- Photon veto

  Photonuclear reaction

  Sampling fluctuation

  Detector inefficiencies (pile-up, hole)

- Charged veto

  π-absorption

  Turning into γ:

  $\pi^- p \to \pi^0(\gamma)n$, $e^+e^- \to \gamma\gamma$

  Slow to be out of time window

  Detector inefficiencies (pile-up, hole)

Process	Modes	Main
Photon veto	$\pi^0\pi^0$,$\pi^0\pi^0\pi^0$,$\pi^0\gamma\gamma$	$\pi^0\pi^0$
Kinematics	$\gamma\gamma$	$\gamma\gamma$
$\overline{Chrg}$+π^0	$\pi^+\pi^-\pi^0$, $\pi^\pm l^\mp\nu\pi^0$	$\pi^+\pi^-\pi^0$
$\overline{Chrg}$+γ "γ"	$\pi^-e^+\nu\gamma$, $\pi^+\pi^-\gamma$, $e^+e^-\gamma$	$\pi^-e^+\nu\gamma$
$\overline{Chrg}$+"γ" "γ"	$\pi^-e^+\nu$,$\pi^-\pi^+$	$\pi^-e^+\nu$
Beam decays	$\Lambda \to \pi^0 n, K^- \to \pi^-\pi^0, \pi \to \pi^0 e\nu$	$\Lambda \to \pi^0 n$
Interactions	n, K_L, γ, π^-, K^-	$n \to \pi^0$
Accidentals	n, K_L, γ	n, K_L, γ

- $K_L \to \pi^0\pi^0$
  Photon veto, Kinematics
- $K_L \to \pi^0\pi^+\pi^-$
  Charge veto, Kinematics
- $K_L \to \gamma\gamma$ (will be used for calibration)
  Kinematics $E^*_\gamma, m_{\gamma\gamma}, E^*_{\pi^0}, \theta^T_{12}$
- $K_L \to \pi^- e^+ \nu$ $(\pi^- p \to \pi^0 n, e^+e^- \to \gamma\gamma)$
  Charged veto $e^+ = 3 \times 10^{-4}, \pi^- = 6 \times 10^{-4}$ $for\ E_{th} = 1 MeV$
  Kinematics $E^*_{\pi^0}$(missing mass$\sim$0), $m_{\gamma\gamma}$
  π^0 cluster finding
- $K_L \to \pi^- e^+ \nu\gamma$ $(\pi^- d \to nn, e^+e^- \to \gamma\gamma)$
  Charged veto, Kinematics
- Accidentals (K_L, γ, n)
  Vertex cut those coming from the beam hole
  TOF separating γ and n
  PID in the preradiator separating K_L and n
- $(\Xi \to)\Lambda \to n\pi^0$
  Low energy Decays before reaching the decay region
  Vertex cut ones produced in the wall
- n interaction
  Vacuum, TOF, Low energy

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December 11, 2000
@KOPIO collab. meeting

Background issues

Can we improve the S/N ratio?

1. Charged veto

- Background reduction by straw chambers in vacuum
  70% efficiency $\Rightarrow$ Rejection$=1/(1-0.7)^2=10$.

2γ conversion

$\pi^0\nu\bar{\nu}$	S/N	$K_{\pi 2}$ even	$K_{\pi 2}$ odd	$K_{\pi 3}$	$K_{e3\gamma}$
56.6	0.87	8.4	18.0	6.8	31.7
50.1	1.03	6.9	9.7	5.8	26.1
38.9	1.17	3.7	4.5	5.3	19.8
26.2	1.50	1.6	1.0	1.9	13.0

2γ conversion and chamber veto (R=10)

$\pi^0\nu\bar{\nu}$	S/N	$K_{\pi 2}$ even	$K_{\pi 2}$ odd	$K_{\pi 3}$	$K_{e3\gamma}$
56.6	1.87	8.4	18.0	0.7	3.2
50.1	2.53	6.9	9.7	0.7	2.6
38.9	3.64	3.7	4.5	0.5	2.0
26.2	6.39	1.6	1.0	0.2	1.3

$K_{\pi 2}$ becomes the dominant background and S/N improved.

- Concerns about the straw chamber option
  - Neutron background hitting the straw ($nA \to nA\pi^0$)
    $R=10^{12}$ from collimation and vertexing
    * Requires upstream active collimator?
    * How close could the straw chamber be?
      $\Rightarrow$ Detailed MC study required.
  - Accidental backgrounds in the straw (X-rays, neutrons)?
    * E787 beam chamber veto works (CF_4 gas).
    * Beam test may be required (KEK beam test?)
  - Do we need chambers in the downstream region as well?
    $\Rightarrow$ Detailed MC required.

- $K_{e3\gamma}$ rejections that are not counted here:
  - Kinematic suppression of $K_{e3\gamma}$ (Zeller)
    Chisquare of the vertex fit is bad for $K_{e3\gamma}$ because
    (a) angular kick due to e^+e^- anihilation and
    (b) energy of the photon which converts first is lower.
    $\Rightarrow$ Detailed prerad MC is needed as Mike did.
  - $R_{e^+} = 3 \times 10^{-5}/E_{e^+}$ (Zeller)
    A factor of 3.3 better that what is assumed above.
  - Additional rejection from residual energy of π^- absorption.

2. Kinematics

Possibility of improving energy resolution (Bryman,Kudenko)

2γ conversion and chamber veto (R=10)

$\pi^0\nu\bar{\nu}$	S/N	$K_{\pi 2}$ even	$K_{\pi 2}$ odd	$K_{\pi 3}$	$K_{e3\gamma}$
56.6	1.87	8.4	18.0	0.7	3.2
50.1	2.53	6.9	9.7	0.7	2.6
38.9	3.64	3.7	4.5	0.5	2.0
26.2	6.39	1.6	1.0	0.2	1.3

2γ conversion and chamber veto (R=10) and $dE/E = 2\%/\sqrt{E}$

$\pi^0\nu\bar{\nu}$	S/N	$K_{\pi 2}$ even	$K_{\pi 2}$ odd	$K_{\pi 3}$	$K_{e3\gamma}$
59.1	2.87	4.6	13.2	0.4	2.4
46.7	5.19	3.5	3.6	0.3	1.6
34.7	9.64	1.4	0.9	0.2	1.1
27.6	10.22	0.7	0.9	0.1	1.0

- $\times 2$ improvement in the S/N ratio.
- S/N improvement gets better with tighter cut:
  With 70% of the nominal acceptance, S/N=10.

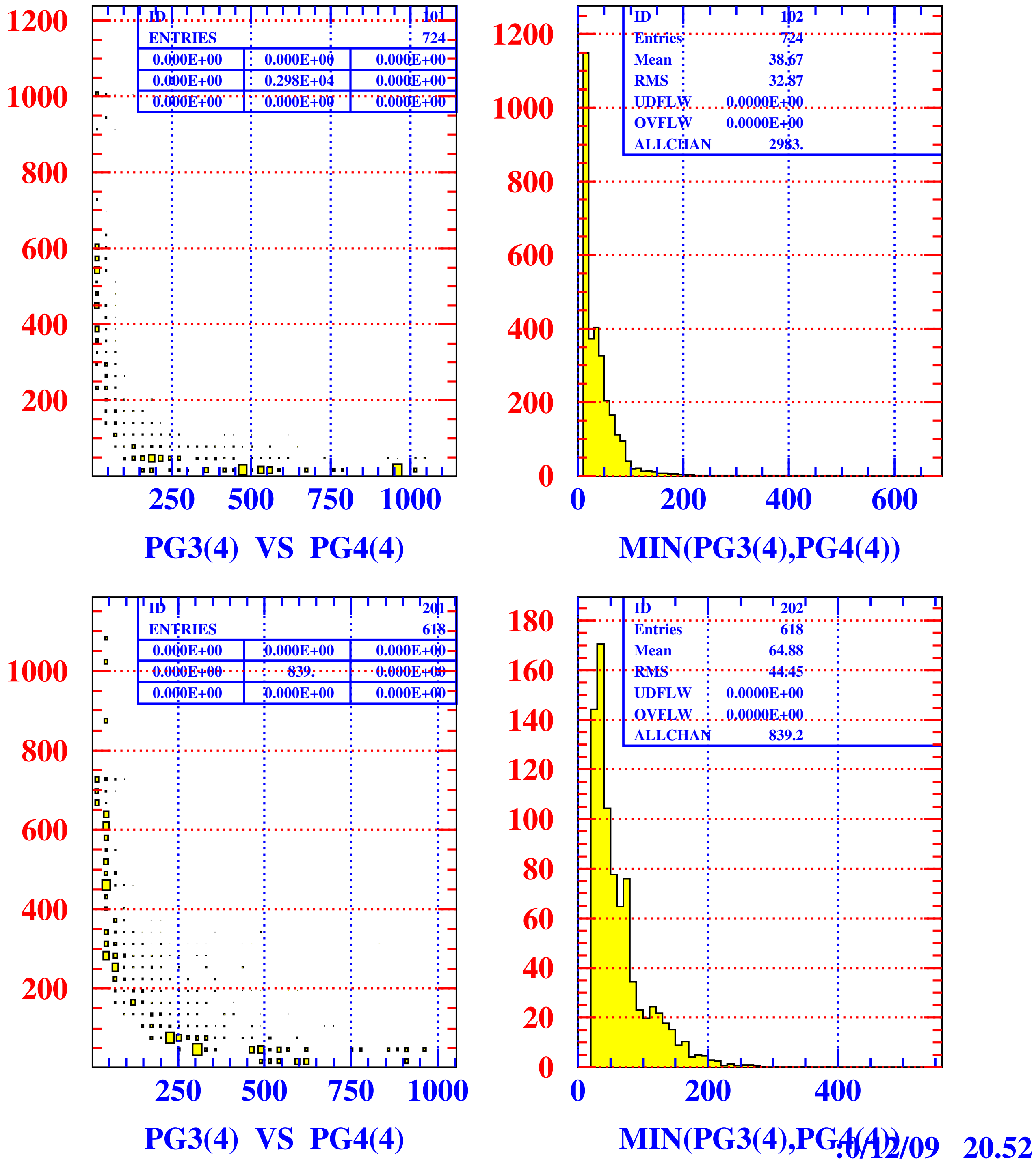
3. Photon veto

Efficiency of lower energy photons ($E < 100MeV$) should be higher, if it is dominated by sampling fluctuations.

$\times$ 2 improvement of PV for $E < 100MeV$

	$K_{\pi 2}$ even		$K_{\pi 2}$ odd	
$\pi^0\nu\bar{\nu}$	default PV	Improved	default PV	Improved
56.6	8.4	4.4	18.0	10.2
50.1	6.9	3.6	9.7	5.7
38.9	3.7	1.9	4.5	2.7
26.2	1.6	0.8	1.0	0.7

- $\times$ 2 improvement in S/N ratio
  Consistent with one of E_γ be less than 100MeV.
- Is the beam hole effect still negligible?
  $\Rightarrow$ Full MC needed.
- Why E787 got much worse efficiency for lower E_γ?
  $\Rightarrow$ Requires investigation.
- Any improvement for higher E_γ as well?
  Residual nuclear excitation after photonuclear?
  $\Rightarrow$ Hard to answer without measurement.



ID 101
ENTRIES 724
0.000E+00 0.000E+00 0.000E+00
0.000E+00 0.298E+04 0.000E+00
0.000E+00 0.000E+00 0.000E+00
PG3(4) VS PG4(4)
ID 102
Entries 724
Mean 38.67
RMS 32.87
UDFLW 0.0000E+00
OVFLW 0.0000E+00
ALLCHAN 2983.
MIN(PG3(4),PG4(4))
ID 201
ENTRIES 618
0.000E+00 0.000E+00 0.000E+00
0.000E+00 839. 0.000E+00
0.000E+00 0.000E+00 0.000E+00
PG3(4) VS PG4(4)
ID 202
Entries 618
Mean 64.88
RMS 44.45
UDFLW 0.0000E+00
OVFLW 0.0000E+00
ALLCHAN 839.2
MIN(PG3(4),PG4(4))
10/12/09 20.52

What comes next on background/sensitivity ?

- Detailed MC studies
  $K_{e3\gamma}$ kinematic rejection
  Beam hole charged veto
  Beam hole photon veto
  Straw chamber geometry:
    Neutron halo? $(nA \rightarrow \pi^0 nA$
    Upstream active collimator?
- Decisions for the base design
  Charged veto
  Photon veto
  Energy resolution
- Standard Monte Carlo analysis packages to be prepared.
- Preparation for TDR.