

LISE⁺⁺ version 9.4.1

- Asymmetry for Gaussian-like momentum distributions
- Asymmetry parameter “alpha”
- Extracting the asymmetry coefficient from the Convolution model (Universal parameterization)
- Example at low energy
- ⁸²Se momentum distribution results (will be soon)

symmetric

$$f(x) = A \cdot e^{-\frac{(x-x_0)^2}{2\sigma^2}}$$

$$CS = A \cdot \sqrt{2 \cdot \pi} \cdot \sigma$$

$$x_{\text{peak}} = x_0$$

$$\langle x \rangle = x_0$$

asymmetric

$$f(x) = A \cdot e^{-\frac{(x-x_0)^2}{2\sigma_{\text{low}}^2}}, \text{ if } x < x_0 \quad \text{and} \quad A \cdot e^{-\frac{(x-x_0)^2}{2\sigma_{\text{high}}^2}}, \text{ if } x > x_0$$

$$CS = A \cdot \sqrt{2 \cdot \pi} \cdot \sigma \quad \text{where} \quad \sigma = \frac{\sigma_{\text{low}} + \sigma_{\text{high}}}{2}$$

$$\text{asymmetry coefficient} \quad \alpha = \frac{\sigma_{\text{low}}}{\sigma} - 1 = 1 - \frac{\sigma_{\text{high}}}{\sigma}$$

$$-100\% < \alpha < +100\%$$

$$x_{\text{peak}} = x_0$$

$$\langle x \rangle = \frac{\int_{-\infty}^{x_0} x \cdot A \cdot e^{-\frac{(x-x_0)^2}{2 \cdot (\sigma_{\text{low}})^2}} dx + \int_{x_0}^{\infty} x \cdot A \cdot e^{-\frac{(x-x_0)^2}{2 \cdot (\sigma_{\text{high}})^2}} dx}{\int_{-\infty}^{x_0} A \cdot e^{-\frac{(x-x_0)^2}{2 \cdot (\sigma_{\text{low}})^2}} dx + \int_{x_0}^{\infty} A \cdot e^{-\frac{(x-x_0)^2}{2 \cdot (\sigma_{\text{high}})^2}} dx} = x_0 - \frac{4 \alpha \sigma}{\sqrt{2 \cdot \pi}}$$

The asymmetry coefficient “alpha” is applied for models [1-3]

asymmetry coefficient “ α ” (in %) and reduced width “ σ ” are used to describe an asymmetrical Gaussian momentum distribution

asymmetry

Projectile fragmentation

Fragment velocity | Momentum distribution | Cross section, Excitation energy and etc

40Ar(140.0 MeV/u) + Be -> 32S

Parallel momentum distribution been used in the program (MeV/c) = 245.9 with Gamma-factor = 282.9*

Parallel momentum distribution

- [1] A.S. Goldhaber
Phys.Lett.B 53(1974)306
 $\sigma_{||}^2 = \sigma_0^2 \frac{A_F(A_P - A_F)}{A_P - 1}$ $\sigma_0 = 90$ $\sigma_{||} = 230.6$
- [2] D.J. Morrissey
Phys.Rev.C 39(1989)460
 $\sigma_{||}^2 = \sigma_M^2 (A_P - A_F)$ $\sigma_M = 87$ $\sigma_{||} = 245.9$
- [3] W.A. Friedman
Phys.Rev.C 27(1983)569
 $\sigma_{||}^2 = \frac{\mu}{2x_0} \left[\frac{1 + 0.5y}{\sqrt{1+y}} + \frac{1}{\mu x_0} \right]$ settings $\sigma_{||} = 155.4$

Asymmetry coefficient for Gaussian-like distributions [1-3] alpha (%) = 11.4 $\alpha = \frac{\sigma_{low}}{\sigma_{||}} - 1 = 1 - \frac{\sigma_{high}}{\sigma_{||}}$? Help

- [4] Universal parameterization (Convolution)
O.Tarasov, NPA 734(2004)536 settings $\sigma_0^{conv} = 91.5$ $\sigma_{||} = 199.7$

Corrections of the momentum distribution width

- [a] Coulomb energy correction [W.A.Friedman, PRC 27(1983) 569] $\sigma_0^* = \sigma_0 (1 - E_B / E_{CM})^{1/2}$ Sigma0(M) corrected, [MeV/c]
- [b] Particle mass correction [R.K.Tripathi, L.W.Townsend, PRC 49(1994)2237] $\sigma_0^* = (\sigma_0 - 20 + 2A_P / 3)$

Perpendicular momentum distribution

$\sigma_{\perp}^2 = \sigma_{||}^2 + \sigma_D^2 \frac{A_F(A_P - 1)}{A_P(A_P - 1)}$ $\sigma_D = 200$ MeV/c

$\sigma_{\perp} = 293.1$ MeV/c

Make default

OK Cancel Help

To obtain distribution characteristics from different models for the current configuration (beam, target, fragment)

C:\user\c\lise_pp_94\results\32S.velocity

40Ar(140.0 MeV/u) + Be -> 32S

Velocity	Mom. width	vv0_mean	vv0_peak	sigma	sigma_g	sigmaL_g	sigmaR_g	Asymmetry	SepEnergy
Borrel	Goldhaber	0.9928	0.9950	230.56	265.21	295.44	234.97	11.40	
DJM	DJM	0.9892	0.9914	245.92	282.89	315.13	251.84	11.40	
Rami	Friedman	0.9917	0.9932	155.37	178.72	199.09	158.34	11.40	
Convol	Qg	0.9958	0.9968	165.75	190.67	197.26	184.08	3.46	8.00
Convol	dS	0.9916	0.9953	193.30	222.35	244.47	200.24	9.95	39.08
Convol	Qg+dS	0.9910	0.9952	197.53	227.22	251.92	202.53	10.87	47.08

set by user (points to vv0_mean, vv0_peak, sigma, sigma_g, sigmaL_g, sigmaR_g)

calculated (points to Asymmetry)

Projectile fragmentation

Fragment velocity / Momentum distribution / Cross section, Excitation energy and etc

Final relation V_f/V_b been used in the program for the setting fragment mean = 0.9892 peak = 0.9914 40Ar(140.0 MeV/u) + Be -> 32S

Mean Fragment velocity

- Constant V fragment / V beam = 1
- Calculation - A [V. Borrel et al., Z. Phys. A314(1983)191]
- Calculation - B [F. Rami et al., NPA 444(1985)349]
- Calculation - C [D. Tarasov, NPA 734(2004)536]
- Calculation - D [from two-body reaction]
- Calculation - E [D. Morrissey, PRC 39(1989)460]

Options

- Velocity after reaction can not exceed fragment velocity from two-body reaction kinematics (at 0 degree). It is important for pick-up reactions!
- Assume symmetric velocity distribution around Aproj / 2. Important for light fragment production.
- Use velocity shift for pick-up reactions R. Pfaf, D. Morrissey et al., PRC51(1995)1348
- Exclude this shift for (p,n) and (n,p) reactions

Shift of V_f/V_b relation velocity (s) 0 (default 0) V_f/V_b 0.993

Energy necessary to ablate one nucleon (Bn) 8 MeV (default 8)

Information (only for simple target)

V_{frag}/V_{beam} from two-body reaction 1.076

Angle (deg) 0.0

V of C.M. / V_{beam} 0.816

Write distribution parameters to file

Fragment momentum distribution: <Convolution> method

Dimension of the plot ONE-dimensional TWO-dimensional

Convolution method characteristic to draw a plot

- 01: v/v0: mean
- 01: v/v0: peak
- 02: v/v0: peak
- 03: FWHM**g*
- 04: sigma**g*
- 05: sigma
- 06: PsigmaL**g*
- 07: PsigmaR**g*
- 08: Asymmetry
- 09: SepEnergy
- 10: tau

OK Quit

Convolution of Gaussian (Fragmentation) and Exponent (Friction) distributions

40Ar(140.0 MeV/u) + Be -> 32S

Settings for Gaussian distribution

P0 (MeV/C) = 16931

V_f/V_b from settings = 0.989

Mom. distribution = [1] D.J. Morrissey

$\sigma_0 = 87$ MeV/c

$\sigma_{||} = 282.9$ MeV/c (*)

$$f(p) \approx \exp\left(\frac{p}{\tau}\right) \cdot \left[1 - \text{ferr}\left(\frac{p - p_0 + \frac{\sigma_{||}^2 - \text{shift} \cdot \tau}{\tau}}{\sqrt{2} \sigma_{||}}\right)\right]$$

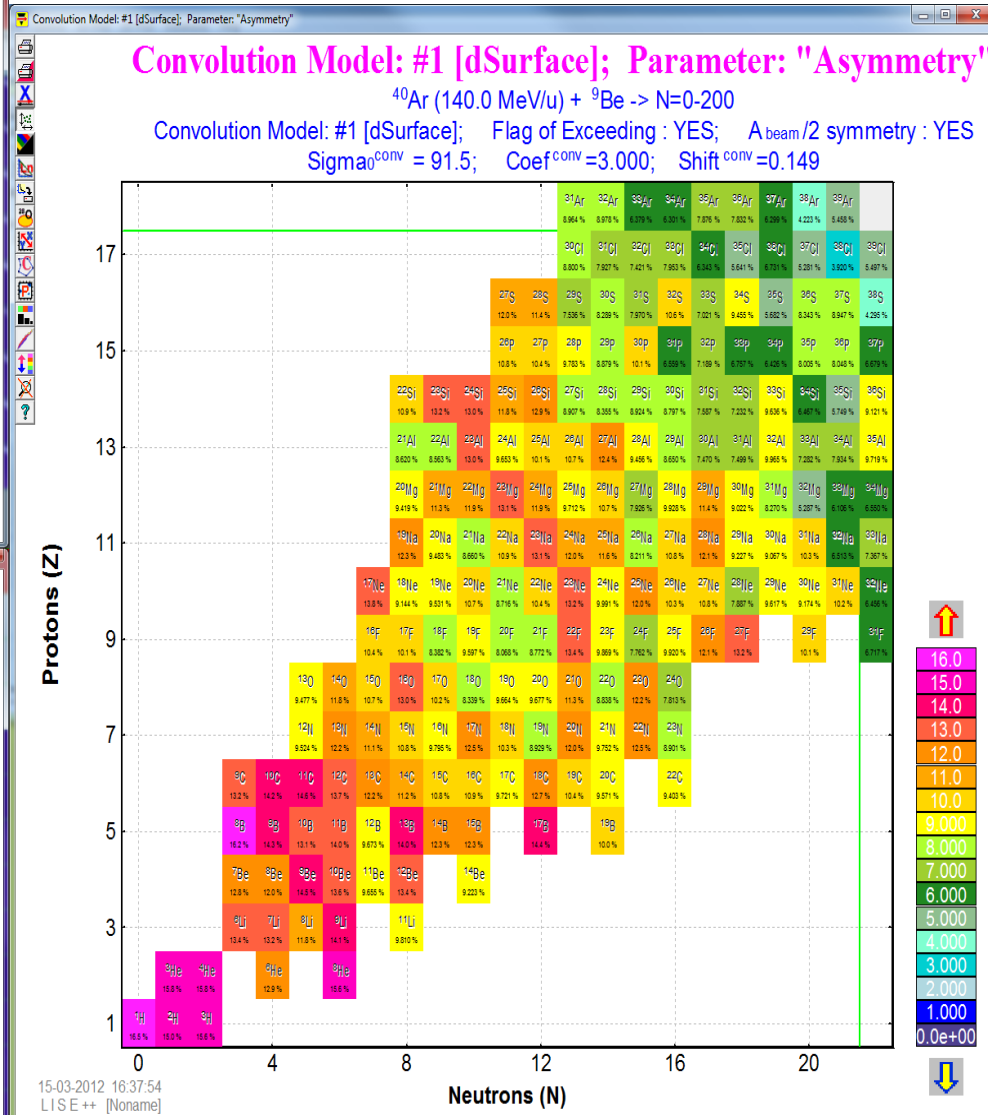
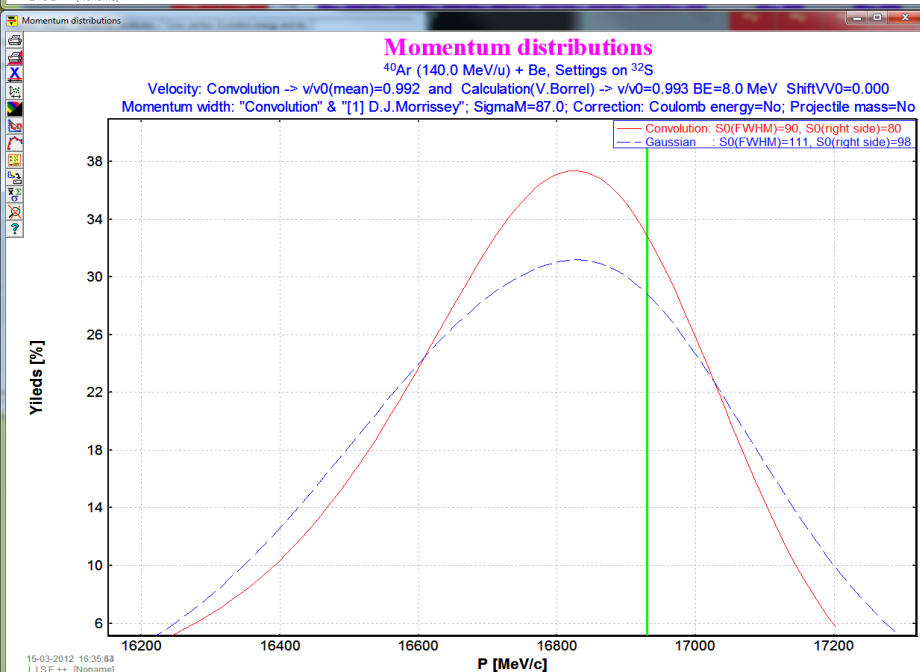
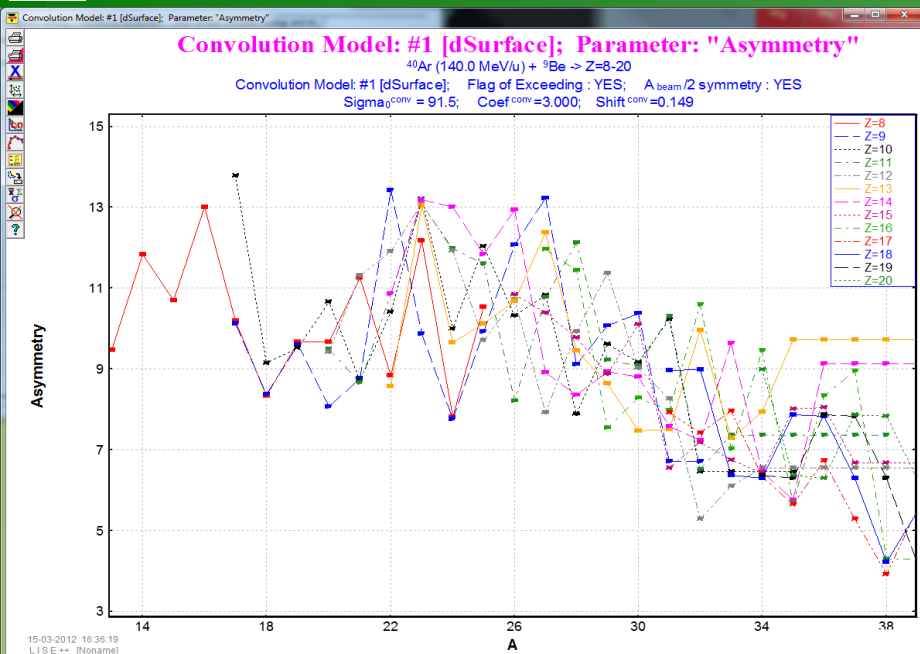
$$\sigma_{||}^2 = (\sigma_0^{\text{conv}} \sqrt{\beta_p})^2 \frac{A_p^*(A_p - A_p^*)}{A_p - 1} \quad \tau = \frac{\text{coef}}{\beta} \sqrt{A_p^* E_s}$$

Settings for convolution

Separation Energy	E _s	coef	shift	FWHM / 2.355 (*)	tau	P(Ymax)	peak	mean
Energy from Qg	8.0	3.344	0.158	190.7	111.5	16859	0.997	0.996
Excitation from dSurface	39.1	3	0.149	222.4	221.0	16788	0.995	0.992
Qg + dSurface	47.1	2.936	0.153	227.2	237.4	16778	0.995	0.991

Plot - Conv. Analysis

See the next slide



Projectile fragmentation

Fragment velocity | Momentum distribution | Cross section, Excitation energy and etc

40Ar(40.0 MeV/u) + Be -> 32S

Parallel momentum distribution been used in the program (MeV/c) = 230.6 with Gamma-factor = 240.5*

Parallel momentum distribution

[1] A.S. Goldhaber
Phys.Lett.B 53(1974)306
 $\sigma_{||}^2 = \sigma_0^2 \frac{A_F(A_F - A_T)}{A_F - 1}$
 $\sigma_0 = 90$ $\sigma_{||} = 230.6$

[2] D.J. Morrissey
Phys.Rev.C 39(1989)460
 $\sigma_{||}^2 = \sigma_M^2 (A_F - A_T)$
 $\sigma_M = 87$ $\sigma_{||} = 245.9$

[3] W.A. Friedman
Phys.Rev.C 27(1983)569
 $\sigma_{||}^2 = \frac{\mu}{2x_0} \left[\frac{1+0.5y}{\sqrt{1+y}} + \frac{1}{\mu x_0} \right]$
settings $\sigma_{||} = 155.4$

Asymmetry coefficient for Gaussian-like distributions [1-3]
alpha (%) = 32
 $\alpha = \frac{\sigma_{low}}{\sigma_{||}} - 1 = 1 - \frac{\sigma_{high}}{\sigma_{||}}$? Help

[4] Universal parameterization (Convolution)
O.Tarasov, NPA 734(2004)536
settings $\sigma_0^{conv} = 91.5$ $\sigma_{||} = 212.6$

Corrections of the momentum distribution width

[a] Coulomb energy correction [W.A.Friedman, PRC 27(1983) 569]
 $\sigma_0^* = \sigma_0 (1 - E_B / E_{CM})^{1/2}$ Sigma0(M) corrected, [MeV/c]

[b] Particle mass correction [R.K.Tripathi, L.W.Townsend, PRC 49(1994)2237]
 $\sigma_0^* = (\sigma_0 - 20 + 2A_F / 3)$

Perpendicular momentum distribution

$\sigma_{\perp}^2 = \sigma_{||}^2 + \sigma_D^2 \frac{A_F(A_F - 1)}{A_F(A_F - 1)}$ $\sigma_D = 200$ MeV/c
 $\sigma_{\perp} = 280.3$ MeV/c

Make default

OK Cancel Help

Projectile fragmentation

Fragment velocity | Momentum distribution | Cross section, Excitation energy and etc

40Ar(40.0 MeV/u) + Be -> 32S

Final relation V_i/V_b been used in the program for the setting fragment
mean = 0.9747
peak = 0.9875

Mean Fragment velocity

Constant V fragment / V beam = 1

Calculation - A [V.Borrel et al., Z.Pyhs.A314(1983)191]
Options
 Velocity after reaction can not exceed fragment velocity from two-body reaction kinematics (at 0 degree). It is important for pick-up reactions!
 Assume symmetric velocity distribution around Aproj / 2. Important for light fragment production.
 Use velocity shift for pick-up reactions R.Pfaff, D.Morrissey et al., PRC51(1995)1348
 Exclude this shift for (p,n) and (n,p) reactions

Calculation - B [F.Rami et al., NPA 444(1985)349]

Calculation - C [O.Tarasov, NPA 734(2004)536]

Calculation - D [from two-body reaction]

Calculation - E [D.Morrissey, PRC 39(1989)460] $dE/dA = 8$ at Afrag = Aproj
Vf / Vb = 0.954 (both default 8 MeV) $dE/dA = 8$ at Afrag = Aproj / 2

A - V.Borrel et al., Z.Pyhs. A314(1983)191

$v_F = s + \sqrt{1 - \frac{E_B(A_F - A_T)}{A_F E_F}}$ Shift of V_i/V_b relation velocity (s) 0 (default 0) Vf / Vb 0.975

Energy necessary to ablate one nucleon (Br) 8 MeV (default 8)

B - F.Rami et al., NPA 444 (1985)349

$v_F = \sqrt{1 - \frac{2S}{A_F E_F}}$ Vf / Vb 0.971 g (MeV/fm2) 0.95
S(MeV) 39.1
Prefragment Mass 33.9

Information (only for simple target)
Vfrag /Vbeam from two-body reaction 1.083
Angle (deg) 0.0
V of C.M. / Vbeam 0.816

C - convolution Vf / Vb (peak) 0.990

Write distribution parameters to file

Make default

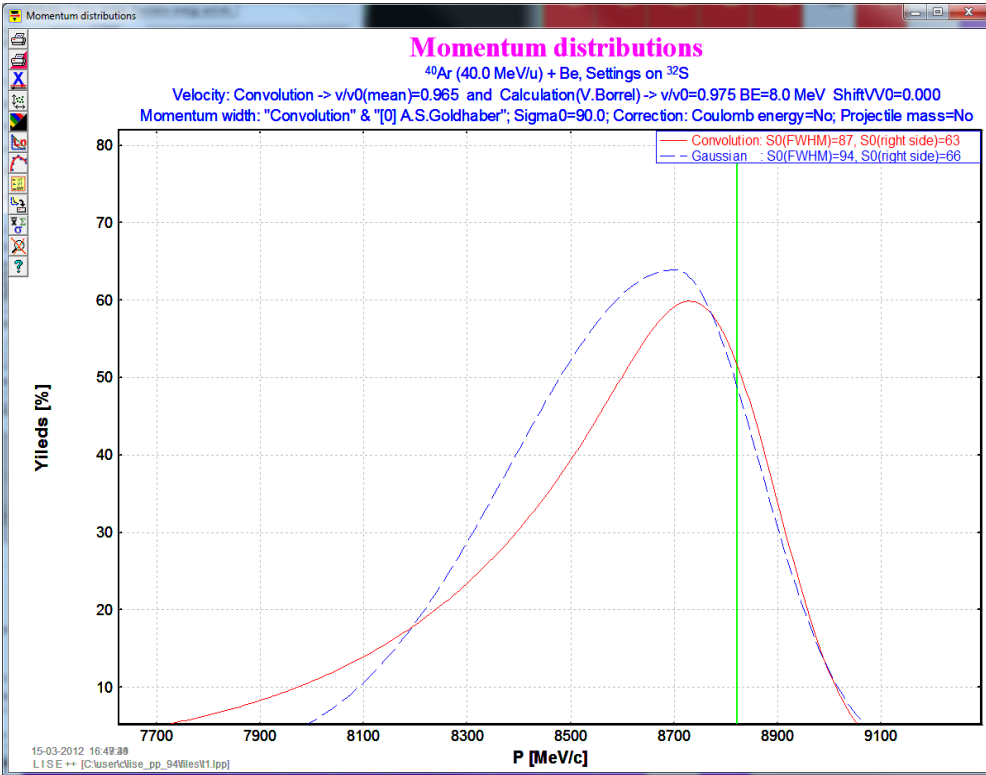
OK Cancel Help

C:\user\c\lise_pp_94\results\32S.velocity

40Ar(40.0 MeV/u) + Be -> 32S

Velocity	Mon.width	vv0_mean	vv0_peak	sigma	sigma_g	sigmaL_g	sigmaR_g	Asymmetry	SepEnergy
Borrel	Goldhaber	0.9747	0.9875	230.56	240.46	317.40	163.51	32.00	
DJM	DJM	0.9538	0.9674	245.92	256.48	338.56	174.41	32.00	
Rami	Friedman	0.9708	0.9794	155.37	162.04	213.89	110.19	32.00	
Convov	Qg	0.9829	0.9920	157.01	163.76	186.60	140.91	13.95	8.00
Convov	dS	0.9654	0.9902	212.58	221.71	283.22	160.20	27.74	39.08
Convov	Qg+dS	0.9634	0.9906	220.97	230.46	297.91	163.01	29.27	47.08

Print

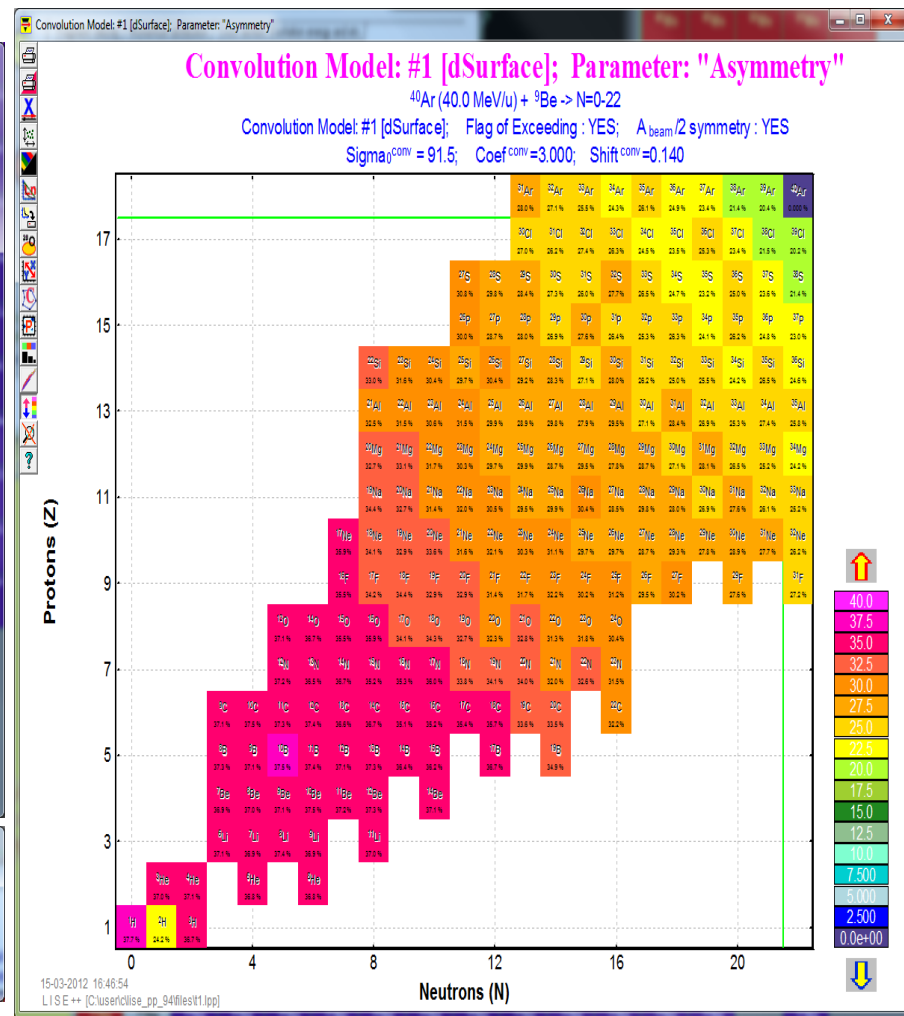


Statistics

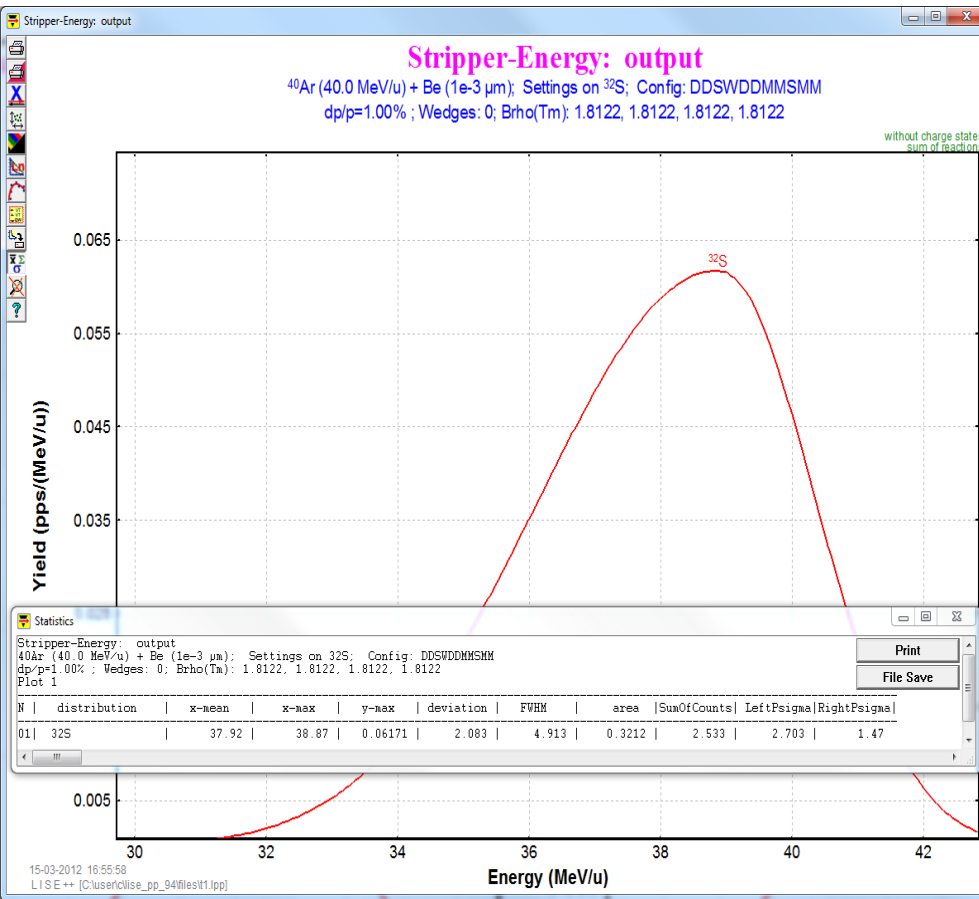
Momentum distributions
 ^{40}Ar (40.0 MeV/u) + Be, Settings on ^{32}S
 Velocity: Convolution $\rightarrow v/v_0(\text{mean})=0.965$ and Calculation(V.Borrel) $\rightarrow v/v_0=0.975$ BE=8.0 MeV ShiftVW0=0.000
 Momentum width: "Convolution" & "[0] A.S.Goldhaber"; Sigma0=90.0; Correction: Coulomb energy=No; Projectile mass=No
 Plot 1

N	distribution	x-mean	x-max	y-max	deviation	FWHM	area	SunOfCounts	LeftPsigma	RightPsigma
01	Convolution: S0(F)	8490	8736	59.82	400.3	522.1	3.846e+04	1157	291	152.4
02	Gaussian : S0()	8580	8701	63.92	243.3	566.3	3.846e+04	2560	317.4	163.6

Print
File Save



“Distribution” method



Monte Carlo method

