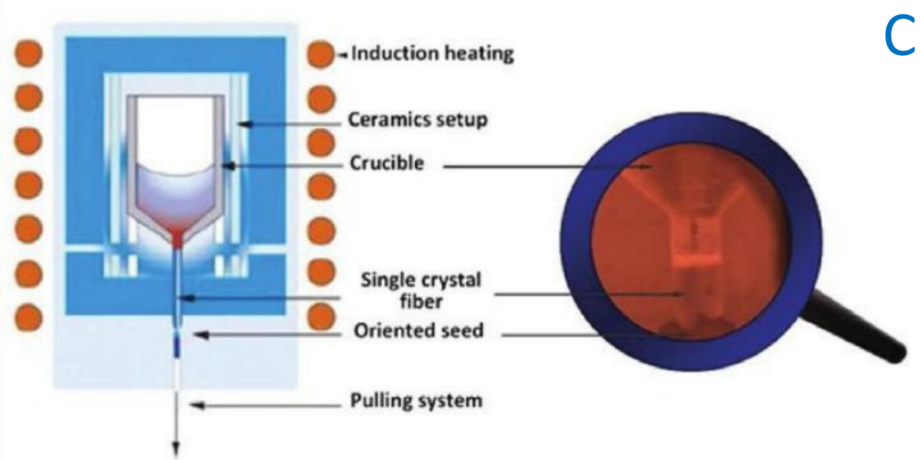
R&D activities on crystals for particle physics at SIC

SICCAS Since 1928

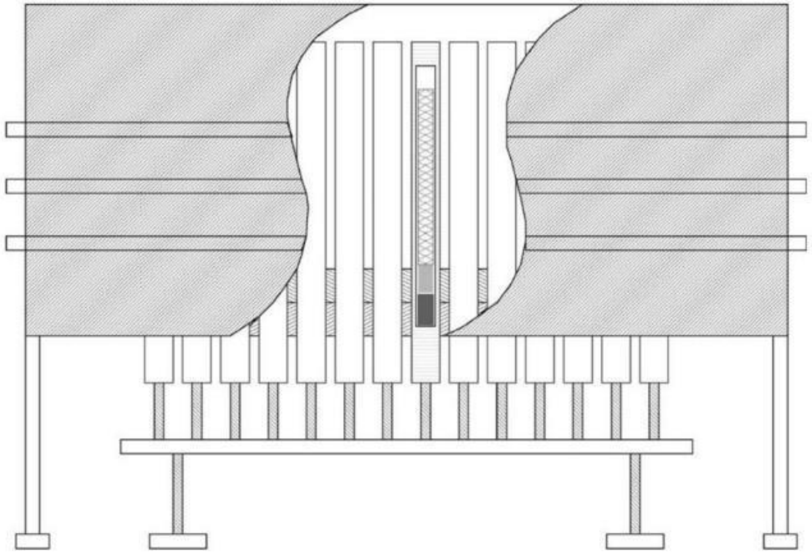
Crystal Growth Techniques



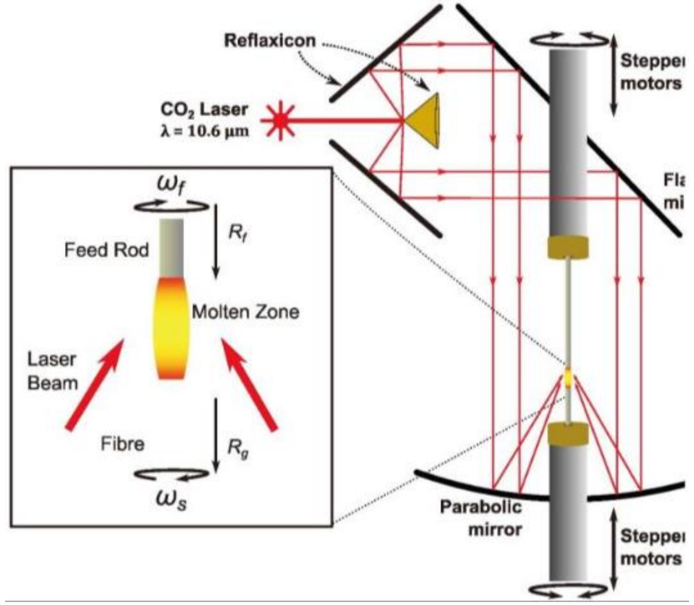
Czochralski Method (Cz)



Micro-pulling down method (μ-PD)



Mult-Crucible Modified Bridgman method (MCMB)



Laser Heated Pedestal Growth (LHPG)

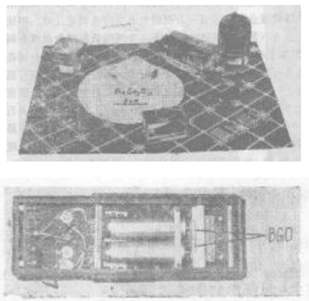
Cost-effective and fast/ultrafast scintillation crystals

Cost-effective and fast/ultrafast scintillation crystals: BGO

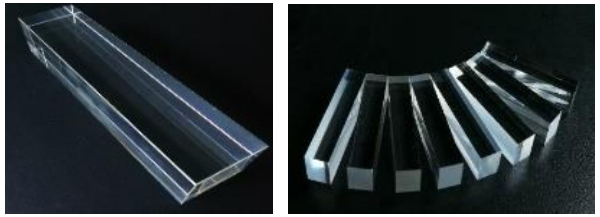
SICCAS Since 1928

- All the SIC's scintillation and Cherenkov crystals' story start from R&D on BGO…

1978-1981 → 1982-1990 → 1998-now → 2010-2014 → 2015-now

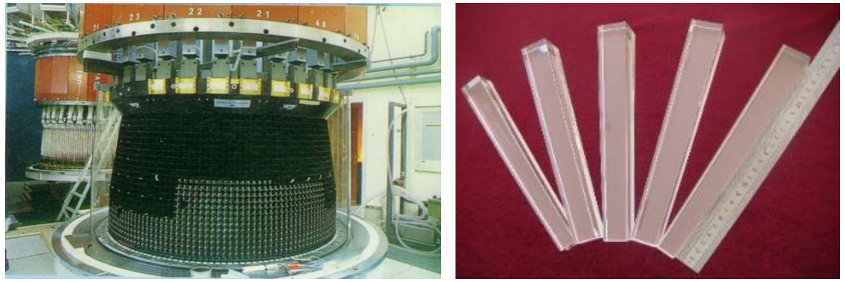


1st CT prototype



Medical imaging

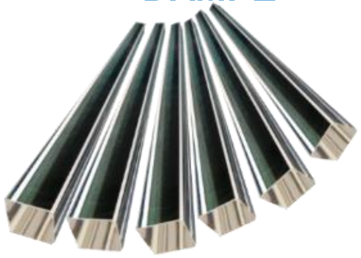
Customized scintillation detector



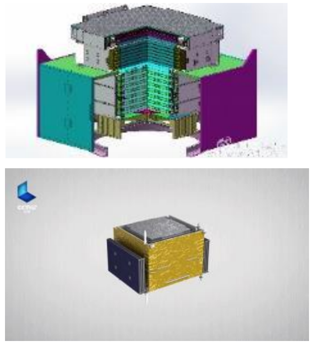
CERN LEP-L3 experiment BGO 24cm, 12,000 pcs

High energy physics

DAMPE

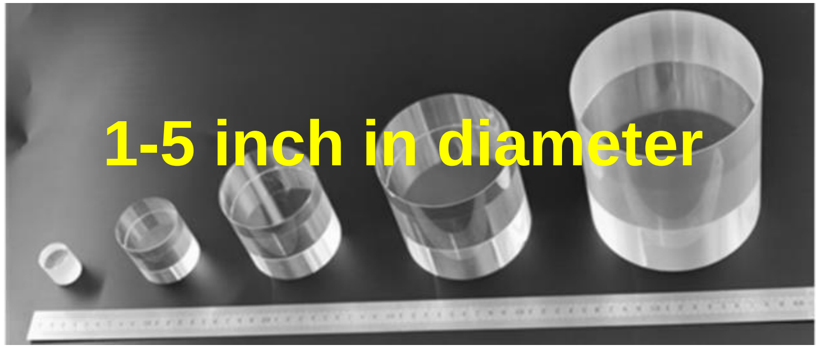


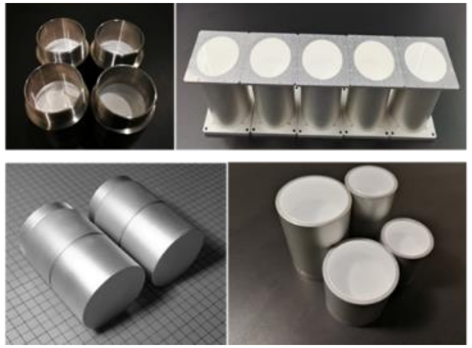
BGO (650 pcs, 60 cm)

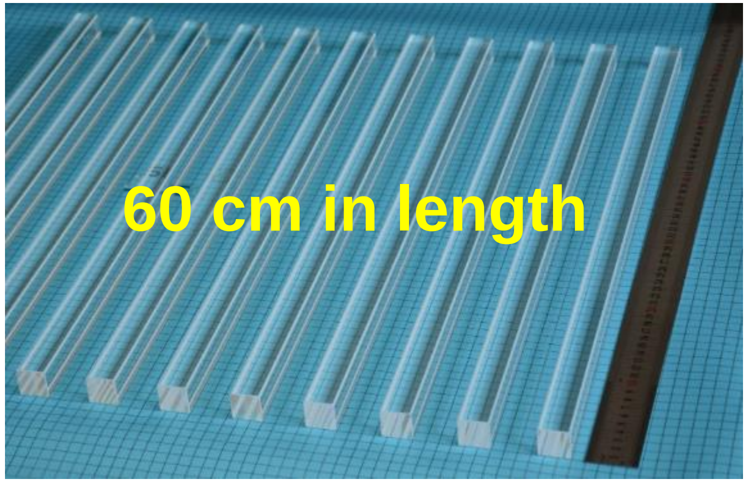


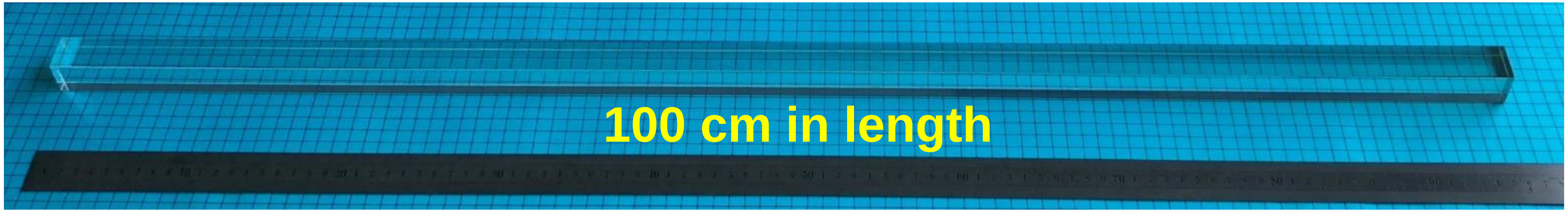
Astrophysics

Cost-effective and fast/ultrafast scintillation crystals: BGO



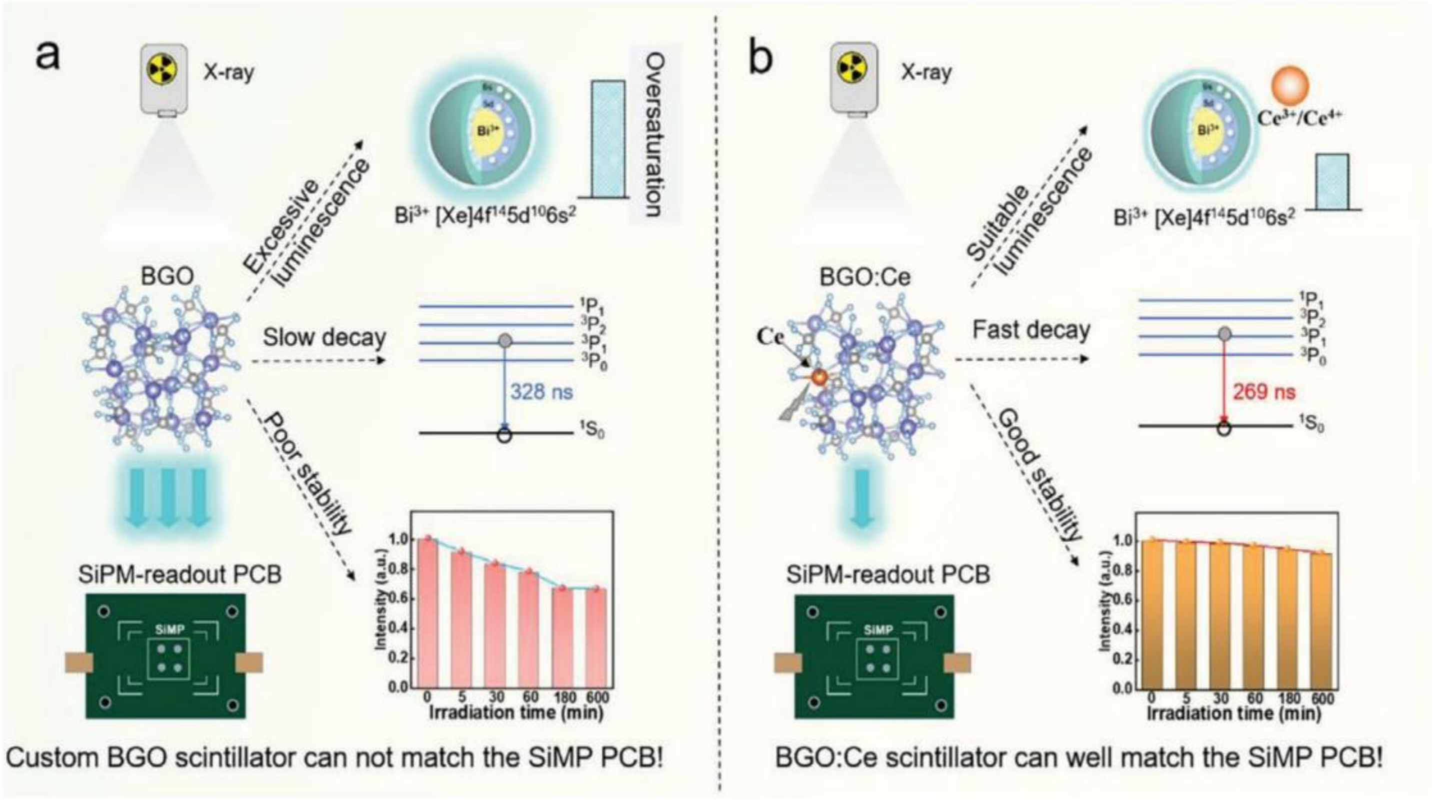




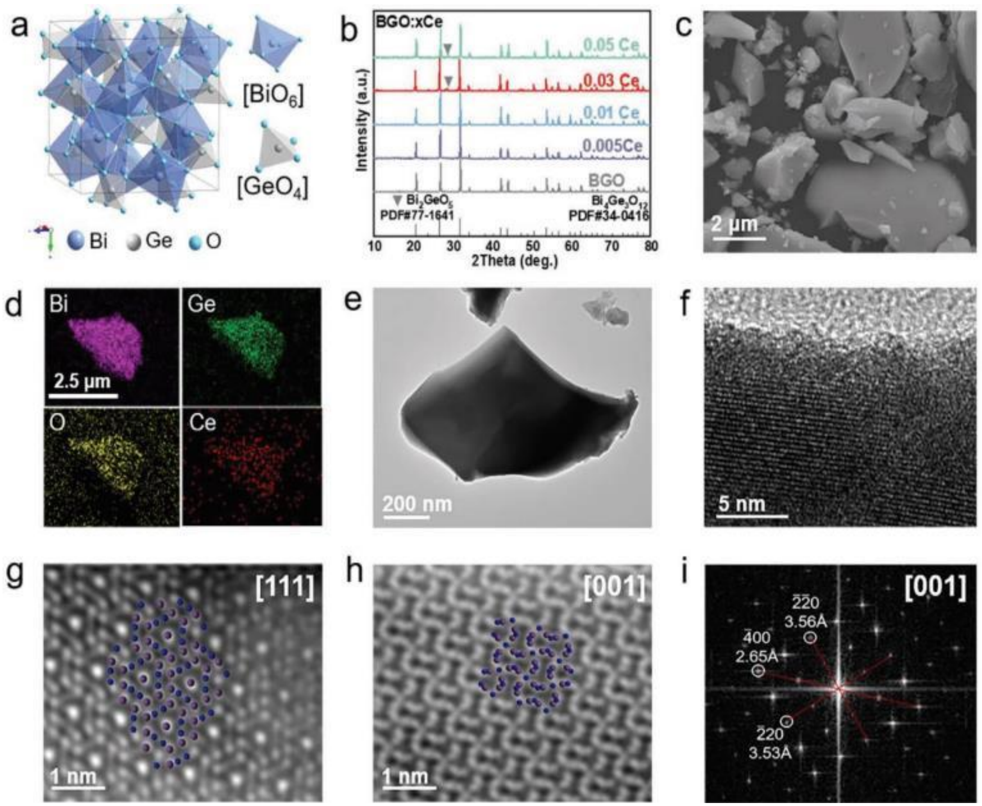


- BGO Crystals as large as 5 inch in diameter and 100 cm in length is routinely produced at SIC.

Cost-effective and fast/ultrafast scintillation crystals: BGO



Design strategy of optimizing comprehensive performance of BGO (luminescence intensity, decay time, and irradiation stability) by Ce ion doping

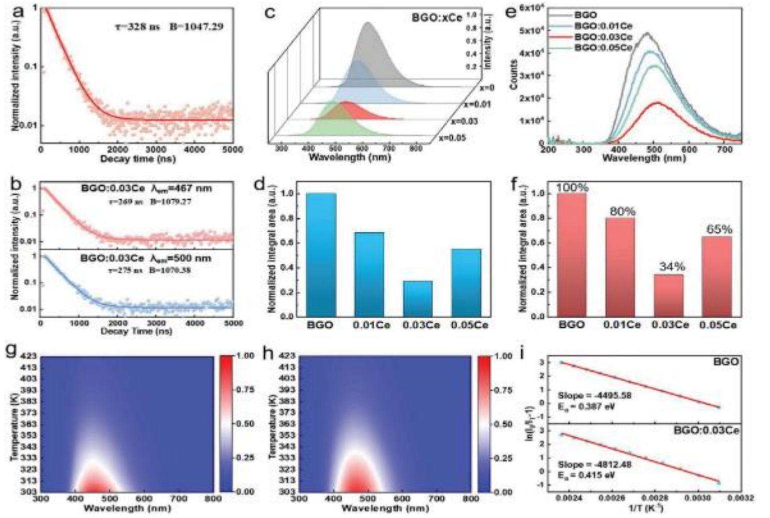


Structure and morphological characterizations of BGO:Ce powder

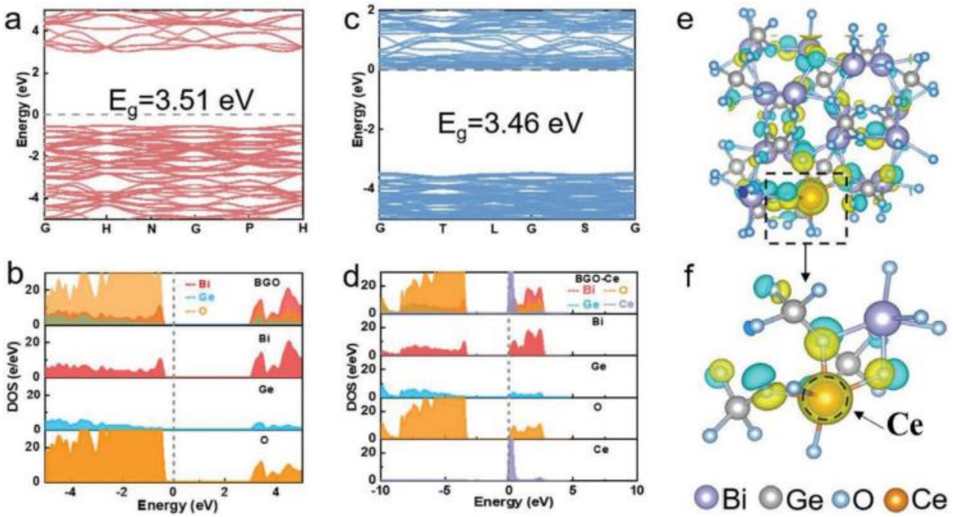
- BGO crystal is too slow (~300 ns), it radiation hardness is yet to be improved, and yield more scintillation light for HEP facilities such as CEPC, FCC etc. at intensity frontier. Cerium ion doping in BGO crystal is proposed to handle the above issues.

Adv. Optical Mater. 2023, 2301332

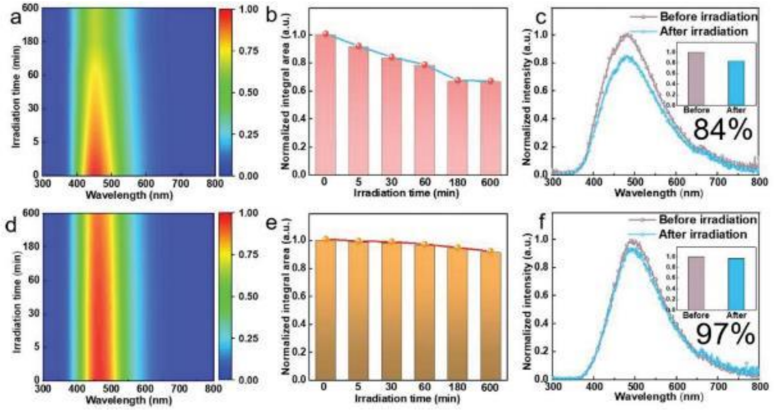
Cost-effective and fast/ultrafast scintillation crystals: BGO



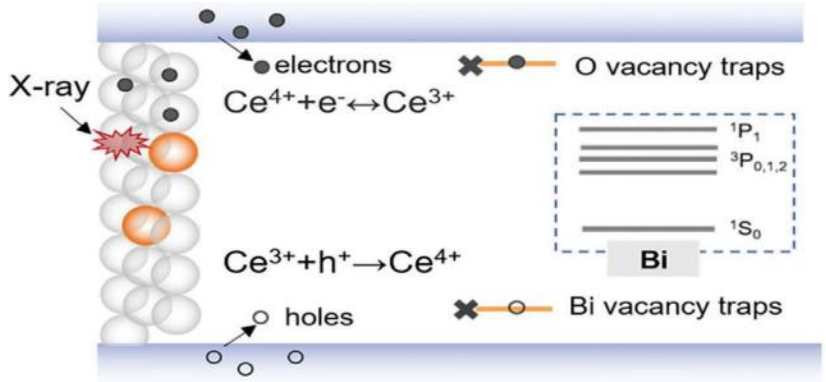
Photoluminescence performance



Theoretical calculation



Enhanced irradiation resistance ability



Modulation mechanisms of irradiation resistance in BGO:Ce

- Ce ion doping in BGO crystal is proposed and has shown great potential in polycrystalline BGO scintillator. The effect of cerium doping in BGO single crystal is yet to be investigated in the future.

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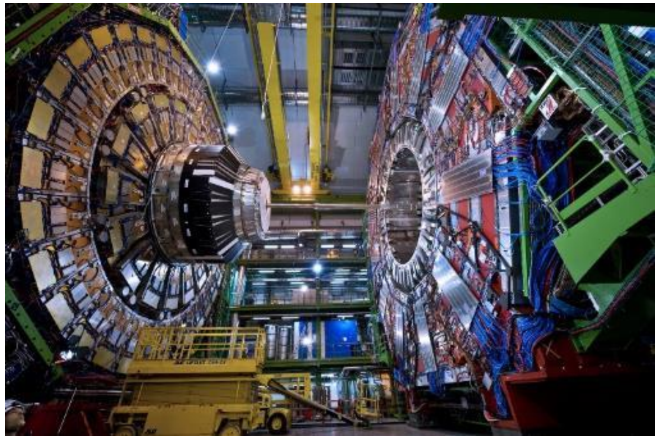
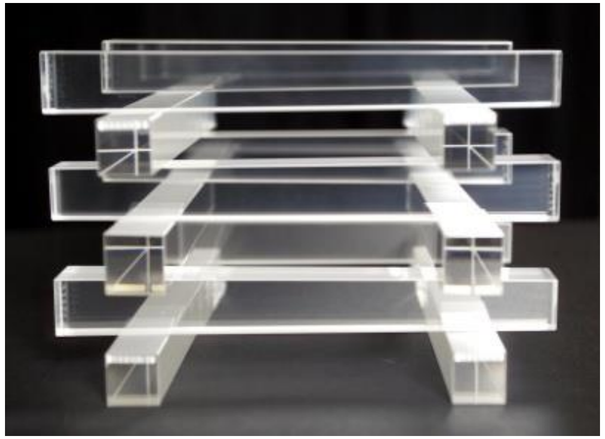
Cost-effective and fast/ultrafast scintillation crystals: $PbWO_4$

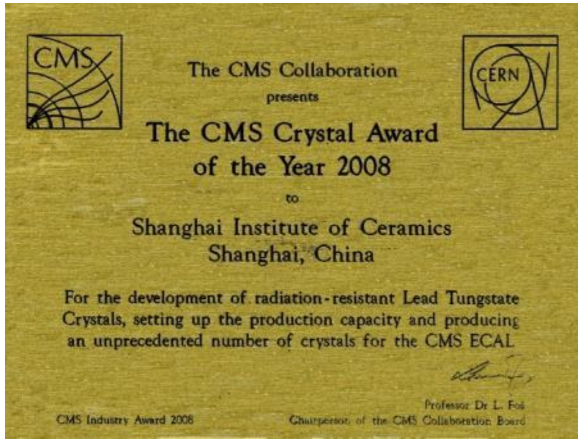


CMS (LHC)

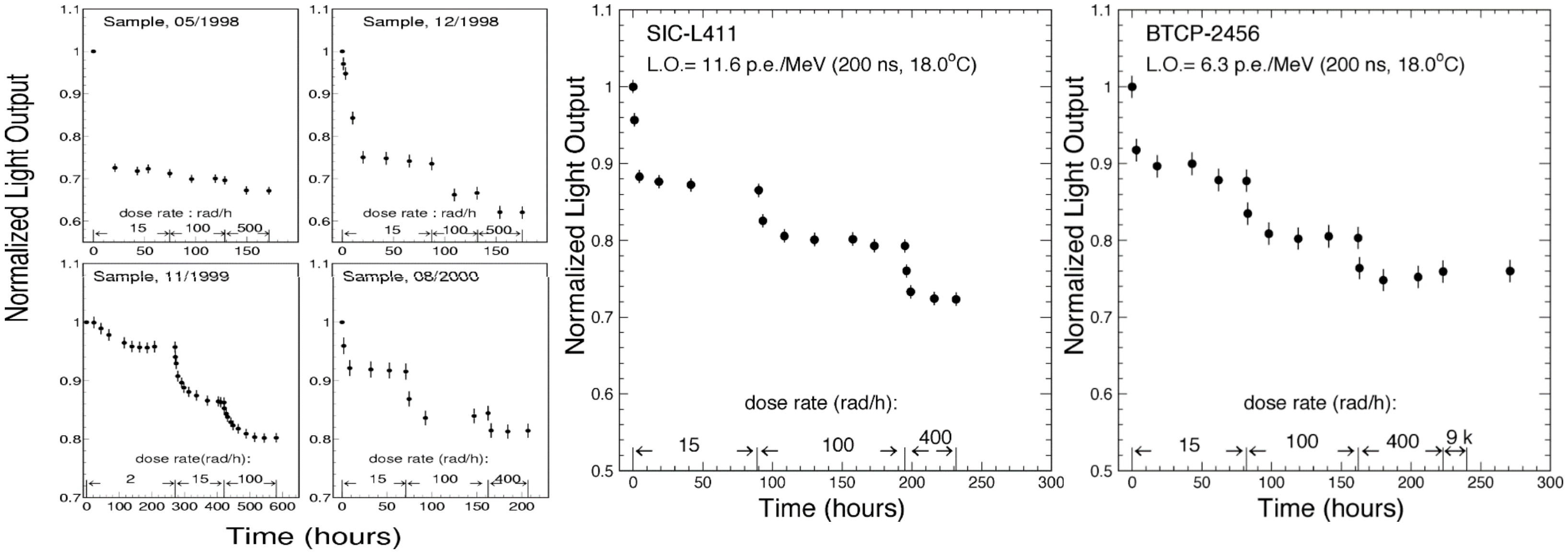
Prof. Yan and visitors from CERN



PWO:Y crystals



CMS Crystal Award



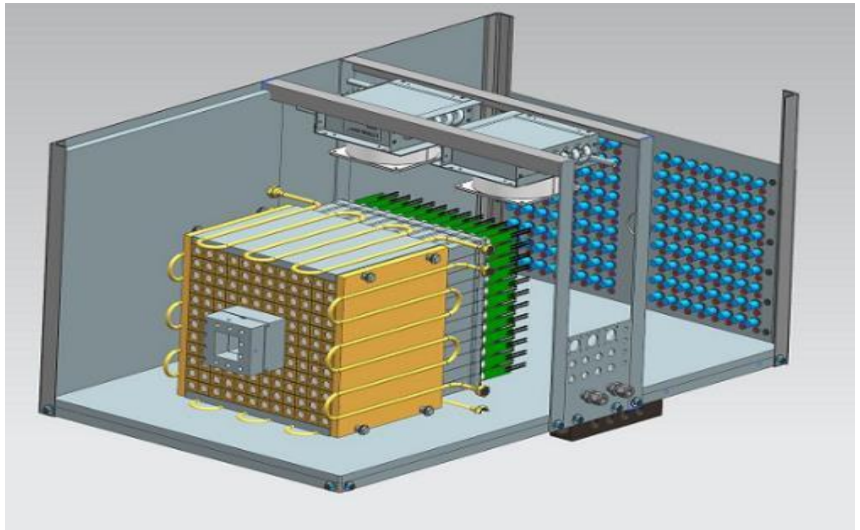
Improved radiation hardness and light output by Y-doping in PWO crystals

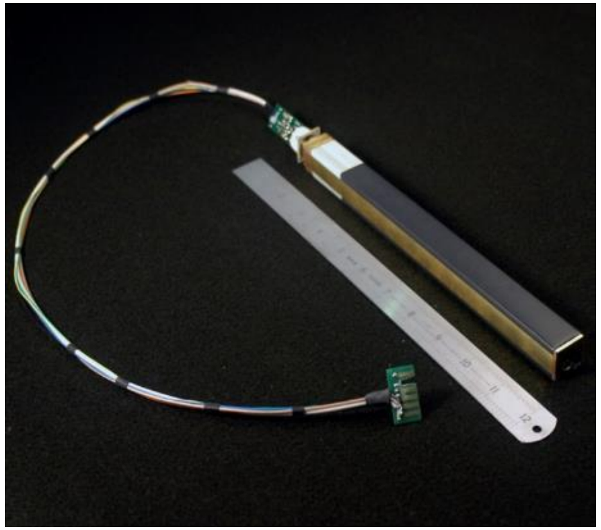
- Improved radiation hardness, light output, light response uniformity of PWO crystals by Y-doping at SIC;
- SICCAS has also provided ~5000 pcs PWO:Y crystals with a total weight of 7.6 ton and total volume of 0.92 m^3.

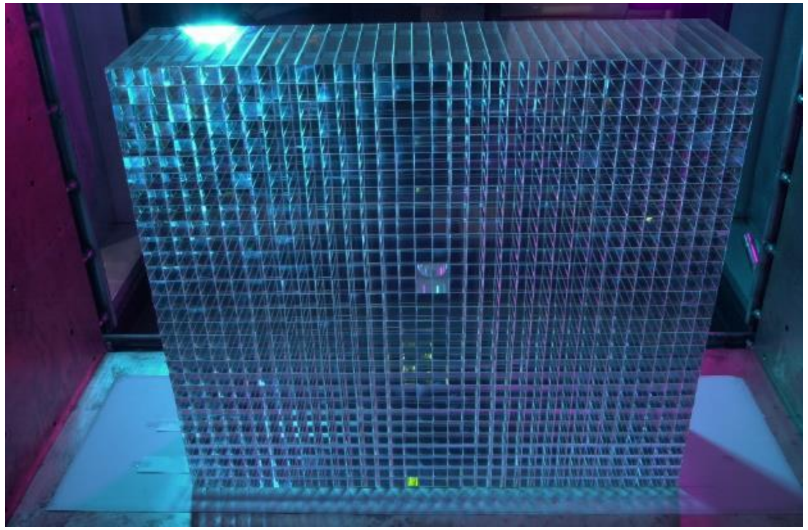
Cost-effective and fast/ultrafast scintillation crystals: $PbWO_4$

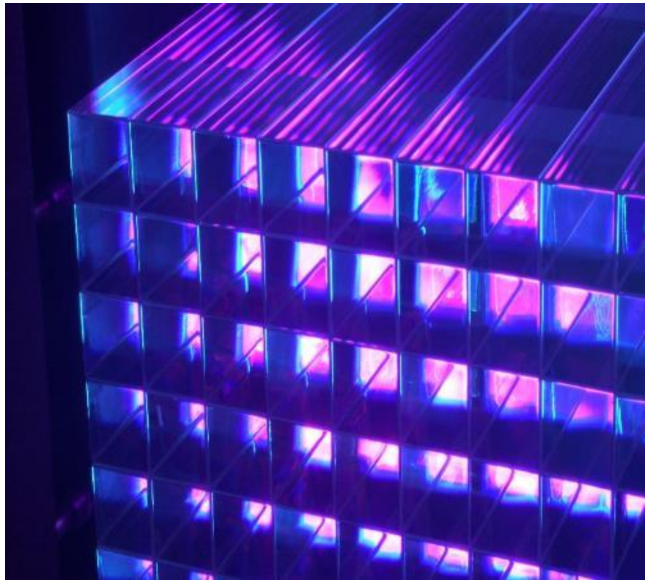
SICCAS Since 1928

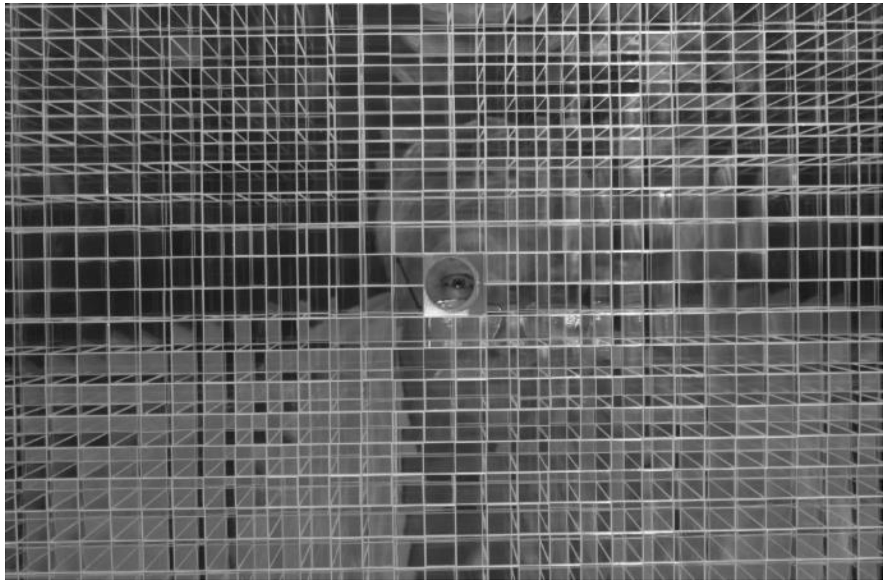
PWO crystals for PrimEx at JLAB (USA)







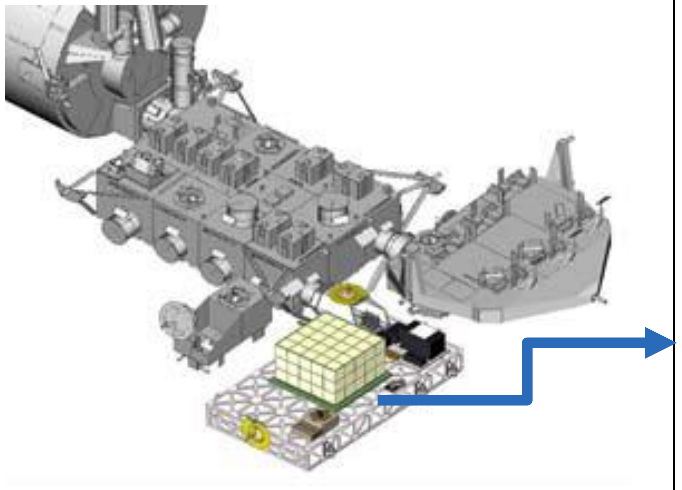




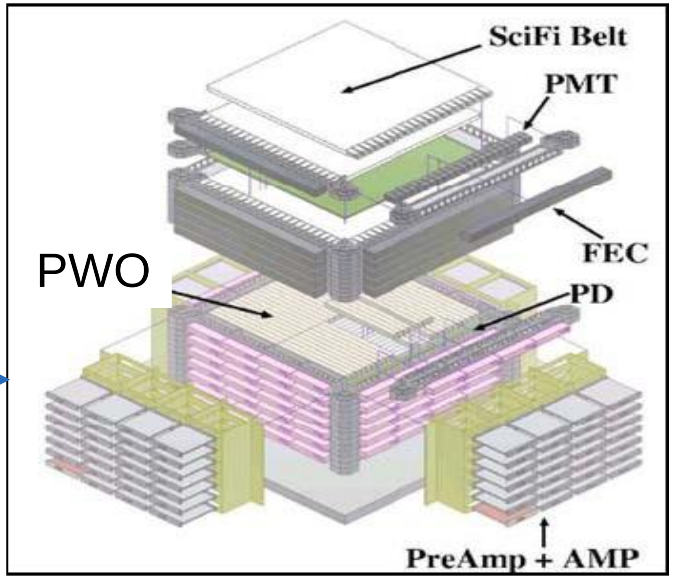
Jefferson Lab PrimEx

- SIC provided PrimEx (JLab) all required PWO crystals (18 cm, 1275 pcs), total weight about 0.8 ton (2001.05 - 2002.06).

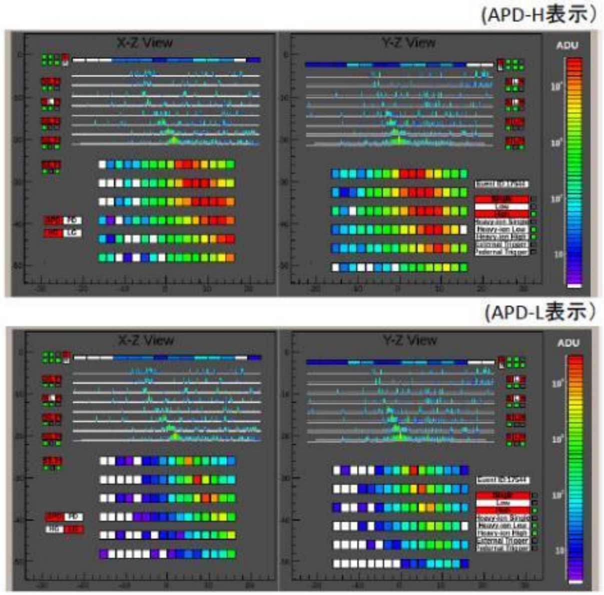
Cost-effective and fast/ultrafast scintillation crystals: $PbWO_4$



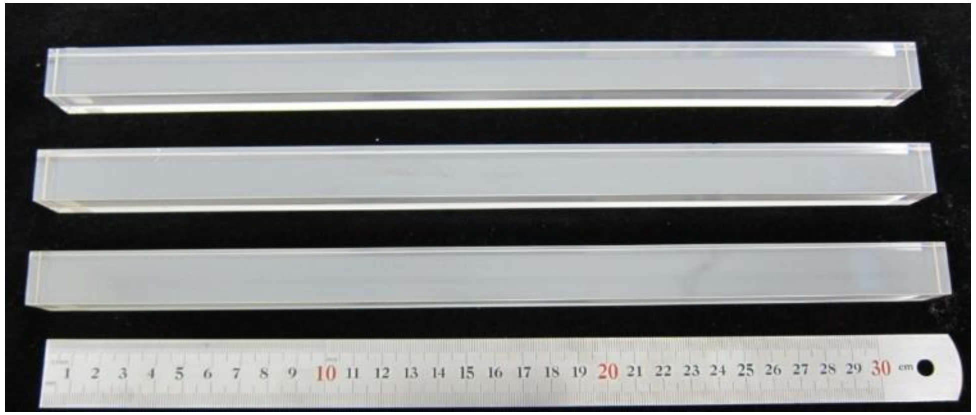
CALET - A Dark Matter detector
on ISS by Wasada Univ/JAXA



CALET and PWO Crystals

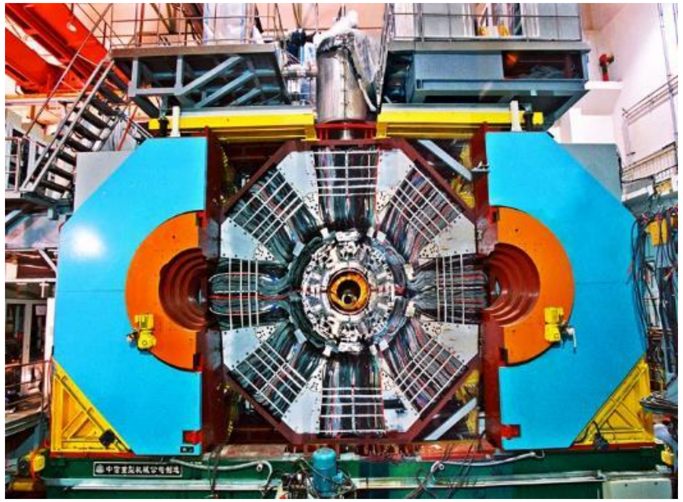


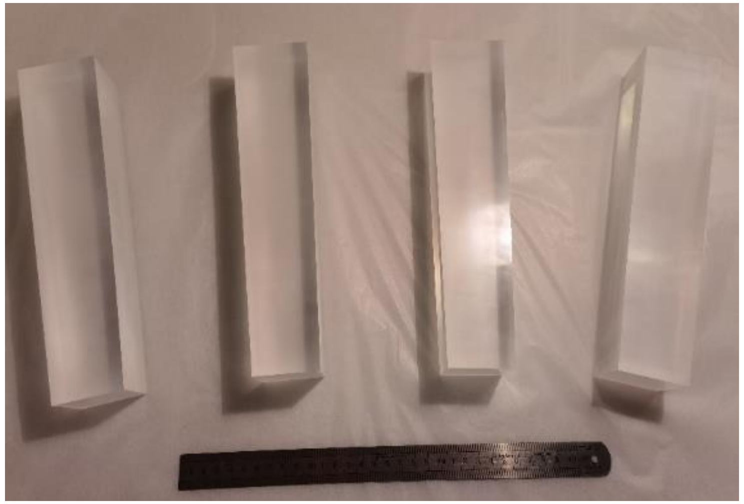
Data taking of CALET



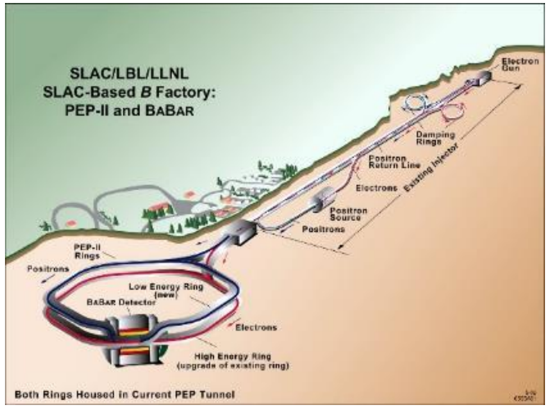
- SIC had provided Wasada Univ/JAXA totally 210 pcs PWO crystals with a length of 32.8 cm for CALET facility, which was launched and installed on the ISS in 2015.

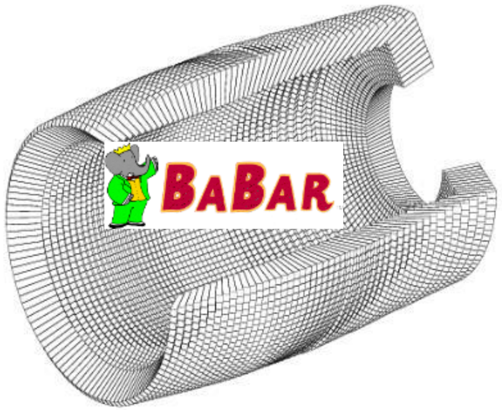
Cost-effective and fast/ultrafast scintillation crystals: CsI:Tl



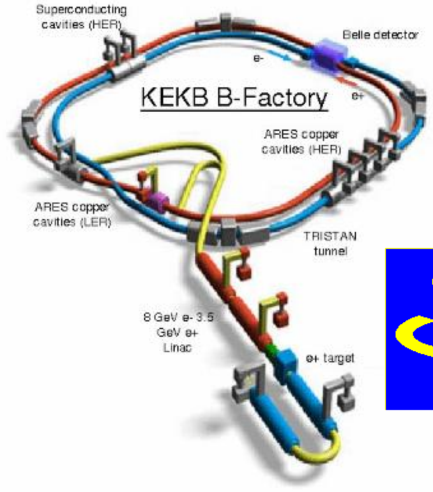


BEPC-BESIII: 1920 pcs large CsI:Tl crystals (28 cm) between 2004-2005





+

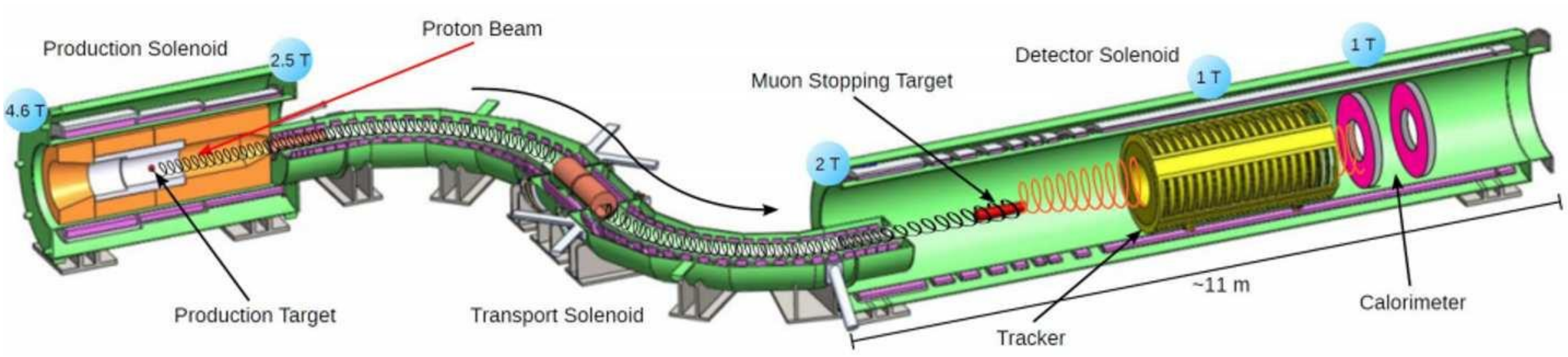


4213 pcs CsI:Tl crystals

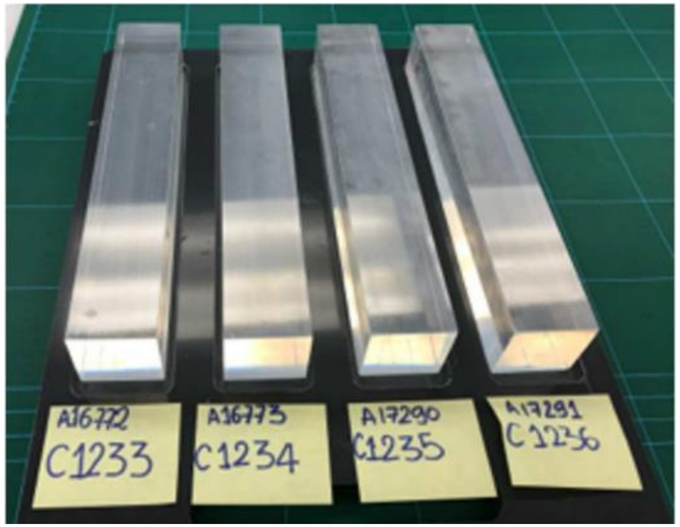
SLAC (BABAR)

KEKB (Belle)

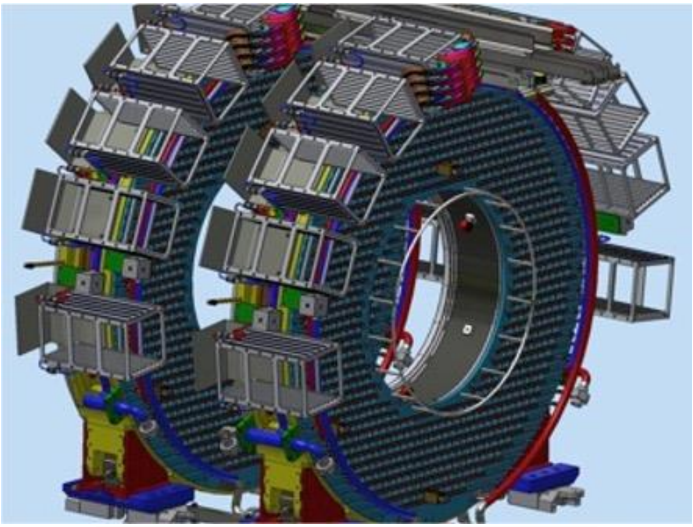
Cost-effective and fast/ultrafast scintillation crystals: pCsI



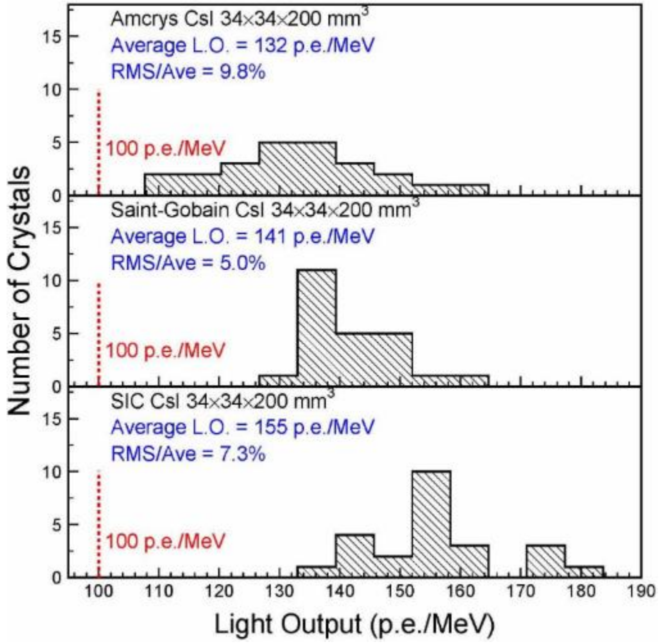
pCsI crystals fof Mu2e Crystal Calorimeter



1055 out of 1500 pcs pCsI crystals from SIC

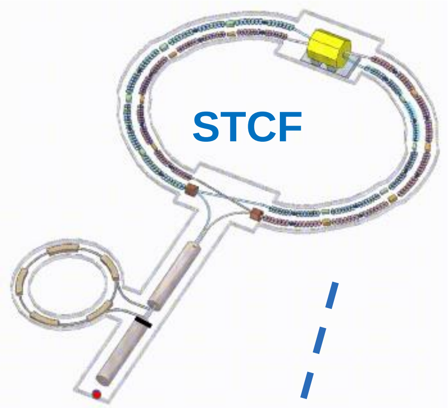


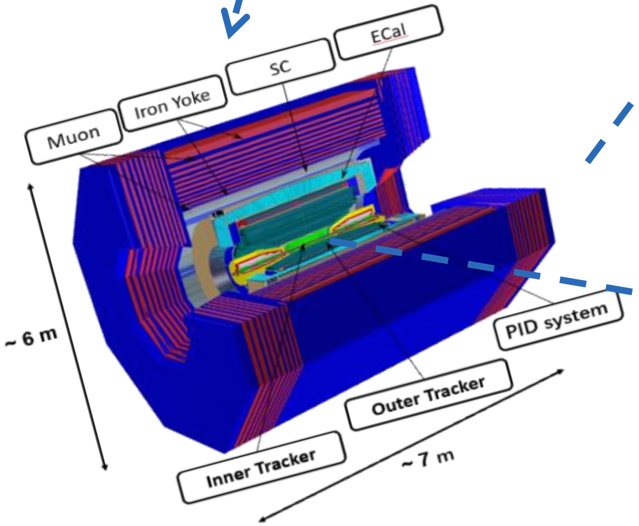
Calorimeter disks with 1500 pcs pCsI crystals



LO comparison of pCsI crystals from three different vendors

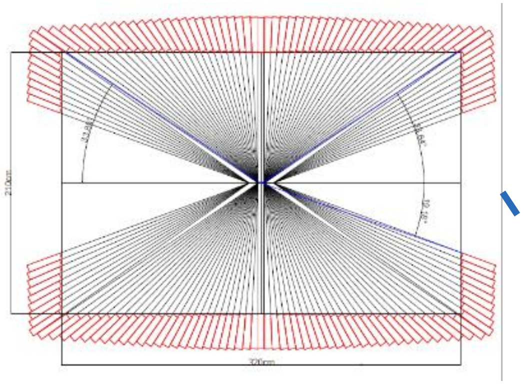
Cost-effective and fast/ultrafast scintillation crystals: pCsI

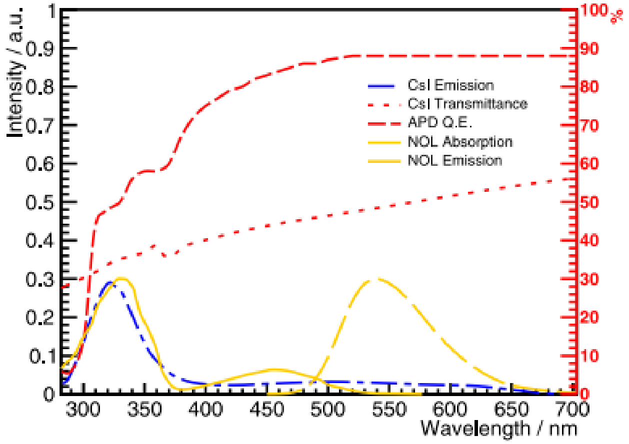




STCF detector

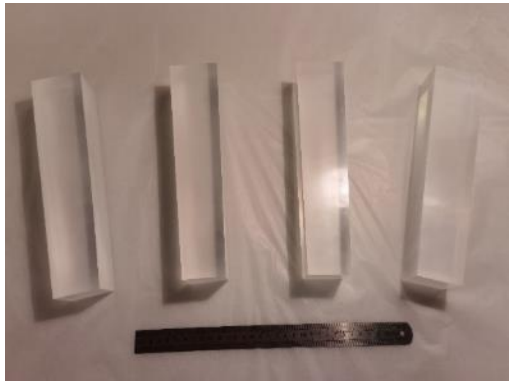
pCsI (8670 pcs)





Before coating **After coating**

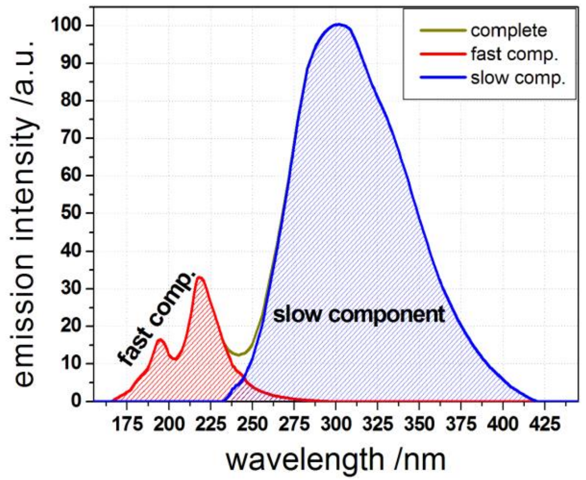
Nuclear Inst. and Methods in Physics Research, A 1050 (2023) 168173



28 cm-long large pCsI crystals before and after coated with nanostructured organosilicon luminophore (NOL) as wavelength shifter

- SIC had provided all the pCsI crystals with NOL coating for STCF pre-study.

Cost-effective and fast/ultrafast scintillation crystals: BaF_2:Y



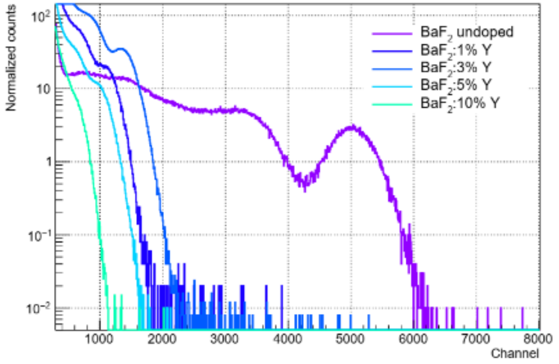
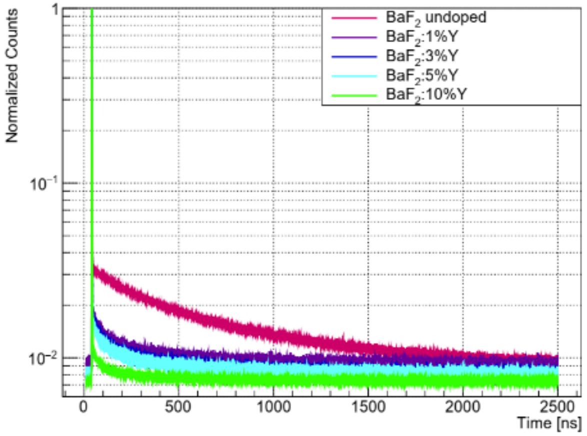
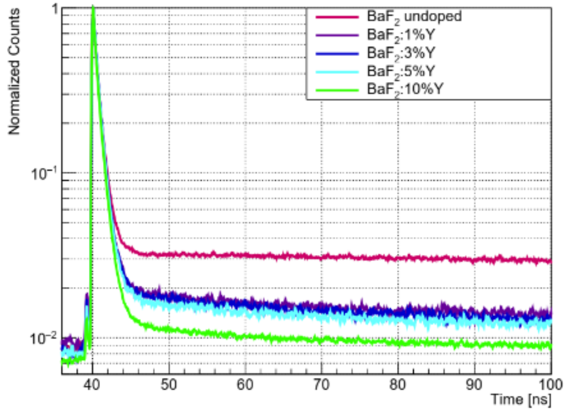
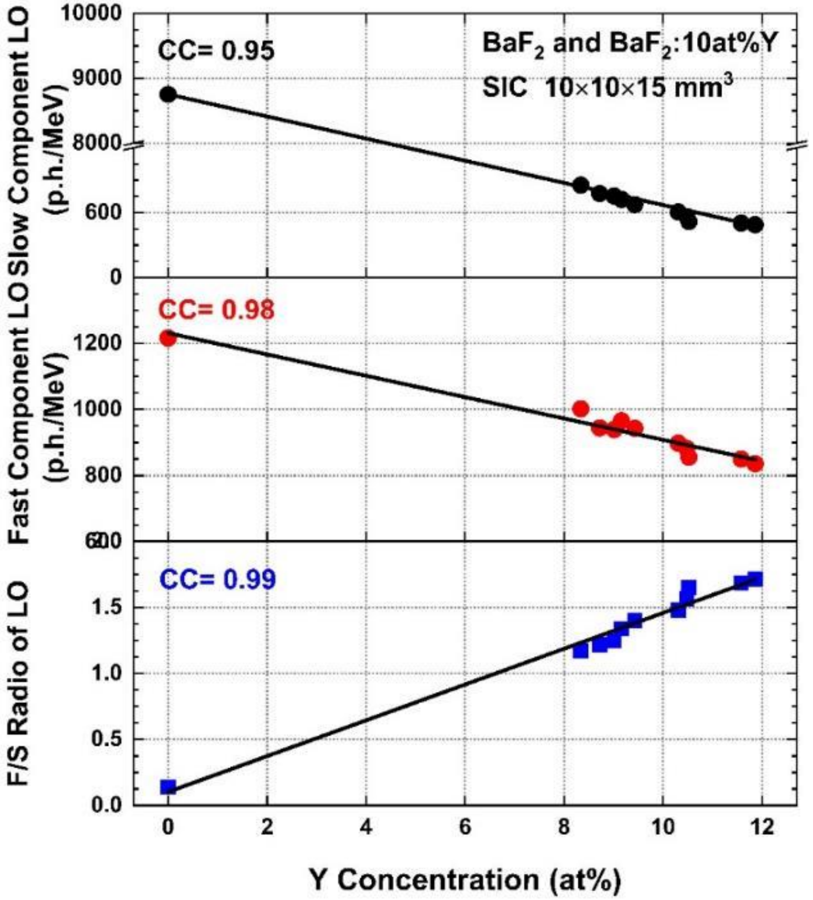


Figure 2: Charge spectra of the samples tested.



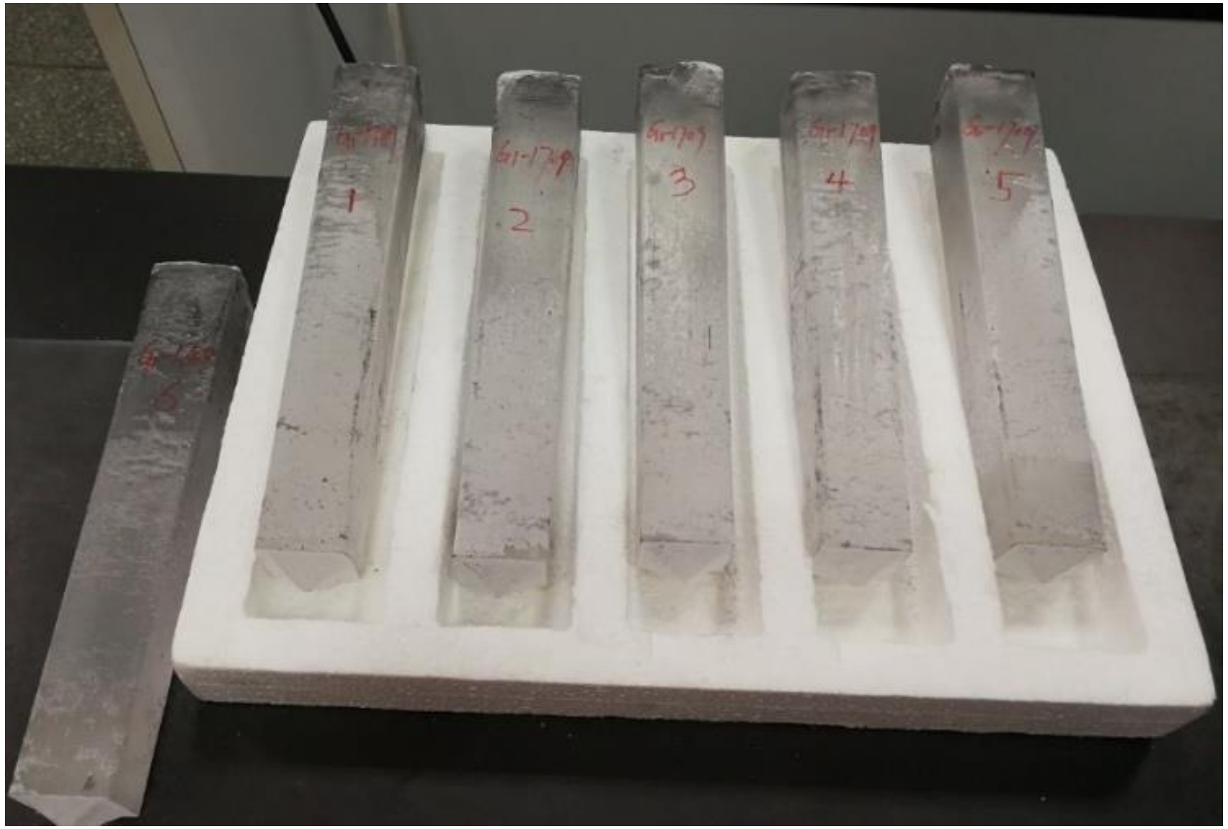




- BaF_2 crystal is an ultrafast scintillator with slow component, which will cause at high counting events.
- Yttrium doping can effectively suppress the 0.6 us slow component in BaF_2 crystal.
- R&D on suppressing the slow component in BaF_2 by Y doping: no change in short decay, time resolution

J. Chen, et al., IEEE Trans. Nucl. Sci., vol. 65, no. 8, pp. 2147-2151, 2018; R. Cala et al, SCINT2022 conference SantaFe Sept2022

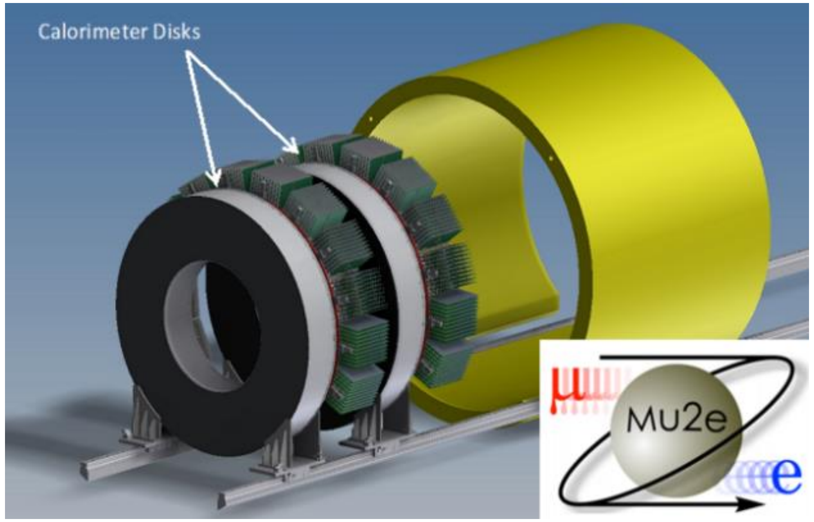
Cost-effective and fast/ultrafast scintillation crystals: BaF_2:Y



BaF_2:Y crystal boules up to 280 mm in length

- Large BaF_2:Y crystals with high optical quality is available at SIC for future HEP pre-study

Cost-effective and fast/ultrafast scintillation crystals: BaF_2:Y



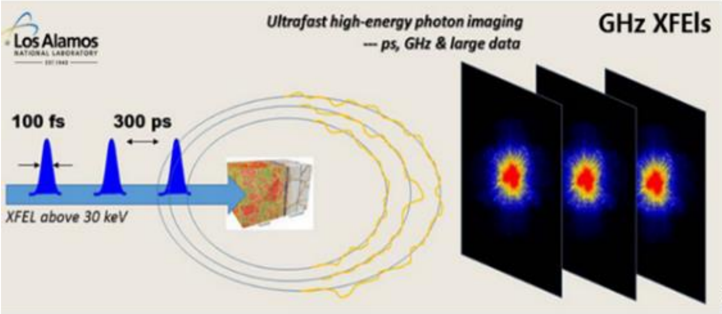
Caltech

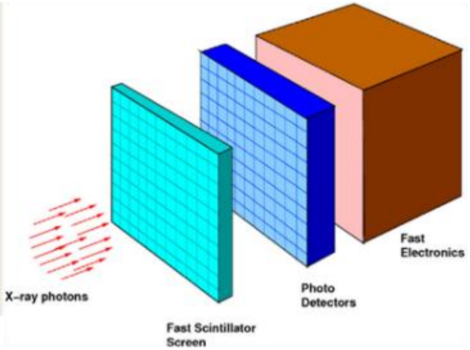
Fermilab

- BaF_2:Y crystal is presently also considered for future Mu2e-II update and has been evaluated for CMS timing layer update (now LYSO crystal).

Cost-effective and fast/ultrafast scintillation crystals: BaF_2:Y

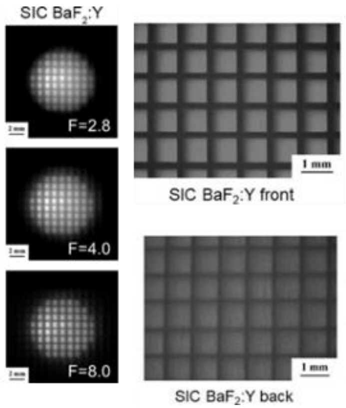
GHz Hard X-ray imaging



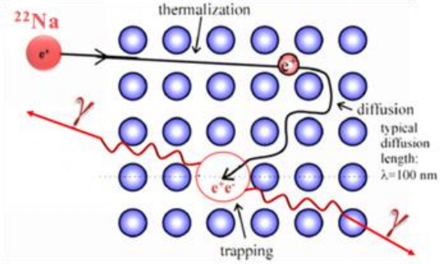


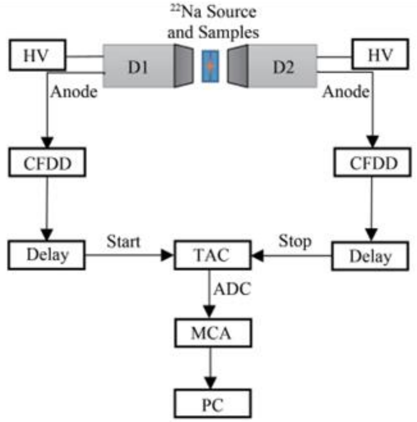
Los Alamos NATIONAL LABORATORY EST.1943

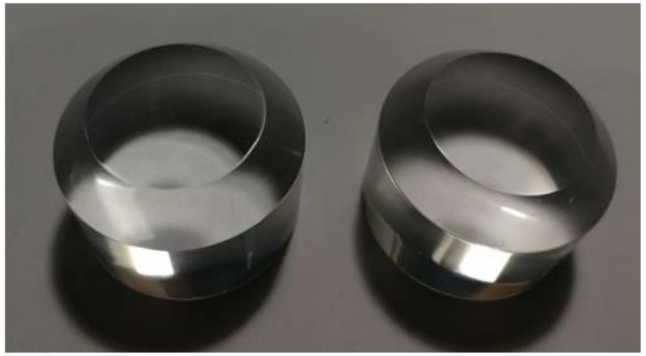
Caltech

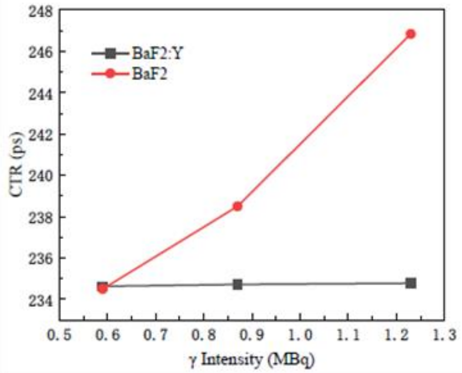


Positron Annihilation Spectroscopy





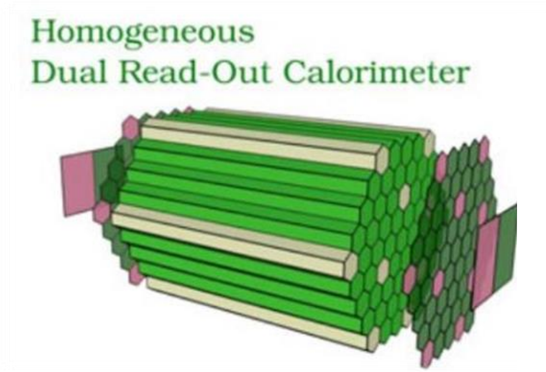


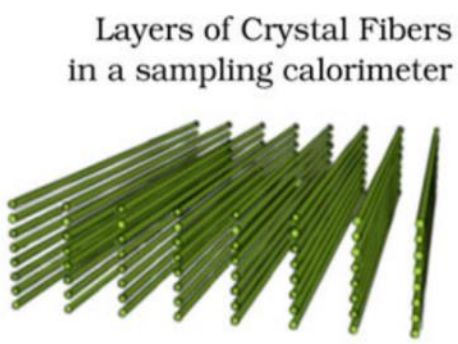


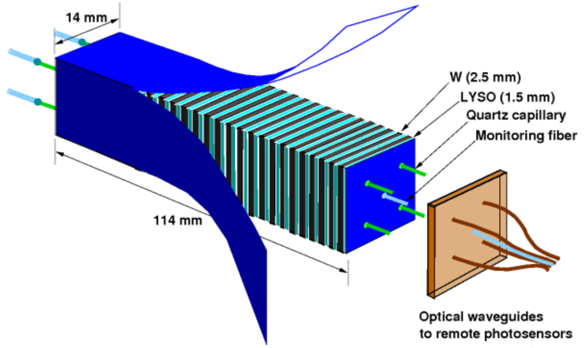
- BaF_2:Y crystals are promising for GHz hard X-ray imaging and positron annihilation spectroscopy

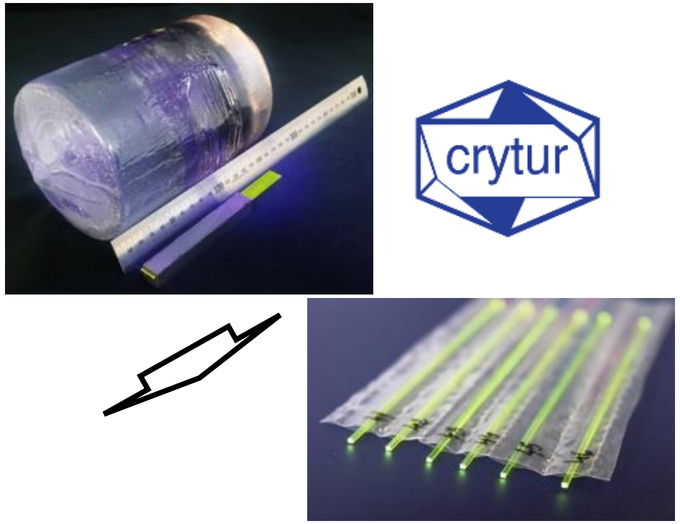
IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 67(6), 2020: 1014-1019.
NUCLEAR TECHNIQUES,43(03), 2020: 21-26.

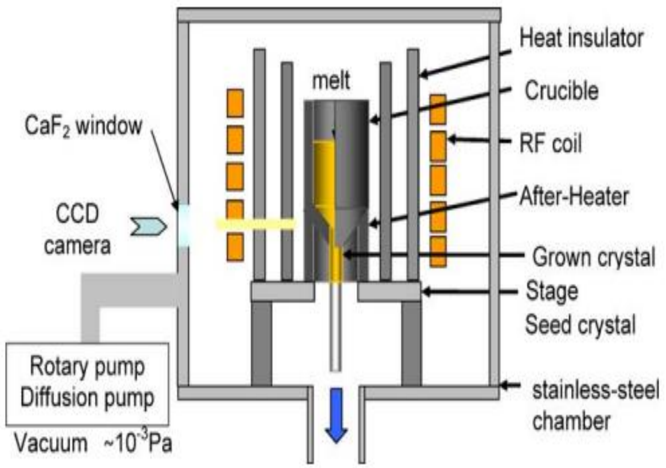
Cost-effective and fast/ultrafast scintillation crystals: Garnet crystal fibers

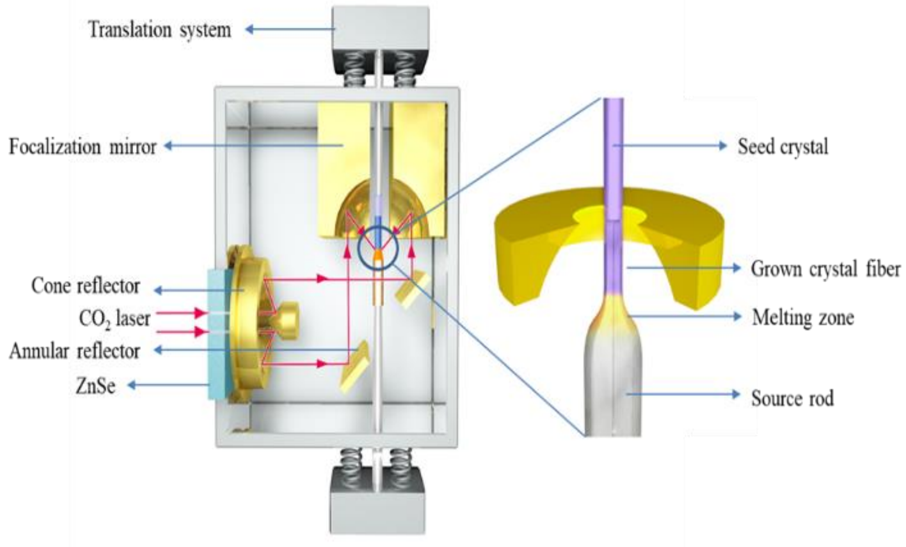












Crystal fibers cut from large crystal

Micro-pulling down (μ-PD)

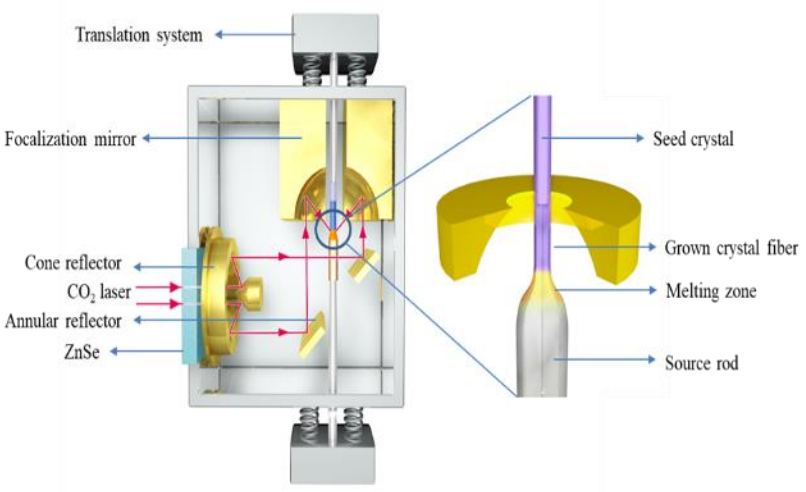
Laser heated pedestal growth (LHPG)

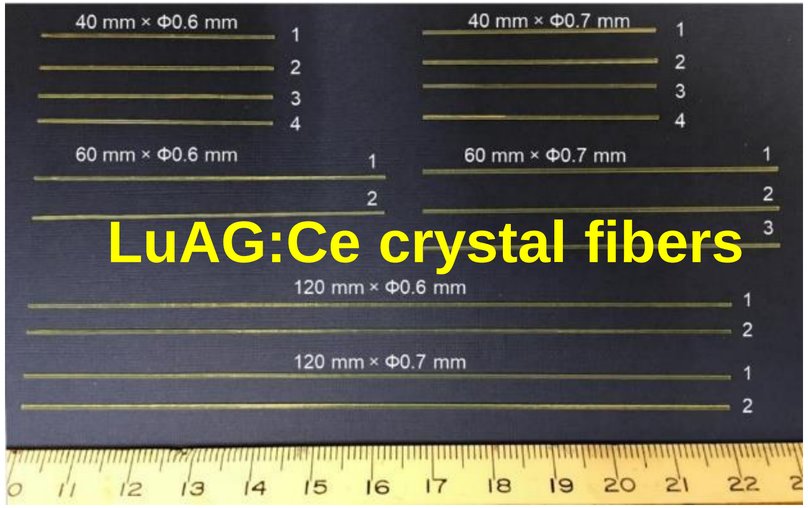
- Garnet crystal fibers are promising for Dual-read-out, sampling, shashlik, Spaghetti calorimeters

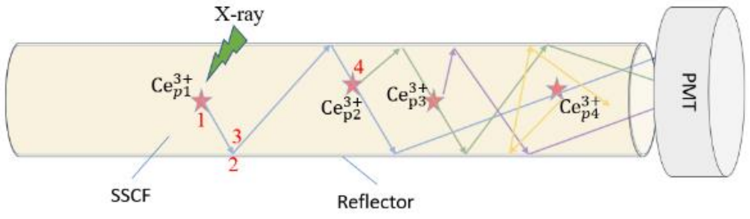
Instruments **2022**, *6*, 27. https://doi.org/10.3390/instruments6030027

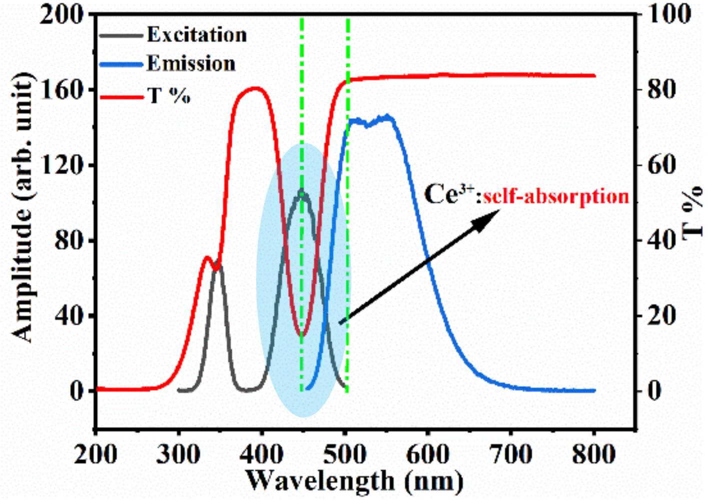
E. Auffray, Trends, Needs And Synergies In Scintillating Materials, the first DRD6 Collaboration Meeting at CERN

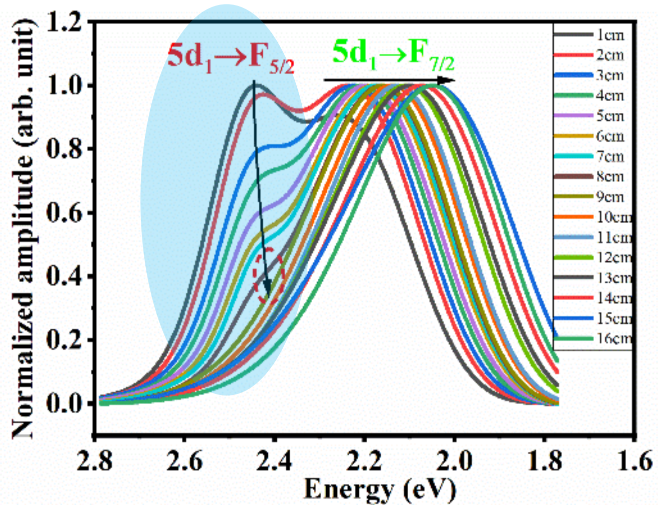
Cost-effective and fast/ultrafast scintillation crystals: Garnet crystal fibers

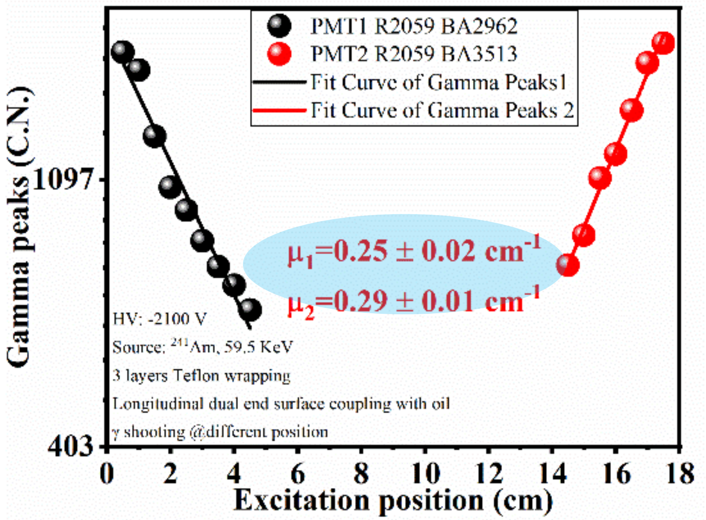










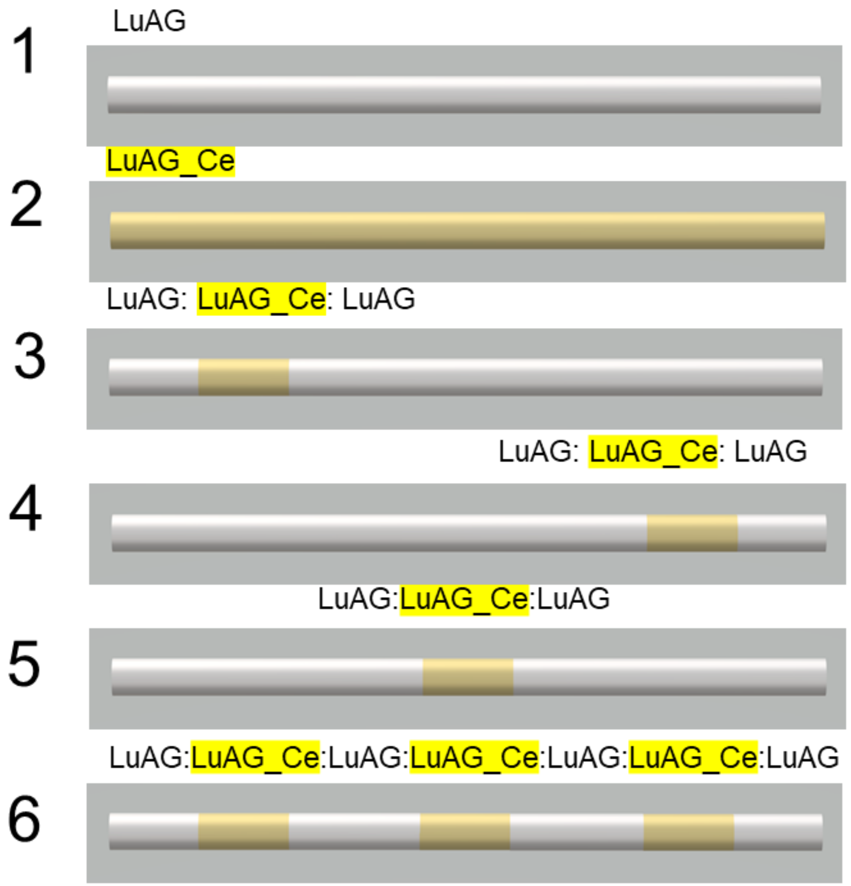


- Serious Ce^{3+} self-absorption effect in garnet crystal fibers results in scintillation light attenuation during light transmission process

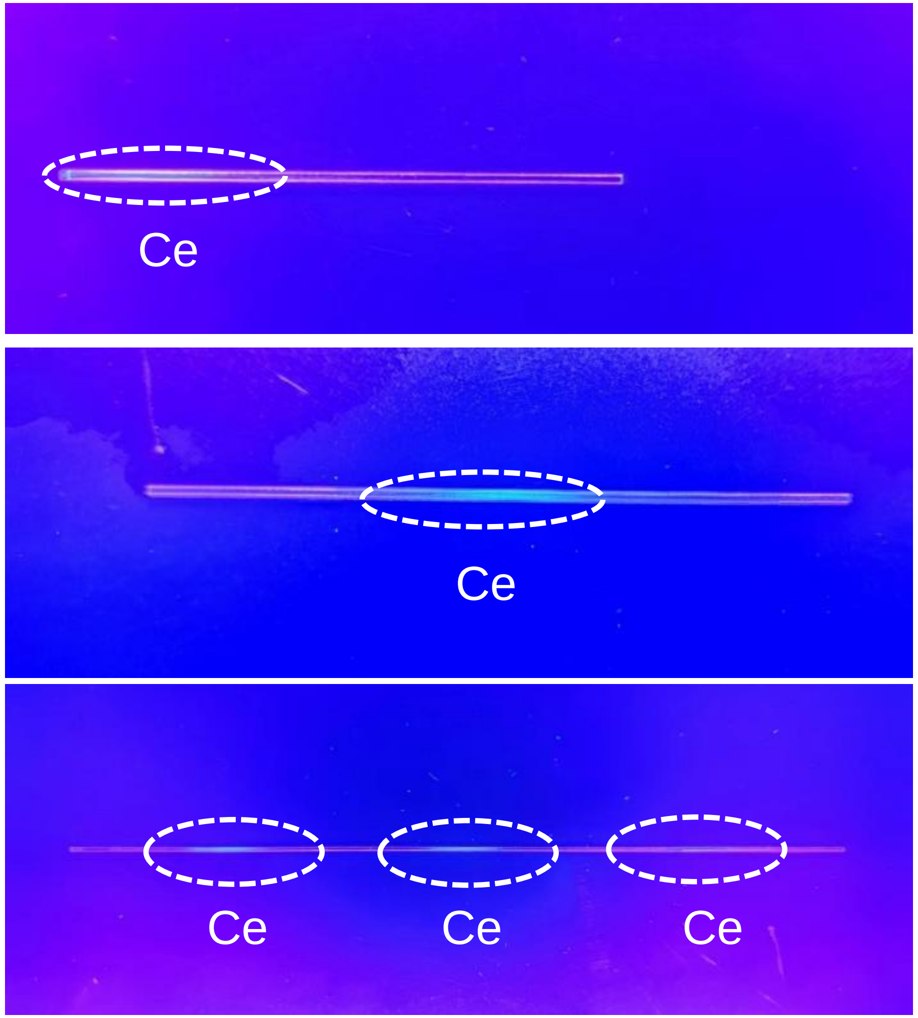
Radiation Measurements 169 (2023) 107017

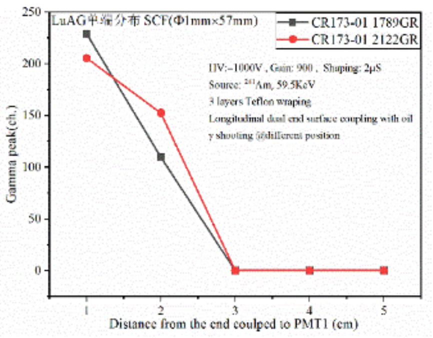
Cost-effective and fast/ultrafast scintillation crystals: Garnet crystal fibers

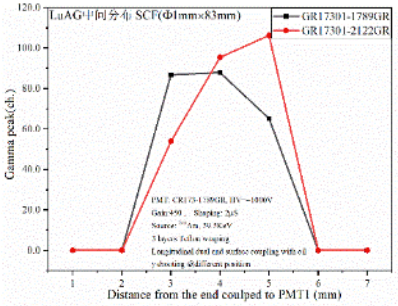
SICCAS Since 1928

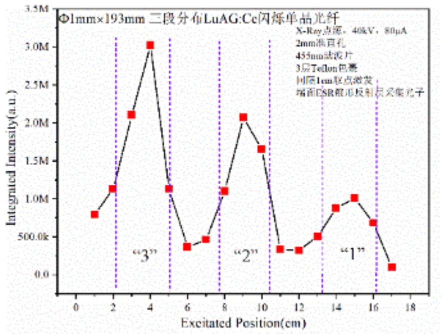


Several LuAG:Ce-LuAG crystal fiber designs





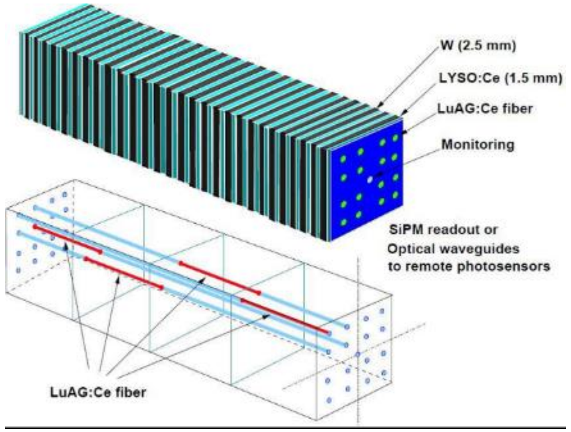




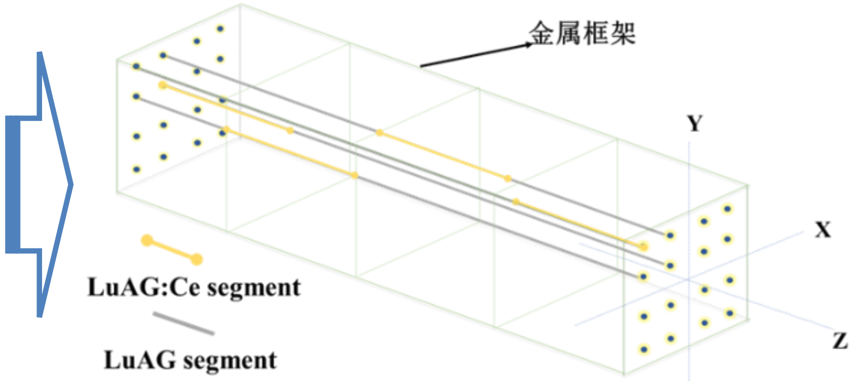
- SIC proposes a novel fiber design: detection transmittance single scintillating crystal fibers (DTSSCF)

Crystal Growth & Design, 2024,24(8): 3333-3341

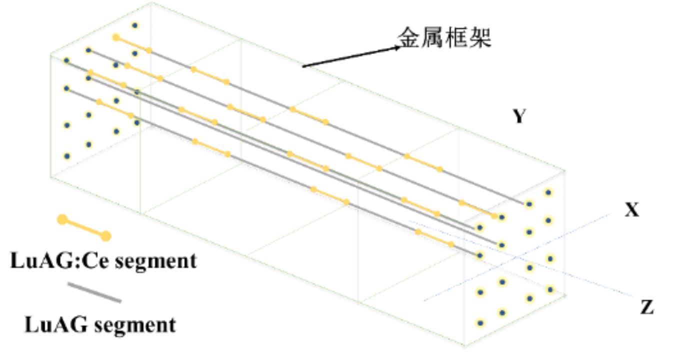
Cost-effective and fast/ultrafast scintillation crystals: Garnet crystal fibers



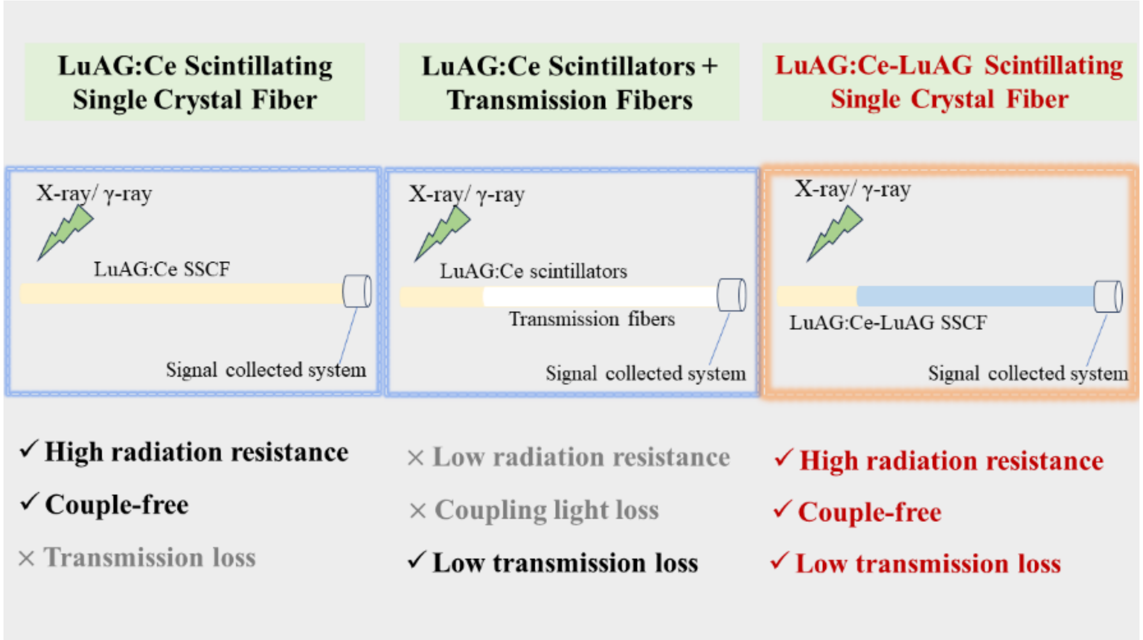
LuAG:Ce + quartz fibres



LuAG:Ce + LuAG fibres



LuAG:Ce+LuAG+LuAG:Ce+LuAG fibres…



LuAG:Ce-LuAG structured crystal fibers

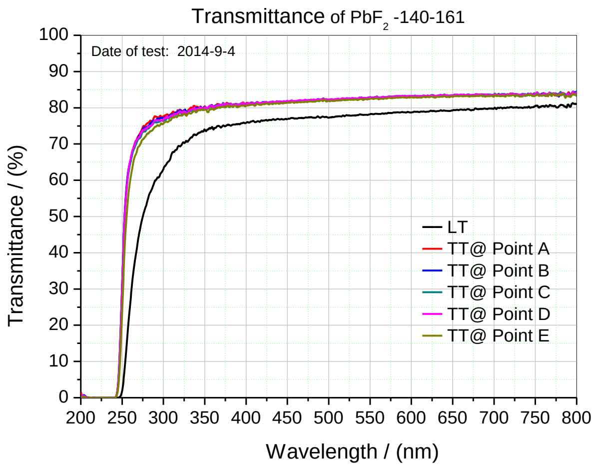
- A couple-free, low transmission loss, radiation hard, high luminosity, robust scintillator!

Crystal Growth & Design, 2024,24(8): 3333-3341

Cherenkov crystals

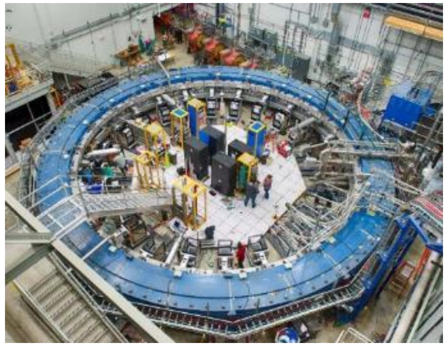
PbF_2, BSO, BGO, PWO

Cherenkov radiator: PbF_2

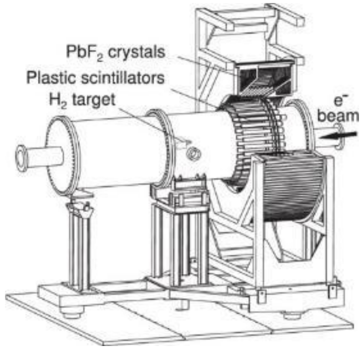


- With a radiation length of 0.93 cm and an effective Molie´re radius of 1.8 cm, lead fluoride (PbF_2) crystal is a well-known pure Cherenkov radiator with high transmission down to 270 nm.

Experiment	Crystal size	Number	Period
Mainz/MAMI A4	26^2*150-180*30^2 mm^3	1022 pcs	1996—1998
Jefferson Lab	30*30*180mm	100 pcs	2008—2009
Fermi Lab g2	25*25*140mm	1325 pcs	2014—2015
Japan, RIKEN	25*25*140mm	30 pcs	2018
…			



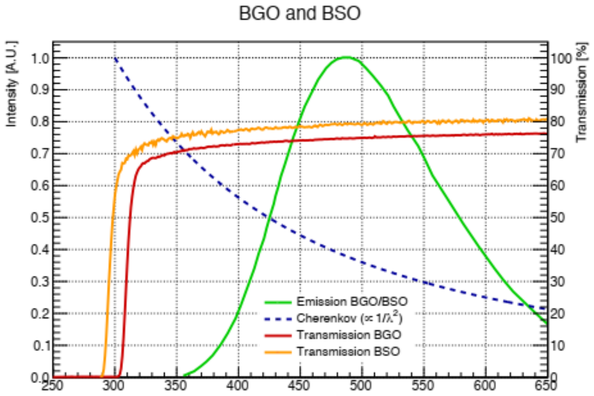
Muon g-2



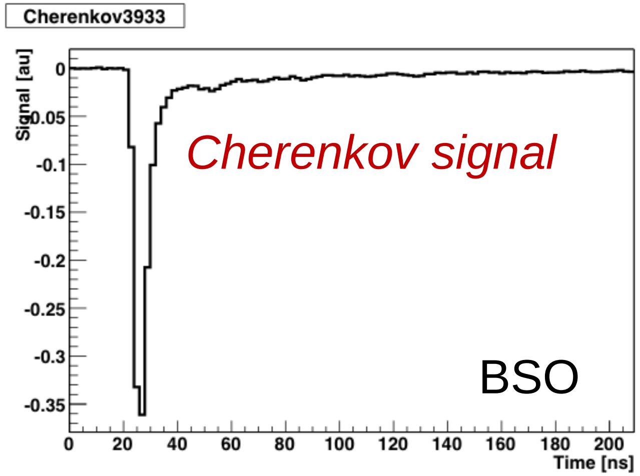
MAMI A4

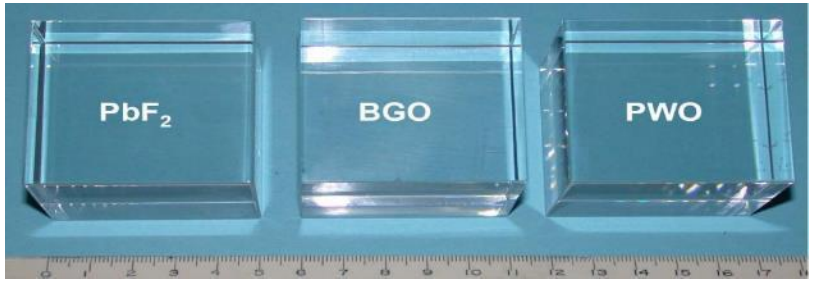
- SIC is the only supplier capable of mass-producing large PbF_2 crystals, and has supplied more than 2500 pcs large crystals for many important experiments, such as, Muon g-2, MAMI A4, etc.

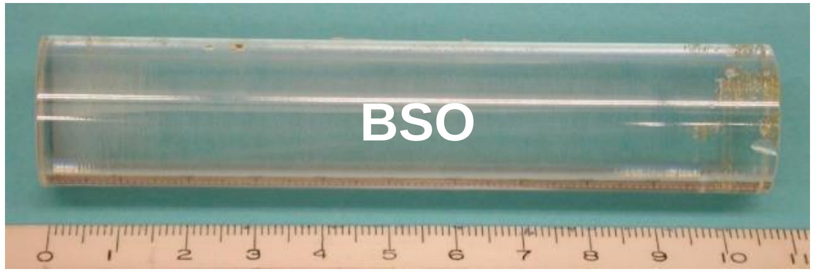
Cherenkov radiators: PWO, BSO, BGO

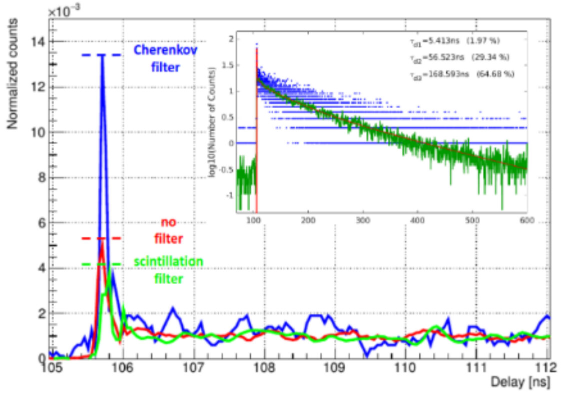


Cherenkov Needs UV Transparency

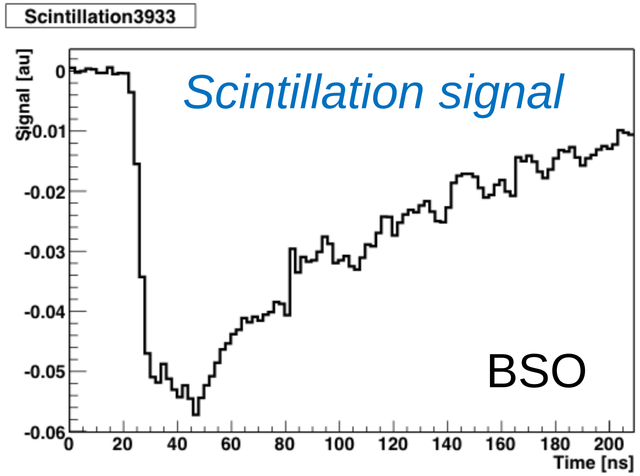








Decay time spectra of BSO under 511 keV excitation without & with filters



Property	BSO	BGO	PWO
Density (g/cm^3)	6.80	7.13	8.28
Radiation length (mm)	11.5	11.2	8.9
Decay time (ns)	~100	~300	~10
Peak emission (nm)	480	480	410-500
Relative light output	0.04	0.1	0.01
Refractive index	2.06	2.15	2.20
Cherenkov angle (º)	61	62	63

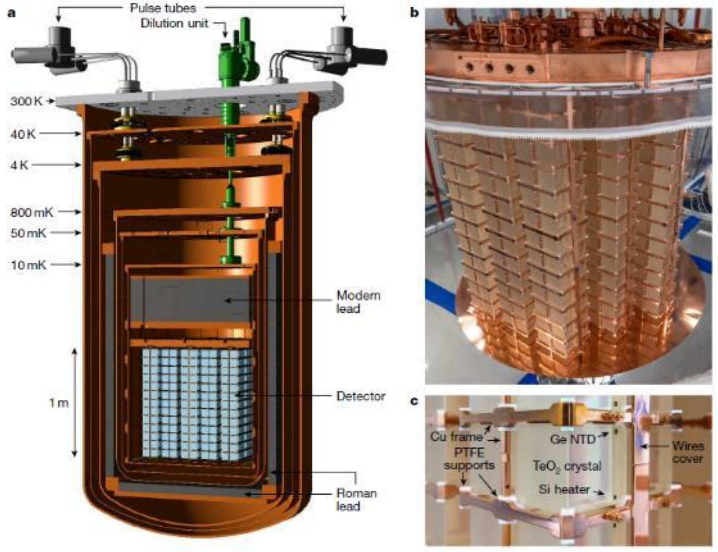
- Exploitation of Cherenkov/scintillation signals in high density crystals: BSO/BGO/$PbWO_4$

R. Cala et al, NIMA 1032, 2022, 166527
Talk presented at Calor2012, Santa Fe, by Ren-Yuan Zhu, Caltech
N. Akchrin, Exploiting Cherenkov in Calorimetry, DRD6 Collaboration Meeting 9-12 April 2024, CERN

Low radioactive background crystals for rare events physics

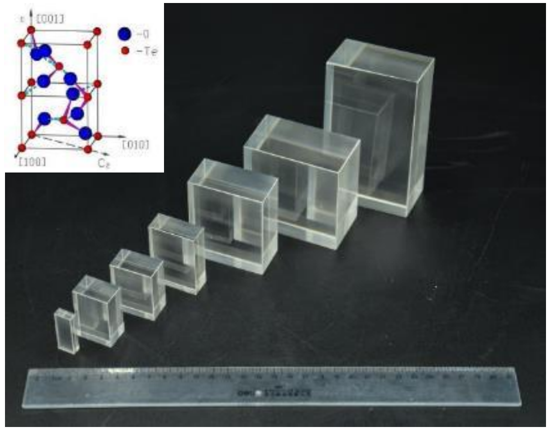
pCsI, CsI:Na, SrI_2:Eu, NaI:Tl, NaI, Li_2MoO_4…

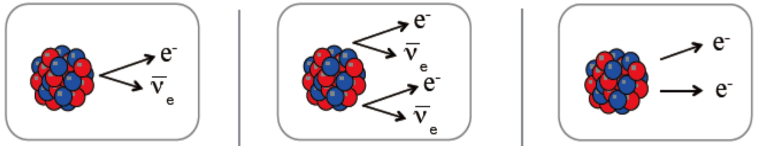
Low background crystals for rare events physics: TeO_2



CUORE

Isotope	A (%)
$^{76}Ge_{32}$	7.8
$^{82}Se_{34}$	9.2
$^{96}Zr_{40}$	2.8
$^{100}Mo_{42}$	9.6
$^{116}Cd_{48}$	7.5
$^{128}Te_{52}$	31.7
$^{130}Te_{52}$	34.5
$^{136}Xe_{54}$	8.9





$^{A}_{Z}X \rightarrow ^{A}_{Z+1}X + e^{-} + \bar{\nu}_e$

β decay

Well known weak process

$^{A}_{Z}X \rightarrow ^{A}_{Z+2}X + 2e^{-} + 2\bar{\nu}_e$

2νββ

Observed, but rare ($T½ > 10^{19}$ yr)

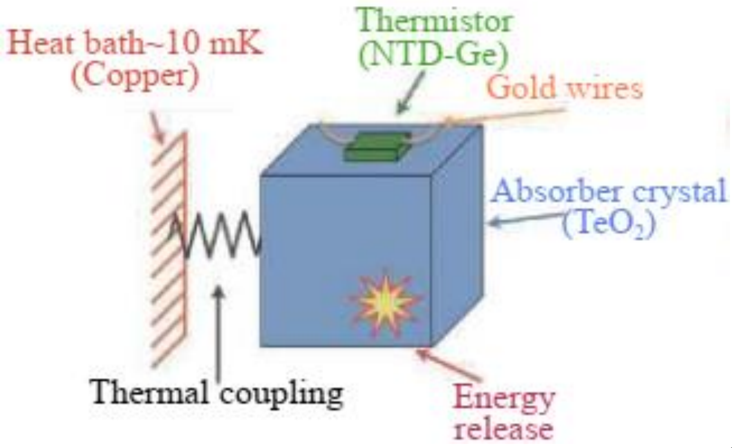
Only visible in nuclei with forbidden single β

$^{A}_{Z}X \rightarrow ^{A}_{Z+2}X + 2e^{-}$

0νββ

Even rarer than 2νββ (if it occurs at all)

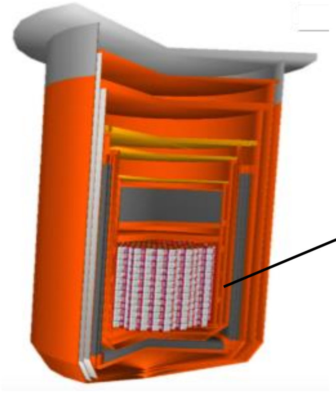
Never observed so far

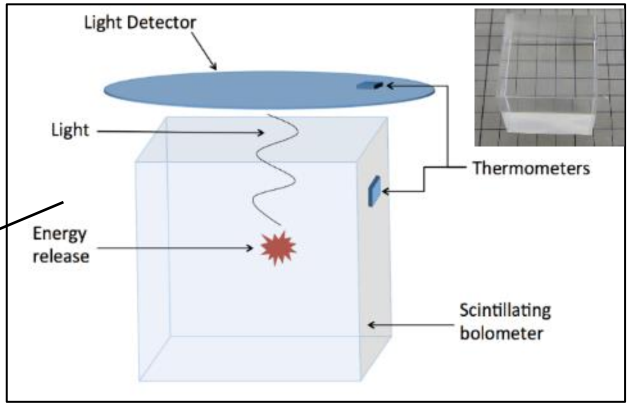


- SIC is the sole vendor providing 988 pcs TeO_2 crystals with low Th and U radioactive background for INFN CUORE experiment

Search for Majorana neutrinos exploiting millikelvin cryogenics with CUORE, Nature, 2022.

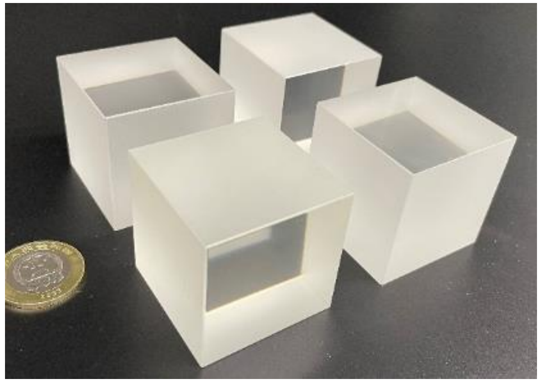
Low background crystals for rare events physics: Li_2MO_4

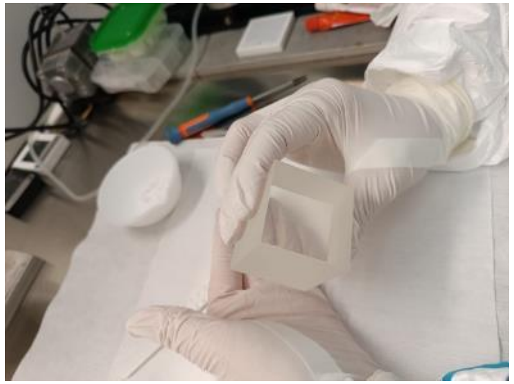




Li_2MoO_4 crystals with ultra low background for CUPID

Raw material /crystal		^{232}Th SINAP	^{232}Th Italy	^{238}U	W	K
Item	Specs	ng/kg（ppt）			mg/kg	µg/kg
Powder	Aqueous solution	7282		10729	16	17349
Crystal	1st growth	112	49.5	831	418	< 100
Crystal	2nd growth	82	5.0	700	464	< 100



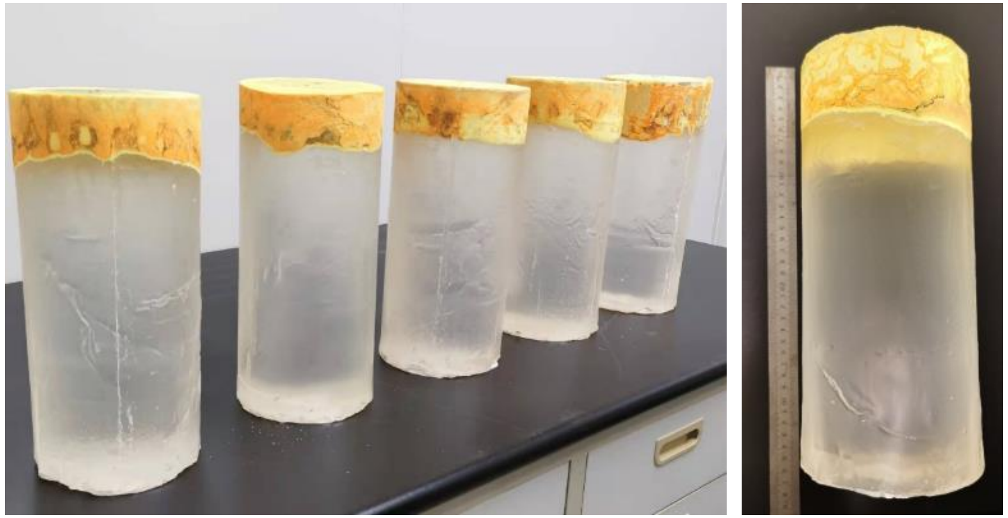


LMO meeting on September 25, 2023

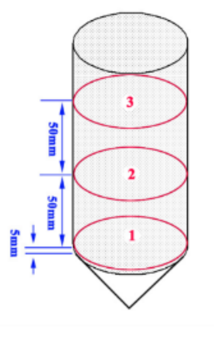
^{100}Mo enriched LMO crystals (45*45*45mm^3) developed in SIC

- ^{100}Mo enriched undoped and doped LMO crystals is prepared for the CUORE Upgrade with Particle Identification (CUPID) experiment

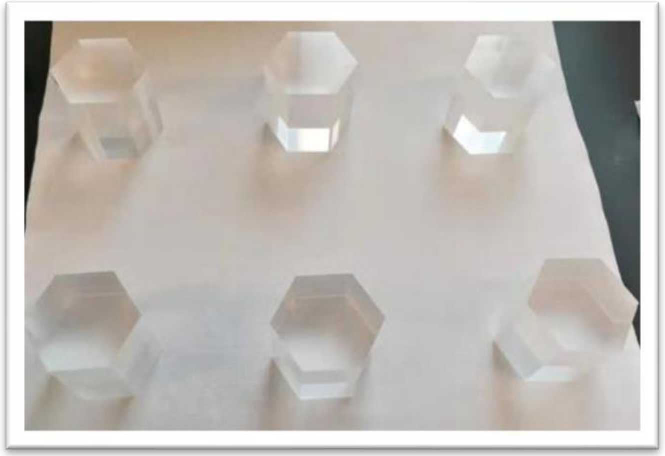
Low background crystals for rare events physics: NaI:Tl



ICP-MS results of potassium (K in ppb g/g)

NaI powder	11	TlI powder		220
NaI crystal	TlI doping (wt.%)	position		Sampling position
2 inch in Diameter	0	1	3	
		2	5	
		3	12	
3 inch in Diameter	0	1	5	
		3	21	
3 inch in Diameter 1#	0.2	1	6	
		3	22	
3 inch in Diameter 2#	0.2	1	9	
		3	35	

- As grown Φ135 mm large NaI(Tl) crystals with low radioactive background are successfully grown at SIC

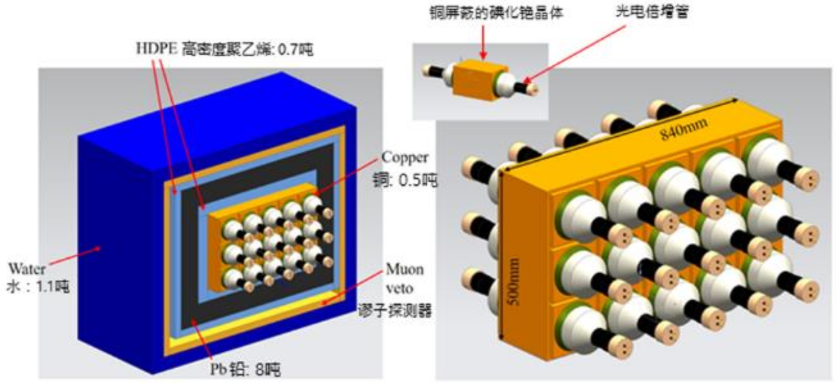


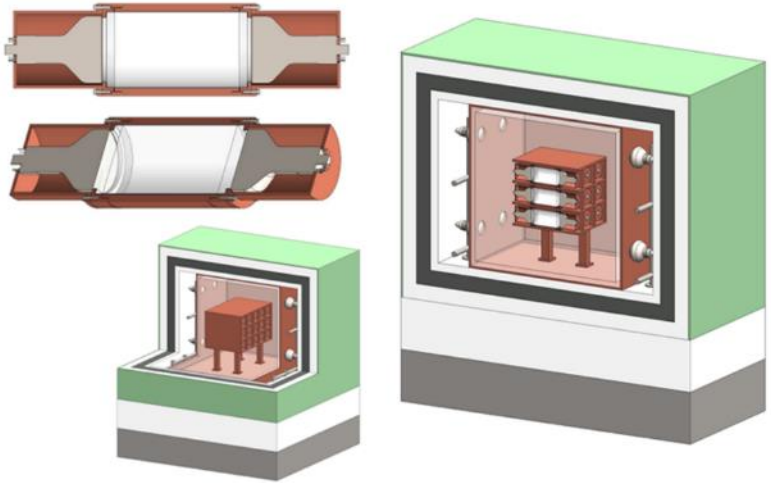
- Low radioactive background (~3 ppb K) hexagonal NaI crystals are grown at SIC for COSINUS experiment

Y. Zhu et al. 2018 IEEE (NSS/MIC), Sydney, Australia, 2018, pp. 1-3.

Low background crystals for rare events physics: CsI:Na

(CICENNS)





Isotopes	^{238}U (ppt)	^{232}Th (ppt)	^{87}Rb (ppb)	^{137}Cs (mBq/kg).	^{134}Cs (mBq/kg).
CICENNS	10±10	30±10	∼0.5	??	??
KIMS	0.75±0.23	0.38±0.07	1.3±0.4	6.3±0.7	14.1±1.1
COHERENT	<1000	<1000	∼20	28±3.	26±2

Kim, Soo-Bong Xiao, Xiang (肖翔)

Sun Yat-sen University

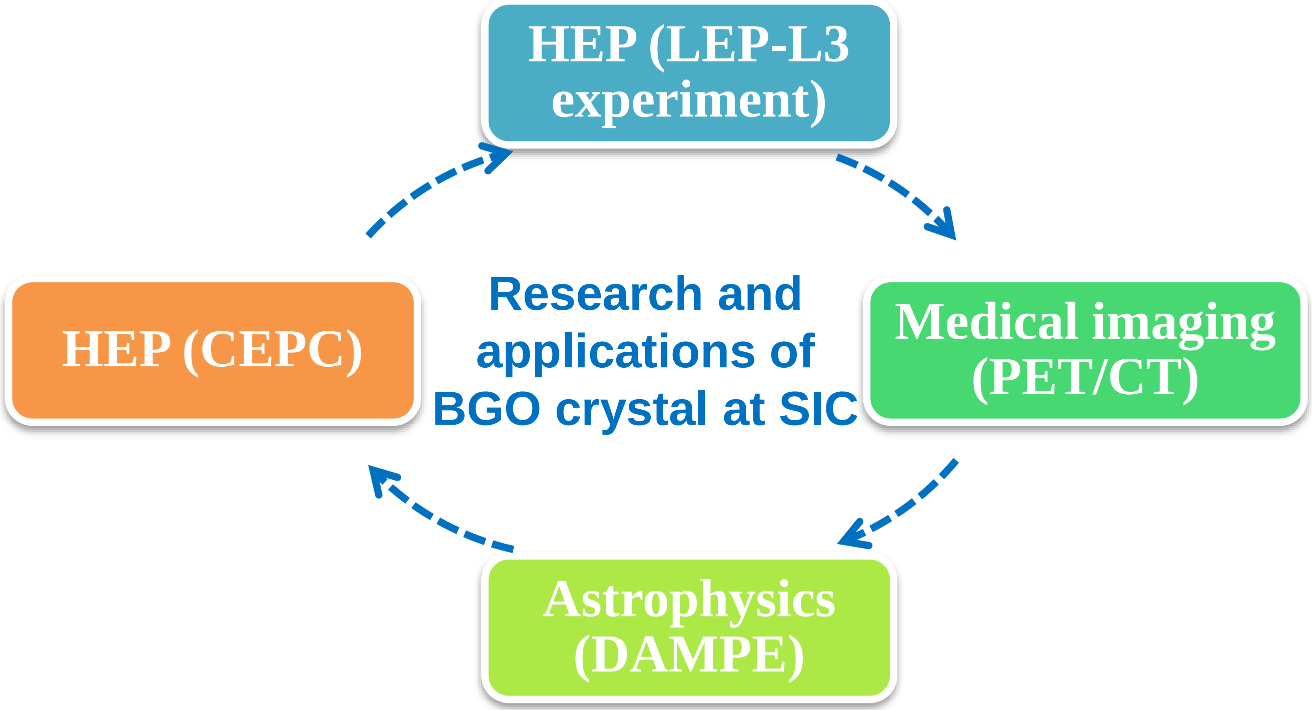
中山大學 物理学院
SUN YAT-SEN UNIVERSITY SCHOOL OF PHYSICS

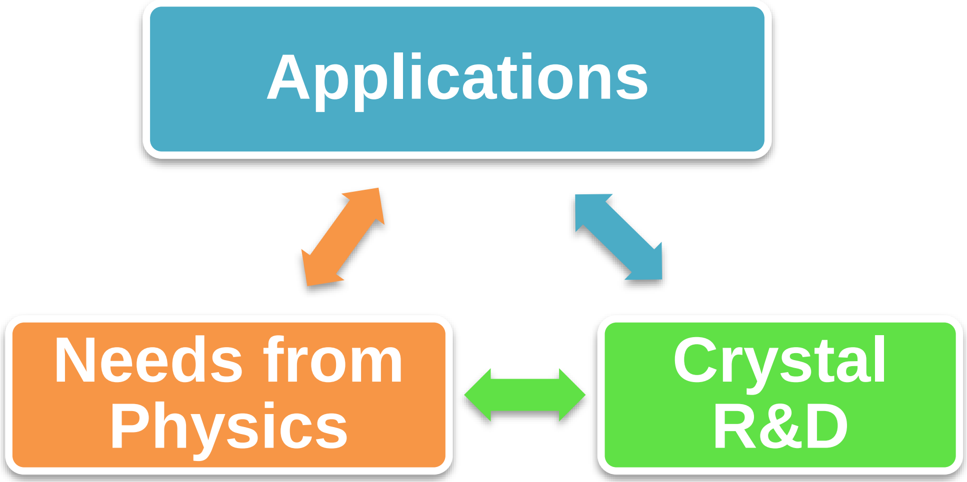
SICCAS Since 1928

- R&D on large CsI:Na crystals (φ5 inch) with low background are carried out at SIC for Coherent Elastic Neutrino-Nucleus Scattering (CICENNS) experiment (total weight: 300 kg)

Concluding Remarks

- Development of “good” crystals needs multidisciplinary (MSE, Physical understanding and needs...,) collaborations and communications, which are mutually beneficial





Success examples in R&D of several important crystals:

- **BGO**: LEP(L3) -> R&D on 24 cm BGO crystal-> PET/CT -> DAMPE (60 cm) -> CEPC (40 cm?)
- **CsI**: Babar/Belle/BESIII -> Security Check -> Mu2e/Belle-II
- **Y-doping**: LHC(CMS) -> PWO:Y -> LYSO:Ce (PET/CT) -> BaF_2:Y -> future HEP(?)......

Thanks for your attention!

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