Liquid Helium Scintillation

Candidate for detecting beam losses in the LHC ?

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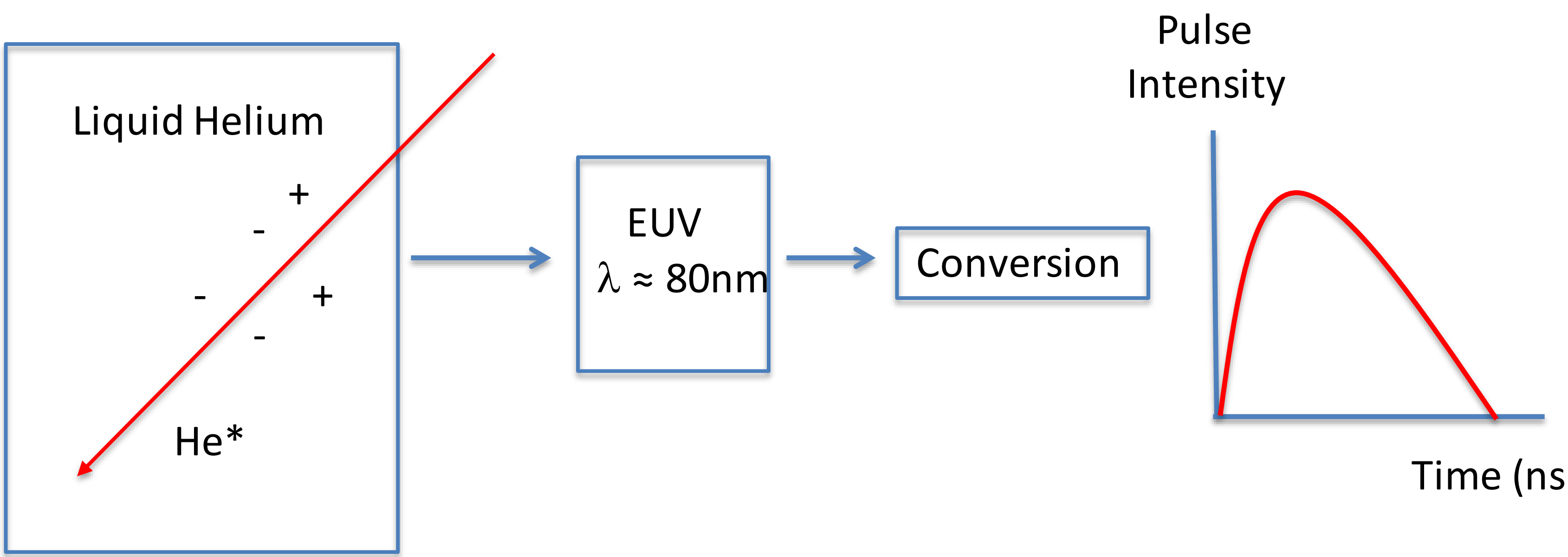
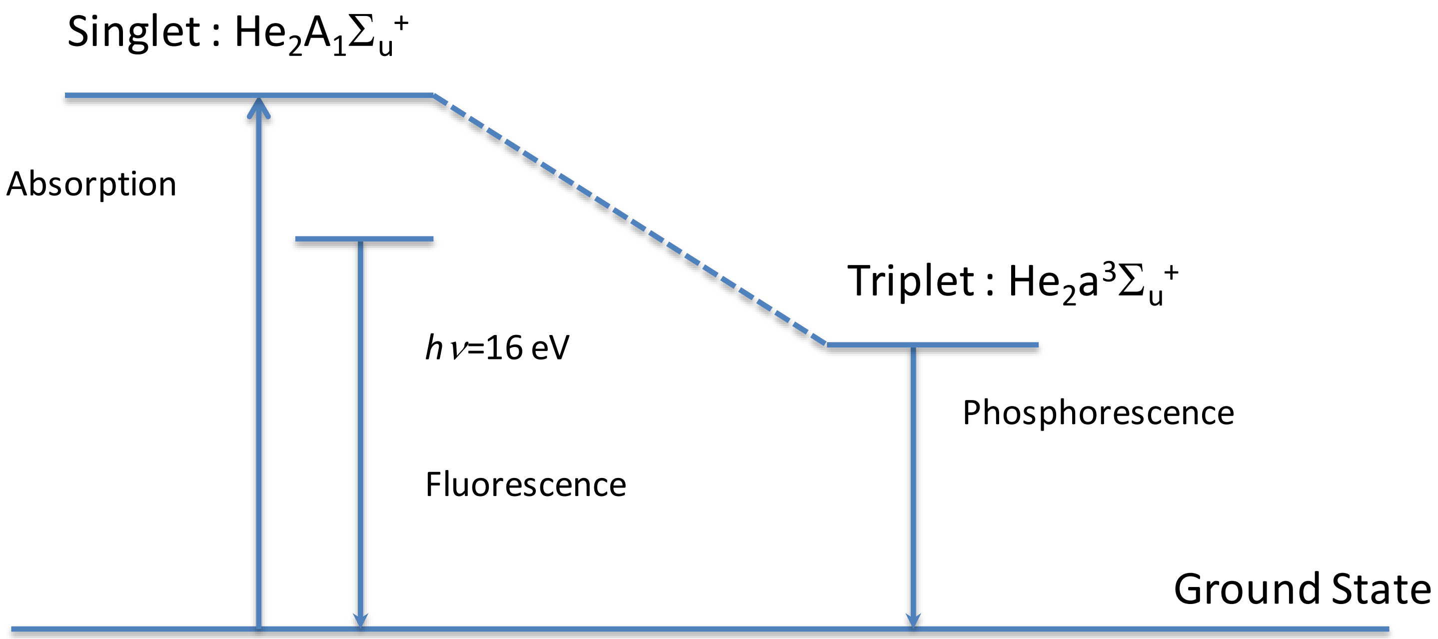
Basic principle



Scintillation mechanism



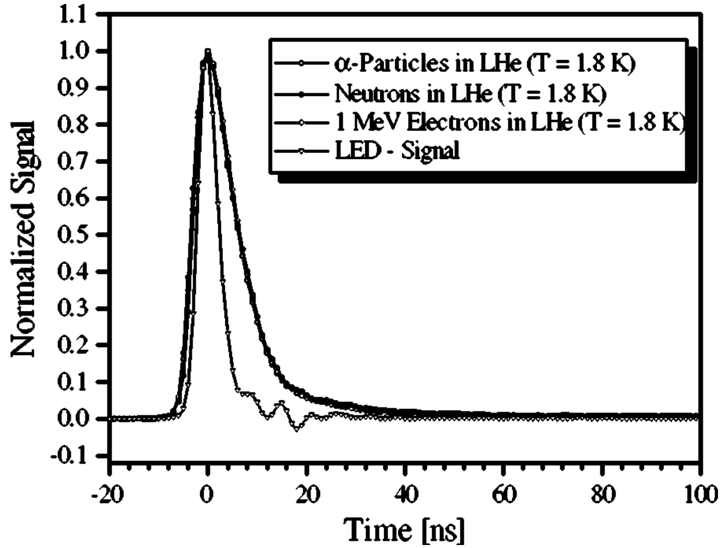
Radiative lifetime = 1 ns

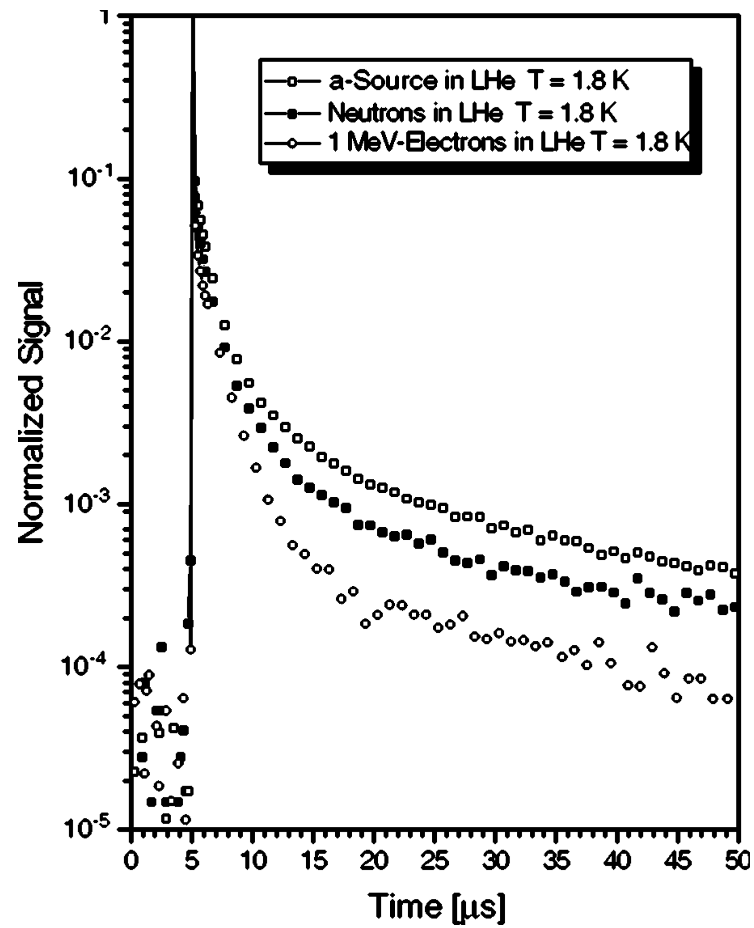
Radiative lifetime = 10 s

‘Scintillation pulse’

‘Afterglow effect’

Scintillation signals



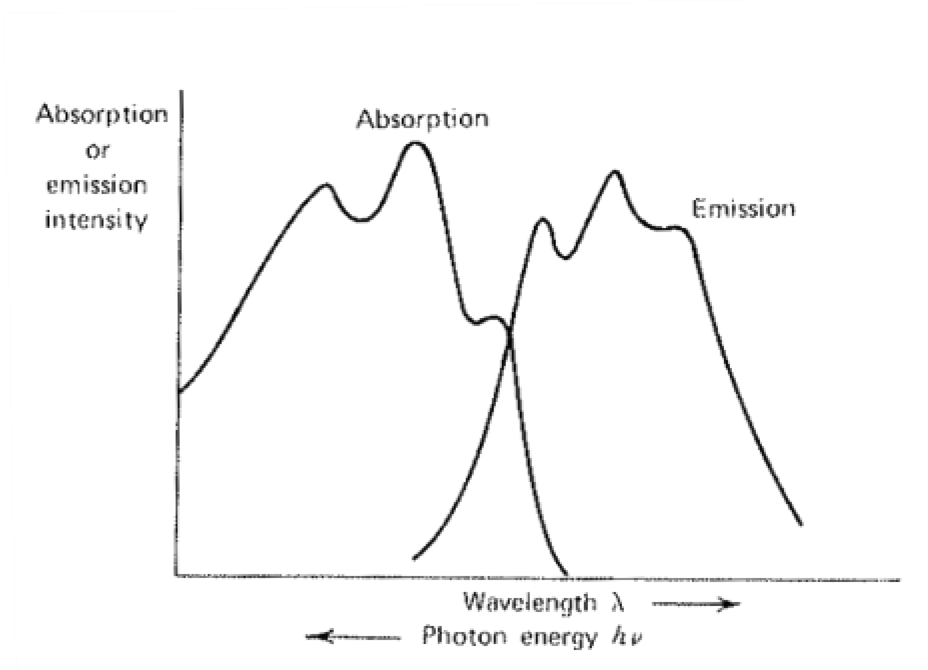


35% conversion efficiency
into scintillation light (β^-)

‘McKinsey et al. Phys. Rev A 67 062716 (2003)’

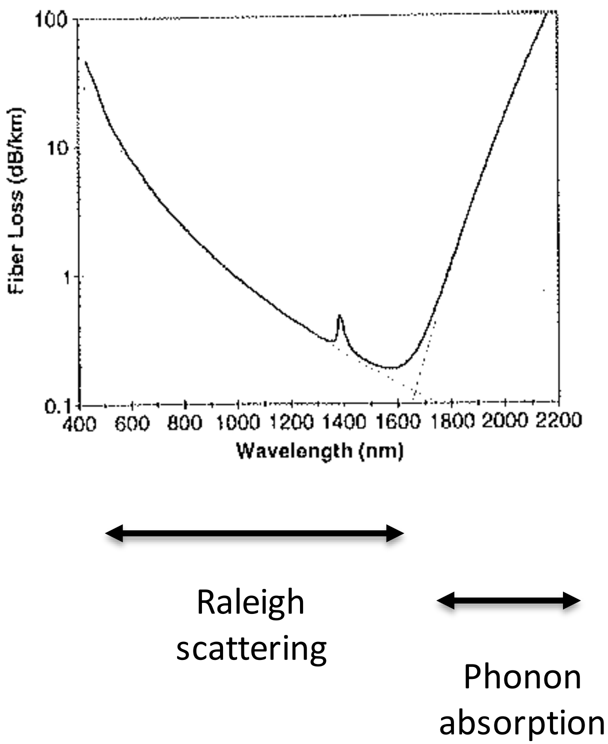
Scintillation light - I

- Fluorescence occurs at a <u>lower</u> energy level than that required for excitation
- There is thus little self absorption of the scintillation light



Scintillation light - II

- The peak of $He_2A_1\Sigma_u^+$ emits light at approximately 80-100 nm (EUV region)
- Light at this wavelength does not propagate through a SM silica optical fibre because of Raleigh scattering (spectral dependencies as $1/\lambda^4$)



Light detection techniques

- Direct detection technique

  Measure extreme UV light at 100 nm with special AXUV photodiodes which have :

  1. No surface dead region i.e. no recombination of photo generated carriers in the doped n-region or at the silicon-silicon dioxide interface
  2. An extremely thin (3 to 7 nm) silicon dioxide junction entrance window
  3. Silicon thickness can be optimized to maximize yield for Helium

- Indirect detection technique
  1. Wavelength shifting via coating of optical fibre to longer wavelength
     - Absorb the primary EUV light
     - Reradiate the energy at a lower wavelength
  2. Use classical detection (PMT) technique

Direct vs. Indirect detection

- Direct detection technique
  - Photodiodes are very resistant to TID
  - Neutron damage may deteriorate the devices rather rapidly (needs investigating)
  - EUV diodes are special R&D developments (http://www.ird-inc.com/)
- Indirect detection technique
  - Wavelength shifters typically induce a loss of 10-30%
  - Reduce the overall response time of the system
  - Wavelength shifting optical fibres are generally not radiation tolerant

Feasability

- Highly efficient conversion into detectable light ?
  - *Depending on detection technique of EUV light (direct/indirect)*
  - *Probably of the order of 10-15%*
- Linear relationship E_{dep} vs. light yield ?
  - *Not checked yet for exotic particles at high E in a HEP radiation field*
  - *Ok for X, neutrons and electron beams at 60 MeV*
- Transparency for $\lambda_{emitted}$? Ok !
- Short decay time without delay Ok !
- High optical quality & easy to manufacture ? Ok !
- Easy coupling to a light sensor ?
  - Needs further investigation, certainly not so easy

Open question : what is the purity of the He in the LHC ?