Functional check of EMC Simulation

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Outline

- ✓ Introduction of Panda
  - Detector
  - Electromagnetic Calorimeters(Target)

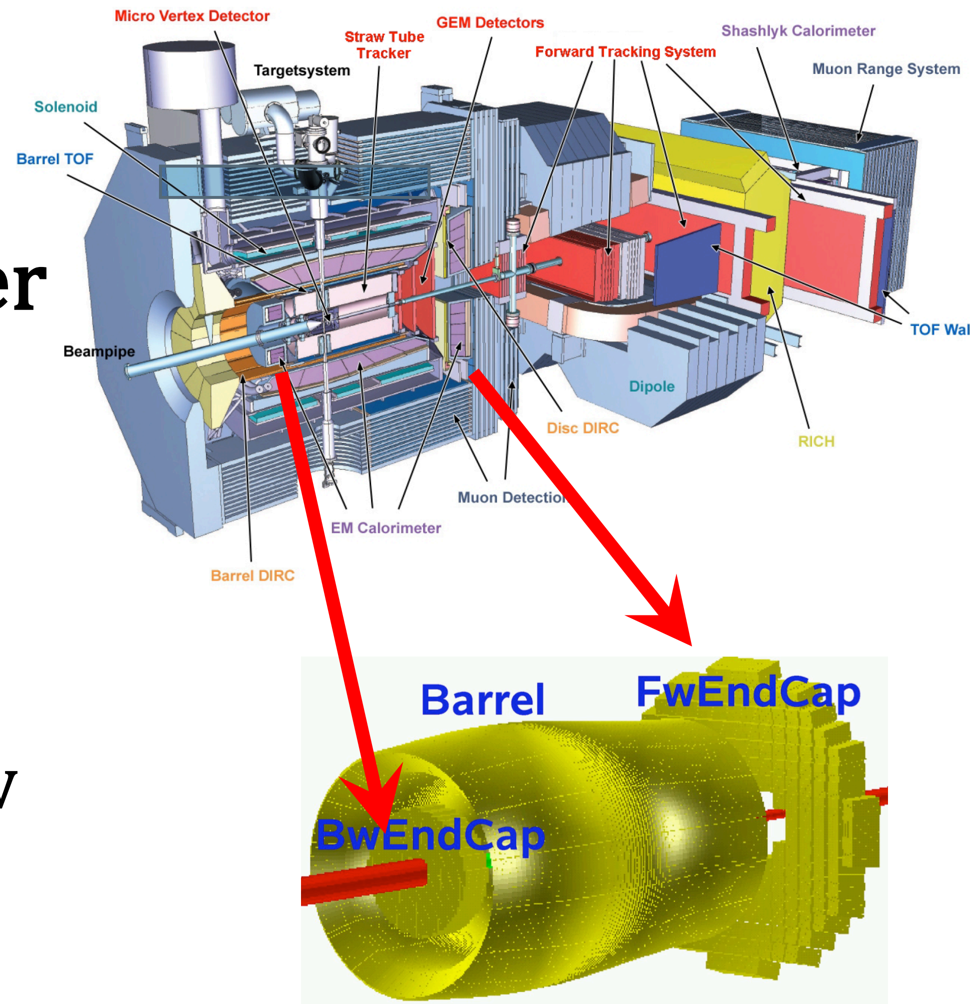
- ✓ EMC in PandaRoot
  - EMC simulation
  - EMC reconstruction

- ✓ Summary

Introduction
[Detector]

✓Panda detector
- Target calorimeter
- Shashlyk calorimeter

✓EMC(TDR 2008)
- $\sigma_E/E < 1\%$
- Spatial resolution(barrel)<0.3°
- $E_{threshold}$(Photon): 10MeV
- $E_{threshold}$(single crystal): <3MeV
- Angular coverage: 99%



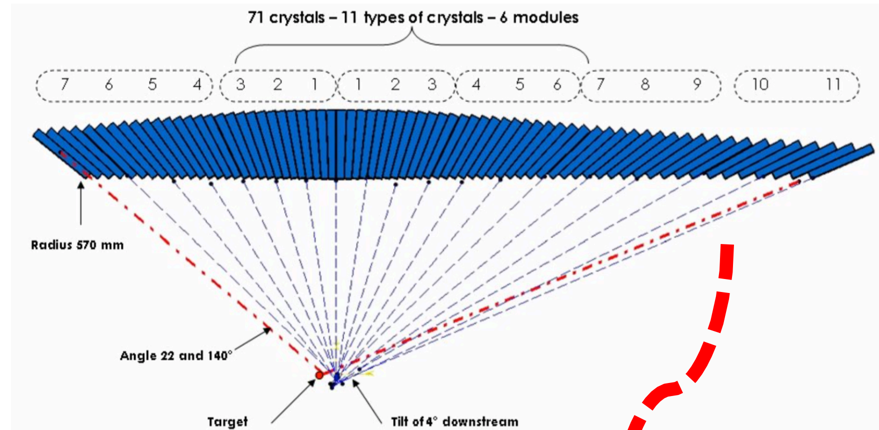
Introduction

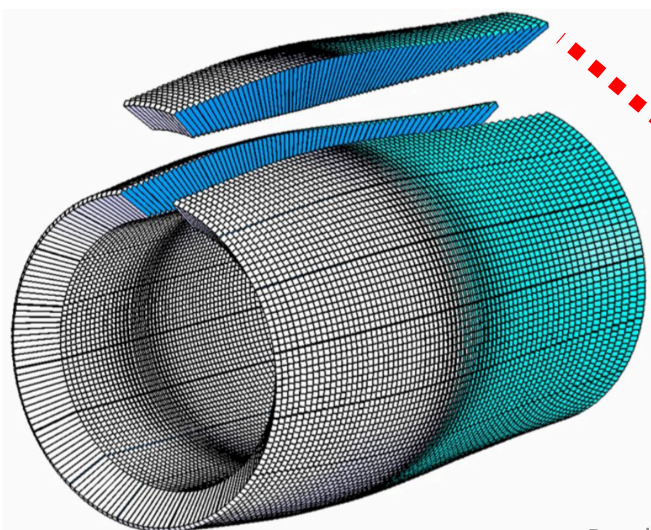
[Target EMC]

Row Crystal

ID:2 01 01 0010

Module Copy





super modules

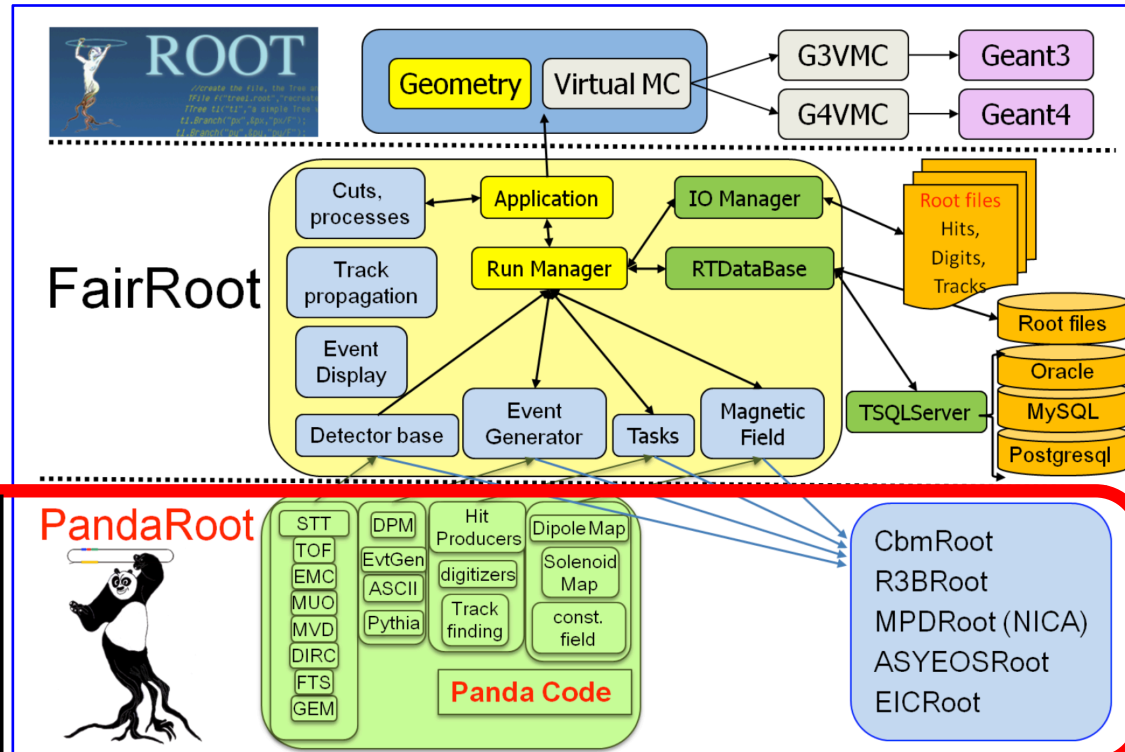
crystal shape left/right	SM1	SM2			SM3			SM4			SM5			SM6			SM7		alveole position
L / R	7me	6me	5me	4me	3me	2me	1me	1pe	2pe	3pe	4pe	5pe	6pe	7pe	8pe	9pe	10pe	11pe	e
L / R	7md	6md	5md	4md	3md	2md	1md	1pd	2pd	3pd	4pd	5pd	6pd	7pd	8pd	9pd	10pd	11pd	d
L / R	7mc	6mc	5mc	4mc	3mc	2mc	1mc	1pc	2pc	3pc	4pc	5pc	6pc	7pc	8pc	9pc	10pc	11pc	c
L / R	7mb	6mb	5mb	4mb	3mb	2mb	1mb	1pb	2pb	3pb	4pb	5pb	6pb	7pb	8pb	9pb	10pb	11pb	b
L / R	7ma	6ma	5ma	4ma	3ma	2ma	1ma	1pa	2pa	3pa	4pa	5pa	6pa	7pa	8pa	9pa	10pa	11pa	a
alveole type	7m	6m	5m	4m	3m	2m	1m	1p	2p	3p	4p	5p	6p	7p	8p	9p	10p	11p	

$\overline{p}$

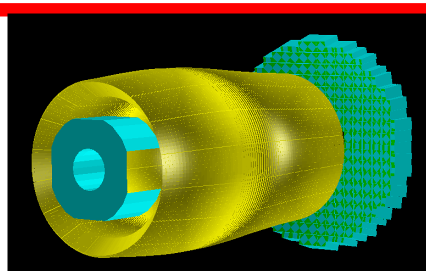
PandaRoot

[EMC Simulation]

- ✓ PandaRoot framework https://github.com/FairRootGroup/FairSoft
  - ➢ FairRoot-17.10b
  - ➢ Root 6.10



Target calorimeter



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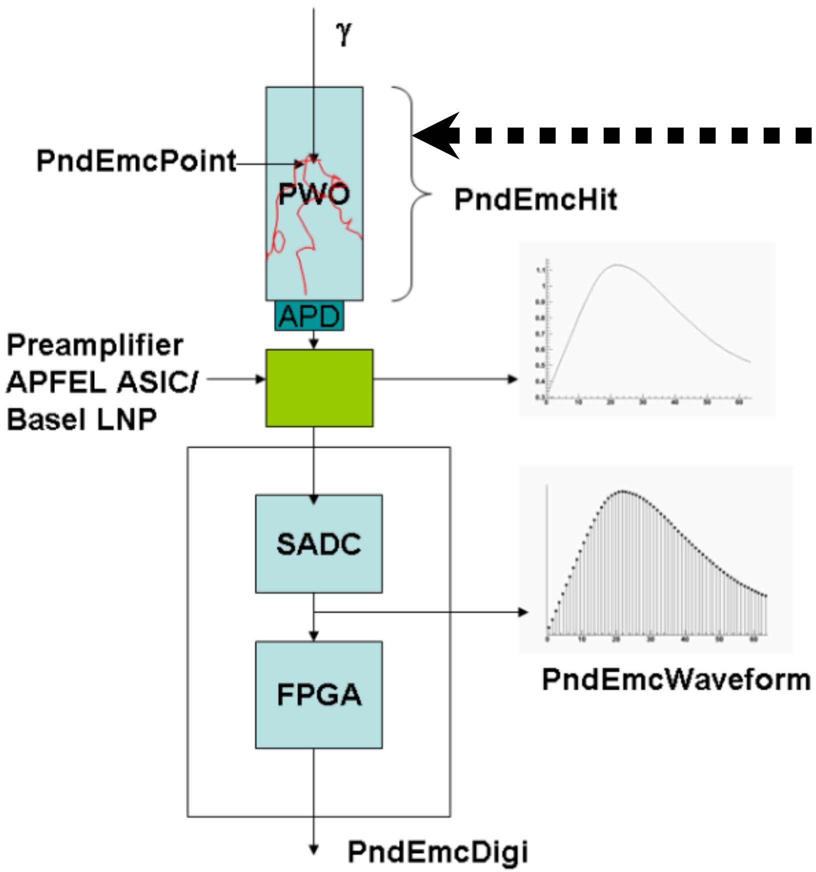
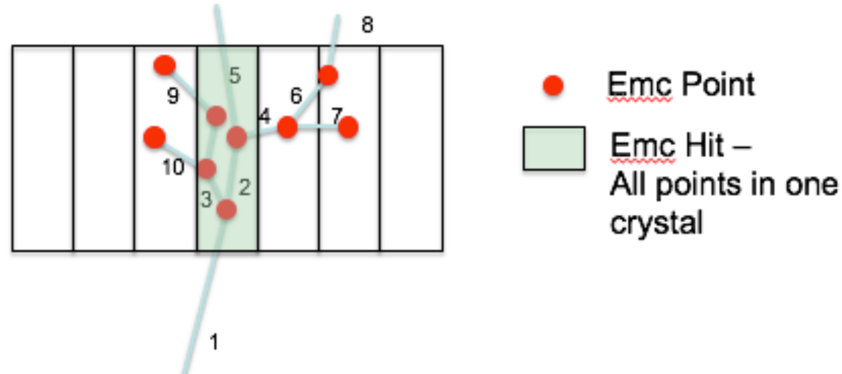
EMC Simulation

[Simulation]



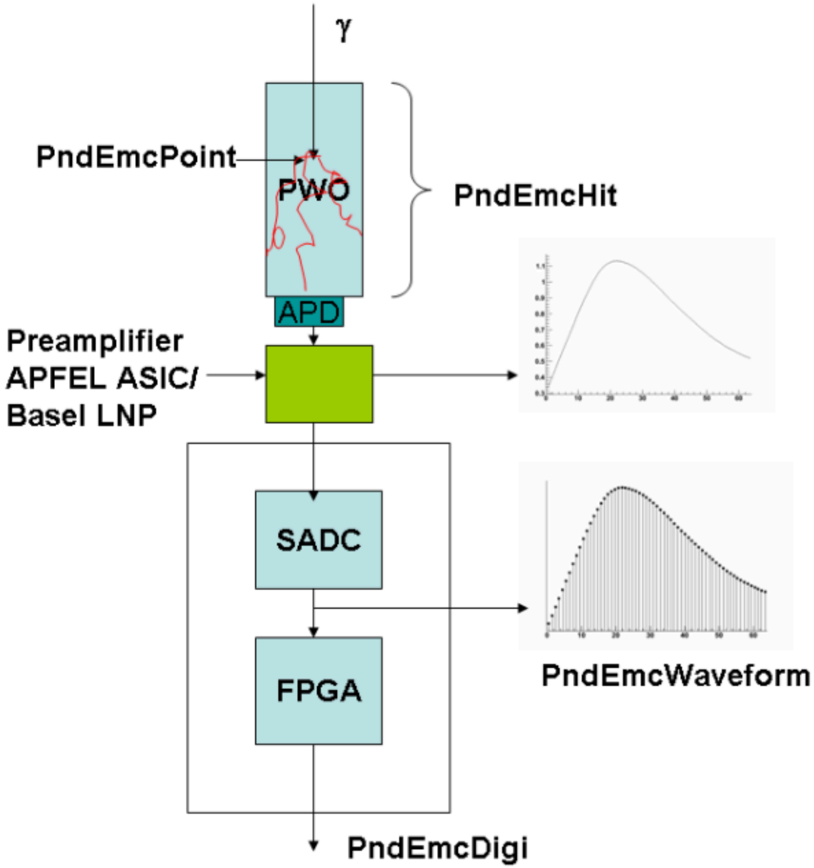


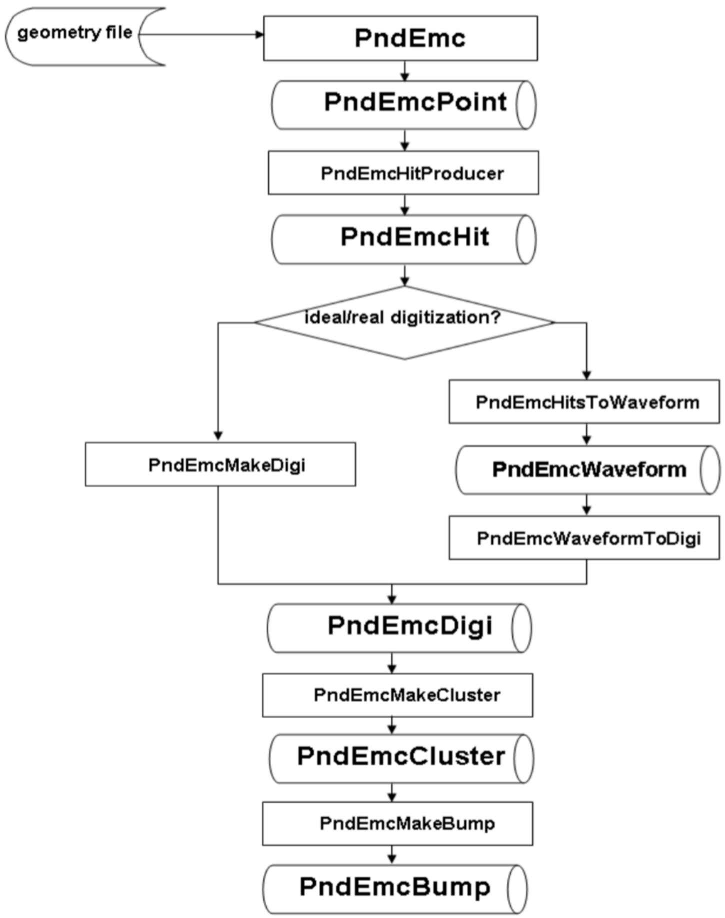
D. Melnychuk 24.07.2012

- ✓ Event Generation
  - ➢ EvtGen, DPM, Box Generator
- ✓ Transport Model
  - ➢ Geant3, Geant4
- ✓ Digitization

Data flow

[Simulation & Reconstruction]





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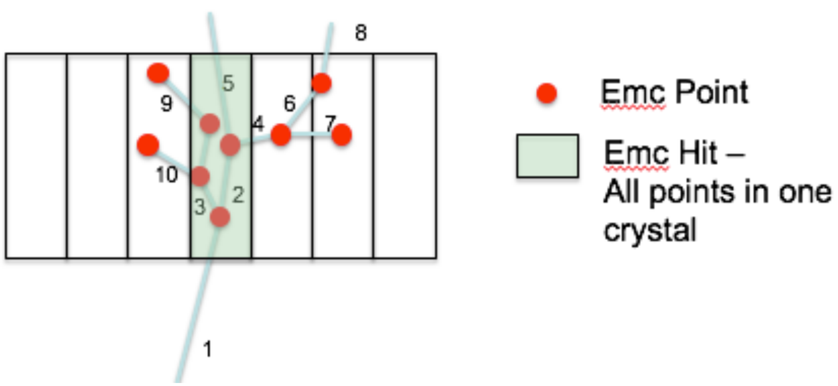
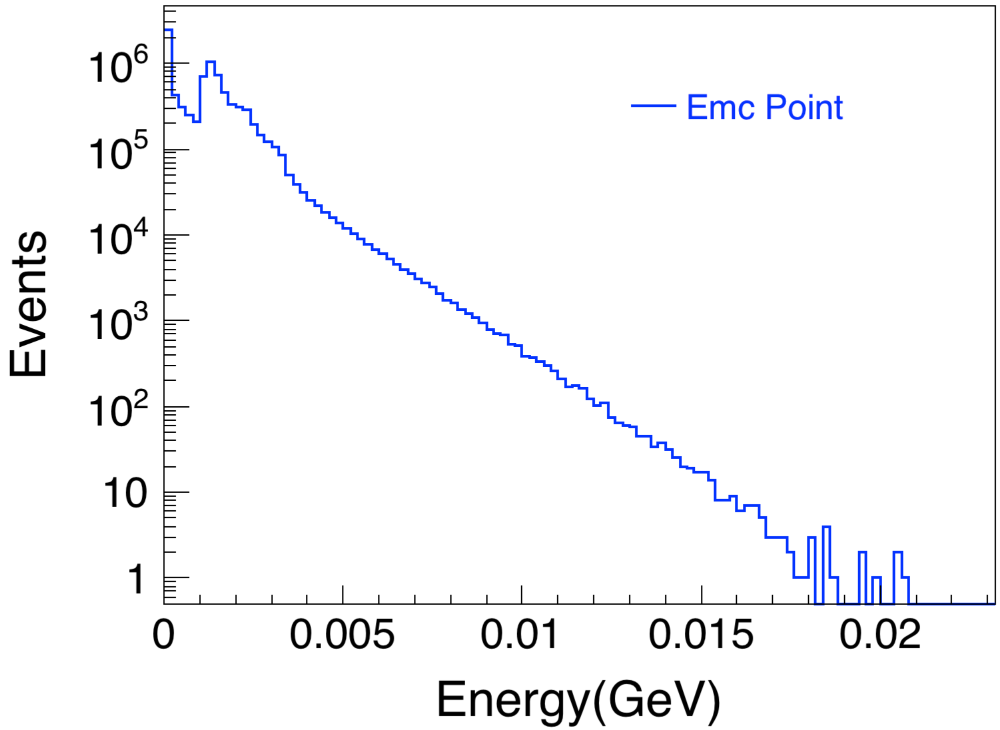
EMC Simulation

[EmcPoint]

✓ PndEmcPoint->FairMCPoint

- Gamma (1GeV)
- Events=10000
- Energy deposition
- Fixed direction



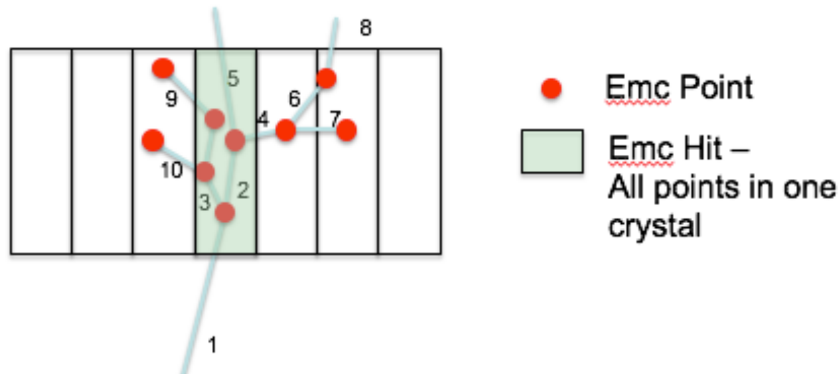


EMC Simulation

[EmcHit]

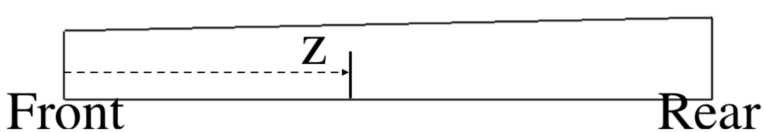
✓ PndEmcHitProducer

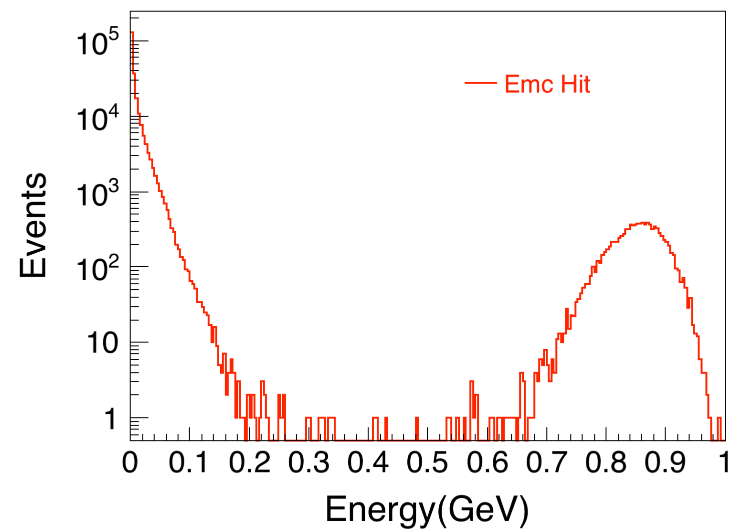
- Gamma (1GeV)
- Events=10000
- Energy deposition
- Nonuniform light yield



$$Energy_{\text{hit}} = \sum factor \cdot Energy_{\text{point}}$$

$$factor = c_0 + z(c_1 + z \cdot c_2)$$

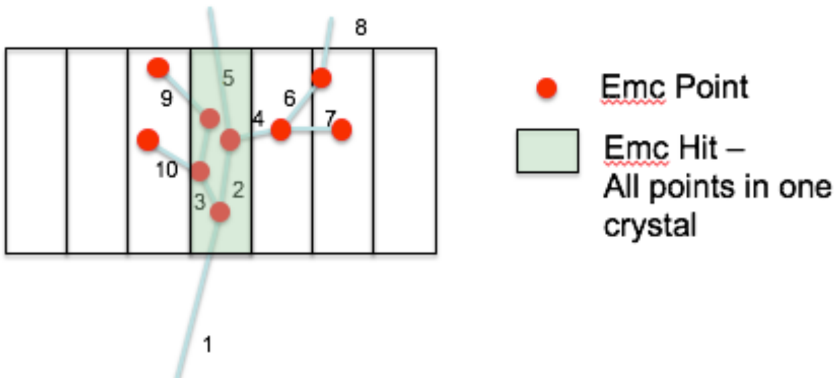


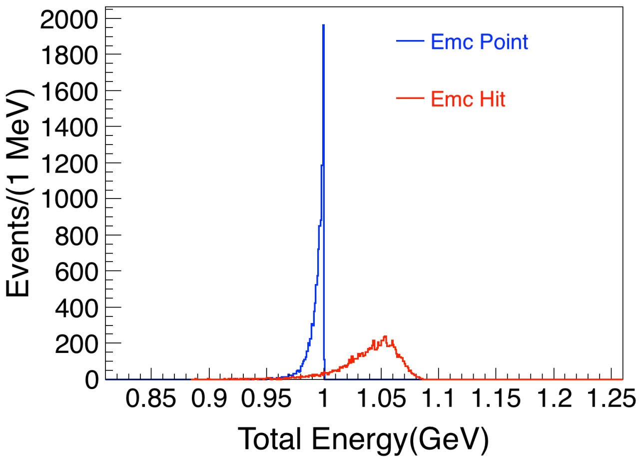


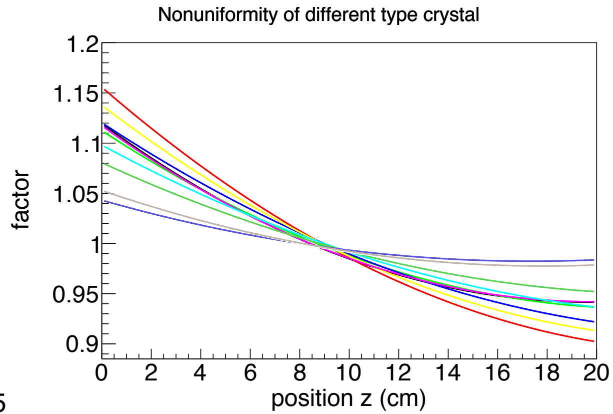
EMC Simulation

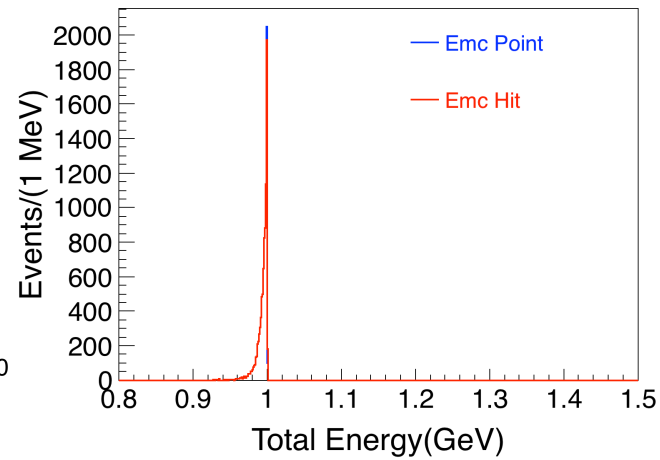
[EmcHit]

- ✓ PndEmcHitProducer
  - Gamma (1GeV)
  - Events=10000
  - Total energy deposition
  - Nonuniform light yield









Nonumiformity **No Nonumiformity**

EMC Simulation

[Pulseshape]

- ✓ PndEmcHitsToWaveform
  - ➢ PndEmcAsicPulseshape
    - Barrel Emc
    - Bwd endcap
    - Fwd endcap

$\Delta t = t - t_0$; $l_{int} = 1/t_{int}$; $l_{sig} = 1/t_{sig}$;
t_{int}: ASIC sampling int time, 70 ns
t_{sig}: crystal sampling time, 12 ns

$$\boxed{A\left(\frac{e^{-\Delta t \cdot l_{int}} \cdot \Delta t^3}{6(l_{sig} - l_{int})} - \frac{e^{-\Delta t \cdot l_{int}} \cdot \Delta t^2}{2(l_{sig} - l_{int})^2} + \frac{e^{-\Delta t \cdot l_{int}} \cdot \Delta t}{(l_{sig} - l_{int})^3} - \frac{e^{-\Delta t \cdot l_{int}}}{(l_{sig} - l_{int})^4} + \frac{e^{-\Delta t \cdot l_{sig}}}{(l_{sig} - l_{int})^4}\right)}$$

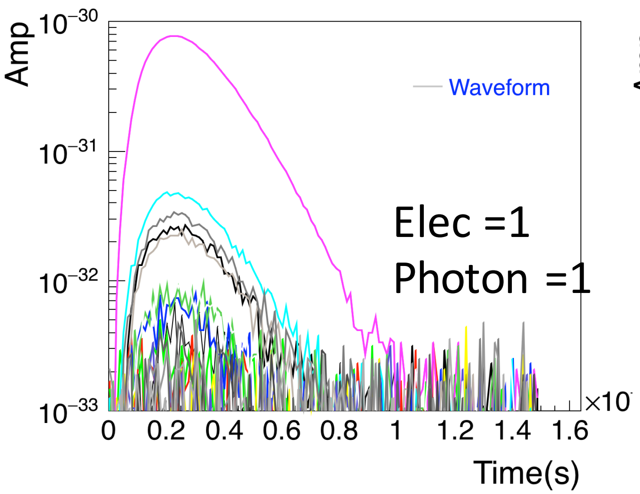
  - ➢ PndEmcCRRCPulseshape
    - Shashlyk calorimeter

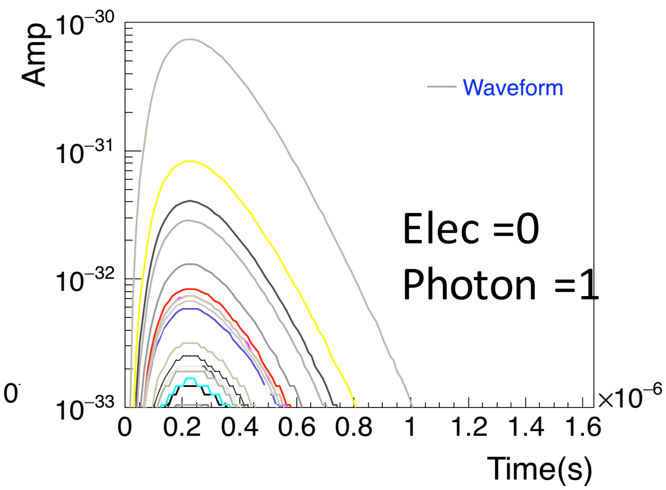
EMC Simulation

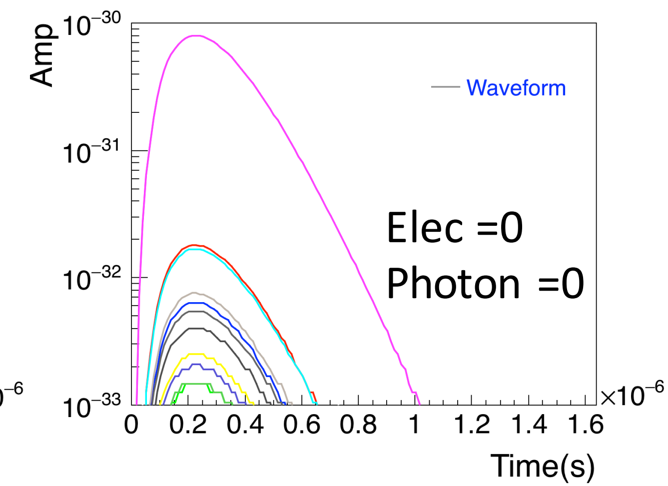
[EmcWaveform]

✓ PndEmcWaveform

- ➢ Gamma (1GeV)
- ➢ Elec-noise(Y/N)
- ➢ Photon statistic (Y/N)



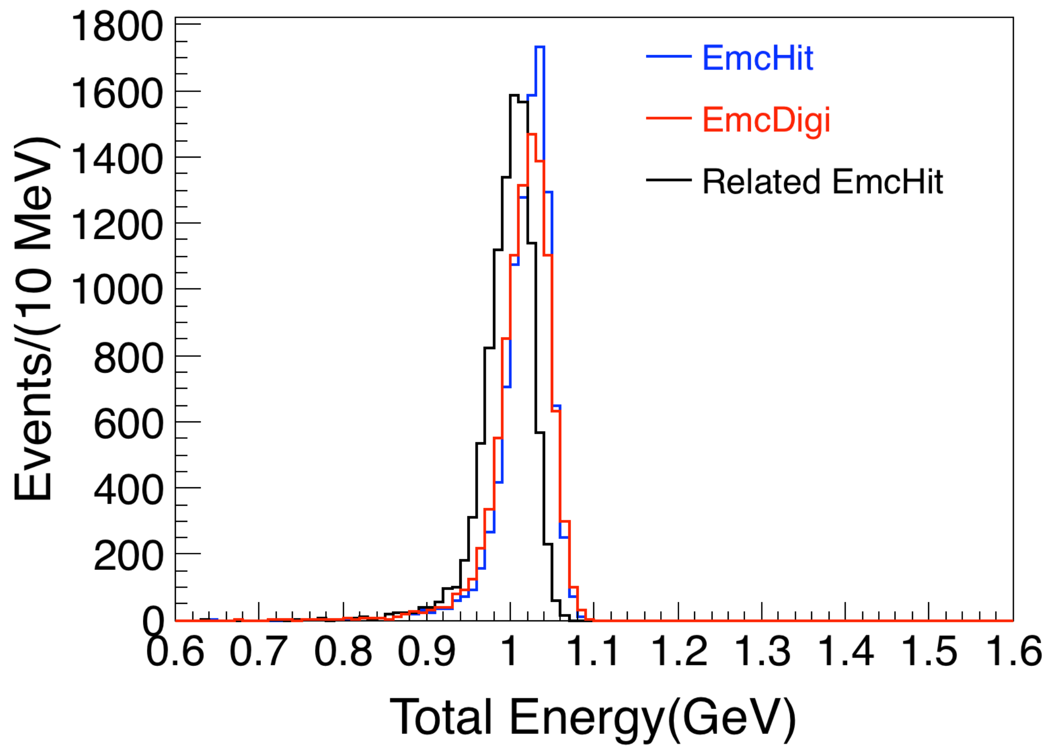




EMC Simulation

[EmcDigi]

- ✓ `PndEmcWaveformToDigi`
  - ➢ Gamma (1GeV)
  - ➢ Events = 10000
  - ➢ Phi(0, 360)
  - ➢ Theta(22, 140)
  - ➢ Total energy depositon

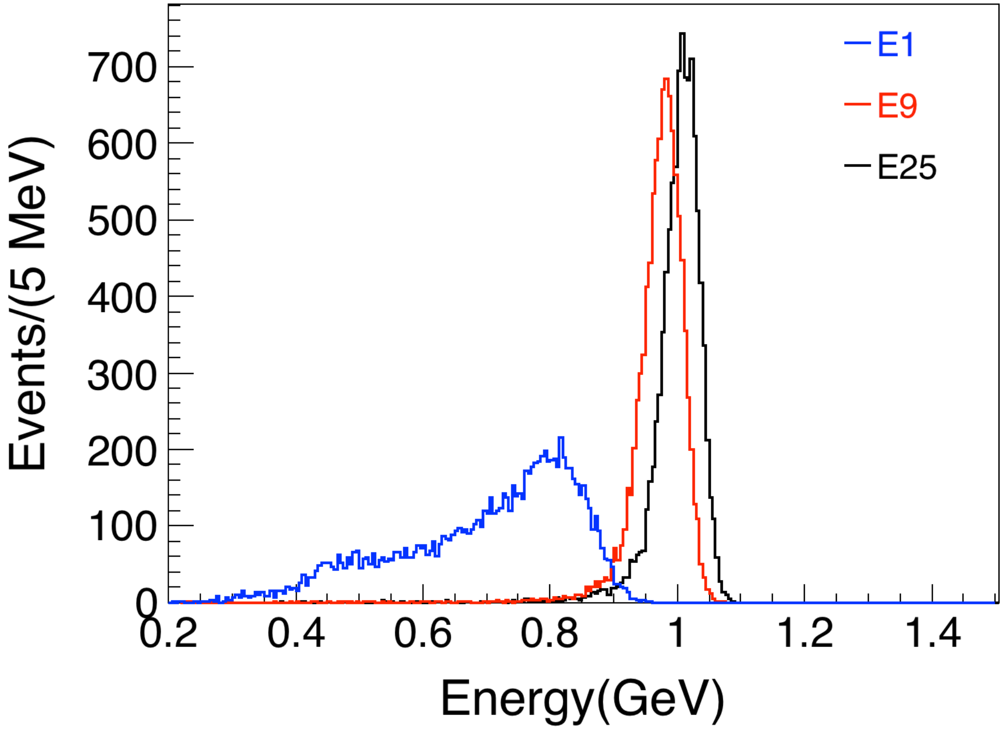


EMC Reconstruction

[EmcCluster]

✓ `PndEmcCluster`

- Gamma (1GeV)
- Events =10000
- Geant3
- Generator: Box
- Phi(0, 360)
- Theta(22, 140)
- E1:maximum energy
- E9:3x3 matrix crystals
- E25:5x5 matrix crystals



EMC Reconstruction

[Resolution]

✓ Energy resolution

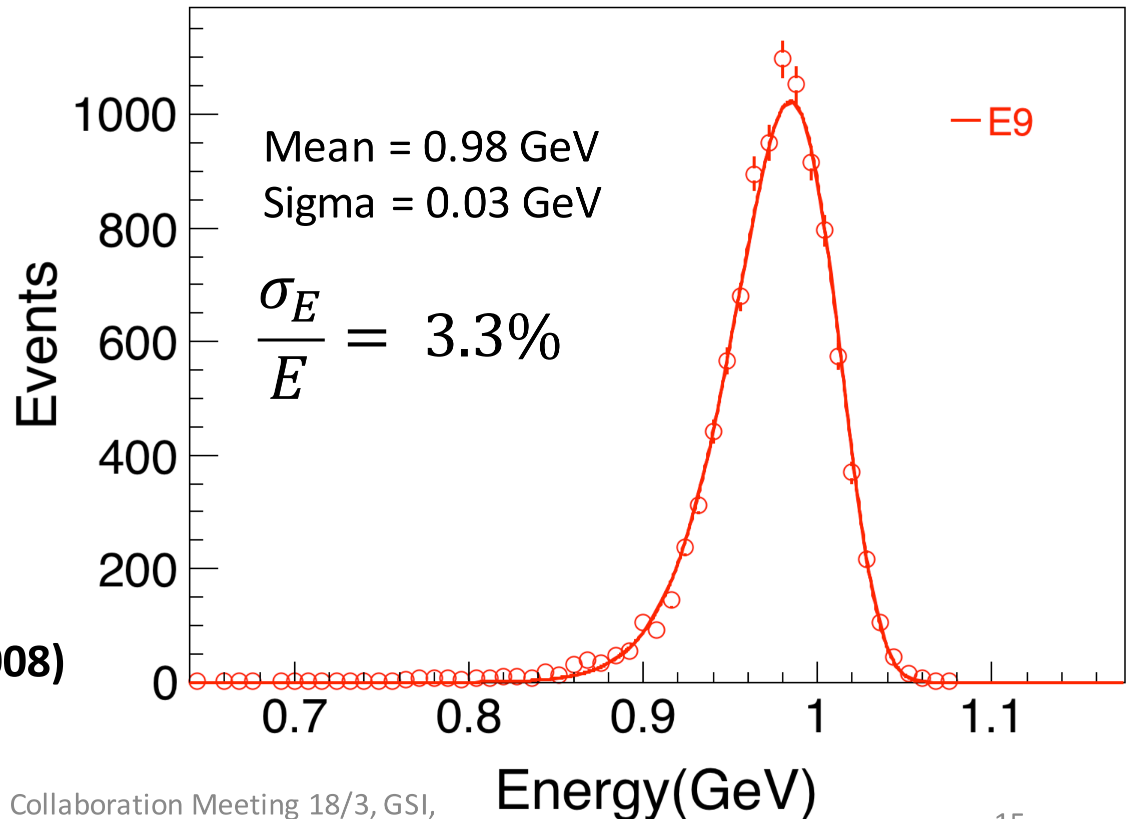
- ➢ Gamma (1GeV)
- ➢ Events =10000
- ➢ Phi(0, 360)
- ➢ Theta(22, 140)
- ➢ 3*3 Matrix crystals
- ➢ Novosibirsk function

$$f(E) = A_S \exp(-0.5\ln^2[1 + \Lambda\tau \cdot (E - E_0)]/\tau^2 + \tau^2)$$

,with

- $\Lambda = \sinh(\tau\sqrt{\ln 4})/(\sigma\tau\sqrt{\ln 4})$,
- $E_0 =$ peak position,
- $\sigma =$ width, and
- $\tau =$ tail parameter

TDR of EMC (2008)



EMC Reconstruction

[Resolution]

✓ Energy resolution

- Gamma (1GeV)
- Events =10000
- Phi(0, 360)
- Theta(22, 140)
- 5*5 Matrix crystals
- Novosibirsk function

$$f(E) = A_S \exp(-0.5\ln^2[1 + \Lambda\tau \cdot (E - E_0)]/\tau^2 + \tau^2)$$

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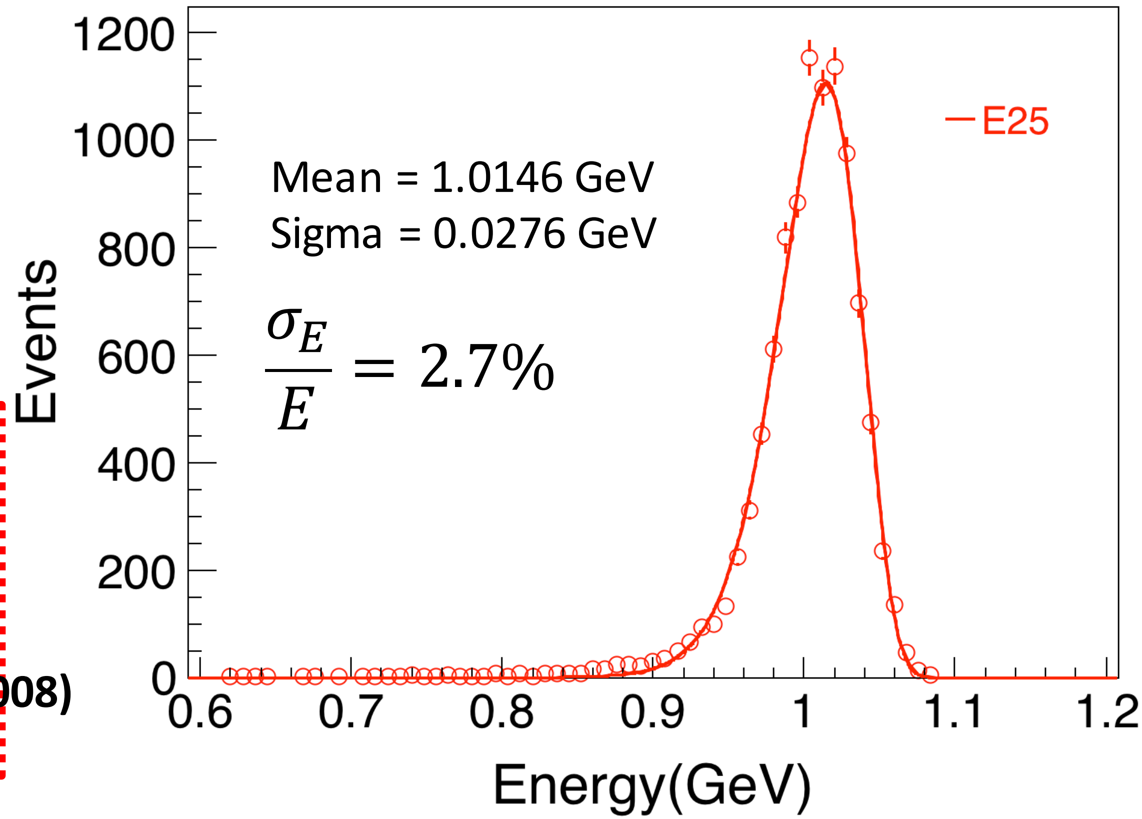


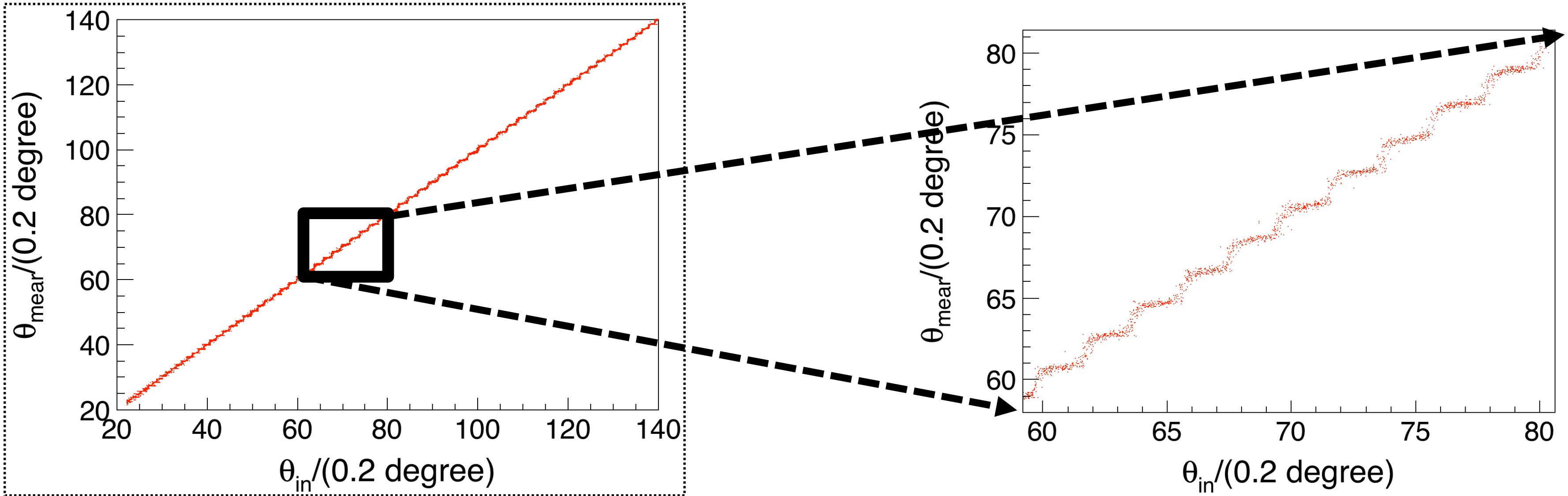
EMC Reconstruction

[Position]

✓ **Position resolution**

- ➢ Gamma (1GeV)
- ➢ Events =10000
- ➢ Phi(0, 360) &Theta(22, 140)
- ➢ 3*3 Matrix crystals

$$X_{mea} = \sum_{i=1}^{n} E_i * x_i \Big/ \sum_{i=1}^{n} E_i$$



EMC Reconstruction

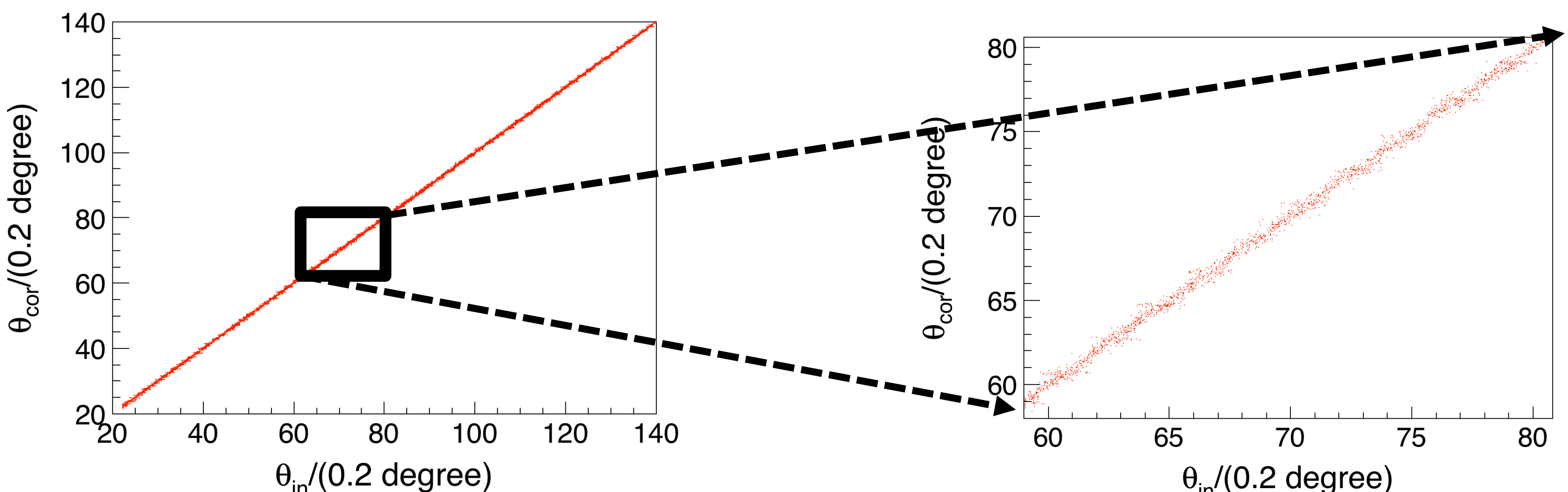
[**Position**]

✓ **Position resolution**

- Gamma (1GeV)
- Events =10000
- Phi(0, 360) &Theta(22, 140)
- 3*3 Matrix crystals

$$X_{cor} = \sum_{i=1}^{n} W(E_i) * x_i \Big/ \sum_{i=1}^{n} W(E_i)$$

$$W(E_i) = Max\left[0, 4.0 + ln\left(E_i \Big/ \sum_{i=1}^{n} E_i\right)\right]$$



EMC Reconstruction

[Position]

✓ **Position resolution**

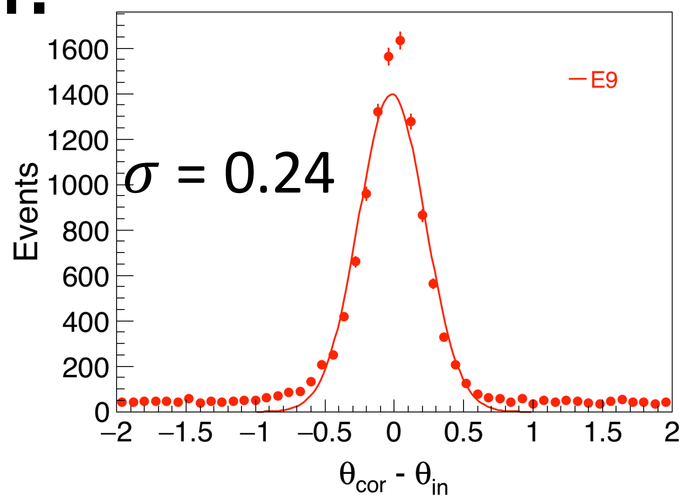
- ➢ Gamma (1GeV)
- ➢ Events =10000
- ➢ Phi(0, 360)&Theta(22, 140)
- ➢ 3*3 Matrix crystals

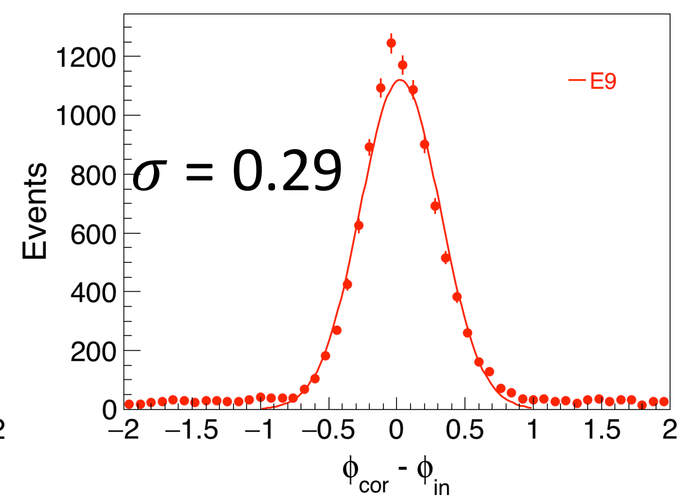
$$X_{cor} = \sum_{i=1}^{n} W(E_i) * x_i \,/ \sum_{i=1}^{n} W(E_i)$$

$$W(E_i) = Max[0, 4.0 + ln(E_i / \sum_{i=1}^{n} E_i)]$$

✓ **Fit function:**

- ➢ Gaussian





Summary

✓ **What we have checked:**

- ➢ Simulation and reconstruction of EMC;
  - Distributions of features about EMC;

✓ **Next to do:**

- ➢ Check whether parameters settings are reasonable
- ➢ Comparison between EMC simulation and experimental test.

Panda is on going!

Artist: Meilin Han

CaliGirl

DreamWorks Animation

Thanks for your attention!

Back Up

EMC

[Main requirement]

	Required performance value		
Common properties			
energy resolution σ_E/E	$\leq 1\,\% \oplus \frac{\leq 2\,\%}{\sqrt{E/\mathrm{GeV}}}$		
energy threshold (photons) E_{thres}	10 MeV (20 MeV tolerable)		
energy threshold (single crystal) E_{xtl}	3 MeV		
rms noise (energy equiv.) $\sigma_{E,noise}$	1 MeV		
angular coverage % 4π	99 %		
mean-time-between-failures t_{mtbf} (for individual channel)	2000 y		
Subdetector specific properties	backward ($\geq 140°$)	barrel ($\geq 22°$)	forward ($\geq 5°$)
energy range from E_{thres} to	0.7 GeV	7.3 GeV	14.6 GeV
angular equivalent of crystal size θ	4°		1°
spatial resolution σ_θ	0.5°	0.3°	0.1°
maximum signal load f_γ ($E_\gamma > E_{xtl}$)	60 kHz		500 kHz
(p$\bar{\text{p}}$-events) maximum signal load f_γ ($E_\gamma > E_{xtl}$)	100 kHz		500 kHz
(all events) shaping time t_s	400 ns		100 ns
radiation hardness (maximum annual dose p$\bar{\text{p}}$-events)	0.15 Gy	7 Gy	125 Gy
radiation hardness (maximum annual dose from all events)	10 Gy		125 Gy

EMC Reconstruction

[Resolution]

✓ Energy resolution

- ➢ Gamma (1GeV)
- ➢ Events =10000
- ➢ Phi(99.3251)
- ➢ Theta(70.7429)
- ➢ 3*3 Matrix crystals
- ➢ Novosibirsk function

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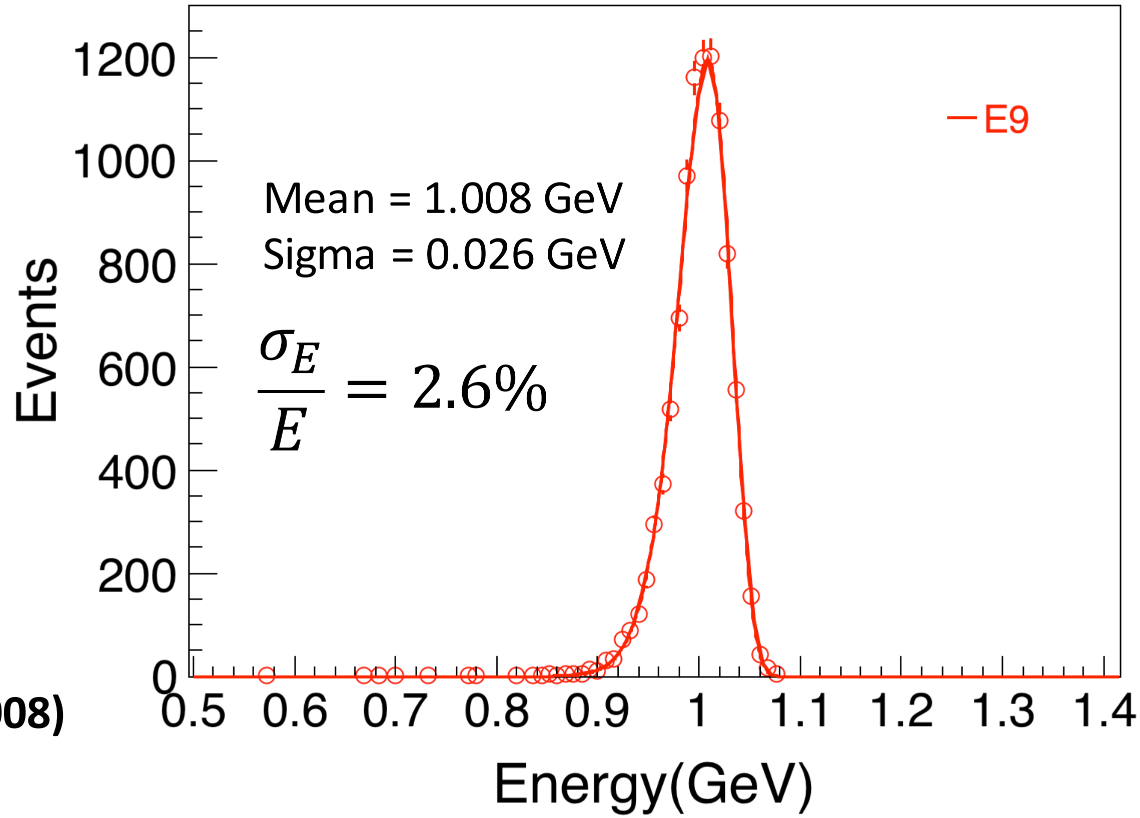

EMC Reconstruction

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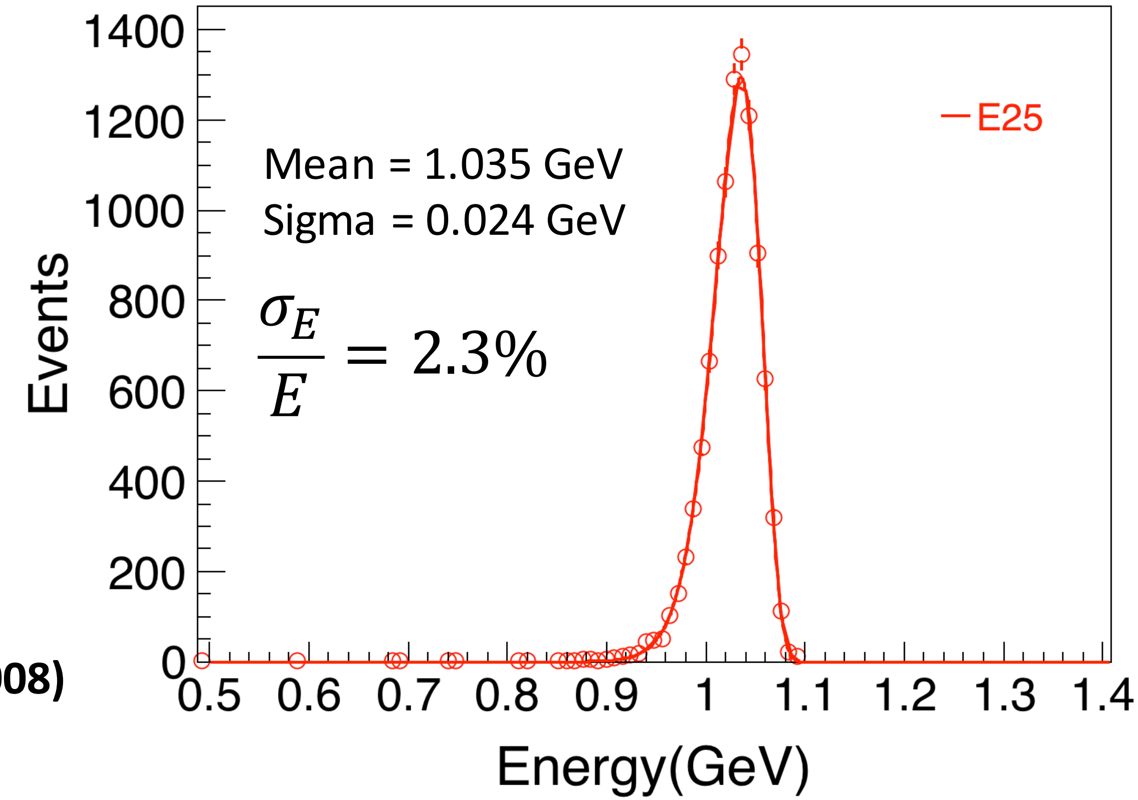

Data Flow

[Simulation & reconstruction]

PndEmcPoint

PndEmcHitProducer

PndEmcHit

PndEmcHitsToWaveform

PndEmcWaveform

PndEmcWaveformToDigi

PndEmcDigi

PndEmcMakeCluster

PndEmcCluster

PndEmcMakeBump

PndEmcBump