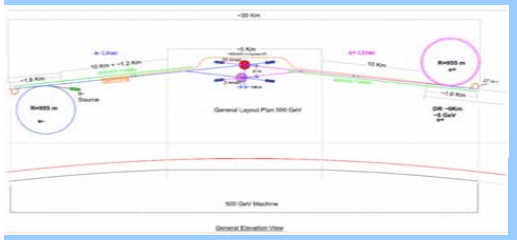

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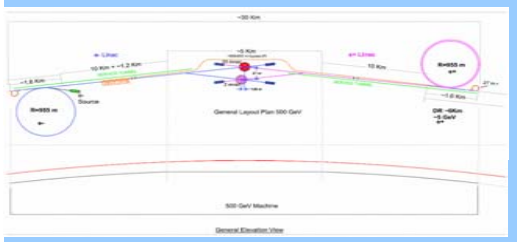
The BeamCal Simulation Project Progress Report

Tera Dunn, Jack Gill, Gleb Oleinik, Uriel Nauenberg, Jiaxin Yu, Francis Yi

University of Colorado at Boulder



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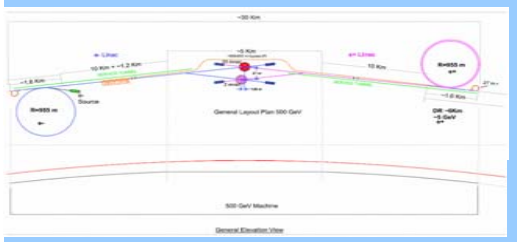
The FCAL Collaboration



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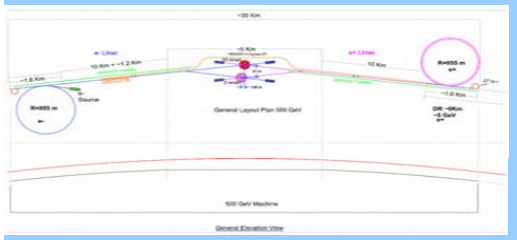
SUPERSYMMETRY STUDIES

- ***Began working in 1994.***
- ***Began working with undergraduates in 1996. First report by students in 1998. Presently we work with 5 to 8 students per year. Most stay with us through 3 years. Involved about 50 students to date.***
- ***Reports presented on the web***

http://hep-www.colorado.edu/SUSY



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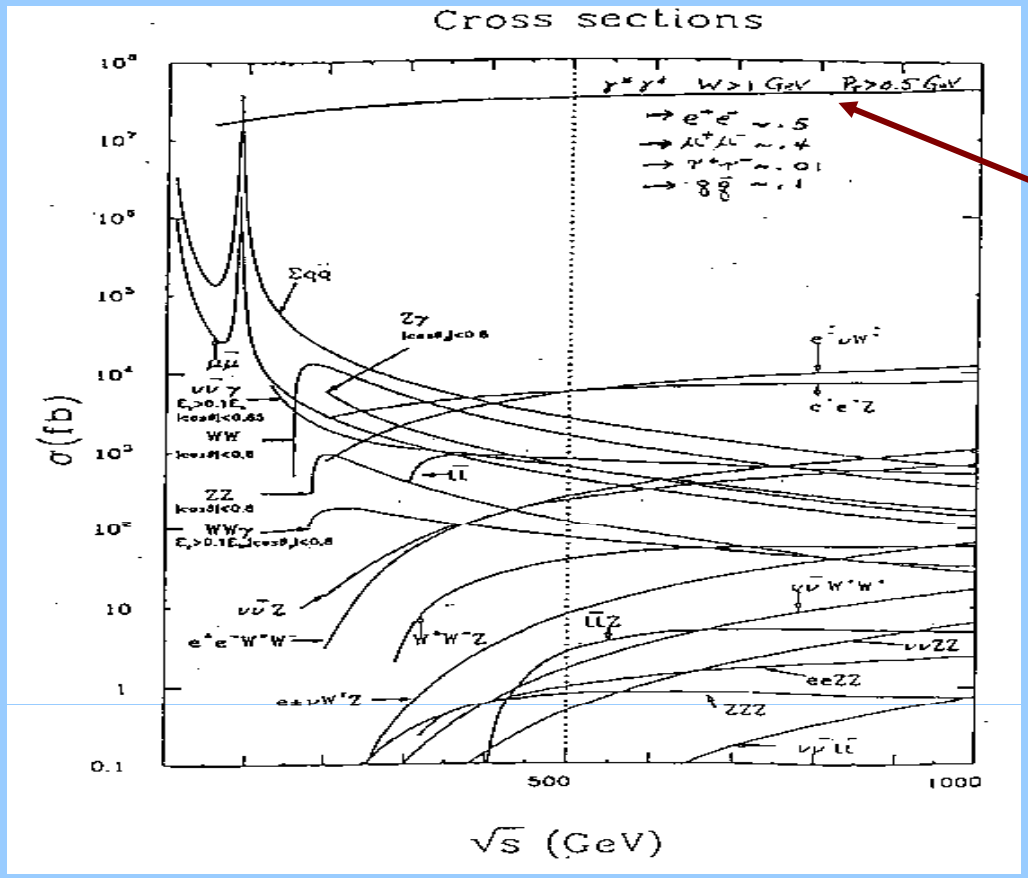
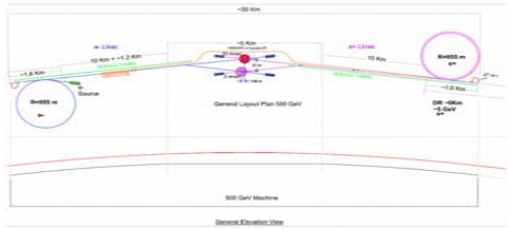
Beam Calorimeter Studies

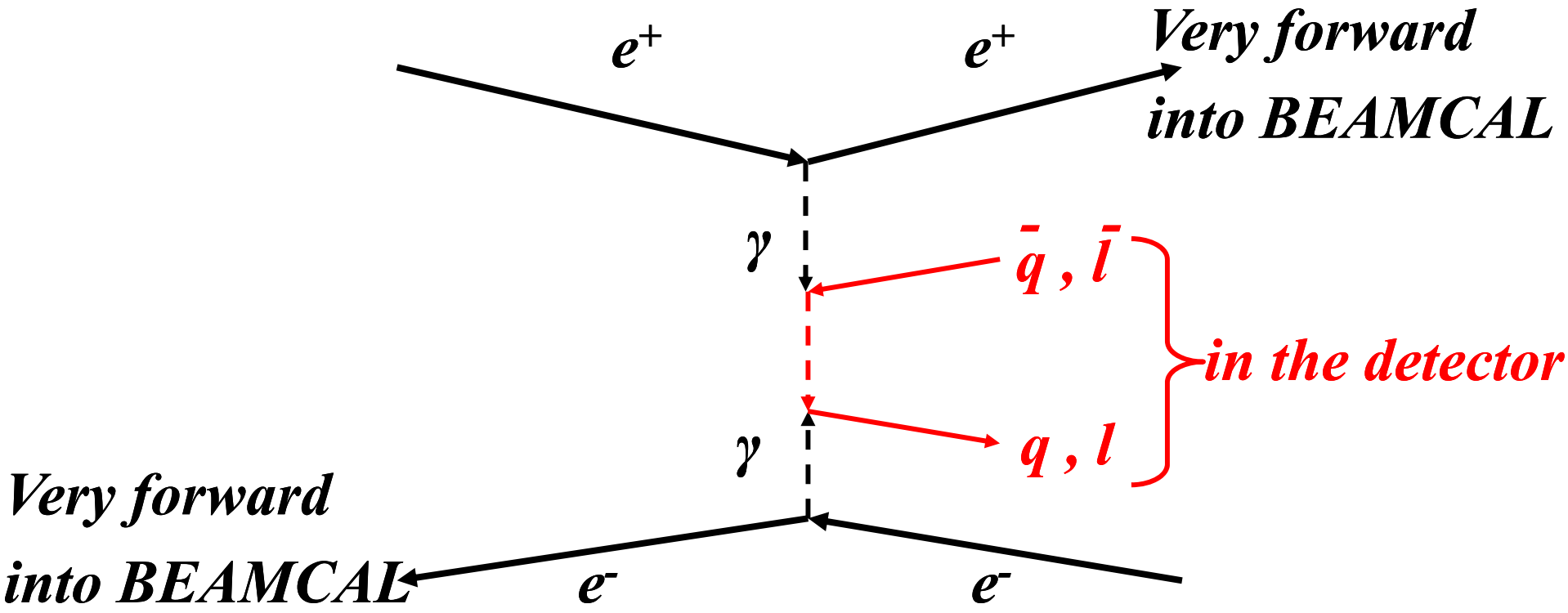


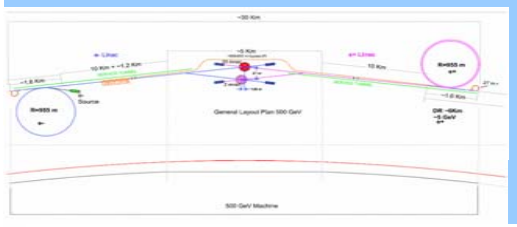
Two photon process cross section about 10^5 larger than SUSY cross section. Serious source of background for SUSY if not tagged .

Pointed out by our group around 1998



2 Photon Process





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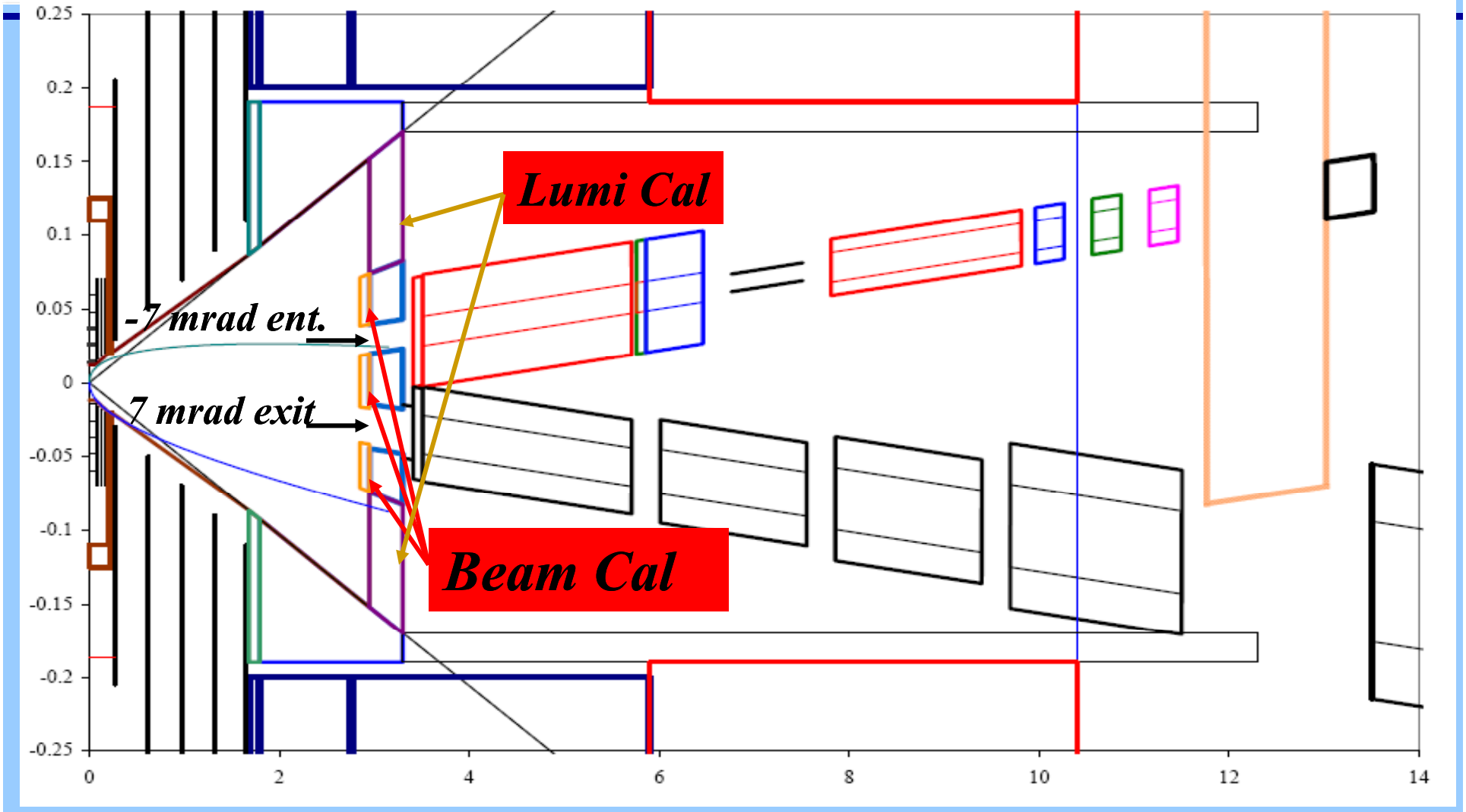

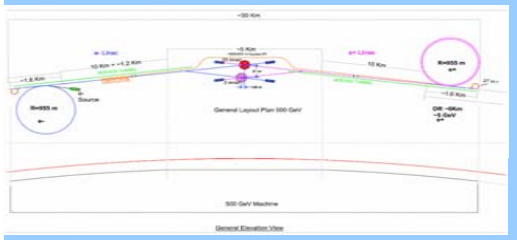

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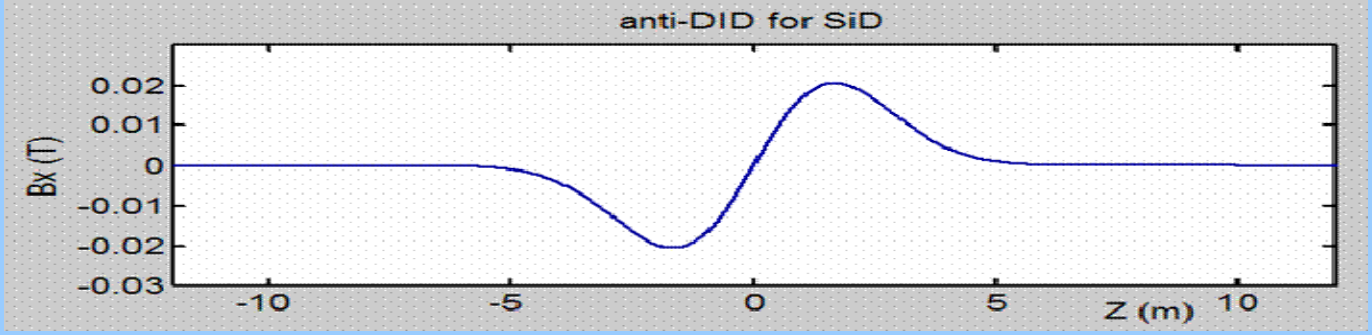
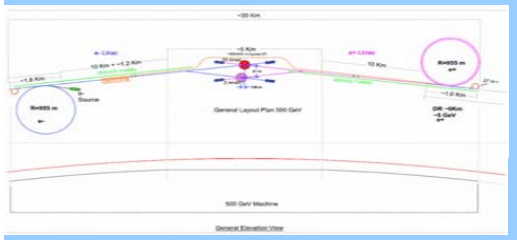
Solenoid field keeps the low energy charged particle in the forward direction. Beam hole is at 7 mrad. Need to add an x field component to move low energy charged particles in the 7 mrad direction. Anti-DiD dipole field proposed by Andrei Seryi.





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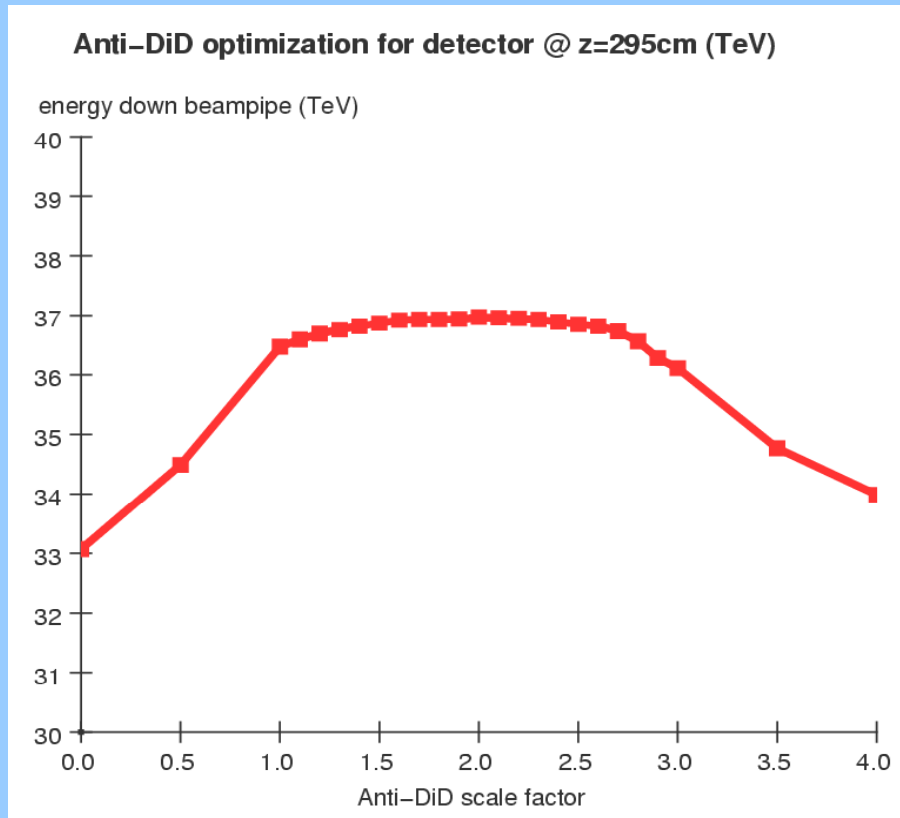

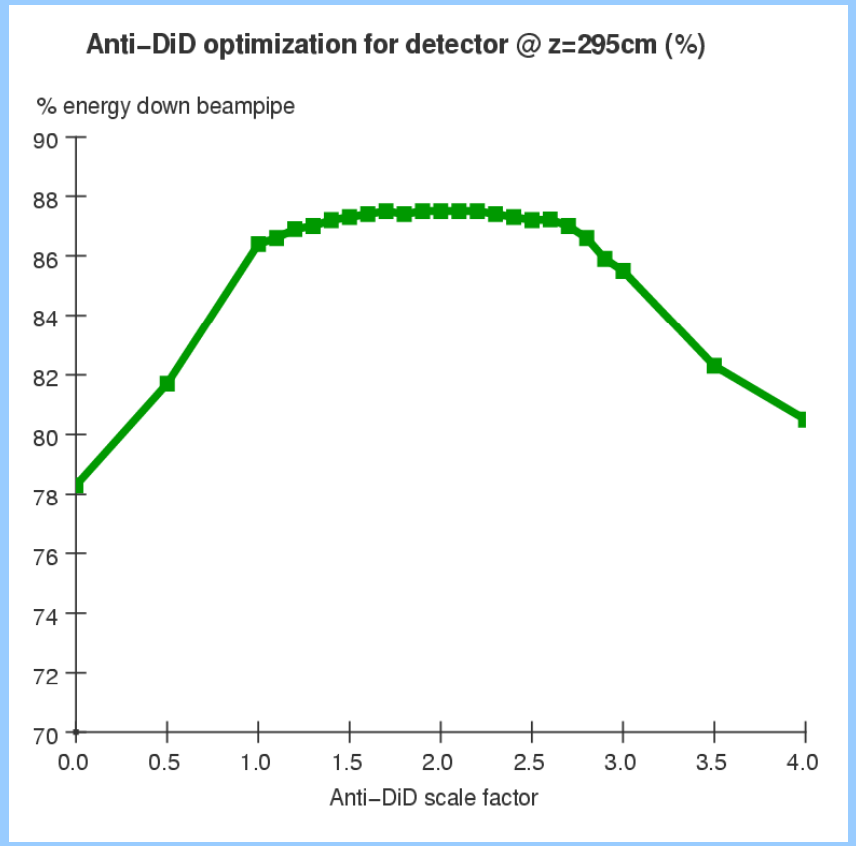

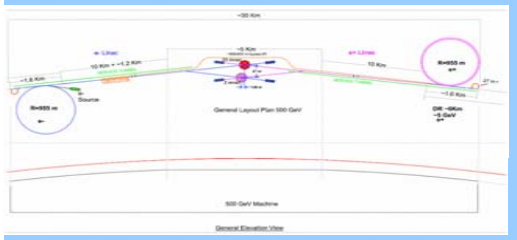

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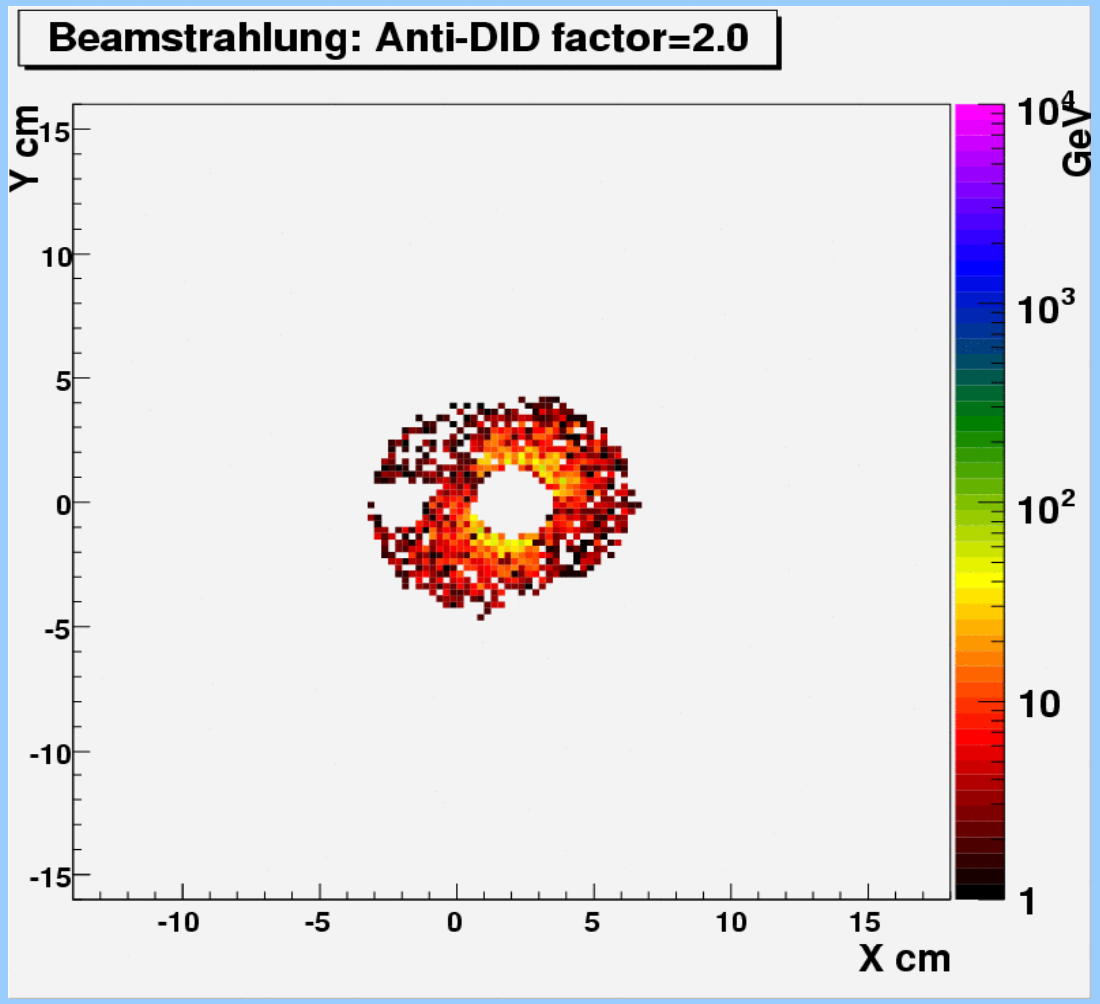
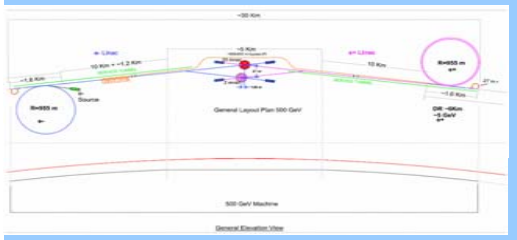


Beamstrahlung e^+e^- pairs. Energy deposited in 0.25 x0.25 cm^2 cells.



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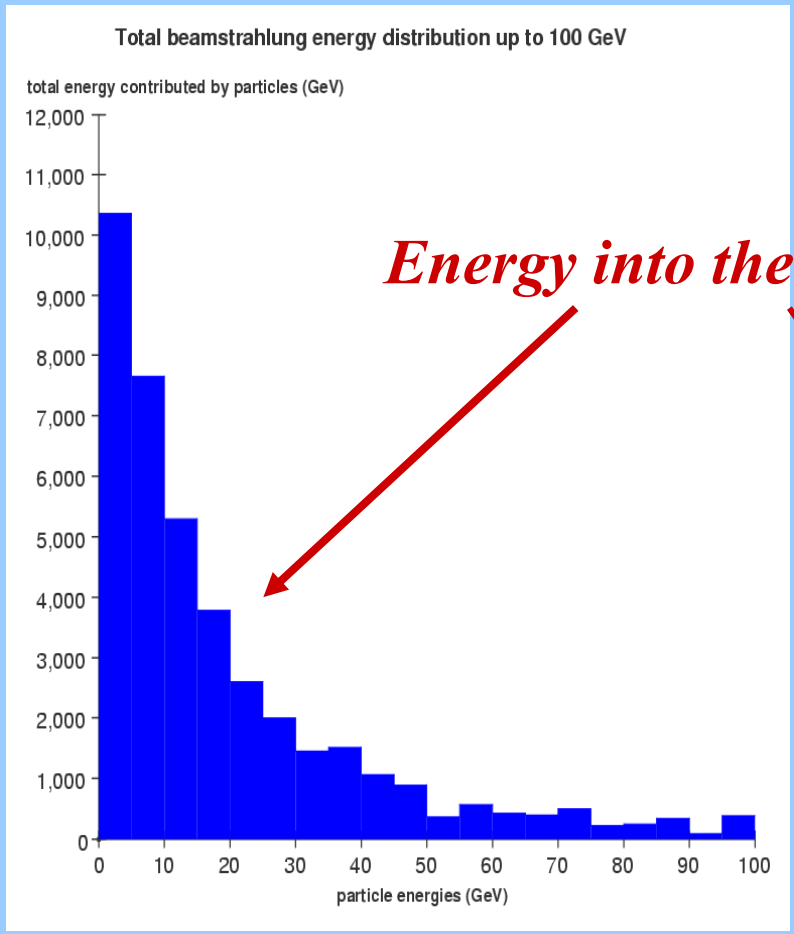
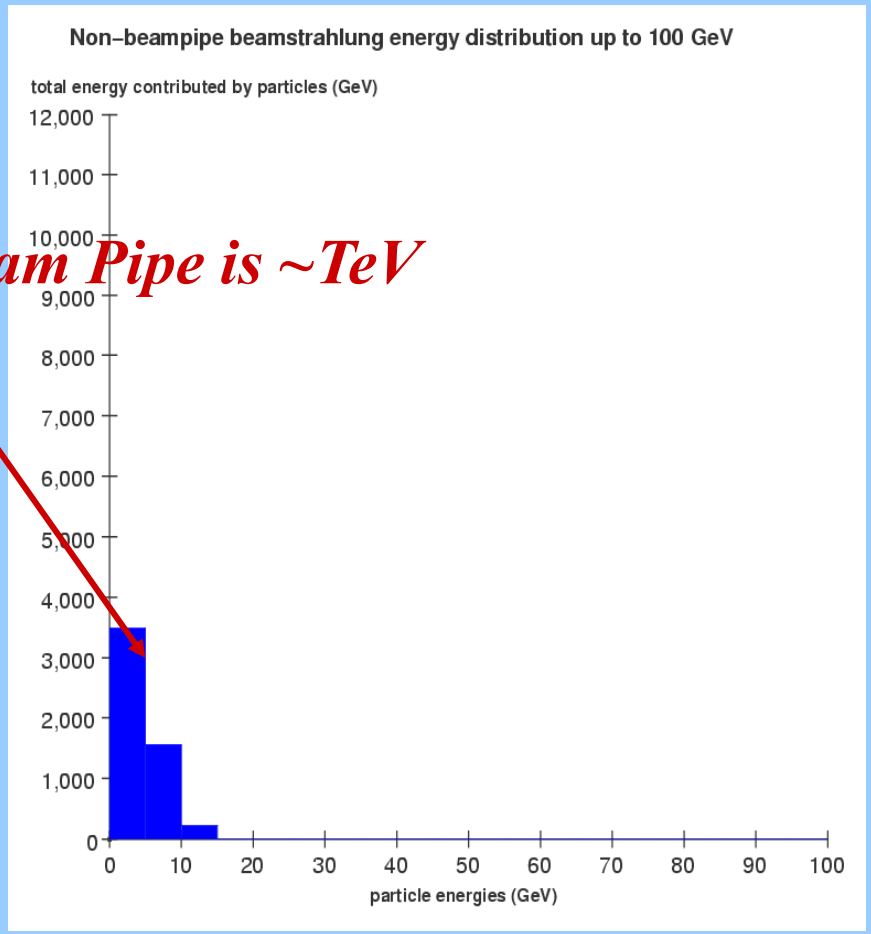
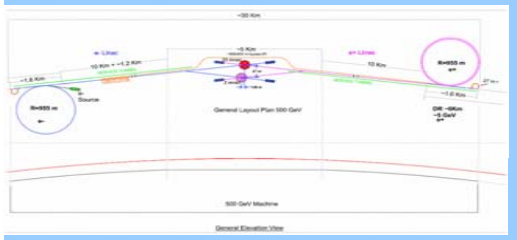
Integrated



Outside Beam Pipe



Energy into the Beam Pipe is ~TeV



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Shower in Beamcal from 2 γ process alone

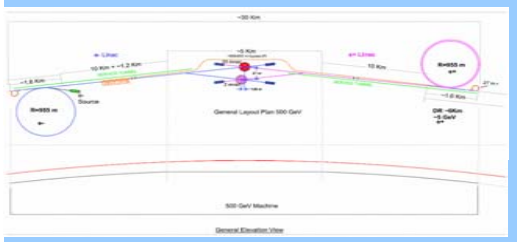
head-on view

side view

core of shower

Radius of 25 mm

Radius of 25 mm



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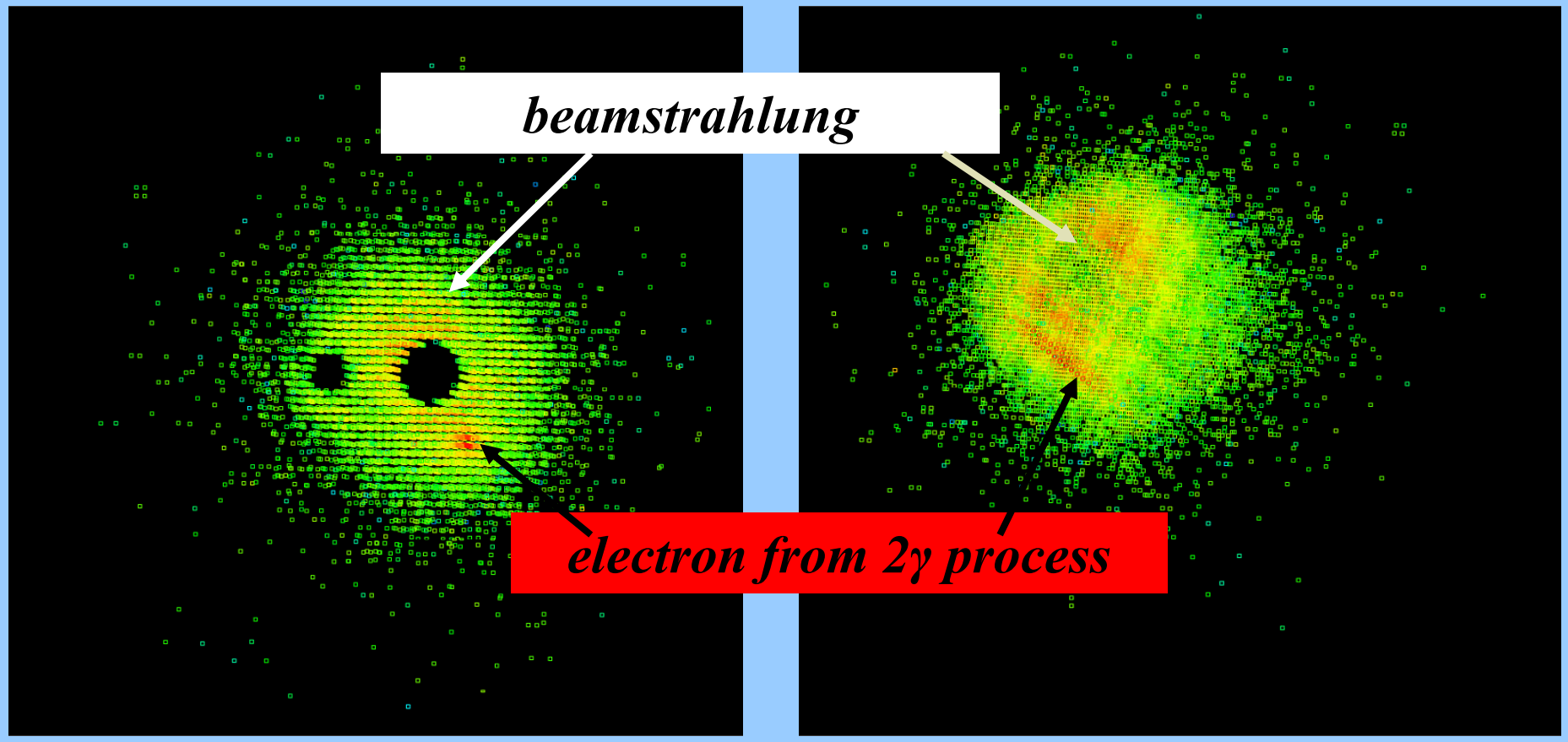
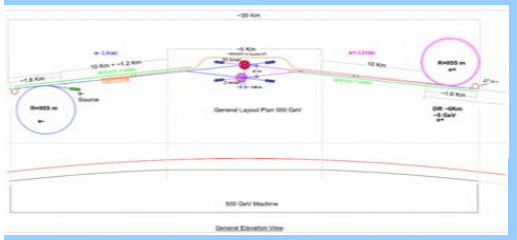
head on view

side view





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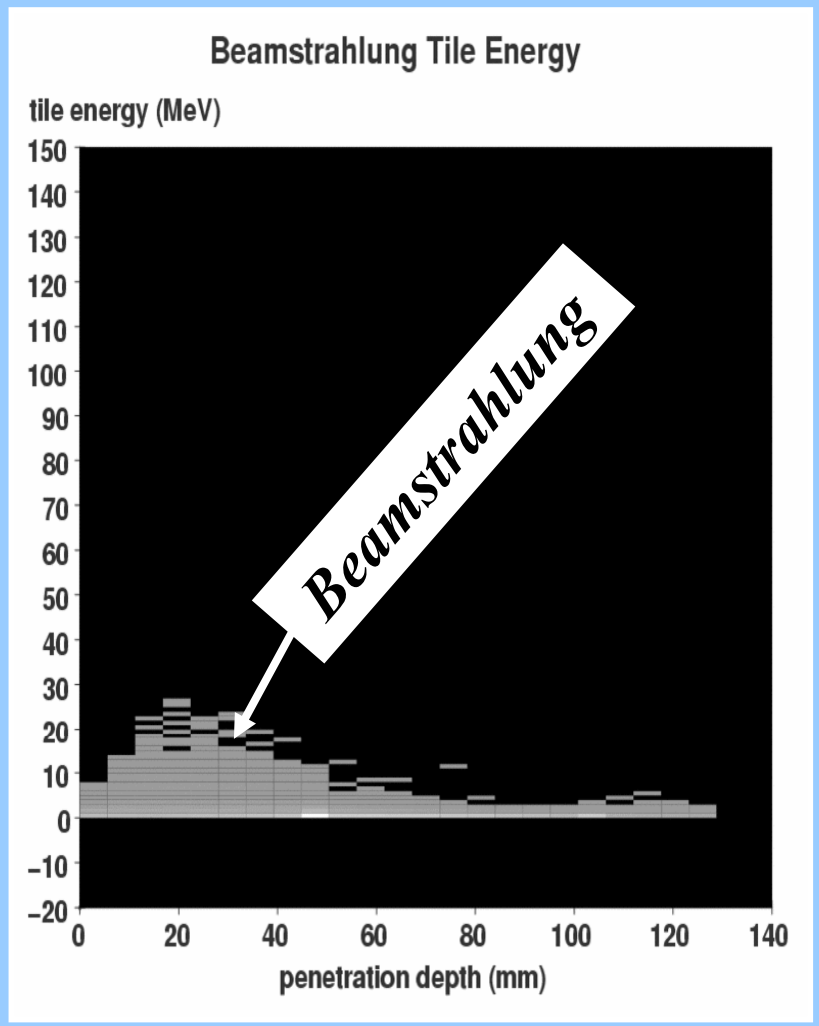

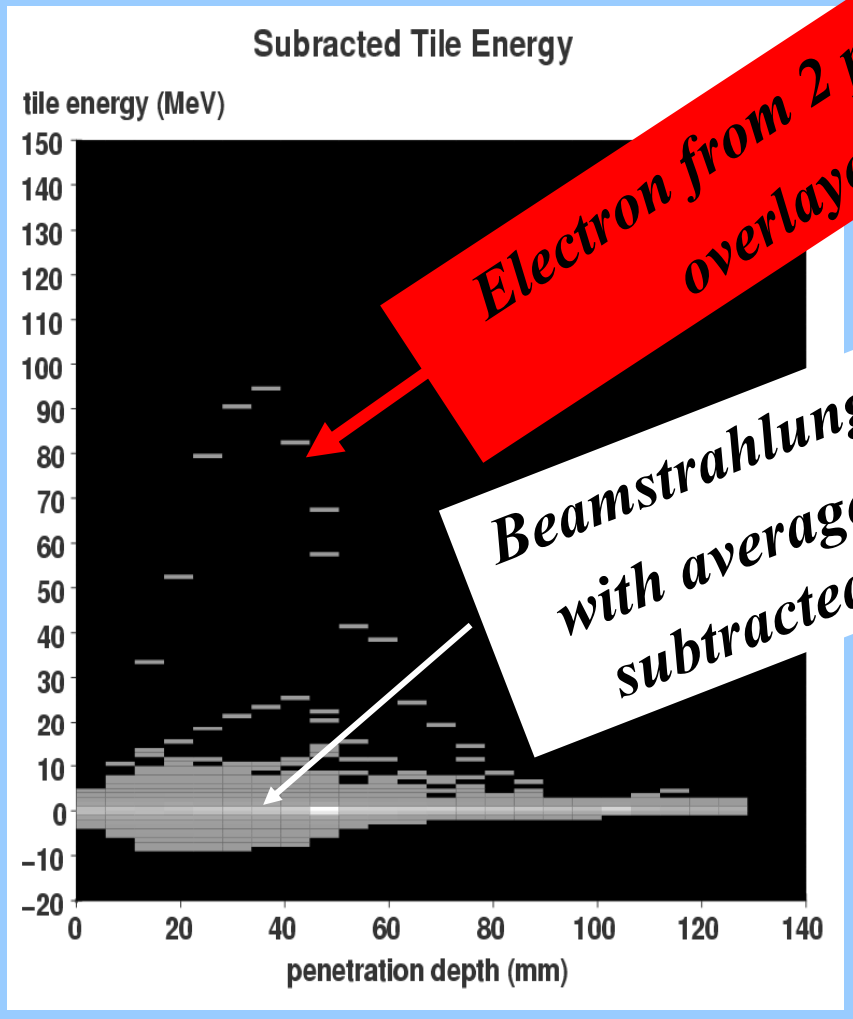

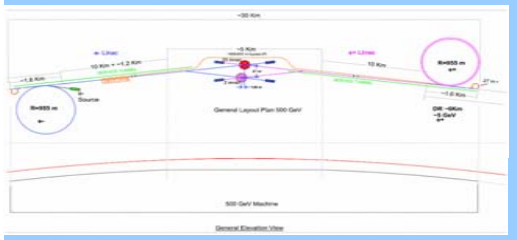

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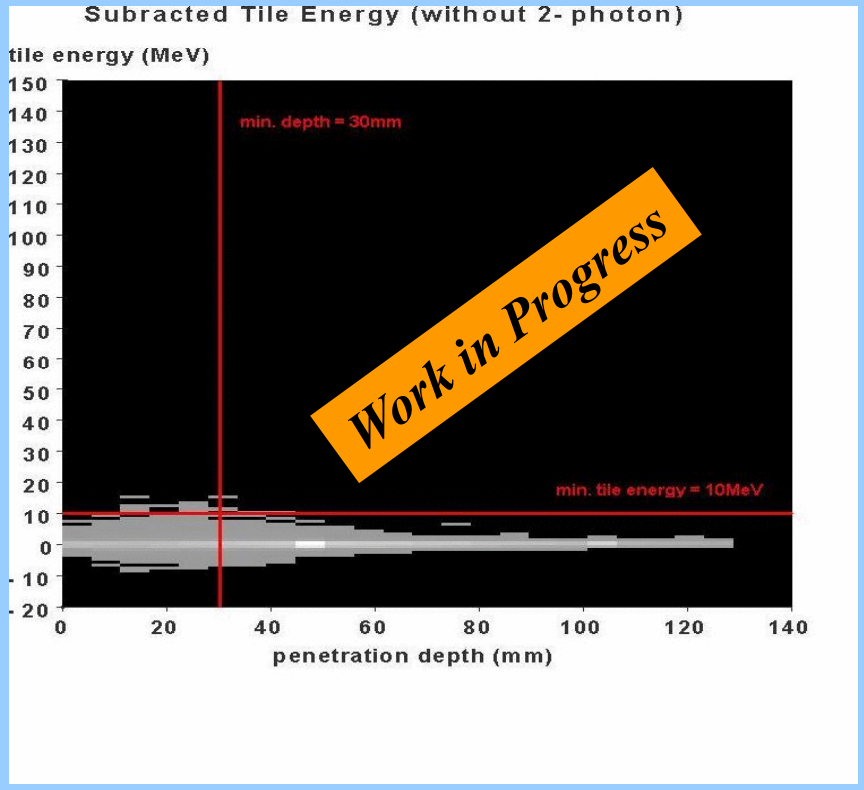
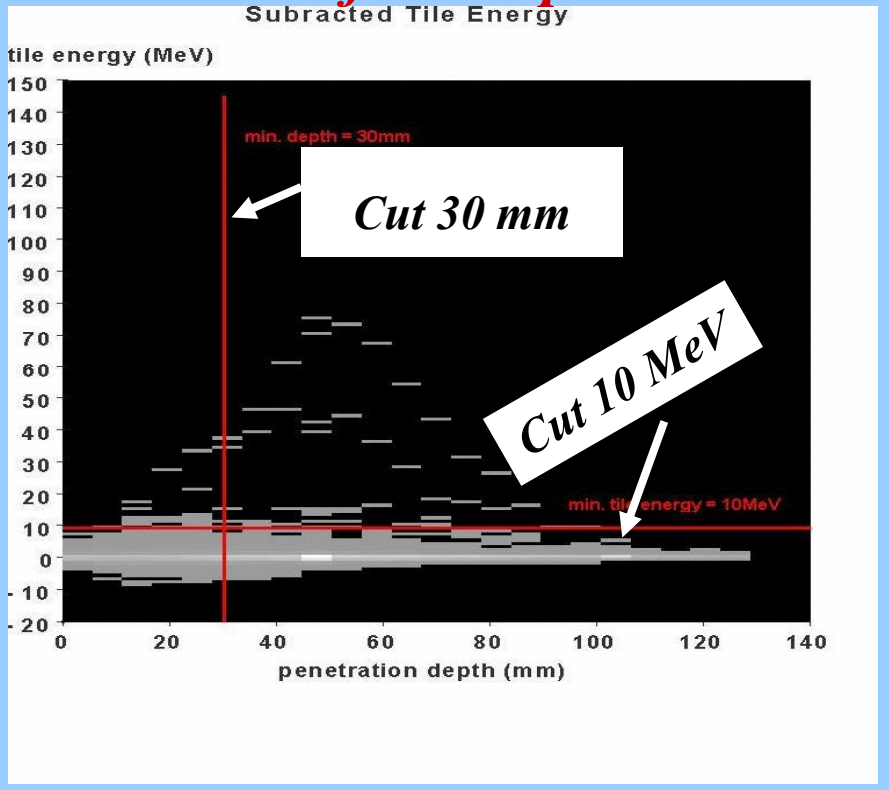
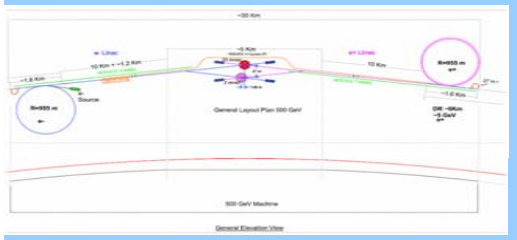
Clustering Cuts in Depth and Energy, Example 1

Beamstrahlung Alone



Beamstrahlung + Electron from 2-photon





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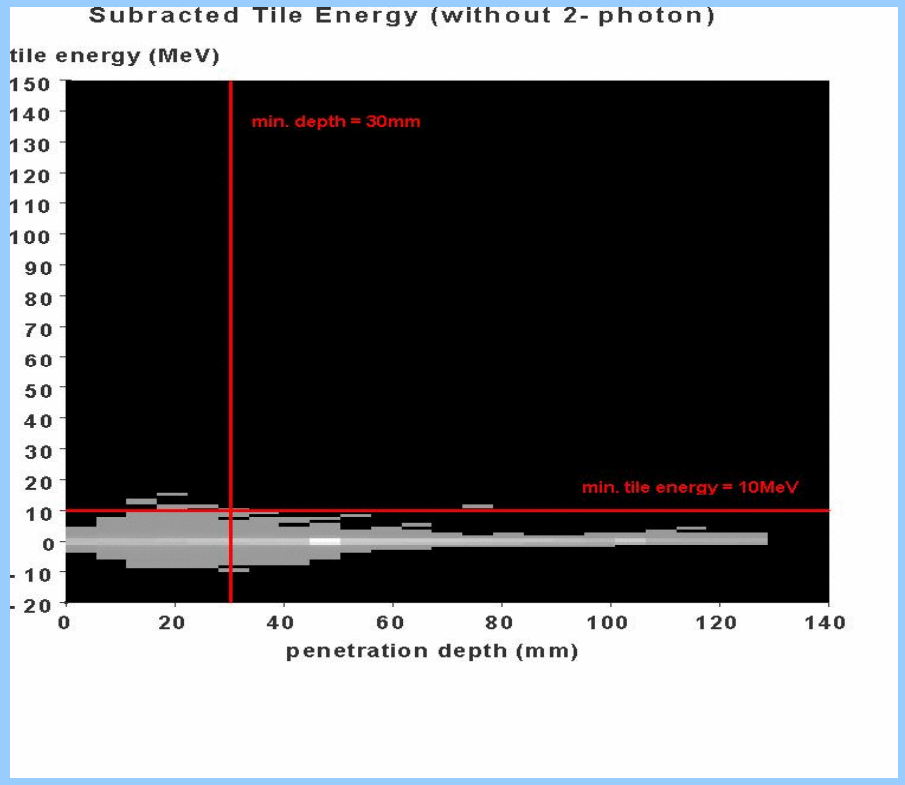
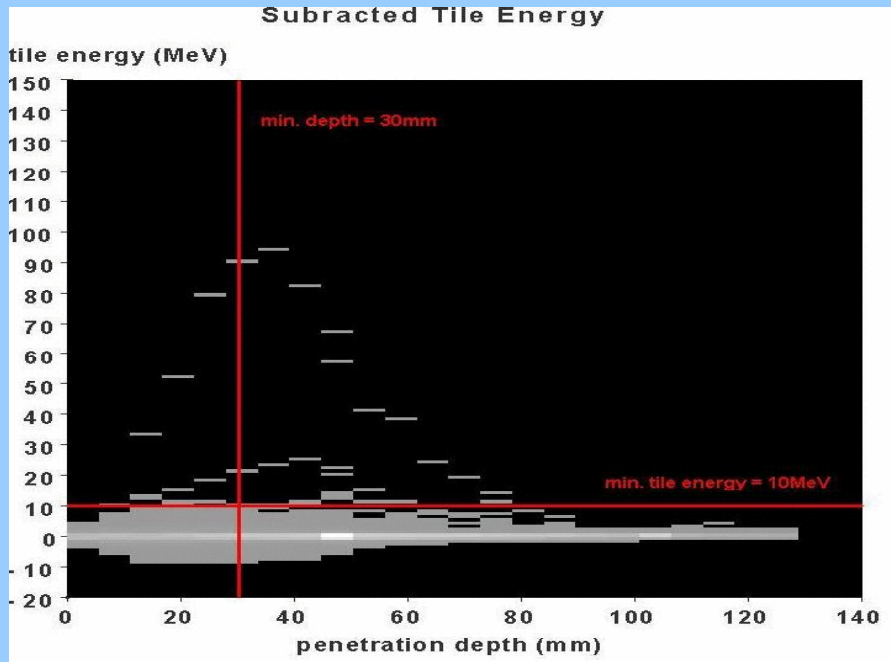
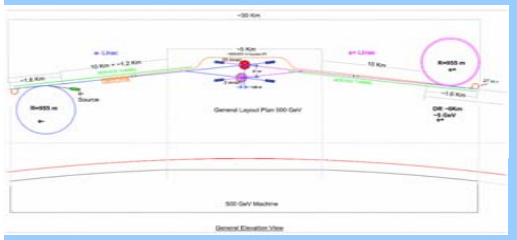
Clustering Cuts in Depth and Energy, Example 2

Beamstrahlung Alone



Beamstrahlung + Electron from 2-photon





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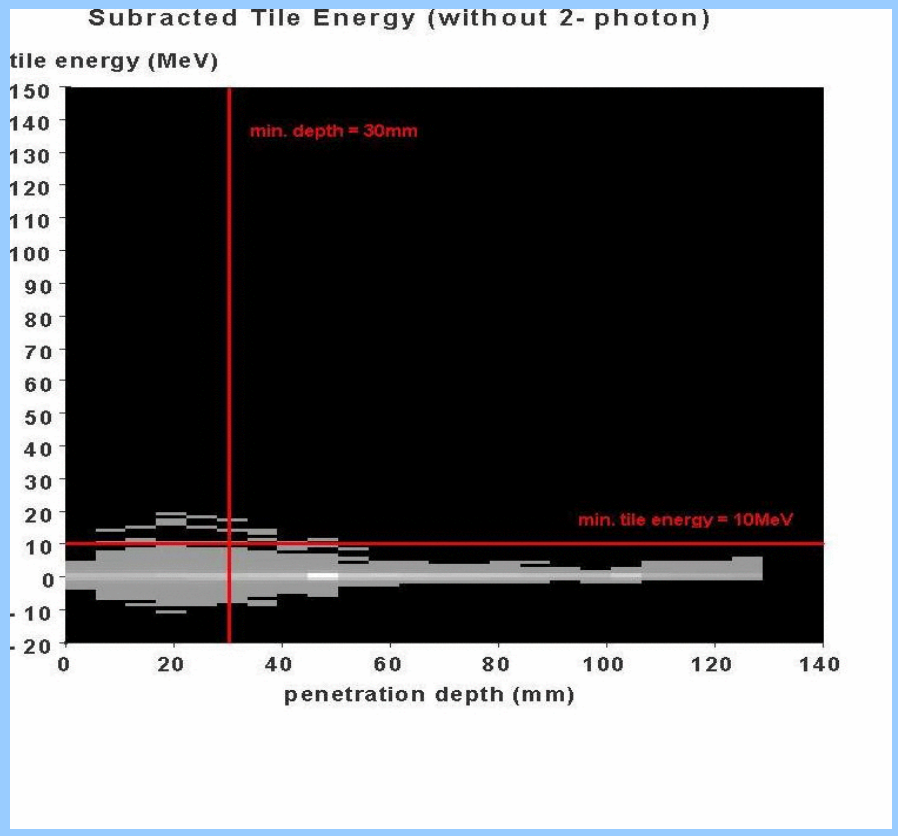
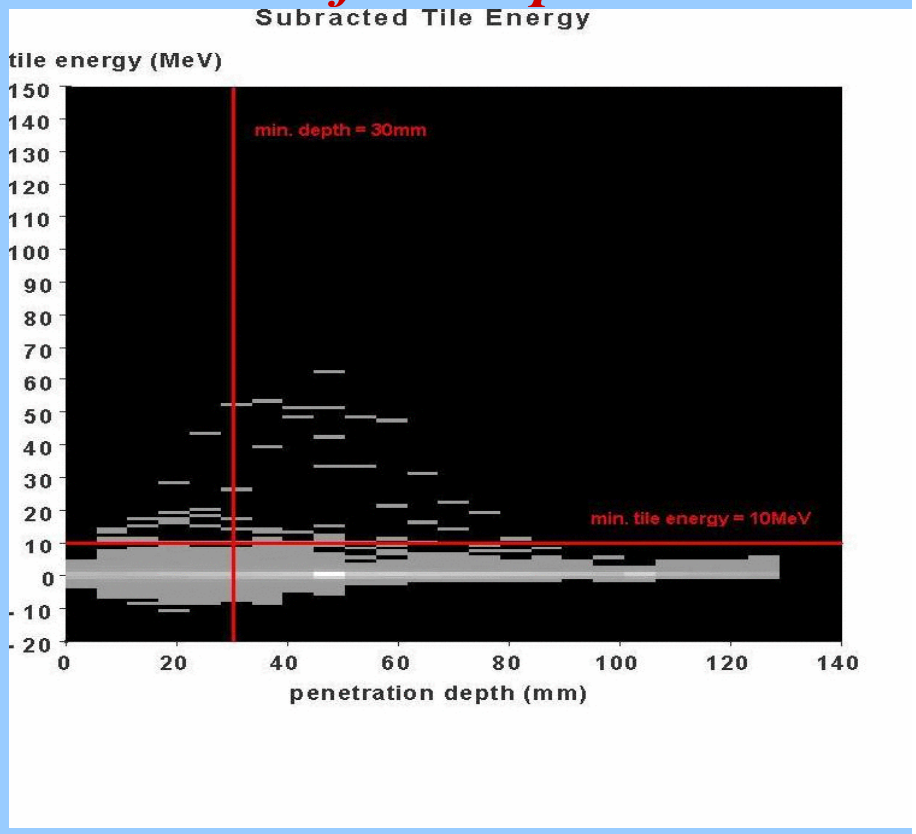
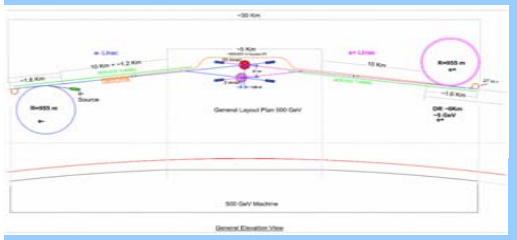
Clustering Cuts in Depth and Energy, Example 3

Beamstrahlung Alone



Beamstrahlung + Electron from 2-photon





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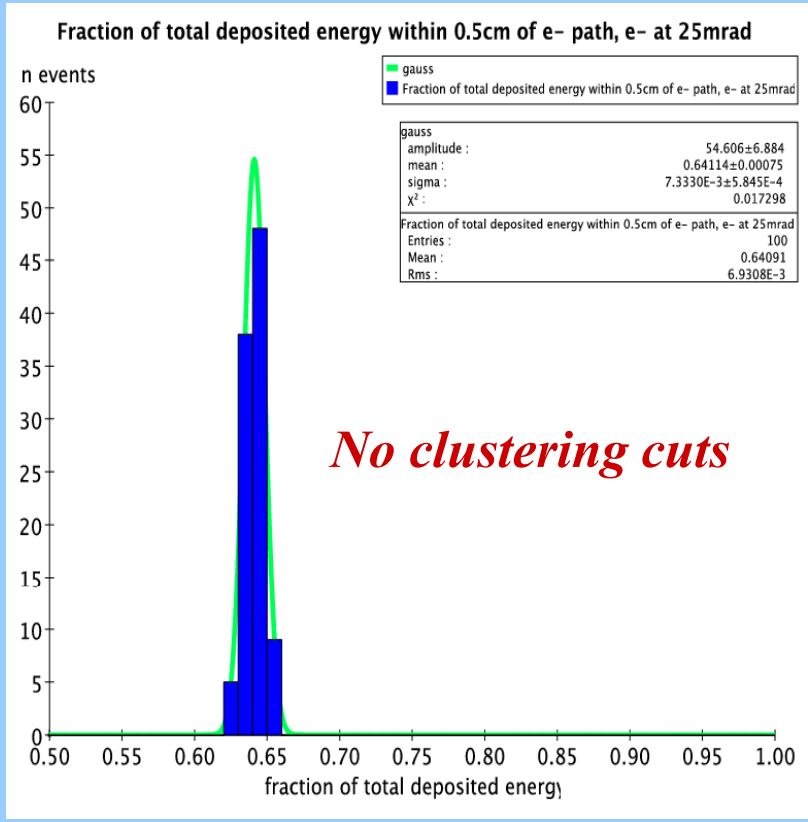
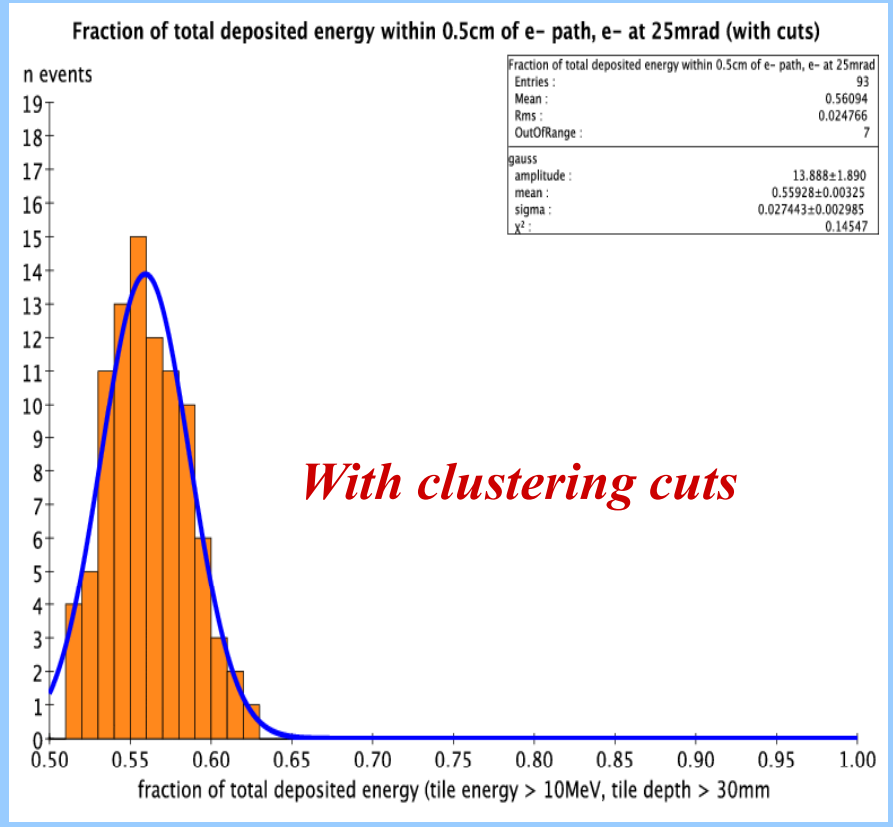
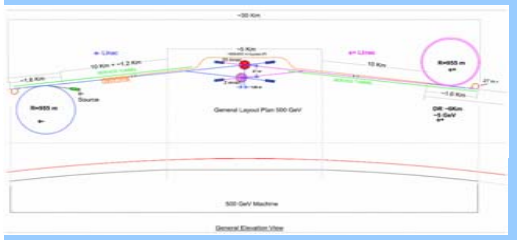
Fraction of Energy Observed within a Radius of 0.5 cm of Electron Path



No clustering cuts



With clustering cuts



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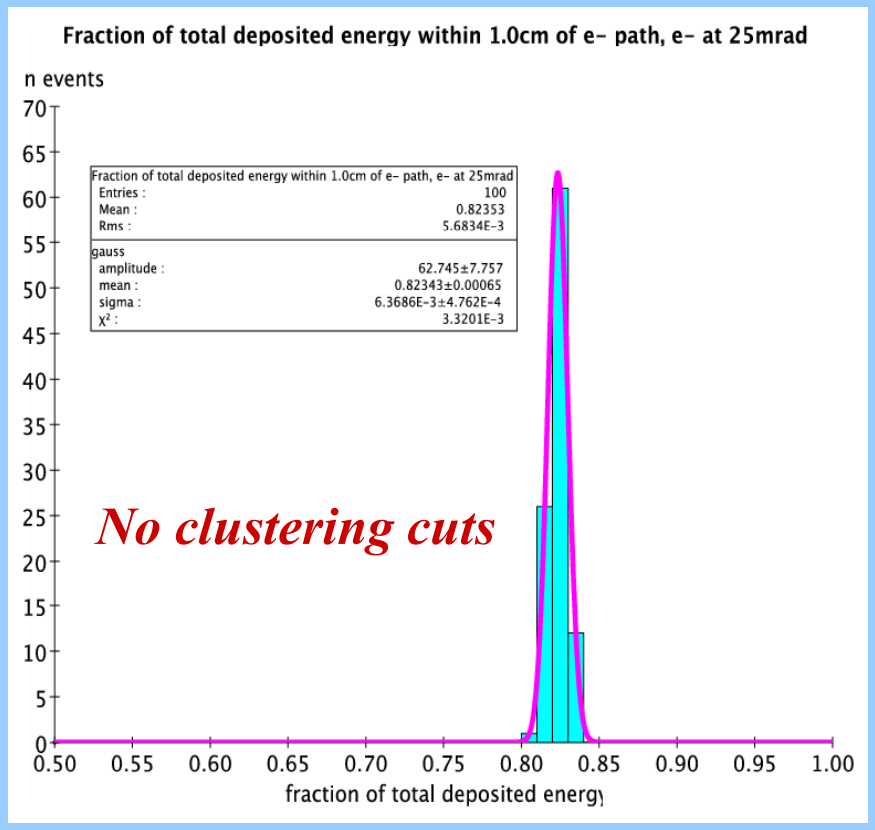
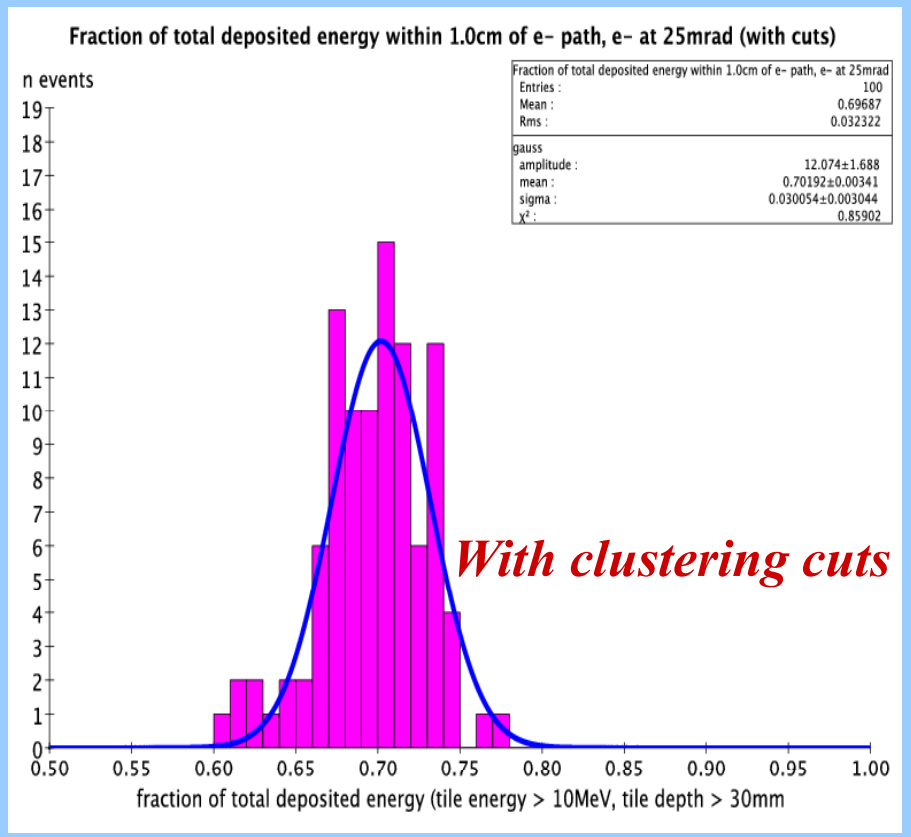
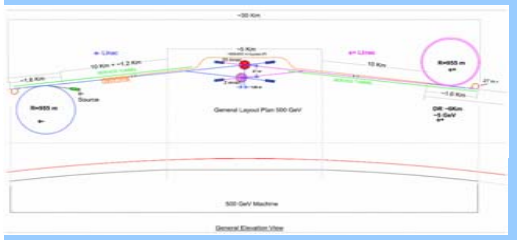
Fraction of Energy Observed within a Radius of 1.0 cm of Electron Path







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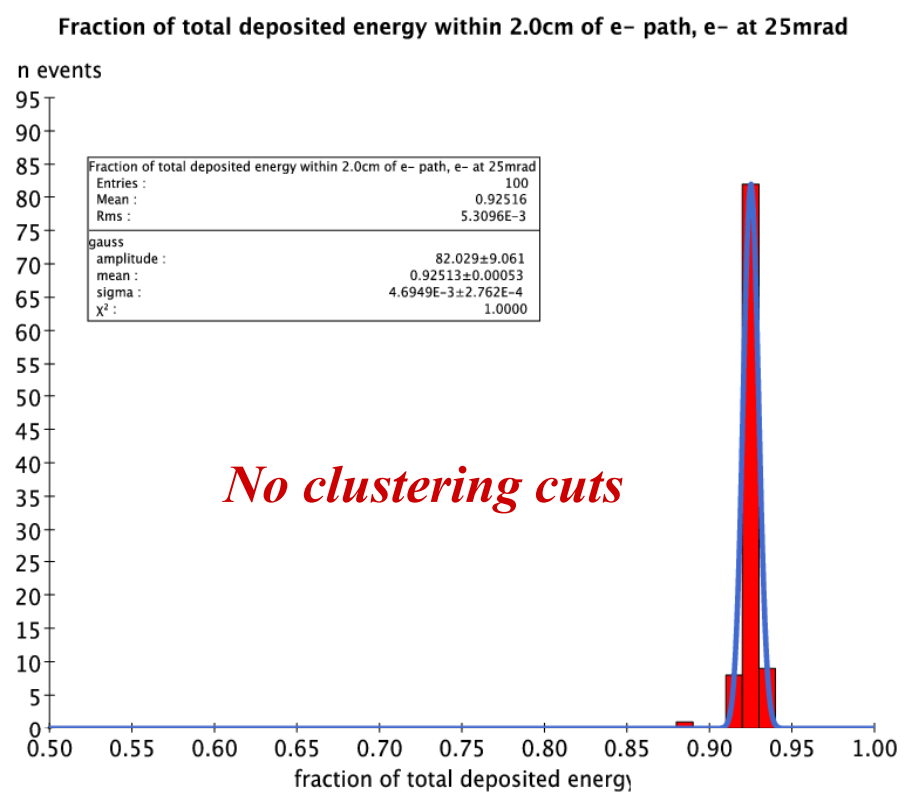
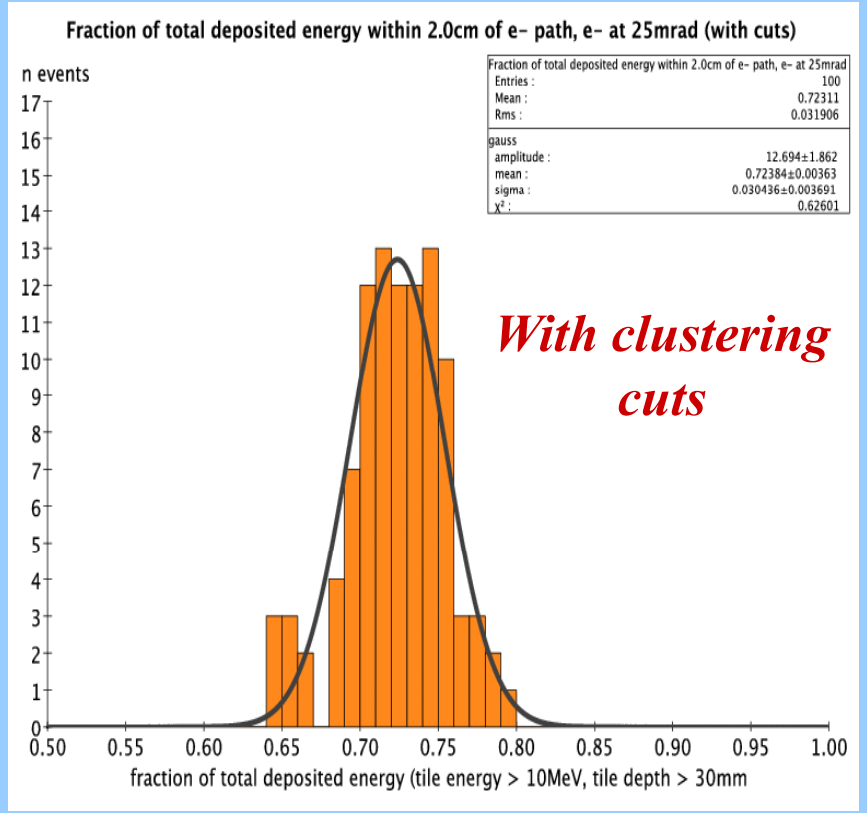
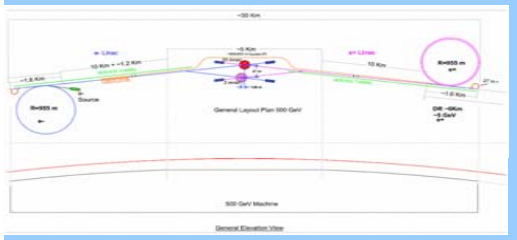
Fraction of Energy Observed within a Radius of 2.0 cm of Electron Path







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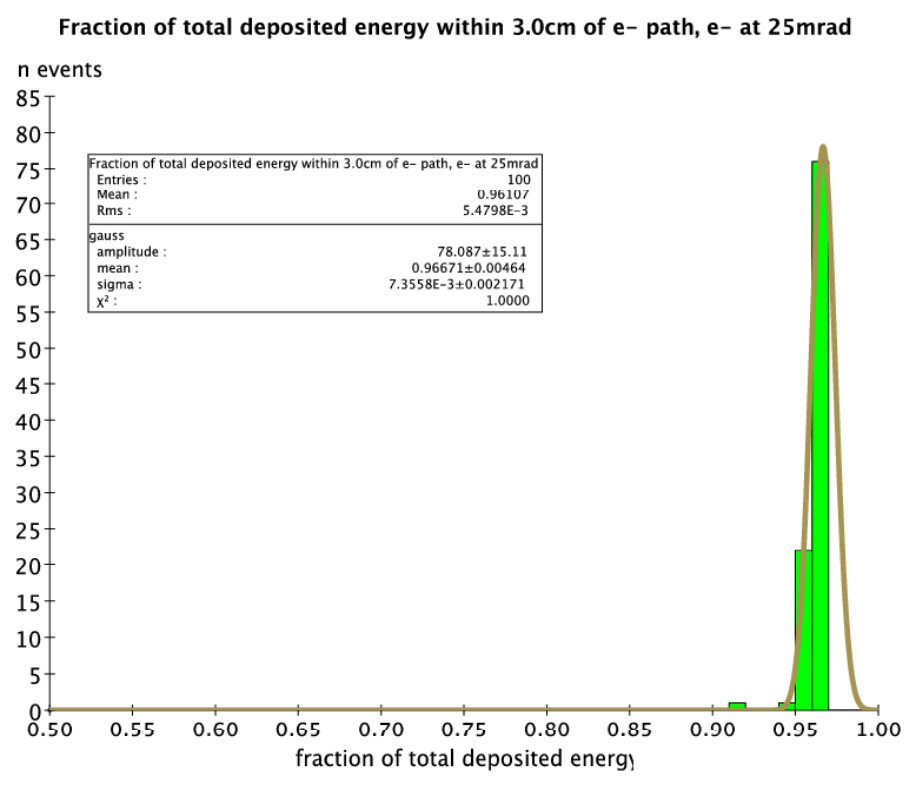
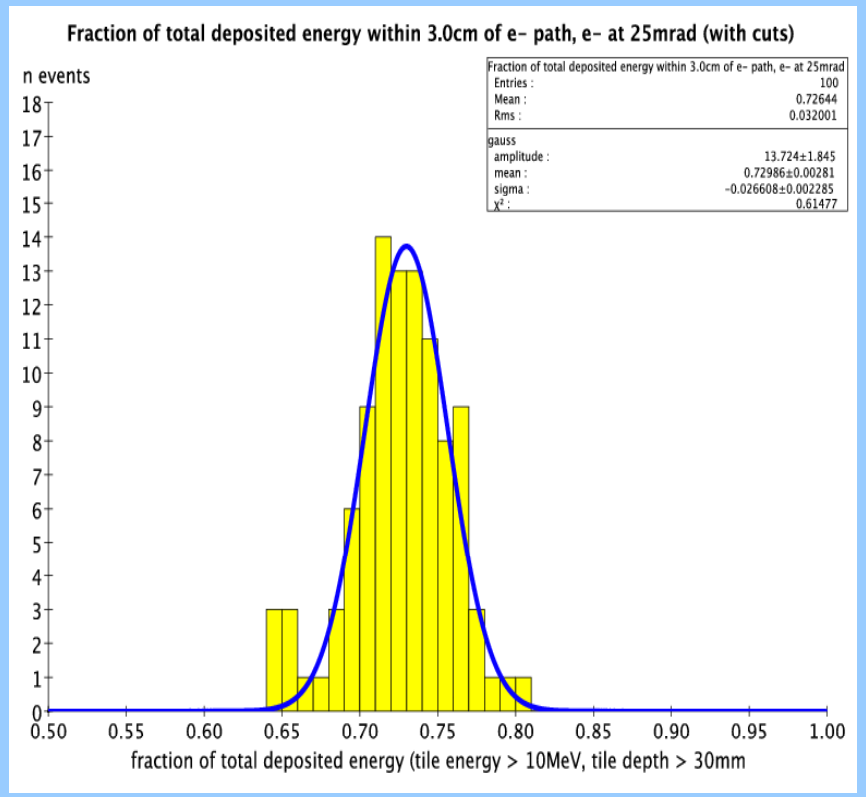
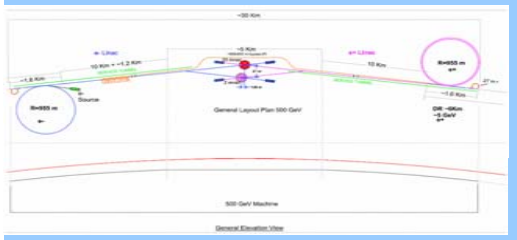
Fraction of Energy Observed within a Radius of 3.0 cm of Electron Path







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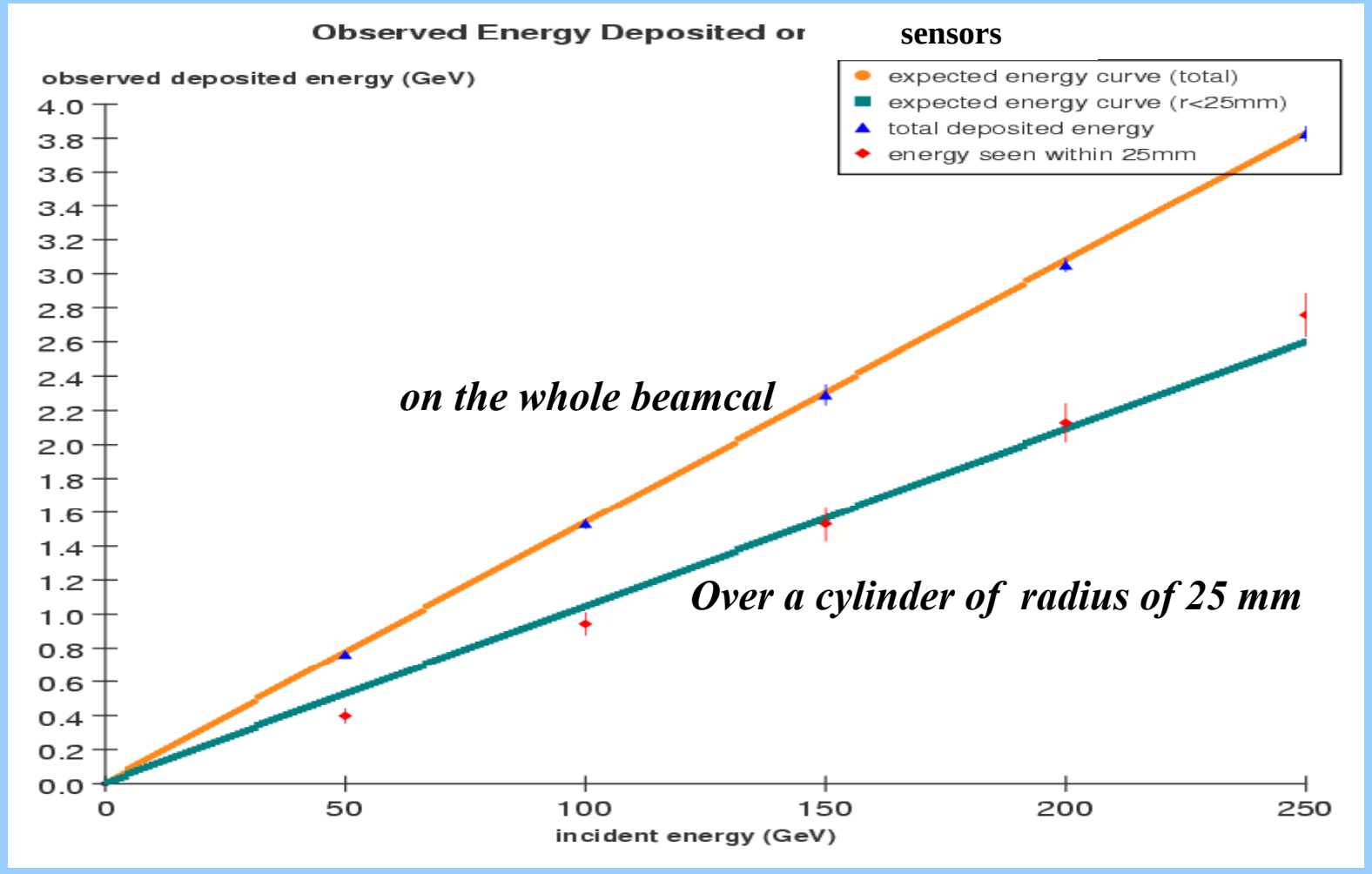

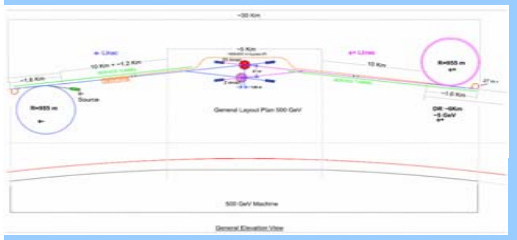

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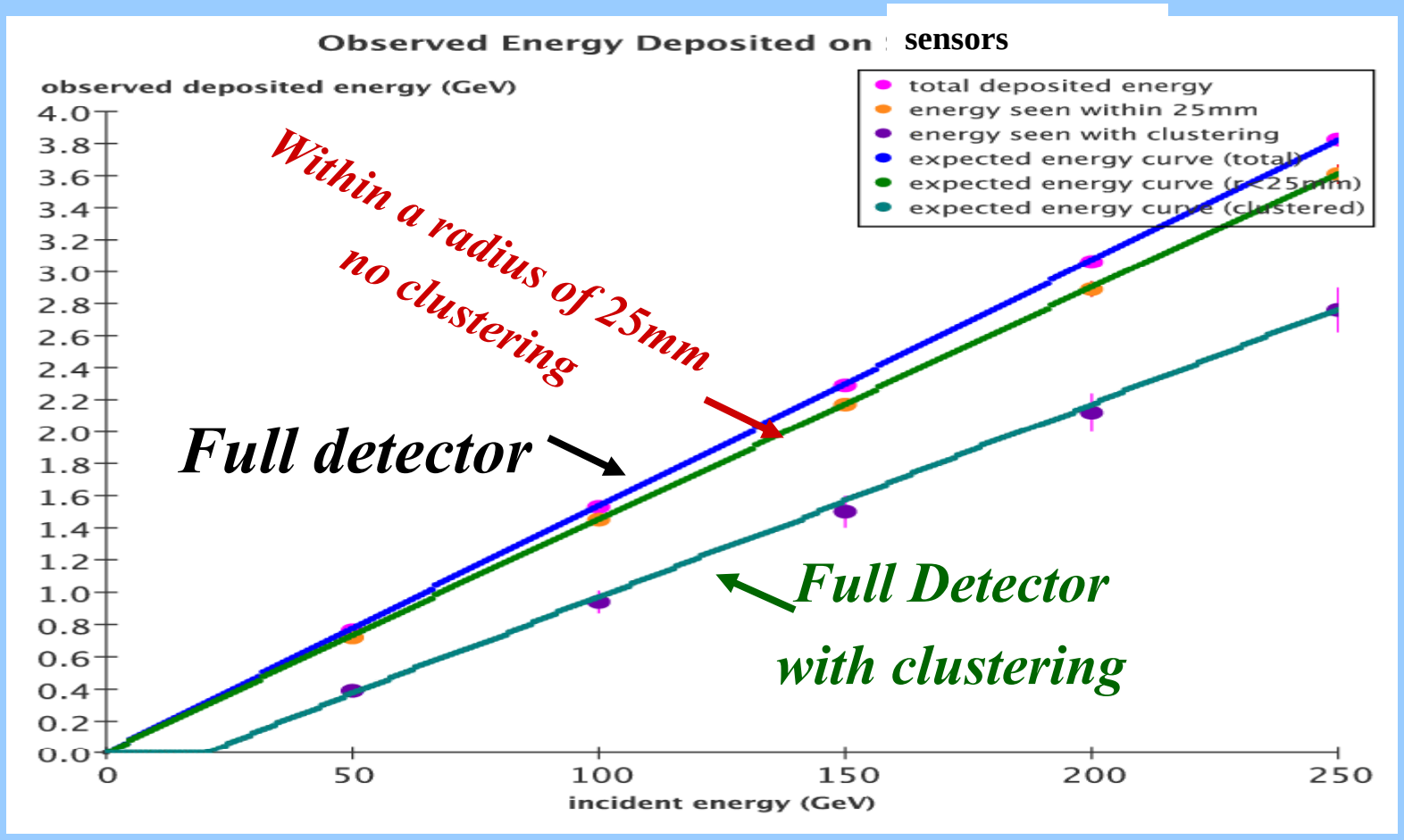

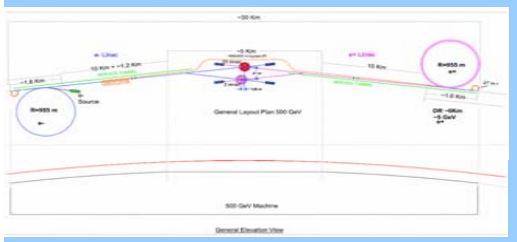

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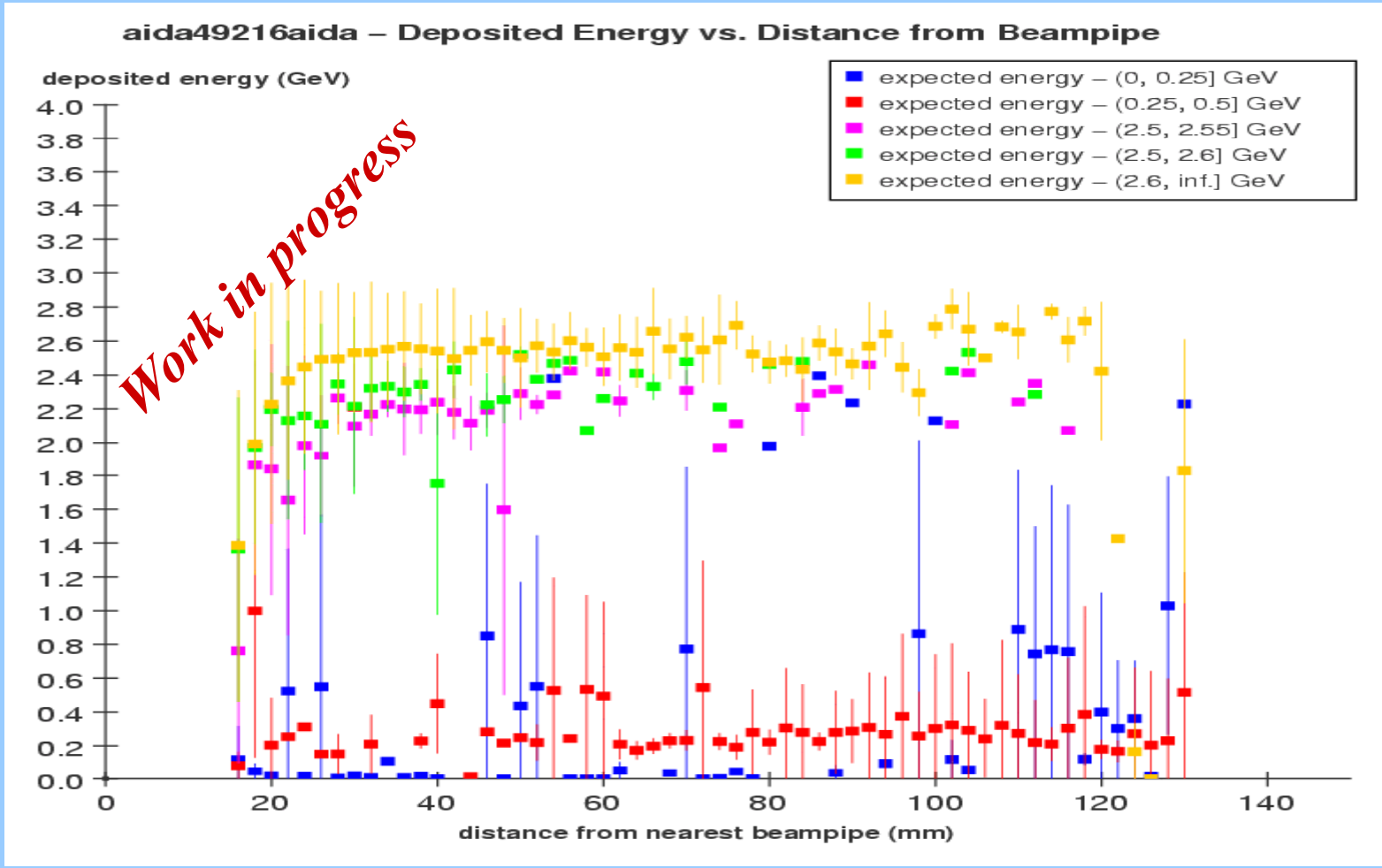
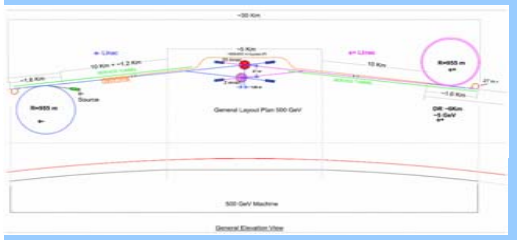
Energy observed as a function of distance from center of beampipe





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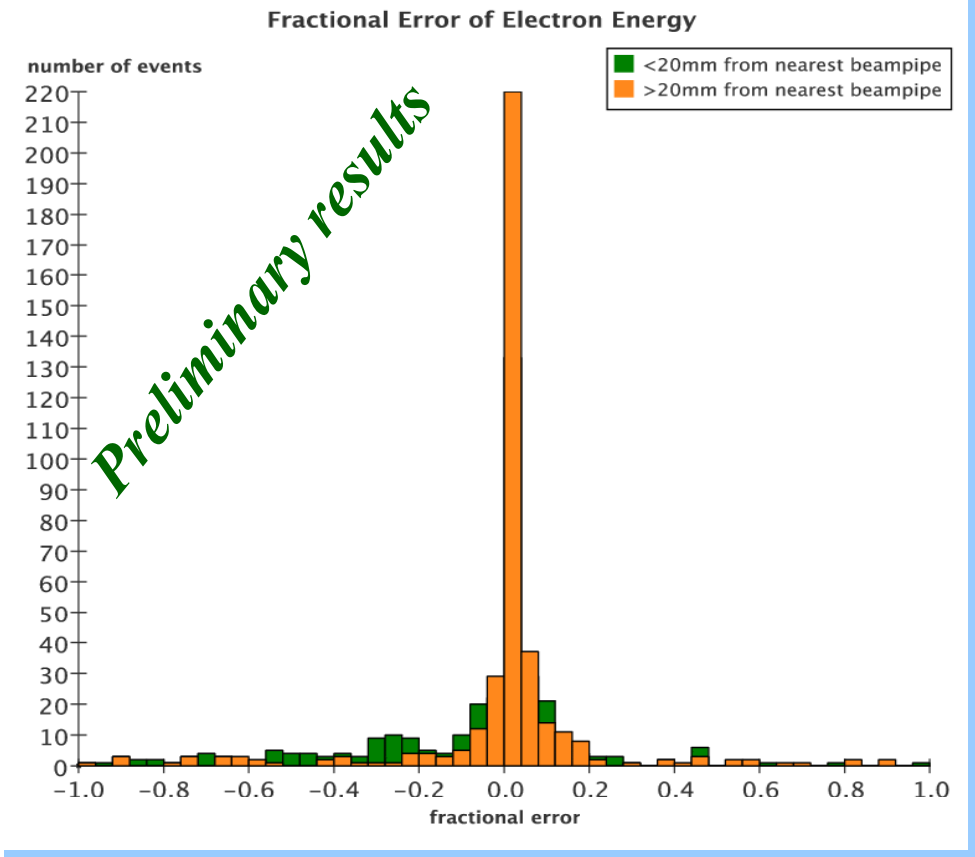
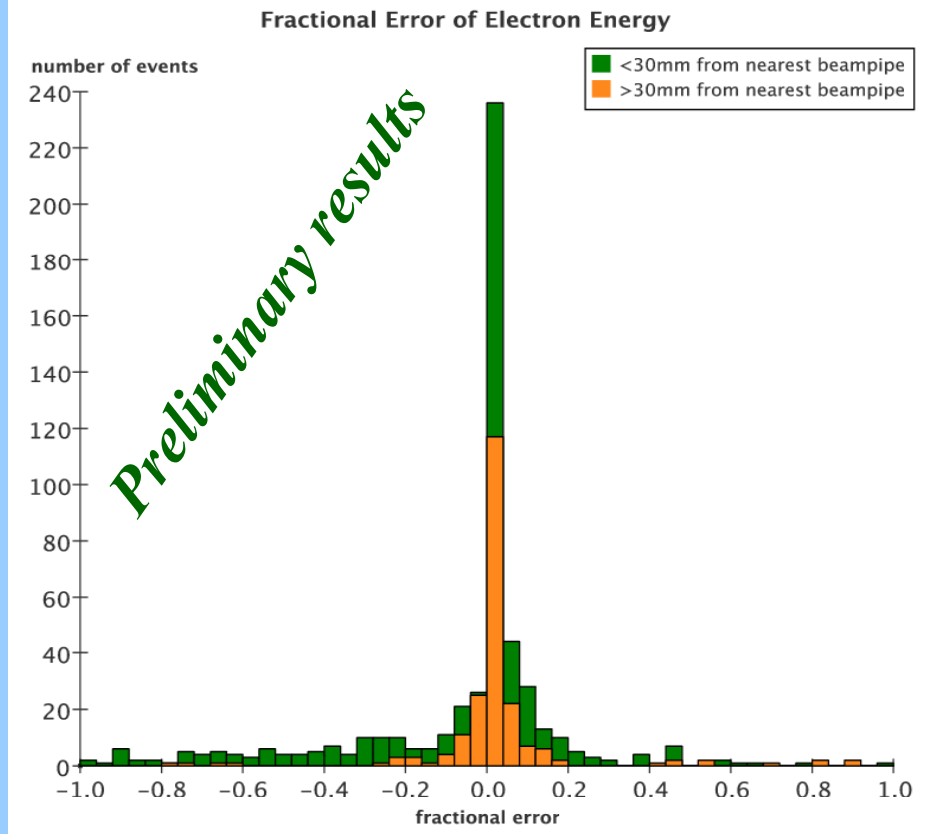
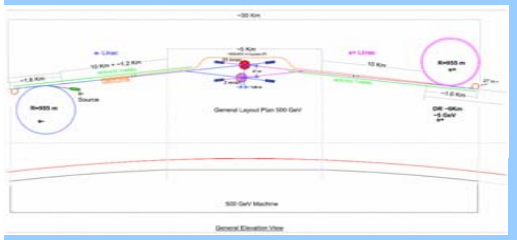
Energy resolution of the reconstruction of the electrons from 2-photon events including the effects of beamstrahlung

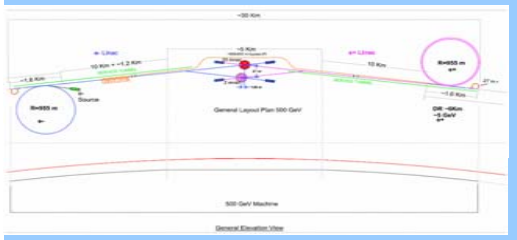






Work to be Done

- ***Optimize signal to Background.***
- ***Check all our Calculations.***
- ***Find other analysis techniques that reduce the beamstrahlung fluctuations and hence improve the signal resolution.***
- ***Study the effect of this analysis on SUSY signal. Missing Pt limits.***



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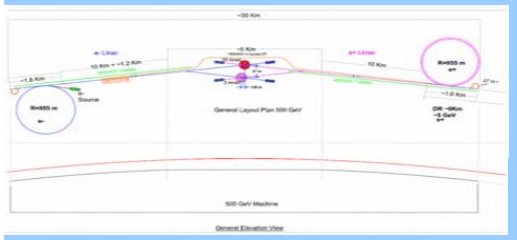
ILC – The International Linear Collider Project



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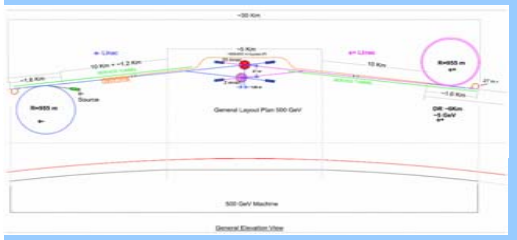

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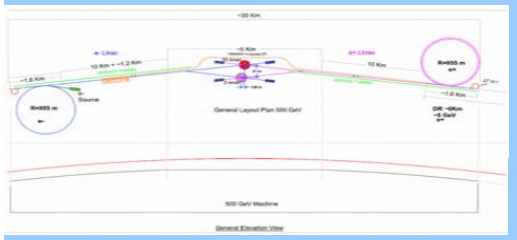

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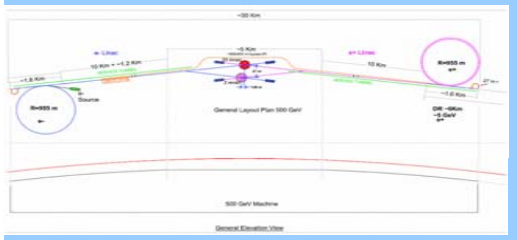

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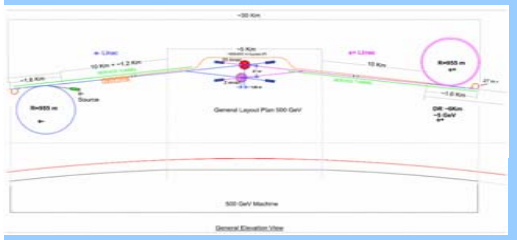

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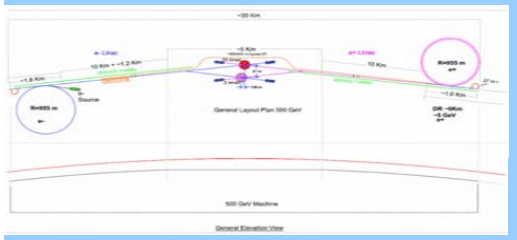

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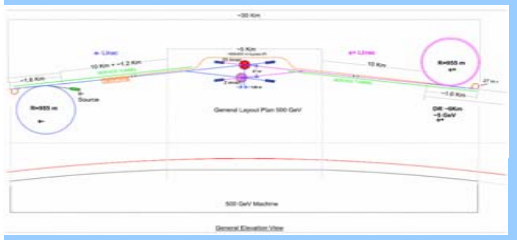
Study of a Scintillator Calorimeter

We are simulating a scintillator based calorimeter where the tiles are offset in alternate layers. We are making now a great deal of progress.



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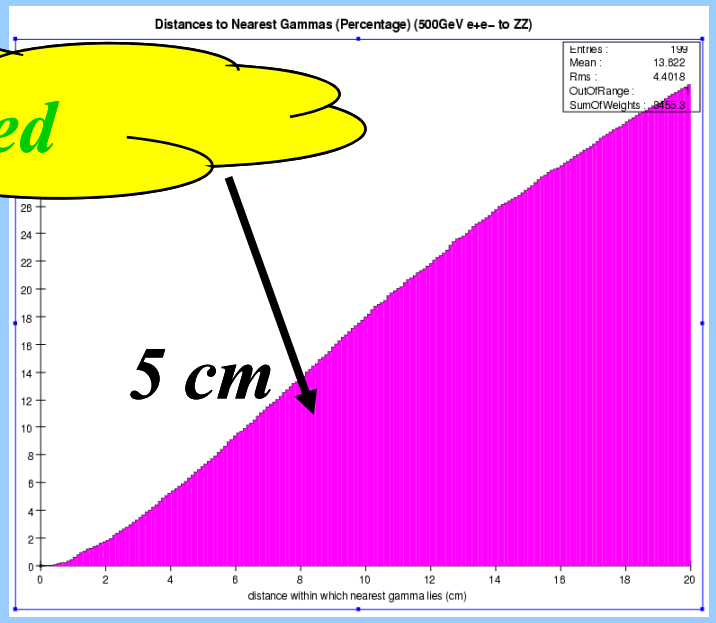
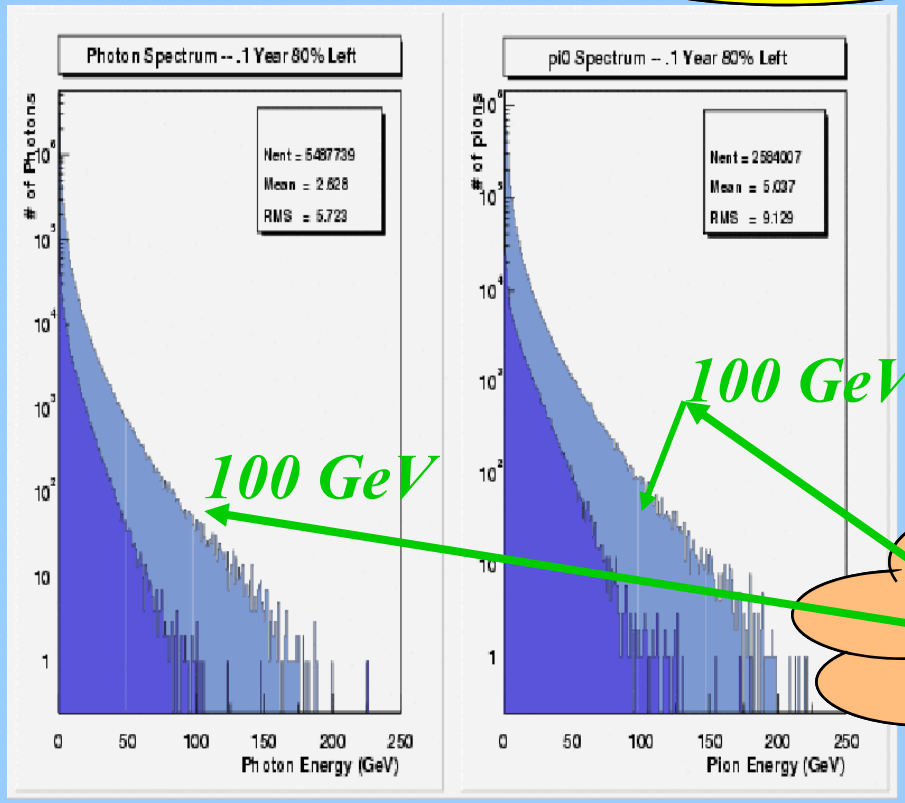
γ s are well separated



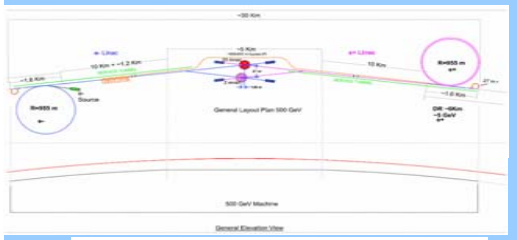
5 cm



100 GeV

100 GeV

π^0 mostly low p



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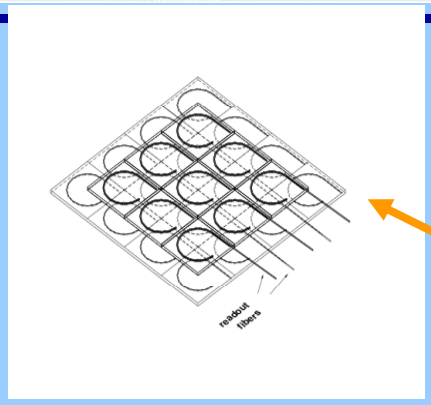
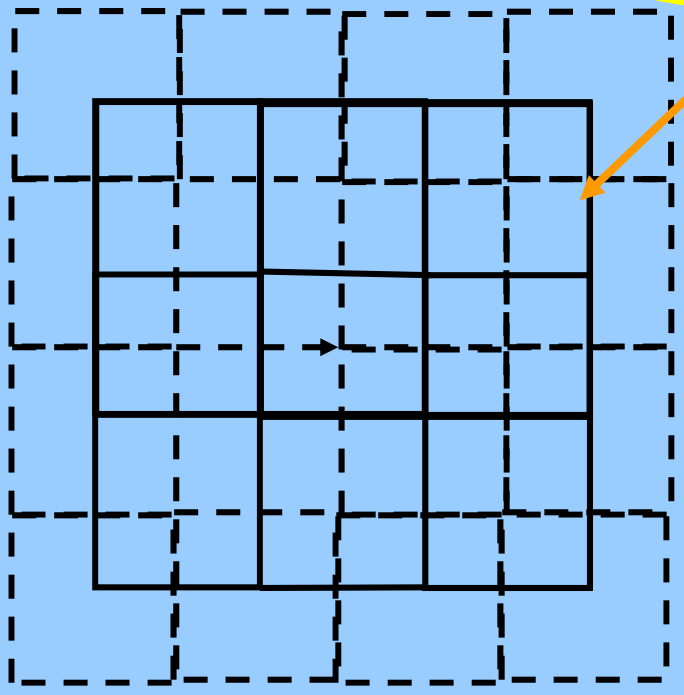
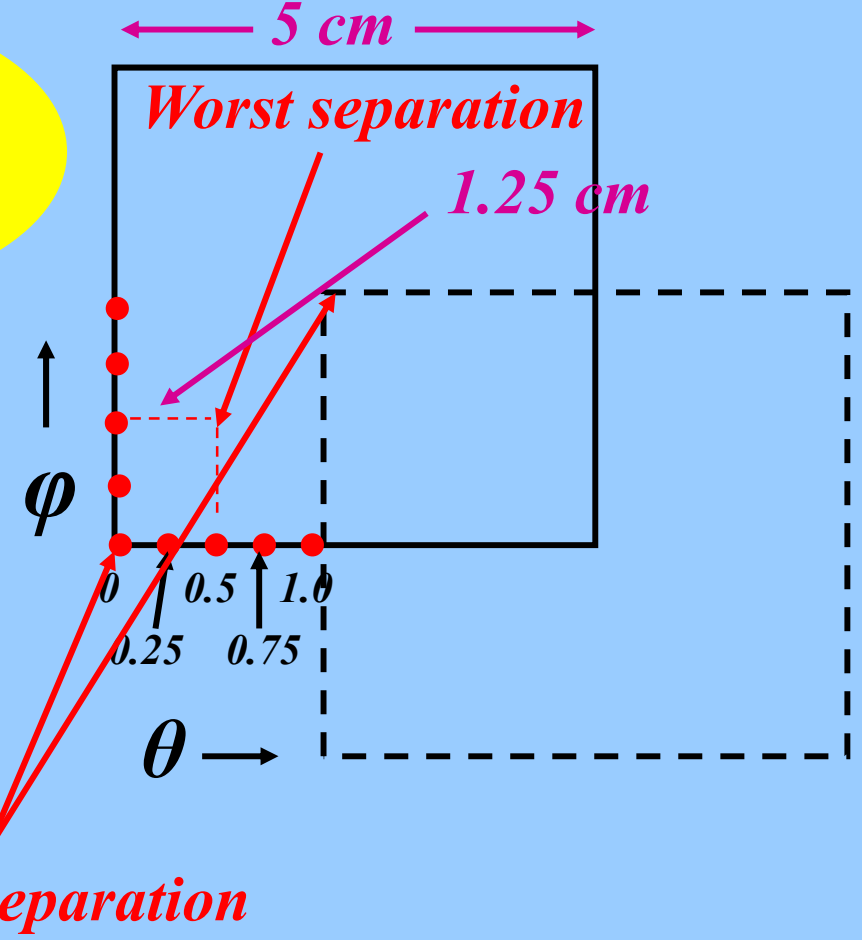
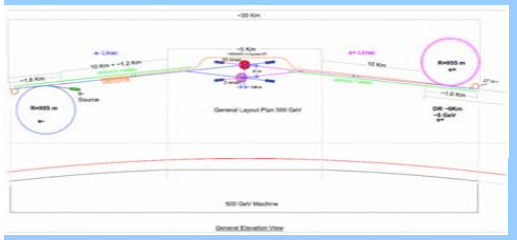


Geometrical Arrangement

Scintillator Panels







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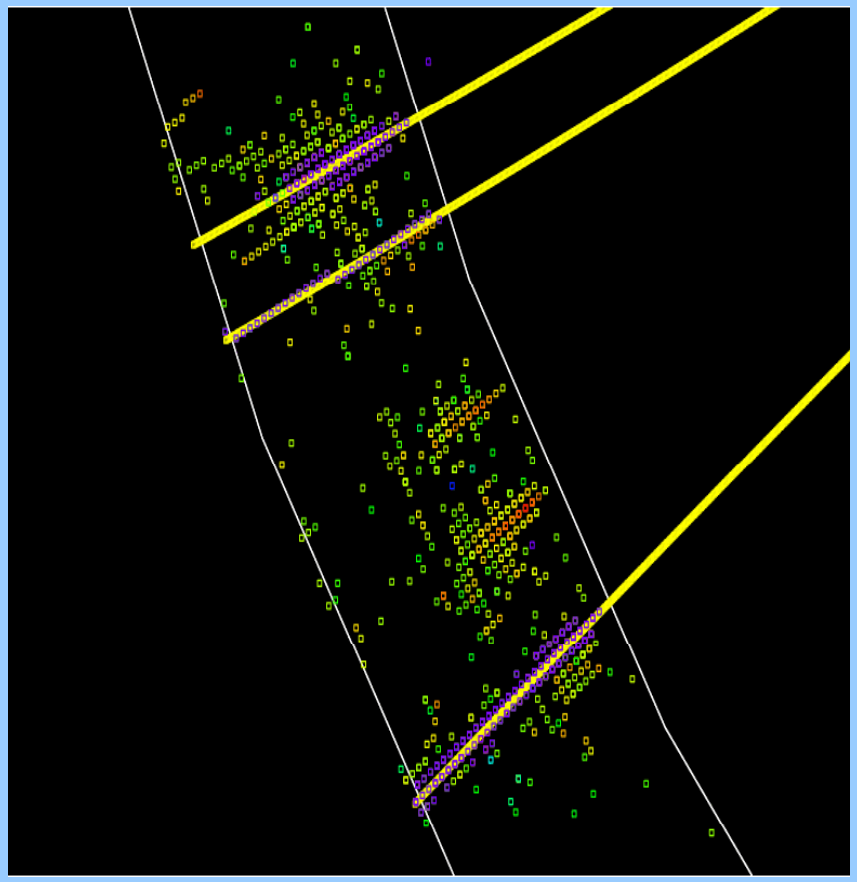
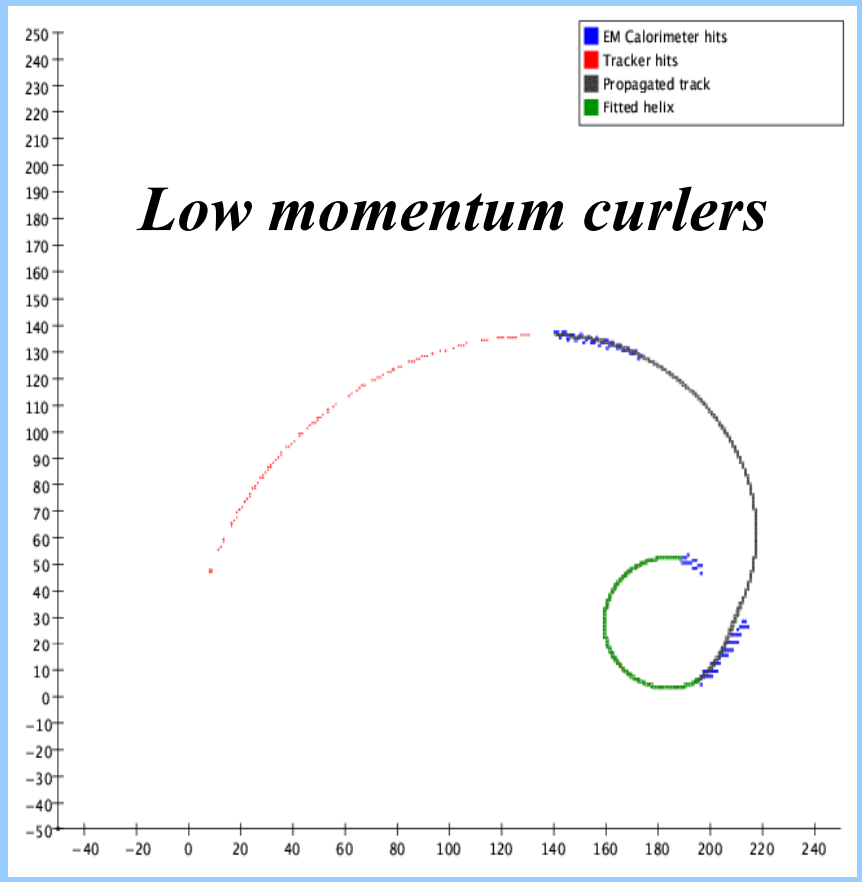
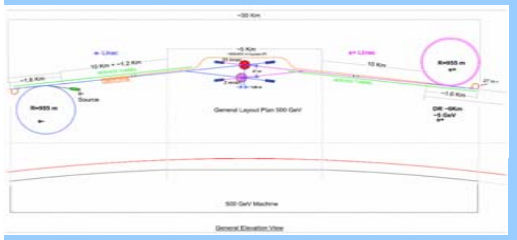
Track Following into the Calorimeter







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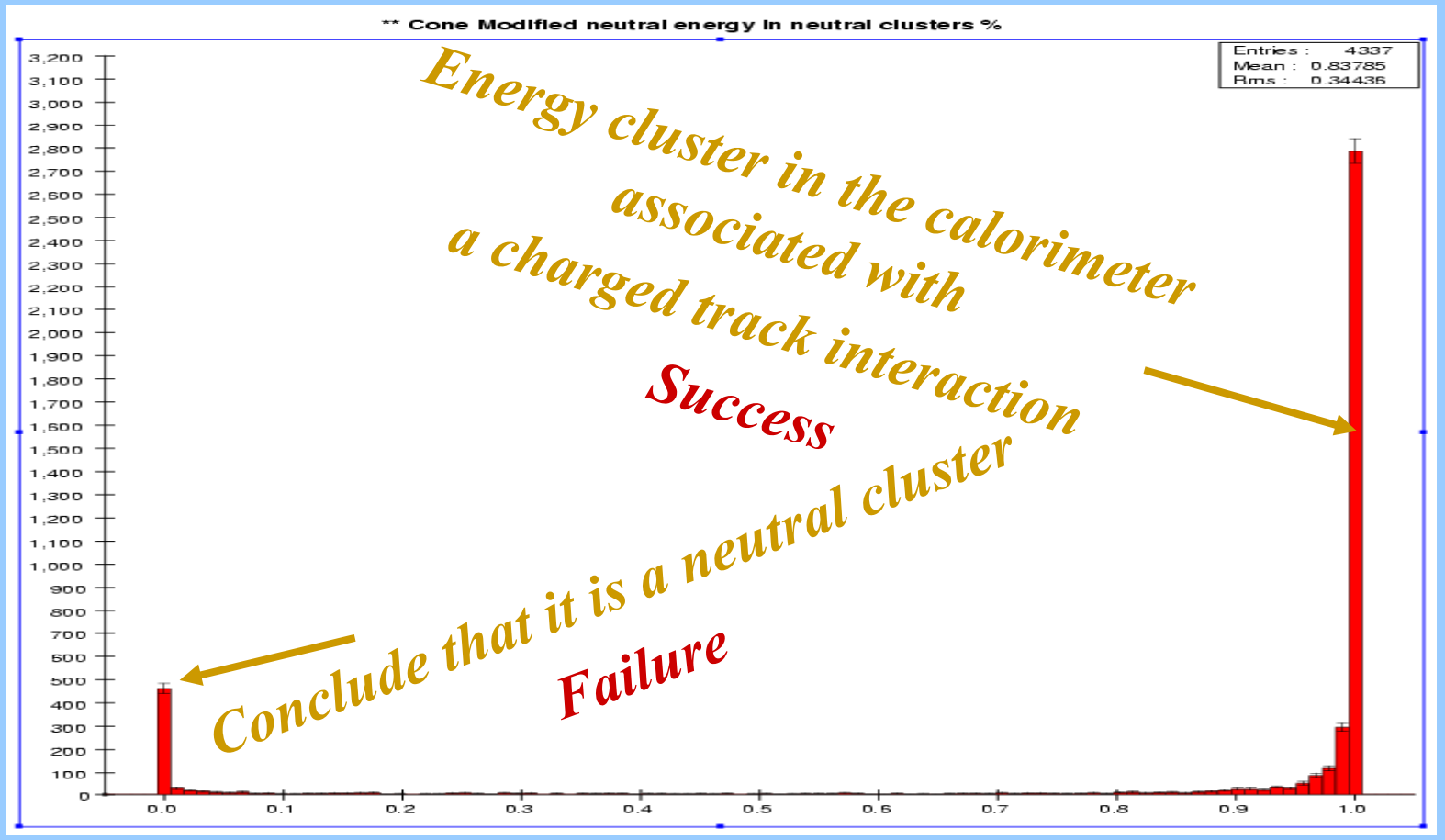
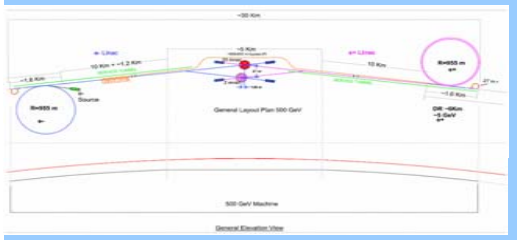
Cluster Correlation with Charged Tracks Success Probability





The Chi-Square Structure

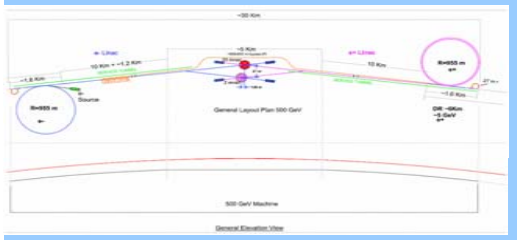
μ_i = average photon energy deposited in ith tile

σ_i = standard deviation in the energy deposition

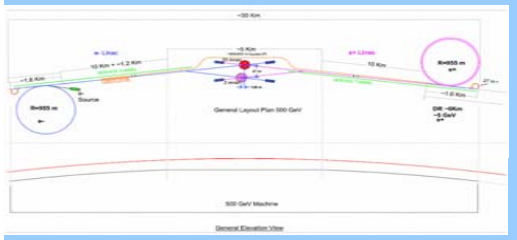
$H_{ij} = \sigma_i \sigma_j$

$$\chi^2 = \sum_{i,j=1}^{9} (x_i - \mu_i) H_{ij}^{-1} (x_j - \mu_j)$$

where x_i is the energy deposited by the shower being tested in the ith tile.



We are now in the middle of trying to separate photon clusters by means of the chi-square method. Hard problem. Crucial aspect of pattern recognition and calorimeter resolution.



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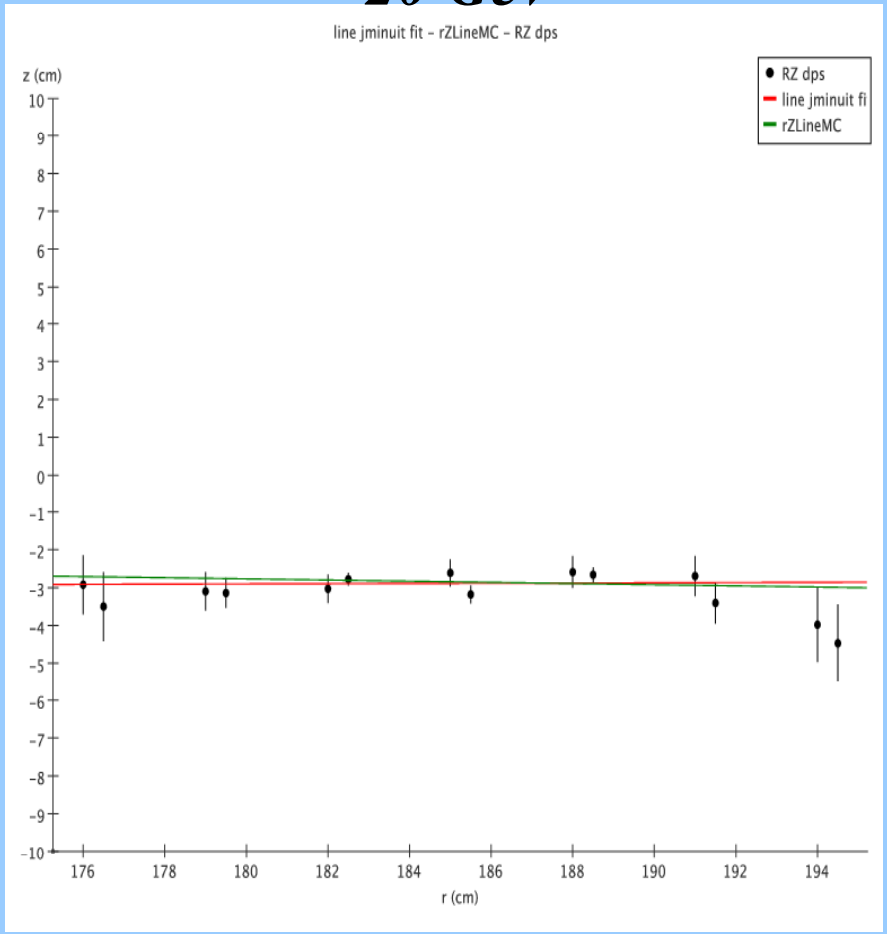
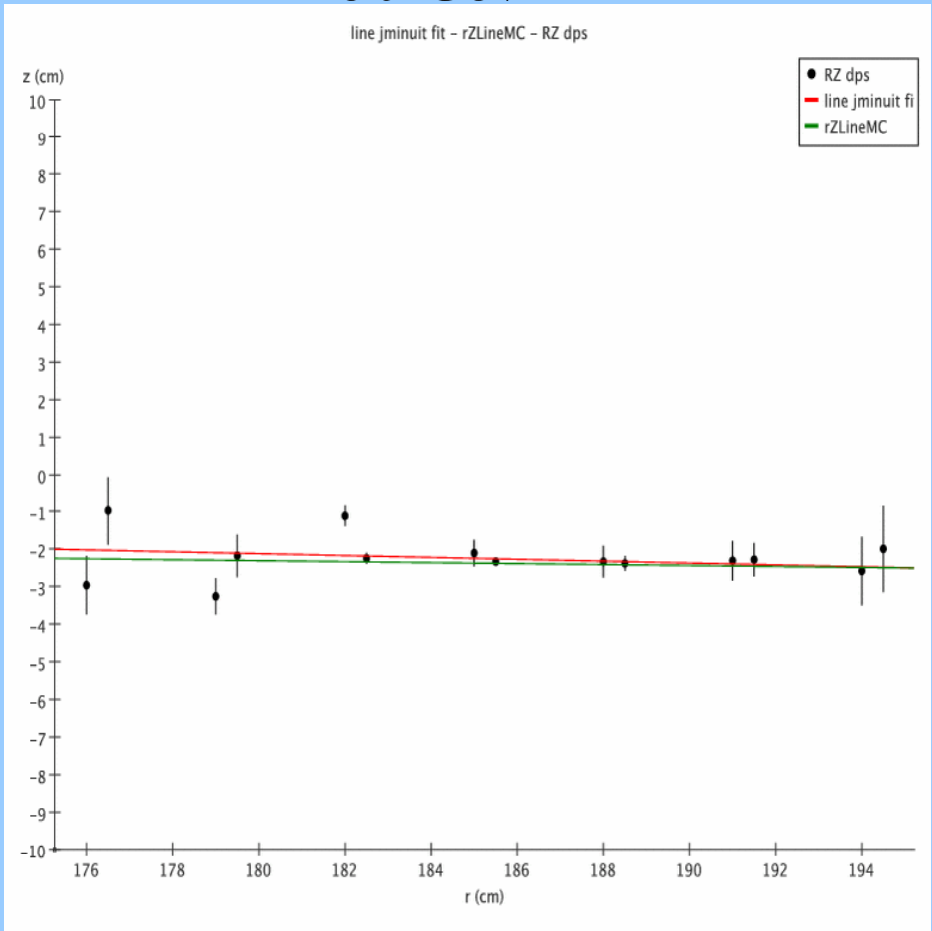
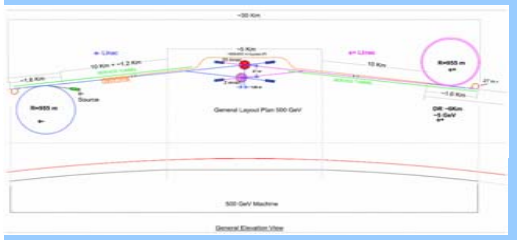
Fitted γ direction from shower energy distribution

20 GeV *Z vs R* ***50 GeV***







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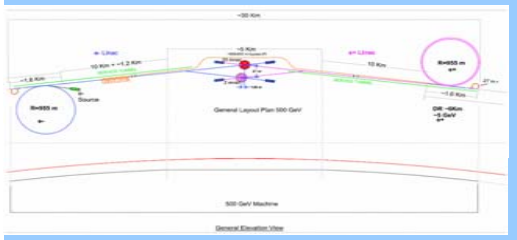
Study of the Characteristics of Silicon Photomultipliers



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New Silicon Photo-Detectors

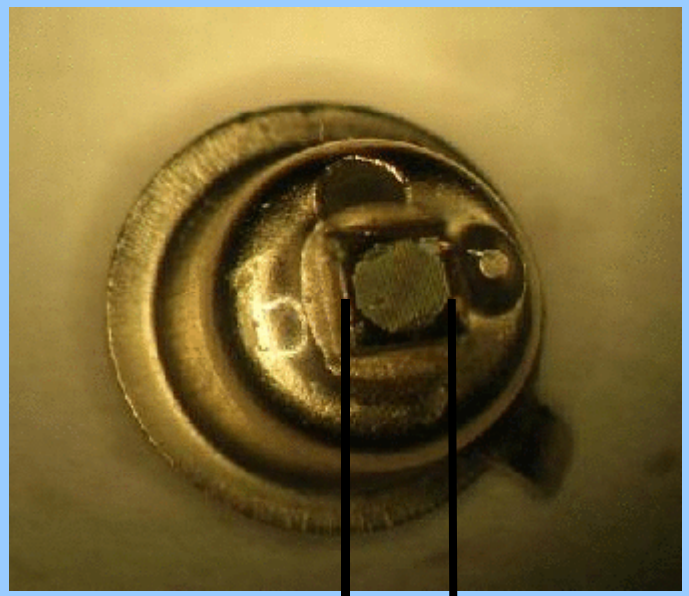
Photonique, SA

Pulsar, Russia

+

Moscow Eng.

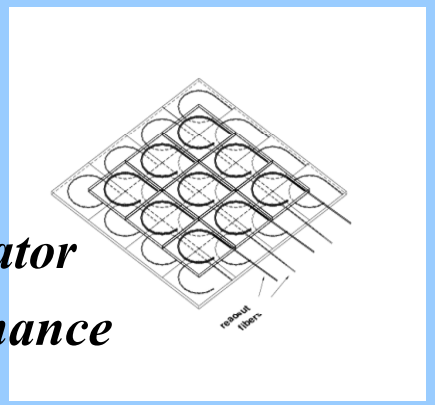
***Physics* Inst.**



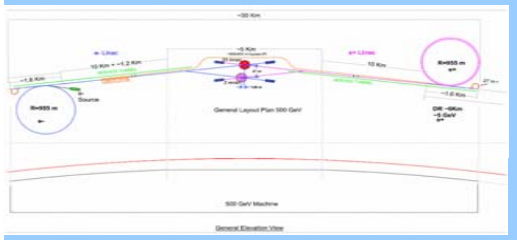
2mm

Bias Voltage

~40 volts



Scintillator performance



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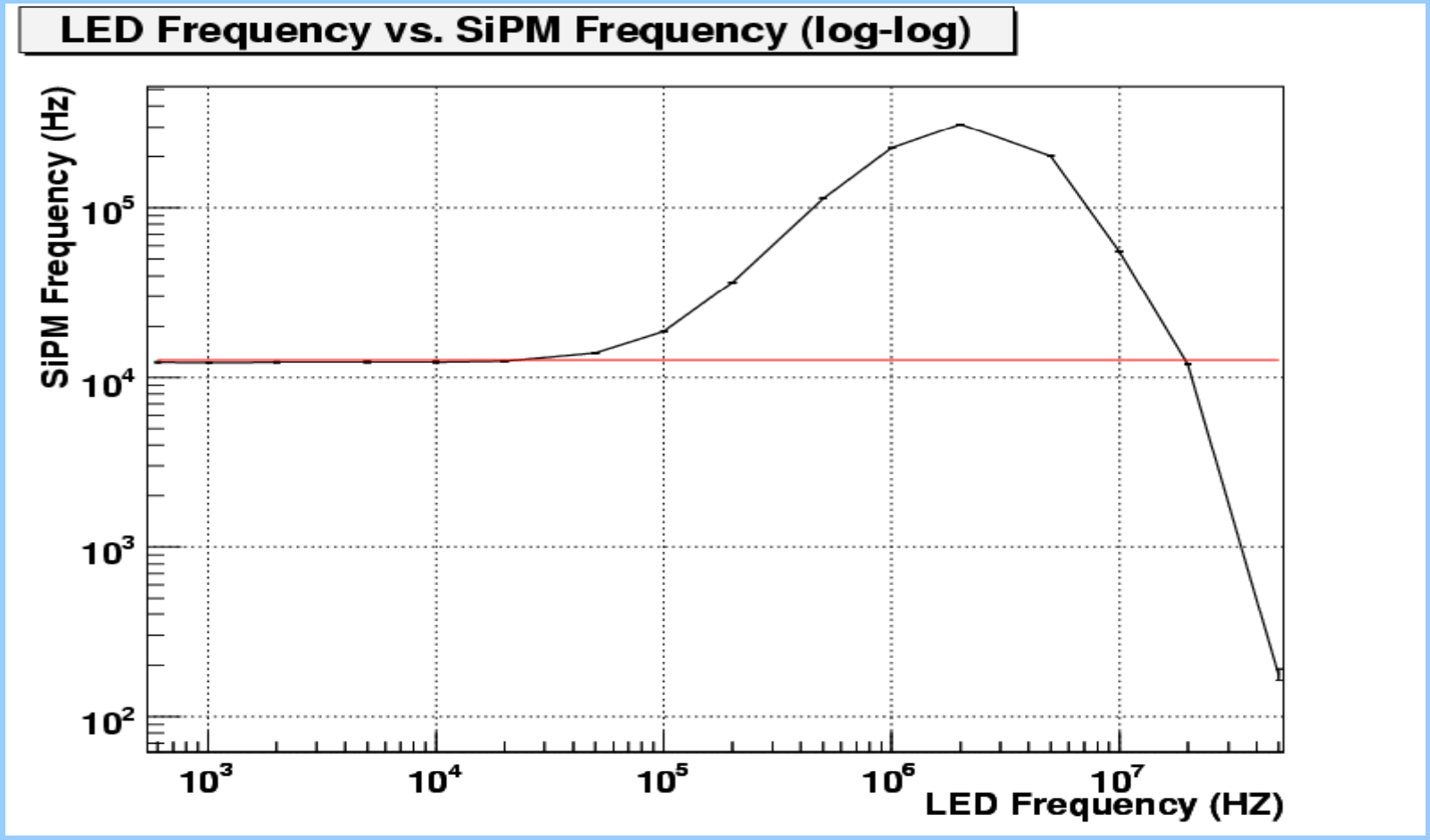

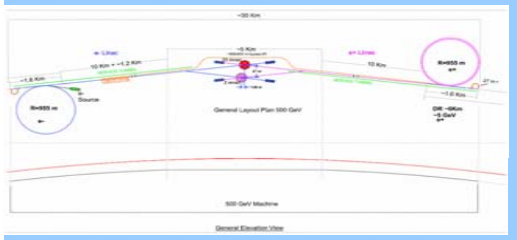

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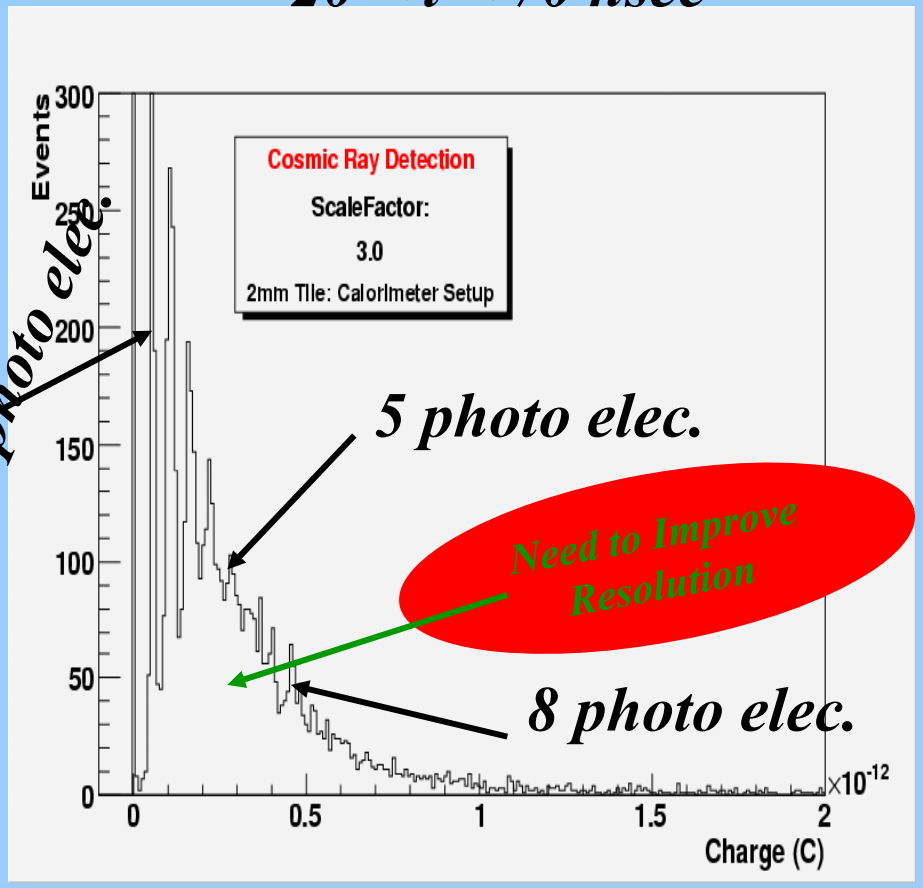
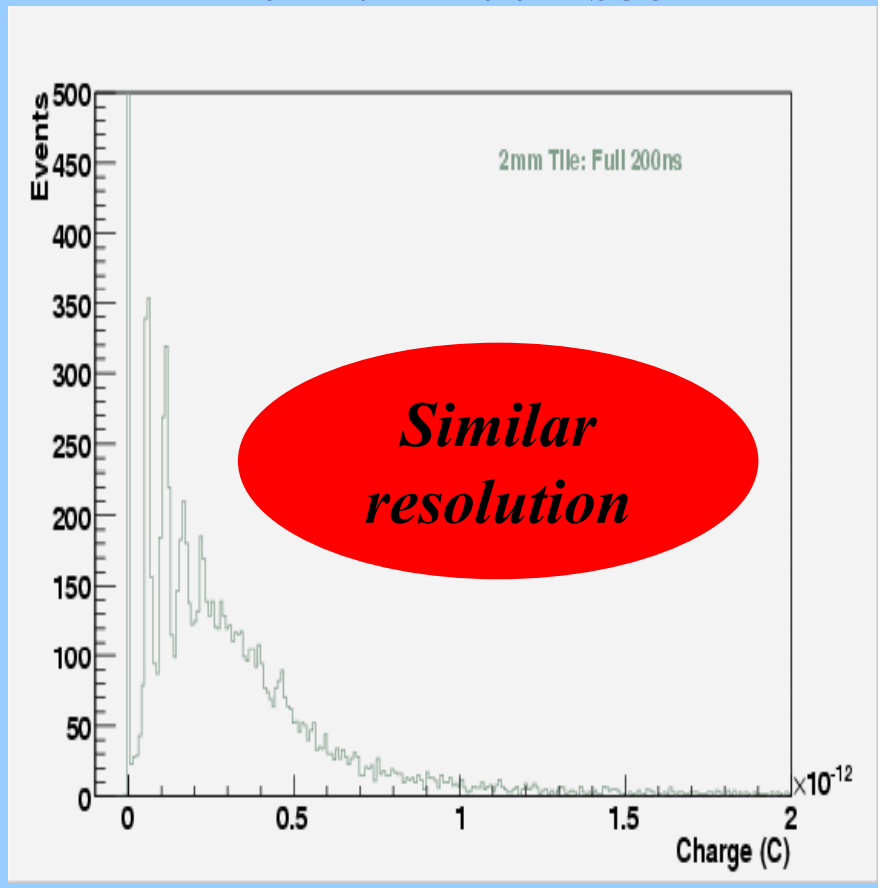
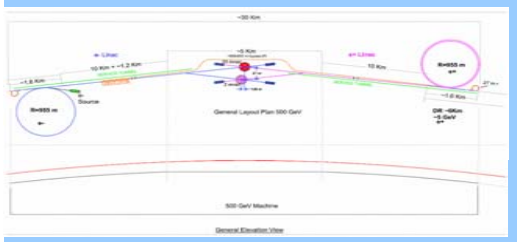
2mm scint., cosmic rays

20 < t < 70 nsec



0 < t < 200 nsec





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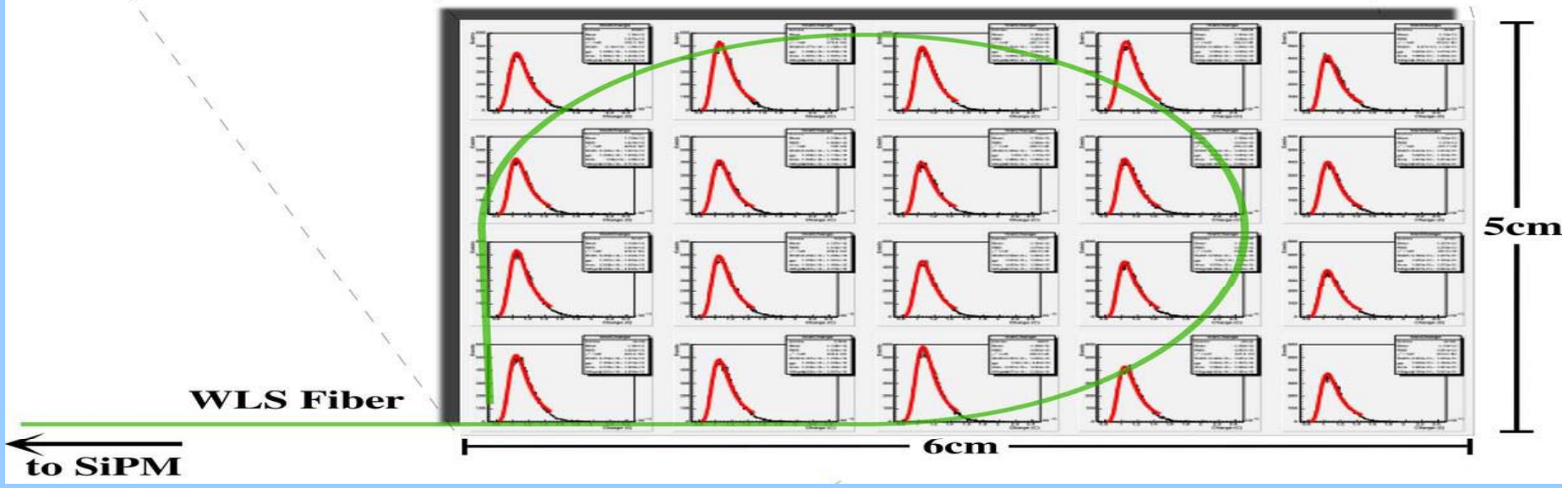
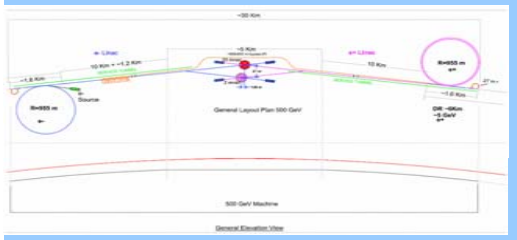
Most Probable Values (Coulombs)				
(1.0352 ± 0.0011)e-12	(1.0385 ± 0.0010)e-12	(1.0365 ± 0.0010)e-12	(1.0381 ± 0.0010)e-12	(1.0261 ± 0.0011)e-12
(1.0332 ± 0.0011)e-12	(1.0325 ± 0.0011)e-12	(1.0297 ± 0.0011)e-12	(1.0321 ± 0.0011)e-12	(1.0263 ± 0.0011)e-12
(1.0372 ± 0.0010)e-12	(1.0323 ± 0.0010)e-12	(1.0330 ± 0.0011)e-12	(1.0304 ± 0.0011)e-12	(1.0245 ± 0.0012)e-12
(1.0345 ± 0.0010)e-12	(1.0322 ± 0.0010)e-12	(1.0395 ± 0.0010)e-12	(1.0337 ± 0.0011)e-12	(1.0282 ± 0.0012)e-12





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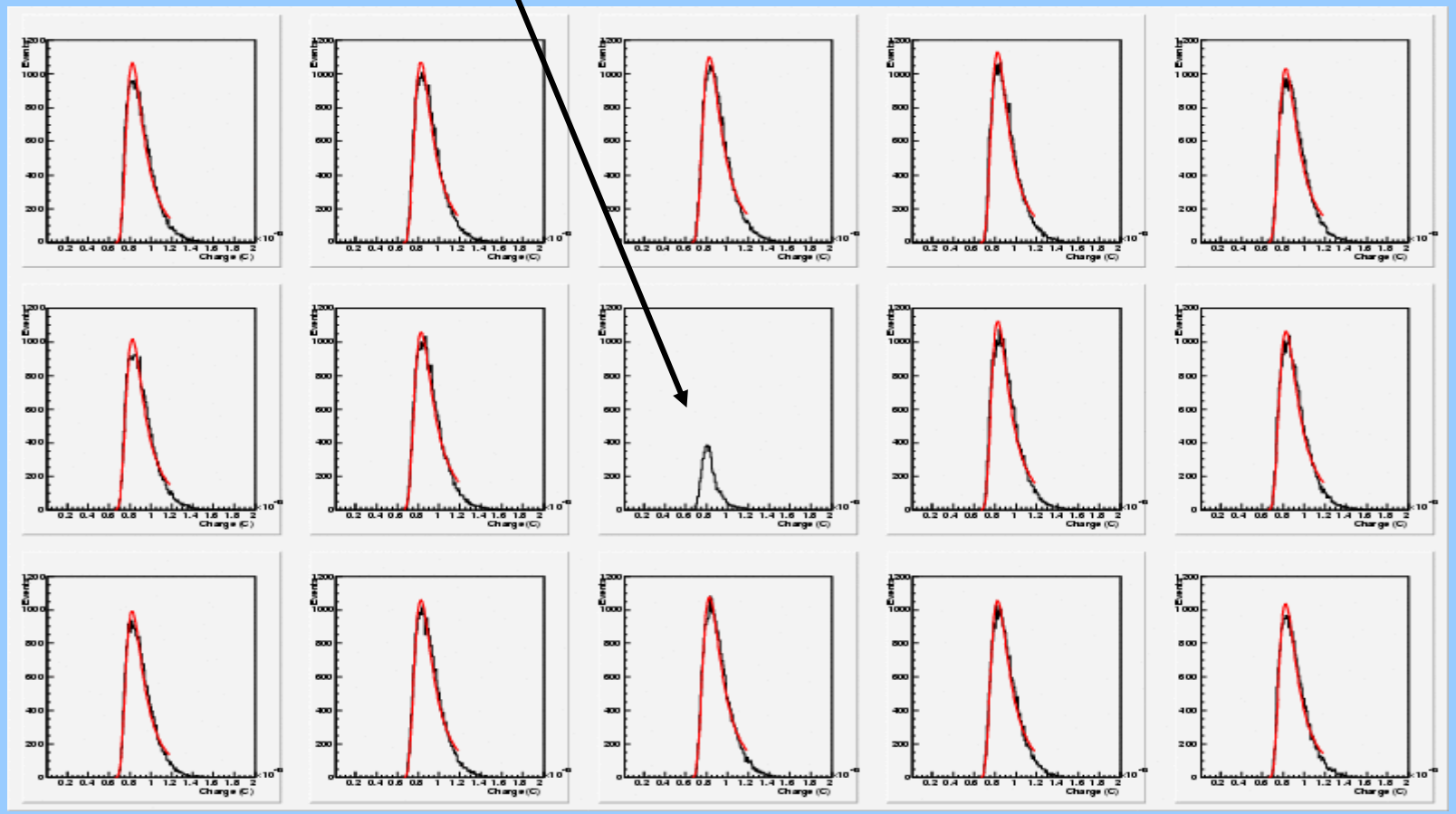
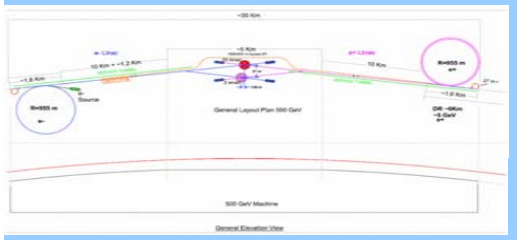
Sipm attached to the center of surface of the scintillator tile





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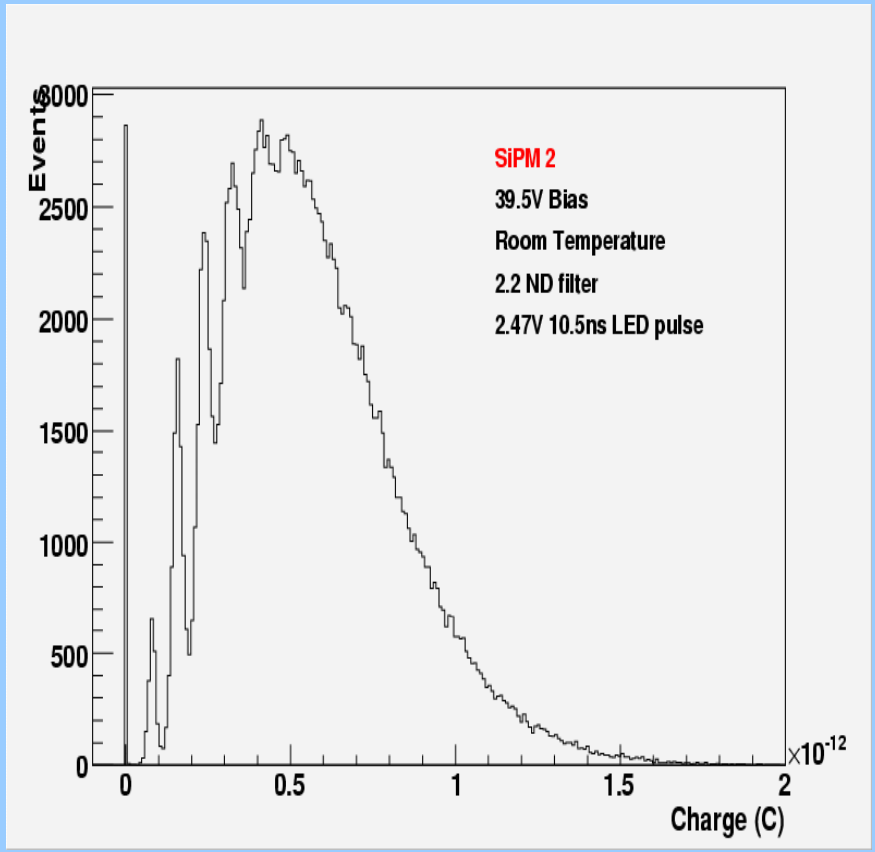
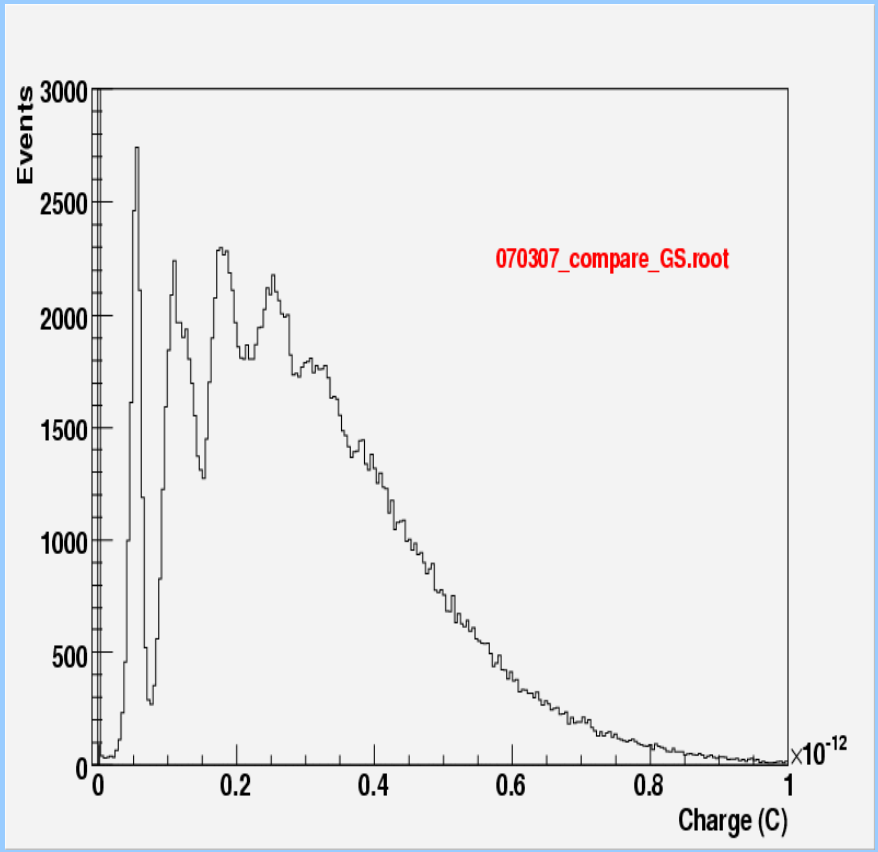
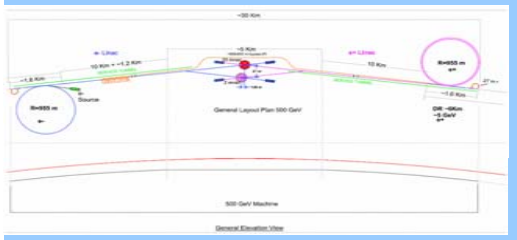
New Nat. Inst. PHA







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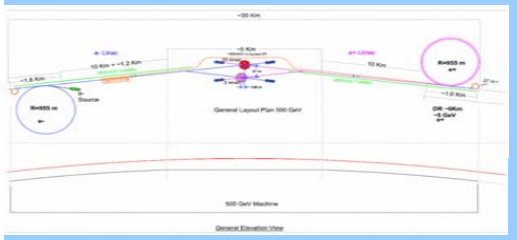
Special Budgetary Issue

ILC R&D in DOE (Paul Grannis) awarded us a $20 K late award that could not be sent to CU but could only be deposited at SLAC because of the timing.

I request that I use these funds for BaBar work and be allowed to used BaBar funds deposited in Colorado for ILC R&D work.



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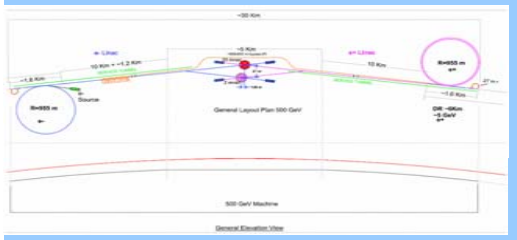
Because ILC R&D funds become available in
~ July the funds cover 2 years of BaBar work

1 year of differential housing costs for Nagel
$5 K
1 year travel costs from Colorado to SLAC
$5 K

The total award from ILC R&D is $53 K



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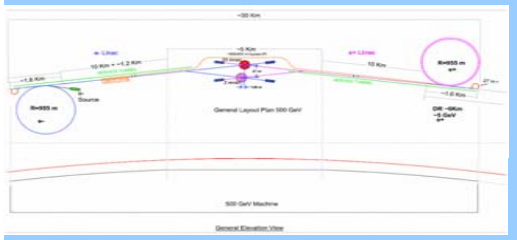
The University has contributed to my research a total of $38 K towards support of a Research Associate since I have become Chair of the Boulder Faculty Assembly and my research time is now limited. I propose to use these and the ILC R&D funds towards the Research Associate if DOE accepts the ILC-BaBar fund exchange.



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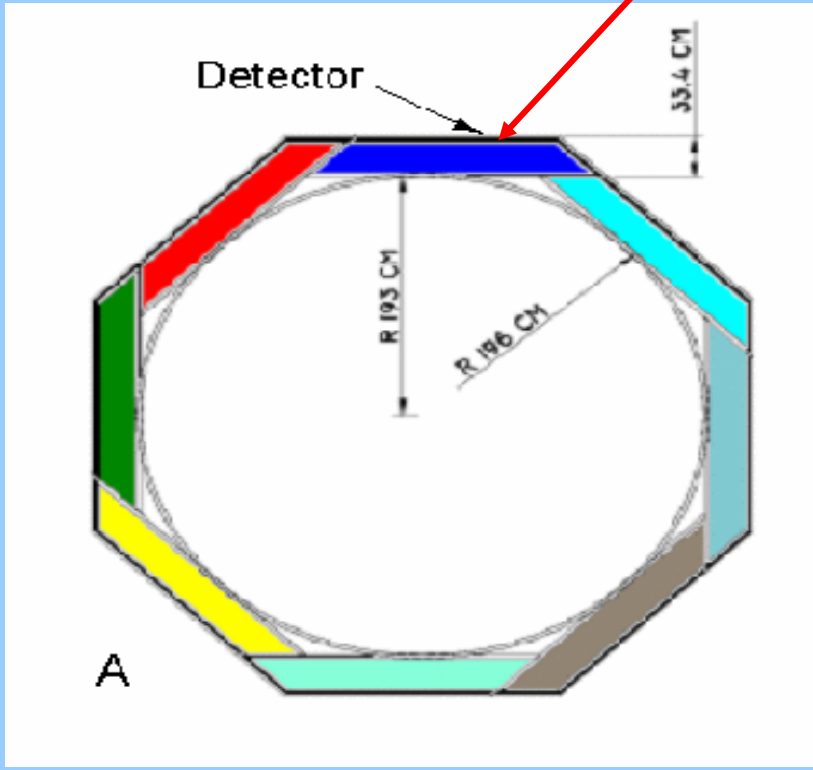
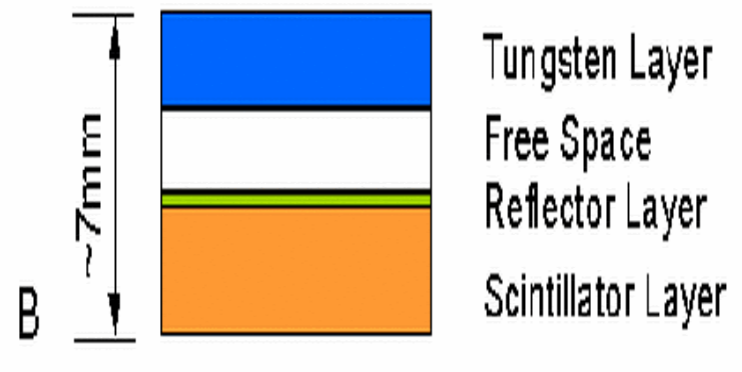
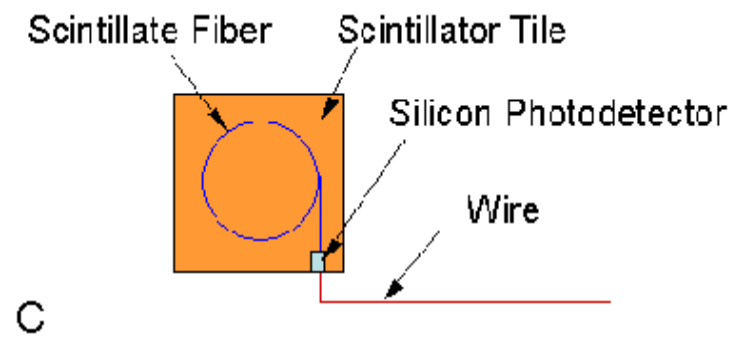
The Calorimeter

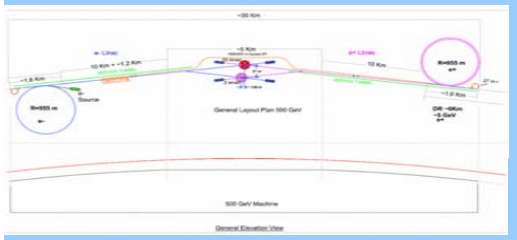
Modules

Each module = ~12 tons









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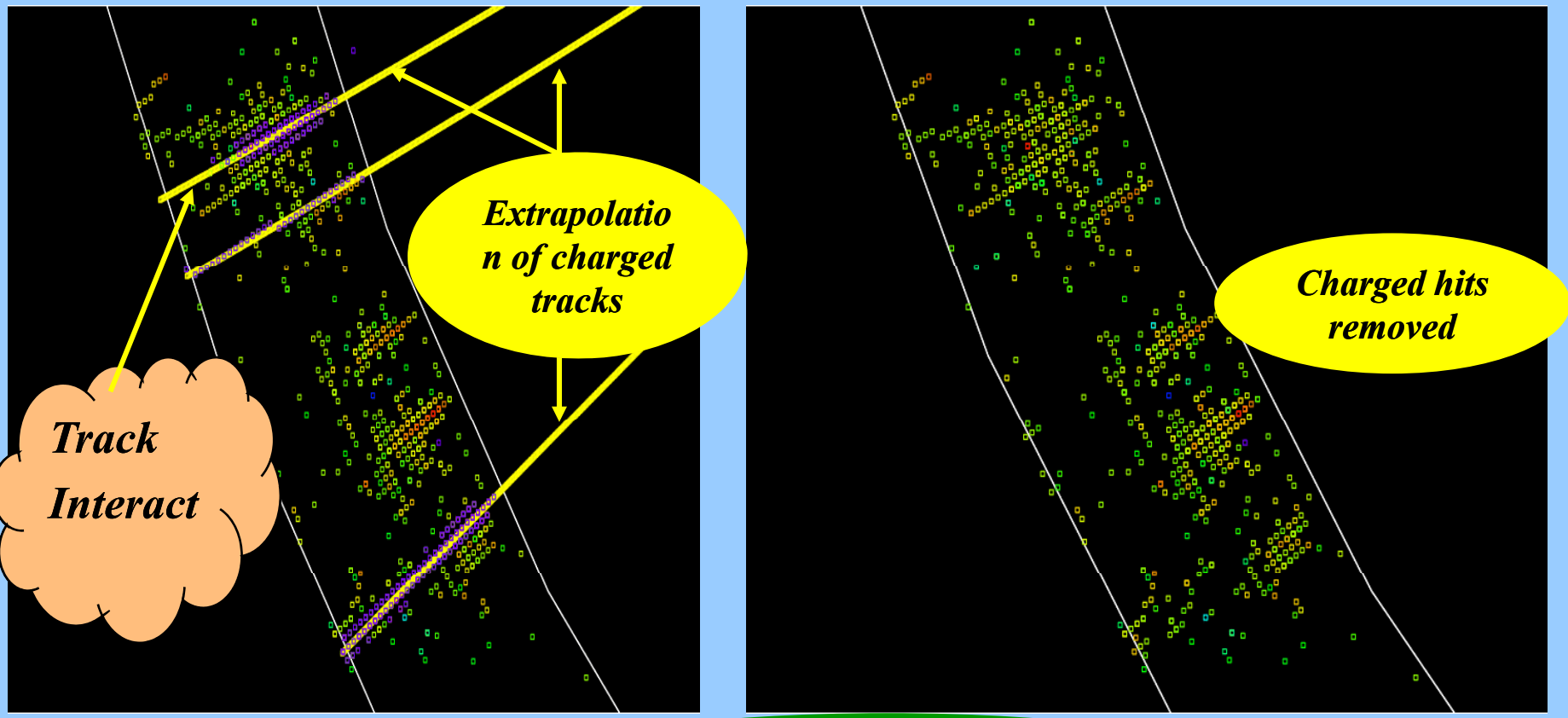
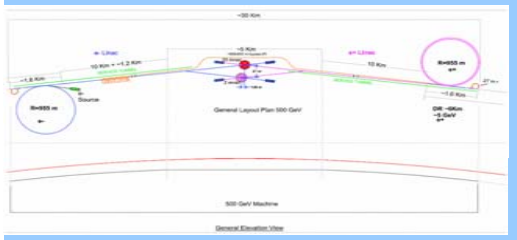
Removal of Charged Track Hits



Jason Gray, Jiaxin Yu



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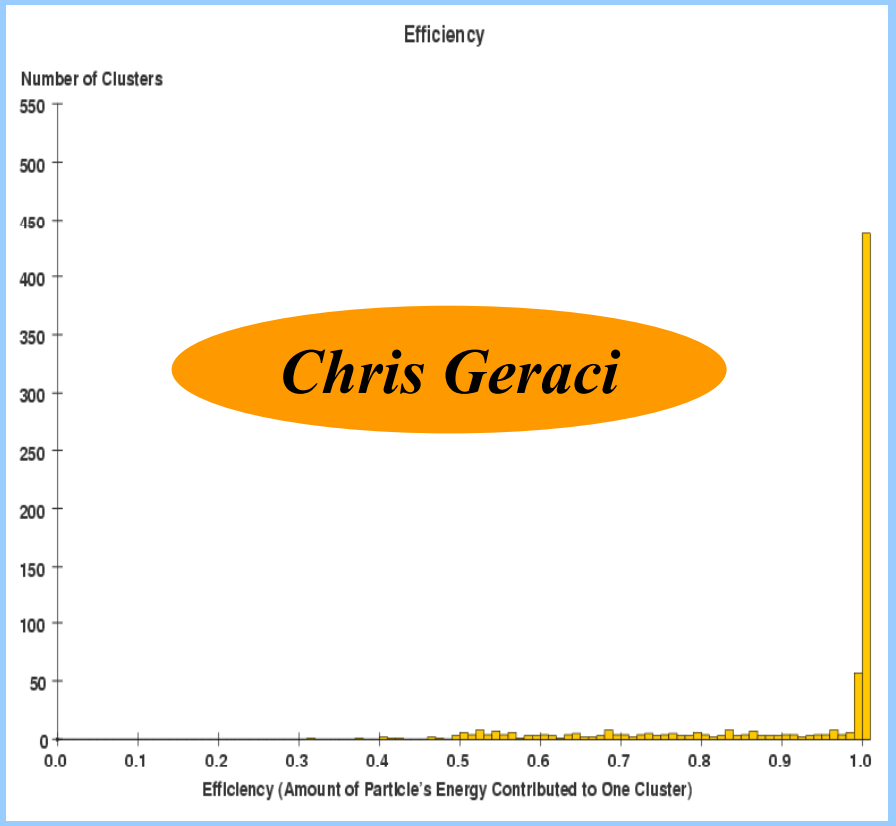
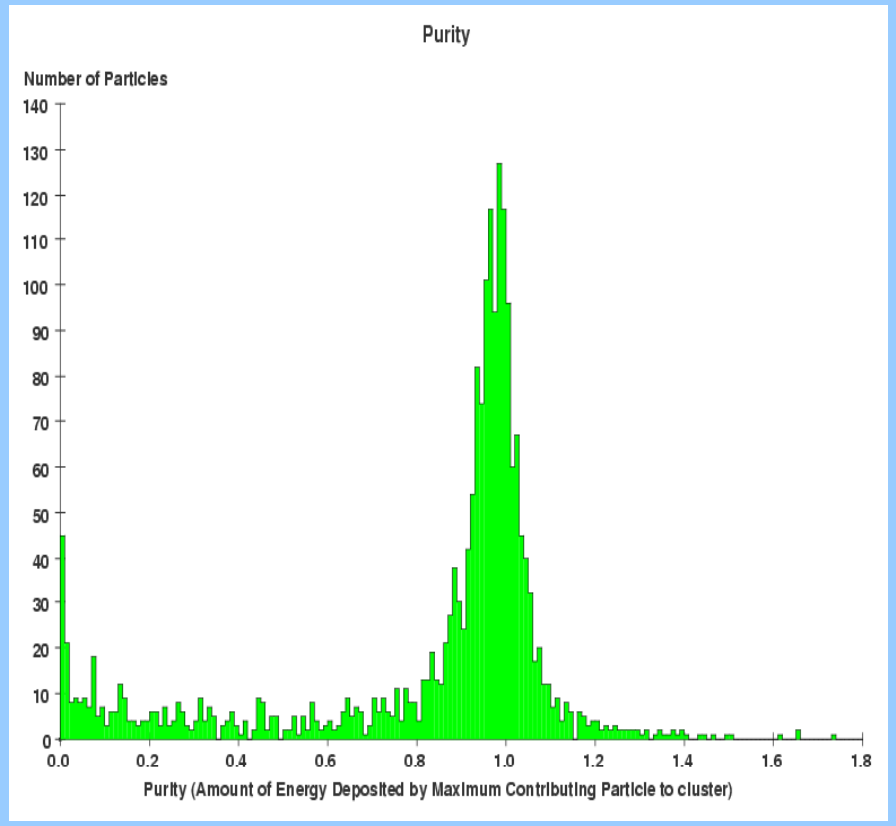
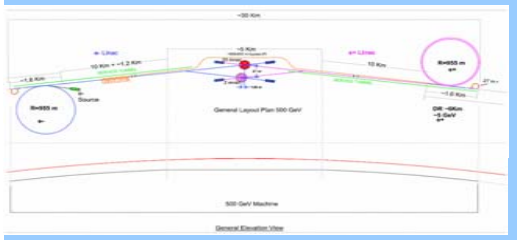
Pattern Recognition of Showers



Chris Geraci





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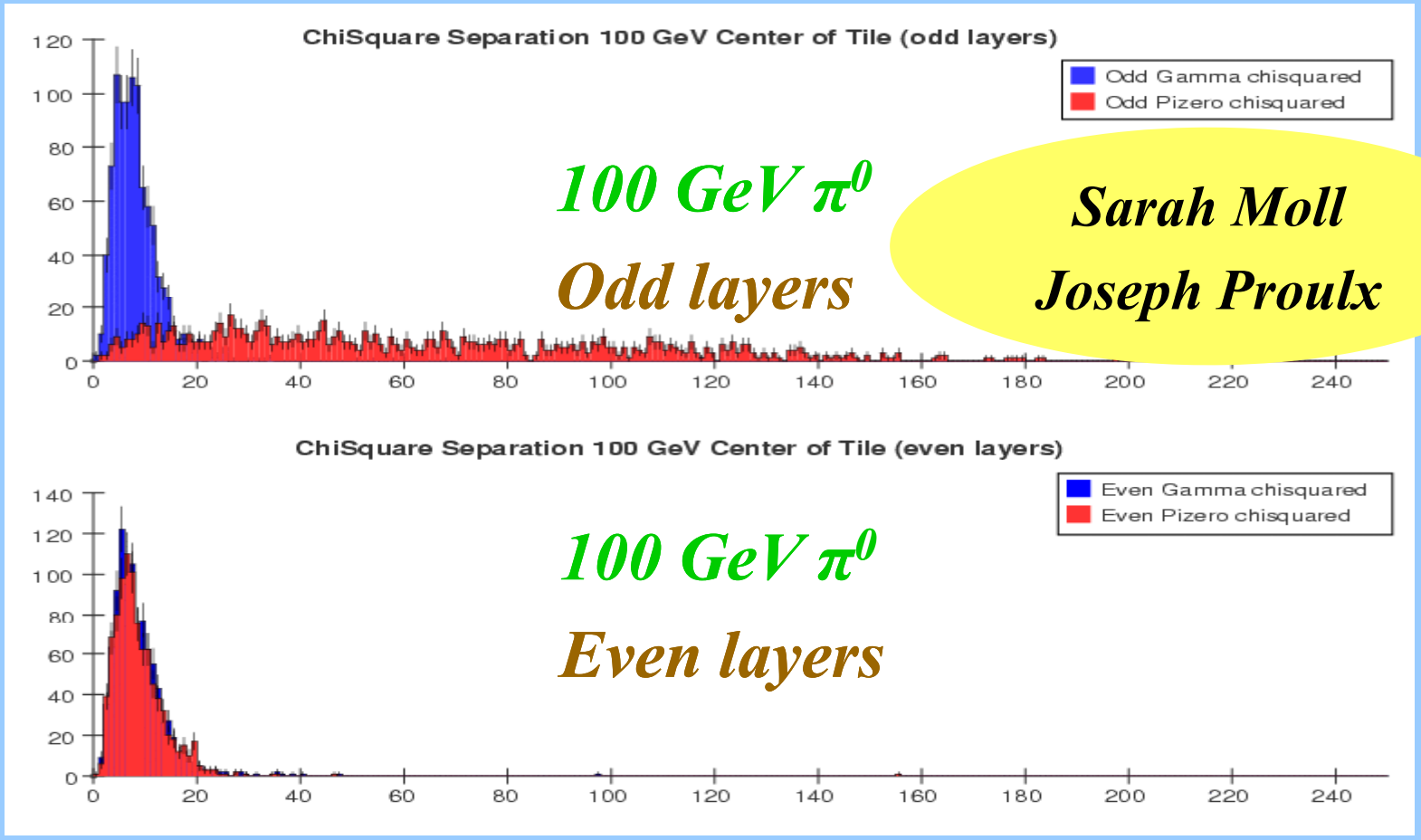
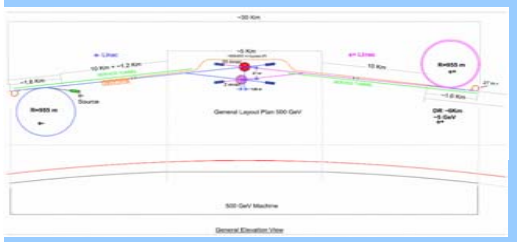
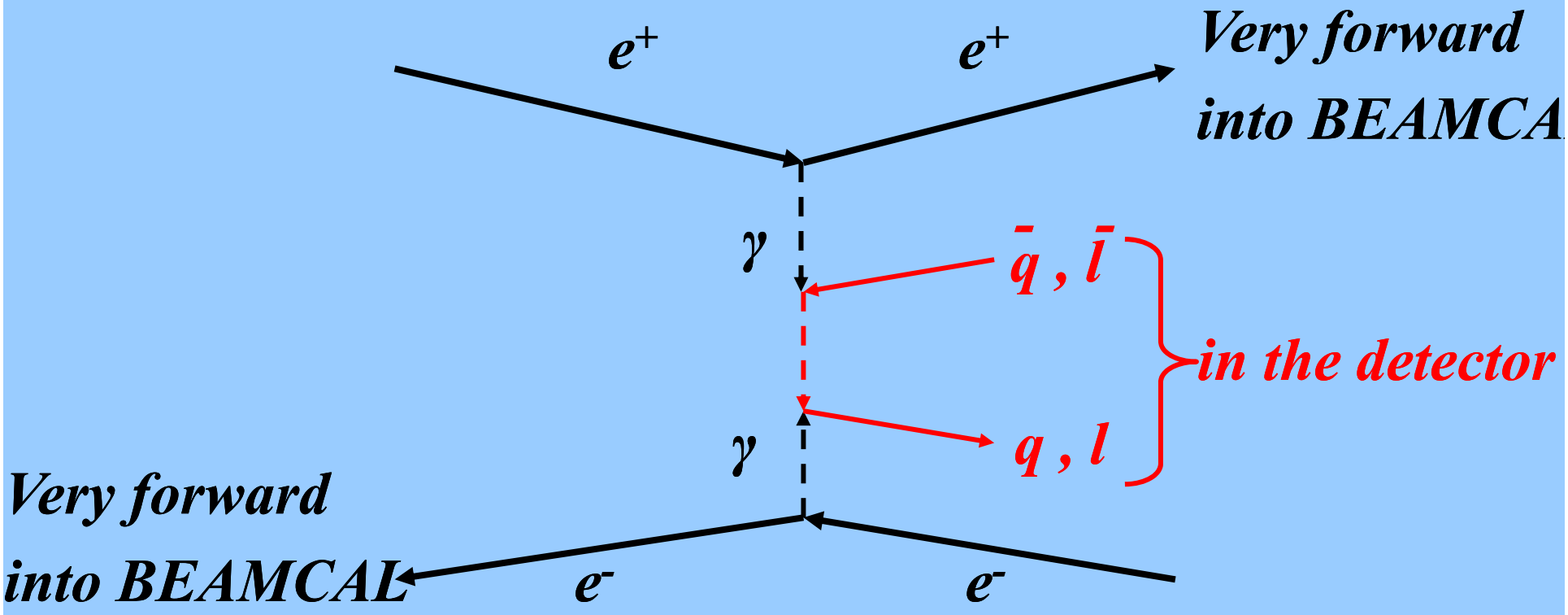
Chi Square Separation, 1st order

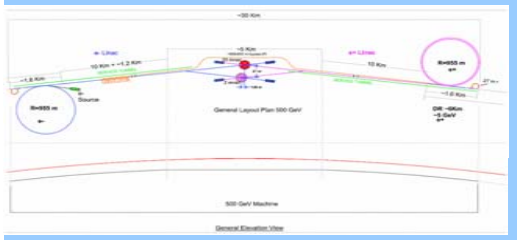




2 Photon Process



Discussion in Beam Cal section at end



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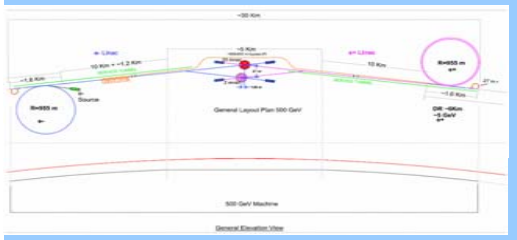
Study the efficiency to observe the electron and positron of the two photon process above the beamstrahlung background

Essential to remove this background in the study of Supersymmetry in the dynamic region of low Pt. Needed to measure the masses.



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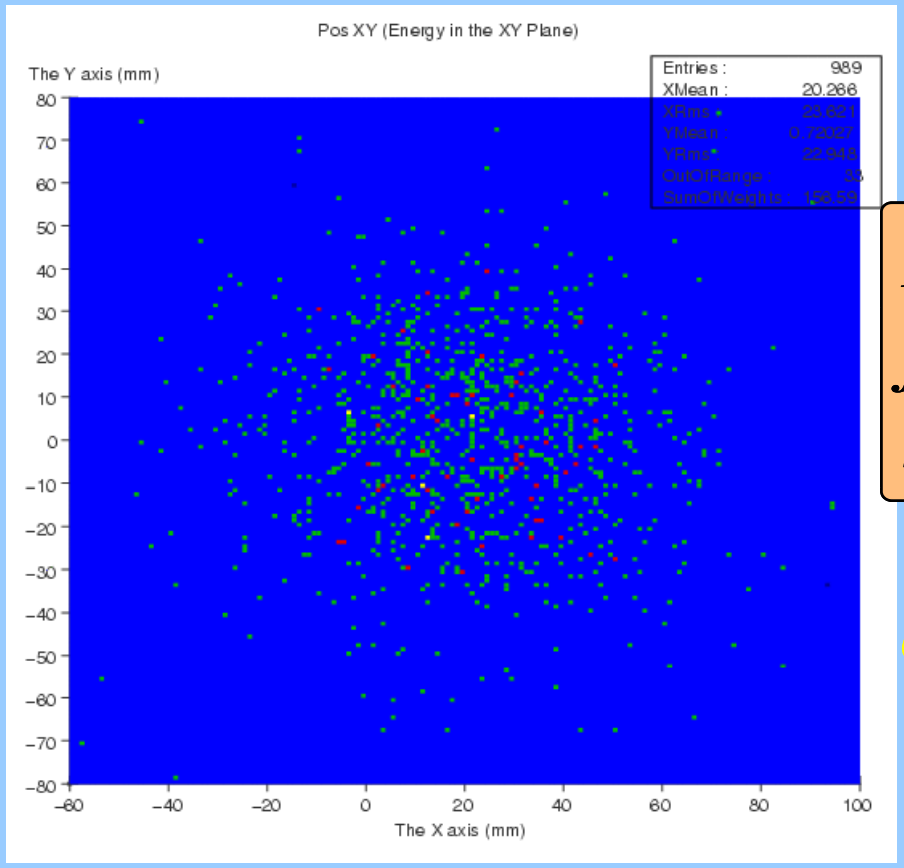
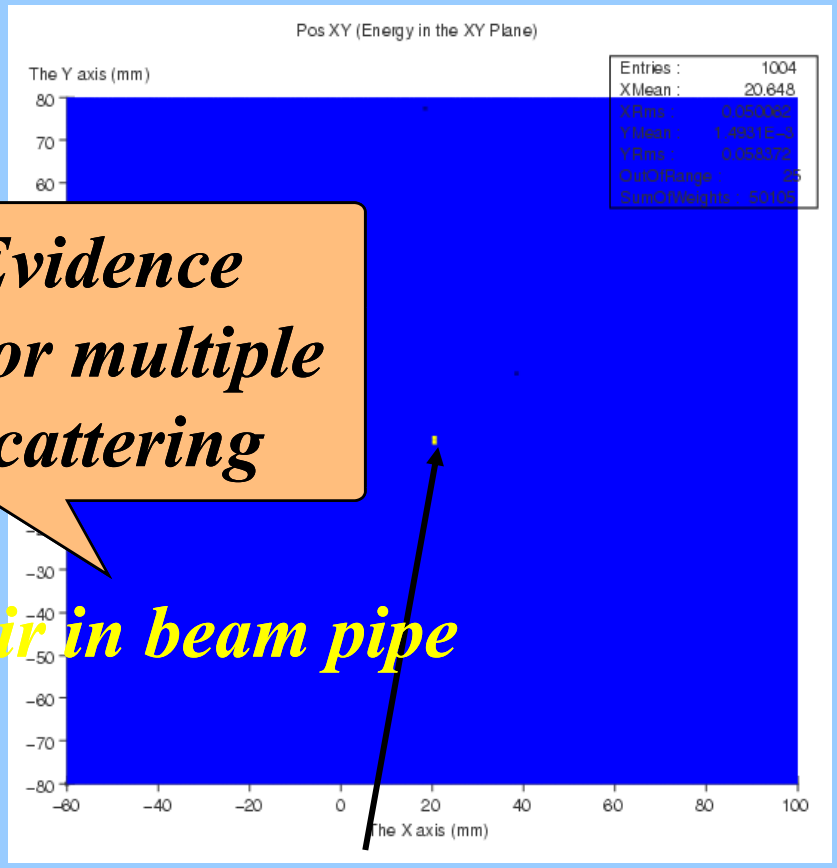
Testing GEANT 4.0



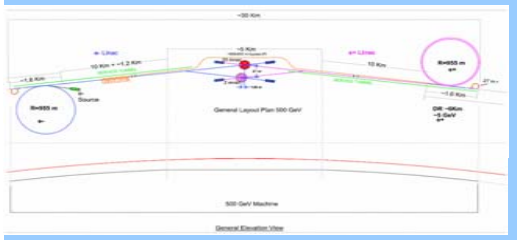


Evidence for multiple scattering

air in beam pipe

No field, 50 MeVmuons

No field, 50 GeV muons



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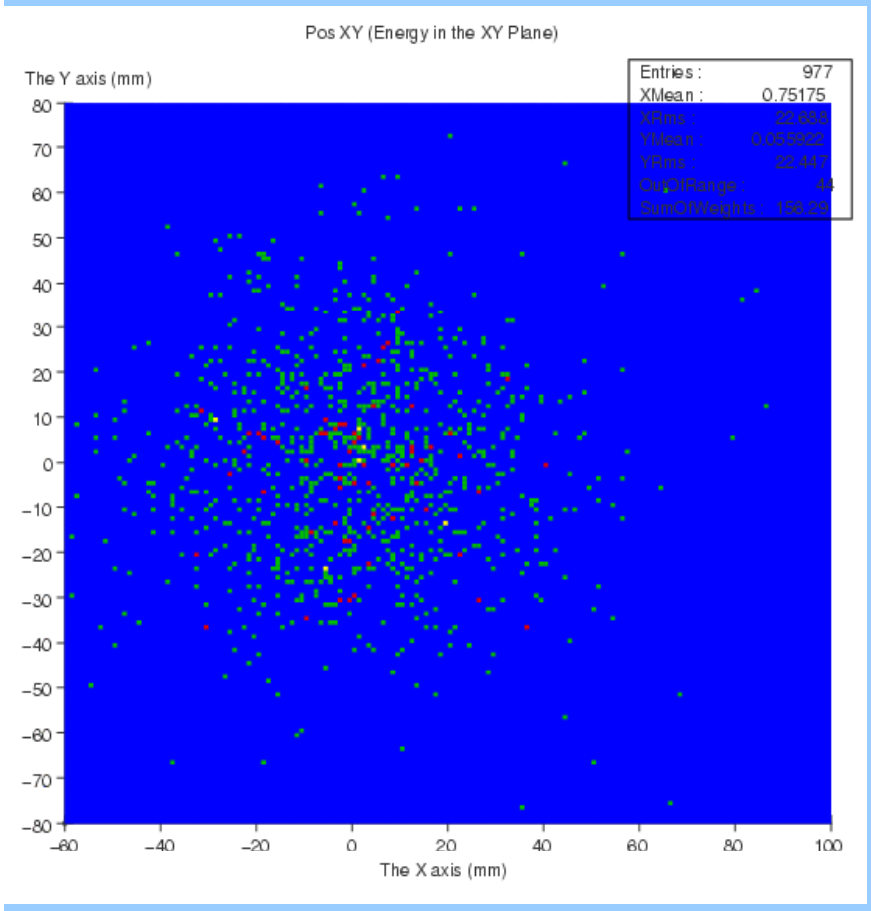
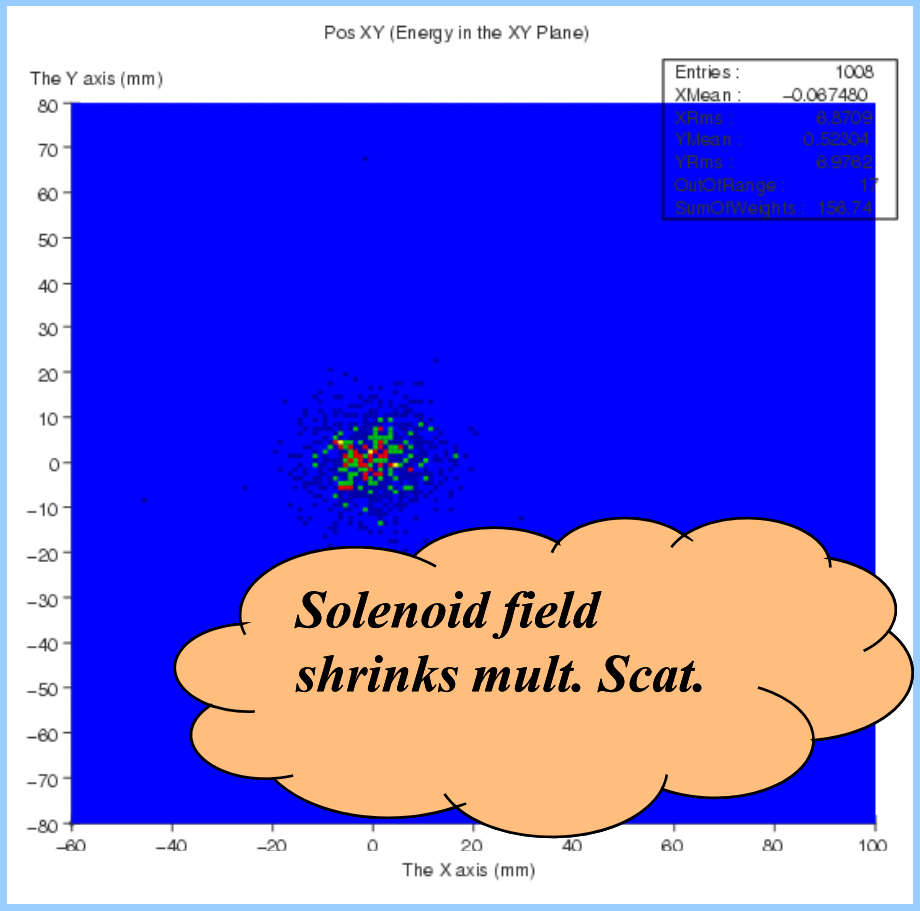
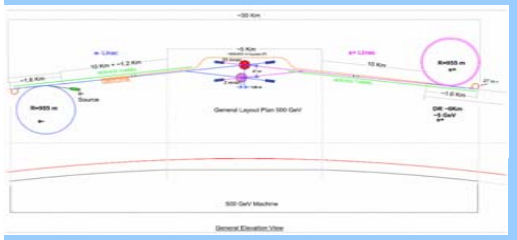
50 MeV, no field, forward



50 MeV, solenoid on, forward





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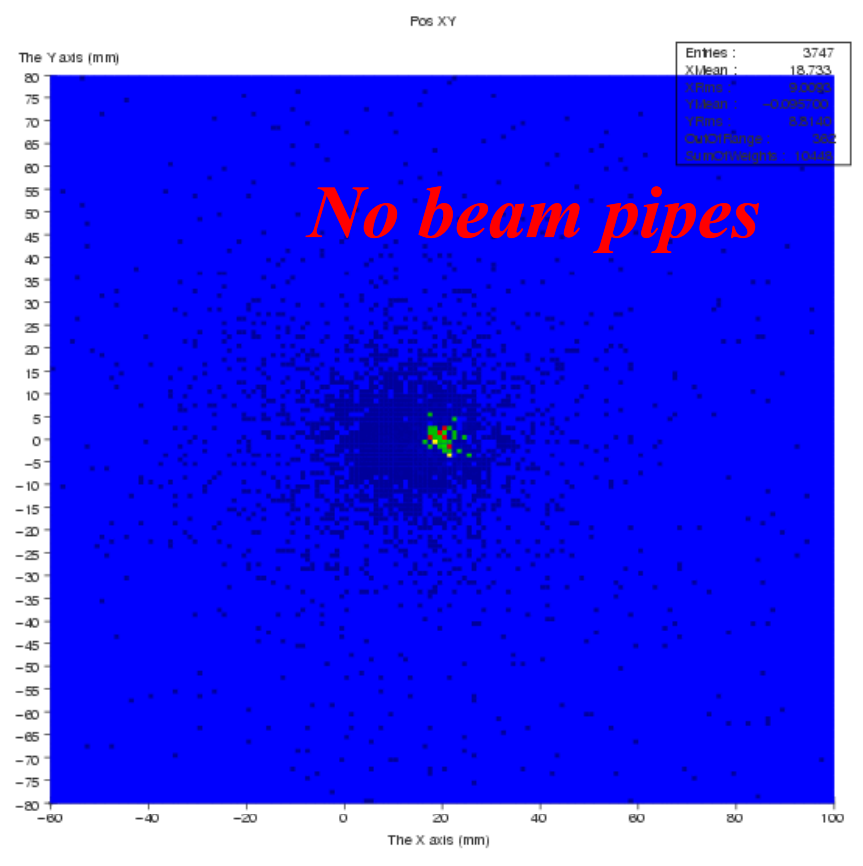
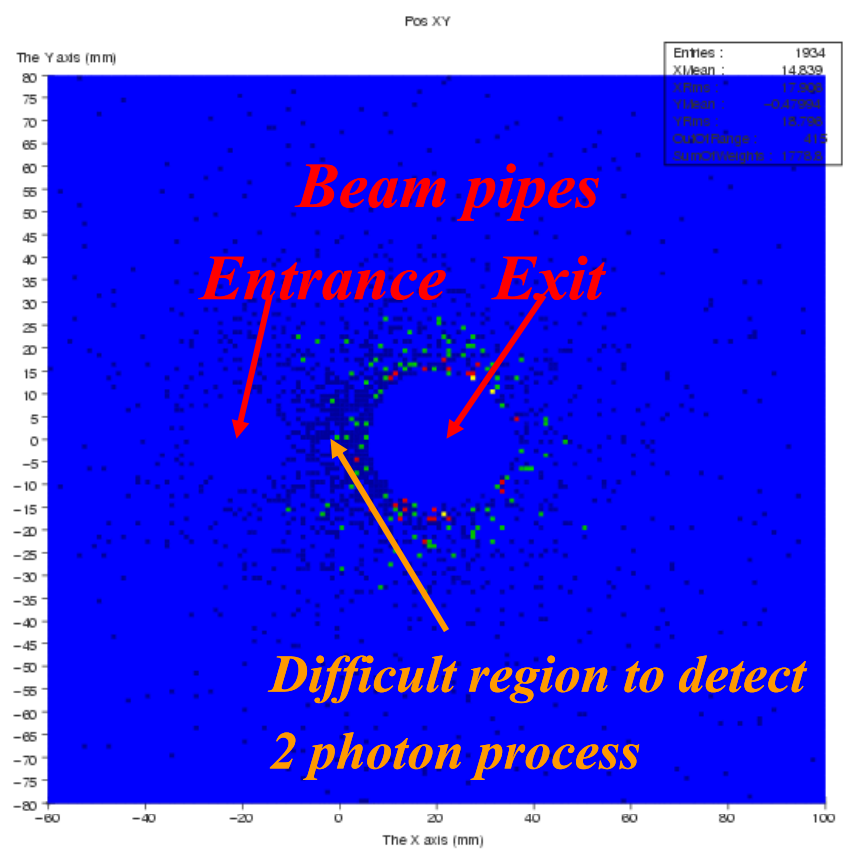
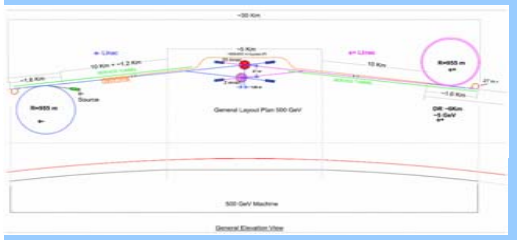
Beamstrahlung Distribution with Solenoid + Anti-DiD







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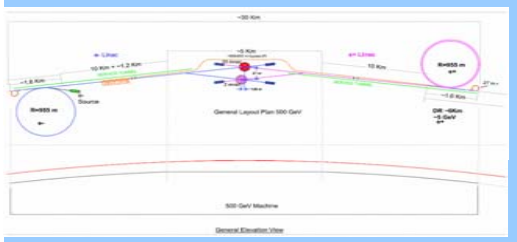
GEANT 4.0 seems to be working properly We have fixed various bugs in collaboration with SLAC team.

All Simulation is work in progress.



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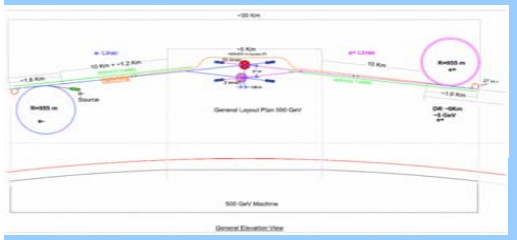
Hardware Studies

Keith Drake, Elliot Smith



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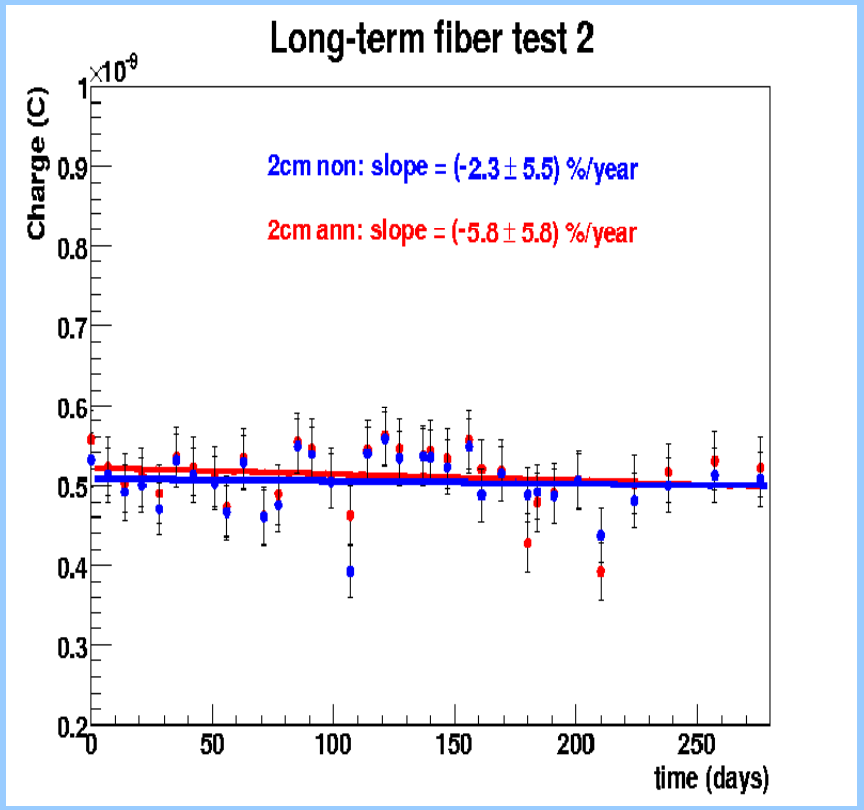
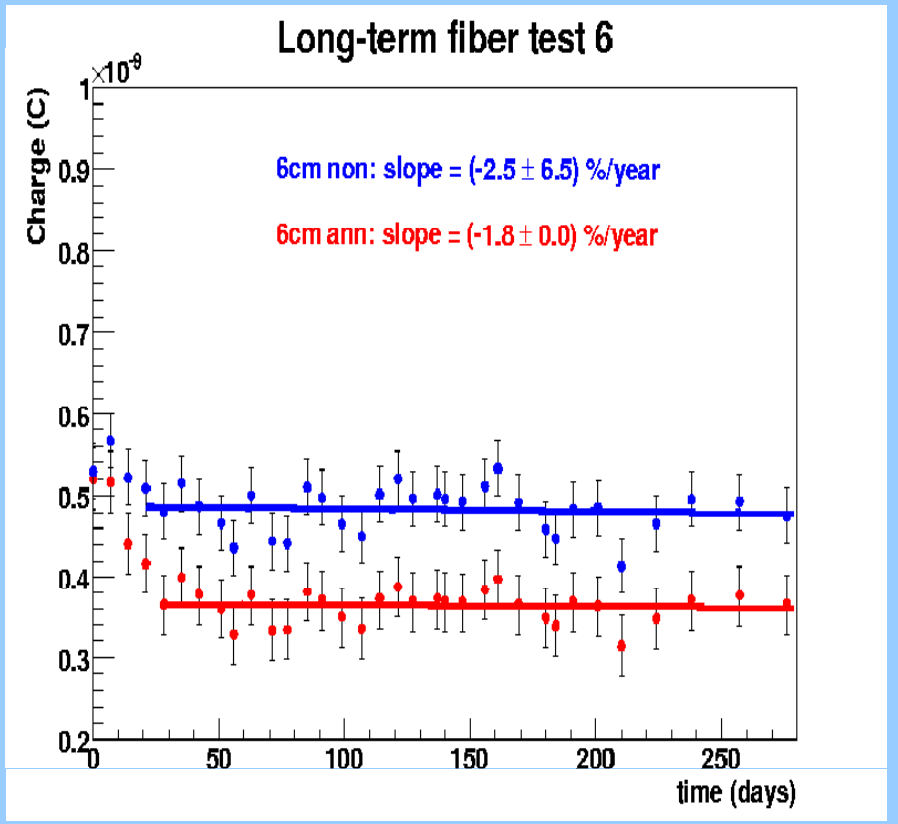
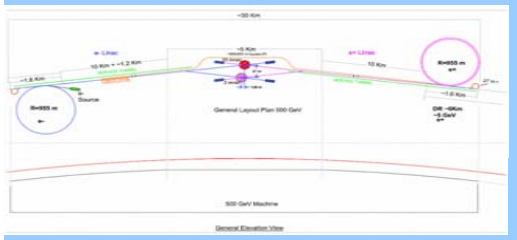
Long Term Tests of Scint. Fiber Stability







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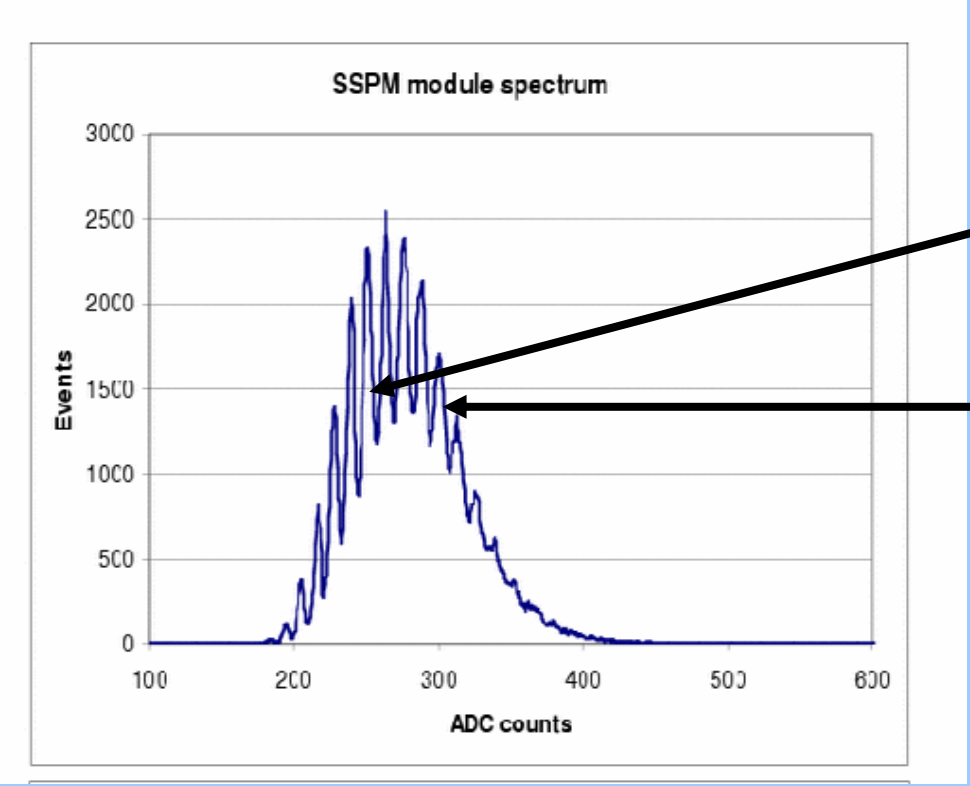
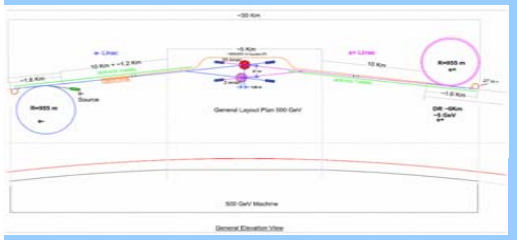
Latest Pulse Distribution from Photonique/Russia



6 photoelectrons

10 photoelectrons



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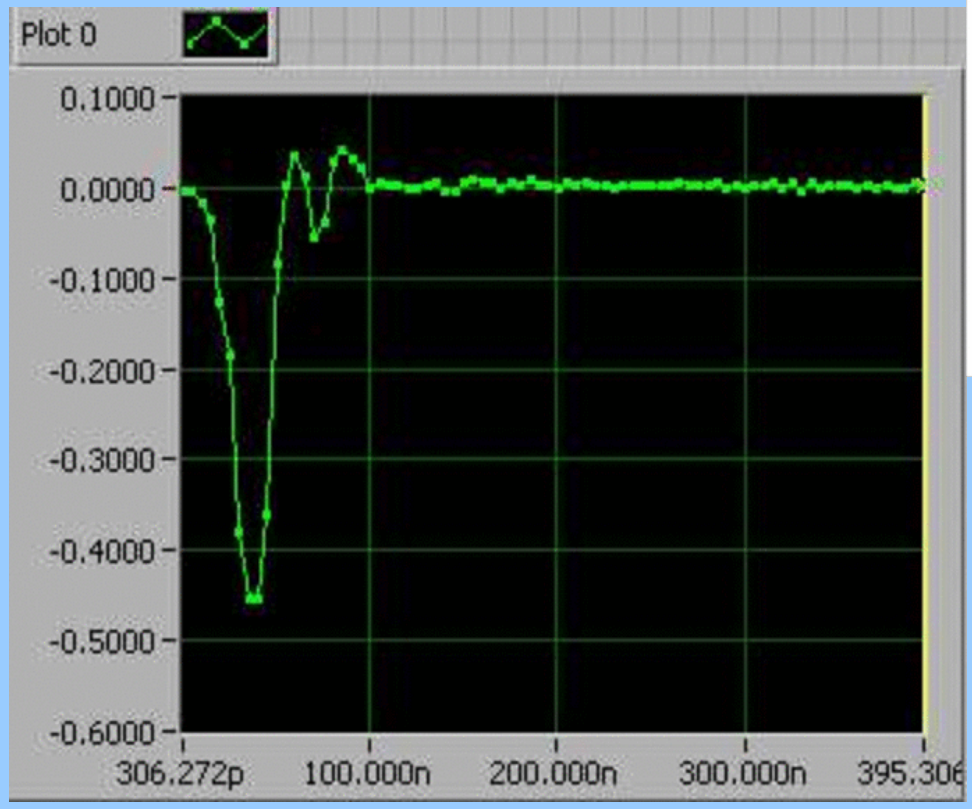
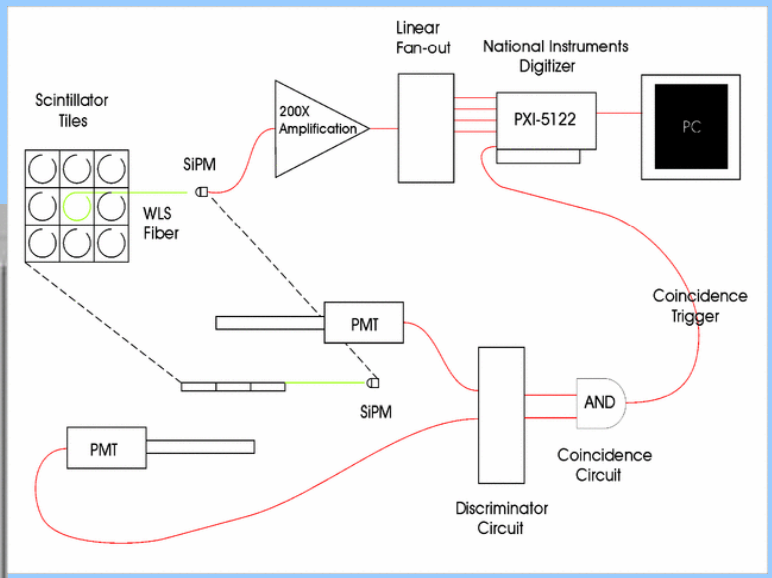
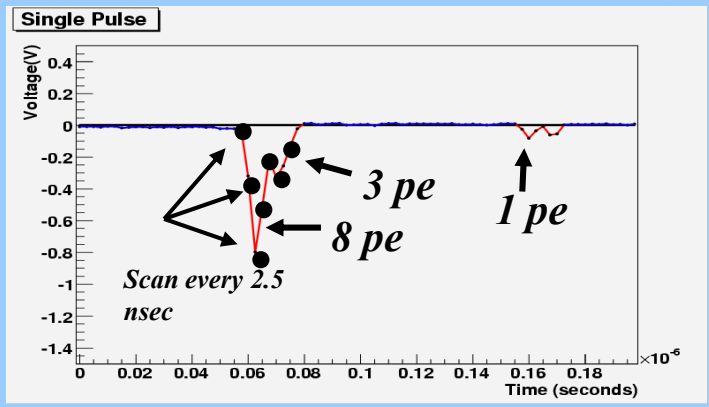
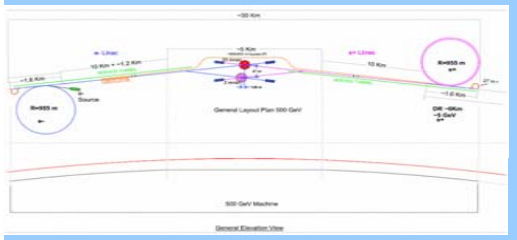
Pulse National Inst.









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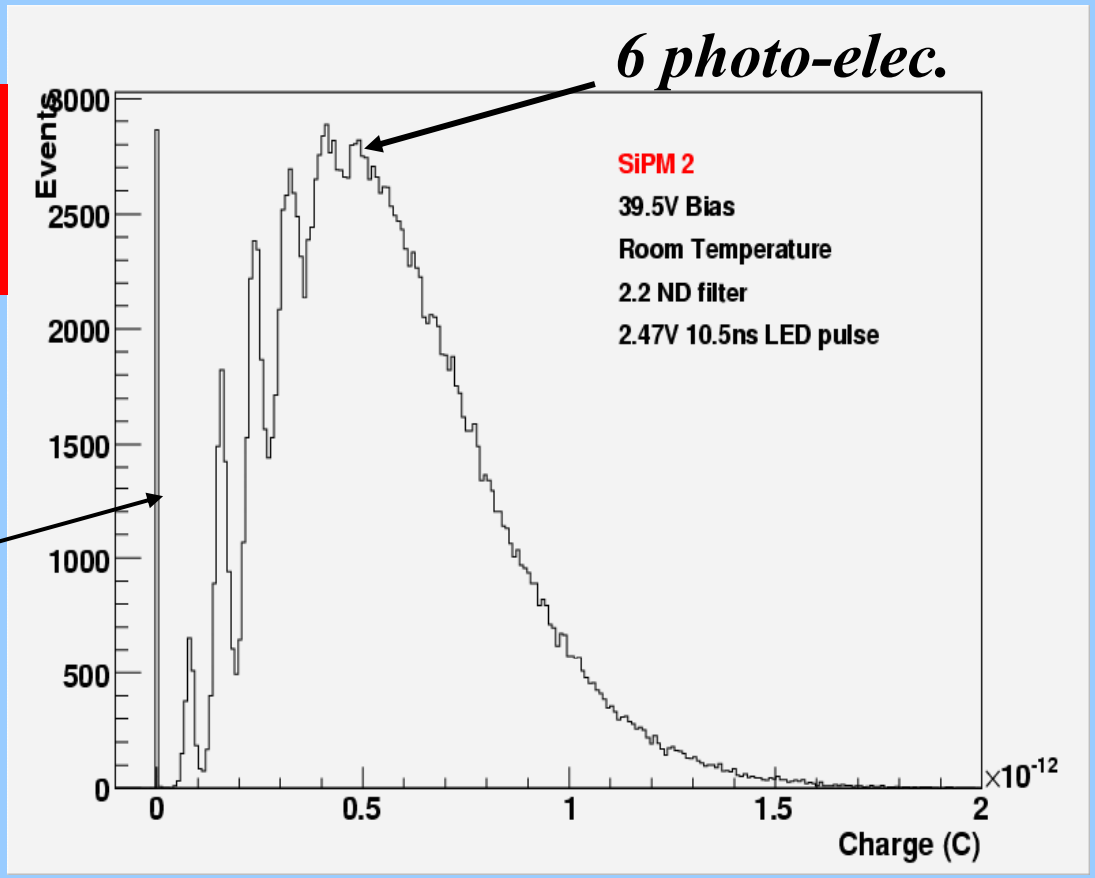
Our Measurements

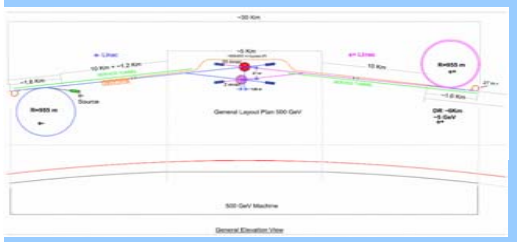
Blue LED,

10nsec, 2.5 volts drive

50 nsec gate

noiseless SiPD





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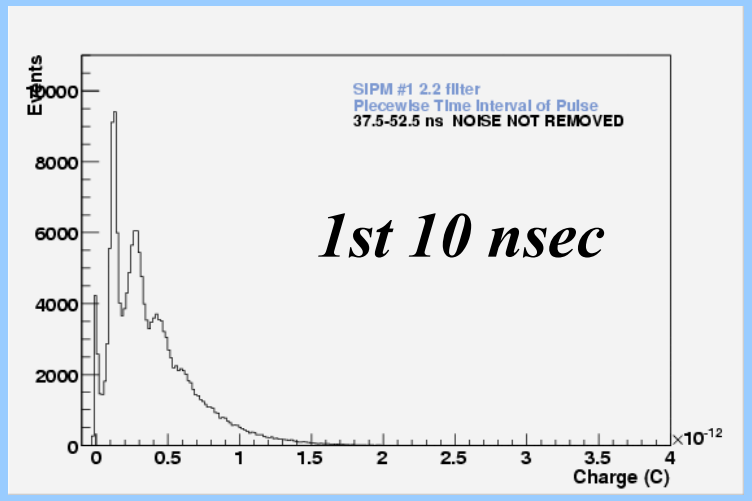

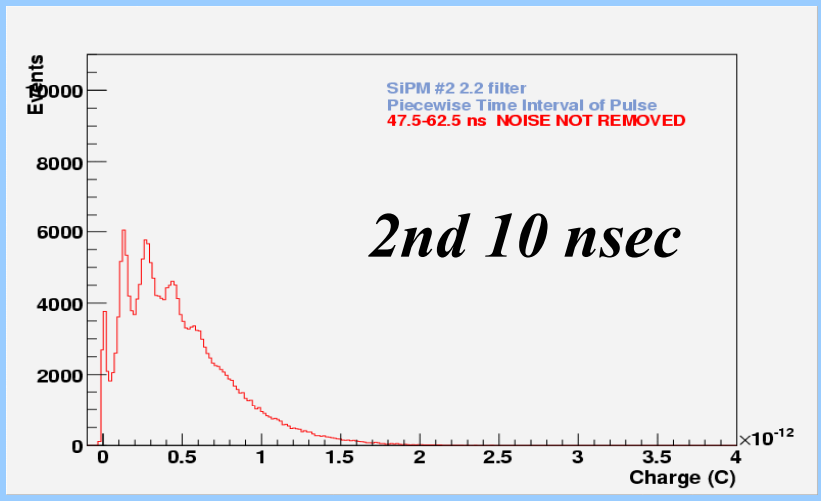

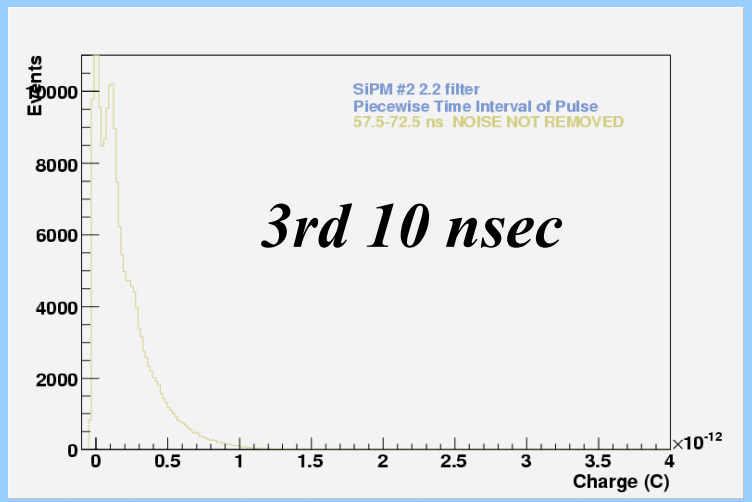

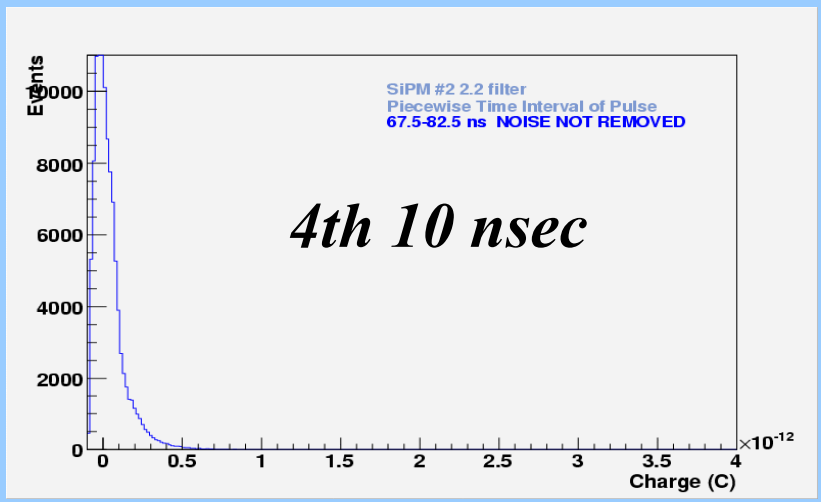

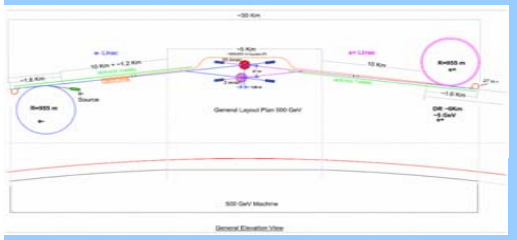

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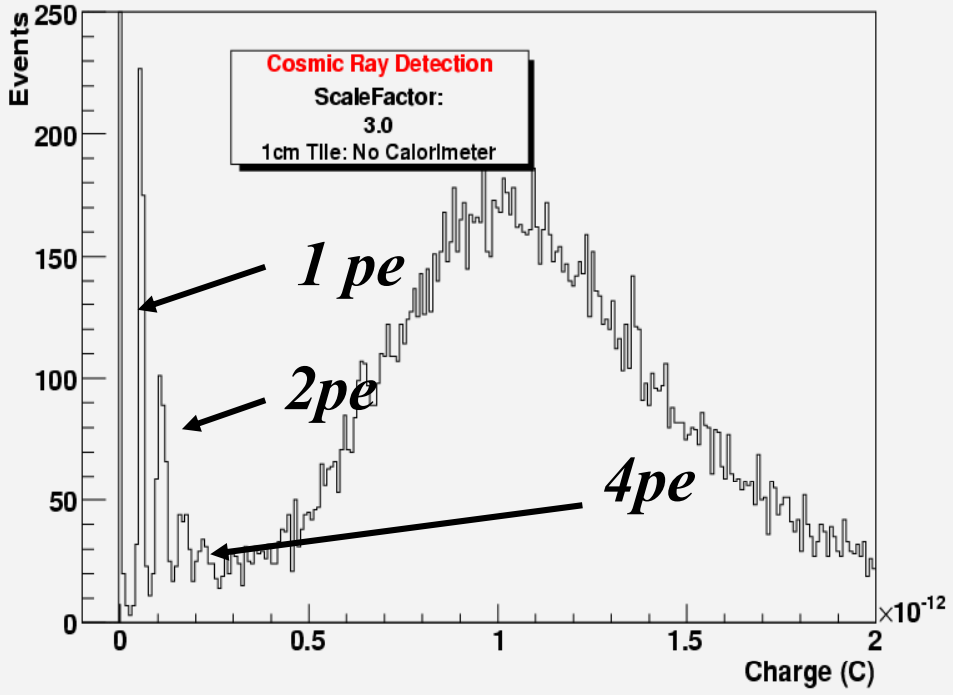
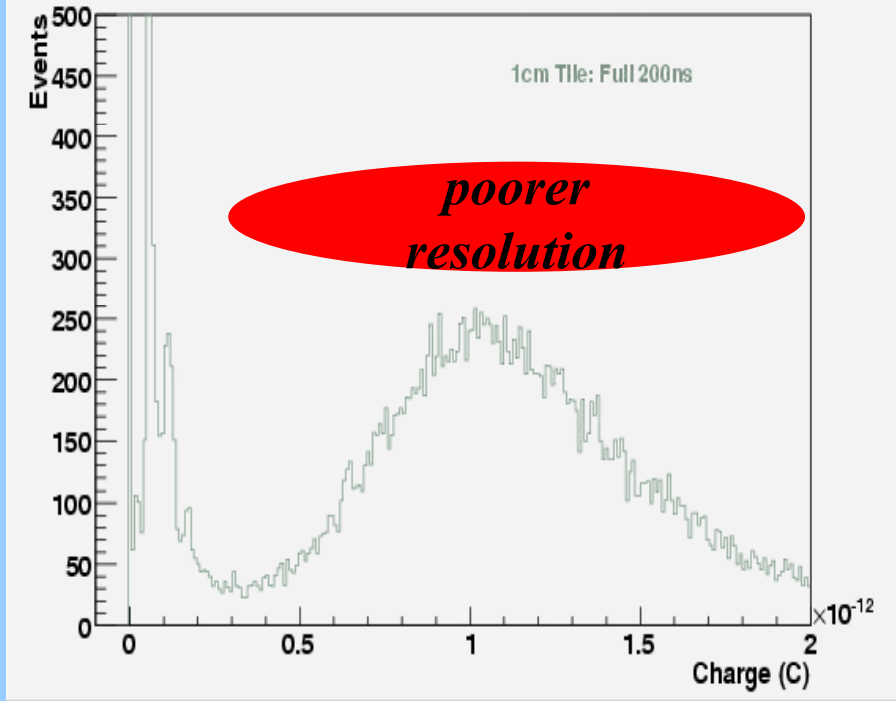
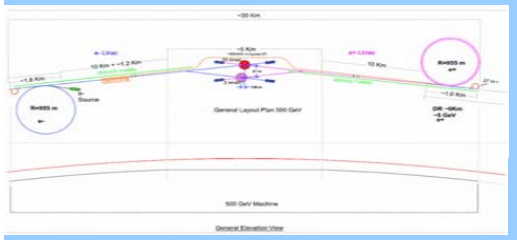
Cosmic Rays in a 1 cm Thick Scintillator

20 < t < 70 nsec



0 < t < 200 nsec





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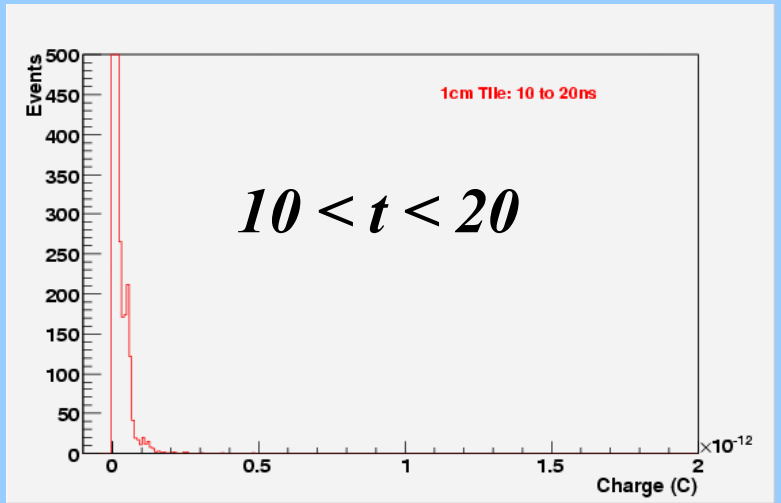
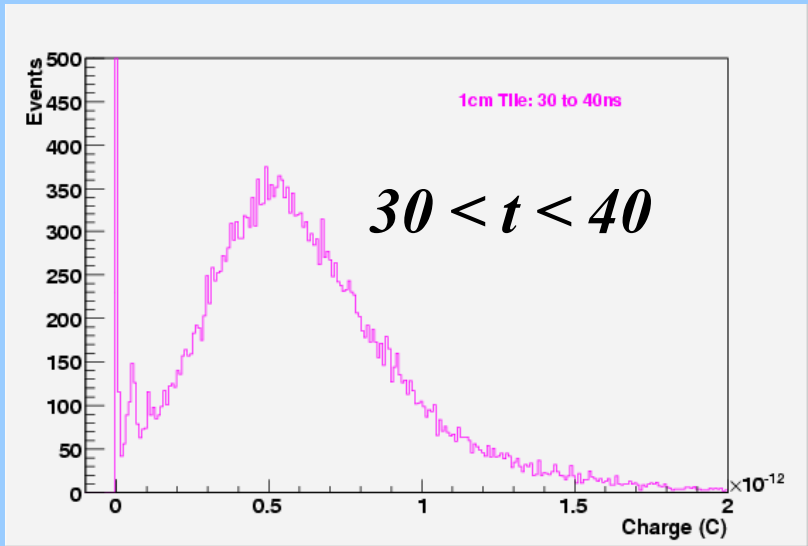
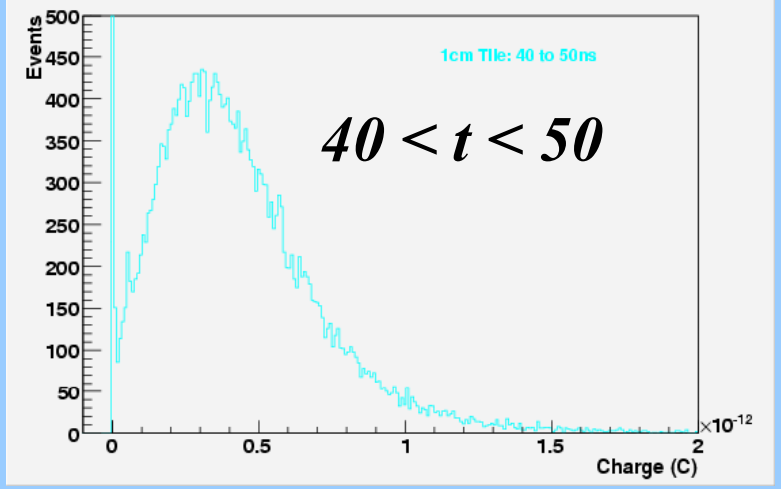
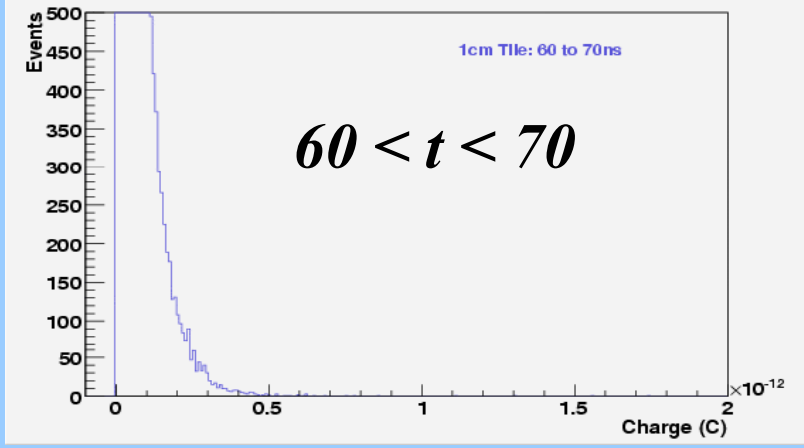
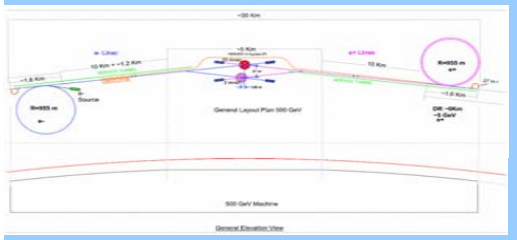
1cm scint











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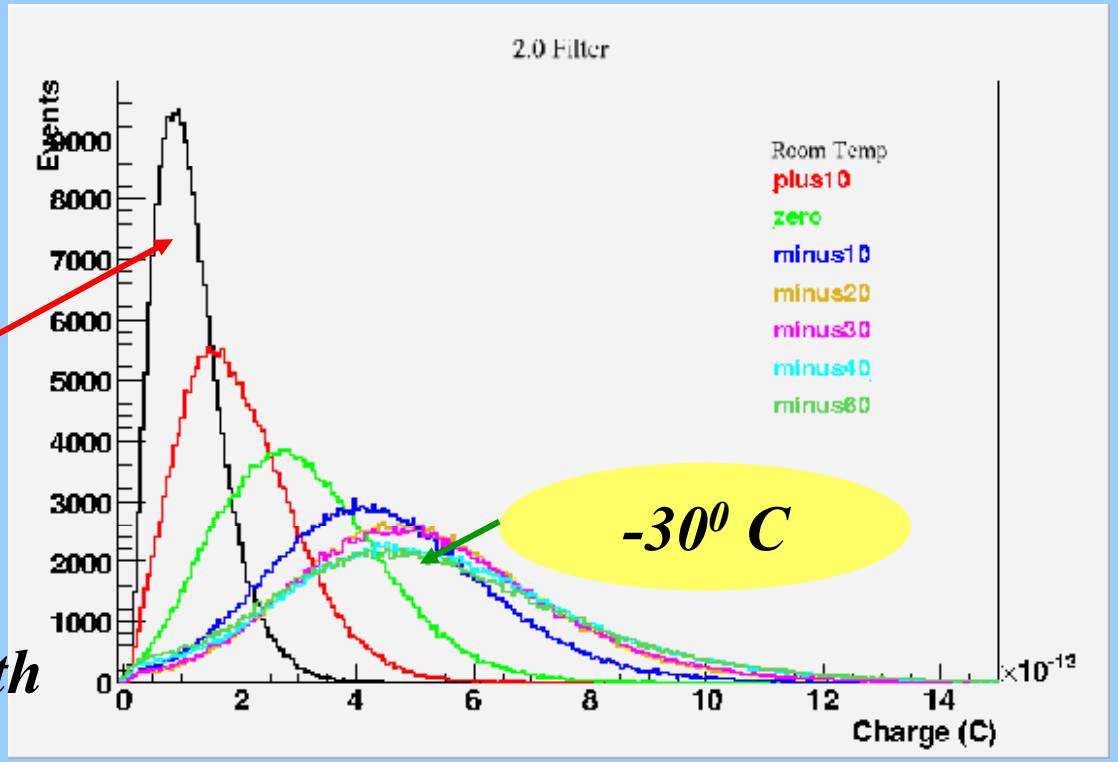
Pulse Height versus Temperature

Gain of SiPD Increases ~x4

Noisy SiPD

Could not detect peaks

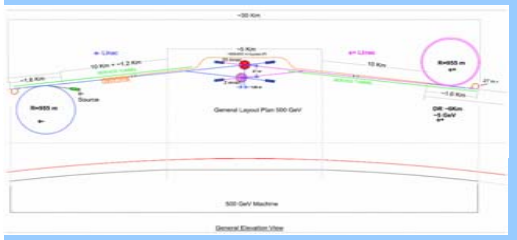


Room temp

-30⁰ C

Needs to be repeated with

New SiPDs; noiseless



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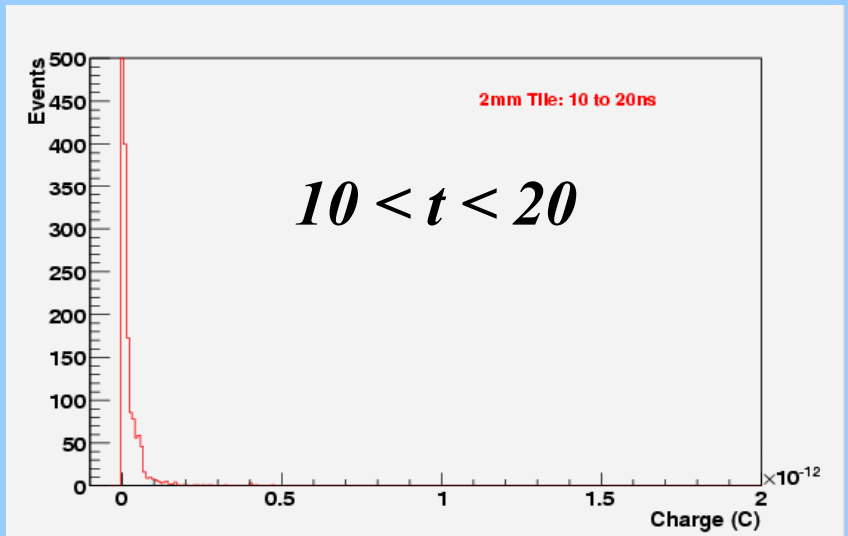
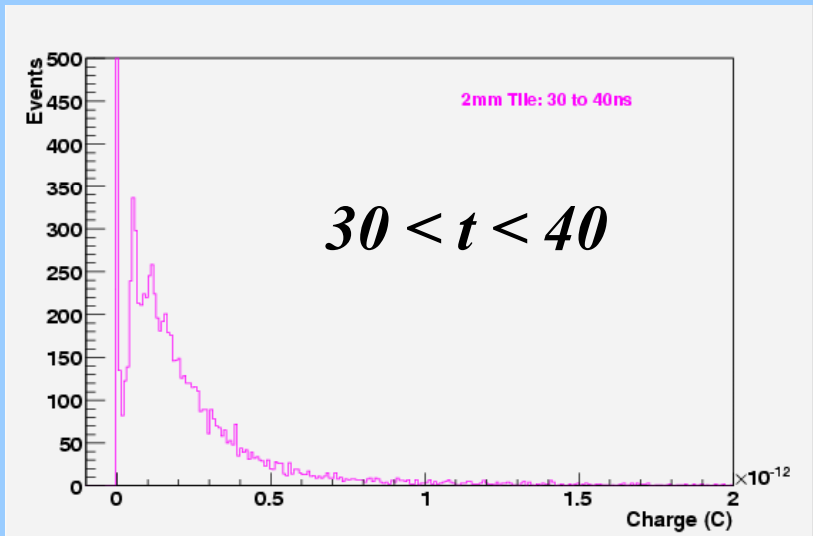
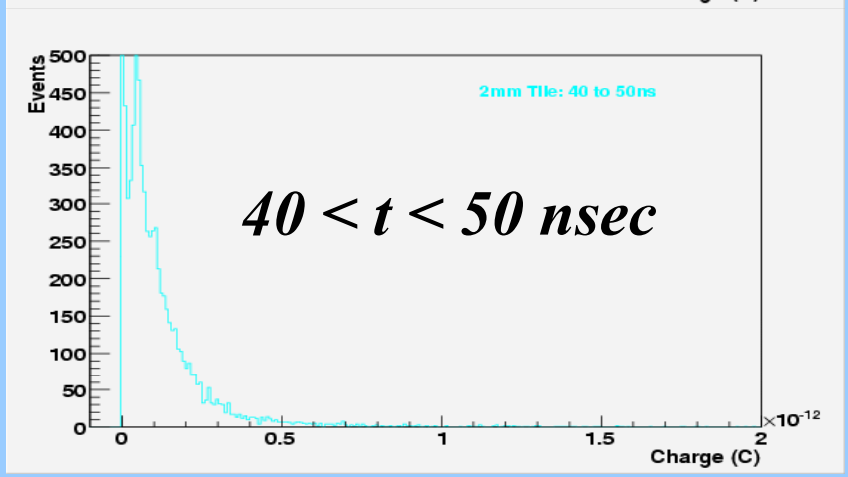
2 mm scint



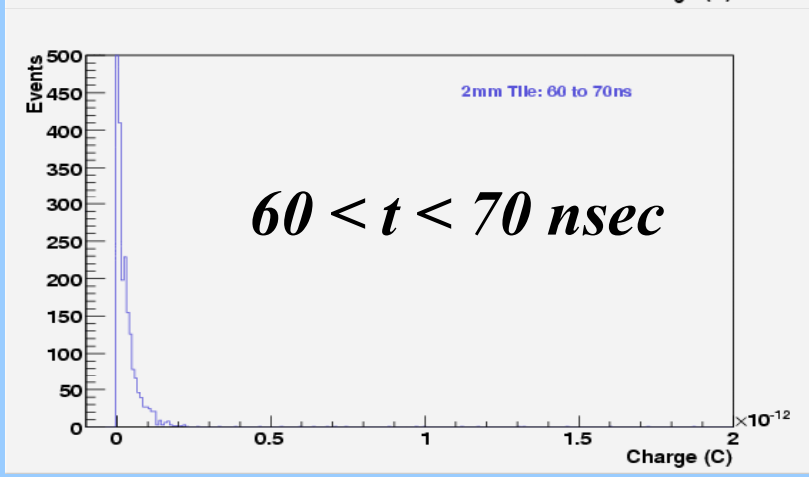
10 < t < 20



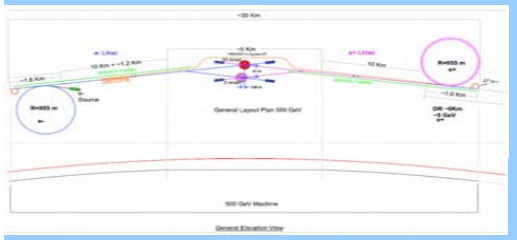
30 < t < 40



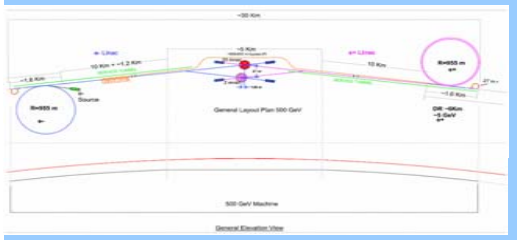
40 < t < 50 nsec



60 < t < 70 nsec



By time tagging we are observing the photons arriving in time sequence. Possibility to use this to improve resolution. Need beam tests to check this hypothesis.



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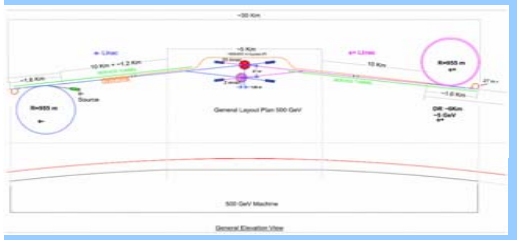
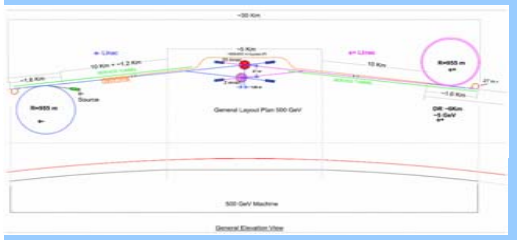
Work still in progress. Comparison with Russian plots indicate 100 Mhz x 4 (measuring pulse height every 2.5 nsec) not enough resolution.

National Instruments has just released a 2 Gigahertz unit. Using our trick of x4 will allow us to scan every 0.125 nsec. A demo is on its way here to check whether 8 bits resolution is good enough.



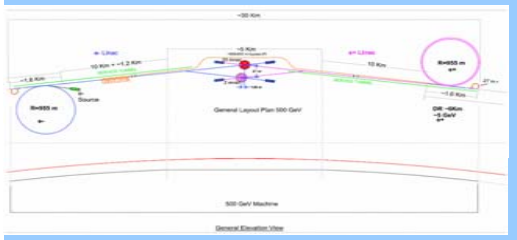
Conclusions

A new revolution in photo-detection. A lot of improvements still possible. A lot of work to be done in this area. If one is bold and reckless one may say that "It may revolutionize calorimetry resolution."



Conclusions

Our simulation work with the undergraduates is moving ahead. A lot of work needs to be done still. Need manpower help. Most of the pieces are in place to study Z and W mass resolution.

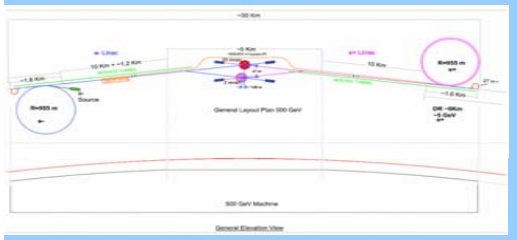


FERMI-ALCPG07

ILC – The International Linear Collider Project

Our ILC Funding Request

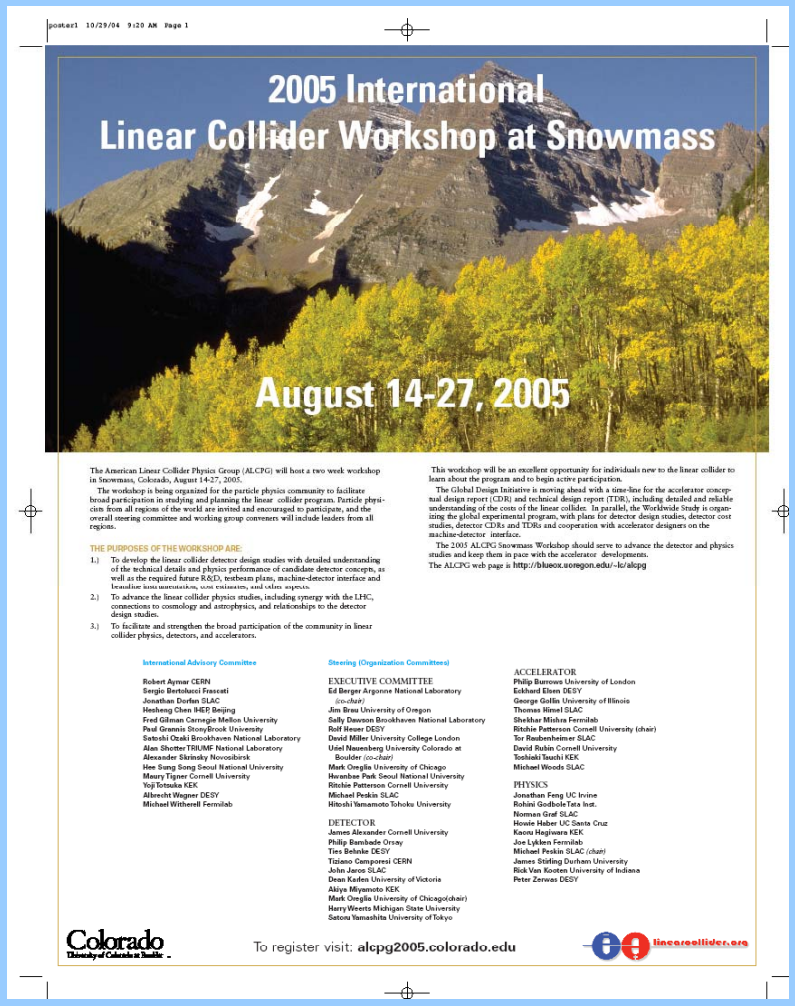
- ***Restore the 50% of a postdoc which we got funded the 1st year. Simulation has been held up as a result of this loss.***
- ***$10 K to purchase the 2 2Gigahertz National Inst. Units***
- ***$4 K to purchase a scope.***
- ***$20 K requested by Fermilab to develop 2 mm. extruded scint. technology. Necessary to develop calorimeter unit for beam tests.***
- ***$10 K to develop with Photonique a 3 SiPD unit with a common readout***



FERMI-ALCPG07

ILC – The International Linear Collider Project

We helped with the organization of the Linear Collider Workshop and the various ALCPG meetings up to but not including Vancouver



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2005 International Linear Collider Workshop at Snowmass

August 14-27, 2005

The American Linear Collider Physics Group (ALCPG) will host a two week workshop in Snowmass, Colorado, August 14-27, 2005.

The workshop is being organized for the particle physics community to facilitate broad participation in studying and planning the linear collider program. Particle physicists from all regions of the world are invited and encouraged to participate, and the overall steering committee and working group conveners will include leaders from all regions.

THE PURPOSES OF THE WORKSHOP ARE:

1.) To develop the linear collider detector design studies with detailed understanding of the technical details and physics performance of candidate detector concepts, as well as the required future R&D, testbeam plans, machine-detector interface and beamline instrumentation, cost estimates, and other aspects.

2.) To advance the linear collider physics studies, including synergy with the LHC, connections to cosmology and astrophysics, and relationships to the detector design studies.

3.) To facilitate and strengthen the broad participation of the community in linear collider physics, detectors, and accelerators.

This workshop will be an excellent opportunity for individuals new to the linear collider to learn about the program and to begin active participation.

The Global Design Initiative is moving ahead with a nine-line for the accelerator conceptual design report (CDR) and technical design report (TDR), including detailed and reliable understanding of the costs of the linear collider. In parallel, the Worldwide Study is organizing the global experimental program, with plans for detector design studies, detector cost studies, detector CDRs and TDRs and cooperation with accelerator designers on the machine-detector interface.

The 2005 ALCPG Snowmass Workshop should serve to advance the detector and physics studies and keep them in pace with the accelerator developments.

The ALCPG web page is http://bluox.uoregon.edu/~lc/alcpg

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To register visit: alcpg2005.colorado.edu

linearcollider.org

Univ. of Colorado, Boulder, Oct.. 2007