Geant4 simulation: geometrical studies and building of photon dictionaries + getting ready for the FDIRC CRT test

Martino Borsato

Laboratoire de l'Accélérateur Linéaire

June 1st 2012

One slide to introduce myself

- master thesis at LAL with Nicolas Arnaud
- participation to the FDIRC CRT test at SLAC
- probably starting my PhD next October with the SuperB LAL group

Focusing DIRC

test geometry, FEE, PMTs, simulation, reconstruction, monitoring, bkg

Forward TOF

detector design, test of components, simulation

Preparation of SuperB data analysis

- use and improve simulation tools (fast and full)
- analyse datasets from simulation and cross-checks with BaBar data

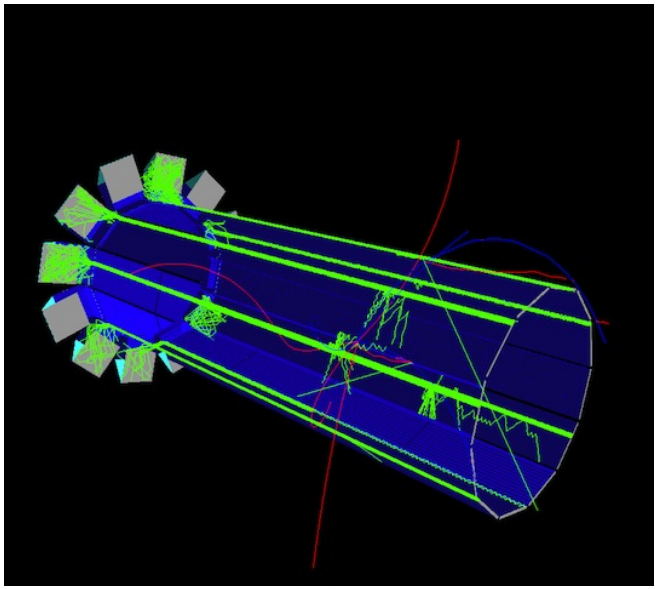
Geant4 Simulation by Doug

Doug's Geant4 simulation: compiled and working well

- see **SuperB wiki** for setup instructions
- now running at *CC-IN2P3* and *ir2-superb queue at SLAC*

Options:

- Single photon gun:
  - geometrical studies
  - photon dictionaries
- CRT test: response to muons with typical distribution
- employ the dictionaries to compute single-photon resolution



Understanding and documenting

I went through Doug's code with help from him and Nicolas

⇒ SuperB Wiki - Simulation of the SuperB Focusing DIRC

SinglePhoton root file branches [edit]

Here is a complete list of the branches contained in the root files `root_files/{YourDirectoryName}/SinglePhoton_{BarNumber}.root`. Some of them do not make sense when, like here, the primary particle is a photon (for example the Cherenkov angle).

Two different *reference frames* are being used:

- *Global*: origin in the C.L. (836.5 cm) below upper barbox, z opposite to FBLOCK, y upwards and x towards bar #1 (of the upper barbox).
- *Bar*: same as *Global* but z is shifted to the end of the entrance of the exit of the bar.
- *PMs*: origin in the centre of the PMs plane, x flipped w.r.t *Global*, y lying perpendicularly in the PMs plane, z pointing out of fblock.

Branches:

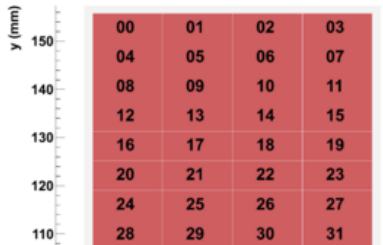
- Event:
  - `Event` = event #
  - `CPUTime` = User time for this event [s]
- Primary particle:
  - `primType` = type of primary particle (PDG code)
  - `primMom` = energy of primary particle [MeV]
  - `primPos{X,Y,Z}`, `primDir{X,Y,Z}` = $\mathbf{x}, \mathbf{p}/p$ in *Global* r.f.
- Particle while hitting the first bar surface
  - `primPosQuartz{X,Y,Z}`, `primDirQuartz{X,Y,Z}` = $\mathbf{x}, \mathbf{p}/p$ in *Global* r.f.
  - `primTimeQuartz` = time elapsed from generation [ns]
  - `primEnteredQuartz` = true if primary particle entered quartz

Testing a Photon Dictionary [edit]

The class "LookAtDictionary" can be used for basic tests (to check whether the dictionnary is empty, to access its information, etc.). In addition, it shows some examples of data accessing and processing. For instance:

```
.x LoadSinglePhoton.C  // Just load other libraries
.L LookAtDictionary.C+
LookAtDictionary blat(<dir>) // <dir> is where the dictionary is located, relative to ../root_files/
blat.Time()->Draw()
blat.Graph_kX_kY(int iBar, int iPixel, int nGamMin = 0, double timeMax = 9999.)
```

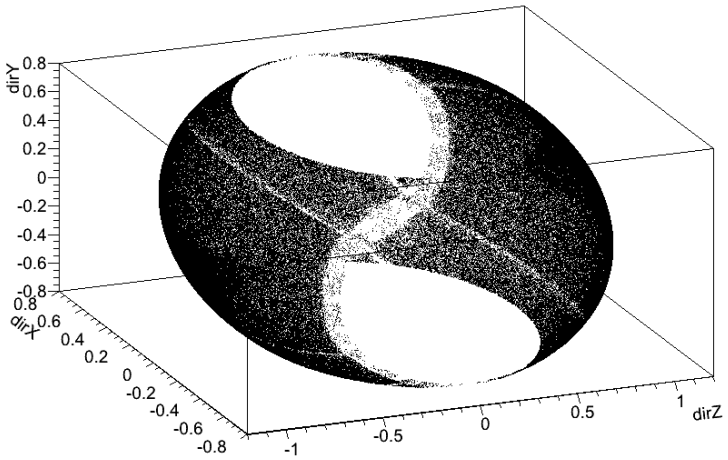
where `ibar`=[1:12], and iPixel=(nTube-1)*32+nPixel. The numbering of tubes and pixels are reported in the following pictures:



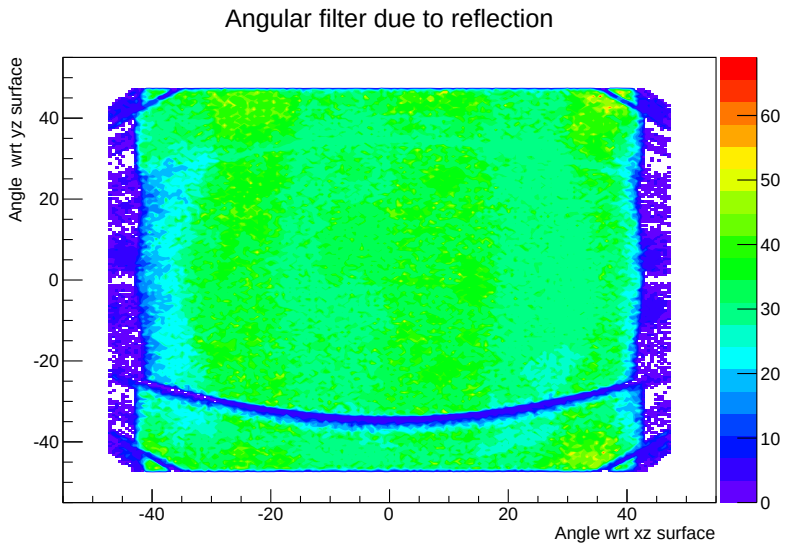
Single photon gun - Geometrical studies

- Snell's law: $\theta > 47\,\mathrm{deg}$ for $\lambda = 410$ nm
- $\sim 70\%$ absorbed in the bar

photon direction acceptance
$\{k_x, k_y, k_z\}$



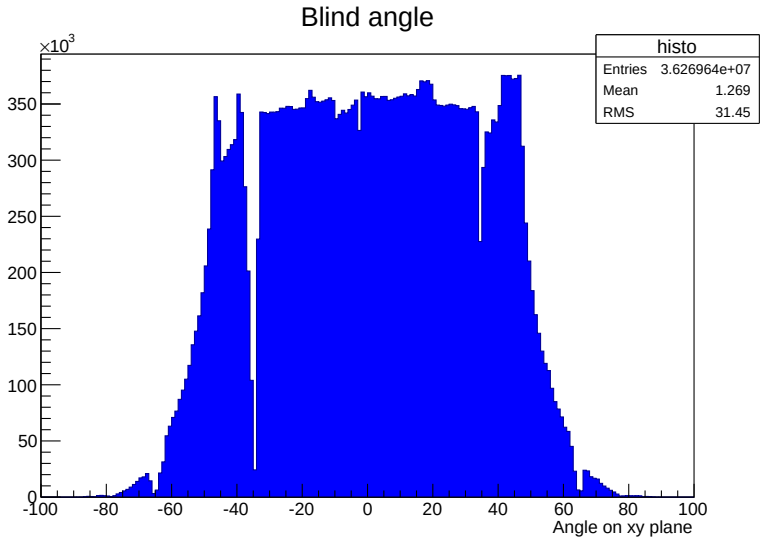
Sharp cut on reflection angle

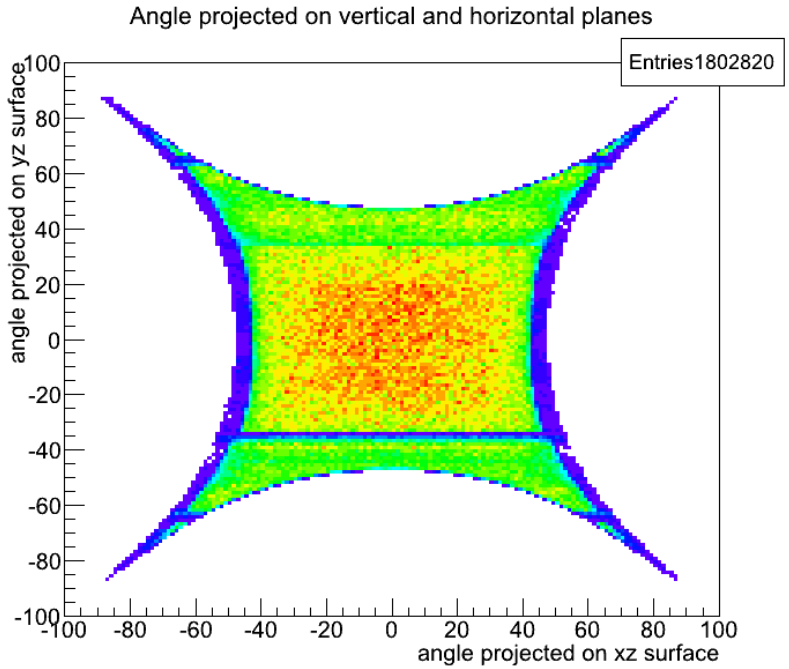


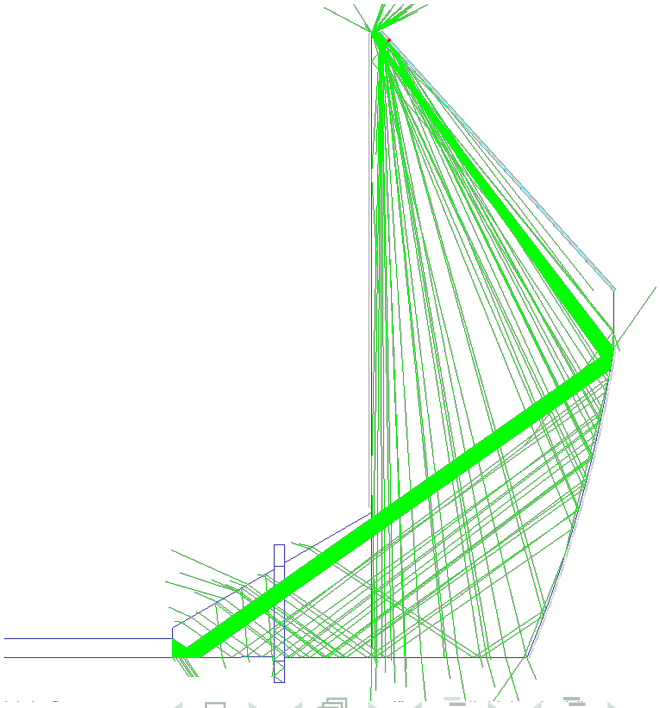
Single photon gun - Geometrical studies

Found little blind angle

- $35\,\mathrm{deg} \Rightarrow$ missing focal plane
- solution could be a longer wedge (Jerry)
- actually missing just 2%





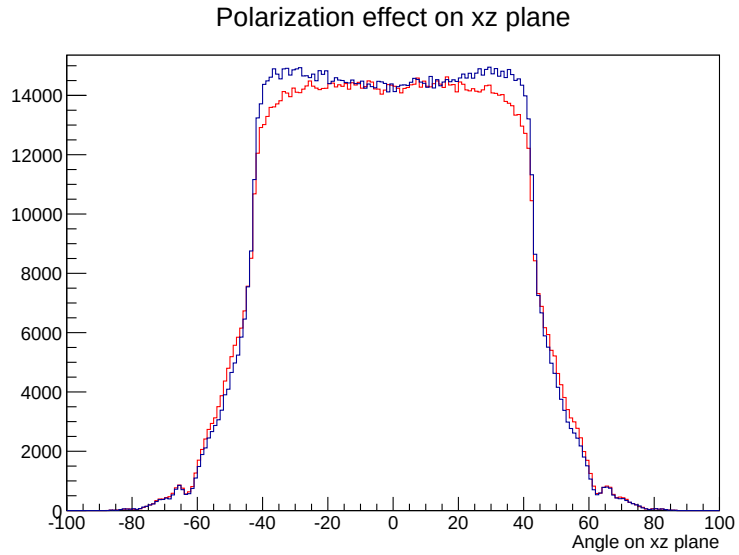


Single photon gun - Geometrical studies

Randomization of polarization

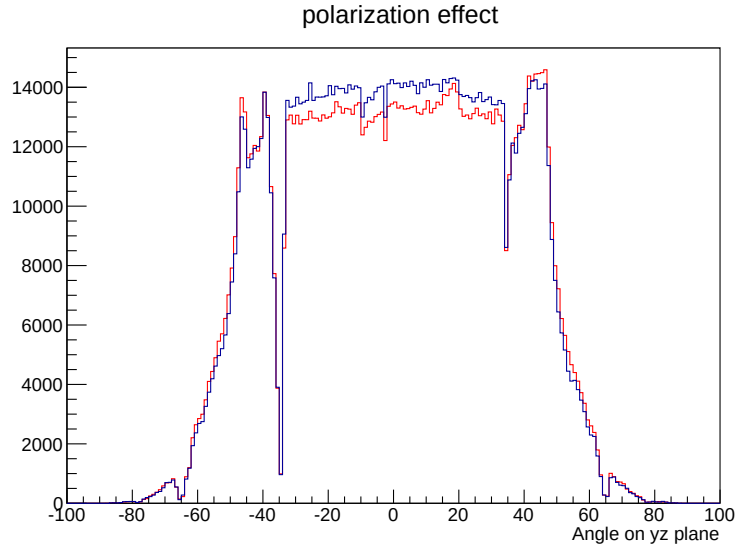
- Polarization can affect reflection probability
- Actually Brewster angle cut by Snell's law $\Rightarrow$ very small effect
- anyway I randomized polarization direction (but still linear)

Polarization randomization effect



blue: not randomized

red: randomized



Photon dictionaries - Clusterization

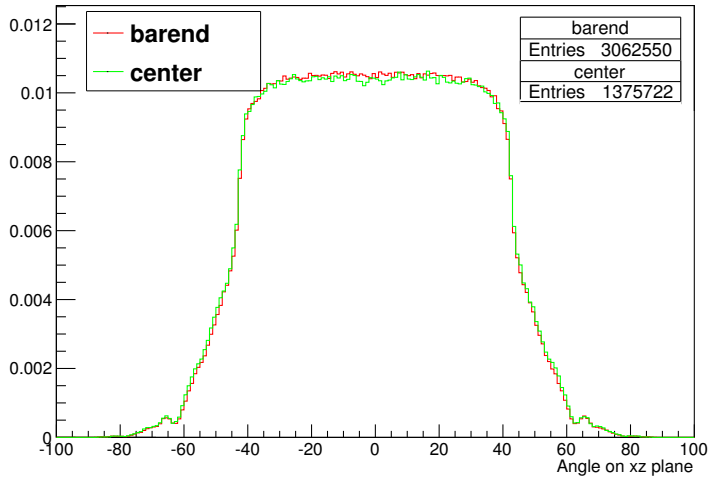
Nearest neighbours clustering (Doug's)

- $(k_x, k_y, t) \rightarrow$ scales as N^3
- Biplab and me got to Doug's point
- 9.5 hours for 5M events
- running at CCin2p3, but still slow

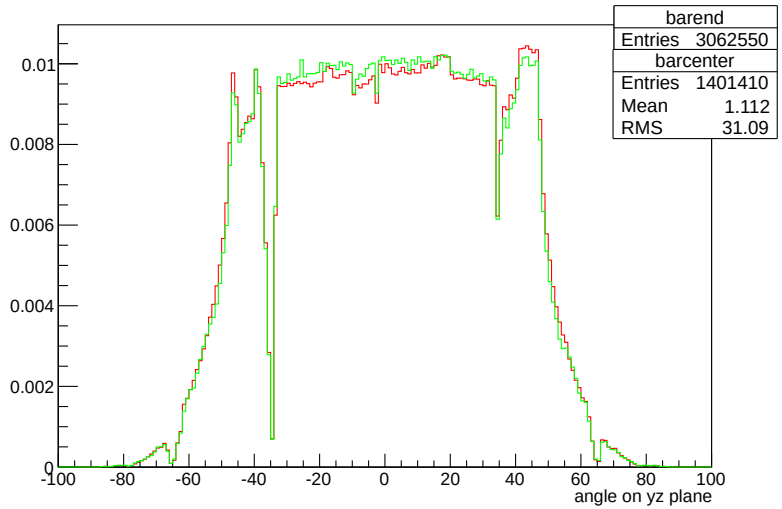
generate photons at FBlock entrance ($k_z < 0$)

- Snell's law by hand
- $n(\lambda)$ could be an issue $\rightarrow$ take smallest wavelength
- no need to disentangle k_z with time at this level

Effect of fake Snell's cut at FBlock entrance



green: bar center
red: FBlock entrance



Getting ready for the CRT test

- simulation of cosmic muons with CRT acceptance by Doug (bar 3)
- PMT positioning implemented by Biplab (to be committed soon)
- use Doug's code to compute single photon resolution
- need to account for resolution of CRT
- need to cope with CRT data format