Quenching Factor Measurement of $CaWO_4$

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CRESST

- Aim of CRESST: direct detection of Dark Matter in form of WIMPs
- WIMPs scatter elastically off the target nuclei
- Target material ($CaWO_4$)
- One advantage: different target materials can be used

Detection System

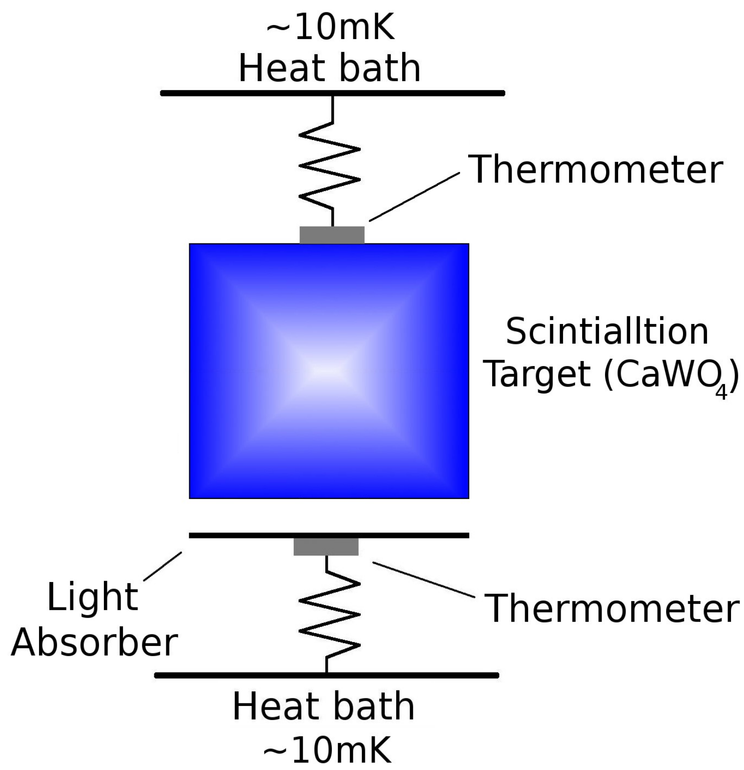
- $CaWO_4$ is a scintillator
- Deposited energy is converted into:

  ~99% phonons

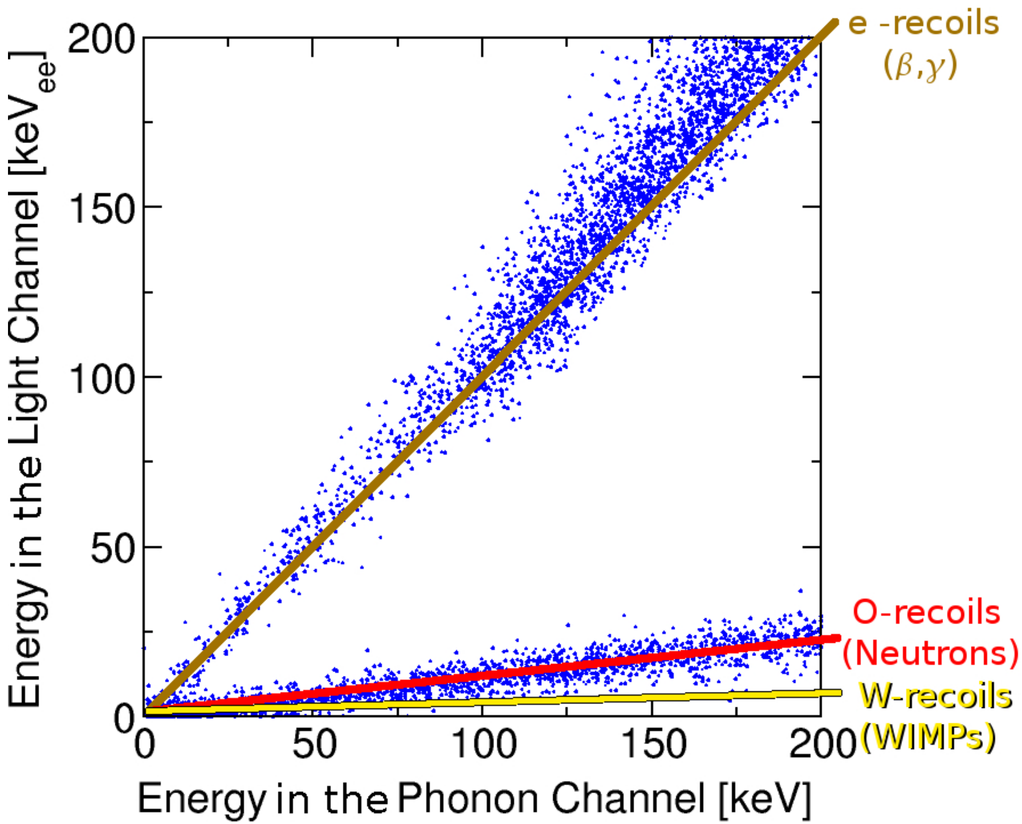
  ~1% scintillation light
- Two channels detection system

  → energy of phonons: E

  → energy of scintillation light: L



Quenching Factor



- Different particles transfer energy to different components of the target (e^- or O, Ca, W)
- $\gamma,\ \beta \rightarrow$ e^--recoil
- Neutron $\rightarrow$ O-recoil
- WIMP $\rightarrow$ W-recoil

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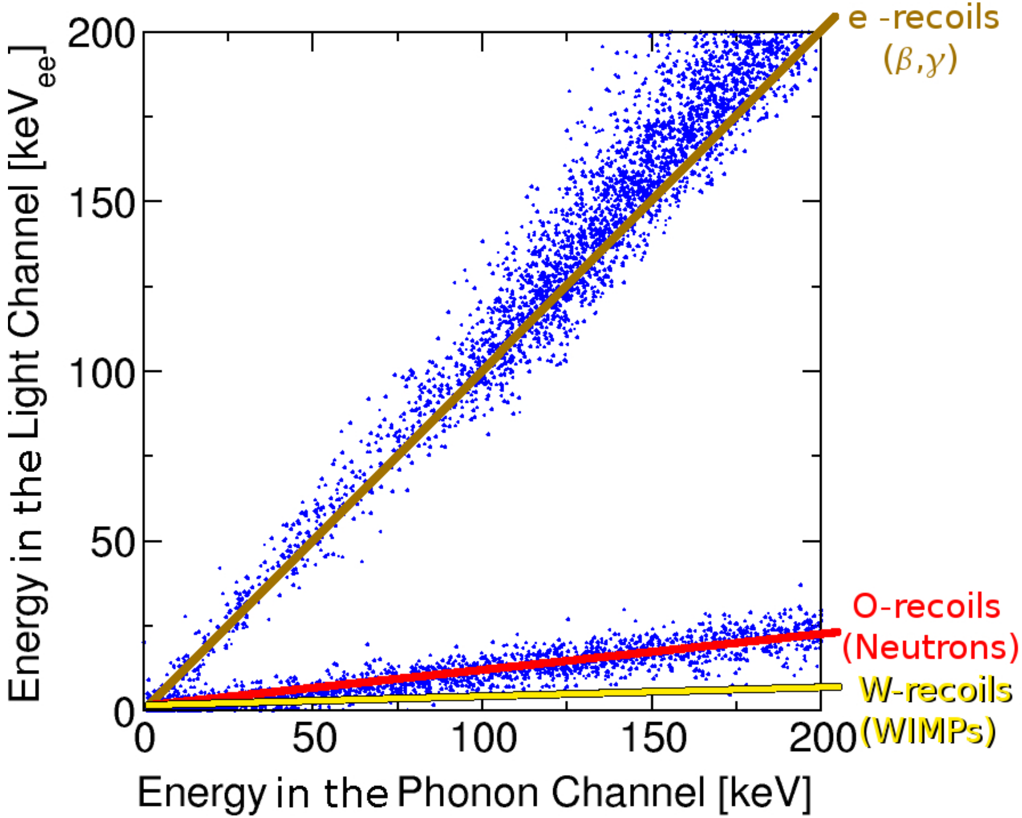

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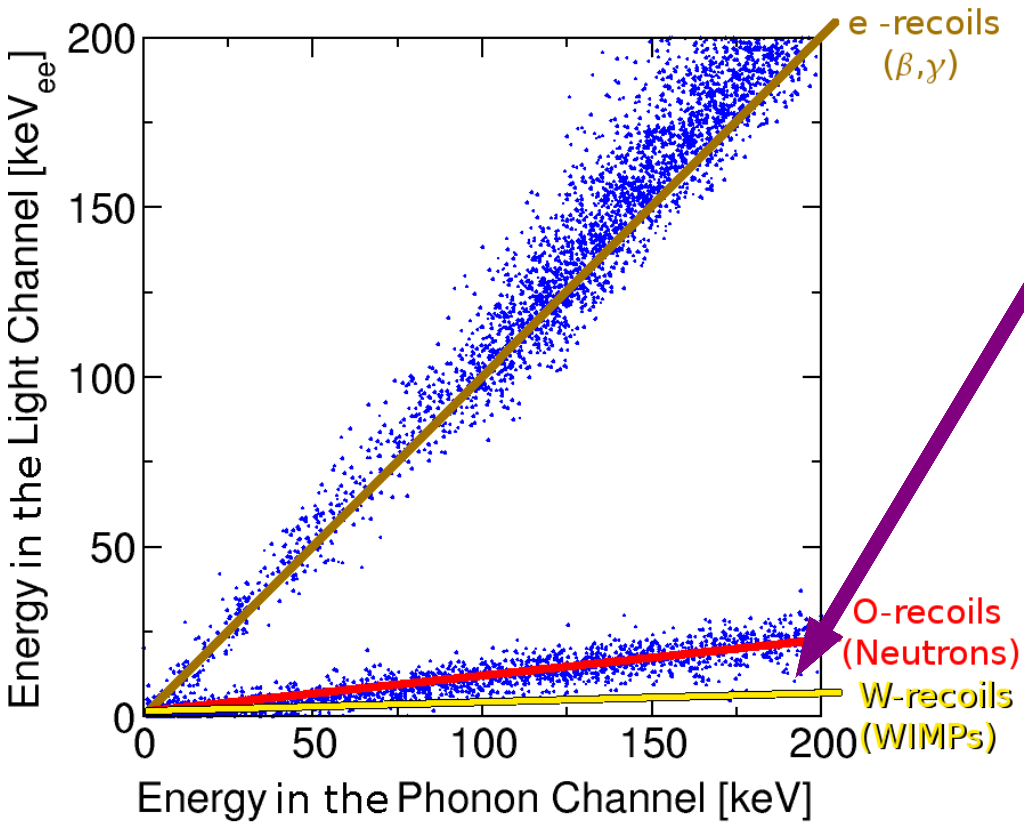
Type of recoil → incident particle

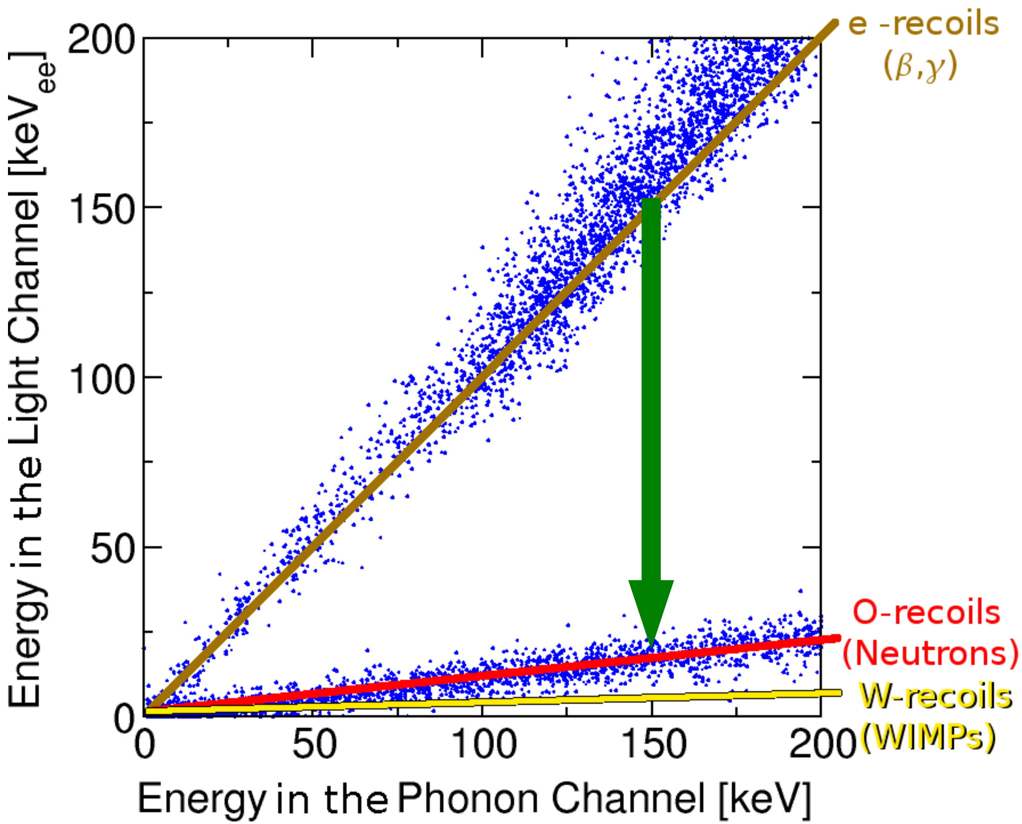
Quenching Factor



- e$^-$-recoil and O-recoil bands were measured!
- W-recoil band cannot be measured directly!

Additional experiment is needed

Quenching Factor



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$$QF := \frac{L(nuclear\ recoil, E_0)}{L(electron\ recoil, E_0)}$$

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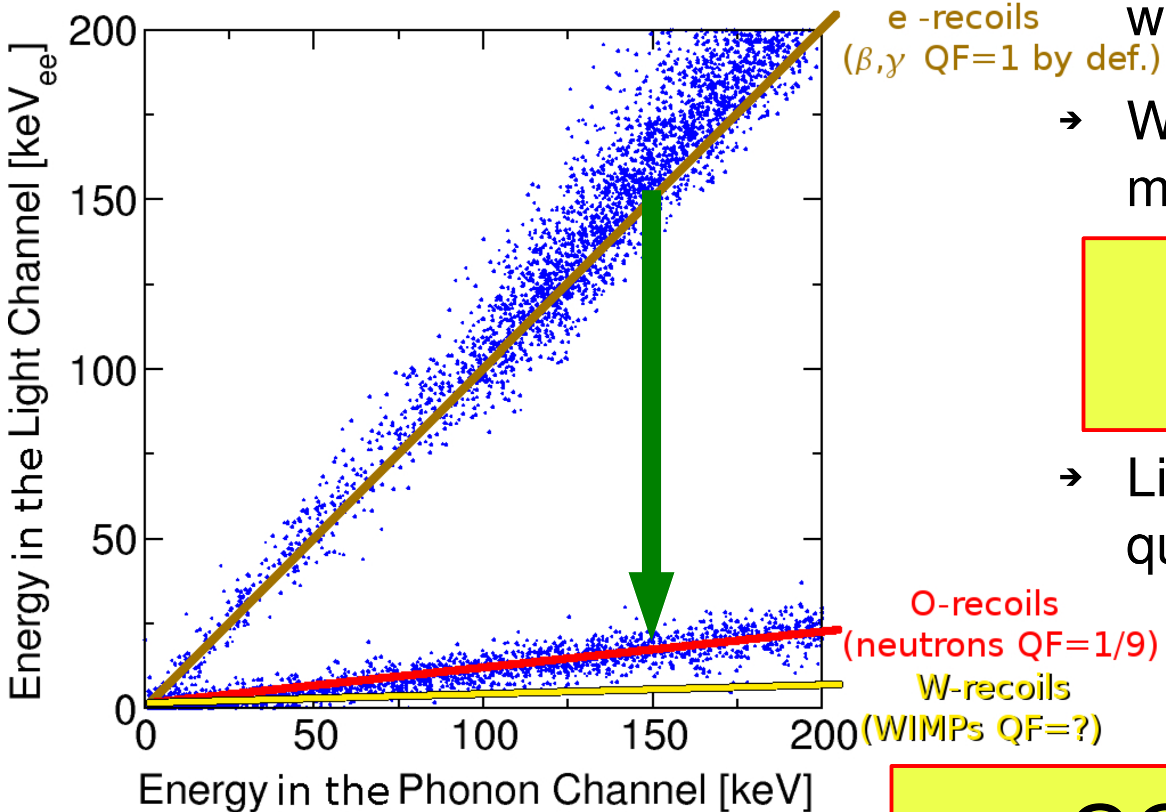

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GOAL : QF(W)

Nuclear Recoil Measurement

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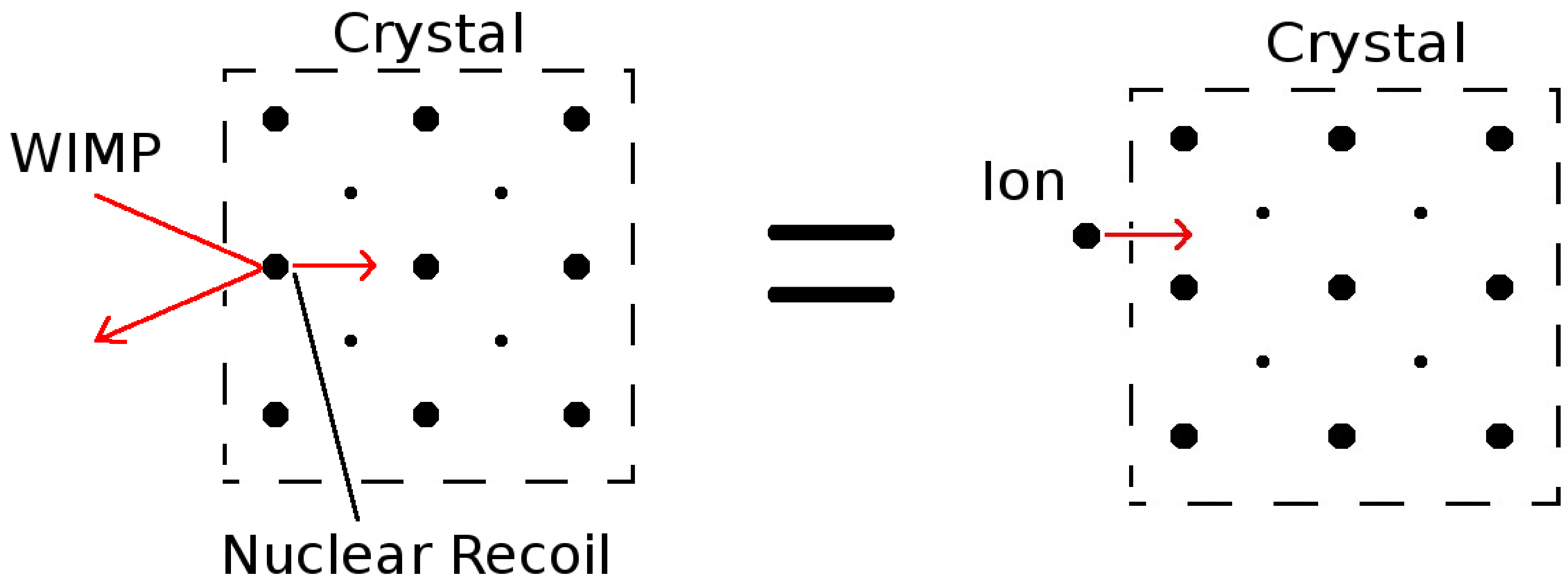
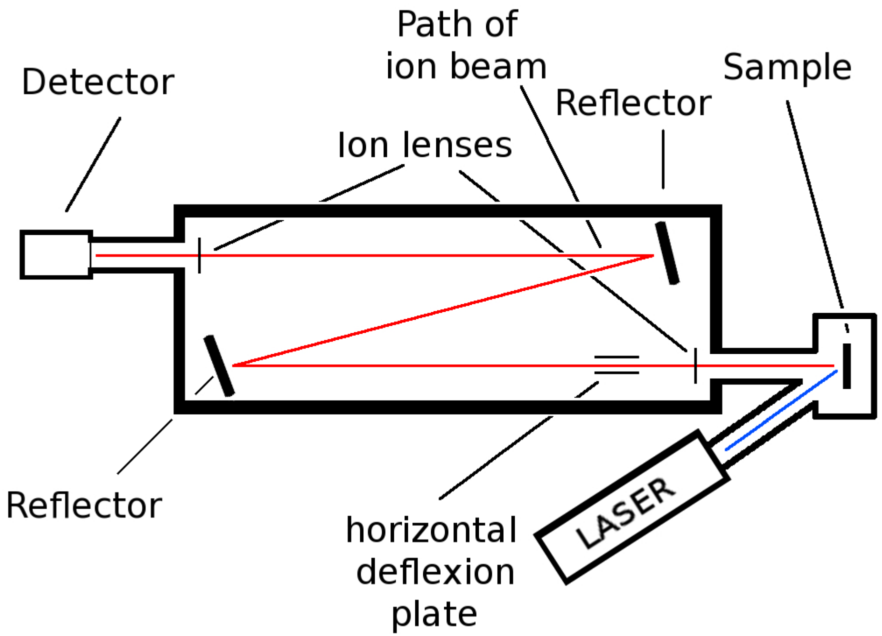


Experimental Setup

- LASER pulse desorbs and ionizes atoms from sample
- Ions accelerated to E_{kin} = 18keV
- Ions with a predefined time of flight can pass the deflexion plate
- Only ions with the correct mass reach the detector

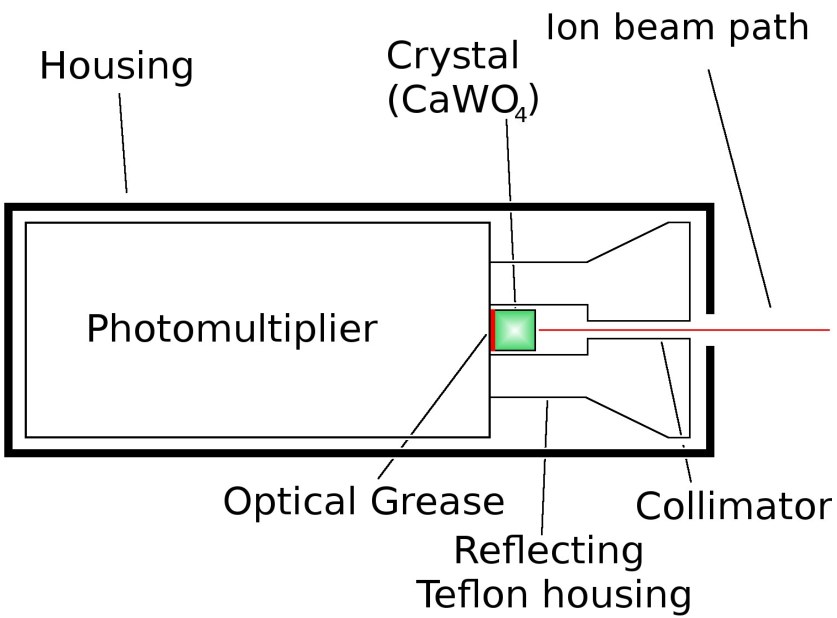
Advantage: knowing arrival time of ions → dark count rate is decreased



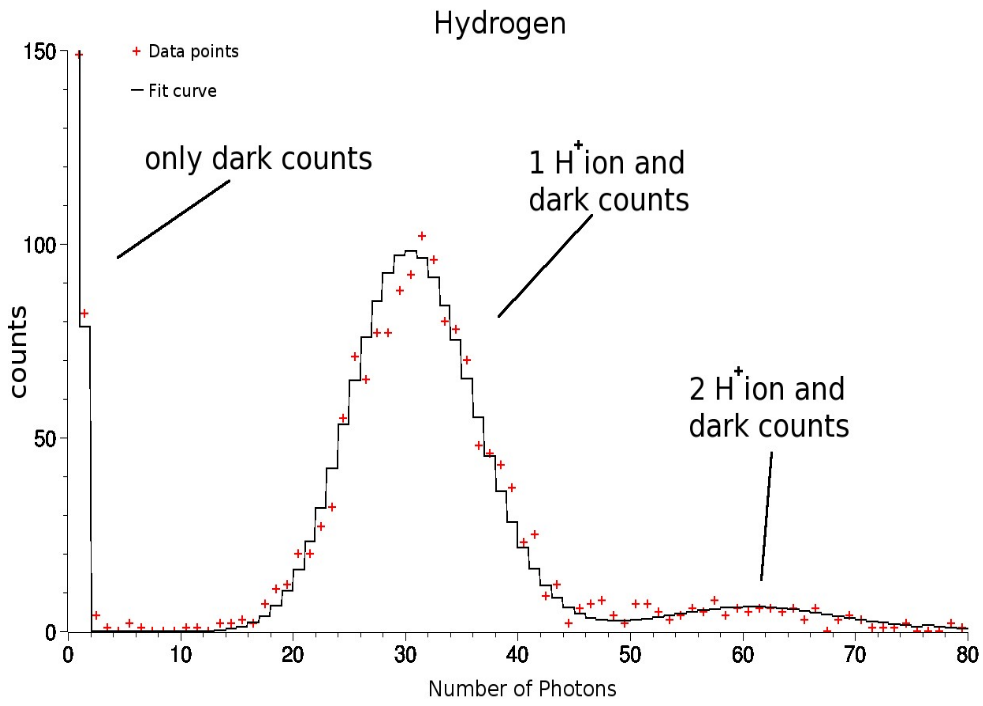
Detection System

- Impinging ions O, Ca, and W mimic recoiling nuclei in the crystal
- Teflon housing reflects scintillation photons into the photomultiplier
- Photomultiplier is in single photon detection mode

In principle light production of all elements can be measured



Ion Measurement

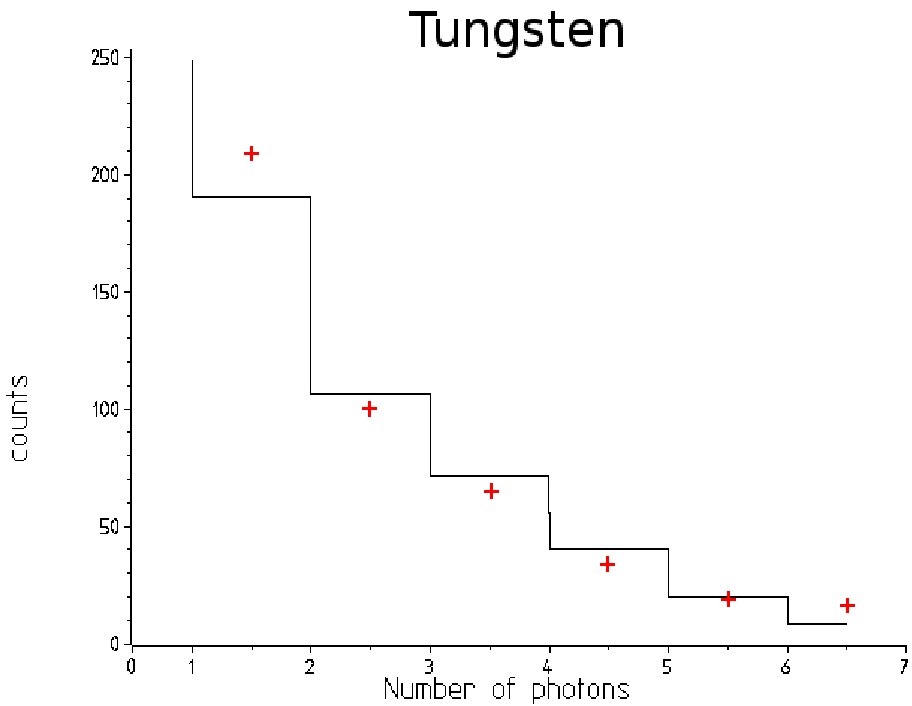


Amount of photons for one Hydrogen ion
≈ 30.34

Aim: Measure the number of photons produced by a single ion

- LASER intensity optimized to have mainly one ion reaching crystal
- In rare cases more ions can reach the crystal at the same time

Ion Measurement



Amount of photons for one Tungsten ion ≈ 1.77

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- For heavy ions less light is produced
- Overlap of 0, 1, and 2-ions peaks
- No clear identification of single ion induced light

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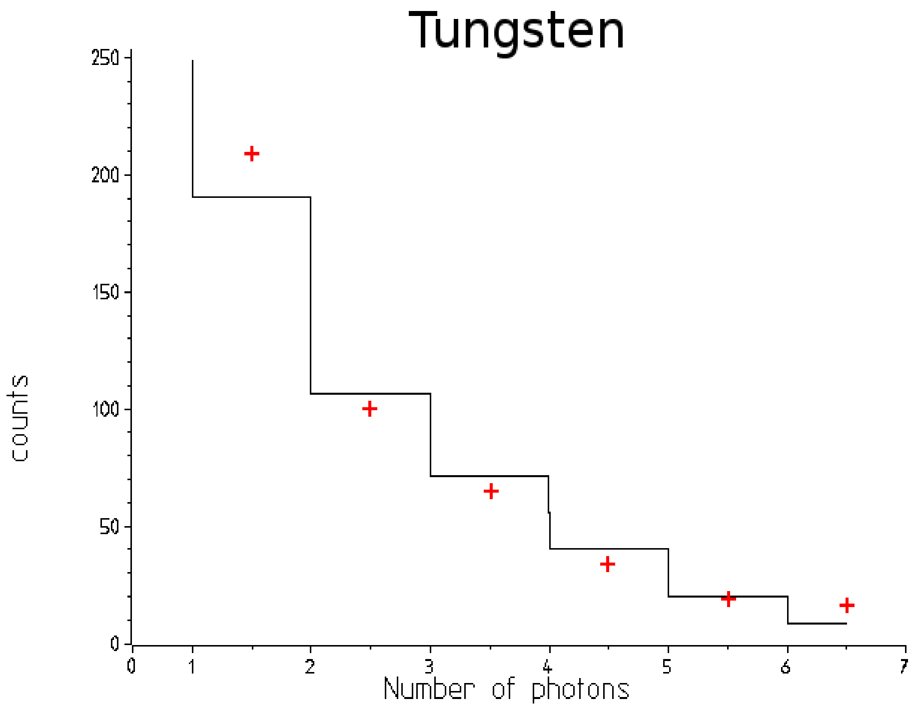

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Main contribution to measurement uncertainties

e^--Recoil Measurement

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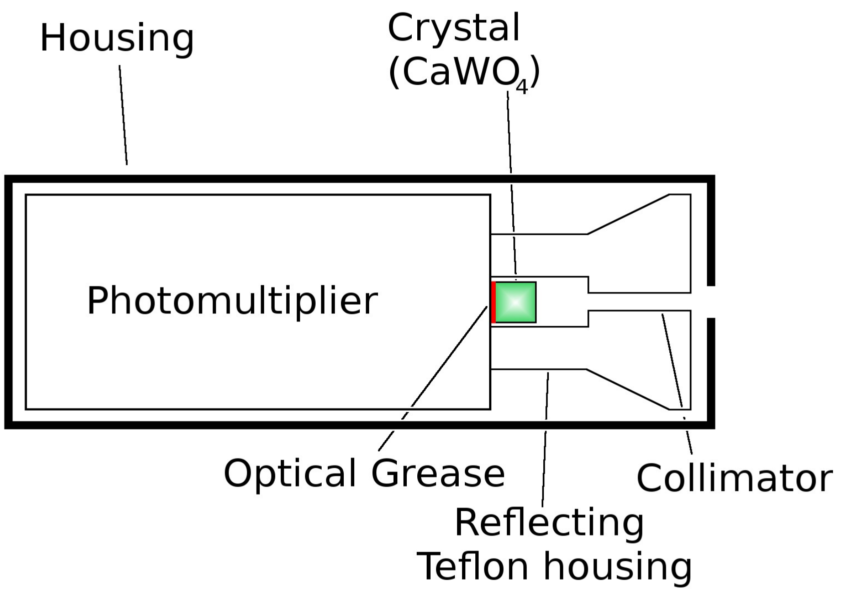
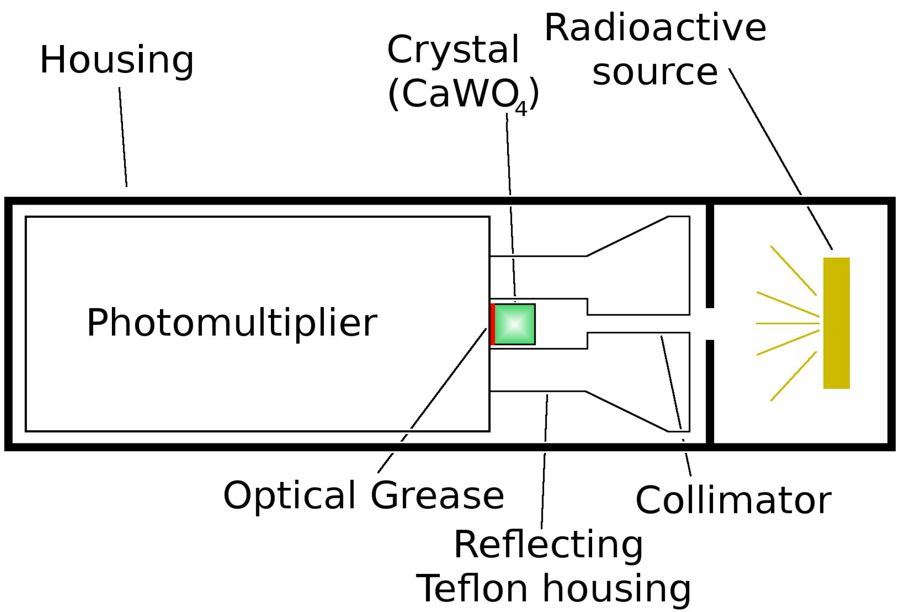


e^--Recoil Measurement

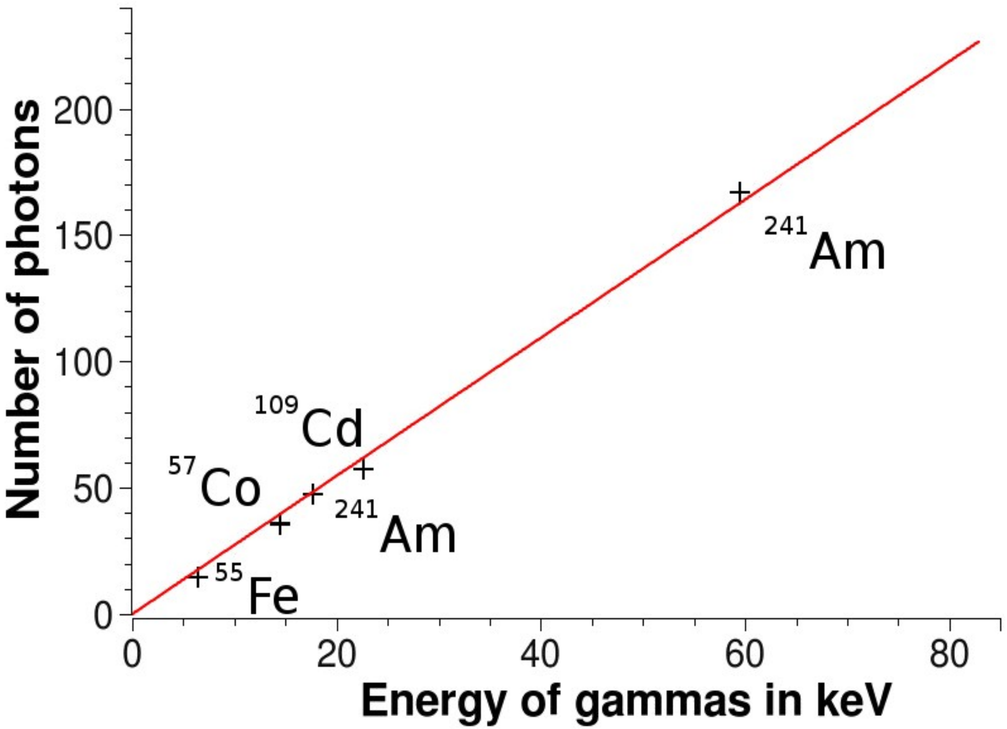
$$QF := \frac{L(nuclear\ recoil, E_0)}{\boxed{L(electron\ recoil, E_0)}}$$

- e^--recoils are produced by gamma radiation
- Radioactive source facing the detector
- Produced scintillation light is measured



Gamma Measurement

- Standard source with 18keV gamma does not exist
- The number of scintillation photons proportional gamma energy
- Interpolation to 18keV



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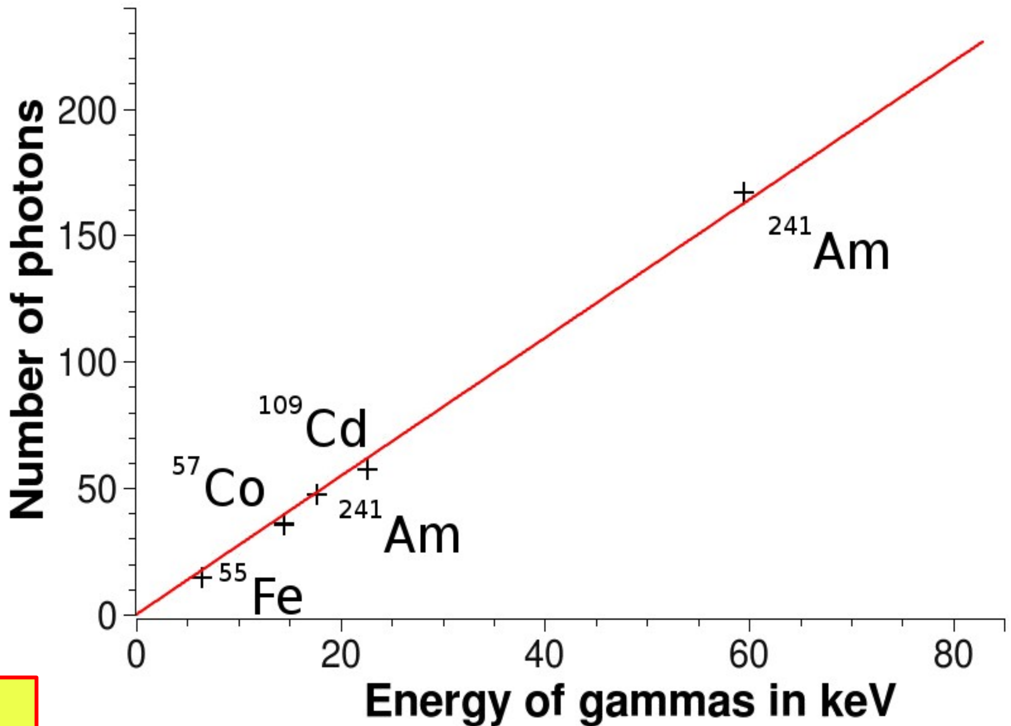
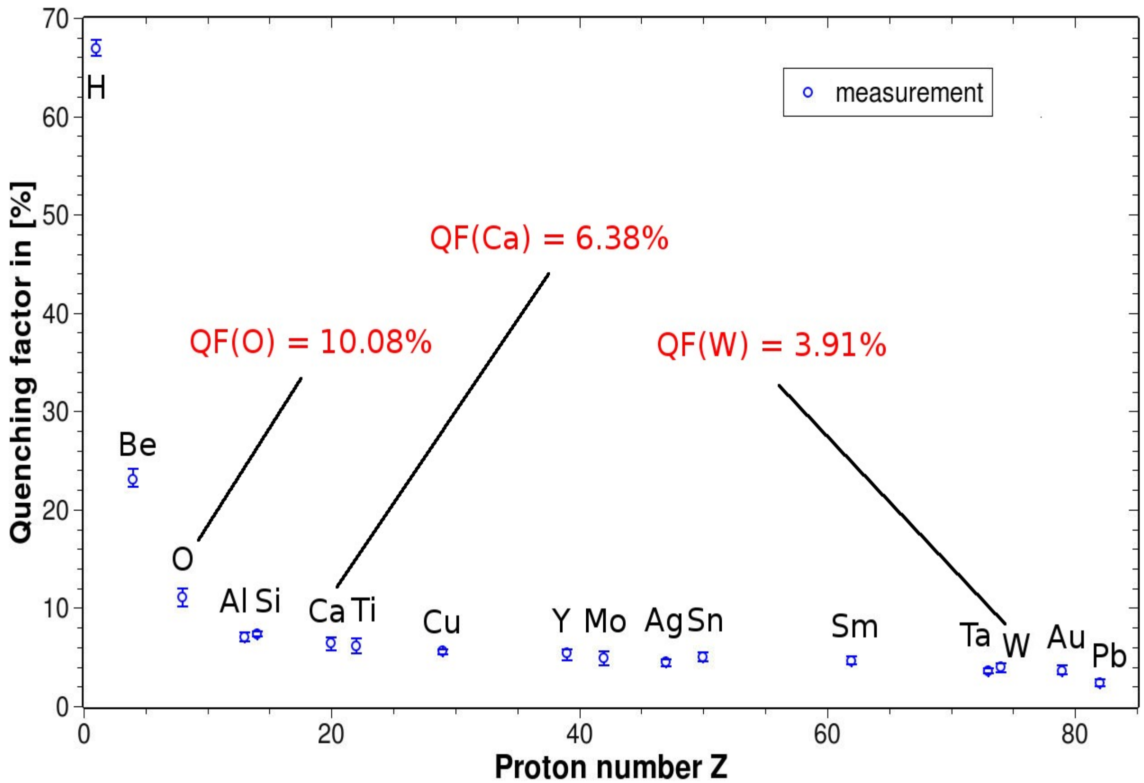


Number of photons for 18keV gamma: 45.35

Quenching Factors - Results

- Produced light decreases with increasing ion mass
- Possible to distinguish recoils from Oxygen, Calcium and Tungsten

Light output measured for 17 different elements



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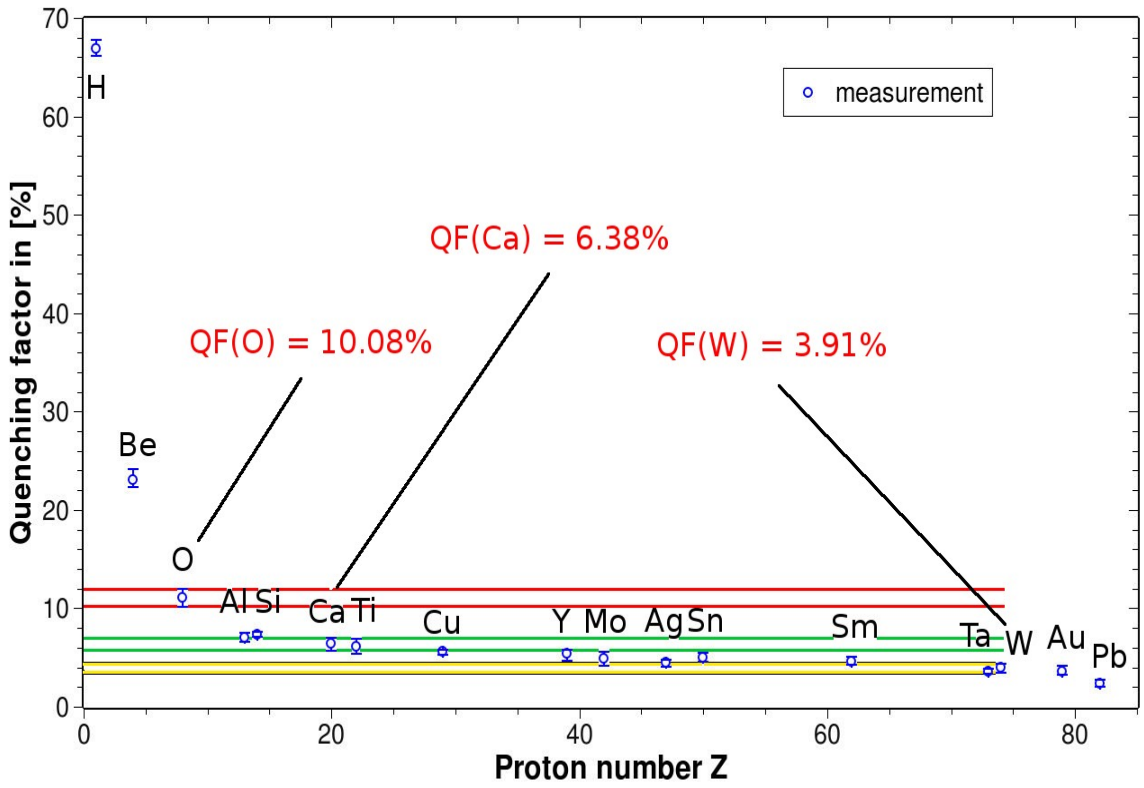

Conclusion - Outlook

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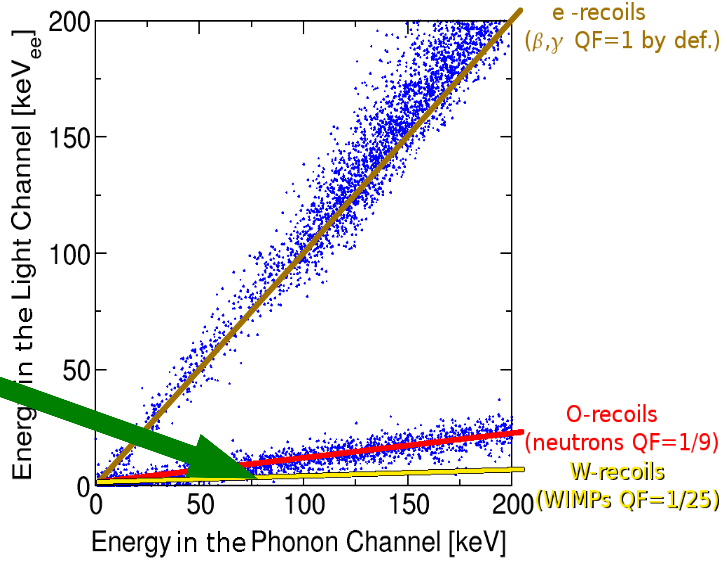

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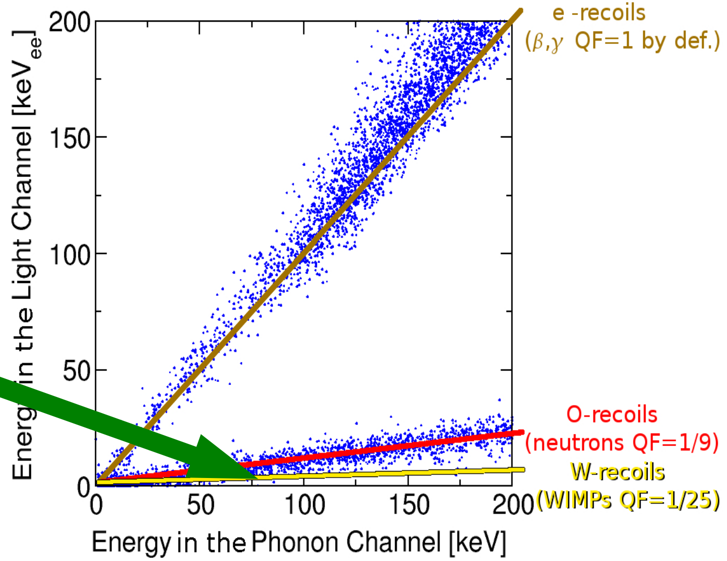
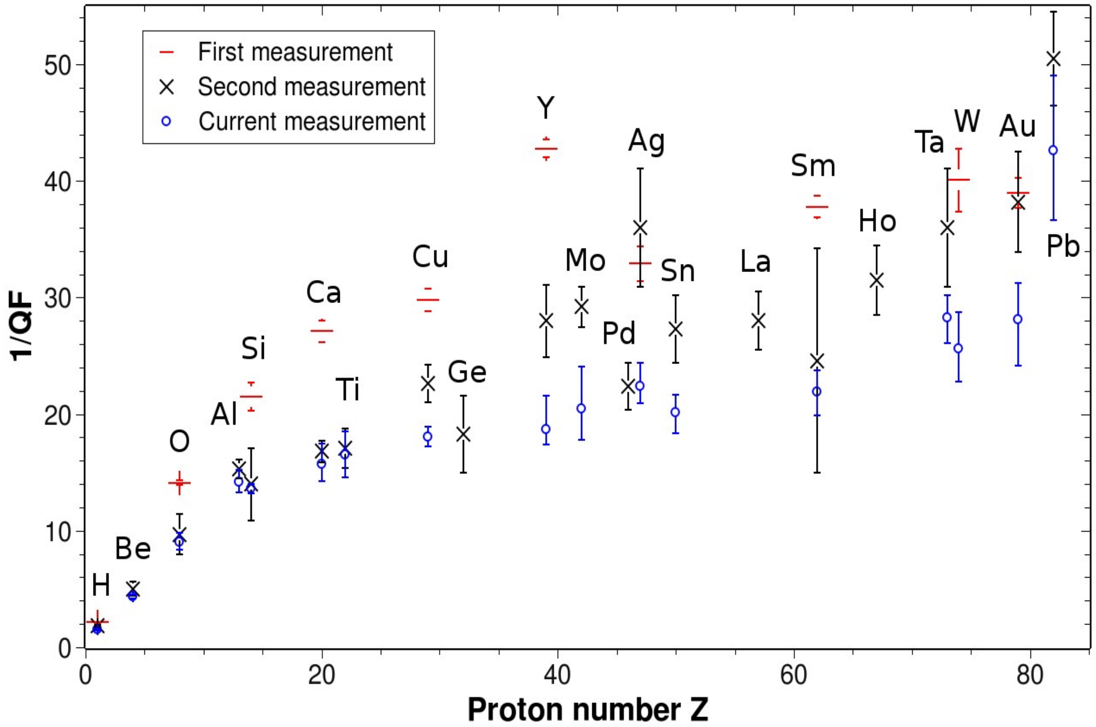


- Outlook
  - Quenching Factor measurements of different target crystals ($CaWO_4 \rightarrow ZnWO_4$)
  - Low temperature measurements with a cryostat as in CRESST

Attachment



Old Quenching Factors

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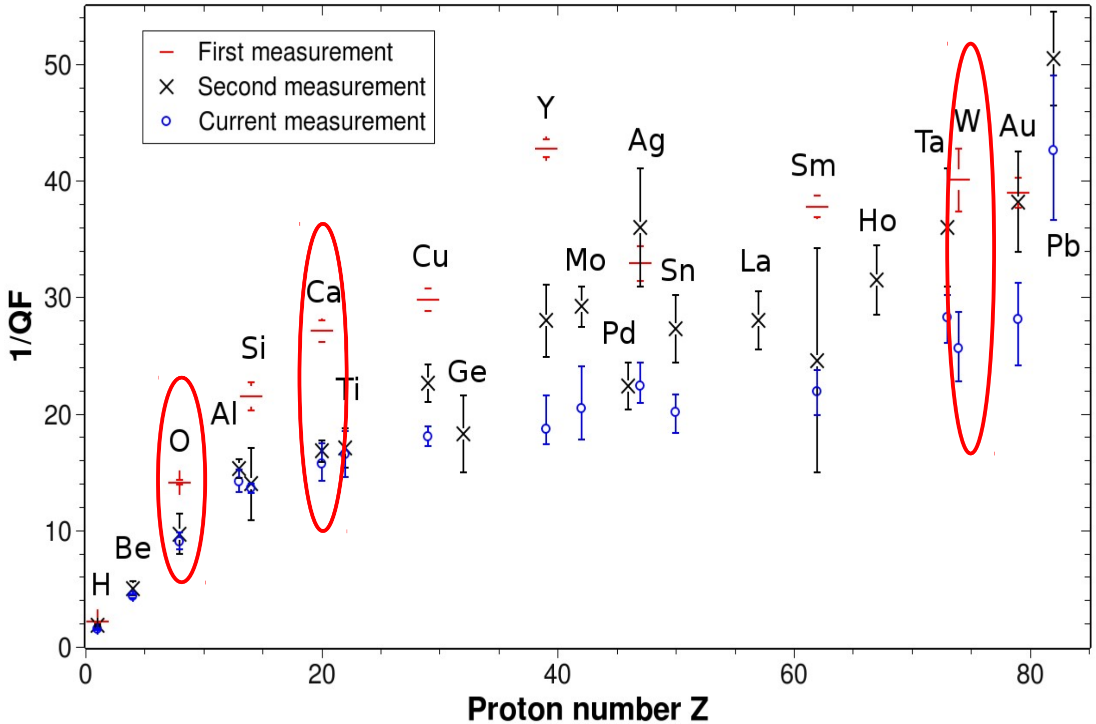


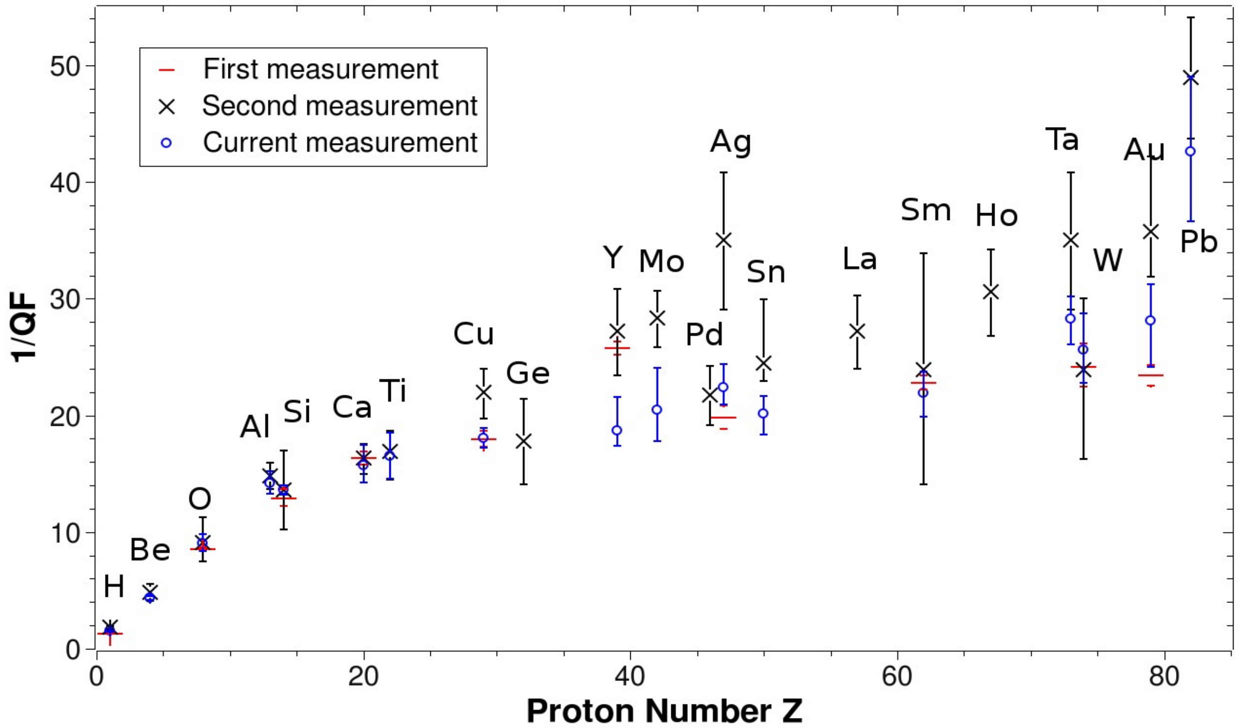
- Number of photons for ions similar but for gammas at 18keV the measurements differs:

First Measurement : 73.48

Second Measurement : 49.00

Current Measurement : 45.36

Attachment



New Quenching Factors

- Tungstate value obtained from second measurement
- Reanalyzed gamma measurement causes consistant