

Belle II Masterclass

Rok Pestotnik, Jožef Stefan Institute, Ljubljana,
for the Belle II collaboration

The screenshot shows the Belle II Masterclass software interface with several control panels:

- Select Particles:** Particles, Charge -1 , Type μon , Histogram.
- Histogram:** Title $\mu\text{ neg Mass}$, Number of bins 40 , Min: 0 , Max: 5 , Variable mass .
- Belle II Masterclass:** Number of events: 10000 , First event: 0 , Data Source hadron-1 , Print particle list? No , Particle List.
- Combine 2 particles:** 1. Particle, 2. Particle, Same particle lists? No , New Particle JPs , Min mass [GeV]: 1 , Max mass [GeV]: 4 , Histogram.

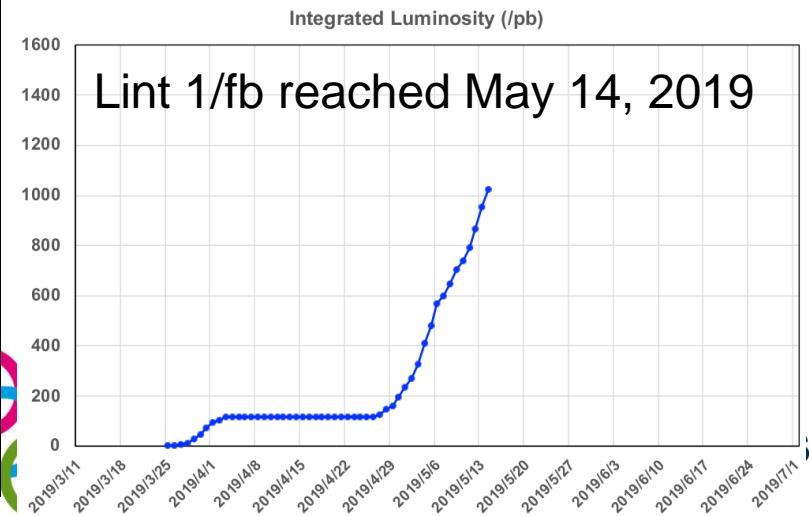
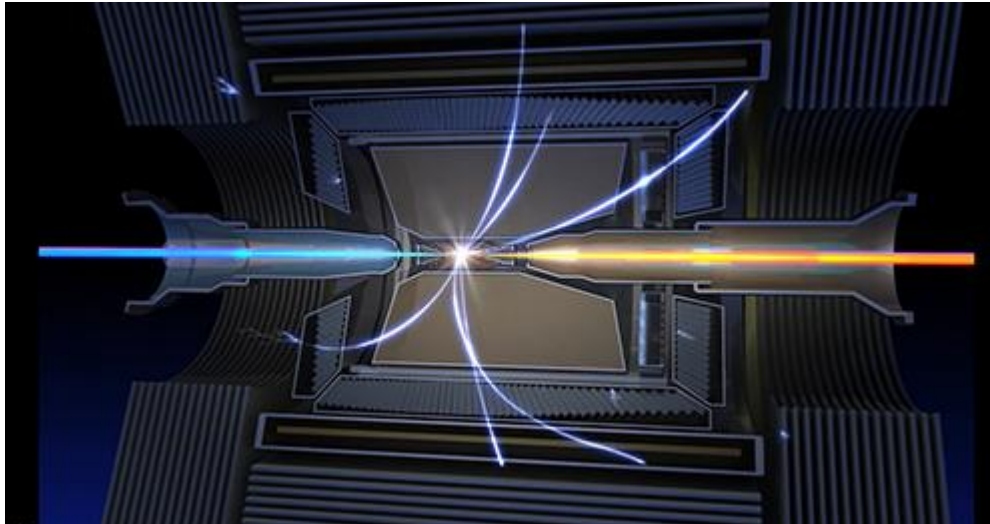
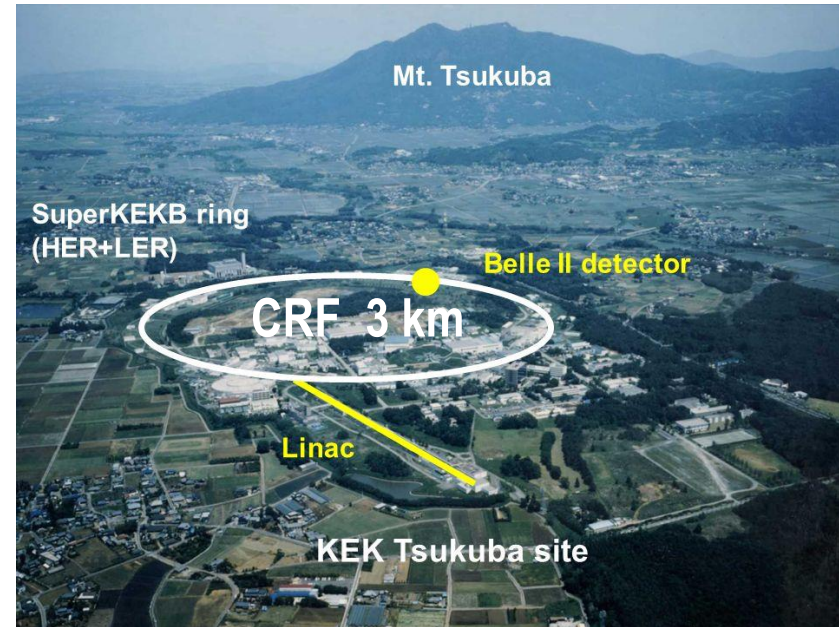
R. Pestotnik: Belle II MC@IPPOG - IMC SG,
May 26, 2019



MASTERCLASS
Belle II Particle Adventure

Belle II

- Belle II
 - study of rare decays of B and D mesons and tau leptons
- @ SuperKEKB
 - e+e- collider at Y(4S) resonance
- Experiment outreach
 - What are we doing ?
 - How do our detectors look like?
 - What are our research methods?
 - What do we see?



Belle II Pilot Run

*support and first drive to Belle II masterclasses from JENNIFER project (MSCA RISE)

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

March 22, 2019 from 9h-17h CET

- Invitations three months in advance
- Technical meeting two weeks before
- Event
- Evaluation and plan - Collaboration meeting in June

INTERNATIONAL MASTERCLASSES
HANDS ON PARTICLE PHYSICS

Vabilo

»International Masterclasses« iz fizike osnovnih delcev nudijo gimnazijem enkratno priložnost, da se sami spoznajo s svetom kvarkov in leptonov, tako da izvedejo meritve na resničnih podatkih, zajetih v CERNu in v drugih raziskovalnih centrih po svetu, da se srečajo s pravimi raziskovalci in se povežejo s svojimi vrstniki – dijaki iz drugih držav in z njimi pregledajo rezultate in izmenjajo mnenja.

Ljubljana, 30. 1. 2019

Dijaki bodo na enodnevnem dogodku s predavaji in delavnico, kjer bodo uporabljali podatke iz poskusa Belle z Japonske (<http://belle2.jp>), spoznavali osnovne deke in sile, ki delujejo med njimi. Dopolnje bomo raziskovalci z Inštituta Jožef Stefan v Ljubljani, Fakultete za matematiko in fiziko Univerze v Ljubljani in Fakultete za kemijo in kemijsko tehnologijo Univerze v Mariboru predstavili fiziko osnovnih delcev in detektorje, ki jih uporabljamo pri naših raziskavah. Pred kosilom si bomo med virtualnim spretnostnim ogledom raziskovalci, ki jih uporabljamo pri naših raziskavah Belle II, Med skupnim kosilom bo obilo priložnosti za pogovor z raziskovalci. Na popoldanski delavnici pa se bodo dijaki sami lotili analize podatkov, ki so bili zajeti s poskusom Belle na italijanski delavnici pa se bodo dijaki sami lotili analize podatkov, ki so bili zajeti s poskusom Belle na Japonskem. Po končanem delu se bomo povezali z drugimi šolami in kontrolno sobo eksperimenta Belle II na Japonskem v video konferenco. Na konferenci bodo dijaki predstavili svoje rezultate in se pogovorili o delu na poskusu Belle II.

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Dogodek bo potekal v petek
22.3.2019 od 9h do 16h na II. gimnaziji Maribor, Trg Miloša Zidaniška 1

Prijava na brezplačni dogodek: <http://belle2.ijs.si/prijava>

Program:

8:45	zbor udeležencev
9:00 - 9:15	Pozdravni nagovor
9:15 - 10:00	Fizika osnovnih delcev
10:15 - 11:00	Eksplozivne metode v fiziki osnovnih delcev
11:00 - 11:30	Virtualni spretnostni ogled
11:30 - 12:15	Uvod v analizo podatkov
12:15 - 13:00	Kosilo in pogovor z raziskovalci
13:00 - 15:00	Praktični del – analiza podatkov, zajetih z eksperimenta Belle II
15:00 - 16:00	Video konferenca



Video Connection details of the event 16:00 - 17:00 CET

Primary channel: Vibe

Join meeting at: <https://vibe.ezuce.com/launcher/?meetingId=7070041770>

Or join at: <https://vibe.ezuce.com> Meeting ID: 7070041770 Password: 2203

Backup channel: <https://vidyportal.cern.ch/join/UXMBGI26CKp5> (Giulio Dujany personal room)

Technical start 15 minutes prior the video conference (at 15:45) to confirm the connection, volume of the rooms, etc.

Event Program

- ❑ Introductory lectures to HEP and Belle
- ❑ Immerse in the Belle II detector: **Belle II Virtual Reality presentations**
- ❑ **Exercises** with a live introduction and instructions + worksheet to fill the results
- ❑ Video conference to discuss the results with other groups

8:45	Registration
9:00 - 9:15	Introduction
9:15 - 10:00	Physics of elementary particles
10:15 - 11:00	Experimental methods in high energy physics
11:00 - 11:30	Belle II Virtual reality
11:30 - 12:15	Data Analysis
12:15 - 13:00	Lunch – meet the HEP researchers
13:00 - 16:00	Belle Data Analysis
16:00 - 17:00	Video conference

- an introduction to HEP, Belle II – designed individually by each site
- hands on exercises:
 - Belle II VR
 - Public analysis – common exercises

Run in parallel at different sites

Multisite international video conference to discuss the results and to conclude the event

Participants

6 participating sites from Europe and ~200 high school students

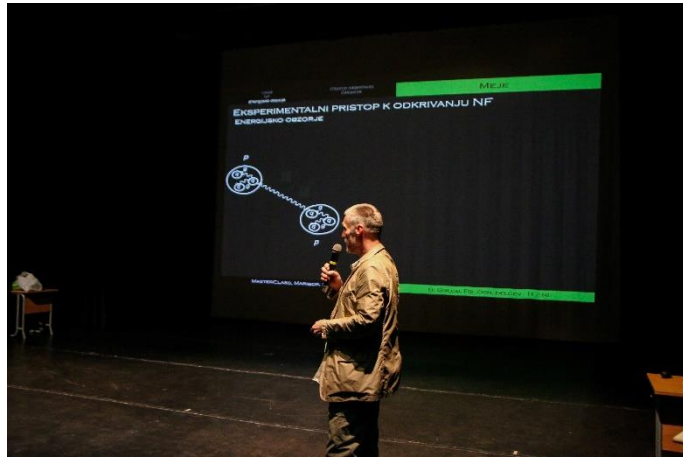
Site	Contact person	Number of students
Padua	Ezio Torrassa	100
Ljubljana	Rok Pestotnik	26
Strasbourg	Isabelle Ripp-Baudot	10
Prague	Zdenek Dolezal	10
Krakow	Andrzej Bozek	20
Roma Tre * April 3	Antonio Passeri	40



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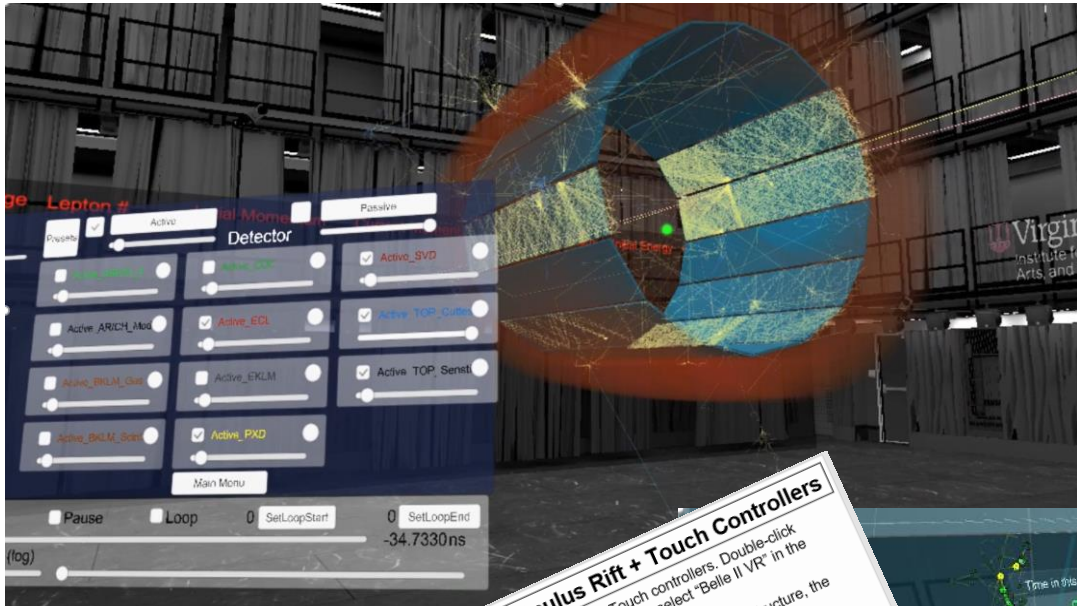
Event in photos

e.g. Maribor, Slovenia - TEDx like atmosphere – very inspiring



Directive 95/46/EC (**General Data Protection Regulation**) – photographs :
Not all sites collected consent forms from the students

Virtual reality - Immersion in the Belle II detector



Belle II in Virtual Reality: Oculus Rift + Touch Controllers

- Put on the Oculus Rift headset and pick up the Touch controllers. Double-click the "Belle_II_VR_OculusRift" icon on the computer or select "Belle II VR" in the headset's menu. Wait for the VR world to appear.
- After the loading scene and an introductory fade-out of the Belle II structure, the animation will begin automatically. The first event is typically $e^- \rightarrow \mu^- \mu^+$.

Y: Hide/show detector-hits
X: Pause / Resume

forward right backward left

up down

earlier later speed up down

Show/Hide Menu Previous Scene

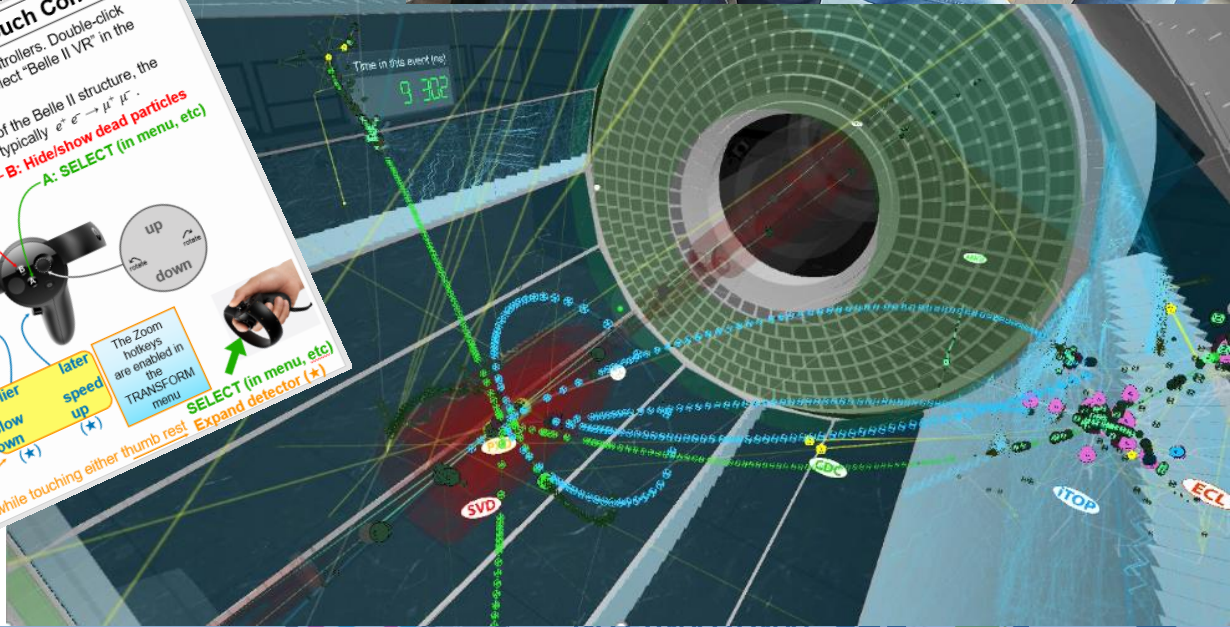
SELECT (in menu, etc) Shrink detector (*)

SELECT (in menu, etc) Expand detector (*)

The Zoom hotkeys are enabled in the TRANSFORM menu

(*) while touching either thumb rest

A: SELECT (in menu, etc)
B: Hide/show dead particles



Public analysis of 6M events from Belle

Interactive web application

<http://belle2.ijs.si/masterclass>

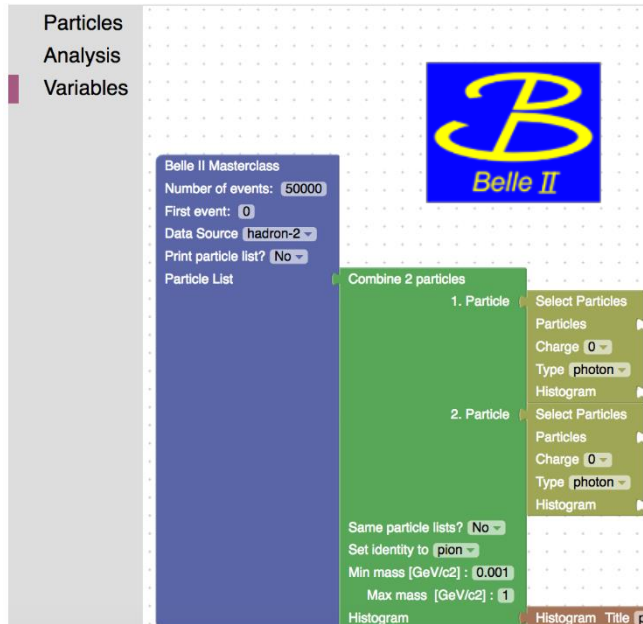
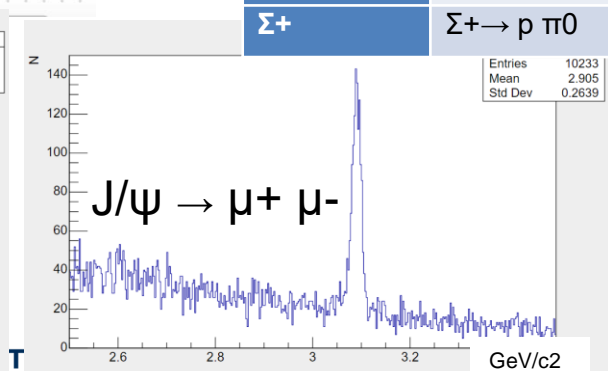
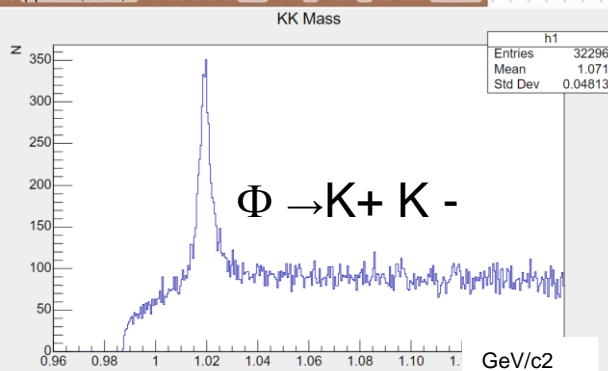
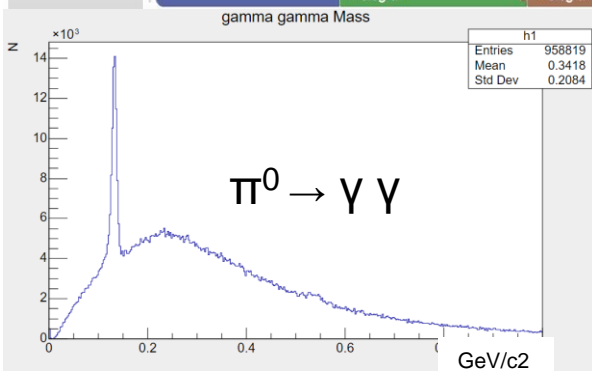
Describe decays, make simple cuts,
"discover" particles

Runs on a **web server** or in a **virtual appliance**



Particle	Process
π^0	$\pi^0 \rightarrow \gamma \gamma$
Ks	$K_s \rightarrow \pi^+ \pi^-$
ϕ	$\phi \rightarrow K^+ K^-$
J/ ψ	$J/\psi \rightarrow e^+ e^-$
	$J/\psi \rightarrow \mu^+ \mu^-$
D^0	$D^0 \rightarrow K^+ \pi^-$
	$D^0 \rightarrow K^- \pi^+$
D^{*+}	$D^{*+} \rightarrow D^0 \pi^+$
D^{*-}	$D^{*-} \rightarrow D^0 \pi^-$
B^+	$B^+ \rightarrow J/\psi K^+$
B^-	$B^- \rightarrow J/\psi K^-$
Λ	$\Lambda \rightarrow p \pi^-$
Σ^+	$\Sigma^+ \rightarrow p \pi^0$

Run Analysis Interrupt Save Diagram Load Diagram

We were impressed how well the exercises went.
The students worked in an enthusiastic and collaborative spirit.

Video conference

Connection with audio quality problems :(terrible sounds with a lot of students in the halls + backup moderator

- 2min : Opening
- 5x5min: Presentation of the results from the
 - collection of the results in a google form
- 5 min: Connection to the Belle II control room – unfortunately beam run has started 3 days after the event
- 10 min :Particle quiz
- 5 min: Closing

- several live entries from KEK (canteen, accelerator control room), during the morning – very interesting for students

Moderated by one of the participating lecturers



Quiz

15 not too serious questions:
10 HEP + 5 Japan

Students answered on their answer sheets

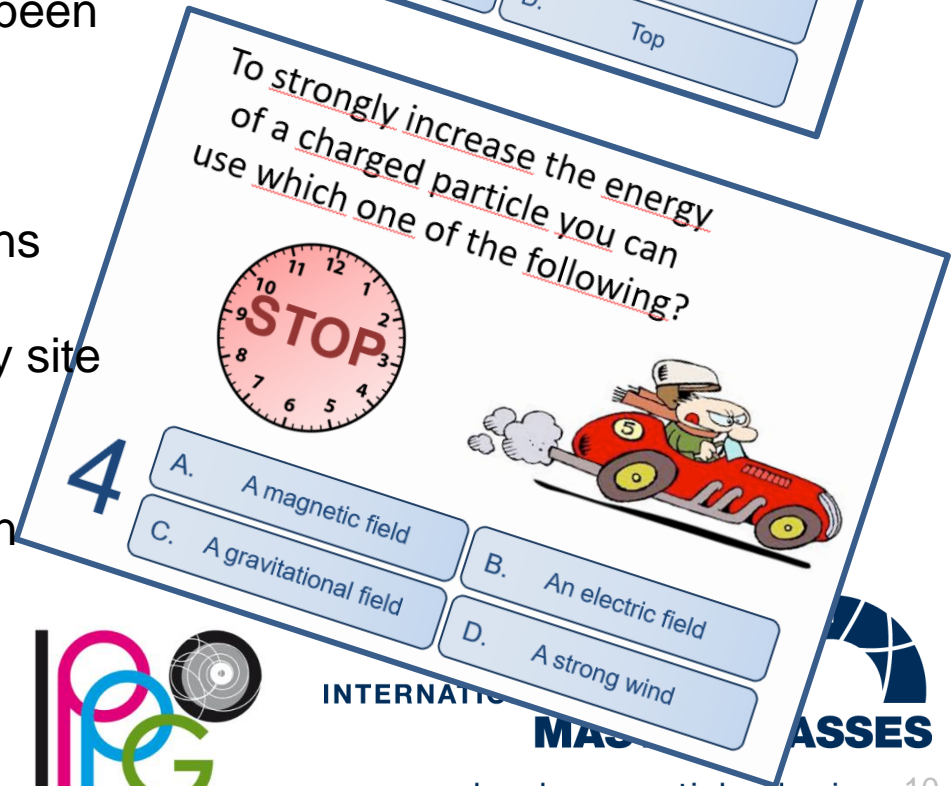
Competition between sites:
the site to answer the next question has been
randomly selected by the computer

A lot of fun:

- students liked the format and questions

Prizes for the best students distributed by site
moderators:

T – shirts, cups, badges from KEK, Japan
purchased with JENNIFER money.



Self evaluation

- Strengths:
 - Simplified physics analysis – real world example
 - 6 millions of clean reconstructed events - decays from e^+e^- collisions – a lot of possibilities for particle “discoveries”
- Weaknesses
 - To illustrate the calculation of the invariant mass in the exercises, several particles should be combined by hand
 - Slow collection of the results in the google forms
 - Audio quality connection – use echo cancellation devices, test in with real equipment and with the expected noise
 - GDPR consent forms not collected by all sites
- Opportunities
 - Add an event display to display the hits on the detector and connect them with reconstructed particles + add simple fitting procedure of the mass peaks
 - Combine individual results and submit them to a common server through the interface
 - Moderation of the event
 - Post info about the event in the local and social media
- Threats
 - Do not convert the exercise into “follow instructions” and produce plots without thinking
 - Do not make it the exercise too complex

Belle II Masterclass resources

Introduction to HEP:

<http://indico.ijs.si/conferenceTimeTable.py?confId=1034#20190322> - documents in Slovene

Belle II Virtual Reality

<http://www1.phys.vt.edu/~piilonen/VR/>

Exercises with data:

<http://belle2.ijs.si/masterclass>

<http://belle2.ijs.si/masterclass/BelleIILabManual.pdf>

You Tube:

- Start: https://youtu.be/q6M2_dnp3pl
- Particle distribution: https://youtu.be/q6M2_dnp3pl
- J/psi to mumu: <https://youtu.be/xUYmXoPfZOU>
- J/psi to ee: <https://youtu.be/3TGsHJ8j8pE>
- Fit: <https://youtu.be/wWbjWYHVLU>
- B to J/psi K <http://youtube.com/watch?v=e-GErqzY3HM>



Conclusions

- 6 sites and 200 high school students participated in the Belle II Masterclass pilot run on March 22nd, 2019
- Very good performance – a lot of enthusiastic students
 - exception : the video conference – problems with audio quality
- We are ready to participate in the regular IPPOG IMC program
 - Program support for outreach activities from JENIFFER2 project (H2020 MSCA RISE)
 - Belle II Lab : Transition from Belle to Belle II data
 - Employ Belle II event display
 - Prepare common materials and translate it to different languages
 - Prepare and test the video-conferencing hardware!!!

