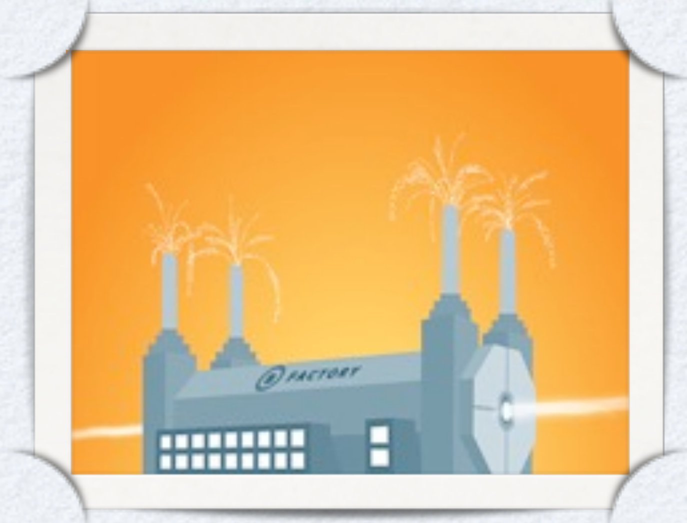
Backgrounds in SuperB



Eugenio Paoloni INFN & Università di Pisa for the
MDI & Background simulation group

Talk topics

- IR: general features
- Backgrounds sources in SuperB:
  old "*friends*" and some unexpected new ones.
- Tools (generators, models)
- What we learned

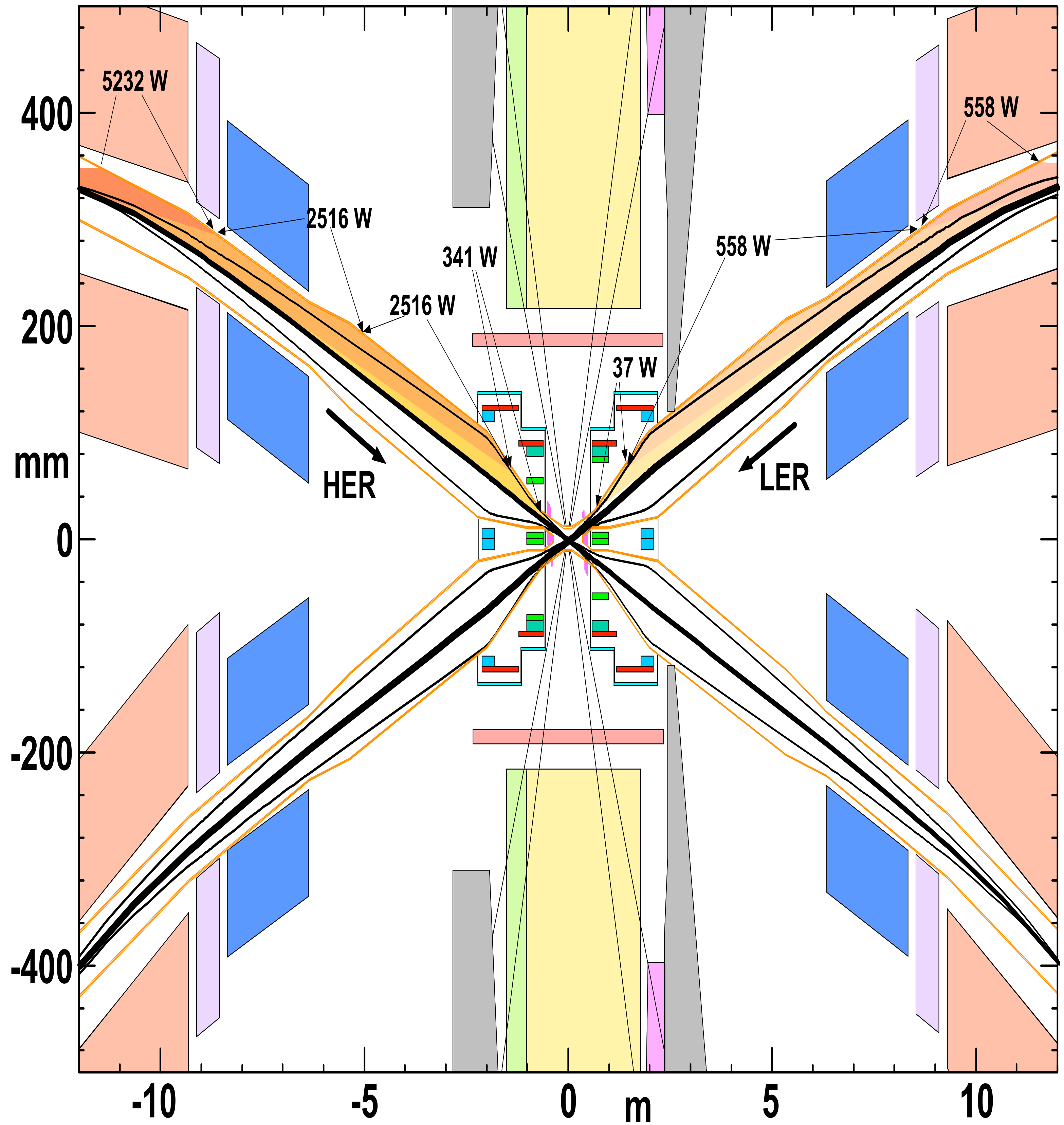
Preliminary remark

Backgrounds in SuperB...

- SuperB will collide beams whose current will be similar to PEP-II (KEKB)
- Synchrotron radiation at the IP was a concern during PEP-II design and is still a concern in SuperB
- Michael Sullivan expertise, knowledge, tools and dedication are simply invaluable.

General IR Design Features

- Crossing angle is +/- 33 mrads
- Cryostat has a complete warm bore
  - Both QD0 and QF1 are super-conducting
- PM in front of QD0
- Soft upstream bend magnets
  - Further reduces SR power in IP area
- Beam stay clear to 30 σ in X and 100 σ in Y
  (7 σ fully coupled)



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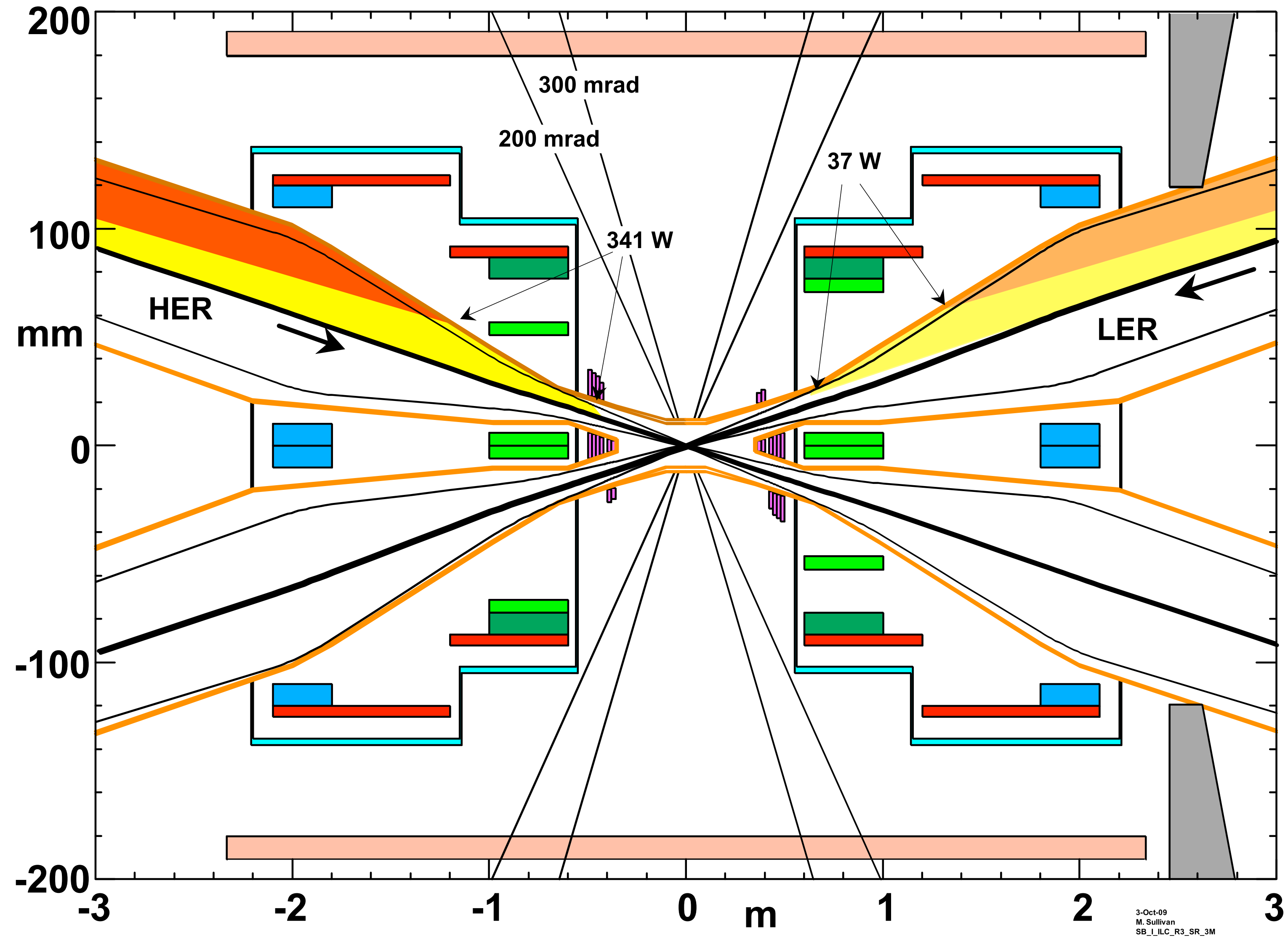
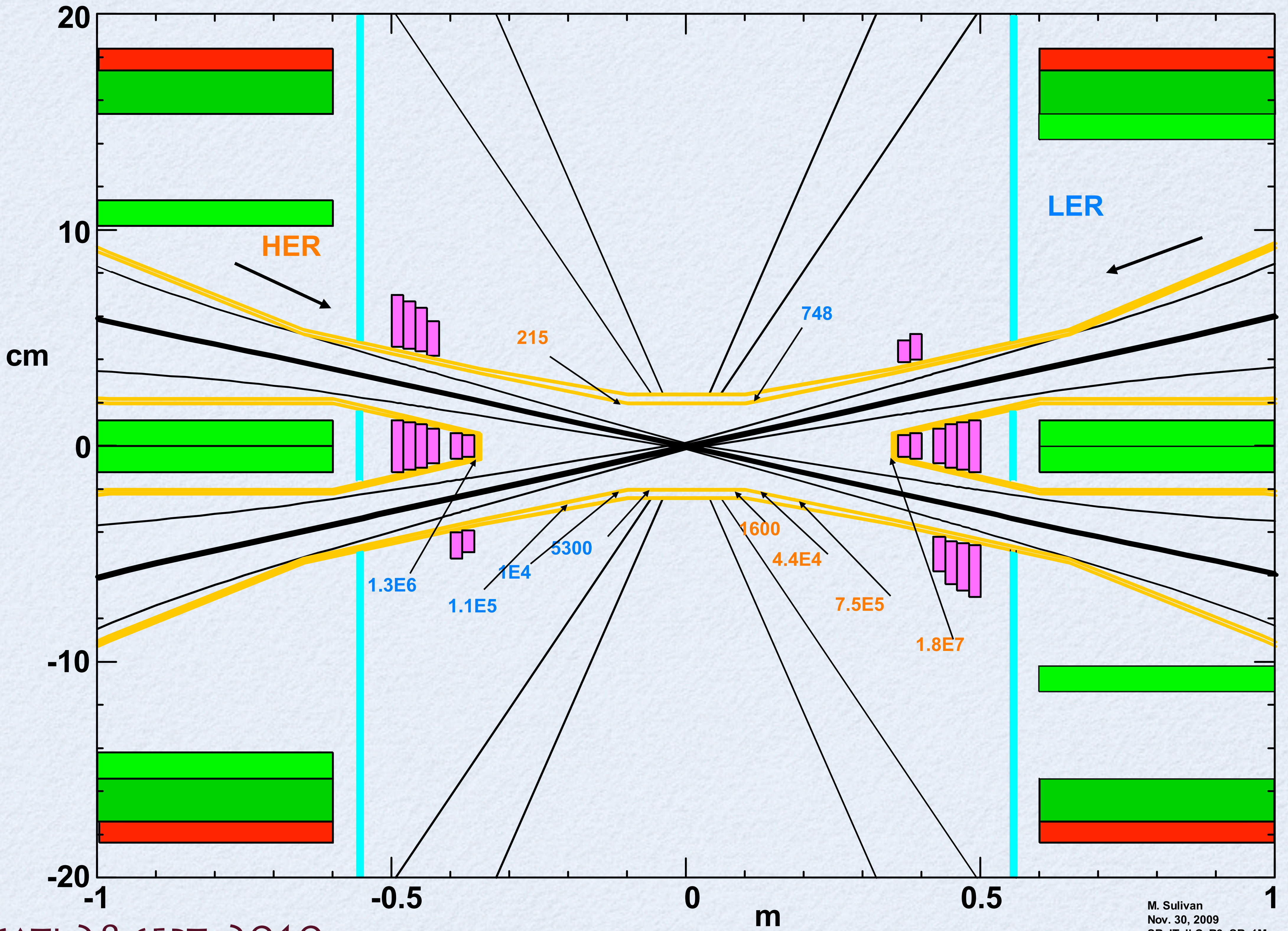


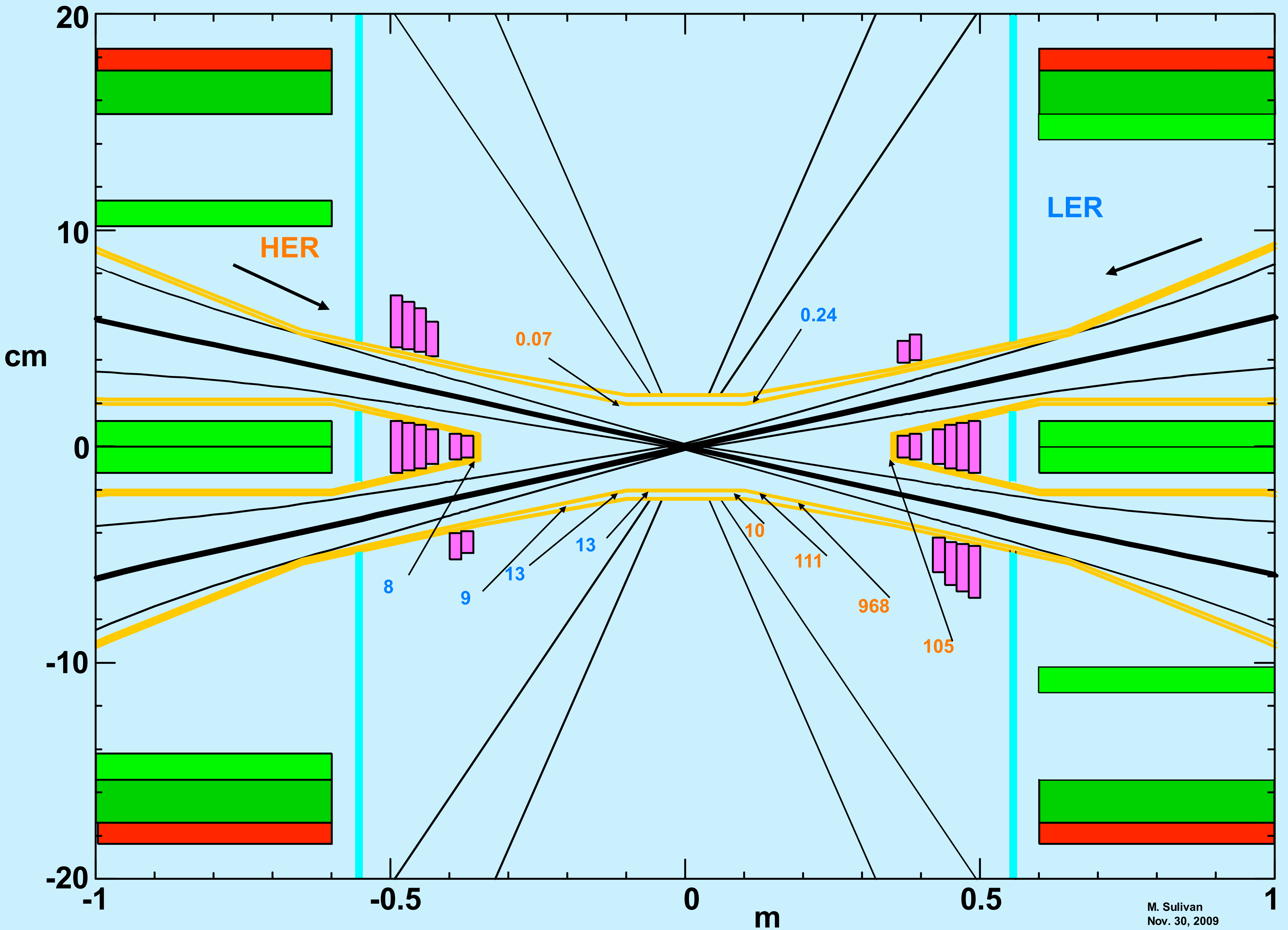
Synchrotron radiation @ IP

SR photon hits/crossing



Synchrotron radiation @ IP

SR photon hits/crossing on the detector beam pipe from various surfaces

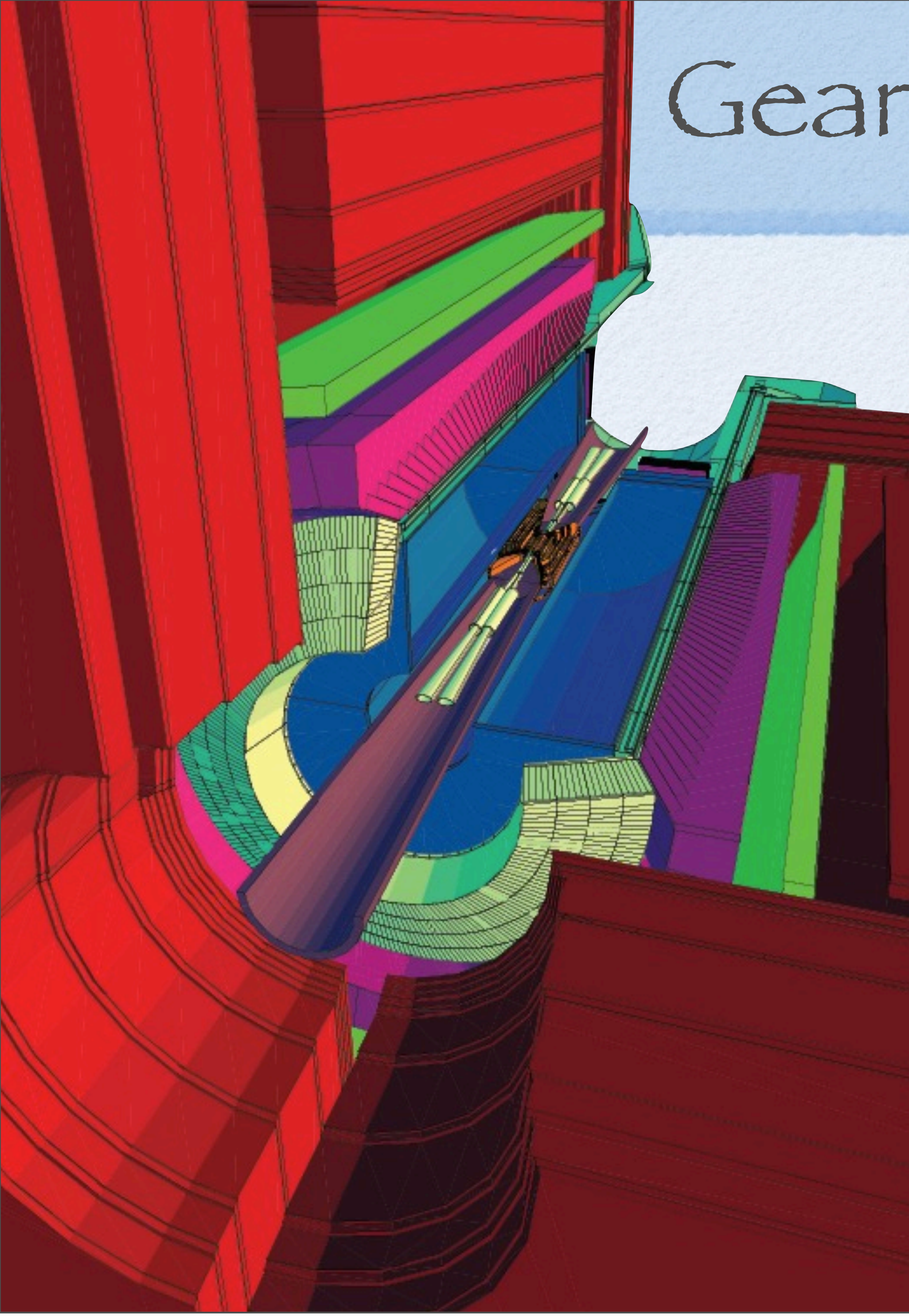


Backscattering SA and absorption rate (3% reflected)

Other background sources

	Cross section	Evt/bunch xing	Rate @ 10^{36}Hz/cm^2	Generators
"Radiative" Bhabha e^+e^- to $e^+e^-\gamma$	~340 mbarn ($E\gamma/E_{beam}$ > 1%)	~850	0.3THz	BBBrem
e^+e^- pair production	~7.3 mbarn	~18	7GHz	Diag36
e^+e^- pair (seen by L0 @ 1.5 cm)	~0.3 mbarn	~0.8	0.3GHz	
Elastic Bhabha	O(10^{-4}) mbarn (Det. acceptance)	~250/Million	100KHz	BHwide
Υ(4S)	O(10^{-6}) mbarn	~2.5/Million	1 KHz	
	Loss rate	Loss/bunch pass	Rate	
Touschek (LER)	4.1kHz / bunch (+/- 2 m from IP)	~3/100	~5 MHz	Star (Manuela Boscolo's code)

Geant 4 Simulation

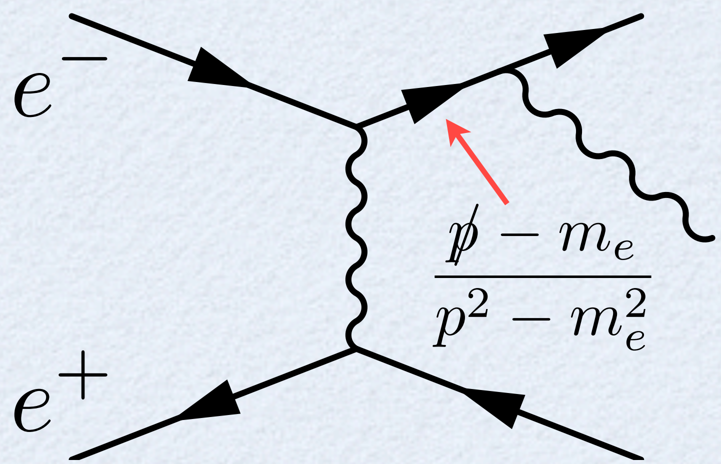


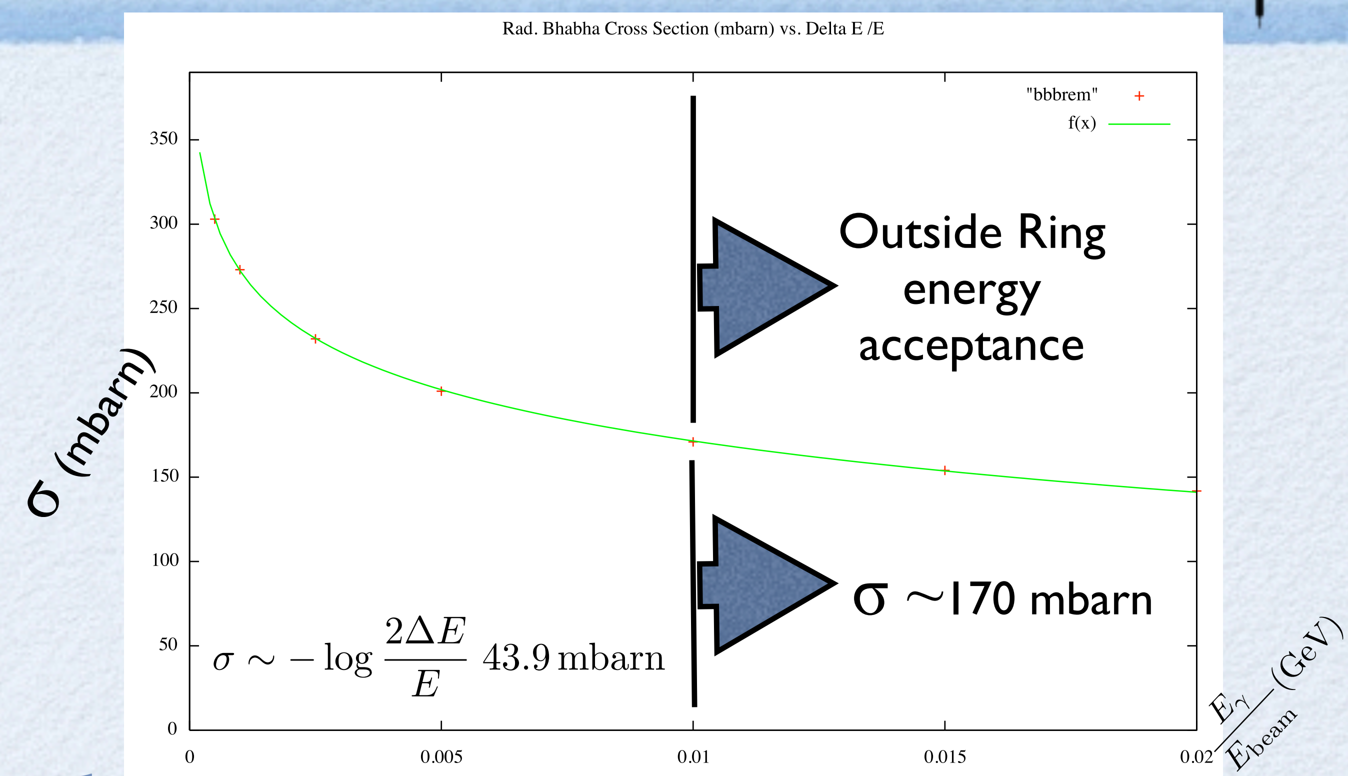
- Full Monte Carlo simulation based on Geant4 written from scratch
- Detector geometry coded in GDML
- First model *"automatically"* translated in GDML from the BaBar Geant4 full Monte Carlo simulation
  - apart the barrel EMC and the outer SVT all recoded in GDML from scratch
- Beam line model:
  - beam pipe
  - QD0 and QF1 Magnetic fields

SuperB

"Radiative" Bhabha

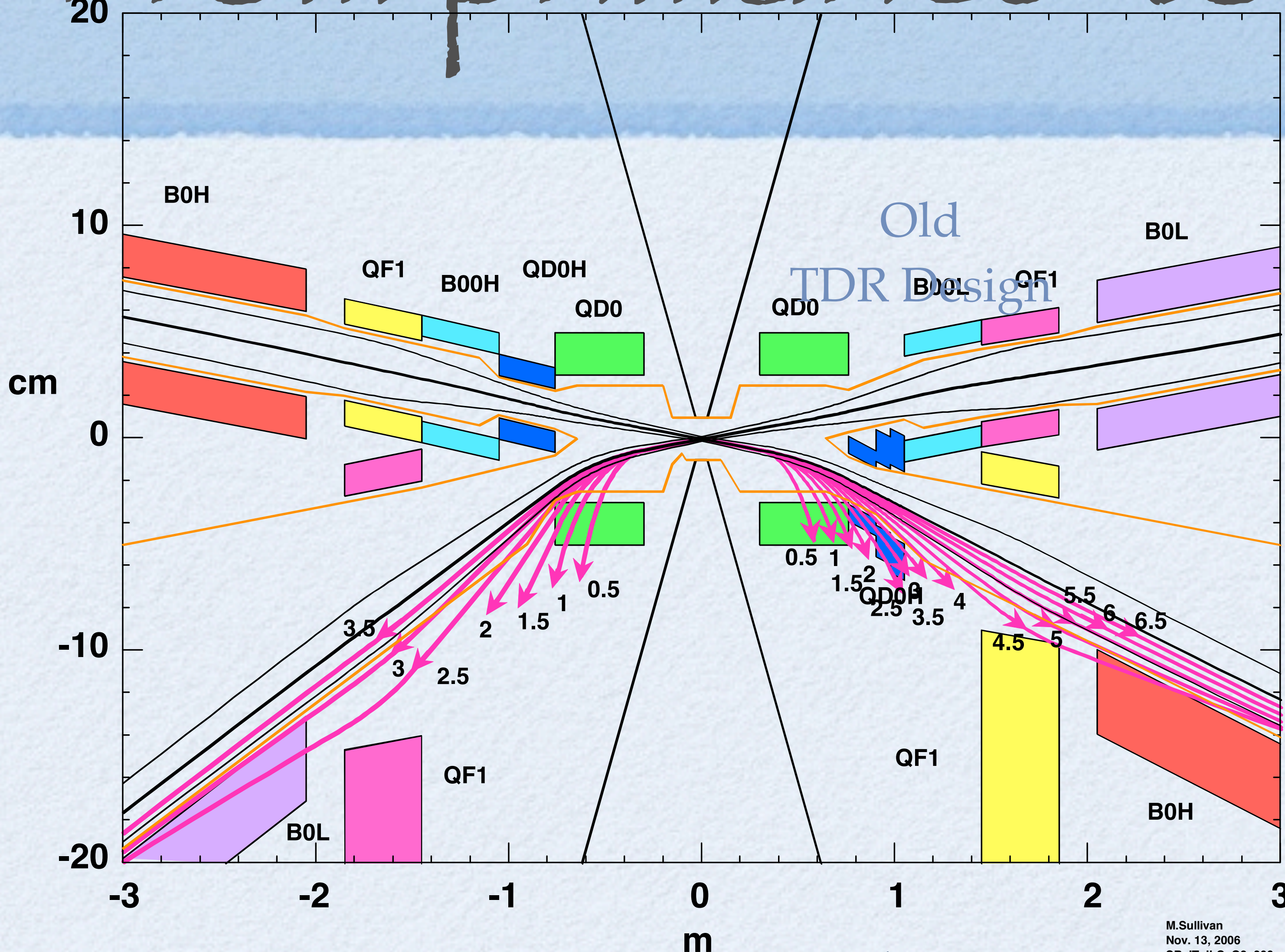
$e^+e^- \rightarrow e^+e^-\gamma \quad (\gamma \sim\parallel e^-)$

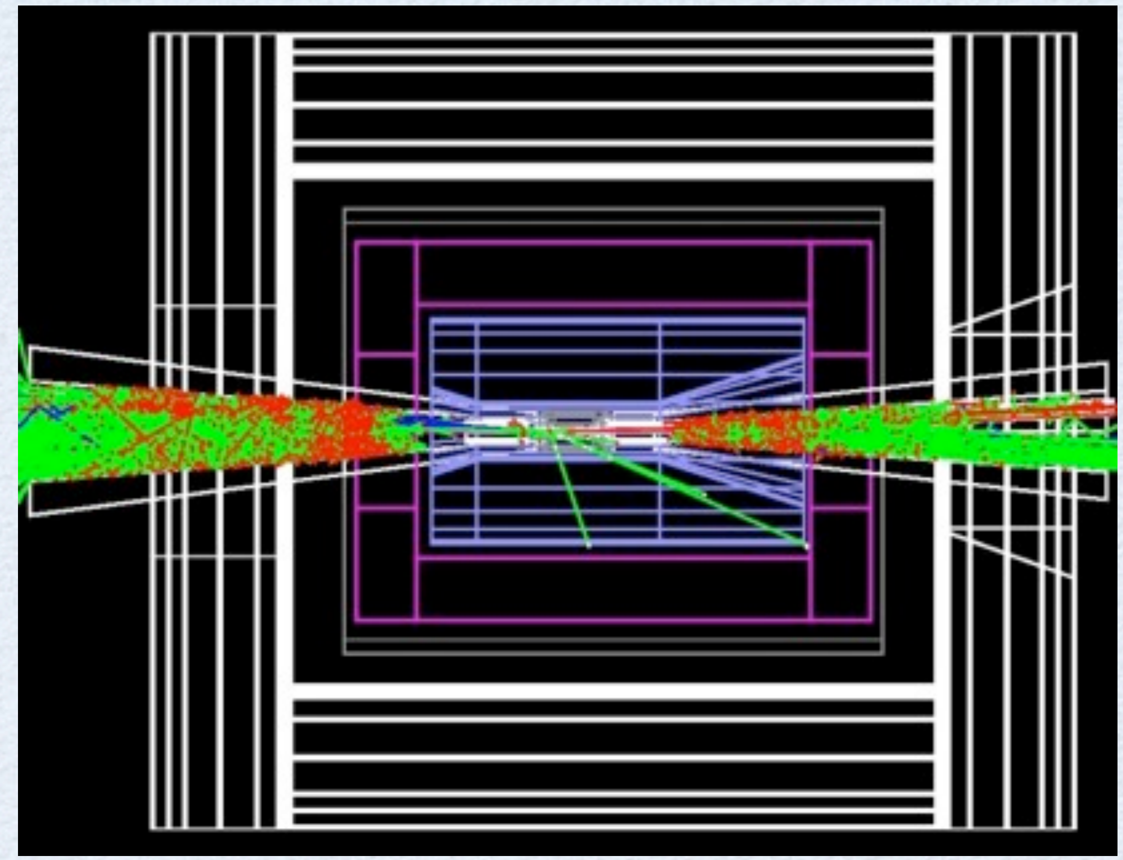




- Quasi elastic Bhabha followed by the emission of a photon
- The virtual photon and the virtual electron are almost on mass shell: infrared divergences
- Both the scattered leptons and the photons escape unseen downstream the beam pipe, till they encounter the first dispersive element of the beam line

From primaries to background

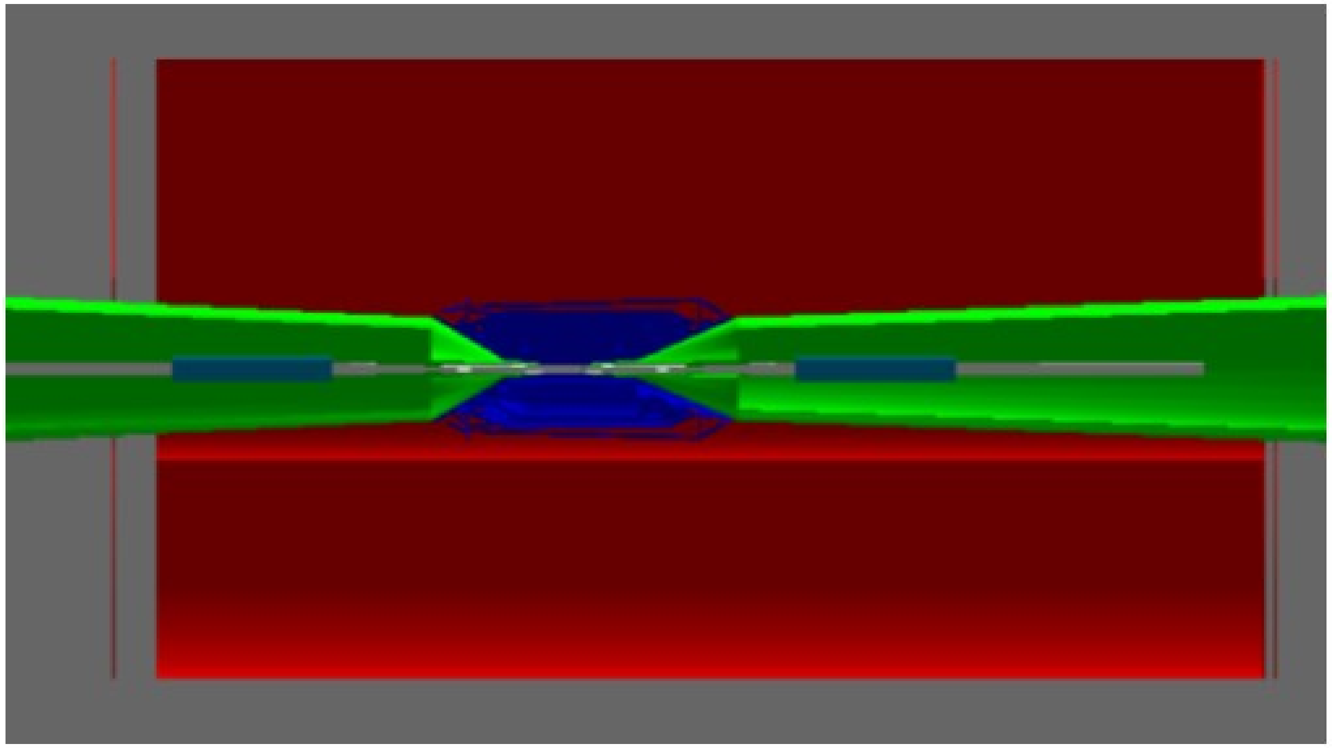


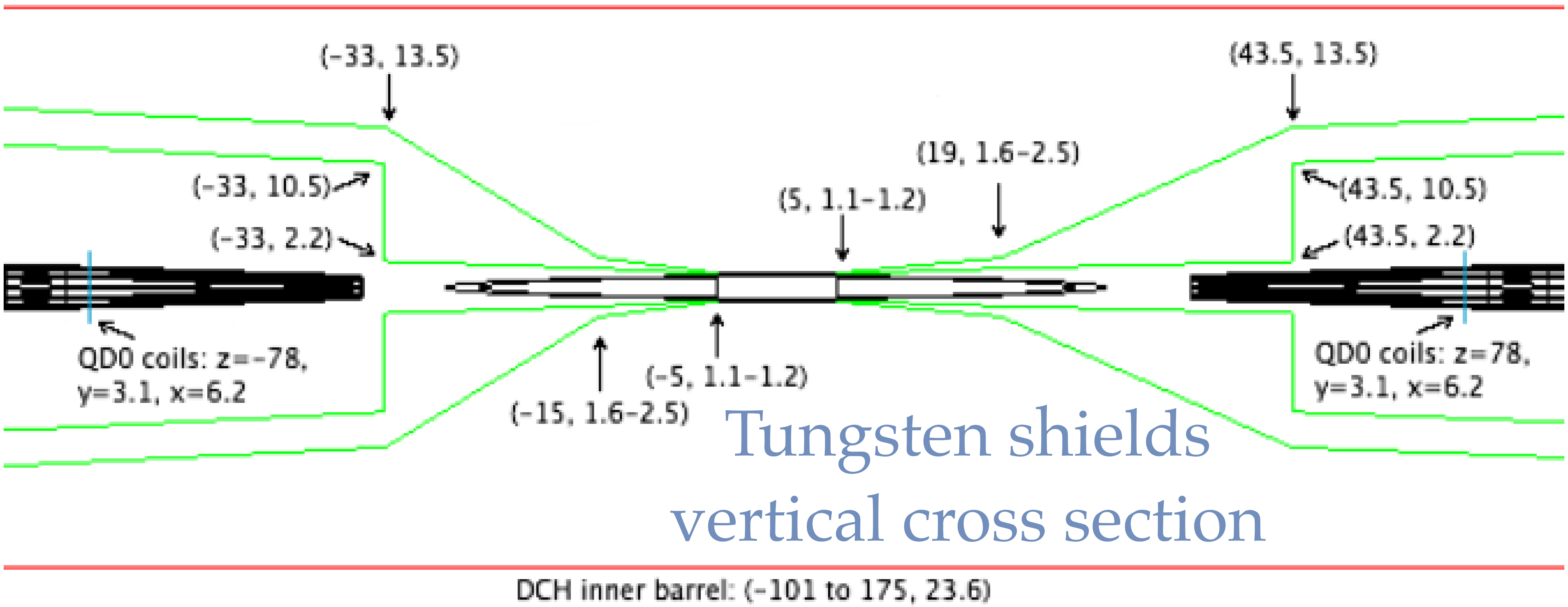


Geant 4 Simulation

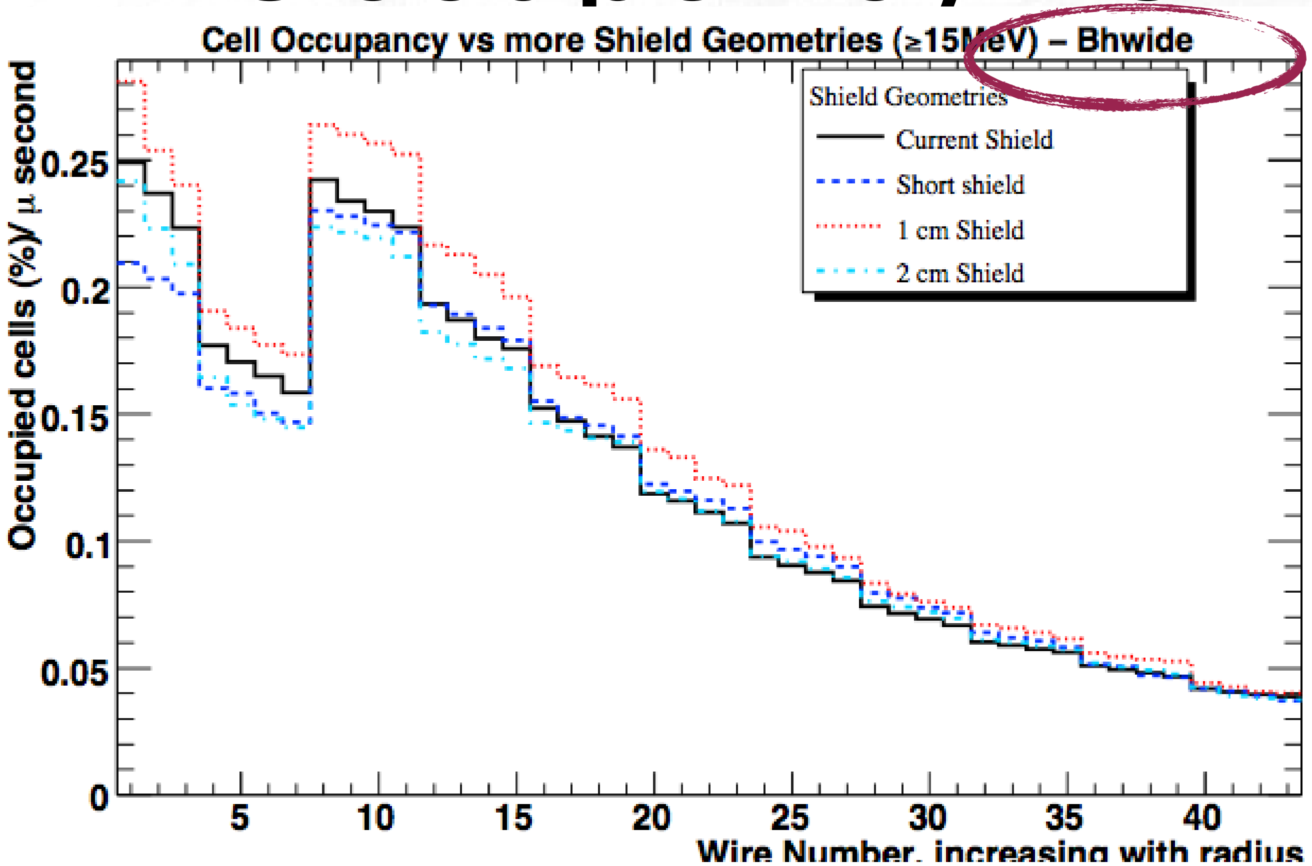
- QD0 axis stands near the incoming beam lines to keep synchrotron radiation fans away from the detector.
- The QD0 becomes a spectrometer for the outgoing particles produced by Radiative Bhabha interactions.
- DCH and EMC are the mostly exposed detectors
- Remediation: splitted QD0 and beam line shields.

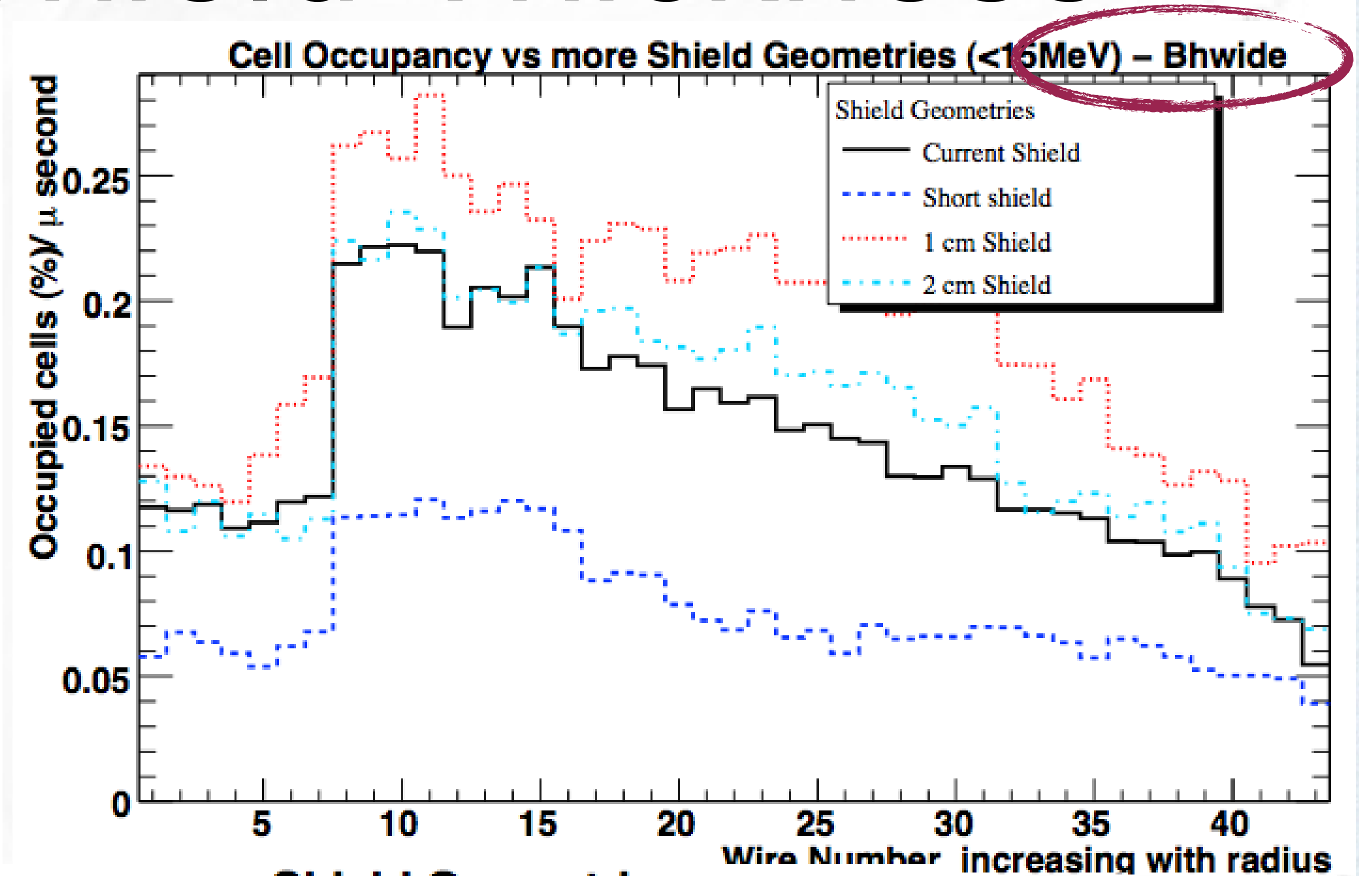
Shield Geometry



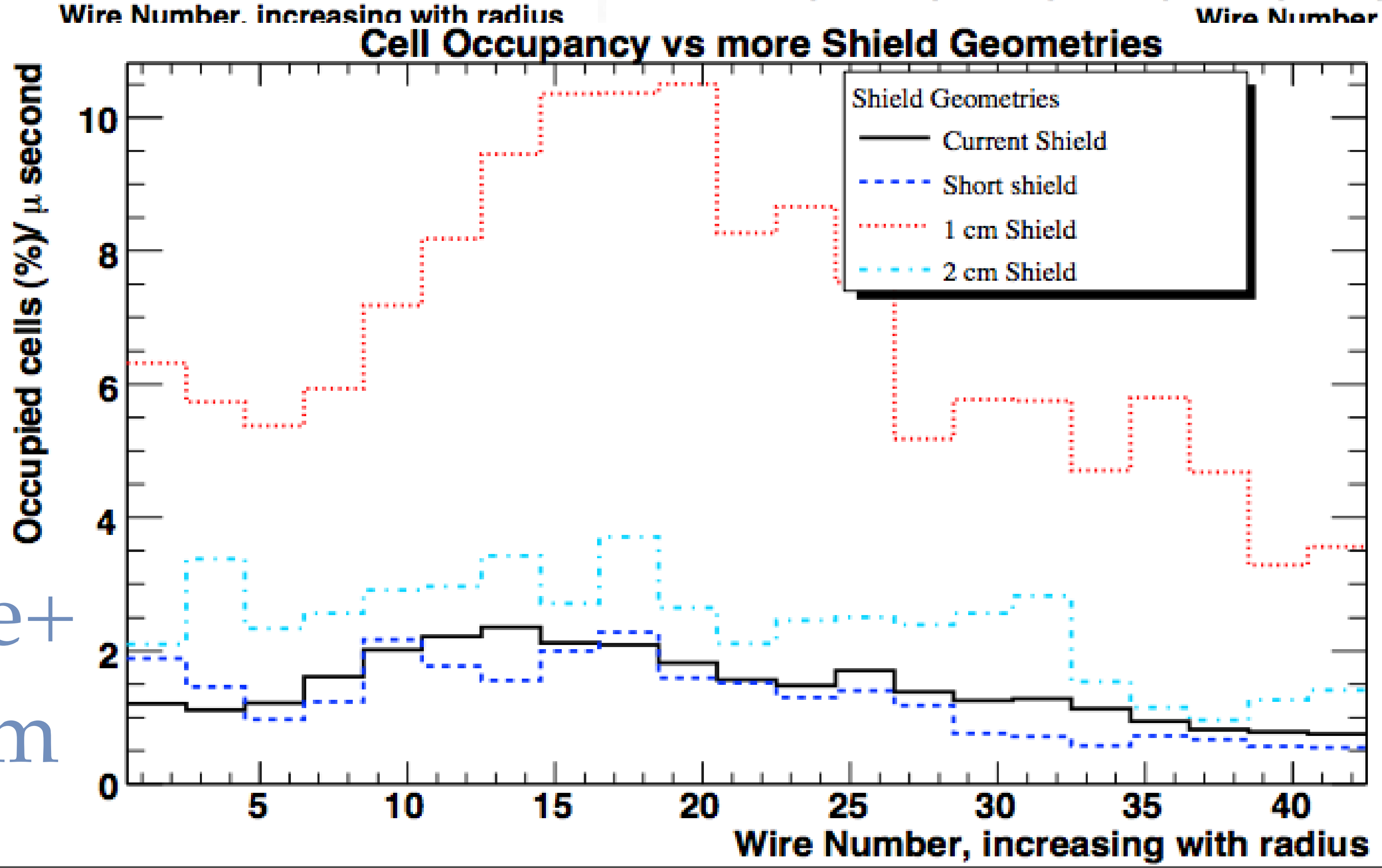


Occupancy vs. Shield Thickness





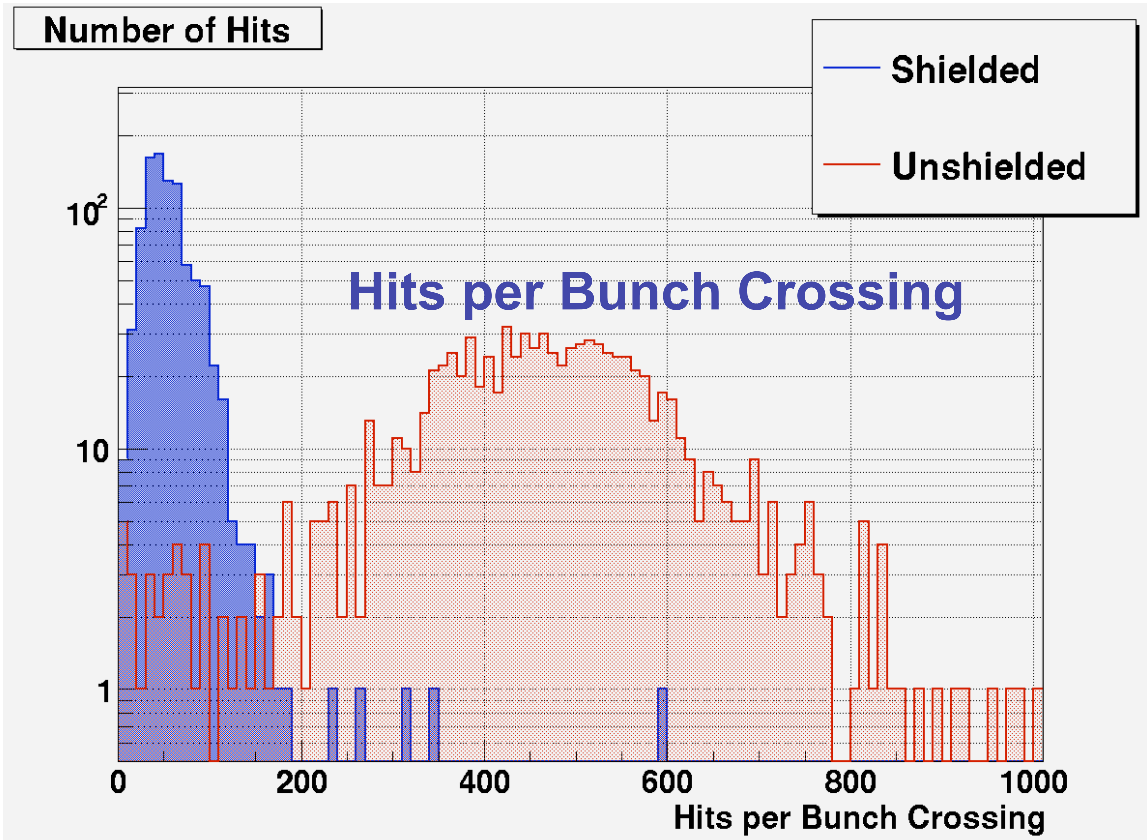
Current shield geometry has a 3 cm thickness

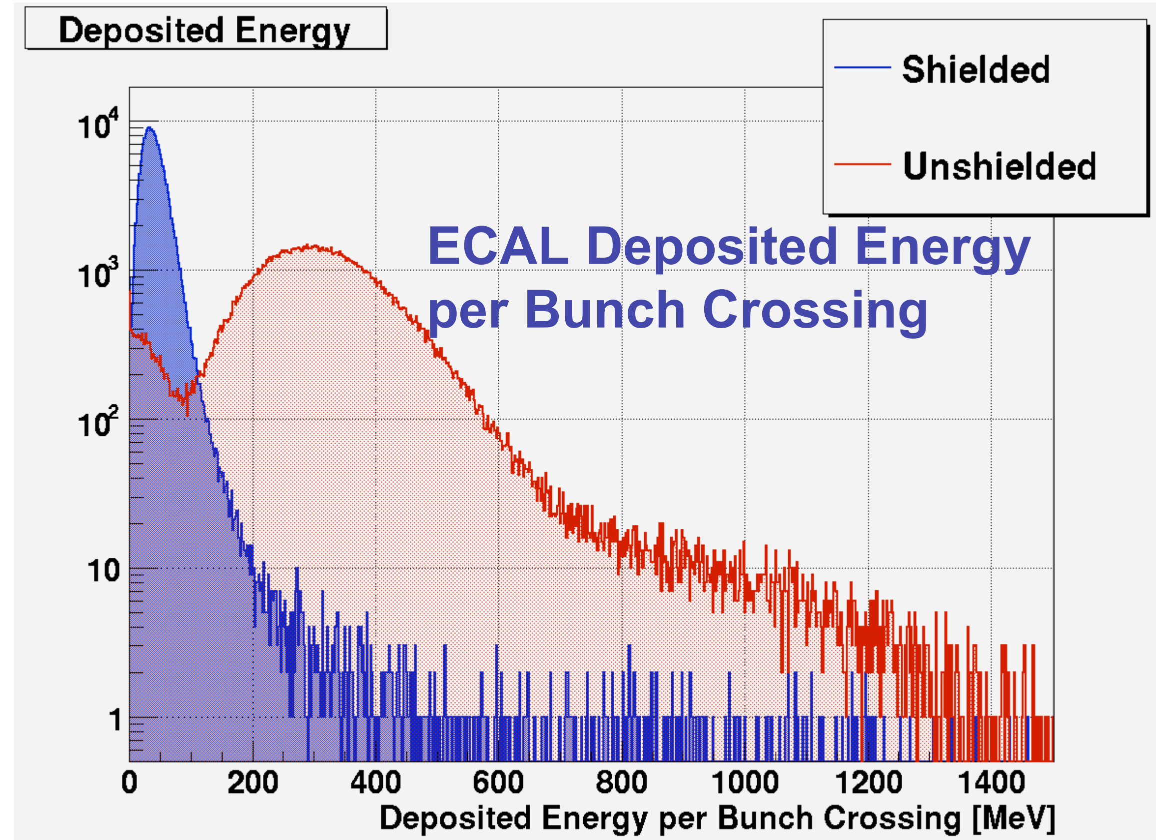


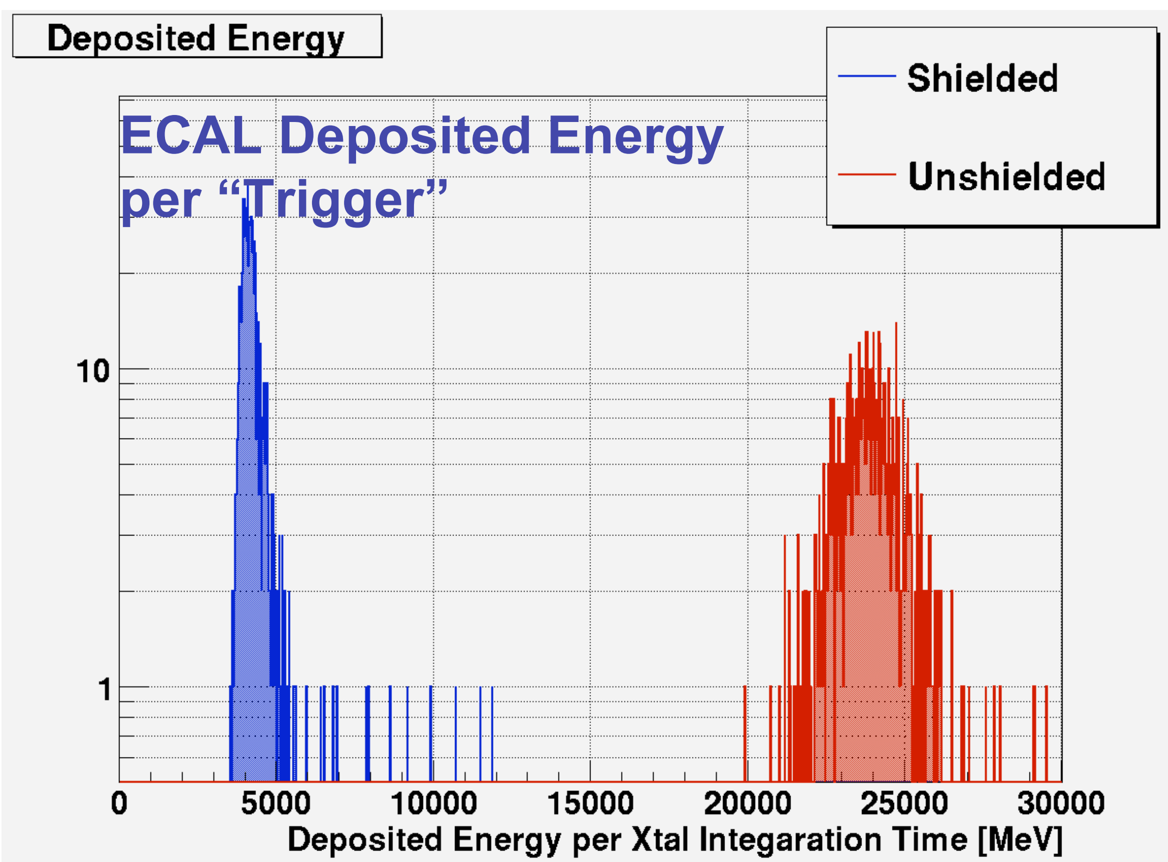
BHwide+
BBBRem

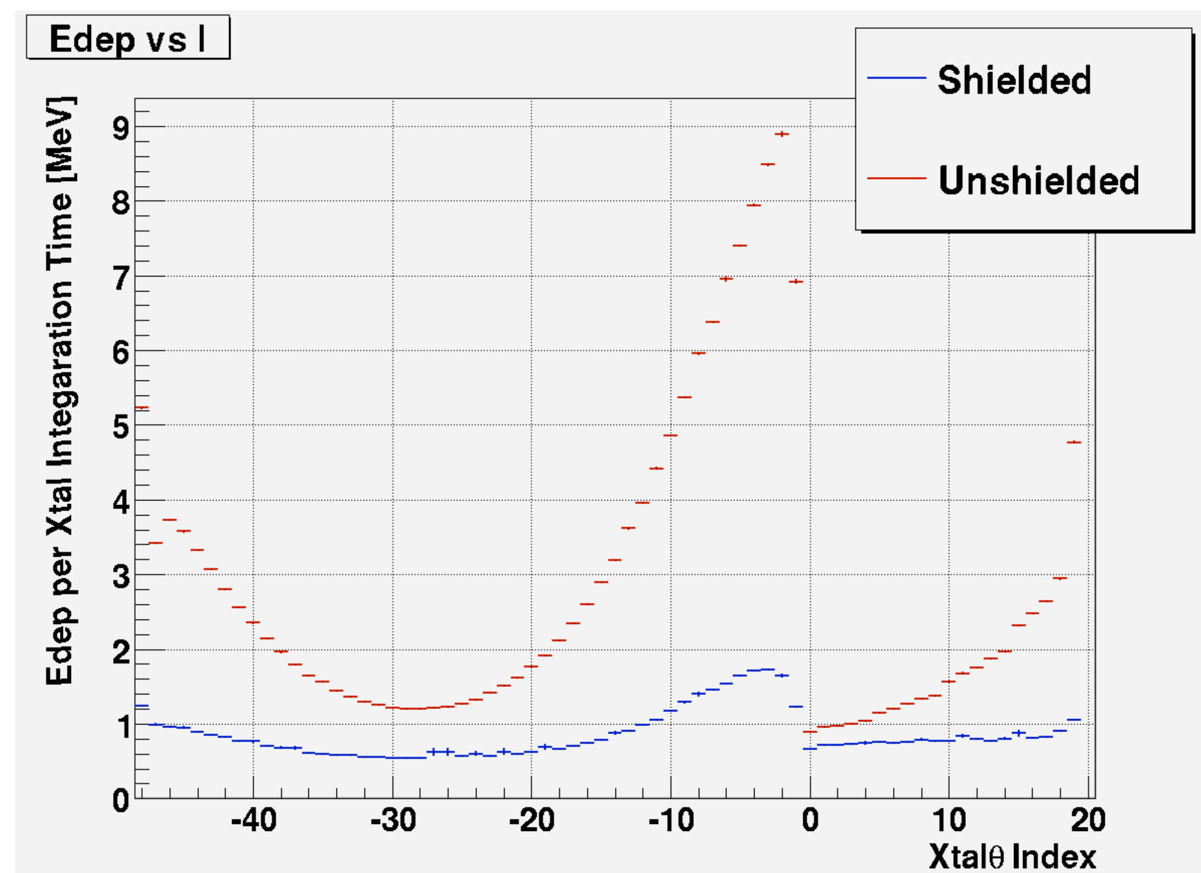
Shielded - Unshielded

Stefano Germani

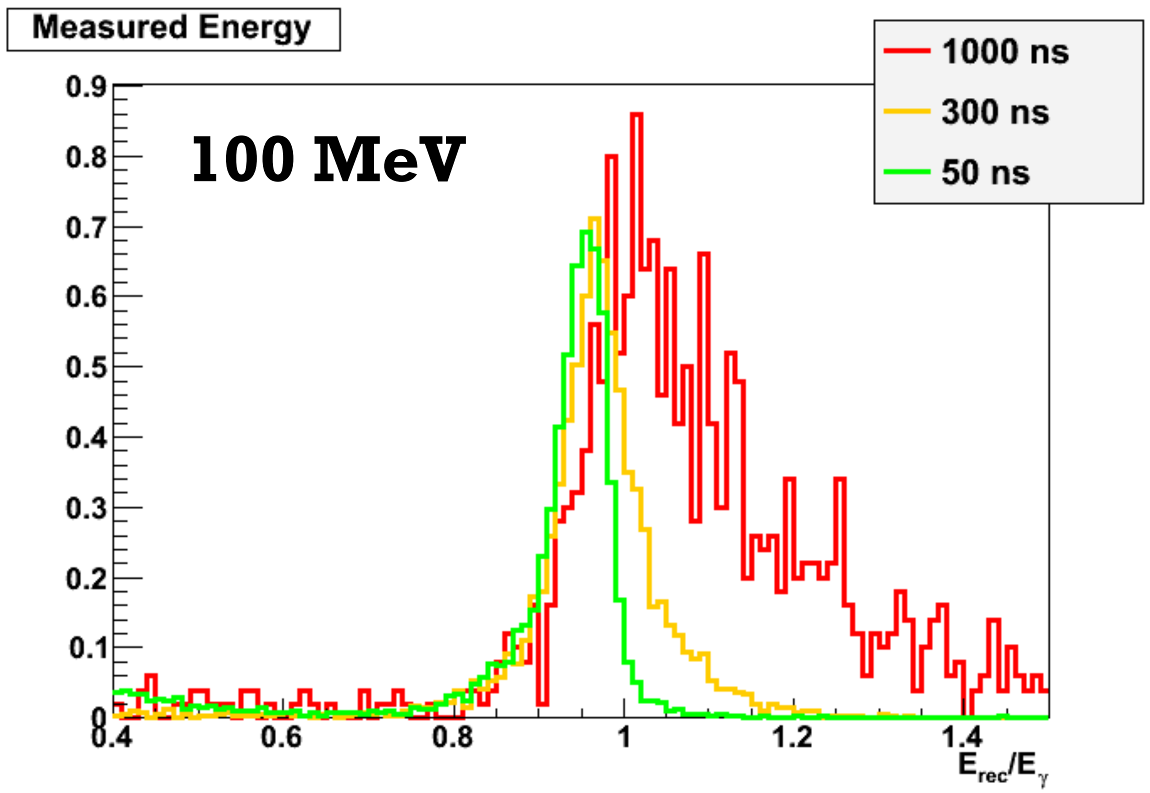


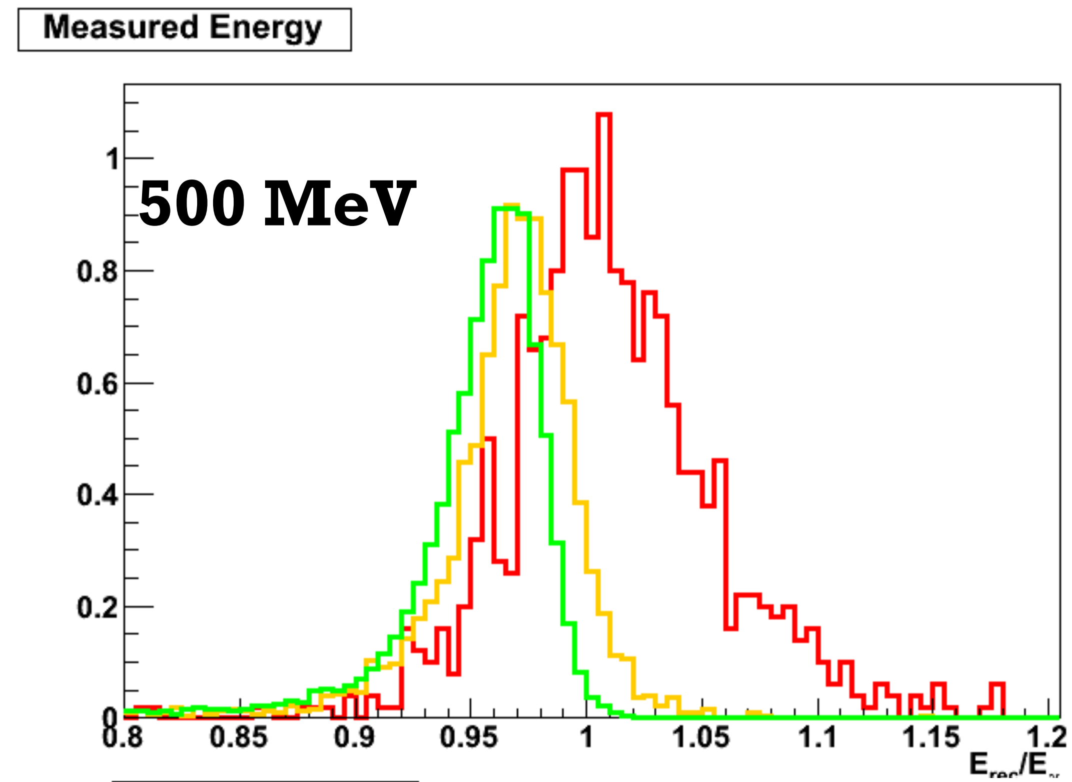


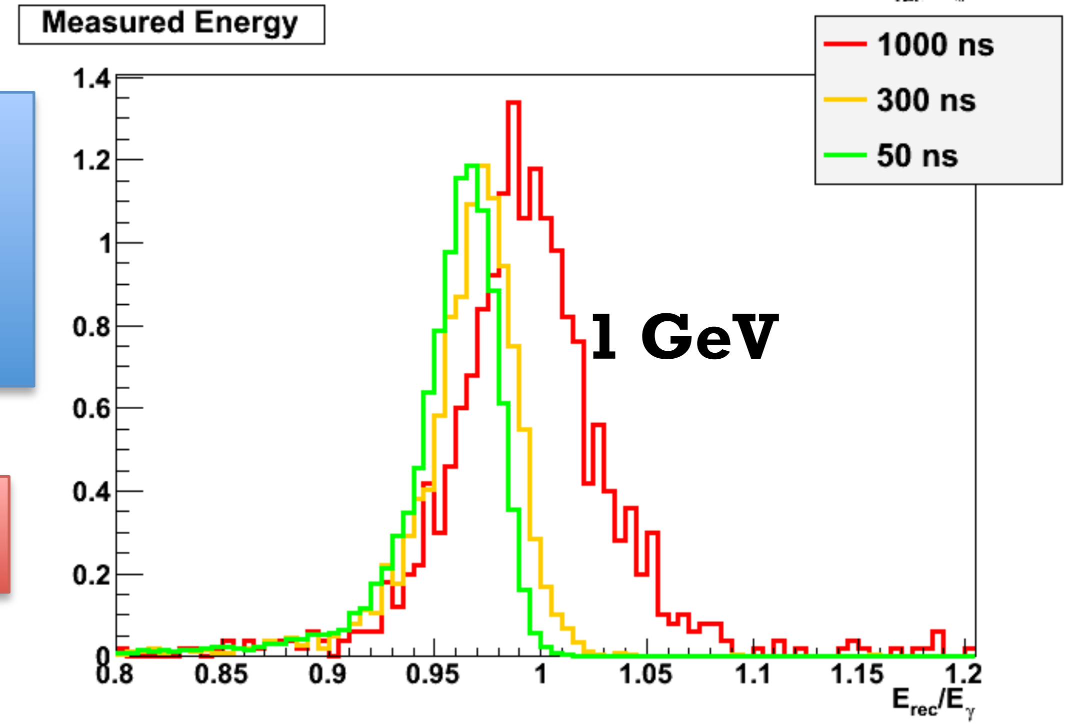




Time Window Width





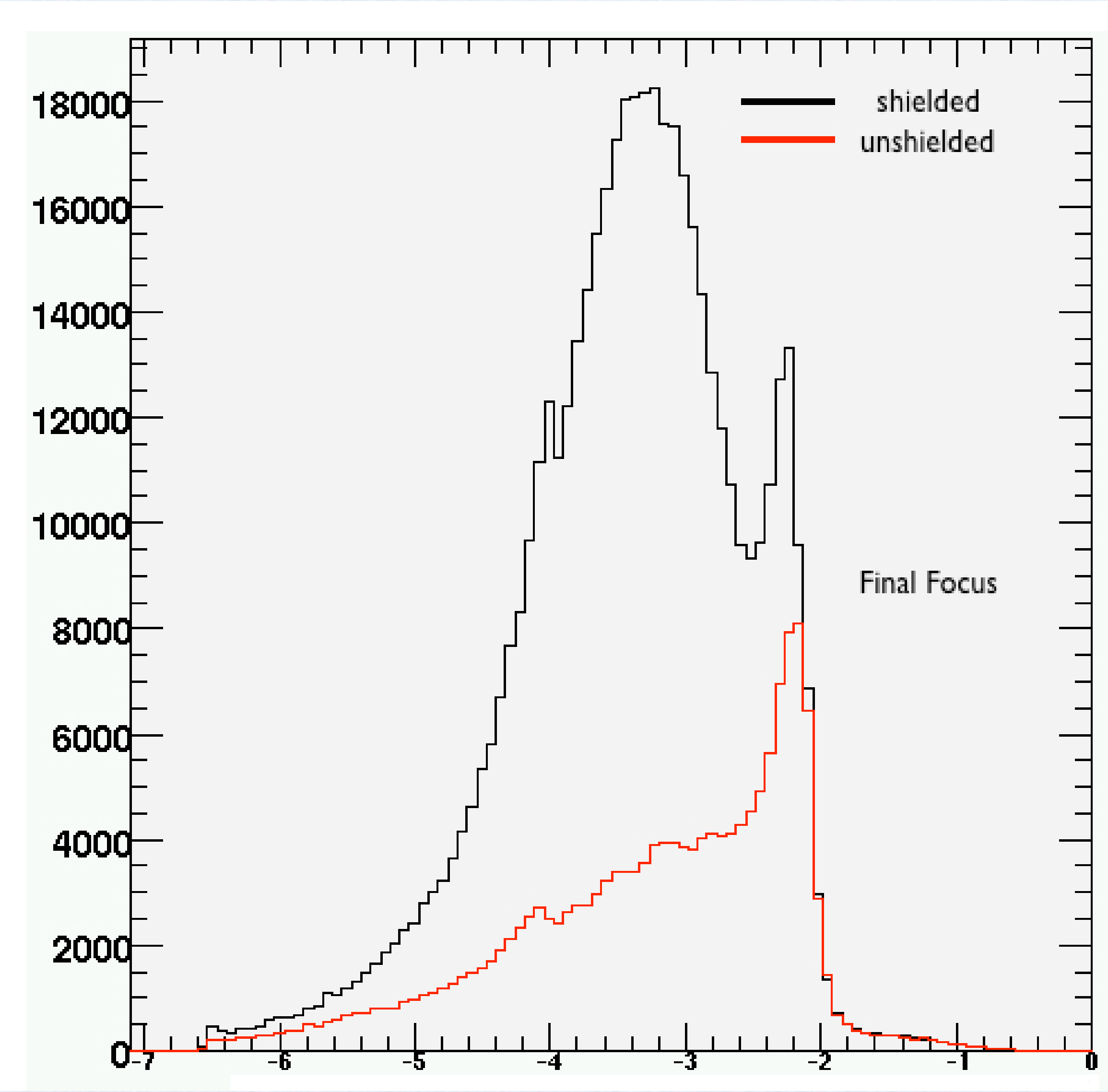


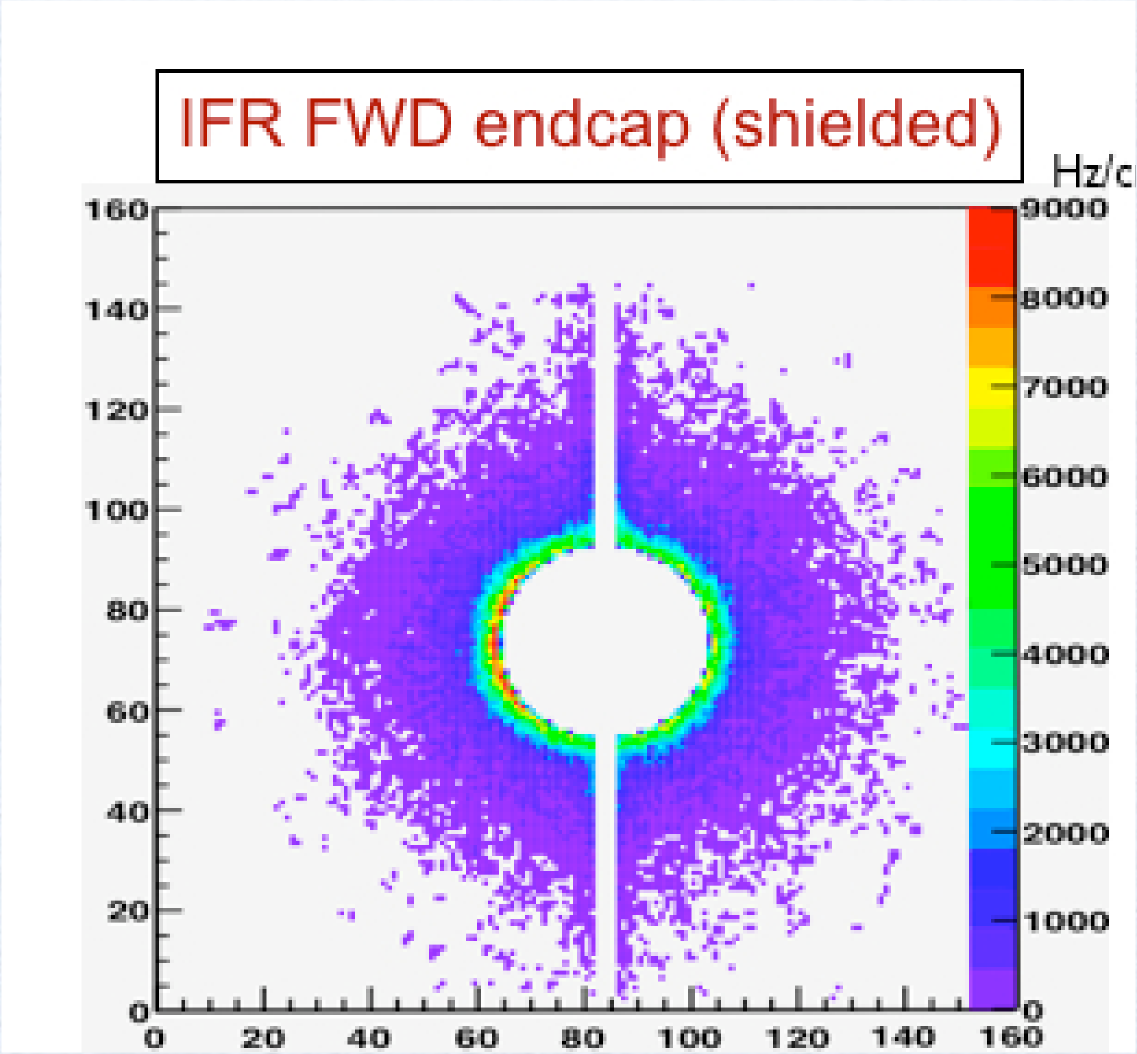
For large windows resolution and distribution shape entirely dominated by background

From Now On Time Window = 300 ns

Shields drawback

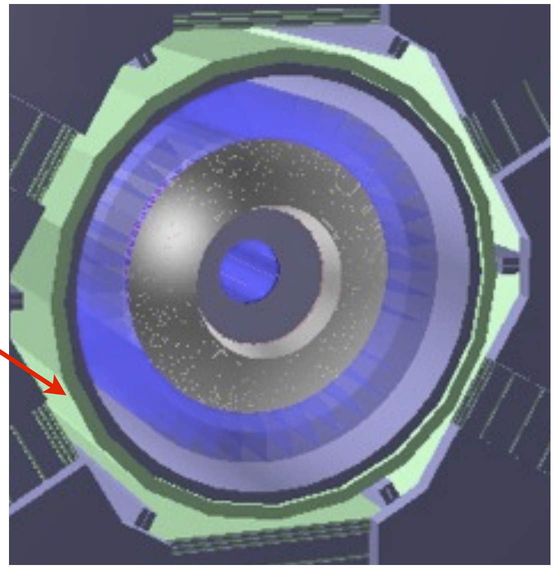
- Shields are very efficient for electrons, photons absorption but they are also efficient neutrons generators

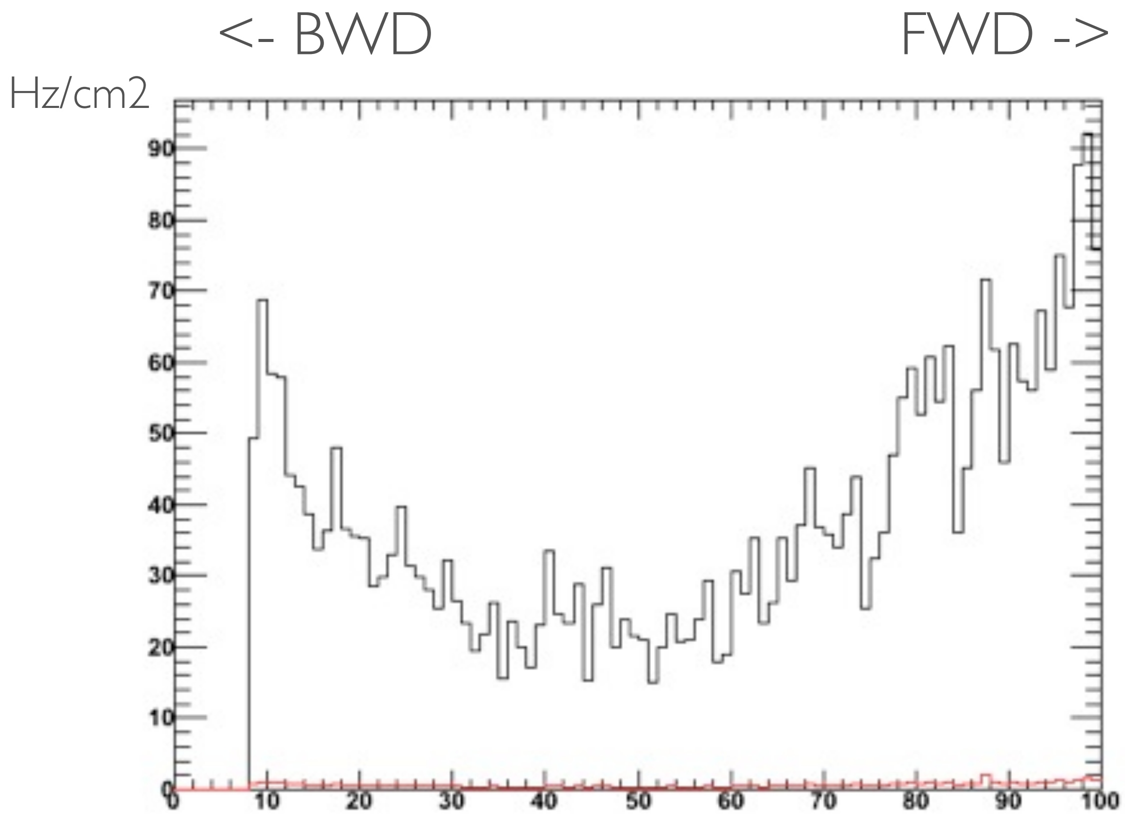




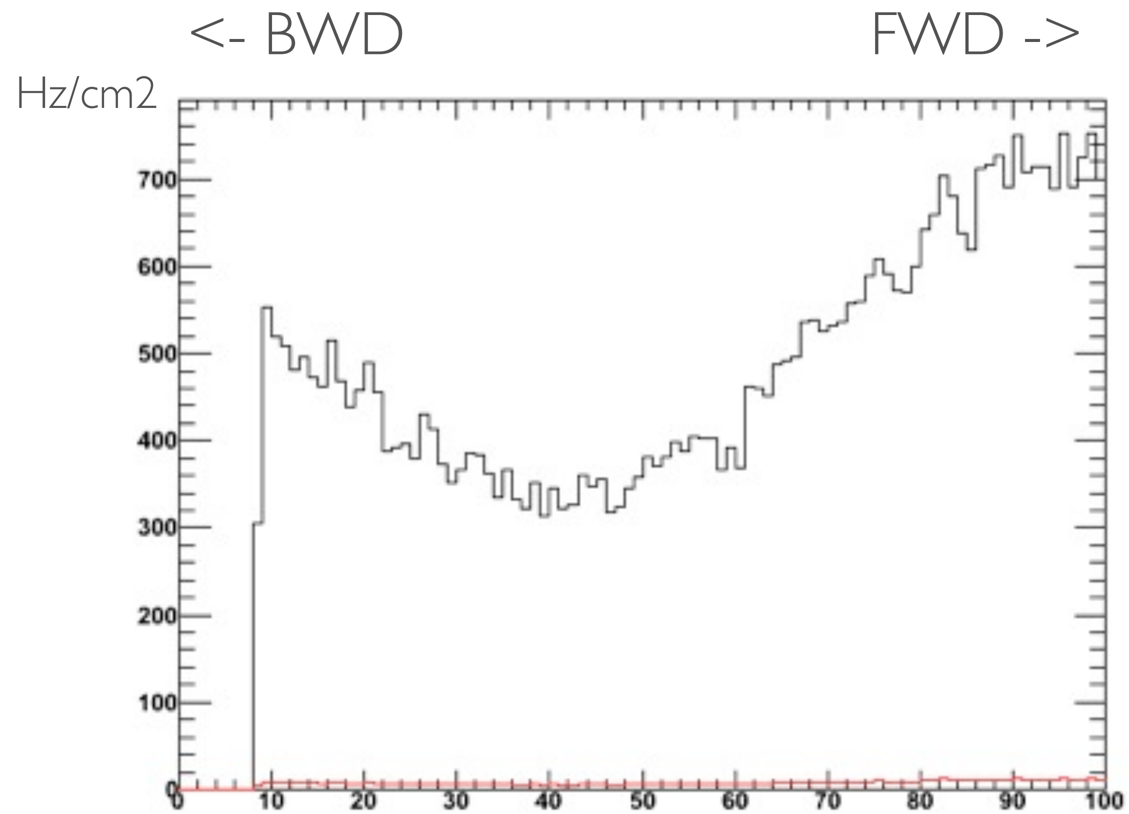
Neutron Shield

A polyethylene
shield has been inserted between
solenoid magnet and barrel.
We want study the impact of this shield
on barrel rate.





Polyethylene
shield



no IFR shield

Factor 10 reduction in the flux

FRASCATI

Pairs production: early days

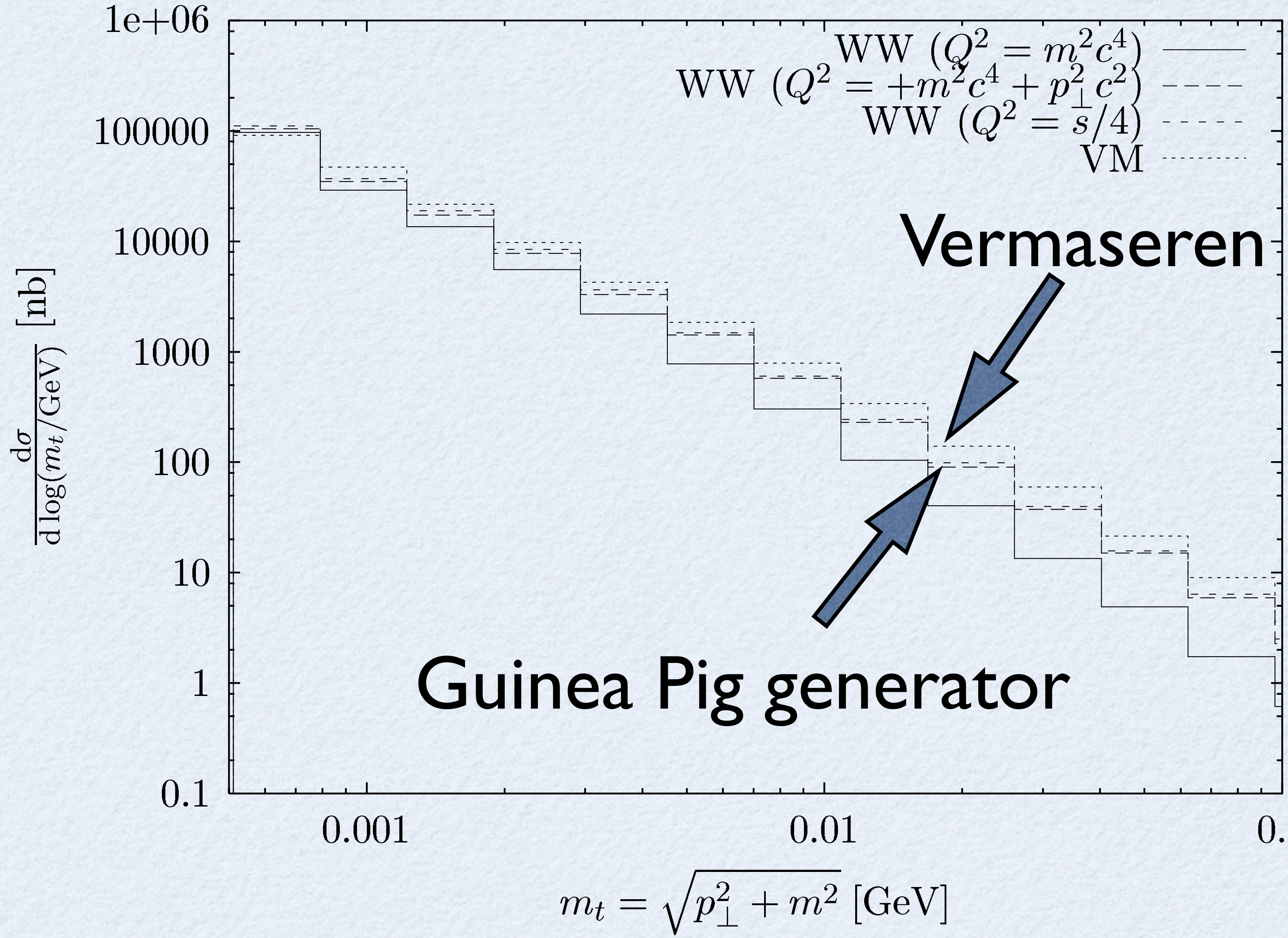


Figure 4.2: The dependence of the pair production cross section on the transverse mass for the equivalent photon approximation (WW) with several different Q^2-scales and the Vermaseren Monte Carlo.

Pairs production: diag36

Diag36
(BaBar)

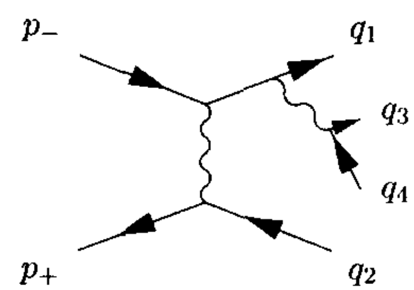


Fig. 1. One of the sixteen bremsstrahlung graphs representing the leading t-channel dynamics.

0.022 mbarn

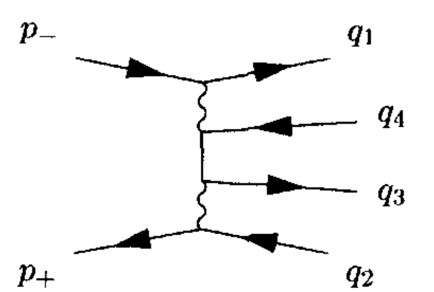


Fig. 2. One of the eight Feynman diagrams for multiperipheral dynamics.

7.27 mbarn

negligible

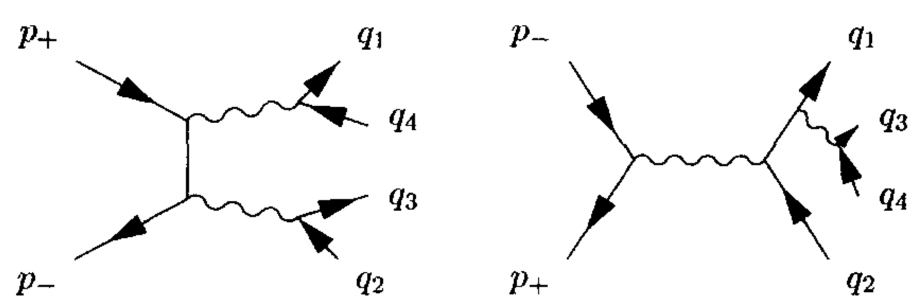
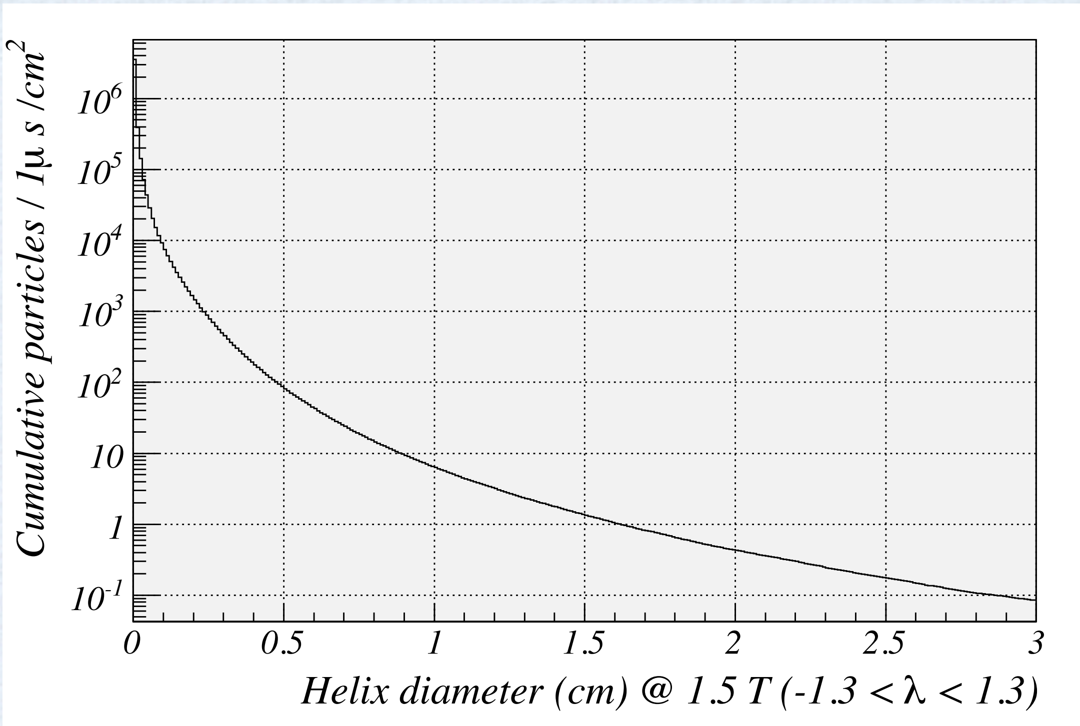
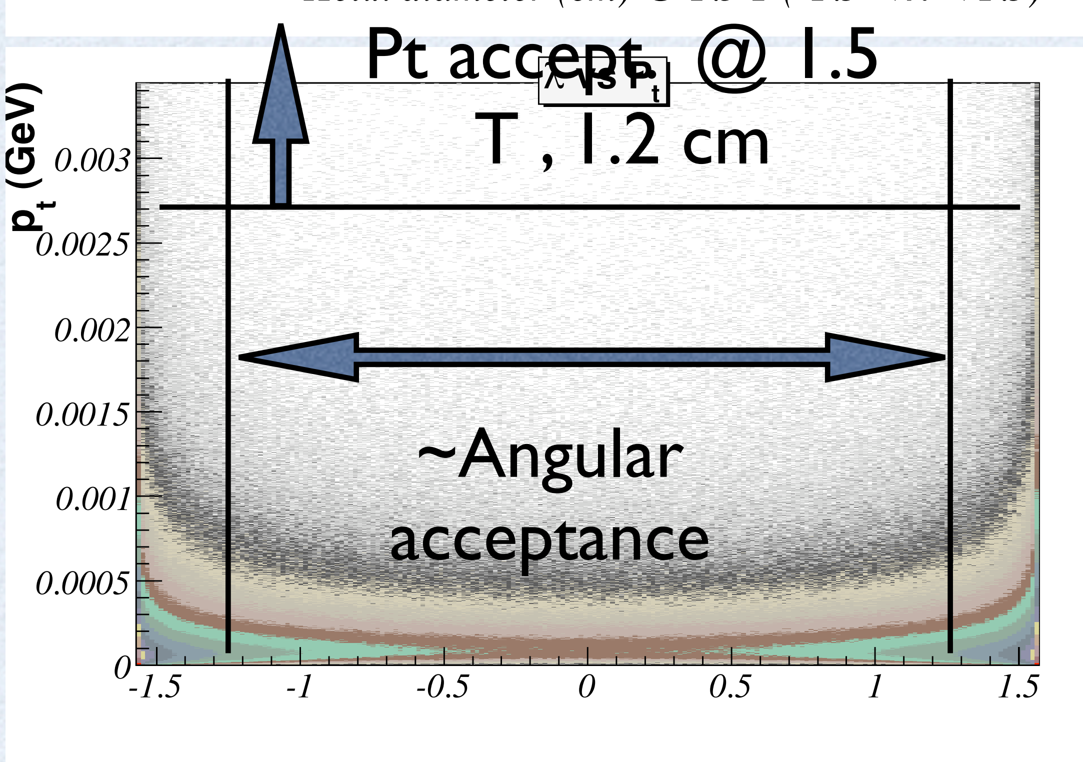


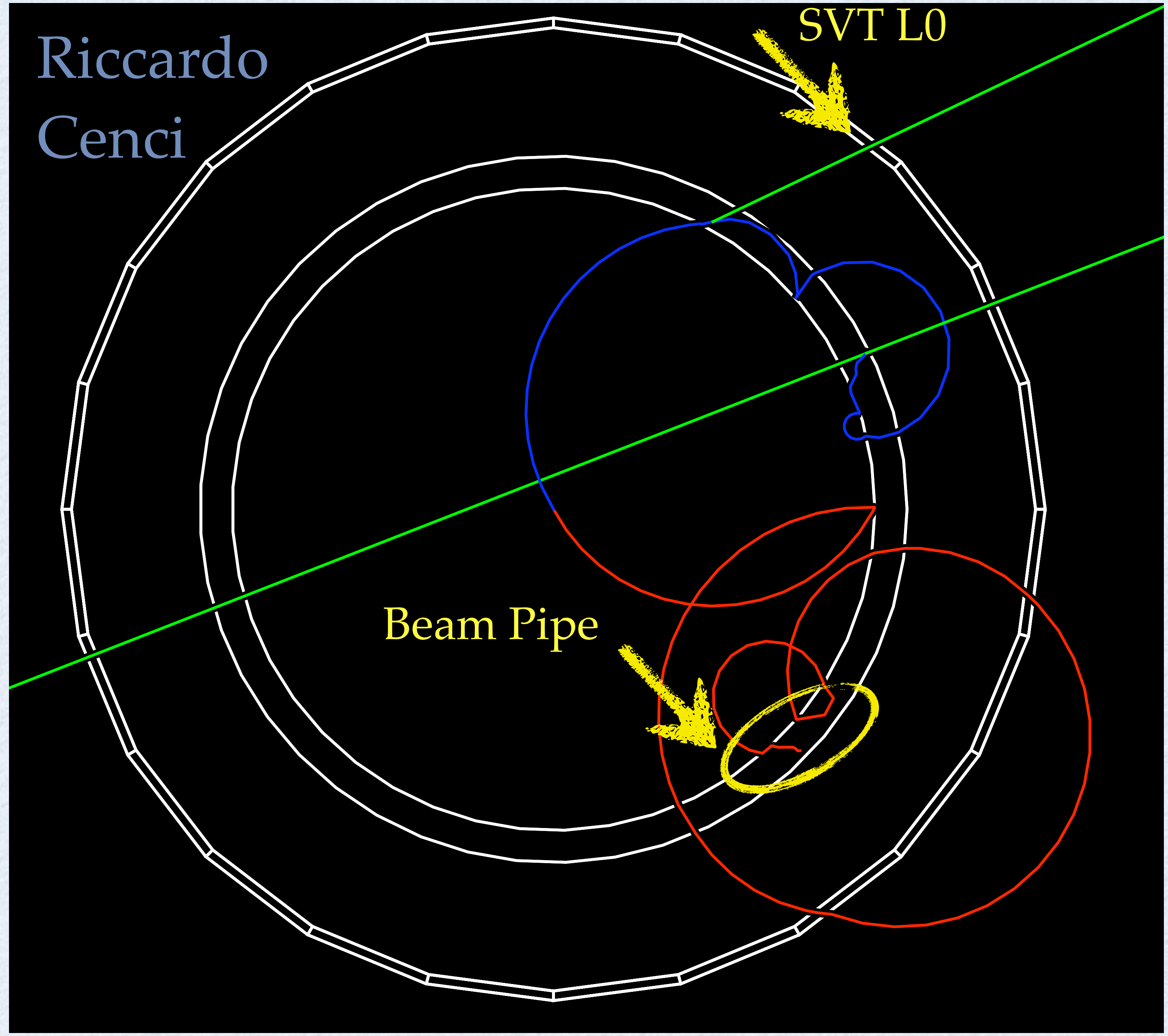
Fig. 3. Two of the twelve Feynman diagrams representing conversion and annihilation dynamics, respectively.

1.1 nbarn

L0 Dominant Bkg.





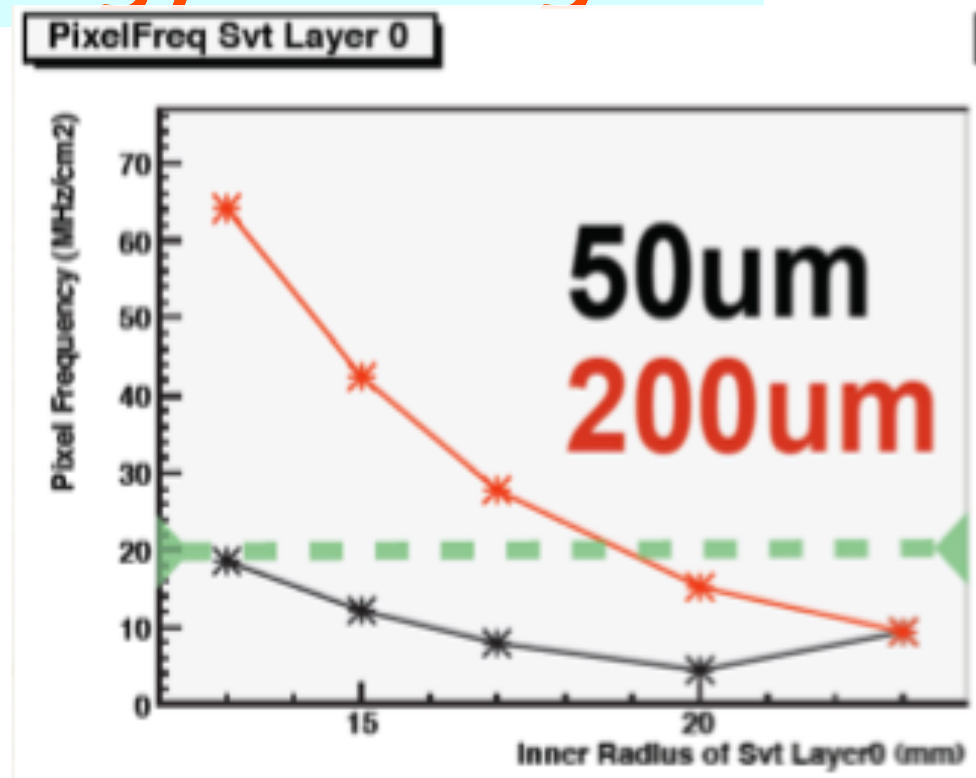


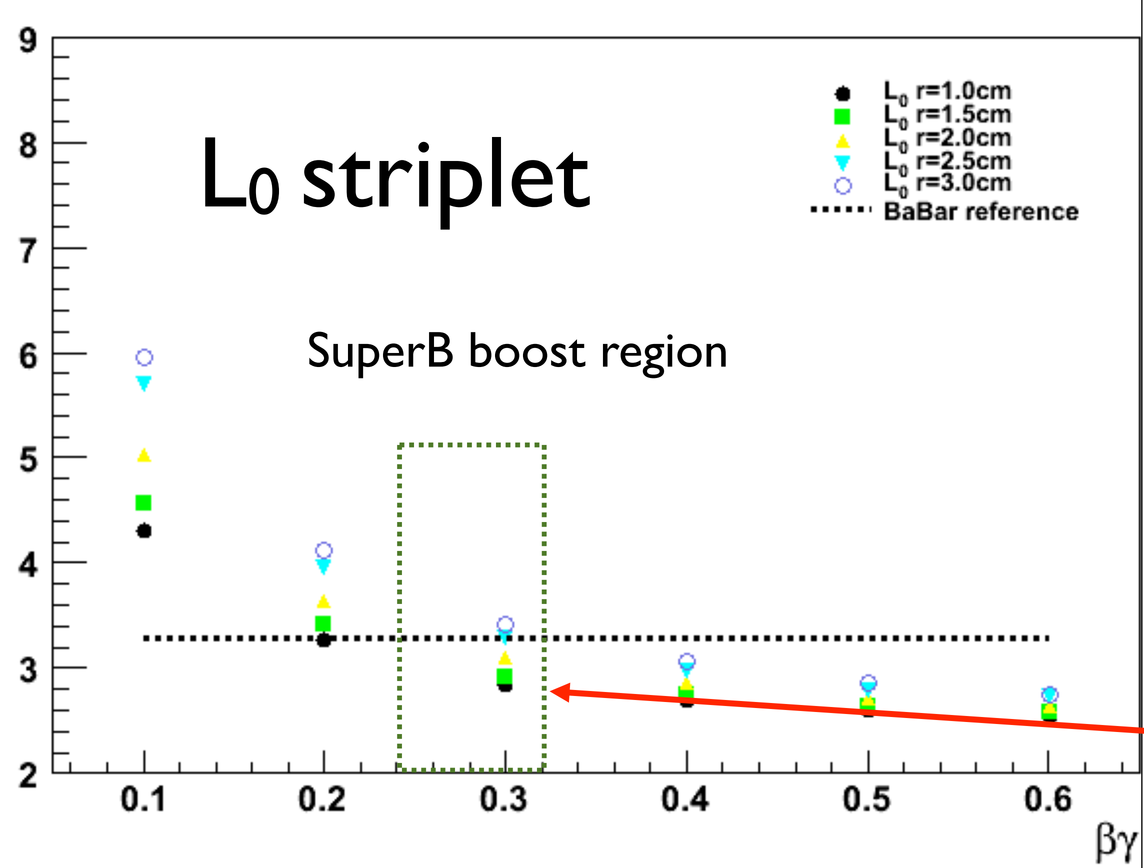
L0 Track rate: Geant4 sim. ~ 8 MHz/cm2

Layer0 radius & technology vs bkg.

Update on background:

- Hit rate vs Layer0 radius from pairs production depends strongly on sensor thickness:
  - on thick sensor larger cluster width for low momentum tracks with large crossing angle
- Large difference for thin pixels (50 um) and striplets (200 um)
- Hybrid pixel with 200 um sensor will be like striplets, unless thinner sensor can be used





Sustainable background hit rate (radius) depends on technology: striplets vs pixel area and readout chip.

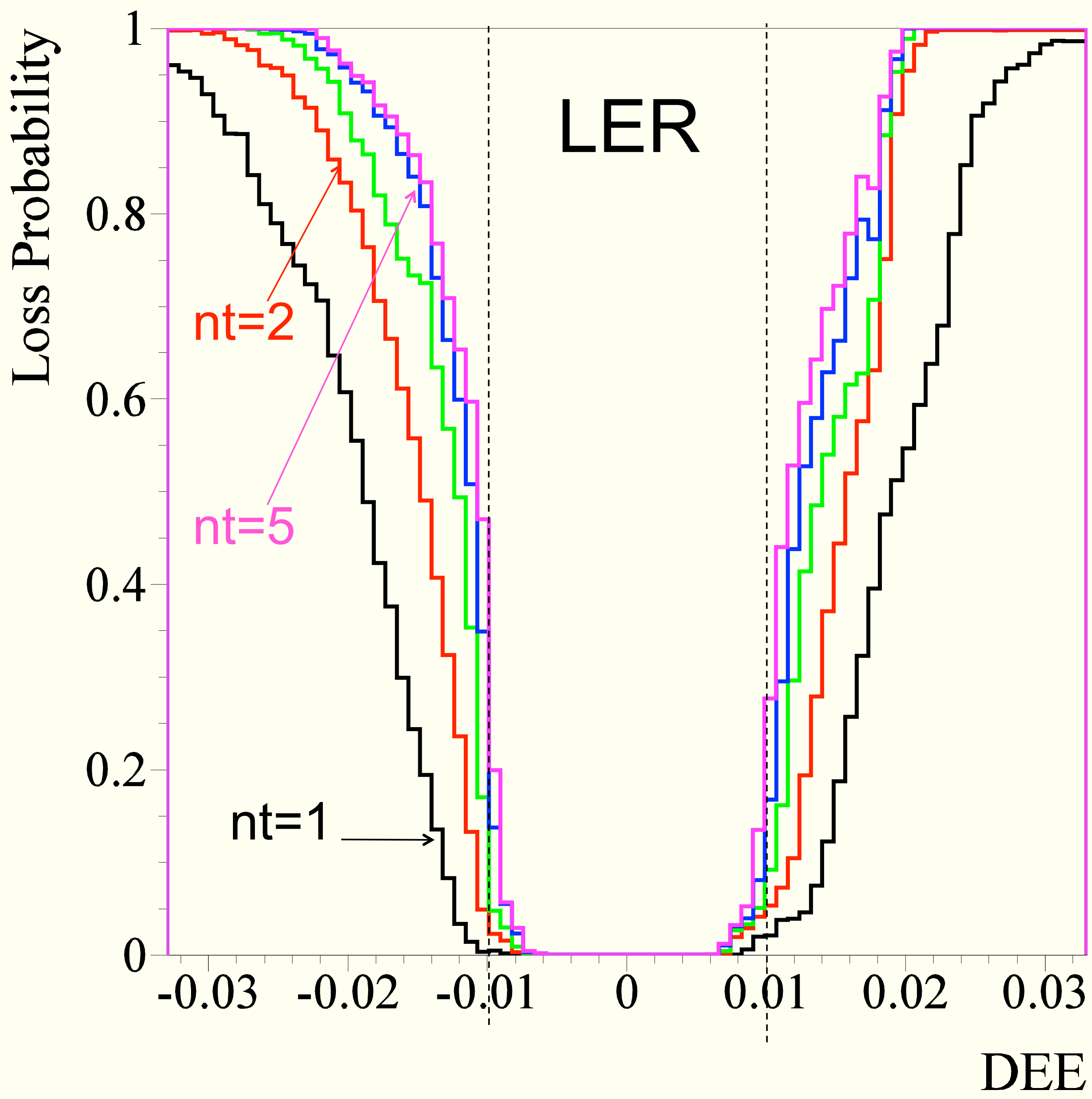
- Development of thin pixel chip readout architecture continue: data push and triggered with target 100MHz/cm2 (safety x5 included) with timestamp 100 ns. → R~1.3cm
  - Still to demonstrate: scaling to large matrix, rad hardness for MAPS,
- Assumed 100MHz/cm2 hard limit for striplets (~ 10% occupancy in 100 ns, area~10^{-2} cm^{-2}) → R~2 cm
  - performance similar to BaBar and thin pixel at lower radius. No margin left!

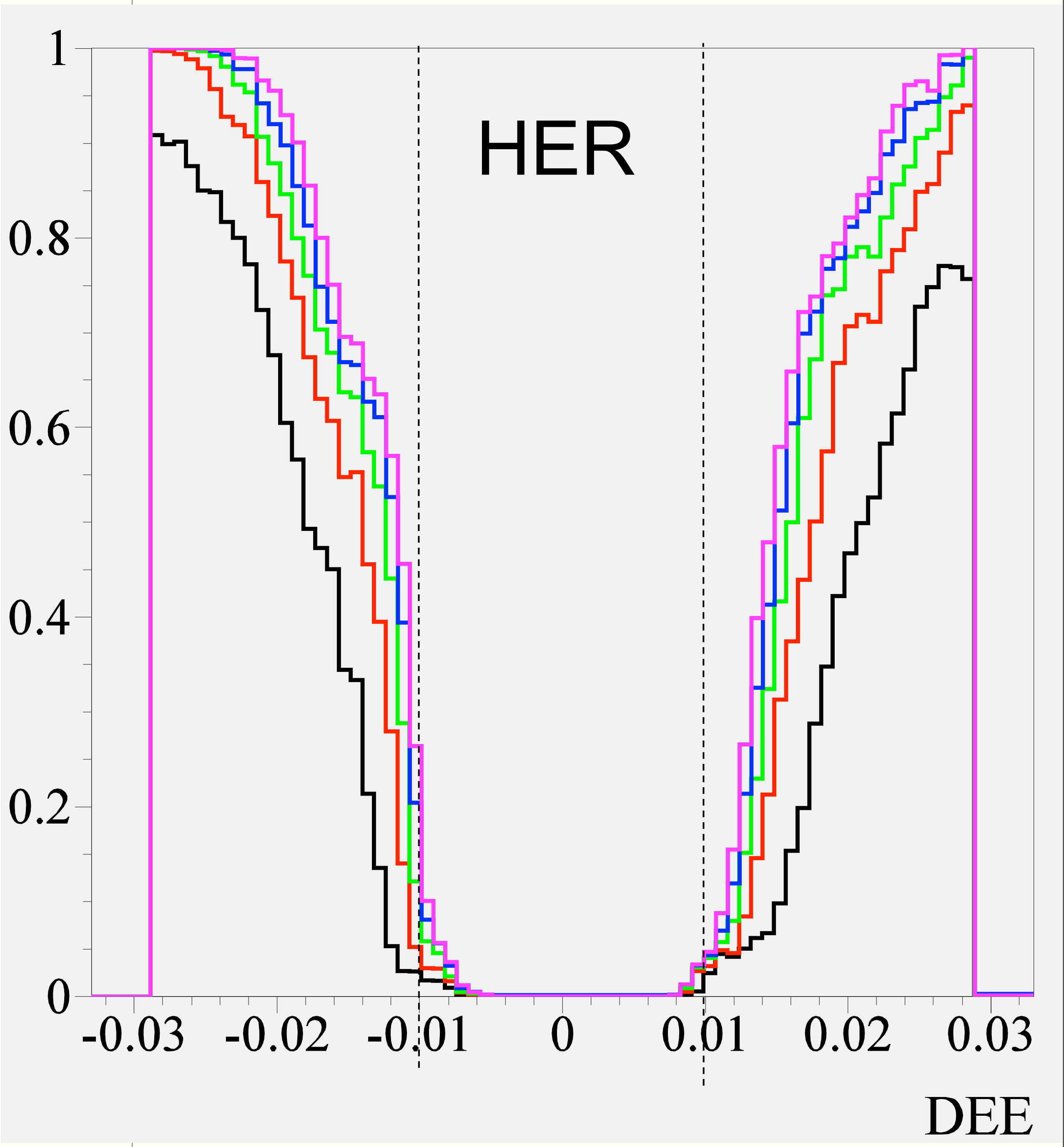
TOUSCHEK BACKGROUND

LER energy acceptance

No IBS, ε_x=1.8nm

Consistent with DA calculations: LER Dynamic Aperture ≈ 20% lower than HER Dynamic Aperture

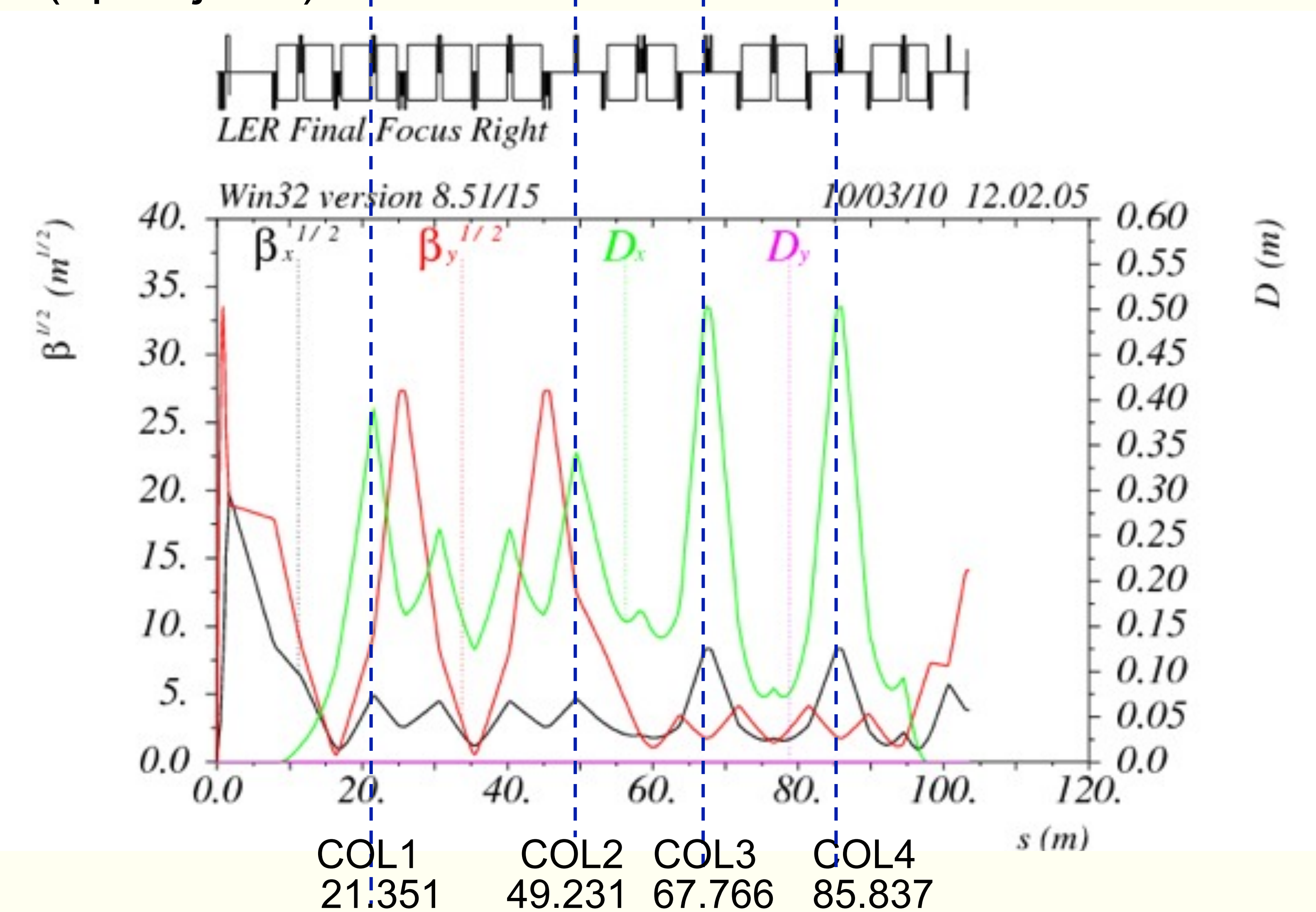


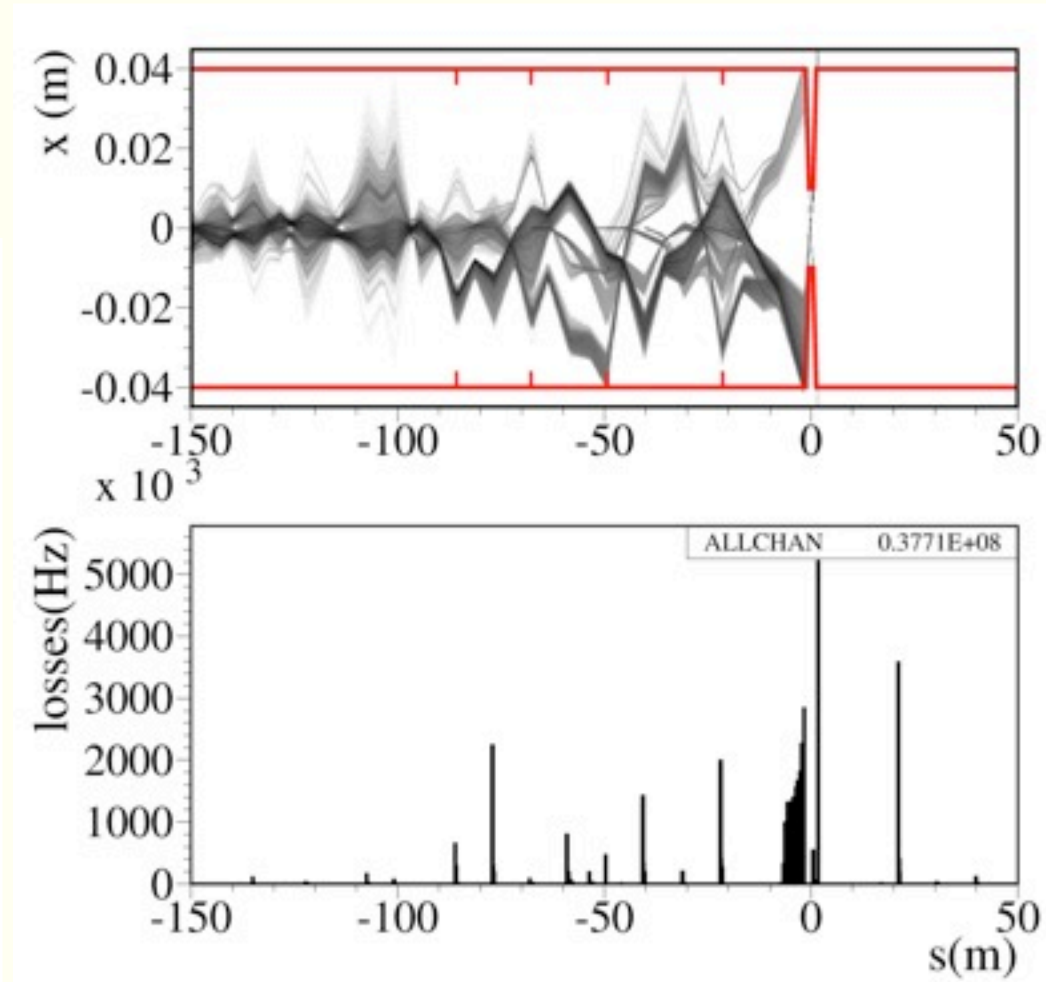


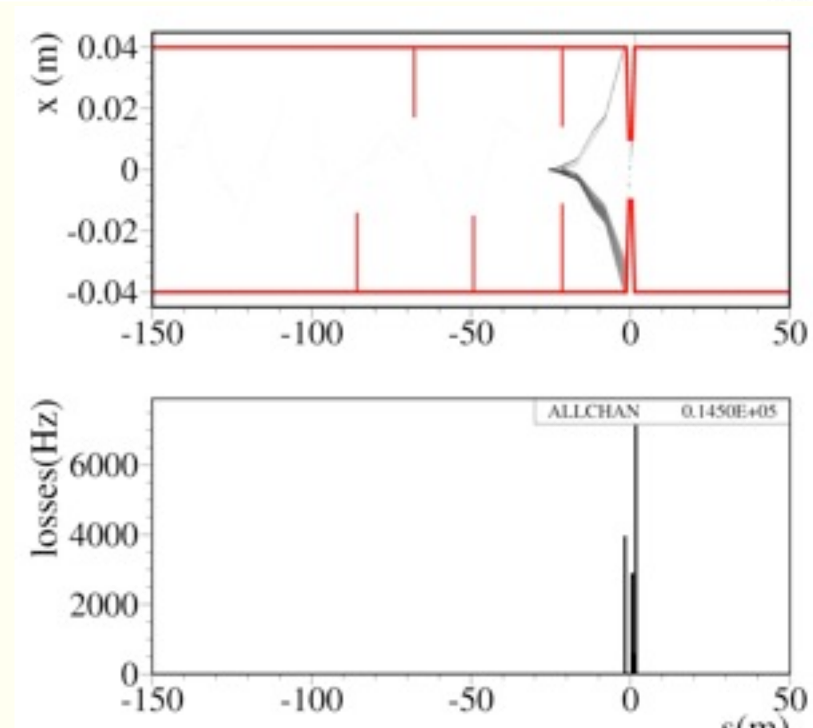
LER Losses

τ_{TOU} = 356 s (5.9 min)

IR losses = 8.6 MHz |s|≤2 nt =1-5
(open jaws)







IR losses = 14.5 kHz/bunch
nt =1-5 (jaws closed)

Conclusions

- An extensive set of tools have been developed to simulate backgrounds in SuperB
- Work in progress
- Intensity dependent backgrounds seems manageable
- The luminosity scaling component does not leave much phase space for sloppy design