INTERNATIONAL
MASTERCLASSES
hands on particle physics
International Particle
Physics Outreach Group
International Particle Physics Masterclasses
(Deploying the Scientists for a Day)
A scalable framework for evidence-based,
technology-enriched physics education.
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SYSTEM STATUS:
PTEE 2026 Briefing | Online

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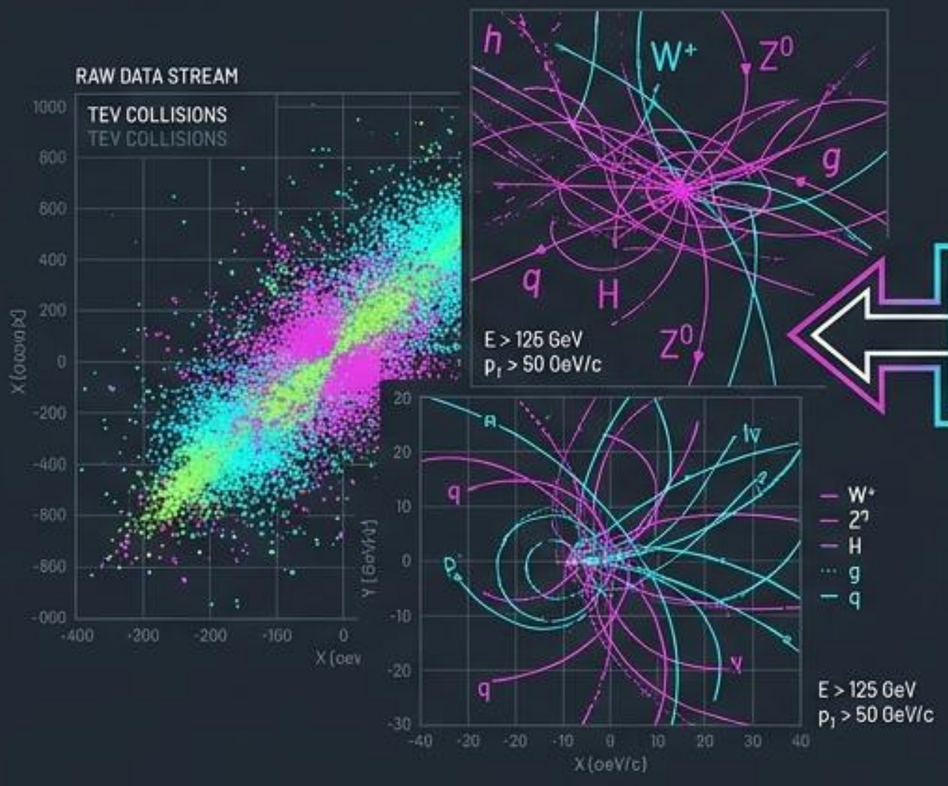
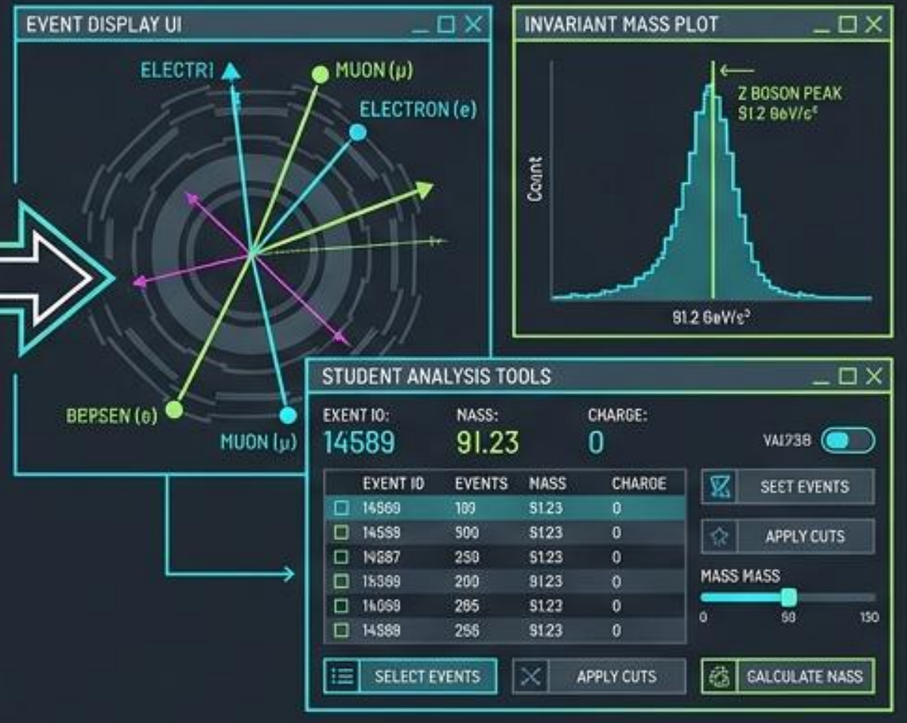
Bridging the Gap Between Cutting-Edge Discovery and the Classroom

The Challenge: How do we translate the excitement of W/Z bosons, Higgs, and Quark-Gluon Plasma into accessible, hands-on high school experiences?



Masterclass Filter

The Framework: The International Particle Physics Outreach Group (IPPOG) developed the Masterclass project. It is not just an event; it is an active-learning architecture where students analyze real data using real scientific tools.



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A Global, High-Scale Educational Network

Coordinated by TU Dresden with an international steering committee, demonstrating robust European-led collaboration.

13,000+

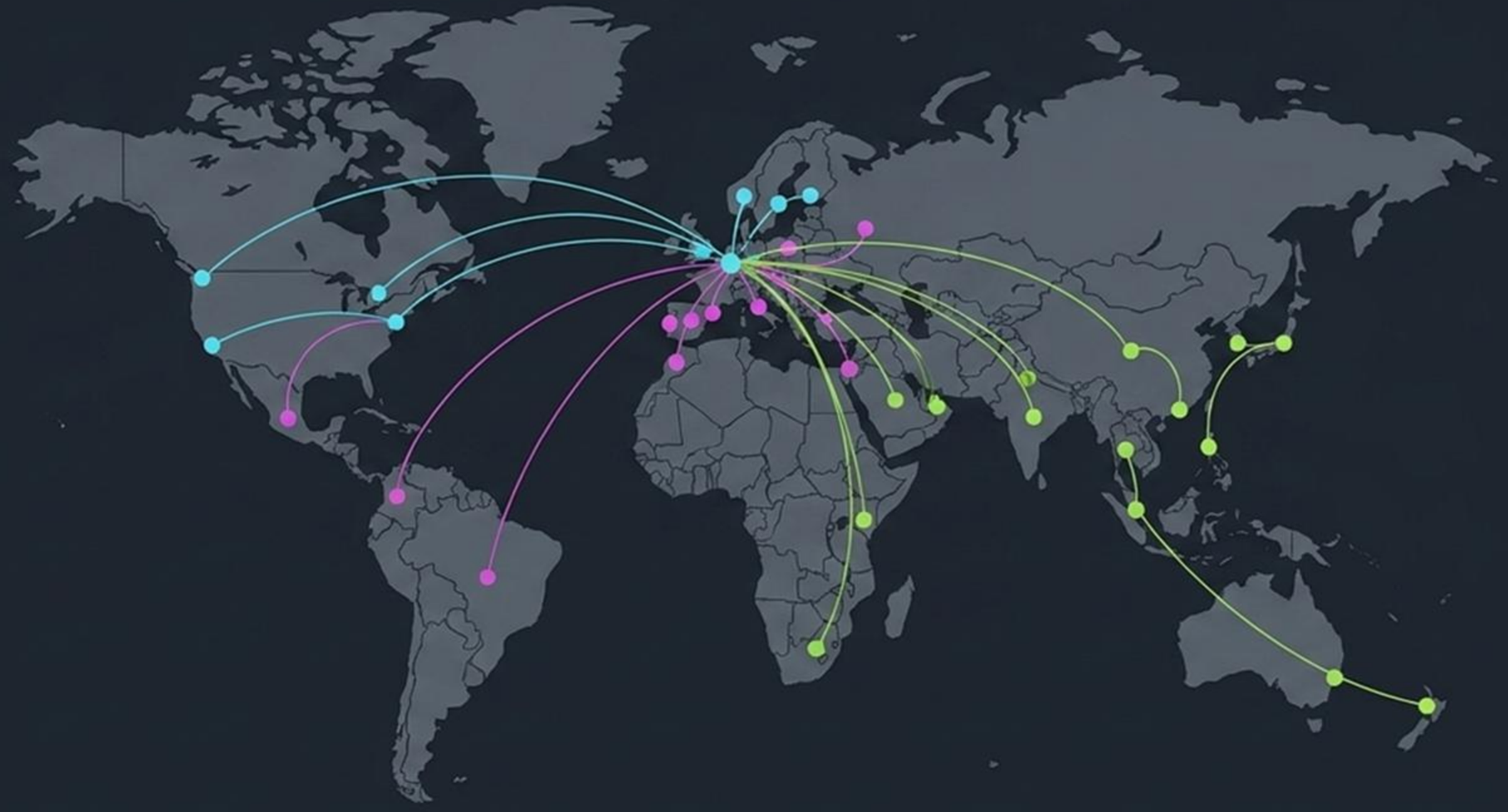
Students Annually

60

Countries Participating

225

Host Institutions



TECHNISCHE UNIVERSITÄT DRESDEN · QuarkNet · CERN

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The Pedagogical Orbit: A Day in the Life

Phase 1: Theory (Morning)

Active scientists deliver brief lectures providing insight into fundamental forces and research methods.

Phase 2: Measurement (Mid-Day)

Students use specialized UI tools to perform scientific measurements.

Phase 3: Interpretation (Afternoon)

Students apply theory to interpret their raw findings.

Phase 4: Collaboration (Afternoon)

International videoconference to merge datasets and debate results with peers and CERN/Fermilab experts.

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One Core Architecture, Infinite Scientific Modules

These are just two examples of the many scientific modules currently available.

EXAMPLES

Module 01: Fundamental Science (ALICE)

Searching for the Quark-Gluon Plasma in extreme density collisions.

Module 02: Applied Science (PTMC)

Using heavy ion research for targeted cancer therapy.

Core Architecture Base: The IPPOG Masterclass Methodology

Hands-on Experience | Real Data Analysis | Global Video Collaboration

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“Module 01: ALICE Strangeness Masterclass” - Web Application

Developed and maintained entirely at Warsaw University of Technology (WUT).

Visual Analysis

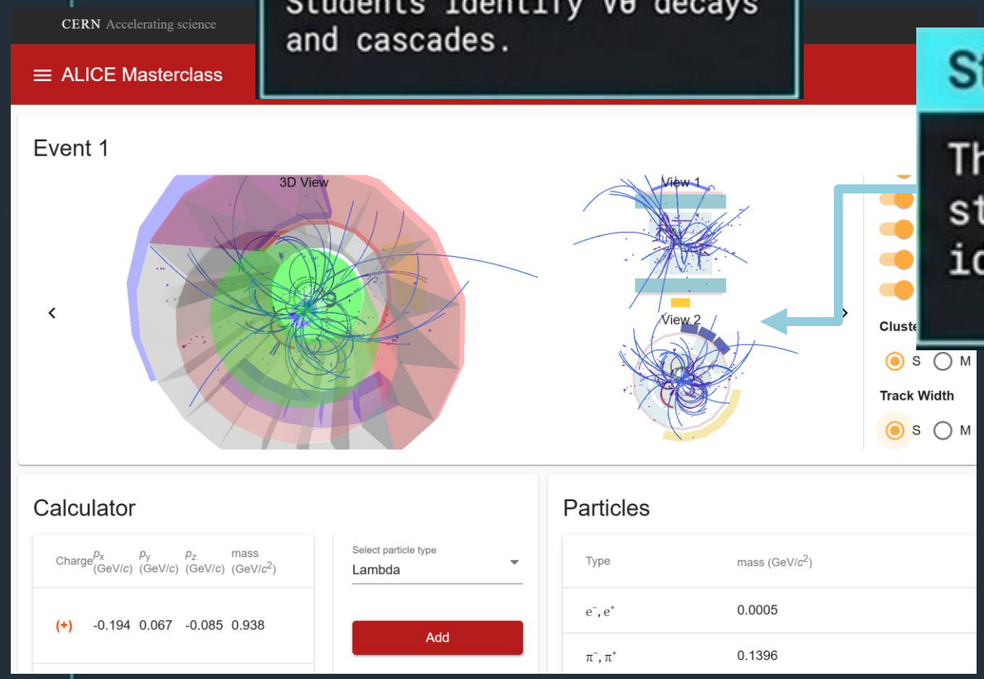
Interactive 3D visual inspection of small Pb-Pb and pp collision samples. Students identify V0 decays and cascades.

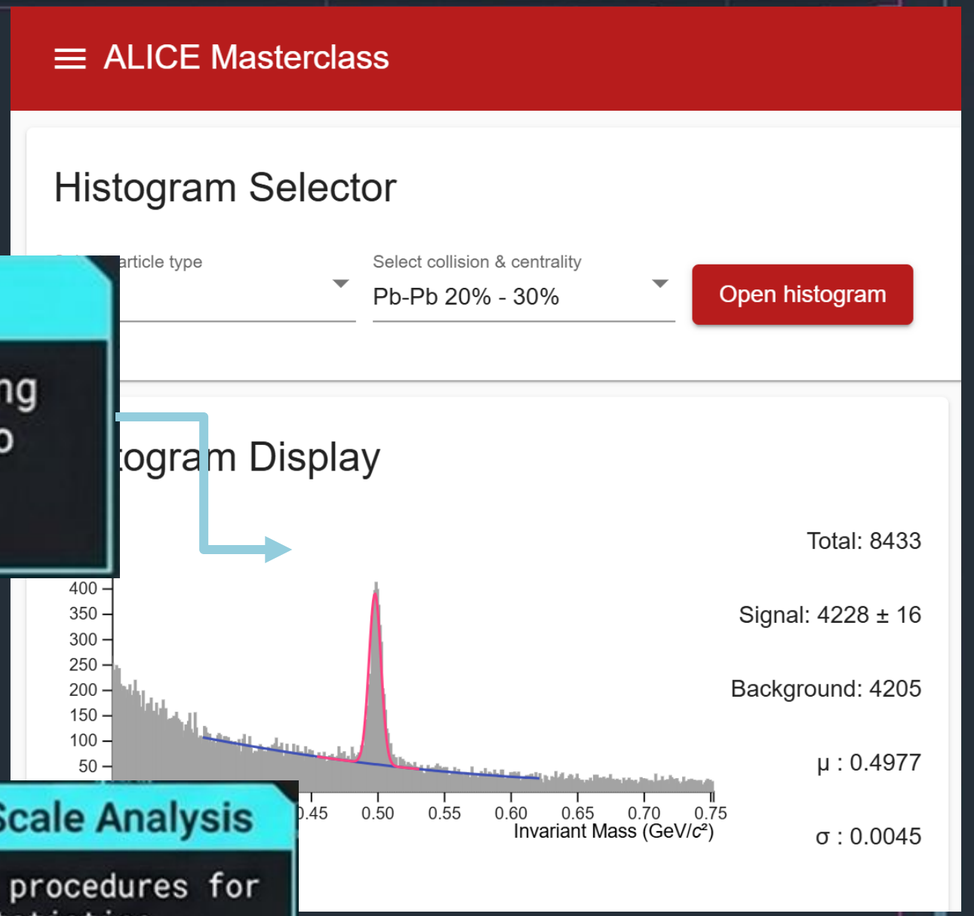
Strangeness Production

The ultimate goal–comparing strange particle yields to identify QGP signatures.

Large Scale Analysis

Fitting procedures for large statistics. Students subtract background and extract particle yields.





https://alice-web-masterclass.app.cern.ch/

http://teacher-alice-web-masterclass.app.cern.ch/

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Module 02: Particle Therapy Masterclass (PTMC)

Context: Translating fundamental physics into societal impact. Students learn how particle accelerators are used to treat cancer.

matRad Tool

Students use the open-source matRad software (DKFZ) to visualize patient CT scans.

Dose Optimization

Hands-on treatment planning. Students manipulate beam angles and depths to target tumors while sparing healthy tissue.

Real-World Application

Directly connects physics formulas (Bragg Peak) to saving lives.

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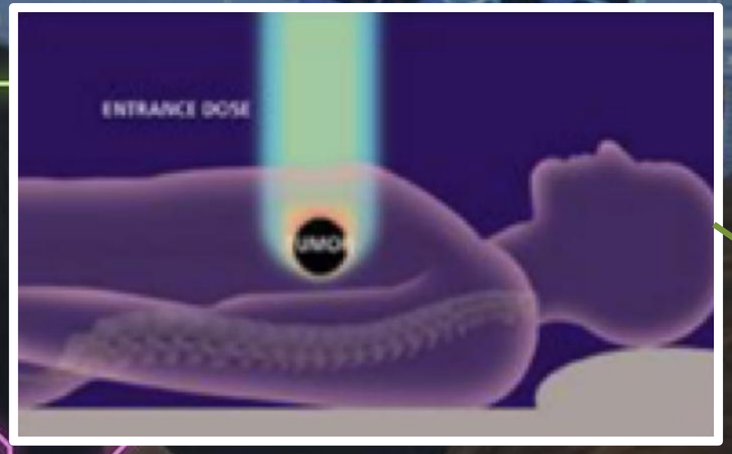

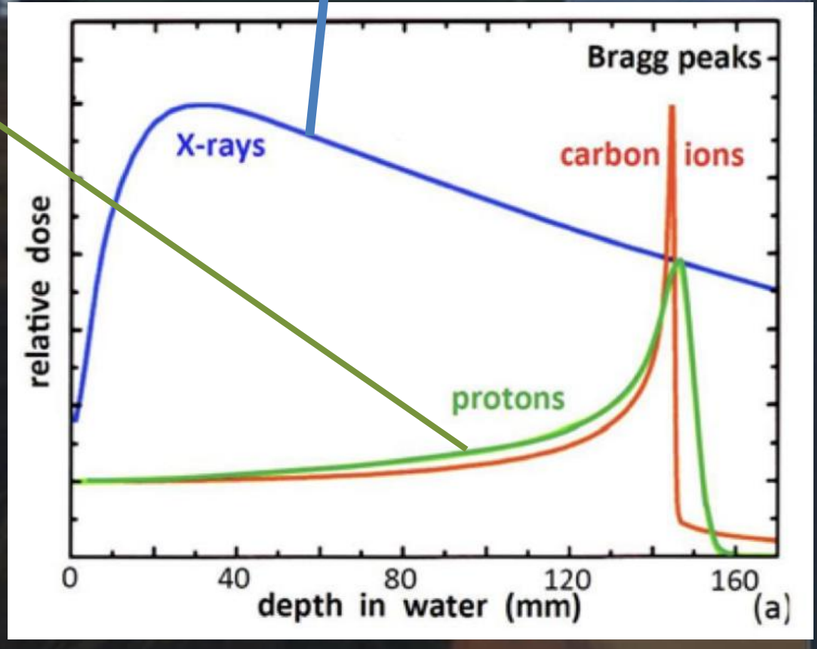

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Cross-Module Synthesis

Axis	Module 01: ALICE	Module 02: PTMC
Subject Matter	Fundamental Particle Physics	Applied Medical Physics
Data Source	LHC Pb-Pb/pp collisions	Patient CT Scans / Dose models
Software Tool	Web App	matRad (DKFZ)
Measurement Target	Invariant mass, Strange particle yields	Tumor coverage, Healthy tissue sparing
Societal Link	Understanding the early universe	Treating cancer

Unified by Hands-On Methodology

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The Global Capstone: Collaboration & Statistics

Scientific Dashboard

The Setup

The Video Conference (Final Session)
At the end of each masterclass day, students participate in a video conference with other participating institutes and moderators, usually located at:

- **CERN** (Switzerland/France)
- **Fermilab** (USA)
- Other locations like **KEK** (Japan) or **Pierre Auger Observatory** (Argentina).

The videoconferences are moderated by scientists who guide students through discussing their findings and comparing results.

The Data Merge

Students upload local measurements to a global pool.

Core Lesson: This is not one person's job... and statistics matters!

The Debate

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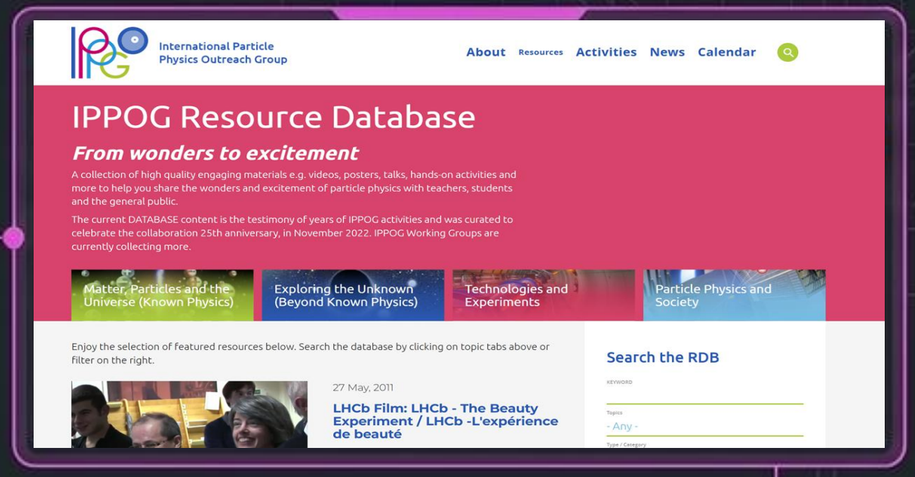
A Fully Loaded, Turnkey Outreach Package

Out-of-the-box Support: Organizers do not start from scratch. The international steering committee provides comprehensive support.

Resource Inventory

- Webpages translated into multiple local languages.
- Pre-packaged analysis software and datasets.
- Detailed instructions for tutors and moderators.
- PR Materials, 3D animations, and video tutorials.



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Masterclass Customization & WUT's Leadership

WUT: Pioneering & Sustaining Masterclasses

- **ALICE Masterclass:** Fully developed by Warsaw University of Technology (WUT). WUT has run it annually for many years as a local organizer, in collaboration with institutes worldwide.
- **Particle Therapy:** WUT also runs the Particle Therapy masterclass, demonstrating the model's versatility.

Adapt & Create Your Own

- **Use as a Template:** Leverage these established masterclasses as proven examples to design an outreach program for your specific topic.

Existing Masterclass Models:

- ATLAS Z path
- ATLAS W path
- ALICE
- Pierre Auger measurement
- CMS WZH measurement
- MINERvA Neutrino
- Quantum Masterclass (new!)

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Co-Designing the Future of Physics Education

01. Evidence-Based

Built on real datasets and authentic scientific processes.

02. Highly Modular

From fundamental QGP research (ALICE) to applied societal challenges (PTMC).

03. Ready to Deploy

Supported by a vibrant European and global network, waiting for your institution.

physicsmasterclasses.org

The Implementation Blueprint

Oct:
Register dates and preferred measurement module with organizers.

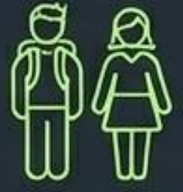
Nov:
Receive preliminary schedule; reserve lecture halls, PC pools, and video links.

Dec:
Update local agenda on physicsmasterclasses.org; create registration links.

Jan:
Send invitation letters to local high schools and students.

Feb/Mar:
Host the event.

Resource Requirements Base



15-19 yr old students

1 lead scientist & 1 tutor per 10-15 students

PC-pool working in groups of 2

Facility for video conferencing

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