# Setting up a Spectrometer
to measure the absolute light yield of scintillating materials

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# Motivation

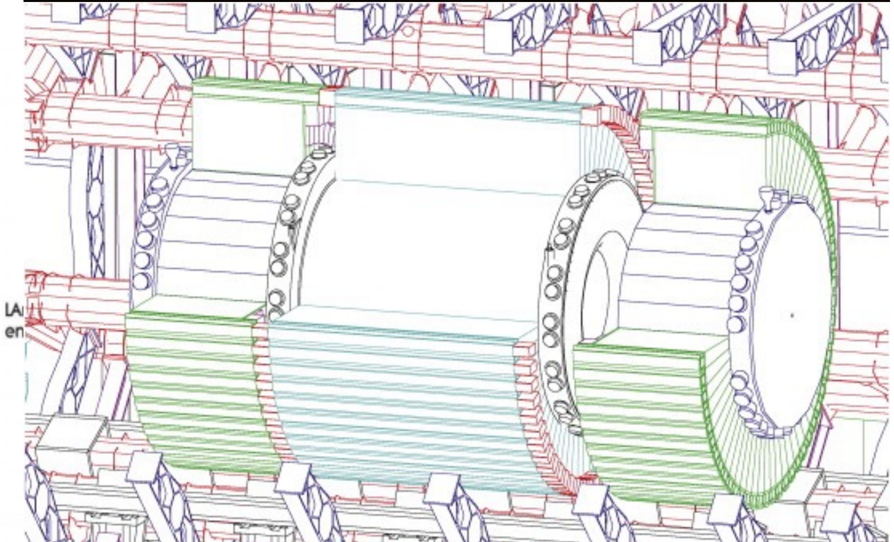
- future experiments require plastic scintillating materials with high scintillation efficiency, long-term stability & high radiation hardness
- measure the absolute light yield: #$\gamma$/MeV

→ compare and find suitable scintillator plastic materials

# Scintillators & ATLAS

- Applications:
  - Triggering
  - Counting
  - Imaging
- As detector systems:
  - Amount of light ∝ deposited energy
  - ATLAS Hadron Calorimeter: TileCal
- Spectroscopy!

[1] https://eljentechnology.com/products/plastic-scintillators/ej-200-ej-204-ej-208-ej-212

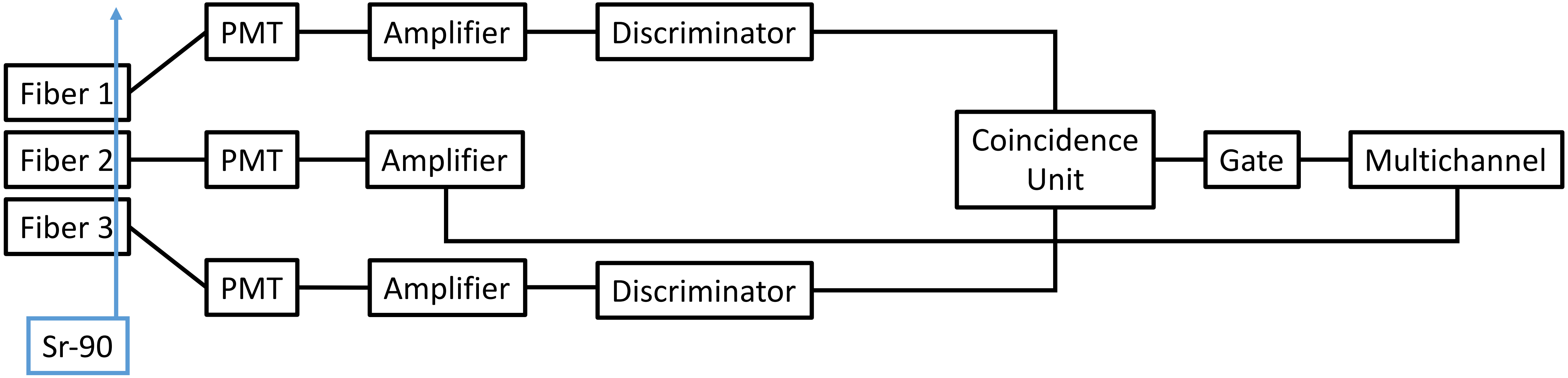


[2] https://www.researchgate.net/figure/The-Tile-Calorimeter-in-the-ATLAS

# Plastic scintillators

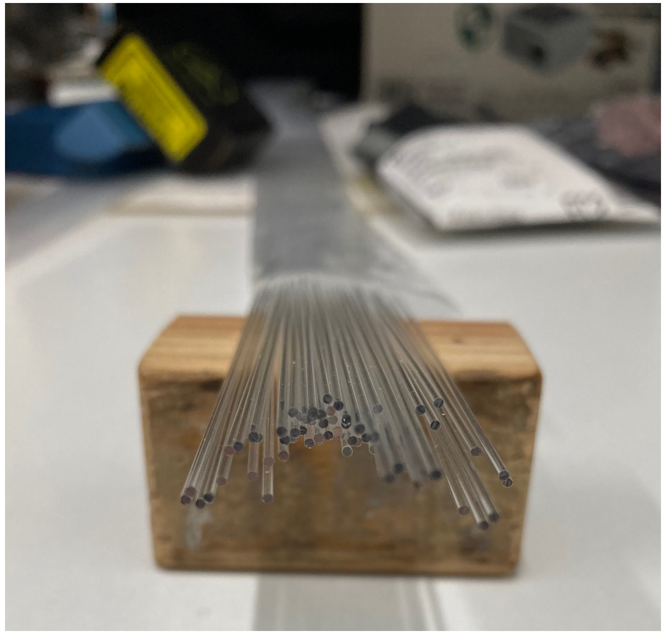
- Organic/inorganic scintillators
- plastic scintillators:
  - O-H compounds
  - materials like PS, PEN, PET
  - fast response (ns), cost effective, manufacturing and molding
- Light yield described by Birks Formula: $\frac{dL}{dx} = S \frac{\frac{dE}{dx}}{1+kB\frac{dE}{dx}}$

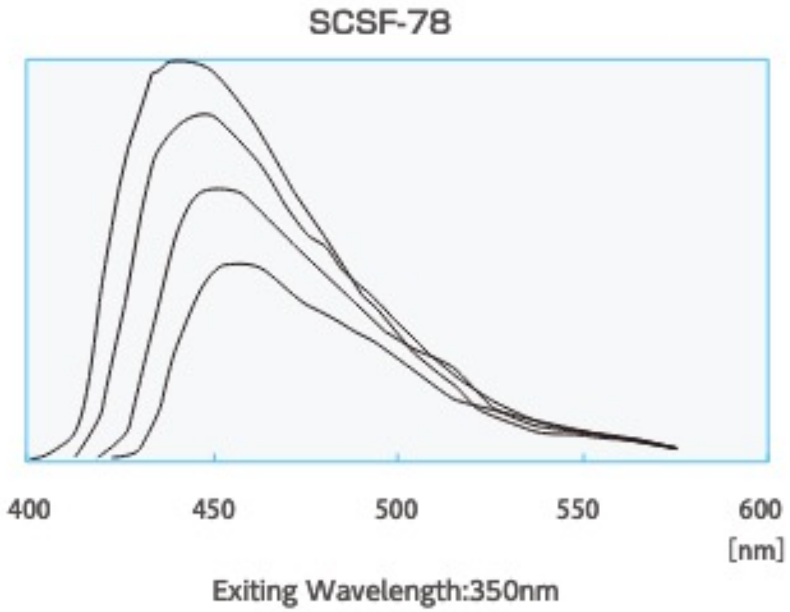
# Spectrometer setup with three fibers

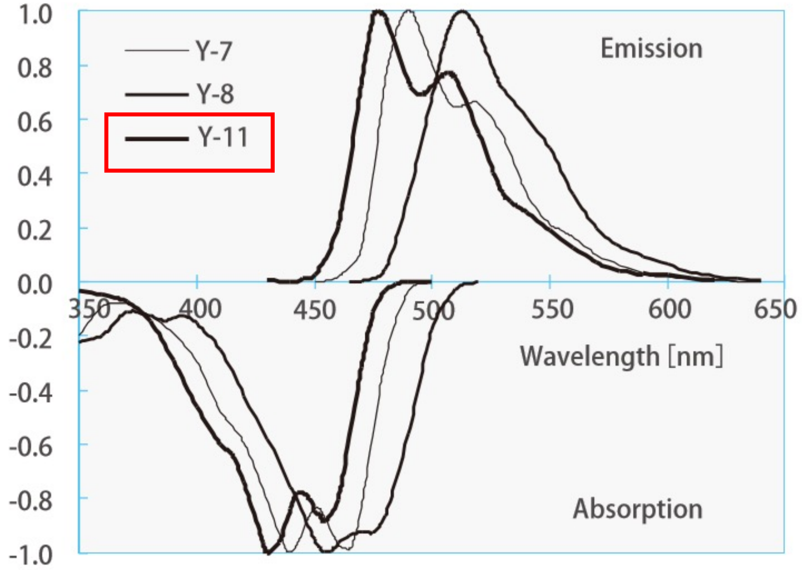


# Used fibers

- 1mm diameter fibers with aluminized endcaps
- WLS Y-11 fibers (exitation 440nm, to emission 490nm)
- For LY setup: SCSF-78 scintillating fibers (emission peak 428nm)



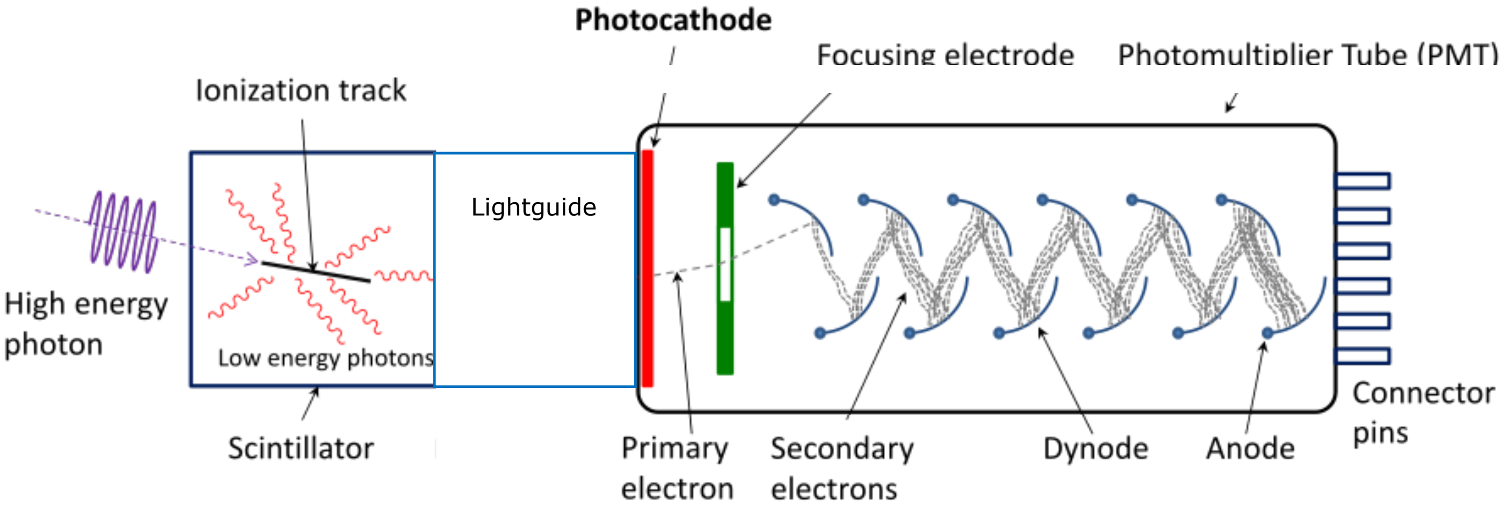



[3] http://kuraraypsf.jp/pdf/all.pdf

# Photomultiplier tubes

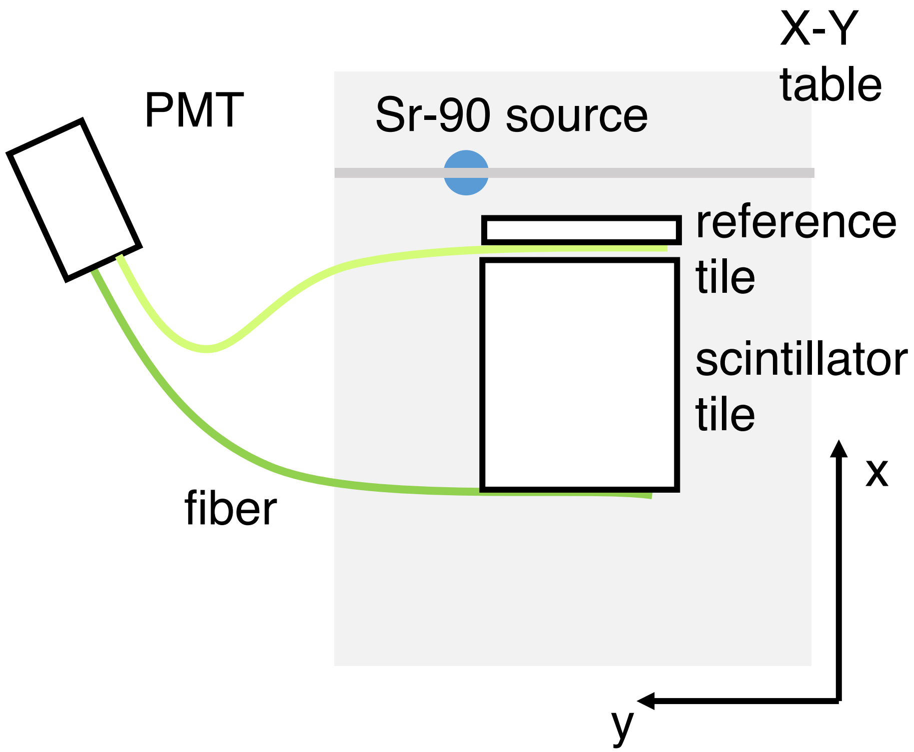
- fiber coupled to PMT via lightguide
- emission of electrons due to photoelectric effect
- multiplied by a system of dynodes (G = $10^6$ )

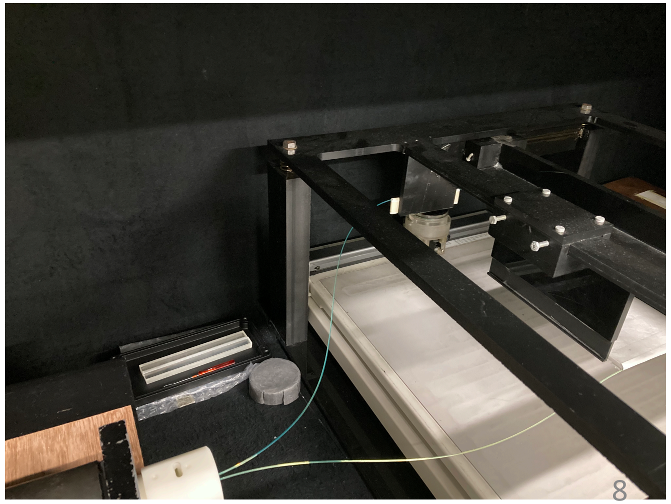



[4] https://en.wikipedia.org/wiki/Scintillation_counter

# Tilemeter

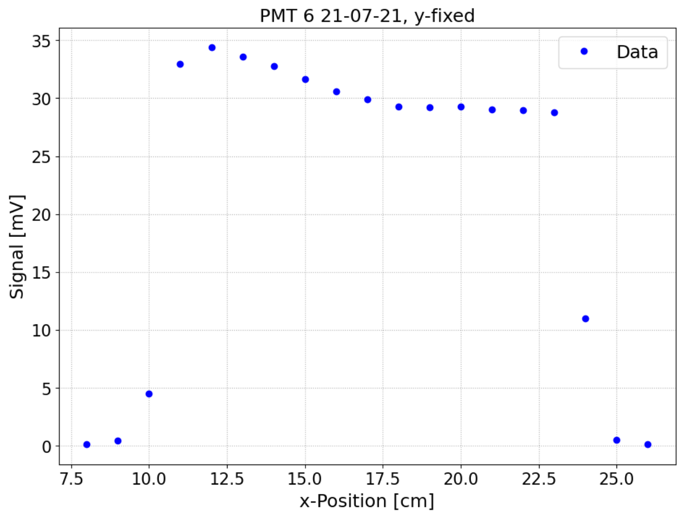
- Setup at LOMaCs Tilemeter:
- Sr-90 $\beta^-$-decay: $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y \rightarrow {}^{90}_{40}Zr$
- Usually used to scan tiles
- PMT Tests performed
  - Tyvek wrapped scintillator tiles
  - Same tiles & base used in all measurements
  - Set of PMT XP2012/2008

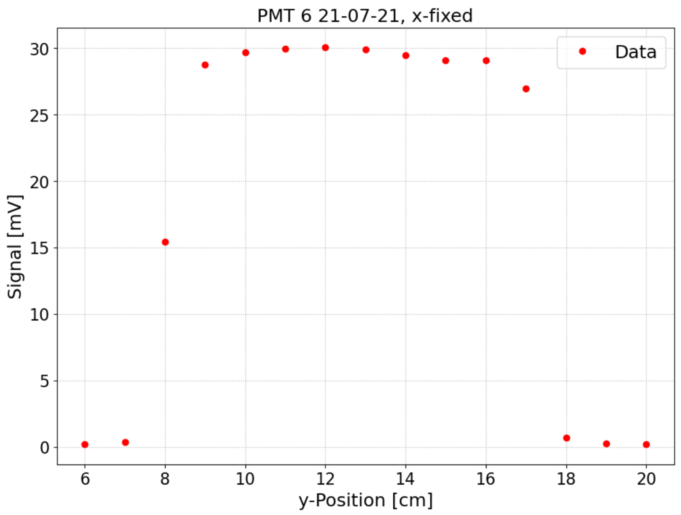


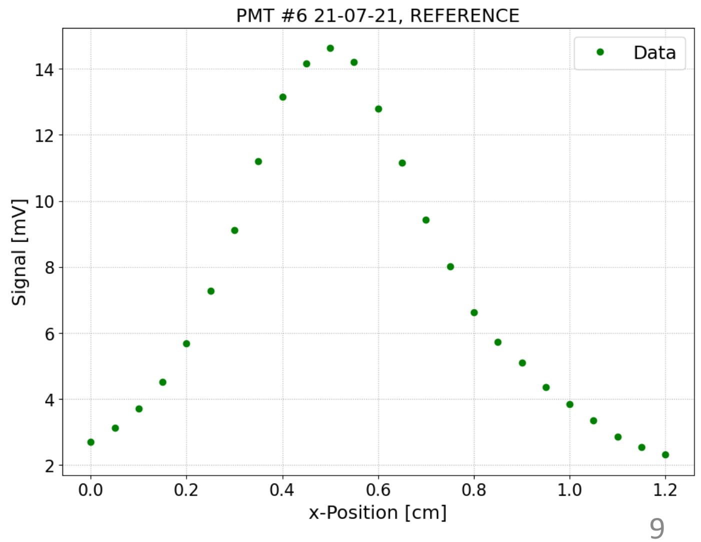



# Tile scanning tests

- Testing the PMTs with the tilemeter setup
  - Longitudinal, transversal and reference tile scan for 13 PMTs
- Uniform response in y-direction
- Biased response in  x-direction (one readout WLS fibre)

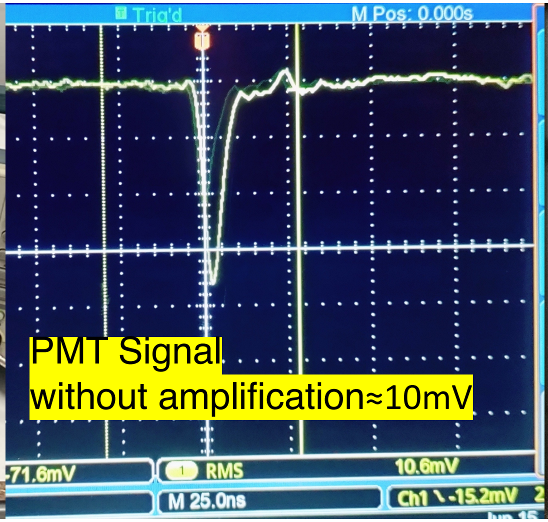


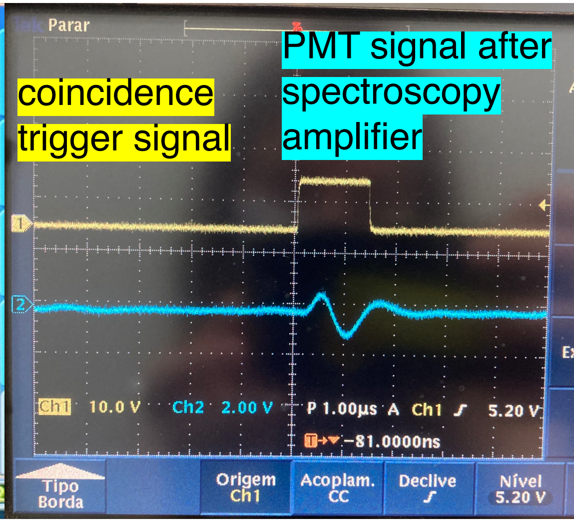



# Hardware & Setup of coincidence unit

- Testing the hardware components with function generator
    - coincidence, gate & delay unit, discriminator
- Designing new parts for the setup in solidworks
- Testing coincidence setup with PMT signal

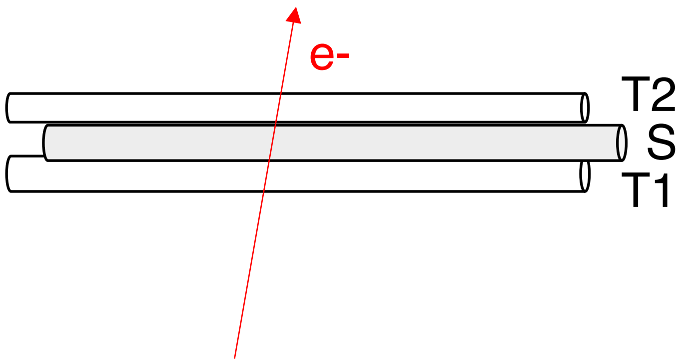


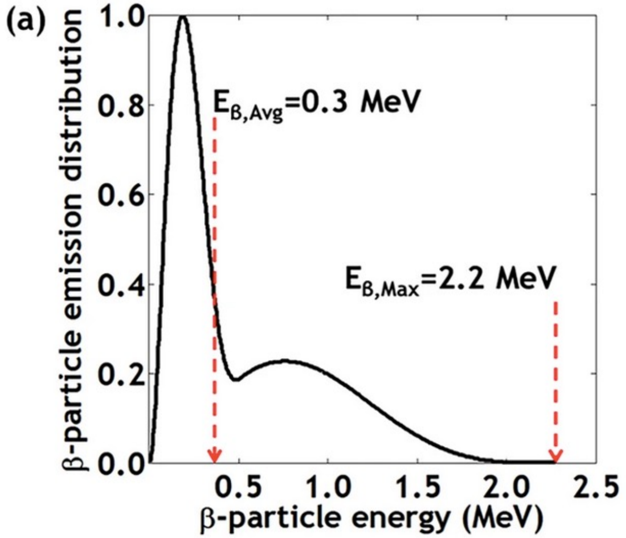



# Assembling & Final setup

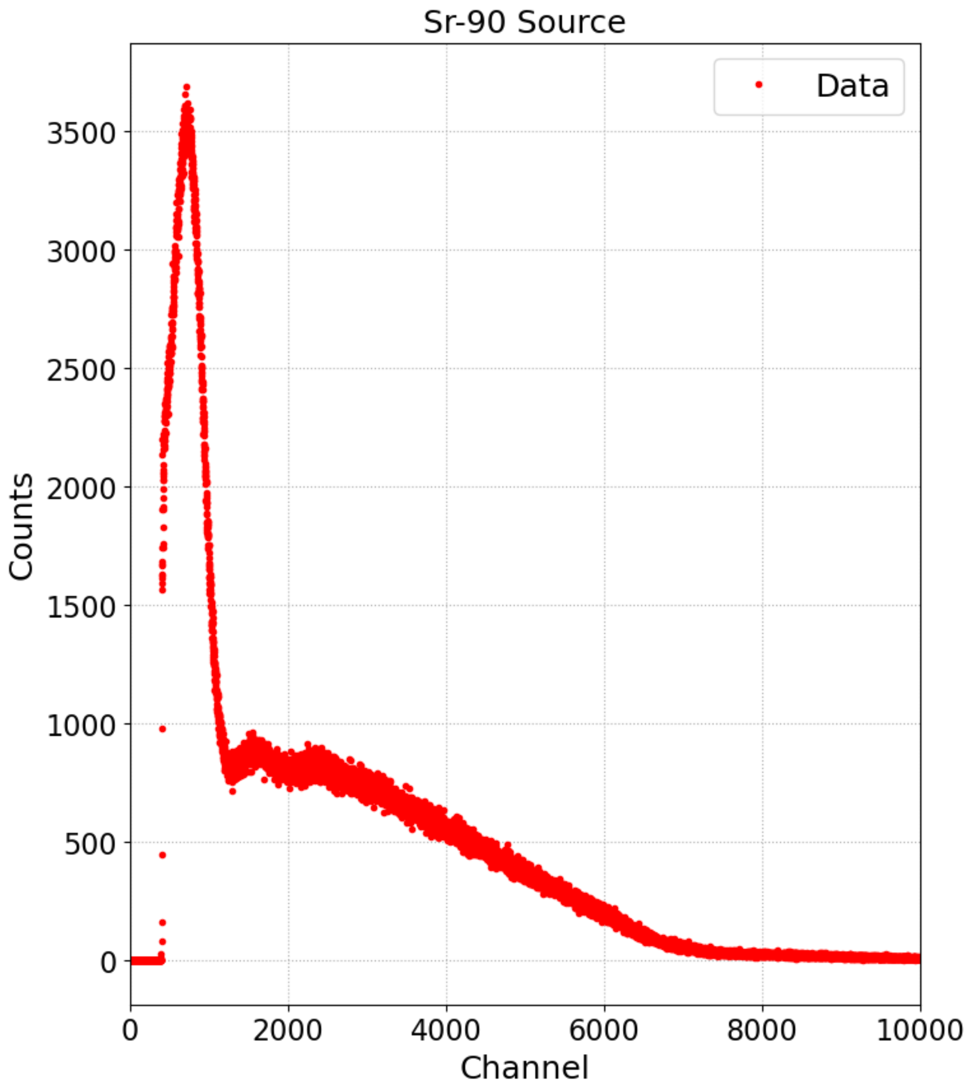
# First spectrum

- Signal of central fibre S
- measuring 360 s with Sr-90 source
- using the coincidence setup




[2] https://www.nature.com/articles/srep38182/figures/1



# Problems

- Setup:
  - High background noise of the PMTs
  - High noise in the lower energy spectrum
  - Trigger/Coincidence window to large
- Calibration:
  - Electrons from Sr-90 source have a continuous spectrum
  - Saturation of PMTs at medium high LED currents

# Summary & Lookout

- Testing and understanding components for a scintillator setup
- Setup a spectrometer
- Obtain fist measurements

- Installing lower noise PMTs
- Calibrate the Spectrometer with a LED

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