PC Overview

Naples Meeting, 25-26/Oct./2016

M. Komatsu

PC meetings since March

- PC meeting 12/5/2016
  - https://indico.cern.ch/event/527558/
  - Multiplicity Distributions in CC Interactions : Cagin
  - Search for the neutrino disappearance in OPERA : Budimir
  - nue analysis update : Svetlana
  - Update on the lepton number measurement : Giuliana
  - Short decay search : Mustafa
- PC meeting 9/6/2016
  - https://indico.cern.ch/event/538383/
  - nue analysis summary : Svetlana
  - Preliminary oscillation analysis : Matteo
  - Electron energy measurement report : Frank
  - Search for the neutrino disappearance in OPERA : Budimir
  - Update on the lepton number measurement : Giuliana
  - Update of hadron interaction analysis : Mizusawa
  - Updates on annual modulation : Nicoletta, Andrea
  - Outline of SPSC presentation : Giovanni

PC meetings since December

- PC meeting 29/6/2016
  - https://indico.cern.ch/event/545561/
  - nue anlysis statistics and plots : Svetlana
  - nue oscillation analysis result : Matteo
  - numu disappearanc: Budimir
  - Draft slides for Neutrino 2016 : Dominique
- PC meeting 28/7/2016
  - https://indico.cern.ch/event/558967/
  - nue oscillation analysis result : Matteo
  - Marginal event analysis : Giuliana
  - Electron energy reconstruction : Frank
- PC meeting 13/9/2016
  - https://indico.cern.ch/event/567633/
  - Electron neutrino update and prospect : Svetlana and Matteo
  - Numu disappearance analysis update : Budimir
  - Marginal event analysis update : Giuliana
  - Update on electron energy measurement : Frank

Svetlana and Matteo

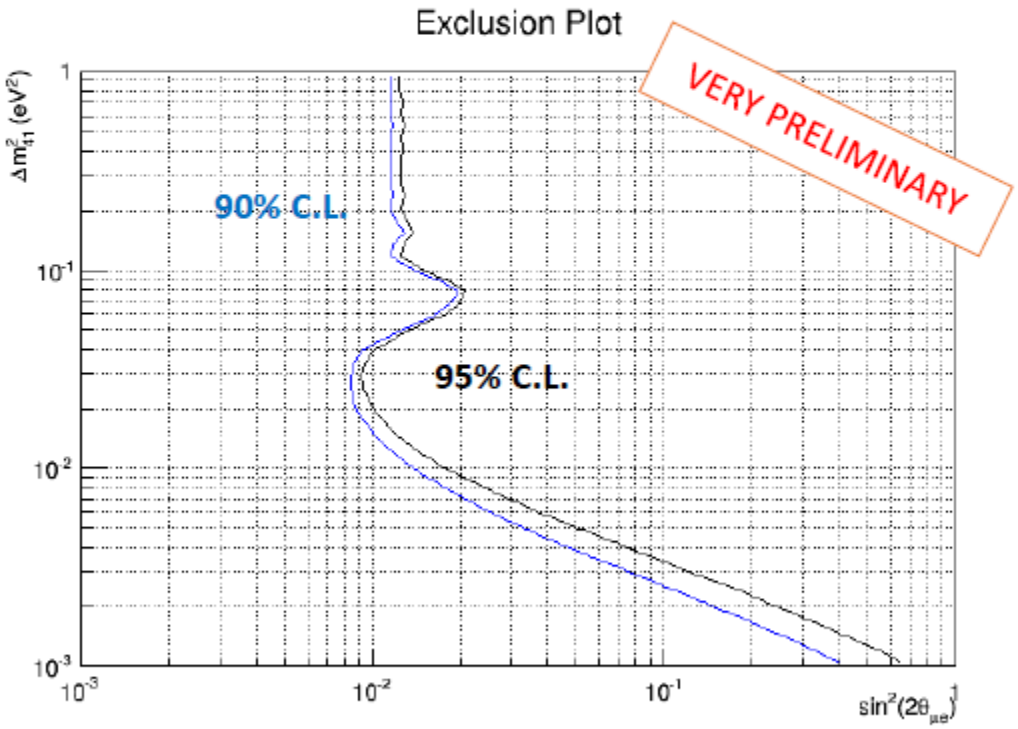
NUE ANALYSIS

Story on nue analysis

- Very preliminary exclusion @ 9th June
  - $\sin^2(2\theta)$ was 0.012 @ high dm^2 without energy cut.
- Updated exclusion @ 29th June
  - $\sin^2(2\theta)$ was about 0.1 @ high dm^2 with 20 GeV energy cut.
- Due to the lack of confidence, we decided to drop exclusion from Neutrino 2016 presentation.
  - We were short in time to get concrete result.
- Sensitivity optimization @ 28th July
  - Best energy cut was not 20 GeV.

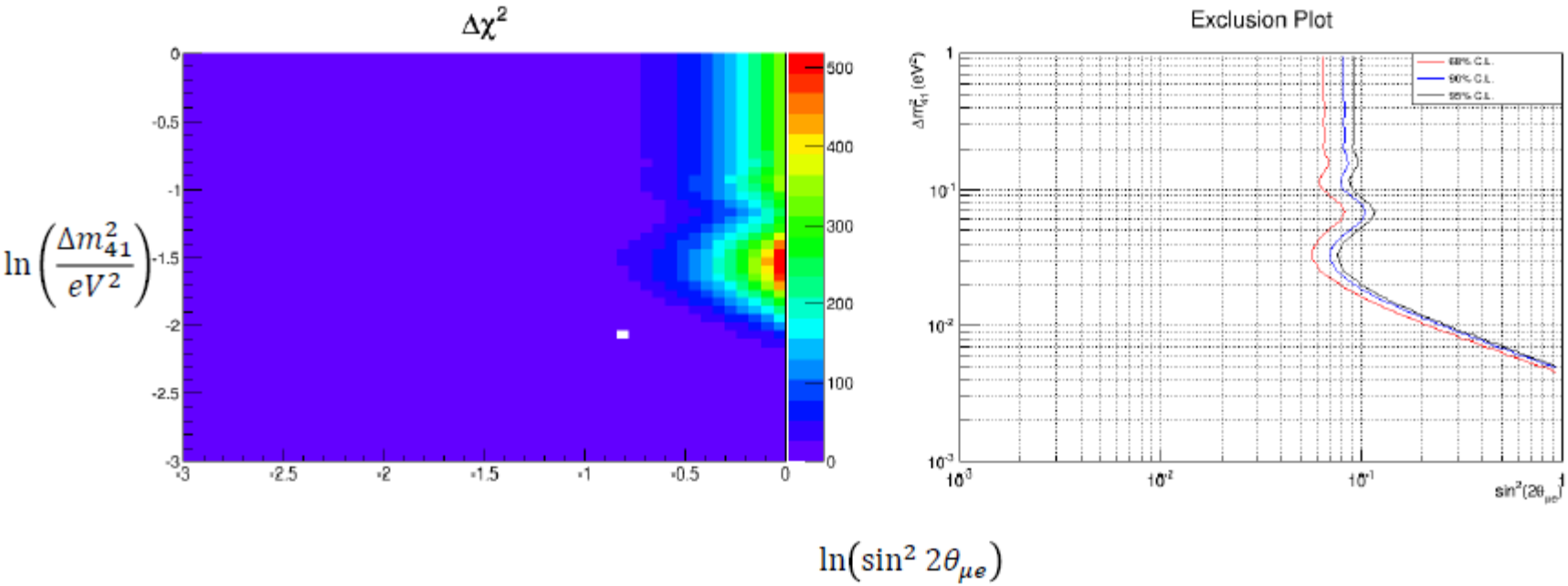
Matteo @ PC 9 June

Exclusion plot



Matteo @ PC 29 June

Preliminary results



Slide in Neutrino 2016

ν_e appearance search

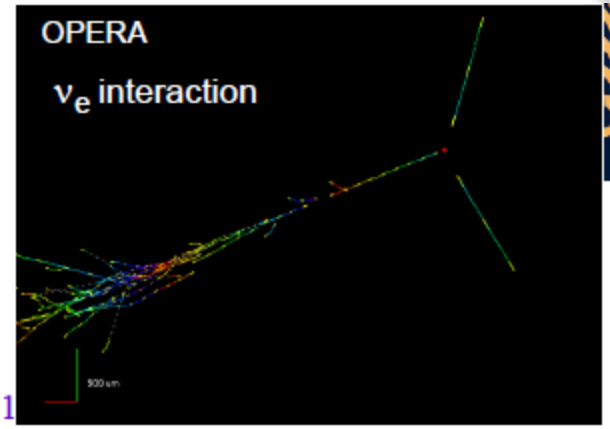
2008-2012 sample (17.97 x 10^{19} p.o.t.)

→ Observed 34 ν_e events

Expected ν_e events :

ν_e beam contamination 36.7 ± 5

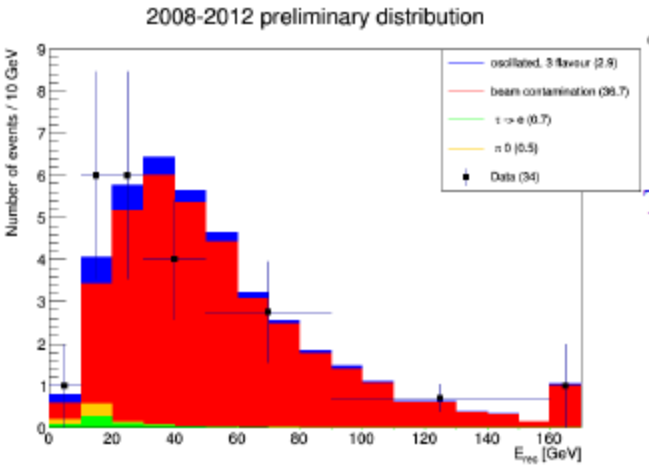
Background $\tau \rightarrow e$ + mis-id'd π^0 1.2 ± 0.1

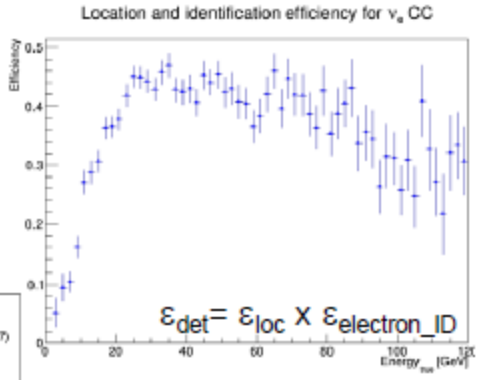


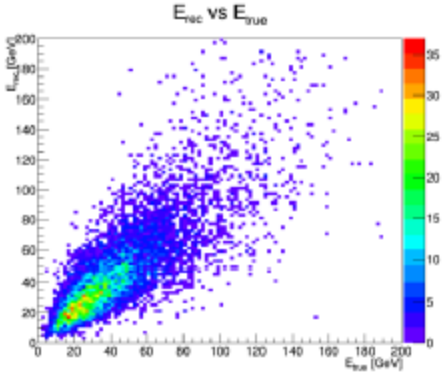
From 3-flavour oscillation:

$\nu_\mu \rightarrow \nu_e$ 2.9 ± 0.4 evts

$(\sin^2(2\theta_{13}) = 0.098)$







To increase signal-to-background ratio: E < 30 GeV

13 observed events for

9.2 ± 1 background expected + 1.4 ± 0.2 (from $\nu_\mu \rightarrow \nu_e$)

=> Good agreement with expected number of events within the 3 flavour ν framework

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Matteo @ PC 28 July

Sensitivity optimization

The sensitivity was maximized over several selections based on the reconstructed energy. The table shows the data used for computation.

Normalization on expected $\nu_e + \overline{\nu}_e$ from beam without oscillation

Cut on rec. energy :	10 GeV;	20 GeV;	30 GeV;	50 GeV	**No cut**
found nue candidates:	1	7	13	21	34
osc(osc-beam) :	0.4(0.1)	2.8(0.7)	9.2(1.4)	14.9(1.7)	39.5 (3.0)
no osc(beam) :	0.3	2.1	7.8	13.2	36.5
tau->e :	0.1	0.4	0.5	0.6	0.7
pi0 :	0.1	0.3	0.4	0.4	0.5
Expected background					
bg(beam+pi+tau->e) :	0.5	2.8	8.7	14.2	37.7

For sensitivity

N.B. These data have a slight difference with respect to the more updated numbers

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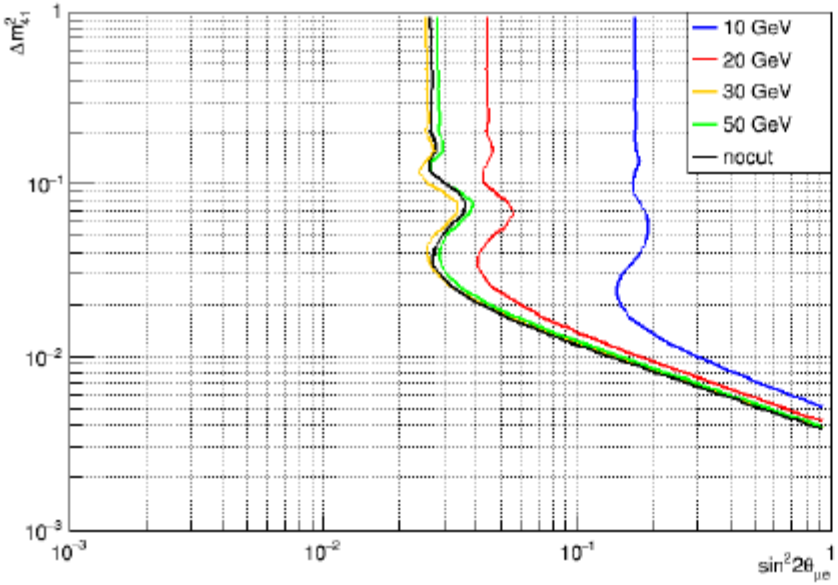
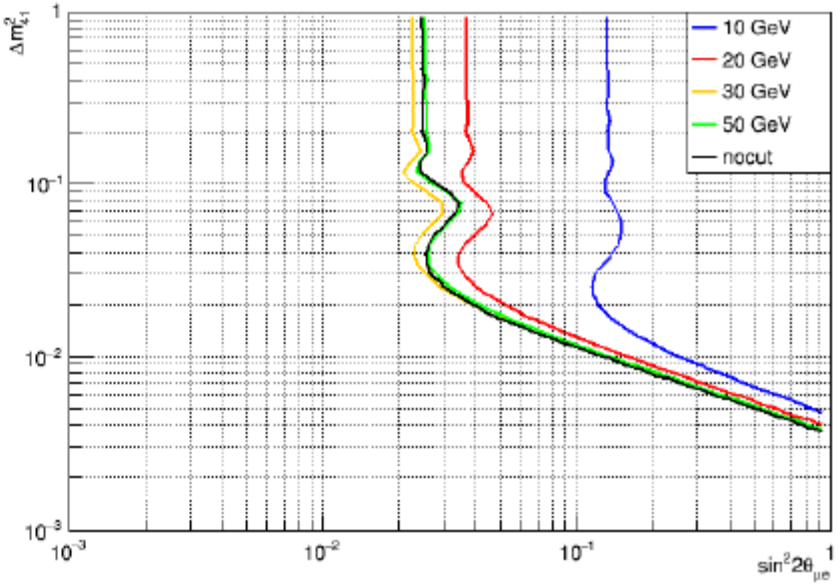
Matteo @ PC 28 July

Sensitivity optimization

95% C.L. exclusion



90% C.L. exclusion



The optimal sensitivity is for cuts at high energy , $E_{cut} = 30\ GeV$ or «no cut» ; but for a final choice we have to run with updated numbers.

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Svetlana @ PC 28 July

Numbers of expected signal, BG and νe found with different energy cuts

Ecut, GeV	10	20	30	40	50	all
pi0	0.11	0.41	0.45	0.46	0.48	0.50
Tau->e	0.10	0.37	0.50	0.57	0.61	0.70
Beam cont	0.40	3.25	8.26	14.18	19.49	36.72
Bg to 3 flavour	0.61	4.03	9.21	15.21	20.58	37.92
osc	0.20	0.82	1.42	1.84	2.12	2.86
Osc/Bg to 3 flavour	0.328	0.203	0.154	0.121	0.103	0.075
Bg to non-stand	0.81	4.85	10.63	17.05	20.70	40.78
Data	1	7	13	19	21	34

Svetlana @ PC 28 July

Plan of νe article: 1st article and difference

1st νe article:

Contents

Similar to the 1st νe article:

- detector
- beam
- data taking
- emulsion scanning
- analysis chain
- CS shower hint and nue search procedure

Different from the 1st nue article:

- analyzed sample
- 0mu/1mu classification (and efficiency cause of it)
- normalization to 0mu data sample
- energy reconstruction
- analysis: separation of results and interpretation

Svetlana @ PC 28 July

Plan of νe article: proposal

- Introduction (brief description of experimental approach, reference to 1st νe article)
- Analyzed data sample (1st, 2nd bricks 2008-2012)
- Energy reconstruction in TT (and in ECC by Frank?) (brief description)
- Oscillation analysis
  - → Background to νμ->νe appearance (new normalization to 0mu sample)
  - – Measured results (spectra of found νe candidates, F&C, Bayesian upper limits and sensitivities for the new statistics)
  - → Interpretation of results (Matteo's analysis)
- Conclusions and prospectives

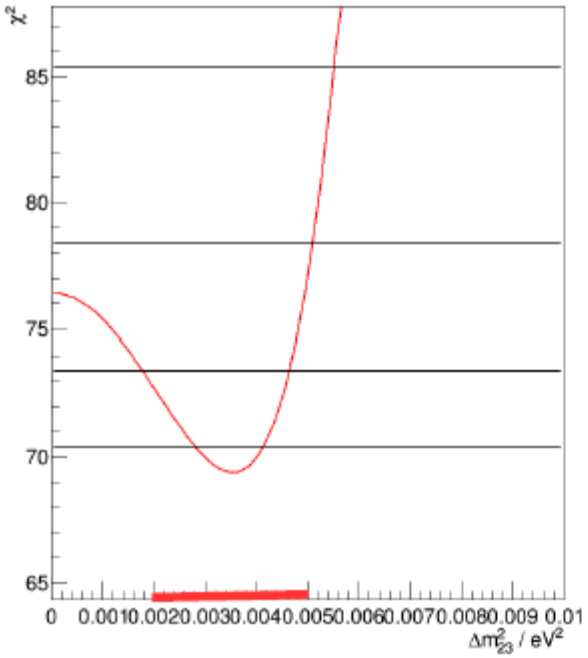
Budimir

NUMU DISAPPEARANCE

Budimir @ PC 29 June

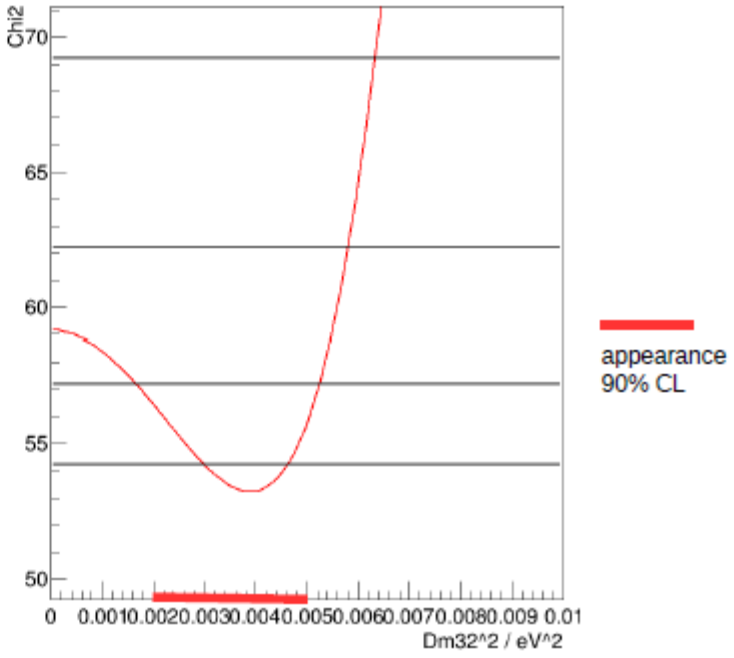
Fit results, mixing angle fixed

χ^2 in NC/CC ratio fit, $M_{\mu\mu}$ = 0.99997



chi2_min=69.377971 ndof=71
chi2_min/ndof=0.977155
(m2_low, m2_best, m2_high)
(0.002812, 0.003538, 0.004129) @ 1s
(0.001786, 0.003538, 0.004640) @ 2s
(0.000000, 0.003538, 0.005096) @ 3s
(0.000000, 0.003538, 0.005510) @ 4s

NC/All ratio, M_mu_mu = 0.99997



chi2_min=53.222128 ndof=72
chi2_min/ndof=0.739196
(m2_low, m2_best, m2_high)
(0.002997, 0.003892, 0.004616) @ 1s
(0.001663, 0.003892, 0.005241) @ 2s
(0.000000, 0.003892, 0.005802) @ 3s
(0.000000, 0.003892, 0.006317) @ 4s

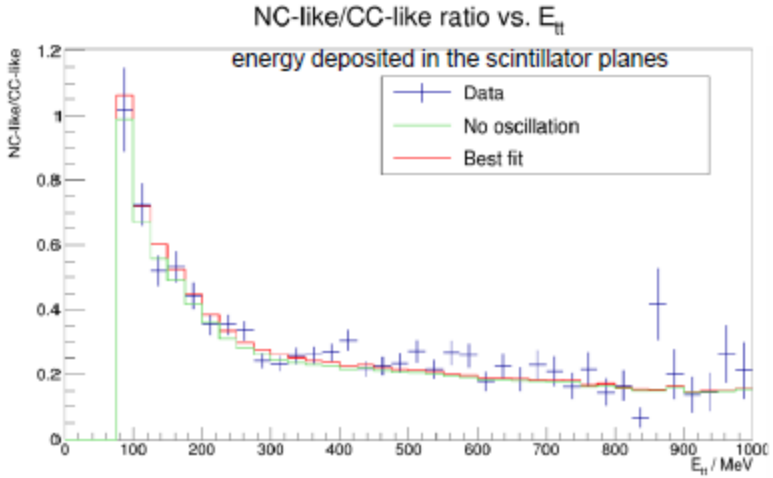
Slide in Neutrino 2016

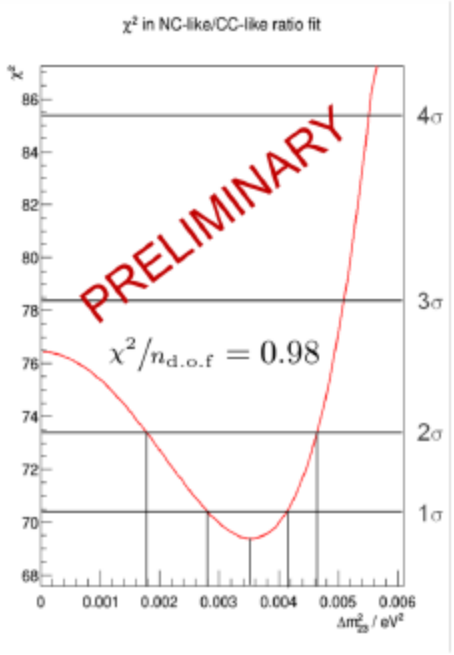
ν_μ disappearance

- Full data sample (2008-2012)
- Use of electronic detector data only and separation between CC and NC like events

a fit using NC-like/CC-like ratio in which all mixing parameters are fixed to the PDG values

but Δm_{23}^2





reweighting MC according to oscillation probability and minimizing χ^2 between MC and data

To reduce systematic effects coming from the beam uncertainty (no near detector), NC like over CC like ratio is used

systematics under study

⇒ Preliminary measurement of Δm_{32}^2

⇒ consistent with the world average and the internal OPERA appearance results

see also poster P1.035 from Budimir Kliček

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Giuliana

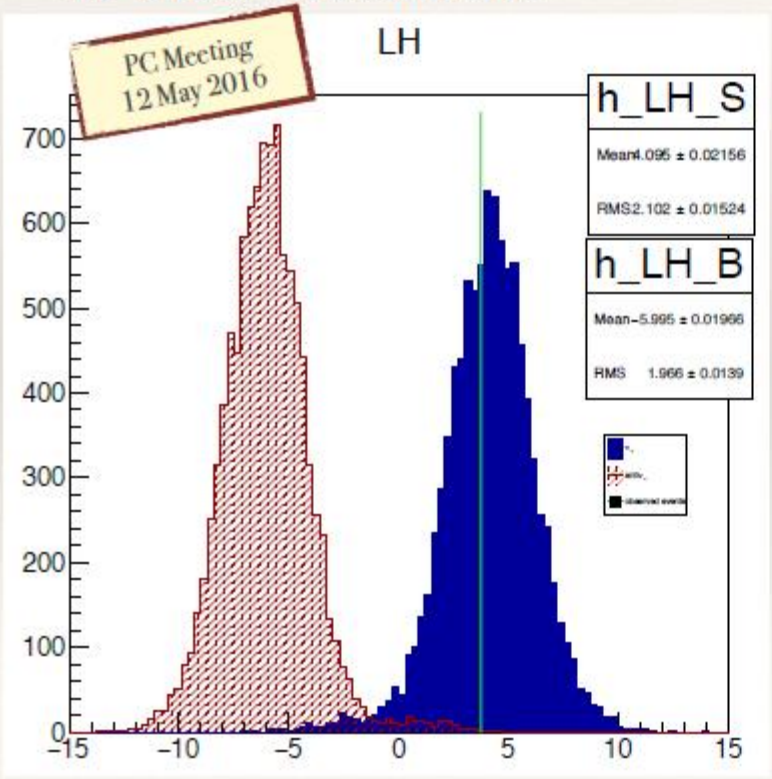
LEPTON NUMBER AND MARGINAL EVENTS

Giuliana @ PC 9 June

4) LH-ratio p-value and significance

Hypothesis to test:
H_0 = all 5 events are ν_τ-like
H_1 = all 5 events are antiν_τ-like

No assumptions about # of expected events



$$LH = -2\log\left(\frac{\mathcal{L}(x_1,x_2,x_3,x_4,x_5;\bar{\nu}_\tau)\times P(q_3;\bar{\nu}_\tau)}{\mathcal{L}(x_1,x_2,x_3,x_4,x_5;\nu_\tau)\times P(q_3;\nu_\tau)}\right)$$

$$\mathcal{L}(x_1,x_2,x_3,x_4,x_5) = \prod_{i=1}^{5} f(x_i)$$

x_i = bdt response
q_3 = muon charge

p-value = 0.0006

SIGMA = 3.24

Result: Supposing the 5 events are either all ν_τ or all anti-ν_τ, the data is compatible with the ν_τ hypothesis while the anti-ν_τ hypothesis is disfavored with a 3.2 sigma significance

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Giuliana @ PC 13 Sep.

Minimum bias criteria

* Topological
  * Kink angle > 20 mrad
  * Z_{dec} < 2600 (2 plates)
* Kinematical
  * Momentum > 1 GeV/c
  * Pt > 0.1 GeV/c
  * In case of short decay at least one primary track > 1 GeV/c satisfying IP requirement

Required analysis

* Evaluation of all kinematical variables
* Large angle track search
  * $\tan\theta < 1$ for kinematical measurement
  * $\tan\theta < 3$ for fragments
* Momentum measurement for daughter(s) and primary tracks
* No track follow down is required

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Giuliana @ PC 13 Sep.

LAB	Event ID	Type	Topology	zdec	DL	ptmiss	phi	P_t (GeV/c)	P_{dau} Total (GeV/c)	psum	kink	massa inv	m min inv	gamma decvtx		TFD
1st cand	9234119599	0μ	kink	435±35	1135±35	$0{,}52^{+0{,}32}_{-0{,}17}$	173±2	$0{,}47^{+0{,}24}_{-0{,}12}$	12^{+6}_{-3}	$24{,}3^{+3{,}9}_{-2{,}7}$	0,041±0,002	/	/	2	7	DON
2nd cand	11113019758	0μ	trident	1446±10	1466±10	0,31±0,11	167,8±1,1	/	8,4±1,7	$12{,}7^{+1{,}7}_{-2{,}3}$	0,0874±0,0015	0,80±0,12	0,96±0,13	0	2	DON
3rd cand	12123032048	1μ	kink	151±10	376±10	/	/	0,69±0,05	2,8 [2,6; 3,0]	$6{,}8^{+0{,}9}_{-0{,}6}$	0,245±0,005	/	/	0	2	DON
4th cand	12254000036	0μ	kink	406±30	1090±30	$0{,}55^{+0{,}3}_{-0{,}2}$	166^{+2}_{-31}	$0{,}82^{+0{,}3}_{-1{,}6}$	6,0 [4,8; 8,2]	$14{,}4^{+3{,}9}_{-2{,}7}$	0,137+0,004	/	/	0	4	DON
5th cand	12227007334	0μ	kink	630±30	960±30	0,3±1	151±1	$1^{+1{,}1}_{-0{,}4}$	11^{+14}_{-4}	12^{+14}_{-4}	90±2	/	/	0	2	DON
Bo-Pd	11143018505	0μ	kink	429,6	1160	0,876	141,1	0,24	2,7 [2,13; 3,70]	23,2	0,090	/	/	1	2	NOT DON
Bern	11172035775	0μ	kink	652	1100	0,90 [0,79;1,16]	140,4	0,68 [0,56; 0,90]	6,9 [5,7; 9,2]	32,2	0,098	/	/	0	5	NOT NEED
Nagoya	9190097972	0μ	kink	10	822	0,46	142,8	0,33	2,2 [1,6; 3,6]	9,6	0,146	/	/	0	7	?
Nagoya	11118001124	0μ	kink	?	2096	ND	55,1	0,092	3,7 [1,3; ∞]	6,57	?	/	/	0	2	?
Bari	10123059807	0μ	trident	-648	140	0,6	82	/	>6,7	> 16,9	0,231	1,2	2	0	4	DON
Nagoya	12253001642	0μ	trident	?	539	245	< 38	0,91	3,56	>35,5	0,297	1,1	1,8	2?	5	?
Nagoya	11213015702	0μ	trident	407	256	?	54,7	>0,40	> 6,3	6,78	0,083	?	?	?	5	?

Multiplicity Distributions in CC Interactions : Cagin

Electron energy measurement report : Frank

Update of hadron interaction analysis : Mizusawa

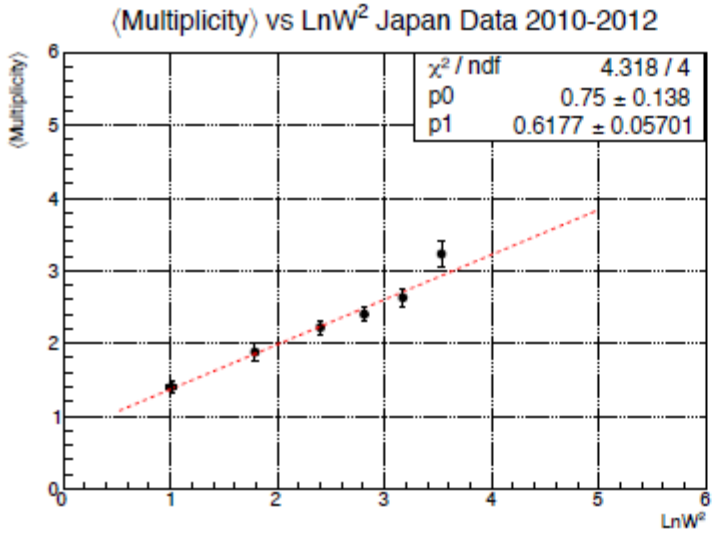
Updates on annual modulation : Nicoletta, Andrea

Short decay search : Mustafa

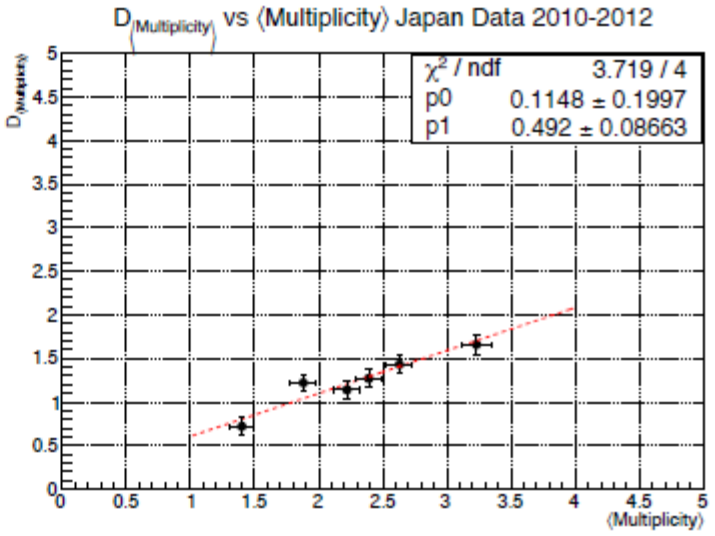
OTHER ACTIVITIES

Cagin @ PC 12 May

⟨Multiplicity⟩ vs LnW² and Dispersion



$$\langle Multiplicity \rangle = (0.75 \pm 0.13) + (0.61 \pm 0.05)\, Ln(W^2)$$



$$D_{\langle Multiplicity \rangle} = (0.11 \pm 0.19) + (0.49 \pm 0.08)\langle Multiplicity \rangle$$

MULTIPLICITY DISTRIBUTIONS IN CHARGE CURRENT NEUTRINO INTERACTIONS,
Çağın KAMISCIOGLU,Colloboration Meeting-Nagoya-JAPAN 30/3-1/4/2016

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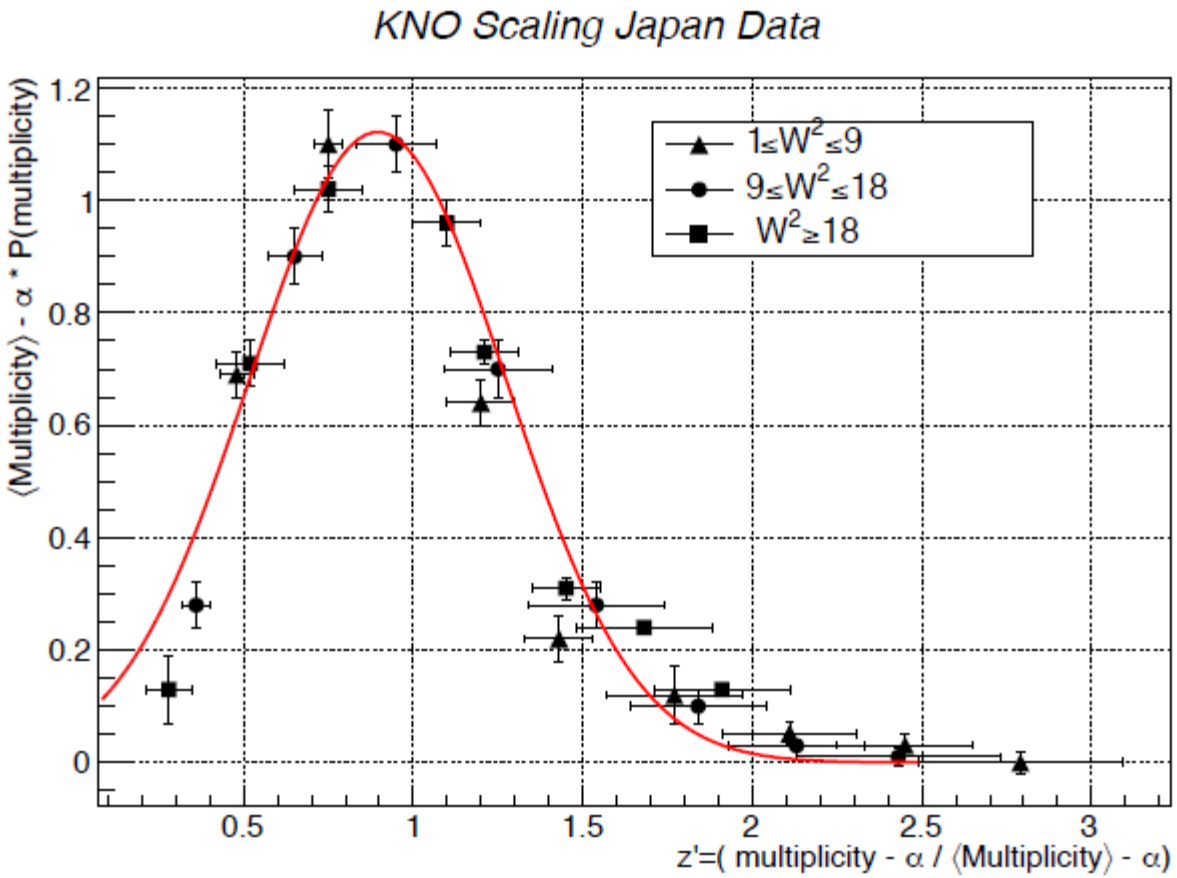
Cagin @ PC 12 May

KNO Scaling for Japan Data



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Frank @ PC 28 July
9 June and 13 Sep.

Work on shower reco/ energy

Current status
and working topics

Frank, 28 July 2016

Frank @ PC 28 July
9 June and 13 Sep.

DB issues: missing nue events

	A	C	D	E	F	G	H	L	M	N	P
1	eventId	brickId	slope	slope	vtxX	vtxY	vtxZ	SCANNING LA	DB-INFO: TS THERE?	Got Files in Other way?	DATA STRUCTURE
5	11154041686	1017991	0,003	0,061	71403	58125	-7319	NAGOYA	NO		
10	11164031847	1032309	0,1003	-0,0139	23512	52883	-17907	NAPOLI	NO	YES, tgz	BERN -like
11	12196039785	1033362	0,0138	0,0284	8928	11948	-56360	BERN	NO		
12	10257032729	1033983	-0,0376	0,1092	51995	80098	-10575	NAPOLI	NO	YES, tgz	BERN -like
13	12162027599	1037011	-0,0158	0,0763	47623	38106	-34934	BERN	NO		
18	12333033193	1049546	0,0816	0,0303	40839	36474	-30362	BERN	NO		
19	10157017947	1050883	-0,0597	0,3925	119172	42831	-16804	LOGNA-PADOVA	NO		
20	11136028585	1053166	-0,0271	0,0466	91899	13031	-25461	BERN	NO		
21	11282000433	1053857	-0,0626	0,1078	89648	36235	-69023	BERN	NO		
23	12092016479	1064585	-0,268	0,105	124020	63817	-13254	NAPOLI	NO	YES, tgz	BERN -like
29	12082052269	1083431	0,0206	0,1004	47234	81121	-70826	BERN	NO		
30	9290026555	1084000	-0,0169	-0,0116	21857	63746	-29428	NAPOLI	NO	YES, tgz	BERN -like
31	11220031747	1085249	0,0011	0,0672	54723	60942	-58602	BERN	NO		
32	12273018341	1090110	0,0154	0,062	85370	51132	-55481	DUBNA	NO	YES, remote cp	
38	11157015941	1100567	0,193	0,0105	78009	24251	-5366	BERN	NO		
47	12272015885	1127631	0,0367	0,0135	26110	70680	-4270	BERN	NO		
50	10312027541	1143854	0,0035	-0,0673	96583	19774	-33702	BERN	NO		
51	10287005238	1145335	0,0682	0,0806	52280	79639	-45290	NAGOYA	NO		
54	11113049106	1155498	0,039	-0,013	38134	39596	-20460	NAGOYA	NO		

Mizusawa @ PC 9 June

Toho University

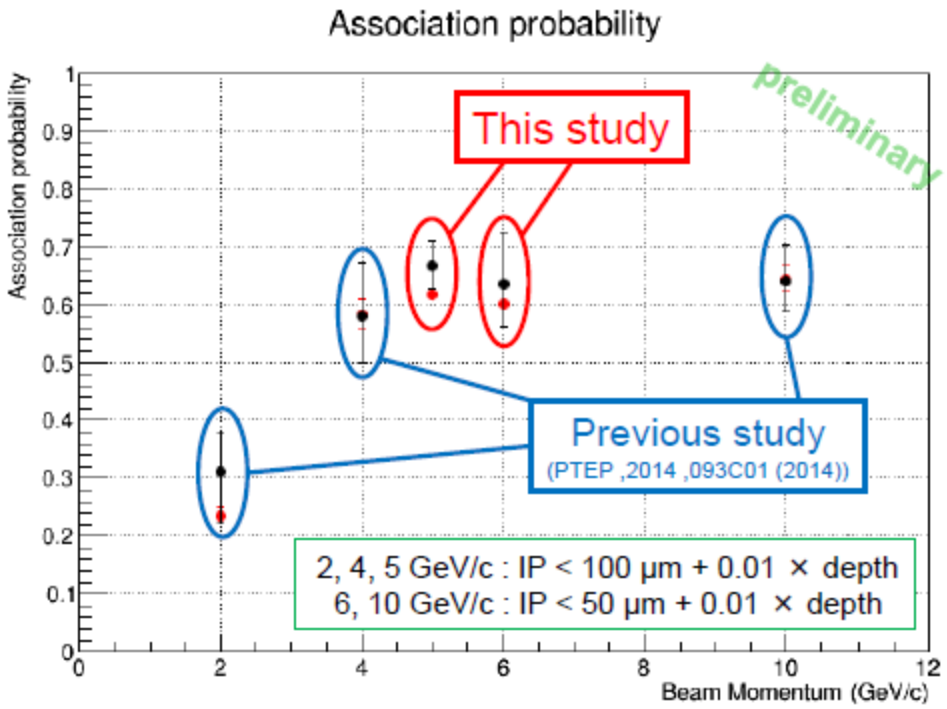
Update of hadron interaction analysis

H. Mizusawa, M. Okubo, J.Ohira, T. Matsuo,
T. Fukuda, H. Shibuya, S. Ogawa, et al.
Toho University

OPERA PC meeting on 9th June 2016

Mizusawa @ PC 9 June

Results (Association probability)



5 GeV/c

	Experimental	MC
Total events	129	13061
Associated events	86	8079
Association probability	$66.7^{+3.9}_{-4.4}\%$	$61.9^{+0.4}_{-0.4}\%$

6 GeV/c (Preliminary)

	Experimental	MC
Total events	33	10120
Associated events	21	6094
Association probability	$63.6^{+7.4}_{-8.9}\%$	$60.2^{+0.5}_{-0.5}\%$

- We obtained new beam momentum data of nuclear fragments.
- The MC data agree reasonably well with the experimental data.

Toho University

OPERA PC meeting on 9th June 2016 14

Nicoletta @ PC 9 June

Update on the annual modulation of atmospheric muons

N. Mauri, A. Longhin, A. Paoloni, F. Pupilli, E. Voevodina

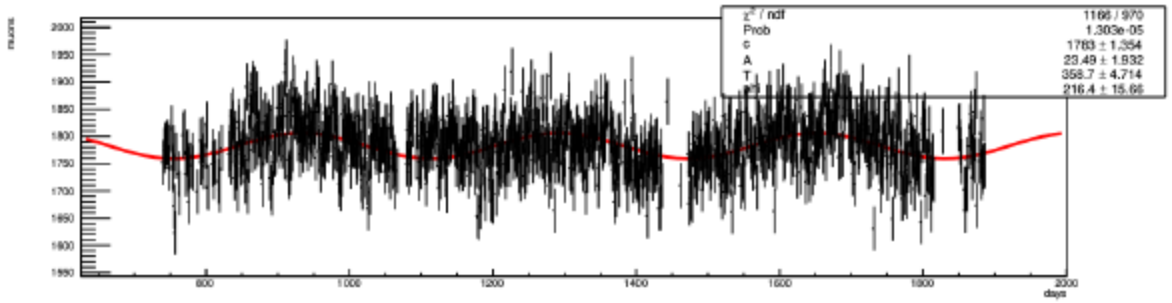
OPERA PC Meeting, 9 June 2016

Nicoletta @ PC 9 June

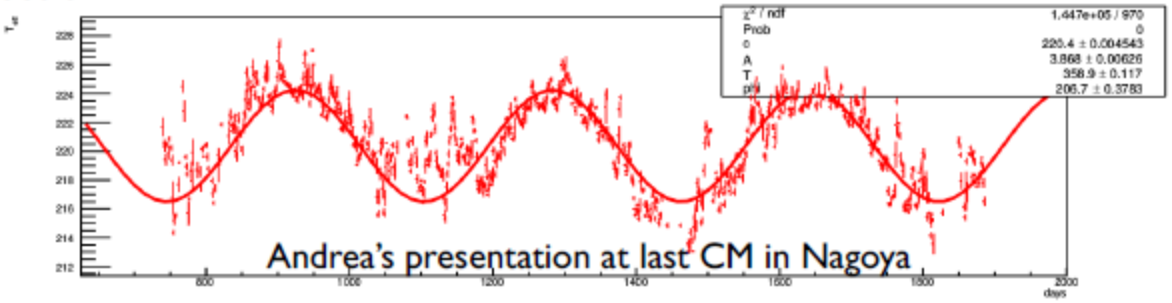
Data Set selection

- Issue on the daily rate expected in OPERA

  → investigate in order to use also 2008 and 2009 data sets
- Rate of atmospheric muons in files stored at ccage seems to be different from what expected: some constraints added in the OpRec production?



TT Selection



Andrea's presentation at last CM in Nagoya

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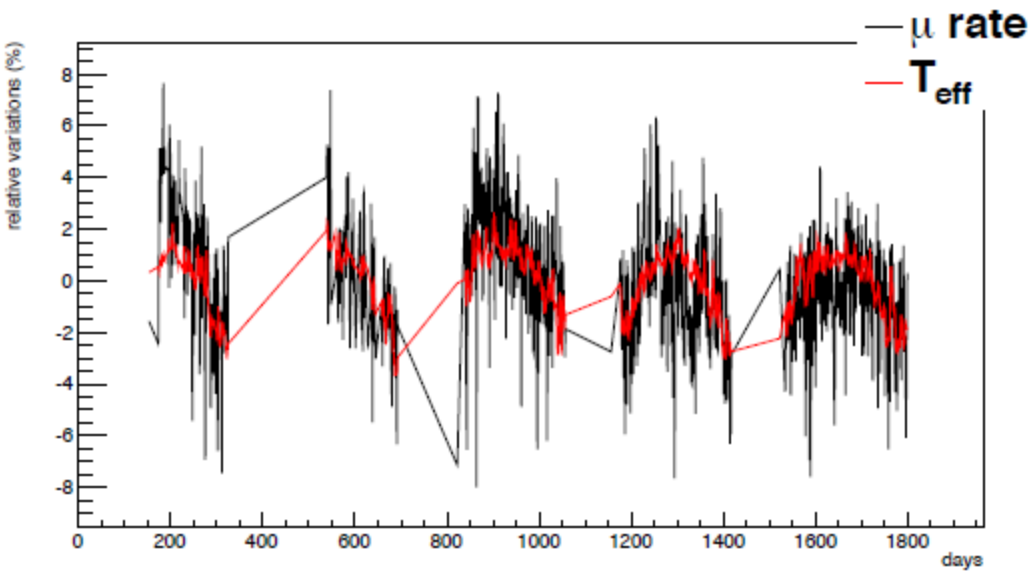
Nicoletta @ PC 9 June

Preliminary results: correlation with temperature variations



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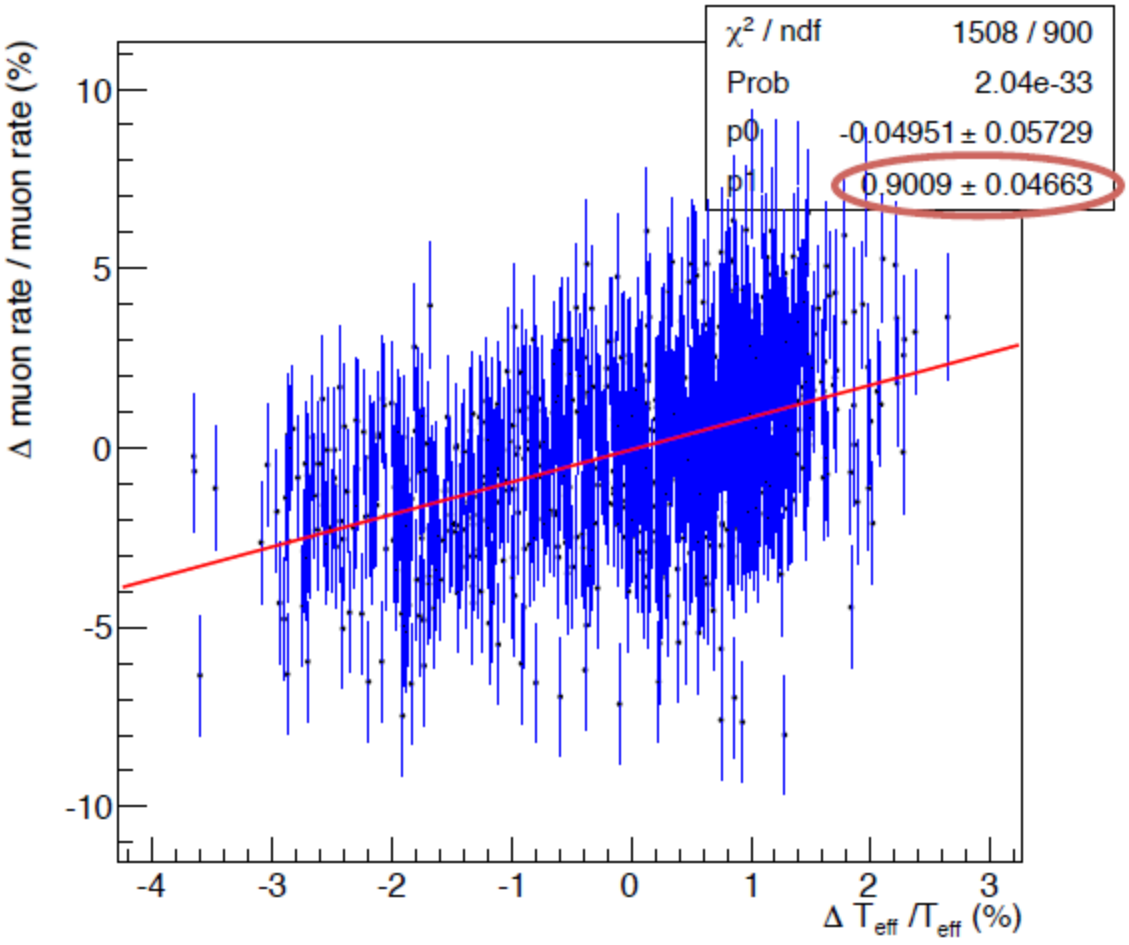
Nicoletta @ PC 9 June

Preliminary results: α_T



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Mustafa @ PC 12 May

Short Decay Search

Mustafa KAMISCIOGLU
METU - OPERA
PC MEETING- May,2016

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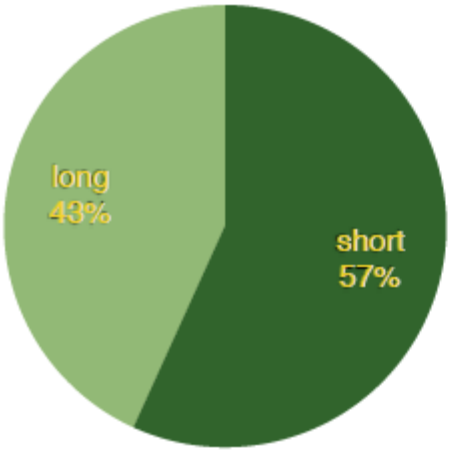
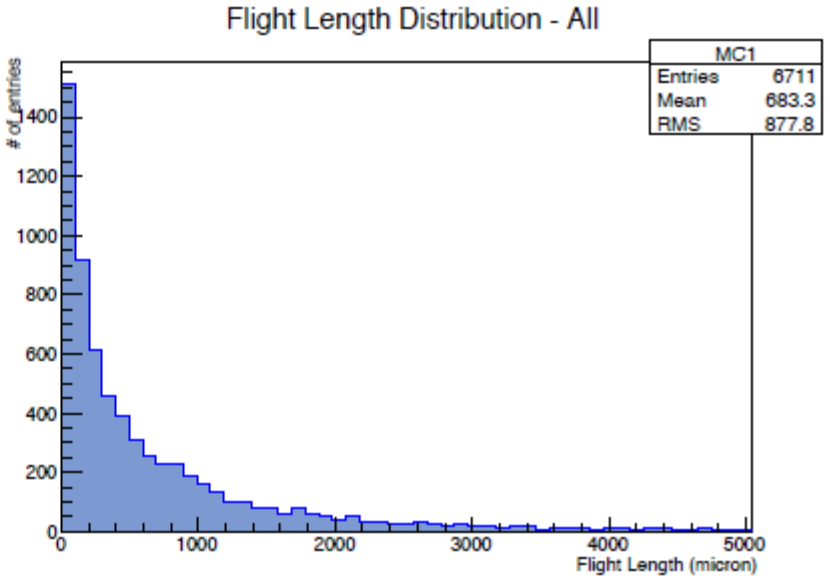
Mustafa @ PC 12 May

Flight Length Distributions of MC Events

Input File: /sps/opera/operap/production/v2015r2/charmall_v5.1_CNAF-svn-trunk-r1802_8200000000413851 6/LOC/RECO_11062015_10:04:00/SYSAL/DS/","SYSAL_DS_charmall_Op5.1TFD_PBPL-500-tfd_CNAF-svn-trunk-r1802_

Run 7000 events





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To do

- Finalize statistics
  - By the end of November
  - We have to declare end of the scanning
- All analysis should be done by April 2017.
  - Regular (at least monthly) PC meeting will be called.
- Several more papers are in the line
  - Keep active until the end.
  - Most of publication : by June 2017.

Agenda

- nue oscillation analysis with 3+1 : Matteo
- Cross check on the oscillation analysis : Alessandro
- nue analysis summary and prospect for the paper : Svetlana
- nue CC electron energy measurement : Frank
- numu disappearance update : Budimir
- Marginal event analysis : Giuliana
- Analysis on neutrino interaction and prospect toward paper : Cagin
- Short decay search : Mustafa

- Electromagnetic shower reconstruction and possible improvements on event location : Andrey
- Open data access: the experience of LHCb : Andrey