Initial study of e+ e- -> mu+ mu- cross section with basf2

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Motivation

The process e+ e− → μ+ μ− is the simplest process in the electroweak theory and at the same time it constitutes an important tool in the high energy physics. It plays a fundamental role for studies of the electromagnetic and weak interactions, electromagnetic properties of hadrons.

This process is used for
(1)quantum electrodynamics (QED) tests, in electroweak interference studies
(2)in leptonic width measurements of the $I^G J^{PC} = 0^- 1^{--}$ vector mesons and Z-bozon,
(3)the study of the running electromagnetic coupling constant α(s).

Procedure of basf2 physics analysis

Motivation: choose one decay mode that has significant physics meaning.

Use signal Monte Carlo sample of this decay, use background MC produced by expert that are well simulated. In my analysis, I only used signal MC.

Write basf2 steering file:
1. Fill particles relevant to the decay channel, apply specific cuts to suppress background events.
2. Reconstruct decay channel.
3. Fill variables we want into Ntuple and generate output root file.

Run steering file with Monte Carlo MDST files.

Draw histograms and have fun playing with them.

Basf2 steering file for reconstruction of e+e- ->mu+mu-

```python
input_file = 'root://dcbldoor01.sdcc.bnl.gov:1096//pnfs/sdcc.bnl.gov/data/bellediskdata/TMP/belle/MC/release-03-01-
00/DB00000547/MC12b/prod00007466/s00/e1003/4S/r00000/3500420000/mdst/sub00/mdst_000247_prod00007466_task10020000247.root'

import basf2 as b2
import modularAnalysis as ma

my_path = b2.create_path()


ma.inputMdstList("default", [input_file], path=my_path)
#b2.set_module_parameters(path=my_path,name="RootInput", cacheSize=100)

#ma.fillperticlelist("pi+:my_pion","pionID>0.5", path = my_path)
ma.fillParticleList("mu+:my_muons","abs(dr)<0.5 and abs(dz)<2 ", path=my_path)

#import stdCharged as sc
#sc.stdMu("higheff", path = my_path)

#ma.applyEventCuts(cut= 'nTracks == 2', path=my_path)
ma.reconstructDecay('vpho:photon -> mu+:my_muons mu-:my_muons', '', path = my_path)
#ma.matchMCTruth('D0:Kpi_B255', path=my_path)

#ma.vertexTree('B+:Dpi', 0.0,path=my_path)

ma.variablesToNtuple('vpho:photon',
                     ['M','p','E',
                      'daughter(0,E)',
                      'daughter(1,E)',
                      'daughter(0,charge)',
                      'daughter(1,charge)'],
                     filename = 'eemumu_analysis.root',
                     path = my_path)
ma.variablesToNtuple('mu-:my_muons',
                     ['dr','dz','E'],
                      treename = 'tree',
                     filename='eemumu_analysis2.root',
                      path = my_path)


b2.process(my_path, max_event = 1000)
```
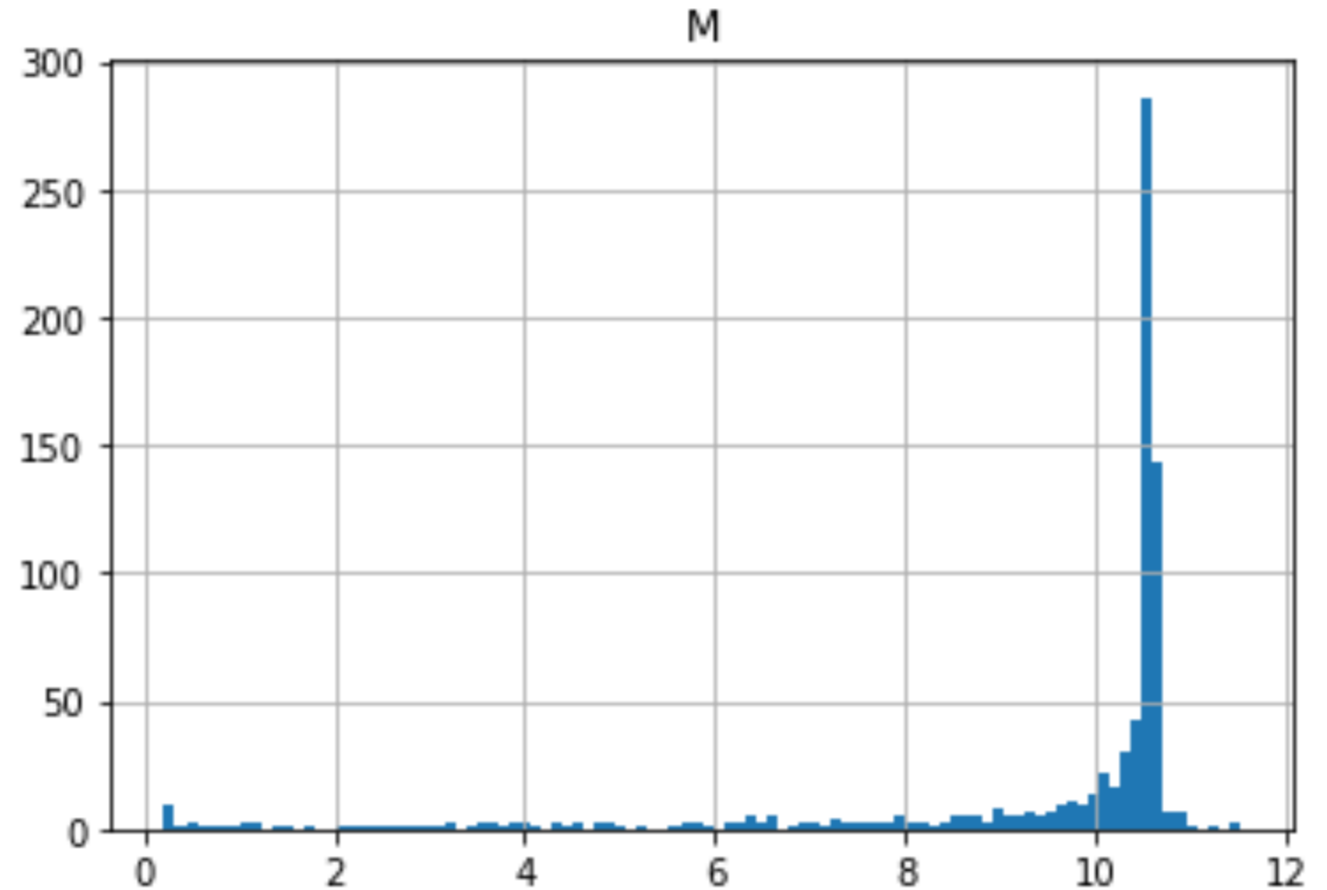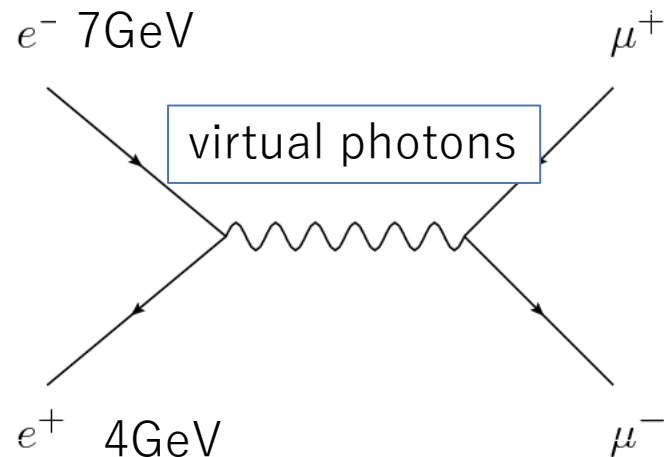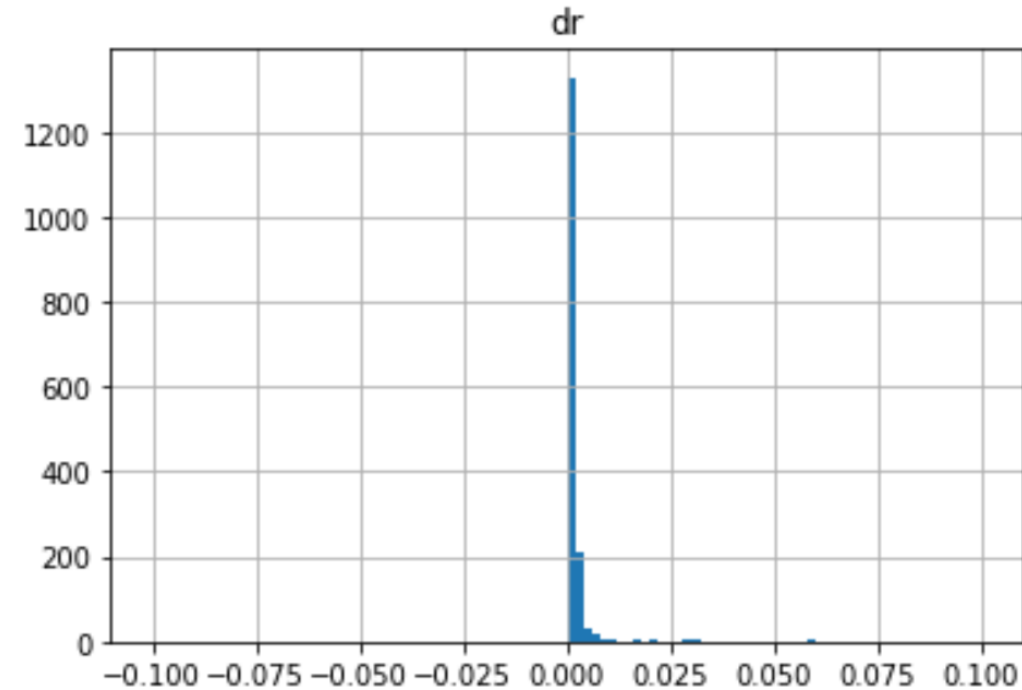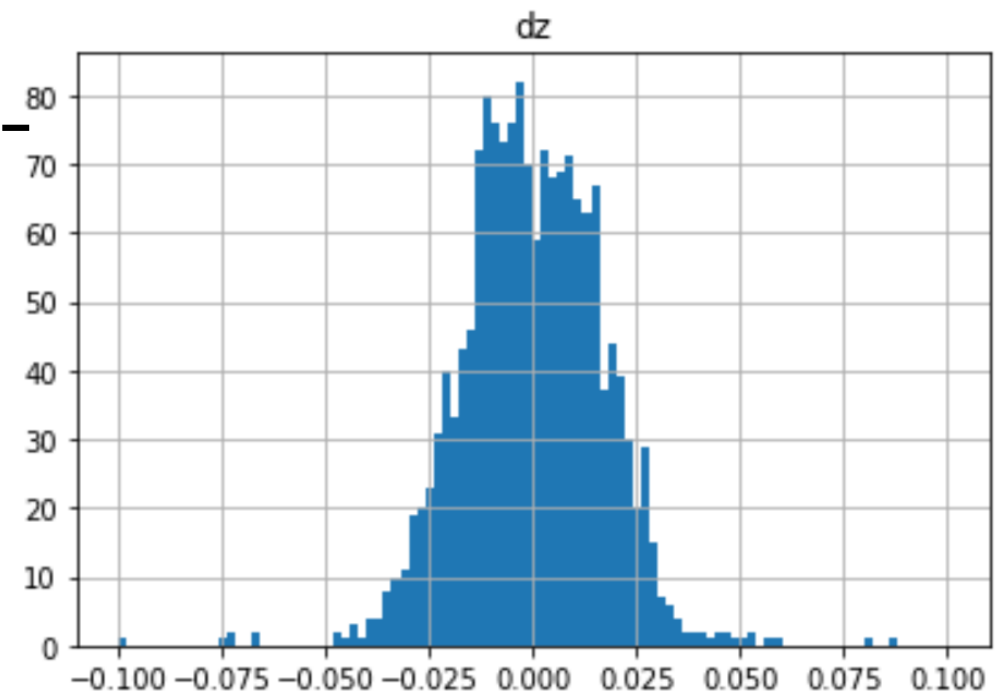
Invariant mass of virtual photon(energy) for signal MC events

- Photon -> mu+ mu-

- In electromagnetic interaction, electric force is due to electric charges emitting virtual photons.
- Energy of e+ is 4GeV and that of e- is 7GeV.

Impact parameters of e+ e- -> mu+ mu- Signal MC events

- Current window for impact parameters: abs(dr)<0.5 && abs(dz)<2

- Based on the plots, we may make tighter cut on impact parameters in the future to further suppress background events.

Energy of muon for signal MC events

Orange: daughter(1,E)
Blue: daughter(0,E)

- Using Matplotlib

- One peak is 4GeV and another is 7GeV.

e^- 7GeV

virtual photons

e^+ 4GeV

μ^+ μ−

μ^- μ+
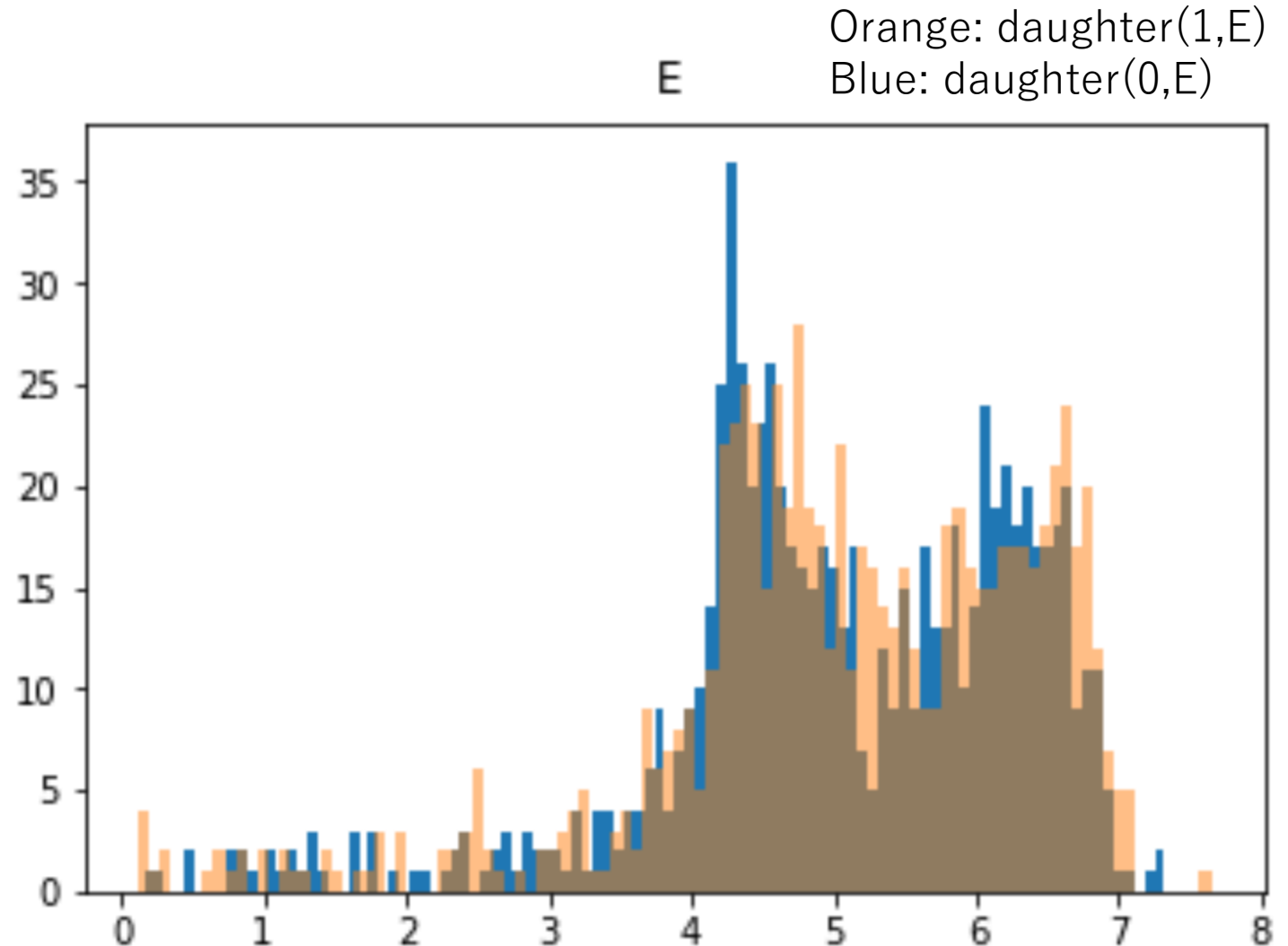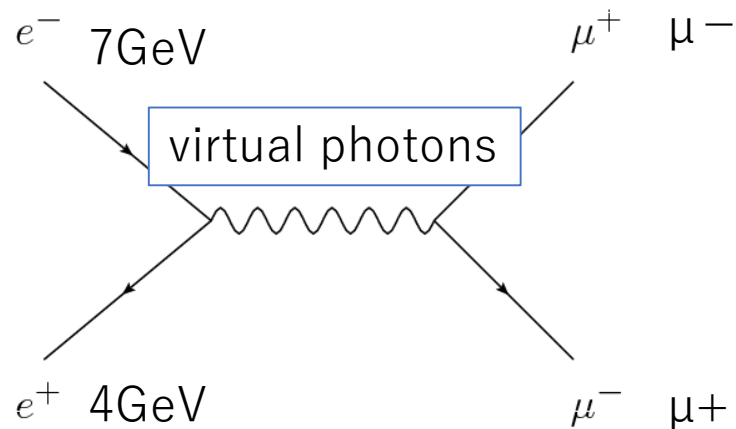
Conclusion

- The process e+ e− → μ+ μ− is the simplest process in the electroweak theory and at the same time it constitutes an important tool in the high energy physics.

- In basf2 physics analysis, making a tighter cut on impact parameters in the future is essential to suppress background events further.

Thank you for your listening!