

Overview and recent progress on

BrilLanCe™ 380 [LaBr₃:Ce] Scintillator

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Presented in Milano
November, 17 2009


SAINT-GOBAIN
CRYSTALS

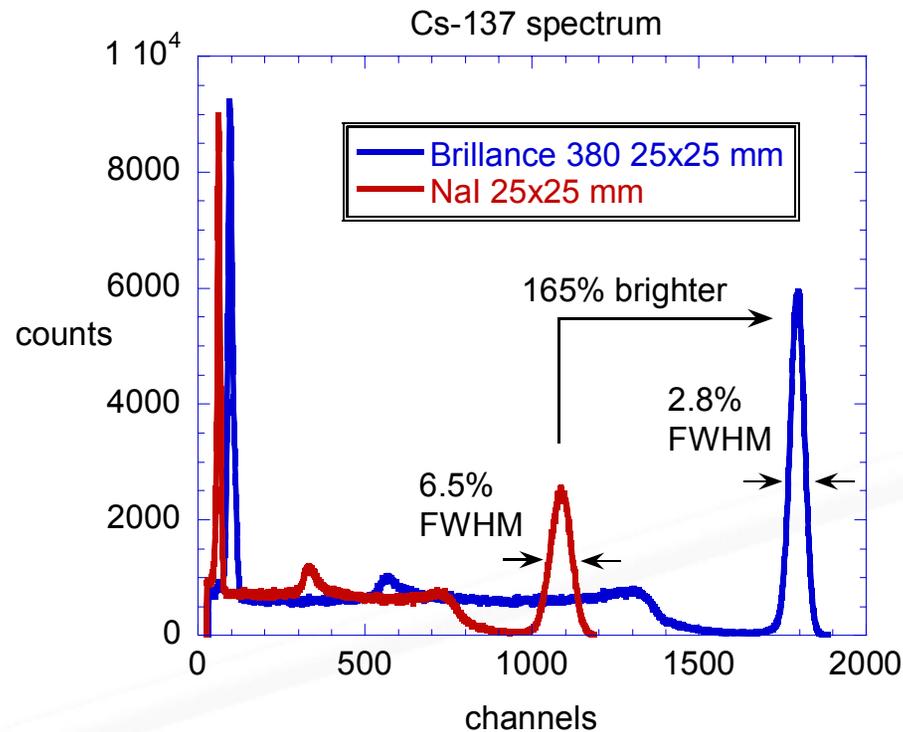
Exceptional performance never reached by a Scintillator

Property	Typical Value – B380	Application advantage
Exceptional energy resolution	PHR <3% @662keV PHR<2%@1332keV	<ul style="list-style-type: none"> • Better peak separation • Higher accuracy of detection systems
Radiation hardness	80%+ L.O. after 100kGy gamma exposure	Possibility to use in high flux environments
Higher density	5.08g/cm ³	Better stopping power, smaller sizes, improved spatial resolution.
Excellent Homogeneity	Performance maintained on large sizes.	Applications requiring large volume can be considered
High L.O. at high temperatures	Two to three times the light output of NaI(Tl) at 175C	Preserve good scintillation performance at high temperatures

A quick look at the properties of BrilLanCe™380 [LaBr₃(Ce)] scintillator

	Density g/cc	Light Yield photons/keV	Decay Time (Tau, ns)	Timing FOM $\sqrt{\text{Tau}/(\text{ph}/\text{keV})}$	Peak emission wavelength (nm)
BrilLanCe380	5.1	65	16	0.5	380
Nal:TI	3.7	39	250	2.6	415
Csl:TI	4.5	60	800	3.7	550
LYSO:Ce	7.1	30	42	1.2	420
BGO	7.1	9	300	5.8	480

65% Greater light output than NaI(Tl)

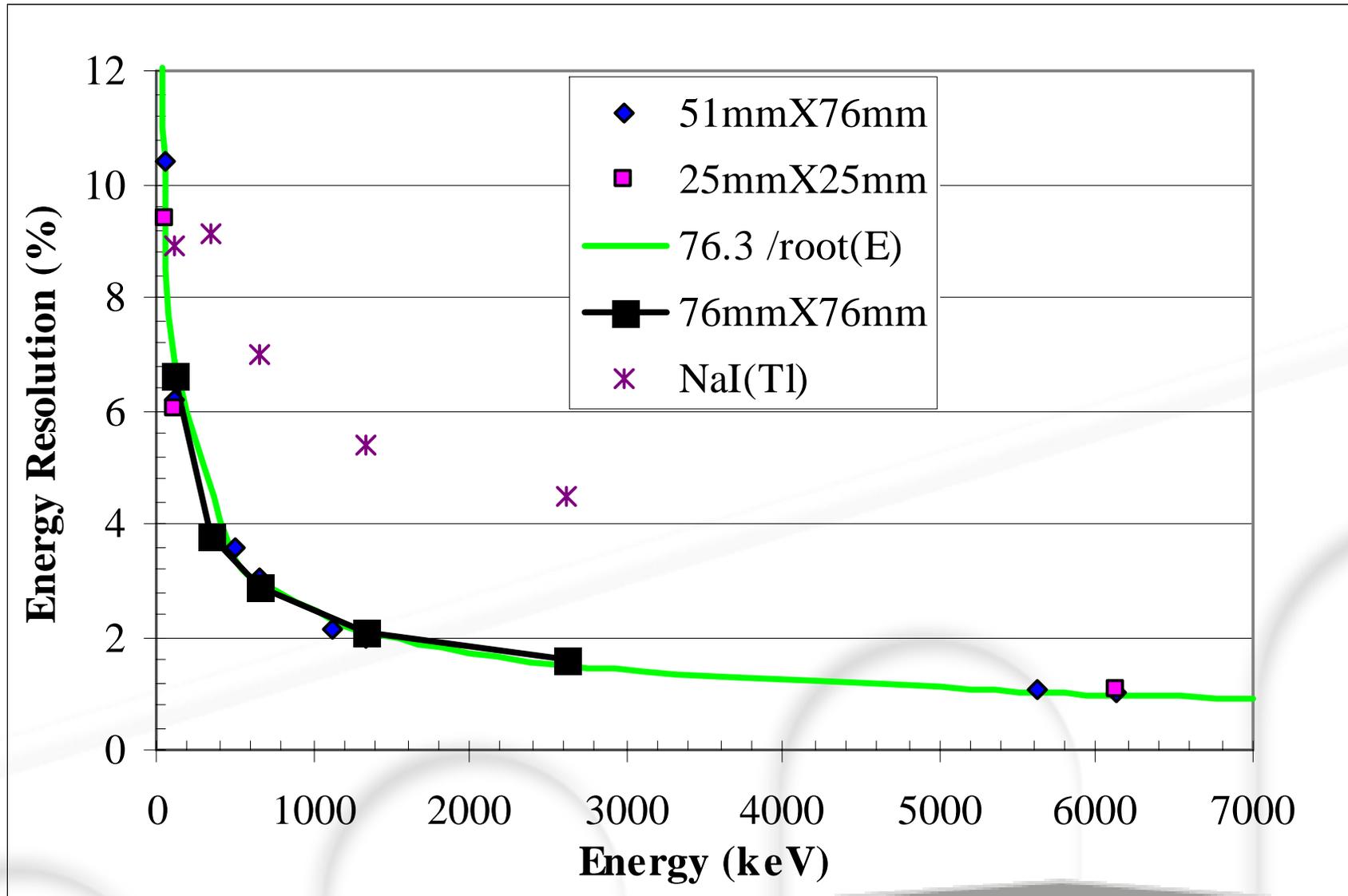


662 keV photopeaks

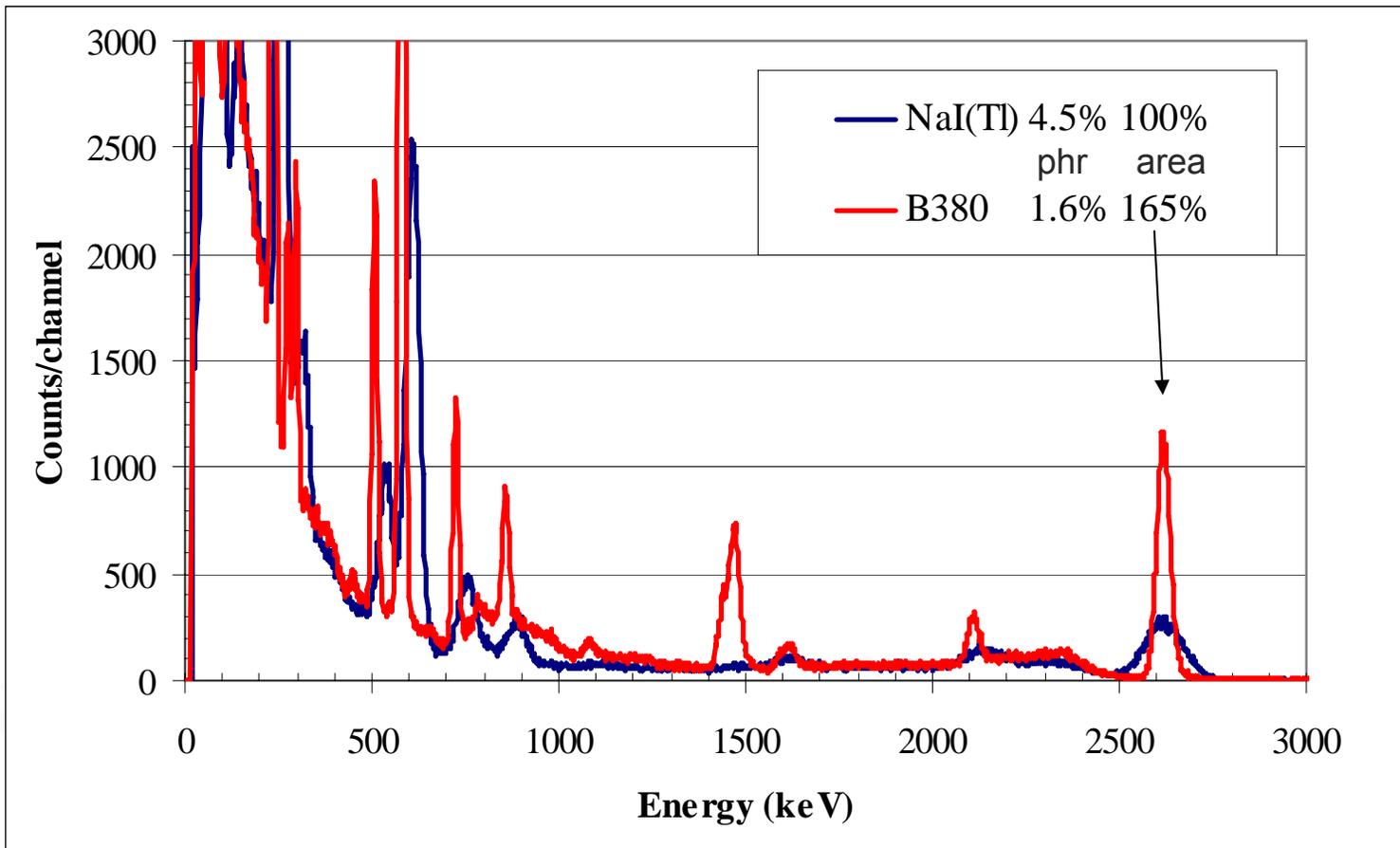
Same sized crystals
-cylindrical
-25x25 mm

Same packaging
-0.5 mm Teflon wrap
-sapphire window

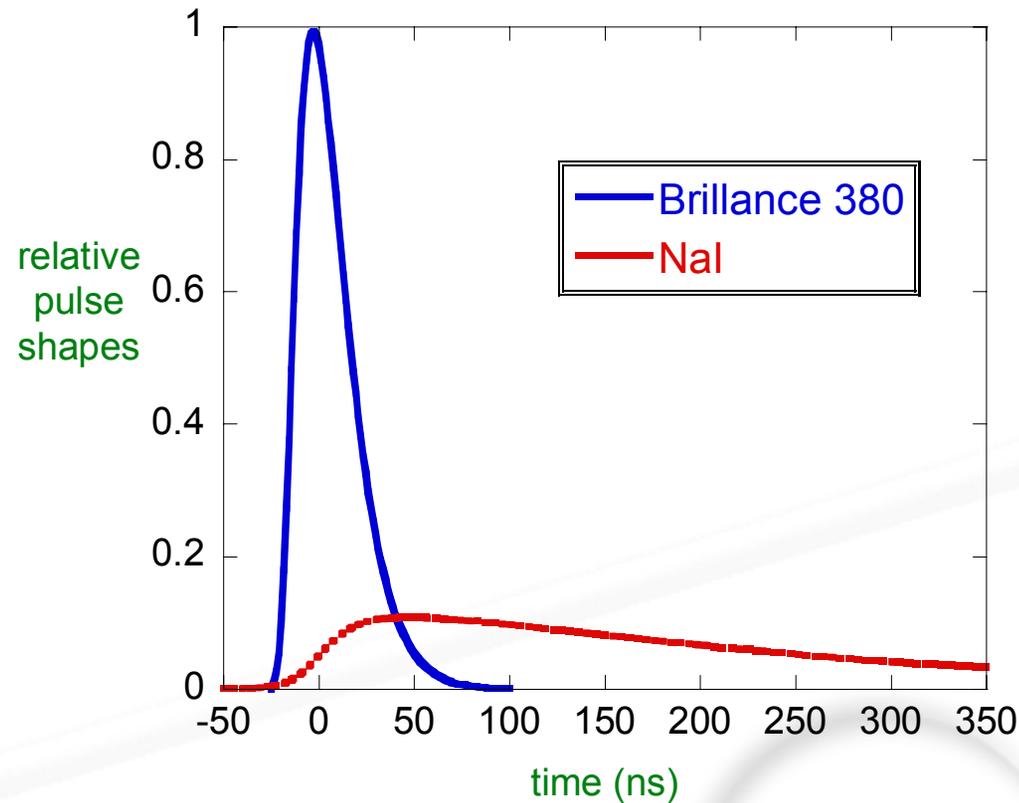
Performance is not affected by size



3x3 BrillanCe™380 crystal compared to 3x3 NaI(Tl) with ^{228}Th source



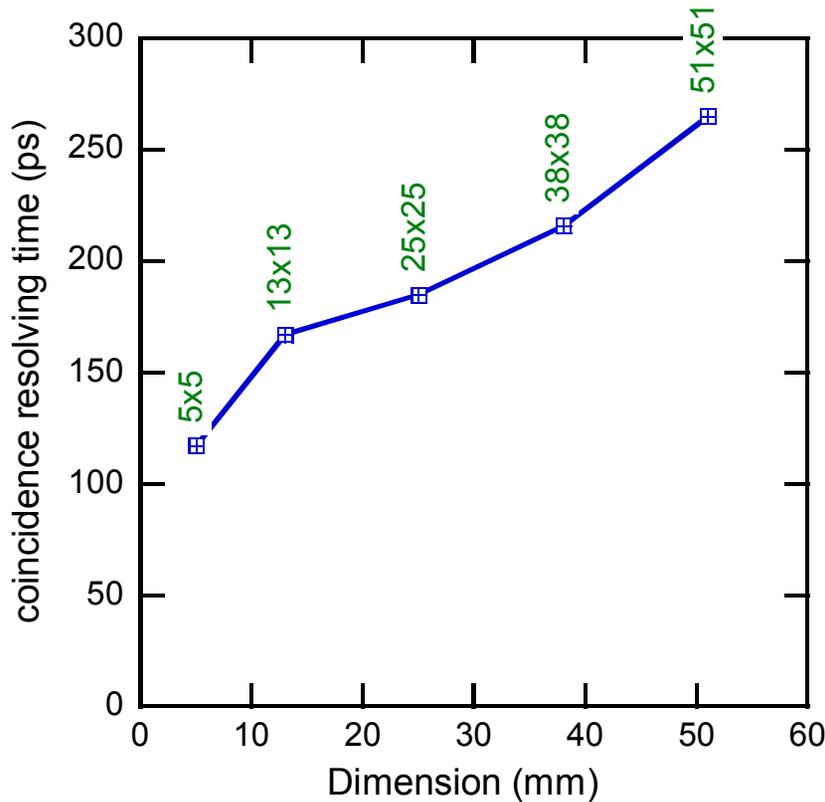
BrillanCe™ crystals are fast and bright



Brillance 380 produces a large number of photons into a short time, producing large PMT signals with much reduced stochastic noise on the pulse

Excellent coincidence resolving time

Coincidence Resolving Time (CRT) of BrillanCe detectors as a function of the crystals' longest dimension measured with fast timing PMTs that have plano-concave face plates.



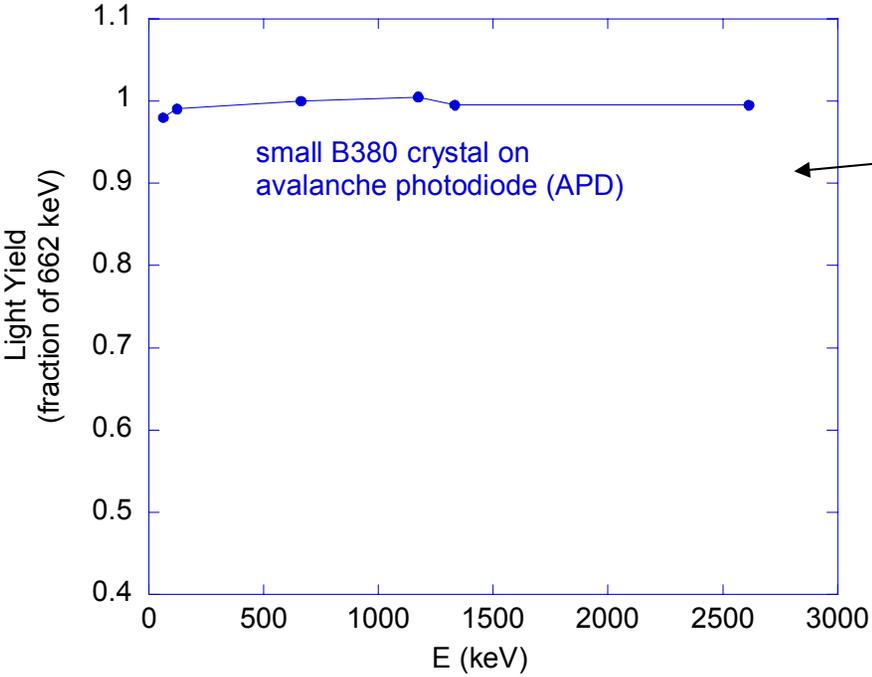
Timing with BrillanCe 380 Integrated Detector

Size (mm)*	CRT** (ns)	PMT Size (mm)	PMT*** Type
25x25	1.08	38	XP2060
38x38	0.36	51	R6231
51x51	0.45	56	XP5500
76x76	0.49	76	XP5300

- * Diameter and length of right cylindrical crystal.
- ** CRT is the Coincidence Resolving Time (single channel)
- *** These are standard PMTs with plano-plano photocathode face plates.

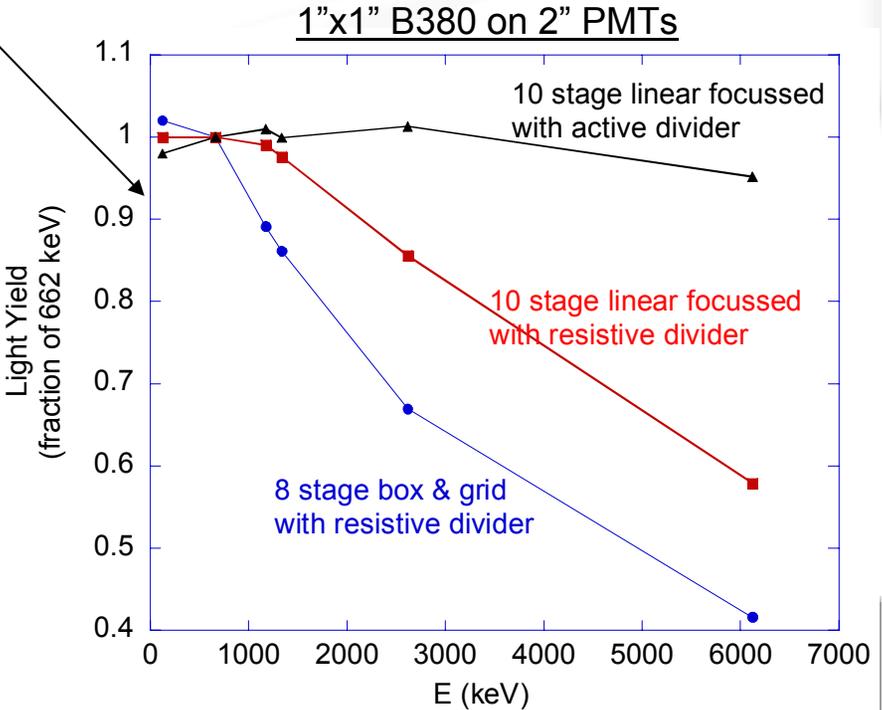
timing comparable to BaF₂

Believe it or not, fast and bright can have drawbacks, especially at high energy



Although B380 material is very linear with energy,

some PMTs and associated electronics will saturate from B380's extremely high photon current

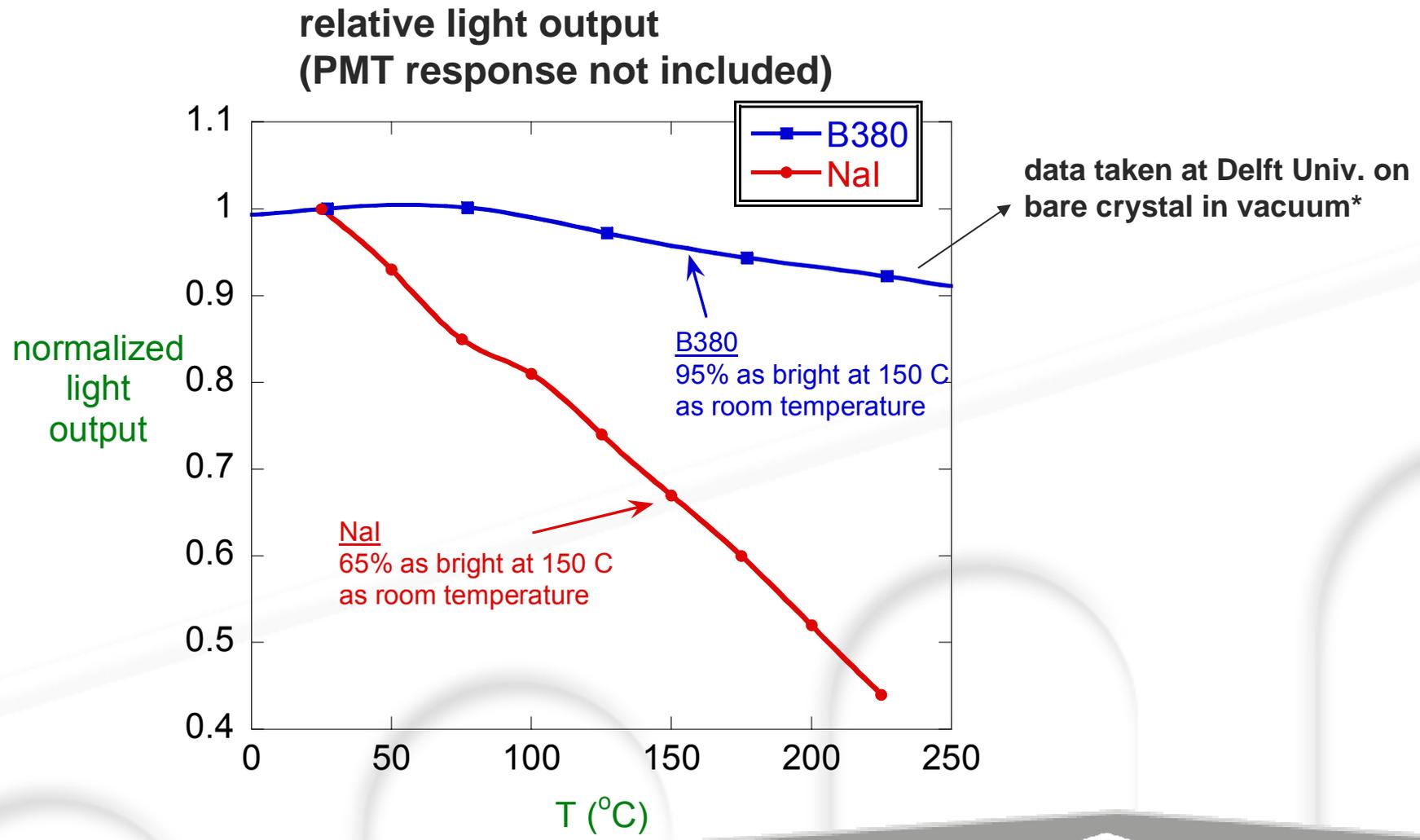


If high energy measurements are required, please consult SGC for PMT and voltage divider recommendations

2009 Focus....

- **BrilLanCe™380 scintillator for rugged, high temperature applications**
 - 250g shock, 175° C operation
 - for geophysical and space flight
- **Prepare the future**
 - Large scale production established
 - Cylinder shapes 3x3 and larger
- **Continue product development**
 - Various shapes
 - Various light sensors

Geophysical Applications: Brilliance™380 can retain its high brightness at high temperatures



* phys stat sol (a) 205 (5) p R41 (2006)

Geophysical Applications: Brilliance™380 performance on rugged, high temperature PMTs

Hamamatsu R1288
rugged high temp PMT

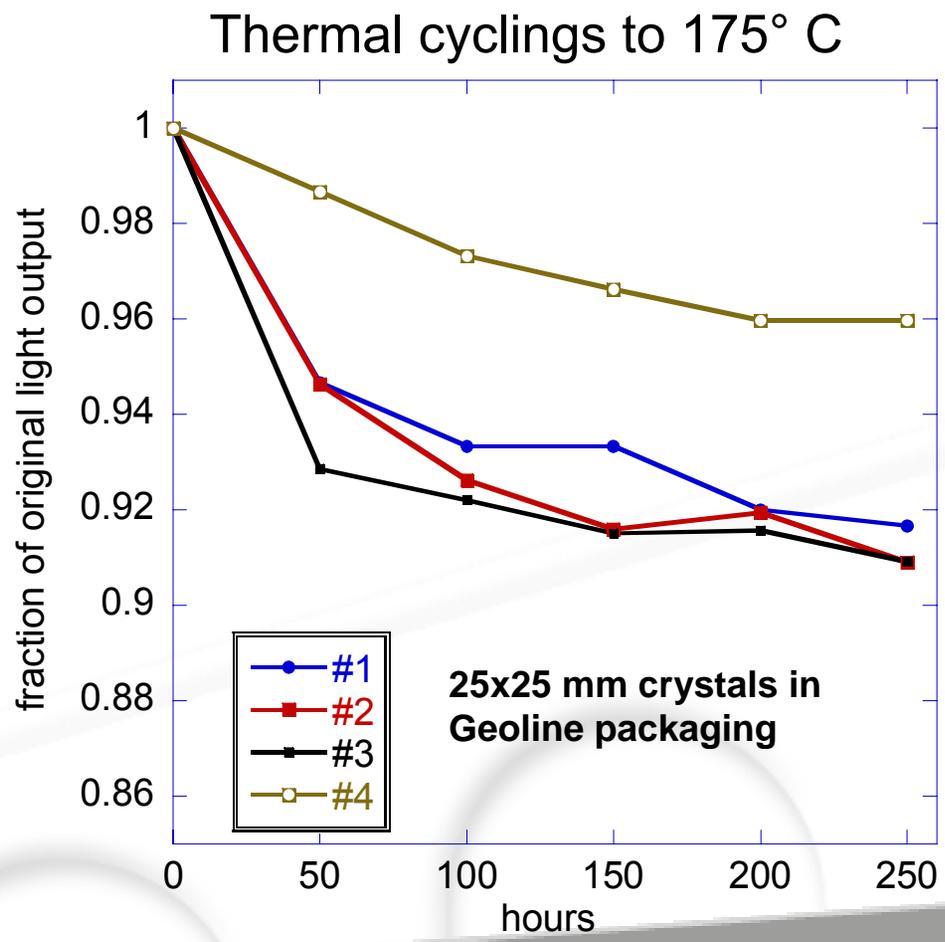
Cs-137 measurements
1x3" crystals

Room temperature

At 150° C

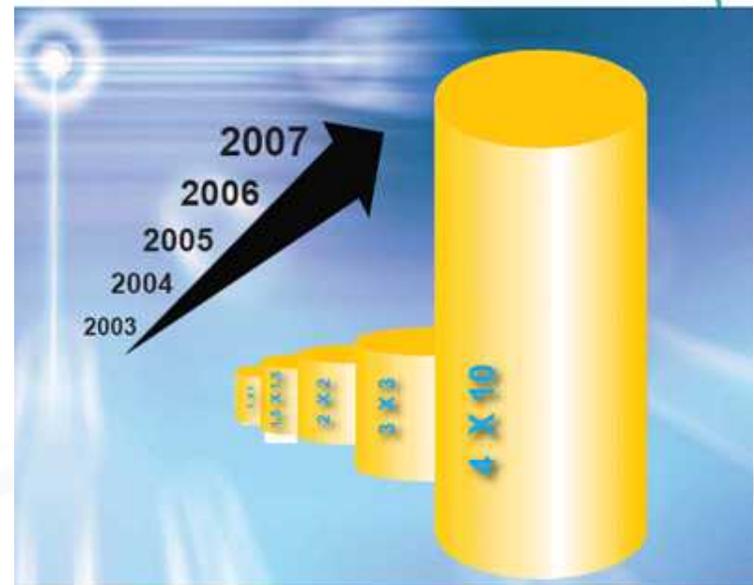
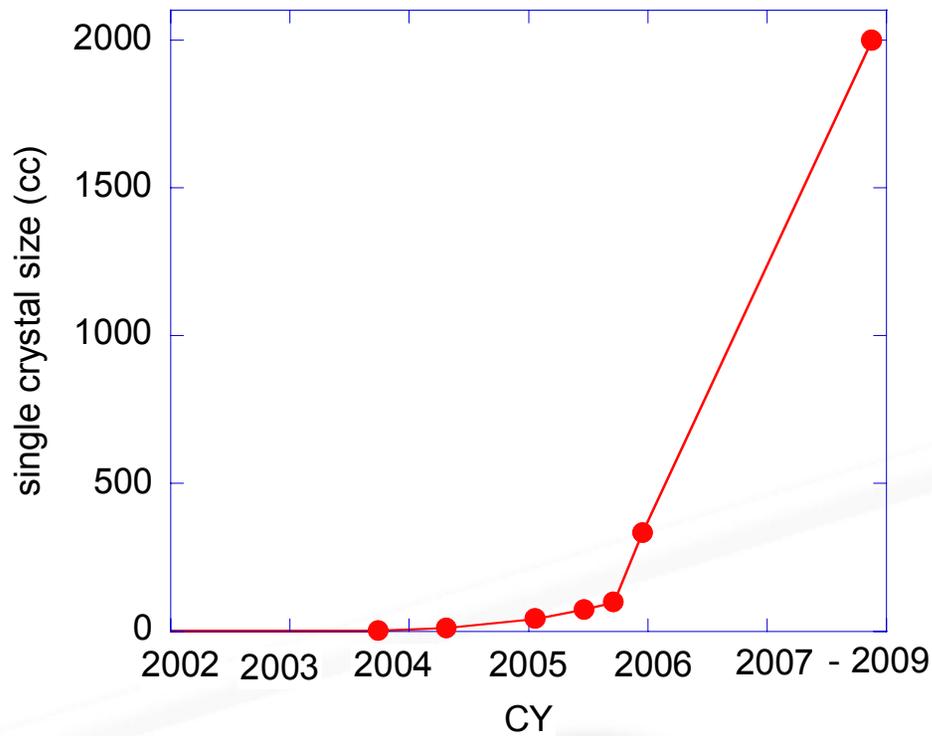
	Relative pulse height	Energy resolution	Relative pulse height	Energy resolution
B380	1.9	5.4%	1.2	7.5%
NaI	1.0	8.4%	0.6	13%

Geophysical Applications: When properly packaged, repeated thermal cyclings have little effect on performance



After 5 thermal cyclings from 25° to 175° C, and a total duration at 175° C of 250 hours, the crystals still retain >90% of their original light output

A fast and steady effort to push crystal growth limits



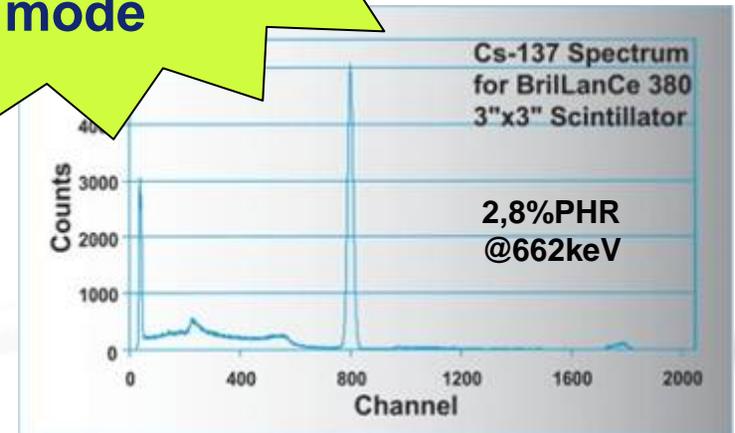
Exceptional performance never reached by a Scintillator

Property	Typical Value – B380	Application advantage
Excellent T° stability	less 1% over [0 /+55°C] less 5% over [- 65°C/+140°C]	Systems more stable with temperature changes
Fast response	Decay time 16ns	Reduction of time analysis
Fast timing properties	CRT ≈ [210ps – 350ps]	Nuclear Physics experiments and TOF applications
High count rate capability	Up to 2 MHz	Counting in intense flux is possible with minimal dead time corrections needed even at 1Mcps

Standard Productions



Less than 3%
PHR @ 662keV
on production
mode



A robust production process is established for mass production

→cylinder shaped

→up to 3" diameter x 3" long

→coupled to PMT

→with performance optimized for spectroscopy application

Continuing efforts towards larger diameters



4" diameter x 10" long

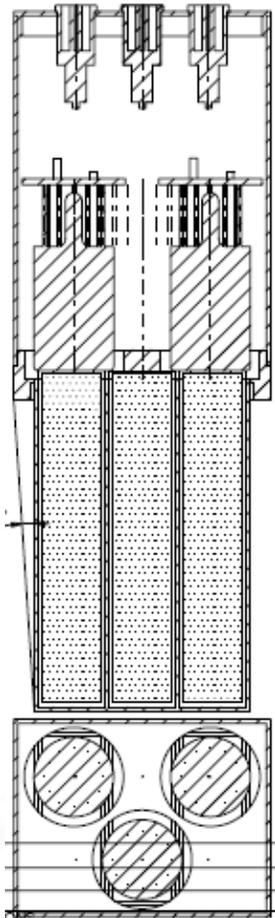
**4,5" diameter
coming soon**

Prototype mode

2008: 3,5" dia x 8" long

2009: 4" dia x 6" long

On prototype mode

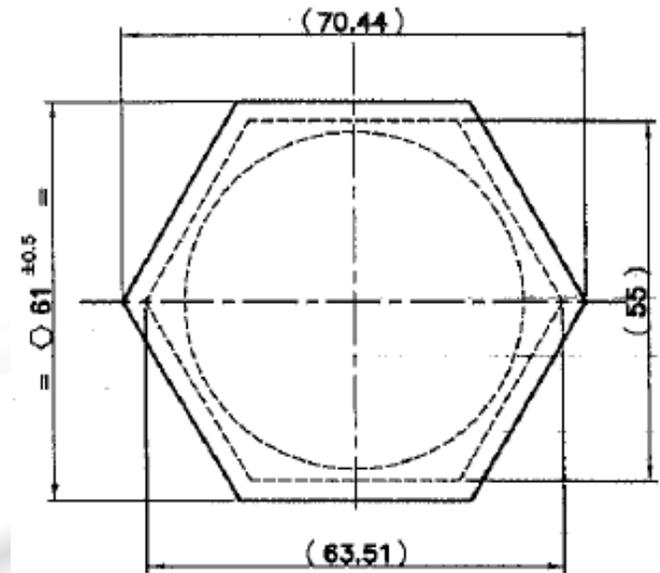


Multiple crystals concept

- reduced dead zones
- crystal sizes 14x40x80mm

Hexagonal shape

- crystal sizes 55x60x102mm



Customized design



Space flight BrillLanCe design

BrillLanCe design 3"x6"

High energy Spectroscopy – 20 MeV

High magnetic field – 50 Gauss



Elongated BrillanCe designs to provide directionality information

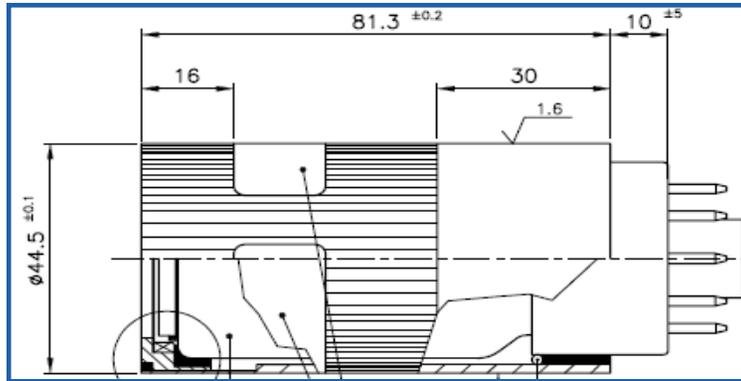


1"x4"

- Unique material homogeneity
- Optimized side on performance
- To collect isotope direction information

	PHR @ 662keV
End on	$\leq 3,2\%$
Side on	$\leq 3,5\%$

BrilLanCe X-Ray designs explore high count rates for X-Ray analysis



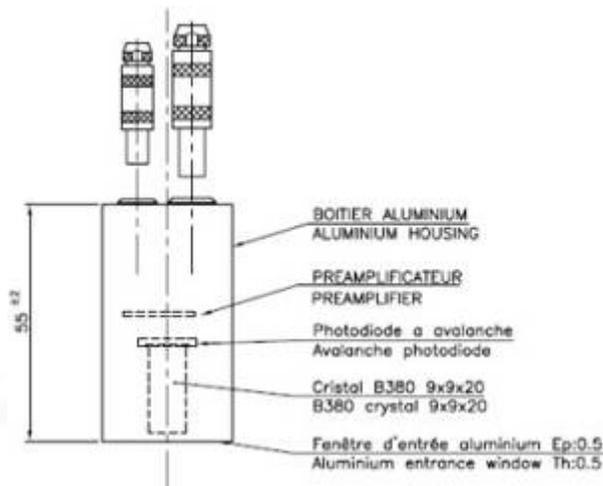
Thin BrillanCe plates
Coupled to fast PMTs

	PHR @ 5,9keV	P/V	Count rates
BrilLanCe™350	≤ 50%	≥ 45	>> 2MHz
BrilLanCe™380	≤ 45%	≥ 70	>> 2MHz
Nal(Tl)	≤ 50%	≥ 45	<500kHz

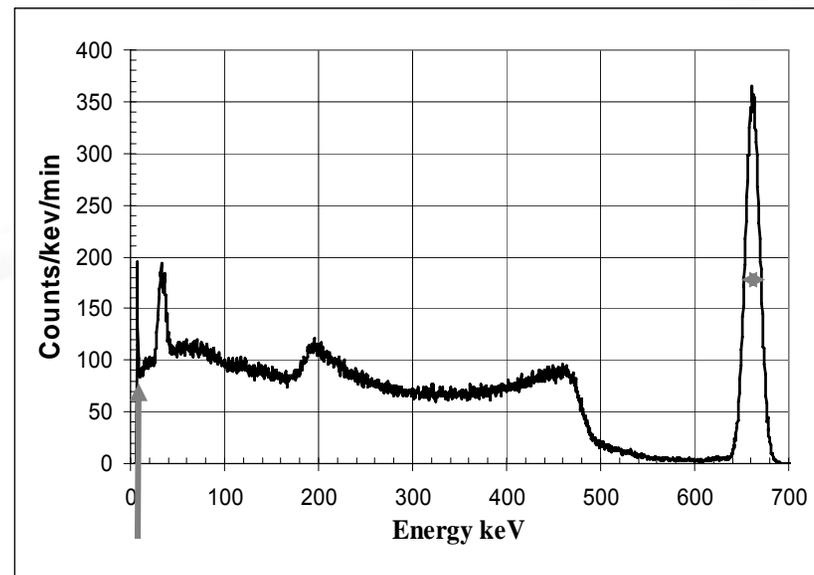
Compact BrillanCe™380 / APD



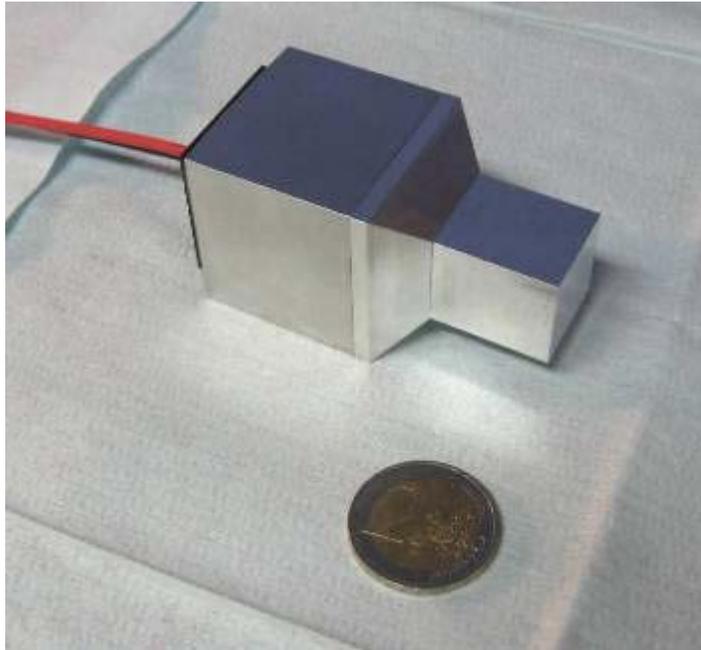
- 55mm long
- Integrated design
- 2,8% PHR @ 662keV
- 10keV noise level



B380 crystal 9mmx9mmx20mm long



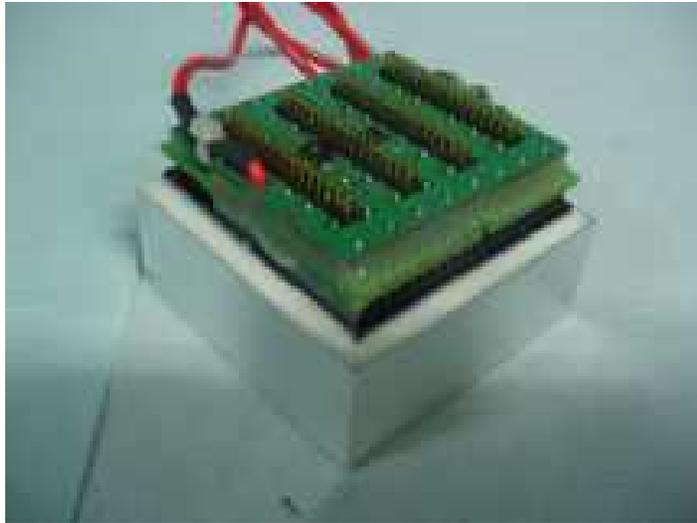
Compact BrillanCe™380 / PMT solutions



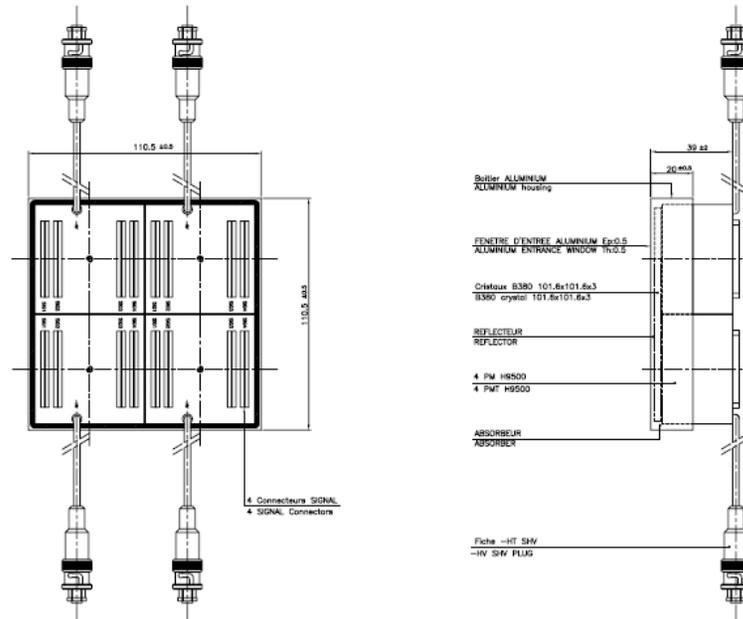
B380 16x16x30

- **71mm long** Integrated design PMT/VD
- **B380 crystal 16mmx16mmx30mm**
- **<3% PHR @ 662keV**

Product developments - medical imaging



102X102mm²

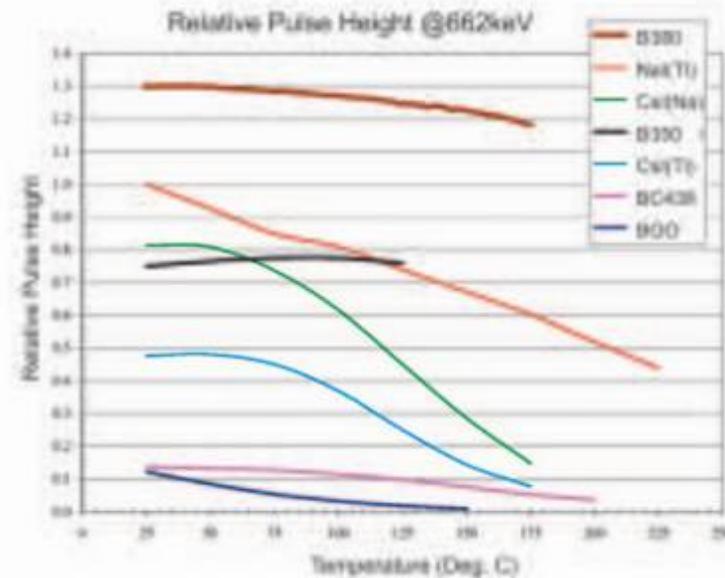


SPECT

- Improved energy resolution
- Dual isotope capability
- Improved spatial resolution

Recent more rugged design

Product developments - High T° designs

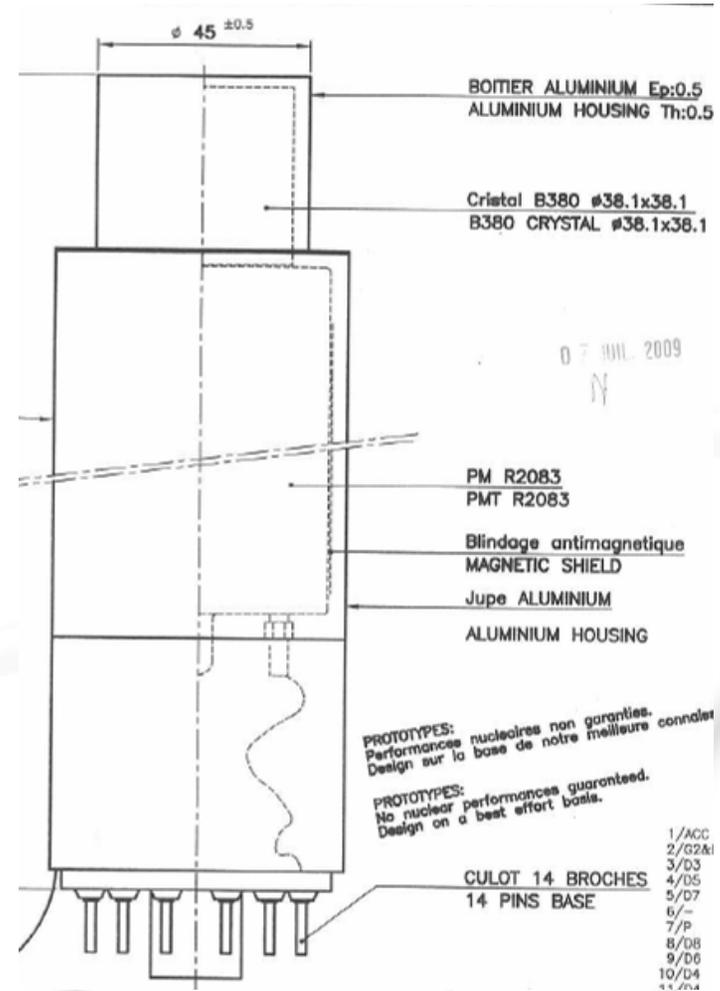


- Rugged design with integrated PMTs
- High L.O. at high temperatures – minimize power consumption downhole
- Excellent energy resolution yields to accurate C/O ratio determination
- High density increases counting efficiency

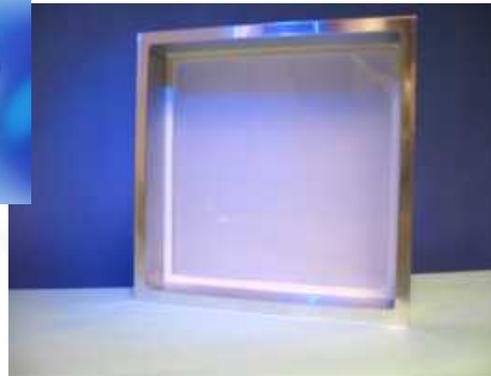
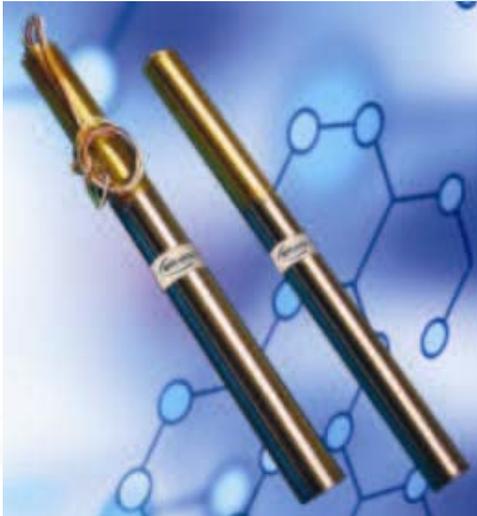
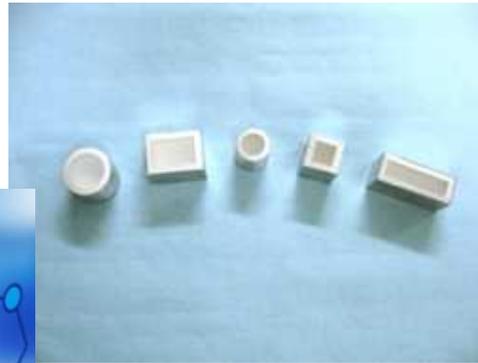
Timing detector

In progress:

Substitution to former
Photonis XP2020,
XP20D0

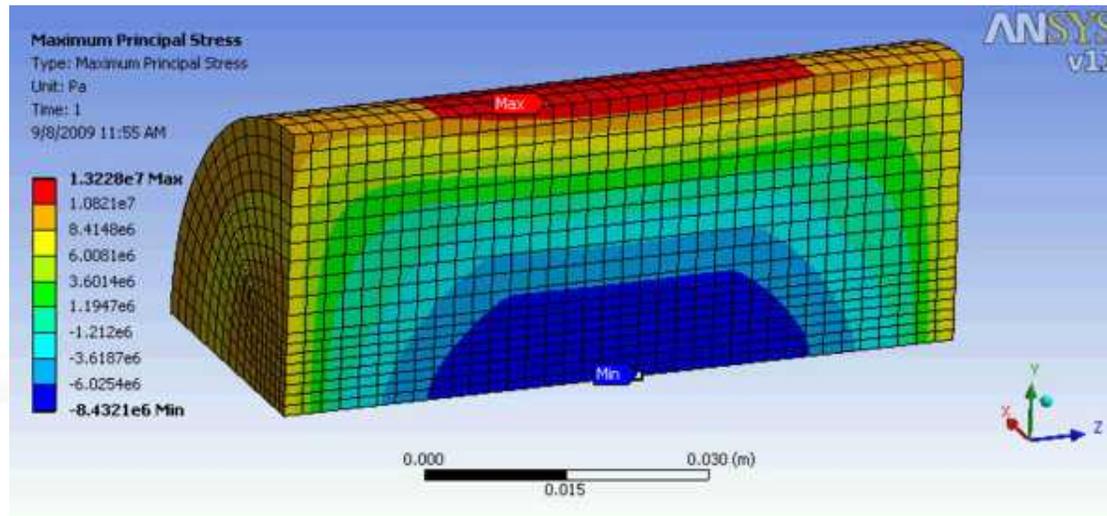


A wide range of products available

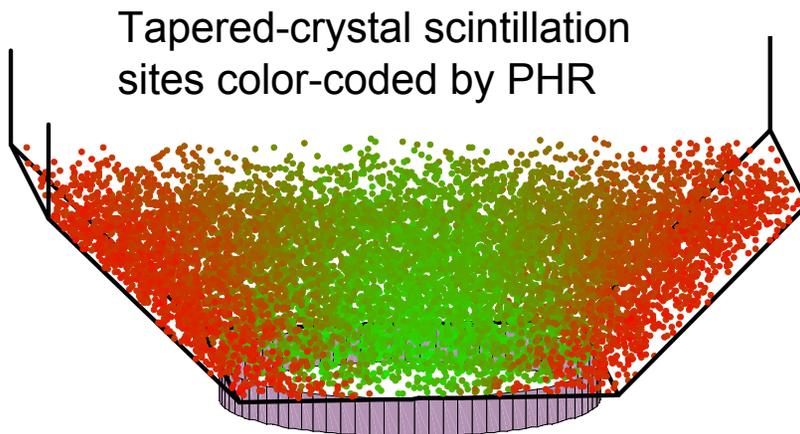


Engineering Design

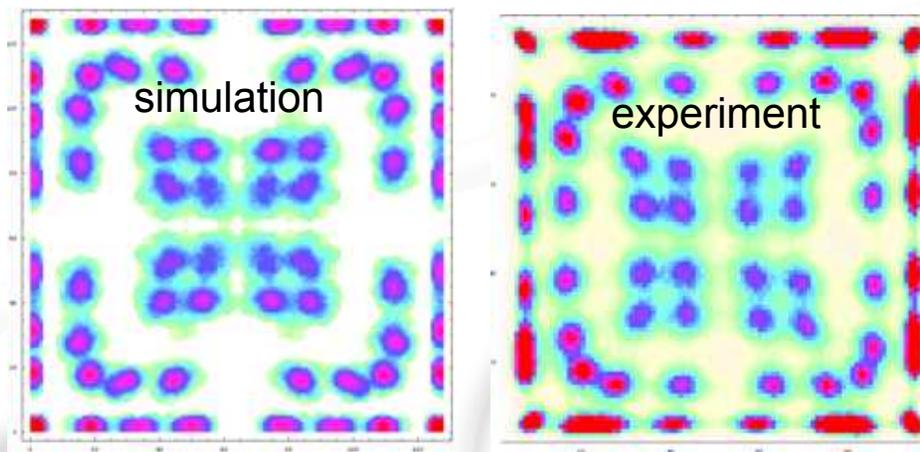
- Saint-Gobain uses advanced design tools, including Pro Engineer 3-D modeling, ANSYS finite element analysis and Cadence/ORCAD electrical software



R&D Capabilities – Detector Simulation



Flat-field image of cargo-imaging module



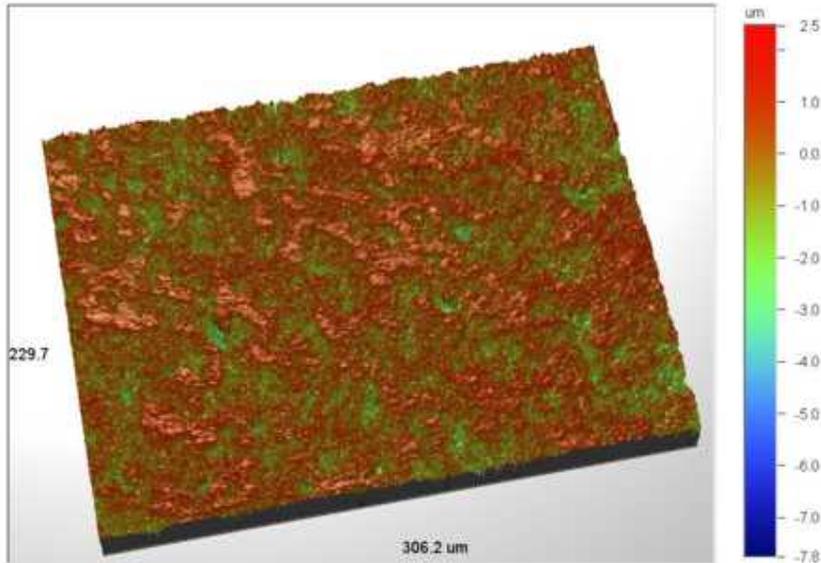
- **MCNP (v5 or vX)**
 - x- & gamma-ray transport
 - Nuclear interactions
- **DETECT2000**
 - optical transport of scintillation light through system to detection
 - includes optical properties & surface topology
 - includes wavelength dependency

With post-processing, can predict: PHR, image quality, DQE, MTF, Swank noise, cross-talk, etc.

Advanced testing - Detector Characterization

- **PSPMT imaging of small pixel arrays**
- **PET module imaging**
- **Detector performance from -80° to 230° C**
- **Solid-state detector testing**
- **Silicon photon detection devices**
- **Coincidence resolving time**
- **Energy linearity up to 6.1 MeV (17 isotopes available)**
- **Neutron response**
- **Anti-Compton detectors**
- **Low background testing**
- **High vacuum testing**

R&D testing – Scintillation Materials Characterization



- **Absolute scintillator light yield**
- **Scintillation pulse-shape**
- **Optical properties –**
(transmission, absorption, reflection, diffusion properties)
- **Surface topology**
(with white-light interferometer)



Testing

- **Saint-Gobain can simulate real-world conditions with its advanced test capabilities**
 - Shock/Vibration
 - Temperature/Vacuum/Humidity
 - Low Background
 - X-Ray
 - Gamma Camera Flood Imager



Advanced, Special Testing



Photo courtesy of Unholtz-Dickie Corp.

- Vibration
- Vibration Control and Data Analysis
- Temperature
- Shock
- Thermal/Vacuum

Scintillators

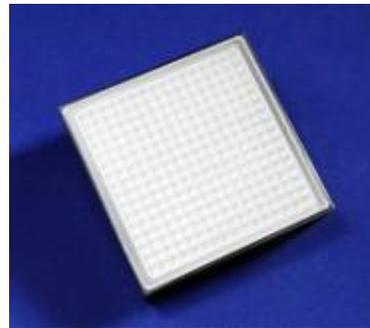
- Saint-Gobain offers an industry leading variety of scintillators and detectors, including:
 - NaI(Tl) (including Polyscin®)
 - BrillanCe™380 [LaBr3(Ce)]
 - CsI(Tl)
 - CdWO4
 - CaF2(Eu)
 - Scintillating Fiber
 - YAG(Ce)
 - PreLude™ 420 (LYSO)
 - BrillanCe™ 350 [LaCl3(Ce)]
 - CsI(Na)
 - BGO
 - BaF2
 - Scintillating Plastic
- Saint-Gobain also continues to develop new scintillators internally and with outside partners to meet current and future market needs



Unique Crystal Shapes

- Saint-Gobain has developed unique cutting, shaping and packaging equipment and facilities that allows for almost any shape:

- Cylinders
- Cubes
- Bars
- Plates
- Annuli
- Curved



- Well
- Spheres
- Arrays
- Large Format
- Near Net Shape



Assemblies and Capacity

- Detectors must be assembled and packaged to achieve and maintain high performance throughout their life
- Saint-Gobain has long experience with hermetically sealing hygroscopic materials and optimizing performance through reflectors, assembly methods and integration with the readout device



- The significant capacity of our crystal growth and assembly facilities allows for easy transition from prototype to volume production



Capacity: Hiram, OH



Nemours (France)



BrilLanCe™ Series
Scintillation Detectors

Non-linear
Optical Crystals

X-ray Monochromators

Alpha Beta Detectors

ISO 9001 Certified

Gières (France)

PreLude™420, BGO, YAG:Ce,
Scintillation Detectors

ISO 9001 Certified



Next Generation Gamma Detection

- As Saint-Gobain did with BrillanCe detectors and Delft, we are closely tracking and exploring emerging technology for commercialization and industrialization
- Preliminary development, fabrication and testing is being done in selective cases
- Please ask to discuss your requirements and our developments in more detail

Thank you for your attention.



It's *what's*
Inside
that **Counts**®


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