A.5: Quarkmodellbeschreibung der Hadroneigenschaften

Static electromagnetic properties and strong decays in a relativistic quark model

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  relativistically covariant constituent quark model on the basis of the Salpeter Equation;
- Static electromagnetic properties:
  novel formulas for magnetic moments and charge radii on the basis of Salpeter Amplitudes;
  Christian Haupt, Bernard Metsch, Herbert-R. Petry,
  Static observables of relativistic three-fermion systems with instantaneous interactions,
  Eur. Phys. J. A 28 (2006) 213, [HEP-PH/0602151] ;
  Christian Haupt, *Electromagnetic properties of Baryons*, PhD-Thesis, Universität Bonn, 2006, HISKP-TH-06-18.
  `http://hss.ulb.uni-bonn.de/diss_online/math_nat_fak/2006/haupt_christian/0754.pdf`
- Strong two-body decay amplitudes.
  Sascha Migura, *Weak and Strong Baryon Decays in a Constituent Quark Model*, PhD-Thesis, Universität Bonn, 2006, HISKP-TH-06-17.
  `http://www.itkp.uni-bonn.de/publications/postscript/migura-thesis.ps.gz`

Computation of static moments $\langle M \rangle$

- In nonrelativistic quantum mechanics $\langle M \rangle$ is given by the expectation value of a (local) operator, *e.g.* :

$$\hat{\mu} = \frac{q}{2m}(\hat{l}_3 + \hat{\sigma}_3)\,, \quad \langle \mu \rangle = \langle \phi | \, \hat{\mu} \, | \phi \rangle$$

$$\hat{r}^2_{\mathrm{charge}} = q r^2\,, \quad q \left\langle r^2_{\mathrm{charge}} \right\rangle = \langle \phi | \, \hat{r}^2_{\mathrm{charge}} \, | \phi \rangle$$

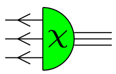
- In the usual fieldtheoretical approach $\langle M \rangle$ is the limit of some formfactor, *e.g.* :

$$\langle \mu \rangle = \lim_{Q^2 \to 0} G_M(Q^2)\,, \quad \left\langle r^2_{\mathrm{charge}} \right\rangle = - \lim_{Q^2 \to 0} \frac{6}{G_E(0)} \frac{\mathrm{d}G_E(Q^2)}{\mathrm{d}Q^2}$$

Question : How can static moments ($\langle M \rangle$) be computed as expectation values with respect to appropriate local operators on a field theoretical basis?

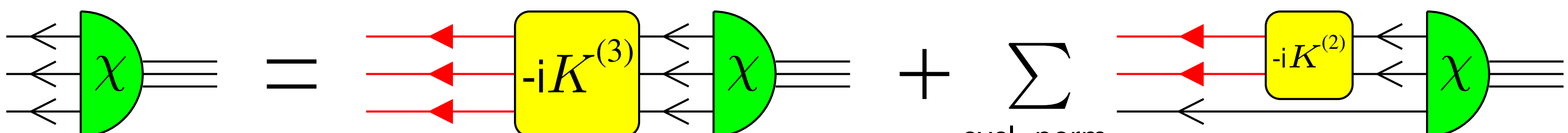
Bethe-Salpeter-equation

Fieldtheoretical description of a three-fermion-sytem is governed by the Bethe-Salpeter-amplitude :

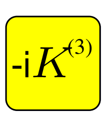


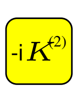
$$:= \langle 0 | T \psi(x_1)\, \psi(x_2)\, \psi(x_3) | \bar{P} \rangle,$$

which fulfills the Bethe-Salpter-equation :



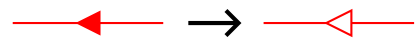
Describes bound states of mass $M^2 = \bar{P}^2$ and total four-momentum $\bar{P} = p_1 + p_2 + p_3$ with ingredients :

-  $= \langle 0 | T \psi(x)\, \bar{\psi}(x') | 0 \rangle = S_F(x - x')$, full quark-propagator
- 

irreducible **three**-particle-kernel
- 

irreducible **two**-particle-kernel

Approximations

- **Free** propagators :  : $S_F^j(p_j) \equiv \dfrac{\mathrm{i}}{\not{p}_j - m_j + \mathrm{i}\epsilon}$

- Interaction kernels do not depend on relative energies p_ξ^0 and p_η^0 in the restframe (**instantaneous** approximation) :

$$\boxed{K_P^{(3)}}(p_\xi, p_\eta; p'_\xi, p'_\eta)\Big|_{\bar{P}=(M,\vec{0})} = \boxed{V^{(3)}}(\vec{p}_\xi, \vec{p}_\eta; \vec{p}\,'_\xi, \vec{p}\,'_\eta)$$

$$\boxed{K_{P_{ij}}^{(2)}}(p_{\xi_k}, p_{\eta_k})\Big|_{\bar{P}=(M,\vec{0})} = \boxed{V^{(2)}}(\vec{p}_{\xi_k}, \vec{p}_{\eta_k})$$

$\Rightarrow$ Eight-dimensional Bethe-Salpeter-equation reduces to six-dimensional Salpeter-equation by integrating out p_ξ^0- und p_η^0-dependencies.

$\Rightarrow$ Static moments are expectation values of suitable operators.

Salpeter-equation

$$\mathcal{H}\Phi_M^\Lambda = M\Phi_M^\Lambda$$

- Eigenvalue equation for restmass M :
- Salpeter-amplitude : $\Phi_M(\vec{p}_\xi, \vec{p}_\eta) := \int \frac{\mathrm{d}p_\xi^0}{2\pi} \frac{\mathrm{d}p_\eta^0}{2\pi} \chi_M(p_\xi, p_\eta)$

  projection : $\Phi_M^\Lambda := \left[\Lambda_1^+ \otimes \Lambda_2^+ \otimes \Lambda_3^+ + \Lambda_1^- \otimes \Lambda_2^- \otimes \Lambda_3^-\right] \Phi_M$
- Φ_M^Λ given in the restframe, $\bar{P} = (M, \vec{0})$
- Salpeter-Hamiltonian : $\mathcal{H} = \mathcal{H}\left(\boxed{V^{(3)}}, \boxed{V^{(2)}}\right)$

Norm : $\langle \Phi_M^\Lambda | \Phi_M^\Lambda \rangle = \int \frac{\mathrm{d}p_\xi^3}{2\pi} \frac{\mathrm{d}p_\eta^3}{2\pi} \Phi_M^{\Lambda\,\dagger}(p_\xi, p_\eta)\, \Phi_M^\Lambda(p_\xi, p_\eta) = 2M$

$\Rightarrow$ induces positive definite scalar product $\langle \Phi_1 | \Phi_2 \rangle$

A quark model for baryons

confinement potential:

$$V^{(3)}_{\text{conf}} = \tfrac{3}{4}a \cdot \Gamma^{\mathcal{D}}_{\text{offset}} + \tfrac{1}{2}b \sum_{i<j} |\vec{x}_i - \vec{x}_j| \cdot \Gamma^{\mathcal{D}}_{\text{string}}$$

inspired by phenomenology:

- Minimizes spin-orbit effects
- Correct description of Regge trajectory (M^2 vs. J)

't Hoofts instanton-induced interaction:

$$V^{(2)}_{\text{'t Hooft}} = -4\,\delta^{(3)}(\boldsymbol{x_1} - \boldsymbol{x_2})\,[\mathbb{1}\otimes\mathbb{1}+\gamma^5\otimes\gamma^5]\mathcal{P}^{\mathcal{D}}_{S_{12}}\otimes\big(g_{nn}\mathcal{P}^{\mathcal{F}}_{\mathcal{A}}(nn) + g_{ns}\mathcal{P}^{\mathcal{F}}_{\mathcal{A}}(ns)\big)$$

- $\mathcal{P}^{\mathcal{D}}_{S_{12}}$: projects on antisymmetric spin configurations
- $\mathcal{P}^{\mathcal{F}}_{\mathcal{A}}(f_1\, f_2)$: projects on flavor-antisymmetric quark pairs
- Regularization: $\delta^{(3)}(\boldsymbol{x_1} - \boldsymbol{x_2}) \to \frac{1}{\lambda^3\pi^{3/2}} \exp\left(\frac{|\boldsymbol{x_1}-\boldsymbol{x_2}|}{\lambda}\right)^2$

  $\Rightarrow$ effective range parameter λ

Model parameters

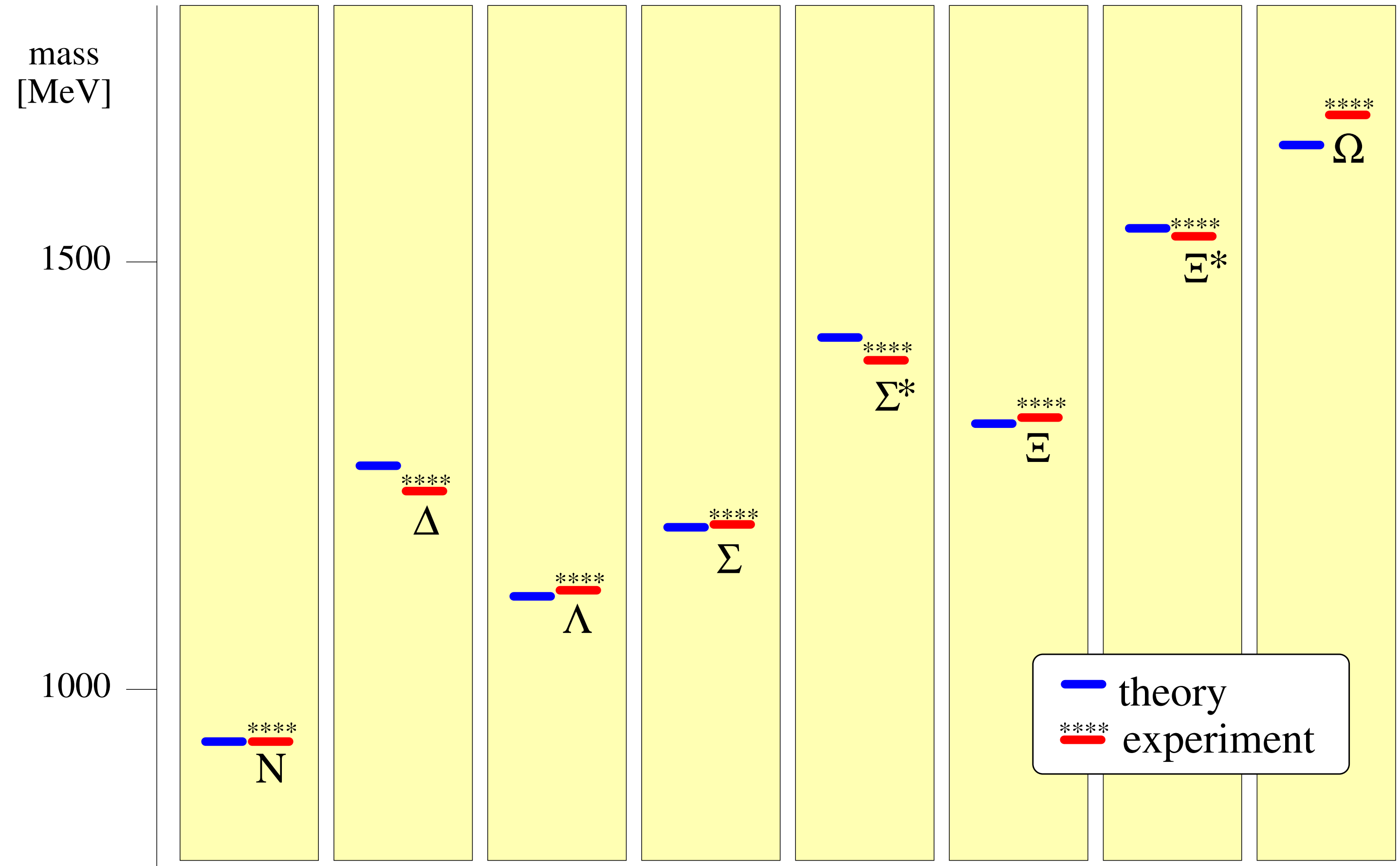
constituent	non-strange	m_n	330	MeV
quark masses	strange	m_s	670	MeV
confinement	offset	a	-744	MeV
force	slope	b	470	MeV fm^{-1}
residual	non-strange/non-strange coupling	g_{nn}	136	MeV fm^3
instanton	non-strange/strange coupling	g_{ns}	94	MeV fm^3
interaction	effective range	λ	0.4	fm

Parameter adjustment in two steps:

- confinement parameters by the Δ spectrum (Regge trajectory)
- instanton force parameters by the baryon ground states splittings

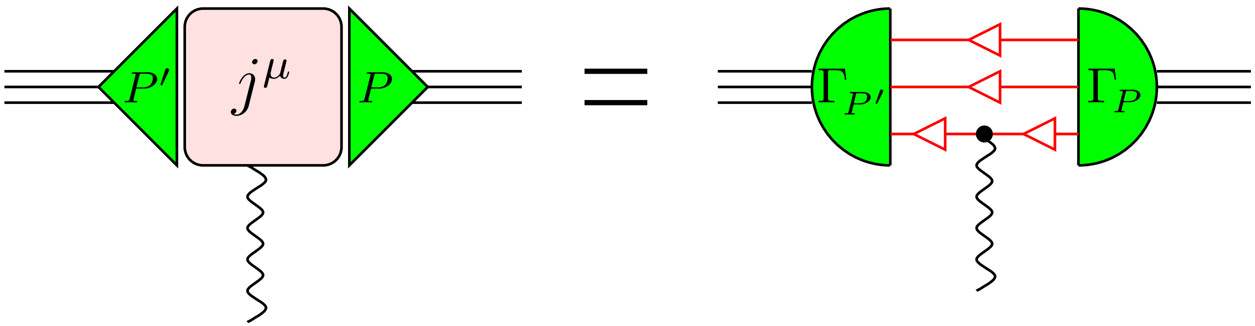
Detailed overview: U. Löring *et al.*, Eur. Phys. J. A **10** (2001) 309, 395, 407

Baryon ground states



Jπ	1/2+	3/2+	1/2+	1/2+	3/2+	1/2+	3/2+	3/2+
T	1/2	3/2	0	1		1/2		0
quark–content	nnn		nns			nss		sss

Current matrix element



$=$ $+$ cycl. perm.

$$\langle P'|J_\mu(0)|P\rangle = -3\int\frac{d^4p_\xi}{(2\pi)^4}\int\frac{d^4p_\eta}{(2\pi)^4}\bar\Gamma_{P'}(p_\eta,p_\xi)$$

$$\times S_F^1(p_\xi+\tfrac{1}{2}p_\eta)\otimes S_F^2(-p_\xi+\tfrac{1}{2}p_\eta)\otimes S_F^3(P'-p_\eta)\,\gamma_\mu\, S_F^3(P-p_\eta)\Gamma_P(p_\eta,p_\xi)$$

Relation between vertex function and Salpeter amplitude:

$$\Phi_M^\Lambda = \mathrm{i}\left[\frac{\Lambda_1^+\otimes\Lambda_2^+\otimes\Lambda_3^+}{M-\omega_1-\omega_2-\omega_3}+\frac{\Lambda_1^-\otimes\Lambda_2^-\otimes\Lambda_3^-}{M+\omega_1+\omega_2+\omega_3}\right]\gamma^0\otimes\gamma^0\otimes\gamma^0\,\Gamma_M^\Lambda$$

$\omega_i=\sqrt{m_i^2+|\boldsymbol{p_i}|^2}$: relativistic energy, $\Lambda_i^\pm(p_i)$: energy projector

Charge distributions and mean square radius

Mean square radius of a charge distribution $\rho(\boldsymbol{x})$: $\langle r^2 \rangle = \frac{1}{q} \int d^3x |\boldsymbol{x}|^2 \rho(\boldsymbol{x})$

Net charge of the system: $q = \int d^3x \, \rho(\boldsymbol{x})$

For quantum systems: $\rho(\boldsymbol{x}) = \frac{\langle \psi | j^0(\boldsymbol{x}) | \psi \rangle}{\langle \psi | \psi \rangle}$

Superposition of momentum eigenstates: $|\psi\rangle = \int \frac{d^3P}{\omega_{\boldsymbol{P}}} \psi(\boldsymbol{P}) |P\rangle$

$$\ldots \Rightarrow \quad \langle r^2 \rangle = -\frac{1}{8Mq} \Delta_{\boldsymbol{P}} \langle \mathcal{P}P | j^0(0) | P \rangle \Big|_{\boldsymbol{P}=0}$$

with spatial reflection: $\mathcal{P}(P^0, \boldsymbol{P}) = (P^0, -\boldsymbol{P})$.

Electric form factor and mean square radius

$$\langle P', \lambda' | j_\mu(0) | P, \lambda \rangle = \bar{u}_{\lambda'}(P') \left[\gamma_\mu \left(F_1(Q^2) + F_2(Q^2) \right) - \frac{P'_\mu + P_\mu}{2M} F_2(Q^2) \right] u_\lambda(P)$$

Sachs form factors: $G_E(Q^2) := F_1(Q^2) - \frac{Q^2}{4M^2} F_2(Q^2)$

$$G_M(Q^2) := F_1(Q^2) + F_2(Q^2)$$

Definition of charge radius:

$$\langle r^2 \rangle := - \frac{6}{G_E(0)} \frac{\mathrm{d} G_E(Q^2)}{\mathrm{d} Q^2} \bigg|_{Q^2=0}$$

$$\Rightarrow \langle r^2 \rangle = - \frac{3}{Mq} \frac{\mathrm{d}}{\mathrm{d}Q^2} \langle \mathcal{P} P, \lambda | j^0(0) | P, \lambda \rangle \bigg|_{Q^2=0} = - \frac{1}{8Mq} \Delta_{\boldsymbol{P}} \langle \mathcal{P} P | j^0(0) | P \rangle \bigg|_{\boldsymbol{P}=0}$$

Charge radius as an expectation value

$$\langle r^2 \rangle = \frac{\langle \Phi^\Lambda_M | \hat{r}^2 | \Phi^\Lambda_M \rangle}{2M}$$

$$\hat{r}^2 = \sum_{\alpha=1}^{3} \left\{ \frac{1}{2} \left[\frac{\Omega}{M} \left(\mathrm{i} \boldsymbol{\nabla}_{\boldsymbol{p}_\alpha} - \hat{\boldsymbol{R}} \right) + \mathrm{h.\,c.} \right] \right\}^2 \hat{q}_\alpha$$

$$\hat{\boldsymbol{R}} = \frac{1}{\Omega} \sum_{\alpha=1}^{3} \omega_\alpha \mathrm{i} \boldsymbol{\nabla}_{\boldsymbol{p}_\alpha} \qquad \Omega := \omega_1 + \omega_2 + \omega_3$$

Features:

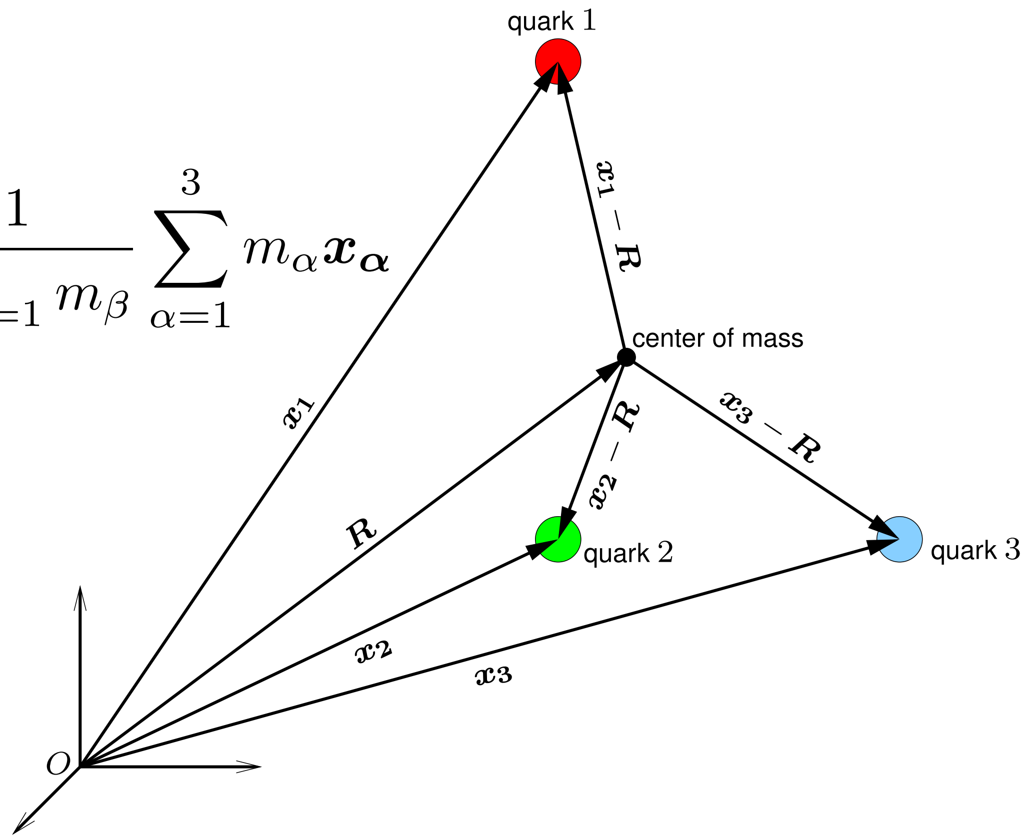
- Charge radius as expectation value with Salpeter amplitudes
- $\langle \Phi^\Lambda_M | \Phi^\Lambda_M \rangle = 2M \quad \Rightarrow$ factor $1/2M$ accounts for correct normalization
- $\hat{r}^2$ is hermitean

Interpretation

In position space: $\mathrm{i}\boldsymbol{\nabla}_{\boldsymbol{p}_\alpha} \rightarrow \boldsymbol{x}_\alpha$.

$$\Rightarrow \quad \hat{r}_x^2 = \sum_{\alpha=1}^{3} \left\{ \frac{1}{2} \left[\frac{\Omega}{M} \left(\boldsymbol{x}_\alpha - \hat{\boldsymbol{R}}_x \right) + \mathrm{h.~c.} \right] \right\}^2 \hat{q}_\alpha]$$

$$\hat{\boldsymbol{R}}_{\boldsymbol{x}} = \frac{1}{\Omega} \sum_{\alpha=1}^{3} \omega_\alpha \boldsymbol{x}_\alpha \quad \underset{\text{nonrel.}}{\longrightarrow} \quad \frac{1}{\sum_{\beta=1}^{3} m_\beta} \sum_{\alpha=1}^{3} m_\alpha \boldsymbol{x}_\alpha$$



Relativistic center of mass!

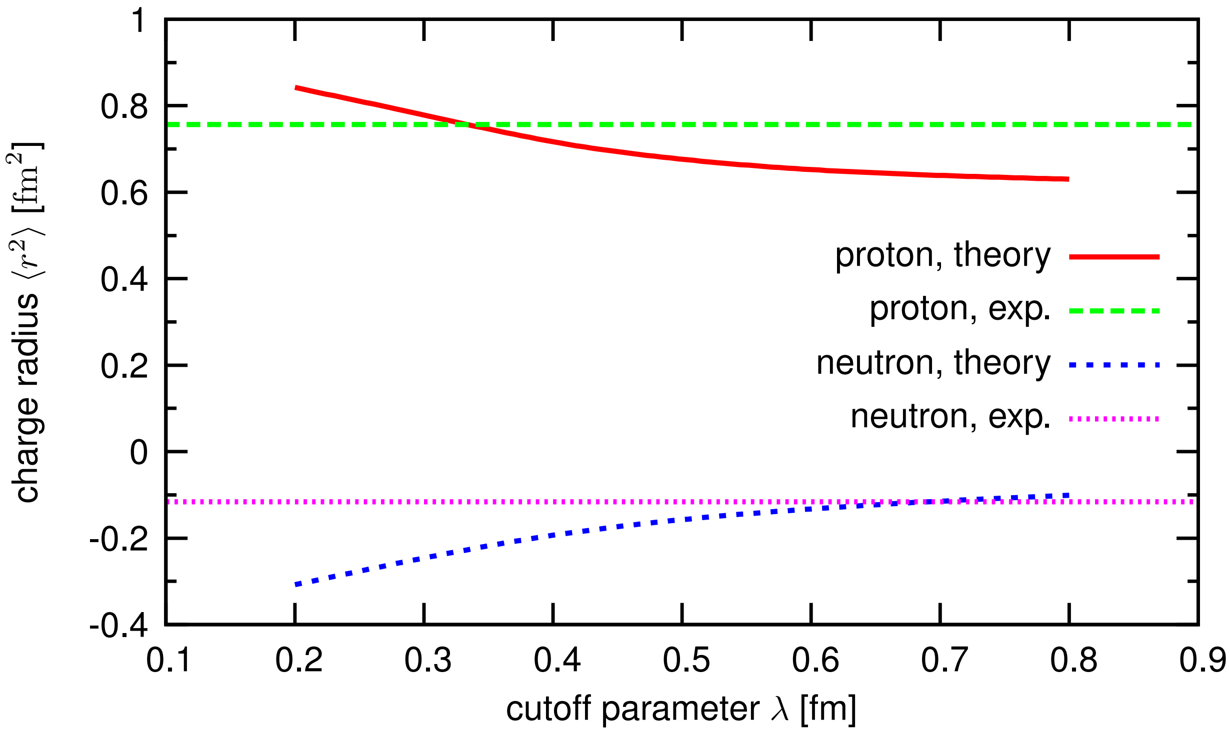
In addition:
$(\boldsymbol{x}_\alpha - \hat{\boldsymbol{R}}_x)$ is weighted with Ω/M
in the nonrel. limit: $\Omega/M \rightarrow 1$

Baryon octet squared charge radii

baryon	this calculation $[\mathrm{fm}^2]$	exp. $[\mathrm{fm}^2]$	nonrel. limit $[\mathrm{fm}^2]$	$\frac{\langle r^2 \rangle_{\text{nonrel}}}{\langle r^2 \rangle_{\text{rel}}}$ [%]
$p(\sqrt{\langle r^2 \rangle})$	$(0.86\,\mathrm{fm})$	$(0.87 \pm 0.008\,\mathrm{fm})$	$0.3\,(0.55\,\mathrm{fm})$	42
n	-0.206	-0.1161 ± 0.0022	-0.08	43
Λ	0.0086		0.002	23
Σ^+	0.64		0.3	47
Σ^0	0.11		0.043	36
Σ^-	0.42	$0.61 \pm 0.21,\ 0.91 \pm 0.72$	0.22	52
Ξ^0	0.075		0.044	59
Ξ^-	0.40		0.26	65

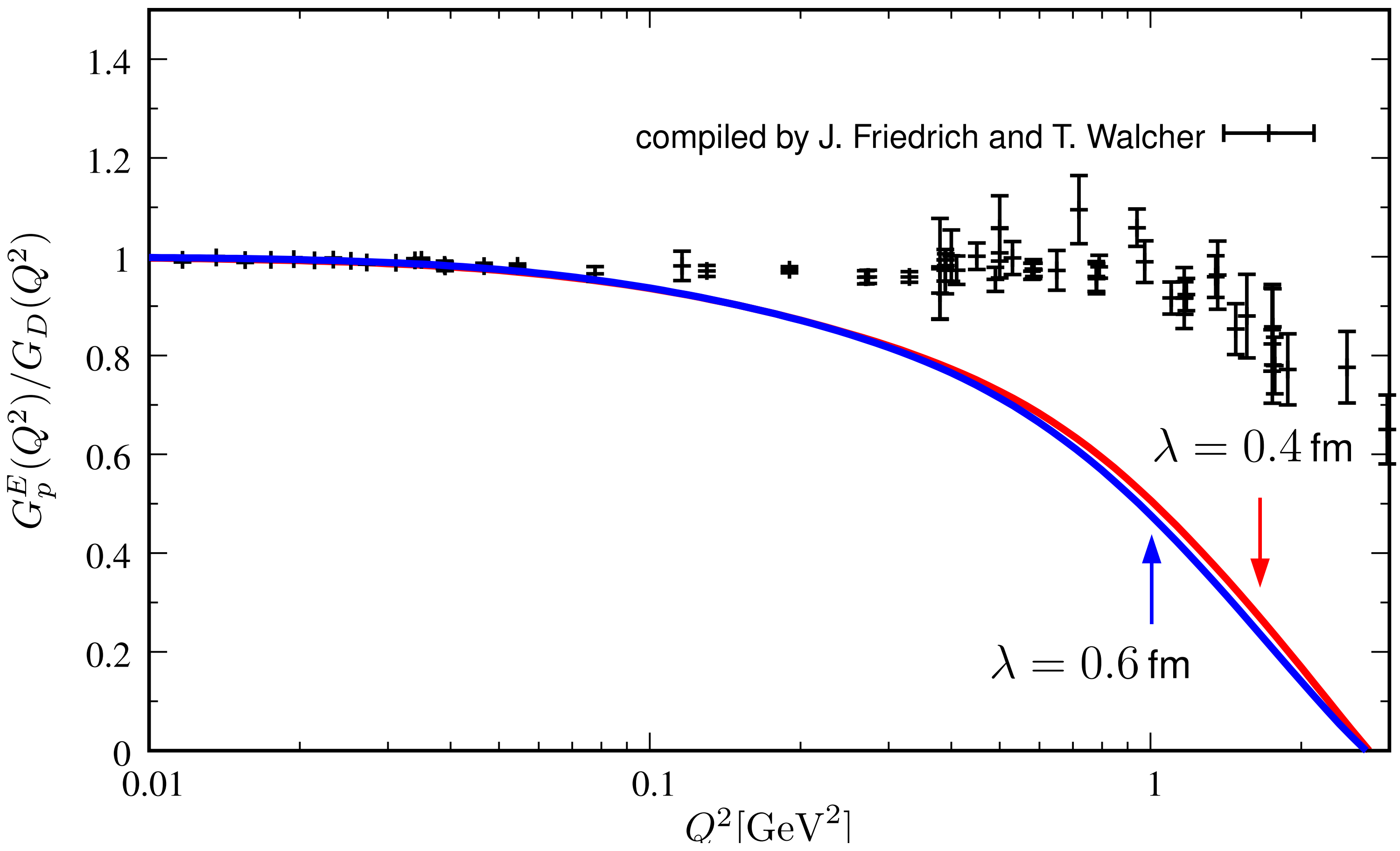
- proton o.k., neutron far off
- nonrel. radii are about half the size $\Rightarrow$ relativistic treatment important

Instanton effective range dependence



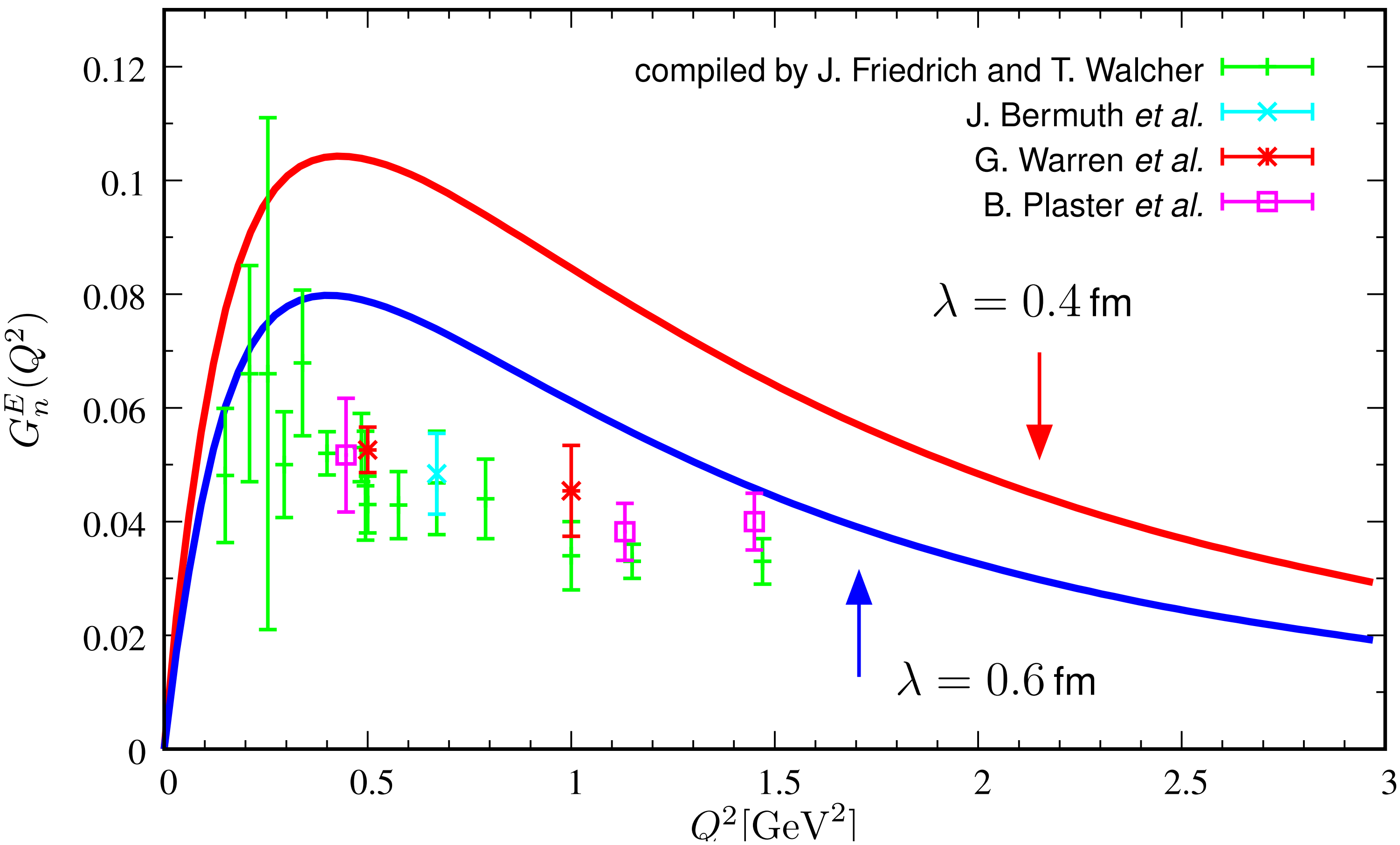
- Both mean square radii decrease about $0.2\,\mathrm{fm}^2$ in magnitude
- The relative effect is larger for the neutron radius
- At $\lambda = 0.6\,\mathrm{fm}$ and $g_{\mathrm{nn}} = 263\,\mathrm{MeV\,fm}^3$ both radii have an error of $14\,\%$ relative to experiment: $\sqrt{\langle r^2 \rangle_p} = 0.81\,\mathrm{fm}$ and $\langle r^2 \rangle_n = -0.132\,\mathrm{fm}^2$

Proton electric form factor



- Only minor dependence on effective range parameter λ
- As for $\langle r^2 \rangle_p$

Neutron electric form factor



- Strong dependence on effective range parameter λ
- As for $\langle r^2 \rangle_n$
- Improved description of exp. data

Magnetic moments

$$\langle \mathcal{P}P, \lambda' | j_+(0) | P, \lambda \rangle = \left[F_1(Q^2) + F_2(Q^2) \right] \bar{u}_{\lambda'}(\mathcal{P}P) \gamma_+ u_\lambda(P)$$

Magnetic Sachs form factor:

$$G_M(Q^2) := F_1(Q^2) + F_2(Q^2)$$

Definition of magnetic moment:

$$\mu := G_M(Q^2 = 0)$$

$$\Rightarrow \quad \langle \mu \rangle = \left. \frac{\langle \mathcal{P}P, \lambda' | j_+(0) | P, \lambda \rangle}{2\sqrt{Q^2}} \right|_{Q^2=0}$$

Magnetic moment as an expectation value

$$\mu = \frac{\langle \Phi_M^\Lambda | \hat{\mu} | \Phi_M^\Lambda \rangle}{2M}$$

$$\hat{\mu} = \frac{1}{2}\left[\frac{\Omega}{M}\sum_{\alpha=1}^{3}\frac{\hat{q}_\alpha}{2\omega_\alpha}\left(\hat{L}_{R\alpha}^3 + 2S_\alpha^3\right) + \text{h. c.}\right]$$

$$\hat{L}_{R\alpha}^i := \epsilon_{ijk} p_\alpha^k \left(\mathrm{i}\frac{\partial}{\partial p_\alpha^j} - \hat{R}^j\right)$$ "CMS-corrected" angular momentum operator

$$\boldsymbol{S}_1 := \boldsymbol{\Sigma}/2 \otimes \mathbb{1} \otimes \mathbb{1}$$

$$\boldsymbol{S}_2 := \mathbb{1} \otimes \boldsymbol{\Sigma}/2 \otimes \mathbb{1}$$ single particle spin operators

$$\boldsymbol{S}_3 := \mathbb{1} \otimes \mathbb{1} \otimes \boldsymbol{\Sigma}/2$$

Decomposition into spin and angular momentum contributions: $\langle \mu \rangle = \langle \mu_L \rangle + 2\langle \mu_S \rangle$

Baryon octet magnetic moments

baryon	experiment $[\mu_N]$	this calculation $[\mu_N]$	form factors ([1,2]) $[\mu_N]$
proton	2.793	2.77	2.74
neutron	-1.913	-1.71	-1.70
Λ	-0.613 ± 0.004	-0.61	-0.61
Σ^+	2.458 ± 0.01	2.51	2.47
Σ^0	–	0.75	–
Σ^-	-1.16 ± 0.025	-1.02	-0.99
Ξ^0	-1.25 ± 0.014	-1.33	-1.33
Ξ^-	-0.6507 ± 0.0025	-0.56	-0.57

[1]: D. Merten *et al.*, Eur. Phys. J. A **14** (2002) 477 [arXiv:hep-ph/0204024]

[2]: T. van Cauteren *et al.*, Eur. Phys. J. A **20** (2004) 283 [arXiv:nucl-th/0310058]

Decomposition $\langle\mu\rangle = \langle\mu_L\rangle + 2\langle\mu_S\rangle$

baryon	$2\langle\mu_S\rangle$ $[\mu_N]$	$\frac{2\langle\mu_S\rangle}{\langle\mu\rangle}$ $[\%]$	$\langle\mu_L\rangle$ $[\mu_N]$	$\frac{\langle\mu_L\rangle}{\langle\mu\rangle}$ $[\%]$
proton	2.53	91	0.24	9
neutron	-1.59	93	-0.12	7
Λ	-0.6	98	-0.01	2
Σ^+	2.33	93	0.23	7
Σ^0	0.7	94	0.05	6
Σ^-	-0.91	89	-0.11	11
Ξ^0	-1.27	94	-0.06	6
Ξ^-	-0.55	98	-0.013	2

$\Rightarrow$ For the baryon octett roughly 90% of $\langle\mu\rangle$ is due to spin.

Magnetic moments of nucleon resonances

nucleon resonance	T_3	magnetic moment $[\mu_N]$	$\langle\mu\rangle_S$ $[\mu_N]$	$\langle\mu\rangle_L$ $[\mu_N]$
$P^{11}(1440)$	$1/2$	1.55	1.39	0.16
	$-1/2$	-0.98	-0.9	-0.08
$S^{11}(1535)$	$1/2$	0.37	-0.14	0.51
	$-1/2$	-0.1	0.034	-0.134
$S^{11}(1650)$	$1/2$	1.85	1.70	0.15
	$-1/2$	-0.69	-0.44	-0.25
$D^{13}(1520)$	$1/2$	1.44	0.51	0.93
	$-1/2$	-0.166	0.019	-0.185
$D^{15}(1675)$	$1/2$	1.74	1.52	0.22
	$-1/2$	0.32	-0.22	0.54

Baryon decuplet magnetic moments

baryon	$\langle\mu\rangle$ $[\mu_N]$	$\langle\mu\rangle_{\rm exp}$ $[\mu_N]$
Δ^{++}	7.62	$3.7 - 7.5$
Δ^{+}	3.81	$2.7^{1.0}_{-1.3} \pm 1.5 \pm 3$ ([1])
Δ^{0}	0	
Δ^{-}	-3.81	
Σ^{*+}	4.73	
Σ^{*0}	0.68	
Σ^{*-}	-3.26	
Ξ^{*0}	1.68	
Ξ^{*-}	-2.91	
Ω^{-}	-2.28	2.02 ± 0.05 ([2],[3])

[1]: M. Kotulla *et al.*, Phys. Rev. Lett. **89** (2002) 272001 [arXiv:nucl-ex/0210040]

[2]: N. B. Wallace *et al.*, Phys. Rev. Lett. **74** (1995) 3732

[3]: H. T. Diehl *et al.*, Phys. Rev. Lett. **67** (1991) 804

Extension to higher moments

$$\langle m \rangle = \sum_{i_1, i_2, \ldots, i_n = 1}^{3} O_{i_1 i_2 \ldots i_n} \int \mathrm{d}^3 x \, x^{i_1} x^{i_2} \cdots x^{i_n} \rho(\boldsymbol{x})$$

In case of the charge radius: $O_{i_1 i_2} = \frac{1}{q} \delta_{i_1 i_2}$

$$\langle m \rangle = \frac{1}{\langle \Phi_M^\Lambda | \Phi_M^\Lambda \rangle} \sum_{i_1, i_2, \ldots, i_n = 1}^{3} O_{i_1 i_2 \ldots i_n} \langle \Phi_M^\Lambda | \sum_{\alpha=1}^{3} \hat{K}'_{i_1 \, \alpha} \hat{K}'_{i_2 \, \alpha} \ldots \hat{K}'_{i_n \, \alpha} \hat{q}_\alpha | \Phi_M^\Lambda \rangle$$

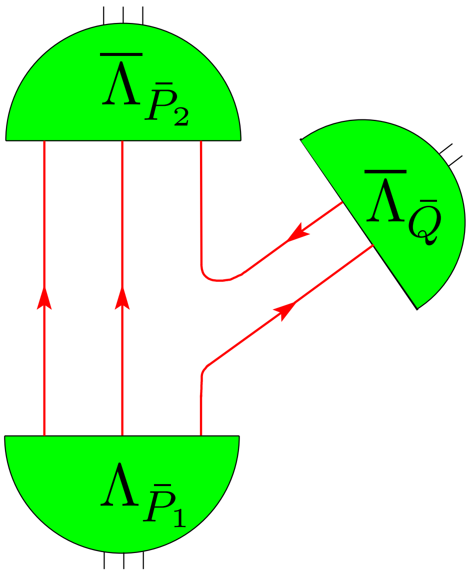
$+$ off-diagonal matrix elements for n>2

$$\hat{K}'_{i \, \alpha} = \frac{1}{2} \left[\frac{\Omega}{M} \left(\mathrm{i} \frac{\partial}{\partial p_\alpha^i} - \hat{\boldsymbol{R}} \right) + \mathrm{h.\ c.} \right]$$

$\Rightarrow$ extension to higher moments possible

Decay Widths of Strong Two-Body Baryon Decays

S–Matrix Element



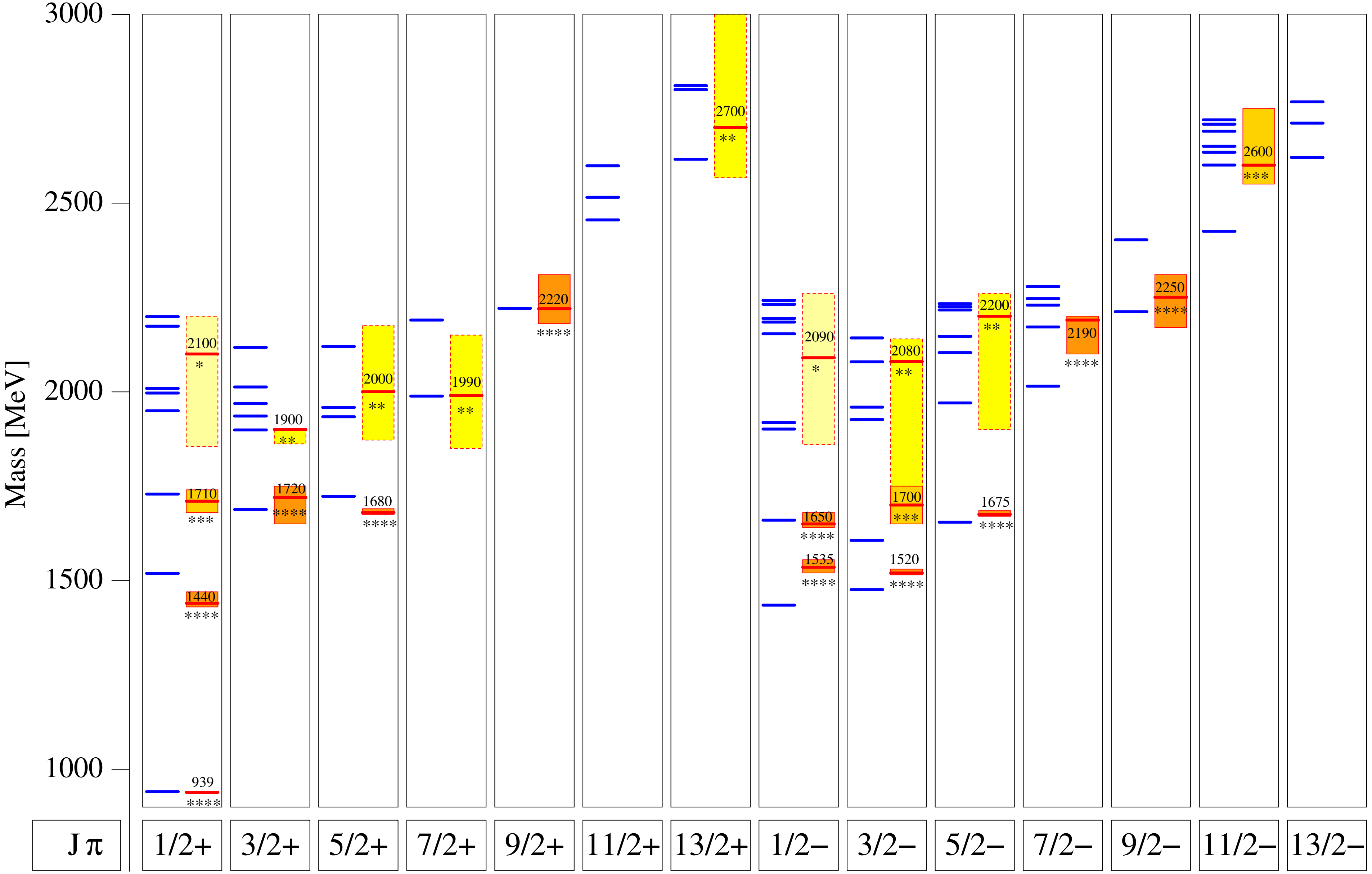
Averaging over spins, the decay width is given by

$$\Gamma^{\rm theo} = \frac{|\mathbf{Q}|}{8\pi M_1^2} \cdot \frac{1}{2J_1+1} \sum_{m_{J_1}, m_{J_2}} |\langle \bar{P}_2(m_{J_2}) \bar{Q} | \mathrm{S} | \bar{P}_1(m_{J_1}) \rangle|^2$$

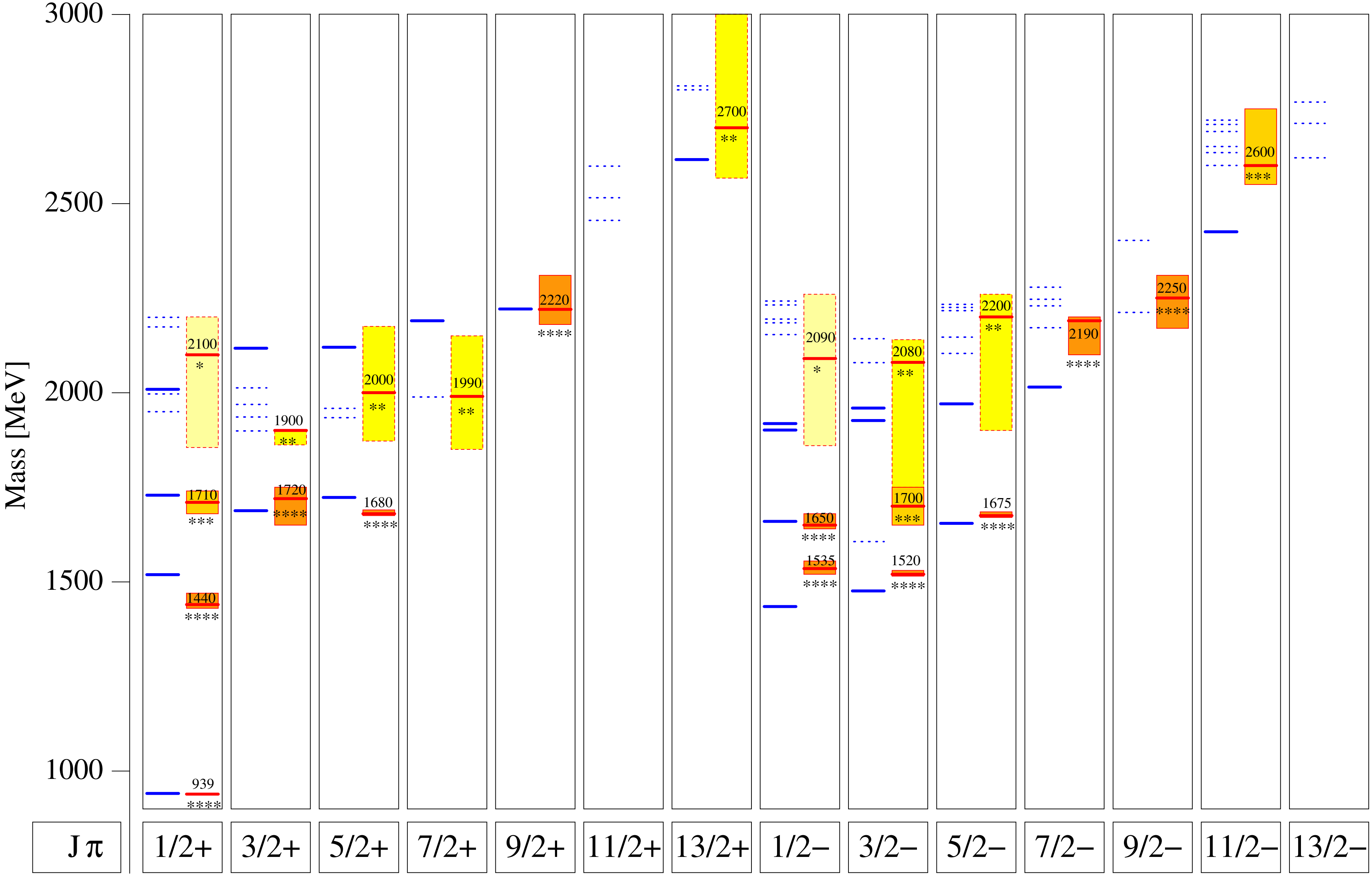
- Again: no additional free parameters
- recoil effects correctly described

Final state interactions are neglected!

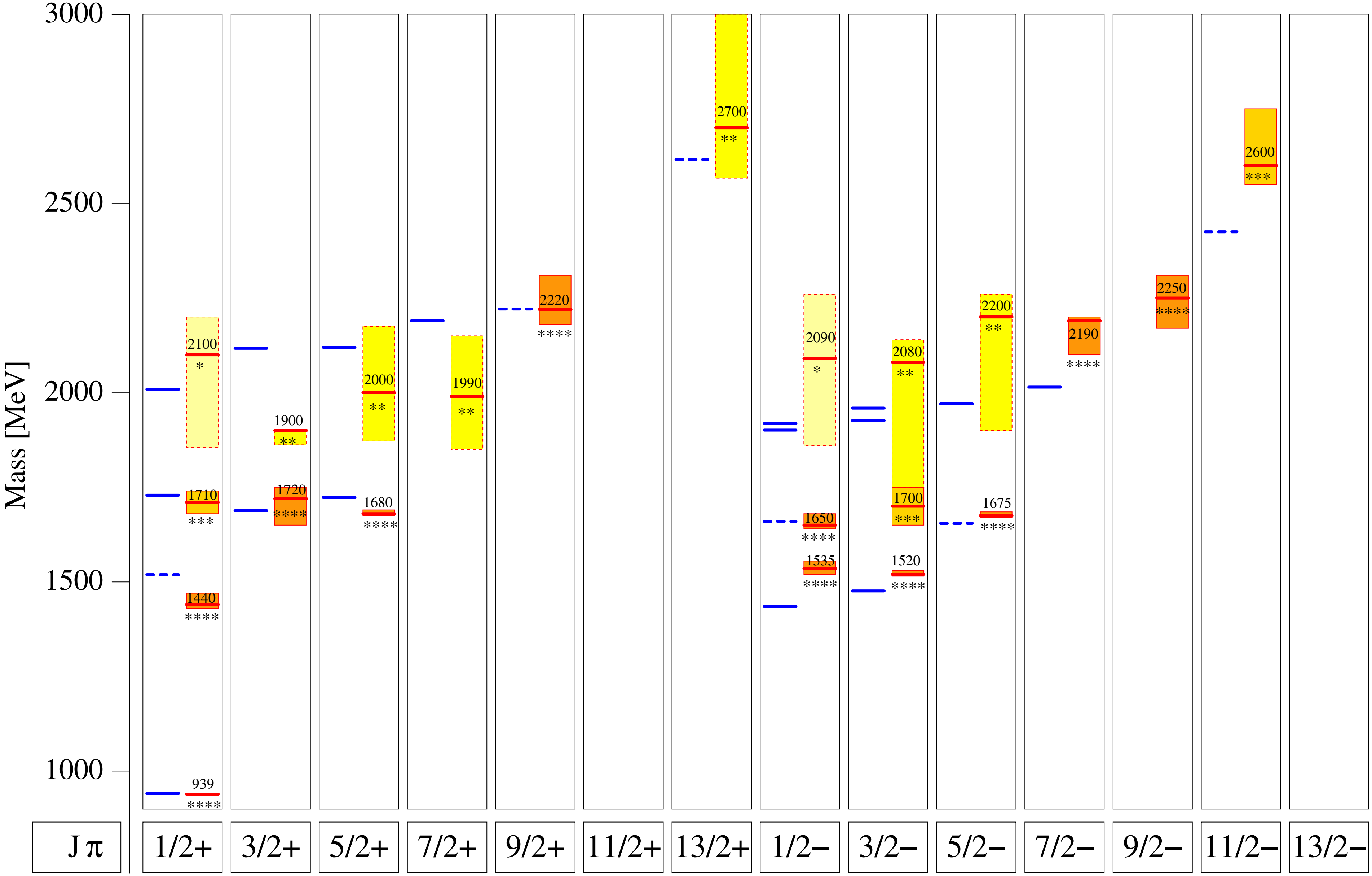
N-resonance spectrum: Couplings to $N\pi$



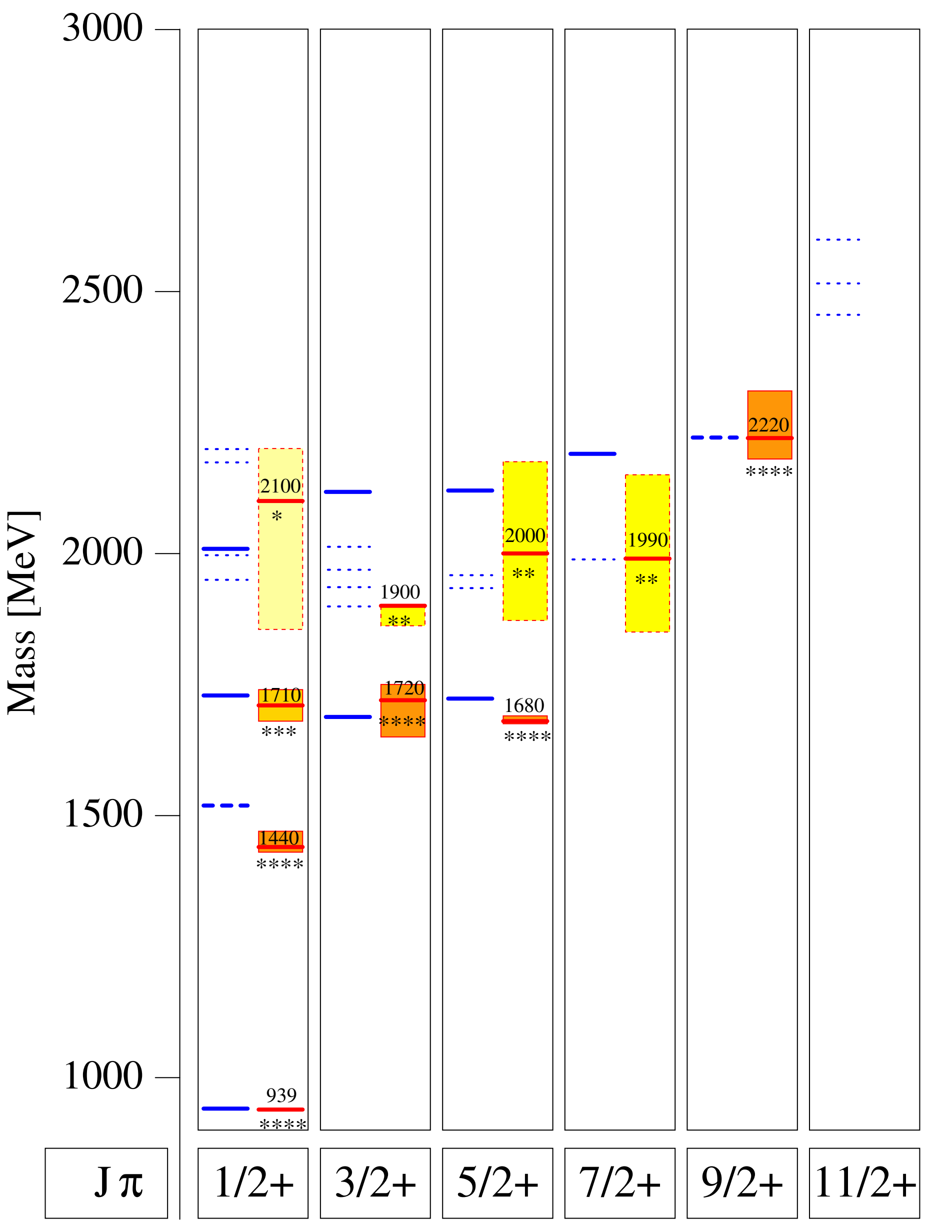
N-resonance spectrum: Couplings to $N\pi$



N-resonance spectrum: Couplings to $N\pi$

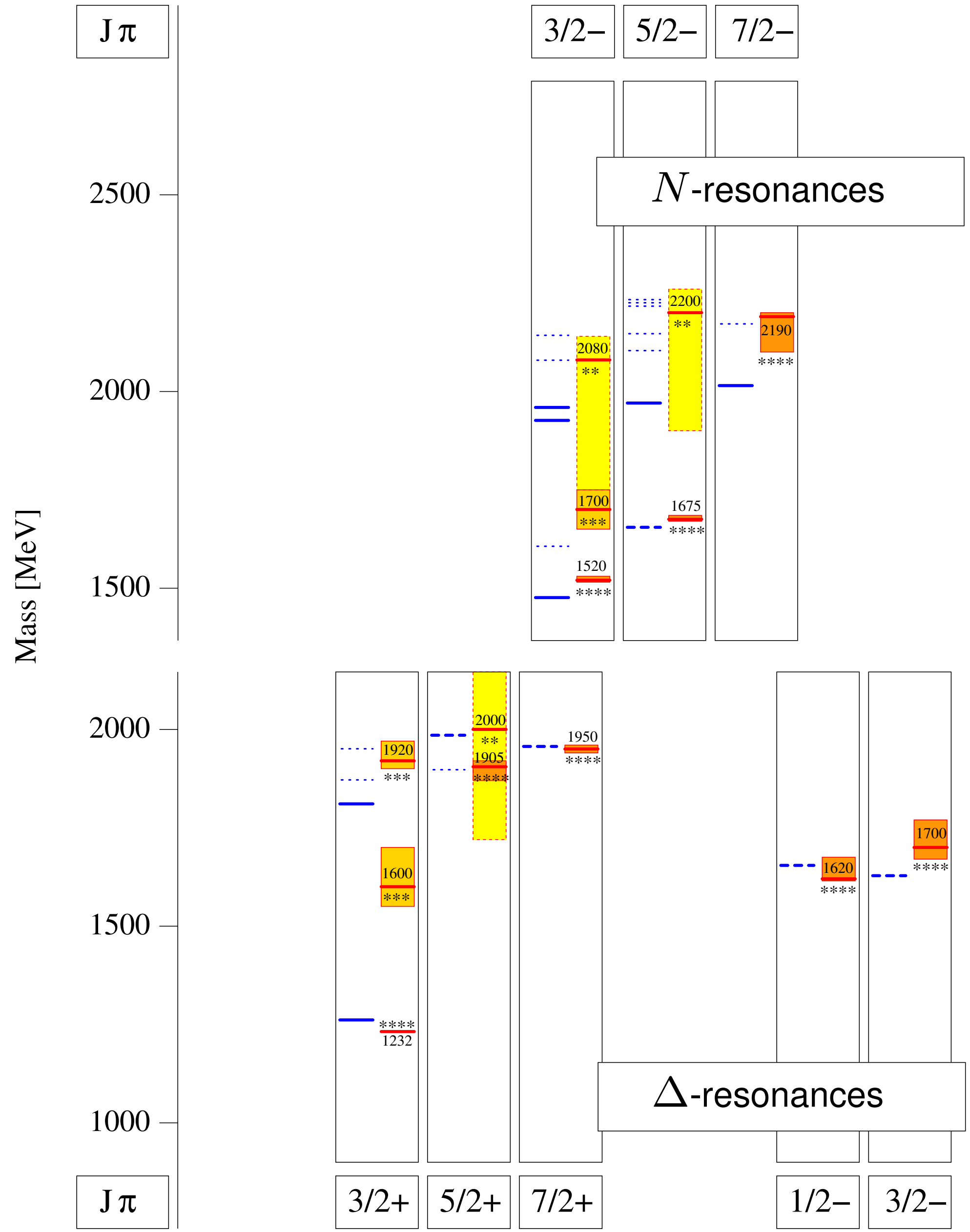


Examples for Strong Decay Widths: $N^* \to N\pi$

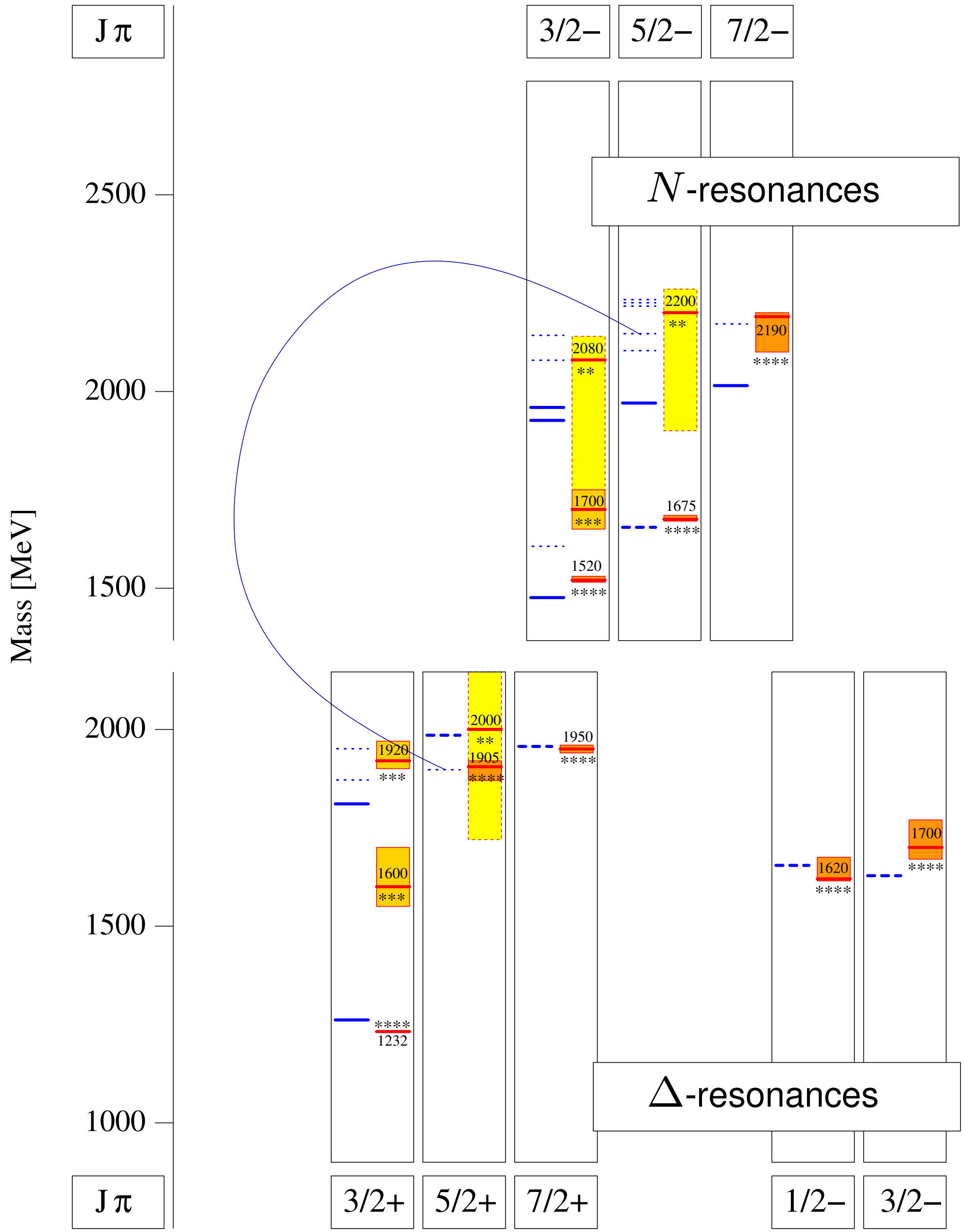


N^*		Γ [MeV]	
$J\pi$	n	BSM	EXP
1/2+	2	38	228^{+67}_{-67}
1/2+	3	5	15^{+23}_{-9}
1/2+	4	0.005	
1/2+	5	0.5	
1/2+	6	24	26^{+27}_{-22}
3/2+	1	15	23^{+11}_{-11}
3/2+	2	0.3	
5/2+	1	40	85^{+9}_{-9}
5/2+	2	0.008	
5/2+	3	0.01	
5/2+	4	28	26^{+85}_{-26}
7/2+	1	0.2	
9/2+	1	7	60^{+30}_{-23}
11/2+	1	0.03	

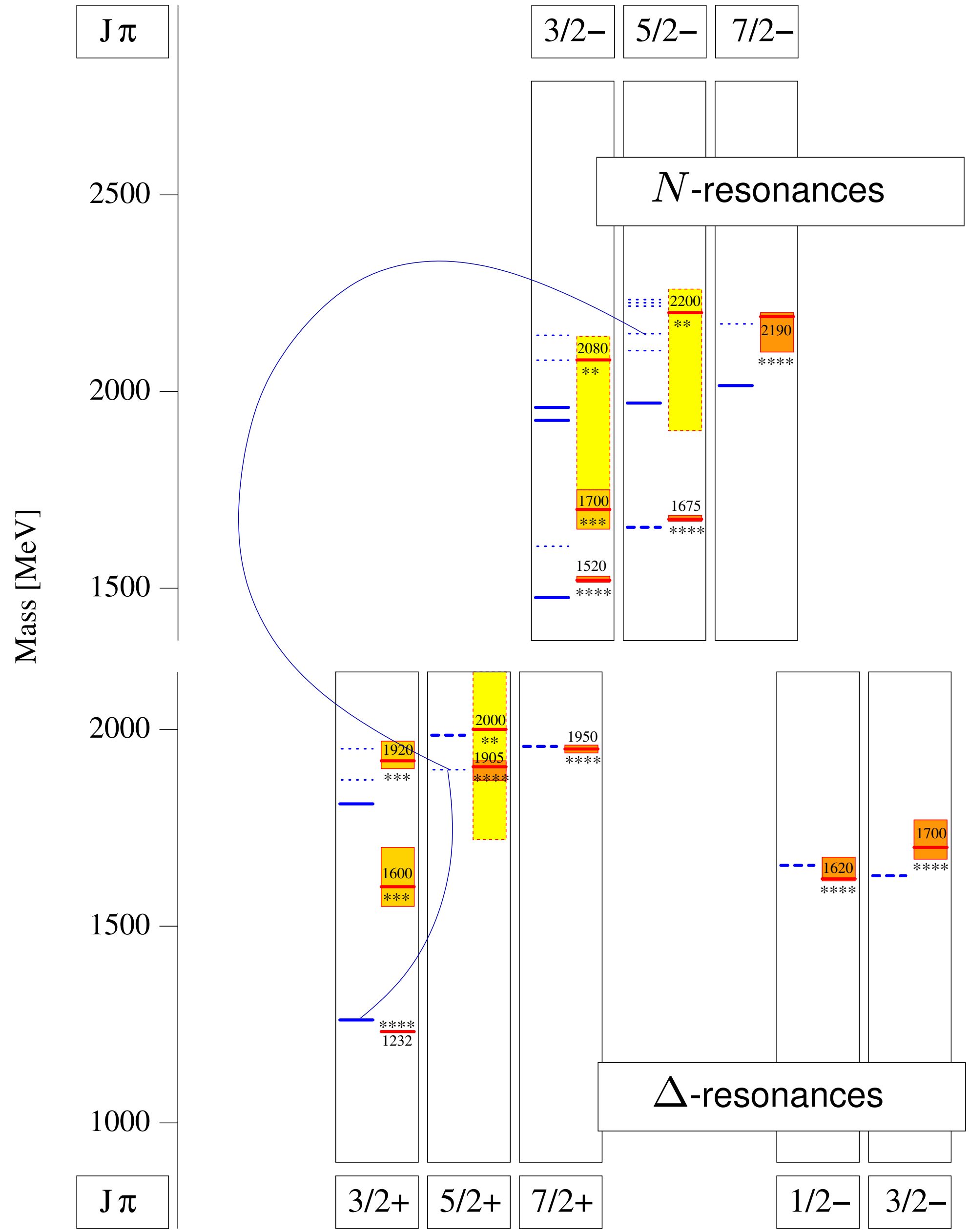
Strong Decays into Excited States and Cascades



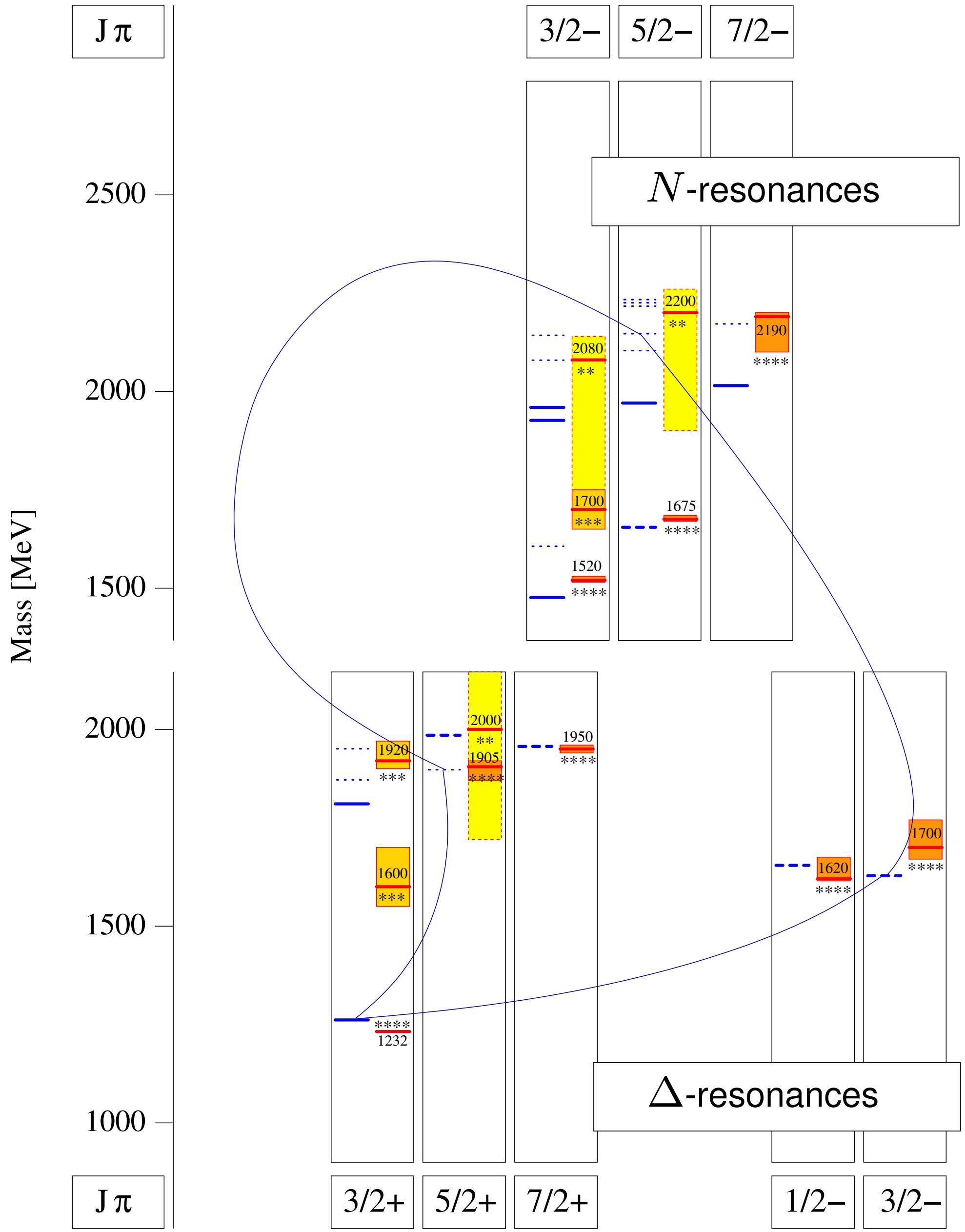
Strong Decays into Excited States and Cascades



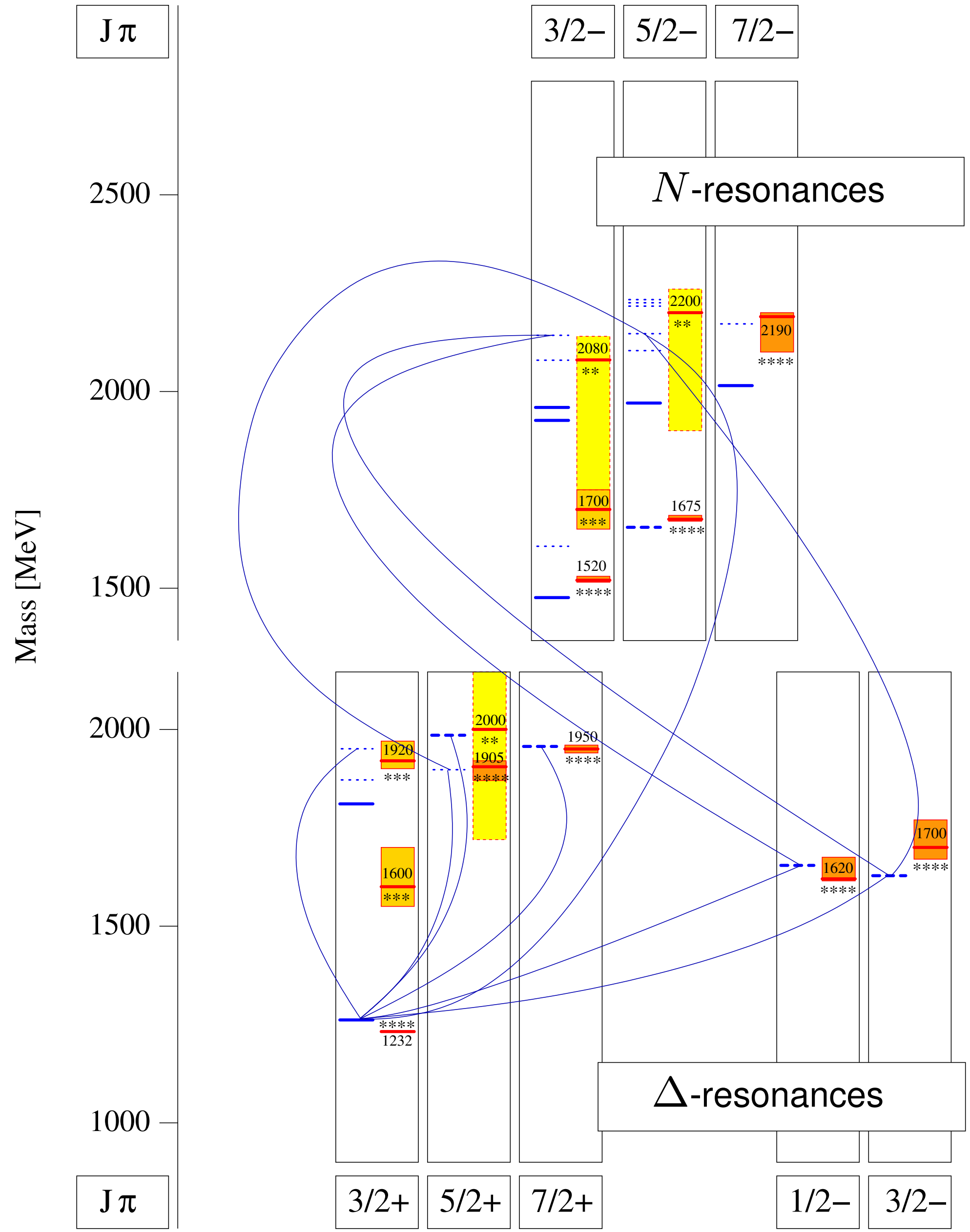
Strong Decays into Excited States and Cascades



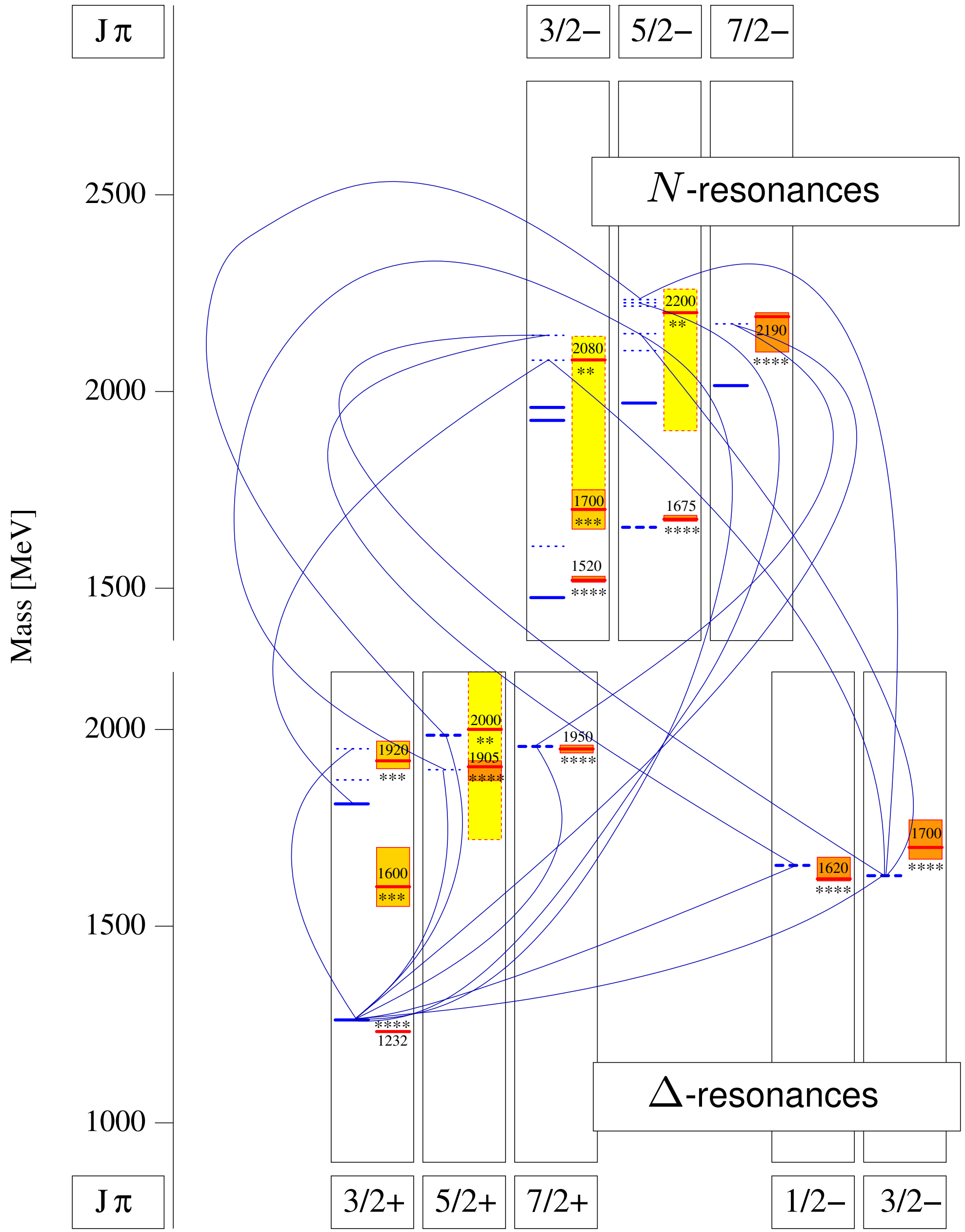
Strong Decays into Excited States and Cascades



Strong Decays into Excited States and Cascades



Strong Decays into Excited States and Cascades



Summary and outlook

- Static properties:
  - $\langle r^2 \rangle$ and $\langle \mu \rangle$ of baryons have been formulated as expectation values with respect to Salpeter amplitudes.
  - Resulting operators allow for a sensible physical interpretation and generalize the well known nonrelativistic expressions.
  - The method is applicable under the assumption of free quark propagators and instantaneous interaction kernels.
  - Satisfactory description of the empirical radii and magnetic moments.
  - ($\Rightarrow$ Magnetic radii, polarizabilities)
- Strong decays:
  - BSM offers a solution to the problem of the missing resonances: They do not couple to $N\pi$ or $N\bar{K}$.
  - There are many allowed quasi-two-body decay cascades.
  - Decay widths are quantitatively not correctly reproduced (calculations do not guarantee unitarity).

A.5 – status

- Funding of personnel ($\frac{1}{2}$ BAT IIa):

period		period	
01.10.04 - 30.06.06	(Ch.H.)	01.10.05 - 30.06.06	(S.M.)
01.07.06 - 30.09.06	(S.M.)		
	24 months		9 months (B.3)

- Goals, achievements, perspectives:

	task	done	publ.	rel.
1.	EM properties:			
	helicity amplitudes (Q^2)	$\surd$	$(\surd)$ $<$	B.1
	static moments	$\surd$	$\surd$	A.3
2.	Strong decays:			
	"missing" resonances	$\surd$	$<$	A.1, A.2
	instanton-ind. $B^* \to B\eta^{(\prime)}$	0	$-$	
	pilot study (SM): not feasible			
3.	Hadron interactions	$-$	$-$	
	(coupl. ch.) -not started yet-			
4.	Field theoretical foundations	$-$	$-$	
	-not started-			
	charmed baryons	$\surd$	$\surd$	
	(semileptonic decays)	$\surd$	$\surd$	

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14. S. Migura, D. Merten, B. Metsch, H.-R. Petry Eur. Phys. J. A **28** (2006) 55
15. Ch. Haupt, B. Metsch, H.-R. Petry, Eur. Phys. J. A **28** (2006) 213-225