

# New developments with Geant4

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# Project Goals

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- **To provide reliable and robust full simulation package for LCD studies**
- **The simulation data can be handled with LCDROOT**
- **The package must be released to be in time for the next LC workshop in Korea.**

# Contents of this talk

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- **Why Geant4?**
- **Specification of the full simulation**
- **Progress history**
- **Test results**
  - MIP energy distribution
  - Energy scale
  - Energy linearity
- **Summary and future**

# Why Geant4?

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- Because many physicists want to use Geant4 instead of Gismo.
- Gismo is not maintained well.
- The current full simulation code (Gismo) is very hard to compile.
- Geant4 is maintained very well.
- Geant4 is the de facto standard full simulation code for HEP.

# Specification of a full simulation with Geant4

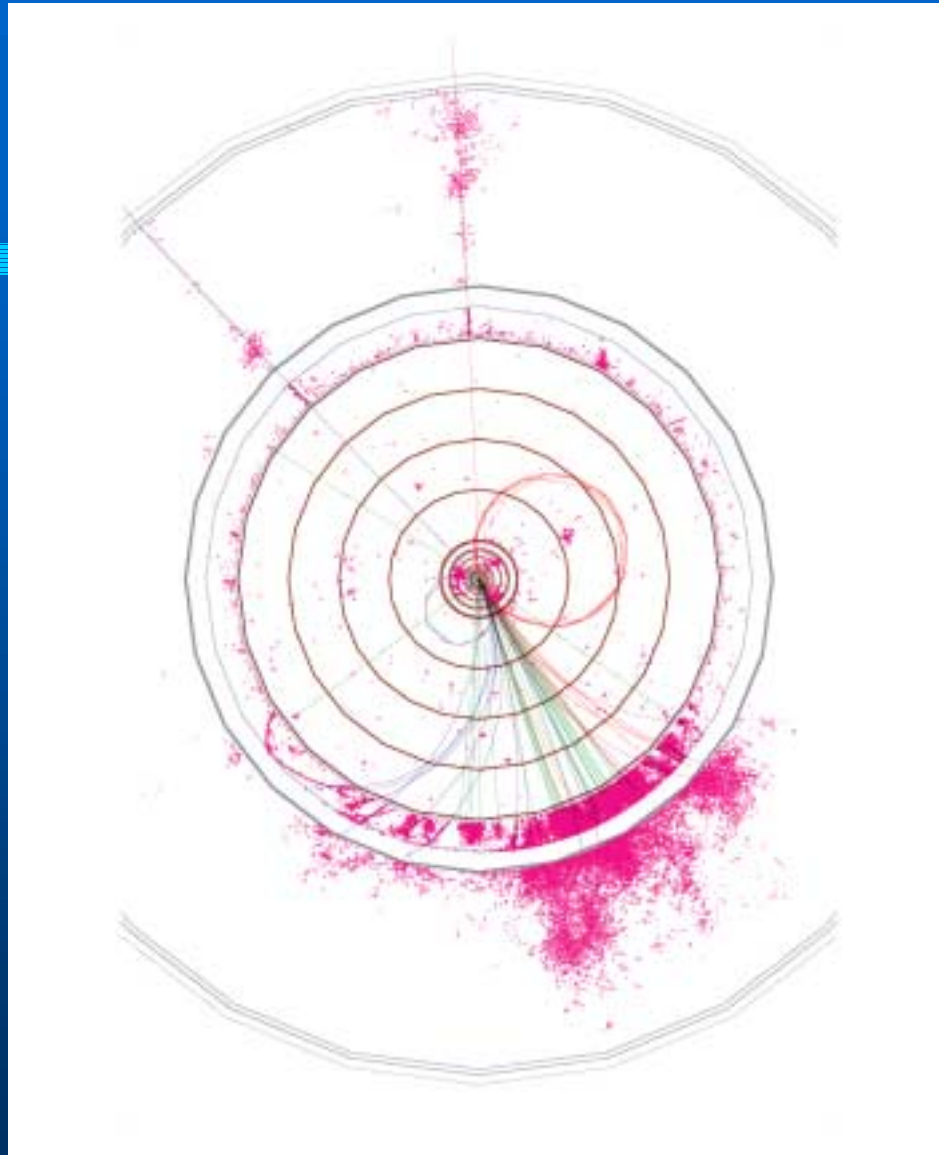
- Detector geometry is given by XML file for a flexible detector setting.
- Output data (hit,...) is written in ROOT file format to take advantage of object oriented I/O.
- The package should work on various computer platforms (UNIX, windows,...).
- The simulation will be released as a part of LCDROOT.

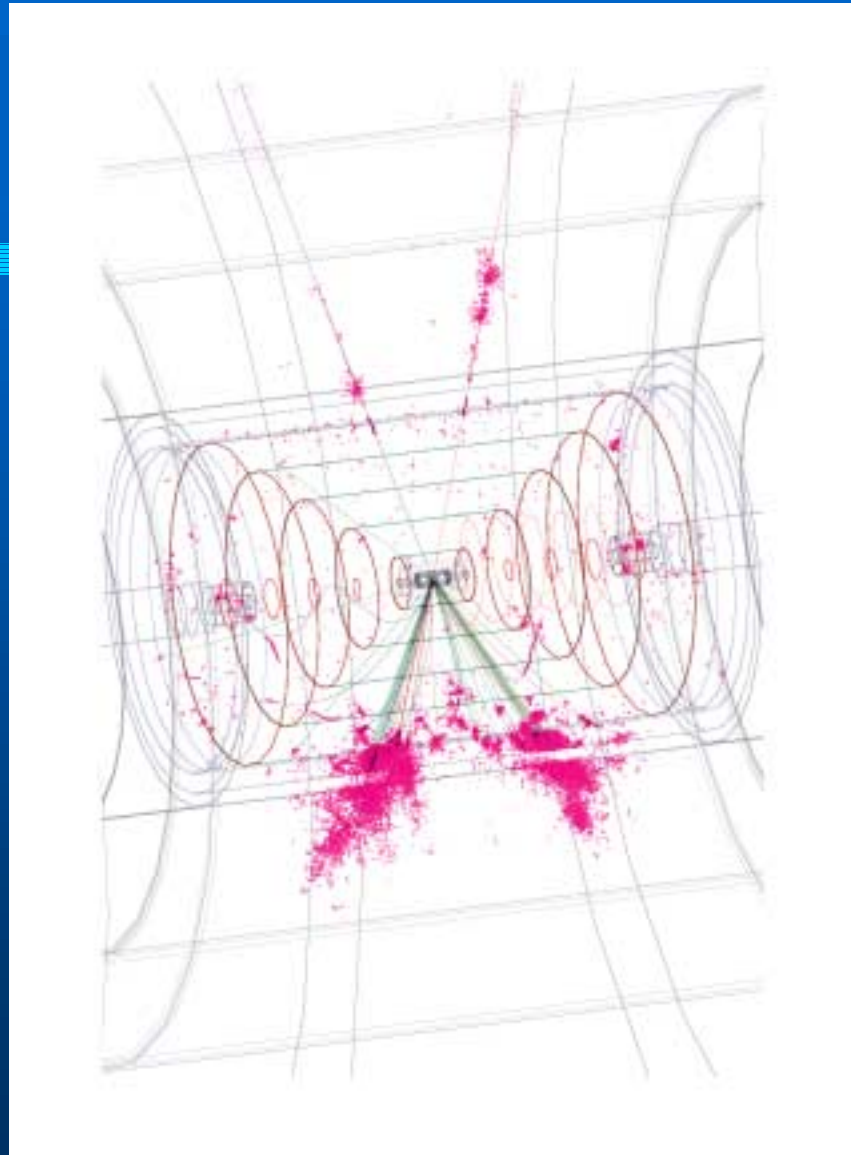
# Progress history

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**Dr. Asai helps me a lot about Geant4.**

- **Middle of Oct.:**  
start the project independently
- **Middle of Nov.:**  
Hit generation was done.  
The hits information was written in ROOT file.
- **Till now (Middle of Dec.):**  
Debug, debug, debug...







# Fist test analysis results

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- **The full simulation code can generate detector hits, with XML detector description file.**
- **The full simulation data can be analyzed with LCDROOT**
- **We check energy linearity and energy resolution with single particle simulation data.**
- **Since these are the first tests, you should not think them seriously.**

# Detector designs



34x



1 cm scint  
2 cm Stainless\_steel



40 cm Al  
4.5  $X_0$



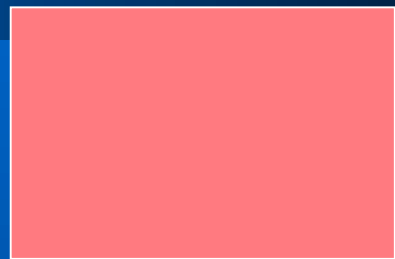
30x



0.1mm Air  
2 mm G10  
400  $\mu$ m Si  
2.5 mm W

SD

coil



29 cm Al

120x



HAD  
Cal



0.2 mm scint  
8 mm Pb



r

40x



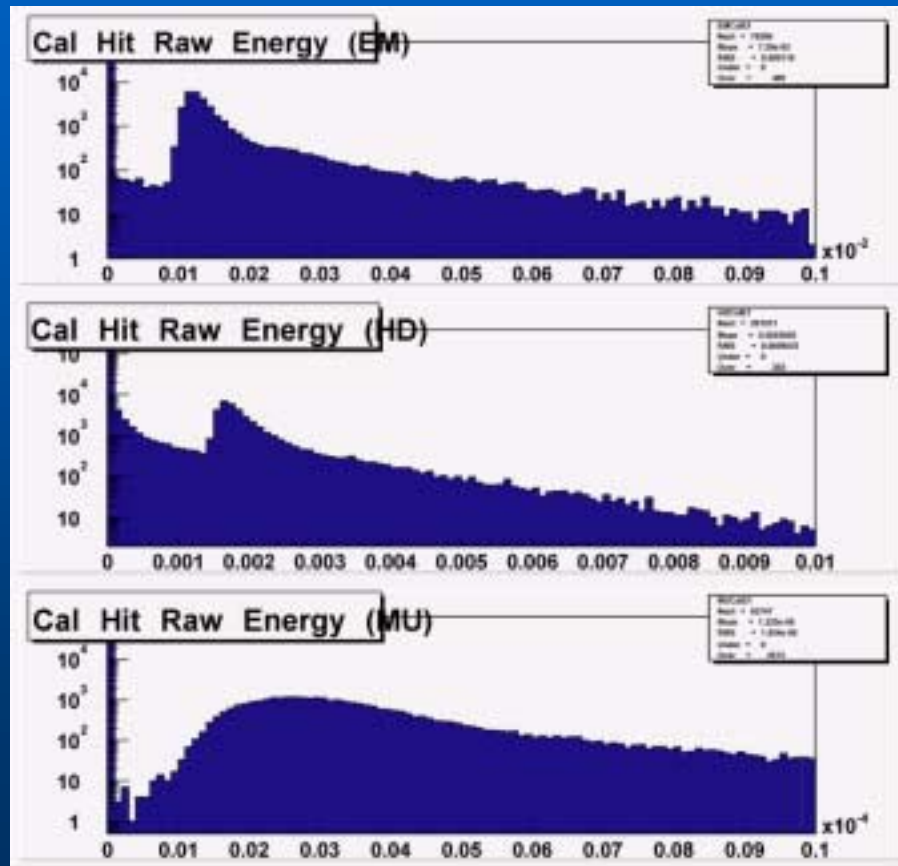
EM  
Cal



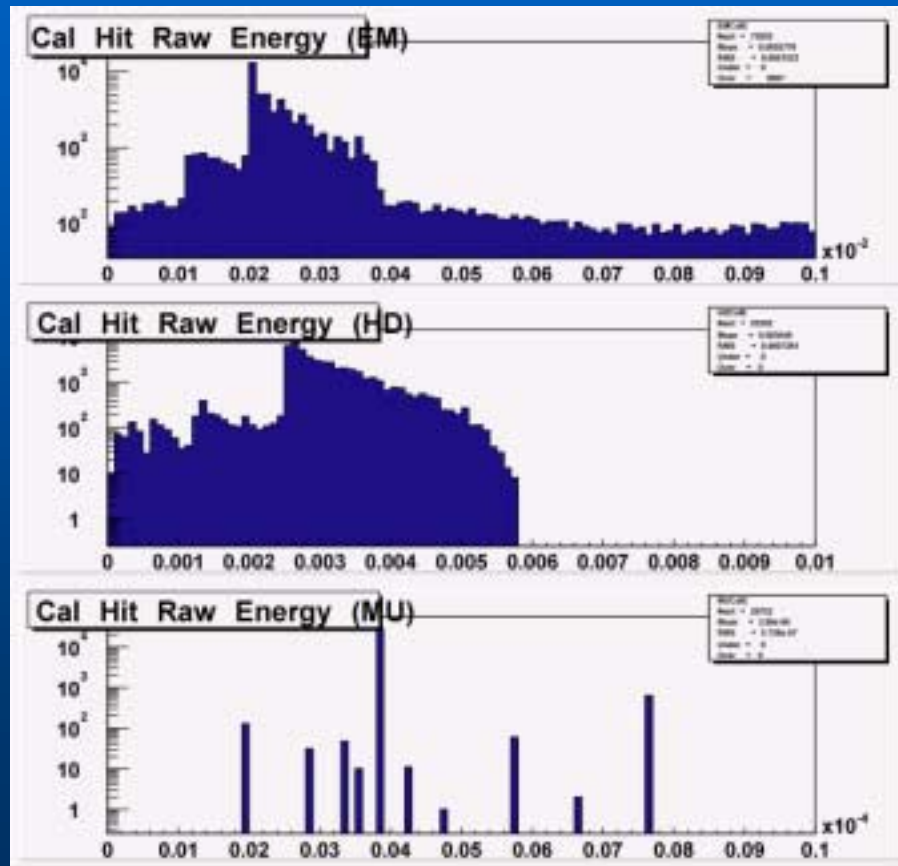
1 mm scint  
4 mm Pb

LD

# Hit Energy ( $\mu$ , SD, Geant4)



# Hit Energy ( $\mu$ , SD, Gismo)



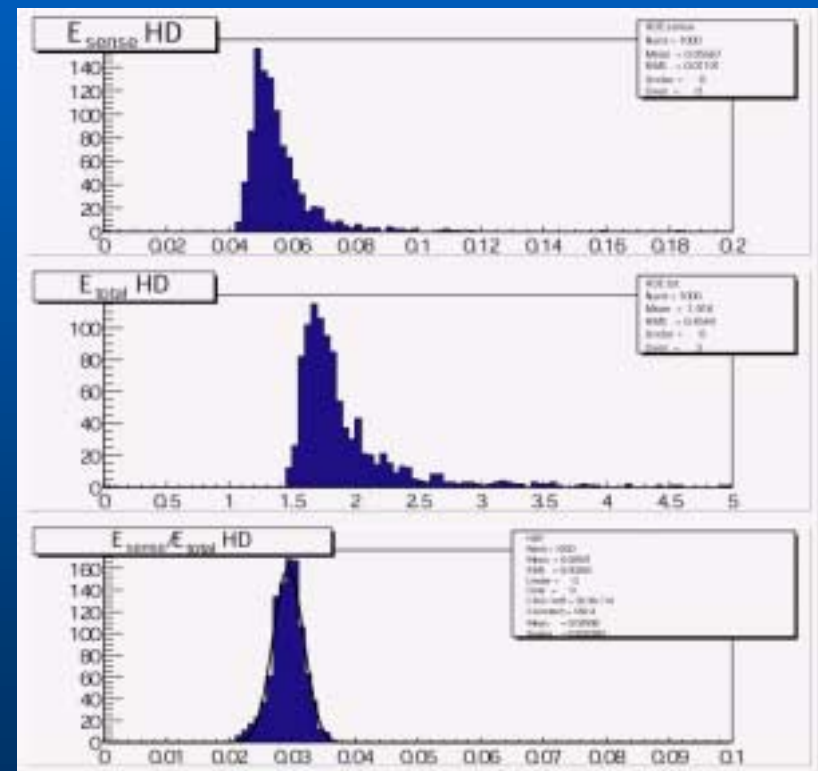
# Energy Scale

$$E_{total} = E_{sense} + E_{radiator}$$

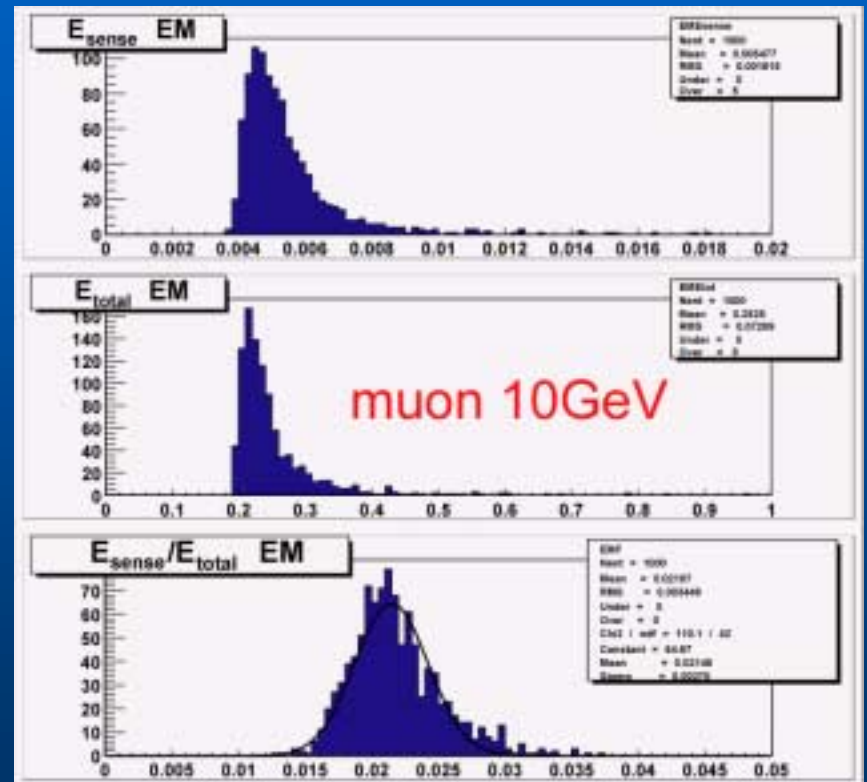
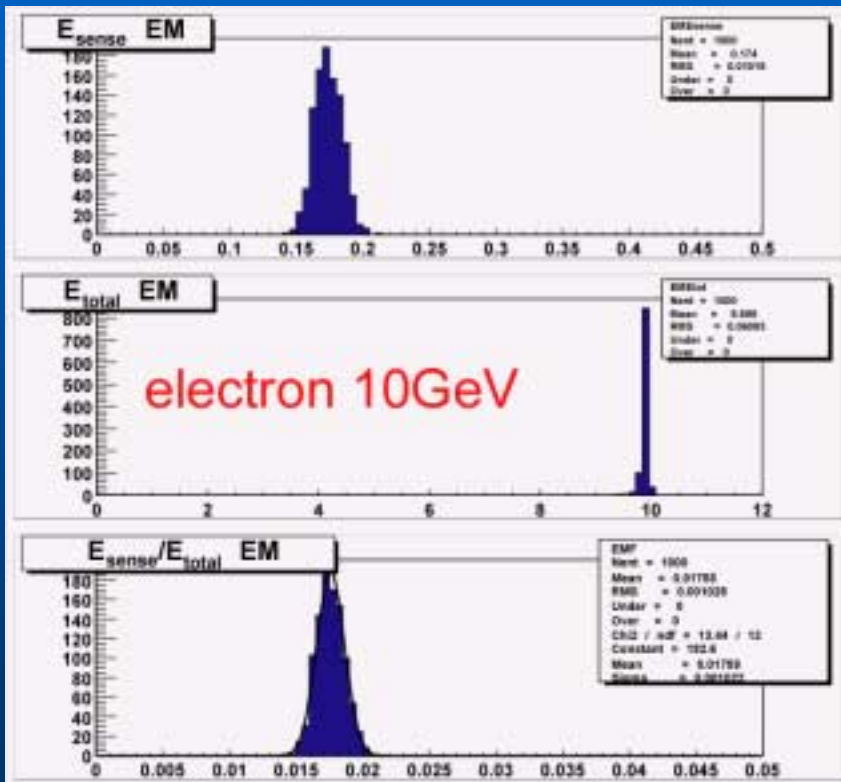
$$f = E_{sense} / E_{total}$$

$$E_{true} = E_{meas} / f$$

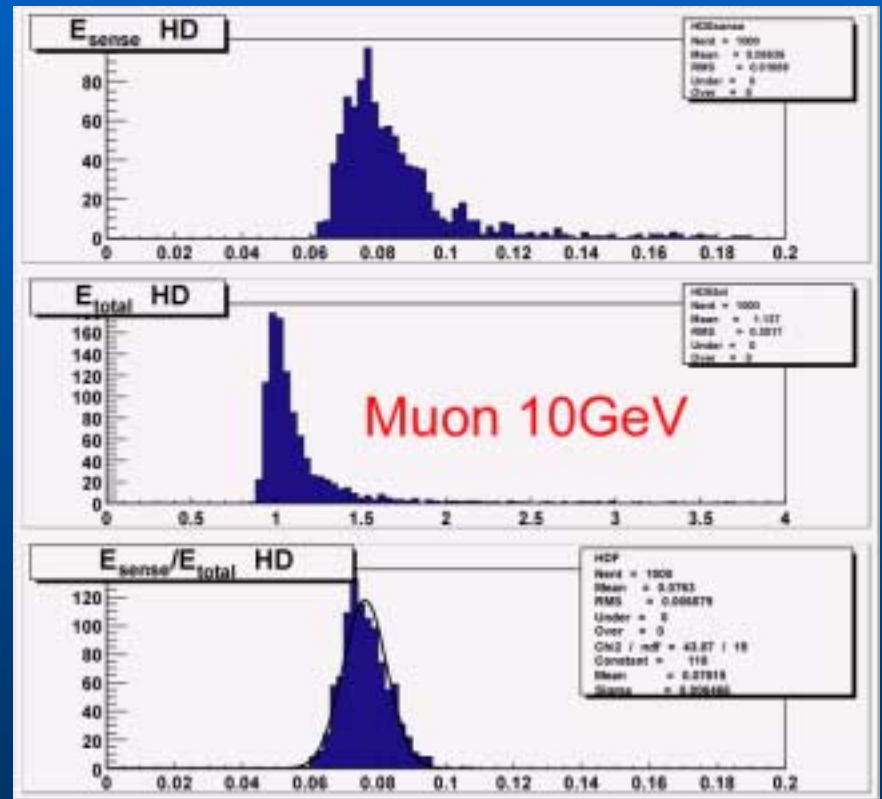
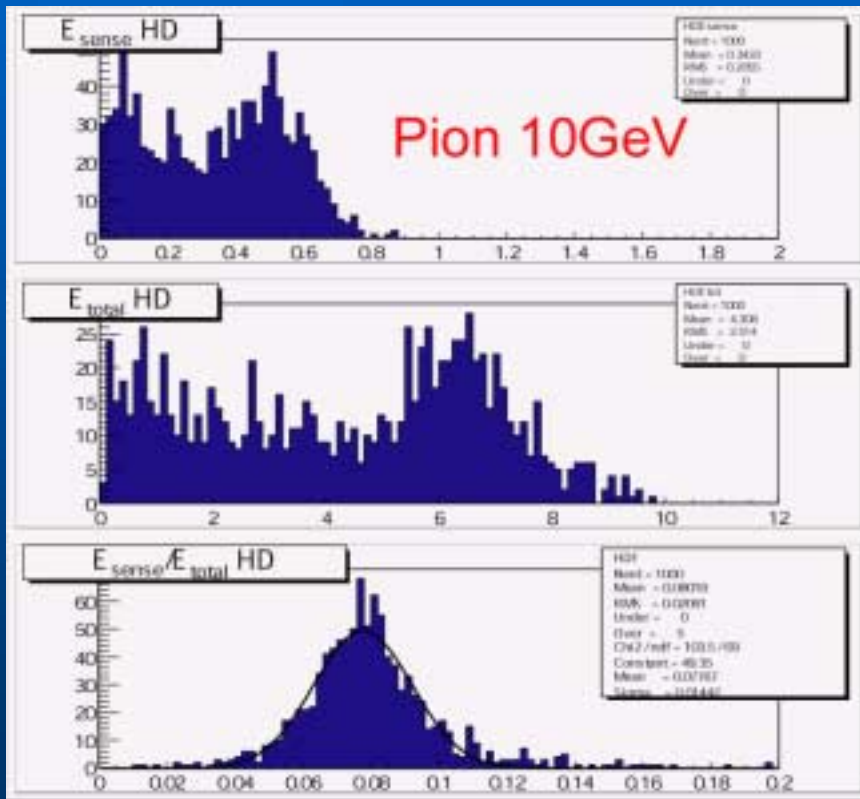
2years ago, Richard used  
Min-I scales. But...



# Energy Scale (EM)

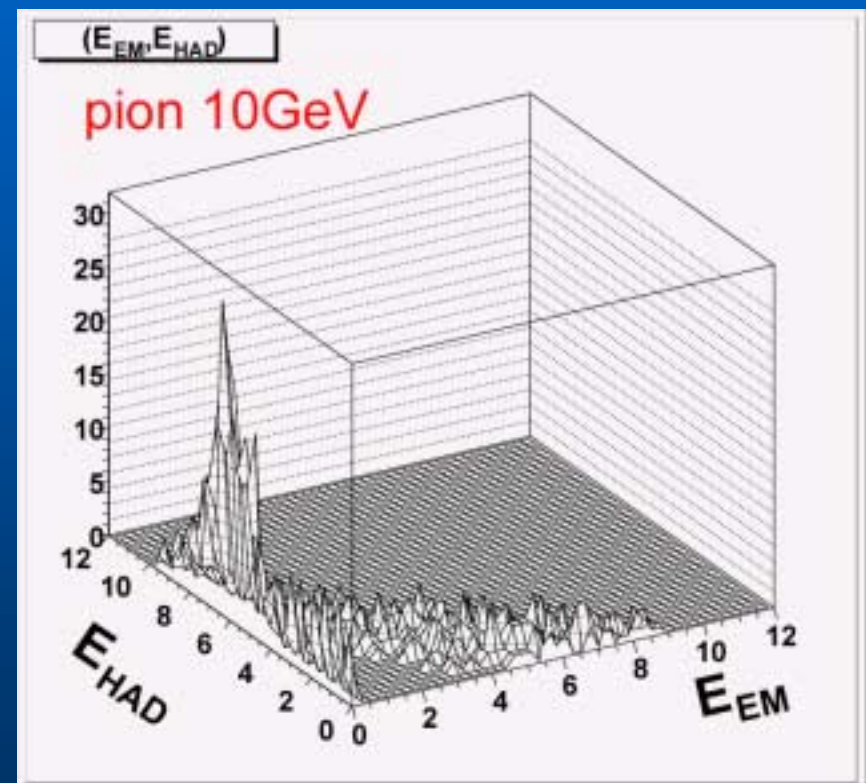
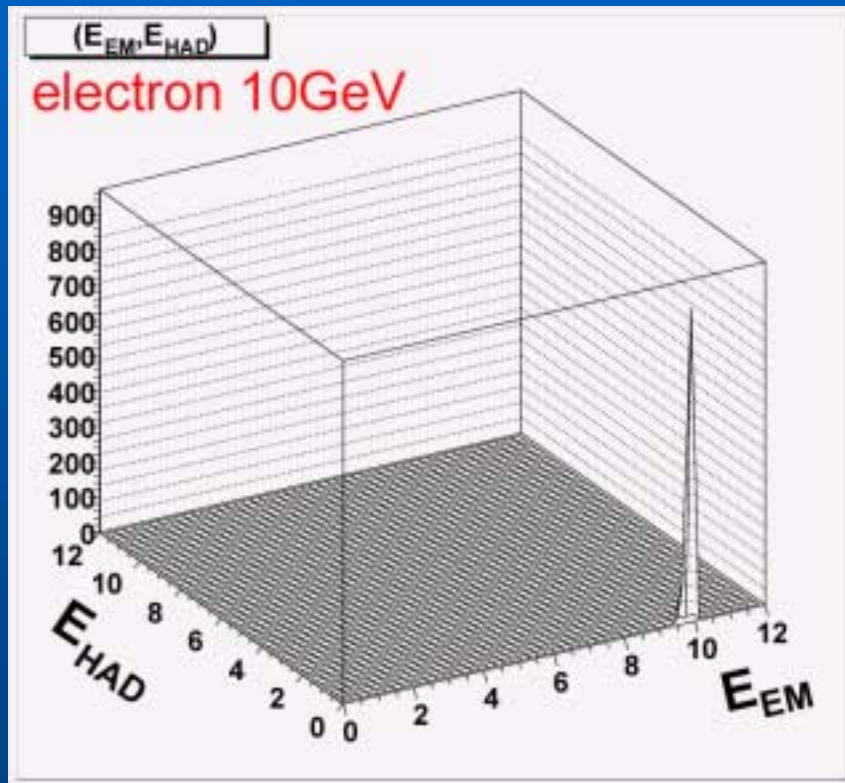


# Energy scale (Hadron)





# EM energy vs. Had. energy



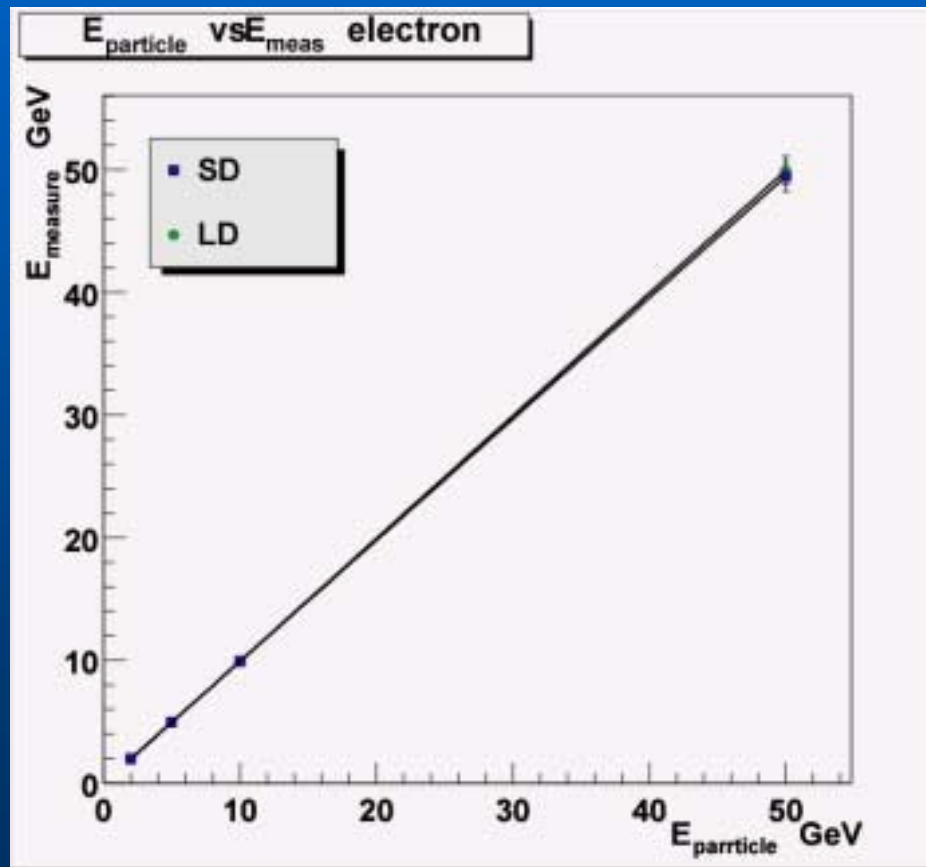


# Energy Scale

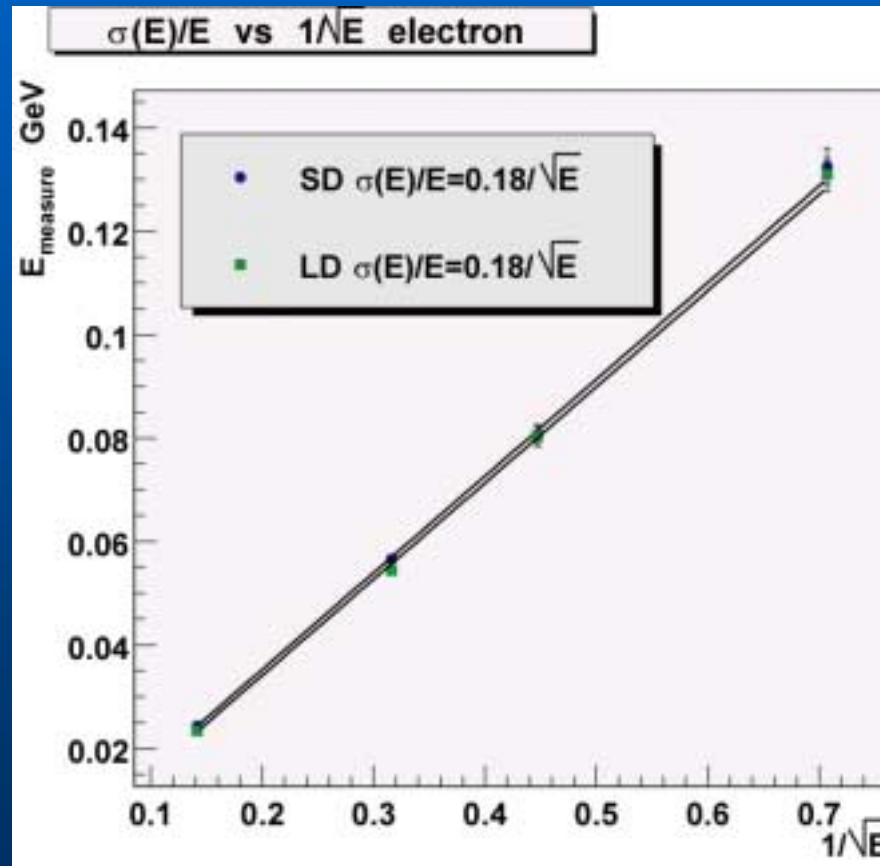
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- **For EM and Lum:**  
Determine  $f$  by single electron simulations.
- **For Had and Muon:**  
Determine  $f$  by single muon simulations.

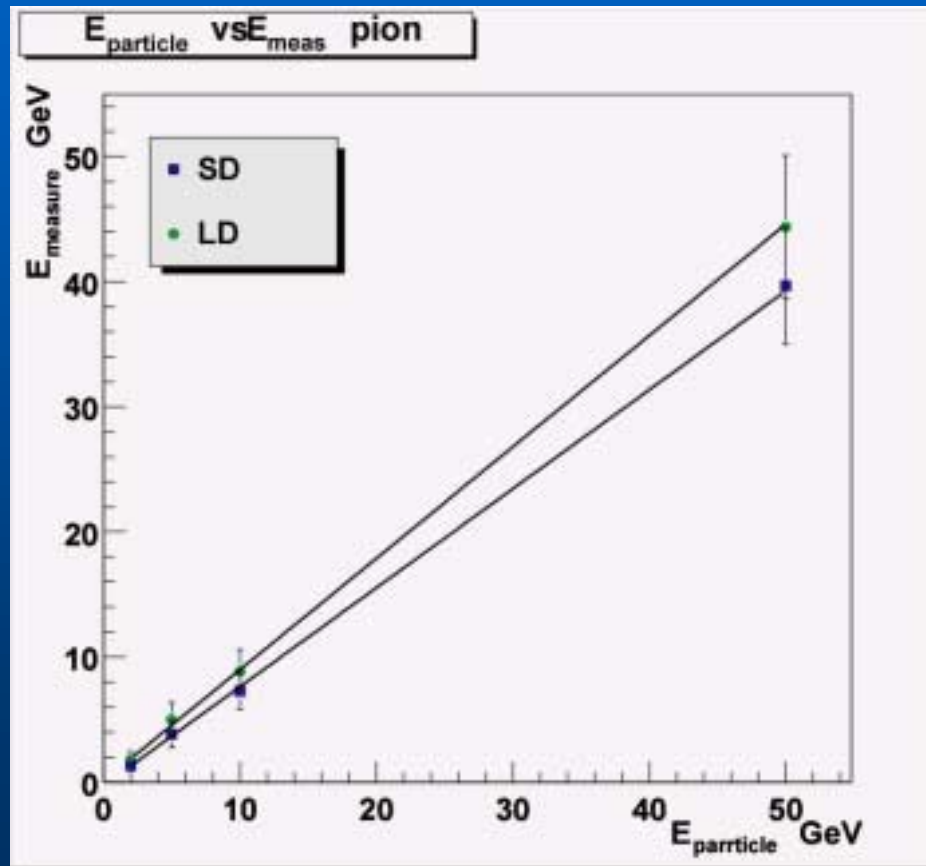
# Energy linearity (electron)



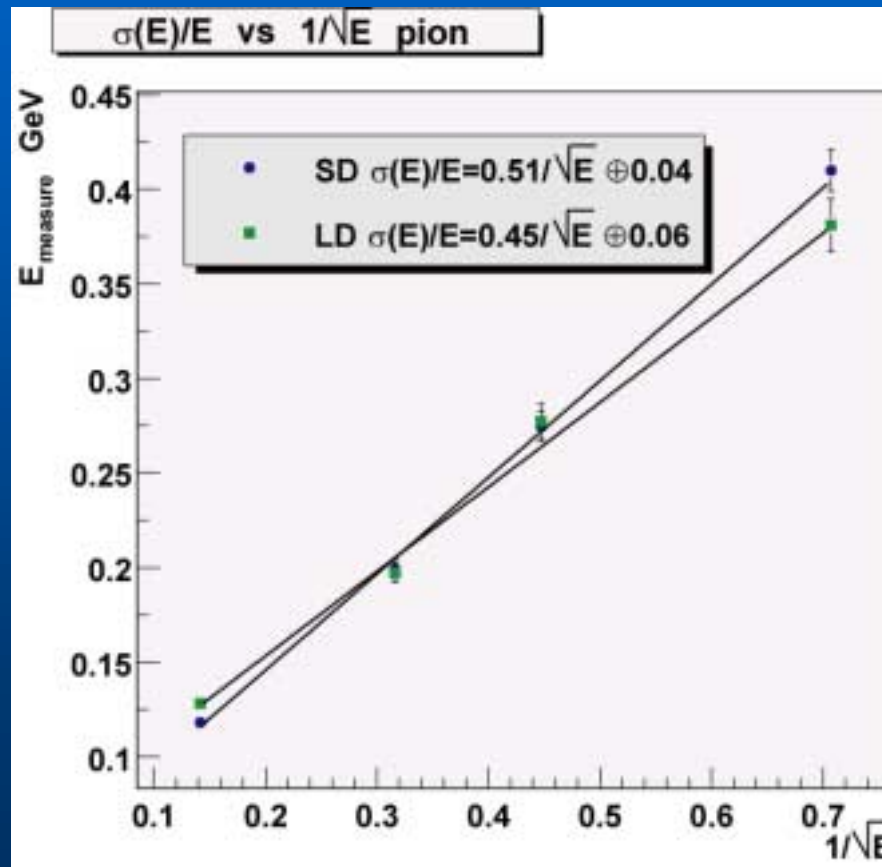
# Resolution vs. Energy (electron)



# Energy linearity (pion)



# Resolution vs. Energy (pion)



# Summary

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- **Detector geometry setup with XML works.**
- **Hits can be generated and saved in ROOT file format.**
- **The simulated data can be analyzed with LCDROOT**
  - **First test results are shown**
- **Need more detailed check and debugs...**