Belle calorimeter upgrade

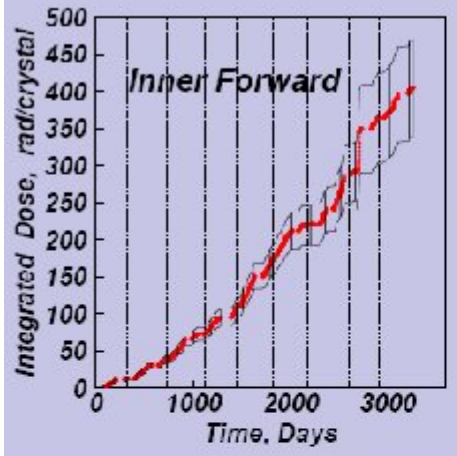
A.Kuzmin

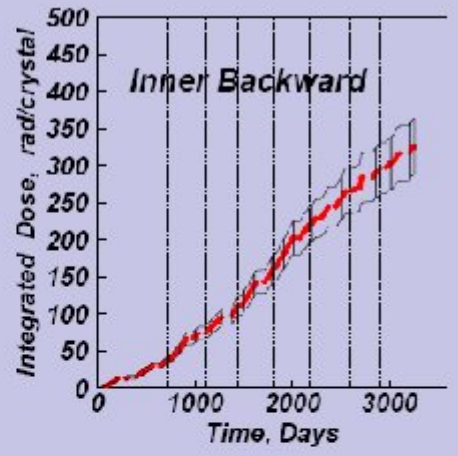
on behalf of sBELLE calorimeter group

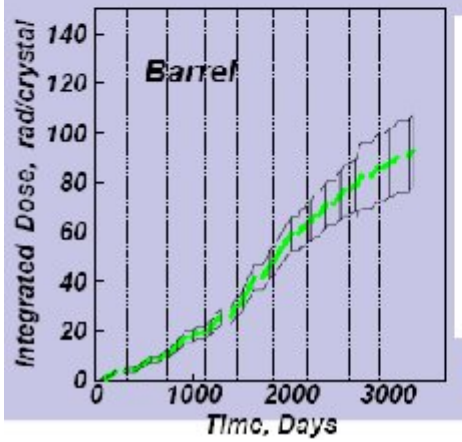
- **Problems with present calorimeter**
- **Baseline solution**
- **Overview of the ECL parallel session**

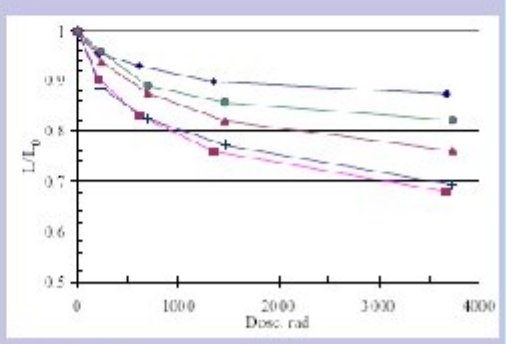
Problems with the present calorimeter

Radiation damages of the crystals



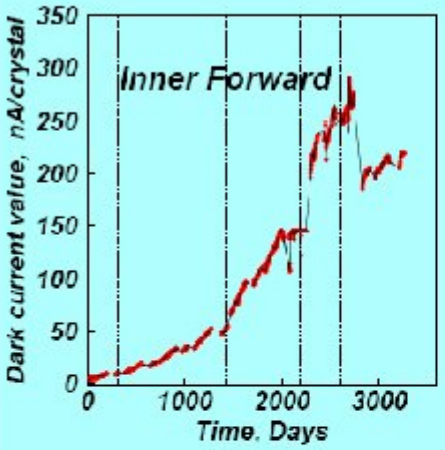


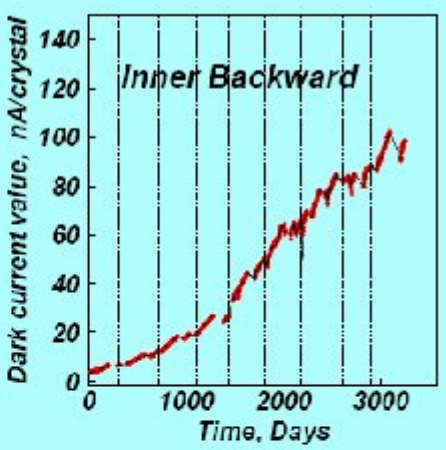


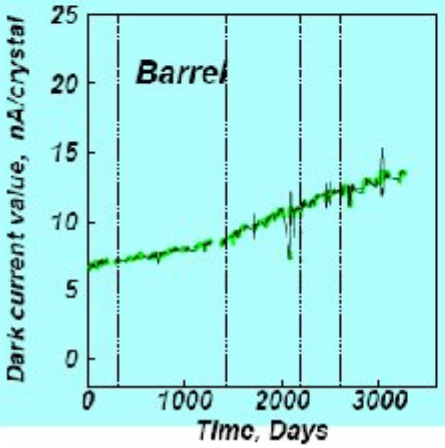


No big problems

Radiation damages of PIN photodiodes







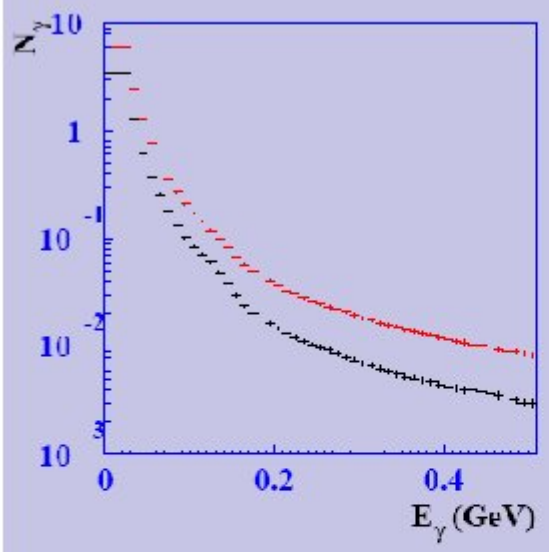
Small increase of the dark current in barrel

Essential increase of the dark current in endcaps

Caused by neutrons flux

Calorimeter performance degradation

Fake clusters

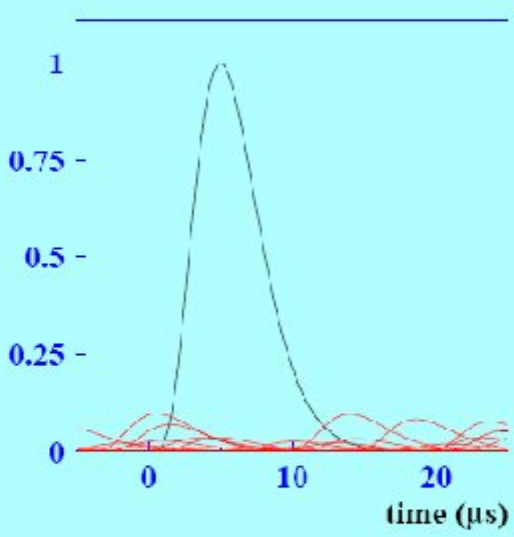


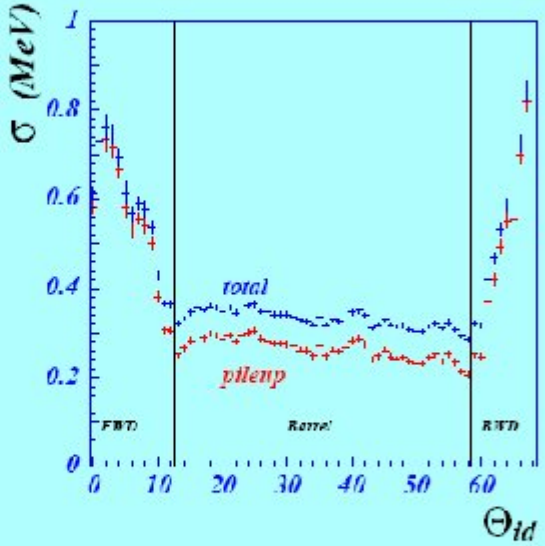
(E>20 MeV) 6 fake clusters, 3 in barrel 3 in endcaps

$\sim$ *background*

Pileup noise

$$\sigma = \overline{E_\gamma}\sqrt{\nu\tau_{eff}} \sim \sqrt{IP}$$

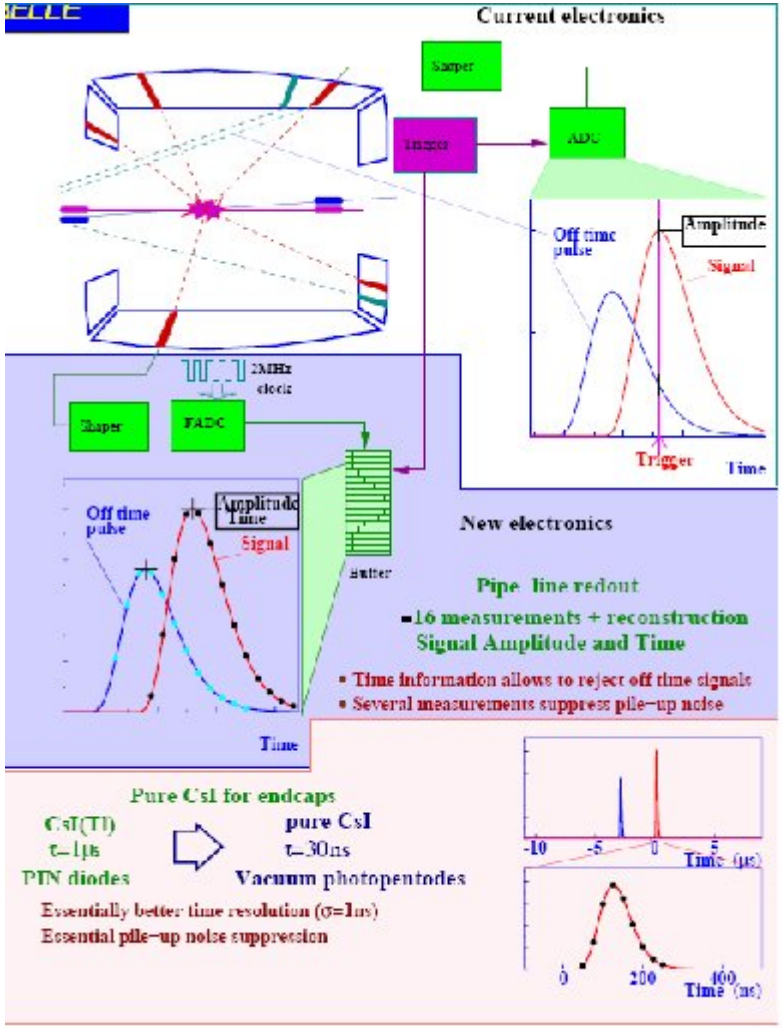




$$\sim \sqrt{background}$$

One of the ways to solve problems of the fake clusters and pileup noise is to reduce decay time of the scintillator and electronics shaping time.

Baseline



- Modify electronics for the barrel.
- Pipe-line readout with waveform analysis:
- Replace the CsI(Tl) by the pure CsI crystals in endcaps.
- 16 points within the signal are fitted by the signal function $F(t)$:

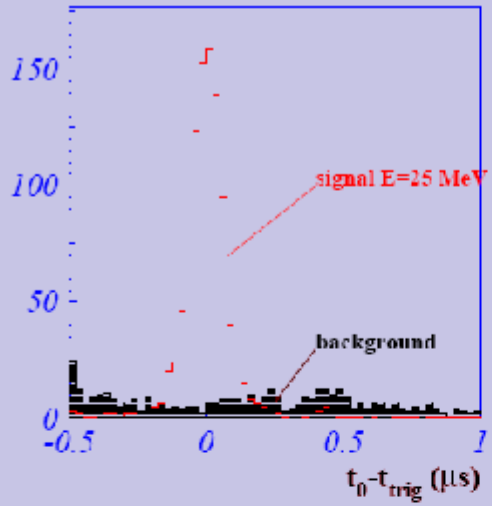
$$F(t) = A\ f(t - t_0)$$

A - amplitude of the signal and
t_0 – time of the signal,

$$\chi^2 = \sum (y_i - A\, f(t_i - t_0))\, S_{ij}^{-1}\, (y_i - A\, f(t_i - t_0))$$

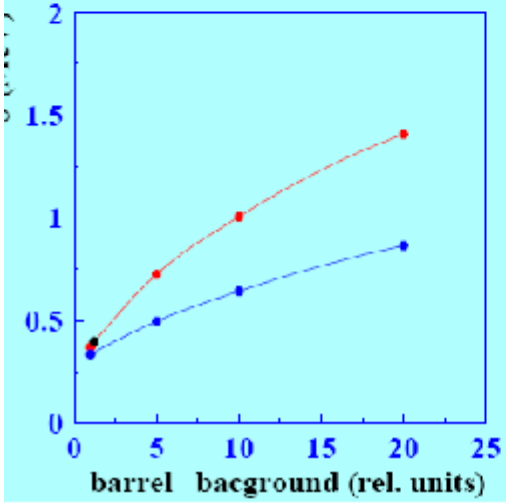
- Both amplitude and time information are reconstructed:

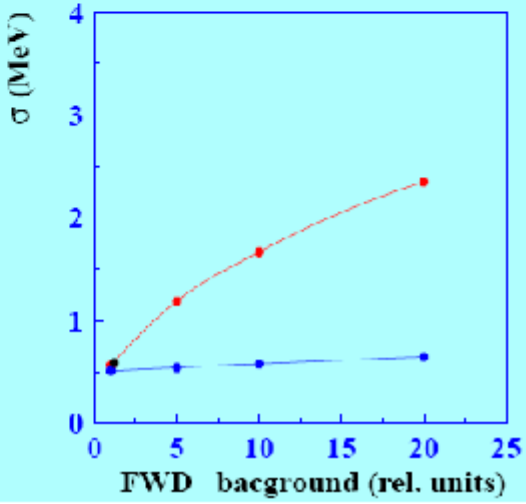
Expected improvement

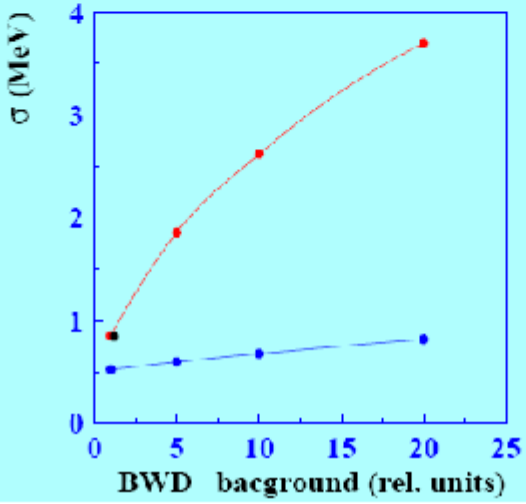


- Time information allows to suppress the fake clusters 7 times for the barrel by rejecting wrong time clusters.
- For endcaps the suppression factor is $7 \times 30 \approx 200$ due to shorter decay time of the pure CsI

- The pileup noise will be reduced factor ~ 1.5 for barrel and factor 5 for endcaps:







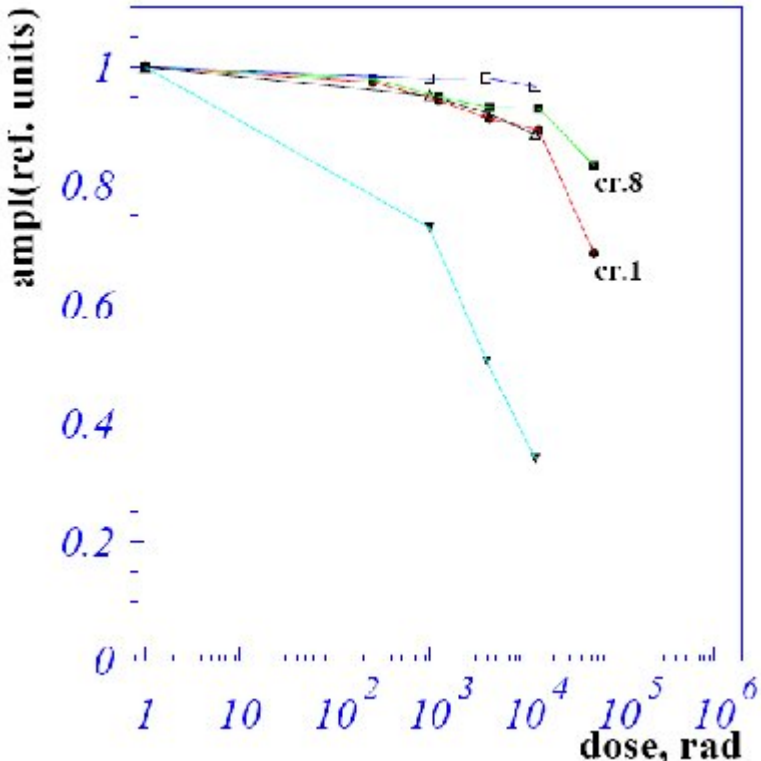
Pure CsI crystals

crystal	ρ, g/cm^3	X_0, cm	λ_{em}, nm	n	N_{ph}/MeV	τ, ns
CsI(Tl)	4.51	1.86	550	1.8	52000	1000
CsI	4.51	1.86	305/400	2	5000	30/1000
BaF_2	4.89	2.03	220/310	1.56	2500/6500	0.6/620
CeF_3	6.16	1.65	310	1.62	600	3
$PbWO_4$	8.28	0.89	430	2.2	25	10
$LuAlO_3$(Ce)	8.34	1.08	365	1.94	20500	18
$Lu_3Al_5O_{12}$(Ce)	7.13	1.37	510	1.8	5600	60
Lu_2SiO_5(Ce)	7.41	1.2	420	1.82	26000	12/40

- **Pure CsI as compromise of good characteristics, price and possibility to produce in time**

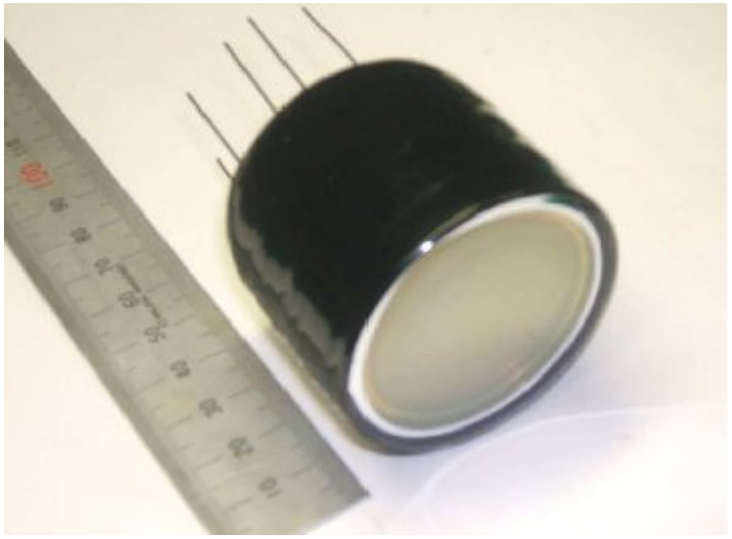
Radiation test with gamma – up to 30 krad:
Lo change less than 10% for 15krad

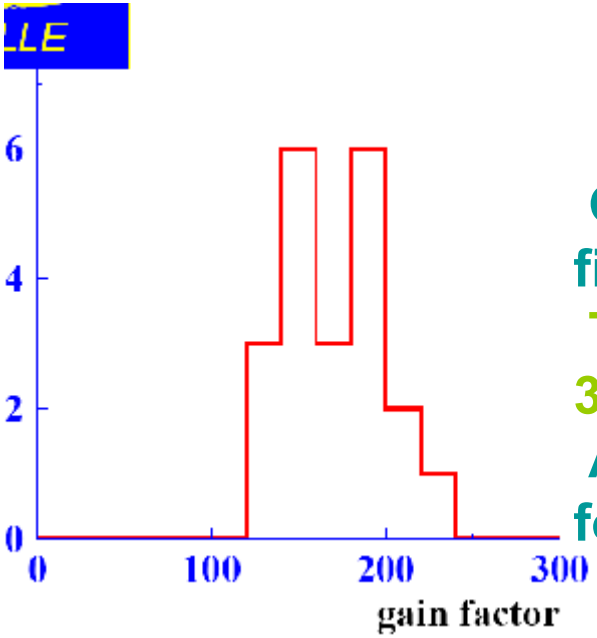
Pure CsI crystals were irradiated by neutrons. Neutron irradiation up to 10^{12}cm^{-2} did not reveal a degradation within 5%



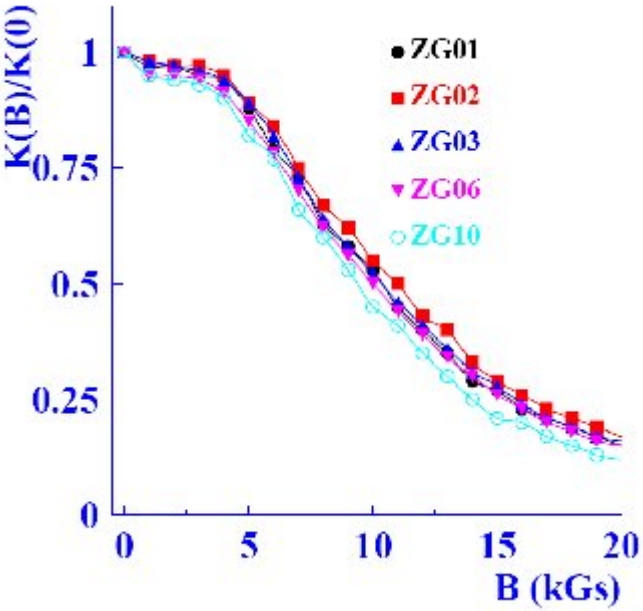
Photodetector

Hamamatsu developed the 2' UV sensitive phototriodes, phototetrodes, photopentods
C 10 pF .
Dependence of gain factor on voltage is close to linear.

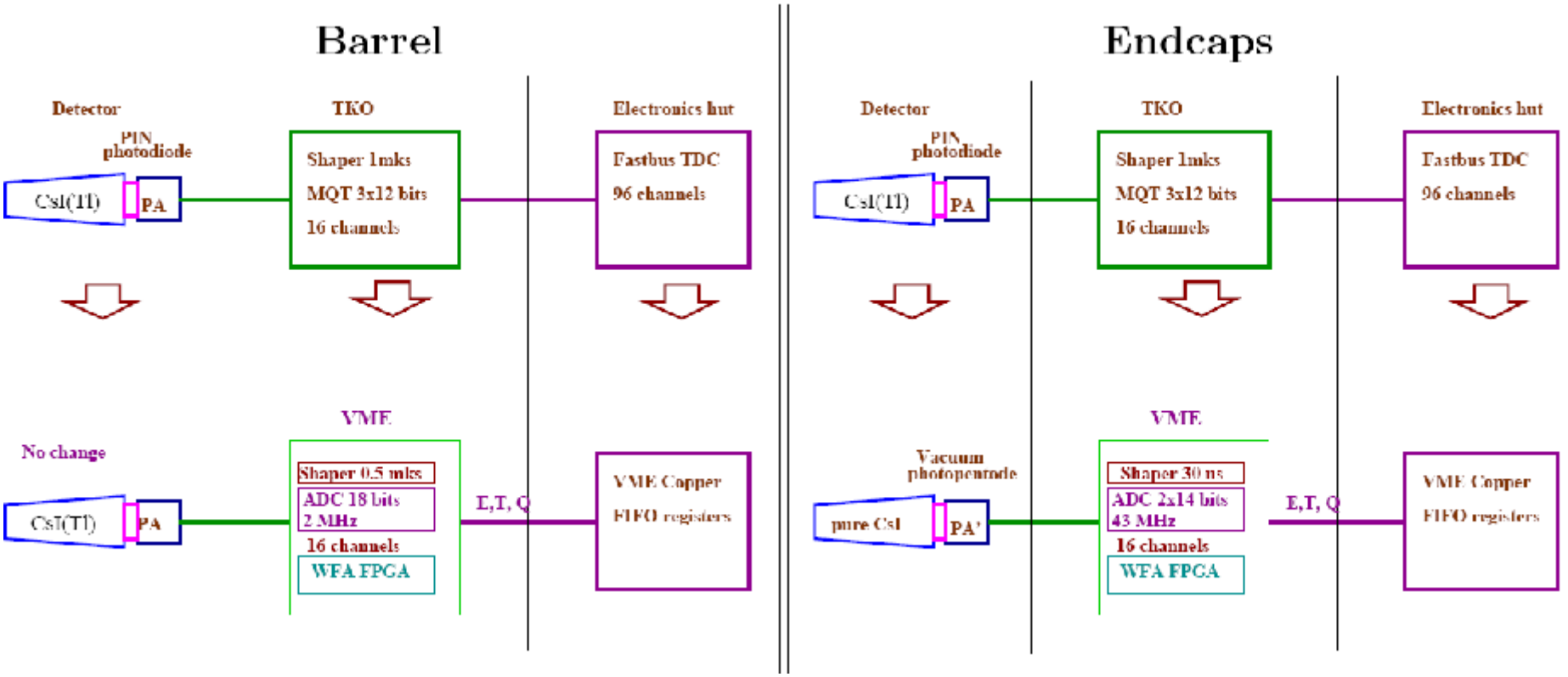




Gain factor without magnetic field is 150-250
The gain factor drops down 3.5 times for B=15 kGs
About 20-30 % improvement for angle 20-45

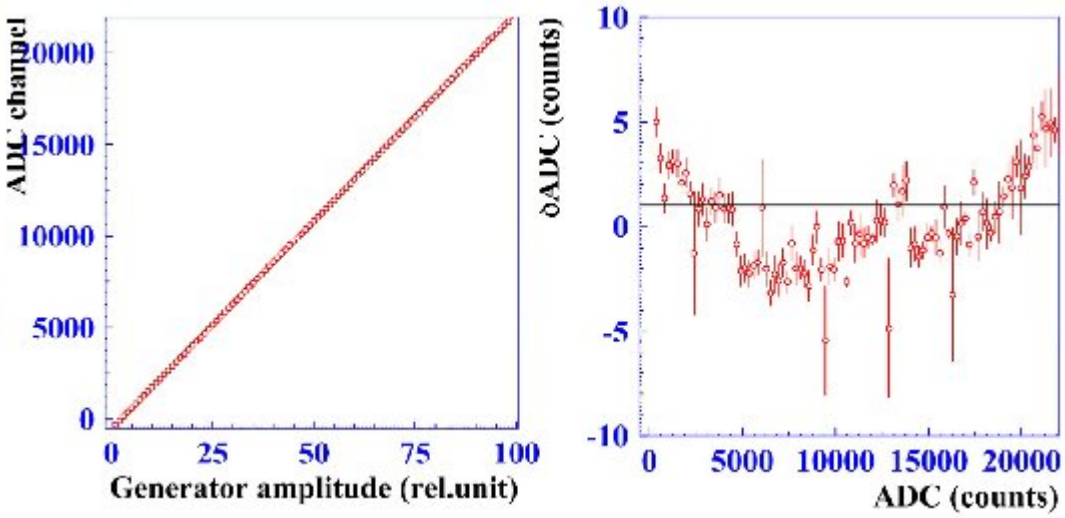


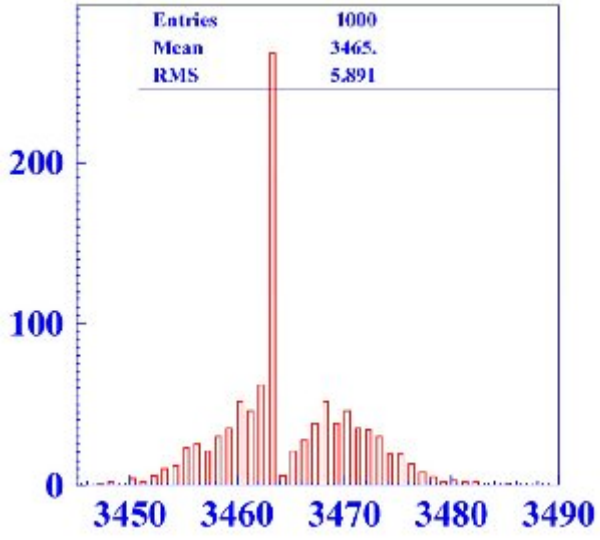
Electronics modication



Vladimir Zhulanov, Yury Usov

Shaper, FADC, WFA and fast trigger sum on board



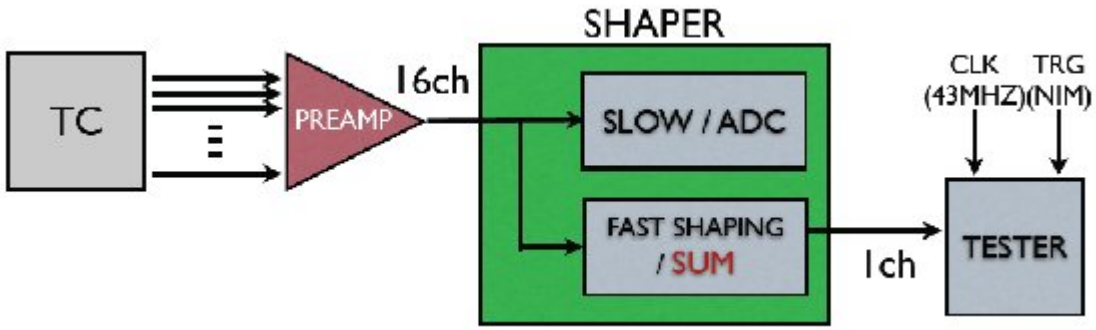


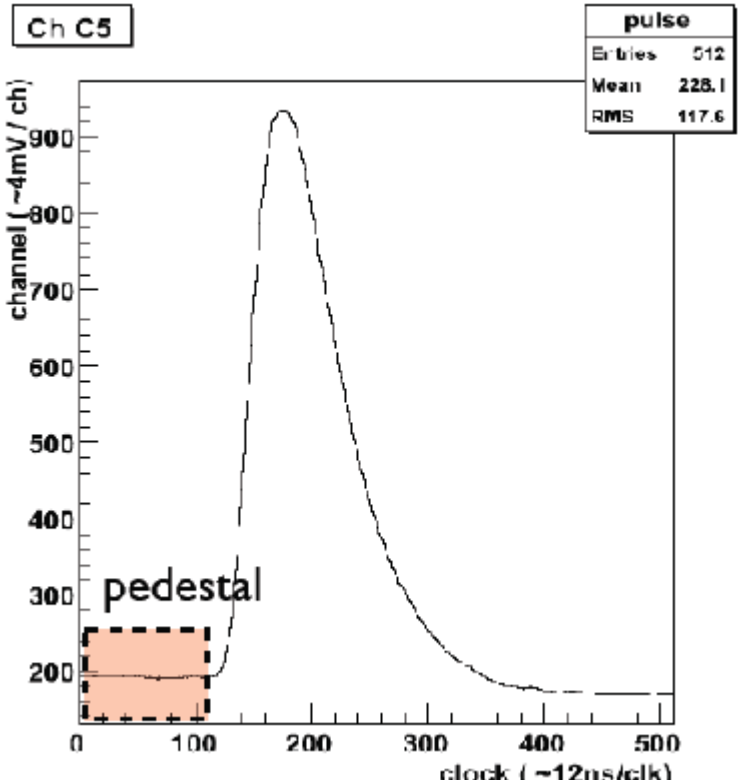
- **Module is being tested**
- **Noise is normal**
- **Linearity is good but dynamical range is limited by power supply**
- **Change +-5V -> 7.5V, 12V ->15V**
- **Diff nonlinearity due to ADC layout (or ADC problem?)**
- **Change tantalum capacitors to ceramic**

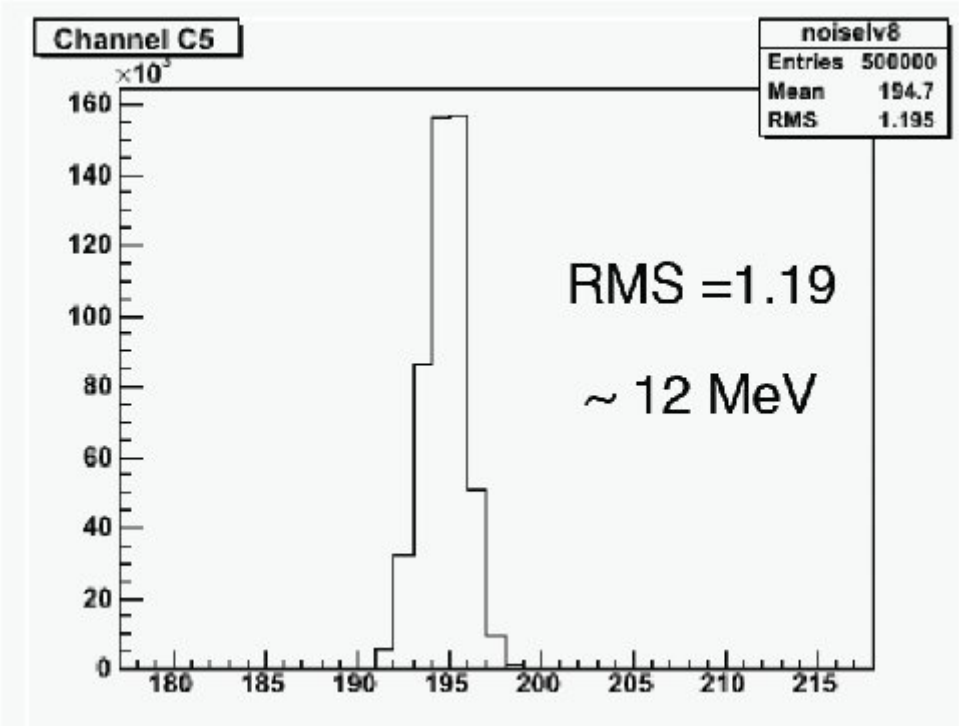
S. Ryu (SNU)

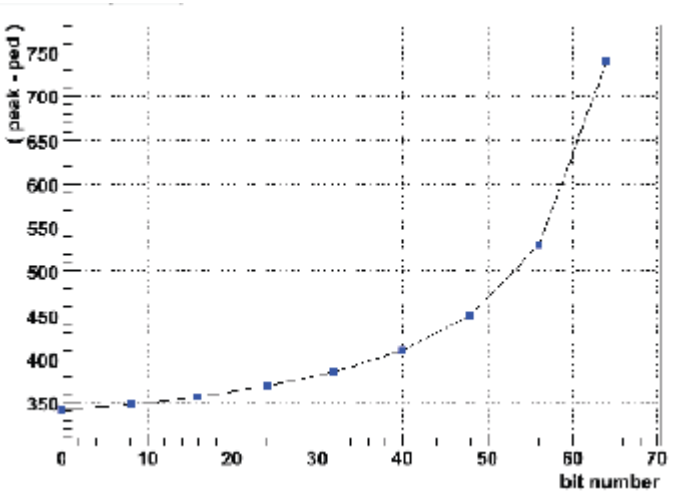
ECL Trigger status

Test bench for the trigger sum measurement was prepared









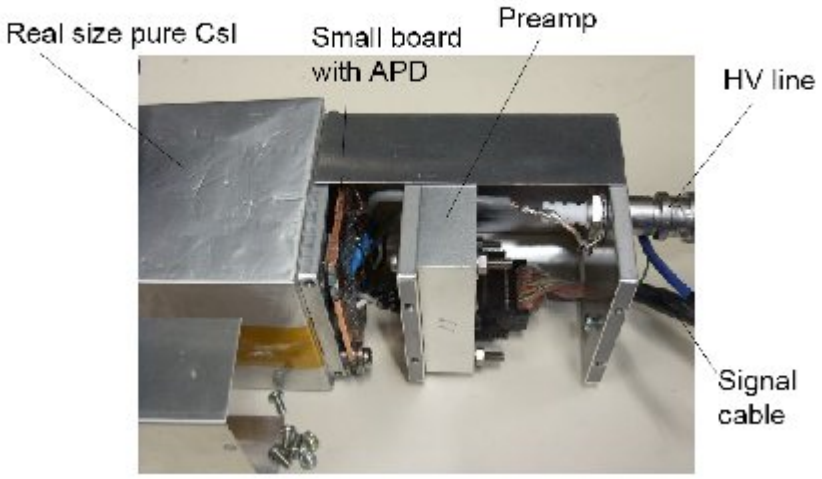
Gain Test for Shaper6 bits are reserved for the gainadjustment

Kenkichi Miyabayashi
for Tamaki Hirai / Tomoko Iwashita

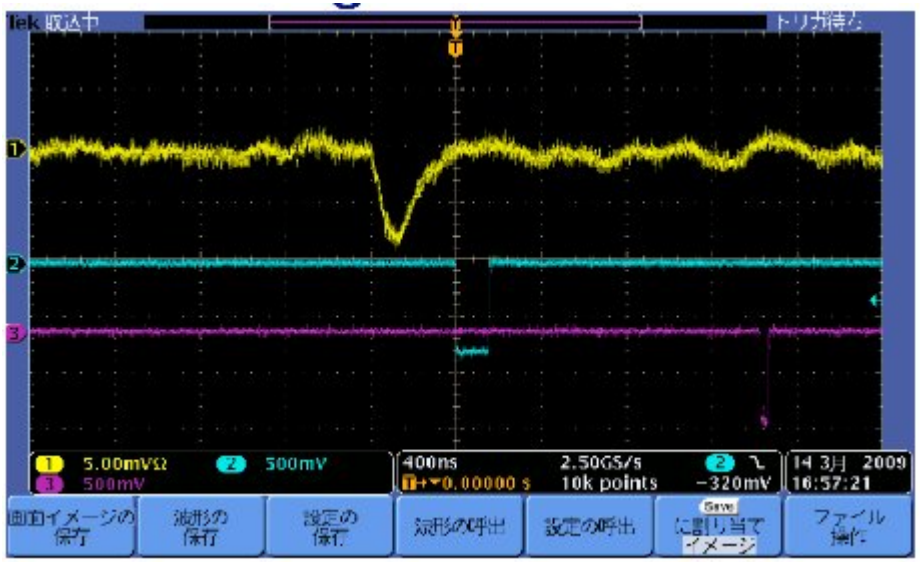
Recent R&D at Nara

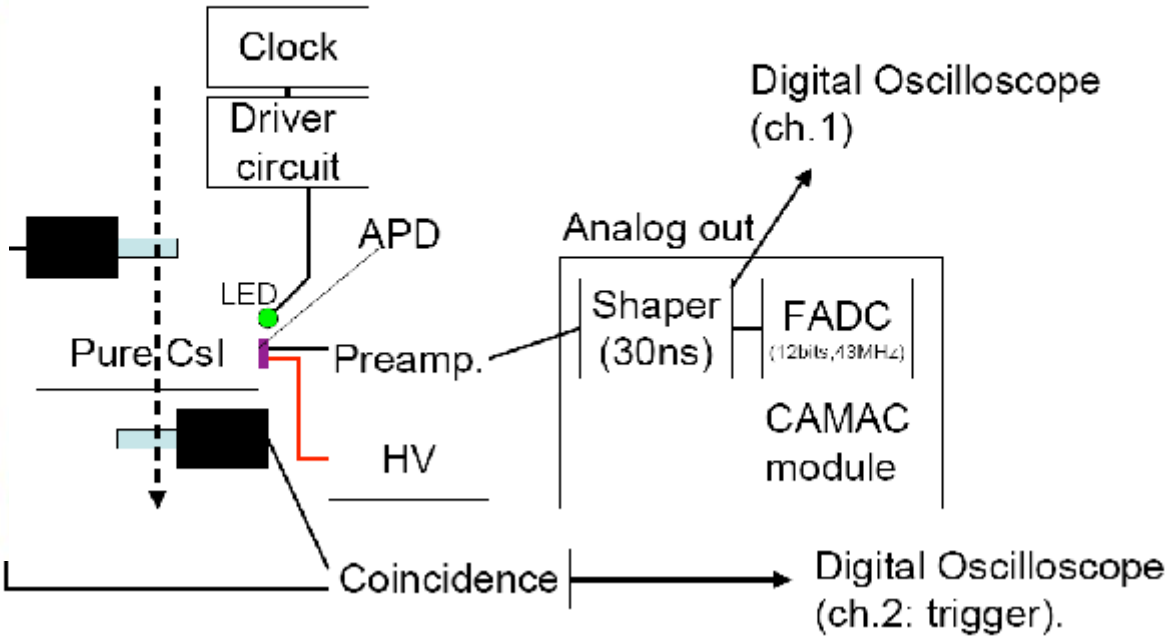
- S8664 series APD readout option
  – Attaching to PureCsI, cosmic signal seen.
  – Comments on 241Am(60keV X-ray) usage.
- Plans of Pr:LuAG
  – As soon as new ceramic sample gotten, radiation hardness will be tested.

Counter preparation



Test by attaching with PureCsI

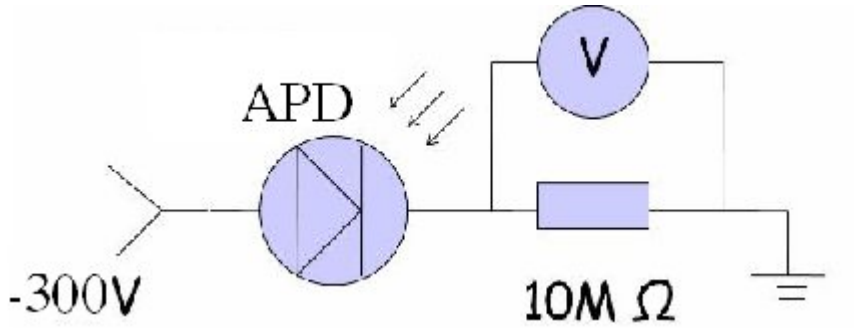




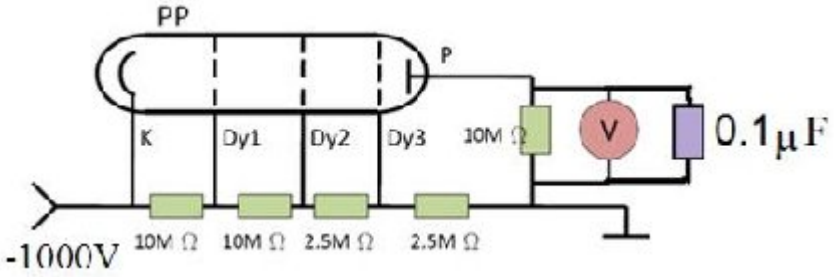
P.P. & APD gain ratio report—4 month testing

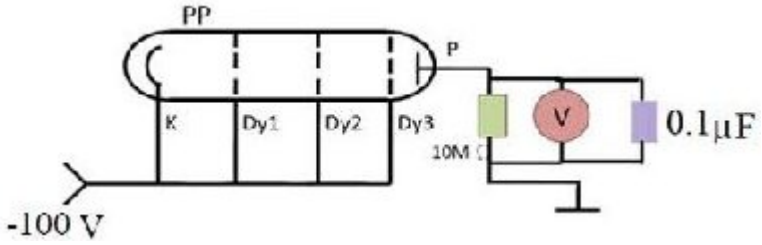
- Ken Chiang, J.Y. Lin, Jeri Chang

Test bench to test long term stability of PP and APD was prepared

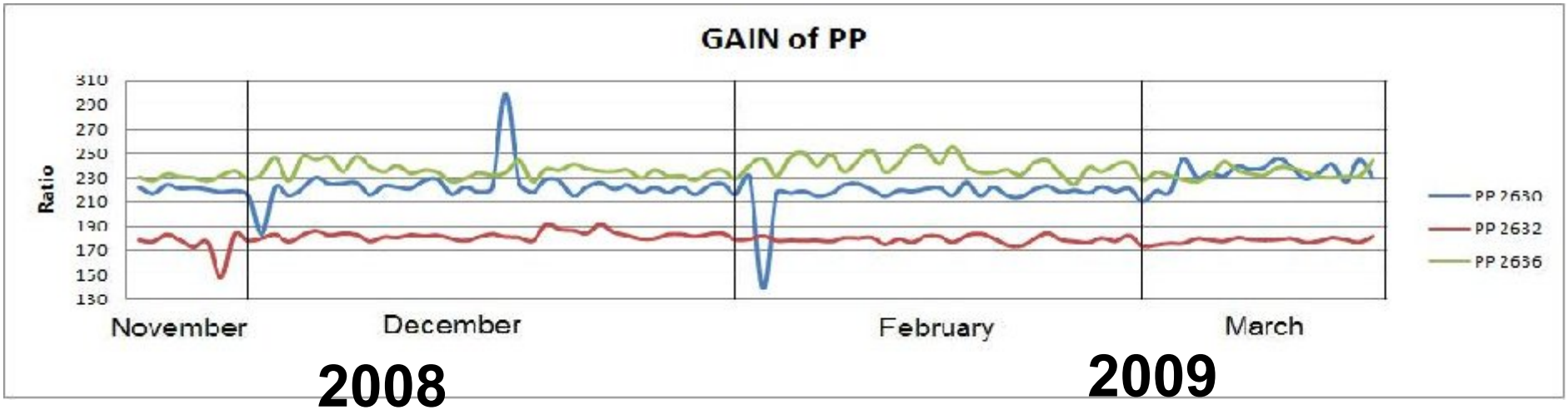


Both QE and gain factor can be measured

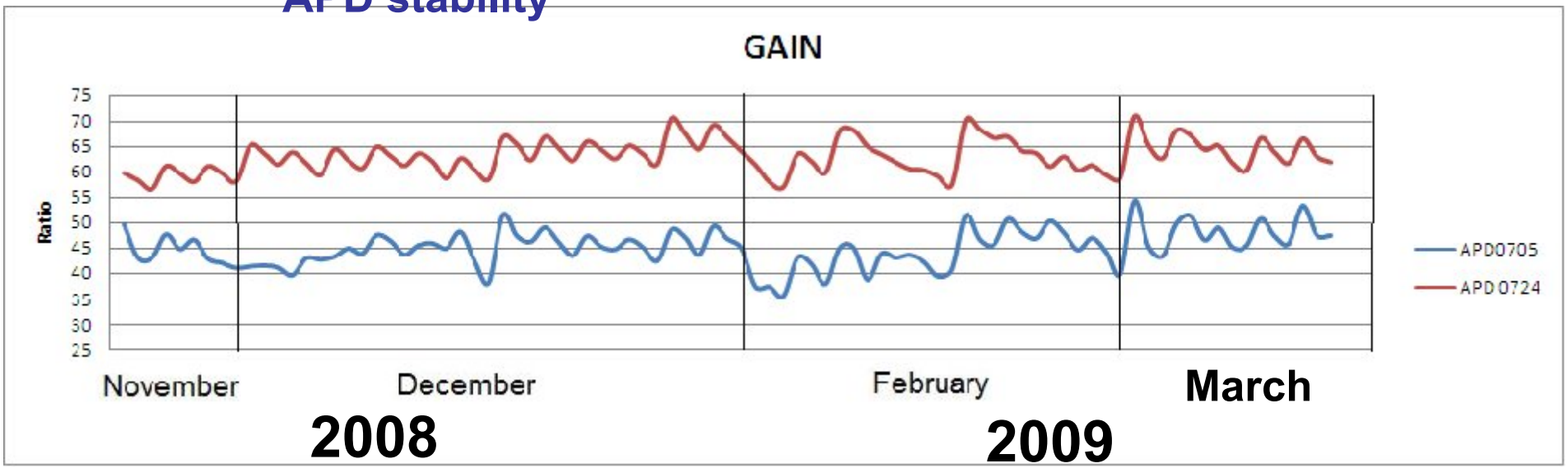




PP gain factor stability



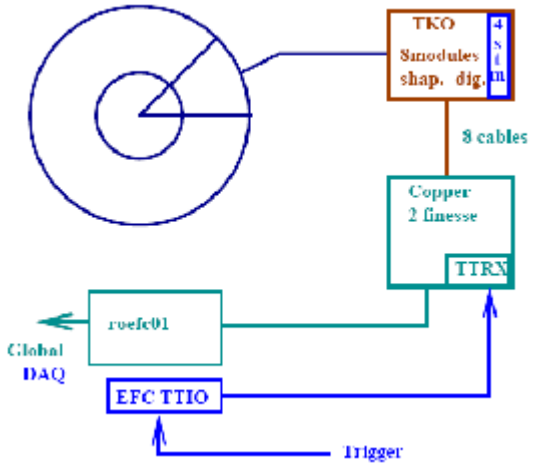
APD stability



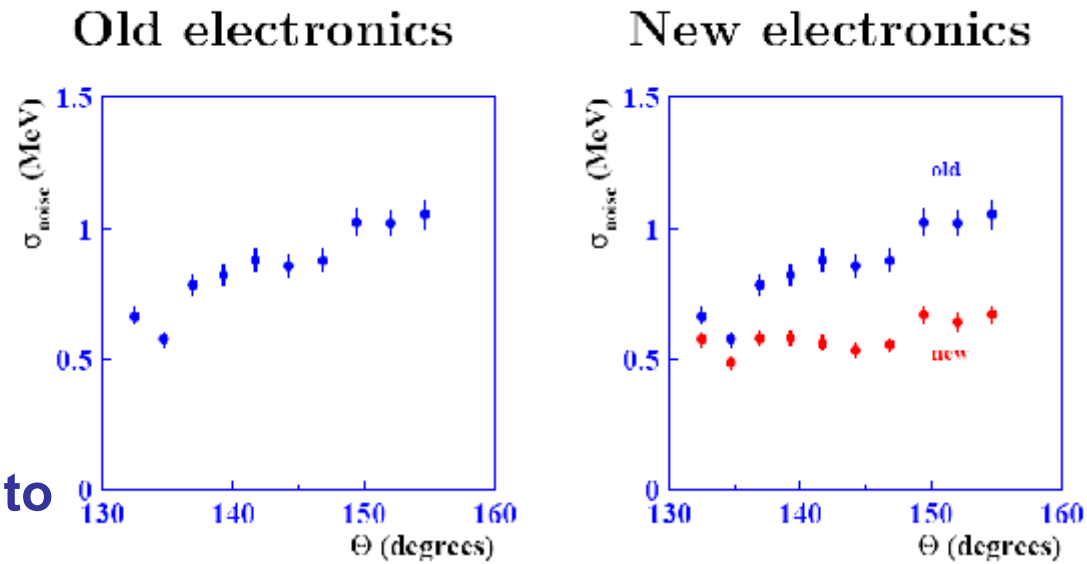
More study with photodetector illumination will be carryout

V.Shebalin/A.Kuzmin

Calibration/processing of data with new electronics



With beam



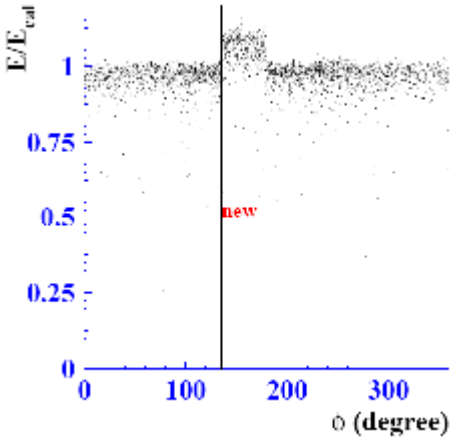
Nakamura san have prepared software to process data with new electronics.

The data from new electronics are unpacked from EFC to
rawecl chits (cid, dspamp,dsptime, dspag(2bits)
rawecl cwaveform (cid, wf(40))

The reconstruction code was modied and data from new electronics are reconstructed to data ECL table. Than the standard procedure of ECL reconstruction is performed.

Bhabha data with new electronics have been processe and saved to disk.

New electronics allows to suppress pile-up noise



Calibration is in progress

B.G. Cheon (Hanyang), H.J.Kim (KNU), E. Won (KU),
S.S. Myoung S.K. Kim(SNU), Y.J. Kwon (Yonsei)

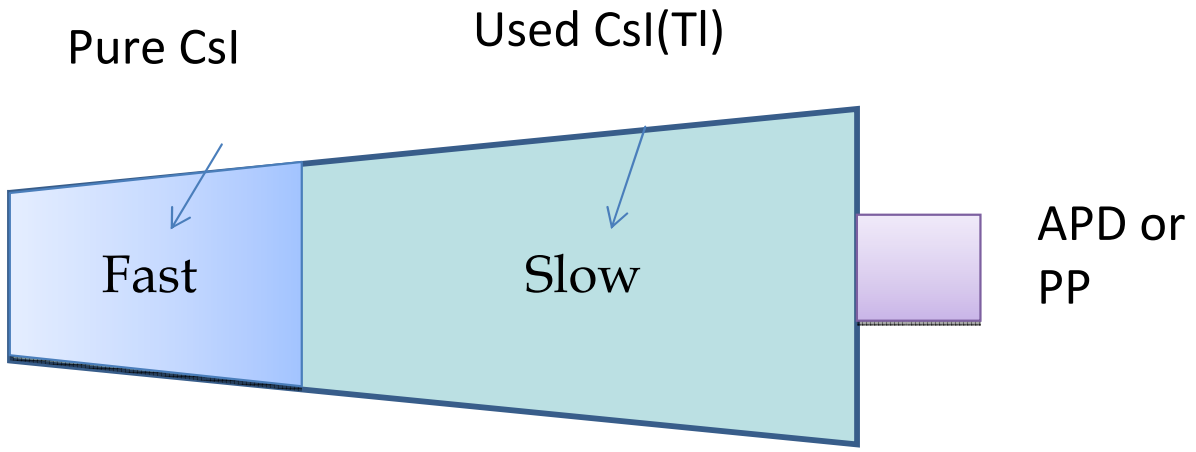
SNU

Review of possibility to usage of different crystals

Other possibility for uppgrade

- LSO : expensive but others look fine
- BSO : decay time 100ns, no mass production
- PbWO4 : operation at -25 oC is desired as feasible alternative options

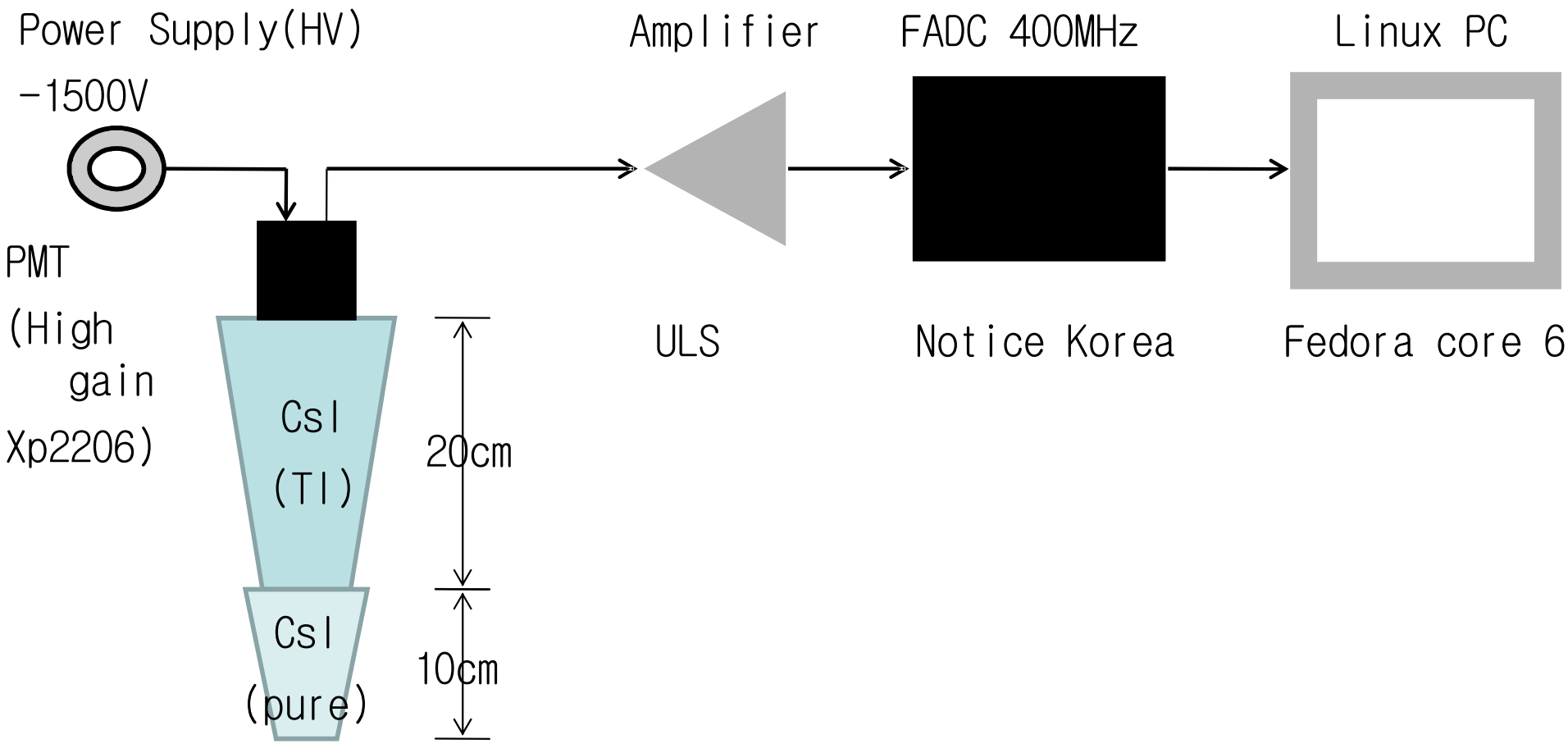
An alternative idea



Logic (and probably advantages)

1.Radiation damage only to front ~10 cm of crystals → need to be checked
2.High energy signals → enough signal in CsI(Tl) crystals ->do not lose resolution
3.Fast/Slow → another handle for shower correction by knowing shower shape
4.Fast trigger signal using fast signal → blind to beam background
5.Much cheaper

R&D started


Power Supply(HV)
-1500V
Amplifier
FADC 400MHz
Linux PC
PMT
(High
gain
Xp2206)
CsI
(Tl)
20cm
CsI
(pure)
10cm
ULS
Notice Korea
Fedora core 6

Summary

- To keep good performance of the calorimeter at high background conditions we need to upgrade the electronics for the barrel and to replace both crystals and electronics in the endcaps .
- Pure CsI with pentode readout shows good performance and is baseline option.
- The work for barrel electronics upgrade is in progress. New version of the electronics has been developed and being tested.
- Trigger modules are developed. Test of the fast shaper trigger output have been performed
- Long term performance of the photodetectors have been started
- R&D works at NWU and in Korea are going on to search for alternative scintilator and phototodetectors.
- Works with the data recorded with new electronics are being continuing. The software for cluster reconstruction has been prepared.
- We need in a decision and budget to start the crystal and electronics production.