$B \to X_u \, l \, \nu$ Prospects for Inclusive $|V_{ub}|$ at Belle II

Challenges in Semileptonic B decays
MITP, Mainz, April 2015

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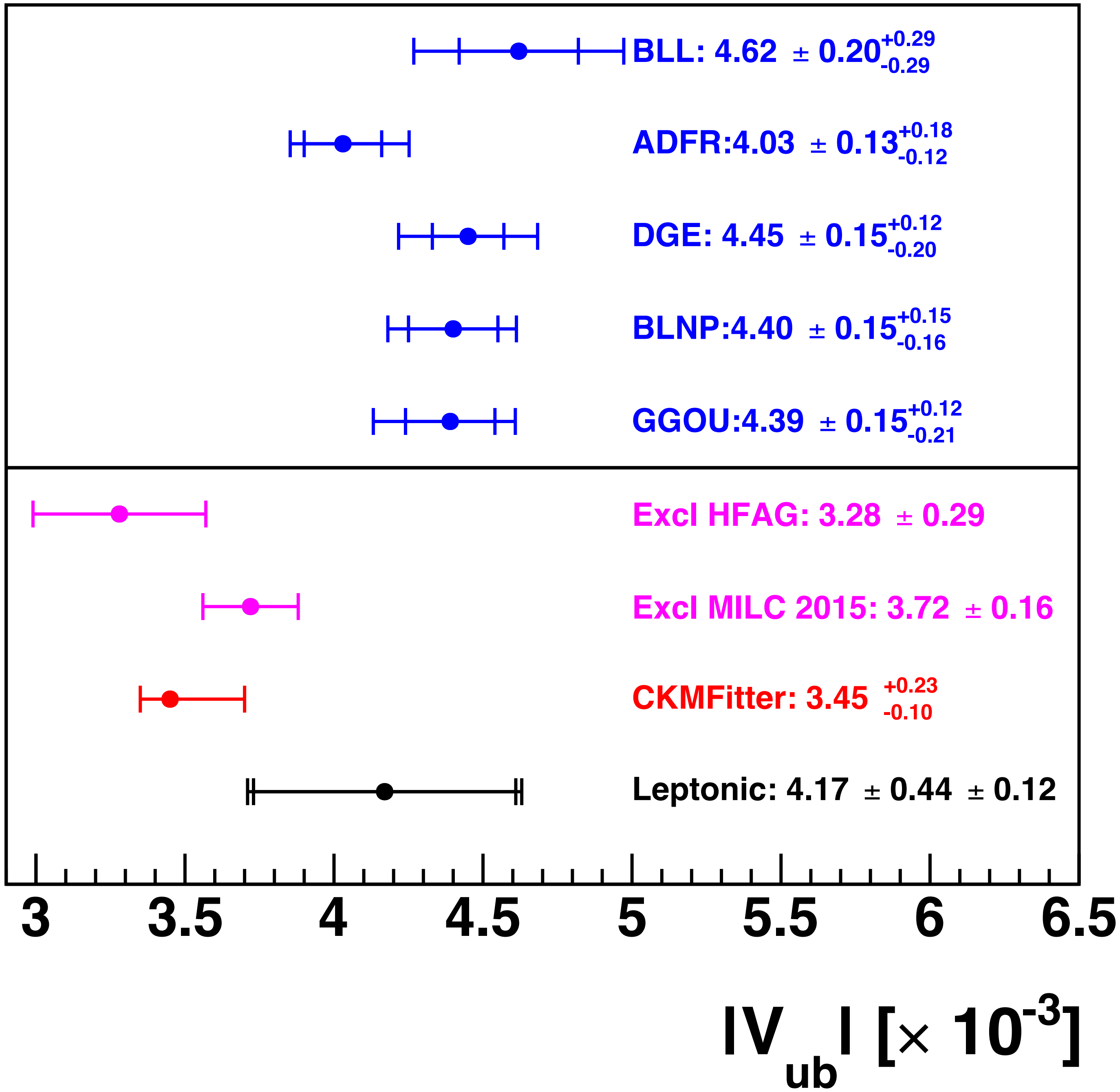
Introduction

Studies must focus on understanding biases and the current error evaluation rather than their reduction.

…Particularly in light of its tension with exclusive methods AND CKM UT fit results.

The good news is that many improvements can be made to the experimental approach.



Summary of CKM

	Belle	*BaBar*	*Global Fit (CKMfitter*	*LHCb Run-2*	*Belle II 50 ab^{-1}*	*LHCb Upgrade 50 fb^{-1}*	*Theory*
φ_1: ccs	*1.4°*		*1.5°*	*1.6°*	*0.4°*	*0.6°*	*negl.*
φ_2: uud	*4° (WA)*		*2.1°*		*1°*		*~1-2°*
φ_3: DK	*14°*		*3.8°*	*4°*	*1.5°*	*1°*	
$\|V_{cb}\|$ inclusive	*1.7%*		*2.4%*		*1.2% ?*		
$\|V_{cb}\|$ exclusive	*2.2%*				*1.4%*		
$\|V_{ub}\|$ inclusive	*7%*		*4.5%*		*3.0%*		
$\|V_{ub}\|$ exclusive	*8%*				*2.4%*		
$\|V_{ub}\|$ leptonic	*14%*				*3.0%*		

Experiment

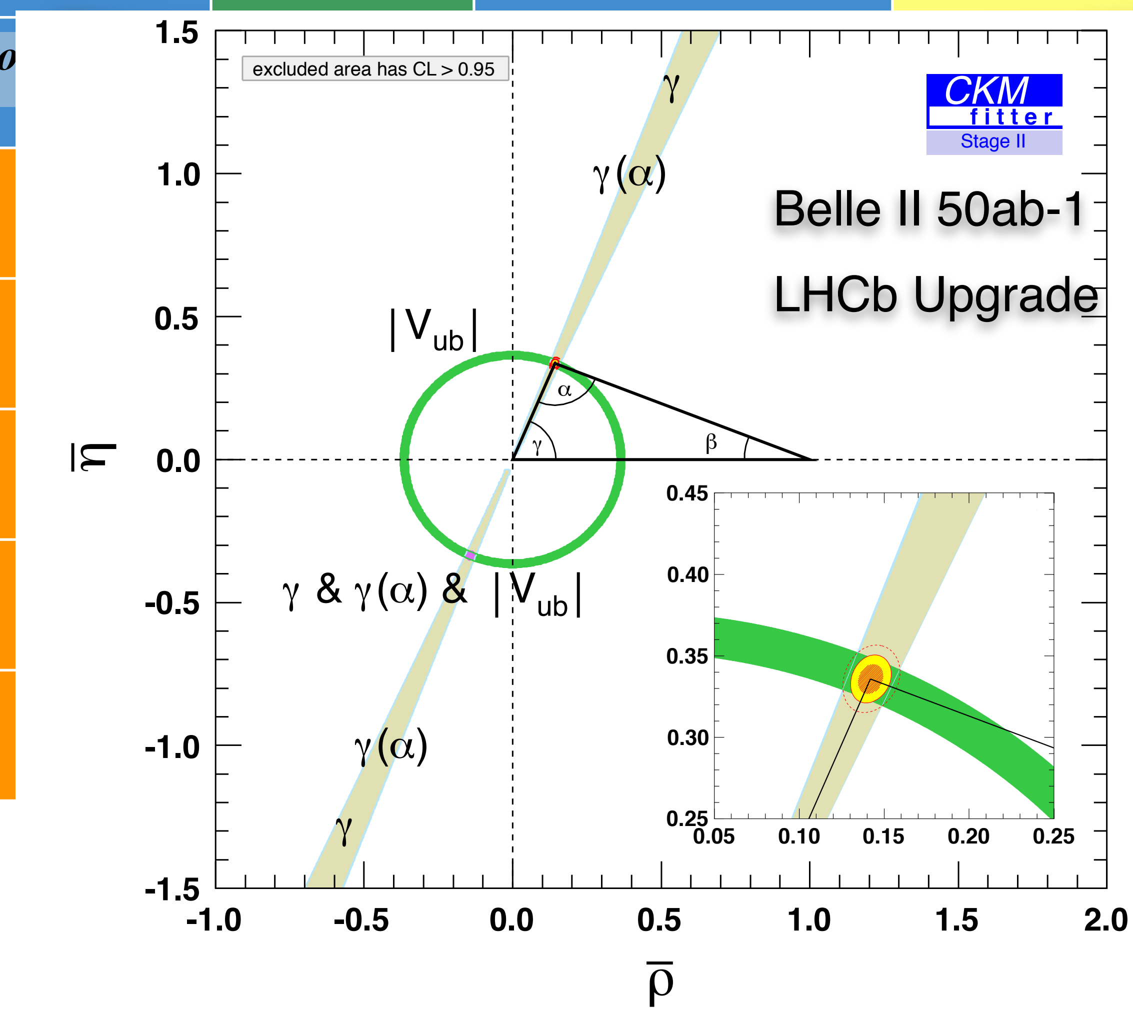
- No result
- Moderate precision
- Precise
- Very Precise

Theory

- Moderate precision
- Clean / LQCD
- Clean

Summary of CKM

	Belle	BaBar	Global Fit (CKMfitter	LHCb Run-2	Belle II 50 ab^{-1}	LHCb Upgrade 50 fb^{-1}	Theory
φ_1: ccs	1.4^o		1.5^o	1.6^o	0.4^o	0.6^o	negl.
φ_2: uud	4^o (WA)		2.1^o		1^o		~1-2^o
φ_3: DK	14^o		3.8^o	4^o			
$\|V_{cb}\|$ inclusive	1.7%		2.4%				
$\|V_{cb}\|$ exclusive	2.2%						
$\|V_{ub}\|$ inclusive	7%		4.5%				
$\|V_{ub}\|$ exclusive	8%						
$\|V_{ub}\|$ leptonic	14%						



Experiment

- No result
- Moderate precision
- Precise
- Very Precise

Clean

Belle II THE UNIVERSITY OF MELBOURNE

Methods

Lepton endpoint

- P(lepton)
- $S_h^{max}(q^2)$

Eff: 15% in lepton endpoint
E_{lep} (1.9-2.6 GeV)
Purity: 10%
Candidates/ab^{-1}: 200k

Lowest lepton energy threshold to reduce theory error, need

- knowledge of charm semileptonic.
- Lots of off-resonance

Inclusive hadron reconstruction

- M_X
- q^2
- $P^+ = E_X - |P_X|$ ($P_X = p_{beam} - p_{Btag} - p_l - p_\nu$)
- BDT & Simulated Annealing

Eff: 0.02% over full phase space
E_{lep}(1.0– GeV) w/ various signal regions
Purity: 10%
Candidates/ab^{-1}: 2.0k

- Data has become quite sensitive to the underlying hybrid model MC.
- Spectra measurements in the future are key to testing models.
- More stats mean looser criteria, more **true inclusivity**.

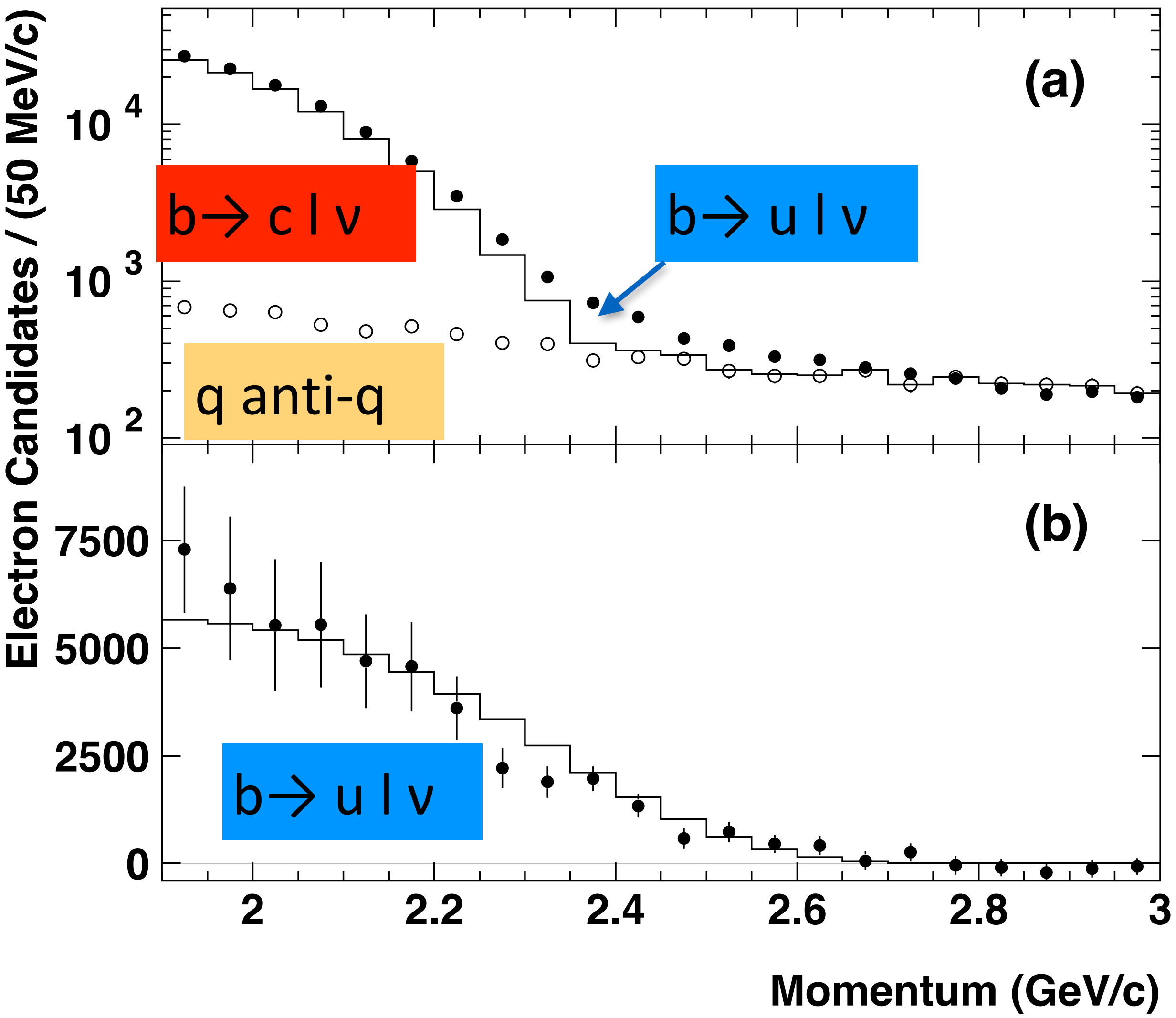
References

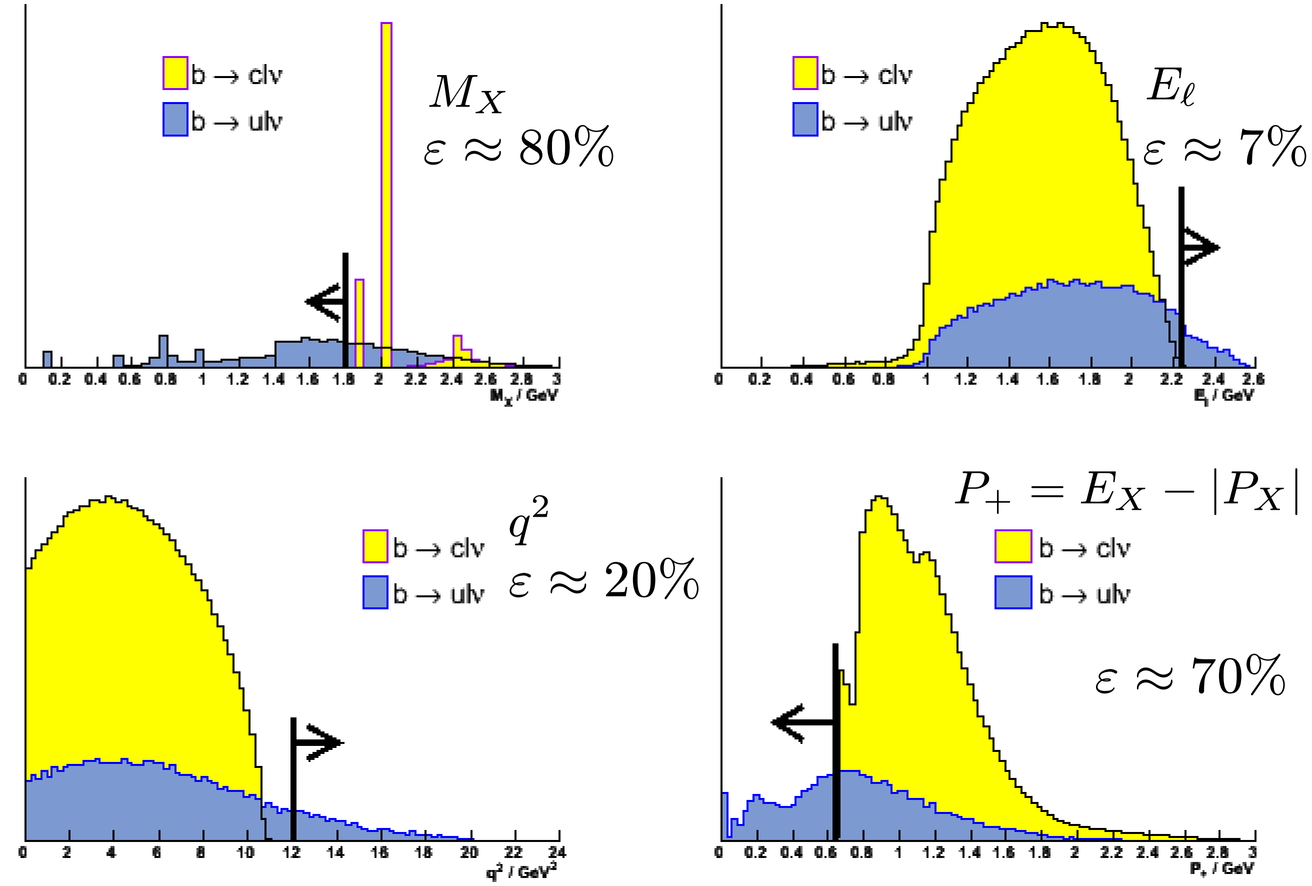
	On	Off	Approach		Comments
CLEO	9.1 fb^{-1}	4.4 fb^{-1}	E_e	Phys.Rev.Lett.88:231803,2002 [arXiv:hep-ex/0202019v1]	2.1 < Ee < 2.6
BELLE	27 fb^{-1}	8.8 fb^{-1}	E_e	Phys.Lett.B621:28-40,2005 [arXiv:hep-ex/0504046v2]	1.9 < Ee < 2.6
BABAR	80 fb^{-1}	9.5 fb^{-1}	E_e	Phys.Rev.D73:012006,2006 [arXiv:hep-ex/0509040v2]	2.0 < Ee < 2.6
BABAR	81.4 fb^{-1}	9.6 fb^{-1}	E_e, S_h^{max}	Phys.Rev.Lett.95:111801,2005 [arXiv:hep-ex/0506036]	
BELLE	87 fb^{-1}		sim. ann. (m_X, q^2)	Phys.Rev.Lett.92:101801,2004 [arXiv:hep-ex/0311048v2]	Cut on m_X<1.7 GeV, q^2>8GeV^2 tag with annealing method
BELLE	253 fb^{-1}		M_X, q^2,P^+	Phys.Rev.Lett.95:241801,2005 [arXiv:0907.0379v1 [hep-ex]]	BRECO tag
BELLE	657·10^6		multivariate (p*)	Phys.Rev.Lett 104:021801,2010 [arXiv:0907.0379v1 [hep-ex]]	BRECO tag; multivariate analysis. Cut on lepton energy at 1 GeV
BABAR	467·10^6		M_X, q^2,P^+,p*	Phys.Rev.D.86:032004, 2012 [arXiv:1112.0702v1]	BRECO tag (Highest efficiency tag)

The Belle analyses use the previous tag algorithm ~ 2.5x lower efficiency than new.

Endpoint & Kinematics

Belle PLB 621:28-40,2005





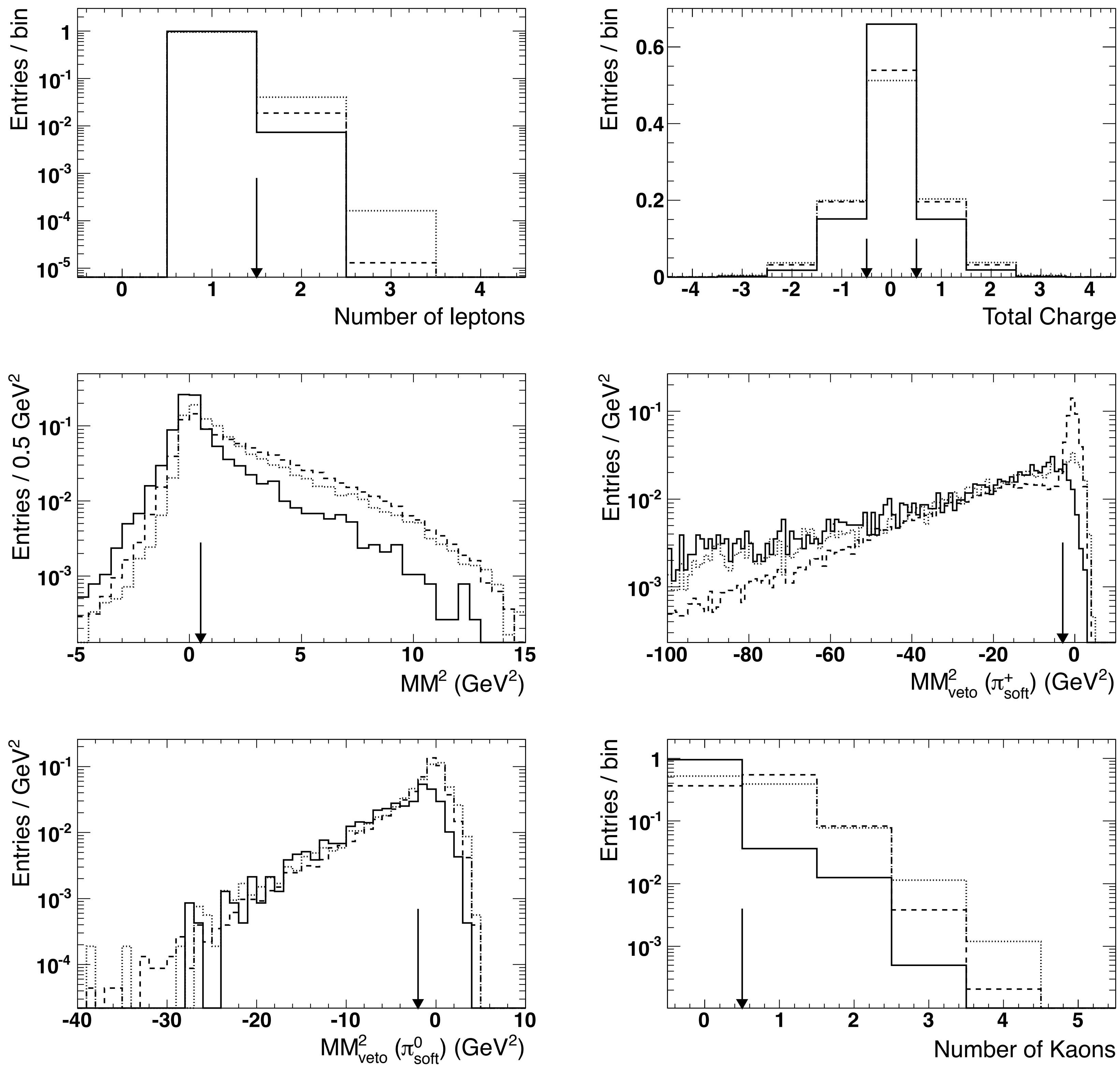
$p_{\rm CM}$ (GeV/c)	$R\,(\lvert V_{ub}\rvert^2 {\rm ps}^{-1})$	$\lvert V_{ub}\rvert\ (10^{-3})$(BLNP)
$1.9 - 2.6$	$21.69 \pm 3.62 ^{+2.18}_{-1.98}$	$5.08 \pm 0.47 \pm 0.42 ^{+0.26}_{-0.23}$
$2.0 - 2.6$	$16.05 \pm 3.05 ^{+1.83}_{-1.72}$	$4.87 \pm 0.43 \pm 0.46 ^{+0.28}_{-0.26}$
$2.1 - 2.6$	$10.86 \pm 2.51 ^{+1.61}_{-1.57}$	$4.83 \pm 0.33 \pm 0.56 ^{+0.36}_{-0.35}$
$2.2 - 2.6$	$6.46 \pm 1.54 ^{+1.54}_{-1.53}$	$4.77 \pm 0.26 \pm 0.57 ^{+0.57}_{-0.56}$
$2.3 - 2.6$	$3.15 \pm 0.88 ^{+1.55}_{-1.54}$	$5.07 \pm 0.71 \pm 0.52 ^{+1.25}_{-1.24}$
$2.4 - 2.6$	$1.12 \pm 0.39 ^{+1.48}_{-1.48}$	$5.70 \pm 1.00 \pm 0.67 ^{+3.77}_{-3.76}$

Analysis Method Overview (Hadron reconstruction)

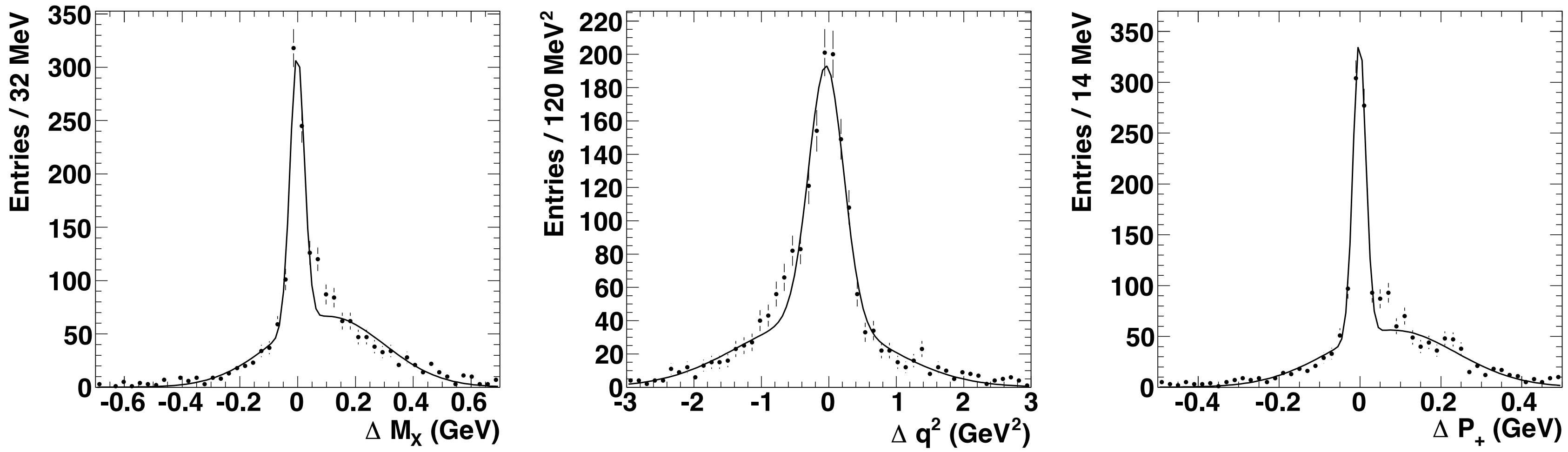
B reconstruction	Full hadronic B tagging
Signal	High momentum lepton, inclusive sum of hadron products
Event	ΣQ=0, $Q(B_{reco}^{+})$ x Q(lep) = -1, no Kaons, D* rejected via slow pions, m^2_{miss} small
Combinatorial background	Fit M_{bc} in bins of fit observable. or Combinatorial estimated from MC, normalised from sideband region.
Semileptonic and other B background	Fit to P_+, M_X, q^2 with various background and signal floated to determine background yield. or 2D fit e.g. M_X, q^2
Branching fraction	$R(B \to X_u l \nu / B \to X_c l \nu)$ or Absolute

Inclusive Hadron Reconstruction

BABAR PRD.86:032004, 2012

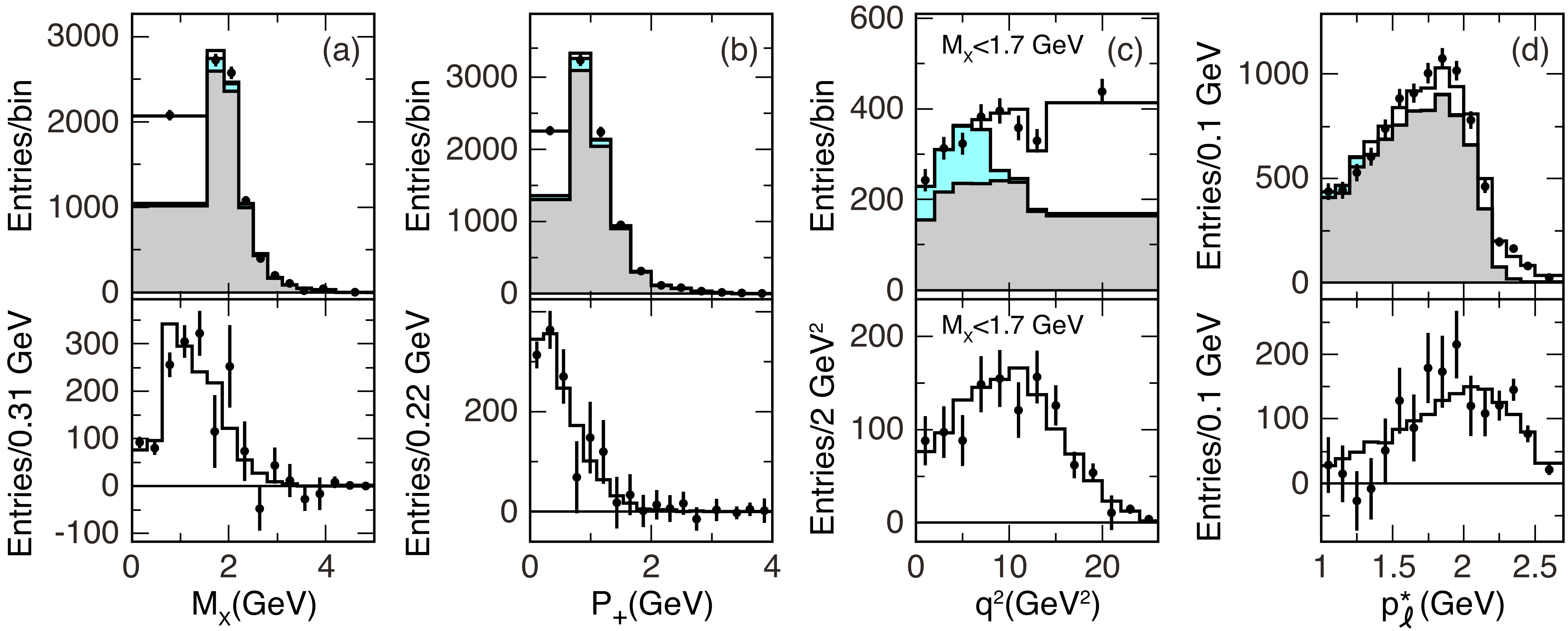


Babar



BABAR PRD.86:032004, 2012

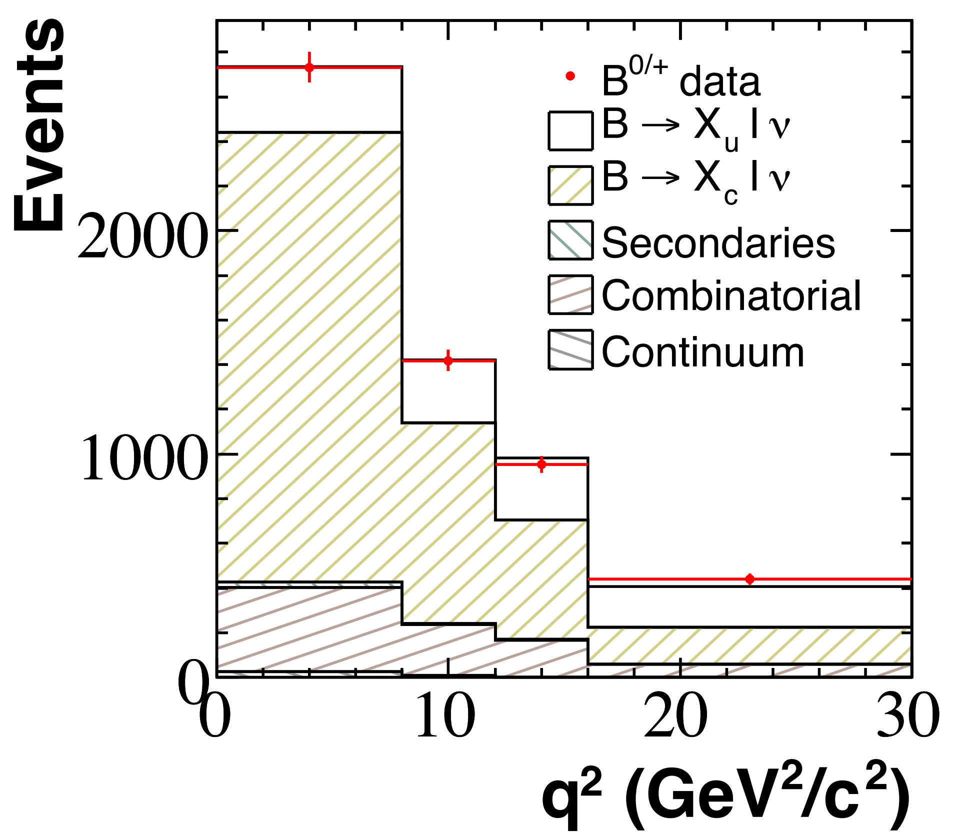
True inclusivity is the big challenge! (also Belle)

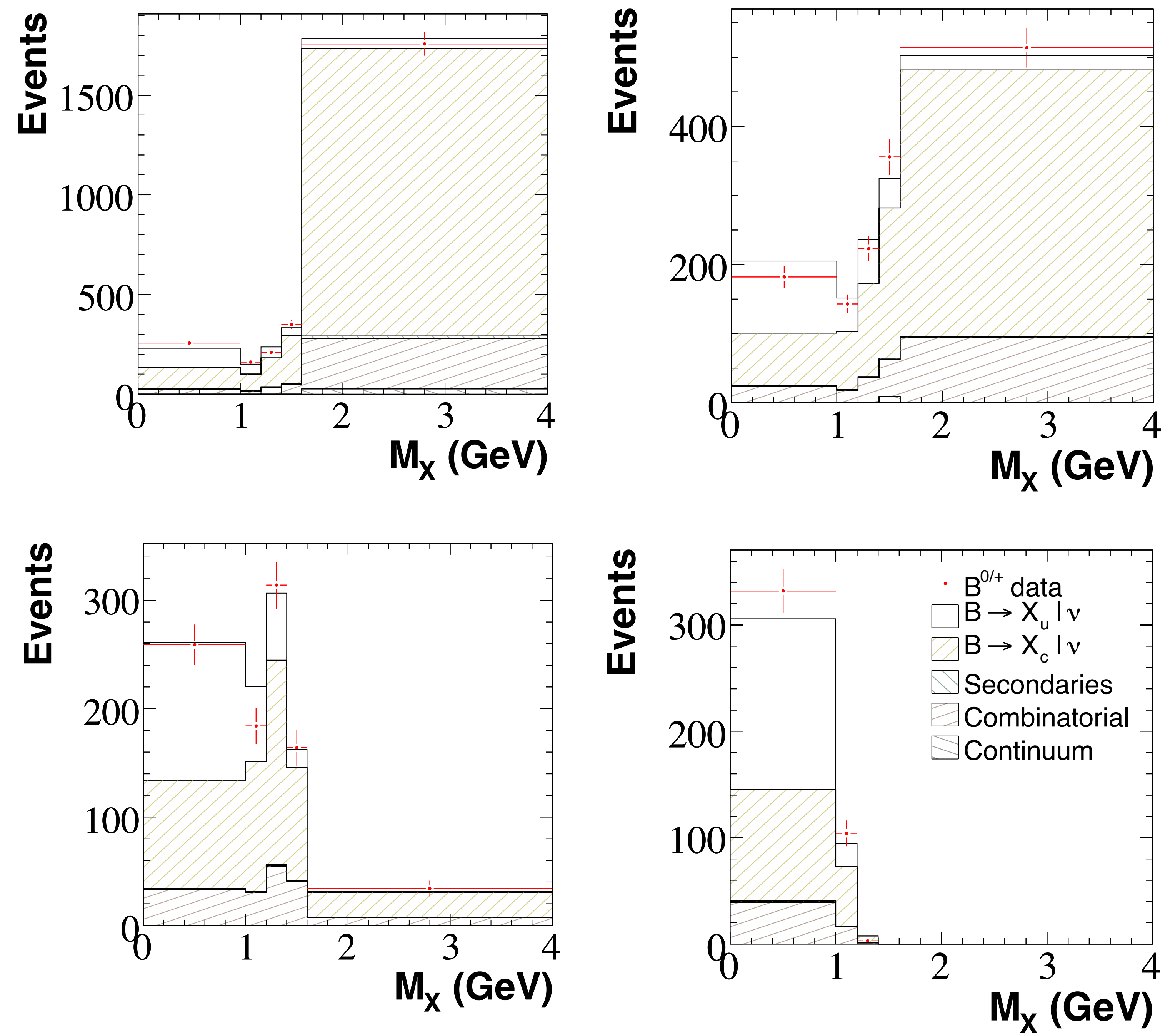


Belle

Belle PRL 104:021801,2010

Explored balance between experimental reach and theoretical model uncertainties. Many variables included. (Old B-tagging in Belle). Less model dependent approaches will be explored in the future.





to be superseded soon (Improved NB B-tagging Eff. ~2.5x, cut based)

BF Uncertainties & possible biases

Belle PRL 104:021801,2010

P_{lepton}> 1 GeV	*ΔBR/BR*
BR($D^{(*)}$ l ν)	1.2
FF($D^{(*)}$ l ν)	1.2
BR & FF ($D^{(**)}$ l ν)	0.2
SF (X_u l ν)	3.6
Xu (g→ss)	1.5
BR(π/ρ/ω l ν)	2.3
BR(η/η' l ν)	3.2
BR($X_{unmeasured}$ l ν)	2.9
Continuum/Combinatorial	1.8
Secondaries/Fakes/Fit	1.0
Particle ID/Reconstruction	4.4
Systematics Total	**8.1**
Statistics	**8.8**

BR & FF ($D^{(*)}$ l ν)

- Parameterisations of F.F. based on HQET2. BR from PDG.
- D l ν: slope parameters, ρ_D^2.
- D* l ν: decay parameters, ρ^2, R_1 and R_2.

BR & FF ($D^{(**)}$ l ν)

- LLSW model for resonant
- Goity&Roberts for non-resonant.
- Normalisation of narrow resonant $D^{(**)}$ and non-resonant $D^{(*)}$ π components are based on WA.
- The remaining unmeasured contribution is matched to the full inclusive rate.

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Signal MC hybrid mix of exclusive with inclusive contributions mopping up. Exclusive X_u BR error from HFAG. **Unmeasured resonant: ISGW2, BR limits from full inclusive BR.**

Inclusive X_u

- Inclusive part uses De Fazio-Neubert SF parameterisation .
- Full hybrid MC matched to moments of the q^2 and M_X of GGOU model by varying input parameters of inclusive part.
- K production via gluon splitting: vary contribution ±25%. **No published searches for these modes!**

Modeling: EvtGen

Snapshot of the default Belle 2010 configuration
(similar picture for Belle II)

```
Decay B-ulnu
0.000073 pi0    e- anti-nu_e PHOTOS SLPOLE 0.261 -2.03 1.293 1 0.261 -0.27 -0.752 1;
0.000149 rho0   e- anti-nu_e PHOTOS SLPOLE 0.261 -0.29 -0.415 1 0.223 -0.93 -0.092 1 0.338 -1.37 0.315 1 0.372 -1.40 0.437 1;
0.000084 eta    e- anti-nu_e PHOTOS ISGW2;
0.000033 eta'   e- anti-nu_e PHOTOS ISGW2;
0.000115 omega  e- anti-nu_e PHOTOS SLPOLE 0.261 -0.29 -0.415 1 0.223 -0.93 -0.092 1 0.338 -1.37 0.315 1 0.372 -1.40 0.437 1;
0.000024 a_20   e- anti-nu_e PHOTOS ISGW2;
0.000027 f_2    e- anti-nu_e PHOTOS ISGW2;
0.000082 b_10   e- anti-nu_e PHOTOS ISGW2;
0.000087 h_1    e- anti-nu_e PHOTOS ISGW2;
0.000065 a_10   e- anti-nu_e PHOTOS ISGW2;
0.000062 f_1    e- anti-nu_e PHOTOS ISGW2;
0.000003 a_00   e- anti-nu_e PHOTOS ISGW2;
0.000005 f_0    e- anti-nu_e PHOTOS ISGW2;
0.001026 Xu0    e- anti-nu_e PHOTOS VUB 4.54 7.5 0.22 1 0.28 1; ****
```

- Note that we vary this model input and regenerate the MC according to a modelling recipe.
- Higher resonances taken from ISGW2 model [PRD 52, 2783 (1995)]
- Only blue items have direct experimental constraint: ~25% of the total.
- Most of the exclusive modes use ISGW2.

Available Generators in EvtGen 2015

Exclusive Modes

- SLPOLE : Light Cone Sum Rules
- ISGW2 : ISGW
- BtoPlnuBK : BK (Becirevic-Kaidalov) parameterisation for pseudoscalar modes (π, η, η`)
- BToVlnuBall : Ball/Zwicky decay model for vector modes (ρ , ω)

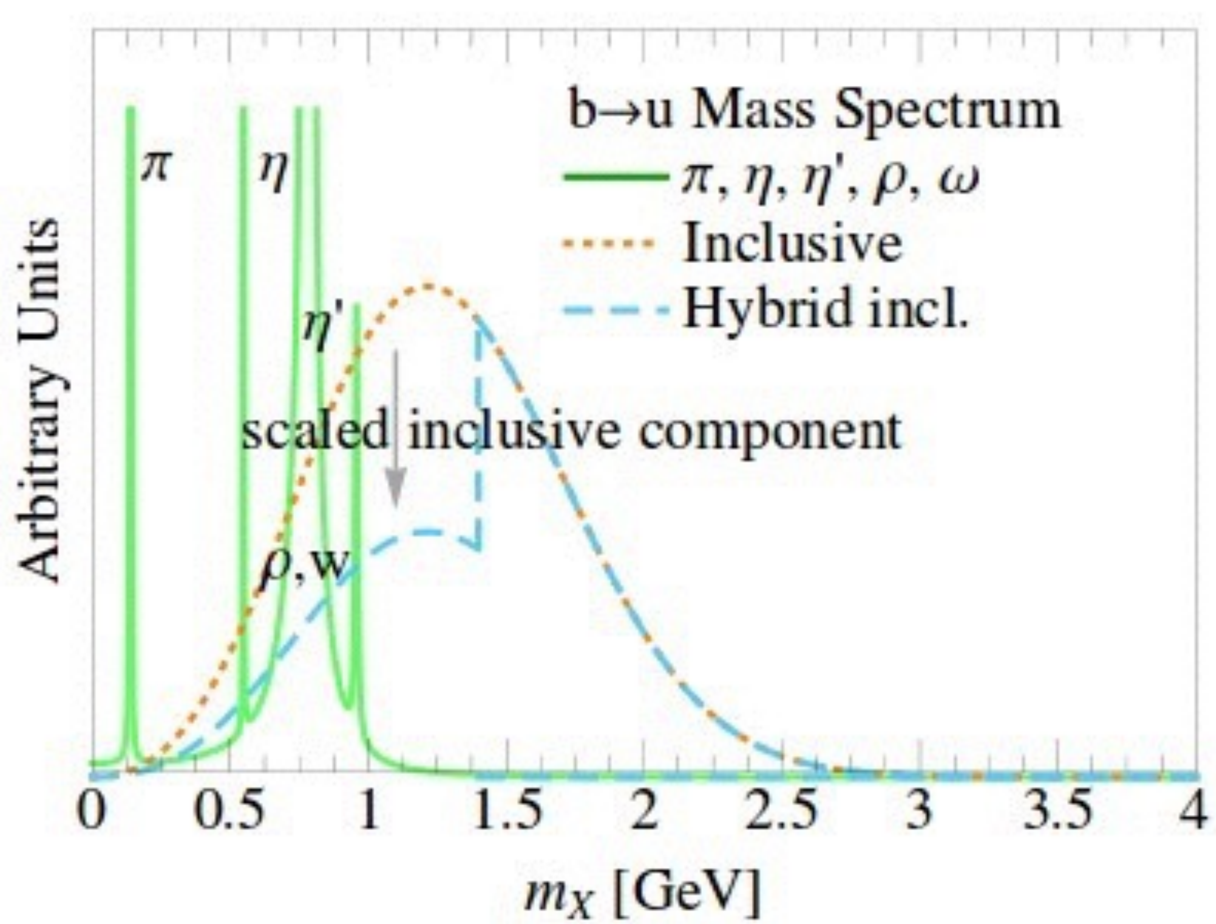
Inclusive Modes (most come from Babar)

- Vub : "DeFazio-Neubert" based approach (takes m_b, μ_π^2)
- VubHybrid : As above, uses "Hybrid" weighting for the excl.+incl. cocktail
- VubBLNP : Based on BLNP4, hep-ph/0504071
- VubBLNPHybrid : As above, uses "Hybrid" weighting for the excl.+incl. cocktail
- VubNLO : Based on BLNP hep-ph/0402094
- VubAC : Analytic Coupling Model (based on hep-ph/0608047 by Aglietti, Ferrera and Ricciardi)

  - These are not state of the art (but the cocktail approach reduces the overall precision anyway)
  - We should still consider updates for Belle II modelling.
  - How should we model "new-physics" in inclusive?

Modeling Recipes

Babar	Belle
• Generate inclusive decays • Reweighing in 3D to match to more recent 2-loop calc. (bins of M_X, q^2, E_{lep}) • Generate resonances (default decay-files) • Below threshold value scale down non-resonant contribution and conserve total BR	• Generate inclusive MC (default Evtgen) • Add on top resonances in higher mass regions (default ISGW2) • Scale down inclusive component • Tune inclusive component's input parameters until entire spectrum's kinematic distributions' moments agree to those in more recent two-loop calculation • Error from SF parameters, GGOU model theory, intrinsic uncertainty in DFN model.



- Future measurements need to self-calibrate this procedure.
- See B→Xs γ Sum of exclusives.

X_u^0 & X_u^+ hadronisation (JETSET/Pythia)

Parton (from hard process)

Parton shower (Pythia, Herwig)

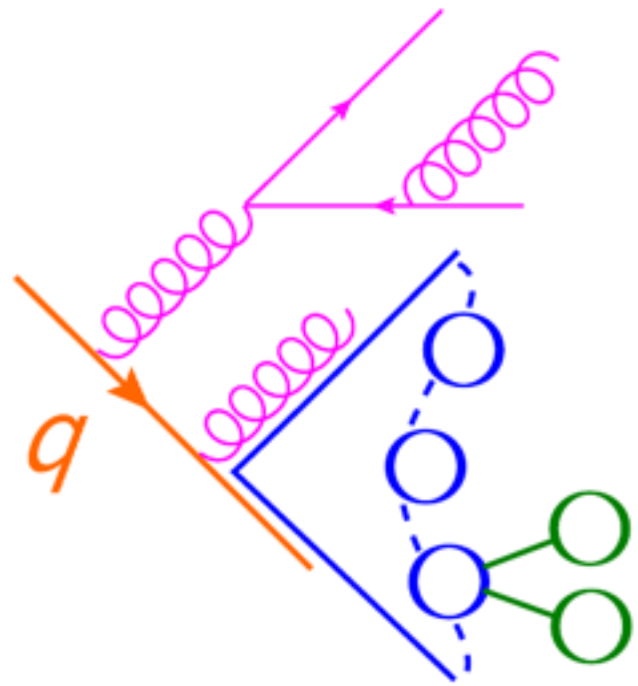
- Gluon emission: $q \to qg$,
- Gluon splitting: $g \to q\bar{q}, gg$
- Good constraints from Z decays

Hadronization (Pythia, Herwig)

- Non-perturbative formation of hadrons along colour strings
- Steered by fragmentation functions and flavour parameters

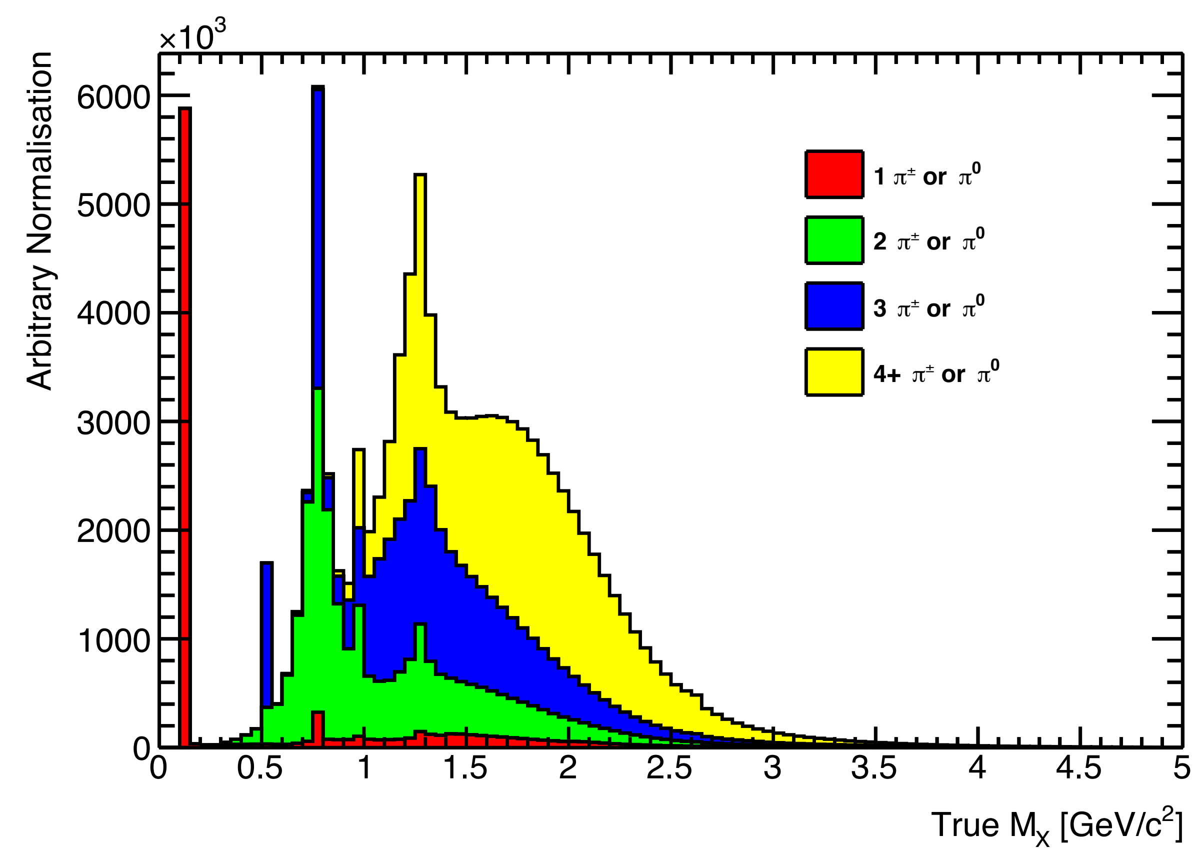
Hadron decays (Pythia, Herwig, EvtGen)

- Steered by decay tables



Clean Z→hadrons events from LEP used for tuning model parameters

Simplistic breakdown:
M_X in $n(\pi^\pm) + n(\pi^0)$ multiplicity
(photons included in M_X)



Efficiency varies with M_X, and with final state multiplicity.

If you get the multiplicity wrong, you could get the overall efficiency correction wrong too (if integrating over multiplicity).

BF Uncertainties & possible biases

Belle PRL 104:021801,2010

P_{lepton}> 1 GeV	*ΔBR/BR*
BR($D^{(*)}$ l ν)	1.2
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BR & FF ($D^{(**)}$ l ν)	0.2
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Mis-tagging (**combinatorial**) error: modify the signal region to shift the ratio of good tags to incorrect tags.

- **Continuum**: 1% error on its yield.
- **Secondary**, cascade decays: vary the branching fractions of semileptonic D decays, and B → D anything by ±1σ.
- **Hadron fake** contribution.
- **QED corrections** incurs negligible sys. error.
- and **Normalisation** errors for B counting.

$|V_{ub}|$ Uncertainties (in %)

HFAG 2014

	Babar 2012		Belle 2005	
	P_{lepton}> 1 GeV		P_{lepton}> 2 GeV	
P_{lepton}> 1 GeV	BLNP	GGOU	BLNP	GGOU
$\lvert V_{ub}\rvert \times 10^{-3}$	4.32	4.27	4.93	4.6
Statistical	3.2	3.2	2.2	2.2
Experimental Systematics	2.1	2.1	2.7	2.7
b→c l v model	1.4	1.4	8.6	8.6
b→u l v model (1)	3.3	3.3	0.8	0.8
HQ parameters/non. pert (2)	2.1	1.2	3.6	2.3
SF + Sub. SF (3)	0.4	1.4	1.1	3.3
matching	3.8		3.8	
Weak Annihilation	0	+0.0 -2.0	0	+0.0 -6.2
q^2 tail model		1.4		2.0

(1) is correlated to (2) and (3) … to be conservative we might want to add linearly.

$|V_{ub}|$ Uncertainties (in %)

HFAG 2014

	Babar 2012		Belle 2005	
	P_{lepton}> 1 GeV		P_{lepton}> 2 GeV	
P_{lepton}> 1 GeV	BLNP	GGOU	BLNP	GGOU
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The future

Towards Belle II

Full reconstruction of B
- modes w/ multiple ν's
- Improved low p_T tracking - more slow π in tag side D* candidates

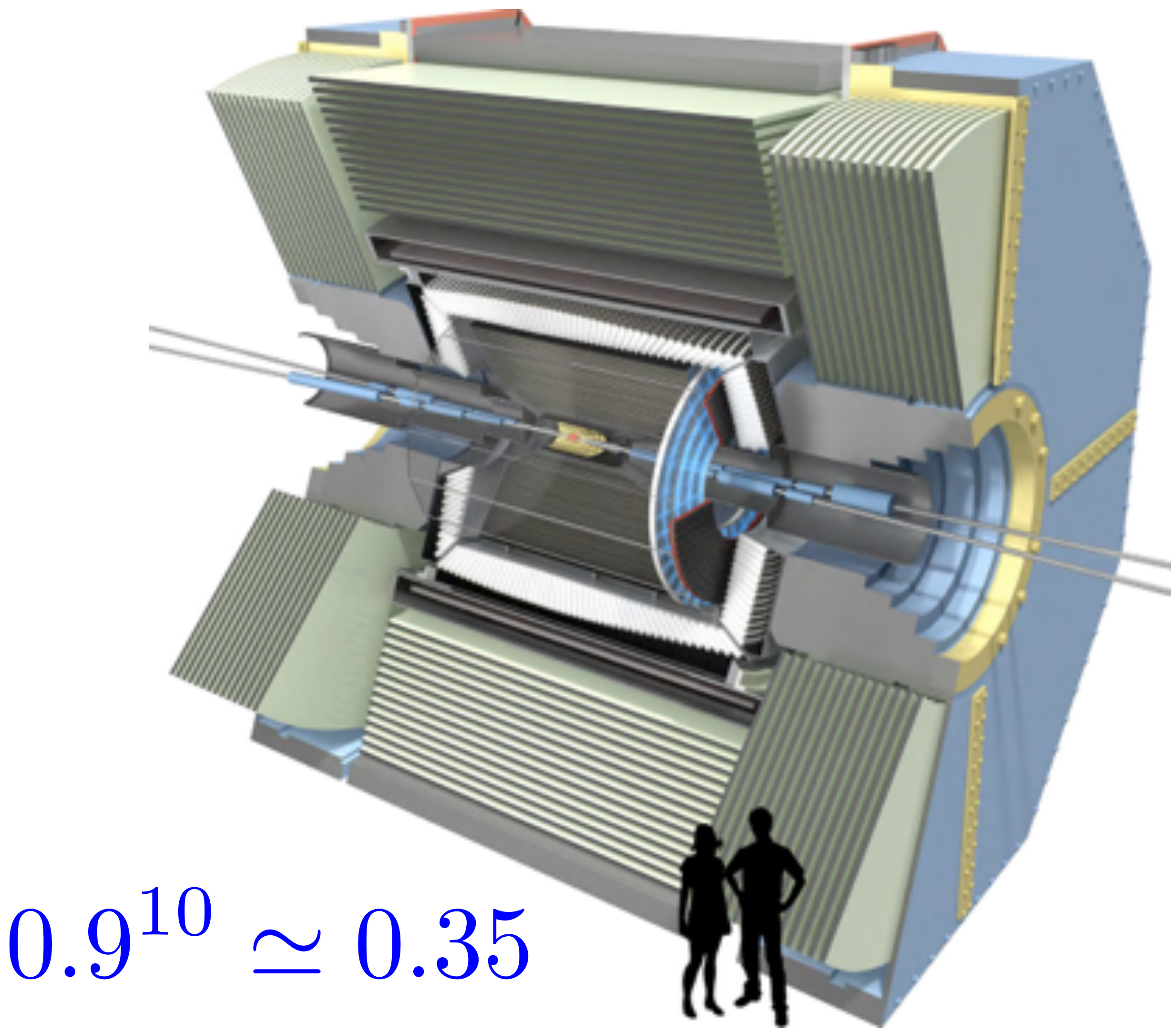
Hermeticity
- inclusive measurements

Neutral particles

π^0, K_S^0, K_L^0

and η, η', ρ^+, etc.

other notable features
- good PID for both $\mu^\pm$ and $e^\pm$
- much better K/π separation



Belle II covering ≳90% of 4π, and ⟨N(track)⟩ ~ 10 per event

|V_{ub}| Simplistic Extrapolation (detector improvements ignored)

P_{lepton}> 1 GeV	*ΔBR/BR*	*Irred.*
BR($D^{(*)}$ l ν)	1.2	0.6
FF($D^{(*)}$ l ν)	1.2	0.6
BR & FF ($D^{(**)}$ l ν)	0.2	
SF (X_u l ν)	3.6	~1.8
Xu (g→ss)	1.5	
BR(π/ρ/ω l ν)	2.3	
BR(η/η' l ν)	3.2	
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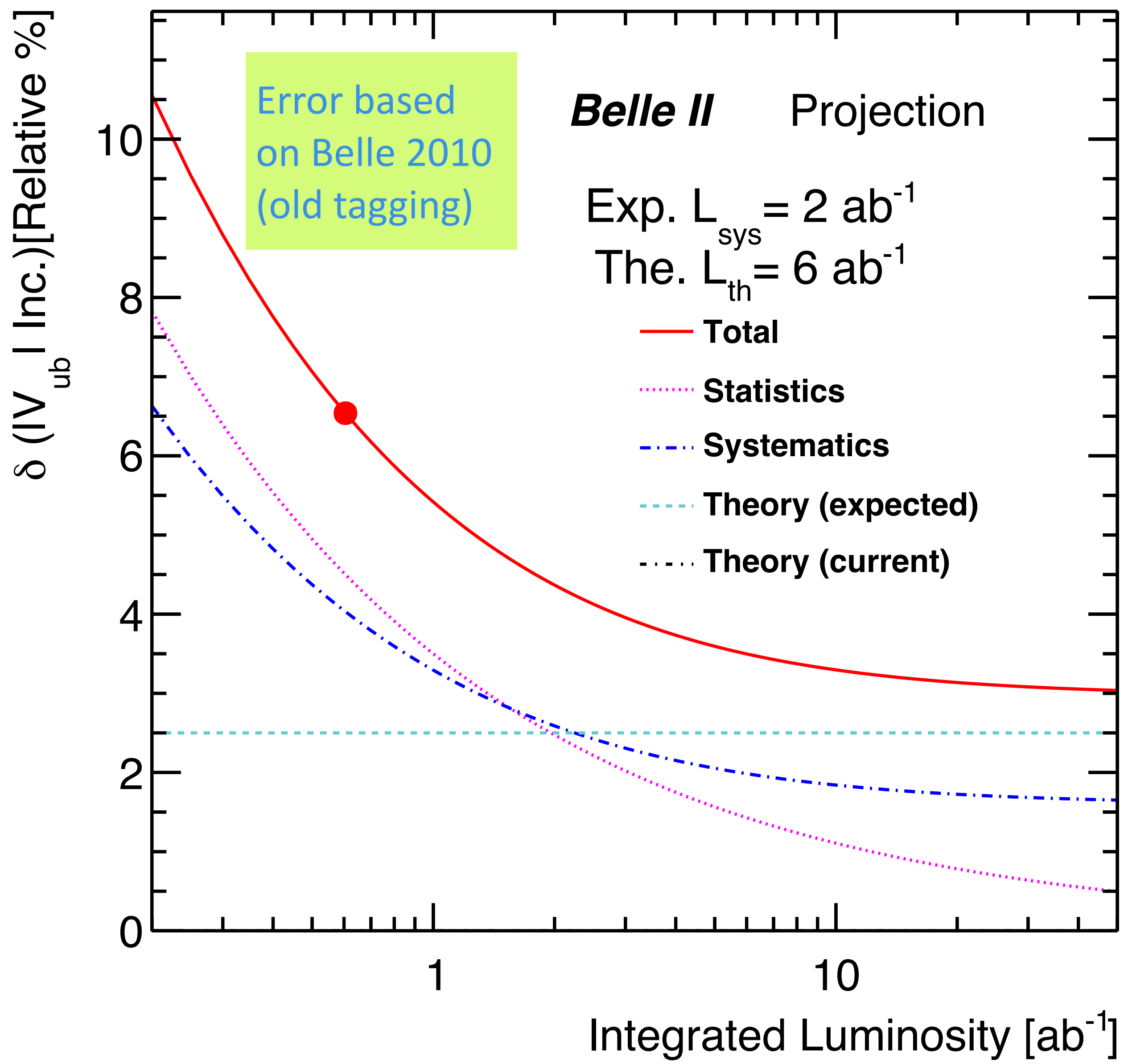
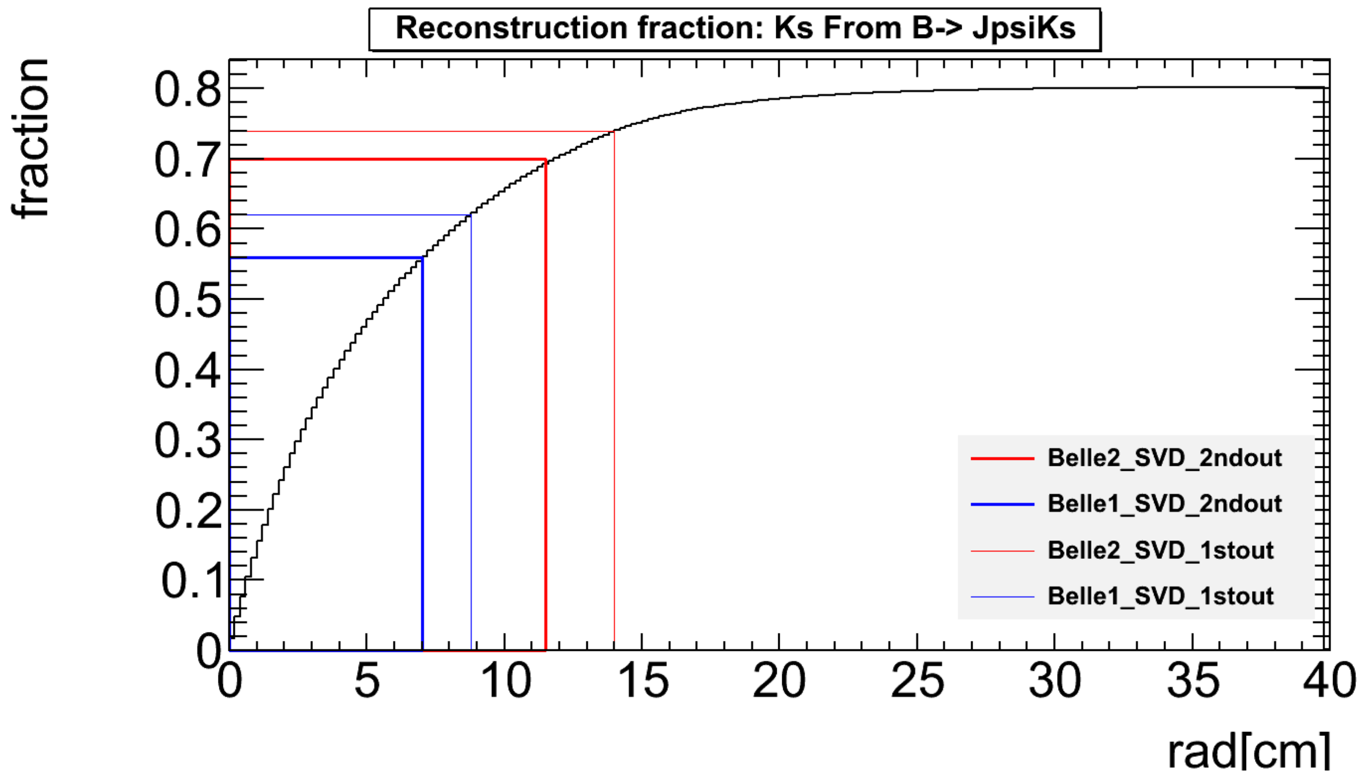


- Many **experimental improvements expected, including better tag algorithms (old Belle tag used above)**
- Measure decay differentials, and increase inclusivity to test decay models, hadronisation, weak annihilation, and KK production in inclusive.

PID and Tracking

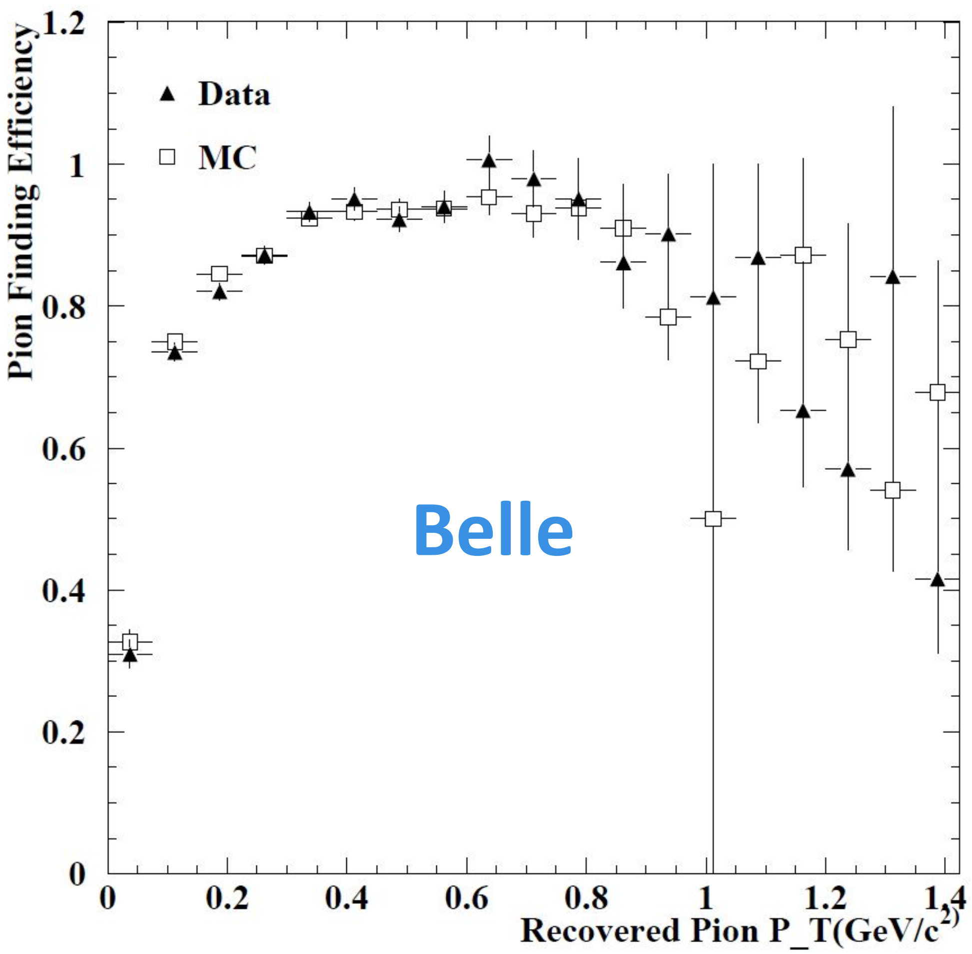
$K^{\pm}$, K_S multiplicity (K_L not often used)

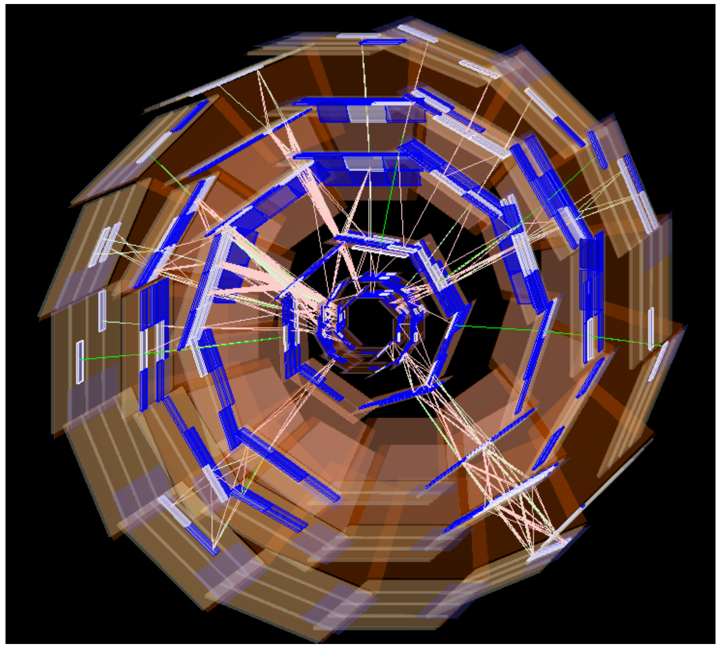
1. K → π fake rate reduced by > 2x
2. K_S acceptance increased by 30%



D^* partial reconstruction

Charge conservation

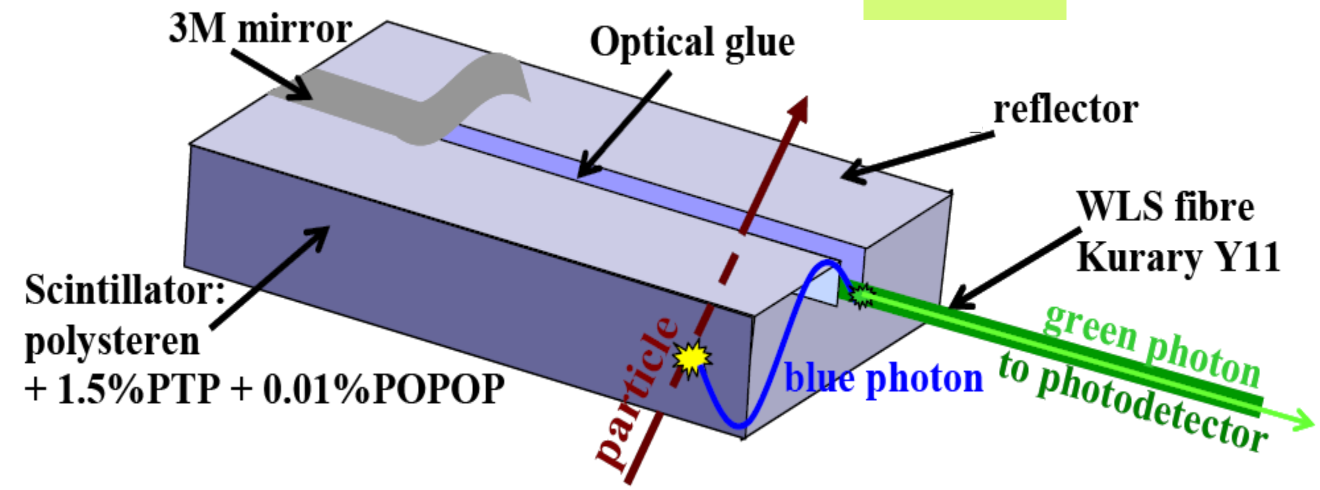




Belle II expects large efficiency improvements for slow pions.

K_L Detection / KLM Detector

K_L suppression can improve background suppression by ~50% or more (after all other criteria).

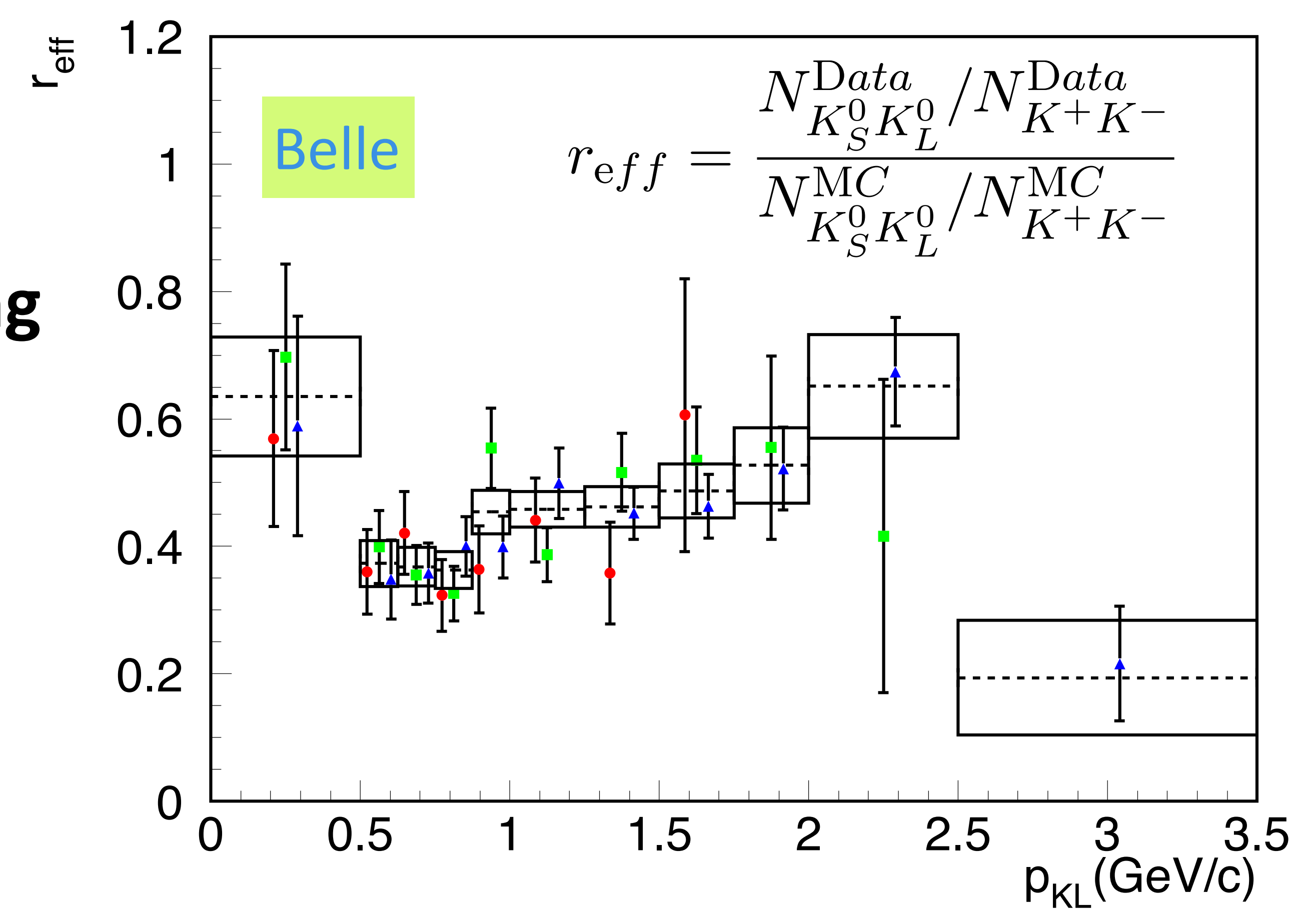


New Belle II system:

> End-cap upgrade: RPC → scintillator-based KLM

> Barrel KLM: some RPC layers may be replaced as background increases with luminosity

Readout upgraded with high speed **timing** info. ,provides precise* K_L momenta. (*unavailable before).



Still outstanding: Accurate simulation of K_L hadronic interactions with matter GEANT4. (c.f. GEANT 3 in Belle)

Fragmentation & m_{Xu}>1 GeV modes

Belle PRD 91, 052004 (2015)

Recent lessons from B→Xs γ sum of exclusives

Relative abundance of final states is vastly different between Data & MC.

Due to Pythia spin fraction parameter (probability of forming a spin 1 meson).

	Relative abundance in %				
B→ Xs γ mode	Data	Error	MC	Ratio	Diff. (σ)
Kπ without π^0	4.2	0.4	10.3	**0.41**	**+17**
Kπ with π^0	2.1	0.2	5.4	**0.39**	**+19**
K2π without π^0	14.5	0.5	12.9	1.12	−3.1
K2π with π^0	24	0.7	15.2	**1.58**	**−12**
K3π without π^0	8.3	0.8	5.9	**1.41**	**−3.3**
K3π with π^0	16.1	1.8	15.7	1.03	−0.2
K4π	11.1	2.8	12.3	0.90	+0.4
K2π^0	14.4	3.5	14.4	1.00	−0.0
K η	3.2	0.8	4.9	**0.65**	**+2.3**
3K	2.0	0.3	3.0	**0.67**	**+3.3**

Belle II: Analogous studies, as B→ l ν ππ, 3π, 4π. (B→ l ν 2π shown in Belle 2013)

Weak Annihilation

CLEO PRL 96:121801,2006

1. CLEO examined q^2 spectra to place a 7.4% limit with 15.5 fb^{-1}. Systematics limited.

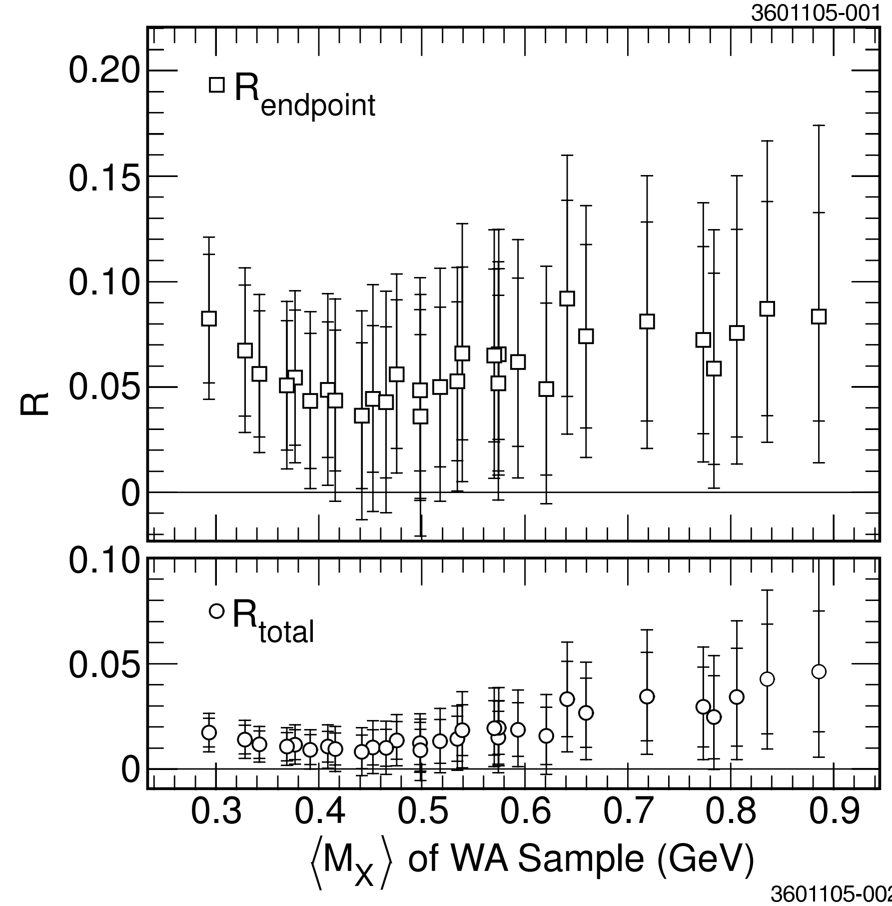
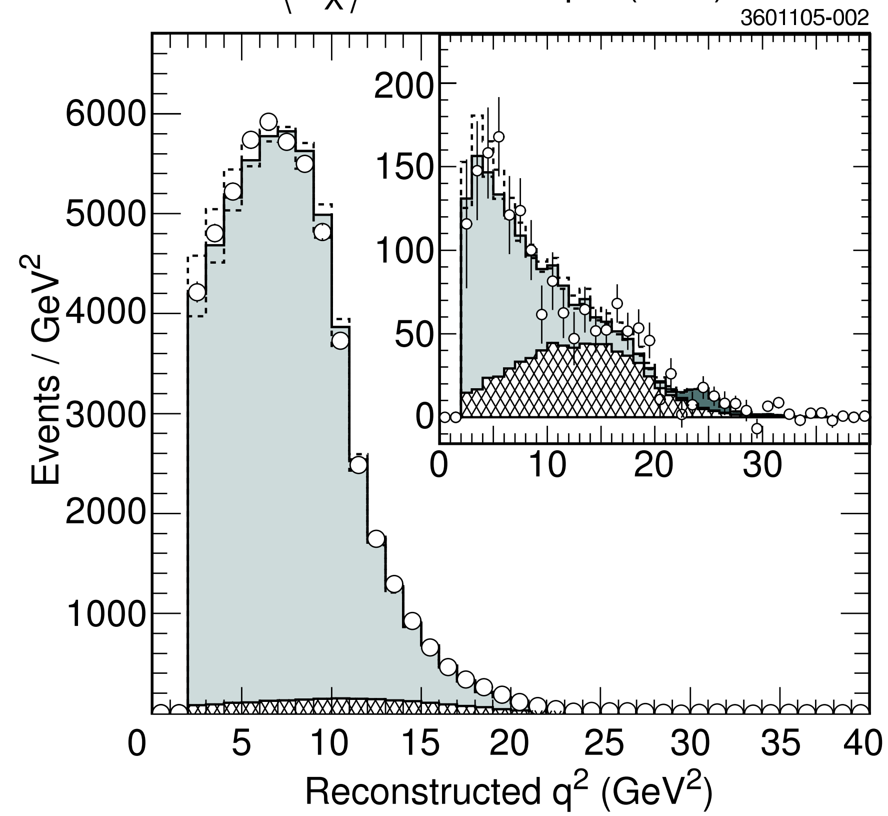


FIG. 2: Fractional size of the WA component for the full phase space (bottom) and restricted to $p_\ell > 2.2\mathrm{GeV}/c$ endpoint region (top). The statistical (total) uncertainties are represented by the inner (full) error bar.

2. Babar & Belle examined BF $B^+ \rightarrow X l \nu$ / $B^0 \rightarrow X l \nu$ ratios in subregions, with a 20% limit.

TABLE II: Systematic uncertainties (WA model of Fig. 1).

Source	$\Delta R_{\rm tot}$	$\Delta R_{\rm tot}/R_{\rm tot}(\%)$
γ efficiency	0.00177	10.2
tracking efficiency	0.00247	14.3
E_γ resolution	0.00095	5.5
$p_{\rm trk}$ resolution	0.00134	7.7
K_L multiplicity	0.00013	0.8
hadronic shower modeling	0.00118	6.8
hadronic shower veto	0.00065	3.8
particle identification	0.00078	4.5
$b \rightarrow c \rightarrow s\ell\nu$	0.00020	1.1
$b \rightarrow c\,\ell\,\nu$ modeling	0.00349	20.1
$b \rightarrow u\,\ell\,\nu$ modeling	0.00309	17.9
Total	**0.00601**	**34.7**



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Hadron Tagged Endpoint for WA?

A rough look suggests Belle II would do well.
Split B^+&B^0, measure q^2 with high resolution.
(dedicated studies yet to be done).

p_{lep}>2.2 GeV, q^2>0 GeV^2/c^2

Belle untagged endpoint 27 fb^{-1} Δ 2.2% statistical (q^2 not analysed)	Belle II tagged endpoint Δ << 1% statistical (estimate)

p_{lep}>2.2 GeV, q^2>20 GeV^2/c^2

Belle II tagged
Δ < 1% statistical
O(25-50k) b→u
O(1-10k) b→c

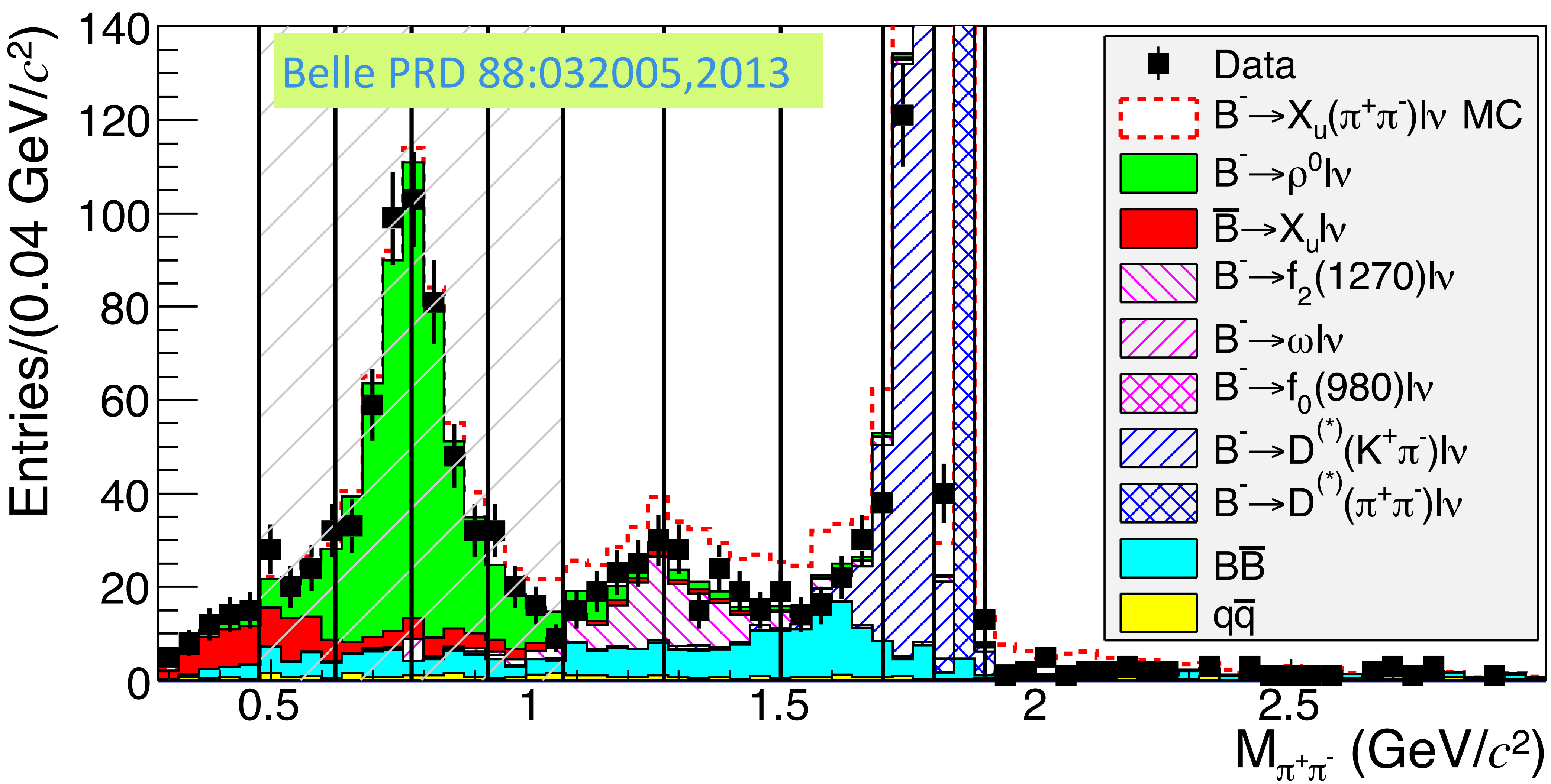
g→ss

B→ l ν KK

K veto to suppress B→D→K may introduce bias on signal efficiency.

We ***know*** there is some: e.g. f_2(1270)→KK, + many other ways,

but no direct tests yet (hence difficult to provide projections).



Ongoing work for Belle II "Full reconstruction"

Belle II PAC 2015

Expect at least 2x better efficiency at Belle II!

B 1. $B^0 \to D^{(*)-}\pi^+$

B 2. $B^0 \to D^{(*)-}\pi^+\pi^0$

B 3. $B^0 \to D^{(*)-}\pi^+\pi^+\pi^-$

4. $B^0 \to D^{(*)-}\pi^+\pi^0\pi^0$

B 5. $B^0 \to D^{(*)-}\pi^+\pi^+\pi^-\pi^0$

6. $B^0 \to D^{(*)-}\pi^+\pi^+\pi^-\pi^-\pi^+$

7. $B^0 \to D^{(*)-}\pi^+\pi^+\pi^-\pi^0\pi^0$

8. $B^0 \to D^{(*)-}K^+K^-\pi^+$

9. $B^0 \to D^{(*)-}K^+K^-\pi^+\pi^0$

10. $B^0 \to D^{(*)-}K^+K^-\pi^+\pi^+\pi^-$

11. $B^0 \to D^{(*)-}K^+K^-\pi^+\pi^0\pi^0$

B 1. $D^0 \to K^-\pi^+$

B 2. $D^0 \to K^-\pi^+\pi^0$

B 3. $D^0 \to K^-\pi^+\pi^+\pi^-$

4. $D^0 \to K^-\pi^+\pi^+\pi^-\pi^0$

B 5. $D^0 \to \pi^+\pi^-$

B 6. $D^0 \to \pi^+\pi^-\pi^0$

7. $D^0 \to \pi^+\pi^-\pi^+\pi^-$

B 8. $D^0 \to K^+K^-$

9. $D^0 \to K^+K^-\pi^0$

10. $D^0 \to K^+K^-\pi^+\pi^-$

B 1. $D^+ \to K^-\pi^+\pi^+$

B 2. $D^+ \to K^-\pi^+\pi^+\pi^0$

B 3. $D^+ \to K^-K^+\pi^+$

B 4. $D^+ \to K^-K^+\pi^+\pi^0$

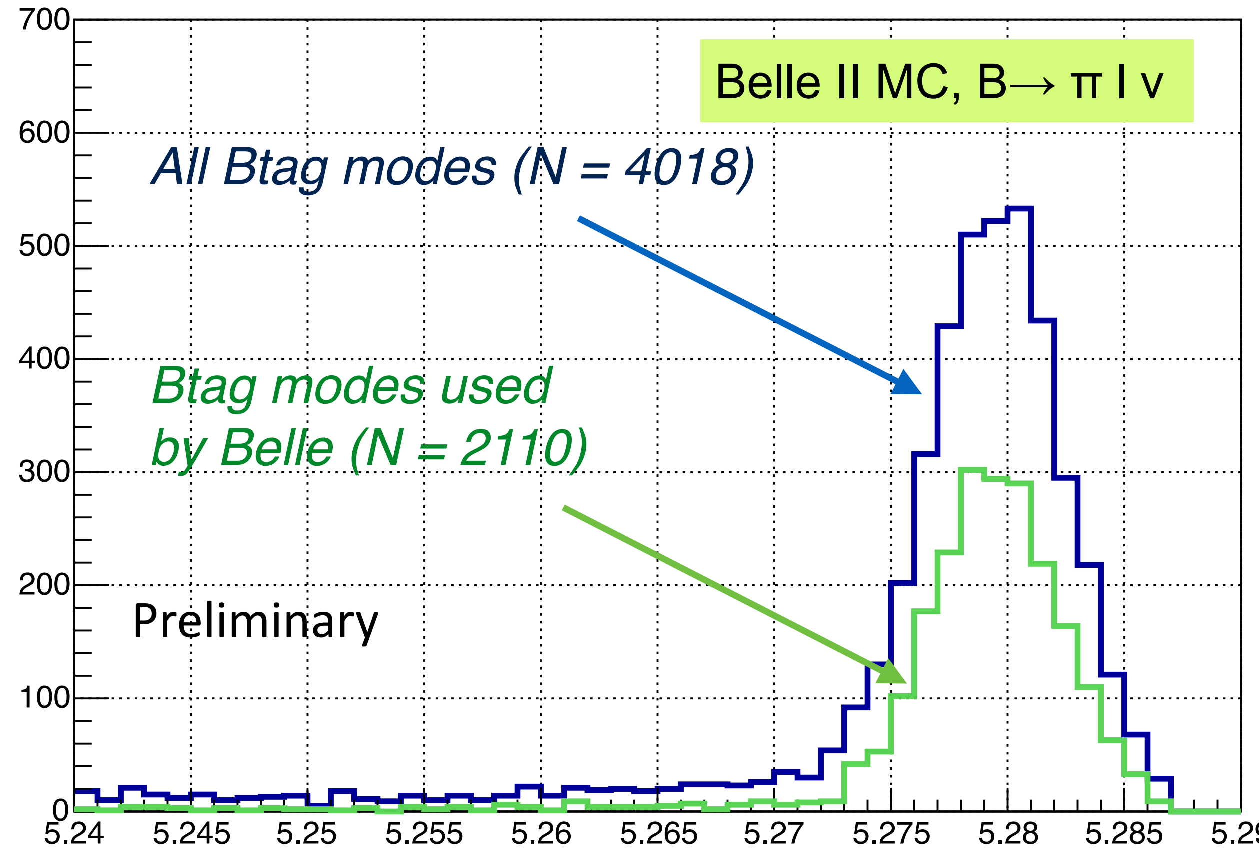
B 1. $D^{*+} \to D^0\pi^+$

B 2. $D^{*+} \to D^+\pi^0$

B - modes used by Belle
(modes with K0s are not included)

Reconstruction/Selection
- Mass constrained fits of D(*) mesoı
- Inv. mass cuts (± few sigmas)
- Delta E cut
- candidates ranked according to min|DeltaE|

Mbc of B_{tag} candidates



Reconstructed B0 tag candidates on signal MC (500k events)

$$e^+e^- \to \Upsilon(4S)$$

$$B^0_{tag}\overline{B}^0_{sig} \text{ or } \overline{B}^0_{tag}B^0_{sig}$$

$$B^0_{sig} \to \pi^-\ell^+\nu_\ell$$

$$B^0_{tag} \to \text{generic}$$

~0.8% of all B0tag decays are reconstructed

c.f. 0.2-0.4% in Belle… (more modes, better slow pion tracking)

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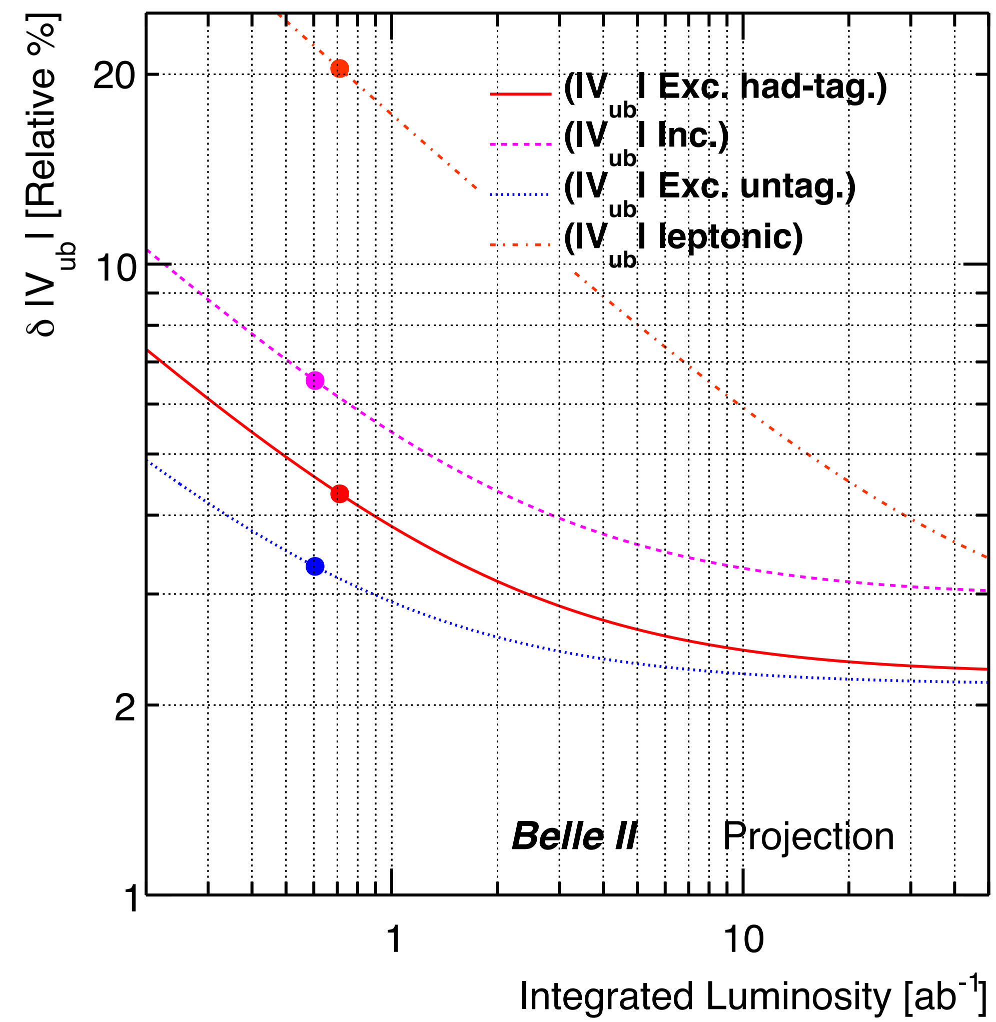
Naive Guesstimate Extrapolation in Bins

Belle II Tag efficiency improves by a factor of 4 (over 2010 “old” Belle tagging)
→ 330x statistical power improvement: ~18 times smaller stat errors!

		Belle (approximate) 0.6 ab^{-1}						Belle II - efficiency x 4, 50 ab^{-1}					
q^2 [GeV]	M_X [GeV]	Signal	Bkg	Δ Stat	Δ Sys Sig.	Δ Sys Bkg	Total	Signal	Bkg	Δ Stat	Δ Sys Sig.	Δ Sys Bkg	Total
{0, 8}	{0.0, 1.0}												
	{1.0, 1.2}												
	{1.2, 1.4}												
	{1.4, 1.6}												
	{1.6, 4.0}												
{8, 12}	{0.0, 1.0}												
	{1.0, 1.2}												
	{1.2, 1.4}												
	{1.4, 1.6}												
	{1.6, 4.0}												
{12, 16}	{0.0, 1.0}												
	{1.0, 1.2}												
	{1.2, 1.4}												
	{1.4, 1.6}												
	{1.6, 4.0}												
{16, 30}	{0.0, 1.0}												
	{1.0, 1.2}												
	{1.2, 1.4}												
	{1.4, 1.6}												
	{1.6, 4.0}												

Summary of work ahead for Belle II

1. Supporting measurements
   - Weak annihilation / precise tagged endpoint measurements
   - ss popping
   - High mass exclusive modes



2. Extensions to the current analyses
   - Differentials (&moments) in tagged approach.
     - for ***testing*** models
   - Multiplicity binning
     - for ***testing*** fragmentation

Finally. We're not yet finished in Belle I. Updated tagging techniques yet to be exploited.