

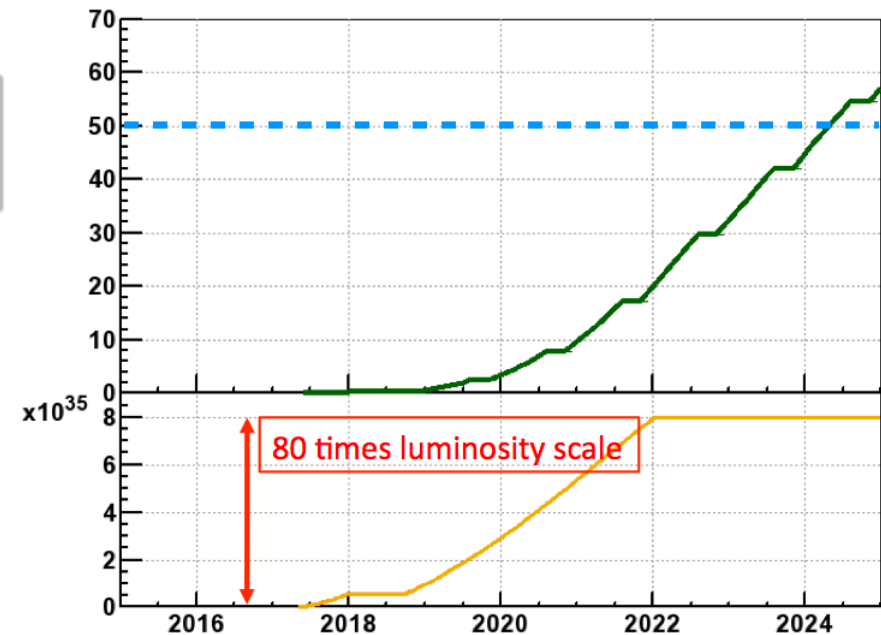
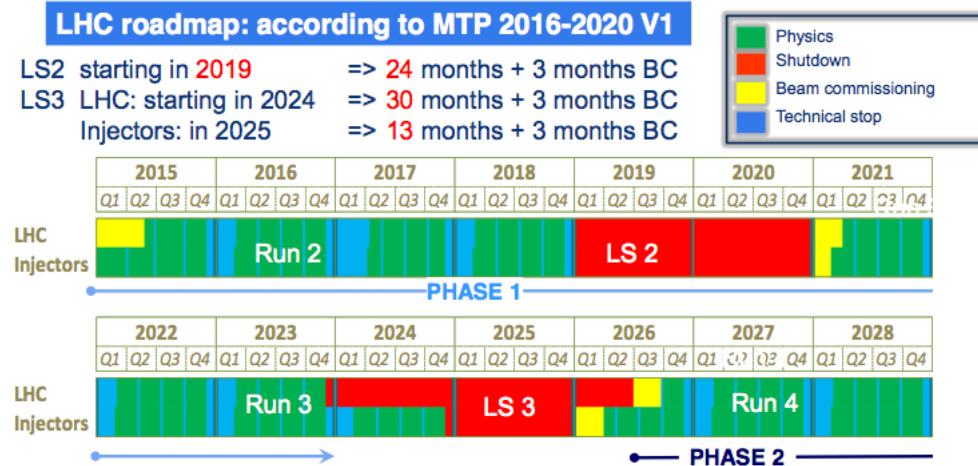
Belle II Physics Tools and Software

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



Riunione con i referee
7 Settembre 2015, Roma

Belle II and LHCb



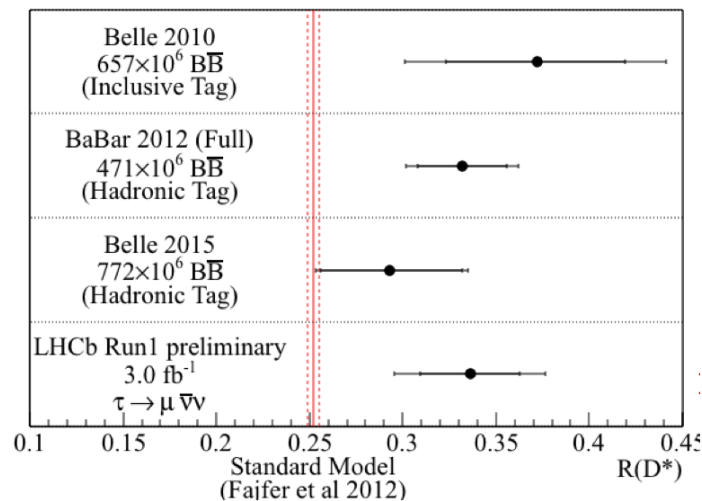
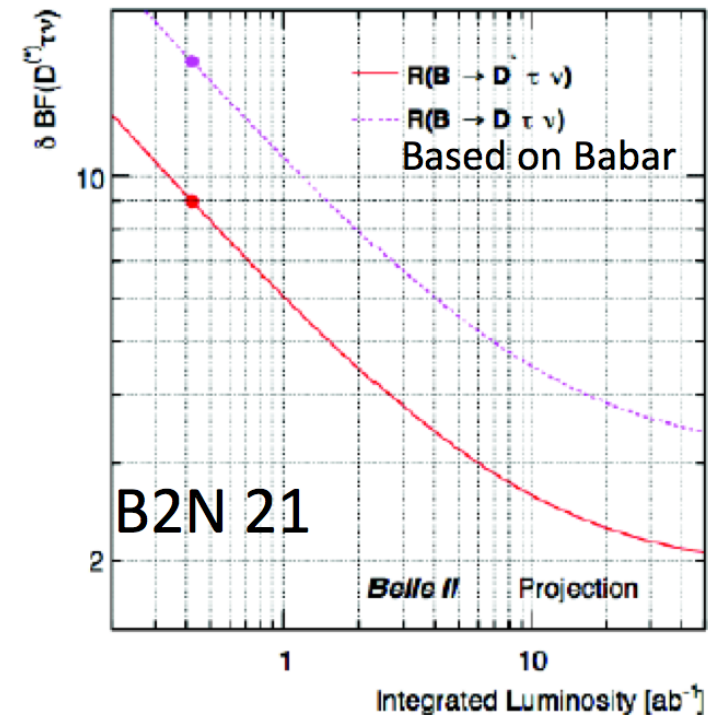
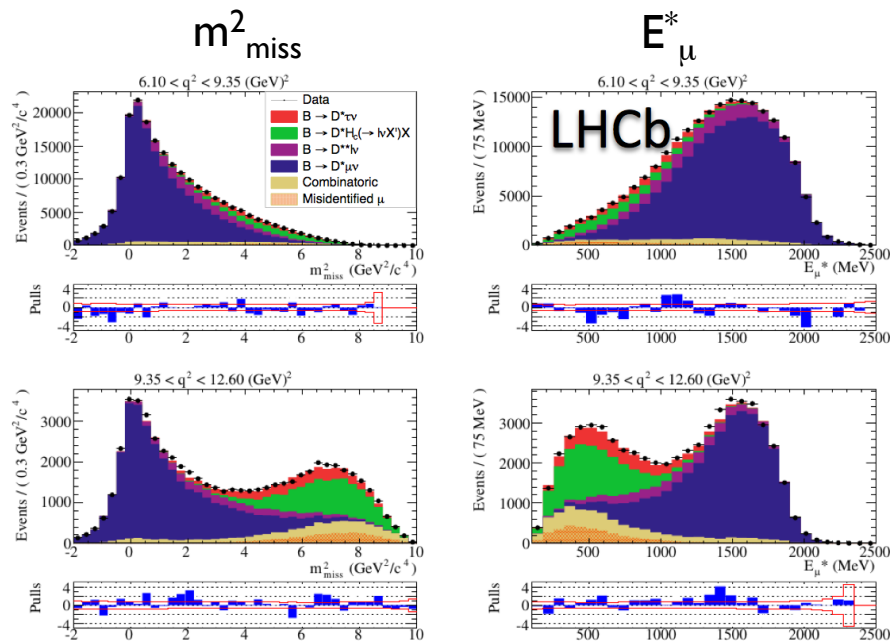
LHC-b: huge statistics from hadronic environment and excellent performances with charged tracks and muons

Belle II : e⁺ e⁻ clean environment and excellent reconstruction performances allows measurements with neutrals and missing energy.

This is why one often speaks of complementarity of the physics programs.
But...at closer look there is a large overlap, too.

Complementarity to competition: even in area that were not foreseen

LHC-b recent measurement with S.L. decays



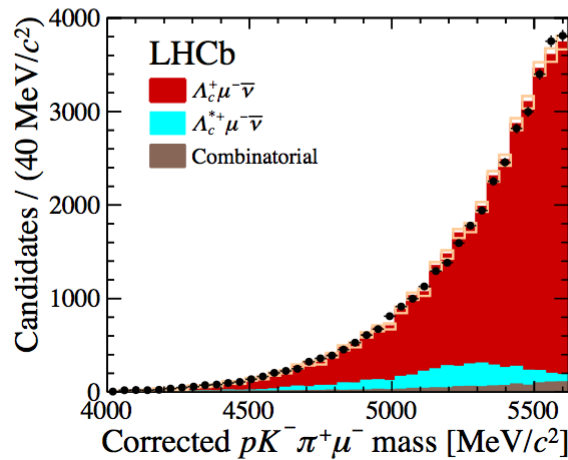
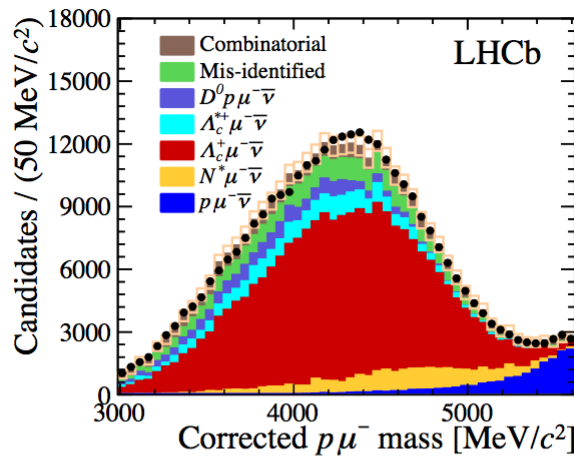
Belle II expected to dominate in long run

LHC-b precision comparable to B-factories now

Better to not delay start of data taking if we want to make a possible discovery first

$|V_{ub}| / |V_{cb}|$ with $\Lambda_b \rightarrow p \mu \nu$

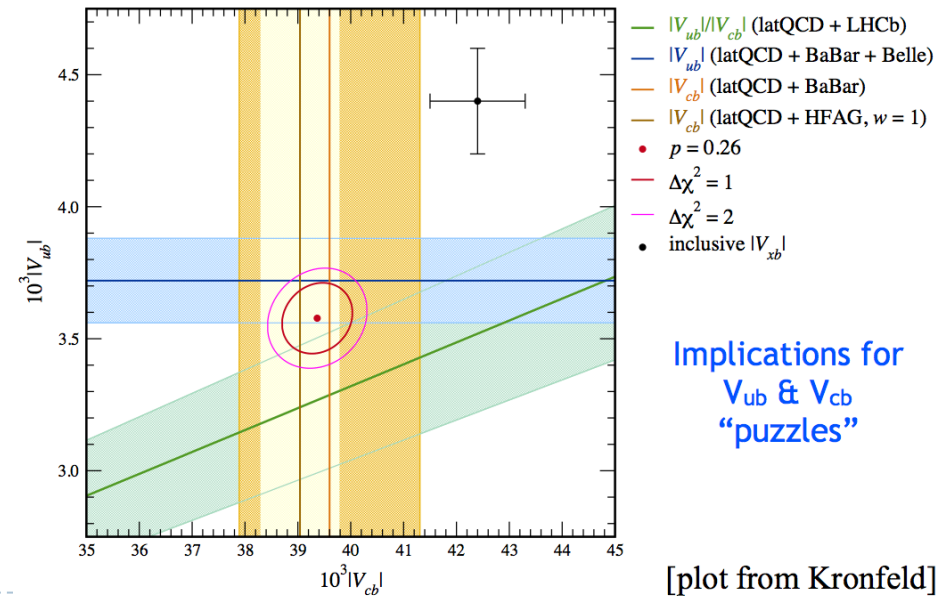
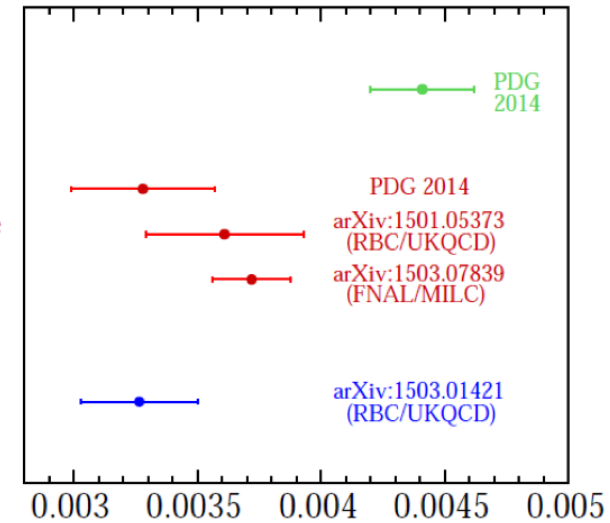
$$\frac{|V_{ub}|^2}{|V_{cb}|^2} = \frac{\int_{15 \text{ GeV}^2}^{q_{\text{max}}^2} \frac{d\Gamma(\Lambda_b \rightarrow p \mu^- \bar{\nu}_\mu)}{dq^2} dq^2}{\int_{7 \text{ GeV}^2}^{q_{\text{max}}^2} \frac{d\Gamma(\Lambda_b \rightarrow \Lambda_c \mu^- \bar{\nu}_\mu)}{dq^2} dq^2} (0.68 \pm 0.07)$$



Inclusive

Exclusive
($B \rightarrow \pi l \nu$)

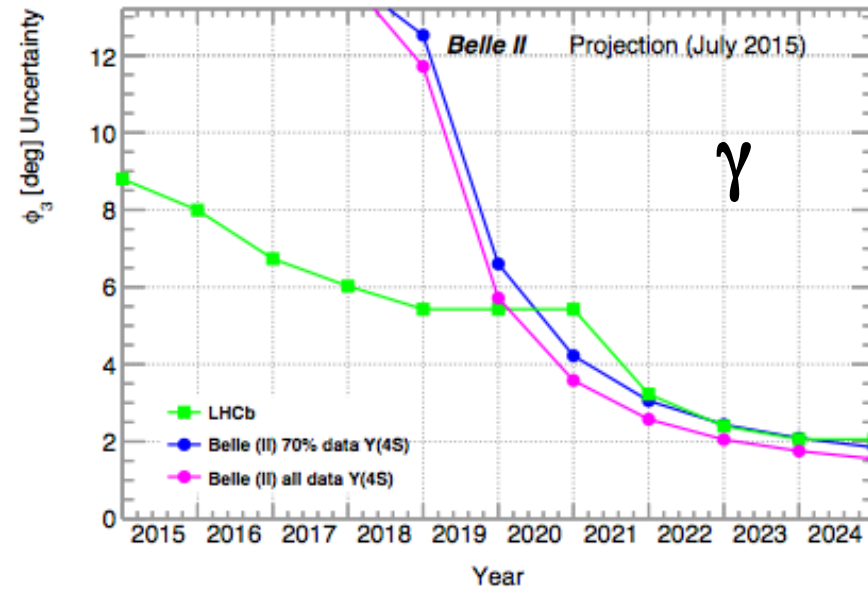
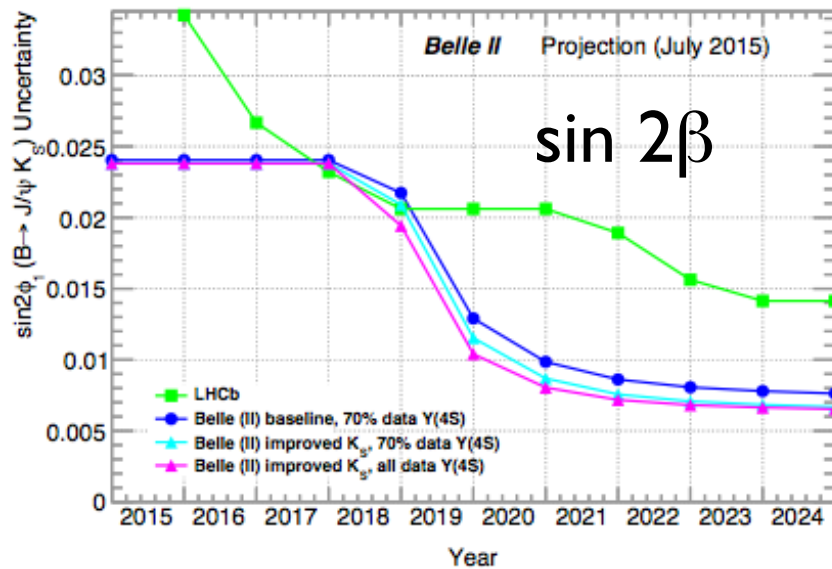
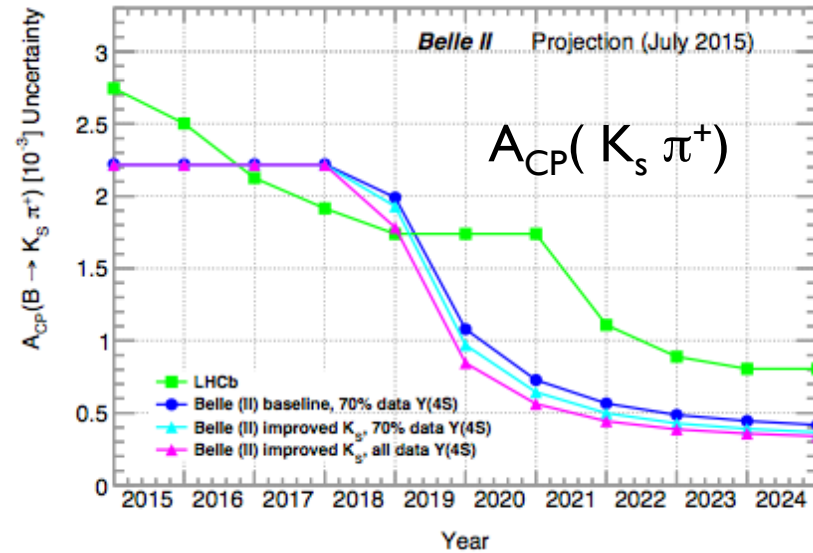
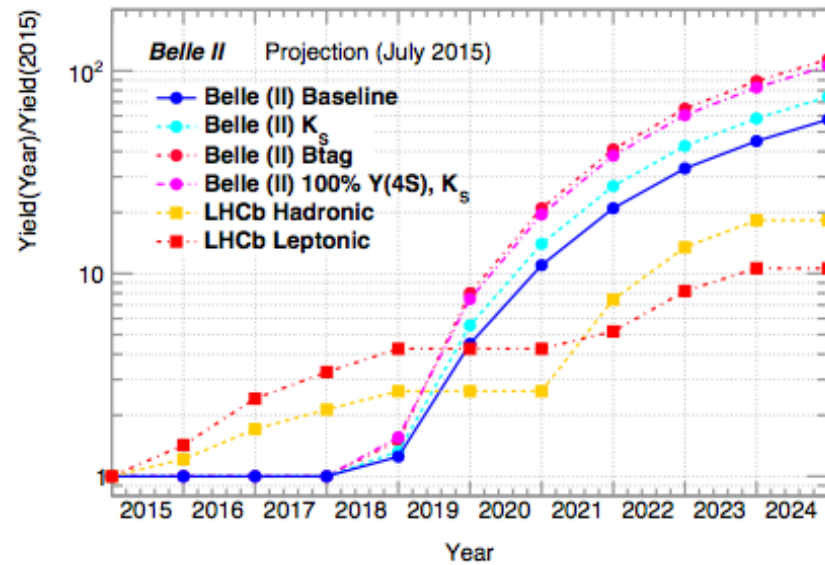
LHCb
($\Lambda_b^0 \rightarrow p \mu \nu$)



Implications for
 V_{ub} & V_{cb}
"puzzles"

[plot from Kronfeld]

From complementarity to competition



Coinvolgimento italiano e progressi

- ▶ **Significativo impegno su software di ricostruzione**
 - ▶ Correlato ai sottosistemi in cui siamo impegnati
 - ▶ Gli studi di Fisica richiedono una simulazione dettagliata realistica e un software di ricostruzione robusto e performante

Item	Persone
Software Tracking	E. Paoloni* (PI), G. Casarosa(PI)
Software Calorimetro	E. De Lucia (LNF), G. De Nardo (NA), E. Manoni (PG), B. Oberhof (LNF)
Identificazione elettroni	G. De Nardo (NA)

* Convener Tracking

Software development

From Software coordinator report talk @ June B2GM

All “accepted” task have been successfully completed

Feature	Status	Responsible	Redmine Issue
CDC local tracking for cosmics	postponed	Oliver Frost	1373
V0 datamodel	accepted	Markus Prim	1014
V0 with mass window criterion for Ks to allow Ks originating from inside the beampipe	accepted	Tobias Schlueter or somebody from Tohoku university	1374
Ks efficiency close to Belle I	postponed		
VXD and CDC track hit pattern available in mdst	accepted	Giulia Casarosa 	1376
Track merging w/o MC information (best candidate selection may still rely on MC)	postponed	Benjamin Oberhof 	
Working ECLCluster to MCParticle truth matching (with beam background mixed in)	accepted	Benjamin Oberhof 	1377
ECLCluster reconstruction without the bias in energy when beam background is mixed in	accepted	Alex Bobrov	1378
Proper treatment of ECLClusters timing and selection to reduce the array size when beam background is mixed in	accepted	Elisa Manoni or Erika de Lucia 	1379
Reasonable dE/dx PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Christian Pulvermacher	1380
Reasonable TOP PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Marko Staric	1381
Reasonable ARICH PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Luka Santelj	1382
Reasonable ECL PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Guglielmo de Nardo 	1383
Reasonable KLM PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Leo Piilonen	1384
Reasonable combined PID likelihoods for all charged stable particle hypotheses (including deuterons)	accepted	Marko Staric	1385
Delta Z resolution better than Belle I	postponed		
Slow pion efficiency close to Belle I	postponed		
Dummy database access	postponed	Lynn Wood	
Decay files signal MC package	accepted	Phill Urquijo	1386

Check	Status	Responsible	Plot or Test
Track finding and fitting efficiency for cosmics in the CDC (produced with the cosmics generator) > 80%	postponed	Oliver Frost	
Ks efficiency if both daughter tracks are found > 90%	passed	Paul Jaeger	
MC matching for ECLClusters works	passed	Anze Zupanc	
Difference between reconstructed and generated ECLCluster energy < 5 MeV	passed	Alex Bobrov	
Any cut on PID LH ratio L_i/L_j increases the signal fraction N_i/N_j for all i and j and all detector combinations	passed	Marko Staric	
No degradation of z vertex resolution	passed	Giulia Casarosa	
Memory usage of a standard simulation and reconstruction job for generic BBbar events in single processing mode < 2 GB	passed	Thomas Kuhr	plot, plot
Crash frequency of a standard simulation and reconstruction job for generic BBbar events on KEKCC < 1e-5	passed	Thomas Kuhr	1 crash observed for 500k even

Tracking

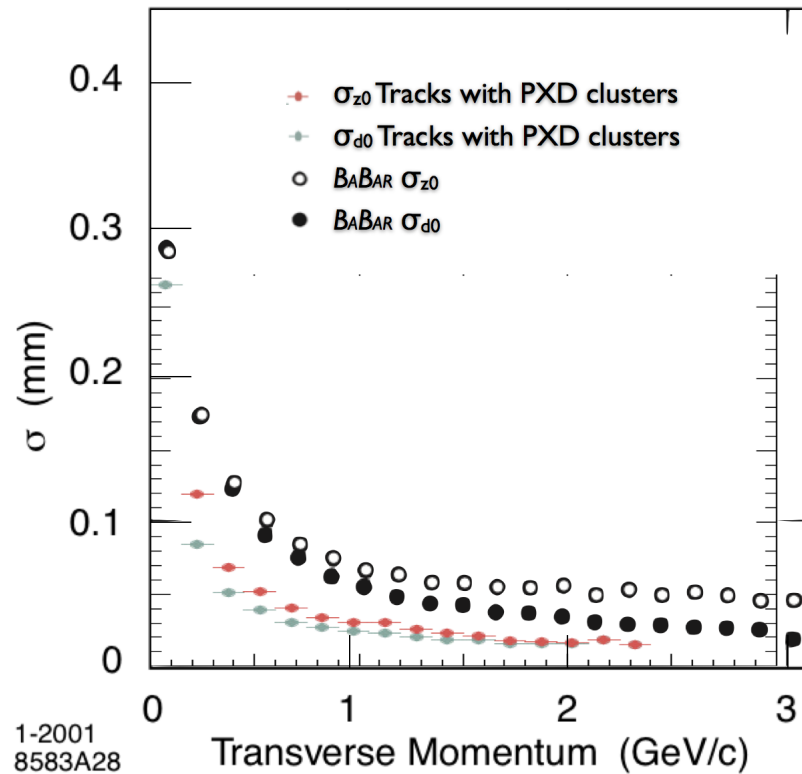
From G. Casarosa talk at June 2015 B2GM

efficiency (%) (*)	release-00-05-01
physical	85.7 ± 0.1
geom. accept. & det. ineff. factored out	94.3 ± 0.1
pattern recognition	96.8 ± 0.1

-12% inefficiency
w.r.t last B2GM

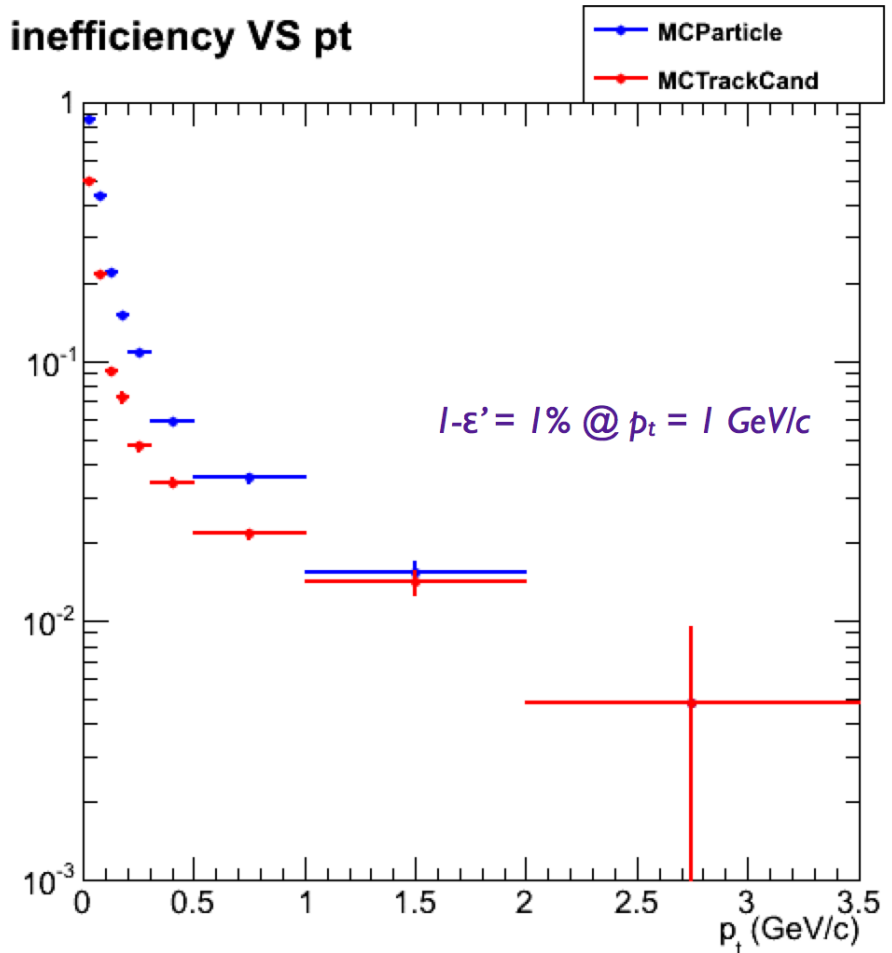
-12% inefficiency
w.r.t last B2GM

-18% inefficiency
w.r.t last B2GM

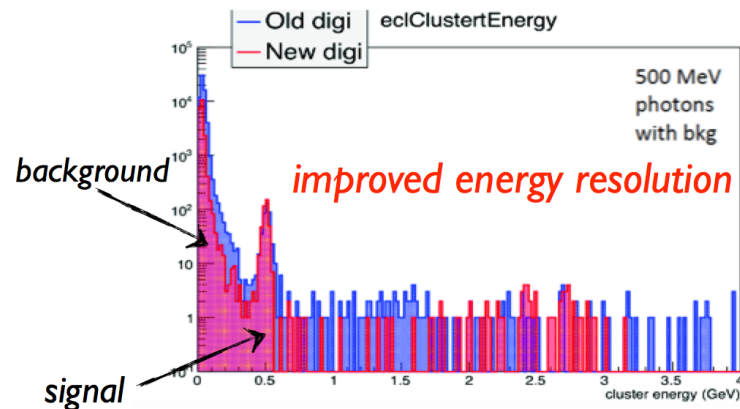


1-2001
8583A28

inefficiency VS pt

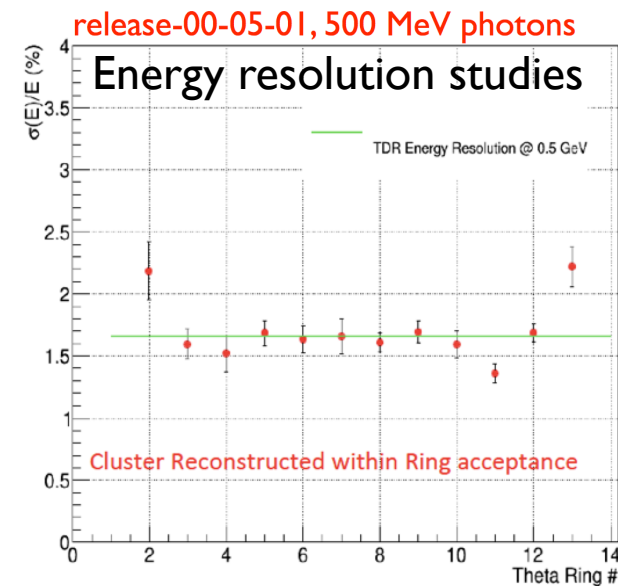
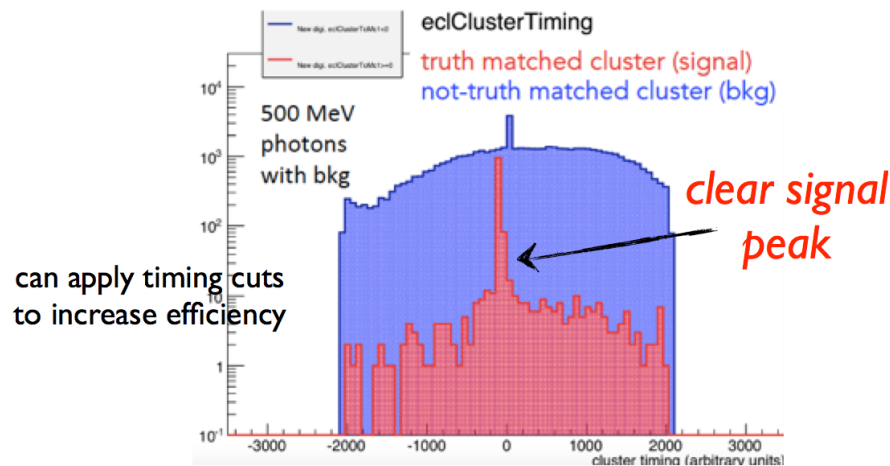


ECL digitization and MC Truth matching

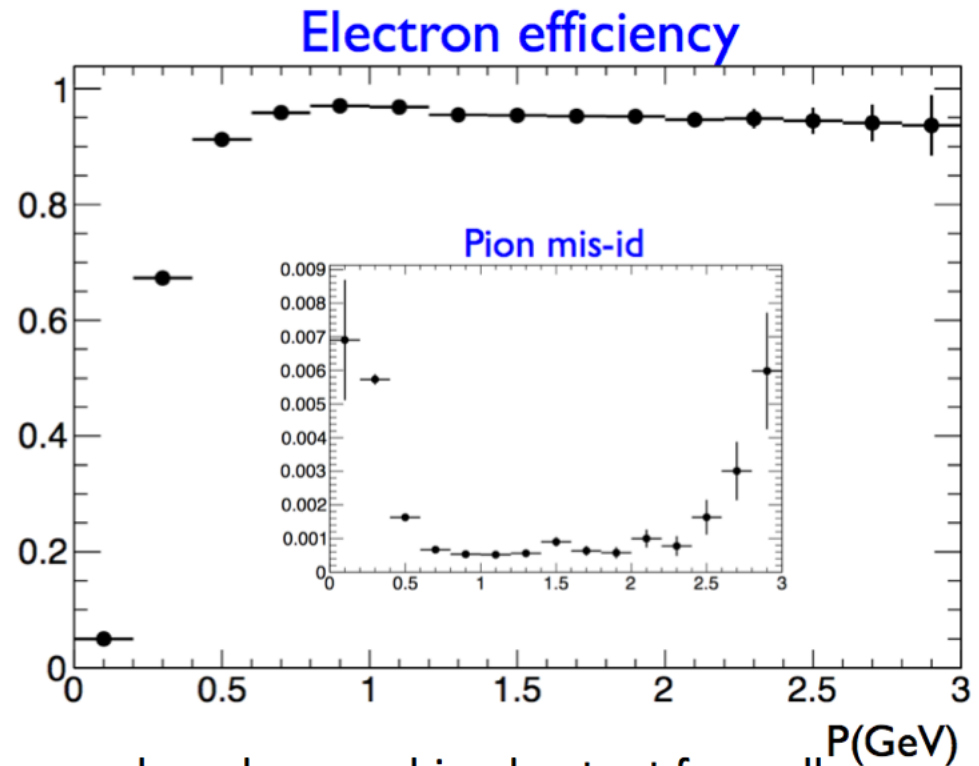
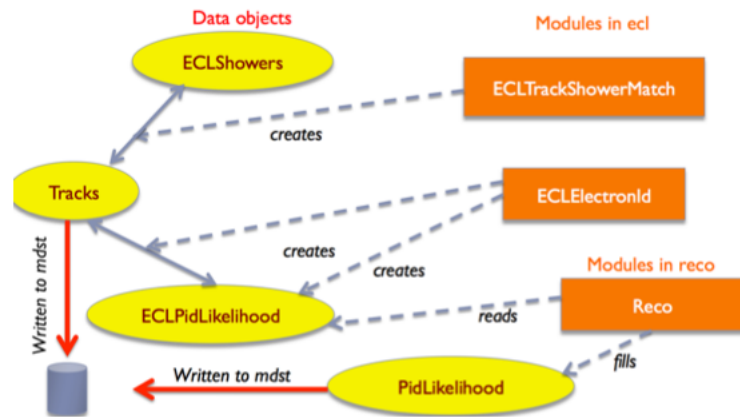


E. De Lucia (LNF)
G. De Nardo (NA)
E. Manoni (PG)
B. Oberhof (LNF)

Timing studies



Electron identification



PID selection base on a likelihood response based on combined output from all Subdetectors capable of PID

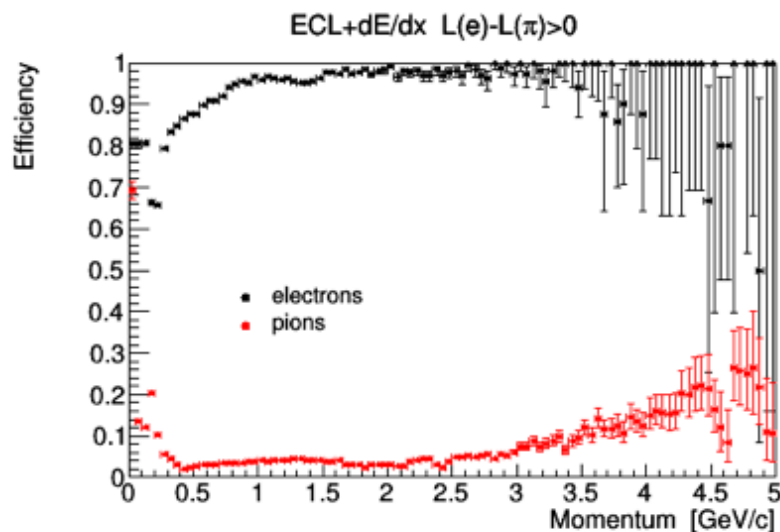
e-ID currently uses E/p from ECL and dE/dx from SVD+CDC

6

Electron identification

From J.Bennet talk @ 28 August
Belle II Physics meeting checking
Ongoing MC production results

MC 4.5

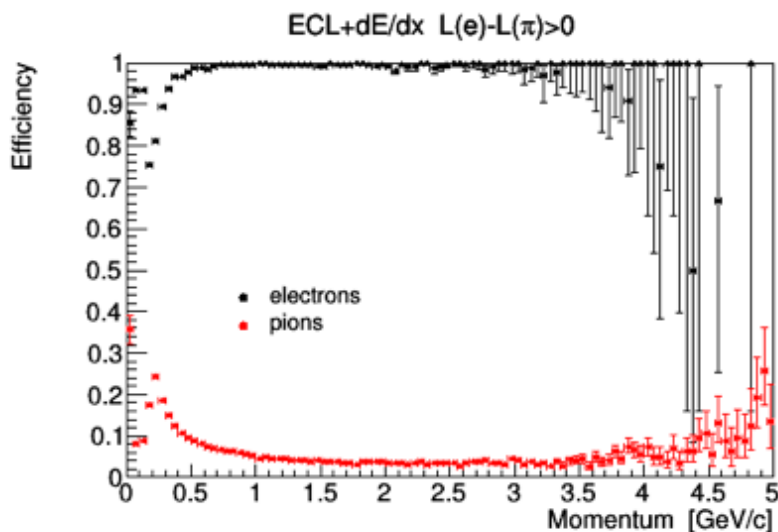


Previous MC production

Improvements from several area

ECL reconstruction (digitization),
dE/dx simulation and reconstruction software in CDC and SVD
Tuning of p.d.f. parameterization (ECL)

MC 5



On-going MC production (August data)

Focus shifting towards Physics Analysis

- ▶ Studiare nel dettaglio il Physics reach dell'esperimento
- ▶ Raffinare le tecniche sperimentale per ridurre gli effetti sistematici
- ▶ Disponibilità di un software core e un set Physics Tools abbastanza completi
- ▶ Prima produzione massiva di eventi generici (fondo fisico)
 - ▶ Iniziata ad Agosto 2015 (vedi talk Computing)

Interessi ed attività

Item	Persone
Modi con Missing energy	E. De Lucia (LNF), G. De Nardo (NA), E. Manoni (PG), B. Oberhof (LNF)
Charm	G. Casarosa (PI)
Charmless	A. Gaz (PD), S. La Caprara (PD)
Fisica alla fase 2	R. Mussa (TO), U. Tamponi(TO)
Tau decays	B. Oberhof (LNF)

Si aggiungeranno presto M. Merola(NA) e E.Bernieri (RM3).

Si spera anche altri!

B2TIP

- ▶ Network sperimentali Belle II e teorici per la definizione del Programma di Fisica dell'esperimento
 - ▶ <https://belle2.cc.kek.jp/~twiki/bin/view/B2TiP>
- ▶ Prossimi appuntamenti:
 - ▶ 28-29 ottobre 2015 (KEK)
 - ▶ 23-25 maggio 2015 (USA)
- ▶ Deliverable: Physics Book da pubblicare nel 2017
- ▶ Status: Preparato outline ed identificati canali di Fisica da studiare nel dettaglio
 - ▶ Lavoro in corso: analisi con full simulation e proiezioni del physics reach e confronto con LHC-b
 - ▶ Qualche mese di ritardo sulla schedule per lo shift della produzione MC (iniziata a metà agosto)

**Emi Kou intro talk
@Cracovia workshop
27 Aprile 2015**

Why B2TiP

See details on the slide at the kickoff meeting:

<http://kds.kek.jp/getFile.py/access?contribId=14&sessionId=0&resId=0&materialId=slides&confId=15226>

KEK where Belle II is hosted is the natural **gathering point** where flavour physics experts meet to discuss and develop topics of flavour physics for Belle II.

**What's new in Belle II
compared to Babar/Belle?**

- ➔ Efficiencies and precision of the new hardware
- ➔ New analysis softwares and methods

**What's new in theory after Babar/
Belle & LHCb result?**

- ➔ Progresses in QCD
- ➔ New physics models and their constraints
- ➔ New observables

NEW IDEAS

Deliverable: “KEK green report” by the early 2017

9 working groups

Emi Kou intro talk
@Cracovia workshop
27 Aprile 2015

See details on the B2TiP website

<https://belle2.cc.kek.jp/~twiki/bin/view/Public/B2TiP>

WG1	G. De Nardo, A. Zupanic, M. Tanaka, F. Tackmann, A. Kronfeld
WG2	A. Ishikawa, J. Yamaoka, U. Haisch, T. Feldmann
WG3	T. Higuchi, L. Li Gioi, J. Zupan, S. Mishima
WG4	J. Libby, Y. Grossman, M. Blanke
WG5	P. Goldenzweig, M. Beneke, C.-W. Chiang, S. Sharpe
WG6	G. Casarosa, A. Schwartz, A. Kagan, A. Petrov
WG7	Ch.Hanhart, R.Mizuk, R.Mussa, C.Shen, Y.Kiyo, A.Polosa, S.Prelovsek
WG8	K. Hayasaka, T. Feber, E. Passemar, J. Hisano
WGNP	R.Itoh, F.Bernlochner, Y.Sato, U.Nierste, L.Silvestrini, J.Kamenik, V.Lubicz

I: Leptonic/Semi-leptonic II: Radiative/Electroweak III: $\phi_1(\text{beta})/\phi_2(\text{alpha})$ IV: $\phi_3(\text{gamma})$
V: Charmless/hadronic B decays VI: Charm VII: Quarkonium(like) VIII: Tau & low multiplicity NP: New Physics

Emi Kou intro talk

@Cracovia workshop
27 Aprile 2015

Workshop schedule

To receive information, subscribe to the mailing list b2tip@... send an e-mail to Ph.Urquijo



Comments on the schedule

✓ While Belle II start up will delay, we will follow our original schedule, i.e. completing the report by the early 2017.

✓ Between completion of report and before Belle II start-up, new LHC results may impact Belle II physics case. For this, we will plan a “second edition/revised version” of the report. Format/procedure is under discussion.

B2TIP phases

Phase 1: Planning and discussion

- Identify the key modes
- Propose and discuss the layout of the sections
- Identify resources and share the work

Done

see attachment

Phase 2: Work on the physics analysis, write draft of the sections

- Detailed studies of the main modes (exp/th)
- Start studies based on Belle II simulation where possible:
 - Look new variables not accessible at Belle.
- Draft theory and experimental sections

2015

All collaborators are welcome to contribute to sensitivity studies - contact the WG coordinators

Phase 3: Editing

- Review of the analyses/the text
- Final editing
- Finalise performance parameters from Belle II simulation
- Finalise physics analyses

2016

Milestones 2015 (B2TiP Driven)

	Physics Group Goal	Topic	Details/Notes	MC data requirements
1	BPAC	BPAC 2015 + B2GM Reports	Algorithm/full-chain demonstration - not full sensitivities yet. Beam background not fully considered. (Receive feedback on MC14 studies)	100 fb ⁻¹ Generic
	B2TiP April Krakow	Experimental reports		
2		Flavour analysis		0.3–1 ab ⁻¹ Generic (u,d,s,c,b,tau)
	KEKFF/ B2TiP October 2015	Scans & First physics (Quarkonium)	BEAST Phase II configuration for Y(3S) running	150 fb ⁻¹ Scan & (3S, 5S+)
		Trigger Simulation & Low Multiplicity	Full detector for all others	10-100 fb ⁻¹ Low Multi & Dark NP
3	B2TiP May 2016	B2TiP Pittsburgh	Towards final report. Partial delivery by the time of B2TiP USA	~5 ab ⁻¹ Generic (inc. tau) 20+ ab ⁻¹ Equivalent ("Rare" MC) 20+ ab ⁻¹ Equivalent (B _{tag} -skim) 300 fb ⁻¹ Scan & non 4S 50-100 fb ⁻¹ low-lumi

S.L. and missing energy

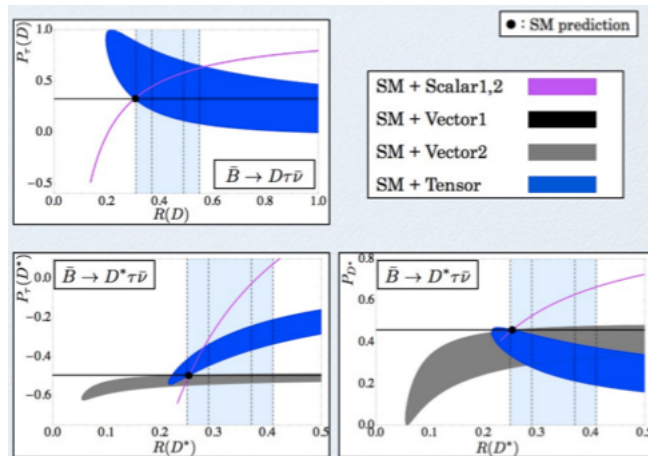
Exp. Conveners:
G. De Nardo (NA)

A. Zupanc
For reference

B2TiP Golden Modes & Report Content

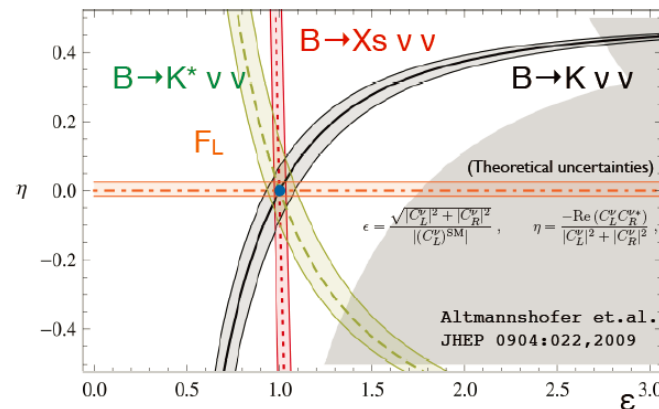
WG 1 Leptonic & Semileptonic $B_{(s)}$:

- Purely leptonic modes ($B \rightarrow \tau \nu, \mu \nu$)
- $B \rightarrow D^{(*)} \tau \nu$: R, q^2, P • **angular analysis**
- Inclusive $B \rightarrow X_c \ell \nu$
- $|V_{ub}|$ exclusive with $B \rightarrow \pi \ell \nu$ – Rate and spectra
- Inclusive $|V_{ub}|$ with hadronic tags
- Semileptonic B_s from $Y(5S)$



WG 2 Radiative & EW Penguin $B_{(s)}$:

- $\Delta A_{CP}(B \rightarrow X_s \gamma)$
- BF, A_{CP} and ΔA_{CP} in $B \rightarrow X_d \gamma$
- BF, q^2 and A_{FB}, LFU in $B \rightarrow X_s \ell^+ \ell^-$
- TCPV in $B \rightarrow K_s \pi^0 \gamma, B \rightarrow \rho \gamma$
- $B \rightarrow K^* \nu \nu$ • **theory & tagging updates**
- $B_{s,d} \rightarrow \gamma \gamma$
- LFV and LNV B decays: $B \rightarrow K \tau \mu, K \tau e, \tau \mu, \tau e$



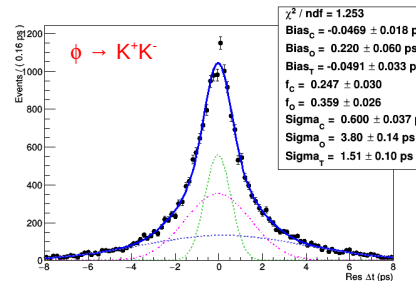
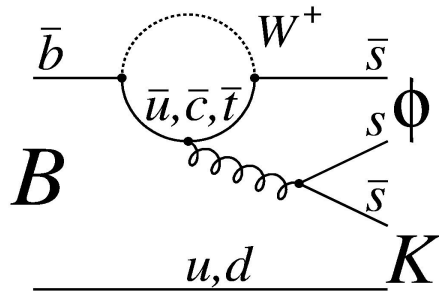
Charmless B decays

TCPV: $B \rightarrow \Phi K_S$ gluonic Penguin

For reference

A. Gaz

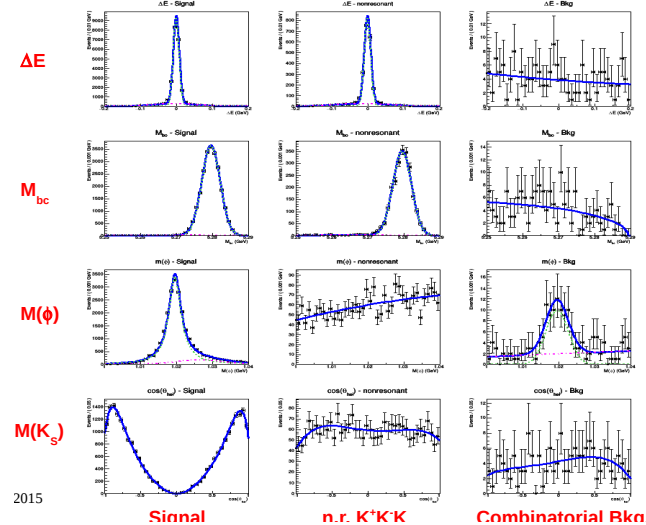
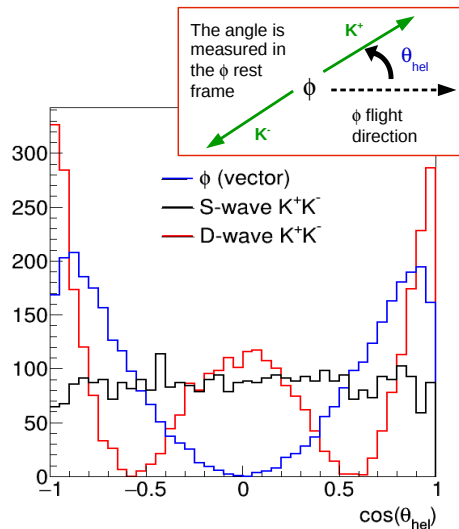
Advanced sensitivity study on Release-00-05-01



Average resolutions:
(weighted average of the components)

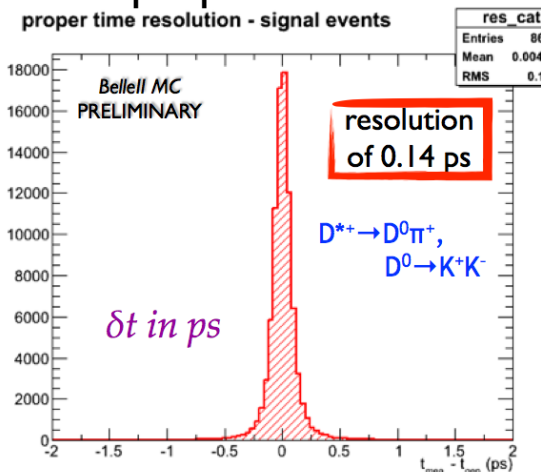
$B \rightarrow \phi(KK) K_S$:	2.11 ps
$B \rightarrow \phi(3\pi) K_S$:	1.42 ps
$B \rightarrow J/\psi(\mu\mu) K_S$:	0.90 ps

Multidimensional fit

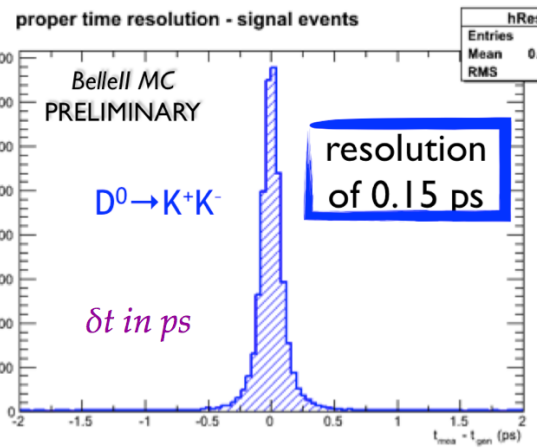


Charm

D^0 proper time resolution with and without a D^* tag



Study by G. Casarosa



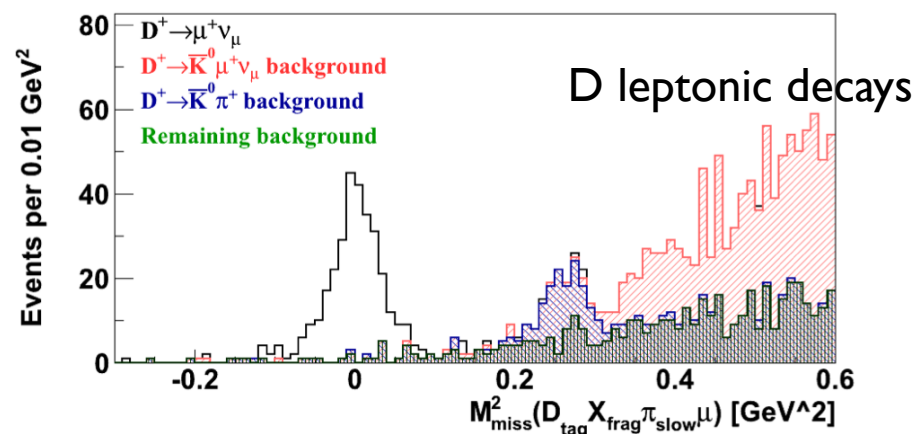
Study by G. Casarosa

Conveners:

G. Casarosa (PI)

R. Briere

MC Simulation [5.5 ab^{-1}]



D mixing

	Belle measured	Belle scaled Staric, KEKFF	PRELIMINARY Belle II simulation Schwartz, ToyMC PRELIMINARY		
luminosity	1 ab^{-1}	50 ab^{-1}	5 ab^{-1}	20 ab^{-1}	50 ab^{-1}
$\chi^2 (10^{-5})$	22	3	7.5	3.7	2.3
$\gamma'(\%)$	0.34	0.04	0.111	0.056	0.035
$ q/p $	0.6	0.06	-	-	-
ϕ	25°	2.3°	-	-	-

Richieste 2016

Ruoli di coordinamento e responsabilità riconosciute dall'esperimento

Task	Persona	Richiesta
Responsabile italiano Fisica + Convener Lept e SL + Responsabile electron identification	G. De Nardo (NA)	10
Convener Tracking	E. Paoloni (PI)	5
Convener Charm	G. Casarosa	5

Partecipazione a lavori del B2TiP

Non-KEK meeting Maggio 23-25 @Pittsburg(USA)

Final meeting and Report ottobre/novembre a Monaco

Per favorire la partecipazione alle attività chiediamo
3KE di missioni per persona (quando non già finanziato)

Sede	Persone	Richiesta
LNF	2	6
NA	1	3
PG	2	6
PD	2	6
TO	1	3
RM3	1	3