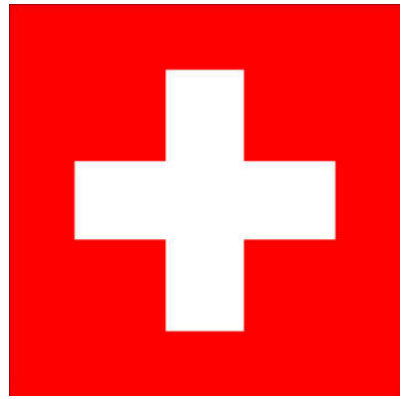
BLAKE



SWISS MADE

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BLAKE-64

for 64-bit words and 64-byte digests

10 cycles/byte

BLAKE-32

for 32-bit words and 32-byte digests

16 cycles/byte

the ChaCha function

bijective nonlinear transform of 4 words

```
a += b                  d = (a ⊕ d) ⋘ 16
c += d                  b = (b ⊕ c) ⋘ 12

a += b                  d = (a ⊕ d) ⋘  8
c += d                  b = (b ⊕ c) ⋘  7
```

BLAKE based on tweaked ChaCha

repeated 80 times in BLAKE-32

$$
\begin{aligned}
a &\mathrel{+}= m_i \oplus const_i \\
a &\mathrel{+}= b & d &= (a \oplus d) \ggg 16 \\
c &\mathrel{+}= d & b &= (b \oplus c) \ggg 12 \\
a &\mathrel{+}= m_j \oplus const_j \\
a &\mathrel{+}= b & d &= (a \oplus d) \ggg 8 \\
c &\mathrel{+}= d & b &= (b \oplus c) \ggg 7
\end{aligned}
$$

BLAKE based on tweaked ChaCha

repeated 112 times in BLAKE-64

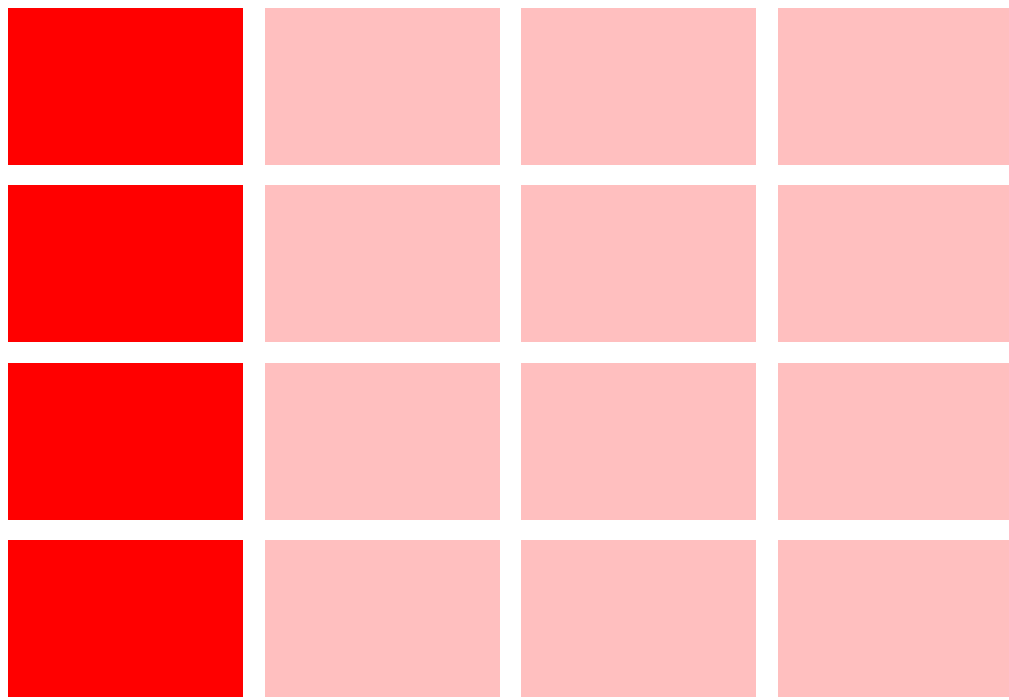
$$
\begin{aligned}
a &\mathrel{+}= m_i \oplus const_i \\
a &\mathrel{+}= b & d &= (a \oplus d) \ggg 32 \\
c &\mathrel{+}= d & b &= (b \oplus c) \ggg 25 \\
a &\mathrel{+}= m_j \oplus const_j \\
a &\mathrel{+}= b & d &= (a \oplus d) \ggg 16 \\
c &\mathrel{+}= d & b &= (b \oplus c) \ggg 11
\end{aligned}
$$

compression function state

`initialized with salt, counter, chaining value`

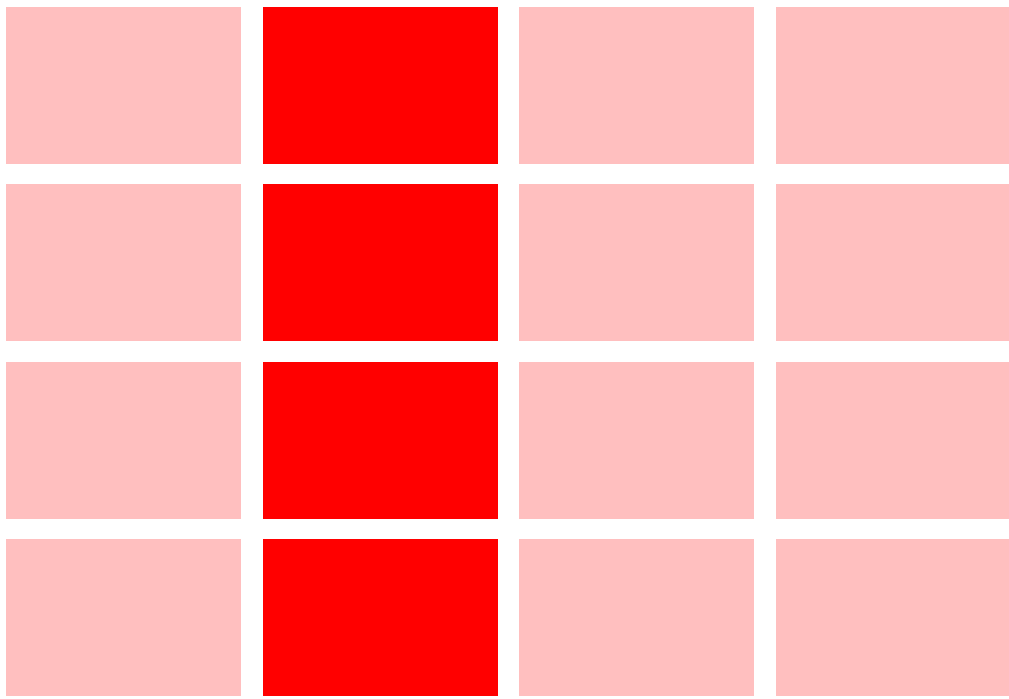
BLAKE round

`apply the ChaCha function to each column`



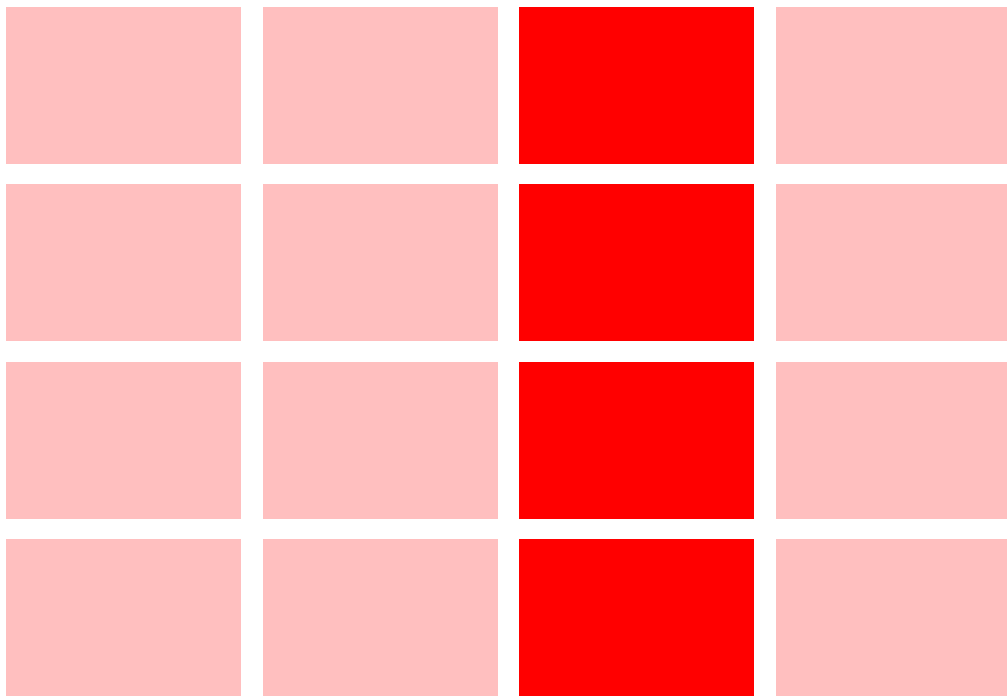
BLAKE round

`apply the ChaCha function to each column`



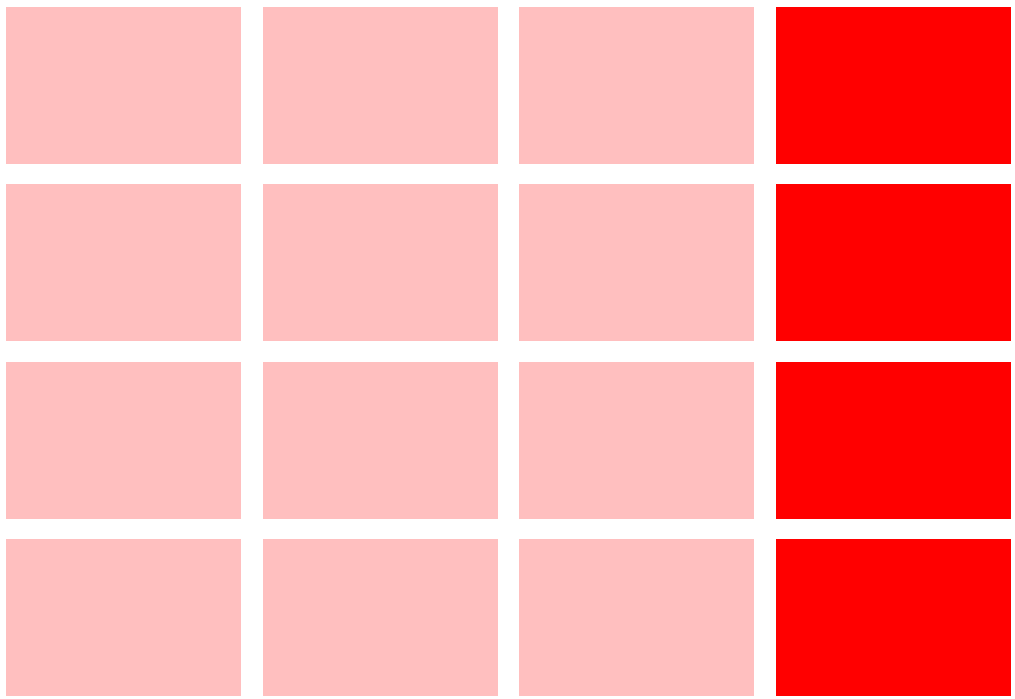
BLAKE round

`apply the ChaCha function to each column`



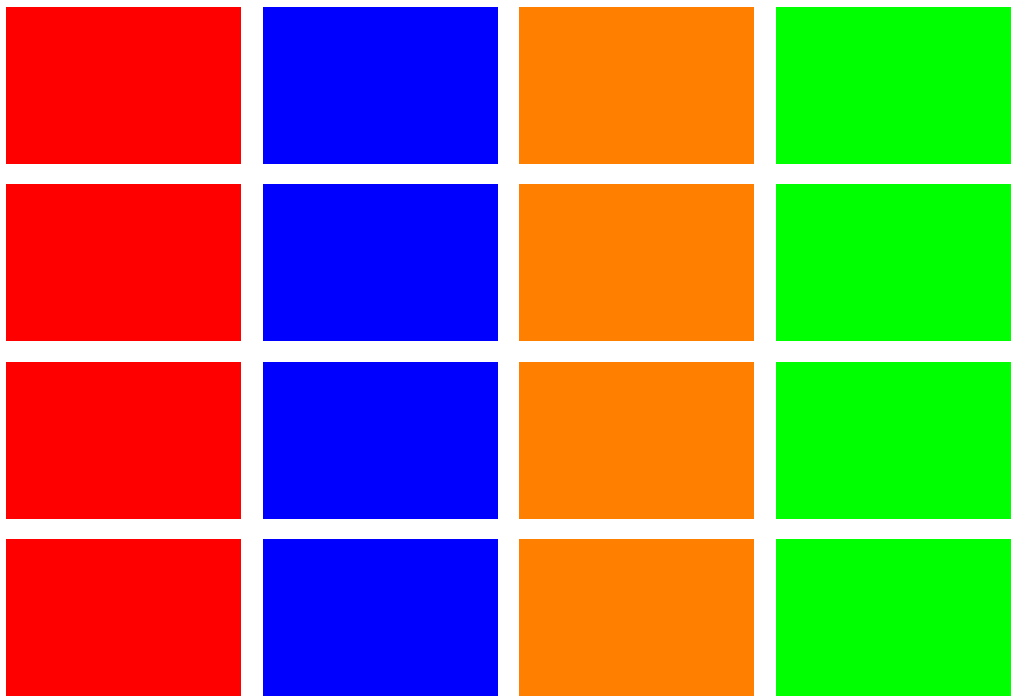
BLAKE round

`apply the ChaCha function to each column`



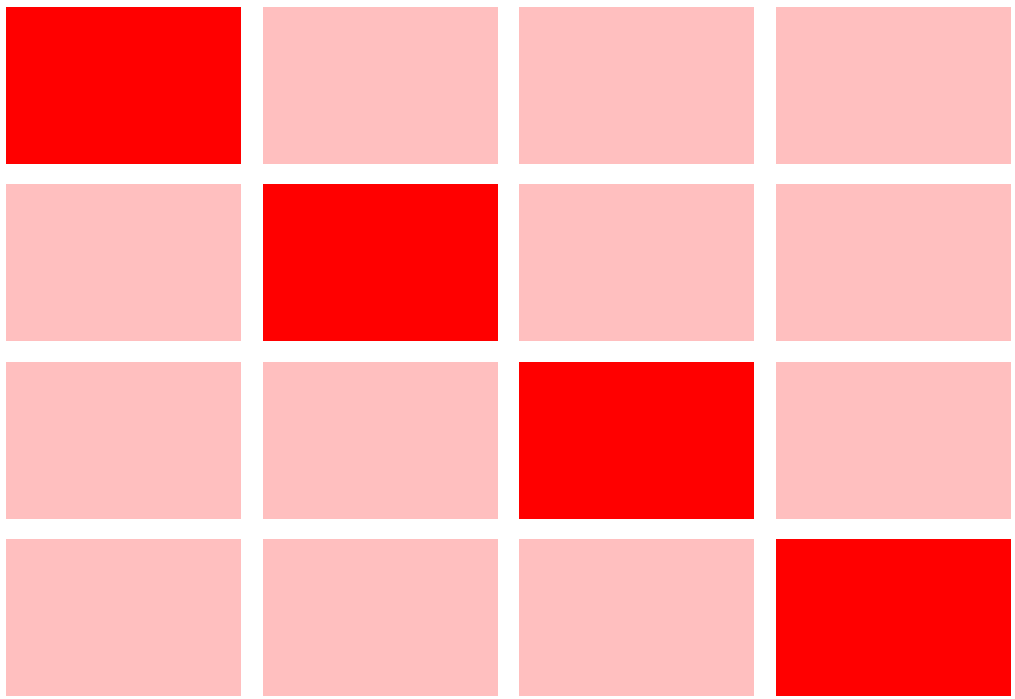
BLAKE round

or to all columns in parallel



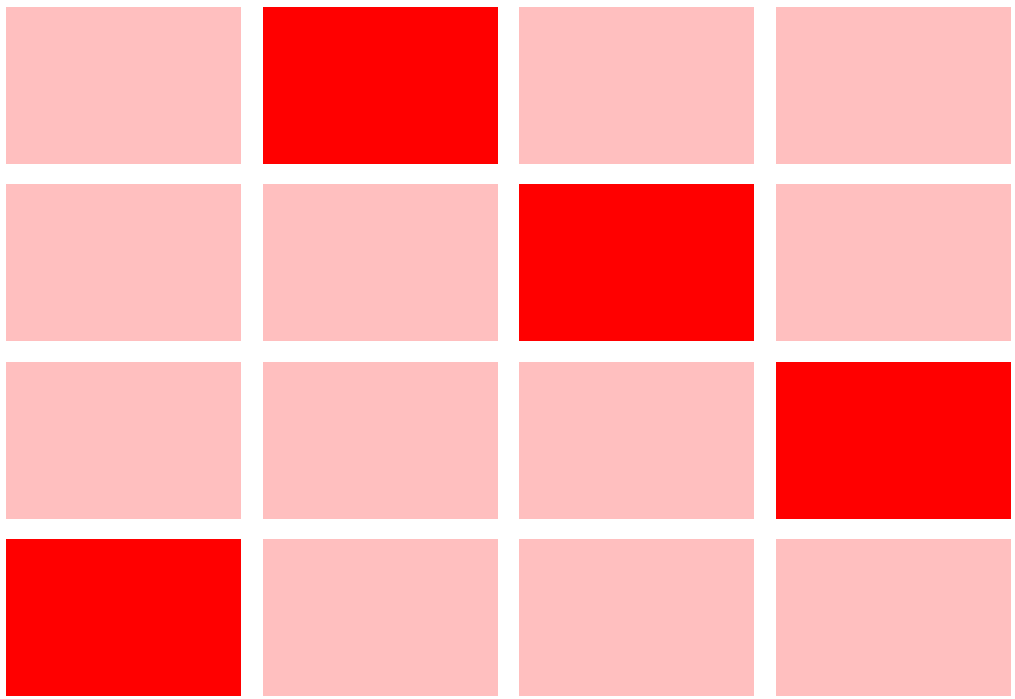
BLAKE round

`apply the ChaCha function to each diagonal`



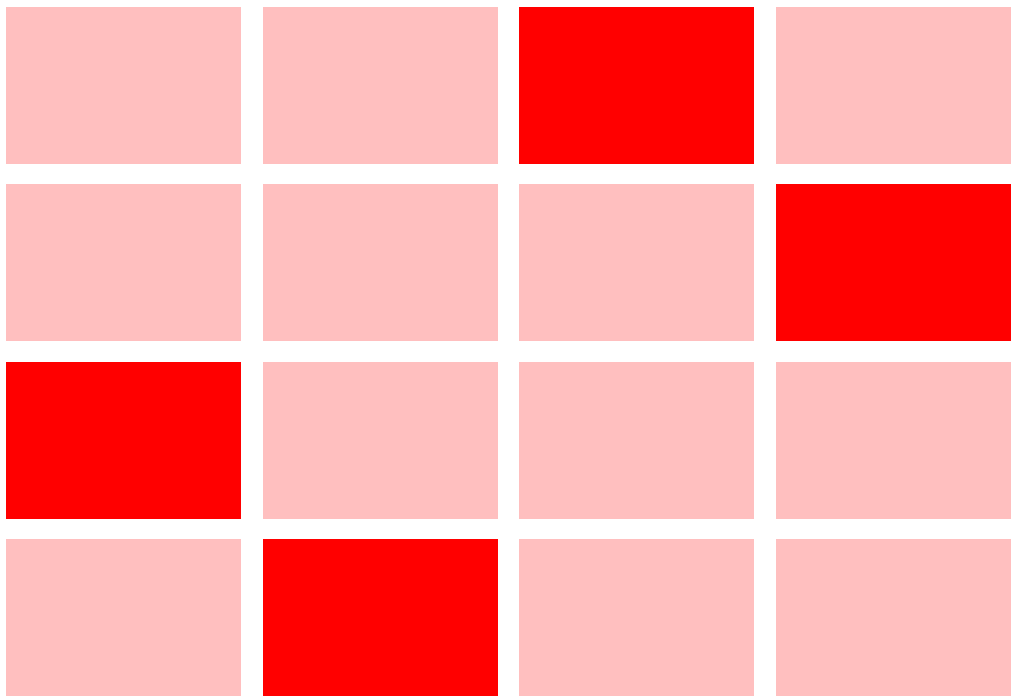
BLAKE round

`apply the ChaCha function to each diagonal`



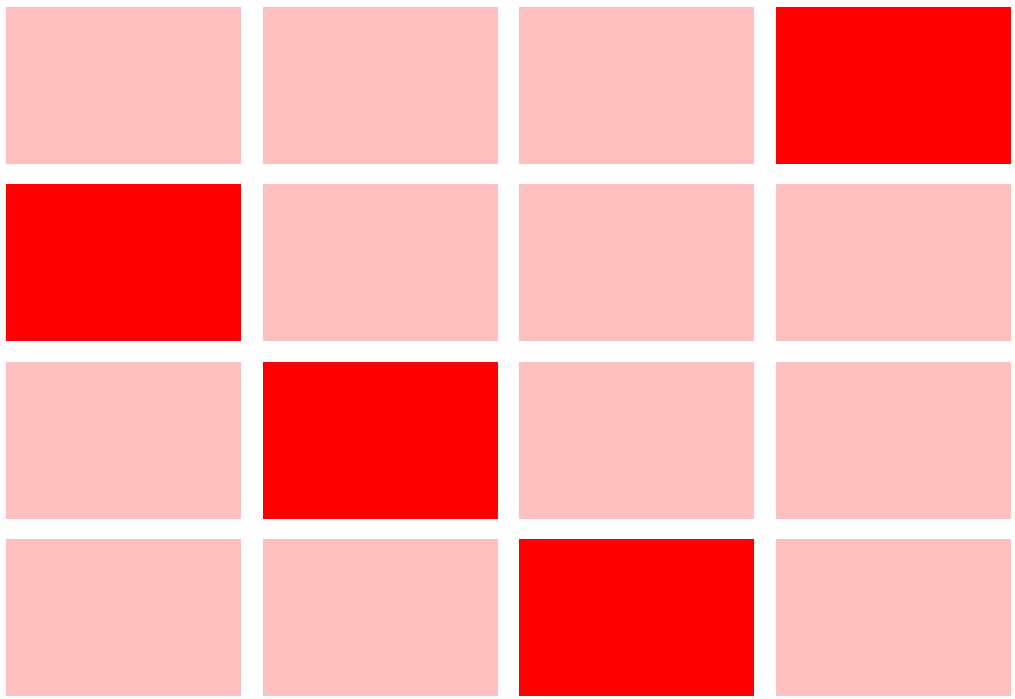
BLAKE round

`apply the ChaCha function to each diagonal`



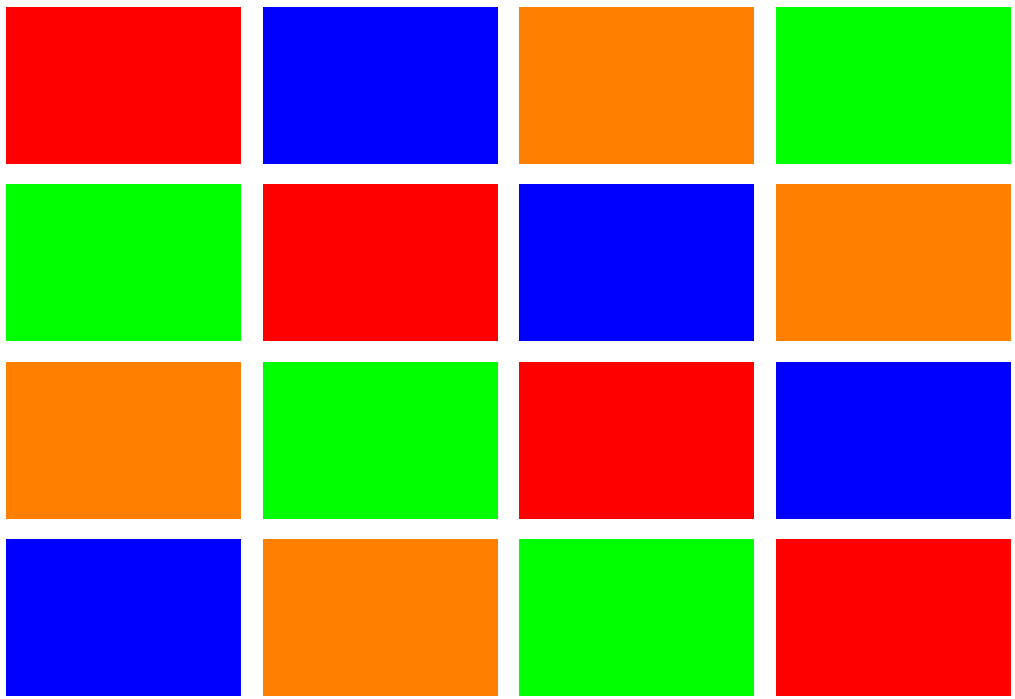
BLAKE round

`apply the ChaCha function to each diagonal`



BLAKE round

or to all diagonals in parallel



14 rounds for BLAKE-64

10 rounds for BLAKE-32

`full diffusion in 2 rounds`

`best attack on ChaCha on 3.5 rounds`

`best attack on BLAKE on 2 rounds`

BLAKE's iteration mode

(simplified HAIFA)

randomized hashing

RO-indifferentiability

2^n second preimage resistance

preserves collision and preimage resistance

BLAKE in hardware

straightforward implementation

various trade-offs speed/area

small memory requirements

our implementations

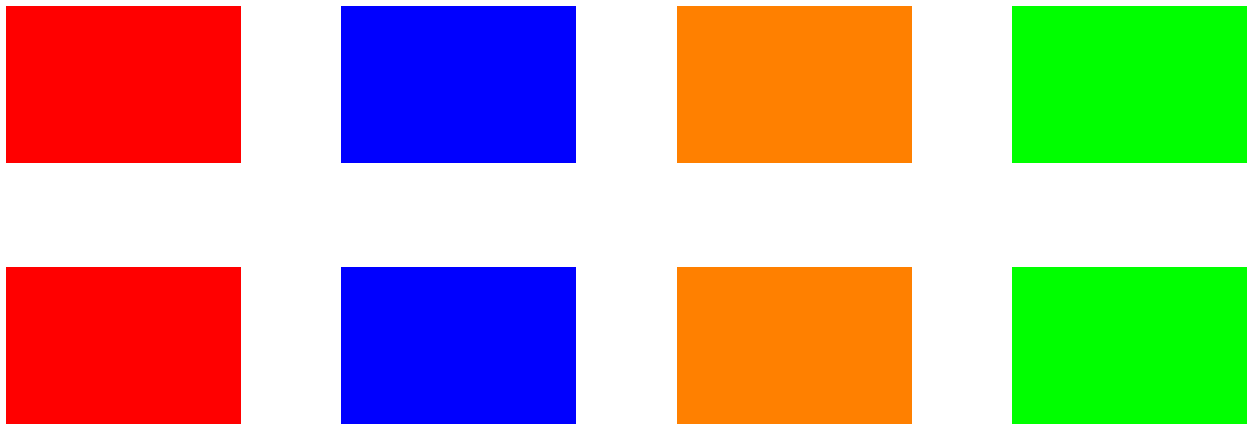
4 different architectures

on 0.18 μm CMOS ASIC

on FPGA (Virtex-4, Virtex-5, Virtex-II-Pro)

ASIC architectures

`high-throughput: 8 ChaCha functions`



BLAKE-64: 132 kGE 5.9 Gbps

BLAKE-32: 58 kGE 5.3 Gbps

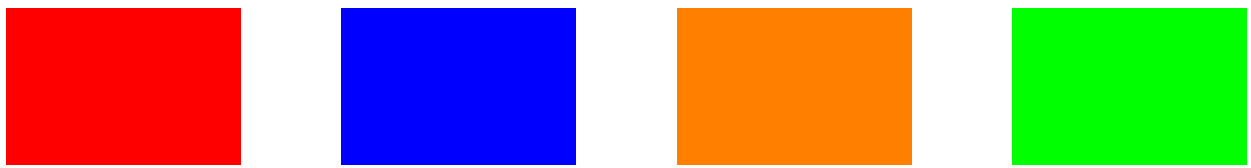
ASIC architectures

`small fingerprint:  1 ChaCha function`

BLAKE-64:	20 kGE	181 Mbps
BLAKE-32:	10 kGE	253 Mbps

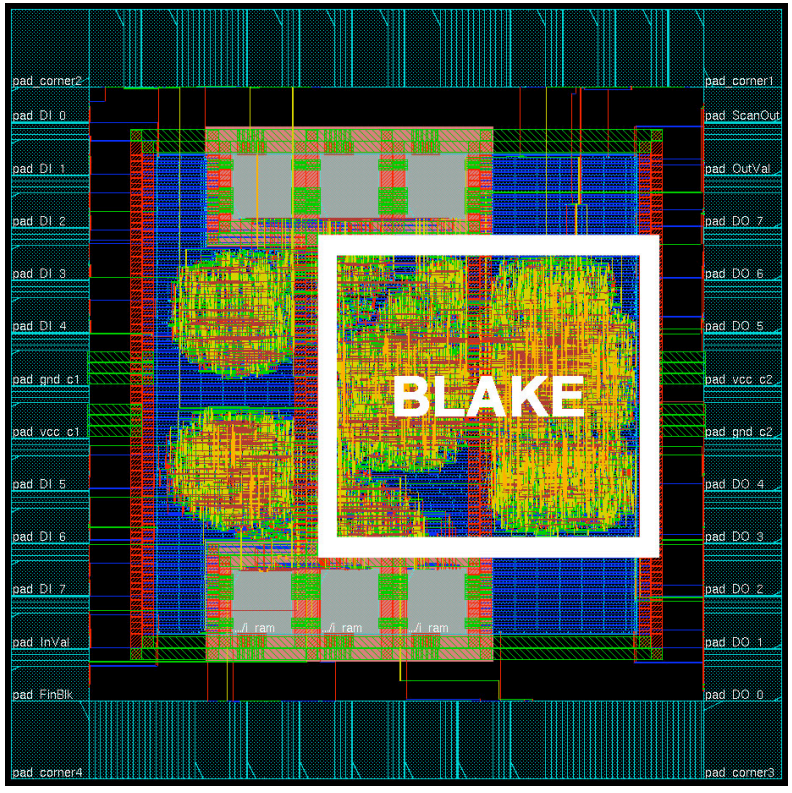
ASIC architectures

`trade-off space/speed:  4 ChaCha functions`



BLAKE-64:	82 kGE	4.8 Gbps
BLAKE-32:	41 kGE	4.1 Gbps

BLAKE-32 lightweight hashing core



13.5 kGE 128 Mbps

BLAKE in software (eBASH)

in the top 5

faster than SHA-2

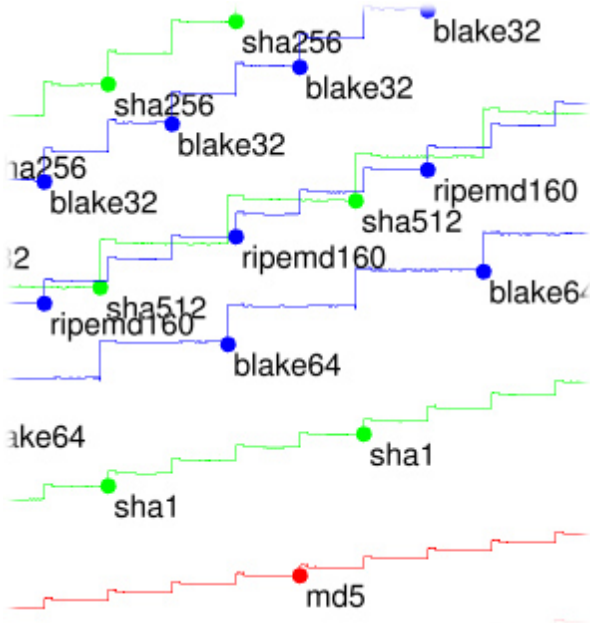
on NIST reference platform

BLAKE-64 $\approx$ 10 cycles/byte

BLAKE-32 $\approx$ 16 cycles/byte

eBASH figures

`amd64, 2000MHz, AMD Athlon 64 X2 (40fb2), mace`

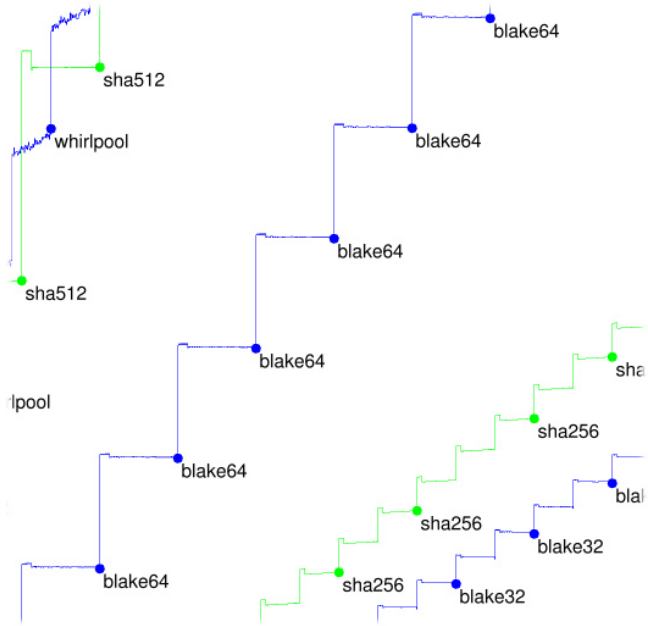


BLAKE-64 `11.32 cycles/byte`

BLAKE-32 `17.86 cycles/byte`

eBASH figures

`x86, 333MHz, Intel Pentium 2 (652), boris`

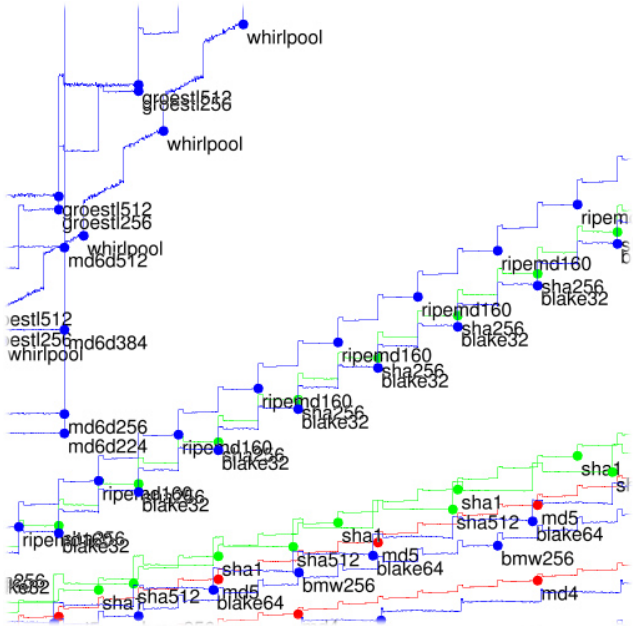


BLAKE-64 `56.32 cycles/byte`

BLAKE-32 `25.74 cycles/byte`

eBASH figures

`ia64, 997MHz, HP Itanium II, nmi0020`



BLAKE-64 `8.54 cycles/byte`

BLAKE-32 `20.69 cycles/byte`

why BLAKE for SHA-3 ?

one of the first candidates published, no attack

faster than SHA-2 and than many SHA-3 candidates

based on a known algorithm (ChaCha/Salsa20)

one of the simplest designs

no AES-dependence

BLAKE's webpage

http://www.131002.net/blake/

`complete specification`

`security analysis`

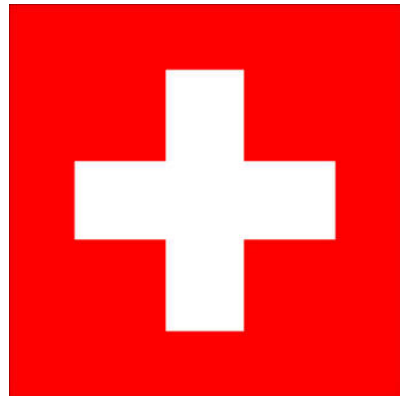
`reference C code`

`eBASH submission`

`light C code`

`VHDL code`

BLAKE



SWISS MADE