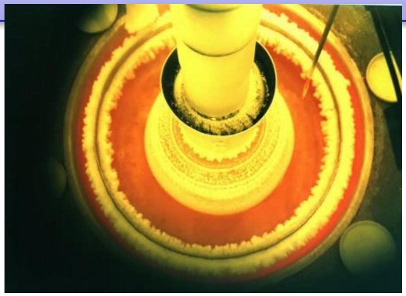
Scintillating materials at ISMA

Scintillating materials at ISMA

Institute for Single Crystals

Institute for Scintillation Materials



Division of Functional Materials Chemistry

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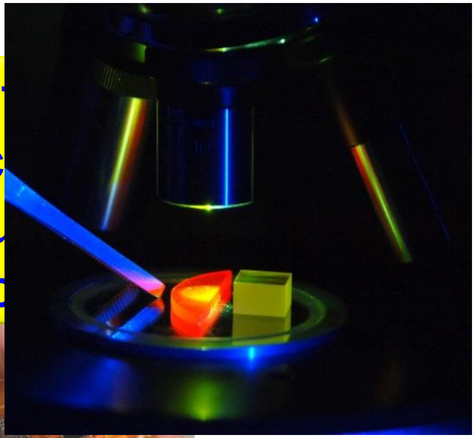
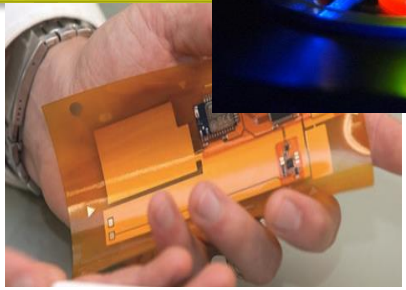




Scintillation and luminescent materials science

Fundamental investigations on radiation-substance interaction

Development of technologies and nanotechnologies for scintillation detectors production and making related devices

- ❑ Crystal Growth Technology Department ISMA
- ❑ Available methods of crystal production
- ❑ Examples of new materials/technologies development

History of Scintillators in ISMA

- **2016** YAG:Ce, LuAG:Ce,GAGG:Ce
- **2014** SrI_2 and BaBrI
- **2012** Flexible ZnSe(Te)-based composites
- **2011** $MgWO_4$
- **2010** $ZnMoO_4$
- **2009** $ZnWO_4$
- **2007** LGSO
- **2004** dedicated imaging system
- **2000** SPECT
- **1994** CsI(Tl) crystals of 525 kg weight
- **1992** PWO
- **1987** Undoped CsI single crystals
- **1986** $CdWO_4$, $BiGe_3O_{12}$
- **1985** “CRYSTAL” technology
- **1978** “ROST” technology
- **1974** ZnSe(Te)
- **1964** CsI(Na)
- **1961** PMMA
- **1959** NaI(Tl)

High Energy Physics

OPERA 2005

PANDA 2005

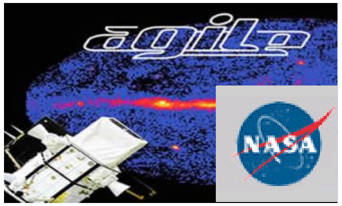
NEMO 2005

CMS 2009-2013

NICA ongoing

Space Missions

GLAST (USA, Sweden) 2008

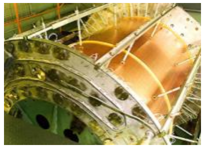


AGILE (Italy) 2007

Medium Energy Physics

BELLE (Japan) 1996

BaBar (USA) 1998



KEDR (Russia) 2000

PiBeta (Switzerland) 2000

FAIR (Germany) 2014

Neutrino Experiments

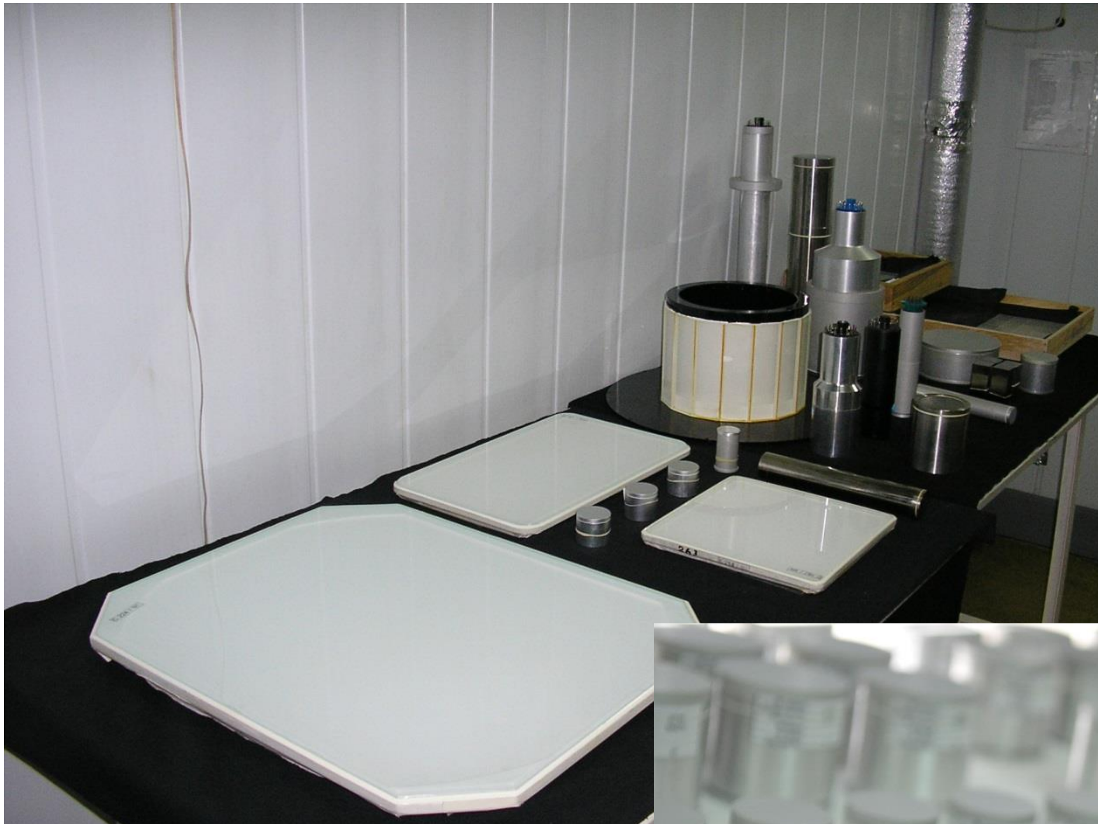
DAYA BAY (China) 2009-2011

Extra-large alkali halide crystals
NaI:Tl, CsI:Tl, CsI

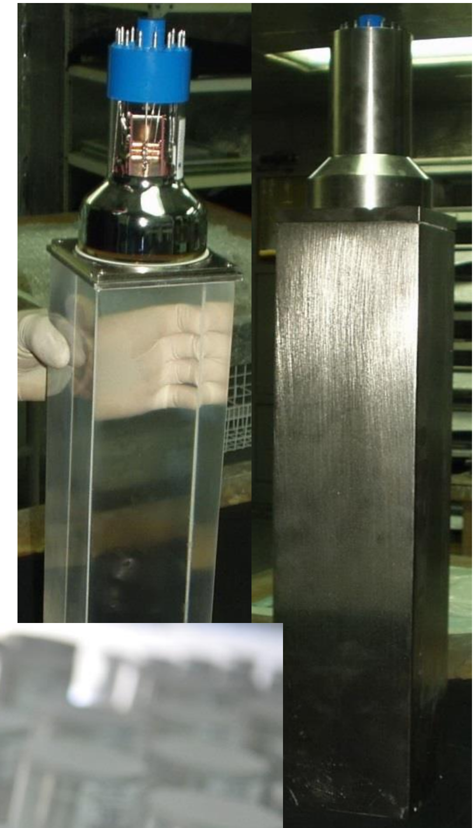
Oxide crystals
PWO, GSO:Ce, LGSO:Ce, YAG:Ce, GPS:Ce, BGO

Chalcogenide crystals ZnSe(Te)

Plastics

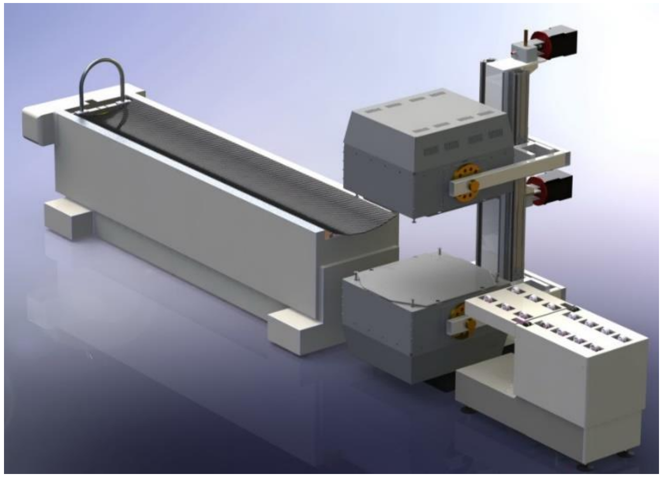


Screens for gamma-cameras



Detectors for portals

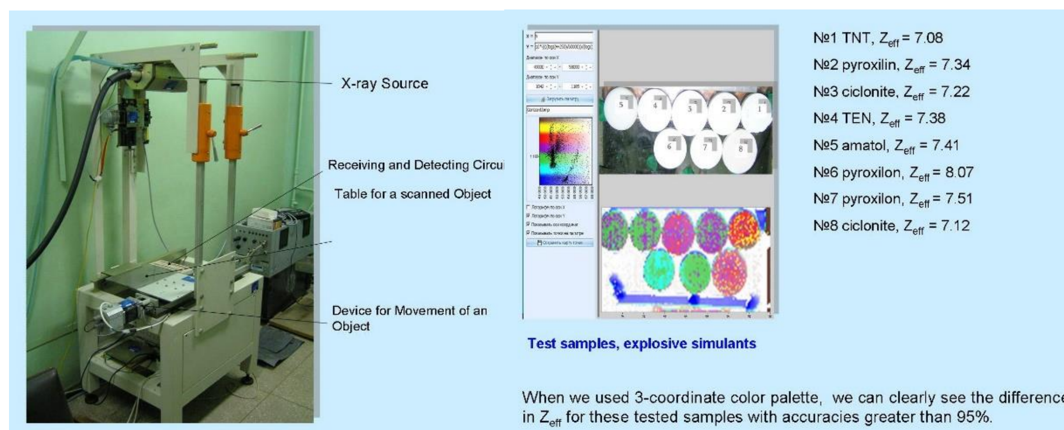
Small detectors for industry



OFECT series of gamma-tomographs

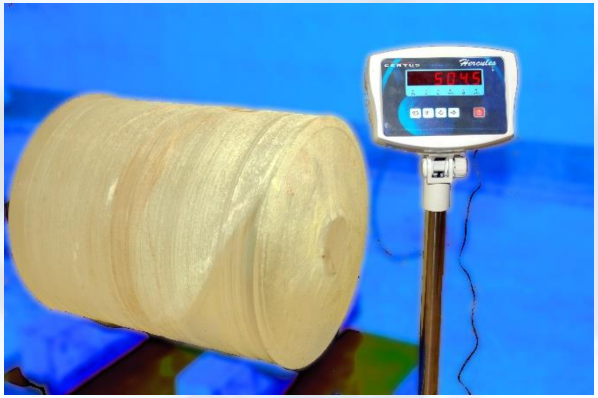
Portal monitors

Dosage calibrator for nuclear medicine radio-pharmaceuticals



Multienergy X-ray Scanner

TOP quality of Alkali-Halide Scintillators

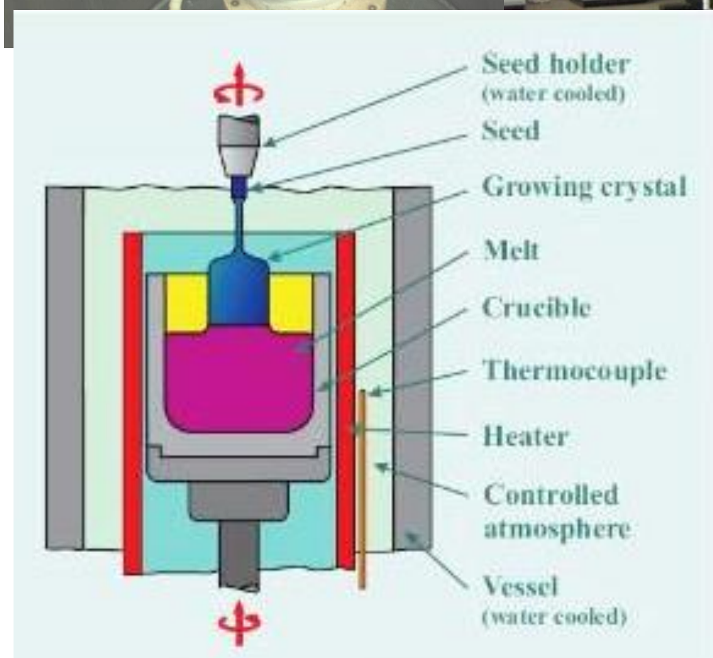


Crystal size up to 800 mm

High uniformity across all crystals volume

Czochralski facilities

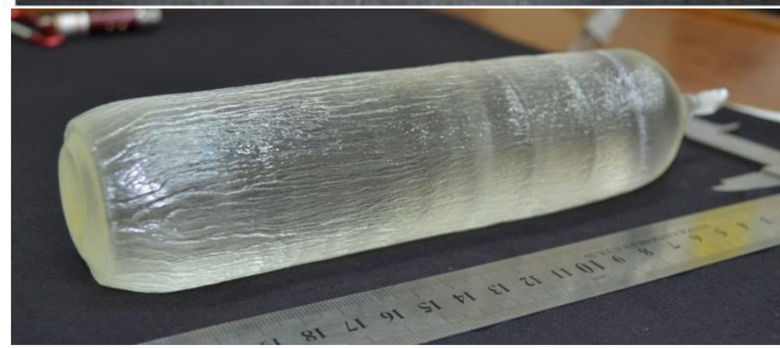
Induction heating setups of “Oksid” and “Kristall” series



- ❑ Induction heating
- ❑ Ir, Mo, W crucibles
- ❑ Controlled vacuum chamber
- ❑ Diameter control by weight sensor
- ❑ Crystallization temperatures – up to ~2200°C

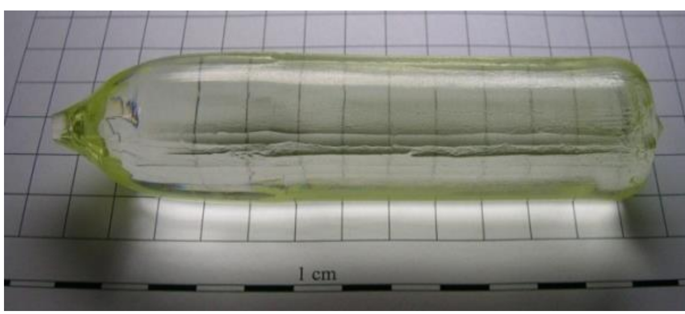
Large oxide scintillation crystals produced by ISMA

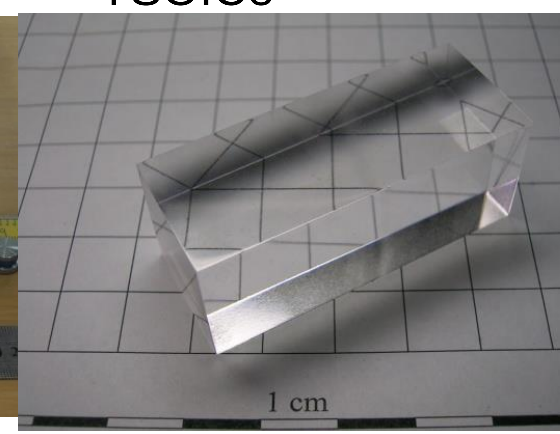
BGO up to 3” in dia.



GAGG:Ce

YSO:Ce





YAG

BGO

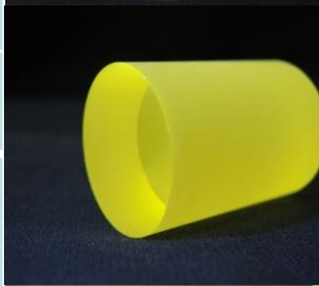
LGSO:Ce

Garnet scintillators

	YAG:Ce,C	LuAG:Ce	GAGG:Ce	YAG:C
Crystal structure	cubic			
Light yield, ph/Mev	30000	15000	50000	22000
Hardness, Mho	-	8.5	-	
Emission	540 nm	535 nm	510-530 nm	400 nm
Density, g/cm³	4.55	6.7	6.6	4.55
Refraction index	~ 1.8	~ 1.8	~ 1.8	~ 1.8
Primary decay time, ns	100	70	100-150	4-6

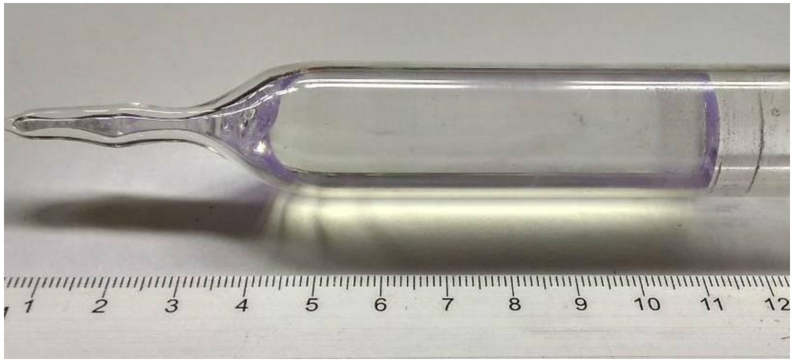
Advantages
- ❑ High light yield (GAGG:Ce);
- ❑ High density (LuAG:Ce, GAGG:Ce);
- ❑ Matching for photodiode and avalanche diode readout;
- ❑ Good machining properties;
- ❑ Fast decay (YAG:C).

Main usage
- ❑ High energy γ and charged particle detection;
- ❑ PET matrices;
- ❑ High spatial resolution imaging screens for X-rays, gamma and beta;
- ❑ LED



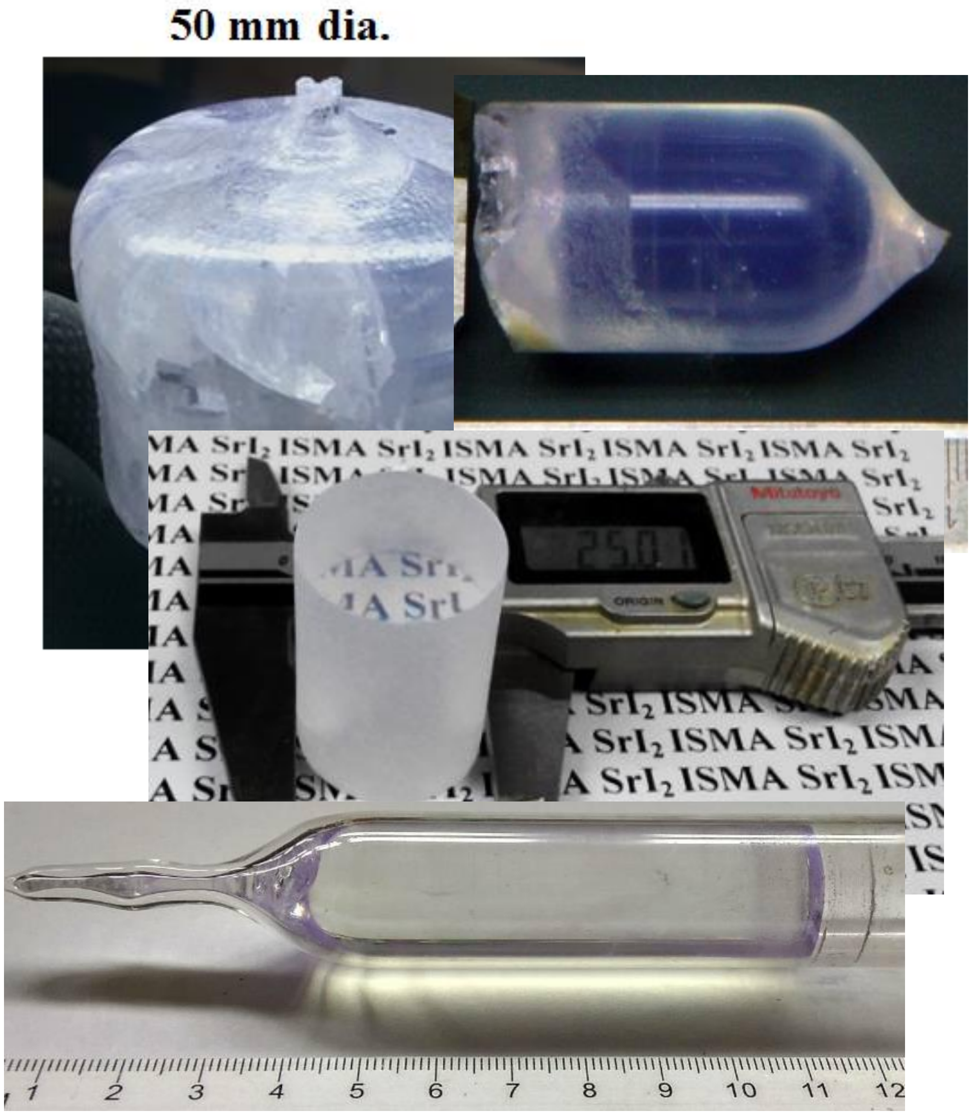
Two zone Stockbarger growth furnaces

Glow boxes to handle hygroscopic materials

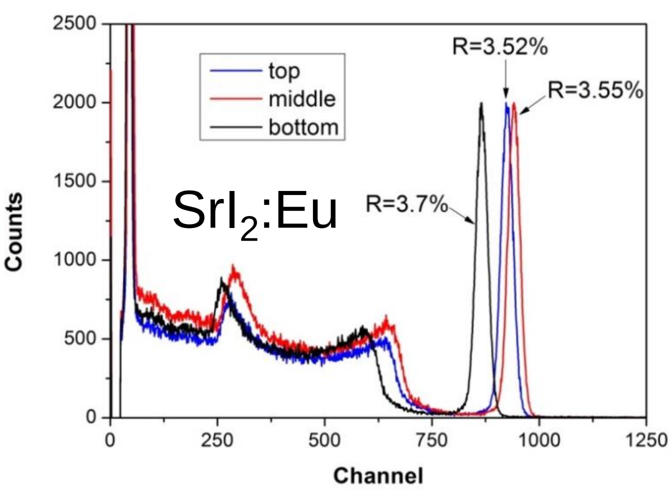


- ❑ Sealed quartz ampoules
- ❑ Pulling speed 0,01-1500 mm/h
- ❑ Crystal diameter up to 2”

∅1-2″ SrI_2:Eu

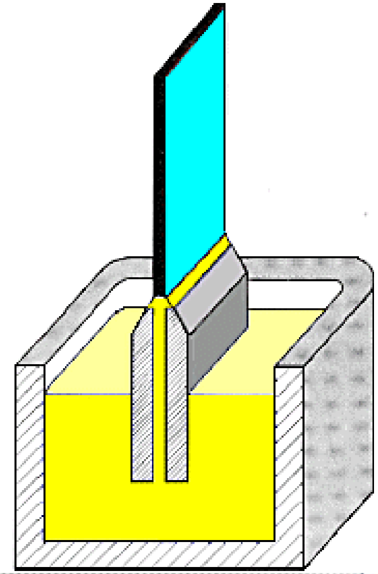


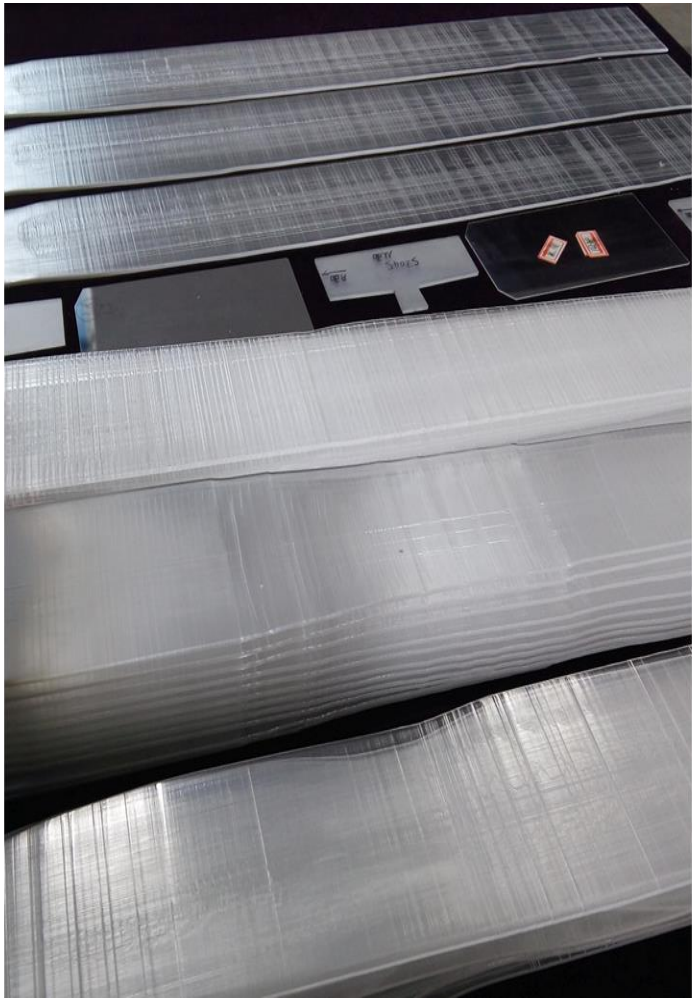
∅2″ BaBrI



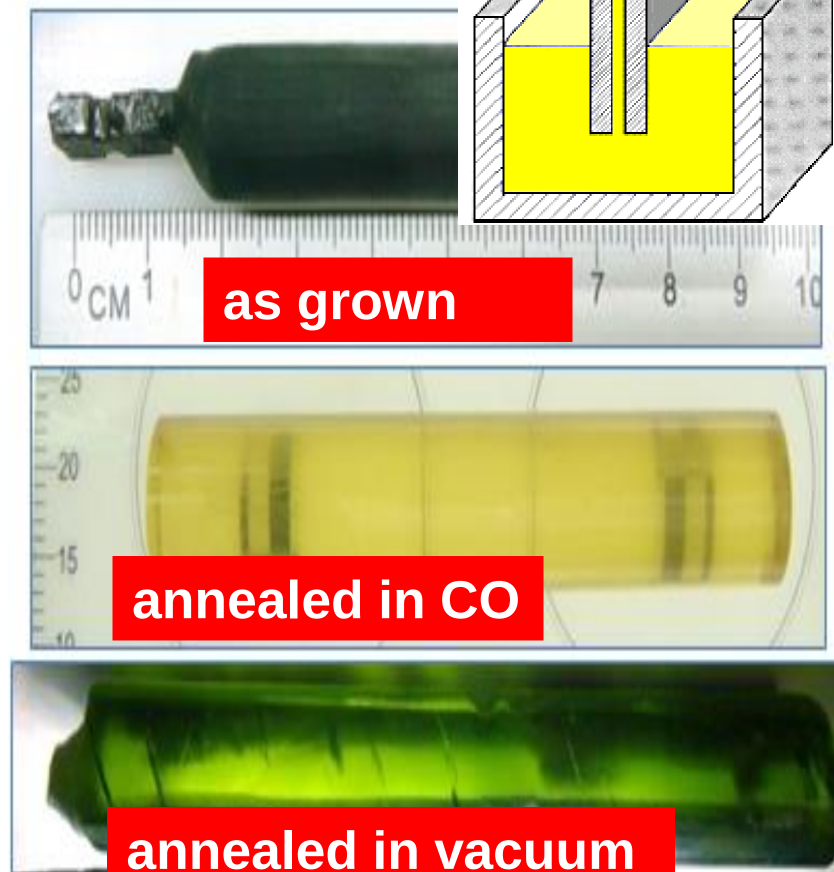
(NATO project SPS984958)

EFG method



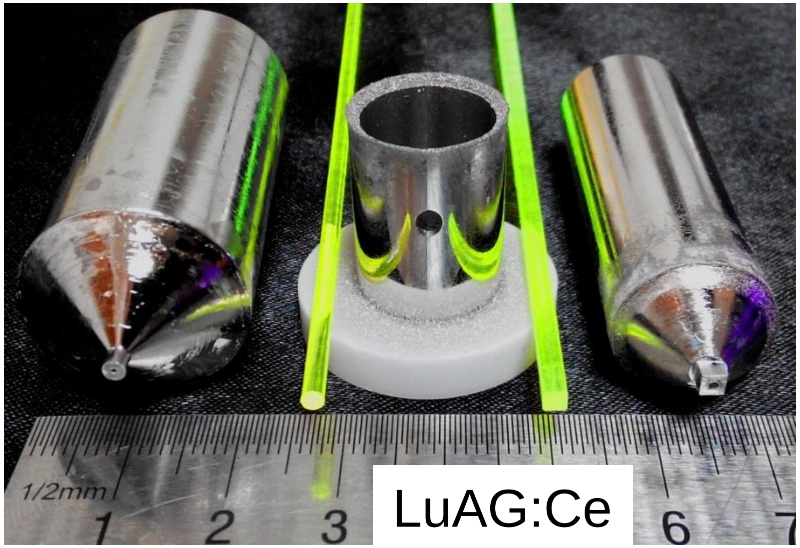


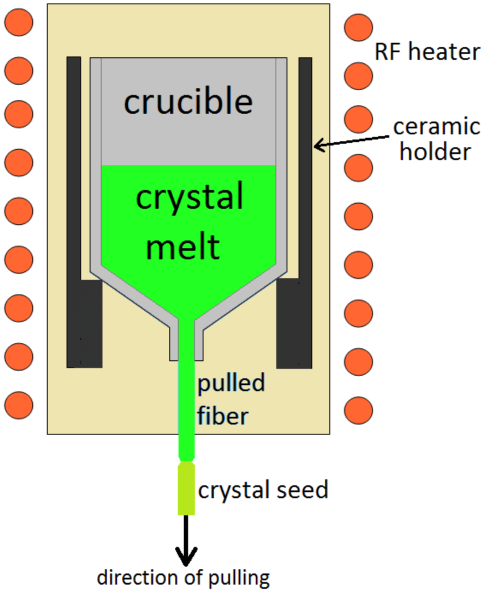
Sapphire tapes

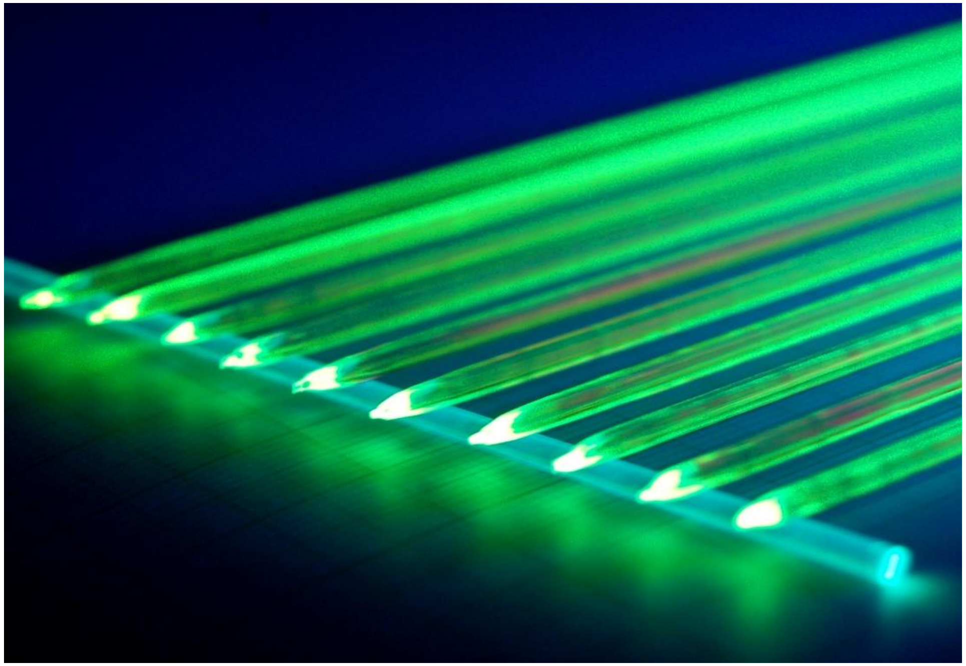


Large $CeAlO_3$

Micro-PD method







- Fiber development for simultaneous registration of Scintillation and Cherenkov emission in a sampling calorimeter module

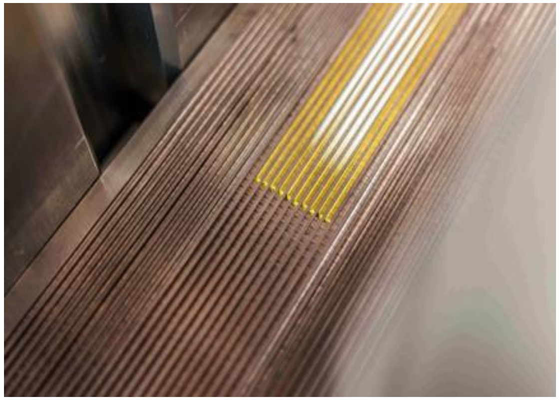
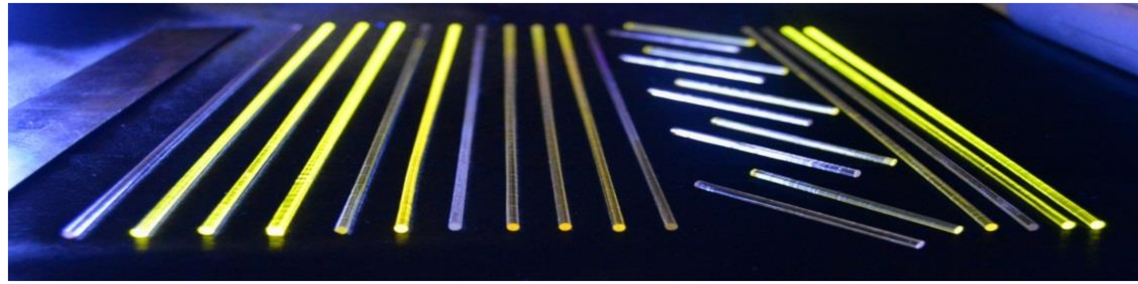
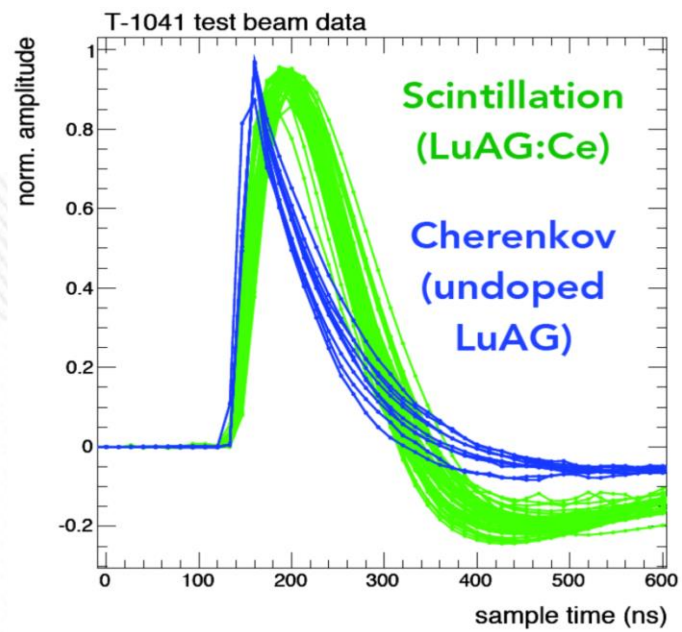


Plate of 0.75W/0.25Cu with groove to insert the fibers

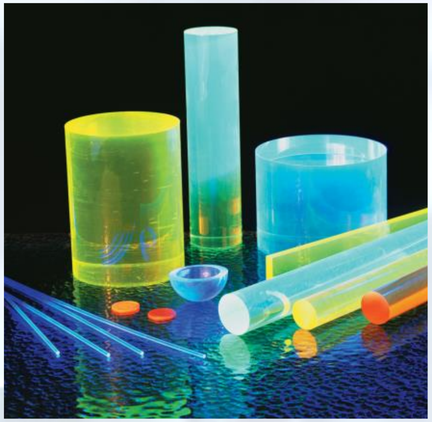
YAG/LuAG-based fibers



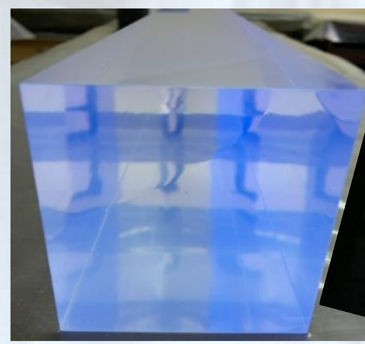


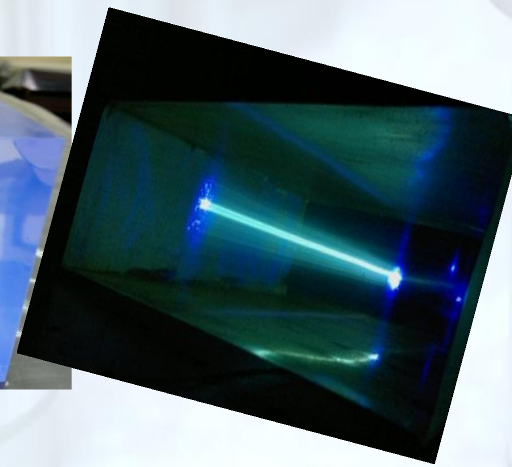
- **Undoped fibers**: promptly emitted Cherenkov photons
  → faster pulse
- **Doped fibers**: scintillation photons dominate
  → slower pulse

European project H2020 MSCA-RISE-2014 -644260 (INTELUM)



- Stability of light output up to 10 years
- High mechanical strength
- Large size and weight single piece polymerization (up to 1 ton)

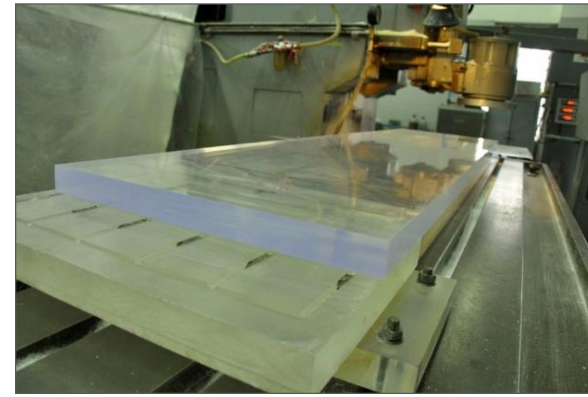




CNC technology for plastic production

Raw material preparation

Cast plastic production



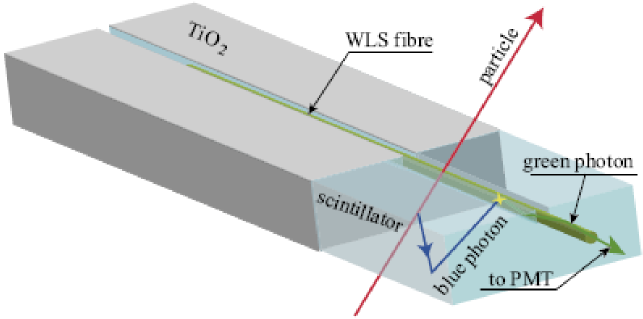
Diamond milling

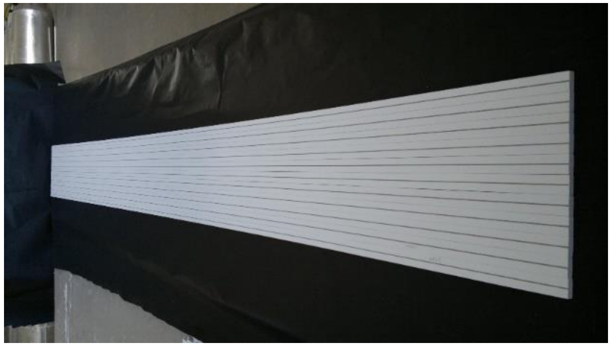
CNC processing

Polishing

Production of scintillation strips and tiles

Light yield ≥16 p.e.



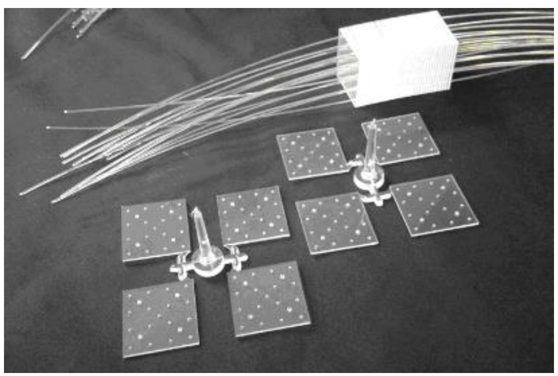


Different length and shape

Molding technology: production of scintillation tiles; «Shashlyk» detectors

Raw material preparation

Injection machine

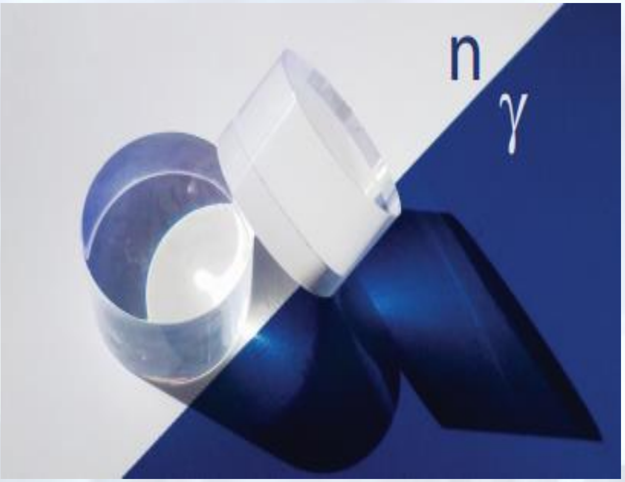


Scintillation tiles

Detectors assembly

QC Control

Production capability: up to 1 000 000 tiles per year

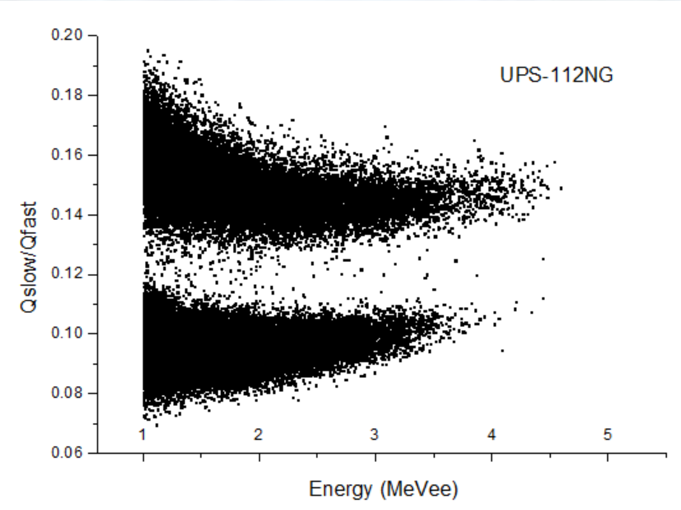


Possible size up to 500 mm

n/γ discrimination:

UPS-112NG……..1.9

UPS-113NG……..2.2



n/γ DISCRIMINATION

Summary

- ISMA expertise in a large range of scintillating materials
- ISMA is our partner in LIA/IRP IDEATE France-Ukraine
- Joint projects with IJCLab

Contract: Andrey Boyarintsev, aboyar74@gmail.com

Raw materials for crystal growth