Halo and Tail Generation Studies

HTGEN task, part of **W**ork**p**ackage WP6 on **I**ntegrated **L**uminosity **P**erformance **S**tudies

by H.Burkhardt / CERN + EuroTeV fellow starting September 2005

- **general study of potential sources of halo and tail generation and modelling**

See next slide and http://hbu.home.cern.ch/hbu/HTGEN.html
for a list of candidate processes. Any comments welcome :
Is the list complete ? Priorities ? Possibilities of benchmarking ?

- **here mainly : progress on generation of one particular process**

synchrotron radiation spectrum generator and its implementation

Halo & Tail. Candidate Processes

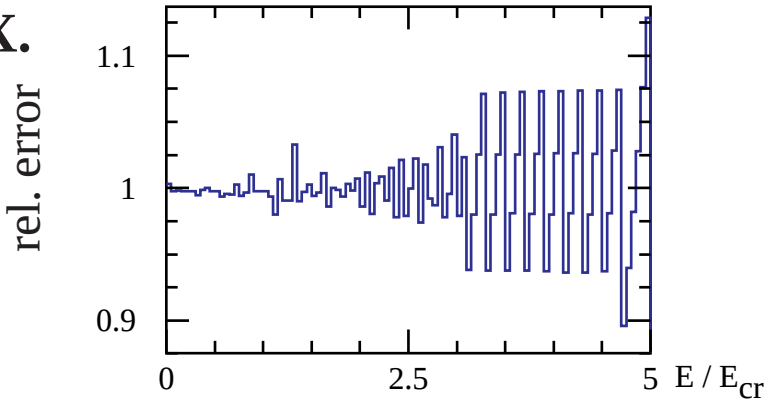
- **Particle processes**
  Beam Gas elastic scattering
  inelastic scattering, bremsstrahlung
  Ion or electron-cloud effects
  Intrabeam scattering
  Touschek scattering
  Synchrotron radiation (coherent and incoherent)
  Scattering off thermal photons

- **Optics related**
  Mismatch
  Coupling
  Dispersion
  Non-linearities

- **Various,** equipment related, collective
  Noise and vibration
  Dark currents
  Space charge effects close to source
  Wake-fields

Synchrotron radiation spectrum generator and its implementation

• implement my accurate (14 decimal digits) and rather fast SynGen
Monte Carlo Generator for Synchrotron Radiation, LEP Note 632, Dec. 1990 http://hbu.home.cern.ch/hbu/gesynrad.pdf
in further programs and in particular in **Geant4** and **Mad-X.**
Mad-X (and mad8 and dimad) still use the slower
and much less accurate (10% above 2 E_{cr})
table search based generator by Ghislain Roy



• and further improve the speed of the generator
SynGen uses internally two approximate expressions, involving x^y and exp library functions
and the hit&miss method to arrive at the accurate synchrotron radiation spectrum
which is an integral over the Bessel $K_{5/3}$, function based on Chebyshev polynomials

• idea : attempt to find the *ultimate* generator, also interesting for other 1-dim. smooth functions,
in which the generation is achieved by a single function call which directly transforms the
flat random generator spectrum into the synchrotron radiation spectrum.
Can be as fast as a standard library function like *sin* or *cos*,
or still about five times faster than my previous version.

Literature:
Y. Luke, “The special functions and their approximations” New York, NY: Academic Press
L. Devroye, Non-Uniform Random Variate Generation. Springer, 1986
W. Press, S. Teukolsky, W. Vetterling, and B. Flannery, Numerical Recipes, Cambridge University Press

the cumulative synchrotron radiation photon spectrum in units of the critical energy :

$z = E / E_{cr}$ $\quad$ SynRadInt(0) = 5π/3

$$\mathrm{SynRadInt}(z) = \int_z^\infty \int_x^\infty K_{5/3}(t)dt\,dx$$

the fraction of photons below z

$$\mathrm{SynFracInt}(z) = \frac{3}{5\pi}\int_0^z \int_x^\infty K_{5/3}(t)dt\,dx = 1 - \frac{3}{5\pi}\mathrm{SynRadInt}(z)$$

Direct inversion : fast (Chebyshev polynomial P_{Ch}) **algorithm for (SynFracInt)$^{-1}$**

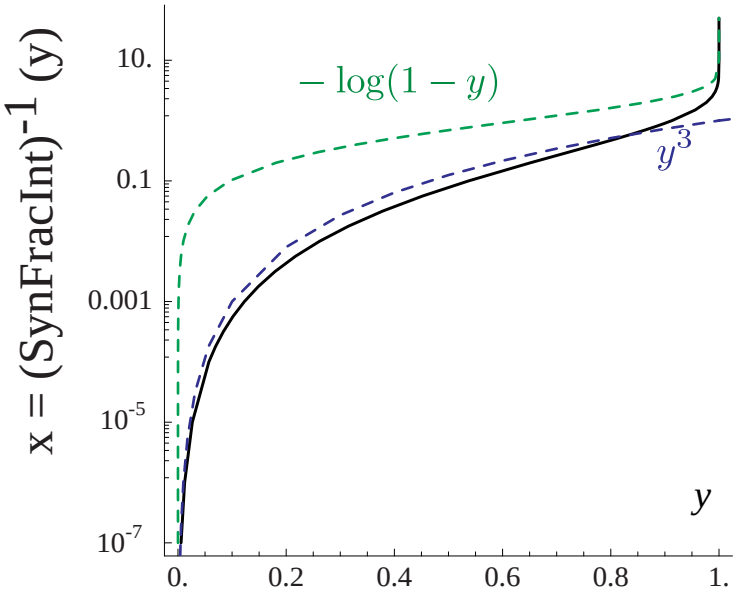
needs several intervals and suitable transformations inspired by the low and high y approximations

y="random" on (0,1)

y < .7 : y^3 P_{Ch} (y)

.7 < y < .9999 : P_{Ch} (y)

y > 0.9999 : -log(1-y) P_{Ch} (-log(1-y))



Status, Summary

- **a list of candidate processes and workplan is on the web**
  within the EuroTeV framework, any comments welcome

- **optimised synchrotron spectrum generator :**

  a Chebyshev polynomial based algorithm for direct generation
  of the synchrotron radiation photon spectrum has been found
  and tested as stand alone routine

  the next step is implementation in Geant4 as standard el.magn. process
  which includes documentation,
  also planned to implement in Mad-X