Strange quarks in pions – and up-down quarks

A view from the Nambu-Jona-Lasinio model

Fabio L. Braghin

Instituto de Física -
Federal University of Goiás, Goiânia, Brazil

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Perceiving the Emergence of Hadron Mass through
AMBER@ CERN- VI

OUTLINE

- Motivations

* global properties (eg. Masses) usually are well described by NJL model/CQM
= to assess strangeness (sea quarks) component of the pion mass

- NJL model and related issues:
Quark-antiquark polarization and flavor dependent coupling constants
Rather for global properties

- Results and different ways of weighting strange-quark/antiquark contribution
for the light u,d quark and pion masses

- Final remarks

F.L.B.
arXiv:2109.02203 [hep-ph]].
Phys. Rev. D **103** (2021) no.9, 094028

QCD:
Strong coupling
(+asymptotic freedom)
AND
non Abelian color sector

Motivations

Hadron
structure/interactions
up to
nuclear interactions…

Color Confinement
Dynamical Chiral symmetry breaking
And other
Mechanisms of Mass generation

Pions/kaons as (quasi)
Goldstone boson
Probed in AMBER

How (in a broad way) do fundamental degrees of freedom (flavor)

survive and show up in hadron and nuclear observables?

NJL has an appeal to make possible an <u>analytical treatment</u>
With clear identification of relation between degrees of freedom
Many groups in the 1980-2010's
Dynamical approach should help with link to QCD
NJL ~ GCM ~SDE (RL)

Constituent Quark Model (CQM)

And extensions

Most of Hadrons Spectra support or suggest the idea For global properties (pion may be an exception)

It can receive corrections:
Diquarks
Virtual n-quarks states from Fock space
etc

Weinberg Large Nc CQM:
F.L.B. Eur.Phys.J.A 52 (2016) 5, 13,
arXiv:1601.04916

Quark masses (from the HIggs) are much smaller than needed to describe hadron masses

S**ea quarks in the NJL**

Are encoded in the quark-condensates

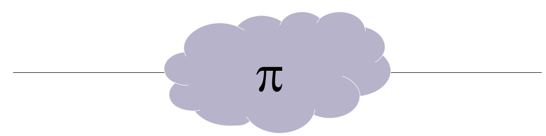
Difficult to generate asymmetry d-anti-d

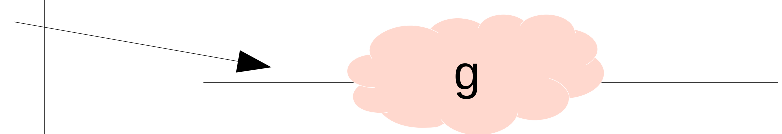
$$< \bar{q}_R q_L + \bar{q}_L q_R > \simeq -(250 MeV)^3$$

<u>From constituent quarks</u>

M*u ~ 360 MeV
M*d ~ 370 MeV
M*s ~ 510 MeV

Constituent quarks:
two main possible contributions
Usually considered separately
Maybe “competing” contributions





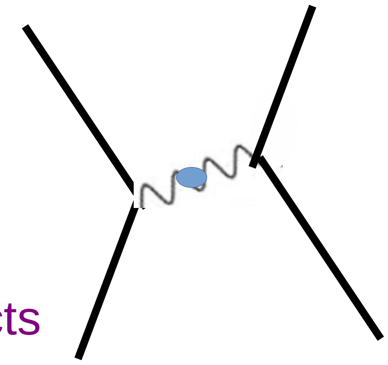
$$m_{qqb} = m_{qb} + m_q + \Delta^1_{spin}$$

$$m_{qqq} = m_q + m_{q'} + m_{q''} + +\Delta^2_{spin}$$

The Nambu-Jona-Lasinio (NJL) model

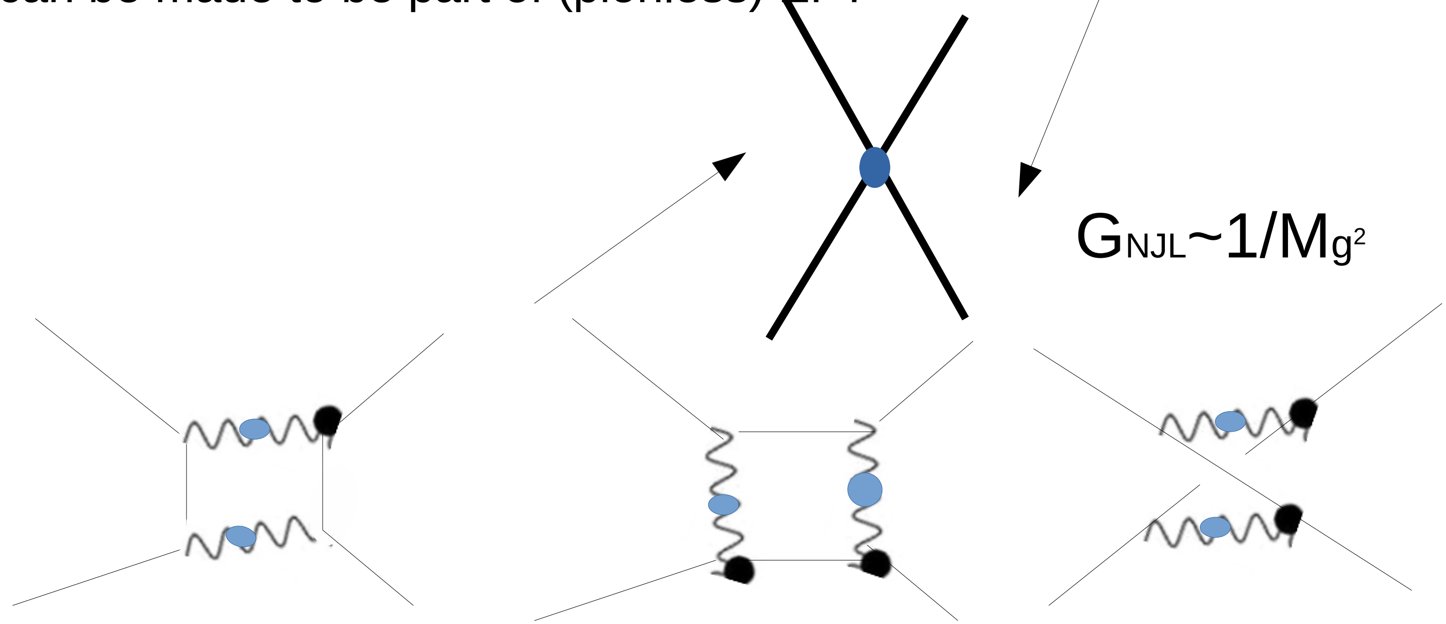
The quark-quark interaction mediated by ONE gluon exchange

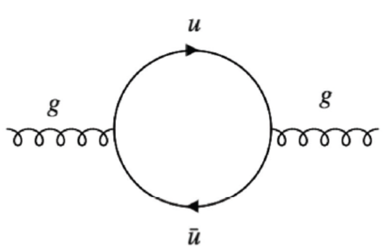
WITH however an improvement due to “non perturbative” (non Abelian) effects



This present approach provides, to some extent, similar results to the QCD-SDE at the rainbow ladder approach

It is not an EFT, however it can be made to be part of (pionless) EFT





Higher energies

Calculation based on Global Color Model
For example by C.D. Roberts, R.T. Cahill, J. Praschifka, P.C. Tandy,

Flavor (i,j $= 0,..N_f^2$) dependent couplings

$$\mathcal{L}_{NJL} = G_{ij}(\bar{\psi}\lambda_i\psi)(\bar{\psi}\lambda_j\psi) + [G_{ij} + \bar{G}_{ij}](\bar{\psi}\lambda_i i\gamma_5\psi)(\bar{\psi}\lambda_j i\gamma_5\psi)$$

Flavor independent
Contribution

+
Flavor dependent
contribution

$$G_{ij} = G_{ji}, \quad G_{22} = G_{11}, \quad G_{55} = G_{44}, \quad G_{77} = G_{66}.$$

CP
+
U(1) invariance

Flavor symmetric limit

Polarization corrections for
An arbitrary G-NJL

$$G^{m}_{i=j} = 10 \times \frac{G_{sym}\delta_{ij} + G_{ij}}{G_{sym}\delta_{ij} + G_{11}}.$$

To keep G11=10GeV-2
(fitting charged pion)

Need to renormalize

Because Gnjl is arbitrary
(many processes
Quark-gluon diagrams
contribute)

$$G_0 = 10\mathrm{GeV}^{-2}$$

Point of Reference

Mechanism for masses considered here
Basically: Dynamical chiral symmetry breaking

Although it may involve other mechanism
Since
- coupling constants are assumed to be large
- Gluon with effective masses

Solution for scalar condensat
GAP / Schwinger Dyson eqs.

$$\frac{\partial S_{eff}}{\partial \phi_q} = 0.$$

Chiral scalar condensate = it corrects quark mass = DChSB
But it easily takes into account
Other effects such as trace anomaly

$$\tilde{M}^* = m + < S > (P_R \tilde{U} + P_L \tilde{U}^\dagger)$$

Vacuum becomes infinitely degenerated

Scalar field
is eliminated by chiral rotation,
With resulting
non linear pion dynamics

Scalar mesons:
Unsolved problem
not considered
- exotic states?

Mixing: change of basis
quark mass eigenstate X meson mass eigenstate

1

$$G_{ij}(\bar{\psi}\lambda_i\psi)(\bar{\psi}\lambda_j\psi) = G_{f_1 f_2}(\bar{\psi}\psi)_{f_1}(\bar{\psi}\psi)_{f_2}$$

$$G_{ij} = G_{ij}(M_u^*, M_d^*, M_s^*).$$

Coupling constant that measure
The strangeness-asymmetry

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$

$$G_{i\neq j} \to G_{03}$$
$$\to G_{08}$$
$$\to G_{38}$$

Mixing between

$$\pi^0 \leftrightarrow \eta \leftrightarrow \eta'$$

$$G_{f_1 f_2} \to M_u^*(M_d, M_s)$$
$$\to M_d^*(M_u, M_s)$$
$$\to M_s^*(M_u, M_d)$$

This is not
Instanton induced mechanism

It is quark-antiquark-polarization

2

$$M_f^* - m_f = G_{ff}\ Tr\ (S_{0,f}(0)),$$

Gap or SDE equations

$$1 - 2G_{ij} I^{ij}_{f_1 f_2}(P_0^2 = -M_{PS}^2, \vec{P}^2 = 0) = 0,$$

Bethe-Salpeter at the Born level

For Numerical estimates

These effective propagators include a
Quark-gluon (running) coupling constant value (GAP eq. for DChSB)

$$D_2(k) = g^2 R_T(k) = \frac{8\pi^2}{\omega^4} D e^{-k^2/\omega^2} + \frac{8\pi^2 \gamma_m E(k^2)}{\ln\left[\tau + (1 + k^2/\Lambda_{QCD}^2)^2\right]},$$

Transversal Propagator from
Tandy- Maris / Chang-Xin

Fitting from SDE at RL level

where $\gamma_m = 12/(33 - 2N_f)$, $N_f = 4$, $\Lambda_{QCD} = 0.234\text{GeV}$,
$m_t = 0.5GeV$, $D = 0.55^3/\omega$ (GeV^2) and $\omega = 0.5\text{GeV}$.

$$\tau = e^2 - 1, \; E(k^2) = [1 - exp(-k^2/[4m_t^2])/k^2,$$

$$D_{\alpha=5,6}(k) = g^2 R_{L,\alpha}(k) = \frac{K_F}{(k^2 + M_\alpha^2)^2},$$

Cornwall effective propagator
- confining

$$K_F = (0.5\sqrt{2}\pi)^2/0.6\,\text{GeV}^2,$$

$$(M_5 = 0.8 \text{ GeV})$$

$$M_6 = M_6(k^2) = \frac{0.5}{1+k^2/\omega_6^2}\text{GeV for } \omega_6 = 1\text{GeV}.$$

Fitting of the parameters

set of parameters	m_u MeV	m_d MeV	m_s MeV	Λ MeV	M_u MeV	M_d MeV	M_s MeV
S	3	7	133	680	405	415	612
V_3	3	7	133	685	422	431	625

$G_0 = 10\text{GeV}^{-2}$

Point of Reference

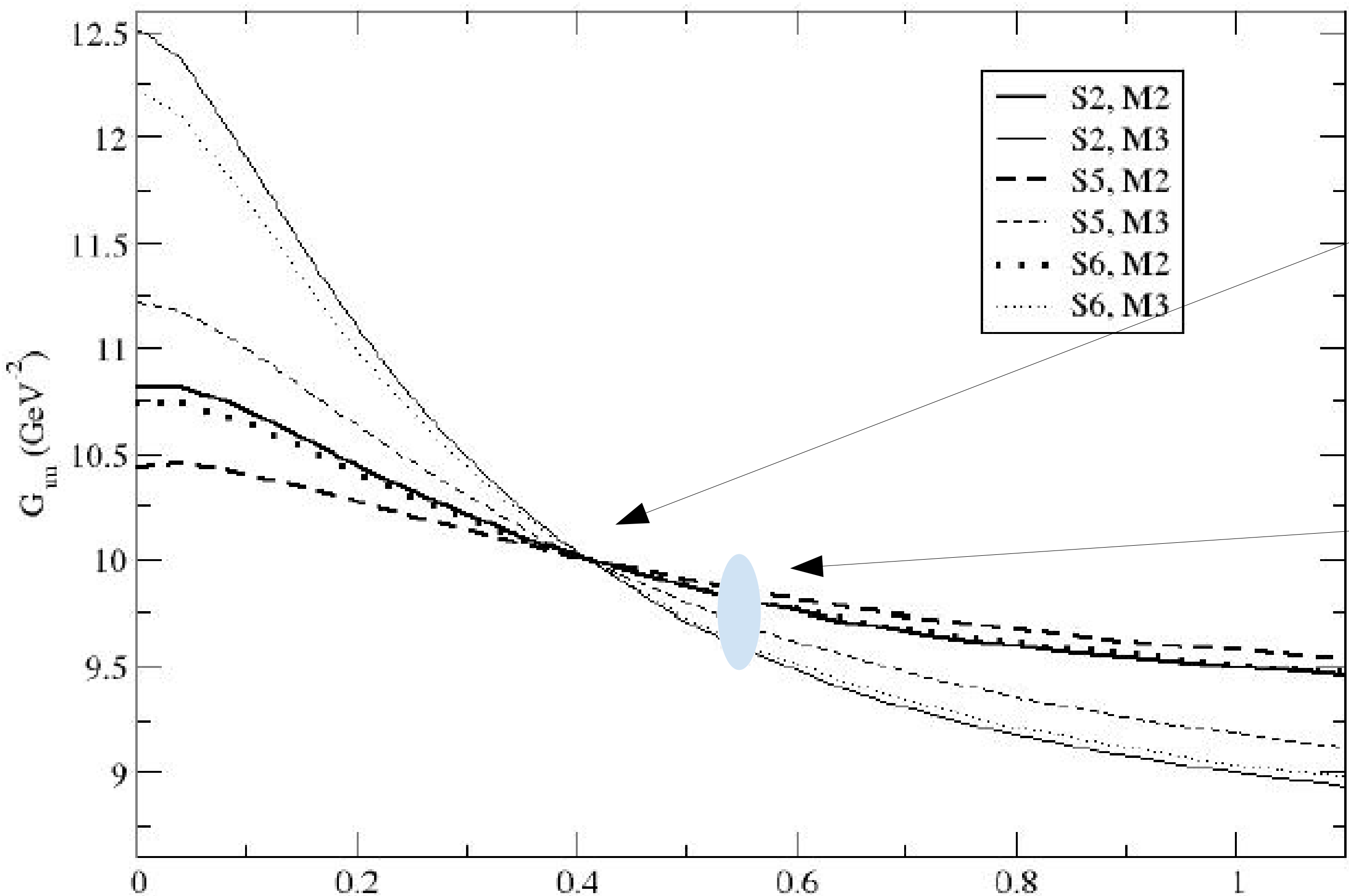
Observable	S2	S5	S6	G_0	V_3-2	V_3-5	V_3-6	V_3-G0	e.v.
M_{π^0}(MeV) [M2]	135.0	135.3	135.1	136.4	135.5	136.1	135.6	137.1	135 [43]
M_{π^0}(MeV) [M3]	133.5	134.2	133.7	136.4	134.15	134.9	134.4	137.1	
$M_{\pi^\pm}$ (MeV) [M2]	135.2	135.4	135.3	136.7	135.7	136.2	135.8	137.4	
$M_{\pi^\pm}$ (MeV) [M3]	133.7	134.4	133.9	136.7	134.4	135.0	134.5	137.4	
$M_{\pi^\pm} - M_{\pi^0}$ (MeV) [M3]	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.3	0.1 [43, 45]
M_{K^0} (MeV) [M3]	498.5	498.5	498.5	499	498	498	499	498	498 [43]
$M_{K^\pm}$ (MeV) [M3]	490	491	493	490	486	487	488	490	494 [43]

Coupling constant Guu
Up quark gap equation

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$

M_s^* M3-(G2) (MeV)	555	567	558	612	566	581	569	625
M_s^* M2-(G2) (MeV)	560	570	563	612	600	595	604	625
ch.lim. $M^*_{ch.L}$ (MeV)	381	381	381	381	415	415	415	415

Chiral limit



M*s (GeV)

Normalization Point

$G_0 = 10\mathrm{GeV}^{-2}$

Point of Reference

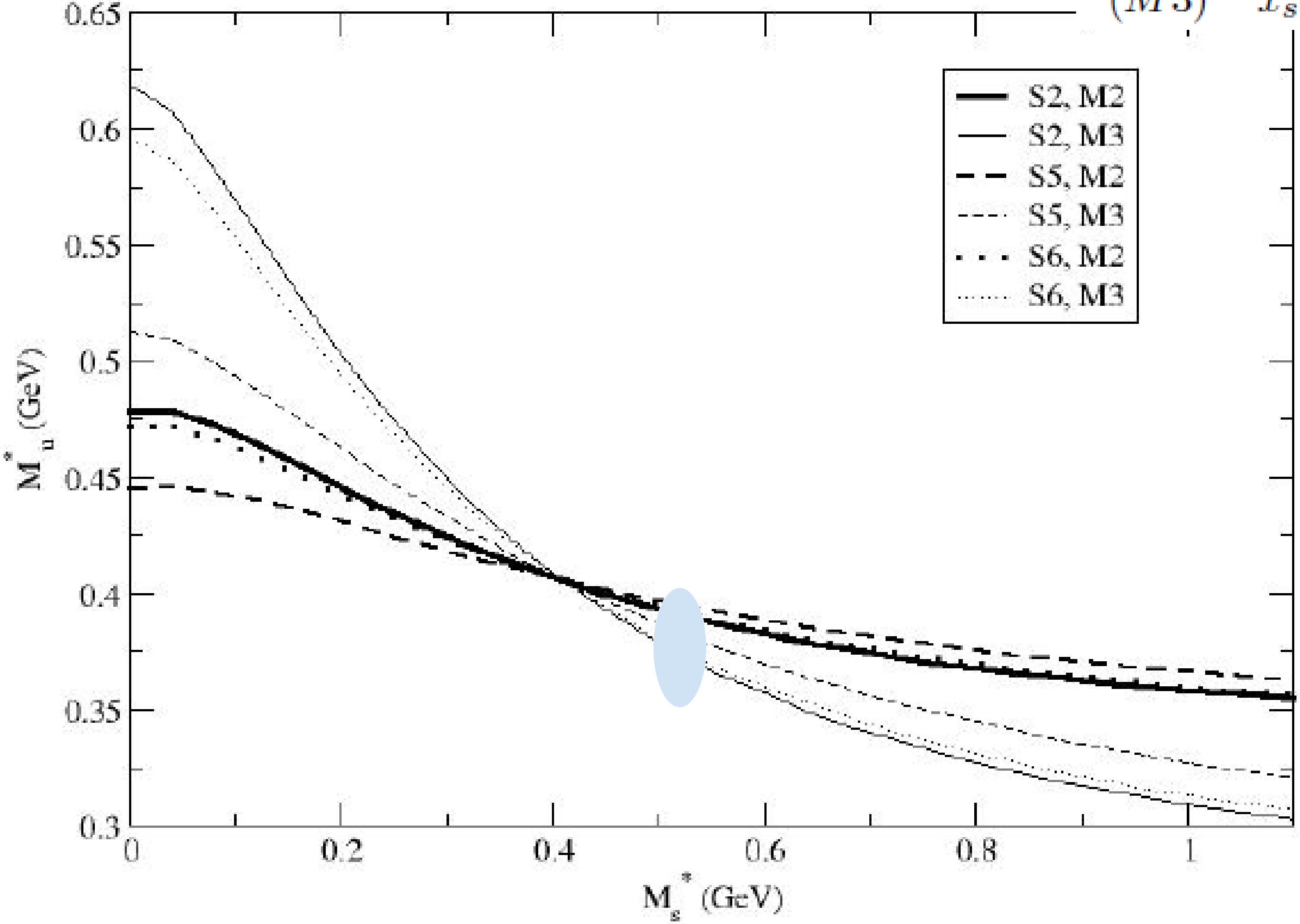
physical points

Non self consistent Variation of Ms*

Up dressed/constituent quark mass

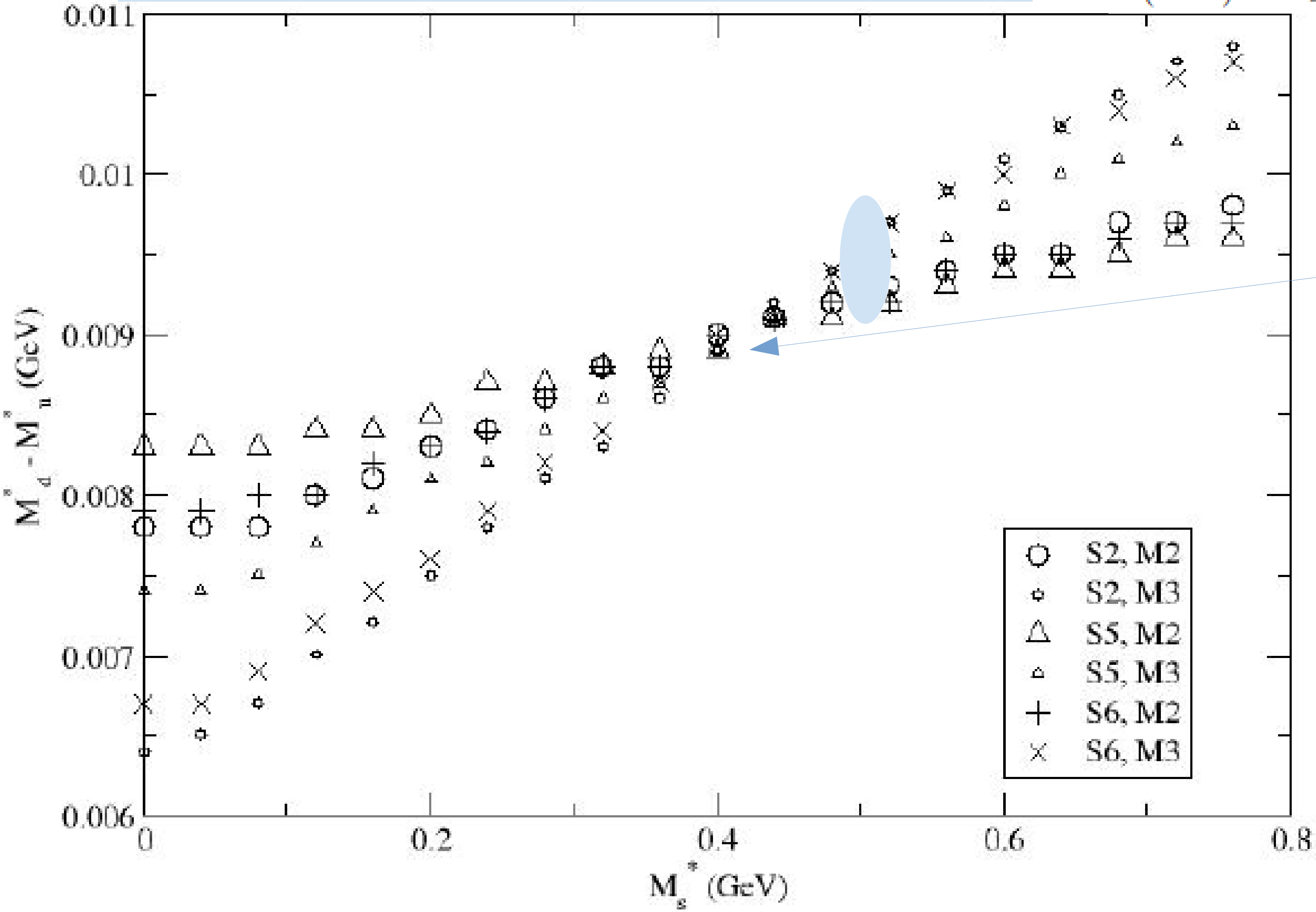
$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$

$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$



Down -Up dressed/constituent quark mass difference

$$(M2) \quad x_s G_{88} = 10 \; GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88} \; GeV^{-2},$$



Normalization Point

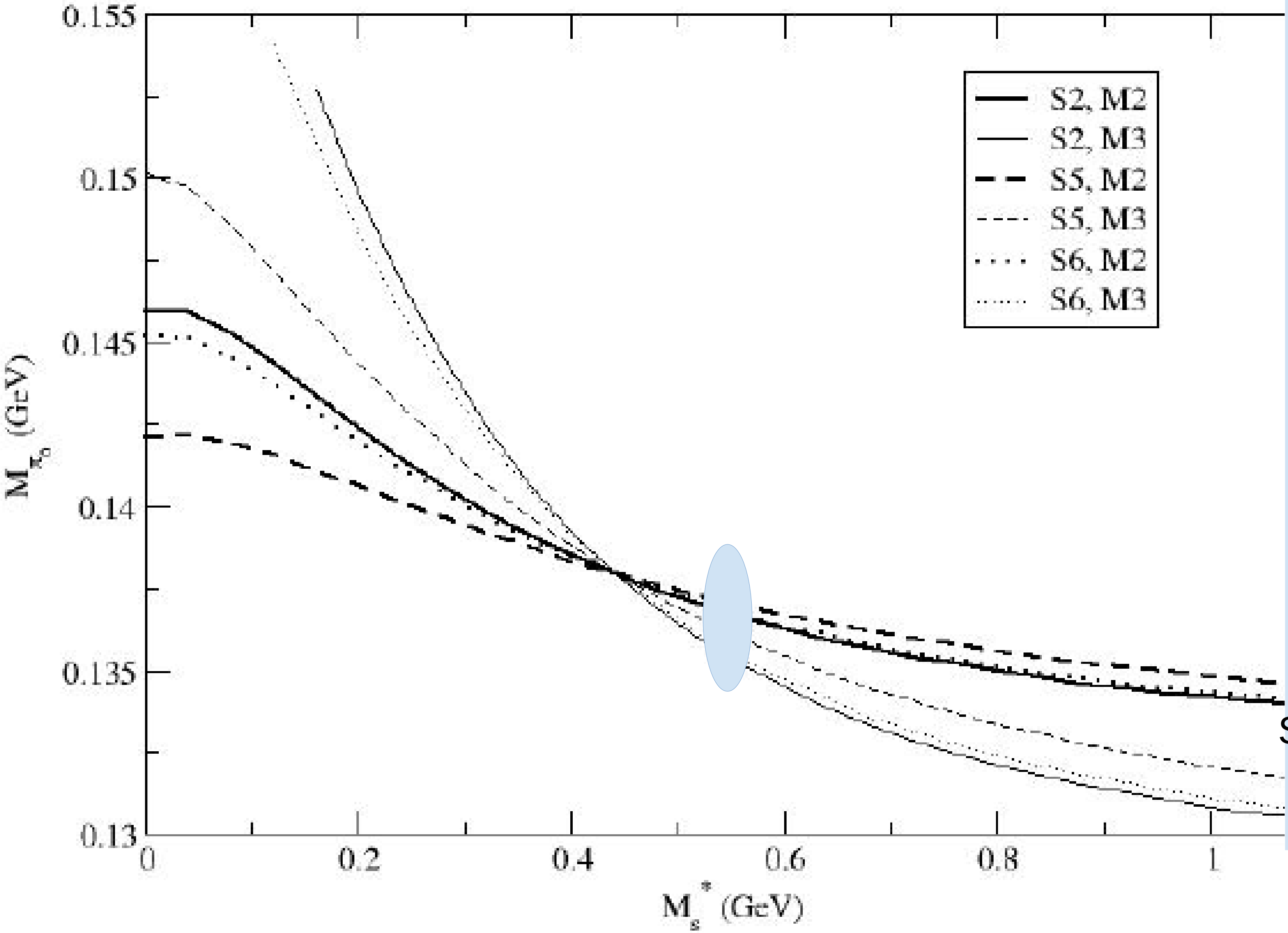
$$G_0 = 10 \mathrm{GeV}^{-2}$$

Point of Reference

set of parameters	m_u MeV	m_d MeV	m_s MeV	Λ MeV	M_u MeV	M_d MeV	M_s MeV
S	3	7	133	680	405	415	612
V_3	3	7	133	685	422	431	625

Neutral pion mass
(fitting observable)

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$



The most
Appealing reading of
These curves is
To compare
The values of the
Pion-masses
At the physical point
With values

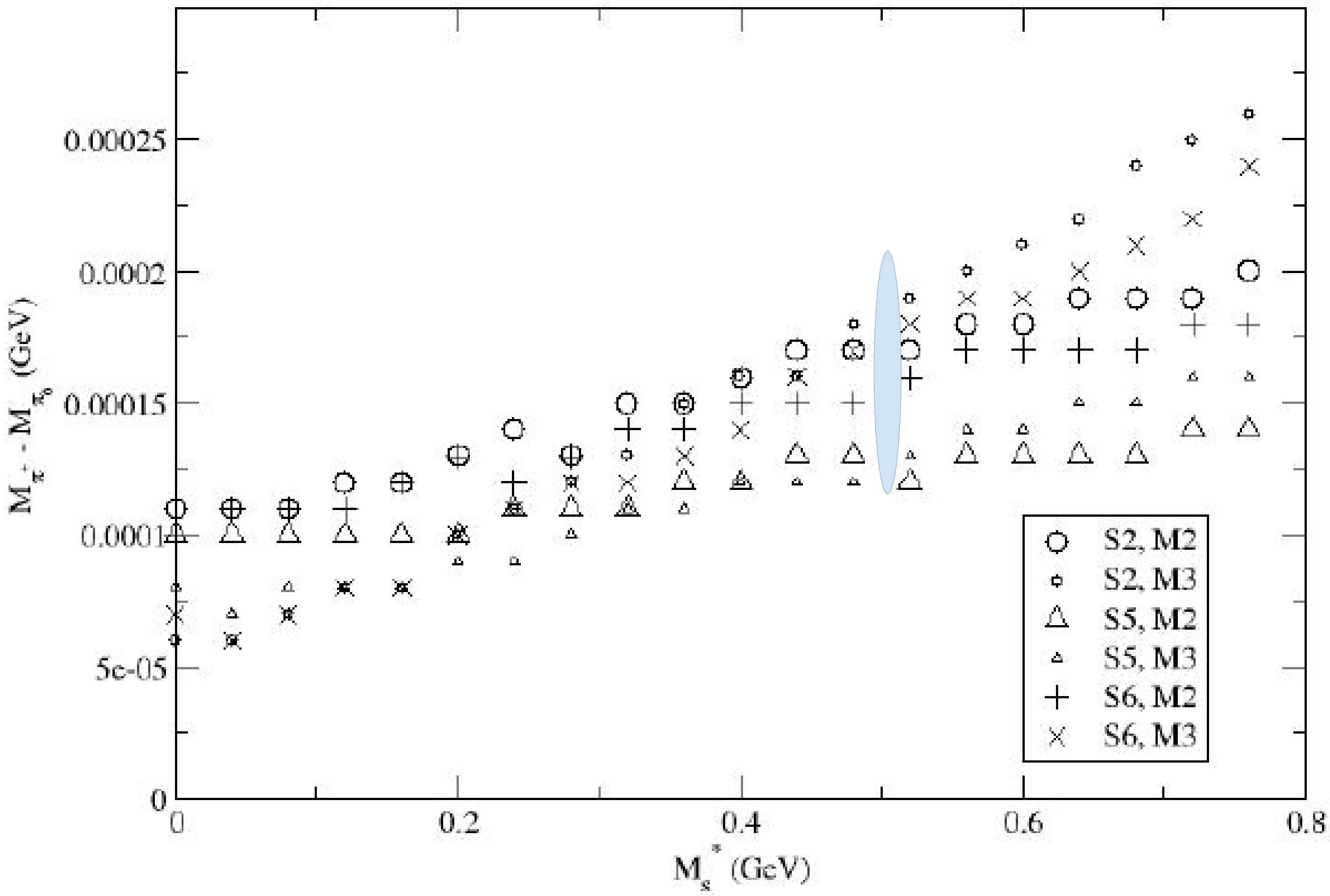
When
Strange-sea quarks=0

But, in the next slides
Other
Subtractions are shown

Neutral-charged pion (strong) mass difference

Gasser-Leutwyler/Donogue: ~ 0.1 MeV

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$



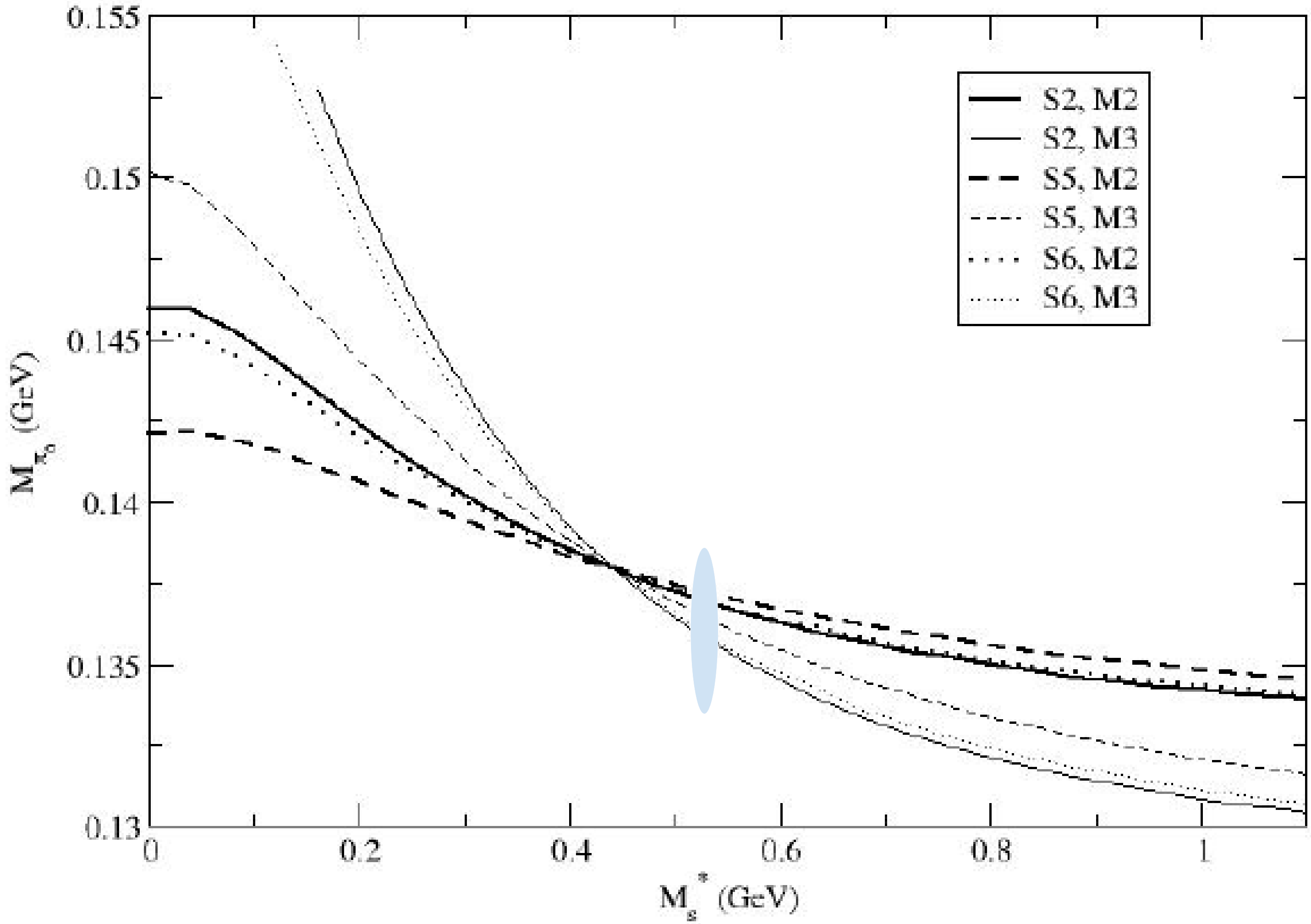
Electromagnetic
Mass difference
Is larger
~4 MeV

Role of the strangeness asymmetry G88

$$\Delta_s^{2,3} = T_{ff}(M3) - T_{ff}(M2),$$

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$

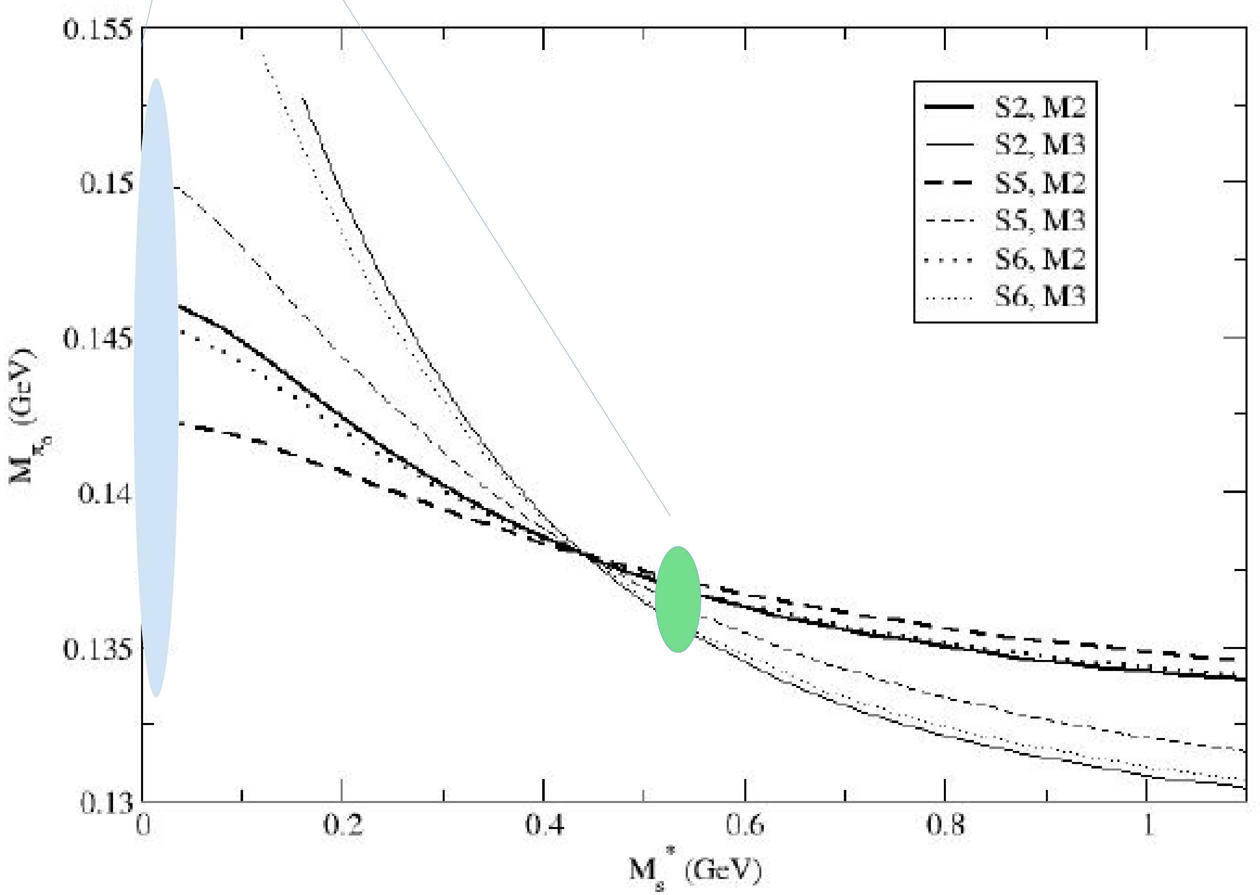
Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
$\Delta_s^{2,3}(M_\pi^*(s))$ (MeV)	-1.5	-1.1	-1.4	0	-1.3	-1.2	-1.2	0



$$\Delta_s^0 = T_{ff}(M_s^{*\prime}) - T_{ff}(M_s^* = 0),$$

$$(M2) \quad x_s G_{88} = 10\ GeV^{-2},$$
$$(M3) \quad x_s G_{88} = G_{88}\ GeV^{-2},$$

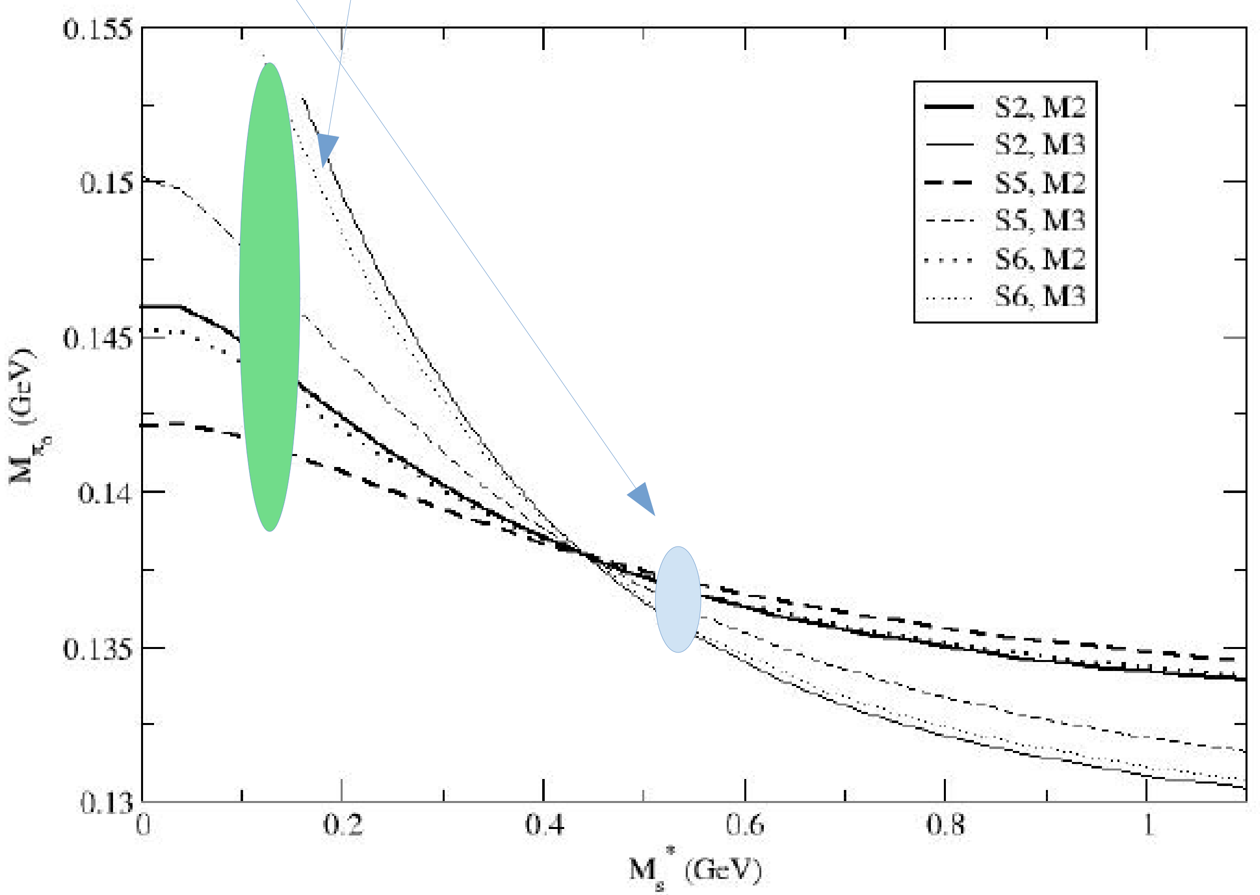
Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
$\Delta_s^0(M_\pi^*(s))$ (MeV)	-24	-13	-22	0	-28	-14	-25	0



Role of the s-quark
Condensate
Around 10% pion mass
At the cost of redefining all variables

$$\Delta_s^{m_0} = T_{ff}(M_s^{*\prime}) - T_{ff}(M_s^* = m_s),$$

Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
$\Delta_s^{m_0}(M_\pi^*(s))$ (MeV)	-16	-10	-16	0	-16	-9	-14	0



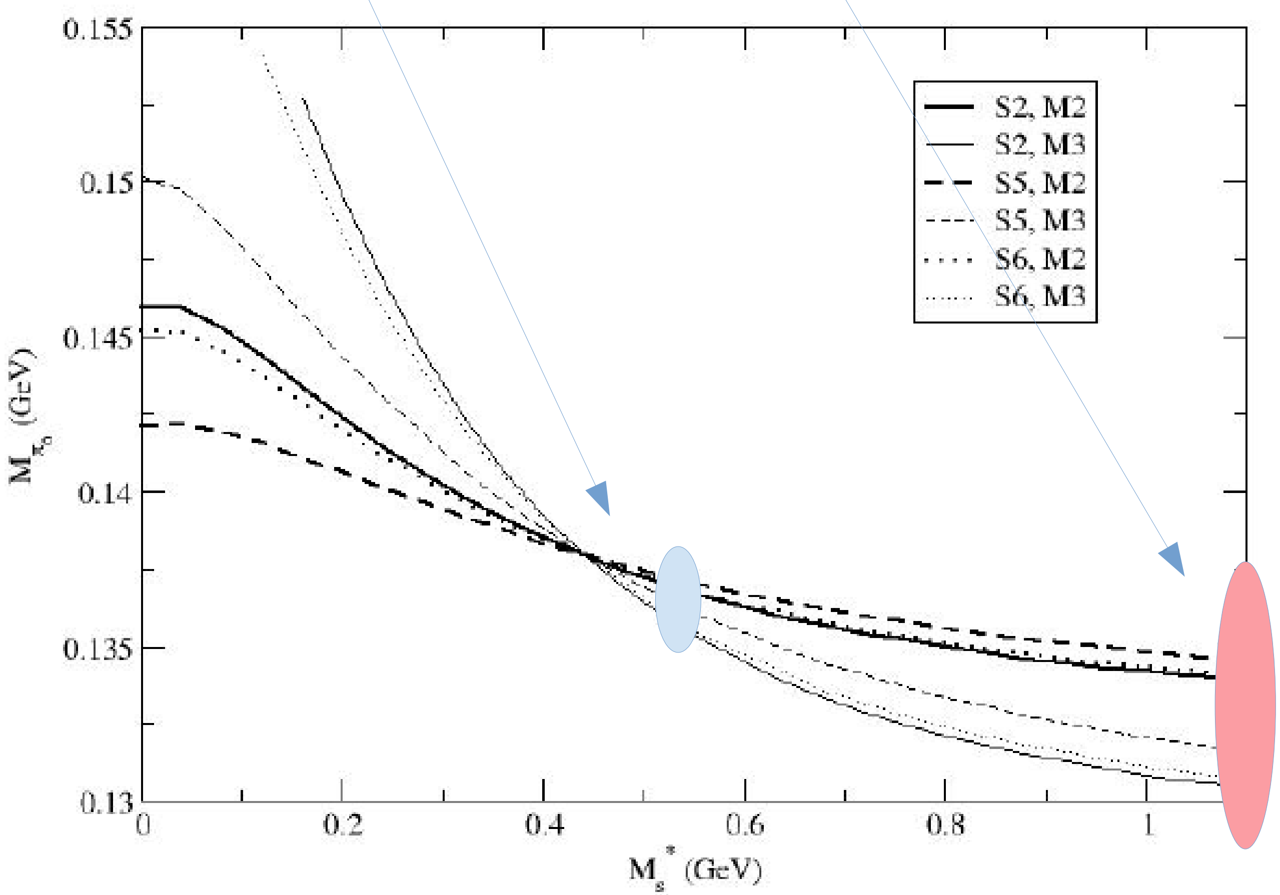
$$\Delta_s^\infty = T_{ff}(M^{*\prime}_s) - T_{ff}(M^*_s \to \infty).$$

Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
$\Delta_s^\infty(M_\pi^*(s))$ (MeV)	6	5	4	0	5	6	5	0

Dynamically:

At low energies
Larger
Strange quark mass
May
Correspond to
Frozen
Degree of freedom

Infinite M*s
May be
Interesting
at low energies



Other observables

1

2

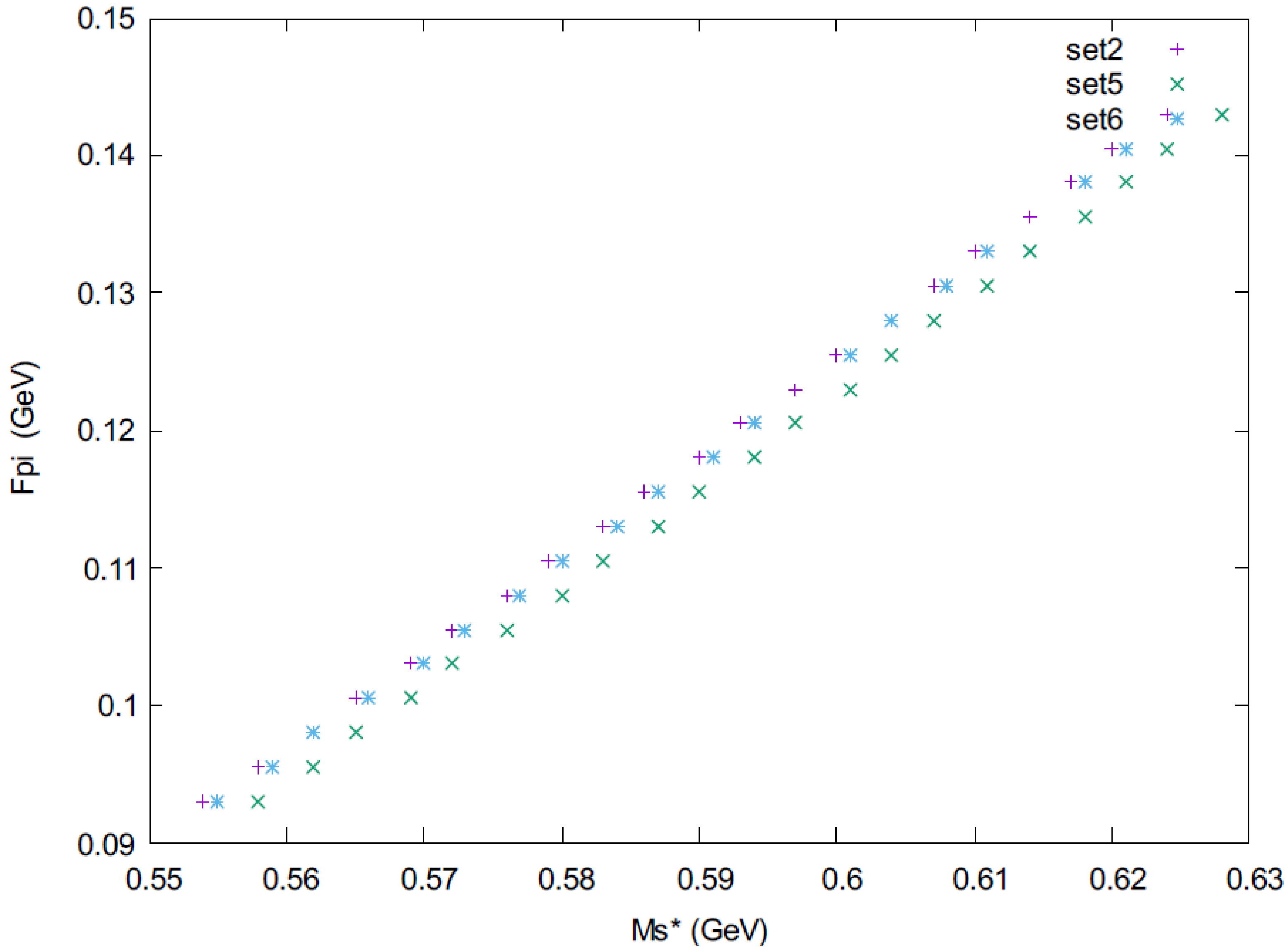
3

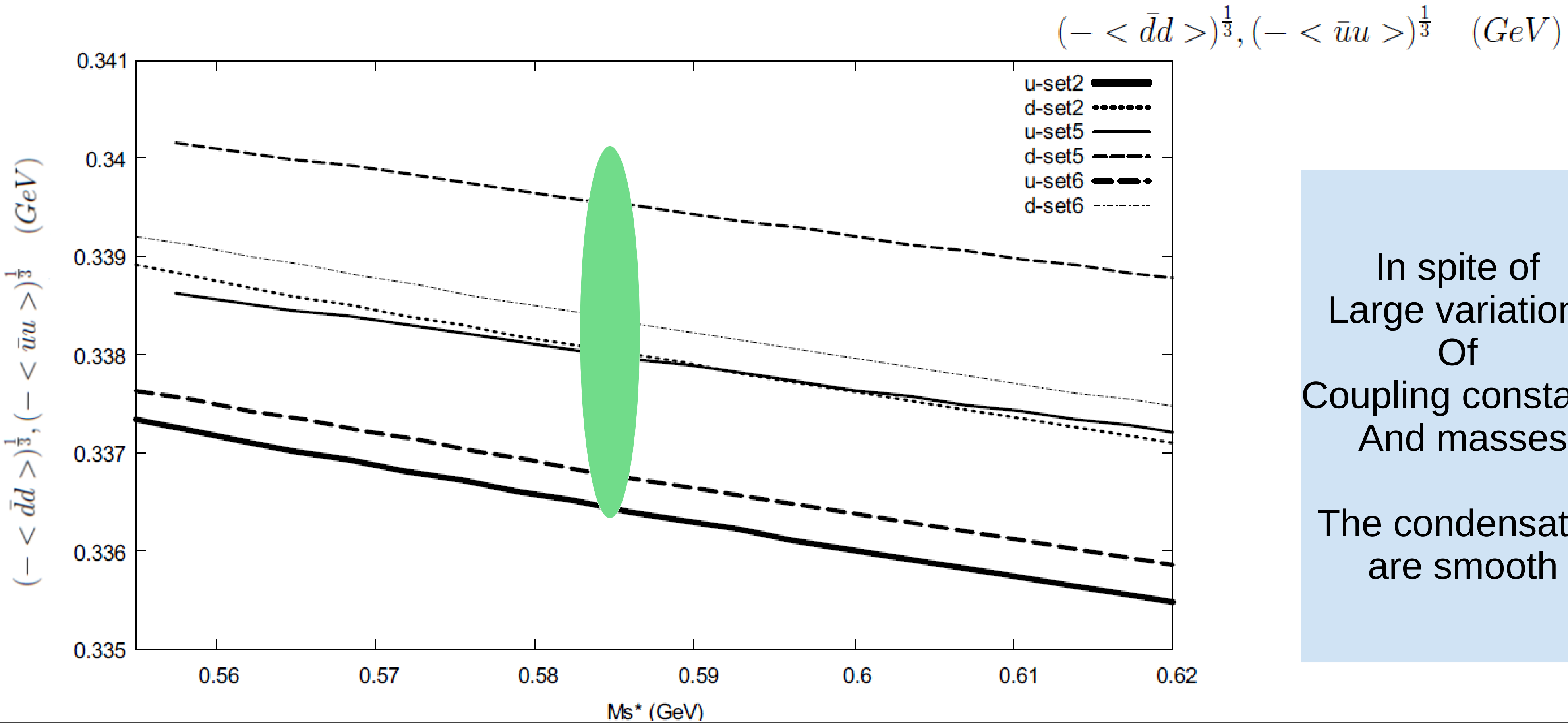
Observable	S2	S5	S6	G_0	V_3-2	V_3-5	V_3-6	V_3-G0	e.v.
M_{π^0}(MeV) [M2]	135.0	135.3	135.1	136.4	135.5	136.1	135.6	137.1	135 [43]
M_{π^0}(MeV) [M3]	133.5	134.2	133.7	136.4	134.15	134.9	134.4	137.1	
$M_{\pi^\pm}$ (MeV) [M2]	135.2	135.4	135.3	136.7	135.7	136.2	135.8	137.4	
$M_{\pi^\pm}$ (MeV) [M3]	133.7	134.4	133.9	136.7	134.4	135.0	134.5	137.4	
$M_{\pi^\pm} - M_{\pi^0}$ (MeV) [M3]	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.3	0.1 [43, 45]
M_{K^0} (MeV) [M3]	498.5	498.5	498.5	499	498	498	499	498	498 [43]
$M_{K^\pm}$ (MeV) [M3]	490	491	493	490	486	487	488	490	494 [43]
F_π (MeV)	99	99	99	102	100	101	101	103	92
F_K (MeV)	111	111	111	112	112	112	111	113	111
$(-<\bar{u}u>)^{1/3}$ MeV	331	334	332	343	336	338	336	347	240-260 [50, 51]
$(-<\bar{d}d>)^{1/3}$ MeV	333	335	333	344	338	339	338	349	240-260 [50, 51]
$(-<\bar{s}s>)^{1/3}$ MeV	348	353	349	366	352	356	353	369	290-300 [52]
$G_{qq\pi}$	3.3	3.2	3.2	3.4	3.3	3.3	3.3	3.6	
G_{qqK}	3.8	3.8	3.8	4.2	3.9	4.0	3.9	4.3	
θ_{ps}	-3.7	-2.7	-3.6	0.0	- 3.4	2.6	3.4	0.0	(-11°)-(-24°) [43]
Pr.s-content π	6%	10%	10%	0	16%	16%	16%	0	
χ^2_{red} (with $<\bar{q}q>$)	103	110	103	146	122	129	123	164	
χ^2_{red} (without $<\bar{q}q>$)	29	30	27	51	37	41	39	56	

Quark condensates with too large values
Because of the large coupling constant:

For low coupling constants: further difficulties with numerical convergence

Pion decay constant
It depends very strongly on Ms*
(probably this is a too much large variation
– model-dependence)





In spite of
Large variations
Of
Coupling constants
And masses

The condensates
are smooth

Sigma terms

Renormalization of coupling constant involves different strange quark mass dependencies

For some set of parameters: positive or negative s-sigma terms (u,d quarks and pion)

[Lattice calculations (Bali et al, 2012) indicated it should be small- large uncertanties

$$\mathcal{L}_{mix} = -\frac{M_{88}^2}{2} P_8^2 - \frac{M_{00}^2}{2} P_0^2 + 2 G_{08}^n \bar{G}_{08} P_0 P_8 + \mathcal{O}(P_3, P_3^2)...$$

$\eta \leftrightarrow \eta'$

pi0-eta mixing
From
Strangeness content
of the pion?

$$|\eta > = \cos\theta_{ps} |P_8 > - \sin\theta_{ps} |P_0 >,$$
$$|\eta' > = \sin\theta_{ps} |P_8 > + \cos\theta_{ps} |P_0 > .$$

To estimate mesons mixings: use of auxiliary field method

$$\theta_{ps} = \frac{1}{2} \arcsin\left(\frac{8 G_{08}^n \bar{G}_{08}}{(M_\eta^2 - M_{\eta'}^2)} \right).$$

F_π (MeV)	99	99	99	102	100	101	101	103	92
F_K (MeV)	111	111	111	112	112	112	111	113	111
$(- < \bar{u}u >)^{1/3}$ MeV	331	334	332	343	336	338	336	347	240-260 [50, 51]
$(- < \bar{d}d >)^{1/3}$ MeV	333	335	333	344	338	339	338	349	240-260 [50, 51]
$(- < \bar{s}s >)^{1/3}$ MeV	348	353	349	366	352	356	353	369	290-300 [52]
$G_{qq\pi}$	3.3	3.2	3.2	3.4	3.3	3.3	3.3	3.6	
G_{qqK}	3.8	3.8	3.8	4.2	3.9	4.0	3.9	4.3	
θ_{ps}	-3.7	-2.7	-3.6	0.0	- 3.4	- 2.6	- 3.4	0.0	(-11°)-(-24°) [43]
Pr.s-content π	6%	10%	10%	0	16%	16%	16%	0	
χ^2_{red} (with $< \bar{q}q >$)	103	110	103	146	122	129	123	164	
χ^2_{red} (without $< \bar{q}q >$)	29	30	27	51	37	41	39	56	

Chi-squared
For 9 observables (2 fitting observables)

Summary

- Dependence of pion observables on the strange quark (effective) mass
→ to assess strange sea quarks contribution for the pion observables
(mass, coupling constants and decay constant)

- eta and etaprime: they mix with pi0 → need of higher precision processes with pi0 exchange

Quark-antiquark polarization offers another mechanism for mesons mixings

- By using the same method:
to assess up-quark contribution to K0 and down-quark contribution for K+-

- In this simpler level of calculation: (strange) quark-antiquark contents are the same

HOW TO ASSESS each component hadron/pion masses:
- momentum dependencies
- spatial distributions?
- are there pion interactions rather sensitive to strange quarks not to up/down quarks?
(eg. pi0-eta-eta' mixing)

PLANNED OR ON-GOING
- parton strangeness content in the pion
- light mesons mixings
- etc

Thank you for your attention!

Deviation from the chiral limit

up/down quark masses

$$\Delta^f_{chL} \simeq M_f - M_{ch.L.},$$
$$\Delta^f_{G_{ij}} \simeq M^*_f - M_f,$$

Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
Δ_u^{chL} (MeV)	24	24	24	24	7	7	7	7
Δ_d^{chL} (MeV)	34	34	34	34	16	16	16	16

$$
\begin{aligned}
\Delta_s^{2,3} &= T_{ff}(M3) - T_{ff}(M2), \\
\Delta_s^{0} &= T_{ff}(M_s^{*\prime}) - T_{ff}(M_s^* = 0), \\
\Delta_s^{m_0} &= T_{ff}(M_s^{*\prime}) - T_{ff}(M_s^* = m_s), \\
\Delta_s^{\infty} &= T_{ff}(M^{*\prime}_s) - T_{ff}(M^*{}_s \to \infty)
\end{aligned}
$$

Observable	S2	S5	S6	G_0	V_3-2	V_3-5	[illegible]	[illegible]	[illegible]
M_{π^0}(MeV) [M2]	135.0	135.3	135.1	136.4	135.5	136.1	[illegible]	[illegible]	[illegible] [43]
M_{π^0}(MeV) [M3]	133.5	134.2	133.7	136.4	134.15	134.9	134.4	137.1	
$M_{\pi^\pm}$ (MeV) [M2]	135.2	135.4	135.3	136.7	135.7	136.2	135.8	137.4	
$M_{\pi^\pm}$ (MeV) [M3]	133.7	134.4	133.9	136.7	134.4	135.0	134.5	137.4	
$M_{\pi^\pm} - M_{\pi^0}$ (MeV) [M3]	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.3	0.1 [43, 45]
M_{K^0} (MeV) [M3]	498.5	498.5	498.5	499	498	498	499	498	498 [43]
$M_{K^\pm}$ (MeV) [M3]	490	491	493	490	486	487	488	490	494 [43]
F_π (MeV)	99	99	99	102	100	101	101	103	92
F_K (MeV)	111	111	111	112	112	112	111	113	111

Observable/M3	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0	e.v.
M_u^* M3-(G2) (MeV)	367	377	368	405	385	393	387	422	
M_u^* M2-(G2) (MeV)	386	394	387	405	401	406	402	422	
$M_u^*(M^*{}_s \to 0)$ MeV	618	512	595	405	651	537	626	422	
$M_u^*(M^*{}_s \to m_{0,s})$ MeV	563	491	547	405	579	508	563	422	
$M_u^*(M^*{}_s \to \infty)$ MeV	290	310	295	405	300	316	304	422	
M_d^* M3-(G2) (MeV)	375	384	378	415	394	402	395	431	
M_d^* M2-(G2) (MeV)	396	399	396	415	410	415	411	431	
$M_d^*(M^*{}_s \to 0)$ MeV	625	520	602	415	657	544	632	431	
$M_d^*(M^*{}_s \to m_{0,s})$ MeV	555	491	541	415	585	514	568	431	
$M_d^*(M^*{}_s \to \infty)$ MeV	305	320	305	415	314	328	316	431	
M_s^* M3-(G2) (MeV)	555	567	558	612	566	581	569	625	
M_s^* M2-(G2) (MeV)	560	570	563	612	600	595	604	625	
ch.lim. $M^*_{ch.L.}$ (MeV)	381	381	381	381	415	415	415	415	
M_{π^0} M3-(G2) (MeV)	133.5	134.2	133.7	136.7	134.2	134.9	134.4	137.4	0.135 [43, 45]
M_{π^0} M2-(G2) (MeV)	135.0	135.3	135.1	136.7	135.5	136.1	135.6	137.4	
$M_{\pi^0}(M_s^* \to 0)$ MeV	158	147	156	136.7	162	149	159	137.4	
$M_{\pi^0}(M_s^* \to m_{0,s})$ MeV	150	144	149	136.7	150	144	149	137.4	
$M_{\pi^0}(M_s^* \to \infty)$ MeV	129	129	129	136.7	129	129	129	137.4	

$$\Delta^f_{chL} \simeq M_f - M_{ch.L.},$$
$$\Delta^f_{G_{ij}} \simeq M^*_f - M_f,$$

Observable	S2	S5	S6	G_0	V_3-2	V_3-5	V_3-6	V_3-G0	e.v.
M_{π^0}(MeV) [M2]	135.0	135.3	135.1	136.4	135.5	136.1	135.6	137.1	135 [43]
M_{π^0}(MeV) [M3]	133.5	134.2	133.7	136.4	134.15	134.9	134.4	137.1	
$M_{\pi^\pm}$ (MeV) [M2]	135.2	135.4	135.3	136.7	135.7	136.2	135.8	137.4	
$M_{\pi^\pm}$ (MeV) [M3]	133.7	134.4	133.9	136.7	134.4	135.0	134.5	137.4	
$M_{\pi^\pm} - M_{\pi^0}$ (MeV) [M3]	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.3	0.1 [43, 45]
M_{K^0} (MeV) [M3]	498.5	498.5	498.5	499	498	498	499	498	498 [43]
$M_{K^\pm}$ (MeV) [M3]	490	491	493	490	486	487	488	490	494 [43]
F_π (MeV)	99	99	99	102	100	101	101	103	92
F_K (MeV)	111	111	111	112	112	112	111	113	111

Observable [M3]	S2	S5	S6	S-G_0	V_3-2	V_3-5	V_3-6	V_3-G0
Δ^{chL}_u (MeV)	24	24	24	24	7	7	7	7
Δ^{chL}_d (MeV)	34	34	34	34	16	16	16	16
$\Delta_{G_{ij}}$ (MeV)	- 38	-28	-37	0	-37	- 29	-35	0
$\Delta_{G_{ij}}$ (MeV)	-40	-31	-37	0	-37	-29	-36	0
$\Delta^{2,3}_s(M^*_u(s))$ (MeV)	-19	-17	-19	0	-16	-13	-15	0
$\Delta^{0}_s(M^*_u(s))$ (MeV)	-251	-135	-227	0	-266	- 144	-239	0
$\Delta^{m_0}_s(M^*_u(s))$ (MeV)	-194	-114	-179	0	-194	-115	-176	0
$\Delta^{\infty}_s(M^*_u(s))$ (MeV)	77	67	73	0	85	77	83	0
$\Delta^{2,3}_s(M^*_\pi(s))$ (MeV)	-1.5	-1.1	-1.4	0	-1.3	-1.2	-1.2	0
$\Delta^{0}_s(M^*_\pi(s))$ (MeV)	-24	-13	-22	0	-28	-14	-25	0
$\Delta^{m_0}_s(M^*_\pi(s))$ (MeV)	-16	-10	-16	0	-16	-9	-14	0
$\Delta^{\infty}_s(M^*_\pi(s))$ (MeV)	6	5	4	0	5	6	5	0