E391a:
The first dedicated experiment for the $K_L \rightarrow \pi^0\nu\nu$ decay

KEK, Saga, Osaka, RCNP, Kyoto, NDA,Yamagata, Taiwan, Pusan, Chicago, JINR

$K_L \rightarrow \pi^0\nu\nu$ decay

Im(Vtd) measurement

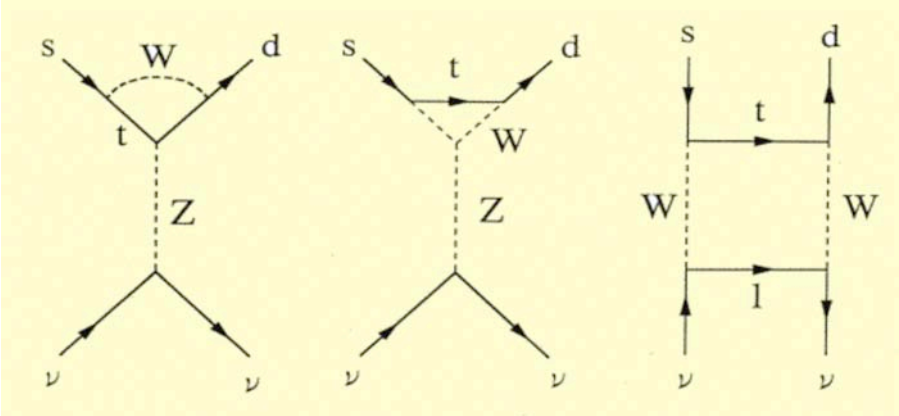
Very small theoretical ambiguity

Only top loop in SM

clean and pure

Last frontier in K-decay

challenging



Why it remains ?: rare decay (Br$\sim 10^{-11}$) without a definite kinematical constraint $\Rightarrow$ **very hard experiment**

Two methods are proposed:

- KOPIO: Kinematical constraint as much as possible
  line shape for the main background from $K_L \rightarrow \pi^0 \pi^0$
- E391a: Meditation
  simply observe 2 γ (high P_T)+ nothing

Pencil beam and full coverage by veto counter with high efficiency

+

Double decay chamber to define the fiducial region redundantly, differential pumping to achieve ultra high vacuum and very thin dead material in front of the detector, etc.

High Acceptance

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It is crucial for high sensitivity

$$S = 1 / (A \cdot T \cdot D)$$

- S: single event sensitivity
- A: acceptance for $K_L \rightarrow \pi^0\nu\nu$ decay
- T: data collection time
- D: decay rate in the fiducial region

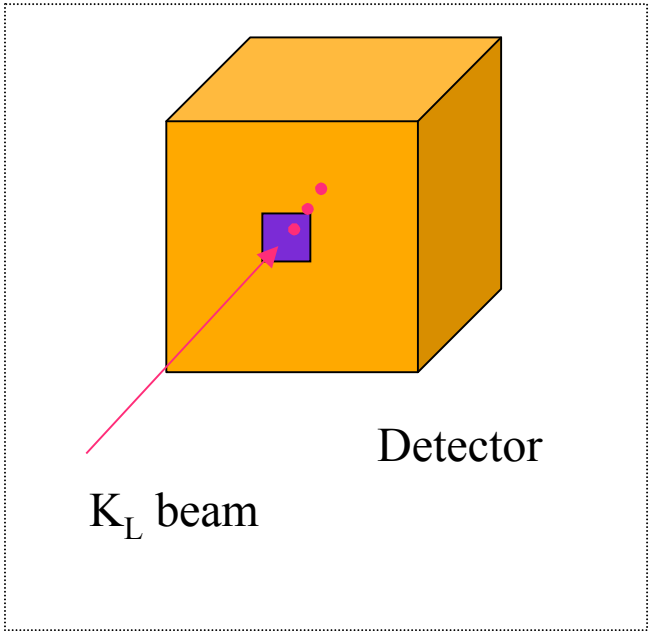
C(counting rate)＞D

$S<10^{-13}$, $T=10^7$ sec

↓

C＞D＞10MHz for A=0.1

C＞D＞100MHz for A=0.01

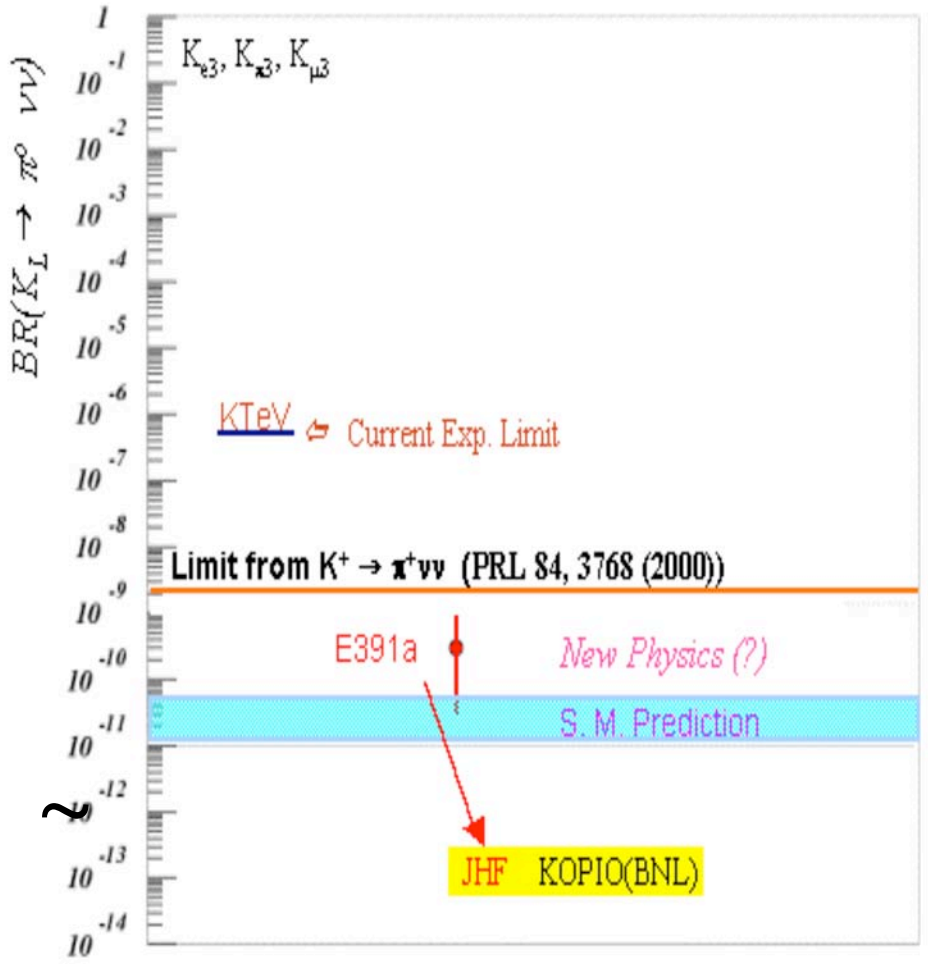


Step-by-step approach

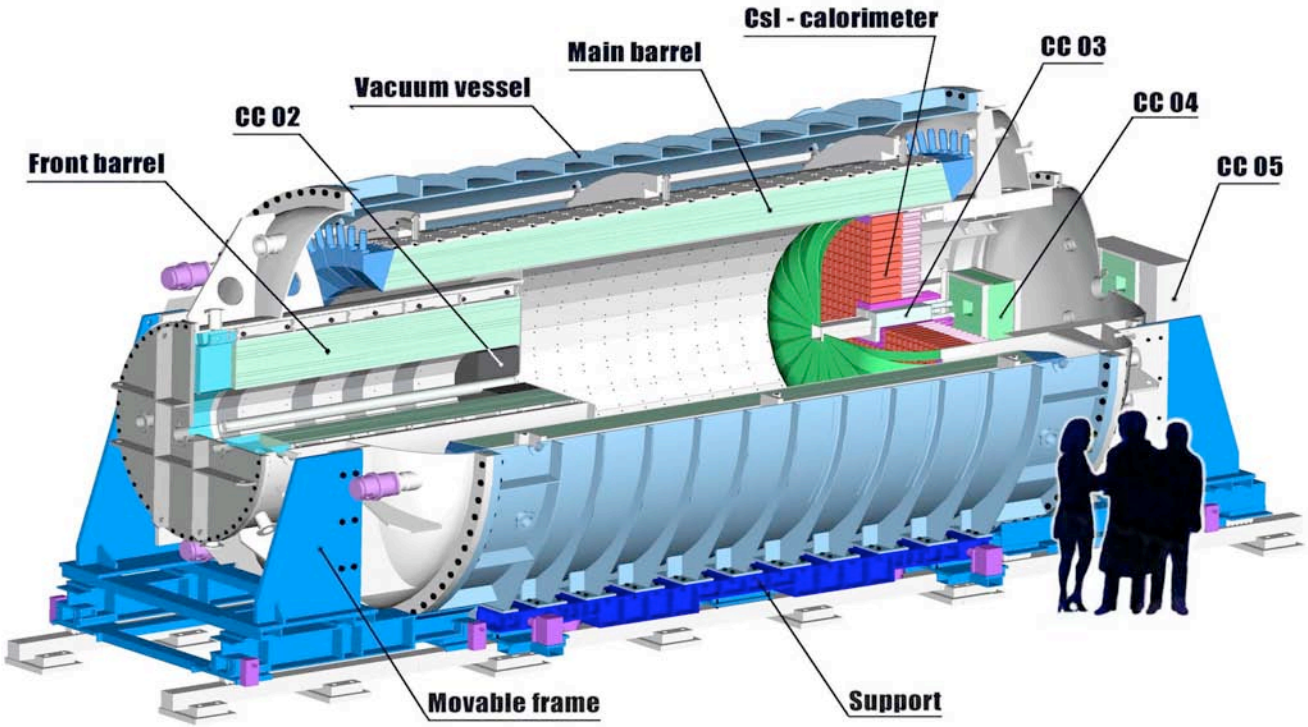
E391a(O(10^{-10}))

↓

J-PARC(O(10^{-13}))



E391a apparatus



100-ton calorimeters are
installed in vacuum chamber

Mile stones

- Dec.1996: conditionally approved
- Mar.1999: constructed the beam line
- July 2001: approved
- Oct. 2002: engineering run
- Nov.2003: middle section (last vacuum chamber) arrived
- 18 Feb. 2004: Started data taking
- In fall 2004: first publication of physics result

Downstream: Fy01

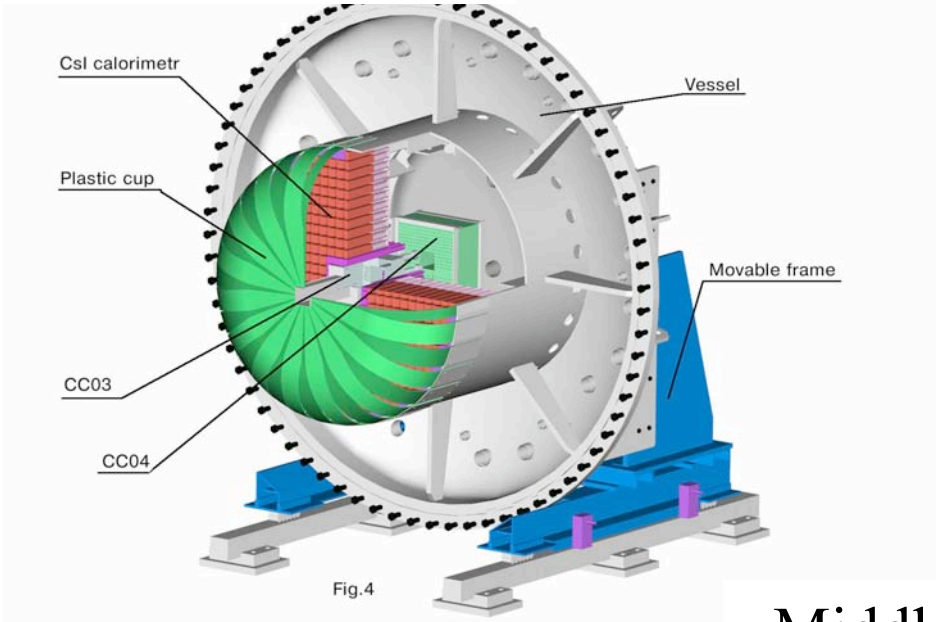


Fig.4

Upstream: Fy02

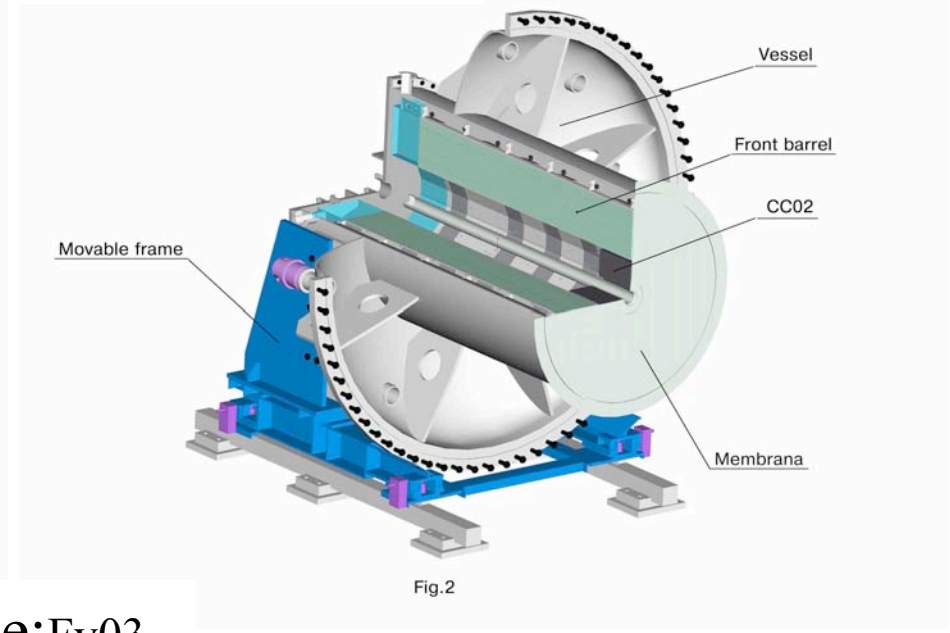


Fig.2

Middle:Fy03

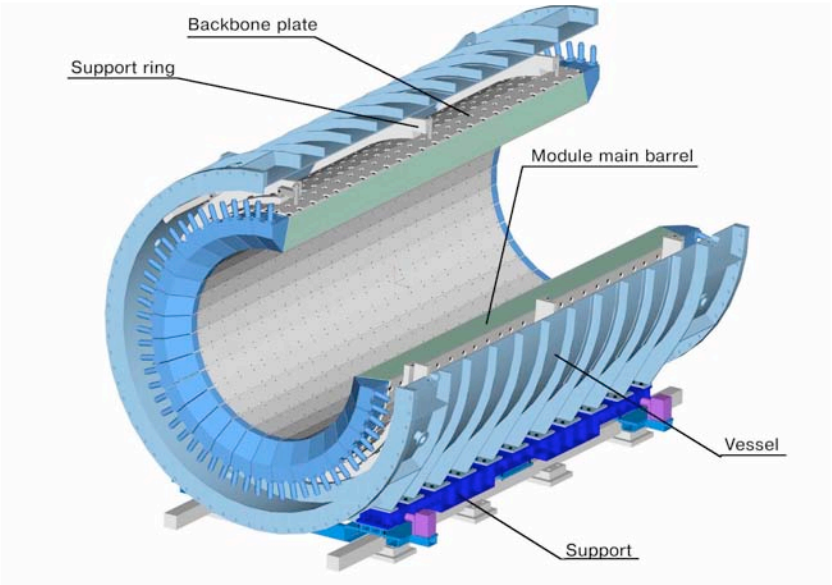
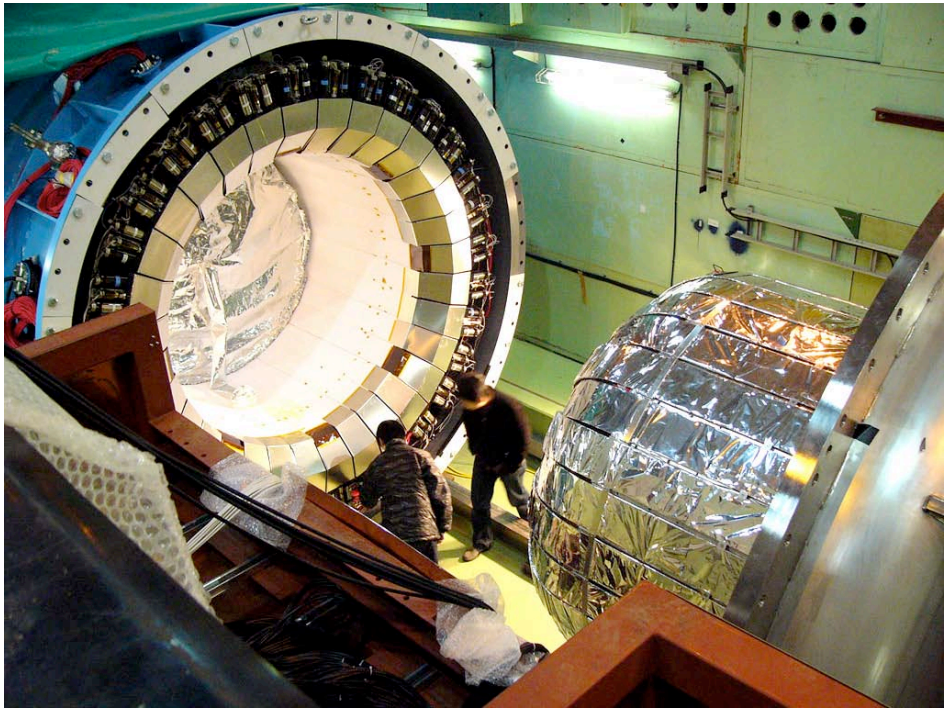
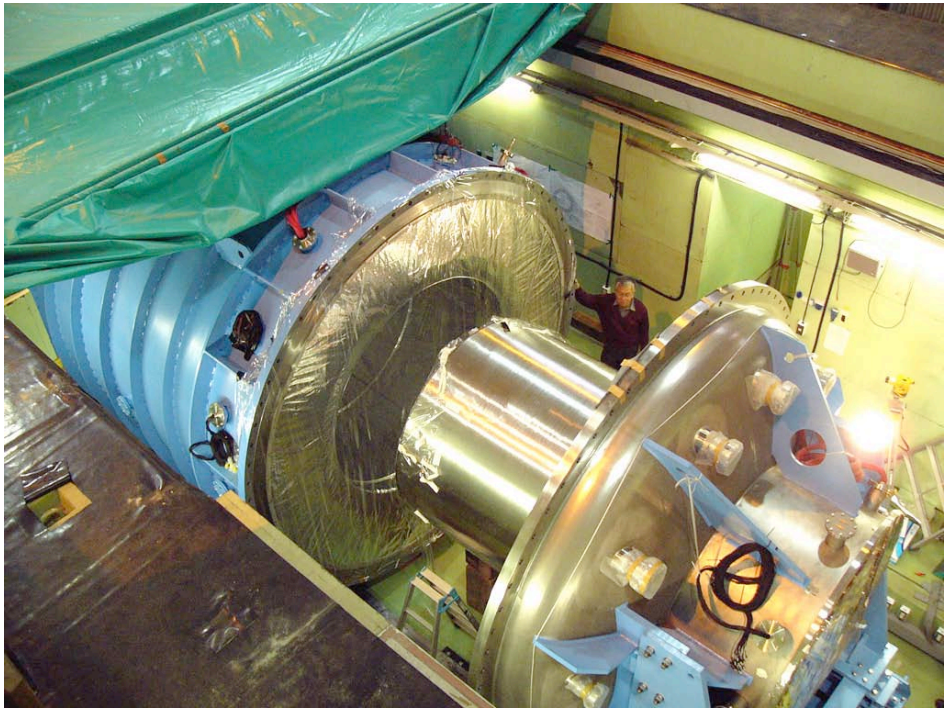
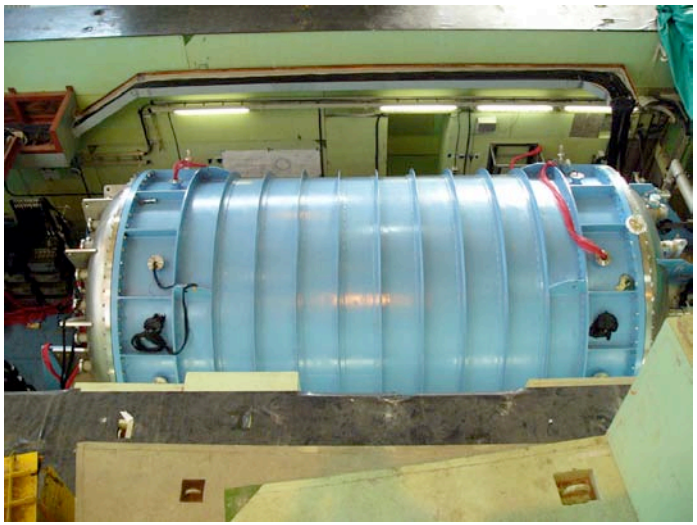


Fig.3

Detector Integration

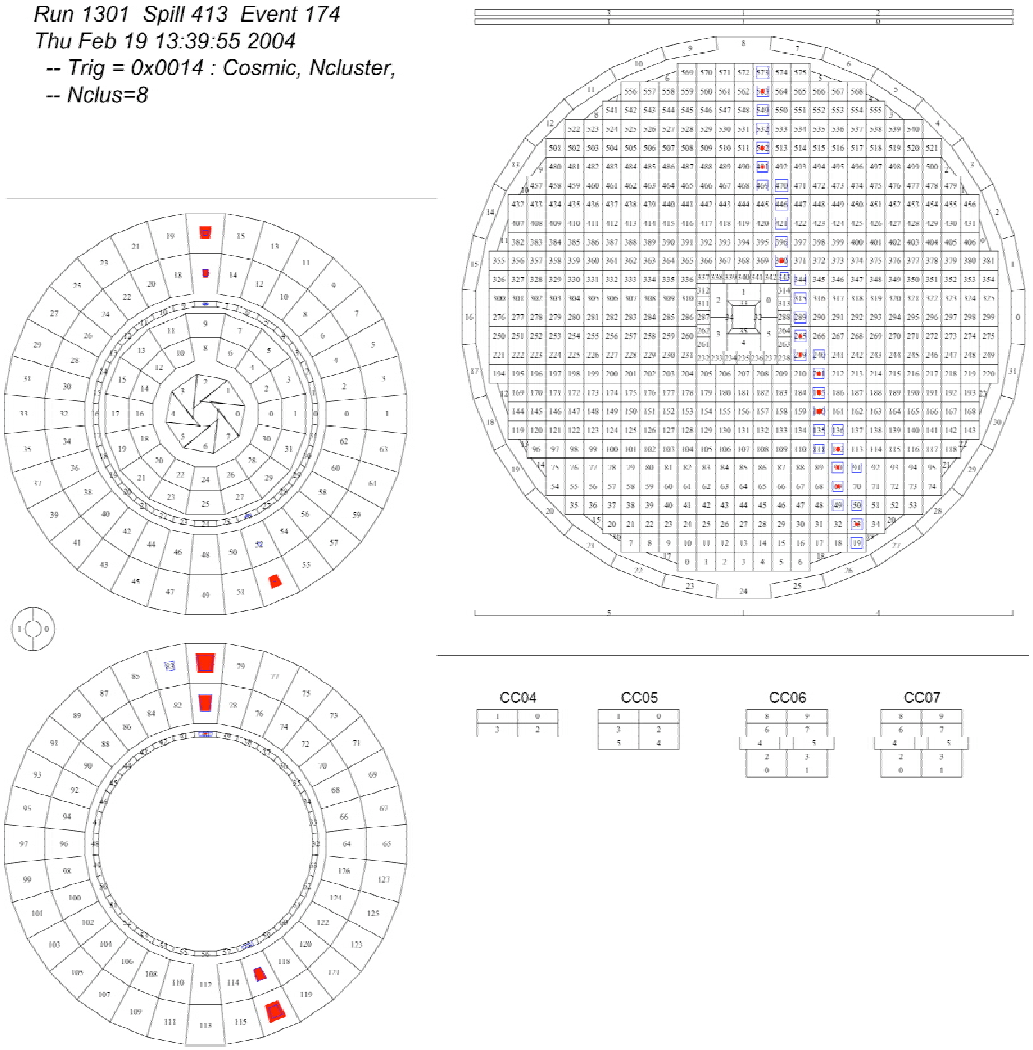


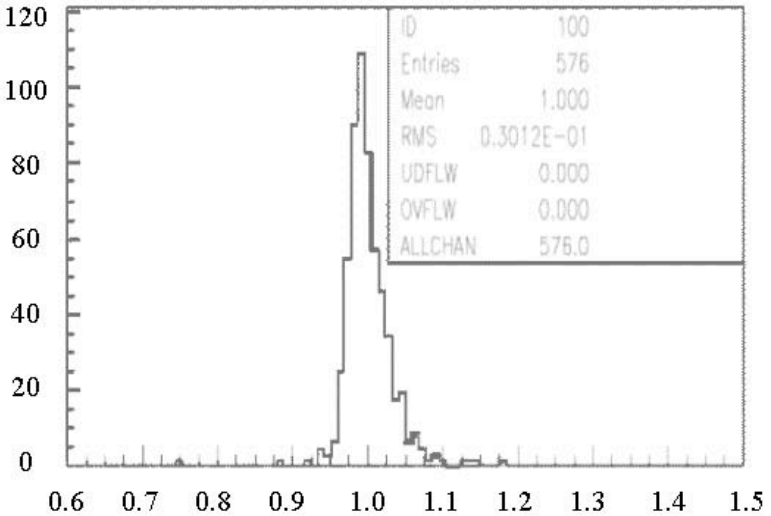




Jan 22, 2004

Calibration in situ





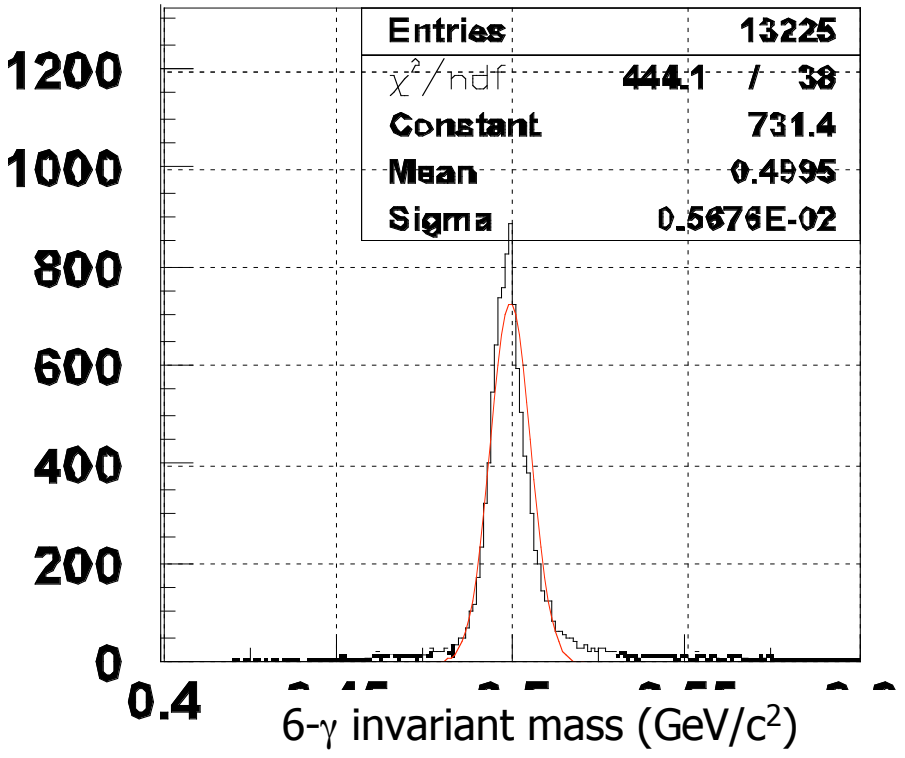
Publications of new techniques

development or first application to high-energy physics

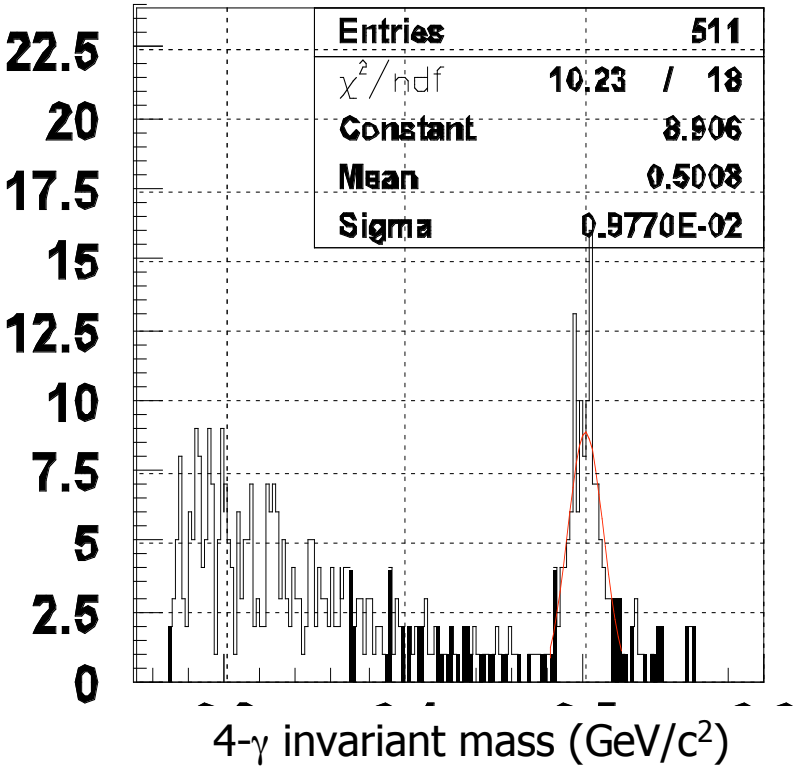
• CeF3 crystal	Published in NIM and patent
• Plastic scintillator (injection molding)	Published in NIM
• Plastic scintillator (extrusion)	Preparing a publication
• High QE PMT at 500nm	Published in NIM
• Techniques for WLSF readout	Preparing a publication
• Ineff. measurement for γ (ES147)	Published in NIM
• Ineff. measurement for γ (ES171)	Preparing a publication
• Ineff. measurement for charged	Published in NIM
• n / γ separation for BA counter	Published in NIM
• Pencil beam line	Preparing a publication
• Vacuum system	Preparing a publication
• Calibration method for CsI	Preparing a publication
• Large sampling calorimeter	Preparing a publication
• Electronics and DAQ	Preparing a publication

Clearly reconstructed K_L decay modes

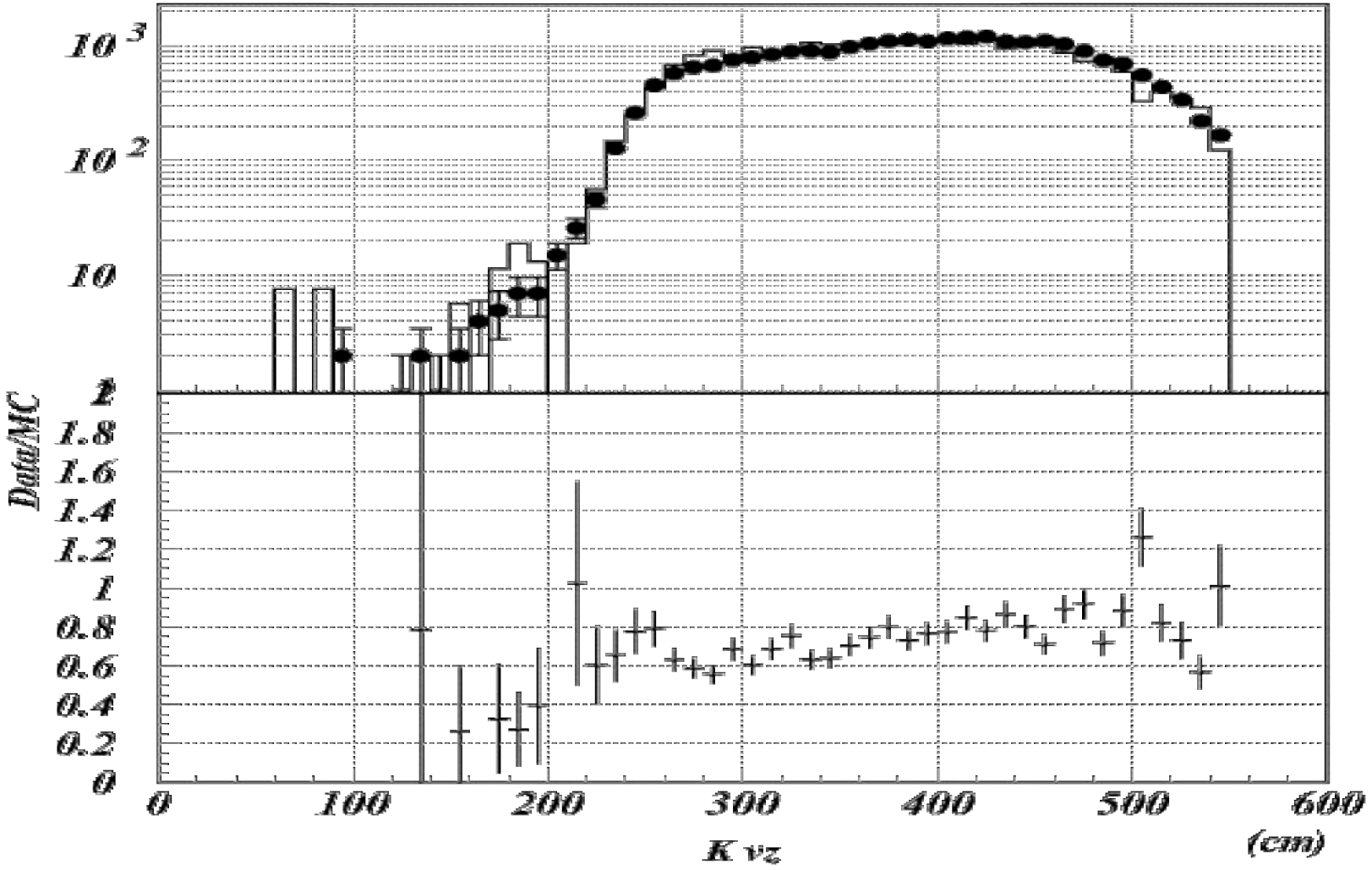
- $K_L \rightarrow \pi^0\pi^0\pi^0$



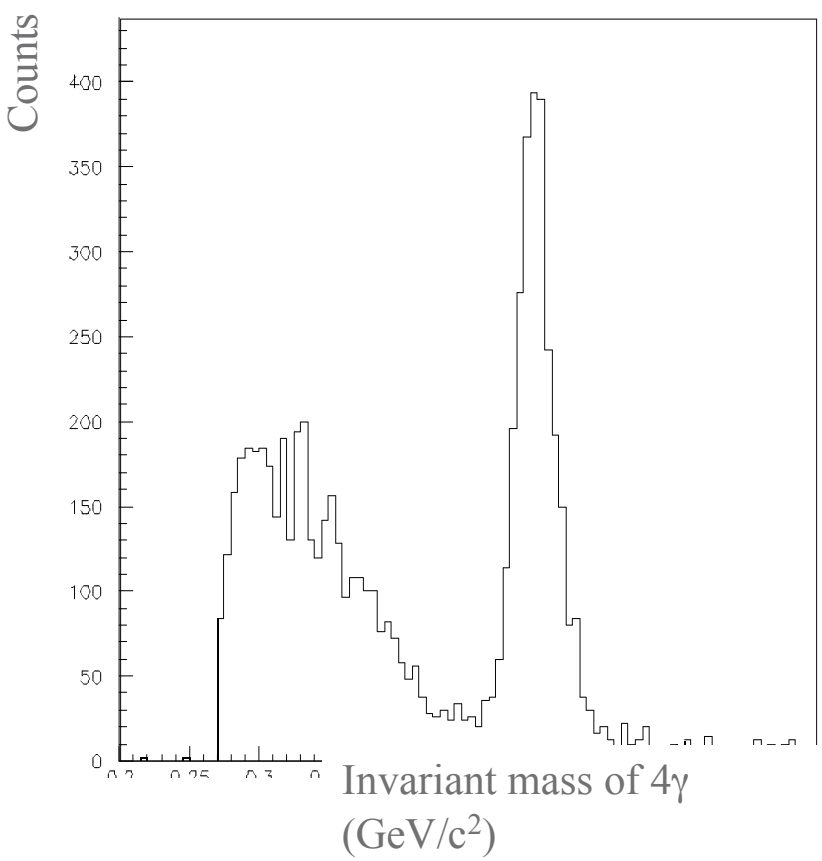
- $K_L \rightarrow \pi^0\pi^0$

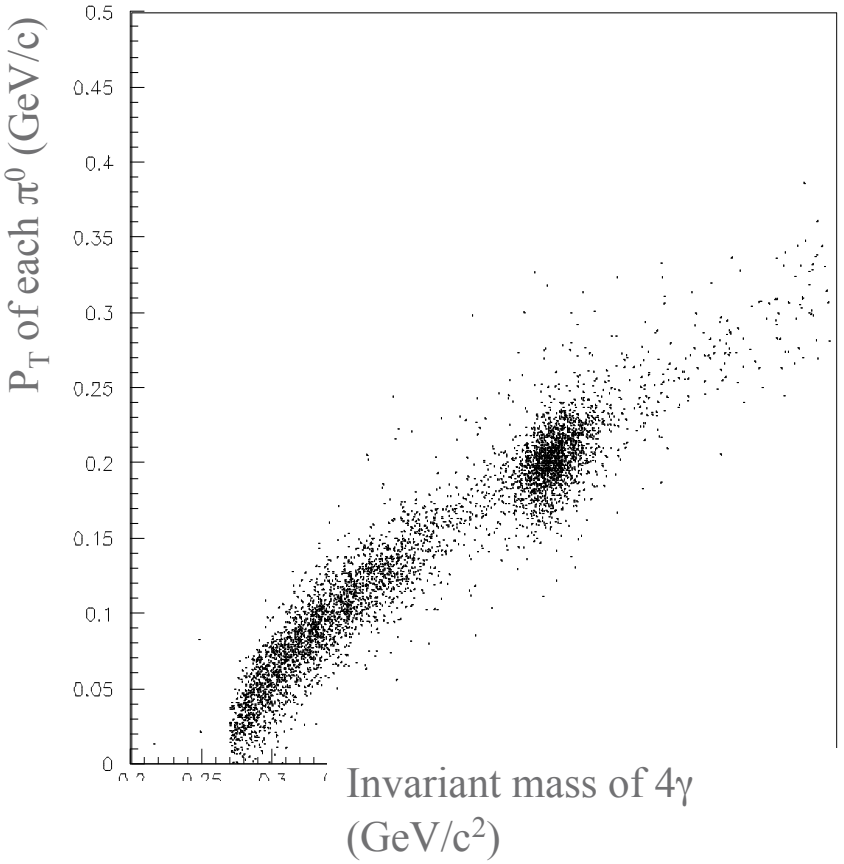


Z-vertex distribution for $K_L \rightarrow \pi^0\pi^0\pi^0$



Two event clusters in $\pi^0\pi^0$ sample





Future prospect

- Run 2 in 2005 (requesting)

  To make more critical check in the frontier region

  Run must be more efficient because detector is ready for prompt start and valuable because tuning parameters can be re-polished.

  New methods for JPARC experiment can be tested.

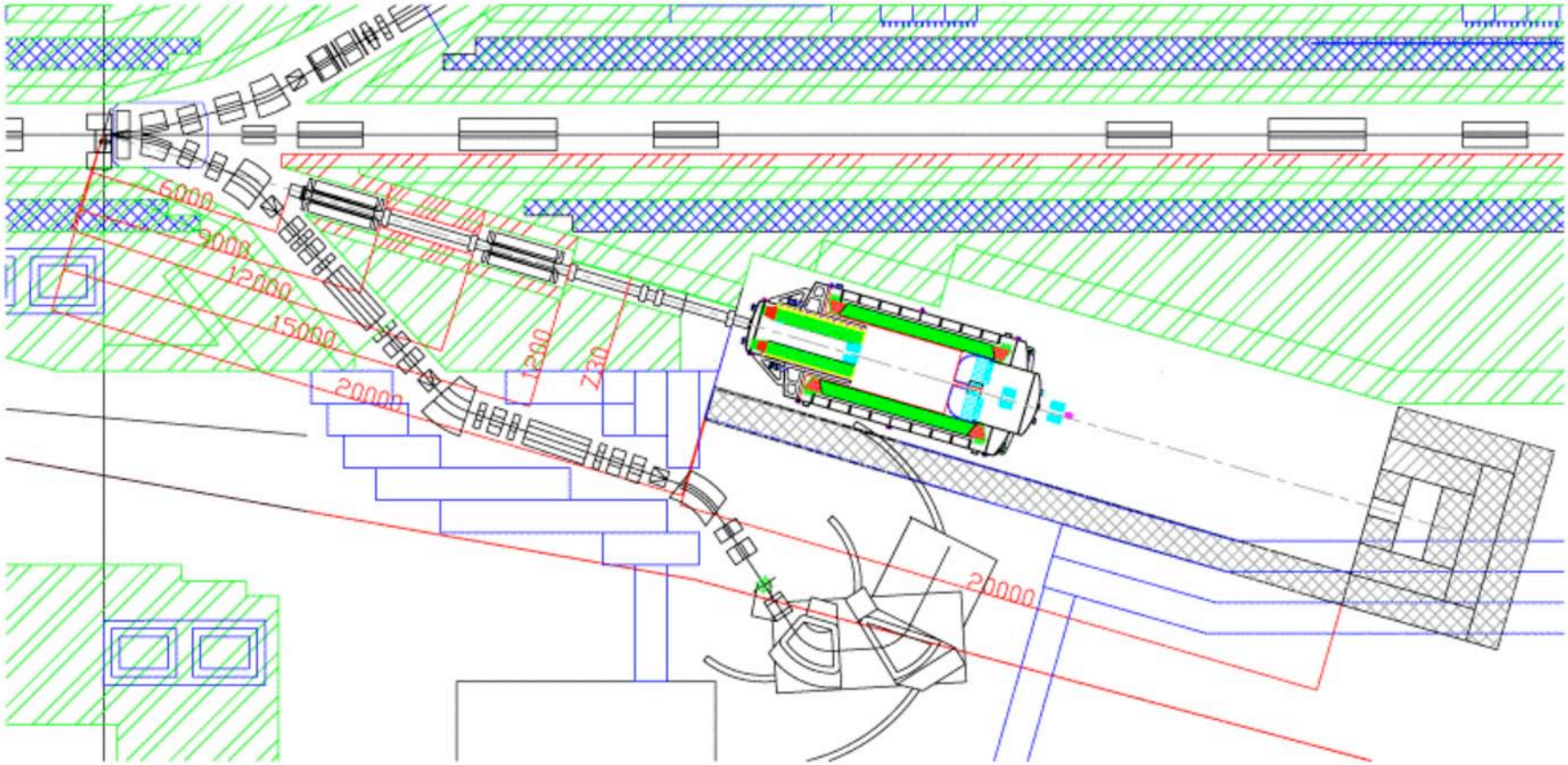
- High sensitive experiment at JPARC (LOI-05)

  Regular video meeting is started for detailed planning.

  Key issues: “based on E391a” and “goal must be an ultimate measurement (>100 SM events)”.

  Mile stones: conceptual design (scenario) by NP04 (August 2004) and full proposal will be submitted within official schedule for day-one.

A-line plan at JPARC



Summary

- E391a data taking started on 18 Feb.2004 as scheduled, and it will finish on 30 June.
- The quality of the data so far collected looks fine.
- We are expecting a continuous support to our Run-2 and JPARK plan and specially asking for a strong recommendation from the present review committee.

Expected sensitivity by Run 1

$$S_{\pi\nu\nu} = (A_{3\pi}/A_{\pi\nu\nu}/Y_{3\pi}) \cdot Br_{3\pi},$$

$A_{3\pi}/A_{\pi\nu\nu} \sim 1/20$

$Y_{3\pi} \sim 19$(/spill) $\cdot$ 7.2×10^3 (spill/shift) $\cdot$ (300-80-3$\times$15)(shifts)

- 80 shifts: cooling water trouble(30)+tuning with shared beam(30)+tuning with full beam(20)
- 3$\times$15 shifts: 3 special runs (air, short bunch, π^0 calibration)

$\sim 2.4\times10^7$

$Br_{3\pi} = 0.21$

$$S_{\pi\nu\nu} \sim 4.3\times10^{-10} \Leftrightarrow 8.6\times10^{-10}$$

If we get another 200 shifts, we can double the statistics.

Physics background for higher sensitivity

- Grossman-Nir limit

  $Br(K_L \to \pi^0 \nu\ \nu) < 4.4 \times Br(K^+ \to \pi^+ \nu\ \nu)$

  1.1×10^{-8} (proposal) $\Rightarrow$ 1.7×10^{-9} (present)

  Require higher sensitivity

- New prediction by Buras *et.al*

  A systematic approach to the recent $B \to \pi\ \pi$, π K data by Belle and BaBar

  Suggest New Physics in the EW penguin sector

  $Br(K_L \to \pi^0 \nu\ \nu)$:

  $(2.6 \pm 0.5) \times 10^{-11}$ (SM) $\Rightarrow$ $(3.1 \pm 1.0) \times 10^{-10}$ (New physics)

  Reachable level