

# Ring Imaging CHerenkov Detectors

The LHCb Detector

RICH2

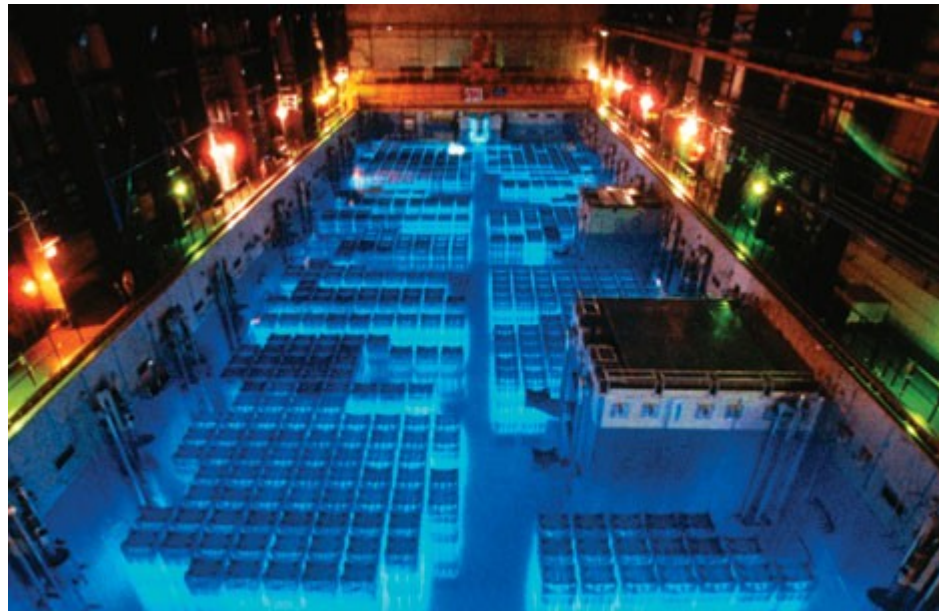
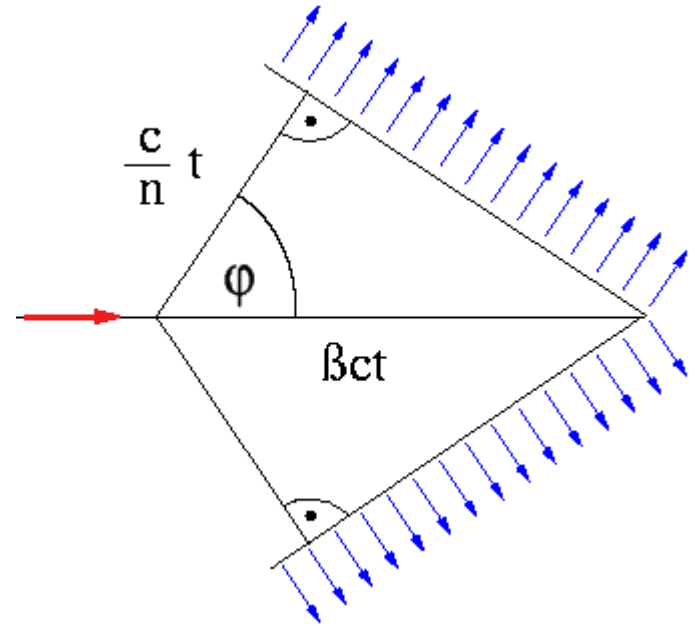
RICH1



# The Cherenkov Effect



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## Essential relativity

Moving massive particles have total energy,  $E$ , made up of motion-energy and mass-energy. The quantity  $E^2 - p^2 = m^2$  relates the total energy to the particle momentum and mass.

The speed of a particle (as a fraction of the speed of light),  $\beta$ , can be found from  $\beta^2 = (E^2 - m^2)/E^2$ , or rearranged  **$\beta^2 = 1 - (m/E)^2$**

**Calculate  $\beta$  for an electron (mass  $0.000511\text{GeV}$ ), pion (mass  $0.1396\text{GeV}$ ) and kaon (mass  $0.4937\text{GeV}$ ) if each has  $10\text{GeV}$  total energy.**

## The Ring Imaging Cherenkov detector

Charged particles moving in a medium of refractive index,  $n$ , and having speed greater than the local speed of light emit photons at an angle,  $\theta$ , to the direction of motion where  **$\cos\theta = 1/n\beta$** .

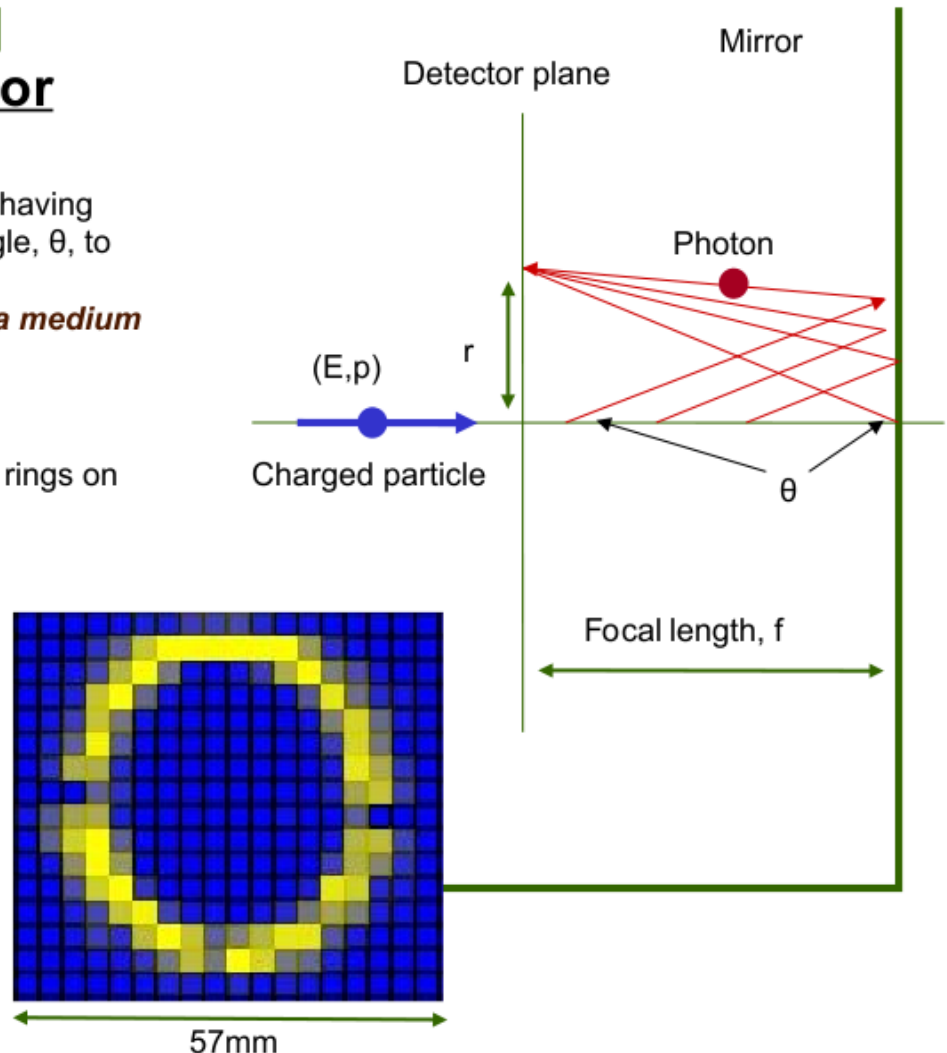
**Calculate  $\cos\theta$  for  $10\text{GeV}$  electrons, pions and kaons using a medium of refractive index  $1.0003$ . Comment on the values you get.**

These parallel rays can be focussed by a spherical mirror to form rings on an image plane.

The radius of the ring image is given by  **$r = f \tan\theta$** .

The Cherenkov ring below is due to  $10\text{GeV}$  particles in a medium of refractive index  $1.0003$  imaged with a mirror of focal length  $f=1143\text{mm}$ .

**Predict the Cherenkov ring radii for electrons, pions and kaons and compare your radii with the image below. Was the image formed by electrons, pions or kaons?**



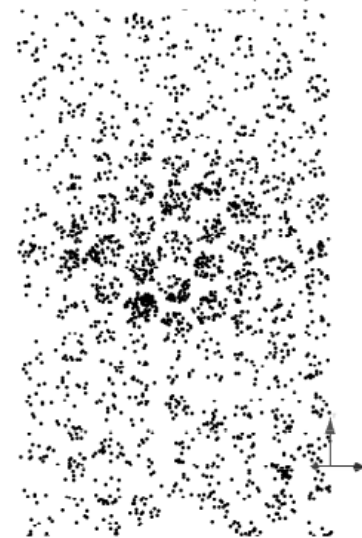
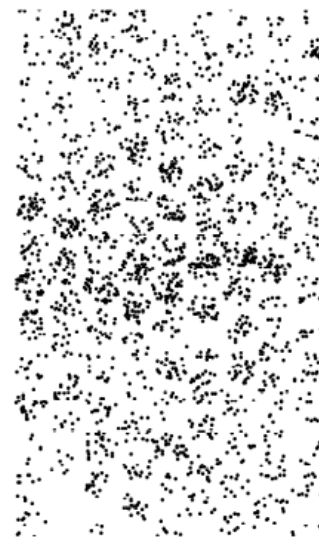
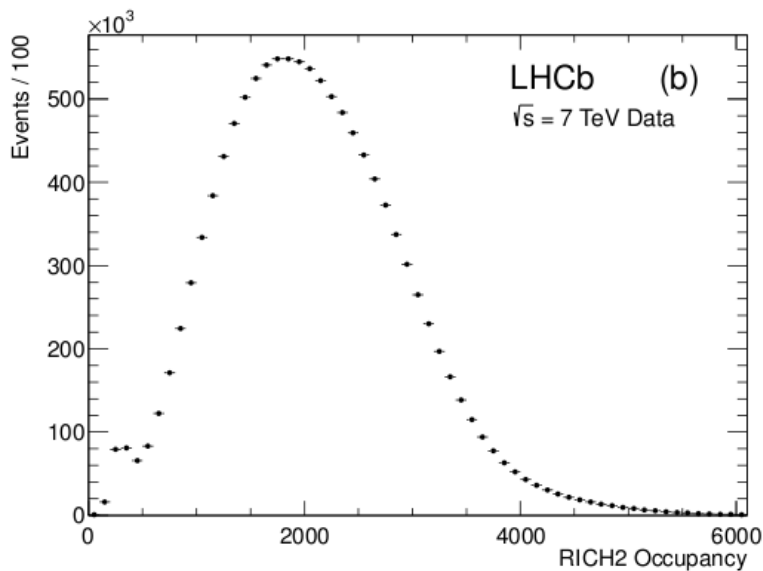
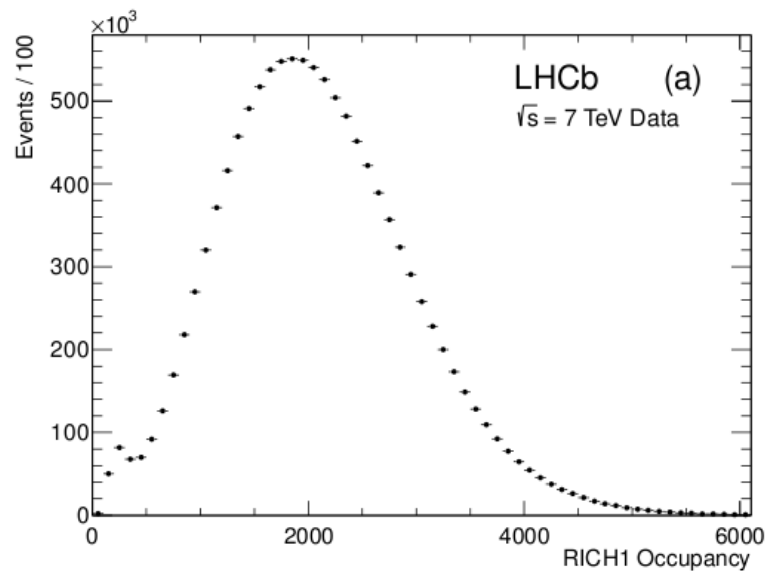
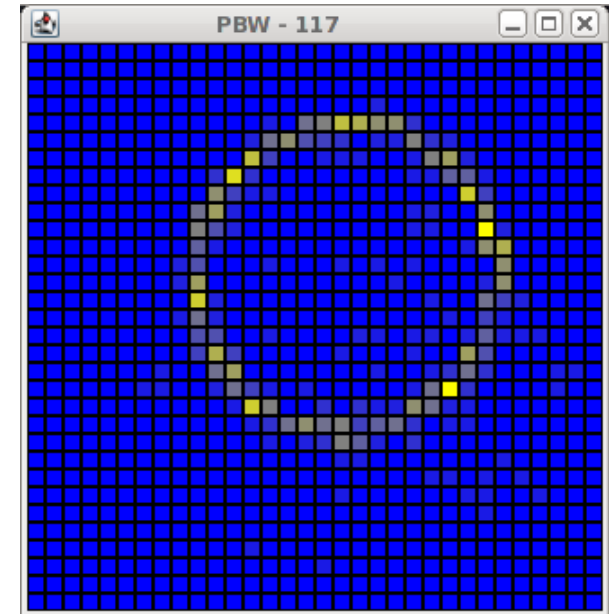
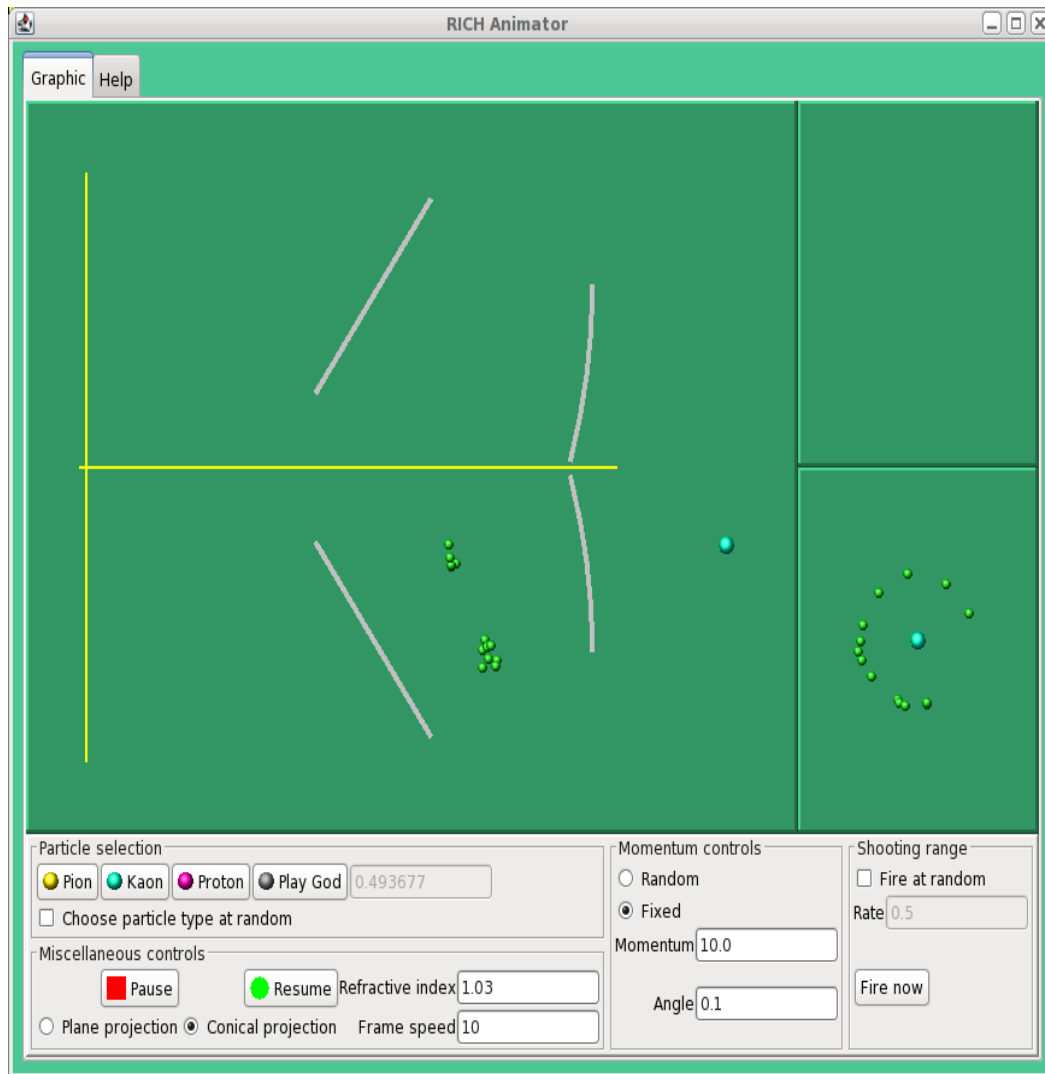


Figure 13: Distribution of the number of pixel hits per event in (a) RICH 1 and (b) RICH 2. An example of a typical LHCb event as seen by the RICH detectors, is shown below the distributions. The upper/lower HPD panels in RICH 1 and the left/right panels in RICH 2 are shown separately

# Applications available from the 'MasterClass' Folder on your desktop

## RICH-Simulator



The PBW window has a title bar "PBW" and a menu bar with "File" and "Options". Below the menu bar is a "Data source URL" field containing the address <http://www.hep.phy.cam.ac.uk/lhcb/applets/pbw/run0013.mdf>. Below this is a section for "Add HPD" with a dropdown set to "0" and a "Delay [ms]" input field set to "100". The main area contains a list of HPD channels with their occupancy values. Each row has a checkbox, a channel number, an occupancy value, a status checkbox, a count input field, and a "Clear" button. The channels listed are 117, 126, 131, 265, 89, 257, 109, 222, 167, 116, and 18. At the bottom, there are buttons for "Sort Up", "Sort Down", "Hardware ID", "Occupancy" (selected), "Stop" (red square), "Go" (green circle), and "Clear all".

Channel	Occupancy	Status	Count	Action
117	13.3	<input checked="" type="checkbox"/>	1	Clear
126	1.0	<input checked="" type="checkbox"/>	1	Clear
131	0.9	<input checked="" type="checkbox"/>	1	Clear
265	1.1	<input checked="" type="checkbox"/>	1	Clear
89	0.6	<input checked="" type="checkbox"/>	1	Clear
257	0.1	<input checked="" type="checkbox"/>	1	Clear
109	0.1	<input checked="" type="checkbox"/>	1	Clear
222	0.1	<input checked="" type="checkbox"/>	1	Clear
167	0.1	<input checked="" type="checkbox"/>	1	Clear
116	0.1	<input checked="" type="checkbox"/>	1	Clear
18	0.0	<input checked="" type="checkbox"/>	1	Clear

Event-Display