# PSA via Singular Value Decomposition

**Tobias Habermann**

HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

GSI

# Outline

AGATA PSA

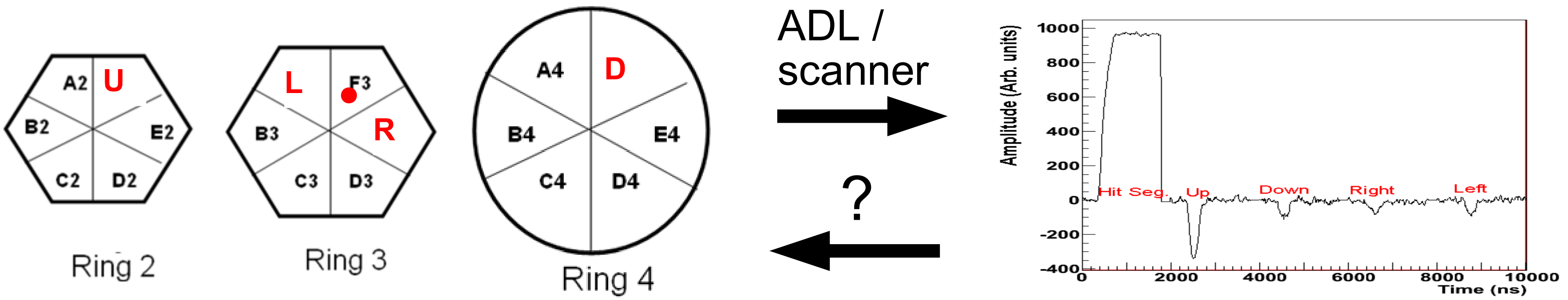
Pulse shape comparison with $X^2$ threshold

SVD & Principal component analysis

Fast pulse shape comparison

Next steps

# PSA




Position of gamma interaction

Pusle shape
(hit segment and direct neighbours)

PSA via reference signals

1. build database of signals for know positions
2. find best fit to reference signal to determine position

→ e.g. Adaptive Grid Search

# Core of the program

- Just a sequence of loops with almost no calculations
- Runs fast because all structures fit in memory

```
#define RERRE 24
#define RPHI  25
#define RZETA 60
#define RTIME 70
#define RSEGM 25

int amplitude[RERRE][RPHI][RZETA][RTIME][RSEGM];  //erre phi zeta time segment      252 MByte

chi2min=1000000000;
for(ierre=4;ierre<=RERRE;ierre+=step1A){
  for(iphi=1;(iphi <=2+ierre)&&(iphi<=RPHI) ;iphi+=step1A){
    for(izeta=zetar[slice][0];izeta<=zetar[slice][1];izeta+=step1A){
      for(dt=-rt;dt<=rt;dt++){
        for(itime=10, chi2=0;  (itime<=RTIME-10) && (chi2<chi2min); itime+=step1B){
          for(kk=1;  (kk<=segments[slice][0]) ;kk++){
            isegm=segments[slice][kk];
            aa=samples[itime-3+dt][isegm-1];
            bb=amplitude[ierre-1][iphi-1][izeta-1][itime-1][isegm-1];
            if (isegm==ref)
              chi2 += (long)(metrica[aa-bb+5000]/weights[mult-1]);
            else
              chi2 += metrica[aa-bb+5000];
          }
        }
        if(chi2<chi2min) {
          chi2min = chi2;
          erreb   = ierre;
          phib    = iphi;
          zetab   = izeta;
          bestdt  = dt;
        }
      }
    }
  }
}
```

* R. Venturelli presentations at AGATA weeks (e.g. Liverpool June 2006) available at at http://www-win.gsi.de/agata/

** R. Venturelli, et al., LNL Annual Report 2002, INFN-LNL(REP)198/2003, pp. 154–156

# Core of the program

- Just a sequence of loops with almost no calculations
- Runs fast because all structures fit in memory

We are not interested in full $X^2$ distribution, but only in the best fit!
→ Use „adaptive threshold“

```
#define RERRE 24
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#define RSEGM 25

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              chi2 += (long)(metrica[aa-bb+5000]/weights[mult-1]);
            else
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          }
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        if(chi2<chi2min) {
          chi2min = chi2;
          erreb   = ierre;
          phib    = iphi;
          zetab   = izeta;
          bestdt  = dt;
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      }
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```

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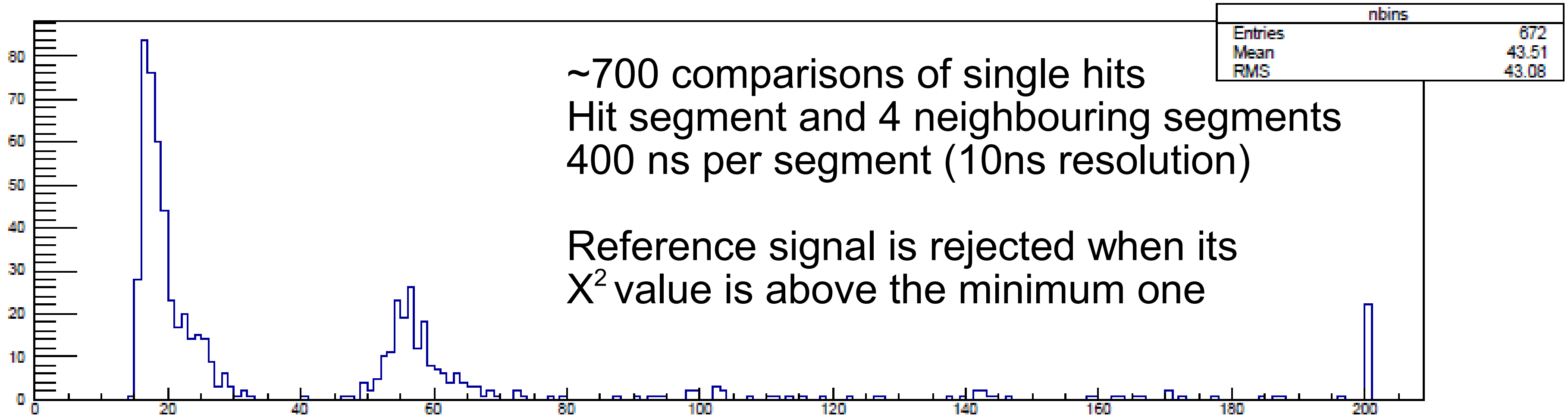
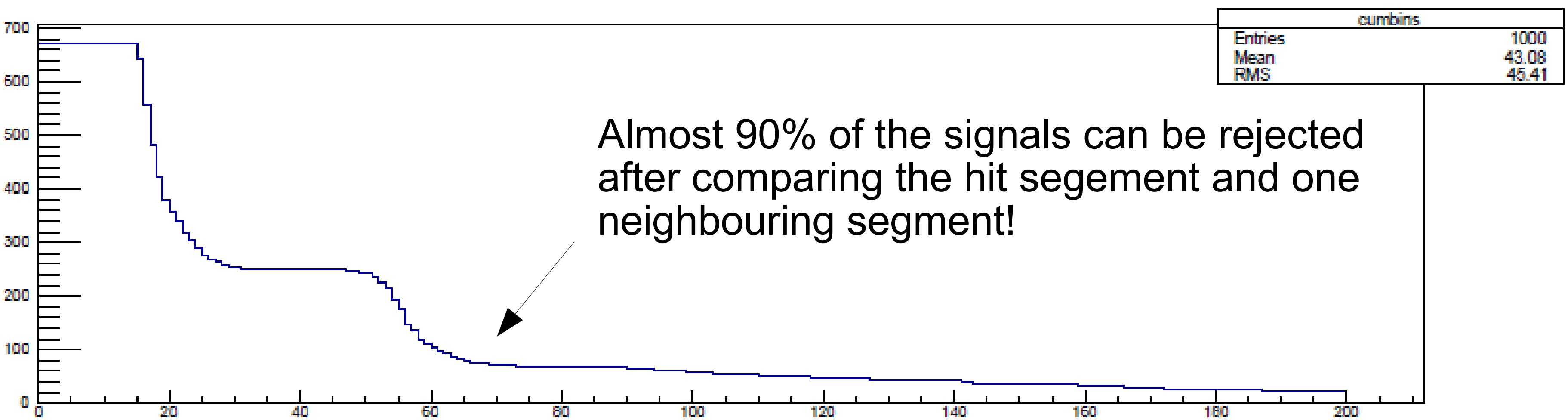
# Pulse Shape Comparison with $X^2$ threshold




number of reference signals that can be rejected after comparing x bins




number of best fit candidates after comparing x bins

# SVD

Published in
P.D. *et al.* behalf AGATA, EPJA 40 (2009)

• method

SVD :

• reduces the size of the signals

• keeping the max. information

• improving the conditioning

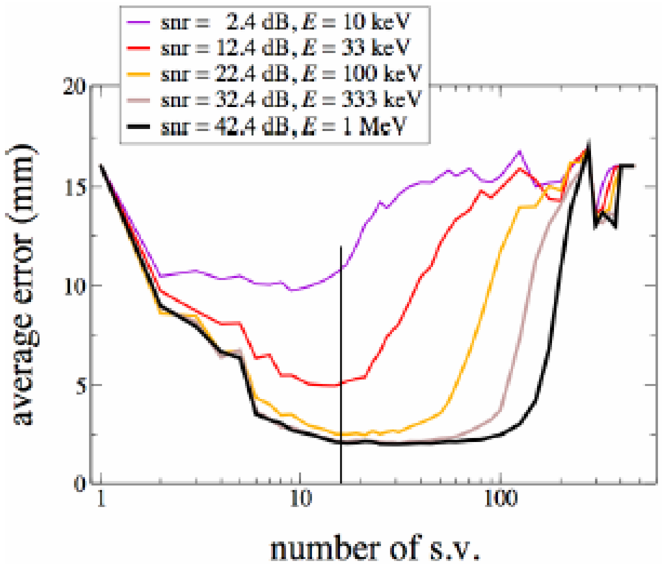
• out-of line calculations

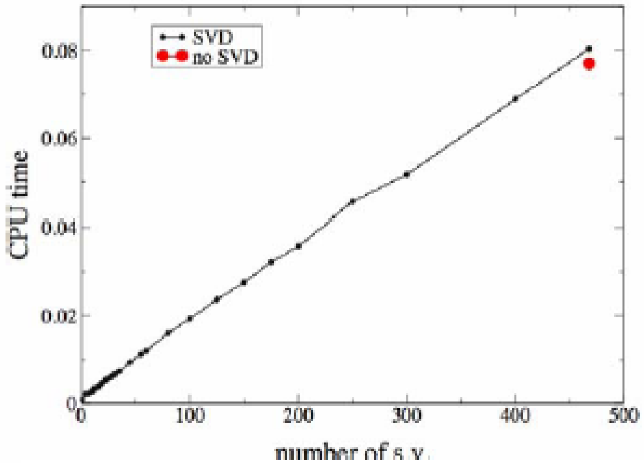
⇒ reduces the CPU time

⇒ no resolution loss

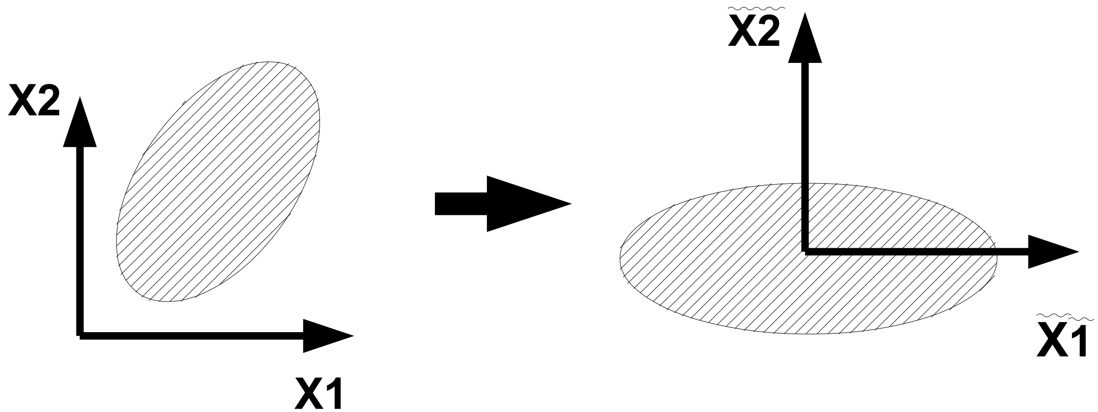
⇒ improve resol. and decomposition power

• results



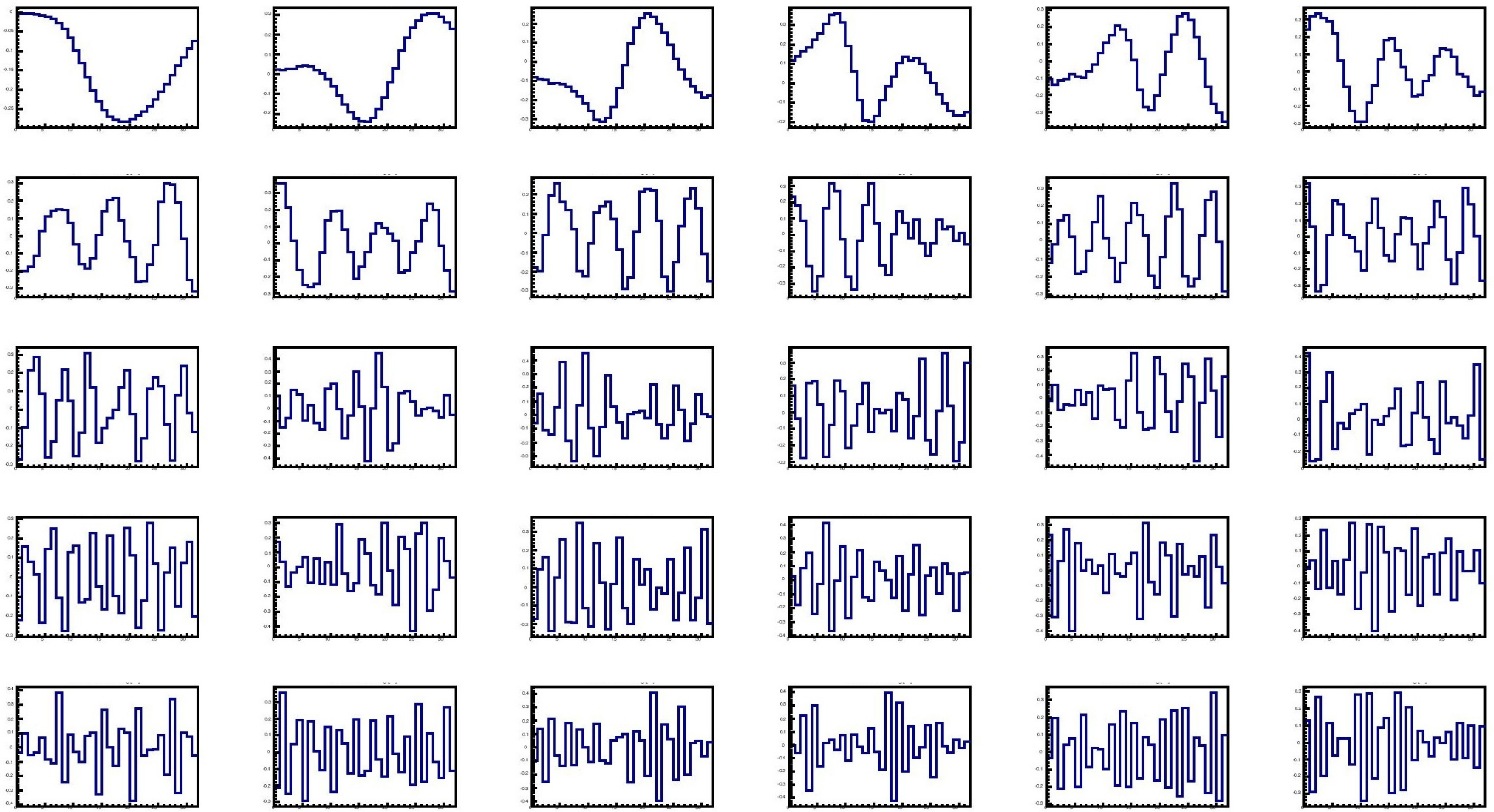
# Principal Component Analysis

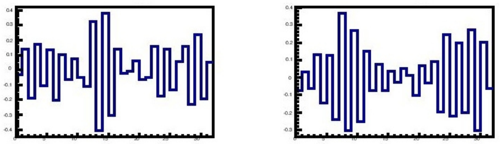



Transform dataset to have maximum information in minimum number of components.

New basis is obtained from singular value decomposition of the set of reference signals (singular vectors).

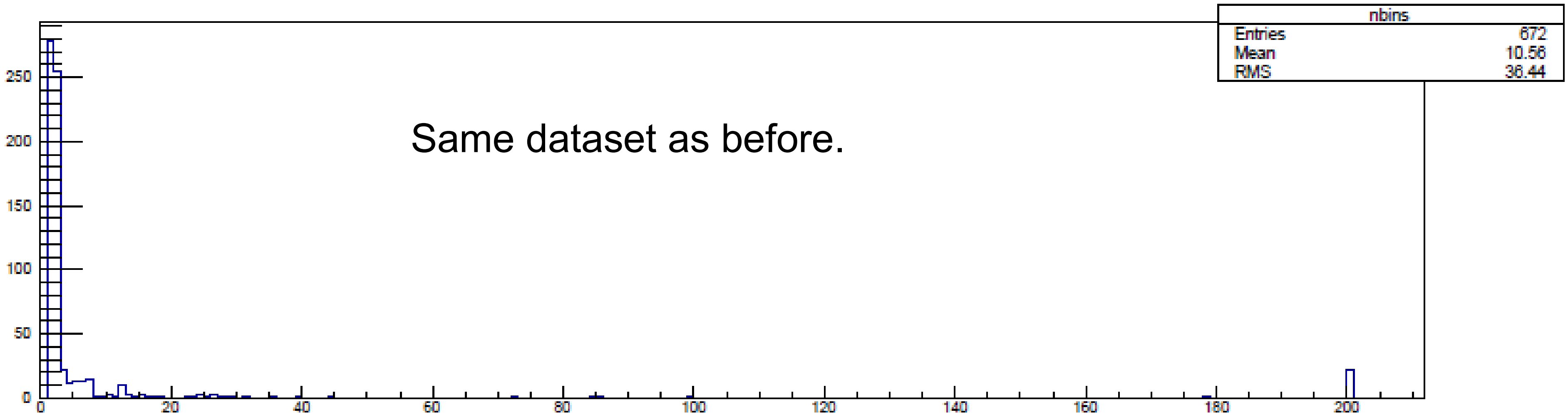
# Singular vectors – Principal components





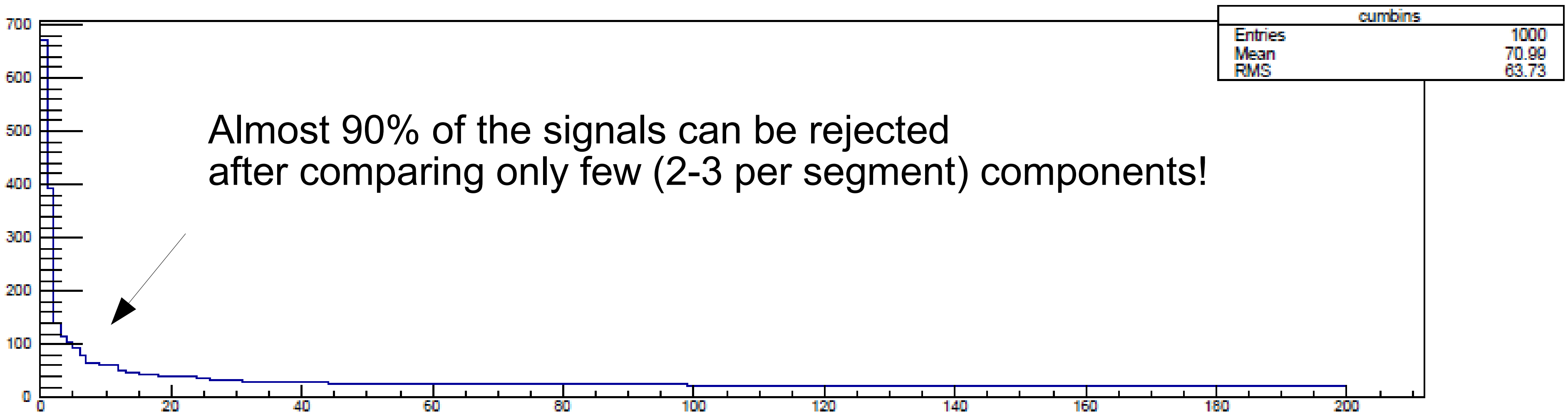
complete basis for a 320ns wide window

# Fast Pulse shape comparison




Same dataset as before.

number of reference signals that can be rejected after comparing x bins




Almost 90% of the signals can be rejected
after comparing only few (2-3 per segment) components!

number of best fit candidates after comparing x bins

# Procedure

OFFLINE

1. Singular value decomposition of signal basis
   → singular vectors / principal components

2.Transform signal basis

ONLINE

1. Transform measured pulse shape

2. Use Adaptive Grid Search
   … but compare the transformed pulse shapes

# Procedure

OFFLINE

1. Singular value decomposition of signal basis
   → singular vectors / principal components

2. Transform signal basis

very time consuming !!!

ONLINE

1. Transform measured pulse shape

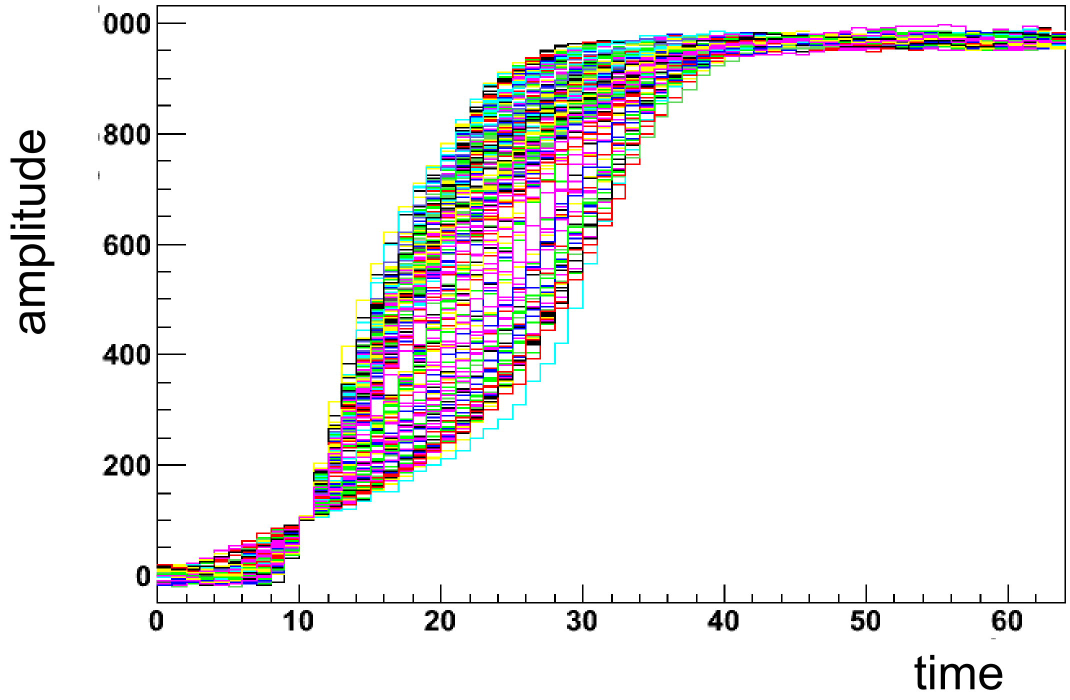
small overhead

2. Use Adaptive Grid Search
   … but compare the transformed pulse shapes

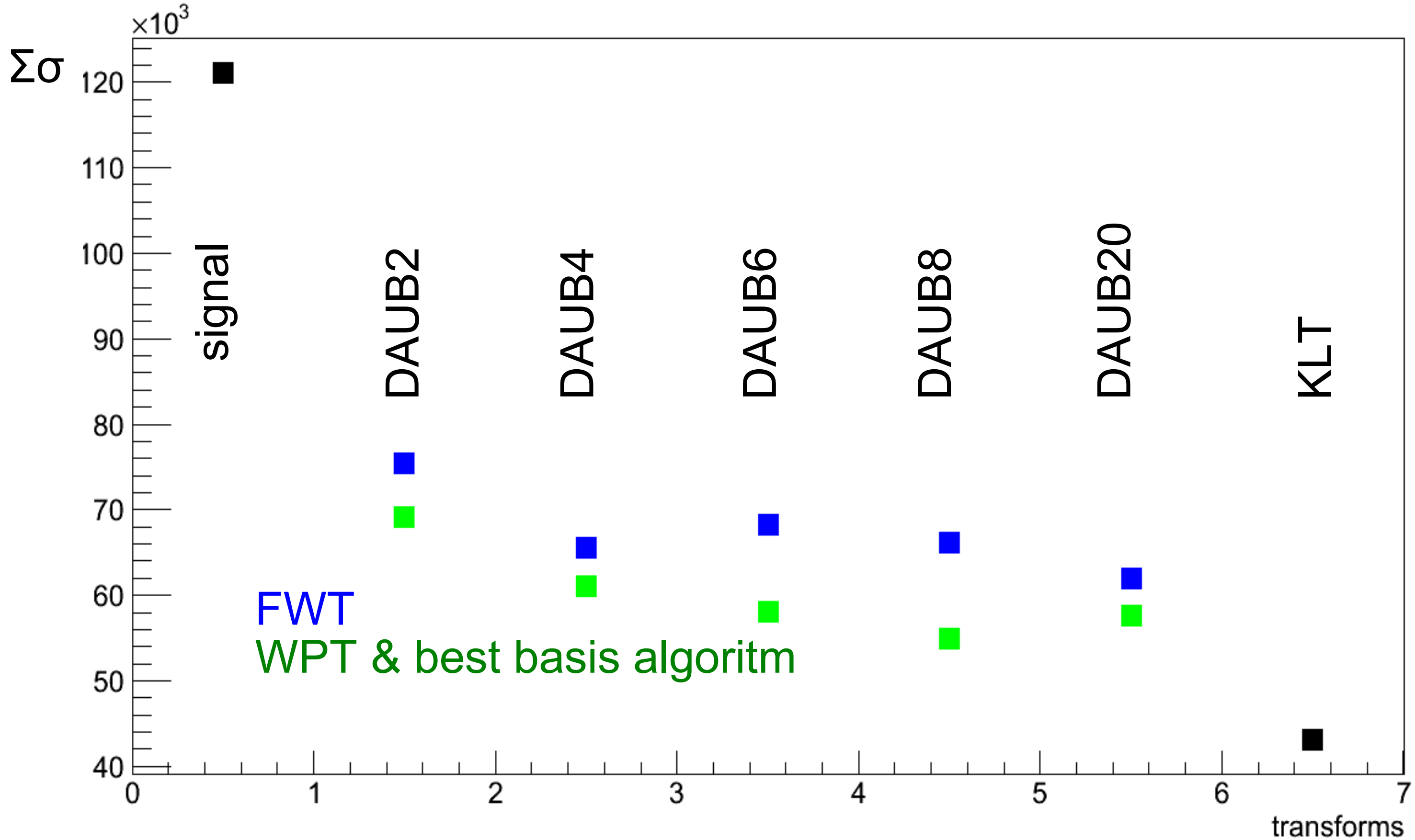
much faster !!!

# Next steps

- Apply SVD on AGATA signal basis
- Implement Fast Pulse Shape Comparison for NARVAL

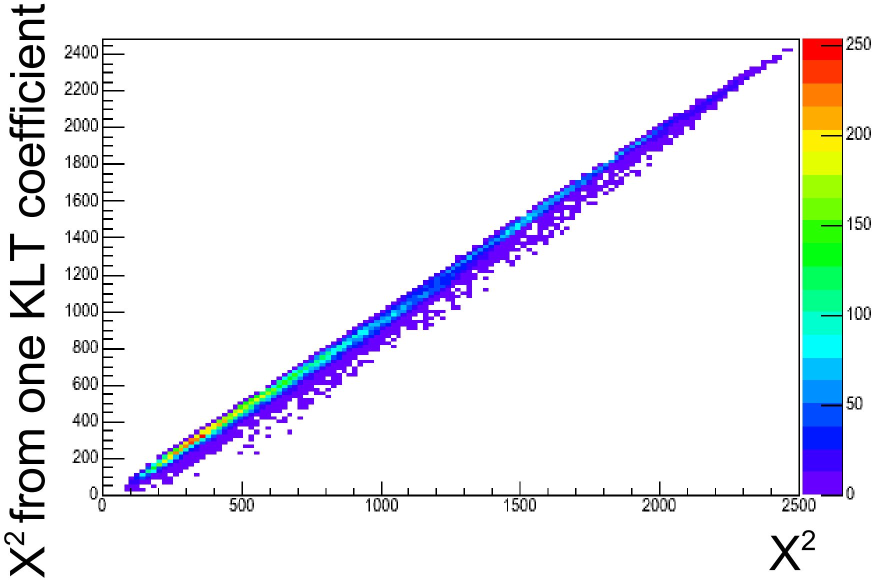

amplitude
000
800
600
400
200
0
0
10
20
30
40
50
60
time

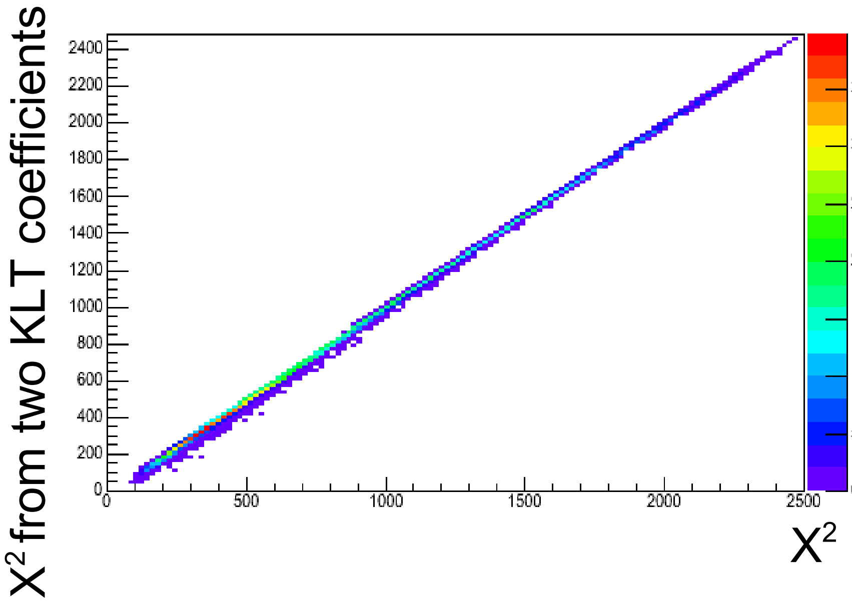
# Wavelet vs KLT/Singular value decomposition




→ **Karhunen-Loeve-Transform is optimal linear filter for linear approximation**

# Results




**Many basis signals can be rejected already with one coefficient.**

**Already two coefficients result in a good approximation of x2.**