

Energy Calibration of Plastic Scintillator Detectors at MAX-lab in Preparation for (γ, π^+) experiments.



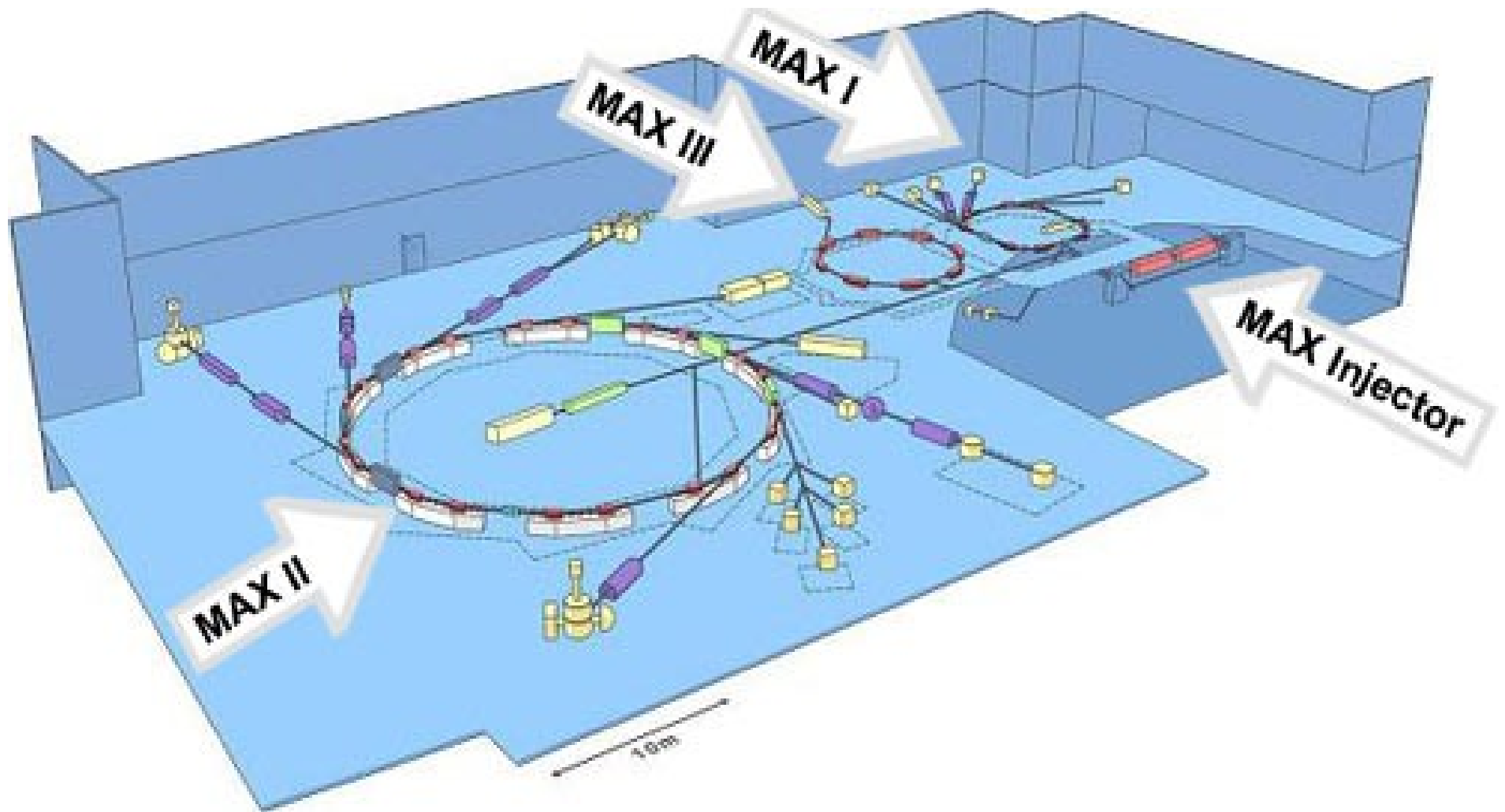
David Jacobsson
2009 – 06 - 24



This talk should give answers to these questions:

- How do we produce photons at MAX-lab?
- How do the xSal detectors work?
- How did we calibrate the detectors?
- What was the result?

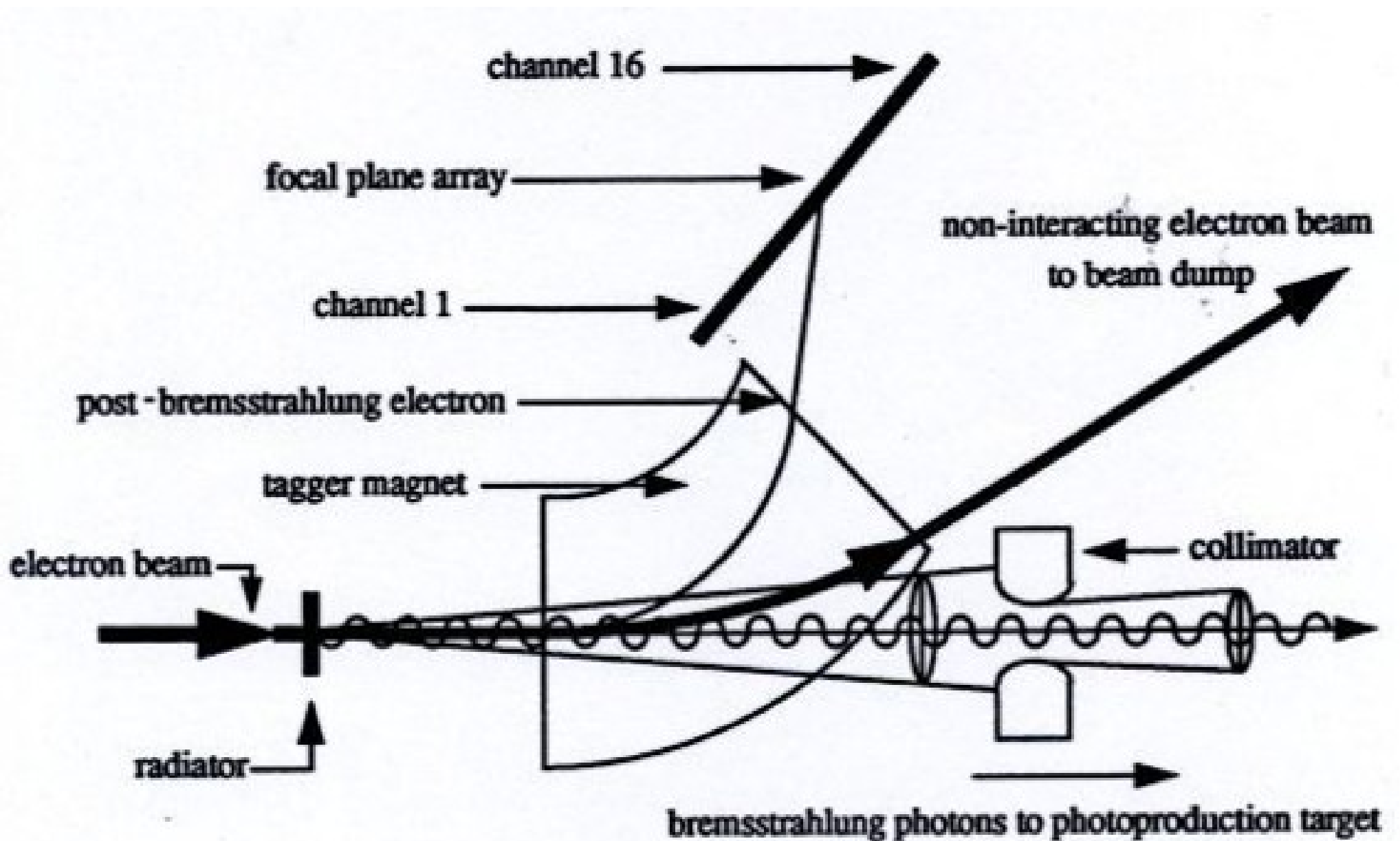
MAX-lab



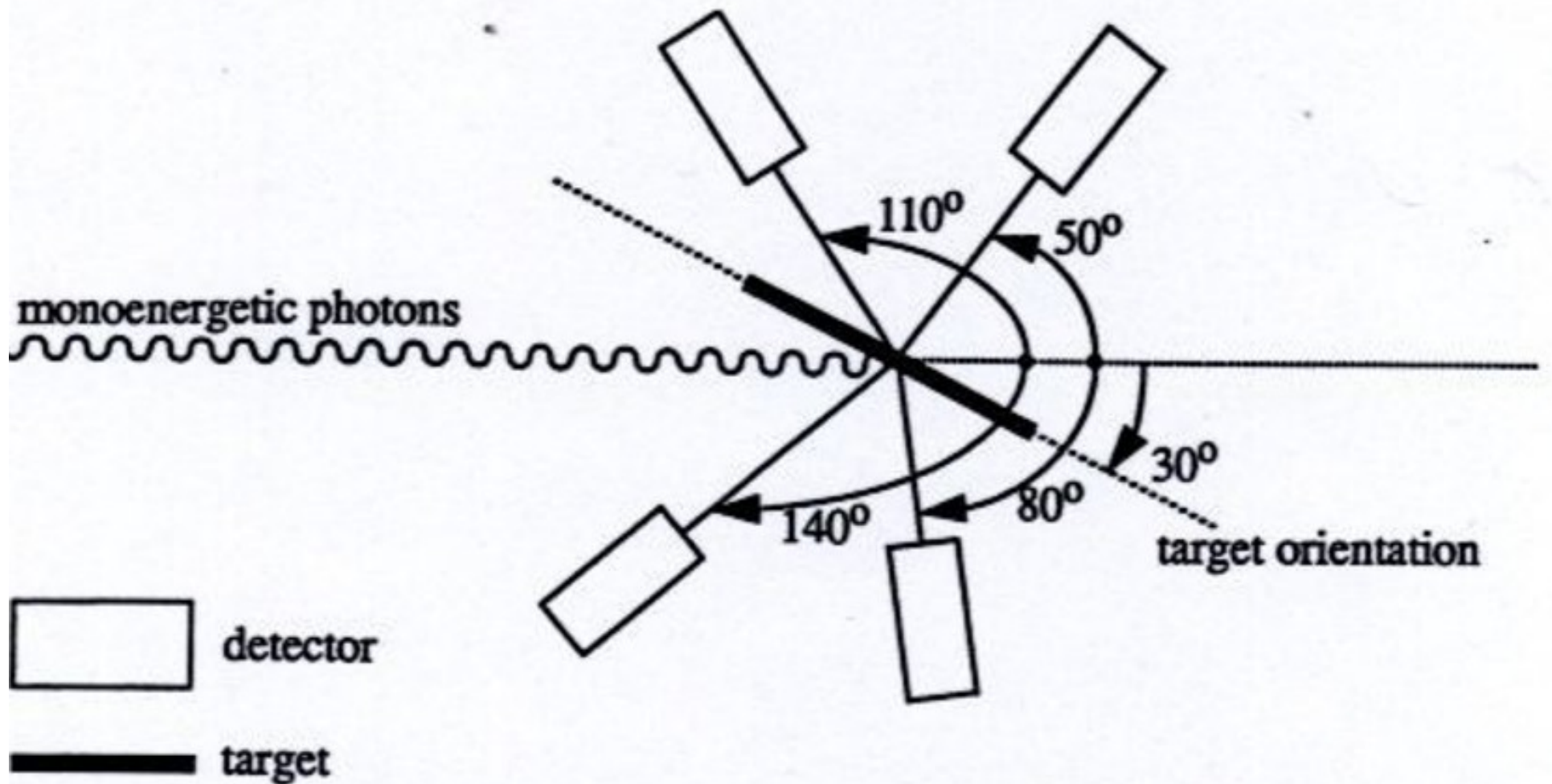
Maxlab Injection

- Electrons are produced at the filament of the Rutherford gun.
- They are then accelerated to 200 MeV by two LINACs and injected into the storage rings.
- At Max 1, the electrons are injected in pulses, between each pulse, the electrons are gradually extracted. In this way a nearly continuous beam is produced.

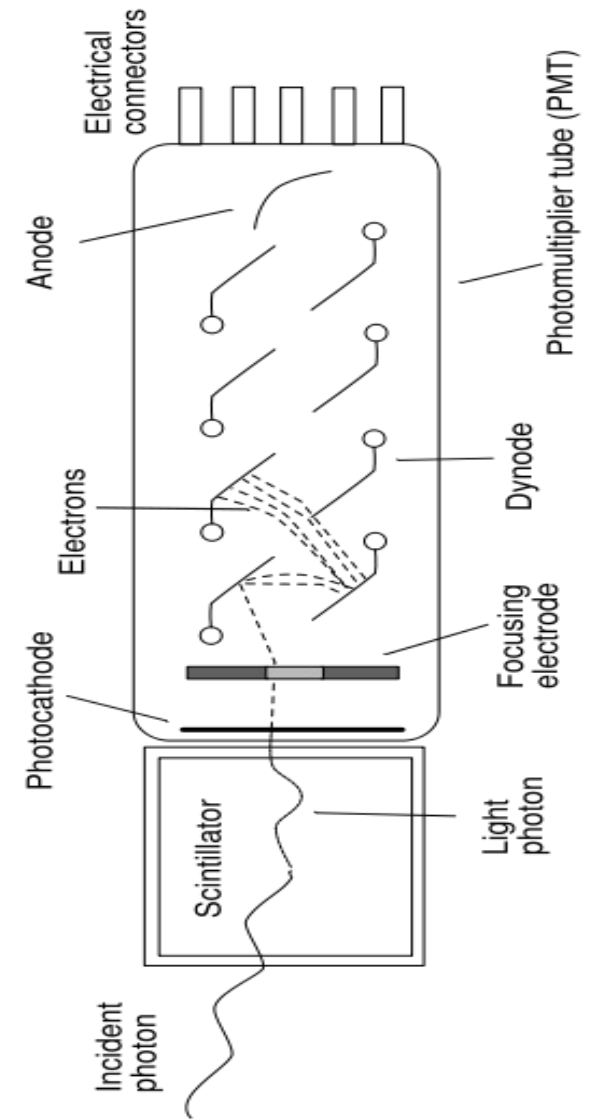
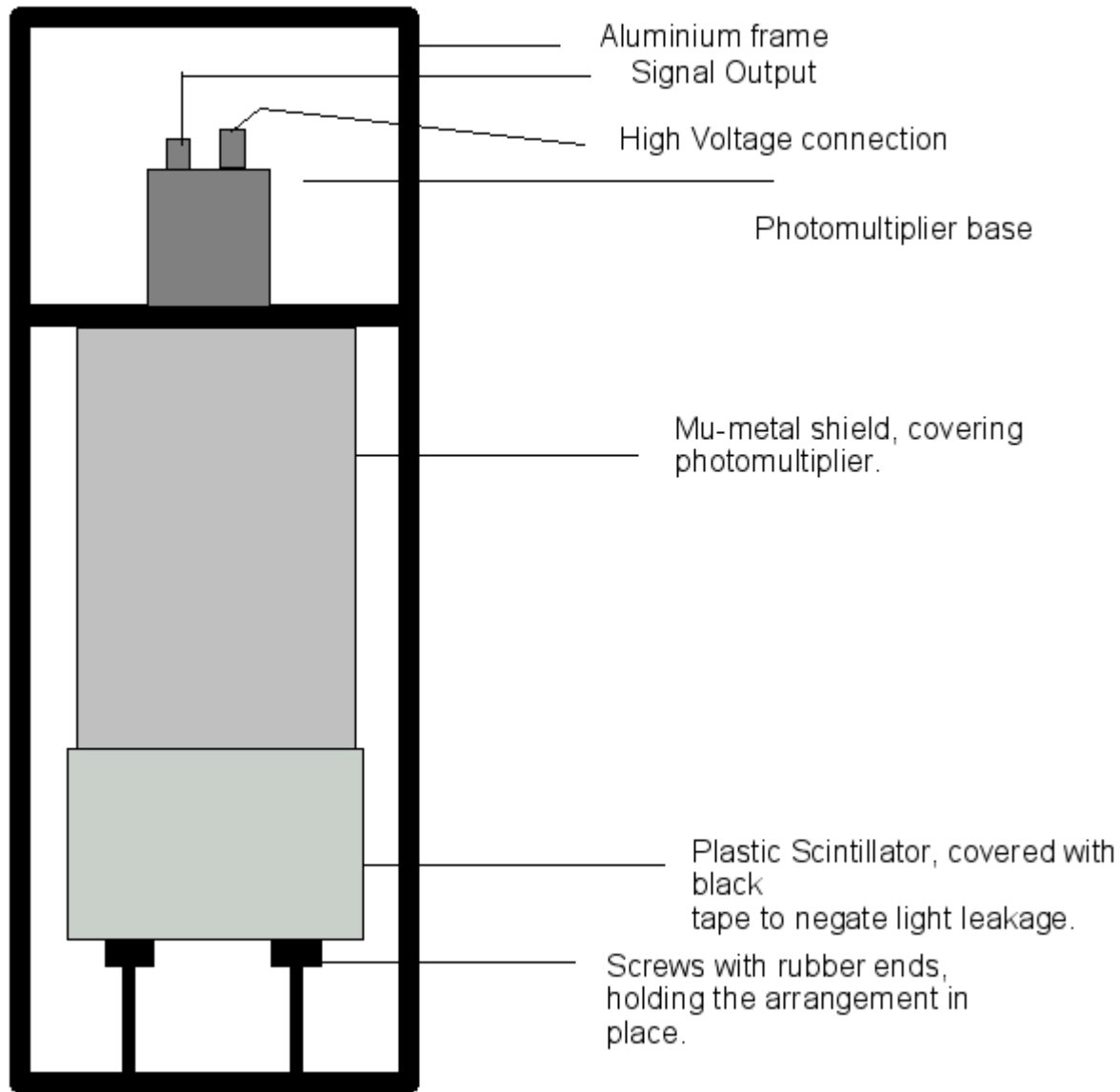
Photon Production and Photon Tagging



A Typical Photonuclear Experiment



xSal0



Plastic Scintillator

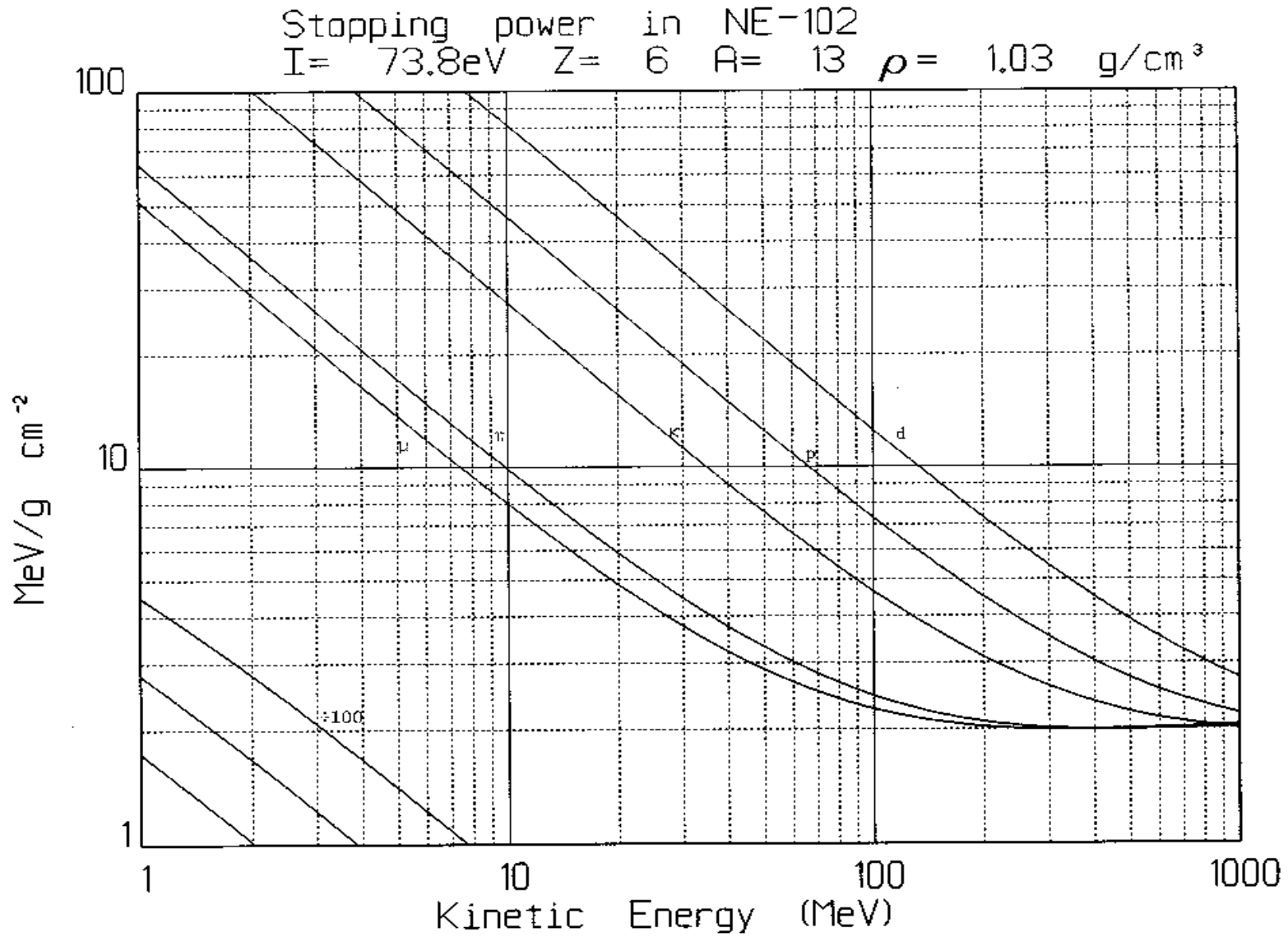
- Although organic scintillator can be both fluid and solid, the energy deposited is absorbed on a molecular level – like in a fluid.
- The scintillator is transparent to the photon radiation that is emitted upon deexcitation of the molecules.

The Bethe Equation

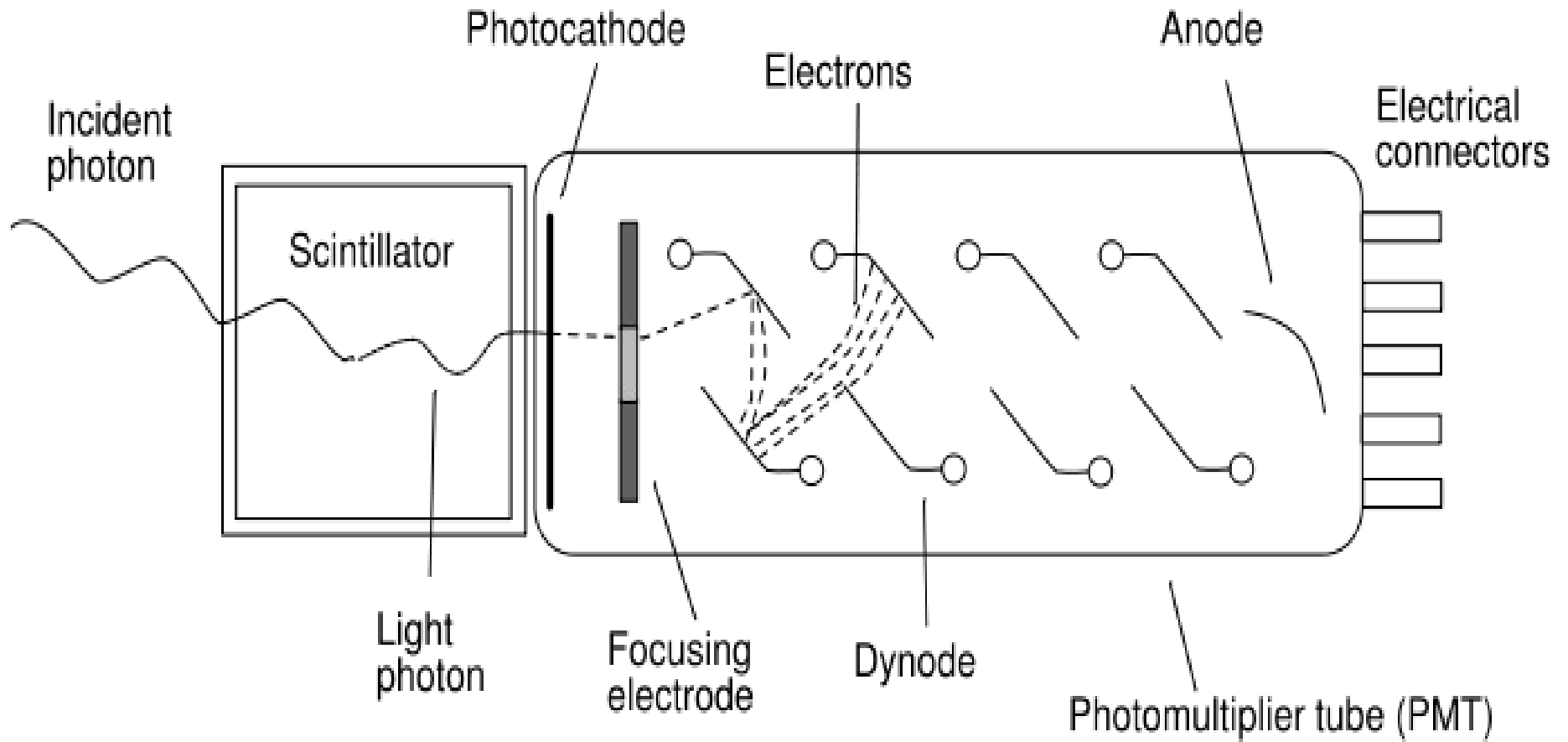
$$-\frac{dE}{dx} = \frac{4\pi}{m_e c^2} \cdot \frac{nz^2}{\beta^2} \cdot \left(\frac{e^2}{4\pi\epsilon_0}\right)^2 \cdot \left[\ln\left(\frac{2m_e c^2 \beta^2}{I \cdot (1 - \beta^2)}\right) - \beta^2 \right]$$

”I” = ”The mean excitation potential” and characterizes the material.

Energy Loss as a Function of Kinetic Energy



Photomultiplier



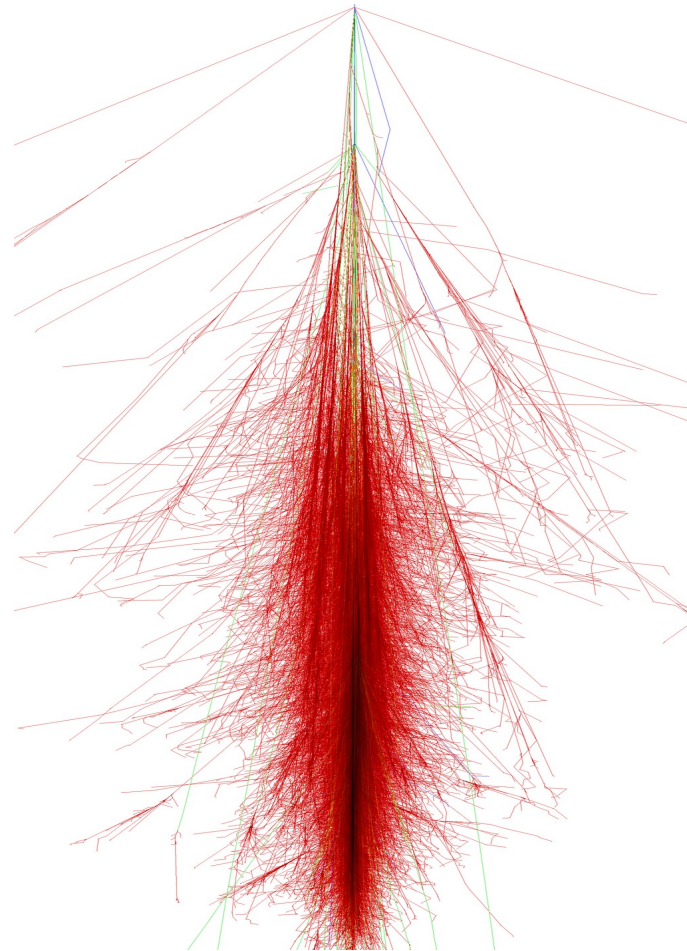
Mu-metal

- Mu-metal is an alloy of nickel and iron of very high magnetic permeability and thereby low reluctance.
- Magnetic flux follows the path of lowest reluctance.



Cosmic Rays

- 90% protons, 9% alpha particles ,1% electrons.



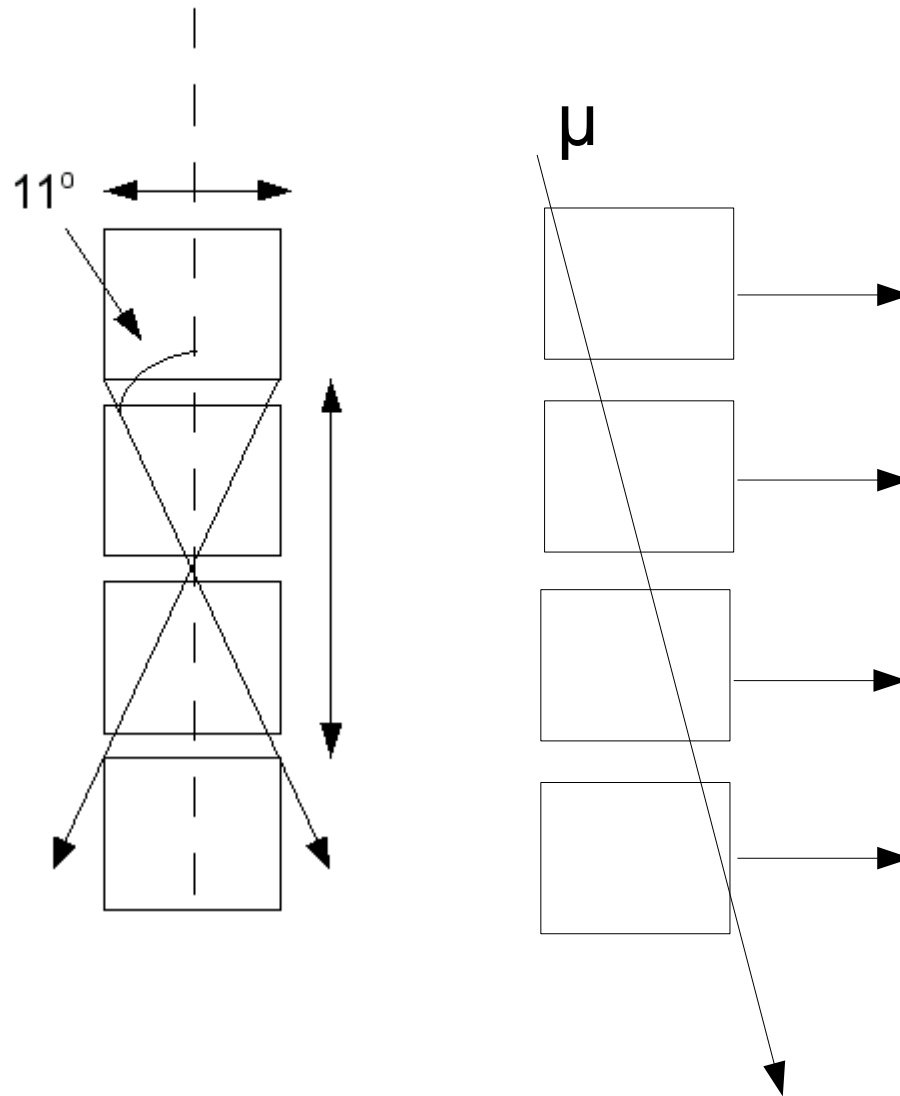
//F. Schmidt, "CORSIKA
Shower Images",
[http://www.ast.leeds.ac.uk/~fs/s
howerimages.html](http://www.ast.leeds.ac.uk/~fs/showerimages.html)

Relativistically corrected muon mean
lifetime:

$$\tau' = \gamma\tau = 34 \mu\text{s}$$

=> Flux of 10 000 muons/m² at sea-level.

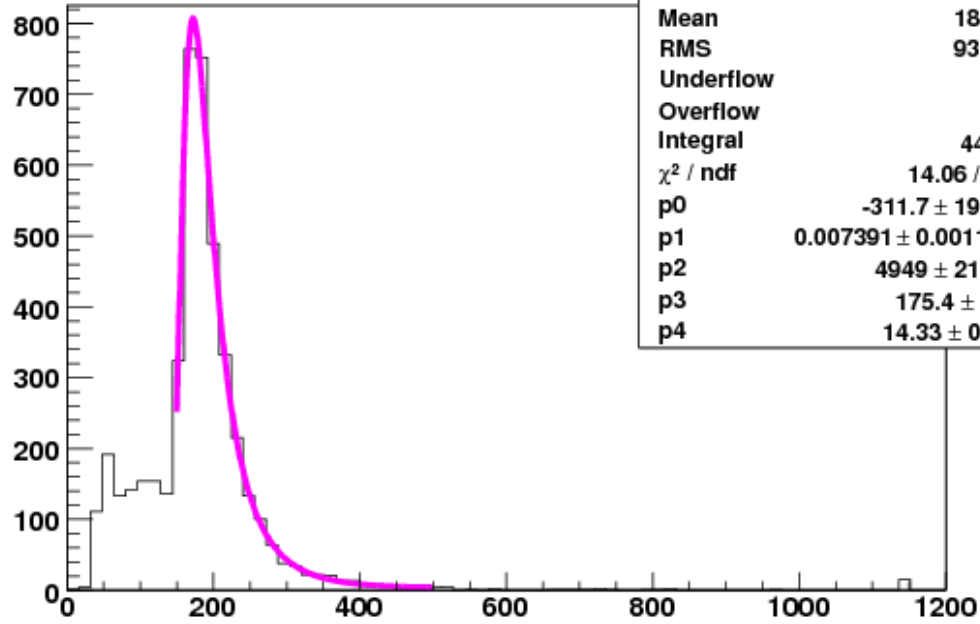
Detector Setup



ADC c2_22_0

xSal0

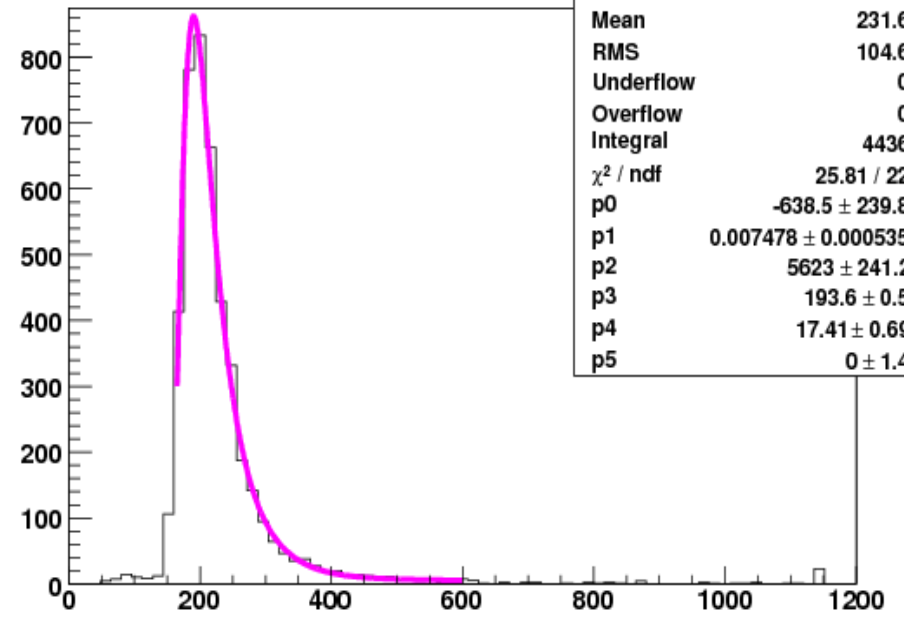
hc2_22_0	
Entries	4436
Mean	180.9
RMS	93.88
Underflow	0
Overflow	0
Integral	4436
χ^2 / ndf	14.06 / 17
p0	-311.7 ± 196.5
p1	0.007391 ± 0.001152
p2	4949 ± 213.3
p3	175.4 ± 0.5
p4	14.33 ± 0.66



ADC c2_22_2

xSal2

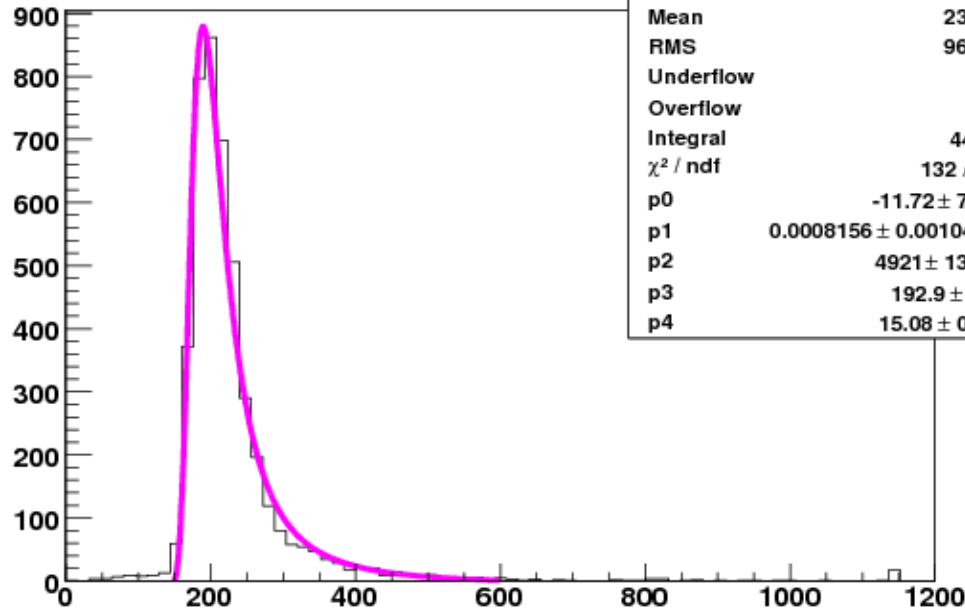
hc2_22_2	
Entries	4436
Mean	231.6
RMS	104.6
Underflow	0
Overflow	0
Integral	4436
χ^2 / ndf	25.81 / 22
p0	-638.5 ± 239.8
p1	0.007478 ± 0.000535
p2	5623 ± 241.2
p3	193.6 ± 0.5
p4	17.41 ± 0.69
p5	0 ± 1.4



ADC c2_22_1

xSal1

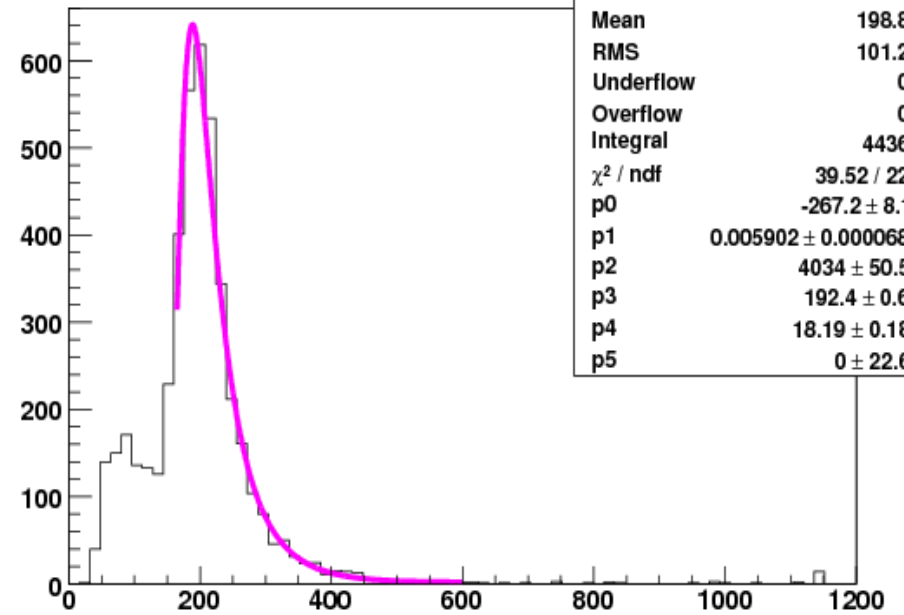
hc2_22_1	
Entries	4436
Mean	230.5
RMS	96.78
Underflow	0
Overflow	0
Integral	4436
χ^2 / ndf	132 / 24
p0	-11.72 ± 7.46
p1	0.0008156 ± 0.0010420
p2	4921 ± 133.2
p3	192.9 ± 0.5
p4	15.08 ± 0.53



ADC c2_22_3

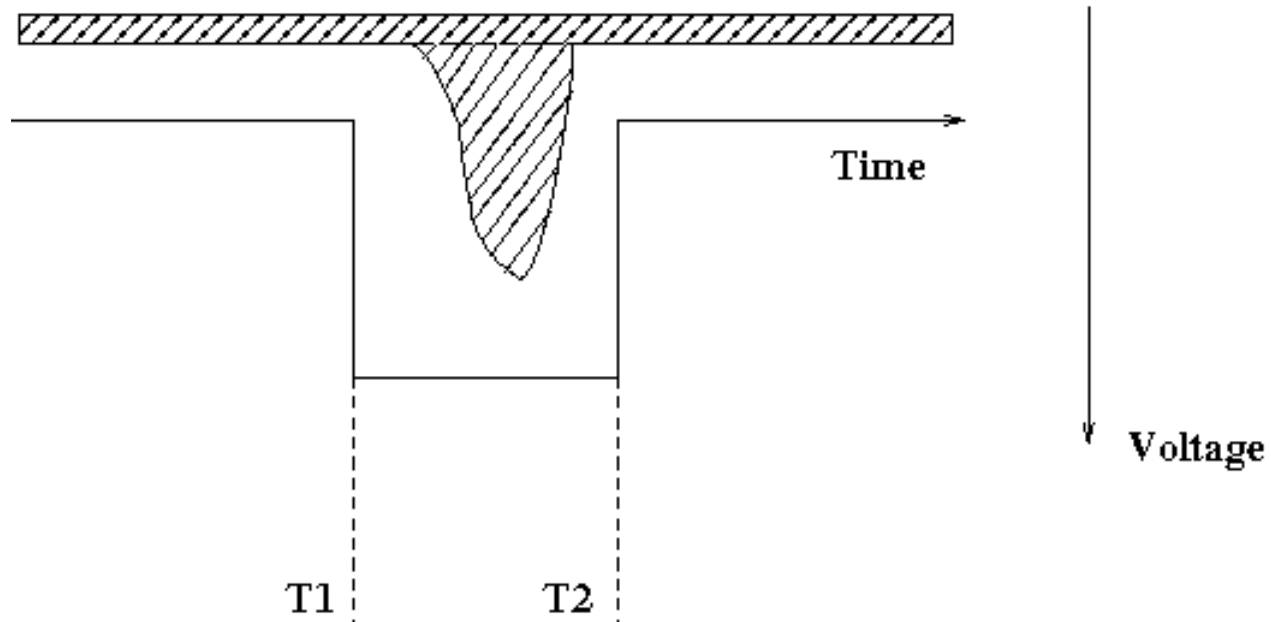
xSal3

hc2_22_3	
Entries	4436
Mean	198.8
RMS	101.2
Underflow	0
Overflow	0
Integral	4436
χ^2 / ndf	39.52 / 22
p0	-267.2 ± 8.1
p1	0.005902 ± 0.000068
p2	4034 ± 50.5
p3	192.4 ± 0.6
p4	18.19 ± 0.18
p5	0 ± 22.6



Gain Matching

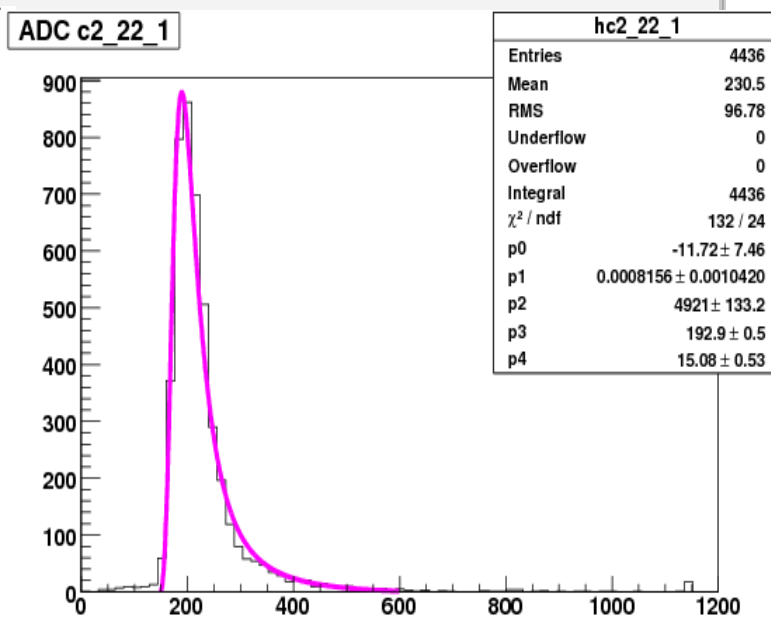
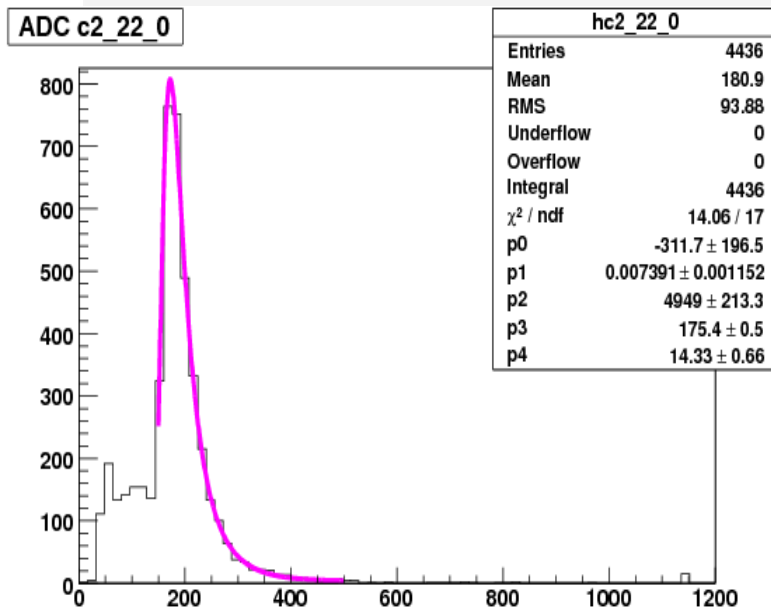
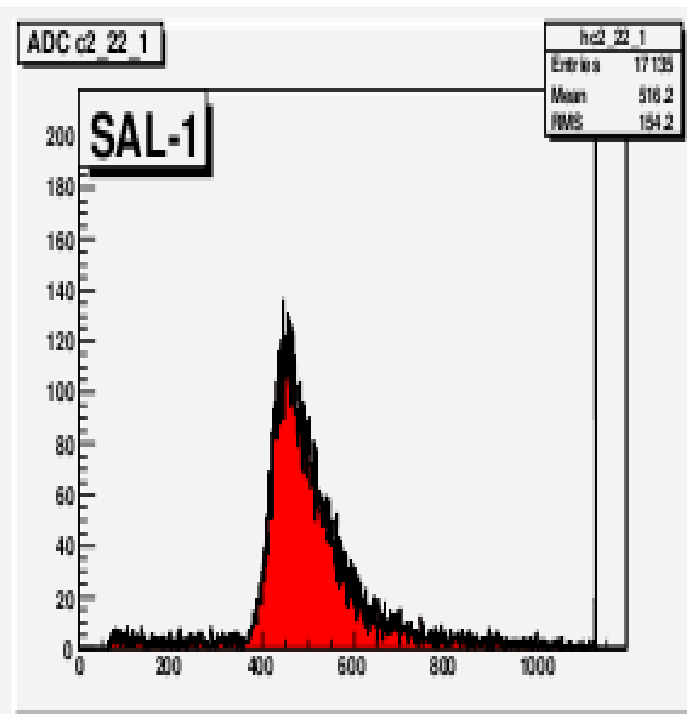
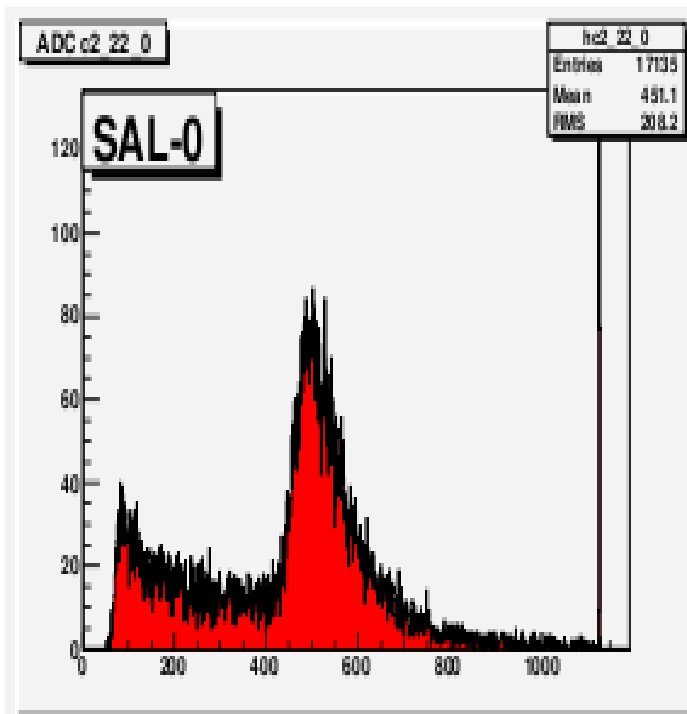
- $\text{Gain} = (\text{Peak} - \text{Offset}) / \text{Energy}$



Final Gain Match

Detector	High Voltage	Gain
xSal0	1865	$6,3 \pm 0,2$
xSal1	1720	$6,9 \pm 0,2$
xSal2	1960	$6,6 \pm 0,3$
xSal3	1900	$6,7 \pm 0,3$

Comparison to Earlier Results



Conclusion

- Gain matching with muons is possible.
- If more exact energy calibration would be needed, more detectors in the stack could be added or the spacing between them increased.

