Electromagnetic calorimeter summary

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for Belle-II Calorimeter group

2009 July 9th

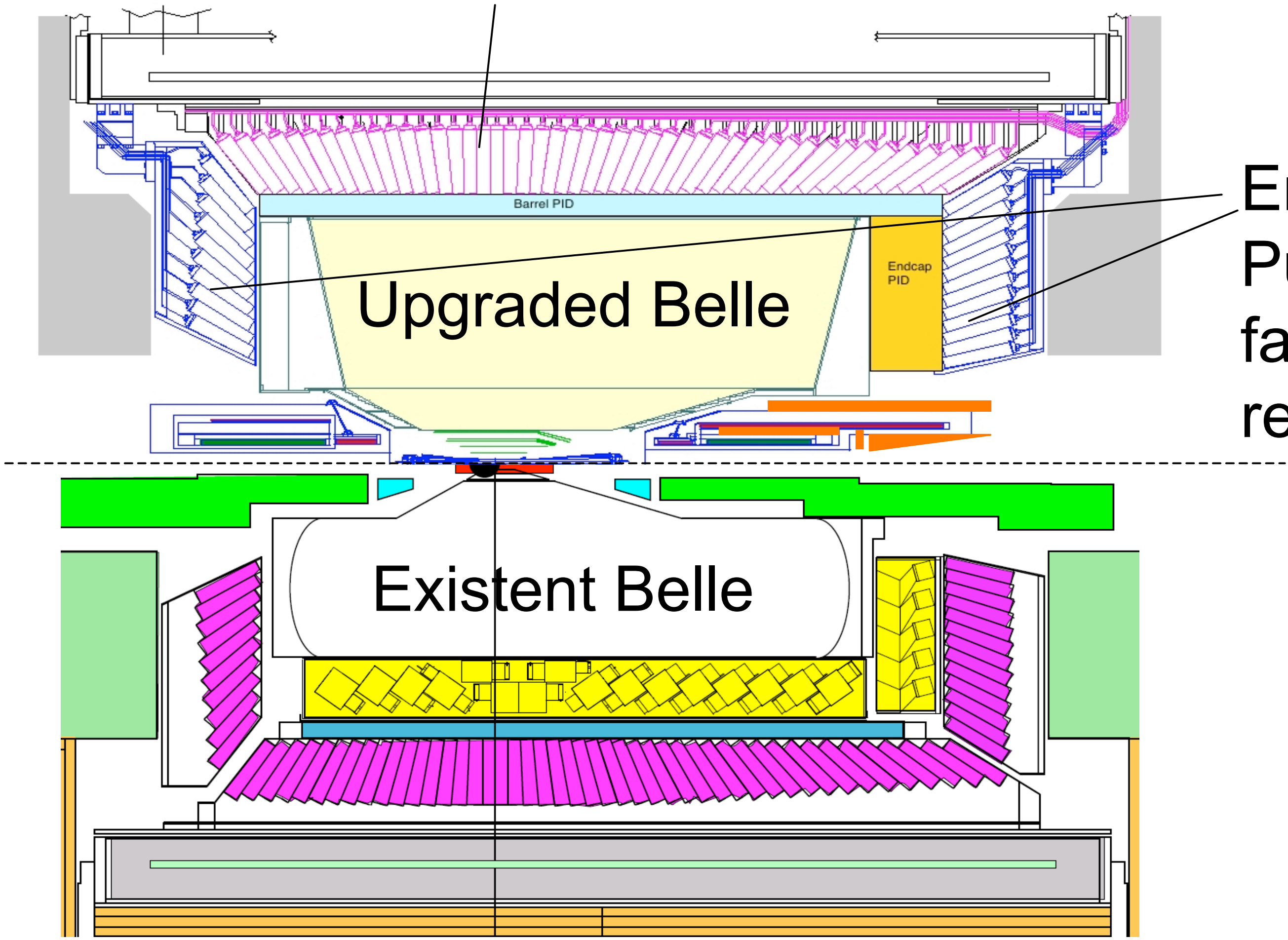
Belle-II meeting

Outline

- Baseline design and other options.
- Requirements on hardware.
- Reported studies of baseline and other options.
  - Electronics
  - PureCsI + PhotoPentrode(PP) readout.
  - PureCsI + APD readout.
  - Phoswitch(PureCsI-CsI(T*l*) combined)
  - BSO scintillating crystal
  - PWO(-II) scintillating crystal
- Toward technology decision.
  - Guiding principle, criteria and timeline.
- Plot construction schedule

Baseline design

Barrel; keep CsI(T*l*),
2MHz waveform sample readout.



Endcaps;
PureCsI+PhotoPentrode,
faster waveform sample
readout.

Requirement of hardware

To discuss about options for endcaps

- Equivalent noise energy/channel
  - ~0.6MeV(pile up by beam background) or less.

- Radiation hardness
  - Up to ~10^5 rad for γ/electrons
  - Up to 10^{11}~10^{12} neutrons/cm^2

- And, of course stable operation, feasible to do mass production with acceptable cost.

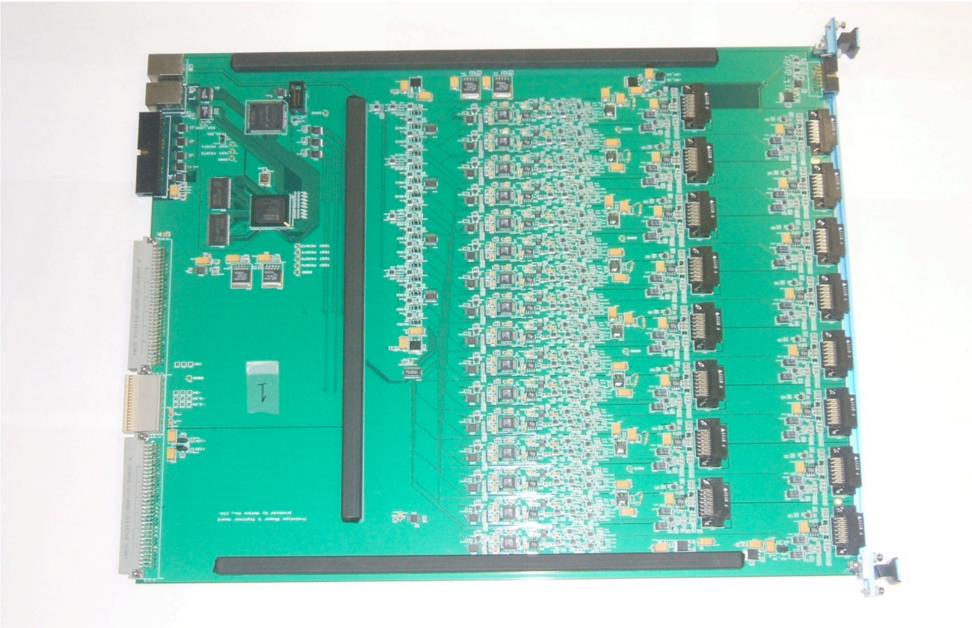
Considered options

	PureCsI+PP	PureCsI+APD	BSO	PWO(-II)
Pro	λ=330nm,ρ=4.8g/cm^3 X_0=1.85cm,R_M=3.5cm •Low noise(0.2MeV) •Well tested. •Established mass production technology.	← ← •Mag. field free. •Redundancy(2pcs) •No need to modify container.	λ=480nm, ρ=6.8g/cm^3 X_0=1.15cm, R_M=2.4cm •Better 2 shower separation •Match all photo-sensors •Same scintillation as PureCsI Mass production technology established.	λ=420nm, ρ=8.3g/cm^3 X_0=0.9cm, R_M=2.0cm ←
Worry or con	•PP long-term stability	•Noise by larger device capacitance. •Q.E. down to ~40%.	•Check mechanical strength of container. •How to assemble as a counter	← ← •Small L.O. •-25deg.C cooling •Discon. of prod.? •Huge # of elec. ch.

Phoswitch option still technically difficult, mentioned later.

Electronics

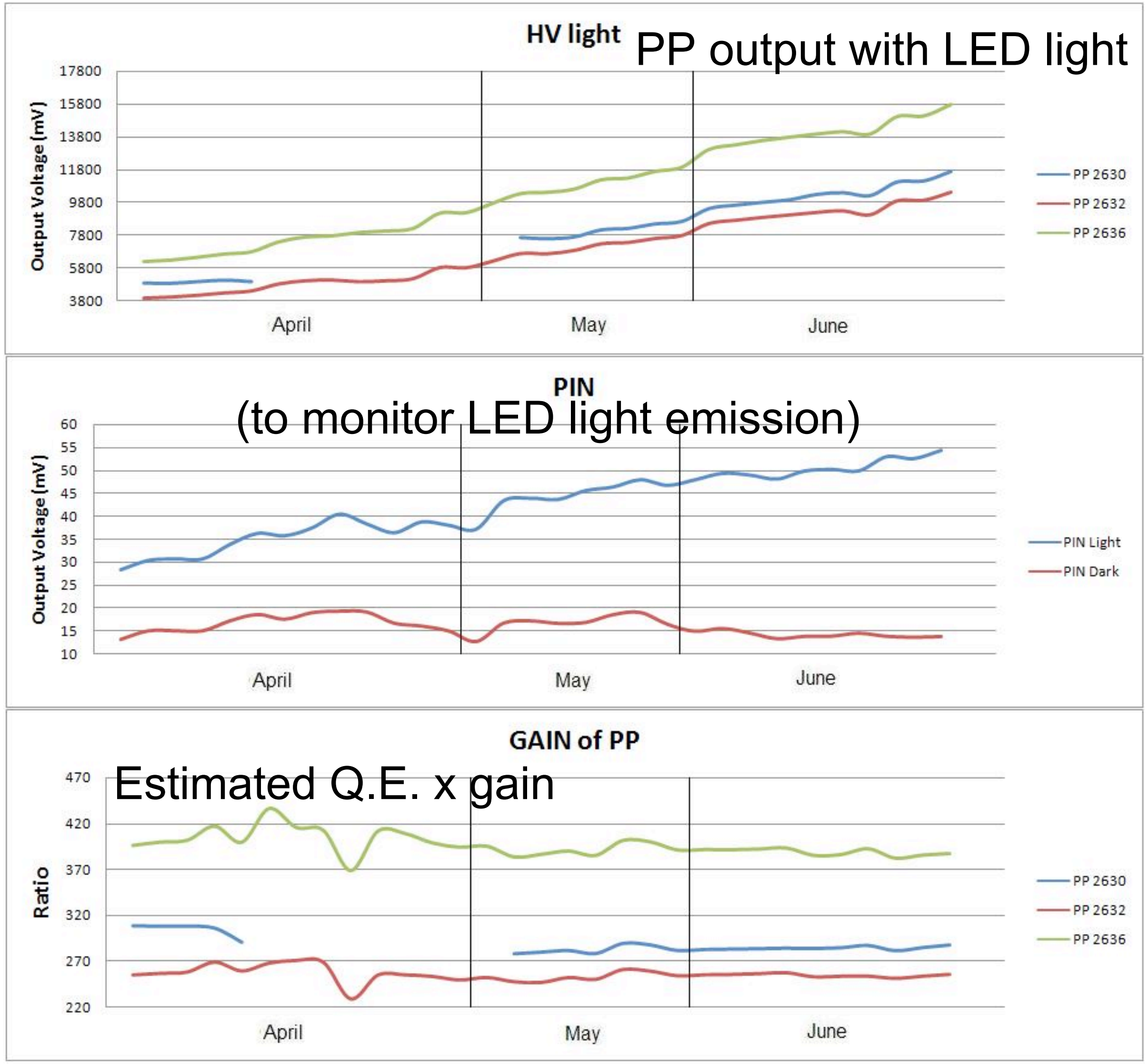
by V.Zhukanov/Yu.Usov



Barrel;
Shaper+DSP board;
Linearity, dynamic range are OK.
Noise/ADC problem to be solved in ver.2.
COLLECTOR ver.1 prototype to be purchased.
FINNESE card to be in our hand.

Endcaps;
Preamplifier design by August, then prototype production.
Shaper designed by Oct., then prototype production.

PhotoPentrode test



by Jeri Chang
Taiwan colleagues join.

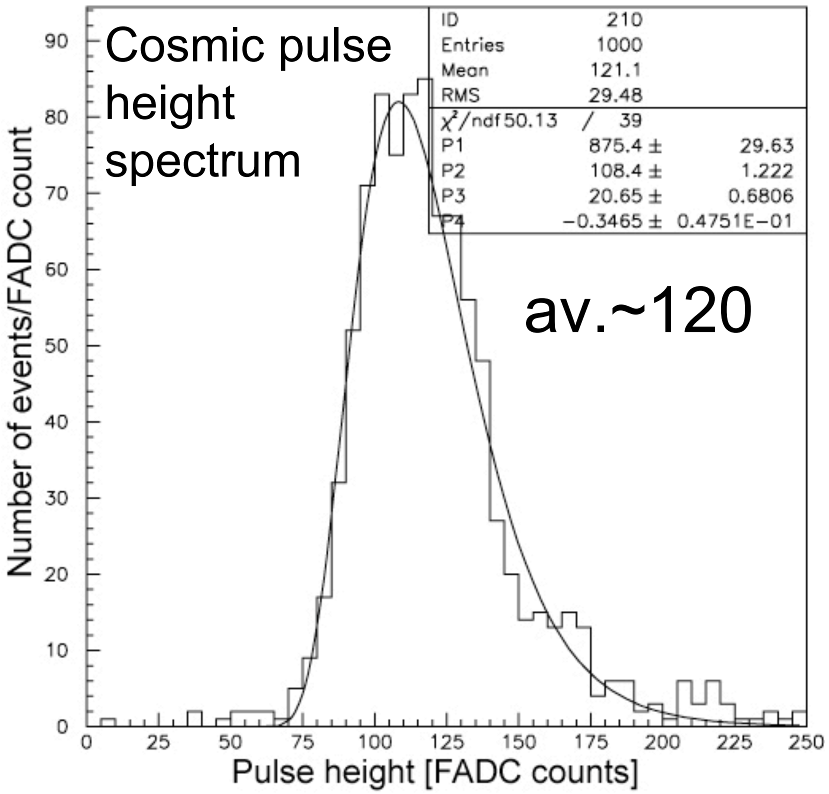
After illuminated by LED corresponding to integrated light amount of 3 years Belle-II operation, still properly working.

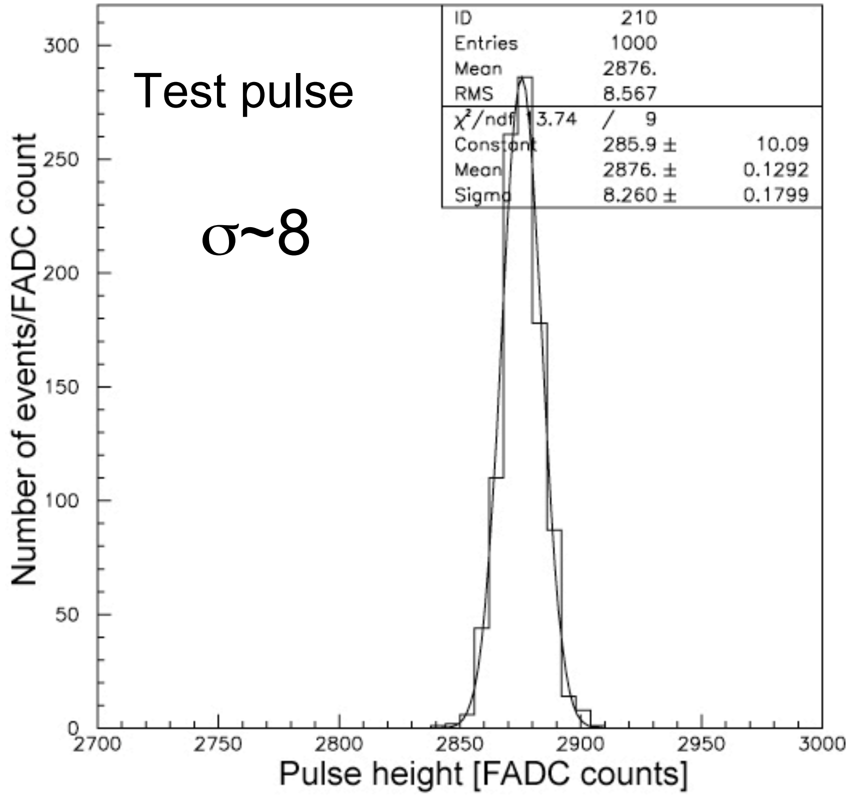
Further test(equiv. to x20 b.g., 10 years operation, with magnetic field) is planned, answer to be given by end of Sept.

PureCsI+APD cosmic test

by N.Maeda

1cm^2 APD; Endcap mechanical str. kept as it is,
Can put 2 pieces/crystal=redundancy, No effect of magnetic field.



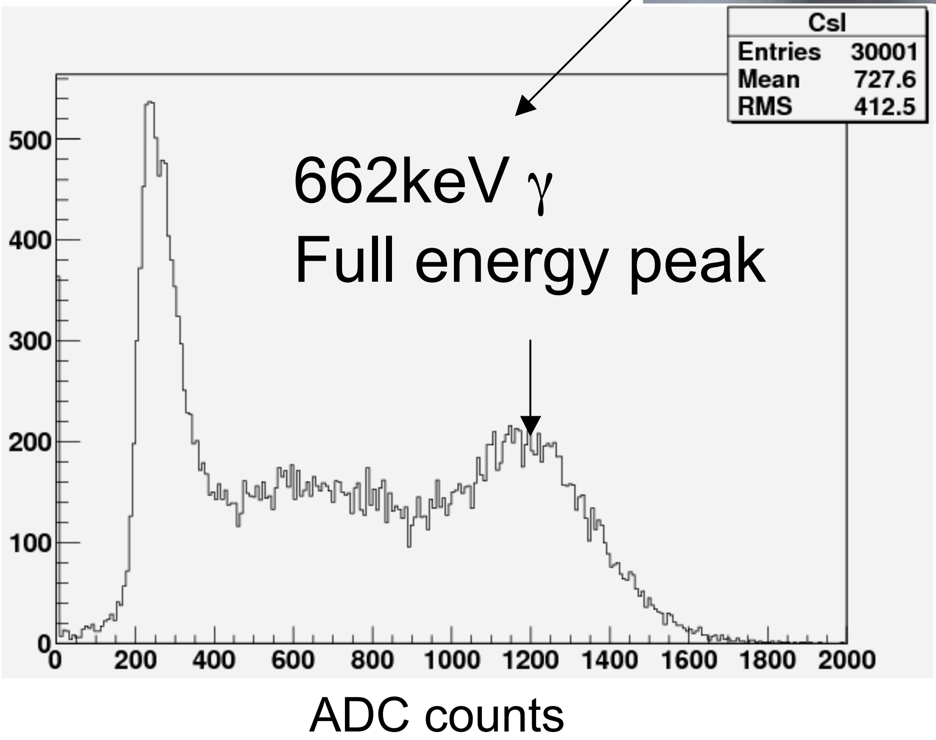


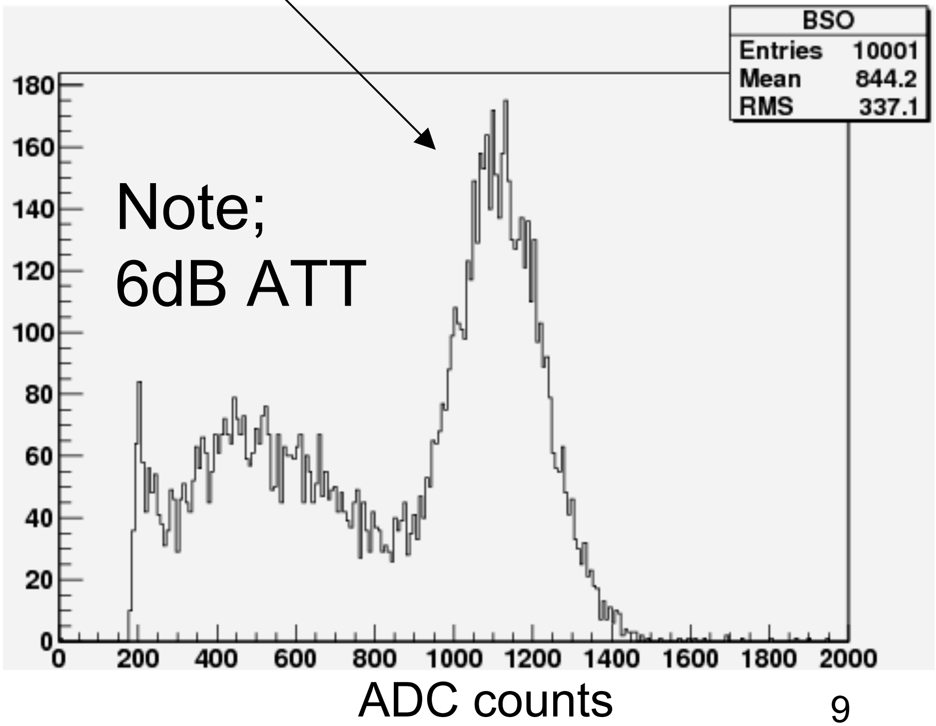
Equivalent nose energy=30MeV x 8/120 = 2MeV in
1 APD/crystal case(too high…)

BSO ~double effective L.O.

by T.Iwashita

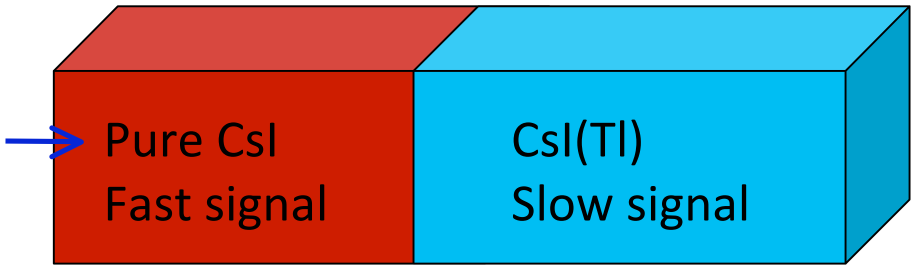
Test with PMT(borosilicate window, bi-alkali).
Thanks to longer wavelength(~480nm)

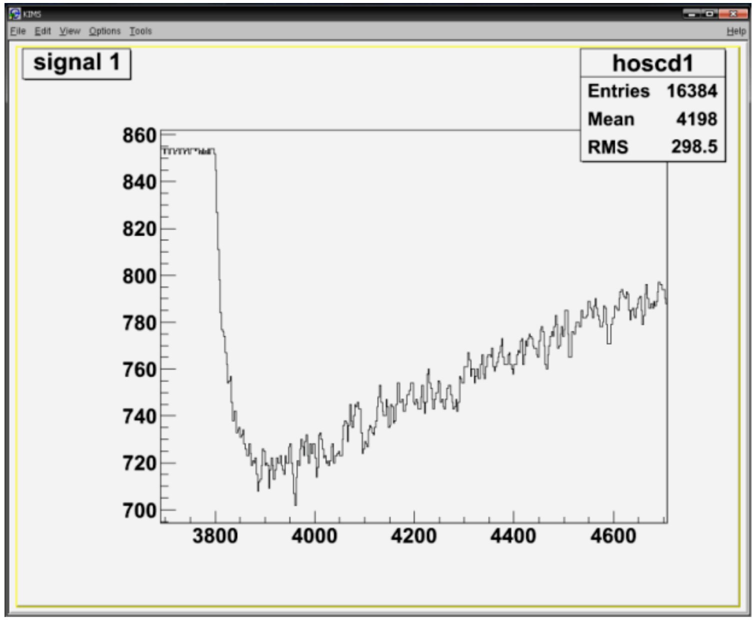




Phoswitch option

by B.G.Cheon, S.K.Kim, et al.





•Low energy beam background stops front fast scintillator.
•Fast and slow components are summed to get total energy deposit in the counter

•PureCsI fast signal component not clearly seen when combined with CsI(Tl).
•Thought to be due to absorption and reemission in CsI(Tl).

… turned out to be difficult.

Toward final technology choice

- Guiding principle;
  - Avoid unnecessary delay of baseline option.
  - Decision to be made slightly before next Belle-II meeting.
    - Set up of PureCsI mass production takes ~half year at Kharkiv.

- Criteria and timeline;
  - Other options have to answer for homework by that time.
  - Otherwise stick to baseline option, PureCsI+PP.

Homework for other options

For items listed below, no reference study exists.

Common for both BSO and PWO(-II) cases;

- Simulation studies to see performance improvement.
- Confirm strength of the Mechanical supporting structure.
- Design to assemble as a counter to match our container.

PWO(-II) case, in addition;

- Make clear mass production prospect.
- Concrete cost estimation including electronics.

Barrel electronics cost

Item	Number	Oku-Yen
VME crates	36+2	0.3
Saper+DSP modules	432+28	1.6
Collector modules	36+4	0.2
FAM(Trigger) modules	36+4	0.1
Crate in Elec. Hut	1	0.1
COPPER boards	9	0.1
Total		2.4

PureCsI+PP cost estimation

Item	Cost/unit	number	OkuYen
Crystal	~0.4MYen	2112	8
PP	80kYen	2112	1.7
Preamp	10kYen	2112	0.2
Elec.			0.9
Mech. Str.			0.5
Test bench			0.1
Assemble			0.3
Total			11.7

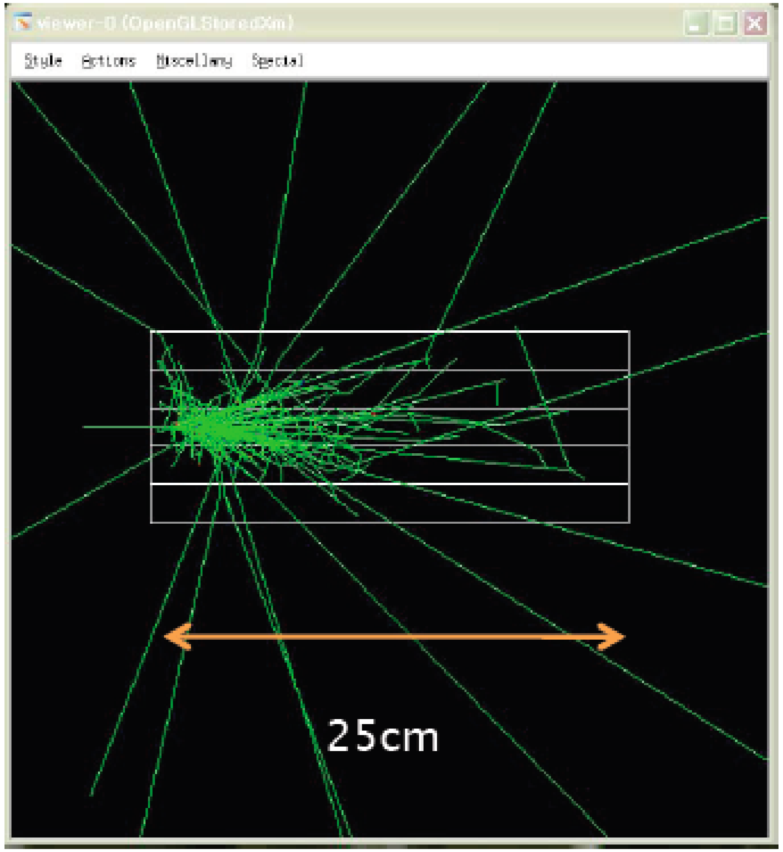
BSO option cost estimation

Item	Cost/unit	number	OkuYen
Crystal	*0.35MYen	~3000	**10
APD	56kYen	~3000	**1.7
Preamp	~10kYen	~3000	**0.30
Elec.			***1.3
Mech. Str.			***0.5
Test bench			***0.1
Assemble			***0.3
Total			14.2

- * may down to 0.30MYen.
- ** depends on crystal final geometry.
- *** taken or scaled from PureCsI+PP option.

As for PWO(-II) option

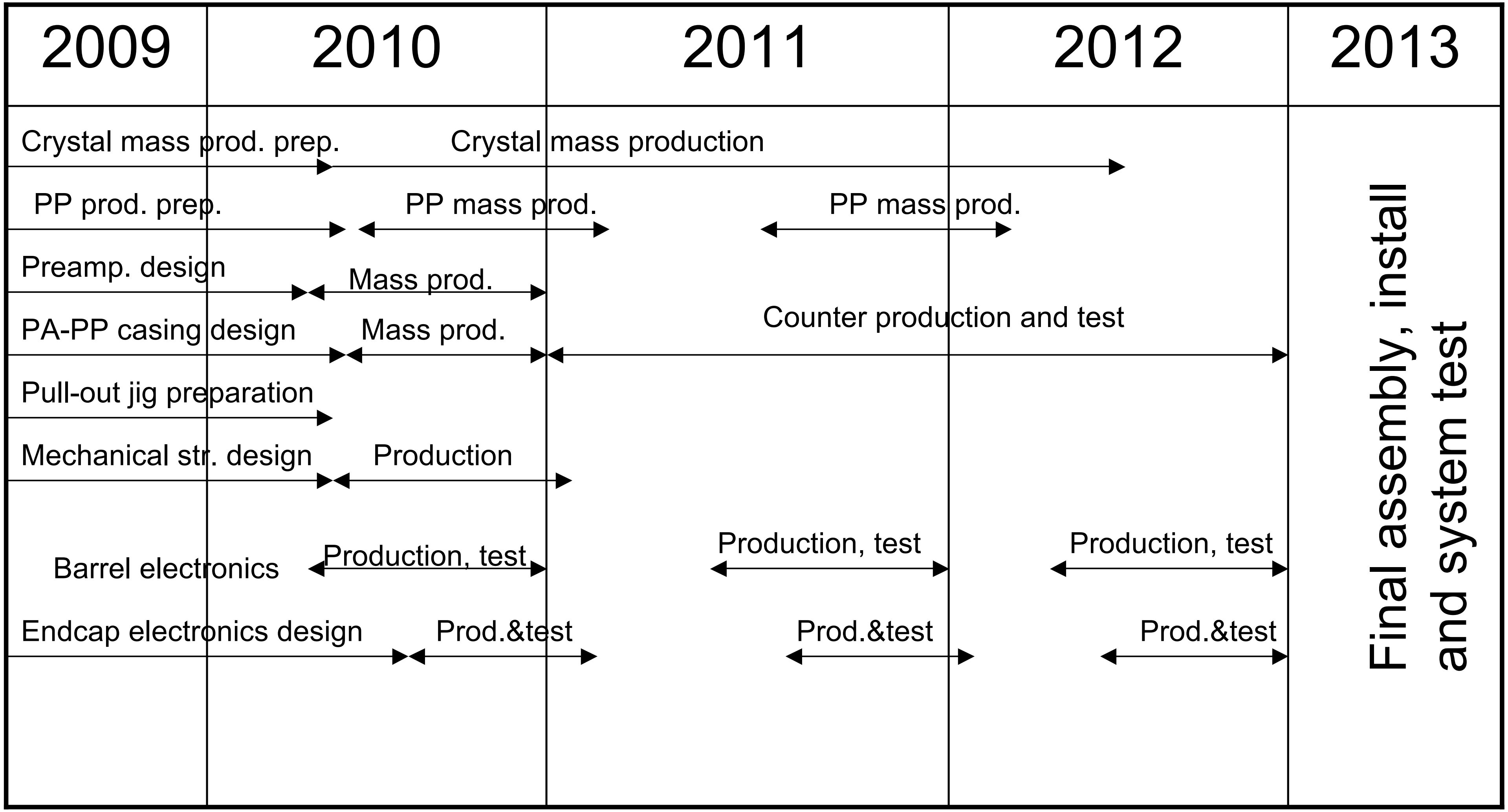
by Eunil Won and Korean group



Geant4 simul. event; 1GeV γ.

- Production facility in BPTP co. planned to be shutdown.
- Continuation asked by our collaboration for R&D, but situation unclear.
- To have adequate light output, -25deg.C cooling is needed.
- If $2x2x20cm^3$ crystals, huge increase of elec. ch.

Plot schedule



Conclusions

- Several options are tested.
  - Barrel electronics work going on in good shape.
  - PhotoPentrode works well with light equiv. to 3 years Belle-II operation.
  - PureCsI+APD; too high equivalent noise energy(~2MeV).
  - BSO exhibit double effective light output; λ=480nm.
  - Unfortunately PWO-II mass production unclear.
  - Phoswitch option turned out to be difficult.
- To make sure endcap baseline option,
  - Further long-term stability test of PhotoPentrode to be performed.

We make decision of technology choice by the next Belle-II meeting in 2009 Nov.