MODULAR TOTAL ABSORPTION SPECTROMETER (MTAS) FOR DECAY HEAT STUDIES OF FISSION PRODUCTS

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Advance Fuel Cycle Applications, Nuclear Structure and Astrophysics
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OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Plan

Oak Ridge MTAS description

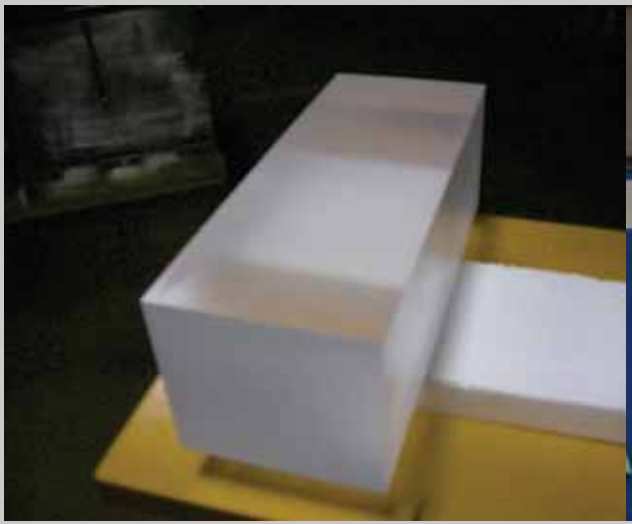
First tests

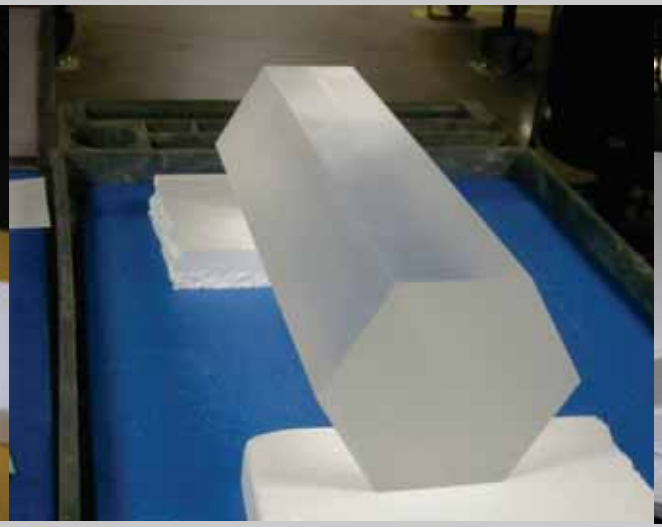
Simulations

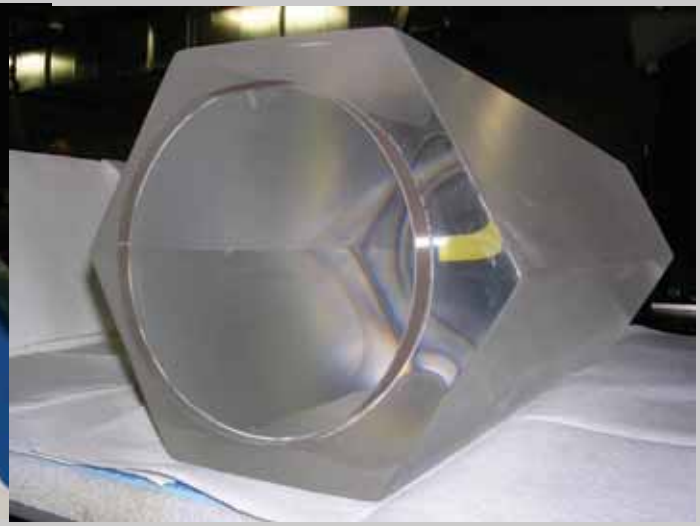
Developments

All modules of MTAS were grown, encapsulated and tested at Saint Gobain Crystal plant in Hiram, Ohio.

PRODUCTION OF MTAS MODULES

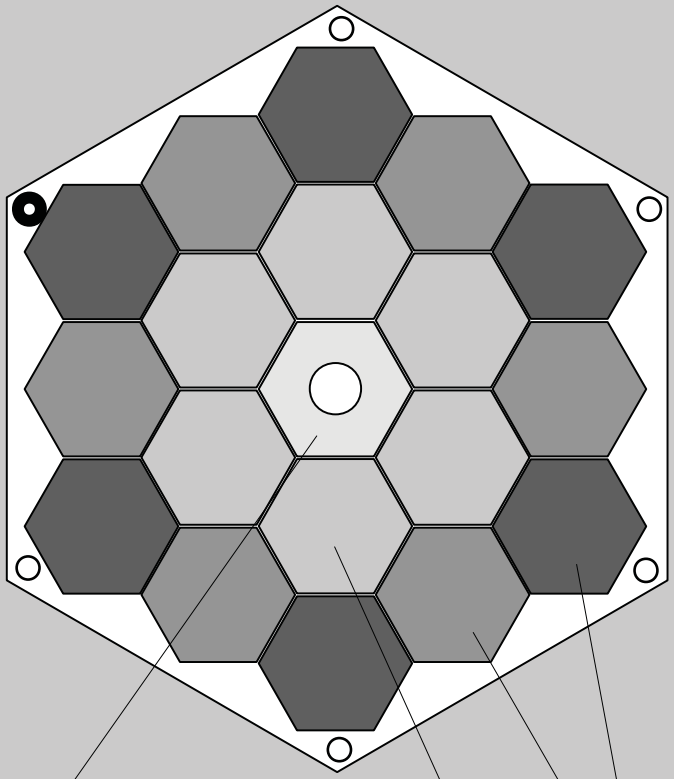


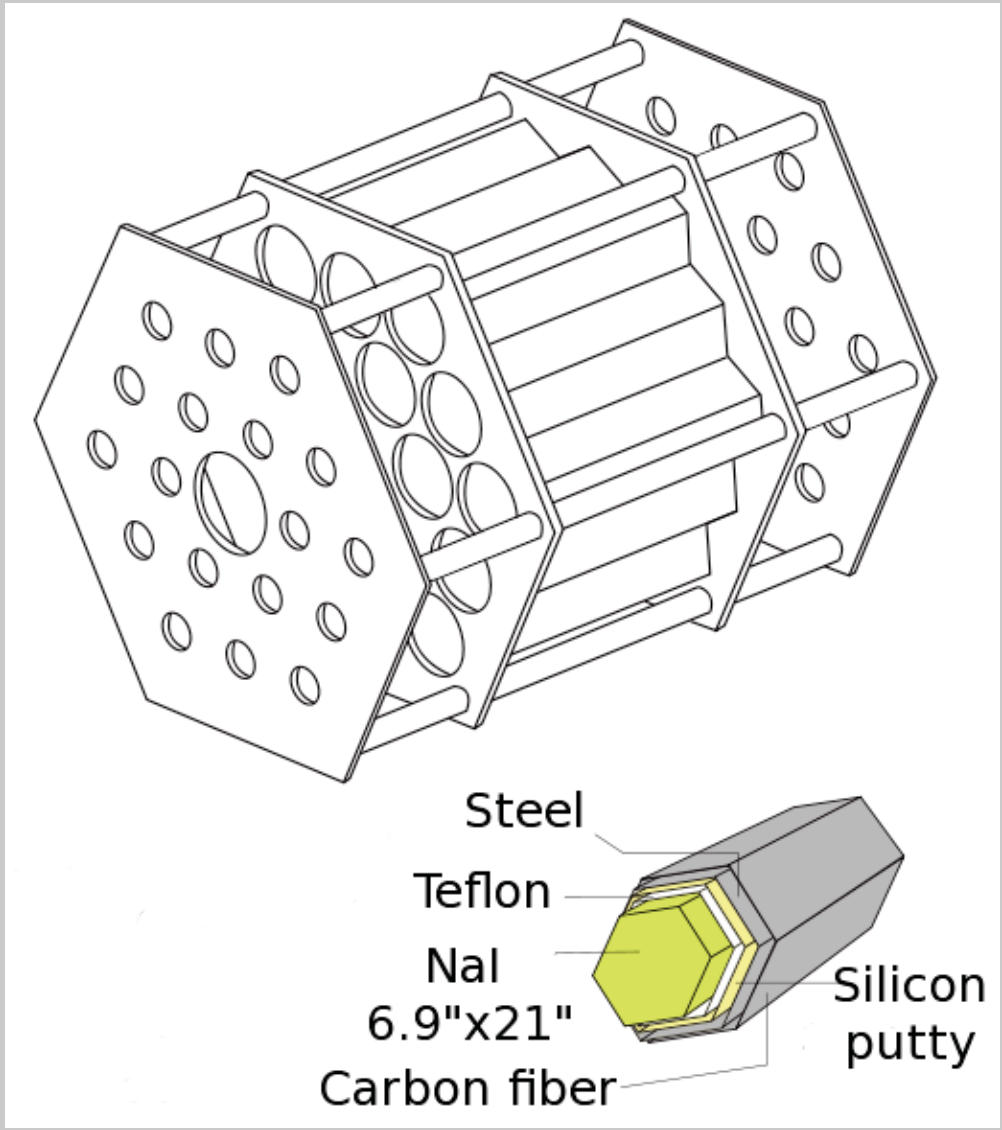




MTAS is constructed from 18 hexagonal modules plus one central with the 2.5” hole

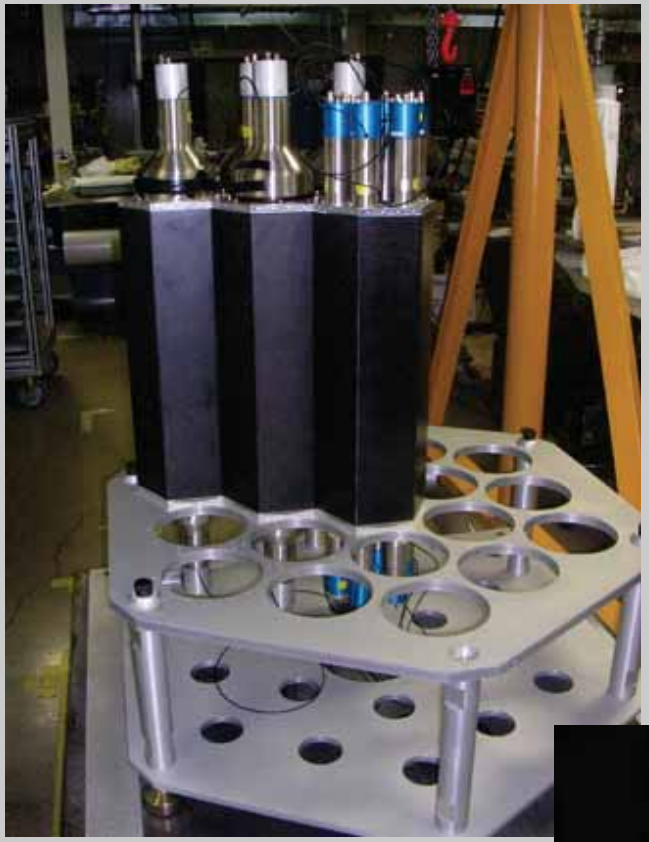
SCHEMATIC VIEW OF MTAS





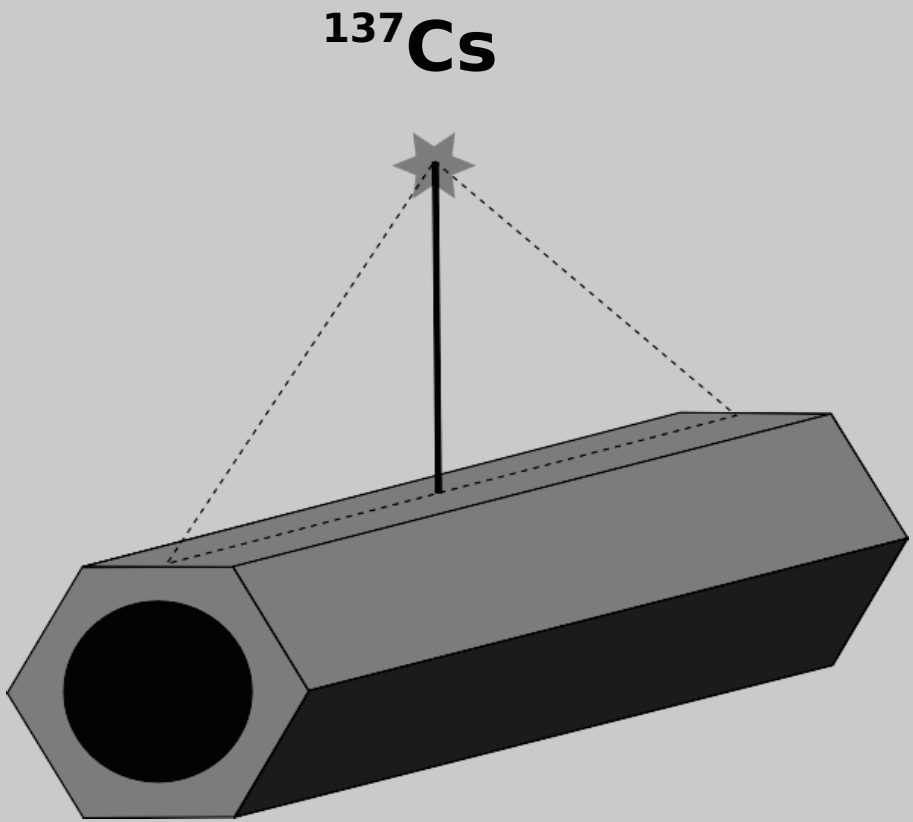
All modules were assembled in one support frame and the detector was shipped to Oak Ridge

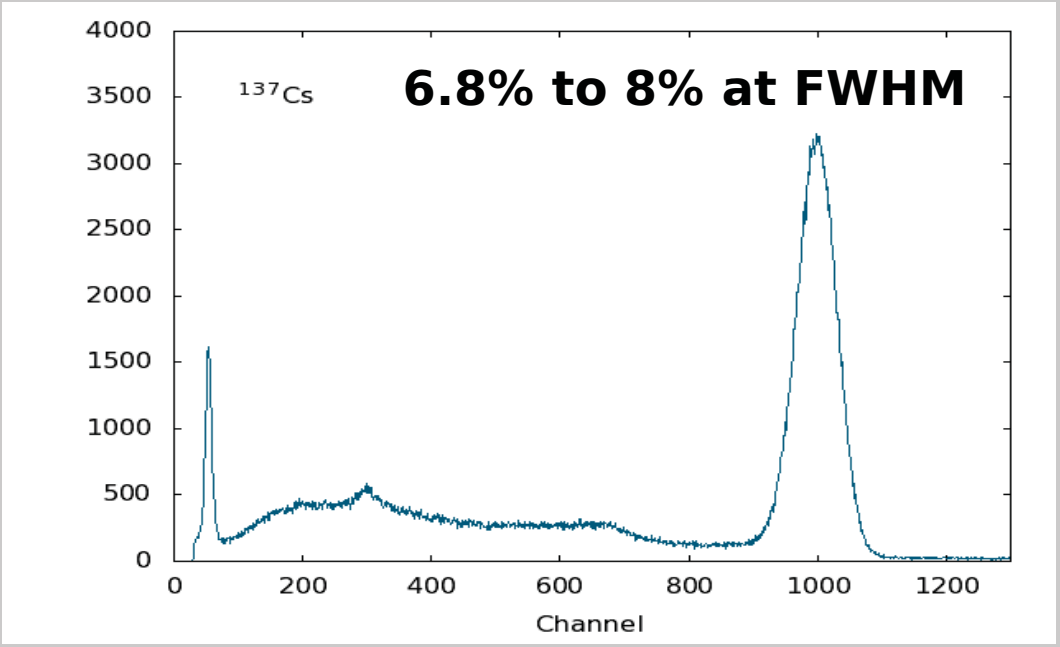
BUILDING THE DETECTOR



Test measurements full modules with a broad beam of ^{137}Cs show a typical resolution of 6.8% to 8% at FWHM for the 661keV line.

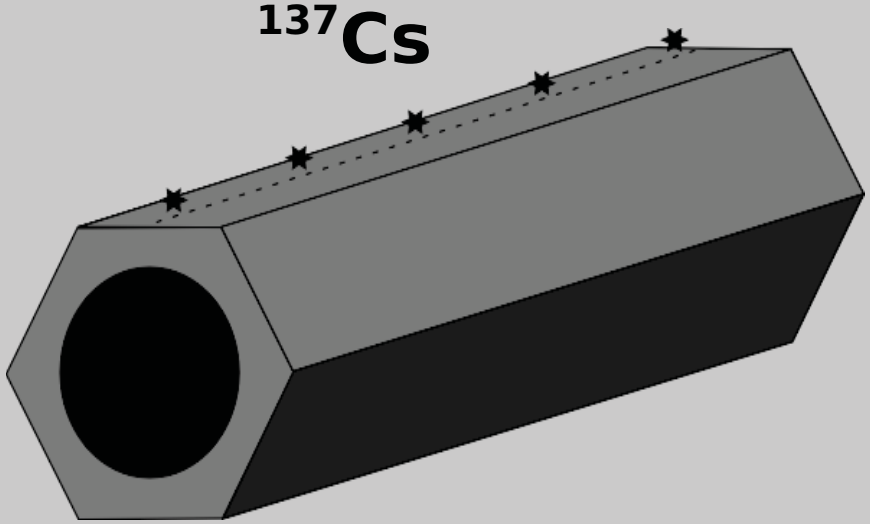
TEST MEASUREMENTS WITH A BROAD BEAM

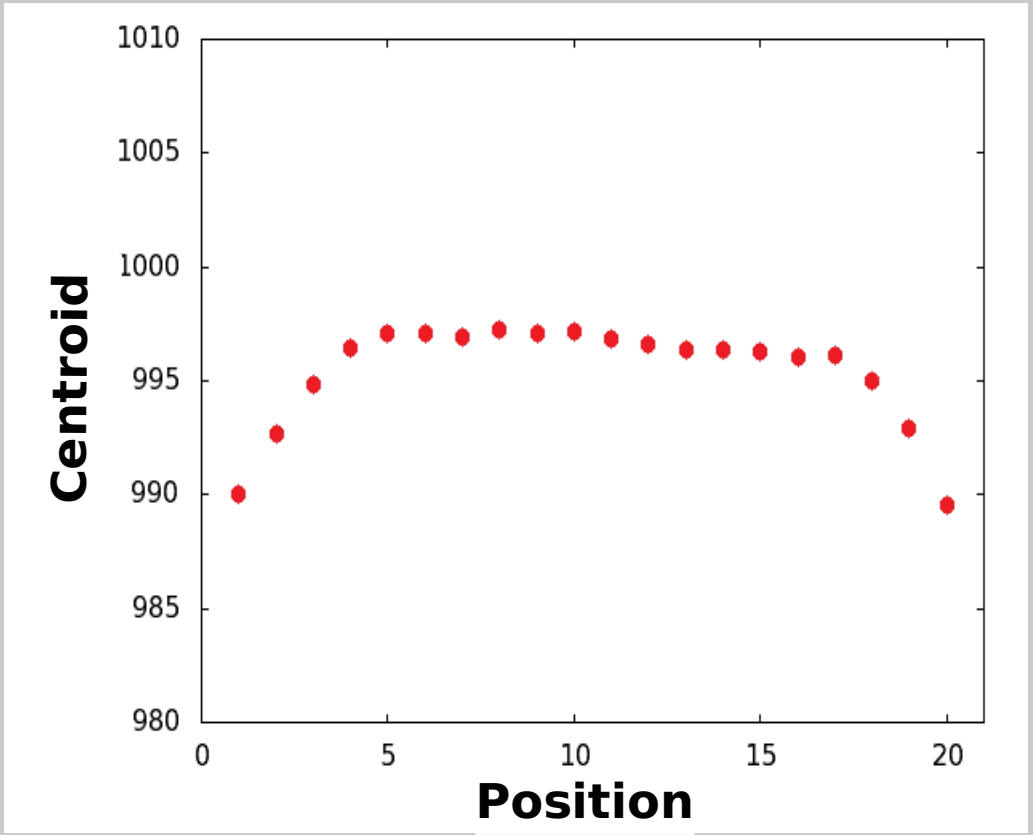




Uniformity of each crystal was measured with ^{137}Cs source placed close to each side (19 measurements 1” each apart)

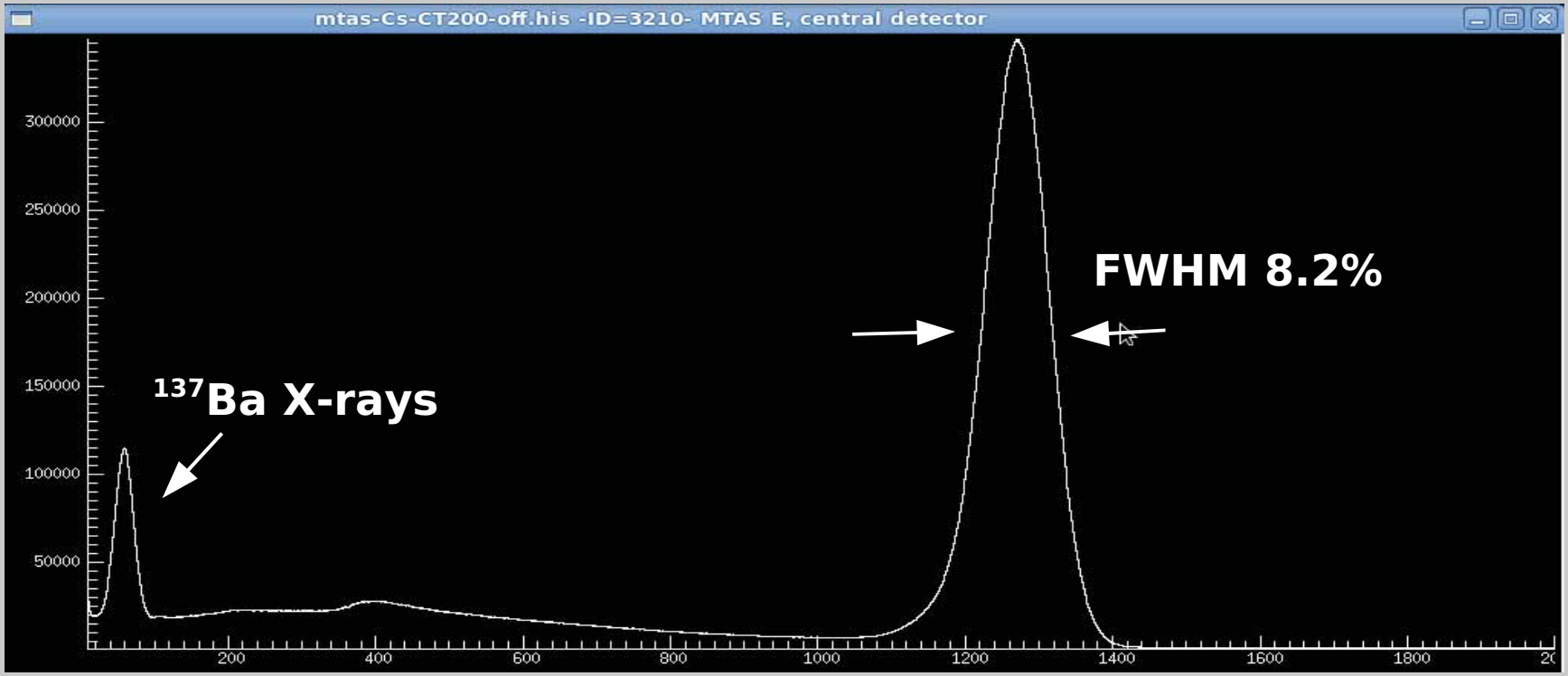
TEST OF A SINGLE MODULE UNIFORMITY

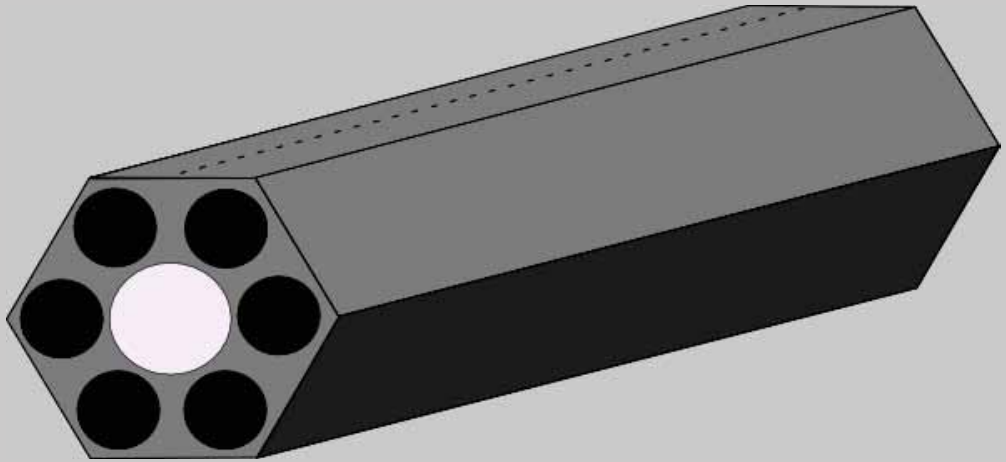




The FWHM for ^{137}Cs 662keV line in central module is below 8.5%, while threshold for all 12 summed signals is below 30keV

CENTRAL MODULE



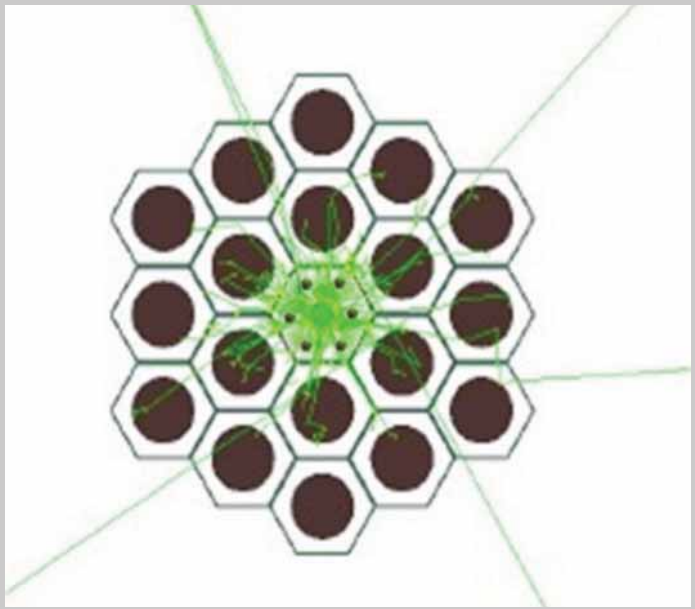


Results of energy deposit simulations for Central and Inner module agree well with the ^{137}Cs measurements

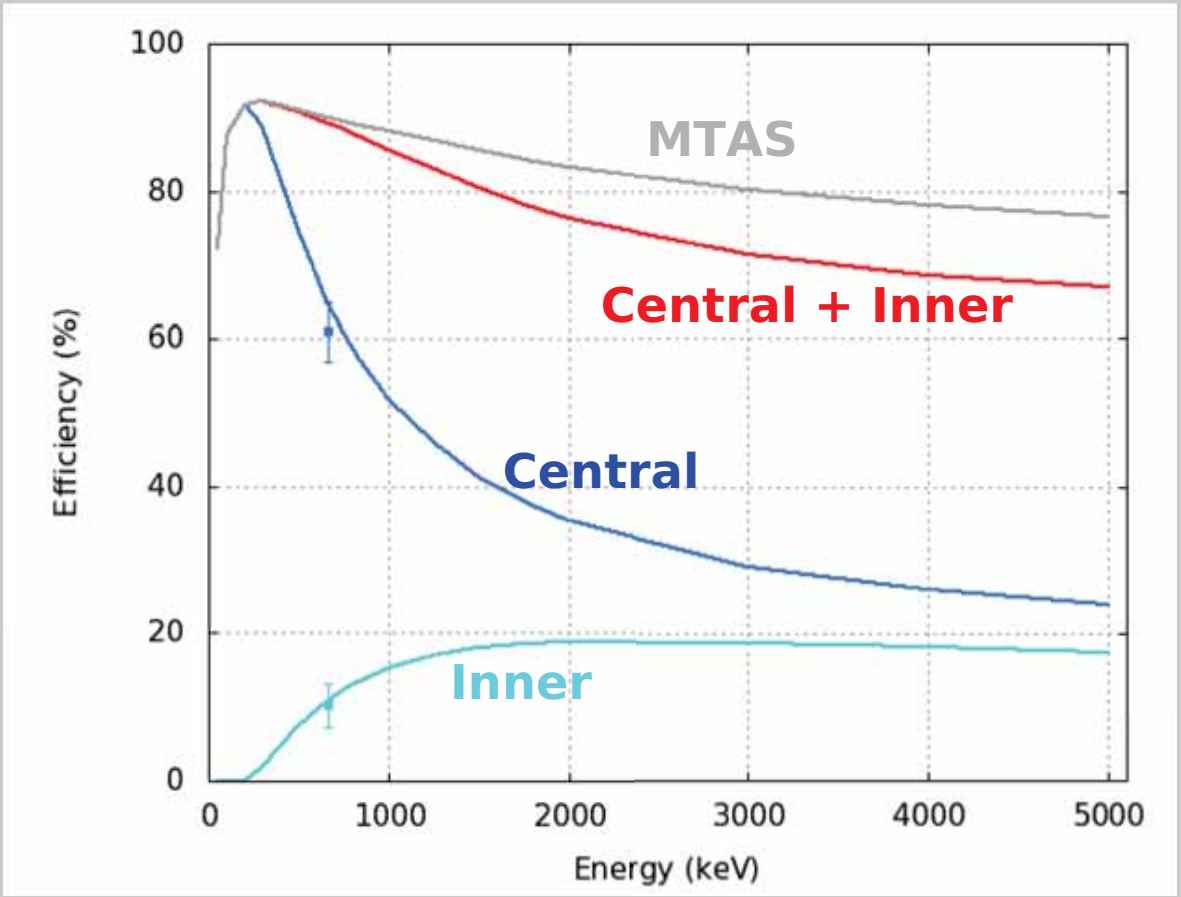
GEANT4 SIMULATIONS OF THE ENERGY DEPOSIT

100 events of

1 MeV gammas



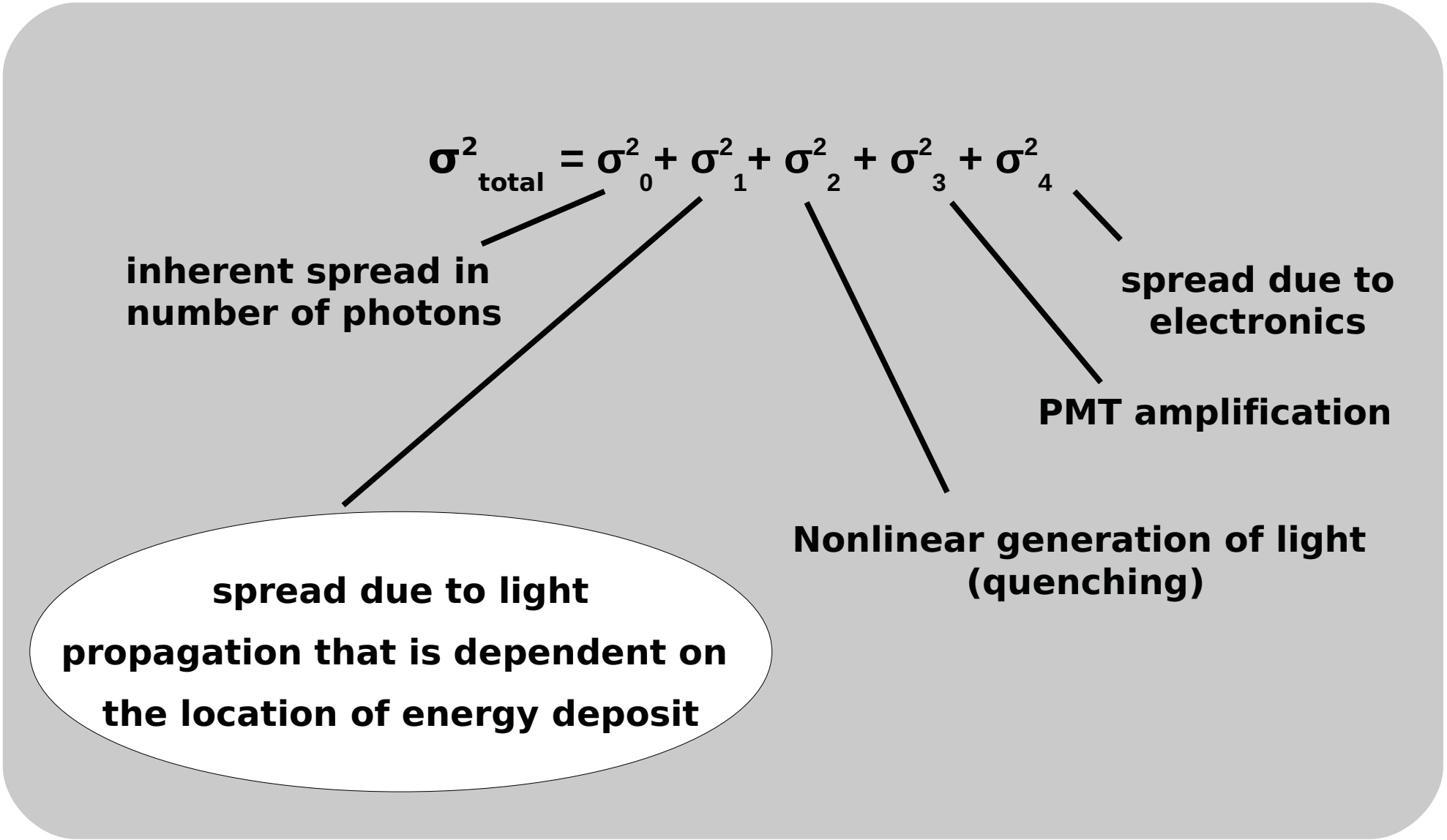
Full γ energy efficiency



Calculation by: A. Kuźniak, University of Warsaw

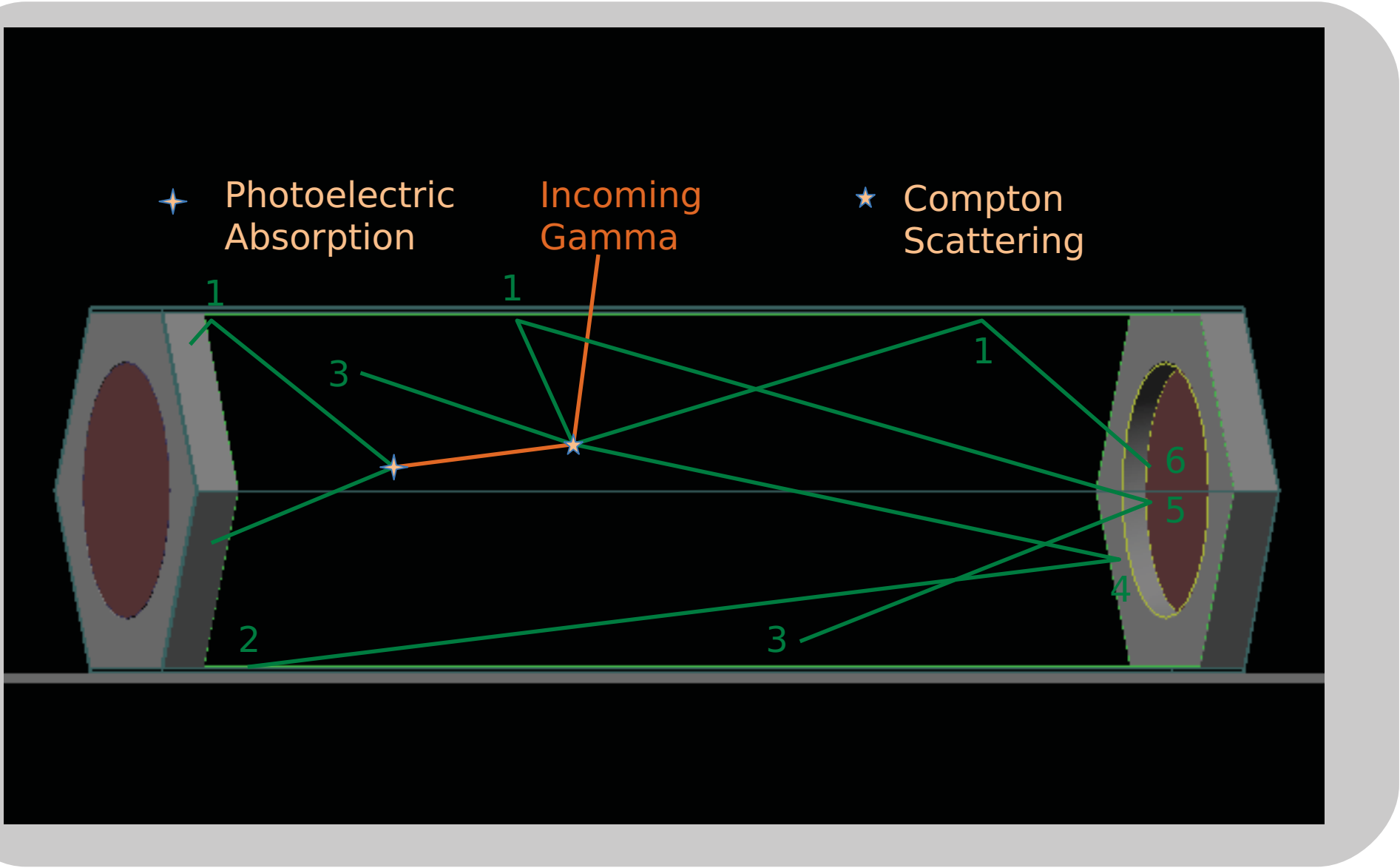
Many process add to the width of the line, with the non-linear light generation being one of the dominant

TOTAL WIDTH OF THE LINES



Different process contribute to the optical photons propagation in the NaI crystal

PATHS OF OPTICAL PHOTONS IN NaI DETECTOR



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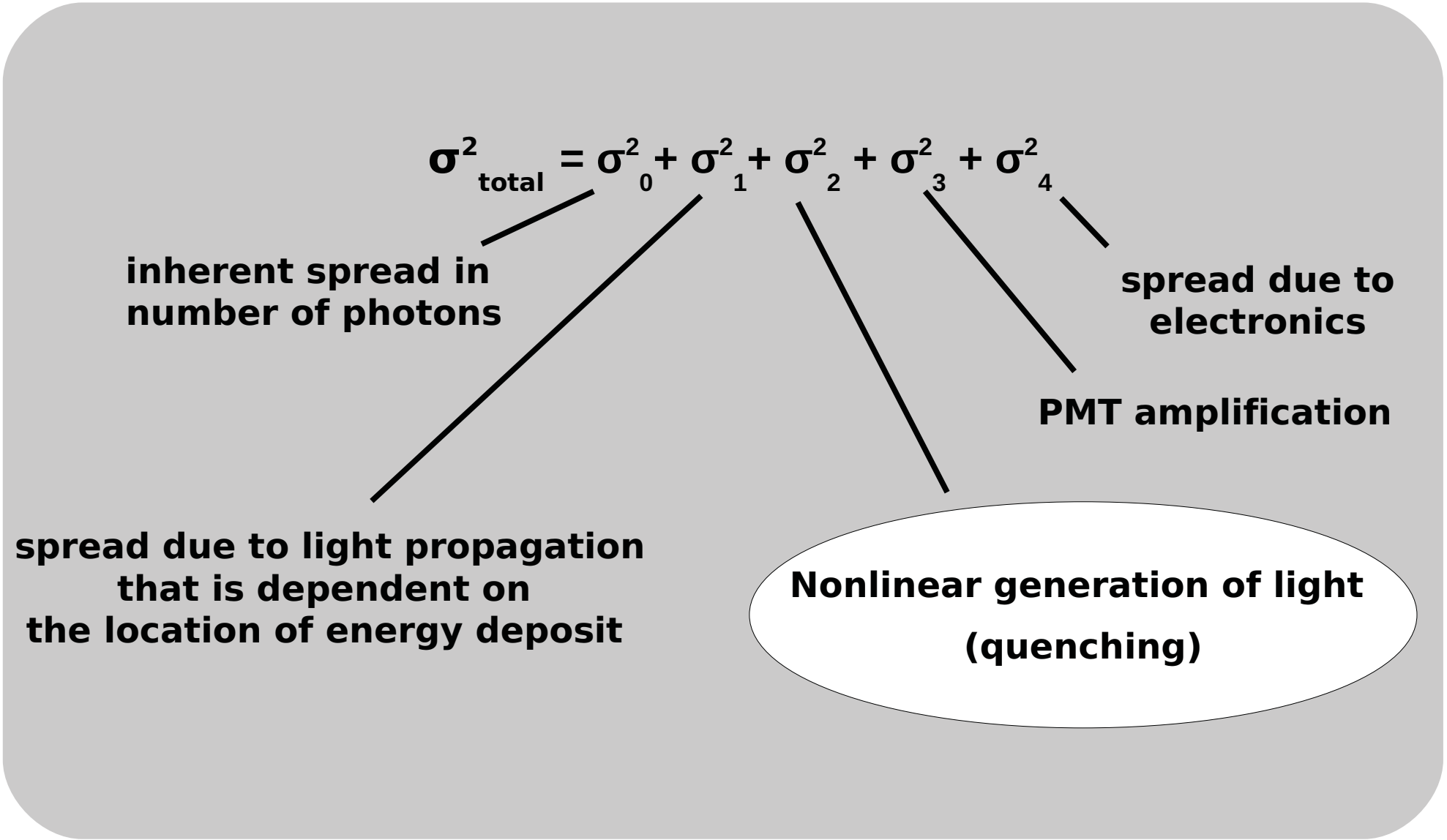
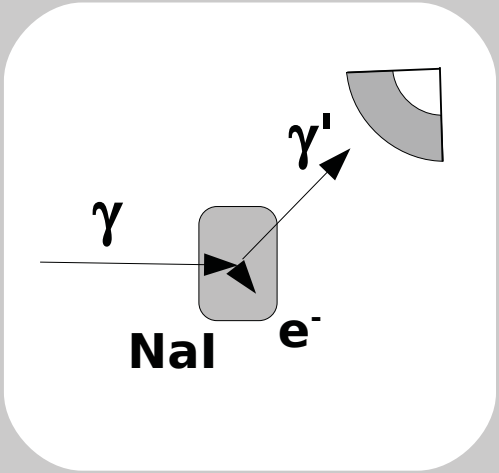
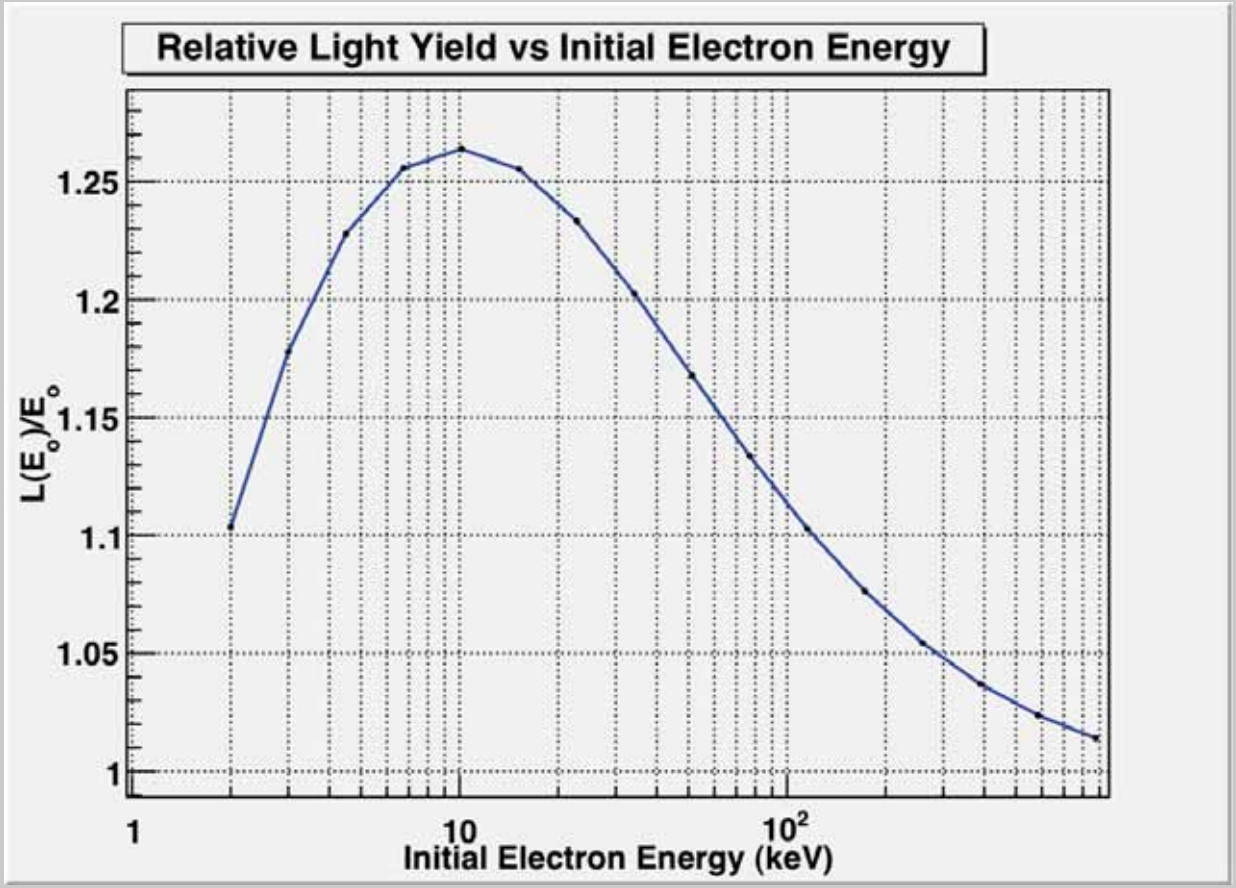


The relative light generation for electrons can be measured using Compton scattering of γs inside the NaI crystal and used in simulation.

LIGHT GENERATION BY THE COMPTON ELECTRON

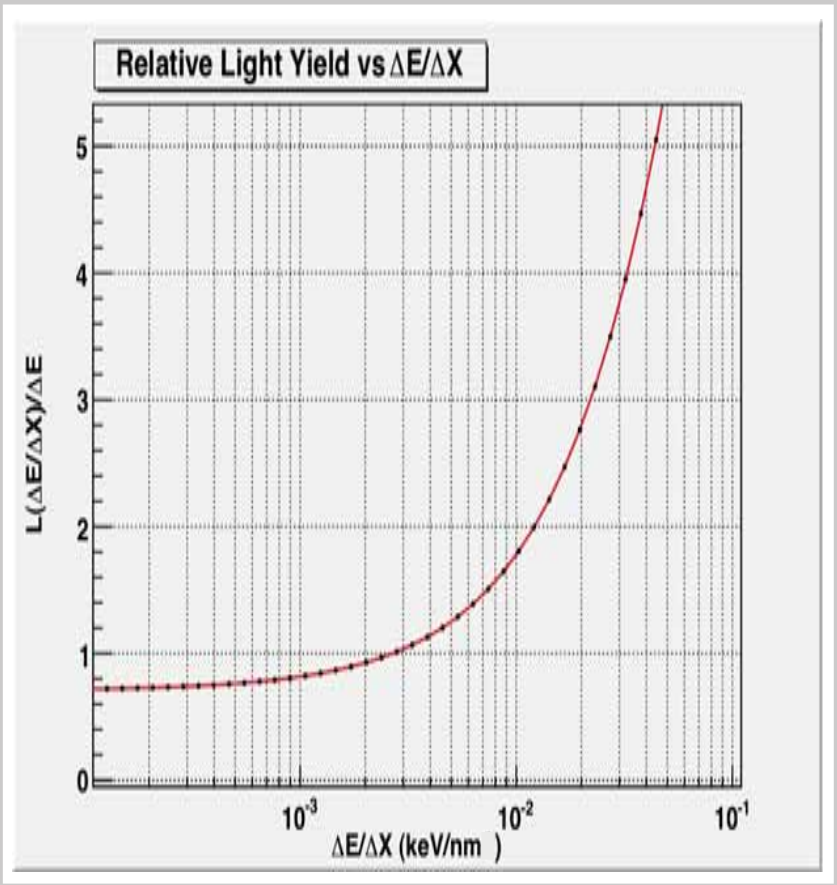


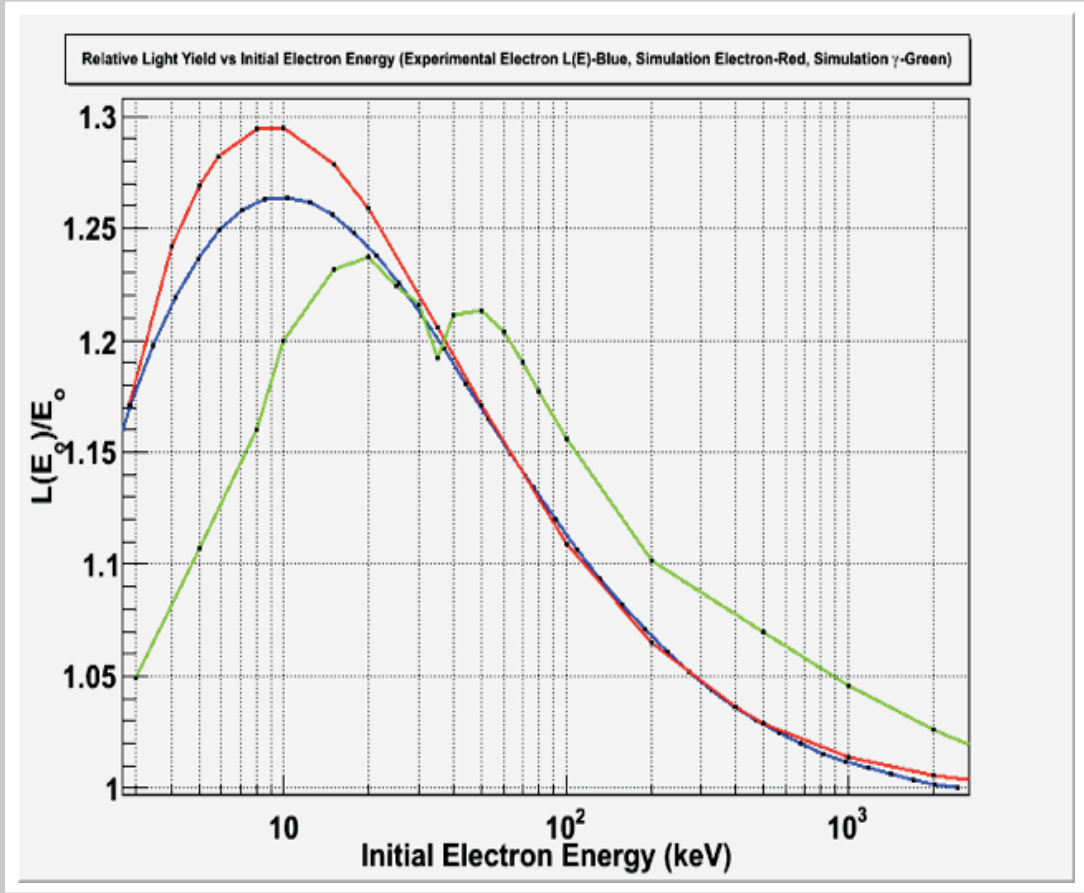


D.Cano et al. NIMA 430, (1999)

For MTAS we also investigate the different approach to the simulation of light quenching in NaI.

OTHER WAY OF INTRODUCING LIGHT GENERATION INTO GEANT4

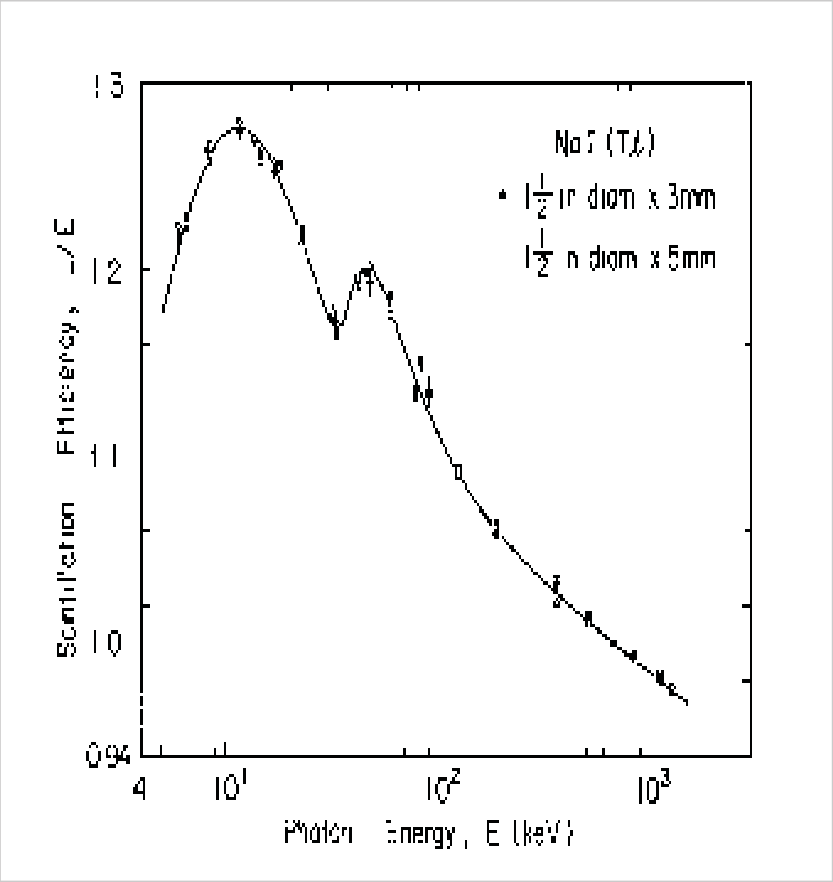


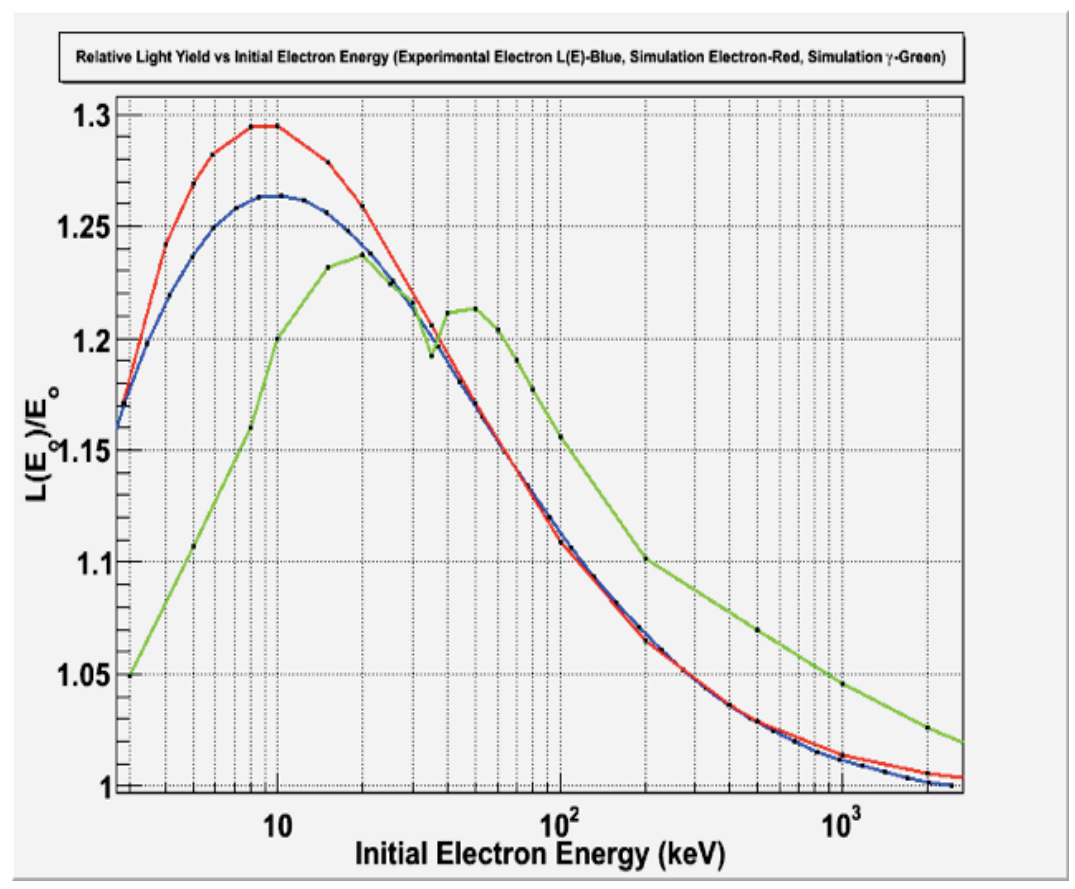


Calculation by: Ch. Rasco, Louisiana State University

Calculated light production function for gamma ray resembles the experimental shape.

INTRODUCING LIGHT GENERATION INTO GEANT4

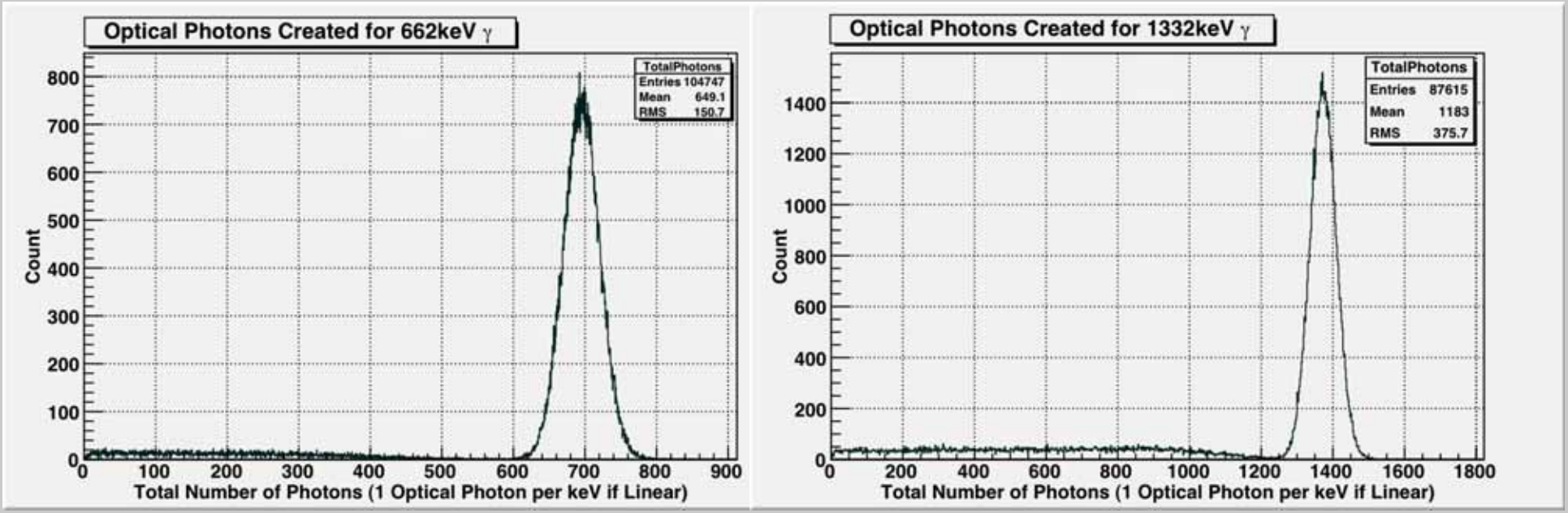




T.Tojo NIM A238 (1985)

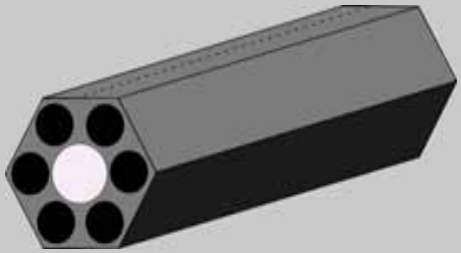
Tested approach to light generation included into the GEANT4 simulations yielded 8% FWHM for 662keV ^{137}Cs line and 6.5% for 1332keV ^{60}Co line, subject to further improvements

LIGHT GENERATION FOR ^{137}Cs AND ^{60}Co



662keV and 1332keV gamma plots 8% and 6.5% at FWHM

Goal: simulation of light propagation in central module

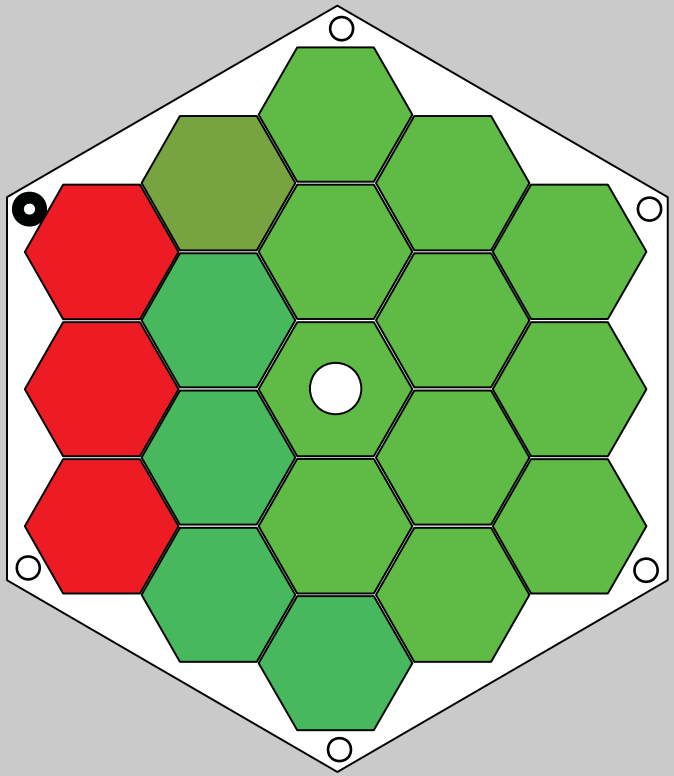


Calculation by: Ch. Rasco, Louisiana State University

Unshielded MTAS registers between 600 and 16 000 counts per second per PMT of background in the testing room.

INITIAL BACKGROUND LEVEL FOR ENERGIES > 60 keV

Low radioactivity waste storage



> 12 000 cps.

8 000 to 12 000 cps.

4 000 to 8 000 cps.

1 000 to 4 000 cps.

< 1 000 counts per sec.

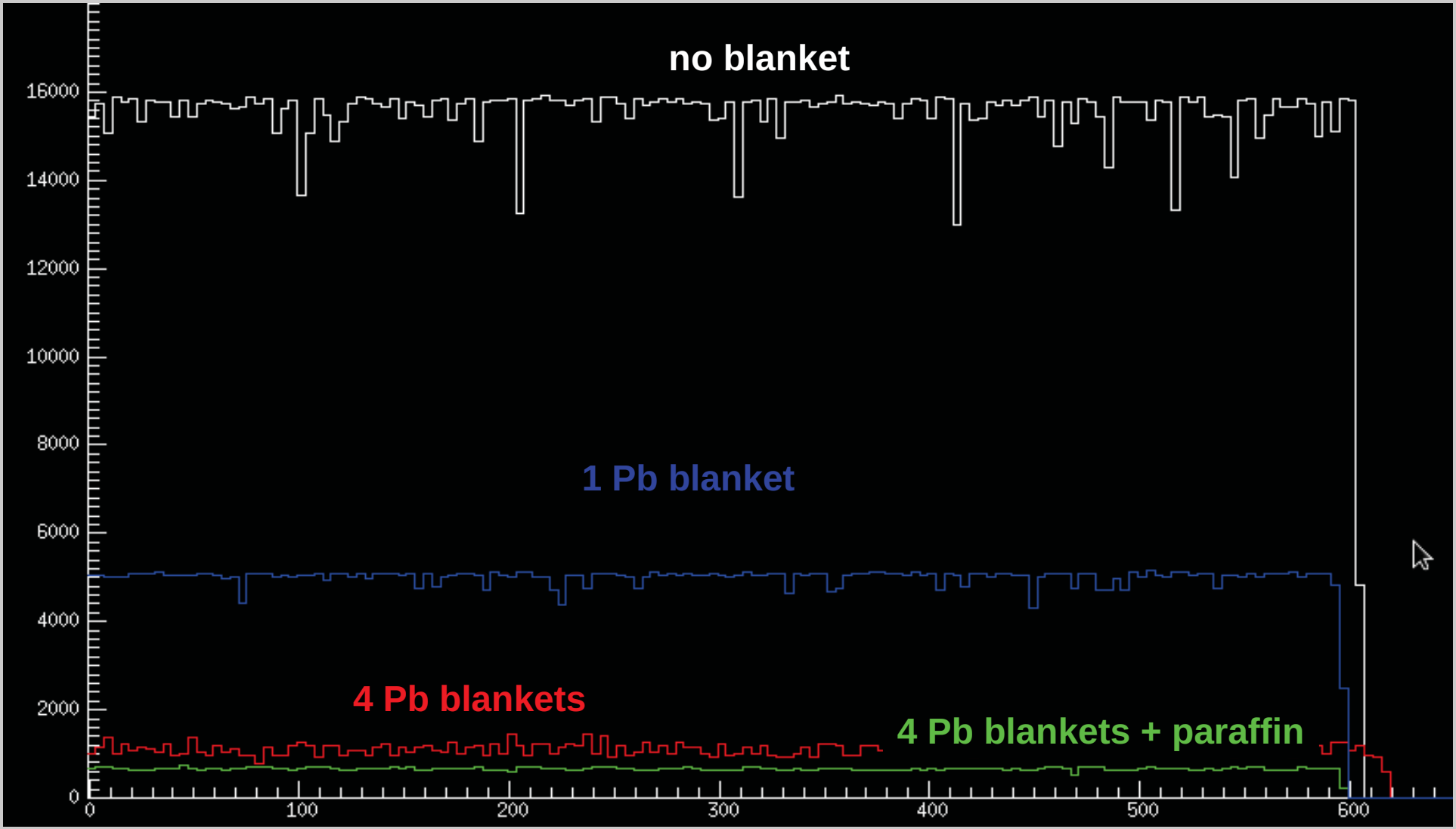
Temporary test shielding of MTAS consists of 4 layers of lead blankets and a paraffin wall

TEMPORARY SHIELDING OF MTAS

With additional sources front-end data acquisition system was tested to be able to handle 60Mb/s of data stream (>5Tb/day)

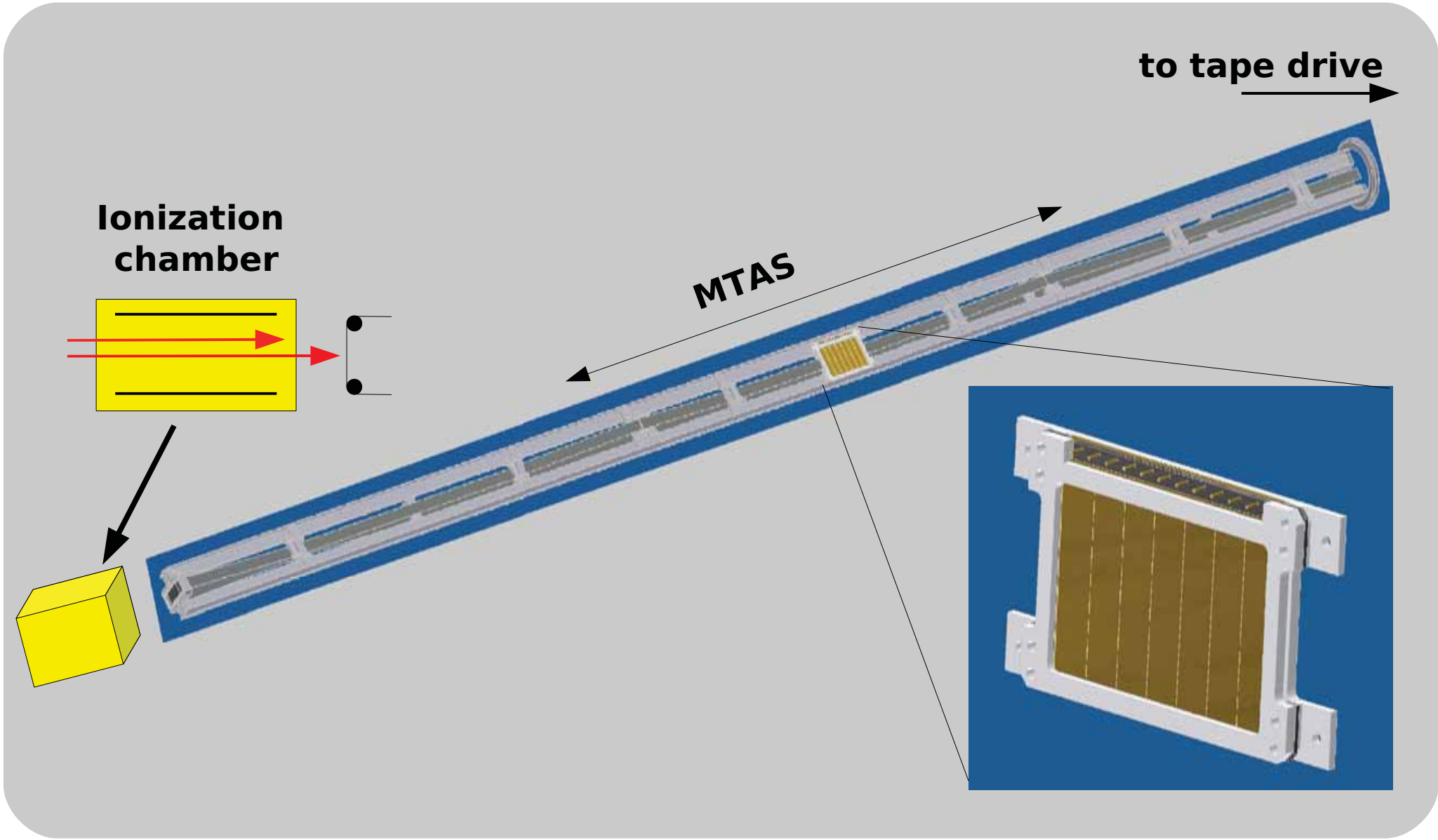
Constructed Pb+Paraffin shielding allowed to lower the background count rate to the reasonable value of 600 counts per sec per PMT

EFFICIENCY OF TEMPORARY SHIELDING



First set of auxiliary detectors for MTAS measurements will consist of Si detectors for β−γ coincidence and ionization chamber for incoming ion counting

AUXILIARY DETECTORS FOR MTAS



Summary

MTAS delivered to Oak Ridge National Laboratory

Tests of modules, response functions, and data acquisition are being performed

GEANT4 simulations of optical photons with non-linear light generation under development

Options for shielding are being explored

Auxiliary detectors are being design

People involved in the MTAS project

K. Rykaczewski - ORNL,

R. Grzywacz - UT and ORNL,

Ch. Rasco - LSU,

M. Wolińska-Cichocka - ORAU/ORNL and UW

A. Kuźniak - UT and UW

J. Jonson - ORNL

C. Gross - ORNL

M. K. – ORISE/ORNL and UW