$B^0 \to \tau^+\tau^-$ Status

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Slide Information

- This slides are based on the recent lab meeting talks
  - 2022.07.04
  - **2022.07.11**

Contents

- MC Sample / Skimmed MC Sample information
- Skim Level Selection
  - Pre-selection
  - Tag side selection
- Basf2 Variables
  - basf2 variables by group
  - basf2 collections of variables

MC Sample / Skimmed MC Sample Information

MC Sample / Skimmed MC Sample Information

- ***MC Sample Information***
  - MC Signal mode: B0 → tau tau [1]
  - MC Signal Code: 1120600000 [1]
  - Skim Type: feiHadronicB0/feiSLB0 [1]
  - Location: /belle/group/physics/SLME/skim_Bd_tautau_21450_1120600000 [1]

- ***Skimmed MC Sample Information***
  - Campaign: **MC14ri_a** [2]
  - Skim Type: **feiHadronicB0 / feiSLB0** [1, 2]
  - Beam background type: **BGx1** [2]
  - Number of events: $\mathbf{20 \times 10^6}$ [3]
  - Ratio without/with background: **0.20 / 0.80** [3]
  - Btag decay type: **generic** [3]
  - Bsig decay type: **tau+ tau-** [3]
  - The Signal MC is generated with basf2 version **release-05-02-11** [2].

- ***Notice***
  - The skim was done before the MC14 data deletion accident.
  - MC Sample: No longer exist
  - Skimmed MC Sample: Exist

[References]
[1] [MC Samples WG1] https://confluence.desy.de/display/BI/MC+Samples+WG1
[2] [JIRA ticket for Signal MC] https://agira.desy.de/browse/BIIDP-4785
[3] [WG1 Skimming Advice and Resources] https://confluence.desy.de/display/BI/WG1+Skimming+Advice+and+Resources

Skim Level Selection

Skim Level Selection: Pre-selection

***static* fei_precuts(*path*)** [source]

Skim pre-cuts are applied before running the FEI, to reduce computation time. This setup function is run by all FEI skims, so they all have the save event-level pre-cuts:

- $n_{\text{cleaned tracks}} \geq 3$
- $n_{\text{cleaned ECL clusters}} \geq 3$
- $\text{Visible energy of event (CMS frame)} > 4\ \text{GeV}$
- $2\ \text{GeV} < E_{\text{cleaned tracks \& clusters in ECL}} < 7\ \text{GeV}$

We define "cleaned" tracks and clusters as:

- Cleaned tracks (`pi+:FEI_cleaned`): $d_0 < 0.5\ \text{cm}$, $|z_0| < 2\ \text{cm}$, and $p_T > 0.1\ \text{GeV}$ *
  Cleaned ECL clusters (`gamma:FEI_cleaned`): $0.296706 < \theta < 2.61799$, and $E > 0.1\ \text{GeV}$ $\Rightarrow 17° < \theta < 150°$

※ From Sphinx manual, basf2 version: **05-02-18**: "17.2.1. Physics skims - Full event interpretation skims"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/skim/doc/02-physics.html#module-skim.fei

Skim Level Selection: Pre-selection - variables

Meta Functions

Here is a list of variables that returns extra info of a given particle:

nCleanedECLClusters(*cut*)

[Eventbased] Returns the number of clean Clusters in the event Clean clusters are defined by the clusters which pass the given cut assuming a photon hypothesis.

nCleanedTracks(*cut*)

[Eventbased] Returns the number of clean Tracks in the event Clean tracks are defined by the tracks which pass the given cut assuming a pion hypothesis.

totalECLEnergyOfParticlesInList(*particleListName*)

Returns the total ECL energy of particles in the given particle List.

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Meta functions"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#meta-functions

Skim Level Selection: Pre-selection - variables

Event Kinematics

These variables are available after adding the event kinematics module. This can be done with the function `modularAnalysis.buildEventKinematics`. The variable collection `event_kinematics` allows to add all of them comfortably to your ntuple.

`visibleEnergyOfEventCMS`

[Eventbased] The visible energy in CMS obtained with EventKinematics module

`pt`

transverse momentum

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Event Kinematics"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#variable-visibleEnergyOfEventCMS

Skim Level Selection: Pre-selection - variables

※ Belle II Glossary Confluence page

POCA

- Point of closest approach.

Tracking

Here is a list of track variables:

d0

Signed distance to the POCA in the r-phi plane

z0

z coordinate of the POCA

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Kinematics"
(cf. basf2 version which was used to skim: 05-02-11)

※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#variable-E

Skim Level Selection: Pre-selection - variables

Kinematics

theta

polar angle in radians

E

energy

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Kinematics"
(cf. basf2 version which was used to skim: 05-02-11)

※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#variable-E

Skim Level Selection: Tag side

class **skim.fei.feiHadronicB0**(*, *OutputFileName=None*, *additionalDataDescription=None*, *udstOutput=True*, *validation=False*) [source]

Note

- **Skim description**: FEI-tagged neutral B's decaying hadronically.
- **Skim name**: feiHadronicB0
- **Skim LFN code**: 11180100
- **Category**: physics, Full Event Interpretation
- **Authors**: Racha Cheaib, Hannah Wakeling, Phil Grace
- **Contact**: Shanette De La Motte

This skim includes a selection on the HLT flag `hlt_hadron`.

Tag side B cuts:

- $M_{\mathrm{bc}} > 5.24\ \mathrm{GeV}$
- $|\Delta E| < 0.2\ \mathrm{GeV}$
- $\mathrm{signal\ probability} > 0.001$ (omitted for decay mode 23)

All available FEI B^0 hadronic tags are reconstructed. From Thomas Keck's thesis, "the channel $B^0 \to \overline{D}^0 \pi^0$ was used by the FR, but is not yet used in the FEI due to unexpected technical restrictions in the KFitter algorithm".

※ From Sphinx manual, basf2 version: **05-02-18**: "17.2.1. Physics skims - Full event interpretation skims"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/skim/doc/02-physics.html#module-skim.fei

Skim Level Selection: Tag side

```
def build_lists(self, path):
    ma.applyCuts("B0:generic", "Mbc>5.24", path=path)
    ma.applyCuts("B0:generic", "abs(deltaE)<0.200", path=path)
    ma.applyCuts("B0:generic", "sigProb>0.001 or extraInfo(dmID)==23", path=path)

    self.SkimLists = ["B0:generic"]
```

※ From Sphinx manual, basf2 version: **05-02-18**: "17.2.1. Physics skims - Full event interpretation skims [code]"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/_modules/skim/fei.html#feiHadronicB0

Skim Level Selection: Tag side - variables

Kinematics

Mbc

beam constrained mass

deltaE

energy difference

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Kinematics"
(cf. basf2 version which was used to skim: 05-02-11)

※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#variable-E

Skim Level Selection: Tag side - variables

Meta Functions

Here is a list of variables that returns extra info of a given particle:

extraInfo(*name*)

Returns extra info stored under the given name. The extraInfo has to be set by a module first. E.g. `extraInfo(SignalProbability)` returns the SignalProbability calculated by the `MVAExpert` module. If nothing is set under the given name or if the particle is a nullptr, NaN is returned. In the latter case please use `eventExtraInfo` if you want to access an EventExtraInfo variable.

```
# Aliases for variables available after running the FEI
vm.addAlias("sigProb", "extraInfo(SignalProbability)")
```

※ From Sphinx manual, basf2 version: **05-02-18**: "6.3.2. Variables by group - Meta functions"
(cf. basf2 version which was used to skim: 05-02-11)
※ https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#meta-functions

basf2 variables:
basf2 variables by group

basf2 variables by group

Variables by group (# of groups: 30, # of variables: 811)

- Kinematics (56)
- Helicity (8)
- Tracking (36)
- V0 Tracking (31)
- PID (14)
- Basic particle information (12)
- (PID for expert) (9)
- ECL Cluster (54)
- Acceptance (18)
- Trigger (14)
- Event (27)
- Parameter Functions (17)
- Meta Functions (88)
- MC matching and MC truth (55)
- Daughter info (3)
- KLM Cluster and K_L^0 Identification (21)
- Time Dependent CPV Analysis Variables (74)
- Flavor Tagger (41)
- Rest of Event (60)
- Continuum Suppression (10)
- Event Shape (42)
- Event Kinematics (14)
- Flight Information (18)
- Vertex Information (36)
- For fully-inclusive particles (5)
- Specific kinematics variables (0)
- Belle and b2bii variables (11)
- (PID for B2BII) (4)
- Miscellaneous (10)
- Calibration (23)

basf2 variables by group: reference

※ From Sphinx manual, basf2 version: **05-02-18** (cf. basf2 version which was used to skim: 05-02-11)
※ "6.3.2. Variables by group - Kinematics"
https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#variables-by-group
※ "basf2 variables index": https://b2-master.belle2.org/software/sphinx/release-05-02-18/b2-varindex.html

basf2 variables:
basf2 collections of variables

basf2 Predefined collections

Predefined collections (# of collections: 29, # of variables: 263)

- variables.collections.belle_track_hit (6)
- variables.collections.cluster (43)
- variables.collections.cluster_average (2)
- variables.collections.dalitz_3body (3)
- variables.collections.deltae_mbc (2)
- variables.collections.event_kinematics (14)
- variables.collections.event_level_tracking (12)
- variables.collections.event_shape (22)
- variables.collections.extra_energy (1)
- variables.collections.flight_info (4)
- variables.collections.inv_mass (4)
- variables.collections.kinematics (6)
- variables.collections.klm_cluster (17)
- variables.collections.mc_event_kinematics (5)
- variables.collections.mc_flight_info (2)
- variables.collections.mc_kinematics (7)
- variables.collections.mc_tag_vertex (10)
- variables.collections.mc_truth (3)
- variables.collections.mc_variables (21)
- variables.collections.mc_vertex (8)
- variables.collections.momentum_uncertainty (4)
- variables.collections.pid (6)
- variables.collections.reco_stats (1)
- variables.collections.recoil_kinematics (6)
- variables.collections.roe_multiplicities (1)
- variables.collections.tag_vertex (20)
- variables.collections.track (8)
- variables.collections.track_hits (4)
- variables.collections.vertex (21)

basf2 Predefined collections

Predefined collections (# of collections: 29, # of variables: 263)

- variables.collections.belle_track_hit (6)
- variables.collections.cluster (43)
- variables.collections.cluster_average (2)
- variables.collections.dalitz_3body (3)
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- variables.collections.**event_shape** (22)
- variables.collections.**extra_energy** (1)
- variables.collections.flight_info (4)
- variables.collections.inv_mass (4)
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- variables.collections.klm_cluster (17)
- variables.collections.mc_event_kinematics (5)
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- variables.collections.mc_kinematics (7)
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- variables.collections.track_hits (4)
- variables.collections.vertex (21)

basf2 Predefined collections

※ From Sphinx manual, basf2 version: **05-02-18** (cf. basf2 version which was used to skim: 05-02-11)
※ "6.3.3. Collections and Lists - Predefined collections"
https://b2-master.belle2.org/software/sphinx/release-05-02-18/analysis/doc/Variables.html#collections-and-lists

Backup

Backup

Imitating Example

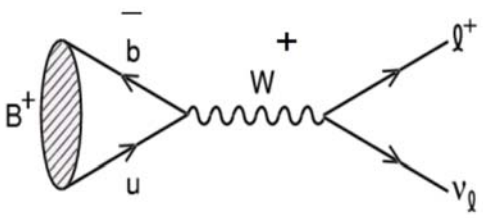
※ WG1 Review Committees
※ b2n-2020-024 discussion
※ 2020.06.19

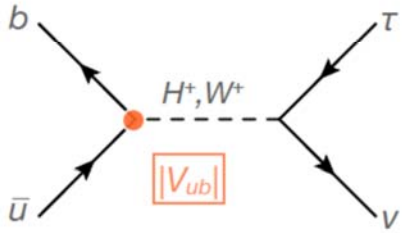
1

$B \to \tau\bar{\nu}$ in early phase III data

Claudia Cecchi, Guglielmo De Nardo, Elisa Manoni,
Mario Merola

First meeting with RC, 19-June-2020





- Note with line numbering attached to the indico agenda
- We'll update the note through the weekend, once we agree in this meeting

Skim Selection and tag side

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1) Skim level preselection:

- #tracks ≥ 4 (p_T > 0.1GeV, d0<0.5cm, |z0|<2cm)
- #clusters ≥ 3 (in CDC acceptance, E > 0.1 GeV)
- R2<0.4
- Visible energy > 4 GeV
- 2 GeV < Total ECL energy < 7 GeV

These cuts are the definition of FEI hadronic skim
https://b2-master.belle2.org/software/development/sphinx/skim/doc/02-physics.html#module-skim.fei

2) Tag side selection:

- Hadronic FEI with Ptag > 0.001
- M_{bc} > 5.24 GeV and |ΔE| < 0.2 GeV
- Pick the highest Ptag B candidate

Require full reconstruction of tag side and only one additional track in the event

Skim / Tag side Selection

- Reference
  - $B \to \tau\bar{\nu}$
    - https://indico.belle2.org/event/2437/
    - https://indico.belle2.org/event/2437/contributions/12032/attachments/5989/9301/Btaunu_RCMeeting_19June2020.pdf