Discover What's Possible™

OTDR Theory Training

Workshop Event
Nov 2010 edition

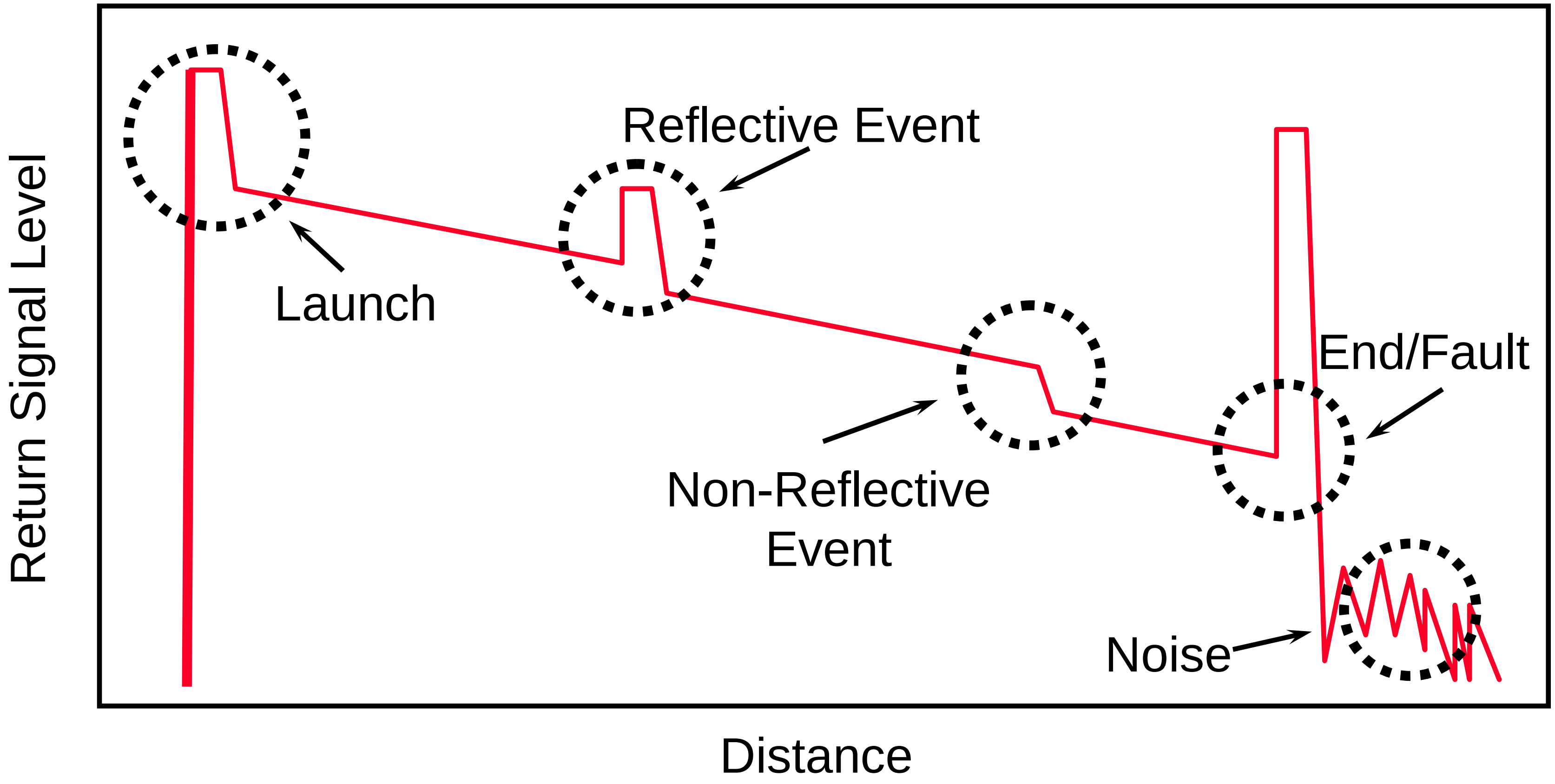
Notice

Agenda

- **OTDR Terminology**
- **OTDR Basics**
  - » Distance Measurements
  - » Loss Measurements
  - » Reflectance Measurements
  - » ORL Measurements
- **OTDR Setups**
  - » IOR
  - » Backscatter coefficient
  - » Wavelength
  - » Range
  - » Resolution
  - » Pulse width
  - » Number of averages
- **Anritsu MT9083x Access Master OTDR**

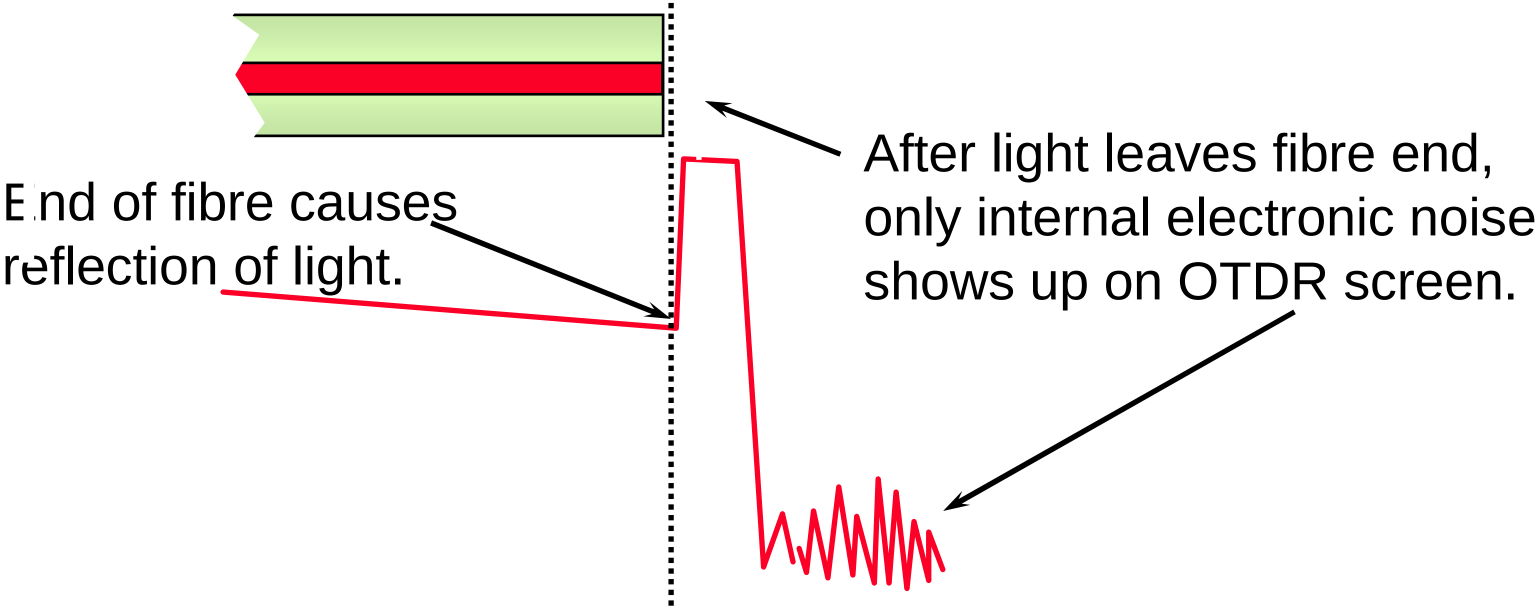
OTDR Terminology

Trace Basics



OTDR Terminology

Locating the end of the fibre



OTDR Terminology
Dynamic Range

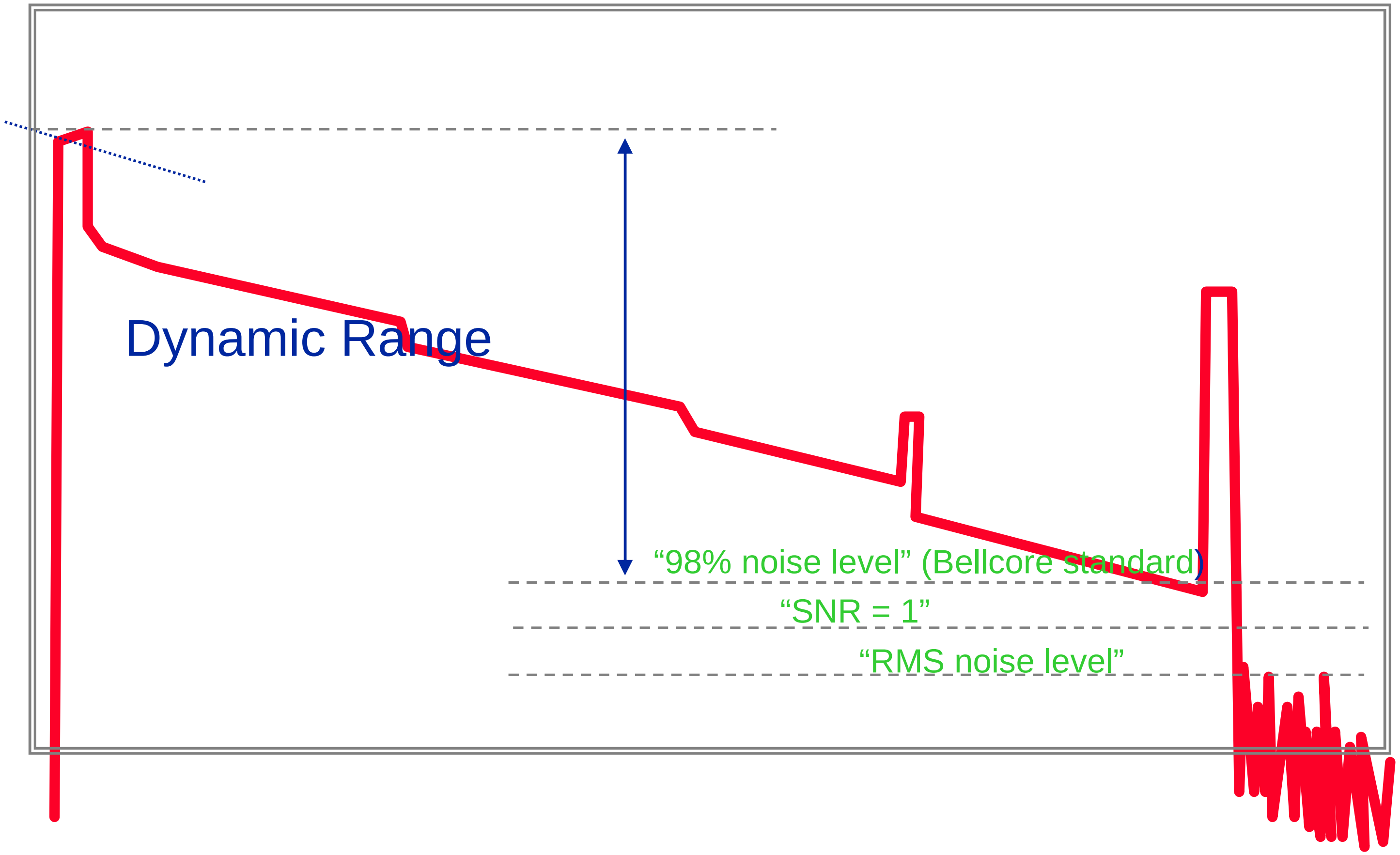
- Measured in dB. Typical range is 20-50dB
- Describes how much loss an OTDR can measure in a fibre, which in turn describes how long of a fibre can be measured
- Directly related to Pulse Width: larger pulse widths provide larger dynamic range
- Increase by using longer PW and by decreasing noise thru averaging

OTDR Terminology
Dynamic Range

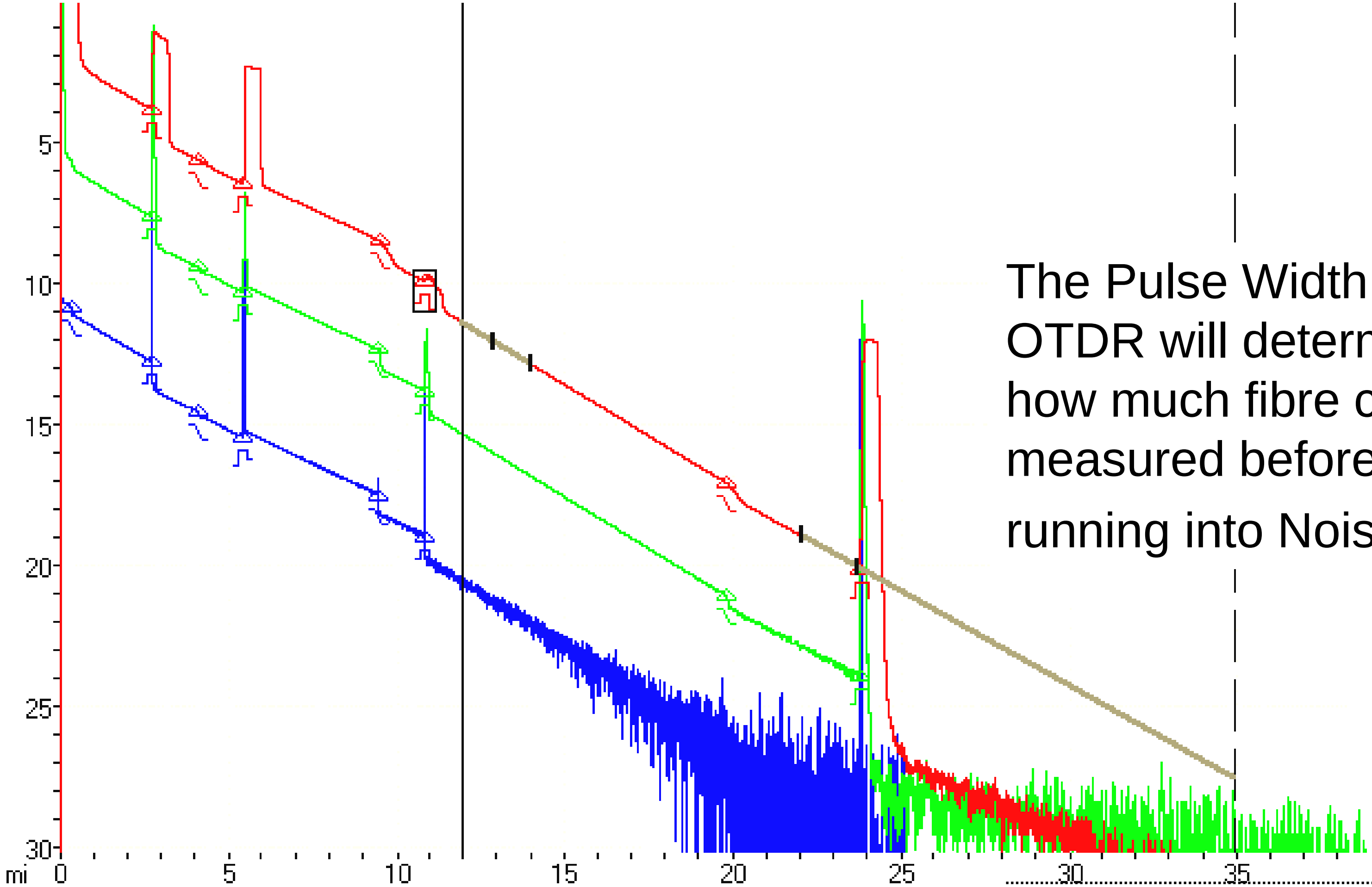
- **Converting Dynamic Range into Distance**
  - » Can only be done on a straight piece of glass (no events)
  - » Need to know the dB/Km loss for each wavelength to be tested.
  - » Need to know the dynamic range at each wavelength.
  - » Distance = $\frac{\text{Dynamic Range}}{\text{dB/Km}}$

OTDR Terminology

Dynamic Range



OTDR Terminology
Dynamic Range Examples



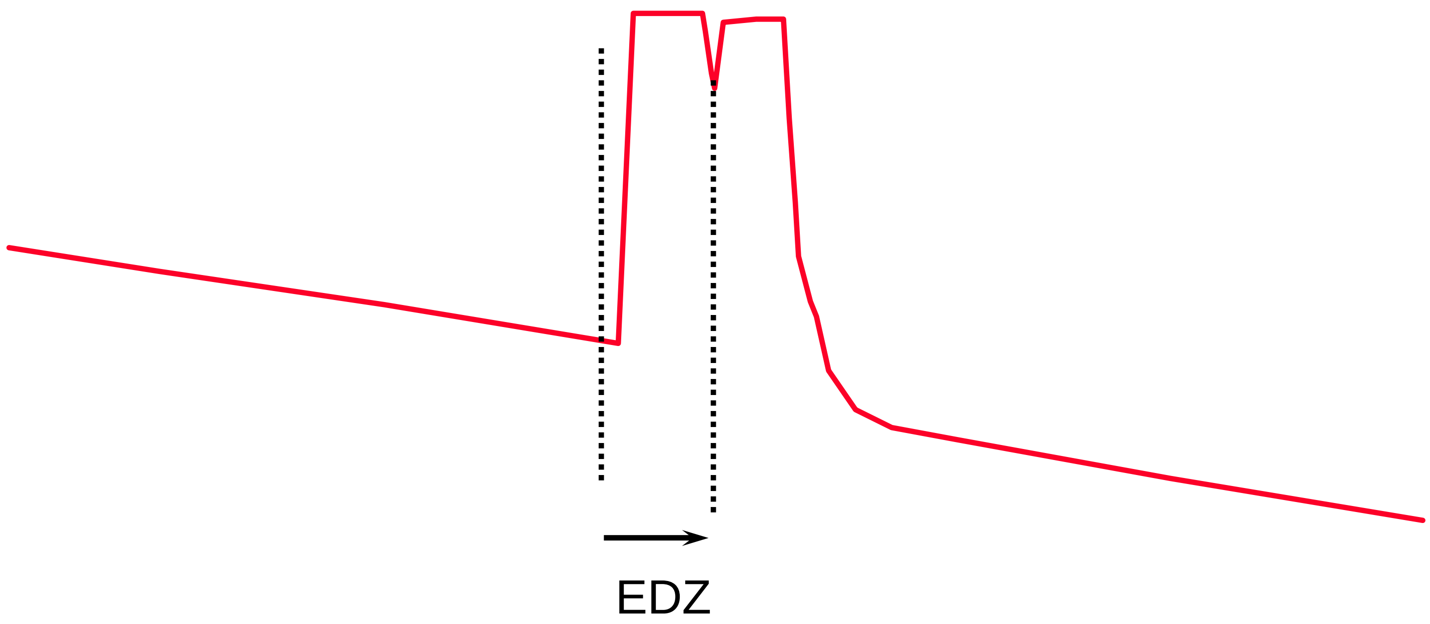
The Pulse Width of the OTDR will determine how much fibre can be measured before running into Noise.

[All measurements taken at 1310nm Wavelength]

OTDR Terminology
Dead zones

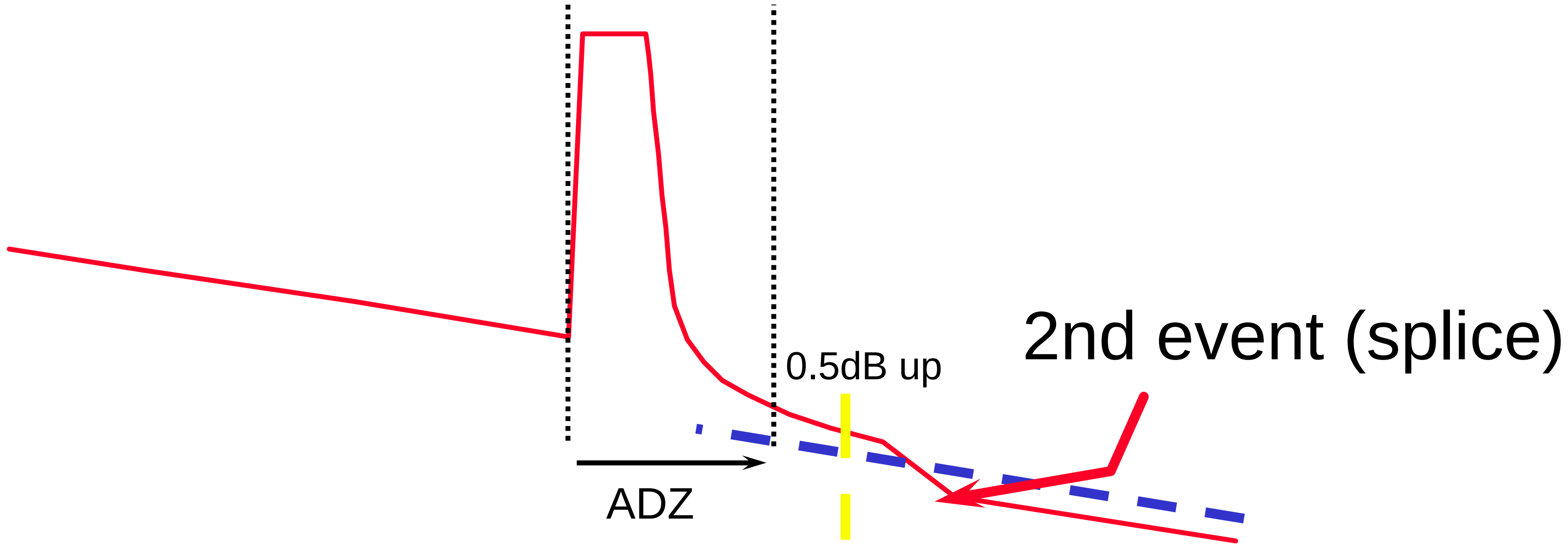
- Specified as a DISTANCE
- Determines how CLOSE to OTDR you can detect and measure a splice loss
- Determines how CLOSE TOGETHER two events (splices) can be measured
- Directly related to PULSE WIDTH: larger pulse widths produce larger dead zones

OTDR Terminology
Reflective or Event Dead Zone



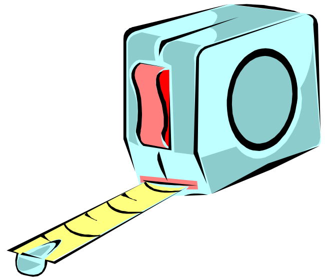
The distance from the start of a reflective event until you can detect another reflective event. Measured at 1.5dB below the peak of the initial reflection.

OTDR Terminology
Non-Reflective or Attenuation Dead Zone



The distance from the start of a reflective event until you can **measure the loss** of another event. Measured at 0.5dB up from the backscatter level after the reflection.

OTDR Basics
Measurements

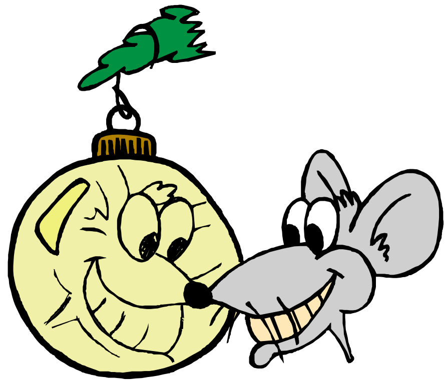


Distance measurements

Locate End
Locate Splice

Loss measurements

Measure splice losses
Measure end to end



Reflectance measurements

Measure Reflectance
Measure ORL

OTDR Basics

Distance Measurements

$$d = \frac{t\,C}{2\,n}$$

Must divide by two to get one way elapsed time.

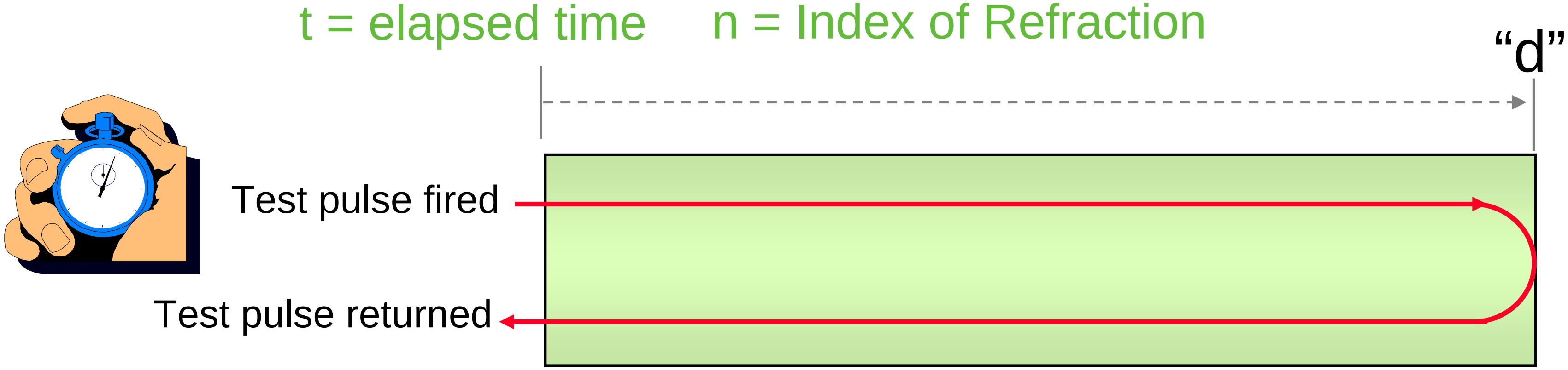
If “n” is incorrect, then the distance measured will also be wrong!!

d = distance

t = elapsed time

c = speed of light in a vacuum

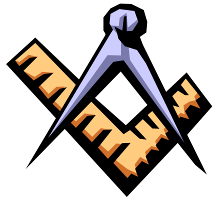
n = Index of Refraction



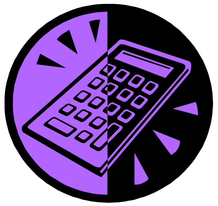
OTDR Basics
Distance Measurements

- Measuring distance
  - » To calculate the speed of light, the OTDR must know the Index of Refraction (IOR).
  - » The IOR is a ratio between the speed of light in a vacuum and the speed of light in a fibre.
  - » The IOR is obtained from the fibre manufacturer, entered into the OTDR by the user and must be accurate.

OTDR Basics
Loss Measurements



- OTDRs *measure* backscatter



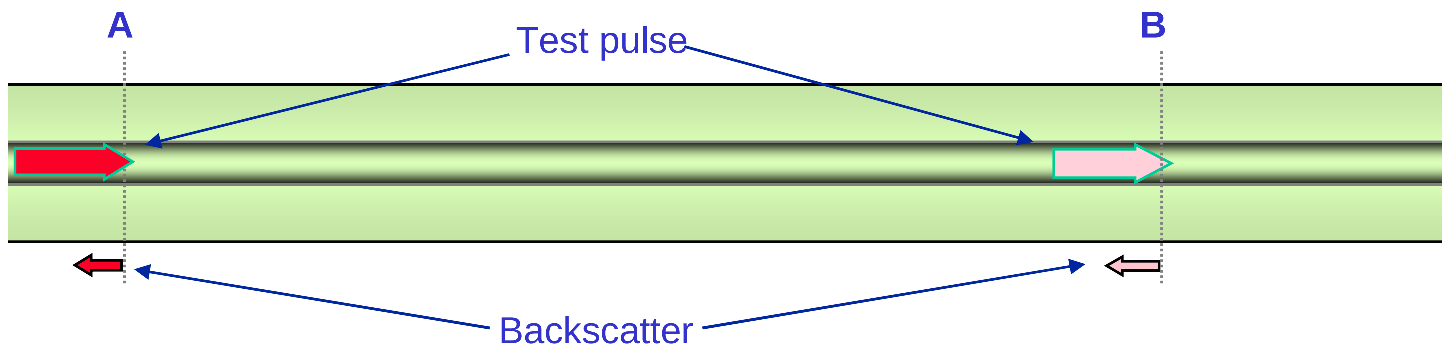
OTDRs *calculate* loss

OTDR Basics

Distance Measurements

OTDR calculates loss by comparing backscatter levels to determine loss between points in fibre

OTDR Basics
Loss Measurements



Backscatter is ***directly related*** to the power of the test pulse. As the test pulse power decreases, so does the backscatter power.

The ***difference*** in strength between two points of backscatter is directly proportional to the difference in strength between the test pulse at the same two points.

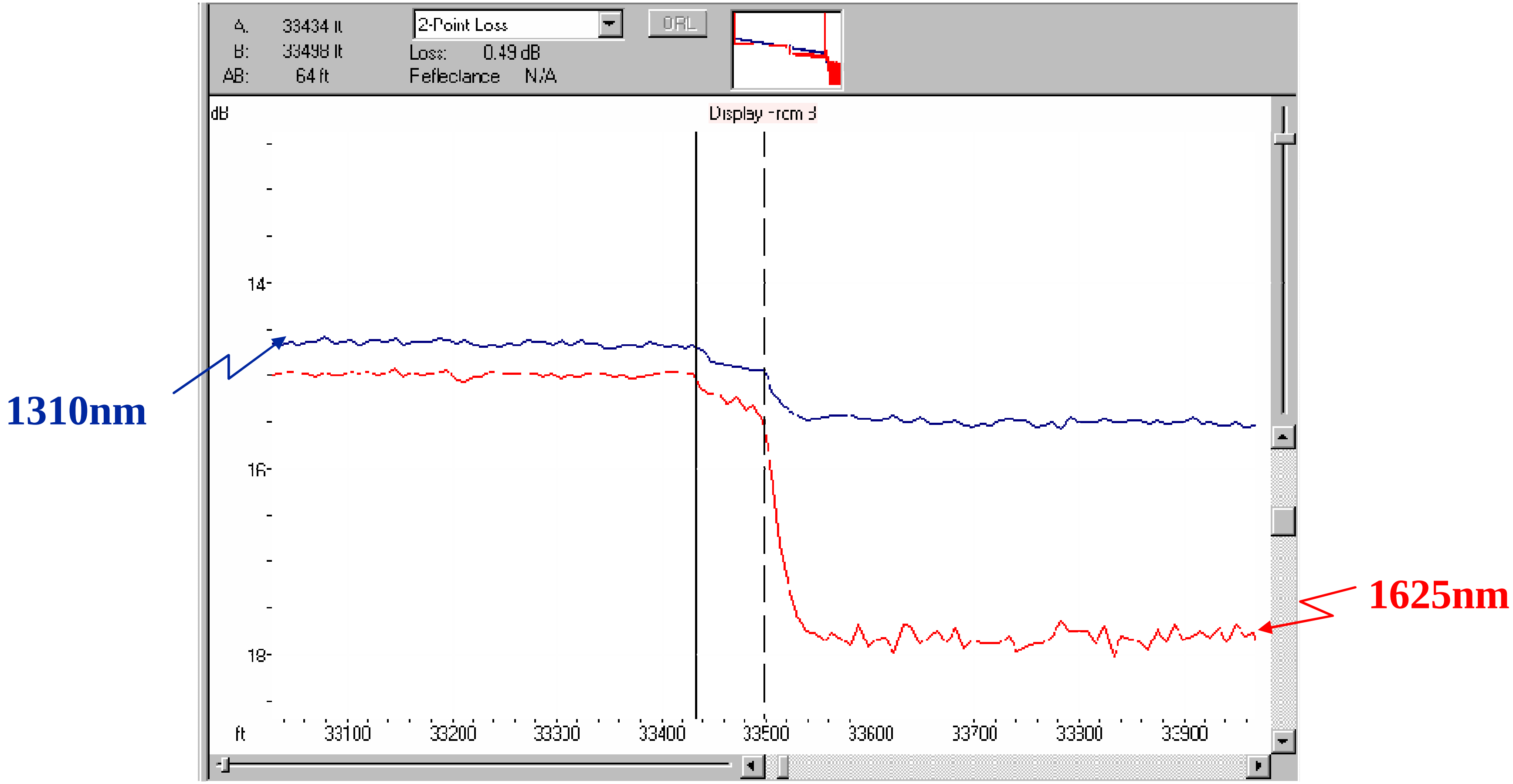
OTDR Basics
Loss Measurements

- Different test wavelengths exhibit different loss characteristics.
  - » 850nm - *extremely susceptible* to Rayleigh scattering loss
  - » 1244nm - *very susceptible* to hydrogen absorption and Rayleigh scattering loss
  - » 1300nm - *very susceptible* to Rayleigh scattering loss
  - » 1310nm - *susceptible* to Rayleigh scattering loss
  - » 1550nm - *very susceptible* to macrobending loss
  - » 1625nm - *extremely susceptible* to macrobending loss

OTDR Basics

Loss Measurements

Different wavelengths respond very differently to various losses.



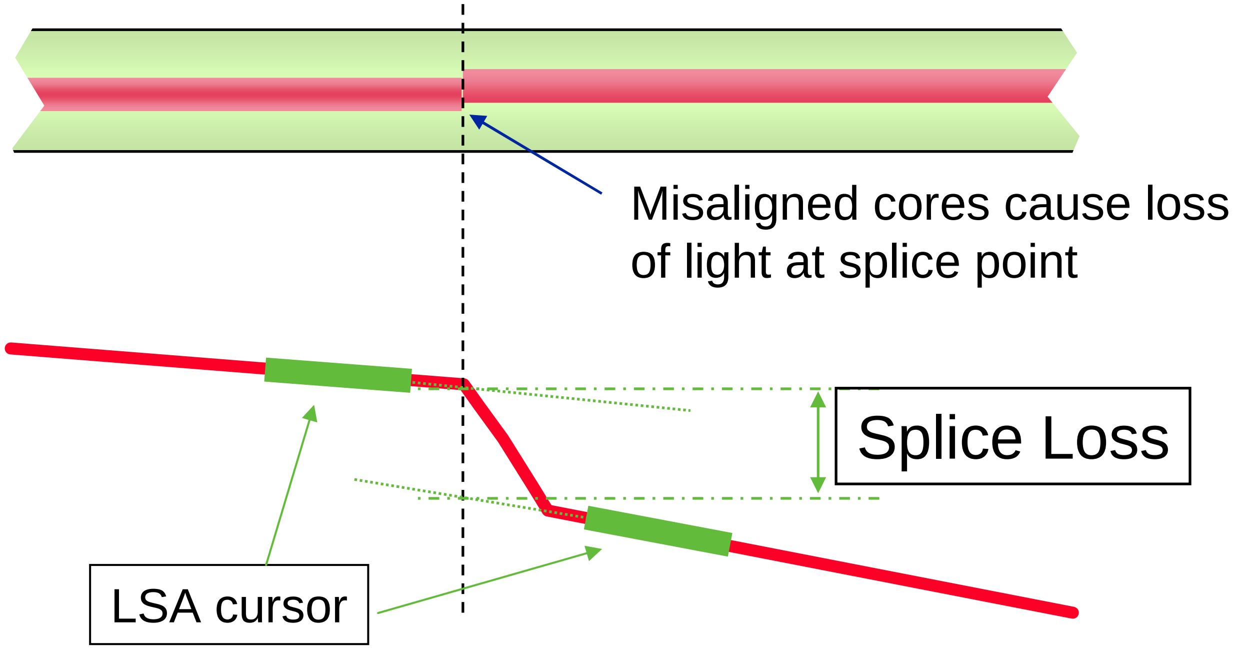
Anritsu

OTDR Basics

Loss Measurements

Splice Loss

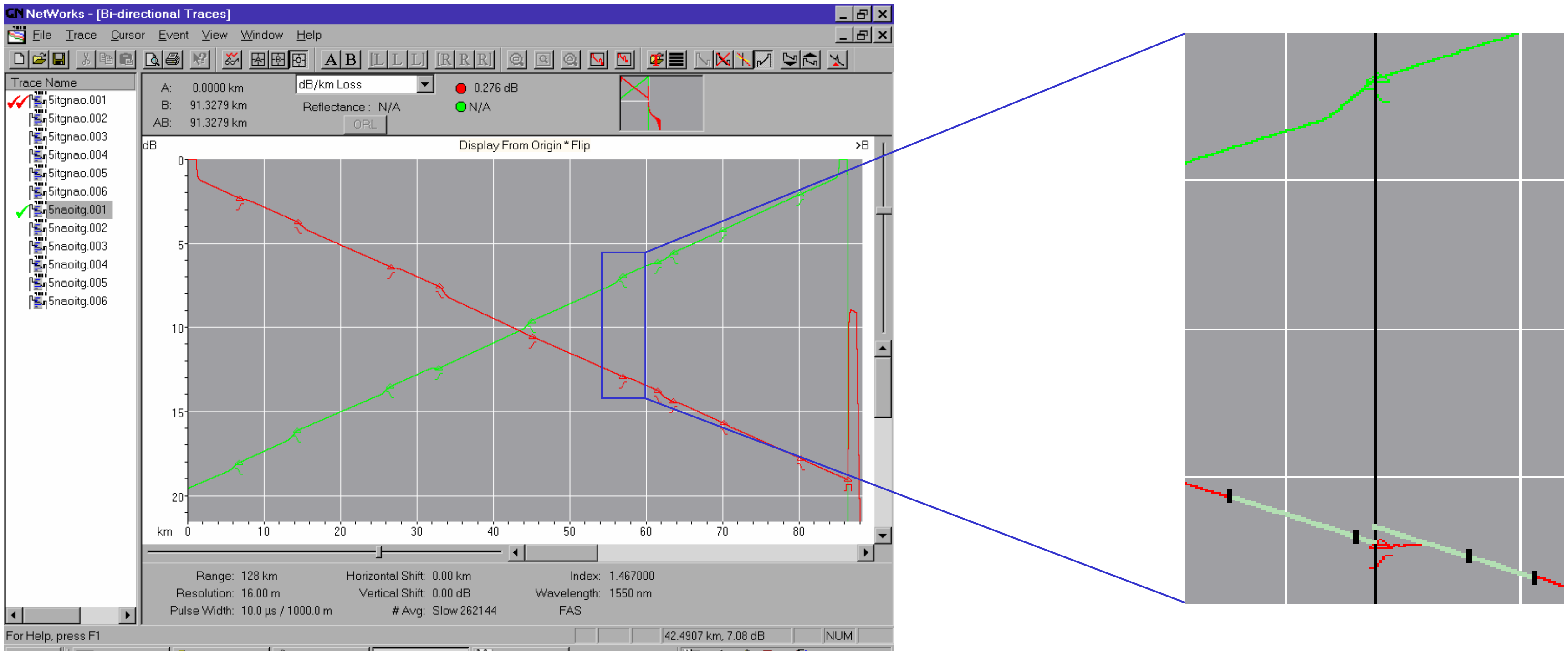
For proper splice loss measurement, the linear backscatter after the event must be extrapolated to the beginning of the event to account for the width of the test pulse. This is accomplished with LSA cursors.



OTDR Basics

Bi-directional Loss Measurements

The most accurate method of OTDR splice loss measurement entails bi-directional OTDR traces. The fibre is shot from both ends and individual event splice losses are averaged together to account for gainers.

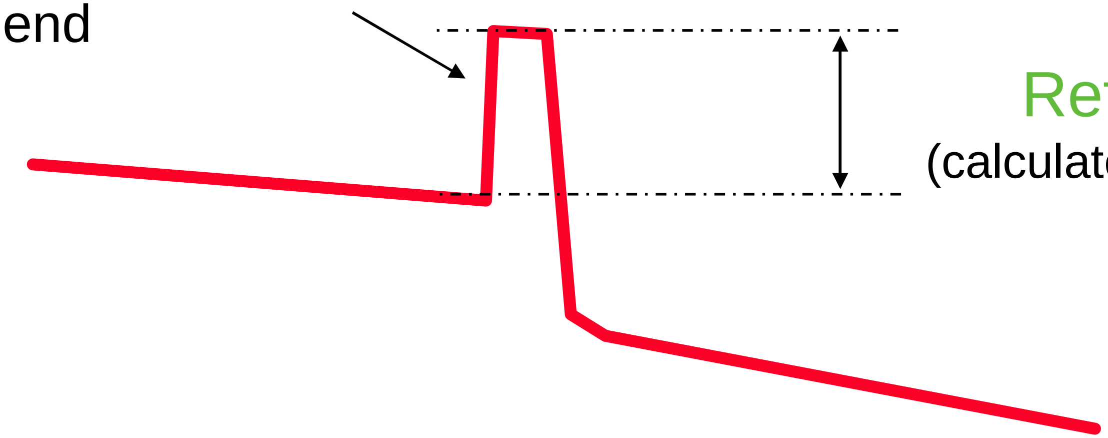


OTDR Basics

Reflectance Measurements

- OTDRs calculate event reflectance by comparing the backscatter level just before an event to the backscatter level during an event.

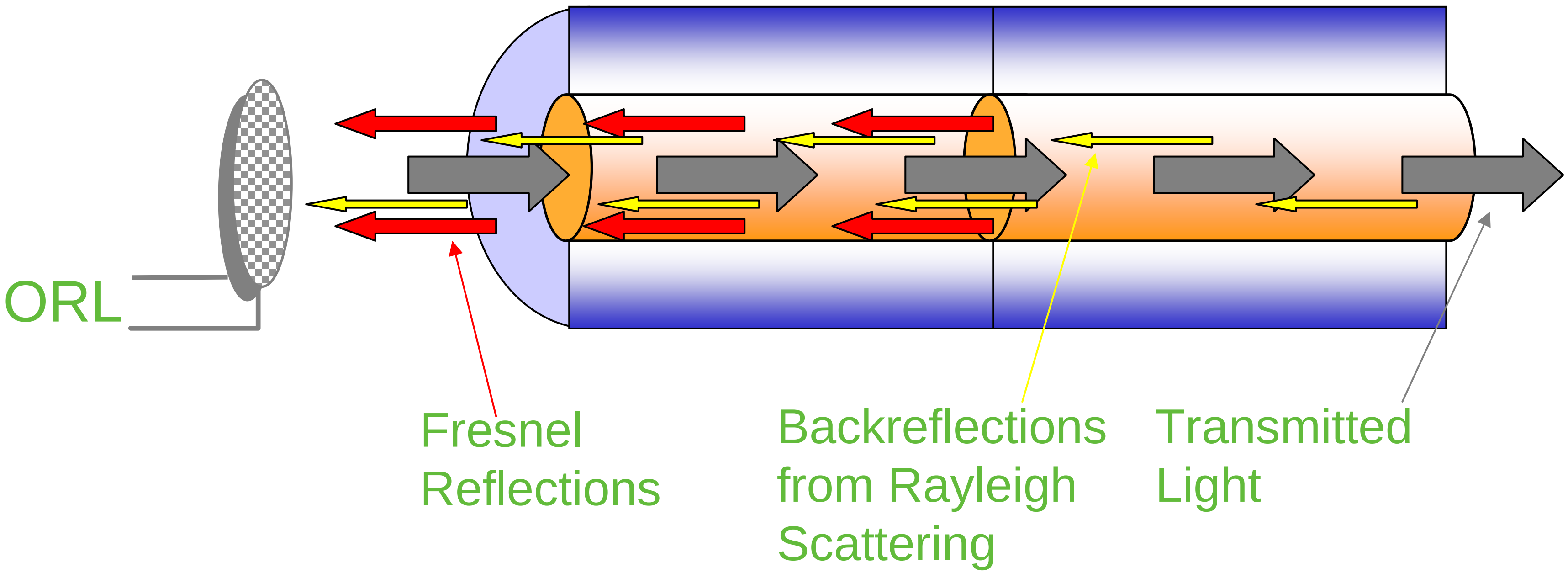
Some events cause reflections, or "spikes" of returned light at the splice point or fibre end



Reflectance
(calculated from formula)

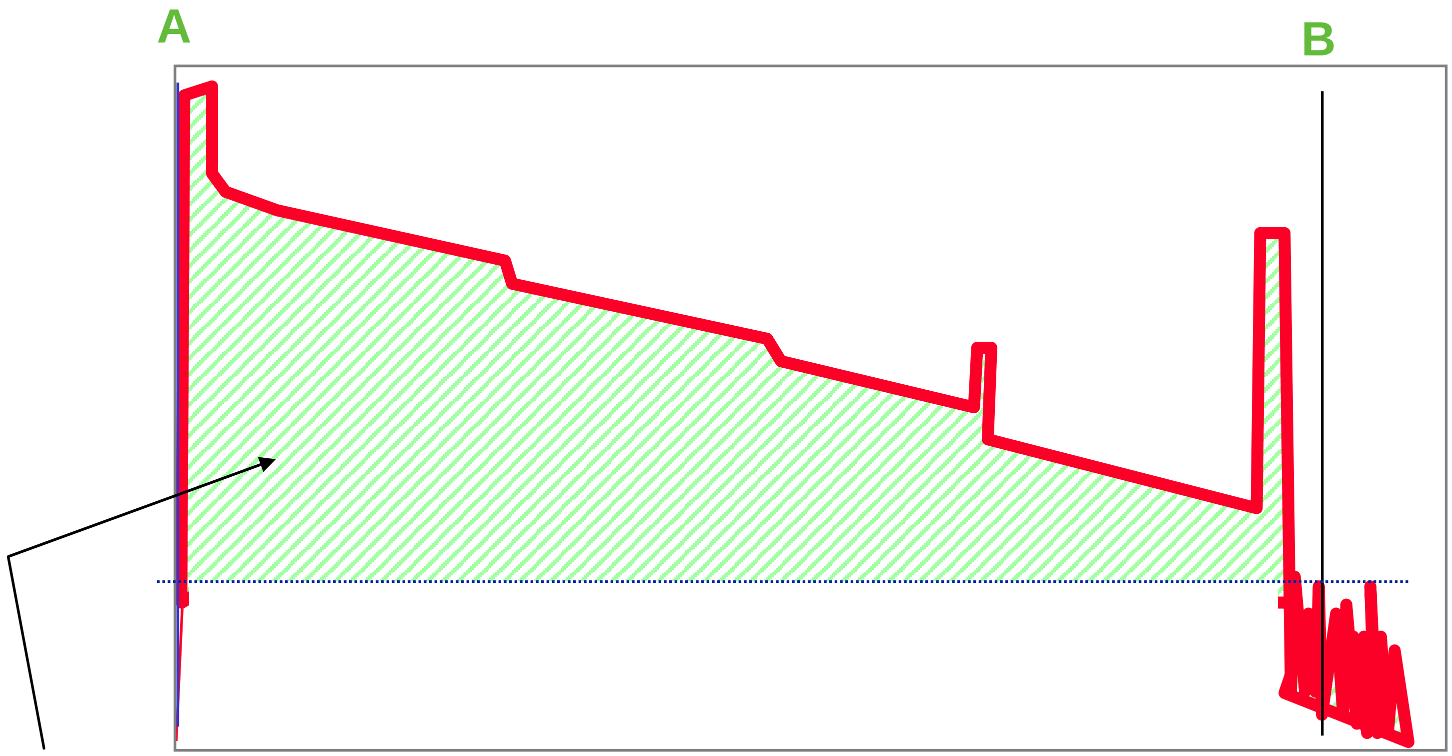
OTDR Basics
ORL Measurements

Optical Return Loss (ORL) is measured in +dB and represents the sum of all individual reflectances within a fibre span**.**



OTDR Basics

ORL Measurements



ORL is *calculated* as the total amount of light returning from the area between the cursors below the trace line to the noise level.
It includes total Backscatter and all Reflections.

OTDR Basics
ORL Measurements

- **Pulsed Light vs. Continuous wave**
  - » **OTDR affected by Noise, distance and Pulse width**
  - » **Deadzones prevent OTDR from measuring small reflections that often follow large reflective events.**
- **OTDR = evaluated ORL Measurement**
- **CMA50 = True ORL Measurement**
- **Accuracy**
  - » **CMA50 ± 0.5dB**
  - » **OTDR ± 4dB**
  - » **CMA5000 SMART ORL ± 1dB**

OTDR Setups

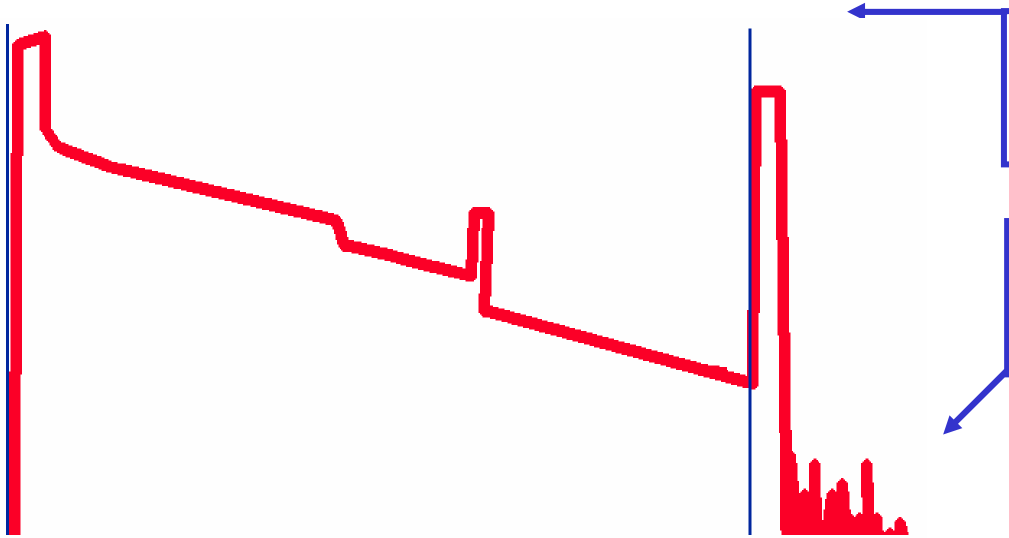
» IOR
» Backscatter coefficient
» Wavelength
» Range
» Resolution
» Pulsewidth
» Number of averages

Setting Up The OTDR
Fibre Details

- **IOR**
  - » obtain from fibre manufacturer, dial in on OTDR
- **Backscatter coefficient**
  - » obtain from fibre manufacturer, dial in on OTDR

Setting Up the OTDR
Range

- Must be at least 25% greater than the fibre under test.
- There is valuable information in the noise floor which must be measured.



If the OTDR stops measuring here...

…this data won't be acquired!

Setting Up the OTDR
Resolution

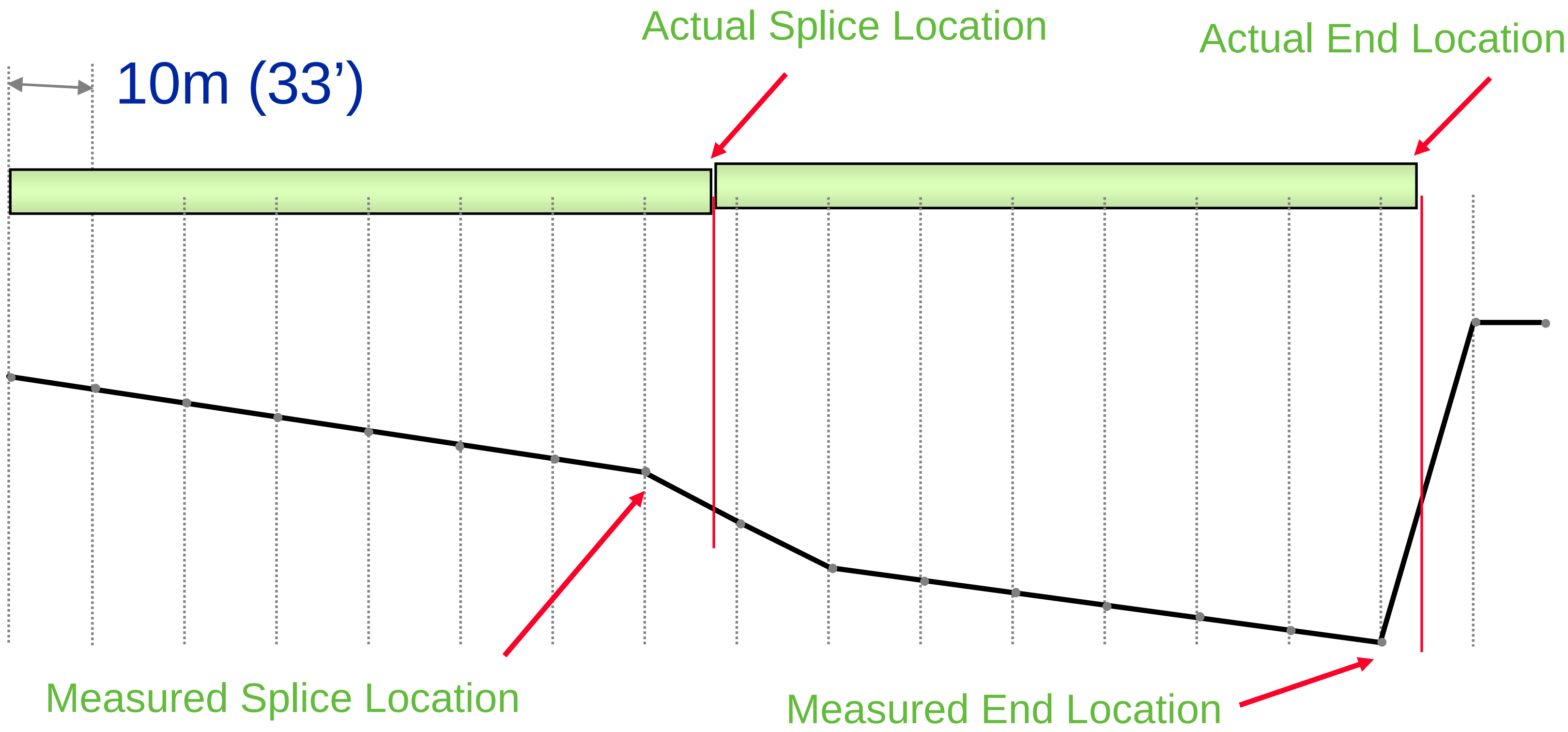
Typically begin with the lowest resolution (highest number) possible.

Pros - *much* faster acquisition time, smaller trace file size

Cons - minimal degradation in accuracy of measurements

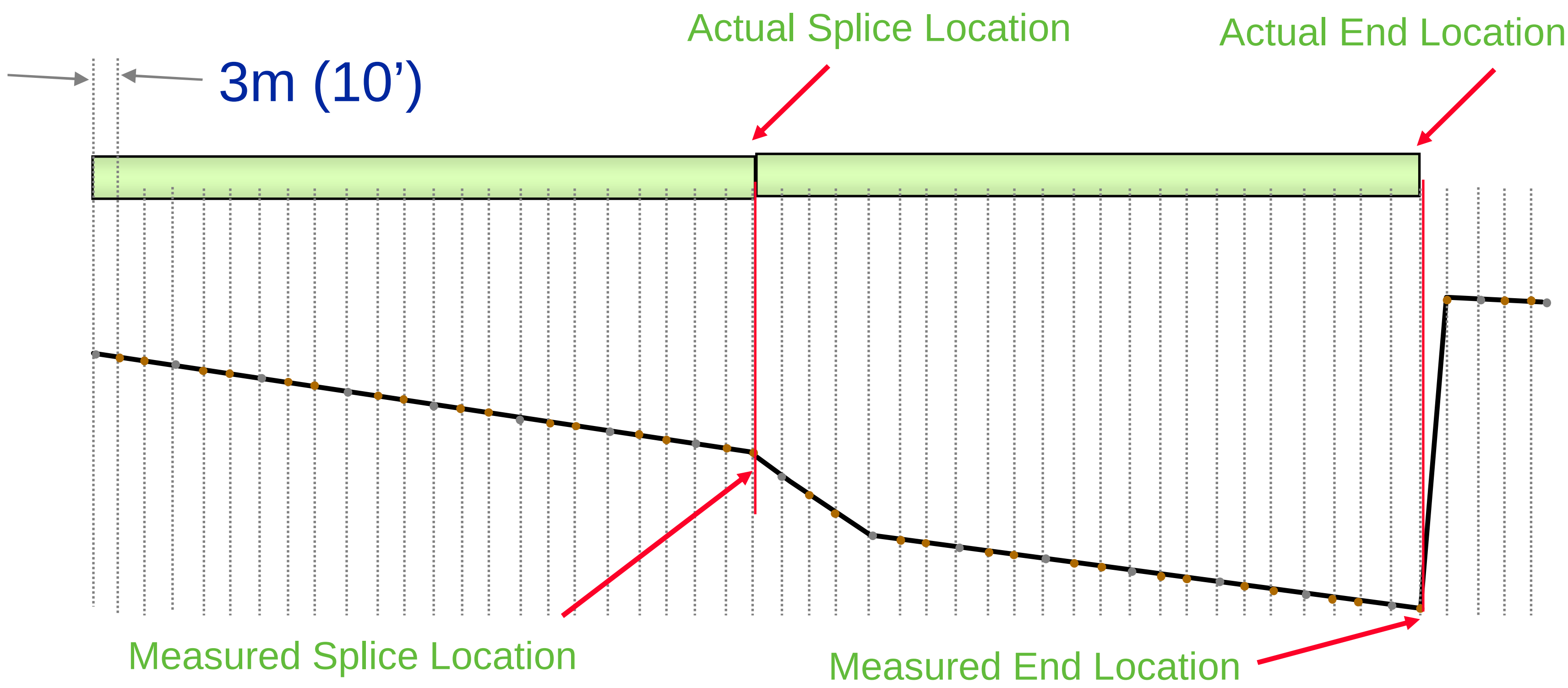
Setting Up the OTDR
Resolution

Low Density (long DPS)



Setting Up the OTDR
Resolution

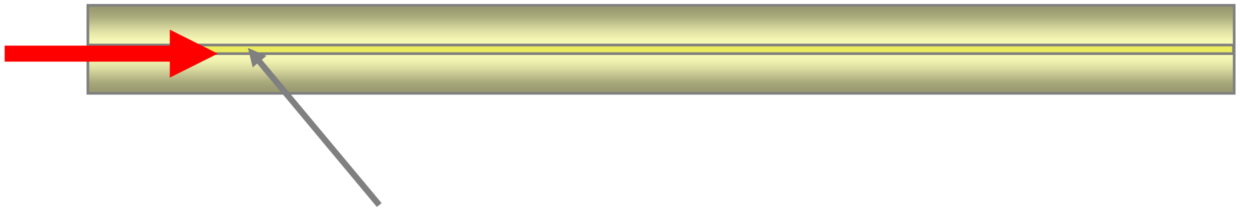
High Density (short DPS)



Setting Up the OTDR

Pulse Width

Controls Dynamic Range and Dead Zone



A light pulse from the OTDR travels along inside the fibre like water through a pipe.

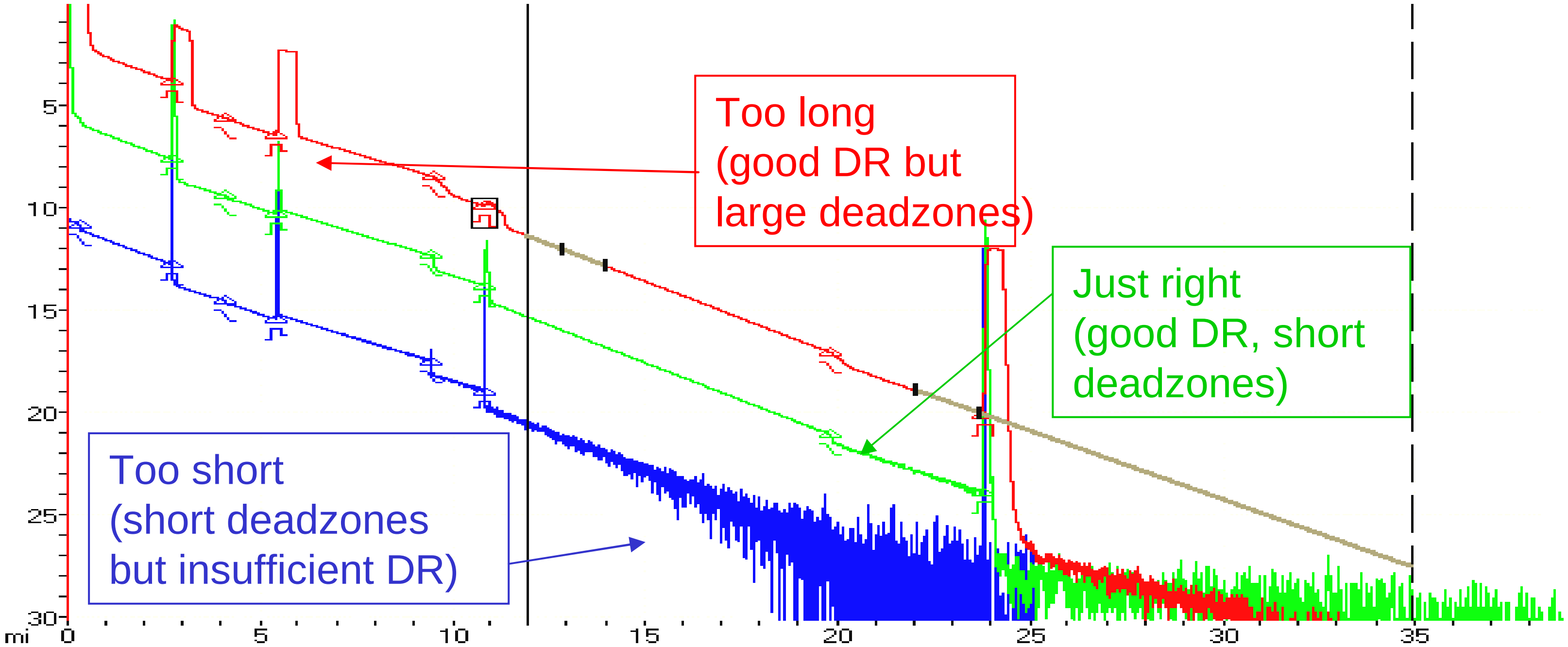
10ns = 1 meter = 3 feet

100ns = 10 meters = 33 feet

10,000ns = 1,000 meters = 3,281 feet

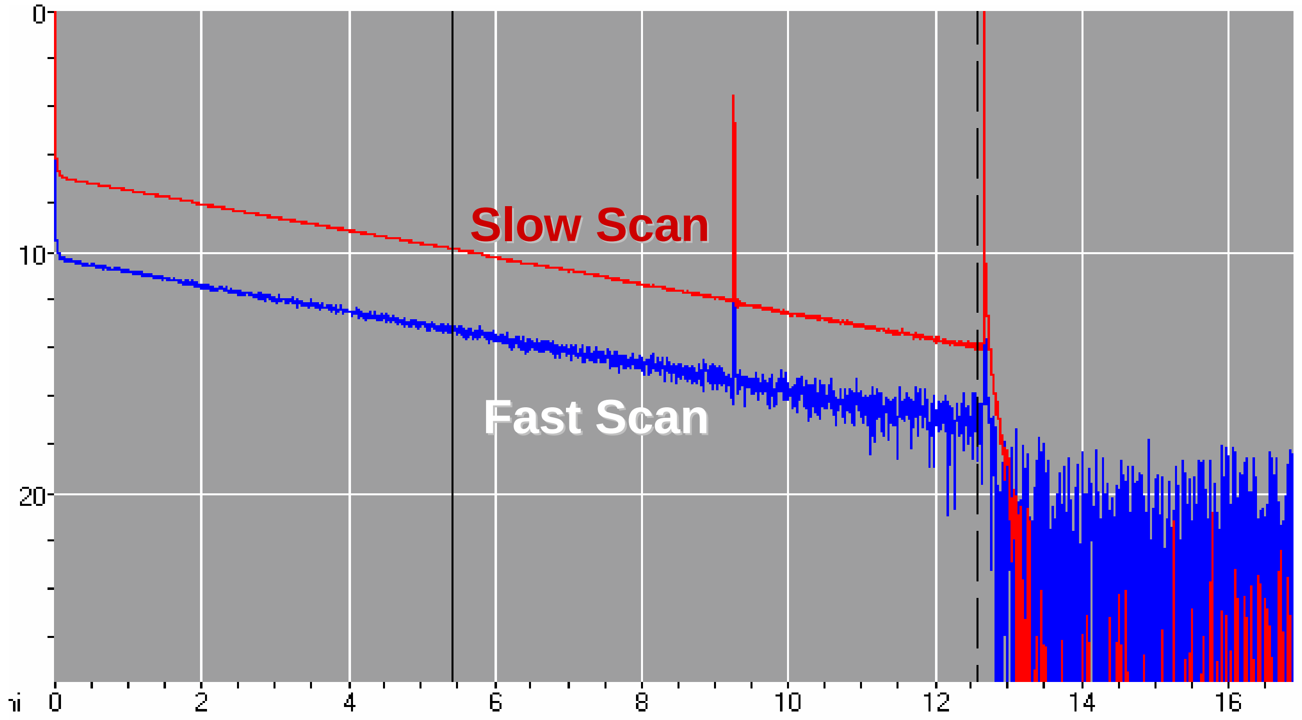
Setting Up the OTDR
Pulse Width

- **The single most important parameter**
- **Use the shortest pulse width which still provides sufficient dynamic range**



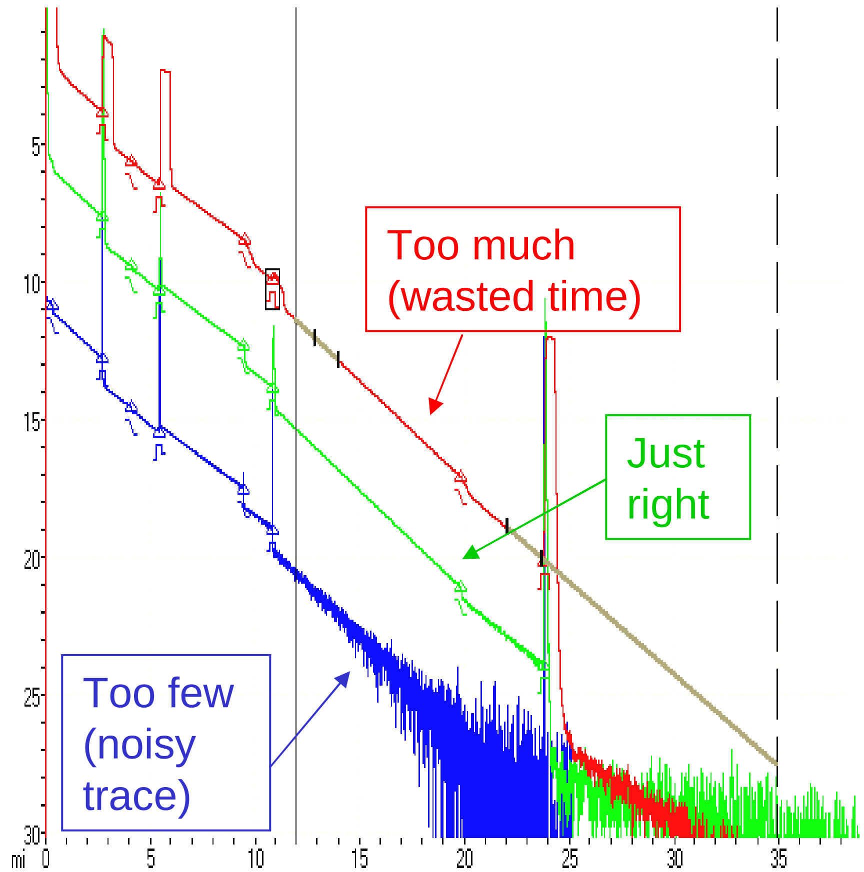
Setting Up the OTDR
Averaging

Noise shows up as variations in the trace line. Longer averaging times reduce the noise level.



Setting Up the OTDR
Averaging

- **Number of Averages**
  - » The number of averages will contribute to the amount of noise present on a trace.
  - » Use the least number of averages which still produces clean, useable traces.



Thank You

Questions?