How to do Belle + Belle II analyses

——How to do Belle analyses on basf2 with b2bii

Xiaodong Shi (KEK)

Thanks to Chia-Ling, Nishida-san, Junhao, Longke, Yubo Li, Yi for help.

2023 Belle II Physics Week
10.30–11.03

What's in this talk

- Why we shall do B1+B2 analysis?
- How to do B1+B2? (Most are from B2BII tutorial)

About me:I joined Belle II 2 years ago. Even I didn't know Belle a lot, I did a B1+B2 analysis. Apologize that I won't cover all thing, e.g. scan data set, trigger thing.

8. B2BII

The b2bii package in basf2 converts Belle MDST files (BASF data format) to Belle II MDST (basf2 data format). This enables performing physics analysis using data collected with Belle detector with the analysis software and algorithms developed for the analysis of data collected with the Belle II detector. The B2BII converter allows for estimation and validation of performances of various advanced algorithms being developed for Belle II.

Previous 7.9. Full list of analysis modules

Next 8.1. Overview

Why we shall do B1 + B2 analysis?

——Why we shall still use Belle data set?

- How to get a better physics result? Naive answers:
  - Learn more from theory experts. → What we are doing this week.
  - Upgrade detectors. → Upgrade WG are working on it.
  - Better MC simulation/systematic control. → Check performance talk…
  - **Need more data**, less fluctuation, smaller statistical uncertainty.

  →Belle II have 426 fb^{-1} for run 1. Aim to exceed 1 ab^{-1} in 2024.

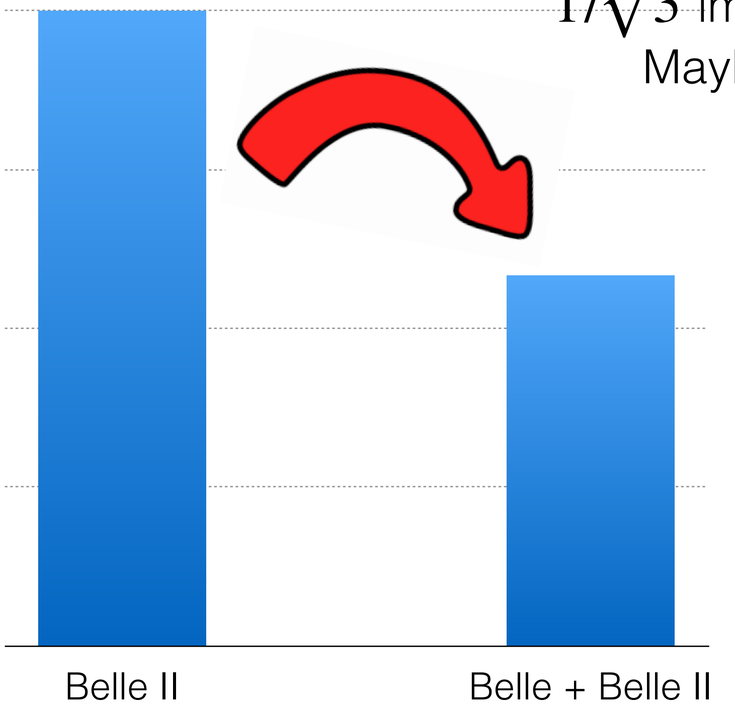
  Okay, let's sit and wait for more data from SuperKEKB🤞

  Wait…… we actually already have "1 ab^{-1}" ~~somewhere~~ in Belle.

Why we shall do B1 + B2 analysis?

Belle's data set: 1 ab^{-1}, $\sim$ 2 times of Belle II's run 1 data set, 426 fb^{-1}

- Naive calculation, for Br measurement, $\sigma(\text{stat}) \propto 1/\sqrt{N}$



$1/\sqrt{3}$ improvement on stat precision. ~0.6
Maybe it could be 2.x σ —> 3.x σ!

Add B1 data now, you will get the stat precision what you can't get until 2025 if you only use B2!

Why we shall do B1 + B2 analysis?

Not only about more statistics. Much more we can get by B1 +B2.

- Two individual experiments can allow us do cross-check on the results.
- We can understand B2 better by comparing to B1.

E.g. for $B \to J/\psi K_L$ study, by comparing the yields, something wrong with KLM. (now this bug is fixed)

JpsiKL/M(BB)	KLM	KLM+ECL	ECL	ALL
Belle II	**2.6**	1.2	6.4	10.3
Belle	5.1	1.9	6.0	12.9

A comparison between B1 and B2

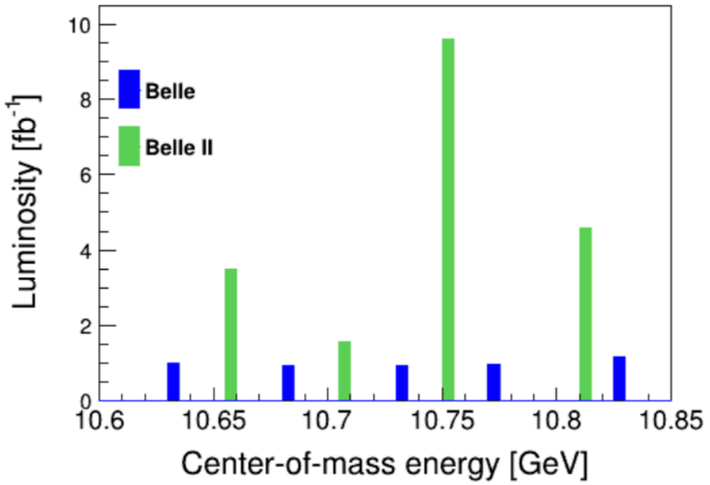
*only related to physics analysis

- Data sample

sqrt(s) GeV	Y(1S)	Y(2S)	Y(3S)	Y(4S)	Y(5S) and scan
Belle	102 M	158 M	13 M	711 fb^{-1}	121 fb^{-1}
Belle II	-	-	-	362 fb^{-1}	19 fb^{-1}

- Belle has unique sample of $\Upsilon(1S)$ $\Upsilon(2S)$ $\Upsilon(3S)$.
- 2 times of $\Upsilon(4S)$ data sample.

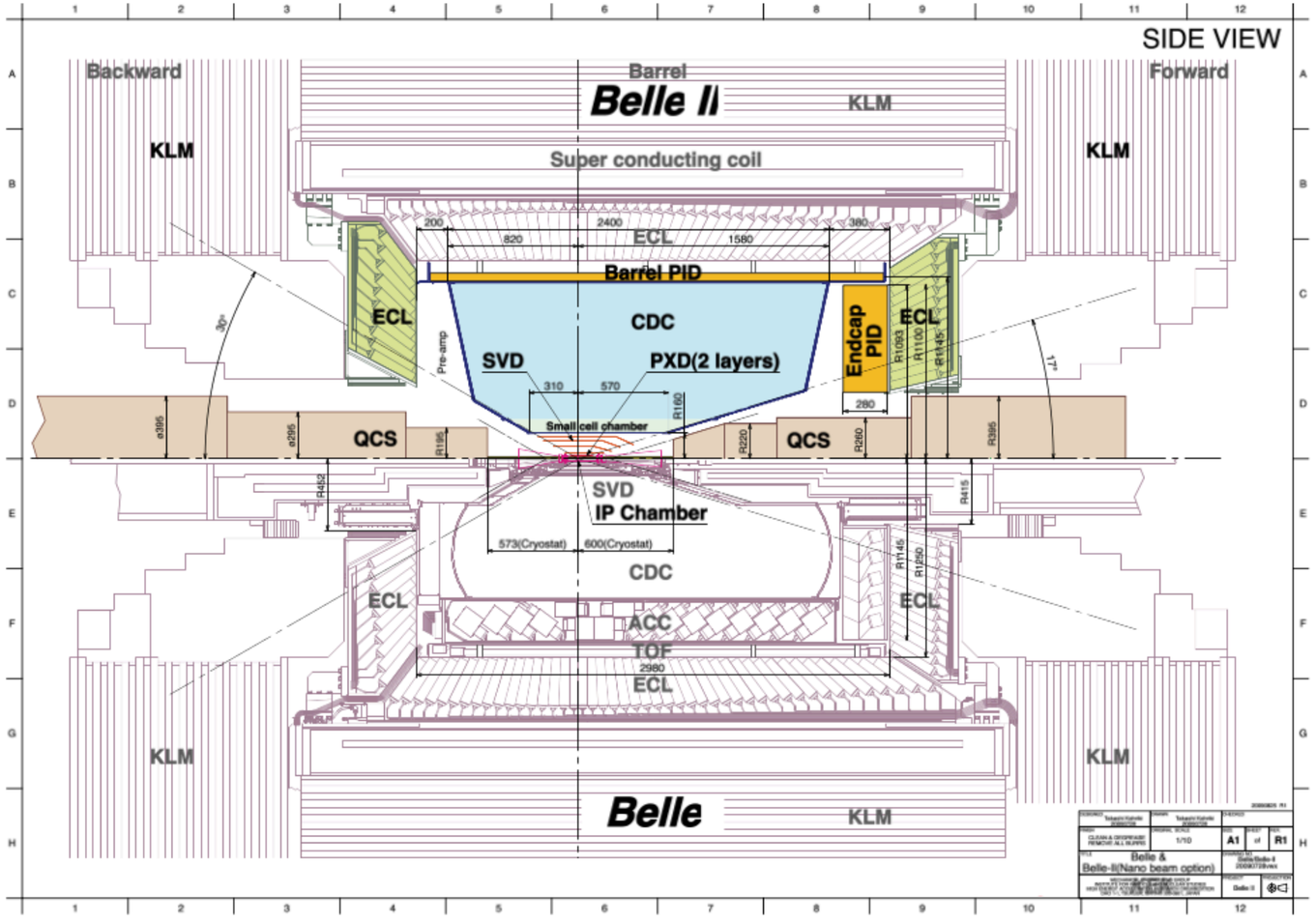
- Belle and Belle II have different scan points. Not experts in quarkonium, but it's obvious to me we shall use both data samples.



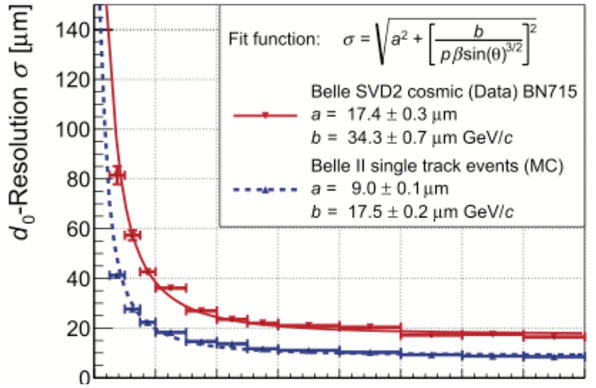
A comparison between B1 and B2

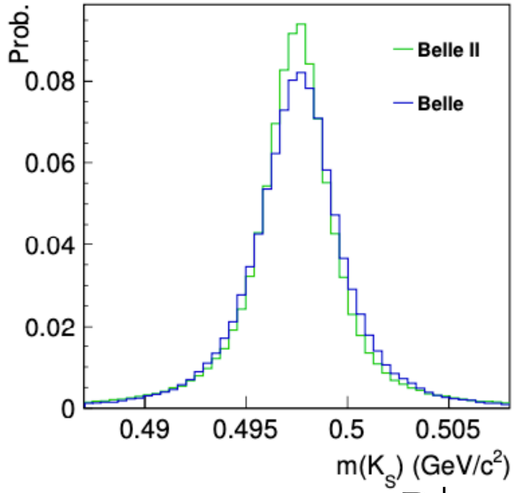
*only related to physics analysis

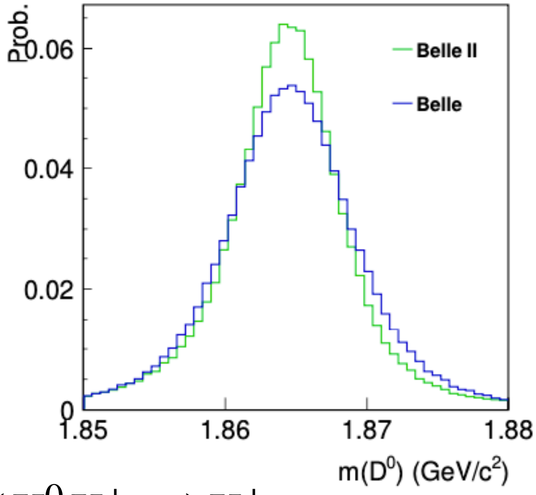
- Data sample
- Detector



- Similar structure. ~4π
- Different performance.







$B^+ \to D(K^0_S K^+\pi^-)K^+$

A comparison between B1 and B2

*only related to physics analysis

- Data sample
- Detector
- MC simulation
  - Geant 3 v.s. Geant 4
  - Different generators
- Basf v.s. basf2
  - Quite different. But, don't worry, we have B2BII. No need to learn how to use basf.
- About systematic
  - Belle: ***almost*** won't change any more [ref]. Some experts are working on new PID or beam background MVA.
  - Belle II: under developed. you shall follow meetings/confluence pages.
- Trigger menu: have large impact on dark matter search
- …

Other reasons for not using B1 data…

- You may say “I’m willing to use Belle data. But ….”

  “I’m not in Belle collaboration. I may spend 6 months or longer to do B1+B2”

- Actually,

  Don’t worry. Not necessary to be in Belle.

  I will show you all you need to do.

  (I hope I cover all steps.)

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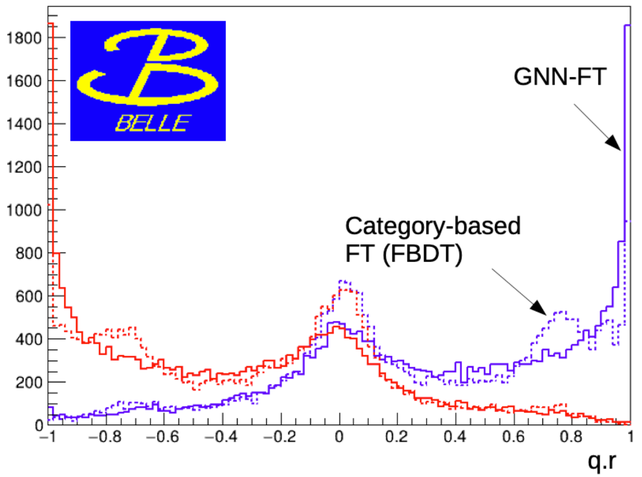
  “Belle collaboration may already publish the result”

- Actually,

  Maybe they didn't use full Belle data set.

  Now we shall have better idea, improved reconstruction method, better bkg control, or external inputs changed so it’s worth to re-do.



From Tadeas

The GNN-FT in B2 is implemented in B1!

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  “shall I need to have review procedure twice?”

- Actually,

  No need. Nothing different in review procedure. One Review Committee in B2.

  Only need to have B1 and B2 CWR in parallel.

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  “where I shall ask question? Report issue?”

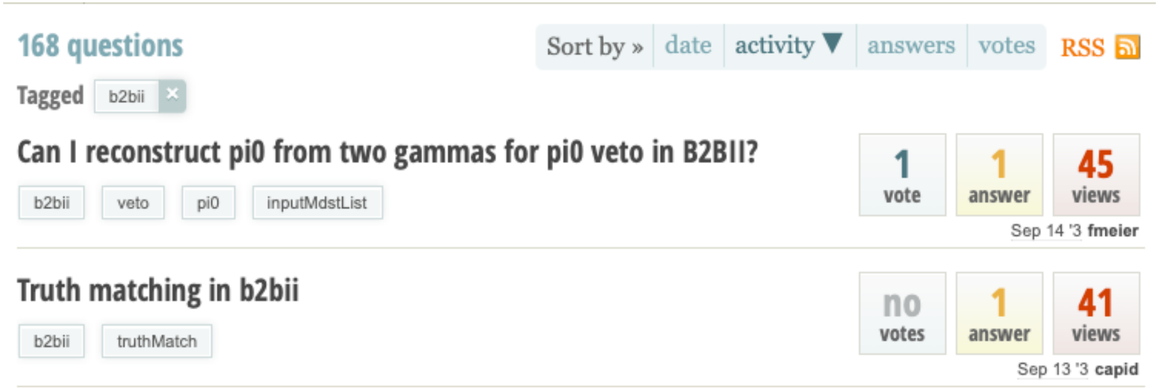
- Actually,

  We have B2BII group meeting, monthly.

  Indico: https://indico.belle2.org/category/67/

  Maillist: software-b2bii@belle2.org

  On B2question:



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- More reason/excuse?
- “Better to run than curse the road”

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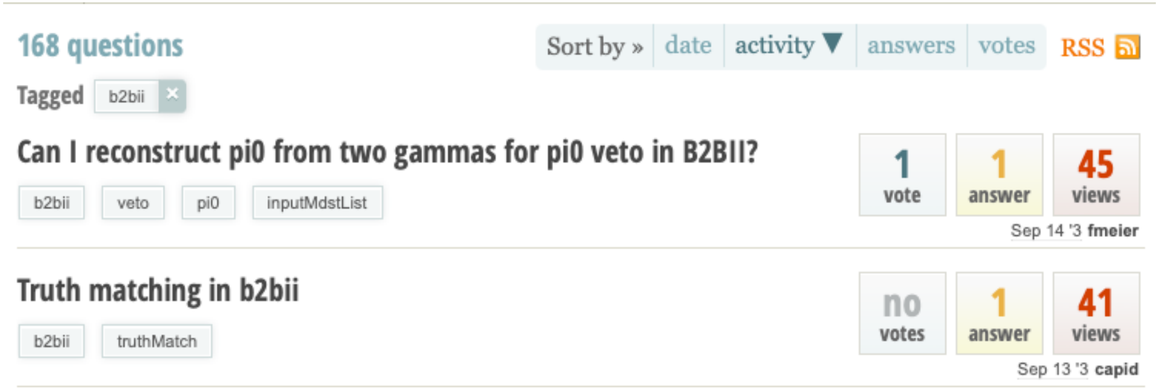

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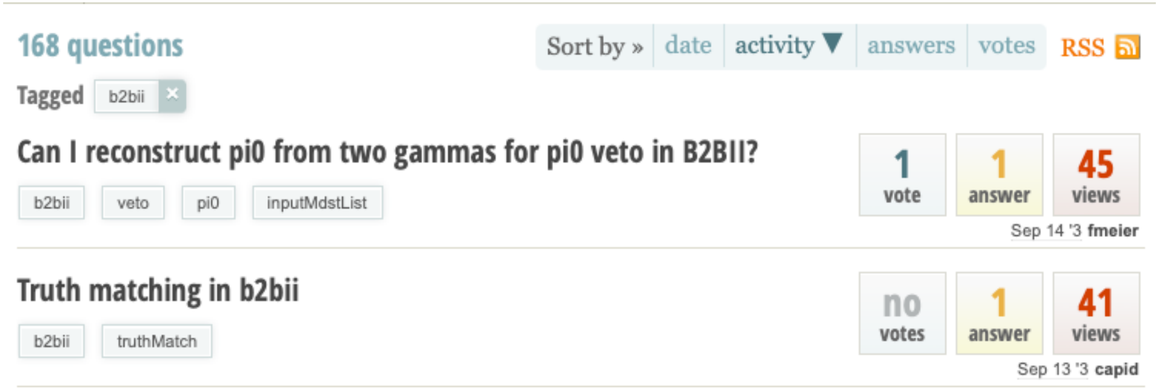

Where to find B1 data / generic MC

- All on KEKcc.
- You shall also run it on KEKcc. (No need to use the busy grid!)

Luminosity of Belle data

Total Integrated Luminosity (fb^{-1})

Exp	Y4S/Off	Y1S/Off	Y2S/Off	Y3S/Off	Y5S/Off	Scan	Total
7-27	140.747/15.621	0/0	0 /0	0/0	0/ 0	0.281(1S)	156.38
7-65	702.623/79.366	5.745/1.815	0/0	2.922/0.246	23.182/1.73	0.029(1S)/0.076(3S)/6.518(5S)	824.533
31-55	457.911/51.915	0/0	0 /0	2.922 / 0.246	23.182/ 0	0.076(3S)/0.168(5S)	536.42
61-73	104.704/21.918	5.745/1.815	24.913/1.708	0 /0	97.879/1.73	0.029(1S)/0.024(2S)/27.406(5S)	288.088
31-73	562.615/73.833	5.745/1.815	24.913/1.708	2.922/0.246	121.061/1.73	0.029(1S)/0.24(2S)/27.574(5S)	824.507
7-73	702.623/89.454	5.745/1.815	24.913/1.815	2.922/0.246	121.061/1.73	0.029(1S)/0.24(2S)/0.076(3S)/27.574(5S)	980.417

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- How to submit jobs on KEKcc.[ref]

```
bsub -q <queue name> "basf2 <your_working_script>"
```

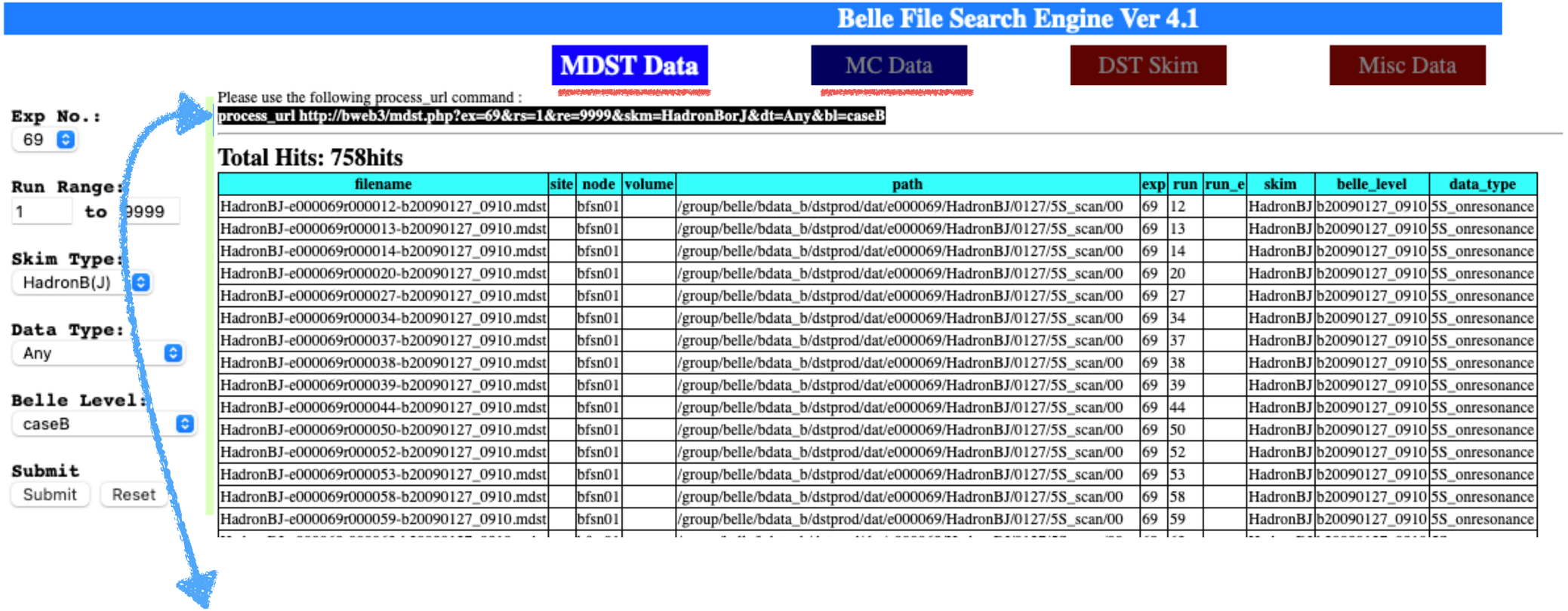
- Queue: s for 6 hours job; l for 48 hours job; h for 240 hours job. [MoreInfo]

```
[xdshi@ccw01 ~]$ date
Mon Oct 30 13:30:40 JST 2023
[xdshi@ccw01 ~]$ bqueues -u xdshi
QUEUE_NAME      PRIO STATUS          MAX JL/U JL/P JL/H NJOBS  PEND   RUN
s               120  Open:Active    4000 1000    -    -   349     2   347
b_index         110  Open:Active     600  100    -    -     0     0     0
b_nagoya        110  Open:Active     600  100    -    -     0     0     0
l               100  Open:Active       - 1500    -    -   634     0   634
h               100  Open:Active    1500  300    -    -   294     0   294
```

- Not much jobs running at KEKcc!

Where to find B1 data / generic MC

- Belle File Search Engine (only accessible within KEK domain or via VPN)



filename	site	node	volume	path	exp	run	run_e	skim	belle_level	data_type
HadronBJ-e000069r000012-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	12		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000013-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	13		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000014-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	14		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000020-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	20		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000027-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	27		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000034-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	34		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000037-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	37		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000038-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	38		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000039-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	39		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000044-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	44		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000050-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	50		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000052-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	52		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000053-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	53		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000058-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	58		HadronBJ	b20090127_0910	5S_onresonance
HadronBJ-e000069r000059-b20090127_0910.mdst		bfsn01		/group/belle/bdata_b/dstprod/dat/e000069/HadronBJ/0127/5S_scan/00	69	59		HadronBJ	b20090127_0910	5S_onresonance

```
convertBelleMdstToBelleIIMdst('http://bweb3/montecarlo.php?ex=37&rs=100&re=200&ty=evtgen-mixed&dt=on_resonance&bl=caseB&st=0', path=mypath)
```

B2BII can directly read the process_url (and also full path of course).

Where to find B1 data / generic MC

- For Υ(4S), some personal scripts to run B1 data, generic MC(6 streams) on gitlab

README.md

source run.sh

Mdst files for each job are already set in the file of belle_fulldata/datalink/4S.datalink. Change it if you want to change the mdst files for each job.

main ⌄ forbellephysicsanalysis / RunB1Data / belle_fulldata / datalink / 4S.datalink Find fil nctions.py)

4S.datalink 61.00 KiB Edit ⌄

```
1  http://bweb3/mdst.php?ex=7&rs=6&re=46&skm=HadronBorJ&dt=on_resonance&bl=caseB
2  http://bweb3/mdst.php?ex=7&rs=47&re=87&skm=HadronBorJ&dt=on_resonance&bl=caseB
3  http://bweb3/mdst.php?ex=7&rs=88&re=128&skm=HadronBorJ&dt=on_resonance&bl=caseB
4  http://bweb3/mdst.php?ex=7&rs=129&re=169&skm=HadronBorJ&dt=on_resonance&bl=caseB
5  http://bweb3/mdst.php?ex=7&rs=170&re=210&skm=HadronBorJ&dt=on_resonance&bl=caseB
6  http://bweb3/mdst.php?ex=7&rs=211&re=251&skm=HadronBorJ&dt=on_resonance&bl=caseB
7  http://bweb3/mdst.php?ex=7&rs=252&re=292&skm=HadronBorJ&dt=on_resonance&bl=caseB
8  http://bweb3/mdst.php?ex=7&rs=293&re=333&skm=HadronBorJ&dt=on_resonance&bl=caseB
9  http://bweb3/mdst.php?ex=7&rs=334&re=374&skm=HadronBorJ&dt=on_resonance&bl=caseB
10 http://bweb3/mdst.php?ex=7&rs=375&re=415&skm=HadronBorJ&dt=on_resonance&bl=caseB
11 http://bweb3/mdst.php?ex=7&rs=416&re=456&skm=HadronBorJ&dt=on_resonance&bl=caseB
12 http://bweb3/mdst.php?ex=7&rs=457&re=497&skm=HadronBorJ&dt=on_resonance&bl=caseB
13 http://bweb3/mdst.php?ex=7&rs=498&re=538&skm=HadronBorJ&dt=on_resonance&bl=caseB
14 http://bweb3/mdst.php?ex=7&rs=539&re=579&skm=HadronBorJ&dt=on_resonance&bl=caseB
15 http://bweb3/mdst.php?ex=7&rs=580&re=620&skm=HadronBorJ&dt=on_resonance&bl=caseB
16 http://bweb3/mdst.php?ex=7&rs=621&re=661&skm=HadronBorJ&dt=on_resonance&bl=caseB
17 http://bweb3/mdst.php?ex=7&rs=662&re=702&skm=HadronBorJ&dt=on_resonance&bl=caseB
18 http://bweb3/mdst.php?ex=7&rs=703&re=743&skm=HadronBorJ&dt=on_resonance&bl=caseB
```

How to generate B1 signal MC

- With B2BII.“$BELLE2_RELEASE_DIR/b2bii/examples/BelleMCGeneration.py”

```
11  # Generation of Belle MC.
12
13  import basf2
14  from generators import add_evtgen_generator
15
16  # Use B2BII local cache
17  basf2.conditions.metadata_providers = ["/sw/belle/b2bii/database/conditions/b2bii.sqlite"]
18  basf2.conditions.payload_locations = ["/sw/belle/b2bii/database/conditions/"]
19
20  # Use B2BII global tag.
21  basf2.conditions.override_globaltags()
22  basf2.conditions.prepend_globaltag('b2bii_beamParameters_with_smearing')
23
24  # Path.
25  main = basf2.create_path()
26
27  # Generate for experiment 55, run 0 (run-independent MC).
28  main.add_module('EventInfoSetter', expList=55, runList=0, evtNumList=100)
29
30  # Add generator.
31  add_evtgen_generator(path=main, finalstate='charged')
32
33  # Add output.
34  main.add_module('BelleMCOutput', outputFileName='charged.dat')
35
36  # Progress.
37  main.add_module('Progress')
38
39  # Generate events.
40  basf2.process(main)
```

Only generation!
Do simulation with basf script.

Generated number

```
add_evtgen_generator(path=mypath,
                     finalstate="signal",
                     signaldecfile="user_defined_decfile.dec"
)
```

Set “signaldecfile” to your own dec file.

How to generate B1 signal MC

- With B2BII.“$BELLE2_RELEASE_DIR/b2bii/examples/BelleMCGeneration.py”
- With basf scripts [ref].

A combined package for the generation and the simulation based on evtgen scripts and gsim scripts.

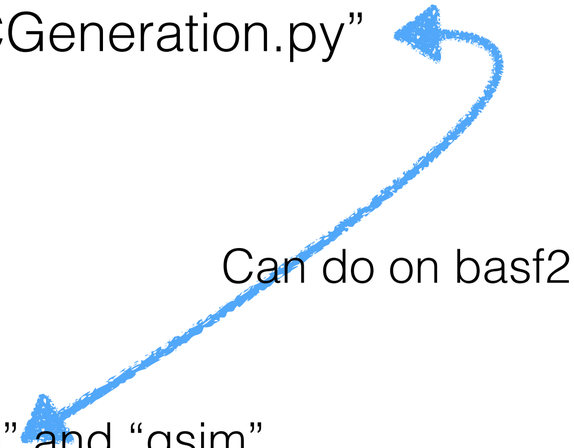
/home/belle/capid/public/mcproduzh.tar.gz

Copy the file and untar.

tar -zxvf mcproduzh.tar.gz

Two directories “evtgen” and “gsim” and one file “README” will appear. Please see “README”.

When using the makeSummaryGsim script in the gsim folder user the -MC flag → ./makeSummaryGsim -MC log/*.log

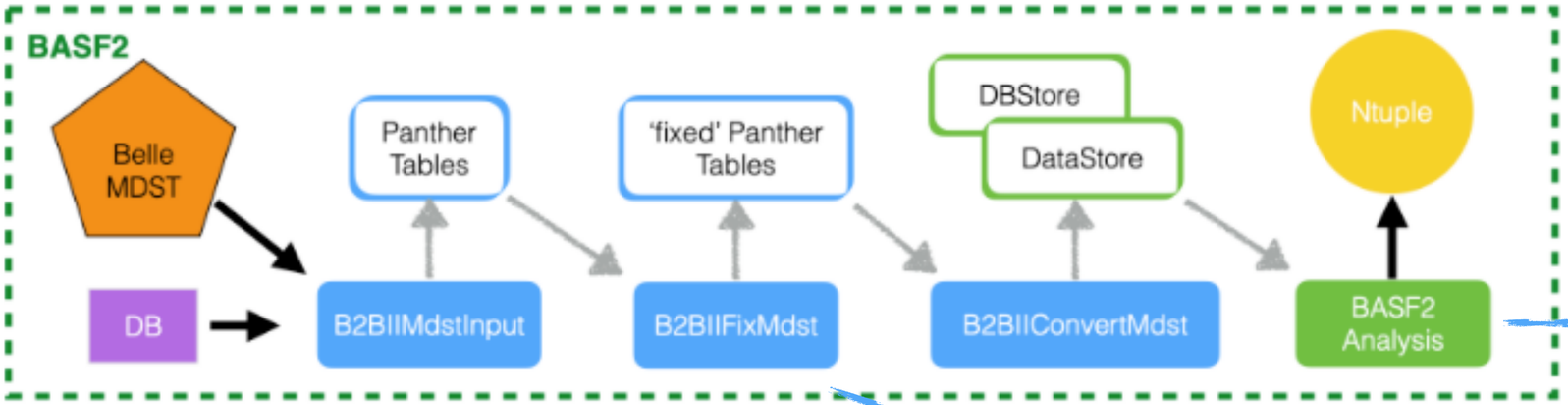


Can do on basf2

Two steps: “evtgen” and “gsim”.

How to read B1 MC/data with B2BII

- B2BII converts Belle MDST within basf2. No need to have extra ROOT file (Belle II MDST format). The converted data is to be analysed in same job.



(Almost) same with what you do on basf2

Preform some corrections. “FixMdst”
Applied HadronB(J) skim by default.

Just two lines

```
from b2biiConversion import convertBelleMdstToBelleIIMdst
convertBelleMdstToBelleIIMdst(inputBelleMDSTFile, path=my_path)
```

The objects of B1 MC/data

Charged tracks

Separation	basf	basf2
K vs π	atc_pid(3,1,5,3,2).prob(...)	atcPIDBelle(3,2)
p vs π	atc_pid(3,1,5,4,2).prob(...)	atcPIDBelle(4,2)
p vs K	atc_pid(3,1,5,4,3).prob(...)	atcPIDBelle(4,3)
electron vs hadron	eid.prob(3,-1,5)	eIDBelle
muon likelihood	Muid_mdst.Muon_likelihood()	muIDBelle
muon likelihood quality flag	Muid_mdst.Prerejection()	muIDBelleQuality

Neutral particles

- “gamma:mdst”
- “pi0:mdst”
- “K_L0:mdst"
- ⚠ Don’t use fillParticleList and reconstruct pi0, gamma.

The objects of B1 MC/data

V0 Particles

- “K_S0:mdst”
- “Lambda0:mdst”
- “gamma:v0mdst” for gamma conversion ee pair.

The quality indicators for K_S^0 and Λ as estimated by the findKs and nisKsFinder (for K_S^0), and FindLambda (for Λ^0) are available as

basf	basf2
findKs.goodKs()	extraInfo(goodKs)
nisKsFinder.nb_vlike()	extraInfo(ksnbVLike)
nisKsFinder.nb_nolam()	extraInfo(ksnbNoLam)
nisKsFinder.standard()	extraInfo(ksnbStandard)
findLambda.goodLambda()	extraInfo(goodLambda)

The vertex fit information of `V0` particles is also attached as `extraInfo` variables.

Handle converter and different objects (Optional)

- generalFunctions.py in BtoCharm WG scripts. (Not official B2BII codes. Just personal recommendation.)

```
174 def importInputFiles(belleOrBelle2=str(), fileList=[], typeOfInput=str(), path=None):
175     """
176     Imports the input MC or data files of Belle or Belle II.
177     @param belleOrBelle2 for Belle or for Belle II
178     @param filelist (list(str)): the filename list of files to be loaded
179     @param typeOfInput type of input file
180     @param path      modules are added to this path
181     """
182     if typeOfInput not in allowedInputFileTypes:
183         b2.B2FATAL("The allowed input file types are 'data', 'mc', 'convertedData' or 'convertedMC'.")
184 
185     if belleOrBelle2 == "Belle":
186         if typeOfInput in ['convertedData', 'convertedMC']:
187             ma.inputMdstList(environmentType='Belle', filelist=fileList, path=path)
188         else:
189             b2bii.convertBelleMdstToBelleIIMdst(inputBelleMDSTFile=fileList, path=path)
190 
191     elif belleOrBelle2 == "Belle2":
192         ma.inputMdstList(environmentType='default', filelist=fileList, path=path)
```

Read B1 or B2 inputs

```
121 def setDefaultAliases(belleOrBelle2=str()):
122     """
123     Sets default aliases.
124     """
125 
126     if belleOrBelle2 == "Belle":
127 
128         vu._variablemanager.addAlias('PID_bin_kaon', 'atcPIDBelle(3,2)')
129         vu._variablemanager.addAlias('PID_bin_pion', 'atcPIDBelle(2,3)')
130 
131     if belleOrBelle2 == "Belle2":
132 
133         vu._variablemanager.addAlias('PID_bin_kaon', 'ifNANgiveX(pidPairProbabilityExpert(321, 211, ALL), 0.5)')
134         vu._variablemanager.addAlias('PID_bin_pion', 'ifNANgiveX(pidPairProbabilityExpert(211, 321, ALL), 0.5)')
```

Unify PID variables

Other things when run B1 with B2BII

For MC match

```
# Gets the options from the command line
if args.belleOrBelle2Flag == 'Belle' :
  if args.typeOfInput == 'mc' :
    ma.setAnalysisConfigParams({'mcMatchingVersion': 'Belle'}, path=main_path)
```

Note: if you have gamma: convertBelleMdstToBelleIIMdst(inputfile, generatorLevelMCMatching=**True**)

Set B2BII magics Some are setting Belle data base

```
if args.belleOrBelle2Flag == 'Belle' :
  print('BELLE2_EXTERNALS_DIR     = ' + str(os.getenv('BELLE2_EXTERNALS_DIR')))
  print('BELLE2_EXTERNALS_SUBDIR  = ' + str(os.getenv('BELLE2_EXTERNALS_SUBDIR')))
  print('BELLE2_EXTERNALS_OPTION  = ' + str(os.getenv('BELLE2_EXTERNALS_OPTION')))
  print('BELLE2_EXTERNALS_VERSION = ' + str(os.getenv('BELLE2_EXTERNALS_VERSION')))
  print('BELLE2_LOCAL_DIR         = ' + str(os.getenv('BELLE2_LOCAL_DIR')))
  print('BELLE2_RELEASE           = ' + str(os.getenv('BELLE2_RELEASE')))
  print('BELLE2_OPTION            = ' + str(os.getenv('BELLE2_OPTION')))
  print('BELLE_POSTGRES_SERVER    = ' + str(os.getenv('BELLE_POSTGRES_SERVER')))
  print('USE_GRAND_REPROCESS_DATA = ' + str(os.getenv('USE_GRAND_REPROCESS_DATA')))
  print('PANTHER_TABLE_DIR        = ' + str(os.getenv('PANTHER_TABLE_DIR')))
  print('PGUSER                   = ' + str(os.getenv('PGUSER')))
```

Other things when run B1 with B2BII

8.5.2. Full Event Interpretation

To utilize FEI, the correct prefix of FEI payloads needs to be set:

```
import fei
configuration = fei.config.FeiConfiguration(prefix='FEI_B2BII_light-2012-mino

feistate = fei.get_path(particles, configuration)

path.add_path(feistate.path)
```

For more details please see `analysis/examples/FEI/B_converted_apply.py`

- Improved FEI weight files coming soon…
- Stay tuned.

8.5.3. Flavour Tagger

To apply flavour tagger in a b2bii analysis, one will need to append the correct global tag.
FlavorTagger will call the corresponding payloads in the module.

```
import flavorTagger as ft

# Flavour Tagger
weightfiles = 'B2nunubarBGx1'
basf2.conditions.append_globaltag("analysis_tools_light-2012-minos")
ft.flavorTagger(
    particleLists=['B+:sig'],
    weightFiles=weightfiles,
    path=my_path)
```

- GNN-FT weight files coming soon…
- Stay tuned.

Other things when run B1 with B2BII

About HadronBJ skim

- # of events to run “B2BIIConvertMdst” is less than the total numbers.

Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
AnalysisConfiguration	500	0	0.00	0.01 +- 0.00
AnalysisConfiguration	500	0	0.00	0.01 +- 0.00
B2BIIMdstInput	500	0	0.12	0.25 +- 0.04
B2BIIFixMdst	500	0	0.10	0.21 +- 0.20
B2BIIConvertMdst	490	6	0.54	1.11 +- 1.05
VariablesToHistogram	490	0	0.01	0.01 +- 0.01
Total	500	6	0.84	1.67 +- 1.24

- Don’t worry. Nothing wrong here.
- The loss is due to skim cut in fix_mdst which is same as HadronBJ [ref]

B1's systematic uncertainties

- Check Belle Systematic page.
- For some, scripts to calculate weights.

Systematics

How to estimate your systematics

- **Tracking efficiency** (Updated June 14, 2011, Bipul Bhuyan, IIT G): Tracking efficiency result for high momentum tracks with Pt > 200 MeV/c has recently been updated (see BN1165 and latest talk) for experiment nos 7 to 71. Based on this new study, we measured the difference in the tracking efficiency in data and MC to be R = (-0.13 +- 0.30 +- 0.10)% per track. Since the ratio is much smaller than the statistical uncertainty, therefore, instead of applying this ratio as a correction, we recommend applying **a systematic uncertainty of 0.35% per track**. Once again, please note that this prescription is valid only for tracks with Pt > 200 MeV/c. For low momentum tracks, an additional systematic uncertainty from low momentum tracks study (see BN480) should be applied.
- Low momentum tracks efficiency: latest BGM talk for $\pi+$ & $\pi0$, BN1176
- KID: data efficiencies, MC efficiencies, correction factors eff(data)/eff(MC) over (plab,cos θ) bins, obtained using inclusive D* sample. BAS talk for usage
- K_S Efficiency and Systematic: Belle Note 1207

New studies

- LID: efficiency correction and systematic errors calculated from the comparison between the data and MC for $2\gamma \rightarrow ee/\mu\mu$.
- Asymmetries in the detector
  1. Charged kaon: Charged kaon asymmetry calculated by D decays.
  2. Charged pion: Charged pion asymmetry calculated by D decays. (Under construction)
- Fake rate ($\{\pi, K, p\} \rightarrow \{e, \mu\}$)
- Proton ID (see BN1279)
- π^0 efficiency: latest BGM talk
- γ efficiency

B1's systematic uncertainties

- Tracking [ref] : 0.35% per track, for Pt > 200 MeV/c
- N(BB) =$N(B\bar{B}) = (771.581 \pm 10.566) \times 10^6$ [ref]
- γ: 2% for each [ref]
- K^0_S:[ref] updated in bn_1437

Selection	SVD1	SVD2	Total
nisK_S	97.612 ± 0.499	97.744 ± 0.177	97.729 ± 0.167
goodK_S	96.594 ± 0.509	97.636 ± 0.182	97.517 ± 0.172

Table 6.3: Efficiency ratio for nisK_S and goodK_S list. The uncertainty is only statistical one.

- PID syst: Belle PID Joint Homepage

There are three groups of lookup tables in Belle:

- **Lepton ID:**
  - Possible cuts for electron: [0.01, 0.10, 0.50, 0.60, 0.80, 0.90]
  - Possible cuts for muons: [0.10, 0.80, 0.90, 0.95, 0.97]
- **Kaon/π ID:**
  - PID cut can be 0.1 - 0.9
- **Proton ID:**
  - Possible cuts for proton: [0.6, 0.7, 0.8, 0.9]

B1's systematic uncertainties

- PID corrections and systematic uncertainties.
  - With "$BELLE2_RELEASE_DIR/b2bii/examples/ApplyBelleWeights.py"

LID as an example

```
lid_table = "BelleLIDe_0.90"
```

→ The cut value.

```
va.variables.addAlias('LID_ratio', 'extraInfo('+lid_table+'_ratio)')
va.variables.addAlias('LID_ratio_stat_err', 'extraInfo('+lid_table+'_ratio_stat_err)')
va.variables.addAlias('LID_ratio_syst_err', 'extraInfo('+lid_table+'_ratio_syst_err)')
va.variables.addAlias('LID_ratio_syst_err_from_2photon', 'extraInfo('+lid_table+'_ratio_syst_err_from_2photon)')
va.variables.addAlias('LID_ratio_syst_err_from_JPsi', 'extraInfo('+lid_table+'_ratio_syst_err_from_JPsi)')
va.variables.addAlias('LID_run_bin', 'extraInfo('+lid_table+'_run_bin)')
va.variables.addAlias('LID_kinematic_bin', 'extraInfo('+lid_table+'_kinematic_bin)')
```

→ Correction weight.

→ Uncertainty of weight.(Syst)

```
lid_weights = ['LID_ratio',
               'LID_ratio_stat_err',
               'LID_ratio_syst_err',
               'LID_ratio_syst_err_from_2photon',
               'LID_ratio_syst_err_from_JPsi',
               'LID_run_bin',
               'LID_kinematic_bin']
```

→ Variables stored into Ntuples.

```
reweighter = b2.register_module('ParticleWeighting')
reweighter.param('tableName', lid_table)
reweighter.param('particleList', 'pi+:all')
my_path.add_module(reweighter)
```

B1's systematic uncertainties

- PID corrections and systematic uncertainties.
  - With "$BELLE2_RELEASE_DIR/b2bii/examples/ApplyBelleWeights.py"
  - With the C++ code. Basf2 free. But need to get it from the webpage.

KID as an example

```
#include "kid_eff_06.h"

class userana : public Module {
...
private:
  KID_eff_06 kideff1;                  // <-- !!
  KID_eff_06 kideff2;                  // <-- !!
}

void userana::init(int *) {
  kideff1.init( .6, 1, "track1", "kideff-2006-svd1-all.dat" ); // <-- !!
  kideff2.init( .6, 1, "track2", "kideff-2006-svd2-all.dat" ); // <-- !!
  // 1st argument : probability cut value (0.1,0.2,...,0.9)
  // 2nd argument : 1 = prob(K/pi)>0.X for kaon (kaon eff)
  //                2 = prob(K/pi)>0.X for pion (pion fake)
  //                3 = prob(pi/K)>0.X for pion (pion eff)
  //                4 = prob(pi/K)>0.X for kaon (kaon fake)
  //                where 0.X is the number given as 1st argument
  // 3rd argument : name (anything is OK. but it should be different
  //                with each other)
}

void userana::event(BelleEvent* evptr, int* status) {
  ...
  if(expno<30) kideff1.addtrack( plab, costheta );     // <-- !!
  else kideff2.addtrack( plab, costheta );     // <-- !!
  // You need to call these functions for events after selection criteria
  ...
}
```

```
================================================================
Output will be as follows (numbers here are just for explanation).

----------------------------------------------------------
...
basfsh% kid_eff_track1
ratio   1.0028 +- 0.0148 (ref. ratio 1.0019)
data    0.9222 +- 0.0110
MC      0.9241 +- 0.0011
used track: 4859   ignored track: 934
ref. ratio is the data/MC ratio assuming that MC is correct for invalid bins
You may take the difference to the ratio (0.0009) as an additional
systematic error (i.e. 0.0149 syst. error)
...
----------------------------------------------------------
```

Many B1+B2 analysis ongoing

- “B1+B2” becomes more and more “popular”.
- From Belle II Authorship confirmation page:
  - Published: 2 ;Submitted:1 ; CWR: 2. (42 in total so 5/42 ~ 12%!)
- Analyses before CWR: data are from group reports last week.
  - (Semi)leptonic: > 2
  - TDCPV: > 5
  - EWP: > 5
  - Charm: > 7
  - Quarkonium: > 3
  - …

Examples ($B^+ \to D(K^0_S h^+ h^-) h^+$)

Full charged case

- First "B1+B2" physics paper $B^+ \to D(K^0_S h^+ h^-) h^+$ (JHEP 02 2022, 063)

TABLE XL: Belle + Belle II hadronic parameters in a combined dataset of (711+128.1) fb^{-1}

Parameter	Belle	Belle II	Belle + Belle II
δ_B	$(130.1 \pm 12.4)^\circ$	$\left(84.5^{+50.9}_{-67.0}\right)^\circ$	$\left(124.2^{+12.7}_{-12.3}\right)^\circ$
r_B^{DK}	0.144 ± 0.028	$0.079^{+0.068}_{-0.062}$	$0.130^{+0.025}_{-0.026}$
ϕ_3	$(79.3 \pm 11.0)^\circ$	$\left(75.3^{+50.1}_{-64.6}\right)^\circ$	$\left(77.8^{+11.5}_{-11.1}\right)^\circ$

Previous Belle result [Phys. Rev. D 85 (2012) 112014]

$\phi_3 = (77.3^{+15.1}_{-14.9} \pm 4.1 \pm 4.3)^\circ$

$r_B = 0.145 \pm 0.030 \pm 0.010 \pm 0.011$

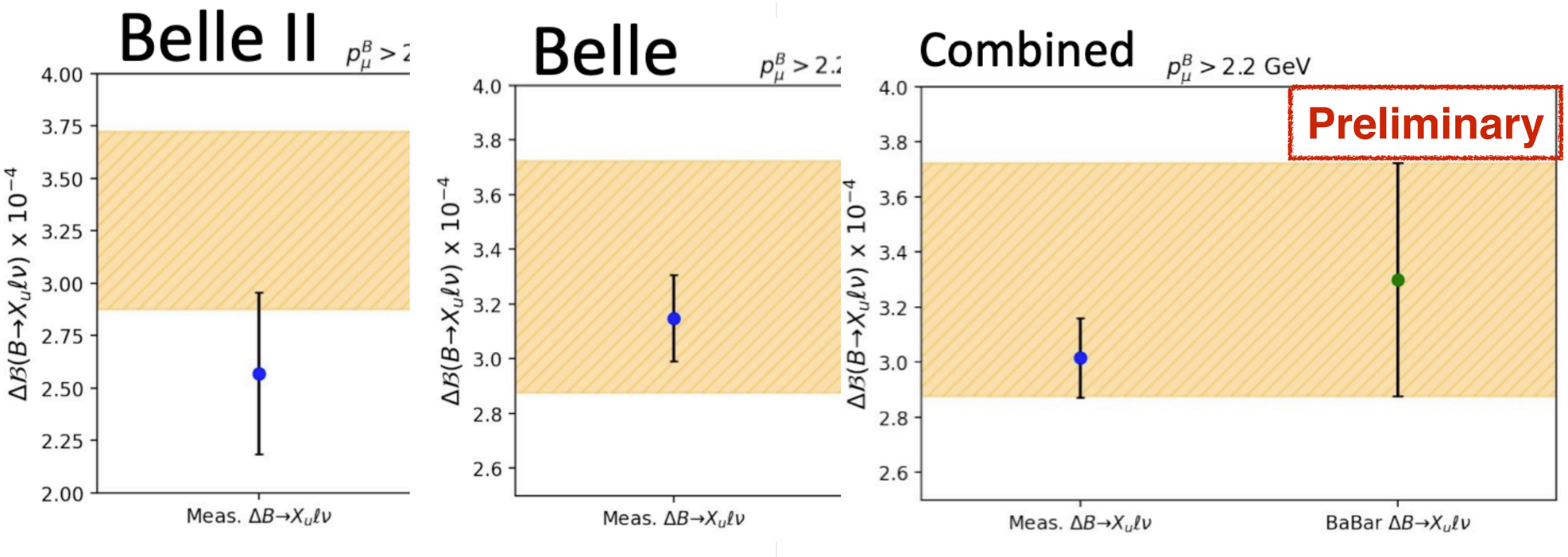
$\delta_B = (129.9 \pm 15.0 \pm 3.8 \pm 4.7)^\circ,$

- Only Belle II data set, large uncertainty on ϕ_3.
- Additional Belle II data set, "pull" r_B^{DK} smaller (close to w.a.)
- Also an example: worth to re-do it even there is a Belle paper! (External inputs changed; better reconstruction method.)

Examples ($B \to \mu\nu$)

Leptonic case

From Markus's slides



- Expected precision of one bkg channel: from ~0.5 $\times 10^{-4}$ (Belle II only) to ~ 0.2 $\times 10^{-4}$ (Belle and Belle II).

Examples ($D^0 \to K^0_S K^0_S$)

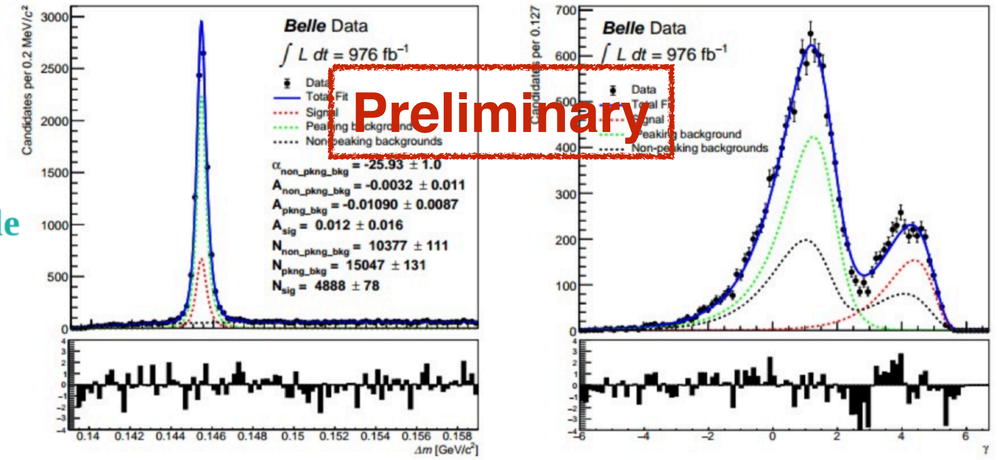
Charm case

γ represents the flight significance: key variable to identify from $K^0_S\pi^+\pi^-$

Δm

γ

D⁰ sample



Preliminary

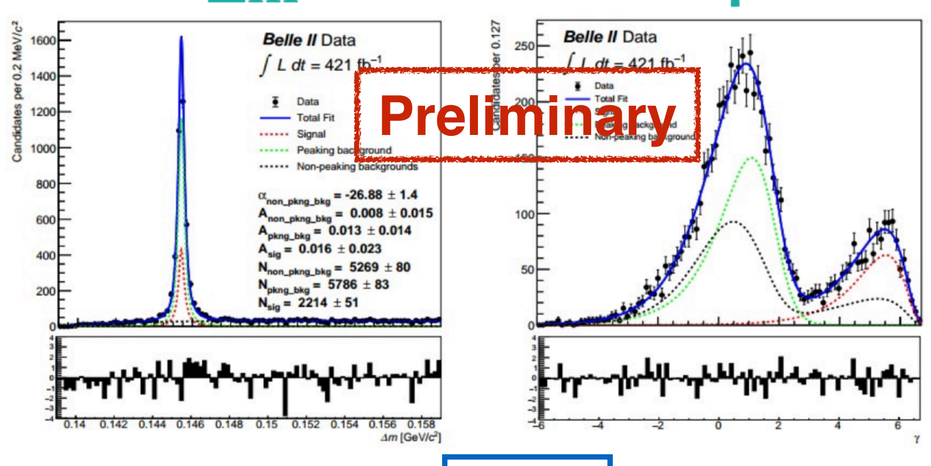
Belle

- **Signal yield / fb^{-1}: 5.00 ± 0.08**

Δm

γ

D⁰ sample



Preliminary

Belle II

- **Signal yield / fb^{-1}: 5.16 ± 0.12**

Final results (blinded): Preliminary

- A_{raw} in signal is blinded using a random offset sampled between [-0.1,0.1].

$A_{CP}(D^0 \to K_s K_s)$ in Belle: (1.2 ± 1.6 (stat.) ± 0.1 (syst.)) %

$A_{CP}(D^0 \to K_s K_s)$ in Belle II: (1.6 ± 2.3 (stat.)± 0.1 (syst.)) %

$A_{CP}(D^0 \to K_s K_s)$ (Belle + Belle II) = (1.3± 1.3 (stat.) ± 0.1 (syst.)) %

Examples ($B^0 \to \gamma\gamma$)

Photons case

BelleII-Note-PH-2023-061 **Preliminary**

	Belle	Belle II	Previous Belle
Luminosity	711 fb^{-1}	362 fb^{-1}	104 fb^{-1}
Signal Efficiency	23.3%	30.8%	11.7% [8]

TABLE LVII: Performance comparison with previous Belle result.

- Got higher efficiency than previous Belle work. Did better work now!

Preliminary blinded result

Belle II $\mathcal{B}(B_d \to \gamma\gamma) < 7.55 \times 10^{-8}\, at\, 90\%\, CL$

Belle $\mathcal{B}(B_d \to \gamma\gamma) < 5.00 \times 10^{-8}\, at\, 90\%\, CL$

Belle + Belle II $\mathcal{B}(B_d \to \gamma\gamma) < 4.19 \times 10^{-8}\, at\, 90\%\, CL$

Summary

- Using B1 data on basf2 is not that difficult.
- Let's add B1 data into our Belle II analyses, for better physics result!
- "How to"
  - generate Belle signal MC,
  - find Belle generic MC/data sample,
  - get systematic uncertainties

Attend B2BII group meeting: get help/help b2bii!

Indico: https://indico.belle2.org/category/67/

Maillist: software-b2bii@belle2.org