

# *2010 update on the ROSEBUD project*

**IDM 2010**

*8<sup>th</sup> International Workshop on  
**Identification of Dark Matter***

*University of Montpellier 2, Tuesday 27 July 2010*



Institut d'Astrophysique Spatiale IAS  
(Orsay, France)

Spectrométrie Thermique pour  
l'Astrophysique et la Physique Group



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Nuclear and Astroparticle Physics Group



# ROSEBUD

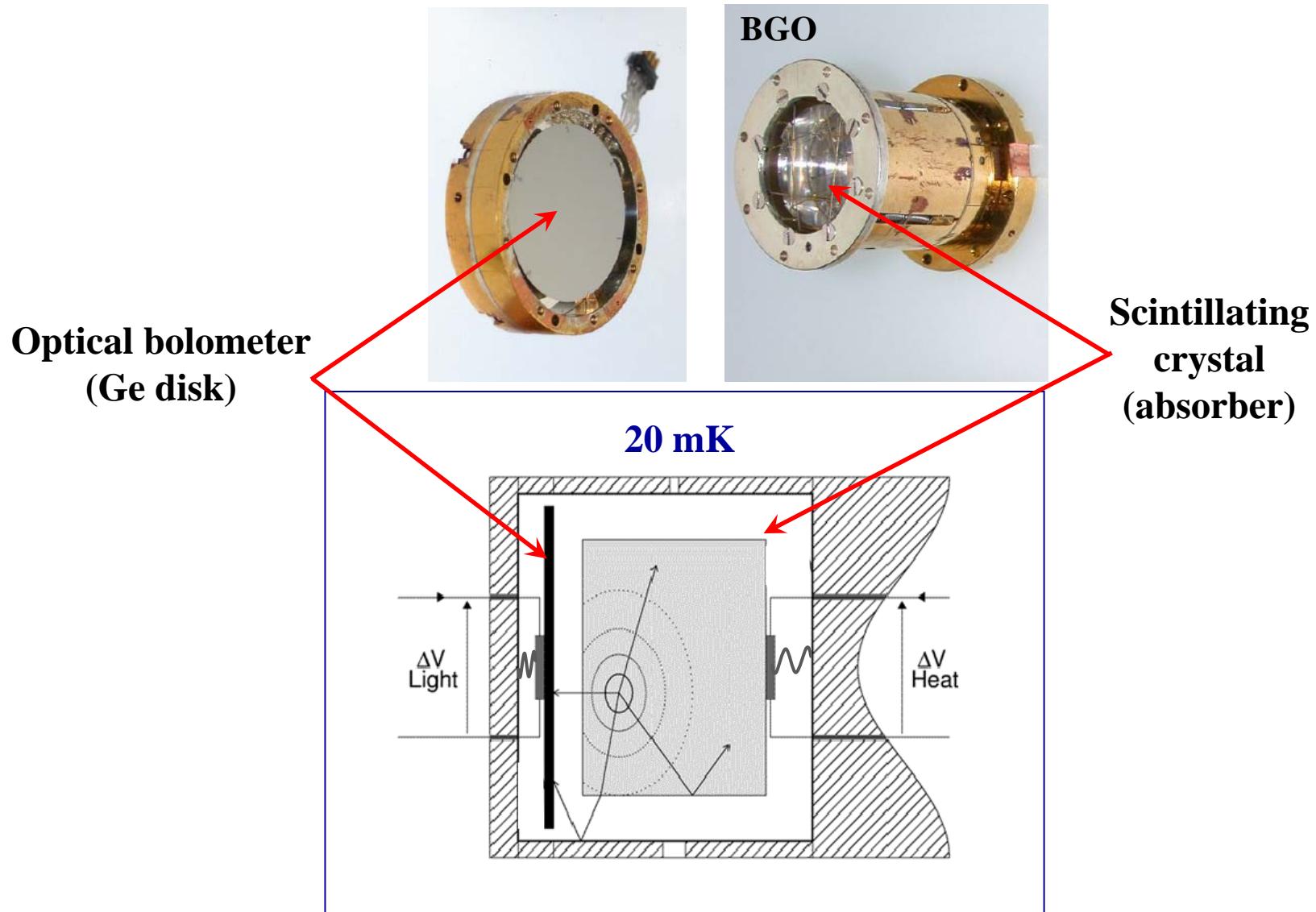
(Rare Objects SEarch with Bolometers UndergrounD)

**ROSEBUD develops scintillating bolometers of different materials to use them in Nuclear and Particle Physics experiments focusing on Dark Matter search**

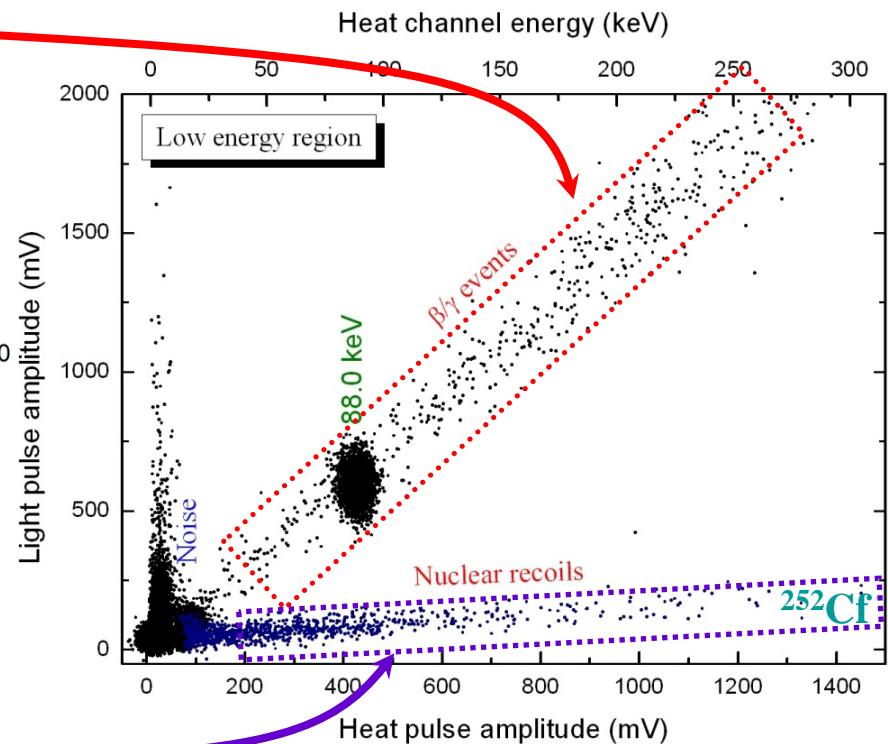
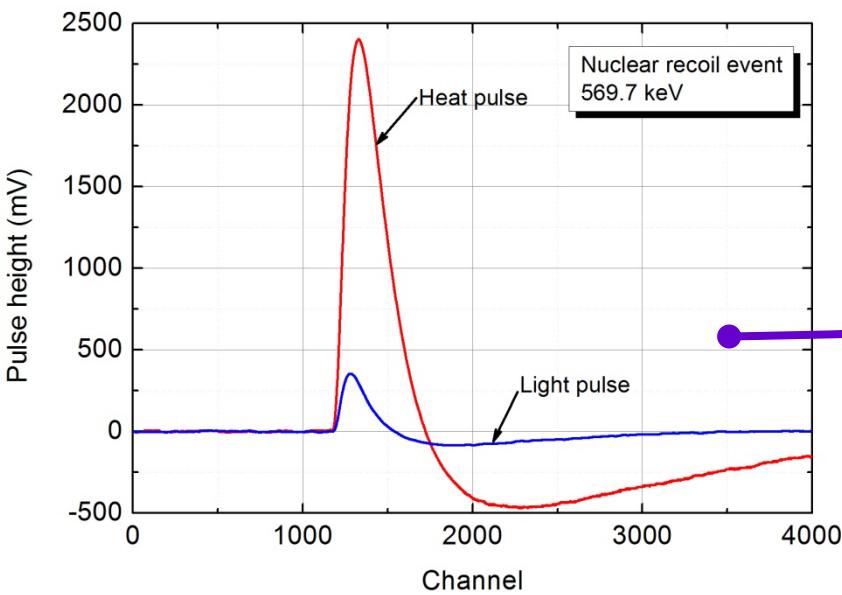
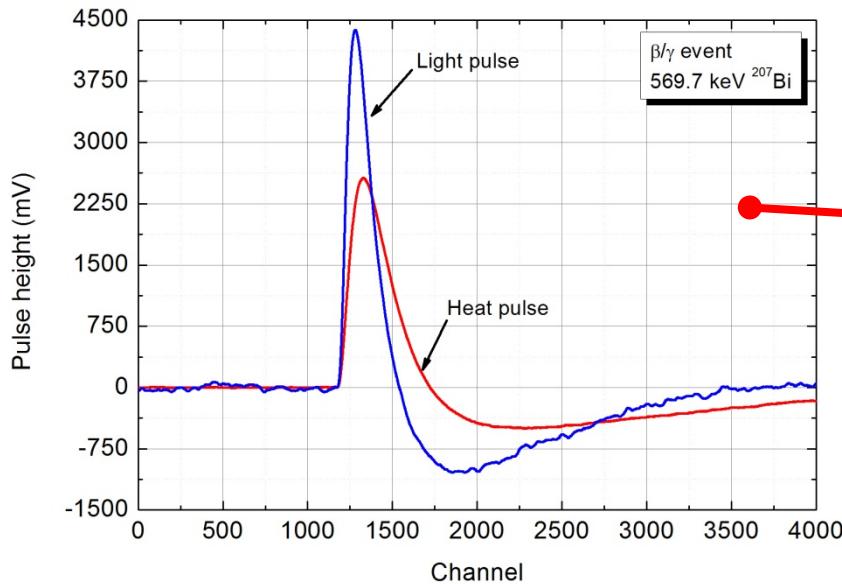
# Outline

- A. The scintillating bolometer
- B. Experimental set-up
- C. BGO ( $\text{Bi}_4\text{Ge}_3\text{O}_{12}$ ) as dark matter detector prototype:
  1. Light REF( $\beta/\gamma$ :nuclear recoils(NR)).
  2. NR spectra at the LSC.
  3. Sensitivity of the 46 g BGO.
  4. Comparison of BGO with other relevant targets.
- D. Neutron spectroscopy with  $\text{Al}_2\text{O}_3$  and  $\text{LiF}$

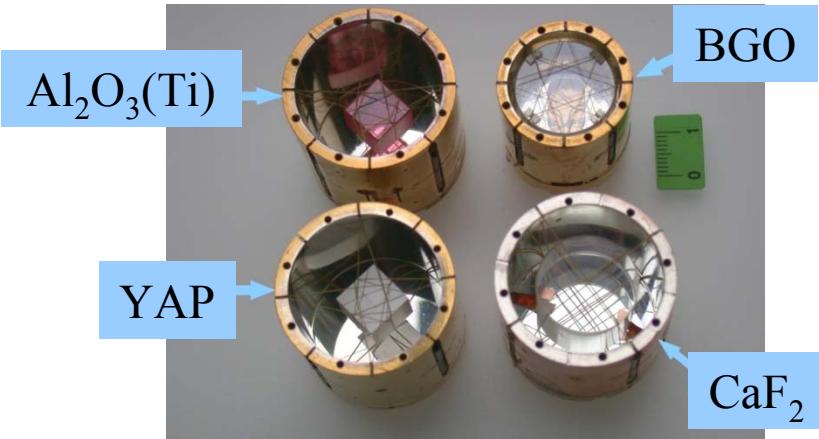
# The scintillating bolometer



# Particle discrimination



# Experimental set-up in IAS

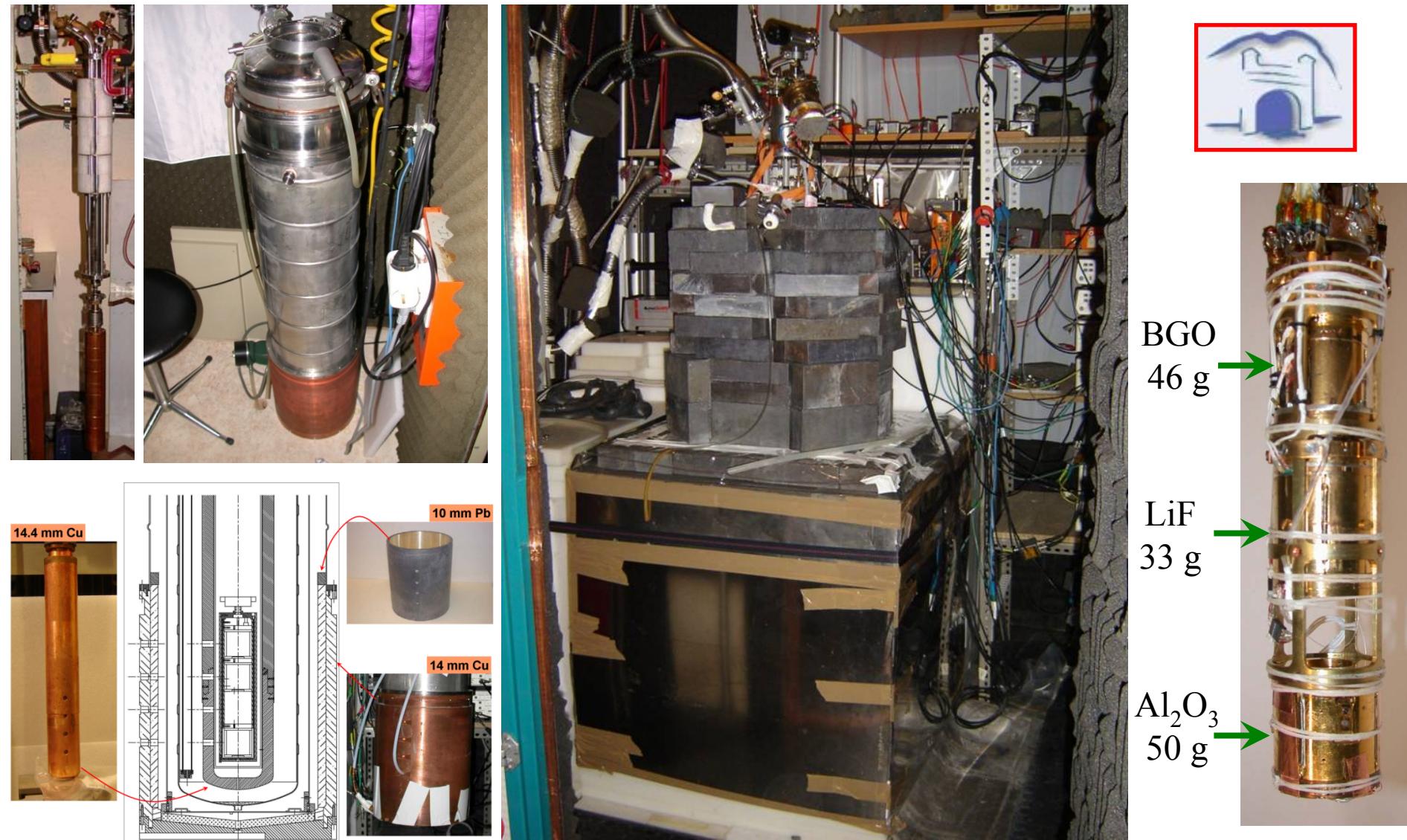


✓ R&D line: characterization of scintillating materials at low temperature. **All materials tested have shown scintillation at low temperature:** CaWO<sub>4</sub>, BGO, LiF, TeO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> (\*), SrF<sub>2</sub>, SiO<sub>2</sub>, CaF<sub>2</sub>

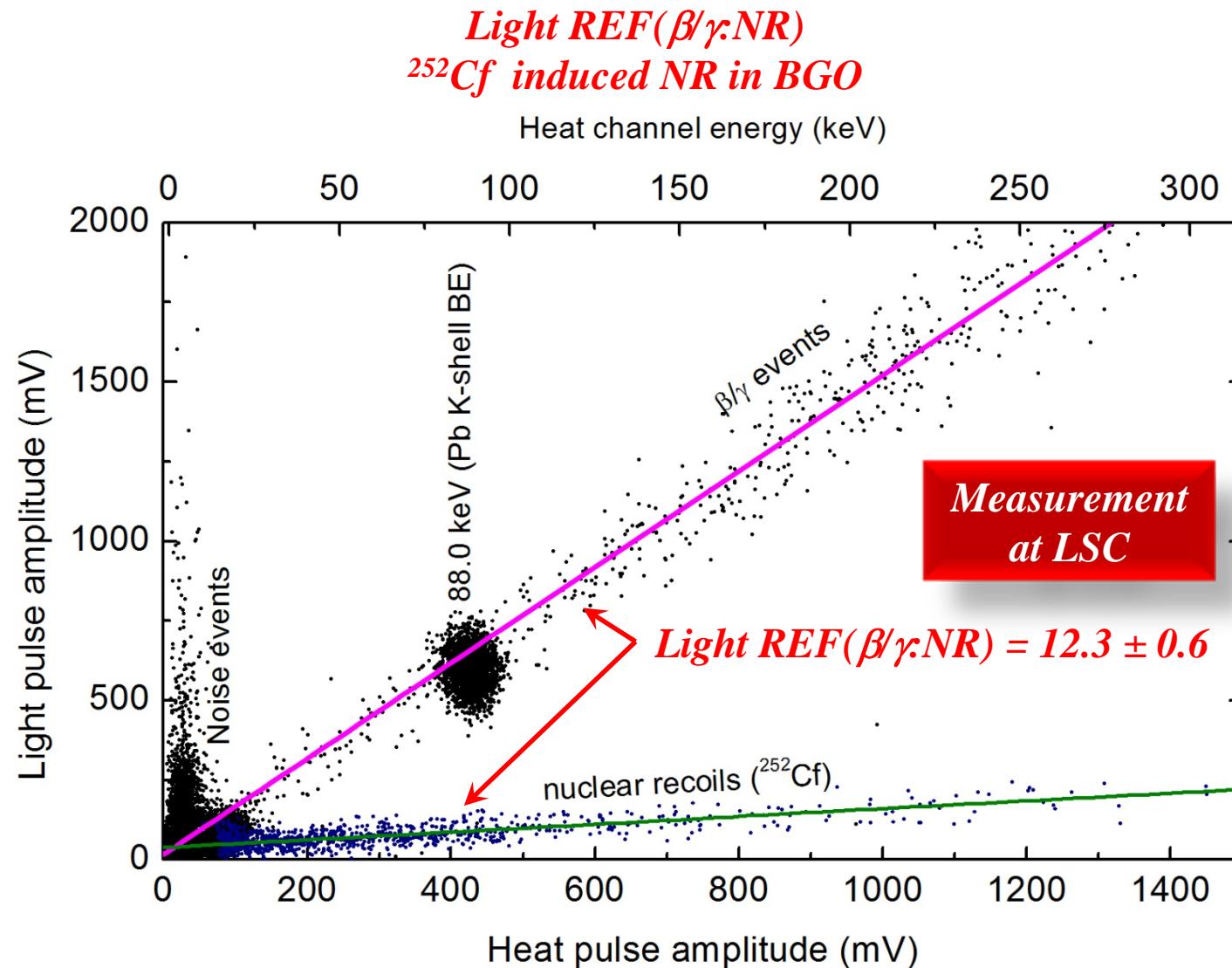
(\*) Results presented at LTD-10 Workshop  
(NIM A 520 (2004) 159-162)



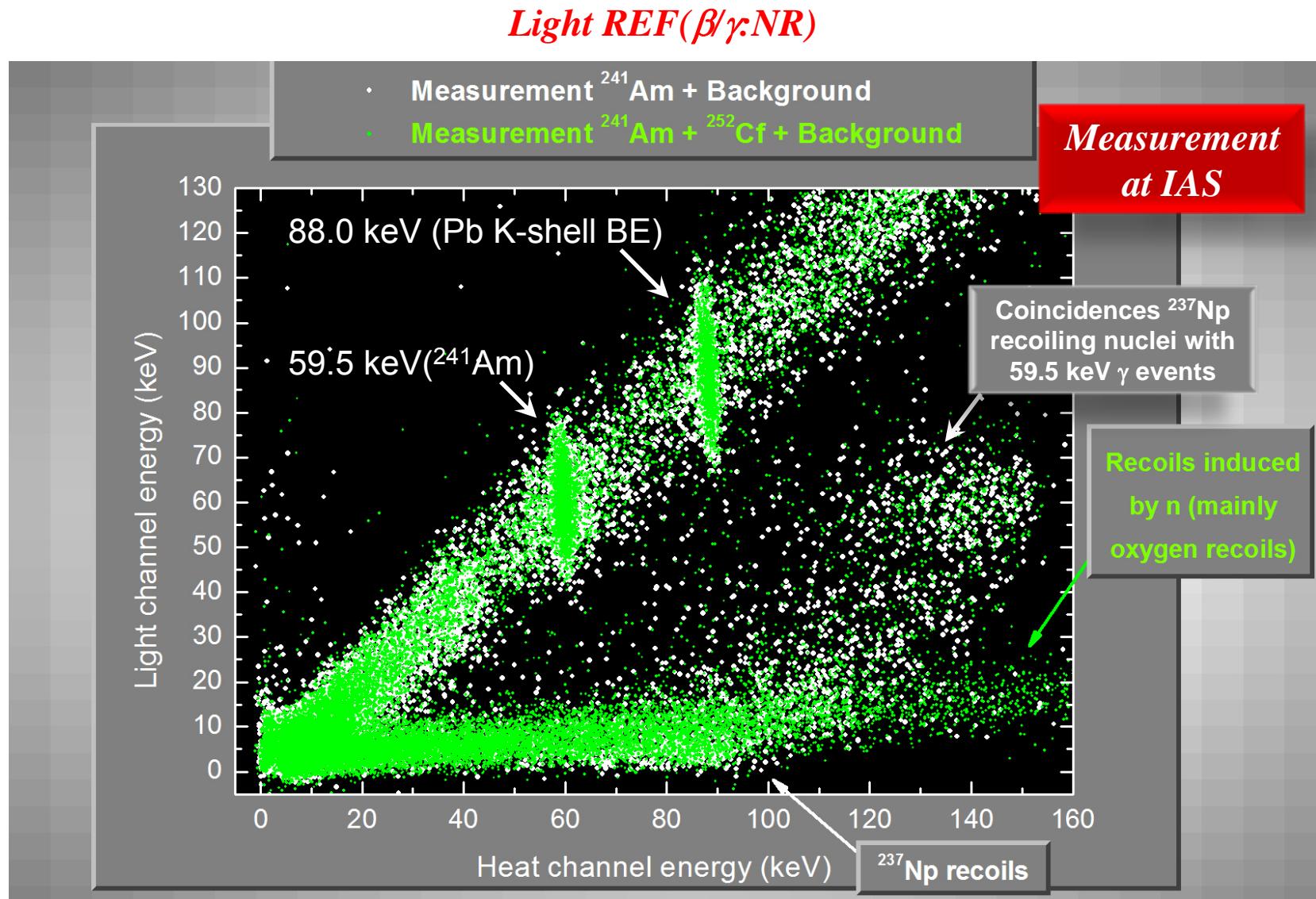
# Experimental set-up in the LSC at 2450 m.w.e.



# Discrimination capability of the BGO scintillating bolometer

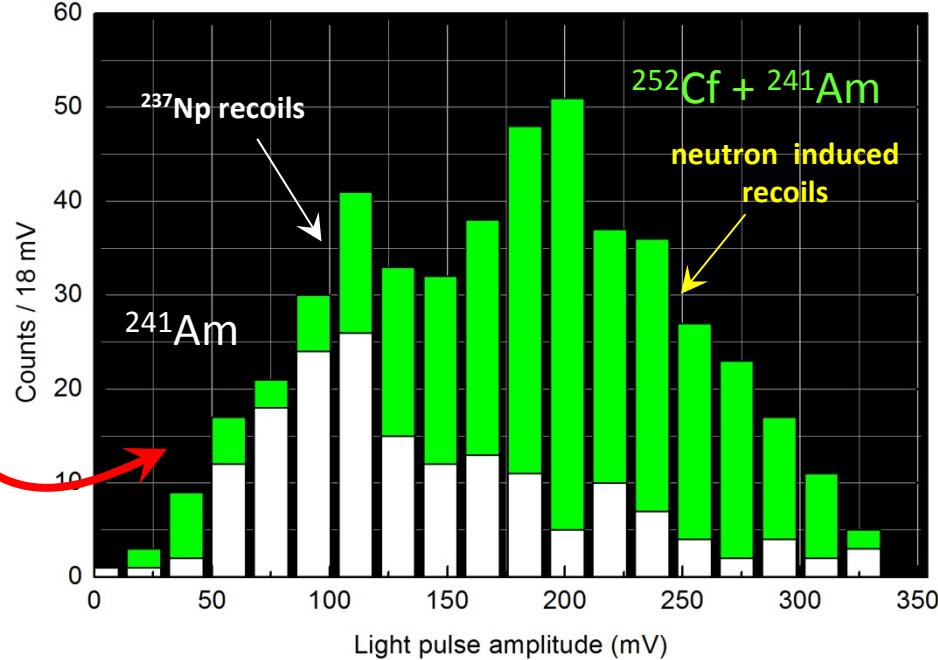
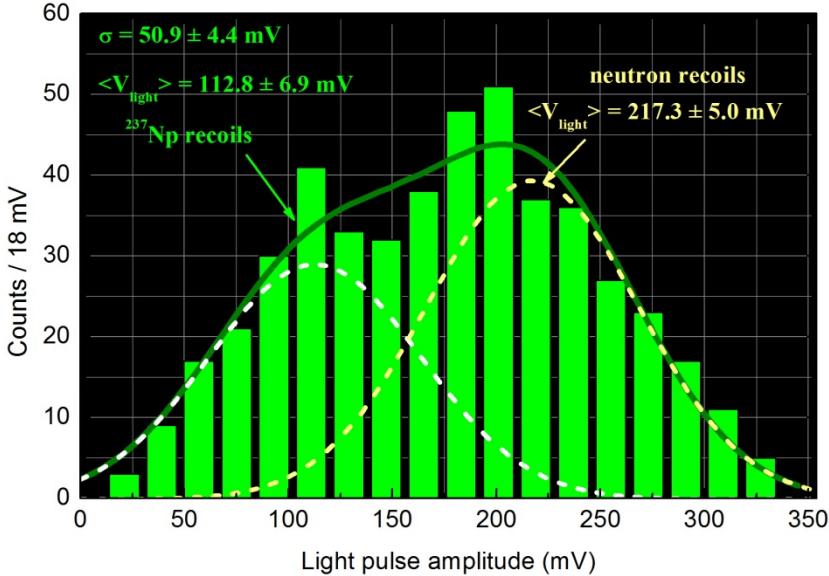
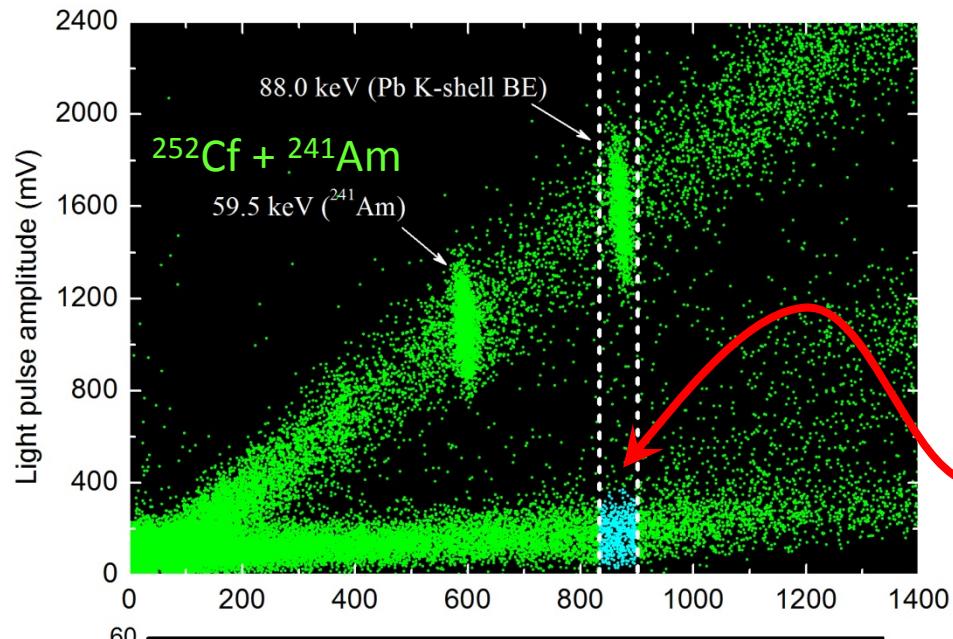


# Discrimination capability of the BGO scintillating bolometer



# Discrimination capability of the BGO

*Light REF( $\beta/\gamma$ :NR)*



*Light REF( $\beta/\gamma$ :NR(mainly O))*

$$10.5 \pm 0.4_{\text{stat}} \pm 0.8_{\text{syst}}$$

*Light REF( $\beta/\gamma$ : NR( $^{237}\text{Np}$ ))*

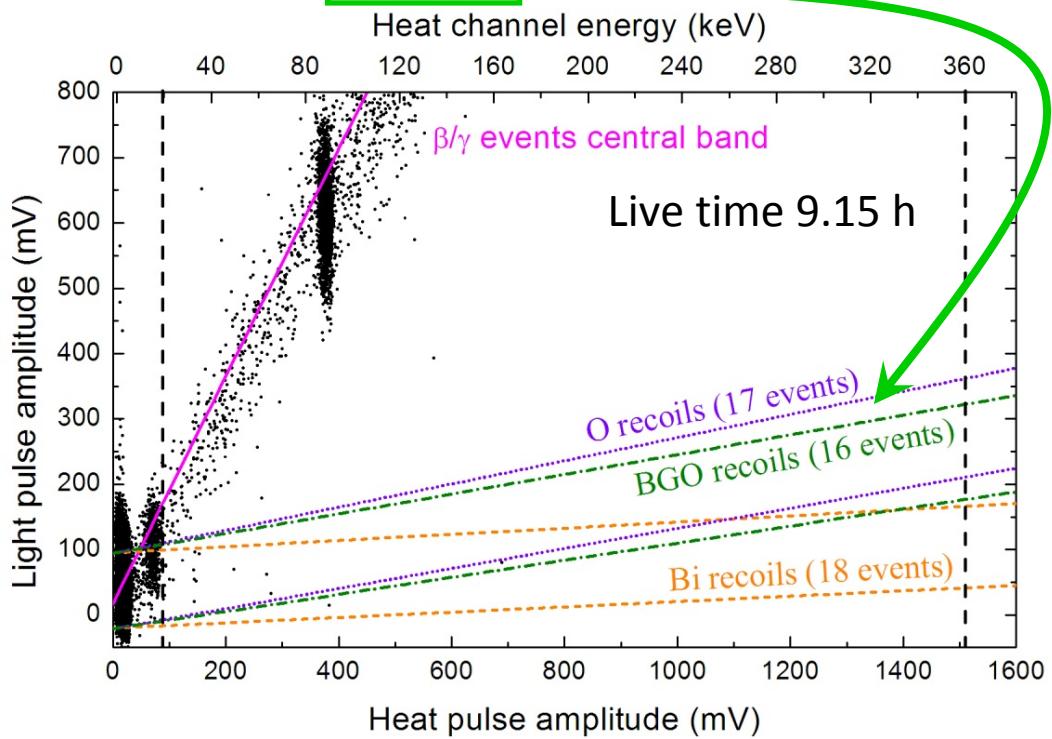
$$39.5 \pm 7.2_{\text{stat}} \pm 13.7_{\text{syst}}$$

# NR acceptance bands in the BGO scintillating bolometer

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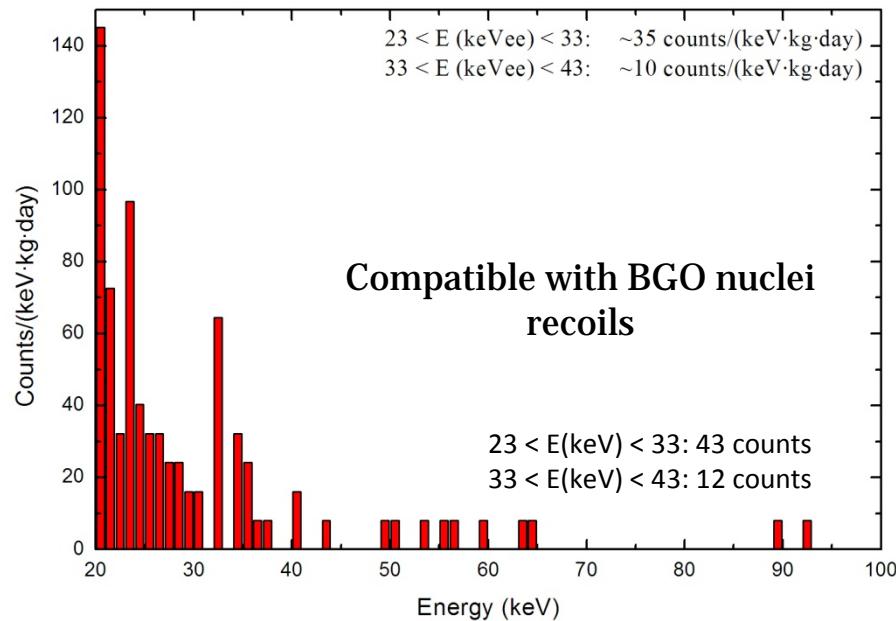
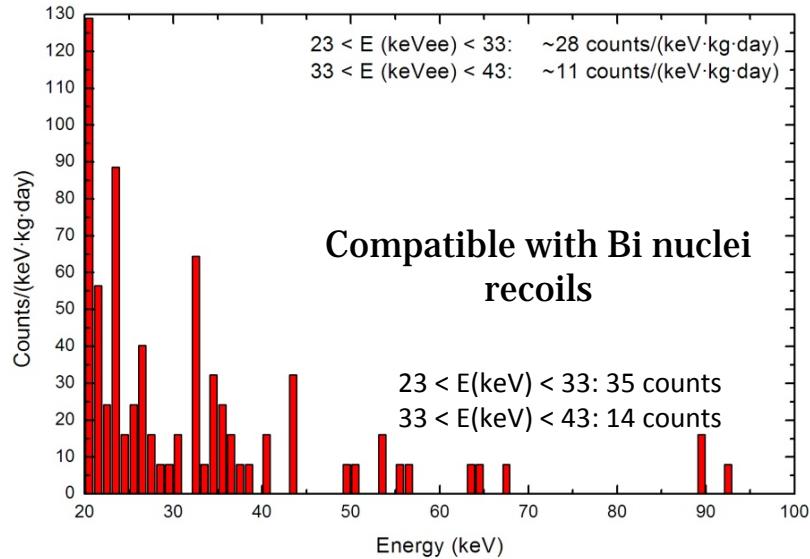
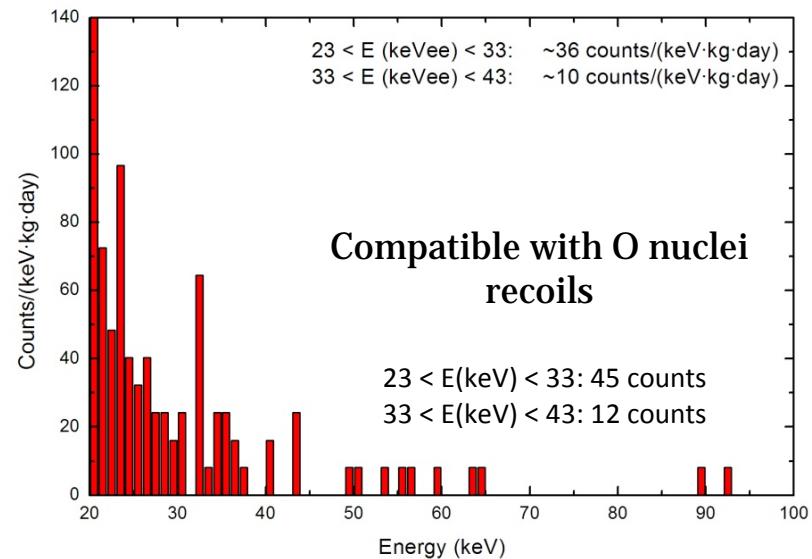
## Discrimination threshold for NR

NR	Light REF	Discrimination threshold in the heat channel (keV)	
		Rejection of $\beta/\gamma$ events	
	REF( $\beta/\gamma$ :NR)	90% CL	99.9% CL
O	$10.5 \pm 0.9$	23.8	33.8
BGO	$12.3 \pm 0.6$	23.5	33.3
Bi	$39.5 \pm 15.5$	22.6	31.6



# Background NR spectra obtained at the LSC with the BGO

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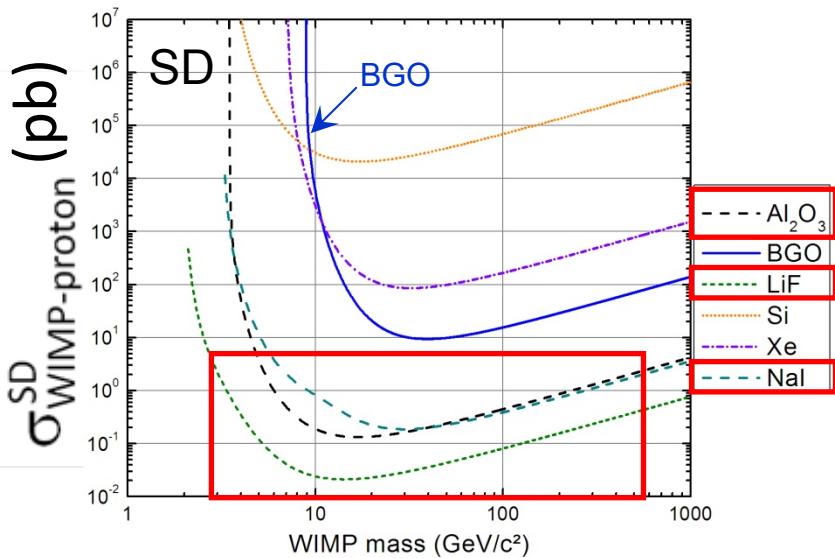


Spectra with  
71.94 h live  
time

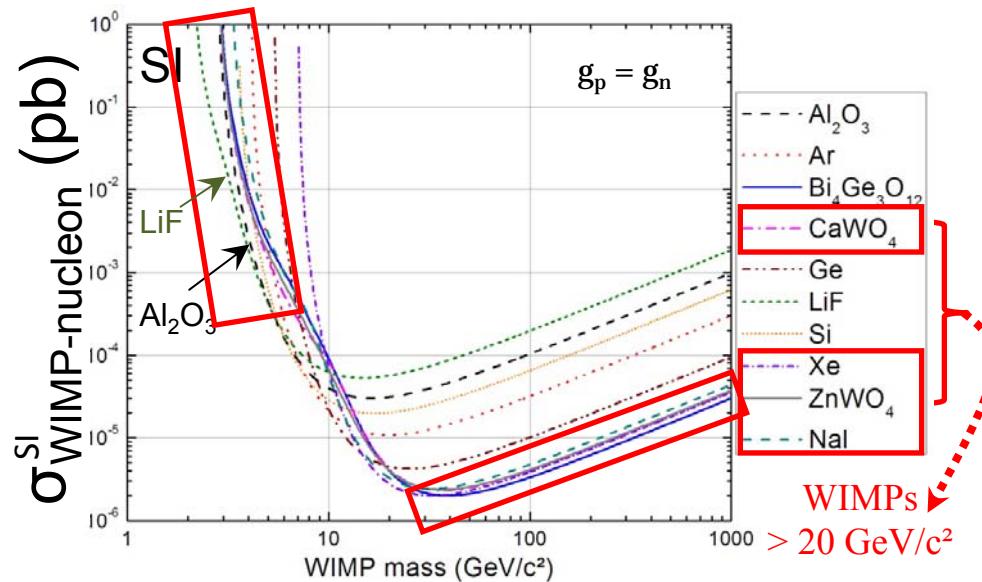
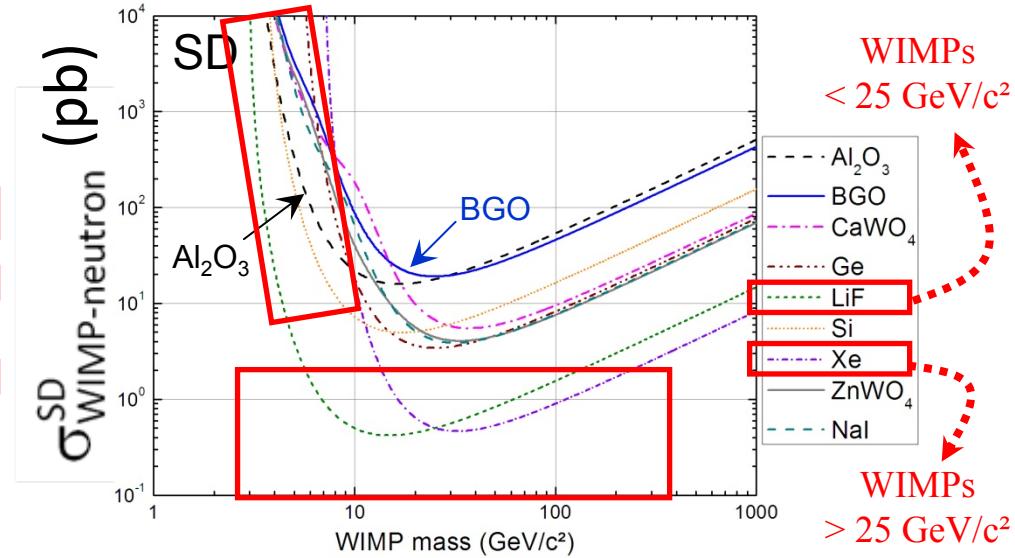
High rates for being  
neutrons in a deep  
underground  
location

# BGO is a good target for SI

## Targets sensitivity in SD and SI interactions



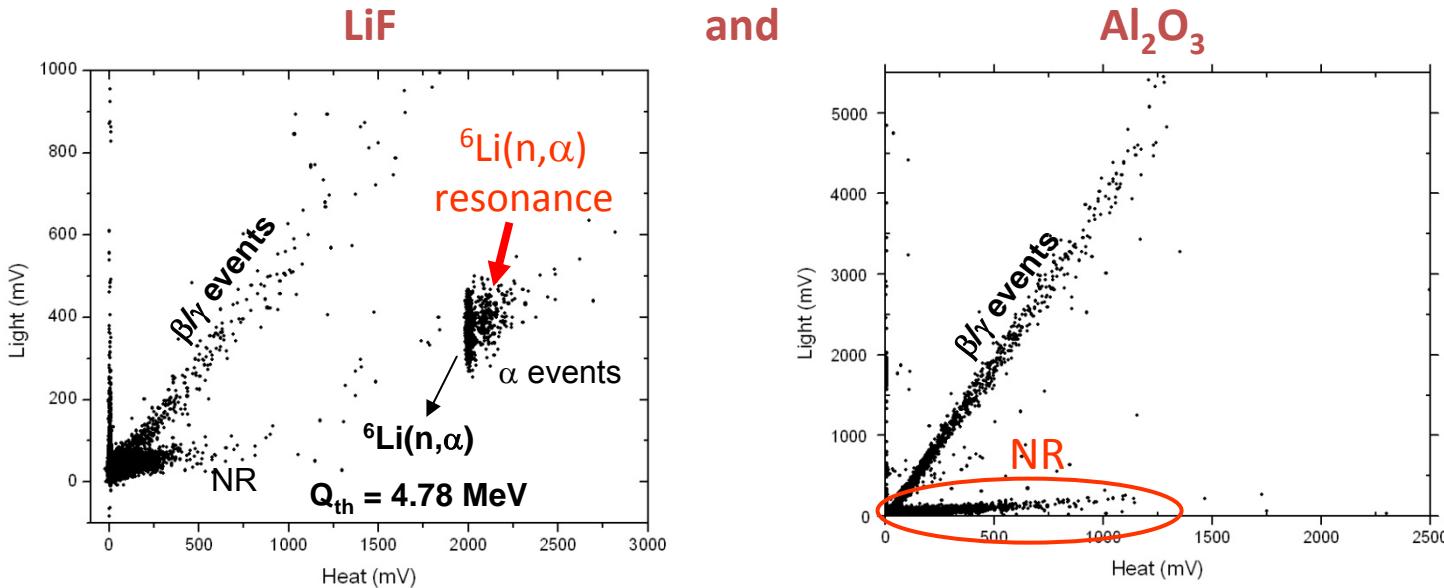
Exclusión curves at 90% CL  
 Energy window 5 keV – 10 keV  
 Flat background = 0.1 counts/(keV·kg·day)  
 Exposition = 100 kg·day  
 $\text{FWHM} \rightarrow 0$   
 $\text{REF } (\beta/\gamma:\text{NR}) = 1$



# Neutron spectroscopy

## Fast neutron flux inside the shielding

Irradiation of a 33 g LiF and a 50 g Al<sub>2</sub>O<sub>3</sub> scintillating bolometers with <sup>252</sup>Cf



Previous work presented at TAUP09: *J Phys: Conf Series 203 (2010)012139*

Hypothesis: fast neutron flux inside the lead shielding

$$\frac{\Phi_0}{\Gamma(\alpha+1)} \left( \frac{E}{T} \right)^\alpha e^{-\left(E/T\right)} \frac{dE}{T}$$

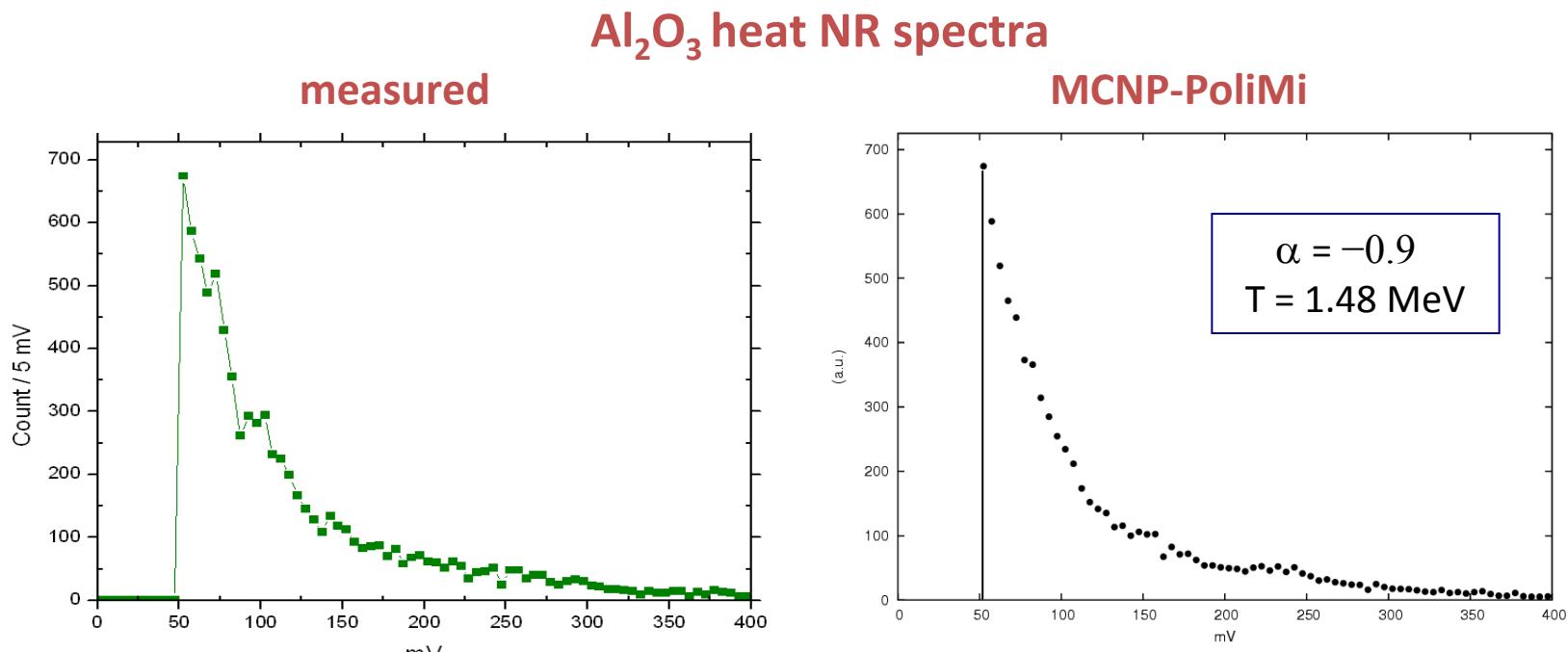
We estimated the region of three parameters ( $\Phi_0, \alpha, T$ ) compatible with experimental data

# Neutron spectroscopy

## Fast neutron flux inside the shielding

Present work: Testing hypothesis about the fast neutron flux inside the shielding

$$\frac{\Phi_0}{\Gamma(\alpha+1)} \left( \frac{E}{T} \right)^\alpha e^{-\left( \frac{E}{T} \right)} \frac{dE}{T}$$



**Spectra shape in good agreement**

**Comparison of full experimental data with MC calculation is in progress**

# CONCLUSIONS

- ✖ We have characterized a BGO scintillating bolometer at 20 mK as dark matter detector prototype.
- ✖ BGO shows a discrimination threshold of 23.5 keVee for NR acceptance.
- ✖ BGO is a good target for heavy WIMPs ( $> 20 \text{ GeV/c}^2$ ) with SI interactions and also LiF and  $\text{Al}_2\text{O}_3$  are interesting targets for light WIMPs.
- ✖ Simultaneous use of LiF and  $\text{Al}_2\text{O}_3$  scintillating bolometers allows us to monitor and estimate the neutron flux spectrum inside the Pb shielding (work in progress).
- ✖ Other possible WIMP and neutron targets are being developed.