ELECTROWEAK STRUCTURE OF THE NUCLEON

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June 7, 2023

HADRON 2023 20th International Conference on Hadron Spectroscopy and Structure

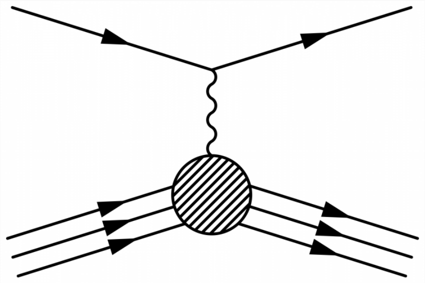
- {Ŝ(N g) ! charge distribution and magnetism

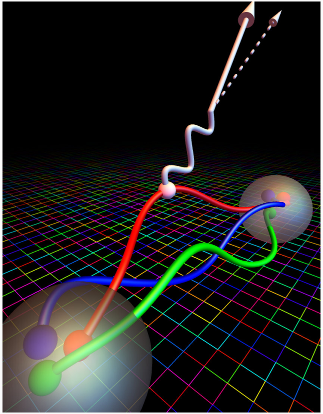
  { ! spin distribution

  Weak interaction is Ŝ

  - Ŝ^m = tɞĚg^{m}tɞ, hÝ(Ꞩ^0)jŜ^m(0)jÝ(Ꞩ)i = ˛^{0} h g^m{$^Ý_1$(tɞ^2) + $\frac{\mathring{0}s^{mn}tɞn}{2gÝ}${$^Ý_2$(tɞ^2) i ˛,
  - ^{m} = tɞg^{m}g$_5$tɞ, hÝ(Ꞩ^0)j ^{m}(0)jÝ(Ꞩ)i = ˛^{0} n g$_m${ (tɞ^2) + $\frac{tɞm}{2gÝ}$~ě(tɞ^2) o g$_5$˛

  tɞ = Ꞩ^0 Ꞩ Ý = Ꞩ; ɧ

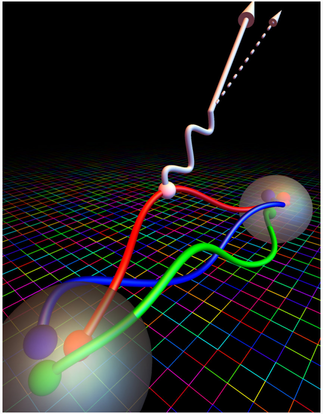




- Experimental determinations
  - Proton radius puzzle [Pohl et al., Nature 466, 213 (2010)]
- Lattice QCD
  - Nucleon f.f. is a benchmark for LQCD
  - Uncertainties reduced for unphysical large $\grave{U}_p$
  - Technical difficulties ! recent progress (cite)
  - Experimental and lattice $t\epsilon^2$ parametrisation:

    - dipole ansatz
    - z-expansion
    - ...

    9 = ; =) different $h_{W_1}^{W2} i$, and { N g in general



- **Experimental determinations**
  - Proton radius puzzle [Pohl et al., Nature 466, 213 (2010)]
- **Lattice QCD**
  - Nucleon f.f. is a benchmark for LQCD
  - Uncertainties reduced for unphysical large M_π
  - Technical difficulties $\to$ recent progress (cite)
  - Experimental and lattice Q^2 parametrisation:

    - dipole ansatz
    - z-expansion
    - ...

    $\Rightarrow$ different $\langle r_1^2 \rangle$, and $\{\mu_N\}$ in general
- **Chiral Perturbation Theory** (χPT)
  - EFT for QCD at low energy
  - QCD based parametrization of Q^2 and M_π dependencies $\Rightarrow$ extrapolate lattice results to the phys. point and extract $\langle r_0^2 \rangle$ and κ from the lattice simulations
  - Account for finite volume, lattice spacing and excited states
  - Determining χPT LECs from the lattice $\Rightarrow$ predicting other observables
- **Dispersion theory**
  - Enlarge the Q^2 range of plain χPT
- **Goal**: Disp+χPT = good Q^2 and M_π description

- Enlarge the q^2 range of χPT (ρ dynamics)

1. Disp. rel. (Cauchy)

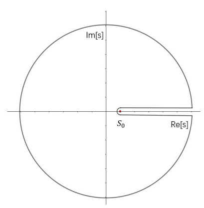
$$f(q^2) = \int_{4M_\pi^2}^{\infty} \frac{ds'}{\pi} \frac{\text{Im} f(s')}{s' - q^2 - i\epsilon}$$

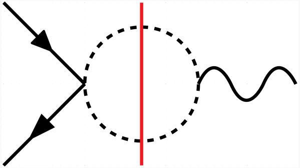
2. Unitarity $\Rightarrow$ $\text{Im} f = \frac{1}{2} \sum_n T_{fn} T^{\dagger}_{n\gamma\gamma}$, $n = \pi^+\pi^-, \ldots$
   - $\ell = 1$, $\pi\pi$ must be iso-vector
     $\Rightarrow f_1 = \frac{1}{2} f_1^{(+)} + f_1^{(-)} \frac{s^3}{2}$

3. Using full $\gamma\gamma\pi\pi$ and $\gamma\pi\pi$ vertices with M_π dep.

$$f(q^2) = \frac{1}{12\pi} \int_{4M_\pi^2}^{\infty} \frac{ds'}{\pi} \frac{T\, \sigma^3_{\pi}\, F_\pi^{V*}}{s'^{1/2}(s' - q^2 - i\epsilon)}\,,$$

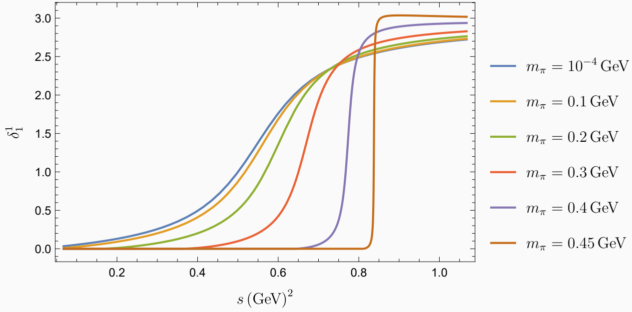
[Granados et al, EPJ A 53 (2017)]





- Our two vertices, $\dot{I}$ and $\{_p^{\hat{S}}$, include nonperturbatively the pp scattering amplitude, ¯
  - $A\,(')=\frac{8}{p}\,\mathring{a}_{\grave{}}\,(2`+1)\breve{e}_{\grave{}}(\cos q)^{¯}{}_{\grave{}}(')$
  - ` = 1, ¯ = $\frac{}{2\,\text{Ϛ}_{\text{H h}}}\sin d\,\bar{a}^{\mathring{0}d}$
  - $(')=\exp\left\{ , \int_{4\grave{U}_p^2}^{¥} \frac{\breve{a}\,'^{0}}{p}\,\frac{d(\,'^{0})}{'^{0}(\,'^{0}\quad,\quad\mathring{0}e)}\right\};$
  - We fit ¯∧8 g to d from [Garcia-Martin PRD 83(2011)]
  - We check that the $\grave{U}_p$ dependence is realistic
  - $\{_p^{\hat{S}}(')=[1+a\cdot']\quad(')$
  - $\dot{I}_{\mathring{0}}(')=\acute{E}_{\mathring{0}}(')+\quad(')\,\breve{e}_{\mathring{0}}+{}^{2}_{\mathring{0}}(')$,
    - ${}^{2}_{\mathring{0}}(')=\quad(')\,'\int_{4\grave{U}_p^2}^{¥}\frac{d\,'^{0}}{p}\,\frac{\acute{E}_{\mathring{0}}(\,'^{0})\sin d(\,'^{0})}{j\quad(\,'^{0})j(\,'^{0}\quad,\quad\mathring{0}e)\,'^{0}}$
    - $\acute{E}$ and $\breve{e}$ from $\acute{Y}\acute{Y}$! pp in cPT M = ˙˛ $\frac{1}{2}$@˙ꞙ˛ ! $\acute{E}$, $\breve{e}$
  -

$$)\quad \{(\text{ꞓ}^2)=\frac{1}{12p}\int_{4\grave{U}_p^2}^{Z¥}\frac{\breve{a}\,'}{p}\,\frac{\dot{I}\;\text{Ϛ}^3_{\text{H h}}\;\{_p^{\hat{S}}}{'^{1=2}(\,'\quad\text{ꞓ}^2\quad\mathring{0}e)};$$



- Our two vertices, $\dot{I}$ and $\{_p^{\hat{S}}$, include nonperturbatively the pp scattering amplitude, ¯
  - $A(') = \frac{8}{p} å_{`}(2` + 1)ĕ_{`}(\cos q)¯_{`}(')$
  - ` = 1, ¯ = $\frac{}{2Ç_{\text{H}}\text{h}}$ $\sin d ă^{\hat{0}d}$
  - $(') = \exp \left\{ ' \int_{4Ù_p^2}^{¥} \frac{ă'^0}{p} \frac{d('^0)}{'^0('^0 \; ' \; \hat{0}e)} \right\}$
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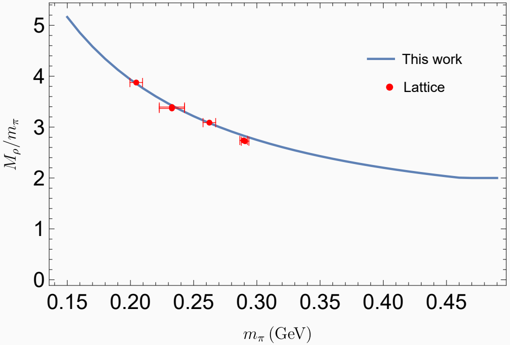
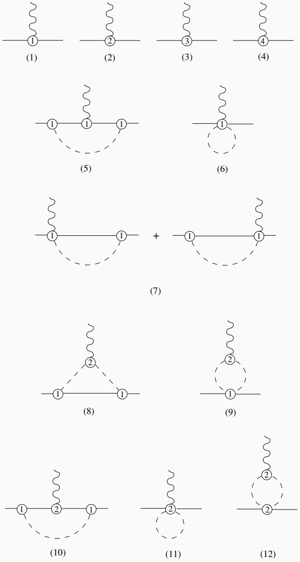
  - We check that the $Ù_p$ dependence is realistic
  - $\{_p^{\hat{S}}(') = [1 + a \cdot '] \;\; (')$
  - $\dot{I}_{\hat{0}}(') = É_{\hat{0}}(') + \;\; (')ĕ_{\hat{0}} + {}^2_{\hat{0}}(')$,
    - ${}^2_{\hat{0}}(') = \;\; (')' \int_{4Ù_p^2}^{¥} \frac{\text{d}'^0}{P} \frac{É_{\hat{0}}('^0)\sin d('^0)}{j \;\; ('^0)j('^0 \; ' \; \hat{0}e)'^0}$
    - $É$ and $ĕ$ from $ÝÝ$! pp in cPT
      $M = \; ` \; \frac{1}{2}@`ŧ` \;$! $É$, $ĕ$
  -

$$) \quad \{(ŧc^2) = \frac{1}{12p} \int_{4Ù_p^2}^{¥} \frac{ă'}{p} \frac{\dot{I} \; Ç^3_{\text{H}}\text{h} \; \{_p^{\hat{S}}}{'^{1=2}(' \;\; ŧc^2 \;\; \hat{0}e)};$$



- Disp+cPT = $\{^{\mathrm{L}\_}_{\mathrm{N}\ \mathrm{g}}{}^{\mathrm{q}}$ + diagrams without 2p cut from cPT
  - $\{^{\mathrm{L}\_}_{\mathrm{N}\ \mathrm{g}}{}^{\mathrm{q}}$
  - + cPT diagrams



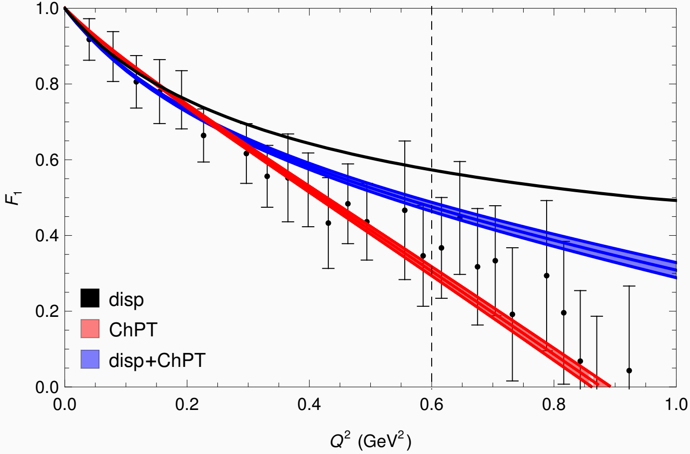
- Disp+cPT = $\{_{N\ g}^{L_{-}\ q}$ + diagrams without 2p cut from cPT
  - $\{_{N\ g}^{L_{-}\ q}$
  - + cPT diagrams
    - Relativistic and with explicit (1232) [Bauer et al., PRC 86 (2012)]
    - green: $\{_1$ $\{_1(0)$ (the charge is trivial)
    - blue: $\{_2$! we add the $O(\text{ʢ}^4)$ = terms

- **Disp+cPT** = $\{^{\mathrm{L}_{-}}_{\mathrm{N\ g}}{}^{\mathrm{q}}$ + diagrams without $2p$ cut from cPT
  - $\{^{\mathrm{L}_{-}}_{\mathrm{N\ g}}{}^{\mathrm{q}}$

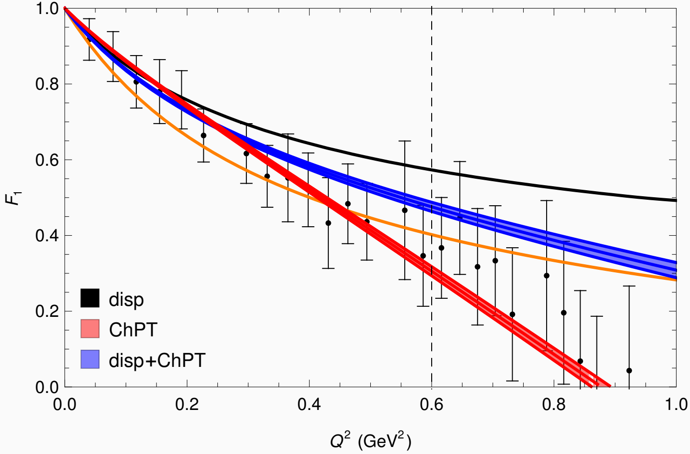
  - + cPT diagrams
    - Relativistic and with explicit (1232) [Bauer et al., PRC 86 (2012)]
    - green: $\{_1 \quad \{_1(0)$ (the charge is trivial)
    - blue: $\{_2 \ !$ we add the $O(\text{Ş}^4)$ = terms
  - Disp and cPT differ in the renormalization (UV)
    - At $O(\text{Ş}^3)$ disp and cPT agree on the $\grave{U}_p$ nonanalyticities
    - Example: the dispersive contribution from $\dot{I}^{\mathrm{q\,n\_j\,§}} \quad \frac{1}{\{^2}$ agrees with cPT

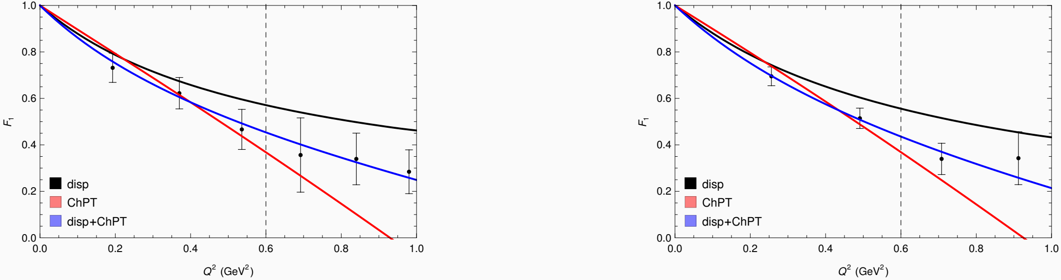
      $\{_1^{\mathrm{q\,n\_j\,§}} \quad \{_1^{(9)} \quad \text{tc}^2 \log \grave{U}_p$
    - differences absorbed in LECs

- Dirac f.f., $\{_1$
  - $h\acute{Y}j\hat{S}^m j\acute{Y}i = \text{h} g^m \{_1^{\acute{Y}}(t^2) + \frac{i s^{mn} t_n}{2 g_{\acute{Y}}} \{_2^{\acute{Y}}(t^2) \text{i}, \{_1 = \{_- + \frac{\check{E}^2}{4g^2} \frac{(\{\grave{U} \ \{_-)}{(1+\check{E}^2=(4g^2))}, \check{E}^2 = t^2.$
  - $\{_1 = 1 + \frac{t^2}{6} \text{h} 12\check{a}_6 + h_{w_1}^{w2(\log \grave{U}_p)} \text{i} \log \grave{U}_p + O(\varsigma^4)$
  - Comparison with LQCD data [Djukanovic PRD 103(2021)] controlled FV and discret. effects
  - In the cPT and disp+cPT $\{_1, \check{a}_6$ is fitted to LQCD
  - Disp $!$ t^2 curvature



- Dirac f.f., $\{_1$
  - $h\acute{Y}j\hat{S}^m j\acute{Y}i = \,\check{}\,^{0} \left[g^m \{_1^{\acute{Y}}(t\!c^2) + \frac{\mathring{0} s^{mn} t\!c_n}{2 g_{\acute{Y}}} \{_2^{\acute{Y}}(t\!c^2) \right] \check{}\,,\ \{_1 = \{_- + \frac{\check{E}^2}{4 g^2} \frac{(\{_{\grave{U}} \ \{_-)}{(1+\check{E}^2 = (4 g^2))},\ \check{E}^2 = t\!c^2.$
  - $\{_1 = 1 + \frac{t\!c^2}{6} \left[12 \breve{a}_6 + h_{w_1}^{w 2 (\log \grave{U}_p)} \log \grave{U}_p \right] + O(\varsigma^4)$
  - Comparison with LQCD data [Djukanovic PRD 103(2021)] controlled FV and discret. effects
  - In the cPT and disp+cPT $\{_1$, $\breve{a}_6$ is fitted to LQCD
  - Disp $!$ $t\!c^2$ curvature



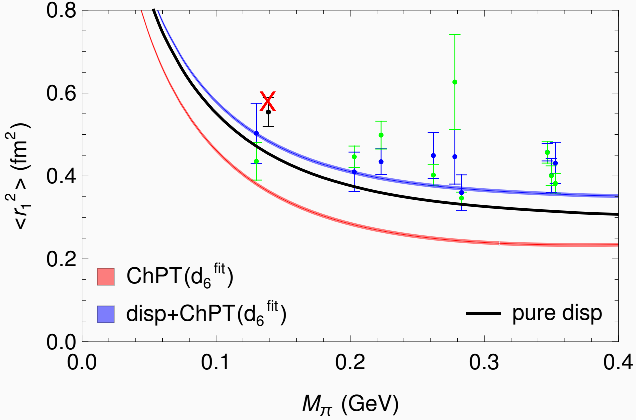


(h) H105 $\grave{U}_p$ = 0:278 GeV

(i) N302 $\grave{U}_p$ = 0:353 GeV

- Disp+cPT describes well the $\grave{U}_p$ dep.
  - good $\breve{a}_6$ fit for $\check{E}^2$ < 0:6 GeV^2 and $\grave{U}_p$. 350 MeV
  - outperforms the pure dispersive and plain cPT descriptions

	Disp (prediction)	cPT	**Disp+cPT**
$\breve{a}_6(m = g_r)$ (GeV ^{2})	-	0:074 0:010	0:416 0:010
$\breve{a}_6(m = g_{\acute{Y}})$ (GeV ^{2})	-	0:422 0:010	0:155 0:010
c^2=LnT	108:9=47 = 2:32	73:9=(47 1) = 1:61	24:6=(47 1) = 0:53
$h^{w2}_{w1} i_{q\backslash}$ (fm^2)	0.4541	0:3626 0:0047	**0:4838 0:0047**

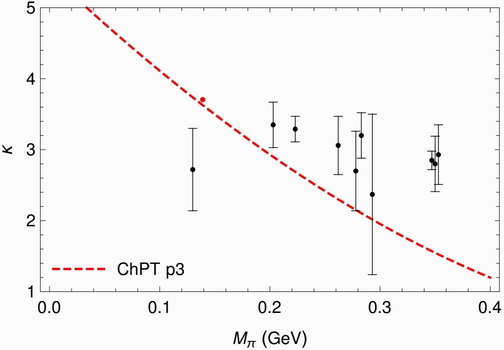


- $\{_1^{(\cdot)} = 1 + \frac{1}{6} h w_1^2 i^{(\cdot)} t\epsilon^2 + O(t\epsilon^4)$,
  $h w_1^2 i^{\mathrm{PKW}} = 0{:}577$ fm^2
- Heavy baryon fit to LQCD from [Djukanovic PRD 103(2021)]: $h w_1^2 i^{[\ ?} = 0{:}554 \quad 0{:}035$ fm^2

	Disp (prediction)	cPT	**Disp+ cPT**
$\breve{a}_6(m = g_r)$ (GeV ^{2})	-	0:074 0:010	0:416 0:010
$\breve{a}_6(m = g_{\acute{Y}})$ (GeV ^{2})	-	0:422 0:010	0:155 0:010
c^2=LnT	108:9=47 = 2:32	73:9=(47 1) = 1:61	24:6=(47 1) = 0:53
$h w_1^2 i_{q\backslash'}$ (fm^2)	0.4541	0:3626 0:0047	**0:4838 0:0047**

- Pauli f.f., $\{_2$
  - $h\acute{Y}j\hat{S}^m j\acute{Y}i = \bar{u}^{\prime}\left[g^m \{_1^{\acute{Y}}(tc^2) + \frac{\mathring{i}s^{mn} tc_n}{2g_{\acute{Y}}} \{_2^{\acute{Y}}(tc^2) \right] u$, $\{_2 = \frac{\{_{\grave{U}} \quad \{}{(1+\check{E}^2=(4g^2))}$
  - $\{_2^{(\cdot)} = k^{(\cdot)}\left[1 + \frac{1}{6} h_{w2}^{w2} i^{(\cdot)} tc^2 + O(tc^4)\right]$
  - $O(\text{Ş}^3)$ cPT is not enough (and subtleties)

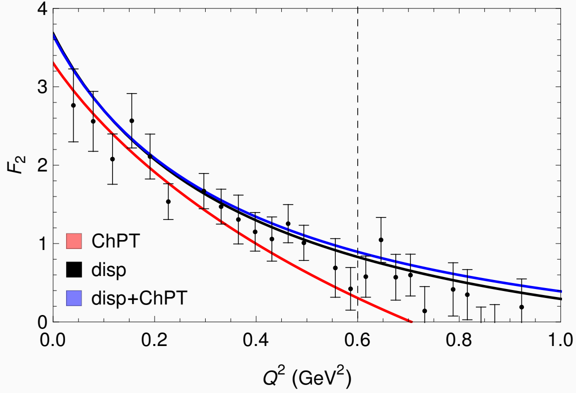
    $\{_2(0)^{\omega(3)} = !_6 \quad \frac{p g_{\acute{Y}} \hat{0}^2}{4p^2\{^2} \quad \grave{U}_p$



  - $=)$ include $= O(\text{Ş}^4)$
  - disp+cPT $O(\text{Ş}^4)$: $\{_2 = \{_2^{\text{L- q}} + \{_2^{\S\}00} + \{_2^{\text{cp ¦ ennq}}$,

    $\{_2^{\S\}00} = !_6 \quad 16\bar{\dot{a}}_{106} g_{\acute{Y}} \grave{U}_p^2 + 2tc^2(\check{a}_6 + 2\bar{\dot{a}}_{74} g_{\acute{Y}})$

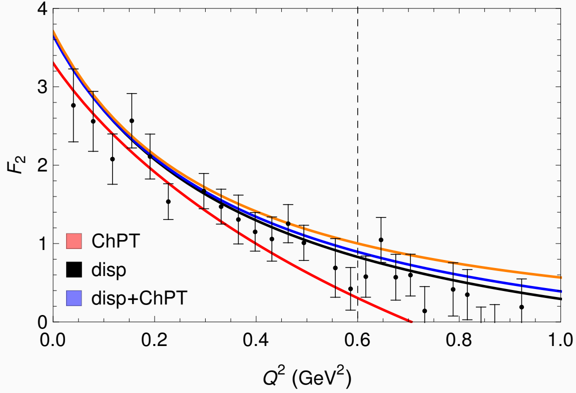
- $\{_2$ fit to LQCD
  - In $\{_2^{\mathrm{L}-\ \mathrm{q}}$ free $!_6$
  - In $\{_2^{c\,\mathrm{p}\,¦}$ and $\{_2^{\breve{a}\mathring{\emptyset}'\text{ʢ}+c\,\mathrm{p}\,¦}$, free $!_6$, $\bar{\dot{a}}_{106}$, $\bar{\dot{a}}_7 4$
  - cPT $O(\text{ʢ}^4)$ and disp separately are good enough to describe the data



(a) H105 $\grave{U}_p$ = 0:278 GeV

(b) N302 g_p = 0:353 GeV

- $\{_2$ fit to LQCD
  - In $\{_2^{\text{L}-\ \text{q}}$ free $!_6$
  - In $\{_2^{c\,\text{p}}$ and $\{_2^{\text{disp}+c\,\text{p}}$, free $!_6$, $\bar{a}_{106}$, $\bar{a}_7 4$
  - cPT $O(\text{Ϛ}^4)$ and disp separately are good enough to describe the data



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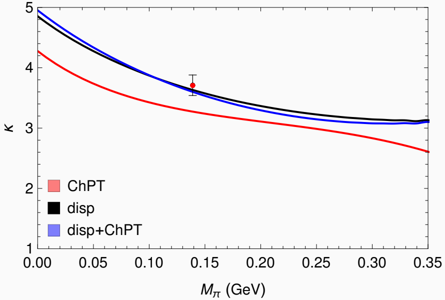
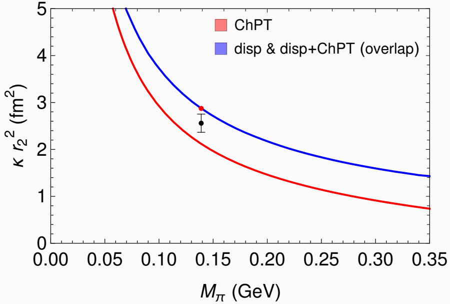




- $\{_2^{(\cdot)} = k^{(\cdot)} \; \text{h} \; 1 + \frac{1}{6} h_{w}^{w2}{}_{2}\, i^{(\cdot)} t\epsilon^2 + O(t\epsilon^4) \; \text{i}$
- . $k_{\text{p KW}} = 3{:}706$,
  $k_{[\ ?} = 3{:}71 \quad 0{:}17$,
  $h_{w}^{w2}{}_{2}\, i_{\text{p KW}} = 0{:}7754$ fm^2,
  $h_{w}^{w2}{}_{2}\, i_{[\ ?} = 0{:}690 \quad 0{:}042$ fm^2.

	Disp+$!_6$	cPT	**Disp+cPT**
c^2=LnT	$\frac{49:95}{47\ \ 2}$ = 1:11	$\frac{44:18}{47\ \ 4}$ = 1:027	$\frac{56:08}{47\ \ 4}$ = 1:304
c_0^2=LnT	1:09	1:027	1:283
$k_{q\,\backslash\,'}$	3:64	3:42	**3:61**
$h_{w}^{w2}{}_{2}\, i_{q\,\backslash\,'}$ (fm^2)	0:673	0:619	**0:668**

- { ! spin distribution
  Weak interaction is Ŝ
  - $^{\hat{0}}m = \text{ŧc} g^m g_5 \frac{t^{\hat{0}}}{2} \text{ŧc},\ h\acute{Y}j \ ^m j\acute{Y}i = \ \check{}\,^0 \Big[g_m \{ (\text{ŧc}^2) + \frac{\text{ŧc}m}{2g\,\acute{Y}} \sim_{\check{e}} (\text{ŧc}^2) \Big] g_5 \frac{t^{\hat{0}}}{2} \check{}$

- Nucleon axial isovector form factor
  - $\{ (\text{ŧc}^2) = \hat{0} \ \ 1 + \frac{1}{6} h_{\text{w}}^{\text{w}2} i \text{ŧc}^2 + O(\text{ŧc}^4)$
  - $\hat{0}$ and $\{$ dependence in ŧc^2 are necessary in n oscillations experiments
  - m capture, b-decay
  - cPT calculation of $\{$
    $=)$ extract $h_{\text{w}}^{\text{w}2} i$ from lattice QCD without ad-hoc parametrization
  - $\hat{0}$ $(\grave{U}_p)$: test of $p\acute{Y}$ scatt. in cPT Alvarado & Alvarez-Ruso PRD 105 (2021)
- $O(\text{Ş}^4)$ $\{$ in relativistic cPT
  - $\{ \ = \hat{0} \ + 4\check{a}_{16}\grave{U}_p^2 + \check{a}_{22}\text{ŧc}^2 + \text{ennq} \ (\grave{U}_p; \text{ŧc}^2)$
  - Difference between orders ' theoretical uncertainty

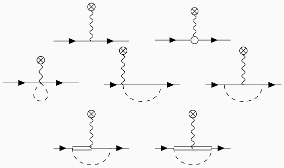


Figure: $O(\text{Ş})$ and $O(\text{Ş}^3)$ (w. f. renormalisation not shown)

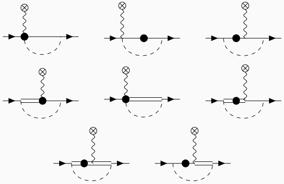
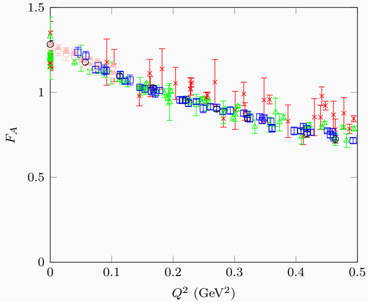
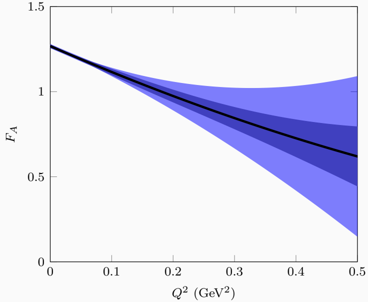


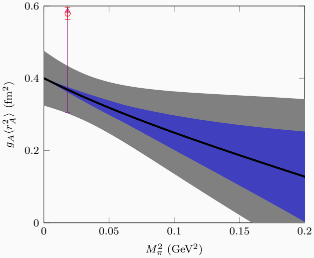
Figure: $O(\text{Ş}^4)$

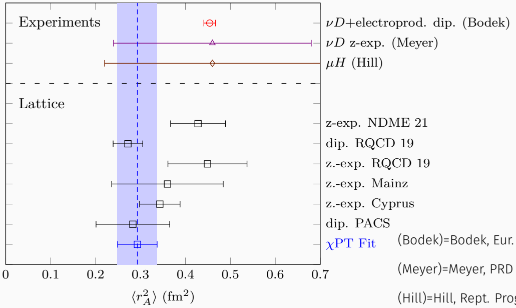
- { : **Meta-analysis of large set of recent LQCD results**
  - Many recent works) substantial improvements
  - RQCD[1] + PNDME[2] + "Mainz"[3] + PACS[4] + ETMC[5]
  - Reasonably good fit: c^2 plateau
    =) $\grave{U}_p^{\text{H«§}}$ ' 400 MeV, $\check{E}^2_{\text{H«§}}$ = 0:36 GeV^2





[1] Bali et al. JHEP 05 (2020)
[2] Park et al. 2103.05599
[3] Meyer et al. Modern Phys. A 34 (2019)
[4] Shintani et al. PRD 102 (2020)
[5] Alexandrou et al. PRD 103 (2021)





(Bodek)=Bodek, Eur. Phys. J. C 53, 349 (2008)

(Meyer)=Meyer, PRD 93, 113015 (2016)

(Hill)=Hill, Rept. Prog. Phys. 81 (2018)

- **Our $O(\text{Ş}^4)$ cPT extraction:**
  - $\grave{U}_p$ slope driven by loops with
  - $\breve{a}_{22}$ = 0:29 1:69 GeV ^{2} (no assumptions on p coupling enlarges error)
    - $\breve{a}_{22}$ compatible with $O(\text{Ş}^3)$ p electroprod. Guerrero et al. PRD, 102 (2020)
  - $h w^2 i(\grave{U}_{q \backslash})$ = 0:293 0:044 Th ^{2}
  - Empirical determinations (model dependent) are in tension with ours and with most of LQCD extractions
  - Tipically the extracted $h w^2 i^{q \backslash}$ value varies depending on the parametrisation
  - **Our QCD based parametrisation leads to a value in line with most of the individual LQCD extractions**

- {N g
  - **Dirac f.f.,** $\{_1$
    - The dispersive calculation supplemented with cPT contributions outperforms the pure dispersive and plain cPT descriptions
    - it fits well the LQCD $\{_1$ at least for $\check{E}^2 < 0{:}6$ GeV^2 and $\grave{U}_p$. 350 MeV
    - $h_{\mathbb{W}_1}^2 i_{q\backslash}$ = 0:4838 0:0047 fm^2
    - value close to the LQCD HB [Djukanovic PRD 103(2021)] extraction and to the experimental one
  - **Pauli f.f.,** $\{_2$
    - Disp, $O(\text{Ş}^4)$ cPT and disp+cPT describe the data well
    - $k_{q\backslash}$ = 3:61 and $h_{\mathbb{W}_2}^2 i_{q\backslash}$ = 0:668 fm^2
    - values in line with the HB and the experimental ones

- {
  - Succesful description of LQCD $\{$ ($t\!e^2$) using $O(\text{Ş}^4)$ relativistic cPT
    - Fit describes data in $\grave{U}_p^{H«§}$ ' 400 MeV, $\check{E}^2_{H«§}$ = 0:36 GeV^2
  - There is tension between the experimental and lattice extraction of $h_{\mathbb{W}}^2 i$
  - We extract $h_{\mathbb{W}}^2 i^{q\backslash}$ = 0:291 0:052 Th^2 without ad hoc parametrisations

- (Useful LEC values extracted from both calculations)

	Disp (prediction)	cPT	**Disp+ cPT**
$\check{a}_6(m = g_r)$ (GeV ^{2})	-	0:074 0:010	0:416 0:010
$\check{a}_6(m = g_{\acute{Y}})$ (GeV ^{2})	-	0:422 0:010	0:155 0:010
c^2=LnT	108:9=47 = 2:32	73:9=(47 1) = 1:61	24:6=(47 1) = 0:53
$h^{w2}_{w1} i_{q \backslash}$ (fm^2)	0.4541	0:3626 0:0047	**0:4838 0:0047**

	$O(ȿ^3)$ =	$O(ȿ^4)$ =	$O(ȿ^3)$	$O(ȿ^4)$
$\hat{O}$ (free)	1:1782 0:0073		1:2041 0:0074	1:274 0:041
$\breve{a}_{16}$ (GeV ^{2}) (free)	1:021 0:048		0:983 0:062	1:46 1:00
$\breve{a}_{22}$ (GeV ^{2}) (free)	1:275 0:086		3:77 1:96	0:29 1:69 (free $\hat{O}_1$)
ḓ	-	-	1:35	1:35
$\hat{O}_1$ (free)	-	-	0:69 0:69	0:66 0:56
$!_1$ (GeV ^{1})	-	0:89 0:06	-	1:15 0:05
$!_2$ (GeV ^{1})	-	3:38 0:15	-	1:57 0:10
$!_3$ (GeV ^{1})	-	4:59 0:09	-	2:54 0:05
$!_4$ (GeV ^{1})	-	3:31 0:13	-	2:61 0:10
$ƕ_1$ (GeV ^{1})	-	-	-	0:90
ε_1 (GeV ^{2}) (free)	-	-	-	0:27 4:96
ε_2 (GeV ^{2}) (free)	-	-	-	2:27 2:28
$\tilde{\varepsilon}_4$ (GeV ^{2}) (free)	-	-	-	12:48 1:28
˙ $_1$ (fm ^{2}) (free)	8:4 5:8	-	5:6 5:9	0:25 16:5 (consistent)
˙ $_2$ (fm ^{2}) (free)	8:6 2:6	-	7:1 2:6	6:36 4:20
˙ $_3$ (fm ^{1}) (free)	0:25 0:21	-	0:08 0:22	0:36 0:47
ˋ $_1$ (fm ^{2} GeV ^{2}) (free)	100 40	-	76 44	64 121
ˋ $_2$ (fm ^{2} GeV ^{2}) (free)	31 21	-	21 22	15 46
ˋ $_3$ (fm ^{1} GeV ^{2}) (free)	0:63 1:49	-	0:36 1:63	2:54 3:98
g (GeV)	0.874	0.874	0.855	0.855
g (GeV)	-	-	1.166	1.166

EXTRA 2

	$O(\varrho^3)$ =	$O(\varrho^4)$ =	$O(\varrho^3)$	$O(\varrho^4)$
$\hat{O}$ (free)	1:1782 0:0073		1:2041 0:0074	1:274 0:041
$\check{a}_{16}$ (GeV ^{2}) (free)	1:021 0:048		0:983 0:062	1:46 1:00
$\check{a}_{22}$ (GeV ^{2}) (free)	1:275 0:086		3:77 1:96	0:29 1:69 (free $\hat{O}_1$)
d	-	-	1:35	1:35
$\hat{O}_1$ (free)	-	-	0:69 0:69	0:66 0:56
$!_1$ (GeV ^{1})	-	0:89 0:06	-	1:15 0:05
$!_2$ (GeV ^{1})	-	3:38 0:15	-	1:57 0:10
$!_3$ (GeV ^{1})	-	4:59 0:09	-	2:54 0:05
$!_4$ (GeV ^{1})	-	3:31 0:13	-	2:61 0:10
$\hbar_1$ (GeV ^{1})	-	-	-	0:90
ε_1 (GeV ^{2}) (free)	-	-	-	0:27 4:96
ε_2 (GeV ^{2}) (free)	-	-	-	2:27 2:28
$\tilde{\varepsilon}_4$ (GeV ^{2}) (free)	-	-	-	12:48 1:28
ˇ$_1$ (fm ^{2}) (free)	8:4 5:8	-	5:6 5:9	0:25 16:5 (consistent)
ˇ$_2$ (fm ^{2}) (free)	8:6 2:6	-	7:1 2:6	6:36 4:20
ˇ$_3$ (fm ^{1}) (free)	0:25 0:21	-	0:08 0:22	0:36 0:47
ˋ$_1$ (fm ^{2} GeV ^{2}) (free)	100 40	-	76 44	64 121
ˋ$_2$ (fm ^{2} GeV ^{2}) (free)	31 21	-	21 22	15 46
ˋ$_3$ (fm ^{1} GeV ^{2}) (free)	0:63 1:49	-	0:36 1:63	2:54 3:98
g (GeV)	0.874	0.874	0.855	0.855
g (GeV)	-	-	1.166	1.166
c_0^2=LnT	857:31=(127 9) = 7:27		533:87=(127 10) = 4:45	196:58=(127 13) = 1:724