# Polarization Pipeline

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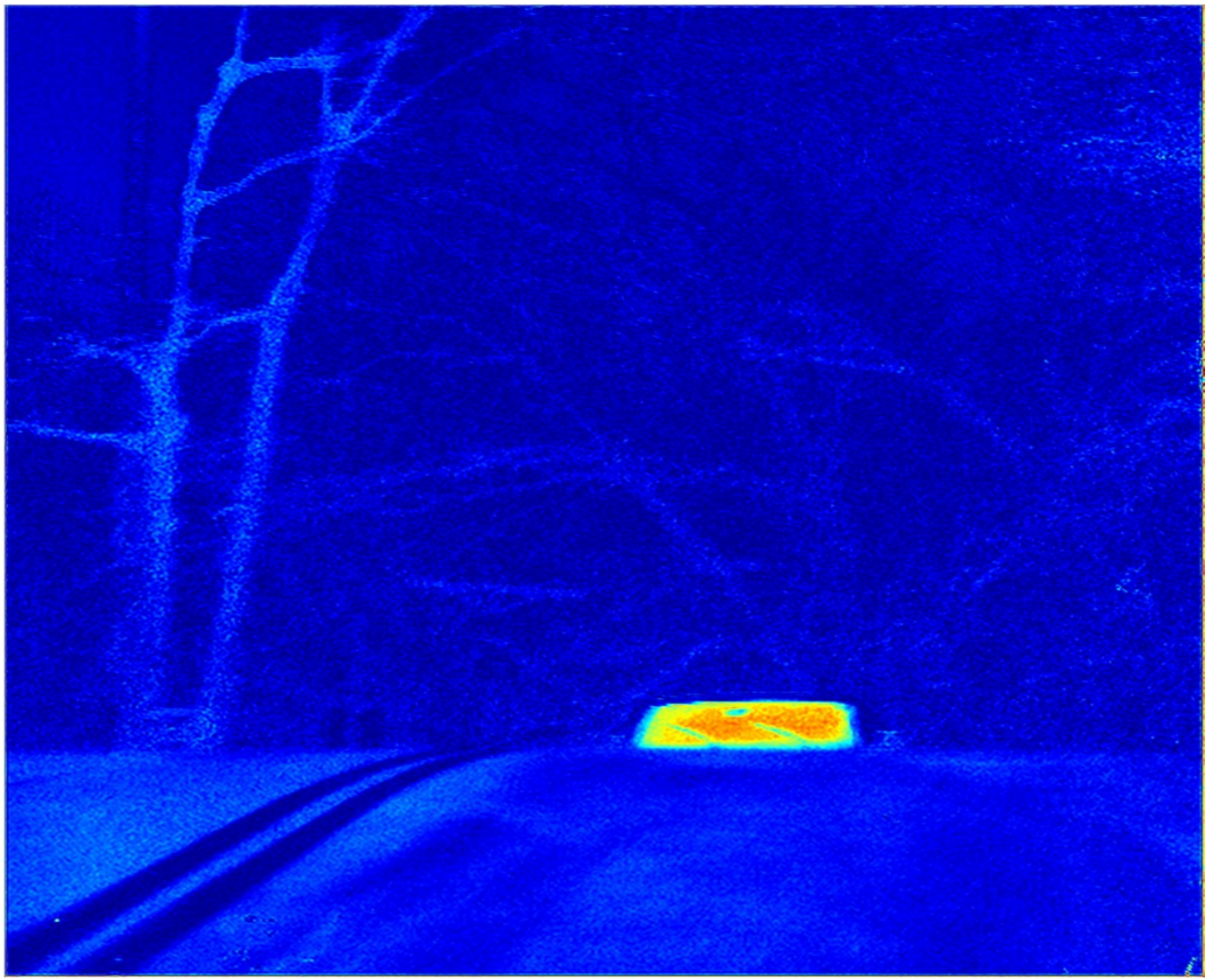
# Background



Viktor Gruev

# Motivation

- Currently on CPU
  - Drains battery life
  - Battery runs out before air tanks

# Where We Come In

- Our task:
  - Create polarized pipeline to be deployed on FPGA using ScalaPipe
  - Time trial individual kernels to determine bottlenecks in pipeline
  - Suggest best architecture for pipeline given bottlenecks

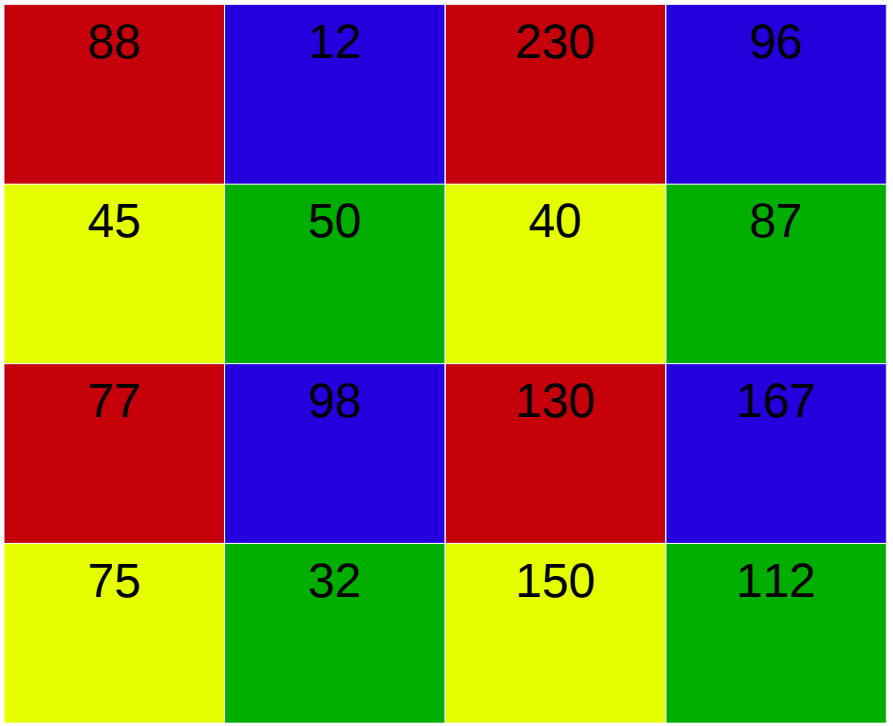
# Where We Come In

- Data Throughput
  - 1920x1080 frames
  - 30 frames/second
  - 62.2 M pixels/second
- FPGA assumptions
  - Virtex 7
    - Best case clock rate: 700 Mhz

# Pipeline Structure

- Border Extension
- Interpolation
- Stokes Parameter Calculation
- Degree of Linear Polarization
- Angle of Linear Polarization
- HSV Generator
- HSV->RGB Image Converter

# Border Extension



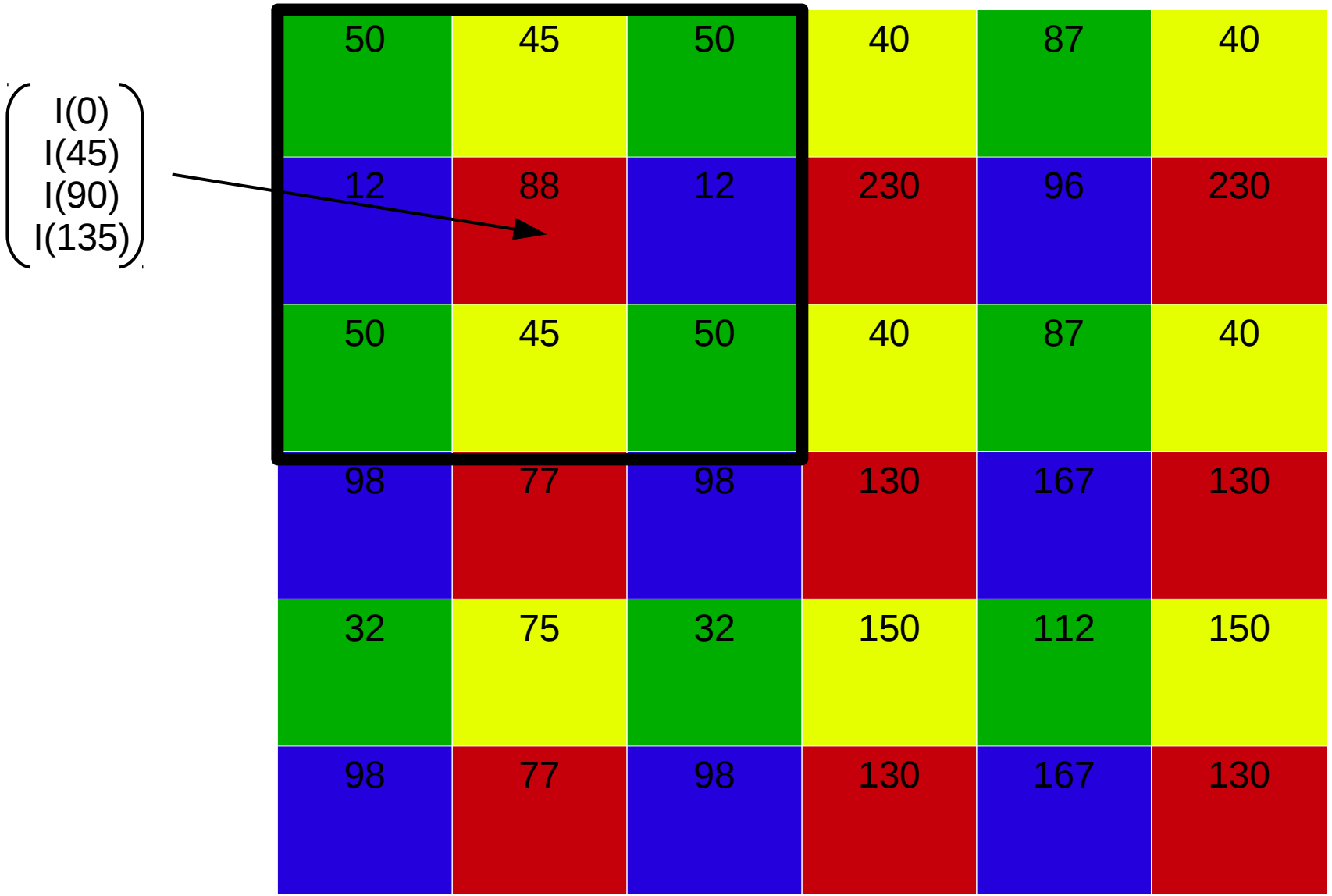
# Border Extension

| | | | | | |
|---|---|---|---|---|---|
| 50 | 45 | 50 | 40 | 87 | 40 |
| 12 | 88 | 12 | 230 | 96 | 230 |
| 50 | 45 | 50 | 40 | 87 | 40 |
| 98 | 77 | 98 | 130 | 167 | 130 |
| 32 | 75 | 32 | 150 | 112 | 150 |
| 98 | 77 | 98 | 130 | 167 | 130 |

# Border Extension

- Inputs:
  - Image Data – UNSIGNED32
- Outputs:
  - Image Data – UNSIGNED32
- Timing:
  - 7.8 cycles/pixel
  - 42.9 frames/second

# Interpolation



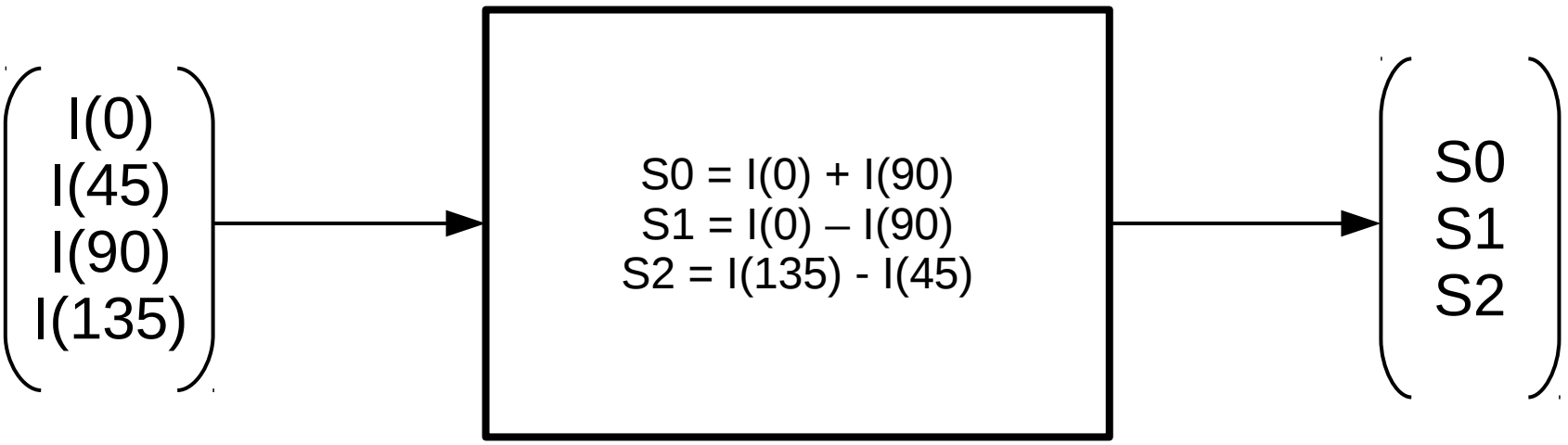
# Interpolation

- Inputs:
  - Image Data – UNSIGNED32
- Outputs:
  - Interpolated Intensities – Vector(FLOAT32, 4)
- Timing:
  - 226.8 cycles/pixel
  - 1.5 frames/second

# Interpolation

- Suggested Optimizations:
  - Parallelization
  - Integer interpolation
    - Loss of accuracy
    - Increase in speed
- Parallelization
  - 21 instances of kernel necessary as is
- Integer Interpolation
  - Timing:
    - 50.8 cycles/pixel
    - 6.6 frames/second
    - 5 instances necessary

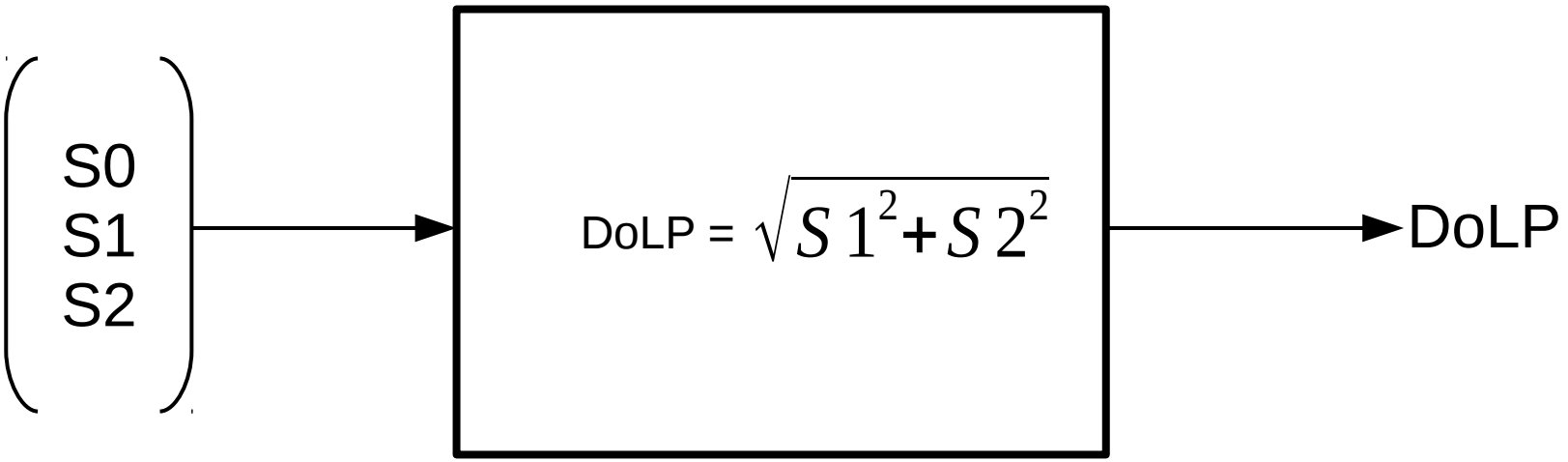
# Stokes Parameters



# Stokes Parameters

- Inputs:
  - Interpolated Intensities – Vector(FLOAT32, 4)
- Outputs:
  - Stokes Parameters – Vector(FLOAT32,3)
- Timing:
  - 23.9 cycles/pixel
  - 14.1 frames/second

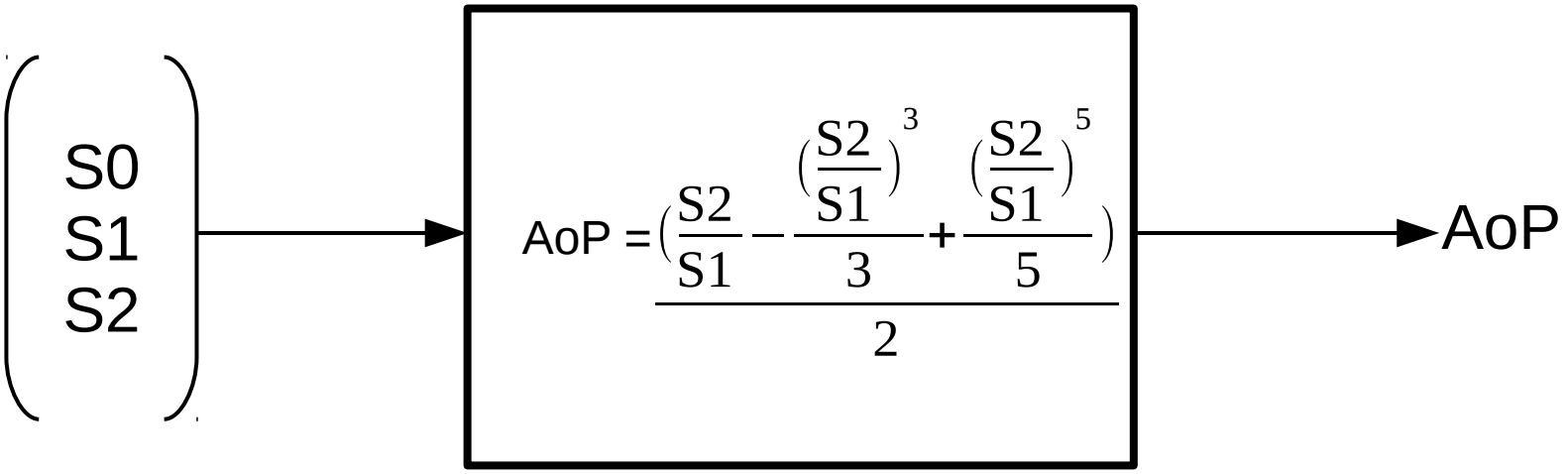
# Degree of Linear Polarization



# Degree of Linear Polarization

- Inputs:
  - Stokes Parameters – Vector(FLOAT32, 3)
- Outputs:
  - Degree of Linear Polarization – FLOAT32
- Timing:
  - 115.9 cycles/pixel
  - 2.9 frames/second

# Angle of Polarization



# Angle of Polarization

- Inputs:
  - Stokes Parameters – Vector(FLOAT32, 3)
- Outputs:
  - Angle of Polarization – FLOAT32
- Timing:
  - 236.5 cycles/pixel
  - 1.4 frames/second

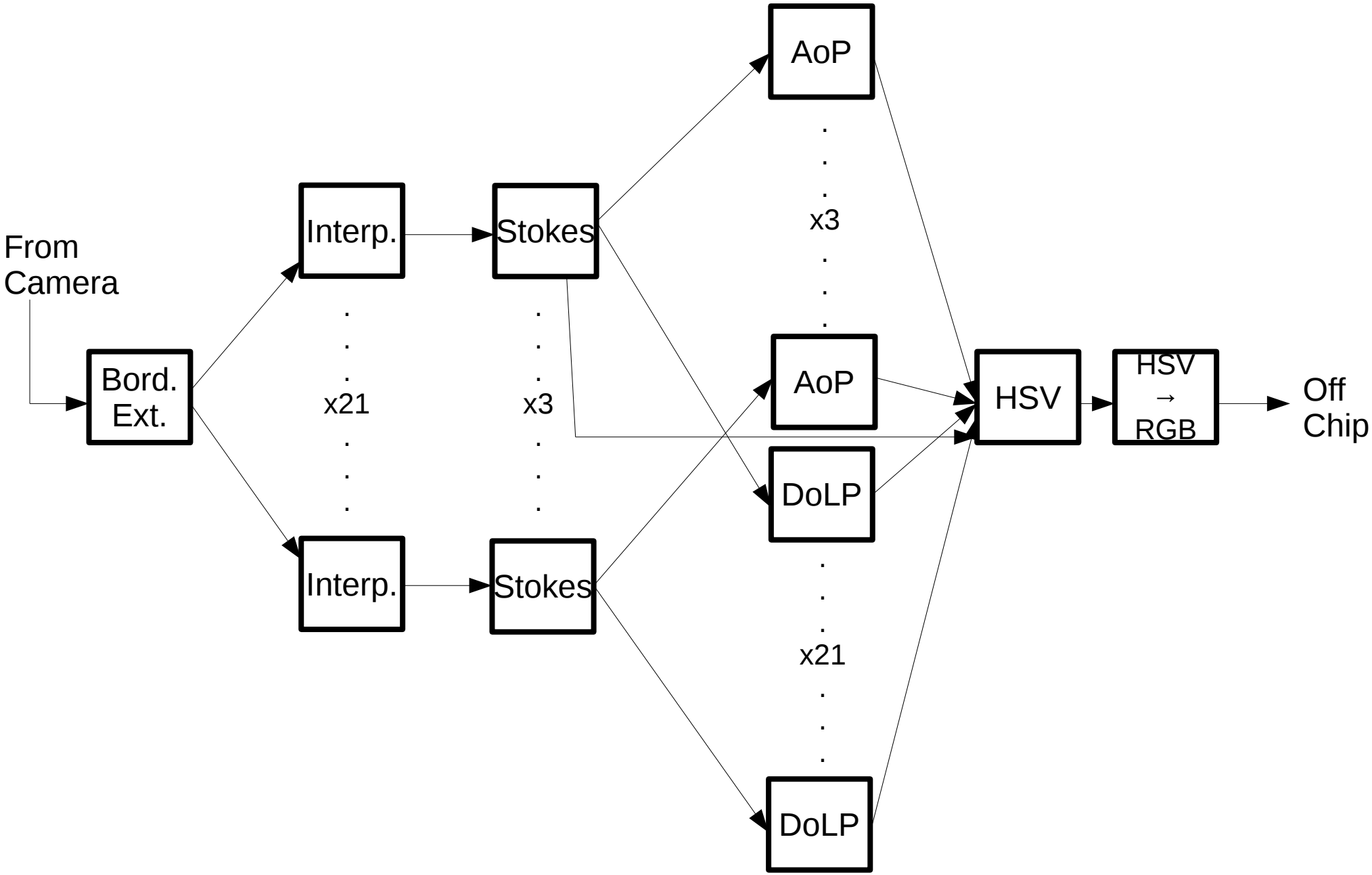
# Generate HSV

- Inputs:
  - S0 – FLOAT32
  - Degree of Linear Polarization – FLOAT32
  - Angle of Polarization – FLOAT32
- Outputs:
  - HSV – Vector(FLOAT32, 3)
- Timing:
  - No results yet, but not a bottleneck

# HSV → RGB

- Inputs:
  - HSV – Vector(FLOAT32, 3)
- Outputs:
  - RGB – Vector(UNSIGNED16, 3)
- Timing:
  - No results yet, but not a bottleneck

# Suggested Architecture



# Questions Still Seeking Answer

- Will this architecture fit on the FPGA?
  - Synthesis issues