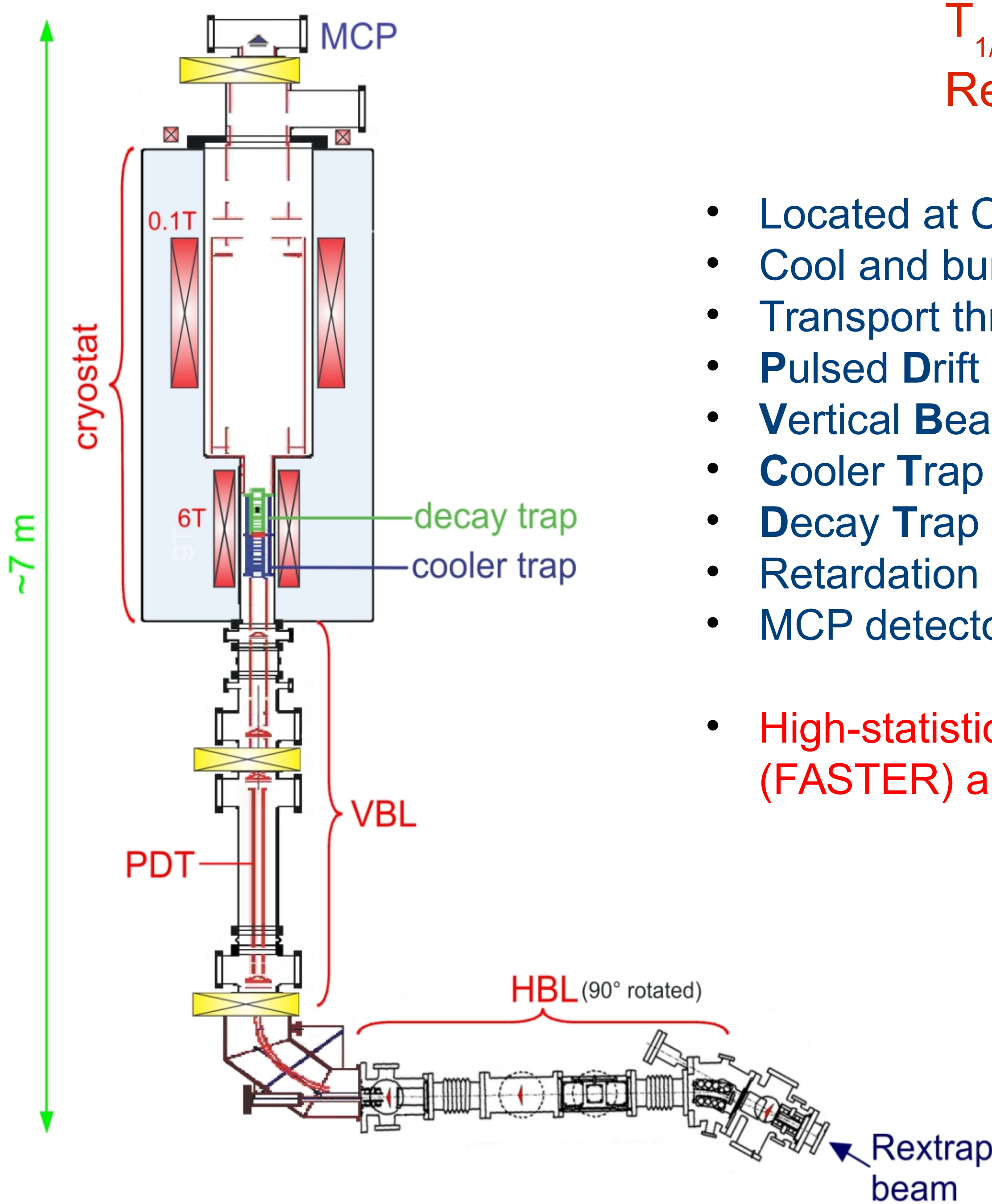
WITCH setup

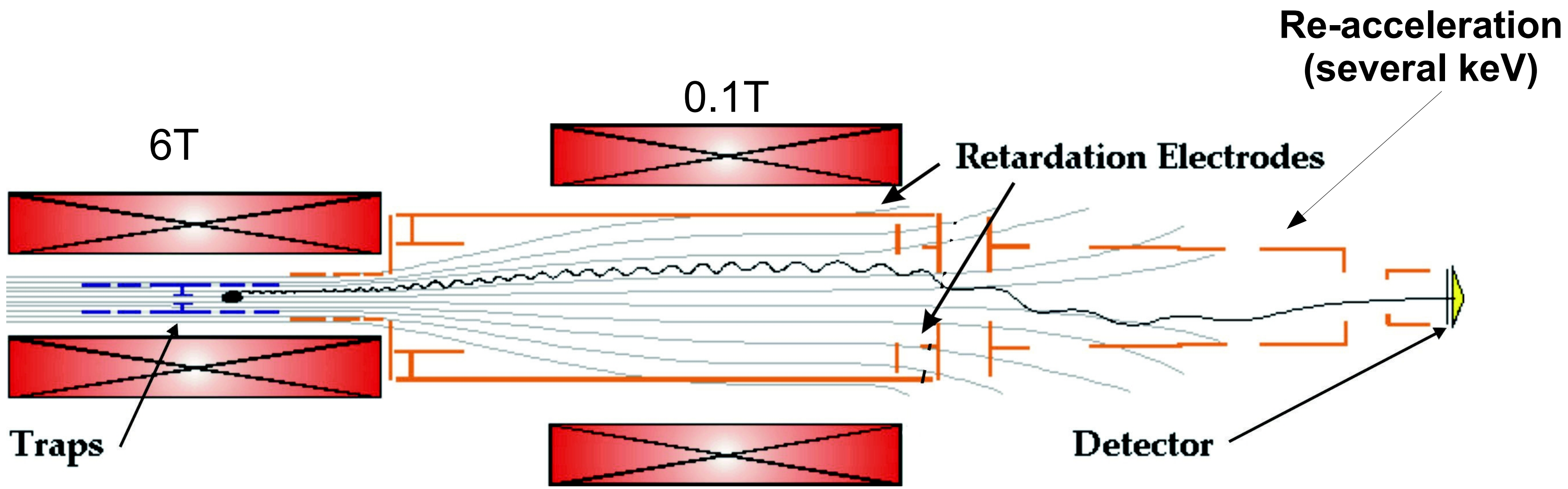


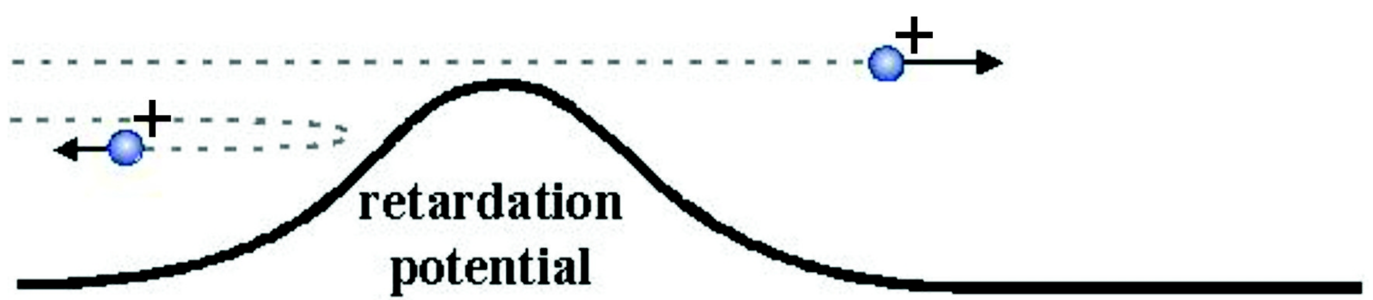
$T_{1/2}(^{35}Ar) = 1.775(4)$ s
Recoil endpoint = 452 eV

- Located at CERN-ISOLDE
- Cool and bunch in REXtrap → 30 keV
- Transport through **H**orizontal **B**eam **L**ine
- **P**ulsed **D**rift **T**ube reduce total energy ~0
- **V**ertical **B**eam **L**ine decelerates ions
- **C**ooler **T**rap (buffer gas) cool/center ions
- **D**ecay **T**rap to store scattering free source
- Retardation Spectrometer for energy analysis
- MCP detector as ion counter

- High-statistics beam time Nov. 2012, new DAQ (FASTER) also provided high resolution

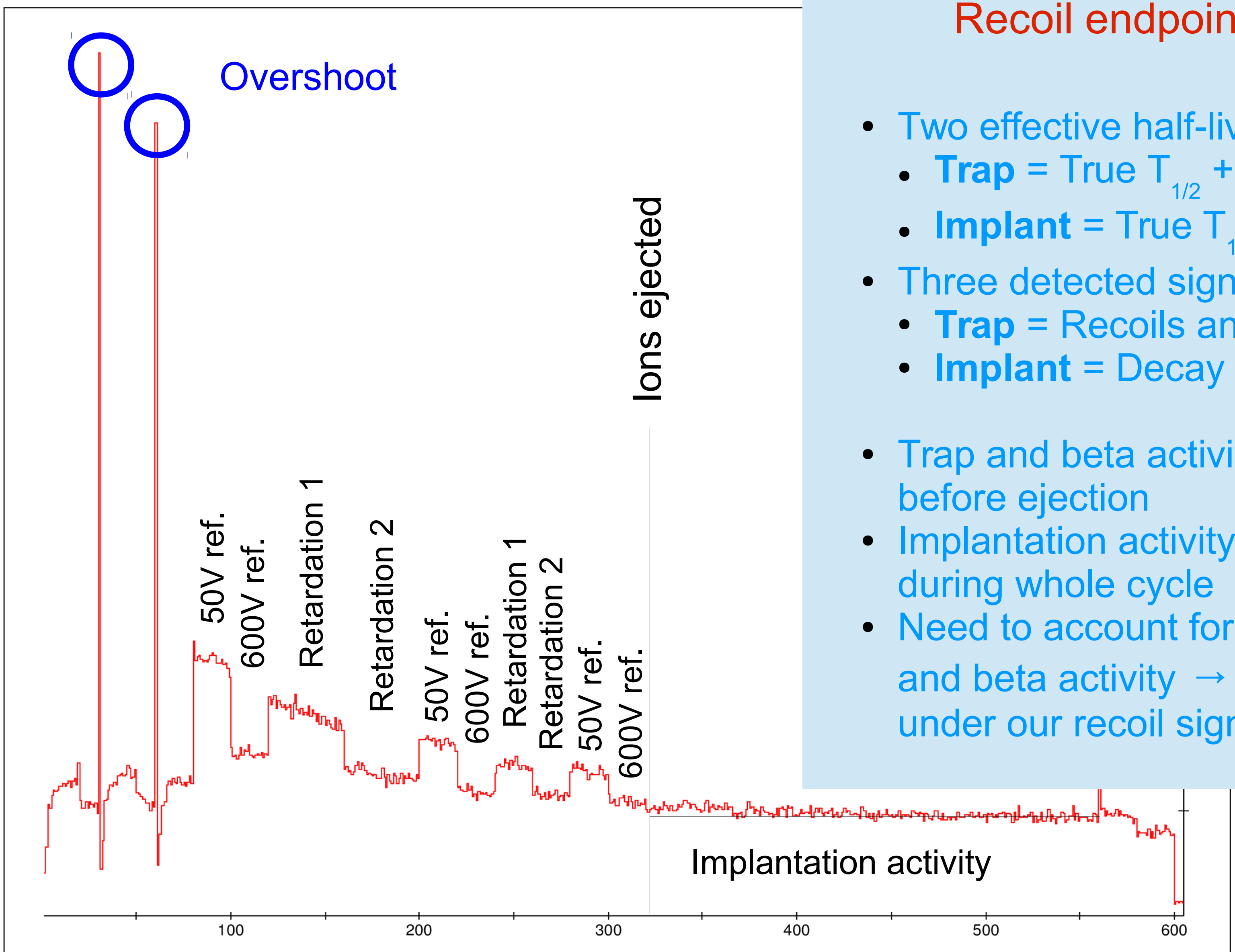
WITCH Spectrometer





Conversion of radial energy $= 1 - B_{spec}/B_{trap} = 98.3\%$

Typical cycle



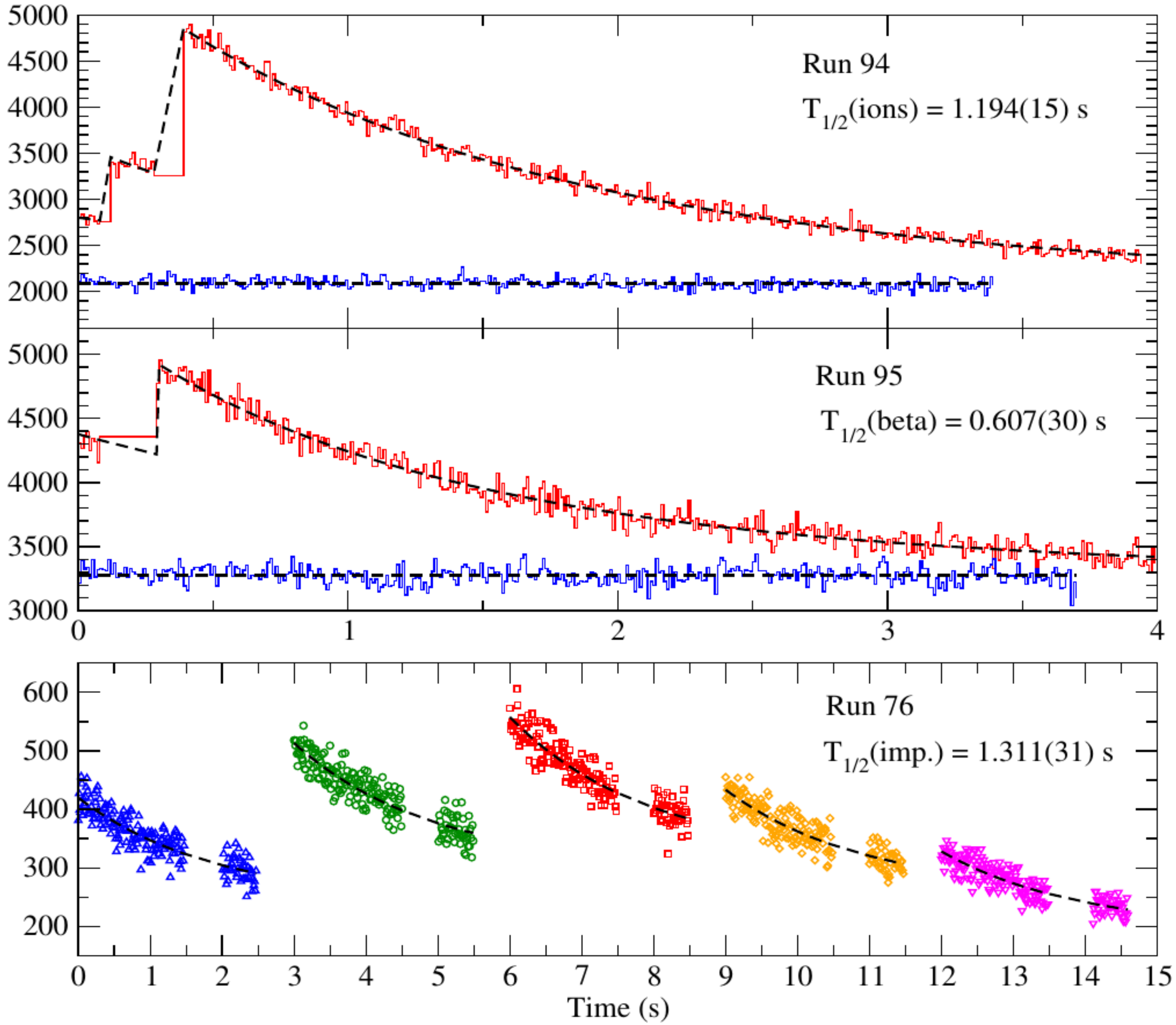
$T_{1/2}(^{35}Ar) = 1.775(4)$ s

Recoil endpoint = 452 eV

- Two effective half-lives:
  - **Trap** = True $T_{1/2}$ + losses
  - **Implant** = True $T_{1/2}$ + diffusion
- Three detected signals:
  - **Trap** = Recoils and betas
  - **Implant** = Decay of ions

- Trap and beta activity present before ejection
- Implantation activity present during whole cycle
- Need to account for implantation and beta activity → background under our recoil signal

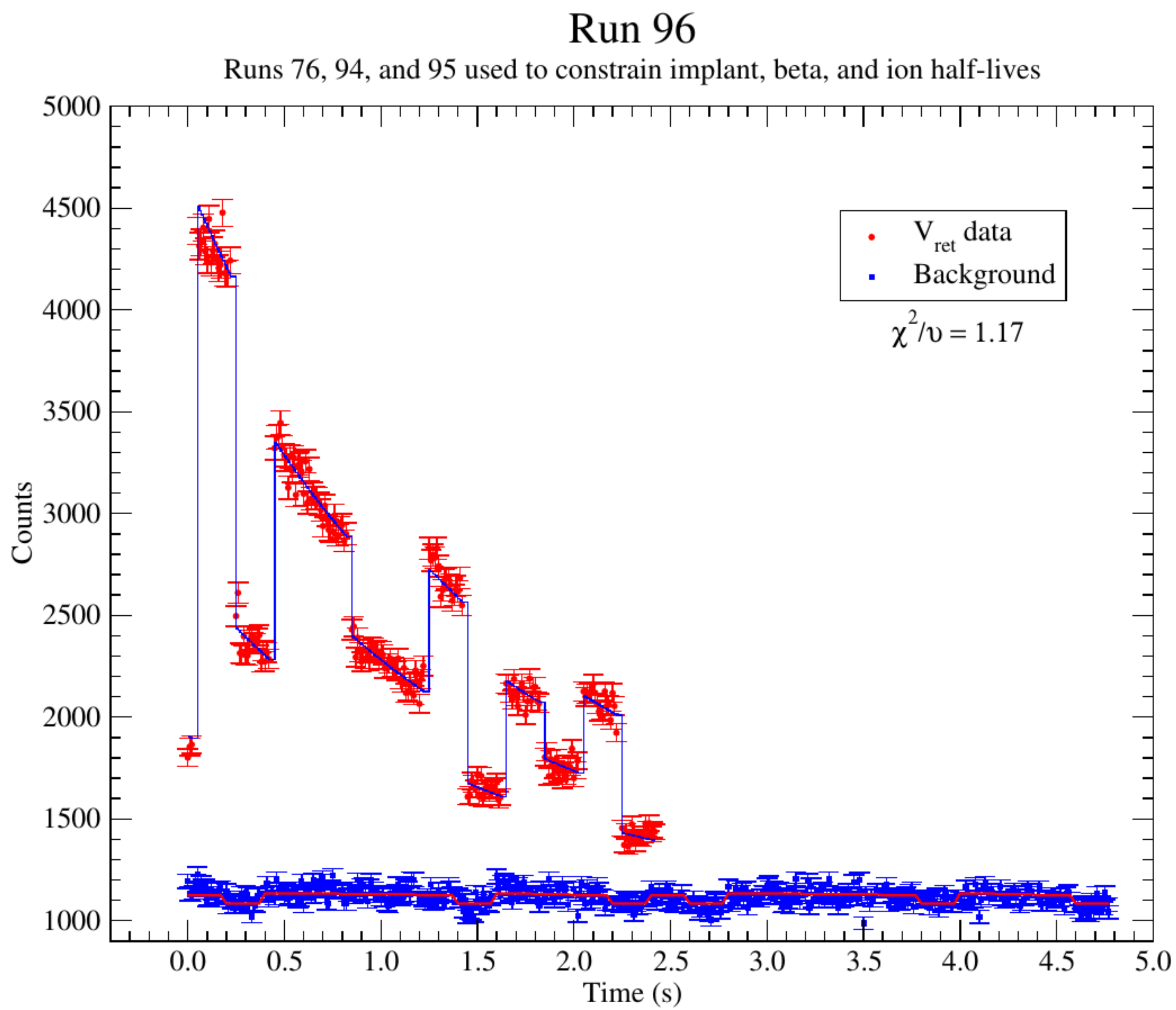
Dedicated half-life runs



- Only implantation activity can be measured in isolation
- Beta activity measured with 600V on spectrometer, implant activity constrained while ions are in cooling trap
- Ion activity measured with 50V on spectrometer, beta activity constrained by brief 600V measurement

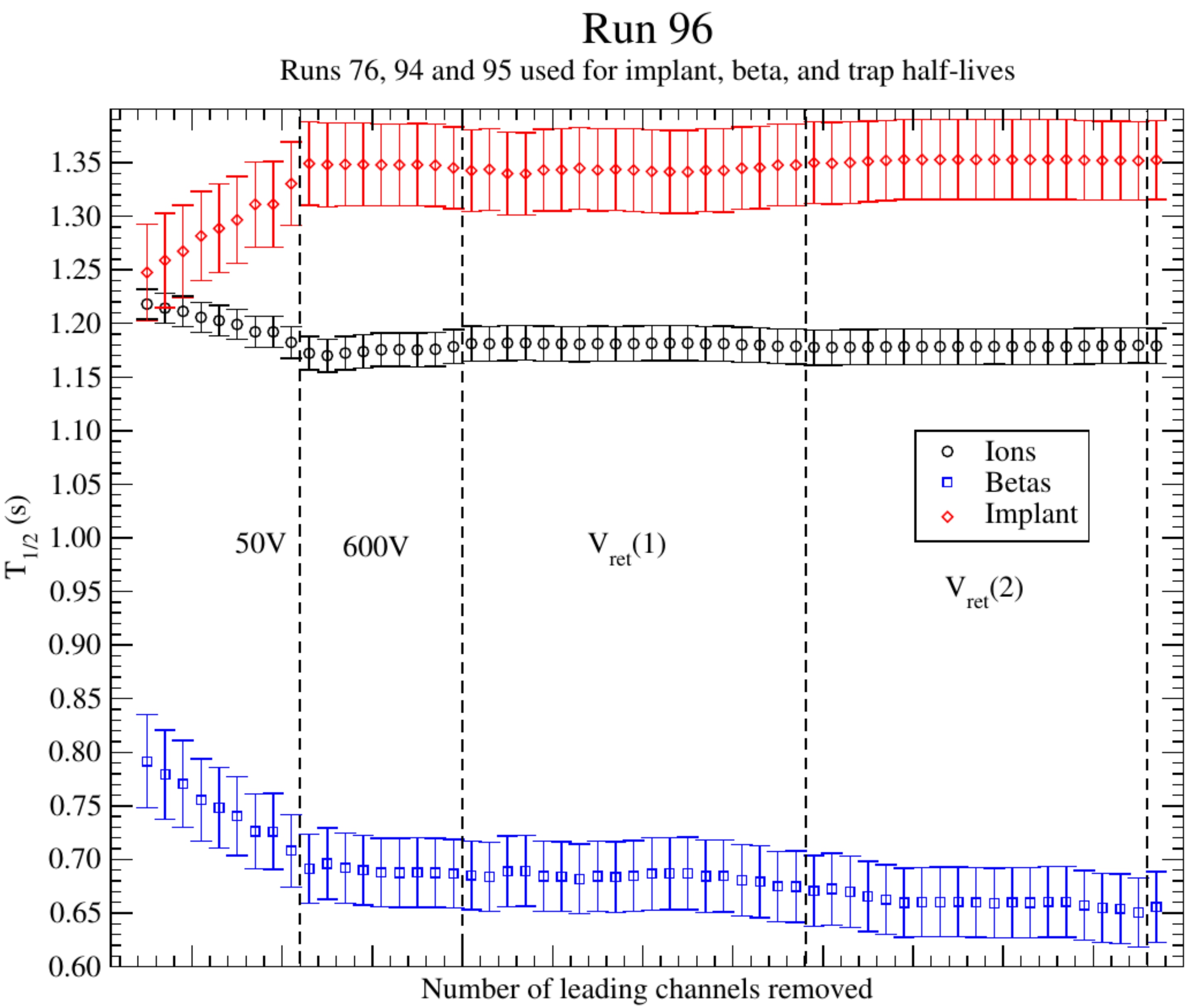
Typical recoil ion run w/fit

- Each recoil run fit simultaneously w/ implant, beta, ion half-life runs.
- Each recoil cycle immediately followed by background cycle, do see some bkg. dependence on spec. voltage
- In my analysis ignore ejected ion portion of cycle

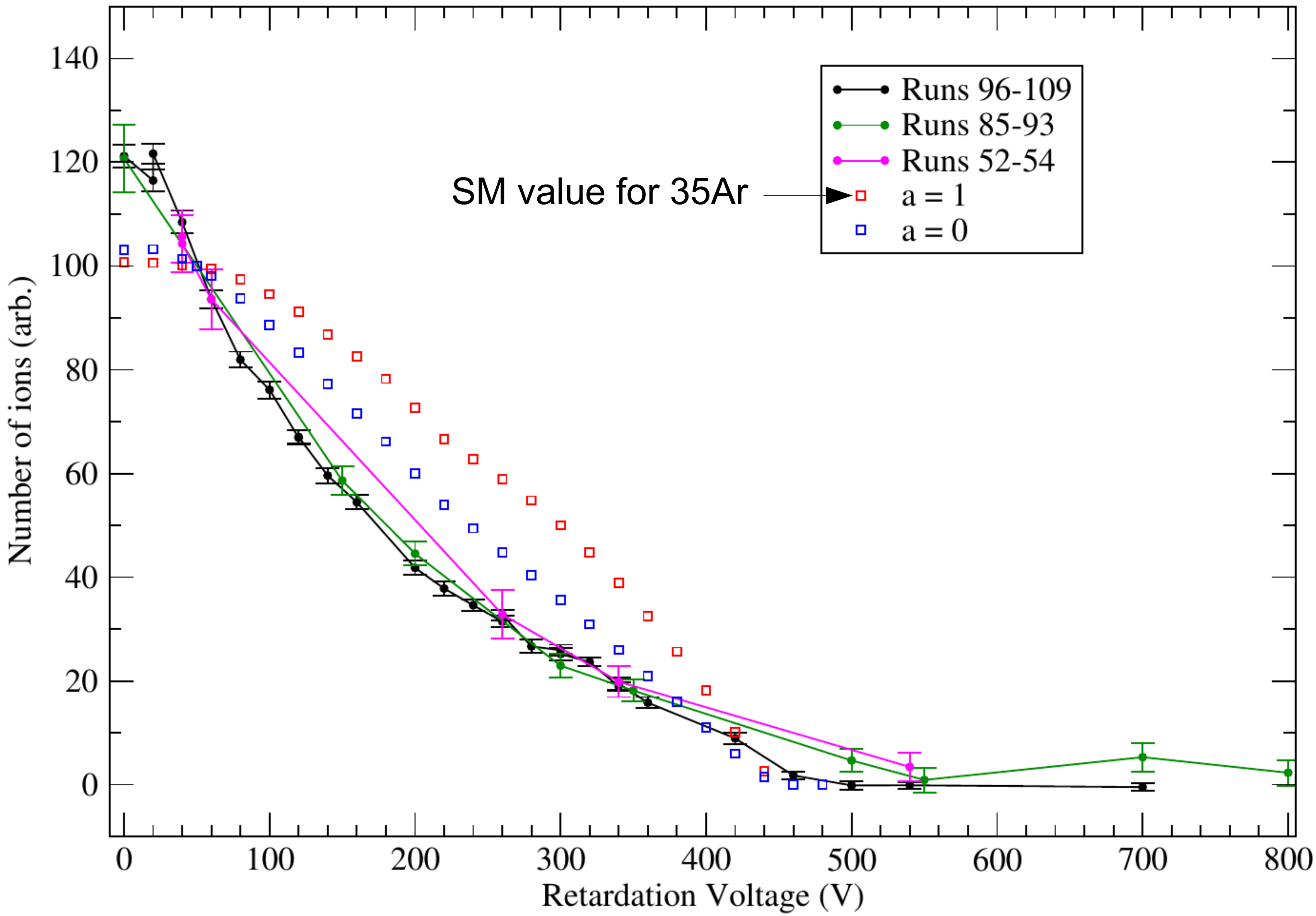


Remove leading channels

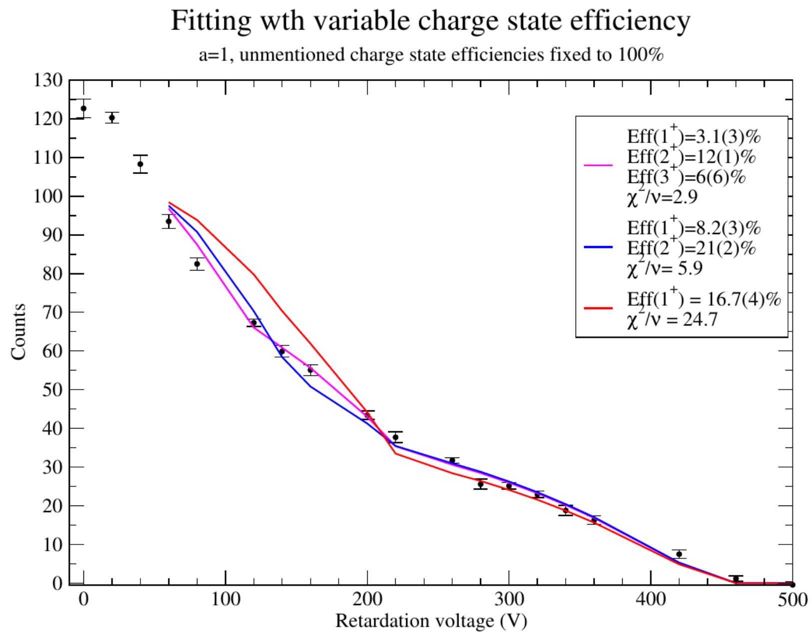
- Chop plot analysis shows some issues, particularly with first 50V region, which is omitted in the final analysis
- Combination of many signals with different half-lives in each region leads to strong correlations between all parameters

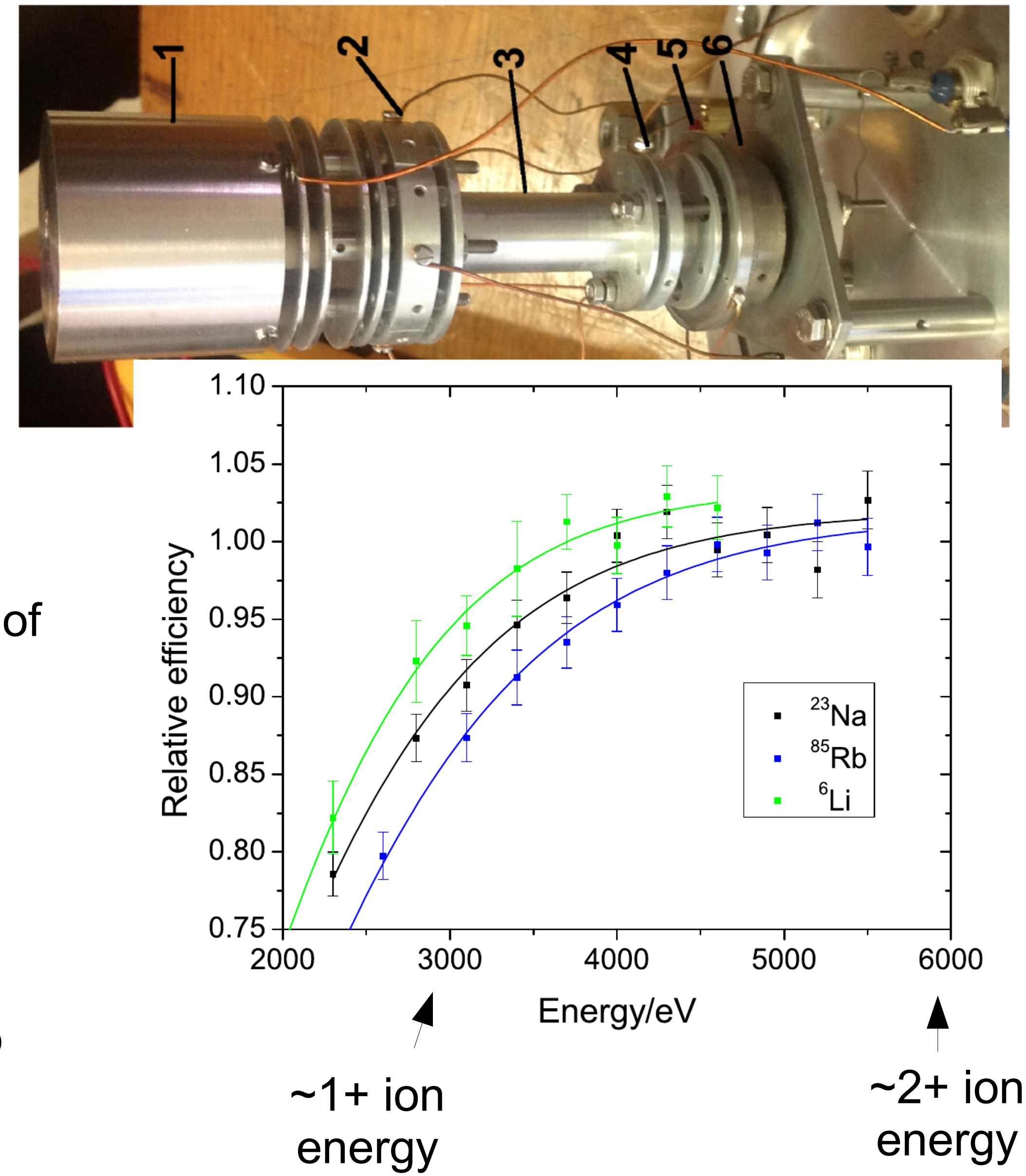


Amplitudes for $a_{\beta\nu}$



Energy-dependent MCP efficiency?





- Different charge states (1+, 2+, etc.) of ions following decay, re-accelerated with different energy
- Simulations of this effect suggestive, made measurements @LPC-Caen
- Do have an energy-dependent efficiency for MCP, but not enough to explain discrepancy

WITCH Monte Carlo Simulations

- Possible presence of unidentified/unaccounted for contaminants/backgrounds in the WITCH data?
- Check:
  - Monte Carlo recoil data based on SM value for recoil distribution (i.e. assume a=1)
  - Add background according to some model (energy spread, time dependence, etc.)
  - Fit the MC recoil data + bkg WITHOUT including background in your fit routine.
  - Compare amplitudes and quality of fits with experimental values.

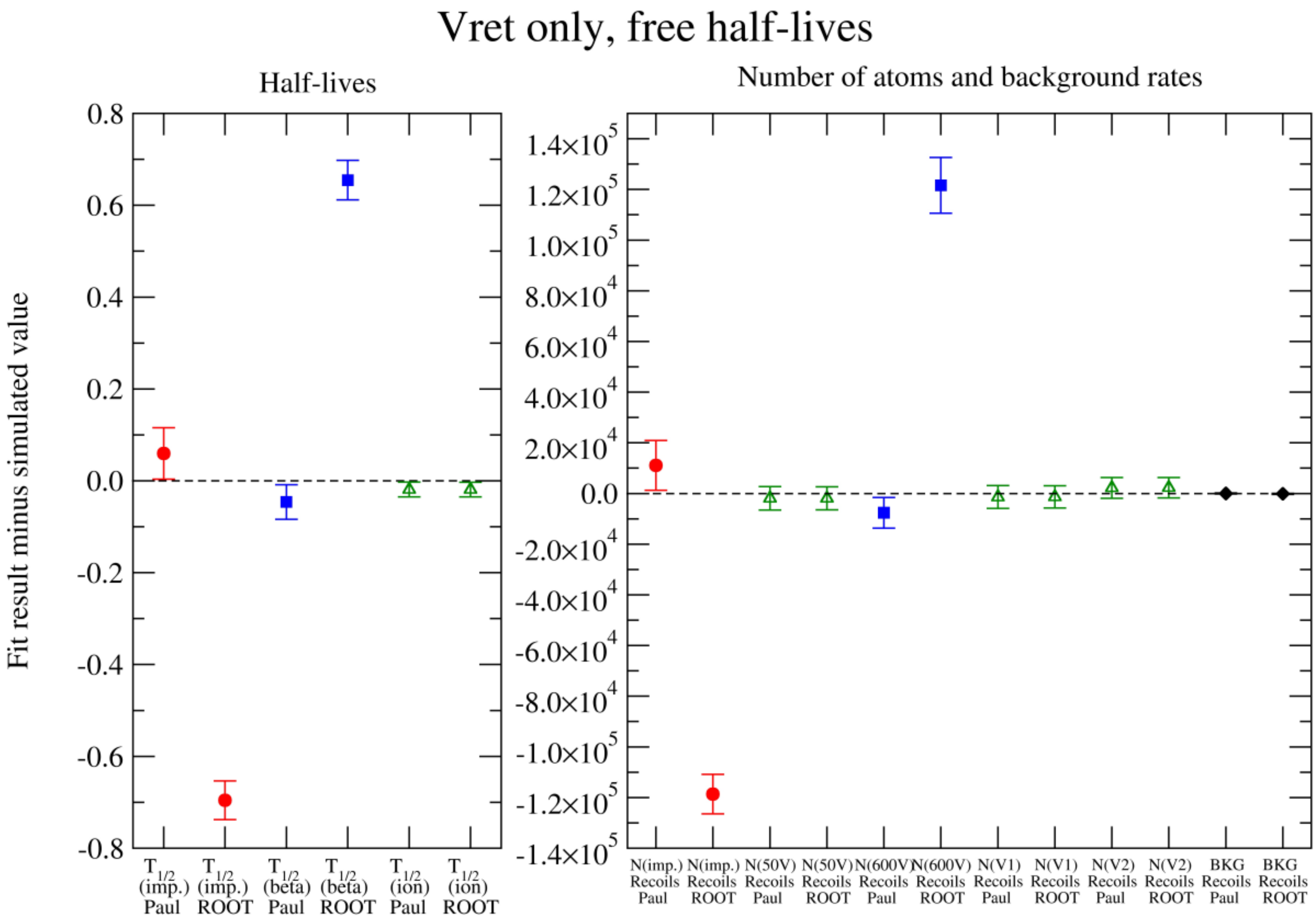
Monte Carlo Data

- C++ code, define Δt via $-\log(r/\lambda)$ with r a random value
- Simulated implantation activity, beta activity, and recoil-ion activity, as well as constant background
- Combined simulated decay curves to reproduce runs 76 (implant only), 95 (implant, betas), 94 (implant, betas, recoils) and typical recoil run.
- Half-lives for each component fixed to values from dedicated half-life runs (76,95,94)

TABLE I: Values for the various effective half-lives of ^{35}Ar measured at WITCH.

Half-life	Simulated value (s)
Recoil ion	1.19
Beta	0.67
Implant	1.30

Fits – Recoils (no bkg)



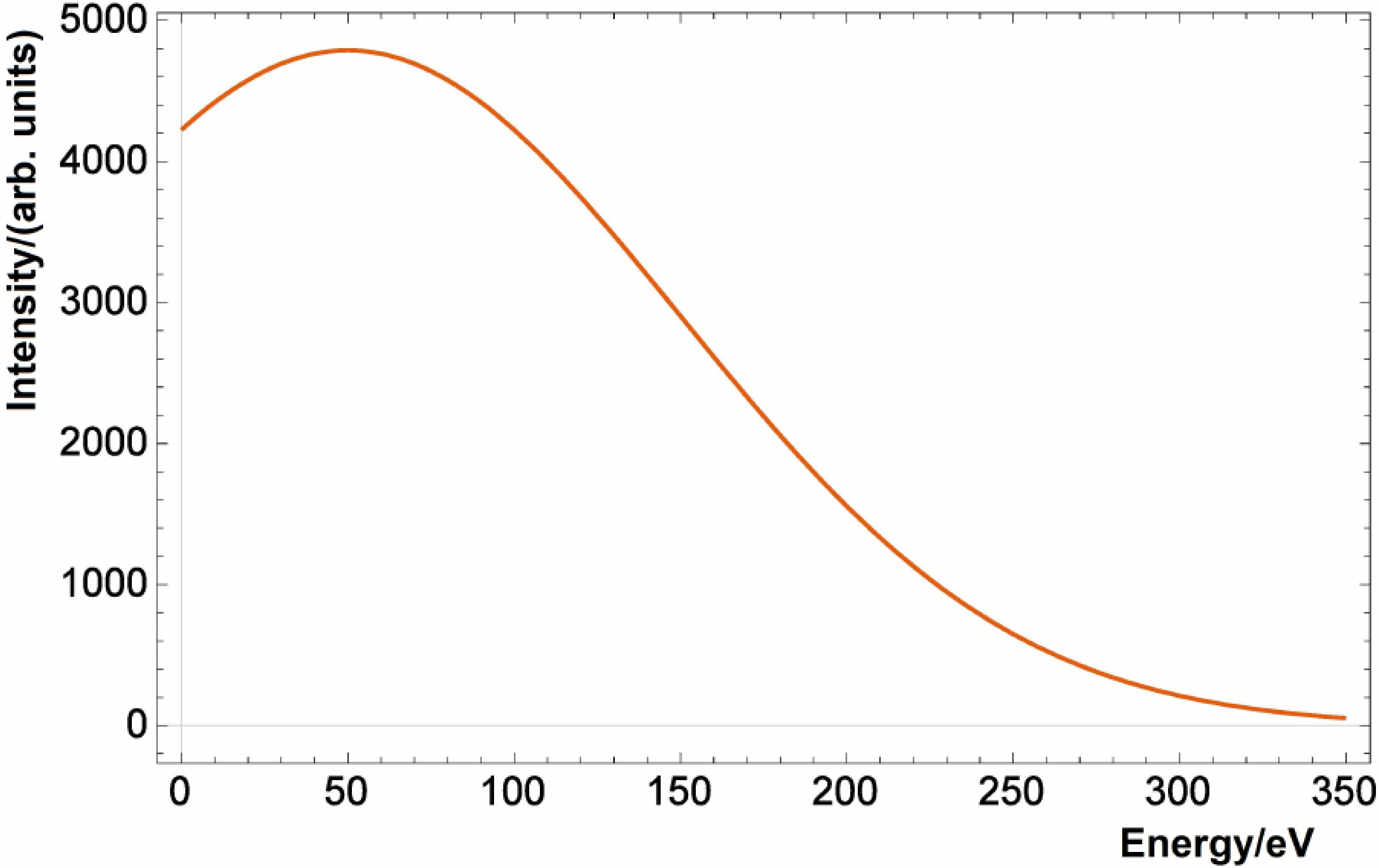
Modeling the background

Assumptions:

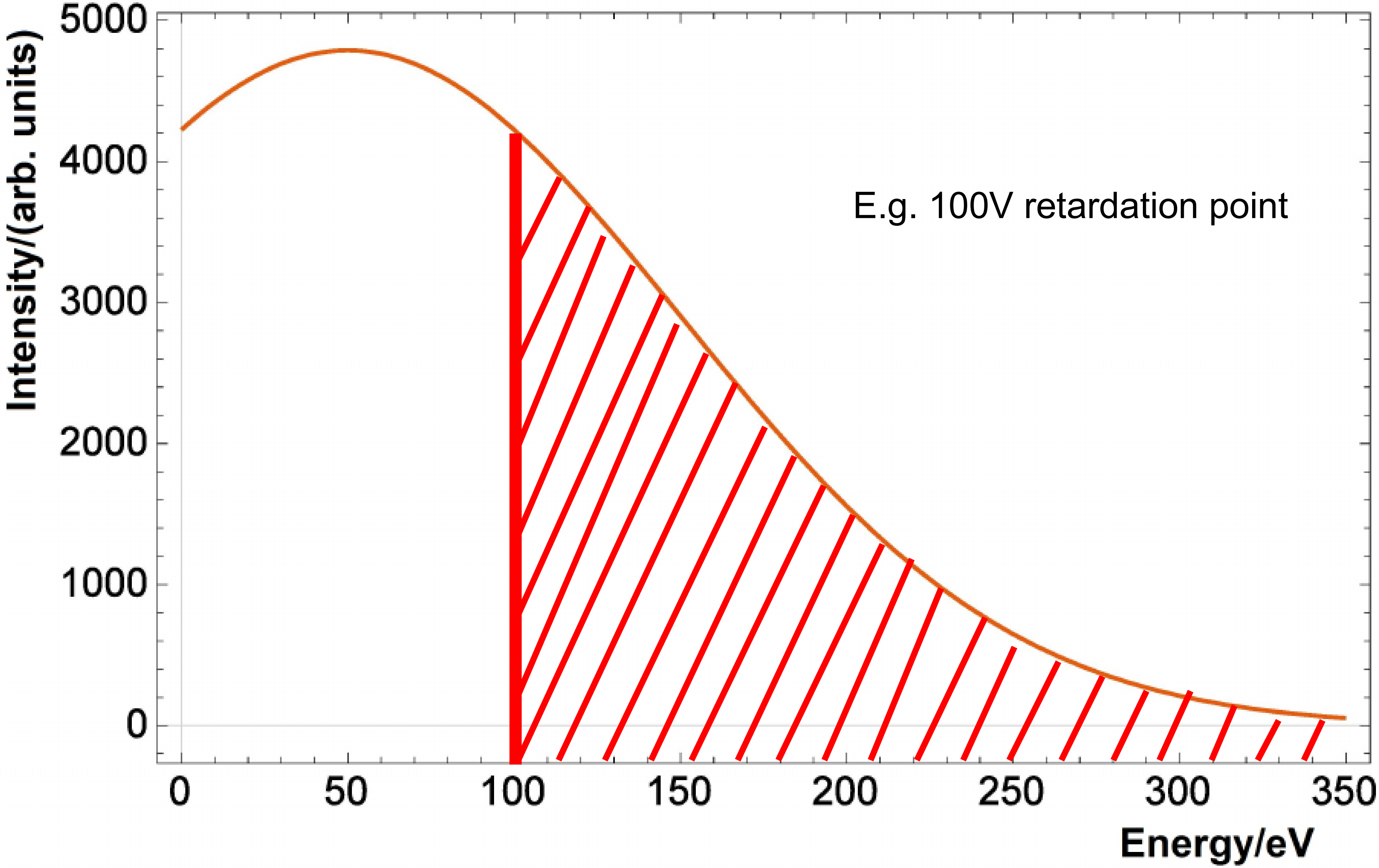
- Radiation-dependent.
- Time (in)dependent.
- Gaussian energy distribution in the 0-450 eV range.

Scan parameter space of background model, add to retardation spectrum generated by SM values, see if we reproduce our experimental fits if background is left unaccounted for.

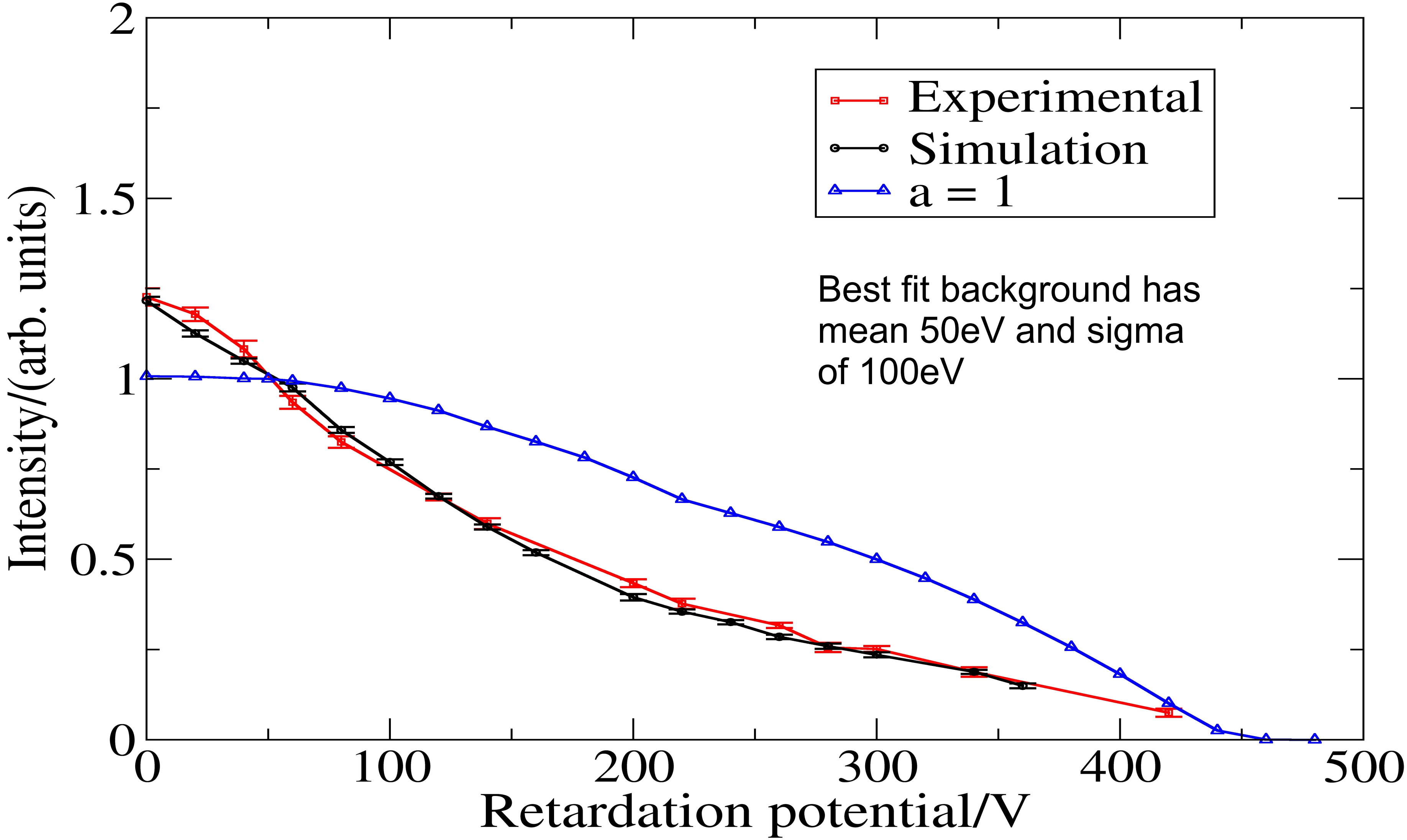
Background distribution



Background distribution

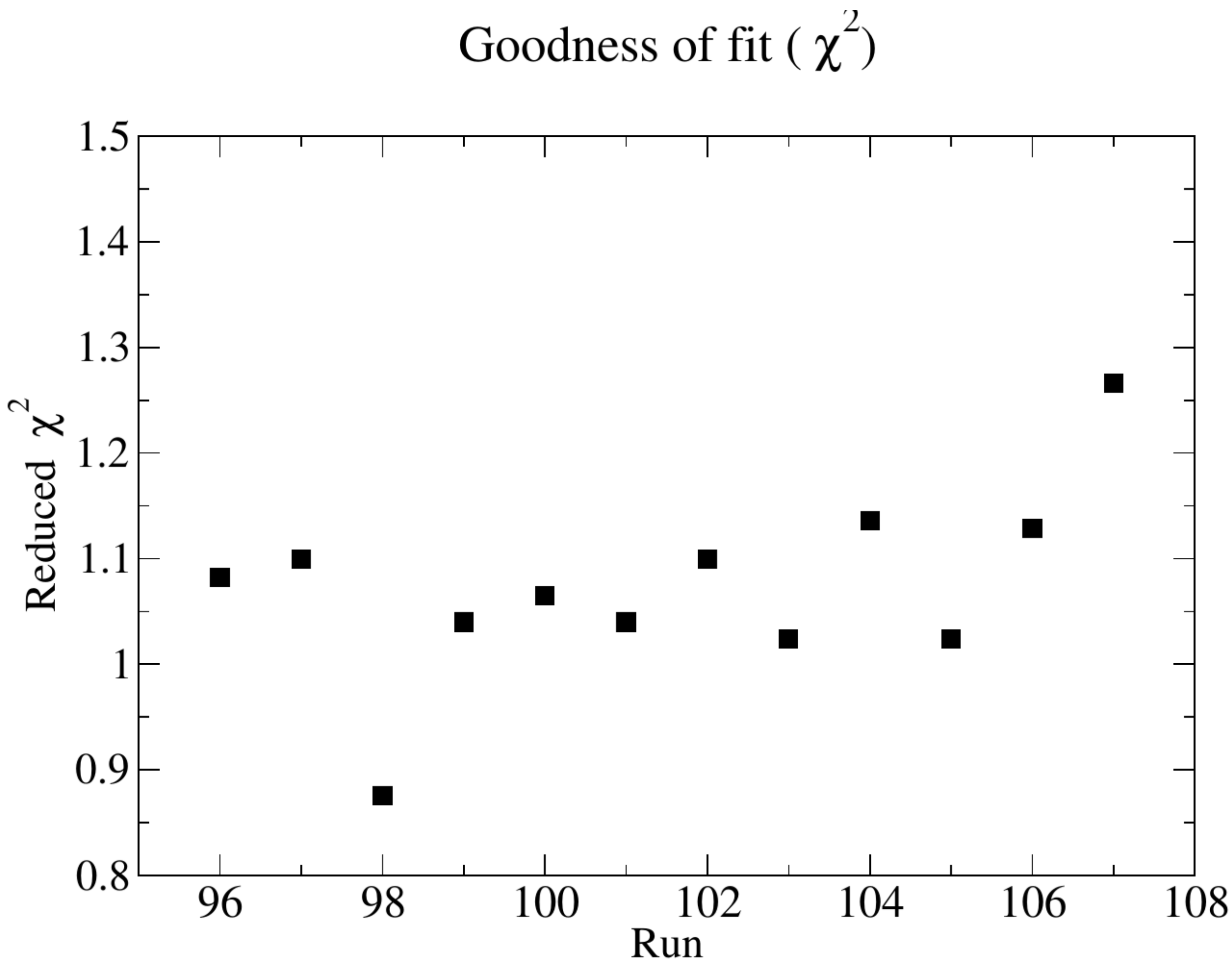


Results



Experimental
Simulation
a = 1
Best fit background has mean 50eV and sigma of 100eV
Intensity/(arb. units)
Retardation potential/V
0
0.5
1
1.5
2
100
200
300
400
500

Reduced chisquares of fits



- Reduced chi-squares from the fits are consistent with what we obtain when fitting the experimental data
- Results of this study strongly suggest that recoil spectrum is contaminated by radiation-induced time-dependent background