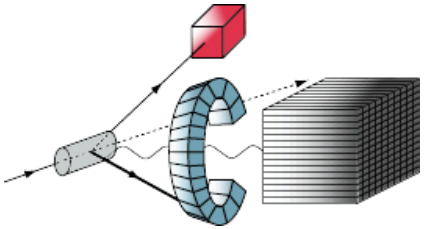


Hall A
Deeply Virtual Compton Scattering
Analysis overview

Alexandre Camsonne

Hall A Jefferson Laboratory

Hall A analysis meeting

December 8th 2010

Jefferson Lab

JSA

Outline

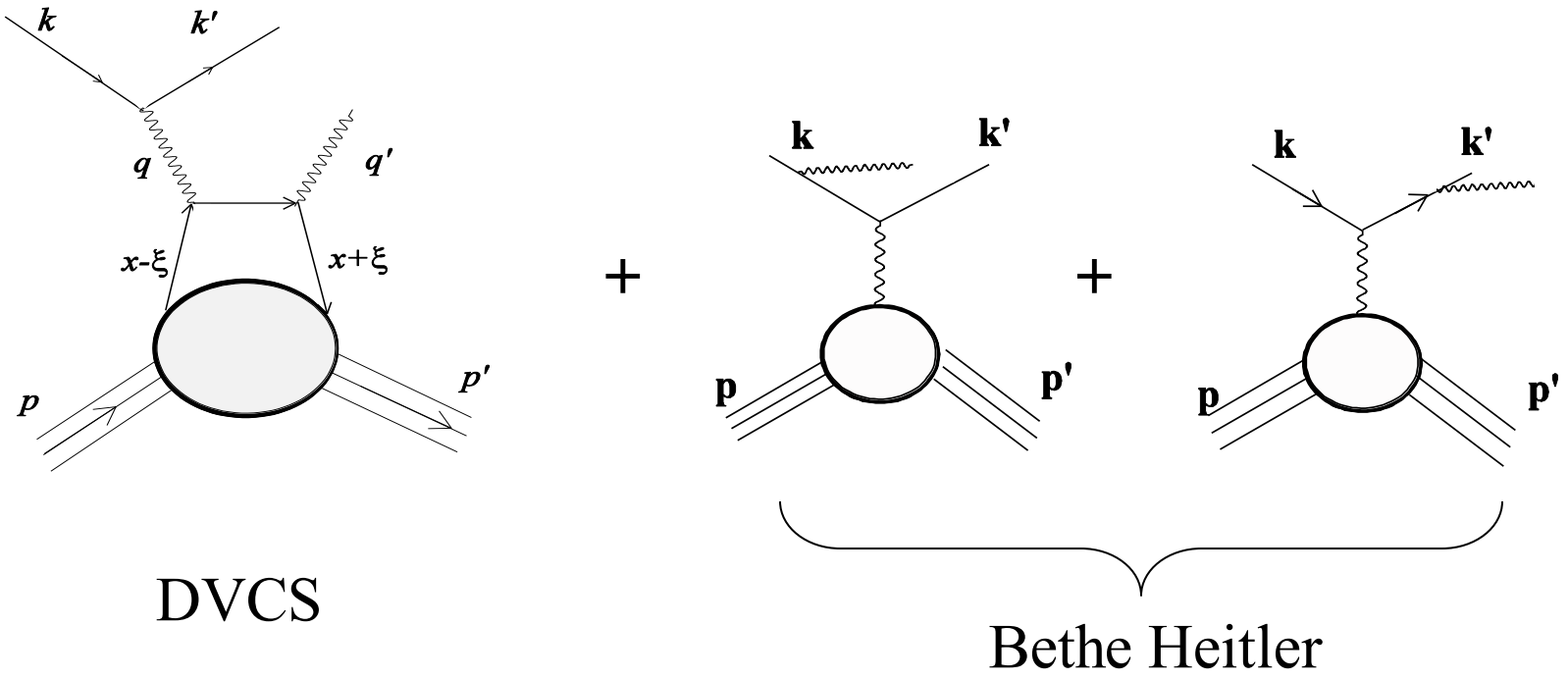
- DVCS
- Experimental setup
- Dedicated electronics
- Analysis overview
  - Data structure
  - Mysql database
  - ARS Waveform analysis
  - Calorimeter clustering
  - Analysis flow
- Pro and cons, outlook of possible improvements
- Conclusion

Deeply Virtual Compton Scattering

Deeply Virtual Compton Scattering

$$ep \rightarrow ep\gamma$$

$$en \rightarrow en\gamma$$



- Observables and their relationship to GPDs

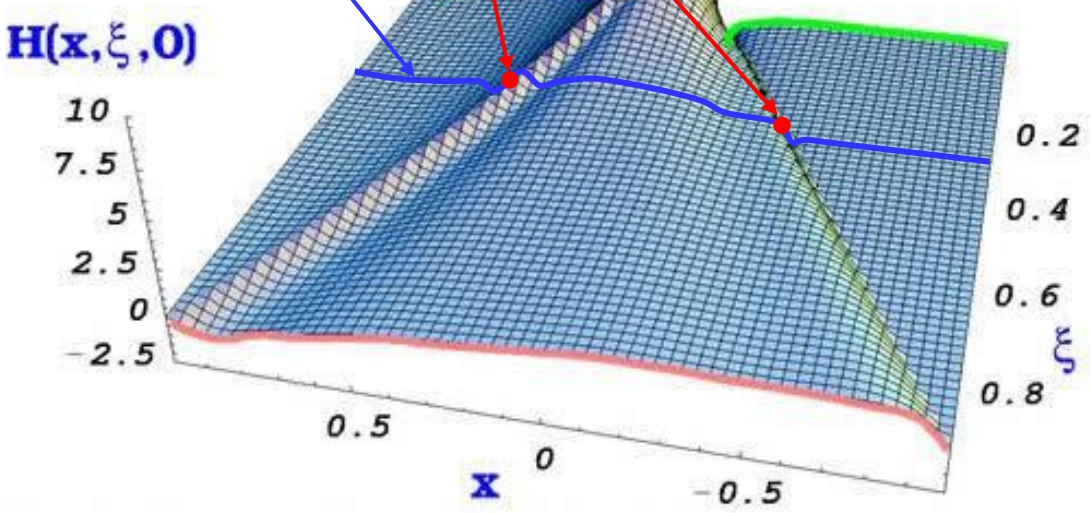
$$T^{DVCS} = \int_{-1}^{+1} \frac{GPD(x,\xi,t)}{x-\xi+i\varepsilon} dx \quad + \quad \cdots$$

-The cross-section difference accesses the imaginary part of DVCS and therefore GPDs at $x = \xi$

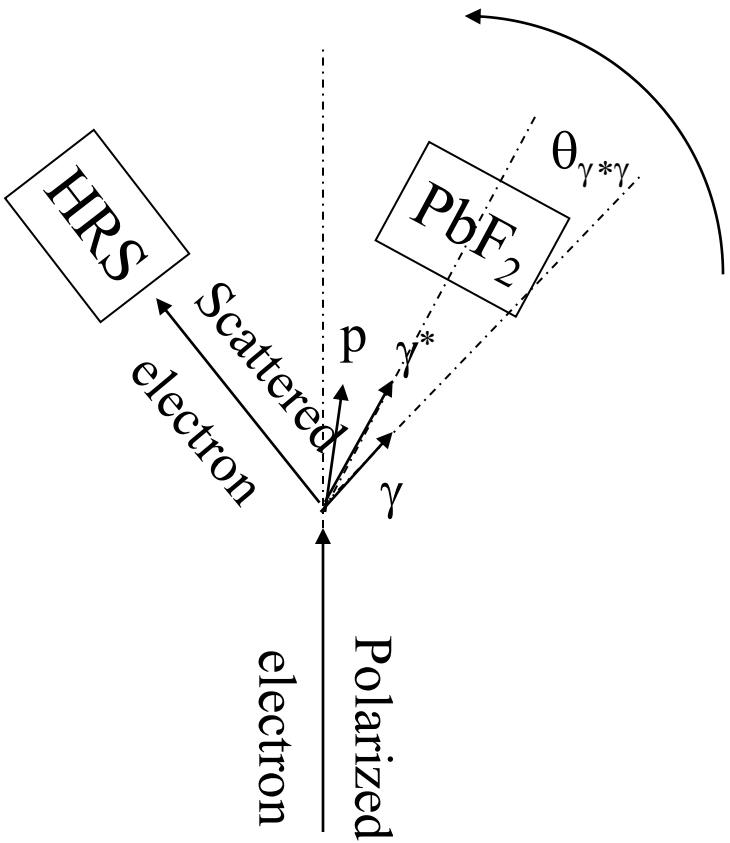
$$= P\int_{-1}^{+1} \frac{GPD(x,\xi,t)}{x-\xi} dx \quad - \quad i\pi GPD(x=\xi,\xi,t) \quad + \quad \cdots$$

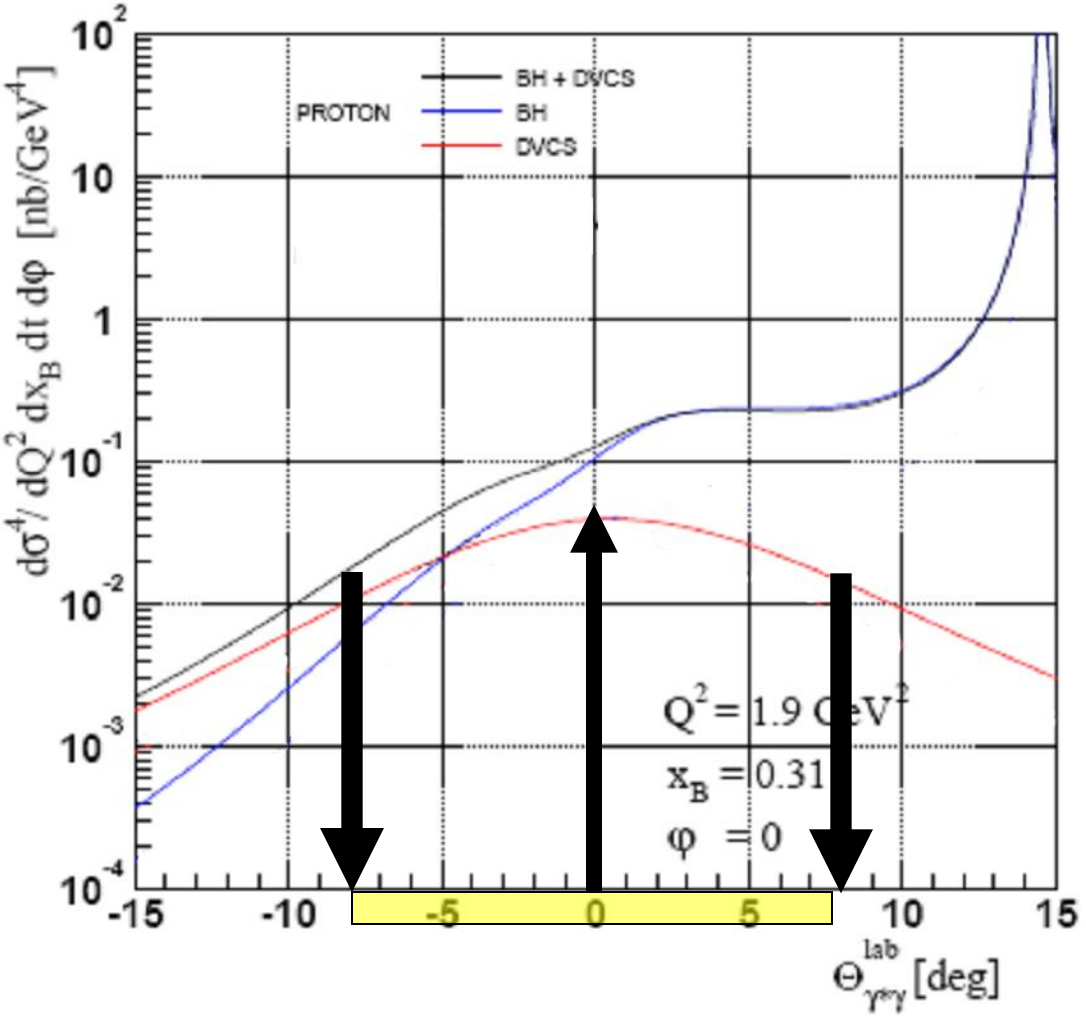
-The total cross-section accesses

-the real part of DVCS and therefore an integral of GPDs over x



Experiment setup





Cross sections measurement

Electron helicity dependent cross sections of photon electroproduction using Jefferson Laboratory polarized electron beam

$$d^5\vec{\sigma} - d^5\overleftarrow{\sigma} \propto BH \cdot \mathrm{Im}(DVCS)$$

$$+ (\overrightarrow{DVCS}^2 - \overleftarrow{DVCS}^2)$$

$$d^5\vec{\sigma} + d^5\overleftarrow{\sigma} \propto BH^2 + \mathrm{Re}(BH \cdot DVCS)$$

$$+ DVCS^2$$

Harmonic analysis

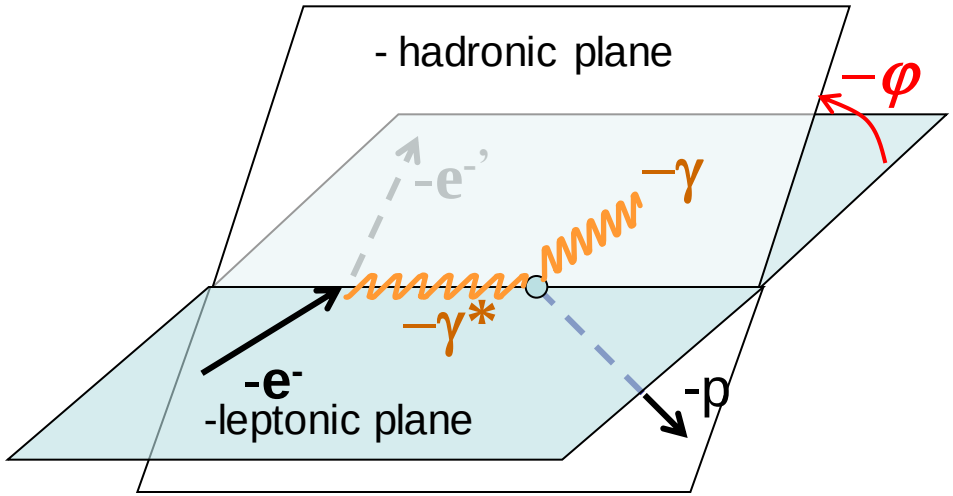
$$\frac{d^4\sigma}{dx_B dQ^2 dt d\varphi} = \frac{1}{P_1(\varphi)P_2(\varphi)}\Gamma_1(x_B,Q^2,t)\left\{c_0^{BH} + c_1^{BH}\cos\varphi + c_2^{BH}\cos 2\varphi\right\}$$

$$+\frac{1}{P_1(\varphi)P_2(\varphi)}\Gamma_2(x_B,Q^2,t)\left\{c_0^{I} + c_1^{I}\cos\varphi + c_2^{I}\cos 2\varphi + c_3^{I}\cos 3\varphi\right\}$$

$$\frac{d^4\vec{\sigma} - d^4\overleftarrow{\sigma}}{dx_B dQ^2 dt d\varphi} = \frac{\Gamma(x_B,Q^2,t)}{P_1(\varphi)P_2(\varphi)}\left\{s_1^{I}\sin\varphi + s_2^{I}\sin 2\varphi\right\}$$

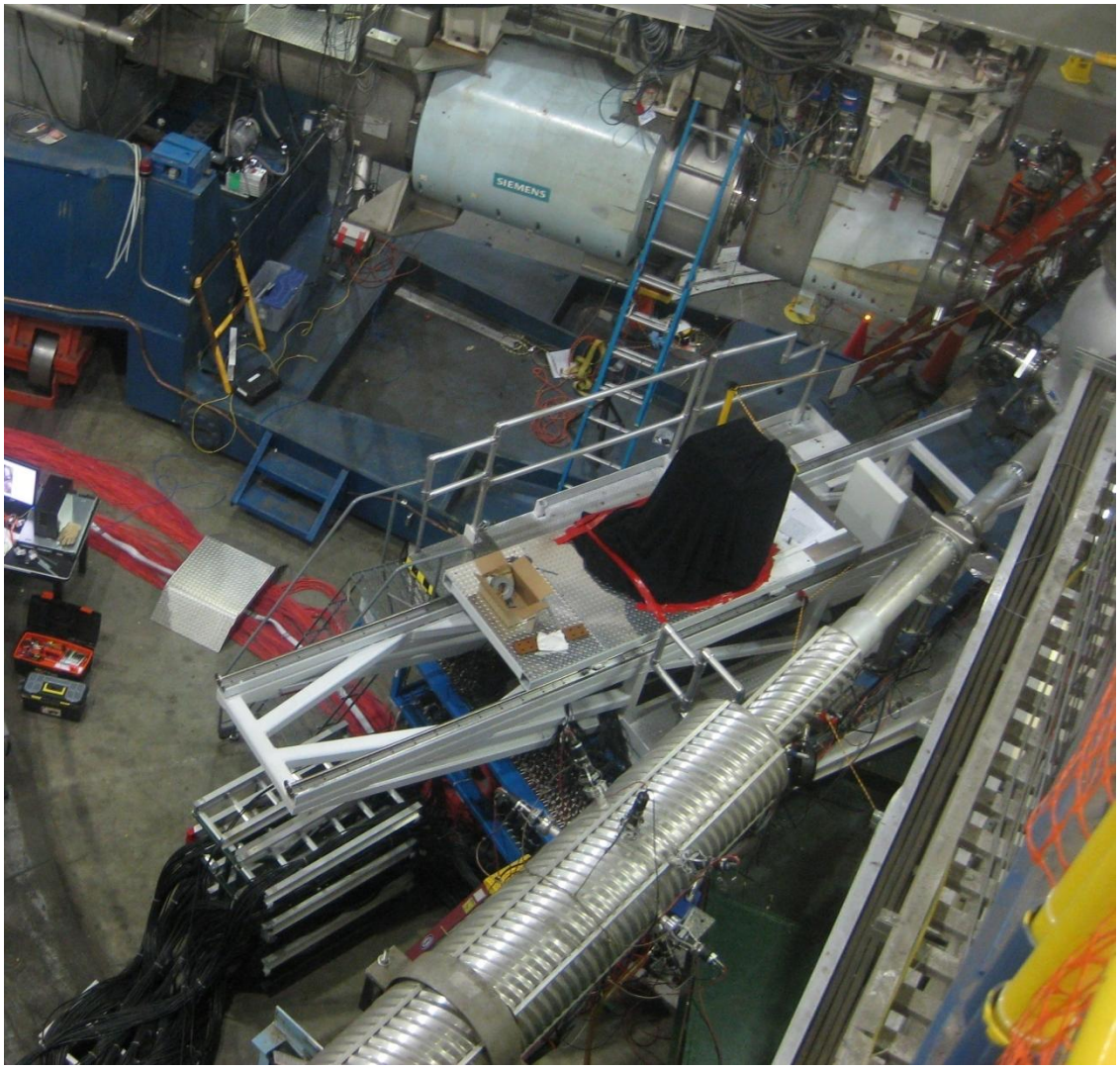
$-|T^{BH}|^2$

-Interference term

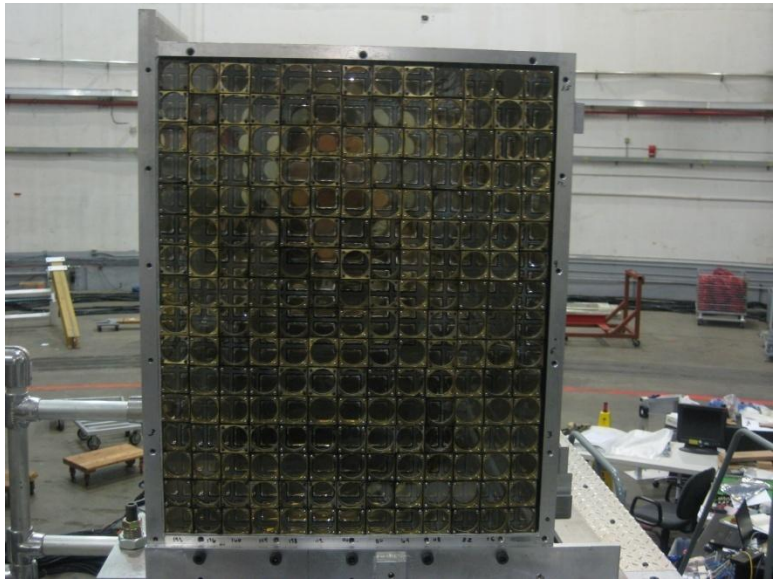


Experimental setup

Experimental setup



Electromagnetic calorimeter



13x16 = 208 blocks

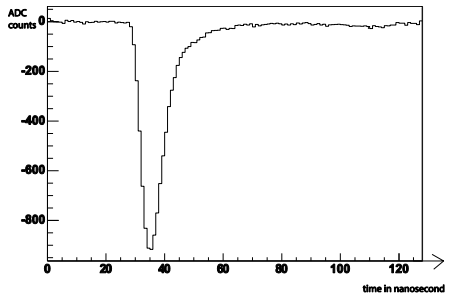
3cmx3cmx18.6cm

110 cm from the target

1msr per block

- Lead fluoride
  - Pure Cerenkov : not sensitive to charged hadronic background
  - density 7.77 g.cm^3
  - X_0=0.93 cm length=20X_0
    Molière radius = 2.2 cm
  - Good radiation hardness

- PMT R7700 Hamamatsu
  - 8 stages
  - Gain : 10^4
  - Rise time 2 ns
  - FWHM 6 ns



- 1 Photoelectron per MeV,
- Energy resolution 4 .2GeV : 2.4 %
- Position resolution: 2 mm

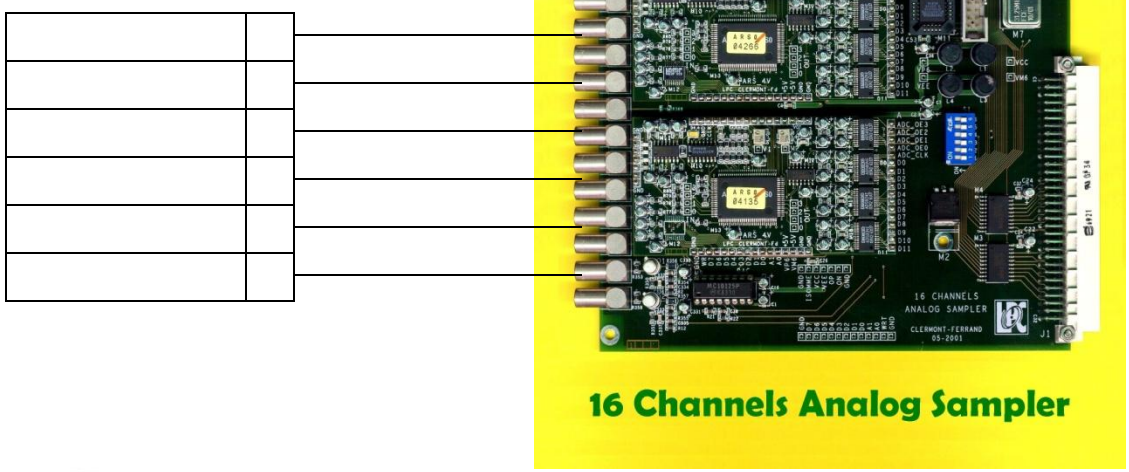
Dedicated electronics

Dedicated electronics

- Sampling system
  - 1GHz Analog Memory sampling system

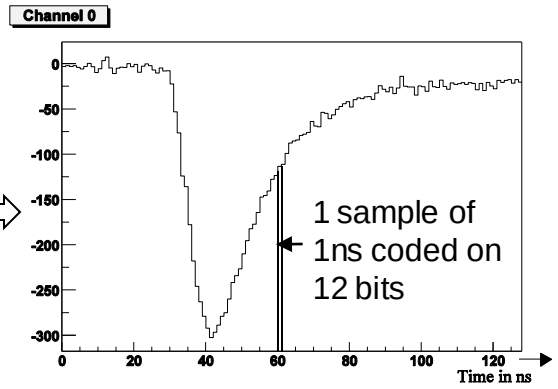
208 channels

PbF_2



Proton array signal

128 samples

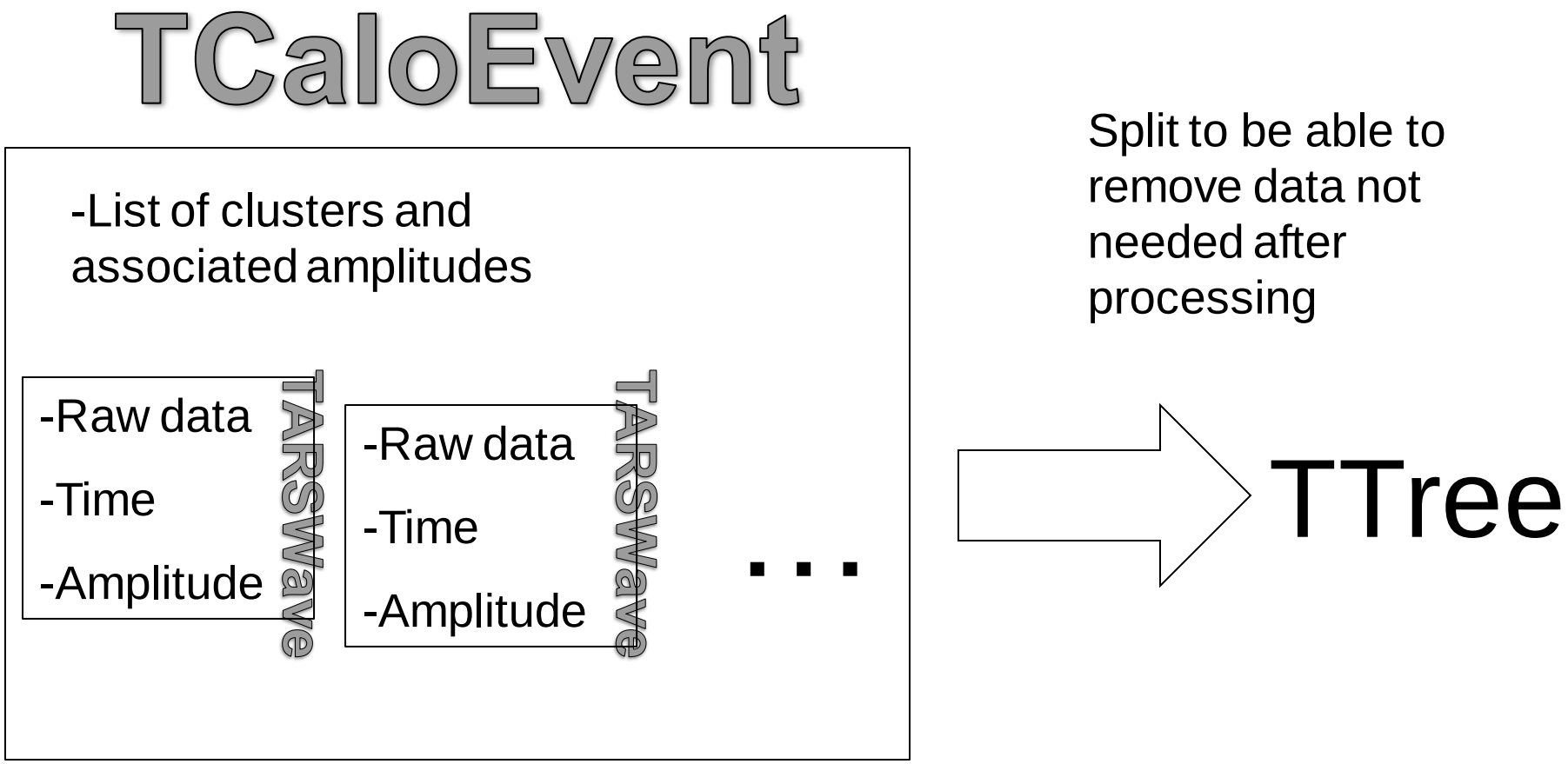


Equivalent to one digital oscilloscope put on each detector channel

Analysis software overview

Data structure

- http://www.jlab.org/~munoz/soft/soft.html



Data structure

- Basic is one detector channel TARSWave :
  - TClonesArrays of Double to hold data
  - Method for pedestal subtraction (dynamic pedestal subtraction, only one value for each sample in an array)
  - Access to Mysql database for calibration data
- Each event is a TCloneArrays of TARSWave with additional data
  - List of clusters with energy and positions

Mysql database

- Holds
  - calibration data
    - Pedestals
    - Conversion amplitude to energy
    - Detector positions
  - Data for cross section
    - Charge (non helicity and helicity gated)
    - Dead time
  - TARSWave access directly to the data for each run

Waveform analysis

http://hallaweb.jlab.org/data_reduc/AnaWork2002/camsonne-ws2002.ps

Linear fit of reference waveform

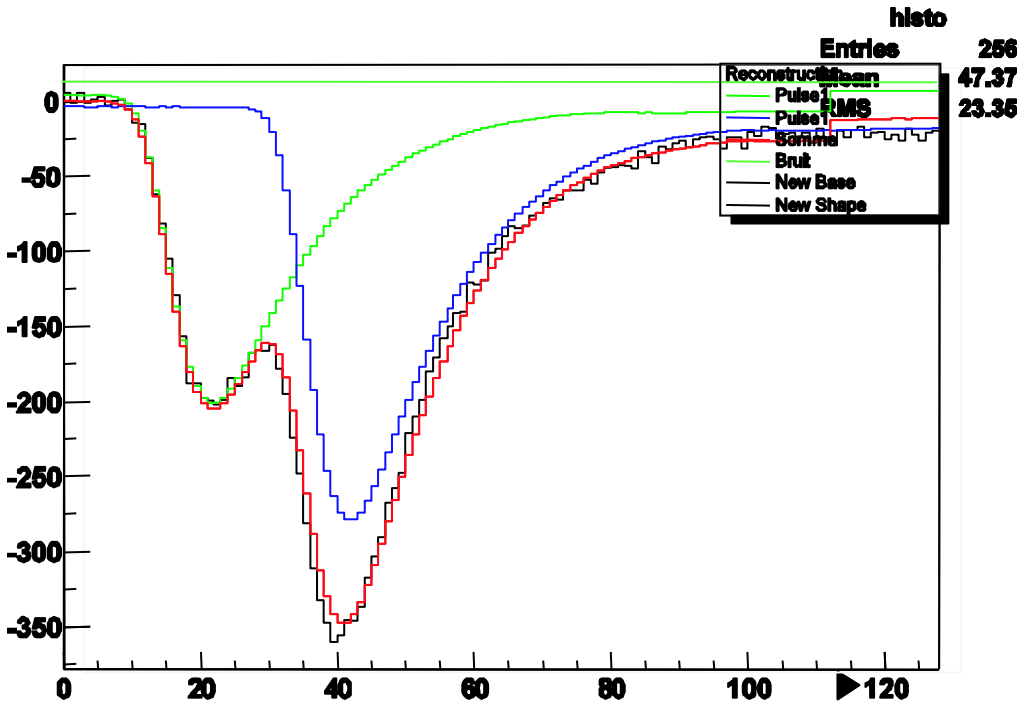
Resolve pile up at

5 ns level

20% of events with pile-up

Timing resolution

0.6 ns



Singles rate in one block up to 1 MHz

Calorimeter clustering

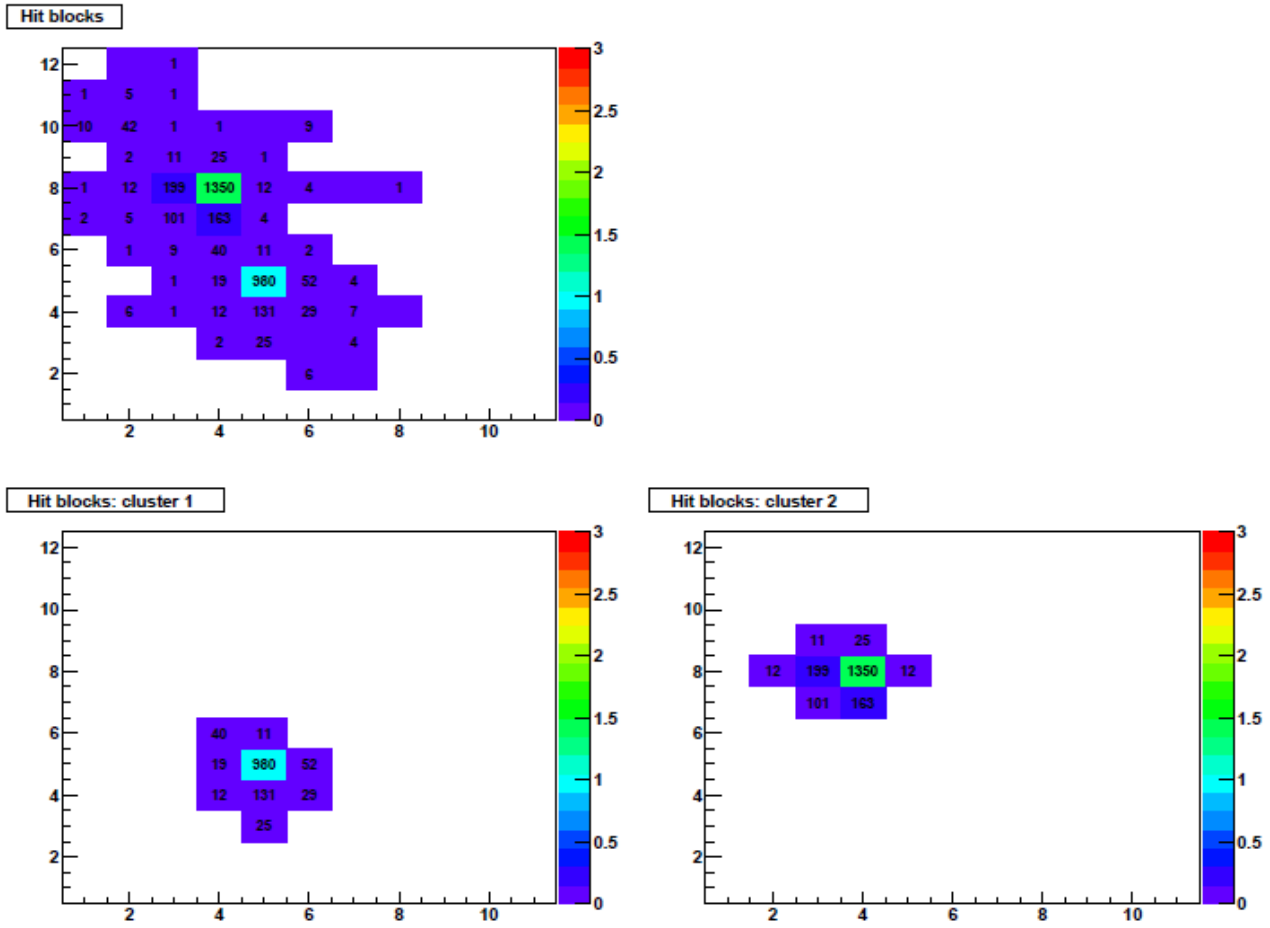
Cellular automata – step by step process

			0.2		
			3.0	1.0	0.2
0.3	0.2	0.4	7.0	2.0	0.2
2.0	8.0	1.0	0.4		
0.2	0.6	0.3	0.2		

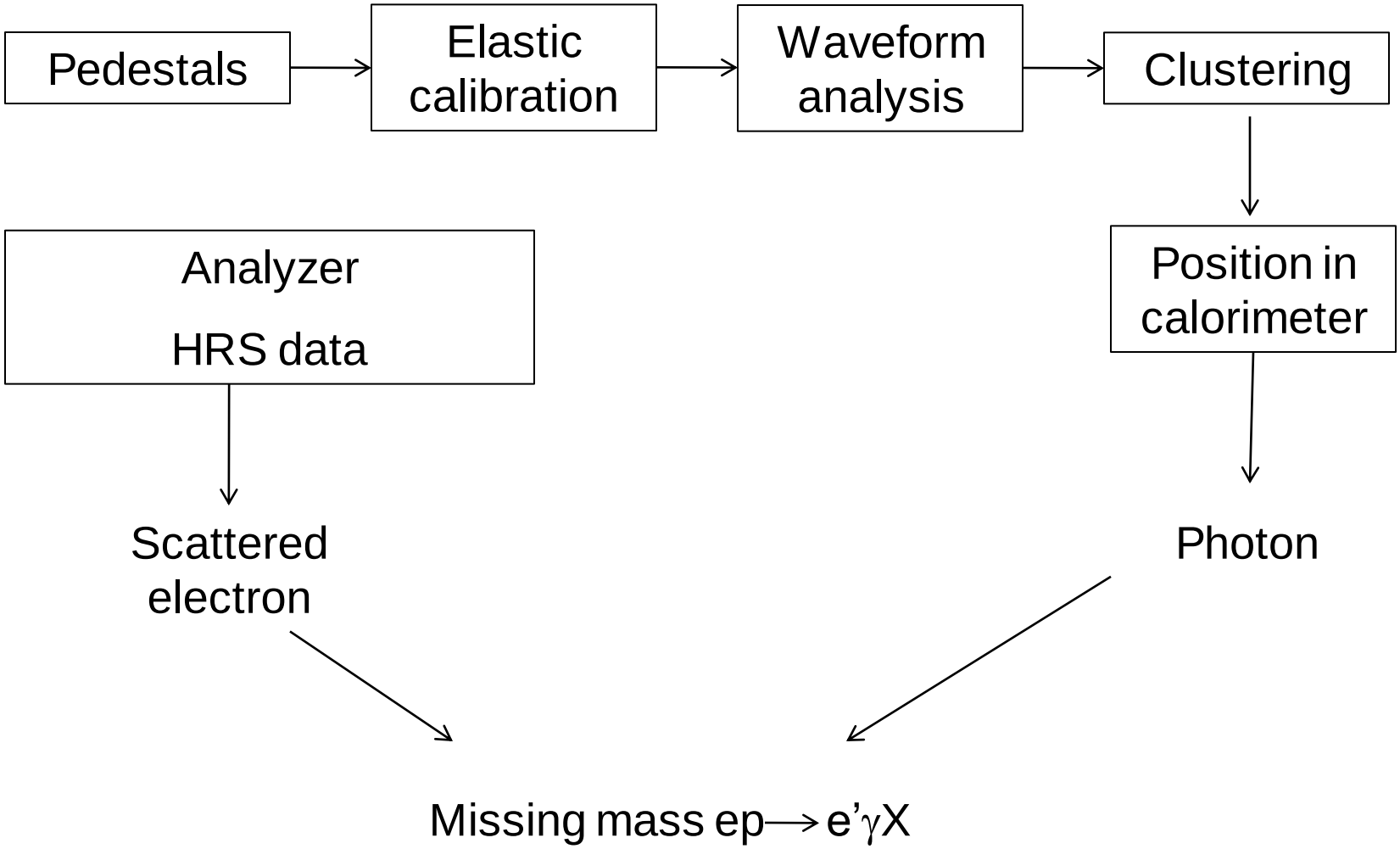
			3.0		
			7.0	7.0	2.0
8.0	8.0	8.0	7.0	7.0	2.0
8.0	8.0	8.0	7.0		
8.0	8.0	8.0	1.0		

			7.0		
			7.0	7.0	7.0
8.0	8.0	8.0	7.0	7.0	7.0
8.0	8.0	8.0	7.0		
8.0	8.0	8.0	8.0		

Calorimeter clustering



Analysis flow



Pro and cons

	Pro	Cons
Data structure	Saves space	No direct access to the data from the tree Trade CPU time vs disk space
Mysql database	Automatic process Keep history of all data All informations needed for analysis	Need a Mysql server
Waveform analysis	Resolves pile-up : improve energy and time resolution	Time and computer ressources consuming
Calorimeter clustering	Improve resolution Allows multiple clusters analysis	

Possible improvements

- Better integration in analyzer
  - Decoding
  - General clustering class
  - Improve insertion of object in the tree

- Improve efficiency of waveform analysis
  - Multithreading
  - Others algorithm

- Mysql sandbox to avoid to rely on a Mysql server to run the analysis

Conclusion

- DVCS software was developped for first DVCS experiment
  - Designed to hold and process large amount of data
  - Waveform analysis takes advantage
  - Mysql database allows to easily access to all analysis parameters

- Software will be almost used as it is for DVCS2

- Few improvements and better integration in Analyzer will be implemented. Help of interested parties welcome.