$K_L \rightarrow \pi^0\nu\bar{\nu}$ experiment at KEK 12-GeV PS

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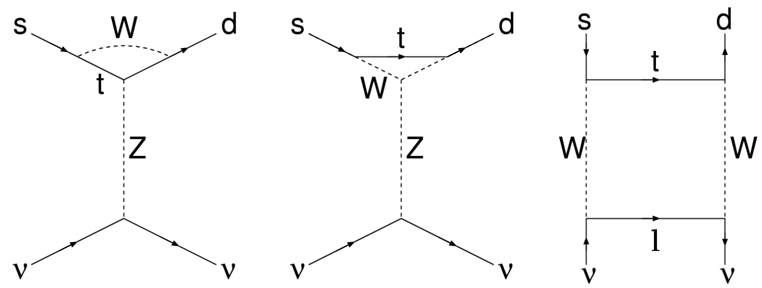
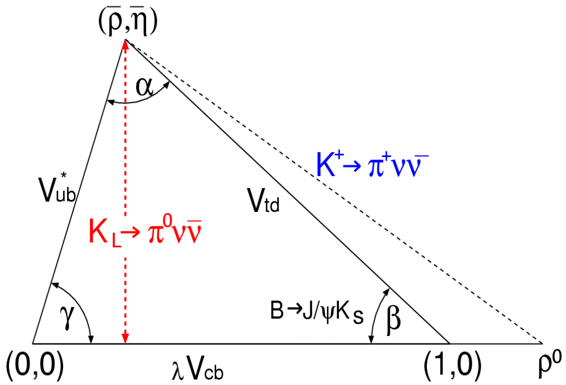
@ 科研費特定領域研究会

Golden channel in K decays

$K_L \to \pi^0 \nu\bar{\nu}$ physics

- Flavor-changing neutral current
- Direct CP violation ($\Delta s=1$)
- Clean measurement of $Im(V_{td}) \sim \eta$





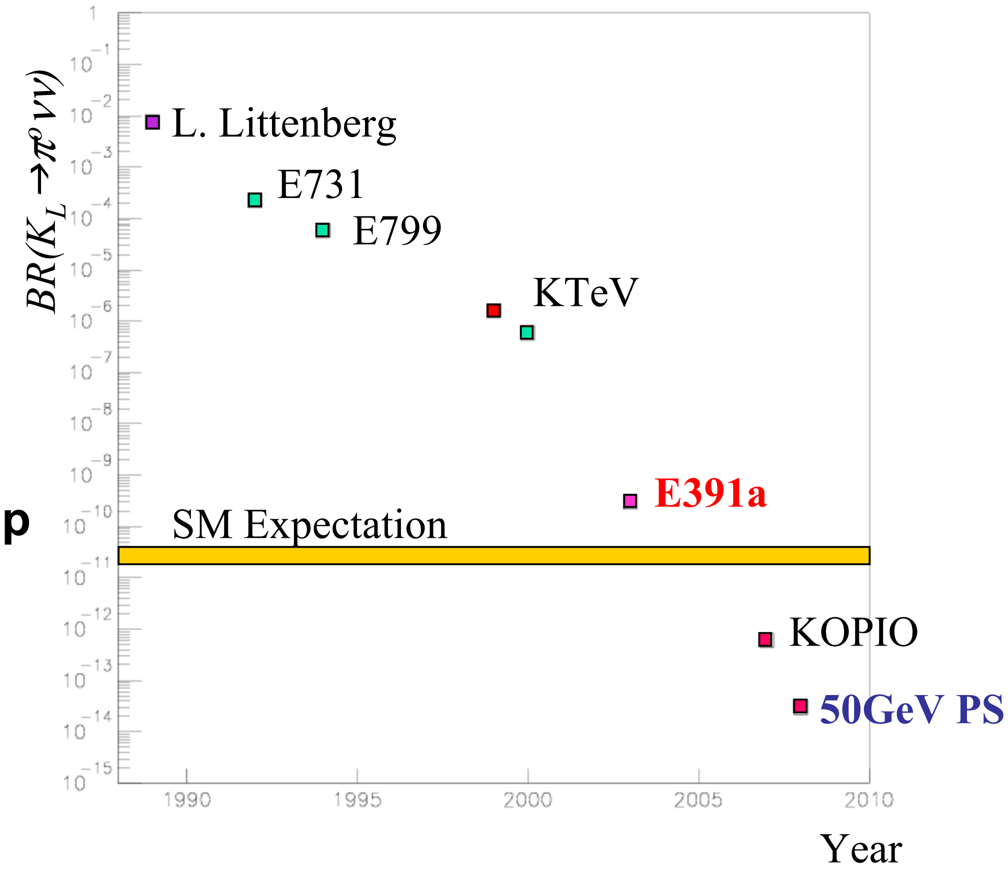
$$Br(K_L \to \pi^0 \nu\bar{\nu}) = 6\kappa_1 (Im(V_{td}V_{ts}^*))^2 X^2(x_t)$$
$$\sim 1.94 \times 10^{-10} \eta^2 A^4 X^2$$

Theoretical uncertainty is very small.

- Sensitive to the New Physics

Goal of the experiment

- Present experimental Limit
  - Br ~ 5.7 x 10^{-7}
- **E391a**
  - **First dedicated experiment**
  - **Last experiment at KEK 12-GeV PS**
  - **~ 3 x 10^{-10} of sensitivity.**
  - **Pilot experiment for next step (50GeV PS)**
- **50-GeV PS**
  - < 10^{-13} of sensitivity,
  - Standard model events > 100
  - $\Delta\eta/\eta < 5\%$



Collaboration

High Energy Accelerator Research Organization, ***KEK***

Faculty of Science and Engineering, ***Saga University***

Department of Physics, ***Yamagata University***

Department of Physics, ***Osaka University***

***R**esearch **C**enter for **N**uclear **P**hysics, Osaka University*

***N**ational **D**efense **A**cademy of **J**apan*

J**oint **I**nstitute for **N**uclear **R**esearch (Dubna)* ***Russia

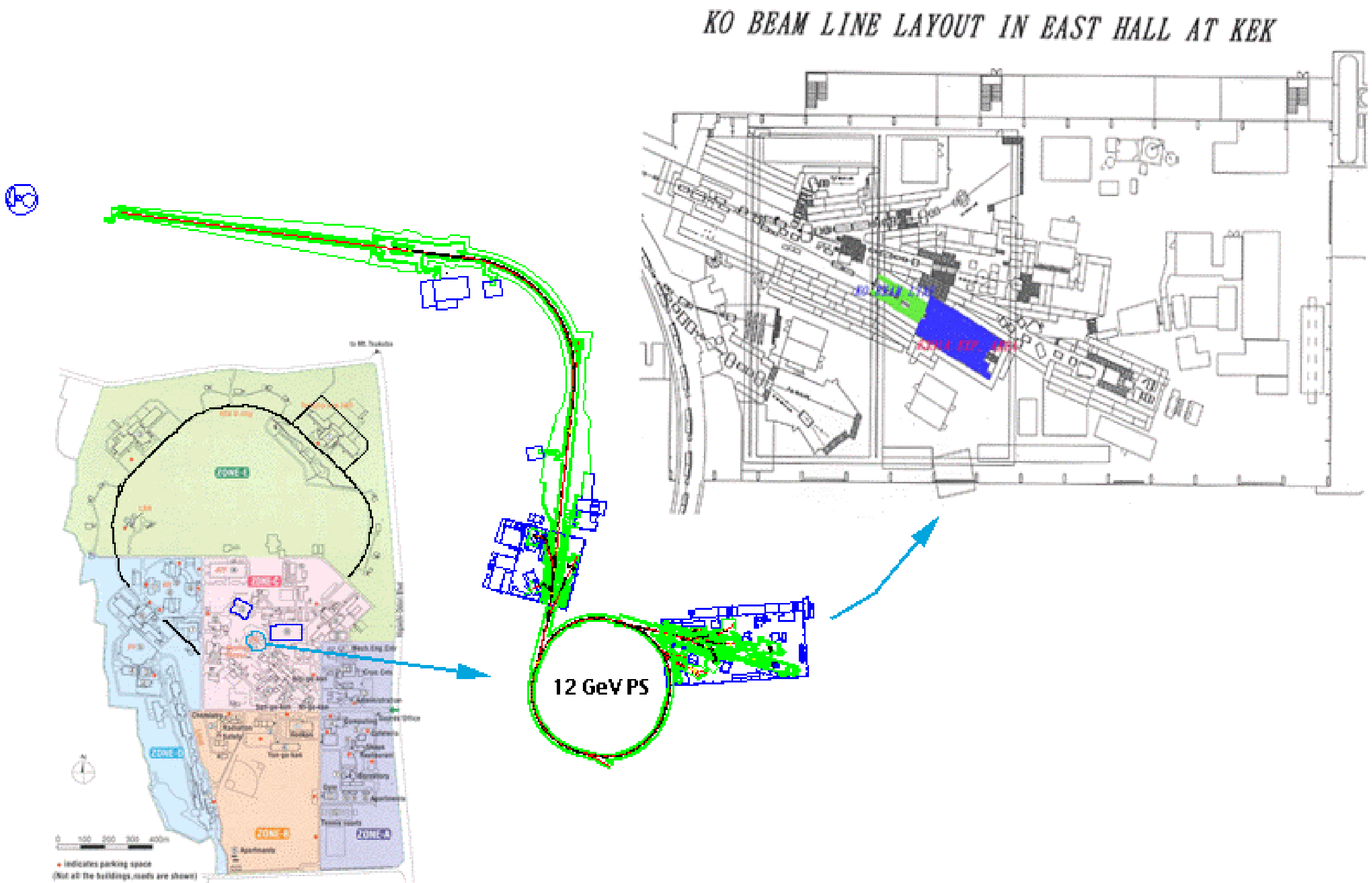
Department of Physics, ***University of Chicago***

Fermi National Accelerator Laboratory

Department of Physics, ***Pusan National University***

10 Institutes from 4 countries, over 50 collaborators.

KEK PS-E391a experiment

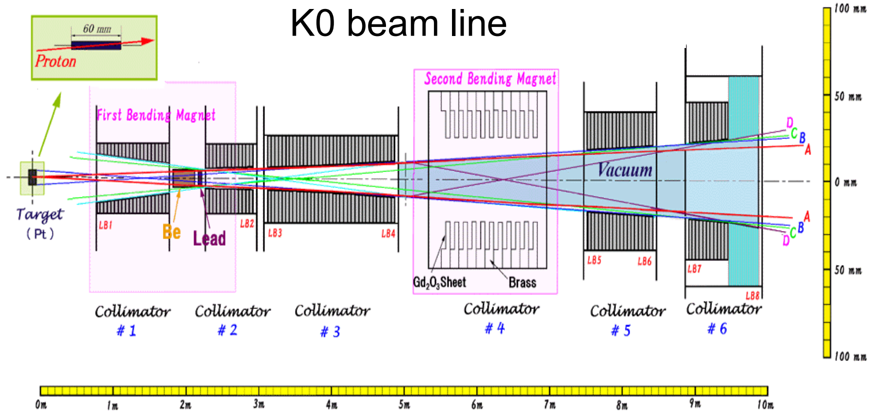


Experimental apparatus

Compact detector system

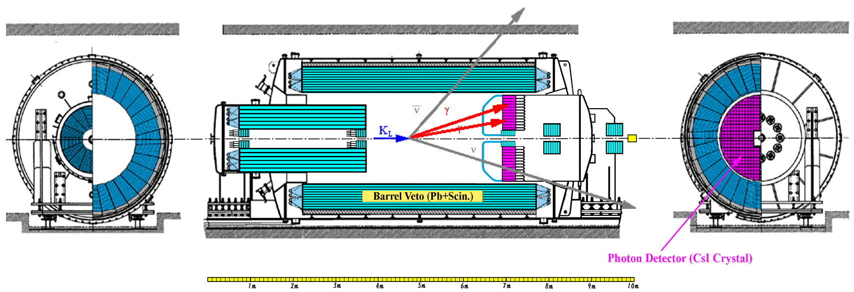
- Pencil beam.
  - Narrow and clean beam.

K0 beam line



- Detector with complete veto system.
  - 4π coverage.
  - Double decay chamber.
  - Highly evacuated decay region.
- High P_T selection for π^0.
- Wide acceptance.

E391a detector



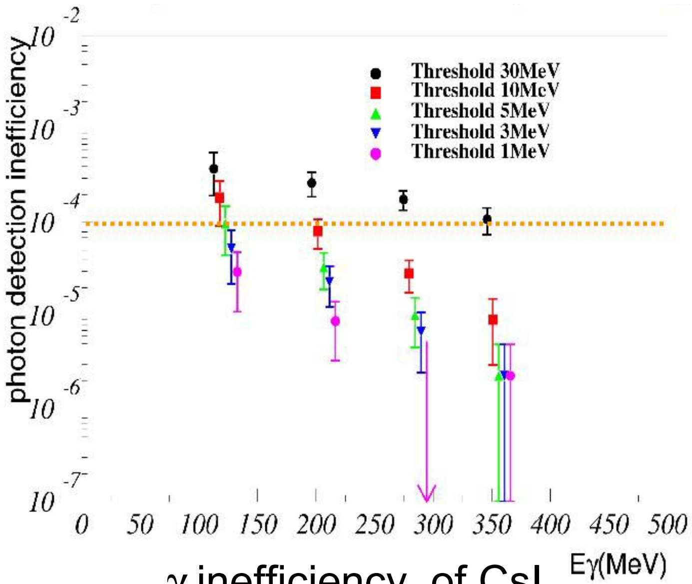
Background rejection

2 photons + ***nothing***

→ pure CsI   Hermetic Calorimeter

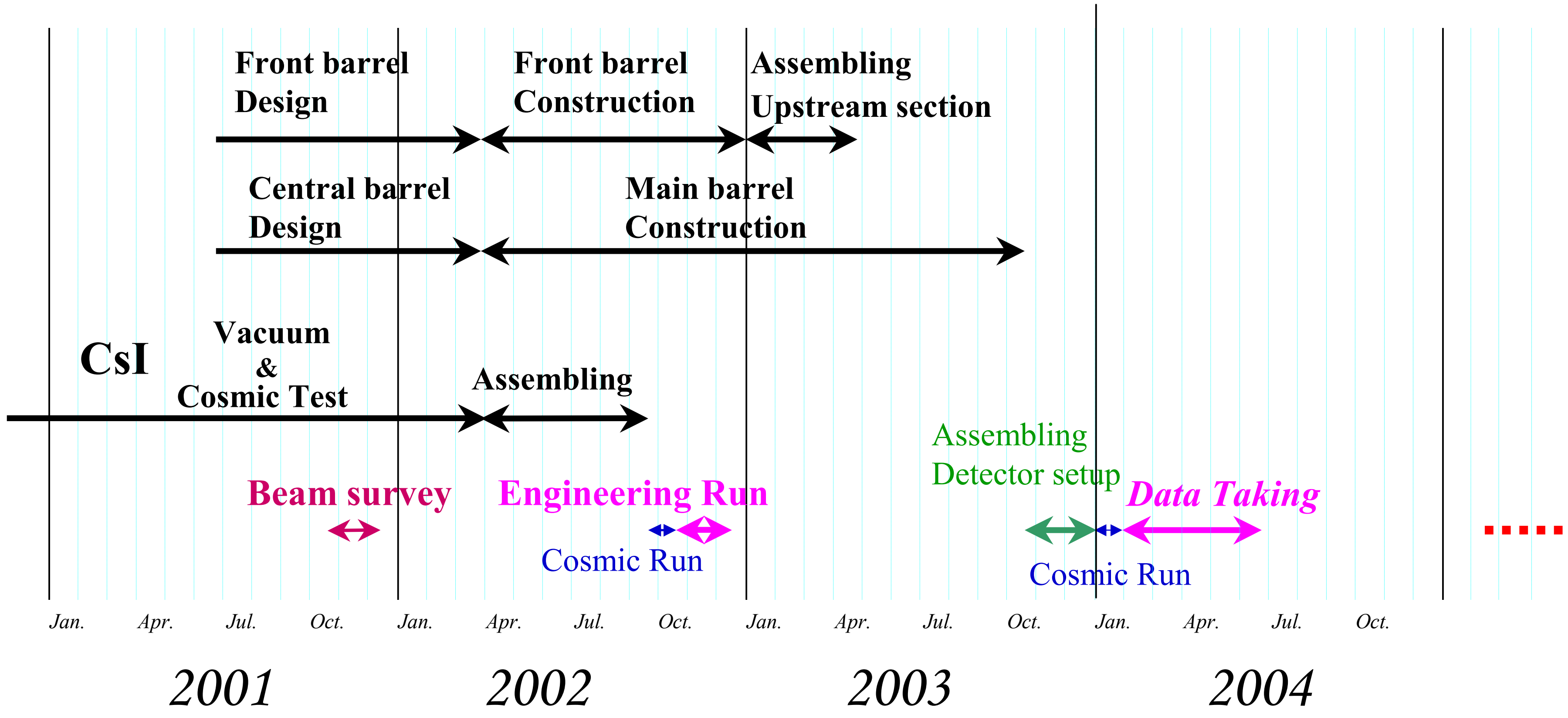
Consider $K_L \rightarrow 2\pi^0(4\gamma)$ as the main BG source.

- Very-high γ detection efficiency required (~10^{-4} inefficiency).
  Could be achieved.
- 1 MeV threshold required.
  ~1mV threshold for discriminator.
  Extremely low-noise operation.



γ inefficiency of CsI
(ES147,ES171)

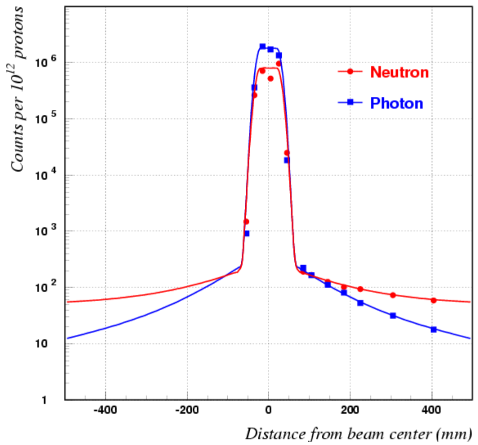
Schedule


Front barrel
Design
Front barrel
Construction
Assembling
Upstream section
Central barrel
Design
Main barrel
Construction
CsI
Vacuum
&
Cosmic Test
Assembling
Assembling
Detector setup
Beam survey
Engineering Run
Data Taking
Cosmic Run
Cosmic Run
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
Jan.
Apr.
Jul.
Oct.
2001
2002
2003
2004

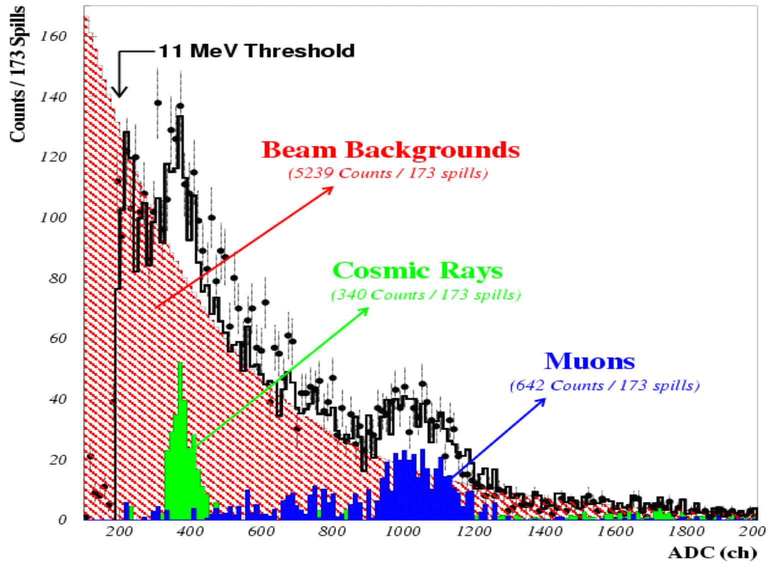
Beam survey

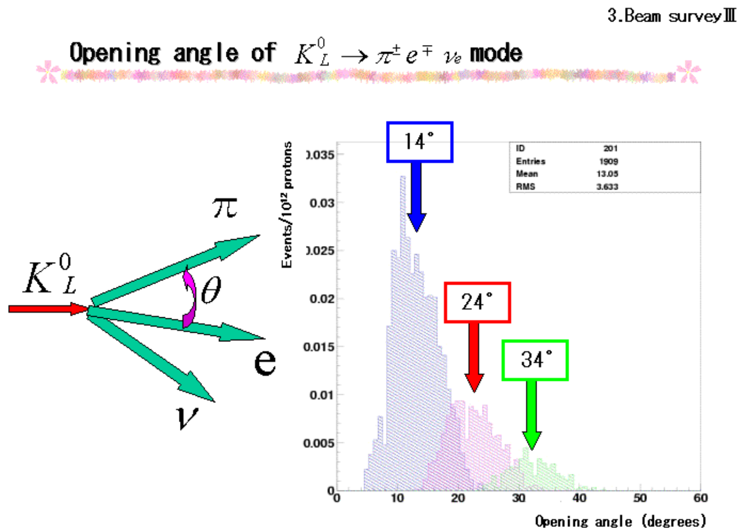
- First survey … April 2000
- γ and neutron … Dec. 2000
- K_L flux … Nov. 2001

Beam profile



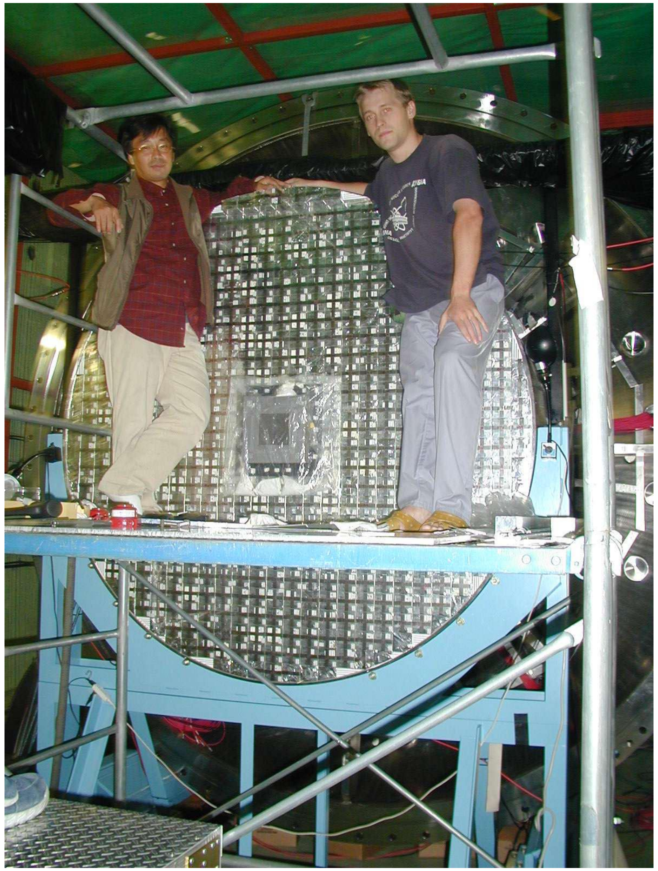
Energy Spectrum

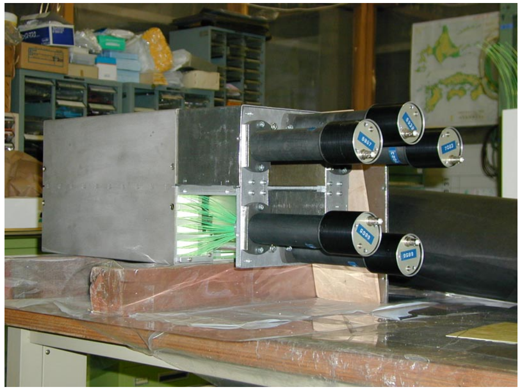




Detector construction

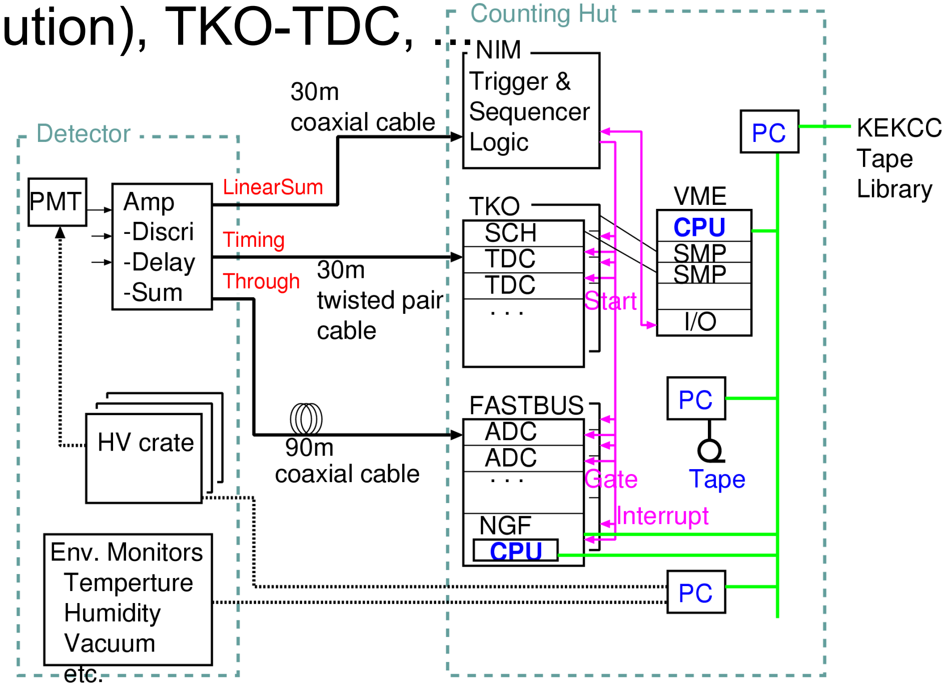
- Going smoothly on schedule.



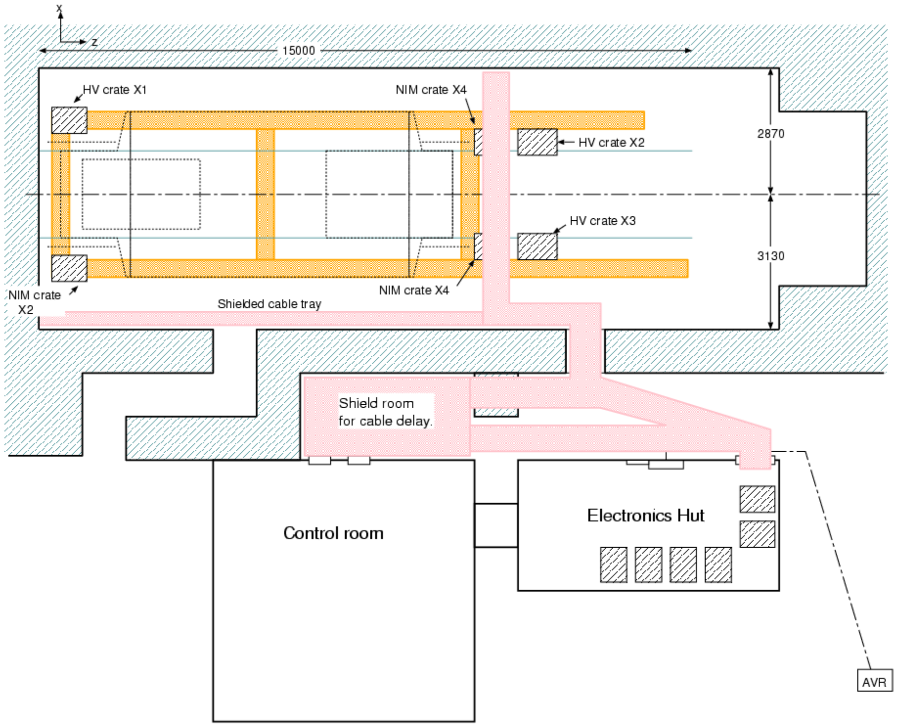


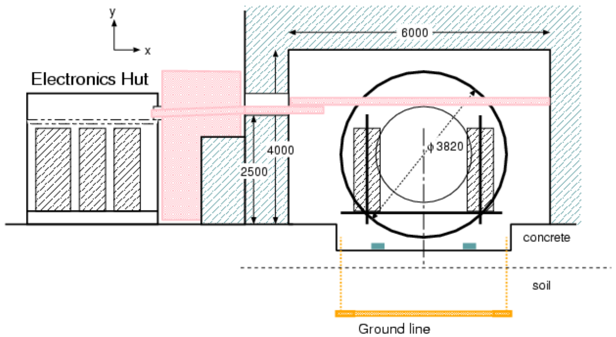
DAQ system

- Network distributed system with MIDAS software.
  - Scalability, stability, ...
- Recycle of the present equipment as much as possible.
  - FASTBUS-ADC (High-resolution), TKO-TDC, ...
  - Cost reduction
- Low threshold, low noise.
  - Clustering module
    - 1mV threshold
  - Noise reduction
    - Stable Ground
    - Shield-room



Ground and Shield-room

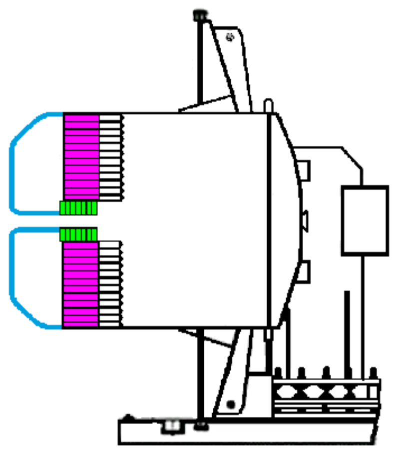




Engineering Run

Oct. 30 ~ Dec. 17, 2002 (49 days)

- Calibration of the calorimeters.
  - Muon from upstream of the beam line, cosmic rays, π^0 from the fixed target, $K_L \rightarrow 2\pi^0, 3\pi^0$.
- Overall check of the DAQ system.
  - 70% of readout channels.
  - Noise test



Performance:

- DAQ was quite stable.
- No serious noise problem for the detector calibration.

→ Proved to be excellent.

In Preparation

Upstream section being ready to assemble.

- Vacuum-vessel
  Feb. 2003.
- Lead-scinti calorimeter
  Dec. 2002
- Collar counter
  ~ Apr. 2003.

Assembling work ~ June 2003.

In Preparation (cont.)

Middle section (5m-long Lead-scinti calorimeters)

- R&D finished for production.
  - 1 modules/week → 32 weeks (8 months)
    March ~ Oct. 2003.
- Vacuum-vessel construction until Oct. 2003.

Installation will finish in Dec. 2003.

Evacuation in Jan. 2004.

Beam time from Feb. 2004.

Summary

- Golden channel to access CP violation .
- Pilot experiment to establish the method.
  - Search at KEK 12-GeV PS.

  $\Rightarrow$ Measurement at 50-GeV PS.

- Detector and DAQ construction on schedule.
- Beam survey, engineering-run.
  - Good understanding for our system.
  - Achieved excellent performance.

  → Significant step to the success of the experiment.

Physics run will start from Feb. 2004.