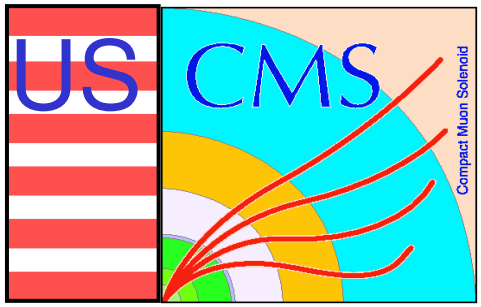
Beam Test Results and ORCA validation for CMS EMU CSC front-end electronics



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Outline

- **Motivation.**
- **CSC cathode strip pulse shape fit.**
- **Comparison with ORCA simulation.**
- **Conclusion.**

Motivation

- **Why to validate ORCA CSC simulation:**
  - **importance of realistic simulation of CSC input signals and electronics response (the coordinate and time resolution, L1 trigger primitives, pile-up, neutron background);**
  - **ORCA simulates input and output CSC signals in great details based on the beam test data and available design parameters;**
  - **no changes in relevant part of ORCA code since year 2000 (see latest status in CMS Note 2001/013 by R. Wilkinson and T. Cox);**
  - **old (prototype) front-end electronics parameters are still in use in ORCA simulation;**
  - **plenty of data available from recent 25 ns structured beam tests of CSC chambers with final set of front - end electronics;**
  - **validation of ORCA simulation is a part of Physics TDR, Vol. 1.**

Motivation (cont'd)

- **Latest developments :**
  - **track fitting, comparator and cross-talk results from beam test data (Y. Zheng, UCLA, Feb 2005 EMU meeting);**
  - **pulser cross-talk measurements in SX5 , S. Durkin, J. Gilmore, F. Geurts, April 2005, http://www.physics.ohio-state.edu/~durkin/file_transfer/crosstalkdoc.pdf ;**
  - **new code matching final cathode amplifier design and pulser cross-talk data, S. Durkin, OSU, May 2005, http://www.physics.ohio-state.edu/~durkin/software/buckeye_utils/Buckeye.htm ;**
  - **S. Durkin's code creating CSC track segments with use of Digis from 2003 and 2004 test beam data plus Y. Zheng's cross-talk and correlation code were committed by J. Mumford to CVS repository (EmuDAQ/AnalysisUtilities) and in use now in slice test at SX5;**
  - **input and output signal simulation is now to be moved from ORCA to OSCAR package.**

CSC cathode strip pulse shape fit (cont'd)

- **How to compare cathode amplifier output signal in beam test data with ORCA simulation:**
  - amplitude of the output signal is sampled in a Switch Capacitor Array (SCA) in 8 time bins each 50 ns long;
  - the 1-st SCA time bin defined as (L1 Accept) * LCT coincidence, details in note by A. Korytov,

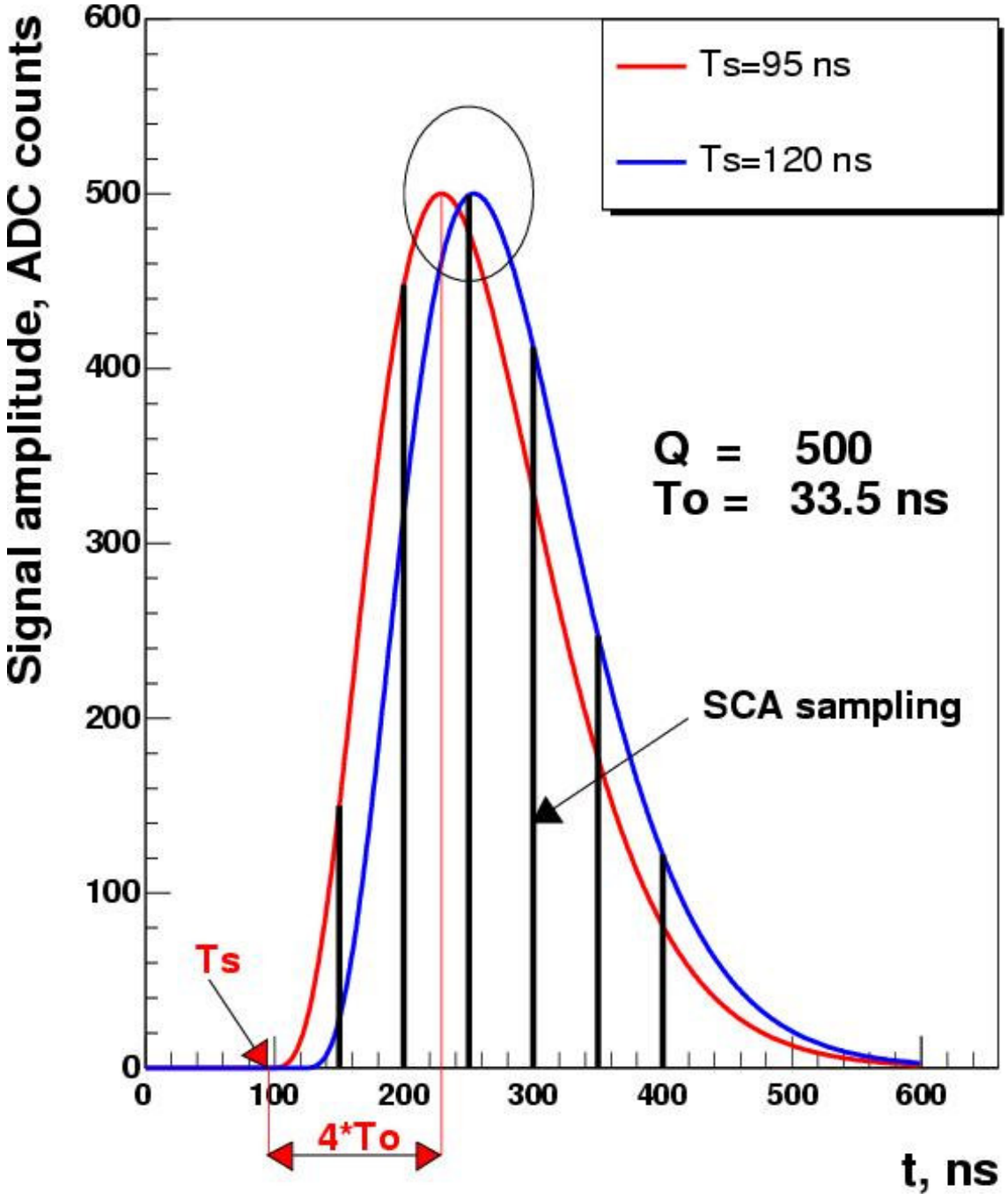
    http://www.phys.ufl.edu/cms/emu/dqm/data_formats/CFEB_data_format_notes.pdf ;
  - the phase of signal (time offset) in the beam test data is different in different CSC's (different DMB/TMB settings);
  - ORCA has its own phase too (max. SCA is always in the 5-th time bin);
  - due to 25 ns beam structure and 50 ns SCA sampling period, can have two positions of signal in time (muon comes with odd/even L1 Accept);
  - therefore fit the SCA pulse shape in beam test data and ORCA simulation data and compare relevant fit parameters;
  - for direct data comparison with simulation choose the signals with the same phase.

CSC cathode strip pulse shape fit (cont'd)

- **Fitting function for signal from one cathode strip:**
  - **semi-Gaussian**

    S(t)~Q*T**4* exp(-T),

    Q = charge, ADC counts,
    T = (t-Ts)/T0,
    4*T0 = peaking time, ns
    Ts = time offset, ns;
  - **good approximation for the top of the signal;**
  - **note example with two pulses 25 ns apart and having max. SCA at one and the same SCA time bin.**



CSC cathode strip pulse shape fit (cont'd)

- **Including strip to strip cross-talk:**
  - **based on recent external pulser data taken at SX5 (S. Durkin, J. Gilmore, F. Geurts, April 2005), http://www.physics.ohiostate.edu/~durkin/file_transfer/crosstalkdoc.pdf;**
  - **cross-talk from pulser data, convoluted by S. Durkin with ion drift time** $1/(t+2.1)$ **and a** 50 *ns* **square wave (drift electron arrival);**
  - **hint from S. Durkin to use his function** buckeye_pulse_full(t,P0,P1,Z1) **approximating the cross-talk to ~1% near the peak;**
  - **cross-talk from the strip with charge Q to the side strip:**

    cross-talk = Q * Ct * Fc,

    Fc = buckeye_pulse_full(t,P0,P1,Z1)/N,

    N **= fixed normalization factor, depending on** P0,P1,Z1,

    Ct **= cross-talk coefficient (to be fitted with the beam test data and ORCA simulation);**
  - **separate fit of the cross-talk pulser data with free** P0,P1,Z1 **and** Ct (Q =1) **yields** Ct ~ **0.1, in agreement with beam test data.**

CSC cathode strip pulse shape fit (cont'd)

- **Events selection:**
  - **single hit in anode and cathode layer;**
  - **pedestals as SCA in the first time bin (RMS=2.7);**
  - **fit SCA using 3 time bins each from 3 cathode strips, 9 in total, with max. SCA time bin in the middle:**

Ql(-50) ,Ql(0) ,Ql(+50) **- SCA for left strip,**

Qm(-50),Qm(0),Qm(+50) **- SCA for middle strip,**

Qr(-50) ,Qr(0) ,Qr(+50) **- SCA for right strip,**

where the largest SCA corresponds to max. charge deposition Qm(0) and the time bin is 50 ns long.

CSC cathode strip pulse shape fit (cont'd)

- **Fitting function for 9 SCA time bins in 3 strips:**

SCA_left(t) = Q_left *S+Ct*Fc*(0 + Q_middle)

SCA_middle(t)= Q_middle*S+Ct*Fc*(Q_left + Q_right)

SCA_right(t) = Q_right *S+Ct*Fc*(Q_middle+ 0)

where S – semi-Gaussian, Fc – cross-talk shape.

Six fitted parameters (NDF=3):

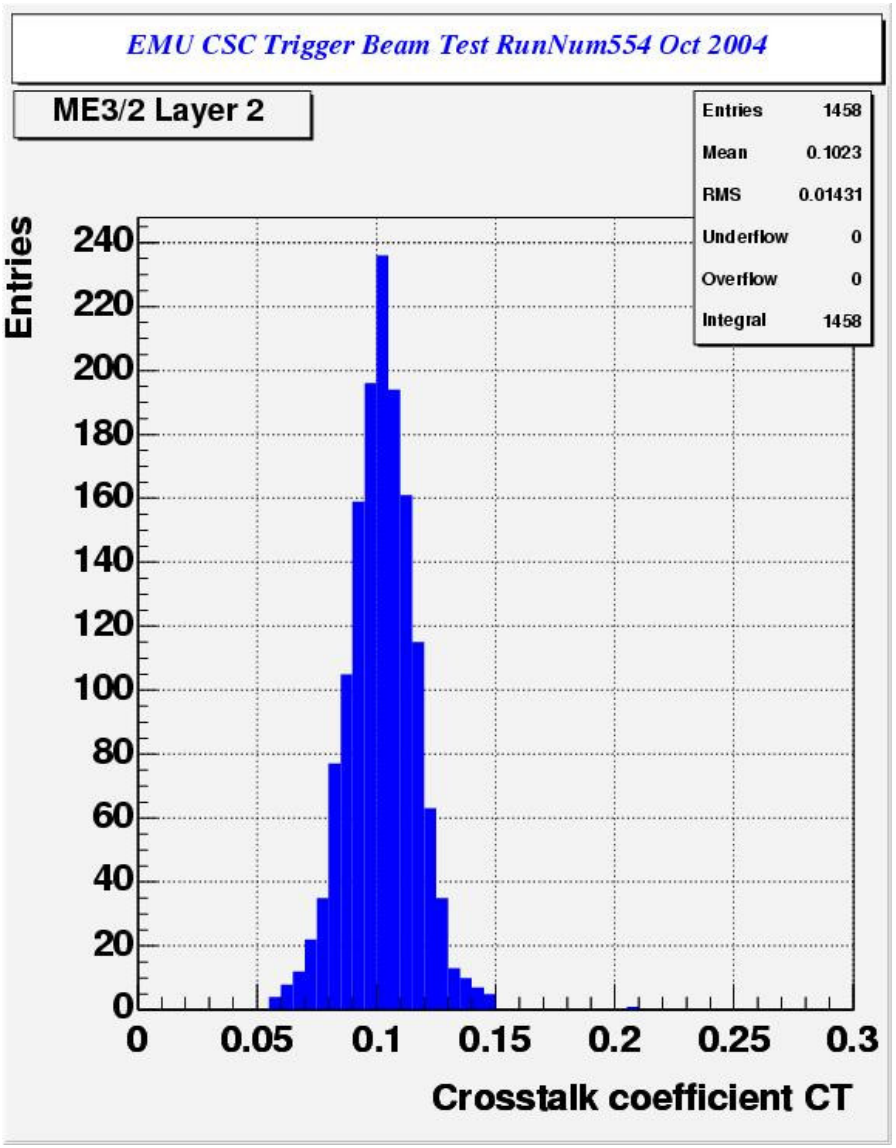
Q_left, Q_middle, Q_right, T0, Ts and Ct.

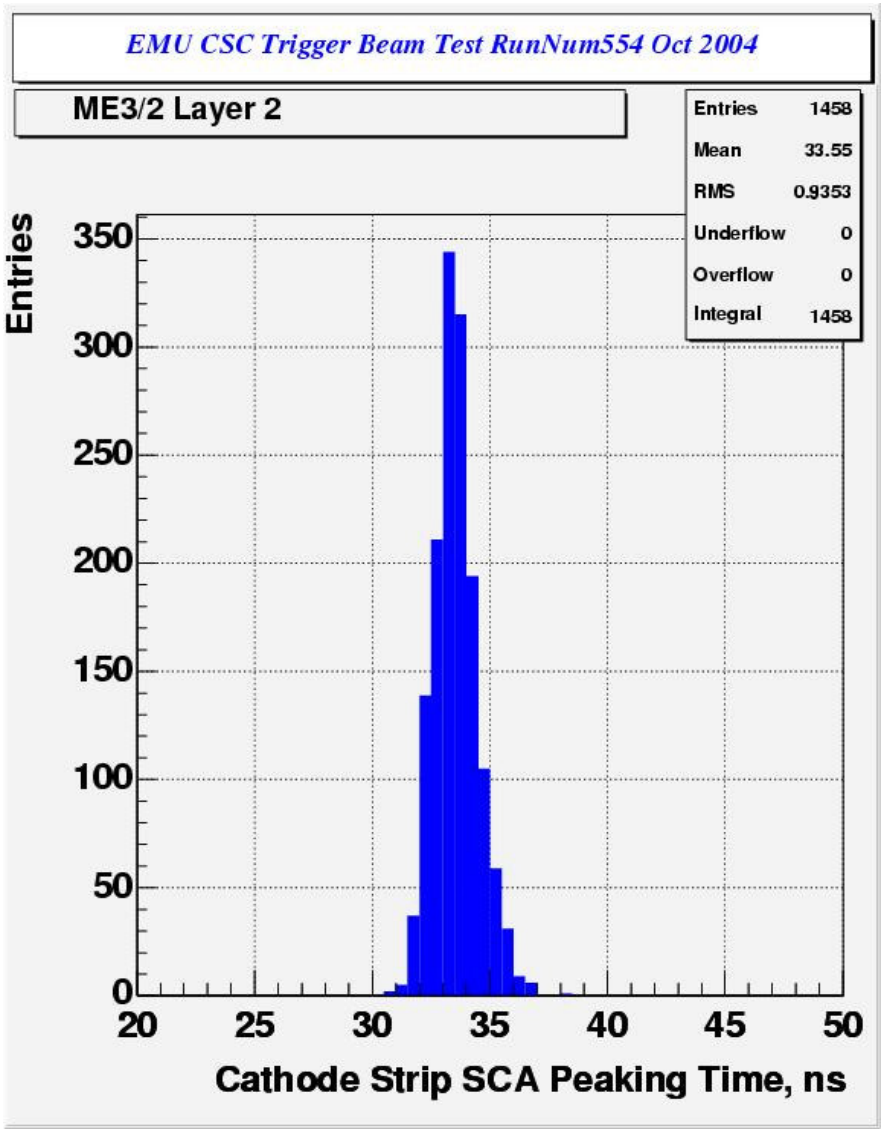
- **for good measurement of the cross-talk coefficient Ct, select hits with large signal and close to the center of the middle strip:**

Q_middle > 200

Q_middle/(Q_left+Q_middle+Q_right) > 0.7

CSC cathode strip pulse shape fit (beam test)

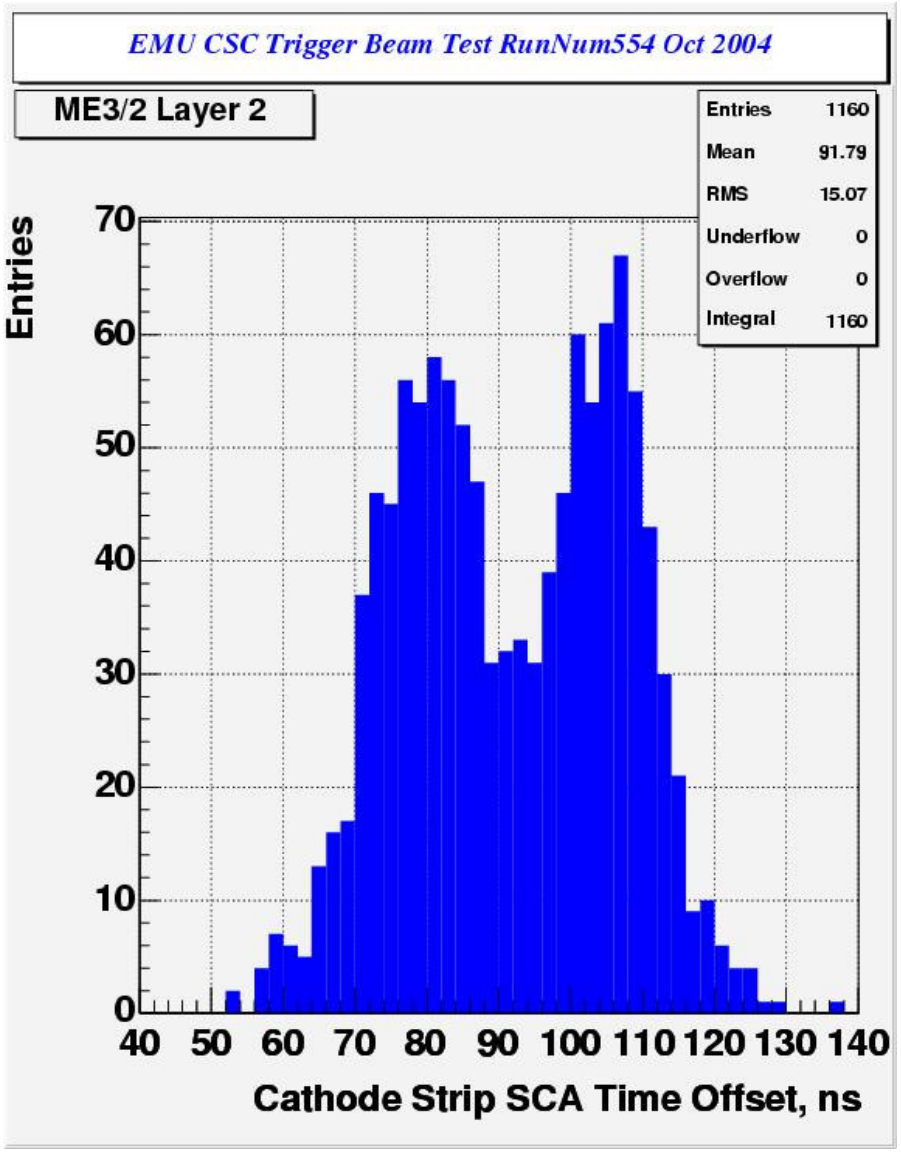


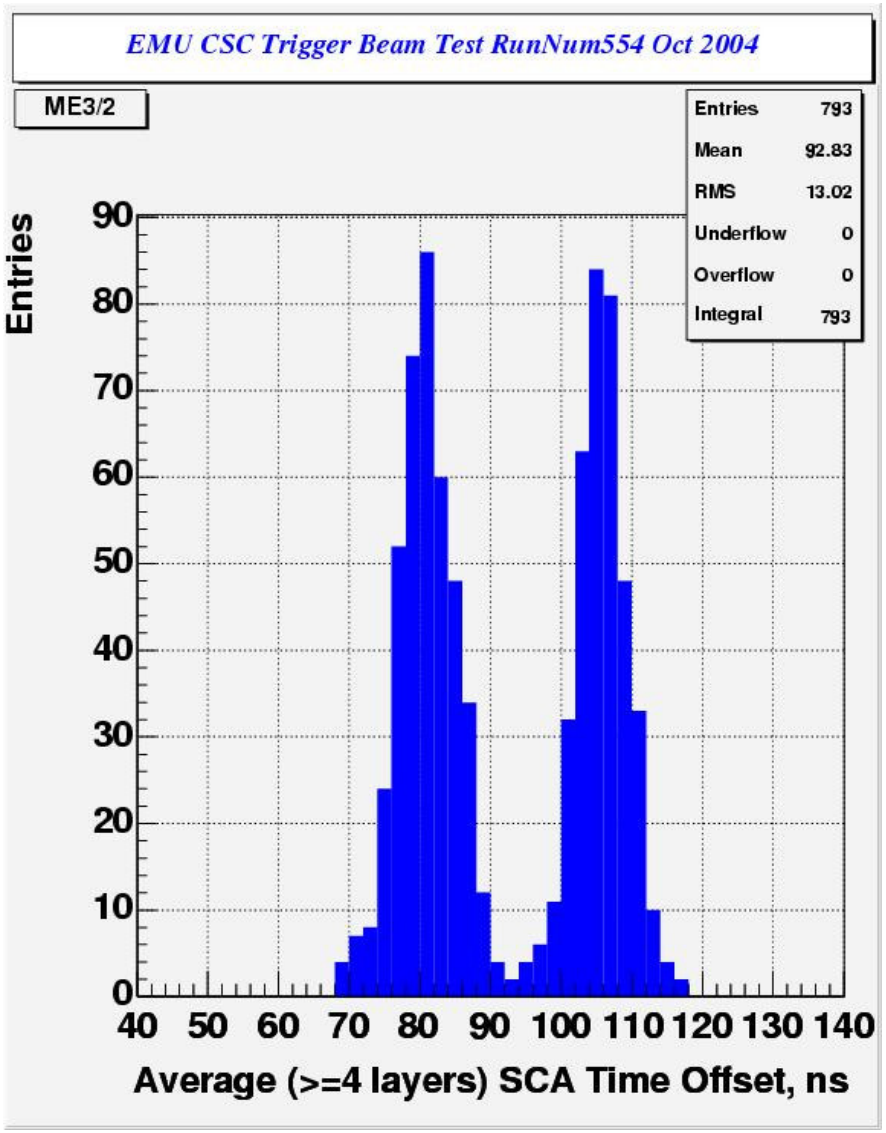


Ct = 0.102 +- 0.014 (RMS)

T0 = 33.5 +- 0.9 (RMS), ns

CSC cathode strip pulse shape fit (beam test)



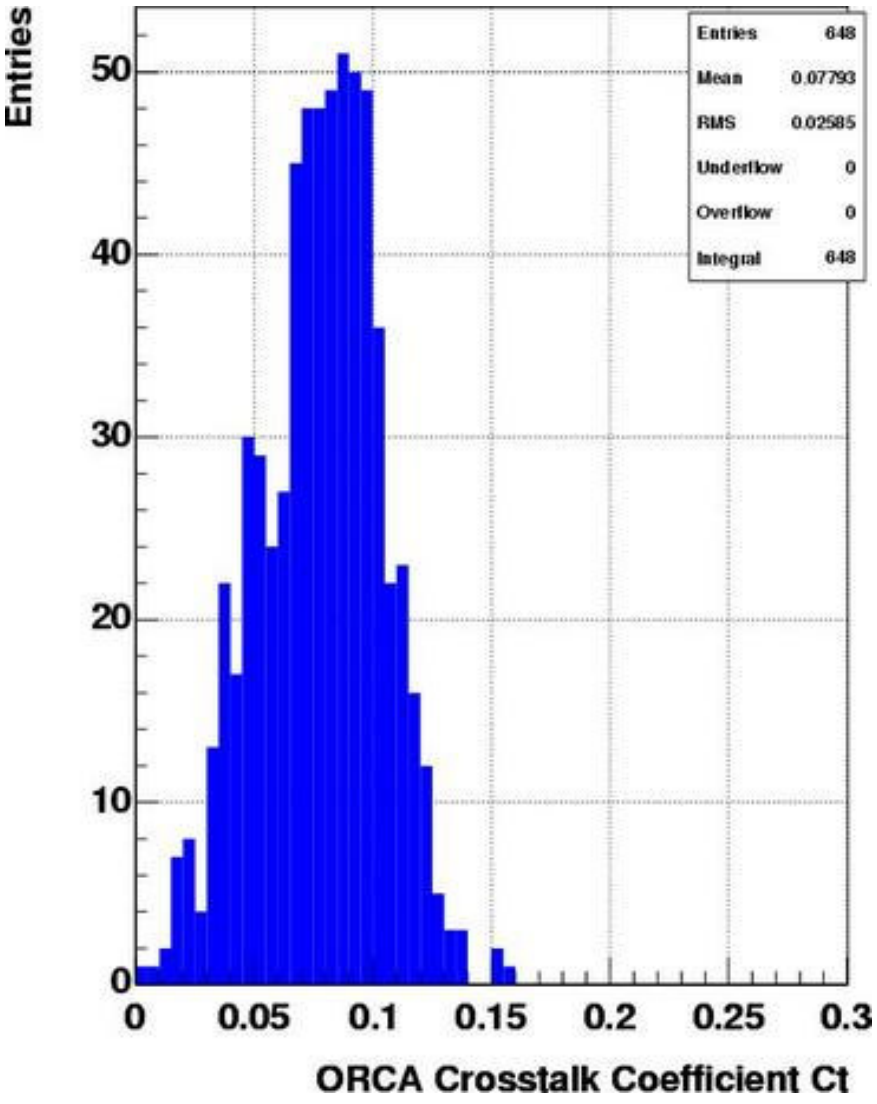


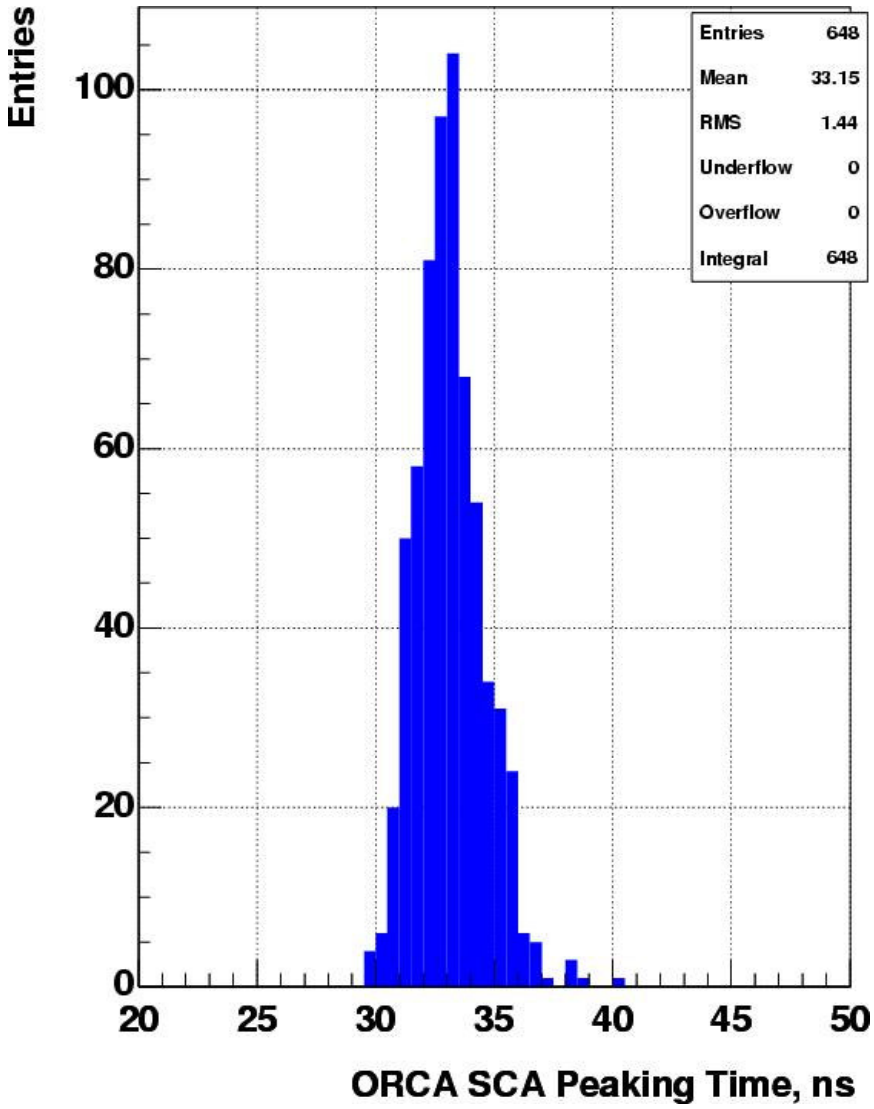
Cathode strip SCA time offset Ts for one CSC layer and averaged over >= 4 CSC layers. The peaks are 25 ns apart.

Comparison with ORCA simulation

- **ORCA (for EMU CSC simulated digitization in full CMS detector, not yet available for beam test geometry):**
  - **the single muon particle gun sample, Pt=100 GeV;**
  - **used OSCAR versions 3_2_2 and ORCA versions 8_1_3 (newer versions have the same code for the CSC raw data).**
- **Events selection in ORCA simulation:**
  - **cut 1.3 < EtaGen < 1.6 (~ as in the beam test);**
  - **all ME234/2 CSC (Station 1 with ME1/1 CSC is excluded);**
  - Q_middle > 150, Q_middle/(Q_left+Q_middle+Q_right) > 0.7 **to look at strong signal from track close to strip center.**
- **Fit by the same function.**

Comparison with ORCA simulation

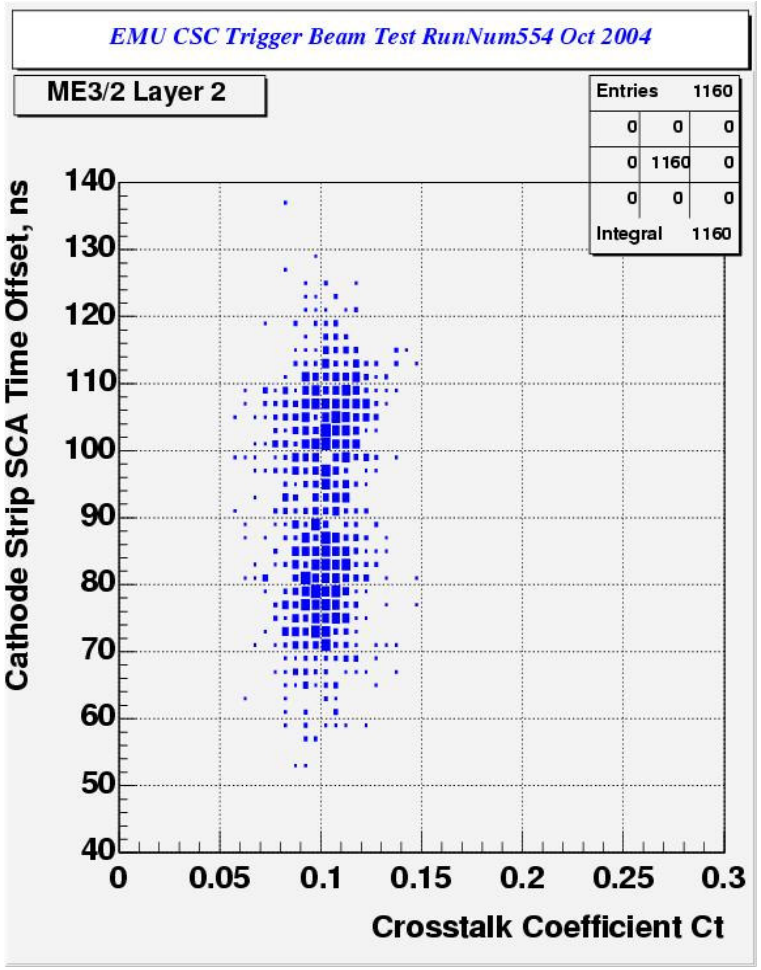


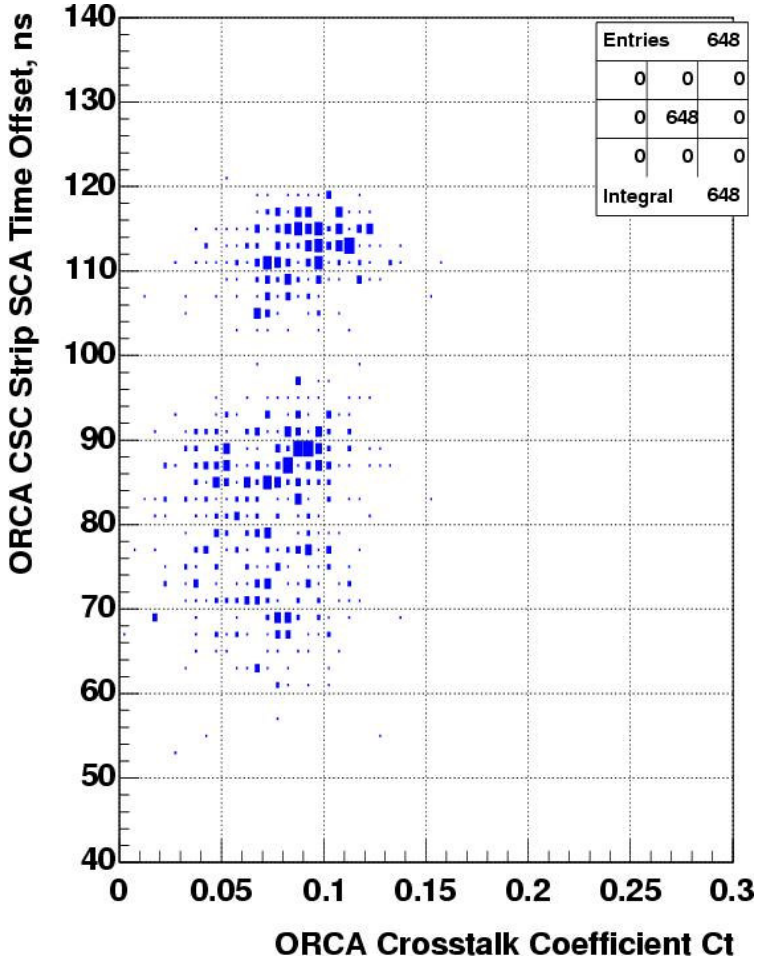


Ct = 0.08 +- 0.03 (RMS)

T0 = 33.1 +- 1.4 (RMS), ns

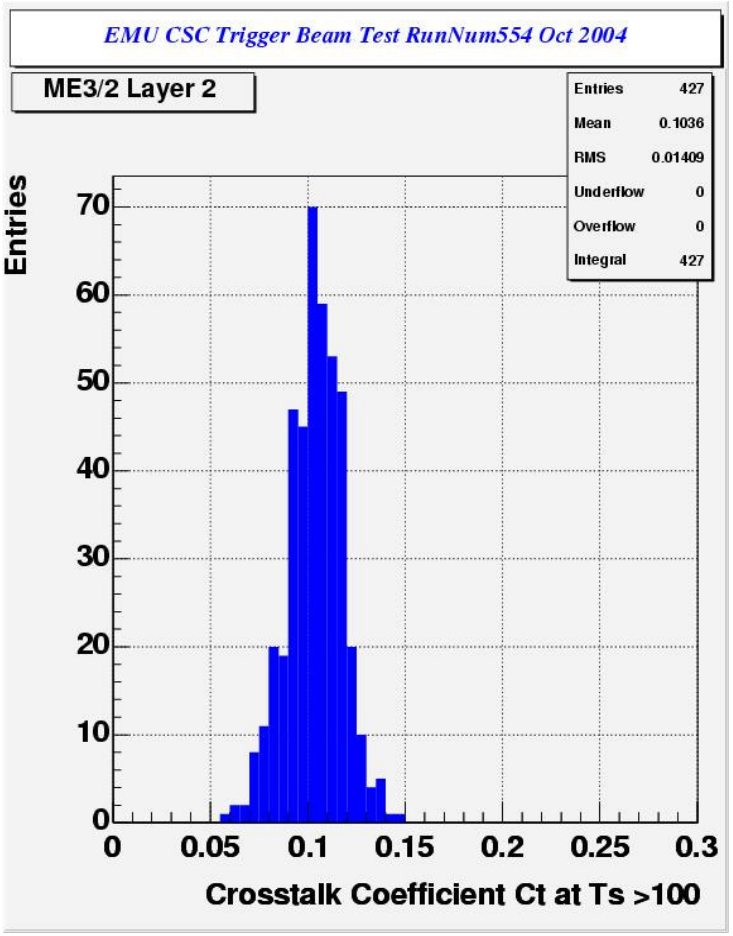
Comparison with ORCA simulation

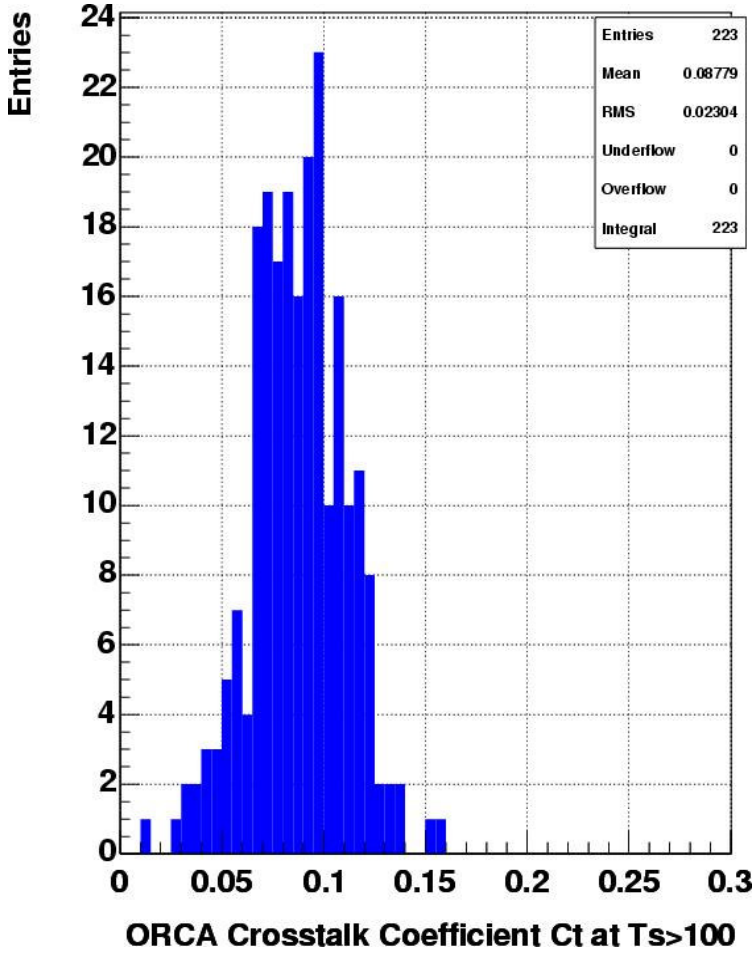




- **Beam test – almost no correlation between time offset Ts and cross-talk coefficient Ct.**
- **Select Ct at Ts>100 in beam test data and simulation for comparison.**

Comparison with ORCA simulation





- **Beam test: Ct = 0.104 +- 0.014 (RMS).**
- **ORCA simulation: Ct = 0.088 +- 0.023 (RMS).**

Comparison with ORCA simulation

	SCA Pedestal	Peaking timeT0	Crosstalk Ct
ORCA	4.0(RMS)	33.1 +- 1.4(RMS)	0.088+-0.023(RMS)
Beam test	2.7(RMS)	33.5 +- 0.9(RMS)	0.104+-0.014(RMS)

Accuracy of the Ct parameter can be improved if use SCA data in the fit from 3 strips with 12 time bins instead of 9 (add the time bin with next to max. of the cross-talk signal to include the cross-talk peak):

Time	-200	-150	-100	-50	0	+50	+100	+150
Left	0	0	41	110	88	41	18	5
Middle	0	3	112	429	512	370	214	122
Right	0	1	33	85	57	16	6	3

Conclusion

- The beam test data and ORCA simulation for the CSC cathode strip output pulses were compared using a fitted function and cross-talk from pulser data.
- Data and simulation seem to agree for the peaking time T0 and cross-talk coefficient Ct. To be confirmed with larger statistics.
- For future use the cross-talk coefficient should be found from pulser data and fixed.
- The ORCA code should be updated to include parameters from the final design of front-end electronics.
- Thanks to S. Durkin and T. Ferguson for helpful discussions.