ν_e analysis statistics and paper status

S. Vasina (Zemskova)

JINR, Dubna, Russia

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Content

The update of the expected background since last PC Meeting:

- The 0μ sample used for the beam contamination normalization updated ($\sim$ 3% reduction , 31.7$\rightarrow$30.8)
- $\tau \rightarrow e$ location and misidentification efficiency was reevaluated by Giuliana (0.7$\rightarrow$0.9)

The ν_e paper draft has been send to internal referees this morning and there are some issues to clarify:

- The systematic error estimation for each bg source
- It is possible to put an upper limit on $sin^2(2\theta_{13})$ since the data is in better agreement with 3-flavour scenario expectation (very very preliminary result is $sin^2(2\theta_{13}) < 0.22$ at 90% C.L. under assumption δ=0 and negligible matter effect, to specify with $\delta = 1.35/\pi$ and matter effect)

The update of expected BG to ν_e analysis

Energy cut, GeV	10	20	30	40	50	No cut
ν_e beam contamination	0.6	4.6	10.2	15.7	20.0	30.8
BG from π^0	0.1	0.4	0.5	0.5	0.5	0.5
BG from $\tau \to e$	0.1	0.5	0.6	0.7	0.8	0.9
Total expected BG	0.8	5.5	11.3	16.9	21.3	32.2
ν_e via 3-flavour oscillation	0.3	1.1	1.8	2.3	2.4	2.7
Expected spectrum in case of 3 flavour oscillations	1.1	6.6	13.1	19.2	23.7	34.9
Data	1	7	13	19	21	34

15th March PC - 1185 events were used (backup slides): The number of located 0μ events in the 1st and 2nd bricks. The cuts on event type (CONTAINED or BORDERSOFTNC only) and CS status (BLACK_CS and WRONG_BRICKHANDLING_CS are excluded).

Update: 1151 events 0μ sample - the additional cut event is not identified as ν_e

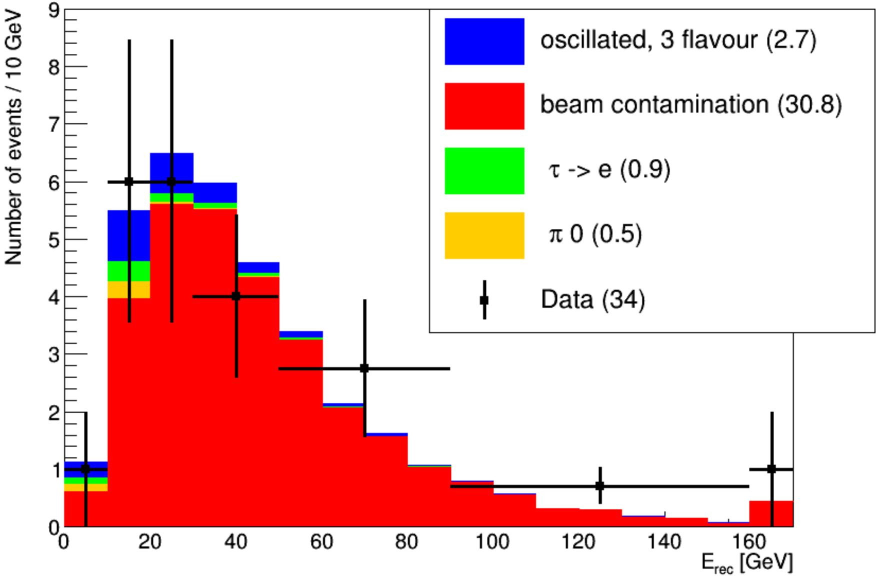
beam contamination: $\sim$3% sample reduction since last PC

π0 bg: no visible changes

$\tau \to e$ bg: The $\tau \to e$ location and DS efficiency were reevaluated by Giuliana. Out of $\sim$ 10k events - 1322 are identified as $\tau \to e$ and 1316 are identified as ν_e BG. According to slide 6, 0.86 $\tau \to e$ are expected -> 0.856 bg is expected

indico.cern.ch/event/618894/contributions/2513197/attachments/1427866/2191584/20170315_PCMeeting_MarginalEv_Galati.pdf

Preliminary energy spectrum of ν_e candidates (2008-2012 data)



The upper limits and sensitivities on N_{osc} and $P_{\mu e}$ (under assumption $P_{ee} = 1$) at 90% C.L.

Energy cut	Upper limit N_{osc} ($P_{\mu e}$, $P_{ee} = 1$)		Sensitivity N_{osc} ($P_{\mu e}$, $P_{ee} = 1$)	
	Bayes	F&C	Bayes	F&C
10 GeV	3.37 (0.0272)	3.56 (0.0288)	3.37 (0.272)	3.57 (0.00288)
20 GeV	6.76 (0.0061)	7.27 (0.0066)	5.81 (0.0053)	5.99 (0.0054)
30 GeV	8.57 (0.0034)	9.22 (0.0037)	6.90 (0.0028)	6.71 (0.0027)
40 GeV	10.01 (0.0037)	11.10 (0.0037)	8.62 (0.0032)	8.62 (0.0028)
50 GeV	9.31 (0.0033)	9.22 (0.0033)	9.35 (0.0033)	9.22 (0.0033)
No cut	11.97 (0.0038)	13.84 (0.0044)	10.48 (0.0033)	11.23 (0.0036)

$N^{osc}_{\nu_e} = POT \times Mass \times \int \epsilon_{locID} \times \sigma_{\nu_e} \times P^{obs}_{\mu e} \times flux_{\nu_\mu} dE$
($POT \times Mass$ - is evaluated from the normalization sample)
The sensitivities and upper limits on N_{osc} are evaluated with the sys. uncertainties, see next slide

Evaluation of the errors for different BG sources

The source of errors (from the 1st ν_e paper):

- Beam contamination: "Conservatively, a 10 % systematics, introduced by the hadron production model in the computed fluxes, can be assessed when averaging over the angular acceptance of $\sim$ 30 mrad of the beam optics."
- $\pi 0$: "In 1106 neutrino interactions, γs converting in the second and third lead plates after the interaction vertex were searched for; 1 event passes the criteria for the ν_e search. This result was converted into the probability to observe background ν_e candidates due to γconversions in the first lead plate, taking into account the radiation length."
- $\tau \rightarrow e$: "... was computed by MC simulation assuming the 3-flavour $\nu_\mu \rightarrow \nu_\tau$ oscillation ..."

We evaluate in the following way:

- For each source (BG_{beam}, $BG_{\pi 0}$, $BG_{\tau \rightarrow e}$ or N_{osc}):
  $N_{0-E} \pm Nsyst_{0-E} = N_{0-E} \pm N_{0-10GeV} * 0.2 + (N_{0-E} - N_{0-10GeV}) * 0.1$
- For the BG_{sum} (BG_{beam}+$BG_{\pi 0}$+$BG_{\tau \rightarrow e}$):
  $Nsyst^{summ}_{0-E} = \sqrt{(Nsyst^{beam}_{0-E})^2 + (Nsyst^{\pi 0}_{0-E})^2 + (Nsyst^{\tau \rightarrow e}_{0-E})^2}$

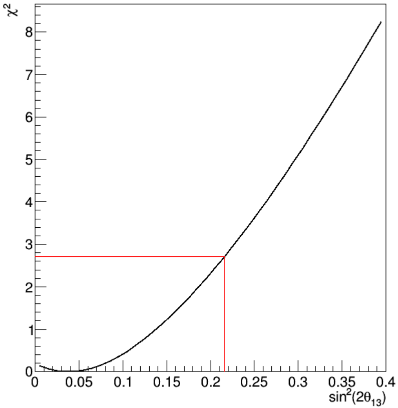
For example for 30 GeV cut:

$$N^{3flbg}_{0-30GeV} = \sqrt{(0.6 * 0.2 + (10.2 - 0.6) * 0.1)^2 + (0.1 * 0.2 + (0.5 - 0.1) * 0.1)^2 + (0.1 * 0.2 + (0.6 - 0.1) * 0.1)^2}$$

Is this a correct way for the errors evaluation?

The possible interpretation of the result in 3-flavour paradigm

Now the number of detected ν_e candidates is $34^{+6.85}_{-5.77}$ (stat.). Bg to 3-flavour - 32.2 ± 3.2 we can try to evaluate $sin^2(2\theta_{13})$



Very preliminary 3-flavour scenario (assumption: $\delta = 0$, no matter effect taken into account)
$sin^2(2\theta_{13}) = 0.0378^{+0.1004}_{-0.0378}$
or
upper limit on $sin^2(2\theta_{13}) = 0.22$ at 90% C.L.
(the following PDG value is $sin^2(\theta_{13}) = 0.0214(0.0218)$ for $\Delta m^2 > 0(\Delta m^2 < 0) \rightarrow sin^2(2\theta_{13}) \sim 0.084$)

Summary

- BG expectation is updated
  - Normalization sample was reduced $\sim$ 3% since last PC
  - $\tau \rightarrow e$ BG update (Giuliana)
- First version of ν_e draft was sent to internal referees this morning
  - There are some questions about the error estimation
  - The interpretation of the results in 3-flavour scenario could be added