Background studies On ATF2

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LLR-Ecole Polytechnique, France

ATF2 Meeting,
October 15th-17th 2007

From HALO to Background

- Halo Measurements @ATF
  - 2005 → Suehara-san
  - 2006 → Lawrence Deacon
- BDSIM-Simulation and input beam HALO
  - Flat distribution HALO
  - Losses/background extraction
  - Background vs signal
- Conclusions, Open points

Background sources

- **Synchrotron radiation :**
  This is major background at FFTB experiment, but at ATF2, critical energy at bending magnet (assuming 1 Tesla) is about 1 keV. As a result, **synchrotron photons can be easily stopped by beam pipe**.
- **Scattering with residual gas**
  Because ATF2 beam line is relatively short (~50m), number of photons of this **background is negligibly small**.
- **Beam halo scattering with beam pipe by Bremsstrahlung**
  This is the **major background in ATF2**. It has large energy up to beam energy (1.3GeV), and large number of photons created without halo cut components
- **Particles from beam dump**
  This may also be large background, but it can be **eliminated by geometry**, if we put the detector behind the beam dump.

Beam Core/Halo

The current theories calculate the rms emittance growth. The rms value is a useful quantity … ribution—but intra-beam scattering … mb scattering has a non-Gaussian di… n due to the scattering will have a … n have a significant contribution to the rms width; the core is due to the multiple soft scattering, while the tails arise from the infrequent hard scatterings.

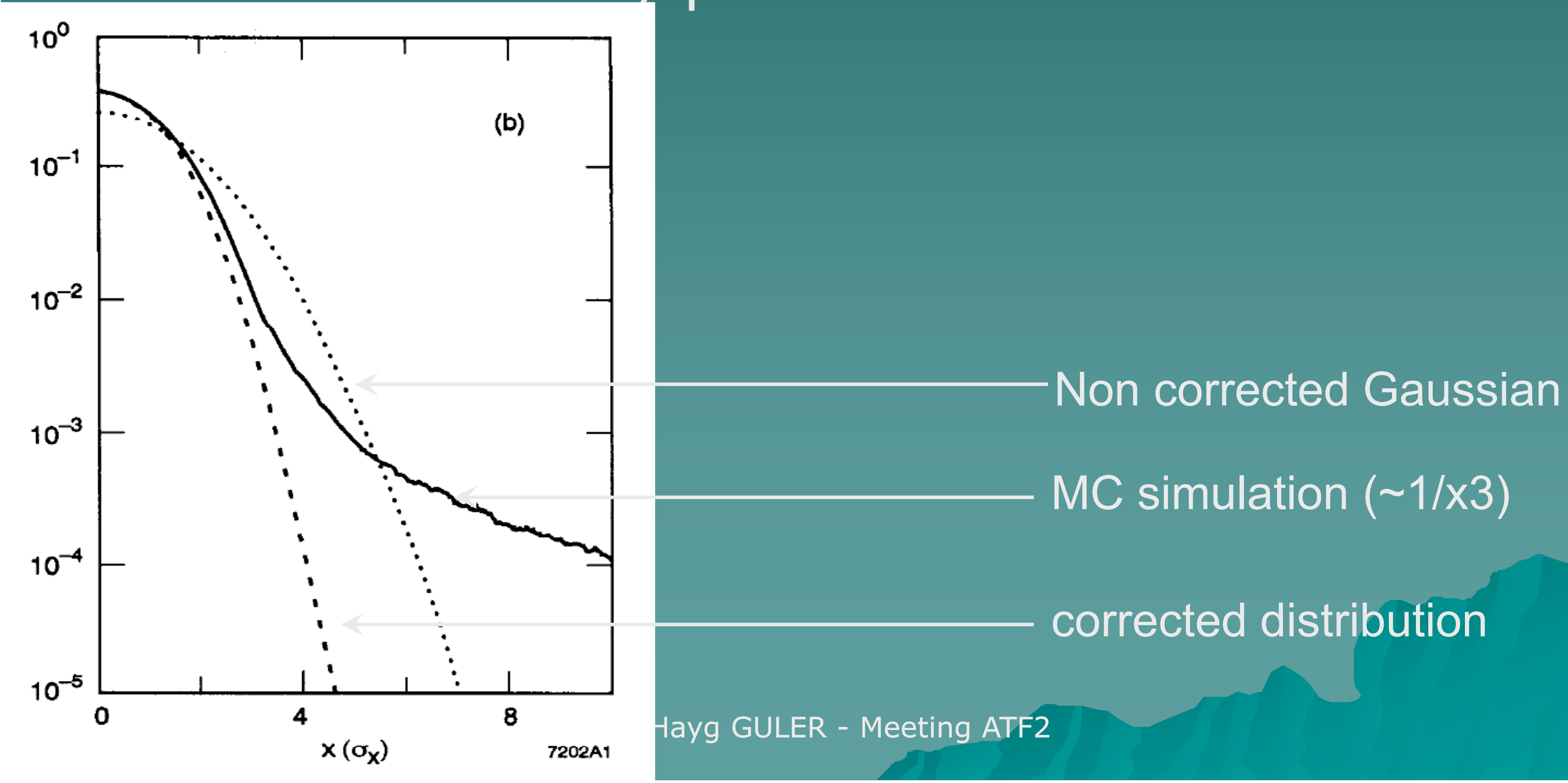
THE CORE EMITTANCE WITH INTRABEAM SCATTERING IN e^+/e^- RINGS*

T. O. Raubenheimer

Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309

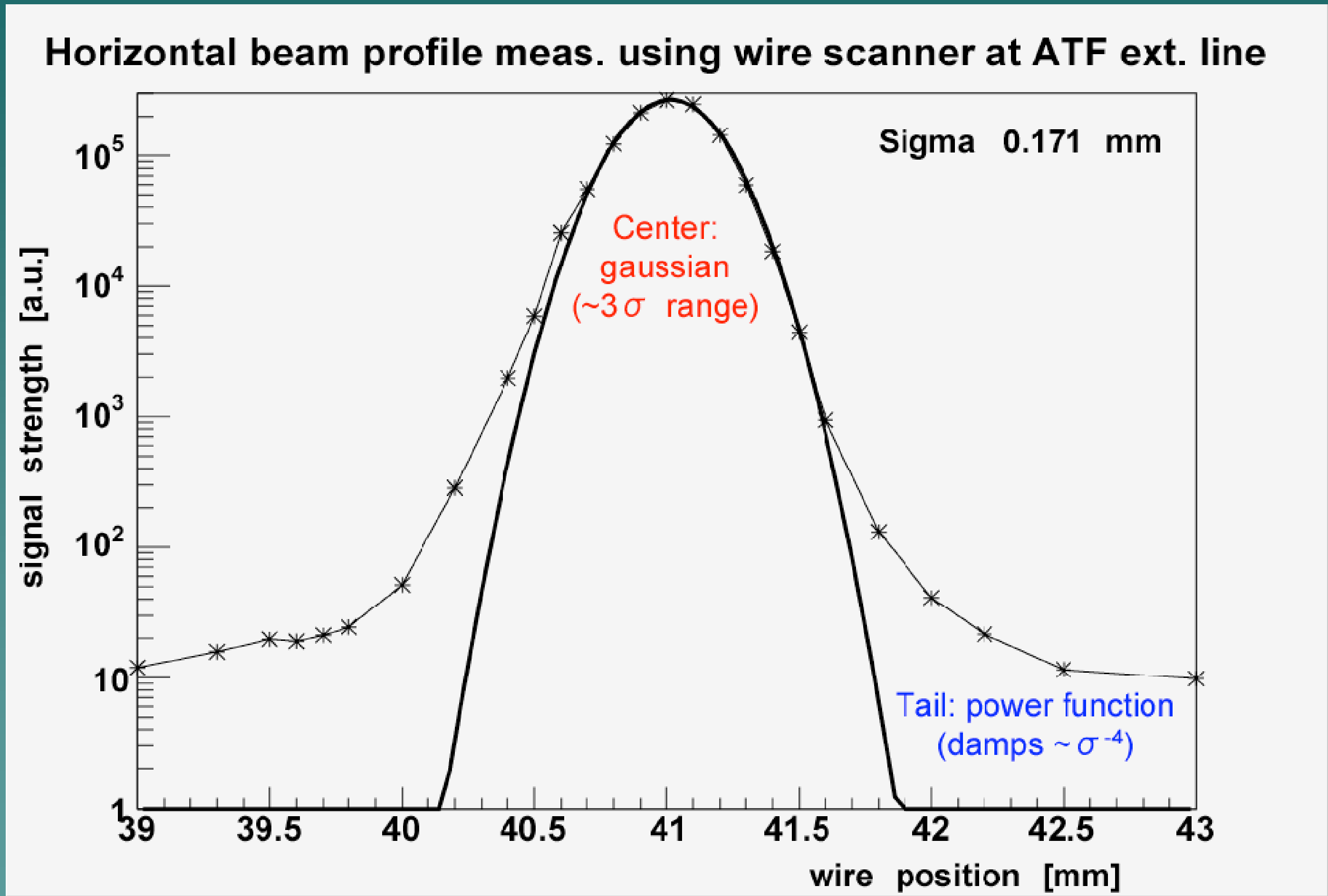
Particle Process: Intra Beam Scattering

- "Tail cut" criteria:
  - Exclude rare scatterings: i.e. small impact parameter with rate smaller than damping rate.
  - Consider only particles in the Gaussian core.



Beam Halo (measurement in 2005)

- 10^7 events outside 10σ (Suehara-san)



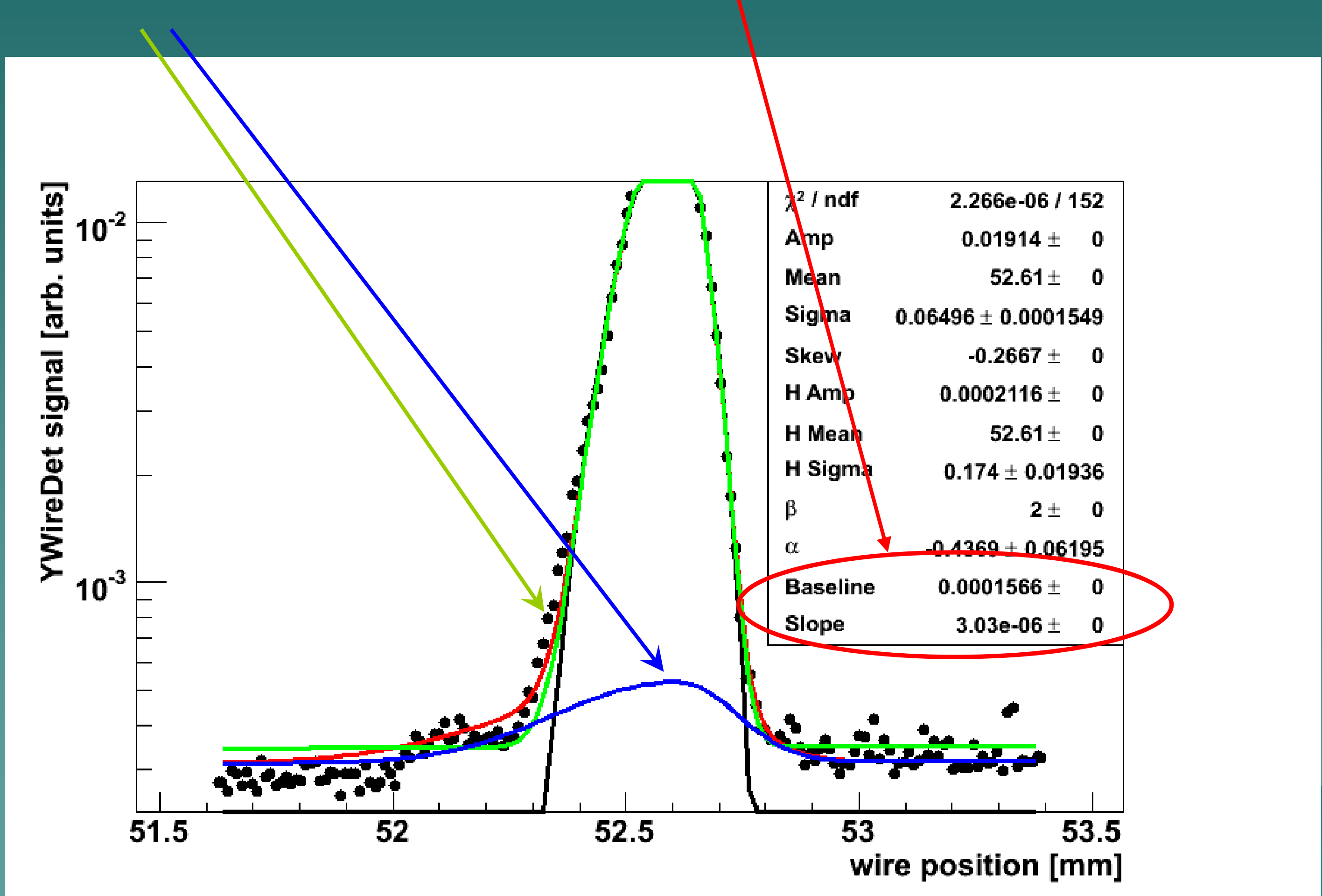
Beam Halo Measurement (2)

Lawrence Deacon, Pavel Karataev,
Grahame Blair, RHUL
ATF2 meeting, KEK, May 9th 2007

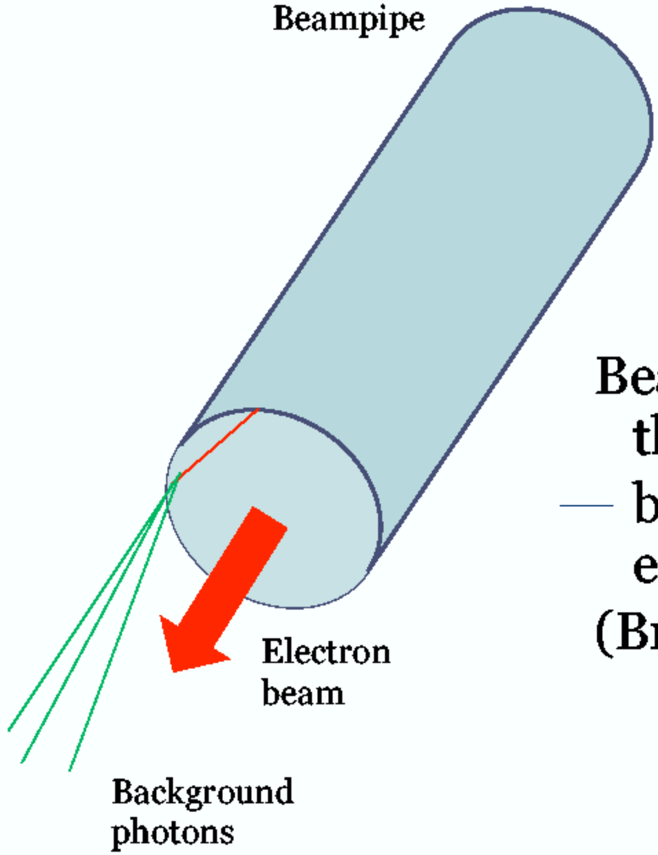
- Halo measured using wire scans
- Fitted to a function
- Fraction of beam in halo estimated
- Halo width versus core width

Beam Halo Measurement (2)

Fit : sum of **two Gaussians** and a **linear function**



Background photons

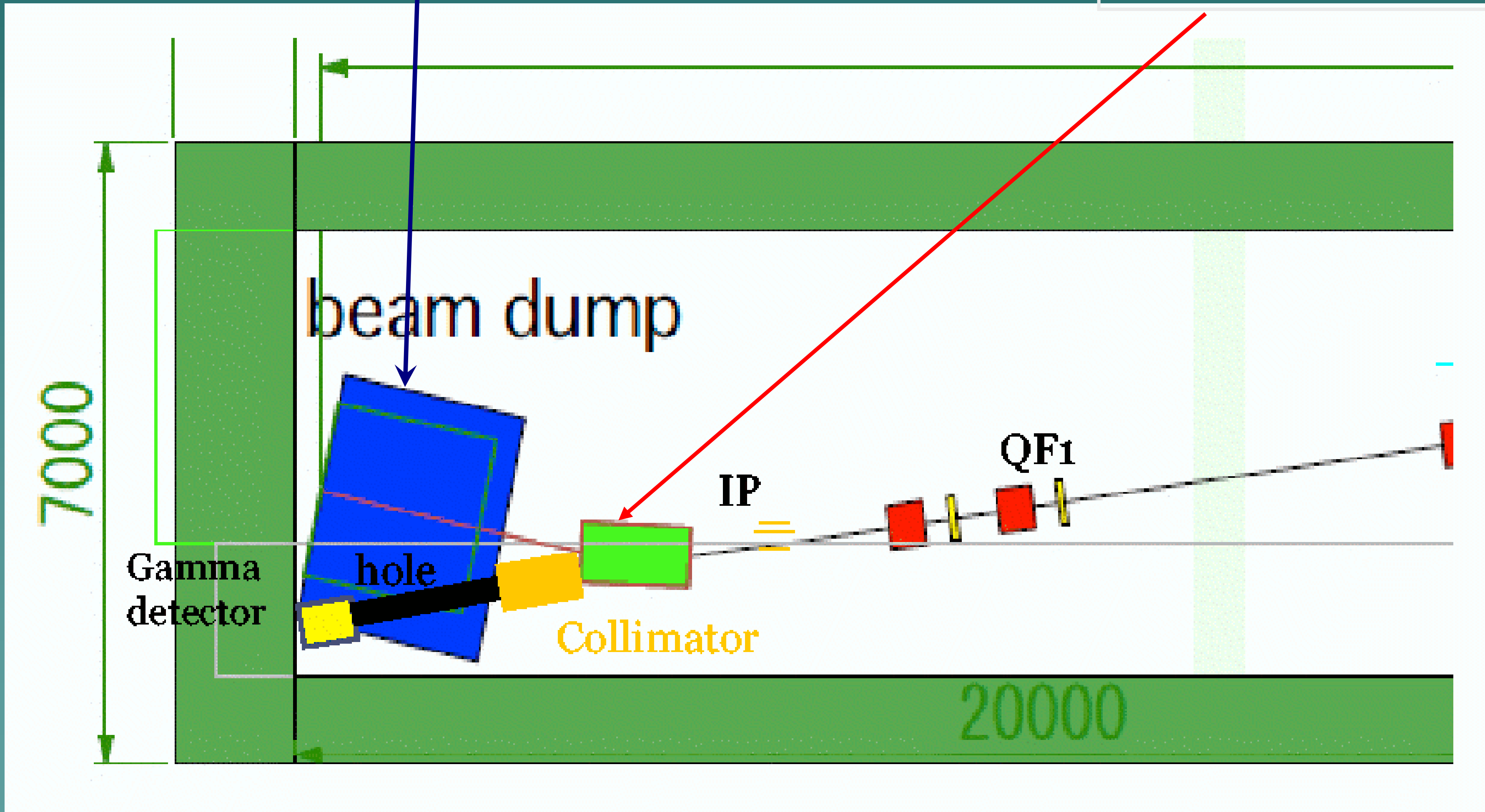


Beam halo electrons hit the beam pipe
— background photons are emitted
(Bremsstrahlung γ–ray)

At the final doublet

Back away → 1m (?)

Eliminate Background photons



HALO propagation →BDSIM

- BDSIM : Beamline Simulation Toolkit based on GEANT4
- Possibility to generate and track secondary particles
- Possibility to include Mokka-type (complicated) geometry → from database

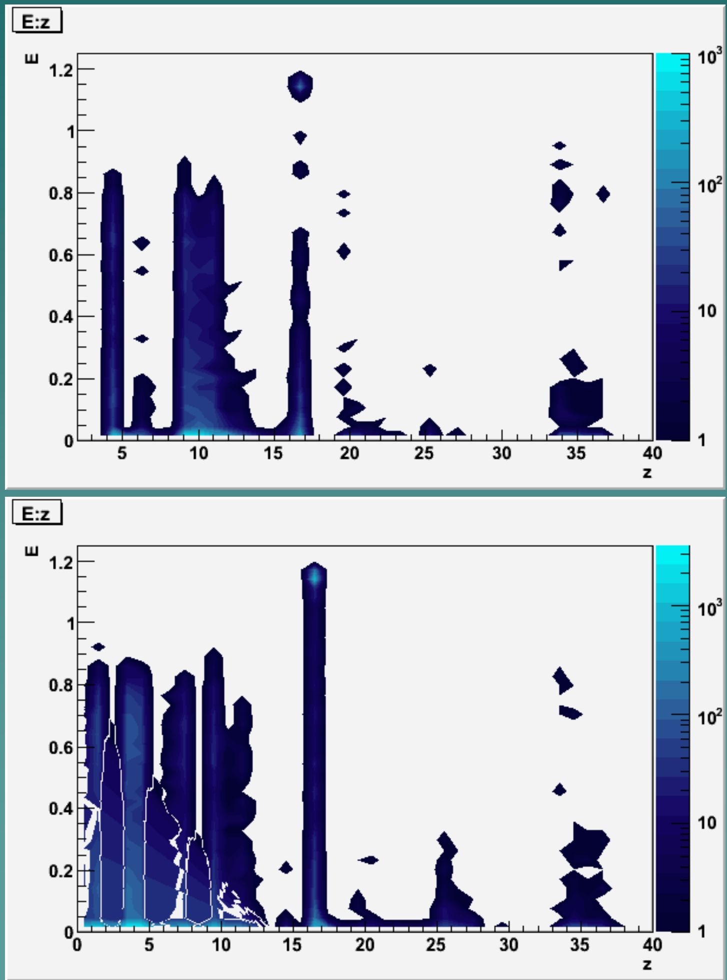
Signal Photons
(From Shintake monitor group)

Category	Parameter	Value	Unit	Reference	Dependence	comments
Compton cross section				SLAC-PUB-8012		
	Electron energy	0.0013	TeV		Complicate(Large -> Small)	
	Laser photon energy	2.3000	eV		Almost inverse	
	X of Compton scattering	0.02287350				
	Thomson cross section	6.65	x10^-25[cm2]			
	Compton cross section	6.50228558	x10^-25[cm2]			
Photon density						
	Laser bunch energy	200	mJ		Linear	100+100mJ
	Electron charge	1.60E-19	C			
	Bunch population	5.43478E+17	Photons			
	Pulse length	5.5	ns		Inverse	1 sigma, Gaussian
	Beam radius	15	um		Inverse	1 sigma, Gaussian
	Light speed	3.00E+08	m/s			
	Pi	3.14159				
	Bunch volume (Gaussian eff)	5.85E-09	m3			
	Bunch volume (z integrated)	1.56E-04	m2		Gaussian beam	
	Photon density (z integrated)	3.49E+21	photons/m2			
Scattered photons						
	Electron bunch population	1.00E+10	Electrons		Linear	
	Scattered photons(ave.)	2272				
	Scattered photons(max.)	4545				
				lambda	1.064	
				w0	3.2	
				f	458.2	
				w	48.49502959	

Flat Halo Study

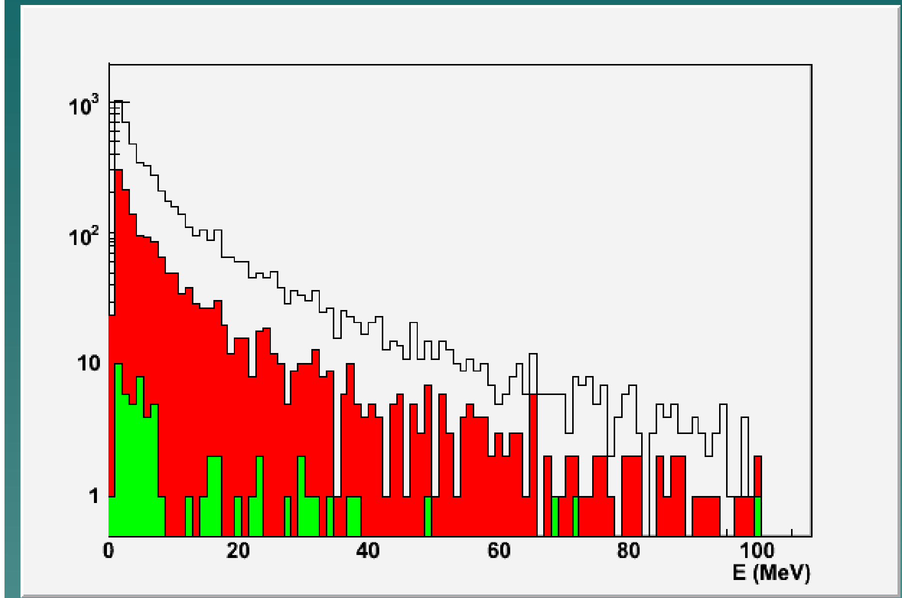
- How large will be the HALO ?
  - Gaussian HALO not realistic because drop too rapidly
  - Ideally a HALO would have a $1/x^3$ -$1/x^5$ tails
  - Simulate how a flat tail would generate background
    - 50σ to 200σ Beam HALO @ the entrance of the FF → use 100% background
    - Use BDSIM to simulate the beam transportation on the FF line part

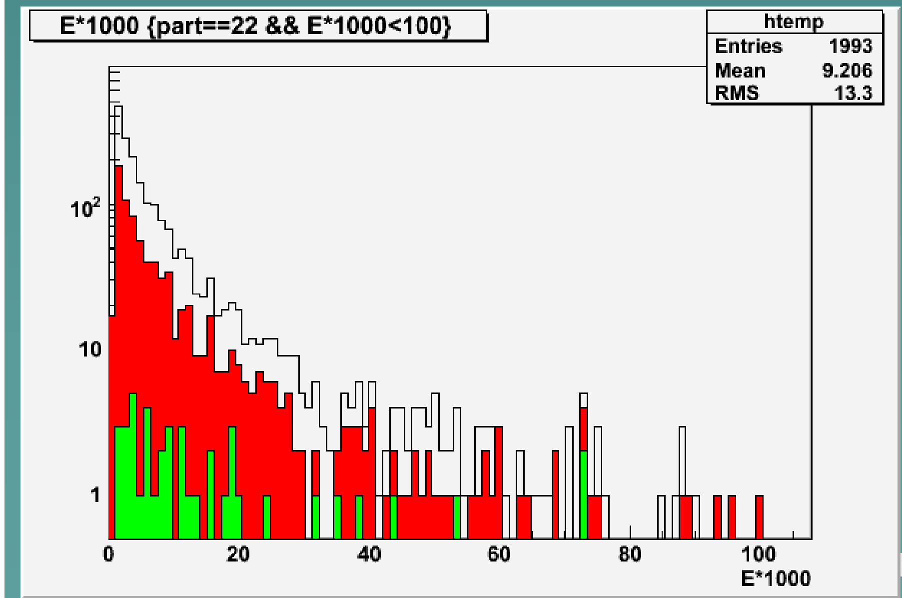
Beam Losses and Secondary generation



- Losses versus z
  - 50σ Flat HALO (4mm)
  - 200σ Flat HALO (16mm)
- @200σ, losses are more important specially @small-z

Background photons energy





- 5k e- Generated
  - Bunch population : $2x10^{10}$ Beam Core Electrons and about 0.1-1 % e- in the HALO ($2x10^7$ to $2x10^8$ e-)

Background Photons inside 1m

Background Photons inside 10cm

- Inside a cylinder around the IP:
  - Less than 4.0 10^6 photons inside 1m
  - Less than 4.0 10^5 photons inside 10 cm
- More events at large-d from z-axis for 200σ Halo beam than 50 σ Halo beam

Conclusion-Next steps

- Background estimation @ IP → Number of photons not "too large"
- Try more "realistic" HALO distribution in order to better estimate the number of background photons around the IP (measurements in Nov. 2007 ?)
- Use collimators to eliminate background photons
- Study backscattered photon from the DUMP


ZIDANE
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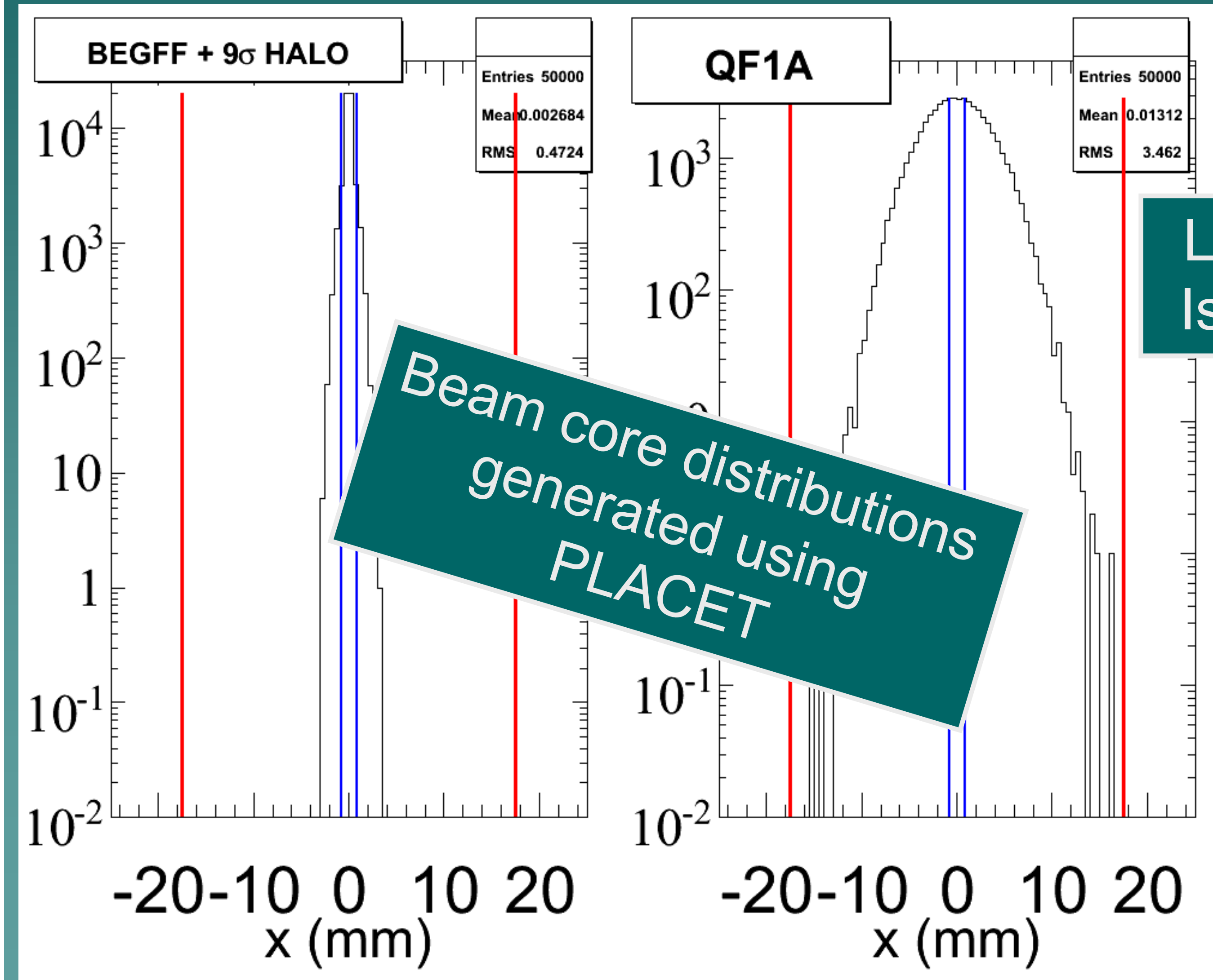
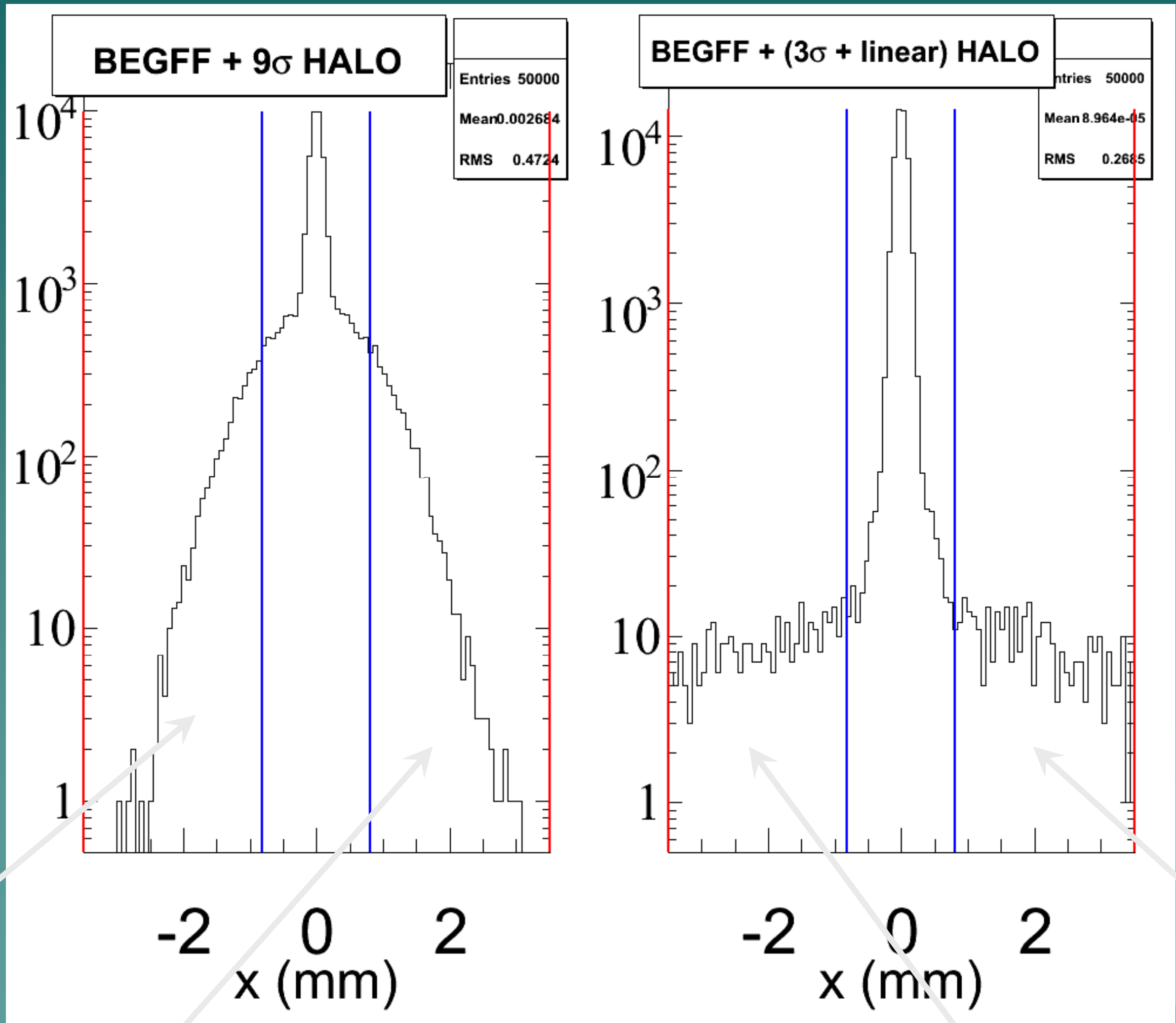
Reuters

Compare input size to the one at QF1



Largest Beam size
Is obtained @ QF1

Compare 9σ to (3σ+Linear) HALO

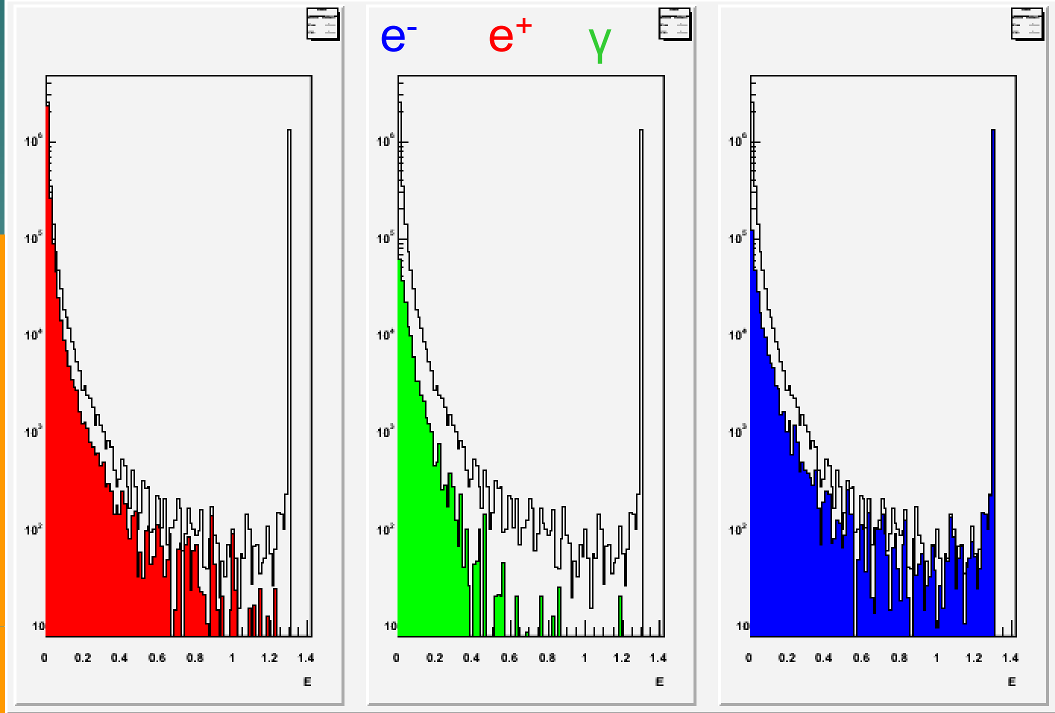


~11.9% events outside 10σ

~1.4% events outside 10σ

Reconstructed particles energy

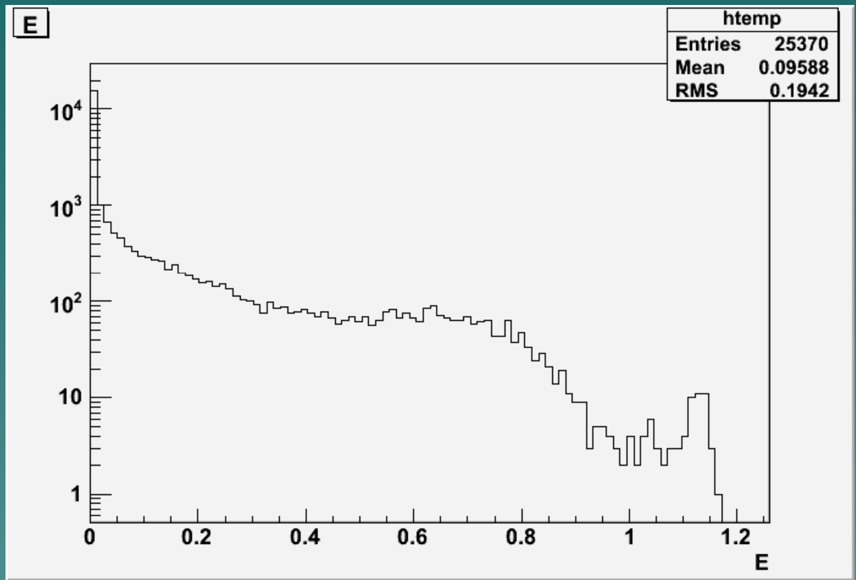
9σ Halo

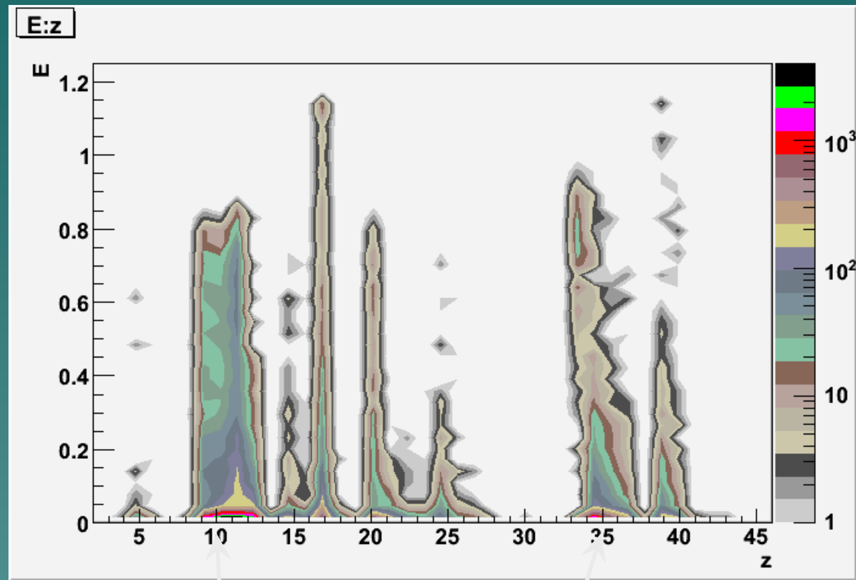


• beam pipe radius = 4 cm
• beam pipe thickness = 1.6 mm
• 10000 generated electrons
• Energy = 1.3 GeV (dE = 0.1%)
• Generated using BDSIM
using a Placet generated
Guineapig type distribution file

Beam Halo : 9σ (40 % events)

Energy Loss for a 9σ HALO



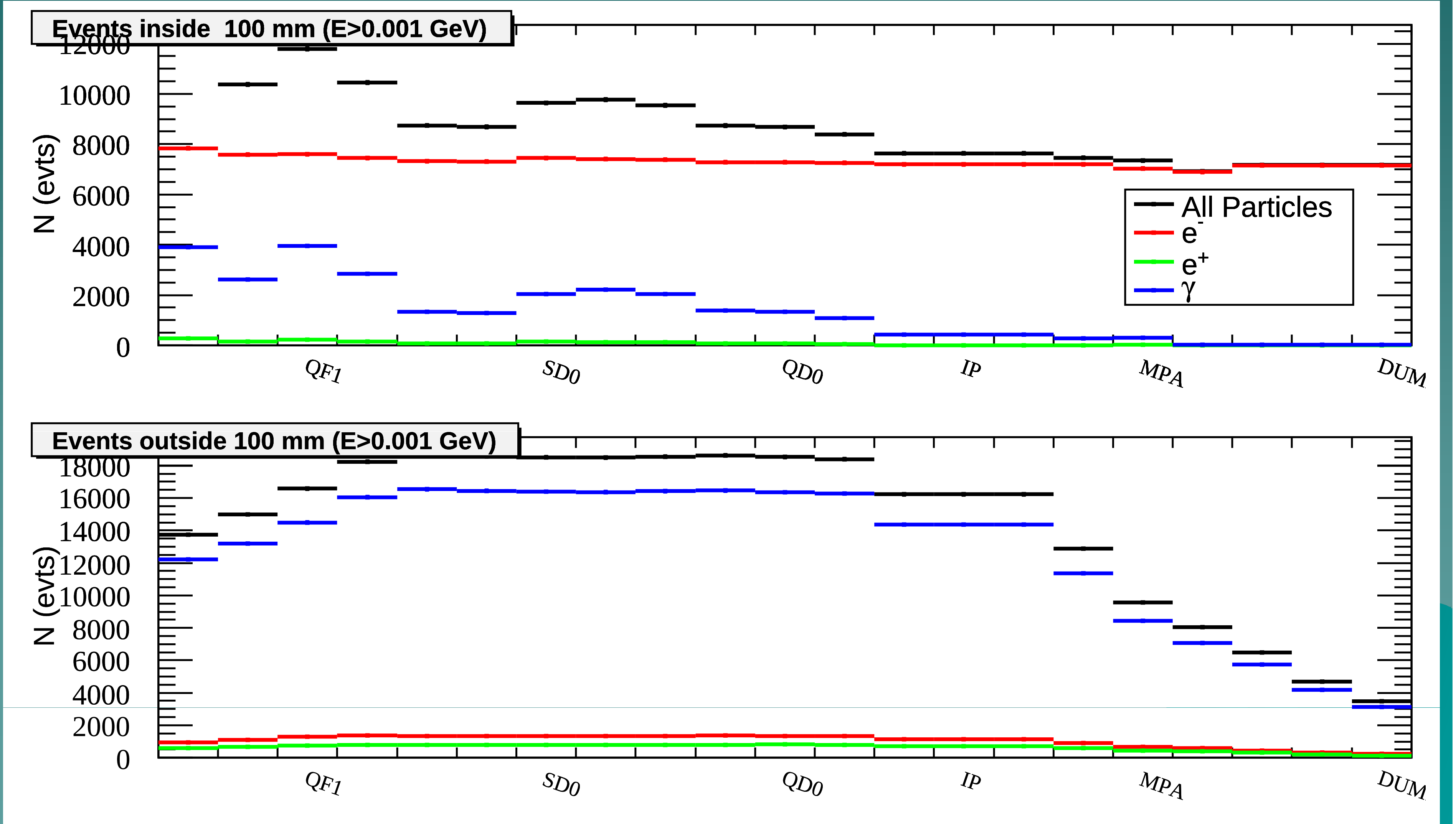


Small loss @ the beginning of the FF

Places where most of particles energy has been lost
(at different optical elements)

Background population (FF)

- 10^4 e^- generated with 9σ HALO (E>1MeV)



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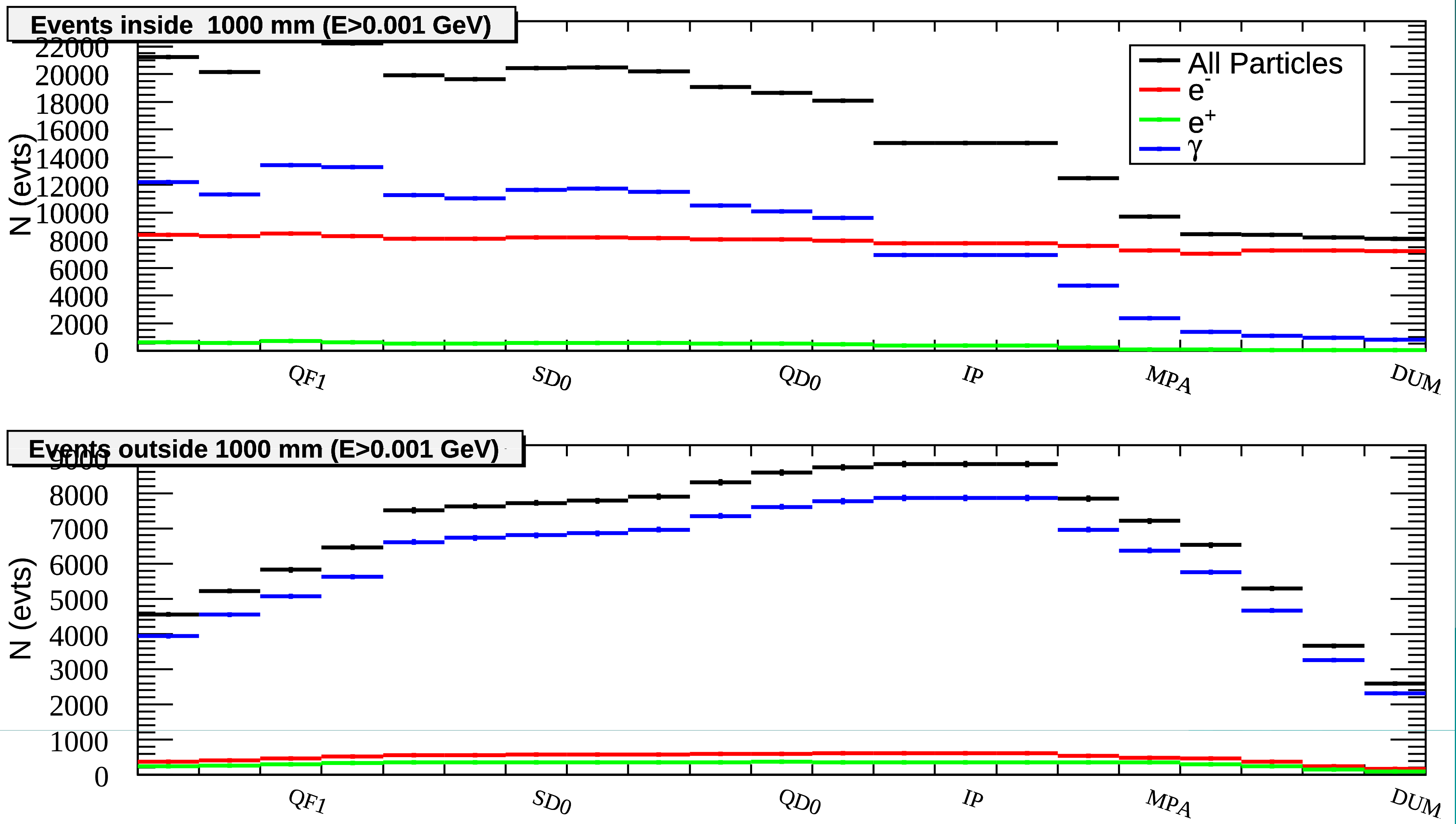
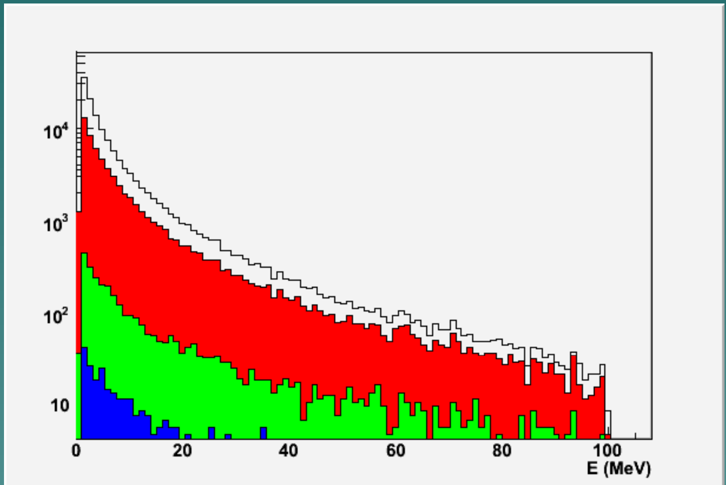


Background photons energy

9σ Halo



- 70k e^- Generated
- Bunch population : 2.0^{10} Beam Core Electrons

Background Photons inside 1m
Background Photons inside 10cm
Background Photons inside 1cm

- Inside 1m around the IP:
  - 10^5 to 10^6 photons (0.1-1% HALO)
- Inside 10cm around the IP : 10 times less