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GABS v12

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GABS – calculating absolute γ-ray intensities and decay branching ratios derived from decay schemes

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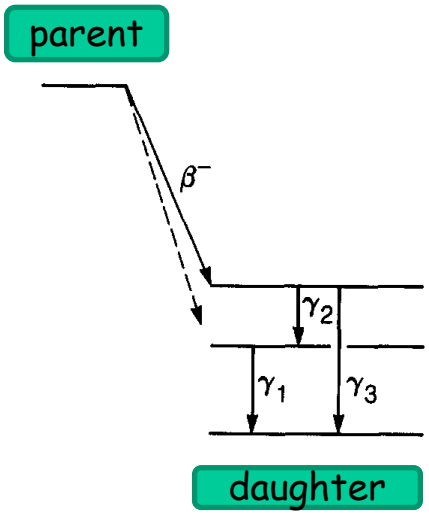
Original author: Edie Browne; modifications: Coral Baglin, Thomas Burrows
Physical & mathematical background:
E. Browne, Nucl. Instr. And Meth. In Phys. Res. **A249** (1986) 461.

Simple decay scheme



$$NR = \frac{100}{RI1 * (1 + CC1) + RI3 * (1 + CC3)}$$

Without direct feeding to the ground state

Definitions:

- Absolute γ-ray intensity: RI(%)=100/(1+α)
- NORMALISATION RECORD:
  - **BR**: Branching ratio multiplier for converting intensity per 100 decays through this decay branch to intensity per 100 decays of the parent nuclide.
  - **NR**: Multiplier for converting relative photon intensity (RI in the *GAMMA* record) to photons per 100 decays of the parent through the decay branch

GABS calculates **NR** & **BR** from **RI** and **CC** or from **TI** (if given) using user assigned transitions feeding to the ground state.

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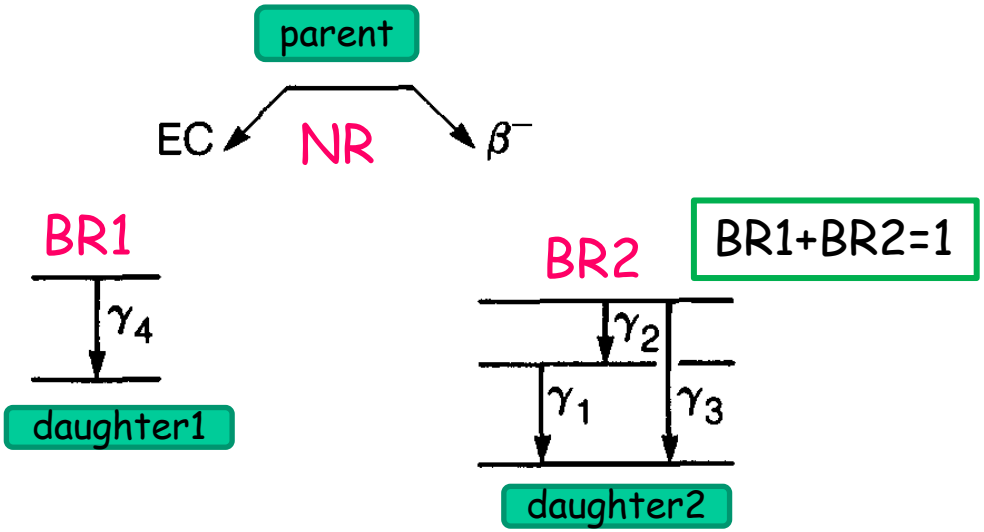
Complex decay scheme



$$NR = \frac{100}{RI_1 * (1 + CC_1) + RI_3 * (1 + CC_3) + RI_4 * (1 + CC_4)}$$

$$BR_1 = \frac{RI_4 * (1 + CC_4)}{RI_4 * (1 + CC_4) + RI_1 * (1 + CC_1) + RI_4 * (1 + CC_3)}$$

$$BR_2 = \frac{RI_1 * (1 + CC_1) + RI_3 * (1 + CC_3)}{RI_4 * (1 + CC_4) + RI_1 * (1 + CC_1) + RI_4 * (1 + CC_3)}$$

Without direct feeding to the ground state

Absolute γ-ray intensity:

RI(%)=RI*NR*BR

Uncertainties in NR and BR:

- Deduced from RI, DRI, CC, DCC or from TI, DTI using first order approximation in a Taylor series expansion
- Care taken to avoid cancellation effects when RI and CC appears in the numerator and denominator in the same time

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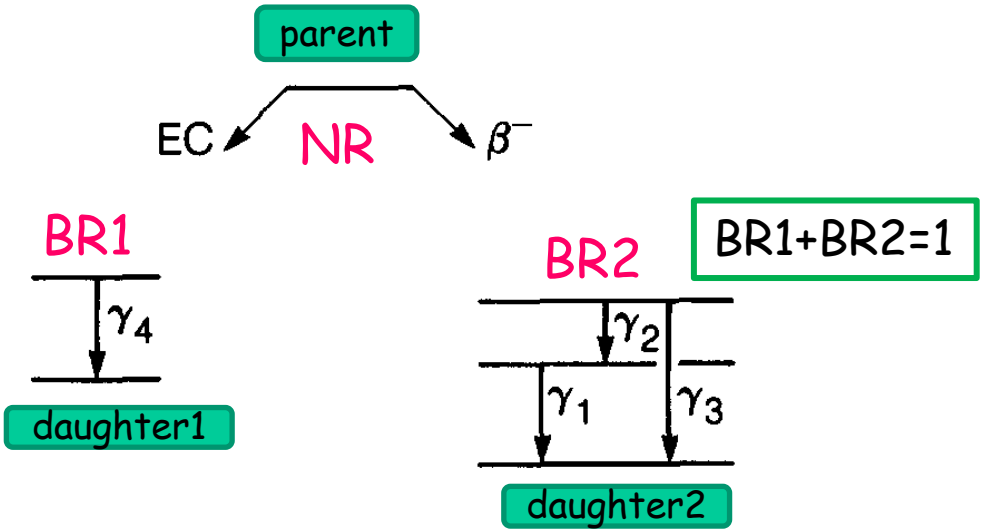
Complex decay scheme



$$NR = \frac{100}{RI_1 * (1 + CC_1) + RI_3 * (1 + CC_3) + RI_4 * (1 + CC_4)}$$

$$BR_1 = \frac{RI_4 * (1 + CC_4)}{RI_4 * (1 + CC_4) + RI_1 * (1 + CC_1) + RI_4 * (1 + CC_3)}$$

$$BR_2 = \frac{RI_1 * (1 + CC_1) + RI_3 * (1 + CC_3)}{RI_4 * (1 + CC_4) + RI_1 * (1 + CC_1) + RI_4 * (1 + CC_3)}$$

Without direct feeding to the ground state

Absolute γ-ray intensity:

RI(%)=RI*NR*BR

Uncertainties in NR and BR:

- Deduced from RI, DRI, CC, DCC or from TI, DTI using first order approximation in a Taylor series expansion
- Care taken to avoid cancellation effects when RI and CC appears in the numerator and denominator in the same time

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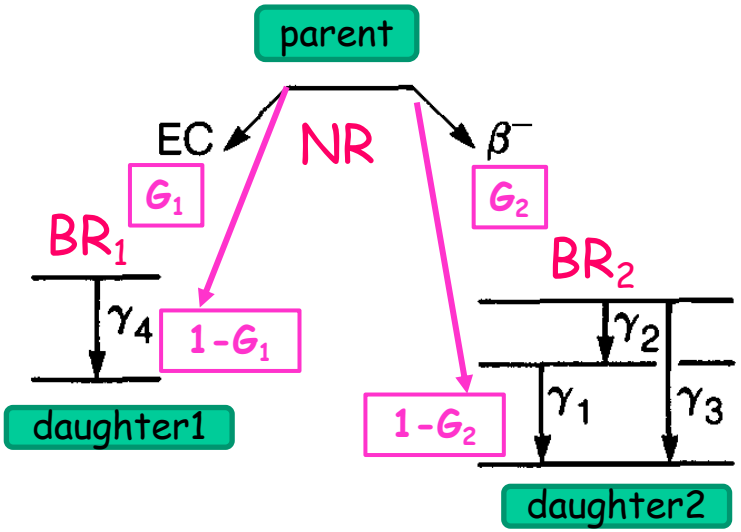
Complex decay scheme – with ground state feeding



G_i – Fraction of the decay branch feeding to excited states

[1-**G_i**] – Fraction of the decay branch feeding to the ground state

Absolute γ-ray intensity

RI_{li}(%): *l*-th γ-ray associated to *i*-th decay branch

$$RI_2(\%) = \frac{100 * RI_2}{\frac{1}{G_1}\times[RI_4(1+CC_4)] + \frac{1}{G_2}\times[RI_1(1+CC_1) + RI_3(1+CC_3)]}$$

GABS: need to adjust manually $BR_i = BR_i * G_i$

Gamma-rays for normalisation

- Must feed to the ground state
- RI or TI must be given
- "X" (no DRI or DTI) or "Y" (DRI or DTI given) in column 79

What is new

- New functions added
  - -F NR and BR will be obtained from a fit (using G`s marked with "X" or "Y"; normal execution)
  - -C Calculate TI using NR and BR from the N-record in the input file
  - -M Mark transitions going to the g.s. by "Y" (DRI>0 or) & "X" (DRI blank)

Default: "-F"

GABS v12 – code improvements

- Program logic simplified
- All variables declared in a single module
- Variable names changed according to ENSDF manual (RI, TI, NR, CC, etc.
- ENSDF file loaded and kept in memory
- Improved user support (error checking)
- Normalisation Gammas: Handles "CA", "AS", "LT", "LE" in RI or TI field. NOTE: "GT" or "GE" is not valid input and will be flagged.
- Calculation mode: NR & BR expected to be numeric. Blank BR assumed to be 1.0.
- "CA" or "AS" in the DNR field will make uncertainty in %TI "CA" or "AS". No provisions to handle limits in NR or BR.

gabs ?

Command: gabs ?

```
==========  GABS Version 12 [26-Nov-2018]  ==========
Usage with command line arguments:
GABS <InputFile> <Mode> ; If Mode omitted "-F" assumed.
  InputFile  ENSDF file, G-rays feeding to g.s. marked with "X" or "Y" (col 79)
  Mode to control execution. If mode omitted (blank), it will be set to -F
    -F   NR and BR will be obtained from a fit (using G`s marked with "X" or "Y")
    -C   Calculate TI using NR and BR from the  N-record in the input file
    -M   Mark transitions going to the g.s. (RI>0 or TI>0) with
                 "Y" (DRI>0 or DTI>0) or "X" (blank DRI or DTI)
Calculation report (*.rpt) and new Ensdf (*.new) files will be created from the InputFile.
For example "GABS gabs.in -F" will produce gabs.rpt and gabs.new files
```

gabs 127Te.in -F

Command: gabs 127Te.in or gabs 127Te.in -F

```
========== GABS Version 12 [26-Nov-2018] ==========
 Loading input file: 127Te.in
 Data set:  127TE B- DECAY (9.35 H)
 <W> No NR given, assumed to be 1.0
 <W> blank BR, BR=1 will be used for CALCULATION mode
     2 Card: 127I   N                          0.012   2

 Calculating new normalisation factors * * * * *
 Report file:      127Te.rpt
 new ENSDF file:   127Te.new

 Data set:  127TE B- DECAY (9.35 H)
 Transitions used for normalisation:
   127I   G 57.609    11     3.0 3M1+E2     0.084   6     3.72                X
   127I   G 202.859   8    5.85 21M1+E2     0.52    5     0.1143 22             X
   127I   G 374.989   9   0.023 APE2                    0.0199              X
   127I   G 417.93    6     100 10M1+E2     0.08    3     0.01599               X
   127I   G 618.4     3   0.013 2M1+E2                  0.0055 7            X
 Normalisation:  127TE B- DECAY (9.35 H)      NR= 0.0098 19  BR= 1.00
```

ENSDF input routine
N and G record tested only

gabs 80Br.in -F

```
Command: gabs 80Br.in -F
========== GABS Version 12 [26-Nov-2018] ==========
 Loading input file: 80Br.in
 Data set: 80BR EC DECAY (17.68 M)
 <W> No NR given, assumed to be 1.0
 <W> blank BR, BR=1 will be used for CALCULATION mode
    2 Card:  80SE  N                    0.145     12
 Data set: 80BR B- DECAY (17.68 M)
 <W> No NR given, assumed to be 1.0
 <W> blank BR, BR=1 will be used for CALCULATION mode
    2 Card:  80KR  N                    0.073      8

 Calculating new normalisation factors * * * * *
 Report file:     80Br.rpt
 new ENSDF file:  80Br.new

 Data set: 80BR EC DECAY (17.68 M)
 Transitions used for normalisation:
   80SE  G 665.94   15  16.1  14E2            1.19E-3         X
   80SE  G 1448.9   3   0.24 LTE2            2.54E-4         X

 Data set: 80BR B- DECAY (17.68 M)
 Transitions used for normalisation:
   80KR  G 616.9    3  100   10E2            1.72E-3         X
   80KR  G 1256.8   3   1.18 10                         X
 Normalisation: 80BR EC DECAY (17.68 M)      NR= 0.893   BR= 0.075 9
                80BR B- DECAY (17.68 M)      NR= 0.072   BR= 0.925 9
```

ENSDF input routine

Data Set #1

Data Set #2

gabs 127Te.in -C

```
Command: gabs 127Te.in -C
==========  GABS Version 12 [26-Nov-2018]  ==========
 Loading input file: 127Te.in
 Data set:  127TE B- DECAY (9.35 H)
 <W> No NR given, assumed to be 1.0
 <W> blank BR, BR=1 will be used for CALCULATION mode
        2  Card: 127I   N                                        0.012     2

 Running in Calculation mode * * * * *
 Output file opened: 127Te.new
  Report  file:       127Te.rpt
 <F> blank NR field not allowed
```

Use 127Te.new from previous run

```
Command: gabs 127Te.new -C
==========  GABS Version 12 [26-Nov-2018]  ==========
 Loading input file: 127Te.new

 Running in Calculation mode * * * * *
 Output file opened: 127Te.new
  Report  file:       127Te.rpt
 Calculations completed
```

Input file will be overwritten!

gabs 127Te.in -C

```
Command: gabs 127Te.in -C
==========  GABS Version 12 [26-Nov-2018]  ==========
 Loading input file: 127Te.in
 Data set:  127TE B- DECAY (9.35 H)
 <W> No NR given, assumed to be 1.0
 <W> blank BR, BR=1 will be used for CALCULATION mode
        2  Card: 127I   N                                        0.012     2

 Running in Calculation mode * * * * *
 Output file opened: 127Te.new
  Report  file:       127Te.rpt
 <F> blank NR field not allowed c
```

Use 127Te.new from previous run

```
Command: gabs 127Te.new -C
==========  GABS Version 12 [26-Nov-2018]  ==========
 Loading input file: 127Te.new

 Running in Calculation mode * * * * *
 Output file opened: 127Te.new
  Report  file:       127Te.rpt
 Calculations completed
```

Input file will be overwritten!

gabs 192Ir.ens -M

Command: gabs 192Ir.ens -M

```
========== GABS Version 12 [26-Nov-2018] ==========
 Loading input file: 192Ir.ens
 Data set: 192IR EC DECAY (73.829 D)
 Data set: 192IR B- DECAY (73.829 D)

 Searching for ground state transitions
 Output file opened: 192Ir.new

 Data set: 192IR EC DECAY (73.829 D)
          Level      GE       RI     DRI  Flag
           205.79442   205.79430  4.001    12  Y
          489.0602     489.06    0.529    18  Y

 Data set: 192IR B- DECAY (73.829 D)
          Level      GE       RI     DRI  Flag
          316.50646    316.50618  100.0      X
          612.46320    612.46215  6.45     9   Y
           1378.03     1378.50    0.00169  23  Y
 Calculations completed
```

What next

- Need extensive testing
- Proper treatment of uncertainties when NR or Br is a limit
- Manual need to be updated

Program developments

- Compiled using Intel compiler on Win, Linux and MacOS. Gfortran
- Uncertainty propagation using Monte-Carlo