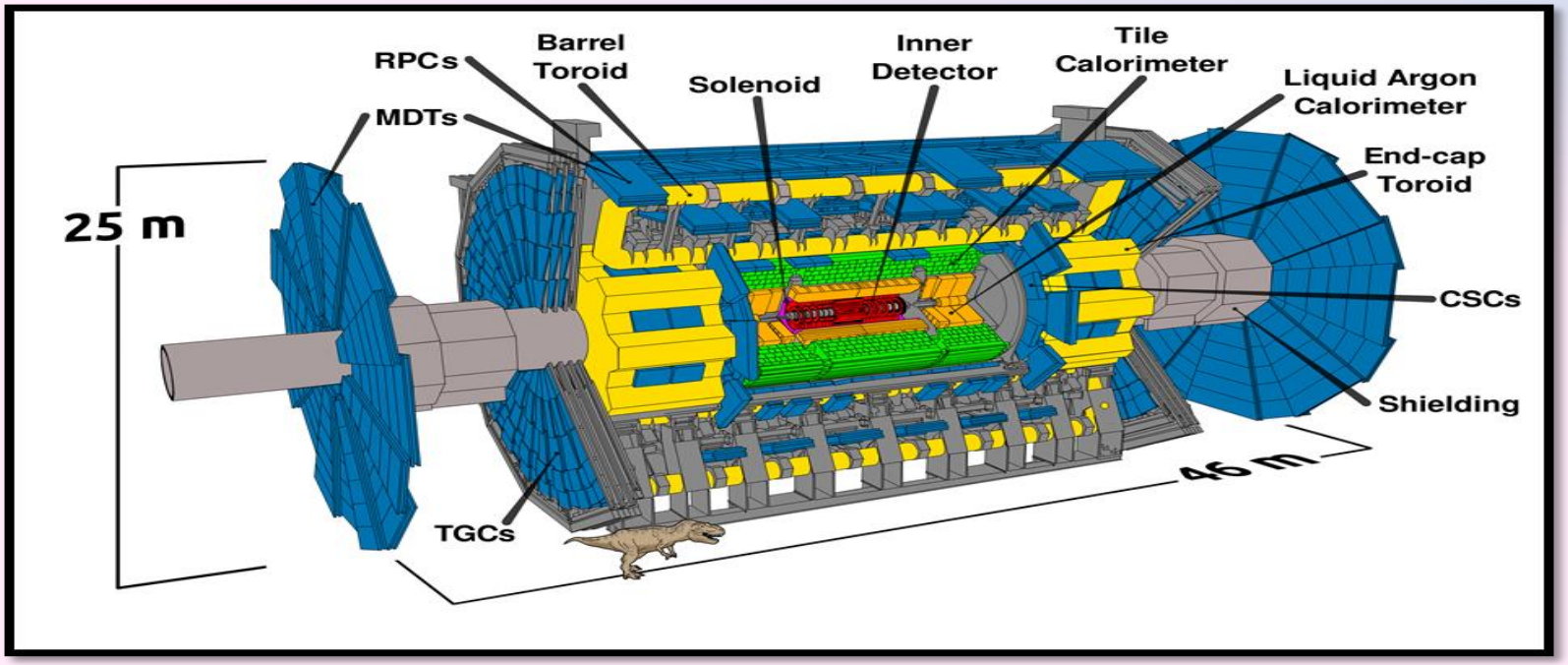
Analysis of systematic uncertainty in transmission experiments on radiation damaged plastic scintillators

Presented by: Phuti Balty Tjale
Supervisor:Prof Bruce Mellado
Co-supervisor: Shell-may Liao and Harshna Jivan

Outline

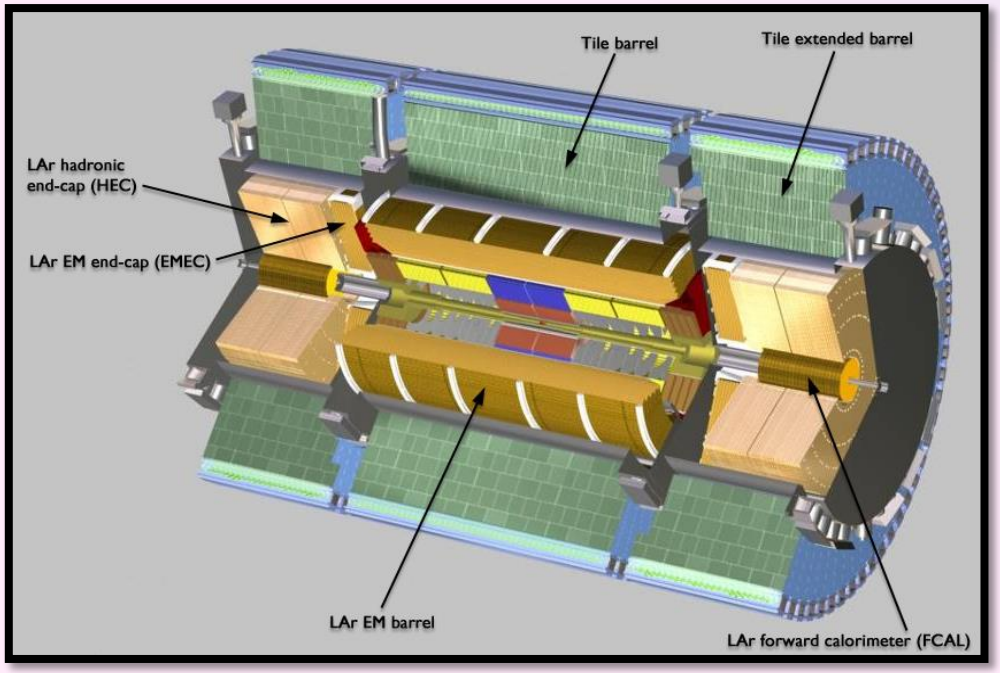
- Introduction
  - The ATLAS detector
  - Tile calorimeter
  - Scintillation
- Methodology
- Results and discussion
- Conclusion

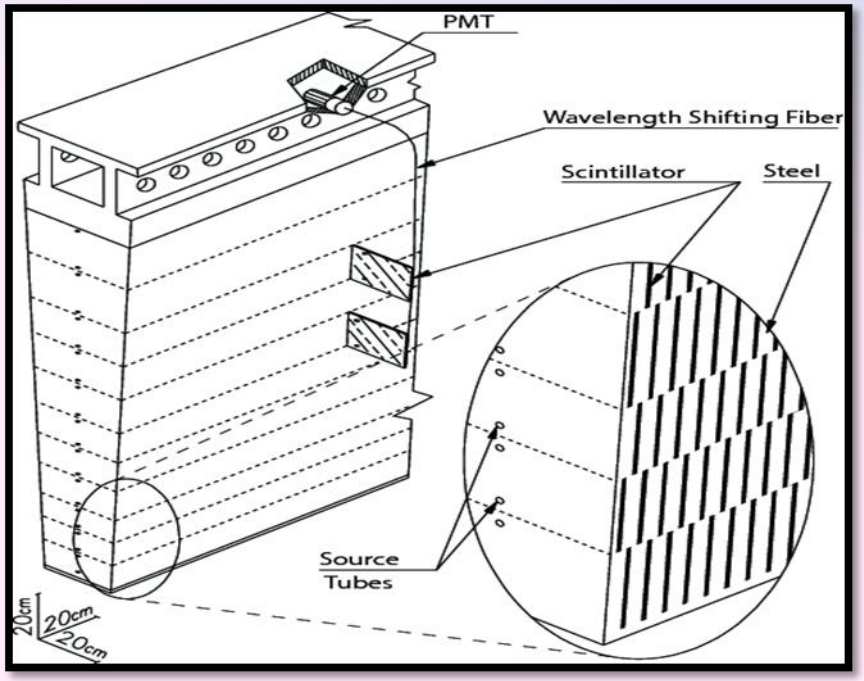
The ATLAS Detector



- The atlas is a physics experiment that is searching for new discoveries in the head-on collision of protons of very high energy.
- It is divided into four major parts, the Inner Detector, the calorimeters, the moun Spectrometer and the magnet systems.
- ATLAS is about 45 meter long, more than 25 meter high and weigh more 7000 tons.

The Tile Calorimeter of ATLAS detector

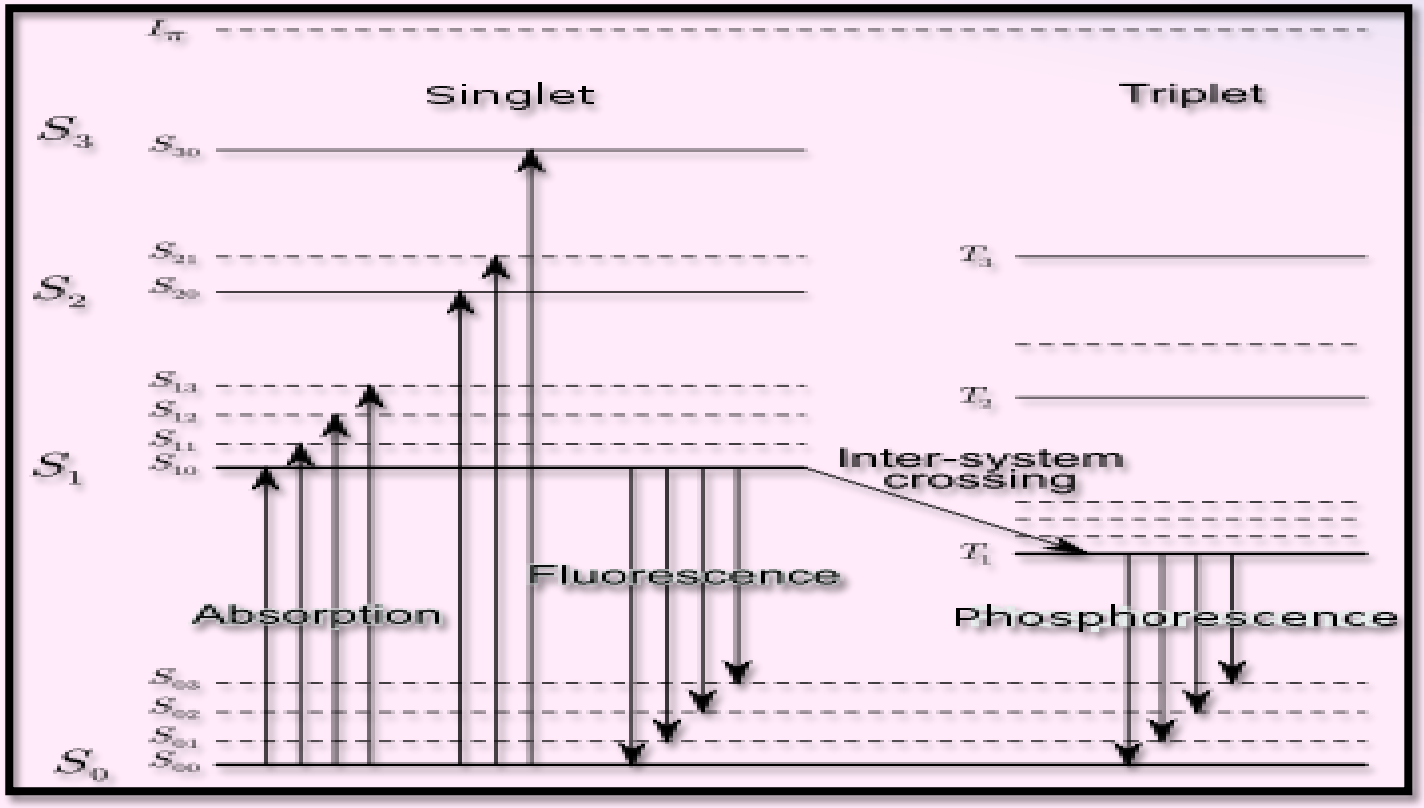




- The tile calorimeter is designed to measure the energy and direction of jets of hadrons.
- It consists of at least 500 000 plastic scintillators responsible for transmission of light produced from proton-proton collision.

- It composed of iron absorber and scintillators as active material.
- The light produced in a scintillating tile is proportional to the energy of the charged particle.
- The light is guided with optical fibres to photomultiplier tube where is converted into electric signal.

Scintillation Mechanism



- The above shows the π-electronic energy levels of an organic molecule
- Absorption of radiation is followed by molecular vibration to the S_1 state and This is followed by a de-excitation to the S_0 state called fluorescence
- The triplet states decay with a much longer decay time than singlet states

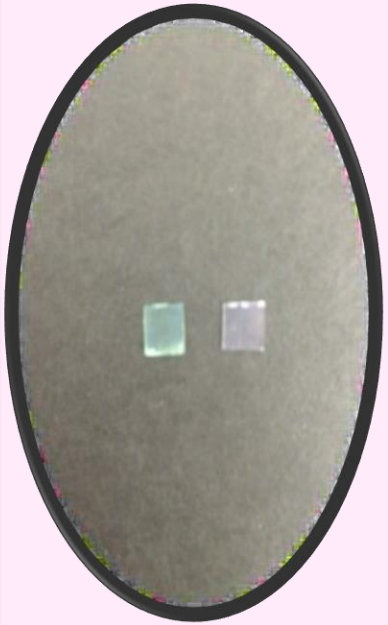
Light Transmission Testing

- The experiment was conducted using the Varian Cary Spectrophotometer
- 12 measurements were taken for each sample over a range of wavelength, 300-800 nm on different days.
- Transmission Spectra for irradiated and un-irradiated sample were measured.
- The ratio of transmission in the irradiated vs un-irradiated sample was determined.

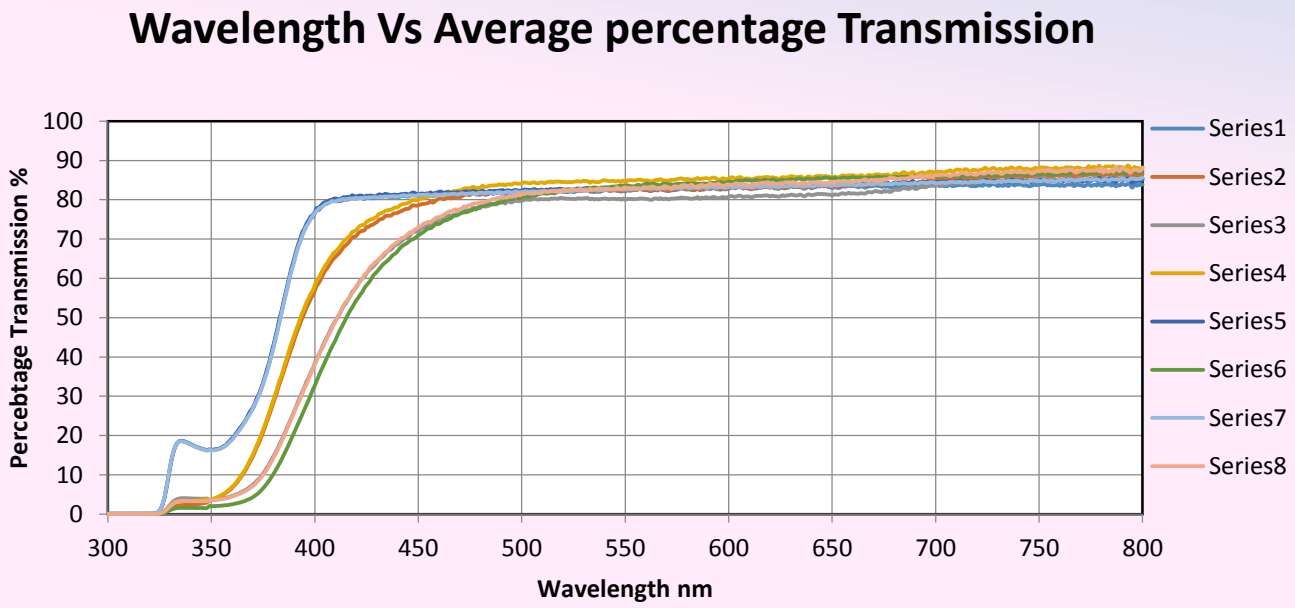
Spectrophotometer

Aluminium sample holder

EJ 208



Results and Discussion



- The transmission loss began from 450 onto 400 nm.
- Spectra fluctuates within this range of wavelength
- Four different fluctuations correspond to four different positions of mounting the sample.

Results and Discussion

- Below is a table containing tabulated data for each sample
- Values in the table are obtained from the transmission spectra at a wavelength of 400,420 and 450nm for analysis.
- The goal is determine the uncertainty in the measurements.

- **EJ 208 15 (15 MGy)**

Average Percentage Ratio	400nm	420nm	450nm
	47.55898	68.01441	84.27471
	51.6966	71.69089	87.13779
	48.63576	69.81565	86.54312
	48.06723	69.82174	86.96883
	47.76403	69.19383	86.41676
	48.41839	69.76377	86.46316
	46.29231	68.20885	85.6957
	47.42817	69.22249	86.63544
	47.92859	70.23923	87.84591
	50.15975	71.51792	88.4856
	47.70953	69.64497	87.21018
	48.70206	70.29147	87.04307

Results and Discussion

- **EJ 208 18 (25 MGy)**

Average Percentage Ratio	400nm	420nm	450nm
	78.83031 78.72613 78.14039 77.94811 78.15202 76.79868 77.71817 78.59416 79.42287 79.95472 78.08777 78.46123	75.09222 79.1513 77.0809 77.08763 76.39437 77.02363 75.30689 76.42602 77.54857 78.96032 76.89246 77.60624	92.47207 95.61364 94.96113 95.42824 94.82248 94.87339 94.03128 95.06243 96.39065 97.09256 95.69308 95.50971

Standard deviation

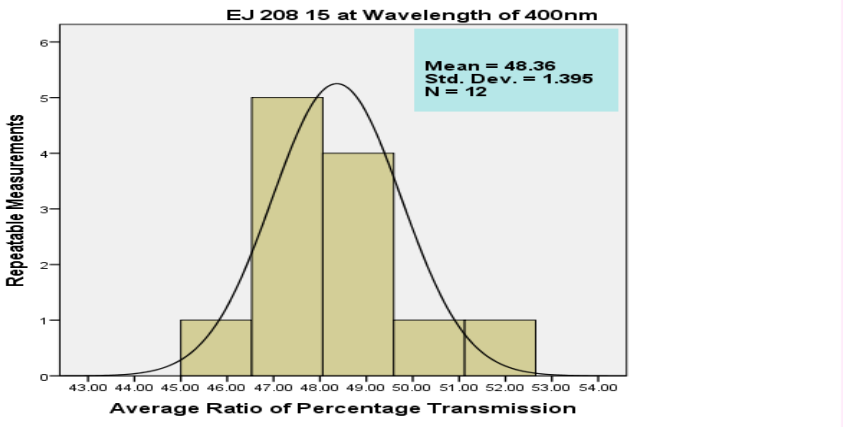
$$S = \sqrt{\frac{\sum_{i=1}^{N}(x_i - x_m)^2}{N-1}}$$

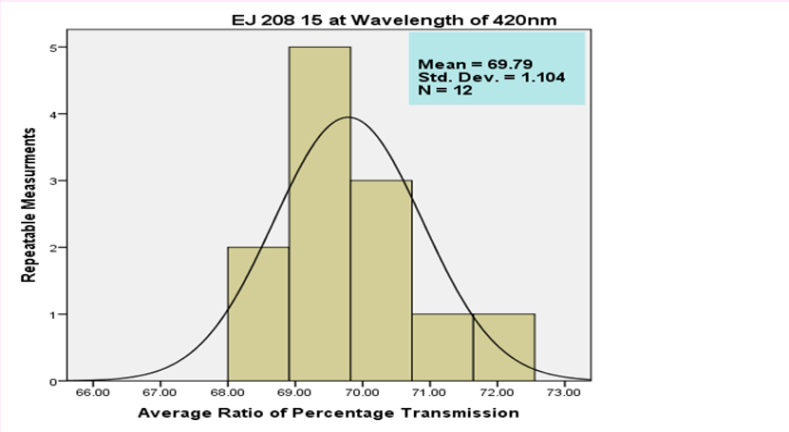
The Standard Deviation of the mean value of a set of measurements

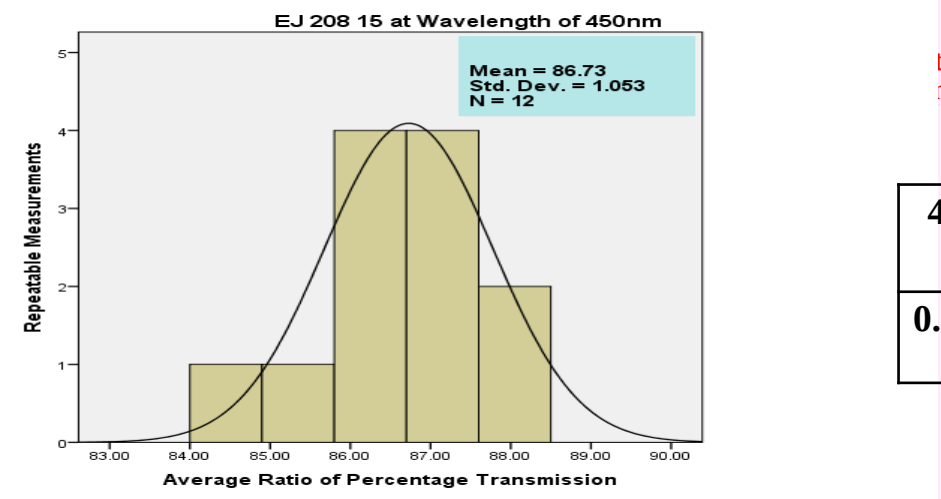
$$\sigma = \frac{S}{\sqrt{N}}$$

Data Analysis

- EJ 208 15
- The following histograms were plotted using TeraPlot software which is a built-in function
- Mean and standard deviation were determined
- Standard deviation of the mean of the set of measurement (sigma) was calculated and this gives us the uncertainty.





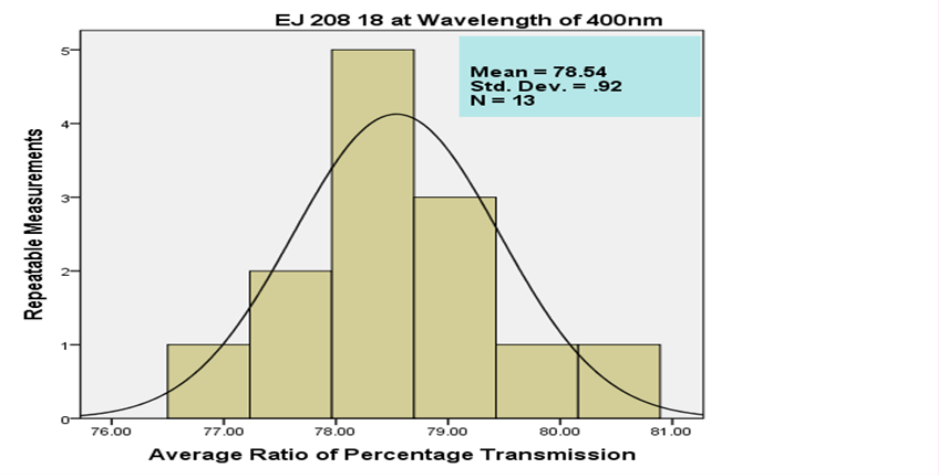


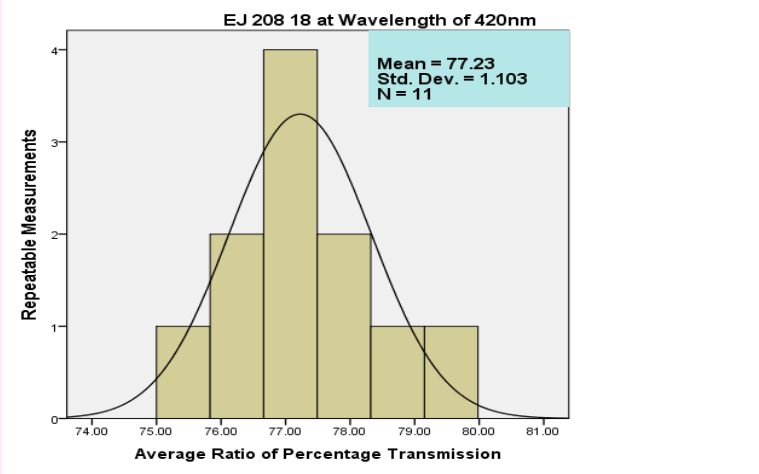
tandard Deviation of the mean value
ments

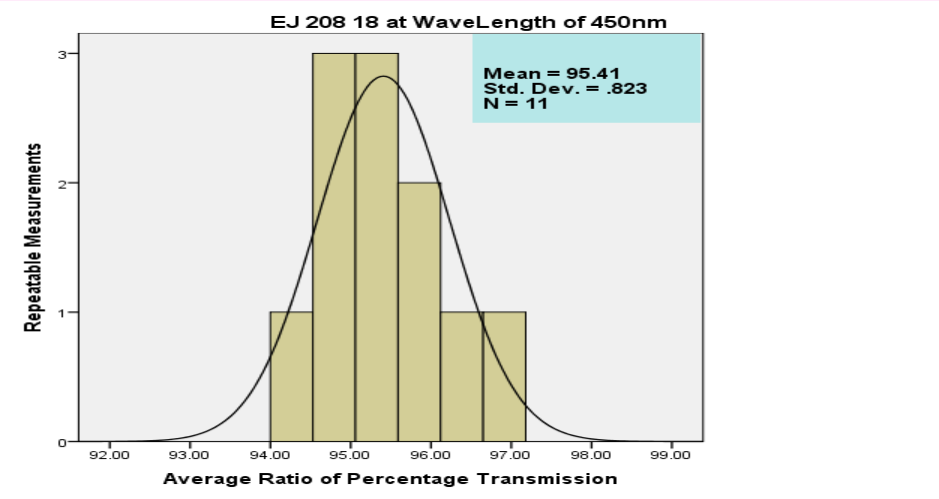
400	420	450	Wave length
0.03	0.033	0.025	sigma

Data Analysis

- **EJ 208 18**







The standard deviation of the mean value of set of measurements

400	420	450	Wave length
0.04	0.032	0.0301	sigma

Conclusion

- 96.5 % of the measurements fall within the standard deviation of the mean
- A systematic error of 3% in the light transmission due to slight changes of position.
- The accuracy of measurements subject to systematic errors cannot be improved by repeating the measurements. These errors are difficult to detect**.**

sources of errors

- Uncertainties arises because of little scratches on the samples.
- The clamp for mounting the sample often changed position because of opening and closing of the machine door, hence this affected calibration a bit.
- The light of spectrophotometer machine had to be in thermal equilibrium.

Recommendation

- Refine the methodology or the technique of the measurements.
- Calibrate the machine with high accuracy before taking the measurement**.**

Thank you