

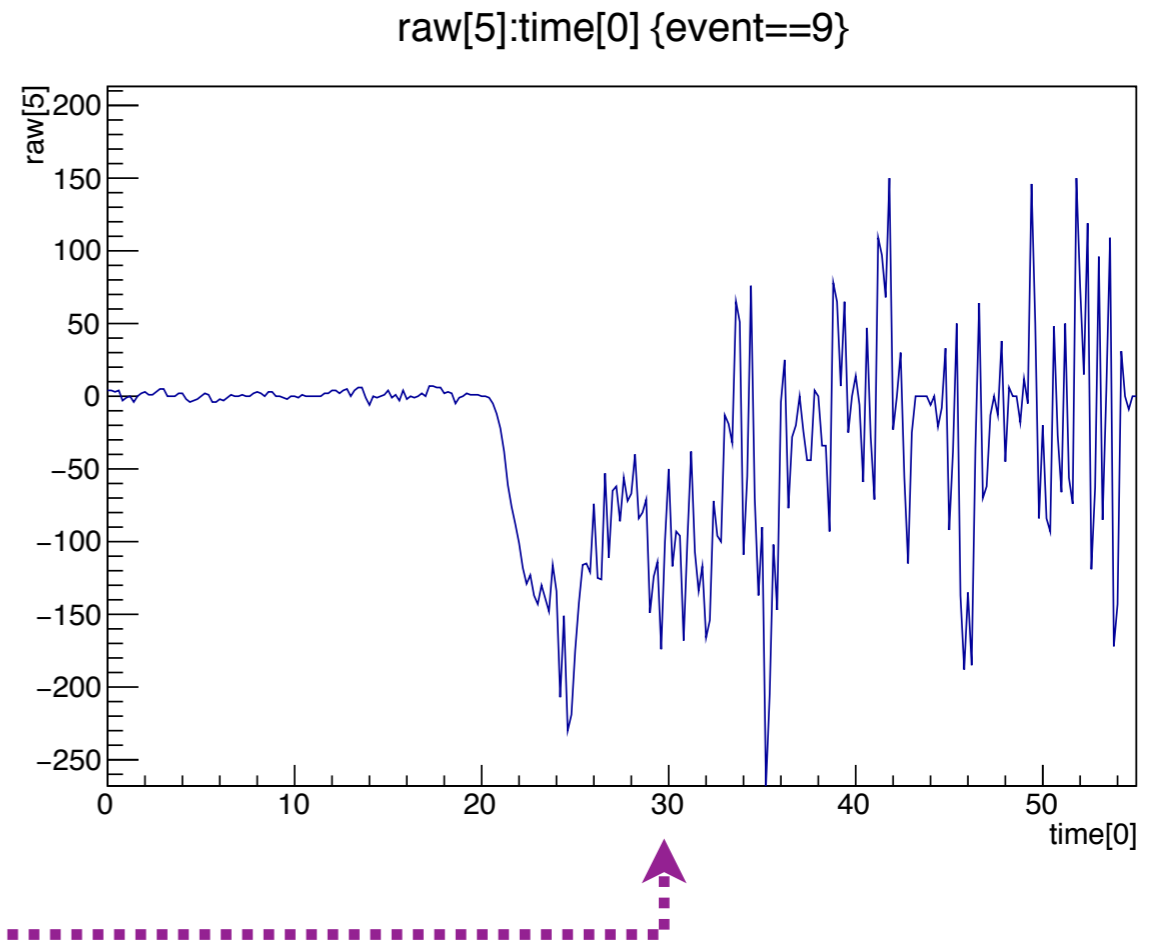
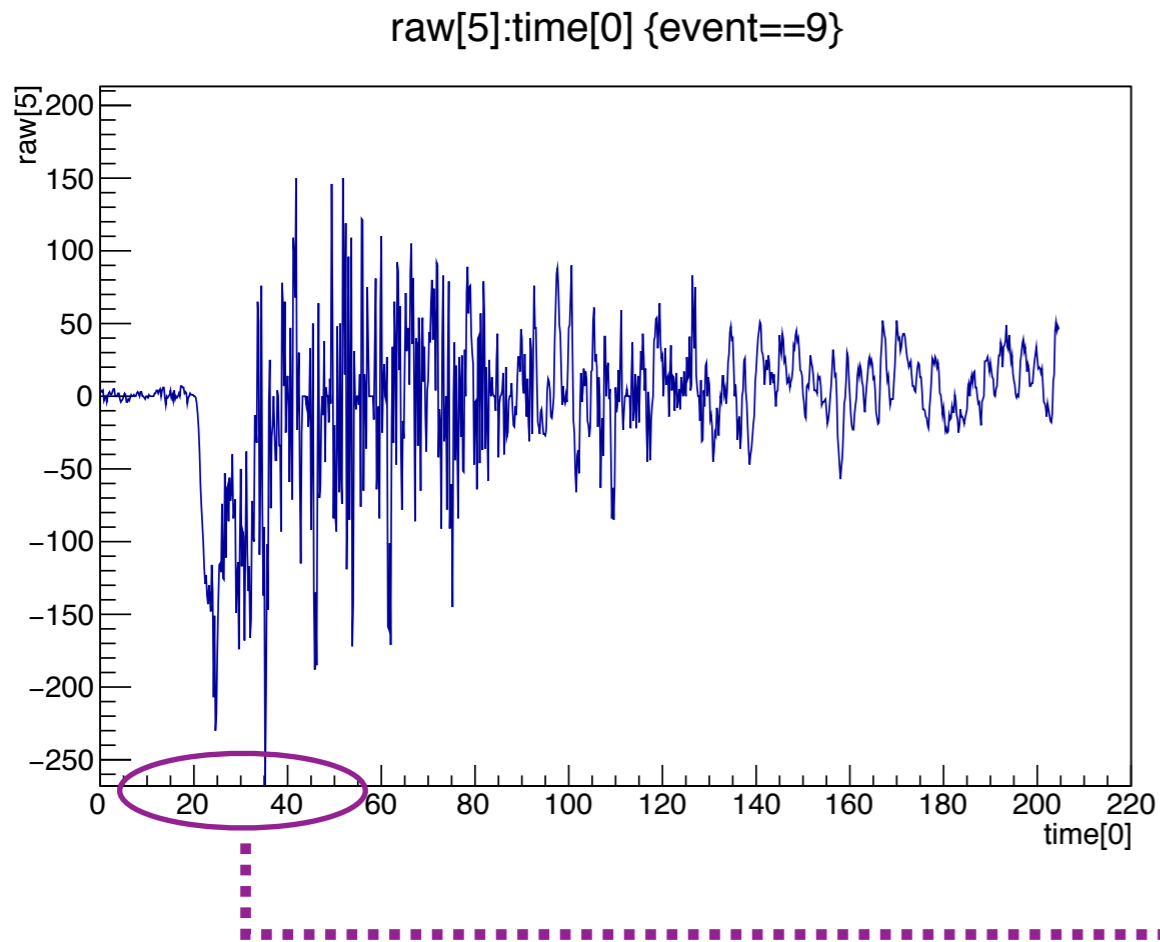
CdTe + LGAD test beam at CERN H4

Adi Bornheim, Cristian Pena, Aashrita Mangu, Jiajing Mao,
Nan Lu, Maria Spiropulu, Si Xie, Zhicai Zhang

Caltech

30 Jun, 2017

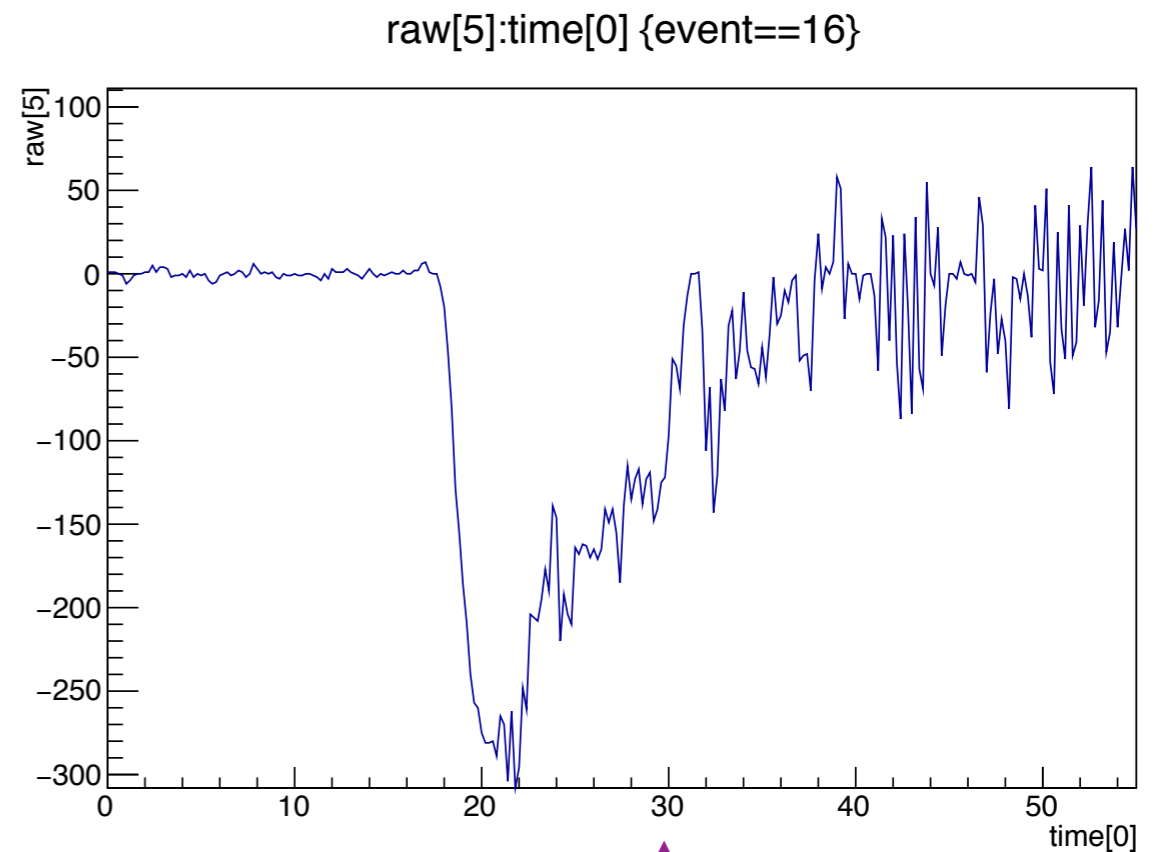
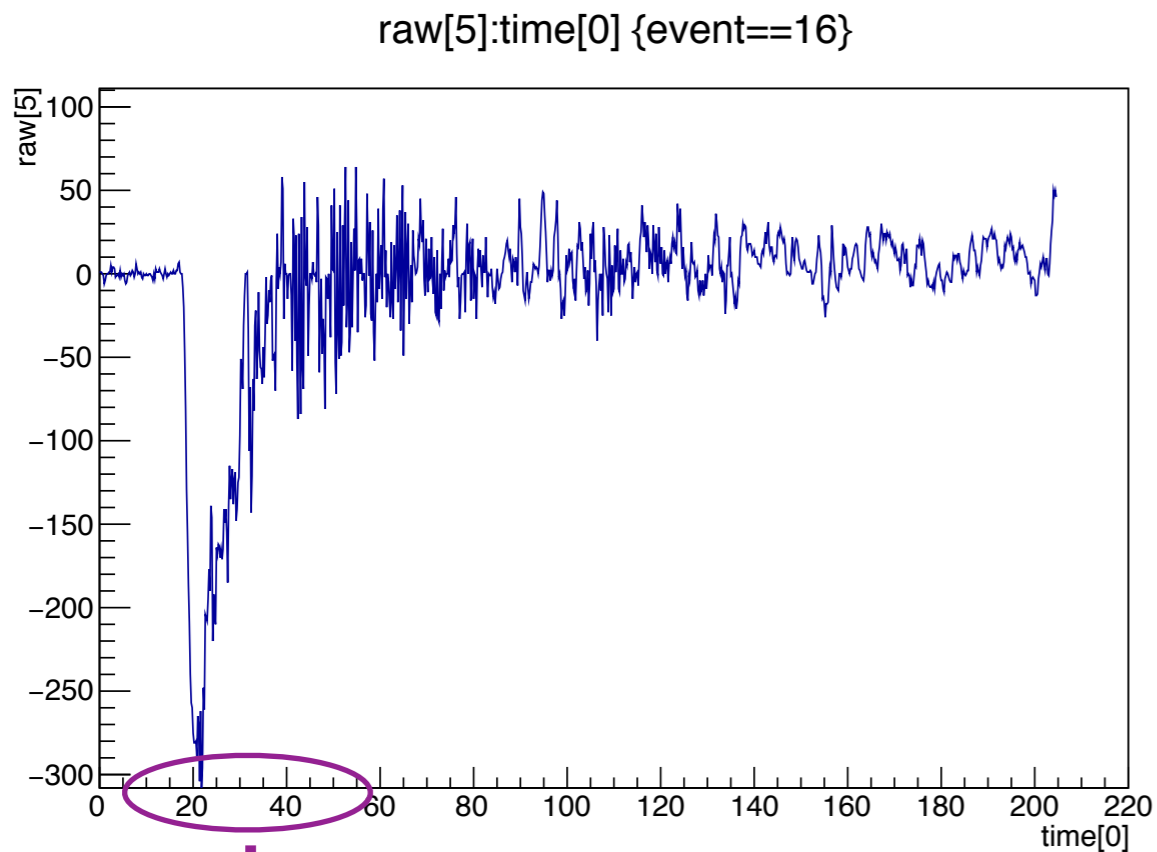
CdTe pulse



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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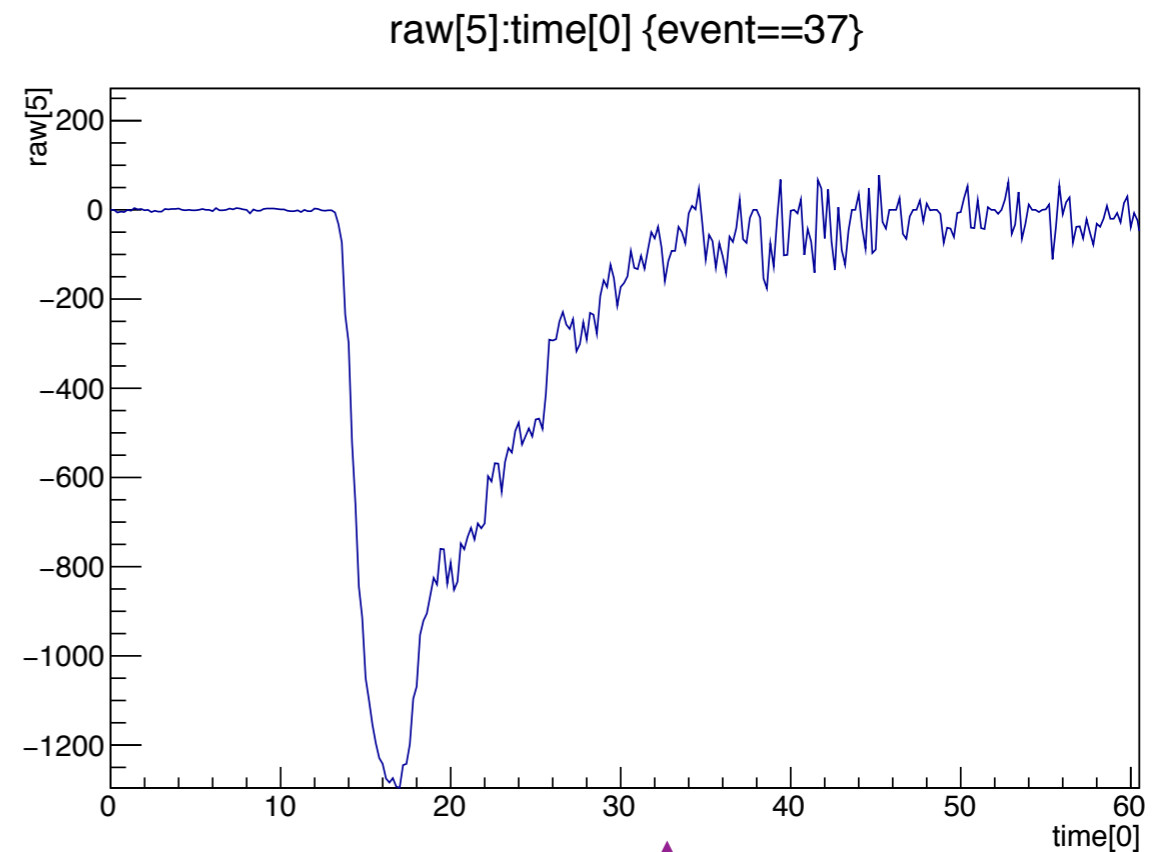
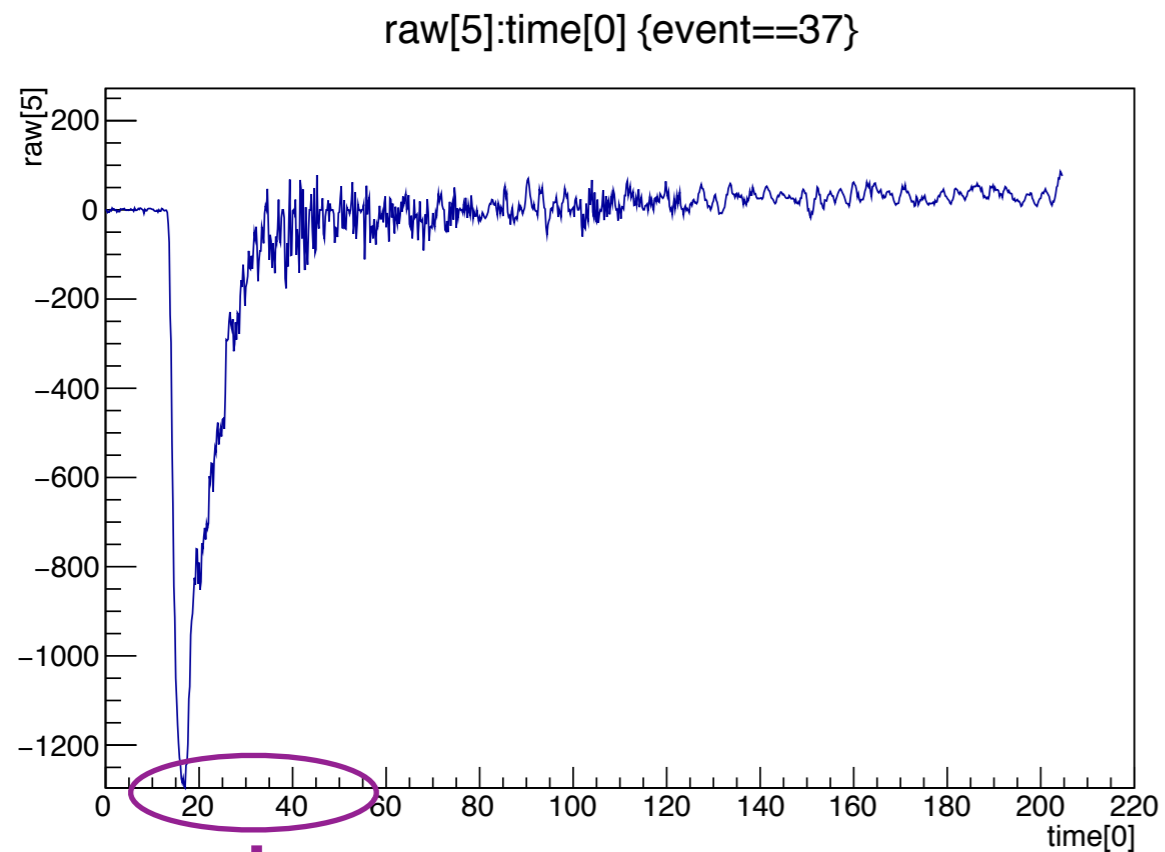
CdTe pulse



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CdTe pulse



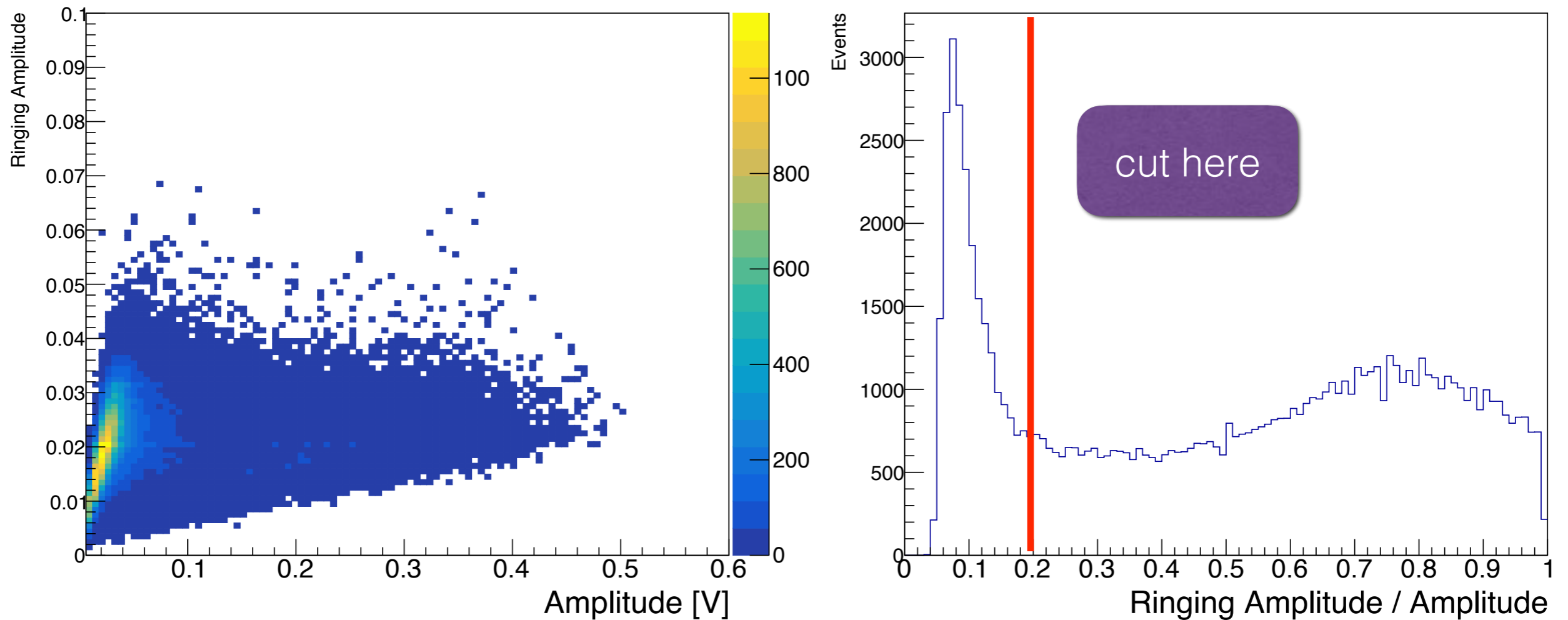
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/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/jobs_v1/
ntuples_v1/analysis_7628_1.root

remove the ringing

- By the ringing amplitude
 - Cut on the ratio of ringing amplitude and the signal amplitude
- By risetime
 - If ringing affects the peak, the risetime will be misreconstructed
 - Risetime is basically constant for different signal amplitude → no bias on signal amplitude

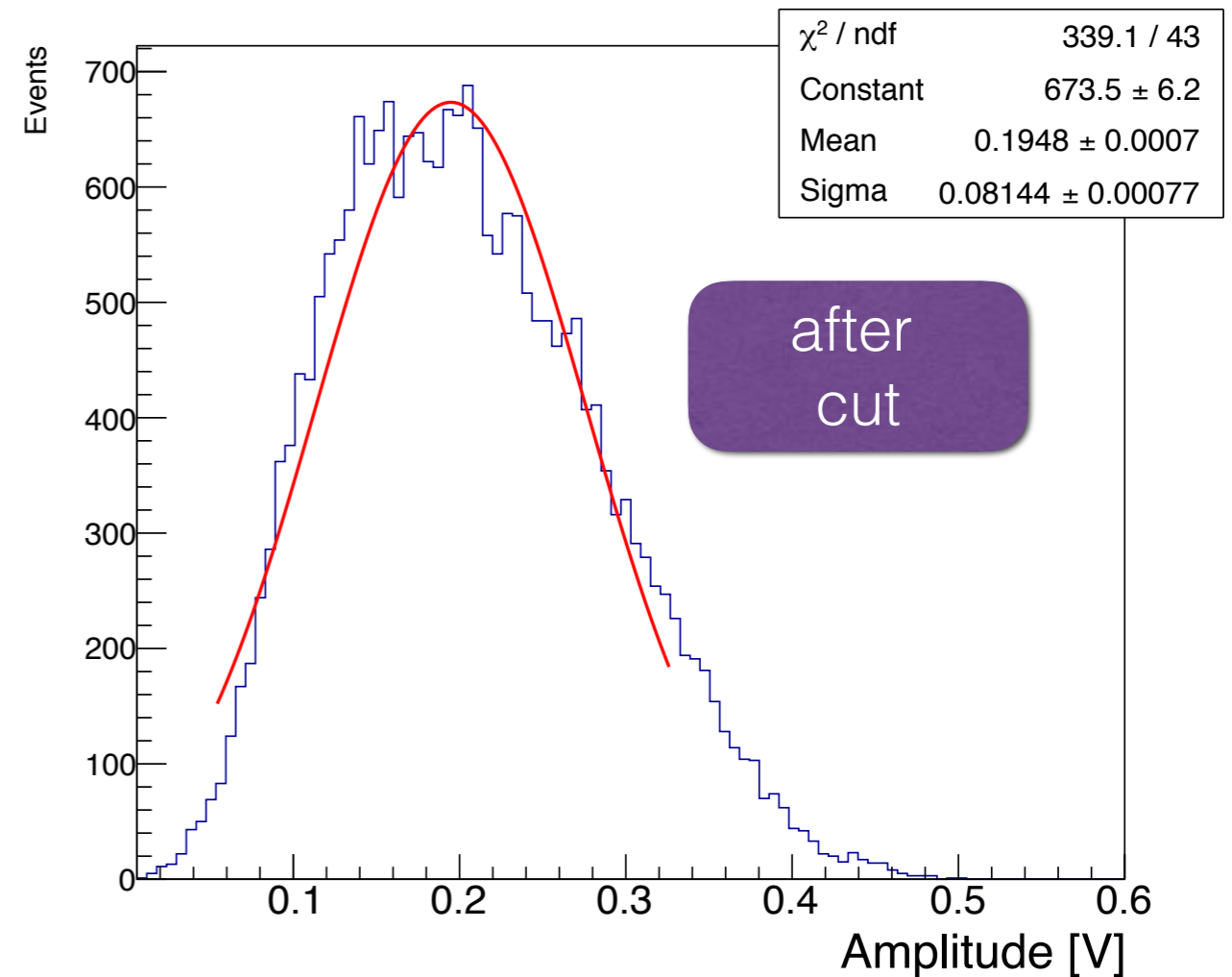
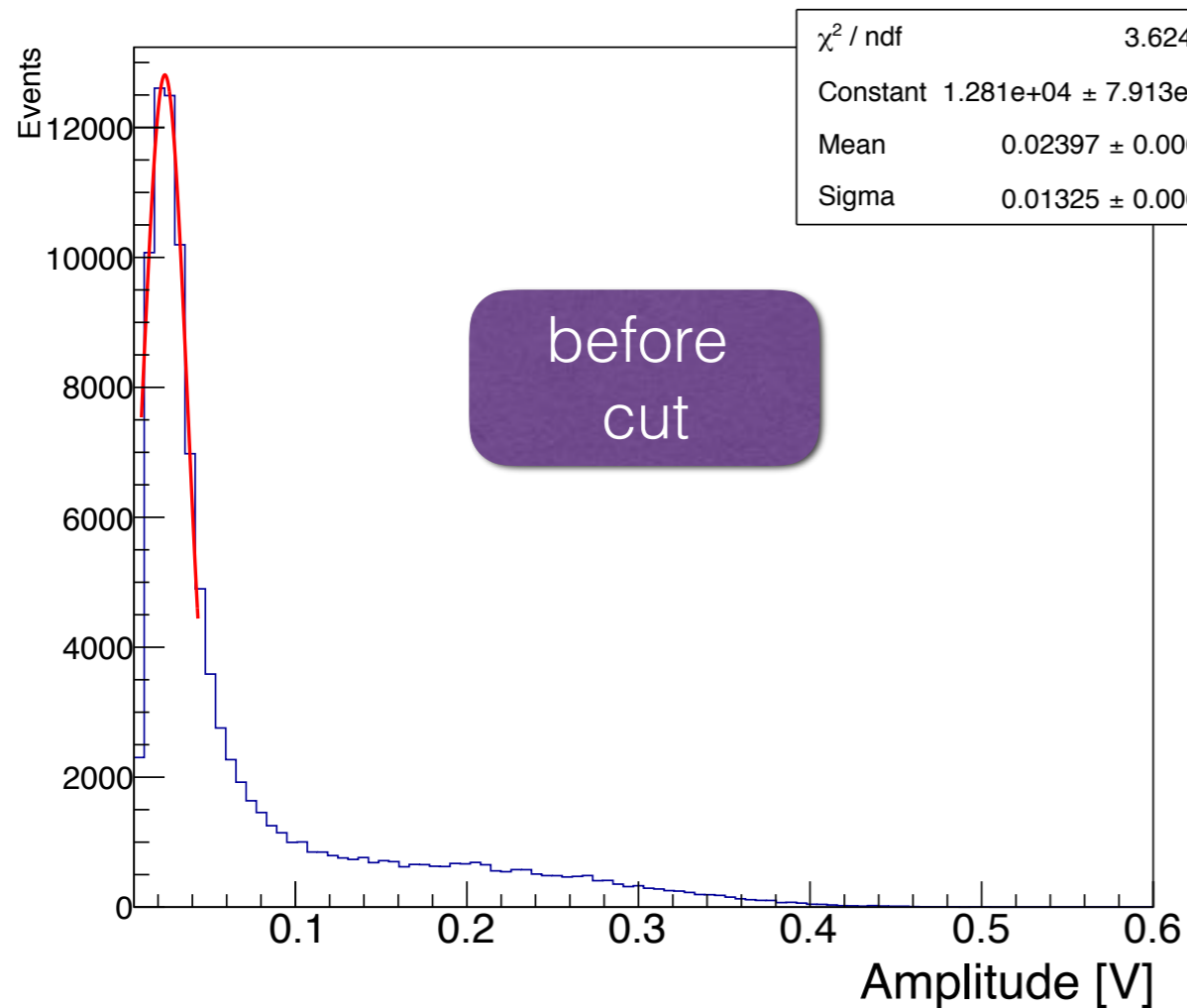
CdTe ringing amplitude



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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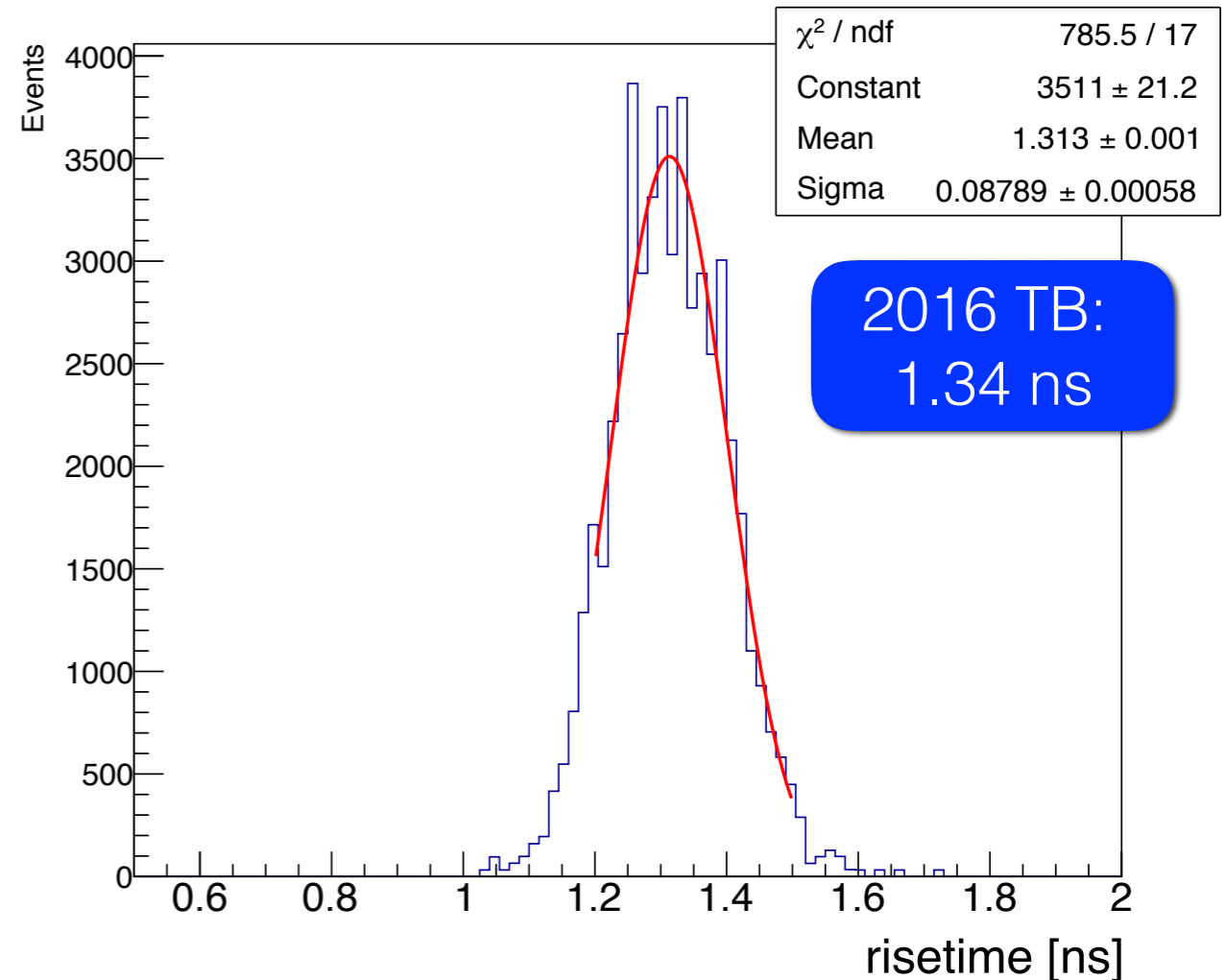
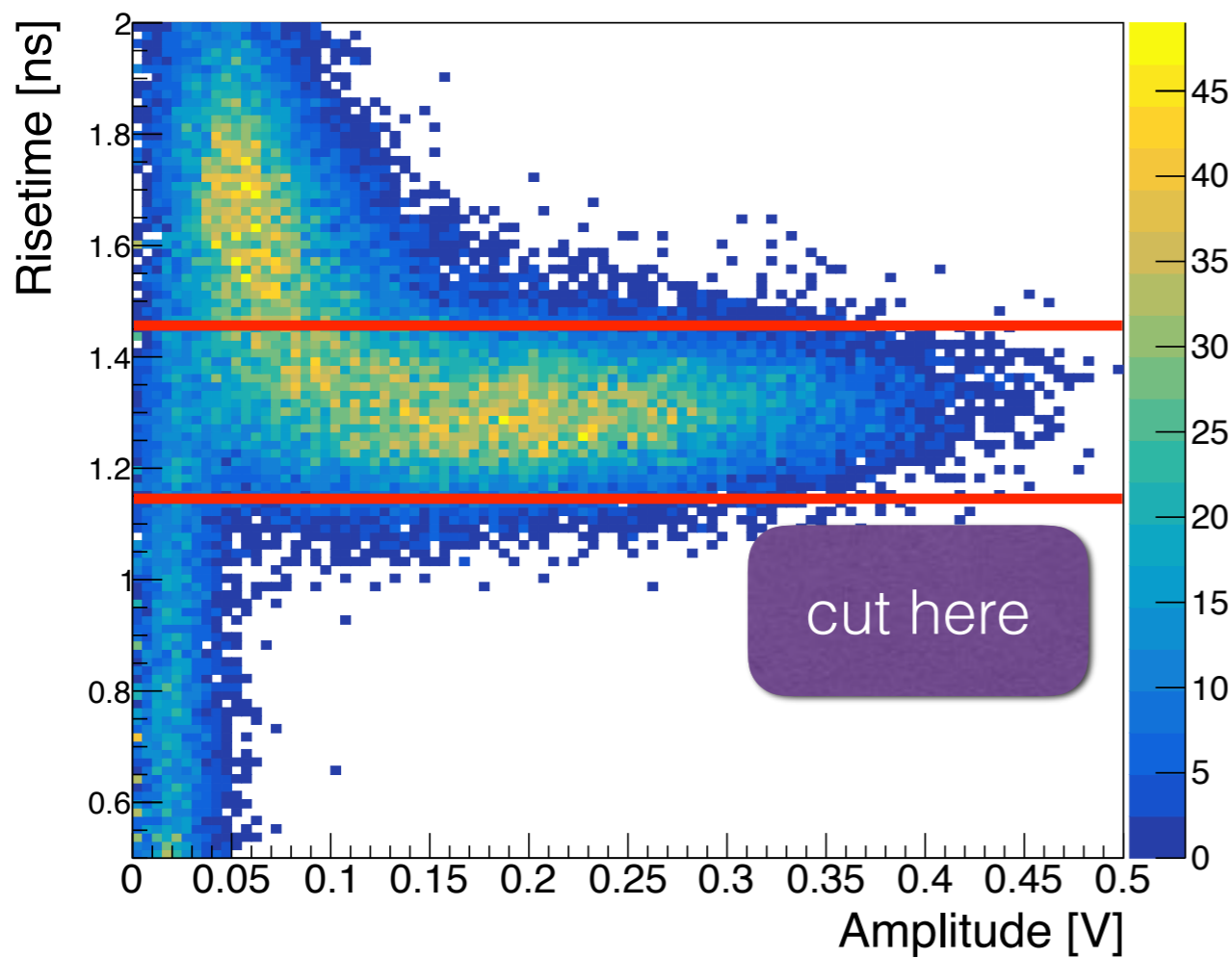
CdTe ringing amplitude



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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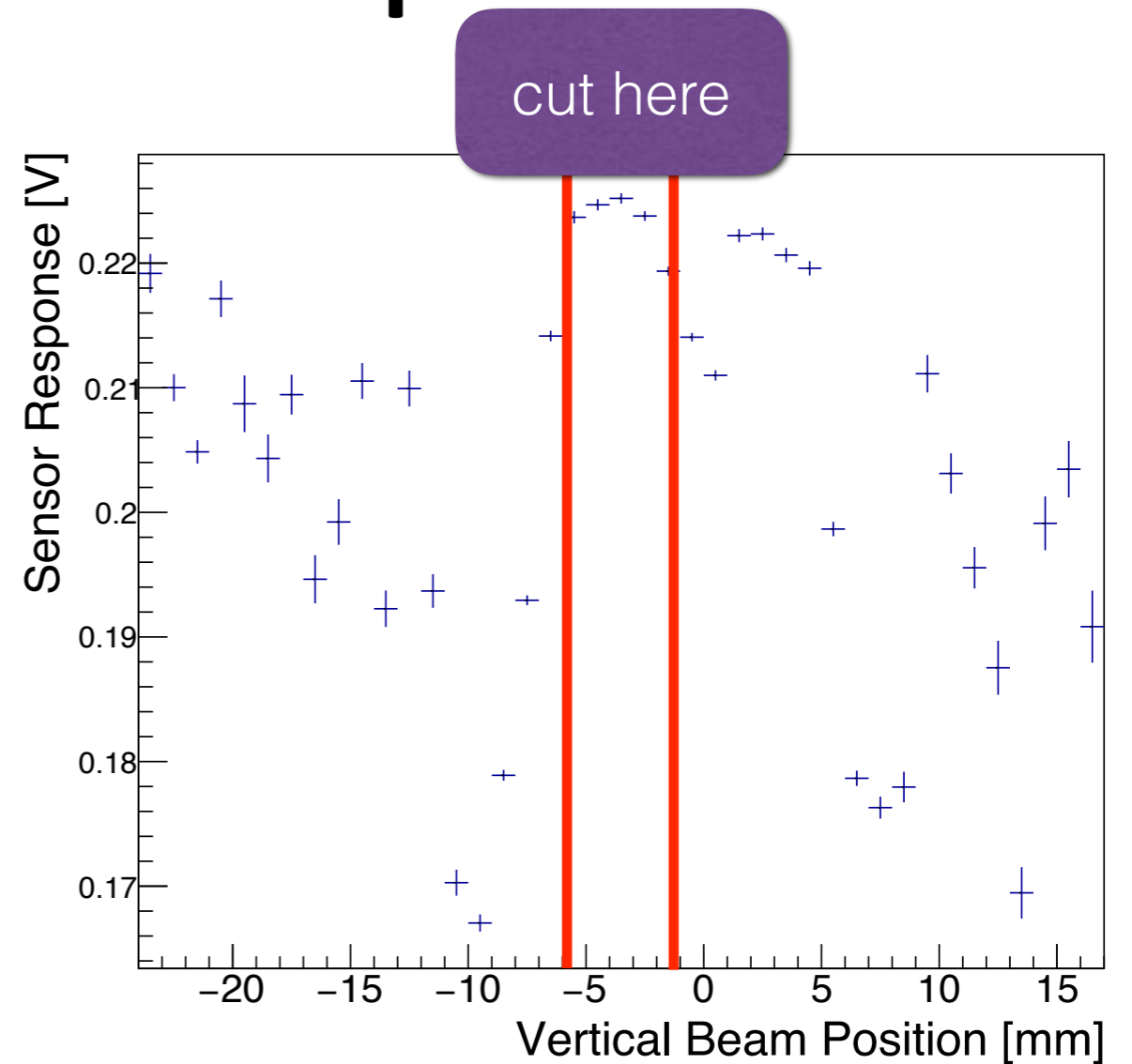
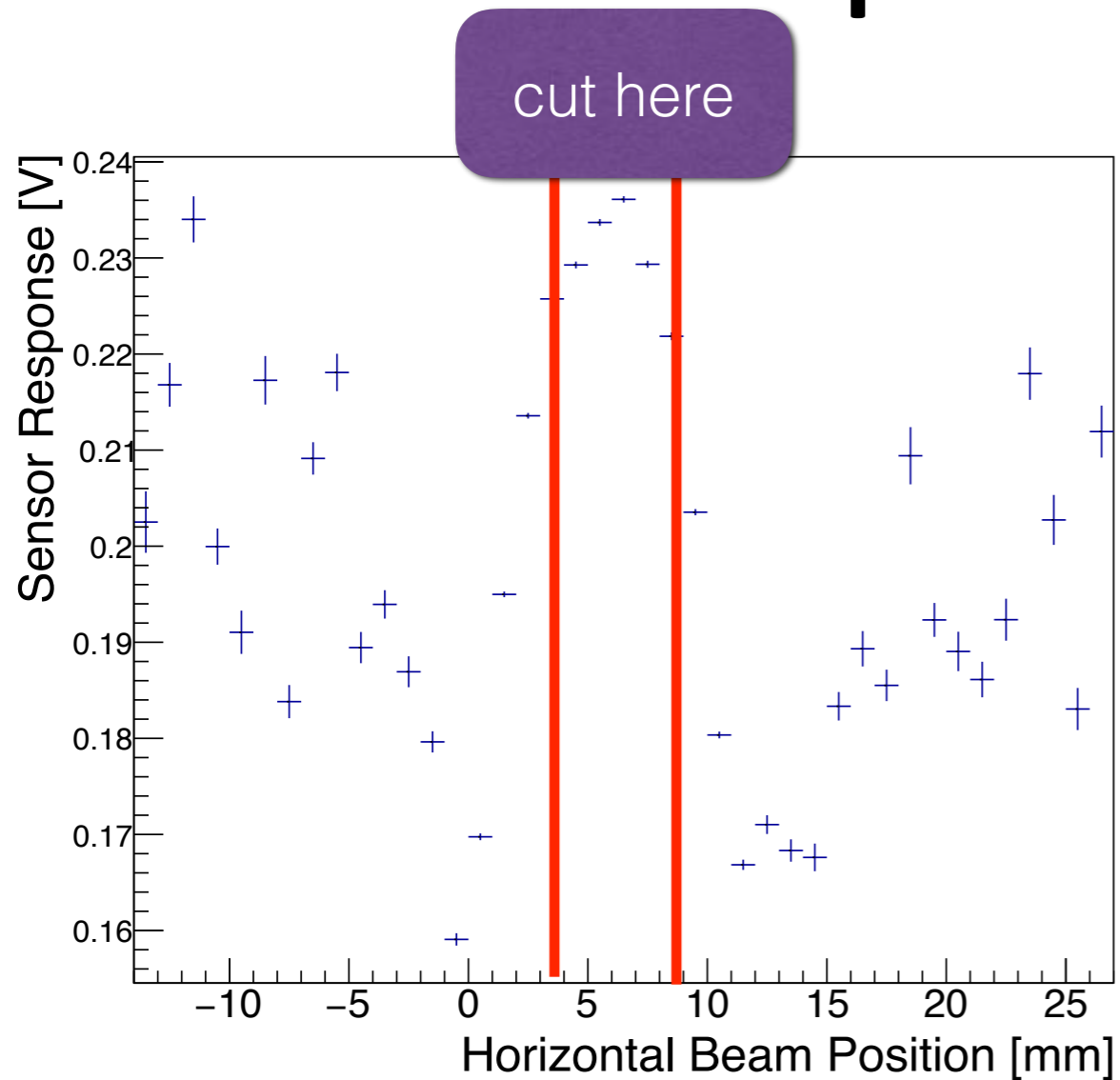
CdTe risetime



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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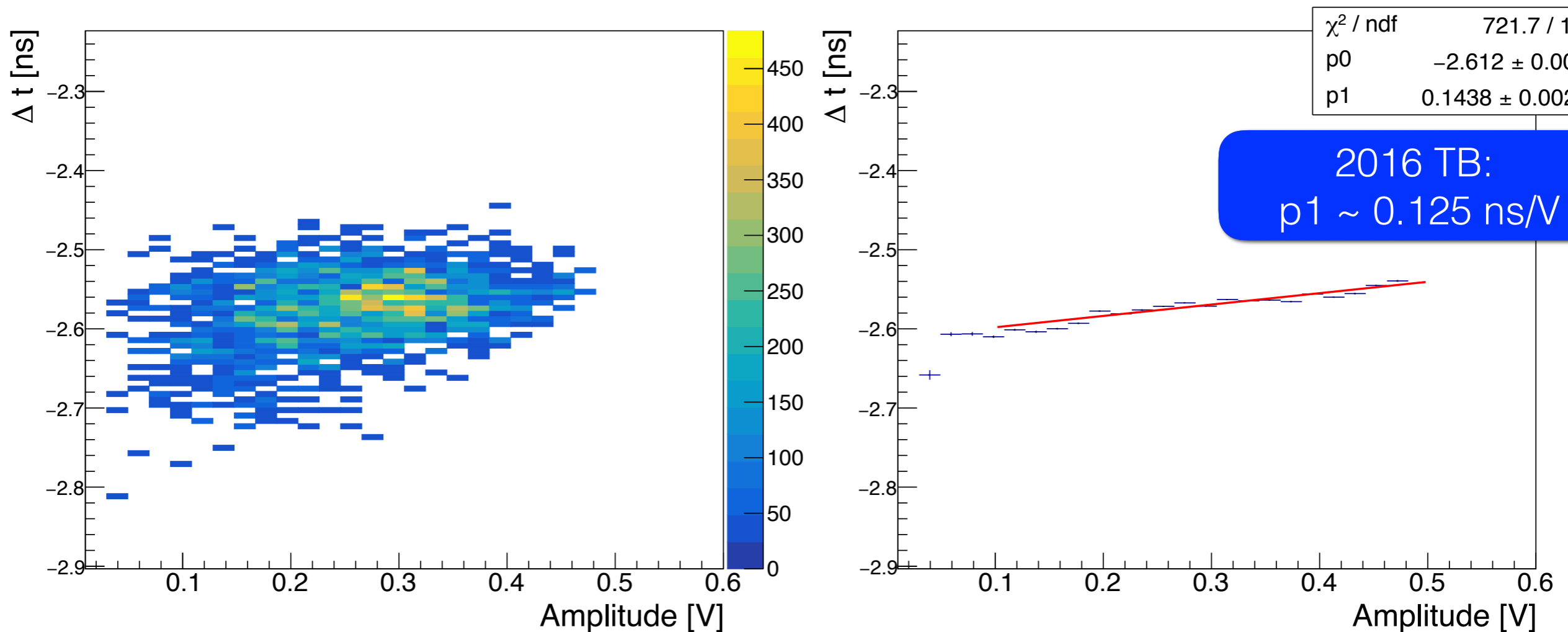
CdTe amplitude vs. position



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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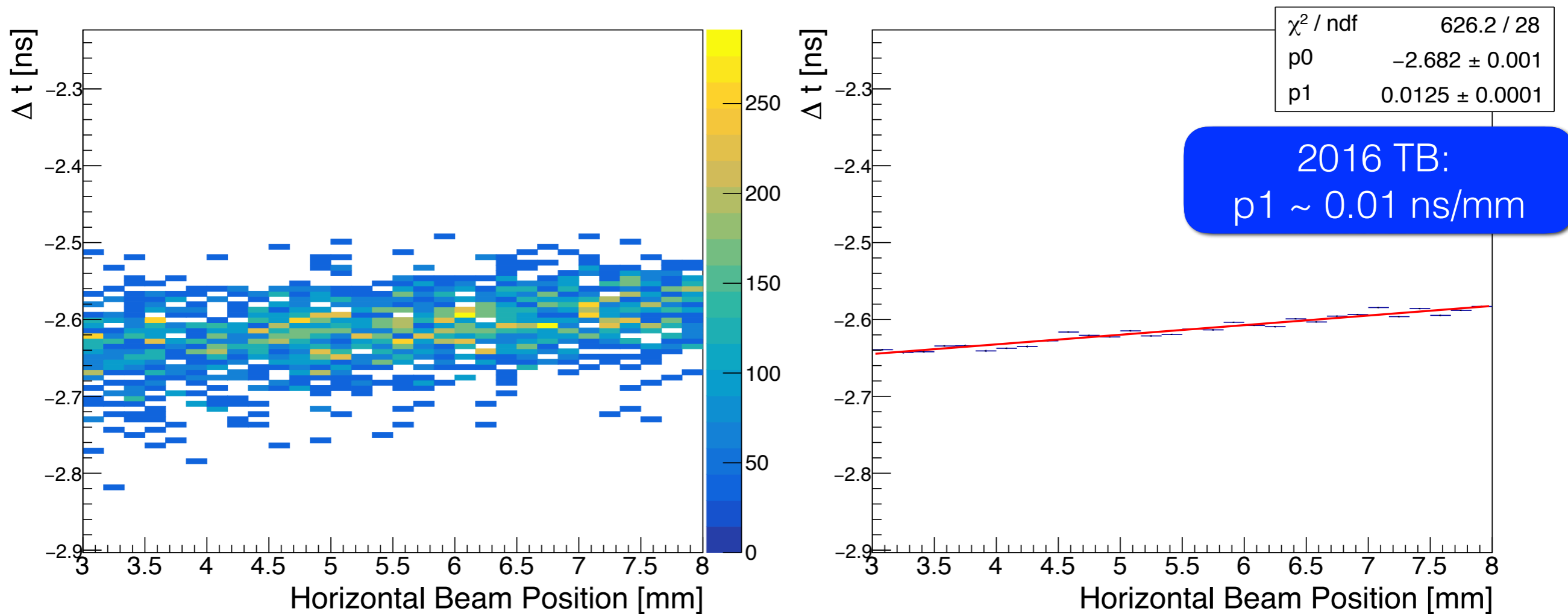
CdTe timing - time walk correction



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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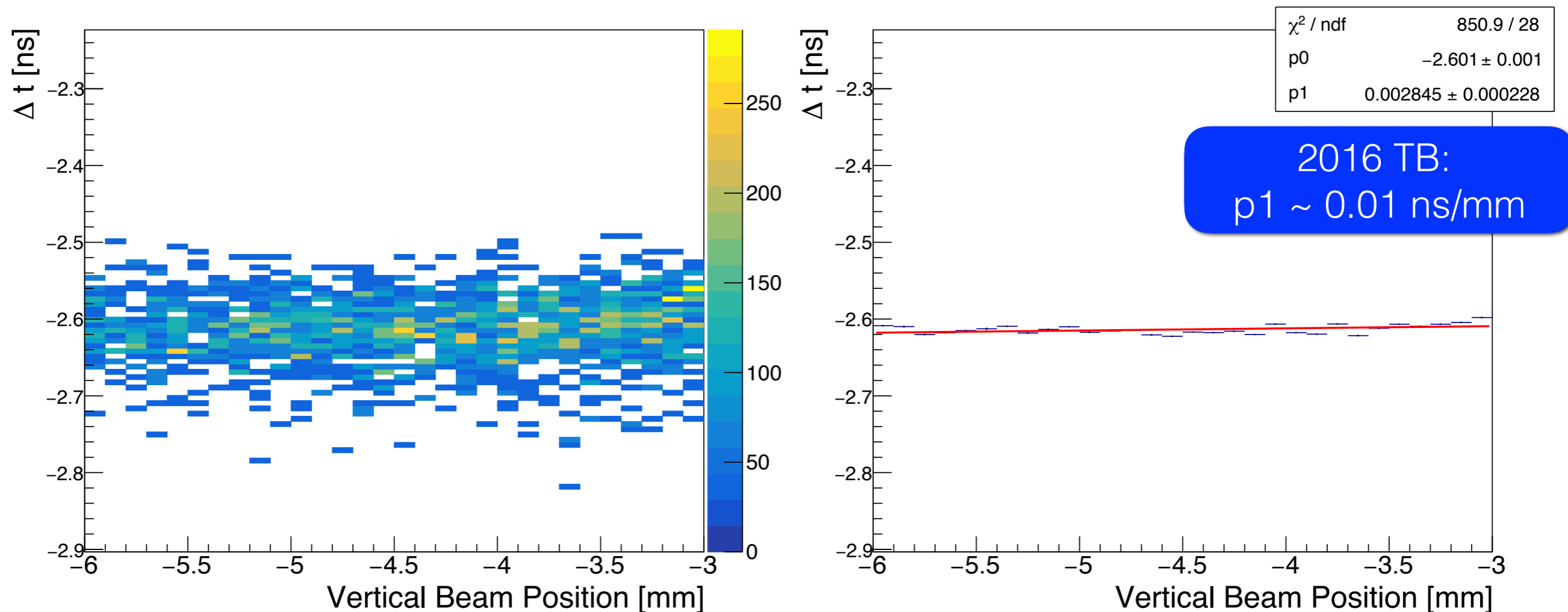
CdTe timing - impact point correction



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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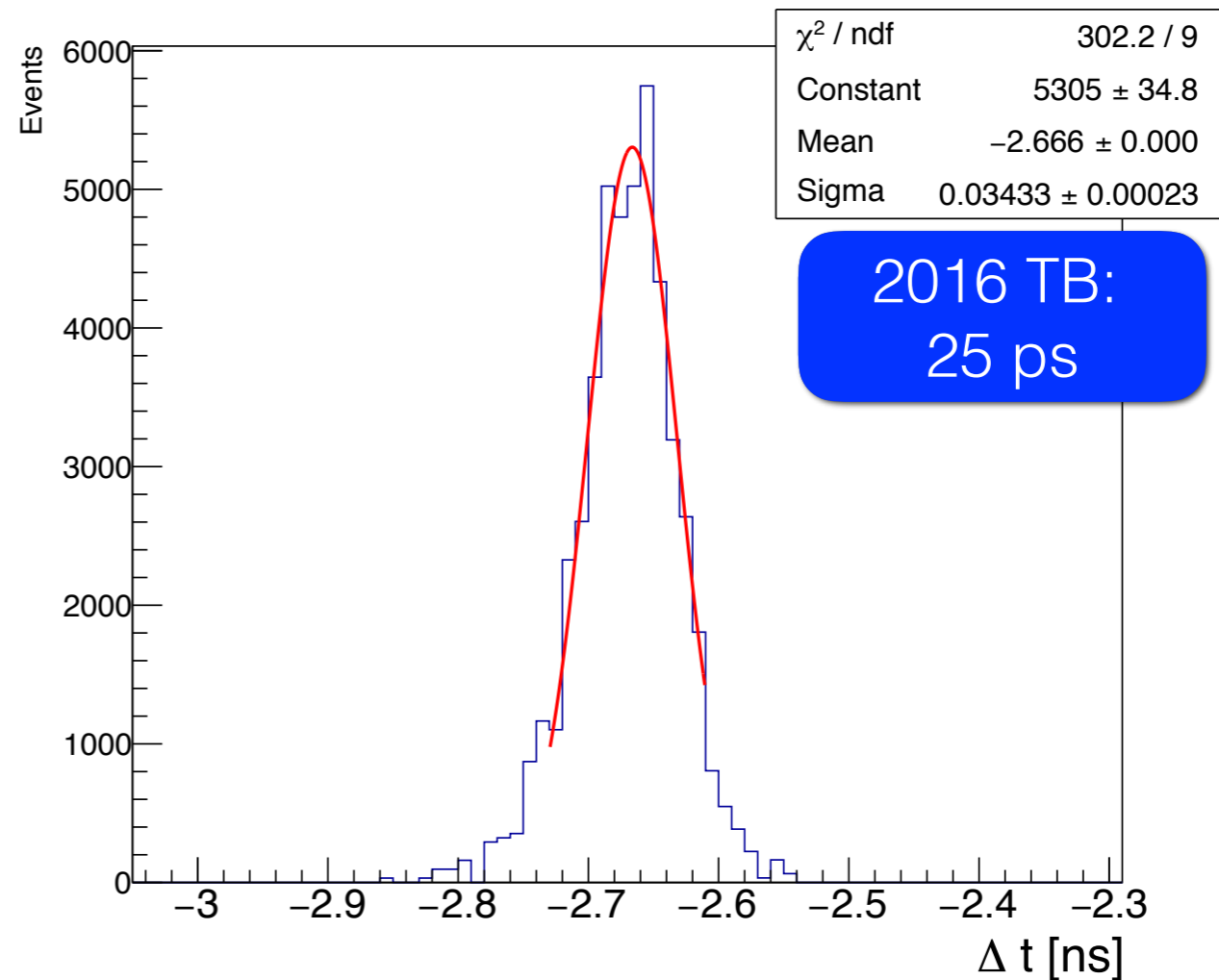
CdTe timing - impact point correction



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

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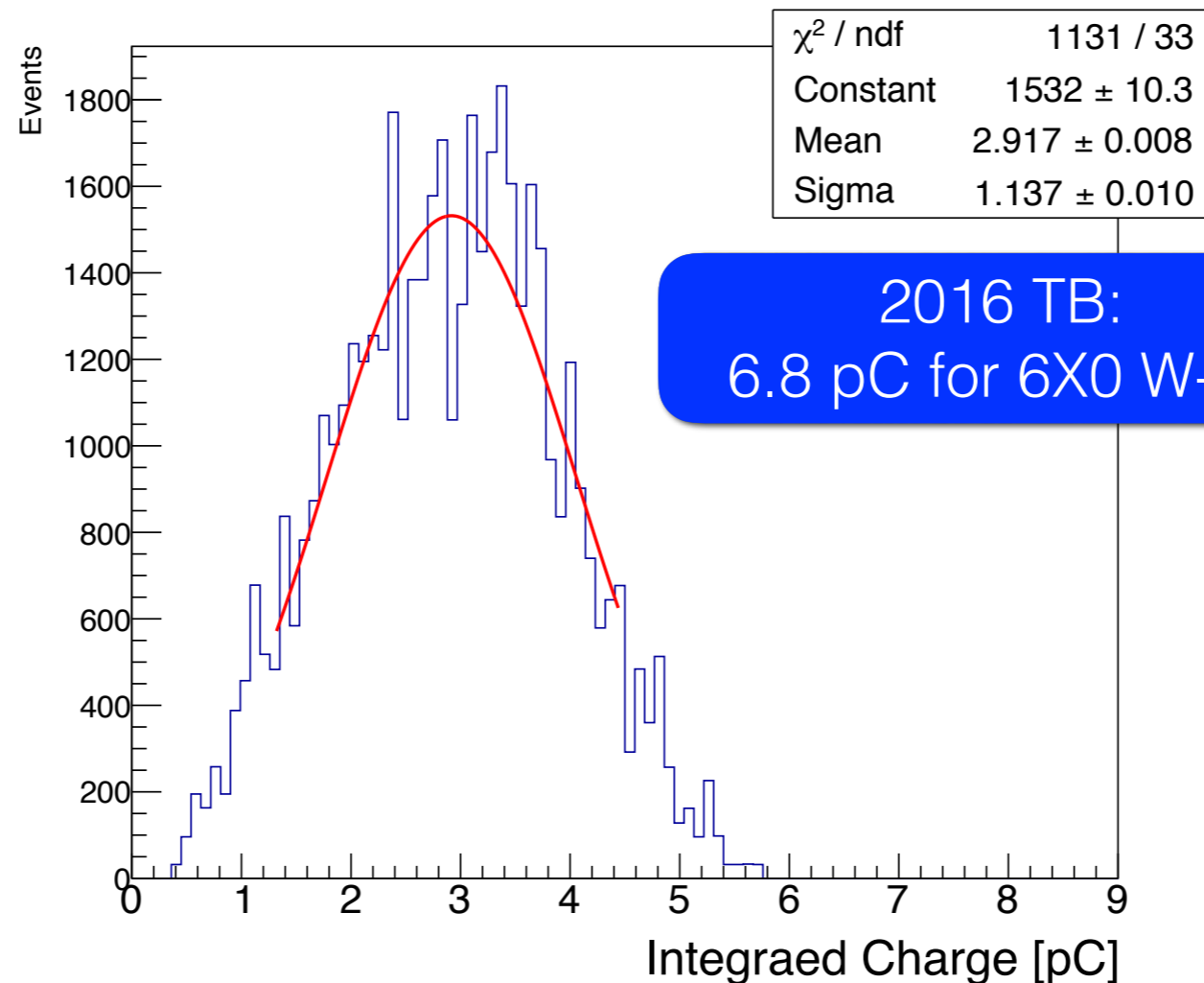
CdTe timing resolution



10x10x1mm CdTe with 100GeV electron on 4.3X0 Pb

/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/
ReReco_analysis_7626_7631.root

CdTe calorimeter - charge



2016 TB:
6.8 pC for 6X0 W-Pb

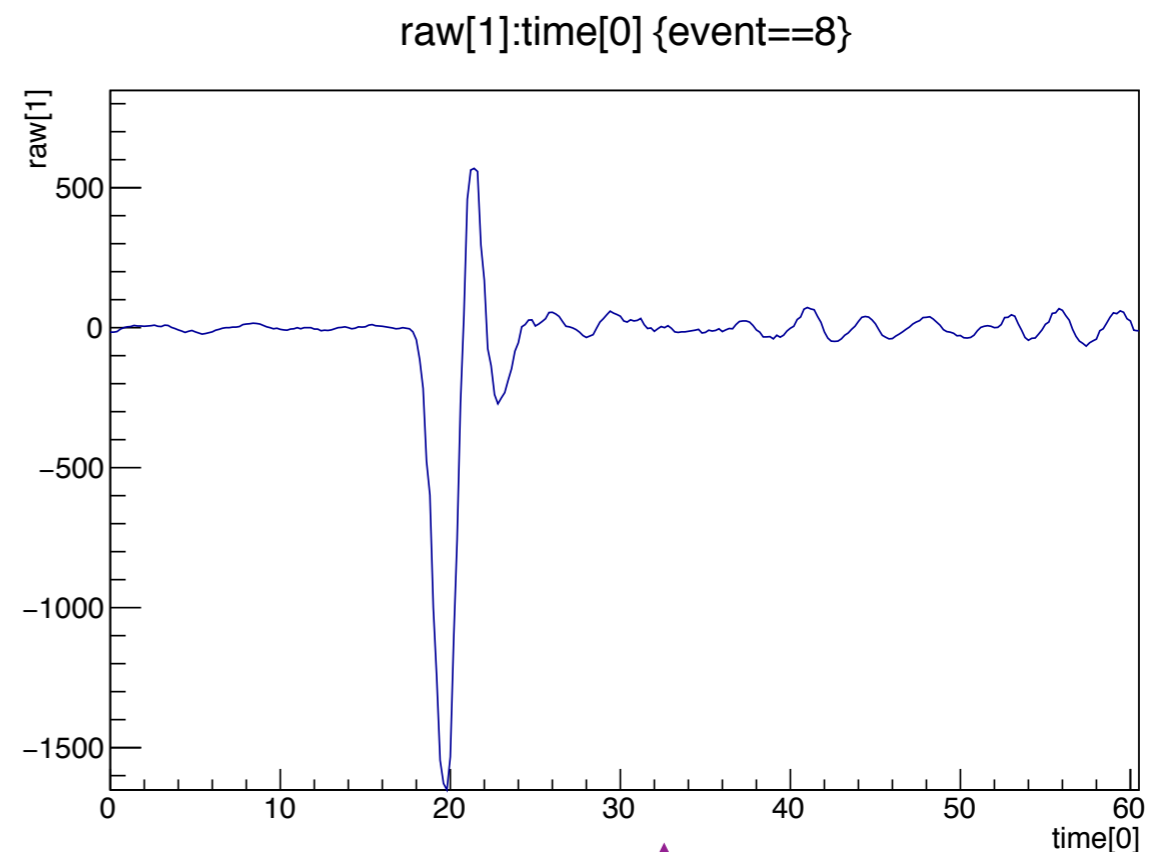
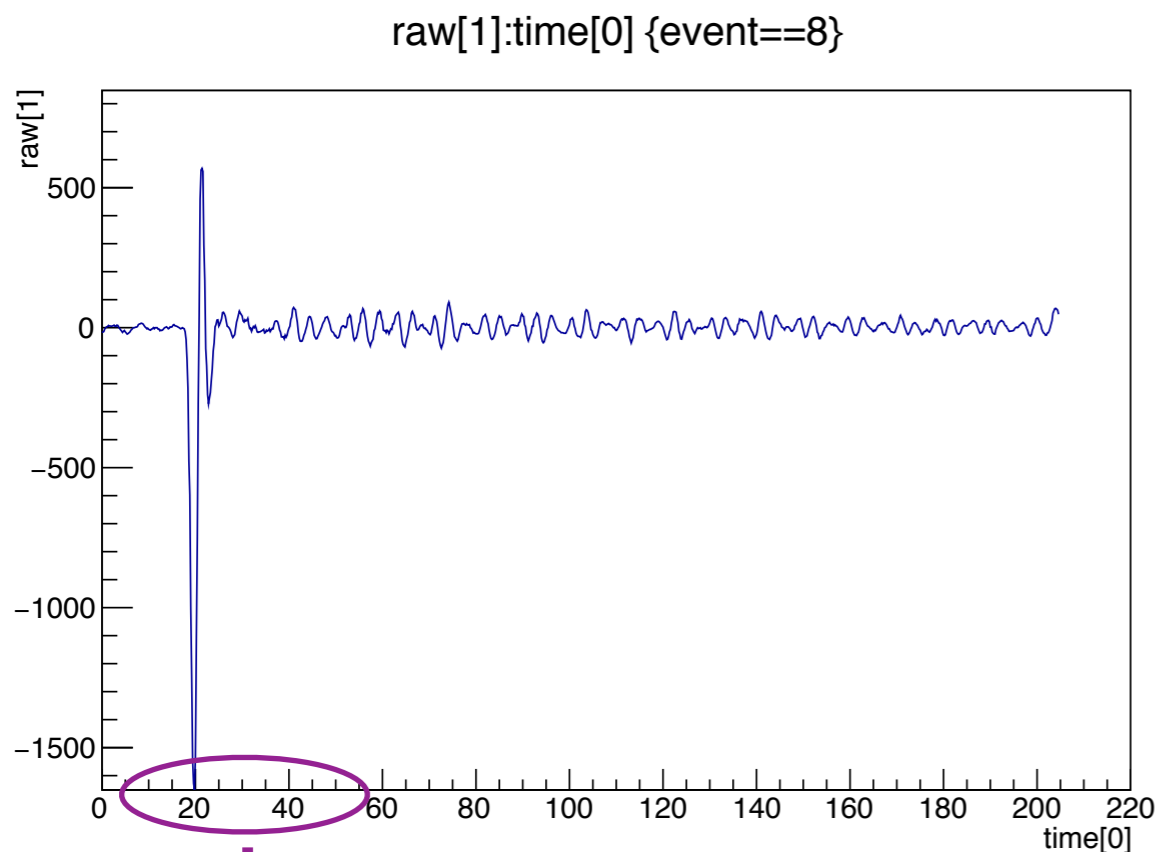
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ReReco_analysis_7626_7631.root

Discussion - CdTe

- Different absorber
 - Tungsten: moliere radius = 0.93 cm
 - Lead: moliere radius = 1.60 cm
- CdTe sensor is only 1x1cm, considering the shower events distribution, the sensor with lead will cover about half the shower events of that with tungsten.
- Which might explain why the charge is about half as 2016 test beam result, and the time resolution is about two times worse.

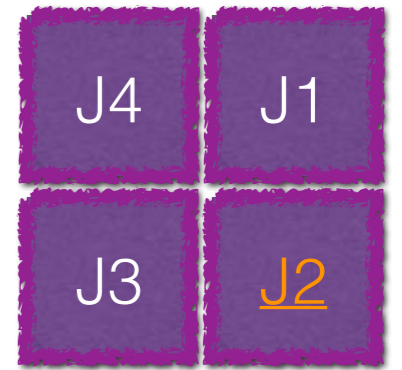
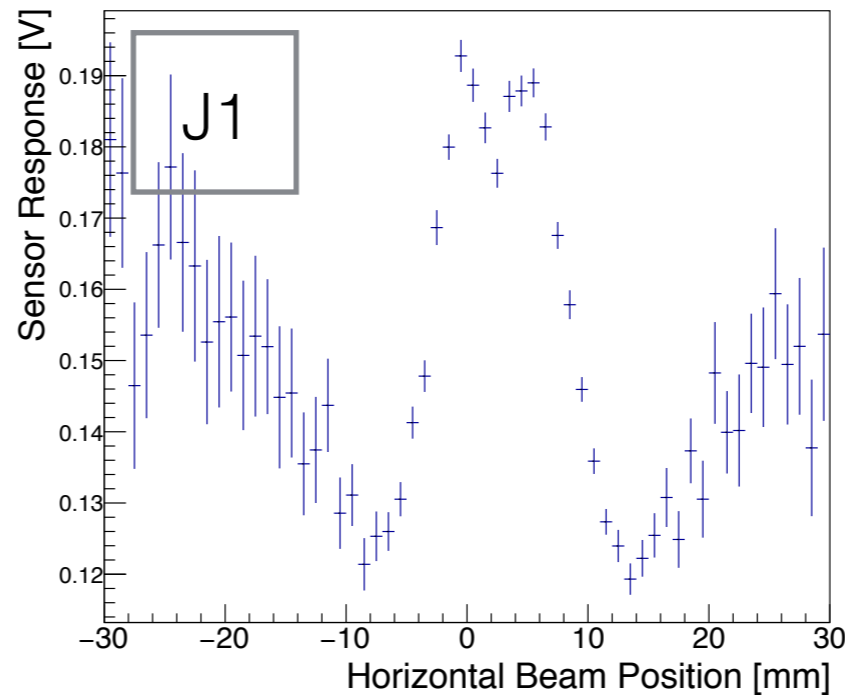
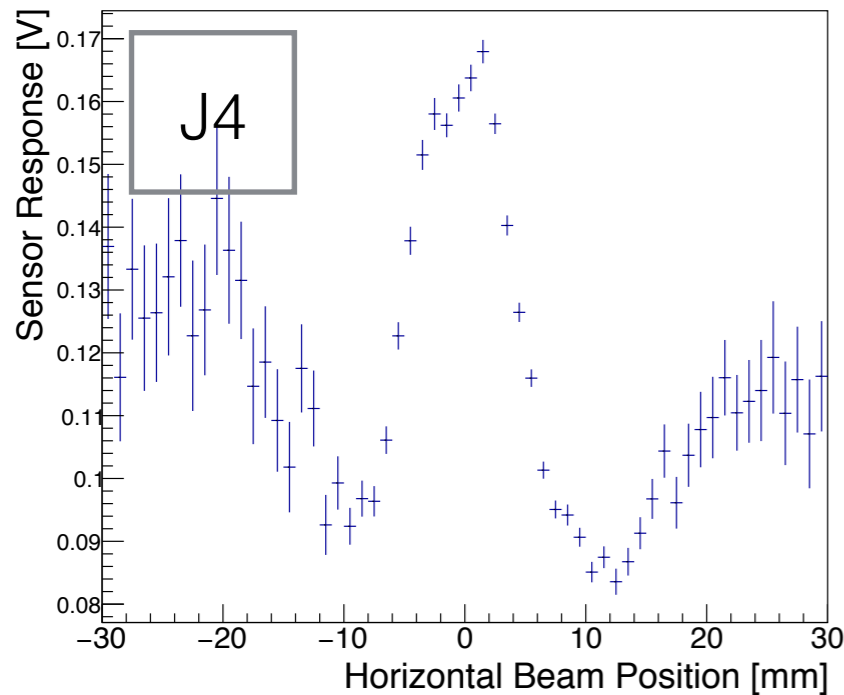
LGAD pulse



3x3x0.08mm LGAD with
100GeV electron on 4.3X0 Pb

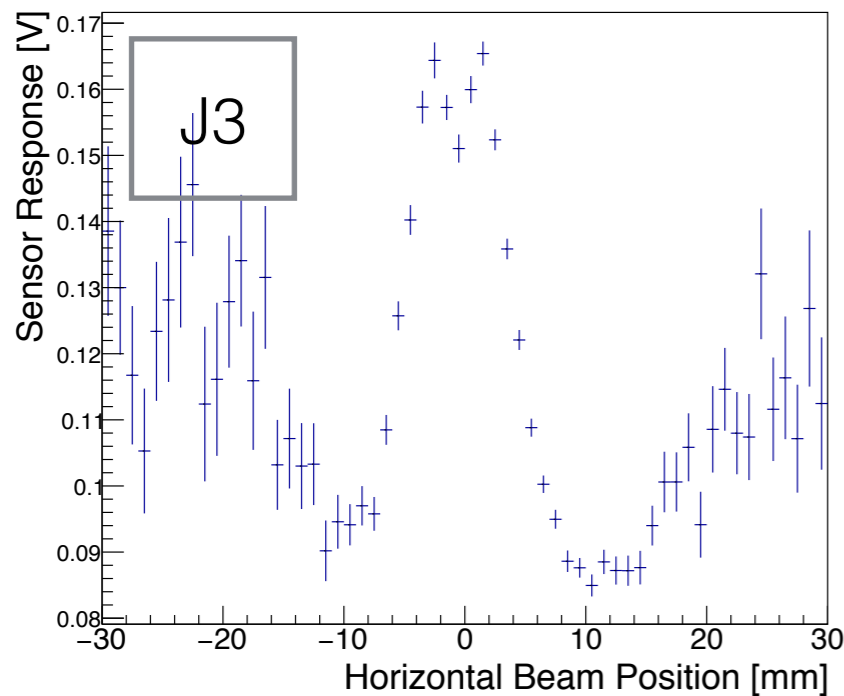
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LGAD - amplitude vs. impact point



J2 is broken

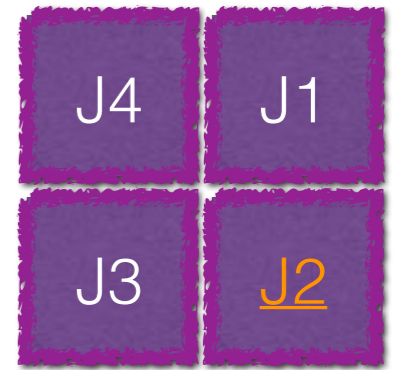
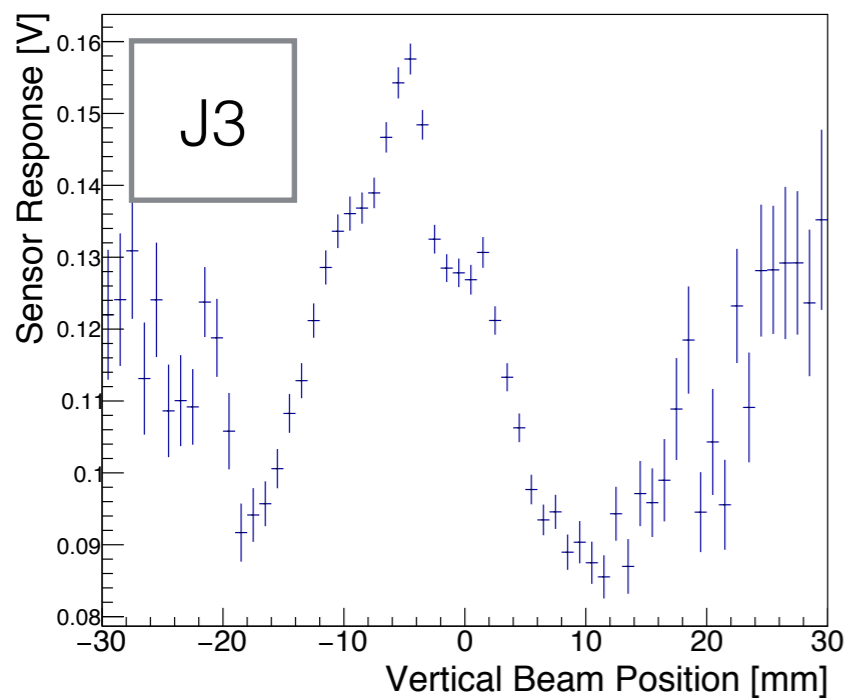
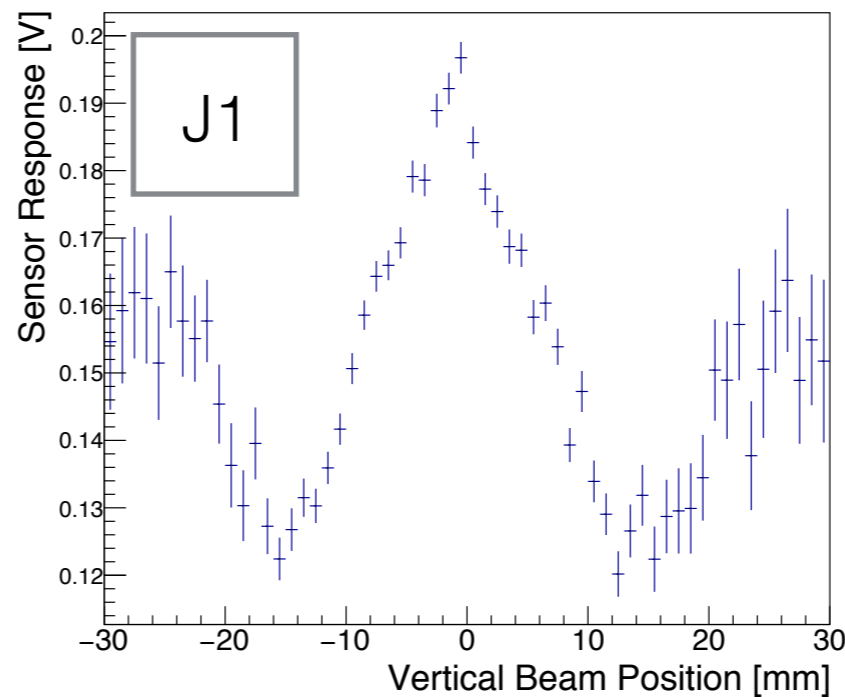
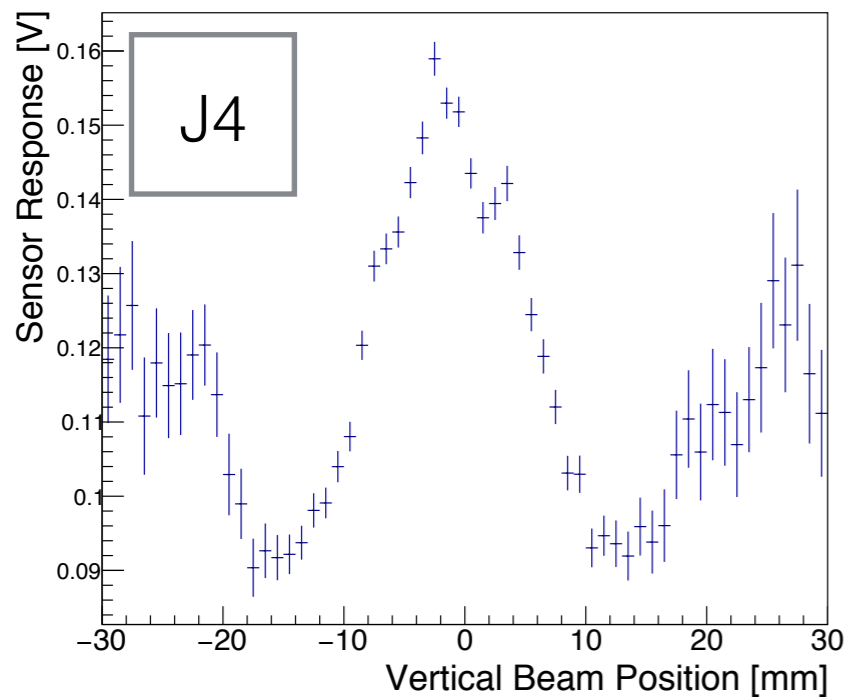
J1, J2: 200 MHz filter
J3, J4: 500 MHz filter



3x3x0.08mm LGAD
with 100GeV electron
on 4.3X0 Pb

/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/
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LGAD - amplitude vs. impact point



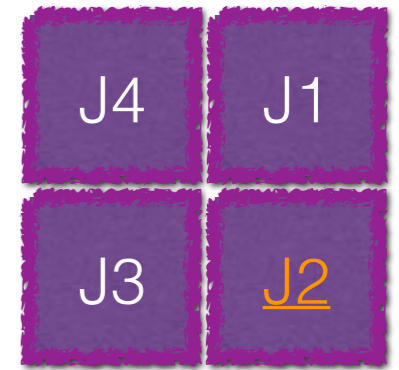
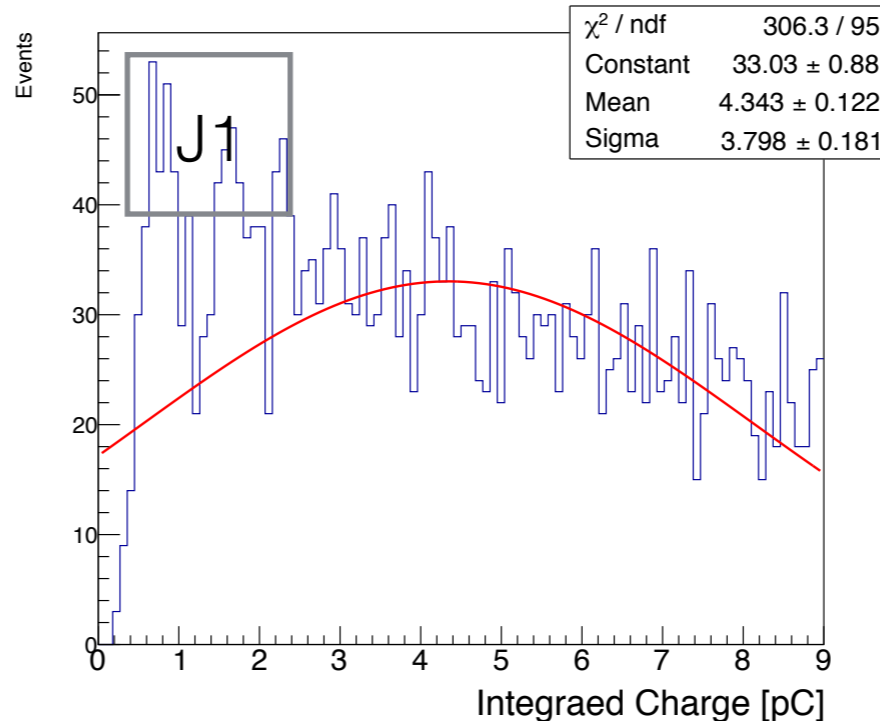
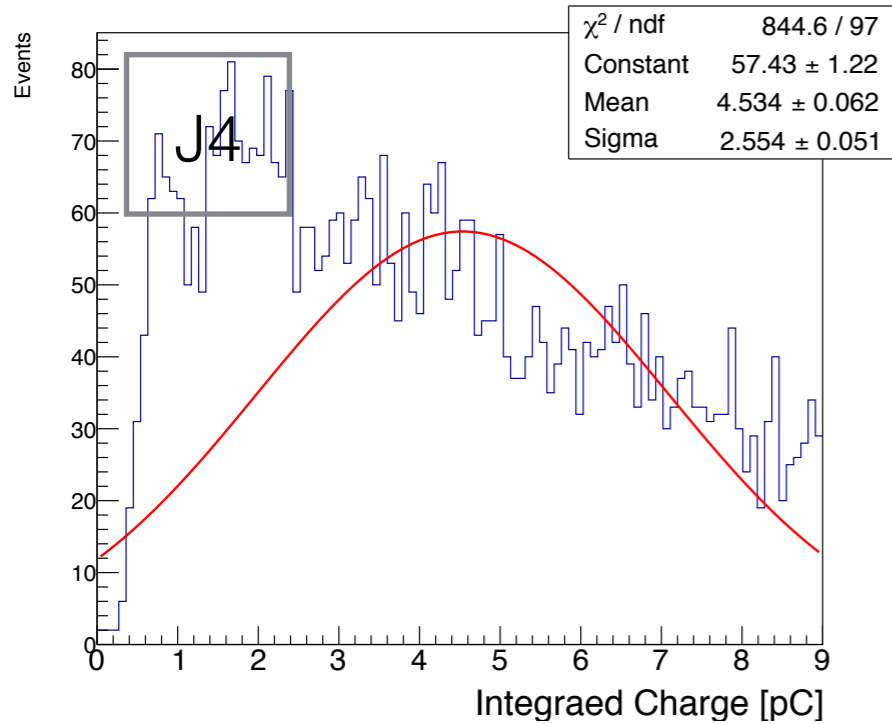
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3x3x0.08mm LGAD
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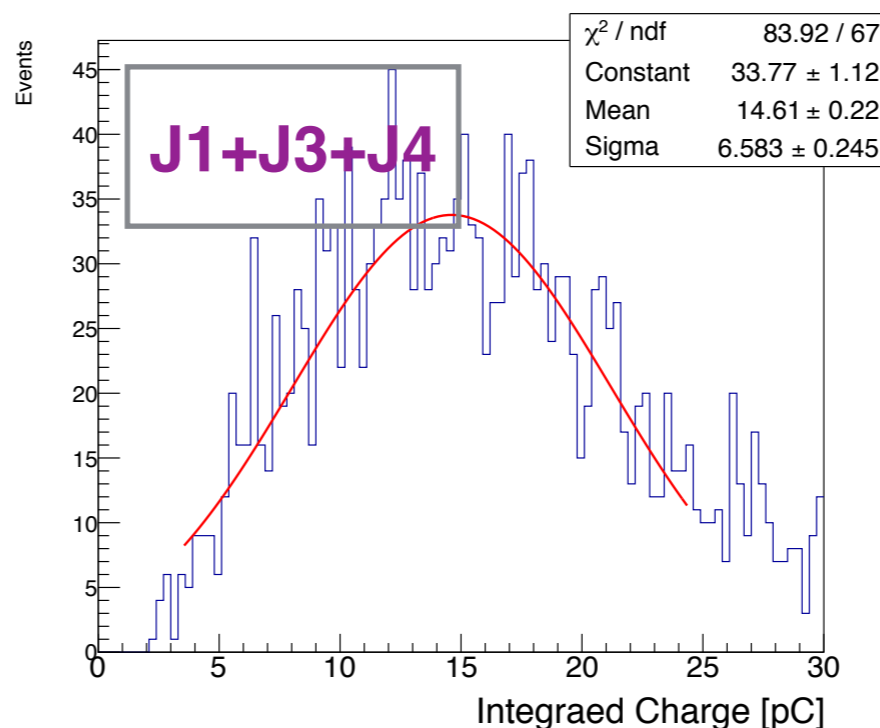
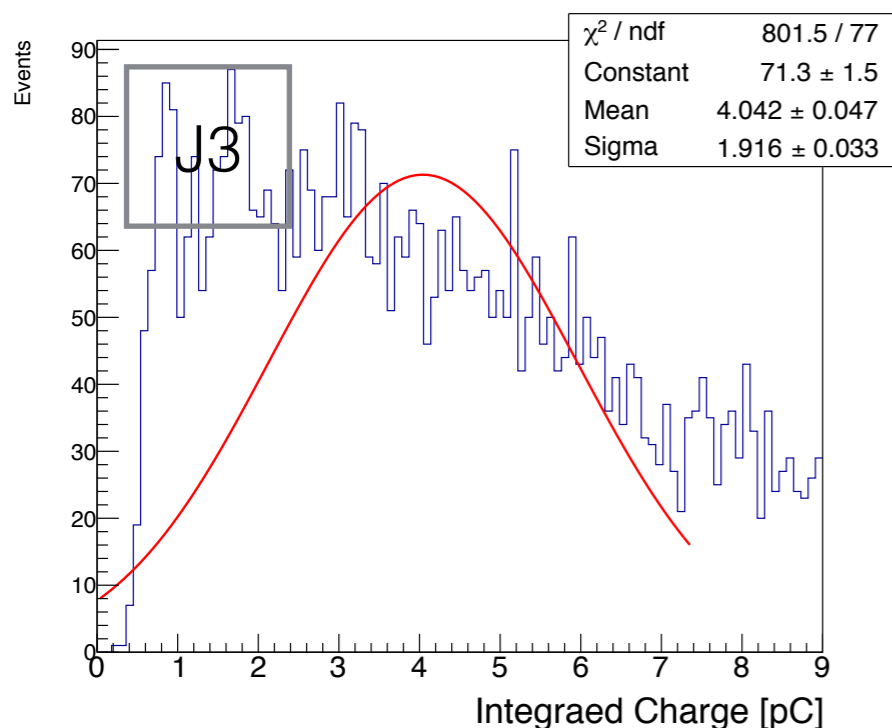
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LGAD - charge



J2 is broken

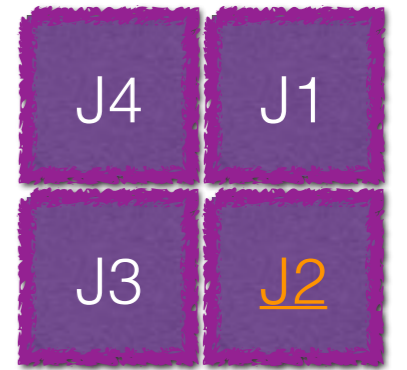
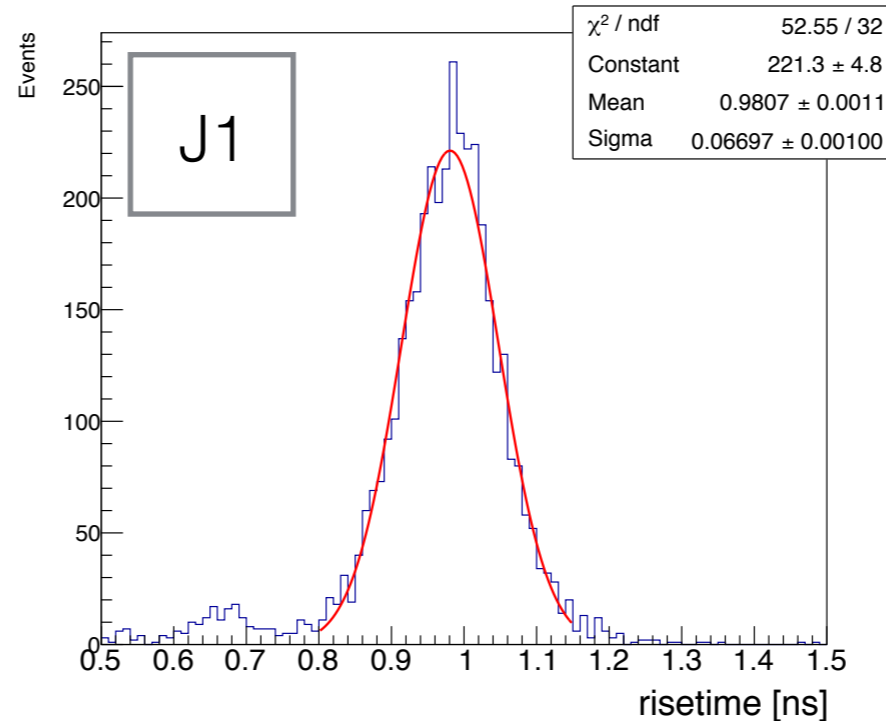
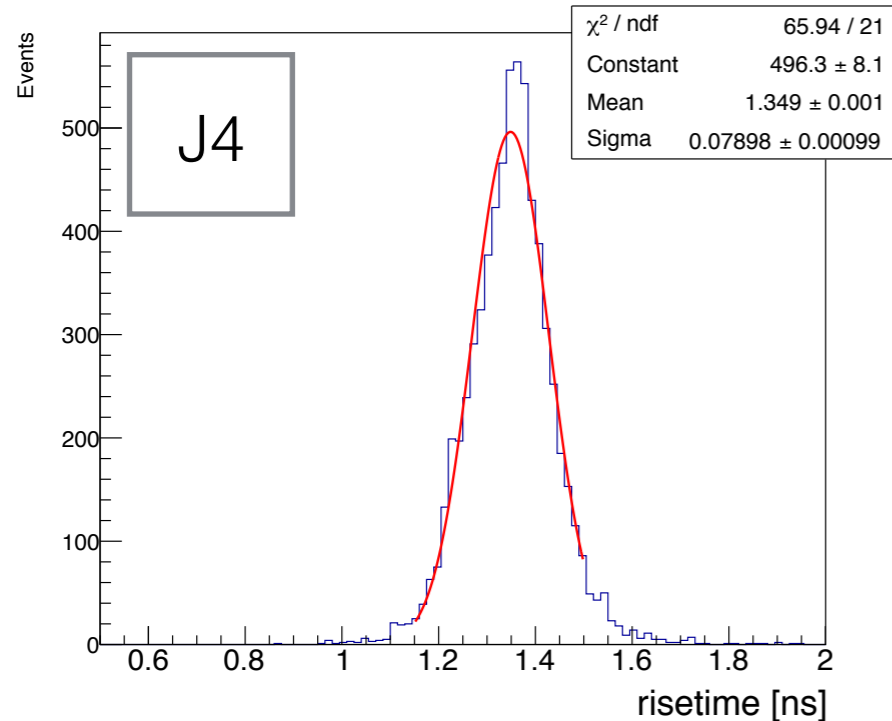
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3x3x0.08mm LGAD
with 100GeV electron
on 4.3X0 Pb

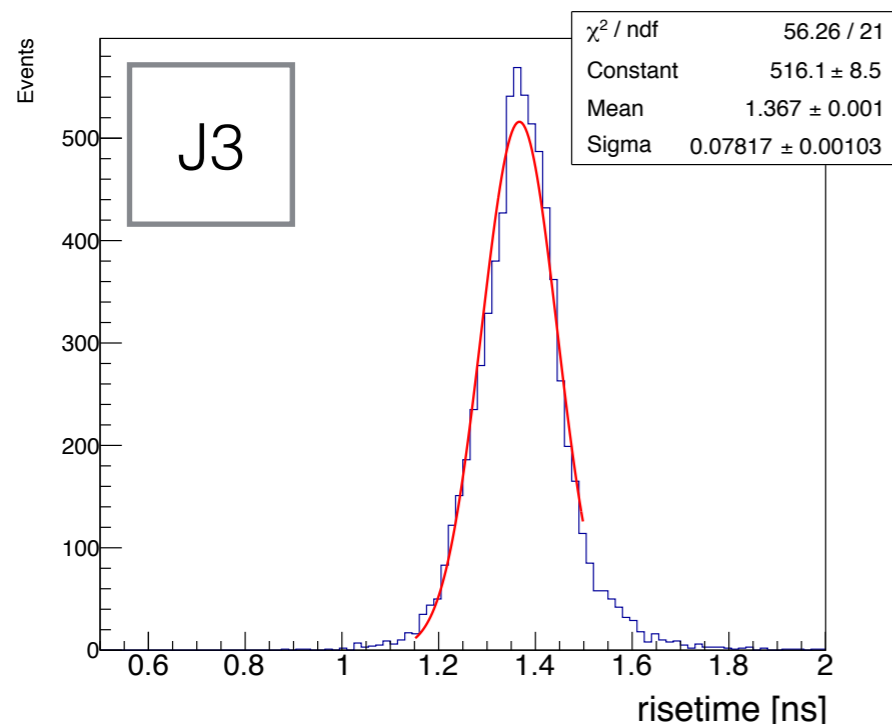
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LGAD - risetime



J2 is broken

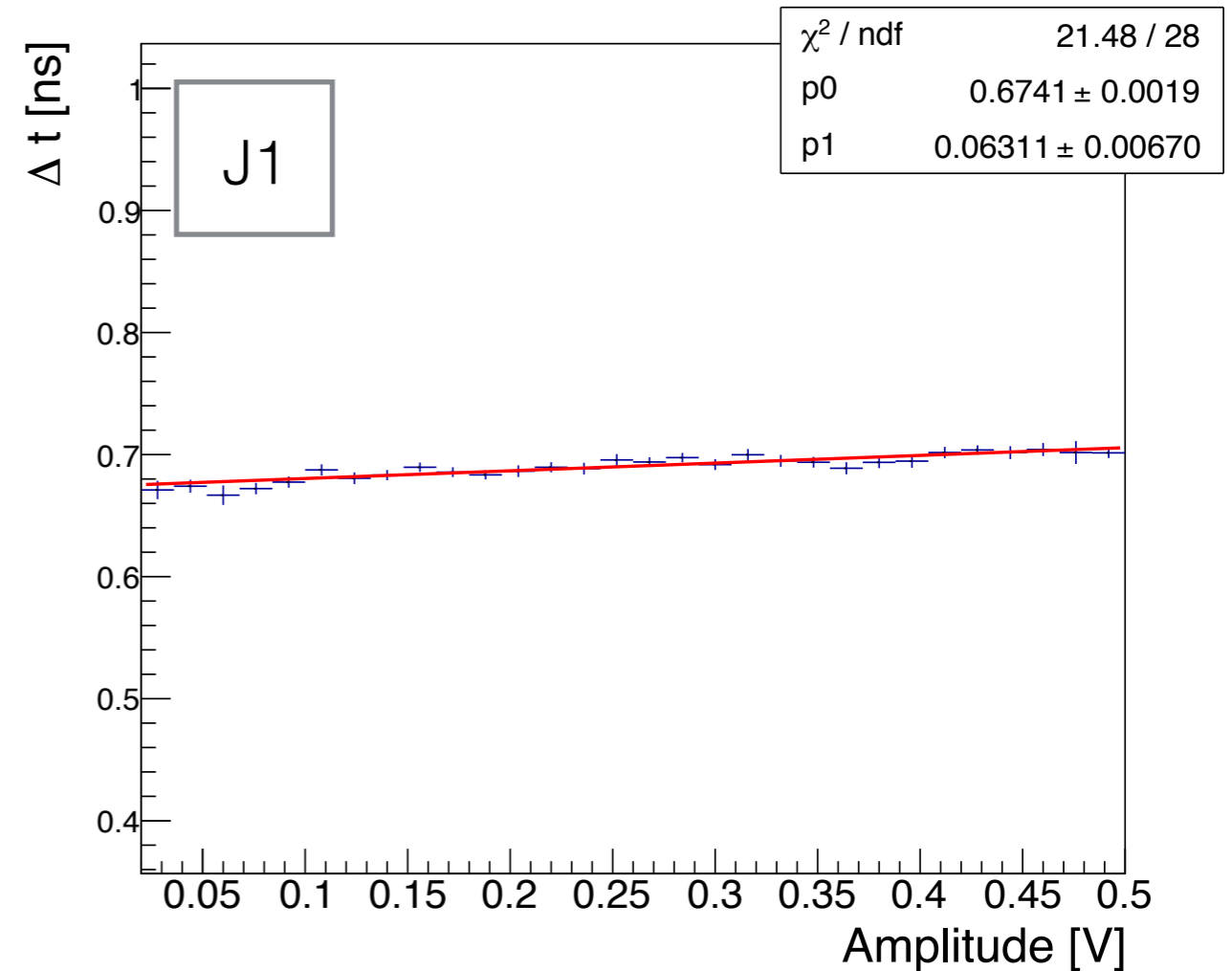
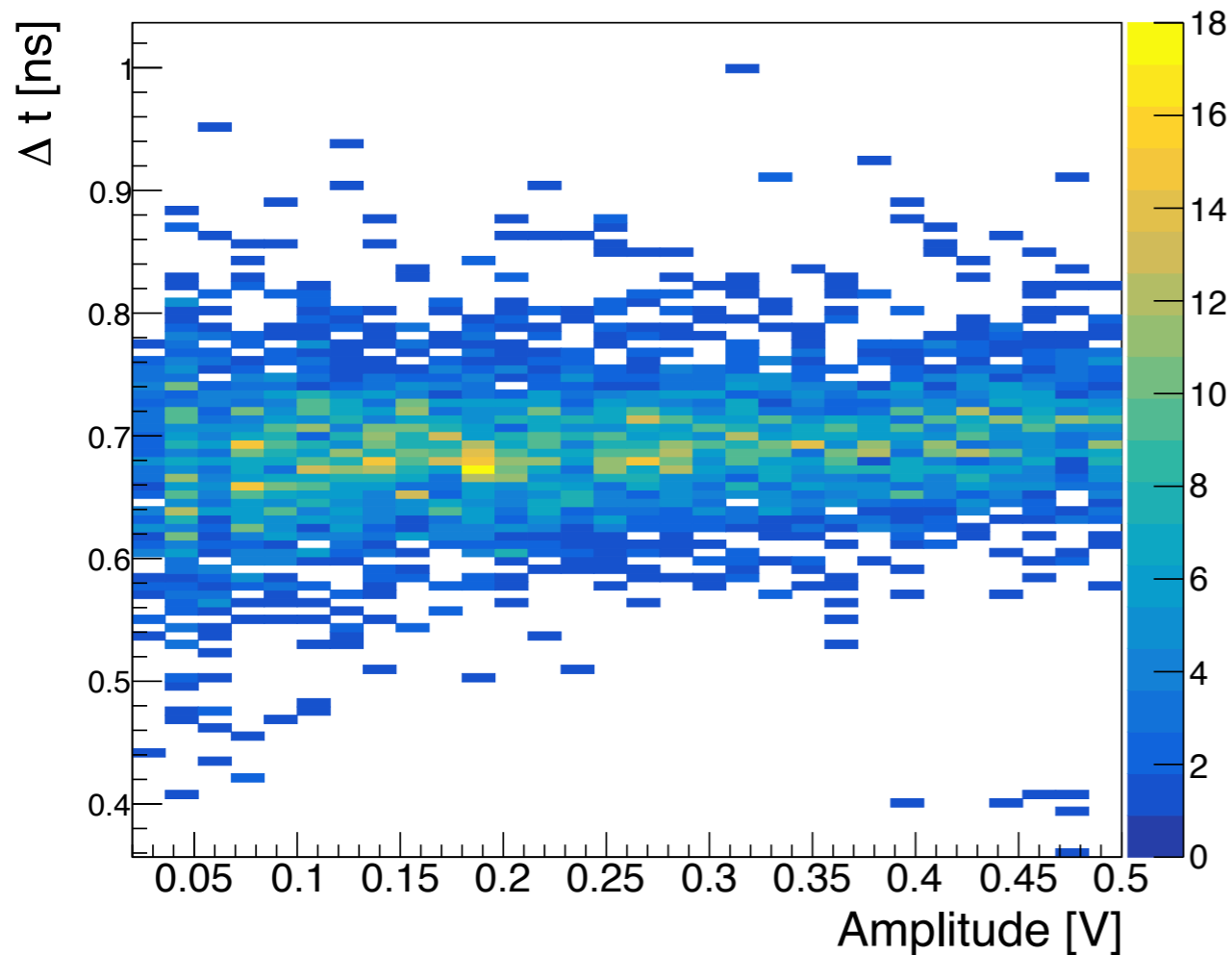
J1, J2: 200 MHz filter
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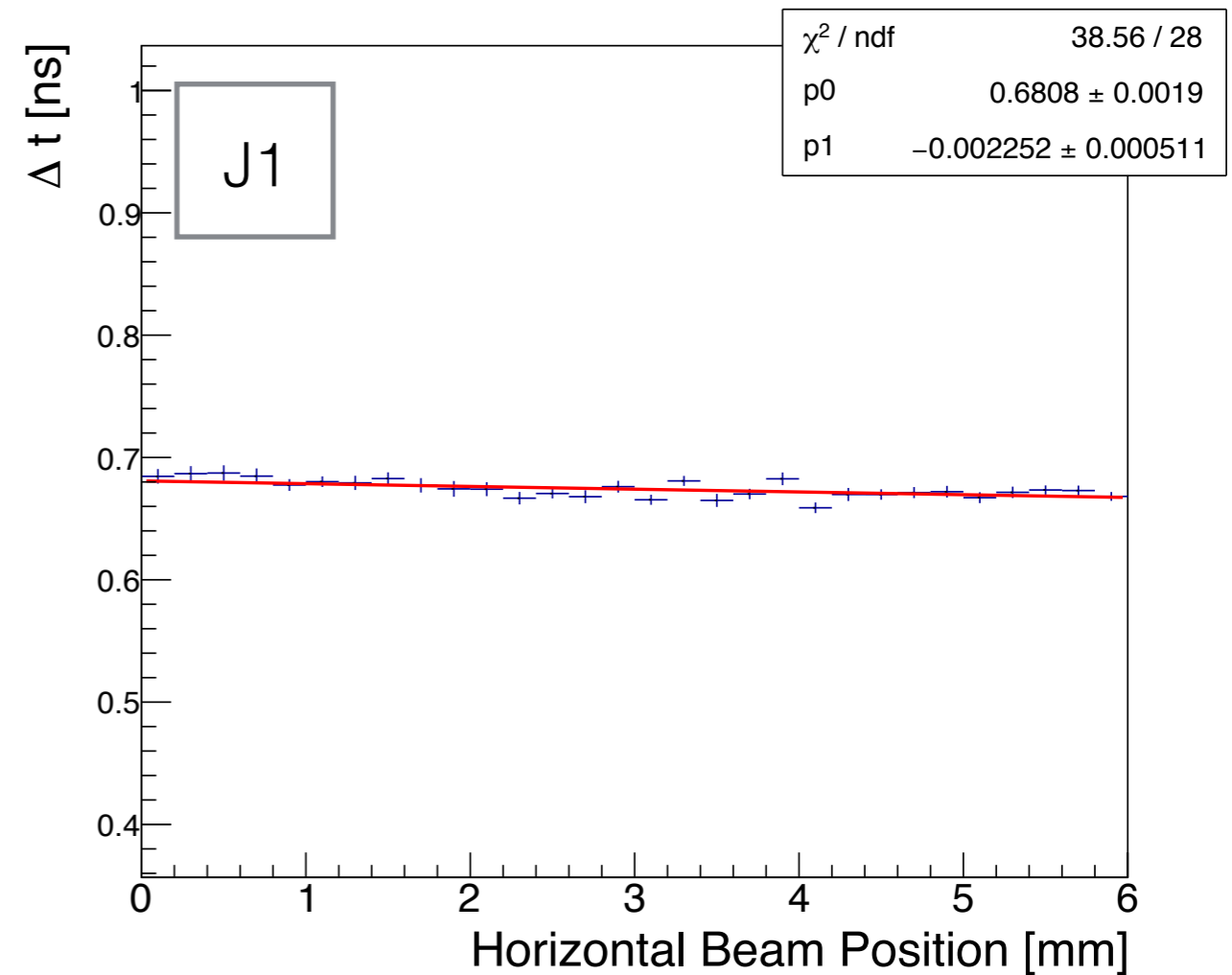
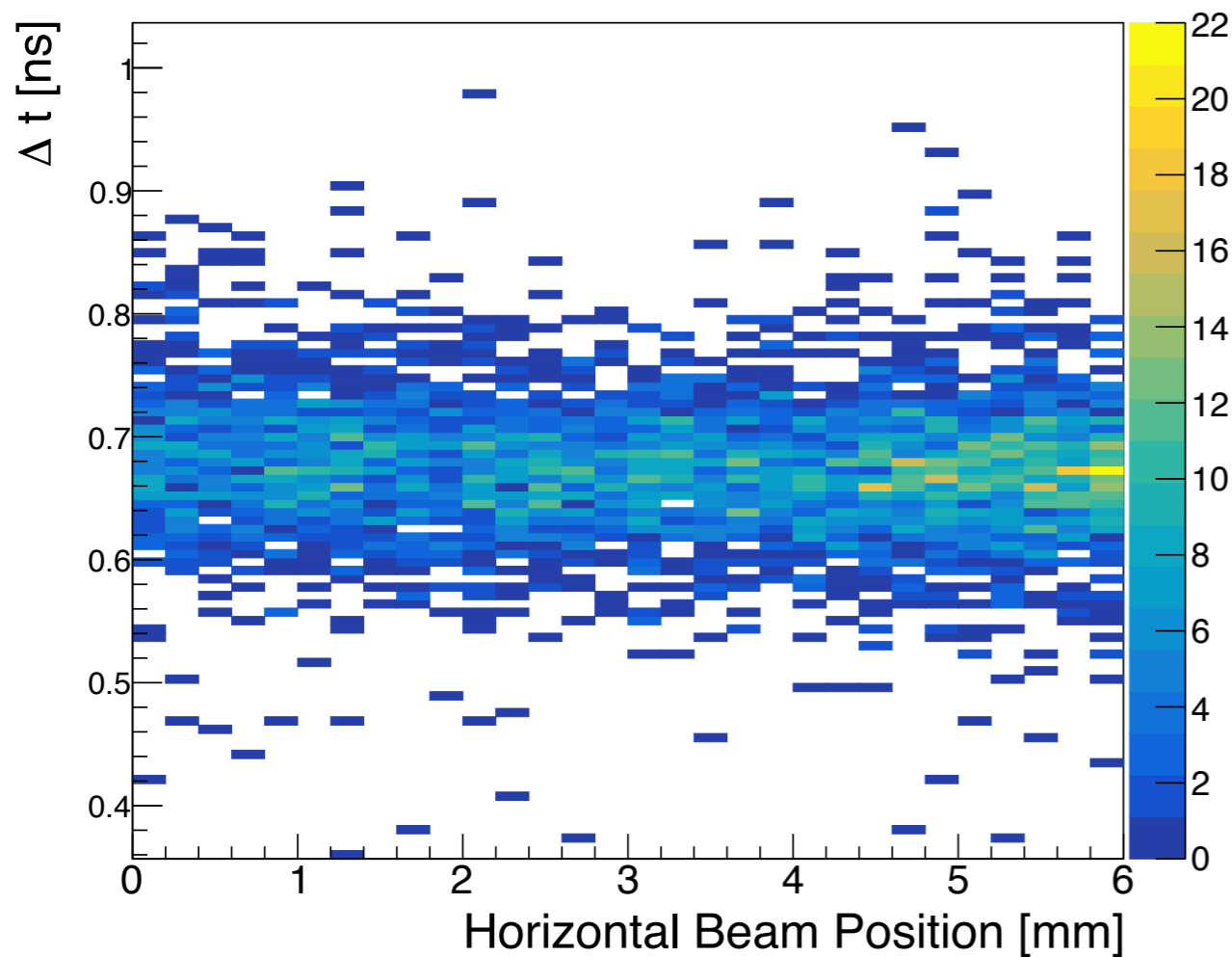
LGAD timing - time walk correction



3x3x0.08mm LGAD with 100GeV electron on 4.3X0 Pb

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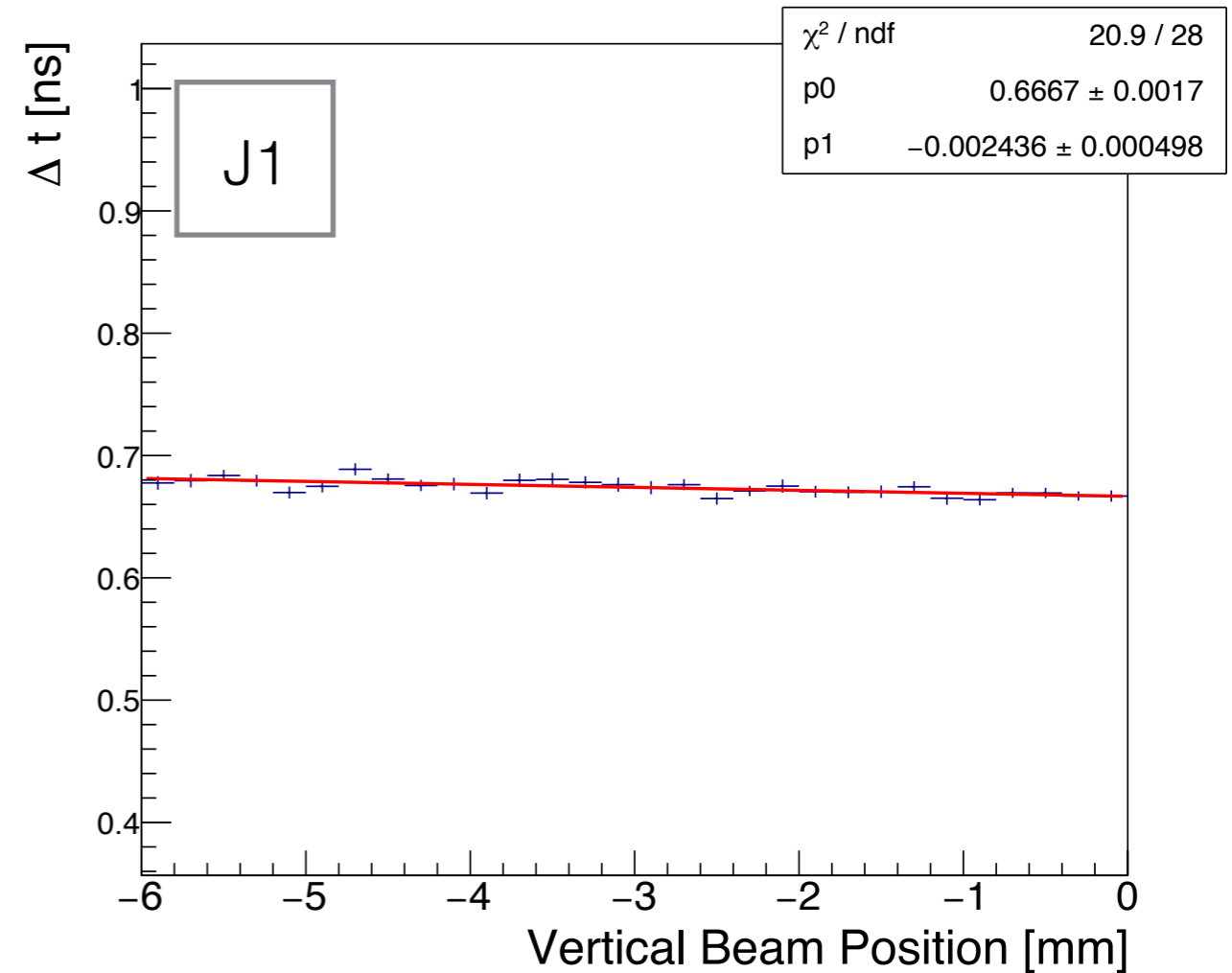
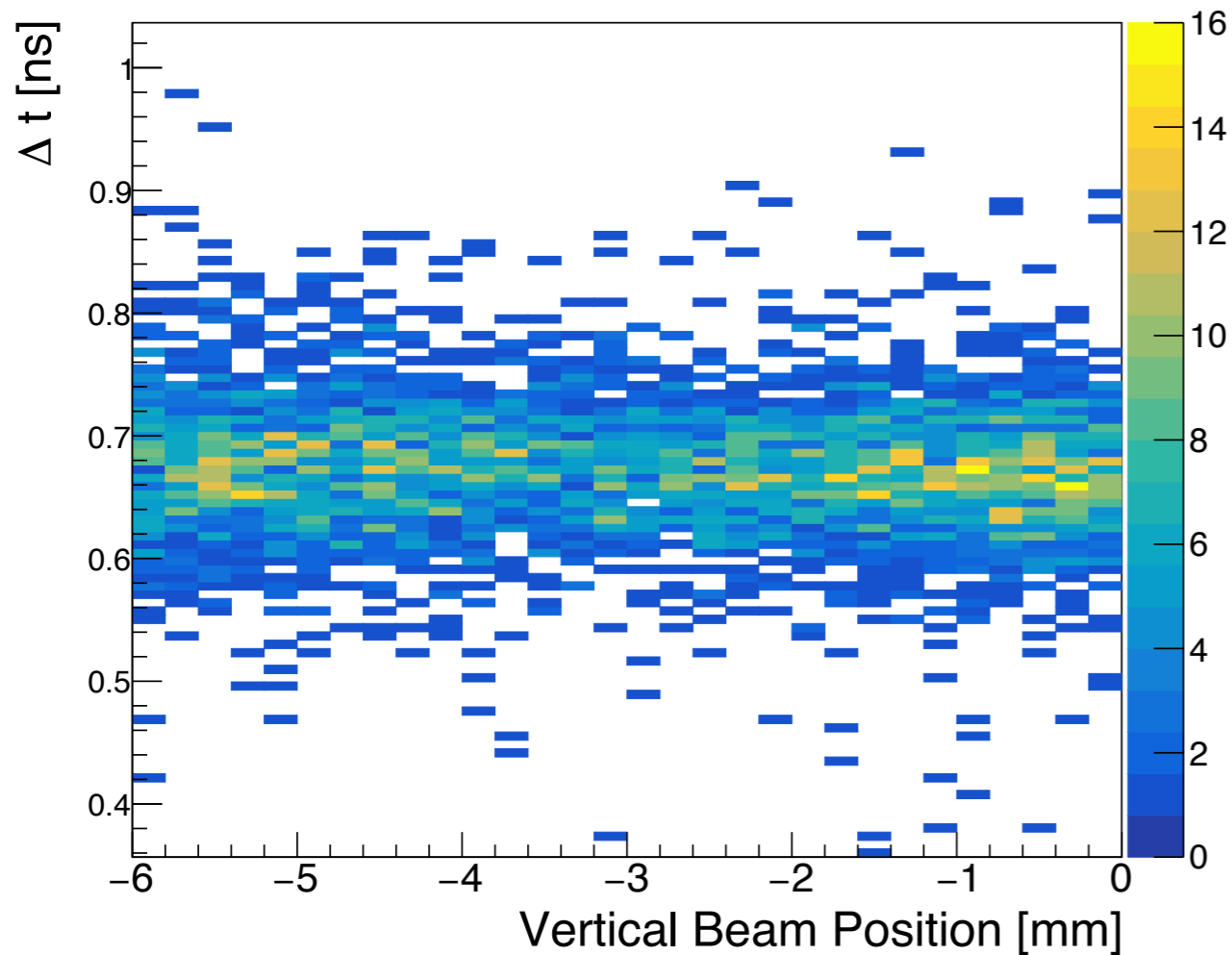
LGAD timing - impact point correction



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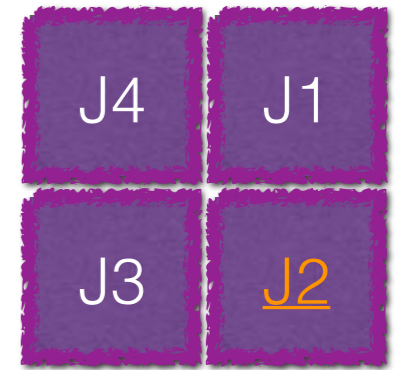
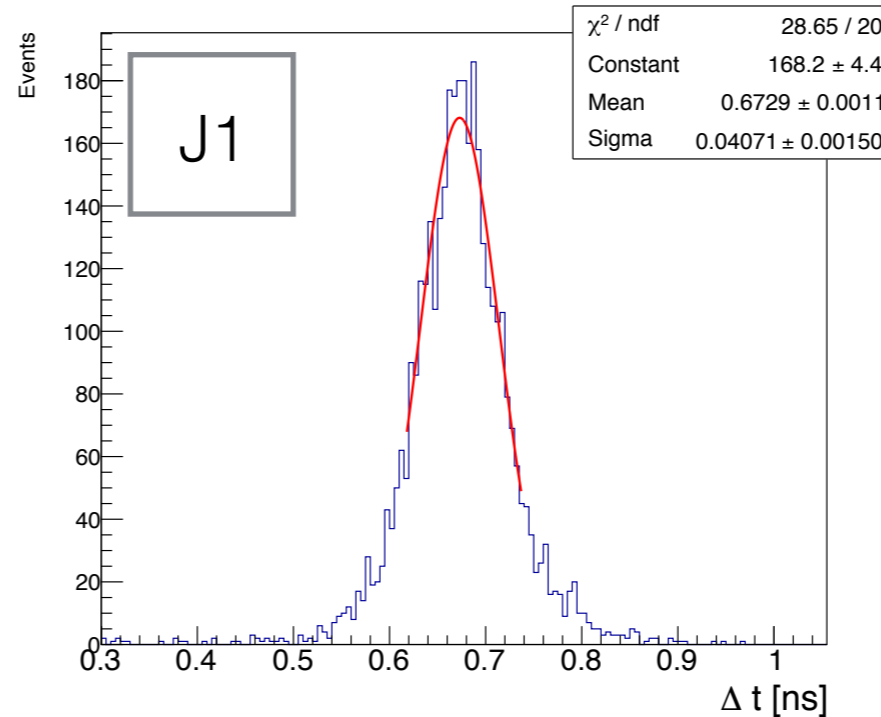
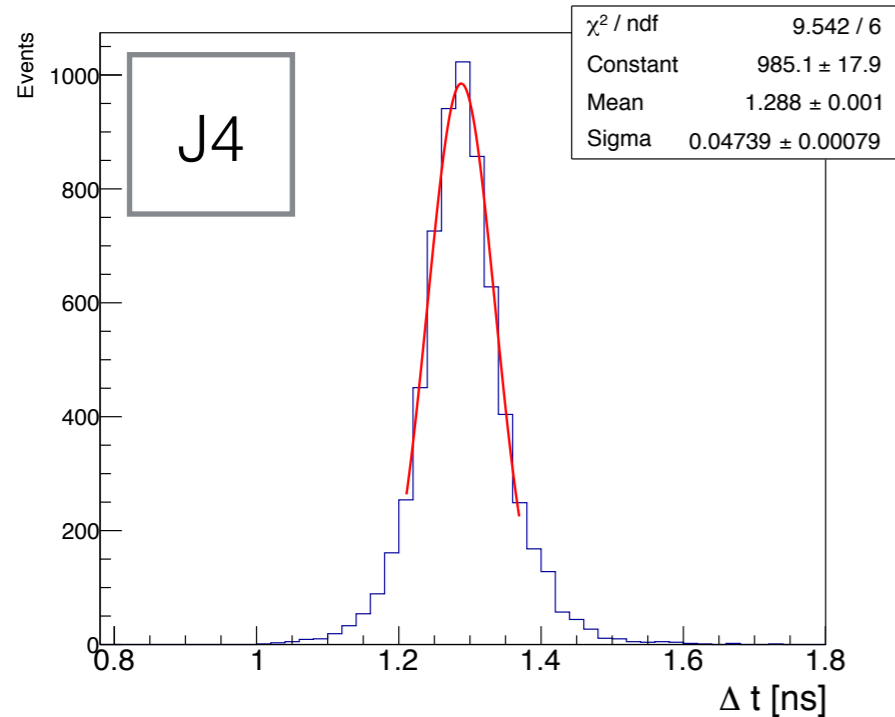
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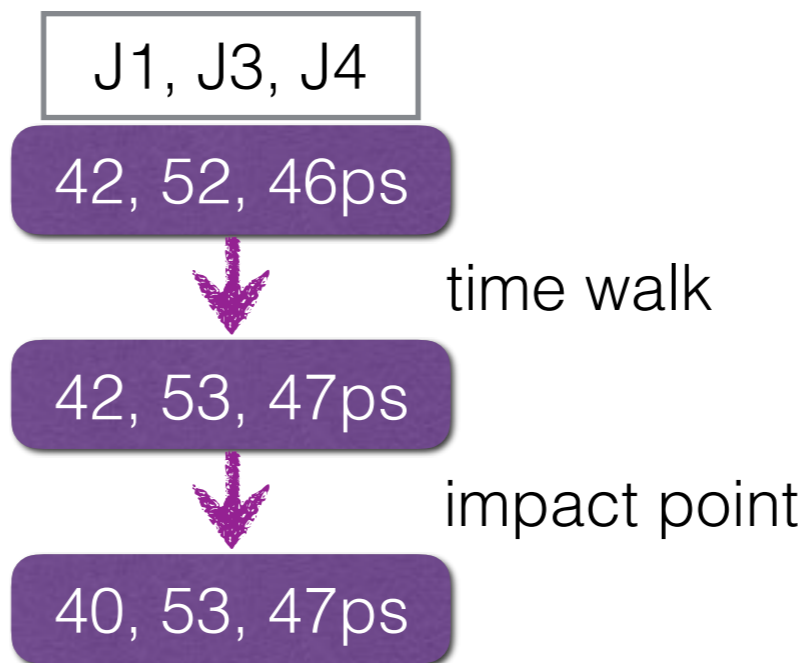
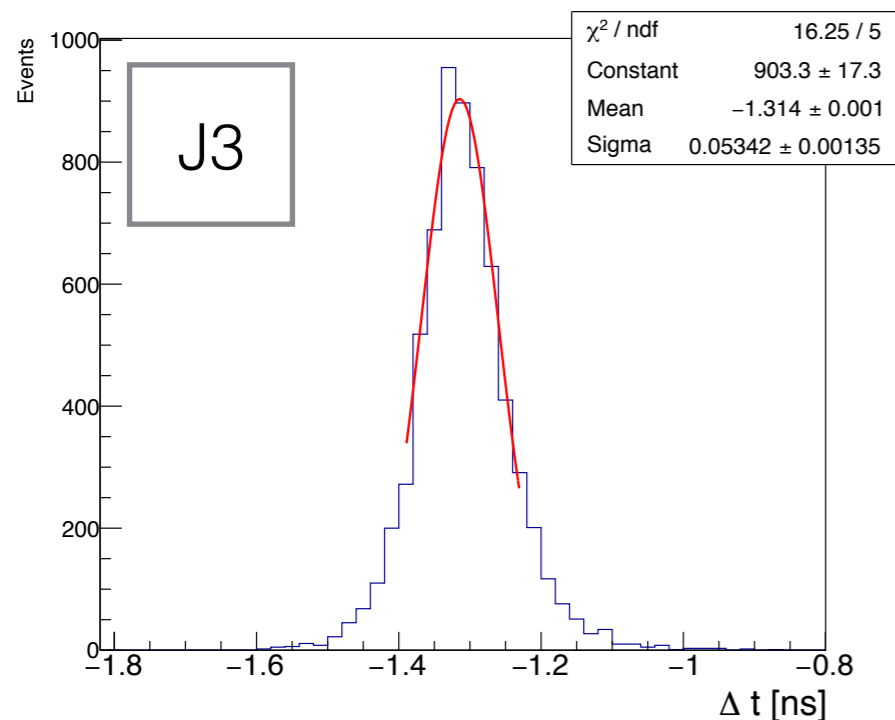
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LGAD - timing resolution



J2 is broken

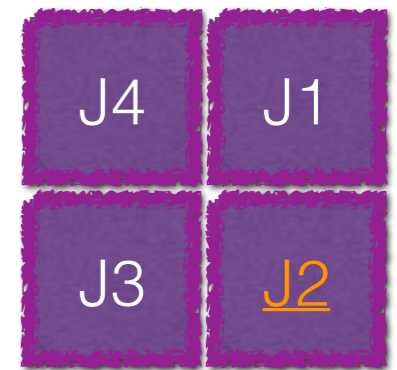
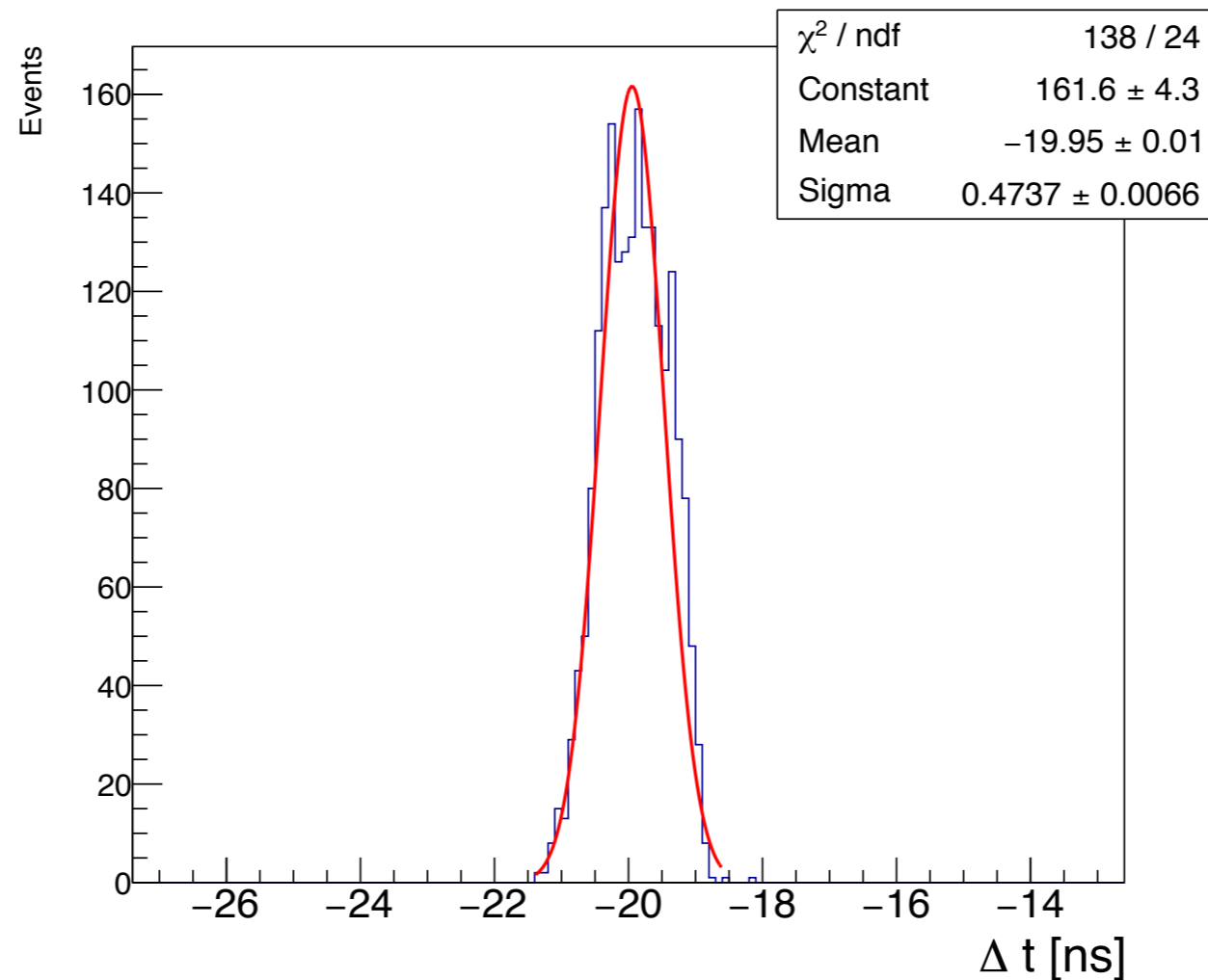
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/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/ReReco_analysis_7634_7651.root

LGAD - timing resolution - combine channels



J2 is broken

J1, J2: 200 MHz filter
J3, J4: 500 MHz filter

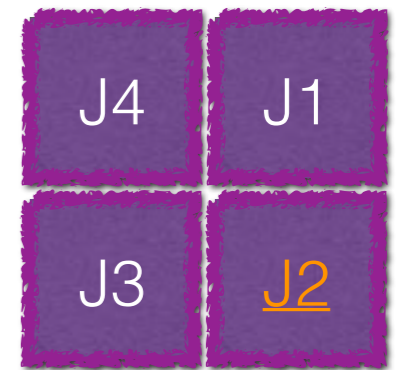
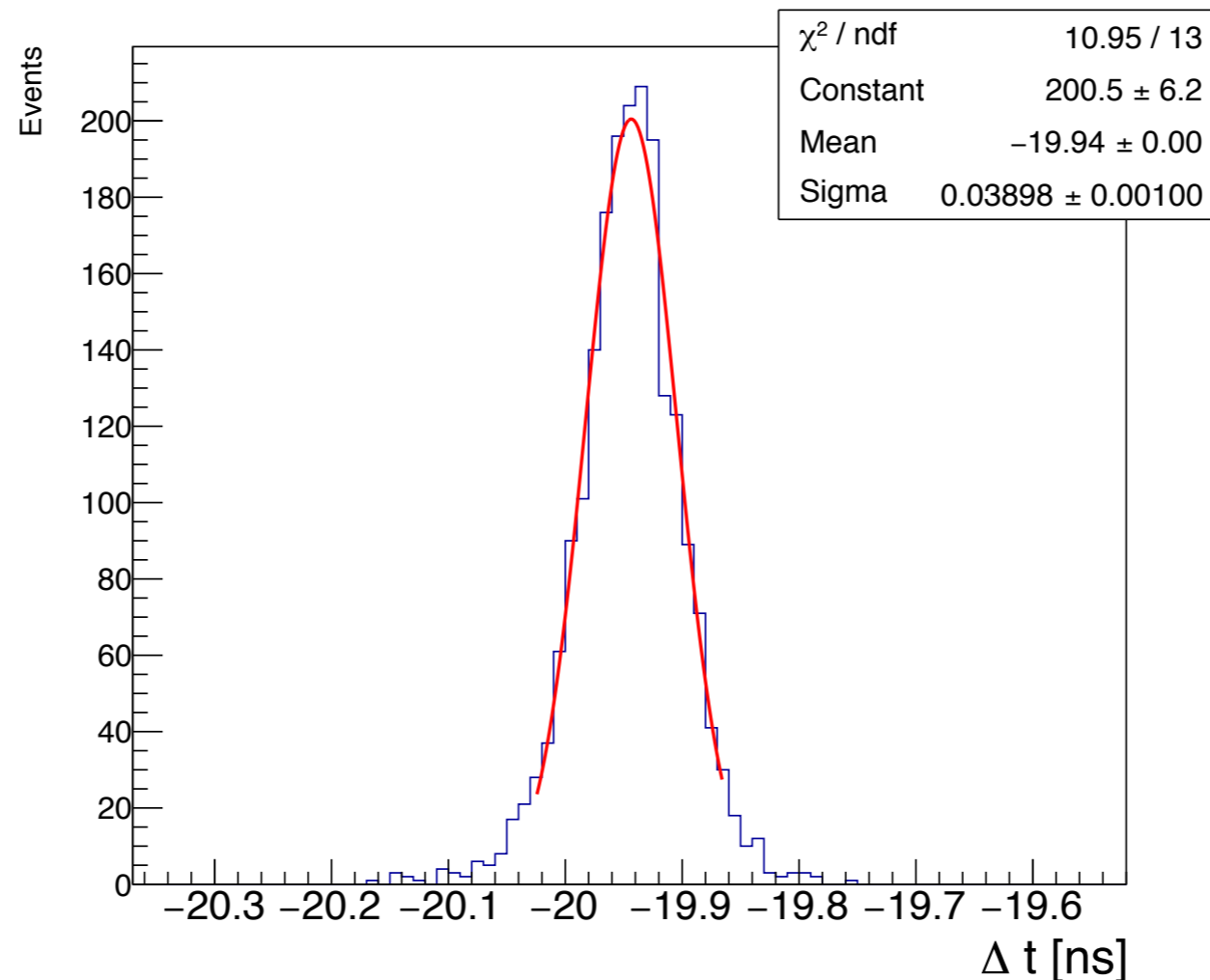
$$t = \frac{t_1 + t_3 + t_4}{3}$$

t_1, t_3, t_4 distributions are shifted to center at 0

3x3x0.08mm LGAD with 100GeV electron on 4.3X0 Pb

/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/ReReco_analysis_7634_7651.root

LGAD - timing resolution - combine channels



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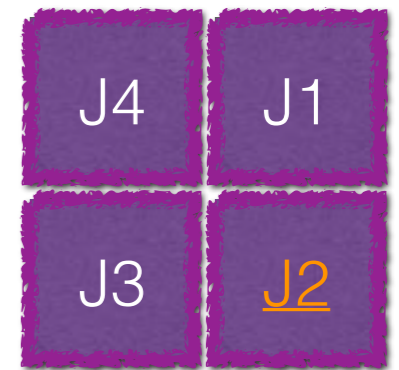
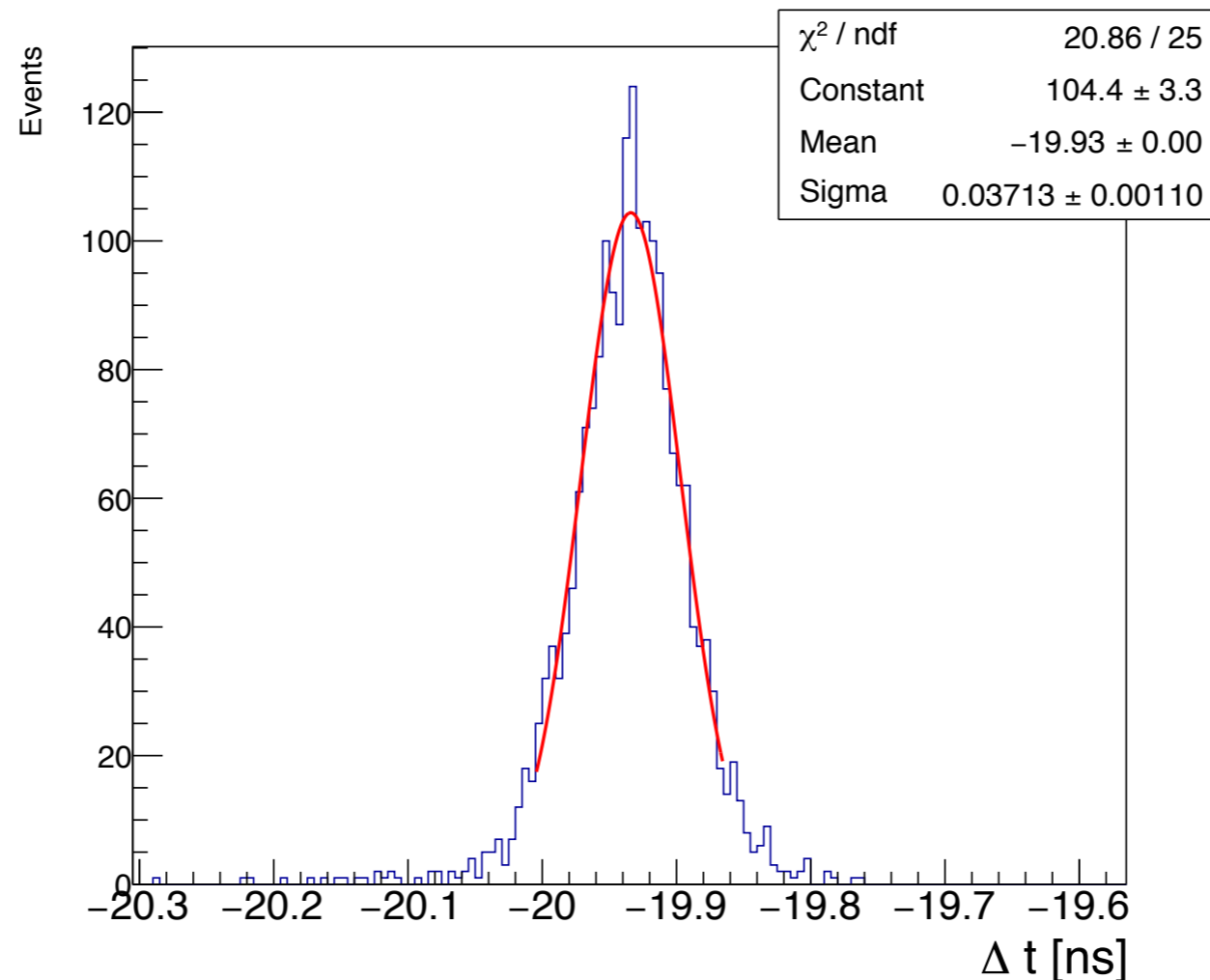
$$t = \frac{Q_1 t_1 + Q_3 t_3 + Q_4 t_4}{Q_1 + Q_3 + Q_4}$$

t_1, t_3, t_4 distributions are shifted to center at 0

3x3x0.08mm LGAD with 100GeV electron on 4.3X0 Pb

/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/ReReco_analysis_7634_7651.root

LGAD - timing resolution - combine channels



J2 is broken

J1, J2: 200 MHz filter
J3, J4: 500 MHz filter

$$t = \frac{V_1 t_1 + V_3 t_3 + V_4 t_4}{V_1 + V_3 + V_4}$$

t_1, t_3, t_4 distributions are shifted to center at 0

3x3x0.08mm LGAD with 100GeV electron on 4.3X0 Pb

/eos/cms/store/group/phys_susy/razor/Timing/Jun2017CERN/ntuples/runs_combine/ReReco_analysis_7634_7651.root

Summary - LGAD

- Timing resolution
 - MIP (from FNAL test):
 - J1 and J2 (large amplitude): ~ 59 ps
 - J3 and J4 (small amplitude): ~ 66 ps
 - Shower (from CERN test):
 - J1 and J2 (large amplitude): ~ 40 ps
 - J3 and J4 (small amplitude): ~ 50 ps
 - All channels combine: ~ 37 ps
- Charge: manage to see a peak when sum all the channels up

BACKUP