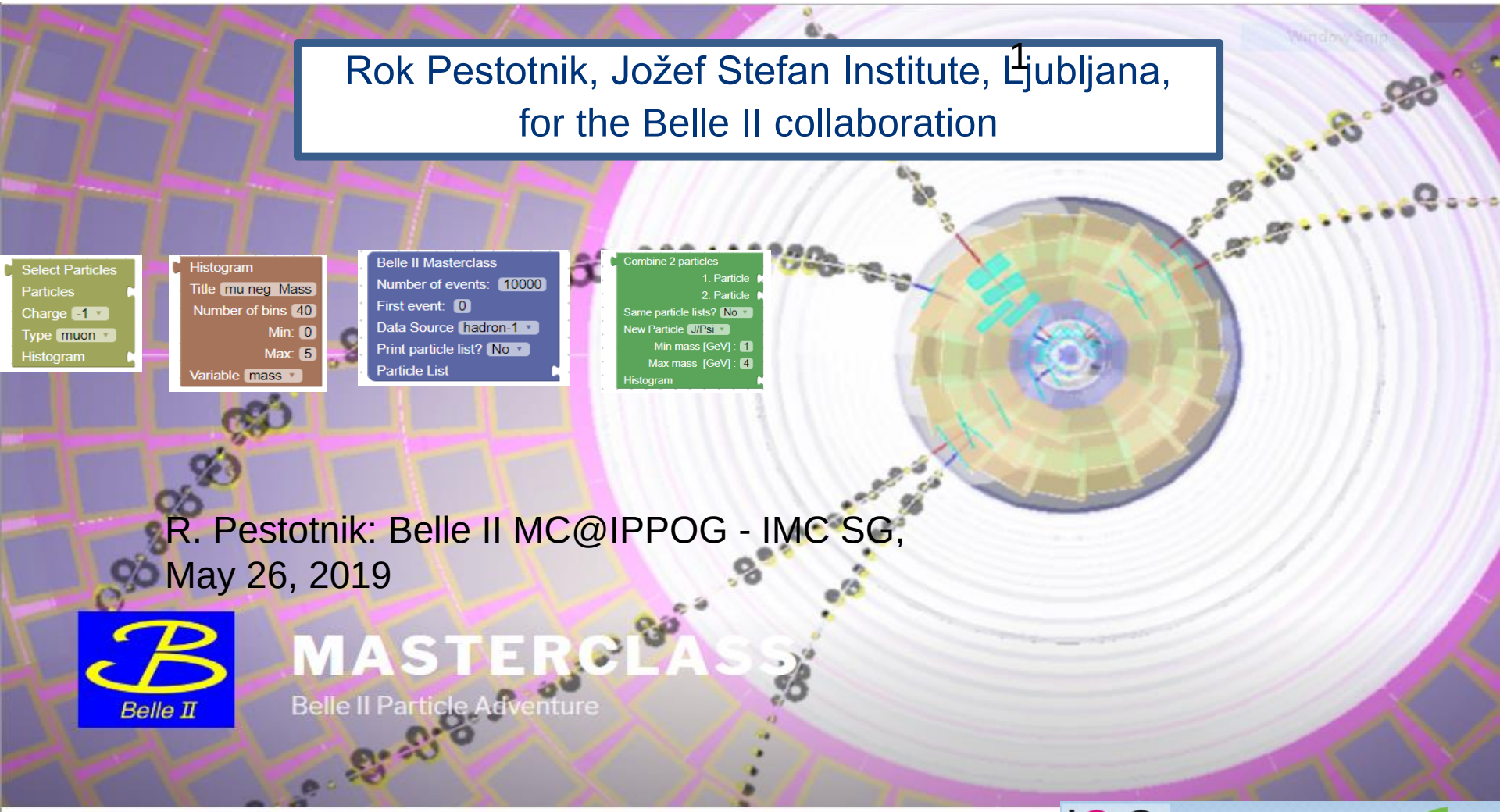
Belle II Masterclass

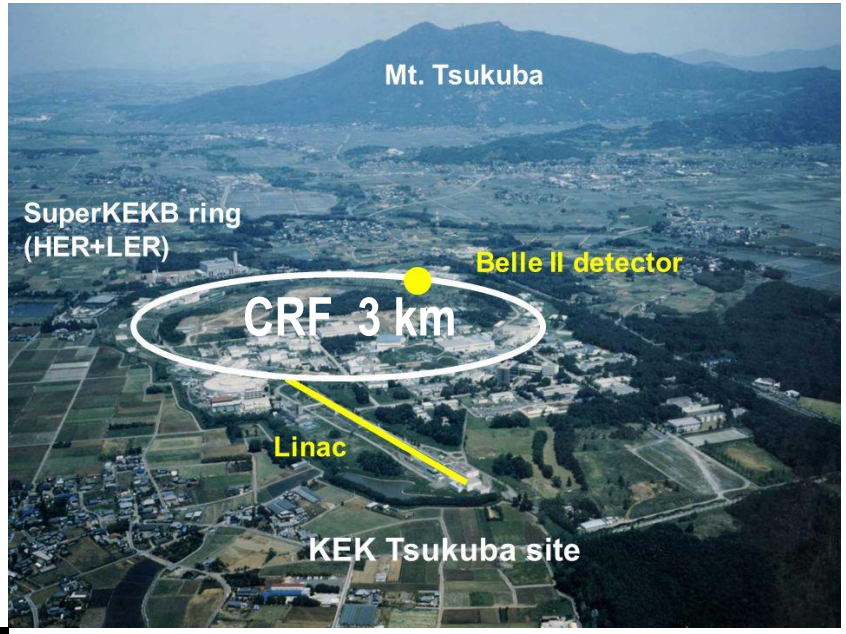
Rok Pestotnik, Jožef Stefan Institute, Ljubljana,
for the Belle II collaboration

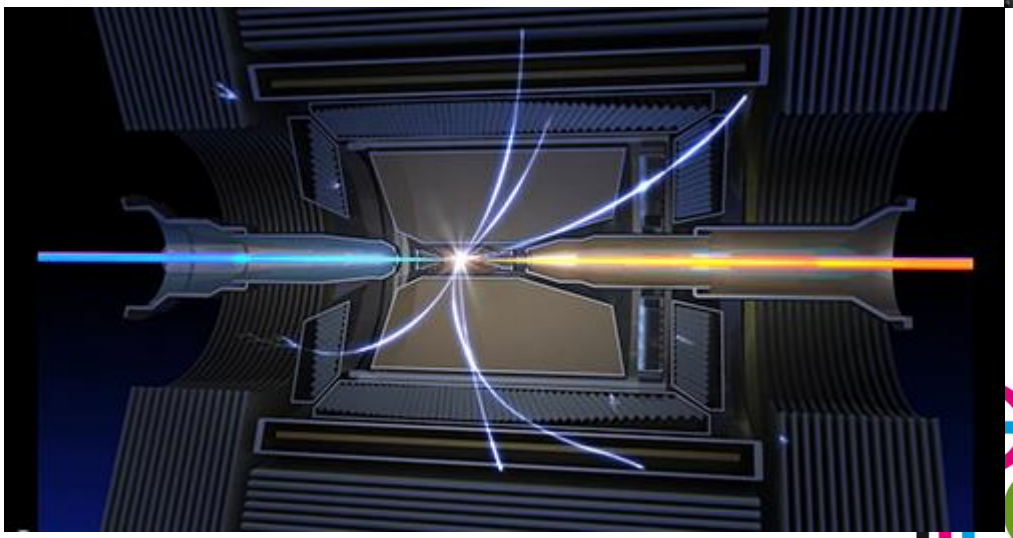


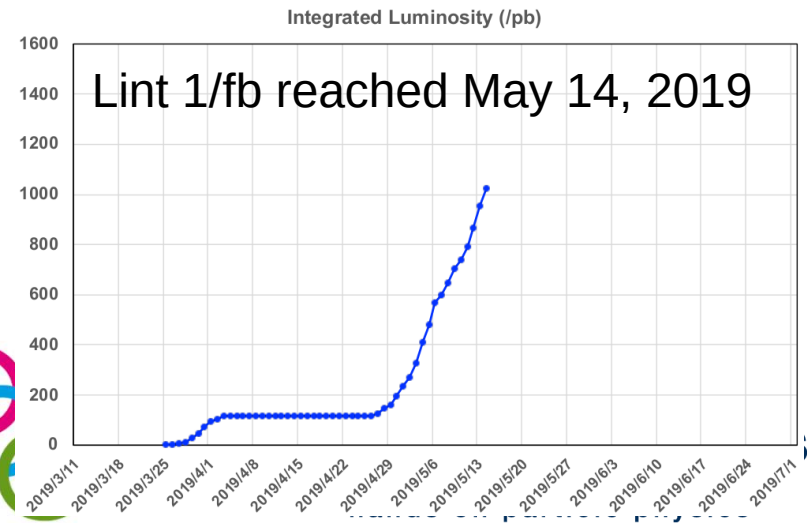
R. Pestotnik: Belle II MC@IPPOG - IMC SG, May 26, 2019

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?







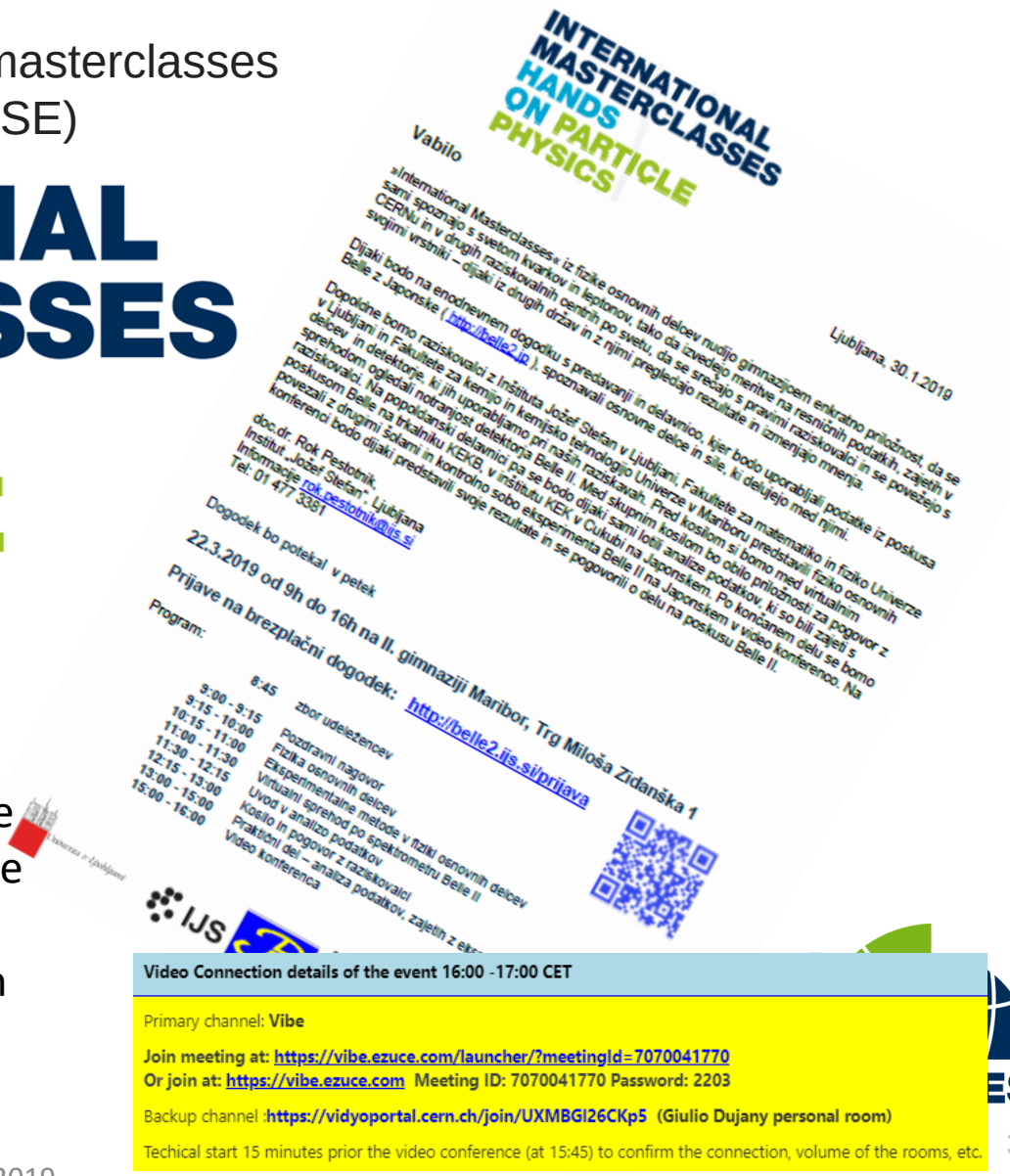
Belle II Pilot Run

*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



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

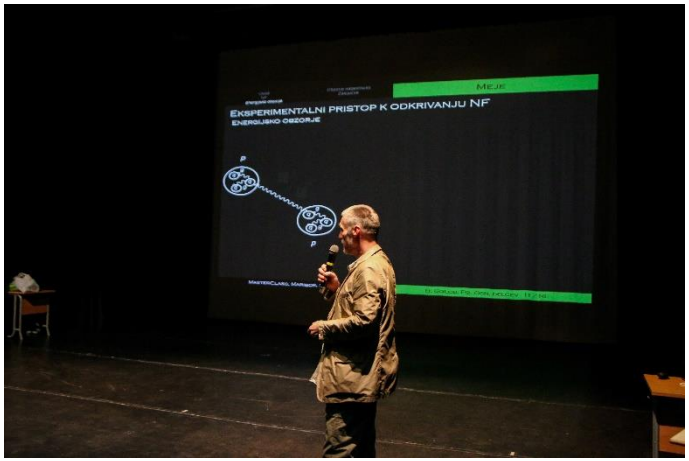
6 participating sites from Europe and ~200 high school students

Site	Contact person	Number of students
Padua	Ezio Torrasa	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

INTERNATIONAL MASTERCLASSES
hands on particle physics

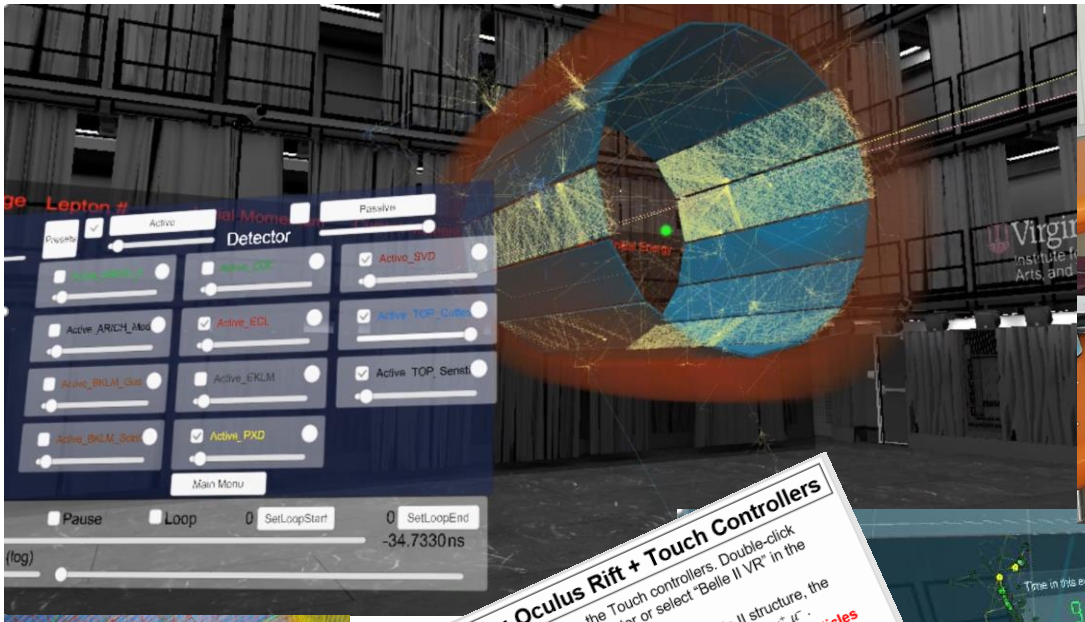
Event in photos

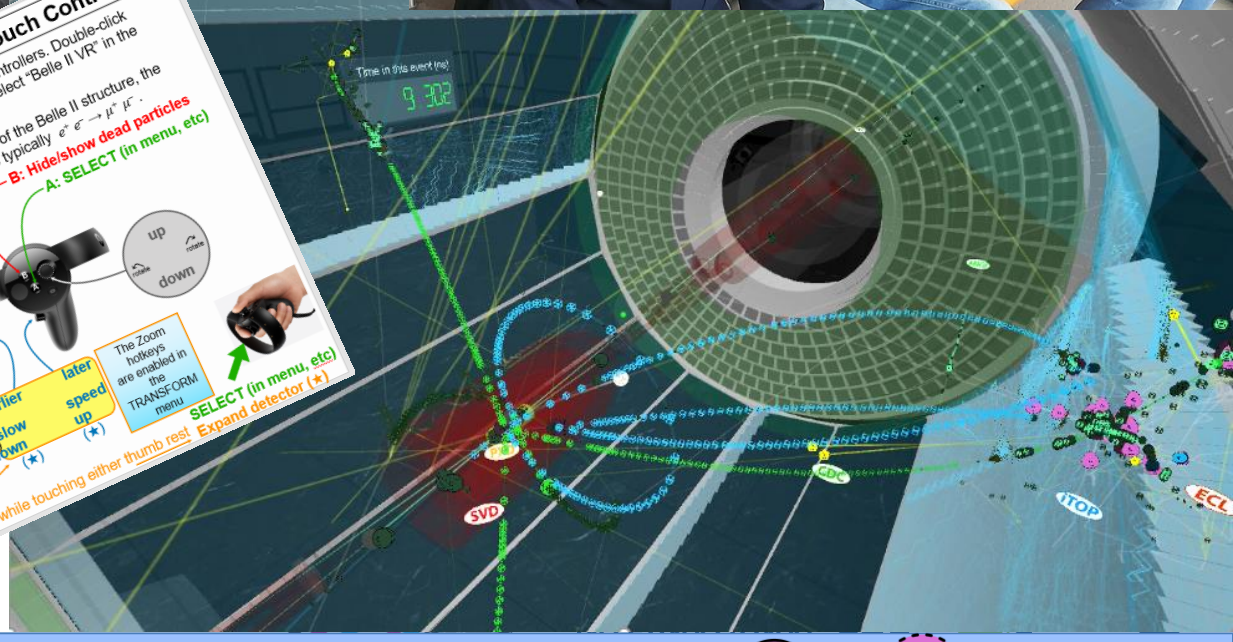
e.g. Maribor, Slovenia - TEDx like atmosphere – very inspiring

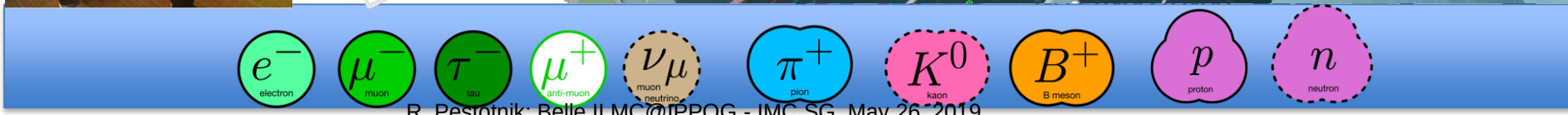


Directive 95/46/EC (**General Data Protection Regulation**) – photographs :
Not all sites collected consent forms from the students

Virtual reality - Immersion in the Belle II detector







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Public analysis of 6M events from Belle

Run Analysis | Interrupt | Save Diagram | Load Diagram

Interactive web application

Particles
Analysis
Variables

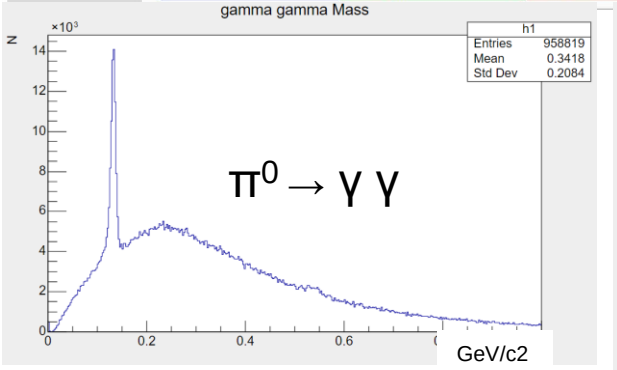
Belle II Masterclass
Number of events: 50000
First event: 0
Data Source: hadron-2
Print particle list? No
Particle List
Combine 2 particles
1. Particle: Select Particles, Particles, Charge 0, Type photon, Histogram
2. Particle: Select Particles, Particles, Charge 0, Type photon, Histogram
Same particle lists? No
Set identity to pion
Min mass [GeV/c2] : 0.001
Max mass [GeV/c2] : 1
Histogram: Title pipi Mass;GeV/c;N, Number of bins 400, Min: 0, Max: 1, Variable mass

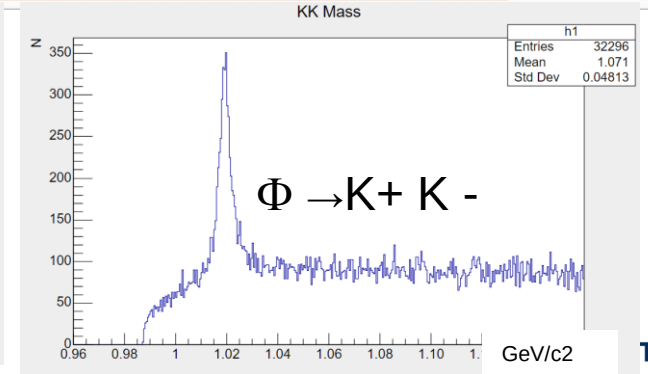
http://belle2.ijs.si/masterclass

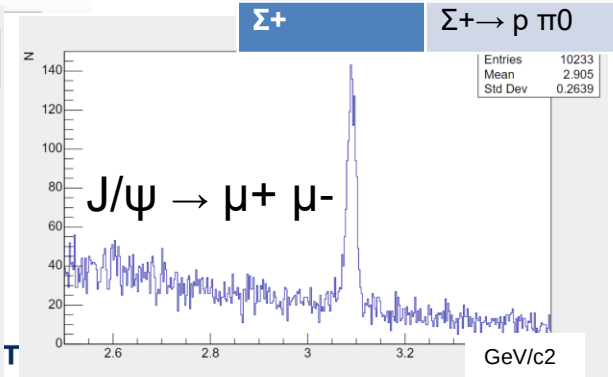
Describe decays, make simple cuts, "discover" particles

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

Particle	Process
π^0	$\pi^0 \rightarrow \gamma\ \gamma$
Ks	Ks → π+ π -
φ	φ → K+ K -
J/ψ	J/ψ → e+ e-
	J/ψ → μ+ μ-
D^0	D^0 → K+π-
	D^0 → K-π+
D*+	D*+ → D^0 π+
D*-	D*- → D^0 π-
B+	B+ → J/ψ K+
B-	B- → J/ψ K-
Λ	Λ→ p π-
Σ+	Σ+→ p π0







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

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Video conference

Moderated by one of the participating lecturers

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

INTERNATIONAL MASTERCLASSES
hands on particle physics

Quiz

15 not too serious questions:
10 HEP + 5 Japan

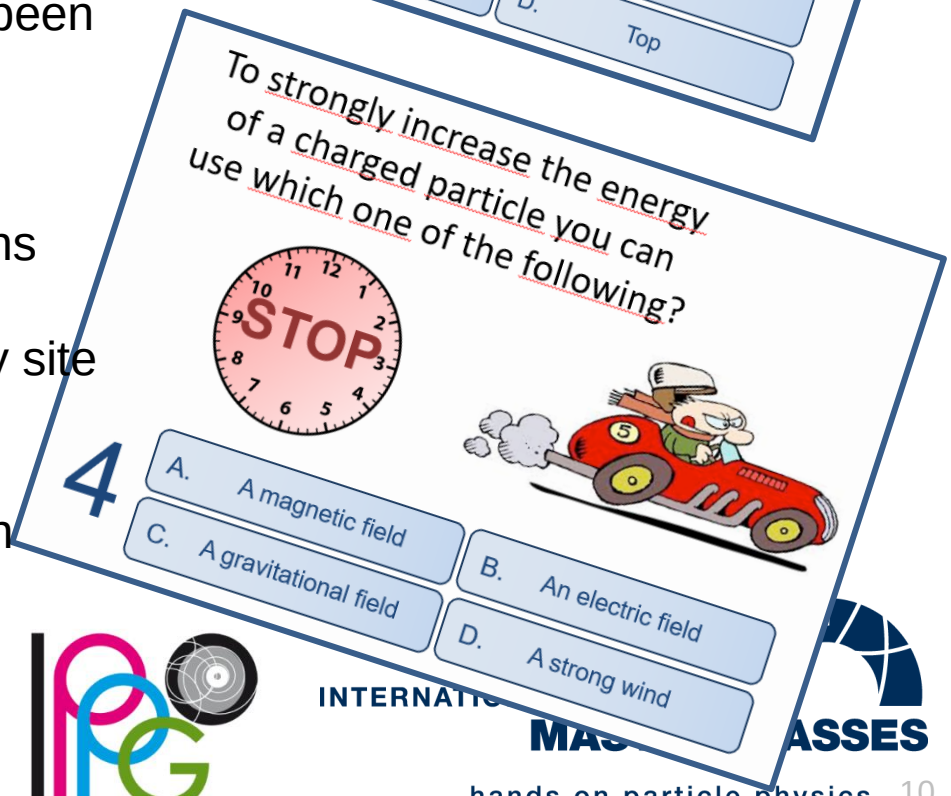
Students answered on their answer sheets

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_dnp3pI
•Particle distribution: https://youtu.be/q6M2_dnp3pI
•J/psi to mumu: https://youtu.be/xUYmXoPfZOU
•J/psi to ee: https://youtu.be/3TGsHJ8j8pE
•Fit: https://youtu.be/wWbjWYHVaLU
•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!!!