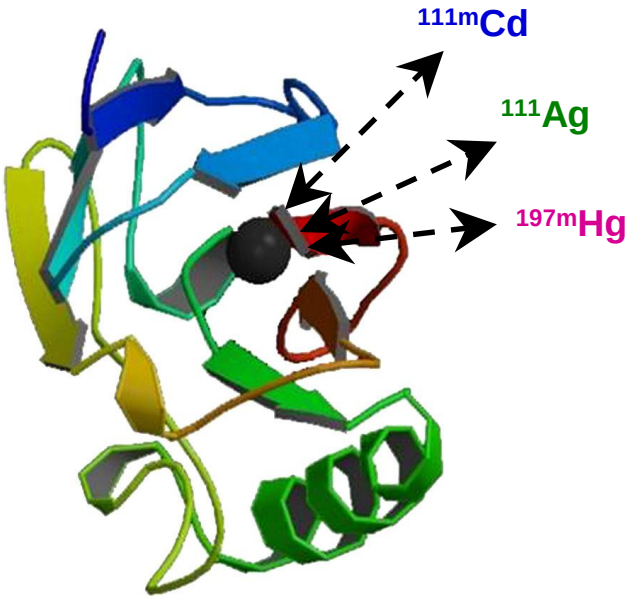
Development of new detectors for SR-PAC on ^{61}Ni atoms and other ‘high-energy’ NR nuclei

Thomas Agne and Tilman Butz
Universität Leipzig

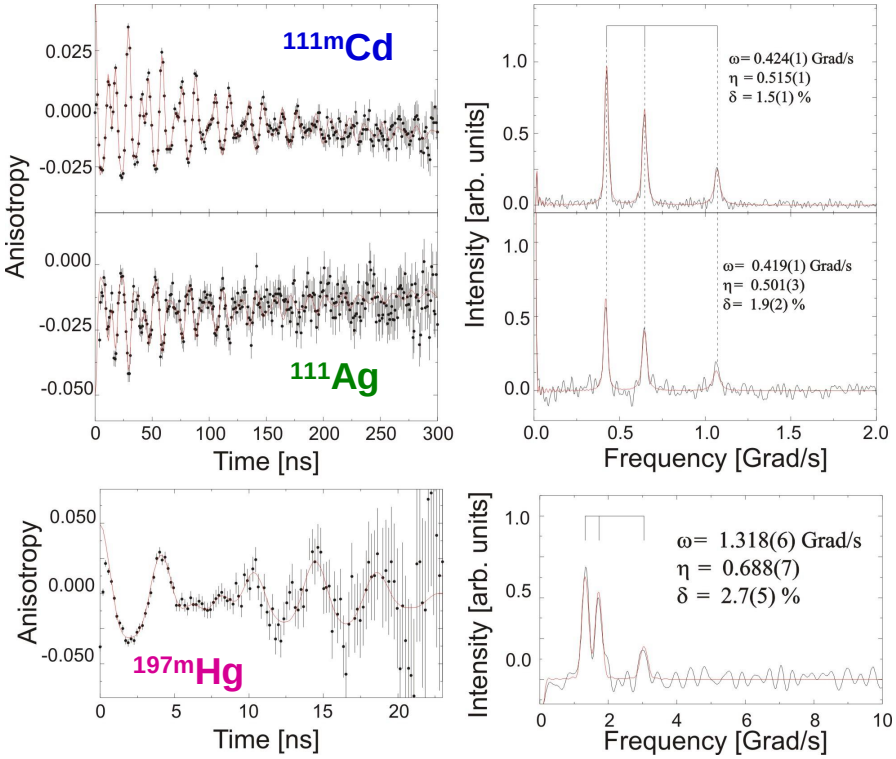
Agne@uni-leipzig.de

SR-PAC on ^{61}Ni in bio-systems

Past: TDPAC on heavy metals in proteins



Azurin protein



W. Tröger and T. Butz, Hyp. Int. **129** (2001) 511.

Future: Properties of bio-molecules containing Ni atoms

Scintillation crystal: LYSO

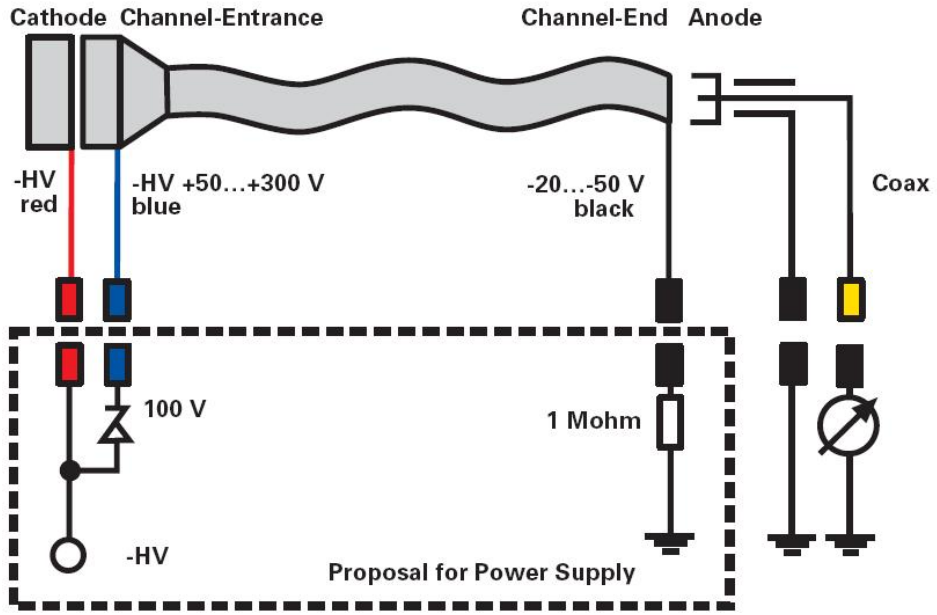
Properties of some scintillation crystals:

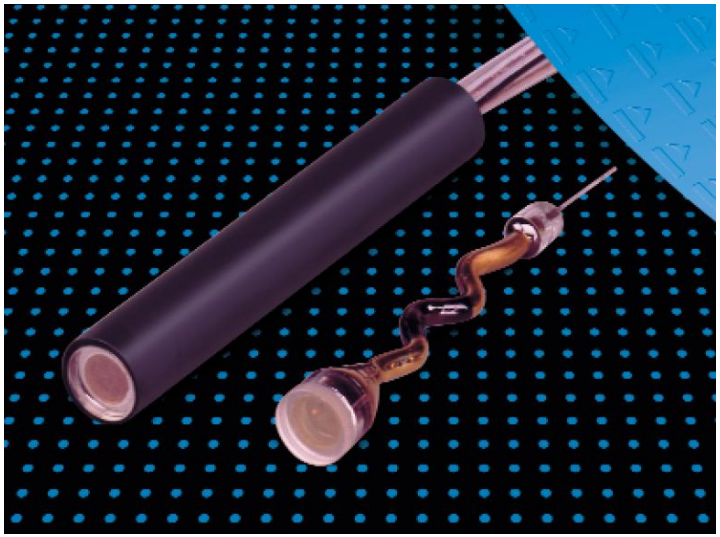
Scintillator	BGO[1)]	LSO[2)]	LYSO[3)]	GSO[4)]	LuAP[5)]	LaBr[6)]
Density (g/cc)	7.1	7.4	7.1	6.7	8.3	5.3
Light yield (photons/keV)	9	27	32	8	10	61
Effective Z	75	66	64	60	65	46.9
Principal decay time (ns)	300	42	48	30-60	18	35
Peak wavelength (nm)	480	420	420	440	365	358
Index of refraction	2.15	1.82	1.8	1.95	1.95	1.88
Photofraction at 511 keV(%)	41.5	32.5	34.4	25	30.6	15
Attenuation length (cm)	1.04	1.15	1.12	1.42	1.05	2.13
Energy resolution (%)	7.9	8	10	6.9	10	2.9
Hygroscopic	No	No	No	No	No	Yes

[1)] $Bi_4Ge_3O_{12}$; [2)] Lu_2SiO_5:Ce; [3)] $LuYSiO_5$:Ce; [4)] Gd_2SiO_5:Ce; [5)] $LuAlO_3$:Ce; [6)] $LaBr_3$:Ce;

Channel Photomultiplier (CPM)

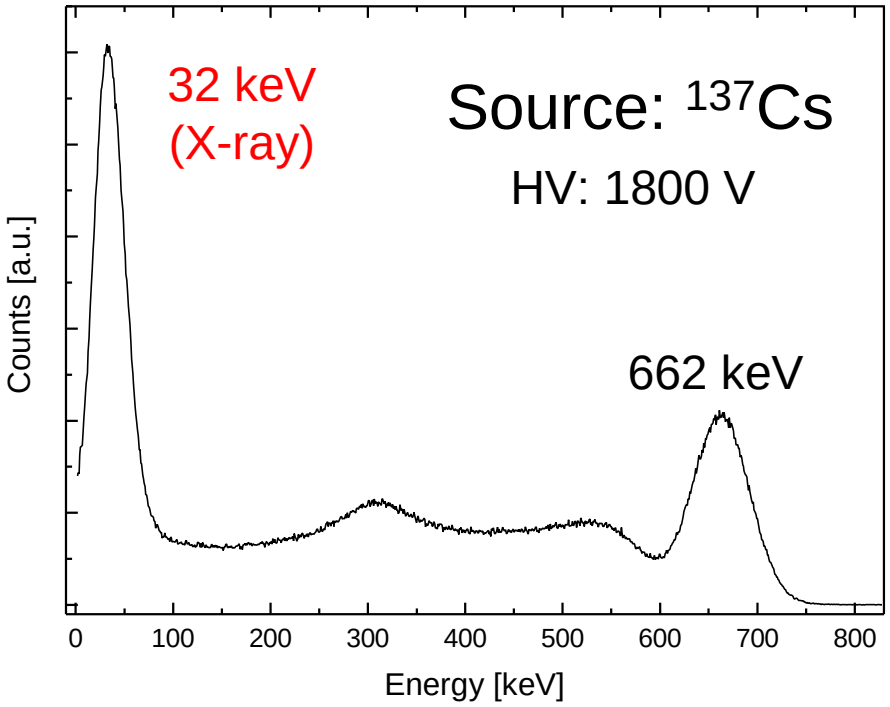
Module type: MH-993P (Perkin Elmer)

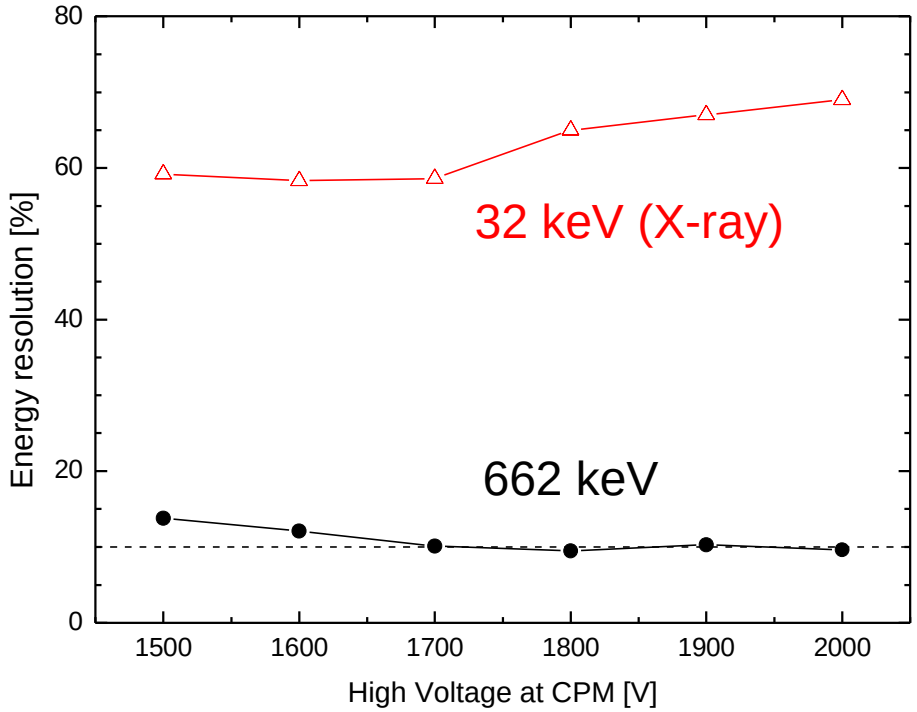




Response time:	3 ns
Pulse width (FWHM):	6 ns
Faceplate Material:	UV-Glas
Gain @ 2000 V:	2.0e+6
Dark current @ 2000V:	4 cps

Energy resolution of LYSO/CPM





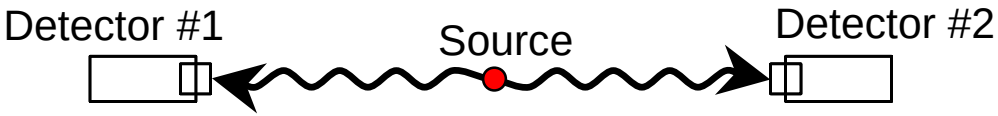
Energy resolution:

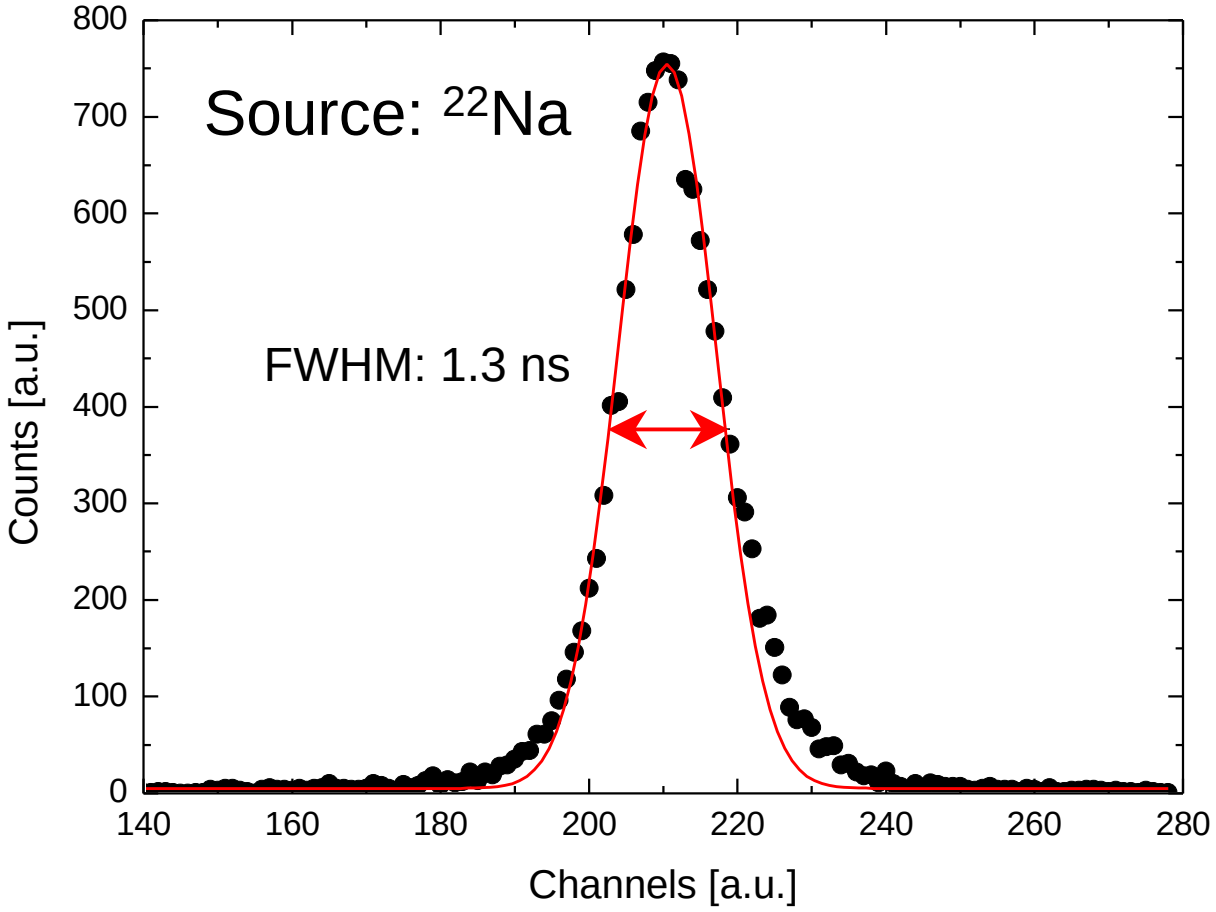
662 keV (Standard): ~ 10 %

32 keV (X-ray): ~ 60 %

Time resolution of LYSO/CPM

Time resolution using the 511 keV annihilation radiation of ^{22}Na



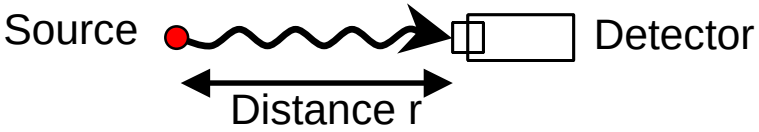


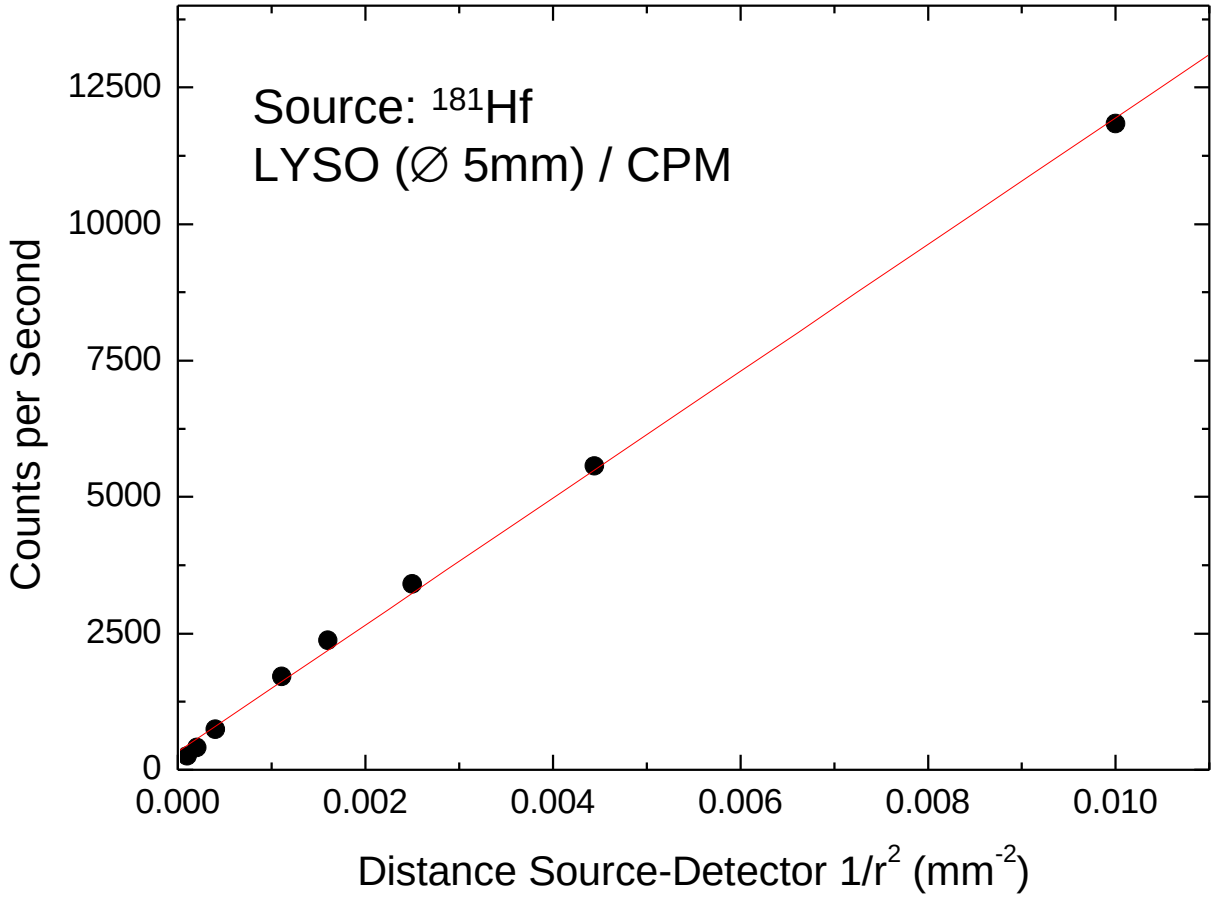
Detectors:
#1: LYSO / CPM
#2: LYSO / PMT

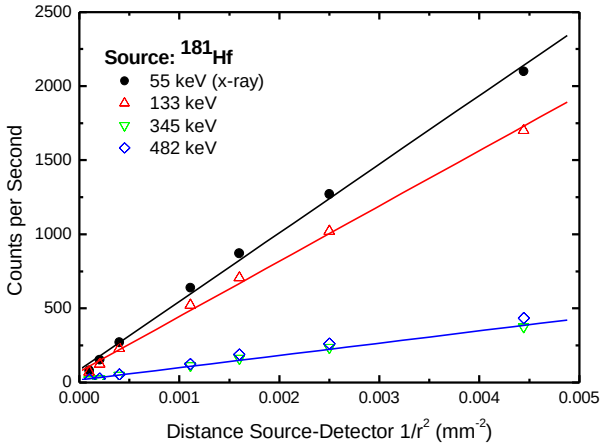
Constant-Fraction

Time resolution:
< 1.3 ns

Rate capacity of LYSO/CPM







Rate capacity:
$\geq 1.25 \cdot 10^4\ s^{-1}$

Next scintillation crystal: $LaBr_3(Ce)$

Properties of some scintillation crystals:

Scintillator	BGO[1)]	LSO[2)]	LYSO[3)]	GSO[4)]	LuAP[5)]	LaBr[6)]
Density (g/cc)	7.1	7.4	7.1	6.7	8.3	5.3
Light yield (photons/keV)	9	27	32	8	10	61
Effective Z	75	66	64	60	65	46.9
Principal decay time (ns)	300	42	48	30-60	18	35
Peak wavelength (nm)	480	420	420	440	365	358
Index of refraction	2.15	1.82	1.8	1.95	1.95	1.88
Photofraction at 511 keV(%)	41.5	32.5	34.4	25	30.6	15
Attenuation length (cm)	1.04	1.15	1.12	1.42	1.05	2.13
Energy resolution (%)	7.9	8	10	6.9	10	2.9
Hygroscopic	No	No	No	No	No	Yes

[1)] $Bi_4Ge_3O_{12}$; [2)] Lu_2SiO_5:Ce; [3)] $LuYSiO_5$:Ce; [4)] Gd_2SiO_5:Ce; [5)] $LuAlO_3$:Ce; [6)] $LaBr_3$:Ce;

Next steps of the project

Test with LYSO/CPM at ESRF

New scintillation crystal: $LaBr_3(Ce)$

New detector: APD coupled with LYSO & $LaBr_3$

Also: New development for TD-/SR-PAC:
Fast digital electronics (2 Gsample/s)

New idea: Semiconductor as Fast scintillator
(inspired by Shunji Kishimoto)