Leptonic, semileptonic and Missing Energy WG – Attività e opportunità

Guglielmo De Nardo
University of Napoli *Federico II* and INFN

Riunione Belle II Italia
Padova, 30 Maggio 2016

Ambito del working group

Decadimenti del B puramente leptonici (B $\rightarrow$ l ν)

Decadimenti del B S.L. (B$\rightarrow X_c$ l ν, X_u l ν)

Decadimenti del B con missing energy (B$\rightarrow\nu\nu$, X_s $\nu\nu$)

Il programma include diversi golden modes e hot topics.
Alcuni:

- Charged Higgs (B$\rightarrow$tau nu)
- FCNC (B $\rightarrow$ s nu nu)
- B $\rightarrow$ D(*) tau nu
- Determinazione di Vub e Vcb (tensione Vub escl vs incl)
- Universalità leptonica e violazione numero leptonico

Pagina web	https://belle2.cc.kek.jp/~twiki/bin/view/Physics/SLMissing
Mailing list	semileptonic@belle2.kek.jp
Meeting regolari	Mercoledi ore 9:00 CET bisettimanale (prossimo 1 Giugno)

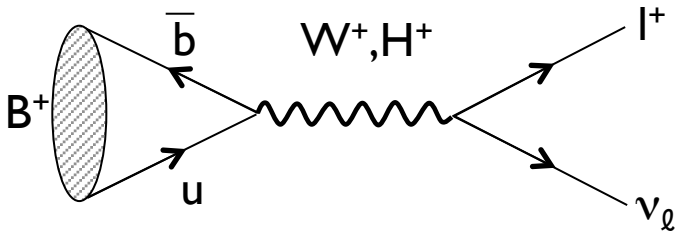
Studi *On going*

Ongoing Studies

Leptonic				
Thomas Keck	Karlsruhe	PhD	B -> tau nu with FEI	Ha sviluppato la FEI
Felix Metzner	Karlsruhe	MSc	B -> l nu gamma (hadronic + semileptonic tag) ‡	Appena iniziato
Mario Merola, Guglielmo De Nardo	Napoli	Staff	B -> l nu tagged	Presentato a WG,B2GM e B2TIP
b -> c l nu				
Lucien Cremaldi, David Sanders	Mississippi	Staff	B -> D* mu/e nu	Segnalato interesse
b -> c tau nu				
Abner Soffer	Nagoya Visitor	Staff & students	Vertexing to improve B -> D(*) tau nu and B -> mu nu	Segnalato interesse
Karol Adamczyk	Krakow	PhD	B -> D* tau nu polarisation	Presentato a WG,B2GM e B2TIP
Himansu Sahoo, Don Summers	Mississippi	Staff	B -> D(*) tau nu	Segnalato interesse
b -> u l nu				
Alexander Ermakov	Melbourne	PhD	B -> Xu l nu (inclusive)	Segnalato interesse, fatto in Belle
Matic Lubej, Anze Zupanc	Ljubljana	Staff and students	B -> pi l nu and Bs -> K l nu	Presentato a WG,B2GM e B2TIP
Missing Energy				
Elisa Manoni	Perugia	Staff	B -> K(*) nu nu tagged	Presentato a WG,B2GM e B2TIP
Johannes Grygier	Karlsruhe	PhD	B -> K(*) nu nu tagged	Segnalato interesse, attivi Belle
James Kahn	LMU	PhD	B -> K(*) nu nu tagged	Segnalato interesse, attivi Belle
Sasha Glazov	DESY	Staff and students	B -> K(*) nu nu tagged	Segnalato interesse, attivi Belle
Gianluca Inguglia	DESY	Staff	B -> nu nu (gamma)	Presentato a WG,B2GM e B2TIP

B →l ν

Status report → Mario Merola



Very clean theoretically, hard experimentally

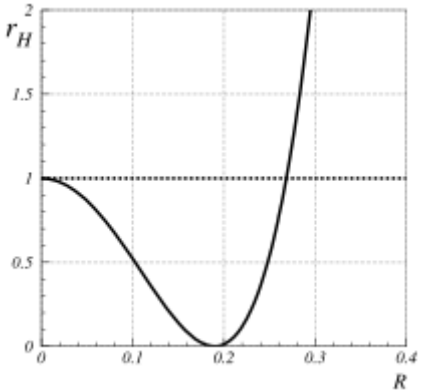
SM contribution suppressed by helicity

Sensitive to NP contribution (charged Higgs)

$$\mathcal{B}(B \to l\nu) = \frac{G_F^2 m_B}{8\pi} m_l^2 (1 - \frac{m_l^2}{m_B^2})^2 f_B^2 |V_{ub}|^2 \tau_B$$

$$\mathcal{B}(B \to l\nu) = \mathcal{B}(B \to l\nu)_{SM} \times r_H$$

$$r_H = (1 - \tan^2\beta \frac{m_B^2}{m_H^2})^2$$



STANDARD MODEL PREDICTIONS

Mode	$\mathcal{B}(B^+ \to \ell^+\nu_\ell)$	
$\tau\nu_\tau$	$(1.01 \pm 0.29) \times 10^{-4}$	*Accessible with current data sets*
$\mu\nu_\mu$	$\sim 0.45 \times 10^{-6}$	*Need Belle II statistics*
$e\nu_e$	$\sim 0.8 \times 10^{-11}$	*Beyond the reach of experiments*

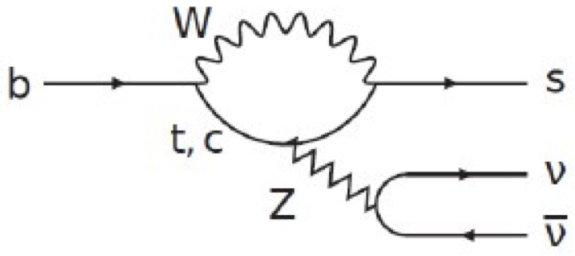
$$R^{\tau e} = \frac{\Gamma(B \to e\nu)}{\Gamma(B \to \tau\nu)}$$

$$R^{\tau\mu} = \frac{\Gamma(B \to \mu\nu)}{\Gamma(B \to \tau\nu)}$$

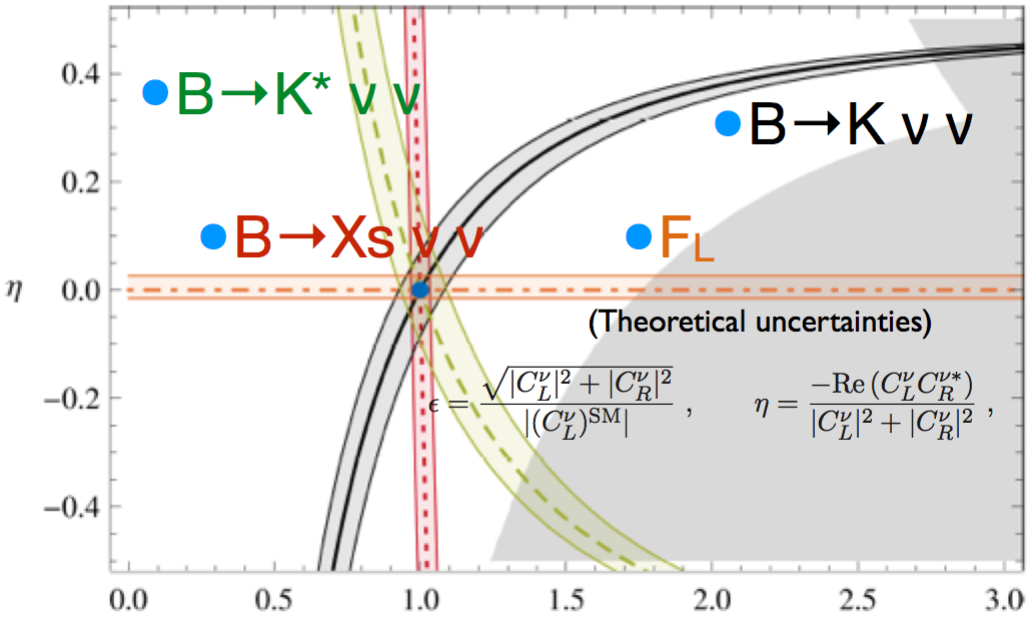
Belle II can also test lepton flavour universality

$B \rightarrow K^{(*)} \nu \nu$

Status report → Elisa Manoni

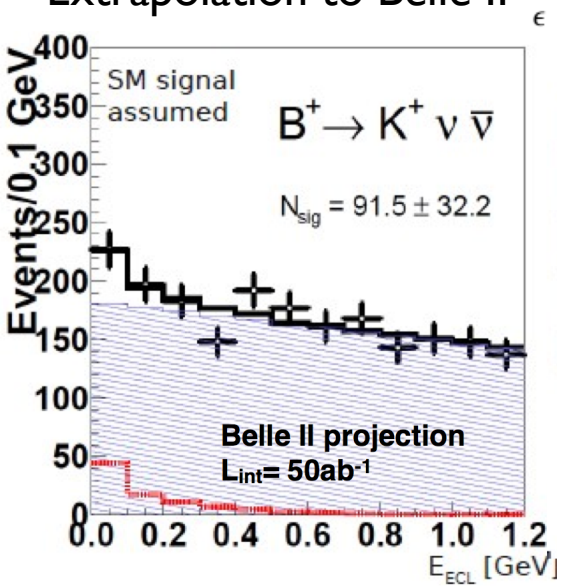


Altmannshofer et al., JHEP 0904:022,2009



B → K(*) ν ν possible only at Belle II

Extrapolation to Belle II



Extrapolation to Belle II 30% accuracy assuming SM
With with one tag method only (hadronic)

To be considered: improvements in PID, tagging efficiency, better K_L rejection, background rejection with ECL timing…

Charmless exclusive

Anze Zupanc, Matic Lubej (Lubjana)

Lavoro in corso
Principalmente su
Misura di B →p l n
untagged

From M. Lubej talk at B2TIP, May 2016

Exclusive $|V_{ub}|$ measurements

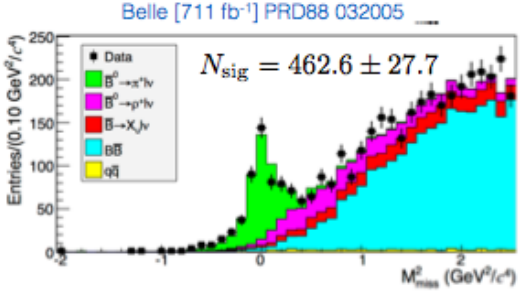
1. Tagged measurements
   - one of the two B mesons fully reconstructed in hadronic decay modes
   - *low efficiency (few 10^{-3})*
   - *high purity* and *good q^2 resolution (~ 0.25 GeV^2)*
   - *dominant source of systematic error -> Btag efficiency calibration*
   - *Expected improvement in reconstruction efficiency at Belle II can be inferred from $B \to \tau\nu$ study presented by **M. Merola on Wed @ 11:15***

2. Untagged measurements
   - neutrino 4-momentum inferred from missing energy and missing momentum of in the whole event
   - *high efficiency (~ 10^{-1})*
   - *low purity* and *bad q2 resolution (~ 0.50 GeV^2)*
   - *dominant source of systematic error -> continuum q^2 dependence + detector induced (tracking, PID)*

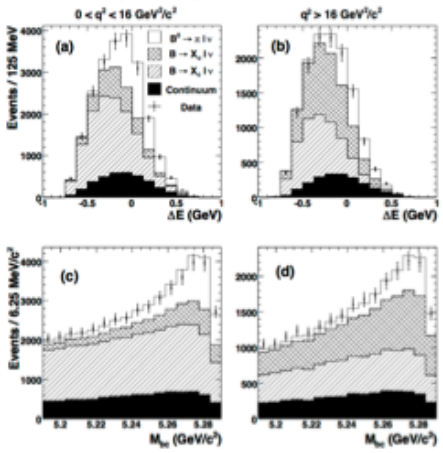
Focus of this talk

3

Belle [711 fb^{-1}] PRD88 032005



Belle [605 fb^{-1}] PRD83 071101



$N_{sig} = 21486 \pm 548$

B → π τ ν

Ryoutaro talk at B2TIP Maggio 2016

Theory side:

$|V_{ub}|$ matter has been long-standing

PDG summary (2015)

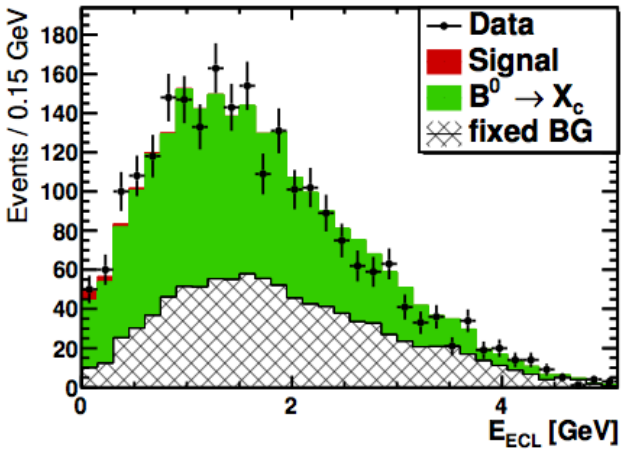
$$|V_{ub}| \times 10^3 = \begin{cases} 3.72 \pm 0.19 & \text{from } \bar{B} \to \pi \ell \bar{\nu} \\ 4.49 \pm 0.23 & \text{from } \bar{B} \to X_u \ell \bar{\nu} \\ 3.55 \pm 0.17 & \text{CKM fit} \end{cases}$$

Ratios should be good observables

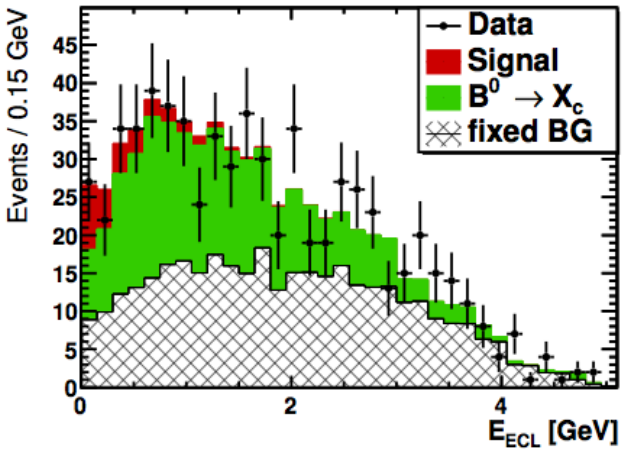
$$R_\pi = \frac{\mathcal{B}(\bar{B} \to \pi \tau \bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to \pi \ell \bar{\nu}_\ell)} \qquad R_{\rm pl} = \frac{\mathcal{B}(\bar{B} \to \tau \bar{\nu}_\tau)}{\mathcal{B}(\bar{B} \to \mu \bar{\nu}_\mu)}$$

- **In analogy with R(D)**
- **Precise theoretical evaluation available**
- **Experimentally obtainable at Belle2 (I believe)**

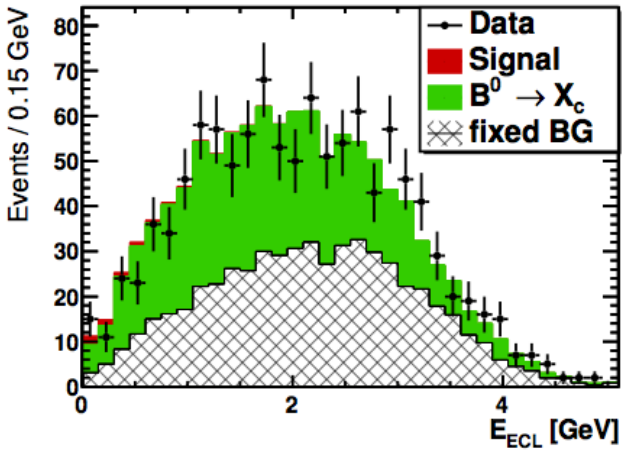
B → π τ ν exp. status



(a) $\tau \to e\nu\nu$



(b) $\tau \to \pi\nu$



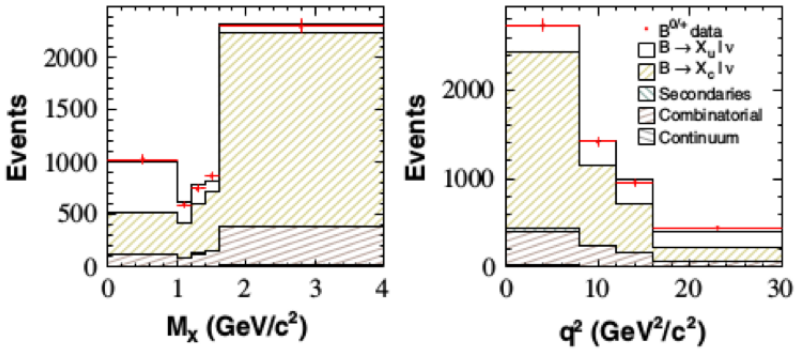
(c) $\tau \to \rho\nu$

Analisi di Belle con full dataset
arxiv:1509.06521v2
Attesa SM 9.3 10-5
BR exp < 25 10-5 @ 90% C.L.

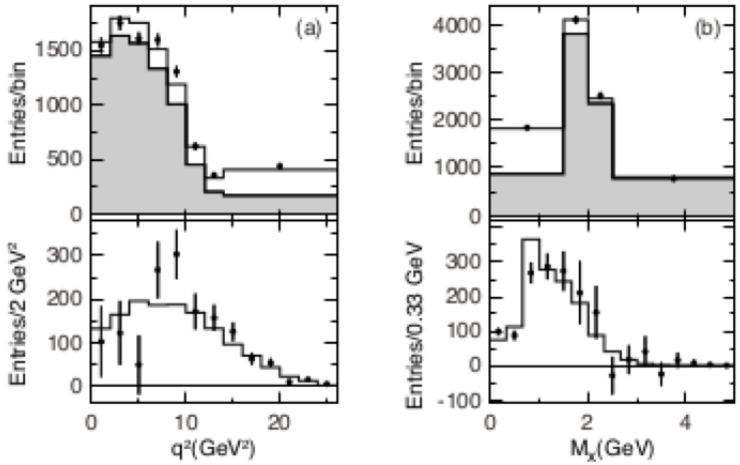
Nessuno ci sta lavorando in Belle II

Vub inclusive

Belle inclusive

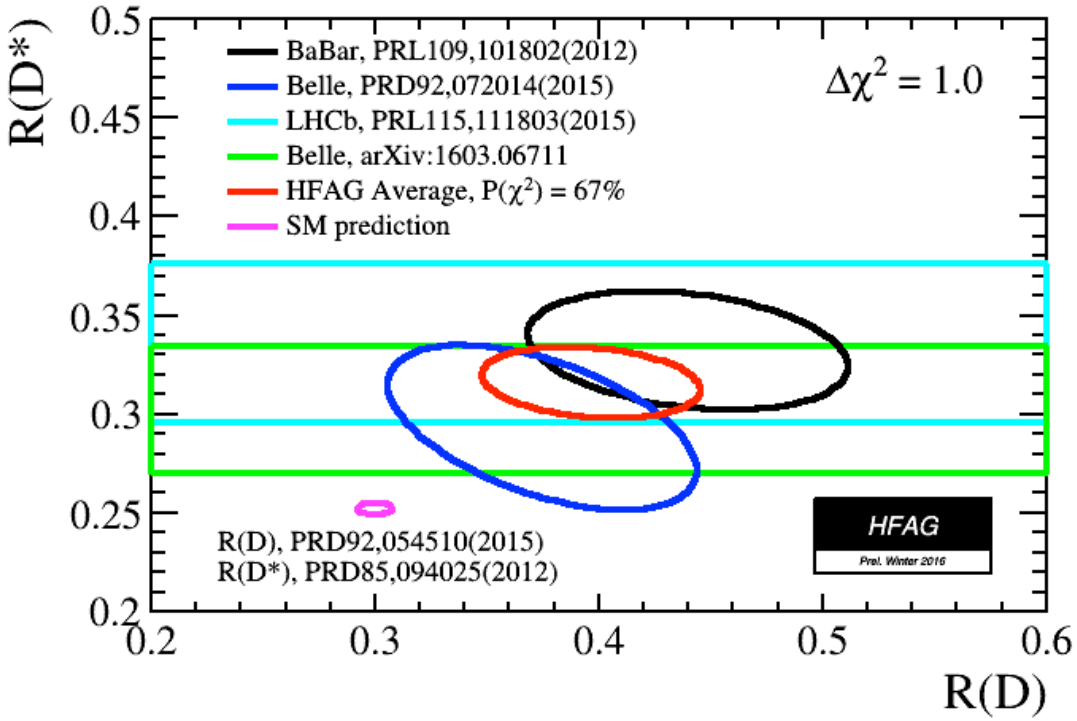


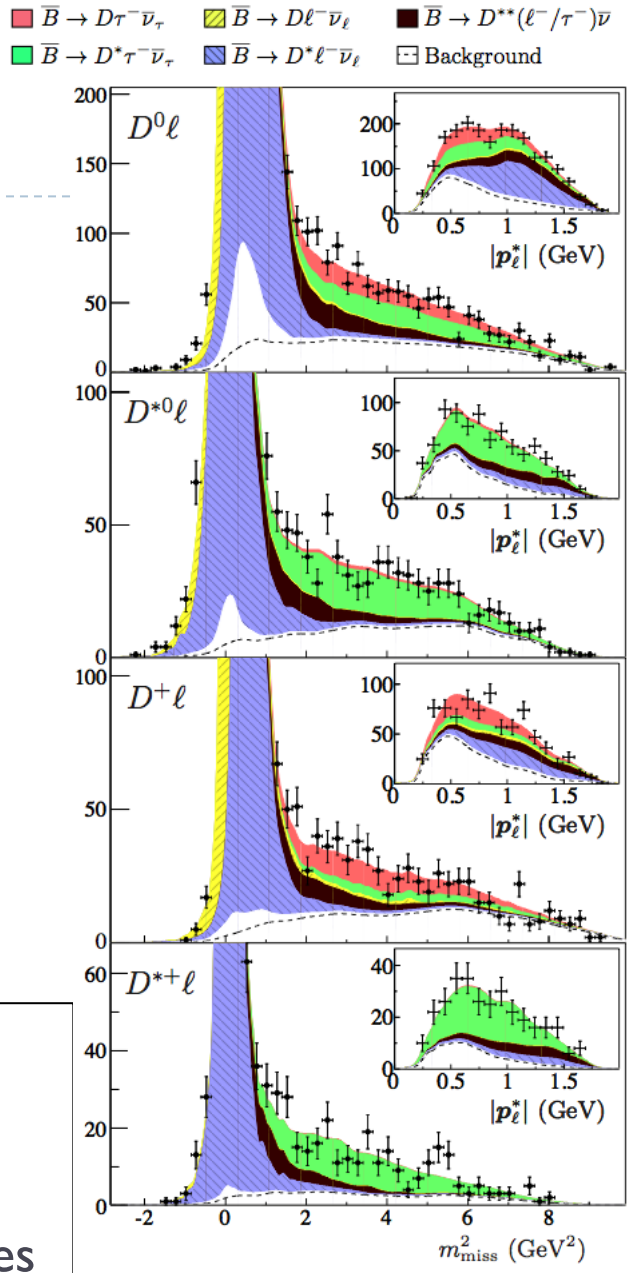
BaBar inclusive



- Principale issue di Belle II: Riduzione e precisa determinazione degli effetti sistematici (molti sono theory-related)
- Cosa vogliono i teorici in particolare?
  - Tutti i possibili spettri (precisi) nel più ampio spazio delle fasi.
- Nessuna analisi con software Belle II
  - Espresso interesse Ermakov (Univ. Melbourne) – attivo in Belle

B →D* τ ν





- Studi in Belle II
  - Karol Adamczyk (Krakow) misura della polarizzazione del tau (NP)
  - Abi Soffer(Tel Aviv/KEK visitor) vertexing studies

$B \rightarrow X_c\, l\, \nu$

(Modest) improvement of experimental uncertainties expected.

- Better determination of $B \rightarrow D^{**}\, l\, \nu$ component
- Improved control on the tag B normalization
- Largest experimental systematics from PID and tracking

We expect a 0.5% ultimate systematic uncertainty

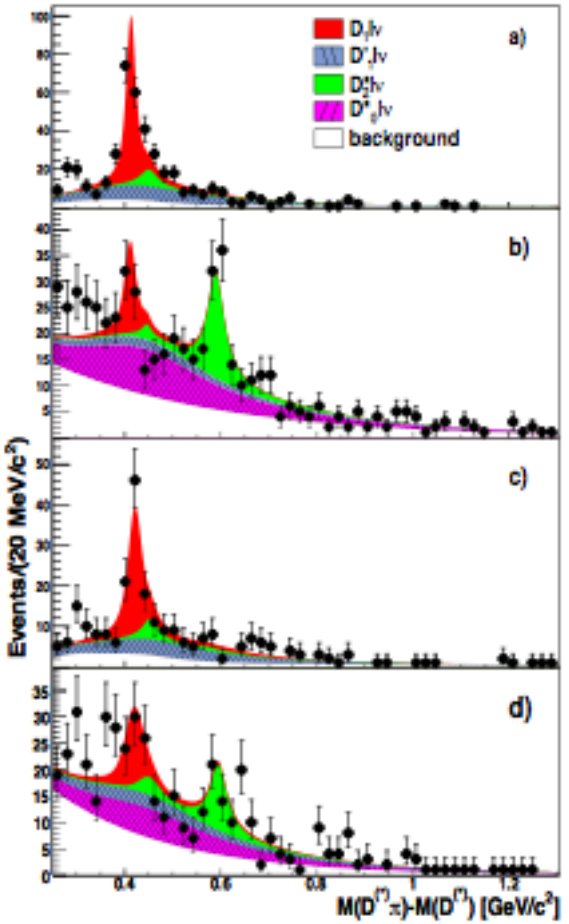
We assume theory uncertainty at 1% that will saturate the error budget

Belle II deliverables:

Detailed exploration of $B \rightarrow D\, n\pi\, l\, \nu$

Solve "puzzles" like the gap between inclusive and exclusive Vcb

Check if exclusive modes saturate inclusive rate



Fitted $D^{(*)}\pi$ mass spectrum of Phys.Rev.Lett. 101 (2008) 261802

Activity table

Canale	Untagged	Tag adronico	Tag SL
B → τ ν	---	OK	needs
B → μ ν, e ν	---	foreseen	needs
B → π l ν	OK	foreseen	needs
B →π τ ν	---	**needs**	needs
B →h l ν	foreseen	foreseen	needs
B →X_u l ν (incl.)	needs	**needs**	needs
B →D* l ν	**needs**	needs	needs
B→D* τ ν	---	foreseen	needs
B→Xc l ν (incl.)	needs	needs	needs
B-> K(*) ν ν	---	OK	needs
B →invisible	---	OK	needs