Simulating LHCb RICH upgrade Test Beam

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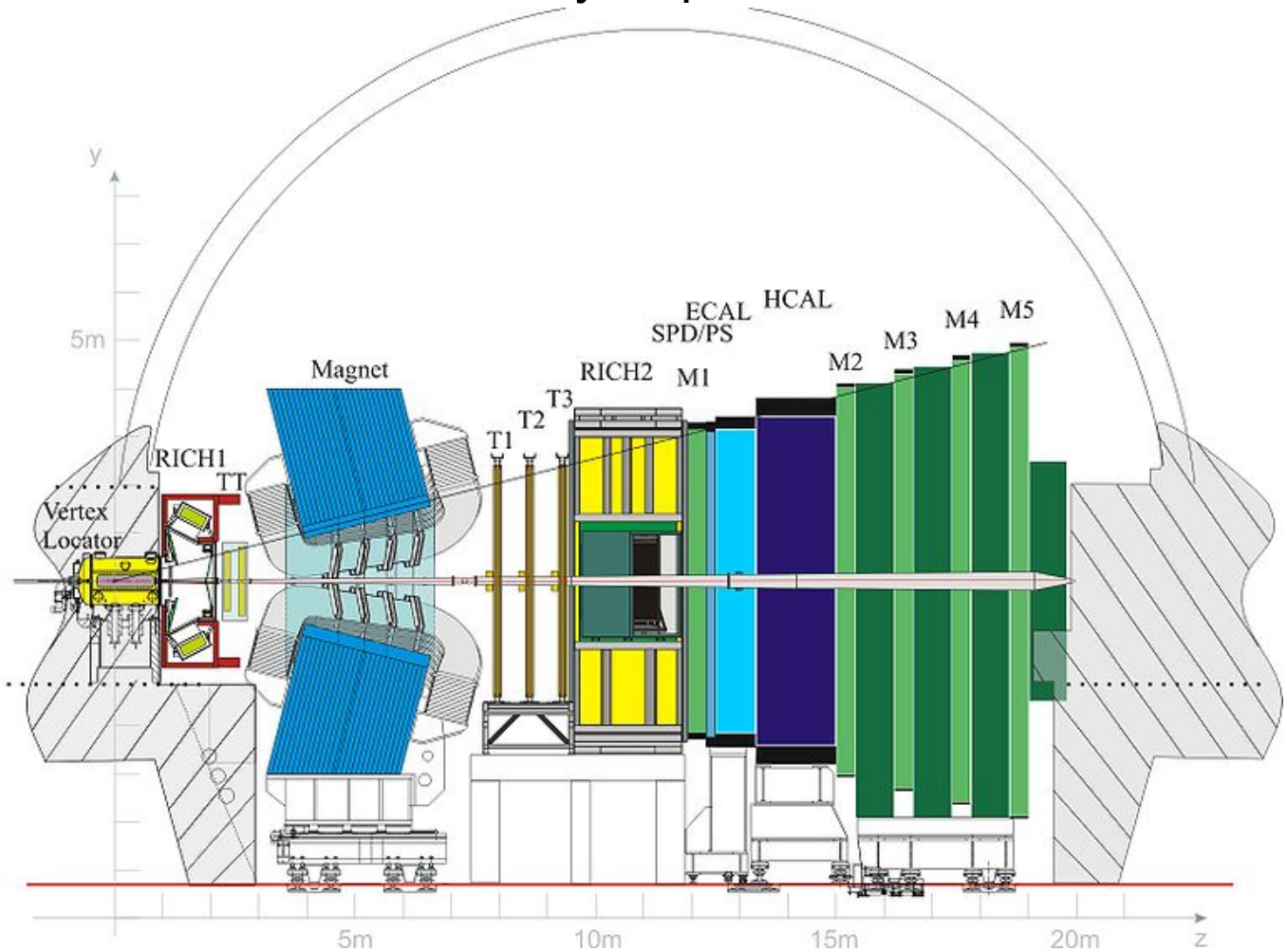
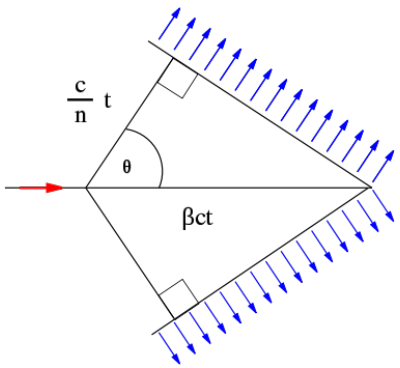
The Beauty Experiment!

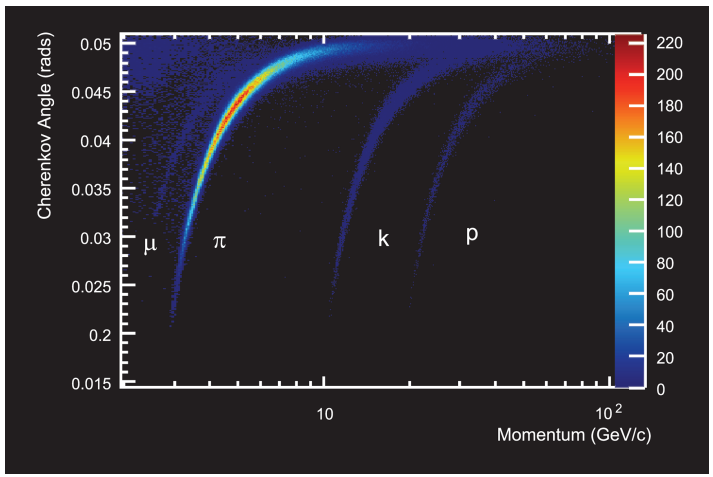


Cherenkov Light and PID

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

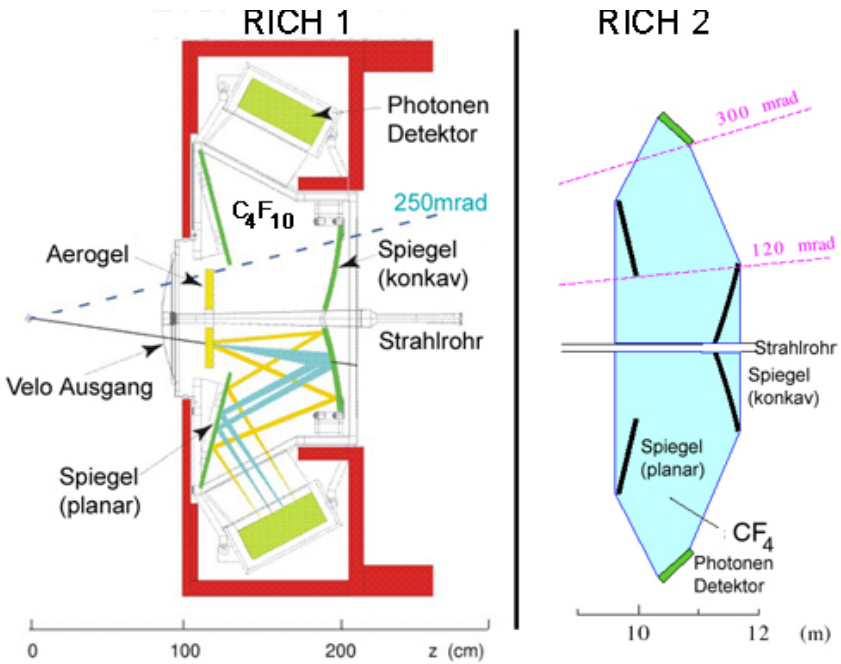
$\rightarrow$ particle identification

LHCb RICH Detector

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: 25-300mrad

RICH2:

- radiator: gas
- acceptance: 15-120mrad

RICH Upgrade and the test beam

- Higher Luminosity
- All software trigger

$\Longrightarrow$ read out at $40\,\mathrm{MHz}$

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 yelds) and resolution of the new PMTs
(October 2014)

The simulation

Goal of my project:

- decide the radiator for the test beam and it's characteristics
- set up the simulation for the analysis

Simulation (based on GEANT4):

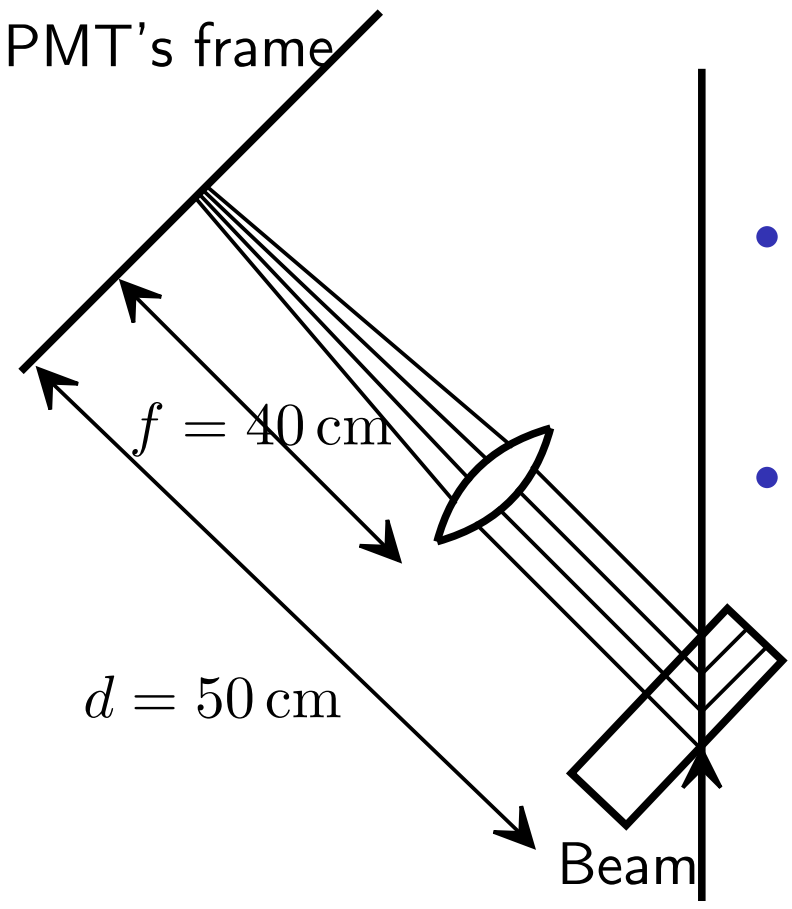
- Beam $\rightarrow 50\,\mathrm{GeV}$ protons (beam width $\approx 10\,\mathrm{mm}$)
- Radiator $\rightarrow$ crystal (shape to be decided)
- Detector $\rightarrow$ PMTs

Focusing system

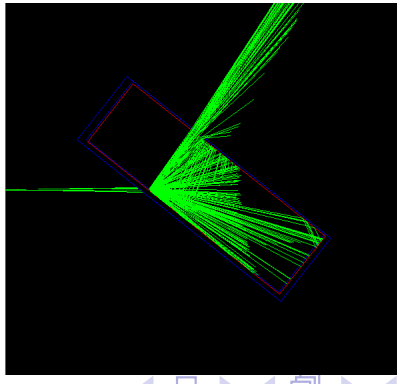
In order to get a better resolution on the measurement of the Cherenkov angle the light must be focused.
2 ideas:

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

Crystal + lens - Geometry

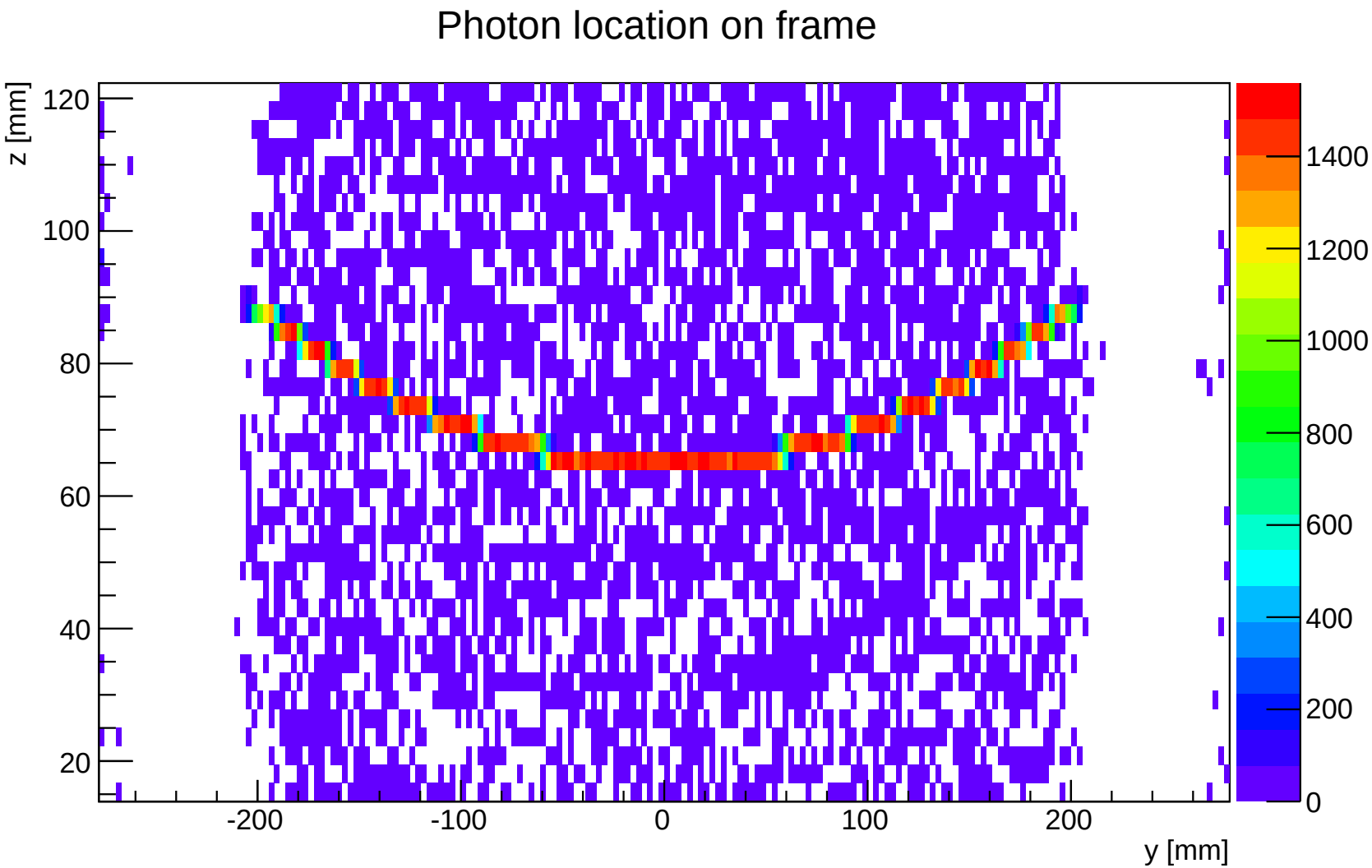


- the crystal is tilted, so the Cherenkov photons are normal to the surface and hence minimal reflection when exiting the crystal
- the crystal is covered upstream and lateral side to block the photons internally reflected
- the lens's focus distance is $R = 400\,\mathrm{mm}$

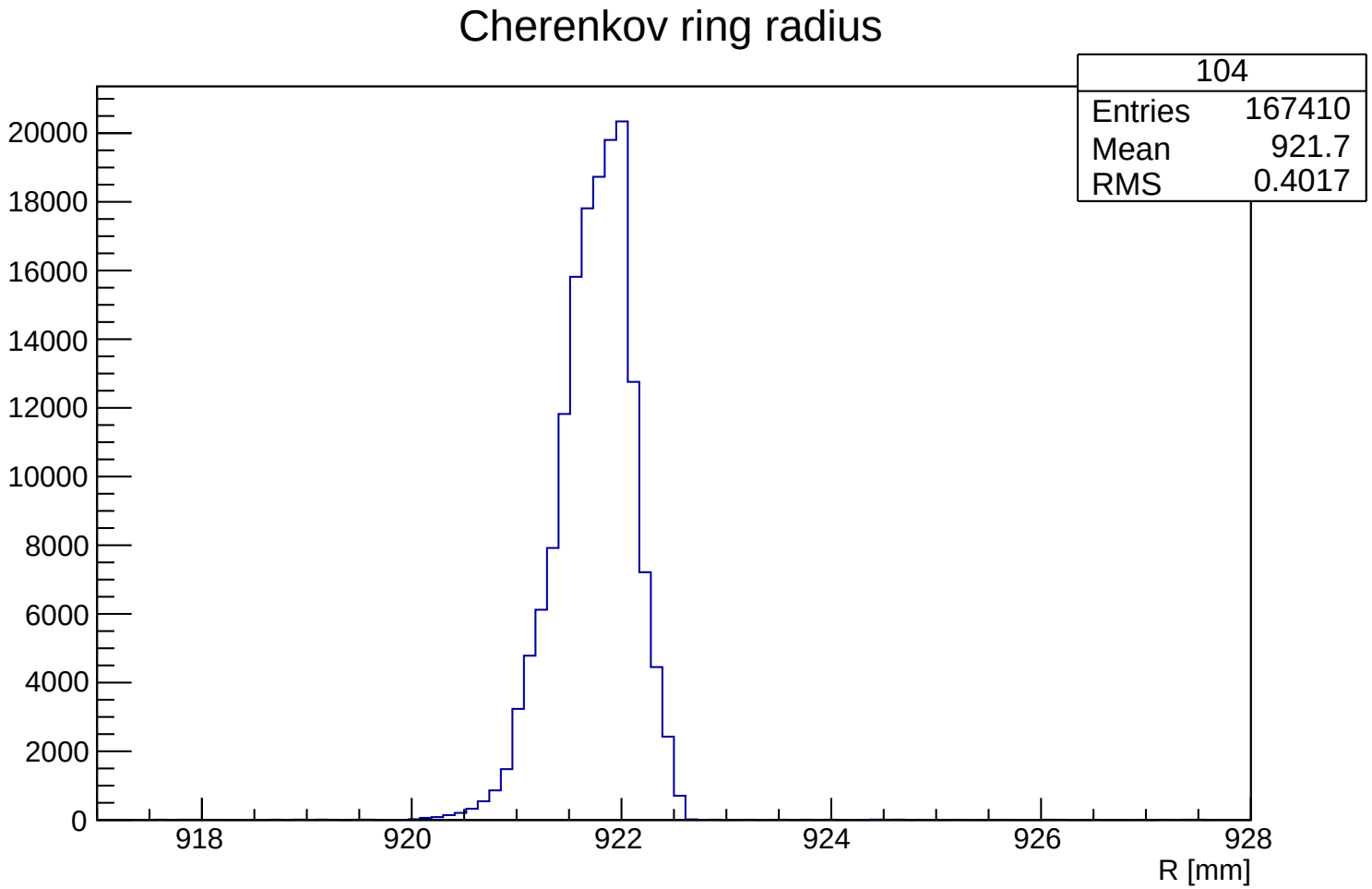


Crystal + Lens - Hits distribution on detector plane

Crystal Refractive Index = 1.5, Crystal Thickness $1\,\mathrm{cm}$

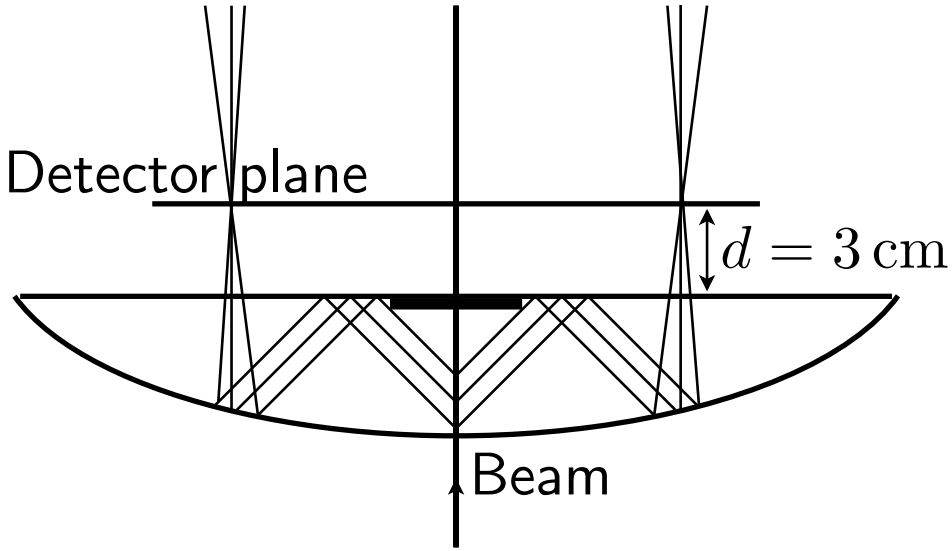


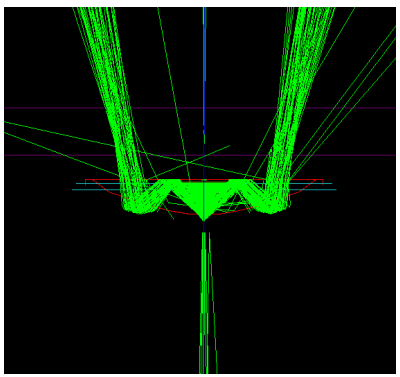
Crystal + Lens - Cherenkov Ring Radius



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

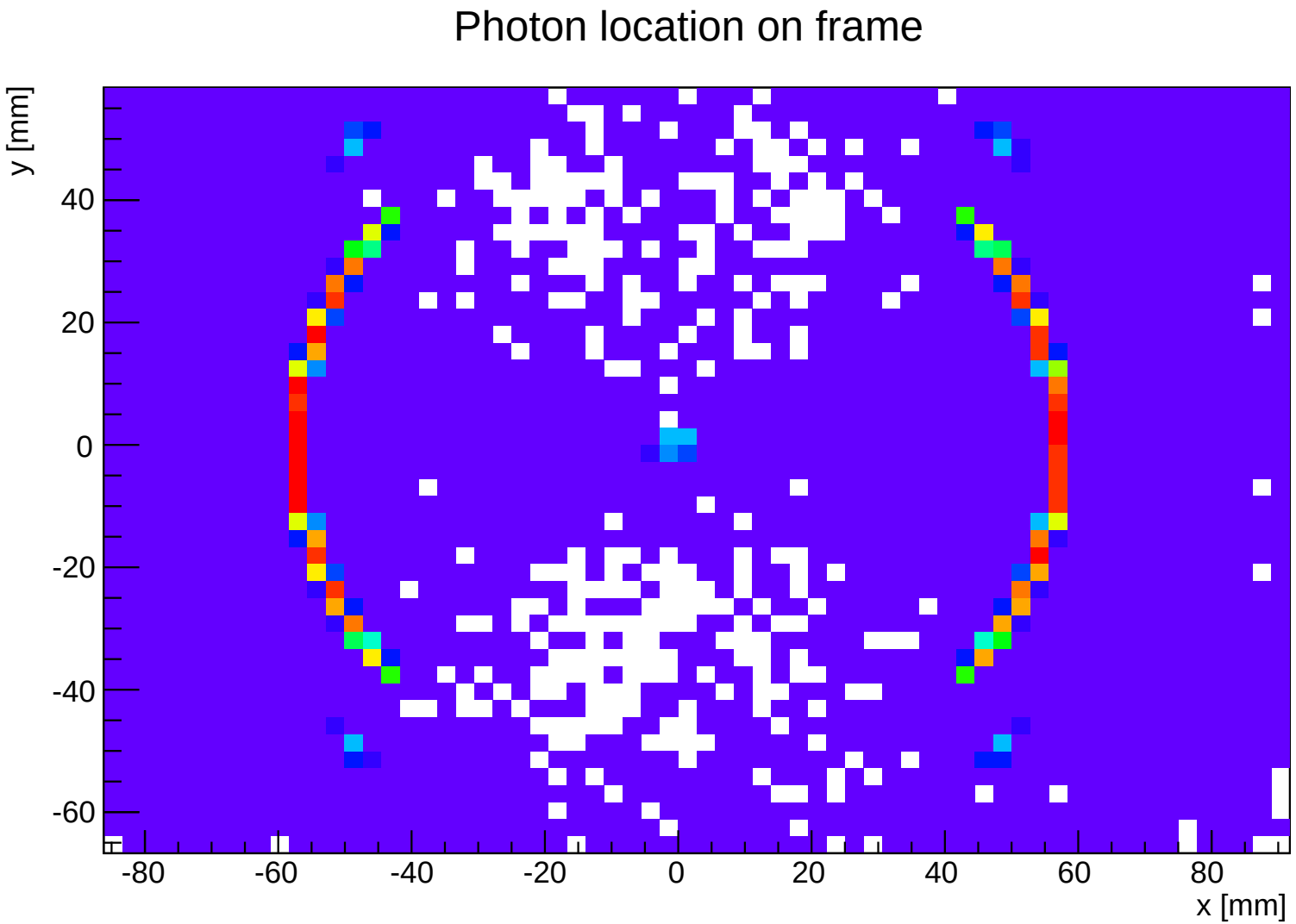
Lens - Geometry



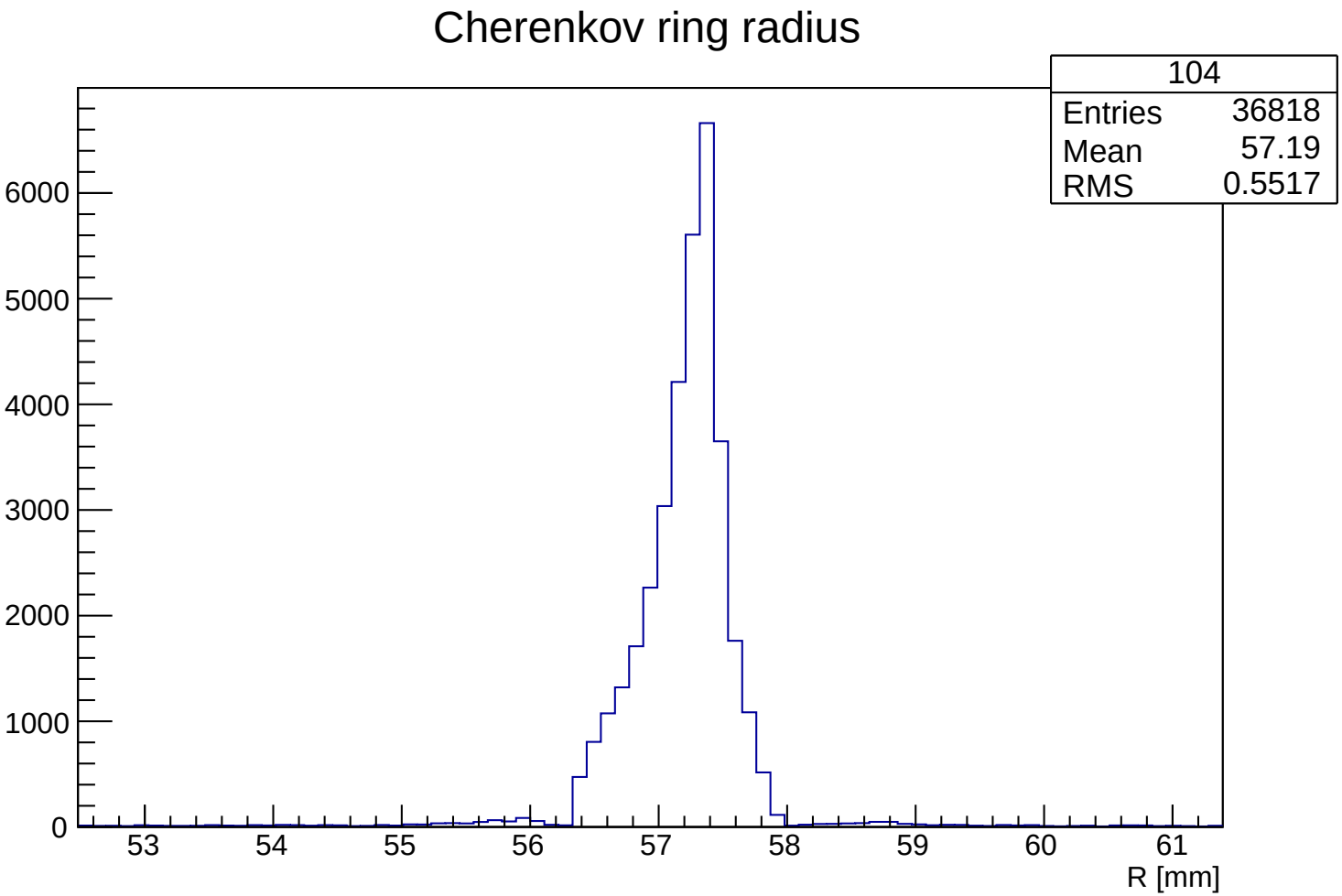


- at first the light is totally internal reflected
- reflective layer on the spherical surface
- absorber layer to choose the photons created in the $1\,\mathrm{cm}$ of material

Lens - Hits distribution on detector plane



Lens - Cherenkov Ring Radius



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

$\downarrow$

No risk of damage for the PMTs

Just lens

2 parts of the ring may be reconstructed

$\downarrow$

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

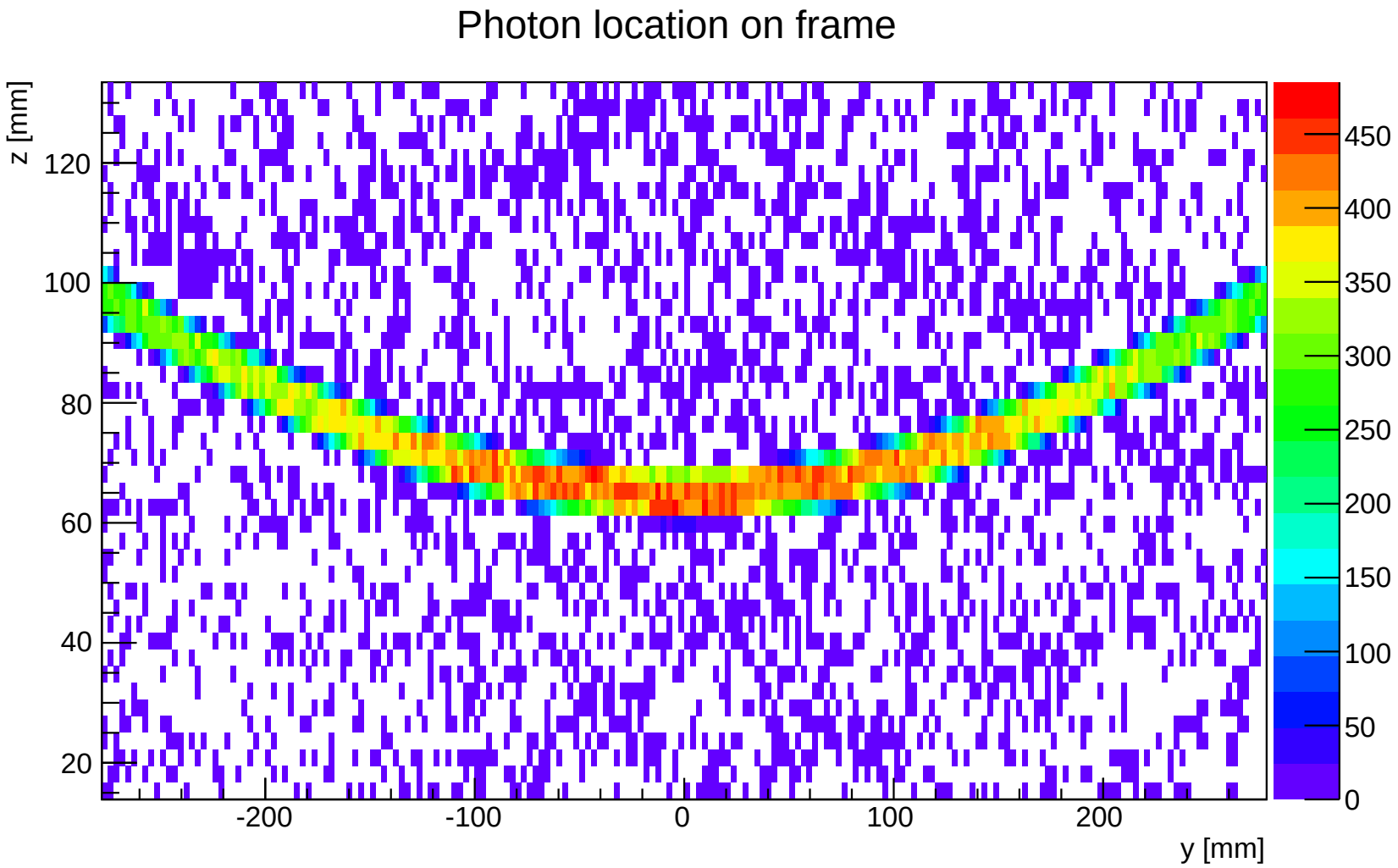
Further steps:

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

Thank you!

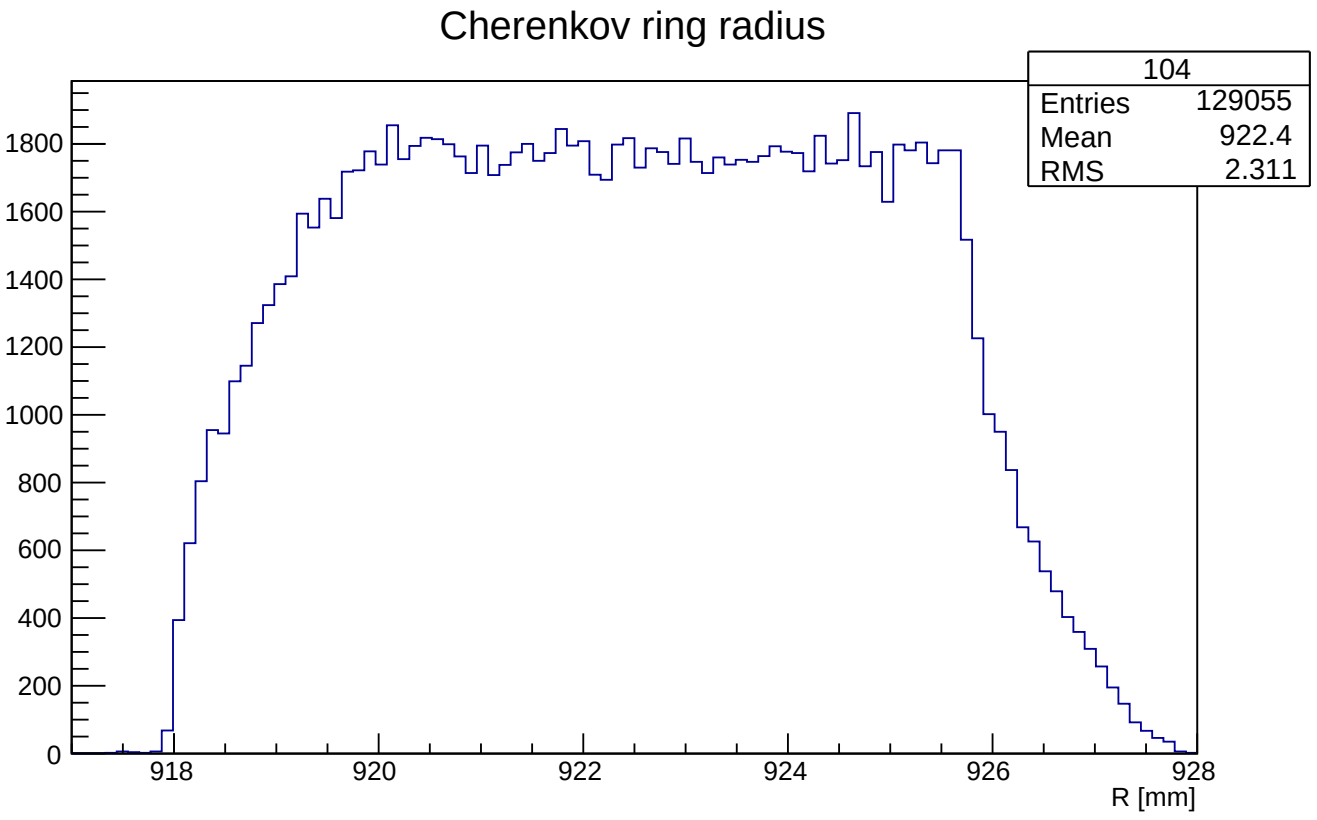
Lens effect

Hits distribution, without the lens focusing



Lens effect

Cherenkov Ring Radius, without the lens focusing



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