The Beauty Experiment!
Cherenkov Light and PID

Cherenkov radiation is created when charged particles travel in a medium faster than light

\[ \cos \theta = \frac{1}{n\beta} \]

Velocity measure + momentum measure \( \rightarrow \) mass measure

\( \rightarrow \) particle identification
Ring Imaging CHerenkov Detector
The cherenkov light is projected on a plane and it creates a ring.
Two detectors to cover different range of momentum

RICH1:
  - radiator: gas + areogel
  - acceptance: 25-300 mrad

RICH2:
  - radiator: gas
  - acceptance: 15-120 mrad
RICH Upgrade and the test beam

• Higher Luminosity
• All software trigger \[\Rightarrow\] read out at 40 MHz

Upgrades:
• optimize the optics to reduce occupancy (remove the areogel in RICH1)
• change HPD with PMTs + external readout electronics (faster)

Test beam to evaluate the efficiency (photon yields) and resolution of the new PMTs (October 2014)
The simulation

Goal of my project:
- decide the radiator for the test beam and its characteristics
- set up the simulation for the analysis

Simulation (based on GEANT4):
- **Beam** $\rightarrow$ 50 GeV protons (beam width $\approx$ 10 mm)
- **Radiator** $\rightarrow$ crystal (shape to be decided)
- **Detector** $\rightarrow$ PMTs
In order to get a better resolution on the measurement of the Cherenkov angle the light must be focused.

2 ideas:

- Light is created in a flat crystal and then focused with an external lens
- Light is created in a crystal with a spherical surface, no need of extra lens
Crystal + lens - Geometry

- the crystal is tilted, so the Cherenkov photons are normal to the surface and hence minimal reflection when exiting the crystal
- the crystal is covered upstream and lateral side to block the photons internally reflected
- the lens’s focus distance is $R = 400$ mm
Crystal + Lens - Hits distribution on detector plane

Crystal Refractive Index = 1.5, Crystal Thickness 1 cm

Photon location on frame
Mean = Cherenkov Radius, RMS = width of the ring (both in mm)
Lens - Geometry

- at first the light is totally internal reflected
- reflective layer on the spherical surface
- absorber layer to choose the photons created in the 1 cm of material
Lens - Hits distribution on detector plane

Photon location on frame
Mean = Cherenkov Radius, RMS = width of the ring (both in mm)
Pros and Cons

Both configuration show similar resolution < than PMTs pixels’ size

Crystal + lens

Focus plane far from the beam

↓

No risk of damage for the PMTs

Just lens

2 parts of the ring may be reconstructed

↓

Possibility to test more PMTs

+ more compact configuration in terms of mechanics
Conclusion

- 2 radiator configurations have been explored
- both of them can be used for the test beam

Further steps:
- Create the hits not on a simple plane, but with PMTs
- Store the hits in an output file for further analysis

Thank you!
Lens effect

Hits distribution, **without** the lens focusing

Photon location on frame
Cherenkov Ring Radius, without the lens focusing

Cherenkov ring radius

Mean = Cherenkov Radius, RMS = width of the ring (both in mm)