Attività di analisi a Milano Bicocca

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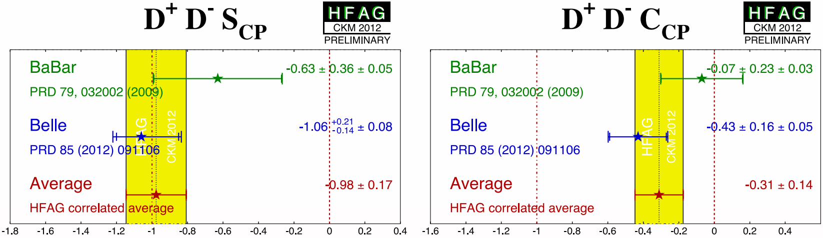
INFN Milano Bicocca

LHCb Italia Meeting, 13 ottobre 2015, Frascati

$\sin(2\beta)$ in $B^0 \to D^+D^-$

- $B^0 \to D^+D^-$ is sensitive to $\sin(2\beta)$
- not as sensitive as other channels though...but interesting for other reasons[1]:
- tension between Belle and BaBar



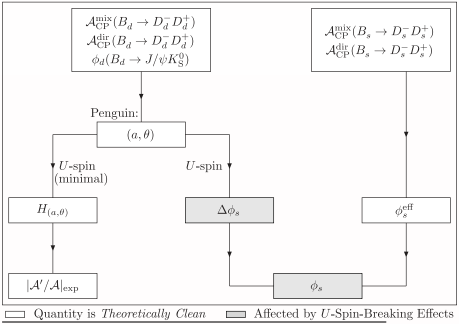
[1] See arXiv:1505.01361 or Kristof De Bruyn at "B2OC Time-Dependent workshop, Padova, July 2015"

sin(2β) in $\mathrm{B^0 \to D^+D^-}$

- $\mathrm{B^0 \to D^+D^-}$ is sensitive to sin(2β)
- not as sensitive as other channels though…but interesting for other reasons[1]:
- tension between Belle and BaBar

- measurement of CP violation parameters in $\mathrm{B^0 \to D^+D^-}$ and $\mathrm{B^0 \to J/\psi K_S}$ together provide handle on penguin contributions in $\mathrm{B}_x \to \mathrm{D}_y\mathrm{D}_z$ systems

⇝ necessary to measure ϕ_s in $\mathrm{B_s^0 \to D_sD_s}$



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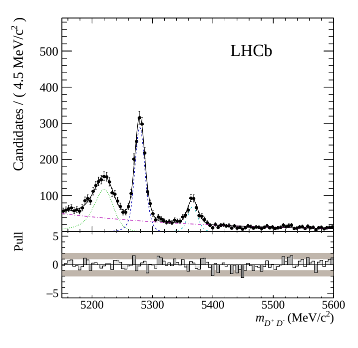
Analysis details

signal channel

- final states:
  - $B^0 \to D^+(K^-\pi^+\pi^+)D^-(K^+\pi^-\pi^-)$
  - $B^0 \to D^\pm(K^\mp K^\pm\pi^\pm)D^\mp(K^\pm\pi^\mp\pi^\mp)$
  adds $\sim 20\,\%$ signal yield



- $\sim 1435\, B^0$ yield
- $\sim 346\, B_s^0$ yield

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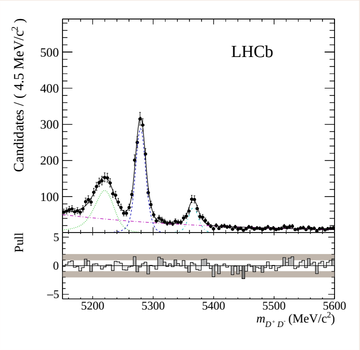
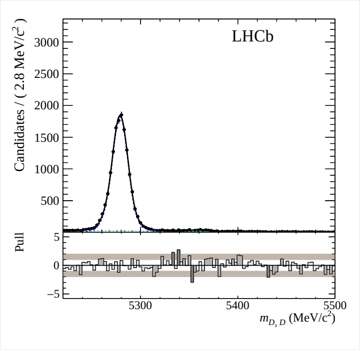


- $\sim 1435\,B^0$ yield
- $\sim 346\,B_s^0$ yield

control channel

- final states:
  - $B^0 \to D_s^\pm(K^\mp K^\pm\pi^\pm)D^\mp(K^\pm\pi^\mp\pi^\mp)$

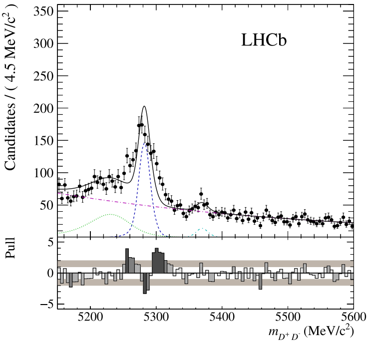


- $\mathcal{O}(10000)\,B^0$ yield
- $\mathcal{O}(100)\,B_s^0$ yield

- statistics increased by factor 2.5 over first analysis at LHCb!

Backgrounds

- when adding $KK\pi$ to the analysis, we observed something unexpected



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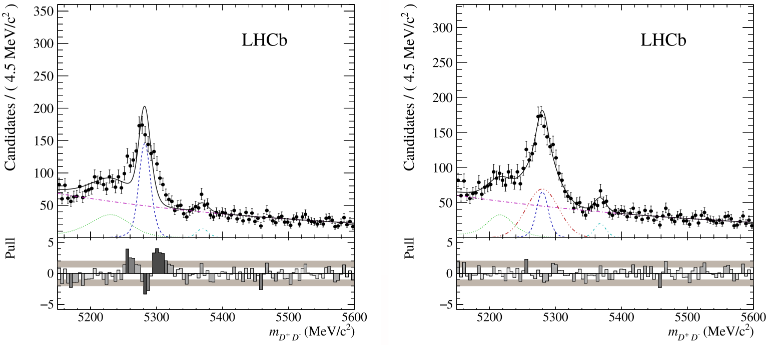


- fixing the B^0 width to the width from $\mathrm{K}\pi\pi$ does not describe the data
- fixing the B^0 width and yield to the expected values requires an additional component
- ↯ background sitting exactly at the signal peak!
- these are $\mathrm{B} \to \mathrm{DKK}\pi$ decays not going through a second D meson
- veto by requiring D flight length significance

Tagging

- expect to be statistically dominated

→ need to optimise statistical sensitivity

  - use all available taggers
    including new (uncalibrated) taggers

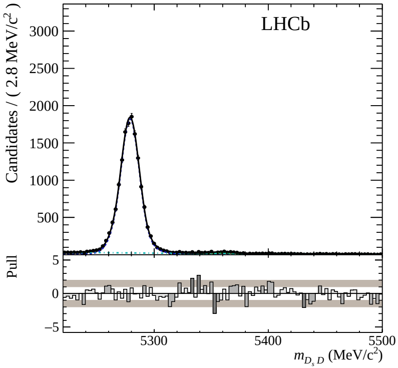
- use $\mathrm{B}^0 \to \mathrm{D_s D}$
  - flavour specific final state

  → know B flavour at decay

  → fit oscillation amplitude to obtain mistag rate
  $\mathcal{A} \propto 1 - 2\omega$

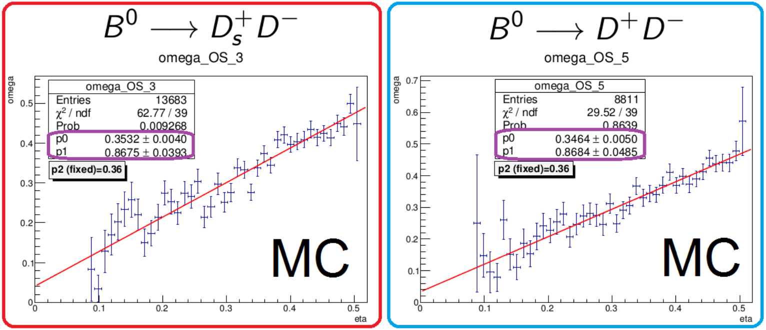
✓ B^0 oscillation is slow ⇒ damping from time resolution not an issue

✓ clean signal ⇒ little to no complication from background expected



Tagging calibration in MC

¿ Is $B^0 \to D_s D$ the right channel?

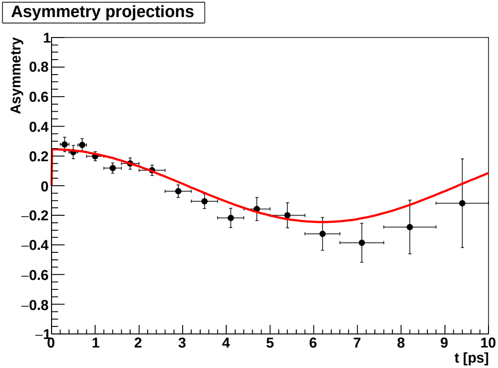


✓ Taggers perform the same on the signal and the calibration channel

- tagging efficiency
- mistag rate
- mistag rate as a function of predicted mistag rate (plot)

Tagging calibration in data (standard opposite side taggers)

- proof of principle: look at standard opposite side tagger combination



- we see an oscillation in data

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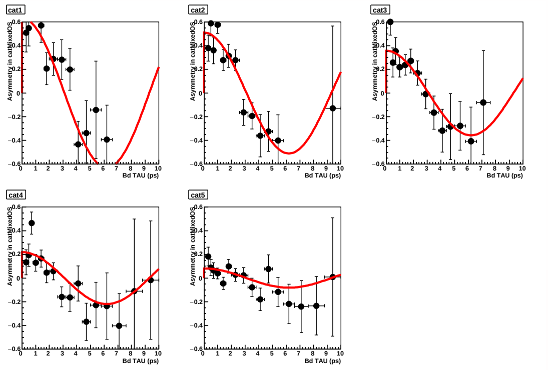

- we see an oscillation in data
- divide the the data according to predicted mistag probability
- fit oscillation in each category

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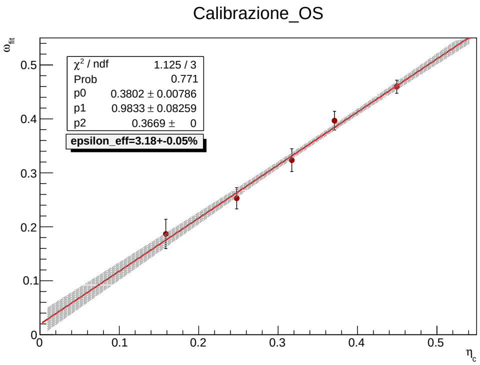
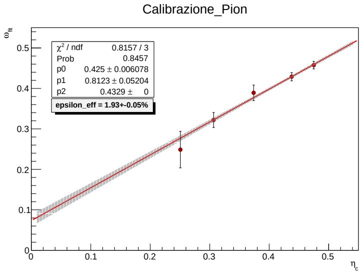
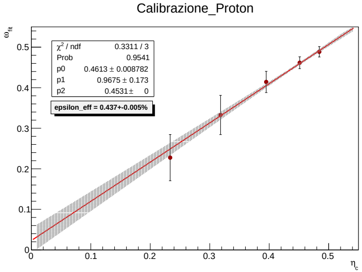


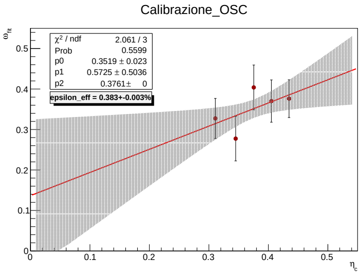
$$\omega = p_0 + p_1(\eta - p_2)$$

- we see an oscillation in data
- divide the the data according to predicted mistag probability
- fit oscillation in each category
- ✓ predicted mistags are accurate
  - $p_0 \approx p_2$
  - $p_1 \approx 1$

Tagging calibration in data (new taggers)







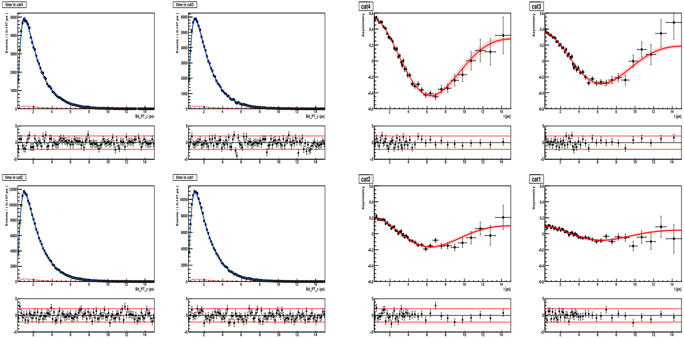
- ✓ first calibration fits are there
- ✓ very high tagging power (expect combined $\sim 6\,\%$)
- ¿ why is χ^2/ndf so good?
- → need to understand systematics!
  - sWeights
  - acceptance effects
  - remaining background

One short item in between

- B^0 oscillation frequency measurement with $B^0 \to D^{(*)}\mu\nu$

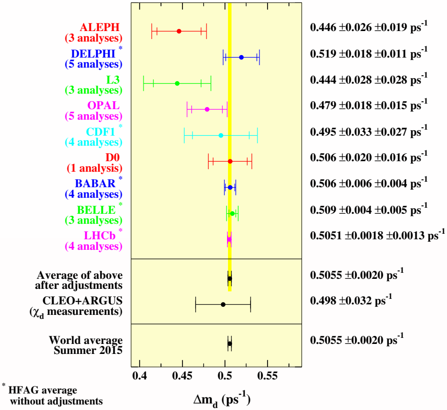
Fit projections: $B^0 \to D^{*-}\mu^+\nu_\mu$

- Time/asymmetry projections for 2012 sWeighted data



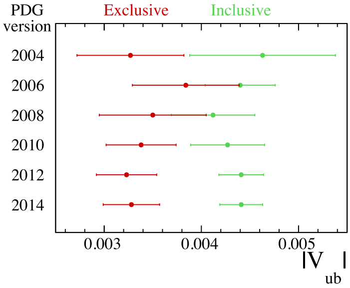
One short item in between

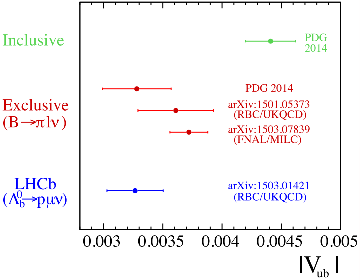
- world's most precise Δm_{d} measurement
- ✓ shown at EPS as CONF note
  $(0.5036 \pm 0.0020 \pm 0.0013)\,\mathrm{ps}^{-1}$
- paper in preparation
  this might be the last Δm_{d} for a long time. It must be done as good as we can!



V_{ub}

- long standing tension between exclusive and inclusive measurements
- so far only one measurement from LHCb: $\Lambda_b \to p\mu\nu$

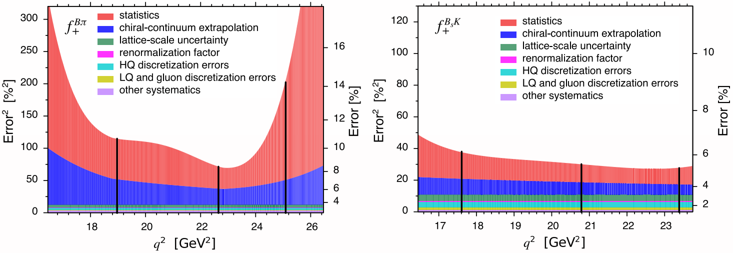




V_{ub}

- long standing tension between exclusive and inclusive measurements
- so far only one measurement from LHCb: $\Lambda_b \to p\mu\nu$
- $B_s^0 \to K\mu\nu$ may become the second channel
- ✓ theoretically well studied

plots from arXiv:1501.05373



expected uncertainties

comparing to $\Lambda_b \to p\mu\nu$

- normalising: $\mathcal{B}(D_s \to KK\pi)$ better known than $\mathcal{B}(\Lambda_c \to pK\pi)$
- production: $f_\Lambda \sim 2f_s$
- no background from D decays in Λ_b analysis

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Backgrounds: a challenge we attacked already

- any N-body B decay with at least one μ and one K is a background
  - $B^+ \to J/\psi K^+$
  - $B \to D_s(K + X)\mu\nu$
  - $B^0 \to J/\psi K^*$
  - ...

$\to$ need to veto these

Background vetos

- backgrounds can be $H_b \to K\mu + X$ where X contains at least one more charged particle

→ we should be able to find X

Isolation variables

- once developed in Marseille for $B_s^0 \to \mu\mu$ (reject backgrounds)
- further improved with a BDT in Milano Bicocca for $\tau \to \mu\mu\mu$ (reject partially reconstructed backgrounds)
- (approach also taken by Matteo Rama for $B \to \mu\mu$, as seen yesterday)
- retuned for Δm_d (distinguish B^+ from B^0)

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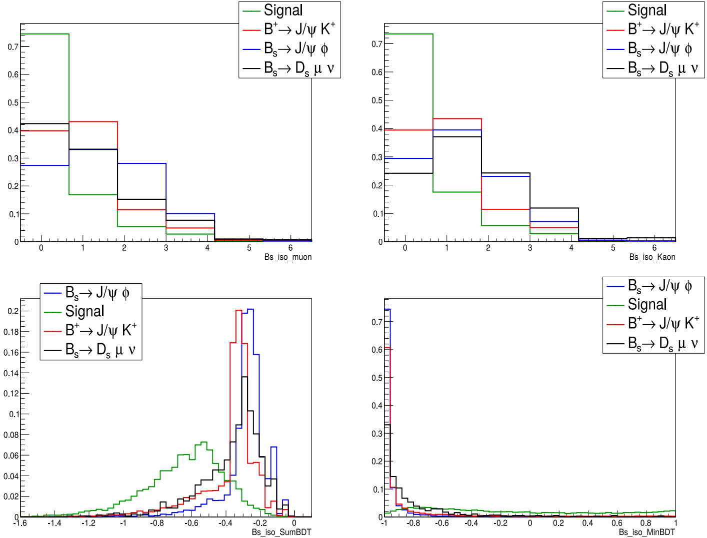

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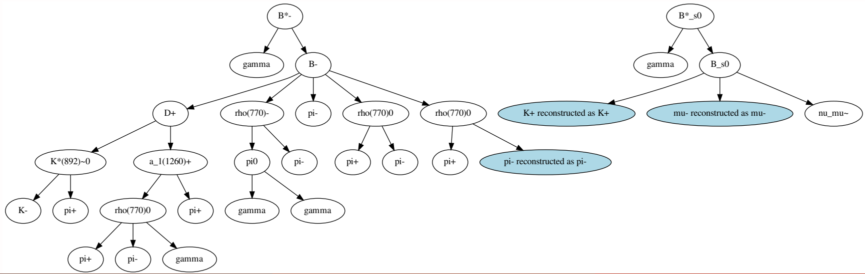

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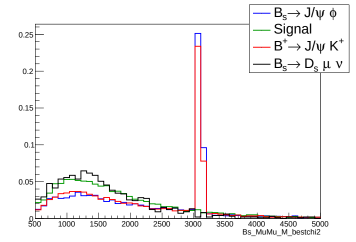
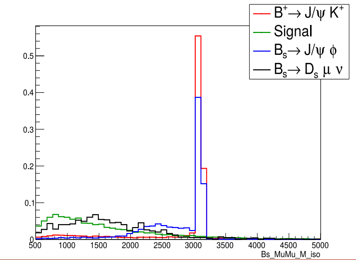
J/ψ veto w/o isolation

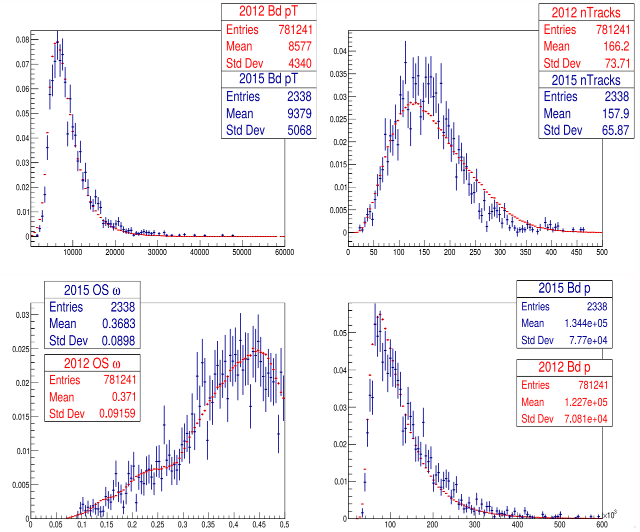


J/ψ veto w/ isolation

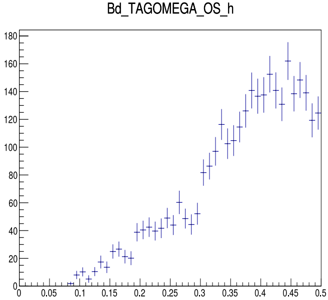


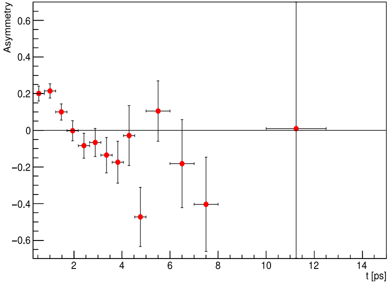
Tagging in 2015

- need to ensure that taggers work on 2015 data
- use $\mathrm{B} \to \mathrm{D}^{*}\mu\nu$ (as in Δm_{d} analysis)



oscillation already visible in 2015!



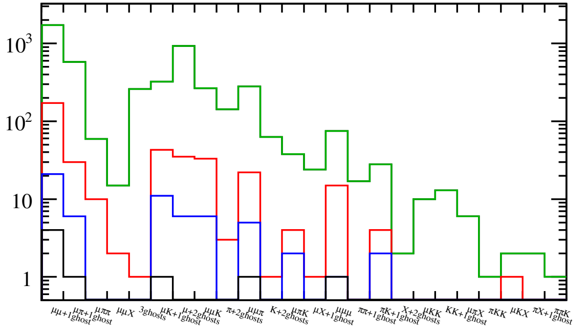


OS μ	$\varepsilon = 7.28 \pm 0.26\,\%$	$\omega = 29.53 \pm 0.37\,\%$	$\varepsilon_{eff} = 1.22 \pm 0.05\,\%$
OS e	$\varepsilon = 2.29 \pm 0.15\,\%$	$\omega = 30.45 \pm 0.55\,\%$	$\varepsilon_{eff} = 0.35 \pm 0.02\,\%$
OS K	$\varepsilon = 14.82 \pm 0.35\,\%$	$\omega = 38.08 \pm 0.17\,\%$	$\varepsilon_{eff} = 0.84 \pm 0.02\,\%$
vertex	$\varepsilon = 19.49 \pm 0.39\,\%$	$\omega = 39.24 \pm 0.15\,\%$	$\varepsilon_{eff} = 0.90 \pm 0.02\,\%$
charm	$\varepsilon = 31.84 \pm 0.46\,\%$	$\omega = 36.88 \pm 0.17\,\%$	$\varepsilon_{eff} = 2.19 \pm 0.04\,\%$
SS π	$\varepsilon = 34.05 \pm 0.47\,\%$	$\omega = 44.77 \pm 0.05\,\%$	$\varepsilon_{eff} = 0.37 \pm 0.01\,\%$
SS p	$\varepsilon = 78.53 \pm 0.41\,\%$	$\omega = 46.21 \pm 0.07\,\%$	$\varepsilon_{eff} = 0.45 \pm 0.01\,\%$

Tracking

- The track reconstruction has a high fake rate at LHCb (although, it depends on your signal and selection if you'll ever see them on ntuples)

$\tau \to \mu\mu\mu$ background in MC (LHCb-ANA-2011-100)



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☹ fakes are a combinatorial background in analysis

- ✓ cut offline on `_TRACK_GhostProb`

☹ fakes are bad for the trigger bandwidth

☹ fakes are bad for CPU time in HLT

- RICH PID for fake tracks
- vertex fits for combinatorics with fake tracks

→ use `_TRACK_GhostProb` already in the HLT

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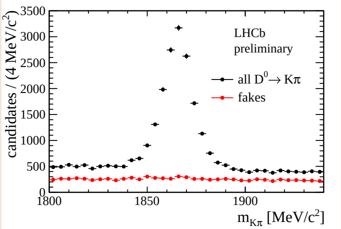
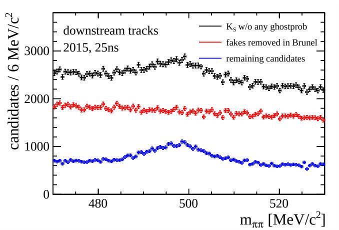
✗ validation cannot wait for stripping and analysts to test it in their selections

test cases

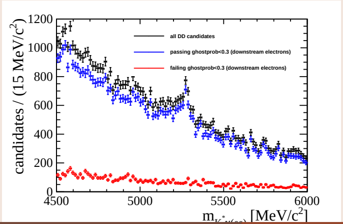
$D \to K\pi$ from the TURBO stream



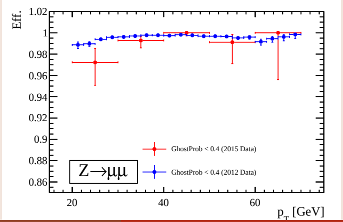
$K_S \to \pi\pi$ with downstream tracks



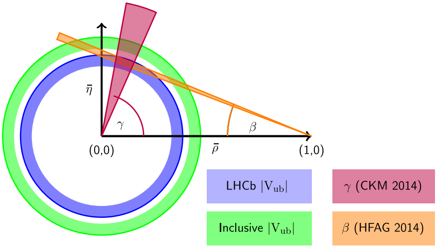
$B \to J/\psi\gamma(ee)$ (reprocessing run1)

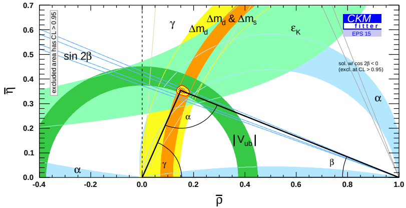


$Z \to \mu\mu$ (Stephen Farry)



Conclusion





- we're attacking the CKM triangle from three sides
  - ✓ Δm_{d} done
  - $\sin 2\beta$ ongoing
  - V_{ub} started
- reuse gained tools and expertise in new topics!
- focus on B2OC and SL
- combine tagging and analysis efforts!
- (not mentioned today) Wbb and $\mathrm{t\bar{t}}$ production