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Durham University

$B \to K^* \mu^+ \mu^-$: SM and Beyond

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A.J. Buras, D. Straub and M. Wick (arXiv:0811.1214 [hep-ph])
also in collaboration with William Reece

IPPP

Joint IPPP-IC Workshop, 28th May 2009

Soon Launching Expedition to 14TeV

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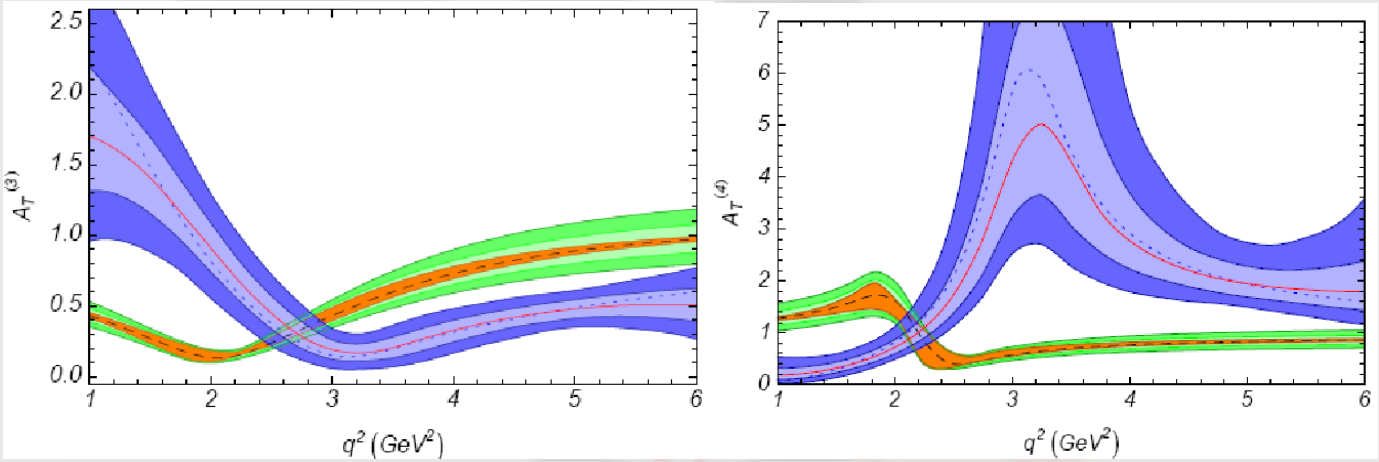
Some Structure

- Brief History
- Angular Observables via B Physics Tool Box
- Theoretical Predictions
- Prospects at LHCb

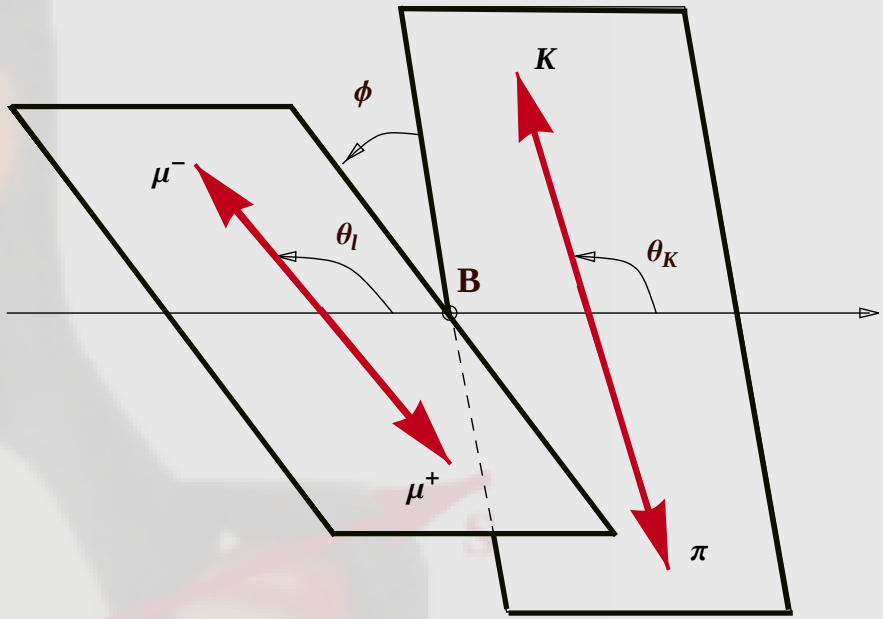
Major Milestones and Recent Developments

- 1999: Ali et al. Naive Factorization hep-ph/9910221
- 2001/4: Beneke et al. full QCDF calculations hep-ph/0412400
- 2008: Bobeth et al. CP Asymmetries arXiv:0805.2525[hep-ph]
- 2008: Egede et al. New Observables arXiv:0807.2589[hep-ph]



Angular Observables

$$\frac{\mathrm{d}^4\Gamma}{\mathrm{d}q^2\mathrm{d}\Omega} = \frac{9}{32\pi} I(q^2, \theta_l, \theta_K, \phi)$$



..where $I(q^2, \theta_l, \theta_K, \phi) = \sum_{i=1}^{9} I_i^{(s/c)}(q^2)\, \omega_i(\theta_l, \theta_K, \phi)$

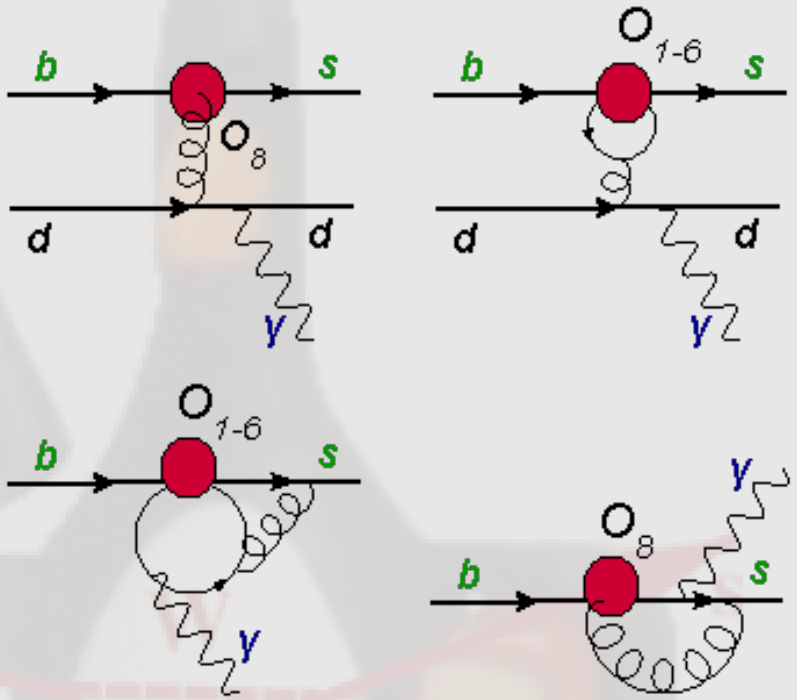
Emphasize CP Conserving and CP Violating[1] Effects

$$S_i^{(a)} = \frac{I_i^{(a)} + \bar{I}_i^{(a)}}{\mathrm{d}(\Gamma+\bar{\Gamma})/\mathrm{d}q^2} \qquad A_i^{(a)} = \frac{I_i^{(a)} - \bar{I}_i^{(a)}}{\mathrm{d}(\Gamma+\bar{\Gamma})/\mathrm{d}q^2}$$

[1] Also considered in C. Bobeth, G. Hiller and G. Piranishvili arXiv:0805.2525

A B Physicists ToolBox

HARD SPECTACTOR EFFECTS- QCD factorization/ SCET/ HQET...



HADRONIC MATRIX ELEMENTS

- eg. $\langle B|J|K^* \rangle$ described by Form Factors
- QCD Sum Rules on the Light Cone[2]/Lattice QCD

[2] Ball/Zwicky 04, Ball 08

Brief Interlude: Form Factors

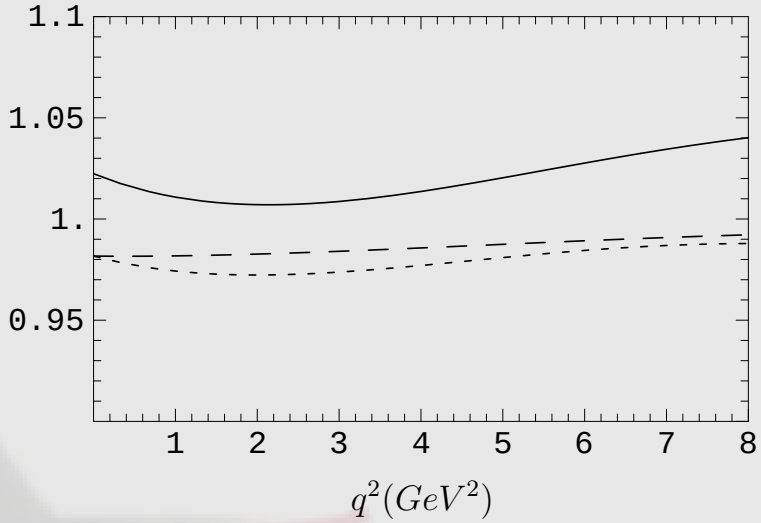
Range of Form Factors:
Kinematic Range: $0 \leq q^2 \leq 20\mathrm{GeV}^2$
QCDF Range: $1 \leq q^2 \leq 6\mathrm{GeV}^2$

Theoretical Prections:

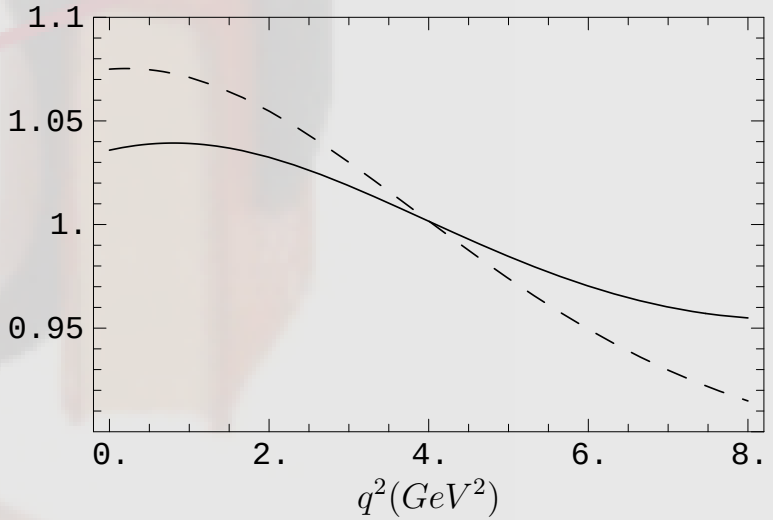
- **Lattice**: High q^2, Unstable particles eg. K^* difficult
- **Light Cone Sum Rules**: Low q^2
- At LO in $1/E(K^*)$, FF's reduce to $\xi_\perp$, $\xi_\parallel$
- $1/m_b$ corrections?

Extrapolation to high q^2?

$\xi_\perp$ Relations



$\xi_\parallel$ Relations



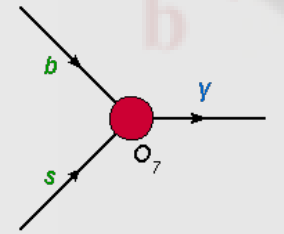
Relating Observables to NP: EFTs

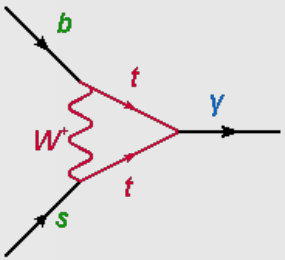
- Disentangle physics governed by different mass scales
- Write $\mathcal{L}$ in terms of **'Effective Operators'** and Effective Coupling Constants known as **'Wilson Coefficients'**

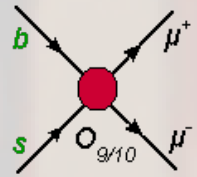
$$\mathcal{L} = \sum_i C_i O_i$$

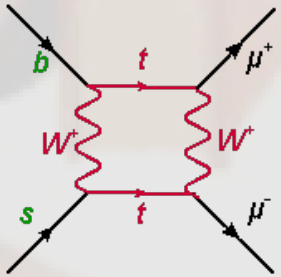
For $B \to K^*(\to K^-\pi^+)\mu^+\mu^-$, important Operators are..

Electromagnetic Dipole O_7 Vector/Axial Current $O_{9(10)}$









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For $B \to K^*(\to K^-\pi^+)\mu^+\mu^-$, important NP O's are..

Spin-Flipped EM Dipole O_7' Scalar/Pseudoscalar $O_{S(P)}$

What will the Flavour Telescope see?

Focus on Additional..

- **CP Violation**
- **Operators** eg. Scalar

Keeping in Mind Bounds from..

- EDM's, CP Asymmetries....
- $B_s \to \mu^+\mu^-$, $B \to X_s\gamma$, $B \to X_s\mu^+\mu^-$

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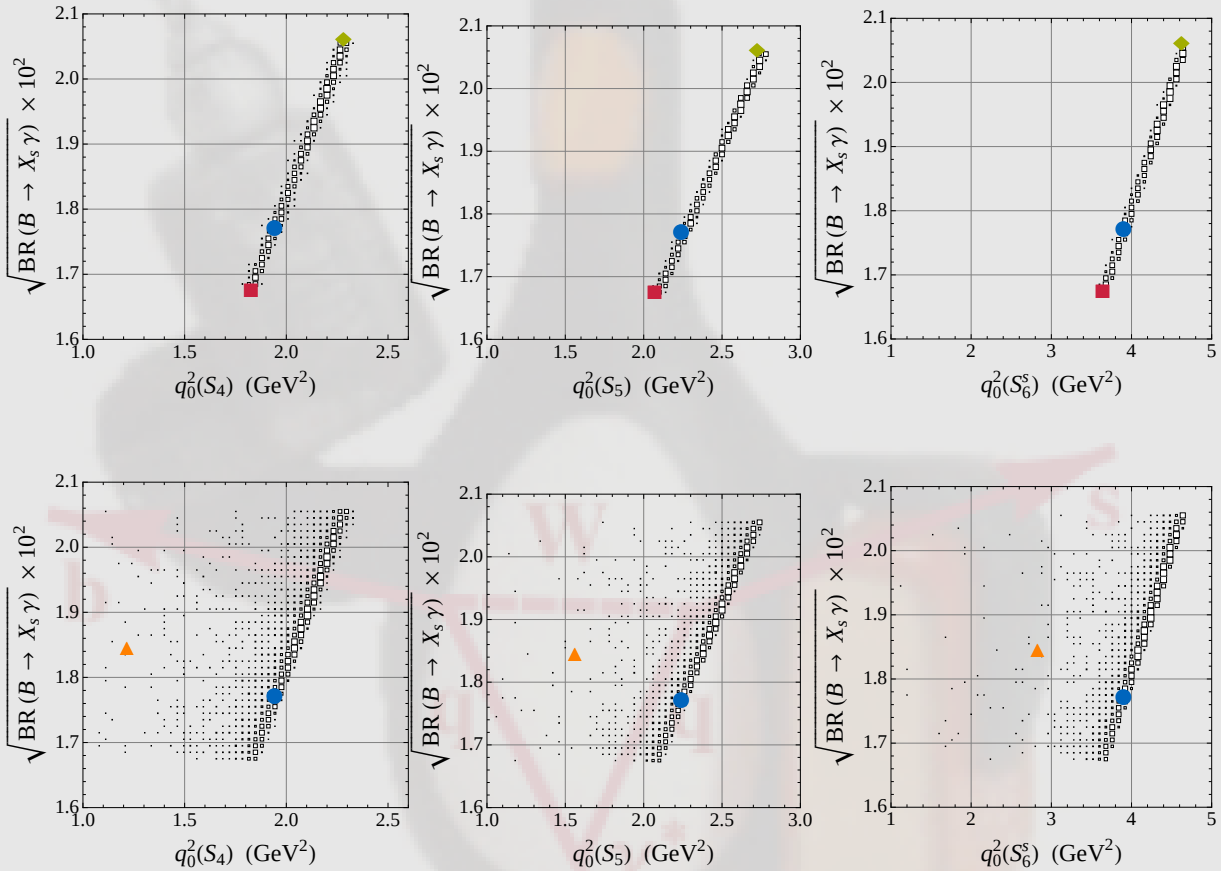
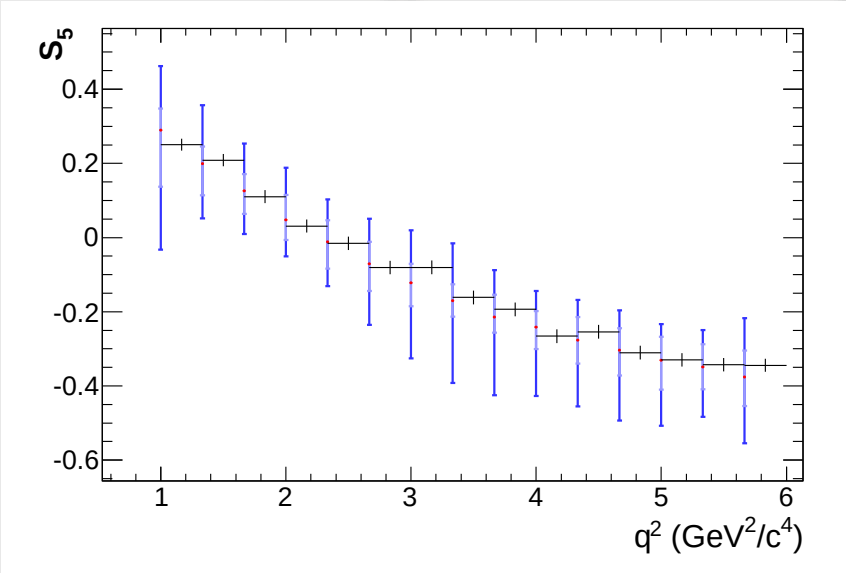
Theoretical Predictions: MFV vs. FBSSM

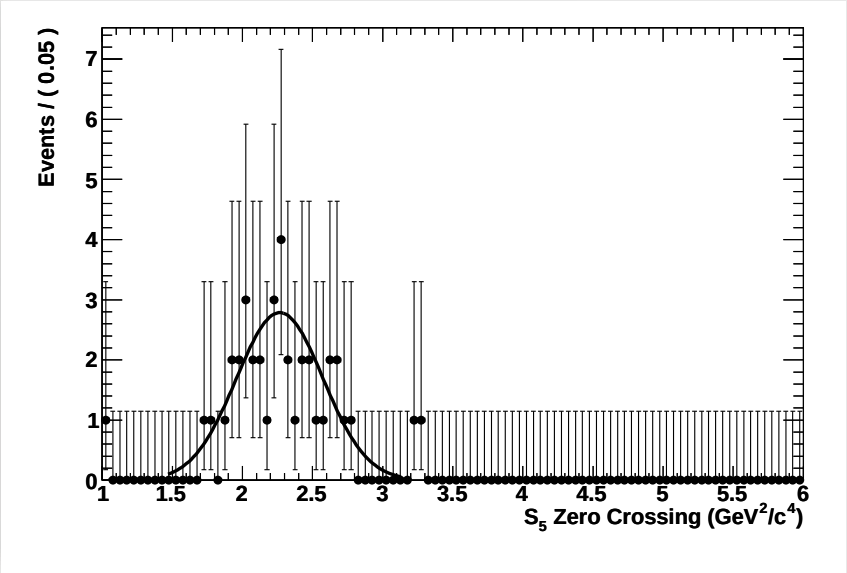
Correlate zeros of S_4, S_5, S_6^s with $B(b \to s\gamma)$

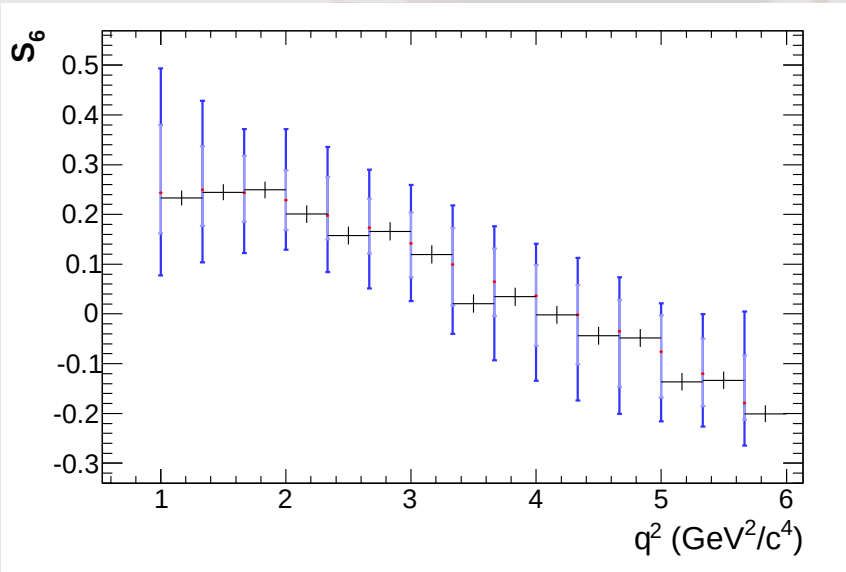


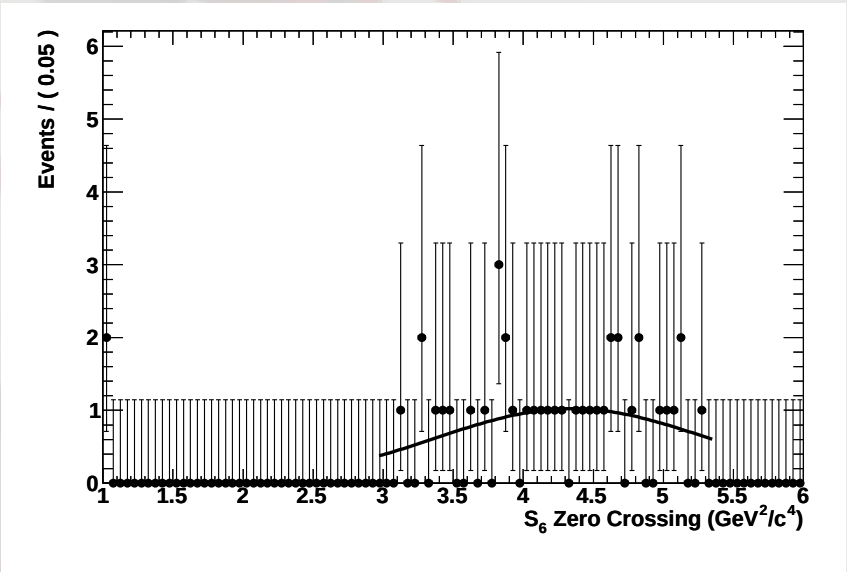
Bound on C_7 from $b \to s\gamma$ weakened if complex FBMSSM has additional CP violating phases..

Prospects at LHCb

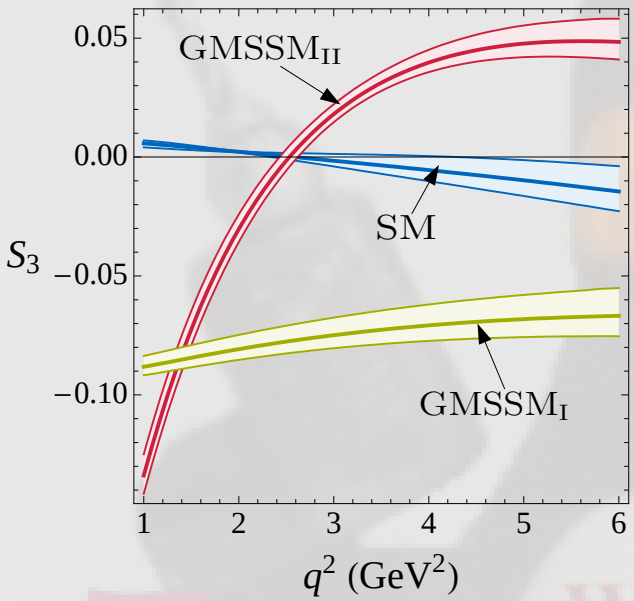


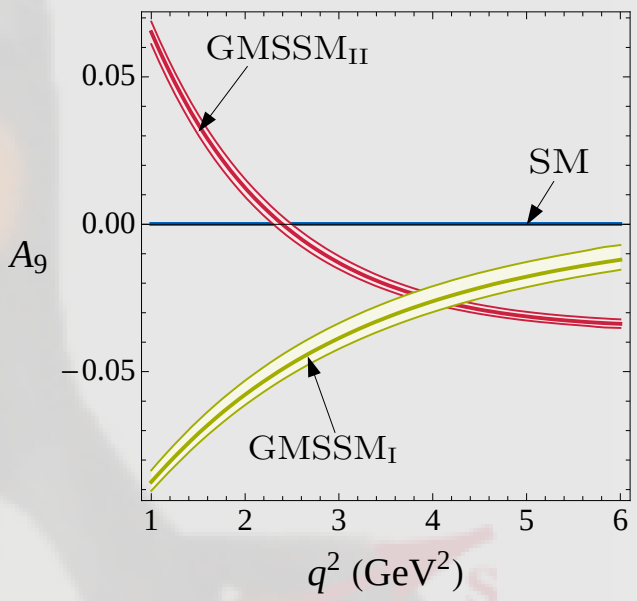


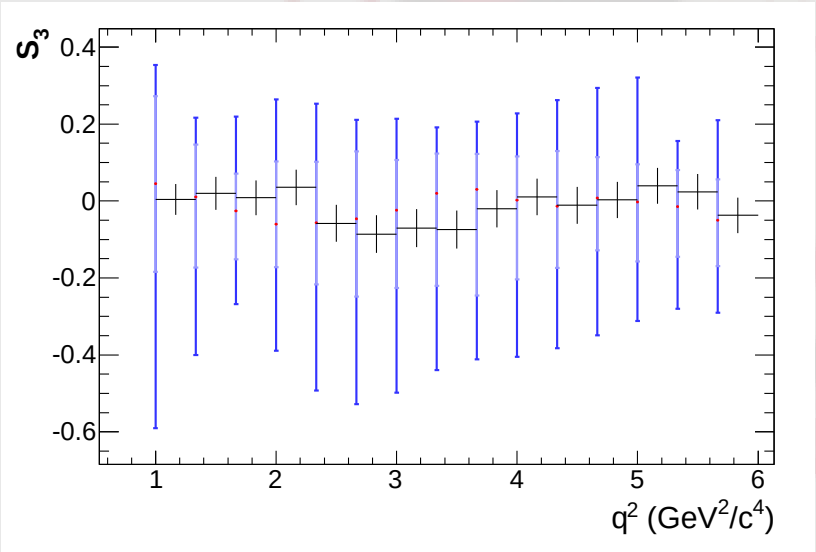


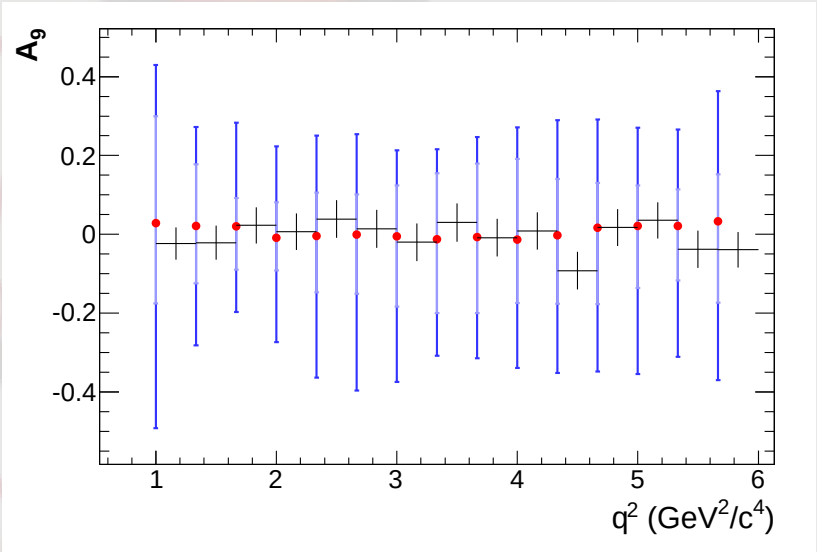


Prospects at LHCb: Additional Operators (O_7')









Summary

- $\mathbf{B \to \bar{K}^* \mu^+ \mu^-}$ will provide a multitude of sensitive observables at the LHC
- New **NLO EvtGen model**, promising preliminary results for zero's of S_5, S_6
- Early observation of S_3 and A_9 possible, but more data required to prove BSM effects.

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