

Belle II VR: A Virtual Reality Tool for Student Training in Subatomic Particle Physics

presented by Prof. Leo Piilonen, Virginia Tech



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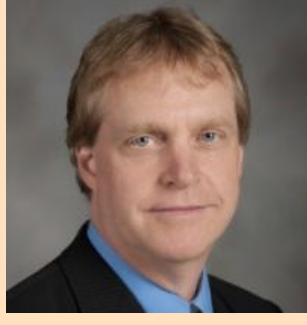


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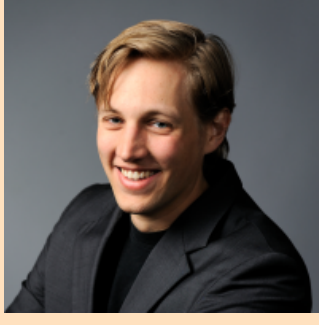
Developed at and with the support of the Institute for Creativity, Arts & Technology (ICAT) at Virginia Tech through a \$25K Science, Engineering, Art & Design grant



with valuable contributions from



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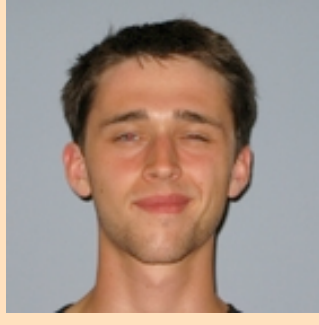
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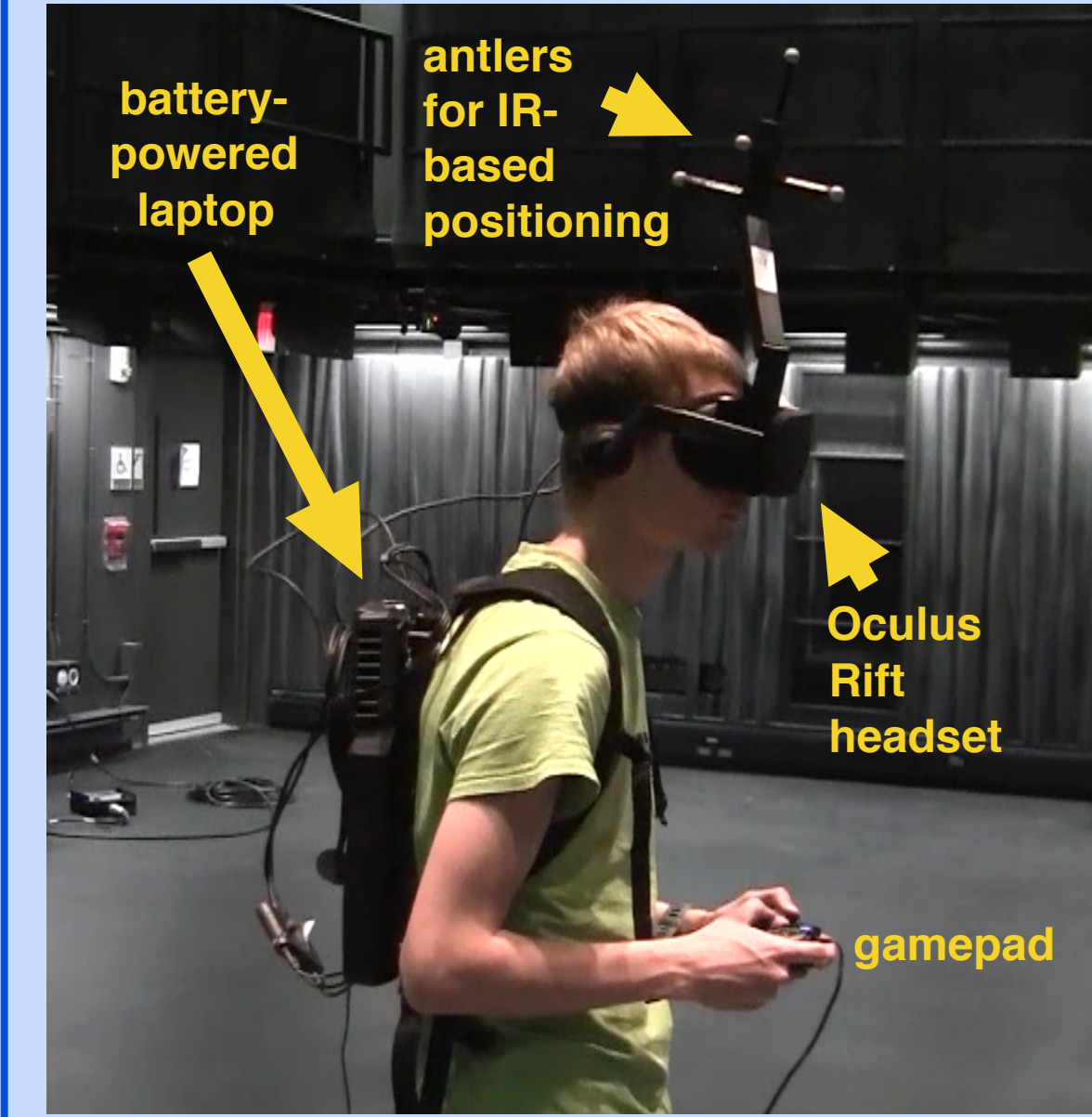


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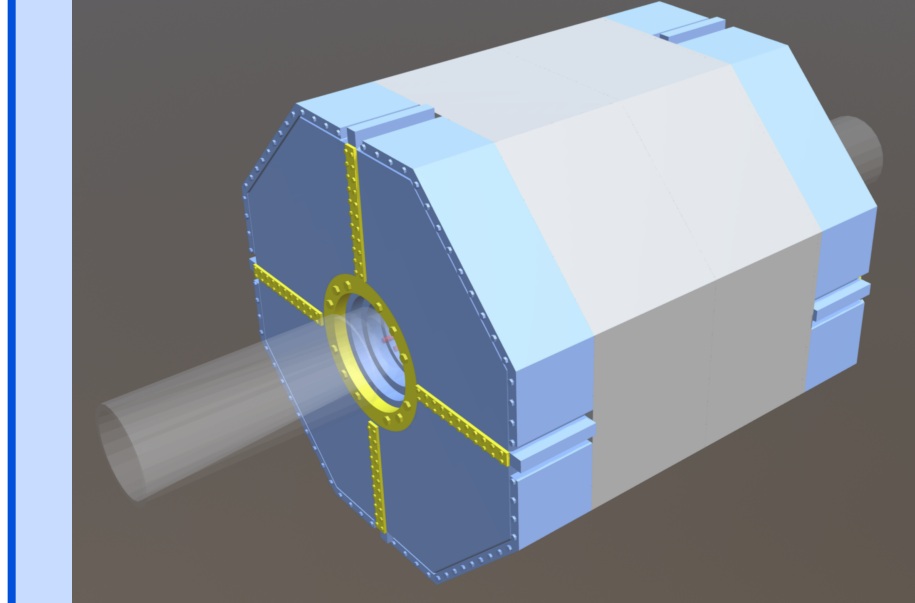
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Why?

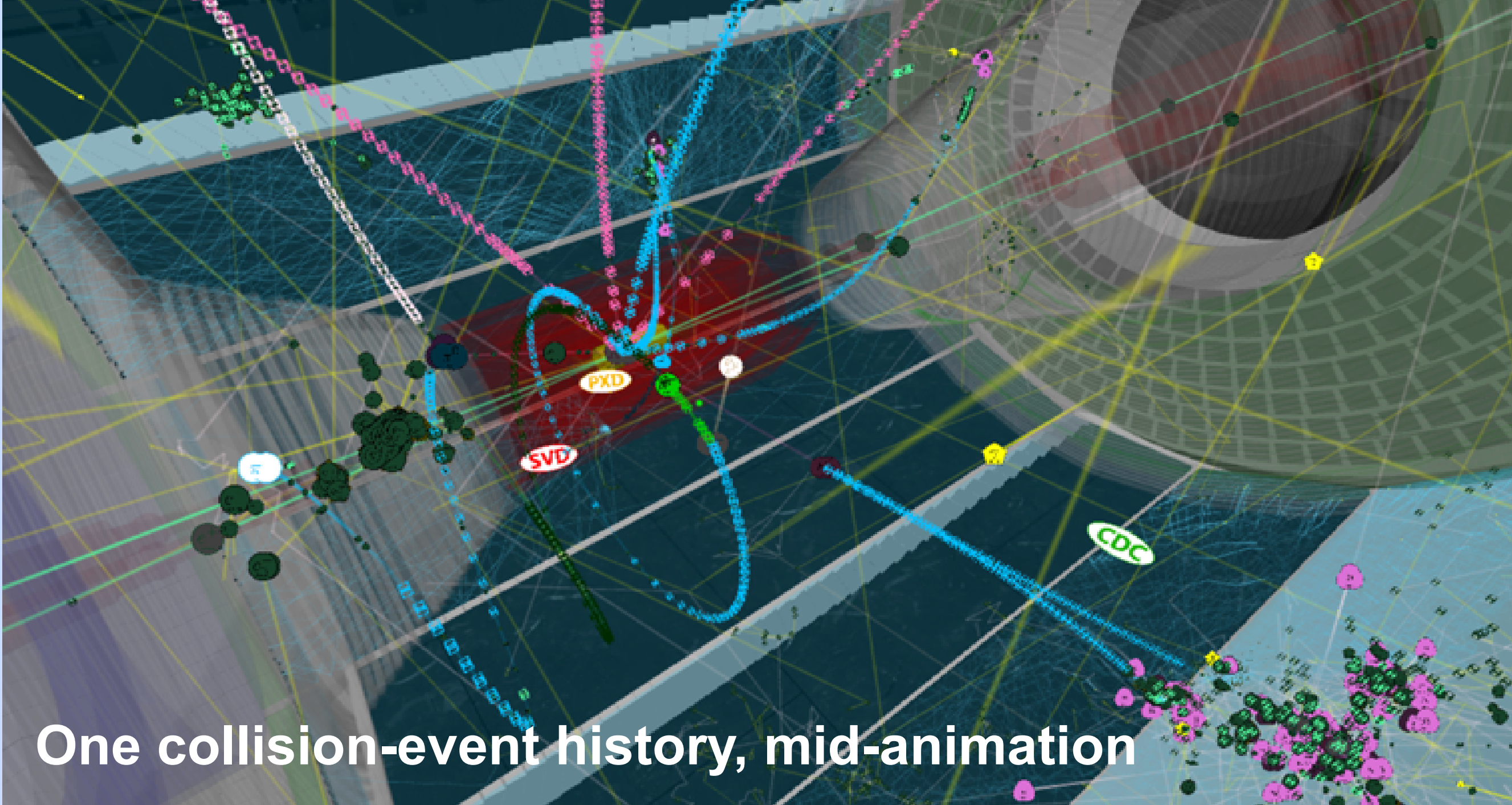
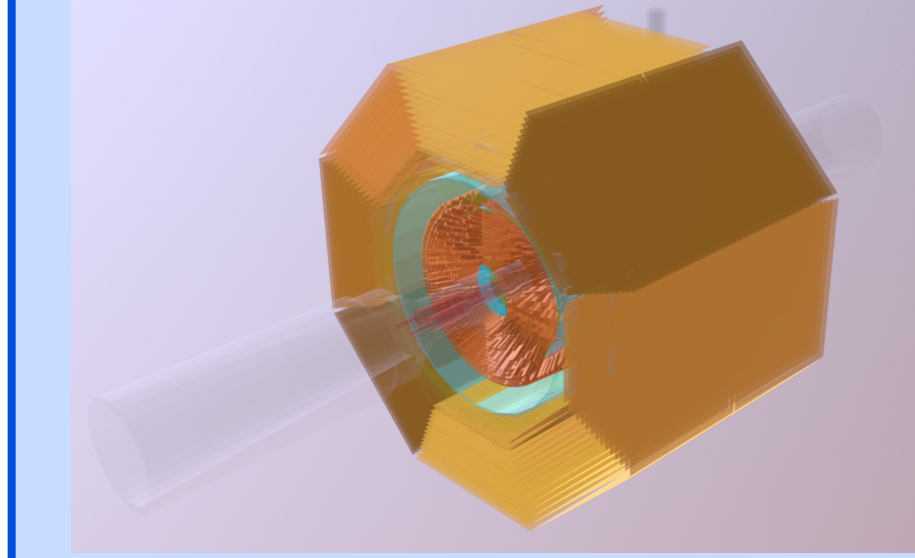


- ✓ Provide experiential training for undergraduate physics majors in the subatomic particle physics course and lab
- ✓ Add life to the dry textbook descriptions of subatomic particle behavior and their interactions with materials
- ✓ Give agency to explore and interact in the virtual-reality world, with gamepad interactive controls to
 - move horizontally and vertically within the 3D world; rotate the user's orientation
 - scale the size of the apparatus (zoom in/out) and move it to inspect its parts in greater detail
 - control the flow of time (forward/backward/faster/slower/pause/resume)
 - interrogate the subatomic particles for their dynamic properties; check conservation of energy and momentum
- ✓ Implement the pedagogical goals and practices of the K-12 Next Generation Science Standards (NGSS) in undergraduate physics education: core ideas, practices, crosscutting concepts, self-guided exploration

How?



3D model of the Belle II apparatus



One collision-event history, mid-animation



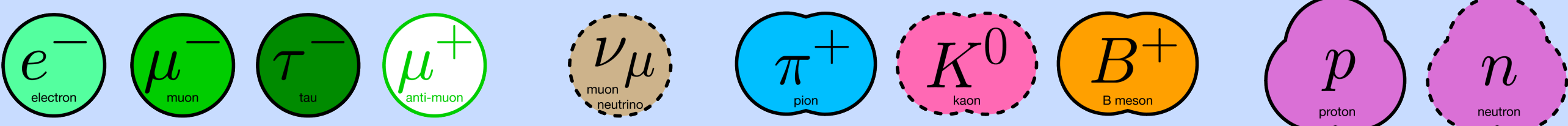
many VR headsets ...



+ 2D screens, WebGL

Features of the event-history interactive animation

- ✓ persistent faint lines show the entire simulation history
- ✓ sprite shows each particle during the animation
 - colour-coded and shape-coded
- de-emphasis [*faded*] after particle's history ends
- ✓ dynamic trails highlight particle motion during animation
- ✓ sensitive-detector hits, with detector-specific sound



Particle info popup panels



muon

2

Focus

Save

X

	Initial	Current	Final
Energy (MeV):	4981.5	3201.7	3200.6
Momentum (MeV/c)	x: 2651.5	1905.1	1903.8
	y: -4142.6	-2527.9	-2527.4
	z: -782.6	-469.3	-469.7

In-game menus



What?

Self-guided activities for students, lesson plan components, ...

- ✓ Gaze at and select the highlighted beam electron and beam positron, save these to the panel on one wall of the room.
- ✓ Sum the saved beam-particle charges, energies and momenta.
- ✓ After the collision, repeat the above for the post-collision particles; check conservation of charge, energy, momentum
- ✓ Find then select a neutral short-lived K meson; save it to the wall panel.
- ✓ After the K meson has decayed, select its daughter pions and save them to the wall panel.
- ✓ Check for conservation of charge, energy and momentum between the parent and its daughters.
- ✓ Find and select the short-lived K meson, then "Focus" to see only its parent and daughters in the animation.
- ✓ Discover how the various kinds of subatomic particles interact with the different materials in the Belle II apparatus.
- ✓ Scavenger hunt: find as many different kinds of subatomic particles as possible.
- ✓ Zoom in by a factor of 20 to see the innermost subdetectors in the Belle II apparatus
- ✓ Slow down the animation; speed up the animation; rewind the animation; loop the animation.

Future work: gamification, saved in-game state, more localization (beyond English, German, French, Italian, Slovenian)

Now available for free on the Steam app store.
store.steampowered.com/app/810020/

