Experimental challenges for future angular and amplitude measurements

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Universität Zürich - SNF Ambizione

Beyond the Flavour Anomalies workshop
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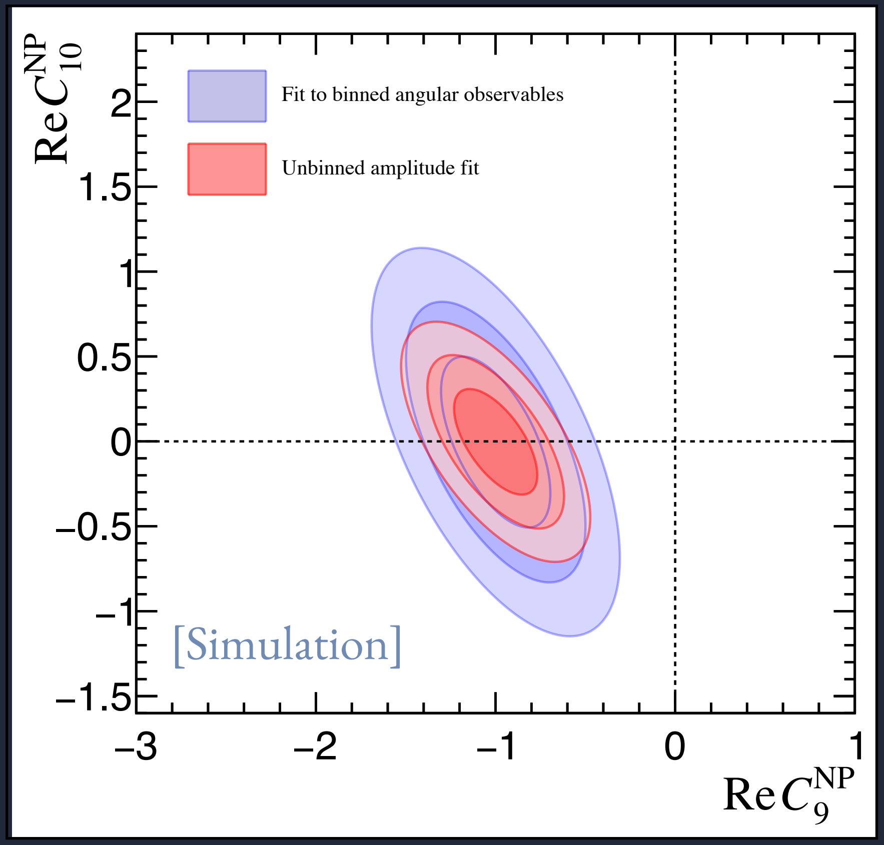
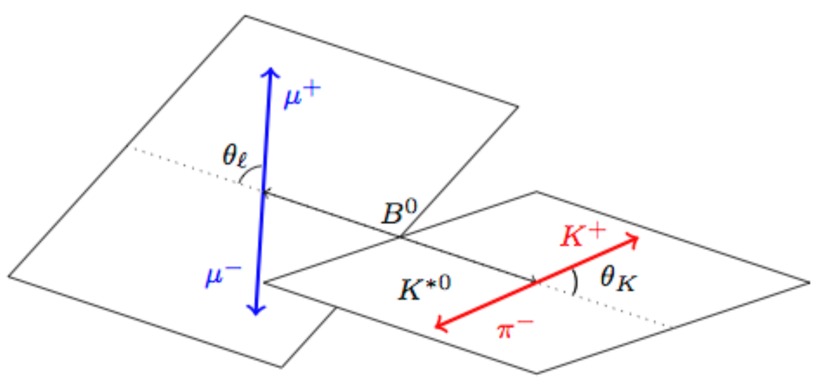


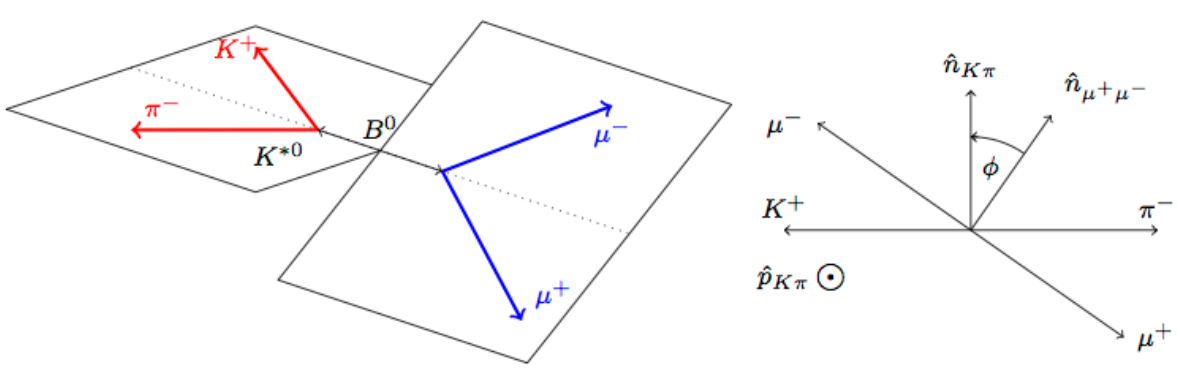
[JHEP 10 (2019) 236]

The (in)famous $B^0 \to K^{*0}[K^+\pi^-]l^+l^-$ decay

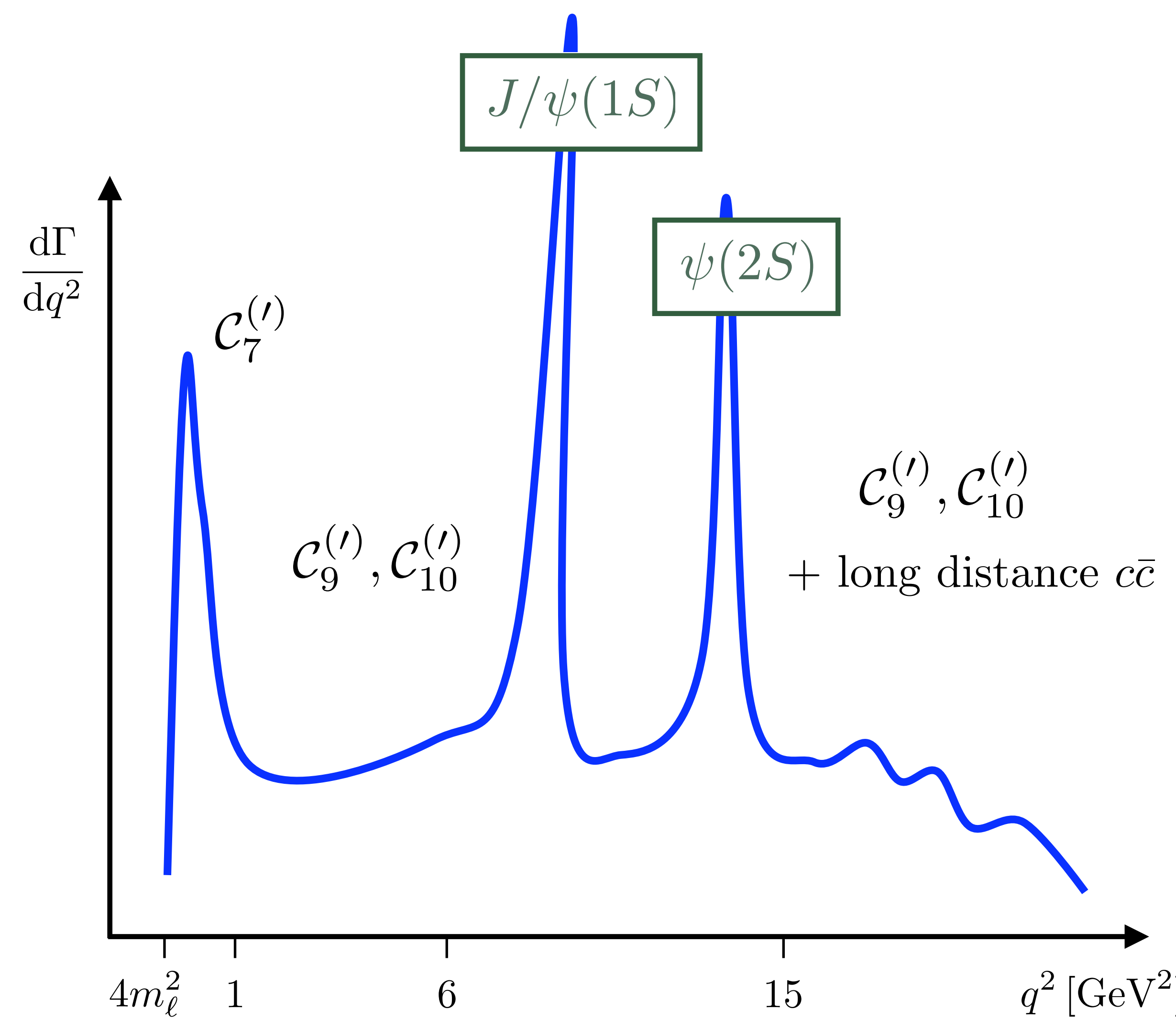
Large number of observables: BF fractions, *CP* asymmetries and angular observables (5-dimension)



(a) θ_K and θ_ℓ definitions for the B^0 decay



(b) ϕ definition for the B^0 decay



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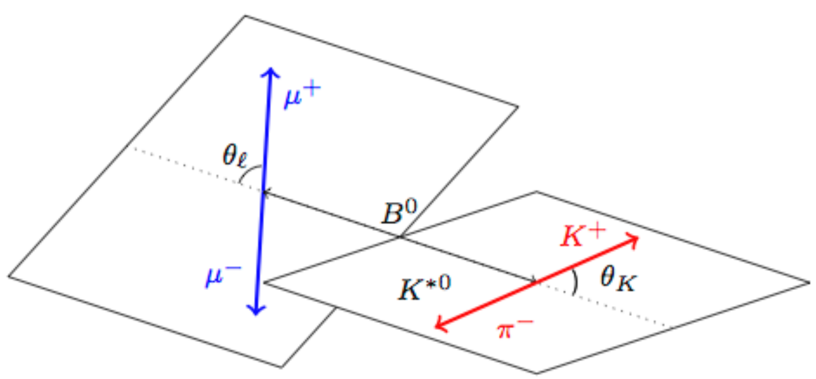

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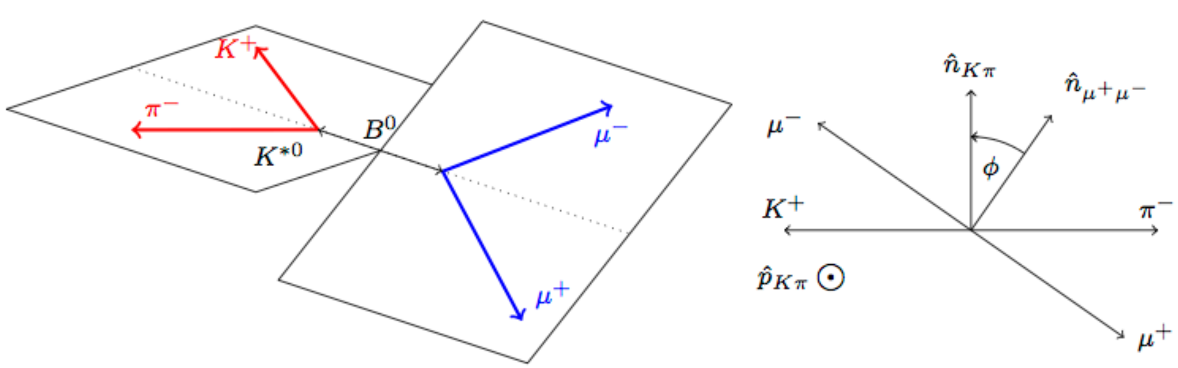
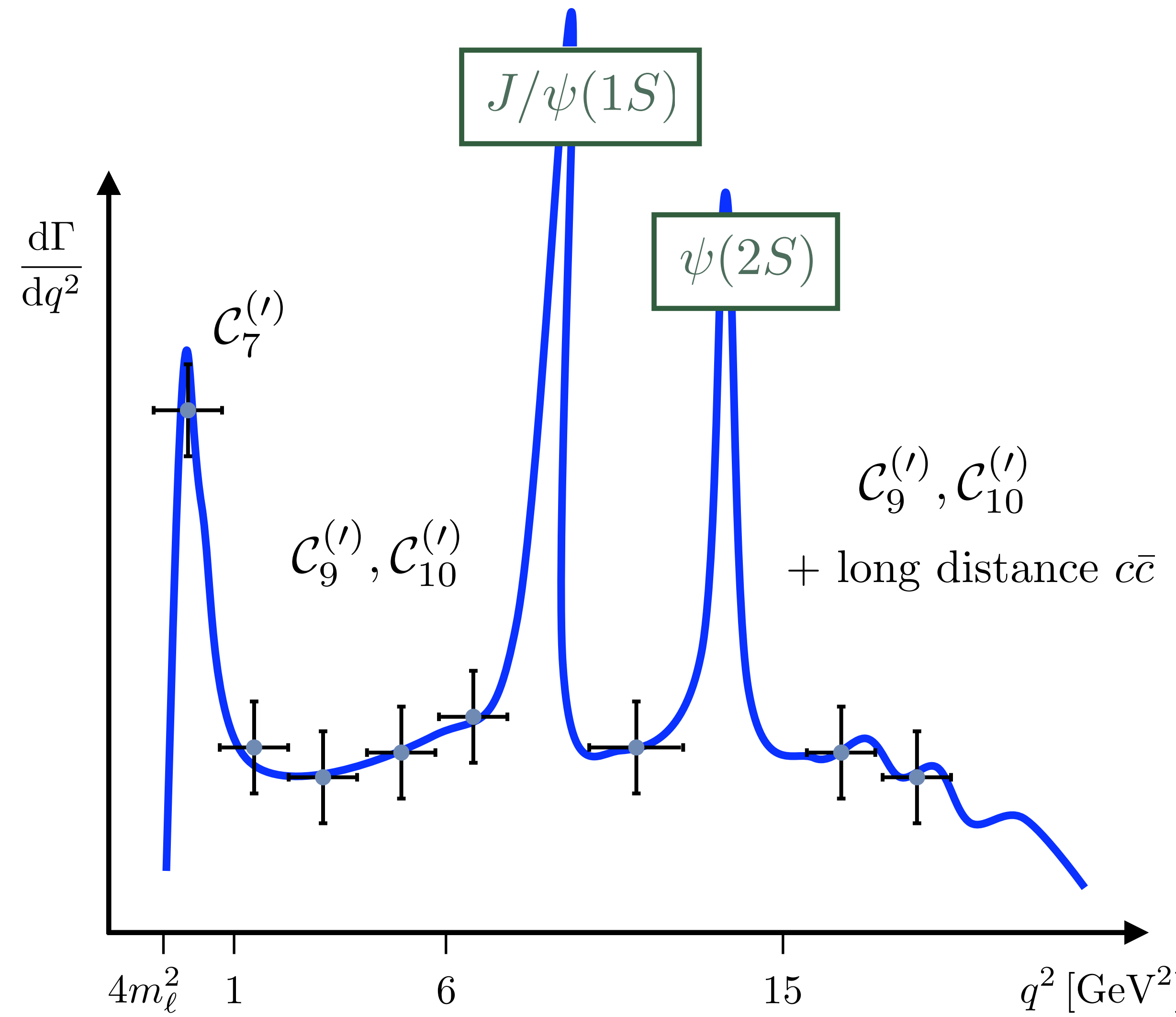


(b) ϕ definition for the B^0 decay

To "bin" or not to "bin"?



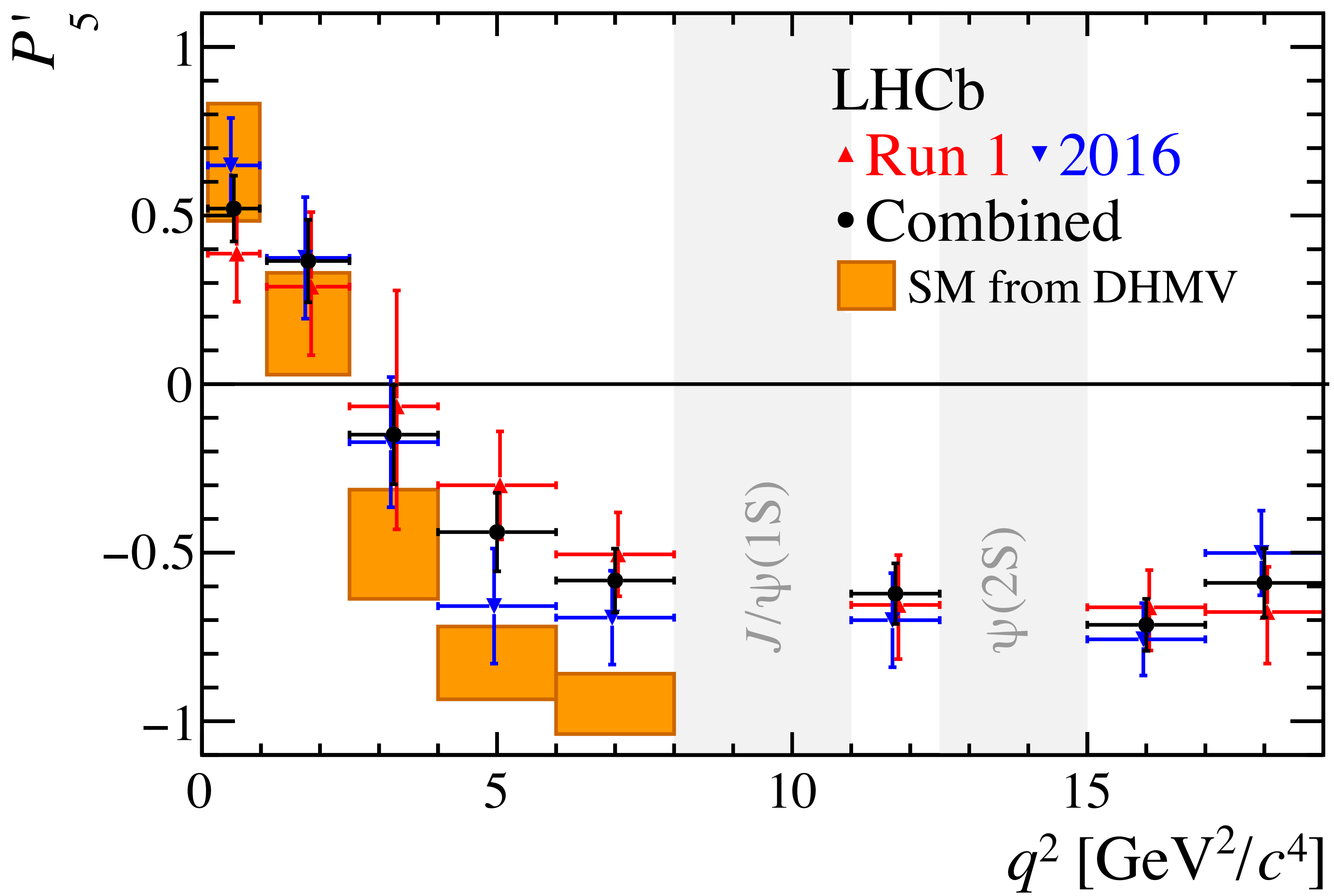
[Angular]: A_{FB}, F_L, P'_5, ...

[Amplitude]: C_9, C_{10}, hadronic terms ...

LHCb Run-I + 2016 $B^0 \to K^{*0}\mu^+\mu^-$ update

[LHCb-PAPER-2020-002, arXiv: 2003.04831]

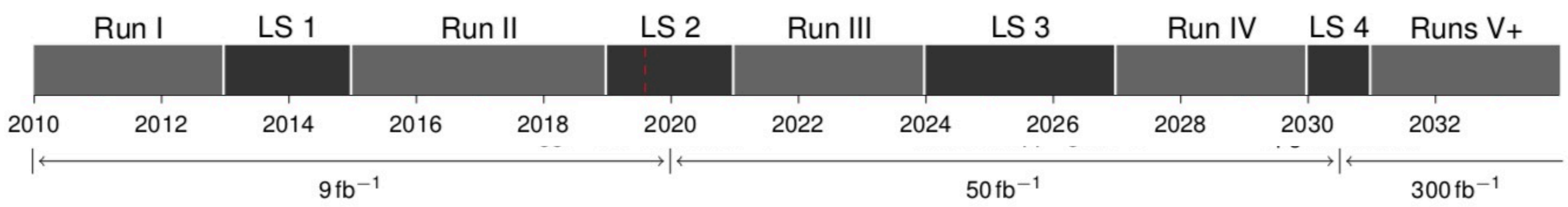
The song remains the same (?) ...



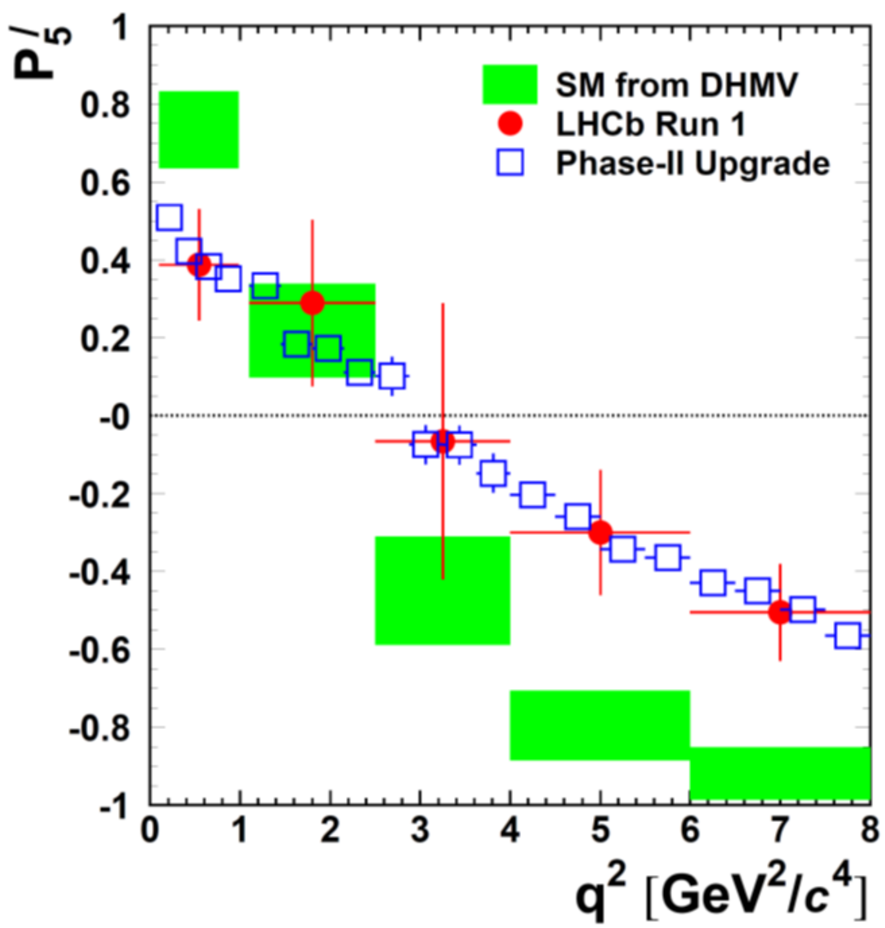
Overall tension with SM remains at the same level

$B^0 \rightarrow K^{*0}\mu^+\mu^-$ prospects

Update with full Run-II underway, but what next?



CERN-LHCC-2017-003, LHCb EoI



Statistical uncertainties extrapolate with $1/\sqrt{\int \mathcal{L} dt}$

$$1.0 < q^2 < 6\,\text{GeV}$$

$\int \mathcal{L} dt$	3 fb^{-1}	23 fb^{-1}	300 fb^{-1}
$\sigma^{\text{stat}}(S_i)$	0.034–0.058	0.009–0.016	0.003–0.004

By C. Langenbruch

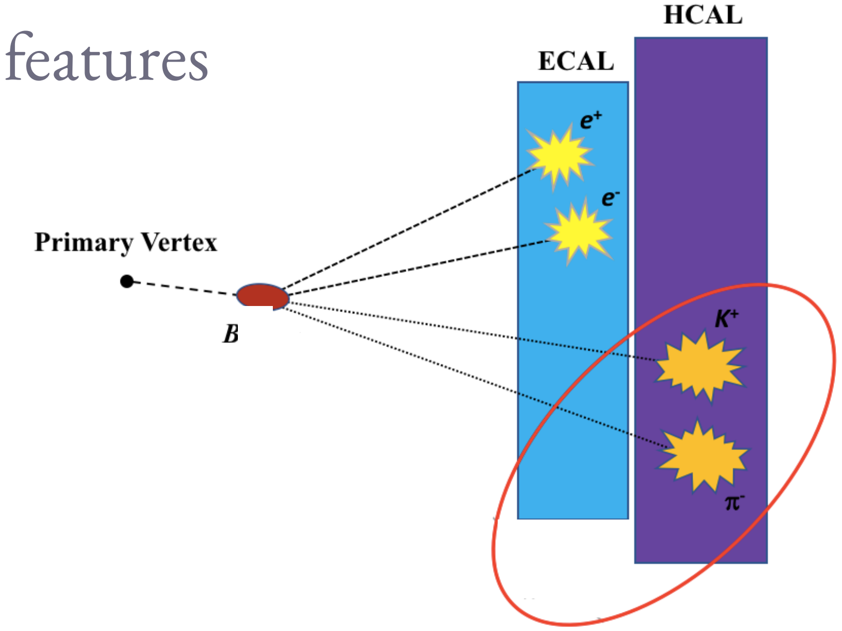
[LHCb-PAPER-2020-002, arXiv: 2003.04831]

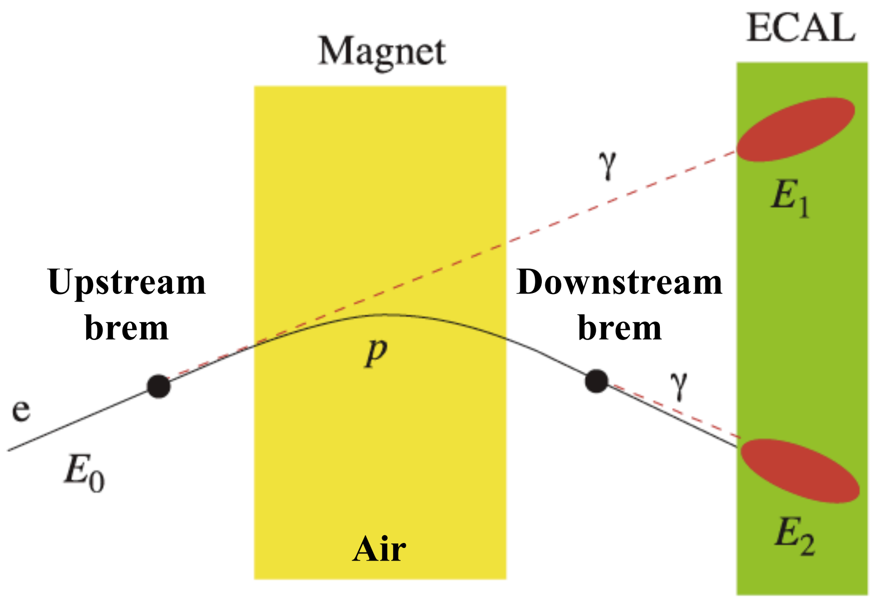
Source	$F_{\rm L}$	$A_{\rm FB}$, S_3–S_9	P_1–P_8'
Acceptance stat. uncertainty	< 0.01	< 0.01	< 0.01
Acceptance polynomial order	< 0.01	< 0.01	< 0.02
Data-simulation differences	< 0.01	< 0.01	< 0.01
Acceptance variation with q^2	< 0.03	< 0.01	< 0.09
$m(K^+\pi^-)$ model	< 0.01	< 0.01	< 0.01
Background model	< 0.01	< 0.01	< 0.02
Peaking backgrounds	< 0.01	< 0.02	< 0.03
$m(K^+\pi^-\mu^+\mu^-)$ model	< 0.01	< 0.01	< 0.01
$K^+ \ \mu^+\mu^-$ veto	< 0.01	< 0.01	< 0.01
Trigger	< 0.01	< 0.01	< 0.01
Bias correction	< 0.02	< 0.01	< 0.03

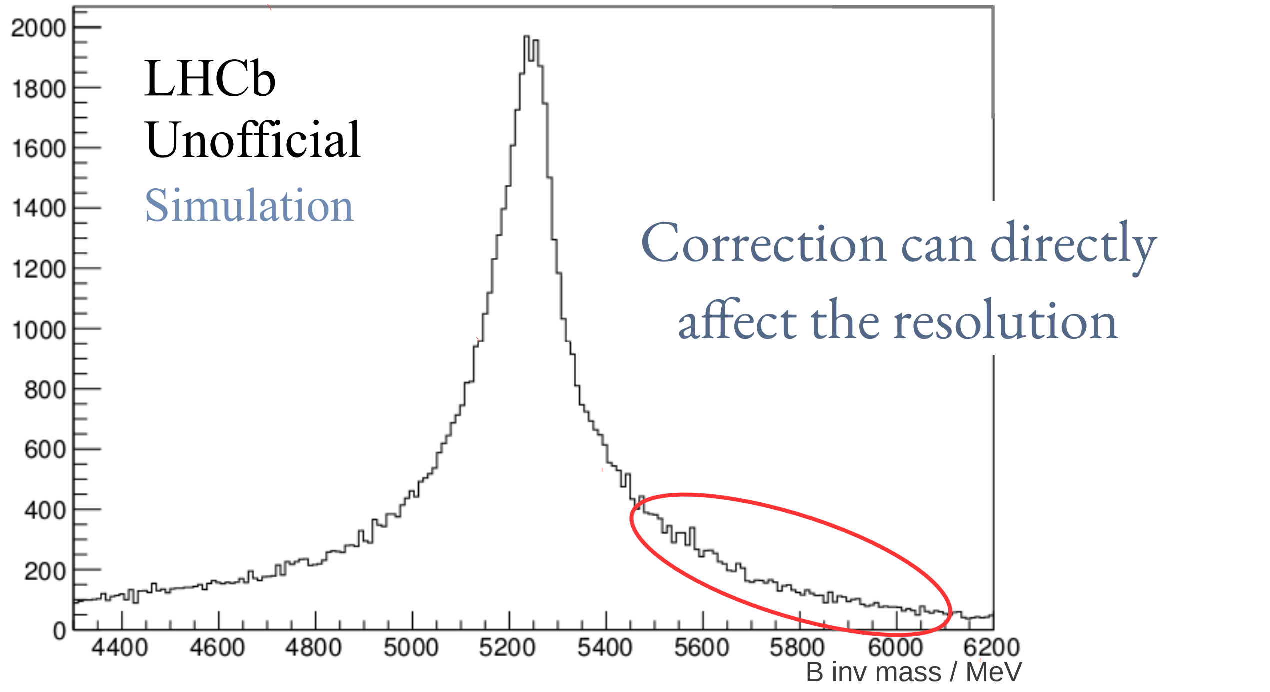
What about $B^0 \to K^{*0}e^+e^-$ analyses?

The electron identification at LHCb relies on a few detector features

- ECAL matching global procedure
- Bremsstrahlung photons extrapolation
- Track energy deposition in the PS and extrapolated particle trajectory into HCAL

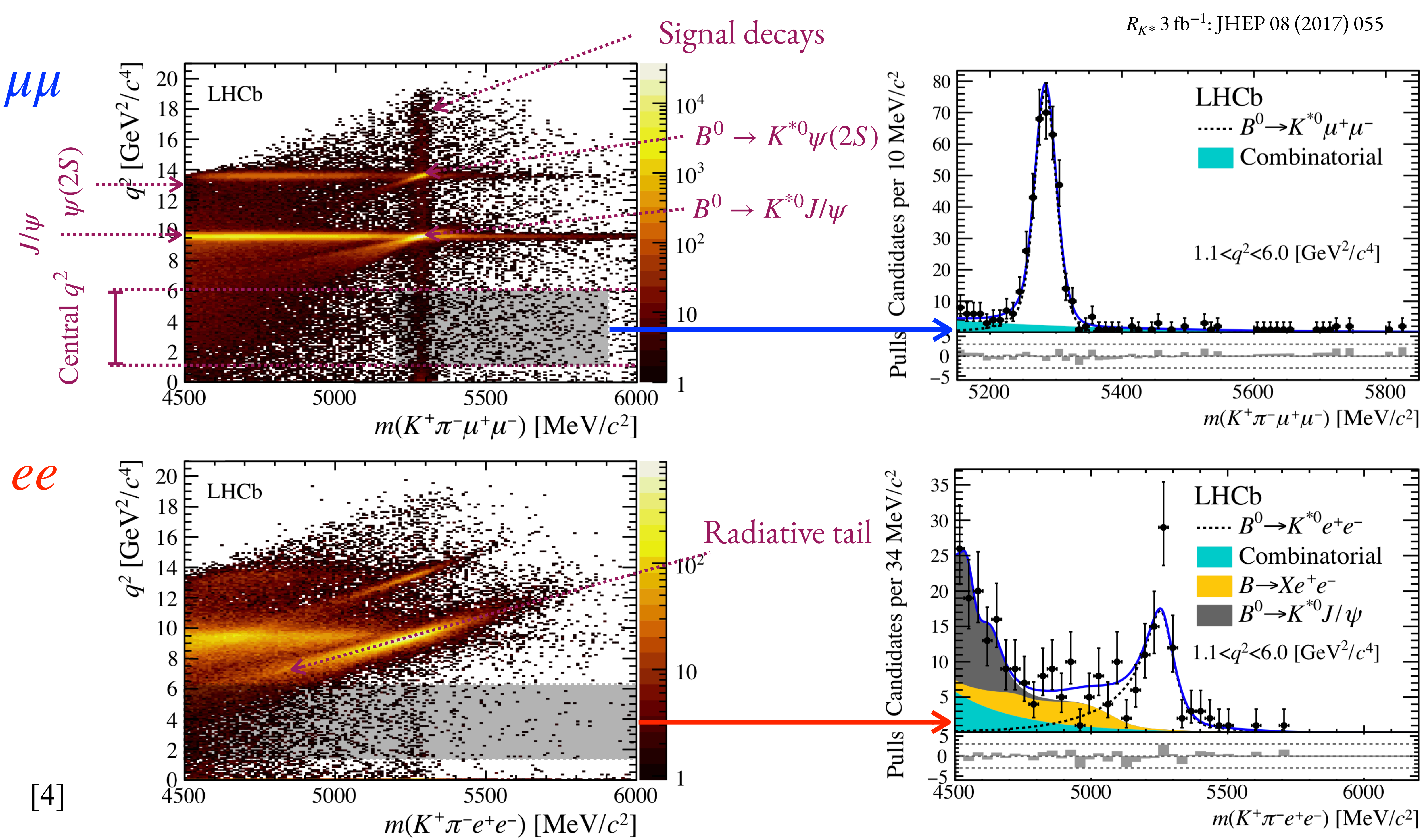






What about $B^0 \to K^{*0}e^+e^-$ analyses?

R_{K^*} 3 fb^{-1}: JHEP 08 (2017) 055



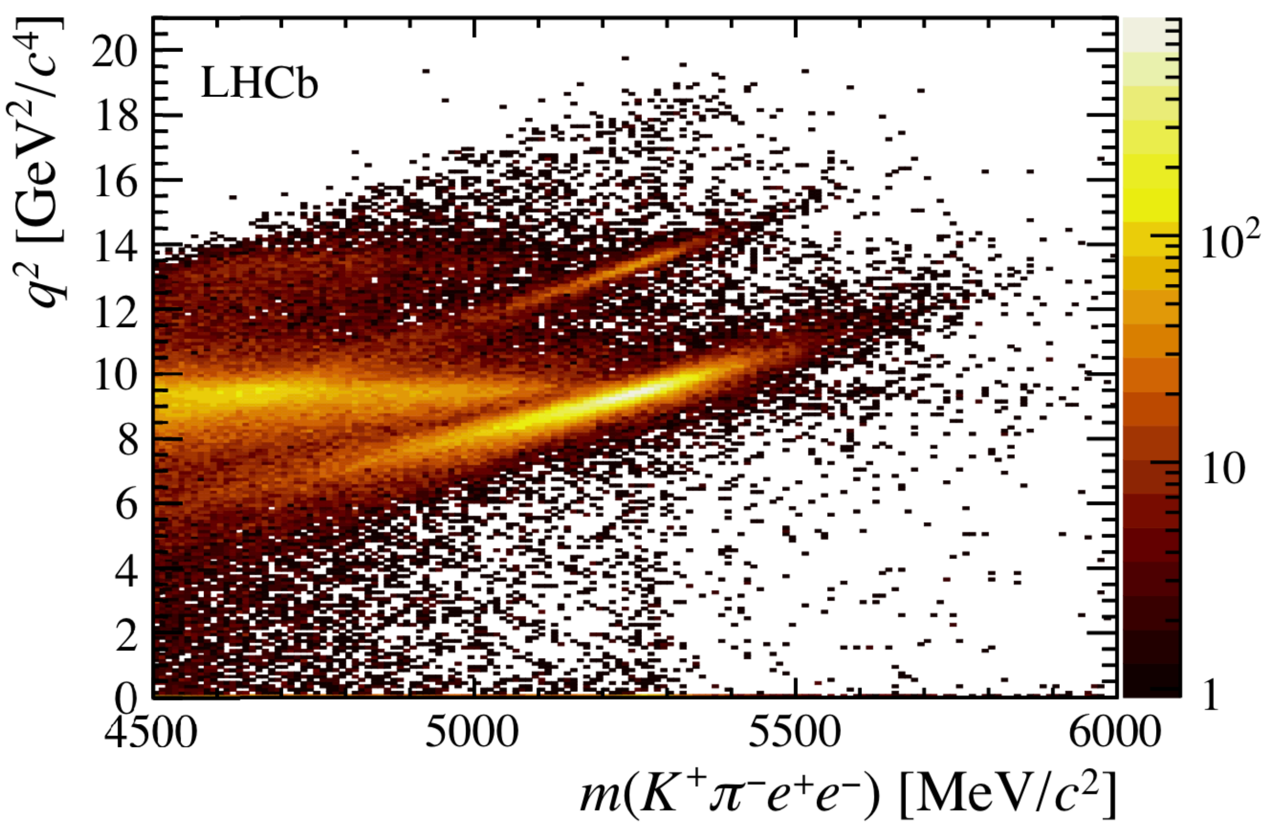
[4]

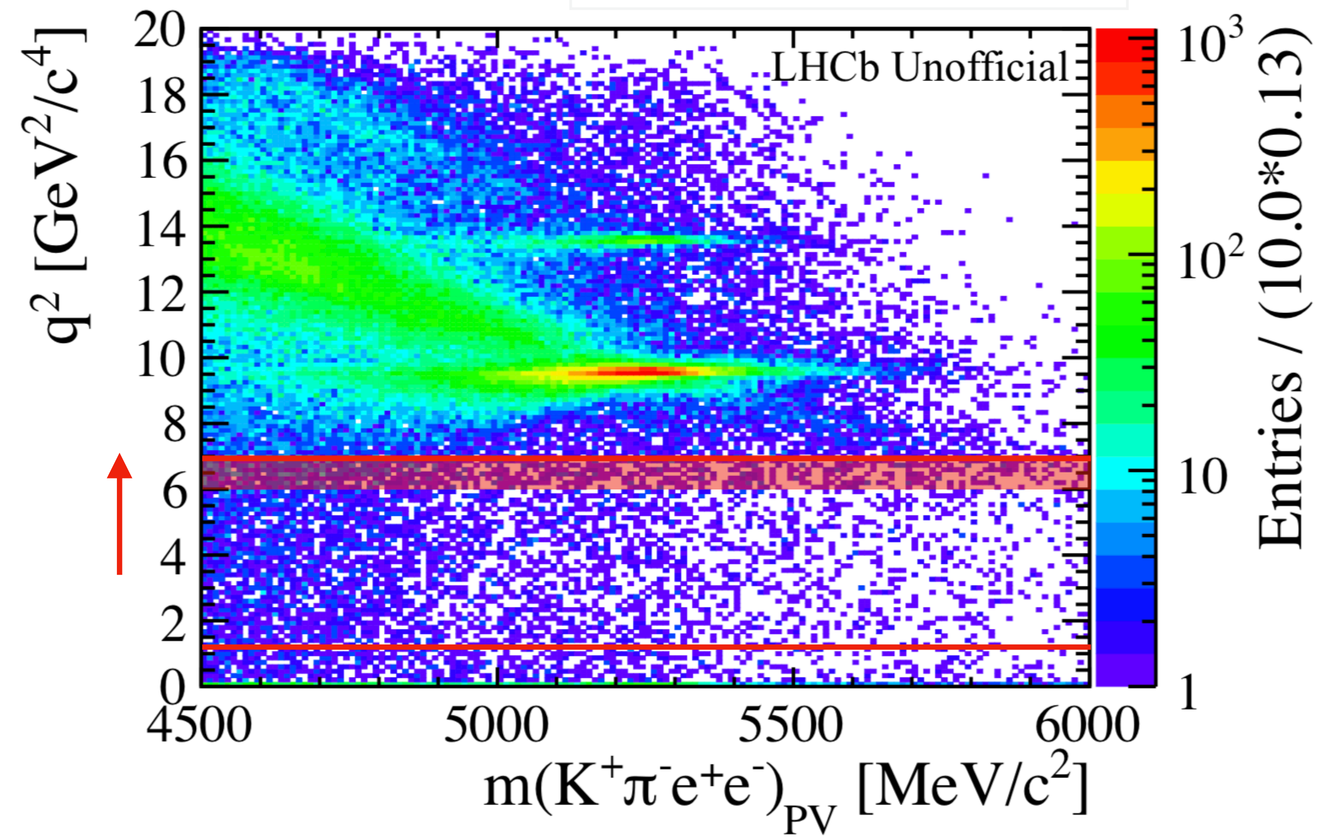
What about $B^0 \to K^{*0}e^+e^-$ analyses?

Strategies to improve signal resolution: "constraint" q^2

Cutting on the q^2 with B^0 primary vertex and B^0 mass constraint allows for the extension of the analysis range up to 7.0 GeV^2/c^4

[F. Lionetto PhD Thesis]





Also reduces potential "bin migration"!

What about $B^0 \to K^{*0}e^+e^-$ analyses?

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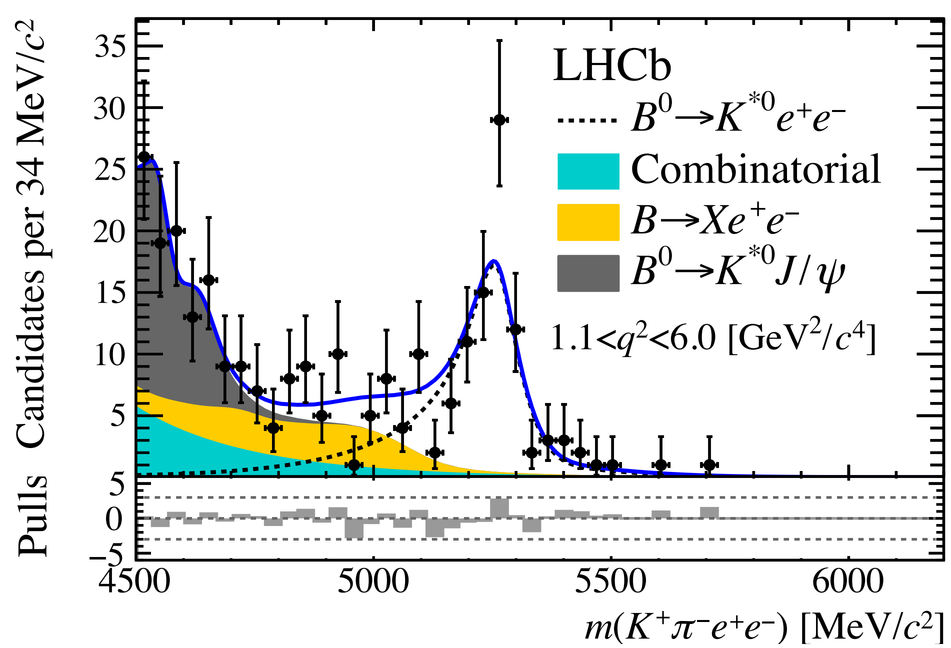
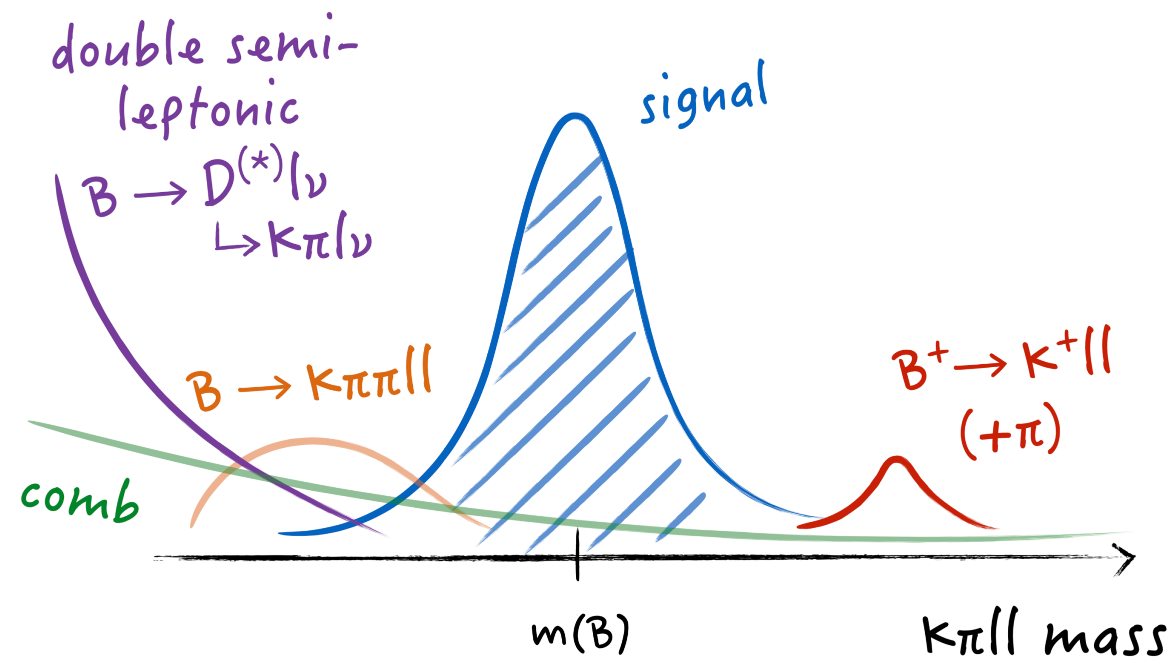




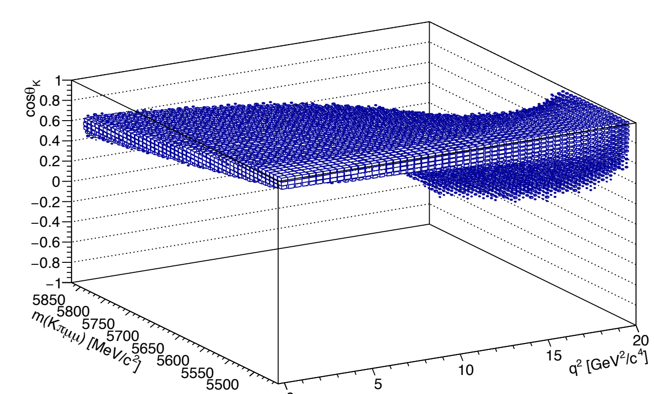
Possible backgrounds:

- $B^+ \to K^+e^+e^-$
- Double semi-leptonic
- Partially reconstructed (e.g. K_1)
- Combinatorial

$B \to K^+ll$ decays vetoed by $m(K\pi ll)$ and $m(Kll)$

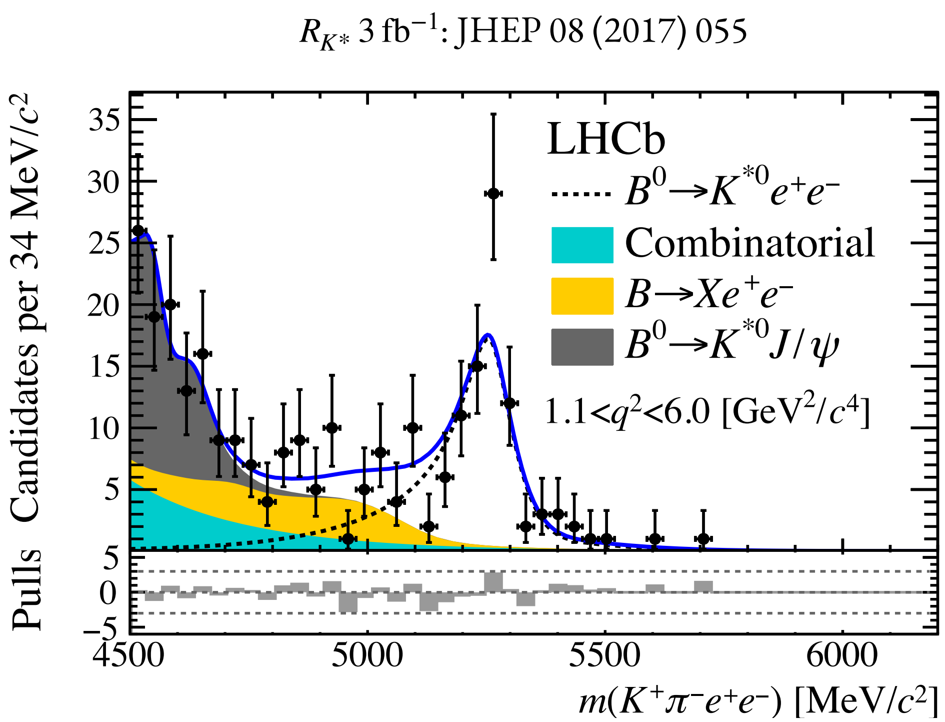
compatible with B mass

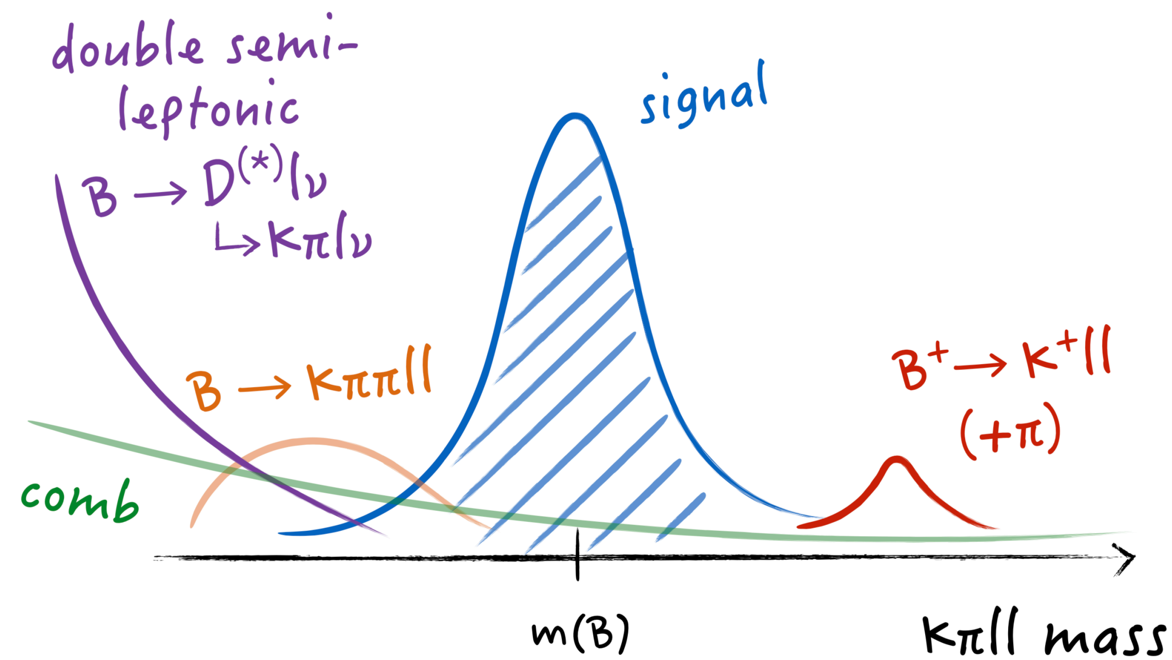
compatible with $B + \pi$ mass



Significant effect for electrons!

What about $B^0 \to K^{*0}e^+e^-$ analyses?





Possible backgrounds:

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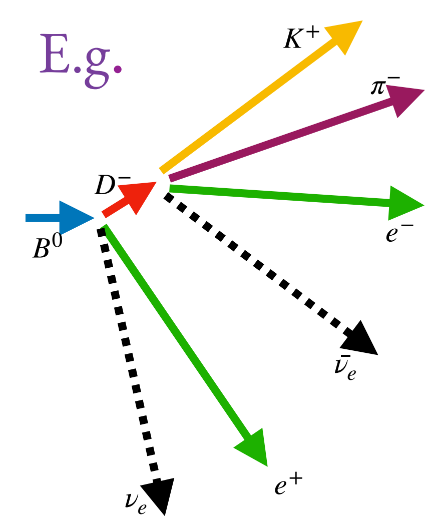
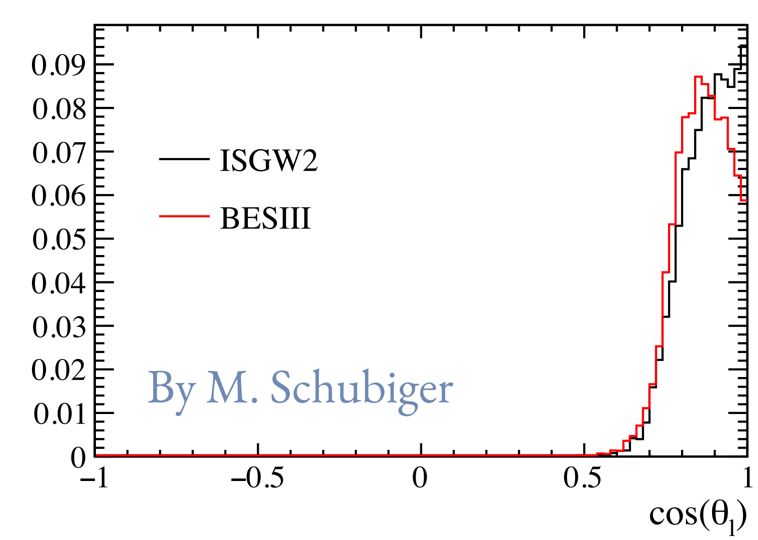
E.g.





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What comes Next?

From binned to unbinned ...

Direct fits to Wilson Coefficients

[Eur. Phys. J. C (2018) 78: 453]
[Eur. Phys. J. C, 78 6 (2018) 451, JHEP 10 (2019) 236]

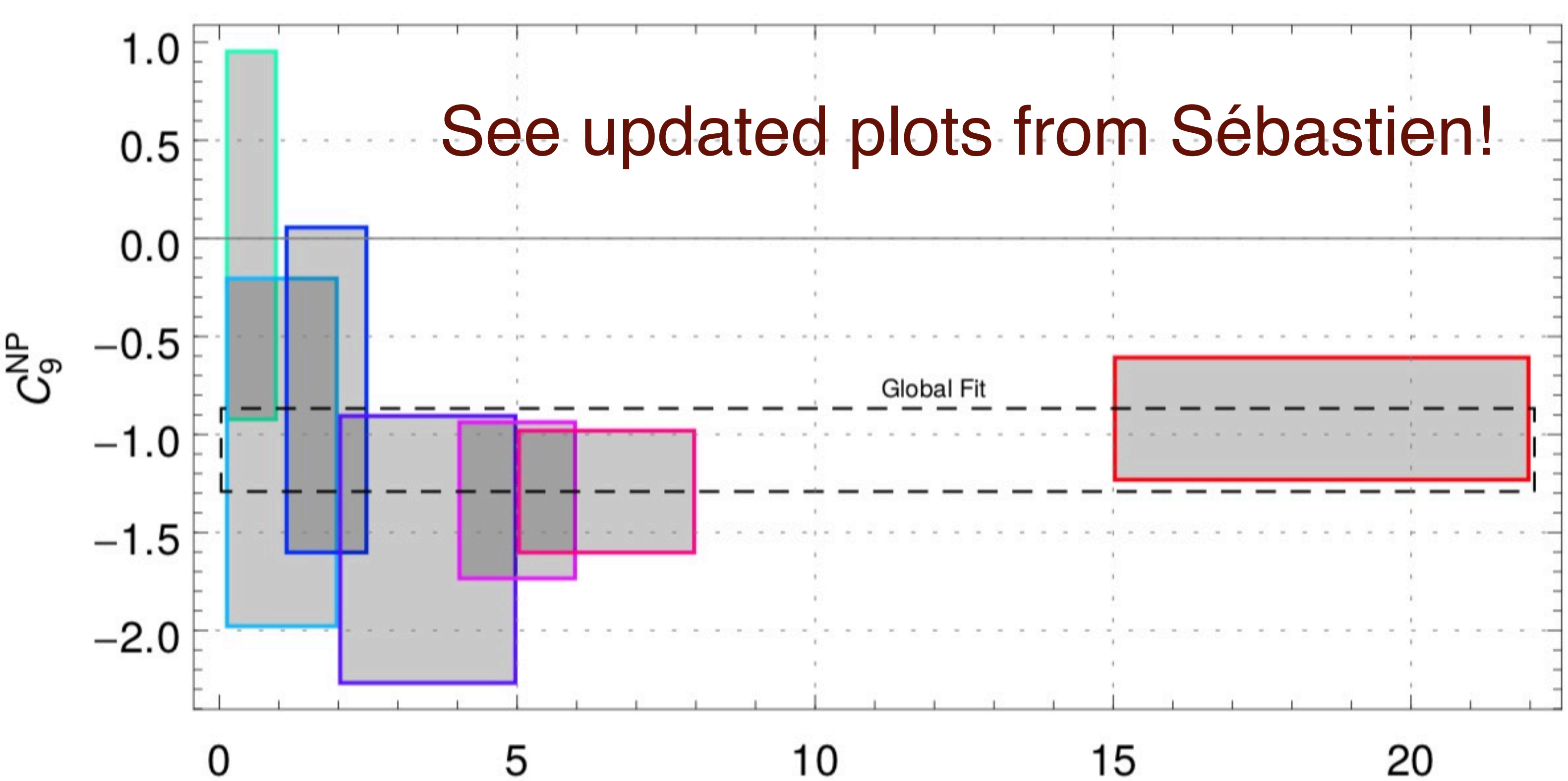
What about electrons?

[Phys. Rev. D 99, 013007 (2019)]

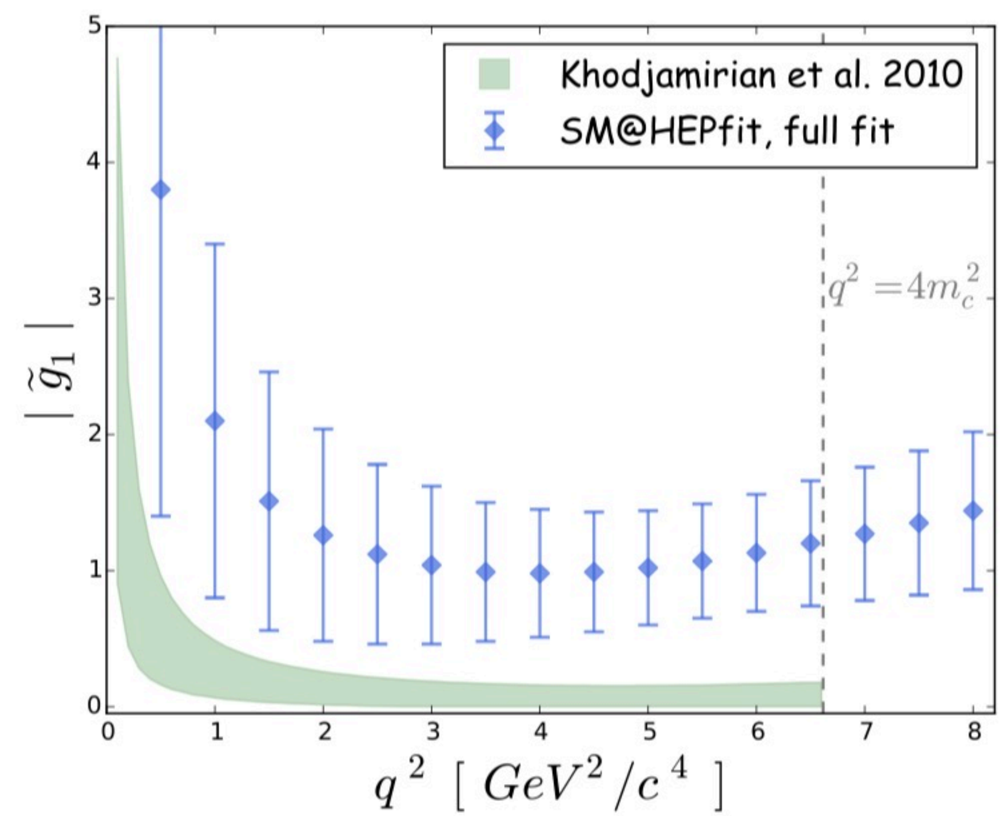
What we can learn from data?

If we are underestimating $c\bar{c}$ contributions then naively expect to see the shift in C_9 get larger closer to the narrow charmonium resonances.

[Decotes-Genon et al JHEP 06 (2016) 092]



[M. Chiuchini et al JHEP 06 (2016) 116]



No clear evidence for a rise in the data (but more data is needed)

Amplitude analyses of $B^0 \to K^{*0}\mu^+\mu^-$

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Observables integrated in q^2 bins are largely theory independent, so important information is lost

- Determination of long-distance contributions
- Improve sensitivity in the measurement

Two approaches at LHCb, *e.g.* for $B^0 \to K^{*0}\mu^+\mu^-$ ($\lambda = \perp, \parallel, 0$):

$$\mathcal{A}_\lambda^{(\ell)\,L,R} = \mathcal{N}_\lambda^{(\ell)} \left\{ \left(C_9^{(\ell)} \mp C_{10}^{(\ell)}\right) \mathcal{F}_\lambda(q^2) + \frac{2 m_b M_B}{q^2} \left[C_7^{(\ell)} \mathcal{F}_\lambda^T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_\lambda(q^2) \right] \right\}$$

- Wilson coefficients [observables]
- Form factors
- Non-local hadronic contributions

["Isobar"-like approach]

LHCb, Eur. Phys. J. C (2017) 77: 161,
Blake et al, Eur. Phys. J. C (2018) 78: 453

[z-expansion approach]

Eur. Phys. J. C, 78 6 (2018) 451,
arXiv:1805.06378

Amplitude analyses of $B^0 \to K^{*0}\mu^+\mu^-$

[“Isobar”-like approach]

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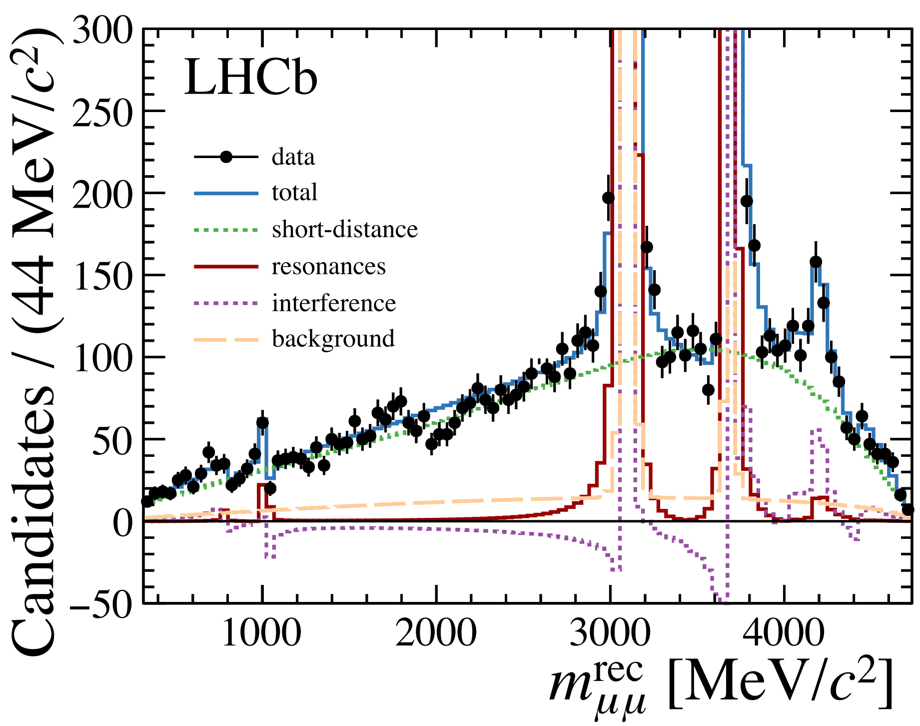
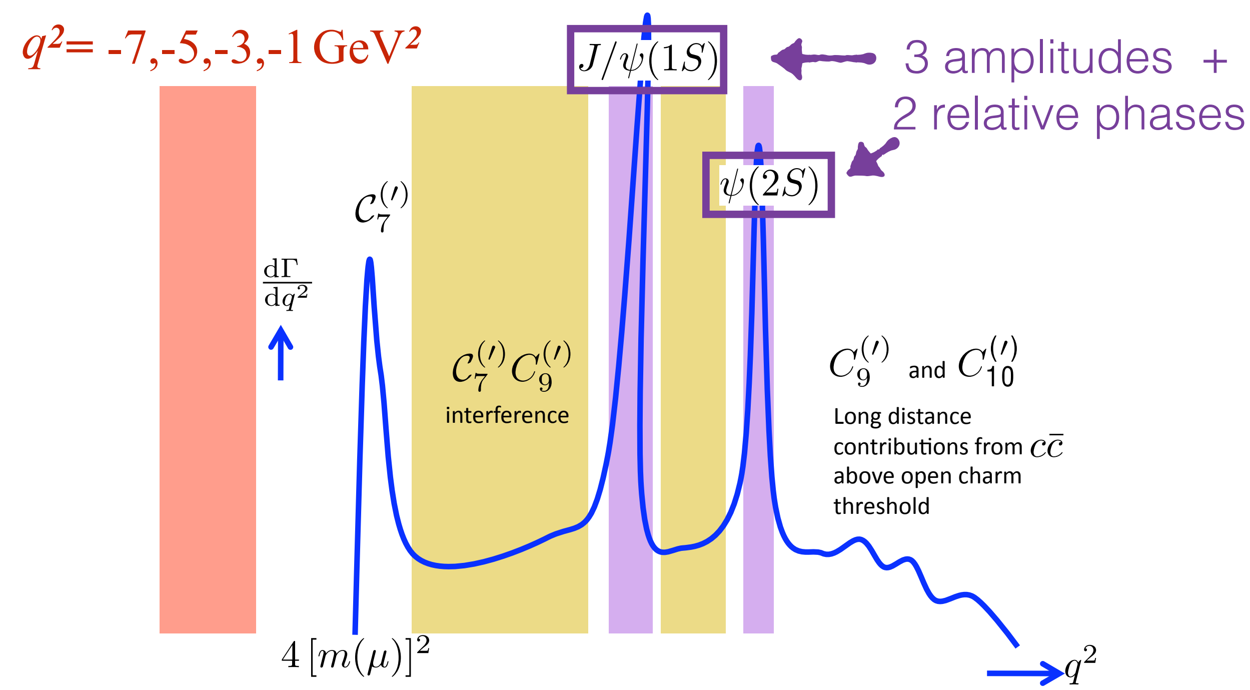


[z-expansion approach]

Eur. Phys. J. C, 78 6 (2018) 451
JHEP 10 (2019) 236



Strategy for each analysis present specific experimental challenges; consistency between these complementary approaches provides interesting information

Guinea pig (isobar): $B^+ \to K^+\mu^+\mu^-$ decays

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[EPJ C77 (2017) 161]

Fit to full di-muon mass spectrum including: ρ, ω, φ, Jψ, ψ(2S), ψ(3770), ψ(4040), ψ(4160), ψ(4415)

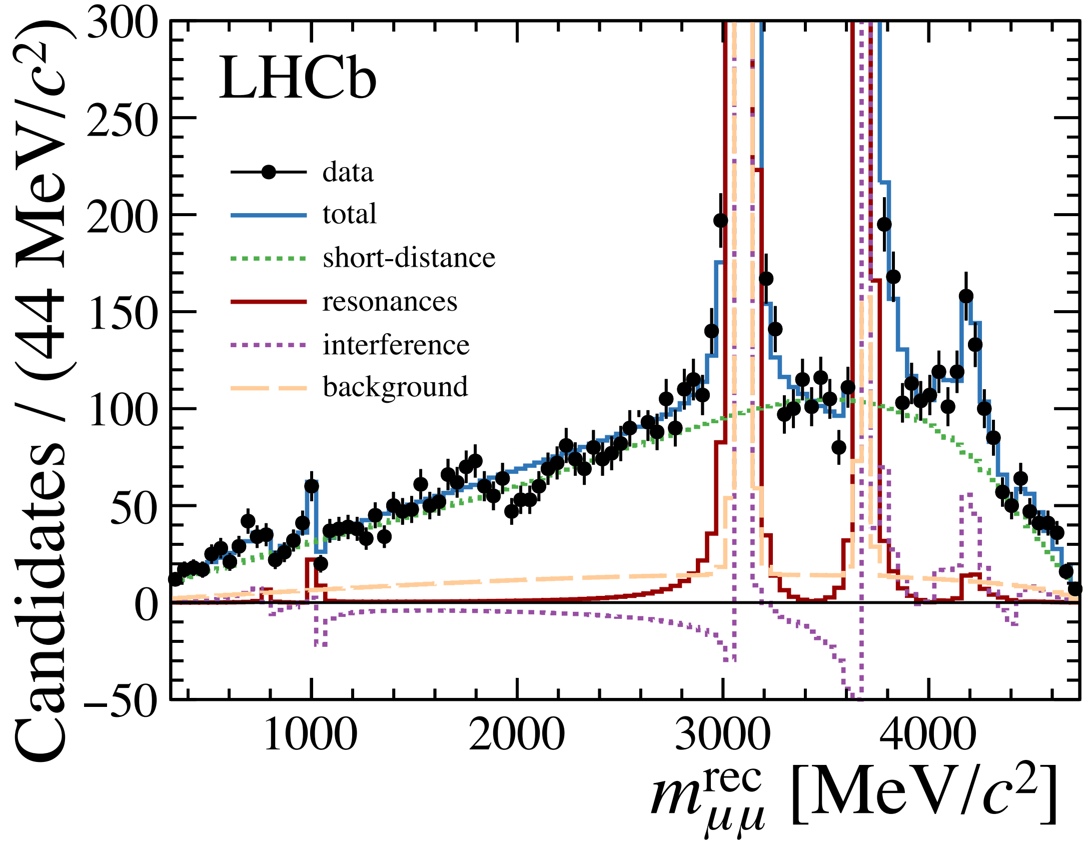
$$\frac{d\Gamma}{dq^2} = \frac{G_F^2\alpha^2|V_{tb}V_{ts}^*|^2}{128\pi^5}|\boldsymbol{k}|\beta\left\{\frac{2}{3}|\boldsymbol{k}|^2\beta^2\left|\mathcal{C}_{10}f_+(q^2)\right|^2 + \frac{4m_\mu^2(m_B^2-m_K^2)^2}{q^2m_B^2}\left|\mathcal{C}_{10}f_0(q^2)\right|^2 + |\boldsymbol{k}|^2\left[1-\frac{1}{3}\beta^2\right]\left|\mathcal{C}_9f_+(q^2)+2\mathcal{C}_7\frac{m_b+m_s}{m_B+m_K}f_T(q^2)\right|^2\right\}$$

Breit-Wigners

$$\mathcal{C}_9^{\text{eff}} = \mathcal{C}_9 + \sum_j \eta_j e^{i\delta_j} A_j^{\text{res}}(q^2)$$

Magnitude and phase of each resonance relative to C₉

Fit suggested J/ψ has little impact outside the region



[isobar] approach in a nutshell

[EPJ C78 (2018) 453]

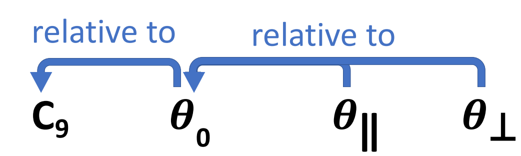
$$\mathcal{A}_\lambda^{(\ell)\,L,R} = \mathcal{N}_\lambda^{(\ell)} \left\{ (C_9^{(\ell)} \mp C_{10}^{(\ell)}) \mathcal{F}_\lambda(q^2) + \frac{2 m_b M_B}{q^2} \left[C_7^{(\ell)} \mathcal{F}_\lambda^T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_\lambda(q^2) \right] \right\}$$

$\frac{M_B}{m_b}\mathcal{H}_\lambda(q^2) \rightarrow \mathcal{G}_\lambda(q^2)$

$$\mathcal{G}_0 = \frac{m_b}{m_B + m_{K^*}} T_{23}(q^2) \zeta^0 e^{i\omega^0} + A_{12}(q^2) \sum_j \eta_j^0 e^{i\theta_j^0} A_j^{\rm res}(q^2)$$

$$\mathcal{G}_{\parallel} = \frac{2 m_b}{q^2} T_2(q^2) \zeta^{\parallel} e^{i\omega^{\parallel}} + \frac{A_1(q^2)}{m_B - m_{K^*}} \sum_j \eta_j^{\parallel} e^{i\theta_j^{\parallel}} A_j^{\rm res}(q^2)$$

$$\mathcal{G}_{\perp} = \frac{2 m_b}{q^2} T_1(q^2) \zeta^{\perp} e^{i\omega^{\perp}} + \frac{V(q^2)}{m_B + m_{K^*}} \sum_j \eta_j^{\perp} e^{i\theta_j^{\perp}} A_j^{\rm res}(q^2)$$



Magnitude and phase of non-local contribution to dipole form factor

Sum over all resonances

Magnitude and phase for each resonance

BW Amplitudes

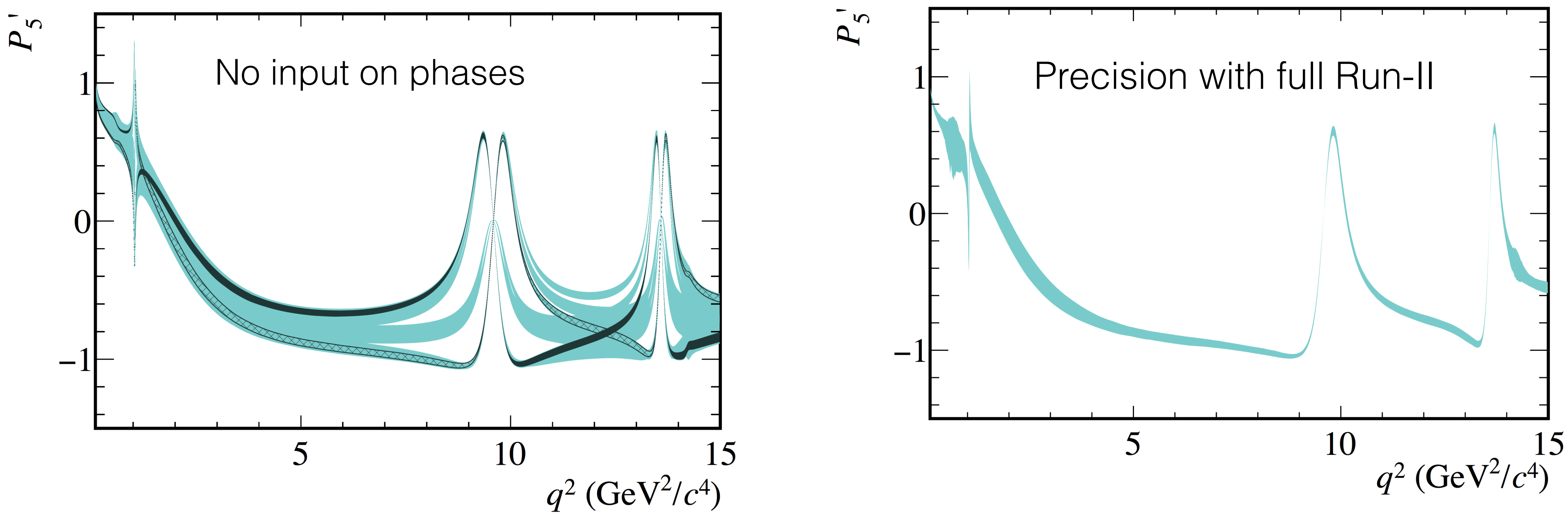
e.g.: $\rho^0, \phi(1020), J/\psi, \psi(2S), \psi(3770), \psi(4040), \psi(4160)$

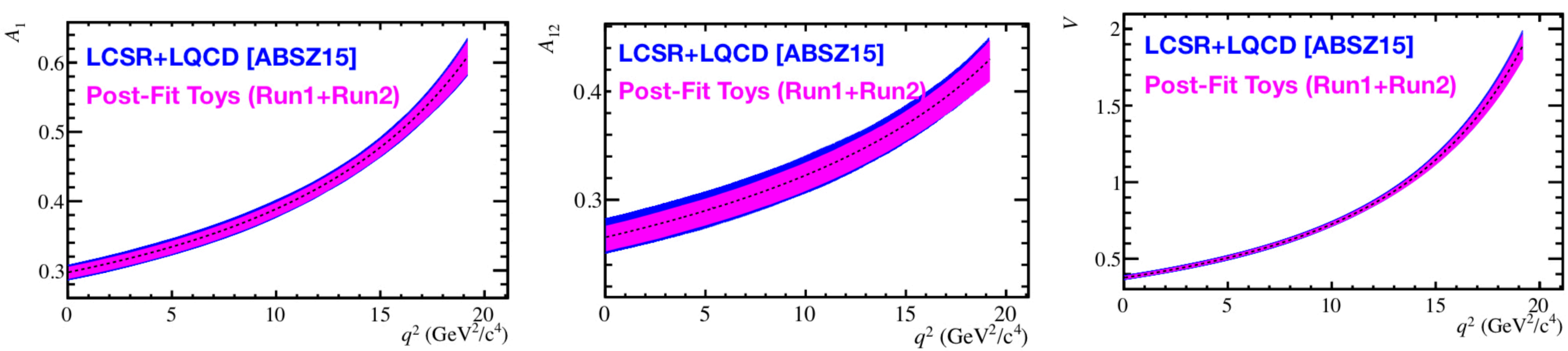
Existing angular analyses and BFs of $B \to VK^{*0}$ can constrain two phases and all magnitudes

[isobar] controlling hadronic paramaters

[EPJ C78 (2018) 453]

Run-II dataset will provide strong constraint on phases, but no improvements on FFs



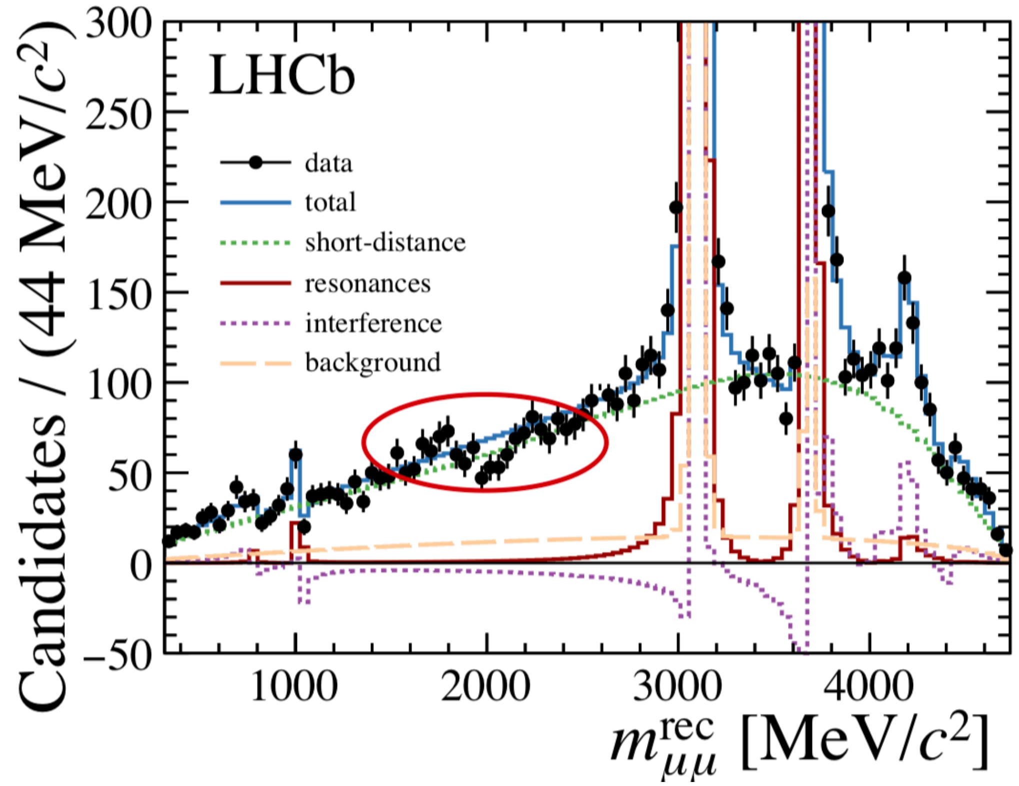


[isobar] going beyond leading charmonium

Nominal model can be affected by several contributions:

- Broad continuum heavy $c\bar{c}$ states [arXiv:2001.04470]
- Heavier states
- Other non-resonant contributions (?)

Decay	% of $B^+ \to K^+\mu^+\mu^-$
Penguin	0.6 %
$B^+ \to \rho K^+$	0.0003 %
$B^+ \to \omega K^+$	0.0006 %
$B^+ \to \phi K^+$	0.003 %
$B^+ \to J/\psi K^+$	92 %
$B^+ \to \psi(2S) K^+$	7.3 %
$B^+ \to \psi(3770) K^+$	0.007 %
$B^+ \to \psi(4040) K^+$	~ 0 %
$B^+ \to \psi(4160) K^+$	0.005 %
$B^+ \to \psi(4415) K^+$	~ 0 %



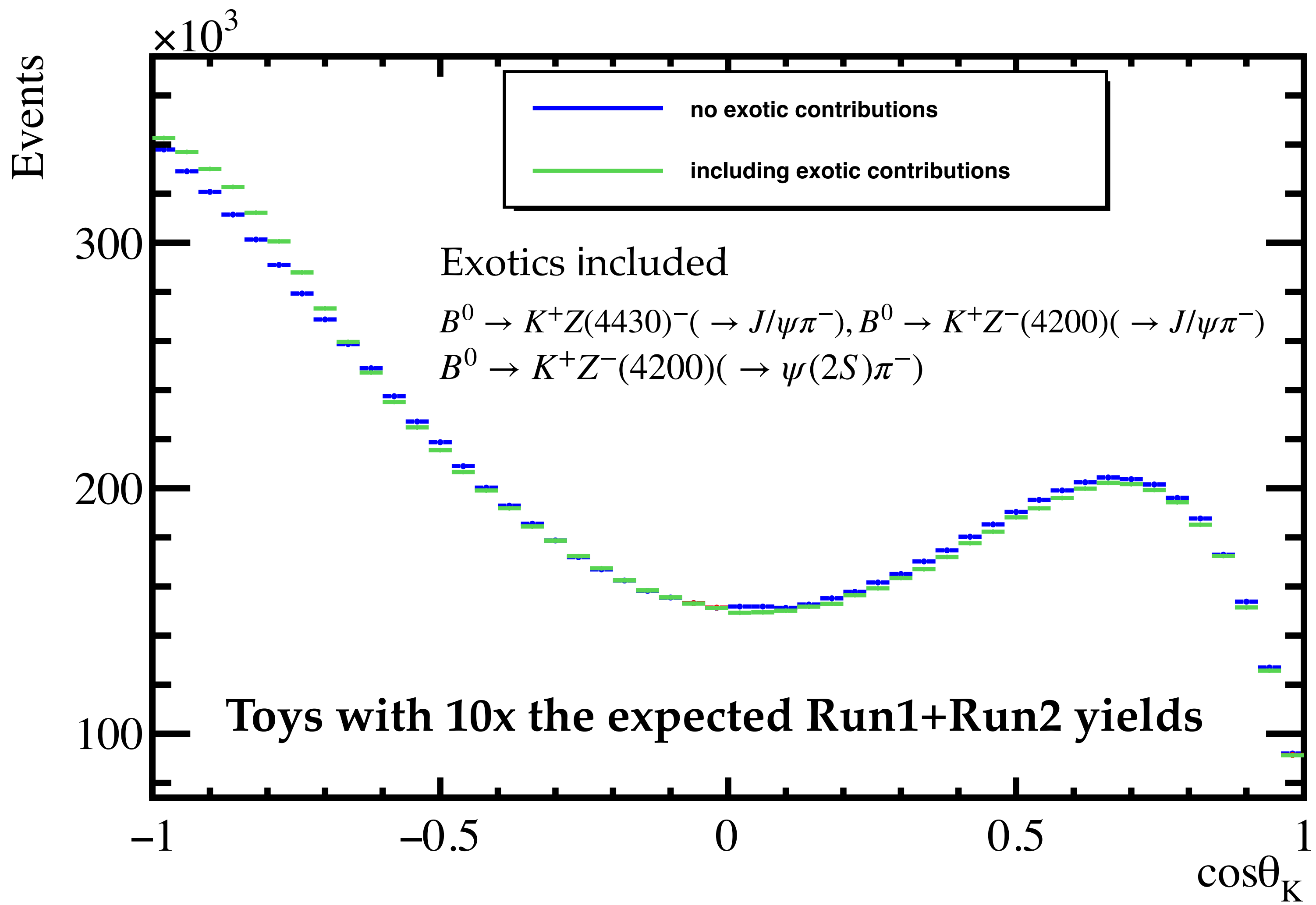
[isobar] exotic contributions

Full q² spectrum is used, hence contributions from exotic states $B^0 \to K^+ Z^-(\to \psi^{(\prime)}\pi^-)$

Studied as systematic uncertainty

- Generate toys including exotic states (including interference with non-local and penguin)
- Fit back with our model ignoring the exotic states

- Impact on the Wilson coefficients is negligible
- Dominant uncertainty on phase difference of J/ψ and $\psi(2S)$ at the level of 10mrad
- Note that similarly this affects the external parameters for other models



[z-parametrisation] $B^0 \to K^{*0}\mu^+\mu^-$ decays

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Parametrisation suggested in [Eur. Phys. J. C, 78 6 (2018) 451]:

$$\mathcal{A}_\lambda^{(\ell)\,L,R} = \mathcal{N}_\lambda^{(\ell)} \left\{ (C_9^{(\ell)} \mp C_{10}^{(\ell)}) \mathcal{F}_\lambda(q^2) + \frac{2m_b M_B}{q^2} \left[C_7^{(\ell)} \mathcal{F}_\lambda^T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_\lambda(q^2) \right] \right\}$$

Non-local hadronic contributions

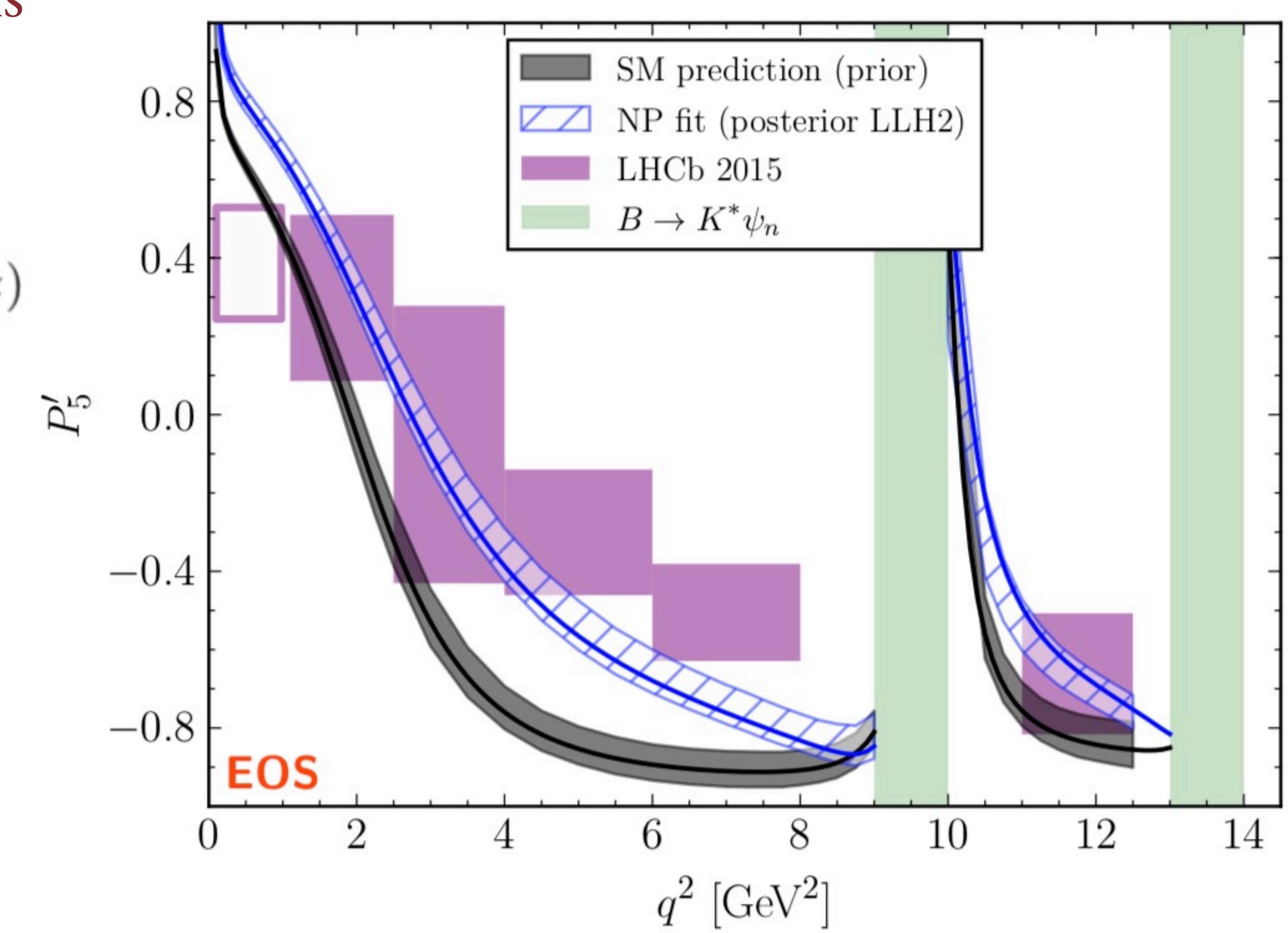
mapping: $q^2 \to z(q^2)$

$$\mathcal{H}_\lambda(z) = \frac{1 - z z^*_{J/\psi}}{z - z_{J/\psi}} \frac{1 - z z^*_{\psi(2S)}}{z - z_{\psi(2S)}} \hat{\mathcal{H}}_\lambda(z)$$

extract the poles

$$\hat{\mathcal{H}}_\lambda(z) = \left[\sum_k \alpha_k^{(\lambda)} z^k \right] \mathcal{F}_\lambda(z)$$

- Analytic within |z|=1
- Cut-off os series at z^2

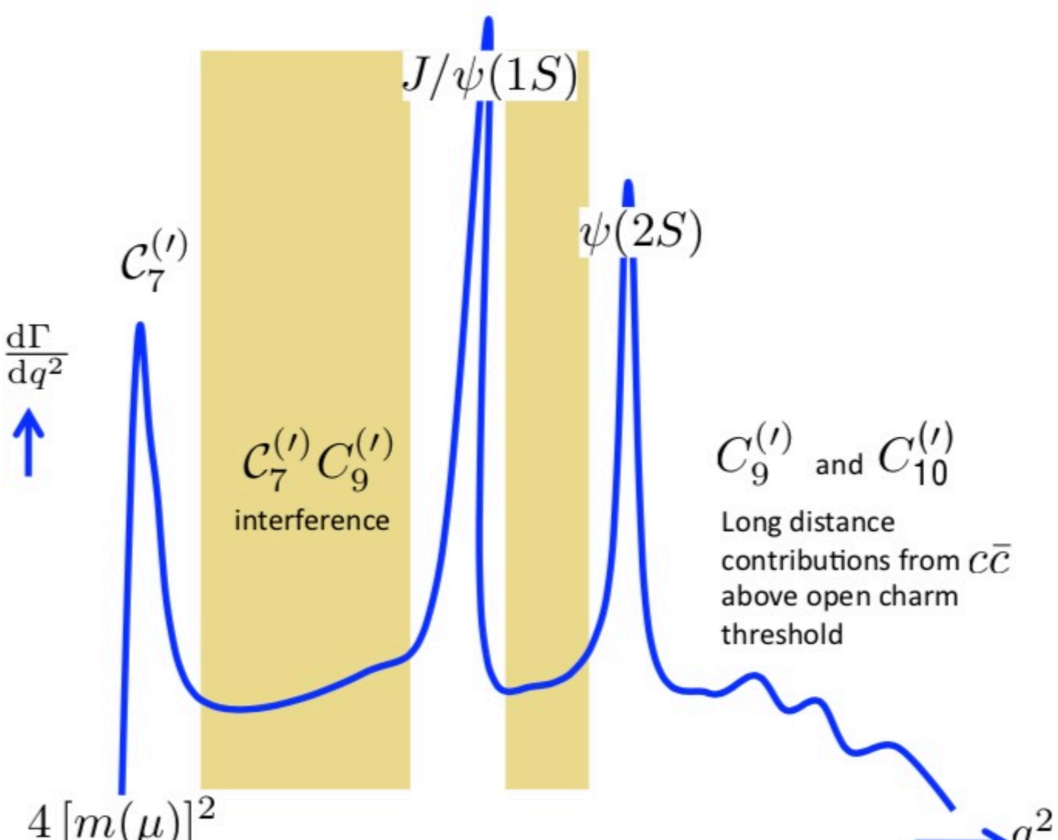


[z-parametrisation] $B^0 \to K^{*0}\mu^+\mu^-$ decays

[JHEP 10 (2019) 236]

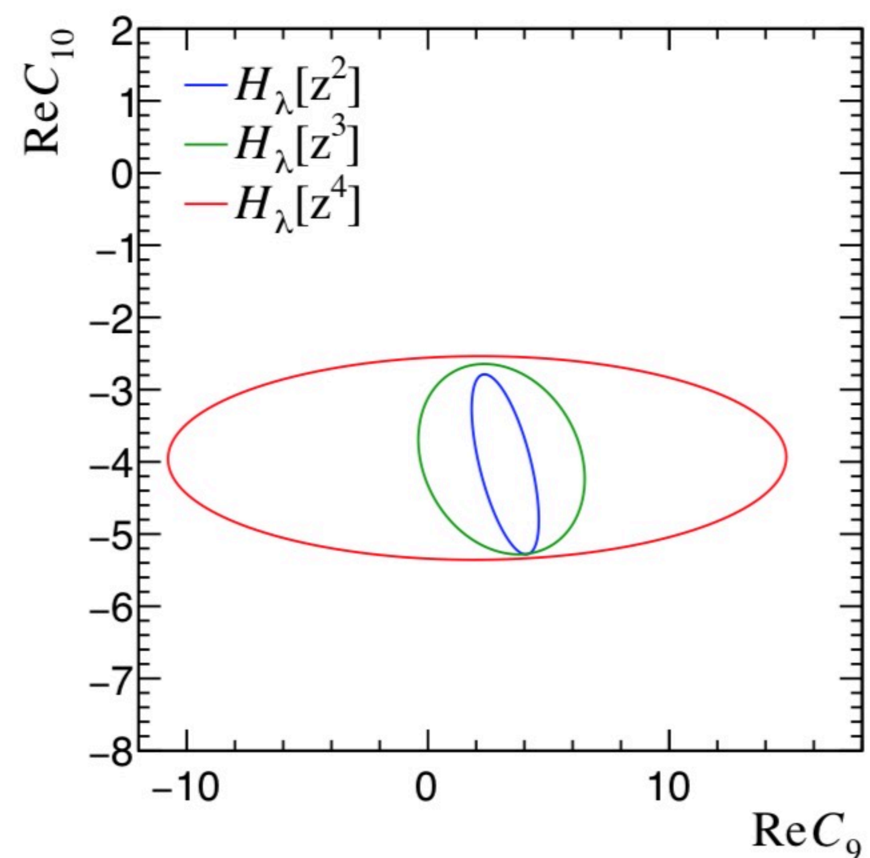
First attempt to study the effect of the theory constraints cut-off

- Signal yield related to the BR
- CKM/FF are floating/gaussian constrained parameters and **H are free**



$[1.1, 9.0]$ & $[10.0, 13.0]$ GeV^2

Strong dependence on the cut-off of the *z*-expansion…



[z-parametrisation] $B^0 \to K^{*0}\mu^+\mu^-$ decays

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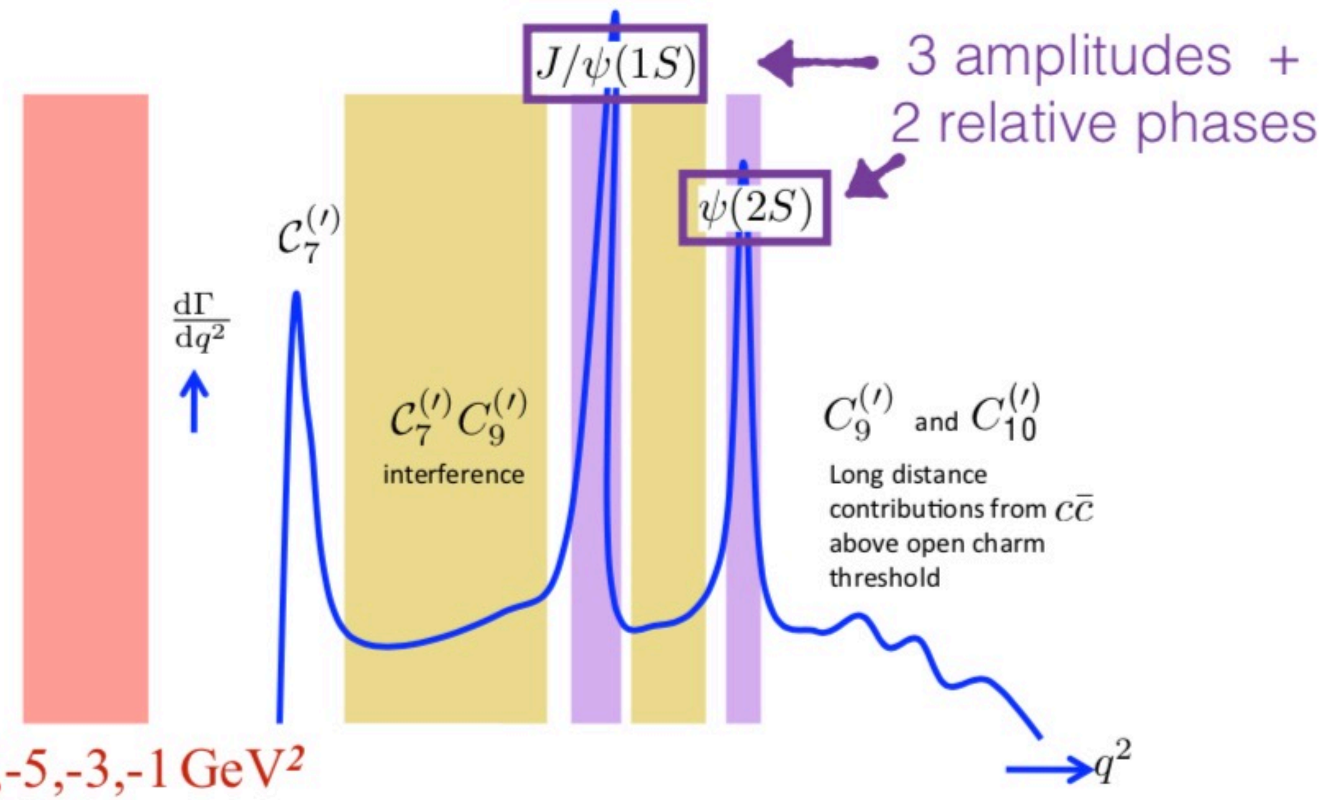
Combined amplitude fit:

[semi-muonic $B \to K^*\mu\mu$ decays]

[theory points at negative q^2]

[hadronic $B \to K^*\{J/\psi, \psi(2S)\}$]



q^2= -7,-5,-3,-1 GeV^2

	LHCb Upgrade [50 fb^{-1}]	
	Re C_9^{NP} mean	Re C_9^{NP} sigma
z^2 fit	-0.996 ± 0.003	0.060 ± 0.002
z^3 fit	-1.015 ± 0.006	0.124 ± 0.004
z^4 fit	-1.012 ± 0.007	0.146 ± 0.005
z^5 fit	-0.983 ± 0.008	0.157 ± 0.006

- unbiased central value
- statistical uncertainty slightly increasing
  - effect strongly mitigated by the introduction of the theory constraints

studying the behaviour of the series expansion at different order allows to access in a quantitative way this model-dependency

[z-parametrisation] $B^0 \to K^{*0}\mu^+\mu^-$ decays

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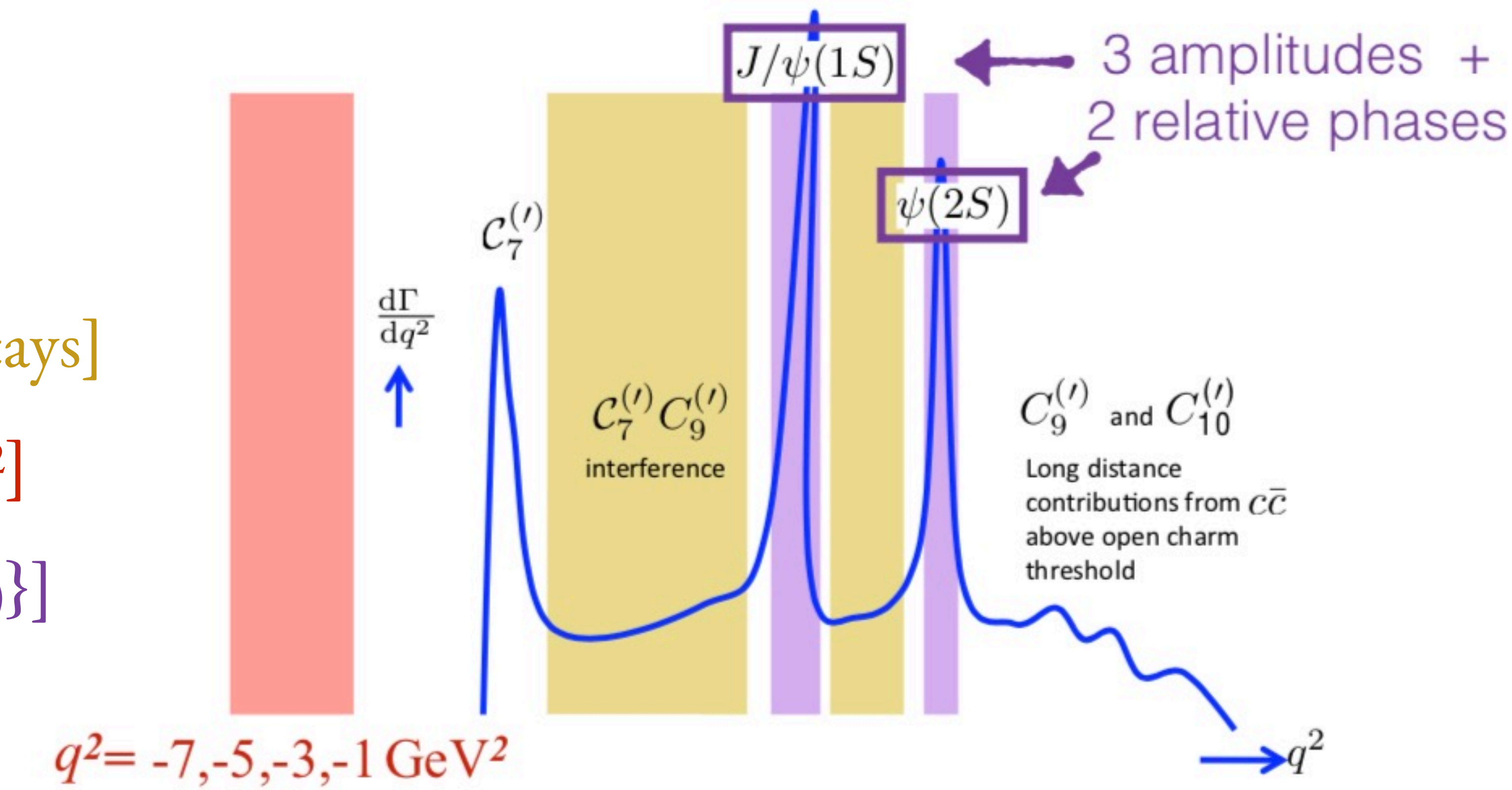


Generating at z^4 order:

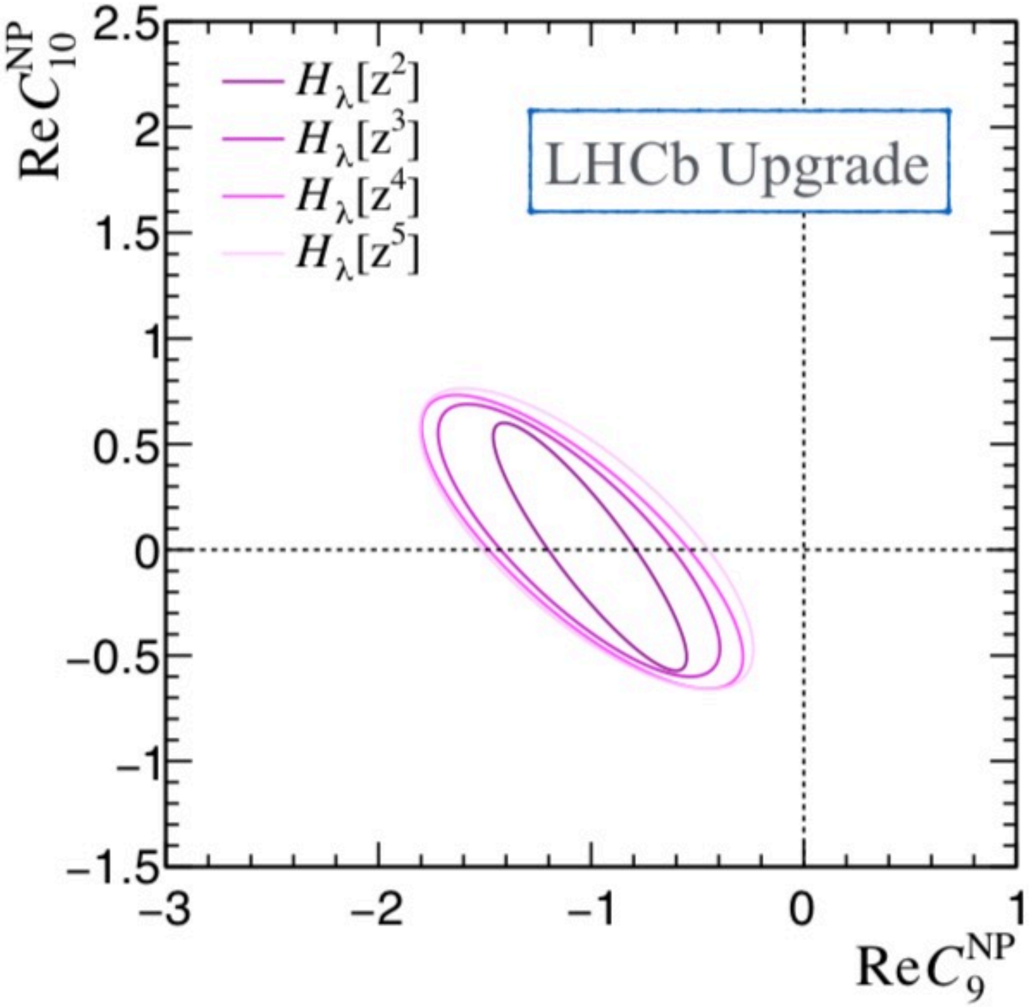
gen. C_9^{NP} = -1	LHCb Upgrade [50 fb^{-1}] $\mathrm{Re}\,\mathcal{C}_9^{NP}$ mean	$\mathrm{Re}\,\mathcal{C}_9^{NP}$ sigma
z^2 fit	-1.824 ± 0.003	0.063 ± 0.002
z^3 fit	-1.188 ± 0.005	0.103 ± 0.004
z^4 fit	-1.018 ± 0.006	0.119 ± 0.004
z^5 fit	-0.985 ± 0.007	0.141 ± 0.005

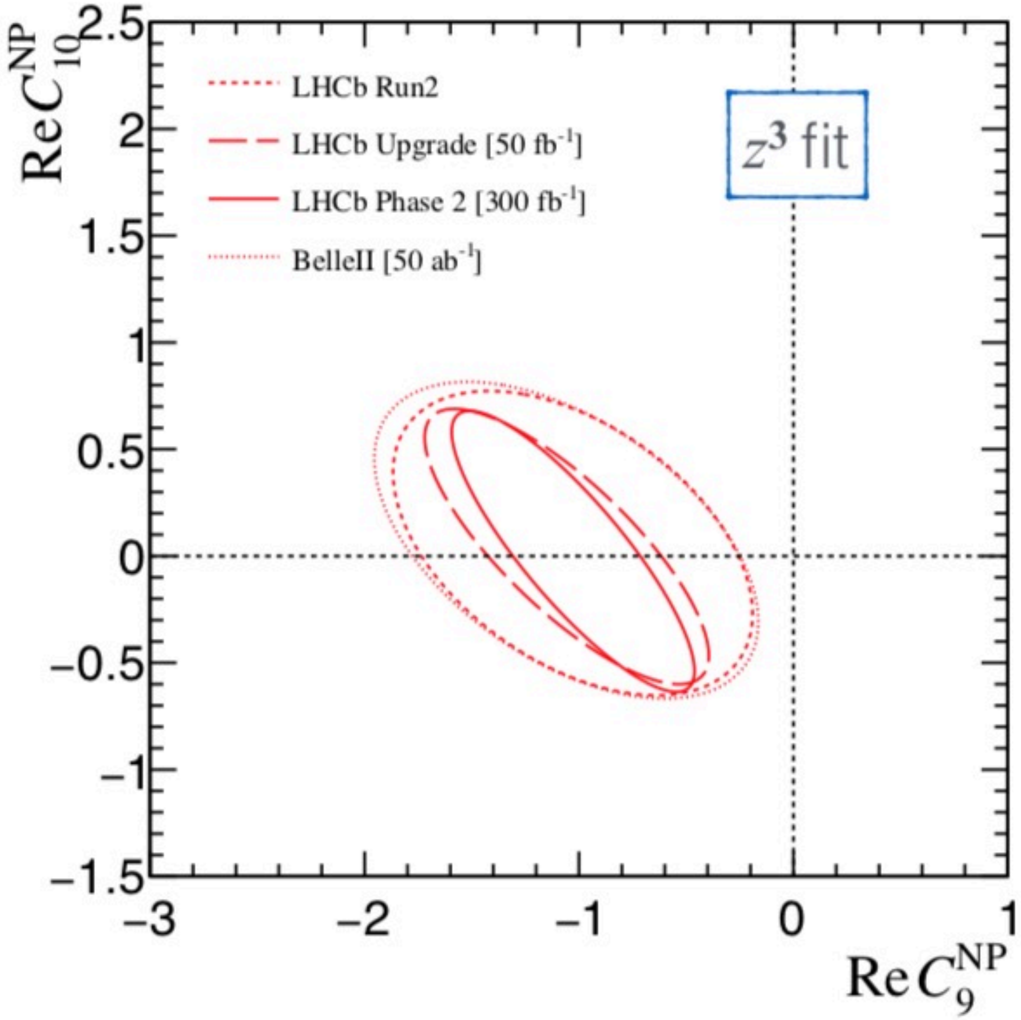
wrong order → C_9^{NP} is biased!!!

right order or higher → mean OK

Simultaneous fit to C_9 and C_{10}

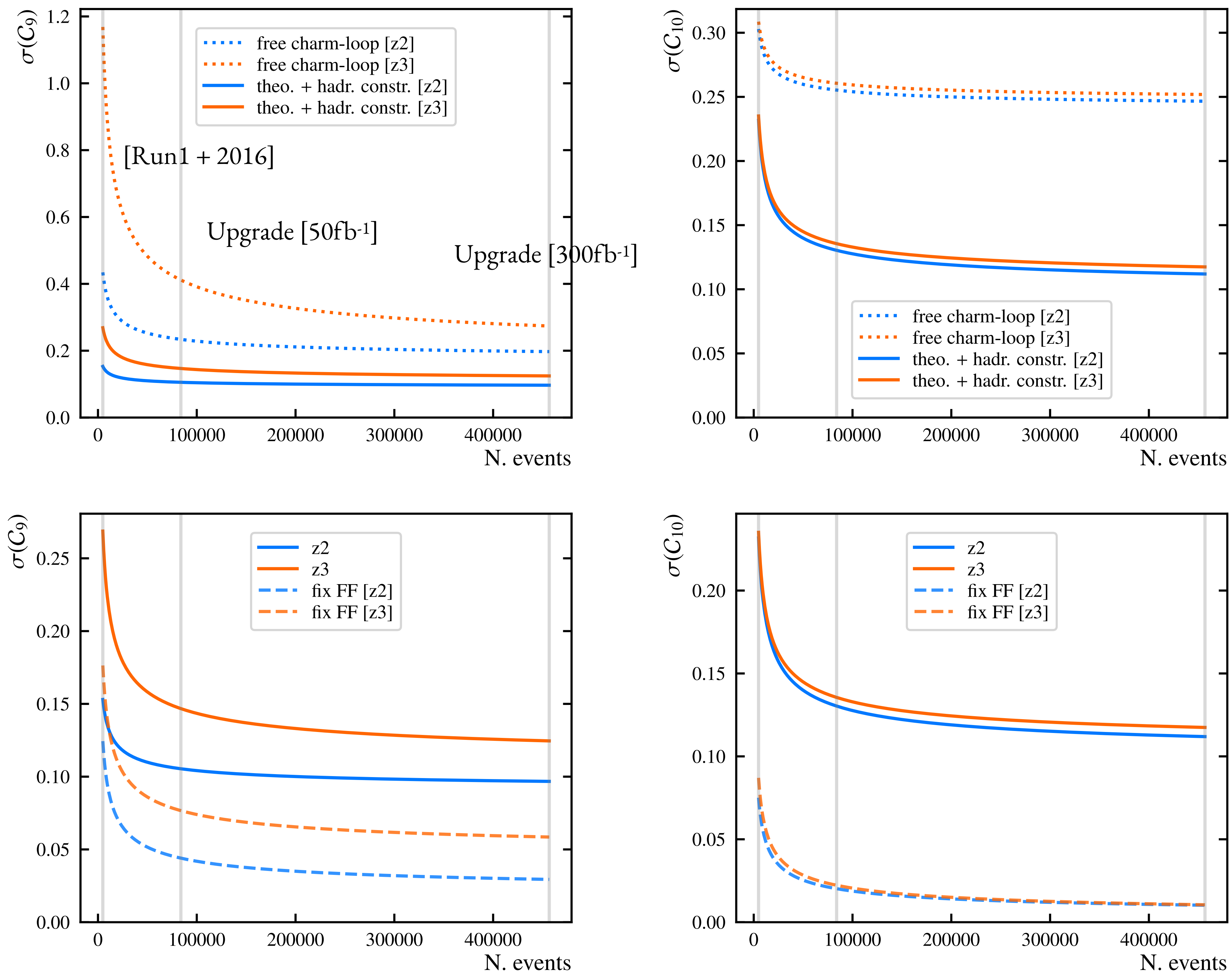
[A. Mauri PhD Thesis]





- uncertainty slightly increase for fit with order higher than z^3
- uncertainty saturates due to the form factors after LHCb Upgrade

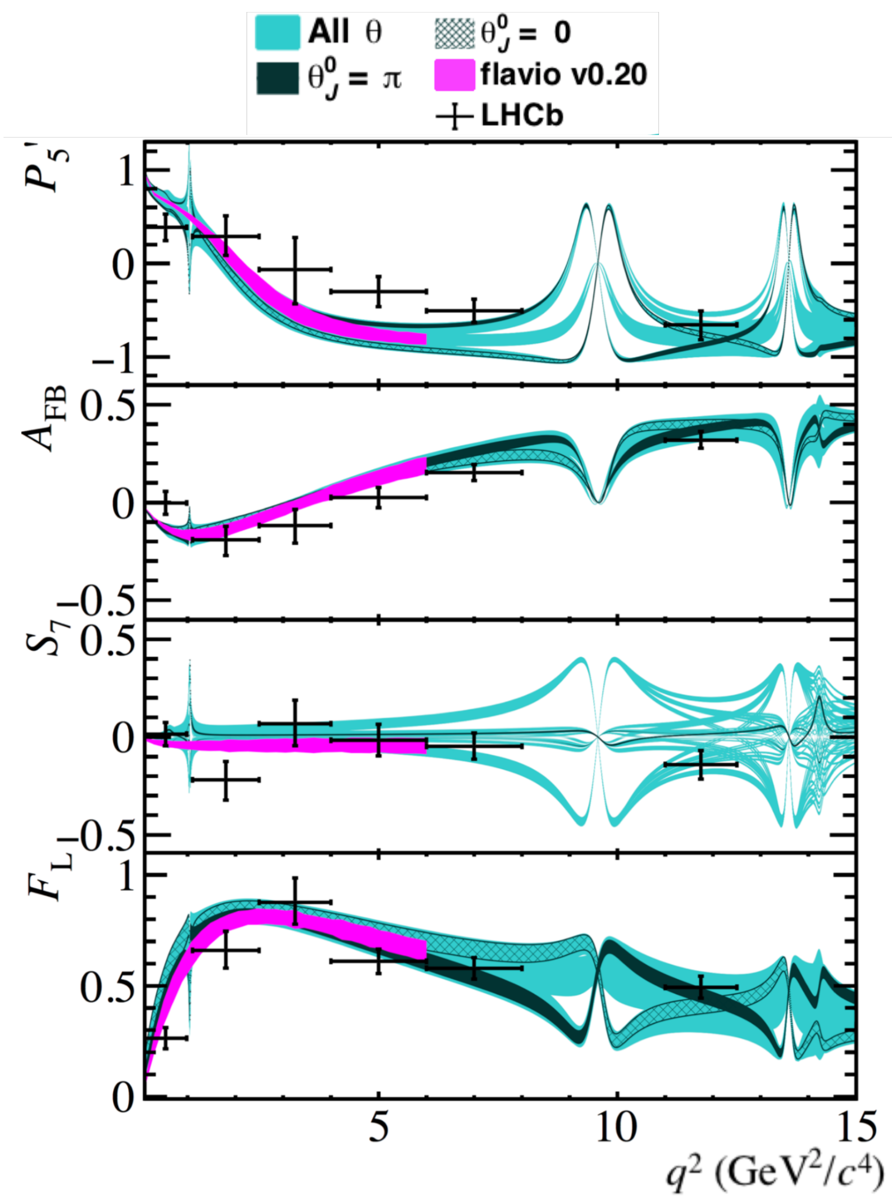
C_9 and C_{10} vs FF and charm-loop interplay



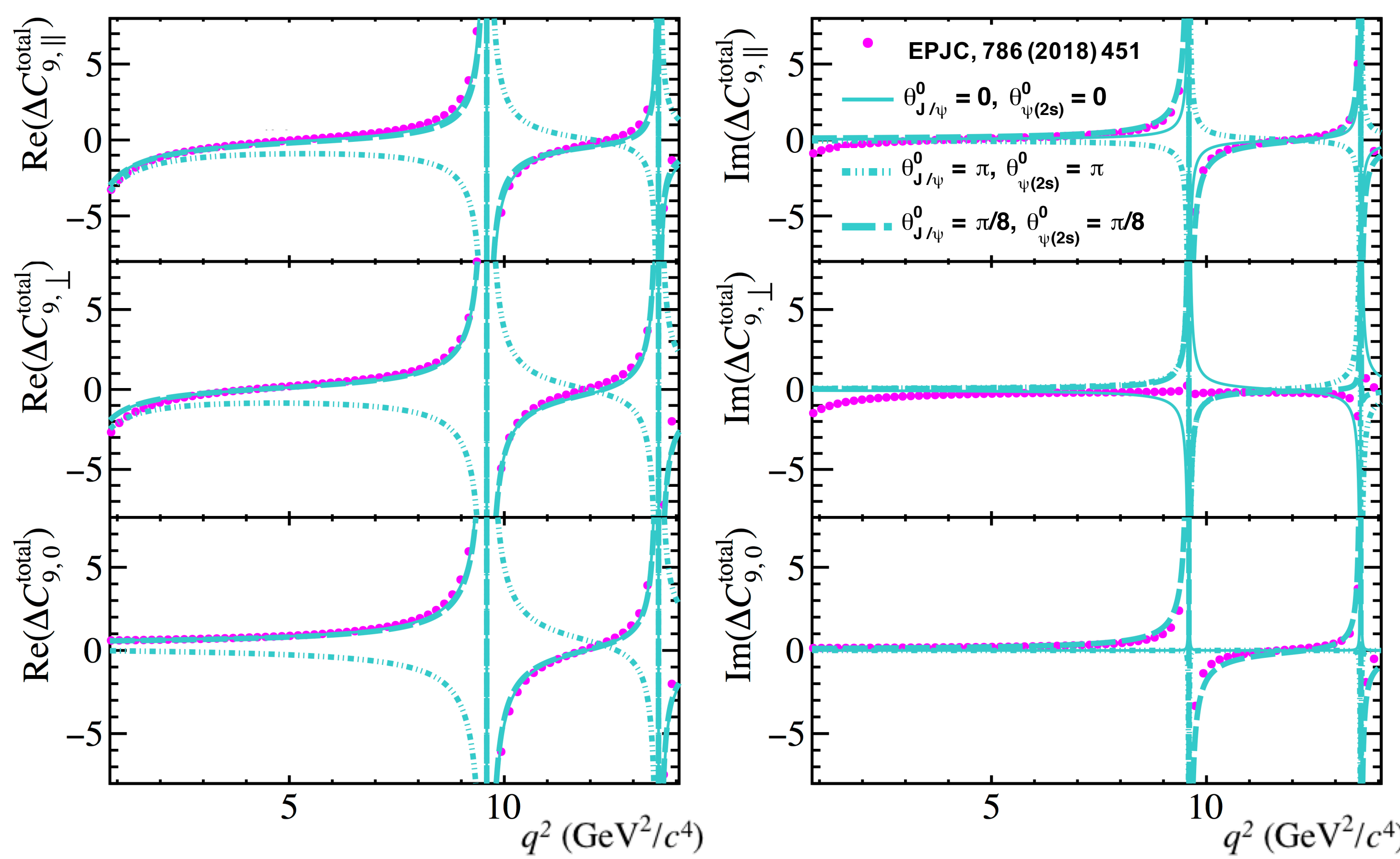
[isobar/z-parametrisation] visualising models

[EPJ C78 (2018) 453]

Angular observables can also discriminate between different phases



Useful validation: compatibility between "Isobar" and z-parametrisation" approaches

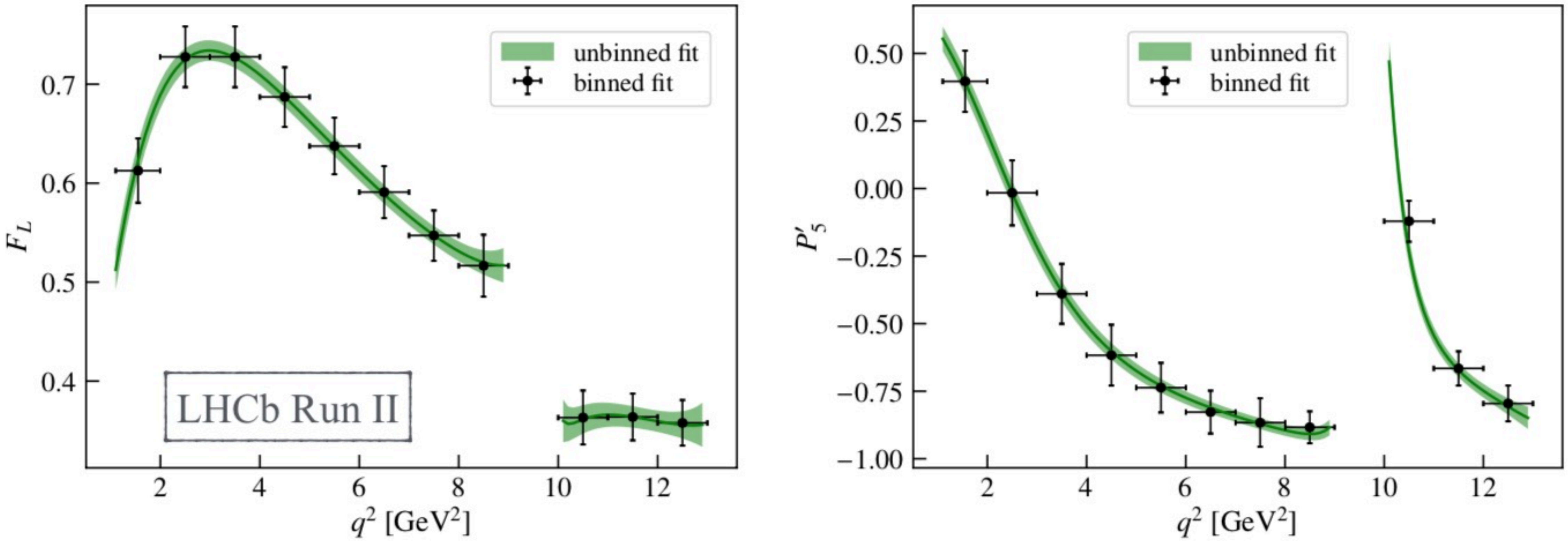


[isobar/z-parametrisation] visualising models

[JHEP 10 (2019) 236]

Similarly to the isobar approach, classical angular observables can be a posteriori calculated

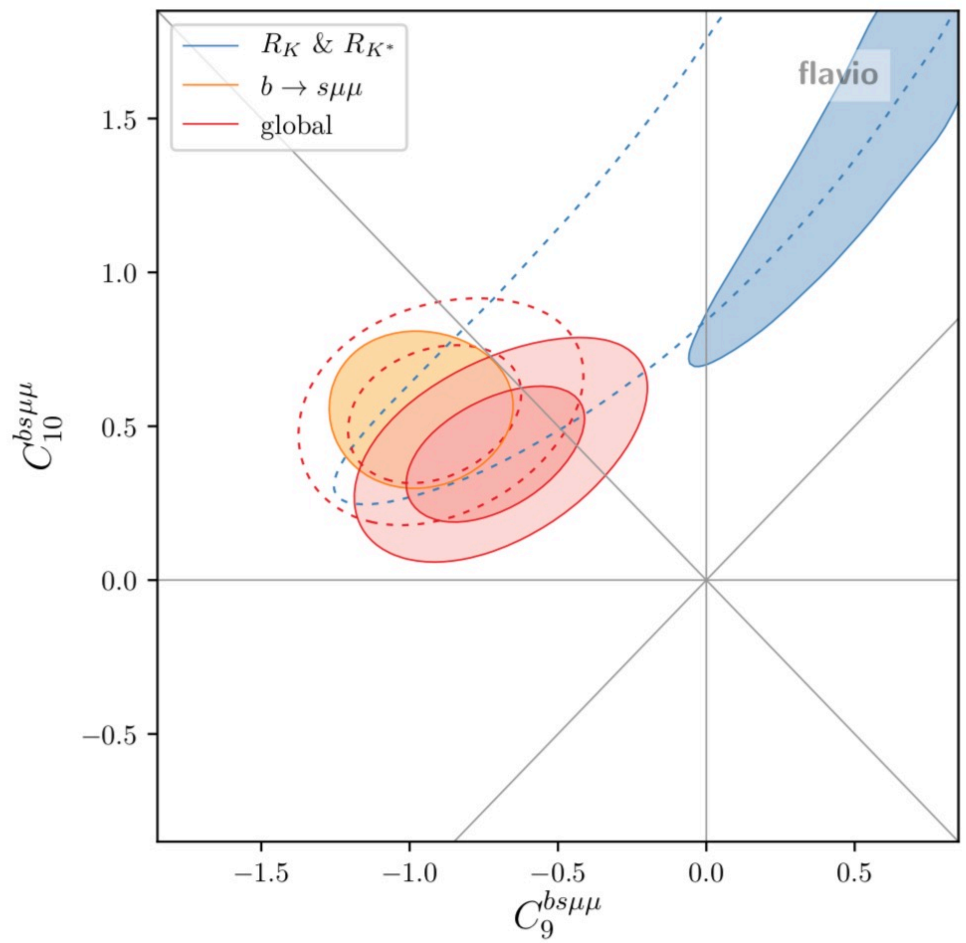
- Signal only ToyMC (no background, acceptance or systematics)
- **Independent on the the truncation of the *z*-expansion!**



How to explore the full LFU information?

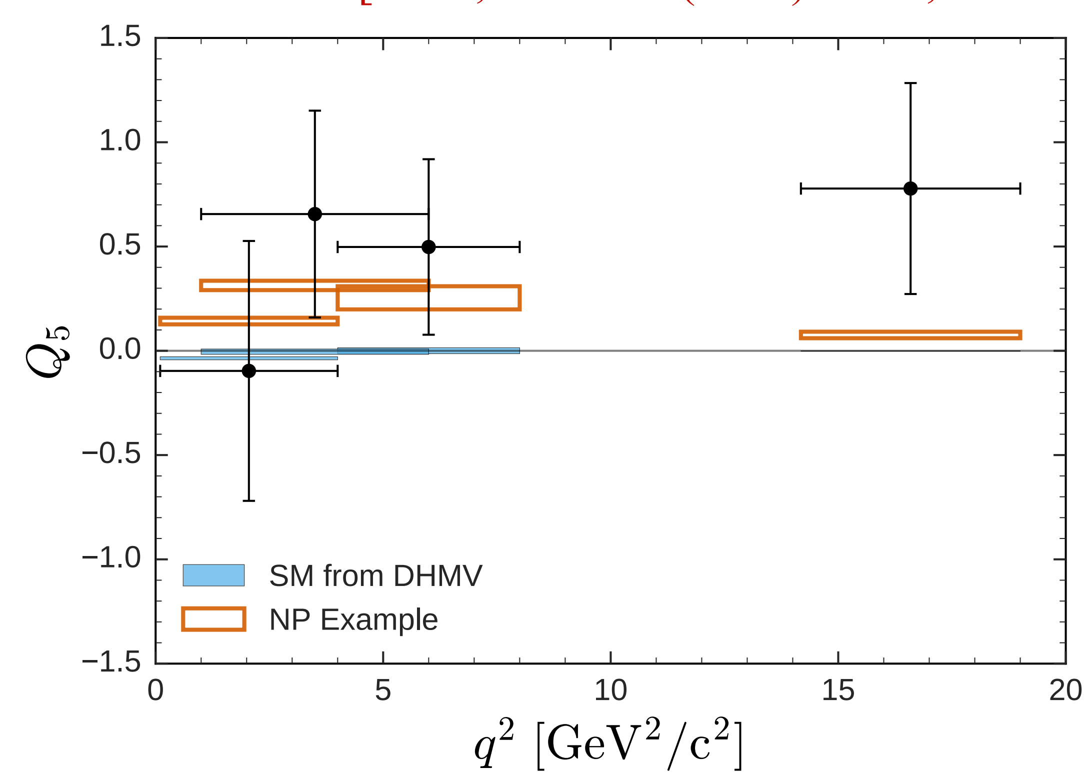
One of the interesting features of the anomalous pattern seen in FCNC transitions is the connection between P'5 and R_{K^*}

Currently, this link is *only* visualised in global fit analyses



First steps towards an experimental direct connection, *i.e.* probes of LFU in observables

[Belle, PRL 118 (2017) no.11, 111801]



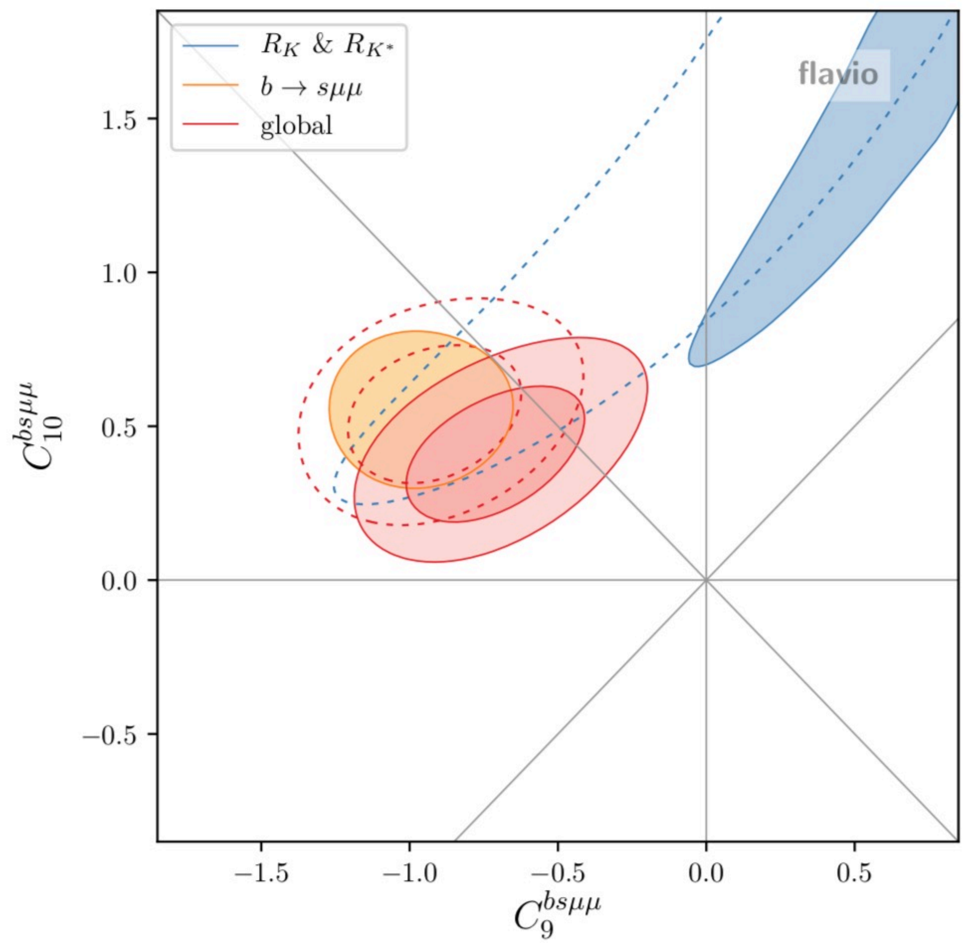
$$Q_5 = P_5'(\mu\mu) - P_5'(ee)$$

[JHEP 10 (2016) 075]

How to explore the full LFU information?

One of the interesting features of the anomalous pattern seen in FCNC transitions is the connection between P'$_5$ and R_{K^*}

Currently, this link is *only* visualised in global fit analyses



First steps towards an experimental direct connection, or combining both angular and branching ratio information

$$D_i(q^2) \equiv \frac{\mathrm{d}\mathcal{B}^{(e)}}{\mathrm{d}q^2} S_i^{(e)}(q^2) - \frac{\mathrm{d}\mathcal{B}^{(\mu)}}{\mathrm{d}q^2} S_i^{(\mu)}(q^2)$$

[PRD 95, 035029 (2017)]

- Still limited to the individual μ/e analyses (*e.g.* cannot share F_L observable)

- Provide set of independent observables, e.g. related to P'$_5$ and A_{FB}, that can be combined and provide higher sensitivity

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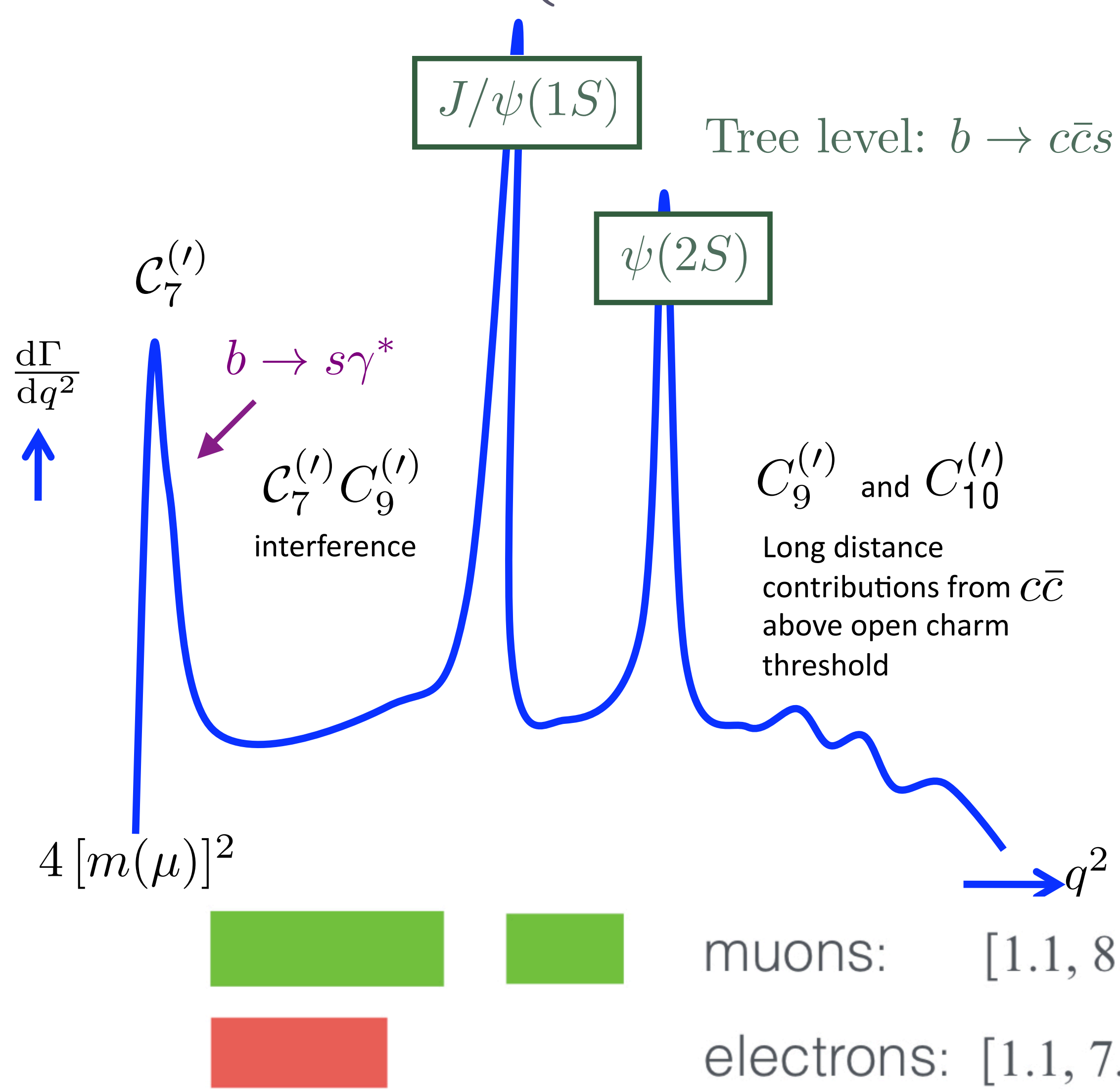
[PRD 99 (2019) 013007]

Simultaneous unbinned analysis of $B^0 \to K^{*0}\mu^+\mu^-$ and $B^0 \to K^{*0}e^+e^-$

$$\mathcal{A}_\lambda^{(\ell)\,L,R} = \mathcal{N}_\lambda^{(\ell)} \left\{ (C_9^{(\ell)} \mp C_{10}^{(\ell)}) \mathcal{F}_\lambda(q^2) + \frac{2 m_b M_B}{q^2} \left[C_7^{(\ell)} \mathcal{F}_\lambda^T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_\lambda(q^2) \right] \right\}$$



muons: [1.1, 8.0] & [11.0, 12.5] GeV^2

electrons: [1.1, 7.0] GeV^2

- All nuisance parameters are shared between electron and muons, *i.e.* CKM and (non) local hadronic
- Extended maximum-likelihood fit, ***i.e.* includes R_{K^*} information**

The correlation bound that enables LFU tests

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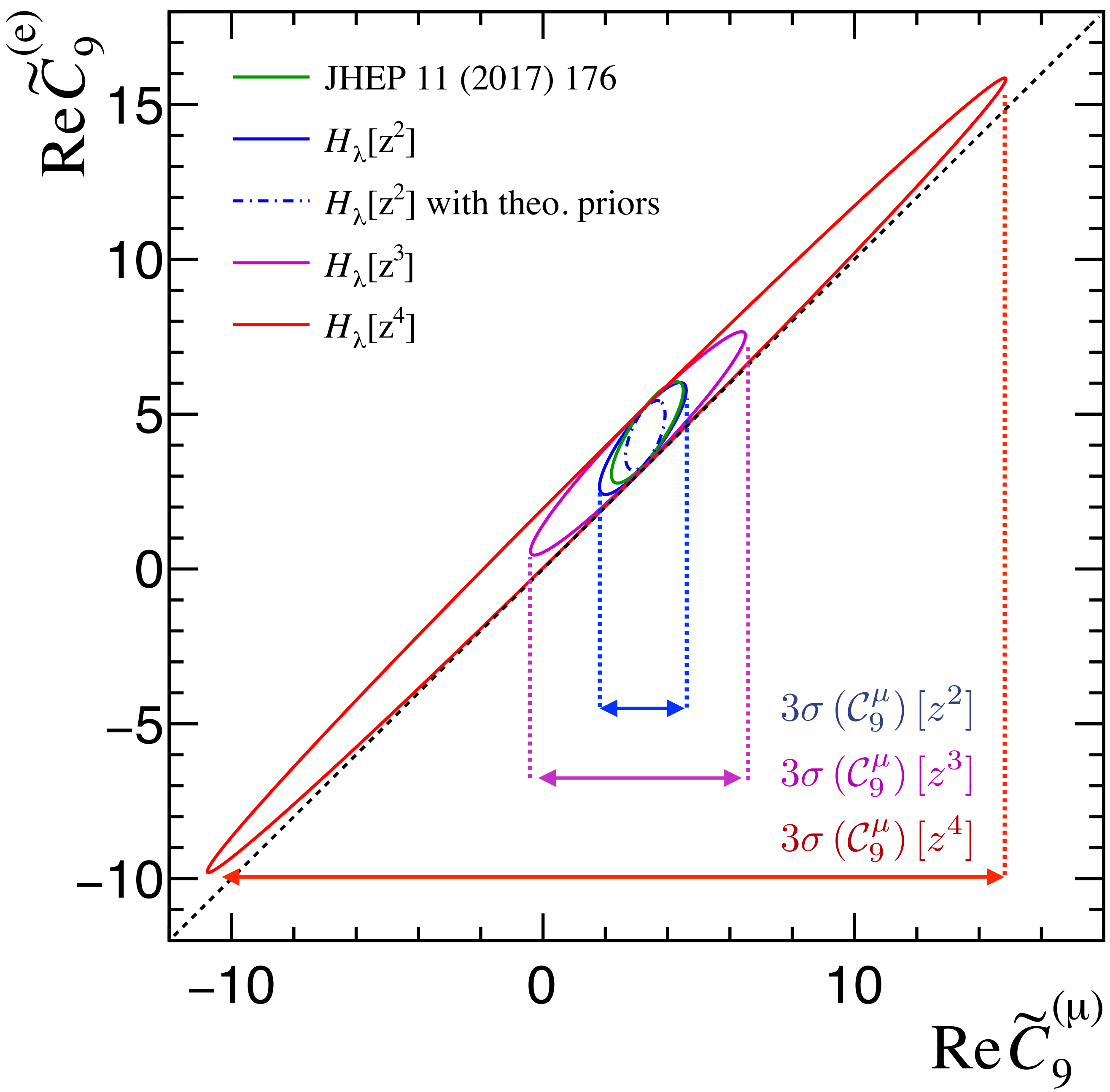
[PRD 99 (2019) 013007]

$$\mathcal{C}_9^{(e)} = \mathcal{C}_9^{\rm SM} = \mathcal{C}_9^{(\mu)} + 1$$



$C_i^{(\ell)}$: **strongly dependent on the model assumption (renamed for simplicity)**

Key feature: *model-independent* determination of the difference between electron and muons WCs

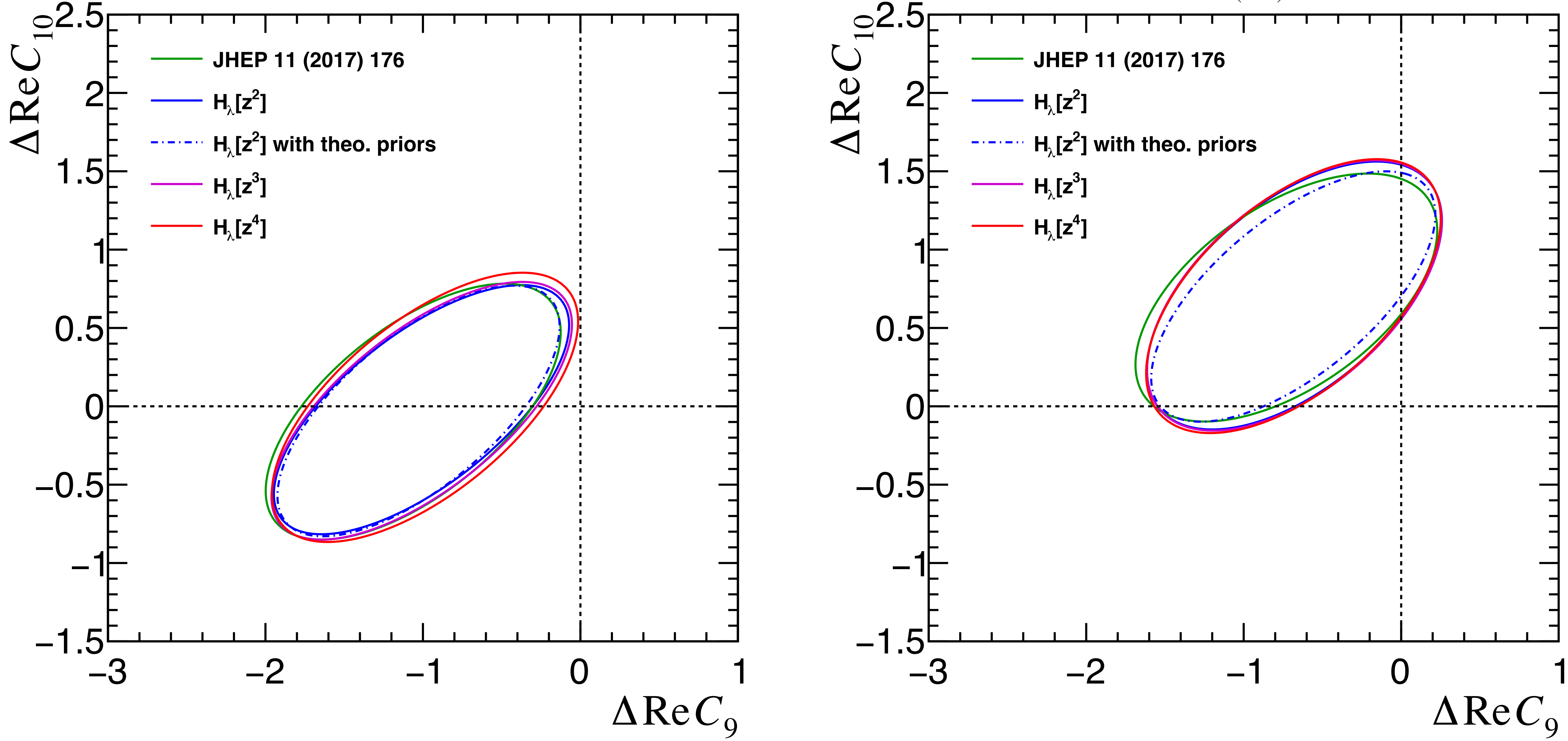
$$\Delta\mathcal{C}_i = \widetilde{\mathcal{C}}_i^{(\mu)} - \widetilde{\mathcal{C}}_i^{(e)}$$

- **Insensitive to the parametrisation of the non-local contributions**
- **Significance wrt LFU hypothesis is unbiased**

Sensitivity to LFU breaking with LHCb Run II

[PRD 99 (2019) 013007]

$\mathcal{C}_9^{(e)} = \mathcal{C}_9^{\rm SM} = \mathcal{C}_9^{(\mu)} + 1$ $\qquad$ $\mathcal{C}_{9(10)}^{\rm SM} = \mathcal{C}_{9(10)}^{(\mu)} + (-)\, 0.7$

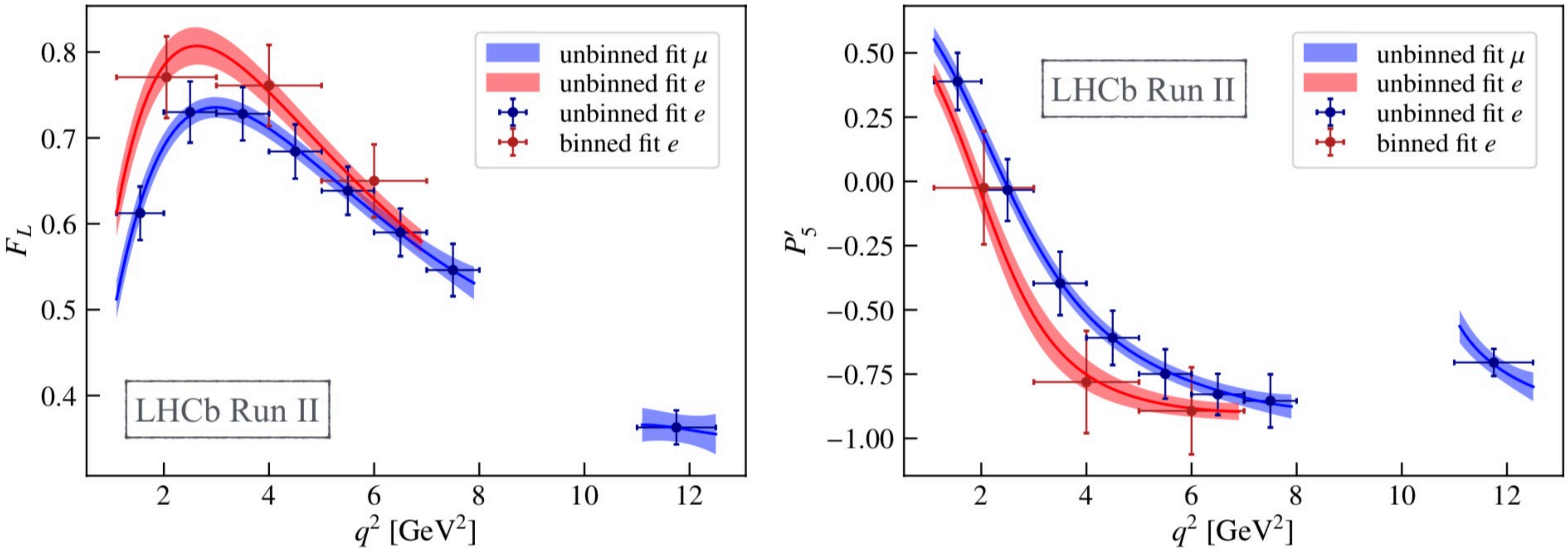


Determination of ΔC_i is stable and model-independent → early first observation of LFU violation can be obtained with LHCb Run II dataset in $B \to K^* l^+ l^-$ decays

Features of the proposed LFU observable

[PRD 99 (2019) 013007]

Notice that the classical binned observables can also be retrieved by this method



Similar to the muonic case this analysis will provide more precise results

How to use the available data in the future?

Release nothing and proceed anyway.	Release background-subtracted data.	Allow for reinterpretation behind an API.
No risk of data mis-use.	Not much work.	Hide experimental details.
No extra work.	Full flexibility given.	Flexibility can be defined.
Cannot update when hadronic information improves	Difficult to use, big risk of mis-use.	A lot of work.
Ultimate sensitivity is lost.	Will people accept this before data is fully exhausted?	Relies on some level of consistency between analyses.

By. P. Owen

How to use the available data in the future?

There are well known packages for fitting observables and generating SM data

http://superiso.in2p3.fr/

https://eos.github.io/

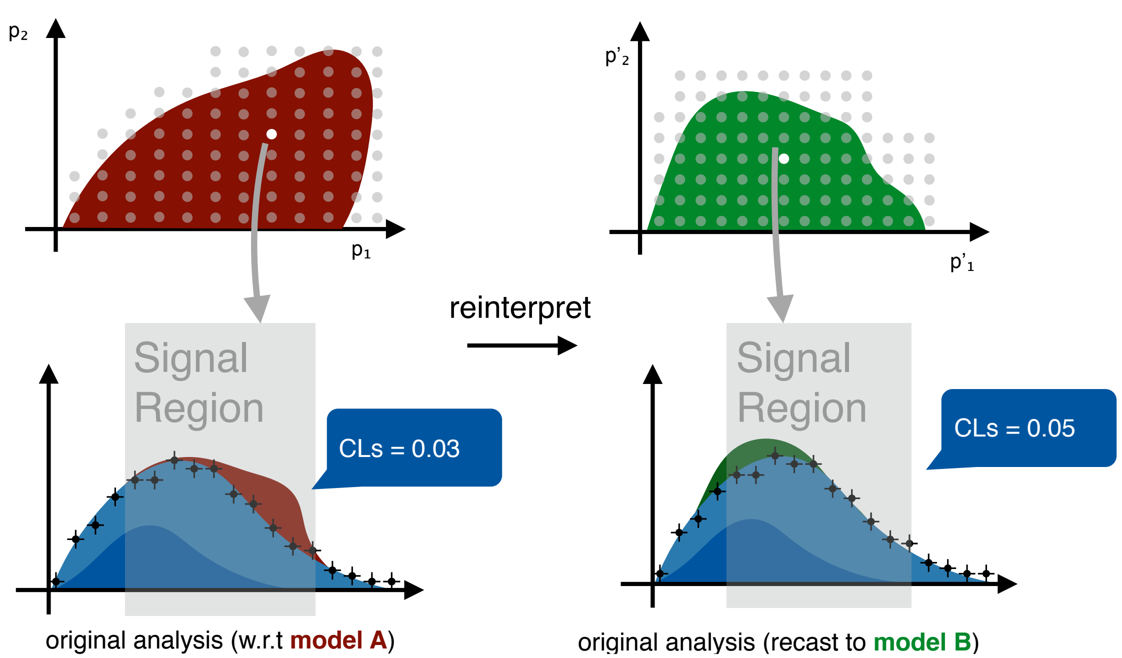
https://flav-io.github.io/

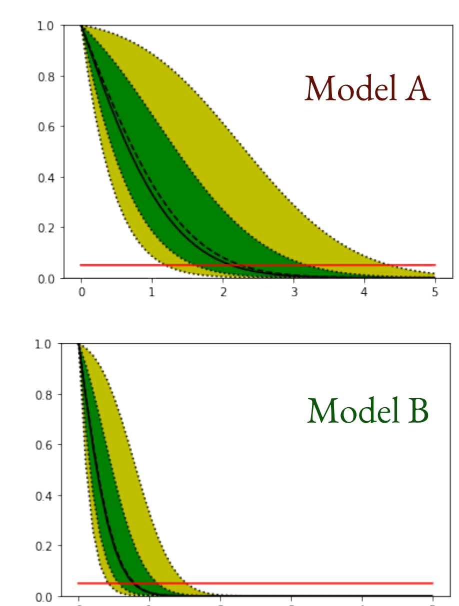
All rely on "binned" data, which in principle it is easy to be "re-used". To further extend this discussion lets consider a typical "search" question:

What impact does an existing analysis have on an alternative signal hypothesis?

E.g. RECAST

[JHEP 1104 (2011) 038]





How to use the available data in the future?

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+ cope with this data?

Perhaps we should build a platform between experiment and theory, *e.g.* create a simple formalism (API) of the [data analysis ↔ data preservation ↔ modelling]

[my personal biased view]

Build on top

hepstats zfit-amplitude

extensions

- vector
- phasespace
- zfit-physics

zfit*

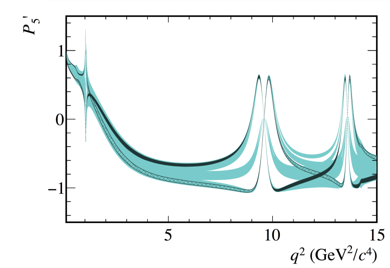
scalable model fitting

Python ecosystem

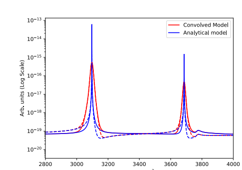
TensorFlow uproot python iminuit Scikit HEP

[Model]

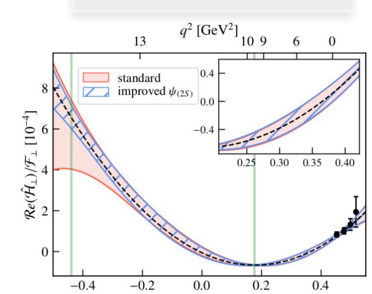
["Isobar"-like approach]



$$\frac{d\Gamma}{dq^2 d\Omega} \otimes R(q^2)$$



[z-parametrisation]



$> \mathcal{O}(10^2)$ parameters

[Published data]

HS3

HEP Statistics Serialization Standard

TensorFlow Hub

* Disclaimer: "zfit" stands for "Zürich fitter"

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Summary

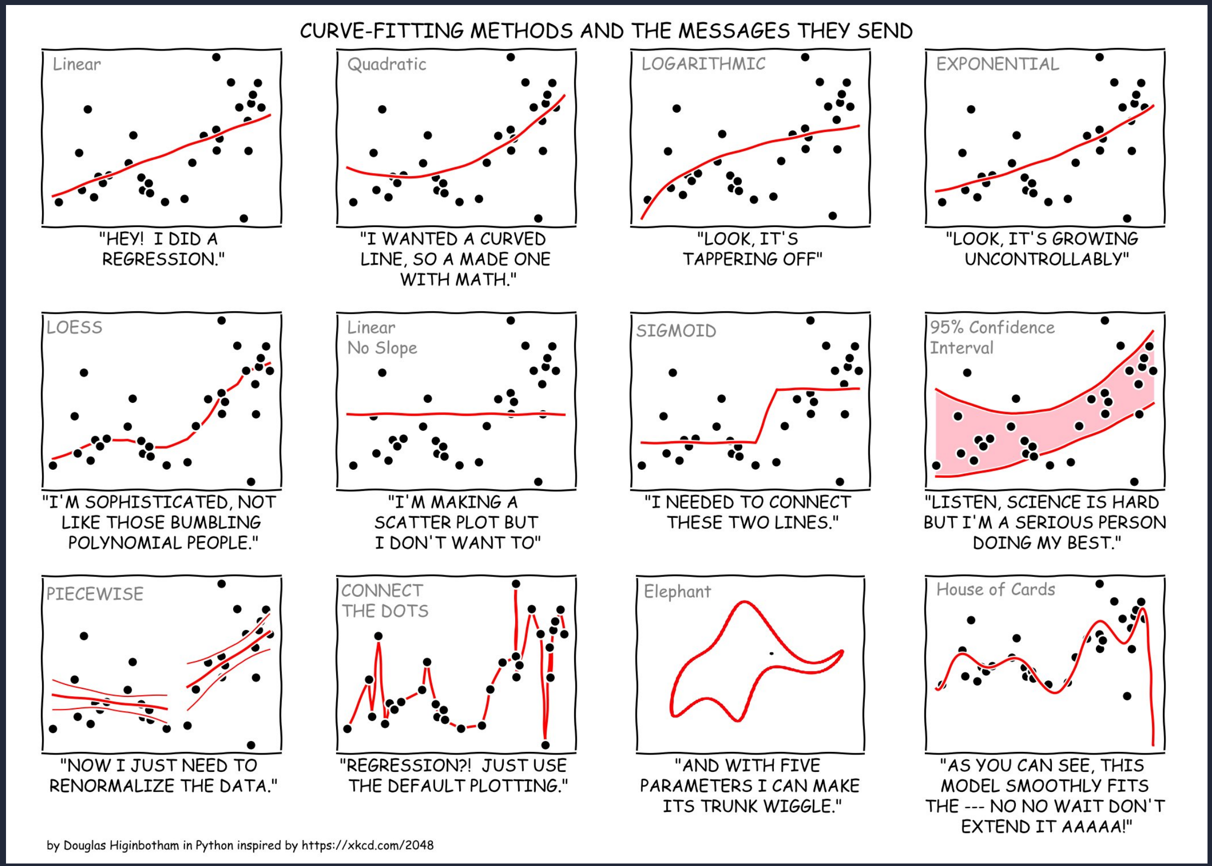
- Angular analyses are still the “cleanest” interplay between experiment and theory

- Flavourful road to amplitude analyses:

  [from empirical to theory-inspired models]

- Challenging analyses from both experimental and theory side → ultimate precision

  [well advanced exploratory work on new strategies towards the understanding of the underline physics]



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The nitty details …

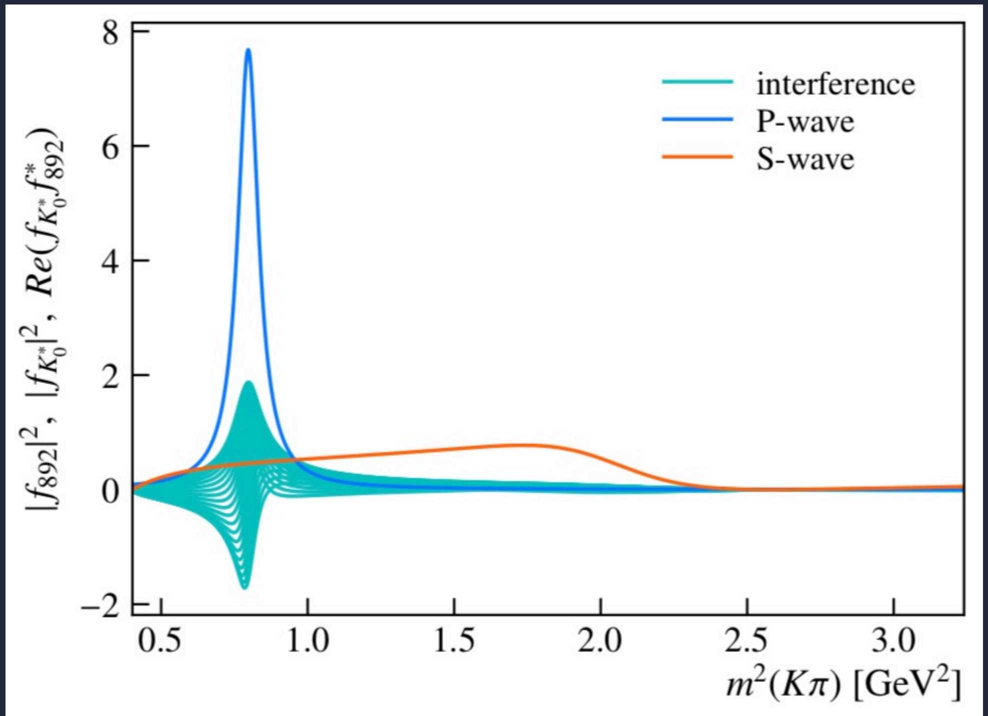
- Exotic states: what is the best strategy?

  [higher level of complexity for the empirical model and enters in the constraints to the charmonium mode]

- S-wave: from form-factors to non-local contribution?

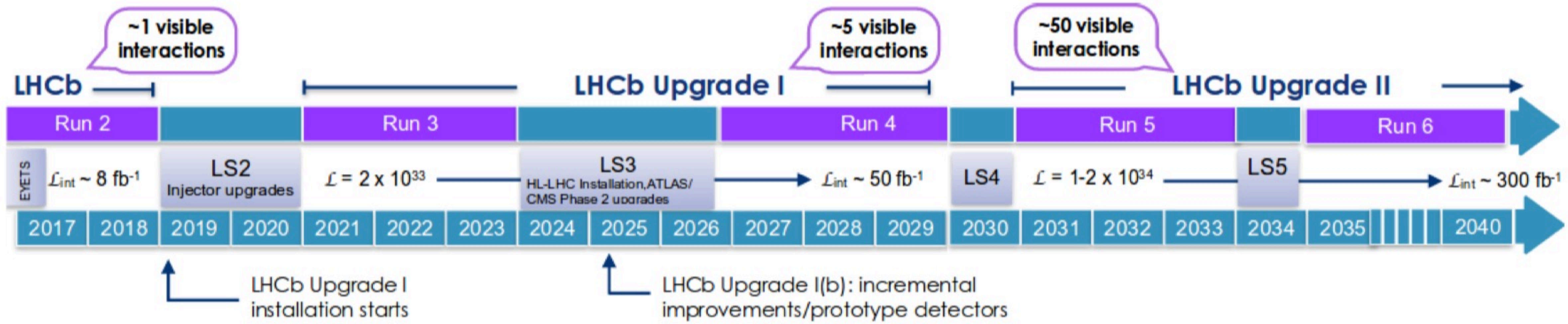
$$\mathcal{A}_{S0}^{L,R} = -N_0 \frac{\sqrt{\lambda_{K_0^*}}}{M_B\sqrt{q^2}} \Big\{ \Big[(C_9 - C_9') \mp (C_{10} - C_{10}')\Big] f_+(q^2) + \frac{2 m_b M_B}{q^2} \Big[(C_7 - C_7') f_T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_{S0}(q^2)\Big] \Big\}$$

$$\mathcal{A}_{St} = -2N_0 \frac{M_B^2 - M_{K_0^*}^2}{M_B\sqrt{q^2}} (C_{10} - C_{10}') f_0(q^2)$$

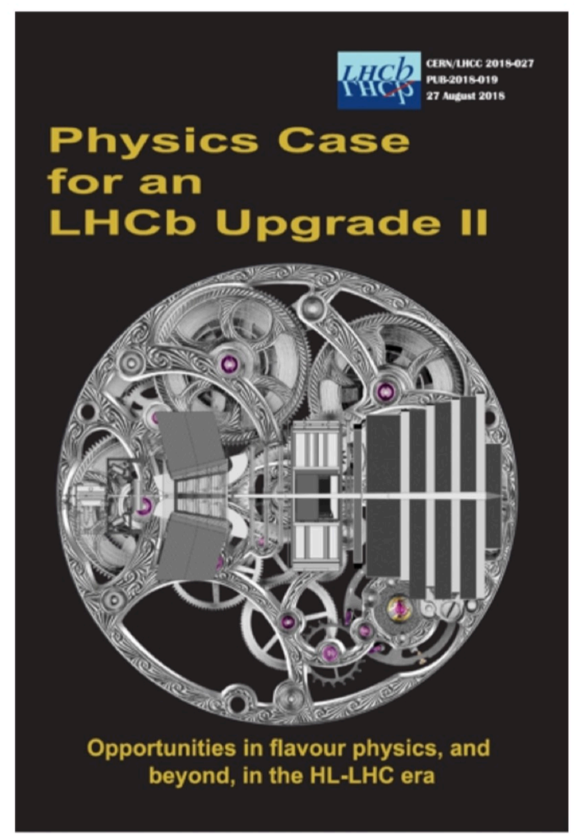


- Form-factors: limiting factor for C_{10}

LHCb upgrades



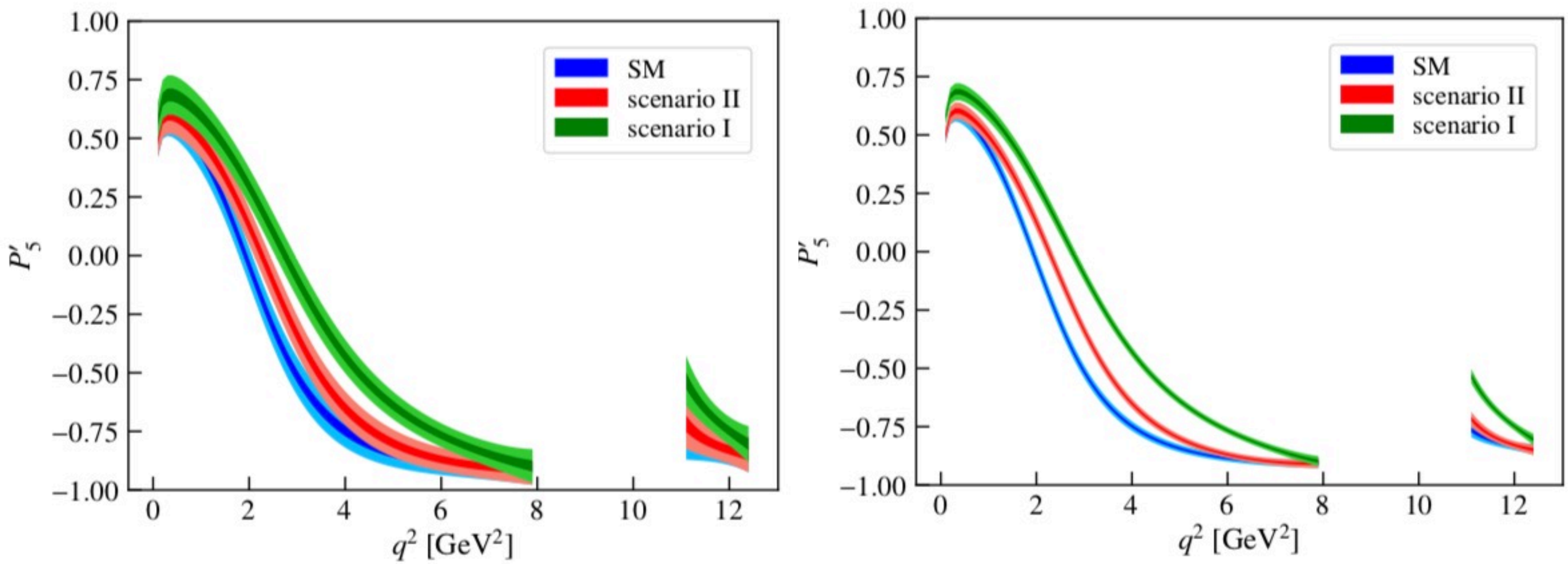
- Upgrade of the LHCb detector during LS2
  - All trigger decision software
  - Expect to collect 50 fb^{-1}
- LHCb phase-II
  - Further major upgrade in LS4 to profit from the HL-LHC program
  - Increase dataset up to 300 fb^{-1}



Sensitivities for the LHCb Upgrade

[arXiv:1812.07638]

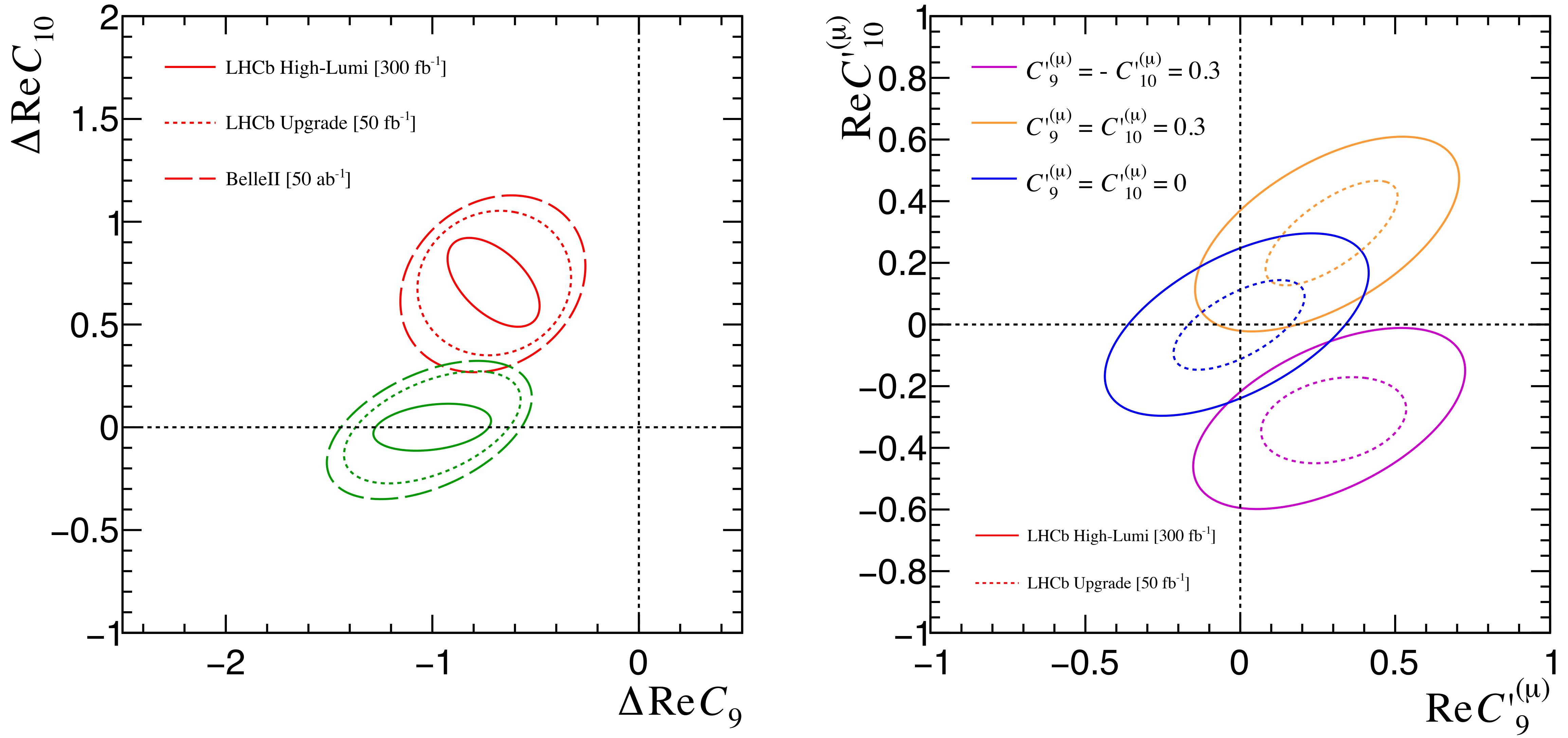
scenario	C_9^{NP}	C_{10}^{NP}
I	-1.4	0
II	-0.7	0.7



Sensitivity to LFU breaking for the Upgrade/C' WCs

[A. Mauri *et al*, PRD 99 (2019) 013007]

$$\mathcal{C}_9^{(e)} = \mathcal{C}_9^{\rm SM} = \mathcal{C}_9^{(\mu)} + 1$$



Interesting opportunities to disentangle different NP hypotheses even with a single measurement

S-wave contribution

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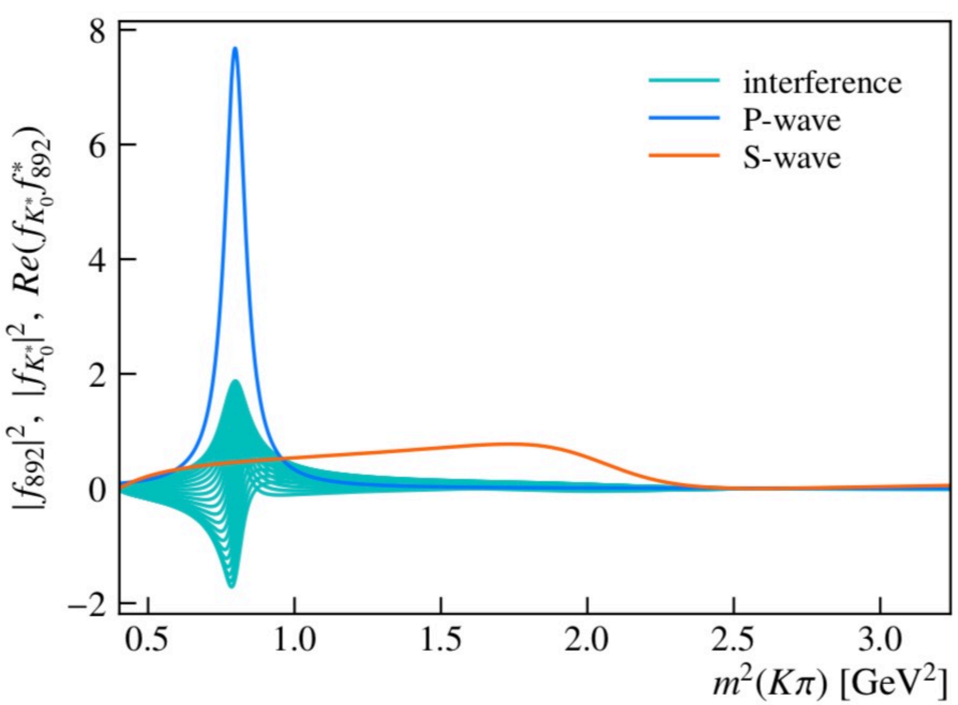
[arXiv:1805.06378]

Since we fully fit the q² dependence, this has also to be extended to the S-wave

$$\mathcal{A}_{S0}^{L,R} = -N_0 \frac{\sqrt{\lambda_{K_0^*}}}{M_B\sqrt{q^2}} \left\{ \left[(C_9 - C_9') \mp (C_{10} - C_{10}') \right] f_+(q^2) + \frac{2m_b M_B}{q^2} \left[(C_7 - C_7') f_T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_{S0}(q^2) \right] \right\}$$

$$\mathcal{A}_{St} = -2N_0 \frac{M_B^2 - M_{K_0^*}^2}{M_B\sqrt{q^2}} (C_{10} - C_{10}') f_0(q^2)$$

Form factors are gaussian constrained from [Nucl. Phys. B868 (2013) 368] and hadronic and H parameters are free in the fit



Simultaneous fit to C_9 and C_{10}

[A. Mauri PhD Thesis]

Considering all experimental effects the sensitivity for the Wilson coefficients are not significantly affected

$\mathcal{C}_9^{\mathrm{NP}}$ mean	$\mathcal{C}_9^{\mathrm{NP}}$ sigma	$\mathcal{C}_{10}^{\mathrm{NP}}$ mean	$\mathcal{C}_{10}^{\mathrm{NP}}$ sigma	correlation $\mathcal{C}_9^{\mathrm{NP}}$- $\mathcal{C}_{10}^{\mathrm{NP}}$
Signal only (P-wave)				
-0.96 ± 0.01	0.22 ± 0.01	0.05 ± 0.01	0.29 ± 0.01	-0.52 ± 0.03
P + S-waves				
-0.94 ± 0.01	0.23 ± 0.01	0.07 ± 0.02	0.31 ± 0.01	-0.54 ± 0.04
P-wave + Acc. + Bkg.				
-0.96 ± 0.01	0.23 ± 0.01	0.09 ± 0.02	0.33 ± 0.01	-0.45 ± 0.05
Full fit				
-0.93 ± 0.01	0.24 ± 0.01	0.08 ± 0.01	0.34 ± 0.01	-0.44 ± 0.03

[isobar] controlling hadronic paramaters

[Preliminary, U. Egede, M. Hecker, P. Owen, G. Pomery, K. Petridis]

In the presence of New Physics, the model of non-local contribution cannot describe data with expected Run-II statistics

Generate toys with $C_9^{NP} = -1.5$