OTHER INTERESTING R&D IN EXTRUDED PLASTIC SCINTILLATORS

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PPD Mini-Review

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OUTLINE

Two main interests:

- Neutron-sensitive extruded plastic scintillator
- High-Z extruded plastic scintillator

Both with potential benefits to the Physics community and Homeland security.

NEW USE FOR EXTRUDED PLASTIC SCINTILLATOR

We started working on neutron-sensitive plastic scintillator a few years ago but lack of funding has brought it to a stop.

- Applications:
  - Neutrinos from Supernova (OMNIS, ADONIS)
  - Neutron Spallation source
    - Detect scattered neutrons from intense beams
      - Nuclear physics
      - Materials science

NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR

- The basic technique is to use the n + ^{6}Li reaction
  - n + ^{6}Li $\rightarrow$ ^{4}He + ^{3}H + 4.79 MeV
    - The alpha and the triton deposit their energy in a plastic scintillator which then produces light which is the detected signal
  - An important aspect of this reaction is that the alpha and the triton deposit all their energy in a very short distance in plastic scintillator
    - Alpha : < 5-10 microns
    - Triton: < 100 microns
  - Very thin layers can therefore be used

NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR

- At issue is how to introduce the ^{6}Li into the polymer-based scintillator
  - Li compounds are insoluble in polystyrene
  - Li compounds can be mixed in the extruder with dopants and polystyrene to form the required material
    - LiF is a good candidate
  - However, since the range of the alpha and triton are small, the Li compound particle size must be small or all the energy will be absorbed in the Li compound and no light will be produced.

NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR

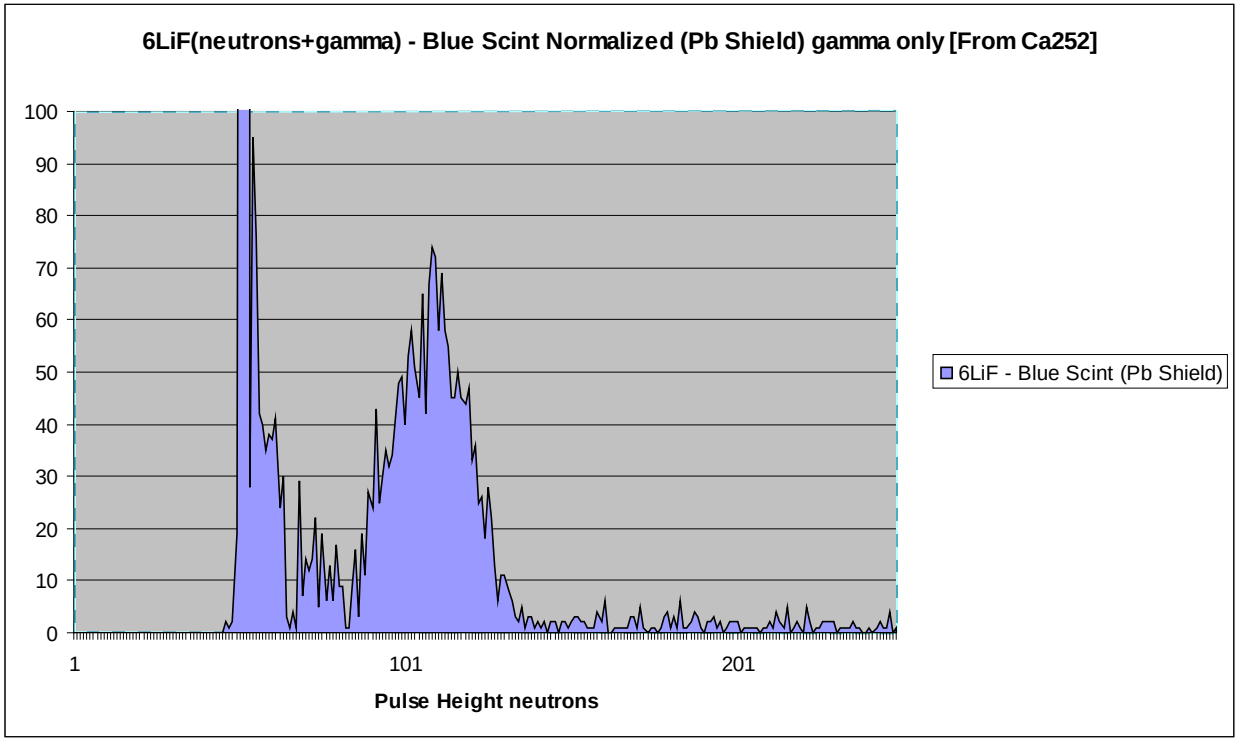
- Compound nano-powders of LiF into the scintillator
  - PS + dopants (for scintillation) + LiF
  - For good scintillation light yield want LiF particle size < 1μ
  - For good optical properties (low optical scattering) want LiF particle size as small as possible - ≤ 30 nm!

Contacted company in Australia with a proprietary process for making nano-size oxides and salts – tested TiO_2/oil, acquired small amount of Li_2CO_3 (about $10k R&D)

NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR

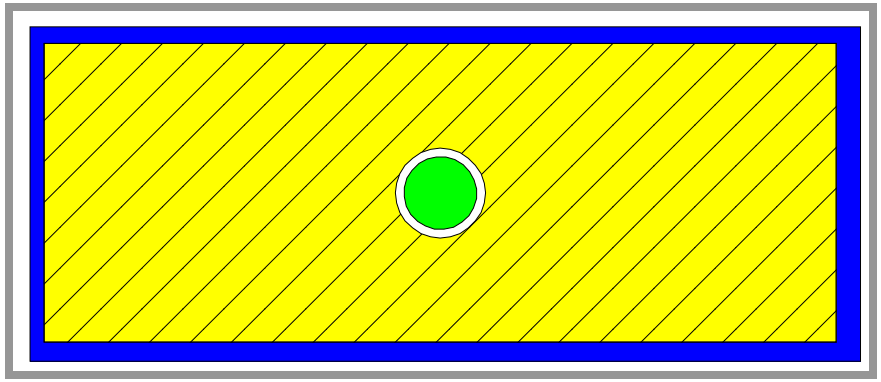
- FNAL/NICADD Extrusion Line is too big for this R&D work:
  - Small twin-screw extruder, volumetric feeder and pelletizer obtained from government surplus list.
    - Output = 1 kg / h
    - Vacuum port
    - Liquid injection port
    - Fully manual
    - Very old equipment, performance is a bit flaky
  - A new machine would be needed for serious work ($200k).

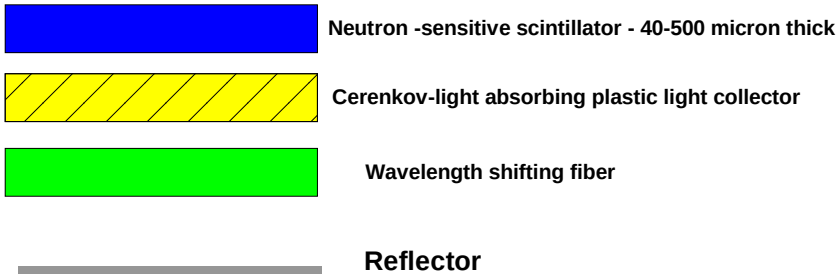
NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR



- We have already produced an efficient neutron sensitive plastic scintillator based on ^{6}LiF
- Of the roughly 4.8 MeV of energy released in the interaction, we see about 1 MeV
  - We need to improve the processing!

NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR





- Because of the short range of the α and the *triton*, very thin layers will absorb all the energy.
- Neutron detection efficiency is determined by the capture cross-section and the ^{6}Li doping level.
- Detectors made this way only sensitive to neutrons
  - Ionizing and x-ray sensitivity greatly reduced due to thin active layer

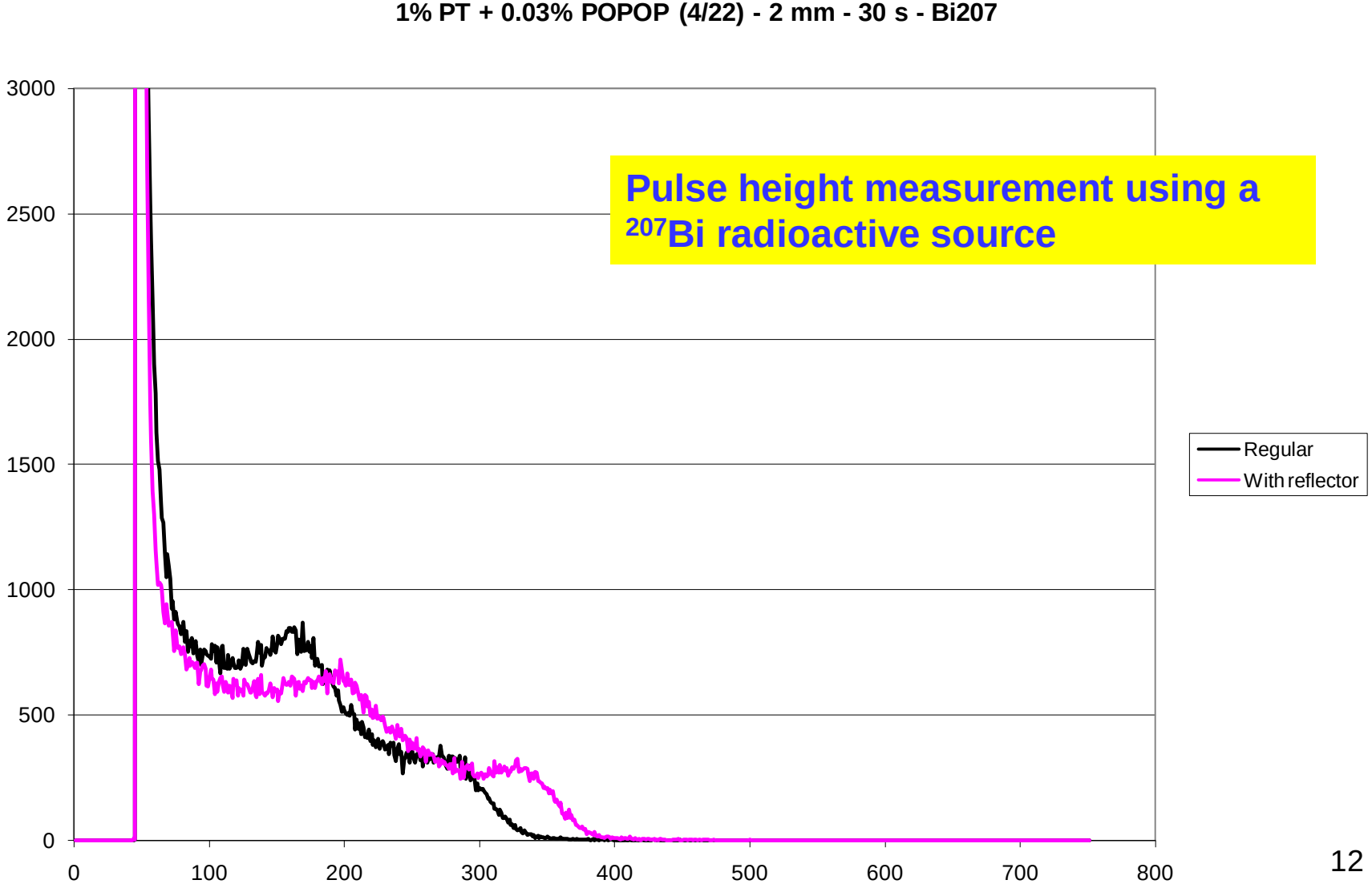
NEUTRON-SENSITIVE EXTRUDED PLASTIC SCINTILLATOR

- Submitted a proposal to a general BAA from a Homeland Security announcement.
- Past first 1-page submission.
- Failed in the second round.
- Tried joining forces with Rockwell for a more complete proposal without any success.

HIGH Z EXTRUDED PLASTIC SCINTILLATOR

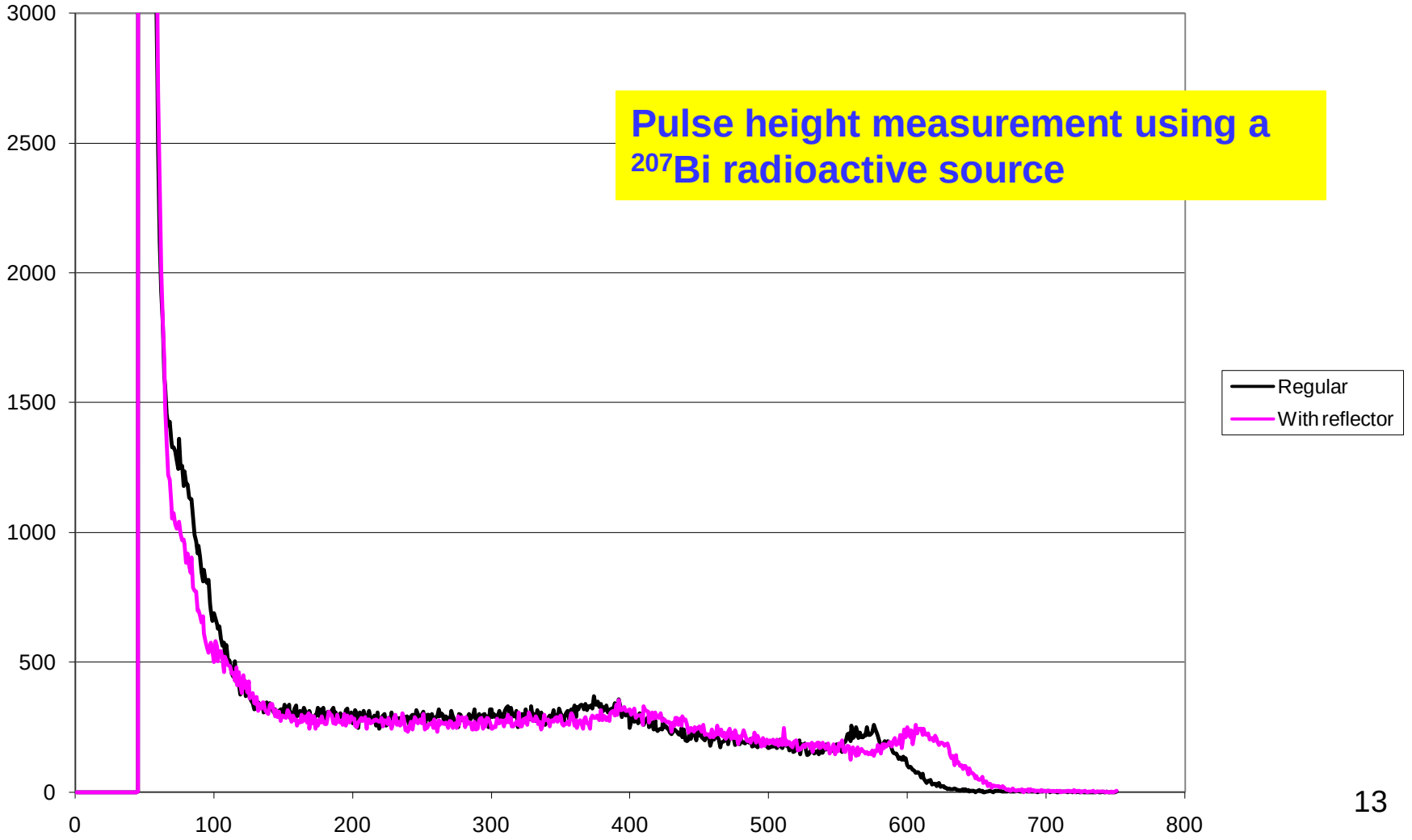
- A logical variation in the extruded scintillator work because, if we manage to successfully incorporate LiF, then other inorganic compounds (halides or oxides) would present similar challenges.
- Approach:
  - Look for colorless, commercial compounds with refractive indices similar to that of polystyrene (1.59) and small particle size.
    - Micrometer range was not ideal but accepted.
    - BaF_2 yielded interesting results right away - Incomplete

HIGH Z EXTRUDED PLASTIC SCINTILLATOR



HIGH Z EXTRUDED PLASTIC SCINTILLATOR

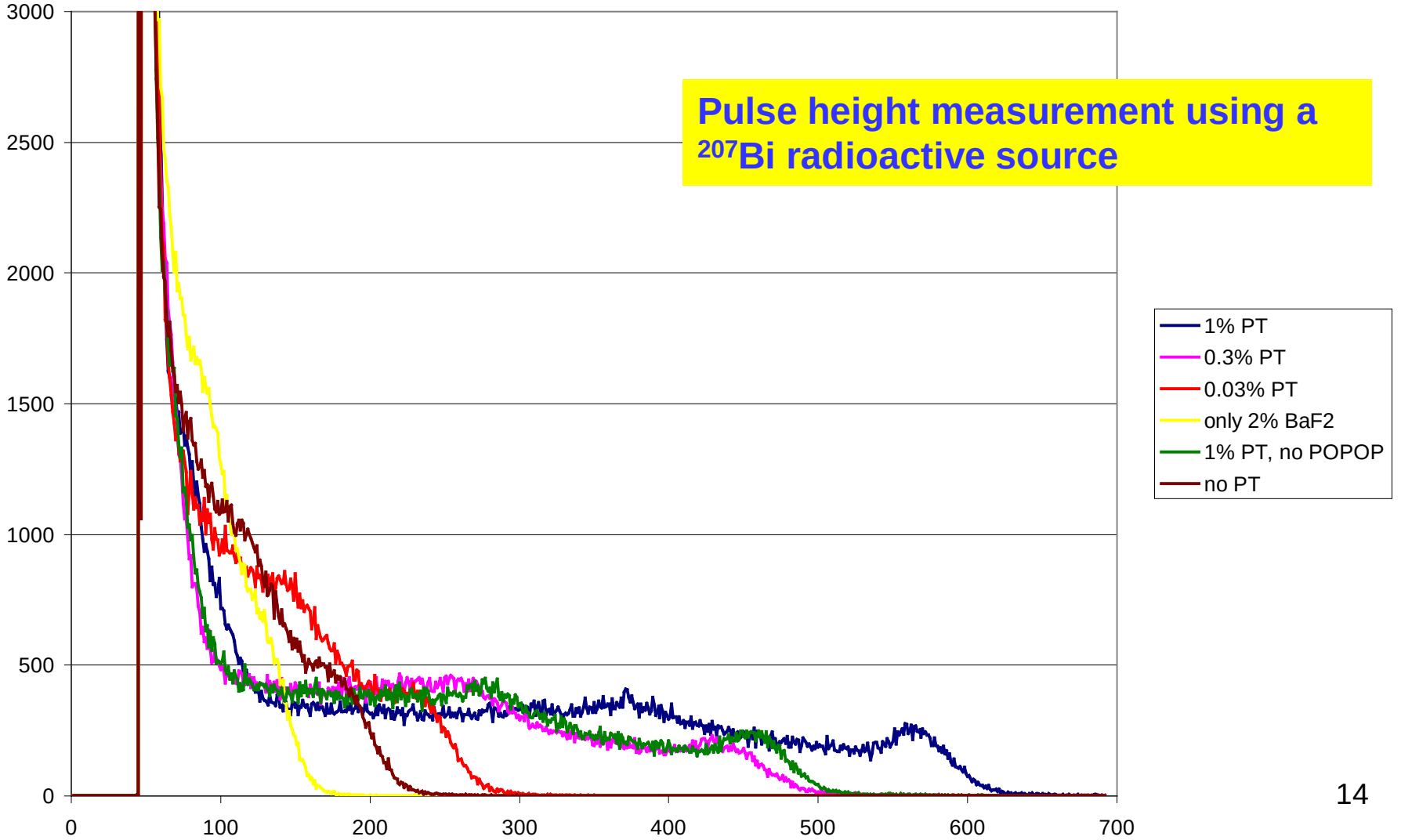
1% PT + 0.03% POPOP + 2% BaF2 (5/22) - 2 mm - 30 s - Bi207



Pulse height measurement using a ^{207}Bi radioactive source

HIGH Z EXTRUDED PLASTIC SCINTILLATOR

2% BaF2 + 0.03% POPOP - 2 mm



Pulse height measurement using a ^{207}Bi radioactive source

CONCLUSION

FOR:

- Neutron-sensitive extruded plastic scintillator
- High Z extruded plastic scintillator

Preliminary work is encouraging.

It would be nice to complete the work.