Public analysis of Belle II Data

Rok Pestotnik, Leo Piilonen[2]

For the Belle II collaboration

[1]*Jožef Stefan Institute*, Ljubljana, Slovenia

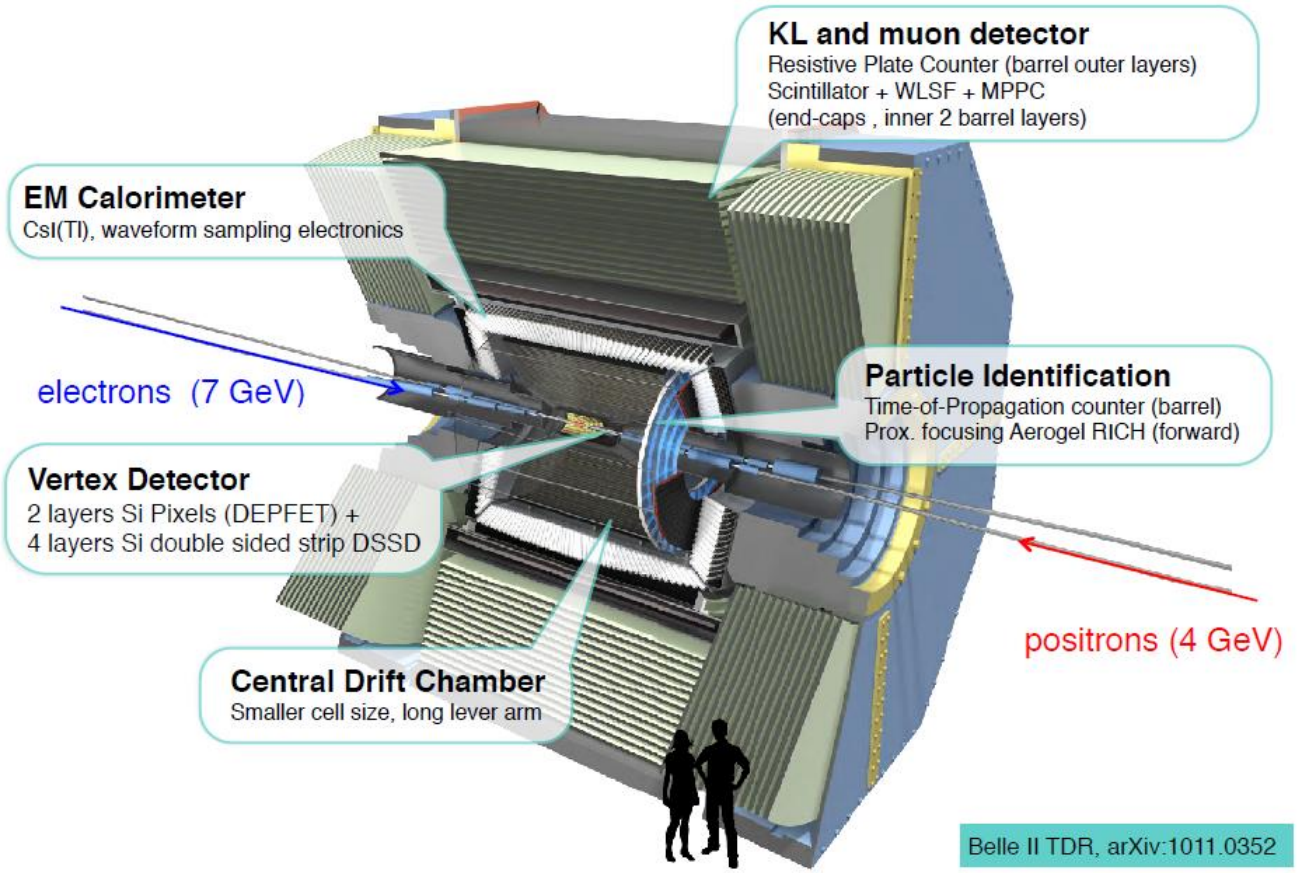
[2]*Virginia Tech, Blacksburg, USA*

Contents

- Introduction – Belle II experiment
- Dissemination
- Design
- Implementation of interface
- Usage

Belle II experiment

Study of rare decays of B, D and τ



Dissemination of our work

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 do we do it?

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 runs on the PC

Web version runs on a single web server

- ❑ enables access to everyone

Virtual appliance with data and the software pre-installed

- ❑ allows download → for schools & workshops

Our approach

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

Several exercises:

- ❑ spectroscopy examples
- ❑ 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

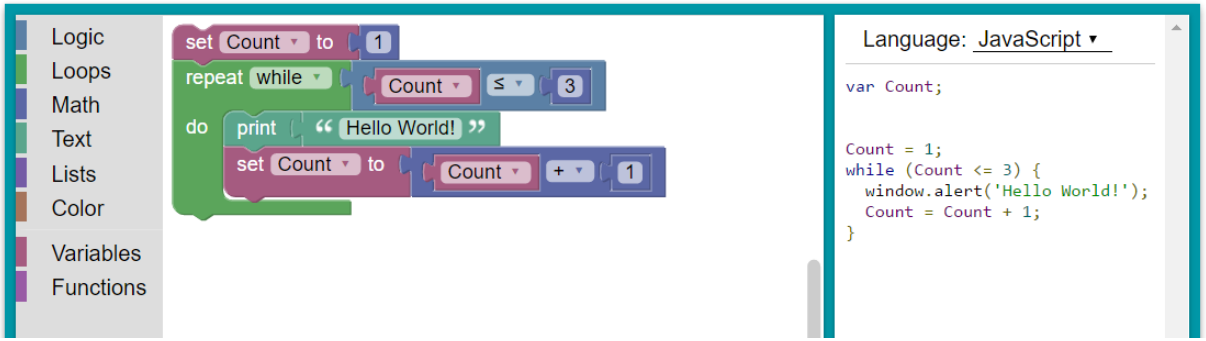
Underlying code based on Belle educational B-lab exercises:
http://belle.kek.jp/b-lab/b-lab-english/

Web interface

The graphical user interface based on Blockly -

Design

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



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

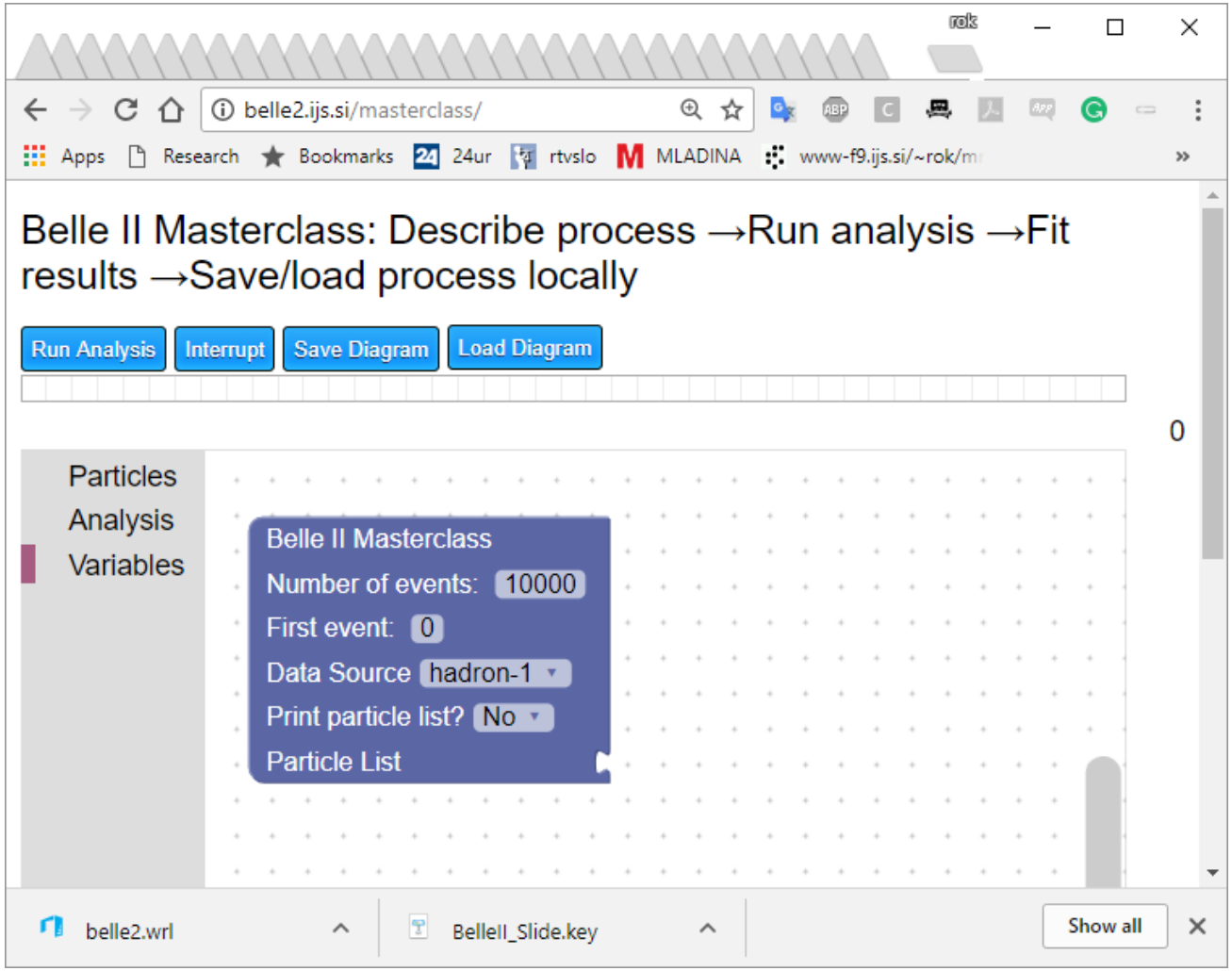
User describes a decay by blocks:

- 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"}} }} }}

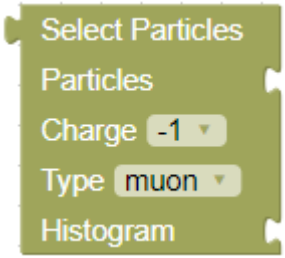
.L BParticle.cc+ .L BEvent.cc+ .L Blab2.cc void Blab2::event(){ combiner(selector(-1,-1,PION,0,2),selector(-1,1,PION,-1,3) ,0,KAON,0,1,1,1) ; } void Blab2::Init(){ fNeve=50000; fNfirst=0; fData=2; fPrint=0; h1d("GetMass","pipi Mass;GeV/c;N",400,0,1,1); h1d("GetMass","pion Mass",100,0,1,0); plist(1);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

Visual programming environment

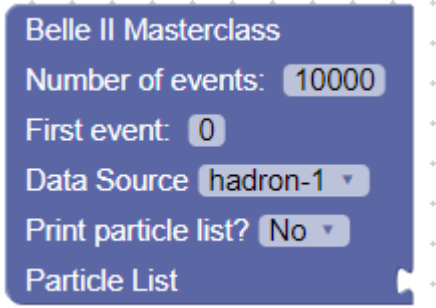


Basic blocks

Limited number of blocks:

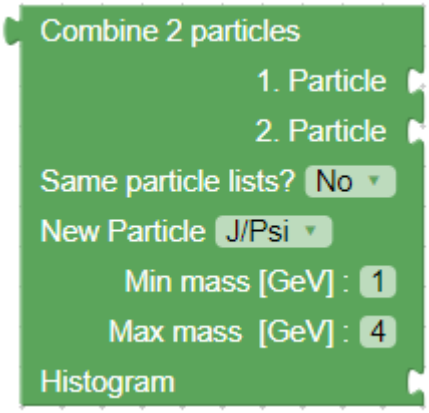


Select particle type for analysis and append histogram for plotting the properties

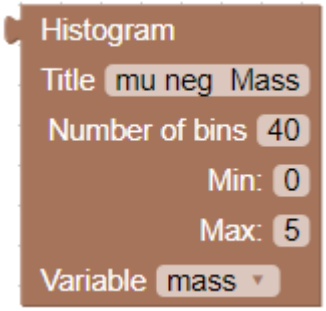


Define main analysis parameters

- ❑ 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



Make a combination of particles from two lists

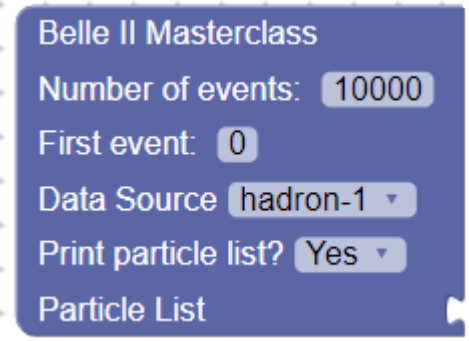


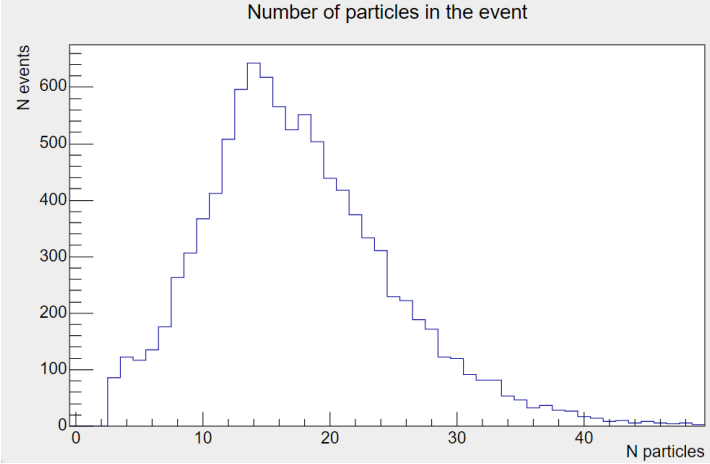
Plot a distribution

Define a range and a variable to plot

Particle list

- Without any connected blocks the particle list is listed if only a main block is included in the sketch





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

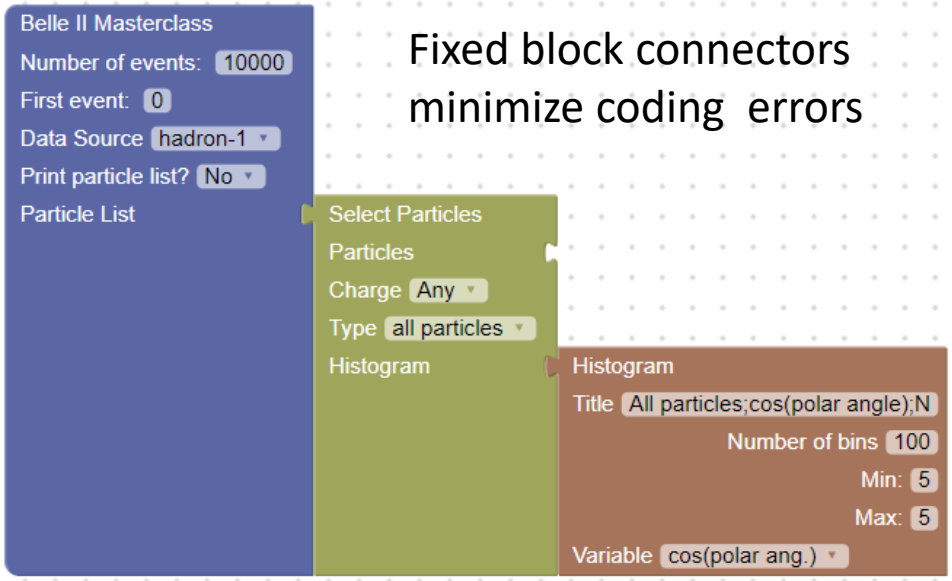
The particle lists for each event are stored in an ROOT tree.

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

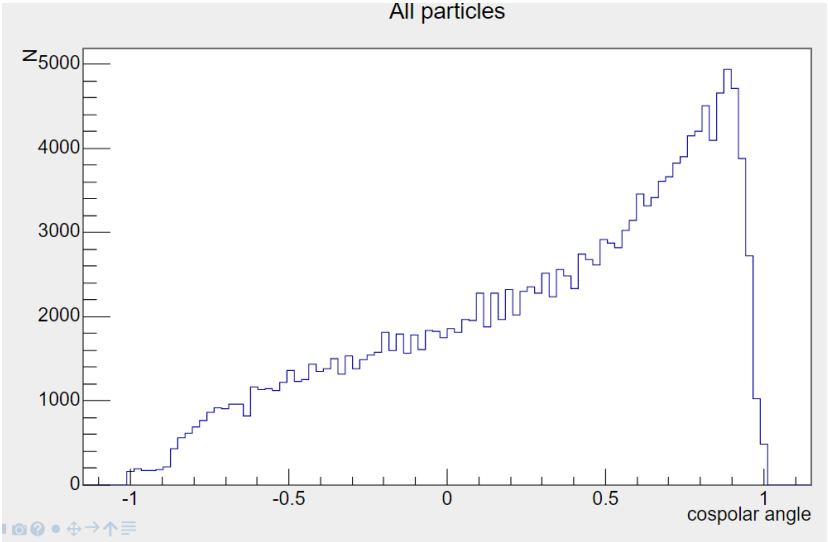
Distribution of different particle quantities can be plotted

Plot different variables :

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



Fixed block connectors minimize coding errors

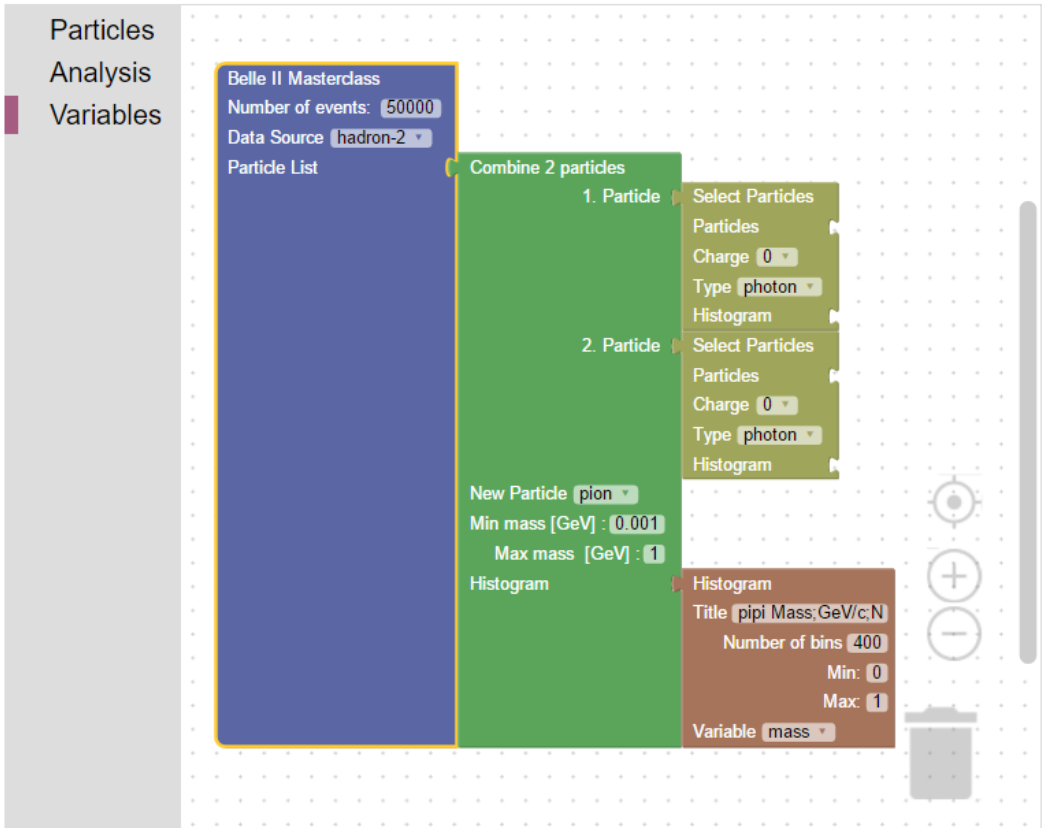


Decay to two particles

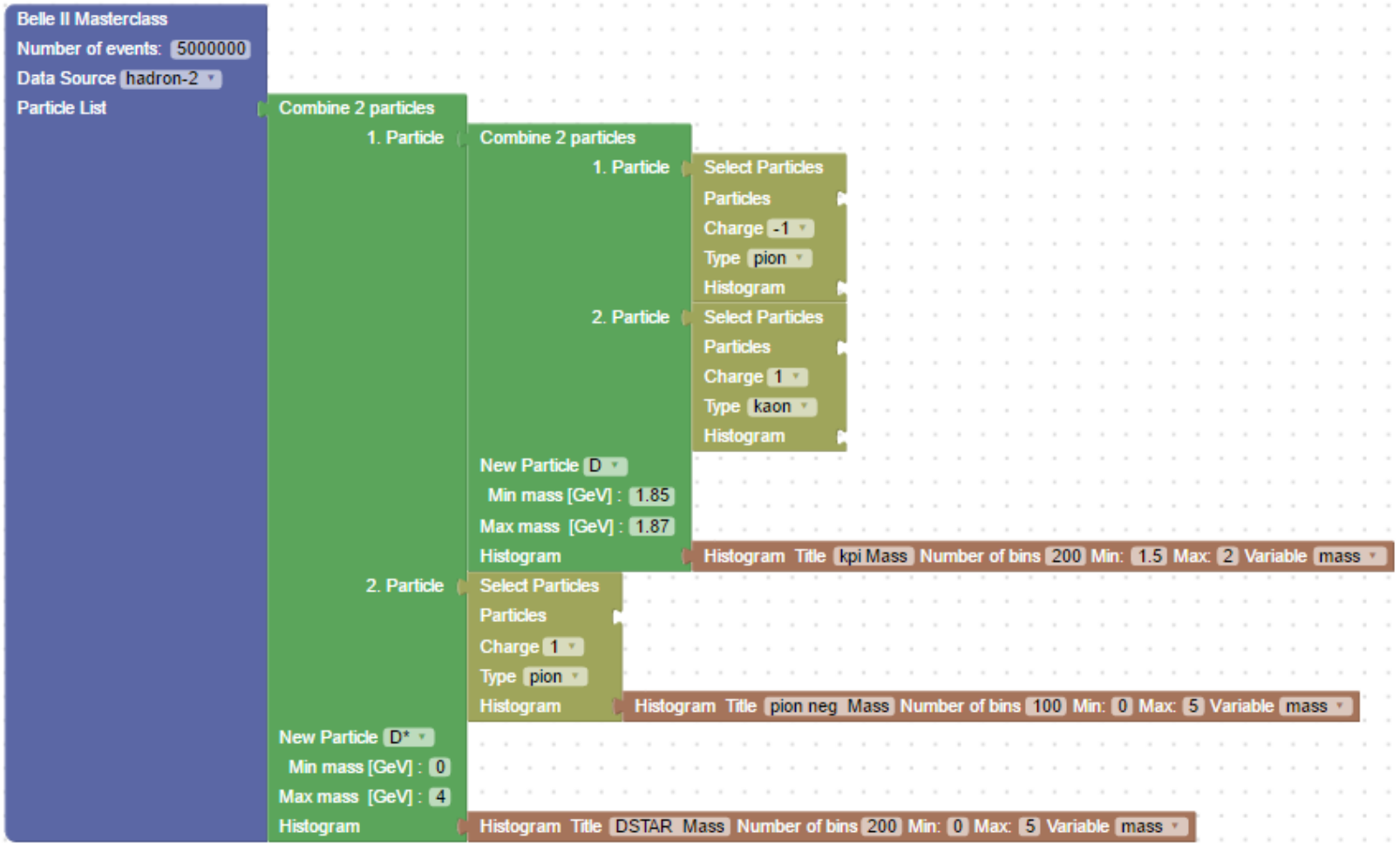
Belle II Masterclass: Define process →Analyse data →Visualise results →Save/load process locally

Run Analysis | Interrupt | Switch between Diagram and Results | Save Diagram | Load Diagram

0

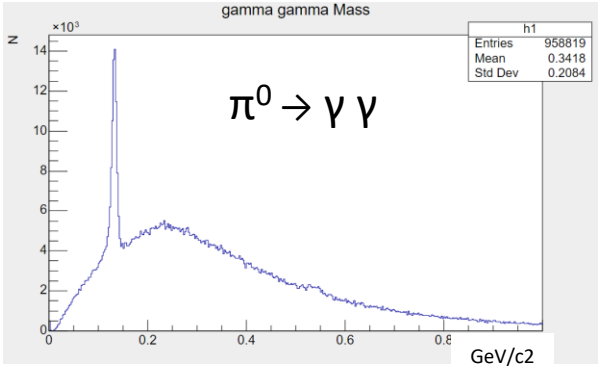


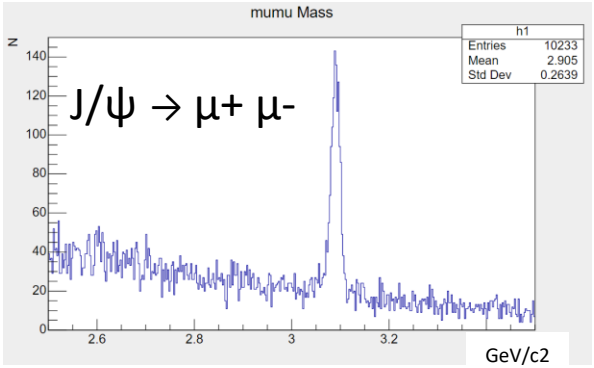
Combination of three particles

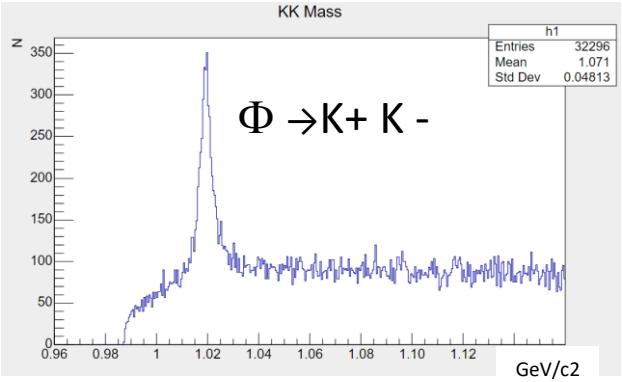


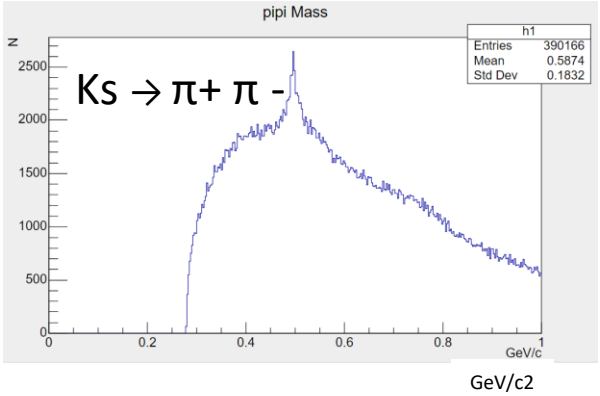
Different decays

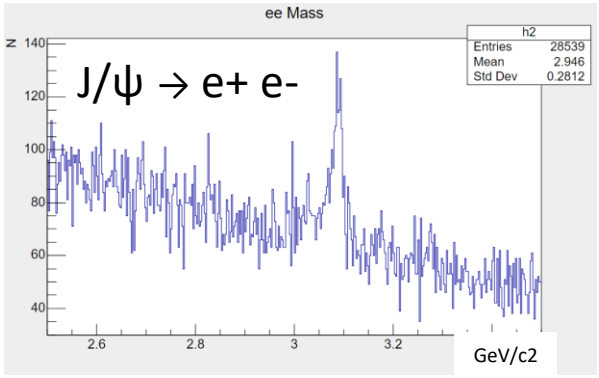
Invariant mass plots for different decays

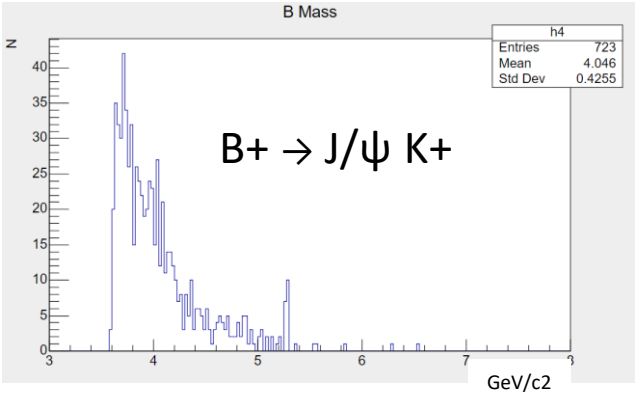






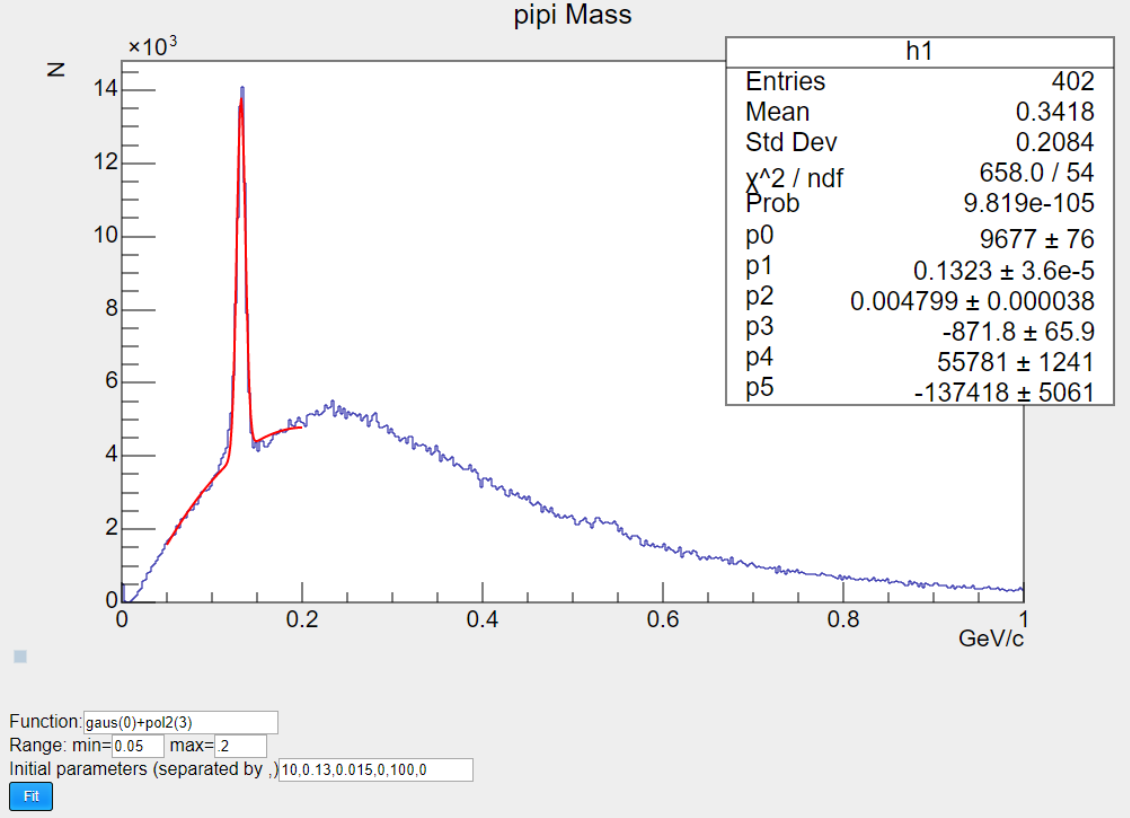






Advanced level

A resulting panel offers the possibility to **fit a resulting distribution** with a ROOT function and calculate width and number of events in the peaks



Worksheet

Exercise table with the list of decays to examine

Particle		Proces	Mass (GeV/c^2)	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	$\frac{1}{\sqrt{2}}(d\bar{s} + \bar{s}s)$	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-					

Conclusions

Part of the Belle II data will be publically available

Simple interface has been designed for analysis, which allows

- ❑ To combine different particles together
- ❑ To plot different distributions
- ❑ To fit the results

Try the web version at http://belle2.ijs.si/masterclass