Measurement of resonance integrals when both the ground and metastable states are formed:

$^{79}Br(n,\gamma)\ ^{81}Br^{g}$ & $^{79}Br(n,\gamma)\ ^{81}Br^{m}$

$^{81}Br(n,\gamma)\ ^{82}Br^{g}$ & $^{81}Br(n,\gamma)\ ^{82}Br^{m}$

Neutron activation Analysis Laboratory

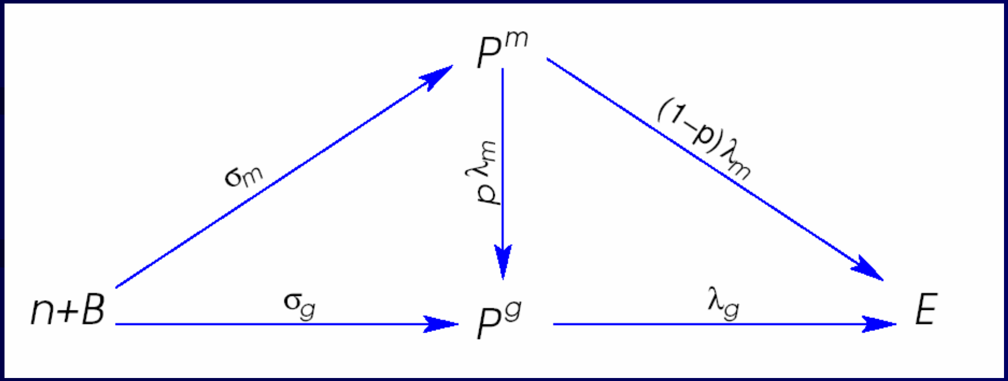
E.L. DORVAL, S. RIBEIRO GUEVARA, M.A. ARRIBERE

RA-6

F. LESZCZYNSKI

Methodology

Reaction $P(n,\gamma)P^{m+g}$



$$\frac{C_\gamma}{N\Phi\varepsilon_\gamma F_m} = \frac{y_g}{\lambda_g}\left(I_g - \frac{p\lambda_m}{\lambda_g-\lambda_m} I_m\right)\frac{F_g}{F_m} + \frac{y_g}{\lambda_m}\left(\frac{p\lambda_g}{\lambda_g-\lambda_m} + \frac{y_m}{y_g}\right) I_m$$

I is defined for a 1/E neutron energy spectrum

Reaction	Half-Life[a]	Decay Mode[a, b]	Branching[a] (%)	Gamma-Ray Energy[c] (keV)	Emission Probability[c] (%)
$^{79}Br(n,\gamma)^{80m}Br$	4.4205 h	IT	100	37.052	39.1 ± 0.8
$^{79}Br(n,\gamma)^{80g}Br$	17.68 m	β-	91.7	616.3	6.7 ± 0.6
		e	8.3	665.8	1.08 ± 0.13
$^{81}Br(n,\gamma)^{82m}Br$	6.13 m	IT	97.6	45.949	0.24 ± 0.01
		β-	2.4	776.52	0.26 ± 0.03
		β-	2.4	1474.88	0.020 ± 0.002
$^{81}Br(n,\gamma)^{82g}Br$	35.282 h	β-	100	554.34	70.7 ± 1.0
		β-	100	776.52	83.5 ± 1.2
		β-	100	1474.88	16.3 ± 0.2

Tasks

1. Efficiency calibration at 26.0 cm:

   Extension of the calibration for different distances

2. Download and set up the STAY´SL unfolding program

3. Create an input for STAY´SL

4. Estimate corrections for γ and neutron self-shielding

   We need to obtain a reasonable analytical representation of the flux (a MNCP source too time consuming at this stage).

5. Irradiate and count Br samples

1. Eficiency calibration

- Efficiency calibration of two counting systems at 26.0 cm:

  HPGe type-n (10%) & HPGe type-p (30%)

- Extension of the calibration for different distances

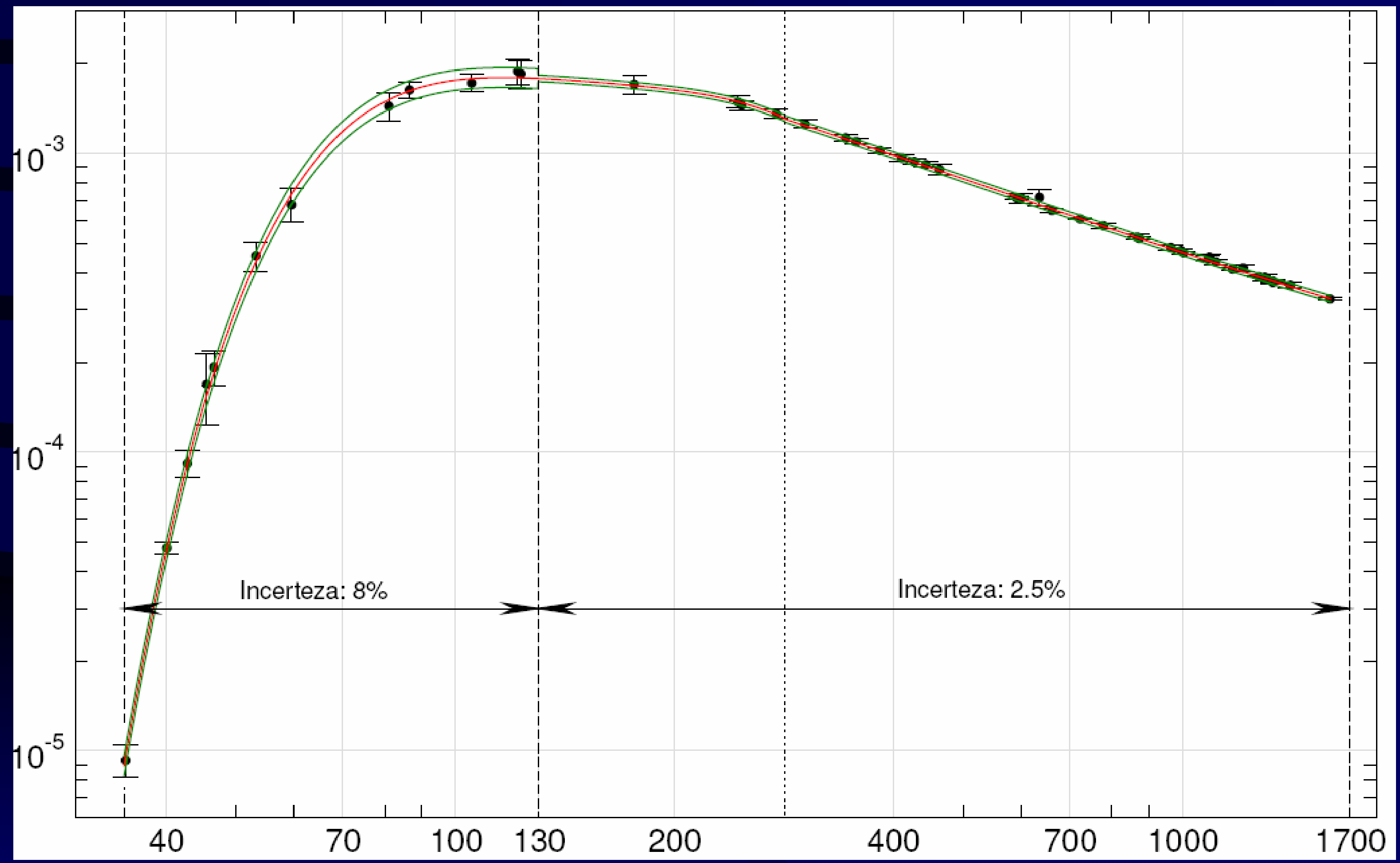
  Less 5% unc. for the 10% eff. detector at 1.8 cm

  Less 5% unc. for the 30% eff. detector at 4.0 cm

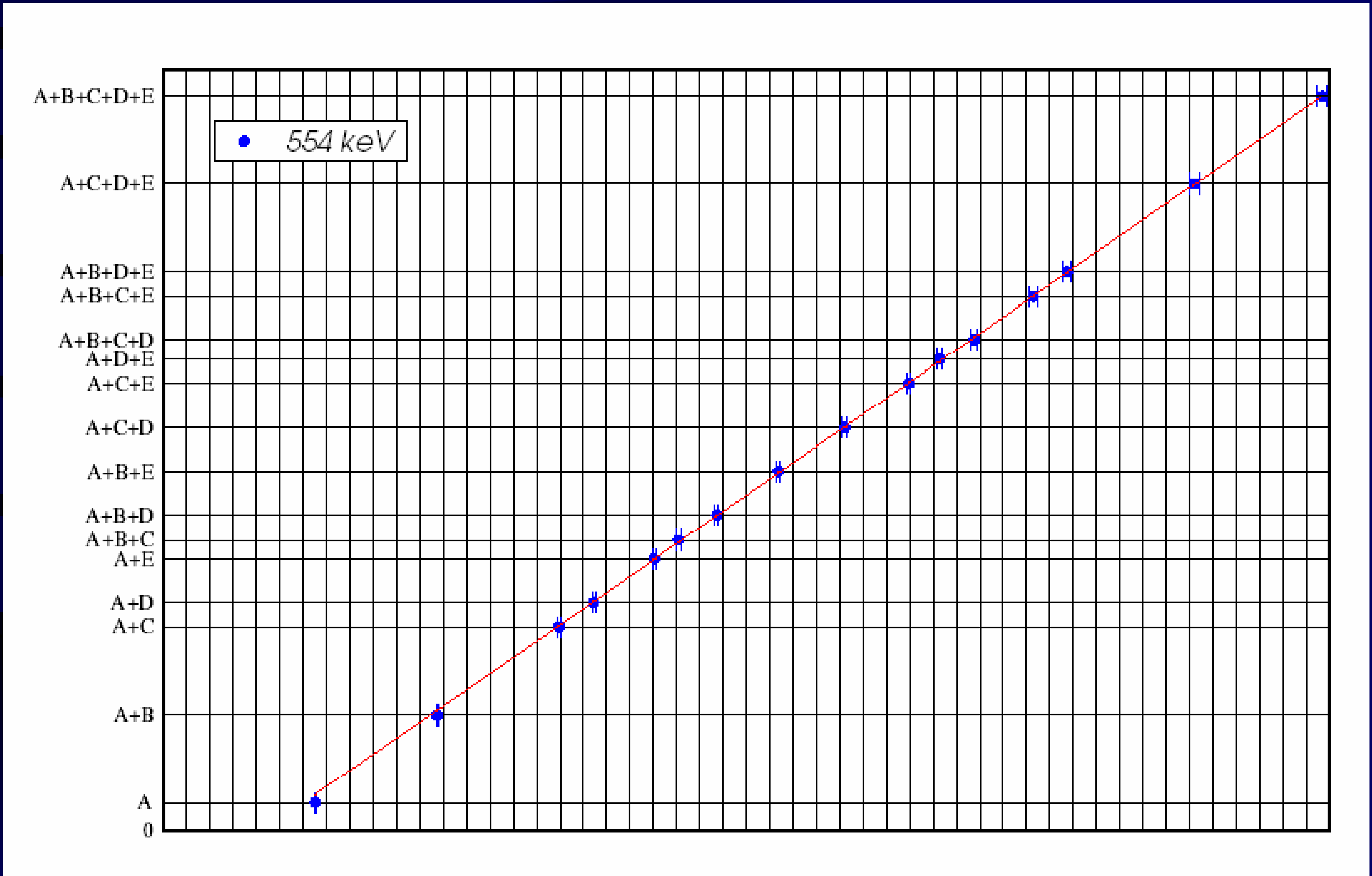
  Sources used: ^{60}Co, ^{82}Br, ^{187}W, ^{198}Au and Ra & daughters

$$\frac{Ef(E,d_0)}{Ef(E,d)} = \left[\frac{d + Y_0(E)}{d_0 + Y_0(E)}\right]^2$$

Efficiency curve, HPGe (30%)



Energy (keV)



A+B+C+D+E
A+C+D+E
A+B+D+E
A+B+C+E
A+B+C+D
A+D+E
A+C+E
A+C+D
A+B+E
A+B+D
A+B+C
A+E
A+D
A+C
A+B
A
0
554 keV

LIBRARIES AND EXISTING PROGRAMS

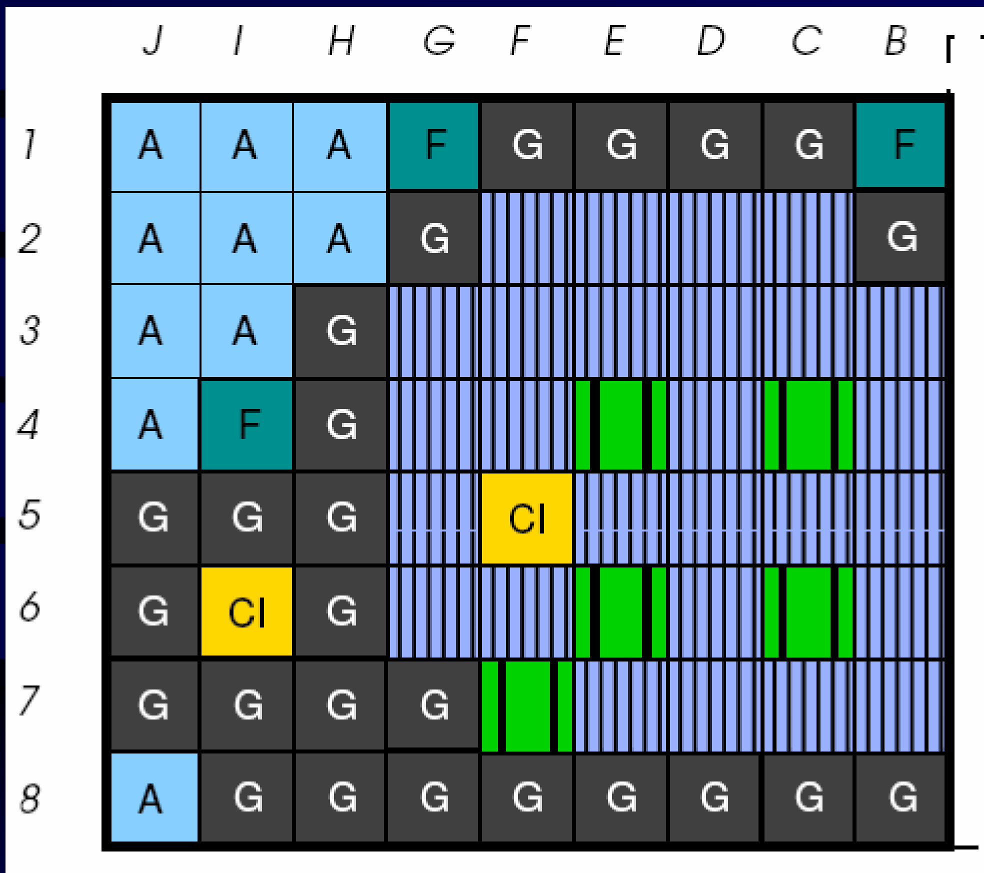
The nuclear data libraries ENDF/B-VI.8, JEFF-3.1, JENDL3.3, IRDF-2002 and RRDF-98, and their access programs, as well as the STAY'SL programs were set up.

Also used: Programs from PREPRO package (LINEAR, RECENT, SIGMA1), endtab routine from ENDVER package, INTER.

Input for STAY´SL: obtained by MCNP

XMUDAT program was used for γ-ray self shielding corrections

Irradiation site



A: water

G: graphite

CI: irradiation sites

F: fission chambers

: control rods

: fuel elements

Flux modeling

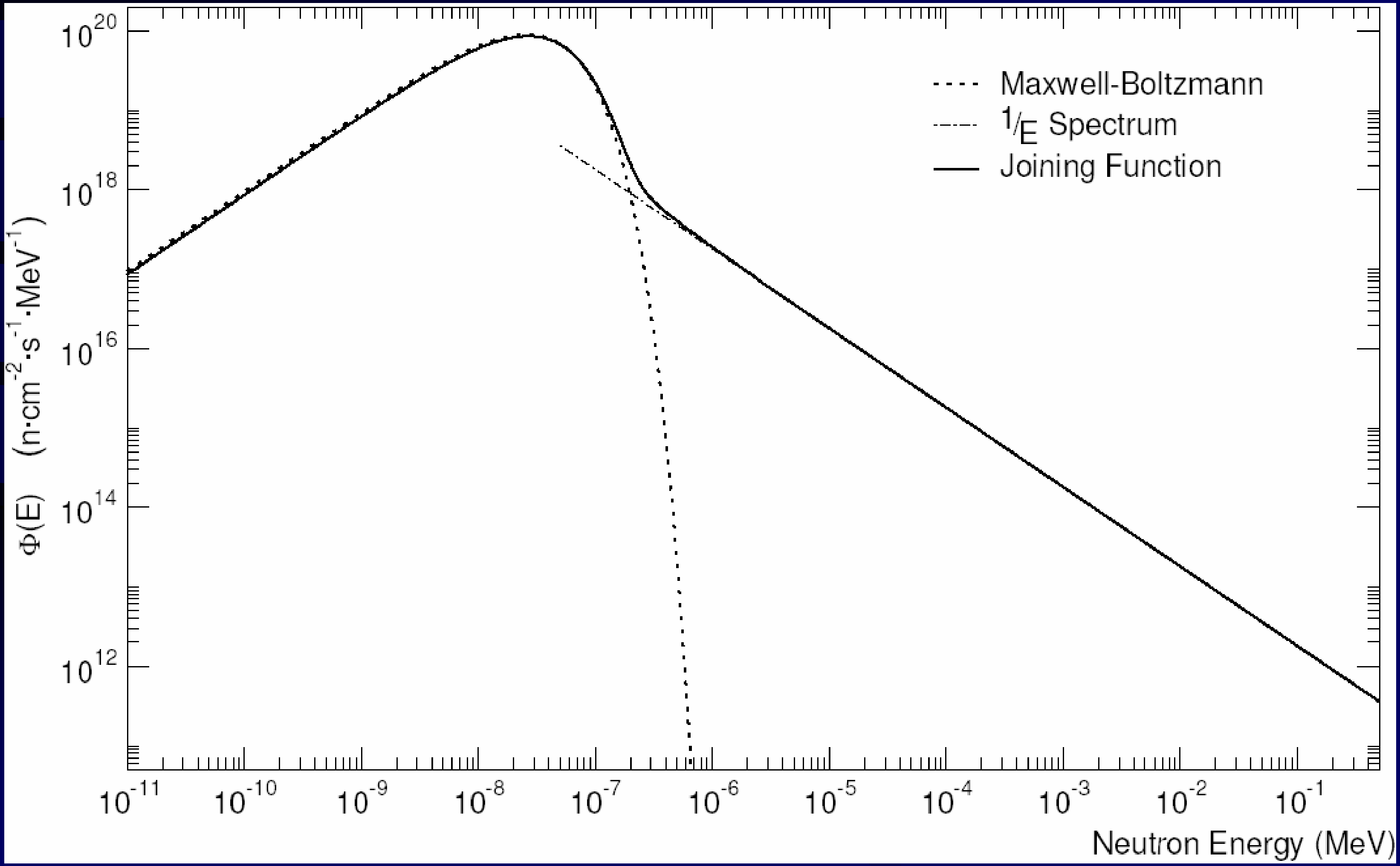
- linear anisotropy
- flux modeled by Maxwell+ 1/E
- joint by the Horowitz-Tretiakoff function

Programs written in C

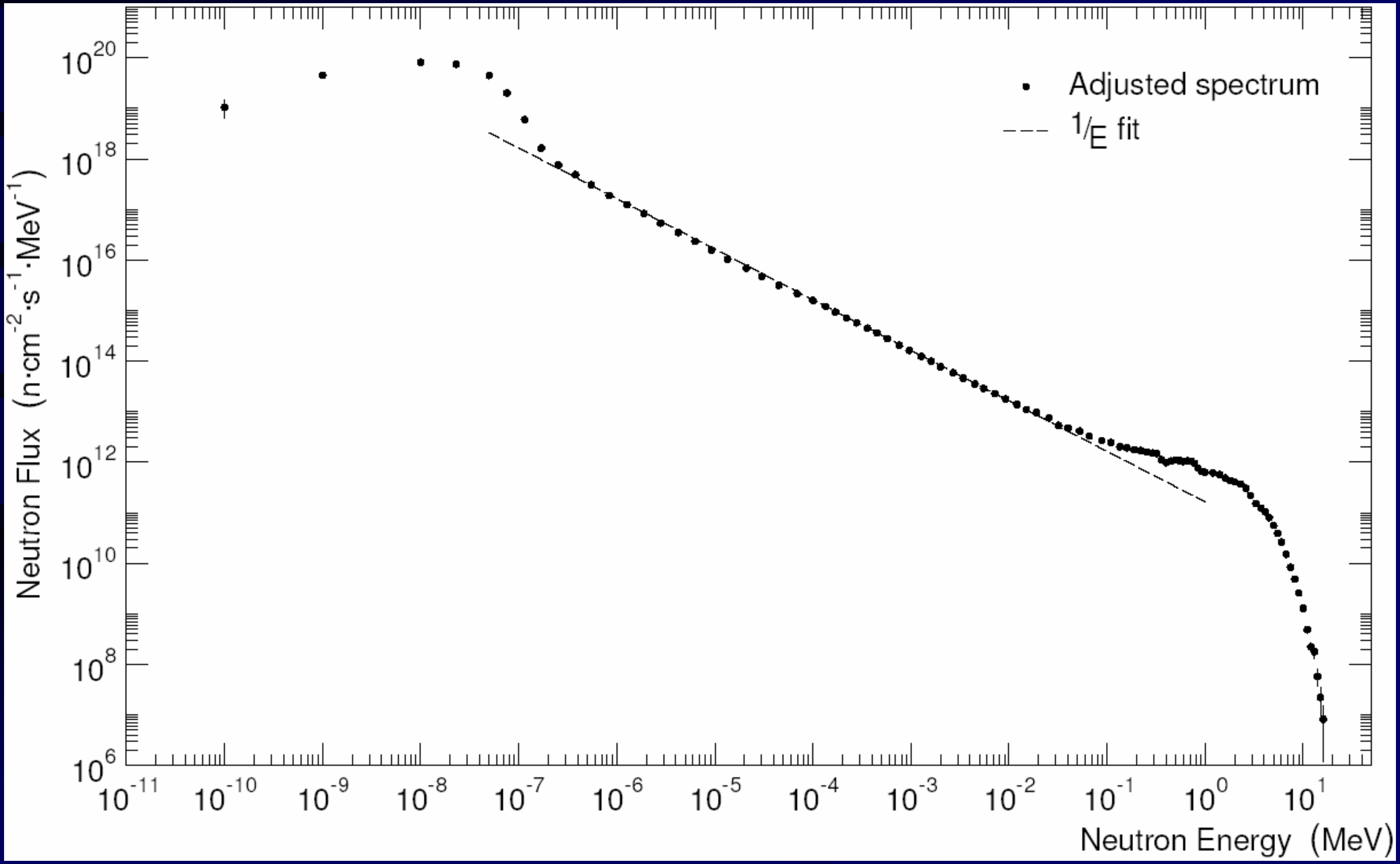
PC 3.4 GHz processor, 2 GB DDRM, 120 GB HD, 800 MHz bus

Software: Mandrake 10.1 Community Linux Platform
Applications taken from libraries under the GNU public license

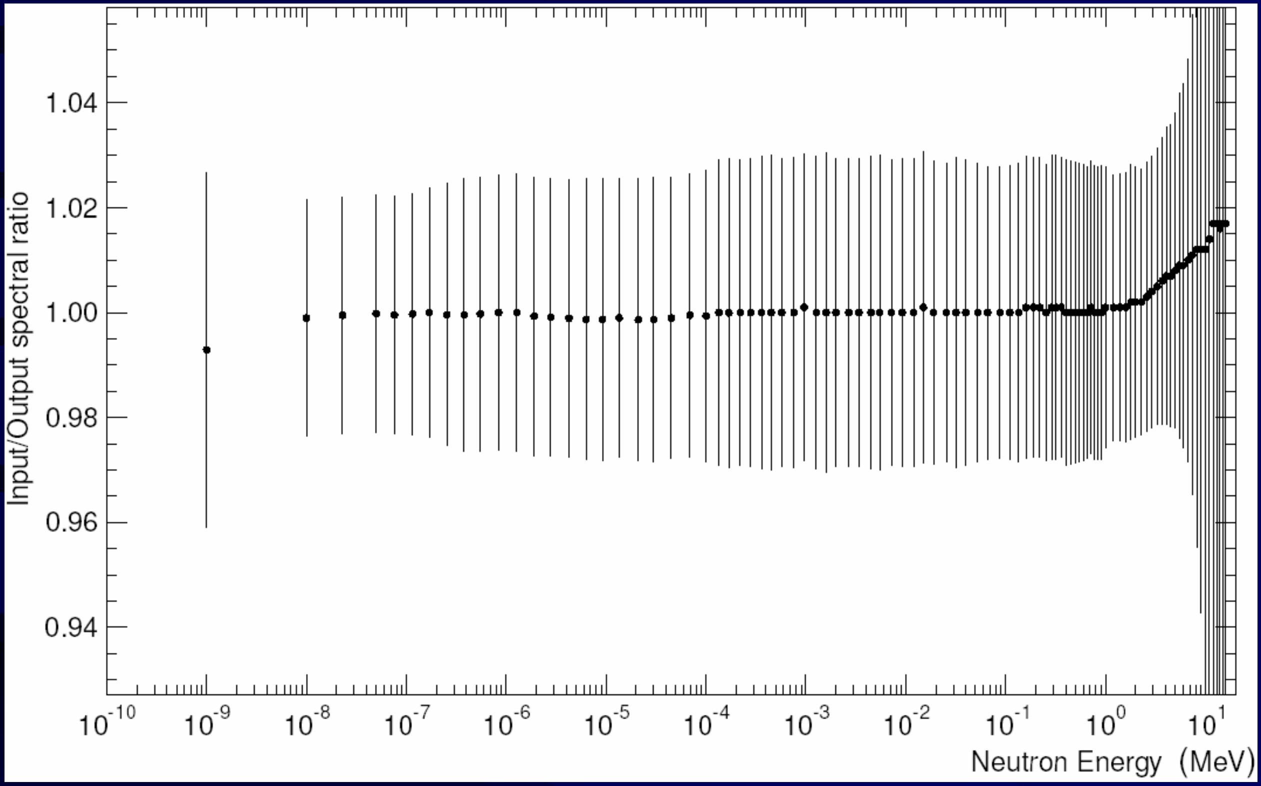
Analytical flux modeling at F5



Deconvolution result



Input/output spectral ratio

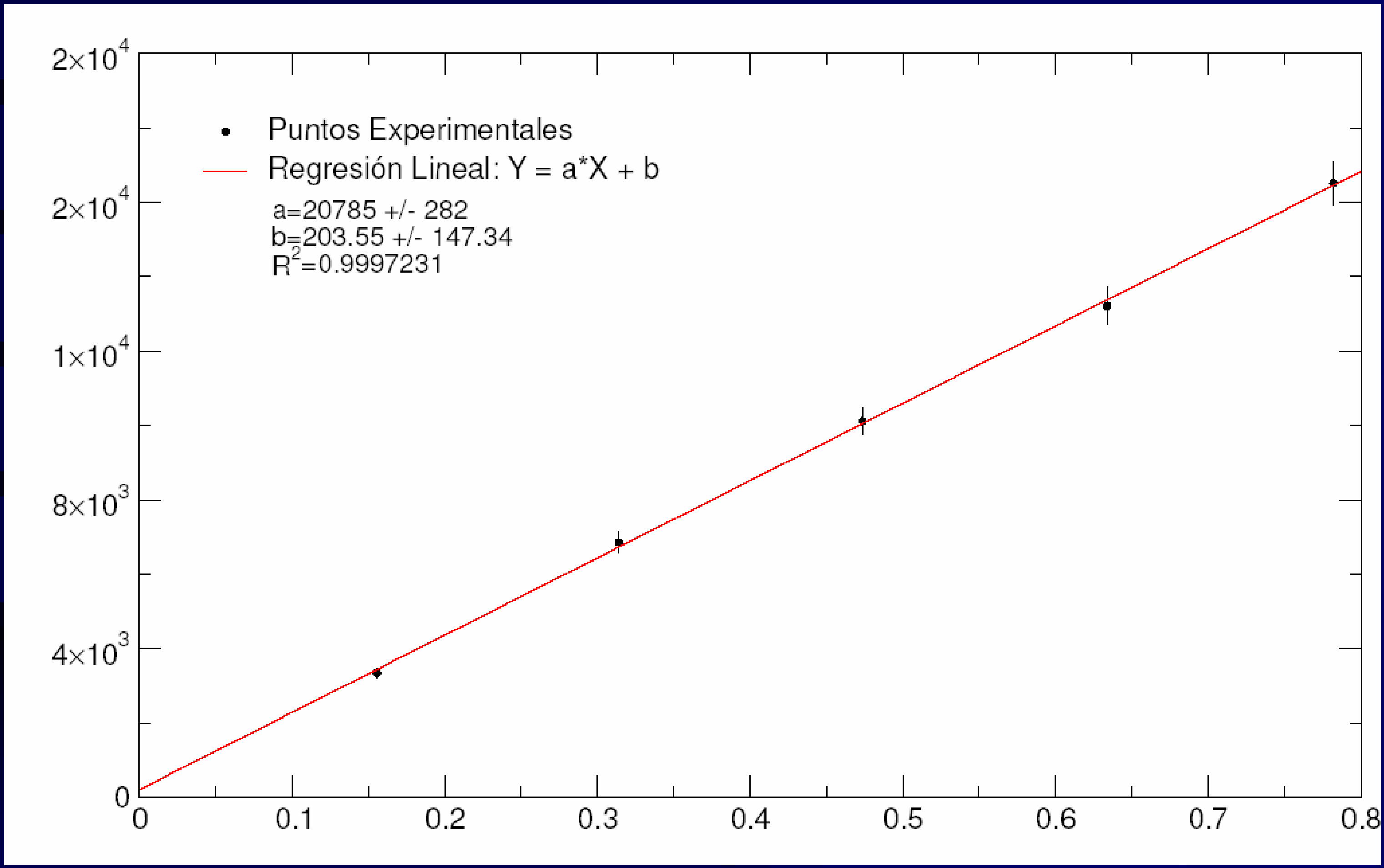


Irradiation of Bromine

There are differential data for the cross sections of the $^{79}Br(n,\gamma)^{80}Br$ and $^{81}Br(n,\gamma)^{82}Br$ reactions, but we found no differential data for the reactions leading to the ground or metastable states.

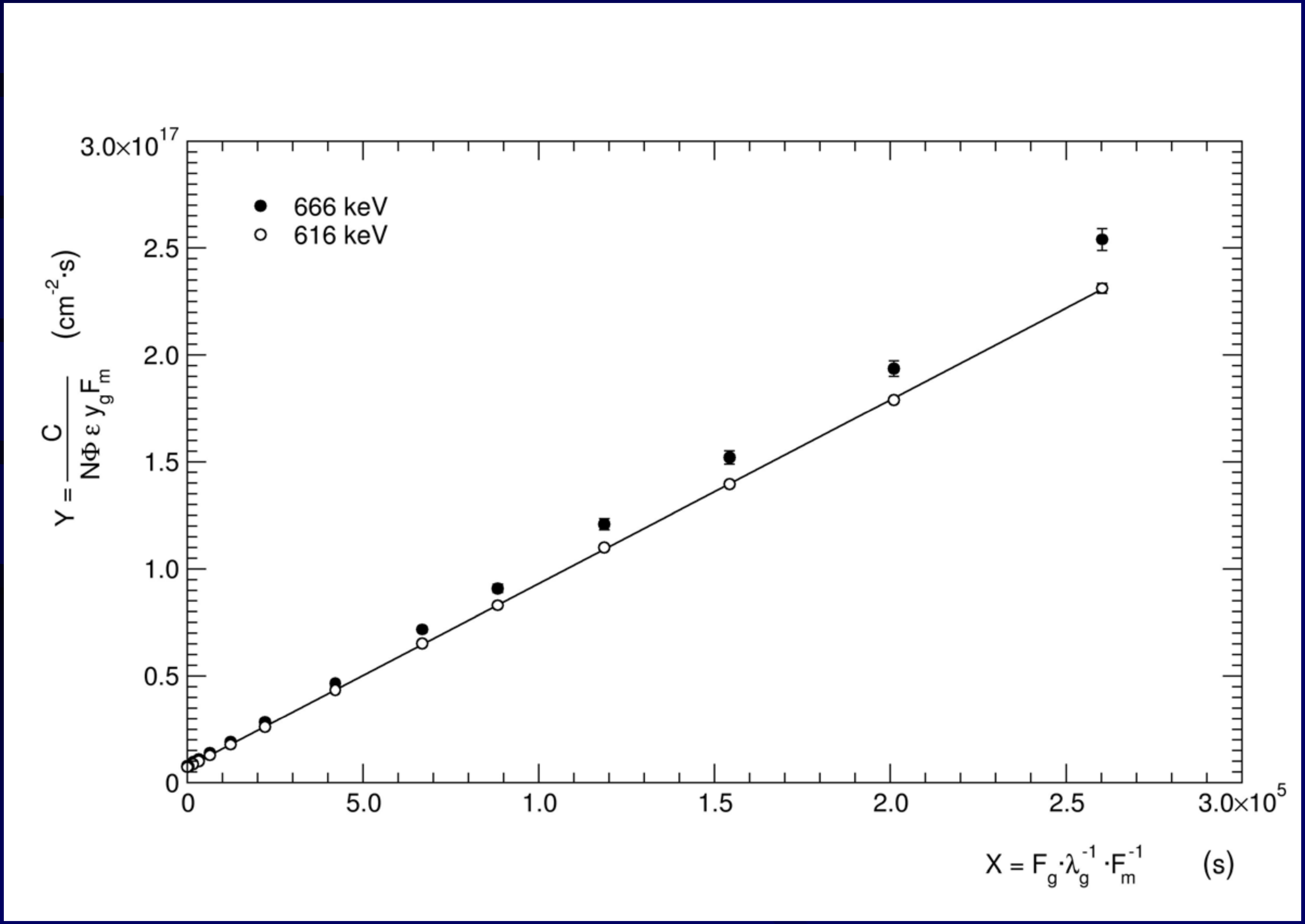
Safe approach: Br concentration should render less than 0.5 % self shielding for both the thermal and epithermal cross sections of the $^{81}Br(n,\gamma)^{82m+g}Br$ reaction.

KBr was dissolved in water and deposited on filter paper. A test was done to check the sample preparation



Puntos Experimentales
Regresión Lineal: Y = a*X + b
a=20785 +/- 282
b=203.55 +/- 147.34
R2=0.9997231
2×10^4
2×10^4
1×10^4
8×10^3
4×10^3
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

^{80}Br - results



Results

$^{79}Br(n,\gamma)^{80m}$ I = 29.2 ± 3.1 b

$^{79}Br(n,\gamma)^{80m}$ I = 30.3 ± 2.6 b (from IT, 37.5 keV)

$^{79}Br(n,\gamma)^{80g}$ I = 86.1 ± 8.9 b

$^{81}Br(n,\gamma)^{82m}$ I = 40.9 ± 2.3 b

$^{81}Br(n,\gamma)^{82m}$ I = 42.7 ± 4.0 b (from IT, 45.9 keV)

$^{81}Br(n,\gamma)^{82g}$ I = 5.5 ± 1.1 b

$^{81}Br(n,\gamma)^{82g+m}$ I = 45.5 ± 2.2 b*

Standard: $^{197}Au(n,\gamma)^{198}Au$ (1562 ± 48) b

* Corrected with a F_{Cd}=0.965