Overview of KEK-PS Experiments

K. Nakamura

IPNS, KEK

June 7, 2004

KEK-PS Extrenal Review

KEK-PS Experiments: From Proposal to Execution

- Proposals are submitted to the director of IPNS.
- PS-PAC (Program Advisory Committee) investigates
  - Scientific merit
  - Technical feasibility
  - Size and experience of the experimental group
  - Demands on the experimental program and resources
- If a proposal is approved, the experiment is fully supported by KEK. (In a few cases, however, experimenters directly apply for a grant-in-aid from MEXT or JSPS.)
- EPPC (Experimental Planning and Program Coordination) Office of Physics Division III deals with
  - Scheduling
  - Funding

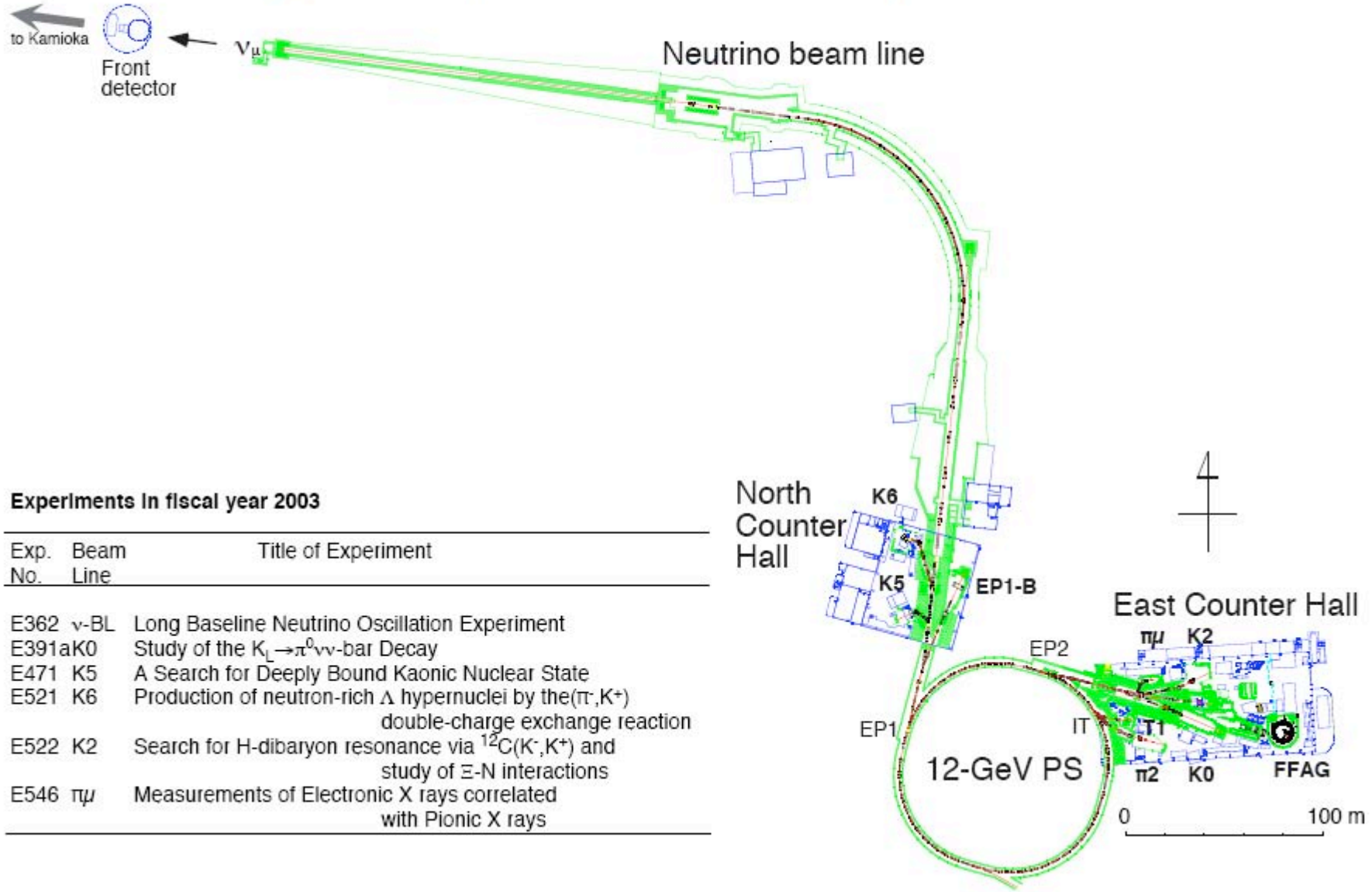
Brief History of KEK-PS

- 1971 April KEK established
- 1976 March Construction of the KEK-PS completed
  Proton beam accelerated to 8 GeV
- 1976 December Proton beam accelerated to 12 GeV
- 1977 May Physics experiments started
  fast extracted beam for bubble ch. exp'ts
  internal target for counter experiments
- 1978 April Slow extracted beams for counter exp'ts
- 1981 June External Review
- 1987 February Polarized proton beam accelerated and
  extracted
- 1990 February New experimental hall (North Hall) completed
- 1990 November External Review

Brief History of KEK-PS, cont'ed

- 1996 September Construction of a neutrino beam line started
- 1998 December Neutrino beam line completed
- 1999 February 3 Fast extraction succeeded
- 1999 February Commissioning of the neutrino beam line
- 1999 June 19 Detection of the first K2K neutrino event in Super-K
- 2000 December External Review
- 2001 November 12 Super-Kamiokande accident, End of K2K-I
- 2002 December Super-Kamiokande rebuilt, Start of K2K-II

Layout of Experimental Areas in September 2003



Experiments in fiscal year 2003

Exp. No.	Beam Line	Title of Experiment
E362	ν-BL	Long Baseline Neutrino Oscillation Experiment
E391a	K0	Study of the $K_L \rightarrow \pi^0 \nu\nu$-bar Decay
E471	K5	A Search for Deeply Bound Kaonic Nuclear State
E521	K6	Production of neutron-rich Λ hypernuclei by the(π^-,K^+) double-charge exchange reaction
E522	K2	Search for H-dibaryon resonance via $^{12}C(K^-,K^+)$ and study of Ξ-N interactions
E546	πμ	Measurements of Electronic X rays correlated with Pionic X rays

Beam Lines in the E-Hall 2004

[Secondary Beam Lines]

Beam Line	Particles	Momentum Range (GeV/c)	Momentum Bite [Δp/p] (%)	Typical Intensity (particles / 10^{12} protons)	
K0	K_L	1-8	-	3.0×10^{7}	
K2	K^+	1-2	± 3	5.0×10^{5}	@ 2 GeV/c
	K^-			1.0×10^{5}	
	π^+	0.5-2	± 3	2.2×10^{7}	
	π^-			1.5×10^{7}	
	$\bar{p}$			1.5×10^{4}	
π2	π^+	1-4	± 1	2.0×10^{5}	@ 3 GeV/c
	π^-			1.0×10^{5}	
$\pi\mu$	π^+	0.1-0.26	± 4	1.2×10^{6}	@ 0.23 GeV/c
	π^-			1.0×10^{6}	
T1	π^+	0.5-2	± 5	5.0×10^{4}	@ 1 GeV/c
	π^-			4.0×10^{4}	

[Primary Beam Line]

Beam Line	Particles	Energy Range (GeV)	Momentum Spread [ΔE/E] (%)	Typical Intensity (particles/ sec)	
P1	pol.p	3.5	± 0.5	4.0×10^{8}	pol. = 40 %
	p	2-12.0		4.0×10^{8}	
	d	2-11.2		2.0×10^{8}	
	n	1-5.6		4.0×10^{8}	

Beam Lines in the N-Hall 2004

[Secondary Beam Lines]

Beam Line	Particles	Momentum Range (GeV/c)	Momentum Bite [Δp/p] (%)	Typical Intensity (particles / 10^{12} protons)	
K5	K^+	0.3-0.6	± 3	5.0×10^4	@ 0.55 GeV/c
	K^-			1.0×10^4	
	π^+			3.5×10^7	
	π^-			2.8×10^7	
	$\bar{p}$			2.6×10^2	
K6	K^+	0.5-2	± 2.8	8.7×10^3	@ 1 GeV/c
	K^-			3.3×10^3	
	π^+			6.5×10^6	
	π^-			5.0×10^6	
	$\bar{p}$			1.6×10^3	

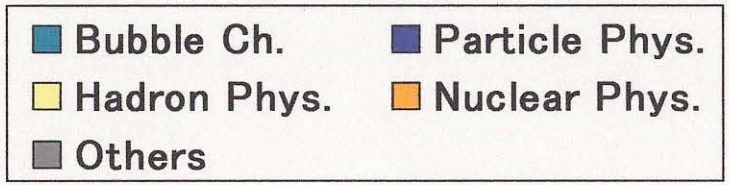
[Primary Beam Line]

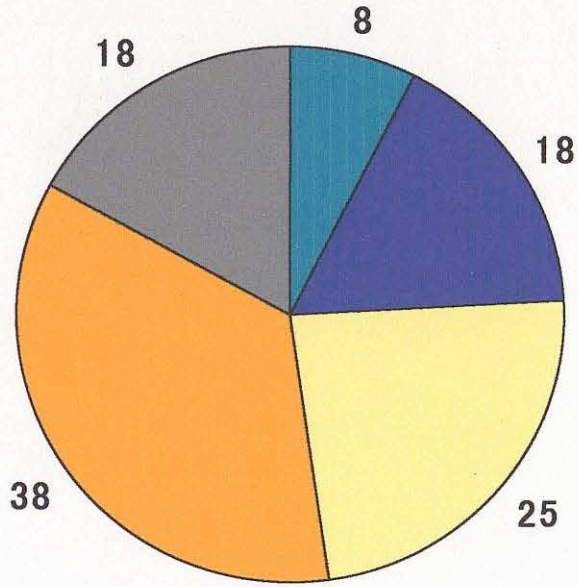
Beam Line	Particles	Energy Range (GeV)	Momentum Spread [ΔE/E] (%)	Typical Intensity (particles/ sec)
EP1B	p	2-12.0		4.0×10^8
	d	2-11.2		2.0×10^8

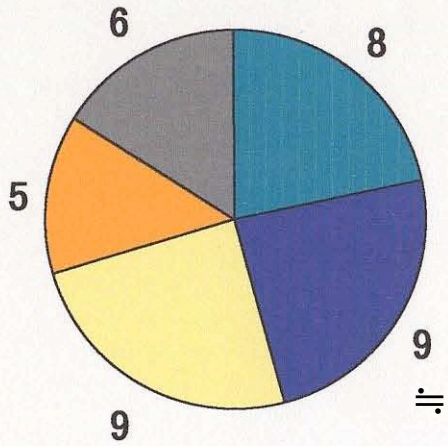
Trend of KEK-PS Experiments

- 1977 - 1984 (Before TRISTAN)
  - KEK-PS was the only high-energy machine in Japan.
  - Particle and hadron physics experiments were dominant.
- 1984 - 1998 (After start of TRISTAN and before K2K)
  - Nuclear and hadron physics experiments were dominant.
  - Particle physics experiments mainly focused on K_L and K^+ decays.
  - Nuclear physics experiments mainly focused on hypernuclear physics.
  - Demands for test beams for detector R&D increased considerably.
- 1999 (After start of K2K) ~
  - As a strategy to provide 10^{20} POT to K2K as early as possible, PS-PAC authorized to allocate
    - 2/3 of available beam time for K2K (fast extracted beam)
    - 1/3 for other experiments (slow extracted beam)

experiments

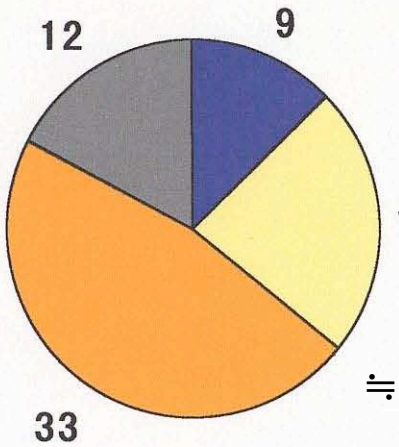






Before E100

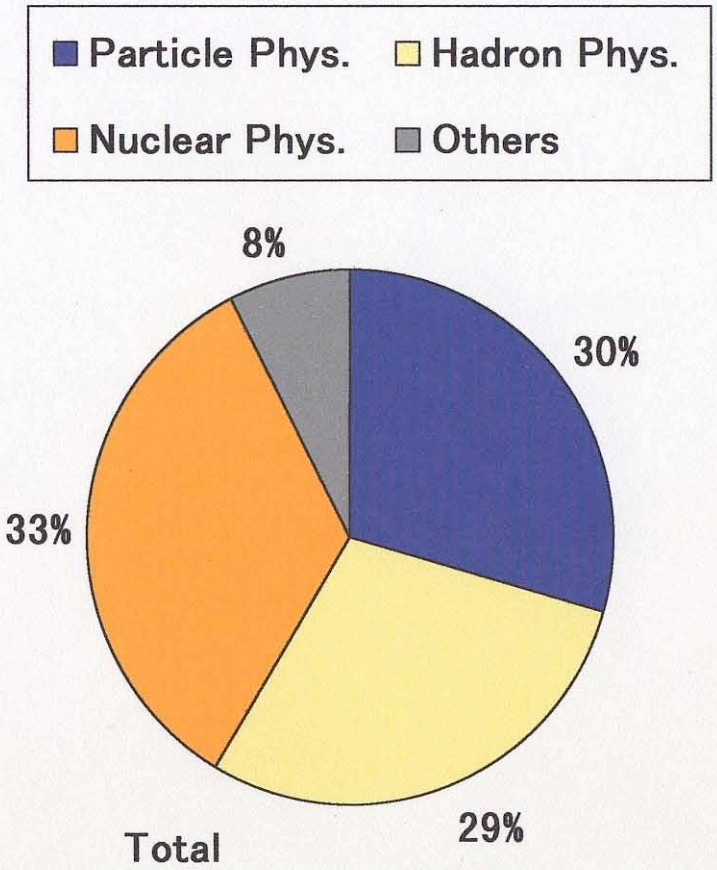
≒ Before TRISTAN

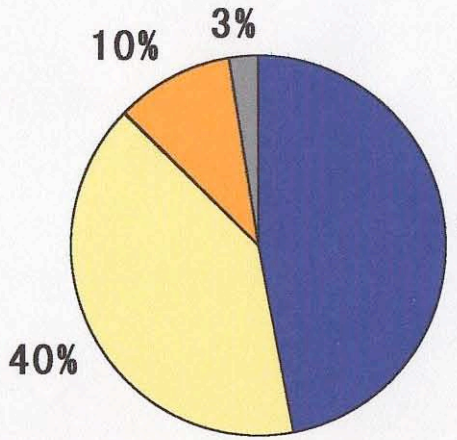


After E100

≒ After TRISTAN and before K2K

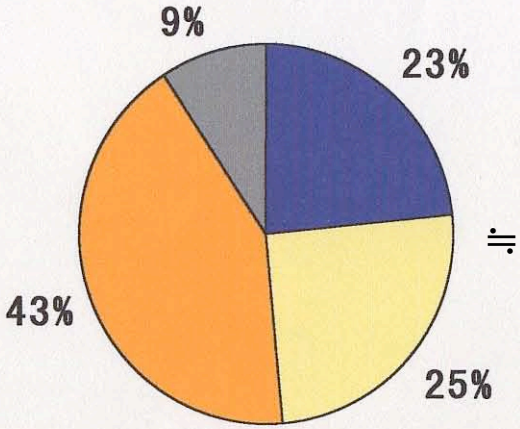
Statistics of KEK-PS Experiments by machine time





Before E100

≒Before TRISTAN



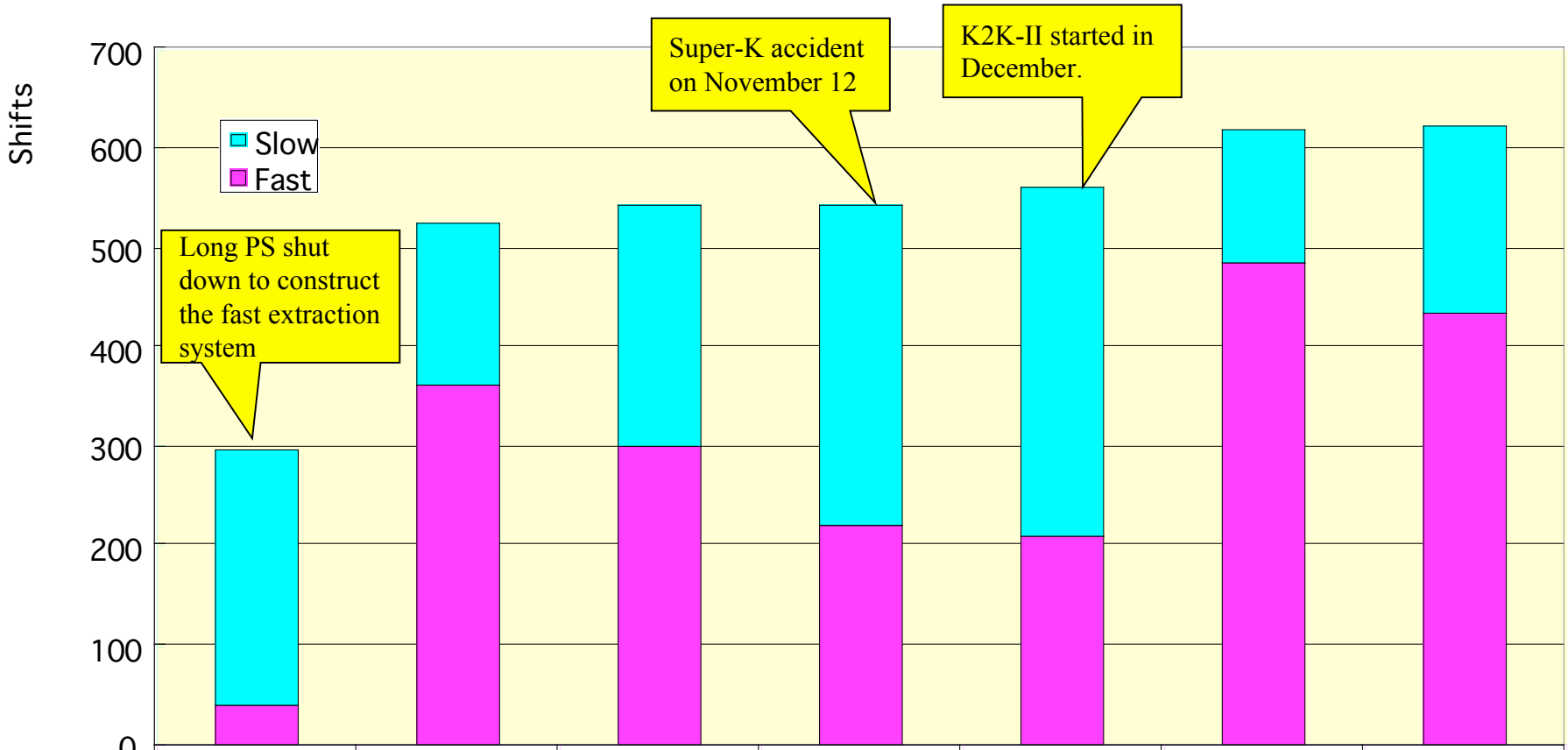
After E100

≒ After TRISTAN and after K2K

KEK-PS Experiments in 2000 - 2004

- Neutrino physics
  - E362 Long Baseline Neutrino Oscillation Experiment
- K Decay Experiments
  - E246 Search for T-Violating Muon Polarization in $K^+ \rightarrow \pi^0\mu^+\nu$ Decay
  - E470 Branching Ratio Measurement of $K^+ \rightarrow \pi^+\pi^0\gamma$ Direct Emission
  - E391a Study of the $K_L \rightarrow \pi^0\nu\nu$ Decay
- Hadron and Neutron Physics (Other than Hypernuclear Physics)
  - E325 Chiral Property of Dense Nuclear Matter Through Measurement of Meson Mass Modification in Medium
  - E443 Neutron-Production Differential Cross Sections in the (p,xn) Reaction at Forward Ang
- Hypernuclear Physics
  - E373 Study of S=−2 Nuclei by Emulsion-Scintillating Fiber Hybrid Method
  - E419 High-Precision Gamma Spectroscopy of $^{7}_{\Lambda}$Li Hypernucleus)
  - E438 Study of Σ-Nucleus Potential by the (π^-, K^+) Reaction
  - E452 Study of the Spin-Dependent Interaction in Σ^+P Scattering
  - E462 Exclusive Measurement of Nonmesonic Weak Decay of $^{5}_{\Lambda}$He Hypernucleus
  - E508 Coincidence Measurement of the Weak Decay of $^{12}_{\Lambda}$C
  - E471 Search for Strongly Bound Kaonic System
  - E509 Gamma-ray Spectroscopy of Hyperfragments with Stopped K^-
  - E518 High-Precision Gamma Spectroscopy of $^{11}_{\Lambda}$B
  - E521 Production of Neutron-Rich Λ Hypernuclei by the (π^-,K^+) Double Charge-Exchange Reaction
  - E522 Enhancement of the $\Lambda\Lambda$ Near the Threshold in the ^{12}C(K^-,$K^+\Lambda\Lambda$) Reactions
- Kaonic Hydrogen X-Ray Experiment
  - E546 Measurement of Electronic X Rays Correlated with Pionic X Rays

Accelerator Operation Mode for Each Fiscal Year

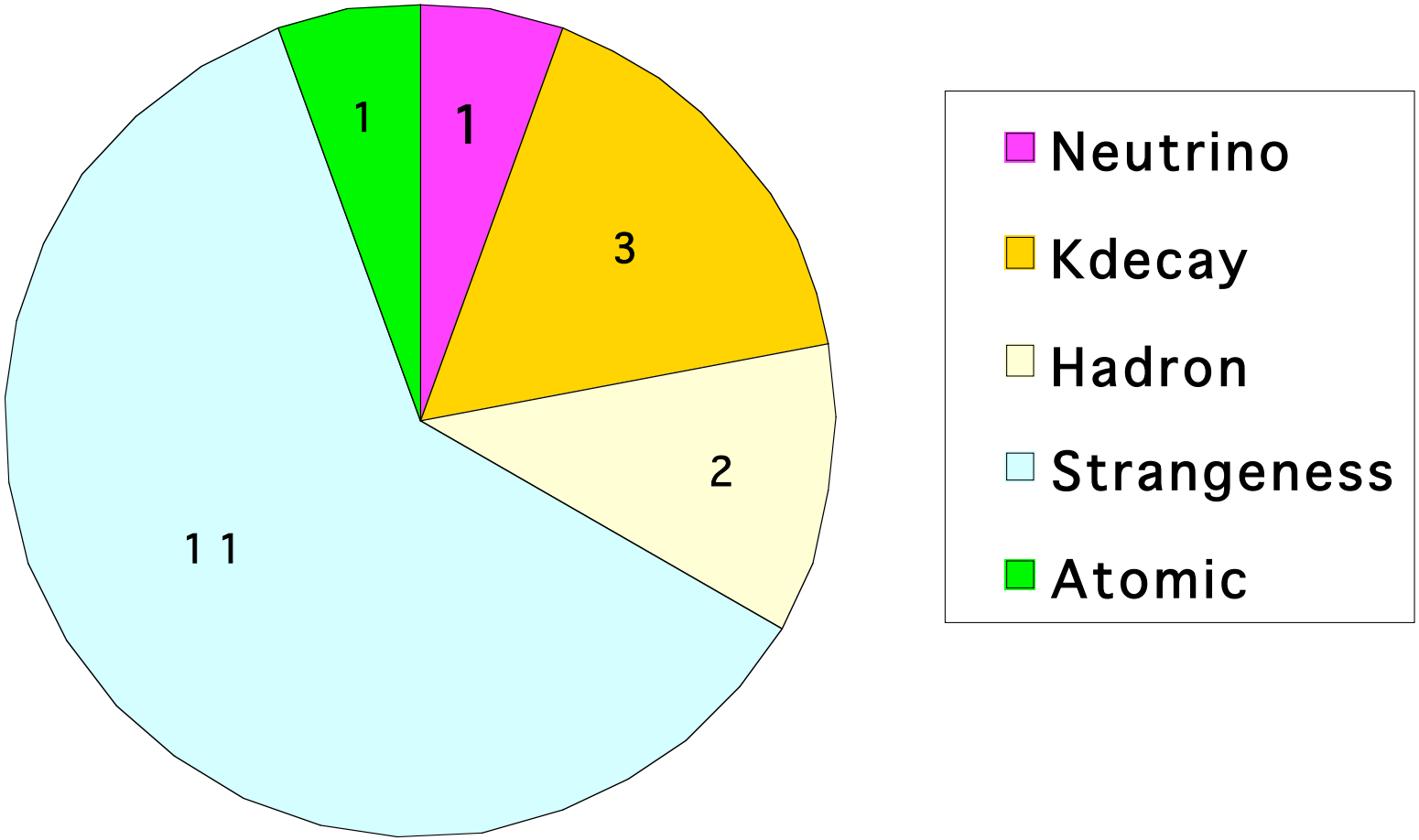


	FY98	FY99	FY00	FY01	FY02	FY03	[FY04]
Slow	256	163	242	322	354	135	190
Fast	42	362	300	222	209	485	434

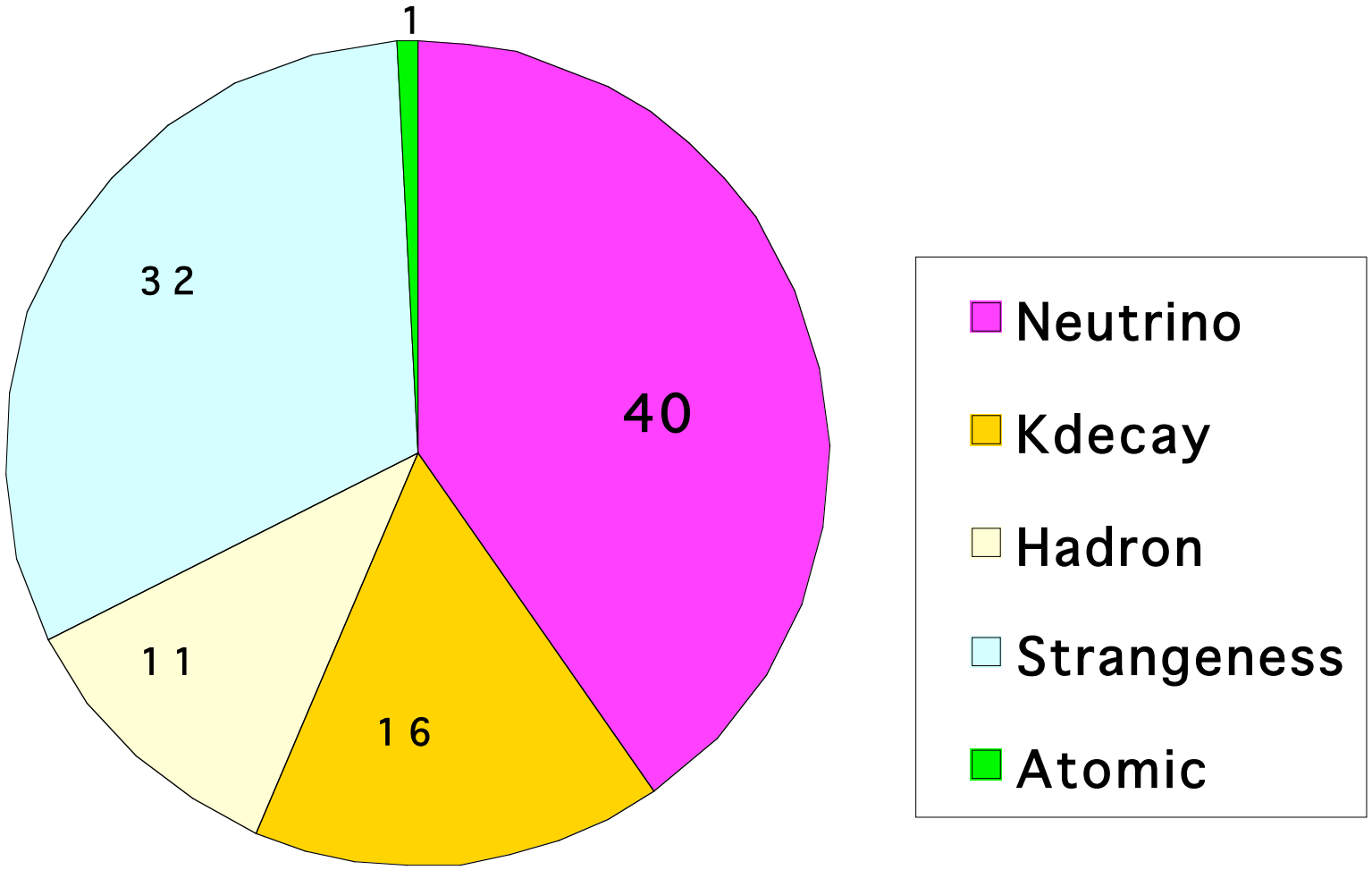
Fiscal Year

FY99－FY04(plan) total Slow 1406 shifts
Fast 2012 shifts

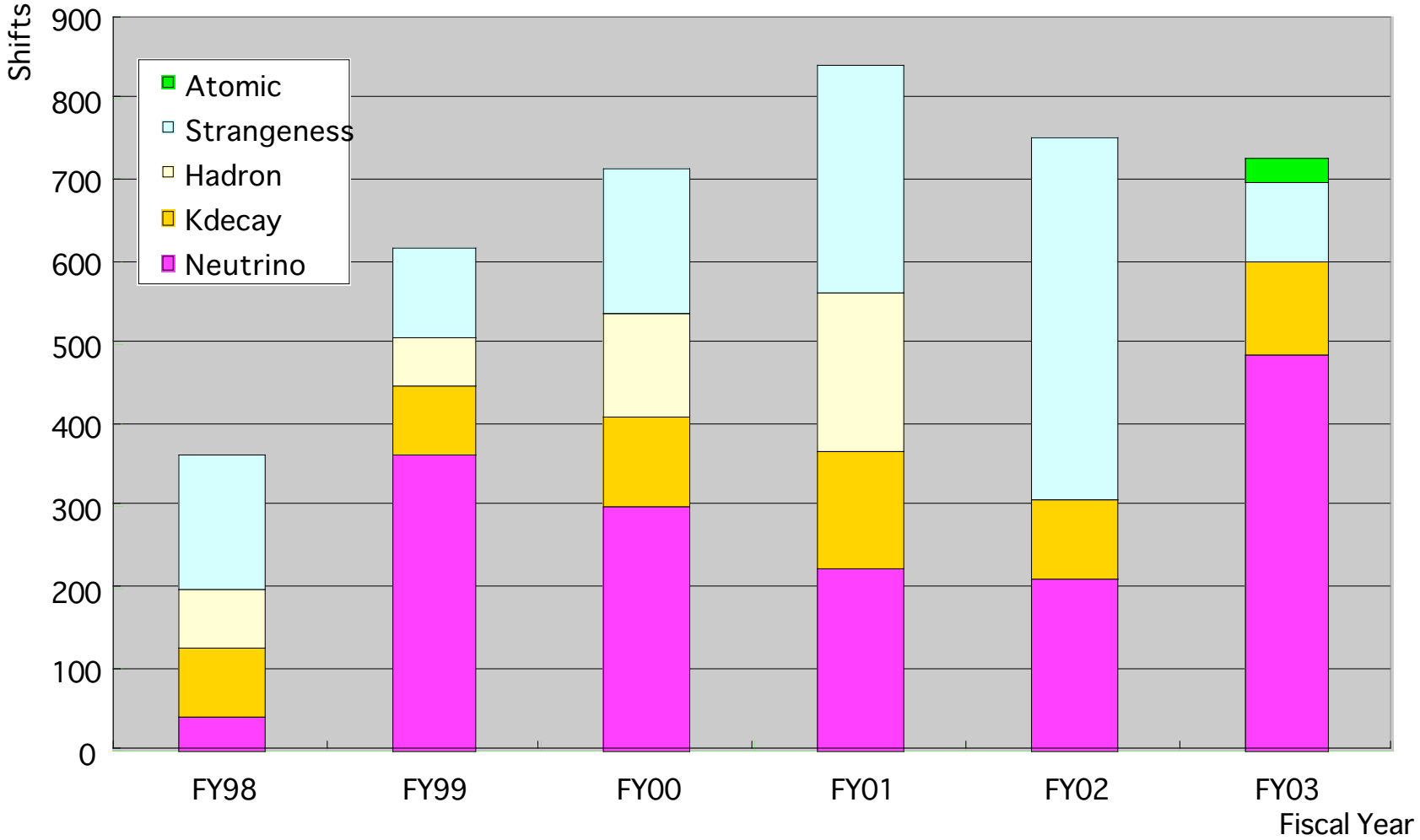
Number of Experiments for Each Category



Total Executed Shifts from FY1999 to FY2003 [%]



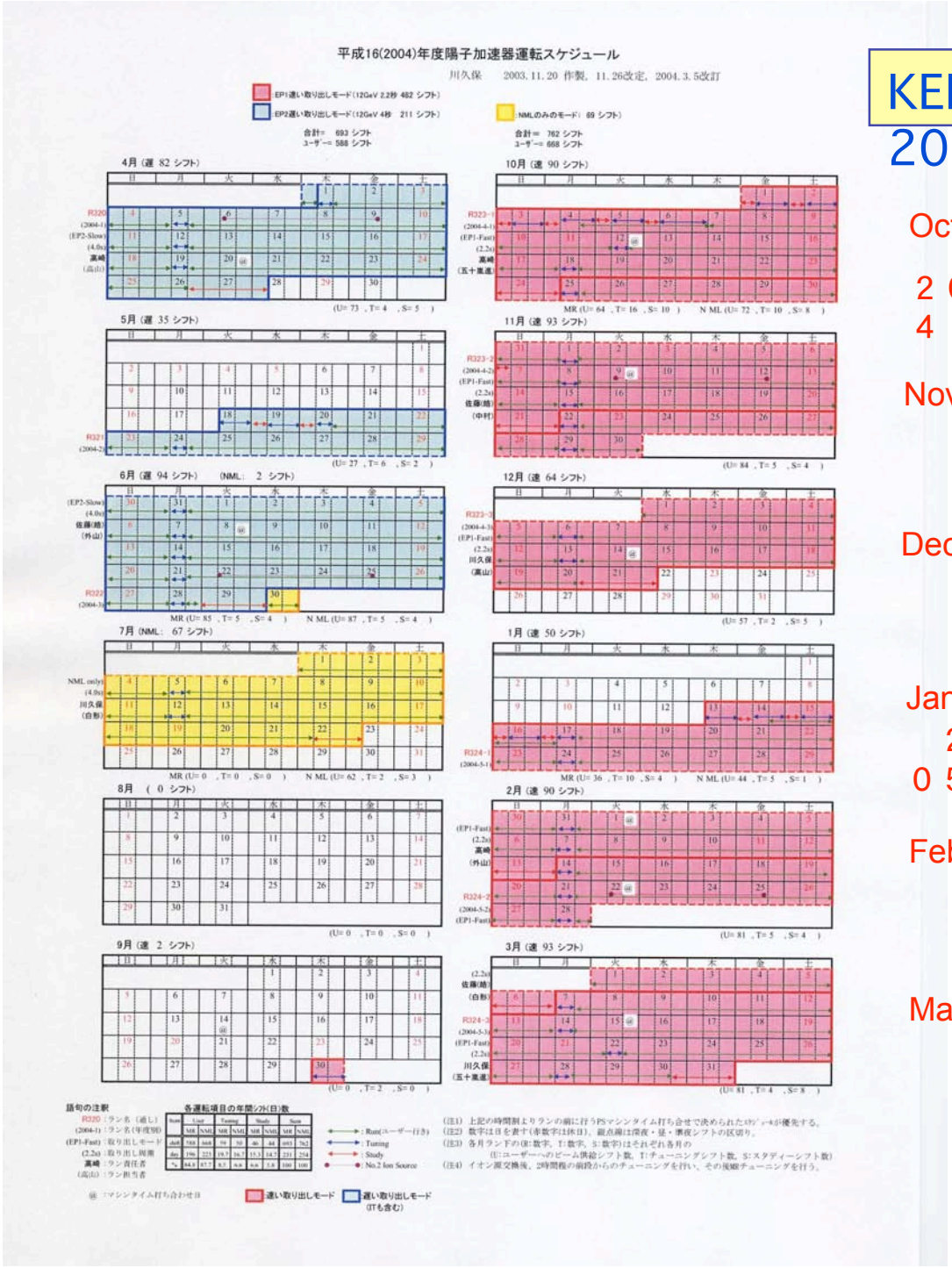
Allocated Machine Time for Each Category of Experiments



KEK-PS Experiments in JFY2004 - JFY2005

- Neutrino physics
  - E362 Long Baseline Neutrino Oscillation Experiment: currently scheduled until end of March 2005
- K Decay
  - E391a Study of the $K_L \rightarrow \pi^0 \nu\nu$ Decay: 200 shifts extension requested
- Hadron and Nuclear Physics
  - E548 Study of Kaonic Nuclei by the (K^-,p) Reactions: 30+3 shifts approved
  - E549 Confirmation of Nuclear Kaonic State and Search for its Excited State: conditionally approved (90 shifts requested)
  - E559 High-Resolution Spectroscopy of Penta-Quark Θ^+ : conditionally approved (80 shifts requested)
- Constraints
  - No experiments can run simultaneously with K2K.
  - Slow extracted protons cannot be shared between the East and North Halls
  - K5 and K6 (SKS) can be operated simultaneously.
  - April - June: ~10 weeks, 180 shifts physics run
  - October - December: ~12 weeks, 215 shifts physics run
  - January - March: ~11 weeks, 195 shifts physics run

KEK-PS schedule (JFY 2004)



October

2 0 0 4

November

December

January

2 0 0 5

February

March

PS Schedule for JFY 2004

Cycle Term User

04-1 :: Apr. 1 - Apr. 28, 2004 ::(slow extraction)

04-2 :: May. 18 - June 30, 2004 ::(slow extraction)

04-3 :: June 30 - Jul. 23, 2004::(Booster)

04-4-1 :: Sep. 30 - Oct. 25, 2004 ::(fast extraction)

04-4-2 :: Oct. 25 - Nov. 22, 2004 ::(fast extraction)

04-4-3 :: Nov. 22 - Dec. 22, 2004 ::(fast extraction)

04-5-1 :: Jan. 13 - Feb. 14, 2005 ::(fast extraction)

04-5-2 :: Feb. 14 - Mar. 7, 2005 ::(fast extraction)

KEK-PS External Review 1990

- Critical comments:
  - Particle physics experiments at KEK-PS in the 80's were topical but "one-shot" type rather than systematic and programmatic. Follow-up efforts needed.
  - Limited use of new detection technologies.
  - Low international visibility.
- Recommendations
  - Maintain flexibility to pursue topical experiments.
  - Develop a small number of well focused and selected projects. Pursue them with the necessary implementation of detector systems taking full advantage of new technology.

KEK-PS External Review 1994

✓: respected or achieved at least partly
✖: not respected or achieved

- Recommendations:
  - ✓ Encourage the neutrino oscillation experiment to start in 1998 and complete data taking with 10^{20} protons hopefully in 1-2 year run.
  - ✓ Higher priority for E246 (T-violation) ; lower priority for E162 (CP-violation)
  - ✓ Among strangeness experiments at KEK-PS, the SKS work on hypernuclei likely to have the highest priority.
  - ✖ Experiments with d and α beams generally encouraged.
  - ✓ Many groups move too quickly from one uncompleted experiment to the next new experiment which requires substantial equipment construction. KEK management and PAC must provide a guide to conduct thorough studies of "hints" explored in one experiment before that group moves on to the next.
  - ✖ Encourage the formation of a strong user's association.

KEK-PS External Review 2000

✓: achieved or will be achieved

- Recommendations:
  - ✓ Give the first priority to the K2K experiment. The proposed detector upgrade and beam time of 1×10^{20} pot (protons on target) should be approved.
  - ✓ Give a reasonable amount of time (about 25%) to slow extracted beam allowing timely completion of on-going experiments and additional beam time for programs including hypernuclei experiments using SKS. Availability of test beams is also an important factor.
  - ✓ Give E391 a priority assuming it successfully passes the laboratory review on the feasibility of the proposed detector construction in a timely manner. Then the laboratory should make an effort to deliver beam time of 50 days to E391.

KEK-PS External Review 2004

- Evaluation of the achievements of KEK-PS experiments in 2000 – 2004
- Evaluation of the achievements of the KEK-PS operation and service for experiments.
- Evaluation of the plan to convert both the experimental activities and resources at the KEK-PS to those at J-PARC.
- Recommendations on
  - how the current activities at the 12-GeV PS should be completed
  - how these activities should be maintained and continued to experiments at the J-PARC 50 GeV PS.