Remarks on the background γ radiation in the RISING fast beam campaign*

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for the RISING Collaboration

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*) Based on discussions with and contributions from:
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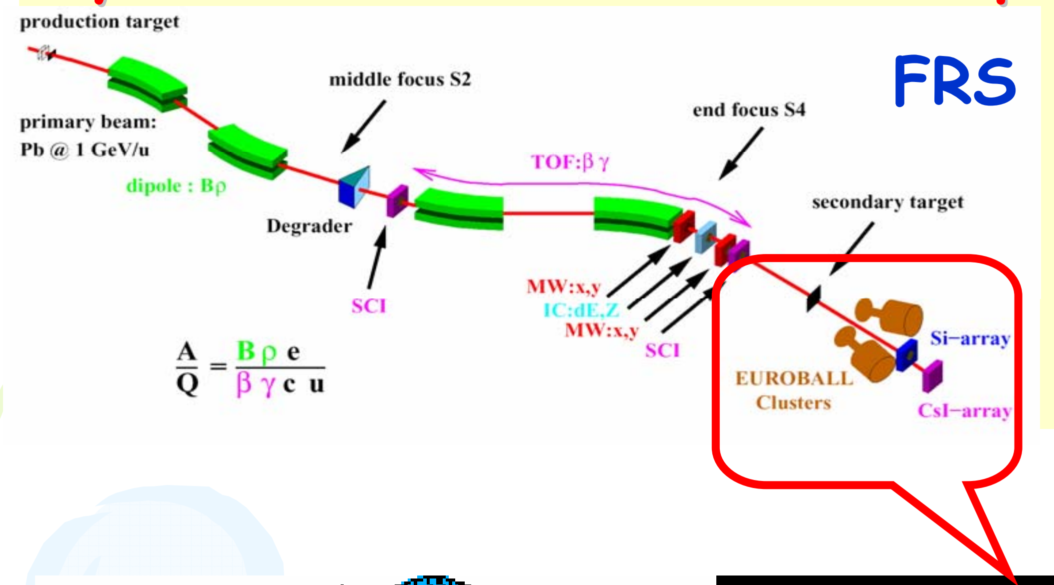
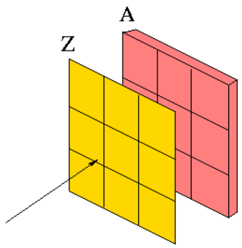
HISPEC/DESPEC MEETING
Valencia (Spain)

15th-16th June

Layout of the fast-RISING experiment

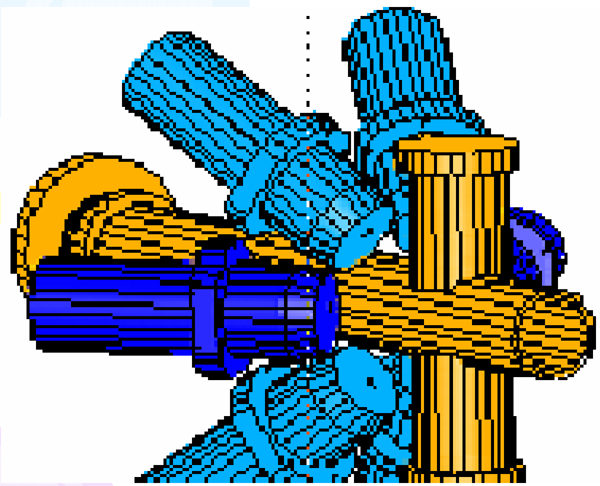


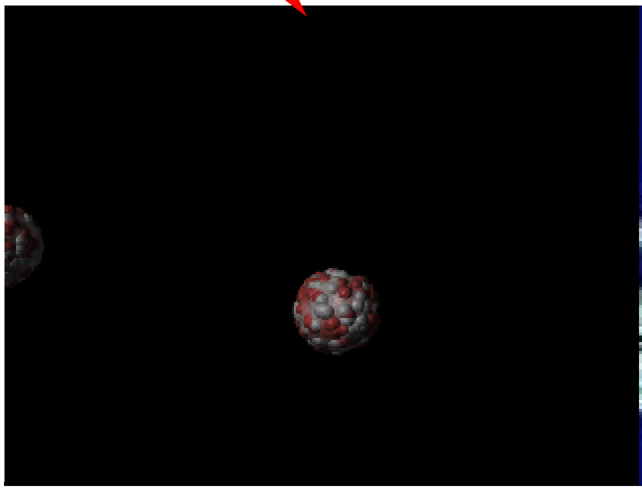
CATE: Position Sensitive Calorimeter Telescope

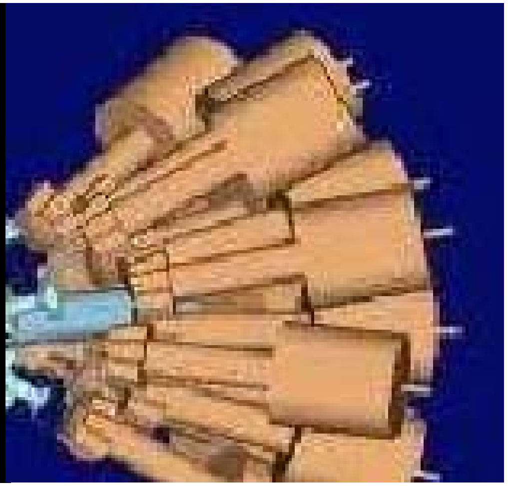


EUROBALL

15 cluster Ge-detectors







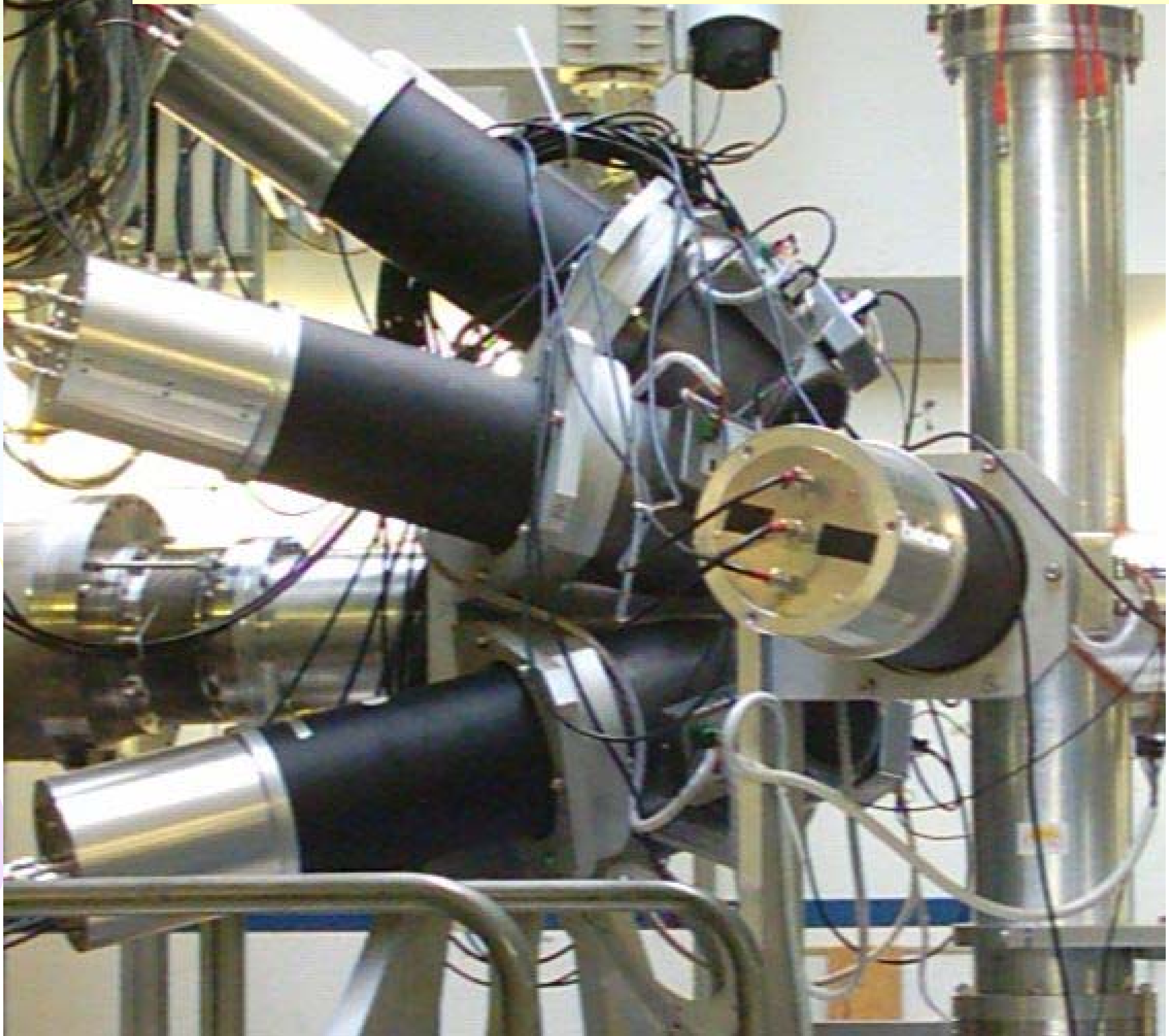
HECTOR

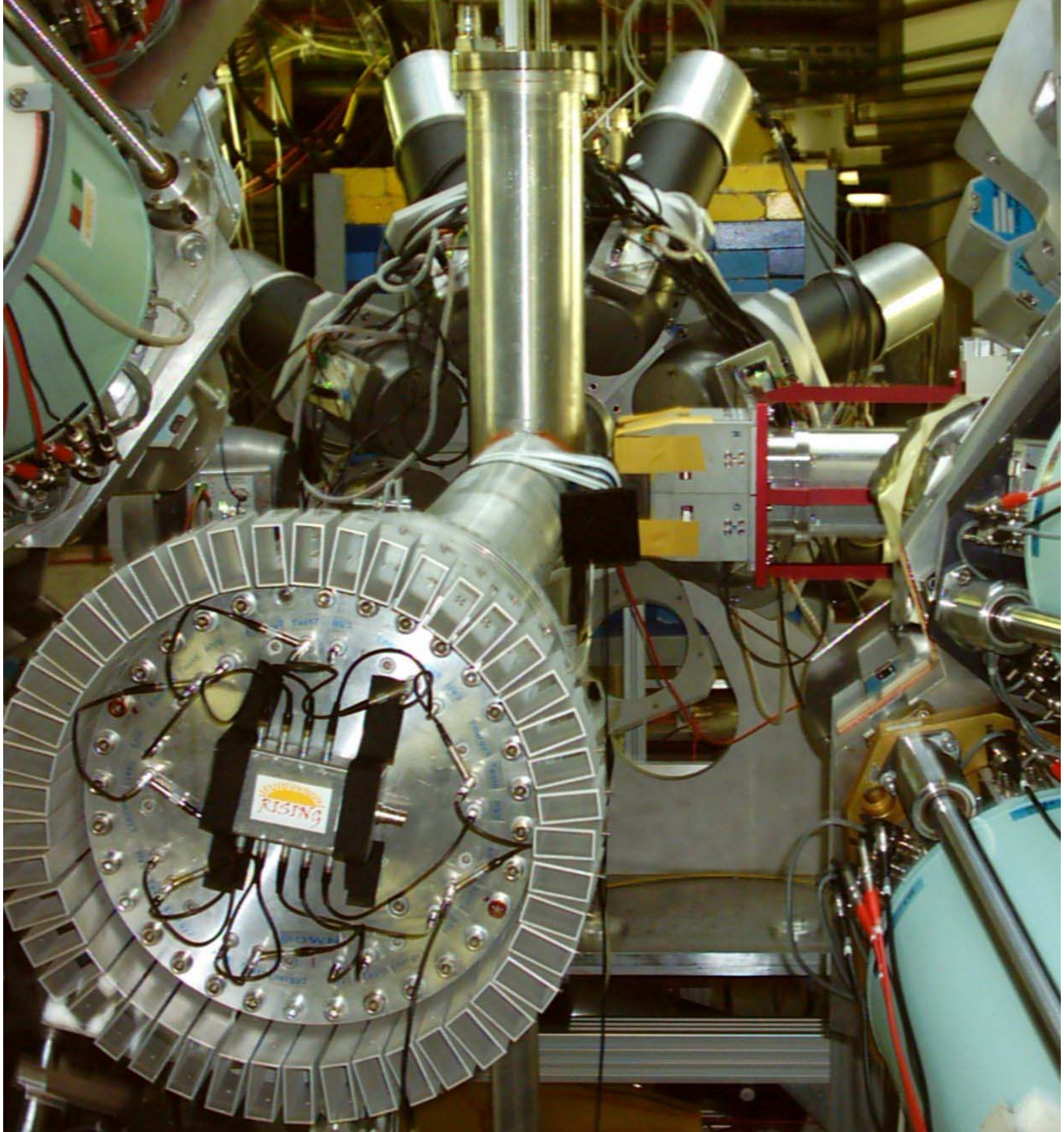
8 BaF_2 scintillators

Relativistic Coulomb
E2 or E1 excitation
of projectile, break-up

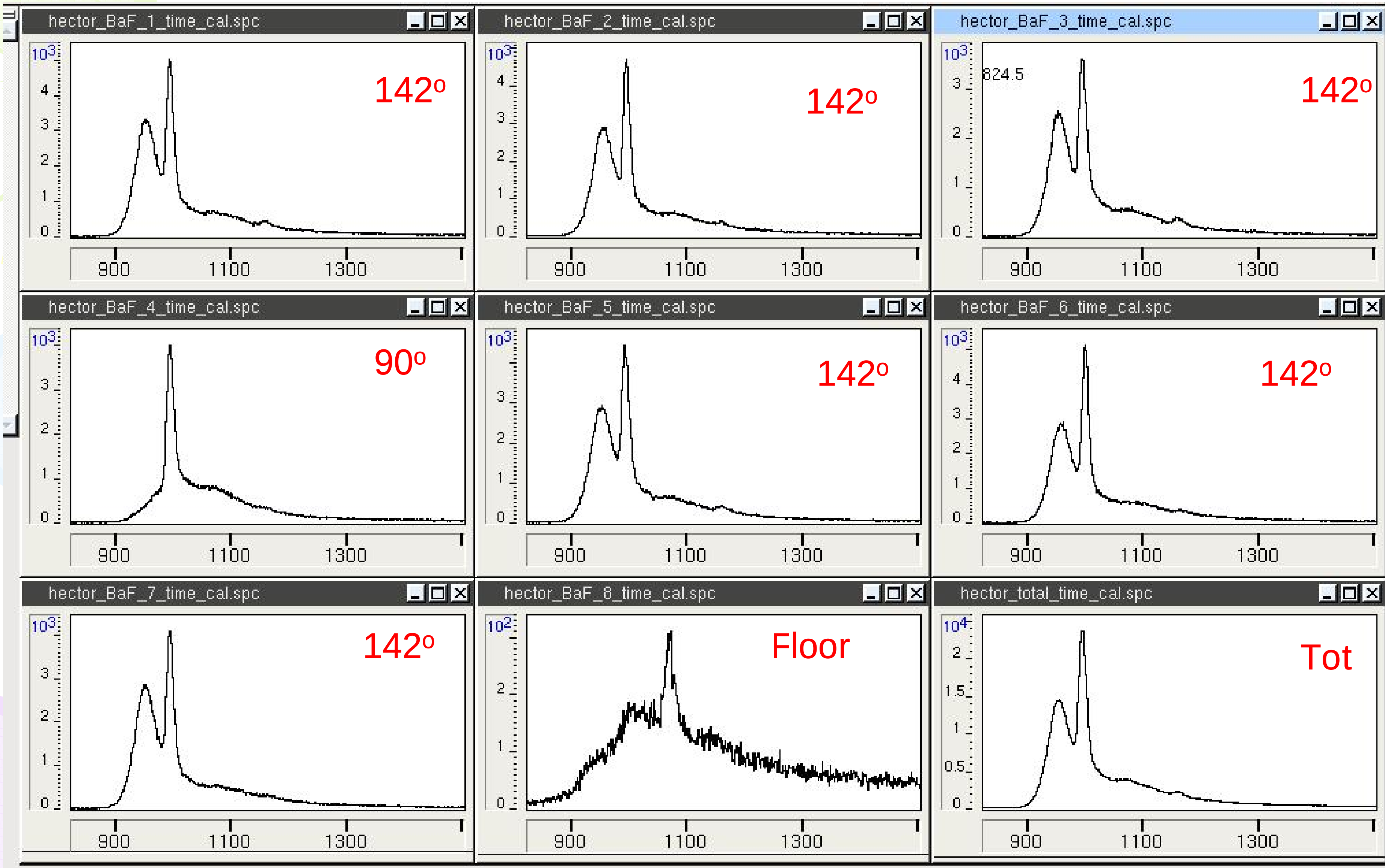
POV-Ray animation: R. Maj

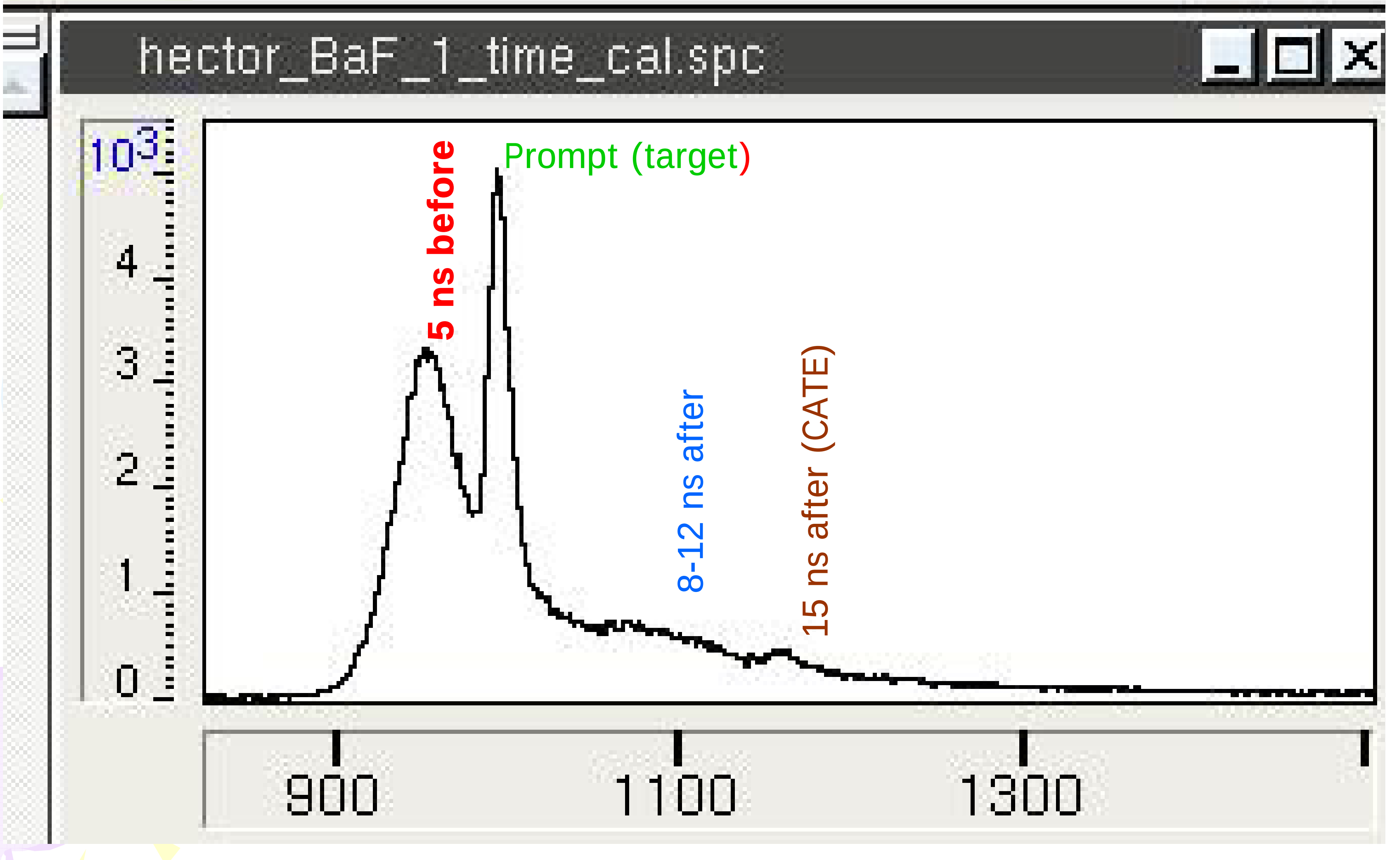
HECTOR SPECTRA




RISING

Hector time spectra (100 MeV/u ^{84}Kr beam)

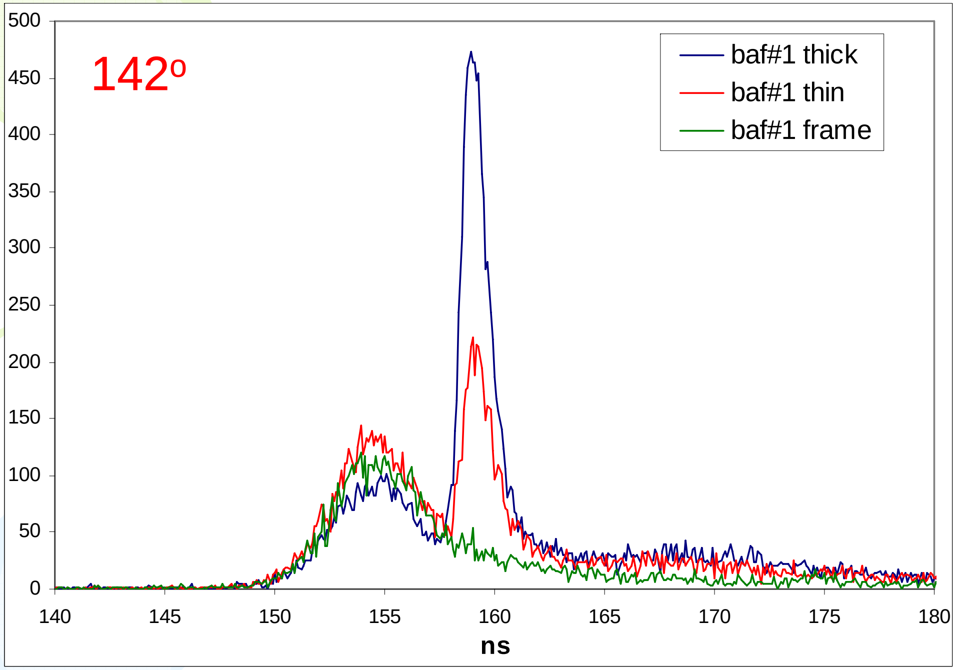


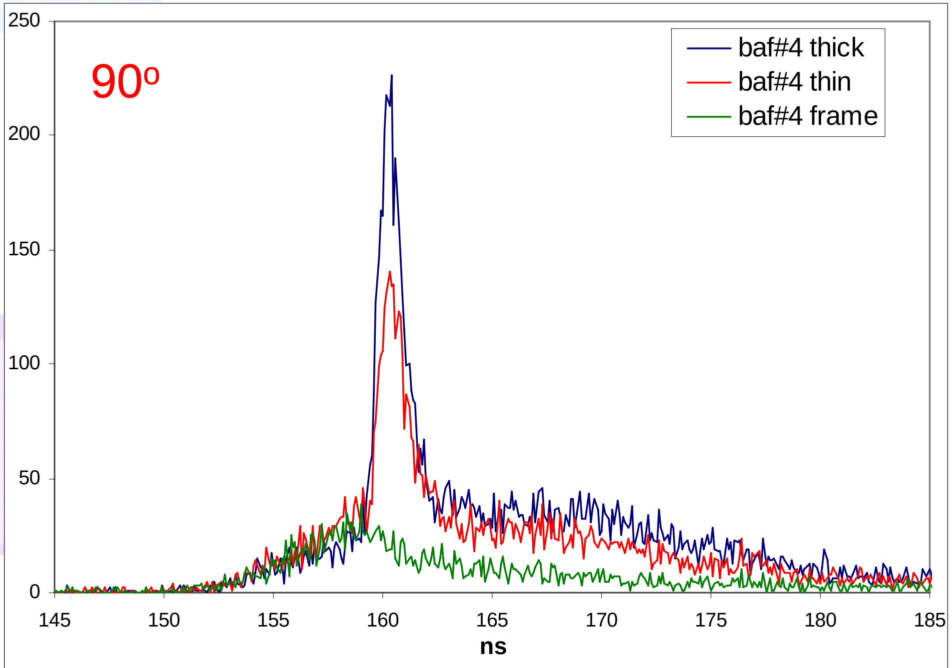


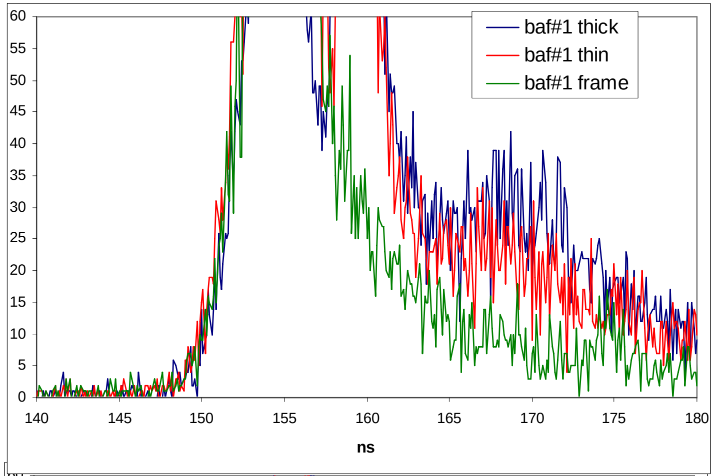
hector_BaF_1_time_cal.spc
10^3
4
3
2
1
0
5 ns before
Prompt (target)
8-12 ns after
15 ns after (CATE)
900
1100
1300

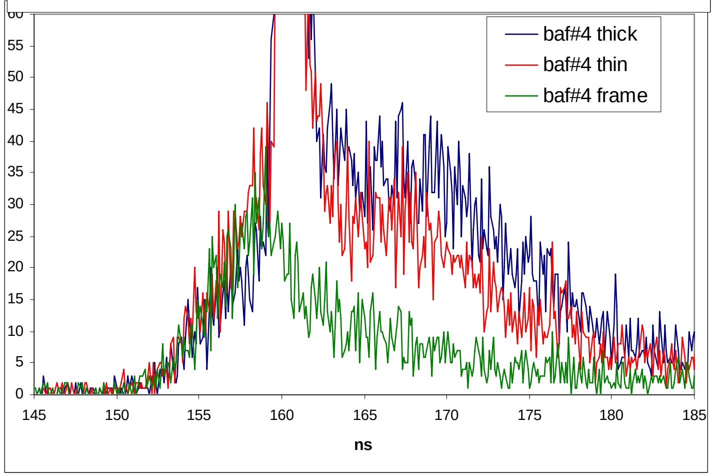
AM1

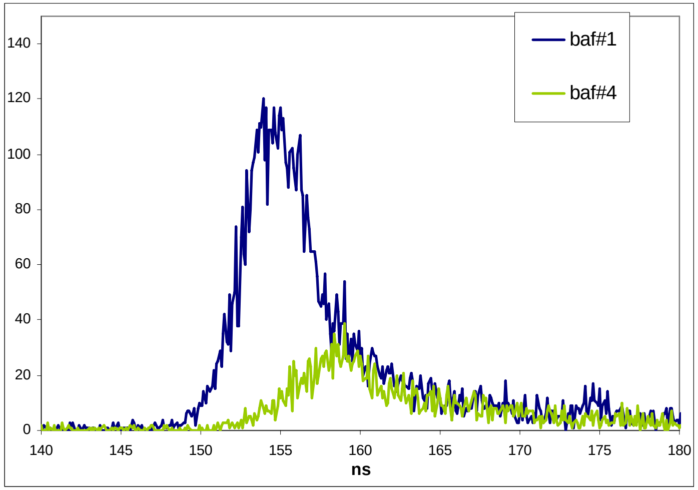
100 MeV/u ^{84}Kr beam









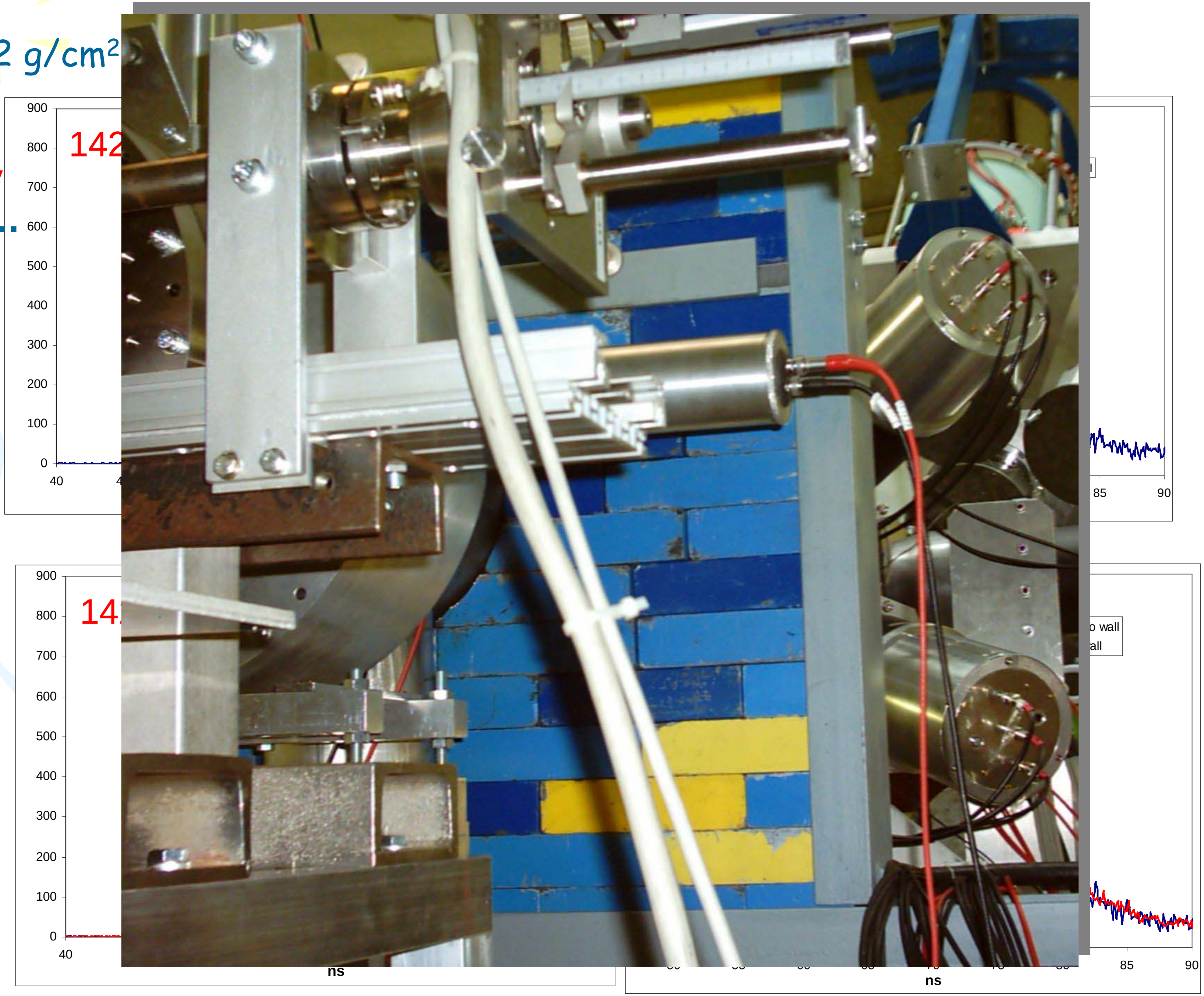


Diapositiva 7

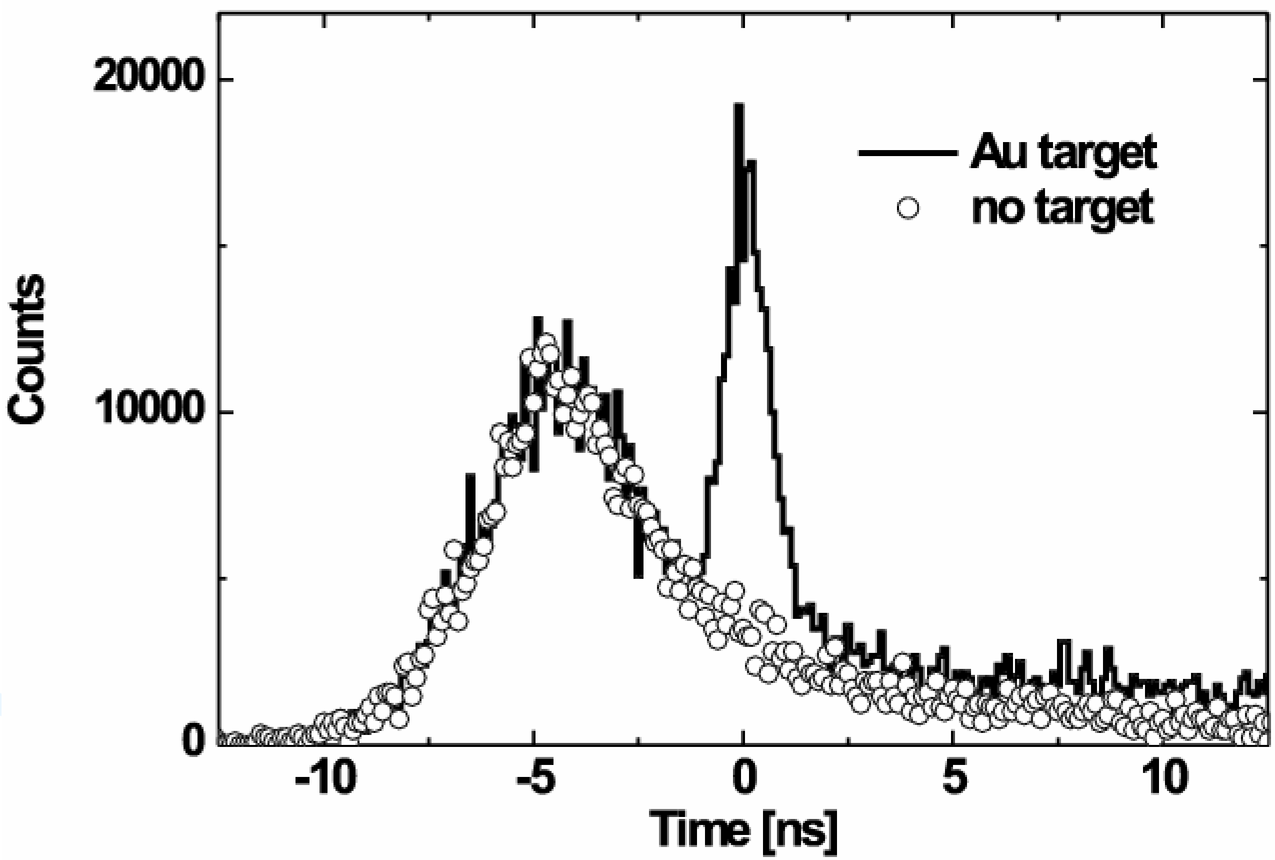
AM1 Adam Maj; 09/10/2003

Thick (0.2 g/cm²

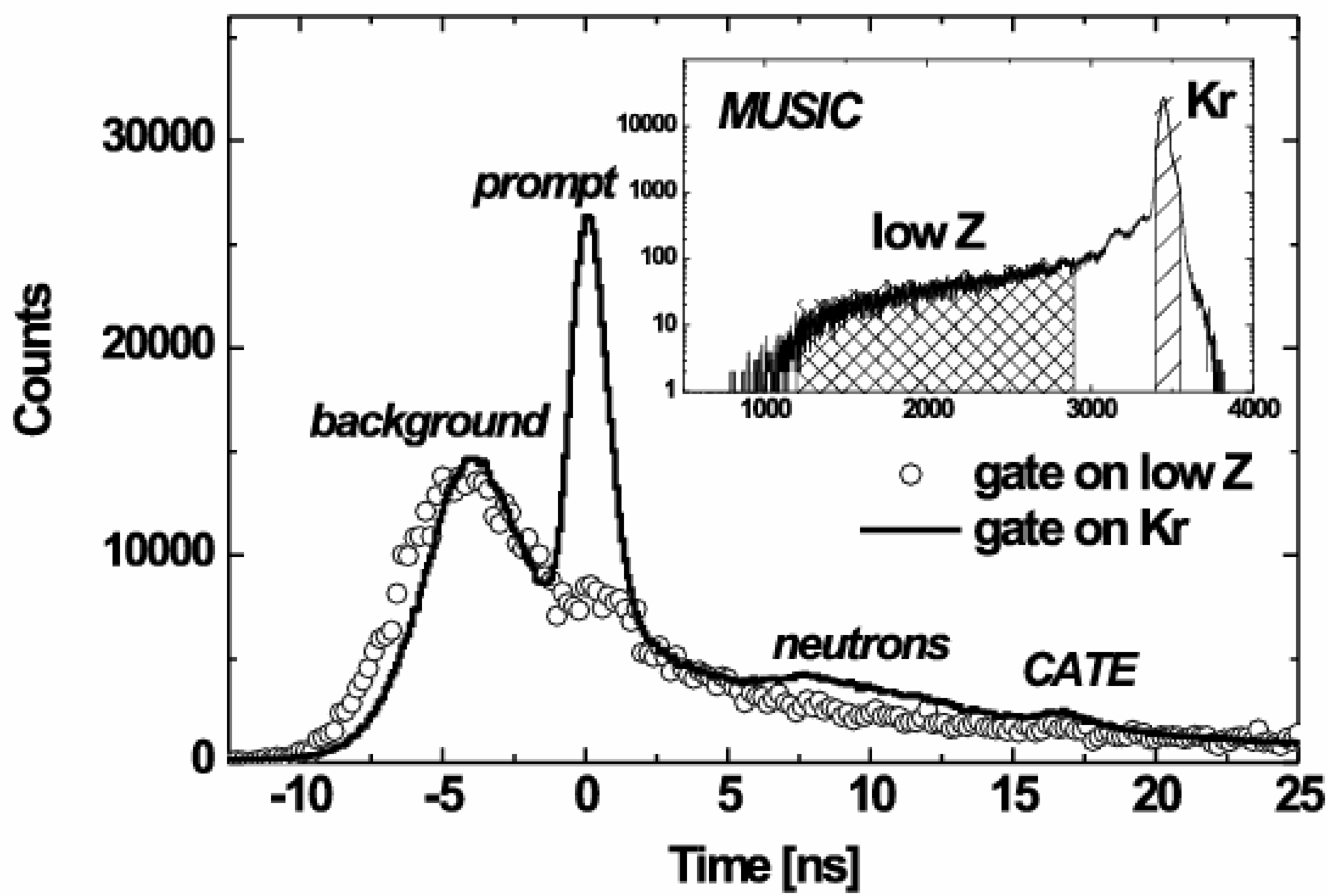
At the very beginning…



Simple wall



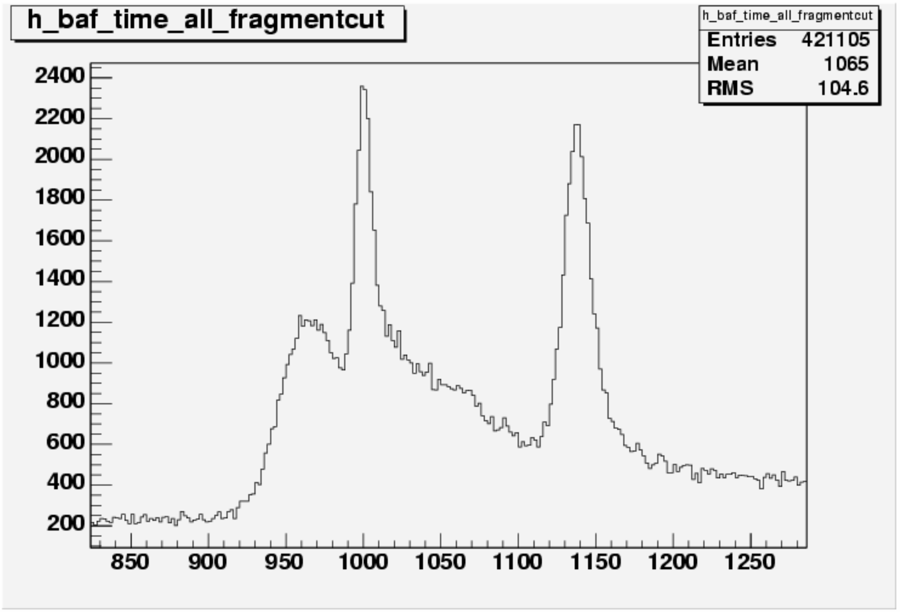
Au target
no target
Counts
20000
10000
0
-10
-5
0
5
10
Time [ns]



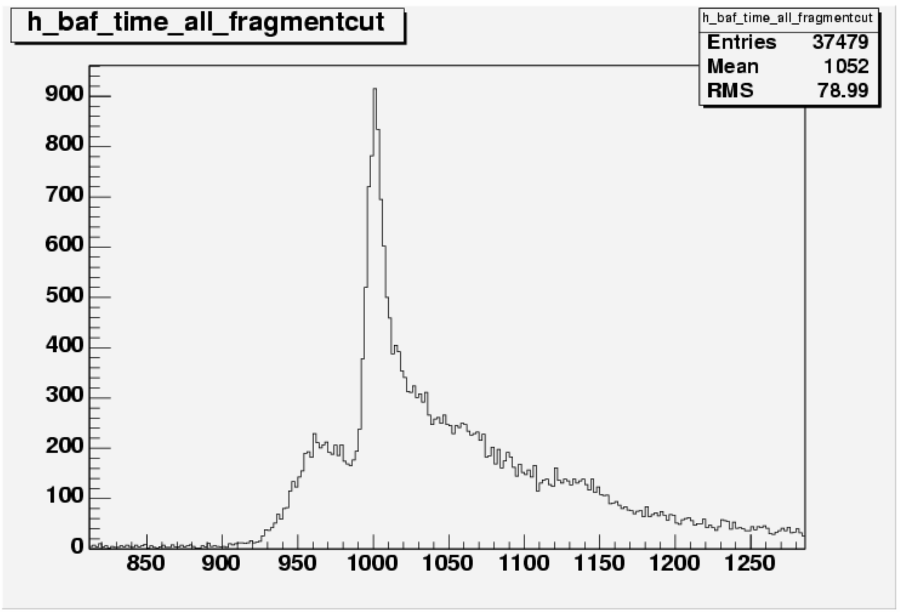
MUSIC
Kr
low Z
10000
1000
100
10
1
1000
2000
3000
4000
30000
20000
10000
0
Counts
prompt
background
gate on low Z
gate on Kr
neutrons
CATE
-10
-5
0
5
10
15
20
25
Time [ns]

37Ca beam @196MeV/u;

A/Q - ^{37}Ca, CATE - Ca

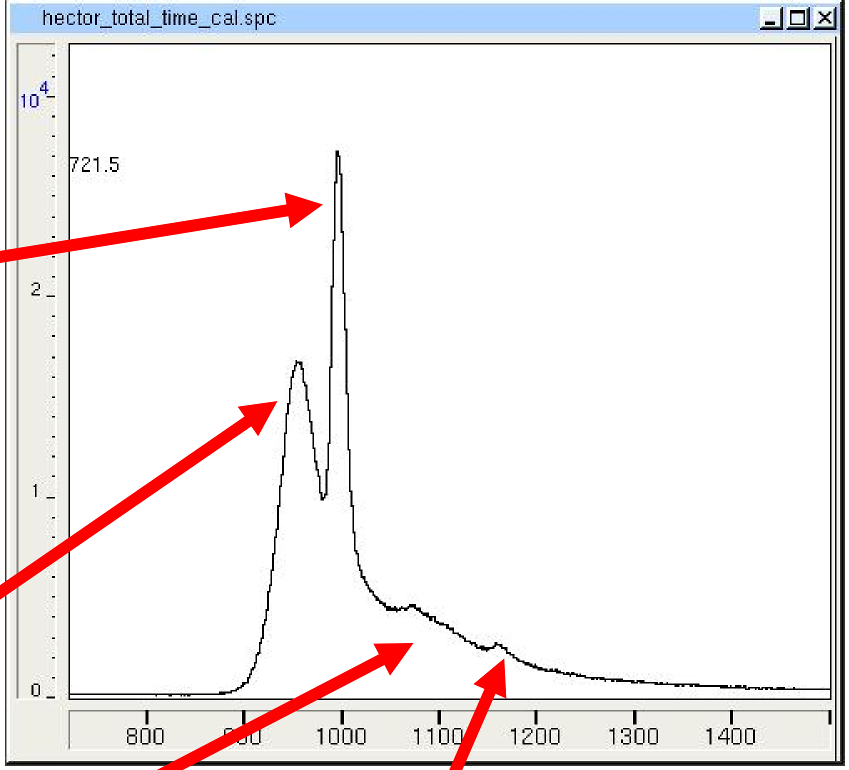


A/Q - ^{37}Ca, CATE -K (mainly ^{36}K)



Conclusions

Prompt radiation from target, increasing with the target thickness



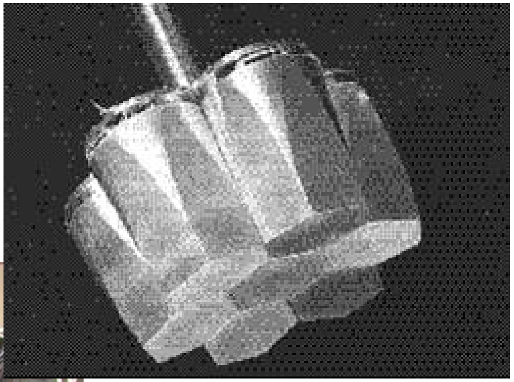
Early gamma radiation, coming from the beam line, caused by the light particles, ranging to very high energies (0-20 MeV)

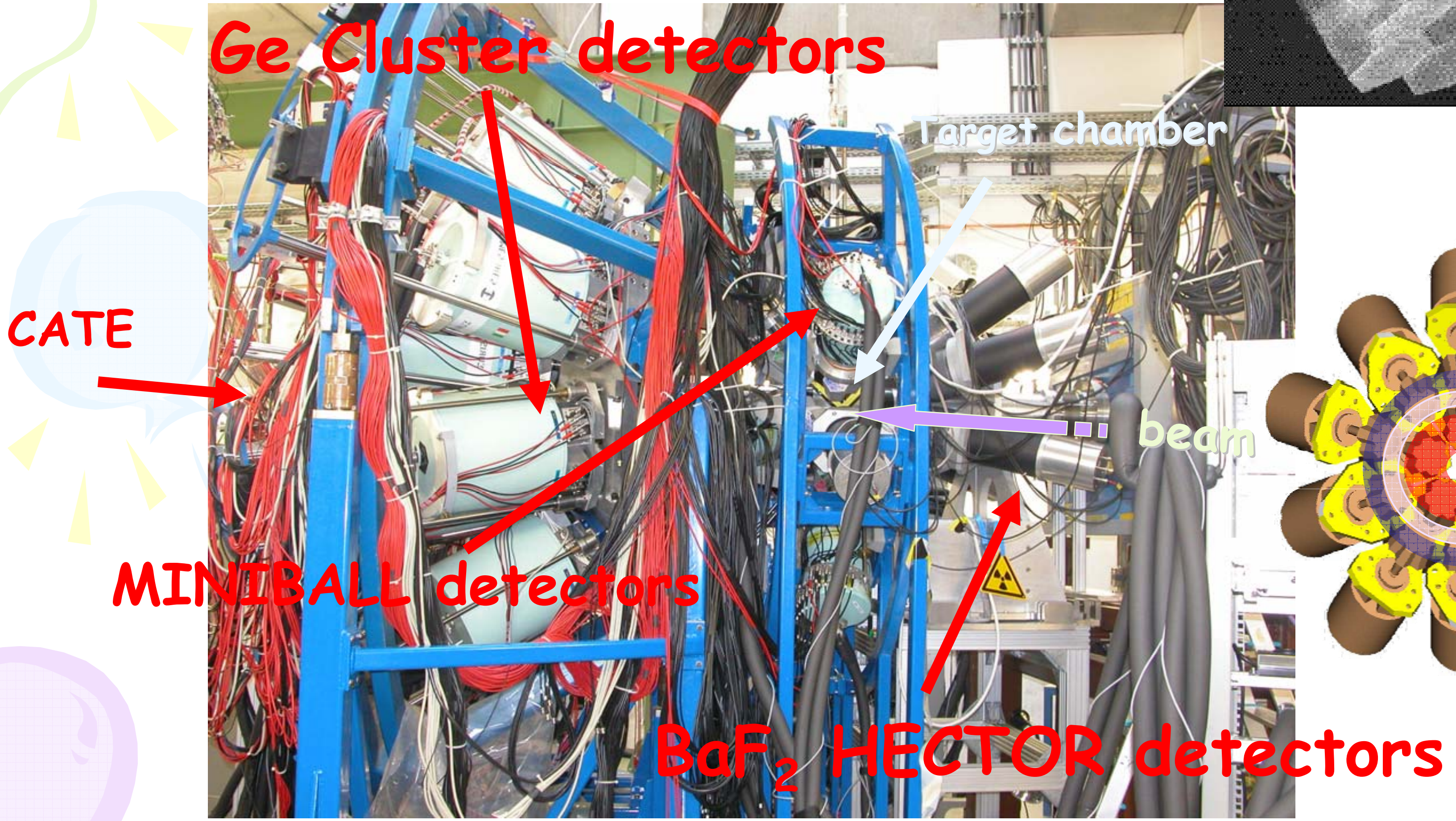
Late gamma radiation (neutrons?)

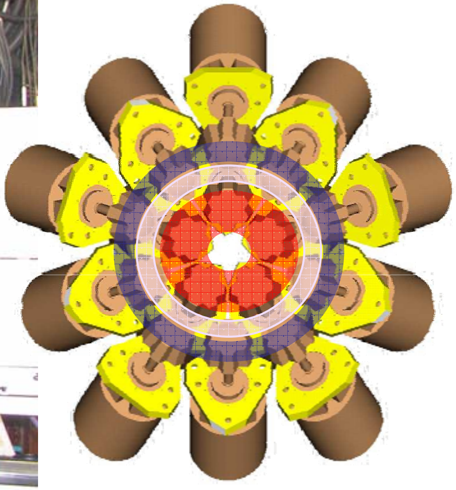
Gamma radiation from the interaction of heavy ions in CATE

Ge SPECTRA

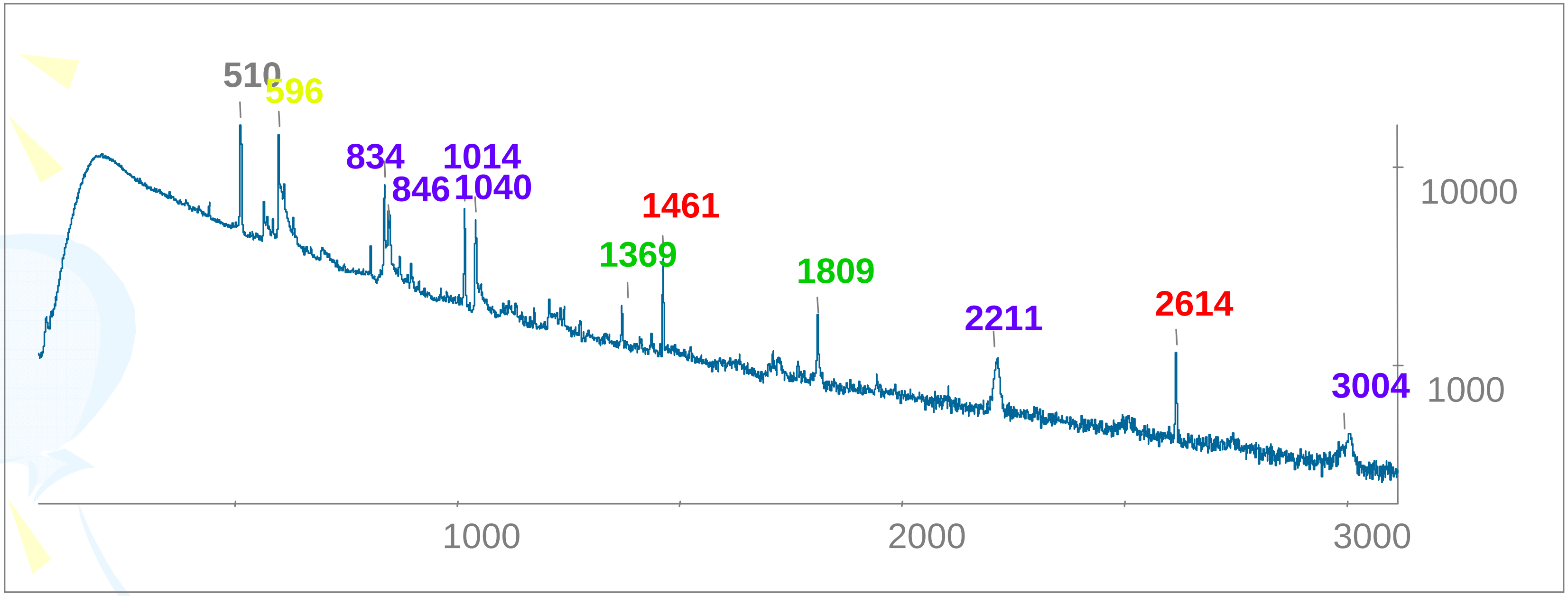
15*7 crystals



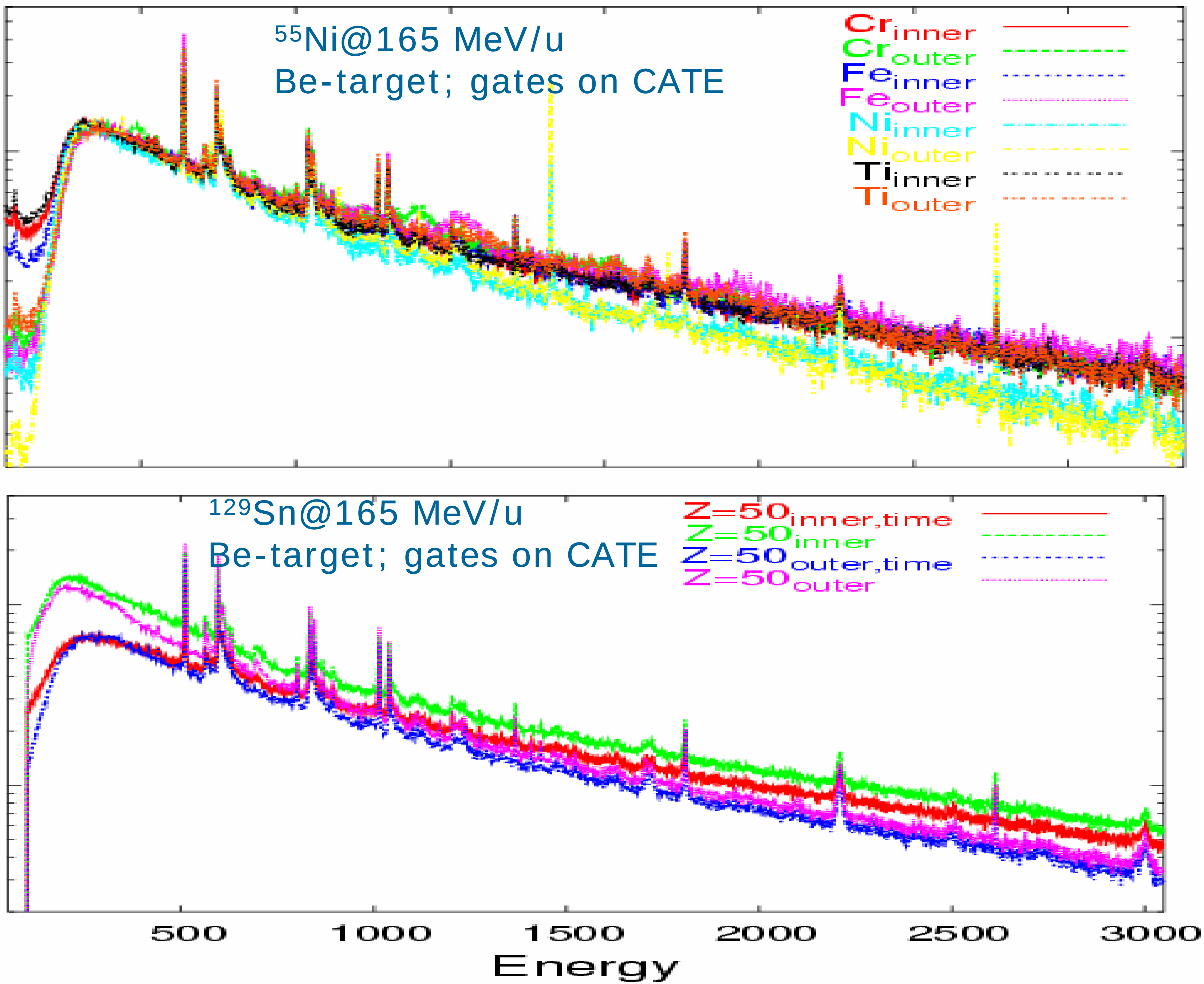




A single gamma spectrum, no condition;
^{86}Kr primary beam, 100MeV/u ^{54}Cr secondary beam on Au target

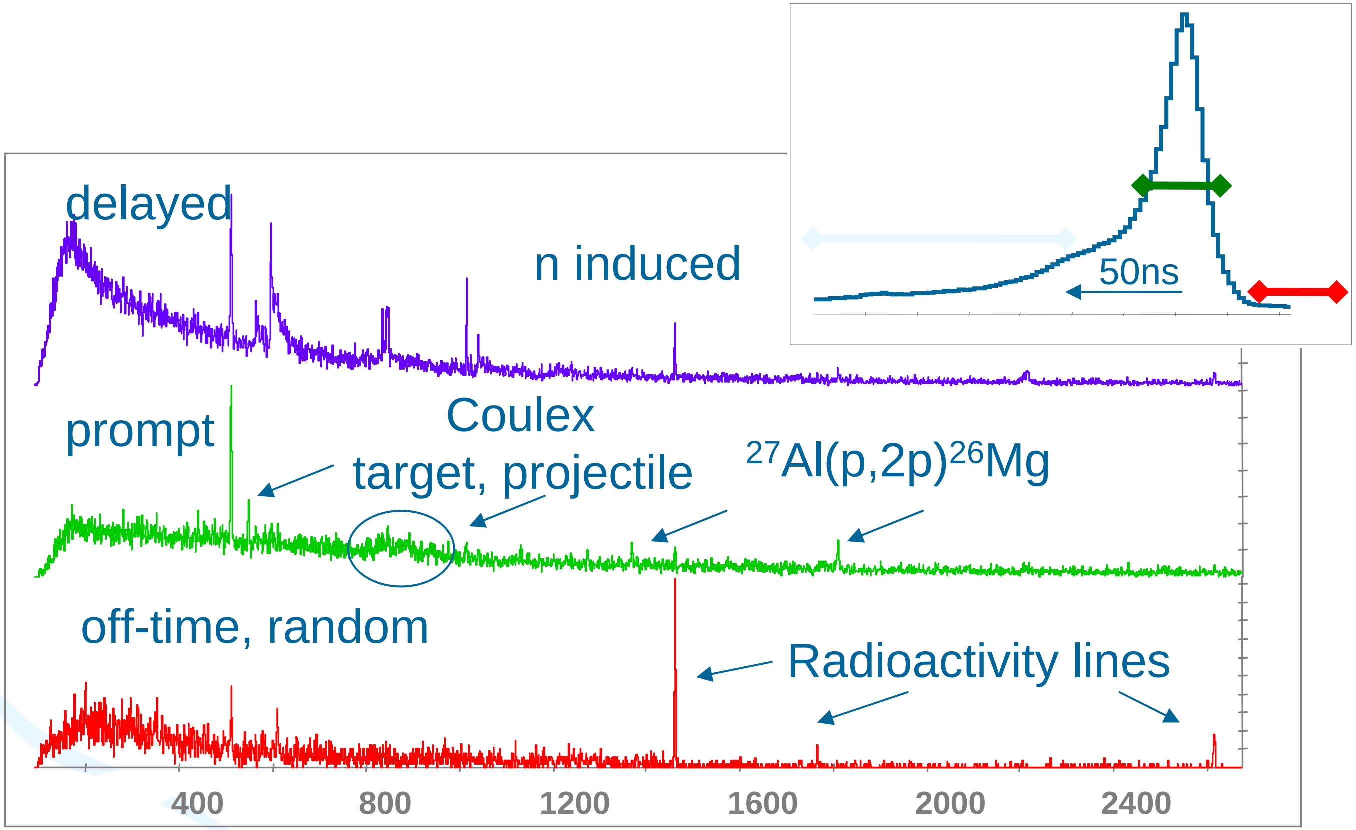


- Natural radioactivity: ^{40}K, ^{208}Pb,…
- ^{27}Al,^{56}Fe(n,n') with fast neutrons, Doppler broadened
- ^{27}Al(p,2p)^{26}Mg; with E_p~E_{beam}/u
- Ge n capture



55Ni@165 MeV/u
Be-target; gates on CATE
Cr inner
Cr outer
Fe inner
Fe outer
Ni inner
Ni outer
Ti inner
Ti outer
129Sn@165 MeV/u
Be-target; gates on CATE
Z=50 inner,time
Z=50 inner
Z=50 outer,time
Z=50 outer
500
1000
1500
2000
2500
3000
Energy

Time structure of an in-beam Ge spectrum
selection: ^{132}Xe primary beam on Au target & Xe outgoing particle



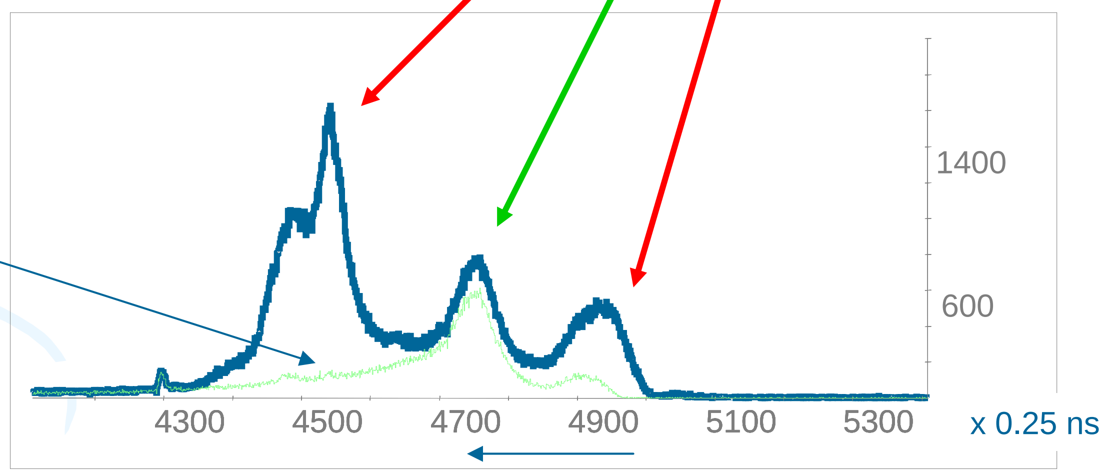
Conclusion : A lot of high energy particles (protons) is emitted in the fragmentation reactions

In-beam (*spill-on*) pre-amplified Ge signal

Huge amplitude (>> 20MeV), overshooting signals due to charged particles directly hitting the Ge crystal (?)

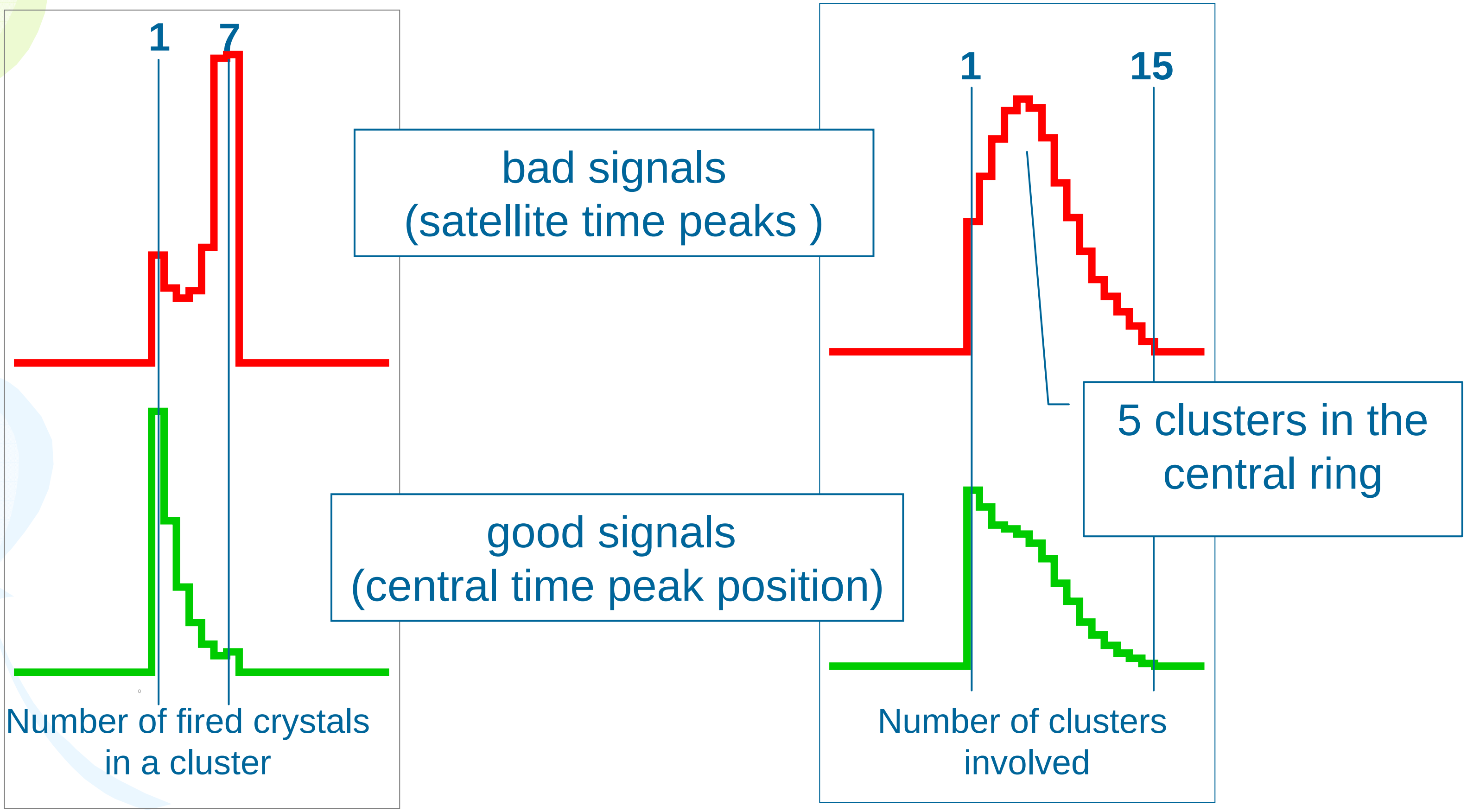
“normal” gammas

If only low amplitudes accepted (DGF filtering)



In-beam Ge time distribution @ 1^{st} EB ring

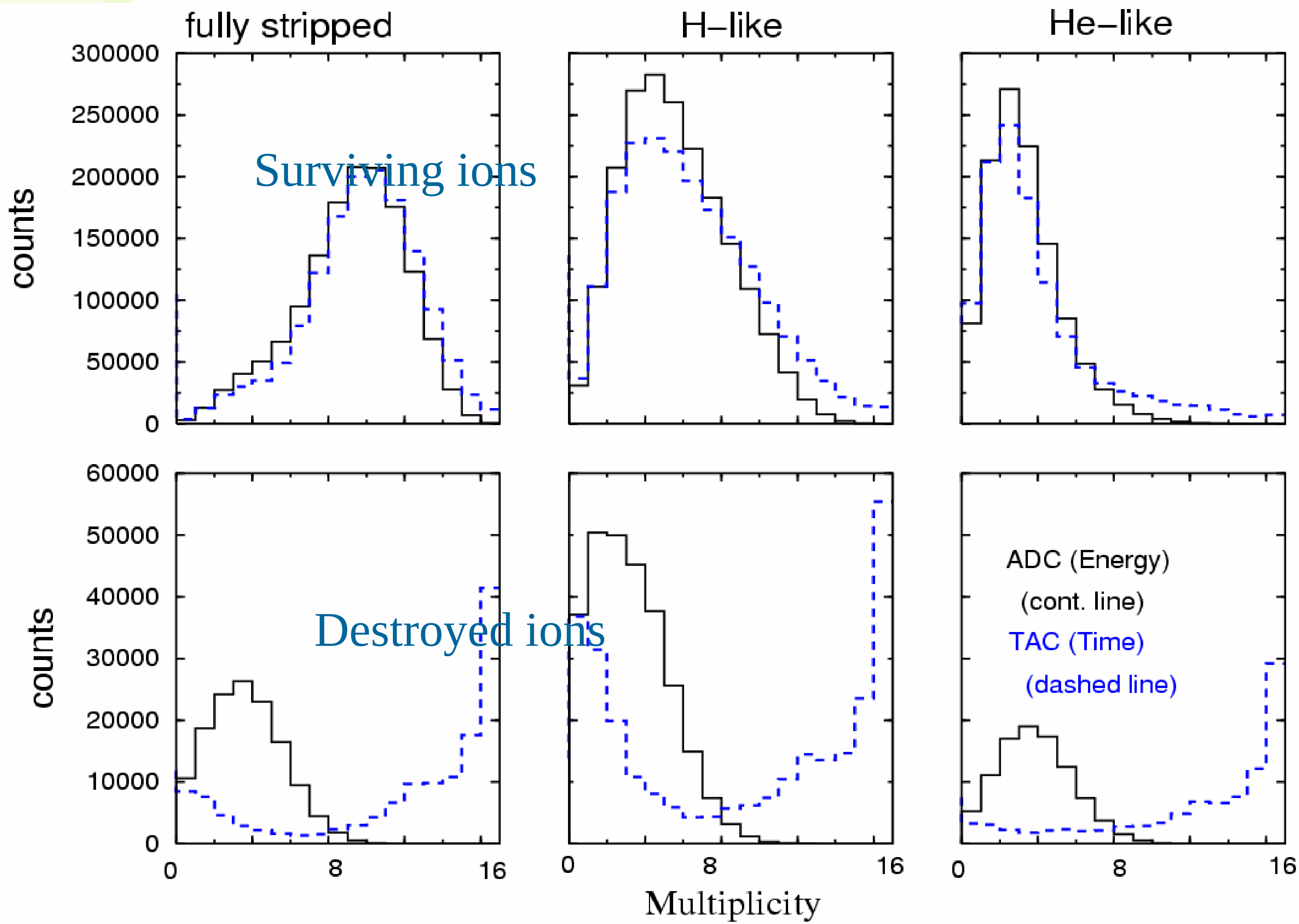
Ge multiplicity distribution

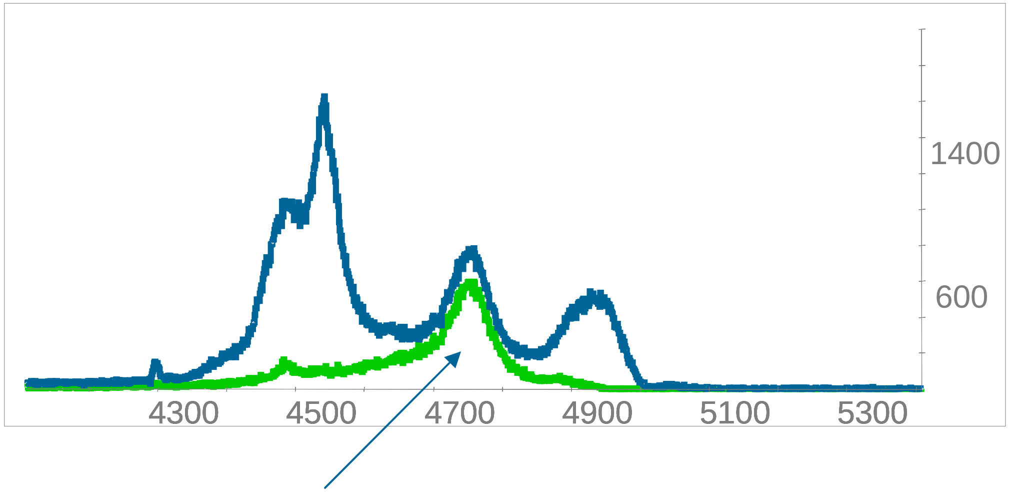


Conclusion: **Radiation/particles of high energy irradiate several Ge detectors (mainly central) in the same time**

Zs. Podolyak et al, Nucl. Phys. A722 (2003) 273c

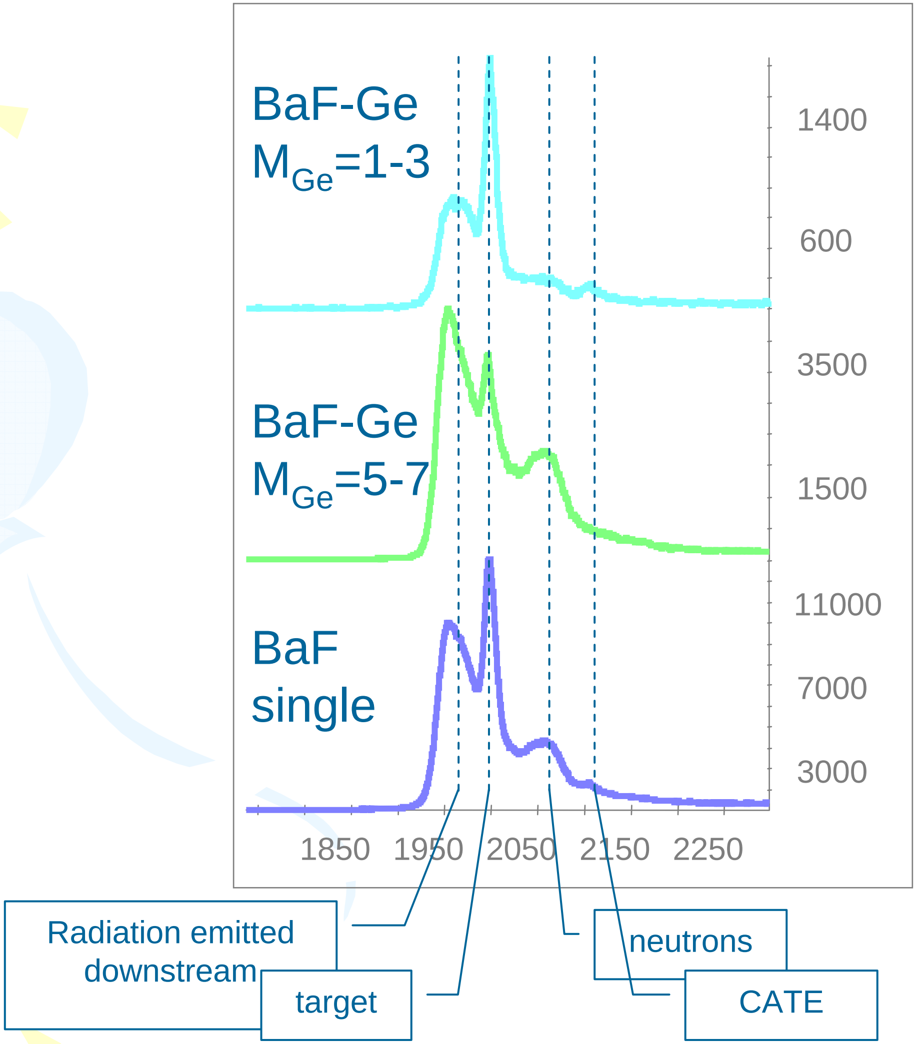
Around: 196Os 200-201Pt 206Hg





Solution: **Multiplicity filtering,**
when the number of crystals in a cluster is 1-3
(physically correct condition to detect the Compton scattering)

A BaF_2 (HECTOR) time distribution in coincidence with a cluster



Conclusion: the source of the high multiplicity, and high amplitude signals is situated downstream in the FRS area

Some other properties of the "bad" signals:

- For the outer rings the number of saturated signals is reduced
- With a primary beam (no fragmentation before a target) the bad signals contribute less
- The higher beam energy and the current the bigger contribution of the bad signals
- No matter if a reaction target is used or not

A general conclusion on that point:

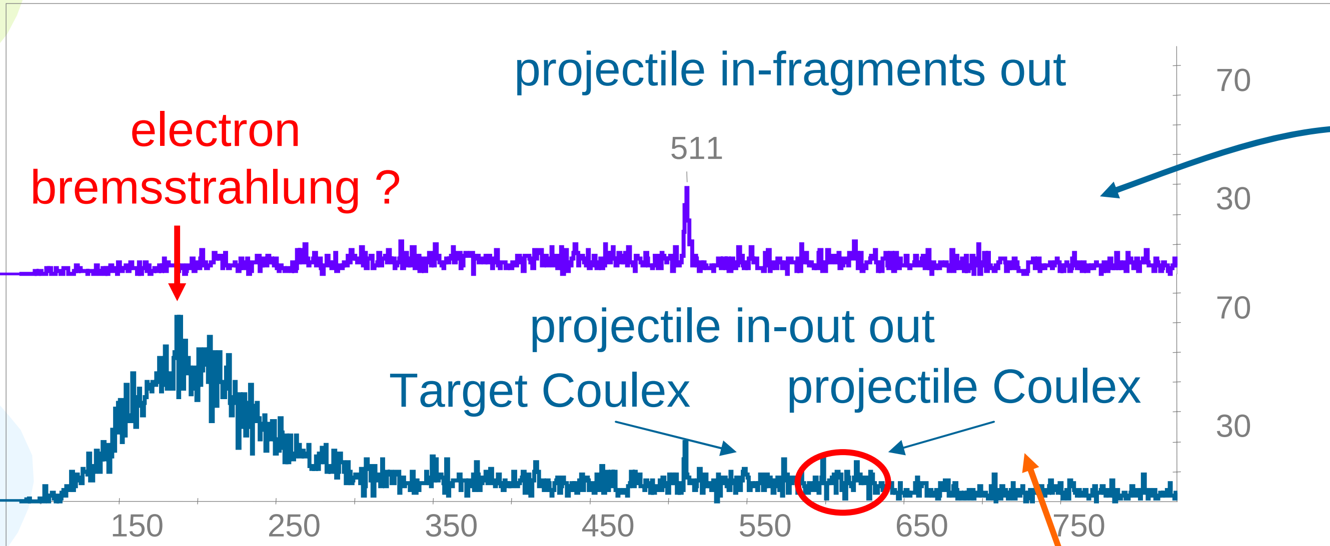
A fragmentation in the FRS area is a source of the intensive background radiation seen by the Ge detectors.

Its nature could be high energy particles* (protons) affecting mainly detectors close to the beam line.

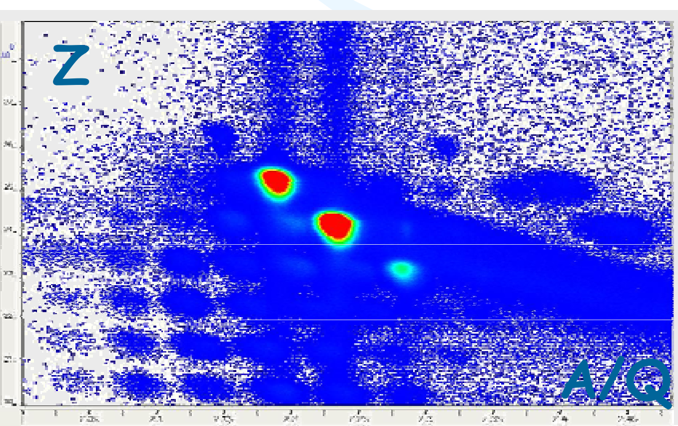
*However a pileup of several hundred gammas irradiating the whole array cannot be excluded (i.e. a very intense bremsstrahlung)

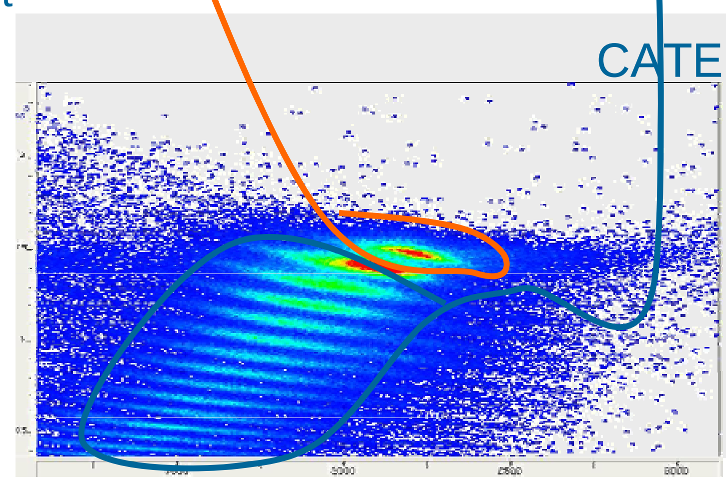
Low energy background in a Ge gamma spectrum

^{134}Cs secondary beam on Au target

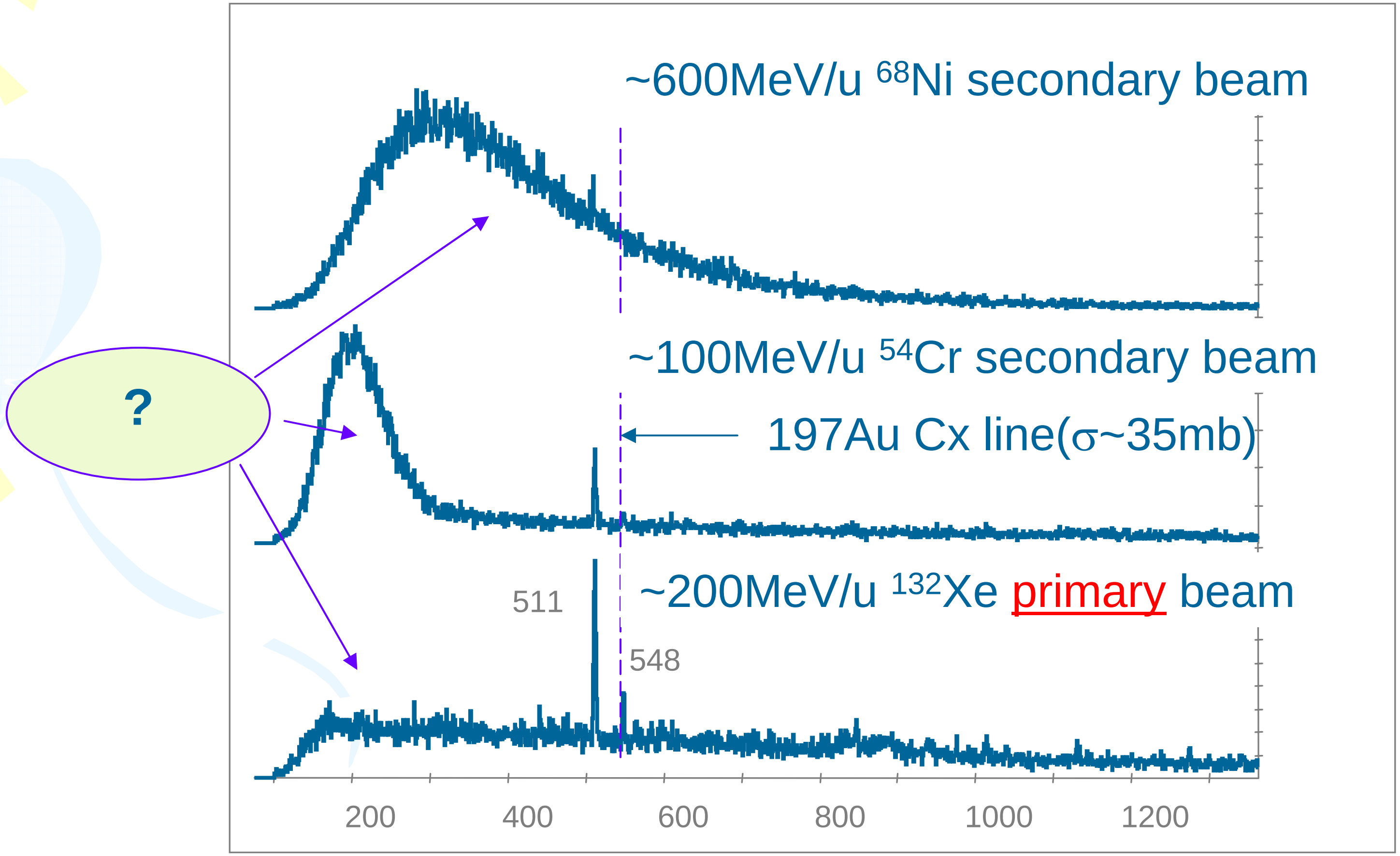


- a few gammas, mainly elastic scattering=> enhanced background (correlated with a beam)
- gammas from excited fragments emitted in flight

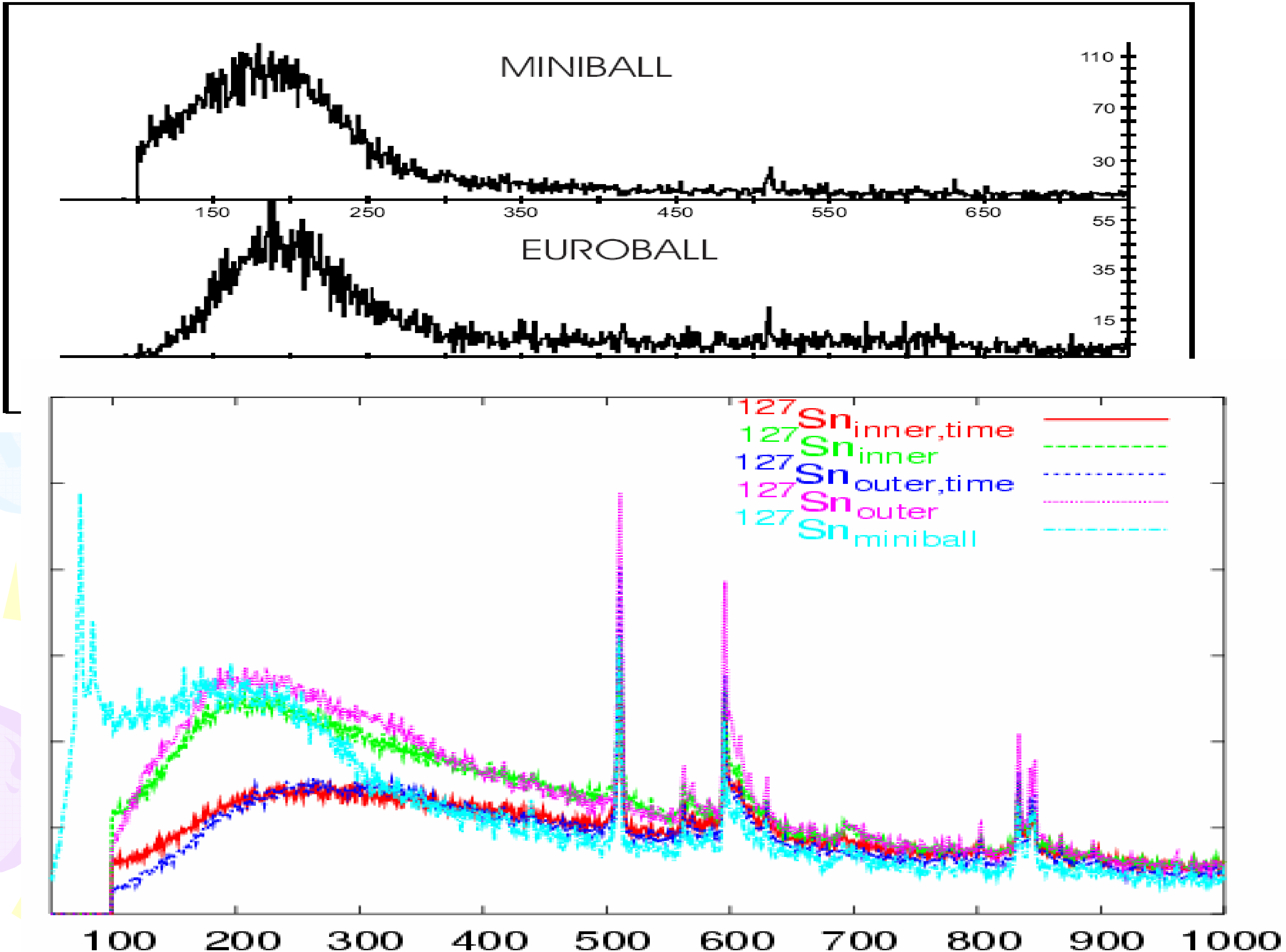




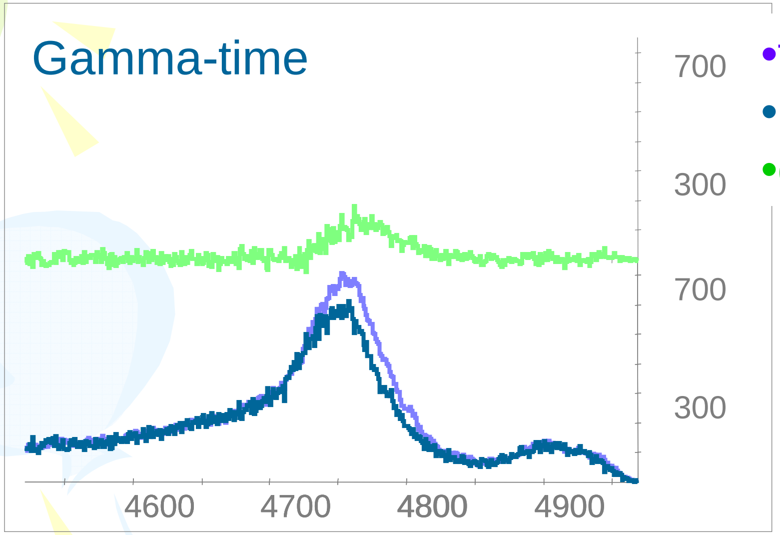
Incoming-outgoing projectile selection, Au target



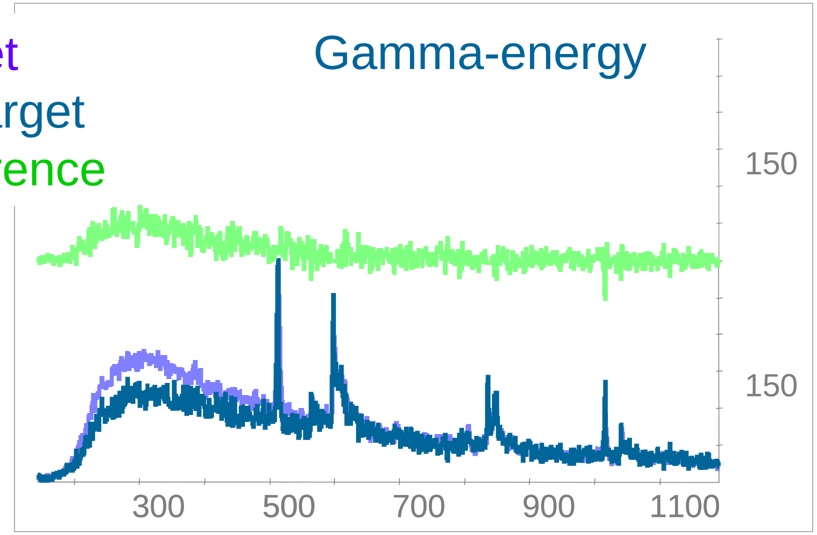
134Cs secondary beam on Au, projectile in-out



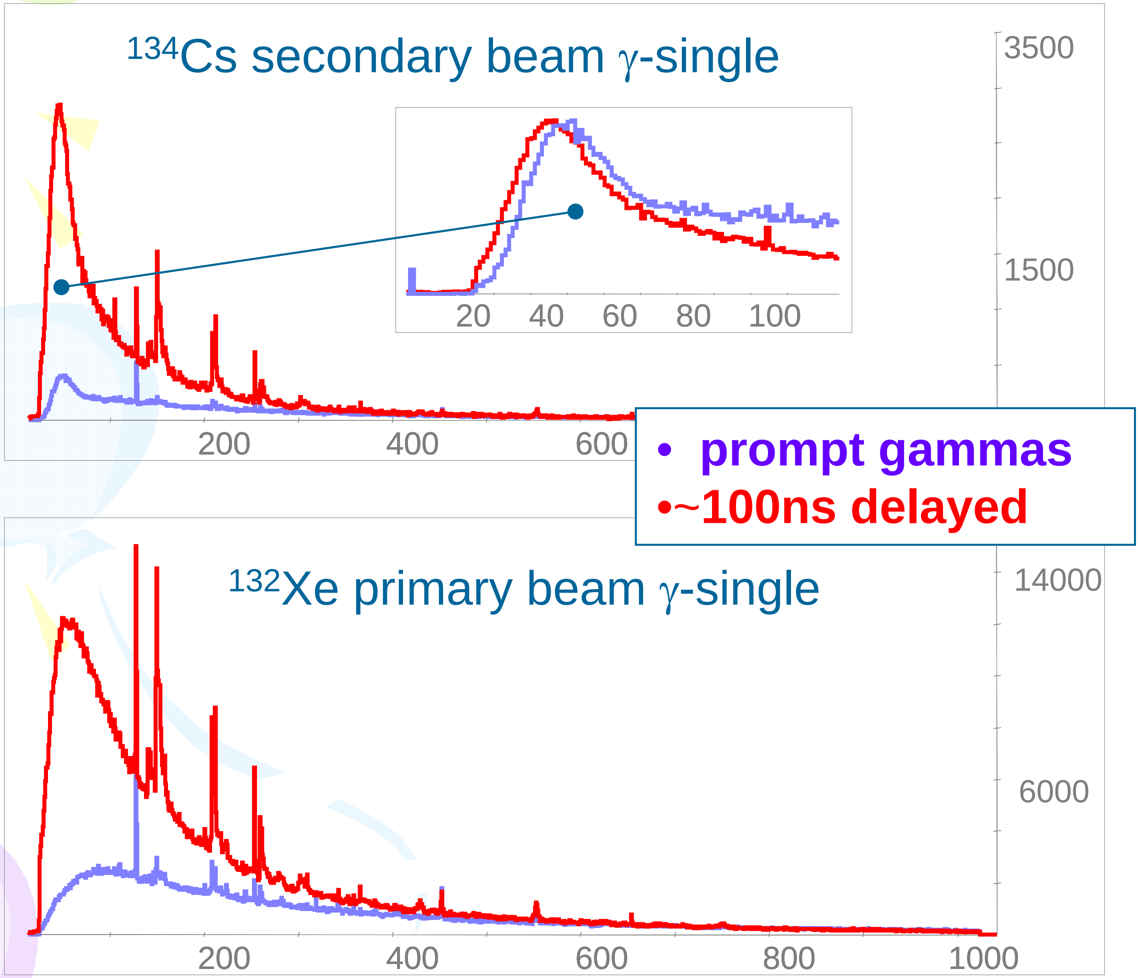
~600MeV/u ^{68}Ni secondary beam



- target
- no target
- difference



Presence of the Au target enhances the <u>prompt</u> low energy gammas.

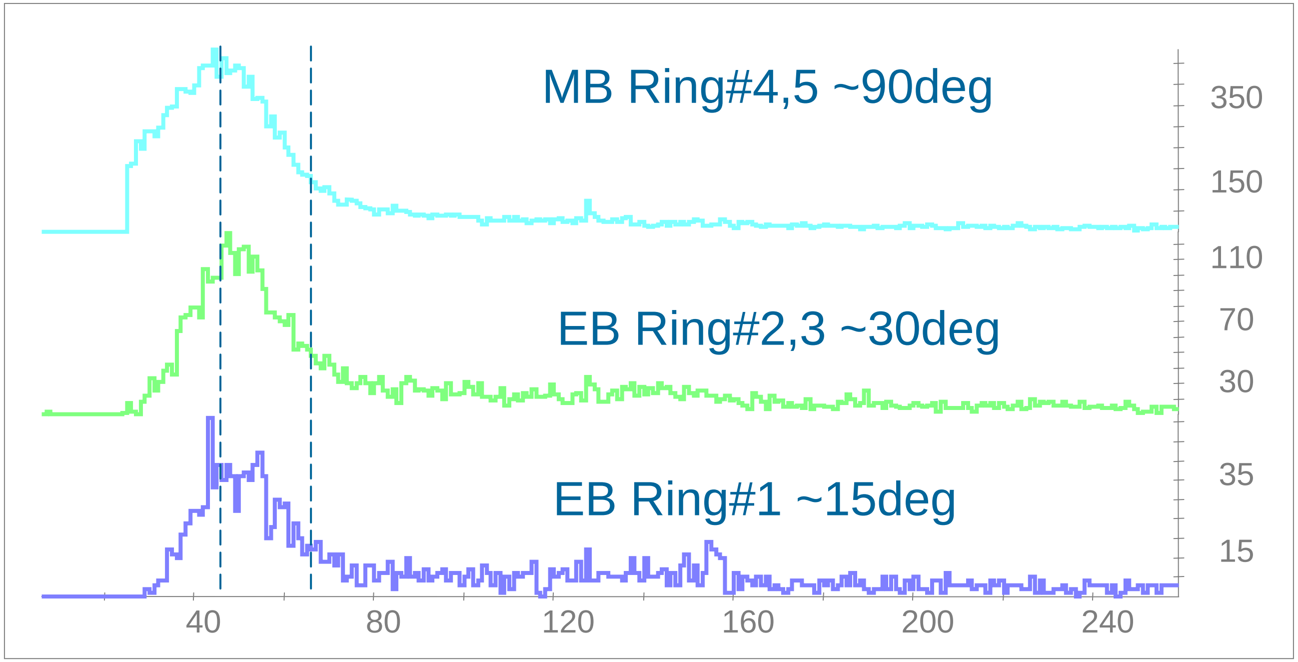


Spectra normalized according to the 400-1000 keV range

The prompt and delayed distributions are shifted in energy

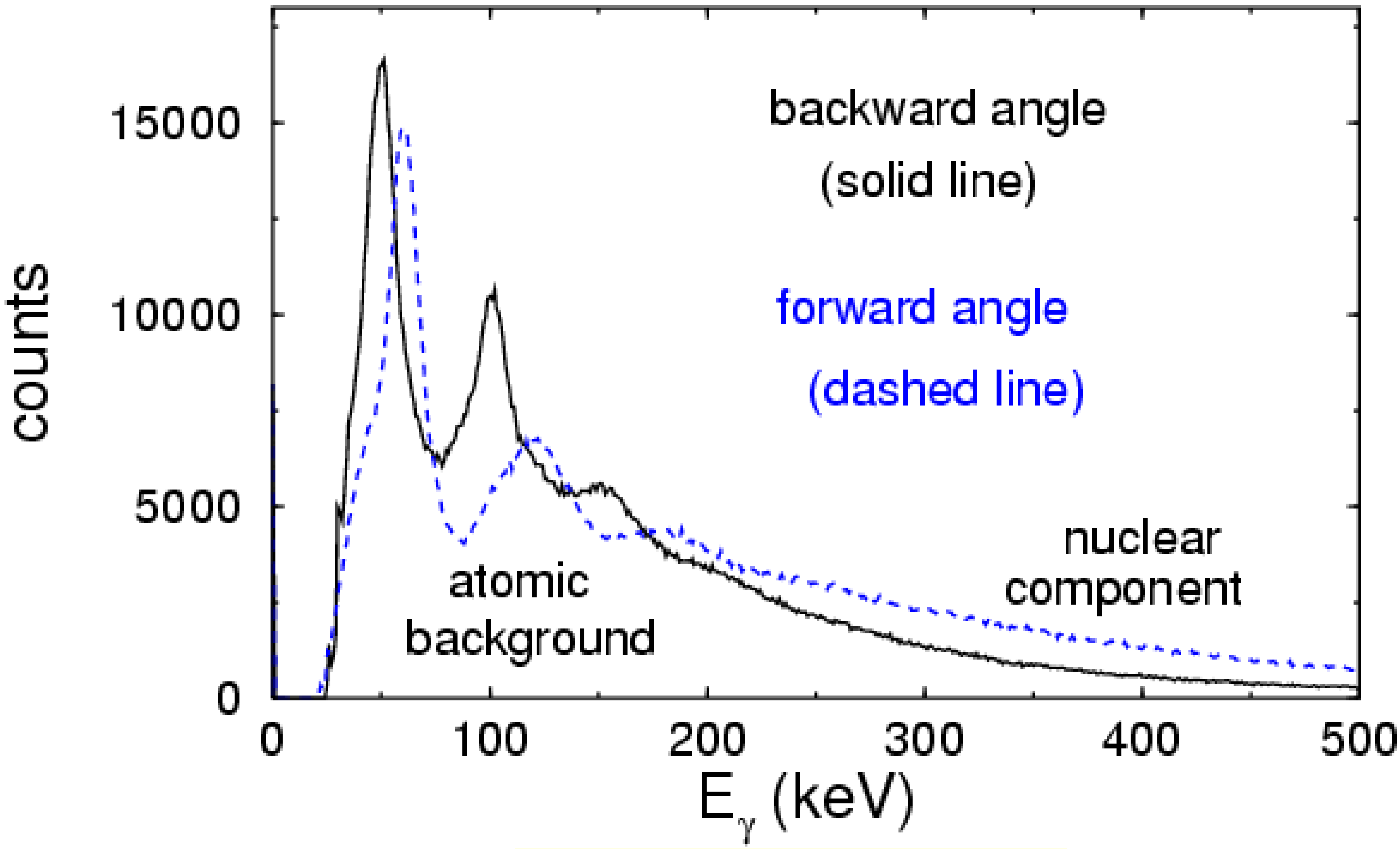
There is (almost) no prompt background bump if only a primary beam is of use

^{134}Cs secondary beam γ-particle



Position of the (prompt) bump very little depends on a detector angle

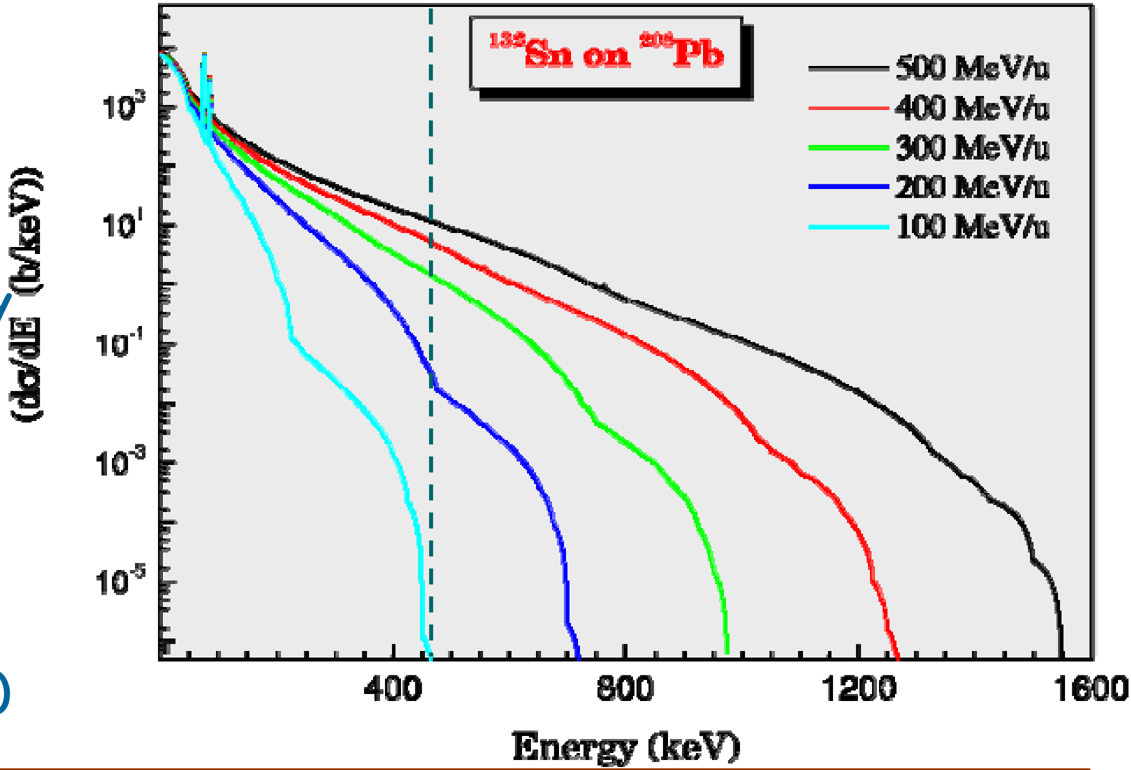
Zs. Podolyak et al, Nucl. Phys. A722 (2003) 273c



At ~60 and~ 120 degrees

Bremsstrahlung components

- **Radiative electron Capture** of target electrons into bound states of the projectile
- **Primary Bremsstrahlung** of target electrons produced by the collision with the projectile
- **Secondary Bremsstrahlung** of high energy knock-out electrons re-scattering in the target



- σ (atomic) ~ 10000 * σ (nuclear)

Components of the atomic background and their properties [31]. Z_p and Z_t are the atomic numbers of the projectile and target, respectively. E_b is the binding energy of the electron in the projectile (see the text for details).

Component	energy	Doppler shift	$\sigma(\theta)$	$\sigma(Z_p, Z_t, v)$
REC	$[(\frac{1}{\sqrt{1-\beta^2}} - 1)mc^2 + E_b]\frac{\sqrt{1-\beta^2}}{1-\beta cos\theta}$	yes	$sin^2\theta$	$Z_p^2 Z_t / v_p^5$
PB	$< (\frac{1}{\sqrt{1-\beta^2}} - 1)mc^2\frac{\sqrt{1-\beta^2}}{1-\beta cos\theta}$	yes	$sin^2\theta(1-\beta cos\theta)$	$Z_p^2 Z_t / v_p^2$
SEB	$< 2\frac{\beta^2}{1-\beta^2}mc^2$	no	isotropic	$Z_p^2 Z_t^2 / v_p^2$

Conclusion:

- The prompt background may result from the (secondary ?) bremsstrahlung of electrons slowing down in the secondary target (Au). These electrons would be produced by fragments scattered on the FRS components.

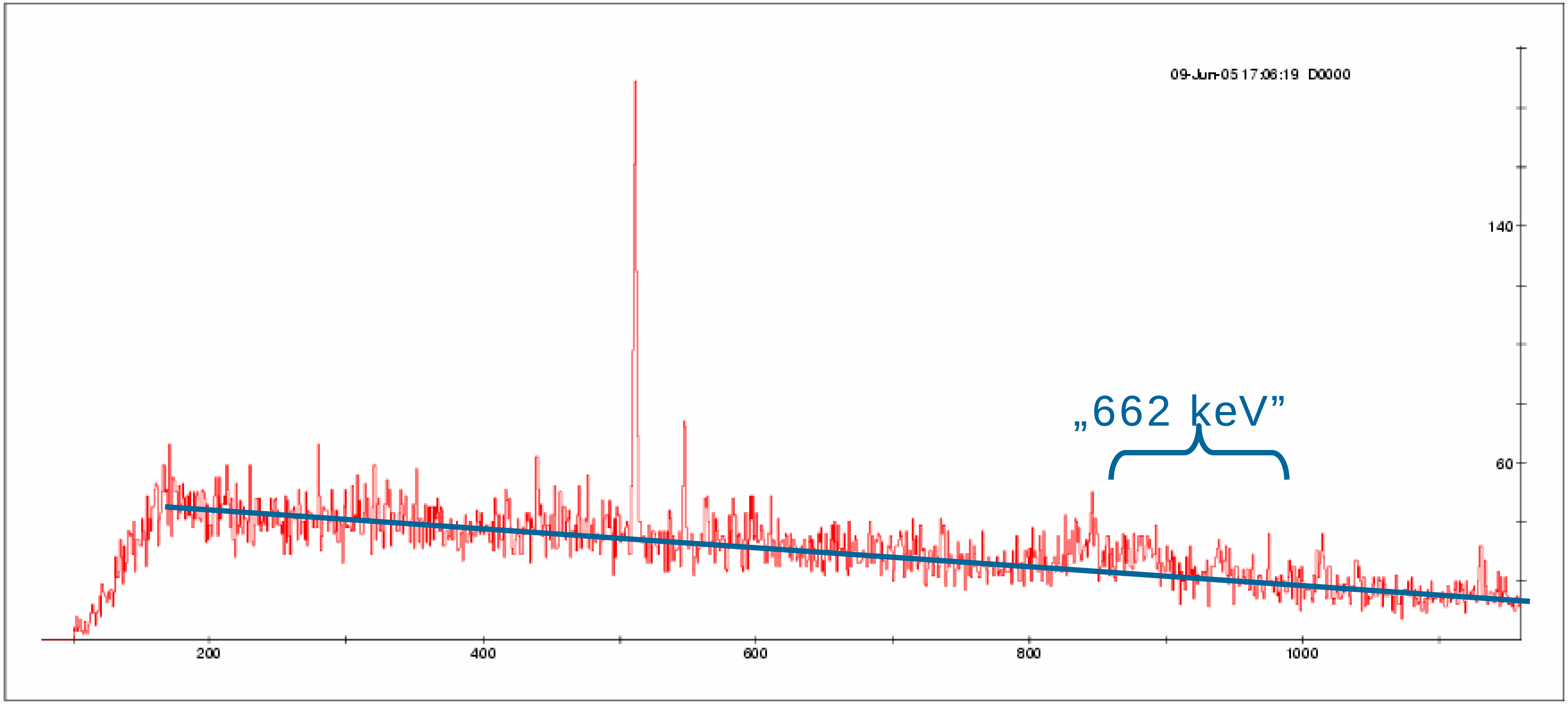
(suppressed if there is no primary or secondary target)

- The delayed component may be than related to the bremsstrahlung of the electrons in CATE (CsI) or in the environment.

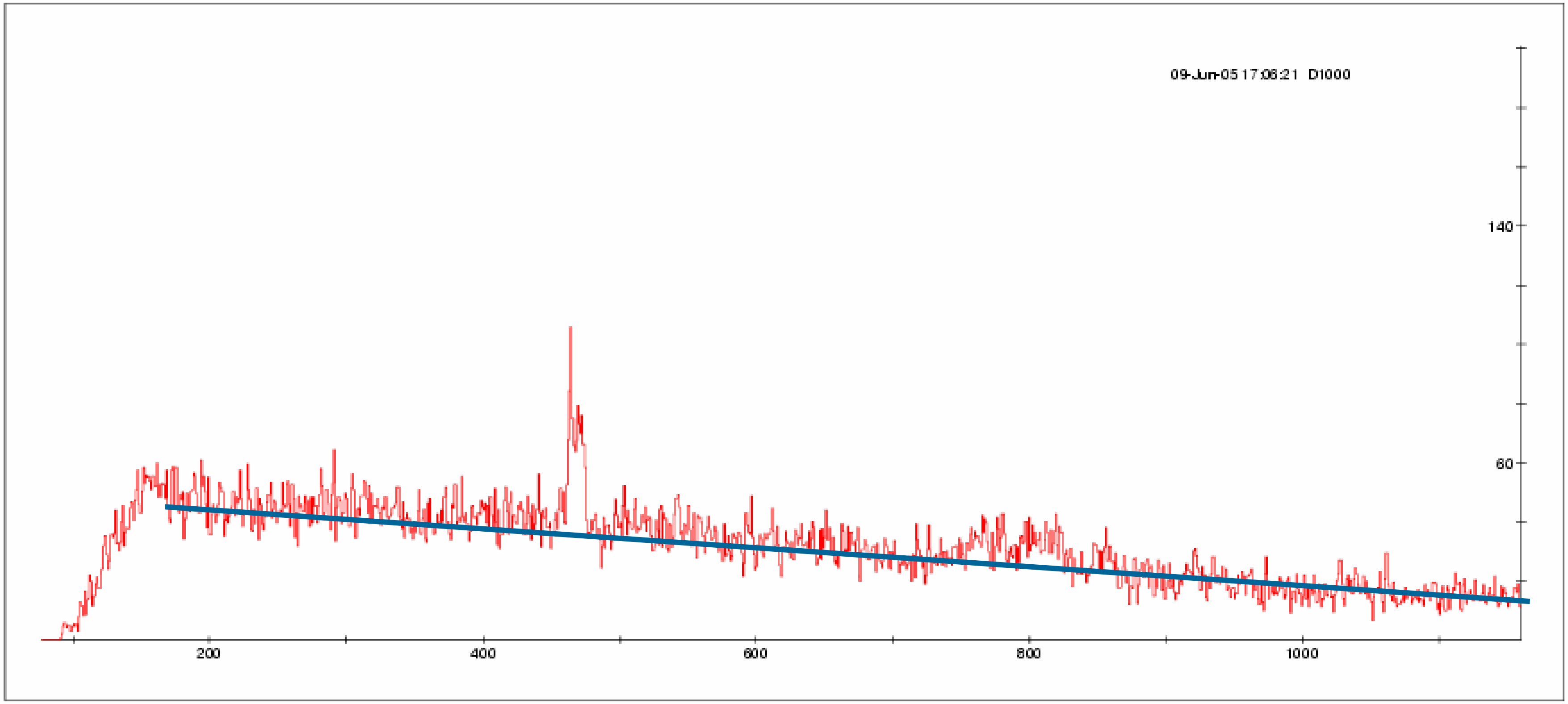
(In this case the electrons could be also emitted from the secondary target)

^{132}Xe (662 keV) v/c = 0.000

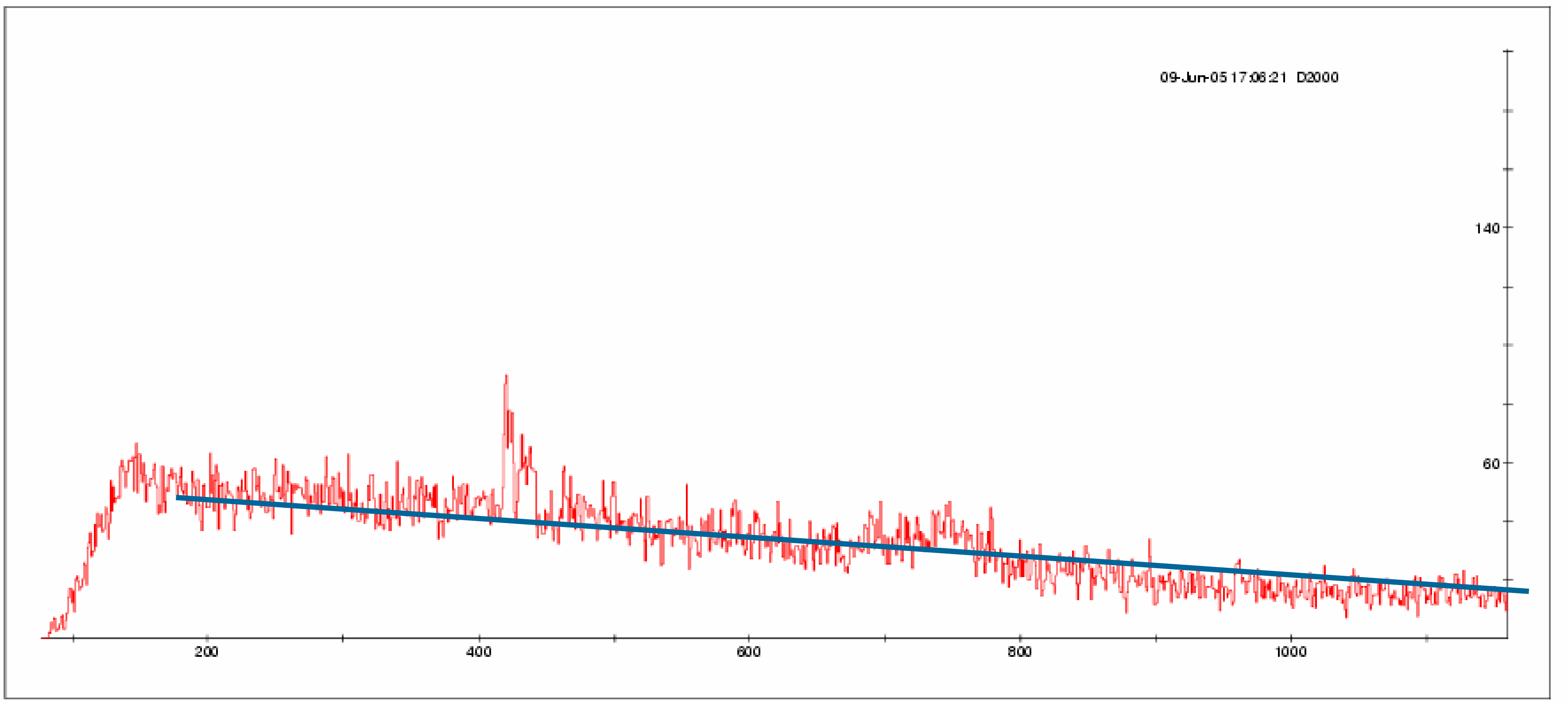
What happens to the spectral shape, when one applies Doppler corrections?



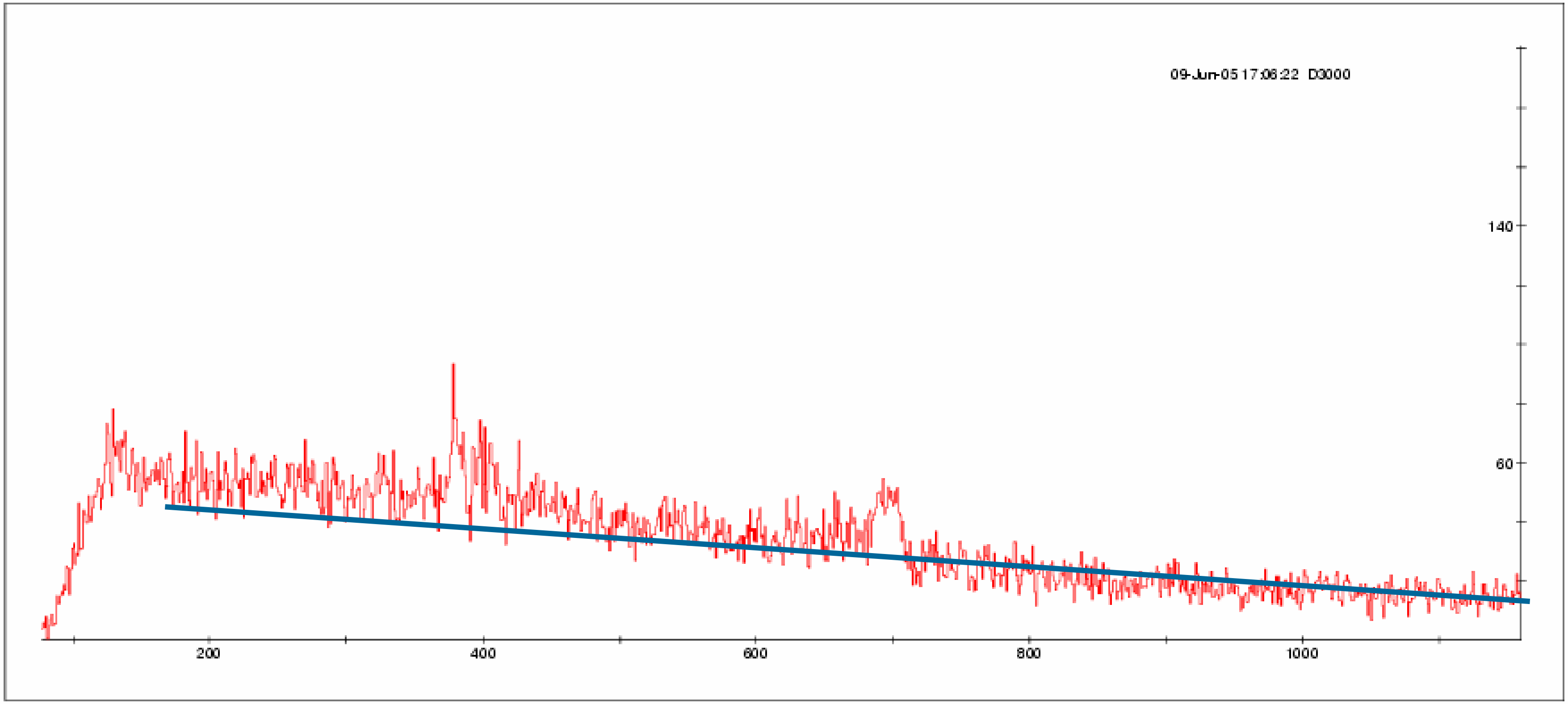
^{132}Xe (662 keV) v/c = 0.100



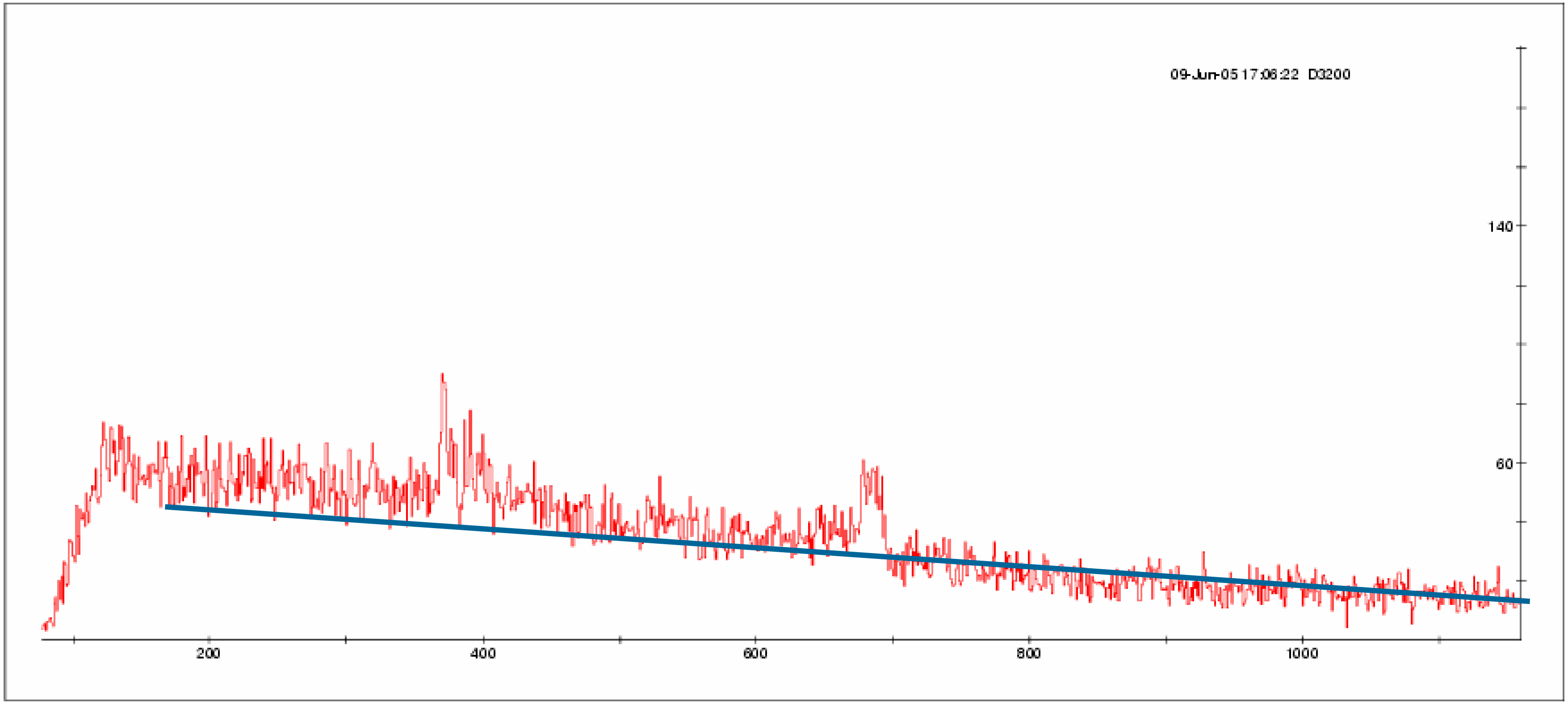
^{132}Xe (662 keV) v/c = 0.200



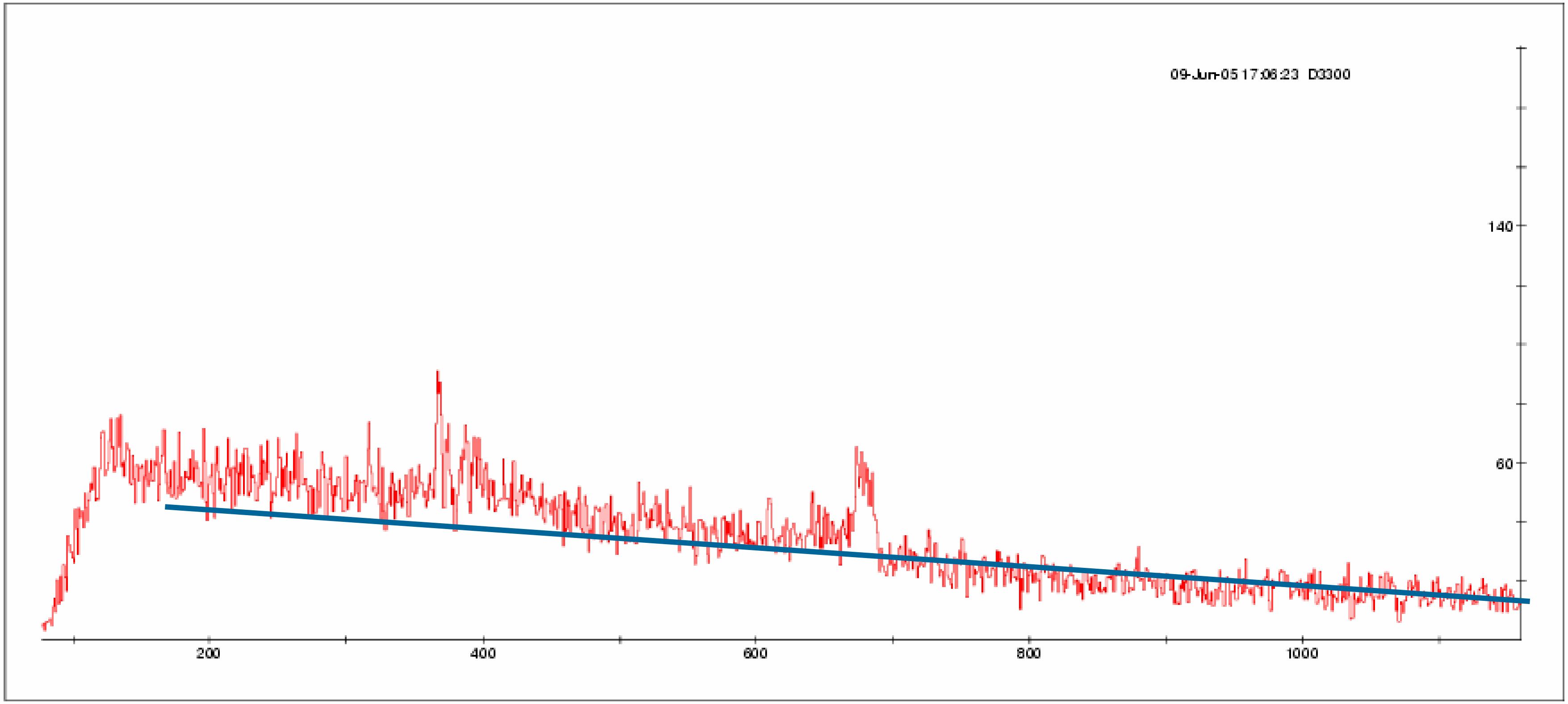
^{132}Xe (662 keV) v/c = 0.300



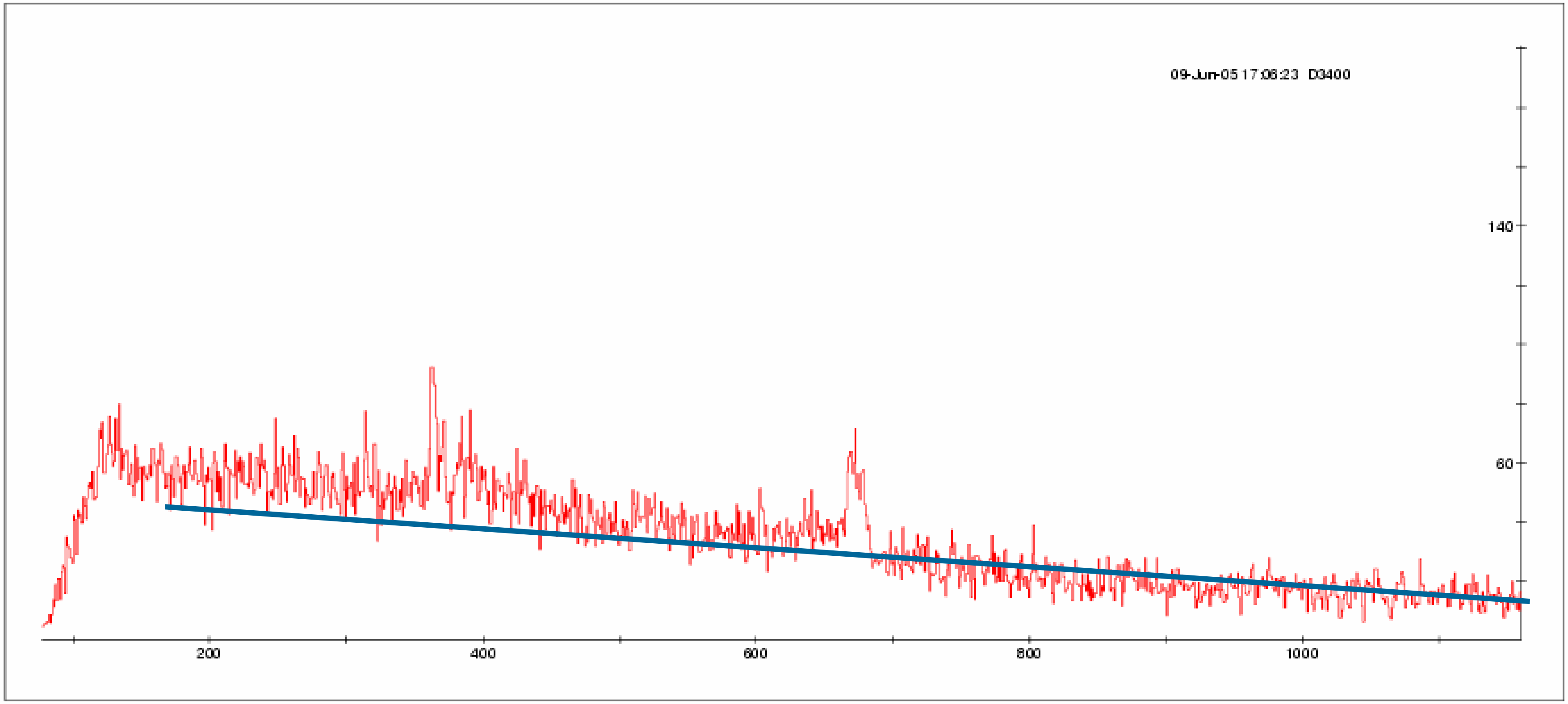
^{132}Xe (662 keV) v/c = 0.320



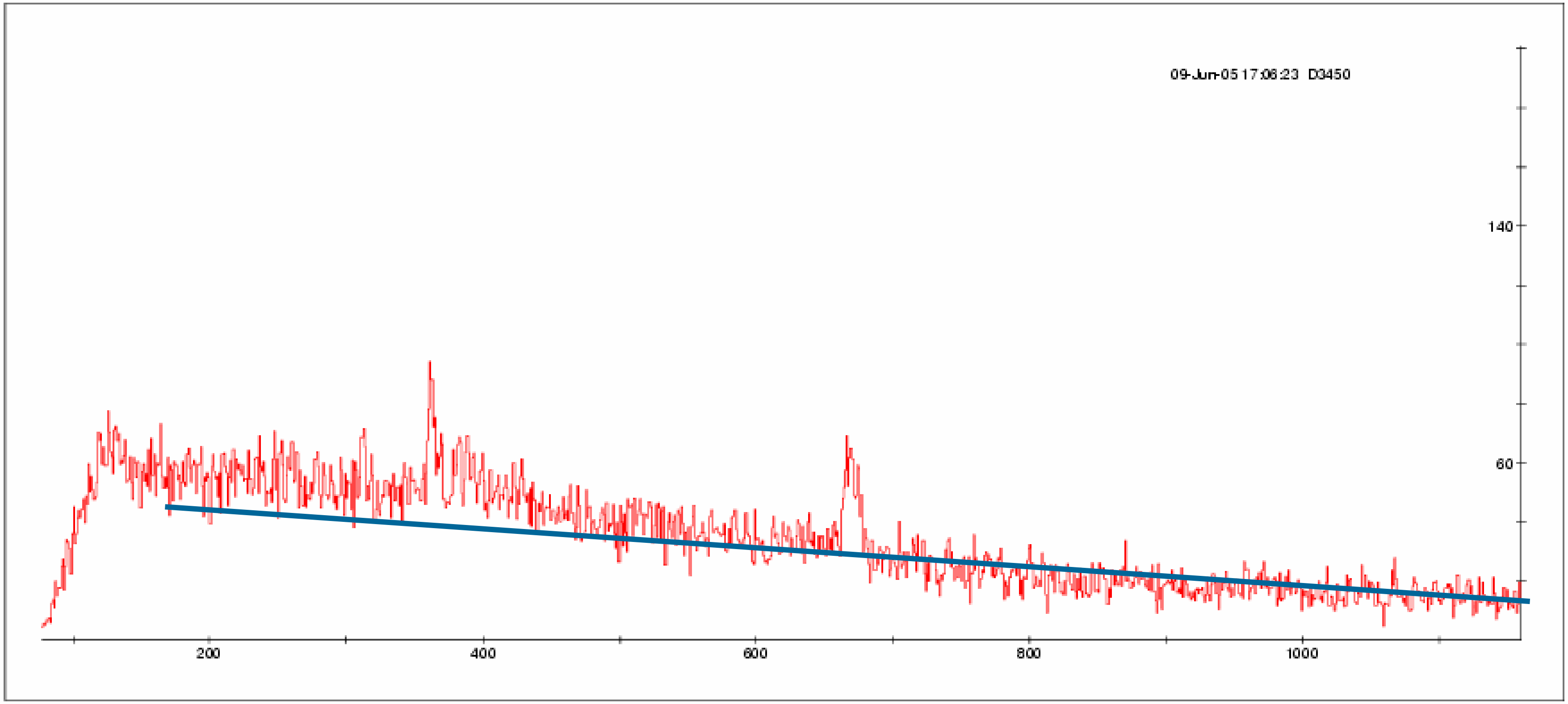
^{132}Xe (662 keV) v/c = 0.330



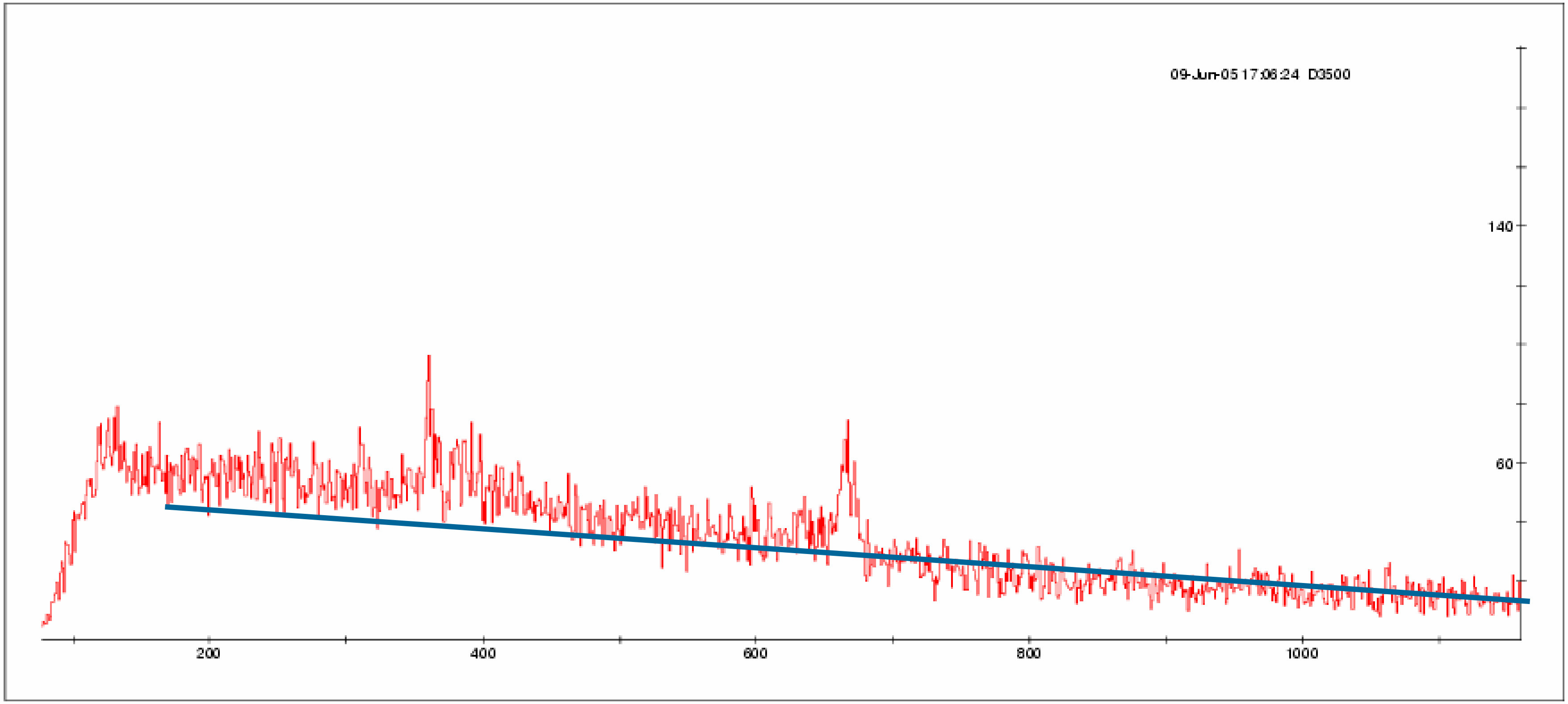
^{132}Xe (662 keV) v/c = 0.340



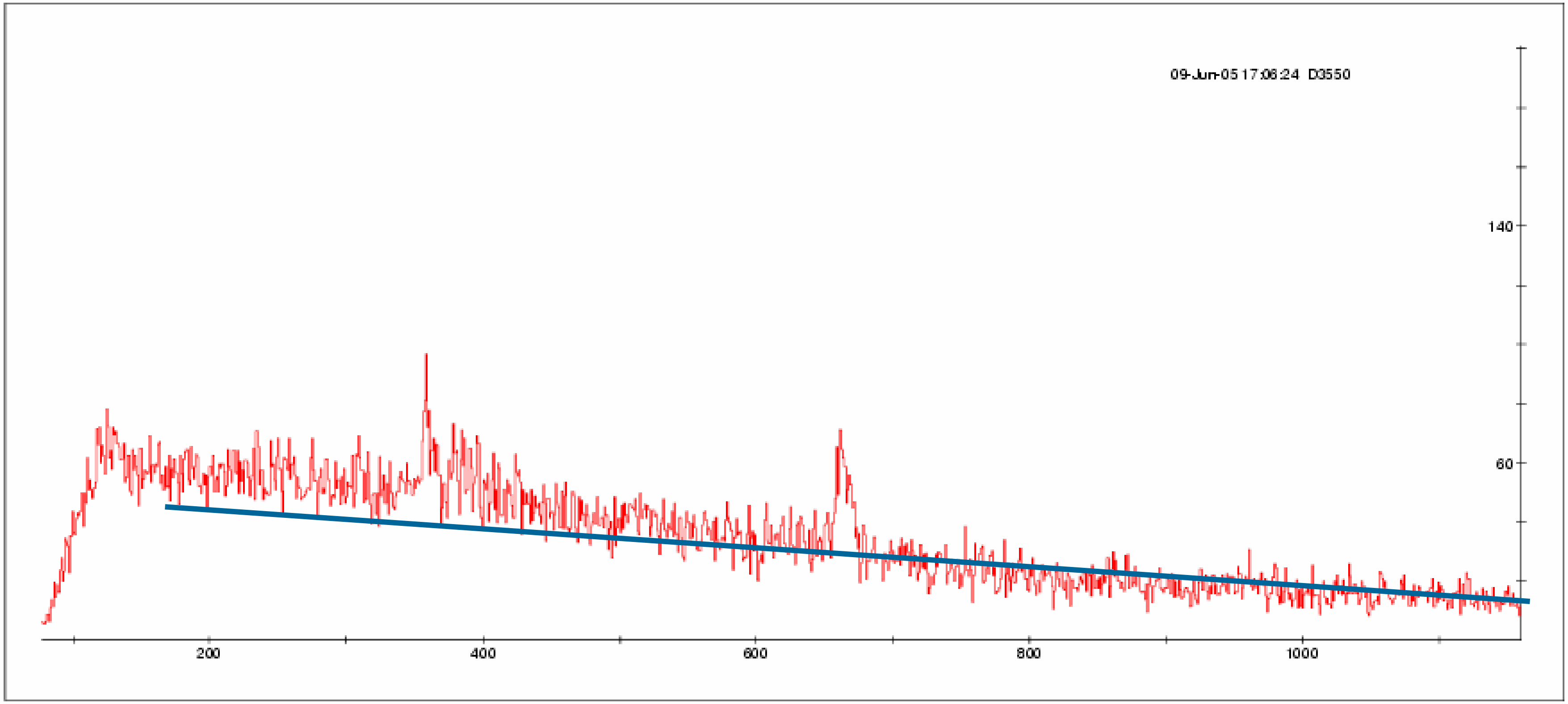
^{132}Xe (662 keV)   v/c = 0.345



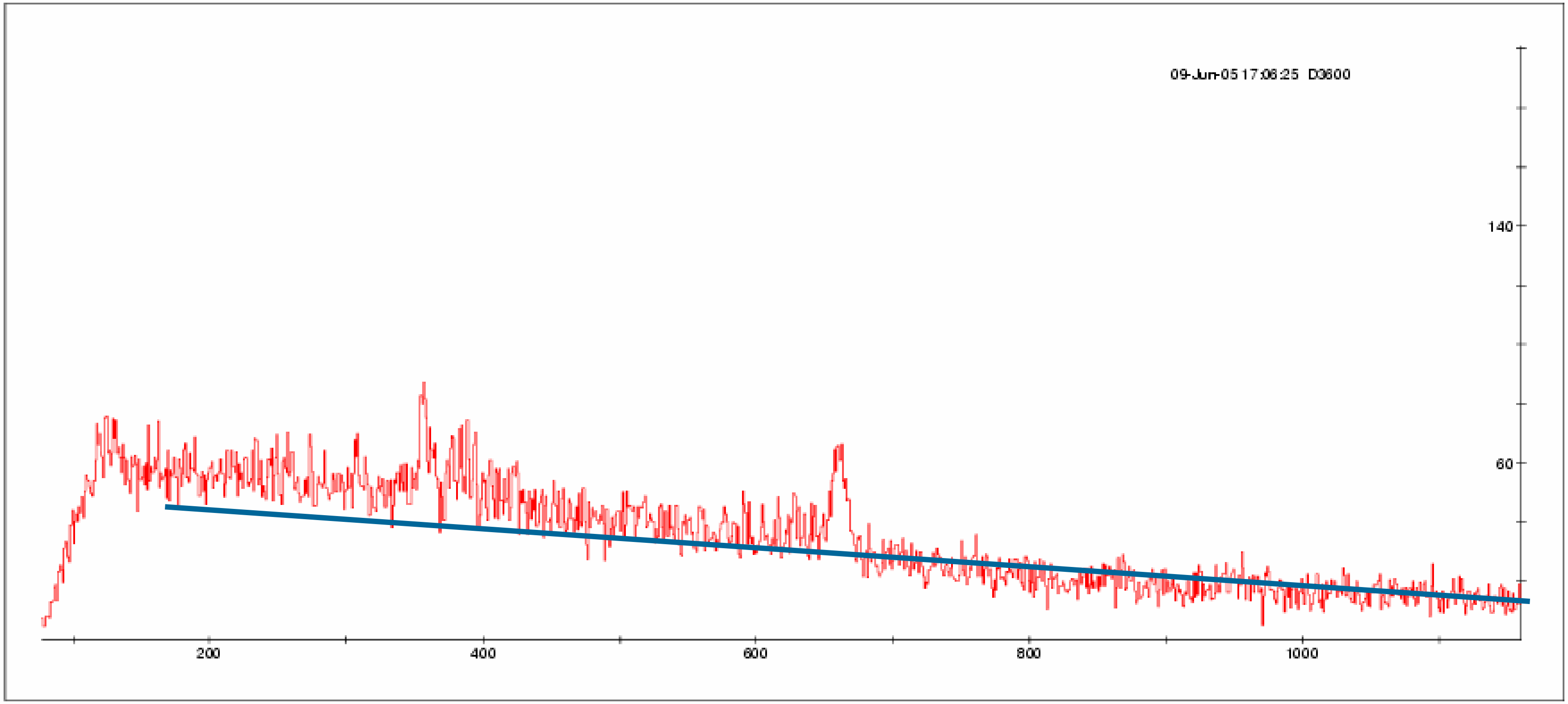
^{132}Xe (662 keV)   v/c = 0.350



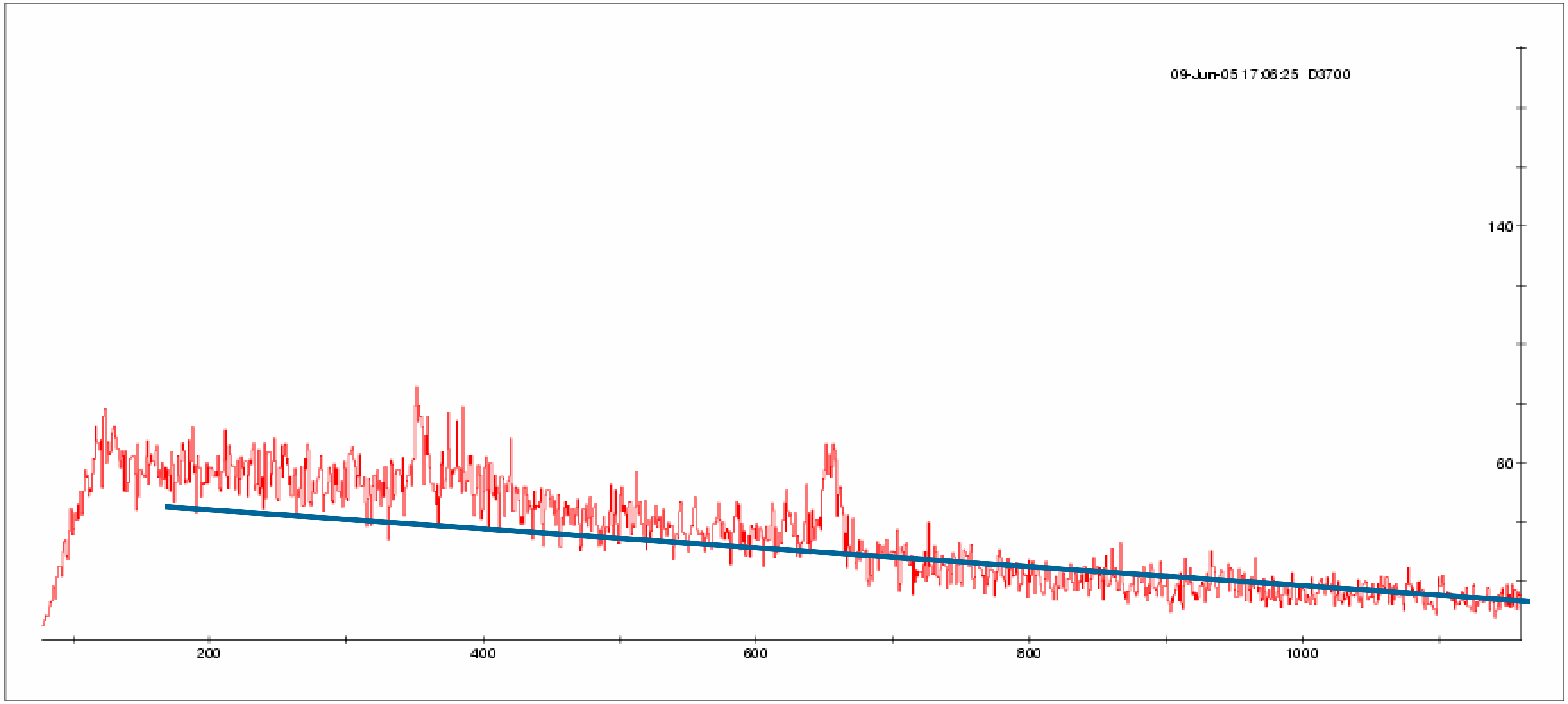
^{132}Xe (662 keV)   v/c = 0.355



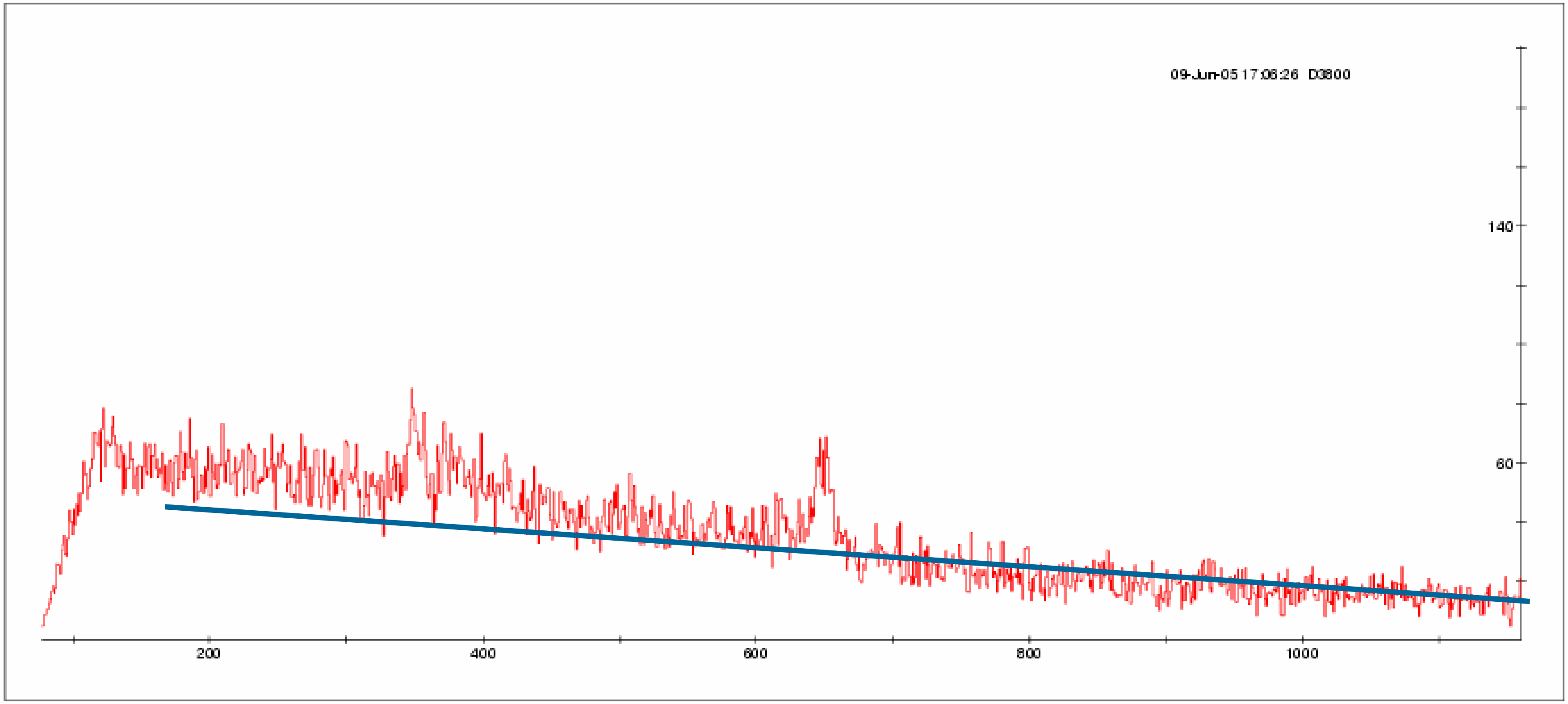
^{132}Xe (662 keV)   v/c = 0.360



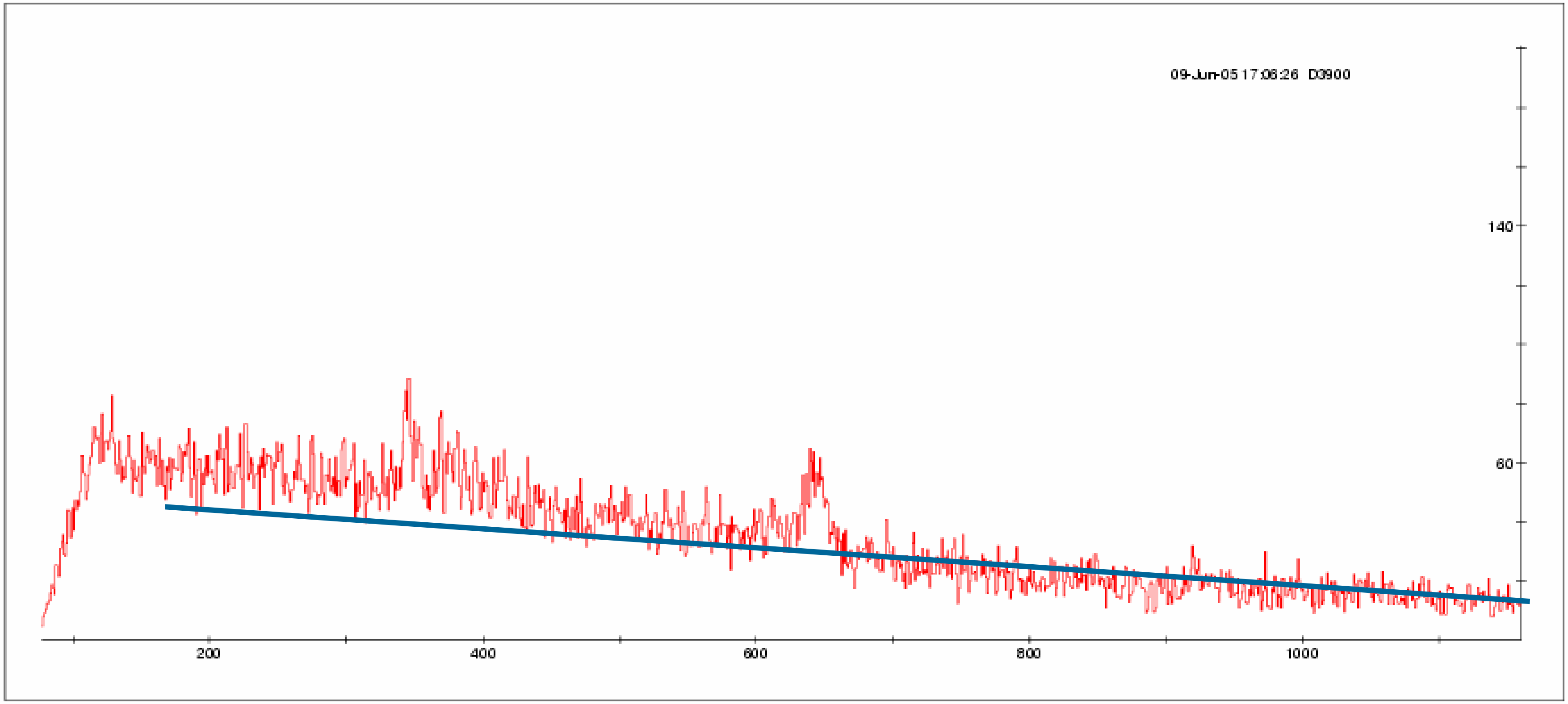
^{132}Xe (662 keV) v/c = 0.370



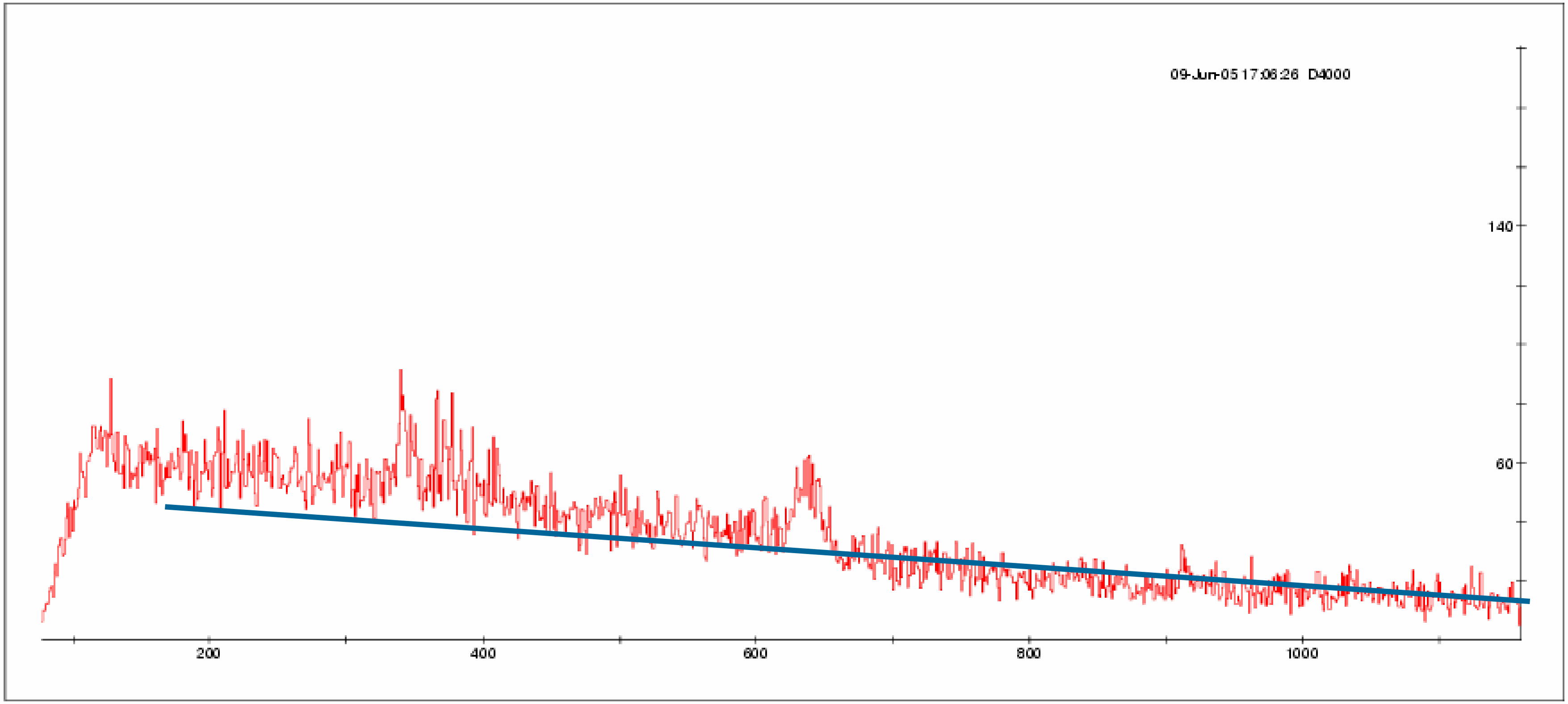
^{132}Xe (662 keV)   v/c = 0.380



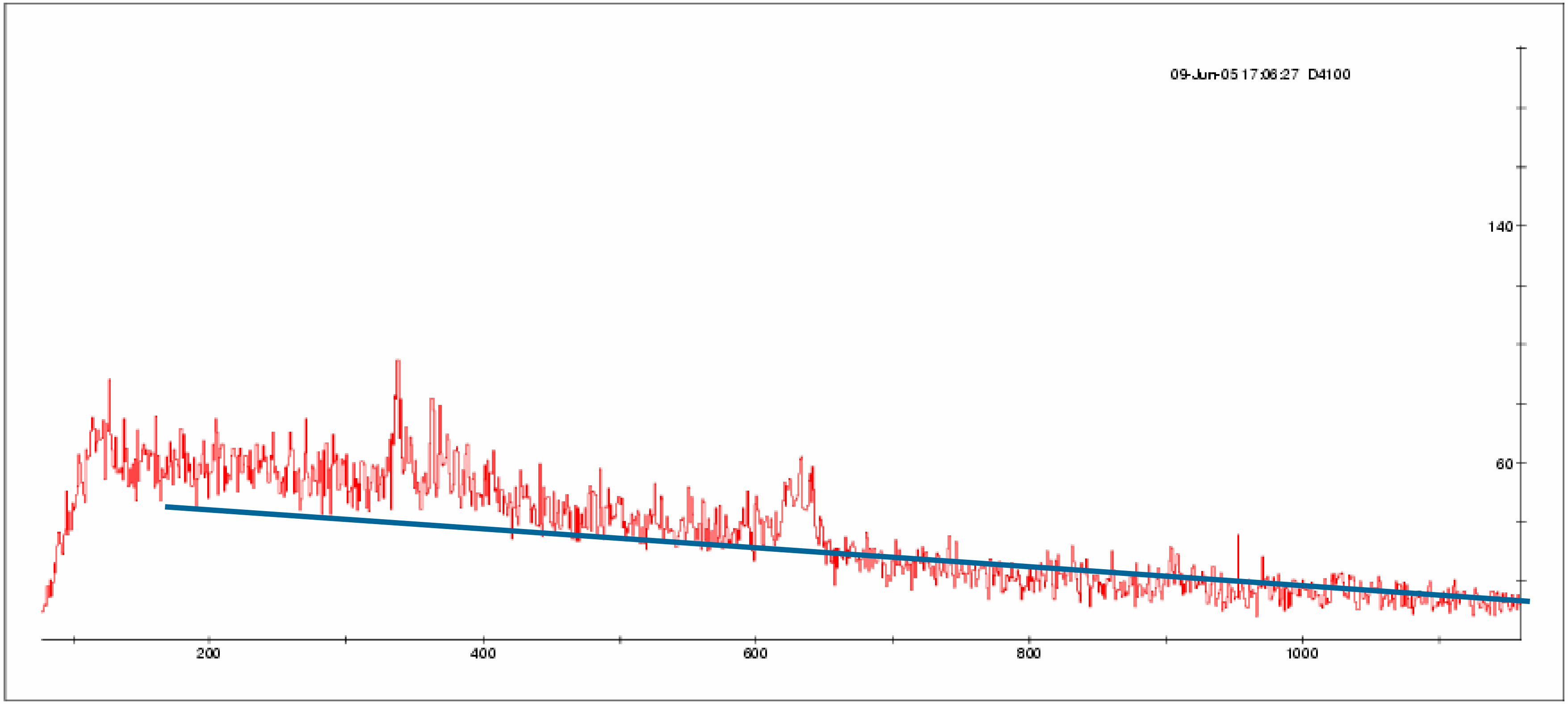
^{132}Xe (662 keV) v/c = 0.390



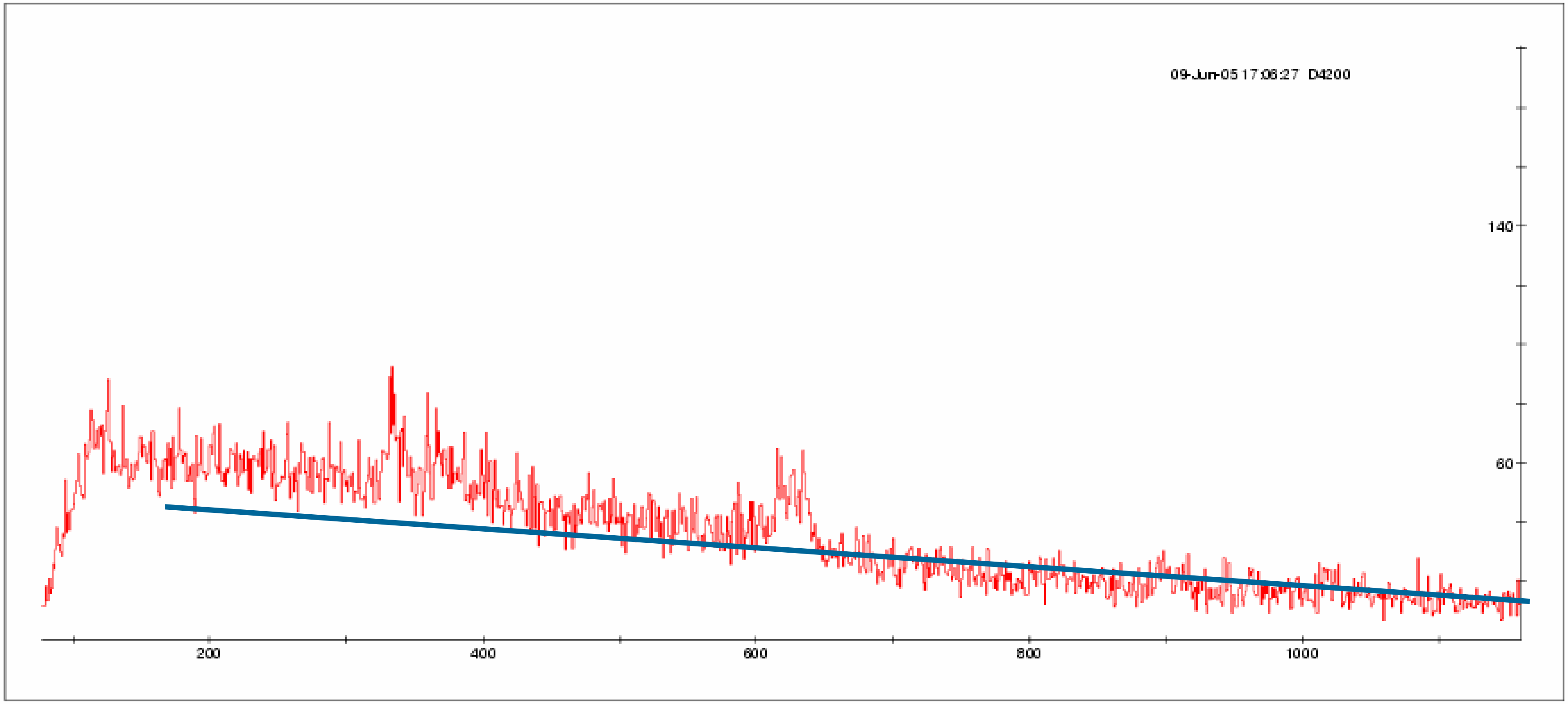
^{132}Xe (662 keV) v/c = 0.400



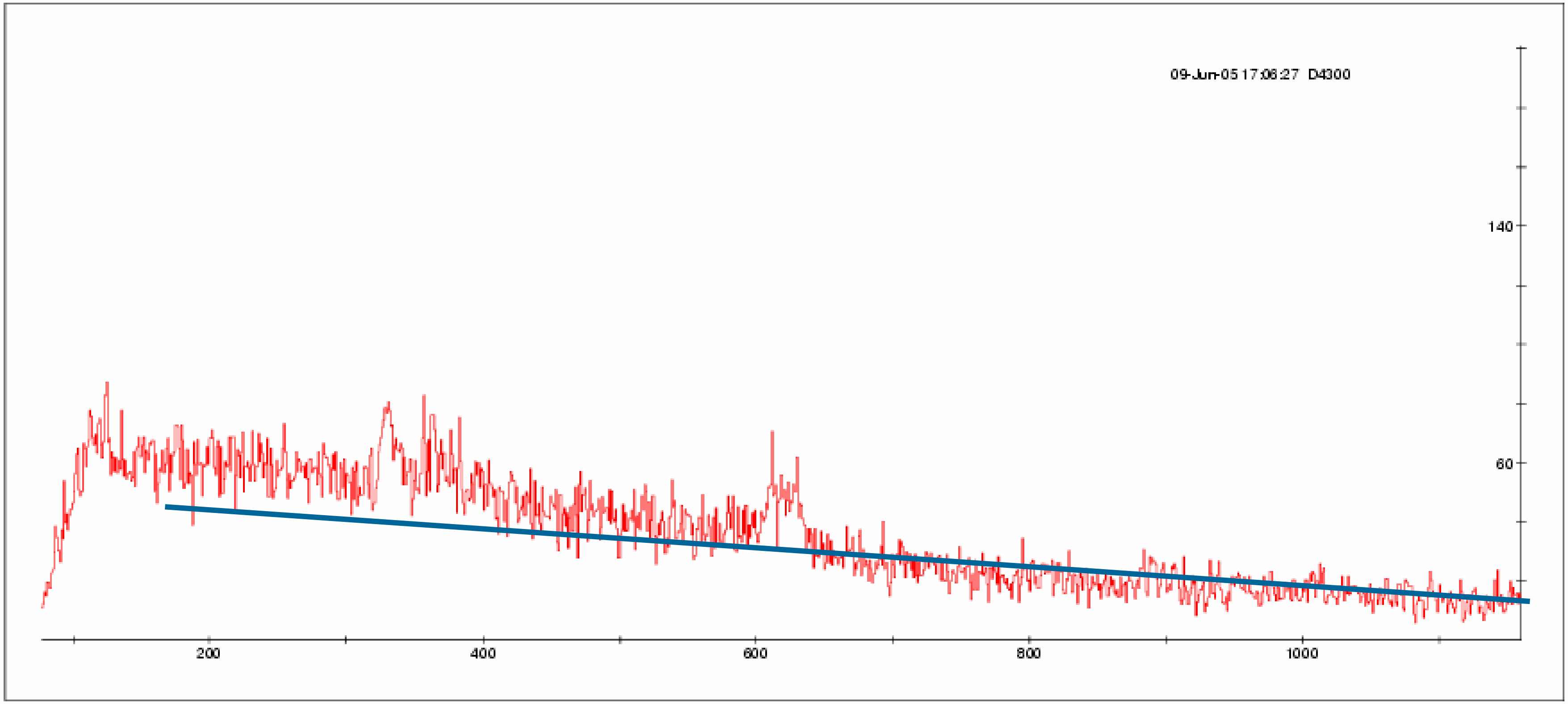
^{132}Xe (662 keV) v/c = 0.410



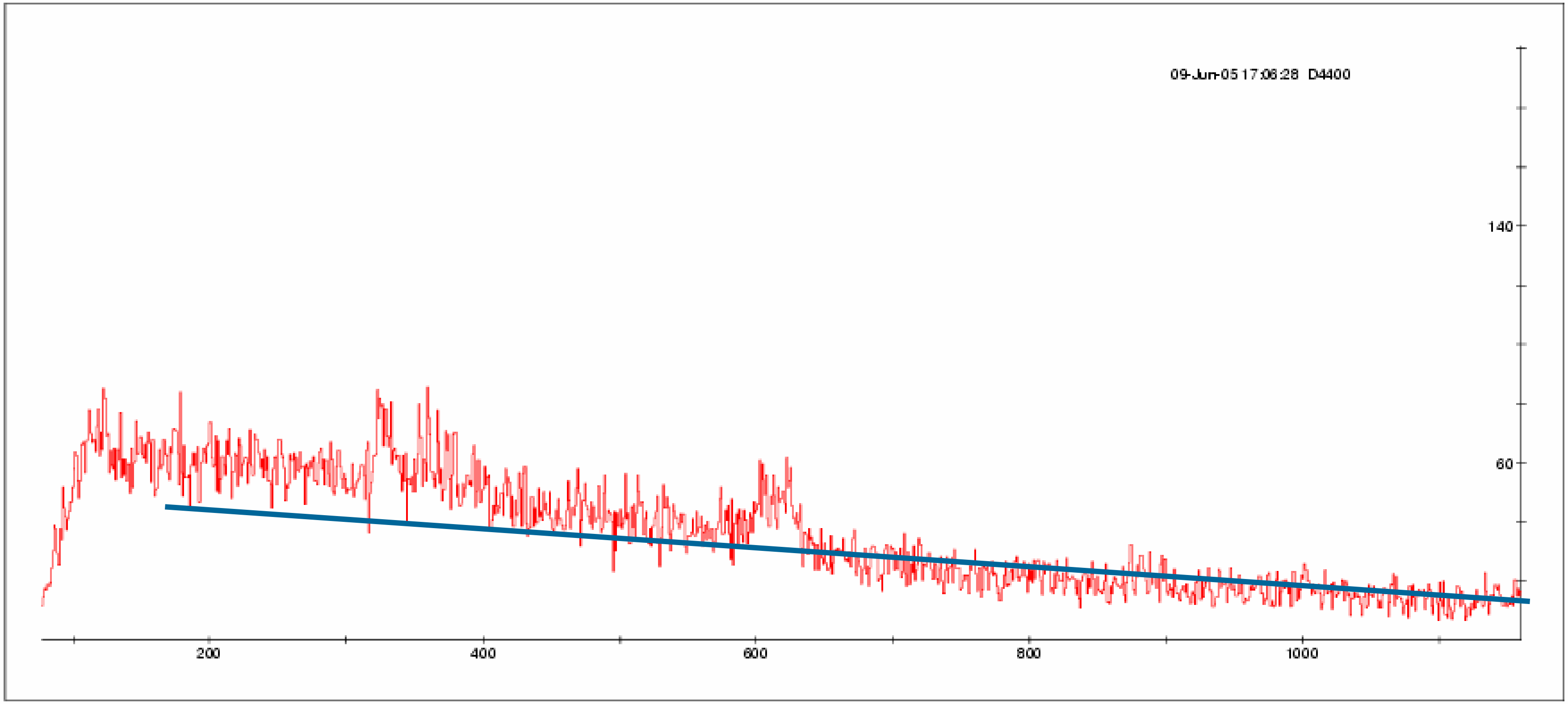
^{132}Xe (662 keV) v/c = 0.420



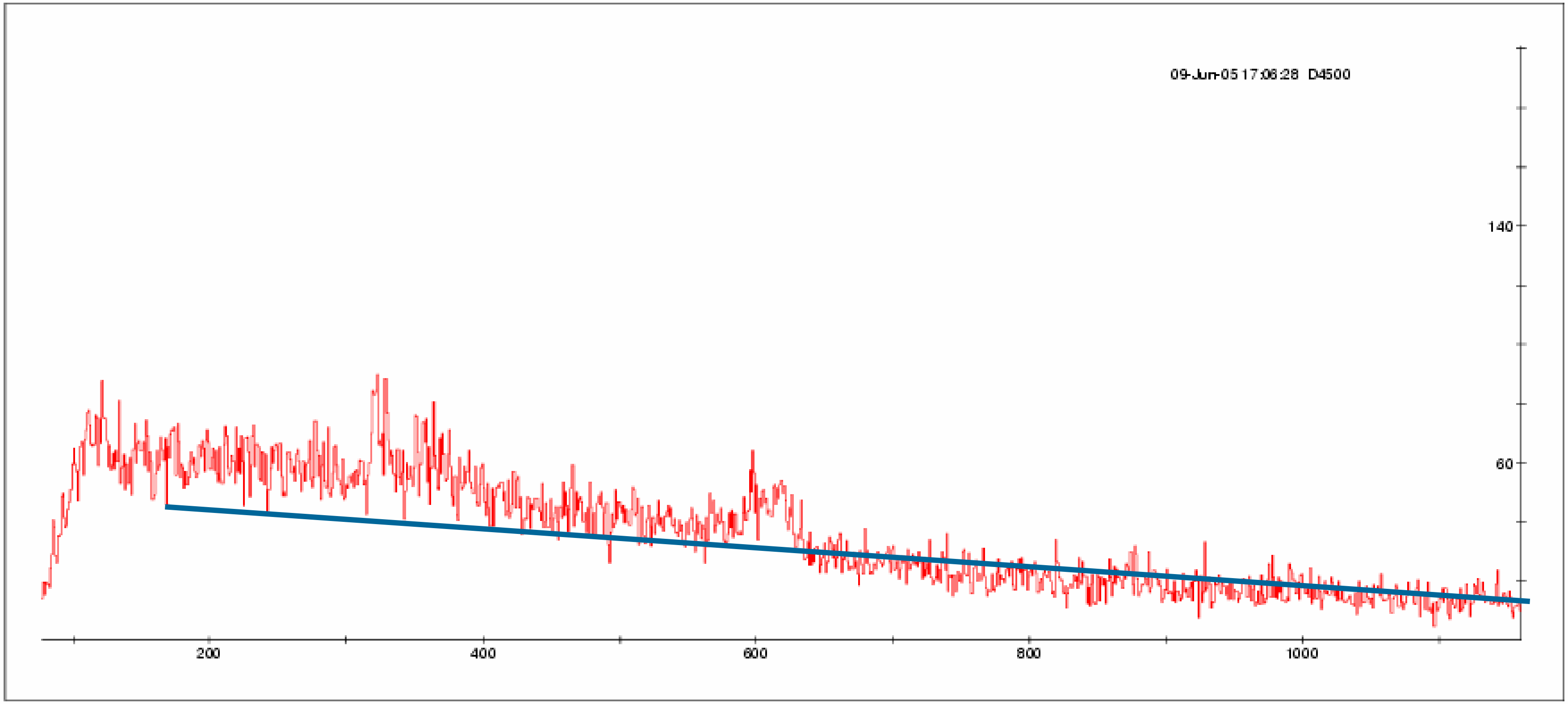
^{132}Xe (662 keV) v/c = 0.430



^{132}Xe (662 keV)   v/c = 0.440



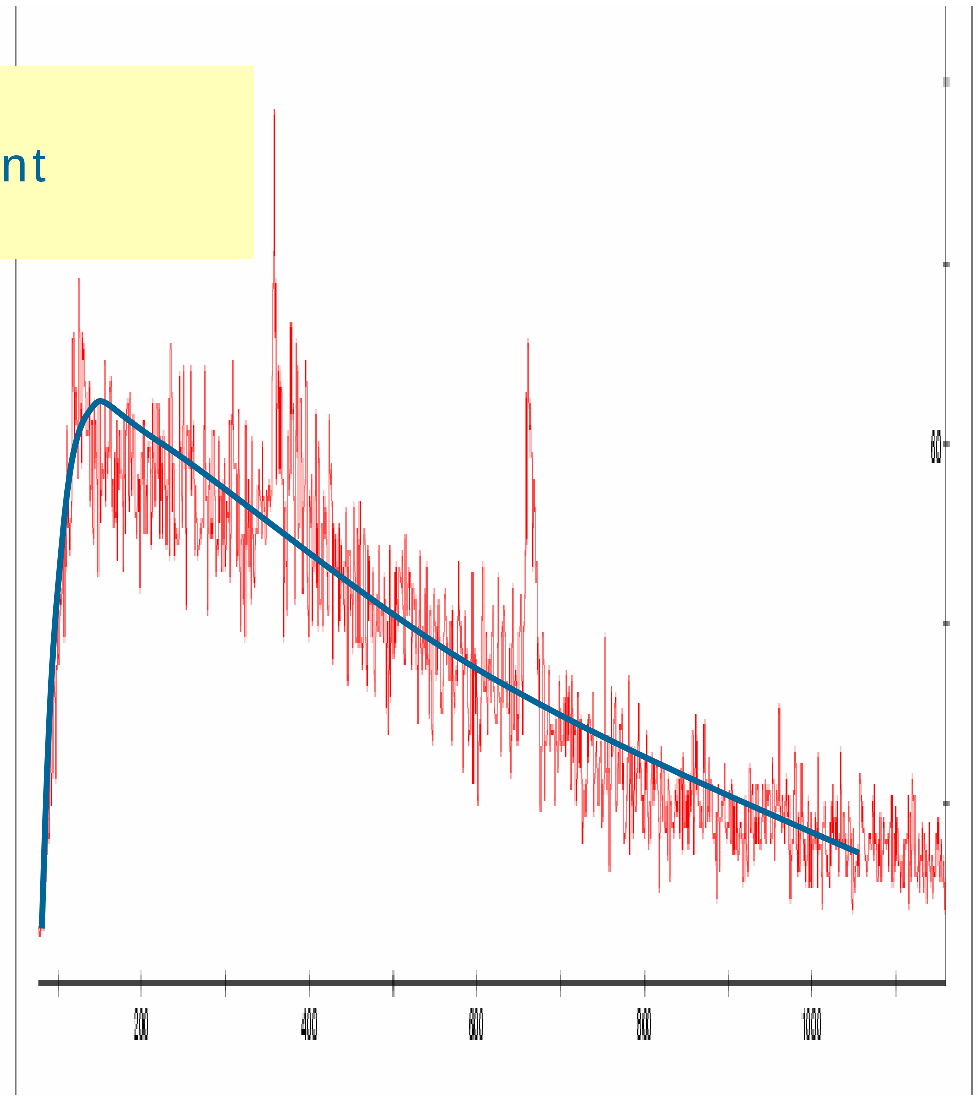
^{132}Xe (662 keV) v/c = 0.450



^{132}Xe (662 keV)

v/c = 0.355

This is NOT bremmstrahlung!
This IS compressed nearly constant background.



^{37}P produced in a fragmentation of ^{48}Ca