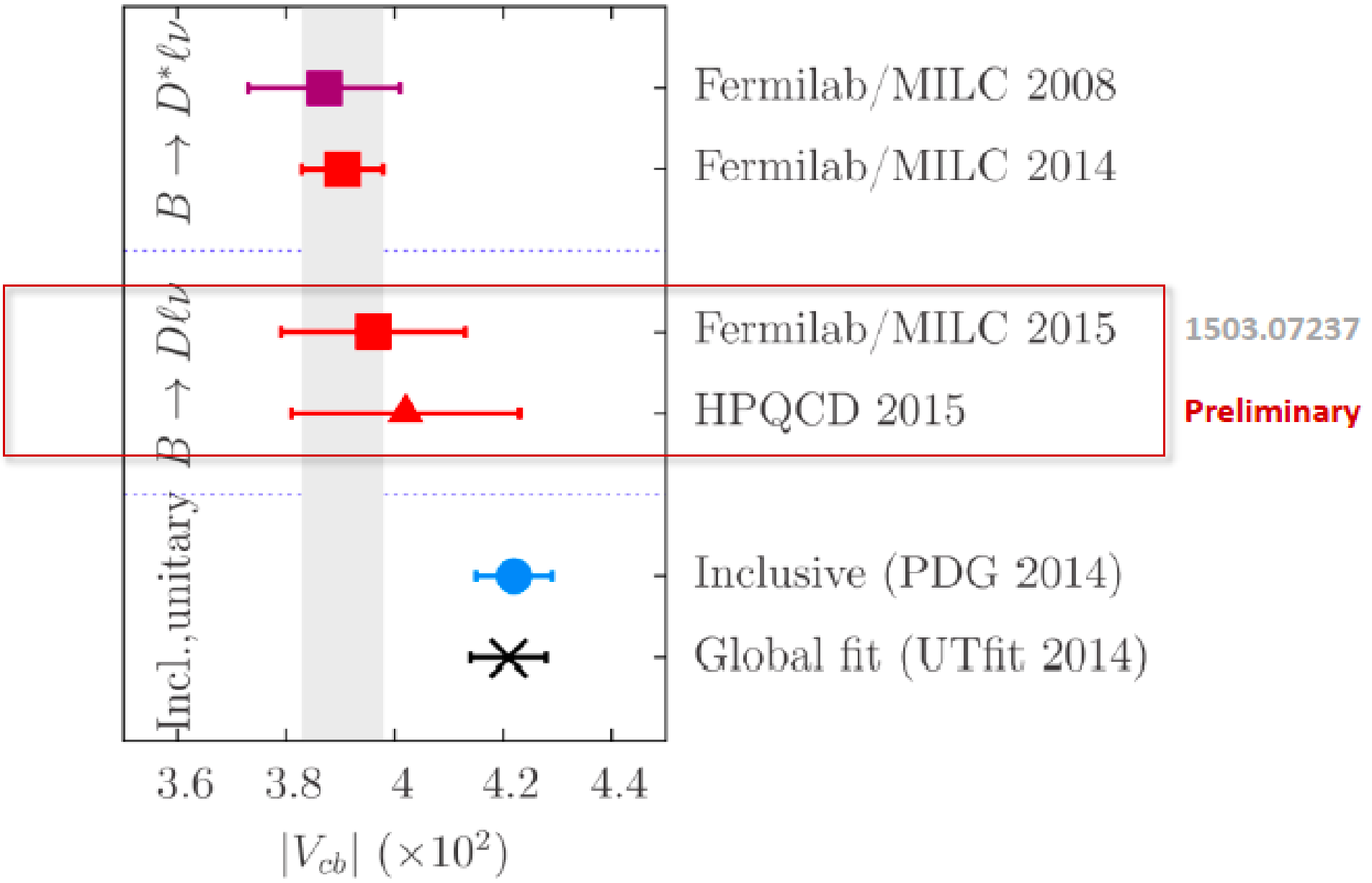
Exclusive $|V_{cb}|$

Exclusive $|V_{cb}|$: status as of 2015



$B \rightarrow D^* l \nu$

- This is still an interesting and well studied channel to extract $|V_{cb}|$
- 2014 LQCD calculation of F(1) + HFAG:

$$|V_{cb}| = (39.04 \pm 0.49_{\text{expt}} \pm 0.53_{\text{QCD}} \pm 0.19_{\text{QED}}) \cdot 10^{-3}$$

  - LQCD error now compatible with experimental error
  - QED error stems from not separating charge and neutral decays
    - Lots of discussions about QED corrections (static Coulomb effects)
  - LCSR estimated lower value for F(1) but the uncertainties are not solids enough
- Progress on Lattice: calculate all 4 FF at non-zero recoil (just starting)
- LHCb: to extract Vcb a normalization channel is needed
  - Which channel?
  - An angular analysis should be possibile and can be combined with the existing BF($D^* l \nu$) measurements to extract $|V_{cb}|$
    - Is the w and angular resolution enough?

$B \rightarrow D\ l\ \nu$

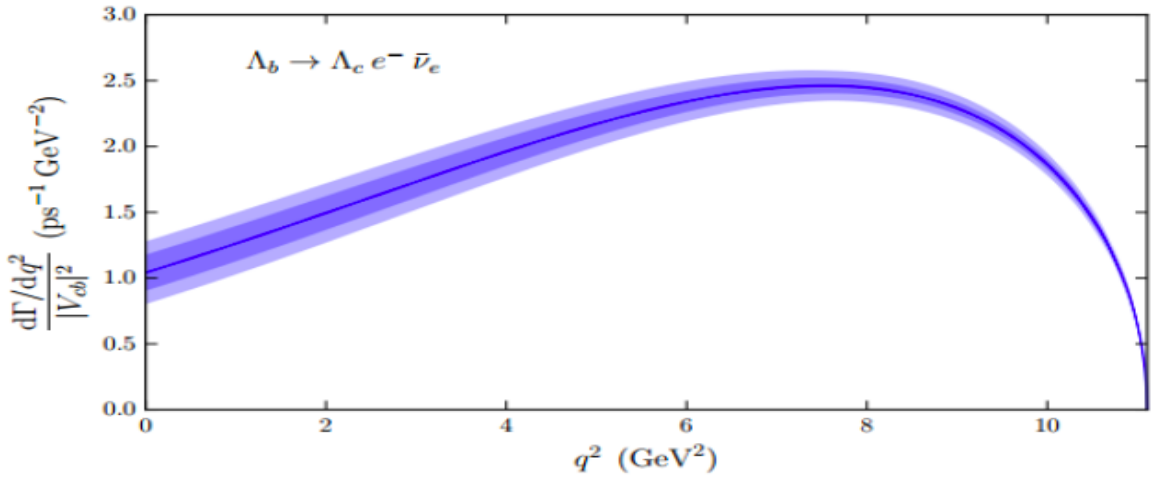
- In the future this could be the golden channel for exclusive $|V_{cb}|$:
- 2015 FNAL/MILC results at non-zero recoil + BaBar data: 4% error
  - Dominated by experimental uncertainty
  - Belle data already available (a combined fit prefers an higher Vcb)
  - HPQCD calculation similar to FNAL/MILC: expected improvements
- LHCb: this could be normalized to D* to cancel the B production uncertainties and some other experimental efficiencies (D reco, trigger, PID)
  - Is this channel feasible?
  - $B \rightarrow D^{+}\ l\ \nu$ no down-feed from $D^{*0/+}$ (still large from D** states)
  - Using B_{s2}^{*} allows to study B^{+} .
    - Pros: The large down-feed from D*/D** can be reduced using the Missing Mass variable.
    - Cons: efficiency is small (very small, ~0.3%)

Others: $\Lambda_b \to \Lambda_c \mu\nu$

- $\Lambda_b \to \Lambda_c \mu\nu$ the FF is known with good precision (some caveats about the use of the z-expansion in the baryonic case)
  - Experimentally: How to normalize this channel?
  - Is the fit of the q^2 spectra interesting? Which model?
  - It could be nice an helicity study of the Λ_c in the final state as a function of q^2 (S.Simula PRD60 (1999) 074018)

$\Lambda_b \to \Lambda_c \ell\nu$ (Detmold et al. 2015)

- Error in high-q^2: ~2%
- Experimental difficulty: Λ_b production fraction; but could determine ratio $|V_{ub}|/|V_{cb}|$ 1504.01568



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Others: $B_s \rightarrow D_s^{(*)}$ l ν

- $B_s \rightarrow D_s^{(*)}$ l ν: interesting channel from theory:
  - Strange spectator: less noisy lattice correlators
  - Chiral extrapolation only for sea quarks
  - Upcoming calculations from HPQCD and other collaborations
  - Experimentally (difficult at Belle-II), what about LHCb?
    - D_s: large down feed from D_s* and D_s**
    - D_s*: no upfeed from D_s and small downfeed from D_s(2460) but requires the reconstrution of the soft gamma
- (We do not cover $B_c \rightarrow$ J/psi l ν)

Recent LQCD calculations for $|V_{cb}|$

D.Du

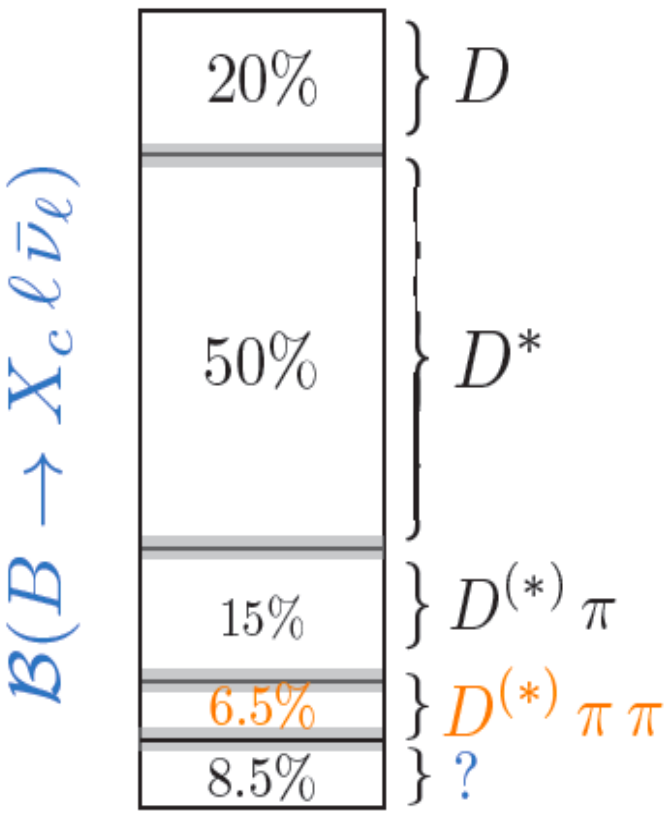
- Not meant to be inclusive, focused on publicized results

Lattice Group	Fermilab/MILC	HPQCD	Atoui et al.	Detmold et al.
Process	$B \to D^* \ell\nu$ $B \to D\ell\nu$ $B_s \to D_s \ell\nu$	$(B \to D\ell\nu)$ $(B_s \to D_s \ell\nu)$	$B_s \to D_s \ell\nu$ $(B \to D^{**} \ell\nu)$	$\Lambda_b \to \Lambda_c \ell\nu$
Gauge Ensembles	MILC asqtad	MILC asqtad	ETMC twQCD	Domain-Wall
Sea flavors	2+1	2+1	2	2+1
a (fm)	0.045–0.12	0.09–12	0.054–0.098	0.086–0.11
M_π	≥ 177 MeV	≥ 354 MeV	≥ 280 MeV	≥ 295 MeV
l-quark action	asqtad	HISQ	Twisted Wilson	Domain-Wall
b-quark action	Fermilab Clover	NRQCD	Wilson (ratio method)	RHQ
current renormalization	mostly non-perturb.	perturb.	non-perturb.	mostly non-perturb.
Ref.	arXiv:1403.0635 arXiv:1503.07237	arXiv:1310.3207	arXiv:1310.5238v3	arXiv:1306.0446 arXiv:1503.01421v2

Lattice Group	lat%	Curr. expt%	Curr. $|V_{cb}|$%
Fermilab/MILC($B \to D^* \ell\nu$)	1.3%	1.4%	1.9%
Fermilab/MILC($B \to D\ell\nu$)	1.4%	3.9%	4.0%
HPQCD($B \to D\ell\nu$)			5.3%
Detmold et al. ($\Lambda_b \to \Lambda_c \ell\nu$)	2.2%		

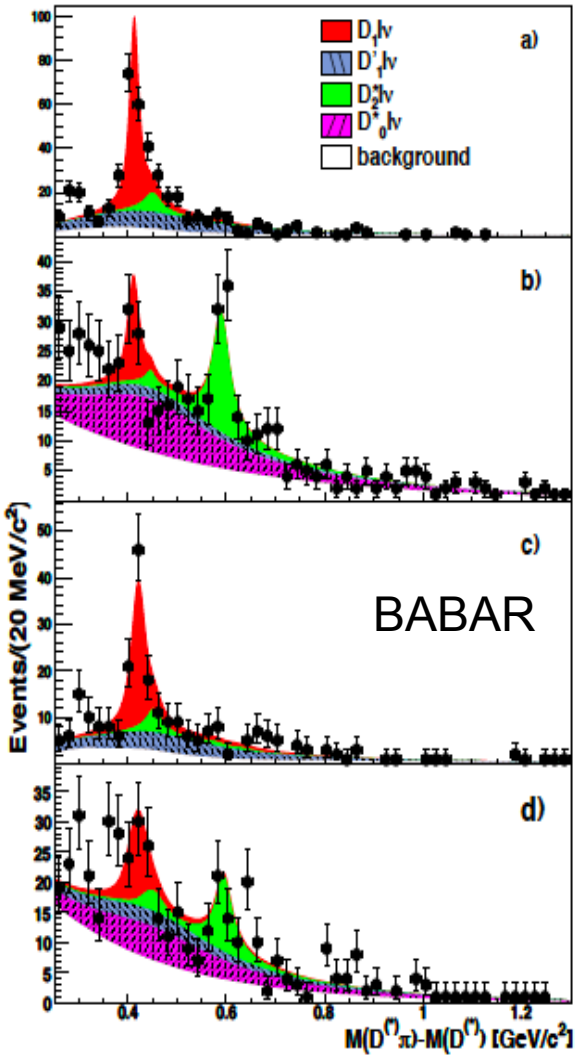
D** (Dnπ)? 3 good reasons

Fill the gap



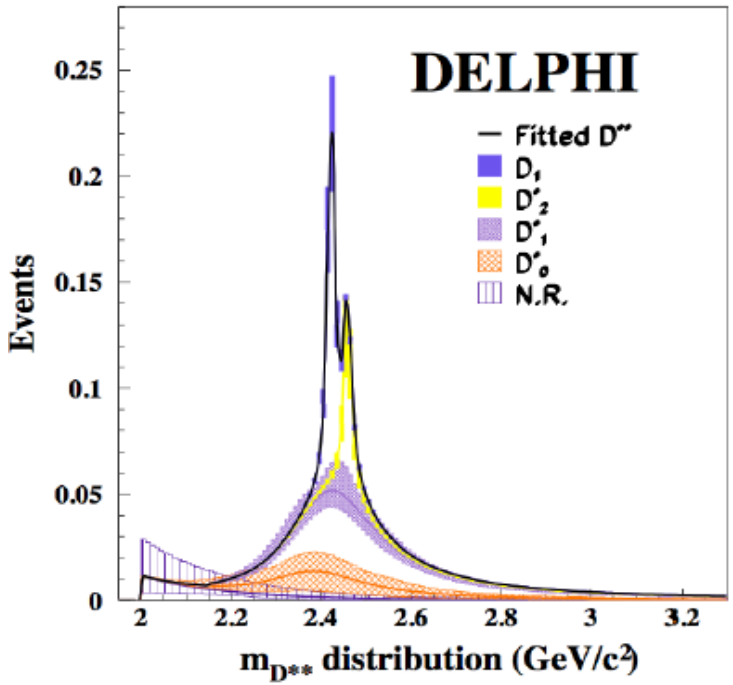
Understand the HQET
(½ < 3/2 puzzle)

Measure
D1' and D2* FF



Extract the hadronic
Moments (with E_{cut} > 0 GeV)
Useful for inclusive Vcb

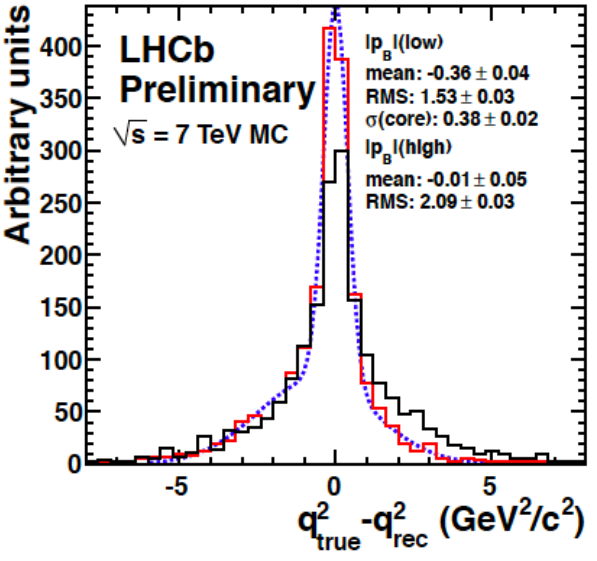
EPJ C45, 35 (2006)

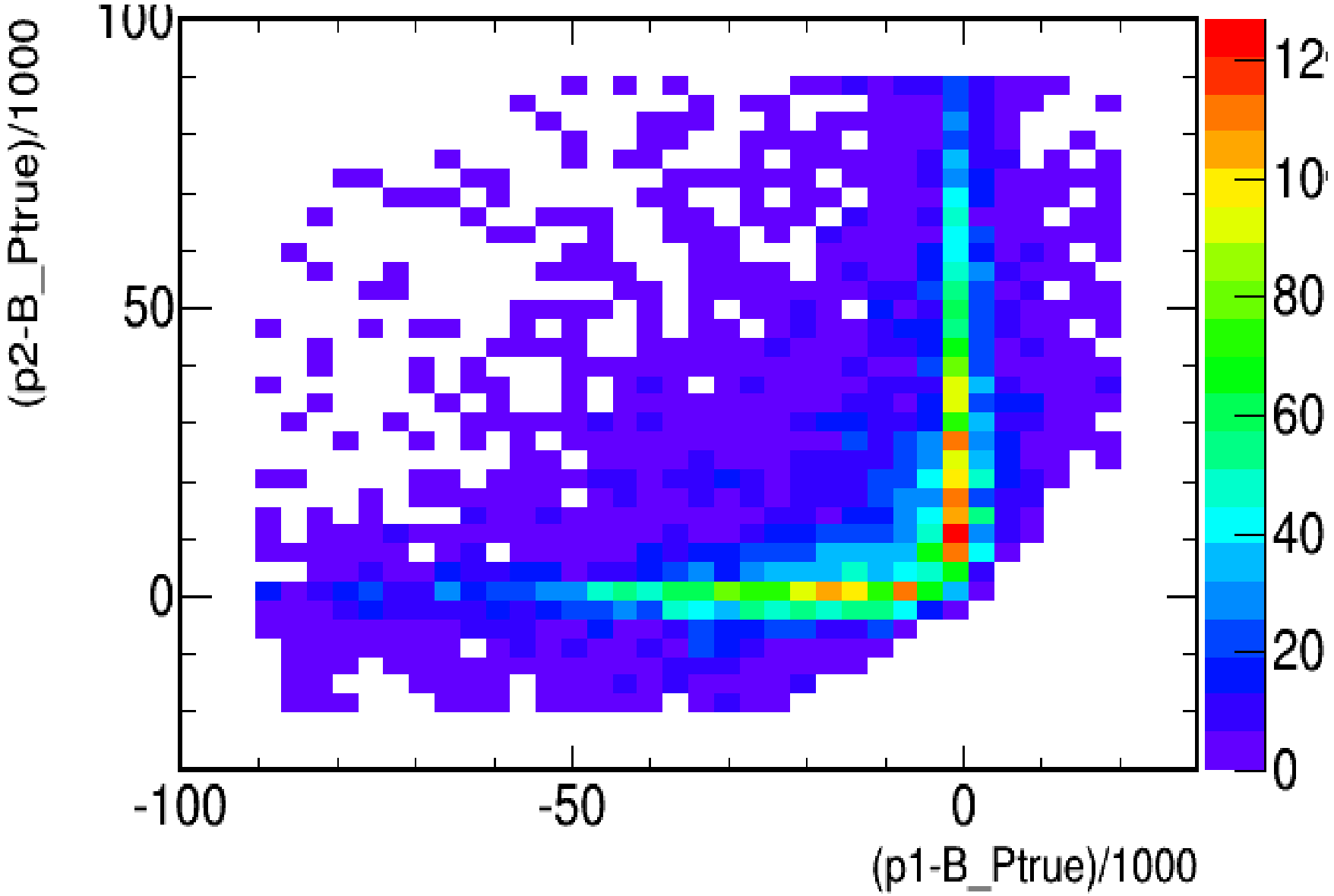


Experimental challenges @ LHCb

- Signal selection:
  - Vertex isolation
  - What about the neutrals?
  - Corrected mass with the cut on the error seems powerful (introduced for Lambdab → pmunu). Is it useful in other channels?
- The neutrino is reconstructed with a 2-fold ambiguity
  - The q2 can still be reconstructed reasonably well
  - How can we check the migration-matrix on data?
    - Control samples
  - How do we choose the best solutions?
  - Other ideas?
    - If we use both the solutions....

- Are there common tools available?

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-100
-50
0
(p2-B_Ptrue)/1000
(p1-B_Ptrue)/1000
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10
80
60
40
20
0