ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

Stopping power and range for proton interaction with Ovary and Testis tissues

Dr.Bashair Mohammed Saied , Shaima Mohsen Hadi

Department of Physics / College of Education Ibn Al-Haitham for Pure Sciences – University of Baghdad- Iraq

ABSTRACT:-In this study, the stopping power and range of protons in the two types of body tissues, (Ovary and Testis) which is a compound of several elements were calculated in energy range from 10KeV to 200MeV using the Bethe and Ziegler equations, RIM program and Ziegler (Vol.3)data. Results are presented and compared with the latest published data.

KEYWORDS: Proton therapy,Braag peak,Stopping power,Range,Bethe, Ziegler equation,SRIM,Ziegler Vol(3).

I. INTRODUCTION

The study of the interaction of ionizing radiation (X-rays, electrons, positrons, protons or heavier ions) with living tissues has a paramount importance in cancer therapy since the amount of energy deposited by the ionizing radiation to tumor cells will determine the outcome of the treatment [1].Proton radiotherapy is becoming popular because it can deliver a high radiation dose to the target while sparing adjacent healthy tissues or critical organs [2].
Proton show an increasing energy deposition with penetration distance and leading to a maximum, called the "Bragg peak",near the end of range of the proton beam[3].The Braag peak is very narrow so if shifted from the desired target will couse healthy tissue to exposed very high doses. the location where proton will stopped is closely related to the amount of stopping power of the medium through which it passes, which is a measure of how much energy is lost given to the medium. the magnitude of the stopping power depends on the proton energy and the type of the target medium [3],one of the roles of physics and computations in the proton radiotherapy is in determining the range of protons in the body tissues, and proper determination of absorbed dose.The range of proton is associated with the amount of stopping power ,by Bethe using quantum mechanics equation of the stopping power for an ion in a homogeneous medim are[4]:

$$\frac{dE}{dx}(MeV/m) = 4\pi r_o^2 z^2 \frac{mc^2}{B^2} NZ[\ln(\frac{2mc^2}{I}B^2\gamma^2) - B^2] \quad (1)$$

Where $r_o = e^2/mc^2 = 2.818*10$^-15 m=classical electron radius

$4\pi r_o^2 = 9.98*10^{-29}\, m^2 \approx 10^{-28} m^2 = 10^{-24} cm^2$

mc^2 = rest mass energy of the electron=0.511MeV

$\gamma = (T+Mc^2)/Mc^2 = 1/(1-B^2)^{1/2}$

B=v/c, c=speed of ligh in vacuum=2.997930*10^8m/s=3*10^8m/s

N=number of atoms/m^3 in the material through which the particle moves

N=ρ(N_A/A), N_A = Avogadros number=6.022*10^23 $\frac{atoms}{mol}$

A=atomic weight

Z=atomic number of the material

z=charged of the incident particle(z=1 for e-,e+,p,d;z=2 for α)

I=mean excitation potential of the material

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

$I(ev)=(9.76+58.8Z^{-1.19})Z$………………………………………………………..(2)

The term stopping power using as $\frac{dE}{dx}$ in eq(1) and this formula are vaild for energies>1Mev [5].

II.ZIEGLER FORMULA

Zieglerin his book attempts to gave a nearly complete presentation of absolute experimental energy data. For hydrogen over the energy range 10 KeV<(E/amu)<20 MeV.The extensive use of active computer programs have allowed a large variety of different fitting functions. To be used the data were finally fitted to simple analytical functions the parameters of which will be computed together with the experimental data for each element. An attempt has been made to calculate the fitting parameters to elements for which there is no experimental data. Finally the stopping powers were integrated to yield path length and projected range data for protons and Deuterons [6].

A) REVIEW OF THEORY: At low energies, stopping power theory is mostly evaluated using the Thomas-Fermi statistical model of the atom. The electronic stopping is found to be proportional to projectile velocity, the specific dependence is given by

$$S_e = z_1^{1/6} 8\pi e^2 a_o \frac{z_1 z_2}{(z_1^{2/3}+z_2^{2/3})^{3/2}} \frac{v}{v_o} \text{..........} \qquad (3)$$

$$v < v_o z_1^{2/3}$$

Here, Z_1 and Z_2 are the atomic numbers of projectile and target, respectively. The projectile velocity is v, e is the electronic charge and a_o and v_o the Bohr radius of the hydrogen atom and the Bohr velocity. The high-energy behaviour of the stopping power is very well described by Bethe-formula

$$S = \frac{4\pi e^4 Z_1^2 Z_2}{m\, v^2} \times [\ln\left(\frac{2mv^2}{\bar{I}}\right) + \ln\left(\frac{1}{1-\beta^2}\right) - \beta^2 - \frac{C}{Z_2}] \text{......................................}(4)$$

Equation (4) predicts the stopping power at high energies to be proportional to Z_1^2. Small deviations have been seen from such a behavior and correction terms proportional to Z_1^3 and Z_1^4 have been proposed. These higher order Z_1 effects have not been isolated, but are grouped under "shell corrections".

To bridge the gap between the high- and low-energy theories, interpolation formulas of different levels of complexity were proposed. Brice suggested

$S(E) = (Z_1+Z_2)S_e(n)f(n)$,Where $n = \frac{E}{Z^2 \; M_1 E_1}$ ……………………………………..(5)

and

$S_e(n)=A([(30n^{\frac{5}{2}} + 53n^{\frac{3}{2}} + 21n^{\frac{1}{2}})/3(1+n)^2] + (10n+1)\arctan(n^{\frac{1}{2}}))$ ... , , , , , , (6)

and

$f(n)=[1 + (4Z^2 á^2 n)^{n/2}]^{-1}$ ………………………………………………………….. (7)

Here A=1.22× 10^{-15} eV cm^2/atom while Z, á and n are fitting parameter. M_1 is the projectile mass, and E_1 = 100 keV. Varelas and Biersack proposed

$S^{-1} = \left(S_{LOW}\right)^{-1} + (S_{HIGH})^{-1}$ or

$S=S_{Low} S_{HIGH} / (S_{Low} + S_{HIGH})$ ………………………………………..(8)

Where S_{Low} (Low Energy Stopping) is

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 8 , August 2017

$S\,Low = A_1 E^{\frac{1}{2}}$ ……………………………………………………….……………..(9)

and $S\,HIGH$ (High Energy Stopping) is

$S\,HIGH = (\frac{A2}{E})\ln[1+(A_3/E)+(EA_4)]$ ....(10)

Here A_1,A_2,and A_3 are fitting constants and

$A_4 = 4m/IM_1$……………………………………………………………………….(11)

The fitting formula eq. (8) asymptotically agrees with eq (3) at low energy, and with eq.(4) at high energy.[6].

B) FITTING THE HIGH-ENERGY REGION

The Bethe stopping-power formula (4) was used as the theoretical basis in the high-energy region. All stopping power data with E/amu > 400 keV were considered in constructing the final fits, Note that both Eq. (3) and Eq. (4) depend on projectile velocity, but not on projectile mass. No theoretical predictions relate electronic energy loss to projectile mass [6].

C) FITTING AT LOWER ENERGIES

For 600 KeV and down both the Brice and Varelas-Biersack interpolation formulas as given by Eq. (5) and Eq. (8). In the low-energy limit except for hydrogen and helium targets where no large difference was found. They decided to use.

$\boldsymbol{S_{LOW} = A_1\, E^{0.45}}$ ………………………………………………………….. (12)

Instead of Eq. (9), the overall fit to the data is better than with a velocity proportional stopping power [6].

D) INTERPOLATION USING 2-PARAMETER FITTING

In order to interpolate stopping to elements without experimental data, they attempted to find a 2 parameter fit (one parameter for low energies. one for high energies). They used the basic 4-parameter fit of Eq. (10), and for A_4 they used:

$\boldsymbol{A_4 = 4m_e/m_pI}$ ……………………………………………………………….(13)

Where m_e and m_p are the mass of the electron and proton. A new fit was made to all elements using this form for A_4.For the targets used to test the fit, A_2 (Eq.10) was found to decrease slowly with Z_2. The variation of A_2 was now approximated

$\boldsymbol{A_2 = (243 - 0.375\, Z_2)\, Z_2}$……………………………………….……….(14)

With these smoothed A_2 coefficients, new optimal values of A_1 and A_3 were sought by the optimization program. The fits turned out to have a χ^2 virtually the same as for the original four-parameter fit. They briefly summarize the various fitting formulae which they combine in the Varelas-Biersack Formula

$\boldsymbol{(S^{-1} = (S_{LOW})^{-1} + (S_{HIGH})^{-1}.}$ ……………………………..……. (15)

These they call:

4-PARAMETER FIT

$\boldsymbol{S_{LOW} = A_1\, E^{0.45}}$ ……………………………………………………..…..… (16)

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

$\mathbf{S_{HIGH}} = (\mathbf{A_2/E})\,\mathbf{ln}[\mathbf{1} + (\mathbf{A_3}\,/\mathbf{E}) + \mathbf{A_4}\,\mathbf{E}]$ …………………………………..….. (17)

3-PARAMETER FIT

$\mathbf{S_{LOW}} = \mathbf{A_1}\,\mathbf{E^{0.45}}$ ……………………….………………………………………..….. (18)

$\mathbf{S_{HIGH}} = (\mathbf{A_2/E})\,\mathbf{ln}\left[\mathbf{1} + (\mathbf{A_3}\,/\mathbf{E}) + (\mathbf{4}\,\mathbf{m_e E/m_p I})\right]$…………………………..…. (19)

2-PARAMETER FIT

$\mathbf{S_{LOW}} = \mathbf{A_1}\,\mathbf{E^{0.45}}$…………………………………………………………………. (20)

$\mathbf{S_{HIGH}} = [(\mathbf{243 - 0.375Z_2})\mathbf{Z_2/E})]\,\mathbf{ln}\left[\mathbf{1} + (\mathbf{A_2}\,/\mathbf{E}) + (\mathbf{4}\,\mathbf{m_e E/m_p I})\right]$ ……… (21)

Finally small adjustments were made to A_2, for elements where considerable data exists and it was desired to make a very accurate fitted curve.The low-energy formula is simple and may easily be evaluated on a pocket calculator [6].

III.SRIM (STOPPING AND RANGE OF IONS IN MATTER)

SRIM is a group of programs which calculate the stopping and range of ions (10 eV - 2 GeV /amu) into matter using a quantum mechanical treatment of ion-atom collisions During collisions, the ion and atom have a screened Coulomb collision, including exchange and correlation interactions between the overlapping electron shells. The ion also has long range interactions with target atoms creating electron excitations and plasmons within the target. These are described by including a description of the target's collective electronic structure and interatomic bond structure when the calculation is setup. The charge-state of the ion within the target is described using the concept of effective charge, which includes a velocity dependent charge state and long range screening due to the collective electron sea of the target.For SRIM-2013**,**Several bugs corrected, including bugs in Compound Dictionary. No major changes [7].

IV.ENERGY LOSS IN COMPOUND AND MIXTURES

For a mixture or, assuming Bragg's additivity rule (Bragg & Kleeman, 1905), for a compound, the mass stopping power is obtained by a linear combination of the constituent stopping powers (ICRU Report 49):

$$\frac{S}{\rho} = \sum_j w_j \left(\frac{S}{\rho}\right)_j$$

…………………(22)where w_j is the fraction by weight,and $\left(\frac{S}{\rho}\right)_j$ is the mass stopping power of the j^{th} constituent .[10]

V.RANGE

Range is the distance traveled by the proton before stopping .If the stopping power is inverted,the distance is obtained per unit of energy loss, and the range of ion with energy E_o can be calculated by integrating it to zero energy

o R(E)=……………………..(23)[4]. $\displaystyle\int_0^{E_o} \left(-\frac{dE}{dx}\right)^{-1} dE$

VI. DATA REDUCTION AND ANALYSIS

Human tissues are composed of atoms composition for different tissue this is according to ICRP(International Commission on Radiation Protection).[4]Chemical composition of human tissues depend in general on breed, diet, age, sex, health, etc., and they mayvary appreciably (5-10%) among individual human beings. [8]The chemical composition of the Ovary and Testis tissues were given in Table(1). [9]

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

composition of Ovary and Testis tissues Table(1): Elemental

S.N	Human Tissues	Composition(element: fraction) by weight
1-	Ovary(ρ=1.050g/cm^3)	**H:**0.105, **C:**0.093, **N:**0.024, **O:**0.768, **Na:** 0.002 , **P:** 0.002, **Cl:** 0.002, **K:** 0.002, **S:** 0.002
2-	Testis (ρ=1.040g/cm^3)	**H:**0.103, **C:**0.113, **N:** 0.032, **O:** 0.741, **Na:**0.001, **P:** 0.003, **Cl:** 0.002, **K:** 0.003, **S:** 0.002

After applying these (element: fraction) in equation (22) and the ionization potential which presented in table (2)we obtained the total stopping power of the Ovary and Testis tissues for each method as shown in fig(1).and fig(2).

Table(2):Ionization potential and atomic numbers of elements consideredfor human tissue.[6]

Atomic number	Elements	Ionization potential(MeV)	Ionization potential(presnt work)(MeV)
1	Hydrogen**(H)**	6.8560*10^-5	6.8560*10^-5
6	Carbon**(C)**	1.0039*10^-4	1.0039*10^-4
7	Nitrogen**(N)**	1.0895*10^-4	1.0895*10^-4
8	Oxygen**(O)**	1.1769*10^-4	1.1769*10^-4
11	Sodium**(Na)**	1.4464*10^-4	1.4464*10^-4
15	Phosphorus**(P)**	1.8155*10^-4	1.8155*10^-4
16	Sulfur**(S)**	1.9088*10^-4	1.9088*10^-4
17	Chlorine**(Cl)**	2.0024*10^-4	2.0024*10^-4
19	Potassium**(K)**	2.1905*10^-4	2.1905*10^-4

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

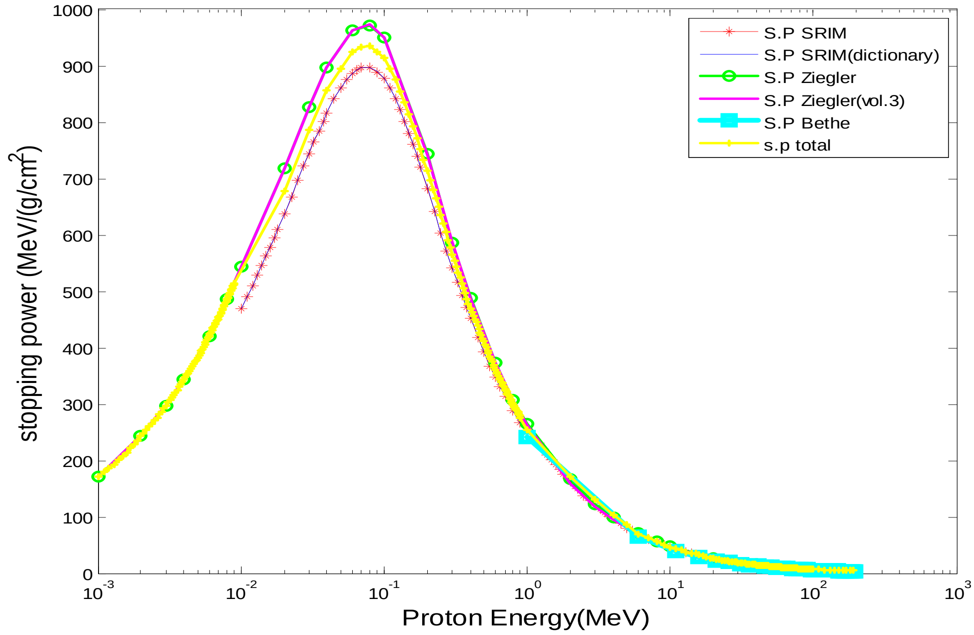

fig 1.Stopping power for proton in Ovary tissue by SRIM and SRIM(dictionary) program,Ziegler and Bethe equations and data Ziegler(Vol.3).

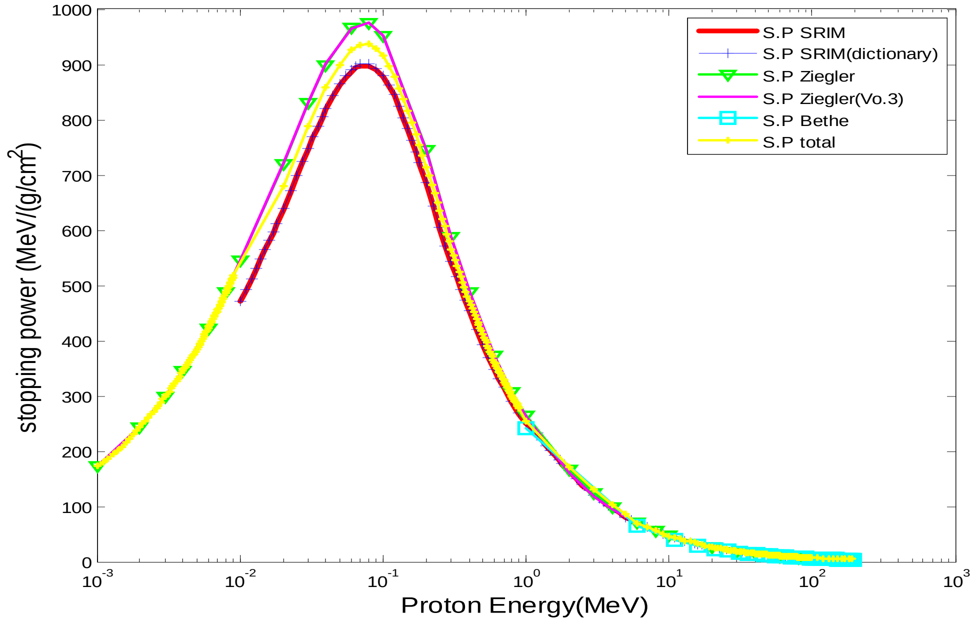

fig 2.Stopping power for proton in Testistissue by SRIM and SRIM(dictionary) program,Ziegler and Bethe equations and data Ziegler(Vol.3)

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

The range calculated from eq (23) has been shown in fig (3) for ovary and in fig(4) for testis tissue.

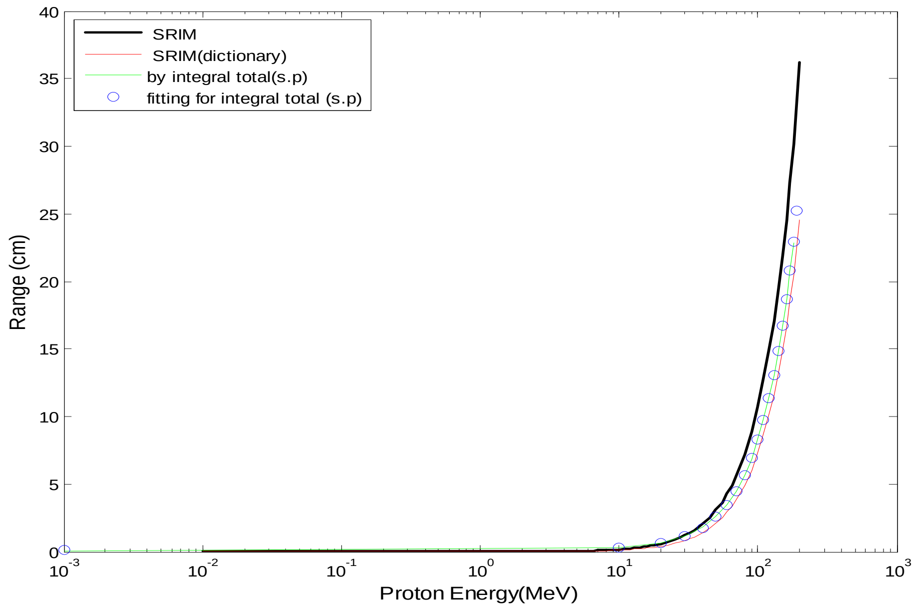

fig 3. Range of proton in the Ovary tissue

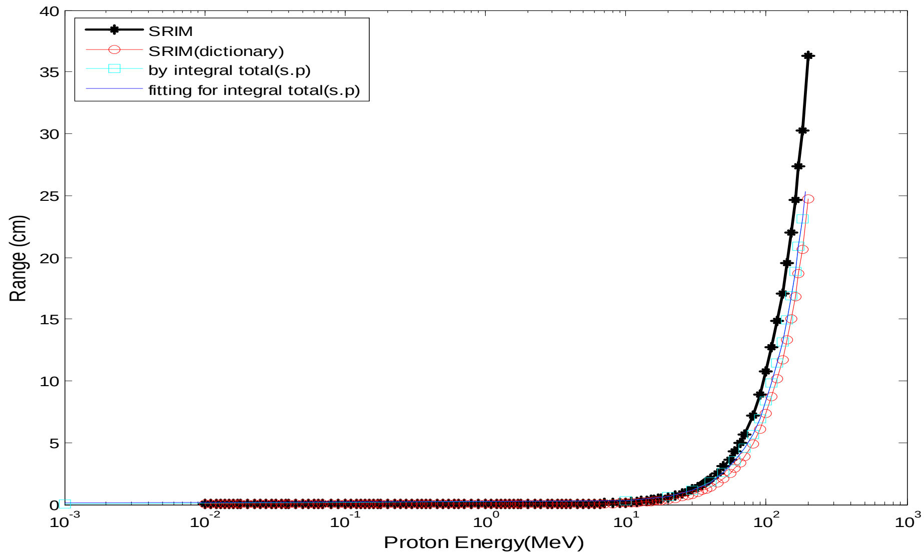

fig 4. Range of proton in the Testis

VII.RESULTS AND DISCUSSION

The mass stopping power forcomponents of the tissue shown in table (1) were calculated using the Bethe equation (eq (1) without corrections), Ziegler equation (eq (15), (16), (17) and (21) (coefficient in ref (6), Ziegler (Vol.3) data, and SRIM program , and also calculated asa compound using SRIM program, are presented in the Tables 3, 4.Figures (1, 2) show the comparison of these calculated stopping power values in the energy region (0.01-200 MeV) using above methods. The range of the proton in the tissue were calculatedin energy range (0.01-200 MeV) as shown in Figure

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

(3),(4) . In table (3) the total mass stopping power values for proton in Ovary tissue calculated in unit (MeV-cm2/g) in the energy range (10 KeV-200MeV) using above methods show Compatible with the low and high energy region and different at median energy range. As shown in figure (1), as well as for total mass stopping power values in table (4) for testis tissue as shown in figure (2). Maximum stopping power of the Ziegler (Vol.3) curve at (0.08 MeV) is (972.5 ,975.9 MeV-cm^2/g) for the Ovary and testis tissue respectively. The maximum stopping power of Bethe at (1MeV) is for Ovary tissue (240.756 MeV-cm ^ 2 / g) and for testis tissue (241.122MeV-cm ^ 2 / g).As for the SRIM and SRIM (dictionary) program, the maximum energy loss at (0.08MeVare (896.6 and 897.4) respectively, for ovary tissue ,and for testis tissue at the same energy is respectively (897.9 and 900.3). Maximum stopping power of Ziegler at (0.08 MeV) is for Ovary (971.6 MeV-cm^2/g) and for Testis (975.0 MeV-cm^2/g) at the same energy .At high energy (>1MeV) stopping power decrease with increase proton energy, i.e, does not have enough time to collide, and at intermediate energy region stopping power reaches maximum value (more ionization and excitation), while at low energies (E <25KeV) we observe the increase of the stopping power with the increase of the proton's energy, The small difference in the stopping power of the ovary and testis tissue, where the stopping power of the proton in the testis (937.3 (MeV-cm ^ 2 / g)) and in the ovary) (934.5 MeV-cm ^ 2 / g), because of the different ratios of their components and the difference in density. Figure (3) and figure (4)shows the proton range in (cm) and the energy range (10 KeV-200MeV) and is consistent with the experimental formula curve for both ovary and testis tissue respectively. From the figures (3,4) show good compatibility in the range curves calculated in that methods, for both tissues, the proton range in the tissue is increased by increasing its energy. The range of the proton in the ovary tissue for energy range (10KeV-200MeV) is (2.2884) (cm) and the range in the testis tissue is (2.3097 cm) of the same energy range. The experimental formula derived from the range for both tissues: **F(x) =a*x^b+c** .Where(a= 0.0002663, b=1.744, c= 0.01113) for Ovary and (a= 0.0002679, b=1.744,c=0.01126) for Testis tissue. This is a simple equation that can be applied to any computer program to calculate the range of the particle in the material by knowing its energy. Percentage deviation $[\frac{S_{cal}-S_{\exp}}{S_{\exp}}]*100$ between the experimental and the calculated stopping power values (using above methods) for Ovary and Testis tissue are shown in Table 1and 2 respectively, From Table 1and 2percentage deviation values convergent where deviation decreases as the energy of the porton increases(except Bethe). For Ovary (Bethe maximum deviation 18.9326%)and for testis(18.8146%) at higher energies, Ziegler (maximum deviation 5.7415%, 5.6729% for ovary and testis respectively as shown 'red' color,and minimum 'green' color in Tables (1) and (2), this leads that Zigler is given better results from other methods especially for Testis.

Table (3). Stopping power in Ovary Tissues in (MeV-cm^2 /g)

Stopping power in Human tissues in (MeV-cm^2/g)											
	Ovary Tissue										
	Stopping power										
E_P (MeV)	Bethe	Error	Ziegler	Error	Ziegler (Vol.3)	Error	SRIM	Error	SRIM dictio-nary	Error	S.P (P.W)
0.001	-	-	171.8923	-0.0559	171.7002	0.0559	-	-	-	-	171.7962
1	240.7208	5.3592	263.8857	-3.8896	262.2131	-3.2765	250.5605	1.2217	250.7095	1.1615	253.6216
2	205.3385	-16.3460	166.8551	2.9479	159.4612	7.7214	163.5337	5.0388	163.6567	4.9598	171.7738
3	169.9561	-23.3582	123.1847	5.7415	117.6899	10.6785	120.1973	8.3697	120.2493	8.3228	130.2574
4	134.5738	-22.7118	98.7877	5.2861	94.4943	10.0698	96.0660	8.2690	96.1235	8.2042	104.0097
5	99.1915	-13.8107	85.3302	0.1902	81.7068	4.6333	80.5944	6.0775	80.6378	6.0204	85.4925
6	63.8396	7.8172	71.8787	-4.2413	68.9250	-0.1377	69.7326	-1.2942	69.7735	-1.3521	68.8301
7	58.9108	4.7779	64.4918	-4.2894	61.8848	-0.2574	61.6497	0.1230	61.6904	0.0569	61.7255
8	53.9821	2.5329	57.1076	-3.0787	54.8471	0.9158	55.3827	-0.0601	55.4275	-0.1409	55.3494
9	49.0534	2.9823	52.3855	-3.5682	50.3630	0.3044	50.3746	0.2813	50.4051	0.2206	50.5163
10	44.1247	4.3506	47.6661	-3.4022	45.8815	0.3550	46.2567	-0.4590	46.2931	-0.5372	46.0444
15	30.8886	10.5660	37.2745	-8.3762	36.0190	-5.1825	33.2811	2.6177	33.2984	2.5644	34.1523
20	24.1457	7.5276	26.8809	-3.4136	26.1545	-0.7310	26.3114	-1.3230	26.3242	-1.3710	25.9633
25	19.9661	9.4986	22.9876	-4.8939	22.4853	-2.7694	21.9327	-0.3196	21.9416	-0.3600	21.8626
30	17.0942	8.6175	19.0943	-2.7600	18.8160	-1.3217	18.9121	-1.8232	18.9198	-1.8631	18.5673
35	14.9880	9.7725	17.0176	-3.3195	16.8762	-2.5095	16.6831	-1.3810	16.6985	-1.4720	16.4527

IJARSET

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 8 , August 2017

40	13.3716	9.5105	14.9409	-1.9918	14.9363	-1.9617	14.9801	-2.2483	14.9875	-2.2966	14.6433
45	12.0888	11.0118	13.8409	-3.0410	13.9056	-3.4921	13.6279	-1.5255	13.6368	-1.5898	13.4200
50	11.0441	11.7846	12.7409	-3.1026	12.8749	-4.1111	12.5317	-1.4850	12.5362	-1.5204	12.3456
60	9.4412	11.1840	10.5410	-0.4165	10.8135	-2.9260	10.8444	-3.2026	10.8452	-3.2097	10.4971
70	8.2655	12.7518	9.3782	-0.6259	9.7242	-4.1618	9.6122	-3.0451	9.6175	-3.0985	9.3195
80	7.3638	12.8792	8.2154	1.1783	8.6349	-3.7372	8.6710	-4.1379	8.6760	-4.1932	8.3122
90	6.6489	14.1753	7.4910	1.3403	7.9581	-4.6079	7.9275	-4.2397	7.9316	-4.2892	7.5914
100	6.0672	13.8350	6.7666	2.0690	7.2813	-5.1461	7.3242	-5.7016	7.3283	-5.7544	6.9066
150	4.2588	18.9326	-	-	-	-	5.4674	-7.3582	5.4692	-7.3886	5.0651
200	-	-	-	-	-	-	4.5080	-	4.5097	-	-

Table 4. Stopping power in Testis Tissues in (MeV-cm^2/g)

Stopping power in Human tissues in (MeV-cm^2/g)											
	Testis Tissue										
	Stopping power										
E_P (MeV)	Bethe	Error	Ziegler	Error	Ziegler (Vol.3)	Error	SRIM	Error	SRIM dictio-nary	Error	S.P (P.W)
0.001	-	-	172.6674	-0.0558	172.4747	0.0559	-	-	-	-	172.5711
1	241.0873	5.3710	264.4506	-3.9382	262.7925	-3.3321	250.5215	1.4029	251.3091	1.0851	254.0360
2	205.6482	-16.3703	167.1867	2.8688	159.7768	7.6395	163.4220	5.2385	163.8570	4.9591	171.9829
3	170.2091	-23.3782	123.4159	5.6729	117.9104	10.6070	120.0913	8.5984	120.4495	8.2754	130.4172
4	134.7701	-22.7355	98.9666	5.2168	94.6642	9.9988	95.9702	8.5019	96.2736	8.1600	104.1295
5	99.3310	-13.8373	85.4817	0.1224	81.8513	4.5632	80.5076	6.3083	80.7579	5.9789	85.5863
6	63.9224	7.7860	72.0029	-4.3102	69.0440	-0.2094	69.6533	-1.0824	69.8735	-1.3941	68.8994
7	58.9870	4.7471	64.6019	-4.3570	61.9900	-0.3271	61.5767	0.3419	61.7804	0.0110	61.7872
8	54.0515	2.4971	57.2034	-3.1505	54.9385	0.8422	55.3150	0.1558	55.4976	-0.1737	55.4012
9	49.1160	2.9487	52.4726	-3.6368	50.4462	0.2341	50.3113	0.5029	50.4752	0.1765	50.5643
10	44.1806	4.3137	47.7445	-3.4729	45.9564	0.2829	46.1973	-0.2401	46.3532	-0.5756	46.0864
15	30.9269	10.5264	37.3346	-8.4431	36.0767	-5.2508	33.2352	2.8500	33.3385	2.5313	34.1824
20	24.1752	7.4907	26.9226	-3.4785	26.1951	-0.7979	26.2734	-1.0935	26.3642	-1.4341	25.9861
25	19.9903	9.4576	23.0229	-4.9603	22.5198	-2.8371	21.9001	-0.0877	21.9716	-0.4128	21.8809
30	17.1148	8.5680	19.1232	-2.8343	18.8446	-1.3977	18.8834	-1.6003	18.9398	-1.8934	18.5812
35	15.0059	9.7255	17.0431	-3.3902	16.9016	-2.5814	16.6574	-1.1532	16.7185	-1.5145	16.4653
40	13.3875	9.4655	14.9631	-2.0611	14.9586	-2.0316	14.9568	-2.0198	15.0076	-2.3515	14.6547
45	12.1031	10.9699	13.8614	-3.1065	13.9263	-3.5580	13.6063	-1.2898	13.6568	-1.6549	13.4308
50	11.0571	11.7264	12.7597	-3.1819	12.8940	-4.1903	12.5117	-1.2628	12.5462	-1.5343	12.3537
60	9.4523	11.1476	10.5563	-0.4765	10.8293	-2.9854	10.8268	-2.9630	10.8652	-3.3060	10.5060
70	8.2752	12.7006	9.3917	-0.6974	9.7383	-4.2317	9.5965	-2.8167	9.6295	-3.1497	9.3262
80	7.3724	12.8249	8.2272	1.1024	8.6473	-3.8093	8.6566	-3.9126	8.6860	-4.2379	8.3179
90	6.6566	14.1198	7.5017	1.2637	7.9694	-4.6791	7.9143	-4.0155	7.9406	-4.3334	7.5965
100	6.0743	13.7217	6.7762	1.9421	7.2915	-5.2623	7.3119	-5.5266	7.3373	-5.8537	6.9078
150	4.2637	18.8146	-	-	-	-	5.4579	-7.1822	5.4762	-7.4924	5.0659
200	-	-	-	-	-	-	4.5001	-	4.5157	-	-

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 8 , August 2017

VIII.CONCLUSION

1) Calculation of the loss of proton energy in the tissue at high accuracy is necessary for the radiation treatment of cancer from their values and the values of the depth of the proton can be drawn data to obtain the curve of (Bragg peak), which corresponds to the location of the tumor in the tissue.

2)The results of the calculation of stopping power in the SRIM program is not exactly the same as (compound) using a Bragg addition rule, because the excitation energy of the compound is higher than the excitation energy of a single atom .

REFERENCES

[1]Al Hamadany W.A., "Electronic excitation produced by proton moving inside liquid water and DNA using Drude and Penn model'' ,M. Sc. Thesis, college of science, university of mustansiriyah (2013).
[2]M Yang ,G Virshup, J CIayton, X R Zhu, R Mohan and L Dong, Physics in Medicine and Biology,55, 1343-1362 .(10 February 2010).
[3] Eko Sulistya, Kusminarto, Arief Hermanto,"Numerical equation for the mass stopping Power of protons in human body subtances"Department of physics, Faculty of Mathema-Tics and Natural Sciences, Universitas Gadjah Mada Yogyakarta, Indonesia,(2014).
[4] Eko Sulistya, Kusminarto, Arief Hermanto,"Stopping power and range of proton In medium; A study for proton radiotherapy'' Physics department faculty of Mathe- Matics and Natural Sciences,Gadjah Mada University, Yogyakarta,Indonesia,(2012).
[5]Nicholas Tsoulfanidis " Measurement and detection of radiation" Second Edition, university of Missouri-Rolla, (1995).
[6]Andreson H. H. and Ziegler J. F., "Hydrogen Stopping power and Range in all elements" Vol. 3, IBM-Research, Yorktown Heights, New York, 10598 USA. (1977).
[7]J.F.Ziegler,M.D.Ziegler,J.P.Biersack (SRIM.com).2013
[8]KIM, YOUNG S. Human Tissues: Chemical Compositions and Photon Dosimetry Data.Radiation Research 57, 38-45 (1974).
[9]ICRU,Vol.49, (1993).
[10]DŽEVAD BELKIĆ,"Advances in quantum chemistry",Vol.65,USA,(2013).