Fast Luminosity Monitoring For Super Luminous Flavor Factories

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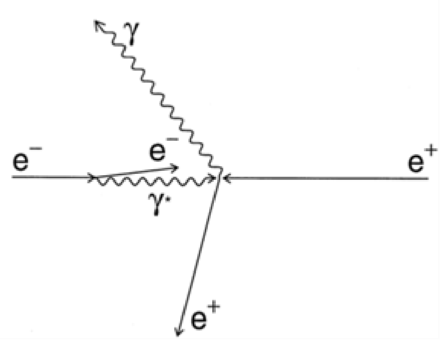
Fast Luminosity Monitoring For Super Luminous Flavor Factories

- Motivation: Fast control of the luminosity with a relative precision up to 10^{-3} in 10 to 1ms
- Based on radiative Bhabha scattering at zero photon angle measurement



- Used technology: 5x5 mm^2 diamond sensors set immediately outside the beampipe (5cm radius)

LAL group resources

Contributors:
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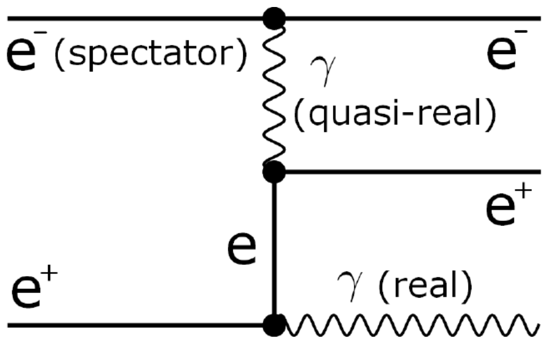
LAL electronics group (SERDI)

Past contributors in the context of SuperB:
F. Blampuy (Master student), S. Tammaro (Master student)

Budget: P2IO LABEX grant, IN2P3, France-Japan bilateral funds

Radiative Bhabha process



e^+e^- beam part. scattering via quasi-real photon exchange at quasi-zero angle. Can be understood as a compton scattering convoluted with the quasi -real photon spectrum (Equivalent Photon Approximation)

- **Main source of background**
- **Main contribution to beam life time limitation**

Y. Funakoshi (KEK)	LER beam lifetime
Touschek effect	~10 min.
Beam-Gas Coulomb scattering	~30 min.
Radiative Bhabha	~30 min.

- **Large cross section (~2mbarn) proportional to luminosity → used for luminosity measurement and control**
- Requirements: $\Delta L/L<10^{-3}$ in 10 ms

Luminosity ($cm^{-2}\,s^{-1}$)	10^{34}	10^{35}	$8\ 10^{35}$
Fraction of Bhabha to be detected for $\Delta\mathcal{L}/\mathcal{L}=10^{-3}$ in 10 ms	$5\ 10^{-2}$	$5\ 10^{-3}$	$6.3\ 10^{-4}$

Radiative Bhabha process-simulation tools

BBbrem: MC simulation for radiative Bhabha process, performed in CM.

Input: CM energy, min energy of real photon i.e. $E_{\gamma} > x\, E_{beam}$, Nb of events

Output: Cross section, 4momentum of each particle (including virtual γ)

GuineaPig ++ : Beam-beam interaction simulation tools. Beam-beam effect such as beamstrahlung and beam size effect

Input: beams spec. Asked backgrounds: Compton

min energy of virtual i.e $E_{\gamma*} > x\, E_0^2/E_{beam}$

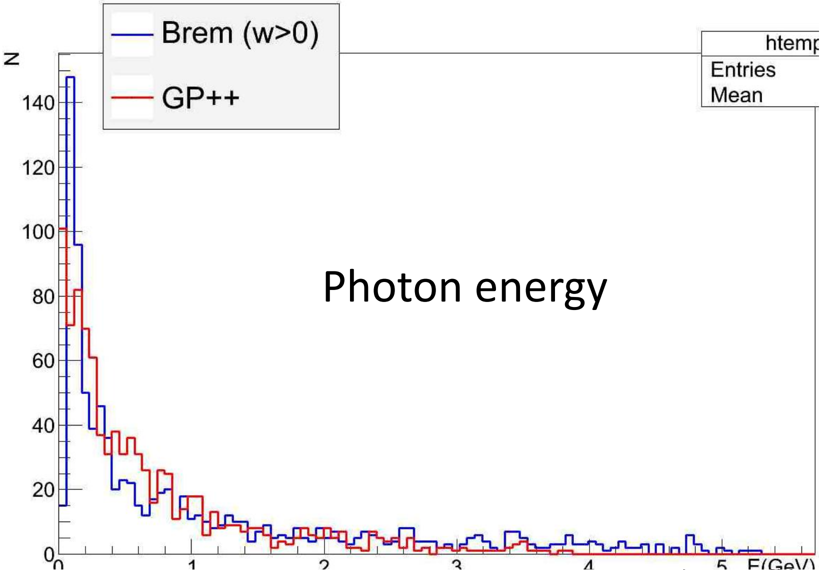
Output: Luminosity, Nb of Bhabha produced, 4momentum of final particle

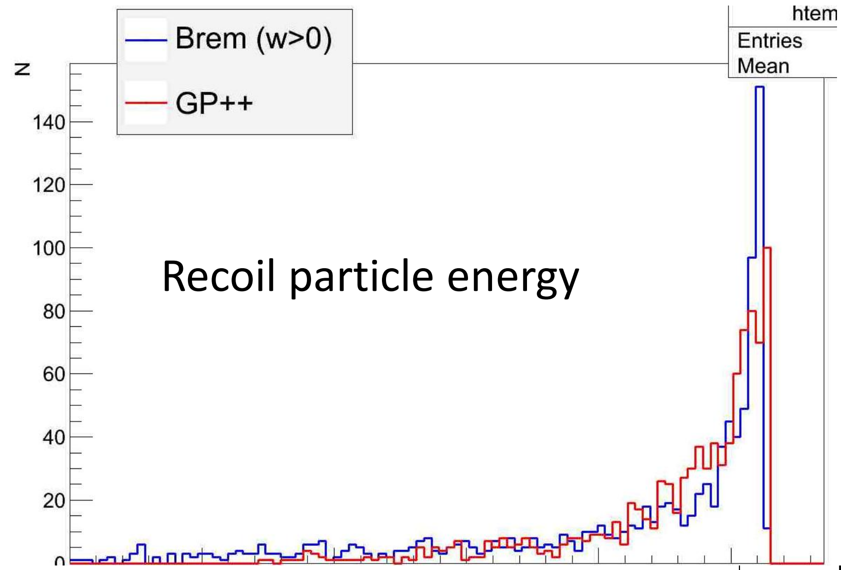
Both include Beam-size effect.

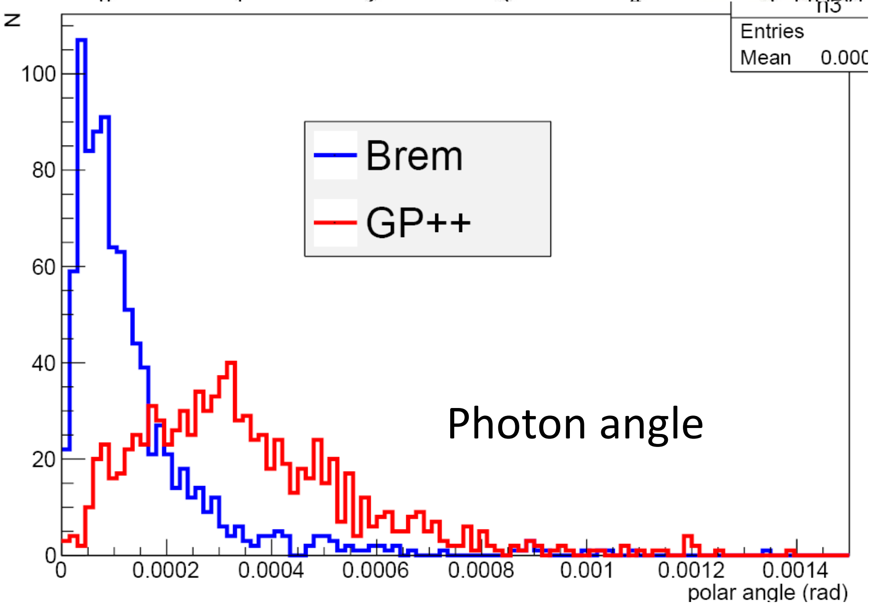
Beam-size effect	Guinea-Pig	BBBrem
with	$\sigma \sim 0.27\ barn$	$\sigma \sim 0.17\ barn$
without	$\sigma \sim 0.44\ barn$	$\sigma \sim 0.27\ barn$

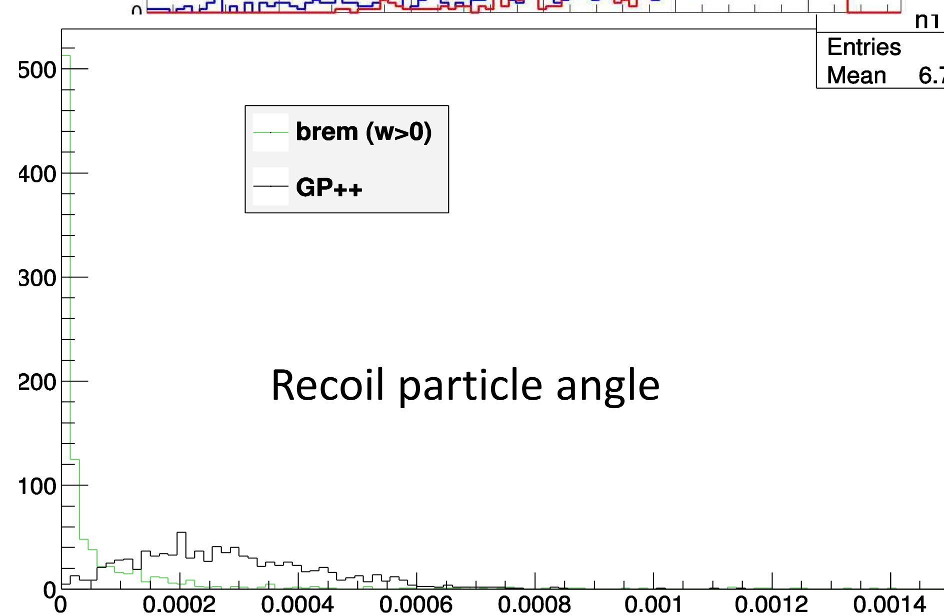
➔ Need a cross-check : RABHAT (K. Tobimatsu and Y. Shimizu)

Comparison of the energy and angular distributions



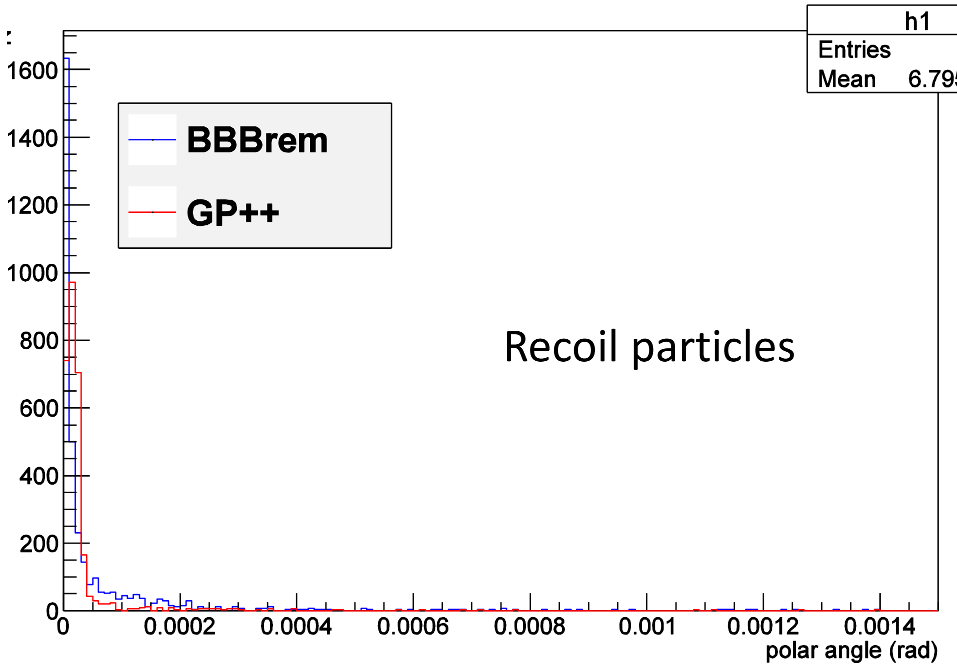


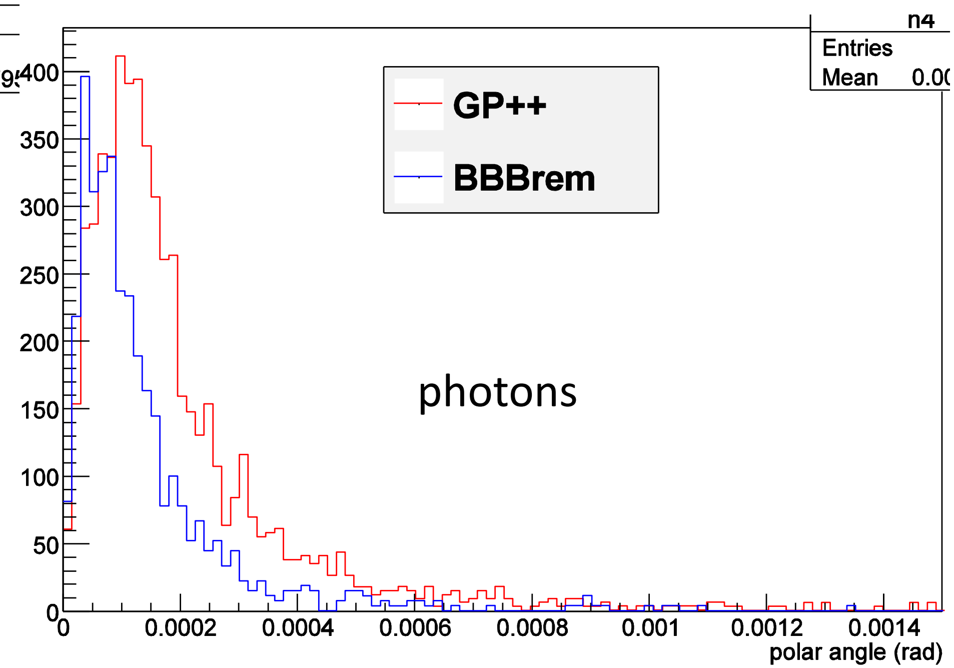


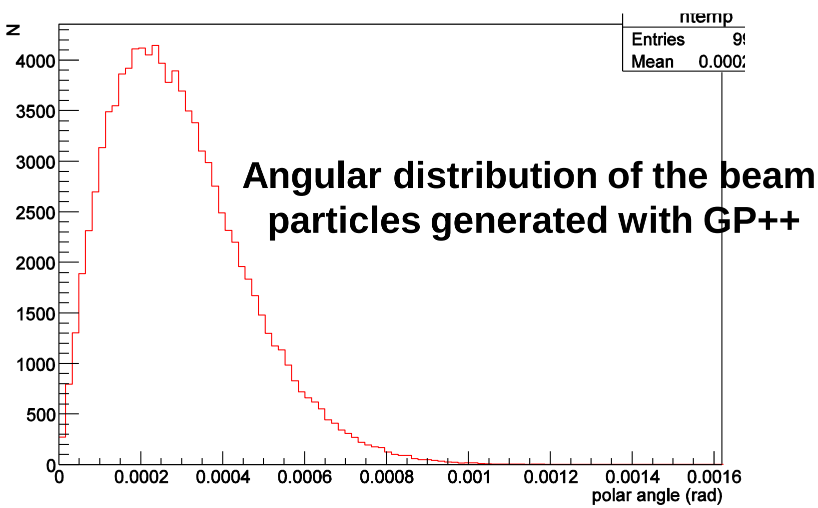


$\sigma_x^{beam} \sim 0.3$ mrad

Comparison of the angular distributions without beam angular divergence

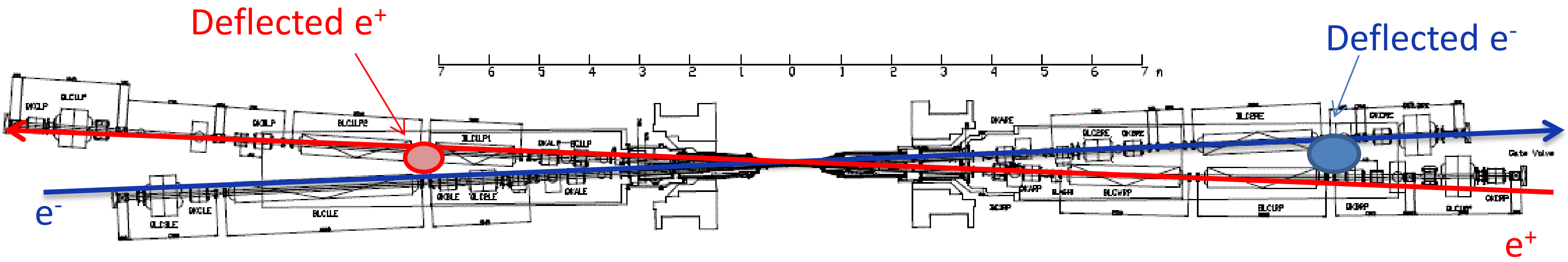




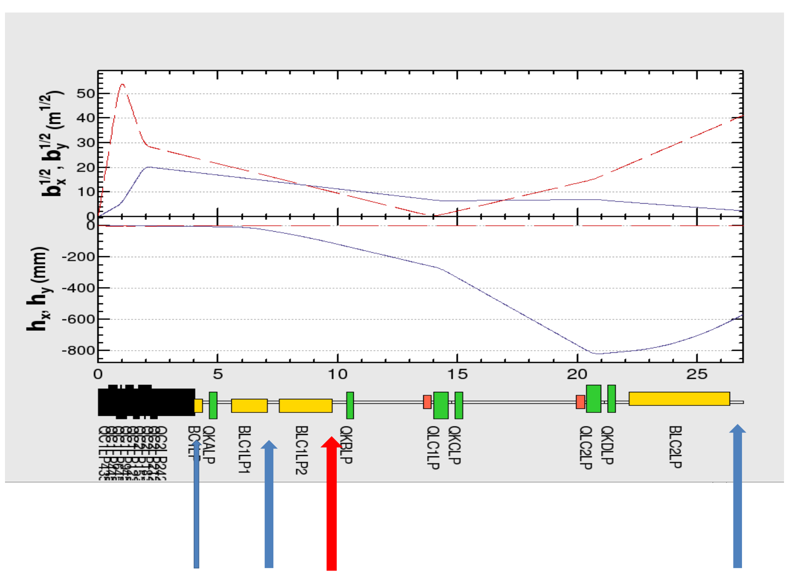


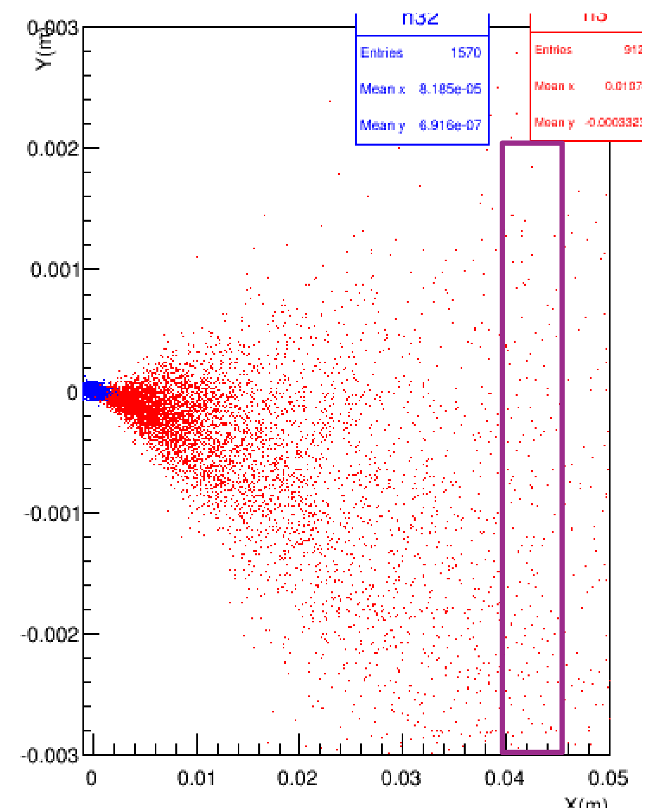
Sensor locations

Outside

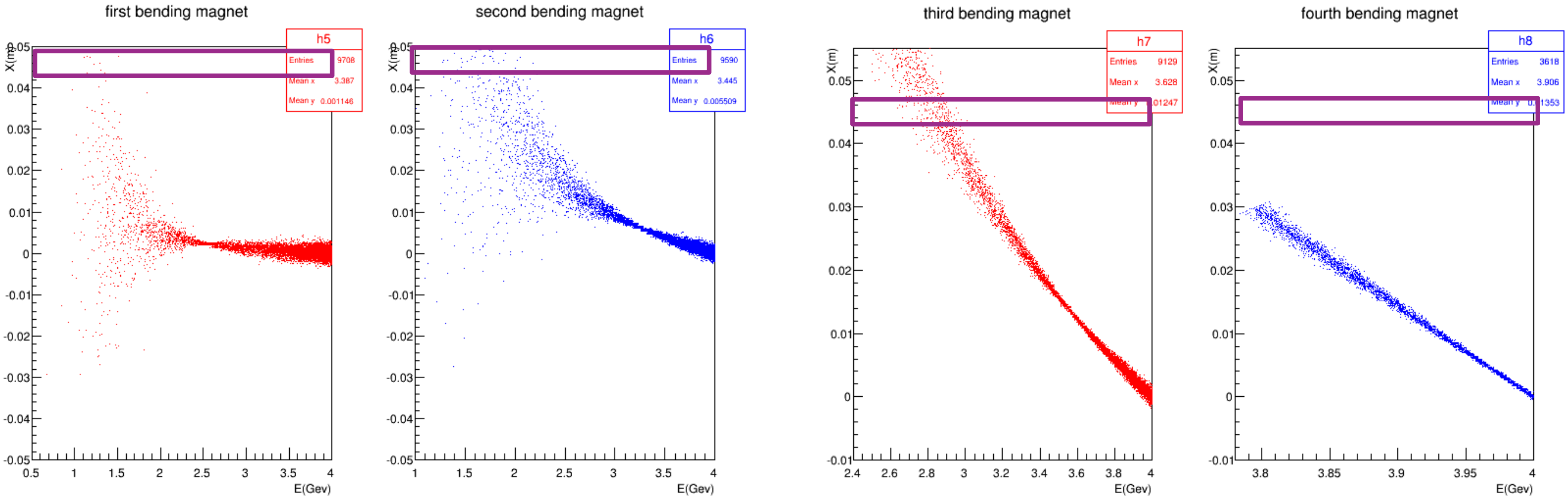


- Low energy e+/e- are deflected downstream the IP after the bends
- Study of Bhabha rates outside the beampipe after the 4 first bends each side of the IP tracking with SAD code





Positron rates in sensors

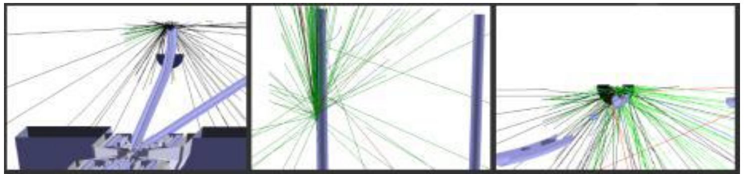


Bending magnets	Rates of the Bhabha particles in the sensors at the exit of the bending magnets	At the exit of the drift
First	$\frac{5}{10320} = 5\ 10^{-4}$	$\frac{6}{10320} = 6\ 10^{-4}$
Second	$\frac{37}{10320} = 3.6\ 10^{-3}$	$\frac{75}{10320} = 7.3\ 10^{-3}$
Third	$\frac{157}{10320} = 1.5\ 10^{-2}$	$\frac{191}{10320} = 1.8\ 10^{-2}$
Fourth	0	0

Plan of Work

Early 2015	Second half 2015	2016
First beam run w/o solenoid	Insertion of solenoid and low beta quadrupoles	Luminosity tuning towards 10^{34} cm^{-2}.s^{-1}

- ✓ Fall 2013-winter 2014:
  - Study of Bhabha signals and background estimations (Toushek...)
  - Study of secondaries interaction with beam pipe using GEANT4.
  - Investigation of optimal sensor localization and geometry regarding backgrounds
- ✓ Spring 2014-winter 2015 :
  - Design of the first prototype sensor and readout.
  - Laboratory tests (Phil @LAL...)
  - Design setup for beam test at SuperKEKB.


Showers produced by just 1 electron 3.4GeV that crosses the iron of beampipe

- ✓ 2015:
  - Installation and tests at SuperKEKB.
  - Initial background measurement.
  - Design of data acquisition for luminosity monitoring.
- ✓ 2016:
  - First data acquisition for luminosity monitoring.
  - Analysis.

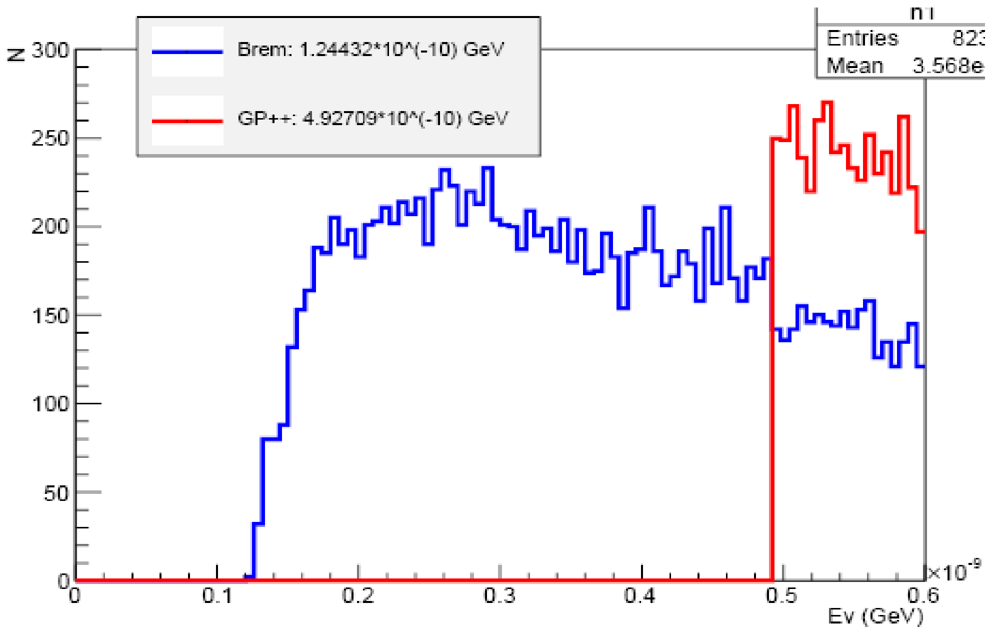
Back-up

BBbrem / GP++ energy cuts comparison (x_{min} = 1%)

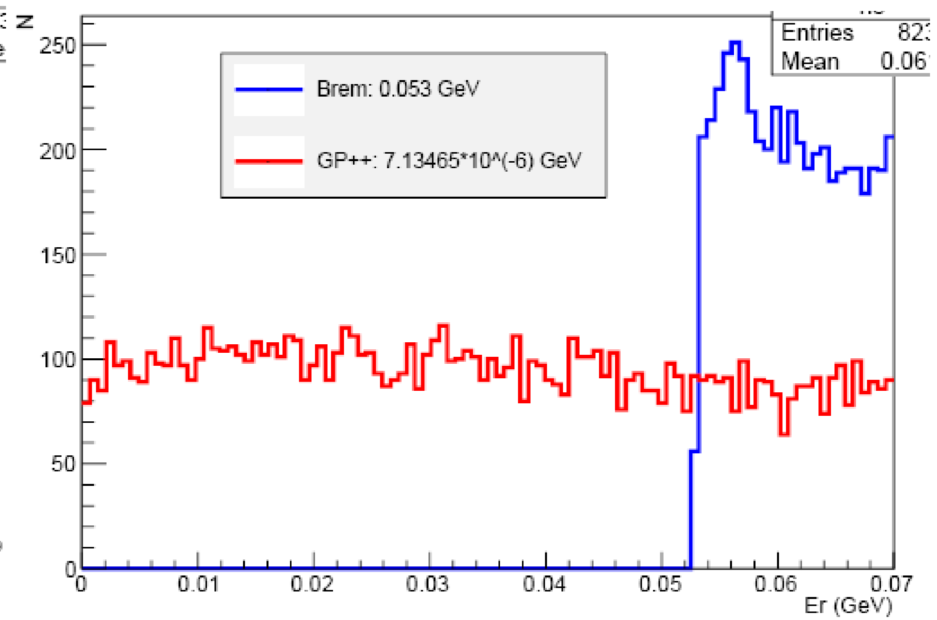
BBbrem: min energy of real photon $E_\gamma > x_{min} E_{beam}$ (0.053GeV)

GP++ : min energy of virtual $E_{\gamma*} > x_{min} E_0^2/E_{beam}$ (~5 10^{-10} GeV)

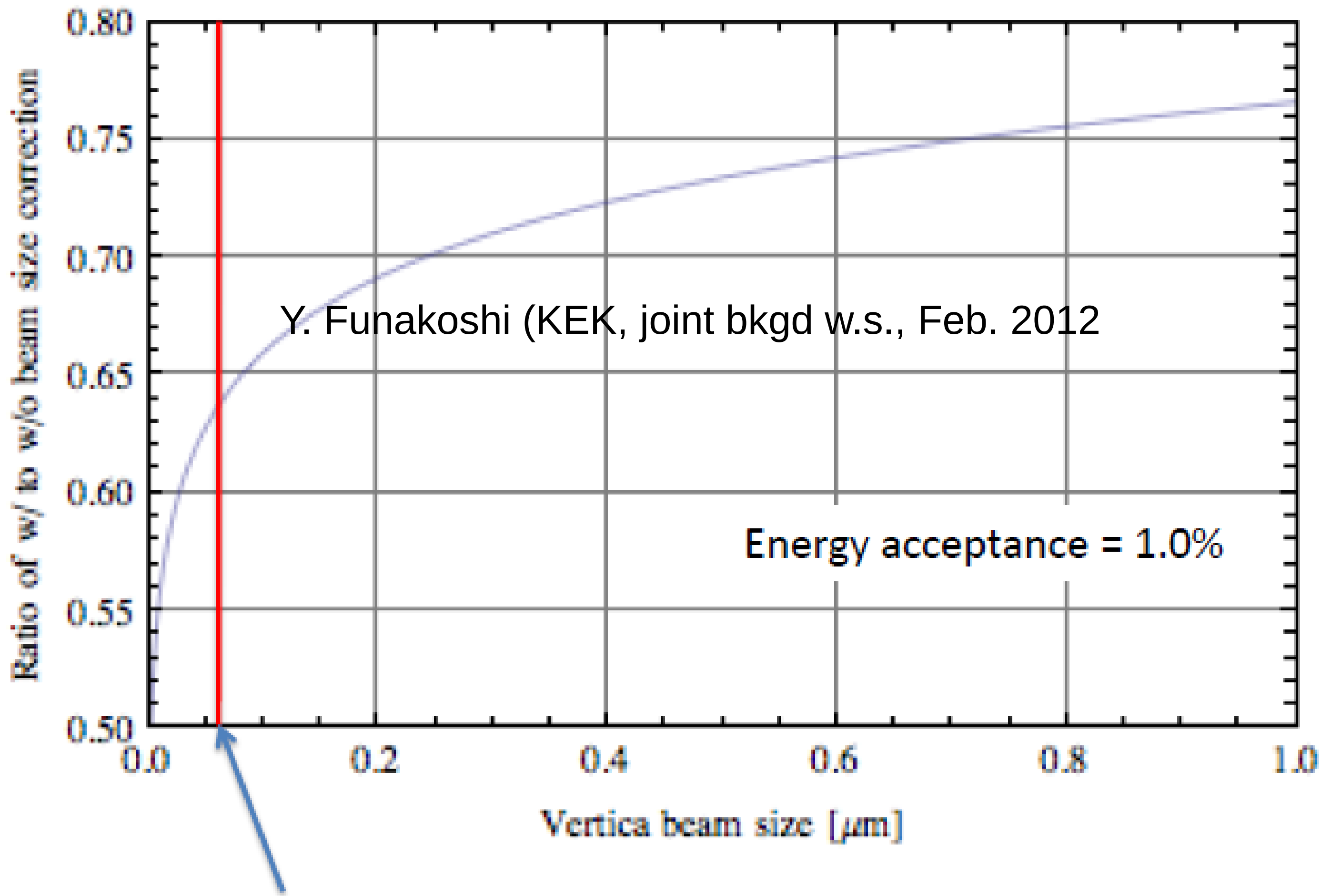
Virtual photon E_{min}



Real photon E_{min}



Correction for cross section due to finite beam size



~60nm (SuperKEKB, κ=0.4%)