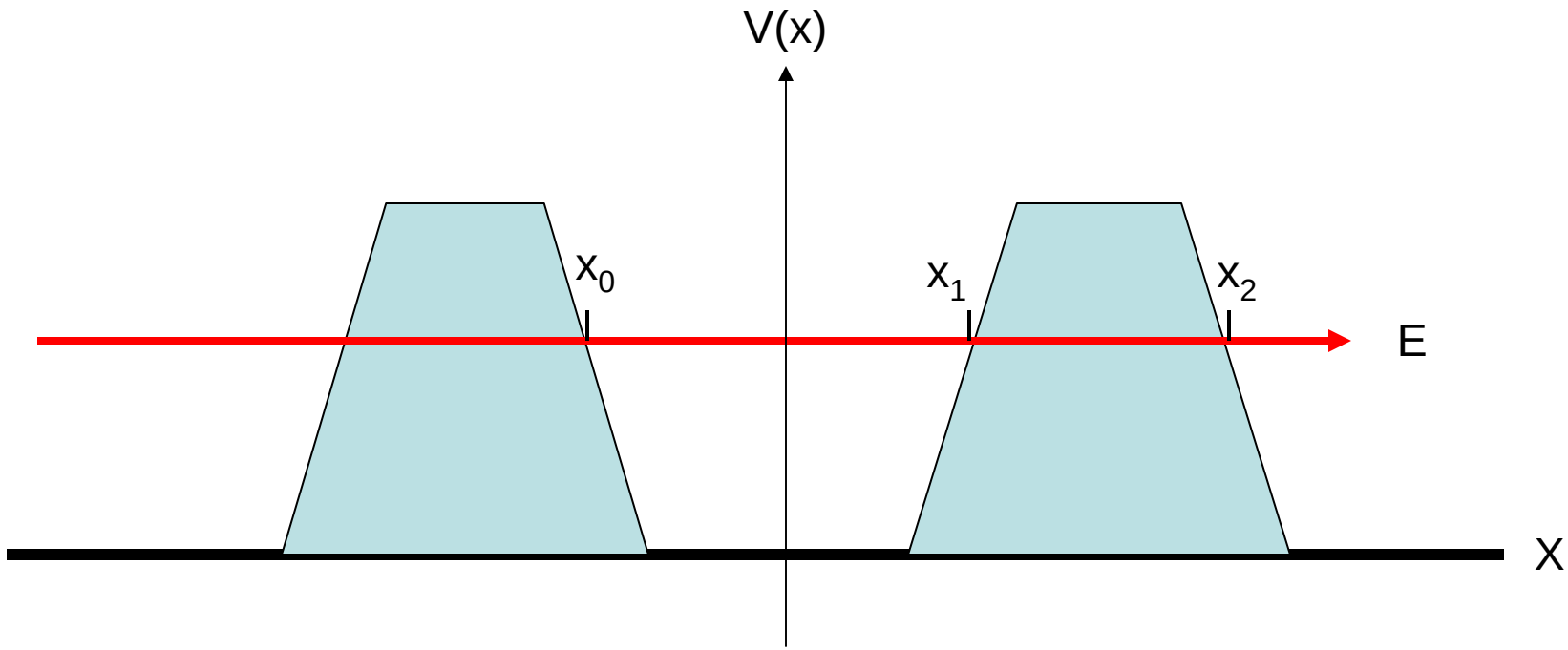
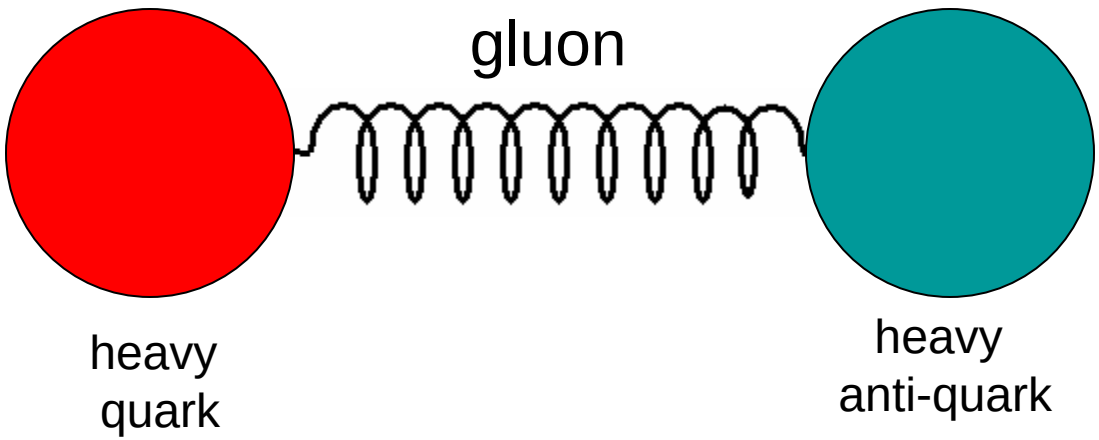
The Physics 156b SHO model of the Strong Interaction

Richard Seto
Physics 156b class
UCR
Feb 2, 2005

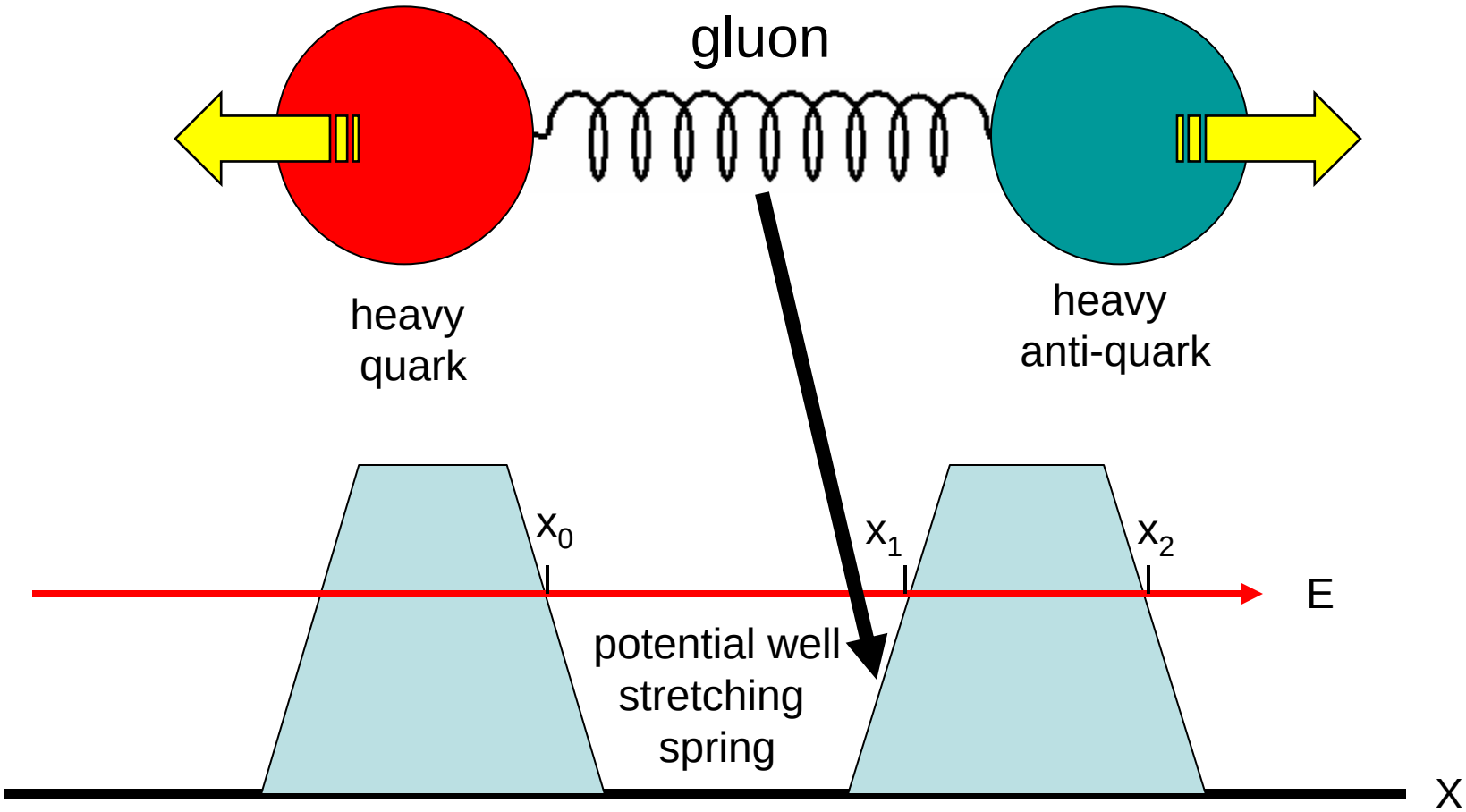
Potential well



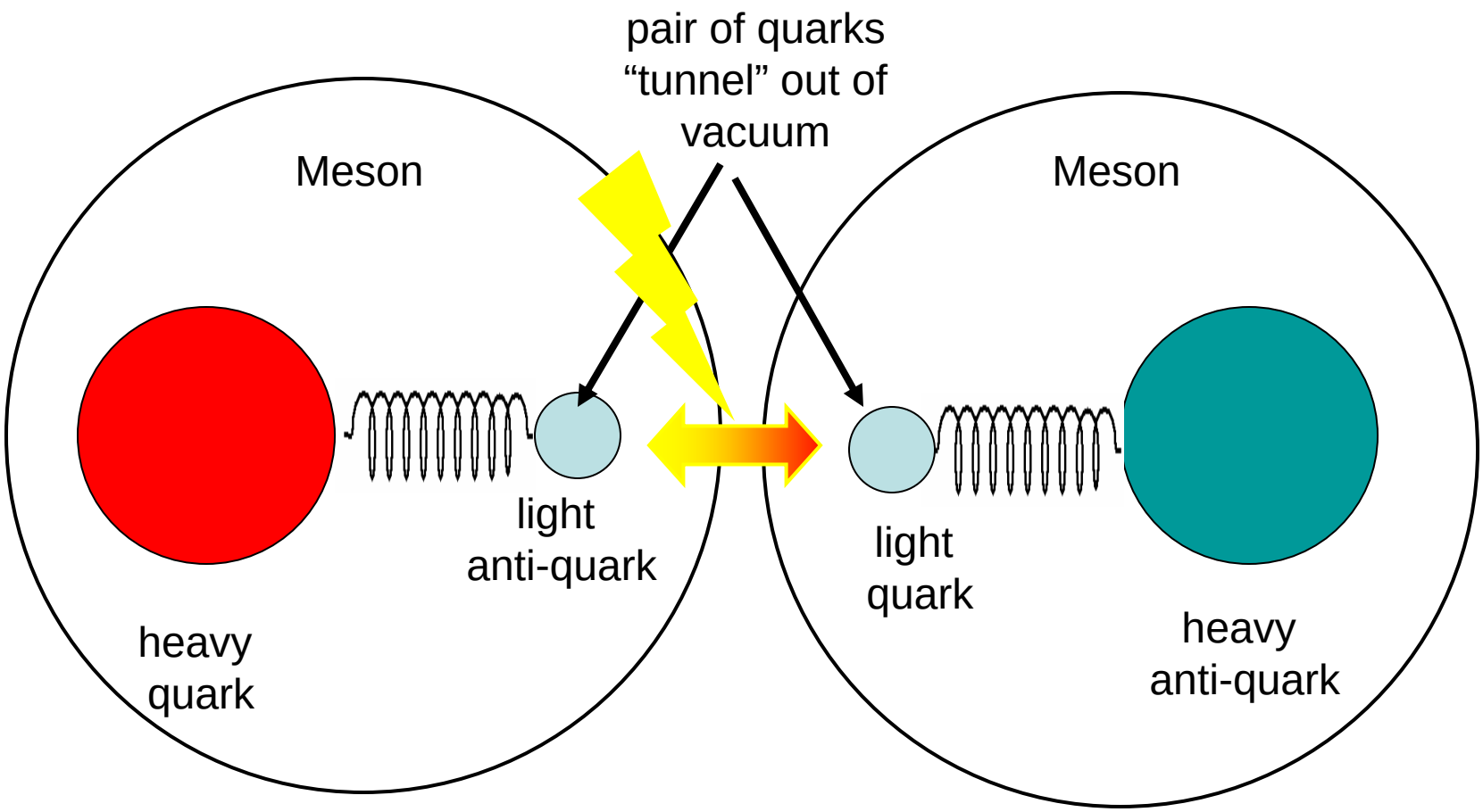
Model of heavy meson



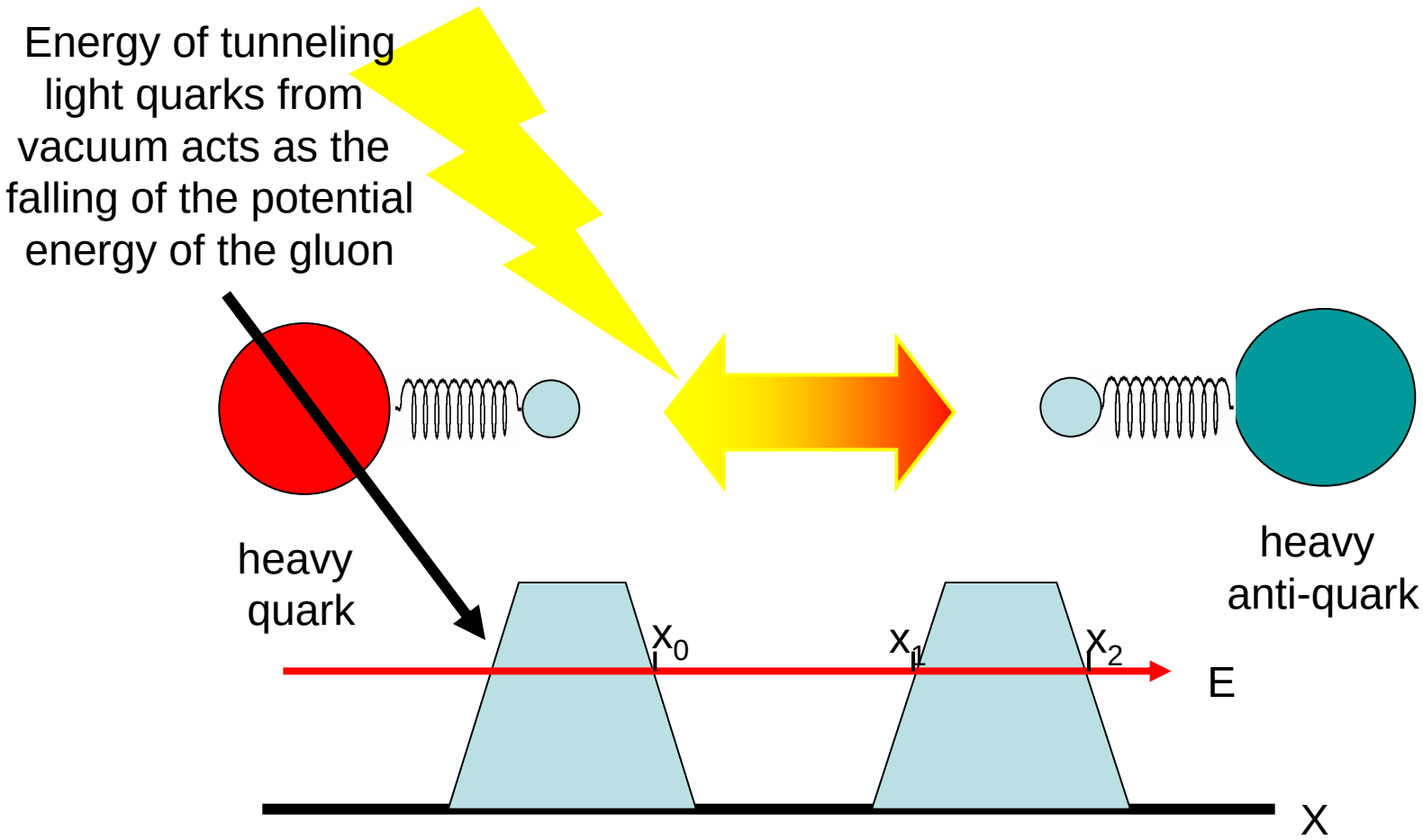
gluon acts like a spring potential



gluon breaks when light quarks tunnel out of vacuum and two mesons are formed



falling side of potential

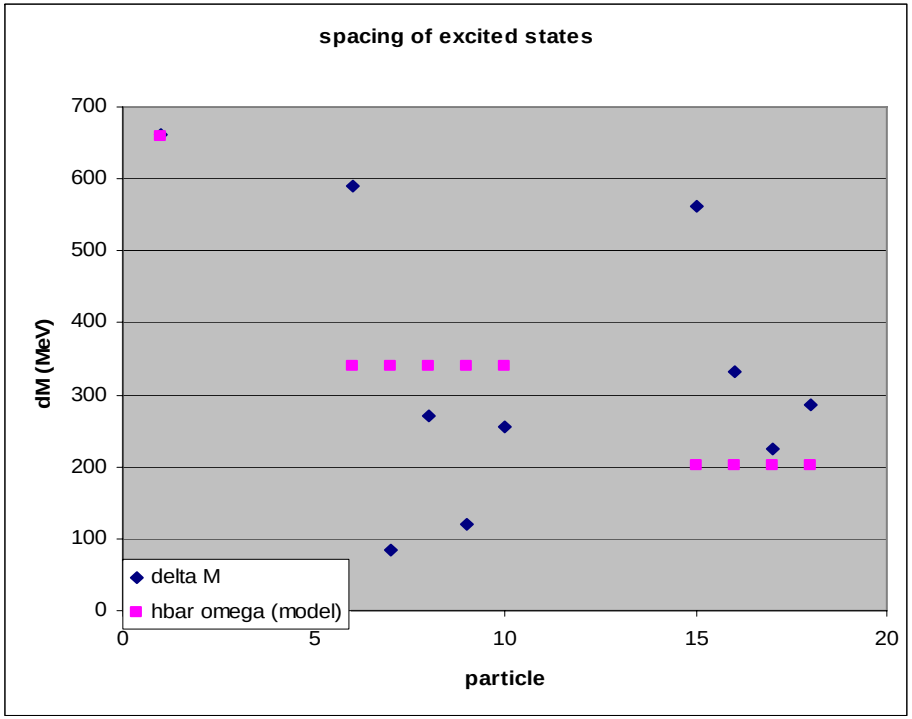


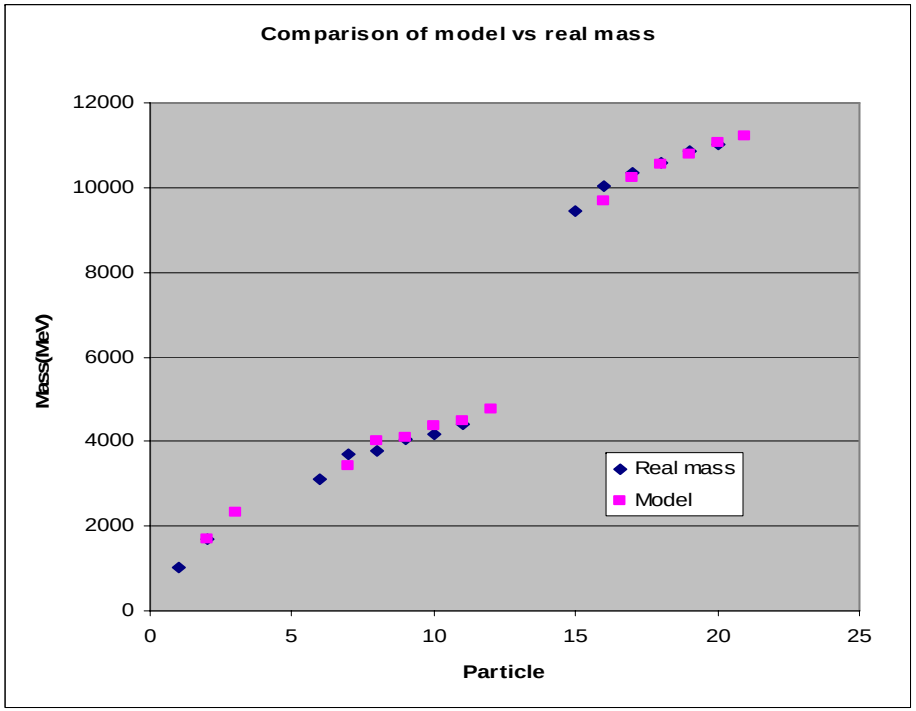
Vector mesons

		Mass	dM	Width	lifetime	lifetime	major
	n	MeV	MeV	MeV	fm/c	sec	decay
							channel
phi	0	1019		4.26	46.24	4.6E-22	KK
	1	1680	661	150	1.3	1.3E-23	KK
K		494					
psi	0	3097		0.087	2264	2.3E-20	ee, μμ
	1	3686	589	0.277	711	7.1E-21	ee, μμ
	2	3770	84	23.6	8.3	8.3E-23	DD
	3	4040	270	52	3.8	3.8E-23	DD
	4	4159	119	78	2.5	2.5E-23	DD
	5	4415	256	43	4.6	4.6E-23	DD
D		1869					
Upsilon	0	9460		0.052	3788	3.8E-20	ee, μμ
	1	10023	563	0.044	4477	4.5E-20	ee, μμ
	2	10355	332	0.026	7577	7.6E-20	ee, μμ
	3	10580	225	20	9.9	9.9E-23	BB
	4	10865	285	110	1.8	1.8E-23	BB
	5	11019	154	79	2.5	2.5E-23	BB

guess 1, k=5545 from phi

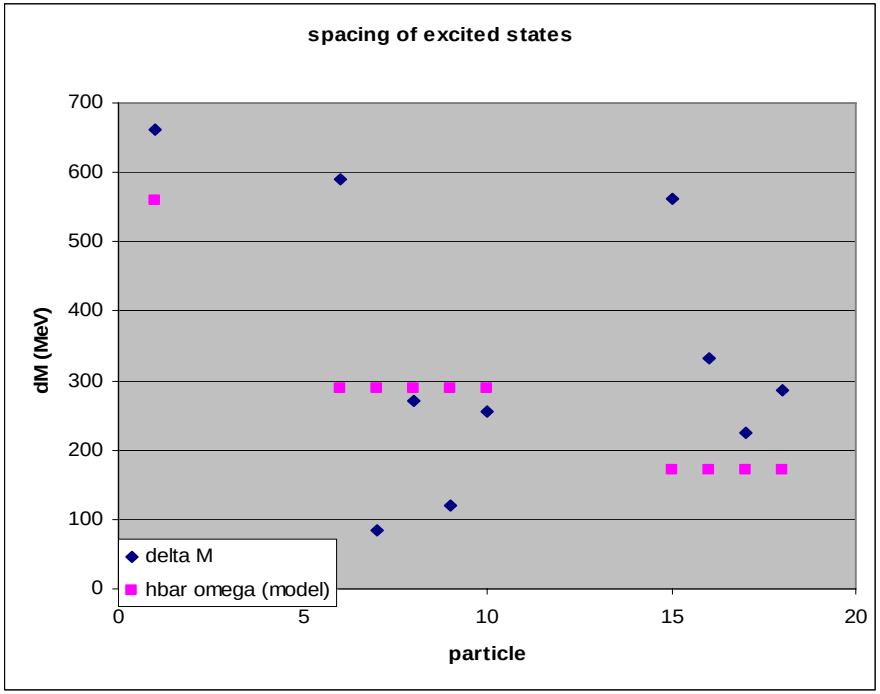
fixed									MeV/fm^2	
		MeV	MeV	MeV		Mev	%	%err	K	MeV
	n	mass	width	delta		m pred	error	dM		mc2
phi										
	0	1019	4.26						5545	494
	1	1680	150	661		1680	0	0	5545	494
guess	2					2340			5545	494
hbaromega				660						494
psi	0	3097	0.087						5545	1869
	1	3686	0.277	589		3436	-7	-42	5545	1869
	2	3770	23.6	84		4025	7	304	5545	1869
	3	4040	52	270		4109	2	26	5545	1869
	4	4159	78	119		4379	5	185	5545	1869
?	5	4415	43	256		4498	2	33	5545	1869
guess	6					4754			5545	1869
hbaromega				339						1869
Upsilon	0	9460	0.052						5545	5279
	1	10023	0.044	563		9662	-4	-64	5545	5279
	2	10355	0.026	332		10225	-1	-39	5545	5279
	3	10580	20	225		10557	0	-10	5545	5279
	4	10865	110	285		10782	-1	-29	5545	5279
?	5	11019	79	154		11067	0	31	5545	5279
guess	6					11221			5545	5279

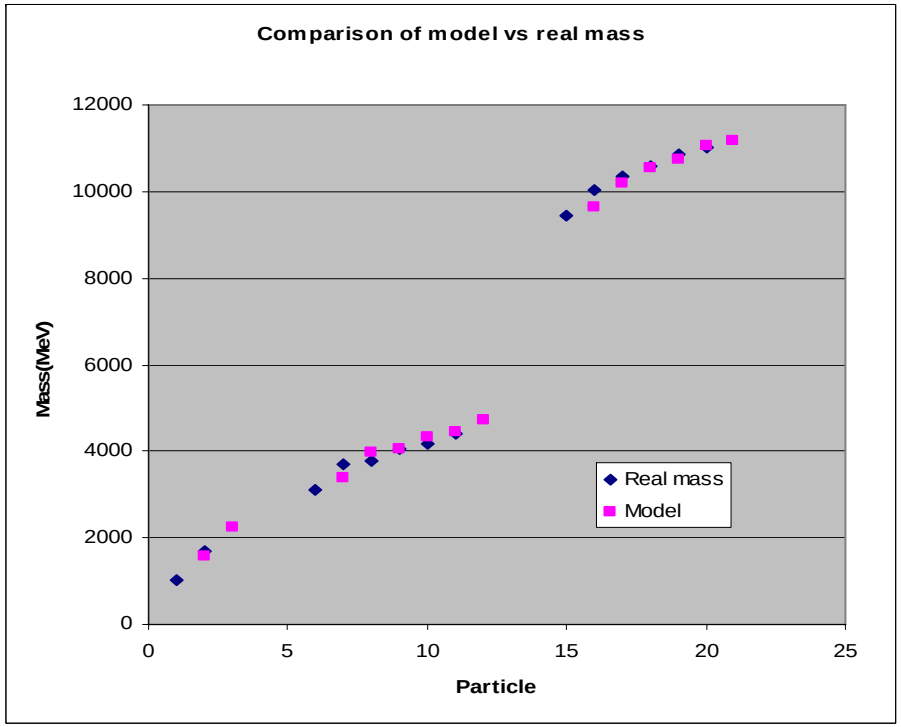


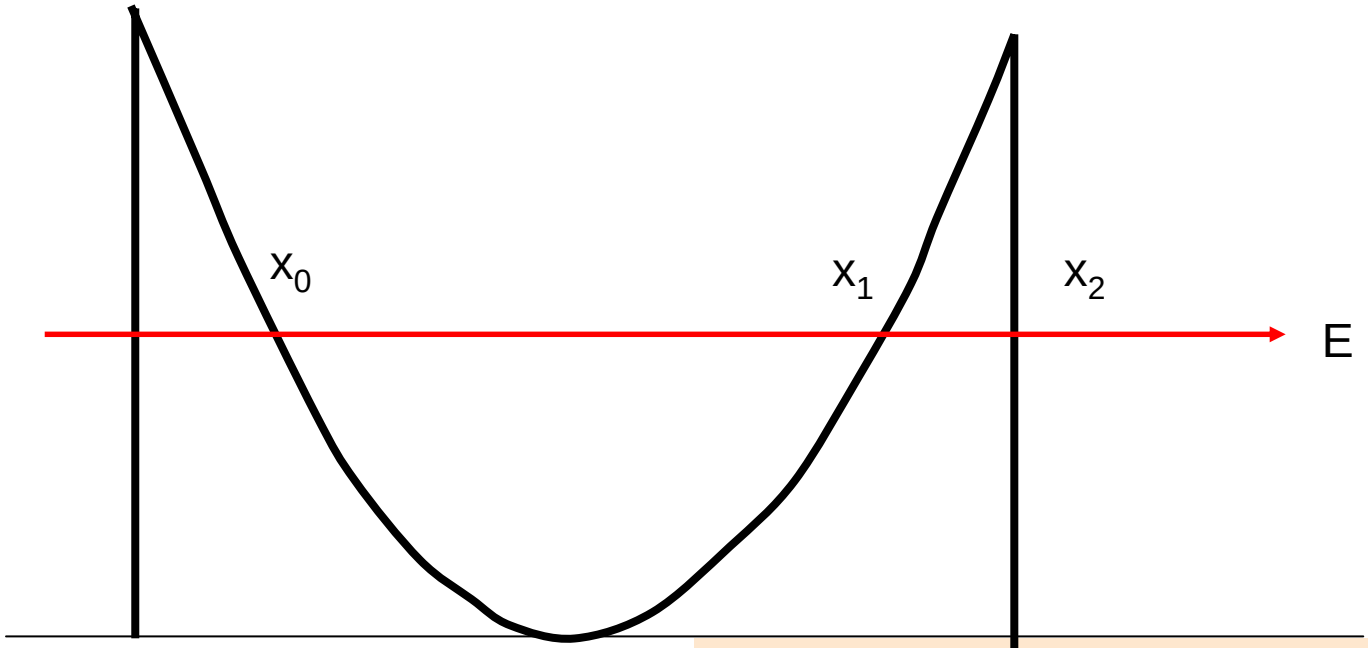


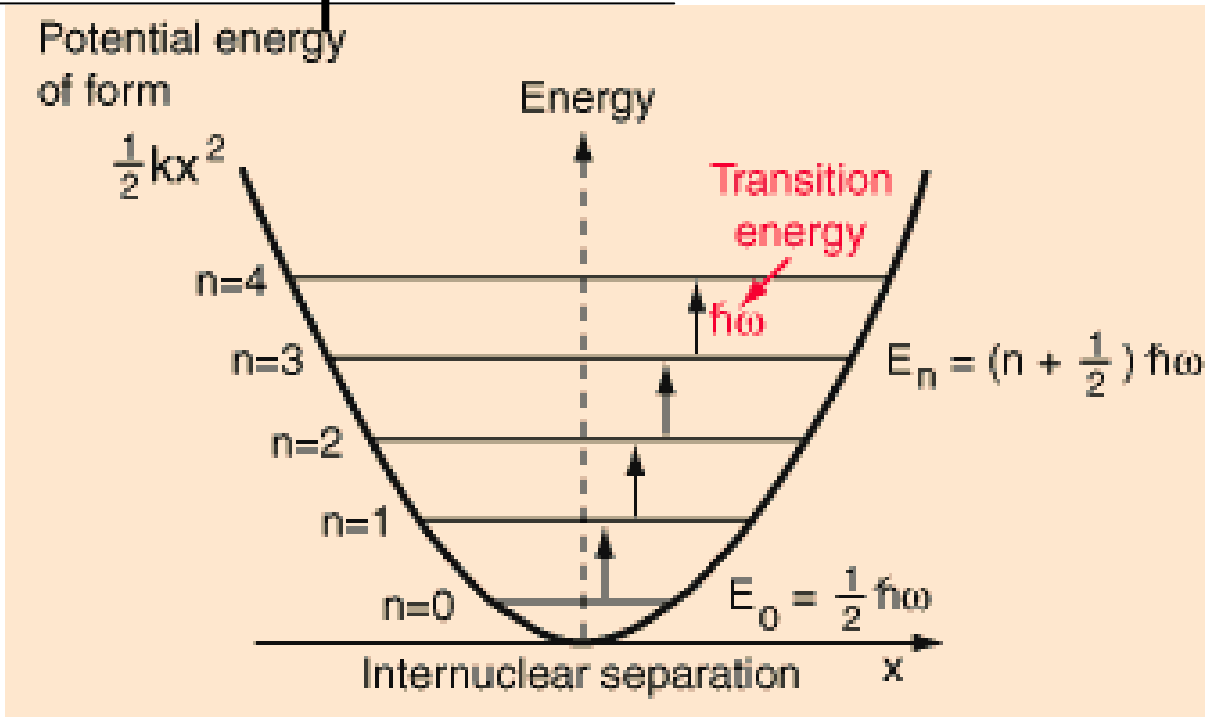
guess 2
k=4000 optimum

fixed									MeV/fm^2	
		MeV	MeV	MeV		Mev	%	%err	K	MeV
	n	mass	width	delta		m pred	error	dM		mc2
phi										
	0	1019	4.26						4000	494
	1	1680	150	661		1580	-6	-15	4000	494
guess	2					2241			4000	494
hbaromega				561						494
psi	0	3097	0.087						4000	1869
	1	3686	0.277	589		3385	-8	-51	4000	1869
	2	3770	23.6	84		3974	5	243	4000	1869
	3	4040	52	270		4058	0	7	4000	1869
	4	4159	78	119		4328	4	142	4000	1869
?	5	4415	43	256		4447	1	13	4000	1869
guess	6					4703			4000	1869
hbaromega				288						1869
Upsilon	0	9460	0.052						4000	5279
	1	10023	0.044	563		9632	-4	-70	4000	5279
	2	10355	0.026	332		10195	-2	-48	4000	5279
	3	10580	20	225		10527	-1	-24	4000	5279
	4	10865	110	285		10751	-1	-40	4000	5279
?	5	11019	79	154		11036	0	11	4000	5279
guess	6					11190			4000	5279






x_0
x_1
x_2
E


Potential energy
of form
$\frac{1}{2}kx^2$
Energy
Transition
energy
$\hbar\omega$
n=4
n=3
n=2
n=1
n=0
$E_n = (n + \frac{1}{2})\hbar\omega$
$E_0 = \frac{1}{2}\hbar\omega$
Internuclear separation
x

Guess at x_2

fixed										MeV/fm^2										
		MeV	MeV	MeV	fm		Mev	%	%err	K			fm	fm					fm	%
	n	mass	width	delta	tau		m pred	error	dM		a	b	x1	x2	v/c	int 1	int2	T gues	tau gue	error
phi																				
	0	1019	4.26		46.2					4000	2.7	7.13	0.374	0.837	0.34	-0.84	0.68	0.049	22.75	-51
	1	1680	150	661	1.3		1580	-6	-15	4000	4.6	7.13	0.649	0.837	0.59	-3.34	-2.88	0.397	2.78	112
guess	2						2241			4000	6.0	7.13	0.837		0.76					
hbaromega				561										0.837						
psi	0	3097	0.09		2264					4000	3.7	13.88	0.268	0.890	0.12	-1.00	3.30	0.000		
	1	3686	0.28	589	711		3385	-8	-51	4000	6.5	13.88	0.465	0.890	0.22	-3.84	-1.05	0.004		
	2	3770	23.6	84	8.3		3974	5	243	4000	8.3	13.88	0.600	0.890	0.28	-7.03	-5.34	0.034	63.33	659
	3	4040	52	270	3.8		4058	0	7	4000	9.9	13.88	0.710	0.890	0.33	-10.43	-9.56	0.175	12.30	225
	4	4159	78	119	2.5		4328	4	142	4000	11.2	13.88	0.805	0.890	0.37	-13.98	-13.69	0.555	3.87	53
?	5	4415	43	256	4.6		4447	1	13	4000	12.4	13.88	0.890	0.890	0.41	-17.64	#NUM!	#####	#NUM!	####
guess	6						4703			4000	13.4	13.88	0.968		0.45	-21.39	#NUM!			
hbaromega				288										0.890						
Upsilon	0	9460	0.05		3788					4000	4.8	23.33	0.207	0.687	0.06	-1.13	3.18			
	1	10023	0.04	563	4477		9632	-4	-70	4000	8.4	23.33	0.359	0.687	0.10	-4.23	-1.43			
	2	10355	0.03	332	7577		10195	-2	-48	4000	10.8	23.33	0.463	0.687	0.13	-7.68	-5.98			
	3	10580	20	225	9.9		10527	-1	-24	4000	12.8	23.33	0.548	0.687	0.15	-11.34	-10.47	0.173	20.84	112
	4	10865	110	285	1.8		10751	-1	-40	4000	14.5	23.33	0.621	0.687	0.17	-15.15	-14.85	0.552	6.54	265
?	5	11019	79	154	2.5		11036	0	11	4000	16.0	23.33	0.687	0.687	0.19	-19.07	-19.07	1.000	3.61	45
guess	6						11190			4000			0.747		0.21					

best try

fixed										MeV/fm^2												
		MeV	MeV	MeV	fm	sec	Mev	%	%err	K	MeV			fm	fm					%	fm	%
	n	mass	width	delta	tau	tau	m pred	errc	dM		mc2	a	b	x1	x2	v/c	int 1	int2	T guess	err	tau gue	error
phi																						
	0	1019	4.26		46.24	4.6E-22				4000	494	2.7	7.1	0.374	0.806	0.34	-0.84	0.51	0.067	-181	16.47	-64
	1	1680	150	661	1.3	1.3E-23	1580	-6	-15	4000	494	4.6	7.1	0.649	0.806	0.59	-3.34	-2.99	0.496	41	2.22	69
guess	2						2241			4000	494	6.0	7.1	0.837		0.76						
hbaromega				561							494				0.806							
psi	0	3097	0.087		2264	2.3E-20				4000	1869	3.7	13.9	0.268	0.806	0.12	-1.00	2.37	0.001			
	1	3686	0.277	589	711	7.1E-21	3385	-8	-51	4000	1869	6.5	13.9	0.465	0.806	0.22	-3.84	-1.87	0.020			
	2	3770	23.6	84	8.3	8.3E-23	3974	5	243	4000	1869	8.3	13.9	0.600	0.806	0.28	-7.03	-6.04	0.137	47	15.68	88
	3	4040	52	270	3.8	3.8E-23	4058	0	7	4000	1869	9.9	13.9	0.710	0.806	0.33	-10.43	-10.10	0.513	10	4.19	11
	4	4159	78	119	2.5	2.5E-23	4328	4	142	4000	1869	11.2	13.9	0.805	0.806	0.37	-13.98	-13.98	0.999	-18	2.15	-15
?	5	4415	43	256	4.6	4.6E-23	4447	1	13	4000	1869	12.4	13.9	0.890	0.806	0.41	-17.64	#####	#NUM!	####	#####	#####
guess	6						4703			4000	1869	13.4	13.9	0.968		0.45	-21.39	#####				
hbaromega				288							1869				0.806							
Upsilon	0	9460	0.052		3788	3.8E-20				4000	5279	4.8	23.3	0.207	0.623	0.06	-1.13	2.25				
	1	10023	0.044	563	4477	4.5E-20	9632	-4	-70	4000	5279	8.4	23.3	0.359	0.623	0.10	-4.23	-2.25				
	2	10355	0.026	332	7577	7.6E-20	10195	-2	-48	4000	5279	10.8	23.3	0.463	0.623	0.13	-7.68	-6.68				
	3	10580	20	225	9.9	9.9E-23	10527	-1	-24	4000	5279	12.8	23.3	0.548	0.623	0.15	-11.34	-11.00	0.504	-38	7.16	-27
	4	10865	110	285	1.8	1.8E-23	10751	-1	-40	4000	5279	14.5	23.3	0.621	0.623	0.17	-15.15	-15.15	0.997	51	3.62	102
?	5	11019	79	154	2.5	2.5E-23	11036	0	11	4000	5279	16.0	23.3	0.687	0.623	0.19	-19.07	#####	#NUM!	####	#####	#####
guess	6						11190			4000	5279			0.747		0.21						
hbaromega				171							5279				0.623							

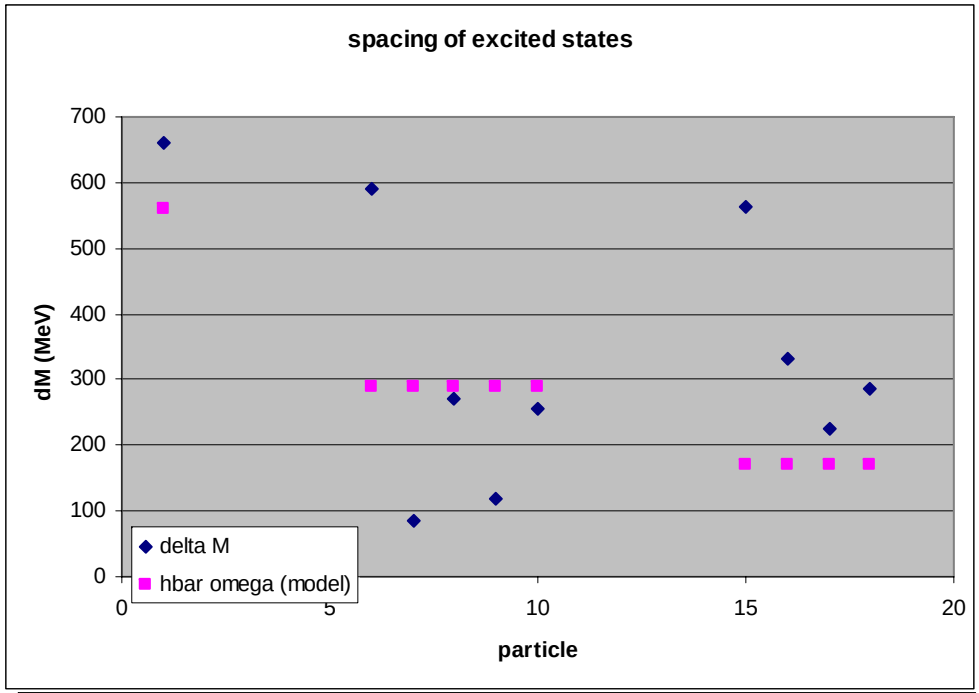
summary

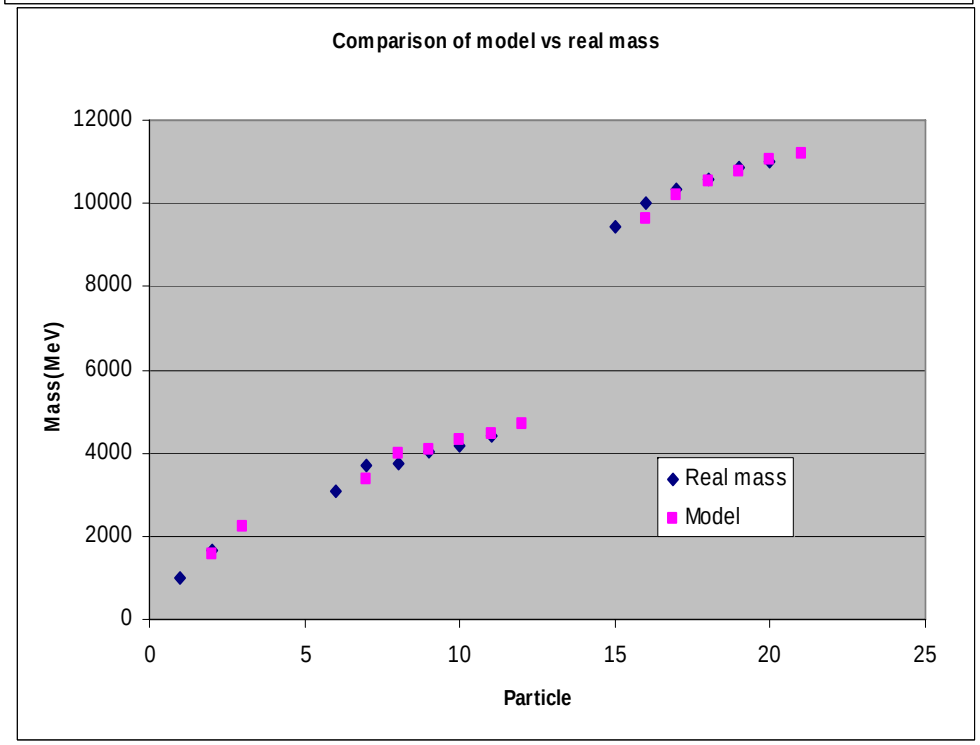
- Here is the best try. K=4000 MeV/fm^2
- mass?, tau? are the model predictions,
- % er gives the error in the prediction

fixed		MeV		%	er	fm		%
	n	mass	mass?	er	dM	tau	tau?	er
phi								
	0	1019				46.2	16.5	-64
	1	1680	1580	-6	-15	1.3	2.2	69
psi	0	3097				2264		
	1	3686	3385	-8	-51	711		
	2	3770	3974	5	243	8.3	15.7	88
	3	4040	4058	0	7	3.8	4.2	11
	4	4159	4328	4	142	2.5	2.1	-15
?	5	4415	4447	1	13	4.6	###	###
Upsilon	0	9460				3788		
	1	10023	9632	-4	-70	4477		
	2	10355	10195	-2	-48	7577		
	3	10580	10527	-1	-24	9.9	7.2	-27
	4	10865	10751	-1	-40	1.8	3.6	102
?	5	11019	11036	0	11	2.5	###	###

how did we do? Masses

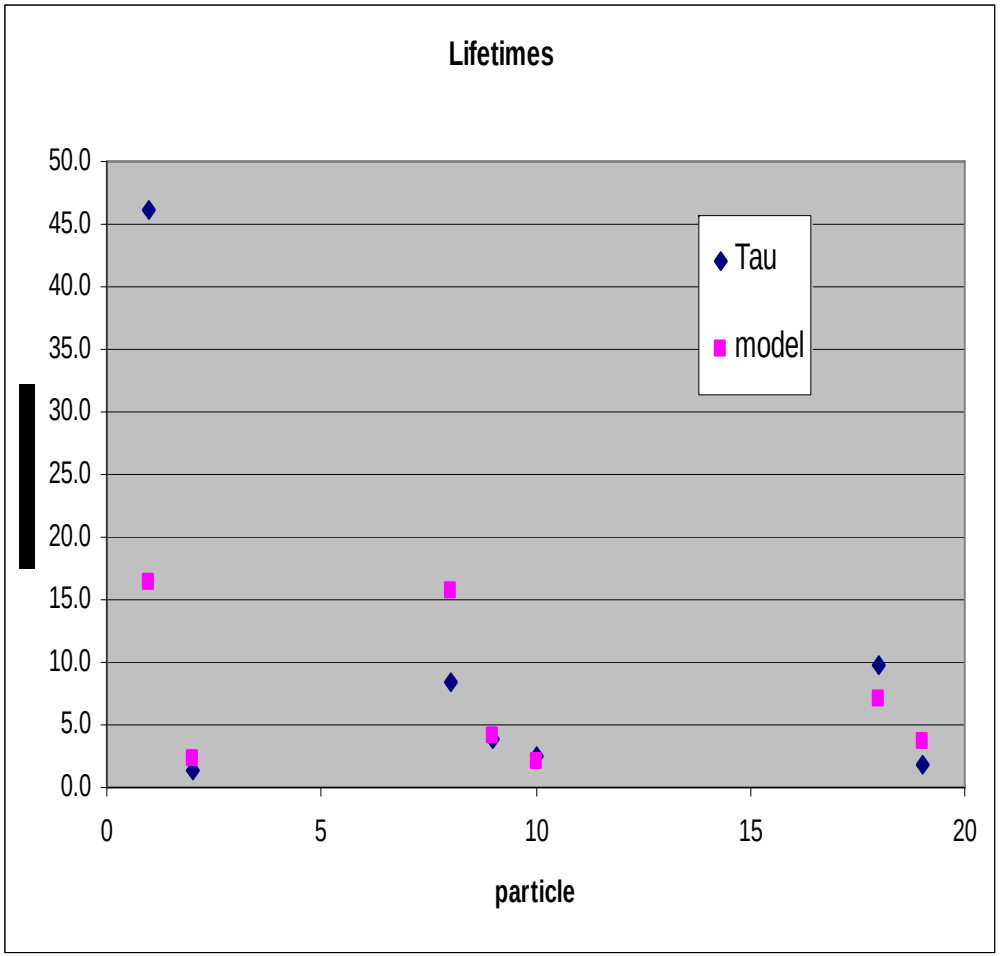
- The masses ~Ok to 10%
- dM not as good
  - problem, lowest states where decay is not strong??

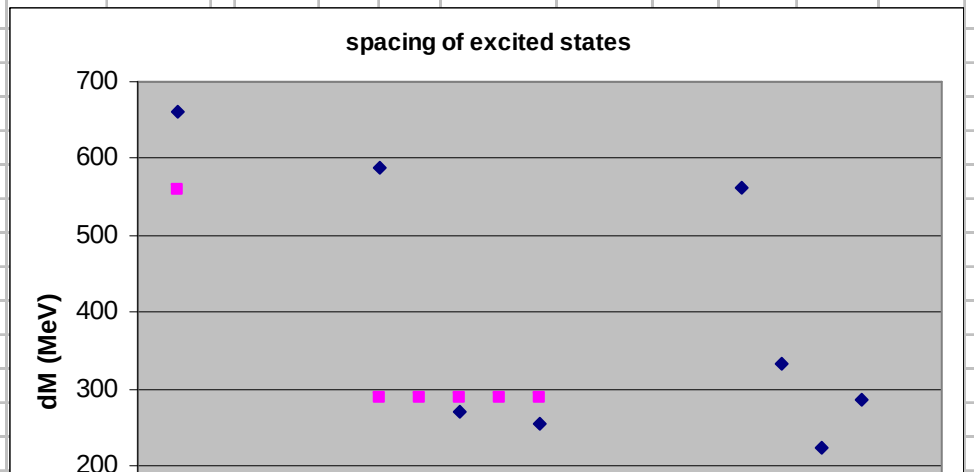
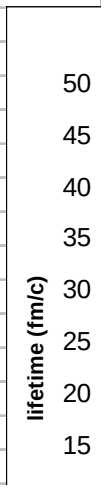




How did we do? – decay time

- within a factor of 2
- pretty good



fixed																						
												MeV/fm^2										
		MeV	MeV	MeV	fm	sec		Mev	%	%err	K	MeV			fm	fm						%
	n	mass	width	delta	tau	tau	T(meas)	m pred	error	dM		mc2	a	b	x1	x2	v/c	int 1	int2	T guess		err
phi																						
	0	1019	4.26		46.24	4.6E-22	0.024				4000	493.67	2.7	7.13	0.374	0.806	0.34	-0.84	0.51	0.067		-181
	1	1680	150	661	1.3	1.3E-23	0.840	1580	-6	15	4000	493.67	4.6	7.13	0.649	0.806	0.59	-3.34	-2.99	0.496		41
guess	2							2241			4000	493.67	6.0	7.13	0.837		0.76					
hbaromega				561								494				0.806						
psi	0	3097	0.09		2264	2.3E-20	0.001				4000	1869.4	3.7	13.88	0.268	0.806	0.12	-1.00	2.37	0.001		
	1	3686	0.28	589	711	7.1E-21	0.003	3385	-8	-51	4000	1869.4	6.5	13.88	0.465	0.806	0.22	-3.84	-1.87	0.020		
	2	3770	23.6	84	8.3	8.3E-23	0.257	3974	5	243	4000	1869.4	8.3	13.88	0.600	0.806	0.28	-7.03	-6.04	0.137		47
	3	4040	52	270	3.8	3.8E-23	0.567	4058	0	7	4000	1869.4	9.9	13.88	0.710	0.806	0.33	-10.43	-10.10	0.513		10
	4	4159	78	119	2.5	2.5E-23	0.850	4328	4	142	4000	1869.4	11.2	13.88	0.805	0.806	0.37	-13.98	-13.98	0.999		-18
?	5	4415	43	256	4.6	4.6E-23	0.469	4447	1	13	4000	1869.4	12.4	13.88	0.890	0.806	0.41	-17.64	#NUM!	#NUM!		#NUM!
guess	6							4703			4000	1869.4	13.4	13.88	0.968		0.45	-21.39	#NUM!			
hbaromega				288								1869.4				0.806						
Upsilon	0	9460	0.05		3788	3.8E-20	0.001				4000	5279	4.8	23.33	0.207	0.623	0.06	-1.13	2.25			
	1	10023	0.04	563	4477	4.5E-20	0.000	9632	-4	-70	4000	5279	8.4	23.33	0.359	0.623	0.10	-4.23	-2.25			
	2	10355	0.03	332	7577	7.6E-20	0.000	10195	-2	-48	4000	5279	10.8	23.33	0.463	0.623	0.13	-7.68	-6.68			
	3	10580	20	225	9.9	9.9E-23	0.366	10527	-1	-24	4000	5279	12.8	23.33	0.548	0.623	0.15	-11.34	-11.00	0.504		-38
	4	10865	110	285	1.8	1.8E-23	2.015	10751	-1	-40	4000	5279	14.5	23.33	0.621	0.623	0.17	-15.15	-15.15	0.997		51
?	5	11019	79	154	2.5	2.5E-23	1.447	11036	0	11	4000	5279	16.0	23.33	0.687	0.623	0.19	-19.07	#NUM!	#NUM!		#NUM!
guess	6							11190			4000	5279			0.747		0.21					
hbaromega				171								5279				0.623						

			dM	dmpred															Tau	Model		
																			46.2	16.5		
			661	561															1.3	2.2		
			589	288																		
			84	288															8.3	15.7		
			270	288															3.8	4.2		
			119	288															2.5	2.1		
			256	288