SABRE: Sodium-iodide with Active Background Rejection

WHAT

An experiment based on NaI(Tl) scintillating crystals and focused on the achievement of an ultra-low background

WHERE

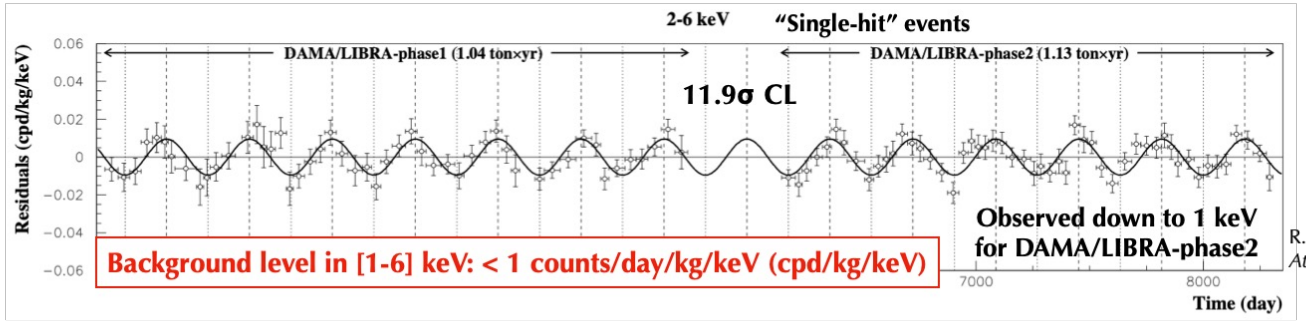
At the Gran Sasso National Laboratory (LNGS, Italy) and Stawell Underground Physics Laboratory (SUPL, Australia)

WHY

Search for galactic dark matter (DM) through the annual modulation effect and model-independent test of the long-standing DAMA result

An annually modulated signal compatible with the DM hypothesis has been observed by the DAMA/LIBRA experiment at LNGS, in Italy.

250 kg of high purity NaI(Tl) crystals + passive shielding

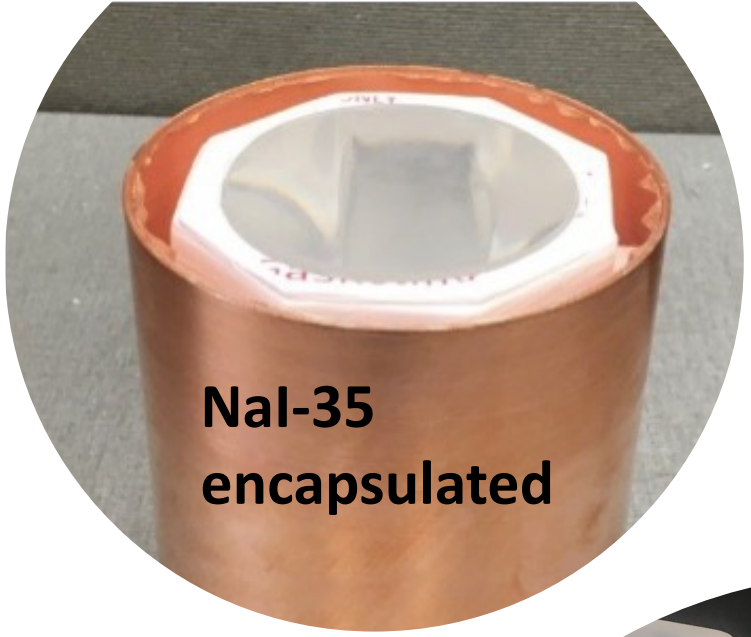


R. Bernabei et al., *Nuclear Physics and Atomic Energy*, 19(4):307–325, 2018.

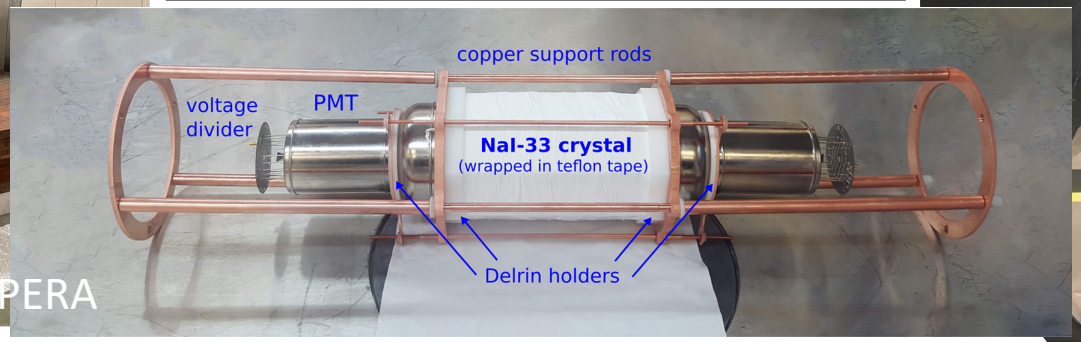
- Experiments using different target materials seem to exclude the interpretation of DAMA signal as due to spin-independent DM scattering off nuclei in the standard WIMP galactic halo hypothesis.
- Currently running experiments using the same target (ANAIS-112 and COSINE-100), have not yet reached the ultra-low background and sensitivity achieved by DAMA → **A new high sensitivity and low background measurement with NaI(Tl) crystals is needed.**

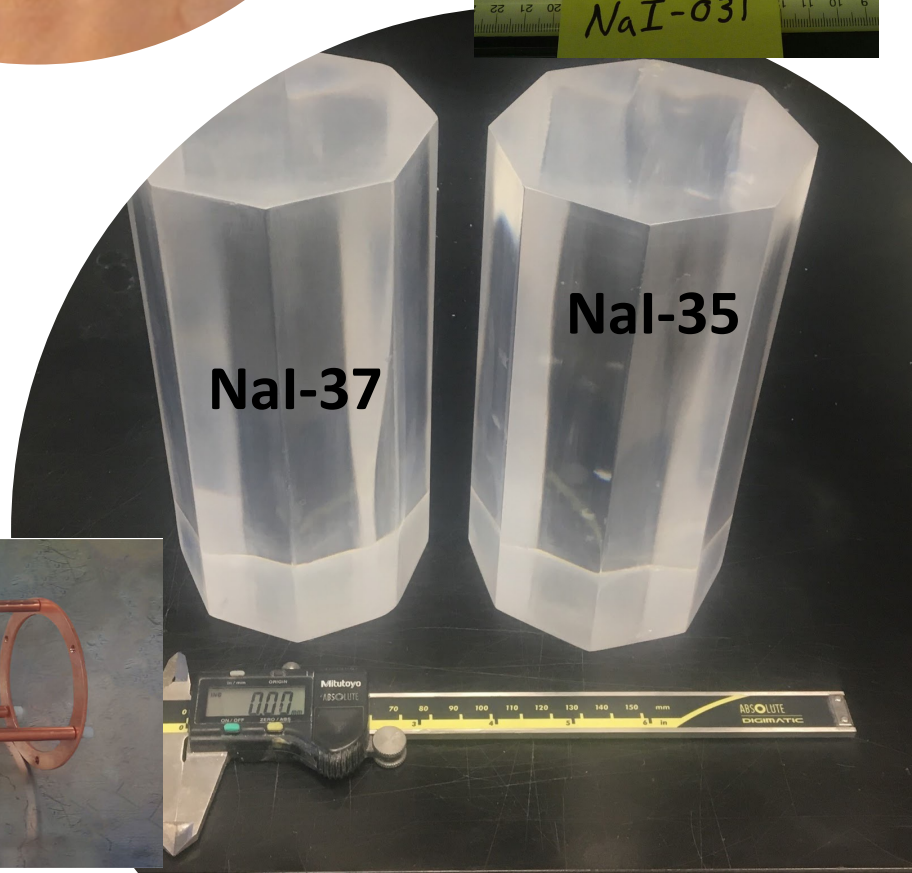
SABRE

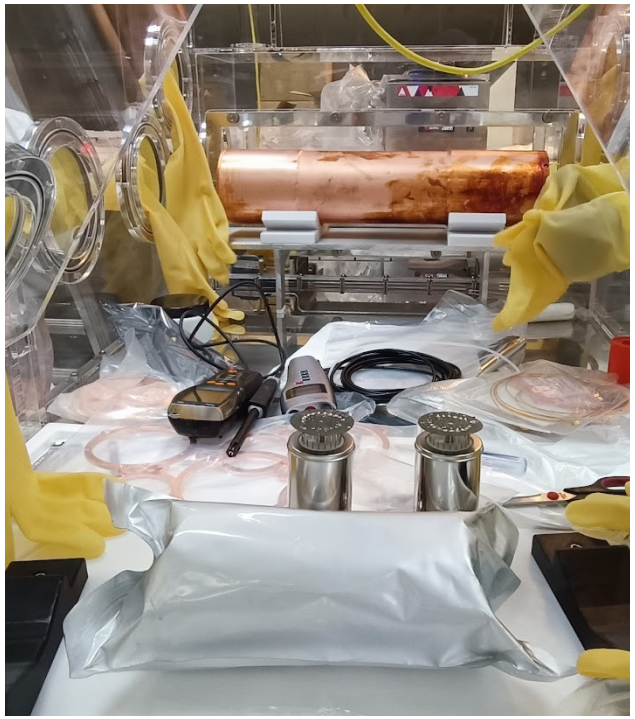
- **NaI-33** (3.4 kg) da agosto 2019, assemblato a Princeton
- **NaI-35** (4.35 kg) da maggio 2022, assemblato ad RMD
- **NaI-37** (4.36 kg) da marzo 2022, assemblato a LNGS

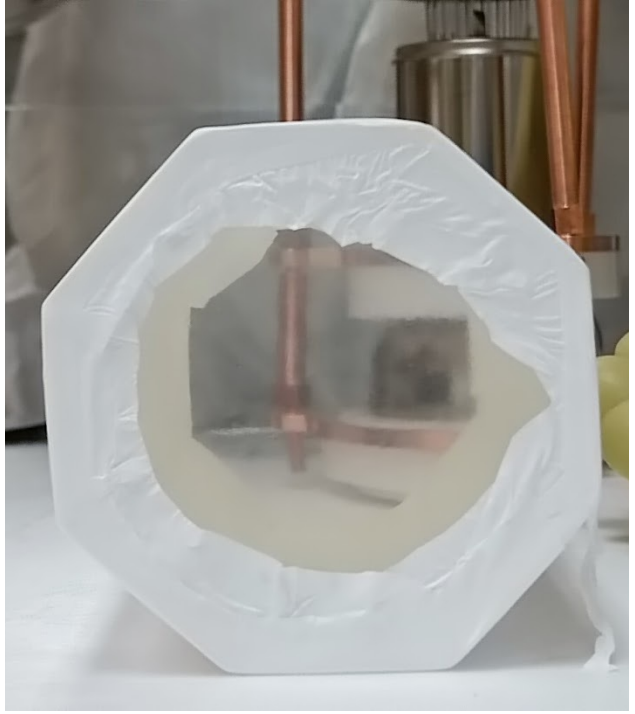


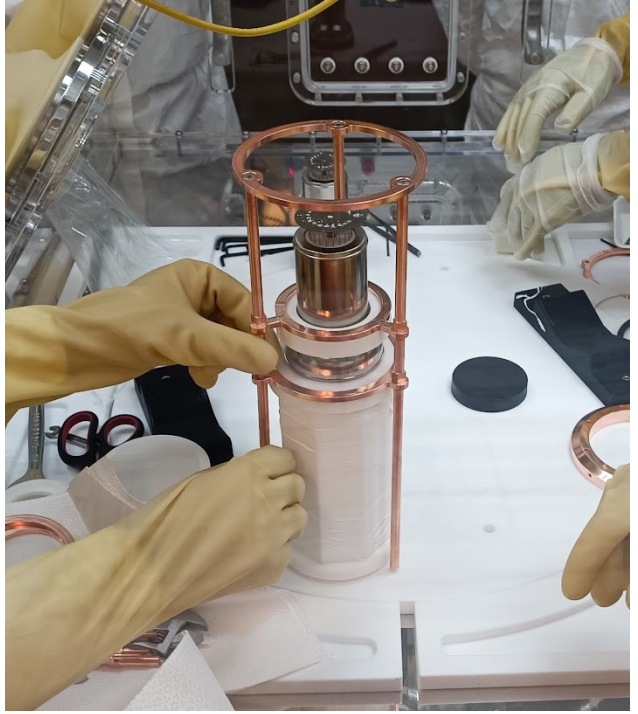
NaI-33 resta il cristallo NaI più radiopuro realizzato dopo DAMA

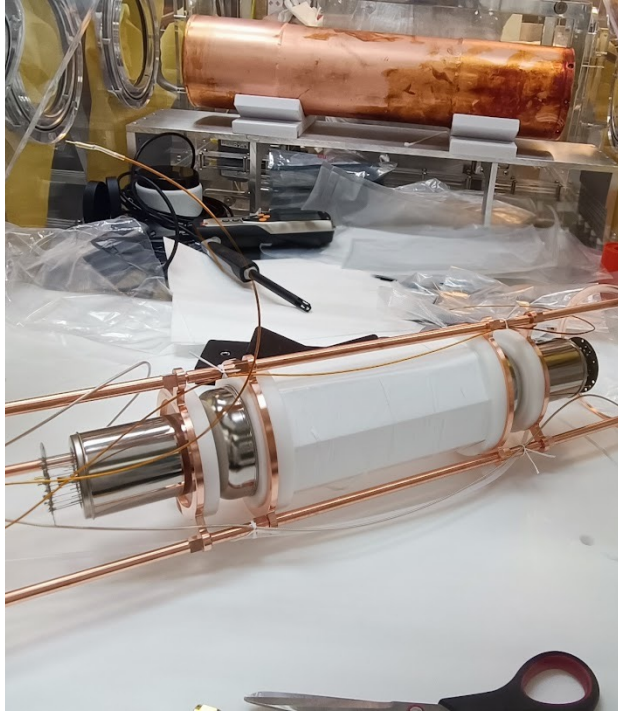










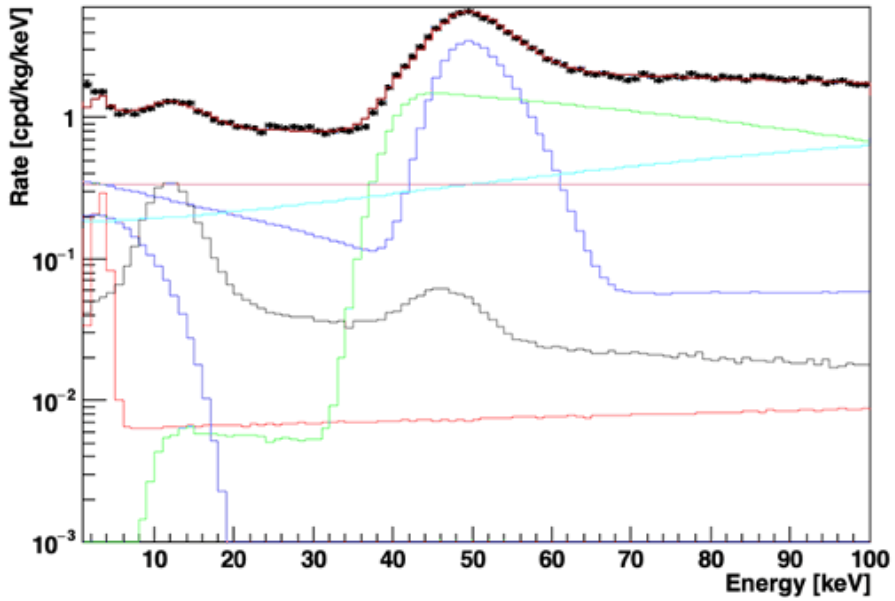


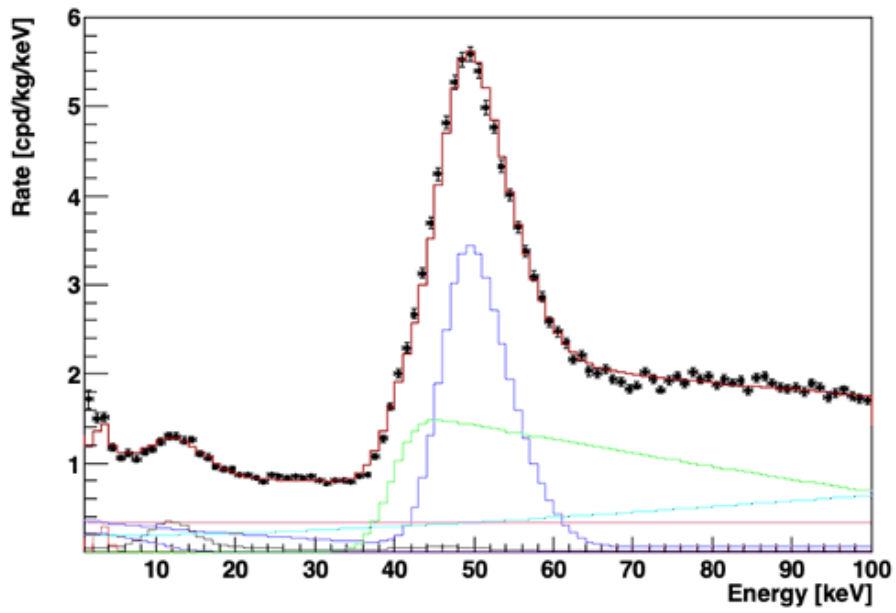
Montaggio NaI-37 in glove box dentro una low-radon clean room ^{222}Rn (400mBq/m^3)

Nuovo background model

Source	Rate in ROI [1,6]keV cpd/kg/keV	Fit results
^{40}K	0.125	0.16±0.01 mBq/kg
^{210}Pb bulk	0.333	0.49±0.05 mBq/kg
^{210}Pb reflector bulk	0.054	11±1 mBq/kg$_{PTFE}$
^{210}Pb reflector surface	0.023	<0.6 mBq/m^2
^{3}H	0.198	24±2 μBq/kg
^{129}I	0.0003	1.03±0.05 mBq/kg
^{238}U	0.006	5.9±0.6 μBq/kg
^{232}Th	0.0003	1.6±0.3 μBq/kg
PMTs	0.003	1.9±0.4 mBq/PMT
External	0.185	
Other β's	0.333	
TOTAL	1.26±0.27	

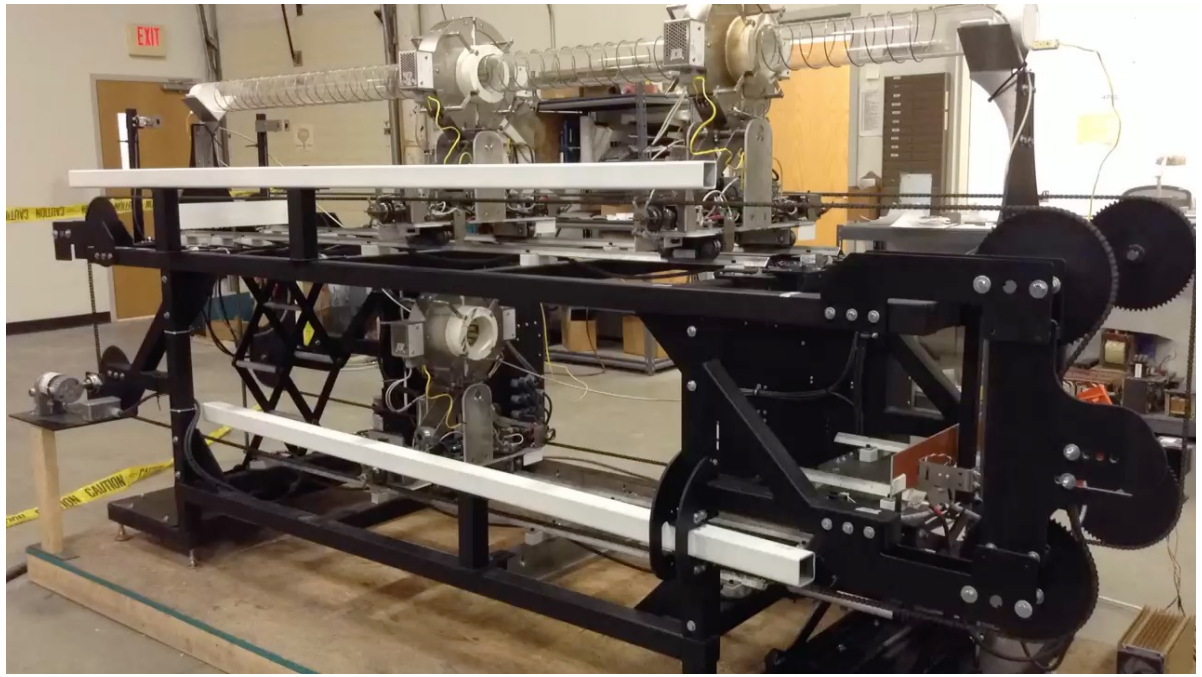
Tesi di laurea magistrale a Milano: M. Galli (Apr 23)





Purificazione a zona

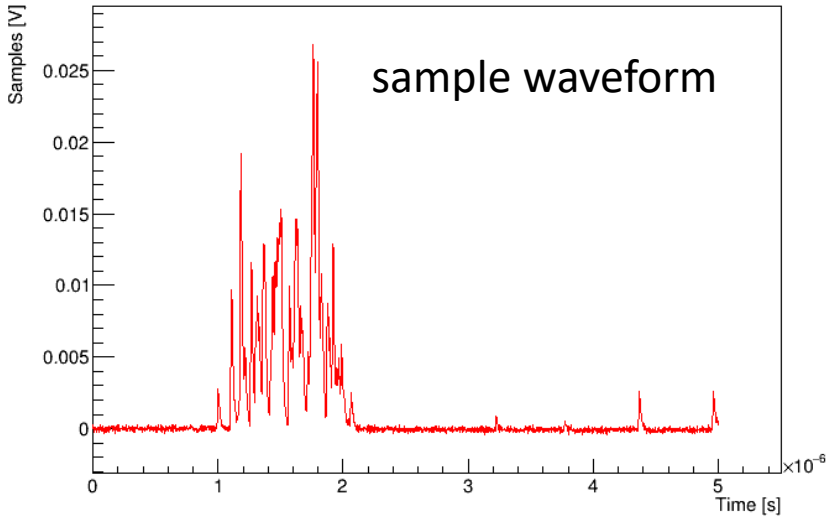
- Prima macchina realizzata in USA da Mellen
- Tubo di quarzo in cui viene inserito un crogiulo con la polvere di NaI.
- 3 forni anulari mobili scorrono lungo l'asse in passaggi ripetuti, fondendo localmente il materiale
- Le impurità vengono concentrate in fondo
- Verrà spostato presso la RMD a Boston, ditta che produce i cristalli
- Cristallo NaI-41, test di crescita con materiale cristallizzato, in arrivo prima della fine dell'anno.

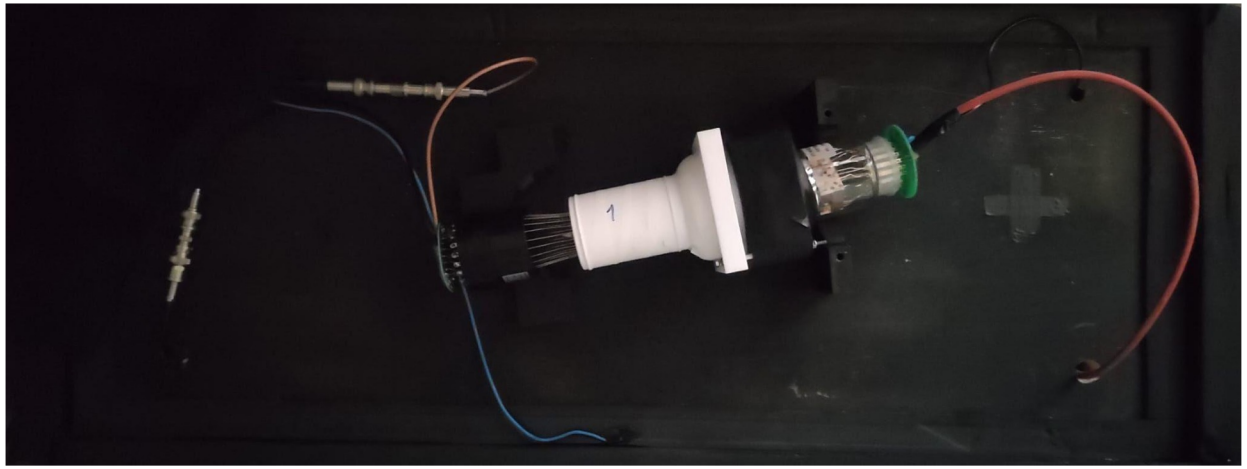


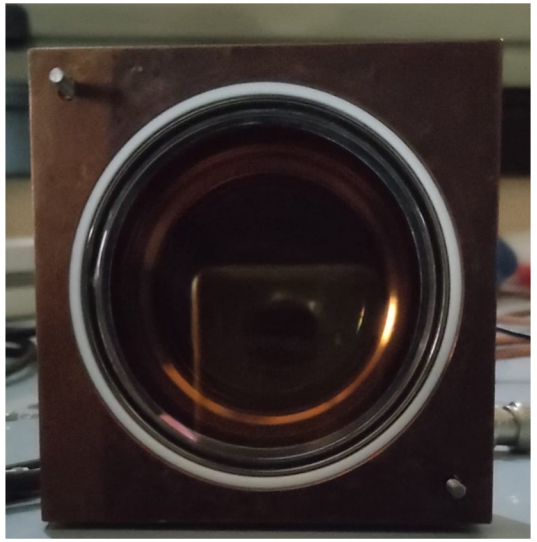
PRIN 2022 – C. Tomei (Roma1) - D. D'Angelo (Mi): ~200k
Costruzione ed operazione di una macchina simile al LASA

Misure elettroluminescenza del Delrin

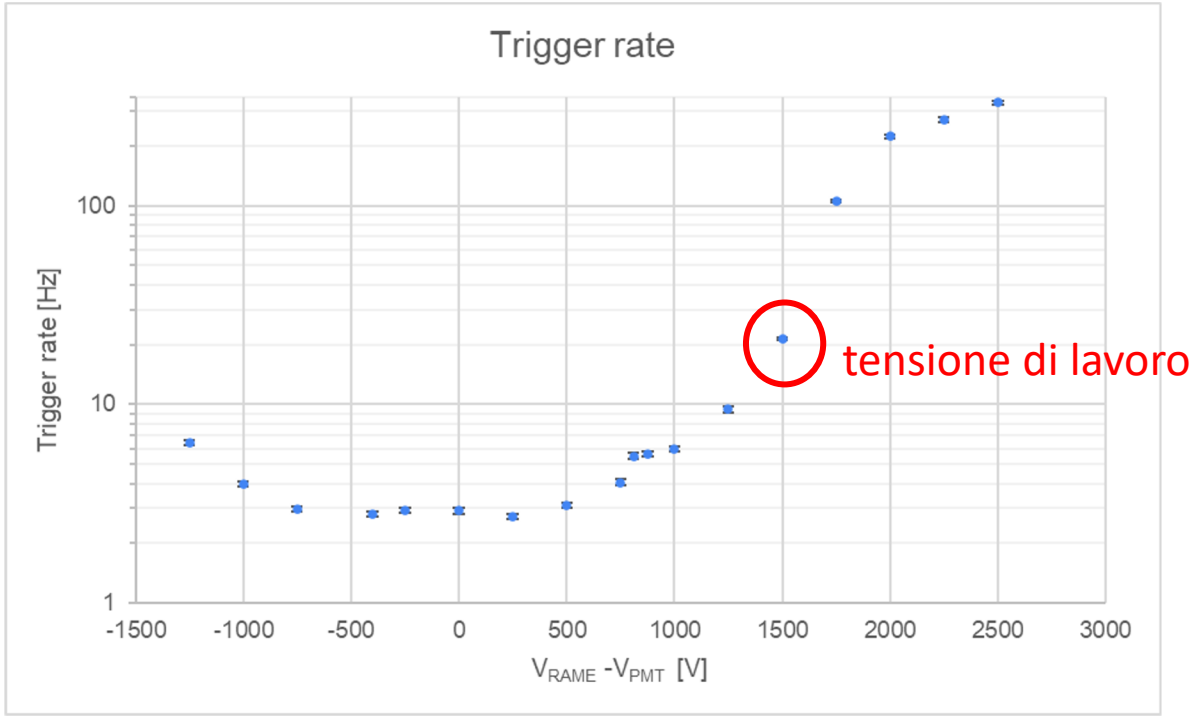
- Osservati eventi «bell» nell spettro NaI-33
- Anello di Delrin sottoposto a 1500V in pochi mm
- Setup a Milano che replica la configurazione LNGS senza cristallo

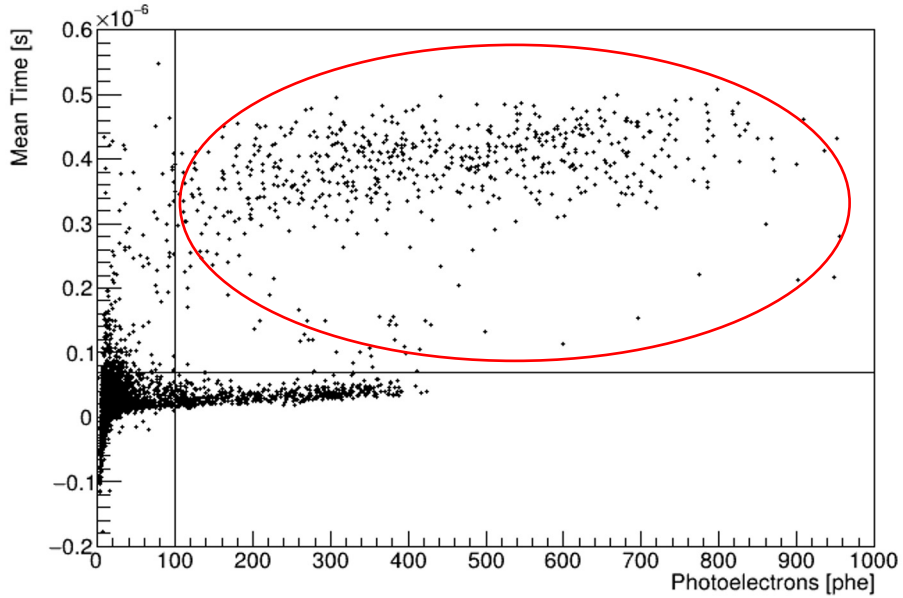


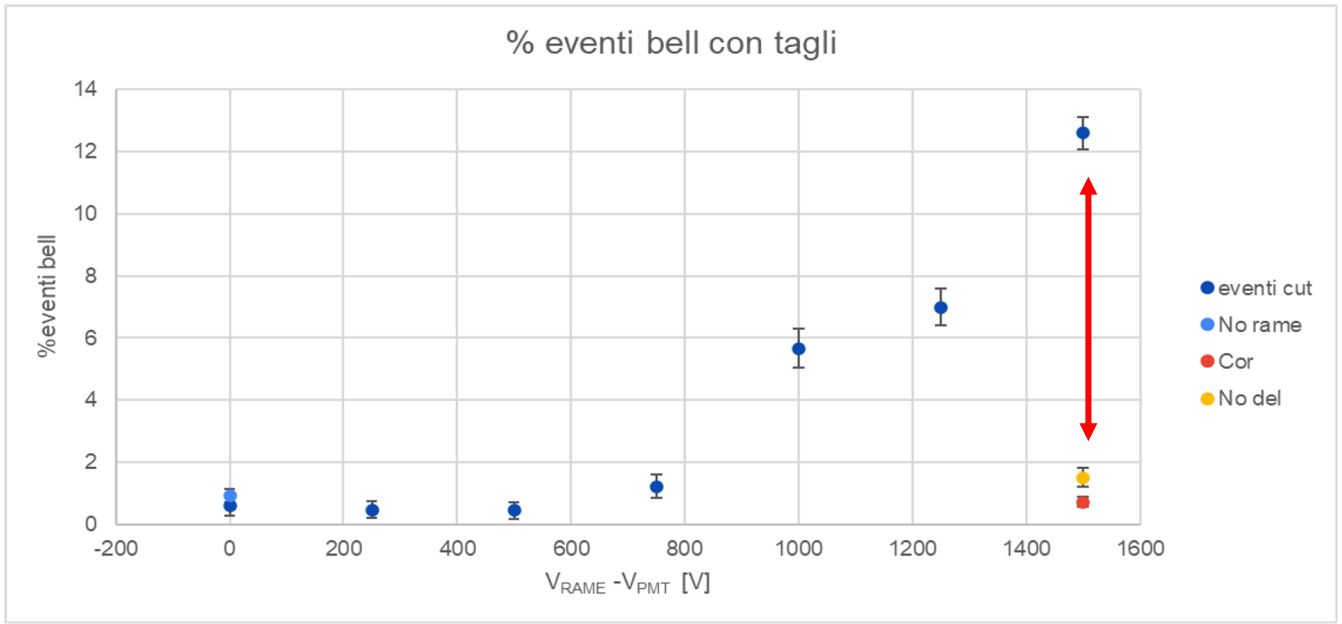




Tesi di laurea magistrale a Milano: R. Brambilla (Jul 23)







- Comportamento simmetrico per polarità
- Effetto importante sopra 1kV
- Triplo controllo di blank
  1. Senza placca di rame
  2. Senza Delrin
  3. Oscurando la visuale dell'anello

Status in CSN2

- Validation phase 2022-23:
  - I due step hanno avuto esito inaspettato:
    1. la sostituzione del riflettore di PTFE ha evidenziato che la contaminazione ^{210}Pb non è localizzata lì ma nel cristallo
       - ma misura indipendente -> constraint nel fit
    2. verifica fondi NaI-37 ~ NaI-33: peggiore di un fattore 2 (^{40}K e ^{210}Pb)
       - condizioni di rumore dovuto al montaggio non permettono di verificare rate in ROI
- <u>Purificazione a zona diventa centrale nella strategia</u>
- Validation phase estesa per un terzo anno
- Presentazione TDR rimandato Jul 23 -> Jul 24
- Richiesto MoU con Australia (in corso di completamento)

Richieste e anagrafica 2024

Sigla sotto dot 2

	Profilo	**FTE**
D. D'Angelo (RL)	P.A.	0.4
V. Toso	AdR univ.	0.4
Totale MI		**0.8**
Totale naz.		5.8

4 sezioni: Lecce, LNGS, Milano, Roma1

AdR in fase di apertura bando (segnalare possibili candidati)

Richieste

- Missioni: 11.5 k
- Inventario: 6 k (1 PMT)
- Consumo: 2 k (metabolismo)

Servizi

- Meccanica: normalmente nulla, ma con il PRIN? Difficile da stimare
- Elettronica: 2 s. u. (A. Andreani)

Backup

Data from tested crystals

- * PoP run
- ** PoP-dry run
- *** NaI-33 in 30cm Cu shielding
- **** from ^{241}Am (59.5 keV)

	Mass [kg]	LY**** [pe/keV]	^{39}K [ppb] powder	^{39}K [ppb] crystal	^{210}Pb [mBq/kg]	Rate ROI [1,6]keV	^{214}Bi-^{214}Po [ppt]	^{212}Bi-^{212}Po [ppt]
NaI-31	3.00	9.1±0.1		16.5±1.1	1.02±0.07	2.74±0.03		
NaI-33*	3.40	12.1±0.2	7.0	4.3±0.6	0.51±0.02	1.20±0.05		
NaI-33**	3.40	11.1±0.2	7.0	4.3±0.6	0.51±0.02	1.39±0.03		
NaI-33***	3.40	11.1±0.2	7.0	4.3±0.6	0.51±0.02	0.95±0.05	0.47±0.05	0.40±0.07
NaI-35	4.36	~9	7.0	8.3±0.6	0.49±0.2	-		
NaI-37	4.35	~8	14.5	8.0±0.6	0.80±0.01	-	0.61±0.05	