GAMMA-RAY LINE CODE

Ramaty, Kozlovsky & Lingenfelter 1979

Monte Carlo code for gamma-ray line production from isotropic accelerated particles

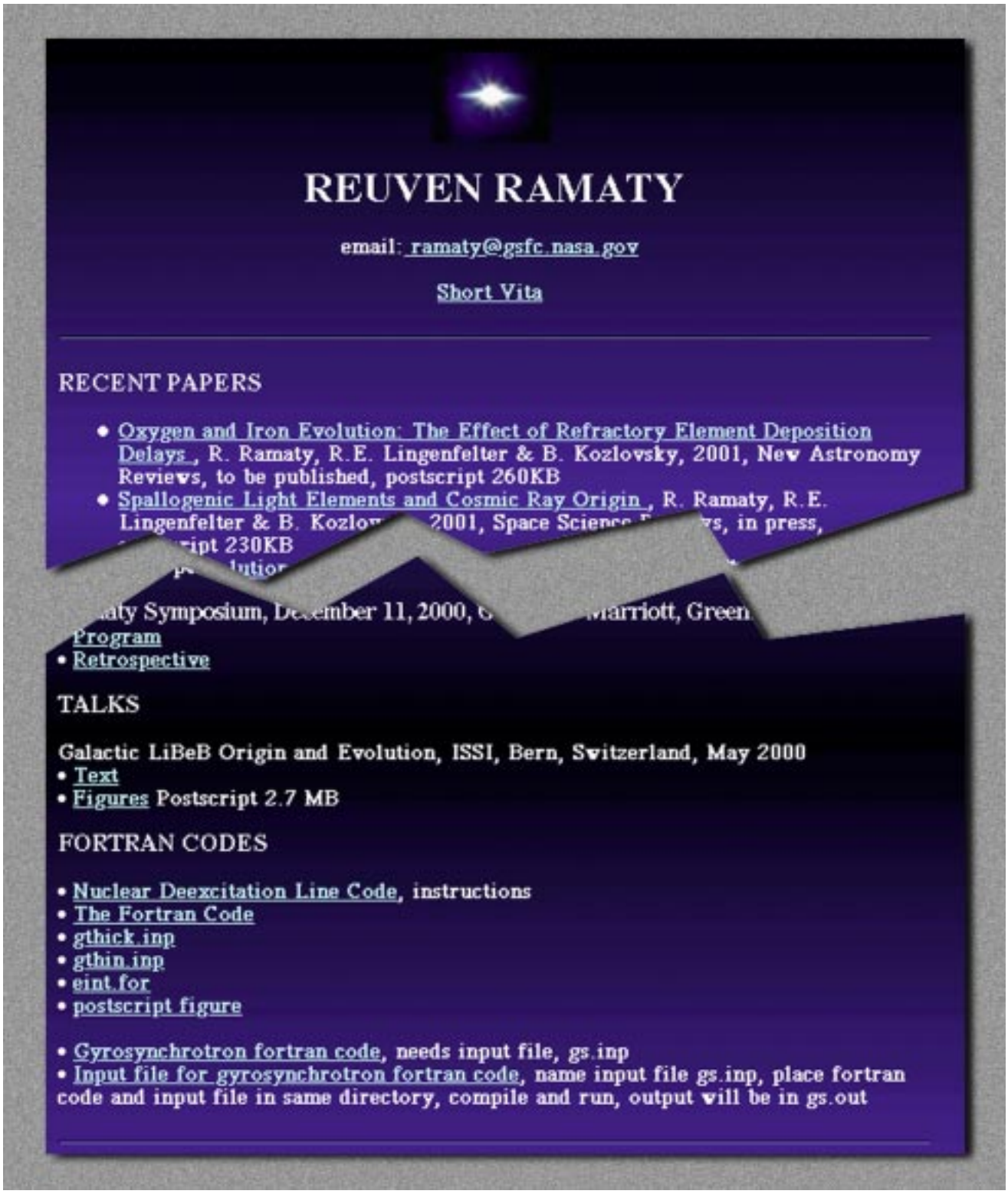
Incorporates measured and synthesized energy- and angle-dependent cross sections and exact relativistic kinematics

Input parameters:

- **ambient abundances (He, C, N, O, Ne, Mg, Al, Si, S, Ca & Fe)**
- **accelerated abundances (^{3}He, α, C, N, O, Ne, Mg, Al, Si, S, Ca & Fe)**
- **accelerated-particle energy spectrum (power law) and low-energy "cut-off" (i.e., becomes flat)**
- **thin or thick target**
- **statistics**
- **switches for:**
  - **unresolved component**
  - **radioactive lines**

Reuven's Web Page

http://lheawww.gsfc.nasa.gov/users/ramaty/ViewPubs/ramaty.html



REUVEN RAMATY

email: ramaty@gsfc.nasa.gov

Short Vita

RECENT PAPERS

- Oxygen and Iron Evolution: The Effect of Refractory Element Deposition Delays , R. Ramaty, R.E. Lingenfelter & B. Kozlovsky, 2001, New Astronomy Reviews, to be published, postscript 260KB
- Spallogenic Light Elements and Cosmic Ray Origin , R. Ramaty, R.E. Lingenfelter & B. Kozlo 2001, Space Scienc s, in press, ipt 230KB

aty Symposium, December 11, 2000, Marriott, Green
Program
- Retrospective

TALKS

Galactic LiBeB Origin and Evolution, ISSI, Bern, Switzerland, May 2000
- Text
- Figures Postscript 2.7 MB

FORTRAN CODES

- Nuclear Deexcitation Line Code, instructions
- The Fortran Code
- gthick.inp
- gthin.inp
- eint.for
- postscript figure

- Gyrosynchrotron fortran code, needs input file, gs.inp
- Input file for gyrosynchrotron fortran code, name input file gs.inp, place fortran code and input file in same directory, compile and run, output will be in gs.out

NUCLEAR DEEXCITATION GAMMA RAY LINE CODE

The code is written in fortran77. It needs an input file named g.inp. Download the code and compile it. Two sample input files are supplied, gthick.inp and gthin.inp. Copy one of these to g.inp and run.

The input file items are: Statistics -- number of photons used in the Monte Carlo simulation, for a good spectrum we recommend 10^6. The unresolved component is due to unresolved gamma ray lines in heavy nuclei; 0 includes this component and 1 excludes it; use 0 for the total spectrum (narrow and broad lines); if you want to see just the narrow lines, you must zero out the accelerated particle abundances of C and heavier nuclei and set the unresolved component parameter to 1. Lines from long term radioactive nuclei (e.g. 0.847 MeV from ^{56}Co produced by a p,n reaction on ^{56}Fe) are excluded with 1 and included with 0. PL-index gives the spectral index of the accelerated particle spectrum which is a power law in kinetic energy per nucleon down to a low energy cutoff (le cutoff) below which the spectrum is constant. Thin/thick of 1 or 2 is thin or thick target respectively; for both the thin and thick target models the accelerated particles are assumed isotropic in the interaction region. For the thick target the ambient medium is assumed to be neutral. The charge state of the ambient medium does not have a role in the thin target because the particles do not lose energy. The ambient abundances are normalized to H. The accelerated particle abundances are normalized to the protons, with all species having the given abundances at the same energy per nucleon. For both the ambient medium and the accelerated particles for each element the abundance should include all the isotopes of that species. The power law, including the cutoff, is normalized to 1 proton of energy greater than 30 MeV.

The output is in g.spc. The 3 columns are photon energy in MeV, bin width in MeV, and photon production spectrum at the source. The photon energy is given at bin center. The code eint.for will integrate the spectrum over any given photon energy range. For the thick target the spectrum is in photons MeV^{-1} and it represents the total gamma ray production for 1 proton greater than 30 MeV. For the thin target the spectrum is in photons MeV^{-1} cm^3 sec^{-1} and it represents the instantaneous production in an ambient medium of unit H density by accelerated particles normalized to 1 proton greater than 30 MeV. The postscript file figure shows the spectrum calculated with gthick.inp with $5x10^6$ photons.

Credit for use of this code should be given to R. Ramaty, R.J. Murphy and B. Kozlovsky, mentioning the WEB page from where the downloading was done. The code is based on the paper by R. Ramaty, B. Kozlovsky and R. E. Lingenfelter, 1979, ApJ (Suppl.), 40, 487 with substantial updates (Kozlovsky, Murphy and Ramaty, 2001, in preparation).

Input file g.inp
(gthick.inp)

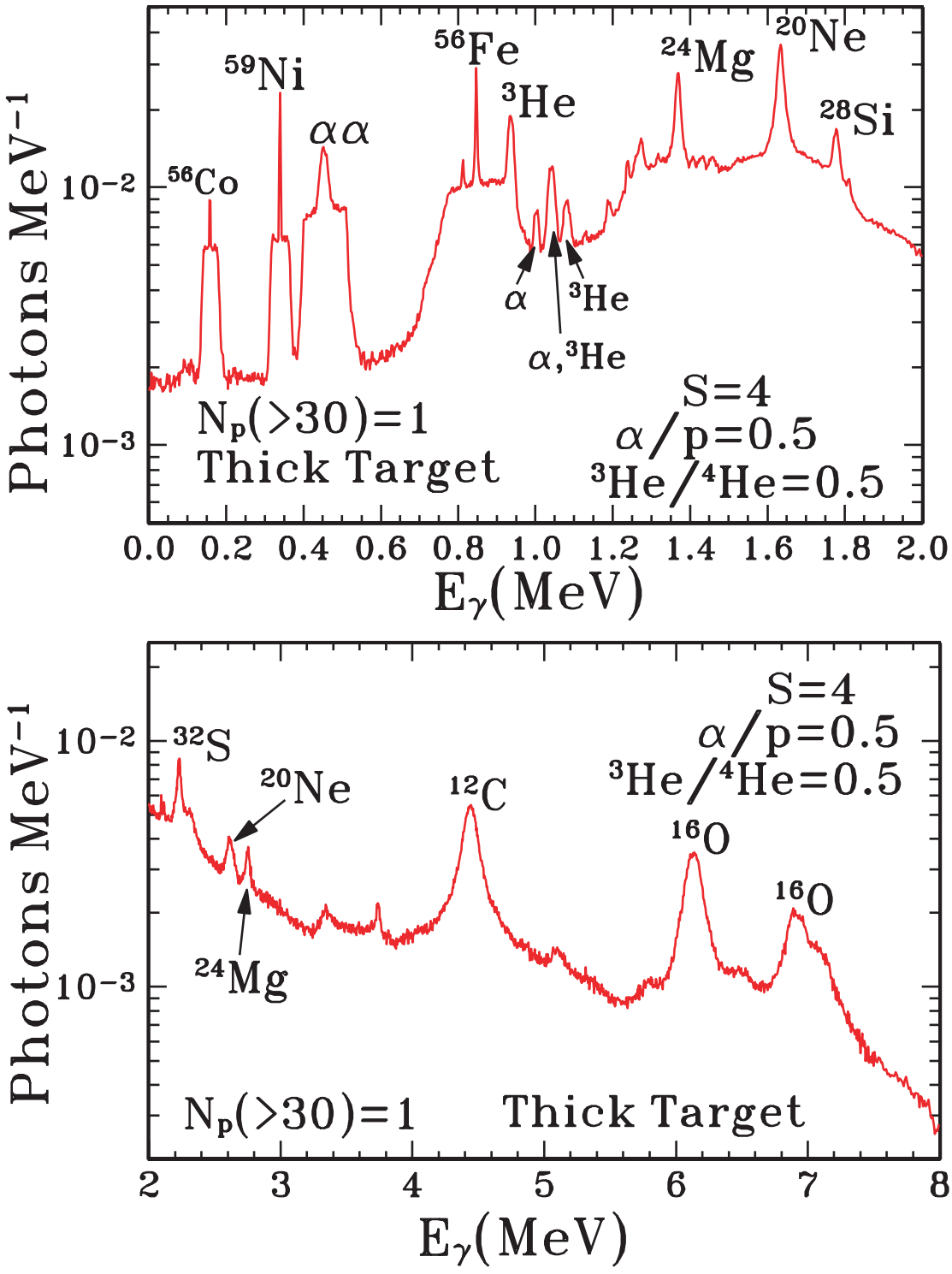
```
statistics          1000000
unresolved          0
longterm radioact   1
pl index            4.
le cutoff           1.
thin/thick          2
ambient abundances
hydrogen            1.000000
helium              0.084000
carbon              0.000311
nitrogen            0.000093
oxygen              0.000741
neon                0.000185
magnesium           0.000145
aluminum            0.000012
silicon             0.000113
sulfur              0.000024
calcium             0.000008
iron                0.000099
accelerated particle abundances
protons             1.000000
alphas              0.500000
helium-3            0.250000
carbon              0.005109
nitrogen            0.001348
oxygen              0.010870
neon                0.004957
magnesium           0.006522
aluminum            0.000522
silicon             0.004891
sulfur              0.001043
calcium             0.000359
iron                0.014130
```

OUTPUT: g.spc

```
0.100000E-02 0.200000E-02 0.205088E-02
0.300000E-02 0.200000E-02 0.250685E-02
0.500000E-02 0.200000E-02 0.135165E-02
0.700000E-02 0.200000E-02 0.264880E-02
0.900000E-02 0.200000E-02 0.180273E-02
0.110000E-01 0.200000E-02 0.157151E-02
0.130000E-01 0.200000E-02 0.109152E-02
0.150000E-01 0.200000E-02 0.222281E-02
0.170000E-01 0.200000E-02 0.268872E-02
0.190000E-01 0.200000E-02 0.163428E-02
0.210000E-01 0.200000E-02 0.158538E-02
0.230000E-01 0.200000E-02 0.148347E-02
0.250000E-01 0.200000E-02 0.193507E-02
0.270000E-01 0.200000E-02 0.215751E-02
0.290000E-01 0.200000E-02 0.173991E-02
0.310000E-01 0.200000E-02 0.148836E-02
0.330000E-01 0.200000E-02 0.142131E-02
0.350000E-01 0.200000E-02 0.176127E-02
0.370000E-01 0.200000E-02 0.231716E-02
0.390000E-01 0.200000E-02 0.266094E-02
0.410000E-01 0.200000E-02 0.223476E-02
0.430000E-01 0.200000E-02 0.247049E-02
0.450000E-01 0.200000E-02 0.111493E-02
0.470000E-01 0.200000E-02 0.154353E-02
0.490000E-01 0.200000E-02 0.694565E-03
0.510000E-01 0.200000E-02 0.107080E-02
0.530000E-01 0.200000E-02 0.327217E-02
0.550000E-01 0.200000E-02 0.260232E-02
.            .            .
.            .            .
.            .            .
```

2300 energy bins

Output spectrum



G.INP

```
statistics          1000000
unresolved          0
longterm radioact   1
pl index            4.
le cutoff           1.
thin/thick          2
ambient abundances
hydrogen            1.000000
helium              0.084000
carbon              0.000311
nitrogen            0.000093
oxygen              0.000741
neon                0.000185
magnesium           0.000145
aluminum            0.000012
silicon             0.000113
sulfur              0.000024
calcium             0.000008
iron                0.000099
accelerated particle abundances
protons             1.000000
alphas              0.500000
helium-3            0.250000
carbon              0.005109
nitrogen            0.001348
oxygen              0.010870
neon                0.004957
magnesium           0.006522
aluminum            0.000522
silicon             0.004891
sulfur              0.001043
calcium             0.000359
iron                0.014130
```

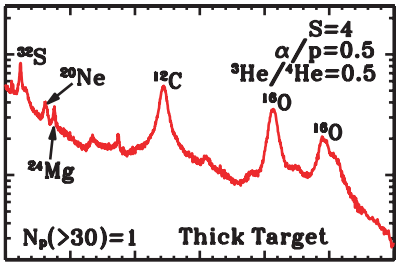
Provides:

relative line intensities
detailed line shapes
fitting templates for weak flares

GAMMA.FOR

G.SPC

```
0.100000E-02 0.200000E-02 0.205088E-02
0.300000E-02 0.200000E-02 0.250685E-02
0.500000E-02 0.200000E-02 0.135165E-02
0.700000E-02 0.200000E-02 0.264880E-02
0.900000E-02 0.200000E-02 0.180273E-02
0.110000E-01 0.200000E-02 0.157151E-02
0.130000E-01 0.200000E-02 0.109152E-02
0.150000E-01 0.200000E-02 0.222281E-02
0.170000E-01 0.200000E-02 0.268872E-02
0.190000E-01 0.200000E-02 0.163428E-02
0.210000E-01 0.200000E-02 0.158538E-02
0.230000E-01 0.200000E-02 0.148347E-02
0.250000E-01 0.200000E-02 0.193507E-02
0.270000E-01 0.200000E-02 0.215751E-02
0.290000E-01 0.200000E-02 0.173991E-02
0.310000E-01 0.200000E-02 0.148836E-02
0.330000E-01 0.200000E-02 0.142131E-02
0.350000E-01 0.200000E-02 0.176127E-02
0.370000E-01 0.200000E-02 0.231716E-02
0.390000E-01 0.200000E-02 0.266094E-02
0.410000E-01 0.200000E-02 0.223476E-02
0.430000E-01 0.200000E-02 0.247049E-02
0.450000E-01 0.200000E-02 0.111493E-02
0.470000E-01 0.200000E-02 0.154353E-02
0.490000E-01 0.200000E-02 0.694565E-03
0.510000E-01 0.200000E-02 0.107080E-02
0.530000E-01 0.200000E-02 0.327217E-02
0.550000E-01 0.200000E-02 0.260232E-02
```

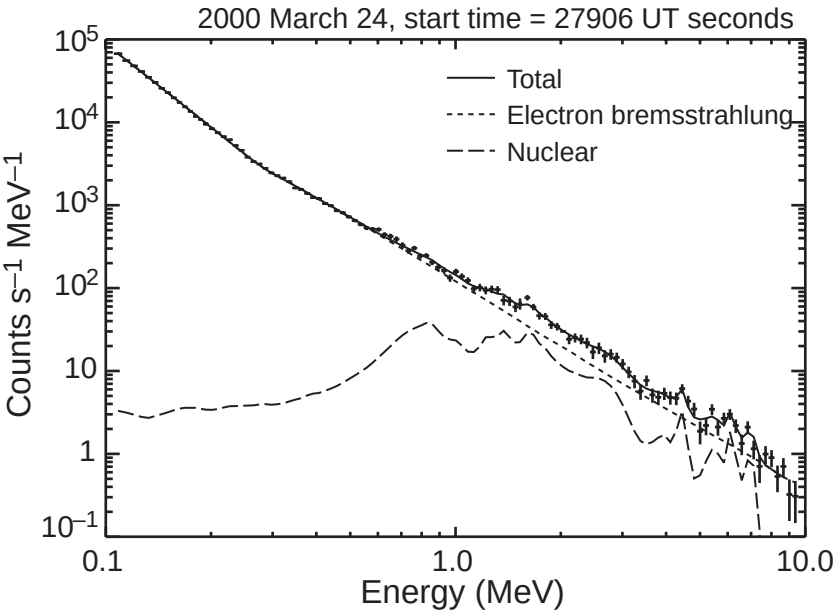


EINT.FOR

E_1, E_2

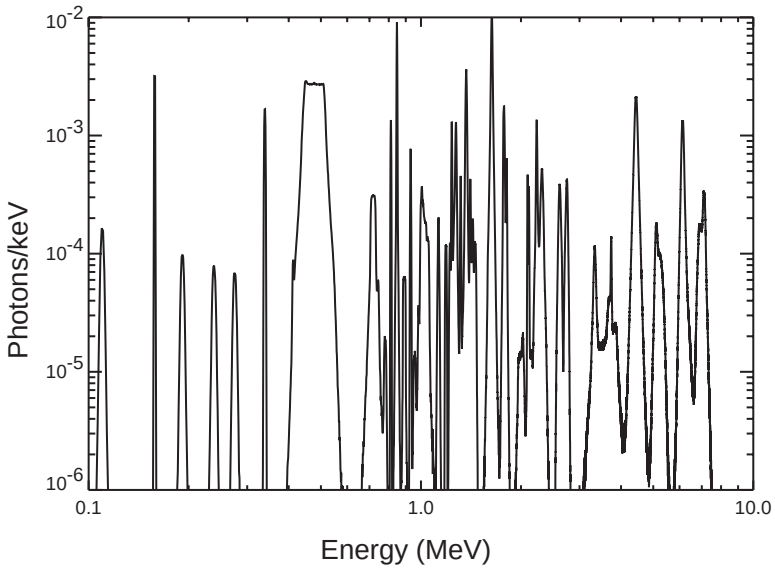
Flux in Energy Window

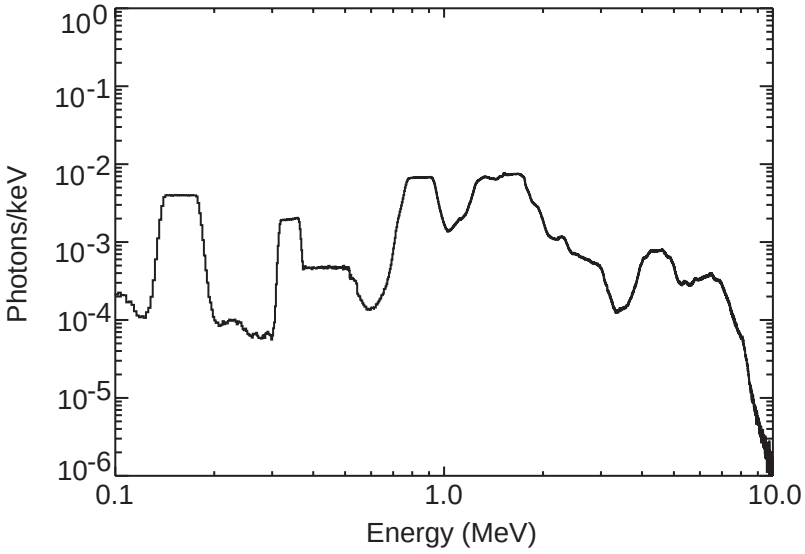
Fitting Templates



OSSE flare

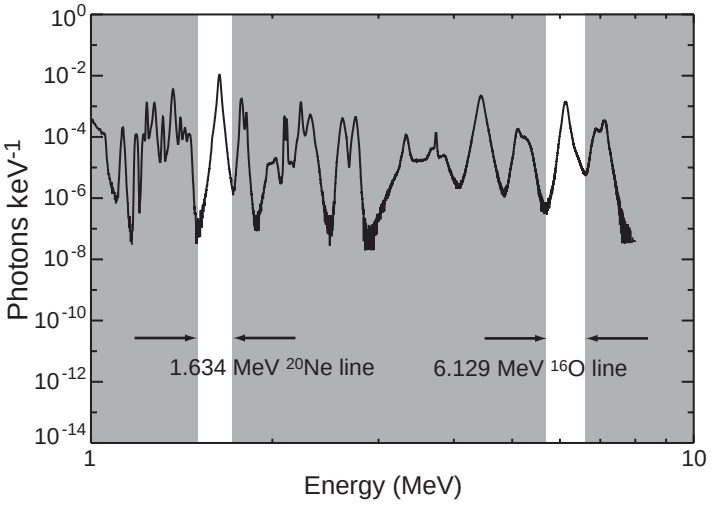
Narrow lines

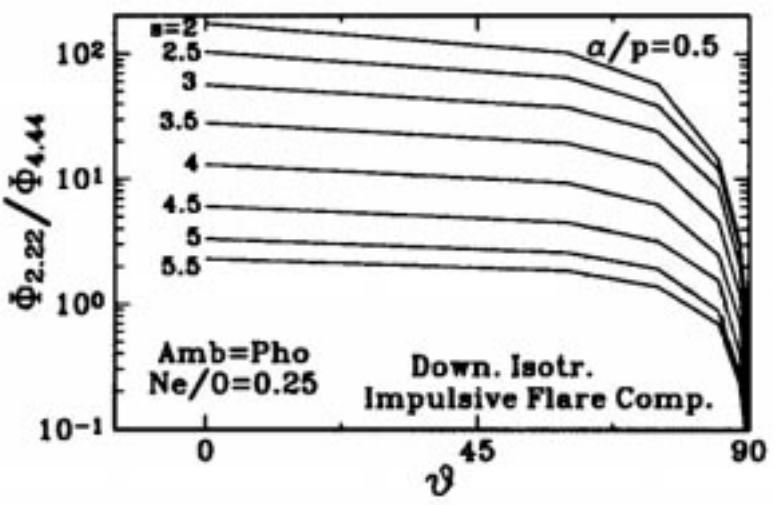


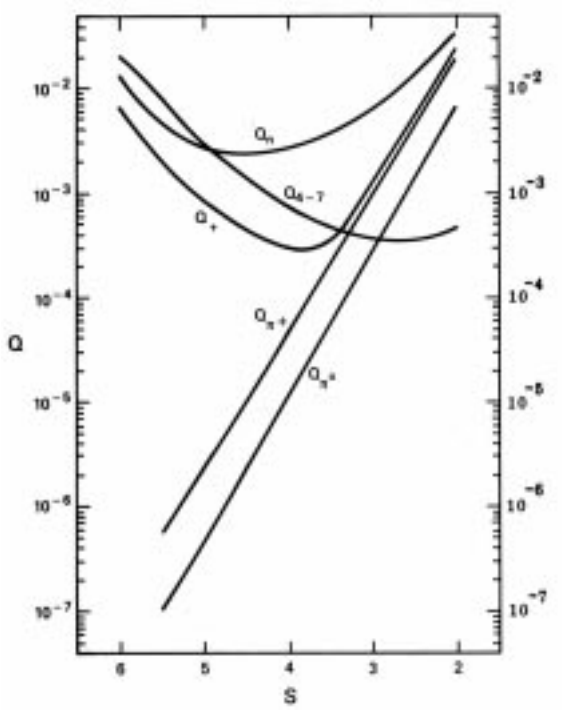


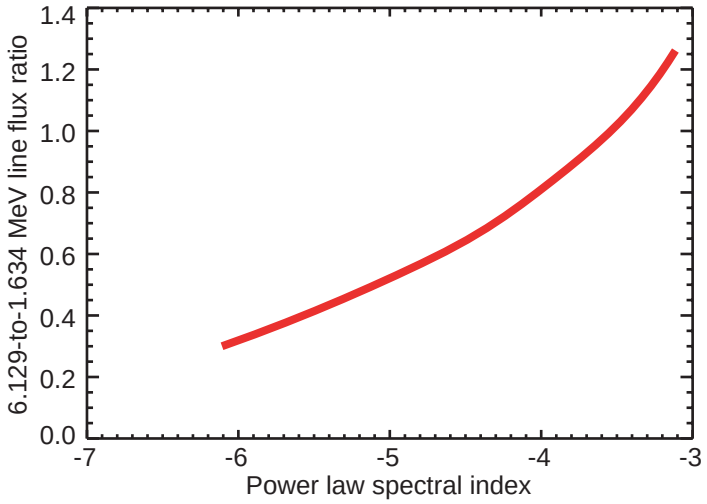
Broad lines

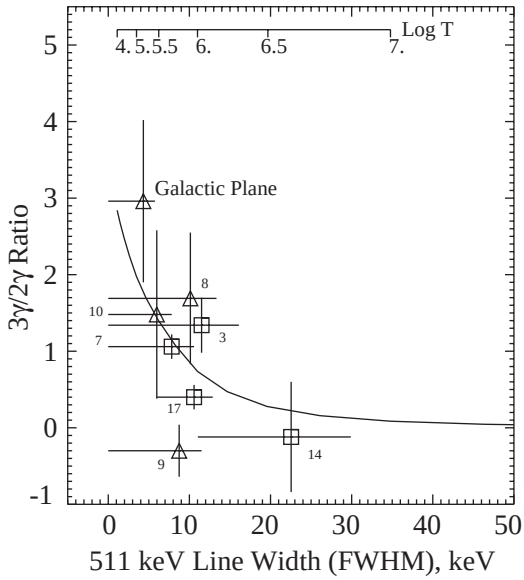
Additional Tools











Provides:

relative line intensities
accelerated-particle spectrum
annihilation region temperature
accelerated-particle numbers