Build your own detector

Theme	Explore
Exhibit No.	Exp-E-04b
Exhibit name	Build your own detector
Exhibit description	Visitors can build their own detector using parts representing the different types of detectors (trackers, calorimeters) and magnets. Once their detector is finished, they can create a collision. The results of their set up will be calculated in real time using the Geant 4 software developed at CERN to simulate experiments. As the different detector types influence the particles as well as measuring them, it is important to consider their order. When assembling the experiment. Visitors can compose their experiment on a smart wall/screen/table. The set-up should lend itself to active exploration. CERN will supply the Geant 4 software adapted to needs of the interactive.
Learning goal	There is not one sensor that can give all the information needed. You need the combined output from different types of sensors to collect data about a collision. As the sensors influence the particles, it is important to consider this when assembling your detector. By comparing what is actually measured in experiments to simulations of what is expected, scientists can check their theories. In the Build you own detector visitors can create their own experiment and simulate a collision. Context ▪ Before one can construct a detector, it is important to know how different particles interact with different detectors and with different materials. ▪ Geant 4, software developed by CERN, simulates how particles interact with different materials. Messages • LHC experiments are built in layers. Each layer is made of detectors measuring a different characteristic of the particles spraying out from the collision in the centre. The choice of materials used for the detectors is key to the experiment's success. • Studying data from particle collisions reveals how the basic ingredients of our universe form and interact. Context • Modern particle detectors consist of layers of sub detectors, each designed to look for particular properties, or specific types of particle. Tracking devices reveal the path of a particle; calorimeters stop, absorb and measure a particle’s energy; and particle-identification detectors use a range of techniques to pin down a particle's identity.

	• Tracking devices
	  ○ Tracking devices reveal the paths of electrically charged particles as they pass through and interact with suitable substances. Most tracking devices do not make particle tracks directly visible, but record tiny electrical signals that particles create as they move through the device. A computer program then reconstructs the recorded patterns of tracks.
	  ○ One type of particle, the muon, interacts very little with matter – it can travel through metres of dense material before it is stopped. For this reason, muon chambers – tracking devices specialized for detecting muons – usually make up the outermost layer of a detector.
	• Calorimeters
	  ○ A calorimeter measures the energy a particle loses as it passes through. It is usually designed to stop entirely or "absorb" most of the particles coming from a collision, forcing them to deposit all of their energy within the detector. Calorimeters typically consist of layers of "passive" or "absorbing" high-density material – for example, lead – interleaved with layers of an "active" medium such as solid lead-glass or liquid argon.
	  ○ Electromagnetic calorimeters measure the energy of electrons and photons as they interact with the electrically charged particles in matter.
	  ○ Hadronic calorimeters sample the energy of hadrons (particles containing quarks, such as protons and neutrons) as they interact with atomic nuclei. Calorimeters can stop most known particles except muons and neutrinos.
	
	Messages
	• LHC experiments are built in layers. Each layer is made of detectors measuring a different characteristic of the particles spraying out from the collision in the centre. The choice of materials used for the detectors is key to the experiment's success.

Type of interactivity	Hands on + multimedia Set up should be so that it lends itself to active exploration
Interaction	Visitors can build their own experiment using parts representing the different types of detectors. Once their detector is finished, they can create a collision. The results of their set up will be calculated in real time using the Geant 4 software developed at CERN to simulate experiments Visitors have a box with different "detectors", if possible, those look like the real detectors they represent. Preferably each type of detector has a different surface. They also have a"magnet". There is a smart wall/screen/table on which they can stick the detectors in any way they want around a collision point. Visitors will have to figure out the ideal order for themselves, ideally they experiment first with the Test station. The parts should be made in such way that visitors can use them to make smaller or larger circles around the collision point (so curvature should not give away whether the parts are best used in the inner or outer rings). A screen with instructions: build your own experiment

	The following detectors should be present • Trackers: Silicon, trackers and Scintillating Fibres: ▪ Tracking devices reveal the paths of electrically charged particles as they pass through and interact with suitable substances. Most tracking devices do not make particle tracks directly visible, but record tiny electrical signals that particles trigger as they move through the device. • Calorimeters: ○ electromagnetic ▪ measure the energy of electrons and photons as they interact with the electrically charged particles in matter ○ Hadronic ▪ sample the energy of hadrons (particles containing quarks, such as protons and neutrons) as they interact with atomic nuclei ○ (Calorimeters can stop most known particles except muons and neutrinos.) • Muon detectors ▪ The muon, interacts very little with matter – it can travel through metres of dense material before it is stopped. For this reason, muon chambers – tracking devices specialized for detecting muons – usually make up the outermost layer of a detector. Visitors also have a magnet that they can choose to use or not. The following particles have to be available for the collision point • Protons Visitor will then construct their own experiment by assembling the detectors of their choice, a reader will detect which parts are used. Visitors can then choose which 2 particles they want to collide. When ready: visitor can start their experiment (by pressing the particles button?) Result is shown on the screen: • feedback on what is detected: tracks, energy, particles created… and the conclusions drawn from that • if needed: visitor can adjust experiment ○ Can we give feedback, suggestions on how to improve their detector: what could have been detected when other detectors would have been there? • ask visitor to disassemble for next visitor (or find way to reset automatically)
Exhibit example, picture, sketches, …	For Geant 4: see https://geant4.web.cern.ch/
Number of users	1 to 3
Accessibility	Must be accessible to wheelchair users. Detector pieces should contain tactile elements for blind and visually impaired to distinguish the different layers. An audio-description shall also be included.

Consumables on daily basis	NA However, a sufficient number of the different types of “detectors” have to be produced so that visitors can create interesting experiments. Two full duplicate sets to be delivered so that in case of damage or theft parts can be replaced. Maybe use anti-theft system for the loose parts? Possibilities are: • system such as used in shop, will then need detector gate at exit/entrance of exhibition • system as used with luggage: if distance between part and exhibit gets large than x, alarm sounds
Work done or parts delivered by CERN	CERN will deliver and configure the GEANT 4 software for the calculation of the simulated results. All hardware, the software for recognizing the objects and the user interface has to be developed by the supplier. Close collaboration between supplier and CERN team will be necessary.
Safety aspects	
Evaluation and/or prototyping already carried out	
Objects related to this exhibit	
CERN stories related to this exhibit	
Where exhibit is in exhibition/ How exhibit connects to other exhibits and/or objects	End of section 2 Possibly when visitors build something that is close to real set up: projection of their collision pattern on the decor
Scientist/engineer	John Apostolakis