Institut
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Belle II

Belle2Lab - Interactive Tool for Public Analysis of Belle II Data

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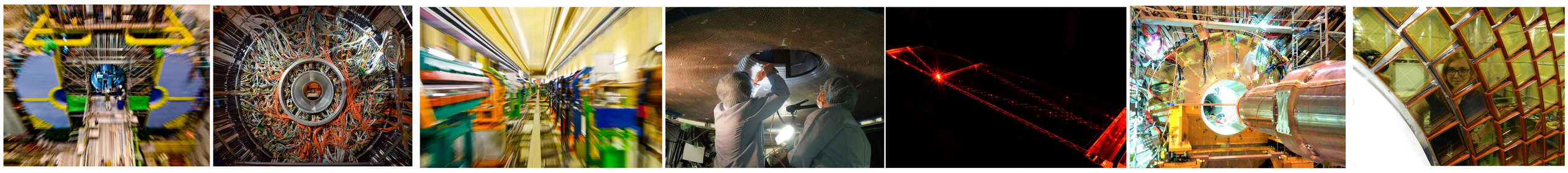
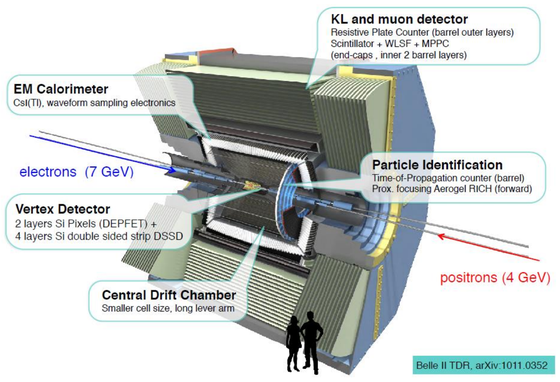
#235
Track 6

Scan me

Several data samples from a Belle II experiment will be available to the general public as a part of experiment outreach activities. Belle2Lab is designed as an interactive graphical user interface to reconstructed particles, offering users basic particle selection tools. The tool is based on a Blockly JavaScript graphical code generator and can be run in a HTML5 capable browser. It allows description of different particle decays by selecting and combining particles from the data file, easy histogramming tools and display of the results by using the JSROOT library. During the analysis, the user has a possibility to apply the cuts on selected variables. A pseudocode generated by the user interface is sent to the execution server which returns the histograms, that can also be interactively fitted. The Belle2Lab is accessible in two ways: hosted on a single public web server http://belle2.ijs.si/masterclass or as a part of the virtual appliance, which consists of a Linux operating system, a data sample, an analysis framework and a private web server. The former can be used for single access, while the latter is for use in a classroom.



Belle II experiment



Disseminate

Disseminate our knowledge to the general public
- ❑ What are we doing ?
- ❑ How does the Belle II detector look like?
- ❑ What are our research methods?
- ❑ What do we expect to see?
- ❑ What are our results?

Audience

- ❑ students of physics
- ❑ high school students
- ❑ primary school students
- ❑ general public (assume finished high school)

How?

Exercises at a different level of complexity
Make **part of the data** available to the public + **Graphical user interface**

Graphical user interface generates pseudocode which runs the analysis in the backend
- ❑ user friendly
- ❑ expose physics of particles
- ❑ minimize the starting errors made during coding

Educational app which can be used on the web and also run od the PC

Web version runs on a single web server
- ❑ enables access to everyone and

Virtual appliance with data and the software pre-installed
- ❑ allows download ⟶ for schools & workshops

Data sample: Belle data, in 2019, switch to Belle II data

Several exercises:
- ❑ spectroscopy examples for the pilot run.
- ❑ Based on the feedback and our experiences we will extend it later with more complex examples.

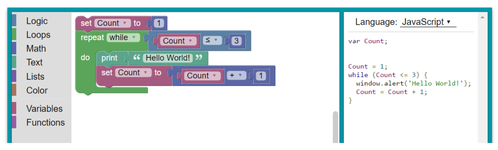
Design the exercises to be used by larger groups of people

Underlying code based on Belle educational B-lab exercises:
http://belle.kek.jp/b-lab/b-lab-english/

Web interface
The graphical user interface based on Blockly -

Design

Based on
Blockly google graphical library http://developers.google.com/blockly/



Inspired by MIT Scratch https://scratch.mit.edu

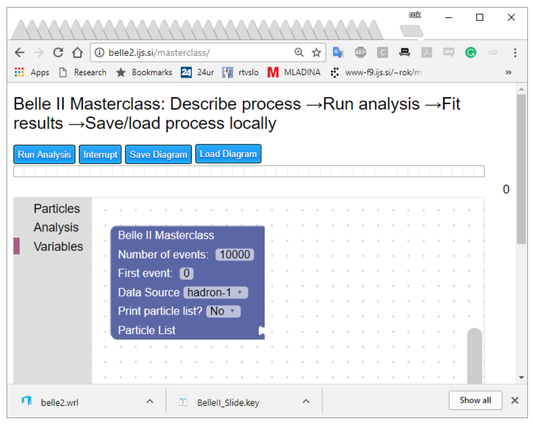
User describes a decay by blocks:

- ❑ Blockly JavaScript generates JSON text strings
- ❑ The strings are sent to the server
- ❑ Converted into the computer code ROOT macro
- ❑ The code is executed on the server
- ❑ histograms are sent back to the client
- ❑ displayed using JSROOT JavaScript.

{"analysis":{"neve":"50000","first":"0","print":"0","datasource":"2","list":{"combiner":{"list1":{"selector":{"list1":"","charge":"-1","pid":"PION","histogram":{"h1d":{"varname":"GetMass","name":"pion Mass","nbins":"100","min":"0","max":"1"}} }} ,"list2":{"selector":{"list1":"","charge":"1","pid":"PION","histogram":""}} ,"sameparticles":"0","pid":"KAON","m0":"0","m1":"1","histogram":{"h1d":{"varname":"GetMass","name":"pipi Mass;GeV/c;N","nbins":"400","min":"0","max":"1"}} }} }

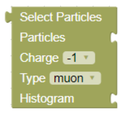
```
.L BParticle.cc+ .L BEvent.cc+ .L Blab2.cc void Blab2::event(){
combiner(selector(-1,-1,PION,0,2) ,selector(-1,1,PION,-1,3)
,0,KAON,0,1,1,1) ; } void Blab2::Init(){ fNeve=50000; fNfirst=0;
fData=2; fPrint=0; h1d("GetMass","pipi
Mass;GeV/c;N",400,0,1,1); h1d("GetMass","pion
Mass",100,0,1,0); plist(1); plist(2); plist(3); } Blab2 *blab2 = new
Blab2();
```

Visual programming environment

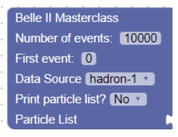


Basic blocks

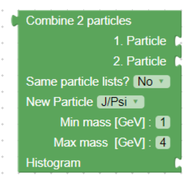
Limited number of blocks:



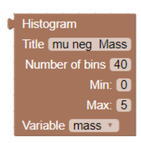
Select particle type for analysis and append histogram for plotting the properties



Define:
- ❑ Number of events to process
- ❑ First event to process
- ❑ Data Source
- ❑ Print particle list for first 100 events
- ❑ Particle list to process/ by default the list from the file is used



Combination of particles from two lists

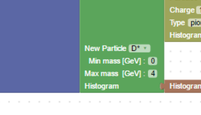


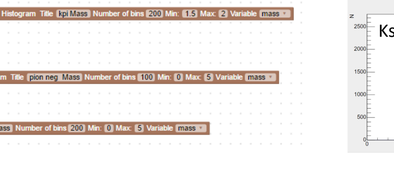
Plot a distribution

Define a range and a variable to plot

Particle list

- ❑ Without any connected blocks the particle list is listed





Primary particle list for Event 1

N	px(GeV/c)	py(GeV/c)	pz(GeV/c)	p(GeV/c)	Energy(GeV)	Charge	ID
1	-0.99205	0.255215	-0.298016	1.06682	1.06682	-1	electron
2	0.379417	0.416063	0.292391	0.634475	0.634475	-1	electron
3	0.448819	0.279332	0.857395	1.00727	1.01689	1	pion
4	-0.381274	0.317797	0.666425	0.830956	0.842596	-1	pion
5	-0.404262	0.0618774	0.419536	0.58589	0.602285	-1	pion
6	0.0363708	-0.337713	0.696636	0.775032	0.787499	1	pion
7	-0.125205	0.251112	0.201202	0.345276	0.372418	-1	pion
8	0.111522	0.10243	0.139017	0.205559	0.248464	1	pion
9	0.0599534	0.0198644	0.0726116	0.0962364	0.169532	-1	pion
10	-0.0335806	0.0421883	0.0666954	0.0857659	0.163816	1	pion
11	0.180846	-0.00941455	0.265317	0.321227	0.321227	0	photon
12	0.354789	0.0498766	0.227253	0.424272	0.424272	0	photon
13	0.393443	-0.310244	0.28901	0.578425	0.578425	0	photon
14	0.254512	-0.0893971	0.113315	0.29259	0.29259	0	photon
15	0.152624	-0.0325375	0.296991	0.335494	0.361627	0	pion
16	0.650451	-0.401558	0.403939	0.864582	0.875054	0	pion

Combine the blocks

The particle lists for each event are stored in an ROOT tree.

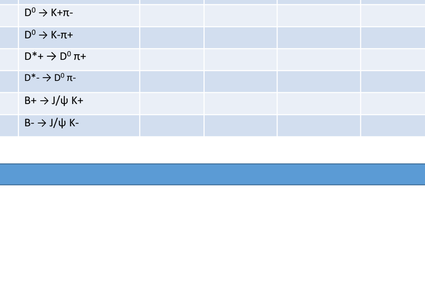
By combining different blocks the event loop is generated. Inside the loop, new particle lists can be generated by combining the existing lists.

Distribution of different particle quantities can be plotted

Fixed block connectors minimize coding errors

Plot different variables :
- ❑ mass,
- ❑ momentum,
- ❑ energy,
- ❑ charge,
- ❑ identity,
- ❑ px,py,pz,pT
- ❑ cos(theta),
- ❑ theta

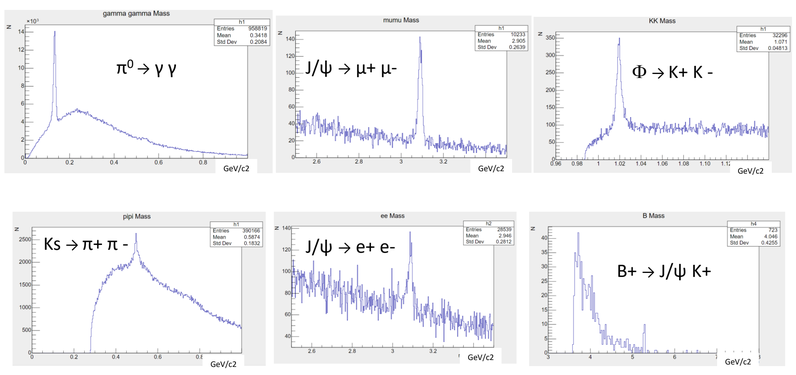
Decay to two particles



Combination of three particles

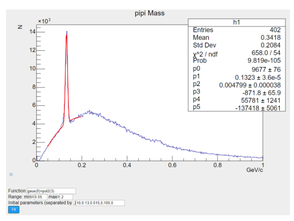
Different decays

Invariant mass plots for different decays



Advanced

Fit the results



Worksheet

Exercise table with the list of decays to examine

Particle		Proces	Mass (GeV/c²)	Number of entries	Number of detected particles	Probability	Decay width (GeV)
π^0	$\frac{1}{\sqrt{2}}(u\bar{u}-d\bar{d})$	$\pi^0 \rightarrow \gamma\,\gamma$					
Ks	$\frac{1}{\sqrt{2}}(d\bar{s}+\bar{s})$	Ks → π+ π -					
ϕ	$s\bar{s}$	ϕ → K+ K -					
J/ψ	$c\bar{c}$	J/ψ → e+ e-					
		J/ψ → μ+ μ-					
D^0	$c\bar{u}$	D^0 → K+π-					
		D^0 → K-π+					
D*+		D*+ → D^0 π+					
D*-	$d\bar{c}$	D*- → D^0 π-					
B+	$u\bar{b}$	B+ → J/ψ K+					
B-	$\bar{u}b$	B- → J/ψ K-					

Try it by yourself