



# 兰州大学西部环境教育部重点实验室

## 高纯锗伽玛能谱仪 培训和操作使用说明手册

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# 特别声明

本材料所列出的有关仪器的操作方法和实验步骤，仅用于西部环境教育部重点实验室内部学生上机前的培训材料，不作为同类仪器操作的指导教程，任何单位或个人不得擅自转载或发表，利用本材料操作仪器发生的人身伤害和仪器损坏问题，本实验室和作者本人不承担任何责任，特此声明。



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# 基本介绍

- 中文名称：高纯锗伽玛能谱仪
- 英文名称：HPGe Gamma Spectrometer
- 所属分支实验室：年代学实验室- $^{210}\text{Pb}$ 、 $^{137}\text{Cs}$ 测年
- 型号：GCW 3523
- 价值：60万元
- 制造商：美国CANBERRA Industries Inc公司
- 仪器功能：适用于各种伽玛衰变核素放射性活度的测量，主要用于近百年来粉末状小样品及液态样品中 $^{210}\text{Pb}$ 、 $^{137}\text{Cs}$ 等核素的放射性活度测量
- 主要技术指标：探测器类型：井型BEGe(GCW3523)；能量范围：3keV-3MeV；分辨率：2.3 keV FWHM@1.33 MeV，1.4 keV FWHM@122 keV；检测器类型：MCA (DSA-1000)；高压范围：1300-5000 Vdc；工作软件：Genie 2000

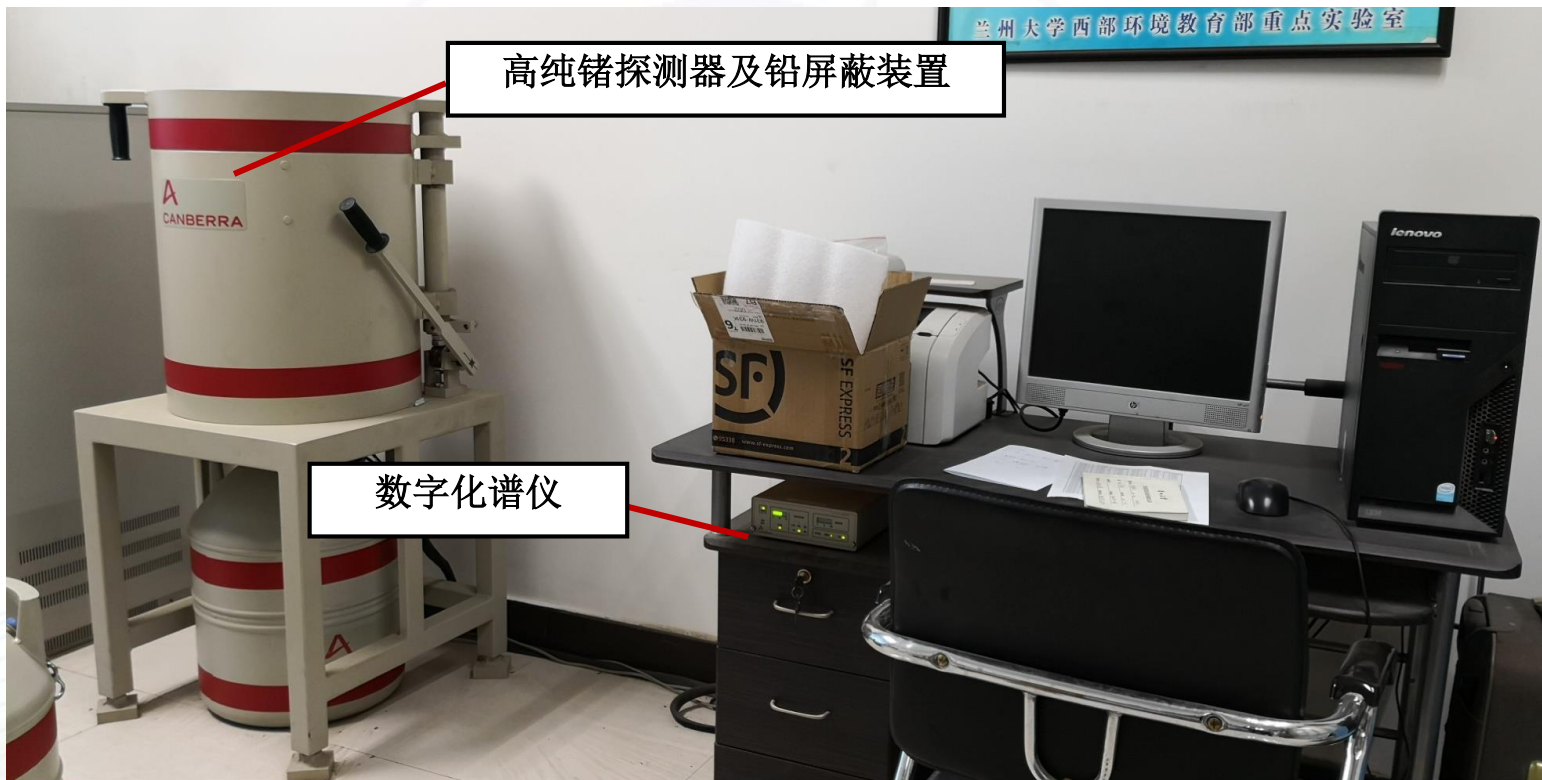


# 工作原理

- $\gamma$  射线与探测器中的HPGe晶体原子相互作用产生的电子-空穴对，在高电压下被收集，经前置放大器放大，输出一个脉冲信号，再经数字化MCB（集高压电源、多道MCA以及模数转换ADC于一体）处理，最后送入计算机由相关软件处理，形成 $\gamma$ 能谱。
- 可以使用解谱软件分析样品  $\gamma$  射线形成的谱形：峰的位置表明了射线的能量，可以根据核素特征射线的能量判断样品中的核素种类；峰面积的大小表明了测量时间内样品放出的  $\gamma$  射线数量，从而判断出样品中核素的活度。
- 高纯锗探测器产生的信号与电压的线性关系更好，可以区分能量差别较小的  $\gamma$  射线，即能量分辨率较好，有利于判断核素的种类。

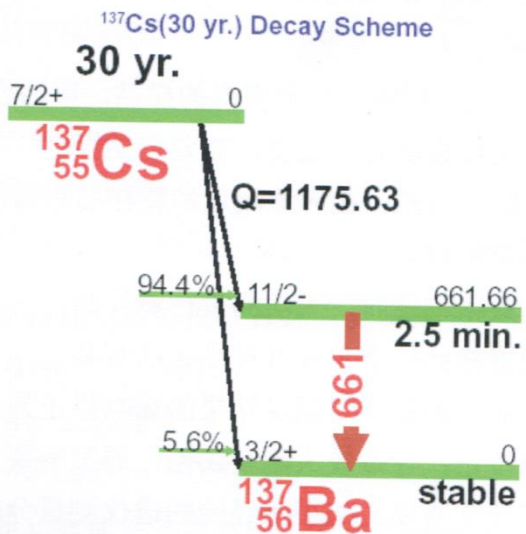


# 仪器外观





# 铯137衰变框图



$E_\gamma$ (keV)	$\sigma E_\gamma$	$I_\gamma$ (rel)	$I_\gamma$ (%)	$\sigma I_\gamma$	S
283.5	0.1		0.0006	0.0001	4
661.657	0.003	100	85.1	0.2	1

$E_\gamma, \sigma E_\gamma, I_\gamma, \sigma I_\gamma$  - 1998 ENSDF Data



# 基本操作内容



- 硬件控制
- 参数预置和谱获取
- 谱仪能量刻度
- 谱仪效率刻度
- 谱分析
- 谱存储



# 硬件控制



- 打开稳定电源
- 启动计算机
- 打开位于数字化谱仪背面的电源开关

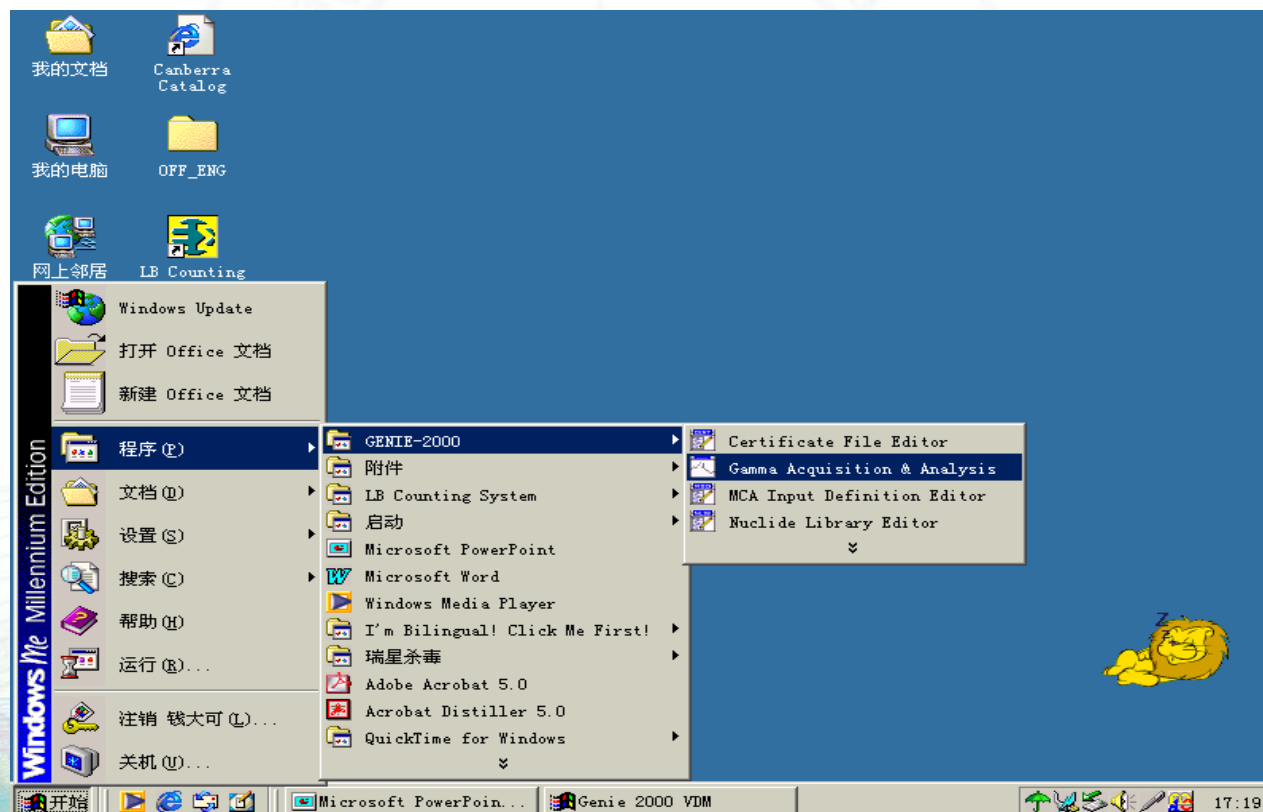




# 硬件控制



## 启动谱获取和分析(Gamma Acquisition & Analysis)程序





# 硬件控制



点击File Open工具靶

Gamma Acquisition & Analysis

File MCA Calibrate Display Analyze Edit Options Help

Channel: Counts: Preset: VFS=16

Acquire

Start Stop

Expand On

Clear

ROI Index:

- +

Datasource

Prev Next

TIME INFO

Next

Prev

Acq. Start: Elapsed Preset

Dead Time: Live (secs.):

Comp. Preset Region: Real (secs.):

Total (cnts.):

For Help, press F1 Execution Status: n/a

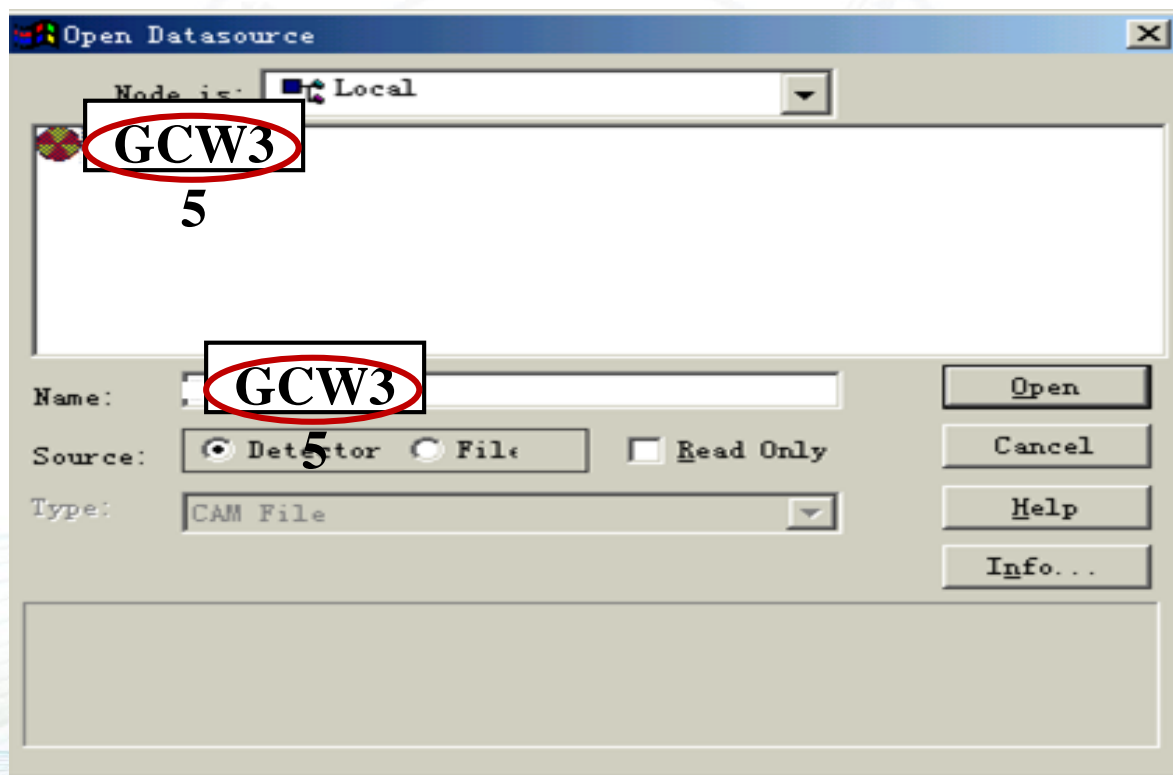
开始 Microsoft PowerPoi... Genie 2000 VDM Gamma Acquisition ... En 17:21



# 硬件控制



选择Detector,加亮GCW35,点击Open,调用完毕





# 硬件控制



在GAA界面MCA下拉菜单中的Adjust,实施DSA 2000的控制

Gamma - SIM

File MCA Calibrate Display Analyze Edit Options Datasource Help

Acquire Start F4  
Acquire Stop F4  
Acquire Setup...  
Clear  
**Adjust...**  
Status  
Advance  
Load...

1.9 keV Counts: 0 Preset: 3600/134.31 VFS-64

Energy(keV)

TIME INFO

	Acq. Start:	2003-4-21 14:09:51	Elapsed	Preset
Next	Dead Time:	0.51%	Live (secs.): 134.31	3600
Prev	Comp. Preset Region:	0 - 0 (channels)	Real (secs.): 135.00	0
			Total (cnts.): 0.00	0

Adjust device settings Execution Status: ready

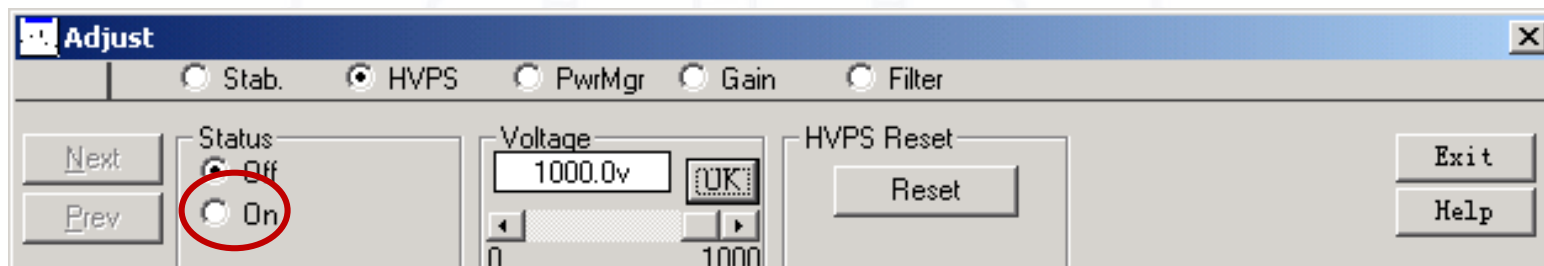
开始 Microsoft PowerPoi... Genie 2000 VDM Gamma - SIM 17:34



# 硬件控制



加载高压，输入高压值(Voltage)，选择On





# 谱仪能量刻度前准备工作 (1)

- 在谱仪能量刻度之前，必须进行以下工作：
- 创建标准源证书文件(.ctf)
- 获取标准源的谱数据
- 谱寻峰(Peak Locate)分析
- 峰面积(Peak Area)分析



# 谱仪能量刻度前准备工作（2）

选择Analyze中Peak Locate的Unidentified 2nd Diff...

TIME INFO

	Acq. Start:	Live (secs.):	Elapsed	Preset
Next	Dead Time: 0.52%	44.768	44.768	1000
Prev	Comp. Preset Region:	Real (secs.): 45.000	0.00	0
	0 - 0 (channels)	Total (cnts.):		0

Execution Status: ready



# 谱仪能量刻度前准备工作 (3)

## 谱寻峰(Peak Locate)分析参数设置

Peak Locate Unidentified 2nd Diff. Setup

Search Region

Start channel:  Stop channel:

Significance threshold:

Tolerance:  FWHM

Energy  FWHM

Add to existing results

Generate Report

Cancel Help Execute



# 谱仪能量刻度前准备工作 (4)

选择Analyze中Peak Area的Sum/Non-Linear LSQ Fit...

TIME INFO

	Acq. Start:	Elapsed	Preset
Next	Dead Time: 0.52%	Live (secs.): 44.768	1000
Prev	Comp. Preset Region:	Real (secs.): 45.000	0
	0 - 0 (channels)	Total (cnts.): 0.00	0

Execution Status: ready



# 谱仪能量刻度前准备工作 (5)

## 峰面积(Peak Area)分析参数设置

**Sum / Non-Linear LSQ Fit Setup**

Peak Area Region  
Start channel:   
Stop channel:

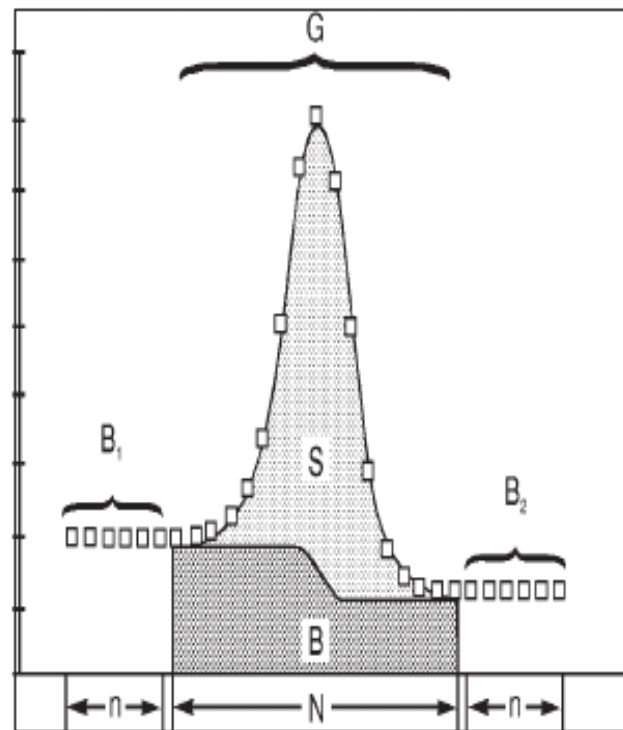
Continuum:  Channels  
 Channels  FWHM

Continuum function:

Residual Search  
 Perform Search    Threshold:   
Minimum separation (FWHM):

ROI Limits Determination  
Max. Num. FWHMs between peaks:   
Max. Num. FWHMs for left limit:   
Max. Num. FWHMs for right limit:

95% Critical level test  
 Use fixed FWHM  
 Use fixed tail parameter  
 Fit singlets  
 Display ROIs  
 Reject zero area peaks

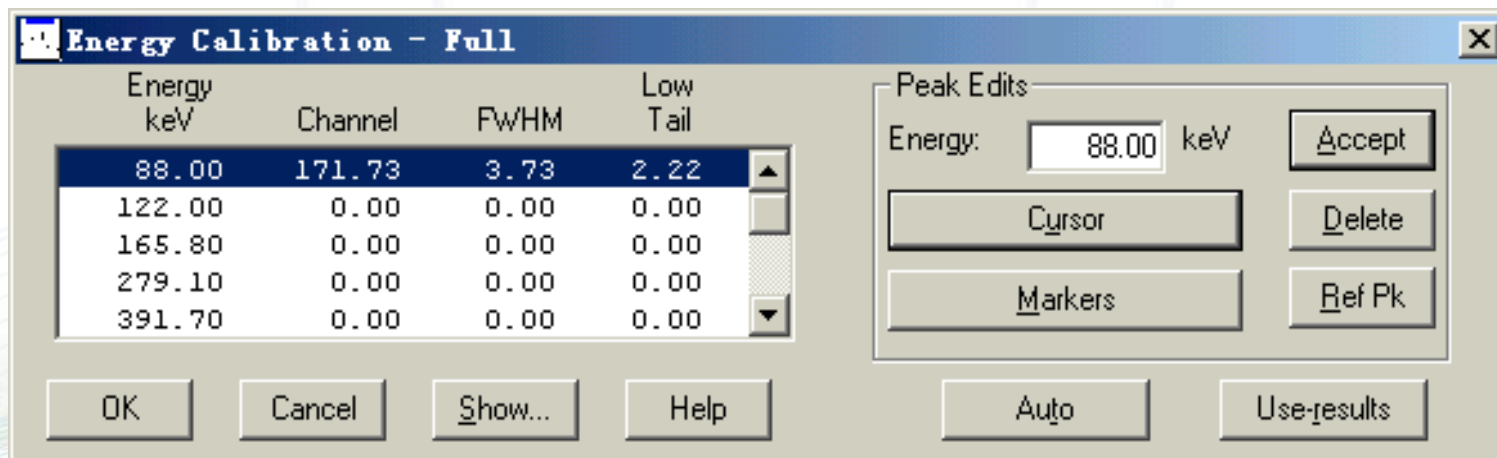




# 谱仪能量刻度 (1)

将标准源或者标准样放置的测量位置，确定测量时间，获取谱

- 根据谱线对应的峰，点击Cursor，
- 相关数据自动输入对话框





# 谱仪能量刻度 (2)

输入第一个和第二个能量峰的数据，点击Show

Energy keV	Channel	FWHM	Low Tail
88.00	171.73	3.73	2.22
122.00	237.68	3.85	4.93
165.80	0.00	0.00	0.00
279.10	0.00	0.00	0.00
391.70	0.00	0.00	0.00
513.90	0.00	0.00	0.00

Peak Edits

Energy:  keV

Accept

Cursor

Delete

Markers

Ref Pk

Auto

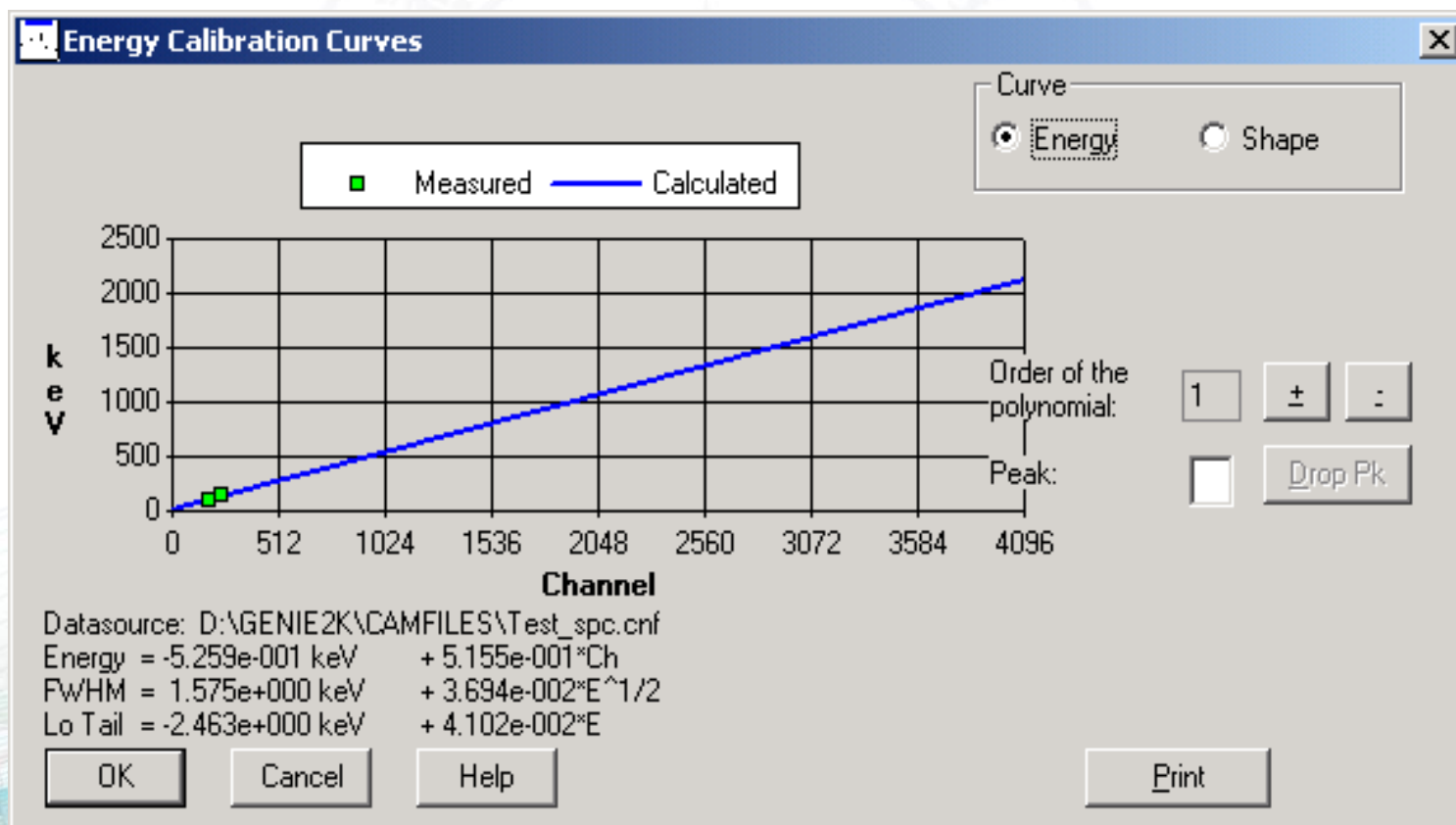
Use results

OK Cancel Show... Help



# 谱仪能量刻度 (3)

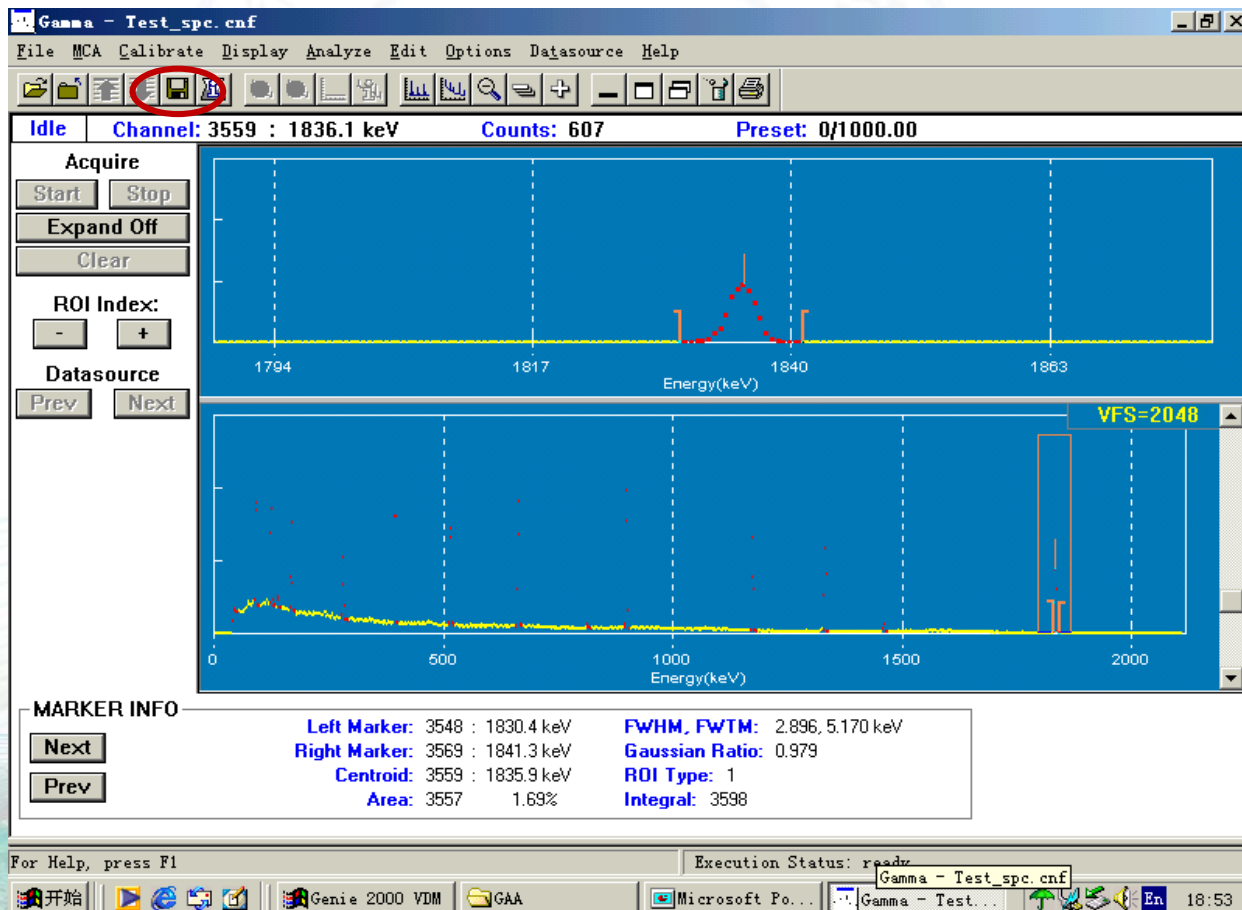
确认后，点击OK





# 谱仪能量刻度 (4)

回到GAA界面，点击存储靶，即可存储刻度结果





# 谱仪效率刻度 (1)

将标准源或者标准样放置的测量位置，确定测量时间，获取谱

选择Calibrate中Efficiency的By Certificate File

The screenshot shows the Gamma software interface. The 'Calibrate' menu is open, and 'Efficiency' is selected. The 'By Certificate File...' option is highlighted with a red circle. The main window displays a gamma spectrum with markers at 1840 and 1863 keV. The 'MARKER INFO' table is visible at the bottom.

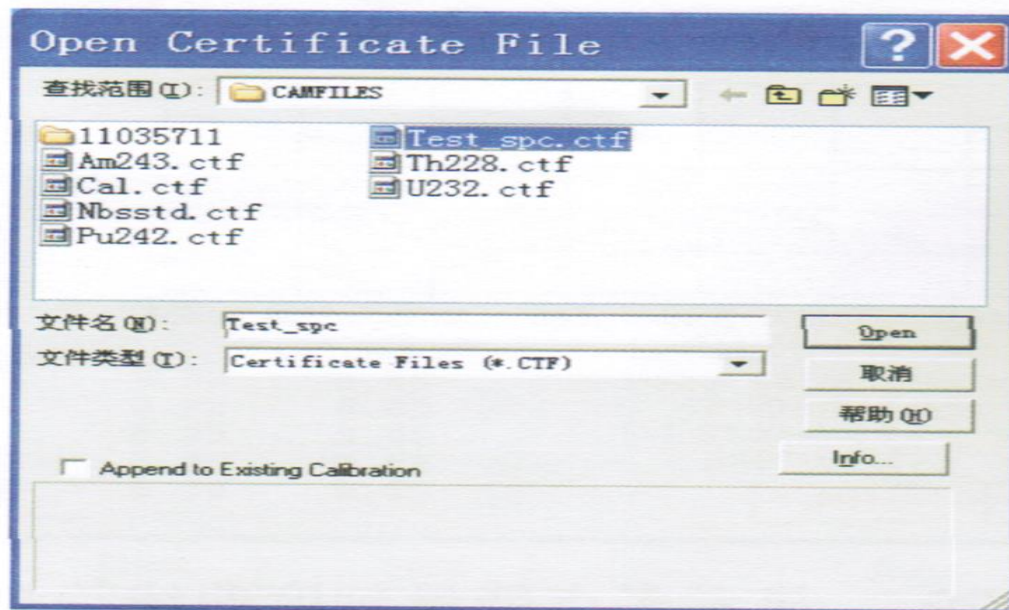
MARKER INFO	
Left Marker:	3548 : 1830.4 keV
Right Marker:	3569 : 1841.3 keV
Centroid:	3559 : 1835.9 keV
Area:	3557 : 1.69%
FWHM, FWTM:	2.896, 5.170 keV
Gaussian Ratio:	0.979
ROI Type:	1
Integral:	3598

Execution Status: ready



## 谱仪效率刻度 (2)

启动Calibrate/Efficiency/By Certificate File菜单命令，出现以下界面



Calibrate/Efficiency/By Certificate File对话框



# 谱仪效率刻度 (3)

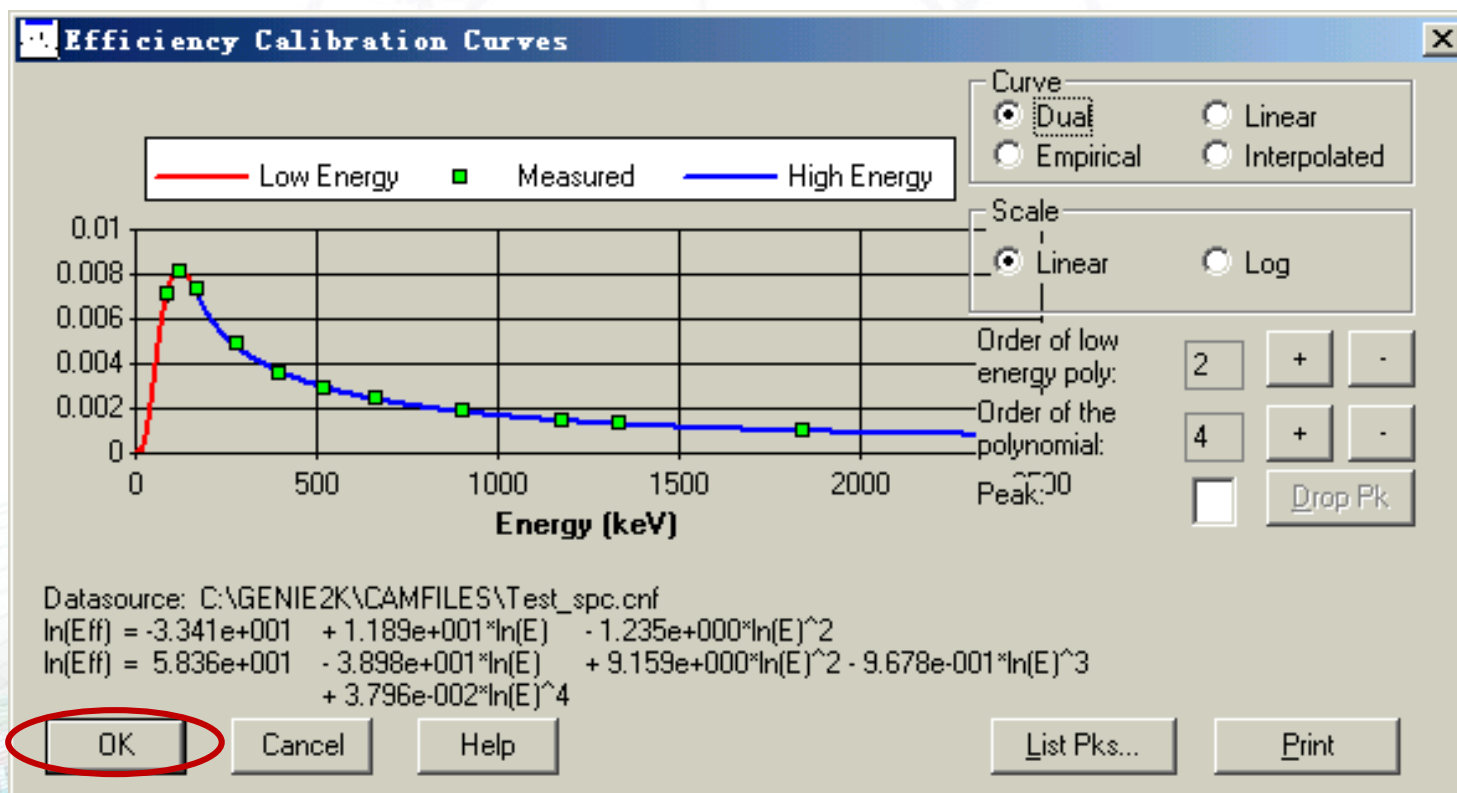
加亮带选刻度文件， 点击Open,出现以下界面

Energy keV	Efficiency	Error (%)
88.00	0.00706	4.13
122.00	0.00810	3.53
165.80	0.00725	4.51 X
279.10	0.00479	4.33
391.70	0.00355	4.28
513.90	0.00287	3.19
661.60	0.00239	3.41
898.00	0.00178	3.05
1173.20	0.00137	1.85
1332.50	0.00124	1.91
1.84e+003	9.24e-004	3.19



# 谱仪效率刻度 (4)

确认后，点击OK





# 谱仪效率刻度 (5)

回到GAA界面，点击存储靶，即可存储刻度结果

MARKER INFO

Left Marker:	3548 : 1830.4 keV	FWHM, FWTM:	2.896, 5.170 keV
Right Marker:	3569 : 1841.3 keV	Gaussian Ratio:	0.979
Centroid:	3559 : 1835.9 keV	ROI Type:	1
Area:	3557 : 1.69%	Integral:	3598



# 谱仪效率刻度 (6)

选择Calibrate中Store,存储刻度文件。

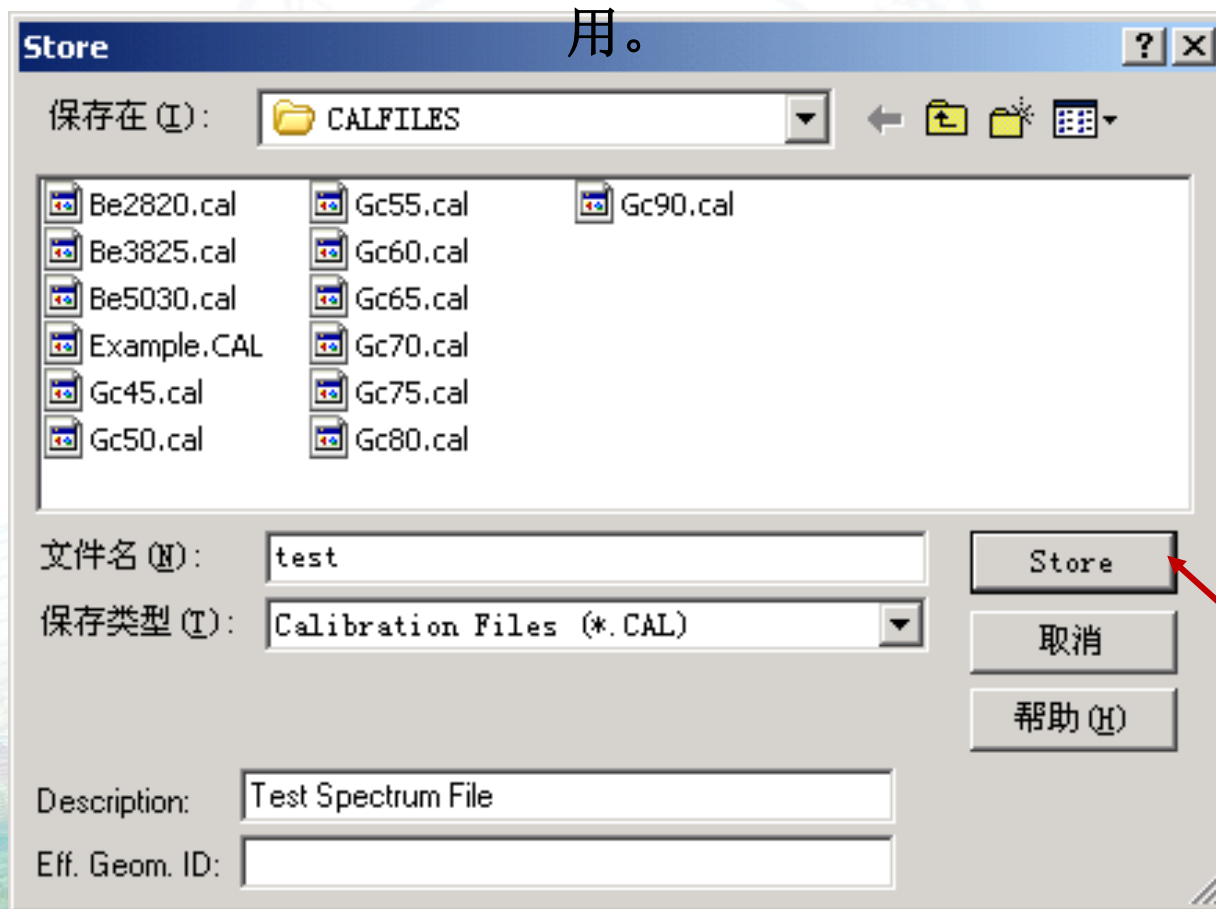
The screenshot shows the Gamma software interface. The 'Calibrate' menu is open, and the 'Store...' option is highlighted with a red circle. The main window displays a gamma spectrum plot with peaks and a 'TIME INFO' table at the bottom.

TIME INFO	Acq. Start:	1983-5-5 8:53:00	Elapsed	Preset
Next	Dead Time:	0.50%	Live (secs.):	1000.000
Prev	Comp. Preset Region:	0 - 0 (channels)	Real (secs.):	1005.000
			Total (cnts.):	0.00



# 谱仪效率刻度 (7)

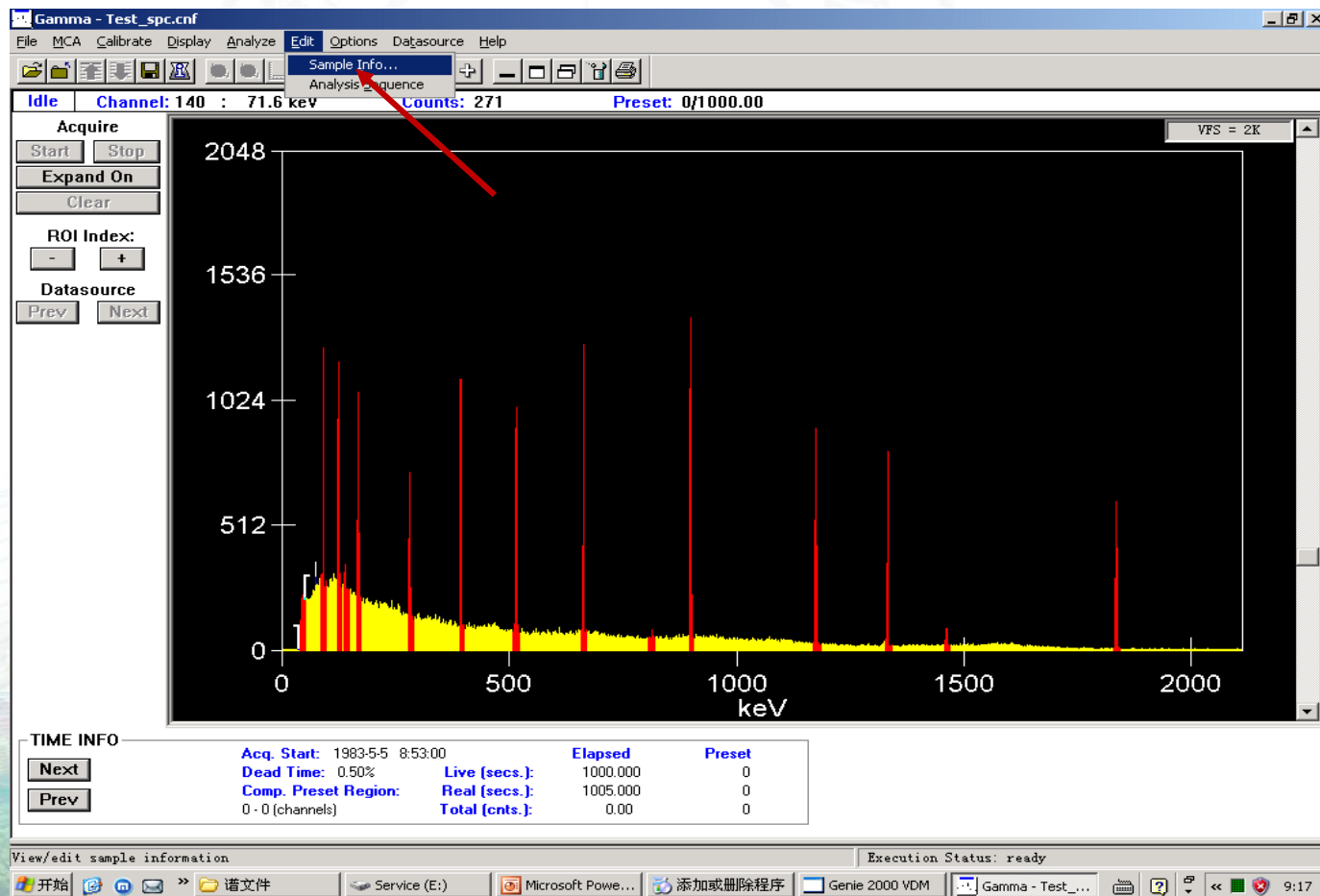
选择Calibrate中Store,存储刻度文件。方便以后调用。





# 编辑样品信息 (1)

在存储谱文件之前，选择Edit中Sample Info....,编辑样品信息。





## 编辑样品信息 (2)

输入完样品信息之后，点Load Cal...,调用合适的效率刻度文件。

**Edit Sample Information**

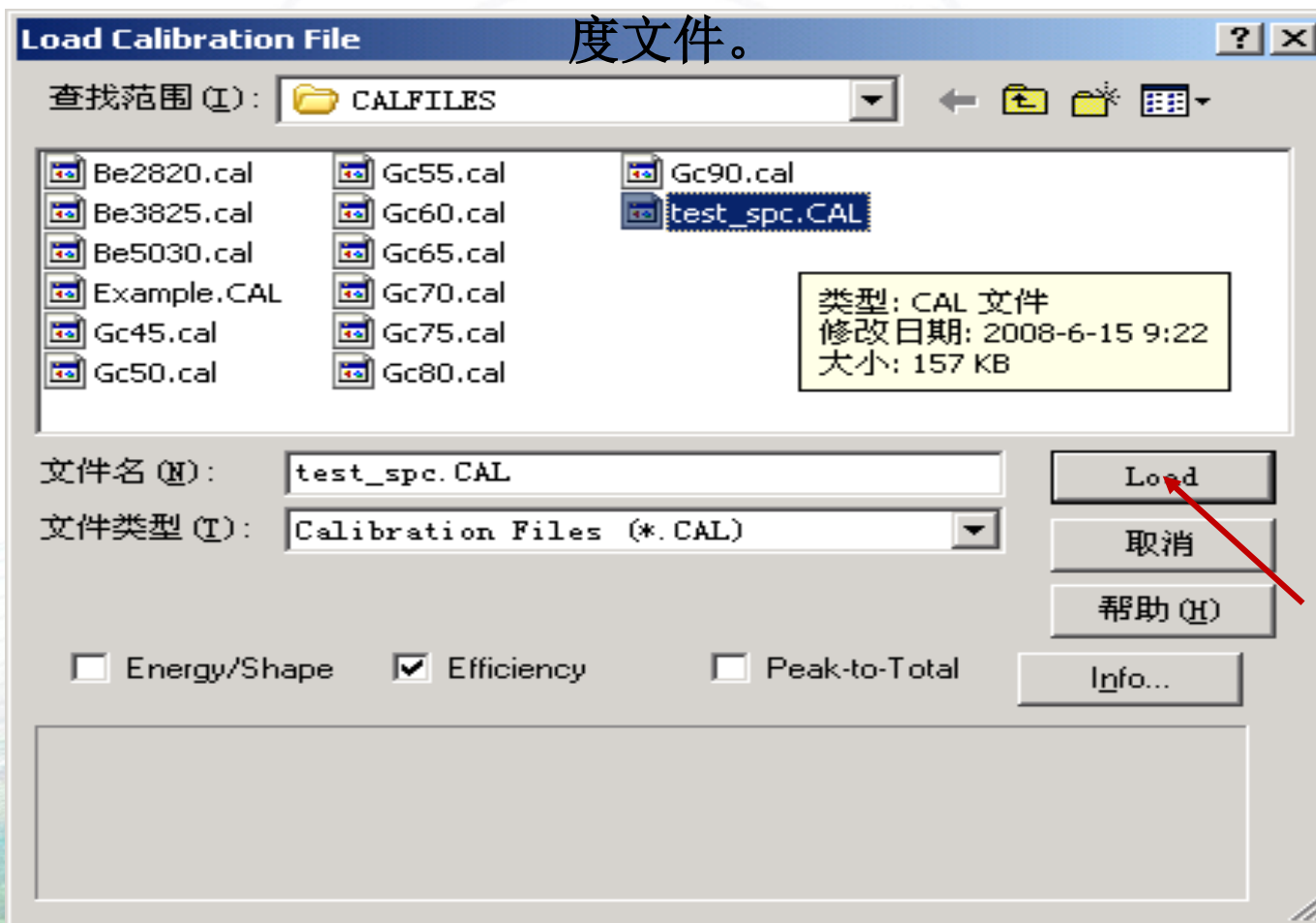
Sample Title:	<input type="text" value="GENIE-PC Spectrum No. 2"/>	Sample ID:	<input type="text" value="0629QB #1"/>
Collector Name:	<input type="text" value="M. J. Koskelo"/>	Type:	<input type="text"/>
Sample Description:	<input type="text" value="Derived from APOGEE File 505"/> <input type="text"/> <input type="text"/>	Quantity:	<input type="text" value="1"/>
Buildup Type:	<input checked="" type="radio"/> None <input type="radio"/> Deposition <input type="radio"/> Irradiation	Uncertainty:	<input type="text" value="0"/>
Begin Date:	<input type="text"/> at <input type="text"/>	Units:	<input type="text" value="Unit"/>
Sample Date:	<input type="text" value="1983-2-1"/> at <input type="text" value="8:00:00"/>	Sample Geometry:	<input type="text" value="Geometry #1"/>
		Random Error (%):	<input type="text" value="0"/>
		Systematic Error (%):	<input type="text" value="0"/>

OK    Cancel    Help    **Load Cal.**



# 调用效率刻度文件

输入完样品信息之后，点Load Cal...,调用合适的效率刻度文件。





# 谱存储



选择File中的Save As

The screenshot shows the Gamma software interface. The 'File' menu is open, and 'Save As...' is highlighted with a red circle. The main window displays a gamma spectrum plot with a peak at 1840 keV. The plot shows Energy (keV) on the x-axis and Counts on the y-axis. A Gaussian fit is overlaid on the peak. The 'MARKER INFO' section at the bottom provides detailed data for the peak.

MARKER INFO	
Left Marker:	3548 : 1830.4 keV
Right Marker:	3569 : 1841.3 keV
Centroid:	3559 : 1835.9 keV
Area:	3557 : 1.69%
FWHM, FWTM:	2.896, 5.170 keV
Gaussian Ratio:	0.979
ROI Type:	1
Integral:	3598

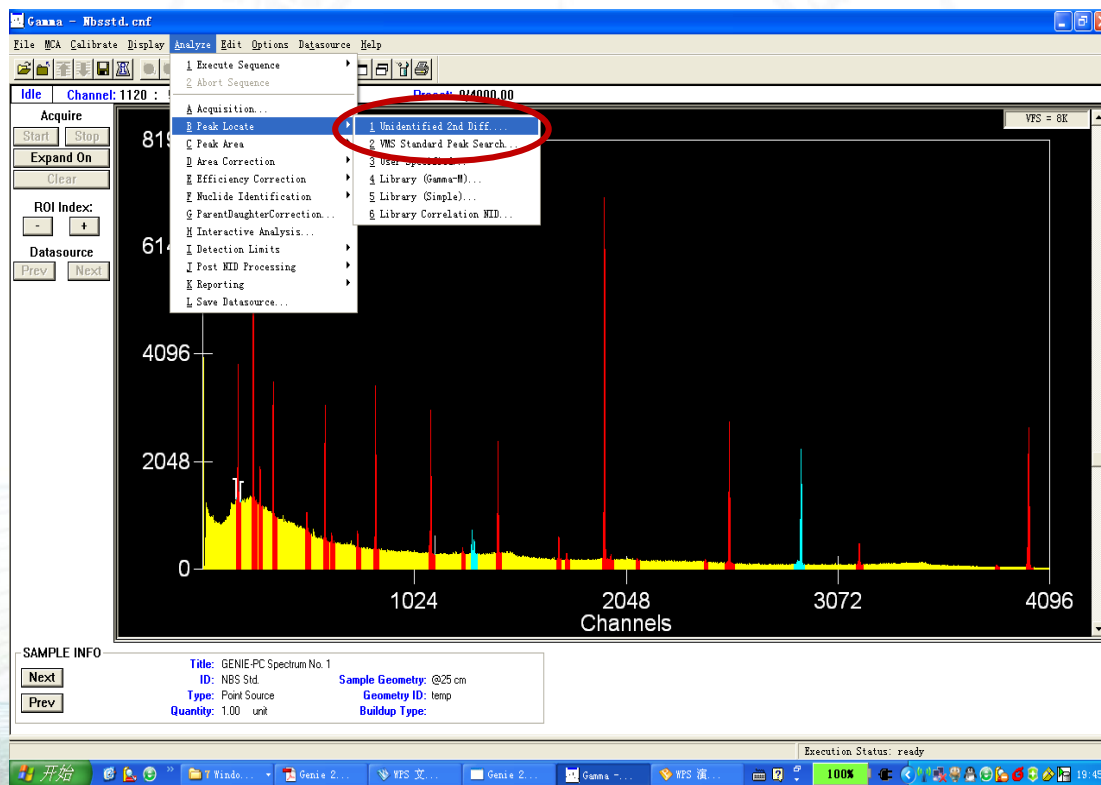
Execution Status: ready



# 谱分析 (1)



寻峰(Peak Locate)推荐参数—Unidentified 2nd Diff

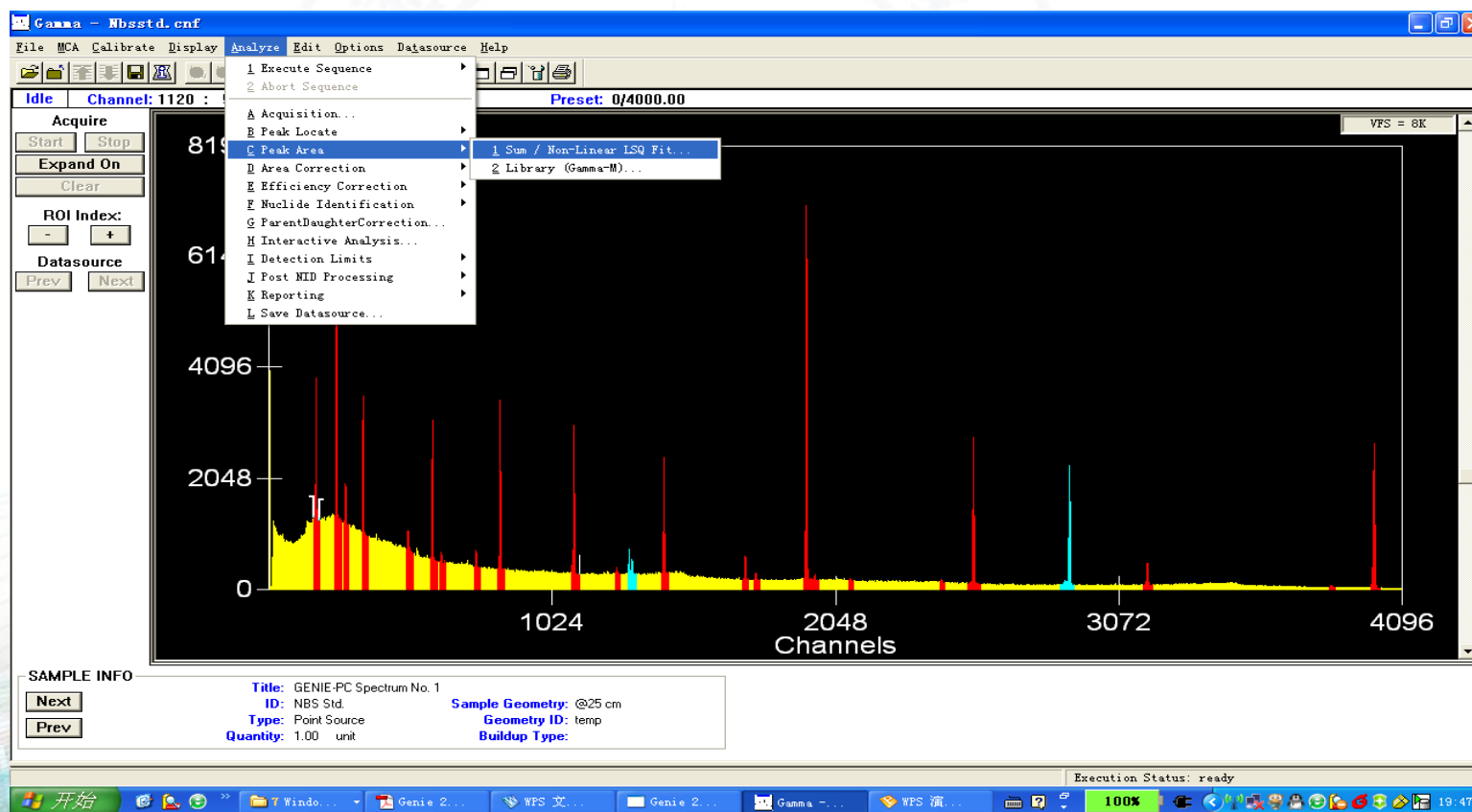




# 谱分析 (2)



峰面积(Peak Area)推荐参数—Sum/Non-Linear Least Squares Fit Peak Area





# 谱分析 (3)



峰面积(Peak Area)推荐参数—Sum/Non-Linear Least Squares Fit Peak Area

**Sum / Non-Linear LSQ Fit Setup**

Peak Area Region  
Start channel:   
Stop channel:

Continuum:  Channels  
 Channels  FWHM

Continuum function:

Residual Search  
 Perform Search Threshold:   
Minimum separation (FWHM):

ROI Limits Determination  
Max. Num. FWHMs between peaks:   
Max. Num. FWHMs for left limit:   
Max. Num. FWHMs for right limit:

95% Critical level test  
 Use fixed FWHM  
 Use fixed tail parameter  
 Fit singlets  
 Display ROIs  
 Reject zero area peaks

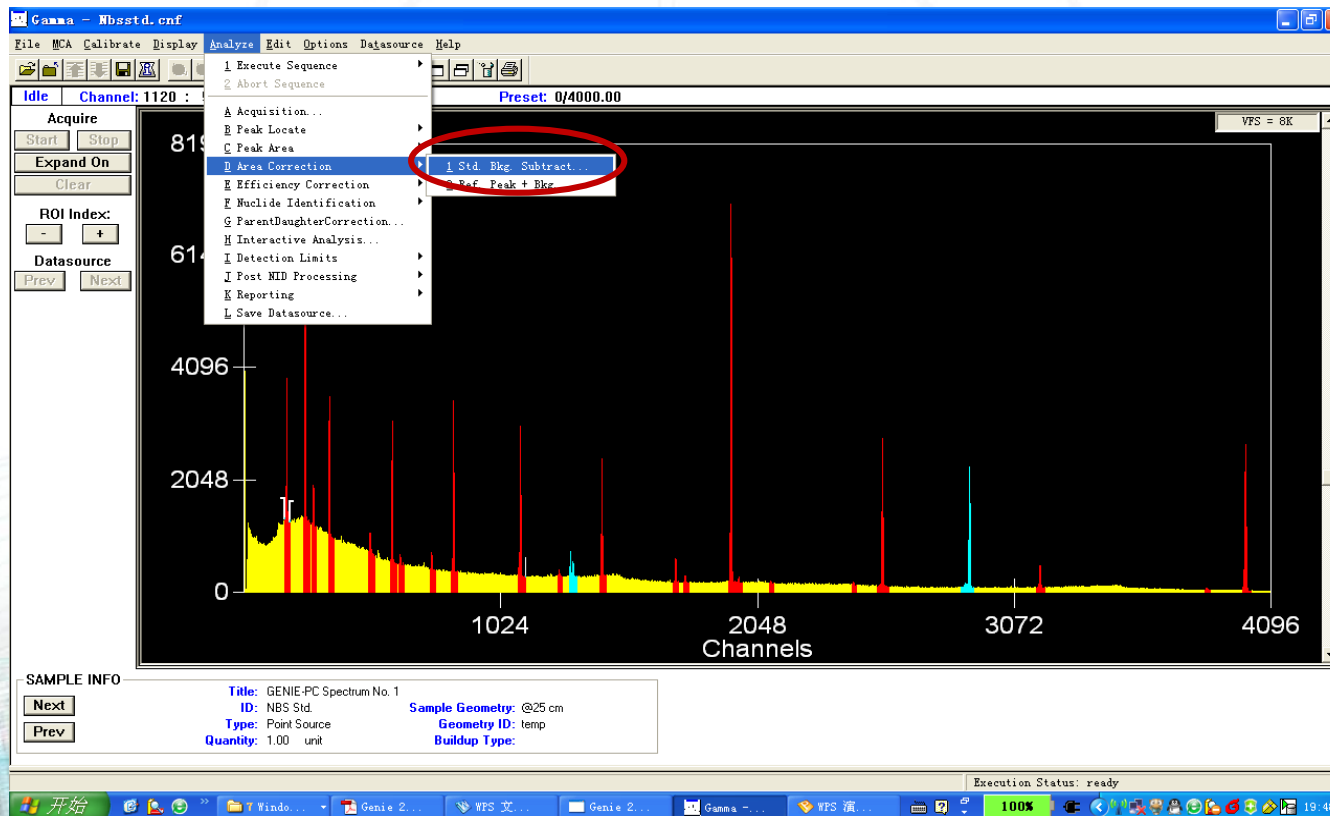
Generate Report



# 谱分析 (4)



本底修正(Area Correction), 推荐 Std. Bkg. Subtract...

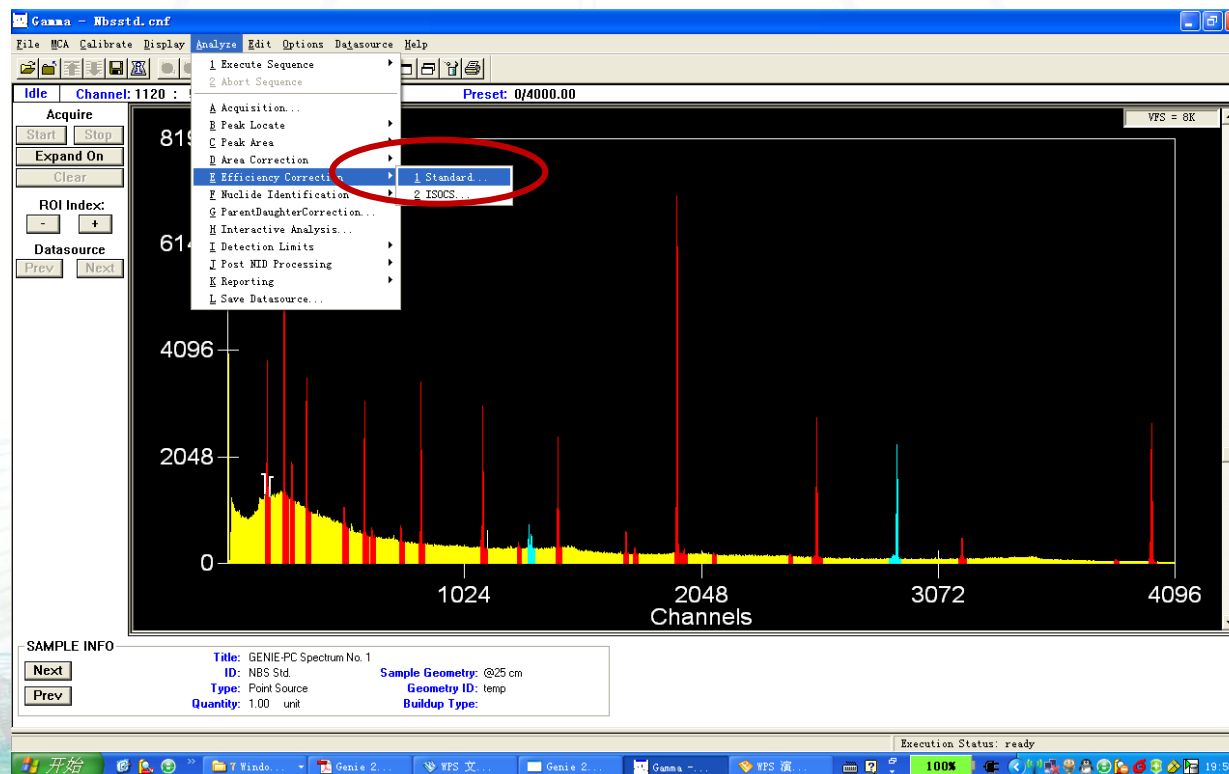




# 谱分析 (5)



## 效率修正(Efficiency Correction)

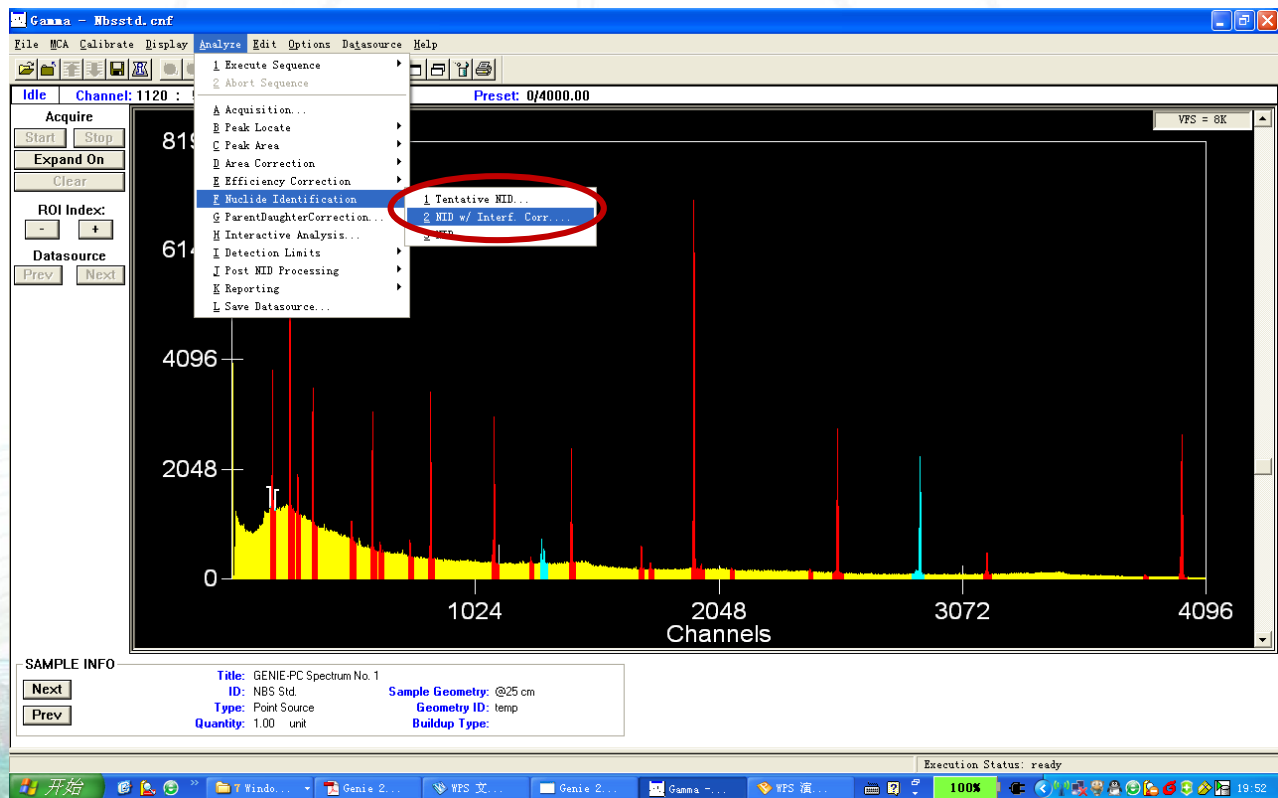




# 谱分析 (6)



## 核素识别(NID)推荐 — NID w/Interf. corr

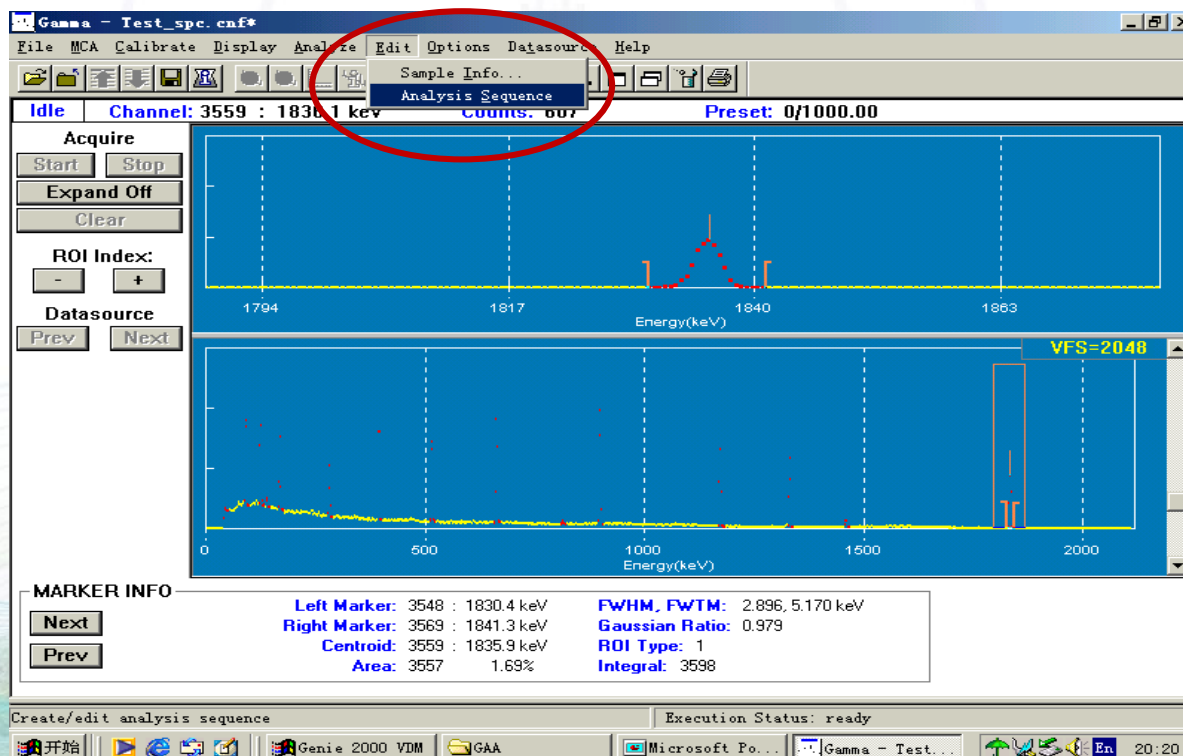




# 谱分析 (7)



- 谱分析批处理编辑
- 选择Edit中Analysis Sequence





# 谱分析 (8)



从Analyze的Execute Sequence中可随时调用

## Basic Analysis

The screenshot shows the Gamma software interface. The 'Analyze' menu is open, and 'Basic Analysis' is highlighted. The main window displays a gamma spectrum with a peak at 40.7 keV. The 'MARKER INFO' section shows the following data:

Parameter	Value
Left Marker	71 : 35.9 keV
Right Marker	84 : 42.6 keV
Centroid	80 : 40.7 keV
Area	312 : 15.42%
FWHM, FWTM	0.661, 4.229 keV
Gaussian Ratio	3.510
ROI Type	1
Integral	1705

The 'MARKER INFO' section also includes 'Next' and 'Prev' buttons. The 'Execution Status' is 'ready'. The taskbar shows the system time as 23:45.