WLS Simulations in Litrani

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Overview

- Overall Goal: Model the geometry proposed by Randy Ruchti
  - Geometry consists of WLS core embedded in Quartz fiber
  - Could be useful for high radiation areas of detectors
- Today's Presentation:
  - Present results of initial testing that was performed to verify that wavelength shifting is occurring in the simulations
  - Discuss implementation of actual absorption/emission spectrum (in particular, BCF91A WLS fiber)

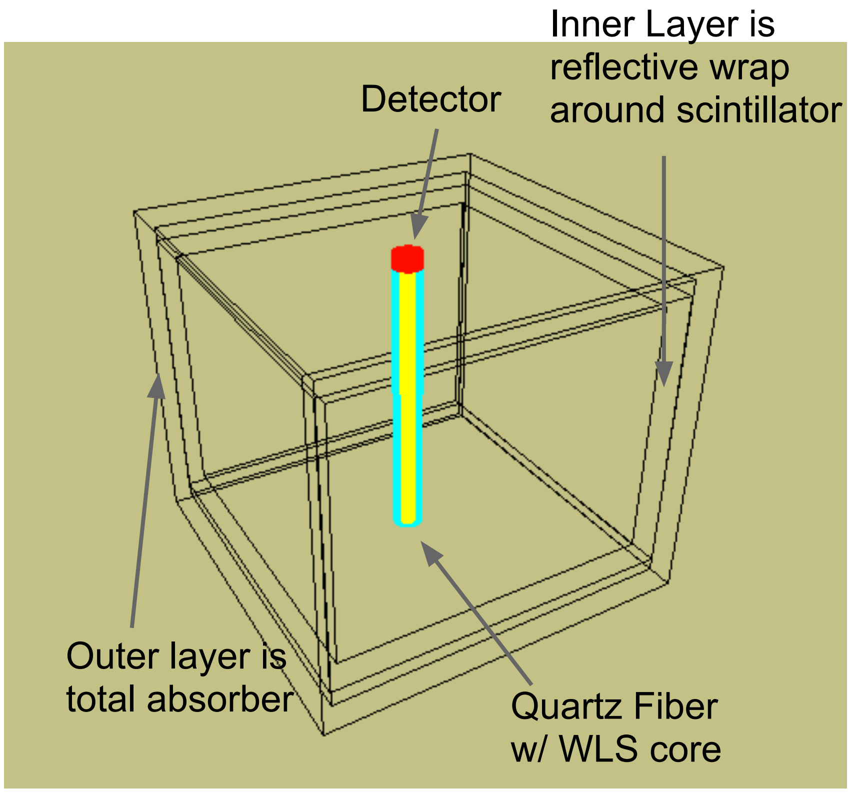
Initial Testing of WLS

Initial Testing

- Want to verify that shifting is actually occurring in Litrani simulations
- Simple Shashlik geometry consists of:
  - Ideal Scintillator with no attenuation of generated photons; this scintillator is enclosed in "perfectly" reflective wrapping
  - Quartz fiber with WLS core
  - Detector situated at one end of fiber
  - Entire setup is inside total absorbing wrapping
- For these simulations:
  - Interaction length for WLS was set to 1mm
  - Interaction length was not wavelength dependent

Verification Geometry

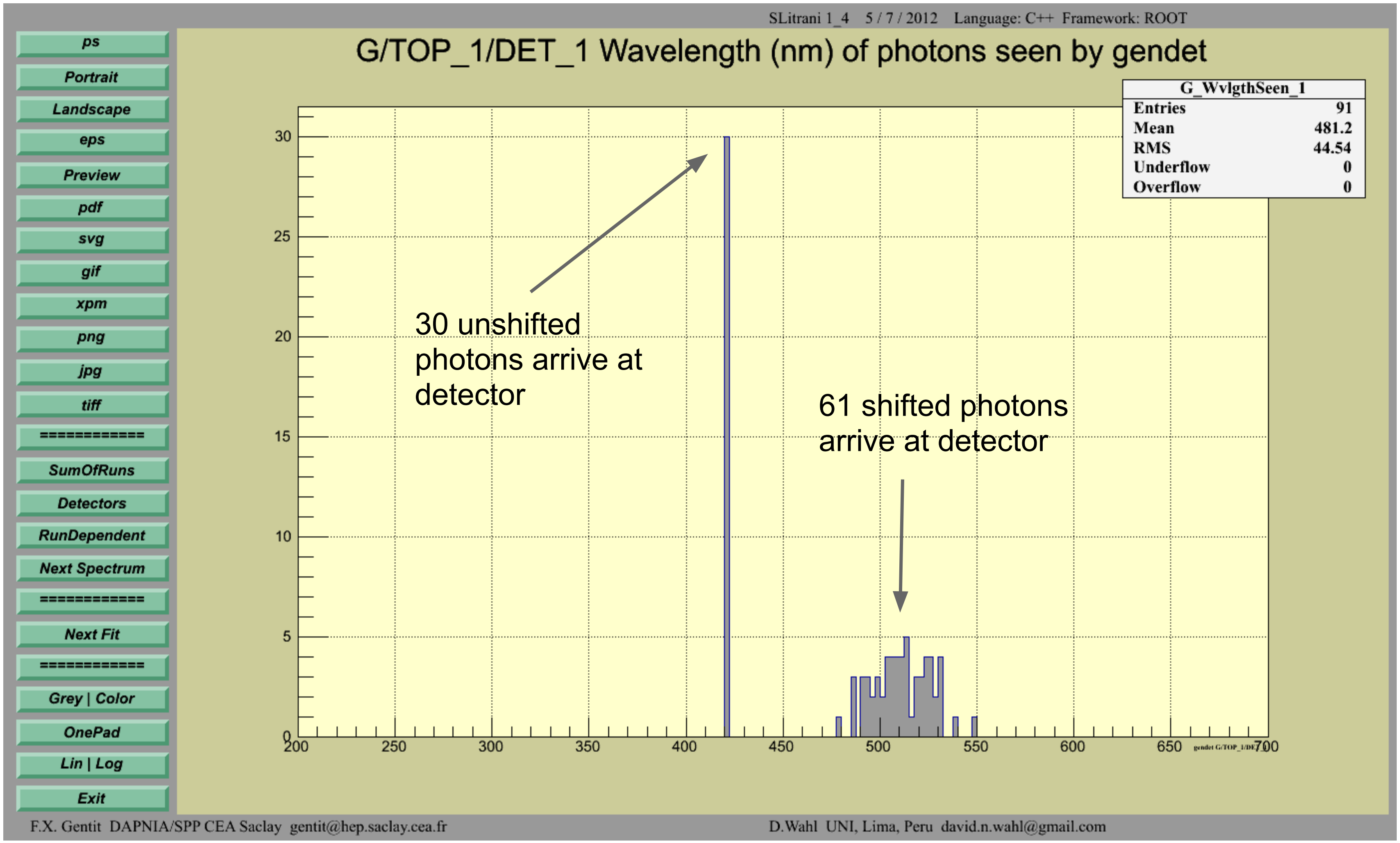
- Scintillator, n=1.6
  - Very high attenuation length
  - Emission at 420nm (only)
- Quartz Fiber, n=1.46
  - Coupling grease b/w scint and fiber
  - grease b/w fiber and WLS
- WLS core
  - n = 1.58
  - Shifts to narrow spectrum centered at 494nm



- Box - 2cm x 2.5cm x 2.5cm
- Fiber - 2cm x 1mm
- WLS core - 0.5mm
- Perfectly reflective wrapping around scintillator

WLS Shifting Demonstartion

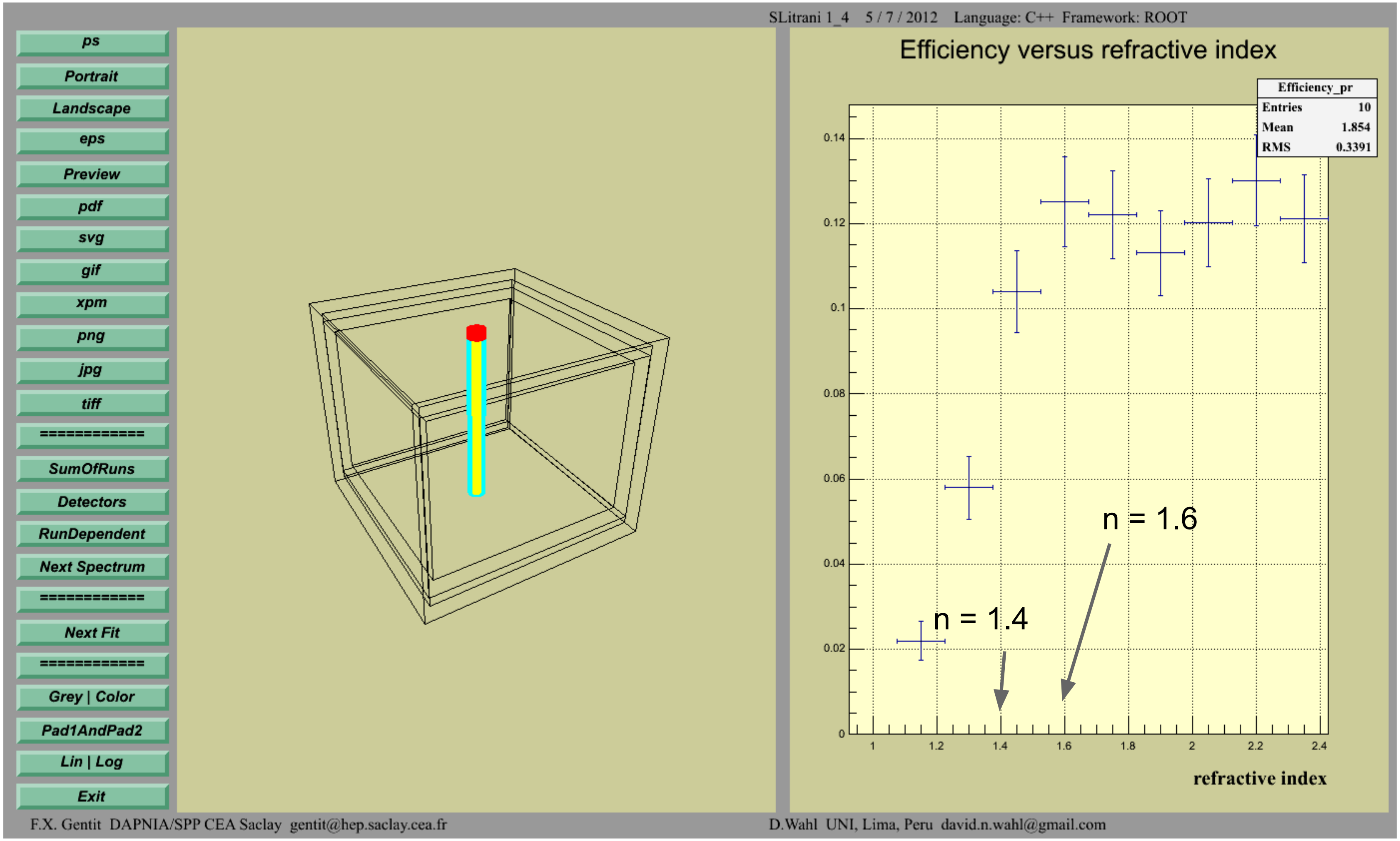
Below is graph of photons seen by the detector. All photons were generated in the scintillator at 420nm.



Optimization of refractive index of coupling grease between scintillator and fiber

- In the next test, we vary the refractive index of a thin slice between the scintillator and the quartz fiber
- Expected behavior: a rise for thin slice indices between scintillator index (n = 1.6) and quartz index (n = 1.46)

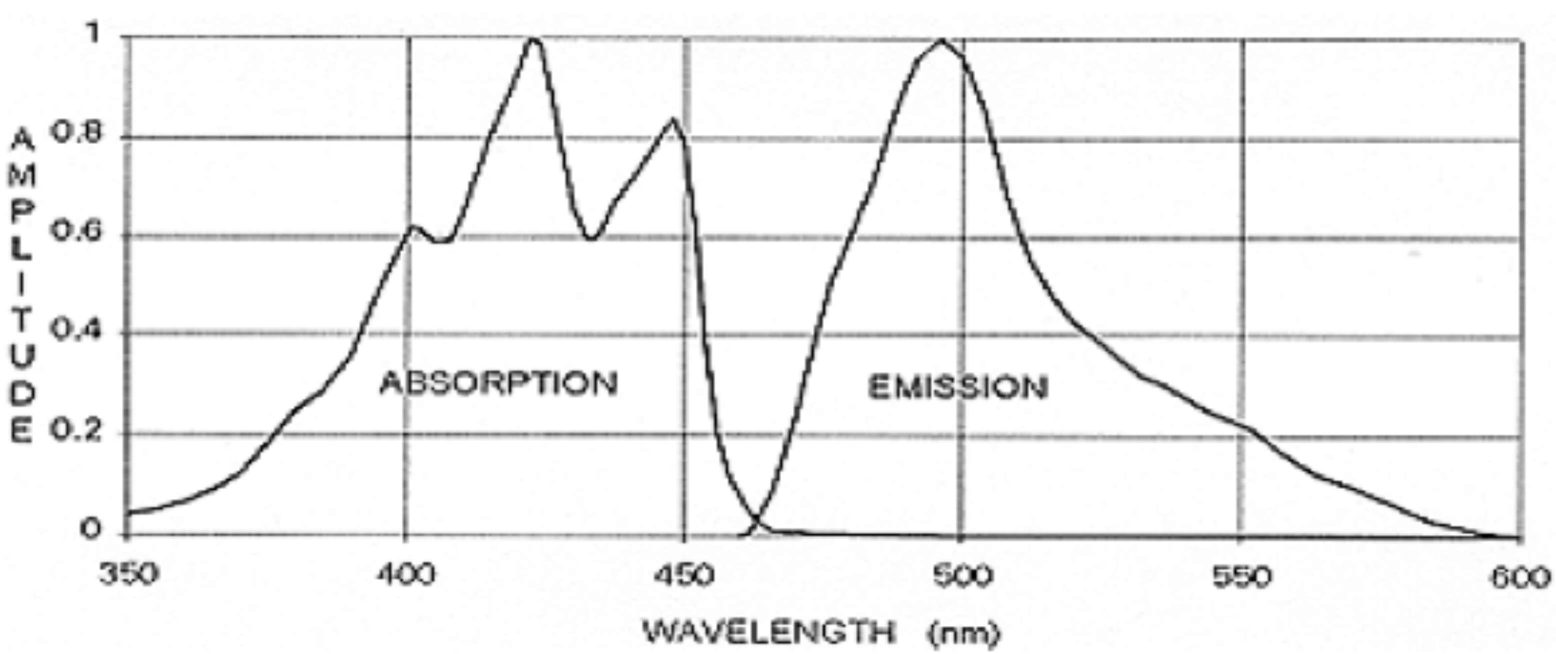
Optimize index (b/w crystal & fiber)



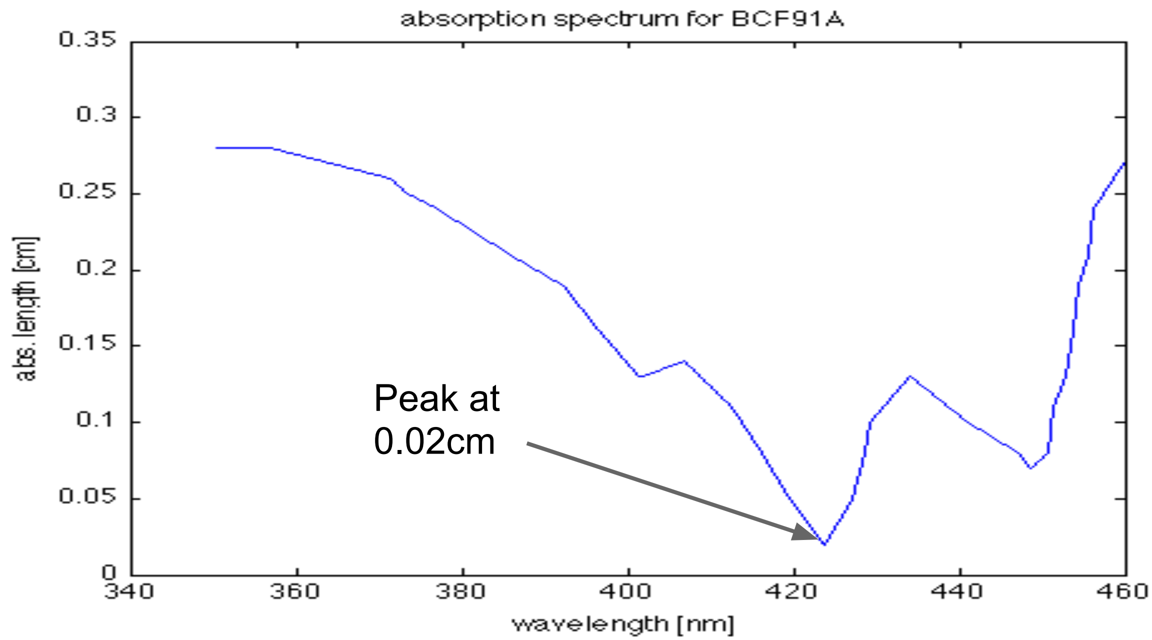
Next:
Implementing the BCF91A Spectrum

BCF91A Spectrum

- The technical documentation (from Saint-Gobain) provides spectrum below
- However, we need to interpret the absorption spectrum in terms of length



Spectrum Input into Litrani



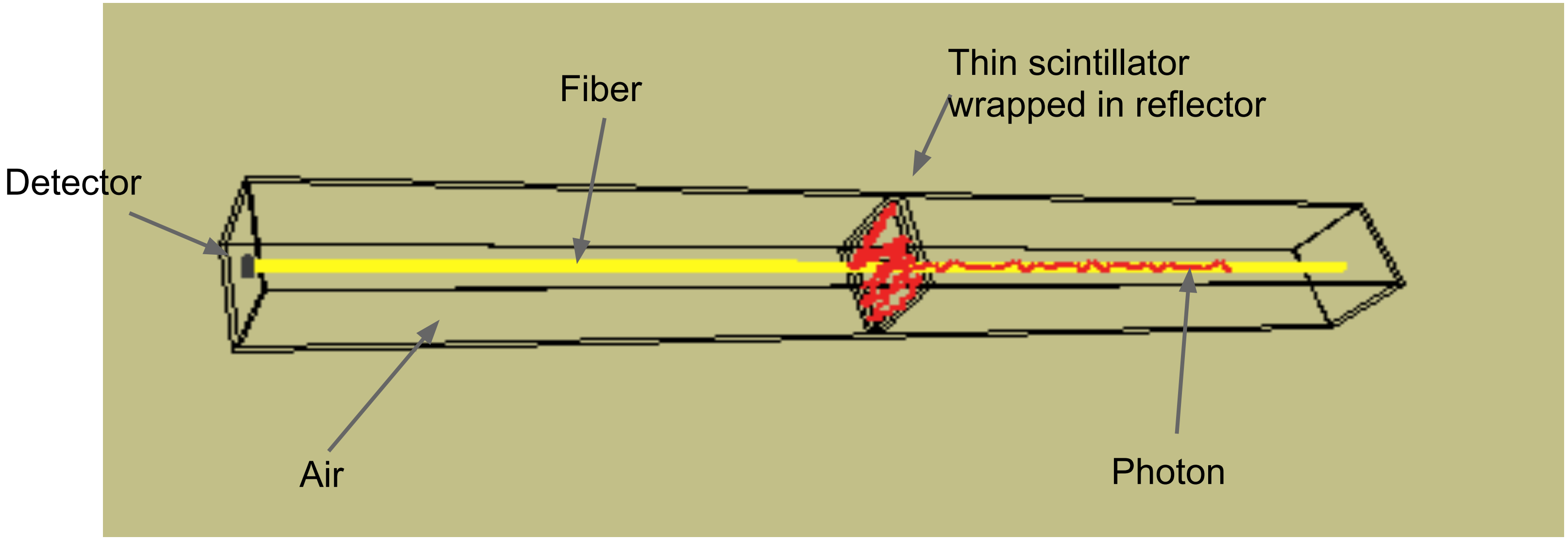
- Used lengths from http://www-zeuthen.desy.de/lcdet/Feb_05_WS/talks/rd_lcdet_sim.pdf to create a spectrum
- One can obtain this graph by 0.3cm - f (lambda)*.28cm, where f(lambda) is spectrum on prev. slide

Where did the numbers come from?

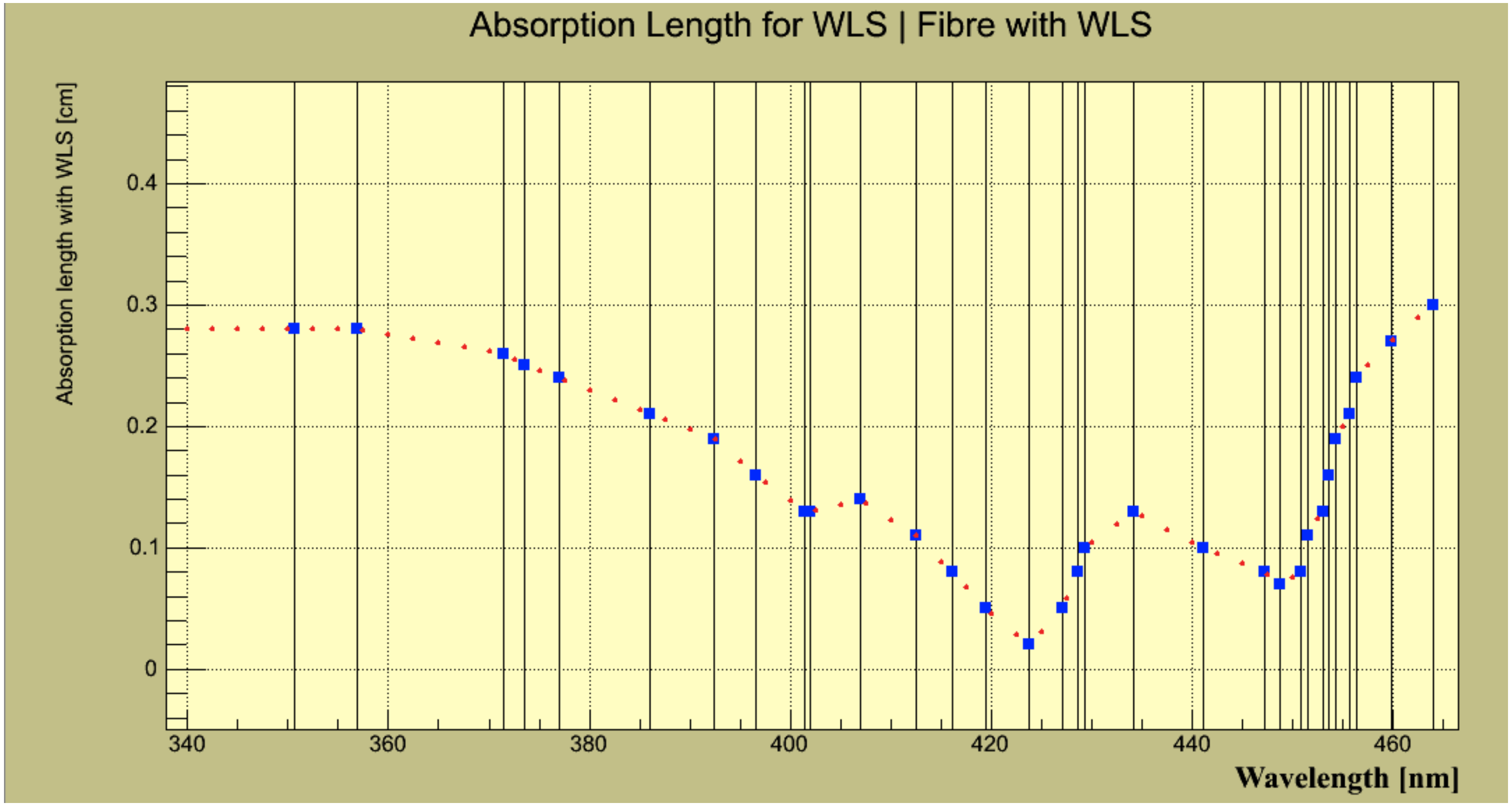
- We'd like to know where the numbers (0.3cm and .28cm) were obtained
- We have contacted Hugh Gallagher (listed on slides) and also posted questions on GEANT4 forum, but still don't have a definitive answer
- In order to verify this spectrum, our next step is a lab measurement of:
  - attenuation of the photons versus length
  - creation of wave shifted photons versus length

Simulations with BCF91A

- Same geometry with new dimensions:
  - Scintillator w/ very high attenuation length: 2mm x 30mm with 1mm reflective wrap
  - Quartz Fiber: 3mm (diameter) x 300mm (length)
  - Entire geometry wrapped in total absorbing box
  - Scint./Fiber coupling n = 1.7
  - Fiber/WLS coupling n = 1.4



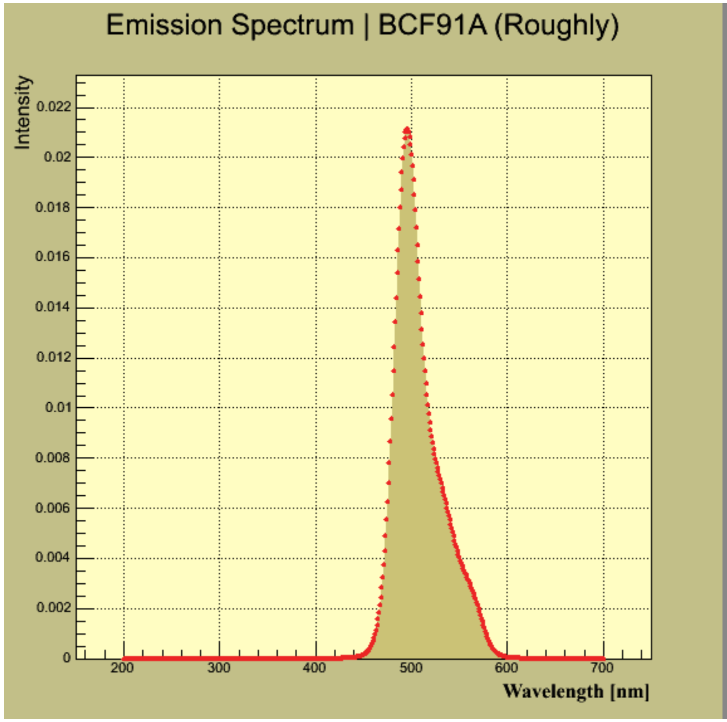
BCF91A Absorption Spectrum in Litrani



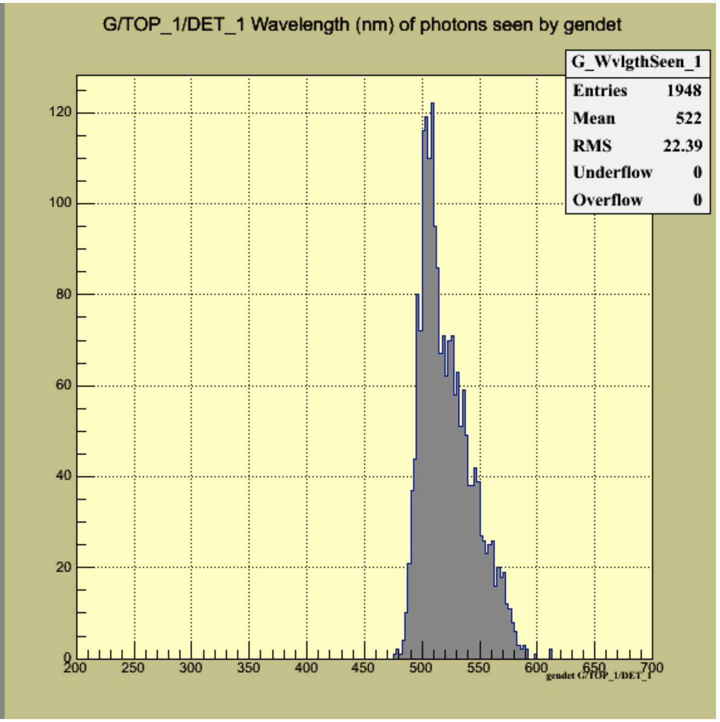
- Note for large wavelengths, absorption length is very large and so it is not shown here

Litrani Simulations with BCF91A

- These results are for an entirely WLS fiber (i. e. no quartz outer), 9.7% efficiency
- 20,000 photons generated b/w 360-460nm



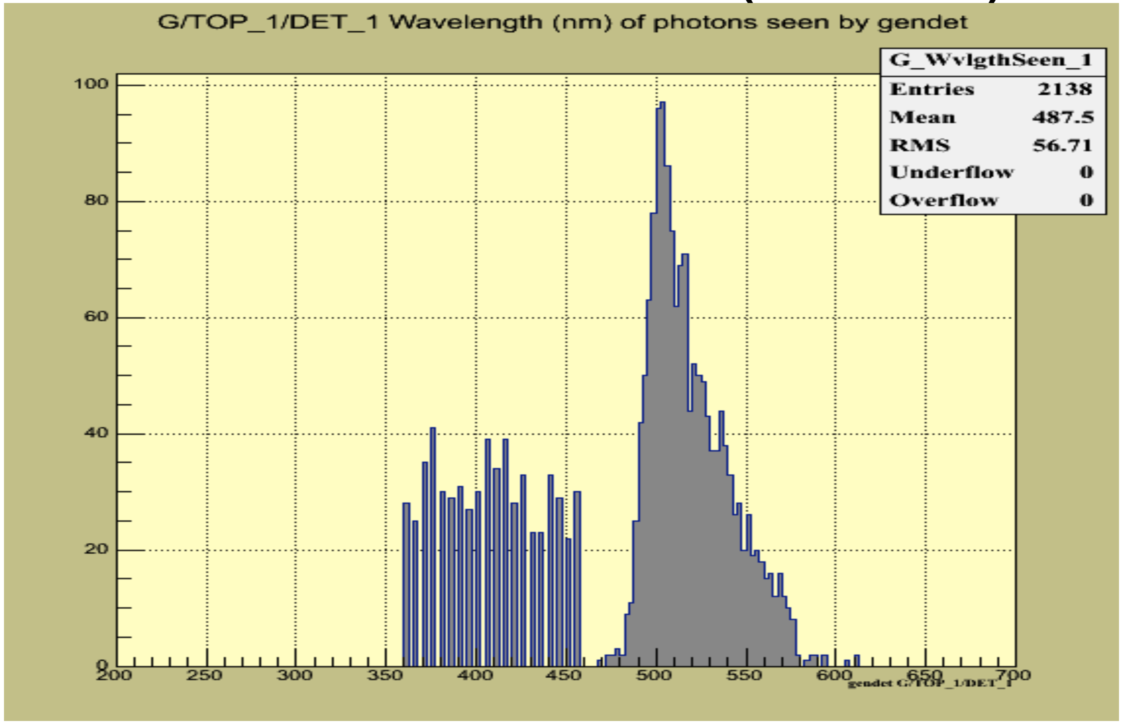
Emission spectrum of BCF91A (Approximately)



Spectrum seen at detector

Ruchti Geometry (WLS Shifting Core in Quartz Fiber)

- Quartz diameter 3mm with 1mm diameter WLS
- ~75% of detected photons were shifted
- Overall Efficiency was 10.7%, WLS attenuation length was same as Quartz (300cm)



Spectrum seen at detector when a WLS core is embedded in Quartz Fiber

Next Steps

- Use actual parameters for materials, including decay times of WLS; for these simulations we've used 12ns (from Saint-Gobain Data)
- Movable cradle; Measure efficiency as function of distance from detector, see Ruchti, et al. at https://indico.cern.ch/getFile.py/access?contribId=3&resId=1&materialId=slides&confId=196078
- Plot efficiency versus attenuation length of WLS (e.g. simulate radiation damage to WLS)

Questions?