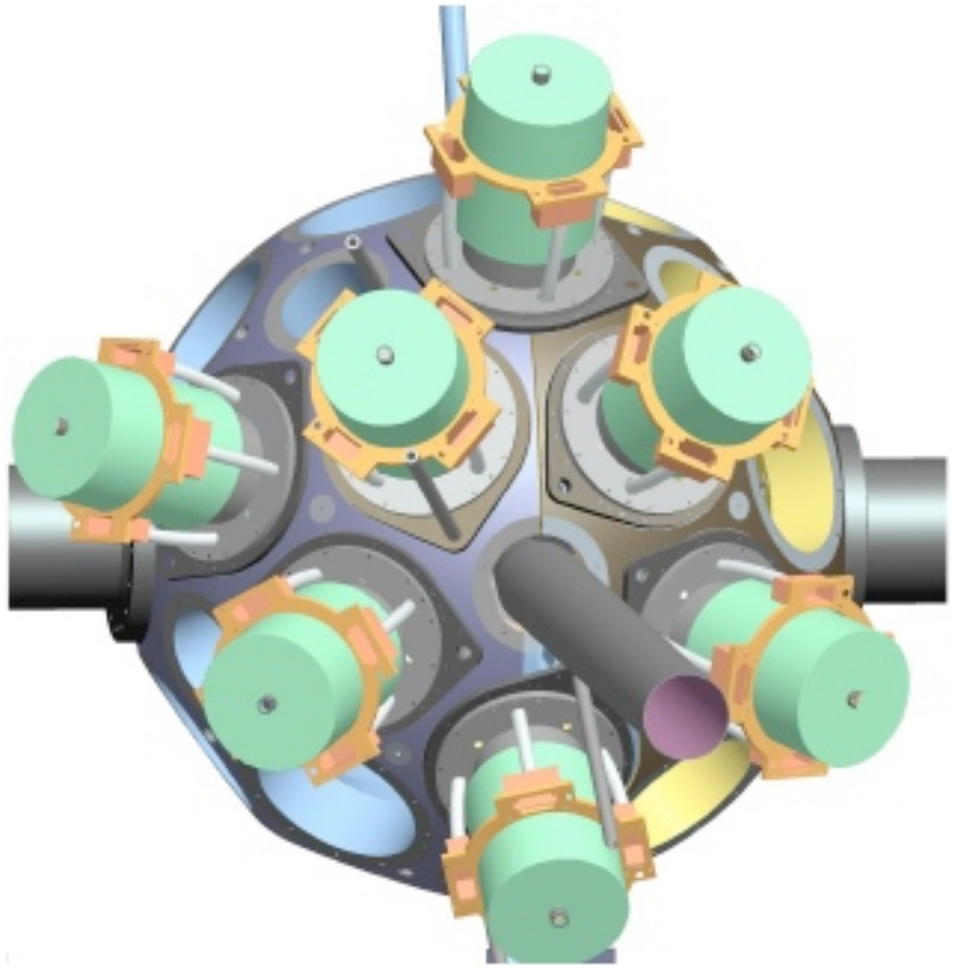
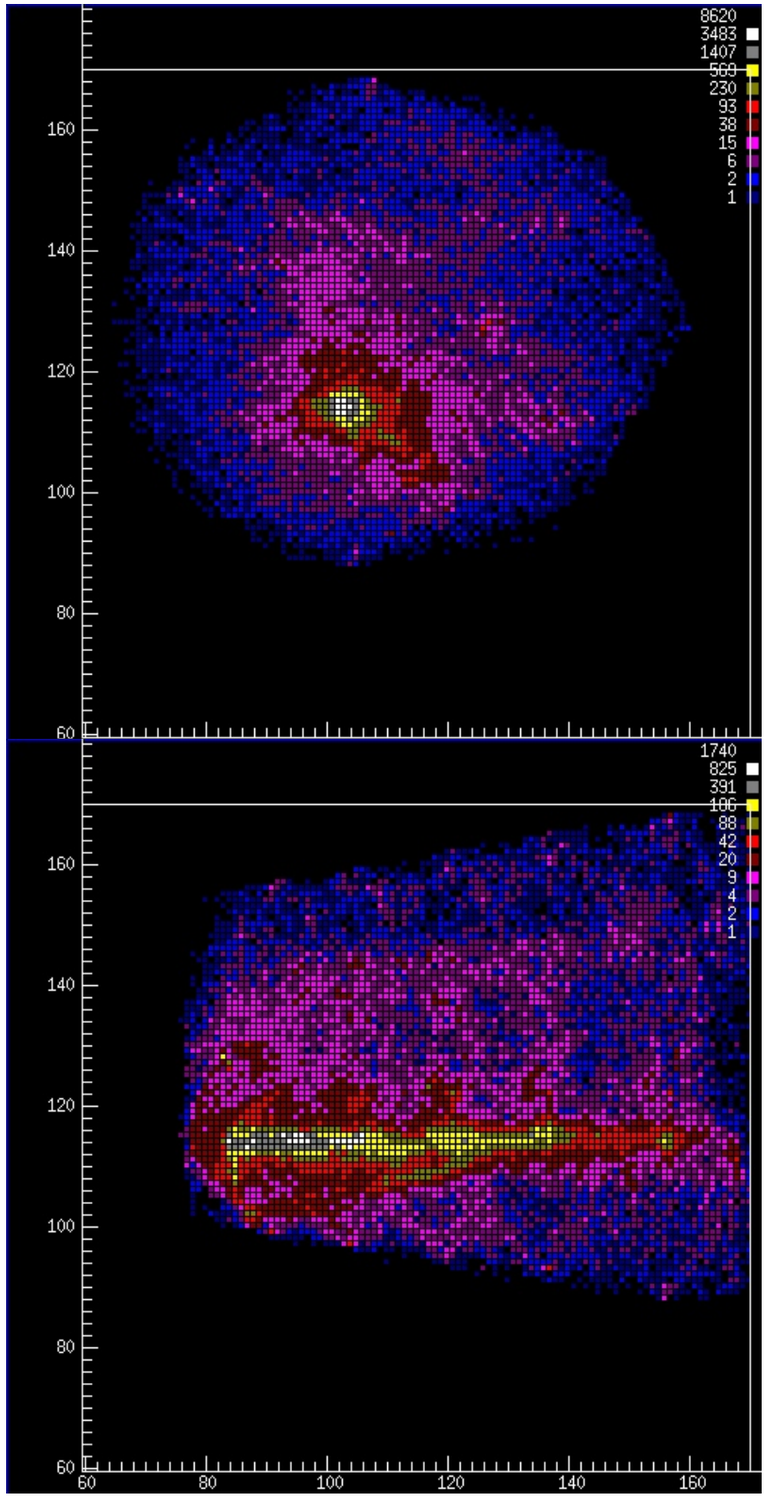
Basis Construction for GRETINA



Mario Cromaz (LBNL)

Outline

- Basis Overview
  - description
  - file format
- Raw Basis
- Crosstalk Corrected Basis
  - response corrections
  - the superpulse method
- Some future needs



Signal Decomposition

- provides sub-segment position sensitivity
- digitized signal recorded from each segment contact and the central contact (37 signals/ traces)
- observed signal fit against a linear combination of basis signals, best fit determines position
- basis signals are calculated, not measured (exhaustive measurement not practical)

Some Definitions

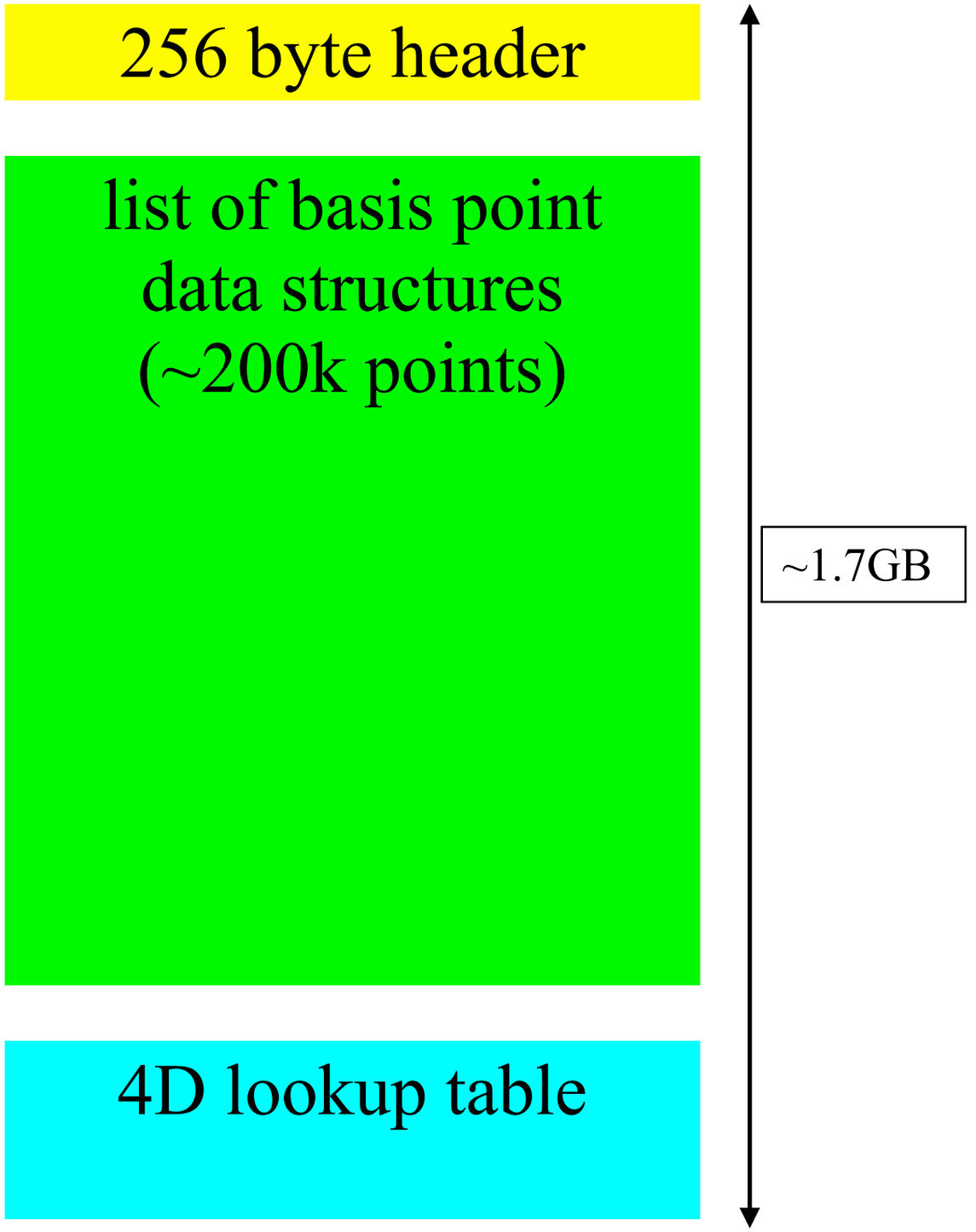
- interaction point:
  - a scattering point of the gamma ray in the Ge crystal where charge carriers are liberated
- net charge segment:
  - the segment pad(s) which collect non-zero charge
- net = 1,2,... event:
  - the number of segments for which net charge is deposited

Basis File

- file containing simulated signals for unit charge deposited on a (non-uniform) grid of points in the crystal
- two types:
  - raw basis (“basis_raw.dat”)
  - crosstalk corrected basis (“basis_xt.dat”) - file used for signal decomposition
- stored in computer memory for efficiency
- a customized basis is required for each of the 28 crystal in the GRETINA array
- constructing signal basis is a large undertaking
- important - determines position resolution of the array impacting Doppler correction, P/T and efficiency

Format (1)

- in GRETINA, a basis is a file consisting of:
  - a header
  - a set of "basis" structs
  - a 4d lookup table
- header gives:
  - version of basis
  - number of basis points
  - size of lookup table (typ: srad=35,sphi=13 szz=22)
- the lookup table allows decomp algorithm quick access to individual basis point structures



Format (2)

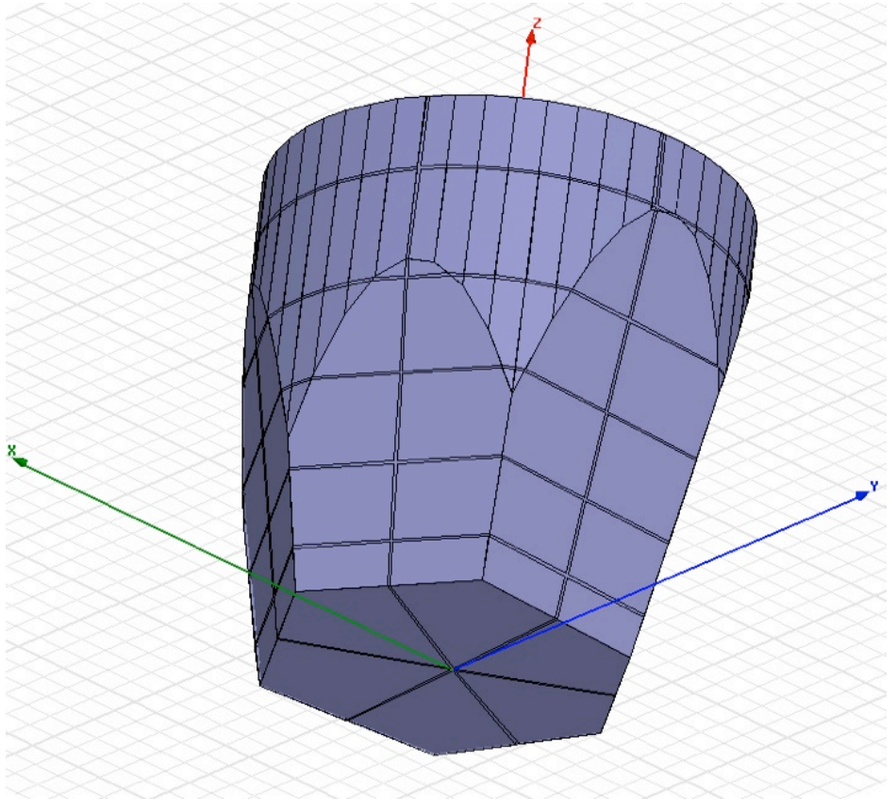
from gdecomp.h

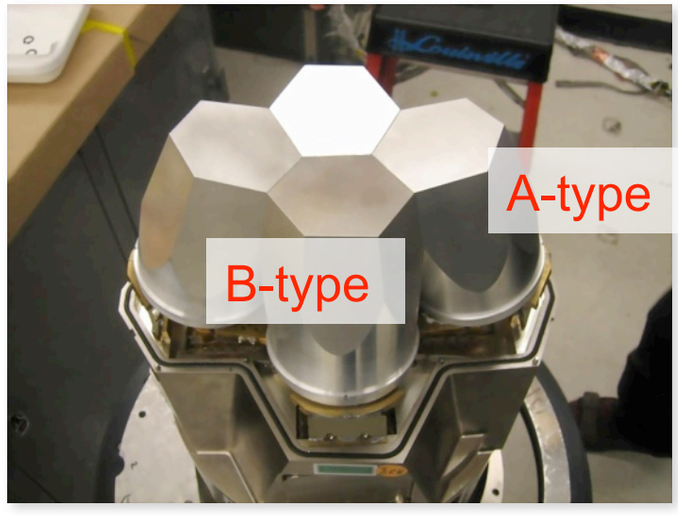
```
typedef struct {
  char  iseg, ir, ip, iz;       /* integer cylindrical coordinates of grid point */
  float x, y, z;                /* cartesian coordinates of grid point */
  float signal[GRID_SEGS][50];          /* actual basis signals */
  int   lo_time[GRID_SEGS], hi_time[GRID_SEGS];     /* limits for non-zero signal */
} Basis_Point;
```

- basis point consists of :
  - index of cylindrical coordinates used by decomposition algorithm (gives neighbors)
  - actual cartesian coordinate of point in crystal coordinates
  - a two-dimensional array of traces corresponding to signals generated by a unit charge at that point
  - limits on trace index to speed signal decomposition

Steps to Generate a Raw Basis

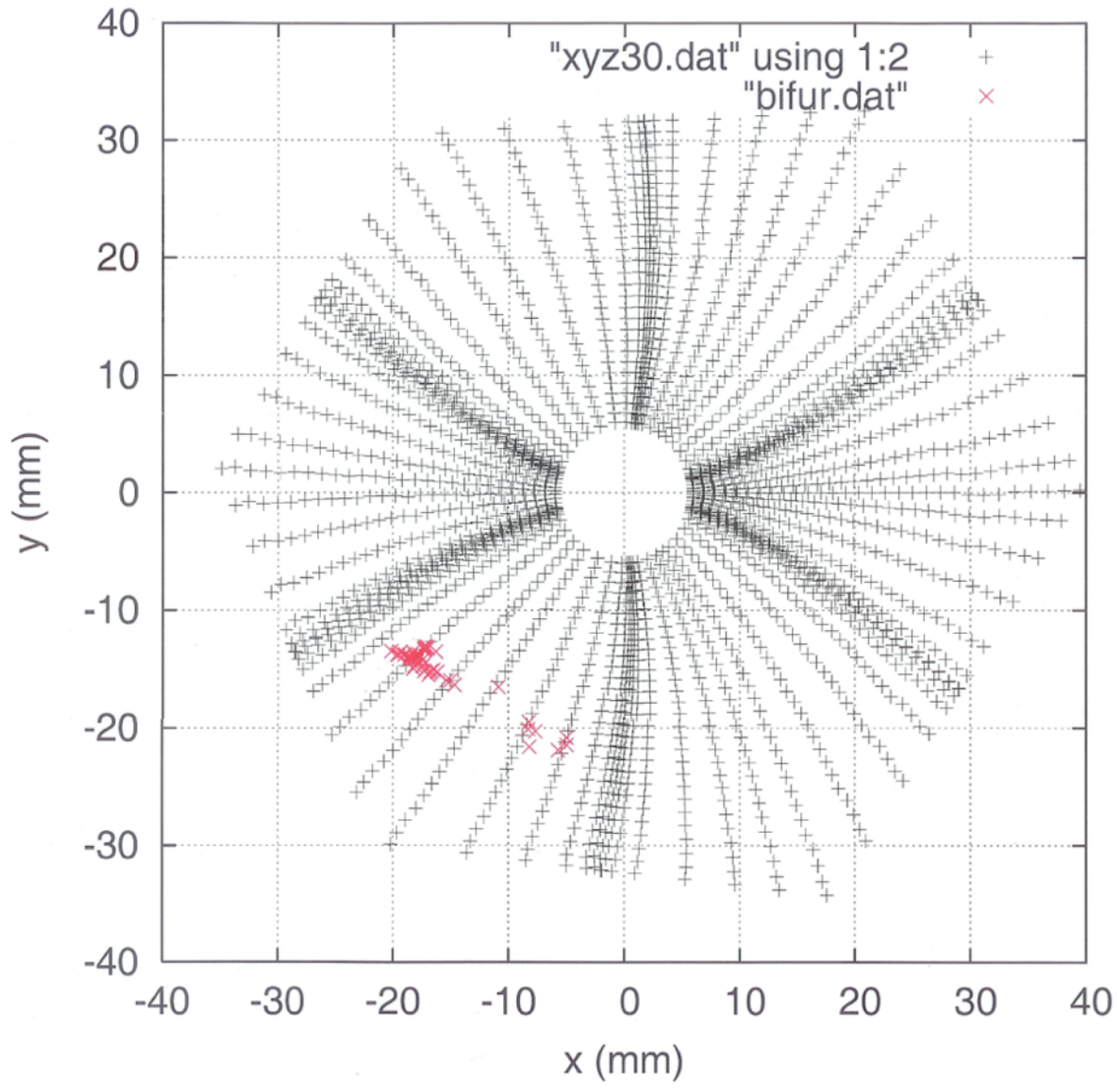
- generate electric fields, weighting potential for a given crystal geometry (A/B), voltage, impurity conc.
- generate a non-uniform grid of points within the crystal whose spacing is a function of the position sensitivity (avg. spacing ~1 mm, ~ 230,000 pts)
- for each point simulate the charge collected on each segment and central contact:
  - 50 samples (500 ns)
  - results in a file: "basis_raw.dat",





Basis Corrections

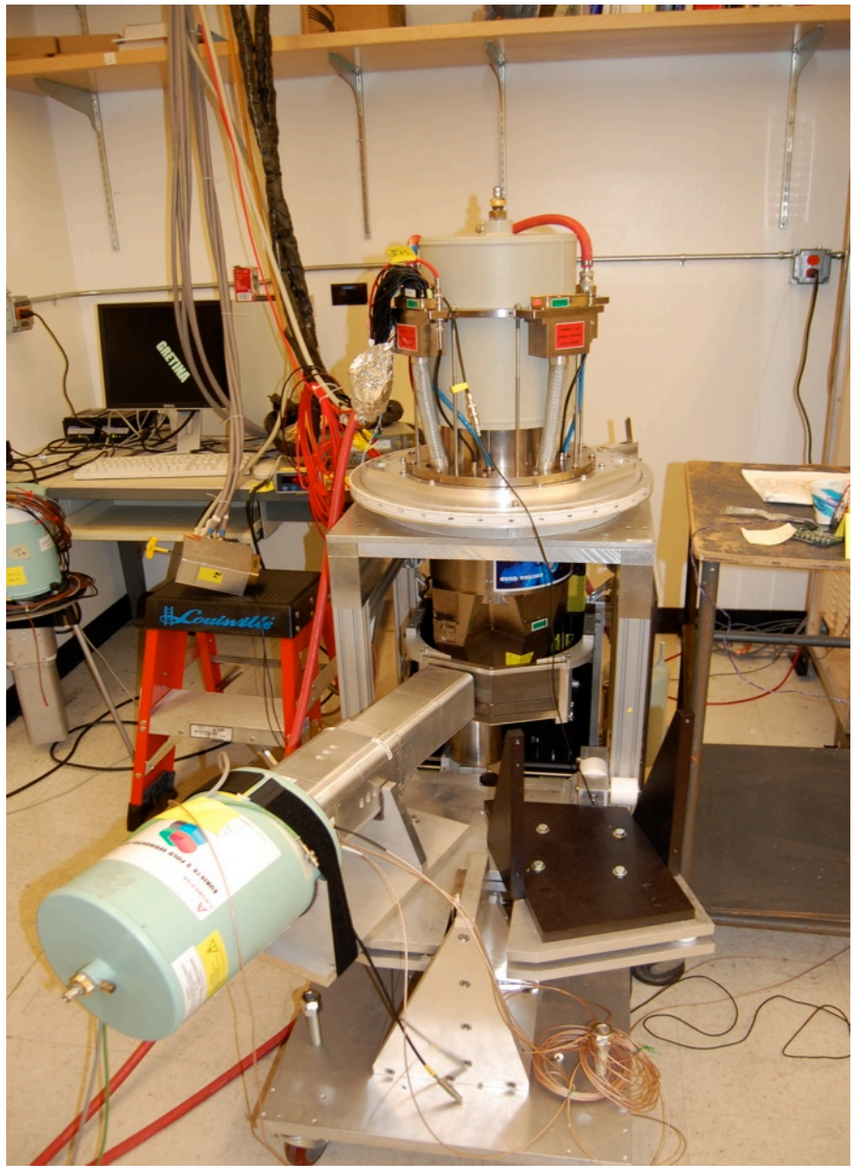
- raw simulated basis is not sufficient
- need to correct traces in basis file for:
  - integral crosstalk
  - differential crosstalk*
  - shaping from preamp
  - time offsets
- differential crosstalk very problematic as it mimics the induced signal in neighboring segments
- these parameters are not easily measured independently



example of position bifurcation in coincidence measurement

Calculating Response Corrections

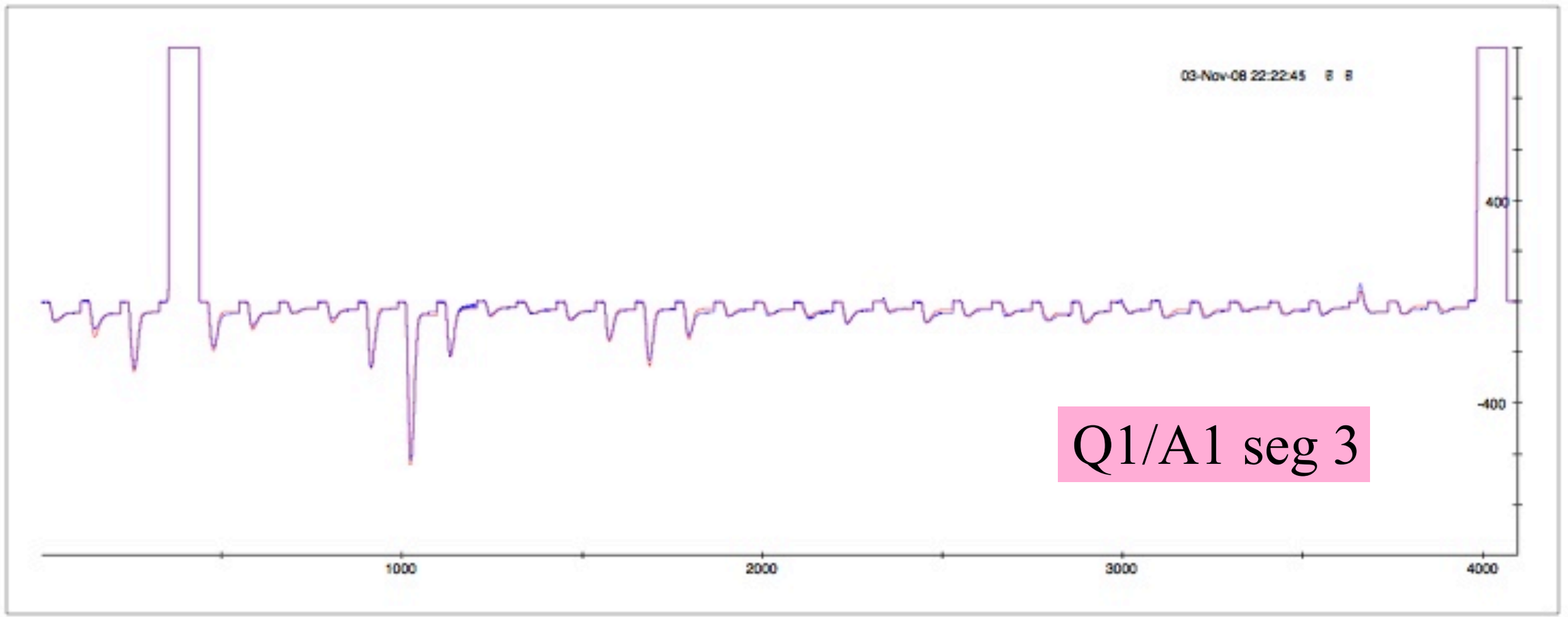
- use average net=1 traces:
  - collect net = 1 data from ^{60}Co source, record average traces for each segment (70-90 GB)
  - simulate average traces using fields originally used to calculate the raw basis
  - apply a model of response corrections to simulated data and fit against measured traces
  - the set of these traces are referred to a superpulses



GRETINA quad mounted in scanning table for coincidence measurement

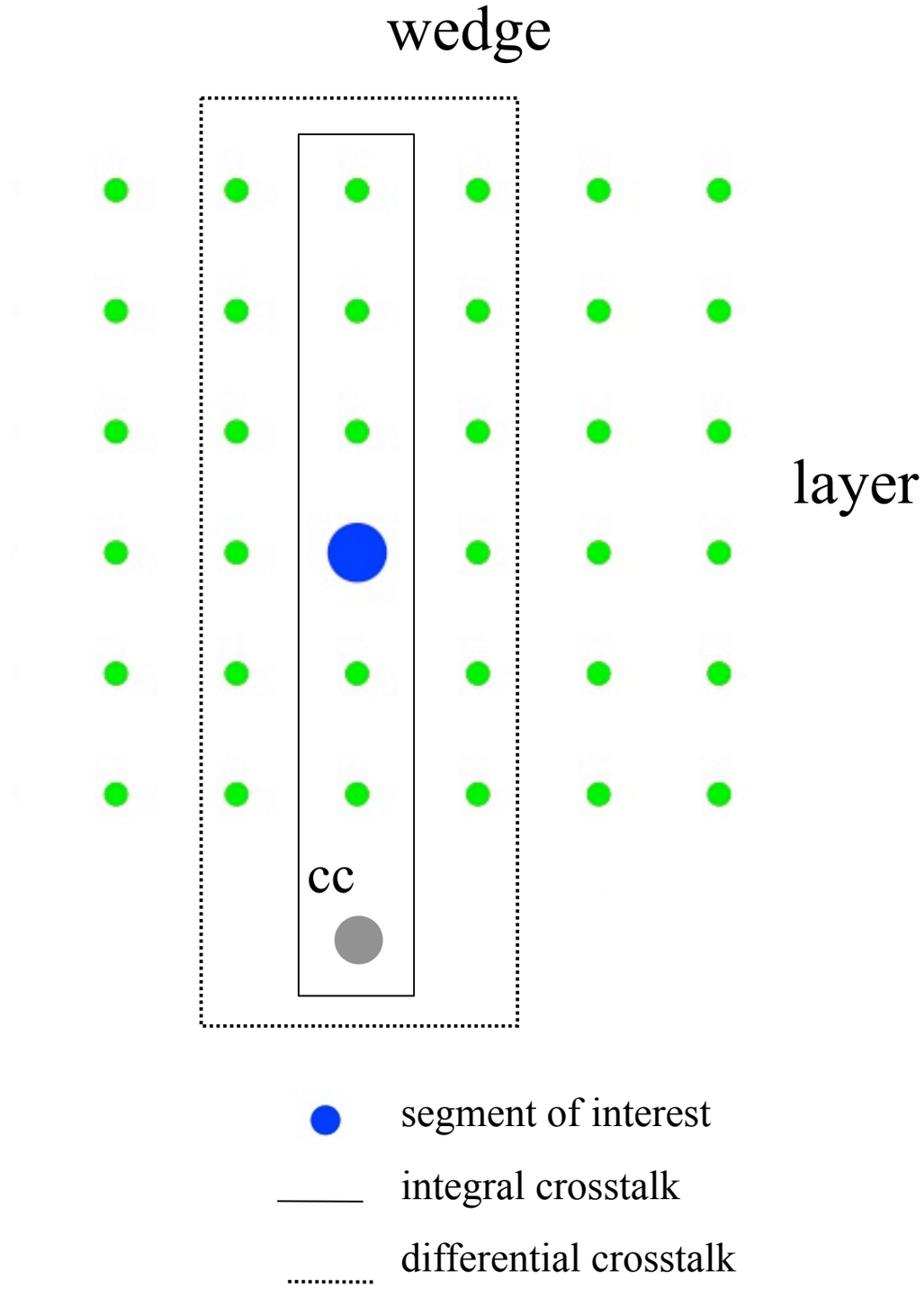
^{60}Co superpulse fits

- superpulses are a concatenation of the 36 traces from the segment and the central contact
  - below a net=1 superpulse from the front face of the detector, superimposed is a fit using the simulation with response corrections



Crosstalk Parameters Calc.

- only a subset of all possible crosstalk parameters are required
- program is flexible, can consider different sets of pairs
- figure to left shows parameters fit for current GRETINA basis
- standard fits involve 669 parameters / crystal



xtalk_pars_in.txt

- each crystal has a unique crosstalk file
- text file containing info on detector response parameters
- divided into sections based on parameter type
- ubiquitous; used in basis construction, preprocessor and signal decomposition

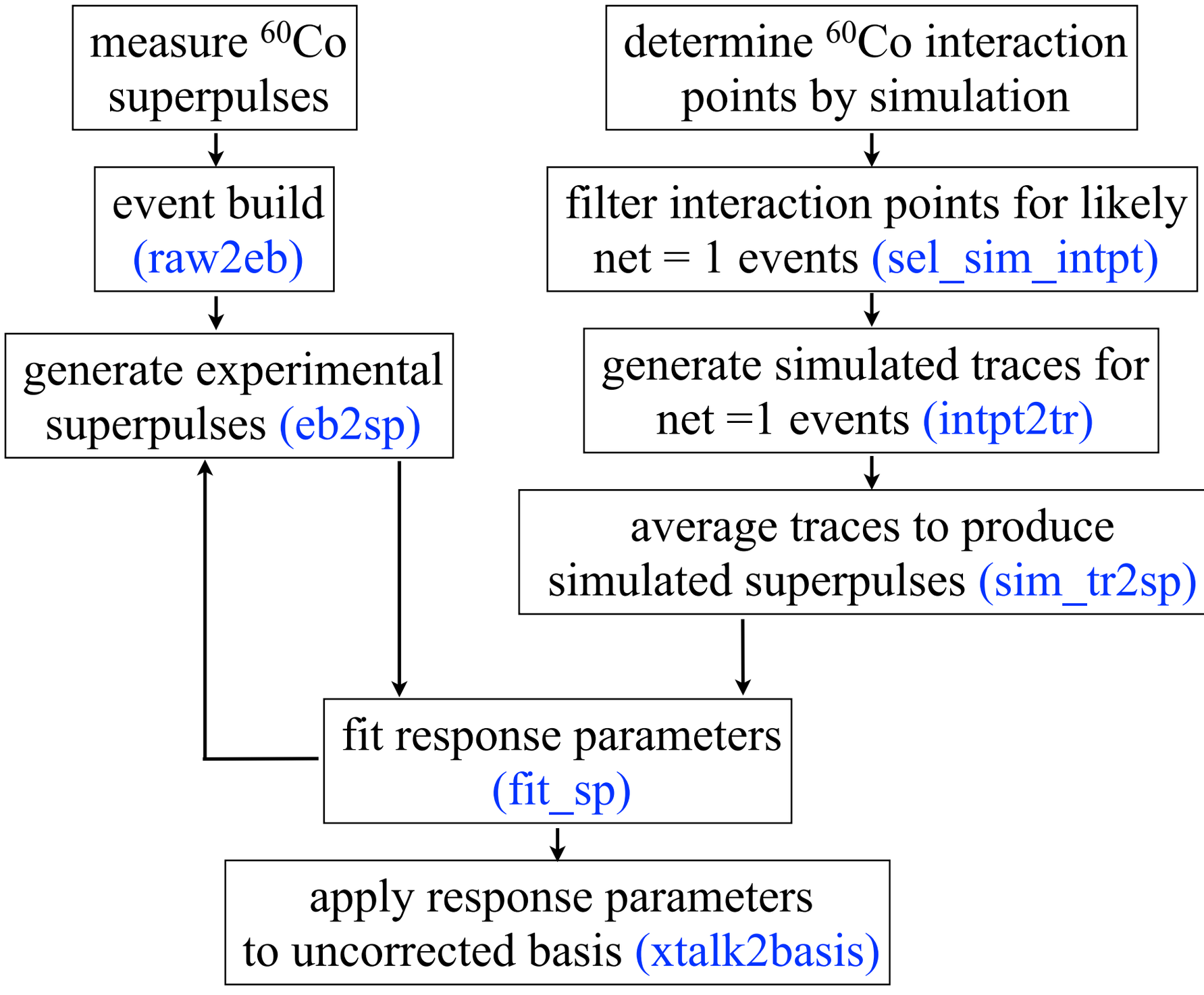
669 parameter values: `from pars669.txt`

```
delay0:
 19.64  21.04  18.01  19.22  19.55  19.14
 19.14  21.78  18.40  18.45  21.18  18.48
 19.59  20.96  18.80  19.71  20.81  20.40
 21.80  23.19  19.31  21.80  19.88  19.88
 21.98  22.77  19.20  19.81  19.16  20.45
 17.63  18.75  17.52  17.97  16.68  17.37

delay1:
  0.28   0.26   1.51   0.68   0.68   1.07
  1.47   0.17   1.58   1.32  -0.16   1.21
  0.76  -0.12   1.33   0.85   0.16   0.03
 -0.28  -0.58   0.37  -0.57   0.06   0.19
 -1.15  -0.96  -0.11  -0.55   0.32  -0.14
  2.00   1.50   1.92   1.46   3.48   2.23

dxt  0:
dxt  1:  0: 0.510
dxt  2:  1: 0.568
dxt  3:  2: 0.516
dxt  4:  3: 0.645
dxt  5:  0: 0.487  4: 0.634
dxt  6:  0: 0.795  1: 0.049  5: 0.027
dxt  7:  0: 0.054  1: 0.605  2: 0.096  6: 0.198
dxt  8:  1: 0.165  2: 0.945  3: 0.071  7: 0.261
dxt  9:  2: 0.146  3: 0.996  4: 0.164  8: 0.262
dxt 10:  3: 0.141  4: 0.980  5: 0.117  9: 0.299
dxt 11:  0: 0.009  4: 0.144  5: 0.960  6: 0.158 10: 0.290
dxt 12:  0: 0.313  1: -0.047  5: 0.005  6: 0.994  7: -0.001 11: 0.036
dxt 13:  0: -0.074  1: 0.323  2: -0.022  6: 0.095  7: 0.460  8: 0.002
        12: 0.189
dxt 14:  1: -0.051  2: 0.284  3: -0.021  7: -0.011  8: 0.880  9: 0.026
        13: 0.240
```

Workflow


measure ^{60}Co superpulses
event build (raw2eb)
generate experimental superpulses (eb2sp)
determine ^{60}Co interaction points by simulation
filter interaction points for likely net = 1 events (sel_sim_intpt)
generate simulated traces for net =1 events (intpt2tr)
average traces to produce simulated superpulses (sim_tr2sp)
fit response parameters (fit_sp)
apply response parameters to uncorrected basis (xtalk2basis)

Current Status

- have a mechanism to generate raw and response (crosstalk) corrected basis for GRETINA
- completed first iteration of basis construction - meets initial project requirements
- basis vary in quality significantly
- basis construction involves a number of disparate programs, time consuming

```
q4a4 -> basis -> basis_raw.dat
                -> basis_xt.dat
                -> xtalk_pars_in.txt
     -> co60  -> Q4Apr10001.dat
                -> Q4Apr10001.eb
                -> co60.eb
                -> expt_sp.spn
     -> sim   -> sim_sp.spno
                -> (config files)

q4a8 -> ...

q4b7 -> ...

q4b7 -> ...

...
```

Future Needs

- a more automated approach to basis creation and crosstalk parameter calculation
  - to support basis testing
  - to validate crosstalk, response model
- a mechanism to fix detector response fit parameters
  - integral crosstalk, shaping time can be determined independently, may be better able to determine differential crosstalk

- remove hard coded 500 ns (50 sample) trace size
- a mechanism to embed / track parameters used in basis into file itself (or the basis and all it's auxiliary files should be a true database ... far future)

Thank you!