Strangeness in the Meson Cloud Model

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Te Kunenga
ki Pūrehuroa

Overview

- History
- Quark – Antiquark Asymmetry
- SU(3) Flavour Breaking
- Conclusion

History

AIS PhD topic (85)

- Related to Ericson + Thomas (83) paper on EMC effect
- Extended Thomas (83) work on Cloudy Bag to strange sector
- Included contributions from both meson and baryon components

1987

Contribution to parton dist is convolution:

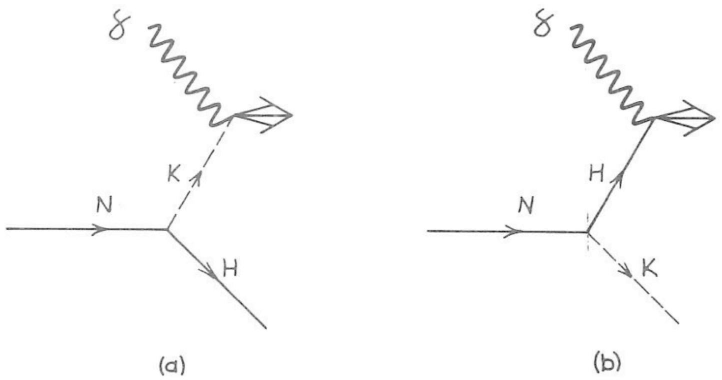


Fig. 1. Non-perturbative contributions to the strange sea of the nucleon. (a) The incoming photon is abosrbed by a virtual kaon. (b) The incoming photon is absorbed by a virtual hyperon.

$$x\bar{s}(x) = \int_x^1 dy\, f(y) \left(\frac{x}{y}\right) \bar{s}_K \left(\frac{x}{y}\right)$$

$$xs(x) = \int_x^1 dy\, f(y) \left(\frac{x}{y}\right) s_H \left(\frac{x}{y}\right)$$

1987

Antistrange dist is harder then strange

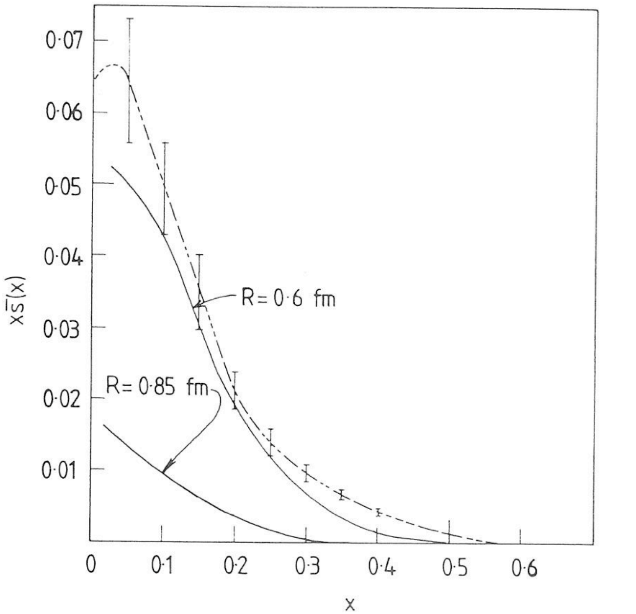
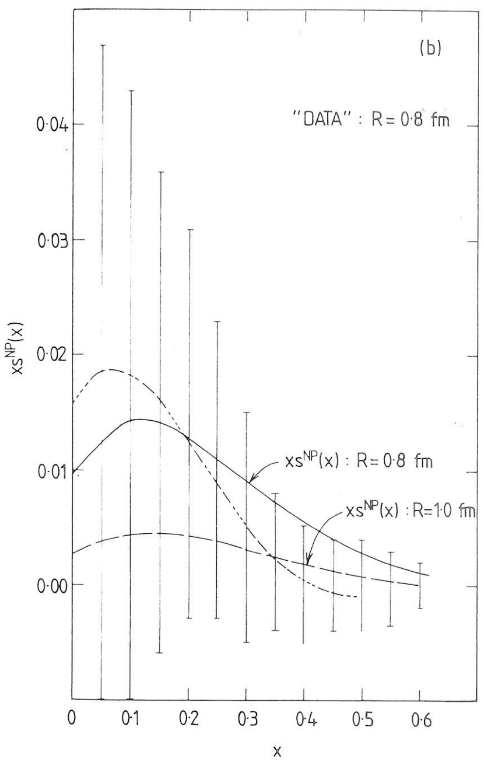


Fig. 2. The non-perturbative contribution to $x\bar{s}(x)$ for two bag radii compared with the experimental determination of $x\bar{s}(x)$ (dot-dash line).



1987

Wasn't perfect -

- Used invariant formulation with off-shell target
- Approximations for hadron structure functions
- No Q^2 dependence
- Net strangeness!

$$\int_0^1 dx\left[s(x)-\bar{s}(x)\right]<0$$

Quark – Antiquark Asymmetry

NuTeV anomaly

- Measured Paschos-Wolfenstein ratio

$$R^{-} = \frac{\sigma_{NC}^{\nu} - \sigma_{NC}^{\bar{\nu}}}{\sigma_{CC}^{\nu} - \sigma_{CC}^{\bar{\nu}}} = \frac{1}{2} - \sin^2\theta_W$$

- Extracted weak mixing angle 2% smaller than world av.
- P-W ratio gets corrections from symmetry breaking pdfs

Quark – Antiquark Asymmetry

- P-W ratio gets corrections from symmetry breaking pdfs

$$R^- = \frac{\sigma_{NC}^{\nu} - \sigma_{NC}^{\bar{\nu}}}{\sigma_{CC}^{\nu} - \sigma_{CC}^{\bar{\nu}}} = \frac{1}{2} - \sin^2\theta_W + 1.3\left[\tfrac{1}{2}\left(\langle \delta u \rangle - \langle \delta d \rangle\right) - \langle x(s - \bar{s}) \rangle\right]$$

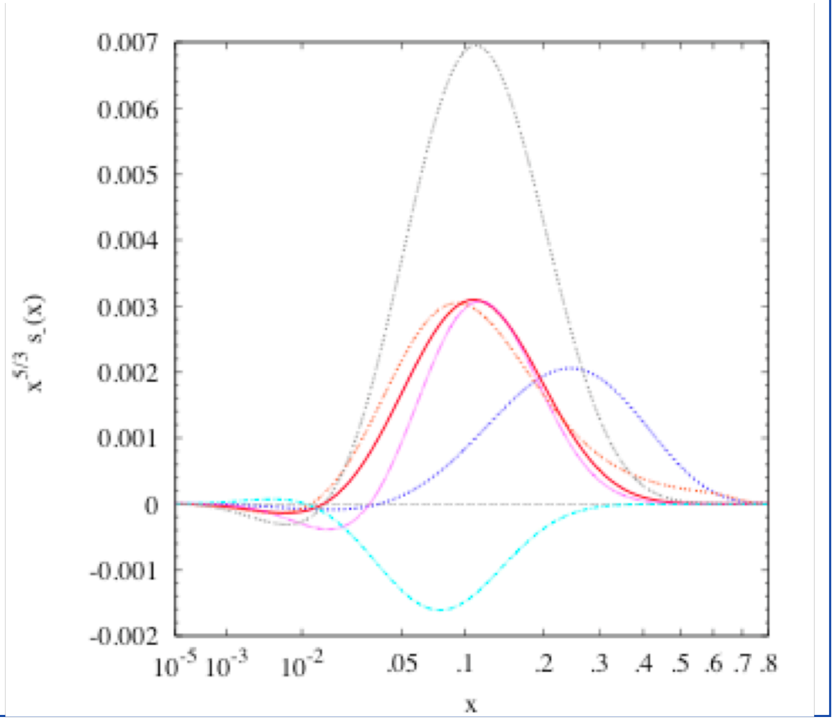
- Only require [ ] = -0.0038 to get NuTeV value = world av.
- Charge Symm. Breaking v. small (PRC **62** 015203 (2000))
- Strange quark – antiquark asymmetry possible explanation

Quark – Antiquark Asymmetry

- CTEQ analysis allows small asymmetry

$$s_{-}(x,Q_0) = s_{+}(x,Q_0)\frac{2}{\pi}\tan^{-1}\left[cx^a(1-\tfrac{x}{b})e^{dx+ex^2}\right]$$

$$-0.001 < \langle x \rangle_{s_-} < 0.005$$



Quark – Antiquark Asymmetry

Revisit original MCM calculation of $s(x) - \bar{s}(x)$

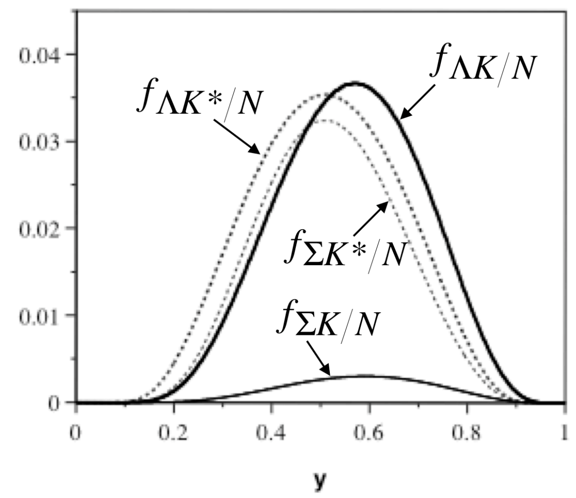
- MCM in TO pert. th. Uses on-shell structure functions
- Fluctuation functions for meson and baryon conserve momentum
  - ie. $f_{\Lambda K/p}(y) = f_{K\Lambda/p}(1-y)$
- Hadron structure functions from expt (K) or bag (Λ, Σ)
- Soft form factors ($\Lambda_c \approx 1$ GeV)
- NLO Q^2 dependence to $Q^2 = 16$ GeV^2

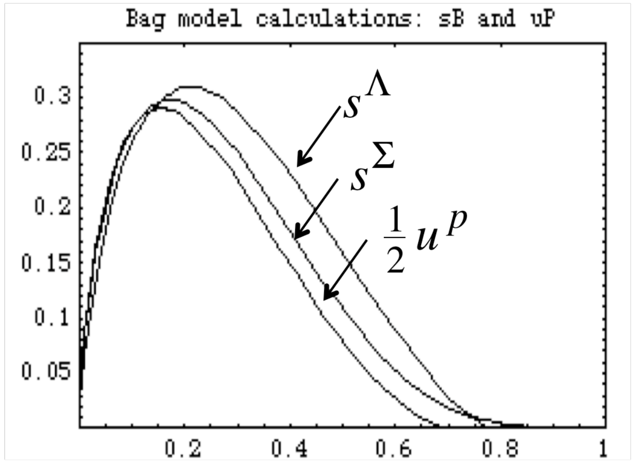
Quark – Antiquark Asymmetry

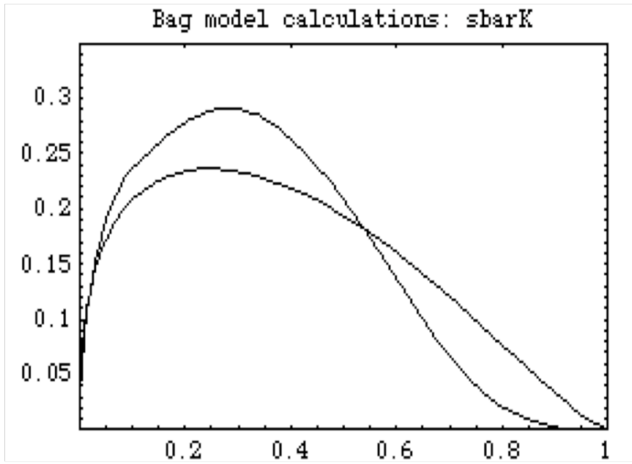
Baryon fluctuation function harder,

but K pdf is harder than Λ Σ

➔ small difference in convolution



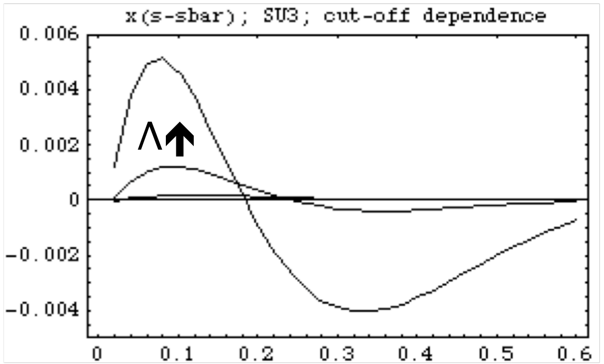


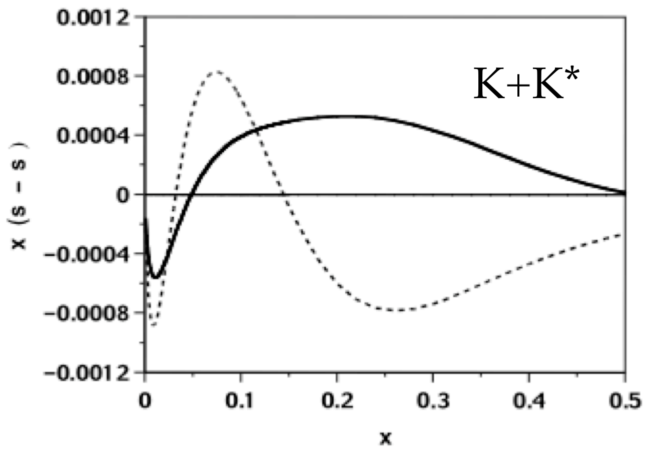


Quark – Antiquark Asymmetry

$$x(s(x)-\bar{s}(x))$$

- is small $\langle x(s-\bar{s})\rangle \sim O(10^{-4})$
- some dependence on form factor
- adding K* states changes sign
- Probably not responsible for NuTeV result

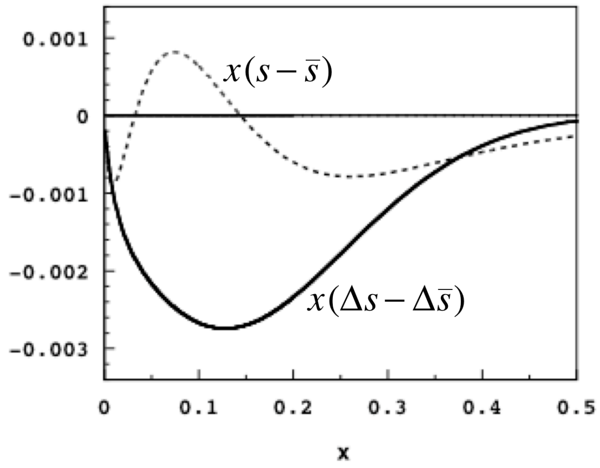


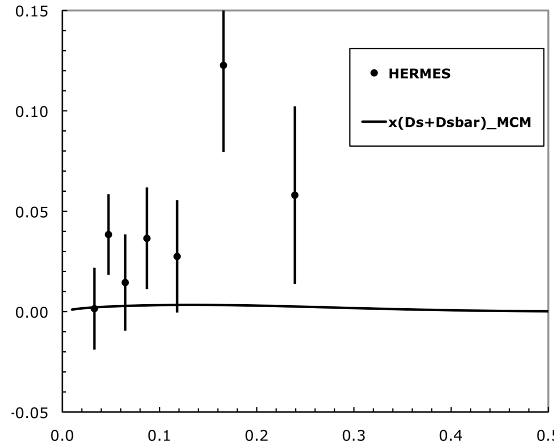


Quark – Antiquark Asymmetry

In polarized case asymmetry is slightly larger (includes K* states)

Overall strange polarization is small in MCM



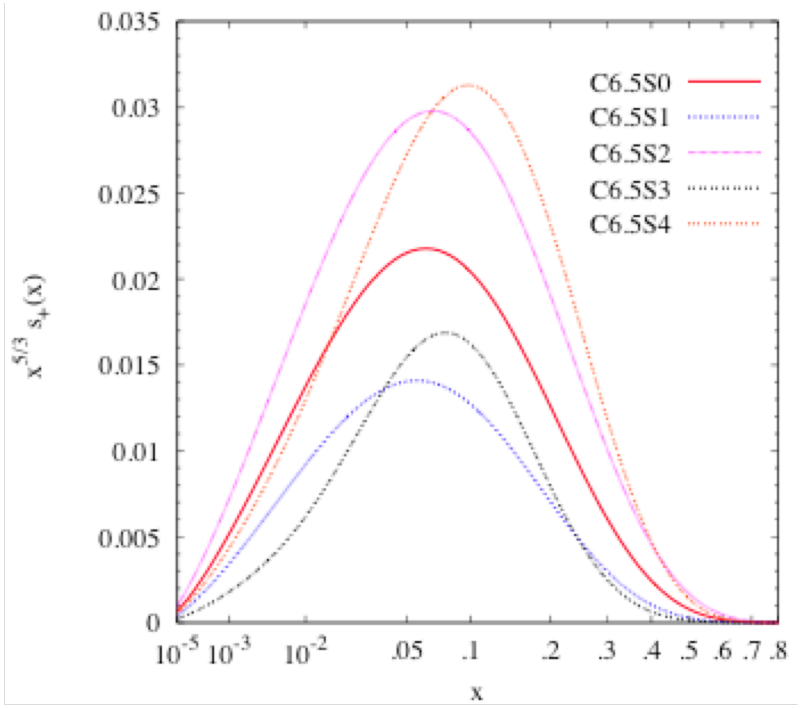


SU(3) Flavour Breaking

Can MCM help in determining strange + antistrange dist?

- Hermes (2008) data not in agreement with NuTeV
- Parameters have large

  uncertainties eg CTEQ6.5



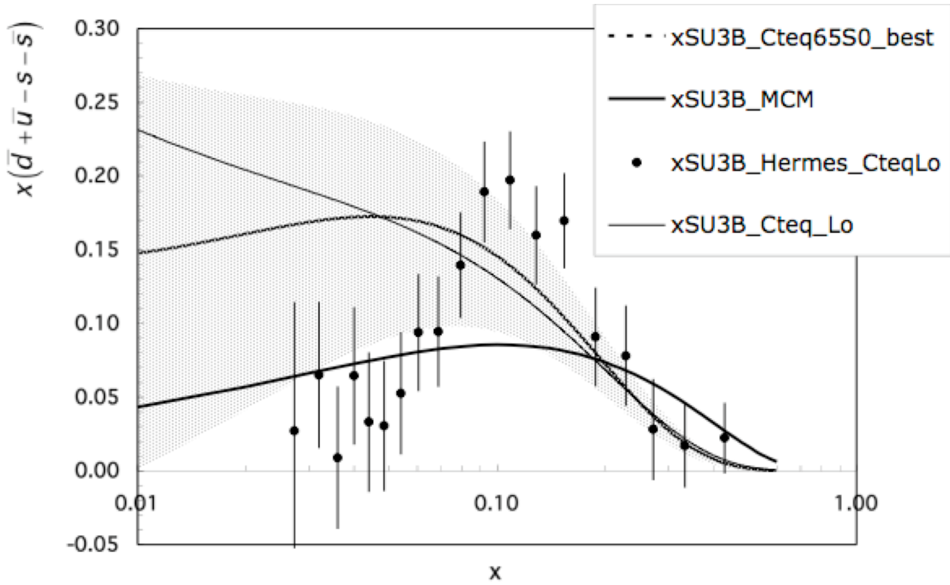
SU(3) Flavour Breaking

SU(3) asymmetry $\bar{u}(x)+\bar{d}(x)-s(x)-\bar{s}(x)$

picks up leading contributions in MCM from

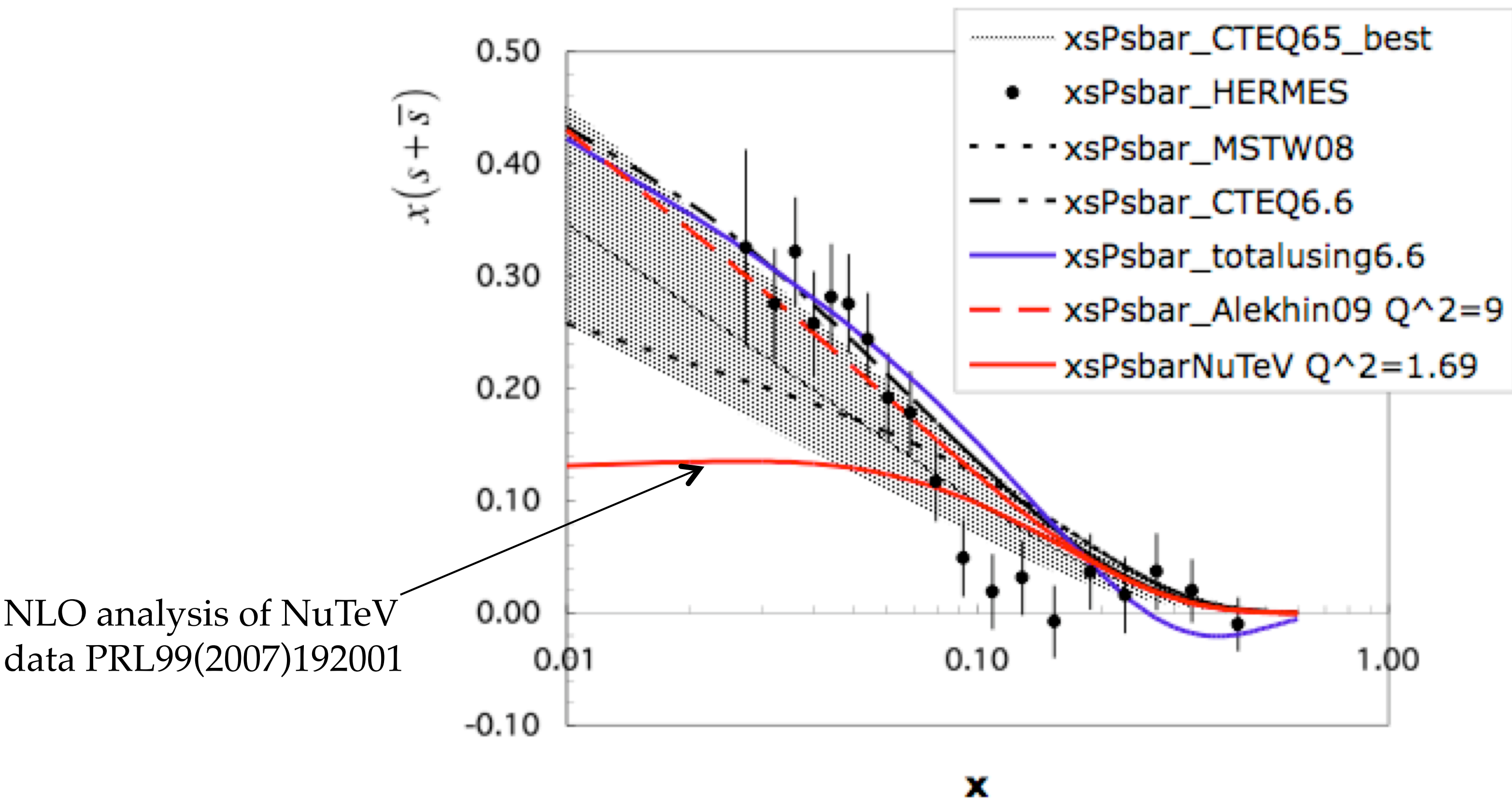
$$|N\pi\rangle-|\Lambda K\rangle,\quad |\Delta\pi\rangle-|\Sigma K\rangle,\ldots$$

- Compares well with Hermes data



SU(3) Flavour Breaking

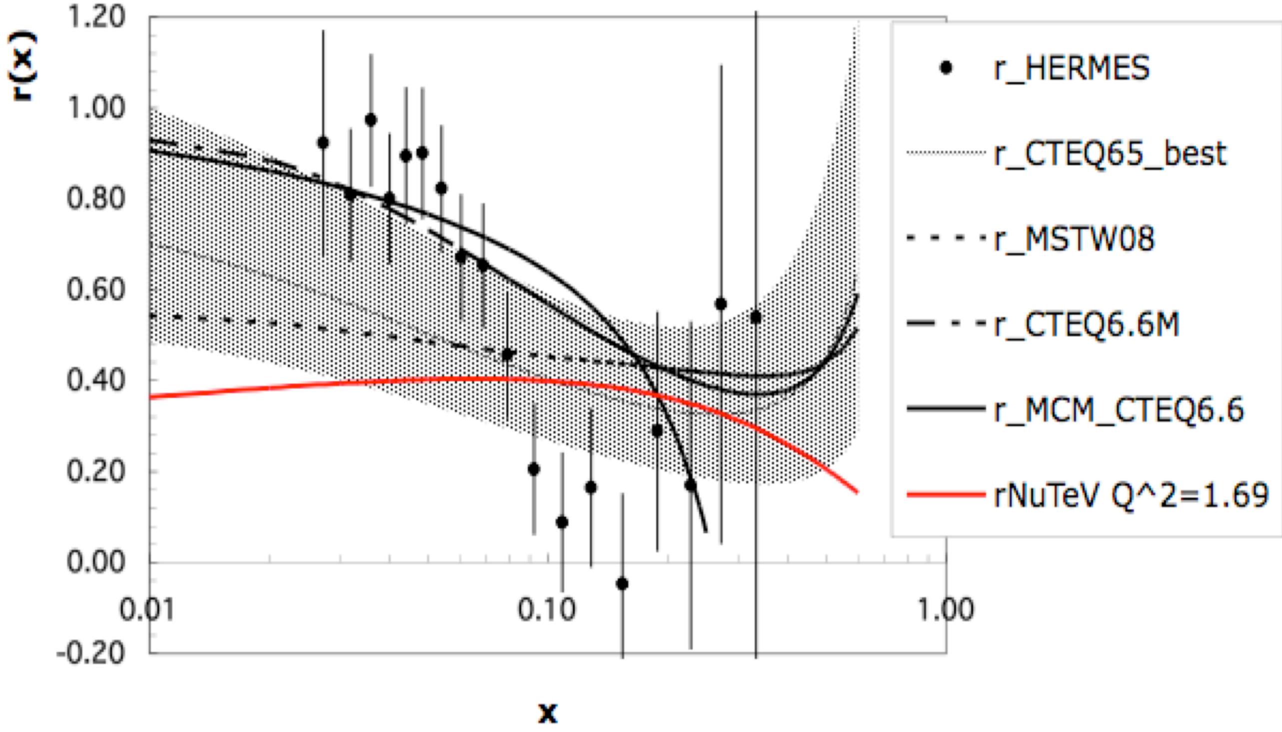
Can estimate $s(x)+\bar{s}(x)$ by subtracting light sea



SU(3) Flavour Breaking

And strange suppression

$$r(x) = \frac{s(x) + \bar{s}(x)}{\bar{u}(x) + \bar{d}(x)}$$



Conclusions

- Strange quarks still have surprises for us
- MCM is good laboratory for non-pert symmetry breaking among quark dists
- Recent paper (Strikman + Weiss PRD80 114029 (2009)) confirms picture at large impact parameter, but requires other symmetry breaking also – Fermi blocking, phase space …

Thanks

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Happy Birthday Tony!