Linear mass rules and hadronic shells: the baryons

Paolo Palazzi *pp@particlez.org*
http://particlez.org

HADRON 07 -- Frascati, 11 October 2007

preprints and published papers on these subjects are available at:

http://particlez.org

?

why?

TABLES FROM UCRL-8030(rev.)

Table S - Stable particles

		$I(J^{PG})CA$	Mass (MeV)	Mass diff. (MeV)	Mean life (sec)	$Mass^2$ $(BeV)^2$	Pa m			p or Pma (MeV/
	γ	$J^P=1^-C^-A^+$	0		stable	0	stable			
LEPTONS	ν_e ν_μ	J=1/2	0(<0.2 keV) 0(<4 MeV)		stable	0 0	stable			
	$e^\mp$	J=1/2	0.511006 ±0.000002		stable	0.000	stable			
	$\mu^\mp$	J=1/2	105.659 ±0.002	-33.95 ±0.05	2.2001×10^{-6} ±.0008 ×scale=2.5	0.011	$e\nu\nu$	100%	105.15	52.
MESONS	$\pi^\pm$	$1(0^{--})C_n^+A$?	139.60 ±0.05		2.55×10^{-8} ±.26	0.019	$\mu\nu$ $e\nu$ $\mu\nu\gamma$ $\pi^0 e\nu$	100% $(1.24\pm.05)10^{-4}$ $(1.24\pm.25)10^{-4}$ $(1.5\pm.3)10^{-8}$	33.95 139.10 33.94 4.08	29. 69. 29. 4.
	π^0		135.01 ±0.05	4.590 ±.004 ×scale=2.4	1.80×10^{-16} ±.29 ×scale=1.3	0.018	$\gamma\gamma$ γe^+e^-	98.8 (1.19±.05)%	135.01 133.99	67. 67.
	$K^\pm$	$1/2(0^-)A^-$?	493.8 ±0.2		1.229×10^{-8} ±.008	0.244	$\mu\nu$ $\pi^\pm\pi^0$ $\pi^\pm\pi^-\pi^+$	(63.1±.4)% (21.5±.4)% (5.5±.1)%	388.1 219.2 75.0	235. 205. 125.
							For other decays see Table S Decays			
	K^0		498.0 ±0.5	-4.2 ±0.5 ×scale=1.2	50% K1, 50%K2					
	K_1				0.92×10^{-10} ±.02	0.248	$\pi^+\pi^-$ $\pi^0\pi^0$	(69.4±5.1)% (30.6±1.1)%	218.8 228.0	206. 209.
	K_2			0.91×$1/\tau_1$ ±0.07 ×scale=2.3	5.62×10^{-8} ±.68	0.248	$\pi^0\pi^0\pi^0$ $\pi^+\pi^-\pi^0$ $\pi\mu\nu$ $\pi e\nu$	(27.1±3.6)% (12.7±1.7)% (26.6±3.2)% (33.6±3.3)%	93.0 83.8 252.7 357.9	139. 133. 216. 229.
	η	$0(0^{-+})C^+A^-$?	548.7 ±0.5		$\Gamma<10$ MeV	0.301	$\gamma\gamma$ $3\pi^0$ or $\pi^0 2\gamma$ $\pi^+\pi^-\pi^0$ $\pi^+\pi^-\gamma$	(35.3±3.0)% (31.8±2.3)% (27.4±2.5)% (5.5±1.3)% ×scale=1.1	548.7 143.7 134.5 269.5	274. 179. 174. 236.
BARYONS	p	$1/2(1/2^+)$	938.256 ±0.005	-1.2933 ±.0001	stable	0.880				
	n		939.550 ±0.005		1.01×10^3 ±.03	0.883	$pe^-\nu$	100%	0.78	1.1
	Λ	$1/2(1/2^+)$	1115.40 ±0.11		2.62×10^{-10} ±.02 ×scale=1.5	1.244	$p\pi$ $n\pi^0$ $p\mu\nu$ $pe\nu$	(67.7±1.0)% ×scale=1.2 (31.6±2.6)% $<1\times10^{-4}$ $(.88\pm.08)10^{-3}$ ×scale=1.7	37.5 40.9 71.5 176.6	100. 103. 130. 163.
	Σ^+	$1/2(1/2^+)$	1189.41 ±0.14	2.9	0.788×10^{-10} ±.027	1.415	$p\pi^0$ $n\pi^+$	51.0±2.4% 49.0±2.4%	116.13 110.26	189. 185.
							For other decays see Table S Decays			
	Σ^0		1192.3 ±0.3		$<1.0\times10^{-14}$	1.422	$\Lambda\gamma$	100%	77.0	74.
	Σ^-		1197.08 ±0.19 ×scale=1.4	4.75 ±.10	1.58×10^{-10} ±.05	1.433	$n\pi^-$	100%	116.94	191.
							For other decays see Table S Decay			
	Ξ^0	$1/2(1/2^+)$?	1314.3 ±1.0	6.5 ±1.0	3.06×10^{-10} ±.40	1.727	$\Lambda\pi^0$	100%	76.9	150.
							For other decays see Table S Decay			
	Ξ^-		1320.8 ±0.2 ×scale=1.3		1.74×10^{-10} ±.05	1.745	$\Lambda\pi^-$ $\Lambda e^-\nu$ $n\pi^-$	100% $(3.0\pm1.7)10^{-3}$ $<5\times10^{-3}$	65.8 204.9 214.7	138. 189. 303.
	Ω^-	$0(3/2^+)$? ?	1675 ±3		$\sim0.7\times10^{-10}$		$\Xi\pi$ ΛK	? ?	221 66	296 216

A. H. Rosenfeld, A. Barbaro-Galtieri, W. H. Barkas, P. L. Bastien, J. Kirz, M. Roos
UCRL-8030 - Part I. June 1964.

The Nobel Prize in Physics 2004 – Information for the Public

http://nobelprize.org/physics/laurea

nobel priz

Address Book ▾ dfs TotemHN bbWEB sort out ▾ read ▾ CERN DCS ▾ PM ▾

HOME SITE HELP ABOUT SEARCH

Nobelprize.org

NOBEL PHYSICS CHEMISTRY MEDICINE LITERATURE PEACE ECONOMICS

LAUREATES ARTICLES EDUCATIONAL

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Nobel Prize in Physics 2004 – Information for the Public

5 October 2004

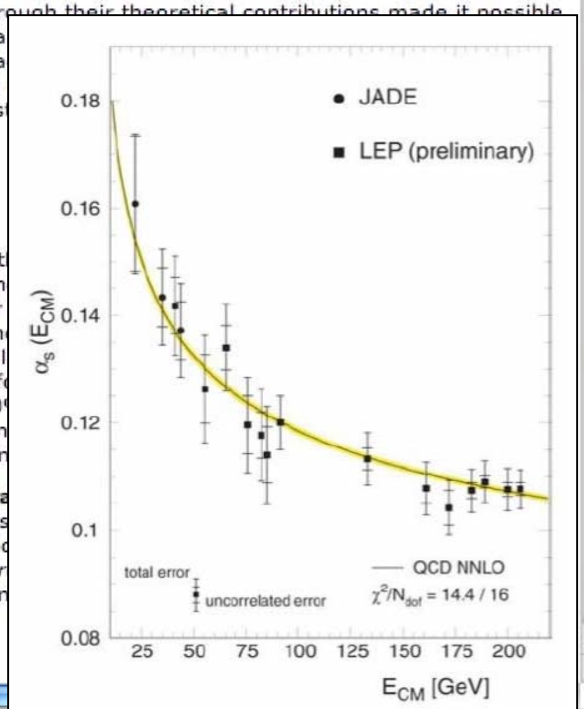
The discovery which is awarded this year's Nobel Prize is of decisive importance for our understanding of how the theory of one of Nature's fundamental forces works, the force that ties together the smallest pieces of matter – the quarks. **David Gross, David Politzer** and **Frank Wilczek** have thr... to complete the Standard Model of Pa... objects in Nature and how they intera... in the endeavour to provide a unified ... the spatial scale – from the tiniest dis... distances of the universe.

?

The strong force explained

The strong interaction – often called t... forces. It acts between the quarks, th... nuclei. Progress in particle physics or... appear hard to grasp for anyone with... analysing an everyday phenomenon l... fact determined by the fundamental f... neutrons, electrons. In fact, about 80... processes in the interior of the proton... This year's Nobel Prize is about this i...

David Gross, David Politzer and **Fra**... interaction which explains why quarks... energies. The discovery laid the foun... more complete name is *Quantum Chr*... great detail, in particular during recen... Physics, CERN, in Geneva.



atomic physics timeline

CHEMISTRY

1808 Dalton: chemistry is atomic

TAXONOMY

1869 Mendeleyev: periodic table

ENERGY LEVELS

1885 Balmer: spectral rules

1890 Rydberg: extended spectral rules

CONSTITUENTS

1987 Thomson: electron

MODEL

1907 Lenard: model with (+,-) charges

1904 Nagaoka: planetary model

1913 Bohr: model of the H atom

THEORY

1925 Heisenberg: matrix (QM)

1926 Schroedinger: equation (QM)

1926 Schroedinger: H atom

1927: Heitler and London, quantum theory explains chemical bonding

1928 Dirac: equation

particle physics timeline

CHEMISTRY
1963 quark-based CKM: accurate, but mixed-up

TAXONOMY
1961 SU(X) multiplets: plausible but incomplete

ENERGY LEVELS (MASSES)
lots of data, but no rules:
1962-64 GMO and 1962 Chew-Frauschi plot,
m^2 rules (?), no longer quoted by the PDG

CONSTITUENTS
1969 partons (.. = quarks, undeconfinable)

MODEL
1964 quark "model" evolved from taxonomy, clunky

THEORY
197x, blessed in 2004: perfect, but …

A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

If we assume that the strong interactions of baryons and mesons are correctly described in terms of the broken "eightfold way" [1-3], we are tempted to look for some fundamental explanation of the situation. A highly promised approach is the purely dynamical "bootstrap" model for all the strongly interacting particles within which one may try to derive isotopic spin and strangeness conservation and broken eightfold symmetry from self-consistency alone [4]. Of course, with only strong interactions, the orientation of the asymmetry in the unitary space cannot be specified; one hopes that in some way the selection of specific components of the F-spin by electromagnetism and the weak interactions determines the choice of isotopic spin and hypercharge directions.

Even if we consider the scattering amplitudes of strongly interacting particles on the mass shell only and treat the matrix elements of the weak, electromagnetic, and gravitational interactions by means ber $n_t - n_{\bar{t}}$ would be zero for all known baryons and mesons. The most interesting example of such a model is one in which the triplet has spin $\frac{1}{2}$ and $z = -1$, so that the four particles d^-, s^-, u^0 and b^0 exhibit a parallel with the leptons.

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" [6] q and the members of the anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations $(q\,q\,q)$, $(q\,q\,q\,q\,\bar{q})$, etc., while mesons are made out of $(q\,\bar{q})$, $(q\,q\,\bar{q}\,\bar{q})$, etc. It is assuming that the lowest baryon configuration $(q\,q\,q)$ gives just the representations **1**, **8**, and **10** that have been observed, while the lowest meson configuration $(q\,\bar{q})$ similarly gives just **1** and **8**.

or, in the notation of ref. [3]),

$$[\mathscr{F}_{1\alpha} + \mathscr{F}^5_{1\alpha} + i(\mathscr{F}_{2\alpha} + \mathscr{F}^5_{2\alpha})] \cos\theta$$
$$+ [\mathscr{F}_{4\alpha} + \mathscr{F}^5_{4\alpha} + i(\mathscr{F}_{5\alpha} + \mathscr{F}^5_{5\alpha})] \sin\theta .$$

We thus obtain all the features of Cabibbo's picture [8]) of the weak current, namely the rules $|\Delta I| = 1$, $\Delta Y = 0$ and $|\Delta I| = \frac{1}{2}$, $\Delta Y/\Delta Q = +1$, the conserved $\Delta Y = 0$ current with coefficient $\cos\theta$, the vector current in general as a component of the current of the F-spin, and the axial vector current transforming under SU(3) as the same component of another octet. Furthermore, we have [3]) the equal-time commutation rules for the fourth components of the currents:

$$[\mathscr{F}_{j4}(x) \pm \mathscr{F}^5_{j4}(x),\ \mathscr{F}_{k4}(x') \pm \mathscr{F}^5_{k4}(x')] =$$
$$- 2 f_{jkl} [\mathscr{F}_{l4}(x) \pm \mathscr{F}^5_{l4}(x)]\ \delta(x-x') ,$$
$$[\mathscr{F}_{j4(x)} \pm \mathscr{F}^5_{j4}(x),\ \mathscr{F}_{k4}(x') \mp \mathscr{F}^5_{k4}(x')] = 0 ,$$

$i = 1, \dots 8$, yielding the group SU(3) × SU(3). We can also look at the behaviour of the energy density $\theta_{44}(x)$ (in the gravitational interaction) under equal-time commutation with the operators $\mathscr{F}_{j4}(x') \pm \mathscr{F}_{j4}{}^5(x')$. That part which is non-invariant under the group will transform like particular representations of SU(3) × SU(3), for example like $(3, \bar{3})$ and $(\bar{3}, 3)$ if it comes just from the masses of the quarks.

(instead of purely mathematical entities as they would be in the limit of infinite mass). Since charge and baryon number are exactly conserved, one of the quarks (presumably $u^{\frac{2}{3}}$ or $d^{-\frac{1}{3}}$) would be absolutely stable *, while the other member of the doublet would go into the first member very slowly by β-decay or K-capture. The isotopic singlet quark would presumably decay into the doublet by weak interactions, much as Λ goes into N. Ordinary matter near the earth's surface would be contaminated by stable quarks as a result of high energy cosmic ray events throughout the earth's history, but the contamination is estimated to be so small that it would never have been detected. A search for stable quarks of charge $-\frac{1}{3}$ or $+\frac{2}{3}$ and/or stable di-quarks of charge $-\frac{2}{3}$ or $+\frac{1}{3}$ or $+\frac{4}{3}$ at the highest energy accelerators would help to reassure us of the non-existence of real quarks.

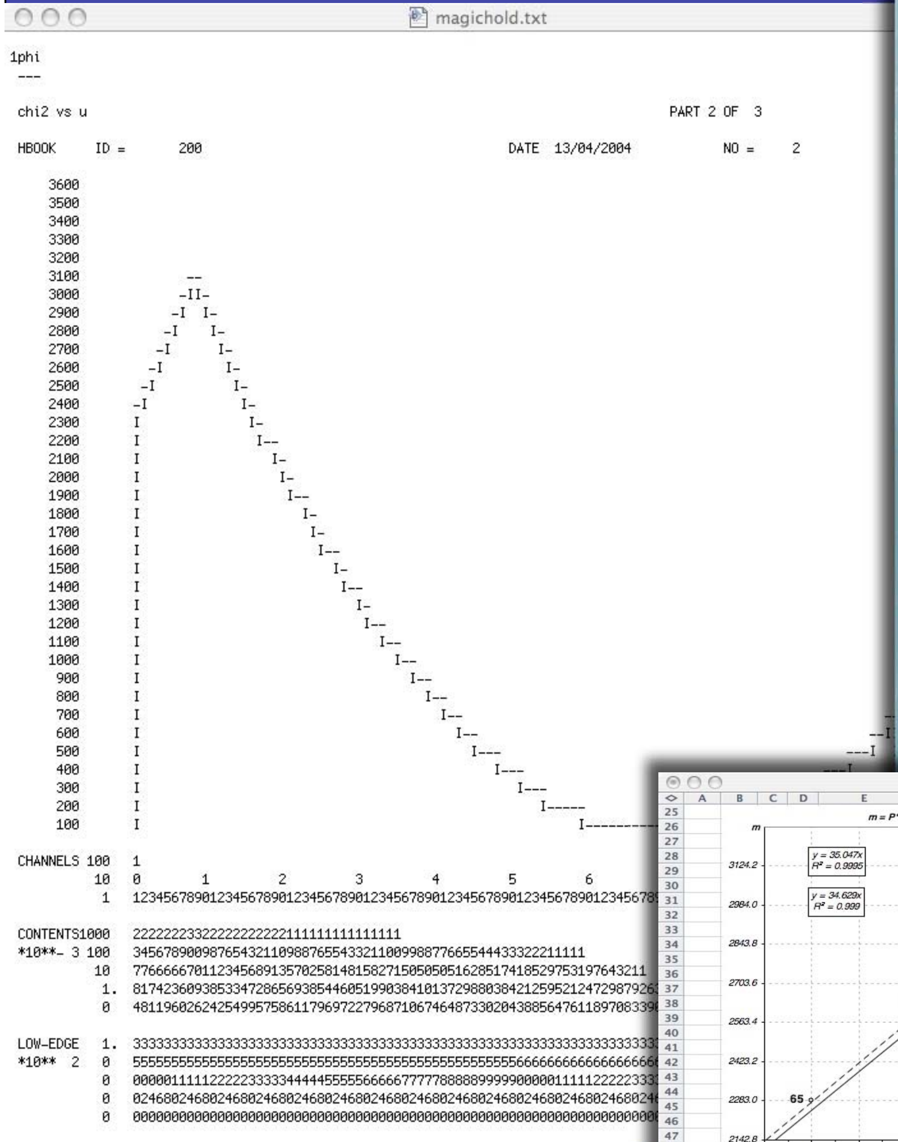
These ideas were developed during a visit to Columbia University in March 1963; the author would like to thank Professor Robert Serber for stimulating them.

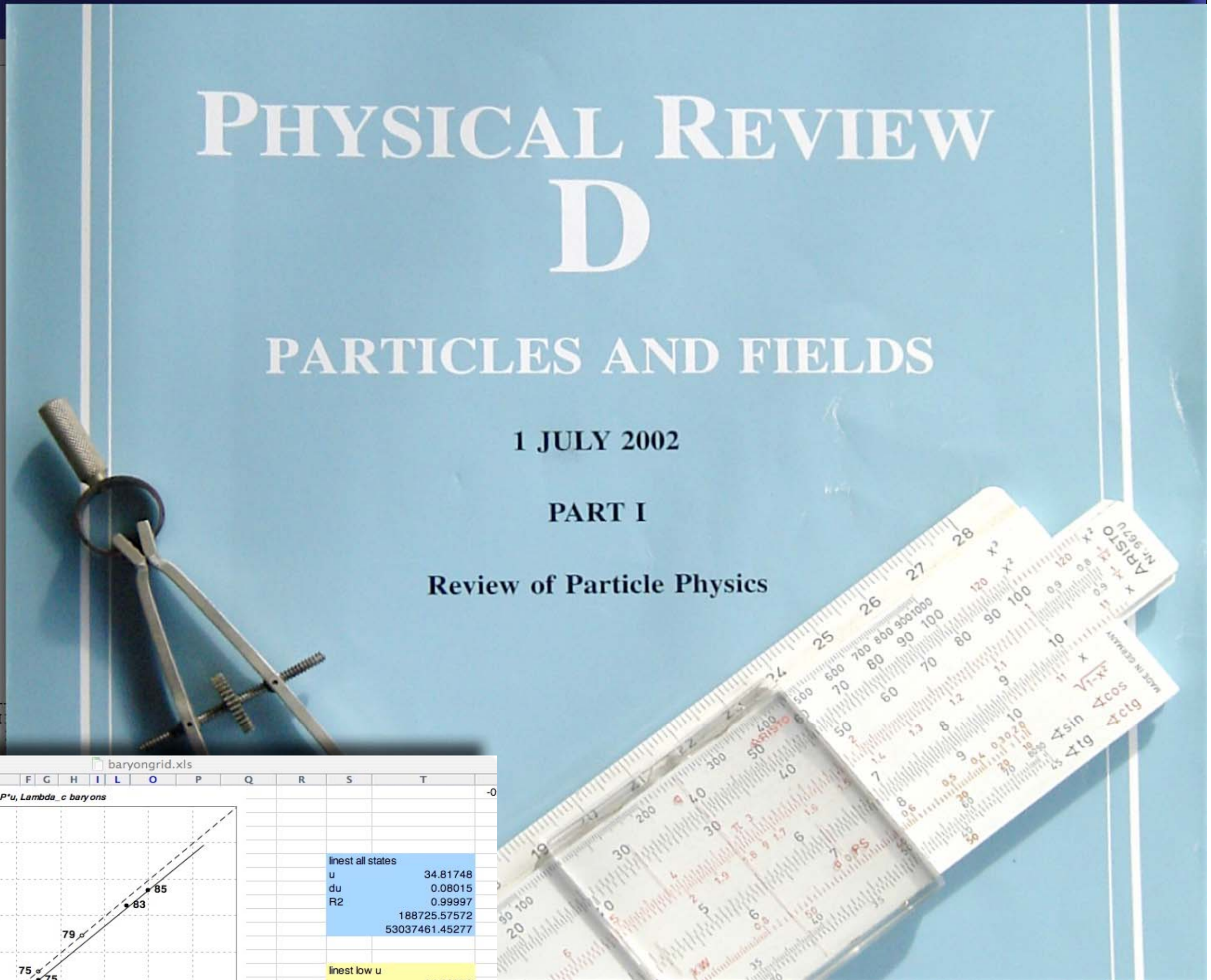
References

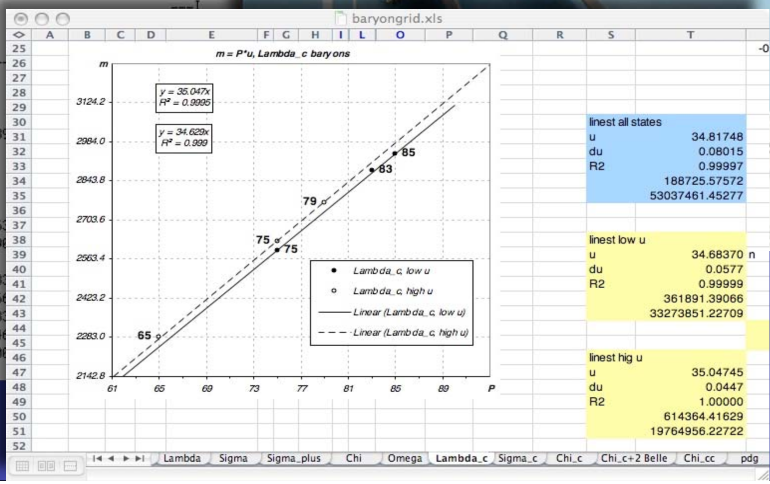
1) M. Gell-Mann, California Institute of Technology Synchrotron Laboratory Report CTSL-20 (1961).
2) Y. Ne'eman, Nuclear Phys. 26 (1961) 222.
3) M. Gell-Mann, Phys. Rev. 125 (1962) 1067.
4) E.g.: R.H. Capps, Phys. Rev. Letters 10 (1963) 312; R.E. Cutkosky, J. Kalckar and P. Tarjanne, Physics Letters 1 (1962) 93;
E. Abers, F. Zachariasen and A.C. Zemach, Phys.

	SM
theory	QCD
model	quark
constituents	quarks
mass rules	--
taxonomy	SU(X)
chemistry	CKM

how: systematics of particle properties







why me?

P. Palazzi

Indicazioni di una struttura a shell delle particelle e conseguenze relative

Elaborato presentato al concorso-esame per l' idoneita' al grado di R5 (ricercatore) dell' INFN.

giugno 1975

1973-75 (unpublished)

RIASSUNTO

Un'ipotesi generale sul contributo dei componenti (sconosciuti) delle particelle alla massa totale, associata ad un semplice concetto geometrico di stabilita', implica che le radici cubiche delle masse delle particelle relativamente piu' stabili sono equispaziate.

La relazione suindicata e' verificata sullo spettro di massa, e si predicono ulteriori zone di stabilita' attorno a 4.6 GeV e 6.8 GeV.

B = 5.3, B_c = 6.5

Si stabilisce un' analogia con i nuclei ed i numeri magici.

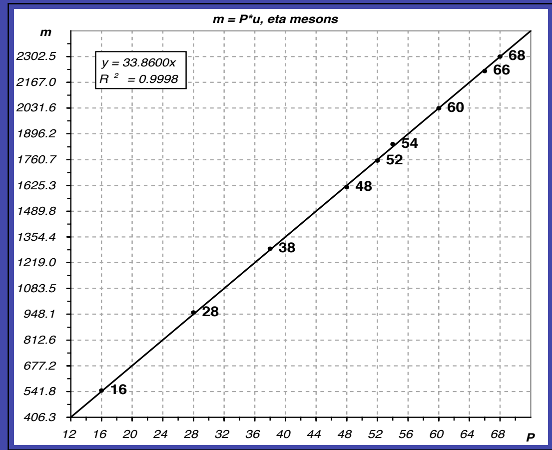
Si traggono delle conclusioni sul numero dei componenti elementari del pione, e si formula l' ipotesi che i leptoni stabili siano i costituenti elementari della materia. Ne derivano alcune proprieta' dell' interazione di legame, e conseguenze sul significato dei numeri quantici, in particolare il numero barionico.

two kinds of linear plots

- mass quantum:
  mass vs integer: linear-linear

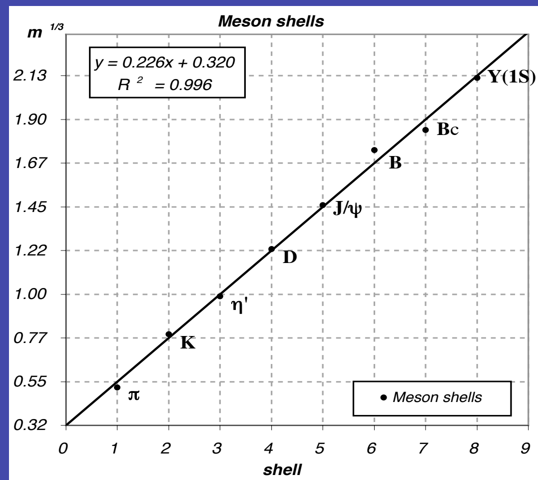
m vs P

(also mass unit vs integer)



- shells:
  $X^{1/3}$ vs integer: cuberoot-linear

$m^{1/3}$ vs i_S



recap on mesons

- **mass rules:** are hadrons masses linearly quantized?

(old story)

m_e/α = 70.02 MeV/c^2

Table I.

Change of coupling constant from the simple formula (4) and (5).

Meson Kinetic Energy (Mev)	40	80	120	160
$(g_I^{\text{effective}}/g)^4$	0.52	0.40	0.28	0.17
$(g_{II}^{\text{effective}}/g)^4$	1.32	1.39	1.46	1.51

Coupling constant was taken $g_1=0.8g$ and the mass of V'-particle to be $3000m_e$. For $g_{II}^{\text{effective}}$, we put $\epsilon_0 \sim \epsilon$ in (5), which is not sensitive to the value listed.

considerably in its magnitude, but the above simple arguments permits us to discuss roughly their angular distributions as follows; the normally scattered meson has angular distribution which is nearly the same as in reference 2, because the effect of V'-particle is only to change the coupling constant. But as to the charge exchange scattering, the angular distribution is more like that of Process II, because this scattering is composed of process I and II and, exact evaluation shows that the process II is predominant[4]. Since the angular distribution of scattered meson given in raference 2 is nearly the same for process I and II, and we may roughly expect almost the same angular distribution for normal- and exchange-scattering.

In conclusion, the writer wishes to express his sincere thanks to Prof. M. Kobayasi and to Mr. S. Takagi for their kind interest taken in this work.

1) For summary of references, see A Pais, preprint.
2) J. Ashkin, A. Simon and R. E. Marshak, Prog. Theor. Phys. **5** (1950), 634.
3) P. J. Issacs, A. M. Sachs and J. Steinberger, Phys. Rev. **85** (1952), 803; Fermi *et al.* Phys. Rev. **85** (1952), 934, 935, 936.

4) Owing to the choice of coupling as given in Fig. 3, for $\pi^- + P \to \pi^0 + N$, we have as effective coupling constant, in (4) and (5)

$$g_I^{2\text{eff}} = g g_N + \frac{[m+m_1][(p_0+q_0)^2-m^2]}{2m[(p_0+q_0)^2-m_1^2]} g_1 g_{N_1},$$

$$g_{II}^{2\text{eff}} = g g_P + \frac{[m+m_1][(p_0-q)^2-m^2]}{2m[(p_0-q)^2-m_1^2]} g_1 g_{P_1}$$

$$= -\left(g g_N - \frac{[m+m_1][(p_0-q)^2-m^2]}{2m[(p_0-q)^2-m_1^2]} g_1 g_{N_1}\right)$$

and thus, $(g_I^{2\text{eff}}/g g_N)^2$ is just corresponding quantity in Table I, $((g_1 g_N)^{1/2}=0.8(g g_N)^{1/2})$, but $(g_{II}^{2\text{eff}}/g g_N)^2$ is

40	80	120	160
0.72	0.67	0.62	0.59

An Empirical Mass Spectrum of Elementary Particles

Y. Nambu

Osaka City University

May 14, 1952

1952

It seems to be a general conviction of current physicists that the theory of elementary particles in its ultimate form could or should give the mass spectrum of these particles just in the same way as quatum mechanics has succeeded in accounting for the regularity of atomic spectra. Even if we disregard any philosophical background in such a postulation of theoretical physics, the recent discovery of many unstable, apparently elementary particles drives us to the efforts towards a systematic comprehension of the variety of elementary particles. With the present undoubtedly insufficient accumulation of our knowledge, however, it may perhaps be too ambitious and rather unsound to look for an empirical "Balmer's law". Nevertheless we should like here to present one such attempt because it

!

happens to be extremely simple, and because the significance and utility, if any, of this kind of attempt could best be appreciated at the stage where it awaits more experimental data to prove or disprove itself by its own predictions.

The nature of V_0 particles[1)] and τ-mesons[2)] has been investigated by several authors. Among other things, we note that their decay Q-values are rather uniform, i.e. of the same order of magnitude of the rest mass of the daughter π-mesons. This gives us a hint that some regularity might be found if the masses were measured in a unit of the order of the π-meson mass. The π-meson mass, being $\sim 274 = 137 \times 2$ electron masses (m_e), gives us a second, rather fanciful hint that $137\ m_e$ could be chosen as the unit. The ensuing result is given in the accompanying table. We see

particle	mass no. n	$137\times n$	experimental mass
lepton	0	0	~ 0
photon	0	0	0
μ	1½	206	$210\pm 3\ m_e$
π	2	274	276 ± 3 $(\pi^\pm)$
V_{02}	6	822	800 ± 30
τ	7	959	966 ± 10
x			$1000\sim 1500$
nucleon	13½	1849	1837, 1839
V_{01}	16, 16½	Q=35, 70 Mev	35 ± 5, 75 ± 3Mev
V^*	17½	Q=280 Mev	~ 280 Mev

that the "mass number" of the observed particles is either integer or half-odd, which is generally valid within a deviation of about $\sim \pm 15 m_e$, or $\sim \pm$ 1/10 mass unit, for those cases in which the experimental error is also of this order of magnitude. In the above table, we have adopted the view that the heavy V_0 particles have two kinds of Q-values, namely $\sim$35Mev (1/2 mass unit) and $\sim$70Mev (1m.u.)[3)], decaying into a proton and a π-meson. V^* means the nucleon isobar whose existence is being conjectured from γ-π reaction and π-proton scattering,[5)] with an excitation of roughly about 280 Mev (4 m.u.).

We can make a few comments on the result. (1) As was pointed out by Enatsu[4)], the adopted mass unit incidentally agrees with Heisenberg's natural unit. (2) Bosons seem to have integral, while fermions half-integral, mass numbers. (3) The small mass value of the electron cannot be explained by the above rule. But we can take the view that this as well as the proton-neutron and $\pi^\pm$-π^0 mass differences correspond to a kind of fine structure. Indeed, their magnitude is just of the order of 1/137 m.u.

It goes without saying that this rule is purely of an empirical nature, and might turn out to be entirely illusory or accidental in the event of getting more reliable data or establishing the true theory of mass spectrum. But the rather strange distribution of the observed mass numbers might simply mean the lack of our knowledge. Indeed, only those particles which have favorable lives as well as abundances for detection have so far been observed, and we have no grounds at all to exclude the possibility that there exist other particles which are liable to escape direct observation. At any rate, an effective and close-by test of this rule may be provided by more accurate determination of the masses of the observed particles. In particular, the x-meson may be predicted to have any of $\sim$1030, $\sim$1100, $\sim$1160, $\sim$1230, $\sim$1300,... electron masses (7½, 8, 8½, 9, 9½,... m.u.).

1) E. g., R. Armenteros et al., Phil. Mag. **42** (1951), 1113.
2) P. H. Fowler et al., Phil. Mag. **42** (1951), 1040.
3) S. D. Wanlass et al., Bull. Amer. Phys. Soc. **27** (1952), No. 3, 7.
4) Remarks by H. Enatsu at the Tokyo meeting of the Physical Society of Japan. April 1–3, 1952.
5) K. A. Brueckner, Bull Amer. Phys. Soc. **27** (1952), No. 1, 50.

 1970

Thus the energy we conventionally associate with a photon, $\hbar\omega$, is here just the electrostatic separation energy, which is by our construction the total energy of the photon. The wavelength of a photon is a longitudinal wavelength in the same sense as the de Broglie wavelength discussed above. Hence we have

$$\lambda = \frac{c}{\omega}, \tag{13}$$

where c is the velocity of the photon and ω is the frequency of rotation of the electron pair. From this, $\lambda/2r = 1/\alpha$.

Although this model for the electron has interesting consequences, can it correspond to reality? The answer at first seems to be clearly no! This is a huge electron, with a radius of $6.7\cdot10^{-11}$ cm and with a ring of charge that generates effective quadrupole, octupole, ... moments that appear in typical processes in order α^2, α^4, ... But a closer examination of this question reveals some interesting facts. There is a general theorem that a spin-$\frac{1}{2}$ particle cannot have an observable quadrupole moment (7); however this is just a statement of the fact that the sign is the same in the two allowed quantization positions. At high energies, we know experimentally that the electron appears always as a pointlike object in scattering processes. When we treat the spin as an ordinary angular momentum, then, in order to conserve angular momentum in the laboratory frame of reference, it appears necessary to preserve the relationship $\sqrt{3}\,\hbar = mRc$ under accelerations.

This model for the electron will also produce observable effects on the atomic level. However a remarkable fact emerges here. If we place the electron in an orbit around a nucleus, the electron spin vector will precess slowly about the normal to the plane of the orbit. If the ring of charge is expanded in Legendre functions, the quadrupole contribution to the energy is proportional to $P_2(\cos\theta)$, where θ is the angle between the electron spin axis and the orbit radius vector. If the angle between the electron spin axis and the normal to the plane is ψ, and if φ is the precessional angle, we have $\cos\theta = \sin\psi\cos\varphi$. Hence if the angle ψ is $\sin^{-1}\sqrt{\frac{2}{3}}$, as specified by the quantum-mechanical rules for vectors, then the quadrupole contribution to the energy, which is of order α^4, cancels out!

The model for the electron can be extended directly to the muon if we increase m and ω by a factor of 207 and decrease R by the same amount. The $(g-2)$ experiments show that this scaling law holds to 1 part in 10^6 for the electron and muon.

This model can be extended to include the production of meson and baryon resonances (3). In fact, it was by noting that the mass of the muon is a natural quantum for elementary particles (3) and by attempting to determine the «size» of a muon that the author was led to the present results. In the meson resonances, the association of an energy with the spin is a decisive factor. The quantum $\mu = 70$ MeV appears in mesons in a nonspinning form (*e.g.* in the η, η' and kaon), in a fully-relativistic spinning form (*e.g.* in the nucleon), and in a less-than-fully-relativistic form (*e.g.* in the ρ and f') (3).

(7) N. F. RAMSEY: *Experimental Nuclear Physics*, edited by E. SEGRÈ, Vol. 1 (New York, 1953), p. 365.

IL NUOVO CIMENTO VOL. 20 A, N. 3 1 Aprile 1974

Experimental Systematics of Particle Lifetimes and Widths (*) (**).

M. H. MAC GREGOR 1974

Lawrence Livermore Laboratory, University of California - Livermore, Cal.

(ricevuto il 31 Luglio 1973; manoscritto revisionato ricevuto il 15 Gennaio 1974)

Summary. — By comparing the lifetimes of the metastable ($\tau > 10^{-17}$ s) elementary particles with one another, we find experimentally that these lifetimes occur both as ratios of 2 and as ratios of $\alpha = e^2/\hbar c$, with supposedly dissimilar particles grouped together, and with no experimental counterexamples. When short-lived ($\tau \sim 10^{-22}$ s) meson and baryon resonances are studied, it is found that the width is a key identification symbol. Grouping together resonances that have similar (narrow) widths, we obtain very accurate linear mass intervals. This mapping can be extended to include essentially all of the observed narrow-width meson and baryon resonances in a comprehensive pattern. These results suggest a weak-binding-energy approach to elementary-particle structure. This is the same conclusion that emerges from a broad overview of the successes of the quark model. The empirical level spacings point to the existence of two basic mass quanta, a spinless quantum $\mu \simeq 70$ MeV and a spin-$\frac{1}{2}$ quantum $S \simeq 330$ MeV. Electromagnetic properties of nucleons also indicate the existence of the 330 MeV mass quantum. In reconciling a 330 MeV mass quantum S with a 939 MeV nucleon mass and a 1795 MeV $\bar{p}n$ bound-state mass, we are led to the Fermi and Yang formulation of the nucleon rather than to the formulation of Gell-Mann and Zweig. The observed spectrum of narrow-width meson and baryon resonances can be reproduced by forming suitable combinations of the quanta μ and S. Broad-width resonances are interpreted as rotational excitations. Basis states $3 = 3\mu$ and $4 = 4\mu$, initially selected to account for observed level spacings in hyperon resonances, are shown to have significance with respect to strangeness quantum numbers and with respect to basic characteristics of baryon and meson resonances. These basis states can also be used to account phenomenologically for the observed factors of 2 and α in the lifetimes of the

(*) To speed up publication, the author of this paper has agreed to not receive the proofs for correction.

(**) Work performed under the auspices of the U.S. Atomic Energy Commission.

MHMG 2007

alternate selection

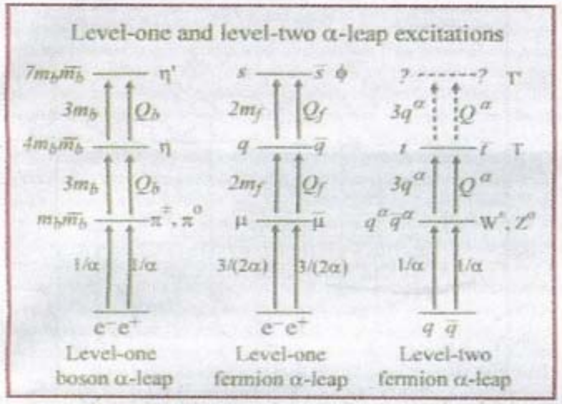
SAVE $18 & FREE Shipping & Handling! See p. 22 for details

The Power of α

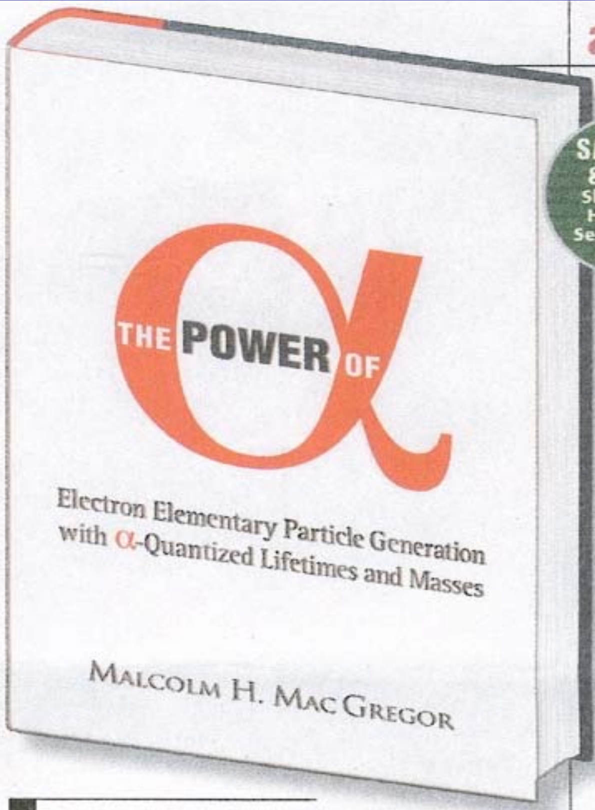
Electron Elementary Particle Generation with α-Quantized Lifetimes and Masses

BY MALCOLM H. MACGREGOR

What determines the specific properties of elementary particles?



THREE α-LEAP excitation towers.



THE AUTHOR MALCOLM H. MAC GREGOR was a physicist at the Lawrence Livermore National Laboratory for 42 years. He is the author of *The Nature of the Elementary Particle* and *The Enigmatic Electron.*

The denizens of the subatomic world are sometimes nicknamed "the particle zoo," but this zoo holds many more mysteries than the ordinary kind. One mystery in particular—why do elementary particles have the masses and lifetimes they do?—is left unanswered by the standard model of particle physics. In The Power of α, Malcolm Mac Gregor goes beyond the standard model to propose a solution.

Mac Gregor focuses on the role played by a particular constant in physics, the so-called fine-structure constant α, which characterizes the strength of the electromagnetic interaction and has a numerical value approximately equal to 1/137. By carefully analyzing the col-

If the author is correct in his analysis, the consequences for particle physics are profound. Solutions to problems that have long defied explanation, such as the proton-to-electron, muon-to-electron, and tau-to-electron mass ratios, emerge from the experimental mass α-quantization in a manner that requires essentially no theory at all. The bulk of the book is devoted to filling in the details leading to this result as well as related issues in areas that range from spectroscopy to cosmology.

These pages are filled with experimental results that bolster Mac Gregor's thesis, but readability of the book is significantly enhanced by his type of analysis, which he

The Power of α
69-5052
Publisher's Price: $82.00
Member's Price: $63.99
Bonus Price: $41.00
Level: Graduate text
158 illustrations
Published by World Scientific in 2007
450 pages
Earns 3 bonus points

Also available

The God Effect Quantum Entanglement, Science's Strangest Phenomenon
By Brian Clegg

Clegg surveys the science and potential applications of entanglement, a quantum process that connects two particles in such a way that changes to one of the particles are reflected—instantly—in the other. HC. 288pp. 2006. 1bp.

Publisher's Price: $24.95
38-5835
Member's Price: $19.99
Bonus Price: $12.47

Buy Both Books

70 MeV/c^2 mass unit timeline

1952	Y. Nambu
1970 -> 2006	M. H. Mac Gregor
1973 -> 2006	PP
1980	E. Jensen, no physics but good statistics
1980	A. O. Barut (mention)
1995 -> 2004	D. Akers
2000 -> 2006	E. L. Koschmieder
2003	B. G. Sidharth
2004	S. Giani

statistical analysis often missing or incorrect !

S.Giani 2004

Particle Mass-Formulae

Simone Giani

CERN, European Organization for Nuclear Research,
CH-1211 Geneva 23, Switzerland
Telephone: +41 22 7679972 e-mail: Simone.Giani@cern.ch

CERN-OPEN-2004-004
02 March 2004

Abstract

Important relations among some particle masses are investigated. The eta-prime / eta masses' ratio is noted to be a fraction of integers with high precision. The masses of muon, kaon, eta, and neutron are observed to fit a linear mass formula within an accuracy of 0.25 MeV.

1. Introduction

Many studies can be found in the literature on calculations of the particle mass spectrum. The complexity of advanced parton models and QCD (PDG 2002, [1]) tries to address the fine structure of particle constituents and their interactions, whereas earlier mathematical studies have been dedicated to outlining the gross correlations between the particle masses of isospin multiplets (Nambu, [2]), (Jensen, [3]), (MacGregor, [4]). The present work focuses on relations between particle masses that are satisfied at a level of precision higher than what should be expected from current theory.

2. Relation η' η

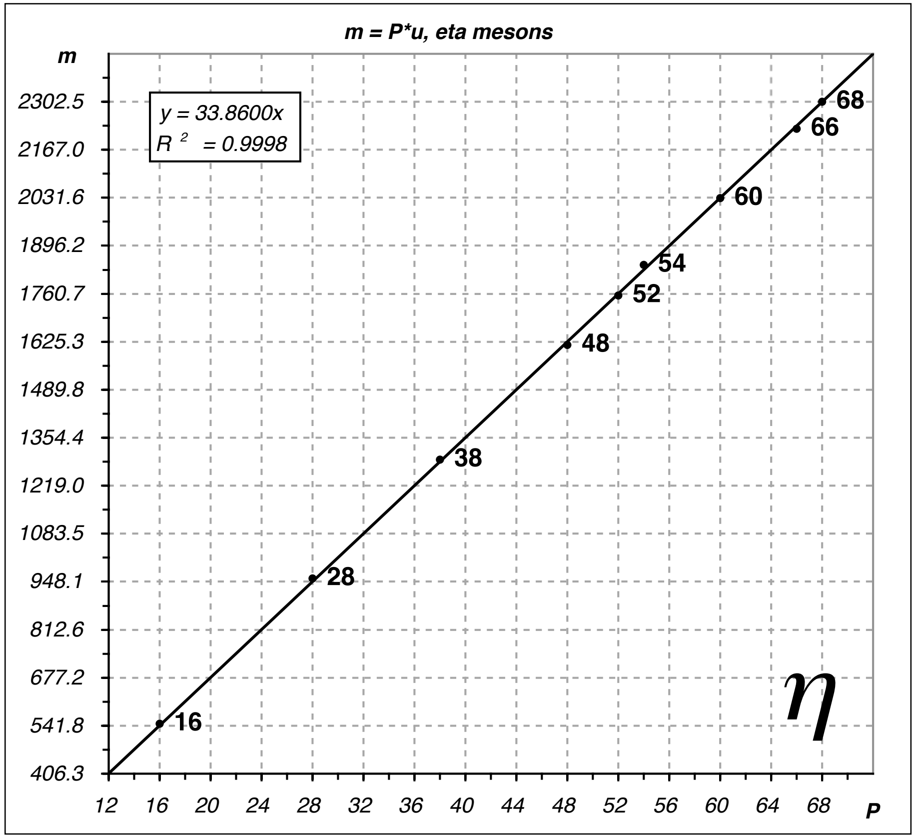
Interesting mathematical relations link the mass values of some elementary particles. One example is given by the formula relating the eta and eta-prime mass values:

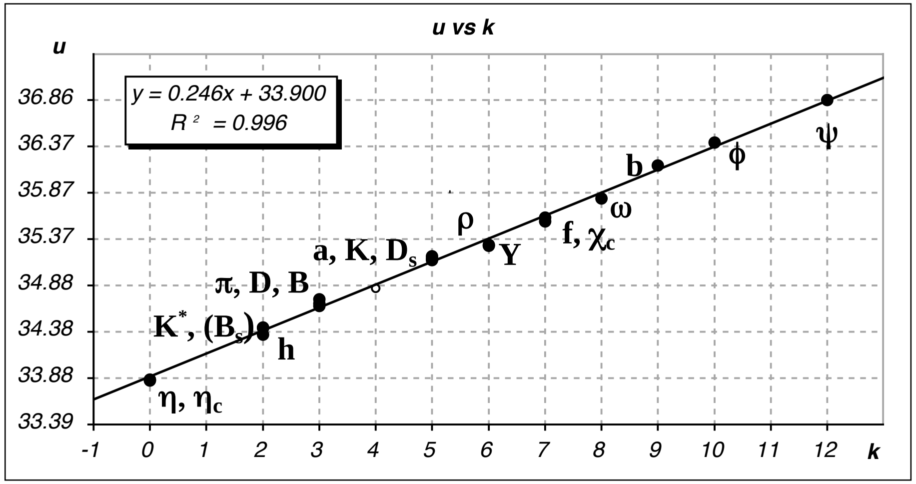
$28u / 16u = 7 / 4$

$$\eta' / \eta = 7 / 4 \quad . \qquad [f.1]$$

η mass saga

In fact the ratio of the eta-prime and eta mass expectation values [1] is: 1.750009, though the error on each of the two masses individually is 0.14 and 0.12 MeV, respectively.





Preprint: p3a-2004-001
28-JUL-2004
Revision 1, 5-APR-2005

Patterns in the Meson Mass Spectrum

Paolo Palazzi   2004

Abstract

The conjecture that particle masses are multiples of a unit u of about 35 MeV has been proposed in various forms by several authors: mesons are even multiples of u, leptons and baryons odd multiples. Here this mass quantization is reassessed for all particles with mass below 1 GeV (stable leptons and $f_0(600)$ excluded), and found to be statistically significant. Subsequently all the mesons listed by the PDG are grouped in families defined by quark composition and J^{PC}, and analyzed for even mass multiplicity with a unit close to 35 MeV separately for each group. For all the the families that can be analyzed unambiguously this multiplicity hypothesis is found to be statistically significant. Most scalar and vector families show a dependence of u from the spin, while for pseudoscalars the effect is not present. Only 5 states out of 120 are rejected due to abnormally large fit residuals. The mass units of the various families are quantized on a grid of 12 intervals of about 0.25 MeV, ranging from 33.88 up to 36.86 MeV. Th location of the values on the u-grid shows an intriguing pattern of c h the quantum numbers.

Address correspondence to: pp@particlez

Download from: http://www.partic

rejected by PRD
rejected by EPJA
blacklisted on arXiv
filtered on CERN-OPEN

mass unit: u = 35 MeV/c^2 to avoid half-integers

hypothesis:

$m_i = u * P_i$: $P \in$ E for mesons

($P \in$ O for baryons and leptons)

procedure:

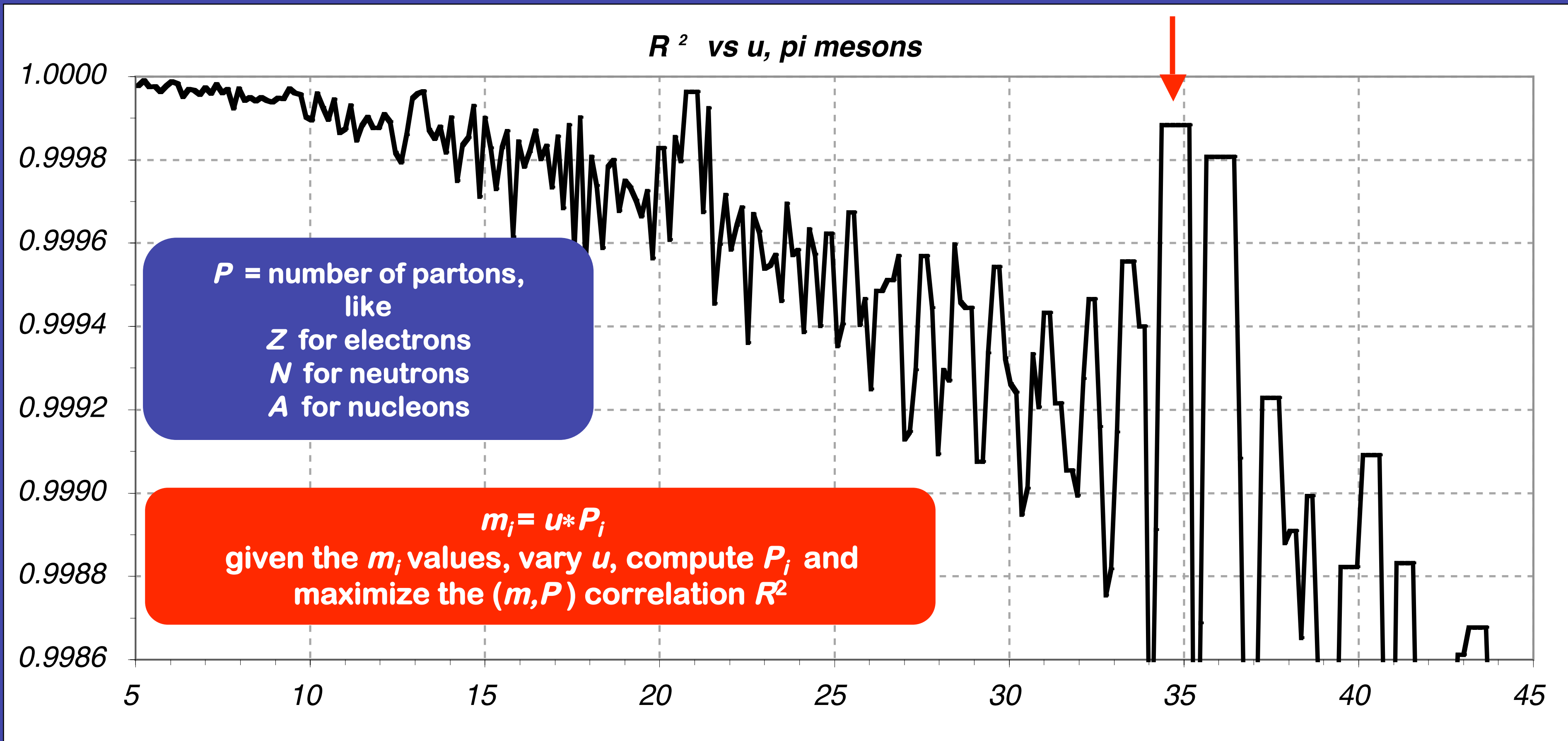
FOREACH group of mesons / (q-qbar, J^{PC}) DO:

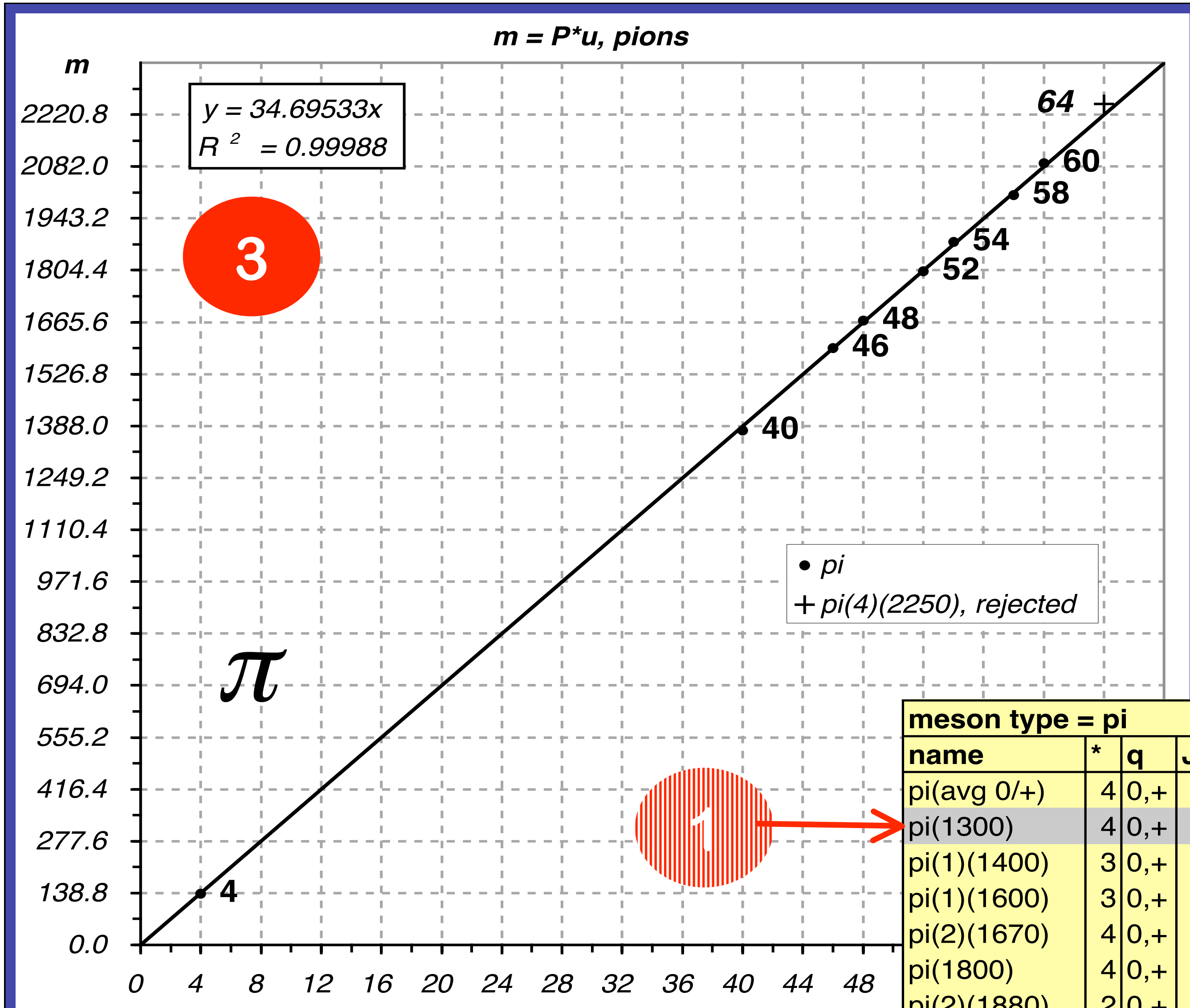
1. discard states with *errm* > 30 MeV/c^2
2. maximize $R^2(m,P)$ varying u around 35 MeV/c^2
3. fit u with the least squares
4. remove outliers with Chauvenet's criterion
5. check for spin dependence du / dJ
6. compute statistical relevance as $p(H_0)$ by MC

ENDDO

example: the pions

1. remove states with large errors
2. maximize R^2 varying u





residuals, compare with [-34.7, 34.7] uniform

1

meson type = pi										
name	*****	**q**	**J**	**x**	**P**	**m**	**errm**	**u=m/P**	**dm**	**dm/m**
pi(avg 0/+)	4	0,+	0		4	137.3	6.0E-04	34.318	-1.8	1.33%
pi(1300)	4	0,+	0	1	38	1300.0	100.0	34.211	-18.4	1.42%
pi(1)(1400)	3	0,+	1		40	1376.0	17.0	34.400	-14.9	1.09%
pi(1)(1600)	3	0,+	1		46	1596.0	20.0	34.696	-3.6	0.22%
pi(2)(1670)	4	0,+	2		48	1670.0	20.0	34.792	0.9	0.05%
pi(1800)	4	0,+	0		52	1801.0	13.0	34.635	-7.2	0.40%
pi(2)(1880)	2	0,+	2		54	1880.0	20.0	34.815	2.2	0.12%
pi(2)(2005)	2	0,+	2		58	2005.0	15.0	34.569	-11.9	0.59%
pi(2)(2100)	3	0,+	2		60	2090.0	29.0	34.833	3.6	0.17%
pi(4)(2250)	2	0,+	4	3	64	2250.0	15.0	35.156	24.5	1.09%

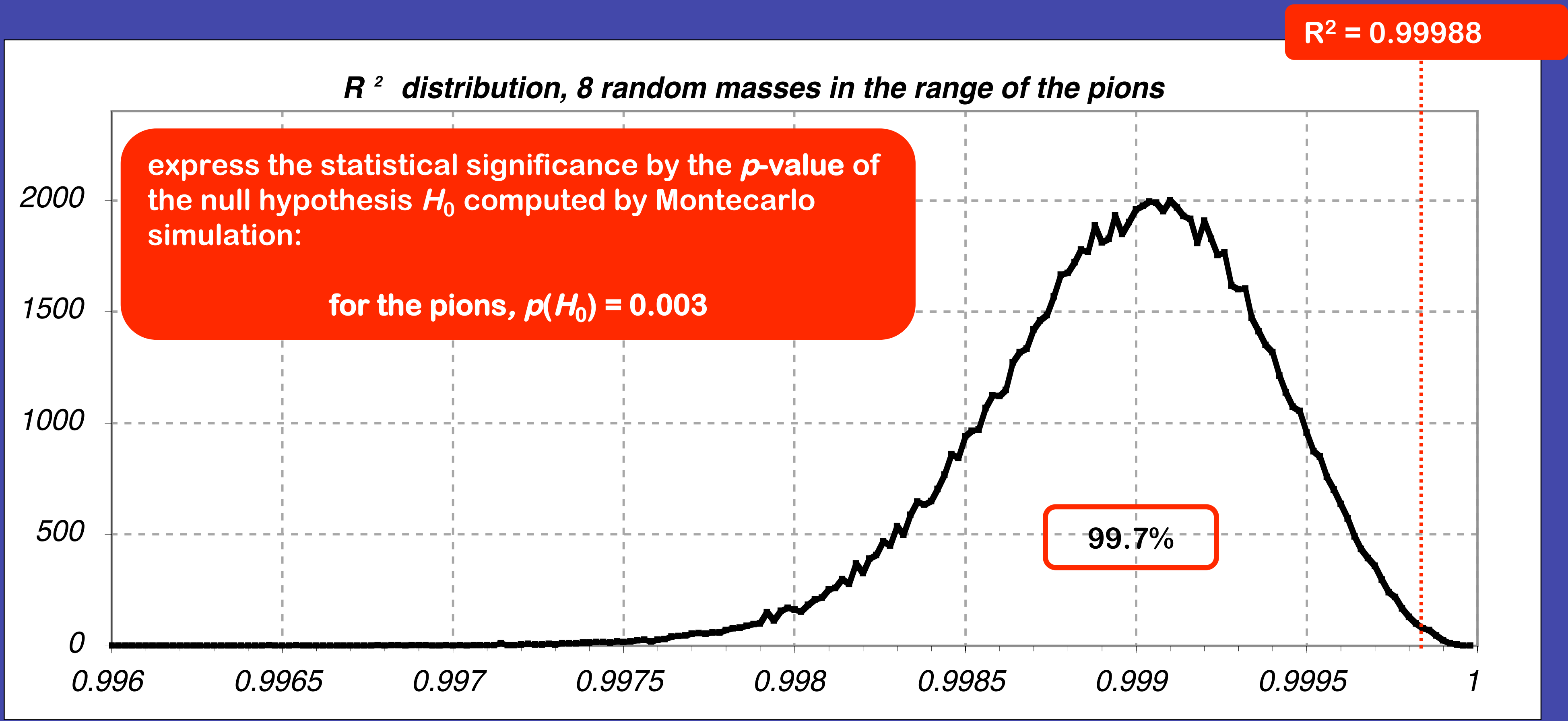
4

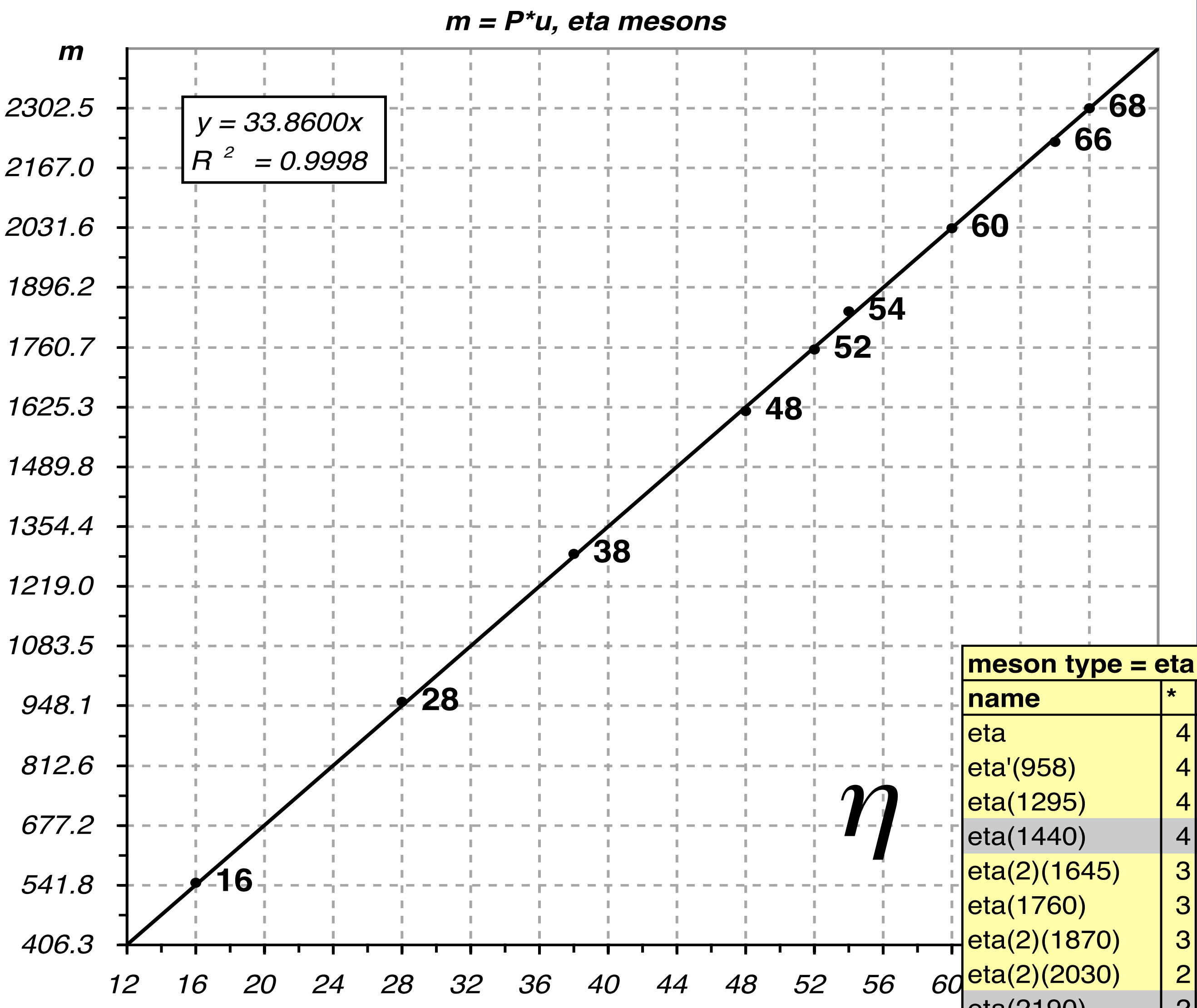
5

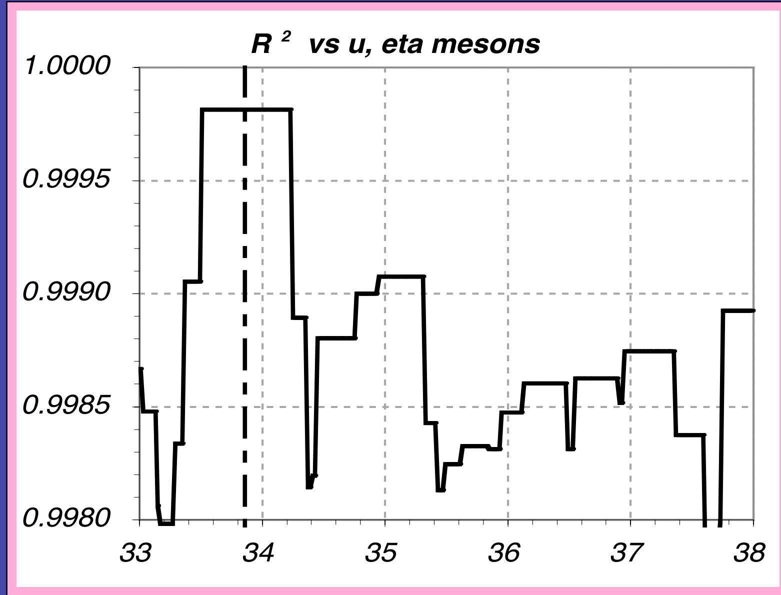
summary pi mesons	
u	34.69 ± 0.051
p-value	0.997 --> $p(H_0)$ = 0.003
spin dependence	no
omitted	3 = 1 averaged + 1 large errm + 1 Chauvenet

6

statistical relevance





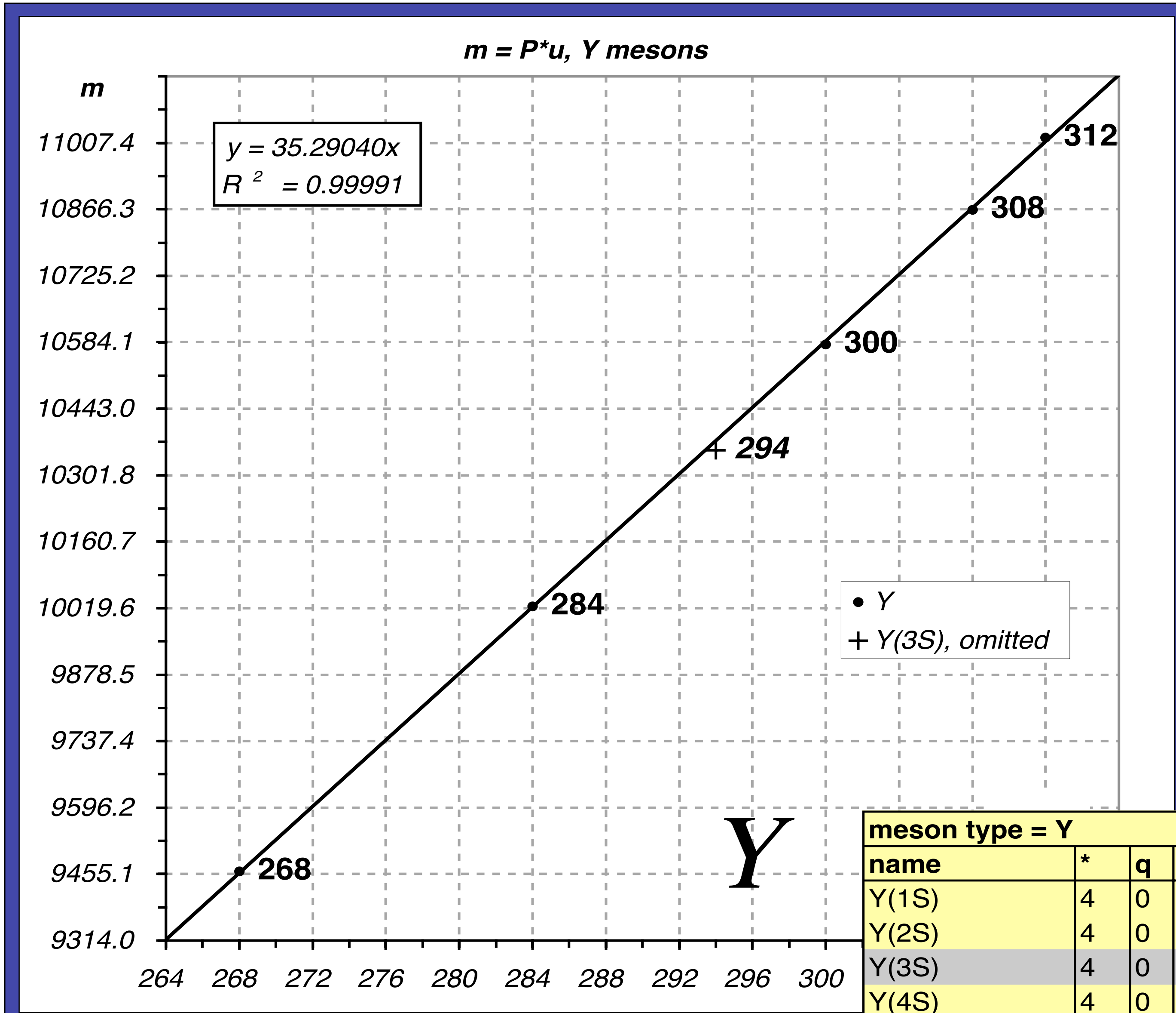


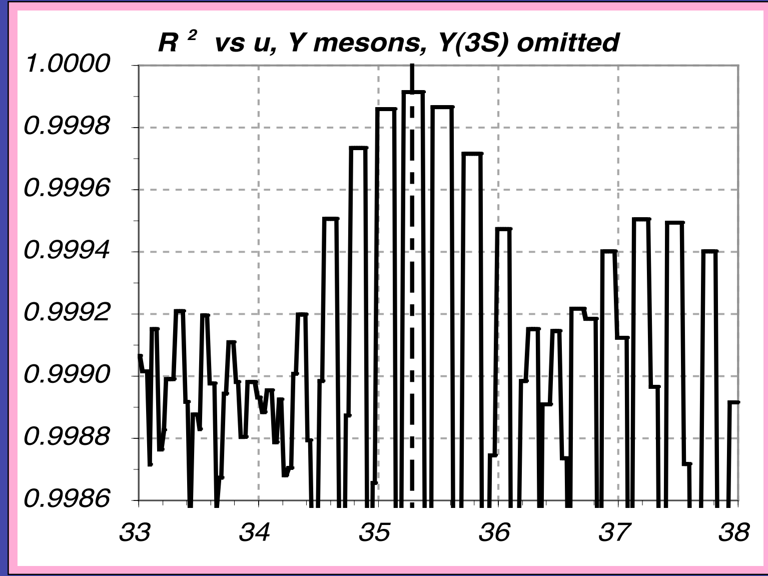
residuals

meson type = eta										
name	*	q	J	x	P	m	errm	u=m/P	dm	dm/m
eta	4	0	0		16	547.3	0.1	34.206	5.5	1.01%
eta'(958)	4	0	0		28	957.8	0.1	34.206	9.7	1.01%
eta(1295)	4	0	0		38	1293.0	5.0	34.026	6.3	0.49%
eta(1440)	4	0	0	1	42	1435.0	35.0	34.167	12.9	0.90%
eta(2)(1645)	3	0	2		48	1617.0	5.0	33.688	-8.3	-0.51%
eta(1760)	3	0	0		52	1756.0	11.0	33.769	-4.7	-0.27%
eta(2)(1870)	3	0	2		54	1842.0	8.0	34.111	13.6	0.74%
eta(2)(2030)	2	0	2		60	2030.0	20.0	33.833	-1.6	-0.08%
eta(2190)	2	0	0	1	64	2190.0	50.0	34.219	23.0	1.05%
eta(2)(2250)	2	0	2		66	2225.8	13.0	33.723	-9.0	-0.40%
eta(2225)	3	0	0	1	66	2227.0	35.0	33.742	-7.8	-0.35%
eta(2280)	3	0	0		68	2302.5	12.0	33.860	0.0	0.00%
eta(4)(2320)	2	0	4	1	68	2328.0	38.0	34.235	25.5	1.10%

summary eta mesons	
u	33.86 ± 0.053
p-value	0.999 --> $p(H_0)$ = 0.001
spin dependence	no
omitted	4 large errm

low mass

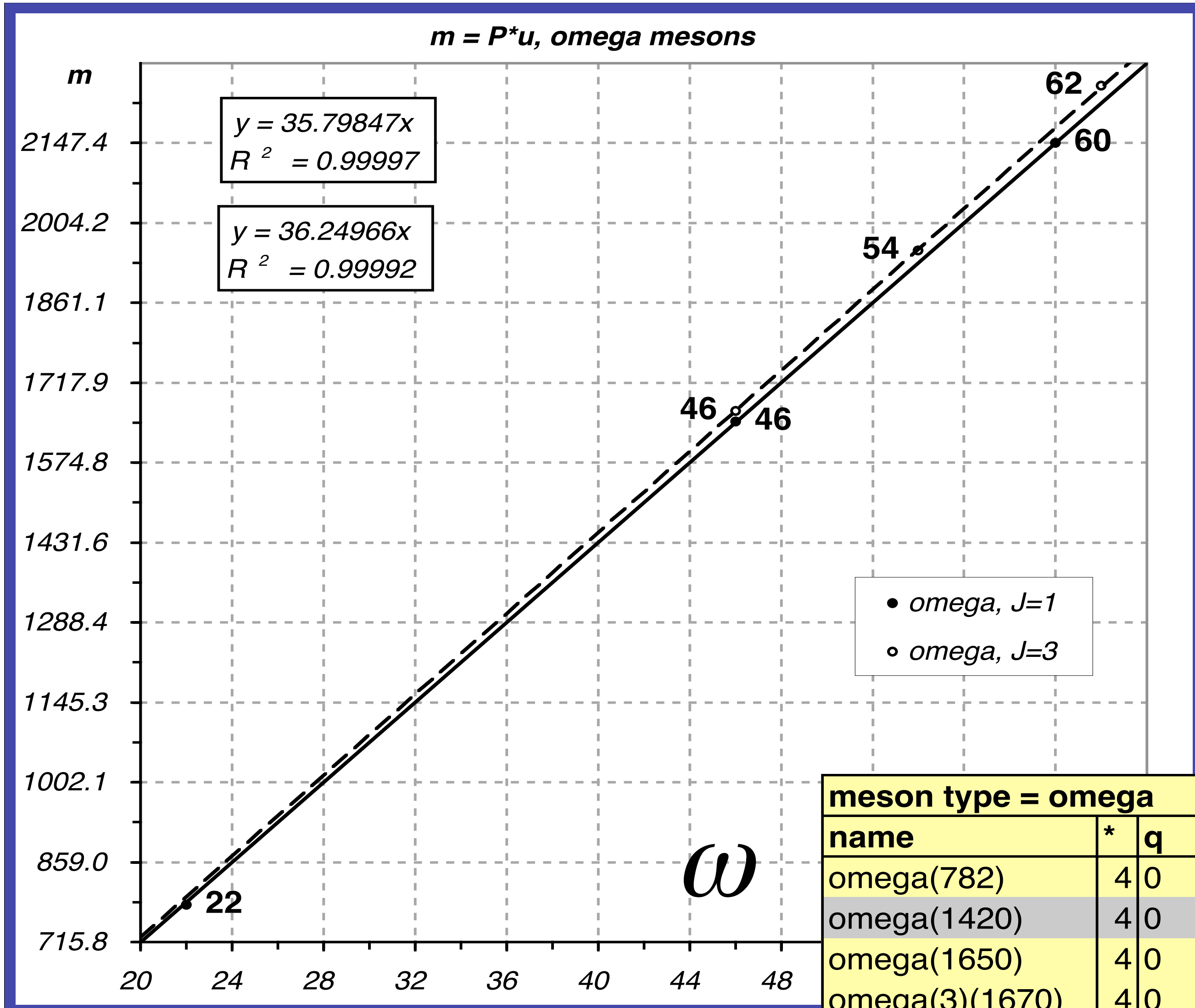




meson type = Y										
name	*	q	J	x	P	m	errm	u=m/P	dm	dm/m
Y(1S)	4	0	1		268	9460.3	0.26	35.300	5.5	0.06%
Y(2S)	4	0	1		284	10023.3	0.31	35.293	4.0	0.04%
Y(3S)	4	0	1	3	294	10355.2	0.50	35.222	-16.8	-0.16%
Y(4S)	4	0	1		300	10580.0	3.50	35.267	-3.7	-0.04%
Y(10860)	4	0	1		308	10865.0	8.00	35.276	-0.9	-0.01%
Y(11020)	4	0	1		312	11019.0	8.00	35.317	11.9	0.11%

summary Y mesons	
u	35.29 ± 0.009
p-value	0.985 --> $p(H_0) = 0.015$
spin dependence	not assessed, all states are J=1
omitted	1 Chauvenet

high mass



meson type = omega										
name	*****	**q**	**J**	**x**	**P**	**m**	**errm**	**u=m/P**	**dm**	**dm/m**
omega(782)	4	0	1		22	782.6	0.1	35.571	-5.0	-0.64%
omega(1420)	4	0	1	1	40	1419.0	31.0	35.475	-12.9	-0.91%
omega(1650)	4	0	1		46	1649.0	24.0	35.848	2.3	0.14%
omega(3)(1670)	4	0	3		46	1667.0	4.0	36.239	-0.5	-0.03%
omega(3)(1995)	2	0	3		54	1955.0	30.0	36.204	-2.5	-0.13%
omega(2145)	2	0	1		60	2148.0	15.0	35.800	0.1	0.00%
omega(3)(2250)	2	0	3		62	2250.0	20.0	36.290	2.5	0.11%

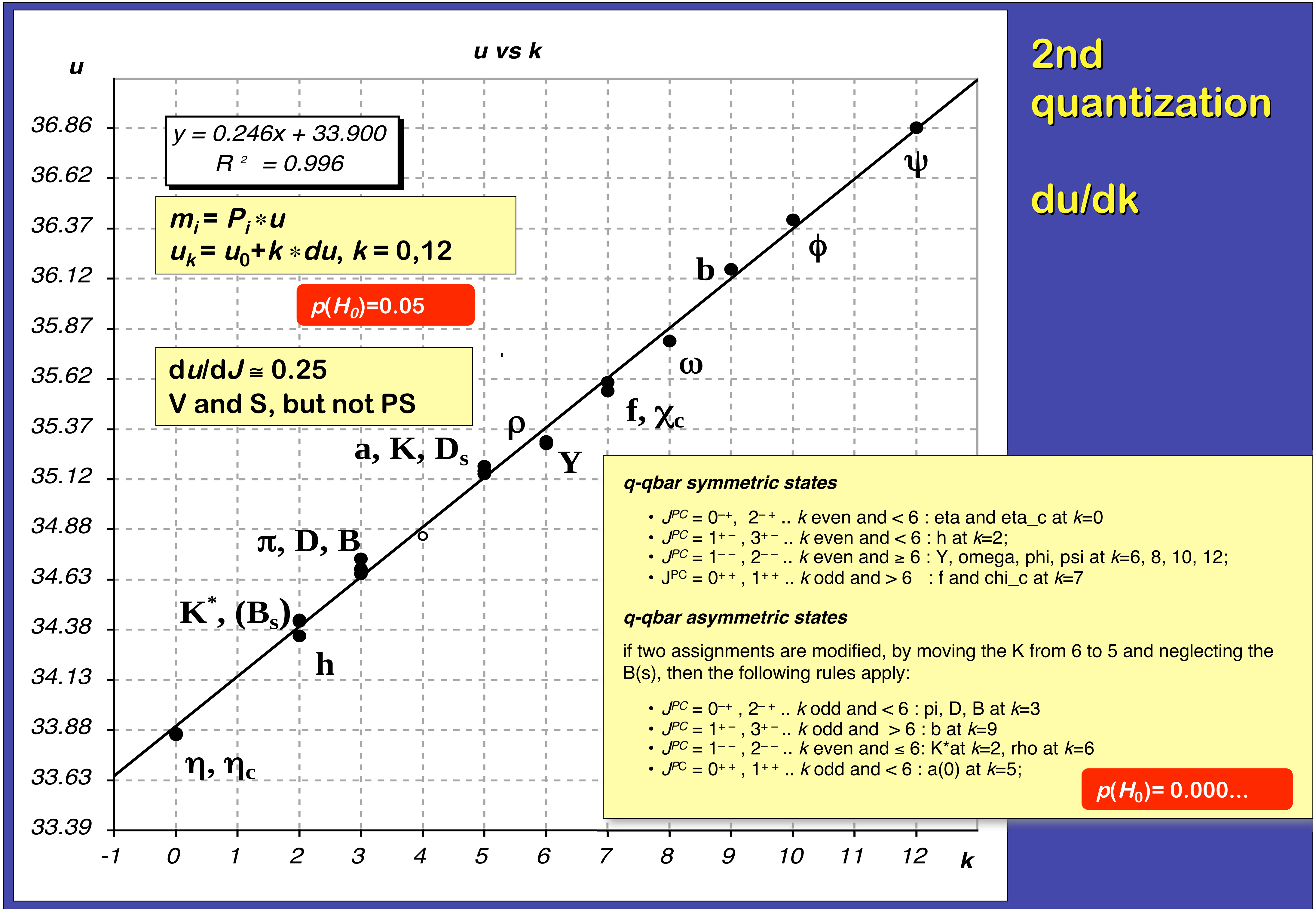
summary omega mesons	
omitted	1 large errm
spin dependence	yes, Z=13.9
u, J=1	35.80 ± 0.049
p-value	> 0.934 (all states), 0.942 for J=1, 0.947 for J=3

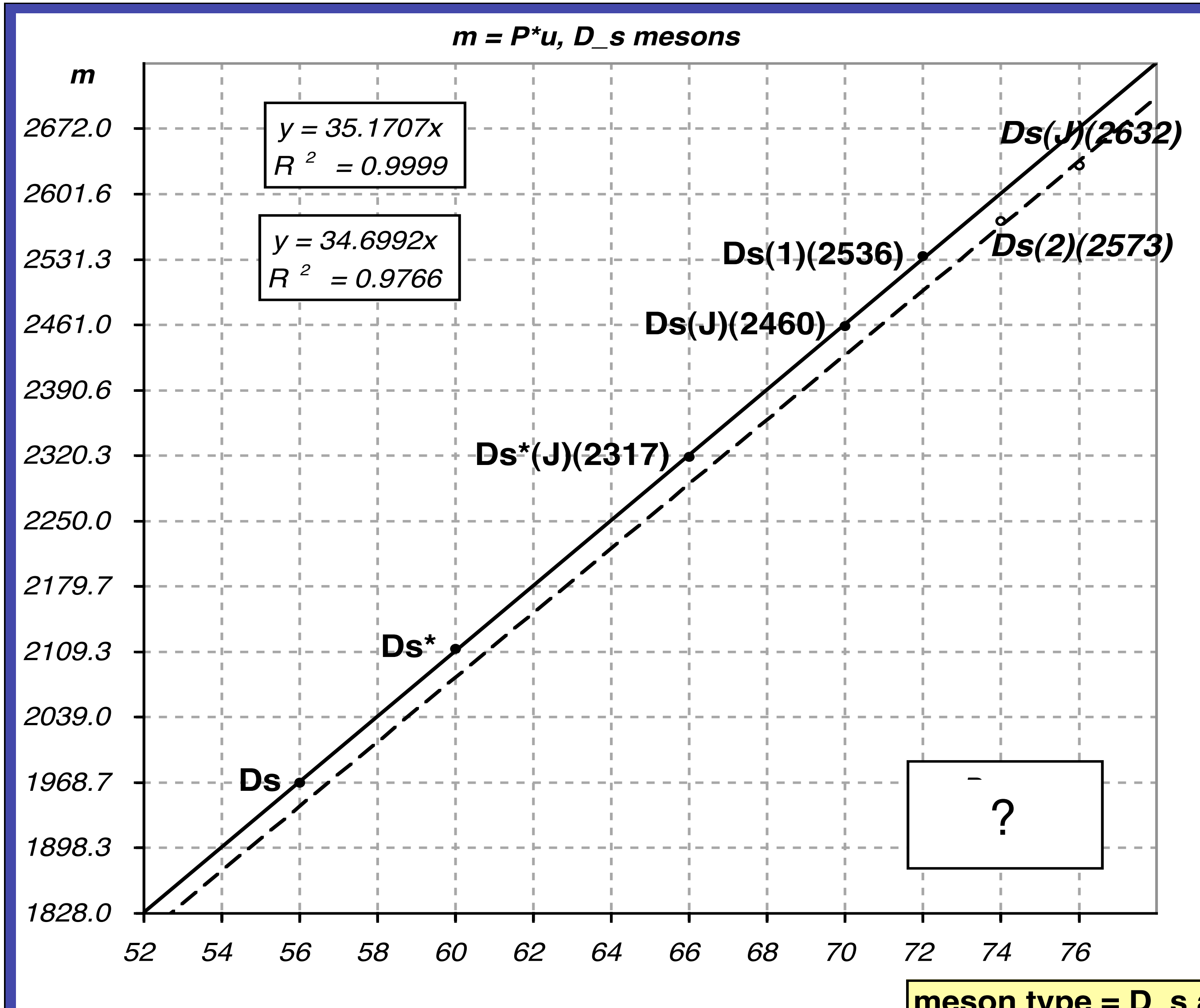
du/dJ

summary

Summary of mass unit analysis, mesons

type	k	u	erru	uw	p-value	du/dJ	states PDG	omitted (1)	(2)	(3)	(4)	tot	used	rating
pi	**3**	34.69	0.051	34.68	0.997	N	11	1		1	1	3	8	****
b	**9**	36.16	0.050	36.16	0.990	N	3						3	***
rho	**6**	35.19	0.071	**35.31**	0.973	N	11	2		1		3	8	***
a					0.995	Y	13	2				2	11	****
a(0)	**5**	35.00	0.073	**35.17**	0.941									
K	**6**	35.34	0.073	35.39	0.943	N	11				1	1	10	***
K*					0.882	Y	12	1		1	2	4	8	
K*(1)	**2**	34.35	0.016	34.35										****
eta	**0**	33.86	0.053	33.86	0.999	N	13	4				4	9	****
h	**2**	34.42	0.056	34.43	0.975	N	6	2				2	4	****
omega					0.934	Y	7	1				1	6	****
omega(1)	**8**	35.80	0.049	35.81	0.943									
phi					0.732	Y	3						3	**
phi(1)	**10**	36.51	0.050	**36.41**										
f	**7**	35.78	0.070	**35.60**	0.998	?	33	5	18			23	10	***
D^+	**3**	34.67	0.016	34.66	0.997	N	5						5	****
D^0		34.58	0.023	34.60	0.960	N	4						4	****
D(s)	**5**	35.16	0.021	35.15	0.997	N	6						6	****
eta(c)	**0**	33.89	0.022	33.87			2						2	**
psi	**12**	36.84	0.034	36.87	0.959		7			1		1	6	****
chi(c)	**7**	35.57	0.006	35.56		Y	3						3	**
B	**3**	34.74	0.005	34.73			3				1	1	2	*
B(s)	**2**	34.42	0.004	34.42			2						2	*
Y	**6**	35.29	0.009	35.30	0.985		6			1		1	5	****
		avg->	0.044		0.949		161	18	18	5	5	46	115	**<-tot**
leptons	**4**	34.84	0.022	34.84			2						2	**


2nd quantization
du/dk
u vs k
u
k
y = 0.246x + 33.900
R² = 0.996
m_i = P_i * u
u_k = u_0 + k * du, k = 0,12
p(H_0)=0.05
du/dJ ≅ 0.25
V and S, but not PS
36.86
36.62
36.37
36.12
35.87
35.62
35.37
35.12
34.88
34.63
34.38
34.13
33.88
33.63
33.39
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
ψ
φ
b
ω
f, χc
ρ
Y
a, K, Ds
π, D, B
K*, (Bs)
h
η, ηc
q-qbar symmetric states
• J^PC = 0−+, 2−+ .. k even and < 6 : eta and eta_c at k=0
• J^PC = 1+− , 3+− .. k even and < 6 : h at k=2;
• J^PC = 1−− , 2−− .. k even and ≥ 6 : Y, omega, phi, psi at k=6, 8, 10, 12;
• J^PC = 0++ , 1++ .. k odd and > 6 : f and chi_c at k=7
q-qbar asymmetric states
if two assignments are modified, by moving the K from 6 to 5 and neglecting the B(s), then the following rules apply:
• J^PC = 0−+ , 2−+ .. k odd and < 6 : pi, D, B at k=3
• J^PC = 1+− , 3+− .. k odd and > 6 : b at k=9
• J^PC = 1−− , 2−− .. k even and ≤ 6: K*at k=2, rho at k=6
• J^PC = 0++ , 1++ .. k odd and < 6 : a(0) at k=5;
p(H_0)= 0.000...

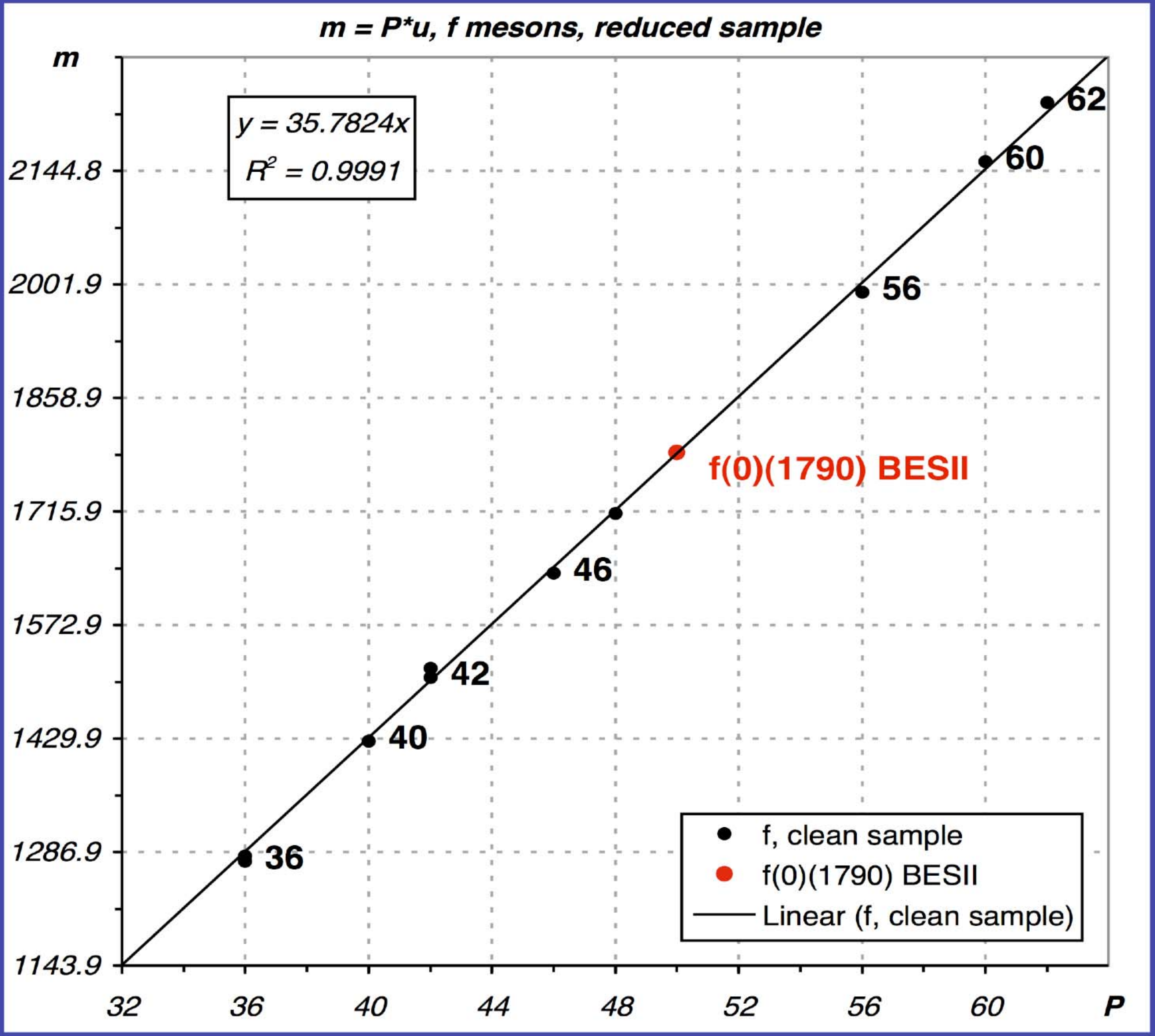


D-D* and D_s-D_s* u-mixing

meson type = D_s and D_s*										
ID	*	q	J	x	P	m	errm	u	dm	dm/m
D_s	4	+	0		56	1968.5	0.6	35.152	-1.1	-0.05%
D_s*	4	+	n		60	2112.4	0.7	35.207	2.2	0.10%
D_s*(J)(2317)	4	0	n		66	2319.0	0.4	35.136	-2.3	-0.10%
D_s(J)(2460)	4	0	?		70	2460.0	0.6	35.143	-2.0	-0.08%
D_s(1)(2536)	4	+	1?		72	2535.3	0.6	35.213	3.0	0.12%
D_s(2)(2573)	4	+	n		74	2572.4	1.5	34.762	4.7	0.18%
D_s(J)(2632)	slx	+			76	2632.6	1.6	34.639	-4.5	-0.17%

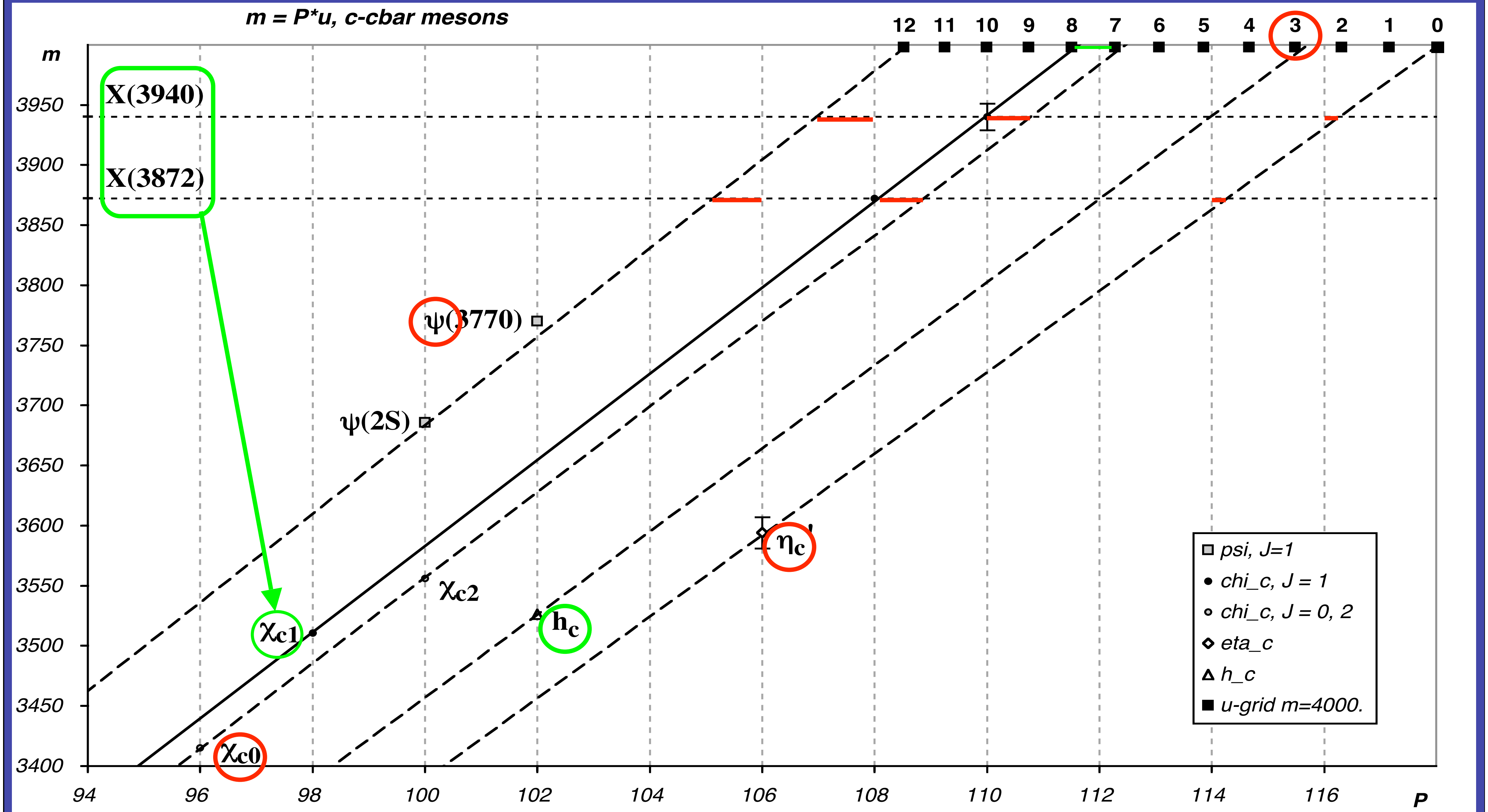
predictions

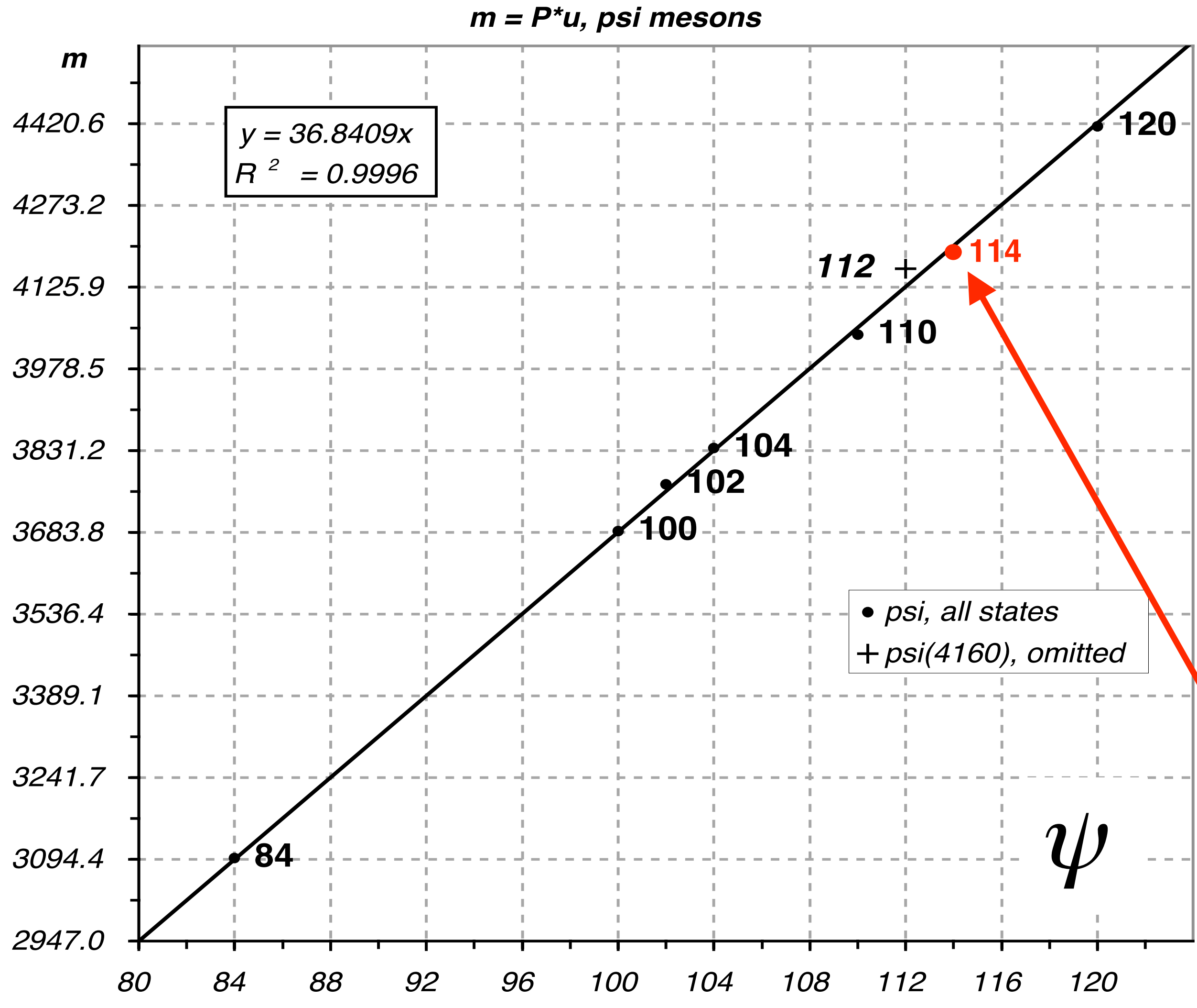
new states



m = P*u, f mesons, reduced sample
m
y = 35.7824x
R^2 = 0.9991
2144.8
2001.9
1858.9
1715.9
1572.9
1429.9
1286.9
1143.9
32
36
40
44
48
52
56
60
P
62
60
56
f(0)(1790) BESII
46
42
40
36
f, clean sample
f(0)(1790) BESII
Linear (f, clean sample)

quantum numbers determination





Reject: psi(4160)

The psi(4160) with a residual of 33, rejected by Chauvenet's criterion. Its mass quoted by the PDG is based on a single measurement by DASP, and in the DASP paper the result of their analysis is compared with MARK1 data showing a more complex peak structure.

Above the psi(4040) the MARK1 data show a peak at around 4110 and possibly more. The psi(4415) is seen unambiguously by both experiments. The DASP view of the discrepancy is: "..our data are in closer agreement with those of SLAC-LBL but show some differences in the finer details of the energy dependence. For instance the 4.16 structure is not resolved in the SLAC-LBL data".

For sure there are differences, but the DASP interpretation is questionable. Apparently some MARK1 peaks were never identified or never made it to the PDG. A possible interpretation of their spectrum around 4100 is: psi(4040), P=110; psi(4125), P=112; possibly a psi(4200) , P=114; no psi(4160).

2007: new BES value = 4191.6 ± 6.0

outliers

meson type = psi

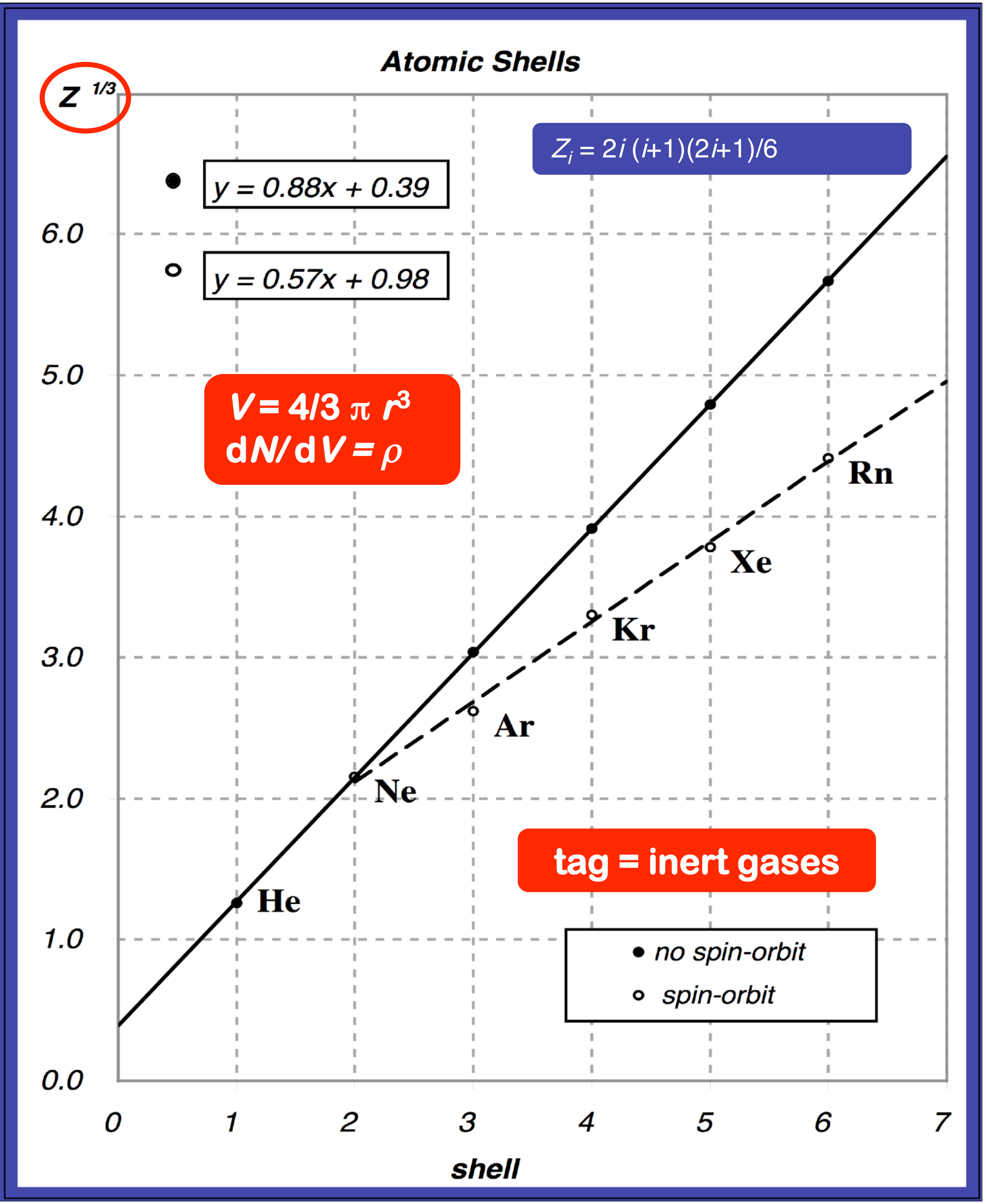
name	*	q	J	x	P	m	errm	u	dm	dm/m
psi(1S)	4	0	1		84	3096.9	4.0E-02	36.868	2.2	0.07%
psi(2S)	4	0	1		100	3686.0	9.0E-02	36.860	1.9	0.05%
psi(3770)	4	0	1		102	3769.9	2.5	36.960	12.1	0.32%
psi(3836)	3	0	2?		104	3836.0	13.0	36.885	4.5	0.12%
psi(4040)	4	0	1		110	4040.0	10.0	36.727	-12.5	-0.31%
psi(4415)	4	0	1		120	4415.0	6.0	36.792	-5.9	-0.13%
psi(4160)	4?	0	1	3	112	4159.0	20.0	37.134	32.8	0.79%

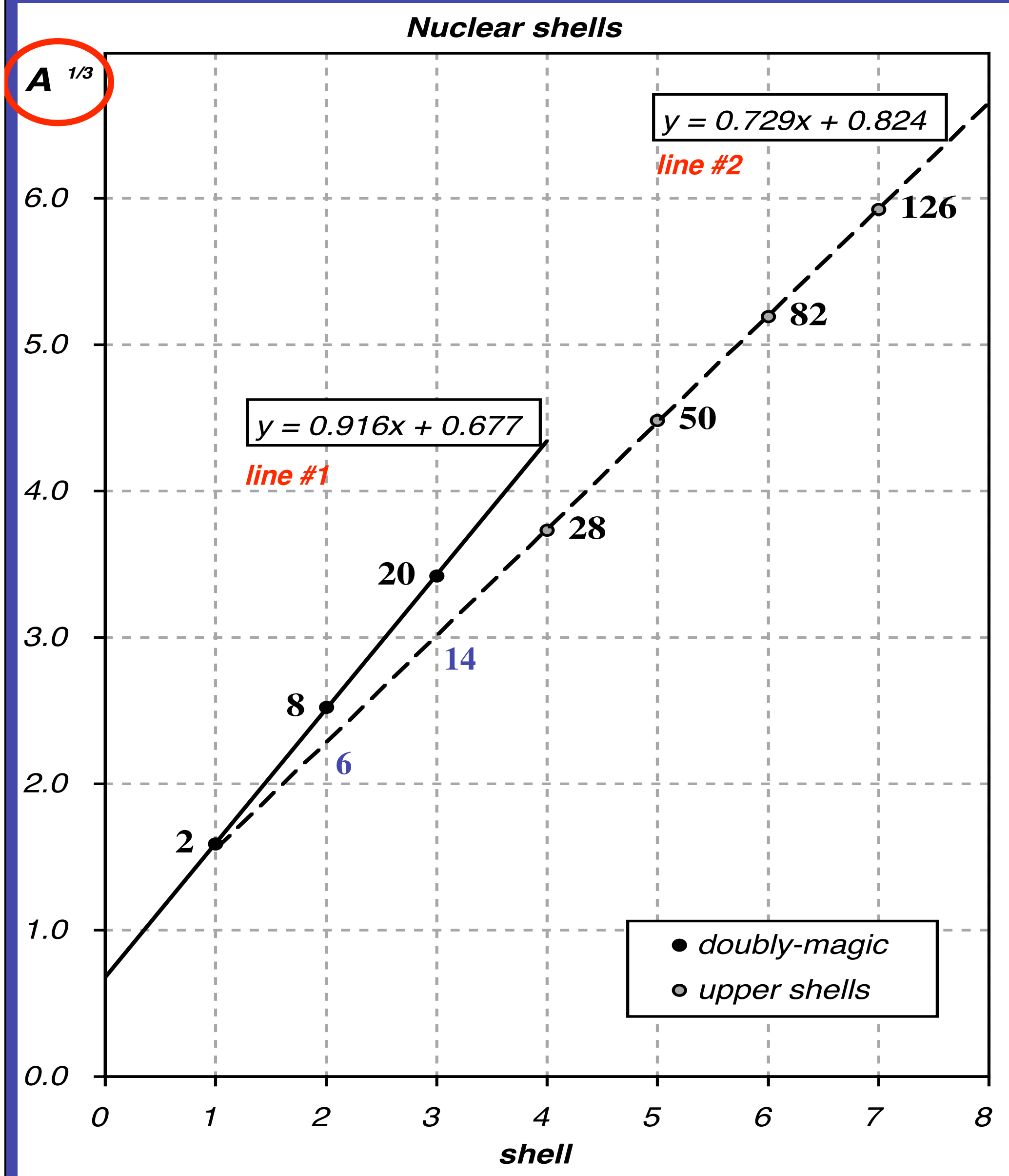
recap on mesons

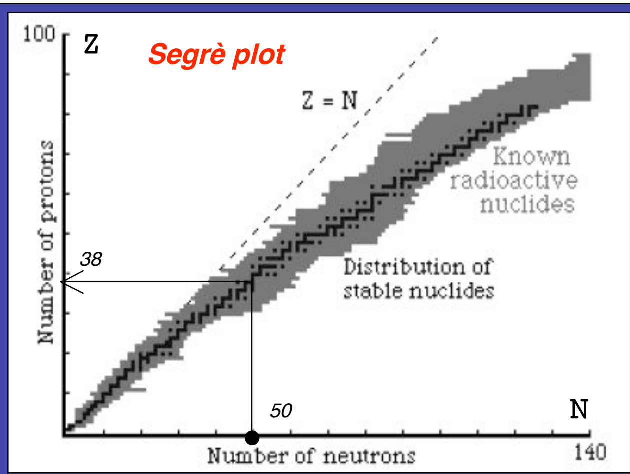
- mass rules
- shells : are hadrons
  shell-structured ?

atomic shells

$Z^{1/3}$







nuclear shells

$A^{1/3}$

2 shell lines with interesting properties:

- **cross at the first shell**, He-4 (δy<3%);
- in shells 2 and 3, line #2 corresponds to values of *A* of **12=6+6** and **28=14+14**; 14 recognized long ago as quasi-magic; the "magicity" of 6 is a more recent result;
- the **ratio of the cubes of the slopes of the two lines is 1.99**, very close to 2: the number of nucleons in series #2 grows from one shell to the next at a rate = 1/2 the one of series #1;
- in line #1 the **"packing fraction" is maximal**:

$$(0.916)^3 = 0.768$$

N_i = 2, 8, 20, 28, 50, 82, 126: magic
Z_i from Segrè plot, max. stability
$A_i = N_i + Z_i$
plot $A_i^{1/3}$ vs i, tag = N_i

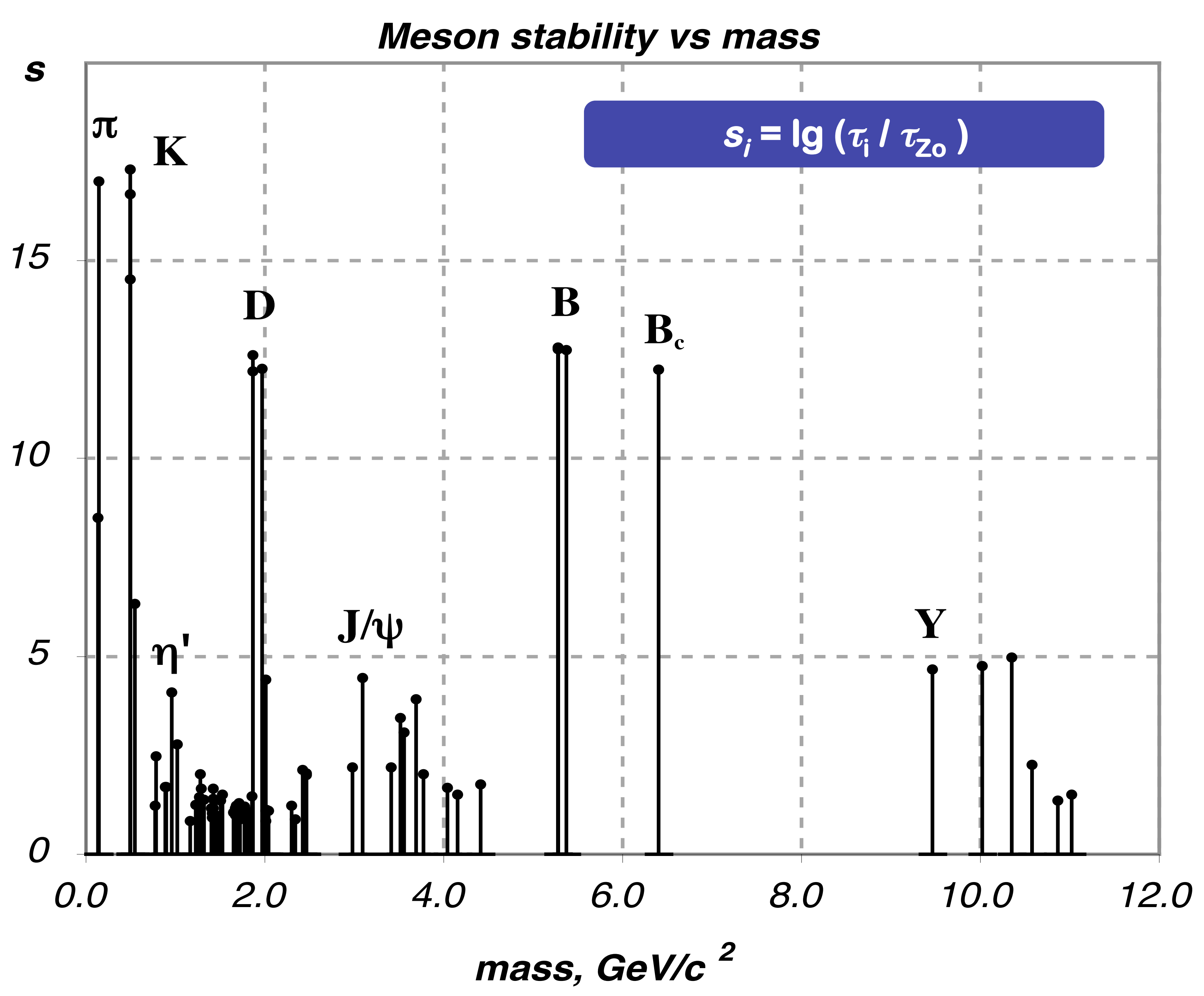
$A1(n) = 2^*[\Sigma(i+1)^*i,\ \ i=n,1,1] = 2^*[(n+1)^*n + n^*(n-1) +..+2^*1]$

$= 4, 16, 40, 80, ...$

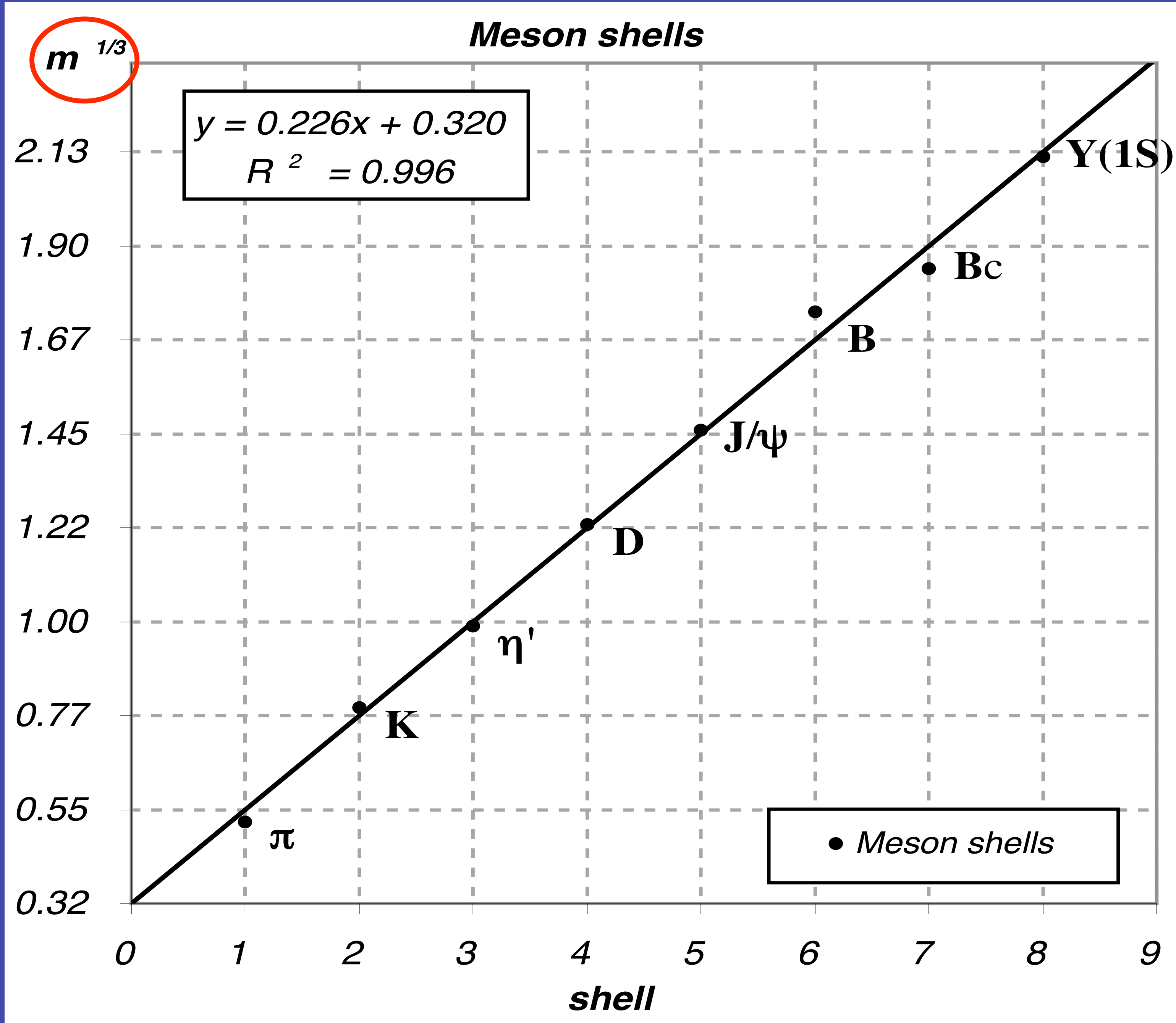
$A2(n) = 2^*[\Sigma(i+1)^*i,\ \ i=n,1,2] = 2^*[(n+1)^*n + (n-1)^*(n-2)+..]$

$= 4, 12, 28, 52, 88, 136, 200, 280$

meson stability



meson shells



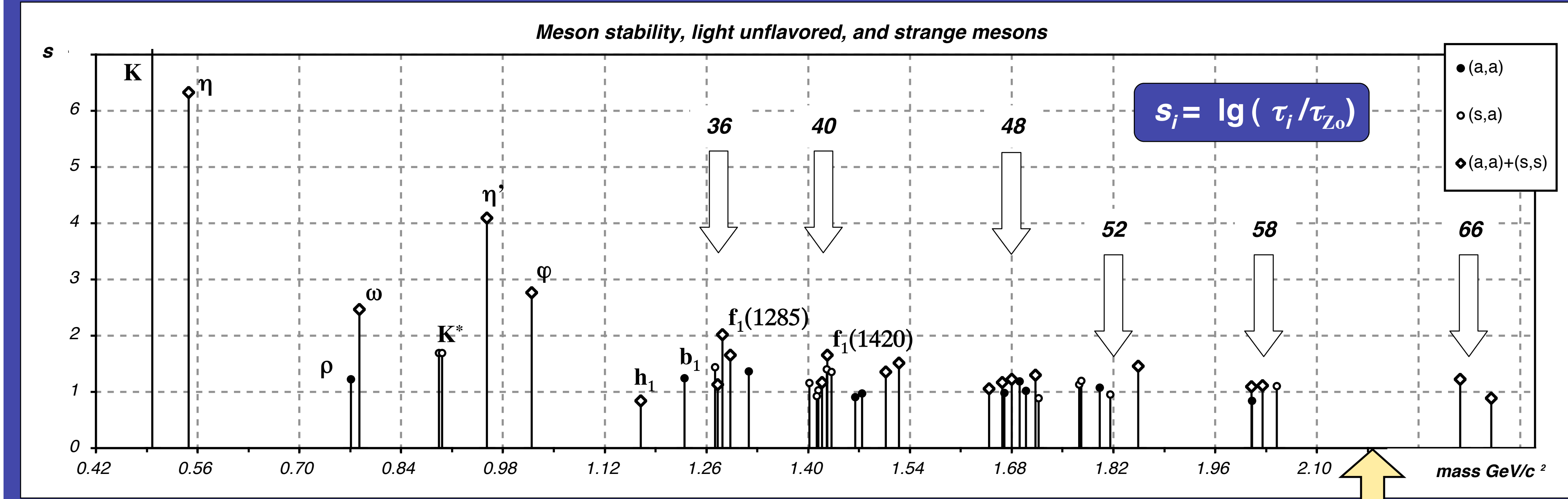
combine meson mass shell plot with mass units:

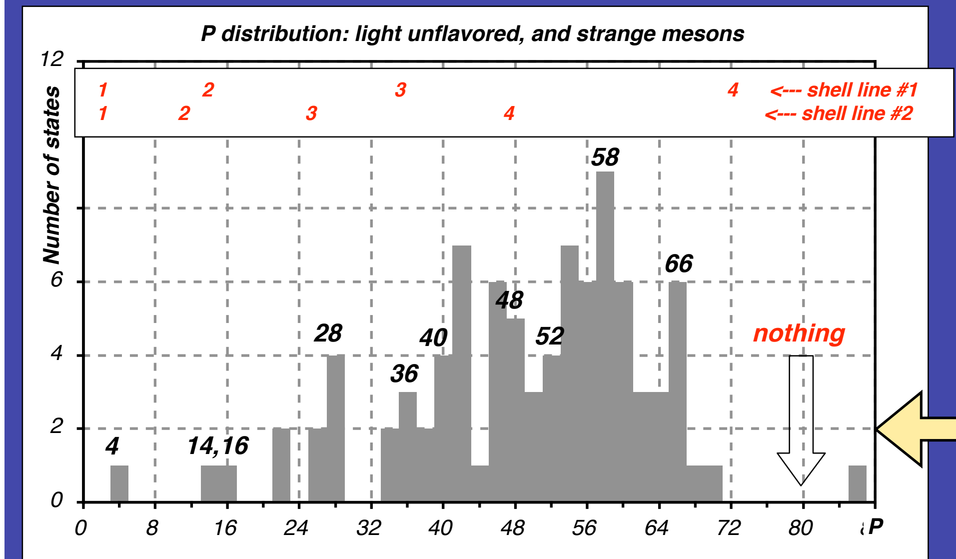
35 MeV/c^2 = 1 parton

M(i)**:** (**4, 14, 28, 54, 84,** 152, * , 294) [*i* =1,8], y = **0.712** ∗ x + **0.894**, R^2 = 0.9981

very similar to the corresponding values for the second nuclear line

N(i)**:** (**4, 12, 28, 52, 88**, 140, 208) [*i* =1,7], y = **0.729** ∗ x + **0.824**, R^2 = 0.9999





meson stability up to 2 GeV/c^2 with mass scale in steps of 70 MeV/c^2:

- the η **at *P*=16**, analogous of the **doubly-magic O-16**
- three clusters around 1260 MeV/c^2 (*P*=36), 1420 MeV/c^2 (*P*=40), and 1680 MeV/c^2 (*P*=48).
- three further clusters with fewer states, ~ 1820 MeV/c^2 (*P*=52), 2030 MeV/c^2 (*P*=58), and 2310 MeV/c^2 (*P*=66).

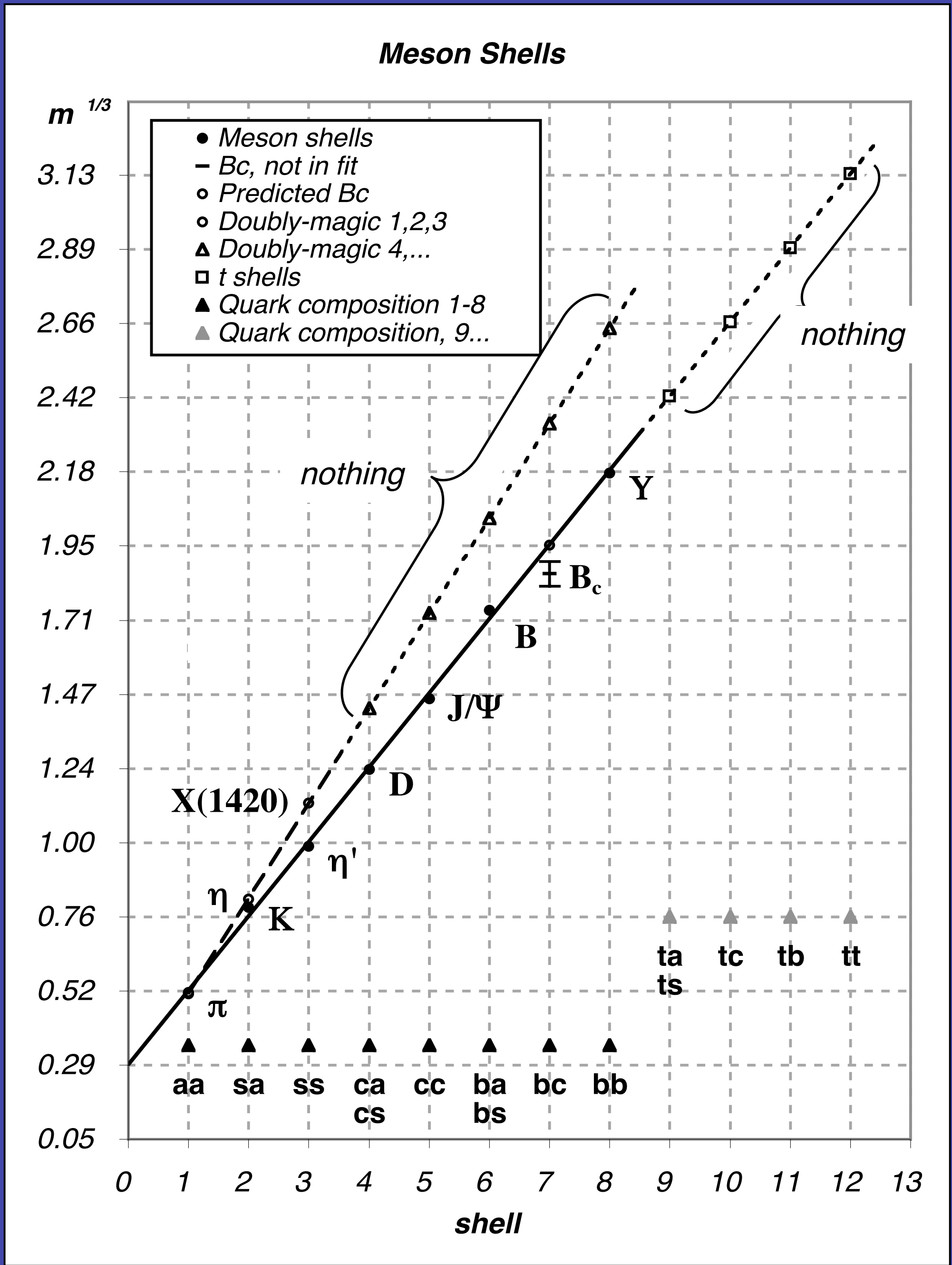
P=40 corresponds to shell 3 in the nuclear line #1, the **doubly-magic Ca-40**.

the *P* distribution for all (a,a), (s,a) and (s,s) states confirms the three clusters around **36, 40** and **48**, as well as at **52, 58** and **66**. In the shell interpretation the peaks at *P*=36, 48, 52, 58 and 56 would correspond to **sub-shells** (to be developed).

***P*=80** is the **doubly-magic shell 4** ~ 2800 MeV/c^2; the histogram is empty from *P*=72 to 84: as in nuclei, the **doubly-magic-equivalent shell series stops at 3.**

sub-shells

meson shells summary



- meson shells 1 to 8 corresponds to nuclear shell line #2, and also **doubly-magic** shells can be identified:
  1) π at $P = 4$ ~ He-4
  2) η at $P = 16$ ~ O-16
  3) states at $P = 40$ ~ Ca-40

  but no states are known near the extrapolated mass values for the following shells in that series, P=80, ...;

- on the main meson shell line, the **quark composition progression** from shell 1 to 8 is:

  aa, sa, ss, ca+cs, cc, ba+bs, bc, bb ;

  – intriguing role of the s quark,

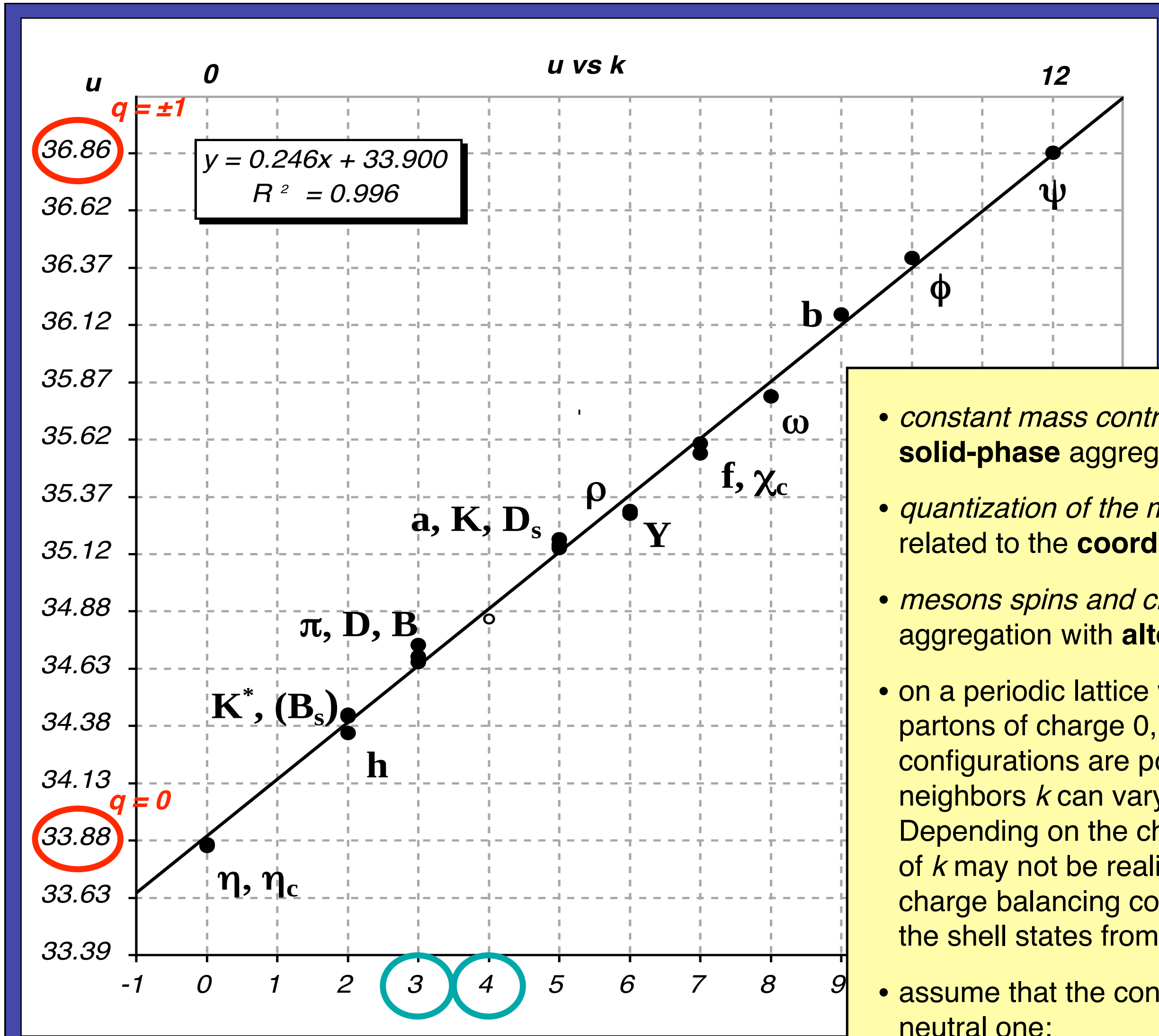
  – explanation of **the mysterious values of quark masses** (for whatever it is worth);

- **t quark:** expect 4 more shells at specific mass values in the range 14 - 31 GeV/c^2, none observed;

  – is shell **8** the **structural limit** for this kind of bound states, like 6 for atoms and 7 or 8 for nuclei?

  – what are the **top events** from FNAL?

  $$m(\mathrm{t}) = m(\mathrm{W}) + m(\mathrm{Z}^0)$$

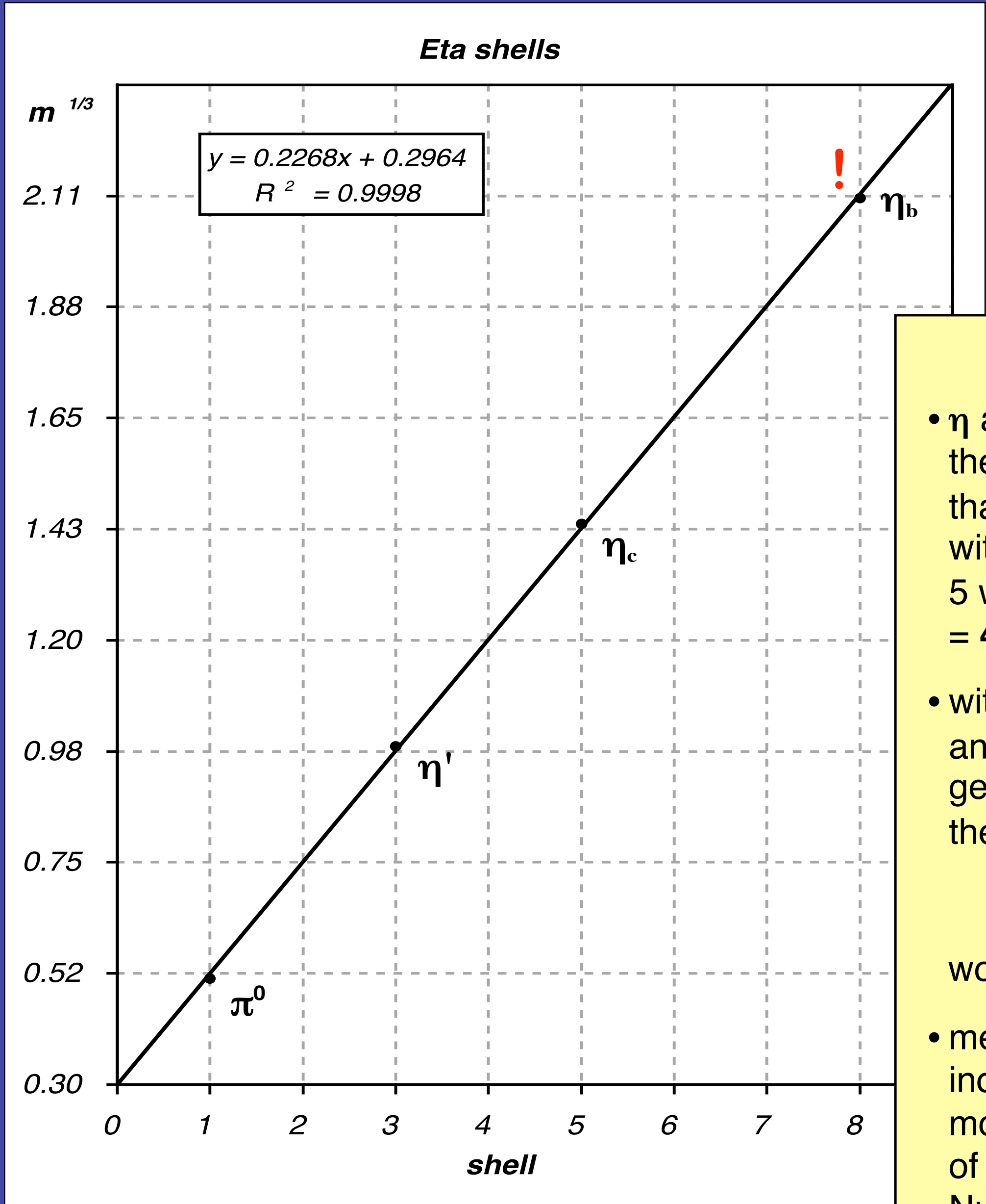


- **solid-phase**
- **coordnum = 12**
- **charges**

- *constant mass contribution for each parton*: suggests **solid-phase** aggregates, possibly a **3D lattice** organization;
- *quantization of the mass unit on a grid of* ***13=12+1*** *values:* may be related to the **coordination number** of the lattice;
- *mesons spins and charges equal or close to 0, with a large number of partons:* aggregation with **alternating up/down spins and +/- charges**.
- on a periodic lattice with **coordination number = 12** (such as the **FCC**), with spin-1/2 partons of charge 0, -1 and +1, arranged as a partially charged "ionic" lattice, several configurations are possible. For a given node of the lattice, the number of charged neighbors k can vary from 0 (all neutral) to 12 (all charged), **a total of 13 values**. Depending on the charge balancing constraints on these lattice variants, some values of k may not be realized, while other may correspond to more than one configuration; charge balancing constraints might be the reason for the deviation of the value of P of the shell states from series S2.
- assume that the contribution to the total mass is larger for a charged parton than for a neutral one:
  - $u(0)$ = 33.88 MeV/c^2, neutral parton,
  - $u(12)$ = 36.84 MeV/c^2 charged parton;

this assumption agrees with the charges of the final products of the decays of the μ (1 charged out of 3 = 4/12, k=4) and of the $\pi^{\pm}$(1 charged out of 4 = 3/12, k=3) as verified by the position of the corresponding points on the u-grid. This would not be true with the neutral parton heavier than the charged one.

interpretation



- η and η_c is at ***k*=0 on the u-grid**, with **all constituents neutral**; the specific mass unit of the π^0 is 33.74, close to *u*(0)=33.88, so that 4 neutral constituents can be assumed; the pion is at shell 1 with *P*=4, while the η' is at shell 3 with *P*=28, and the η_c at shell 5 with *P*=88, right at the nominal values of *P* in the series A2(*n*) = **4**, 12, **28**, 52, **88**, ...
- with no charged constituents, the η and η_c do not need to obey any **charge balancing constraints** and can sit right at the geometrical shell closure; this should also apply to the η_b, therefore it is expected that the mass shell line with:

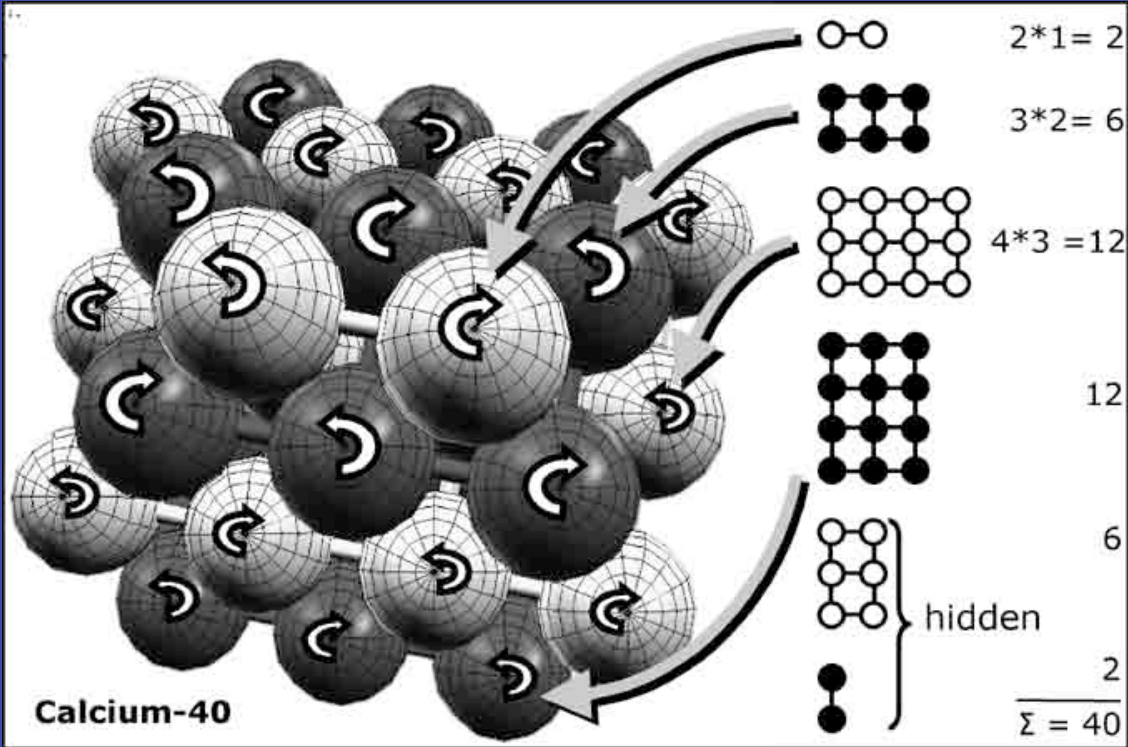
  π^0, η', η_c, η_b in shells **1, 3, 5, 8**

  would show a **sharper alignment,** as verified by the chart;
- mesons are similar to nuclei and at the same time show indications of a solid-phase FCC structure, and this may be more than a coincidence: **FCC nuclei** are not new, see the work of **N. D. Cook**, and his recent book: Models of the Atomic Nucleus (Springer).

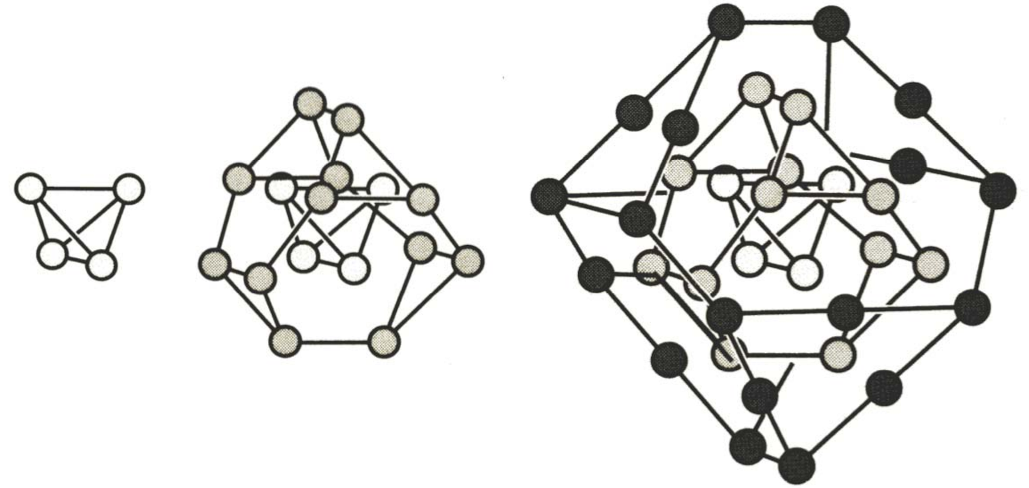
η shells

$$A1(n) = 2*[\Sigma(i+1)*i,\ \ i=n,1,1] = 2*[(n+1)*n + n*(n-1) +..+2*1]$$

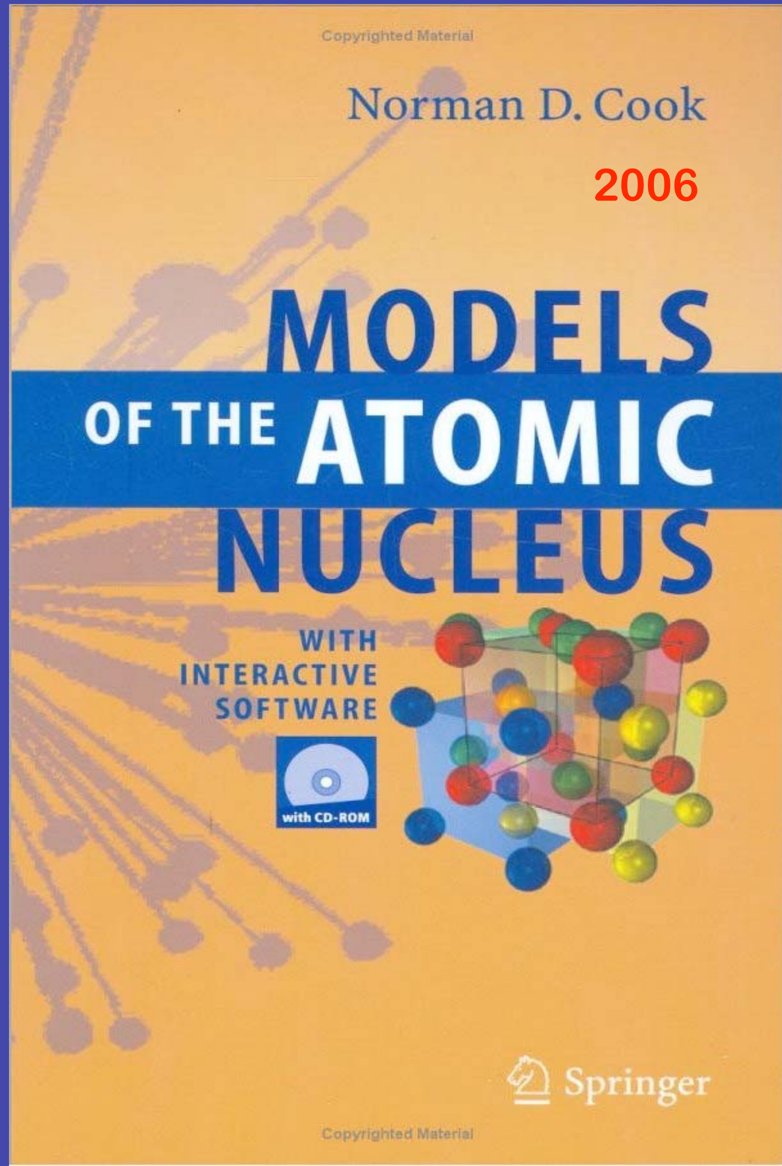
$$A2(n) = 2*[\Sigma(i+1)*i,\ \ i=n,1,2] = 2*[(n+1)*n + (n-1)*(n-2)+..]$$



[tetrahedrically-truncated tetrahedrons]



He-4 O-16 Ca-40



HADRON 07 logo with 8 tetrahedrical meson shells, 4 partons in the first shell and the hexagonal mesh of the fcc lattice

recap on mesons

- mass rules
- shells
- constituents

Looking for neutral and charged partons and antipartons with spin 1/2 and mass less than 30 MeV/c^2, and with **more than one type of neutrals**, among the known particles there is only one possible choice:

the stable leptons -->

constituents:

stable leptons?

Surveys in High Energy Physics
Volume 1(2), January 1980, pp. 113-140
0142-2413/80/0102-113-140$04.50/0
© 1980 harwood academic publishers gmbh
Printed in the United States of America

STABLE PARTICLES AS BUILDING BLOCKS OF MATTER

1980

A.O. BARUT
Department of Physics, University of Colorado,
Boulder, Colorado 80309

Only absolutely stable indestructible particles can be truly elementary. A simple theory of matter based on the three constituents, proton, electron and neutrino (and their antiparticles), bound together by the ordinary magnetic forces is presented, which allows us to give an intuitive picture of all processes of high-energy physics, including strong and weak interactions, and make quantitative predictions.

I. INTRODUCTION

SU(3) from permutations

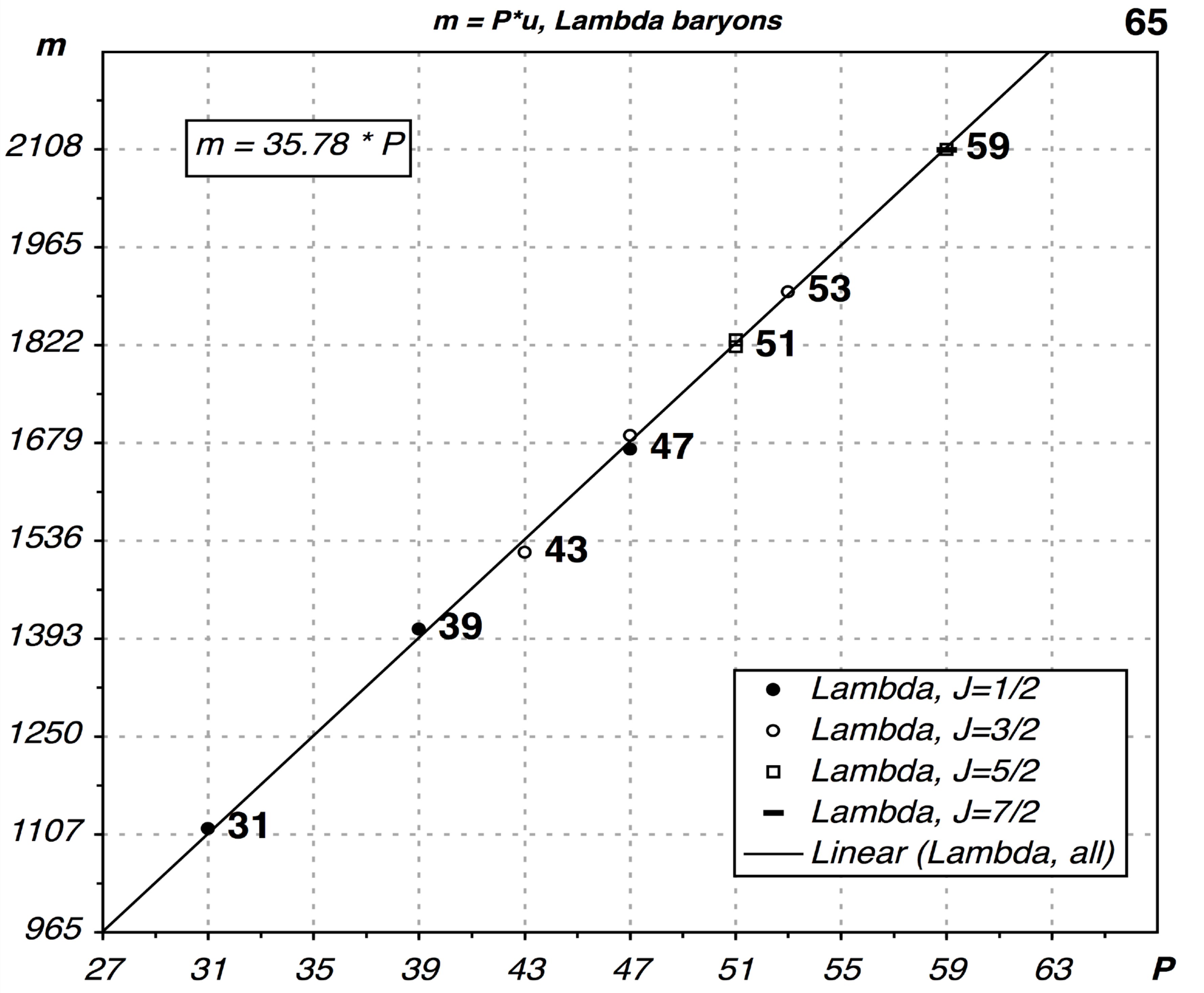
At present, the picture of elementary particle physics mostly used in high-energy phenomenology is becoming admittedly very complicated. Besides leptons (which we see), one introduces families of "quarks", each with different colours, then the so-called "gluons", which are the gauge vector mesons binding the quarks, then there are the so-called "Higgs particles", which give masses to some of the vector mesons (all of which are not seen in the laboratory). One is already beginning to talk about a second generation of more fundamental and simpler objects for these quarks and gluons etc., even though these first generations of "basic" objects have not been seen. This type of framework seems to create more problems than it solves [1].

the baryons

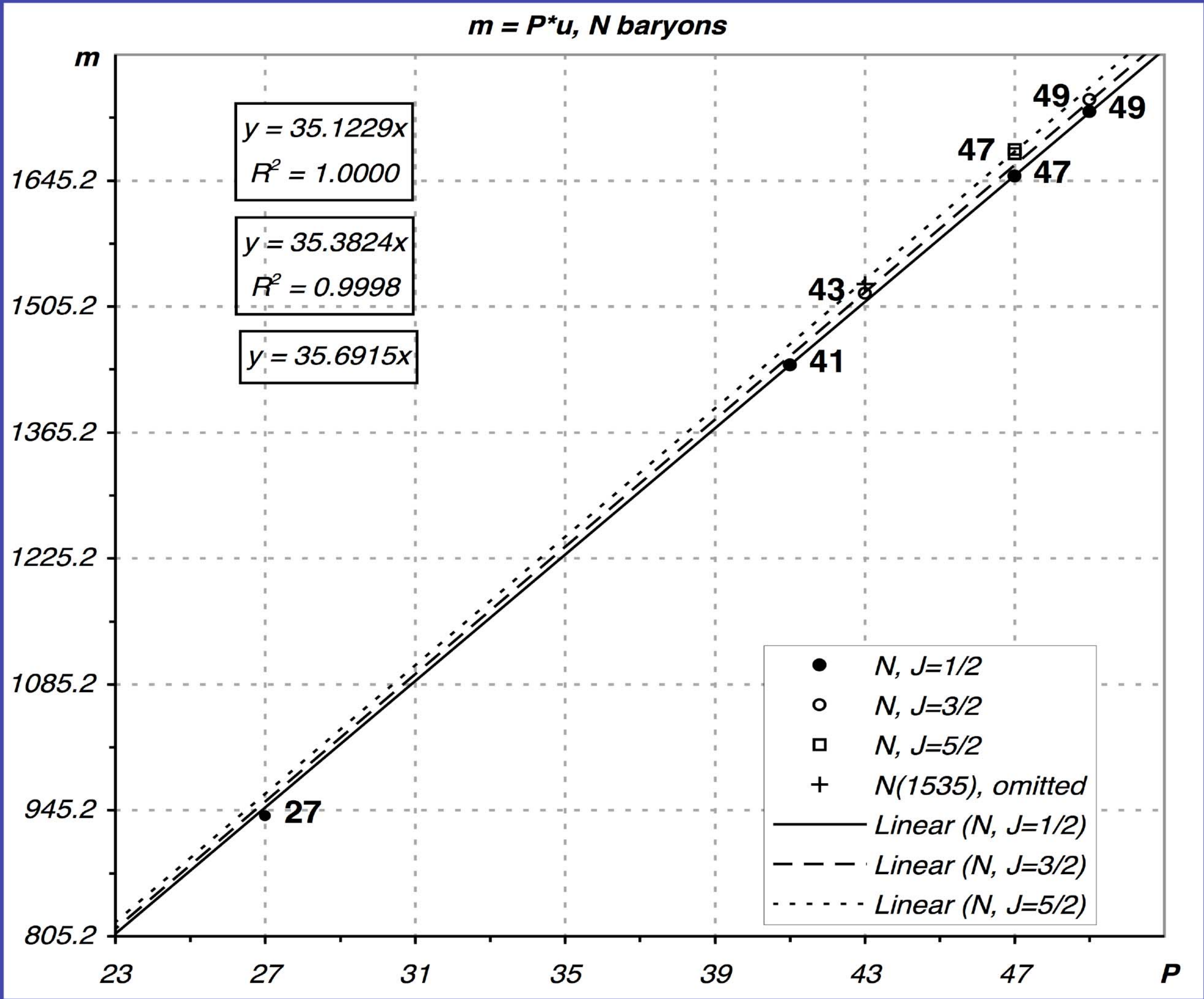
- mass rules

PRELIMINARY

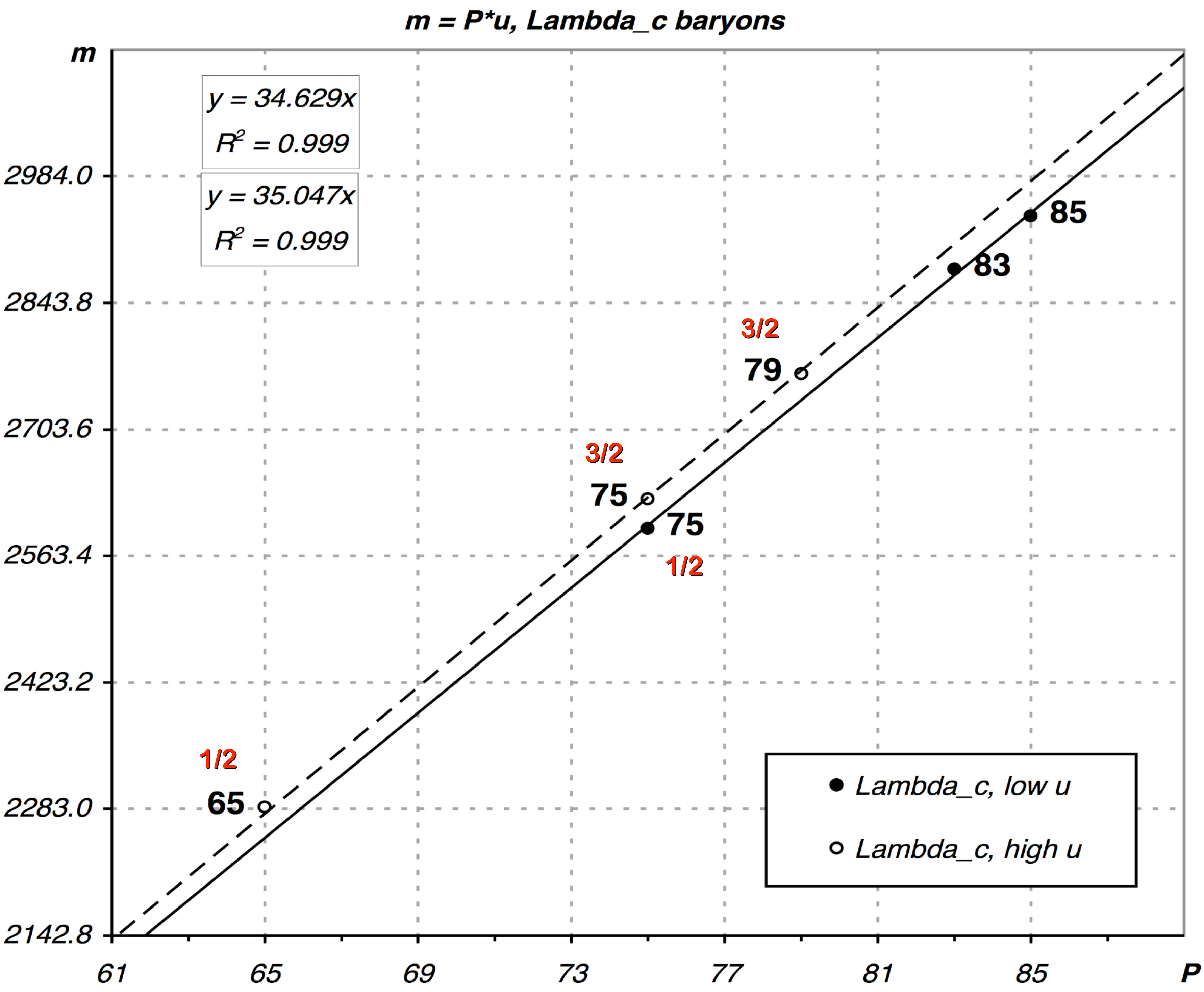
regs


m = P*u, Lambda baryons
m
m = 35.78 * P
2108
1965
1822
1679
1536
1393
1250
1107
965
27
31
35
39
43
47
51
55
59
63
P
59
53
51
47
43
39
31
Lambda, J=1/2
Lambda, J=3/2
Lambda, J=5/2
Lambda, J=7/2
Linear (Lambda, all)

du/dJ

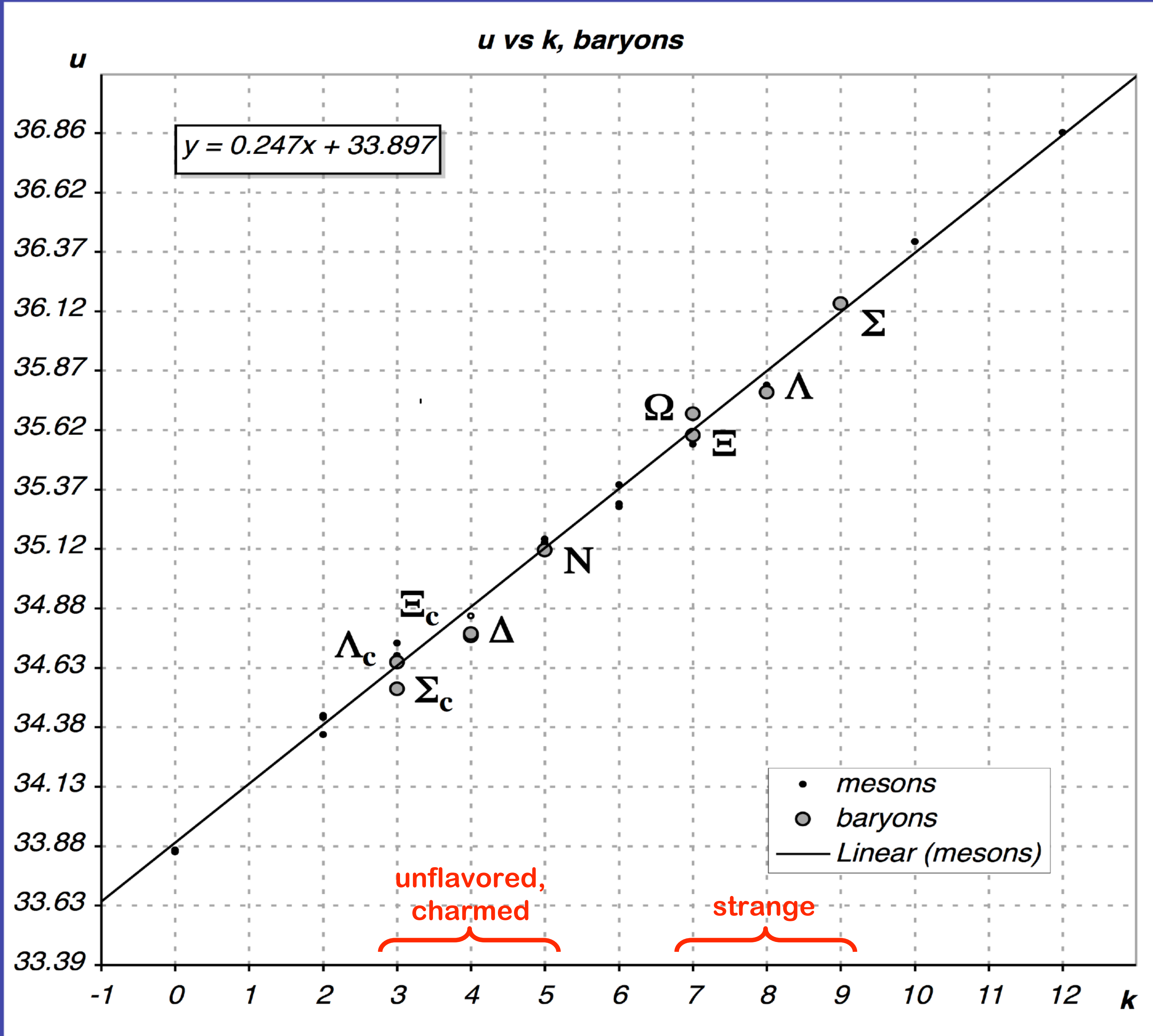

m = P*u, N baryons
m
y = 35.1229x
R2 = 1.0000
y = 35.3824x
R2 = 0.9998
y = 35.6915x
1645.2
1505.2
1365.2
1225.2
1085.2
945.2
805.2
23
27
31
35
39
43
47
P
49
49
47
47
43
41
27
N, J=1/2
N, J=3/2
N, J=5/2
N(1535), omitted
Linear (N, J=1/2)
Linear (N, J=3/2)
Linear (N, J=5/2)

mix



m = P*u, Lambda_c baryons
m
y = 34.629x
R2 = 0.999
y = 35.047x
R2 = 0.999
2984.0
2843.8
2703.6
2563.4
2423.2
2283.0
2142.8
85
83
3/2
79
3/2
75
75
1/2
1/2
65
Lambda_c, low u
Lambda_c, high u
61
65
69
73
77
81
85
P

u vs k

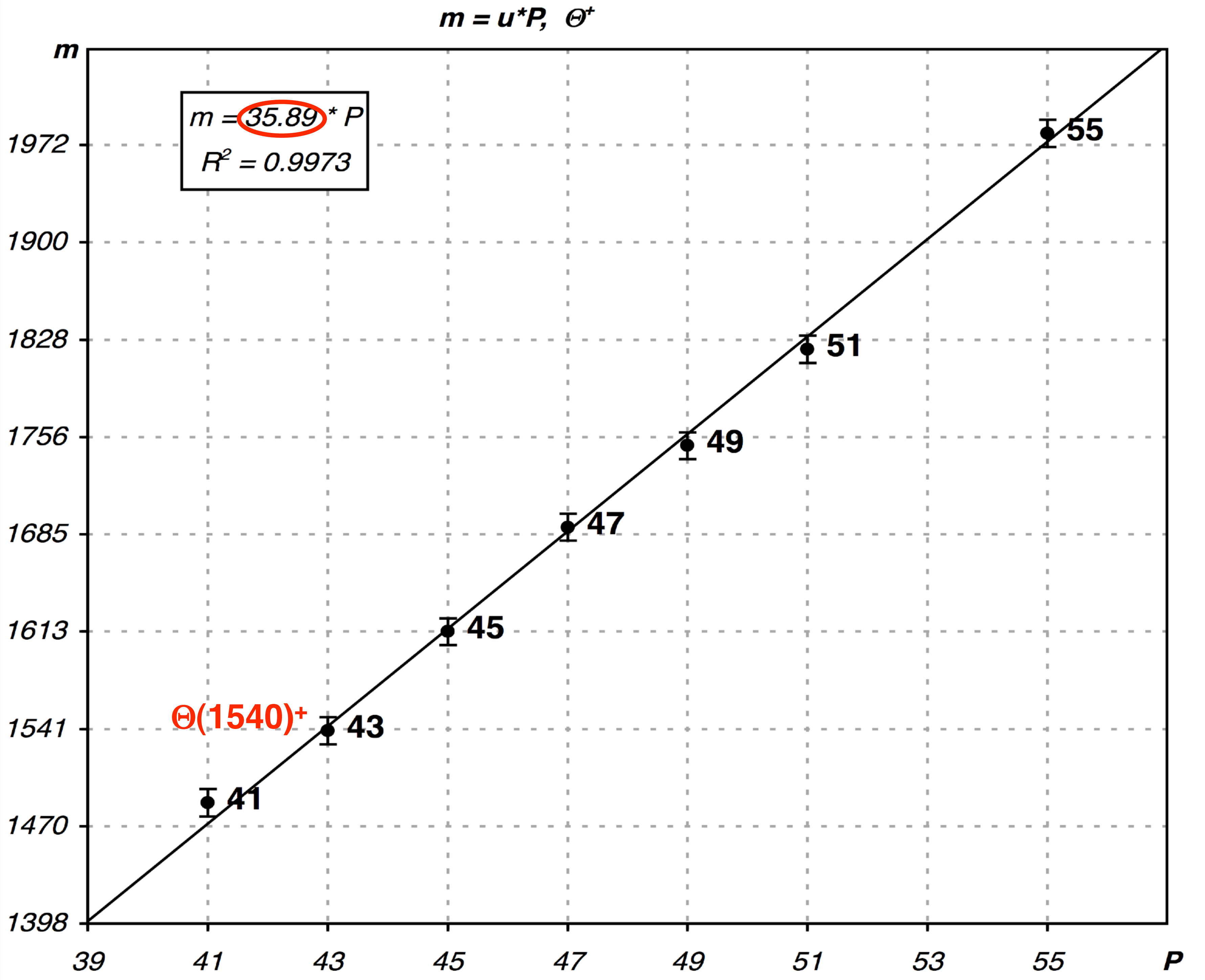


u vs k, baryons
u
y = 0.247x + 33.897
36.86
36.62
36.37
36.12
35.87
35.62
35.37
35.12
34.88
34.63
34.38
34.13
33.88
33.63
33.39
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
k
Σ
Λ
Ω
Ξ
N
Ξc
Δ
Λc
Σc
mesons
baryons
Linear (mesons)
unflavored,
charmed
strange

special baryons

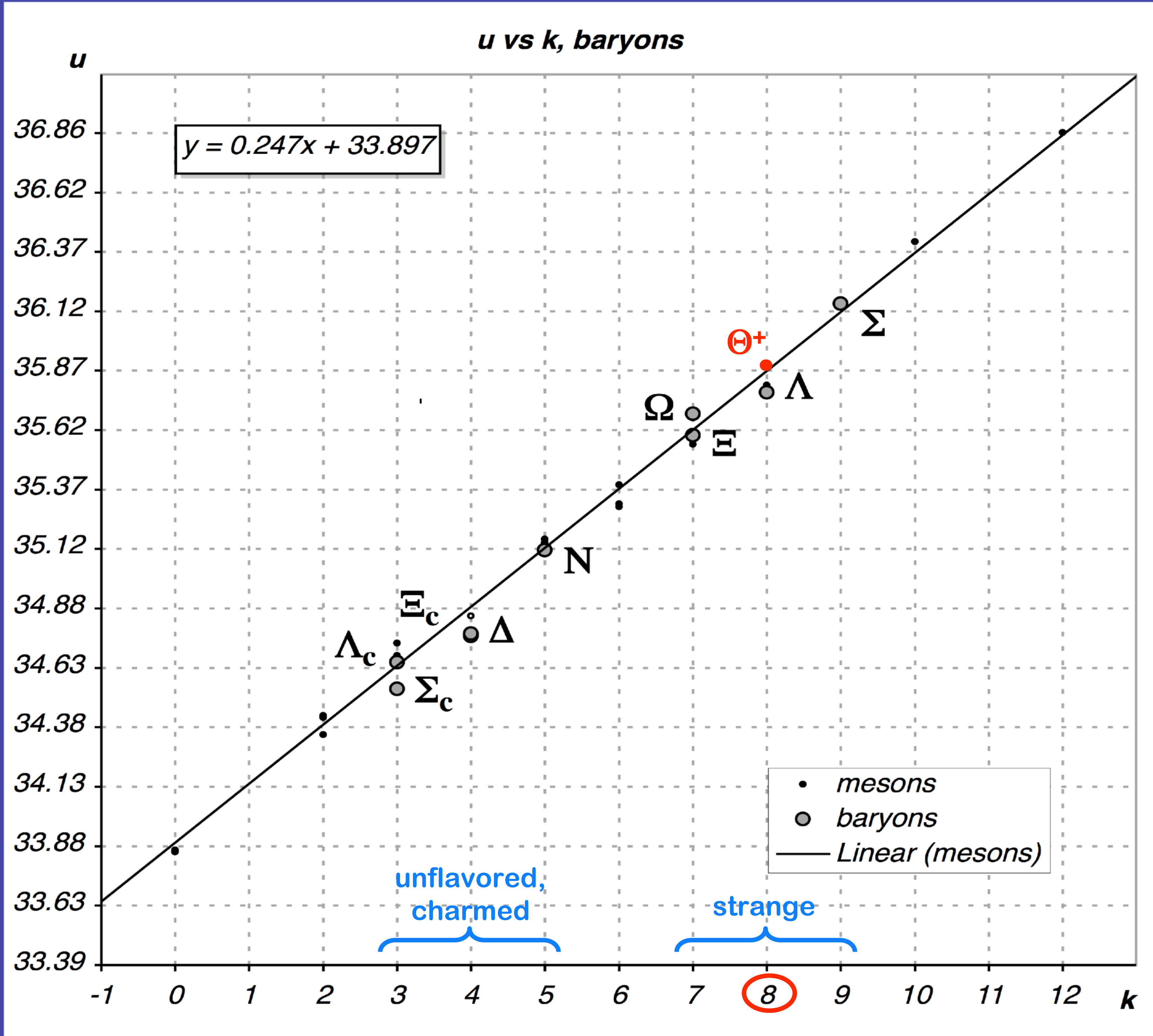
7 Θ+

P. Aslanyan



u vs k

Θ^+

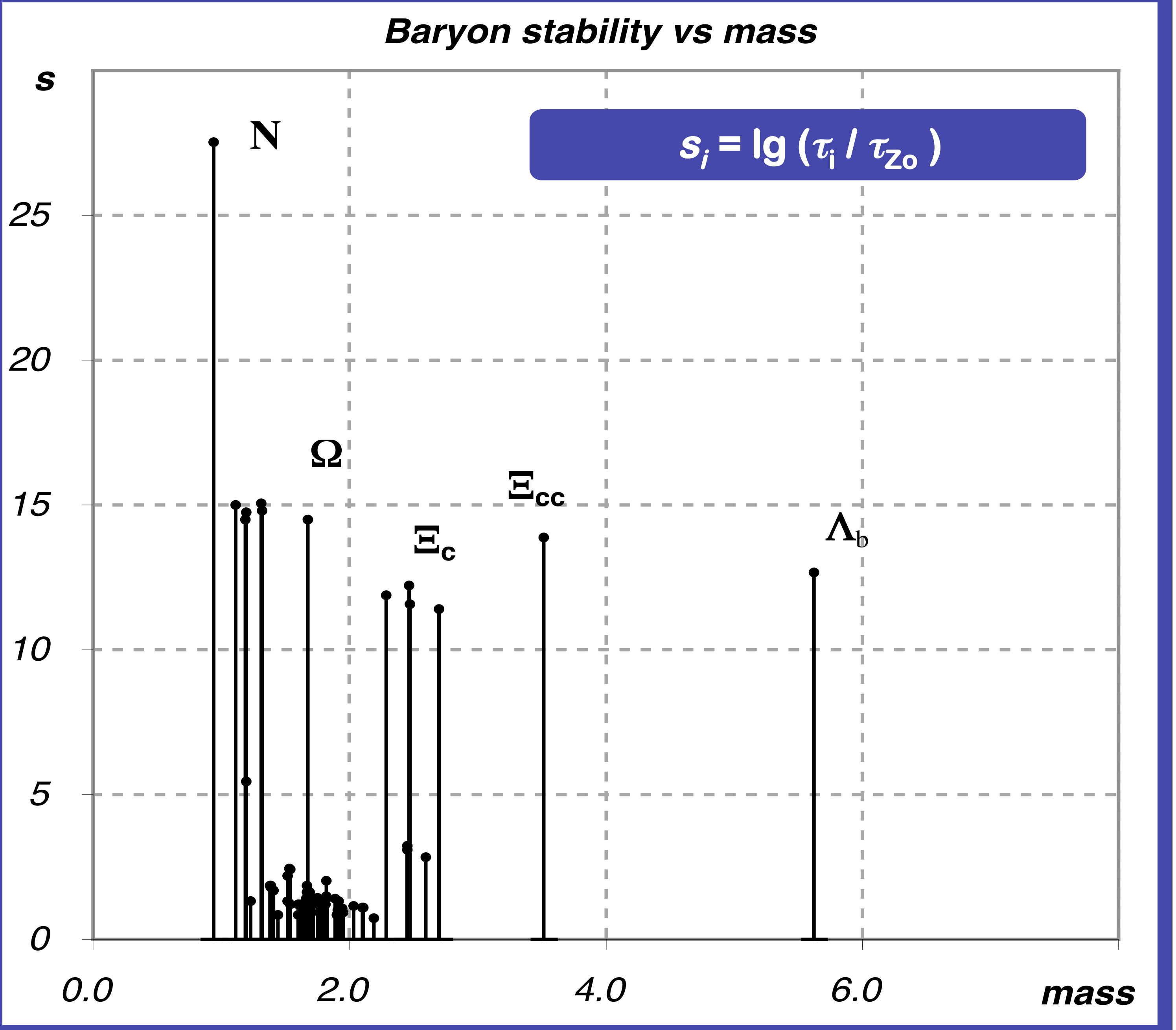

u vs k, baryons
u
y = 0.247x + 33.897
36.86
36.62
36.37
36.12
35.87
35.62
35.37
35.12
34.88
34.63
34.38
34.13
33.88
33.63
33.39
-1 0 1 2 3 4 5 6 7 8 9 10 11 12
k
Θ+
Σ
Λ
Ω
Ξ
N
Ξc
Δ
Λc
Σc
mesons
baryons
Linear (mesons)
unflavored, charmed
strange

the baryons

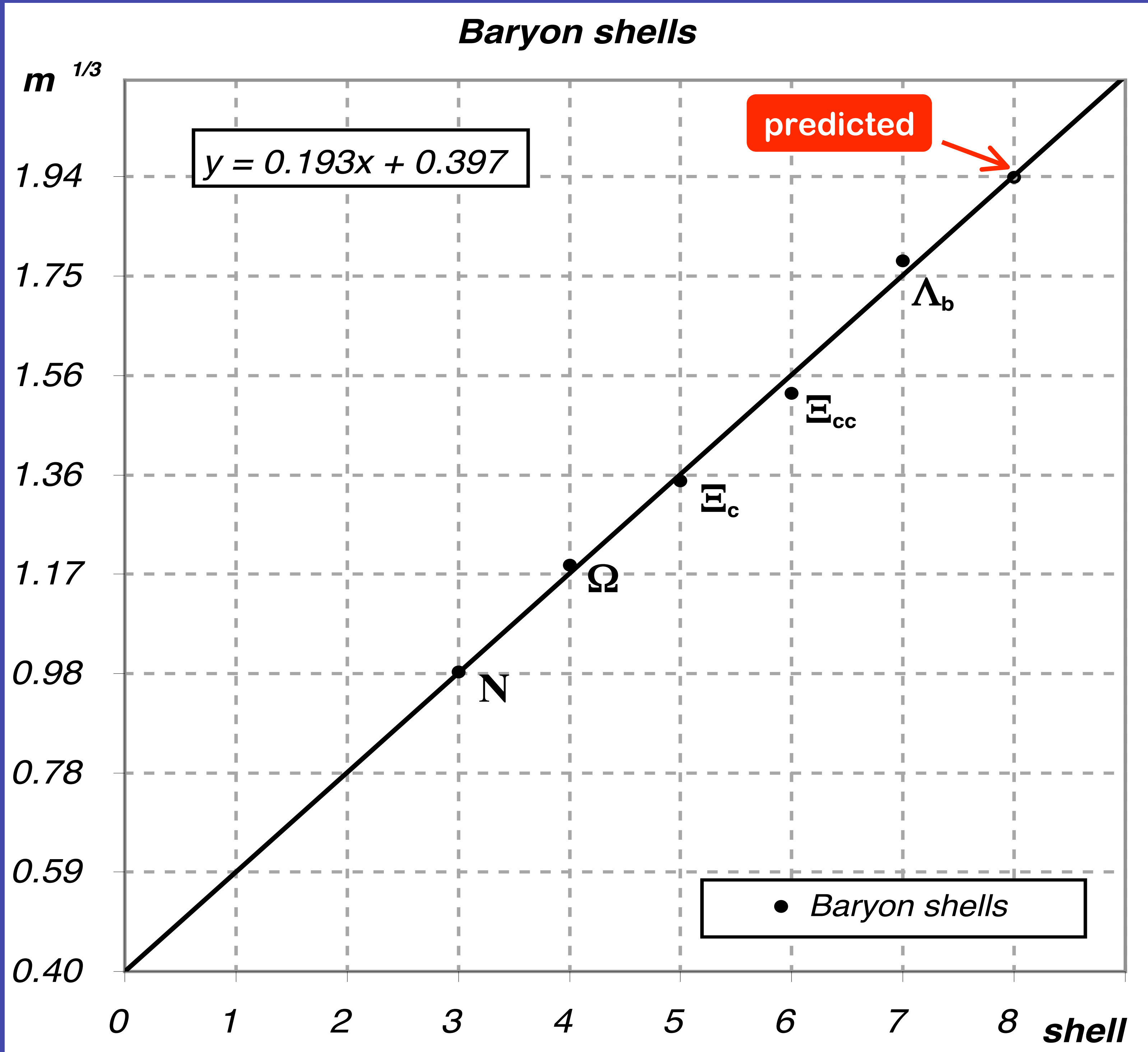
- mass rules
- shells

PRELIMINARY

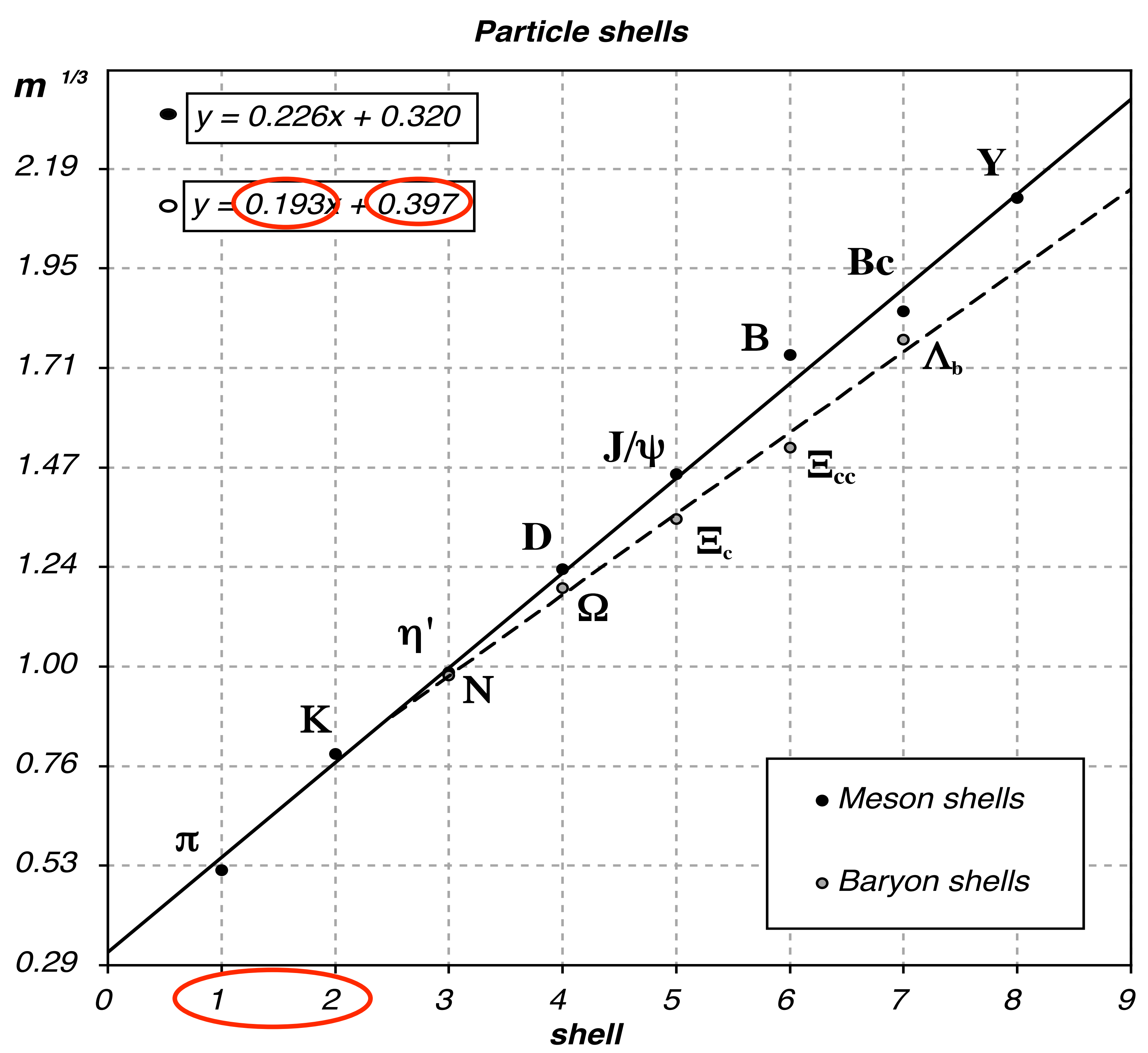
baryon stability



baryon shells



baryon vs meson shells

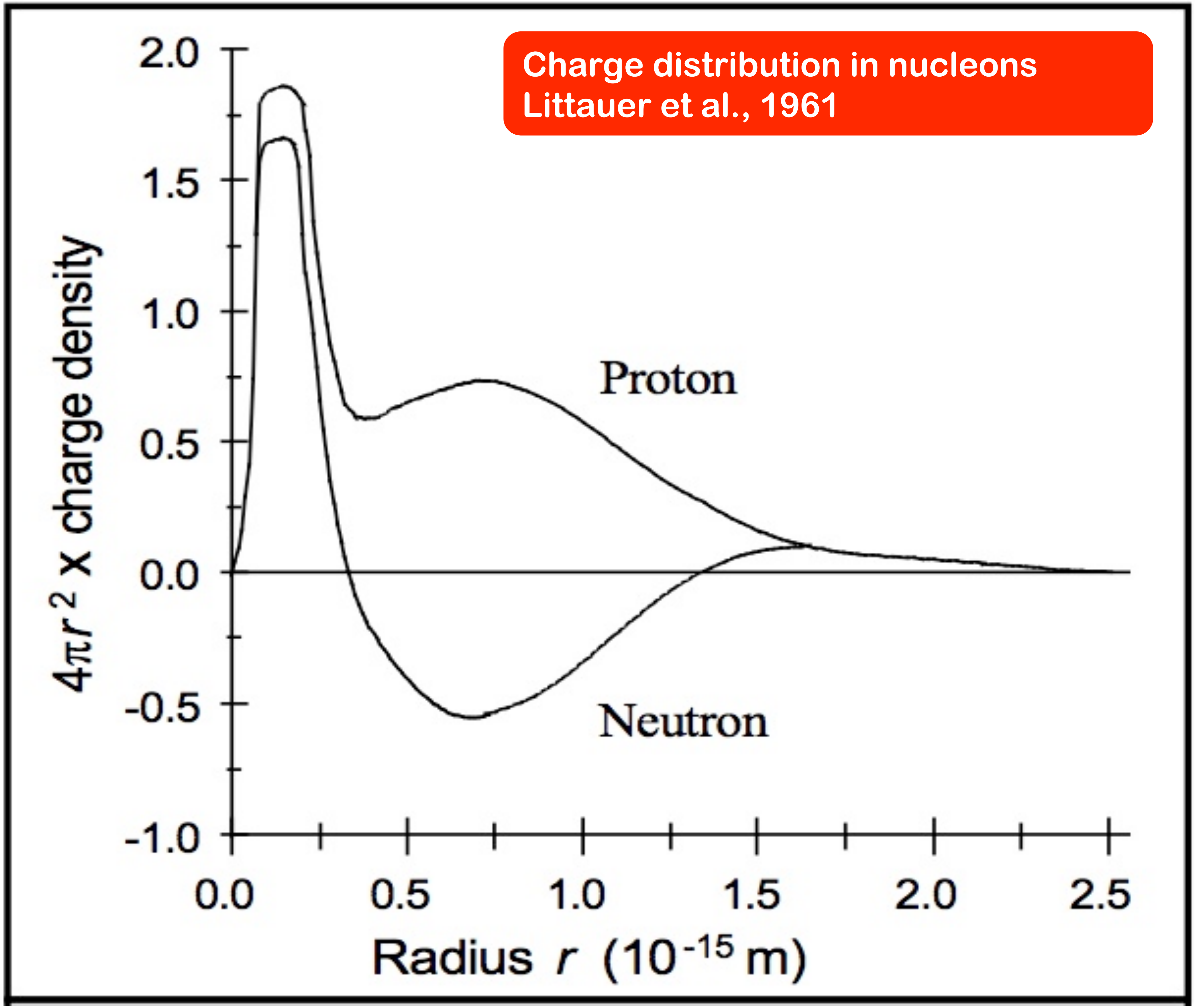


baryon shells organization, clues:

- shells 1 and 2 not cohesives
- 1 node in the center
- "density" = 1/3 of the full fcc
- more than 4 nodes at shell 1
- P sequence: 27, 47, 71 ....
- compatible with nuclear force

we are not yet there...

further indications of the shell structure of the nucleon



Charge distribution in nucleons
Littauer et al., 1961
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
4πr² x charge density
Proton
Neutron
0.0
0.5
1.0
1.5
2.0
2.5
Radius r (10⁻¹⁵ m)

totemtdr24-03-04.pdf (219 pages)

LHC

2.2 Elastic scattering

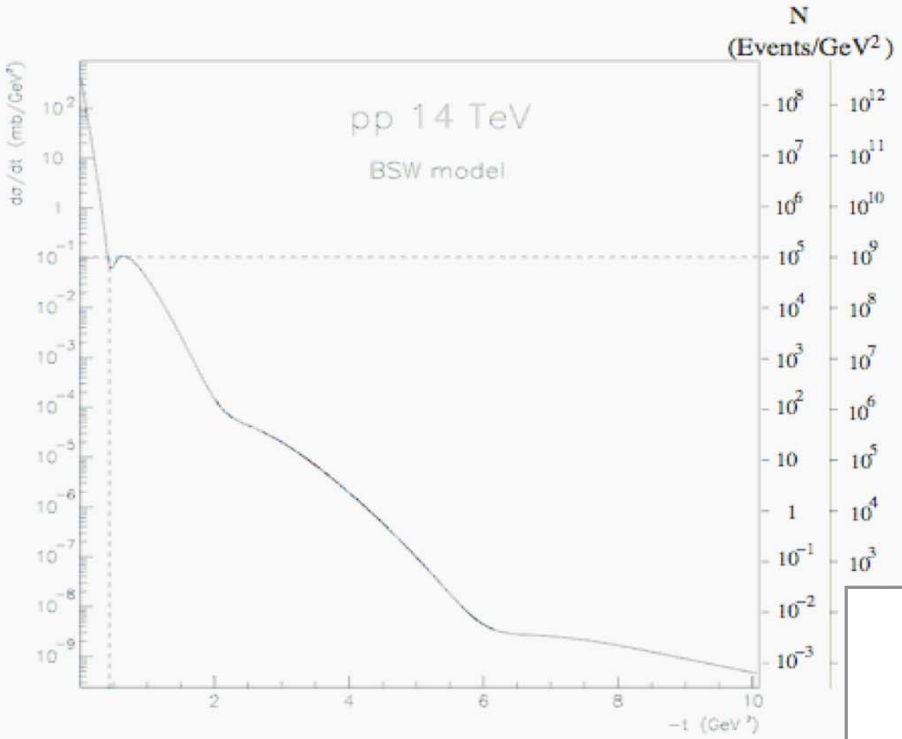


Figure 2.2: Elastic scattering cross-section, using the model from BSW [9]. The numb… right scale corresponds to an integrated luminosity of 10^{33} cm^{-2} and 10^{37} cm^{-2}. The d… the highest observable t-value due to aperture limitation in the high-β^* optics

High-energy elastic nucleon scattering represents the collision process in which the … over a large energy range at the CERN ISR [3], the SPS collider [4] and the TEVATR… gathered. These data have been confronted with various phenomenological models. … about the behavior of the phenomenological approaches at very high energies can … the help of so-called asymptotic theorems derived from first principles and only va… energies [6]. They tell us how models should behave in the limiting case of infinite energies and show us the trends in their high-energy behavior.

In the past, many models describing high-energy elastic hadron scattering have been formulated with different approaches [7]. In many of them the eikonal approach has been used, in analogy to optics. In other models the nucleons consist of a central core with a surrounding meson cloud or of a series of partonic clusters whose interaction is formulated with the help of Glauber's multi-scattering method.

M. M. Islam et al.

Figure 1: Nucleon structure emerging from our investigation. Nucleon has an outer cloud of $q\bar{q}$ condensed ground state analogous to the BCS ground state in superconductivity, an inner core of topological baryonic charge probed by ω, and a still smaller quark-bag of massless valence quarks.

interaction

Q uantum   sure !

~~C hromo~~   no need   autoPauli

~~D ynamics~~   none

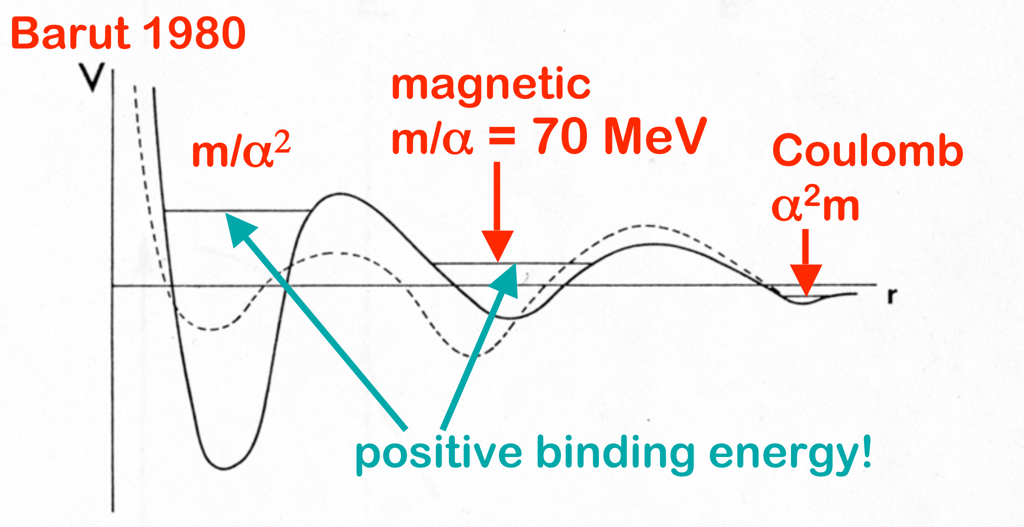


FIGURE 1. Schematic form of the effective radial magnetic potential V as a fuction of the radial distance r for two different fixed values of energy and angular momentum.

Q uantum

M agneto

S tatic

hadrons are "elastic solids"

summary and roadmap

	SM	magic
interaction	QCD	*QMS (e.m.)*
constituents	quarks	*stable leptons*
model	quark	shells (M, *B*)
mass rules	--	multi-linear
taxonomy	SU(X)	*SU(X)++*
chemistry	CKM	CKM

!?

?

Fewer parameters: SM $\geq$ 26

- quarks are valence properties, so their masses are not defined (-6)
- the W-quark couplings are derived from the expression of the quarks in terms of the constituents (-4)
- the muon and the tau leptons are composite, their mass is computed (-2)
- strong interactions are a collective manifestation of electromagnetism, and the strong coupling constant can be computed (-1)

TOT= -13

thanks you for your interest !

pp@particlez.org
http://particlez.org