Technische Universität
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Time Resolution of the AGATA Detectors

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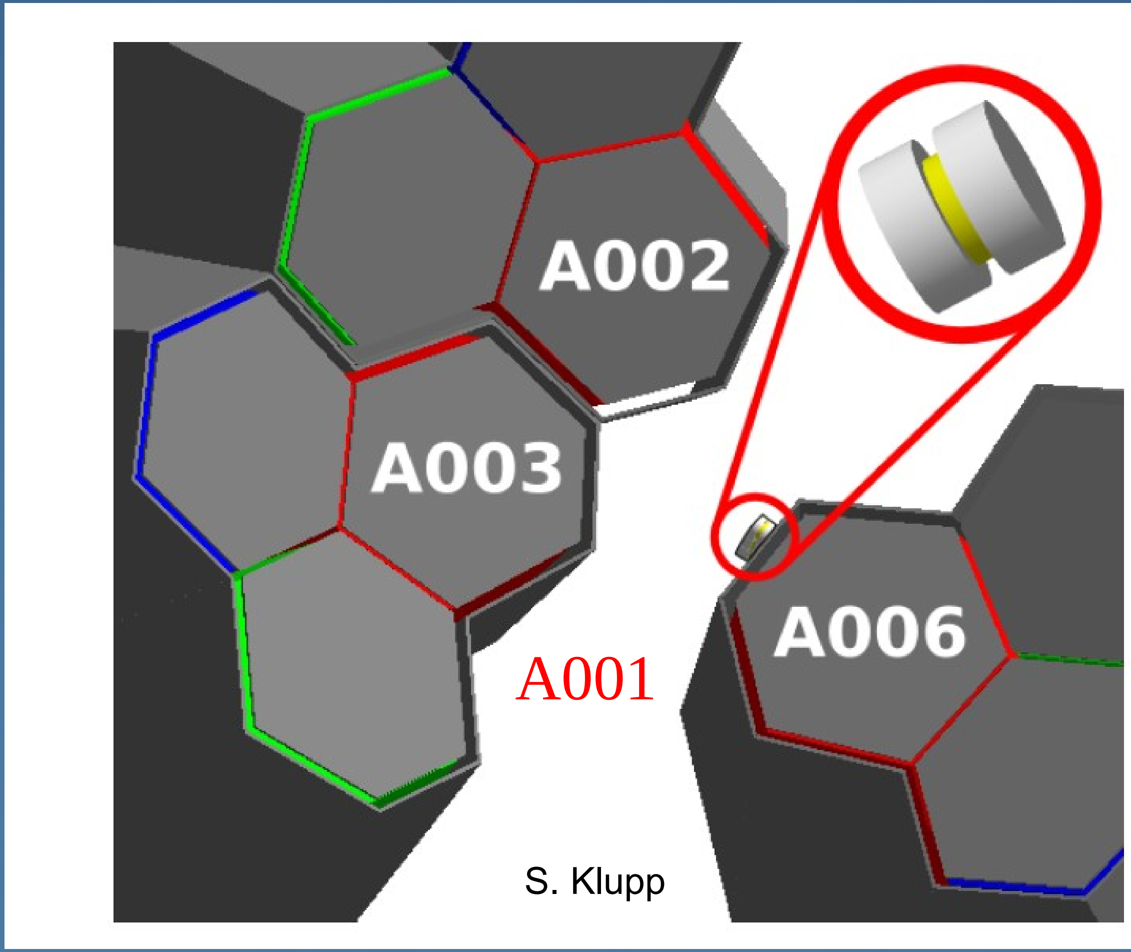
AGATA Week 2012
GSI

Outline & Motivation

- Waht do we need a good time resolution for ?
  - PSA: Alignment of pulse shapes
  - Reduction of background (PreSpec)
- Measuring the time resolution with ^{22}Na
- Determining T0
  - Straight-Line Fit
  - Neural Networks
- Summary and Outlook

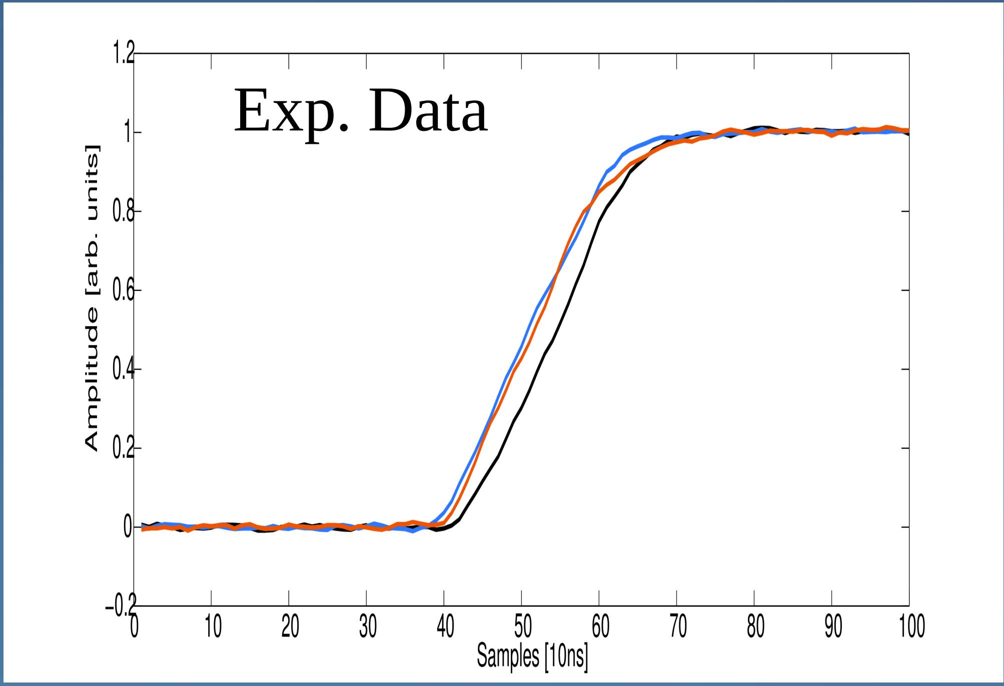
Measuring the time resolution with ^{22}Na

- Source placed directly at cryostat
- Coincident γ's with 511 keV
- Run data through femul
  - Combination of two crystals
- EventBuilder
  - MinFold 2
- Global Timestamps
- Same T_0 in both crystals



Determining T_0 with Straight-Line Fit

- Observation at LNL
  - Sum of all net-charge signals (Core inverted sign)
  - Approximately straight-line
-

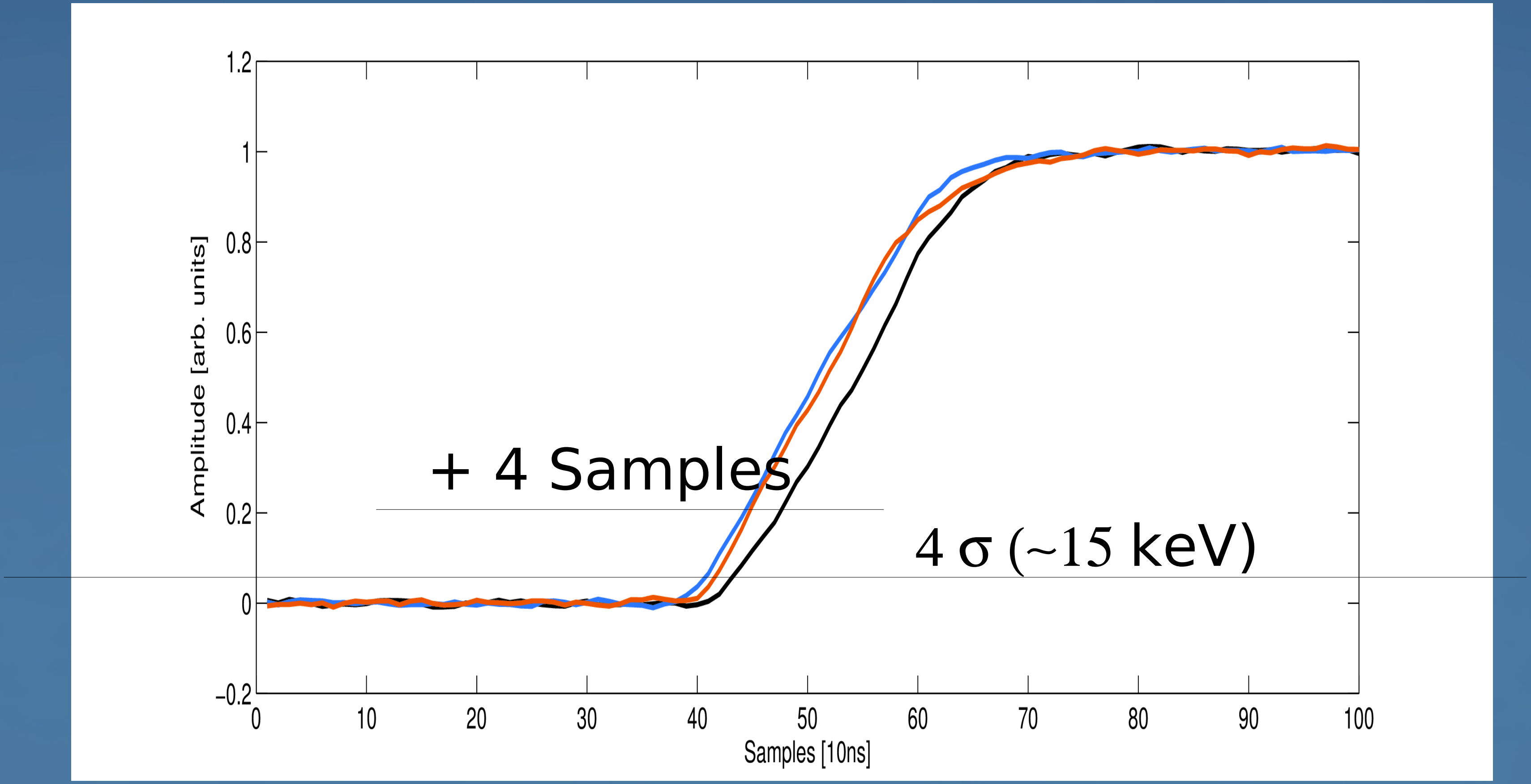


$$S_{Core}(t) = \Phi_c(\vec{r_e}(t)) - \Phi_c(\vec{r_h}(t))$$

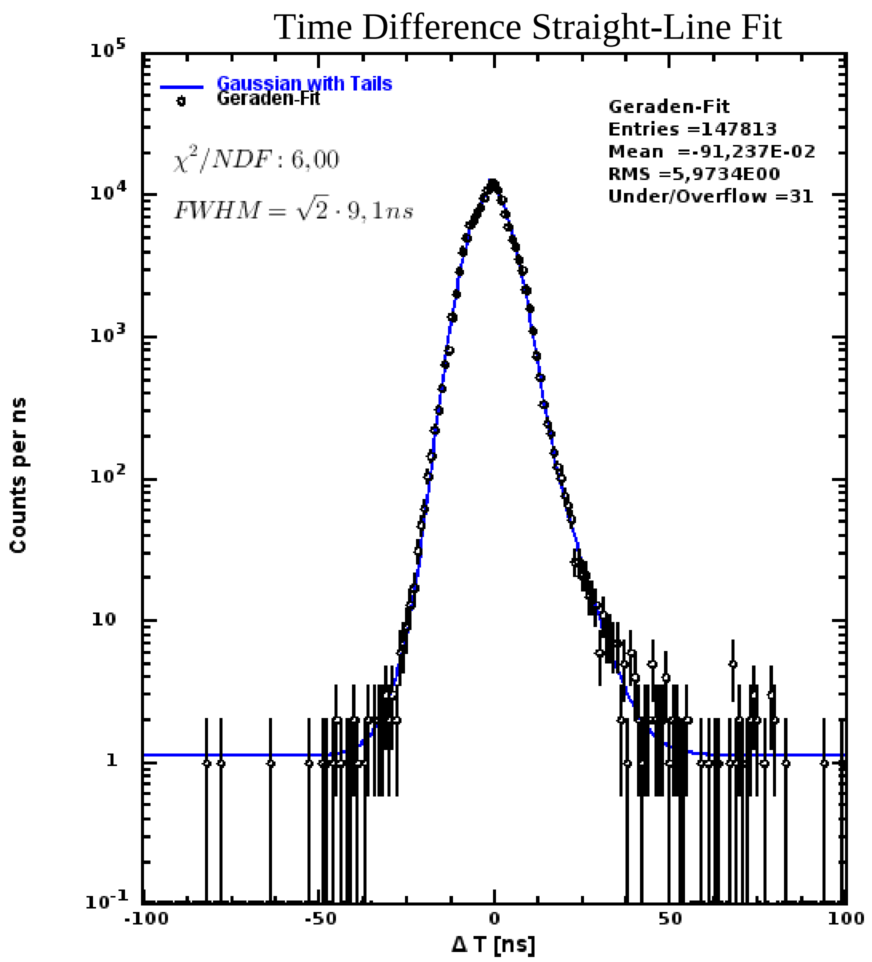
$$S_{Seg}(t) = \Phi_s(\vec{r_e}(t)) - \Phi_s(\vec{r_h}(t))$$

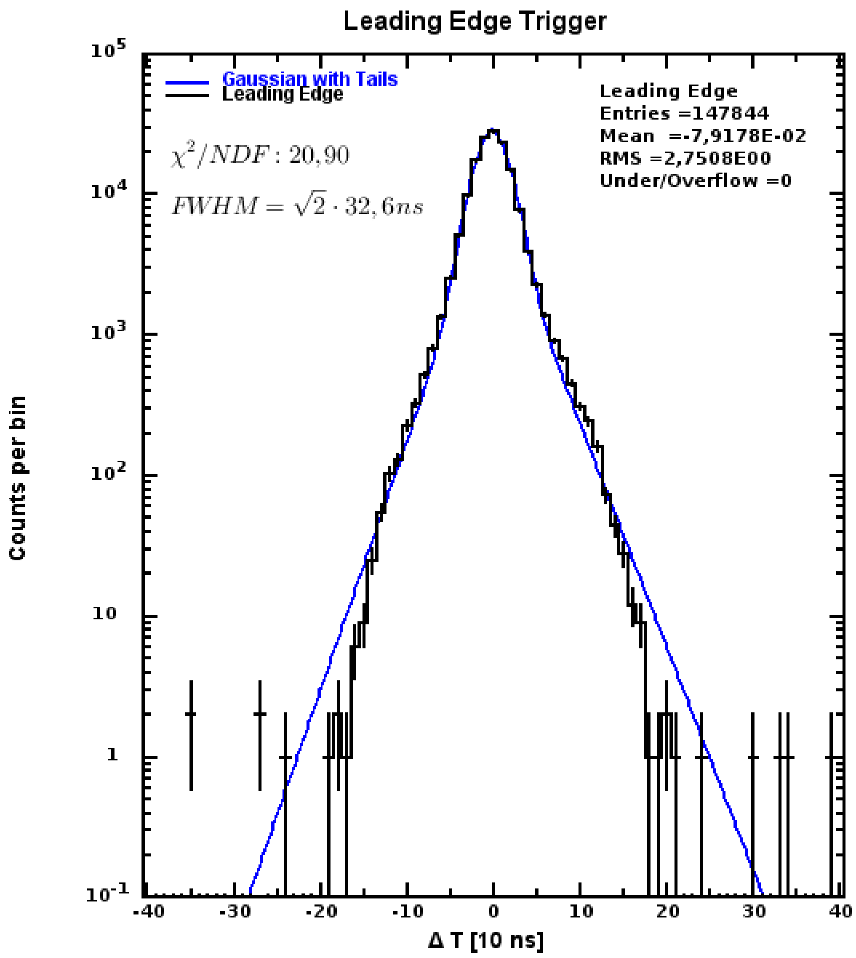
$$S_{Seg}(t) - S_{Core}(t) = (\Phi_s(\vec{r_e}(t)) - \Phi_c(\vec{r_e}(t))) - (\Phi_s(\vec{r_h}(t)) - \Phi_c(\vec{r_h}(t)))$$

Determining T_0 with Straight-Line Fit

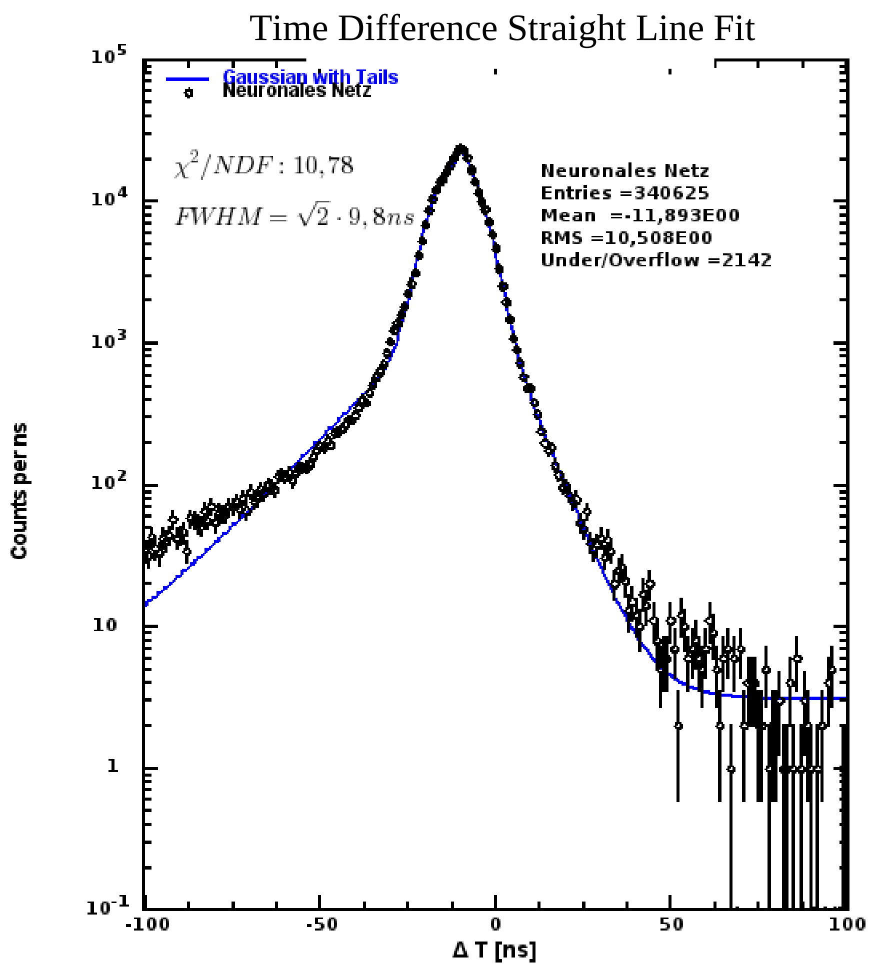


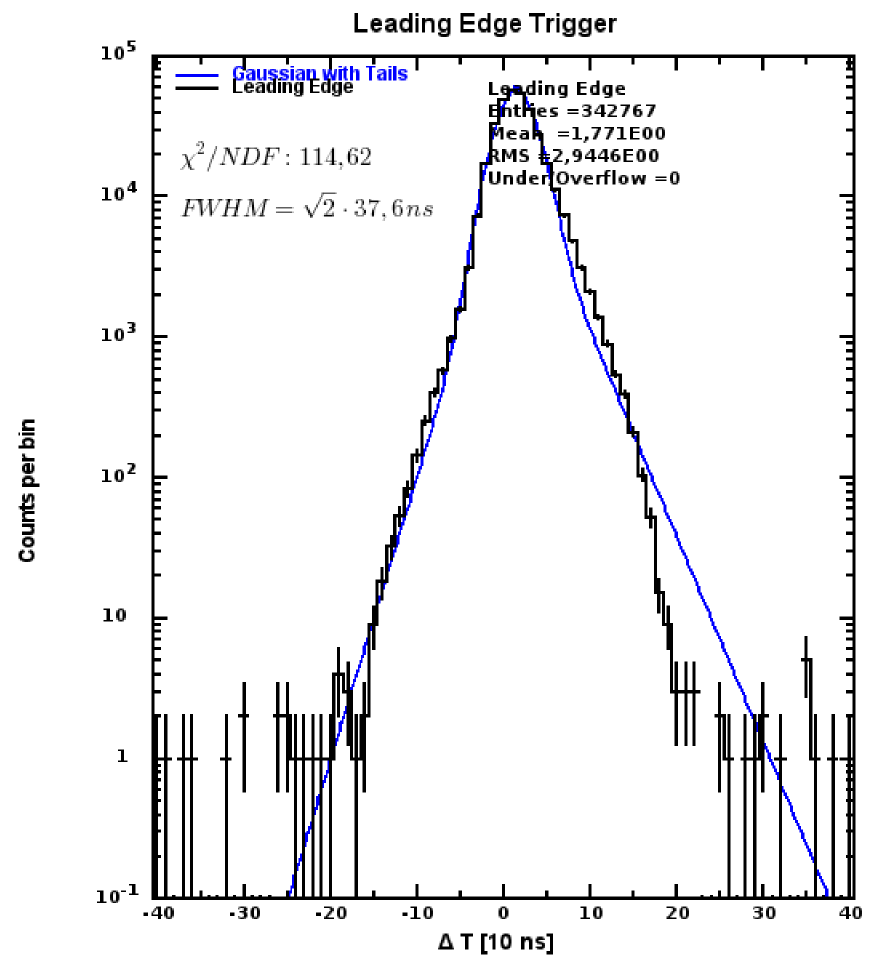
Time Resolution Straight-Line Fit I (A006, A003)



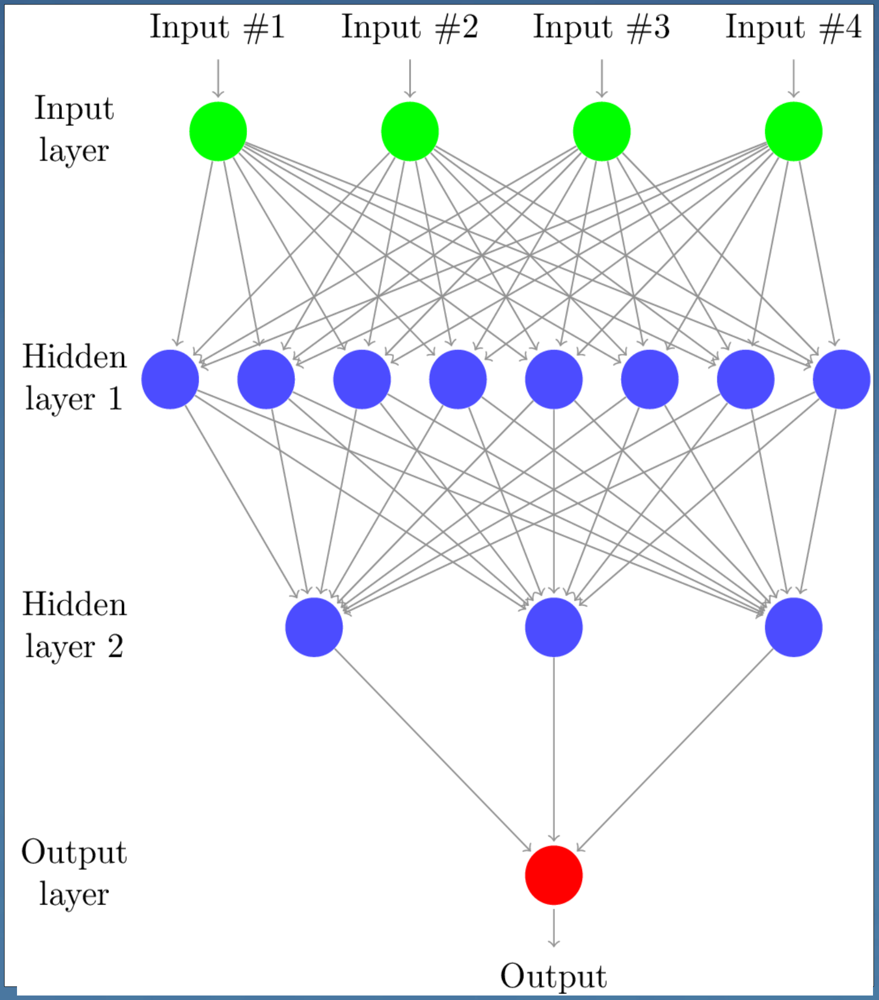


Time Resolution Straight-Line Fit II (A002, A001)





Feedforward Neural Network

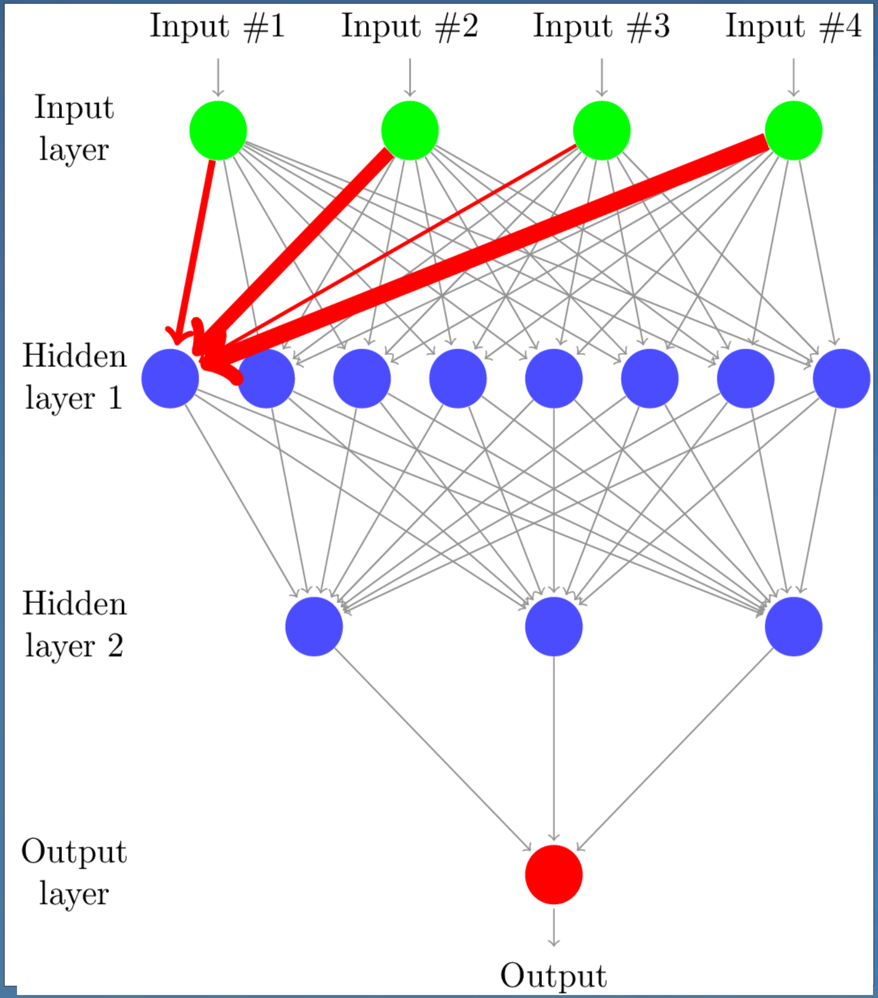


- Neurons in Layers
  - Connected to all neurons from previous layer
  - Weighted connections
- Activation of Neuron i

$$A_i = f\left(\sum_{j=0}^{j=n} w_{ij} \cdot A_j\right)$$

$$f(x) = \tanh(x)$$

Feedforward Neural Network



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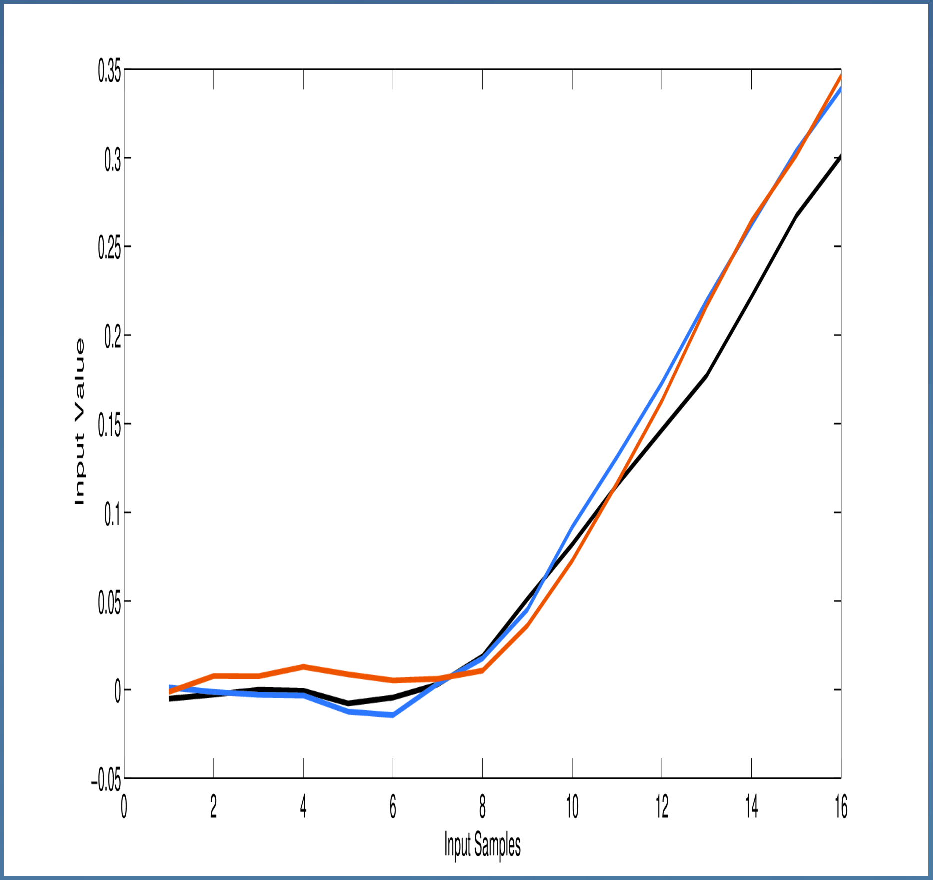
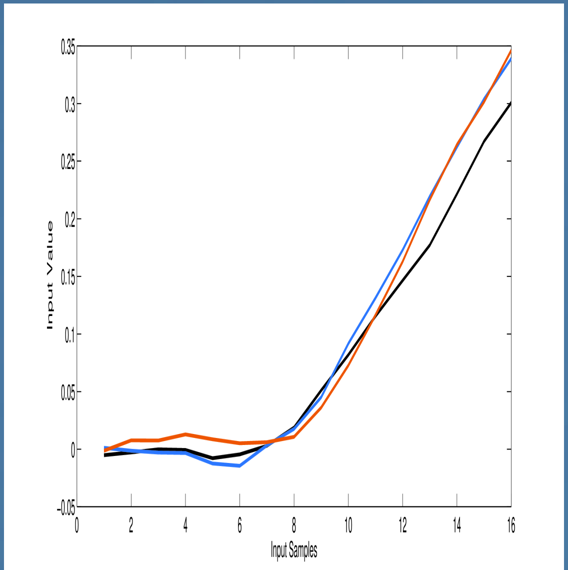
Data selection for Neural Network



- Neural Net
  - 17 Input neurons
  - 15 Neurons in hidden layer
  - 1 Output neuron
  - 286 Parameters
- Input data:
  - 2 σ Sample, 6 Samples back
  - 16 Samples + SNR

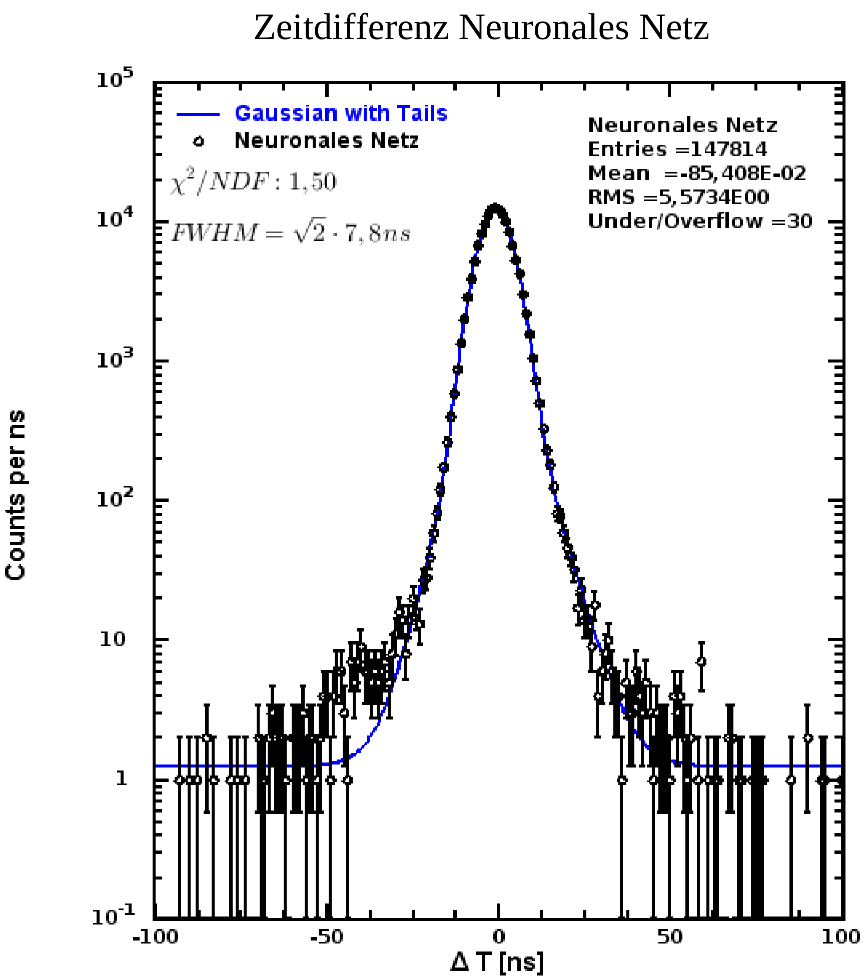
Training the net with experimental data

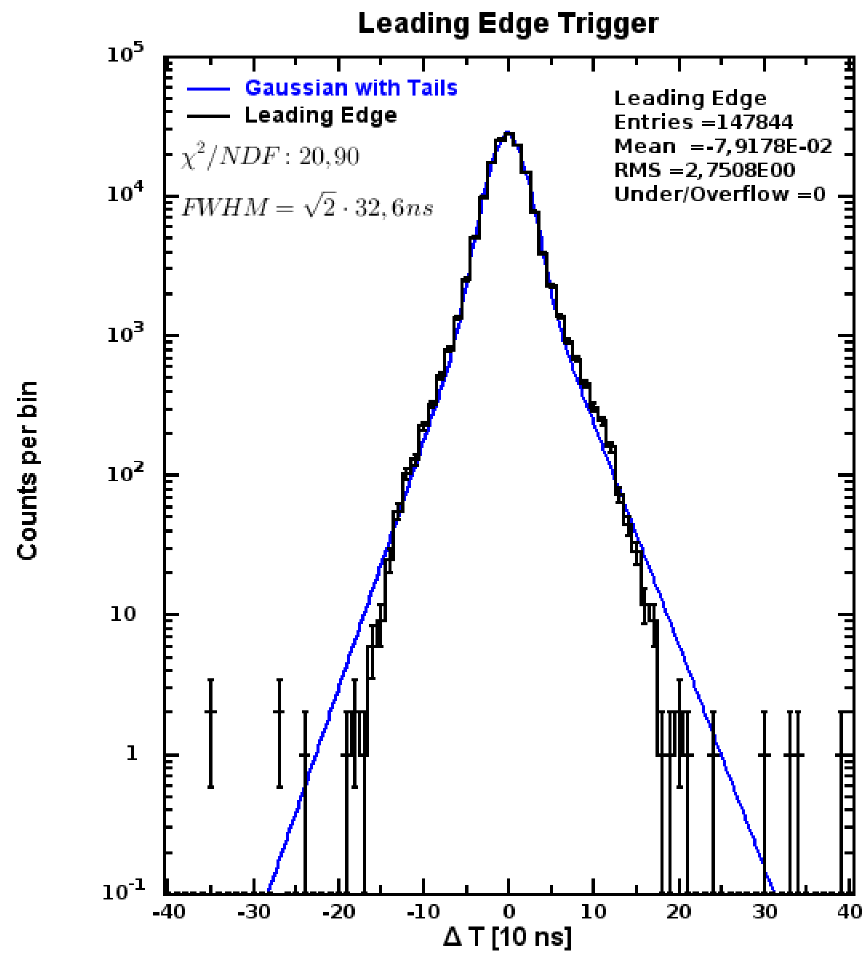
- Usual case (Supervised)
  - Data set with known result (T_0)
  - Exact error of net output known
  - Gradient based training
    - Converges fast



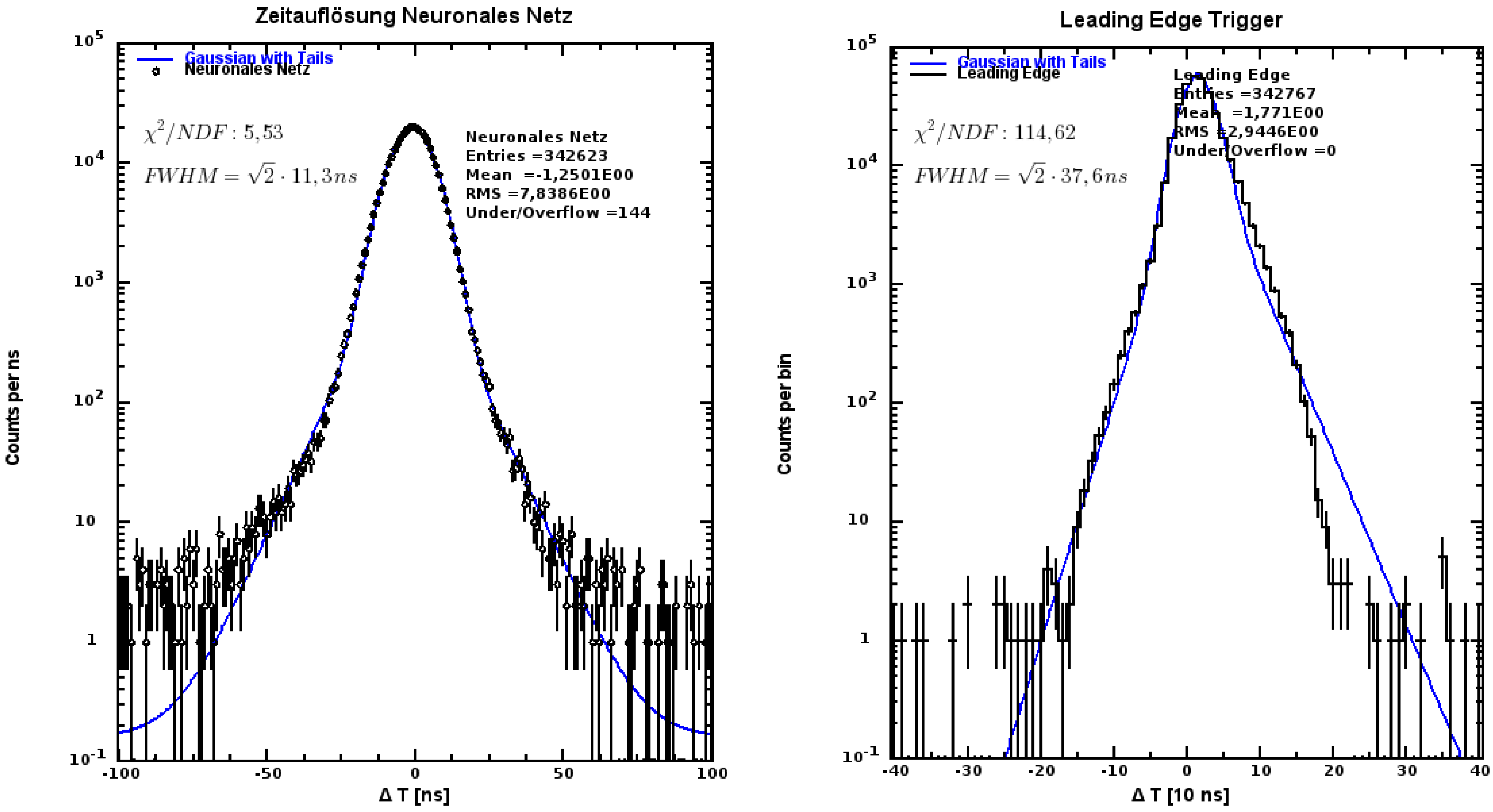
- Our Case:
  - Results not known
  - But:
    - 2 γ's in coincidence
    - Same T_0 (incl. Timestamp)
    - Unknown errors for single event ->no gradient
- „Reinforcement Learning“
  - Differential Evolution
  - 10% of the data
  - Error Terms
    - $(T_{0,1}-T_{0,2})^2$
    - $T_0<0$: T_0^2
    - $T_0>16$: $(T_0-16)^2$

Time Resolution Neural Net (A006, A003)





Time Resolution Neural Net II (A002, A001)

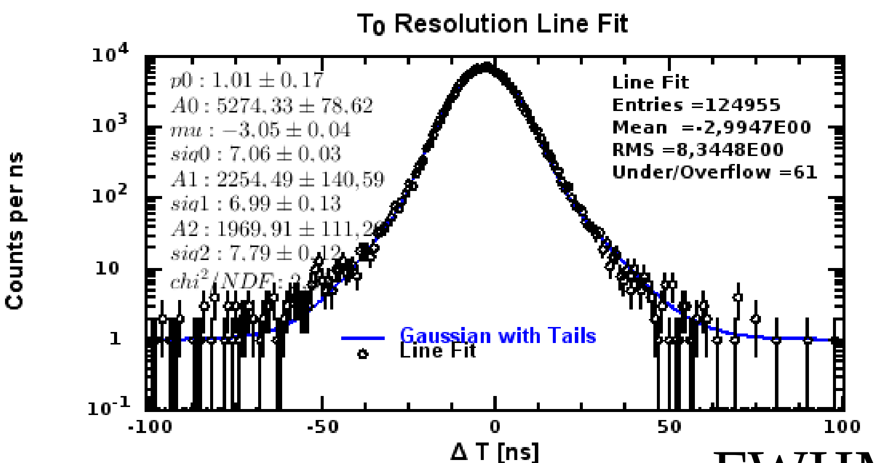


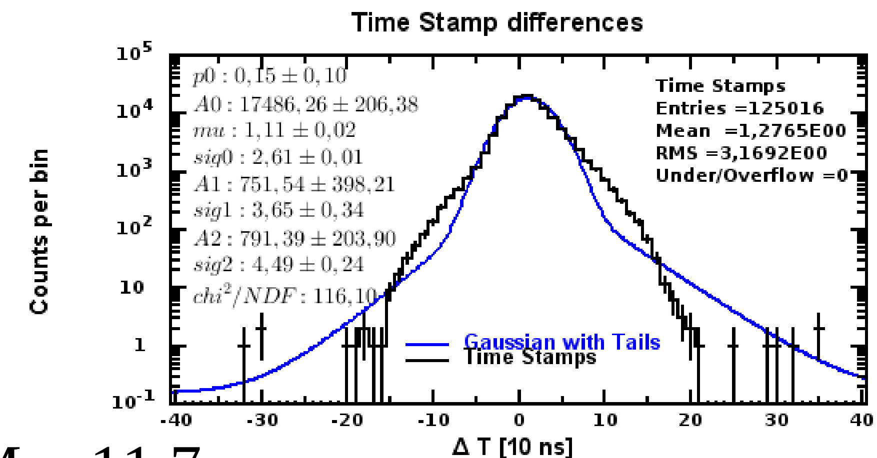
Summary & Outlook

- Strong influence of electronics => Calibration
- Straight-Line Fit
  - Good time resolution ~9 ns (FWHM)
- Neural Net
  - Better time resolution ~ 7,8 ns (FWHM)
  - Can cope with time shifts up to a certain extent

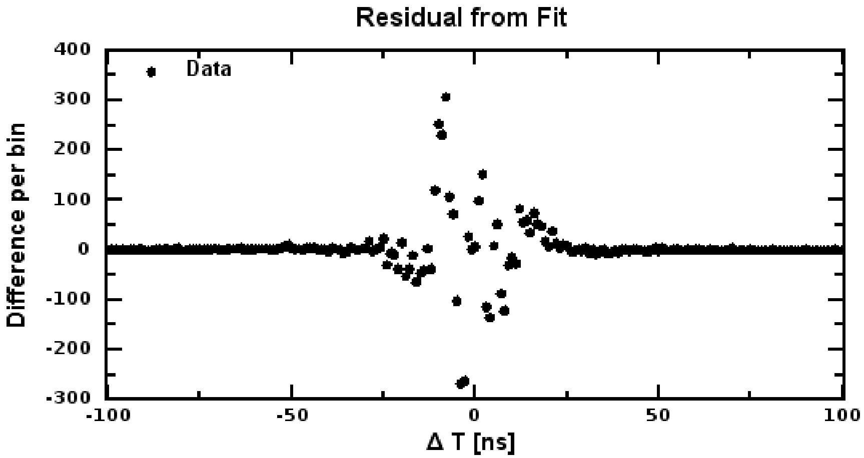
- PreSpec
  -

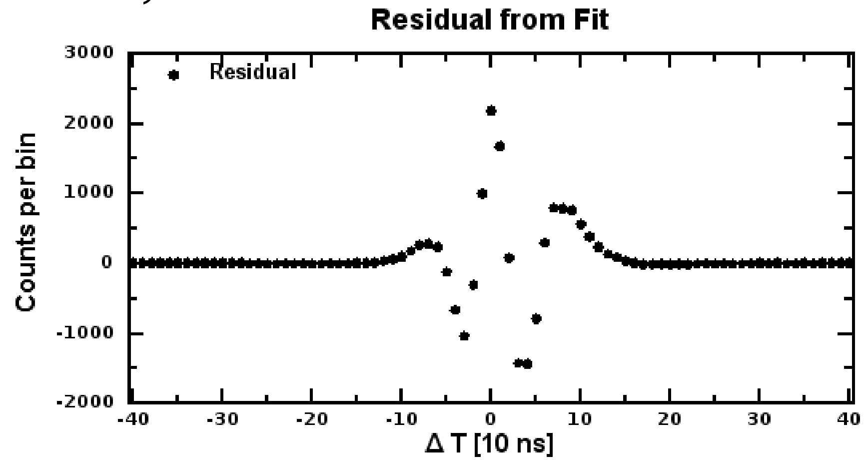
Zeitauflösung Neuronales Netz (Kristalle 3R,4R)





FWHM = 11,7 ns





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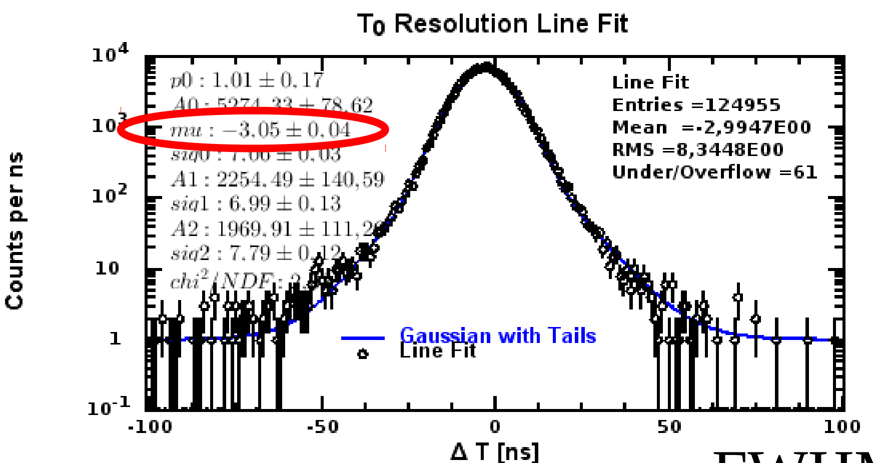

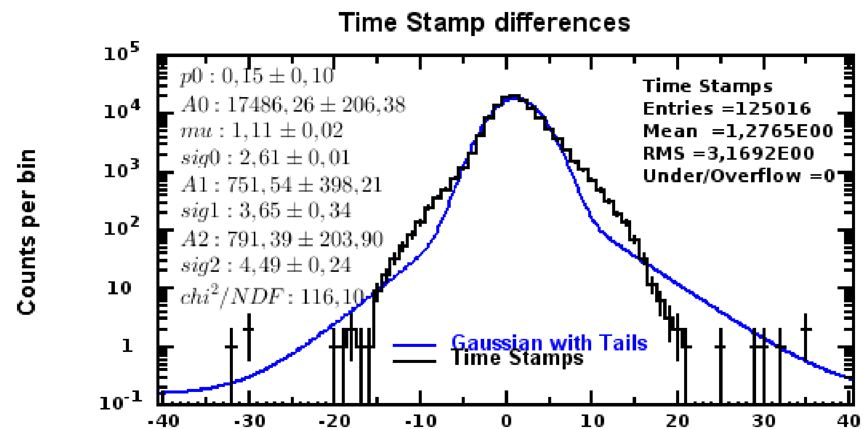

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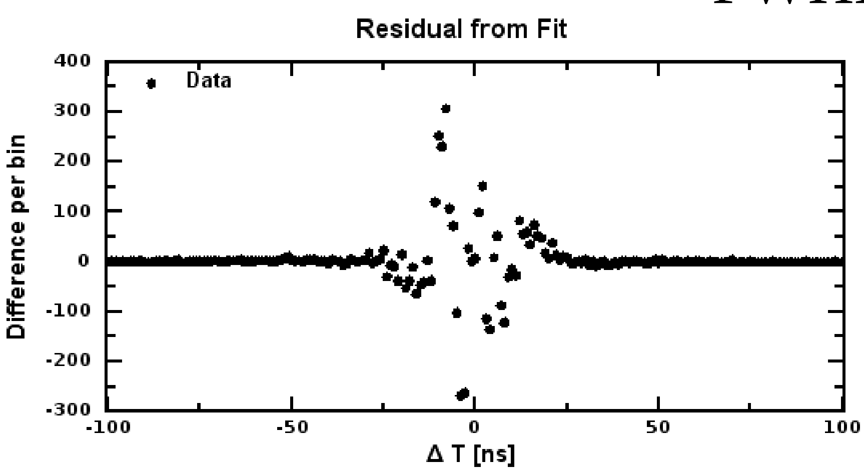
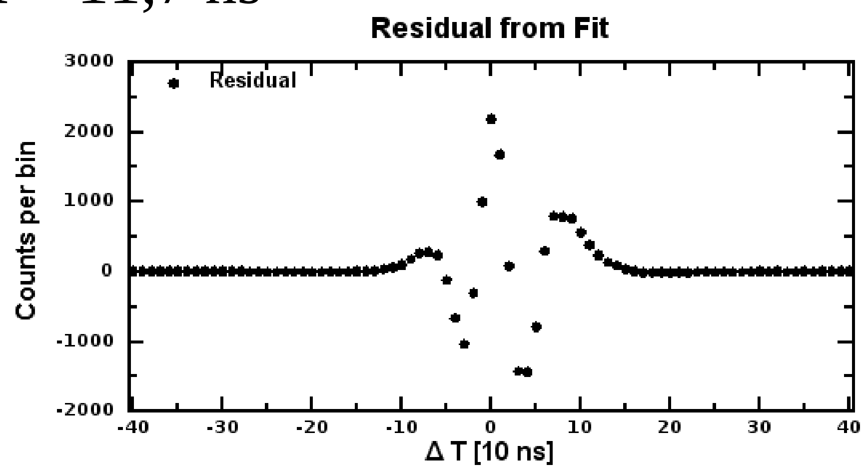
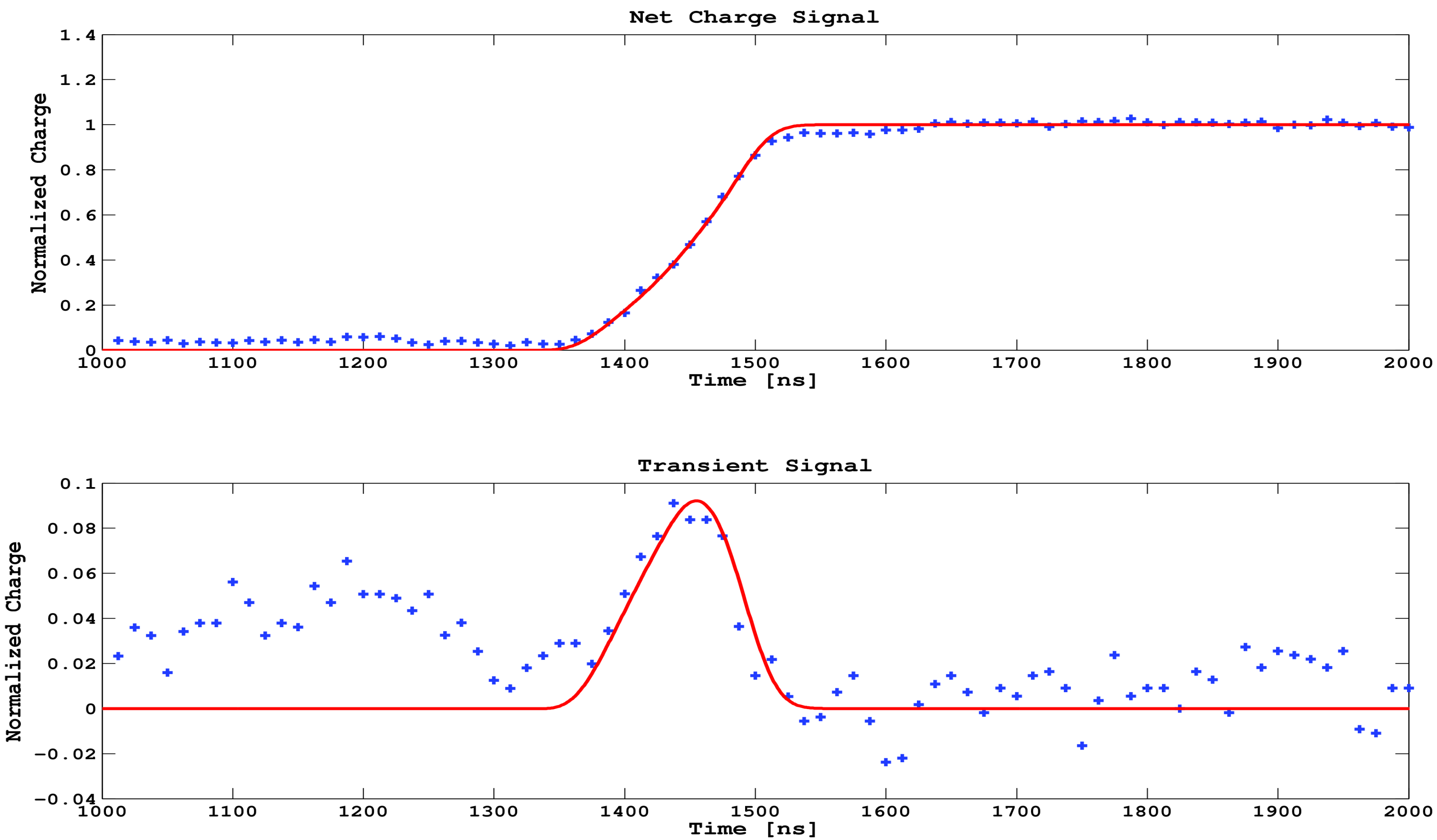




Pulsform Analyse



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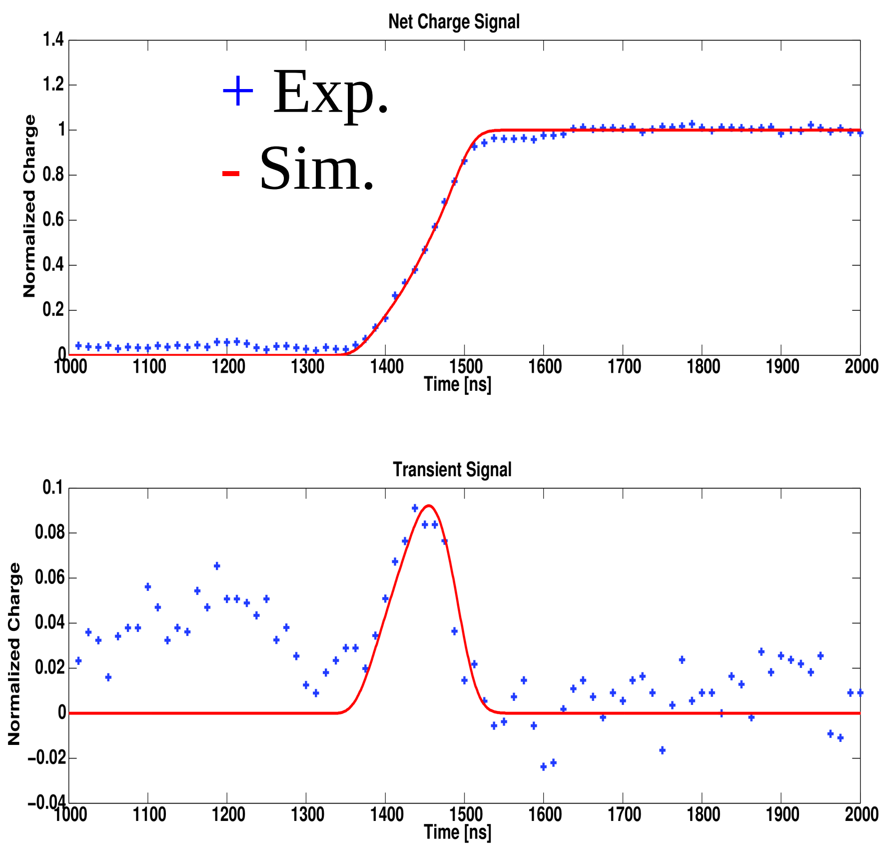
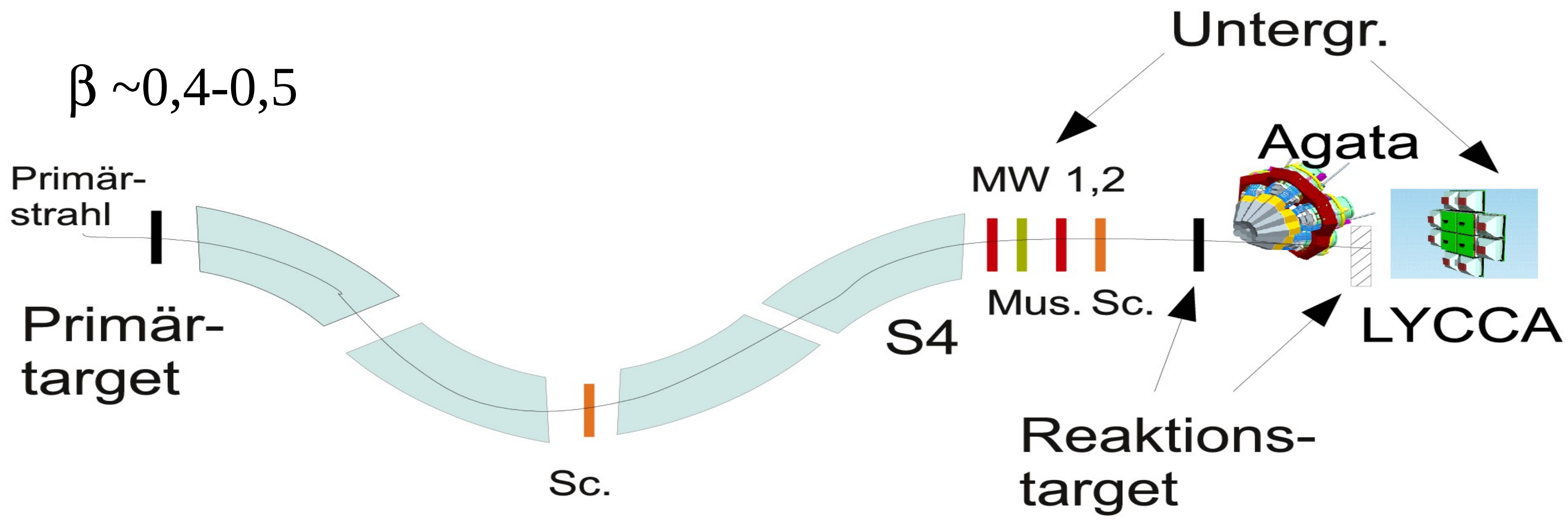


- AGATA Pulsformen
  - Starke Ortsabhängigkeit
- Vergleich von simulierten Pulsformen mit experimentellen Signalen
  - Simulation: JASS, M. Schlarb et al., EPJ A, Vol. 47, Nr. 10, 132
  - Suche in Echtzeit:
    - Particle Swarm Optimization
    - M. Schlarb et al., EPJ A, Vol. 47, Nr. 10, 131
  - Präzises Zeit-Alignment
  - Zeitauflösung beeinflusst Ortsauflösung

Reduktion des Untergrunds bei AGATA-PreSpec



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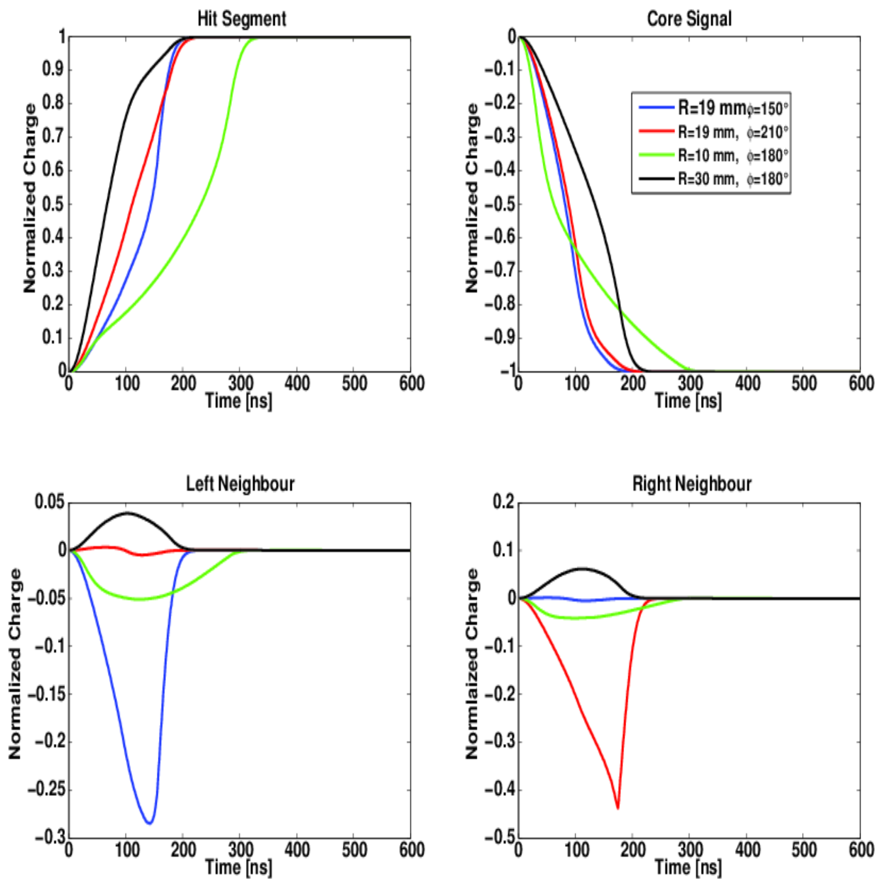

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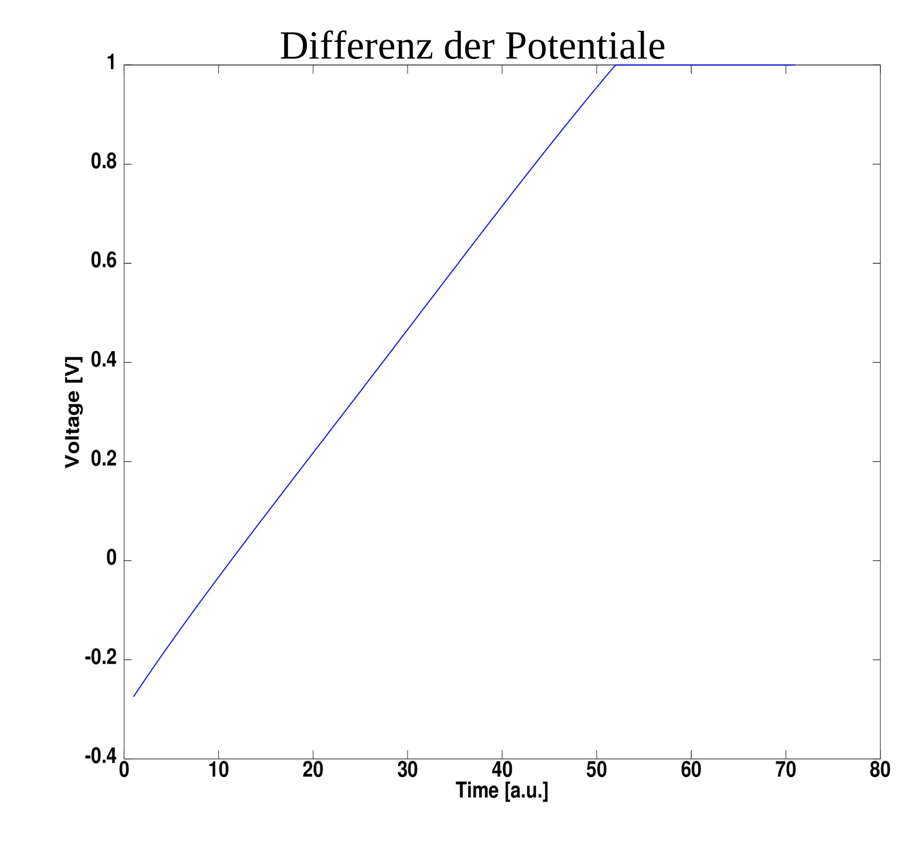
T_0-Bestimmung mit Geraden-Fit

- Signale stark ortsabhängig
  - Unterschiedliche Steigungen, Krümmungen, etc.
- Beobachtung:
  - Summe aller Nettoladungssignale (Core vorzeicheninvertiert)
  - Annähernd gerade
-



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$$S_{Seg}(t)=\Phi_s(\vec{r_e}(t))-\Phi_s(\vec{r_h}(t))$$

$$S_{Seg}(t)-S_{Core}(t)=(\Phi_s(\vec{r_e}(t))-\Phi_c(\vec{r_e}(t)))$$
$$-(\Phi_s(\vec{r_h}(t))-\Phi_c(\vec{r_h}(t)))$$