A FOrward CALorimeter for the PHENIX experiment

Y. Kwon
Yonsei Univ.

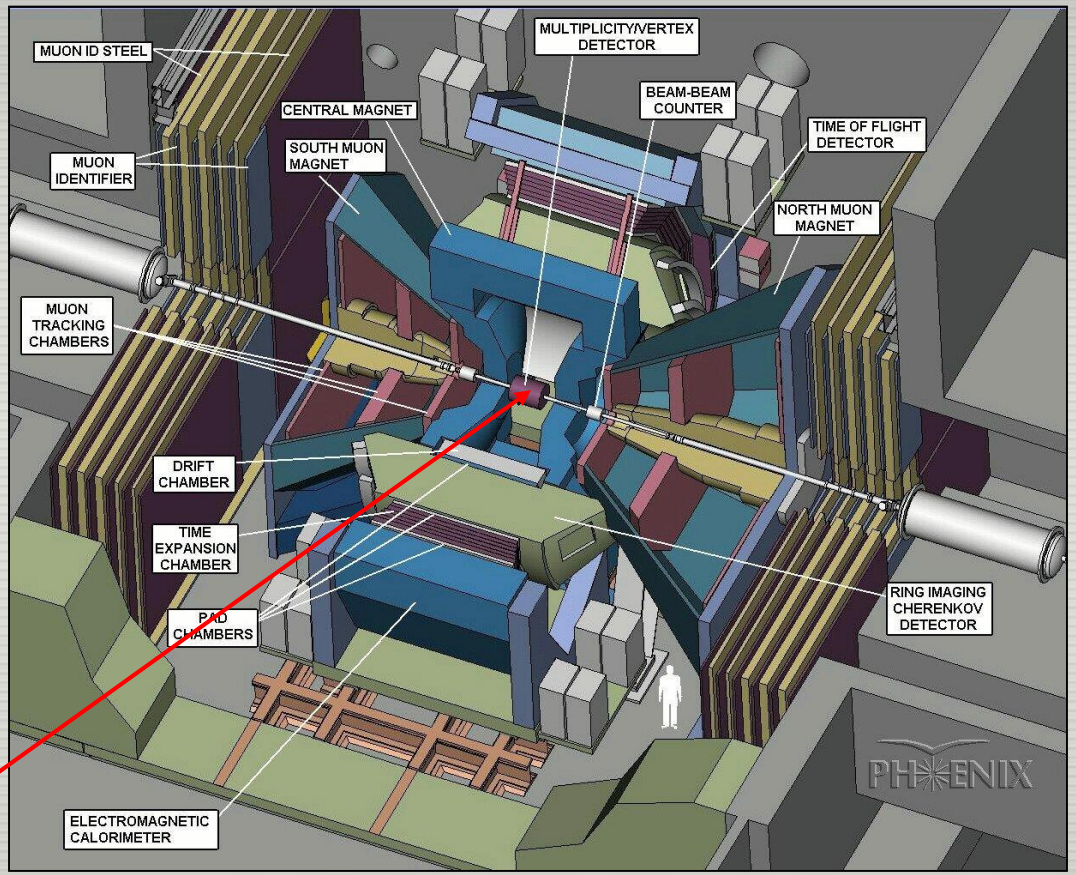
Korean FOCAL group
Chonbuk National Univ.,
Ewha Woman's Univ. ,
Korea Univ.,
Myungji Univ.,
Yonsei Univ.

PHENIX

Optimized for

Rare probes

e, γ, μ, high p_T hadrons



Collision location

FoCAL & PHENIX

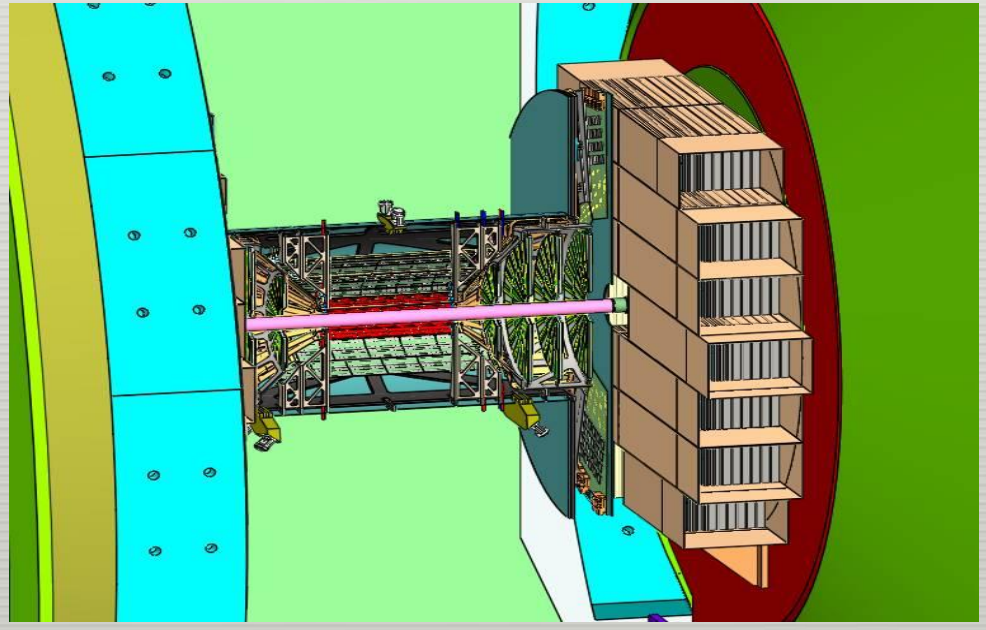
PHENIX : Focus on rare processes

limited rate →Luminousity

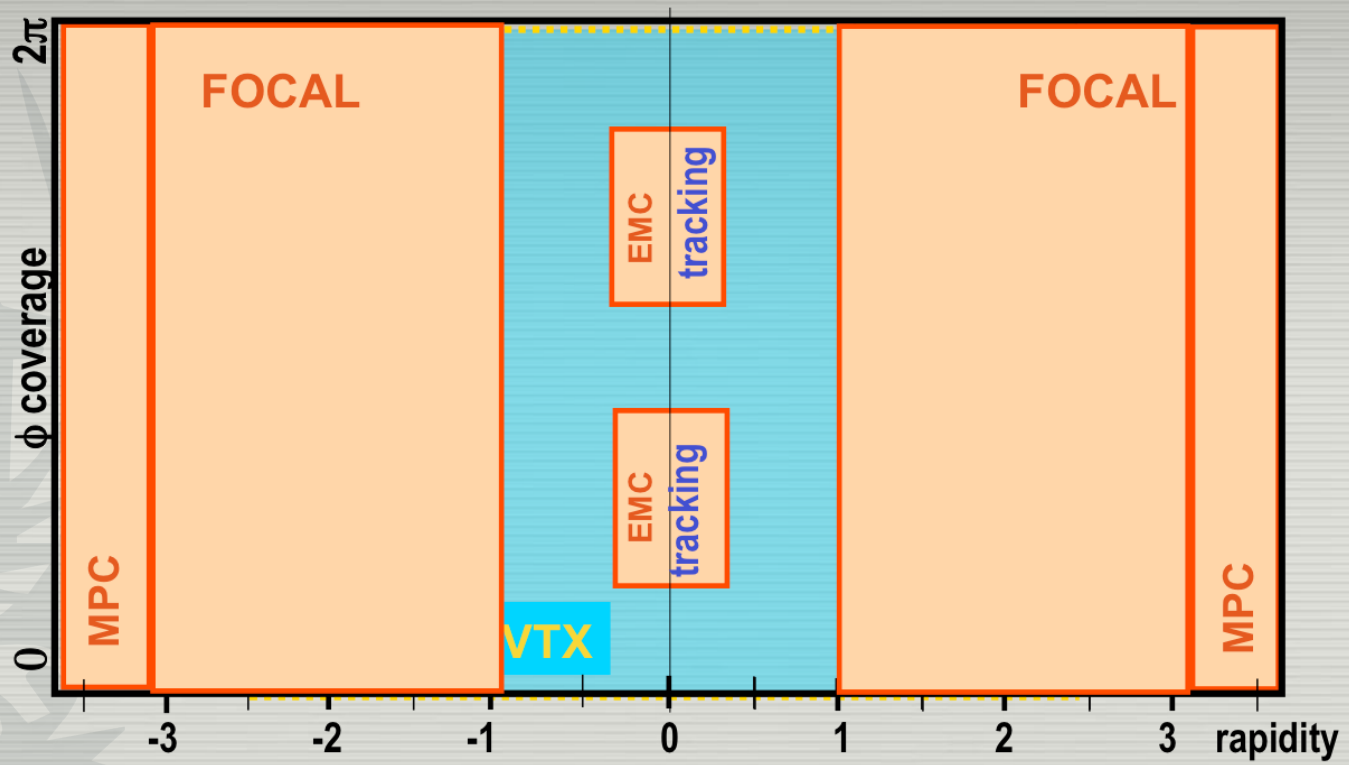
limited acceptance

→ Upgrade?

FoCAL : Forward upgrade, A high density, high granularity Si-W tracking calorimeter.



Acceptance



2π coverage in azimuth and $0.9 < \eta < 3.0$

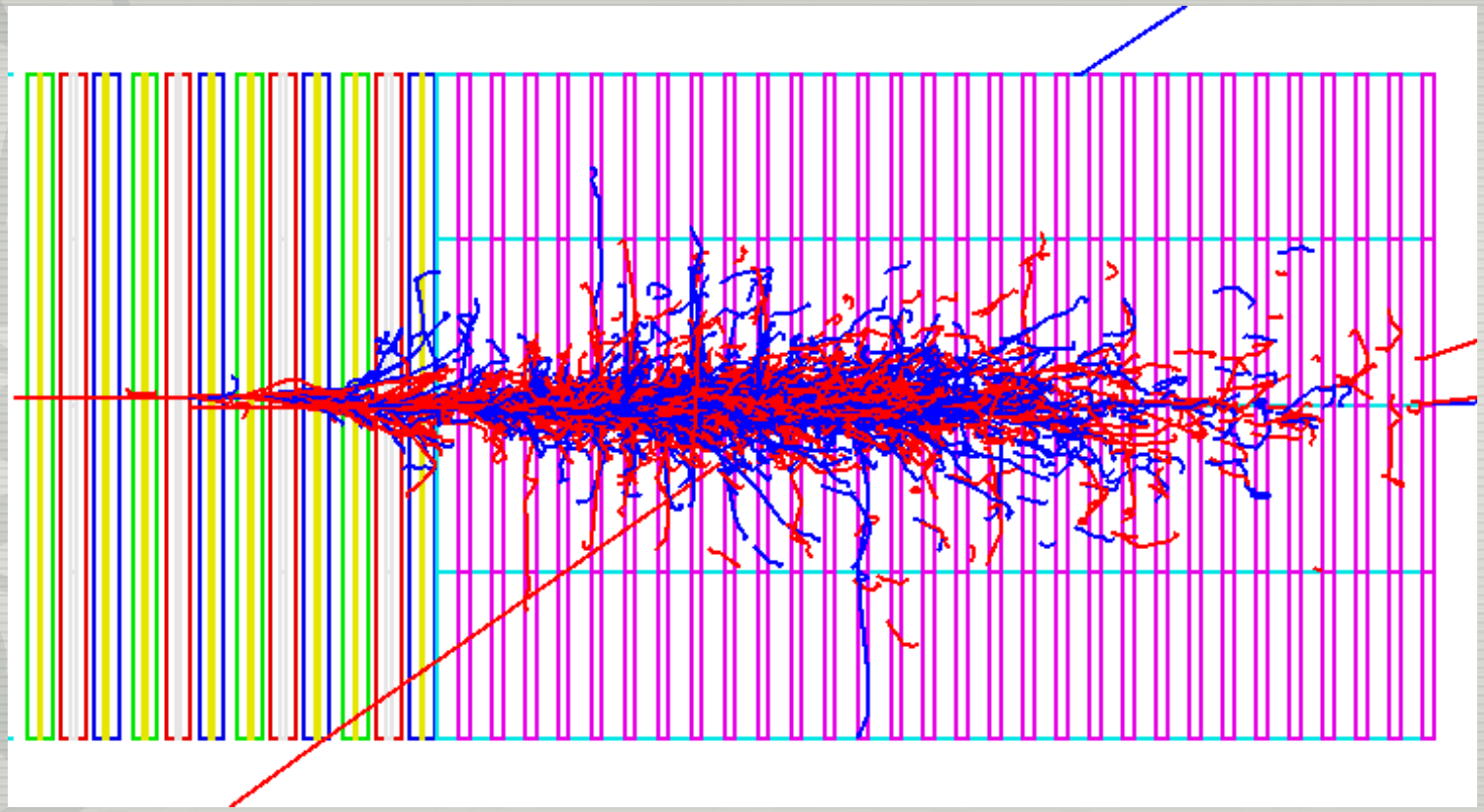
Technically, EMCal

Focus on

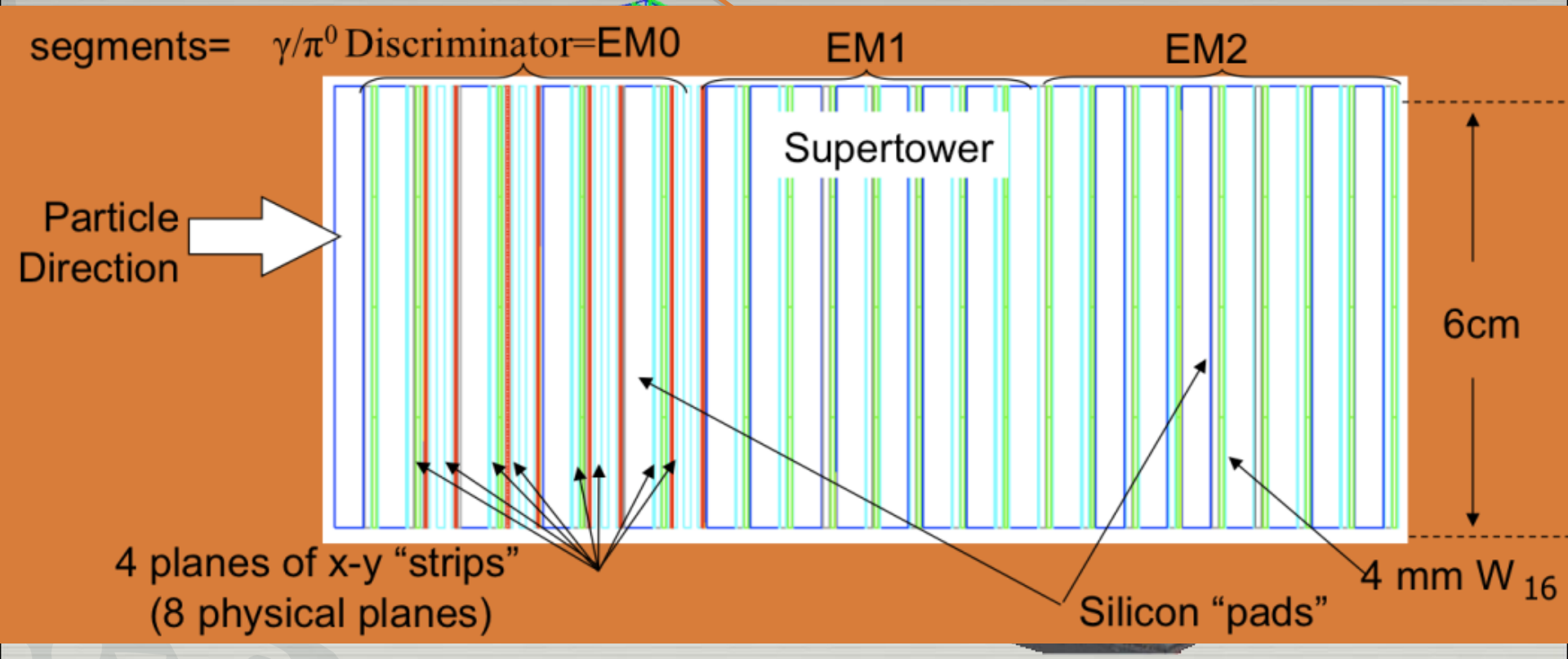
Ability to distinguish between photons and π^0's up to 60 GeV

Ability to identify EM/hadronic activity

When e/γ enters material…



Detector Design Scheme



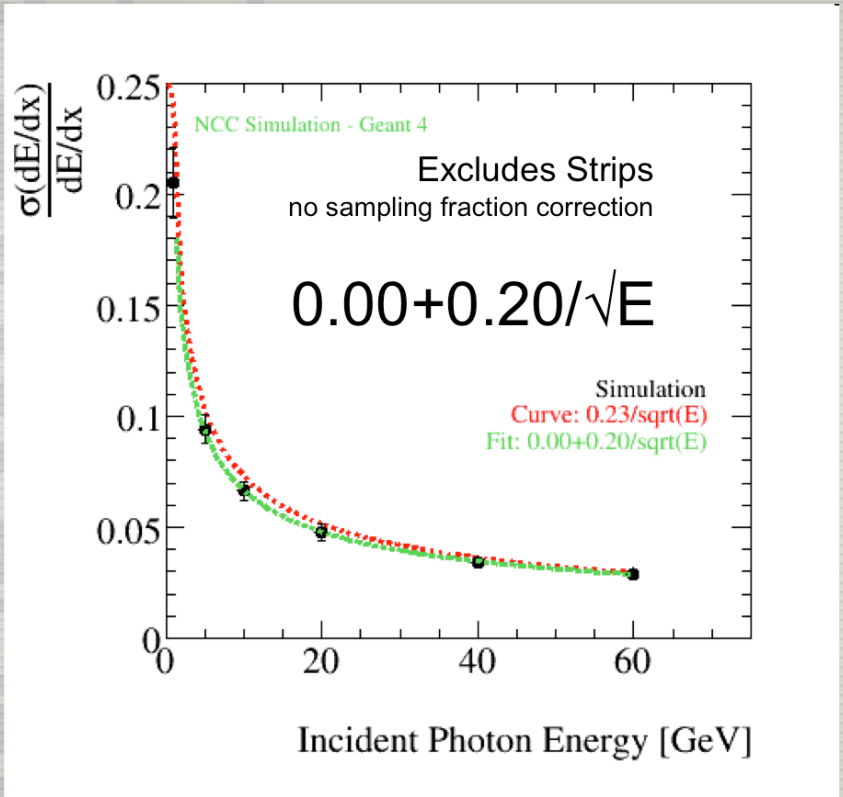
Spatial restrictions

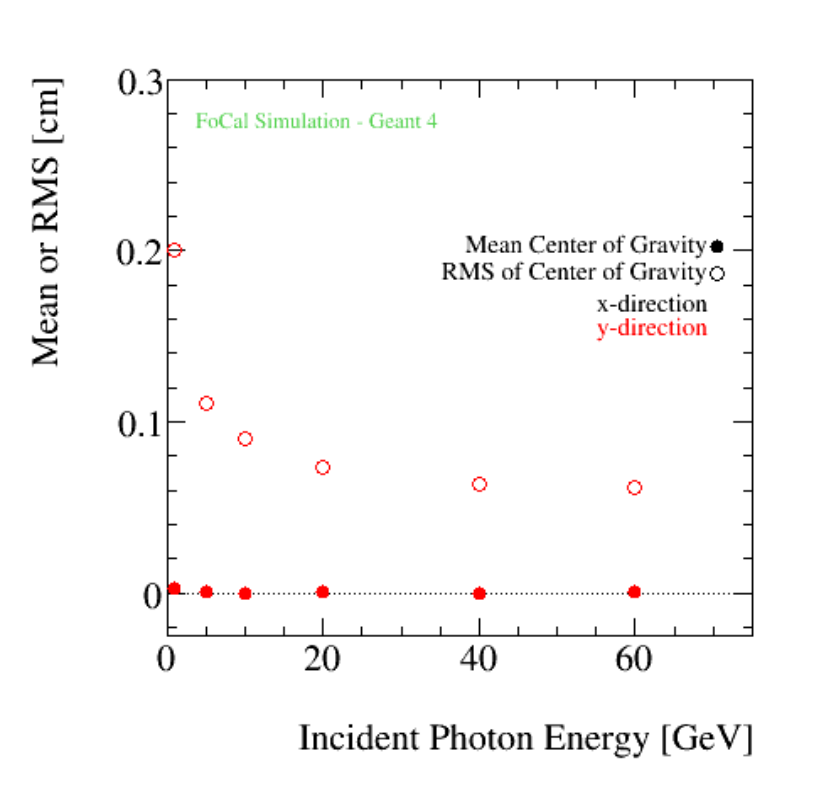
→ Compact detector, ~ 20 cm depth with high granularity

→ Small Moli'ere radius ~ 14 mm.

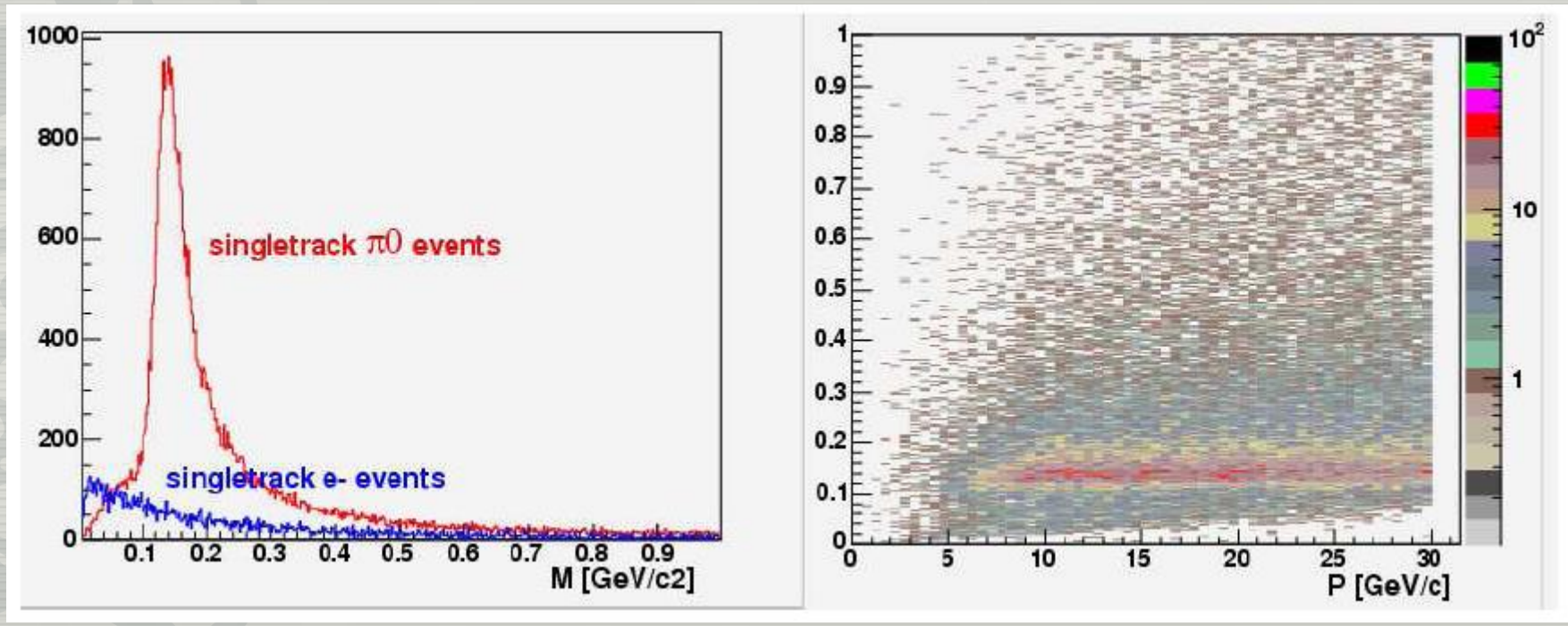
→ Si-W supertowers stacked in brick-like manner.

Resolution

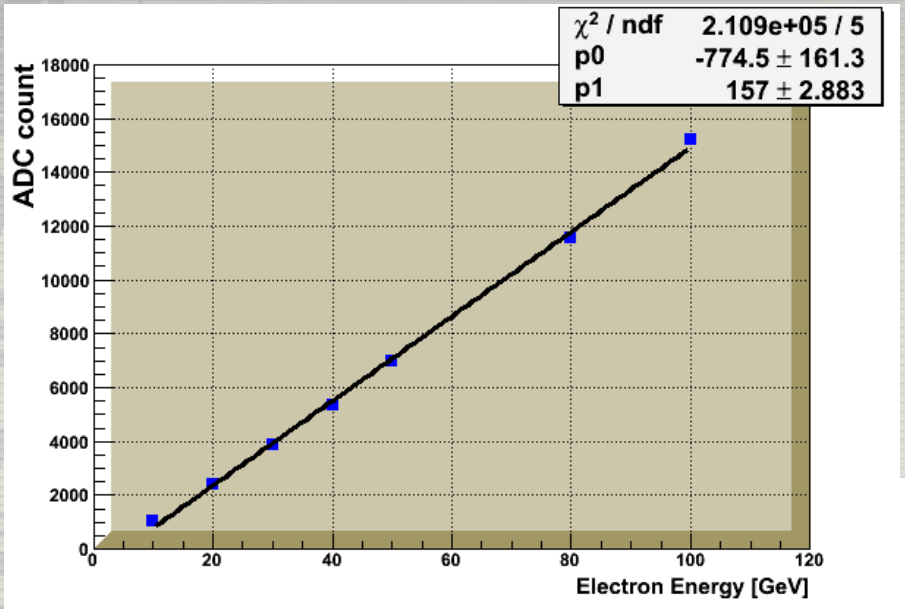

σ(dE/dx) / dE/dx
NCC Simulation - Geant 4
Excludes Strips
no sampling fraction correction
0.00+0.20/√E
Simulation
Curve: 0.23/sqrt(E)
Fit: 0.00+0.20/sqrt(E)
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
Incident Photon Energy [GeV]


Mean or RMS [cm]
FoCal Simulation - Geant 4
Mean Center of Gravity
RMS of Center of Gravity
x-direction
y-direction
0.3
0.2
0.1
0
0
20
40
60
Incident Photon Energy [GeV]

π^0 reconstruction

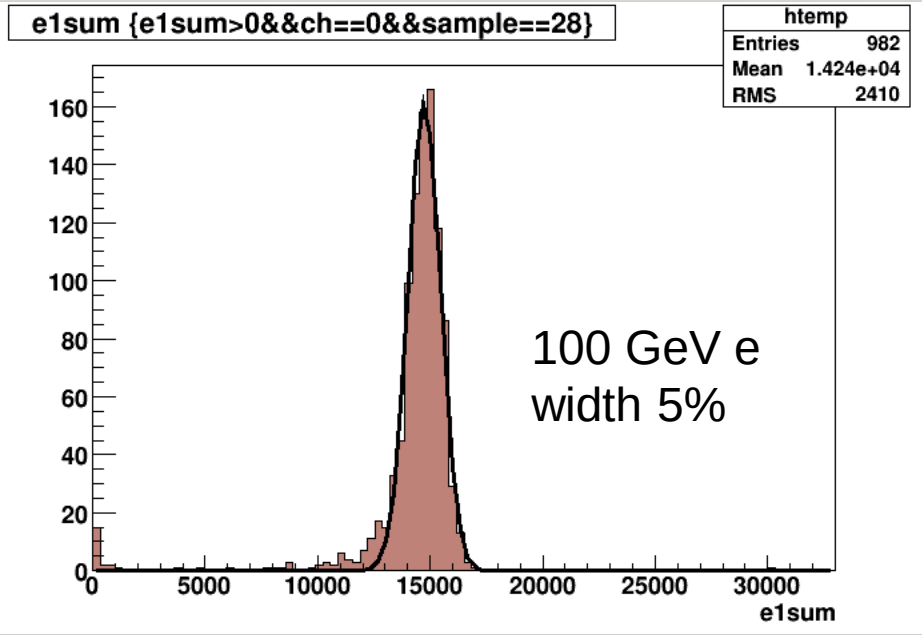


Beam test 2007



✓ ADC mean value shows linear dependence on incident electron energy

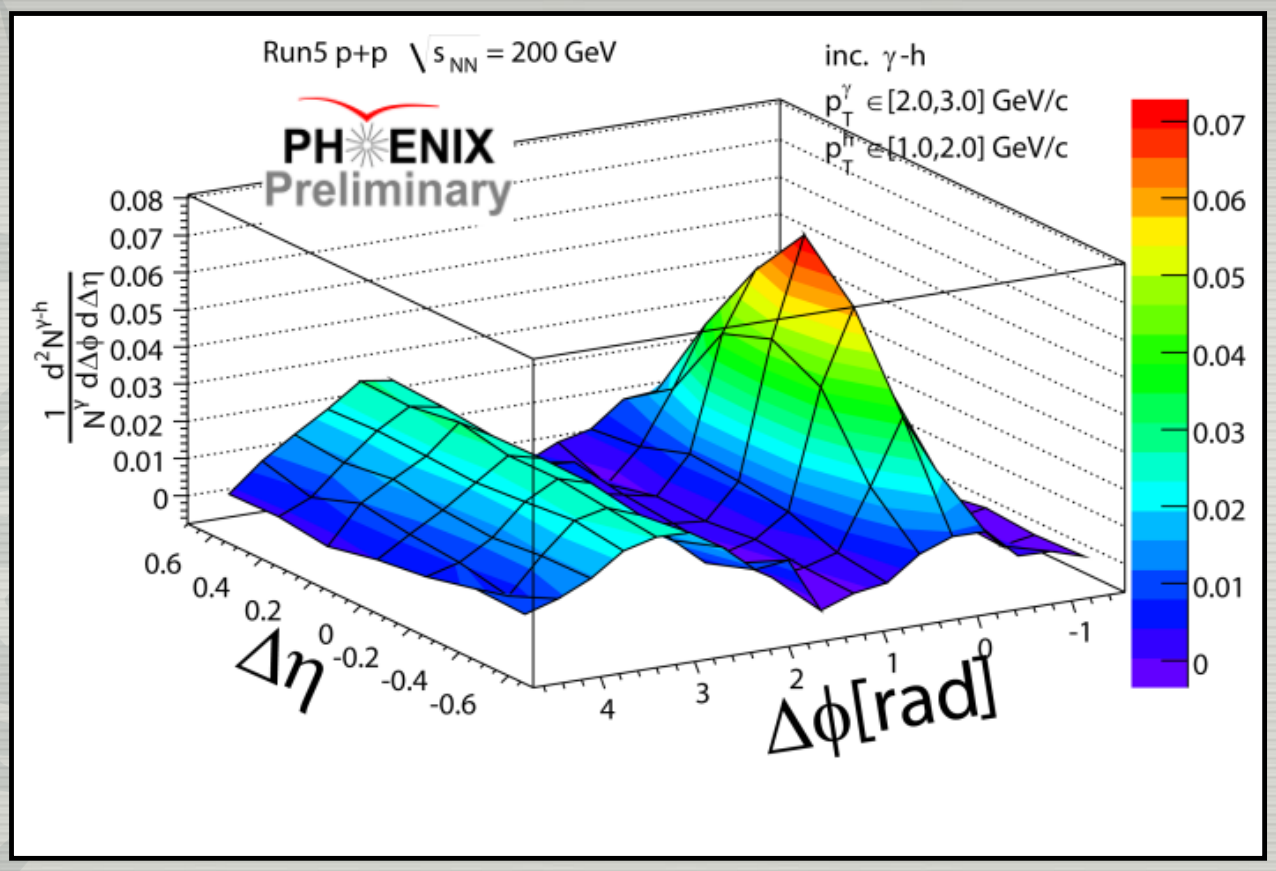
high density, high granularity



Close to simulation result

$$\frac{\Delta E}{E} = \frac{23\%}{\sqrt{E}} + 1\%$$

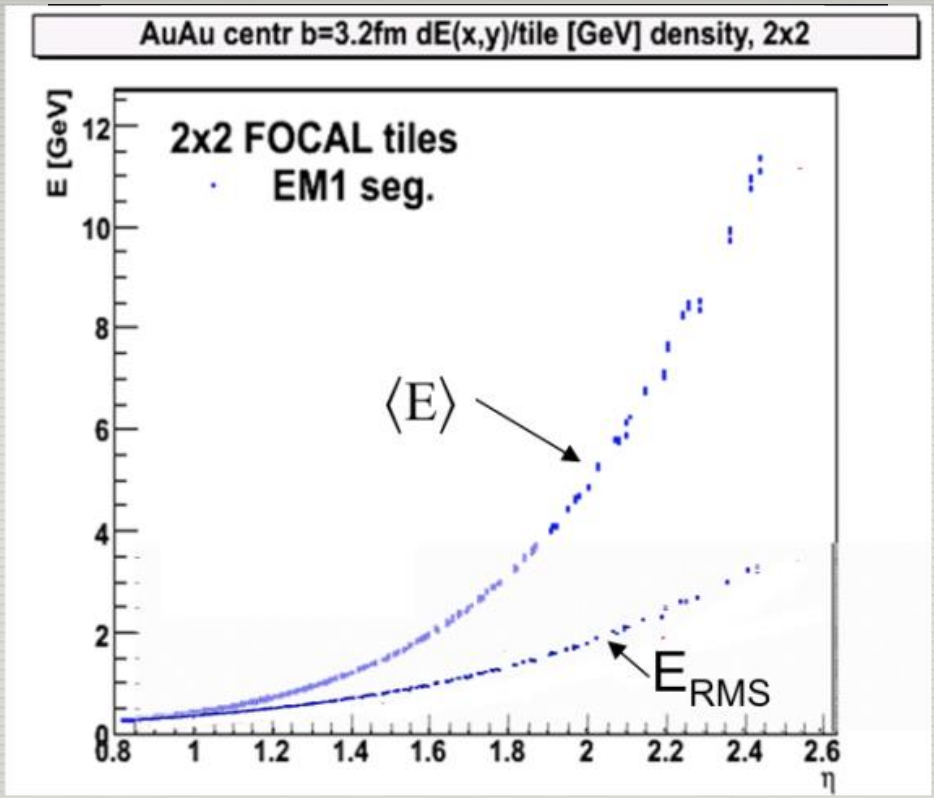
A native picture



FOCal would allow us to study the medium via long range correlations.

FOCAL will extend η reach, $\Delta\eta \sim 5$.

Under study



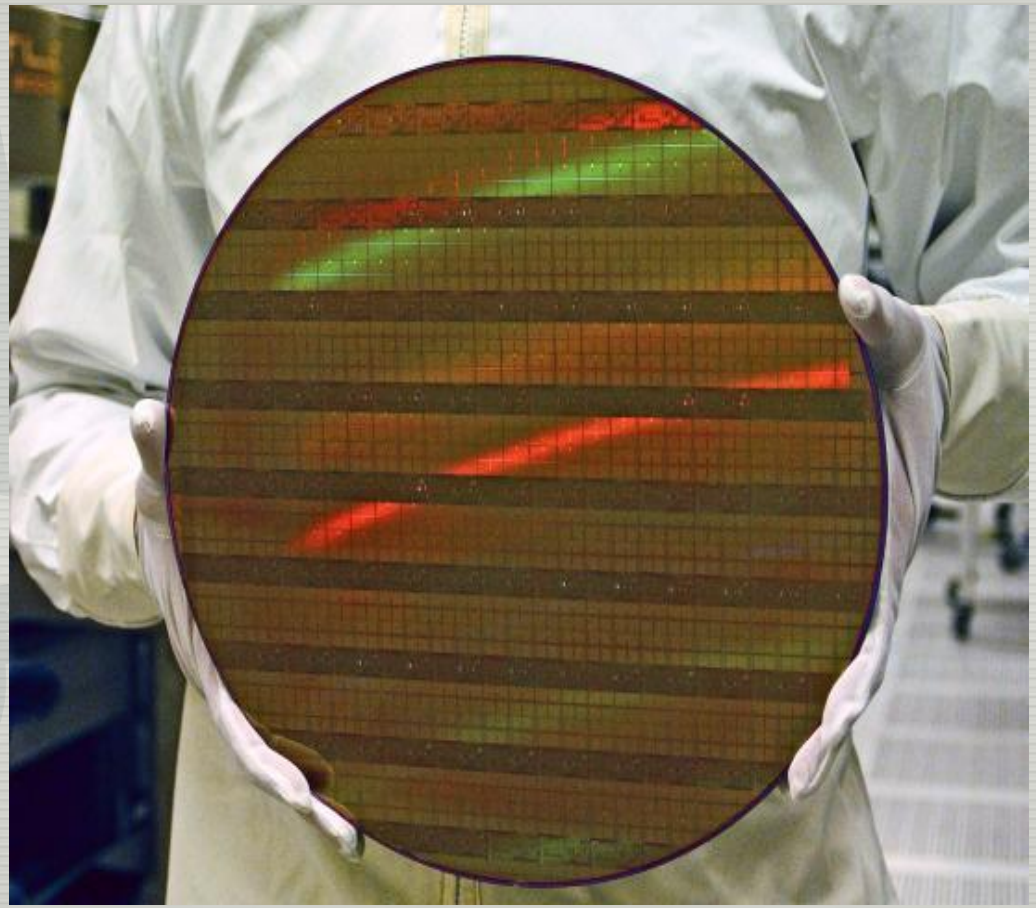
Parameterized background by studying average energy deposited in the detector (E) and its fluctuations (RMS).

NSAC milestones

Year	#	MileStone	FOCAL
2012	DM8	Determine gluon densities at low x in cold nuclei via p+ Au or d + Au collisions.	Required for direct photon
2013	HP12	Utilize polarized proton collisions at center of mass energies of 200 and 500 GeV, in combination with global QCD analyses, to determine if gluons have appreciable polarization over any range of momentum fraction between 1 and 30% of the momentum of a polarized proton.	Low-x Direct γ
2014	DM10 (new)	Measure jet and photon production and their correlations in A≈200 ion+ion collisions at energies from medium RHIC energies to the highest achievable energies at LHC. DM10 captures efforts to measure jet correlations over a span of energies at RHIC and a new program using the CERN Large Hadron Collider and its ALICE, ATLAS and CMS detectors.	Marginal without FOCAL
2015	HP13 (new)	Test unique QCD predictions for relation between single-transverse spin phenomena in p-p scattering and those observed in deep-inelastic lepton scattering. New theoretical breakthroughs of recent years in understanding the parton distribution functions accessed in spin asymmetries for hard-scattering reactions involving a transversely polarized proton	Required

Another motivation

D-Ram? CPU? Si-detector?



40나노급 8기가 플렉스원낸드 출시
이달 양산 예정..모바일 및 컨슈머칩셋社와 협력 강화
원낸드 제품도 40나노급 공정 적용

삼성전자(005930)는 업계 최초로 퓨전메모리 제품에 40나노급 공정을 적용한 `8기가 플렉스 원낸드(Flex-OneNANDTM)`를 개발했다고 10일 밝혔다.

삼성전자에 따르면 이 제품은 기존 60나노급 4기가 플렉스 원낸드보다 생산성이 약 2.8배 향상됐다.

8기가 플렉스 원낸드 특징 중 하나는 휴대폰업체가 고용량의 저장장치를 갖춘 제품을 개발할 때 별도의 소프트웨어가 필요없다는 점.

즉 대용량·고성능·저소비전력 등 고효율 동작을 요구하는 하이엔드 휴대폰에 적합한 소프트웨어 솔루션을 제공한다.

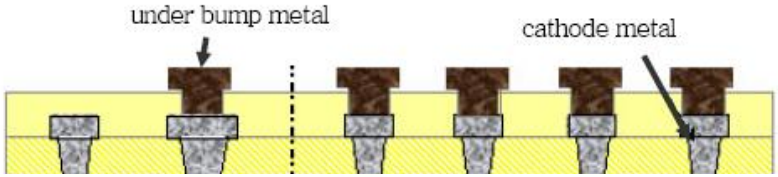
삼성전자는 8기가 플렉스 원낸드의 소프트웨어 솔루션은 휴대폰업체에서 SLC(싱글레벨셀) 및 MLC(멀티레벨셀) 용량을 자유자재로 디자인할 수 있다고 설명했다.

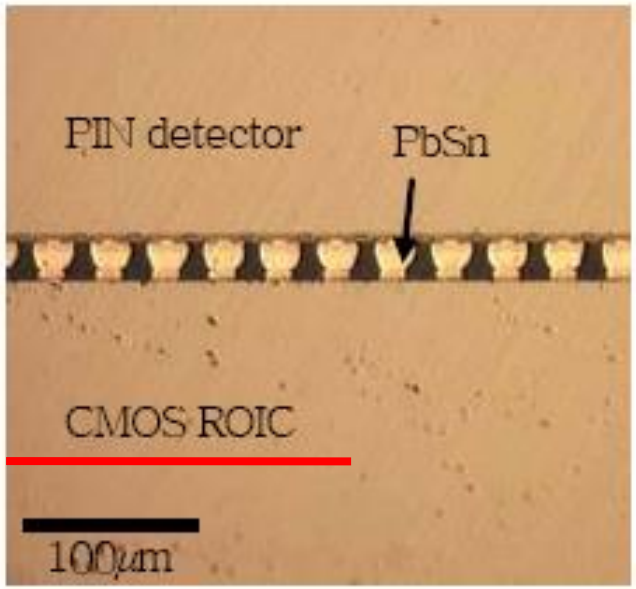
즉, 프로그램을 지원하는 코드용 SLC 플래시와 동영상 등 데이터 저장용 MLC 플래시를 하나의 칩으로 구현할 수 있고, 내장 타입의 확장 스토리지인 Movi-NANDTM도 콘트롤할 수 있다.

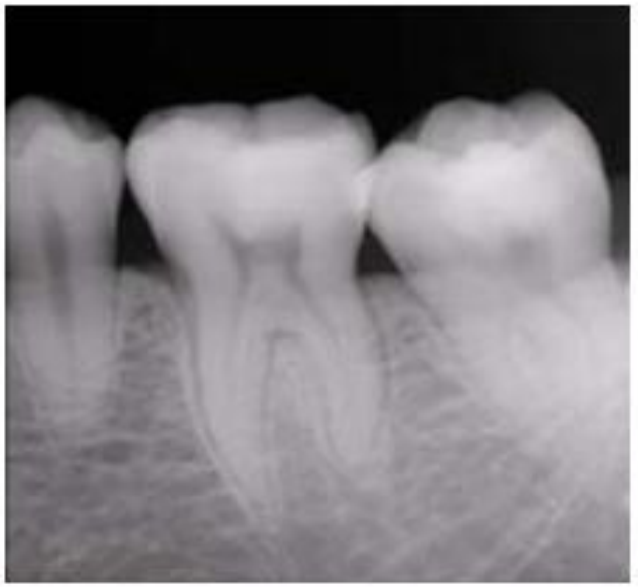
삼성전자는 올해 스마트폰은 32기가바이트 용량의 메모리가 내장될 것으로 보이며, 8기가 플렉스 원낸드를 탑재하면 별도의 소프트웨어 개발이 필요없이 사용할 수 있다고 설명했다.

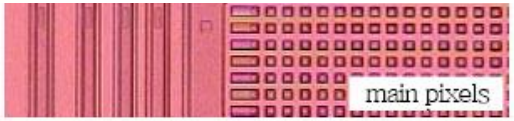
또 8기가 플렉스 원낸드는 그 자체로 약 1기가바이트의 MLC 낸드 용량을 갖추고 있고, MLC 낸드 플래

ETRI









(b) 평면 사진

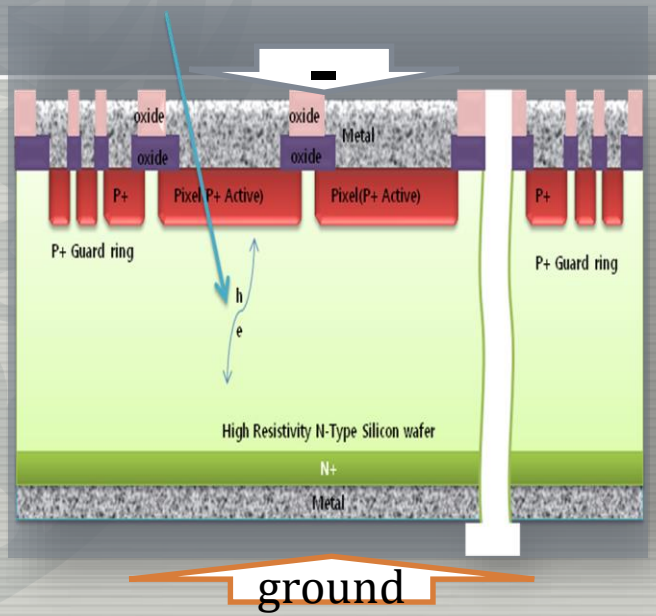
(그림 3) 치아 X-선 영상 촬영용 실리콘 픽셀 디텍터

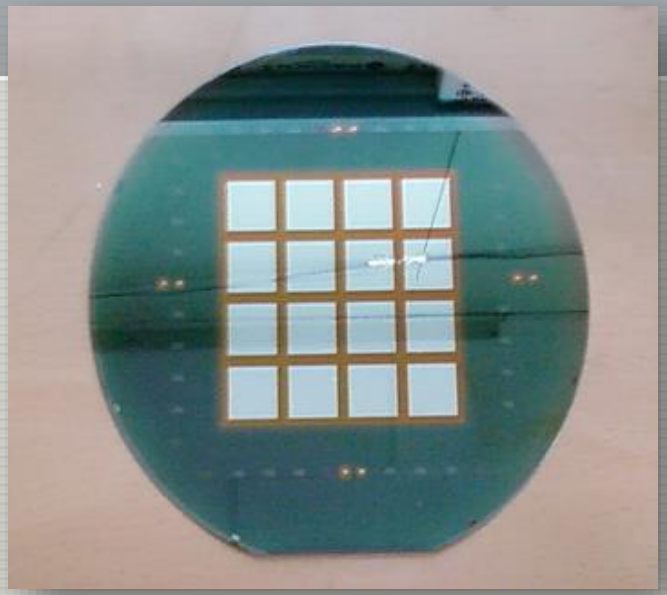
Really competitive?

- Cost
  - (10±3)\$/cm^2 is typically quoted price.
  - 5\$/cm^2 or so for ETRI processing… probably lower side. Cost includes
    - yields and fabrication capability (good infra-structure).
  - PHENIX FOCAL plans to purchase from Korea if … (already helped R&D by about 30k\$).
- Future
  - Cost for nanoFAB will be even lower… It will remain to be so for a while.

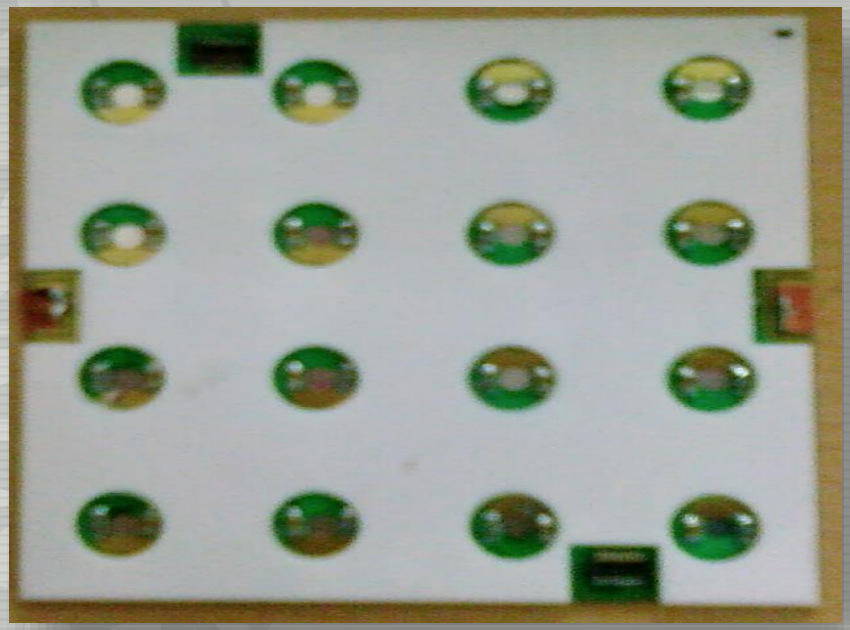
Silicon pad sensor

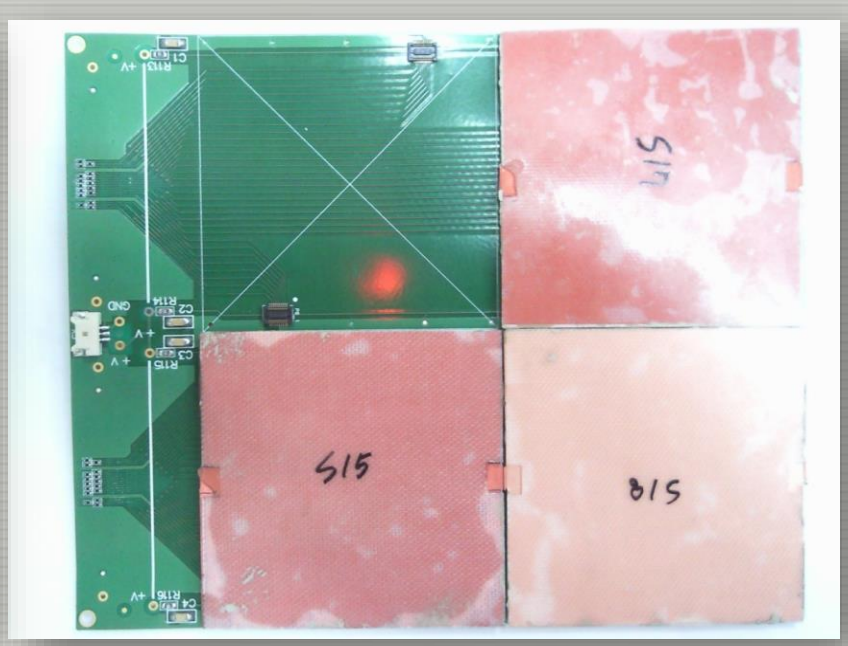
- **Basically PN junction diode in reverse bias mode.**
  - N-type substrate and p-type pattern for high energy application => electrons are carriers
- **16 square(1.5cm×1.5cm) pads in one micro-module**



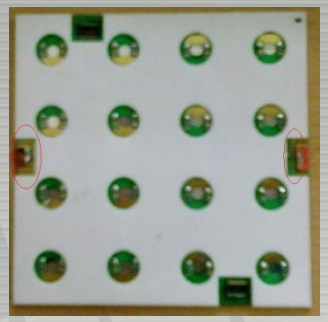


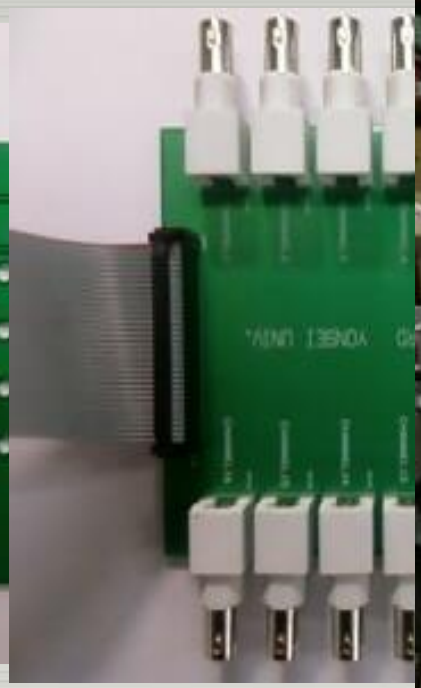
Production results



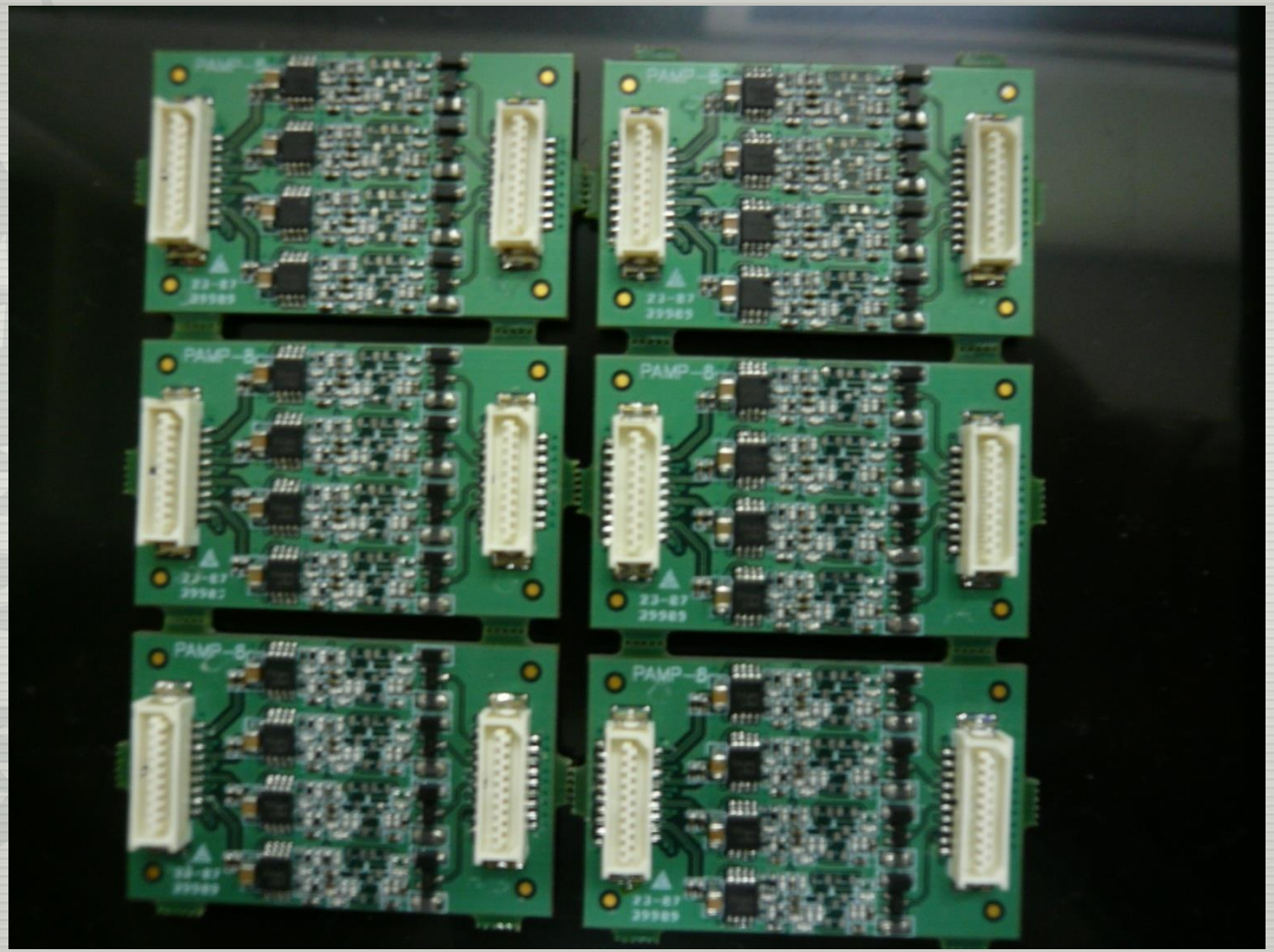


- 4 sample micro-module production has completed.
- Mechanical and electrical issues have been checked

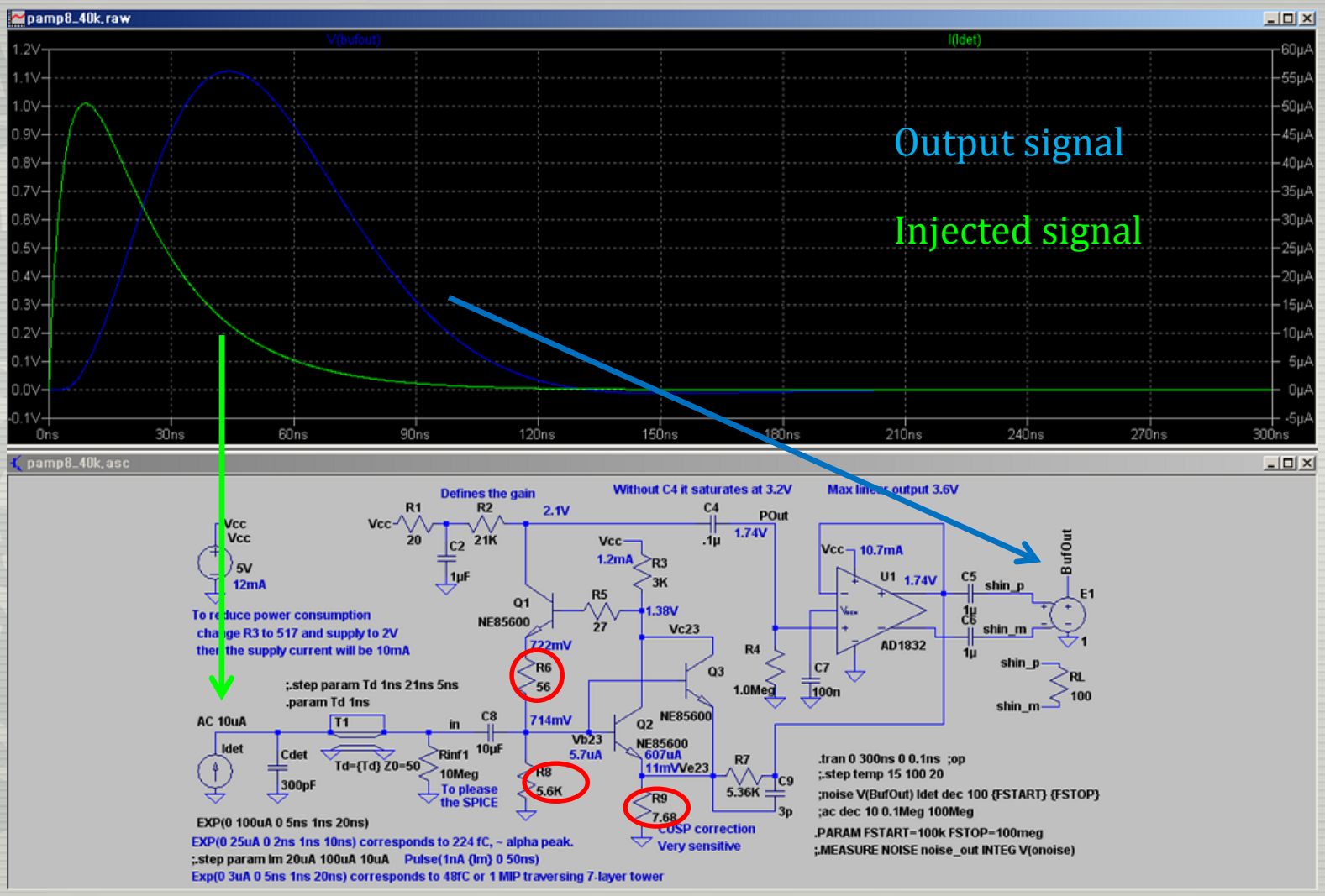




Preamp Card



Preamp Card


pamp8_40k.raw
V(bufout)
I(Idet)
Output signal
Injected signal
pamp8_40k.asc
Defines the gain
Without C4 it saturates at 3.2V
Max linear output 3.6V
To reduce power consumption
change R3 to 517 and supply to 2V
then the supply current will be 10mA
;.step param Td 1ns 21ns 5ns
.param Td 1ns
EXP(0 100uA 0 5ns 1ns 20ns)
EXP(0 25uA 0 2ns 1ns 10ns) corresponds to 224 fC, ~ alpha peak.
;.step param Im 20uA 100uA 10uA Pulse(1nA {Im} 0 50ns)
Exp(0 3uA 0 5ns 1ns 20ns) corresponds to 48fC or 1 MIP traversing 7-layer tower
To please the SPICE
COSP correction
Very sensitive
.tran 0 300ns 0 0.1ns ;op
;.step temp 15 100 20
;noise V(BufOut) Idet dec 100 {FSTART} {FSTOP}
;ac dec 10 0.1Meg 100Meg
.PARAM FSTART=100k FSTOP=100meg
;.MEASURE NOISE noise_out INTEG V(onoise)

Summary

- Explored FOCAL acceptance ~ $0.9 < \eta < 3.0$
- FOCAL will trigger, detect, and identify e, γ, and π^0.
- γ energy resolution ~ 5% at p = 25 GeV/c or p_T ~ 10 GeV/c .
- Technically, W/Si calorimeter
  - High density, high granularity.
  - Replacing existing auxiliary absorbers in the muon spectrometers.
- Test beam scheduled at CERN and assisted by ALICE.
- Evaluation by full simulation in progress.

- Korean groups are marching aggressively.
  - Sensor production & test
  - Readout (preamps)

- We plan on having FOCAL fully installed and operational by 2012.