

# Digital pulse analysis in scintillation detection

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**PHOTONIS** in collab. with **JSI**

December 14, 2007

# Outline

- digital timestamping of low-E scintillation
  - timing of nuclear pulses (solid-state vs. scint.)
  - state of the art with PMT+crystals, digitally
- statistical limits to digital calorimetry
  - pulse shape influence on calorimetry precision
  - proofing with LaBr pulses
- outlook

# Timing of nuclear pulses

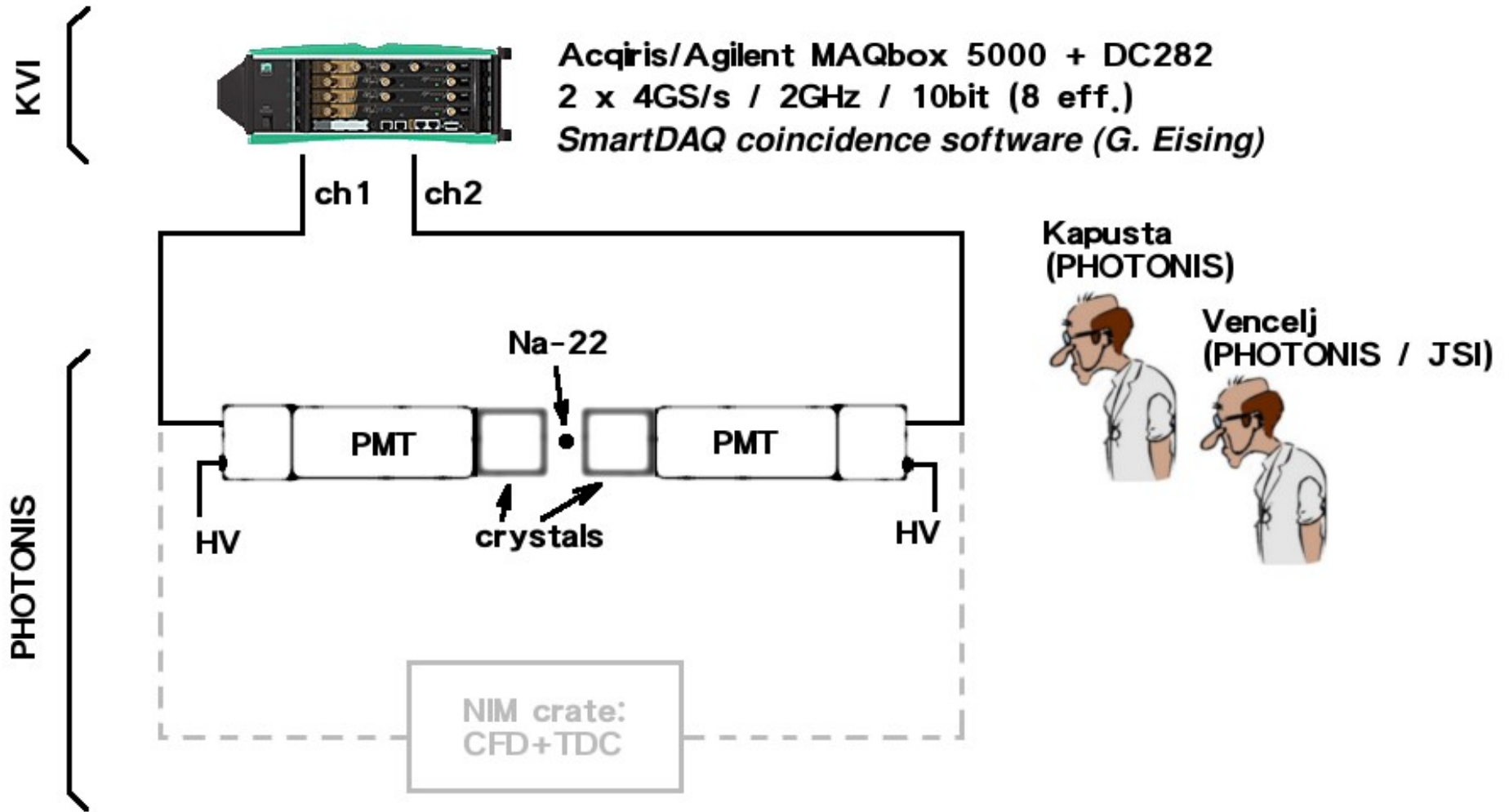
- Solid-state

- uncertainty: charge transport geometry
- works well in thin detectors (Poggi 2004, NIM A: 100ps with 100MS/s@12bit)
- most of leading edge of pulse useful

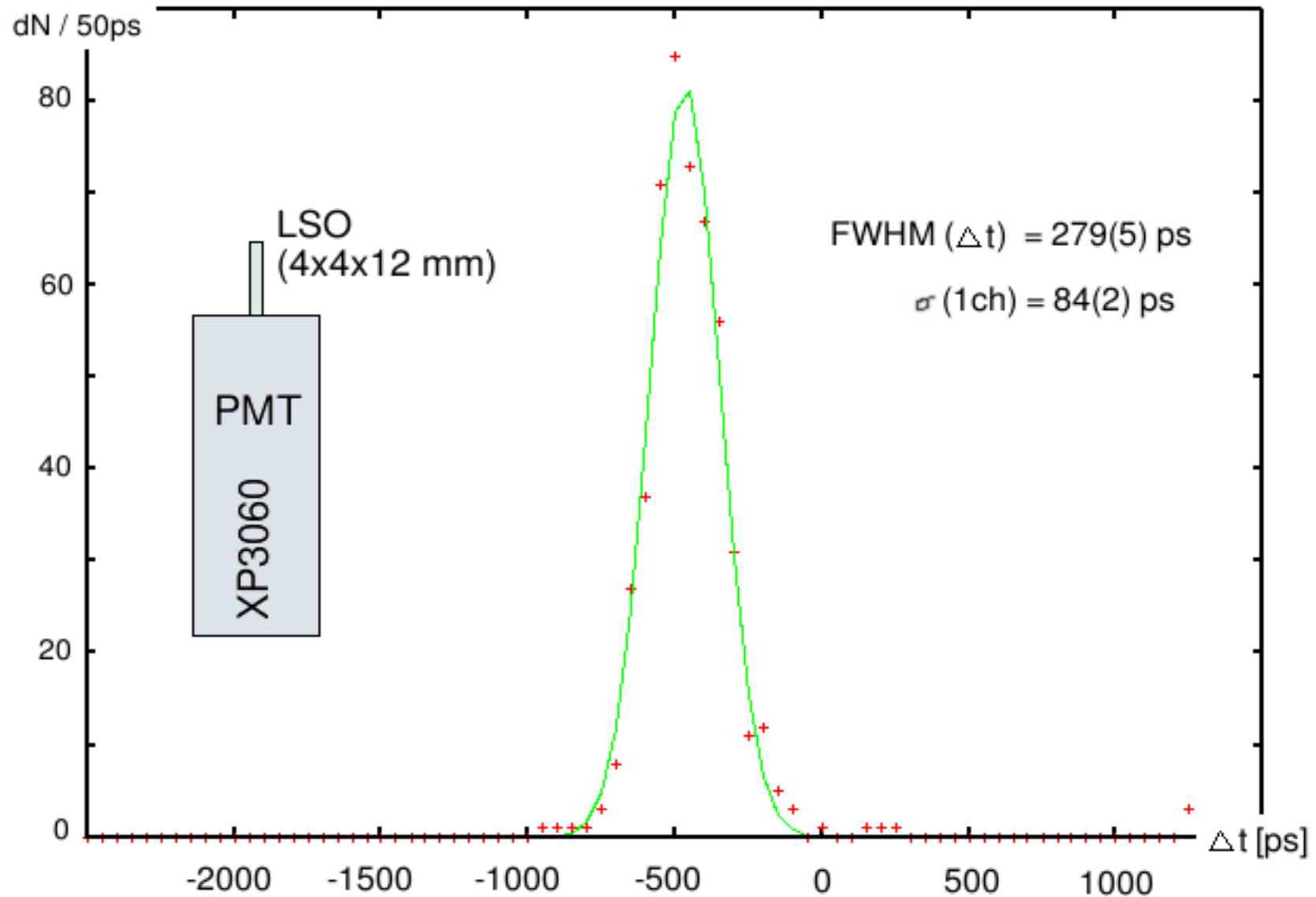
- Scintillation

- uncertainty: scintillation photon statistics, internal reflections, electron optics
- info concentrated in tiny part of leading edge

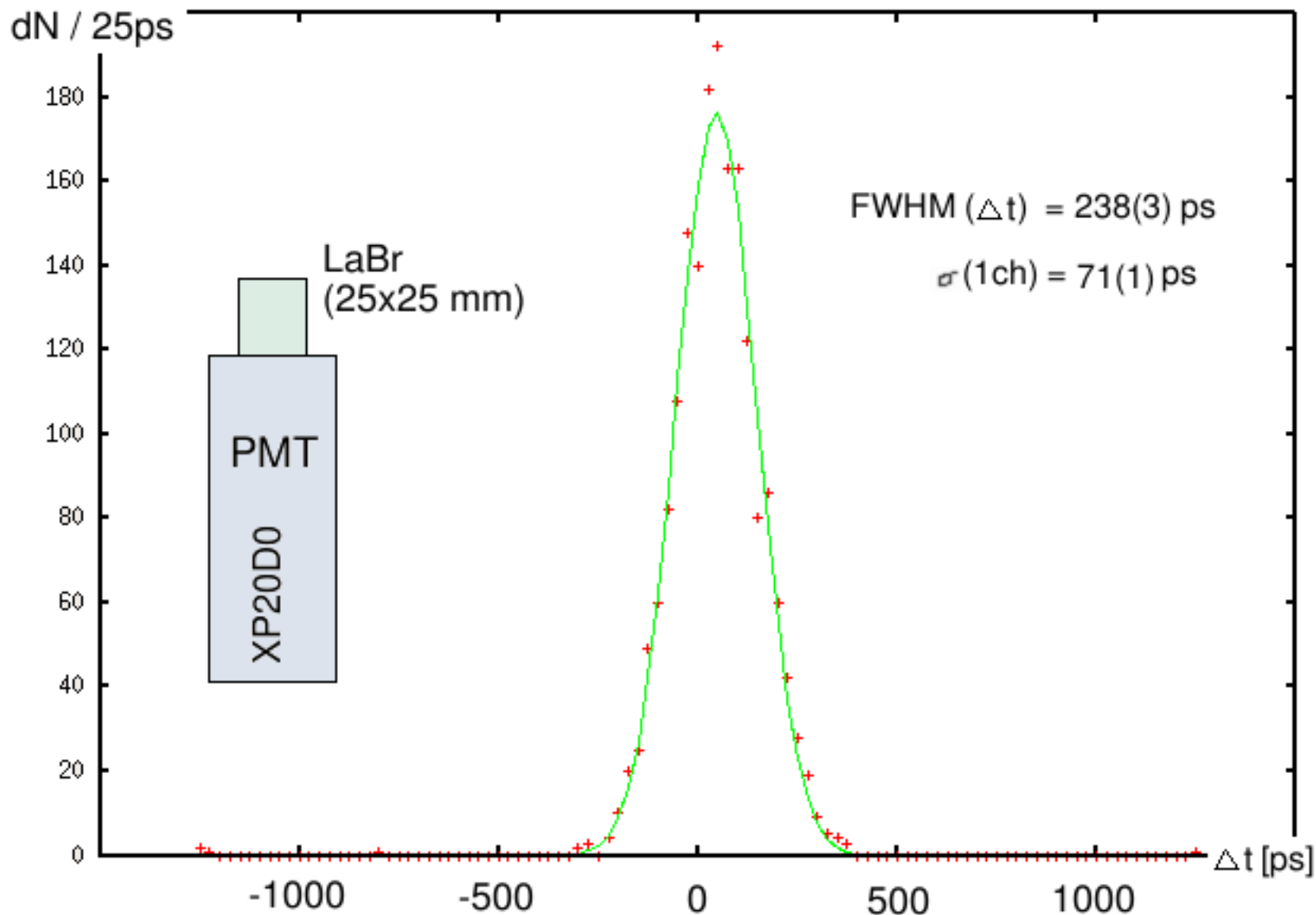
# 511keV timing, Brive, Sep. '07



# XP3060 + LSO



# XP20D0 + LaBr<sub>3</sub>

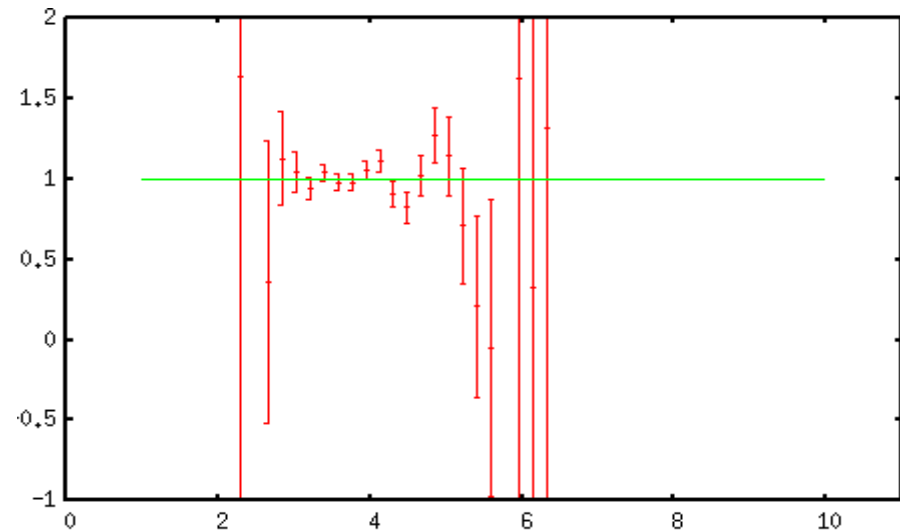
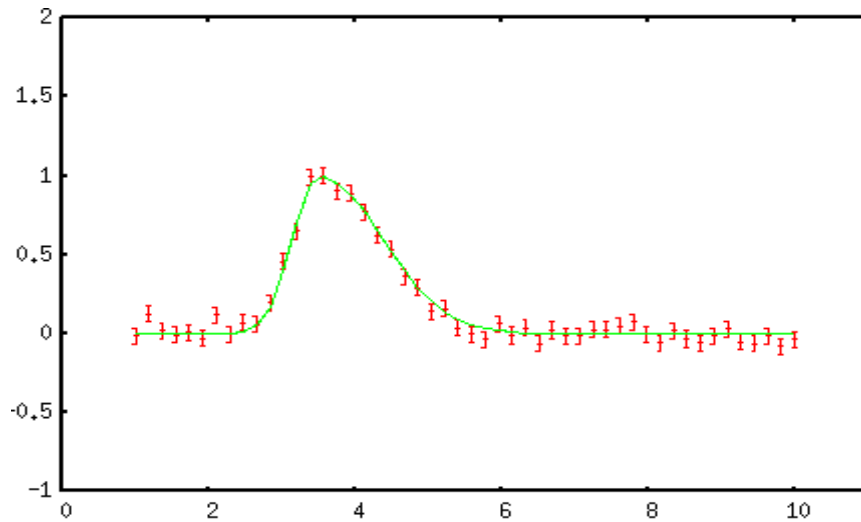


# Optimal digital calorimetry

- variation in scintillation process
  - NIM A, 2004-2007
- readout chain
  - quant. eff., dark, current, noise, ...
- digitization:
  - quantization error, ENOB
  - precision vs. real-time performance
  - quantify!

# Construction of optimal estimator

- Assumptions:
  - stable pulse shape
  - normal uncorrelated noise component
  - known baseline value (J. Jungmann et al.)



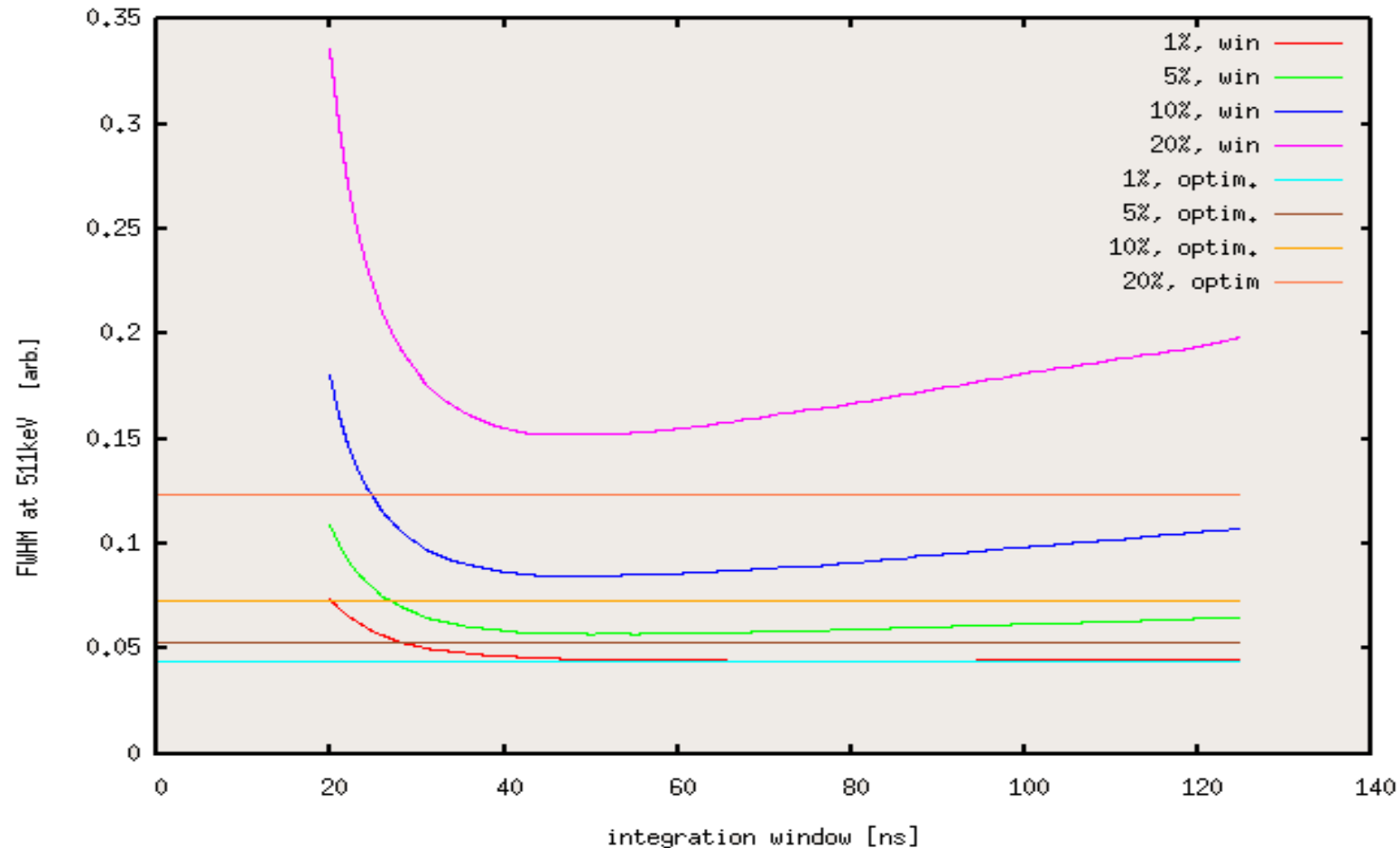


# Precision of optimal estimator

- $\mathbf{s} = A \mathbf{m} + \mathbf{n}$
- $A$  to be measured as  $\mathbf{s} \cdot \mathbf{m}$
- precision?  $DPRG = \sqrt{(\mathbf{m} \cdot \mathbf{m})} \rightarrow \sqrt{(w SR)}$
- $DPRG$  in special case:
  - exponential pulse:  $DPRG = \sqrt{(T/2 SR)}$
- example: NaI, 100MS/s,  $DPRG=2$
- windowed integration?

# Comparison to suboptimal

- optimal weighting vs. windowed integration



# Outlook

- plan: derive further specific optimal filters
- plan: efficient HDL implementations
- plan: benchmarking (precision, RT performance, power dissipation)
- propose: library of digitized pulses
- propose: barebone FEE controls protocol