Update on QED Pairs Bkg studies in FastSim

Nicola Neri
INFN - Sezione di Milano
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Outline

- QED Pairs Bkg in FastSim
- Open issues
- Plans

Validation tests

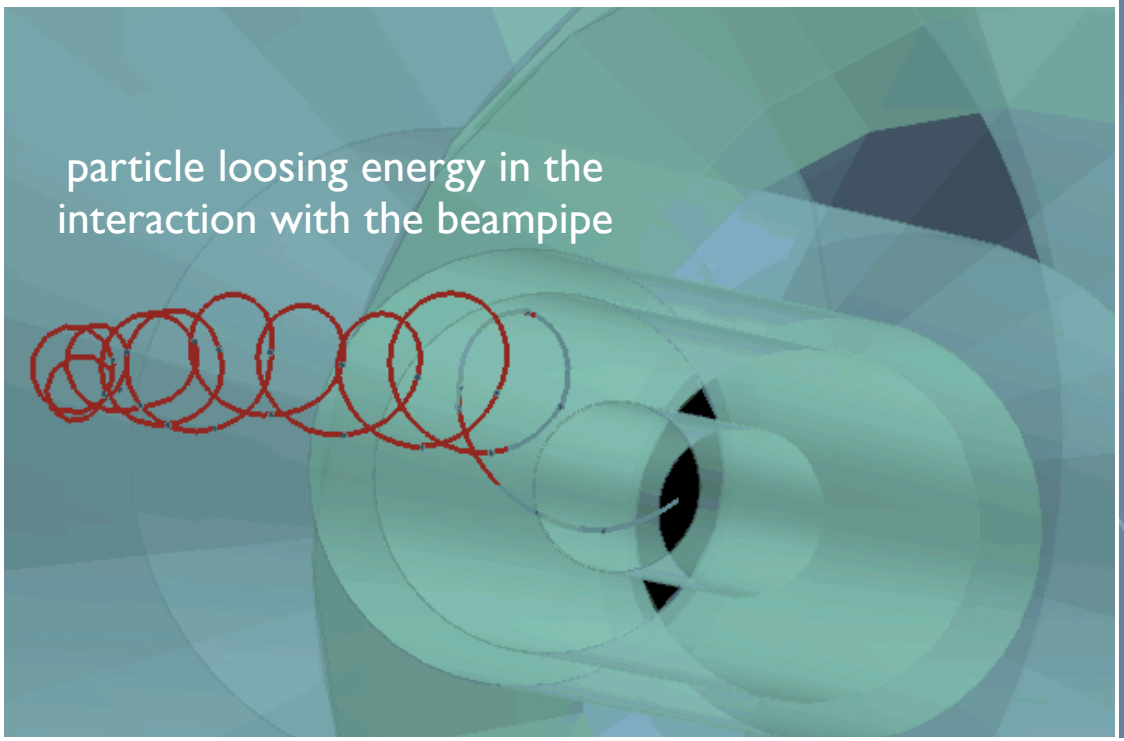
- Generate single track electron events:
  - scan in p_t and $\cos(\theta)$ for validating the number of intercepts with sensitive layers; ✓
  - use simplified geometry with silicon (and vacuum based) sensors only for debugging with and without beam pipe; ✓
  - setup/debugging of simulation parameters:
    - configuration files: PacDetector/IP_SuperB_shielded.xml does not work for this studies. Use instead PacDetector/IP_SuperB.xml at present without shielding. ✓
    - voxels definition in PacDetector/IP_SuperB.xml was not correct for this studies and had to be fixed. Voxel definition in configuration files is still under investigation.
    - change of very basic FastSim parameters that regulates simulation of particle interaction with material (min momentum for Bremms, shower and simulation). ✓

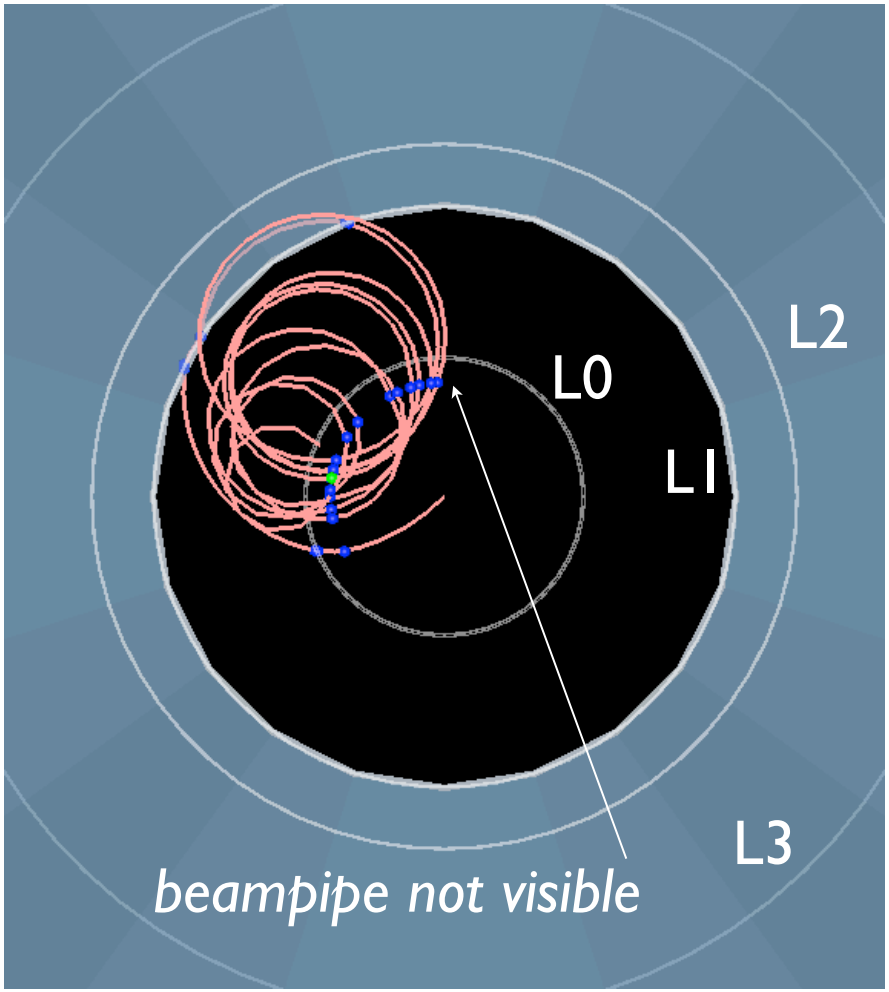
Single Track Events

Electron

p_t = 10 MeV/c

θ=45°



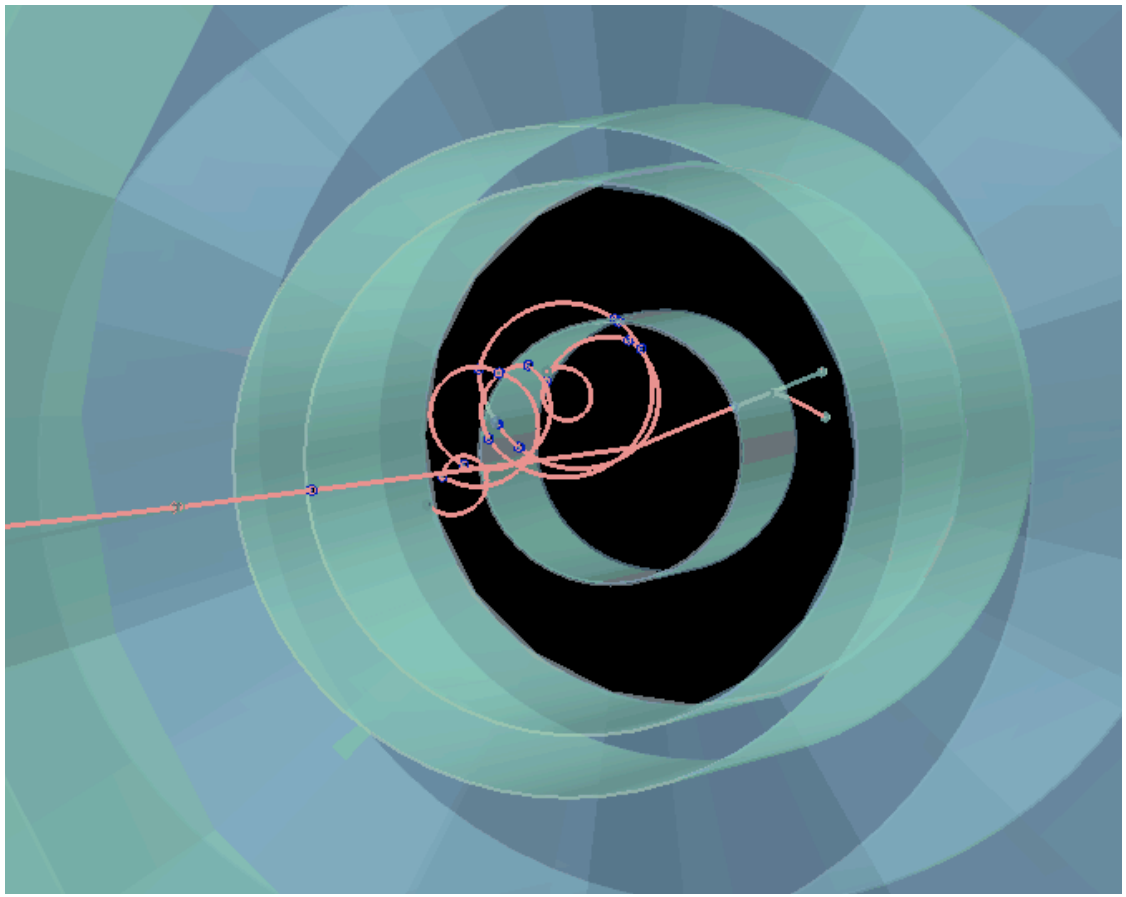


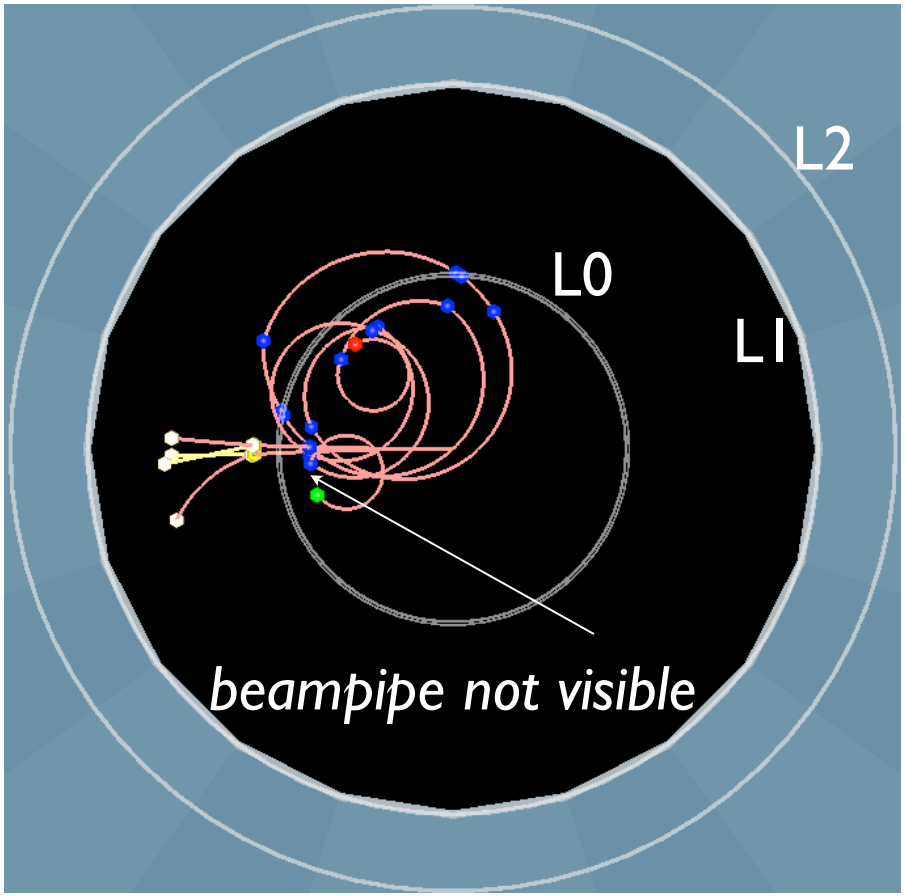
Validation test with Diag36

- Generate events of QED pairs in FastSim (not using BkgFrames and the technology to import them):
  - confirmation of track rate results of Matteo (FastSim) and Alejandro (FullSim):
    - 1.20 MHz/cm^2 at L0 radius 1.6 cm and beampipe radius 1.3 cm (L0 area 100 cm^2) ✓
  - evaluate rate of of track and clusters at each layer; ✓
  - study different configurations: ✓
    - beampipe radius = 1.0 cm, 1.3 cm
    - L0 radius = 1.4 cm, 1.6 cm
    - Beam spot position in (0, 0, 0) and in (0.2, 0, 0) cm units.

QED Pairs Event

A track has multiple intersections with L0





Pairs Bkg Rates in FastSim

Beampipe radius = 1.3 cm
L0 radius = 1.6 cm

Diag36	NEvt Gen	Pairs rate	N Evt at Layer	<# intercept>/ evt	<# trk>/evt	<#intercept> /trk	Radius	HM Length	Trk rate/ cm^2	Cluster rate/ cm^2
L0	100000	7.30E+09	1372	2.77	1.19	2.32	1.6	5.172	1.15E+00	2.67E+00
L1	100000	7.30E+09	374	3.126	1.152	2.71	3.32	10.73	7.03E-02	1.91E-01
L2	100000	7.30E+09	263	3.076	1.156	2.66	4.02	13	3.38E-02	8.99E-02
L3	100000	7.30E+09	121	2.785	1.132	2.46	5.92	19.14	7.02E-03	1.73E-02
L4	100000	7.30E+09	22	4.273	1.091	3.92	12.22	22.28	5.12E-04	2.01E-03
L5	100000	7.30E+09	16	5.062	1.062	4.77	14.22	30.91	2.25E-04	1.07E-03

Beampipe radius = 1.0 cm
L0 radius = 1.6 cm

Small change (<10%) according to FastSim in rates at L0 when changing beampipe radius from 1.3 to 1.0 cm and L0 radius = 1.6 cm

Diag36	NEvt Gen	Pairs rate	N Evt at Layer	<# intercept>/ evt	<# trk>/evt	<#intercept> /trk	Radius	HM Length	Trk rate/ cm^2	Cluster rate/ cm^2
L0	100000	7.30E+09	1495	2.73	1.18	2.32	1.6	5.172	1.23E+00	2.86E+00
L1	100000	7.30E+09	382	3.065	1.136	2.70	3.32	10.73	7.08E-02	1.91E-01
L2	100000	7.30E+09	268	2.996	1.146	2.61	4.02	13	3.41E-02	8.93E-02
L3	100000	7.30E+09	124	2.911	1.129	2.58	5.92	19.14	7.18E-03	1.85E-02
L4	100000	7.30E+09	24	2.75	1.083	2.54	12.22	22.28	5.55E-04	1.41E-03
L5	100000	7.30E+09	18	3.556	1.056	3.37	14.22	30.91	2.51E-04	8.46E-04

...with Layer0 at 1.4 cm

Beampipe radius = 1.3 cm
L0 radius = 1.4 cm

Diag36	NEvt Gen	Pairs rate	N Evt at Layer	<# intercept>/ evt	<# trk>/evt	<#intercept> /trk	Radius	HM Length	Trk rate/ cm^2	Cluster rate/ cm^2
L0	100000	7.30E+09	1627	2.855	1.215	2.35	1.4	4.55	1.80E+00	4.24E+00
L1	100000	7.30E+09	369	2.846	1.163	2.45	3.32	10.73	7.00E-02	1.71E-01
L2	100000	7.30E+09	258	2.988	1.155	2.59	4.02	13	3.31E-02	8.57E-02
L3	100000	7.30E+09	123	2.821	1.171	2.41	5.92	19.14	7.38E-03	1.78E-02
L4	100000	7.30E+09	24	3.750	1.042	3.60	12.22	22.28	5.34E-04	1.92E-03
L5	100000	7.30E+09	17	3.294	1.118	2.95	14.22	30.91	2.51E-04	7.40E-04

Beampipe radius = 1.0 cm
L0 radius = 1.4 cm

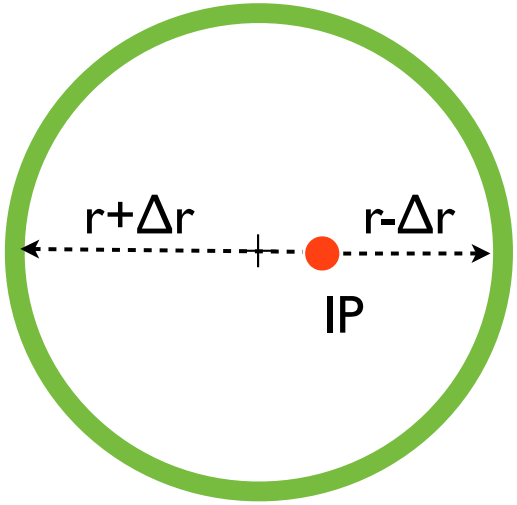
Small change (10%) according to FastSim in rates at L0 when changing beampipe radius from 1.3 to 1.0 cm and L0 radius = 1.4 cm

Diag36	NEvt Gen	Pairs rate	N Evt at Layer	<# intercept>/ evt	<# trk>/evt	<#intercept> /trk	Radius	HM Length	Trk rate MHz/cm^2	Cluster MHz/cm^2
L0	100000	7.30E+09	1869	2.772	1.194	2.32	1.4	4.55	2.04E+00	4.72E+00
L1	100000	7.30E+09	389	2.889	1.159	2.49	3.32	10.73	7.35E-02	1.83E-01
L2	100000	7.30E+09	273	2.81	1.139	2.47	4.02	13	3.46E-02	8.53E-02
L3	100000	7.30E+09	128	3.469	1.133	3.06	5.92	19.14	7.44E-03	2.28E-02
L4	100000	7.30E+09	24	4.167	1.042	4.00	12.22	22.28	5.34E-04	2.13E-03
L5	100000	7.30E+09	19	3.105	1.105	2.81	14.22	30.91	2.77E-04	7.80E-04

...with IP not in nominal position

Beampipe radius = 1.0 cm
L0 radius = 1.4 cm
IP in (0.2, 0, 0)

Diag36	NEvt Gen	Pairs rate	N Evt at Layer	<# intercept>/ evt	<# trk>/evt	<#intercept> /trk	Radius	HM Length	Trk rate/ cm^2	Cluster rate/ cm^2
L0	100000	7.30E+09	2006	2.85	1.19	2.39	1.4	4.55	2.18E+00	5.22E+00
L1	100000	7.30E+09	386	3.018	1.14	2.65	3.32	10.73	7.18E-02	1.90E-01
L2	100000	7.30E+09	262	3.328	1.149	2.90	4.02	13	3.35E-02	9.69E-02
L3	100000	7.30E+09	121	3.017	1.124	2.68	5.92	19.14	6.97E-03	1.87E-02
L4	100000	7.30E+09	23	3.739	1.043	3.58	12.22	22.28	5.12E-04	1.83E-03
L5	100000	7.30E+09	17	4.647	1.059	4.39	14.22	30.91	2.38E-04	1.04E-03



Moderate variation (+20%) according to FastSim in rates at L0 when moving the IP about 2 mm far in the XY plane from the nominal position. This is consistent with the naive expectation of null increase in case of linear approximation in a small interval Δr around r of the bkg rate vs r.
Local maximum increase of bkg rate at L0 can be estimated by reducing the radius from 1.6 cm to 1.4 cm (+60%).

- *According to FastSim studies*:
  - +10% variation in cluster rates at L0 when changing the beampipe radius from 1.3 to 1.0 cm;
  - reduction of a factor 0.6 in cluster and track rates when changing the L0 radius from 1.4 to 1.6 cm;
  - +20% variation in cluster rates at L0 when moving the IP 2 mm far in the XY plane from the nominal position;
- *Validation with FullSim:*
  - caveats: geometry in FullSim is different from FastSim, material budget is also different;
  - would be useful to perform a validation with FullSim with identical geometry as in FastSim;

Comparison with FullSim

FastSim
Beampipe radius = 1.0 cm
L0 radius = 1.4 cm

Diag36	N Evt at Layer	Trk rate MHz/cm^2	Error MHz/cm^2	Cluster MHz/cm^2	Error MHz/cm^2
L0	1869	2.04E+00	4.66E-02	4.72E+00	1.08E-01
L1	389	7.35E-02	3.72E-03	1.83E-01	9.27E-03
L2	273	3.46E-02	2.09E-03	8.53E-02	5.15E-03
L3	128	7.44E-03	6.57E-04	2.28E-02	2.01E-03
L4	24	5.34E-04	1.09E-04	2.13E-03	4.36E-04
L5	19	2.77E-04	6.37E-05	7.80E-04	1.79E-04

Few events in L4, L5 large statistical uncertainties.

FullSim Rate
Carlo Stella
July 2011

	Cluster MHz/cm^2
L0	4.52E+00
L1	2.00E-01
L2	9.00E-02
L3	2.25E-02
L4	1.70E-03
L5	1.30E-03

FullSim Rate from
Riccardo Cenci
Vienna 2012

	Track MHz/cm^2	Cluster MHz/cm^2
L0	3.20E+00	8.22E+00
L1	1.20E-01	2.70E-01
L2	7.18E-02	1.52E-01
L3	3.12E-02	5.78E-02
L4	9.79E-03	1.31E-03
L5	5.88E-03	7.65E-03

Quite good agreement with July 2011 results

Open issues

- When importing background frames in a FastSim job I experience some problems:
  - track rate on L0 and intercept multiplicity makes no sense;
  - this is at least one of the reason of the results that I showed last time;
  - this technology requires some validation before proceeding with the SVT performance studies.

Safety factor for QED Pairs

- After Vienna meeting it was proposed to reconsider the safety factor for QED Pairs:
  - Belle II does not apply a safety factor because they claim they understand this bkg very well: their simulations agree with the test on data with last run of Belle;
  - we decided to apply a safety factor based on the fact that the IP could be not in the nominal position during the running. About 1-2 mm far in the XY plane at maximum.
  - an average increase of +20% was found in the bkg rate at L0 and a maximum value of +60% in the L0 part nearest to the IP.

Plans for performance studies

- Validation of setup/technology for importing bkg frames in FastSim:
  - Alejandro will work on this issue starting Wednesday next week;
- Validation of PatRec Confusion and HitMerging will follow right after;
- Touschek bkg is important for the outer layers. This source of bkg need to be generated in FullSim:
  - here the shielding at the IP becomes important. We need to fix the xml configuration file for the IP in FastSim first.

Some considerations

- FastSim seems to have a quite detailed description of the interaction of the particles with the material even at relatively low momentum (few MeV);
- Validation of FastSim vs FullSim is very important for the robustness of the bkg studies: using same geometry and material;
- An independent analysis in FastSim would improve our understanding bkg rates and would be a valid control check.

Backup

Typical QED Pair event