DCH Background study using FullSim

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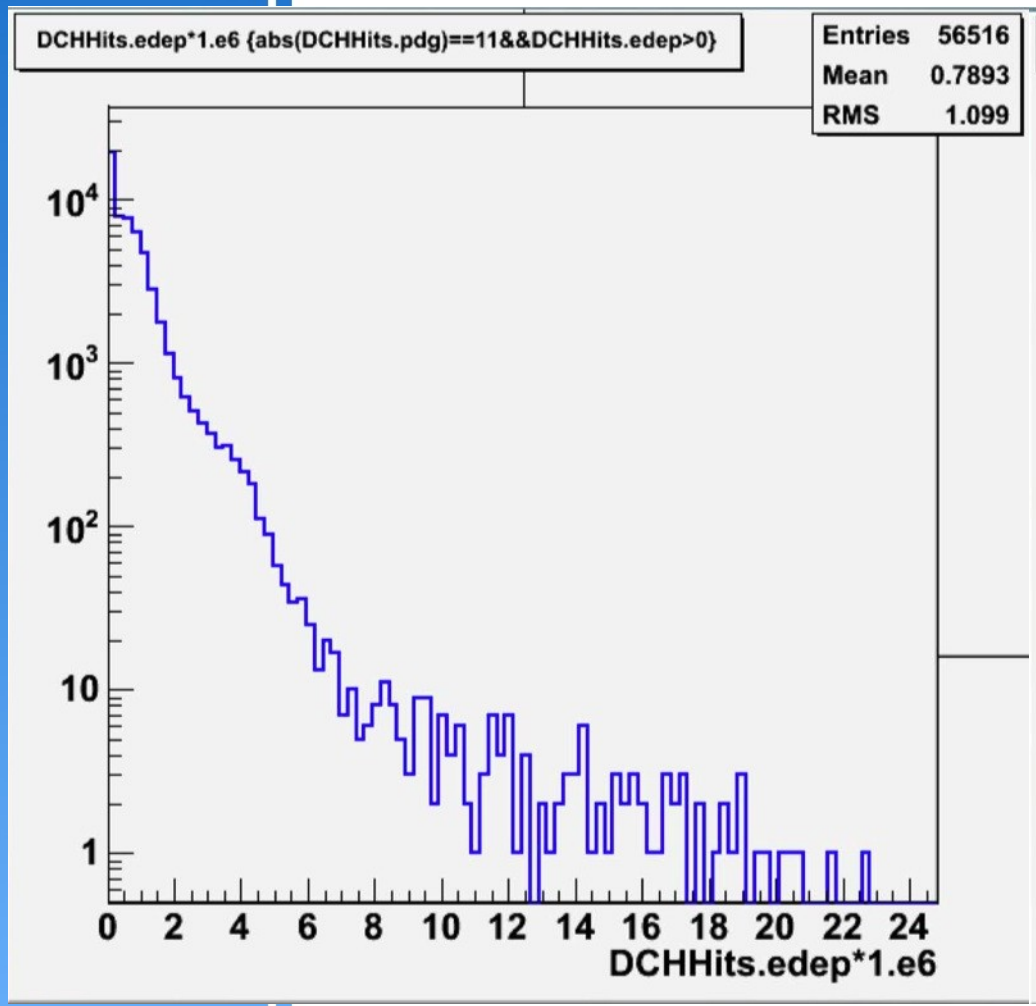
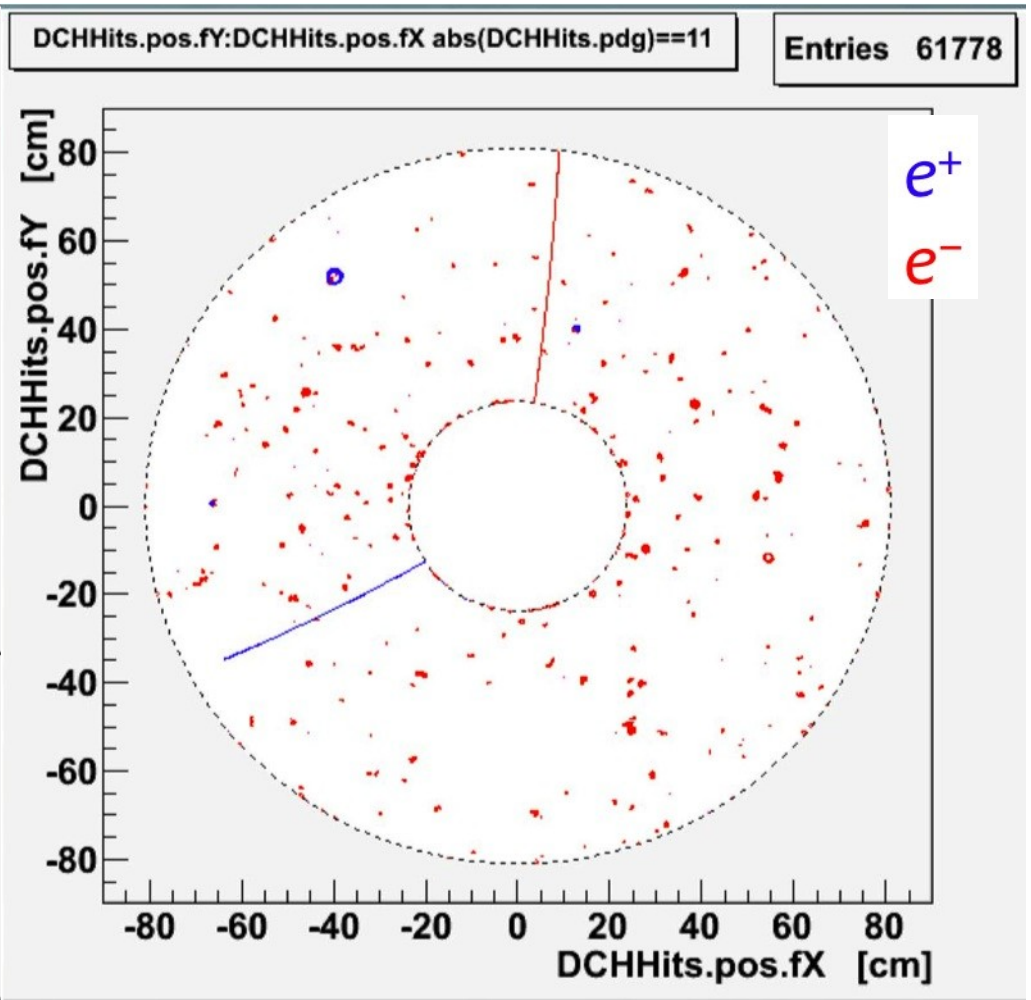
Goal for this background study

- **Occupancy** of Drift Chamber
- Parameters:
  - Chamber inner radius
  - Cells size
  - Stereo or axial superlayers
  - Different shape of endplates
  - Cell shape
- **First study** by G. Finocchiaro on 6.1us evts from Bhabha radiative (or Beam-strahlung)
- **Full study** on new data (Bhabha radiative and pairs bkg) using a systematic approach

First study by G. Finocchiaro

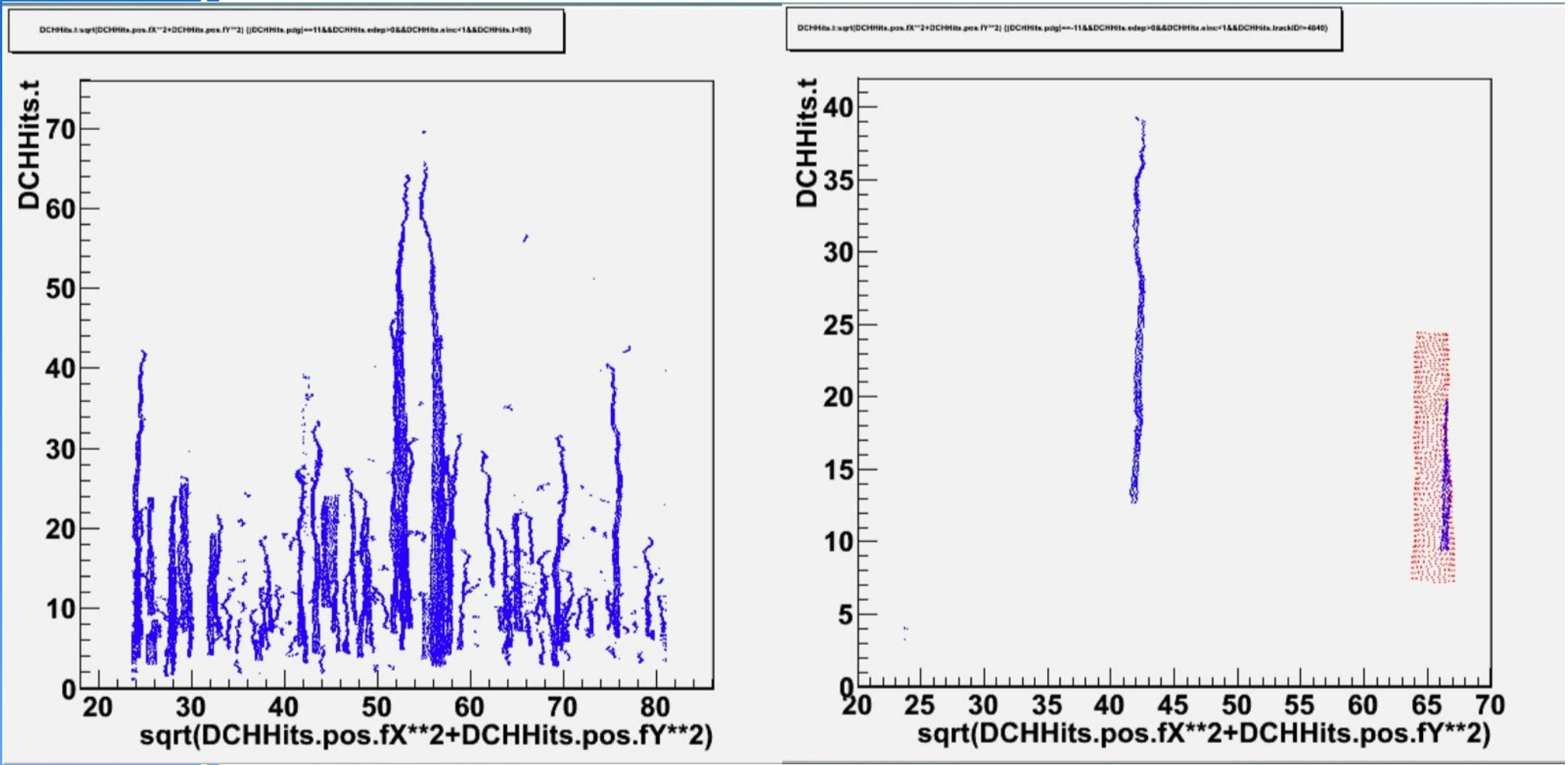
- 6.1us (1400 evts) early data, radiative Bhabha
- **Sanity checks**: energy, Y vs X





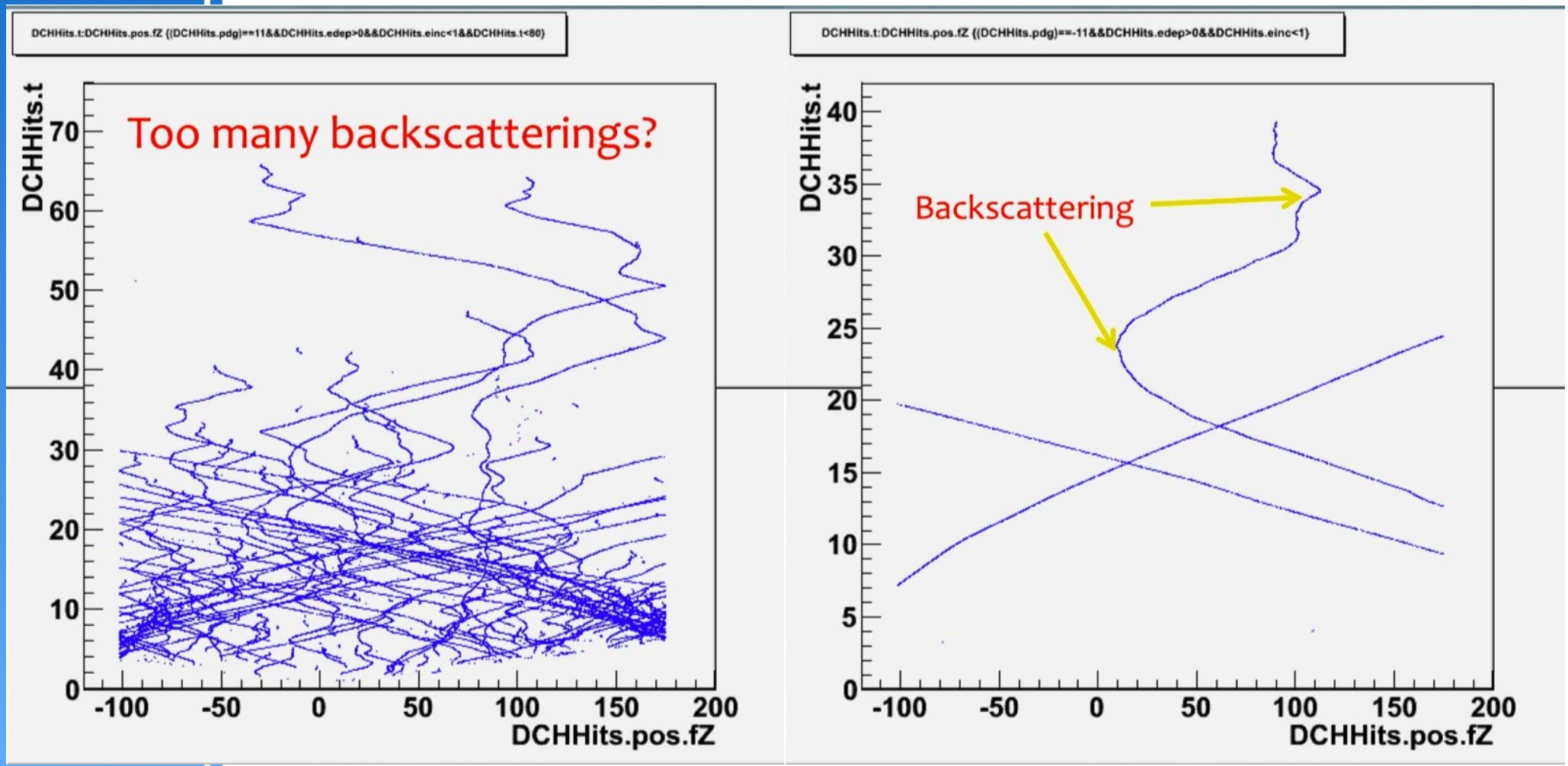
How look like the tracks? (1)

- Low momentum tracks go along spirals



How look like the tracks? (2)

- Tracks back-scattering



Back-of-the-envelope rates

- Based on how tracks look like, preliminary estimate of the rates in the DCH counting the number of spiraling e+e- tracks in the X-Y hit distribution

Hit rates

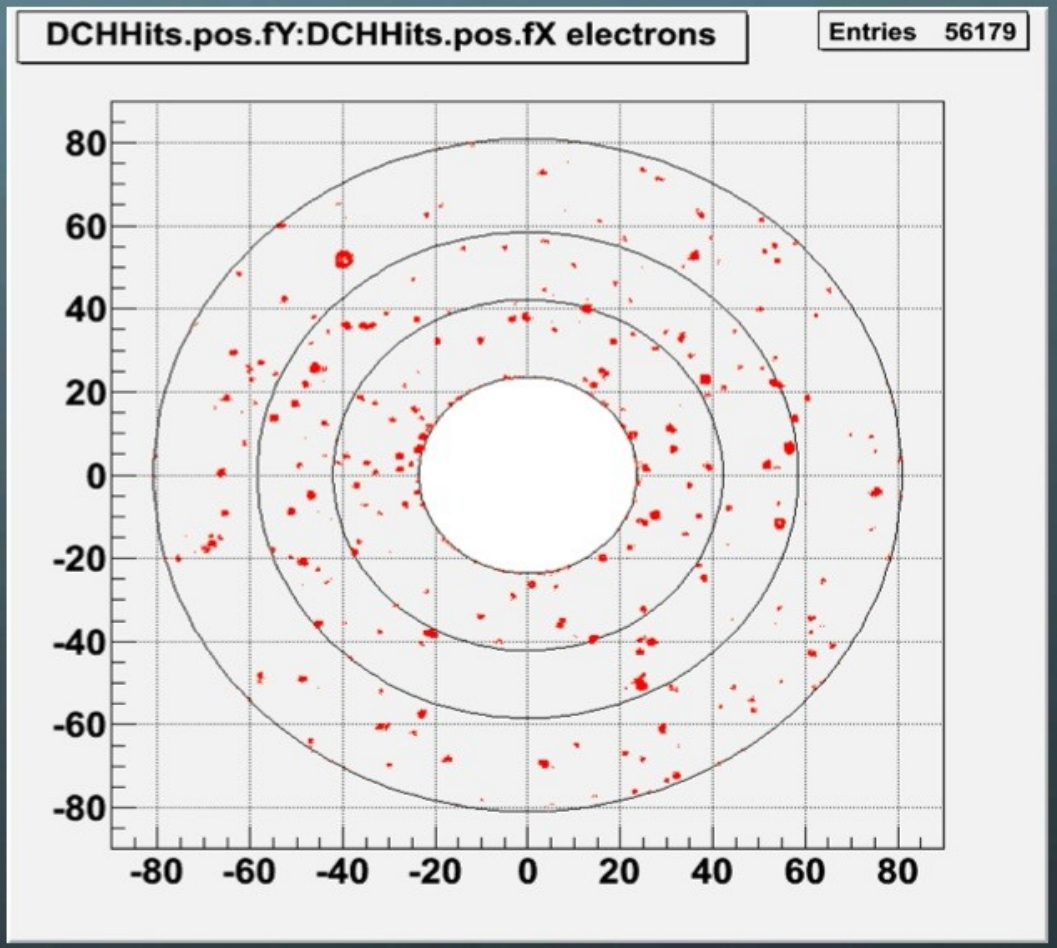
1. Assuming for simplicity that each spiral only traverses just one cell (spirals with sufficiently large PT will actually cross more than one cell), the fraction of hit cells averaged over the whole drift chamber in 1μs is

$$f_{axial} = N_{spirals}/N_{cells}/time$$

2. In this case f_{axial} = 232/7104/6.1μs = 0.54%
3. Considering the stereo angle, ranging from 45 to 80mrad, on average a spiralizing electron crosses 9.1 cells (in an all-stereo chamber) → **rate=4.9%**

Hit rates: rates vs. R

- Divide the DCH in 3 radial regions, corresponding to Superlayers (SL) 1-3, 4-6, 7-10 respectively.



- Count spirals separately in each radial region

Hit rates: rates vs. R

- Number of cells, cell widths and average stereo angles as in BABAR

SL	# of cells	Radius (mm)	Width (mm)	Angle (mrad)
1	96	260.4	17.0–19.4	0
2	112	312.4	17.5–19.5	45–50
3	128	363.4	17.8–19.6	−(52−57)
4	144	422.7	18.4–20.0	0
5	176	476.6	16.9–18.2	56–60
6	192	526.1	17.2–18.3	−(63−57)
7	208	585.4	17.7–18.8	0
8	224	636.7	17.8–18.8	65–69
9	240	688.0	18.0–18.9	−(72−76)
10	256	747.2	18.3–19.2	0

$N_{stereo} = L_{DCH}/w_{cell} * stereo\_angle$

Hit rates: rates vs. R

- N_{stereo} is calculated for an *all-stereo chamber*. Figures for n. of crossed cells are 30-50% smaller for an axial+stereo chamber
- On the other hand, see remark #1 on page 16.

SLs	f_{axial}	$\langle N_{stereo} \rangle$	f_{stereo}
1,2,3	76/1344/6.1=0.93%	2764/18.2*0.051= 7.7	0.93%*7.7 = 7.2%
4,5,6	64/2048/6.1=0.51%	2764/18.2*0.060= 9.1	0.51%*9.1 = 4.6%
7,8,9,10	92/3712/6.1=0.41%	2764/18.2*0.071=10.8	0.41%*10.8=4.4%
1-10	232/7104/6.1=0.54%	2764/18.2*0.051= 9.1	0.54% *9.1=4.9%

- Observed radial dependence apparently not very strong
  - due to averaging over 3/4 SLs (12/16 layers)]
    - e.g. ⟨rate(layer1)⟩~2x⟨rate(SL1)⟩~4x⟨rate(SL1-3)⟩
- Effect further counterbalanced by the increase of stereo angle with R

Full study: Bruno version and geometry

- **Bruno v00-01-04, r247**
  - Only Svt code has been committed
- **Geometry**:
  - Beampipe (BP) thickness: 1mm
  - SVT Layer 0 is a tube, not a pin-wheel
  - SVT L0 length 10 cm, thickness 300um, Rmin 1 cm
  - BaBar SVT
  - Gold foil outside BP: 10um
  - BP and L0 centered at z = 0
  - Cylindrical drift chamber
    - Rmin 230mm, Rmax 830mm
    - Length 2775mm, centered at z = +367mm
    - Carbon fiber structure filled by material with density averaged from gas and wires

Background events

- **Beam-strahlung (radiative Bhabha's)**
  - 1k evts
  - Processing time: 30 evts/hour
  - Generator embedded into Bruno
- **Pairs production**
  - 40k events
  - External standalone generator
  - Processing time: 10k evts/hour
  - Main known bkg for SVT
- Not a big statistics for Svt outer layers and Dch
- More events can be generated or any other bkg events, if readable by Bruno, can be used to produce easily the same plots

Clean-up, fixes and additions

- Main geom parameters to be changed written in a single file, **SuperB_constants.xml,** included in different GDML modules
- Geometrical par's can be written into the Root file as TParameter
- G4 geometry tolerance set to main volume size to avoid crashing jobs
- Geometry checked for overlapping over all the volume levels:
  - Output file @CNAF: /home/BABAR/cenci/simu_sb/Bruno/out/geomtestfull/geomtestfull_090930.log
  - Problems in SVT, many from EMC (visualization problem with HepRep), still need to go through it
- G4Step reduced to 1cm for e+ and e-: technical issue, just to have hits points along the track, don't affect physics

Bruno Hits

- Hits stored corresponds to G4Step
- Many similar classes for different subsysts, starting to write a common class and derive specific ones when needed (not yet in repo)
- **Bruno hits**
  - Starting point coordinates, time, step length, incident and released energy, particle and track ID

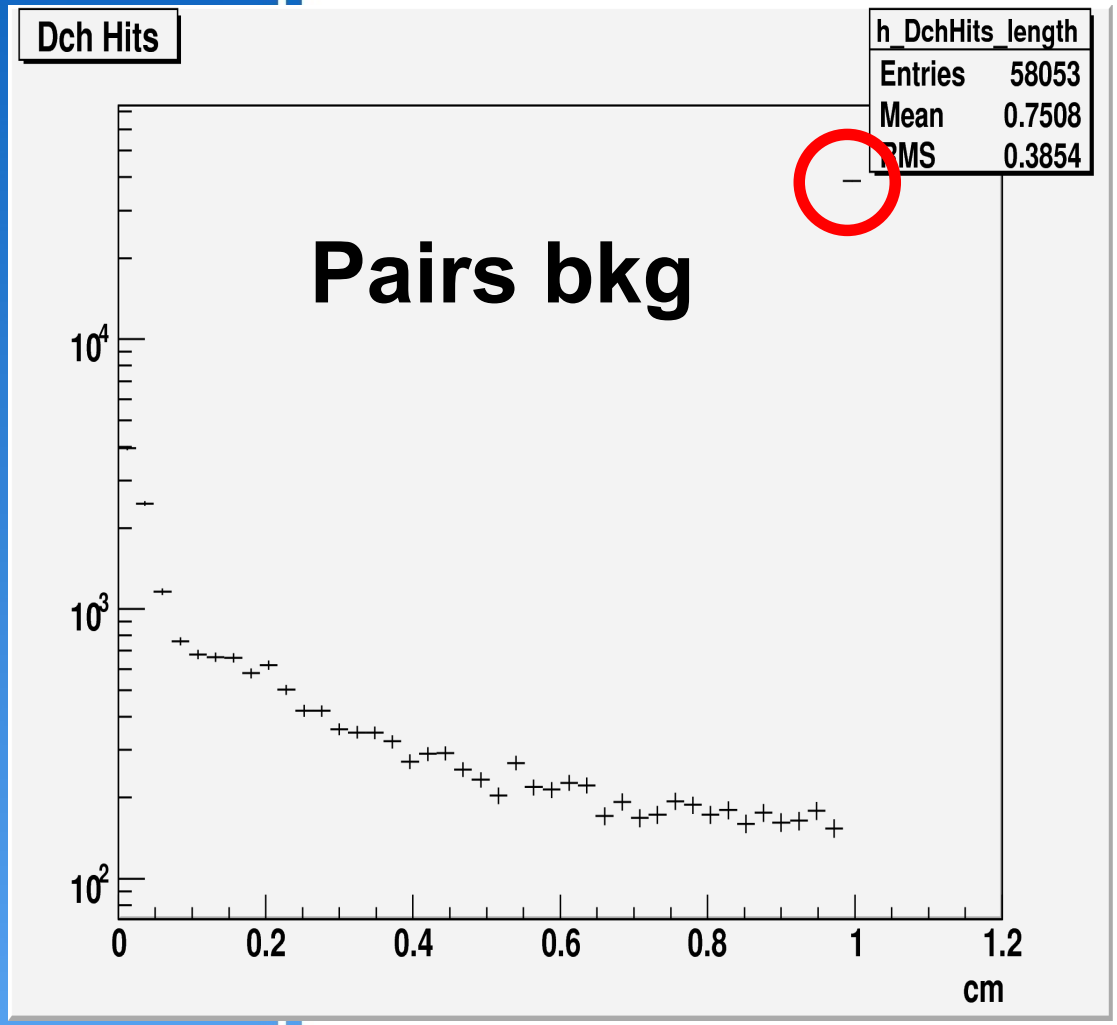
Getting the DCH occupancy... (1)

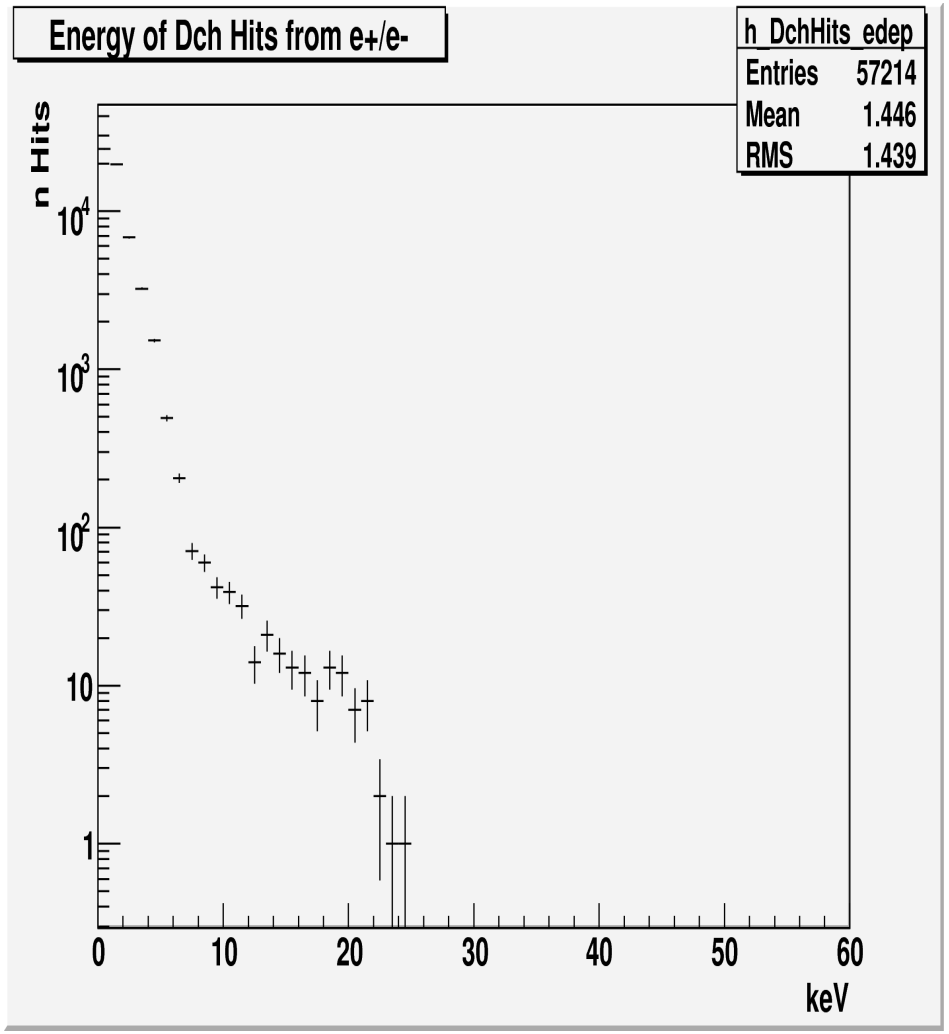
- **DCH Hits** on Root file are std Bruno hits
- A **DchRootStructure** object is build by a Root macro using superlayer objects, made by layer objects. Layers are defined only by cell size r and phi
- DchRootStructure contains the number of cells per layer and a matrix with the energy released for each cell
- Processing the root file, we match each hit with a cell and add the energy in the matrix
- One event of bkg sample is not equivalent to the Daq Dch slot (1us, is it ok?), so we collect hits from more events: 750 for pairs, 266 for bbbrem bkg (to be checked)

Getting the DCH occupancy... (2)

- **Basic Dch configuration**:
  - Inner radius: 23 cm, Outer radius: 83.5cm
  - 1.4 (r) x 1.4 (phi) cm, cell size
  - Superlayer made by 4 layers
  - 10 superlayers (spaced 0.5 cm), **9540 cells**
  - Cells are not staggered
  - Only axial layers
- Caveats:
  - Hits correspond to energy release in 1cm or less, it can be shared by two cells
  - Low statistics
  - Particles with very low energy, trajectories are small spirals through z (1 or 2 cells)

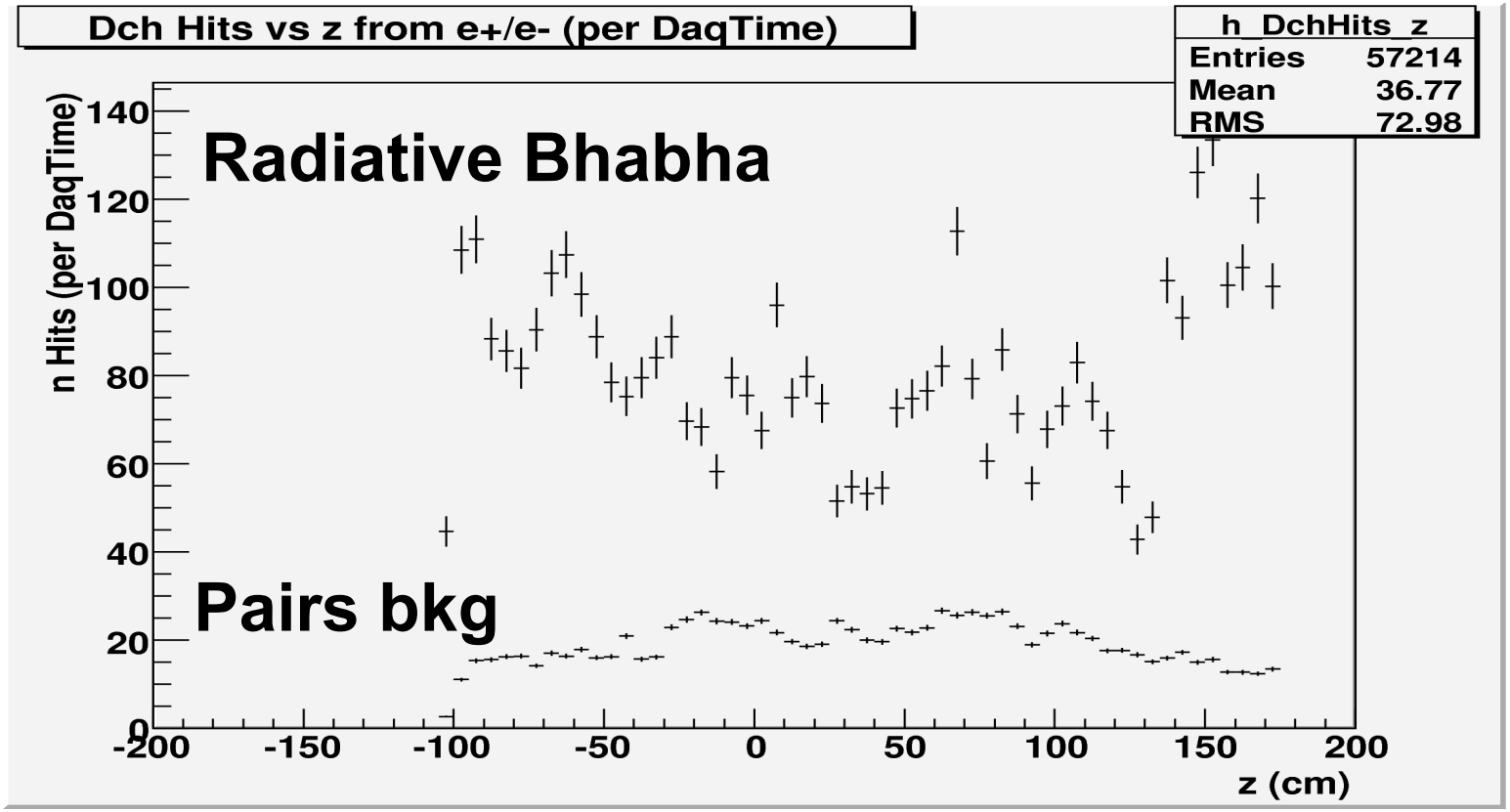
Hits sanity checks: length and energy





- Huge peak in step length at 1cm, as from Bruno setting
- Mean released energy compatible with MIP in Dch gas

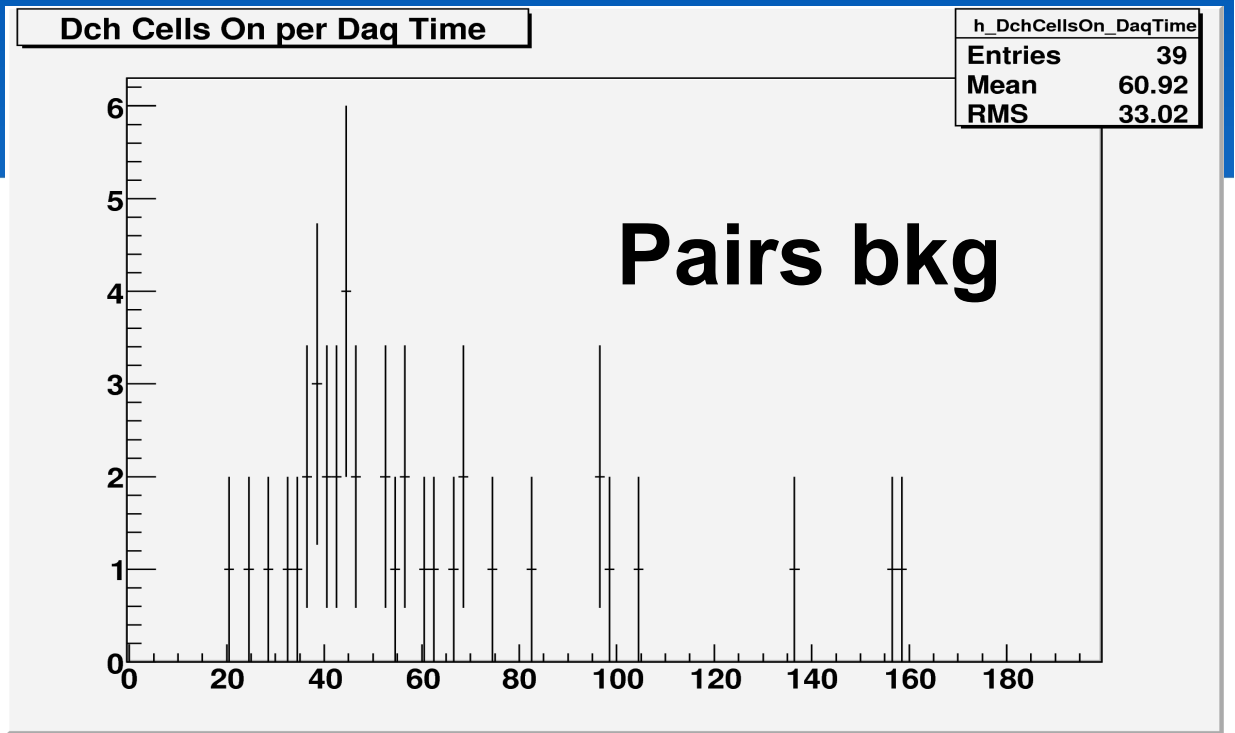
DCH Hits vs z

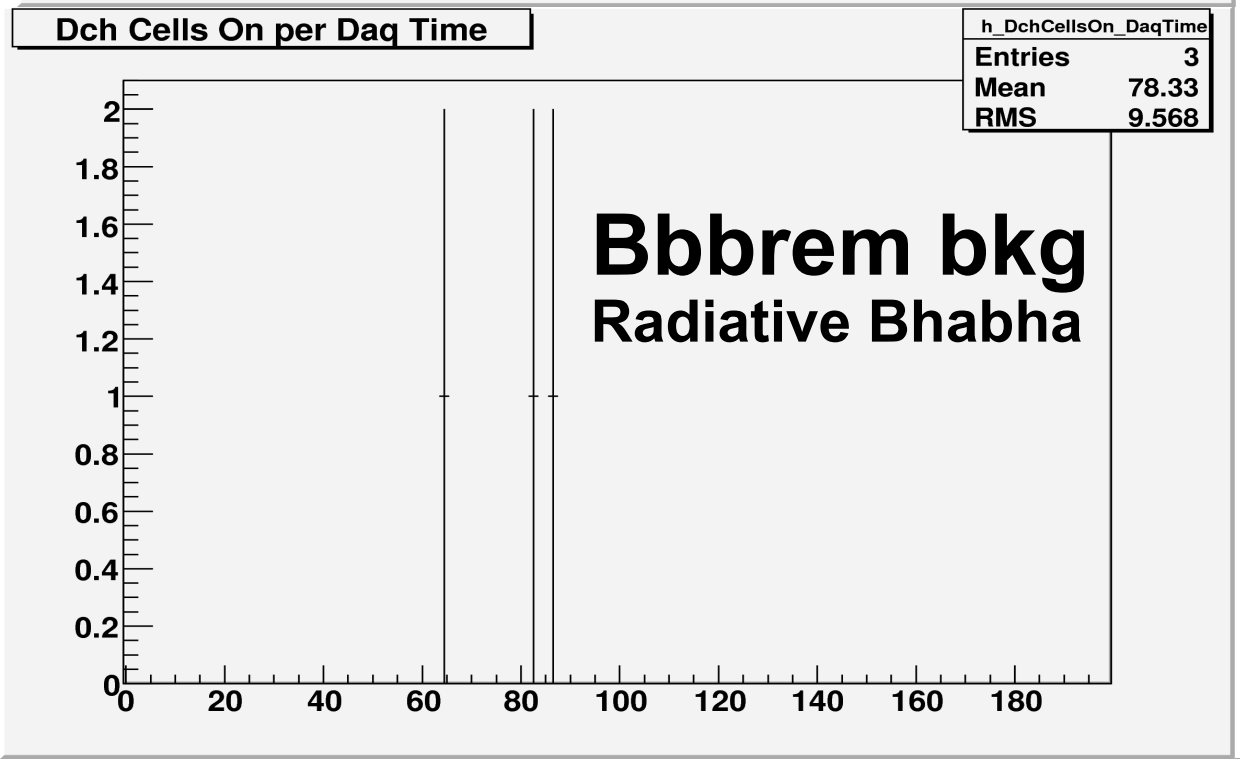


- Not weighted by released energy
- Bump on fwd direction for Radiative Bhabha, pretty flat for Pairs bkg
- Bhabha rad bkg most probably not from IP, but from upstream off-shell e+/e- that create a shower

DCH Results

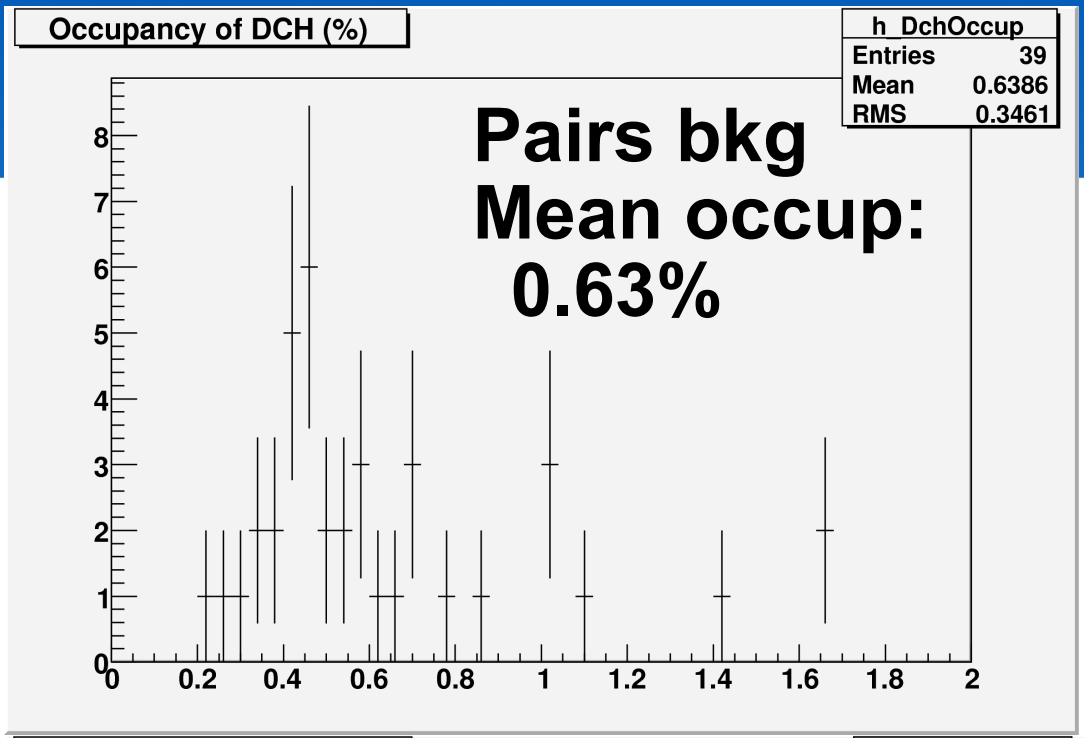
- Number of cells with energy > 0 during a Daq time slot (1us)
- No energy threshold

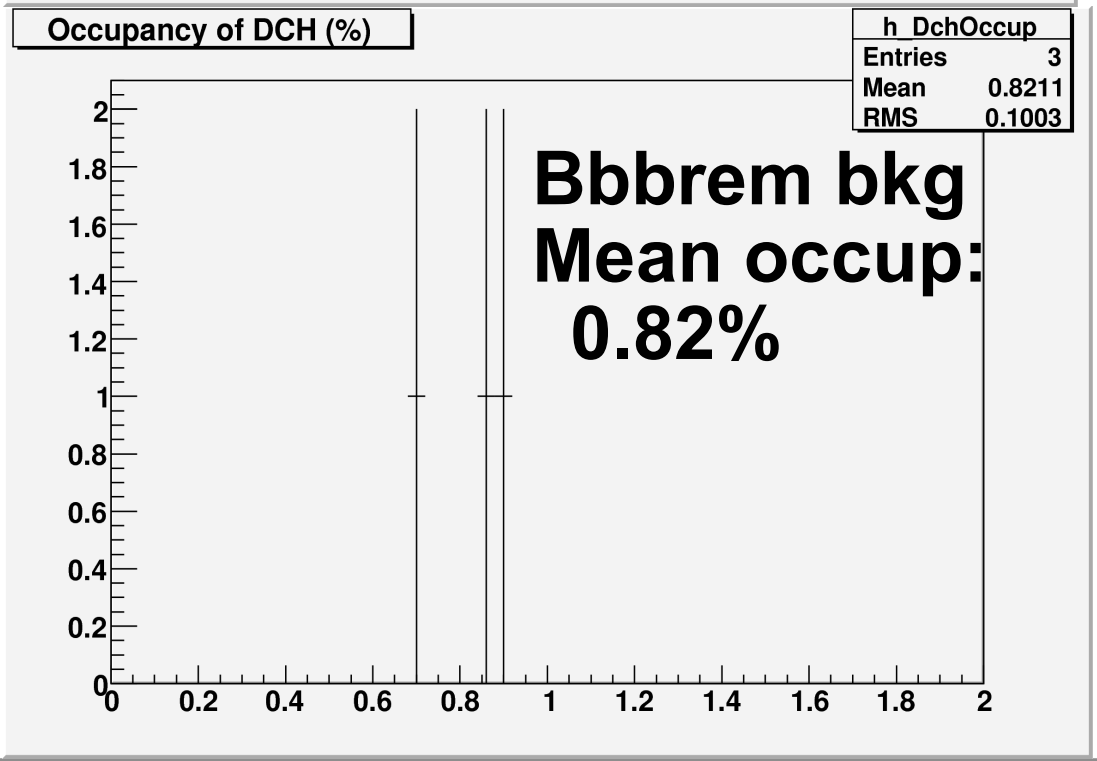




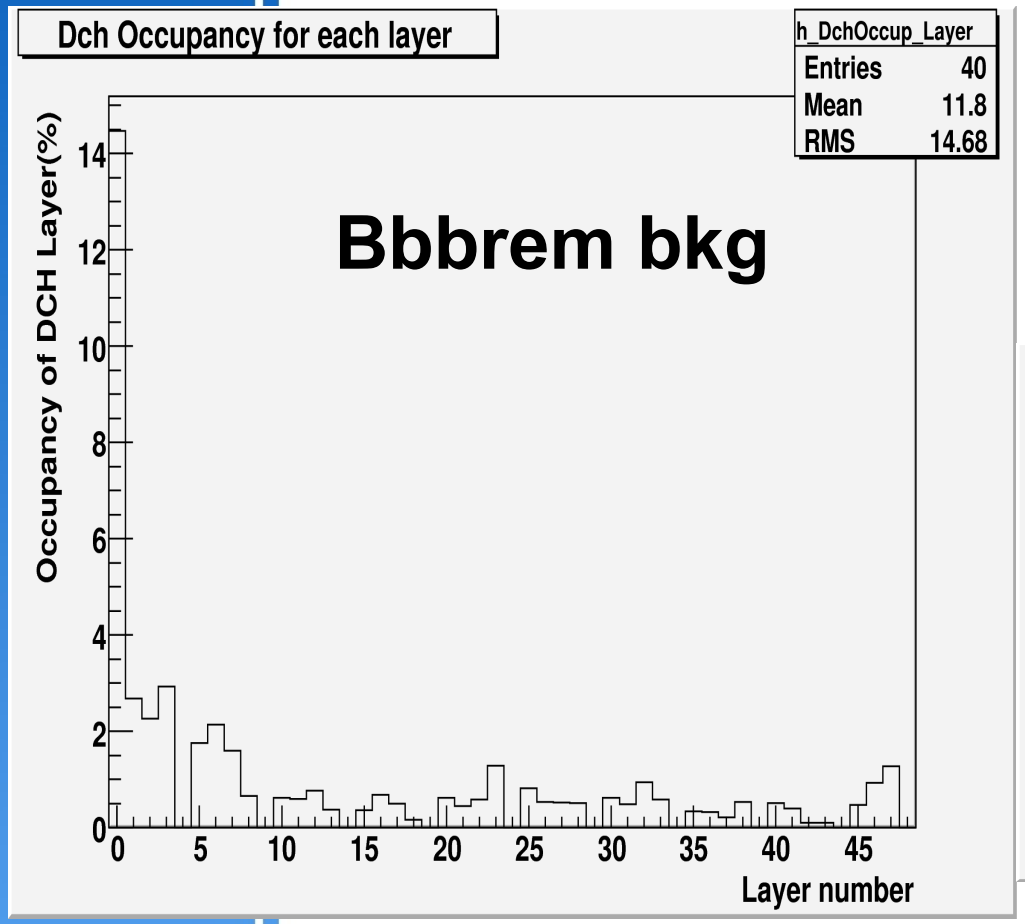
DCH Results

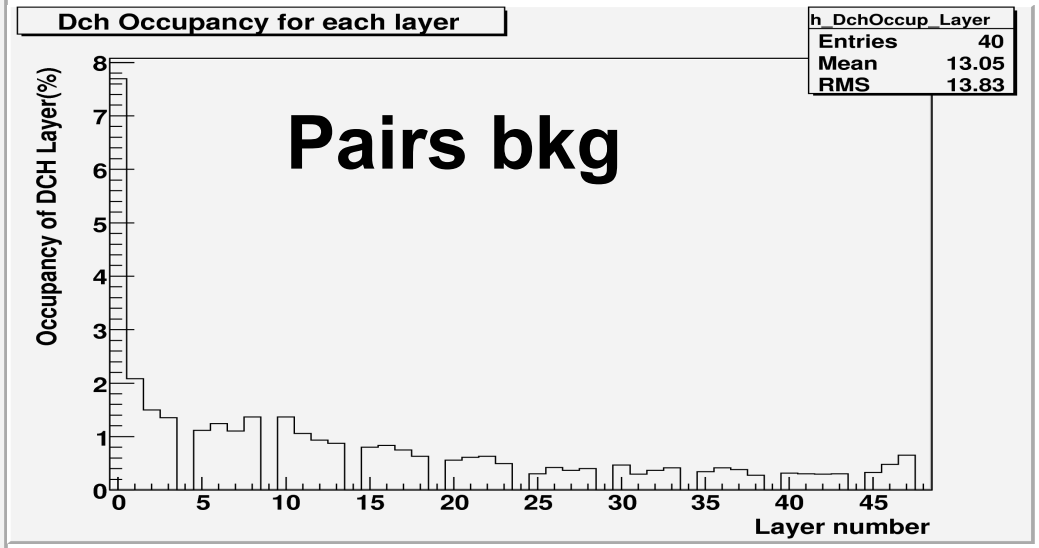
- Dividing by total number of cells...
- **Occupancy 1.5%** (found bug in the code respect to the values shown at Dch Meeting)





DCH Occupancy per layer





- Occupancy by layer, same y scale
- 22% total on layer 0, it can be shielded by guard wire
- Reasonable occupancy on other layers, correlated with radius

Conclusions

- Preliminary occupancy seems to be reasonable, but more checks are needed to understand tracks, specially back-scattering
- Tools for producing std bkg plots of occupancy, more can be added, easy to get them using different bkg types and geometrical configurations
- Some settings (pixel size, Dch structure) are available also after running FullSim
- Results:
  - Background mostly from interaction on chamber wall
  - Occupancy values seem reasonable apart from the first layer (22% total)
- Many requests from people: priority list, but they are encouraged to look into the code and get their own plots

General Todo List (not in priority order)

- DCH
  - Stereo layers
  - Cell shape + staggering (?)
  - Test other geometrical configuration (smaller inner radius, wedding cake end-plate, different tugsten shielding)
- Make a FullSim Production
- Add error bars on bkg quantities
- Other bkg sources, try to embed them into Bruno, if possible
- Clean-up the code and std naming for classes