

LAAPD studies: status report

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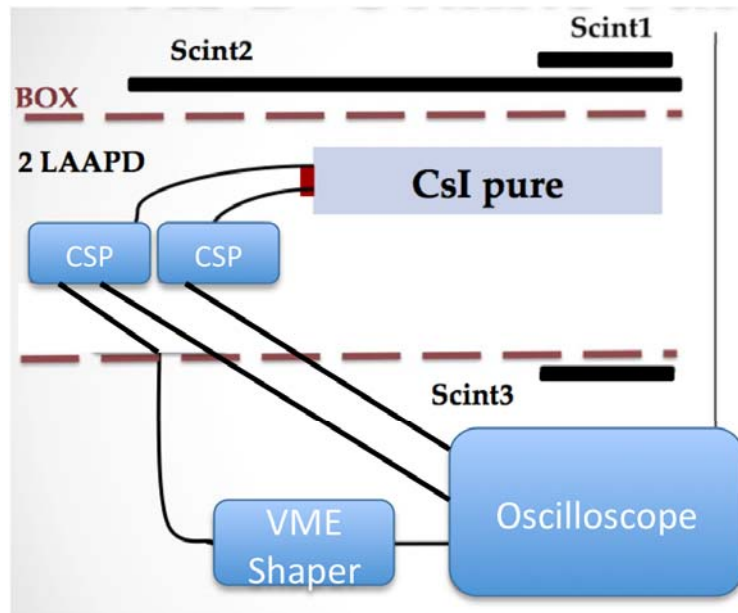
ECL-IT meeting, LNF

Outline

- Experimental setup
- Data acquisition and Analysis method
- Results with CREMAT CSP
- Results with CAEN CSP
- Conclusions and next steps

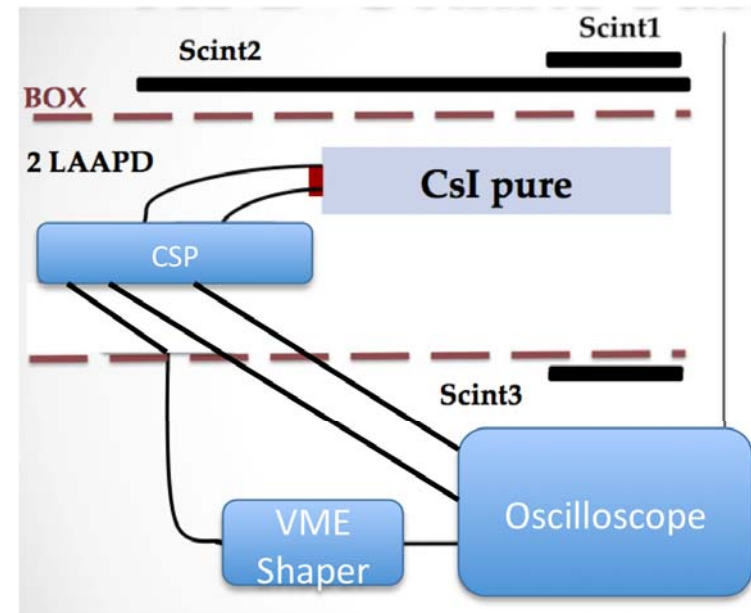
Experimental setup

- CREMAT CSP



— gain: 1.4 V/pC

- CAEN CSP



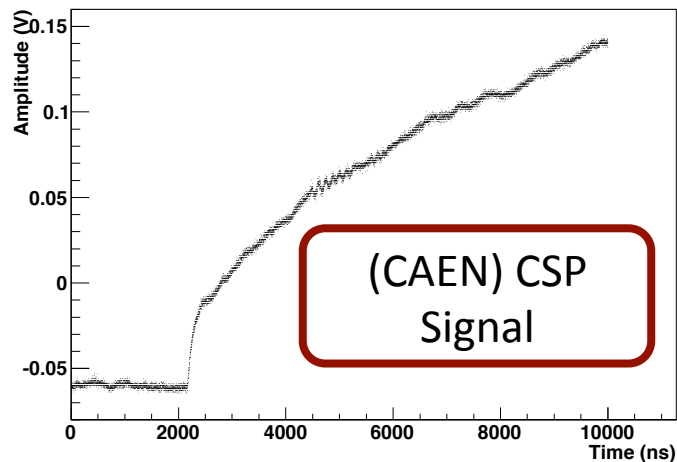
— gain: 2 V/pC



- simultaneous acquisition of 2 CSP channel + 1 HARDWARE SHAPER channel
- shaping time hardware shaper: 100 ns

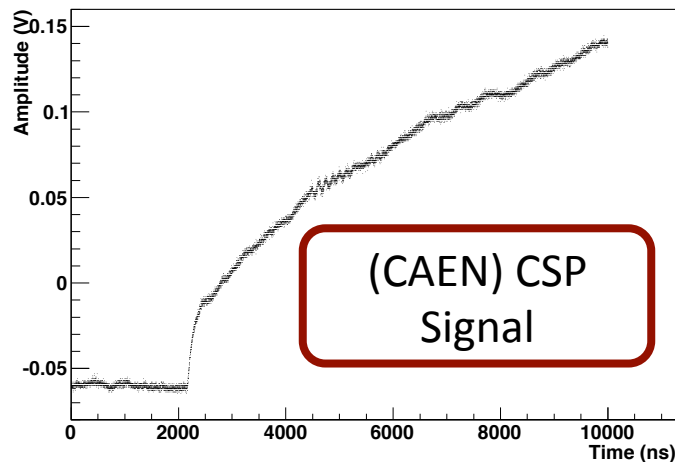
Data Acquisition and Analysis strategy

- Aim of the study:
 - compare ENE from **CSP**, **hardware shaper** and **software shaper** (100ns sh. time)
 - compare results with different software shaping times (100ns, 50ns, 30ns)



Data Acquisition and Analysis strategy

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 - compare ENE from **CSP**, **hardware shaper** and **software shaper** (100ns sh. time)
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CSP signal

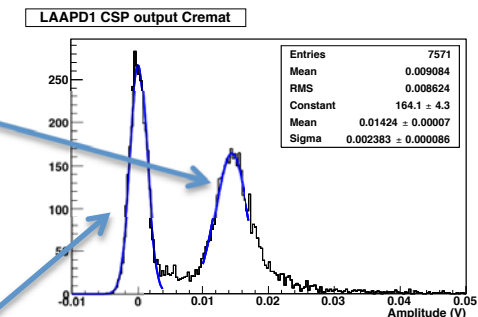
Pedestal : mean of 200 samplings (from 1300 to 1500)

Max Amplitude: mean of 200 samplings (from 2400 to 2600)

Amplitude = Max Amplitude - Pedestal

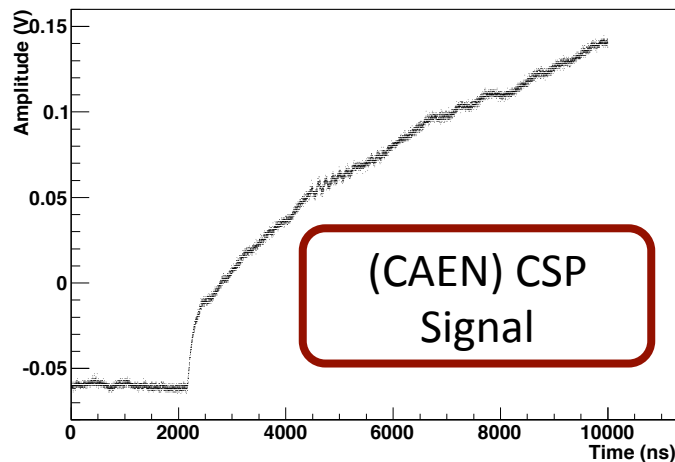
Signal Amplitude:
 μ from this gauss. fit

Noise:
 σ from this gauss. fit



Data Acquisition and Analysis strategy

- Aim of the study:
 - compare ENE from **CSP**, **hardware shaper** and **software shaper** (100ns sh. time)
 - compare results with different software shaping time (100ns, 50ns, 30ns)



Hardware shaper

Pedestal : mean of first 2000 samplings

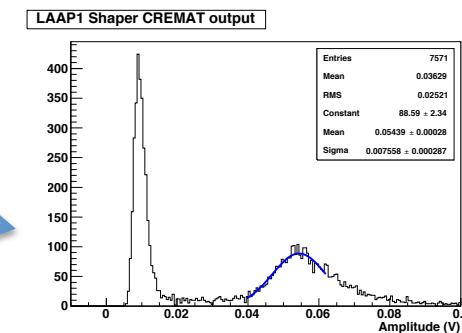
Max Amplitude: max val in the full range

Amplitude = Max Amplitude - Pedestal

Signal Amplitude:
 μ from this gauss. fit

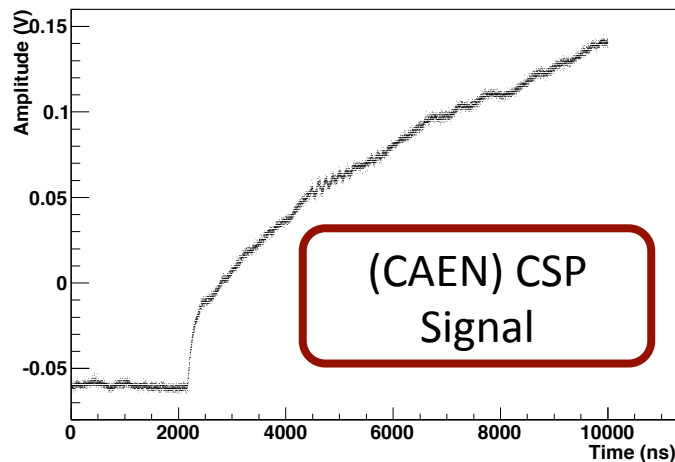
Noise:

σ from gauss. fit to ped-subtracted sampling distribution for the first 2000 samplings



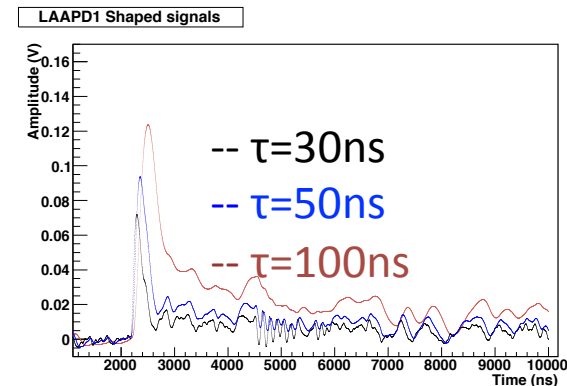
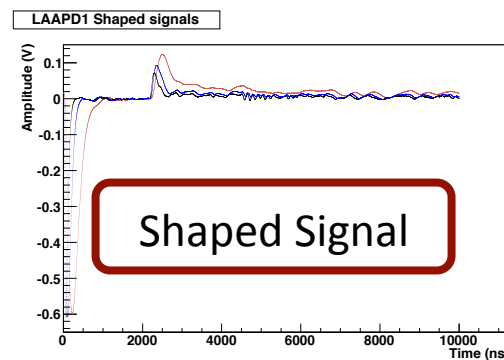
Data Acquisition and Analysis strategy

- Aim of the study:
 - compare ENE from **CSP**, **hardware shaper** and **software shaper** (100ns sh. time)
 - compare results with different software shaping time (100ns, 50ns, 30ns)



Software shaper

FFT of CSP signal -> apply CR-RC⁴ in frequency domain (3 different shaping time used) -> transform back to time domain

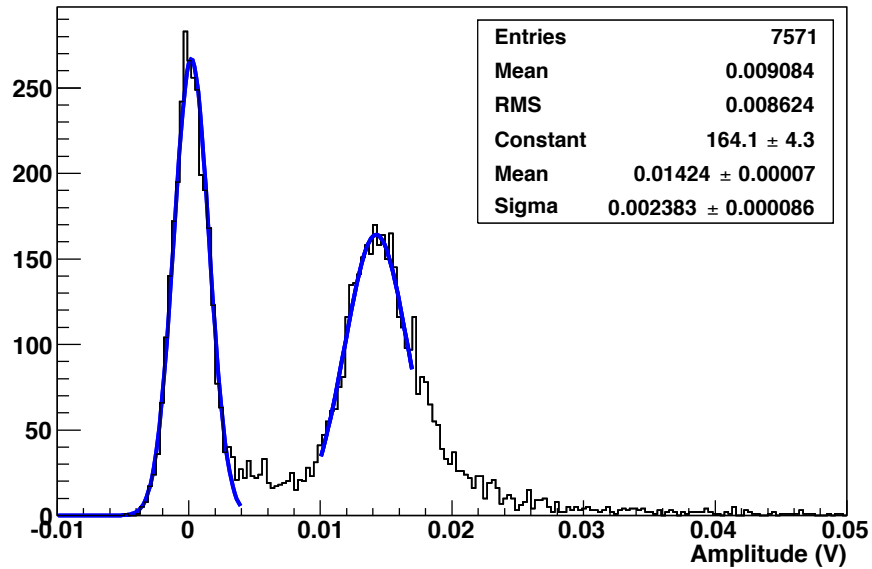


Amplitude and pedestal as for Hardware shaper, but use samplings in [1000-2000] range to compute pedestal

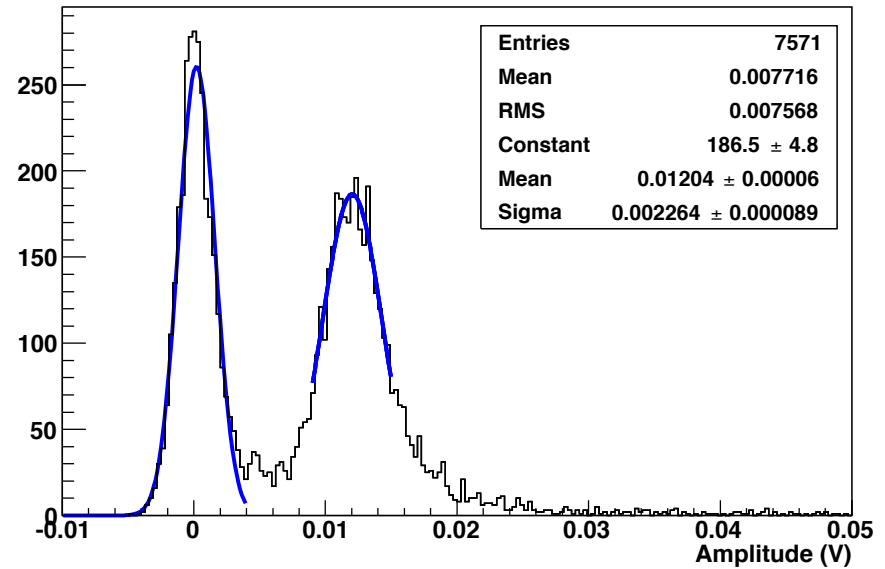
CREMAT CSP

CSP Output

LAAPD1 CSP output Cremat

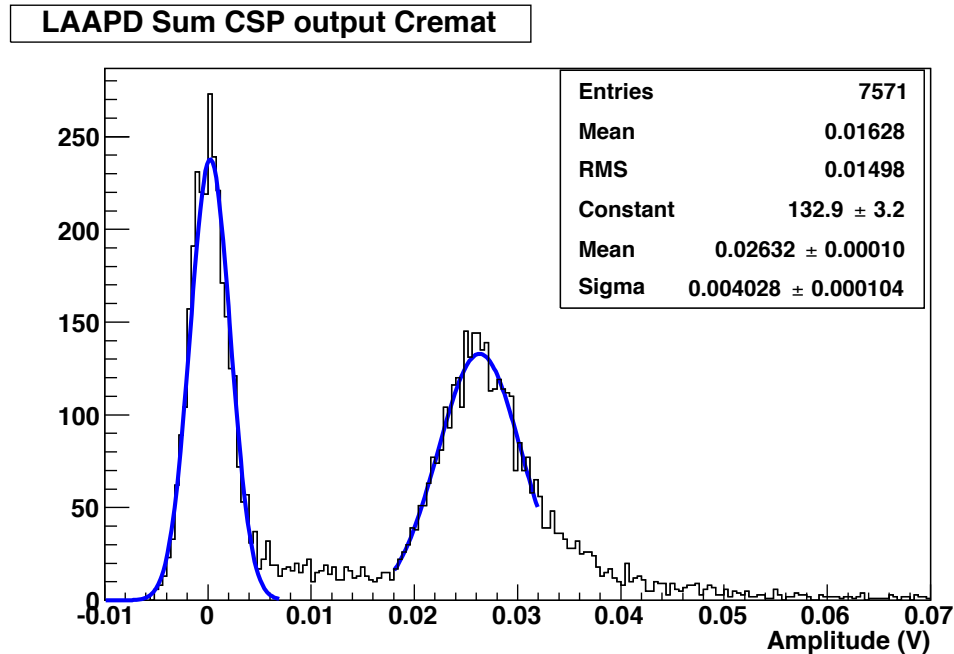


LAAPD2 CSP output Cremat



- LAAPD1
 - S=28.4mV N=2.6mV ENE=2.7MeV
- LAAPD2
 - S=24.0mV N=2.8mV ENE=3.5MeV

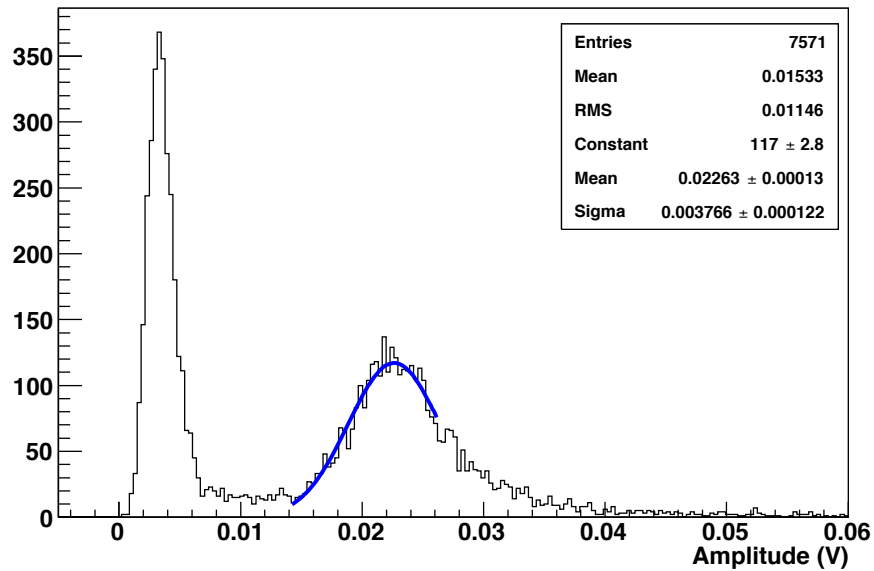
CSP output LAAPD SUM



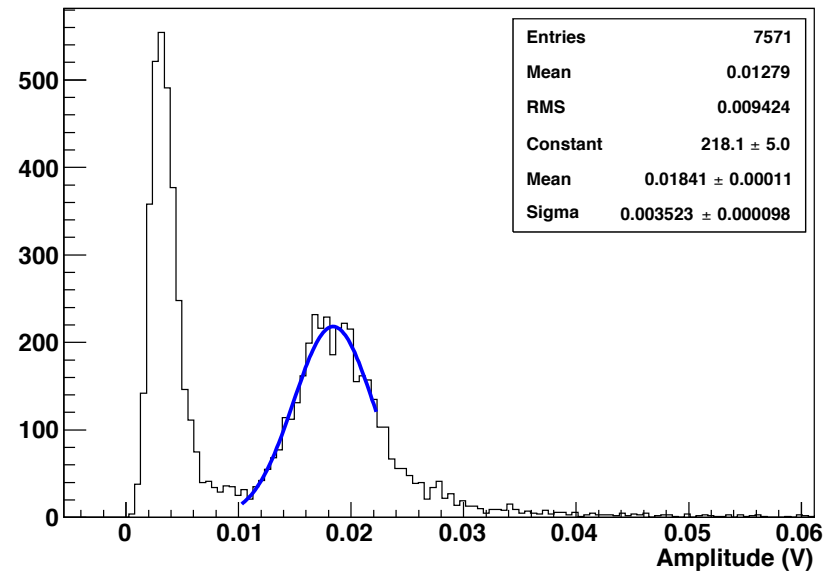
- LAAPDSUM
 - S=52.6mV N=3.8mV **ENE=2.2MeV**

Software Shaper Output, 30ns

LAAP1 Shaper 30ns output



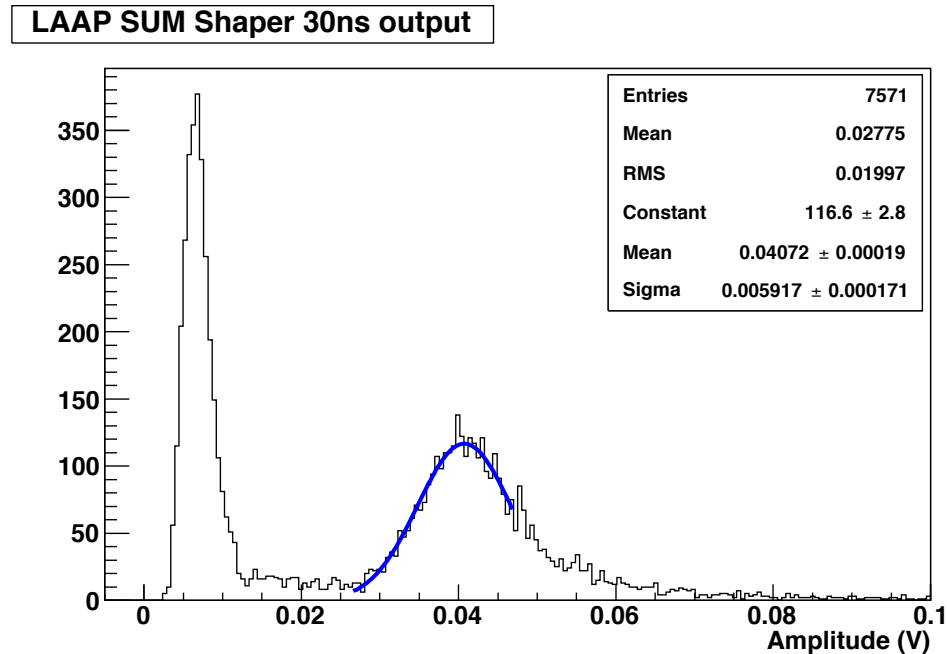
LAAP2 Shaper 30ns output



- LAAPD1
 - S=45.2mV N=3.2mV ENE=2.1MeV
- LAAPD2
 - S=36.6mV N=3.2mV ENE=2.6MeV

Software Shaper Output, 30ns

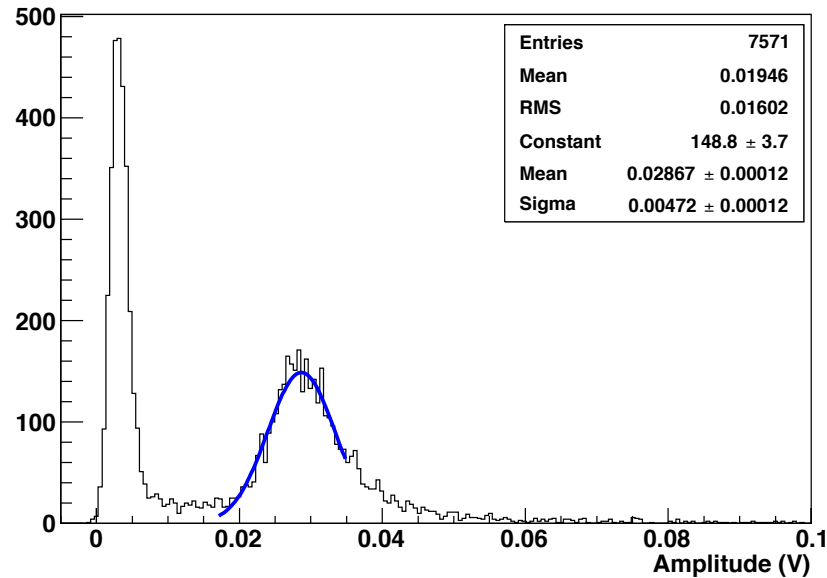
LAAPD SUM



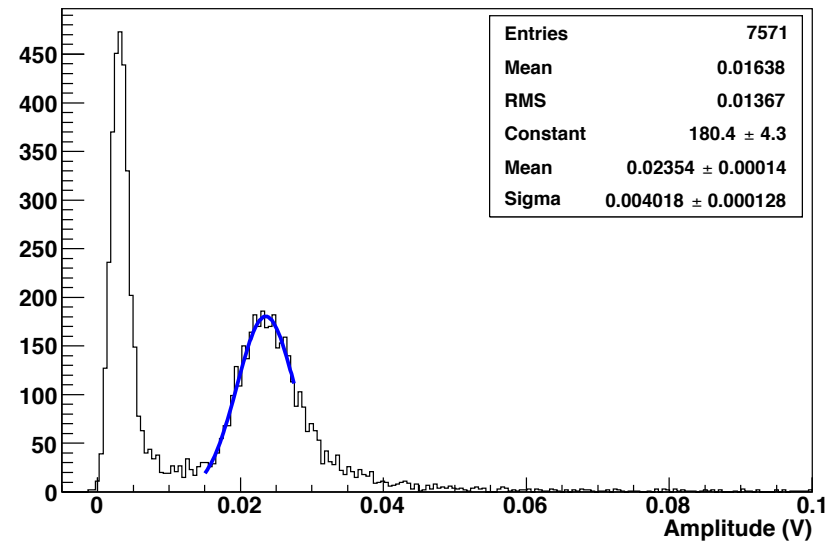
- LAAPDSUM
 - S=81.4mV N=4.5mV **ENE=1.7MeV**

Software Shaper Output, 50ns

LAAP1 Shaper 50ns output



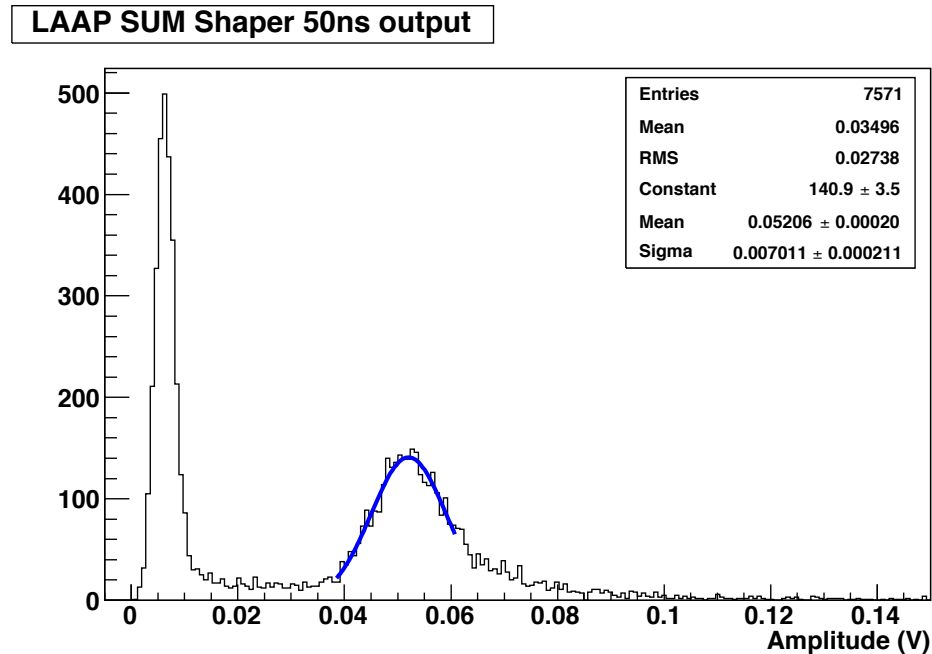
LAAP2 Shaper 50ns output



- LAAPD1
 - S=57.4mV N=3.4mV **ENE=1.8MeV**
- LAAPD2
 - S=47.0mV N=3.2mV **ENE=2.0MeV**

Software Shaper Output, 50ns

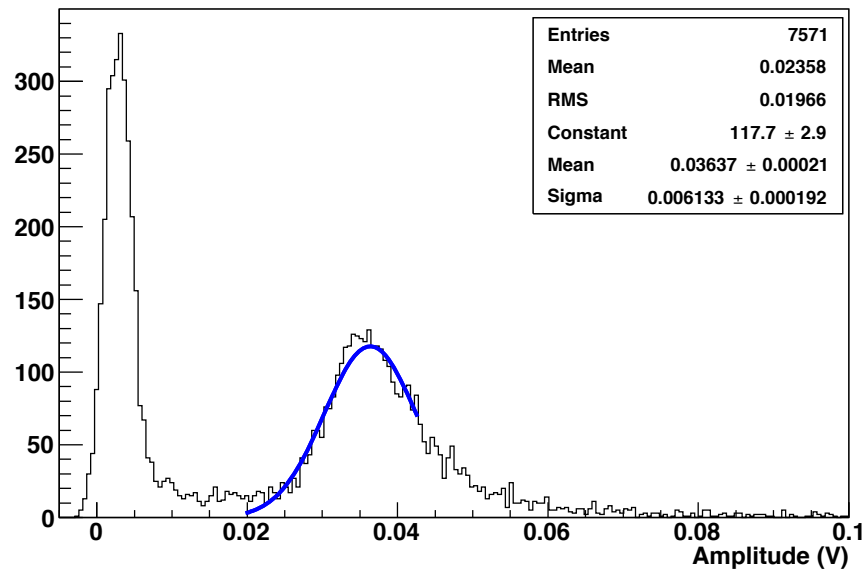
LAAPD SUM



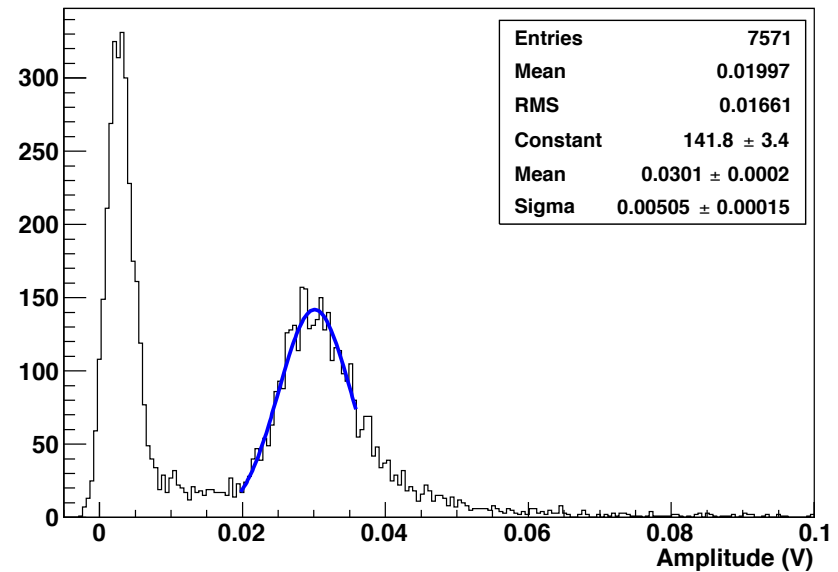
- LAAPDSUM
 - S=104.2mV N=4.6mV **ENE=1.3MeV**

Software Shaper Output, 100ns

LAAP1 Shaper 100ns output



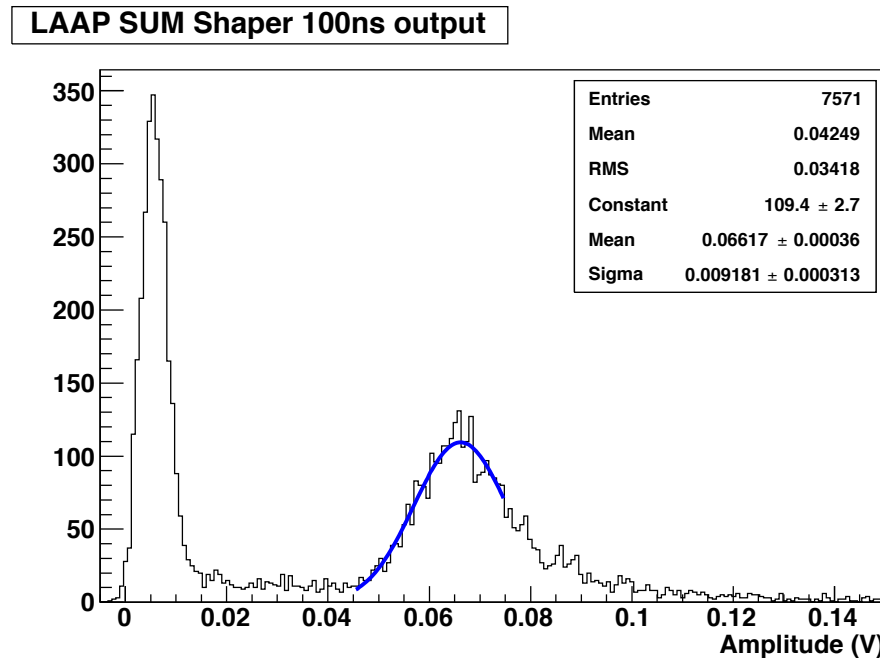
LAAP2 Shaper 100ns output



- LAAPD1
 - S=72.8mV N=3.4mV ENE=1.4MeV
- LAAPD2
 - S=60.2mV N=3.4mV ENE=1.7MeV

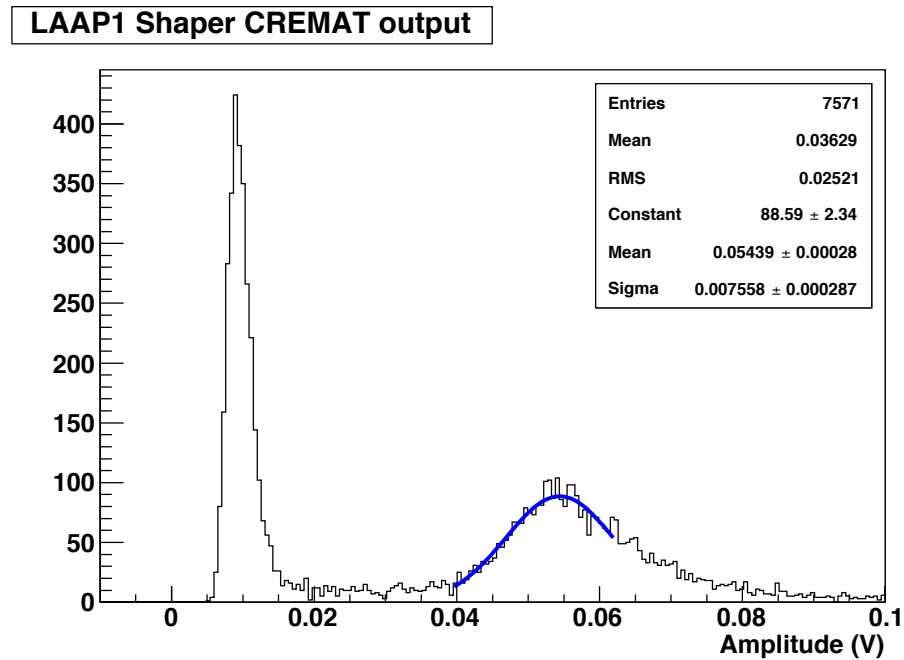
Software Shaper Output, 100ns

LAAPD SUM



- LAAPDSUM
 - S=132.0mV N=4.6mV **ENE=1.0MeV**

Hardware Shaper Output, 100ns



- LAAPD1
 - $S=54.4\text{mV}$ $N=2.6\text{mV}$ $\text{ENE}=1.4\text{MeV}$

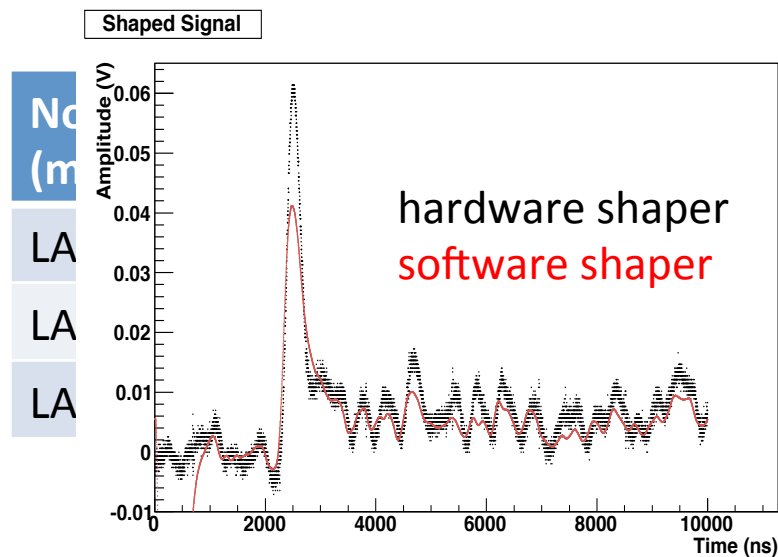
CREMAT CSP: result comparison (I)

Sig. Ampl. (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	28.4	45.2	57.4	72.8	108.8
LAAPD2	24.0	36.6	47.0	60.2	
LAAPDSUM	52.6	81.4	104.2	132.0	

Noise (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	2.6	3.2	3.4	3.4	5.2
LAAPD2	2.8	3.2	3.2	3.4	
LAAPDSUM	3.8	4.6	4.6	4.6	

CREMAT CSP: result comparison (I)

Sig. Ampl. (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	28.4	45.2	57.4	72.8	108.8
LAAPD2	24.0	36.6	47.0	60.2	
LAAPDSUM	52.6	81.4	104.2	132.0	



Sh.	Softw. Sh. 100 ns	Hardw. Sh 100 ns
	3.4	5.2
	3.4	
	4.6	

CREMAT CSP: result comparison (II)

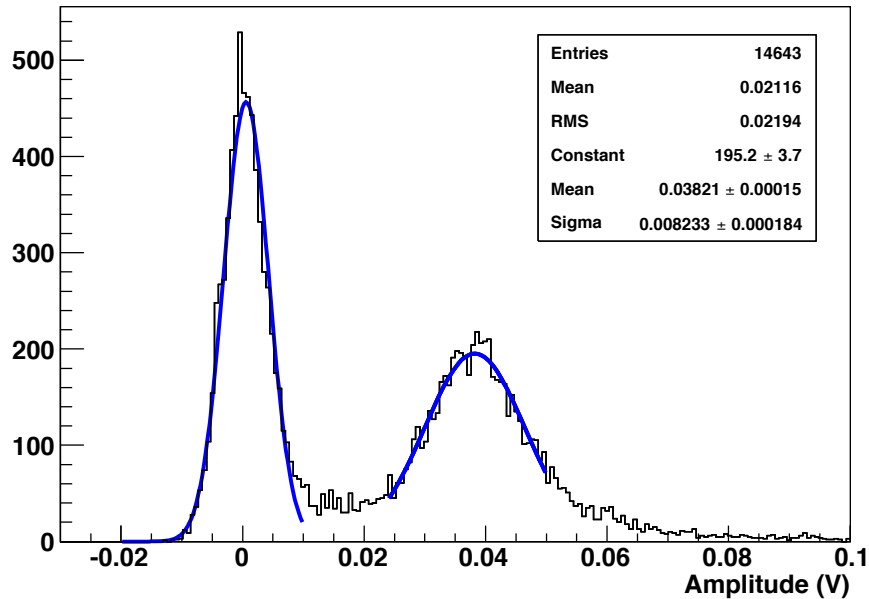
ENE (MeV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	2.7	2.1	1.8	1.4	1.4
LAAPD2	3.5	2.6	1.2	1.7	
LAAPDSUM	2.2	1.7	1.3	1.0	

- Improvement in S/N with shaper, both software and hardware
- Shaping time reduction degrade S/N
- equivalent results with hardware and software shaper (100ns shaping time)

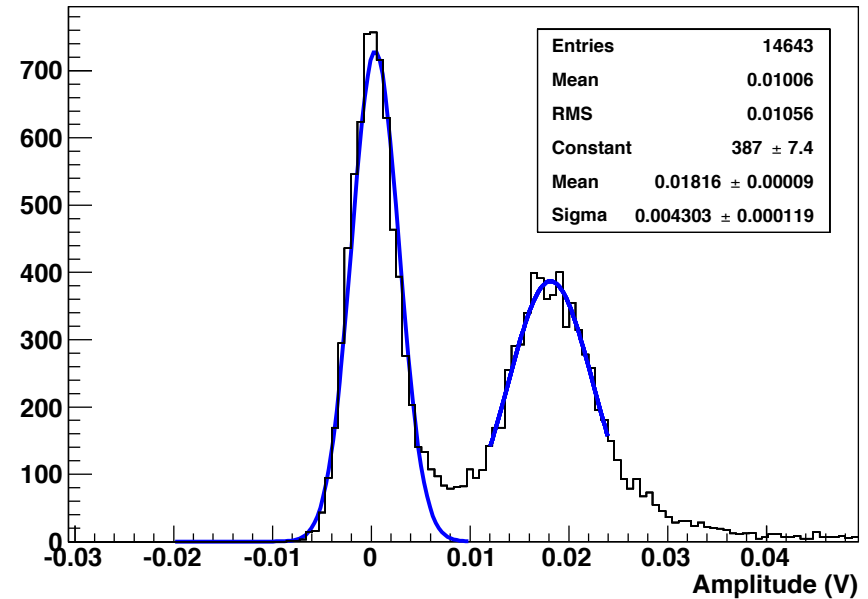
CAEN CSP

CSP Output

LAAPD1 CspCAEN



LAAPD2 CspCAEN

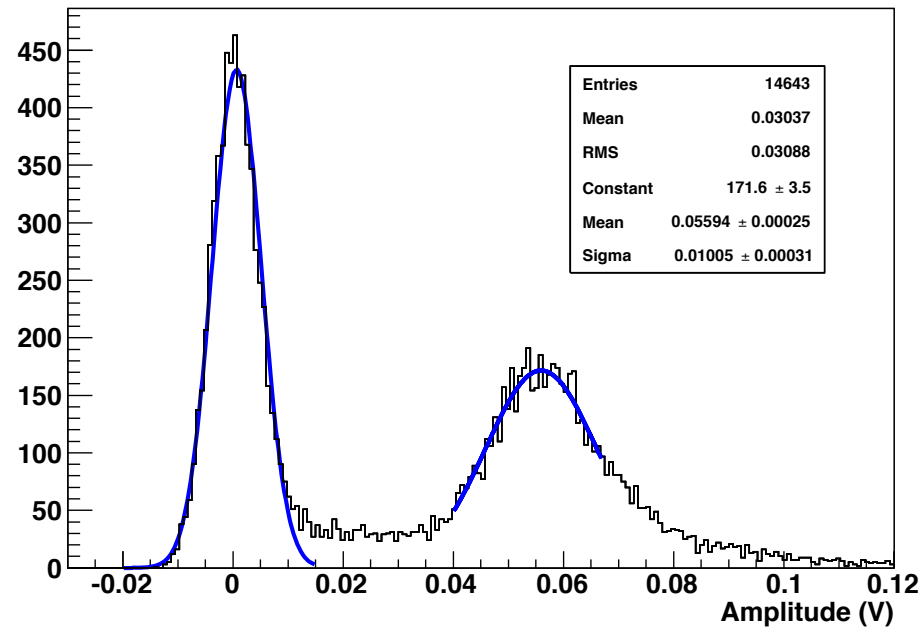


- Signal from LAAPD2 smaller than LAAPD1
 - in part due to different LAAPD response (to be investigated)
- LAAPD1
 - $S=38.2\text{mV}$ $N=3.7\text{mV}$ $\text{ENE}=2.9\text{MeV}$
- LAAPD2
 - $S=18.4\text{mV}$ $N=2.4\text{mV}$ $\text{ENE}=3.9\text{MeV}$

CSP output

LAAPD SUM

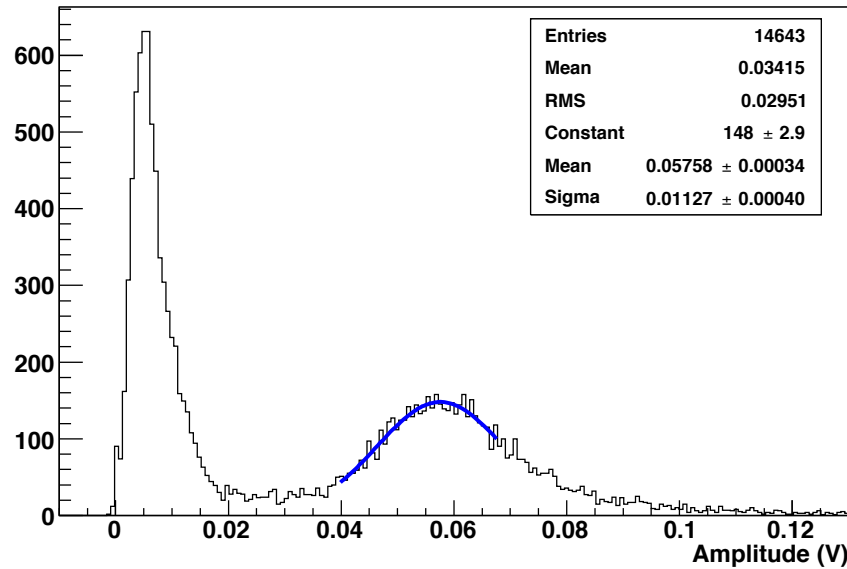
LAAPD SUM CspCAEN



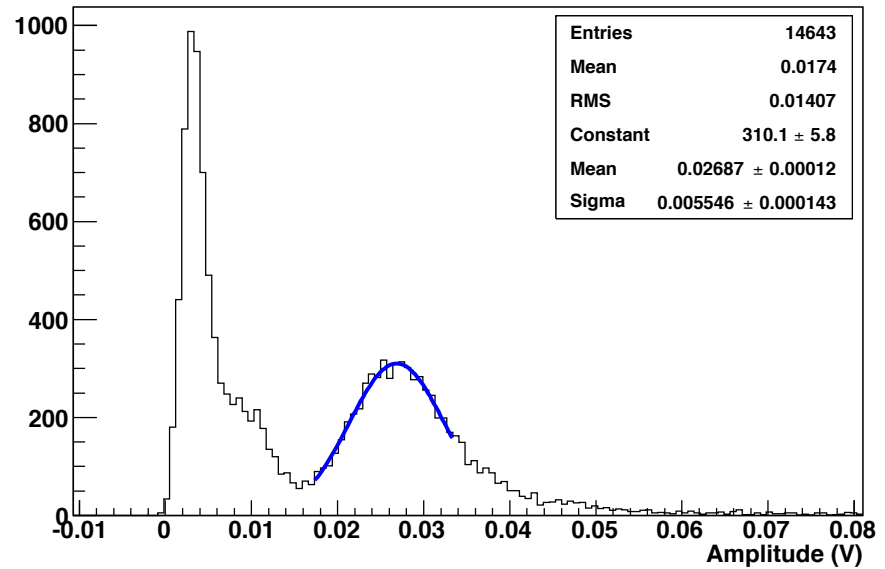
- LAAPDSUM
 - S=55.9mV N=4.5mV **ENE=2.4MeV**

Software Shaper Output, 30ns

LAAPD1 Shaper 30ns



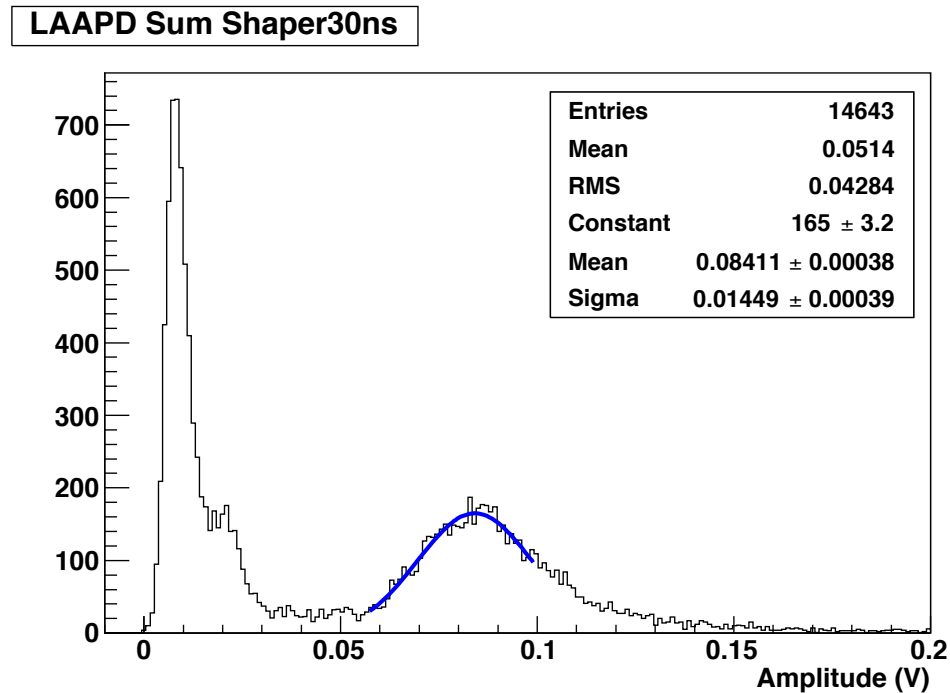
LAAPD2 Shaper30ns



- LAAPD1
 - S=57.6mV N=2.8mV ENE=1.5MeV
- LAAPD2
 - S=26.9mV N=1.8mV ENE=2.0MeV

Software Shaper Output, 30ns

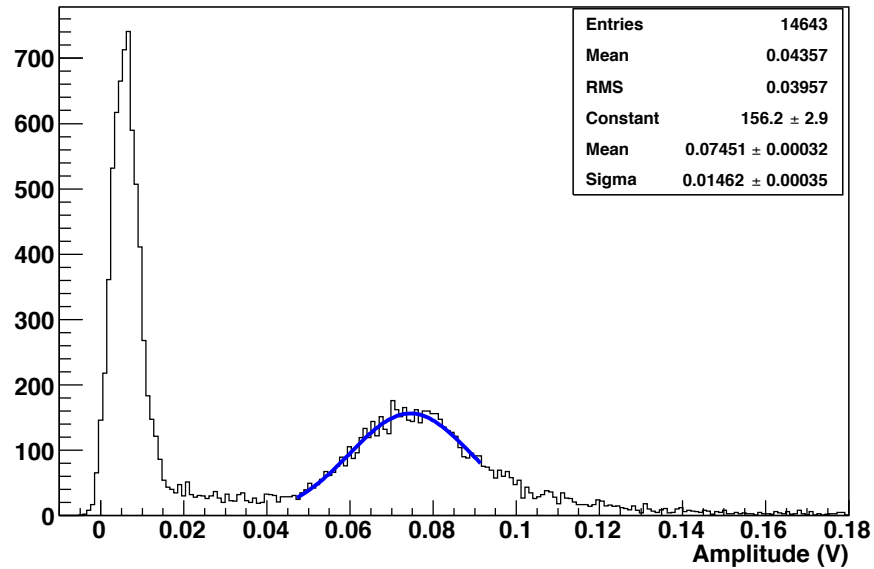
LAAPD SUM



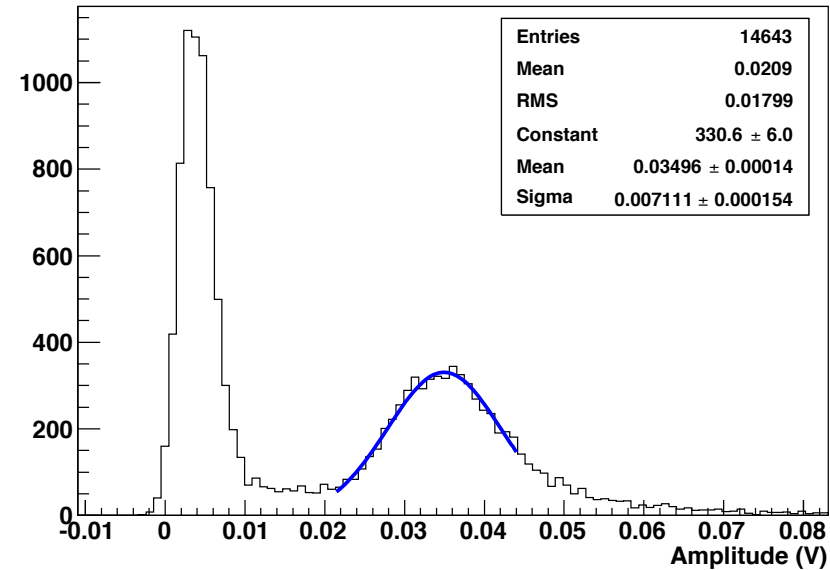
- LAAPDSUM
 - S=84.1mV N=3.5mV **ENE=1.2MeV**

Software Shaper Output, 50ns

LAAPD1 Shaper50ns



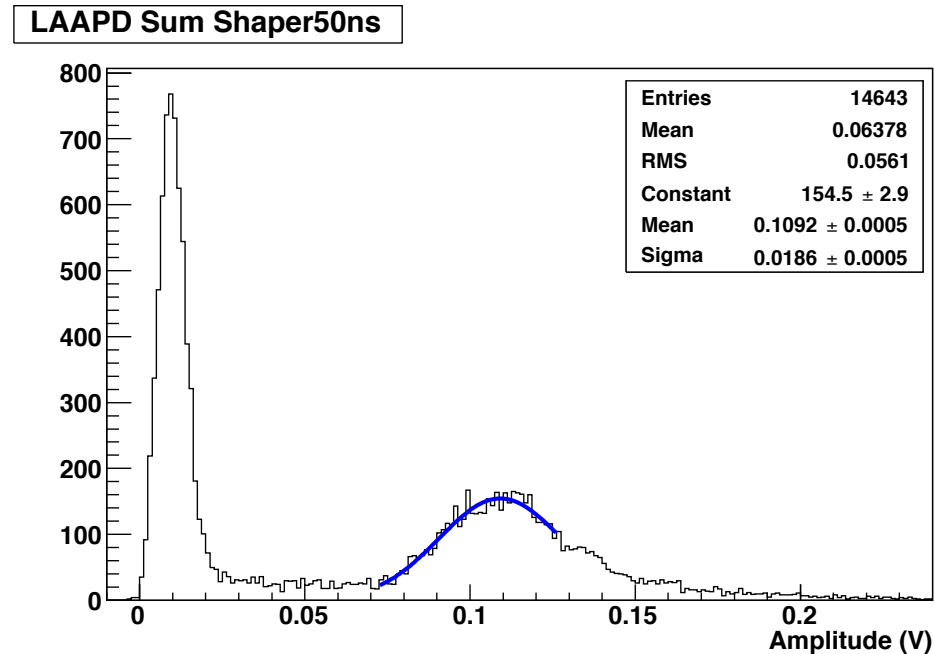
LAAPD2 Shaper50ns



- LAAPD1
 - S=74.5mV N=3.4mV **ENE=1.4MeV**
- LAAPD2
 - S=35.0mV N=2.2mV **ENE=1.9MeV**

Software Shaper Output, 50ns

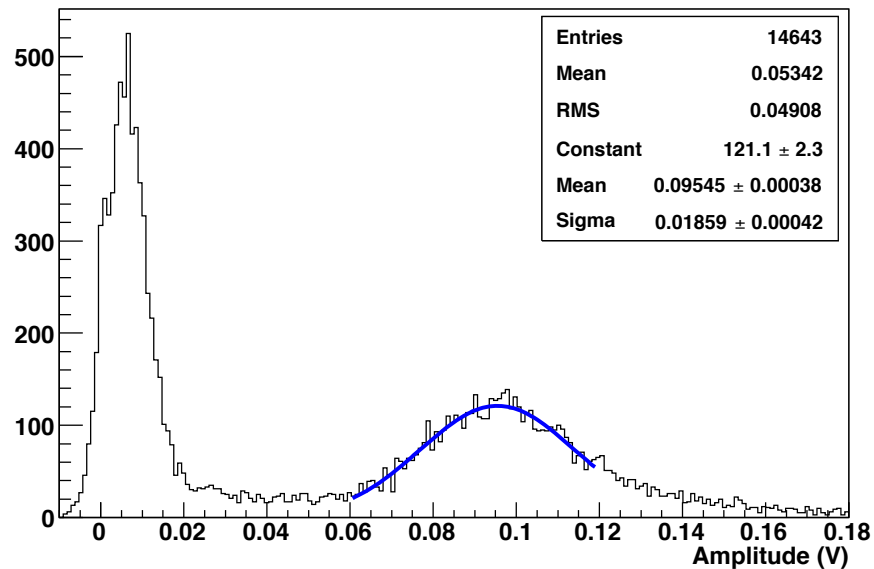
LAAPD SUM



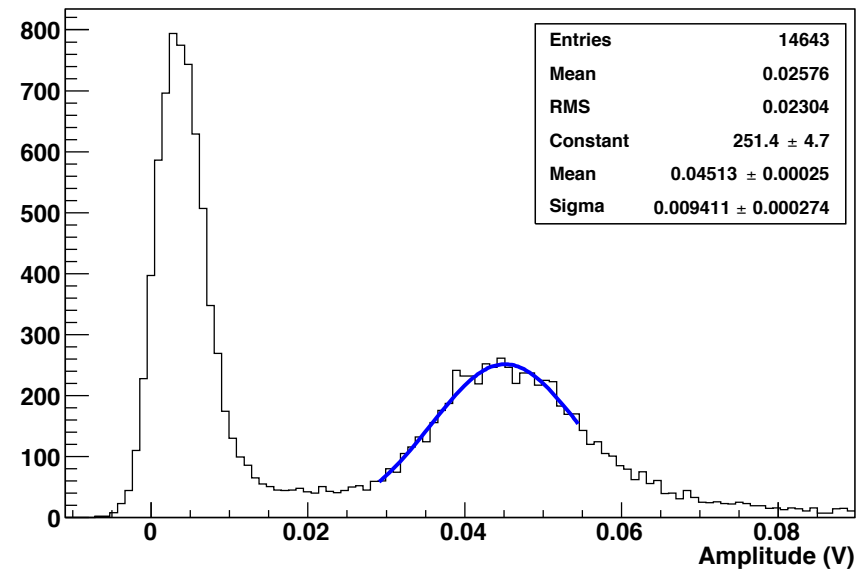
- LAAPDSUM
 - S=109.2mV N=4.3mV **ENE=1.2MeV**

Software Shaper Output, 100ns

LAAPD1 Shaper100ns



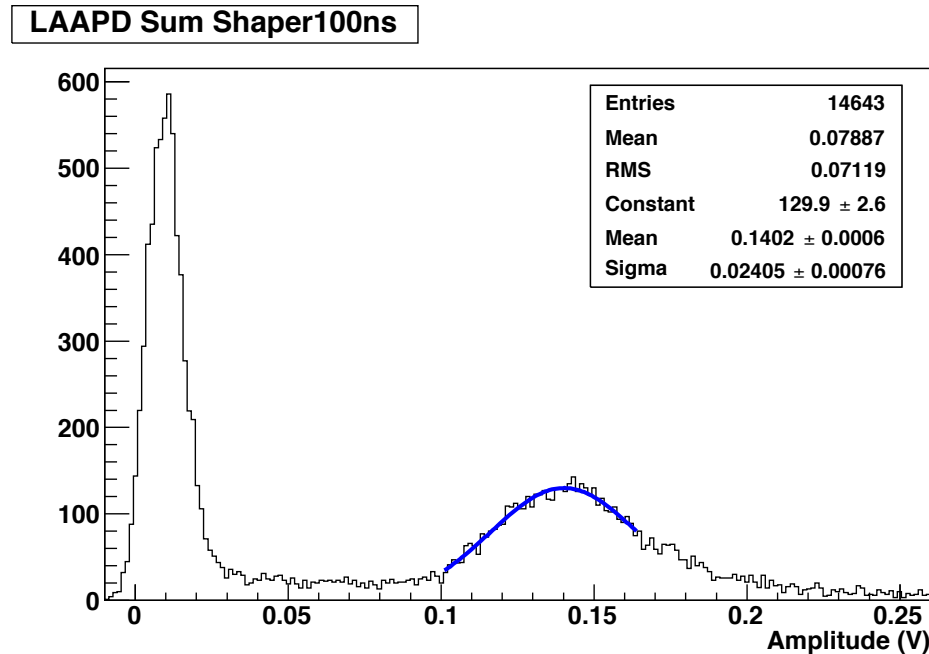
LAAPD2 Shaper100ns



- LAAPD1
 - S=95.4mV N=3.4mV ENE=1.1MeV
- LAAPD1
 - S=45.1mV N=2.4mV ENE=1.8MeV

Software Shaper Output, 100ns

LAAPD SUM



- LAAPDSUM
 - S=140.2mV N=.5mV **ENE=1.2MeV**

CAEN CSP: result comparison (I)

Sig. Ampl. (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	38.2	57.6	74.5	95.4	N.A.
LAAPD2	18.4	26.9	35.0	45.1	
LAAPDSUM	55.9	81.4	109.2	140.2	

Noise (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	3.7	2.8	3.4	3.4	N.A.
LAAPD2	2.4	1.8	2.2	2.4	
LAAPDSUM	4.5	3.5	4.3	5.5	

CAEN CSP: result comparison (II)

ENE (MeV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	2.9	1.5	1.4	1.1	N.A.
LAAPD2	3.9	2.0	1.9	1.8	
LAAPDSUM	2.4	1.2	1.2	1.2	

- Results driven by small signal in LAAPD2
- Improvement in S/N with shaper, both software and hardware
- Shaping time reduction degrade S/N

CSP comparison

CAEN CSP vs CREMAT CSP (I)

CREMAT (1.4 V/pC)

Sig. Ampl. (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	28.4	45.2	57.4	72.8	108.8
LAAPD2	24.0	36.6	47.0	60.2	
LAAPDSUM	52.6	81.4	104.2	132.0	

CAEN (2.0 V/pC)

Sig. Ampl. (mV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	38.2	57.6	74.5	95.4	N.A.
LAAPD2	18.4	26.9	35.0	45.1	
LAAPDSUM	55.9	81.4	109.2	140.2	

CAEN CSP vs CREMAT CSP (II)

CREMAT

ENE (MeV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	2.7	2.1	1.8	1.4	1.4
LAAPD2	3.5	2.6	1.2	1.7	
LAAPDSUM	2.2	1.7	1.3	1.0	

CAEN

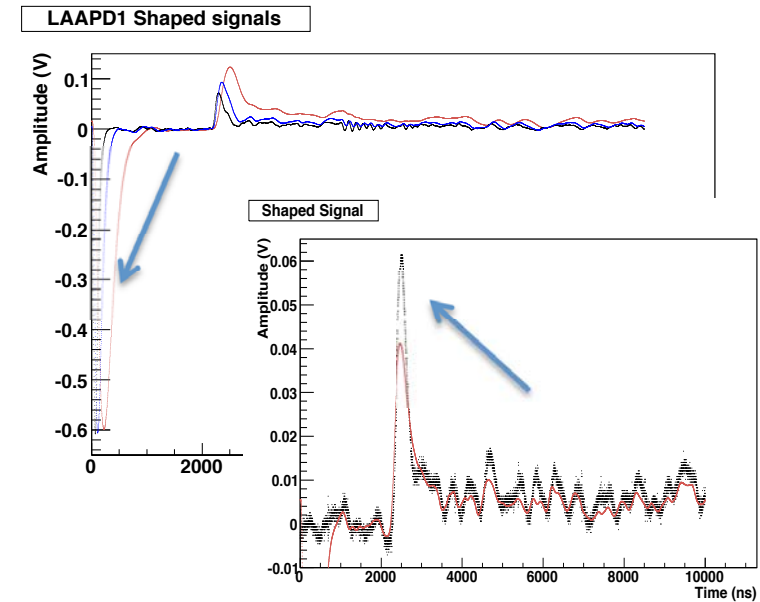
ENE (MeV)	CSP	Softw. Sh. 30 ns	Softw. Sh. 50 ns	Softw. Sh. 100 ns	Hardw. Sh 100 ns
LAAPD1	2.9	1.5	1.4	1.1	N.A.
LAAPD2	3.9	2.0	1.9	1.8	
LAAPDSUM	2.4	1.2	1.2	1.2	

Conclusions

- Improvement in S/N with shaper, both software and hardware
- Shaping time reduction degrade S/N
- equivalent results with hardware and software shaper (100ns shaping time)
- Best tested configuration: CREMAT CSP with 100ns shaping time, ENE LAAPDSUM 1MeV

To-do-list for b2gm

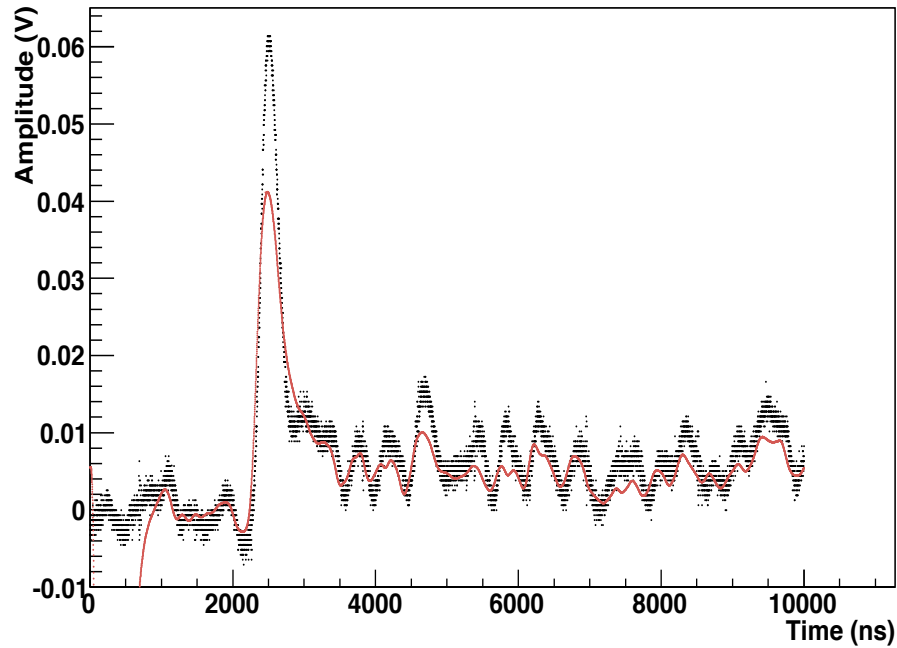
- Open issues with shaping algorithm: 
- Understand difference in signal response of two LAAPD's with CAEN CSP (e.g. check temperature)
- Improve measurement with CAEN CSP (check CSP input connection to reduce noise)
- Perform measurements with Advanced photonics APD's using a new box.



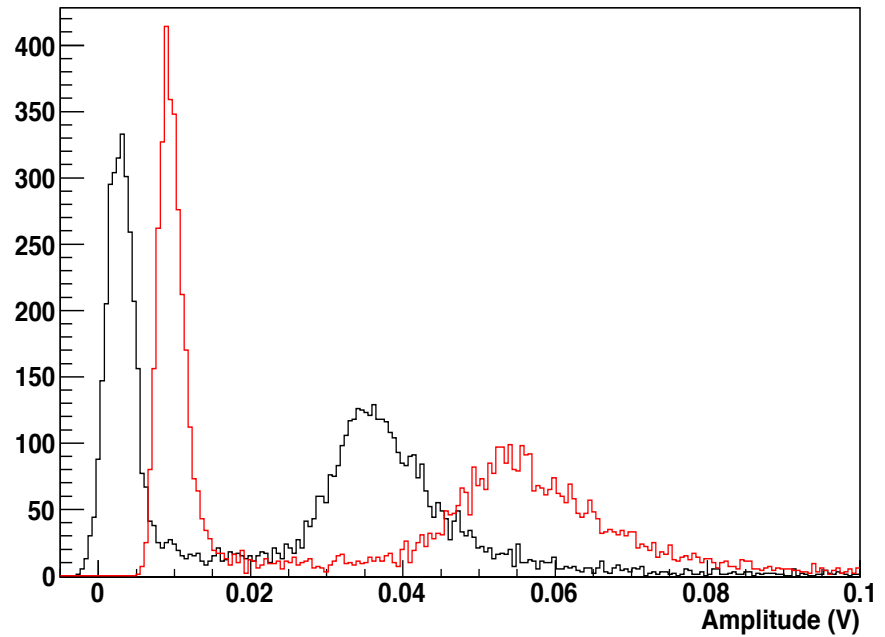
Extra slides

Shaper comparison

Shaped Signal



LAAP1 Shaper 100ns output



- Different gain (to be tuned)