# Optical Switching of Multiplexed PDV Systems
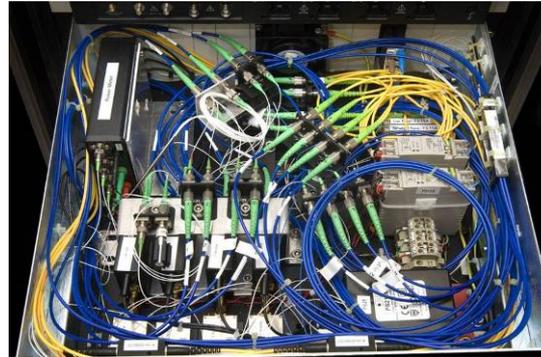
**2012 PDV Workshop**

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# Introduction

- XIS built first 4 channel system in 2007

- Have since constructed multiple 1-4 channel systems

- Channel count limited by oscilloscope channels (1 per channel)

# Customer requirement

- To develop a highly-multipoint PDV system for ITraC and half peach (snowball, onionskin, hairball, furball)

  - Minimum 8 channels
  - Goal >30 channels
  - Maximum velocity of 5 km/s
  - Time resolution of <1 ns
  - Transportable between sites
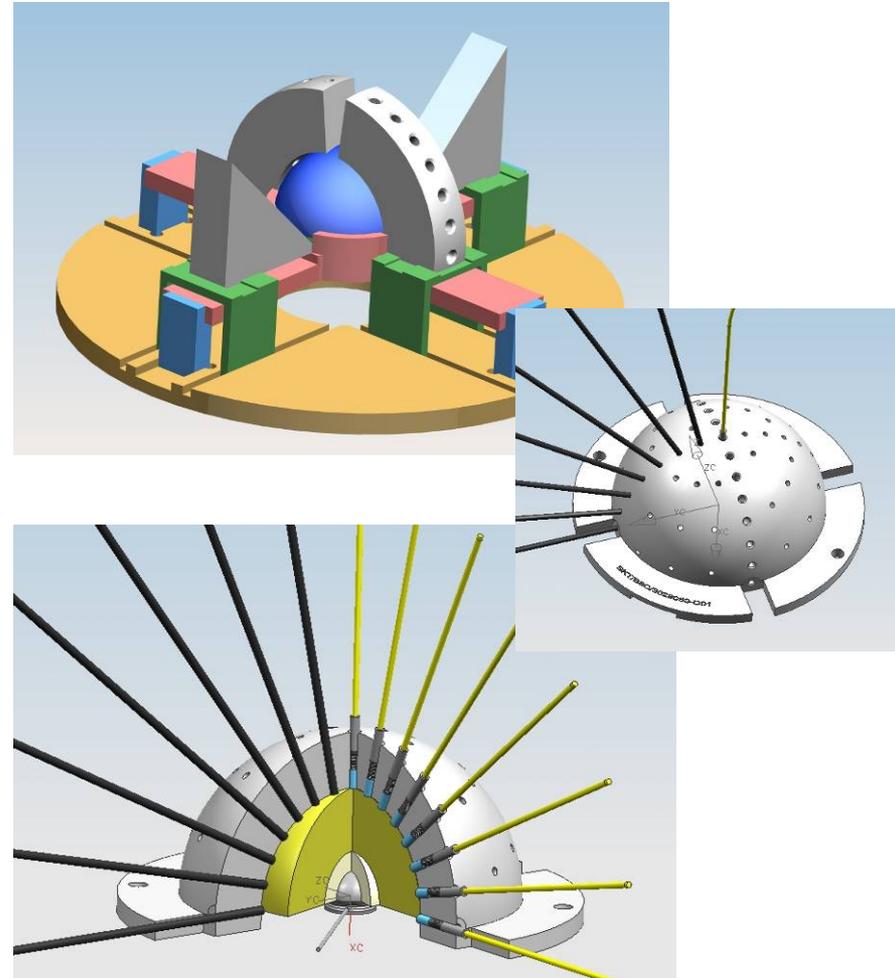
# How do we get >30 channels?

- Simple answer: 8+ oscilloscopes at $100K each

- However, typical experiment is <10 µs duration, <8 GHz frequency range

- Oscilloscope has 16 GHz bandwidth, 100 µs record length

- Can only multiplex 2 channels in frequency domain

- Can multiplex many channels in time domain!

# Time domain multiplexing

- Use delay legs to delay signals relative to each other

- 2 km = 10 μs spacing

- Oscilloscope record length 10 MPts = 100 μs
  - Maximum 10 channels per oscilloscope channel

- 8 channels per oscilloscope channel
  - 32 channels, room for expansion

- Twin laser (optical upshifting) to improve signal to noise
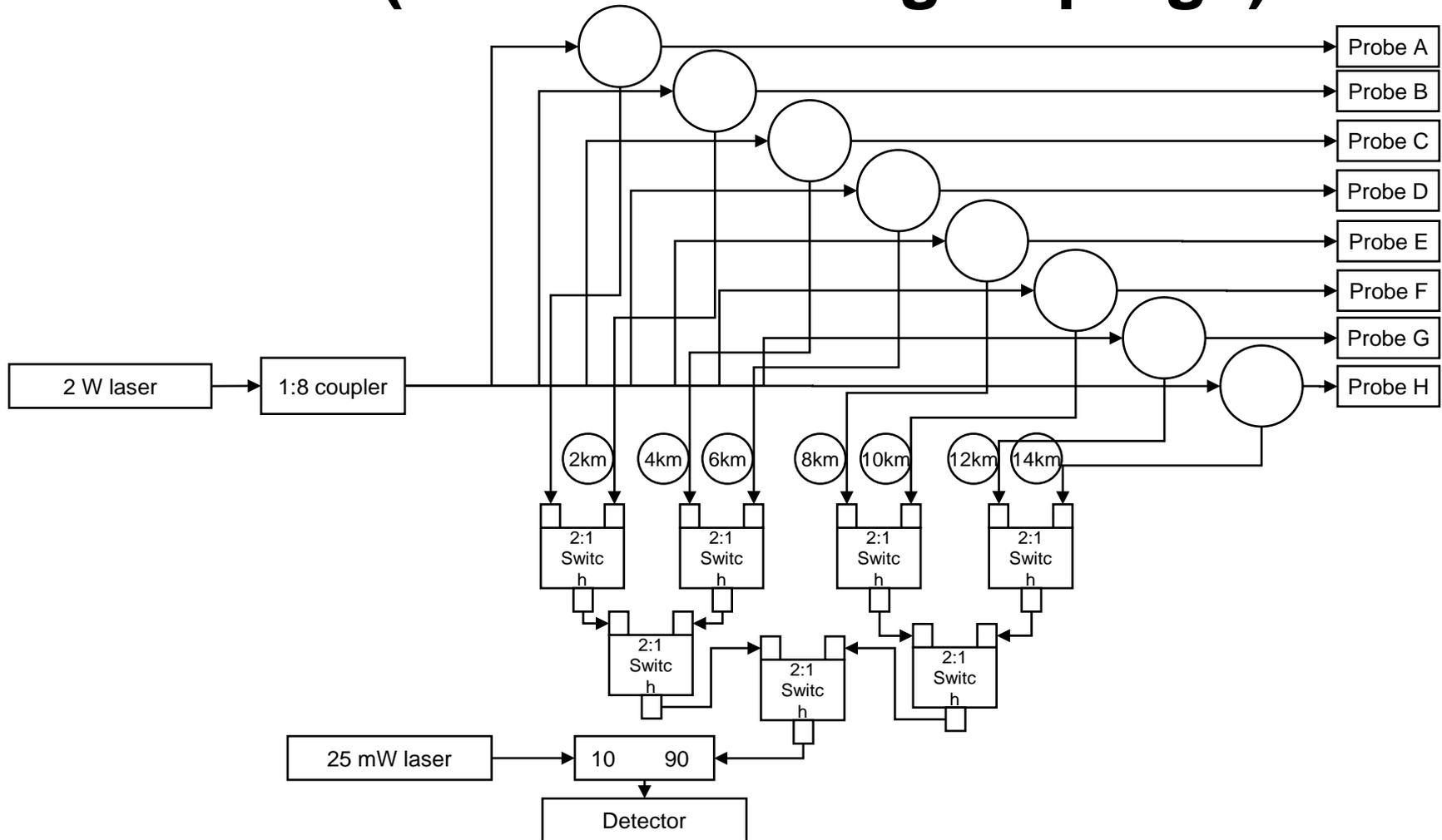  - Aim for 2 GHz upshift

# Combination options

- 8 to 1 combiner
  - Cheap
  - Very high insertion loss (>10 dB)
  - Cross talk between channels
- Fast fibre switch
  - Expensive
  - Fast switching time (300 ns)
  - Low insertion loss (2 dB)
- Fibre switch recommended

# Schematic (1 of 4 channel groupings)

# Fibre Switch

- Agiltron custom build to AWE specification

- SMA electrical inputs on front, each controls 4 switches (as per colour code)

- LC/UPC inputs/outputs on rear

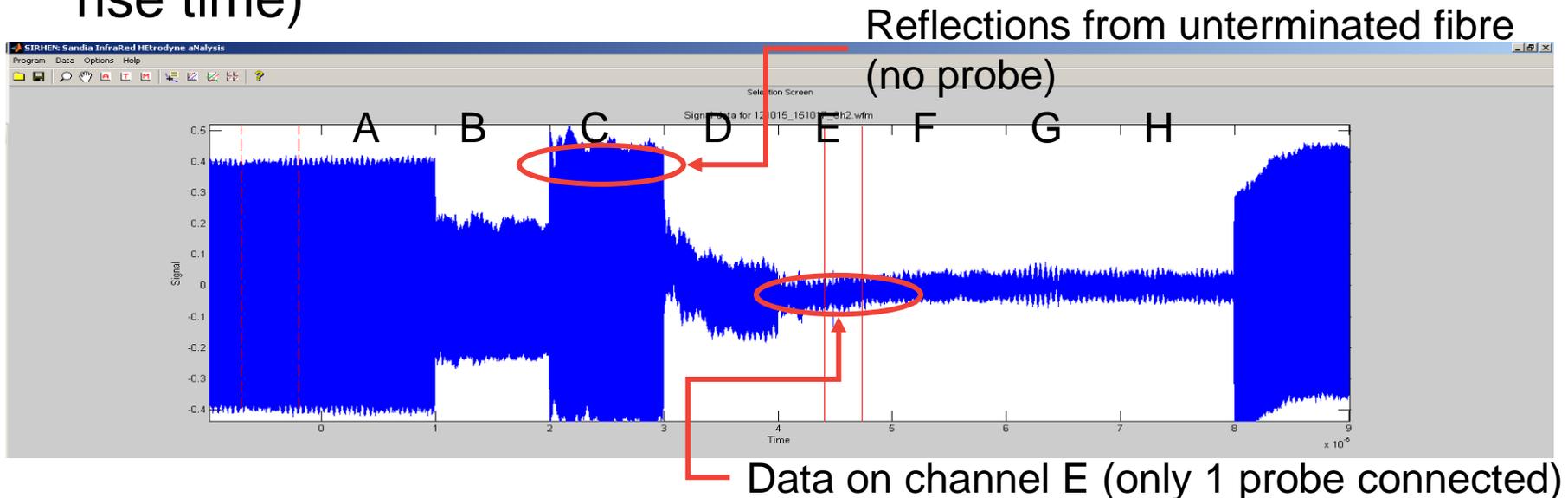| Specs | Min | Typical | Max | Unit |
|---|---|---|---|---|
| Rise Time (Tr)[1] | | 85 | 100 | ns |
| Fall Time (Tf)[2] | | 85 | 100 | ns |
| Switch Speed (Rise) (Sr) [3] | | 315 | 350 | ns |
| Switch Speed (Fall) (Sf) [4] | | 315 | 350 | ns |
| Repetition Rate | DC | | 100 | KHz |
| Pulse Width[5] | 1.0 | | $\geqslant 1.0$ | us |
| Control Input (TTL pulse) | 0 | | 5 | V |
| Power Consumption[6] | 1 | | 12 | W |
| Power Current[6] | 0.08 | | 1 | A |
| Power Supply | | 12 | | V |
| Operating Temperature | -5 | | 70 | º C |
| Storage Temperature | -40 | | 80 | º C |
| Electrical Connector | | SMA | | |
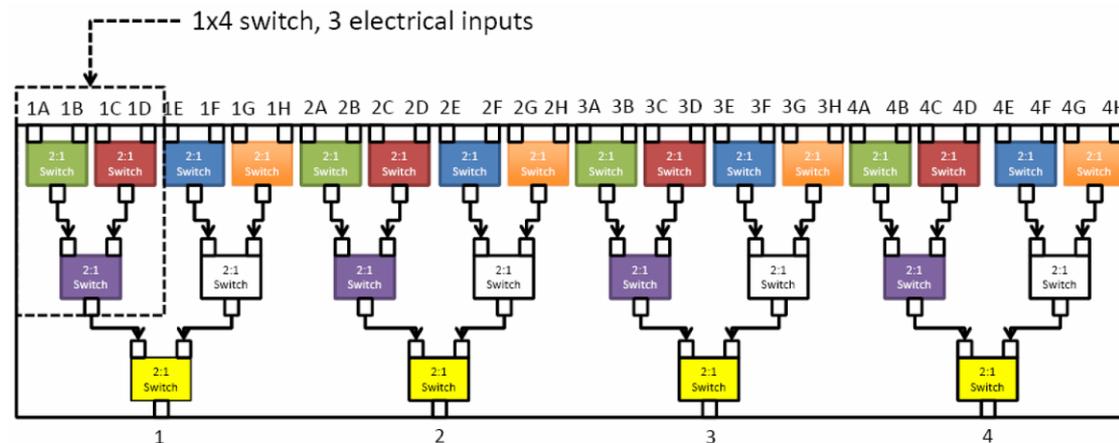
# The MEDUSA PDV system

- 20 channel optically-upshifted system (0-50 µs delay)

- Planned expansion to 32 channels (need additional delay legs)

- 10 µs record length each channel

- Insertion loss from laser 1 input to probe outputs: 16.8 dB (2W laser ≈ 42 mW per probe)

- Insertion loss from probe to detector, switch open = 5.1 dB (36.4 dB with switch closed)
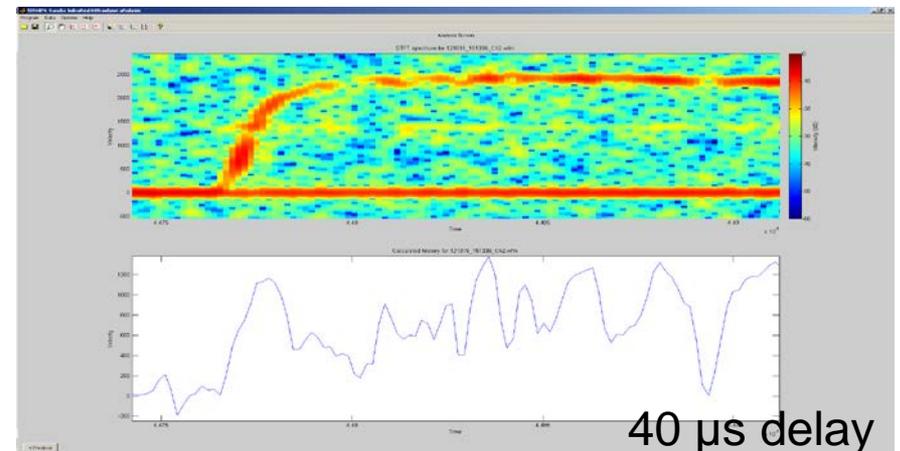
- Switching time: 85 ns to open, 68 ns to close
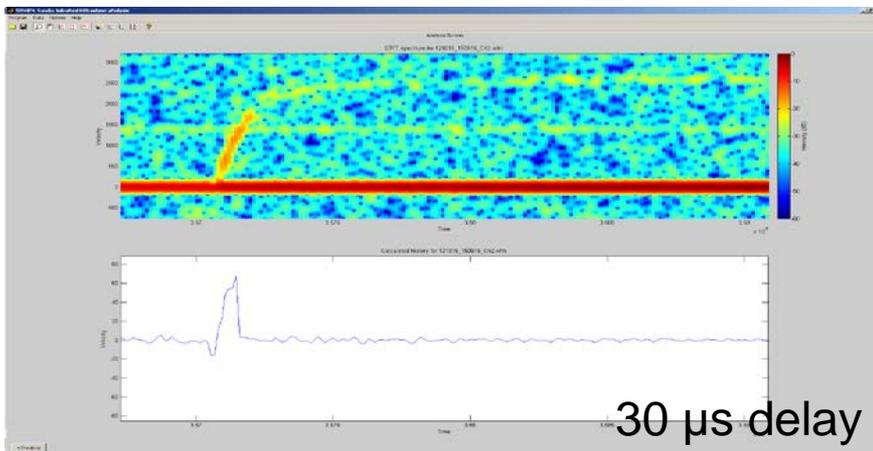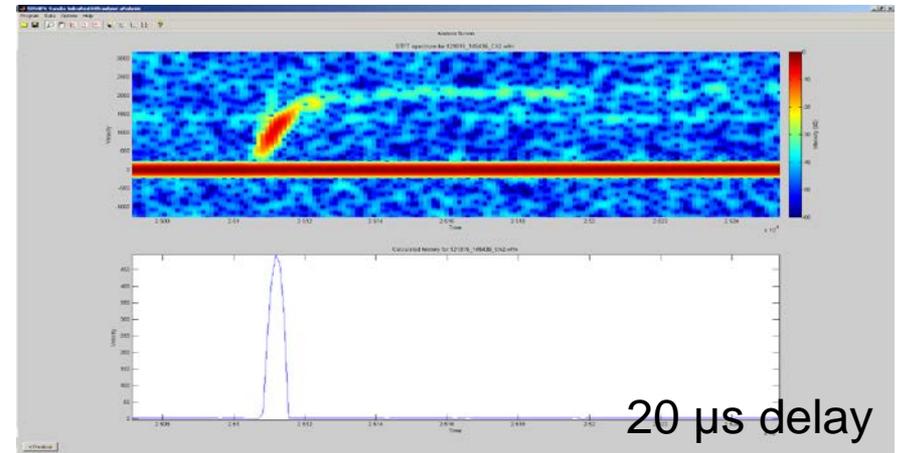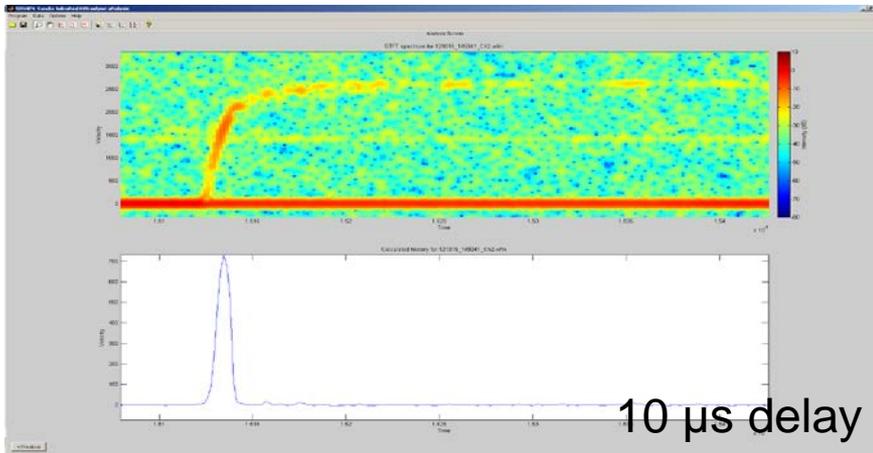
# Obligatory pretty pictures…
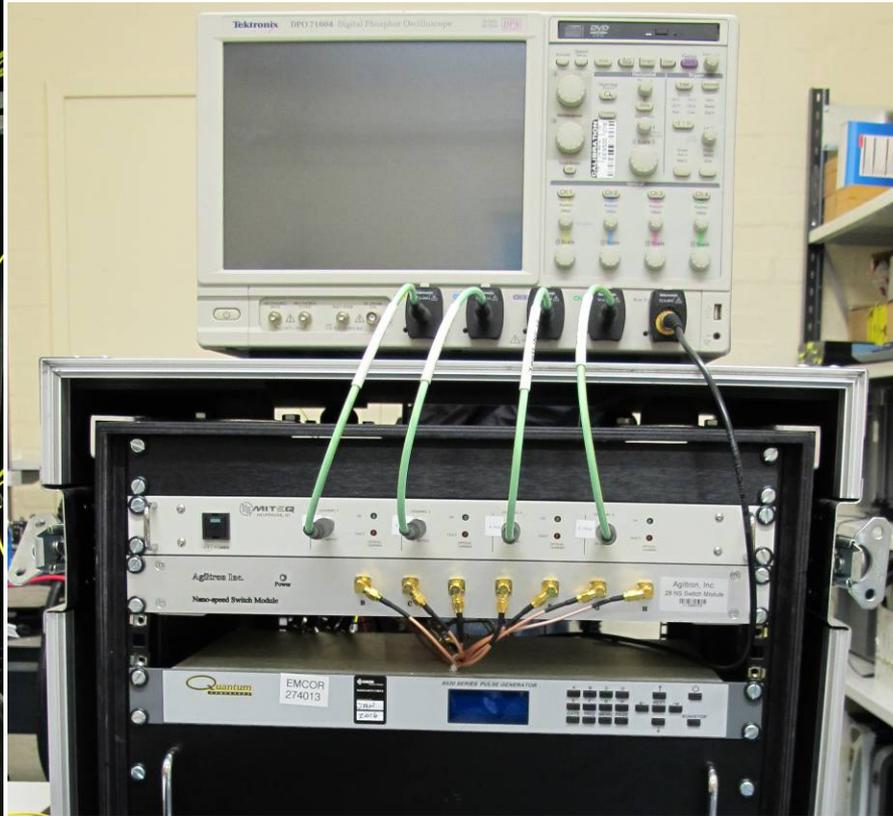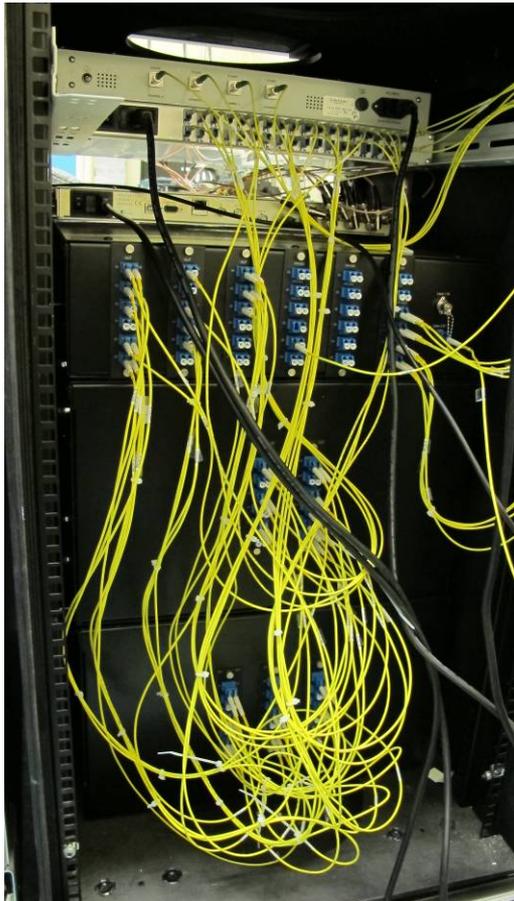
# System verification

- Could not test all channels simultaneously due to time constraints

- 10 mW per probe (faulty shutter = lower laser power)

- Laser-driven flyers used to test each channel (5 km/s, 5 ns rise time)

Reflections from unterminated fibre (no probe)

Data on channel E (only 1 probe connected)

# Example data



10 µs delay

20 µs delay

30 µs delay

40 µs delay

# Conclusion

- The MEDUSA PDV system has been designed, constructed and commissioned

- It offers up to 32 channels, each with 10 µs record length using optical switching to reduce insertion losses and cross-talk between channels

- Each channel has been tested, full verification on all channels simultaneously is planned