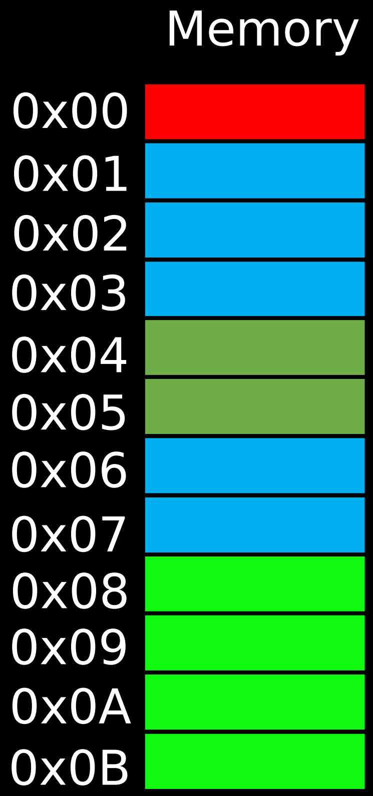
Pointers

Embedded Software Essentials

C2M1V3

Pointer Types [S2a]

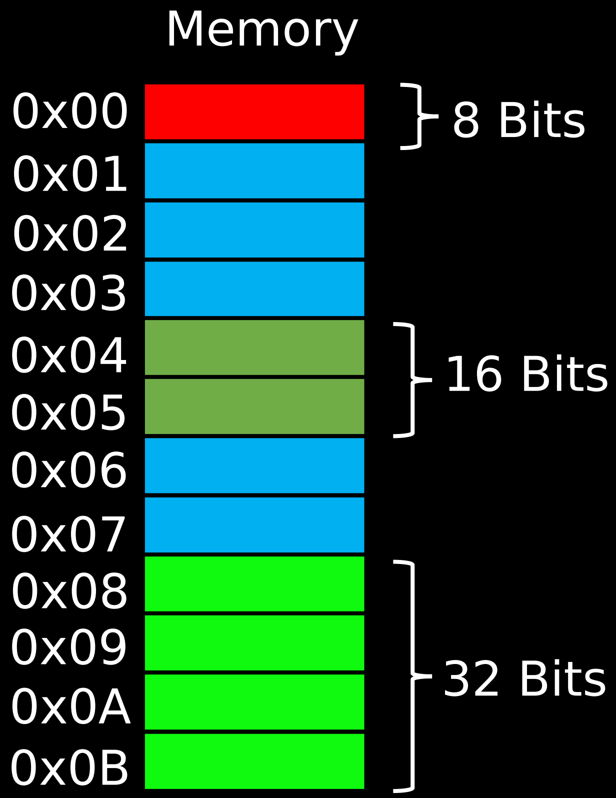


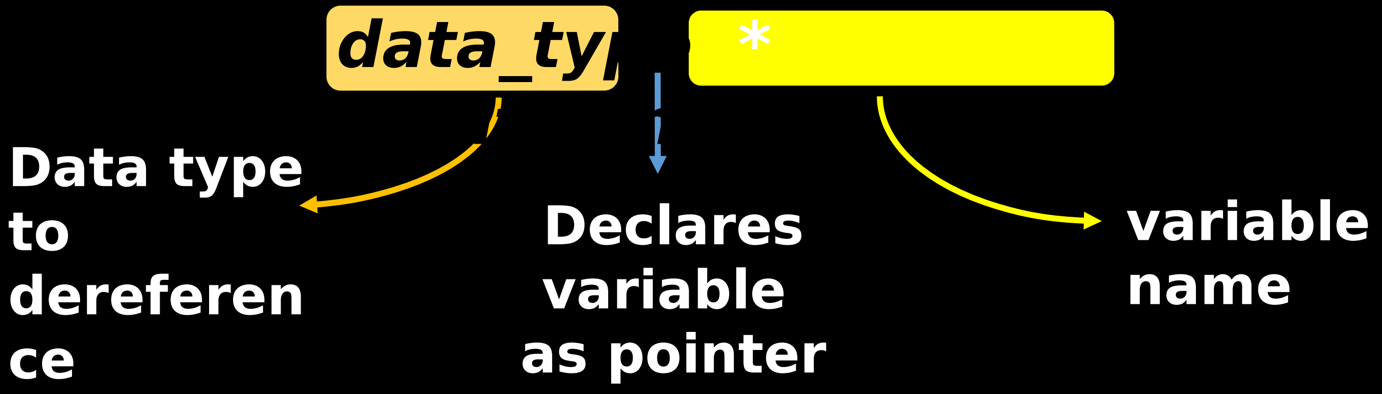
Pointer type denotes the **data type** that a pointer will ***dereference***

data_type * pointer_name;

Pointer Types [S2b]

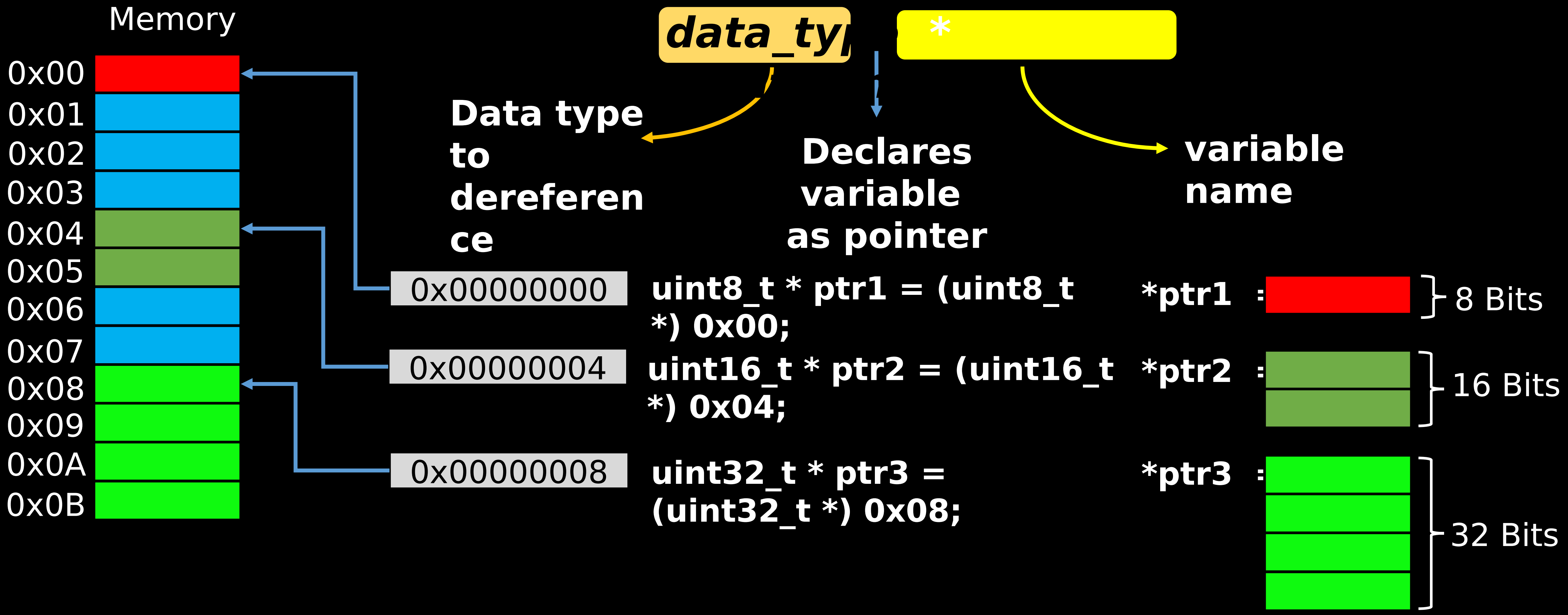
Pointer type denotes the **data type** that a pointer will ***dereference***





Pointer Types [S2c]

Pointer type denotes the **data type** that a pointer will ***dereference***



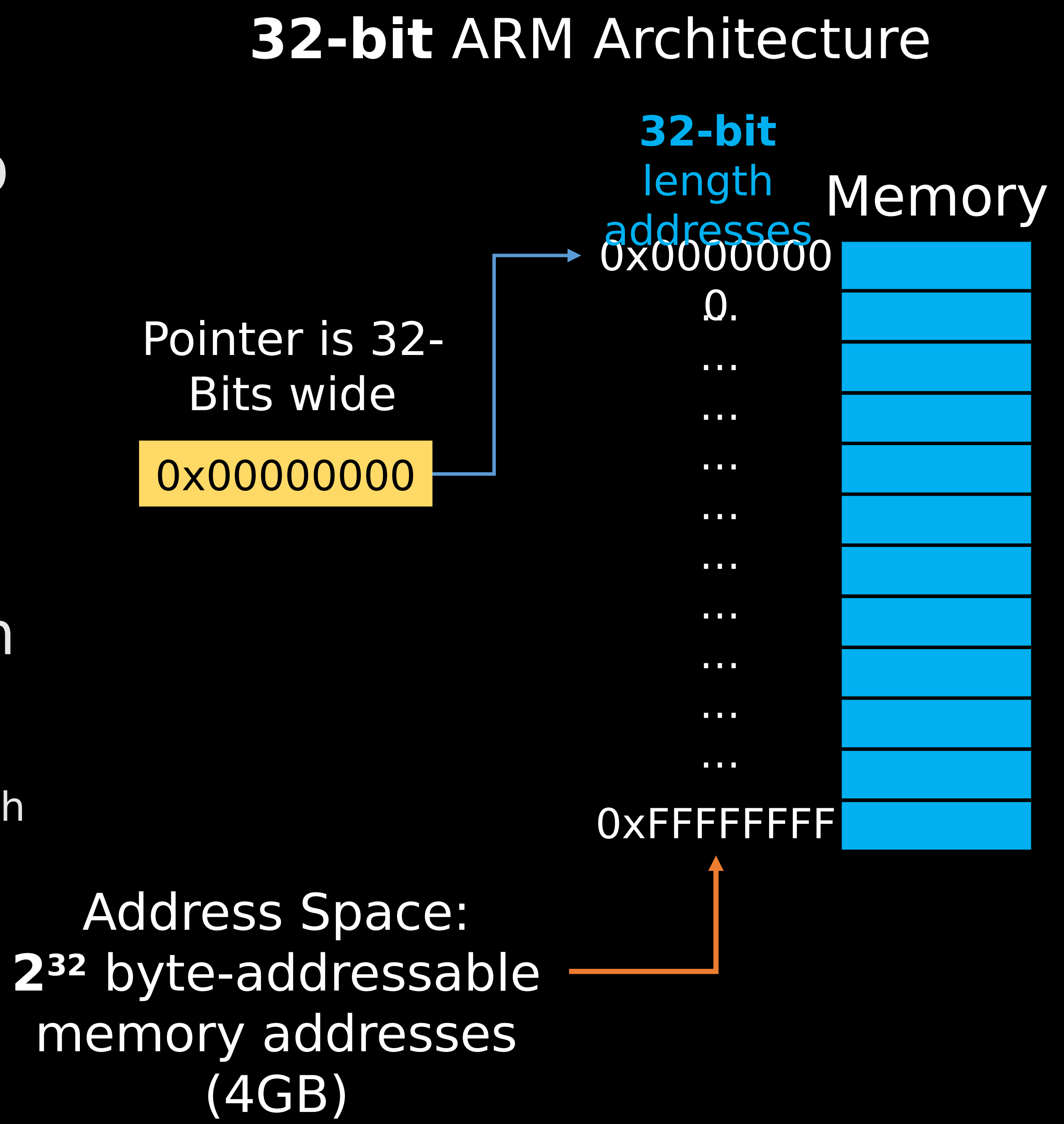
```
uint8_t * ptr1 = (uint8_t *) 0x00;
uint16_t * ptr2 = (uint16_t *) 0x04;
uint32_t * ptr3 = (uint32_t *) 0x08;
```

Pointer Size [S3]

- Pointers hold Addresses to a location in memory

- All Pointers are the same length
  - ARM 32-bit Pointer Length

- Address Space = $2^{\text{PointerLength}}$



32-bit ARM Architecture
32-bit length addresses
Memory
0x00000000
...
Pointer is 32-Bits wide
0x00000000
0xFFFFFFFF
Address Space: 2^{32} byte-addressable memory addresses (4GB)

Pointer Size [S4]

- All Pointers are the same length

```
  uint8_t * ptr1  = (uint8_t *) 0x00;
uint16_t * ptr2 = (uint16_t *) 0x04;
uint32_t * ptr3 = (uint32_t *) 0x08;
    float * ptr4 = (float *) 0x0C;
```

sizeof(uint8_t*) = sizeof(int16_t*)
= sizeof(uint32_t*)
= sizeof(float*)
= 32-Bits!

sizeof(ptr1) = sizeof(ptr2)
= sizeof(ptr3)
= sizeof(ptr4)
= 32-Bits!

- Pointers Dereference different sized data

sizeof(*ptr1) ≠ sizeof(*ptr2) ≠ sizeof(*ptr3) ≠ sizeof(*ptr4)

sizeof(*ptr1)	sizeof(*ptr2)	sizeof(*ptr3)	sizeof(*ptr4)
1 Byte	2 Byte	4 Byte	4 Byte

Pointer Operators [S5]

- Dereference Operator = *
  - Accesses data at address
- Address-of Operator = &
  - Provides address of variable

```
uint32_t  var;

uint32_t * ptr = &var;

*ptr = 0xABCD1234;
```

- Integers are not addresses
- Cast to explicit address for Peripheral Memory

```
uint16_t * ptr = (uint16_t *)
0x480C0000;
```

Casts Integer to address

Null Pointers [S6]

- At time of pointer declaration, you might not know the address
   - Use a NULL Pointer for Initialization

- Null Pointers point to nothing
   - Used to check for valid pointer

- Dereferencing a NULL Pointer can cause an exception

This pointer will have garbage data

```
uint32_t * ptr;
```

Using un-initialized pointer can potentially corrupt your memory

```
#define NULL ((void*)0)
uint32_t * ptr = NULL;
if (ptr == NULL) {
    /* error! */
}
*ptr = 0xABCD1234;
```

Pointer Example [S7a]

```
typedef struct foo {
    uint8_t   varA;
    uint8_t   varB;
    uint16_t varC;
} foo_t;
```

At least 32 Bits

```
  foo_t  varS;
  uint8_t Num;


foo_t  * varS_ptr = &varS;
uint8_t * ptr_Num = &num;
```

Each Pointer is 32-bits

Pointer Example [S7b]

```
typedef struct foo {
     uint8_t   varA;
     uint8_t   varB;
     uint16_t varC;
} foo_t;


  foo_t  varS;
  uint8_t Num;


foo_t  * varS_ptr = &varS;
uint8_t * ptr_Num = &num;
```

varS_ptr->varA Derefences 8-bits

varS_ptr->varB Derefences 8-bits

varS_ptr->varC Derefences 16-bits

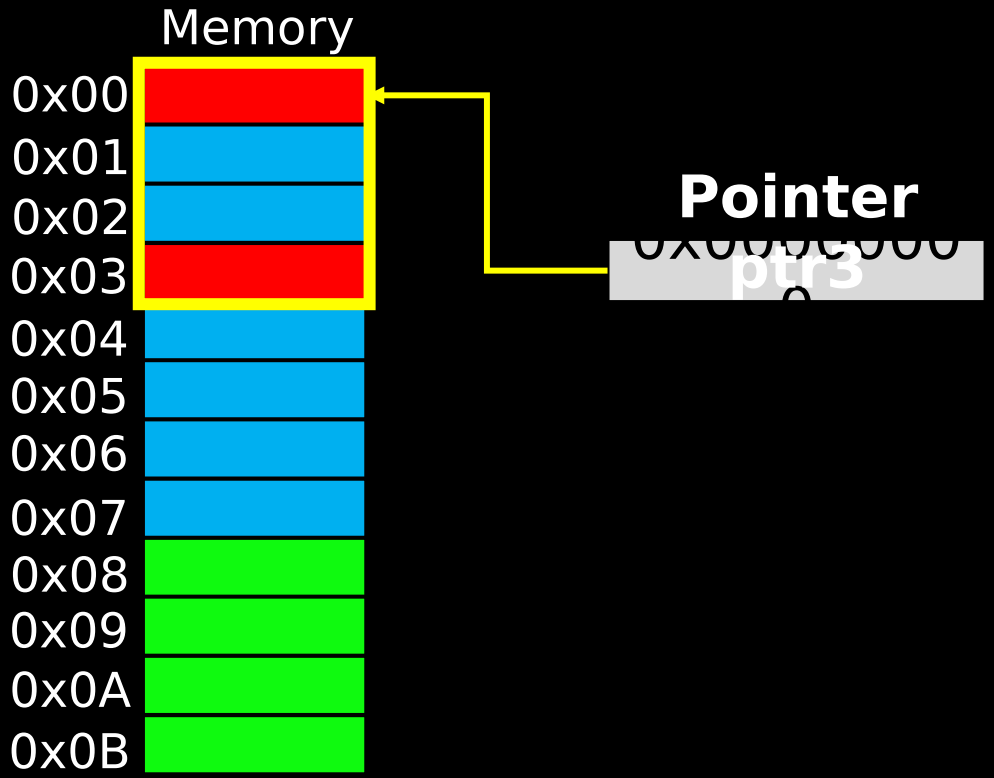
*ptr_Num Derefences 8-bits

varS_ptr->varC

Structure Pointer Dereference Operator

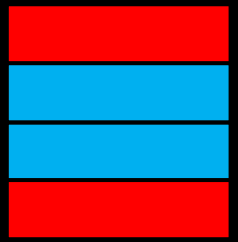
Pointer Casting [S8a]

Cast pointers to dereference **different sizes** from **same address**



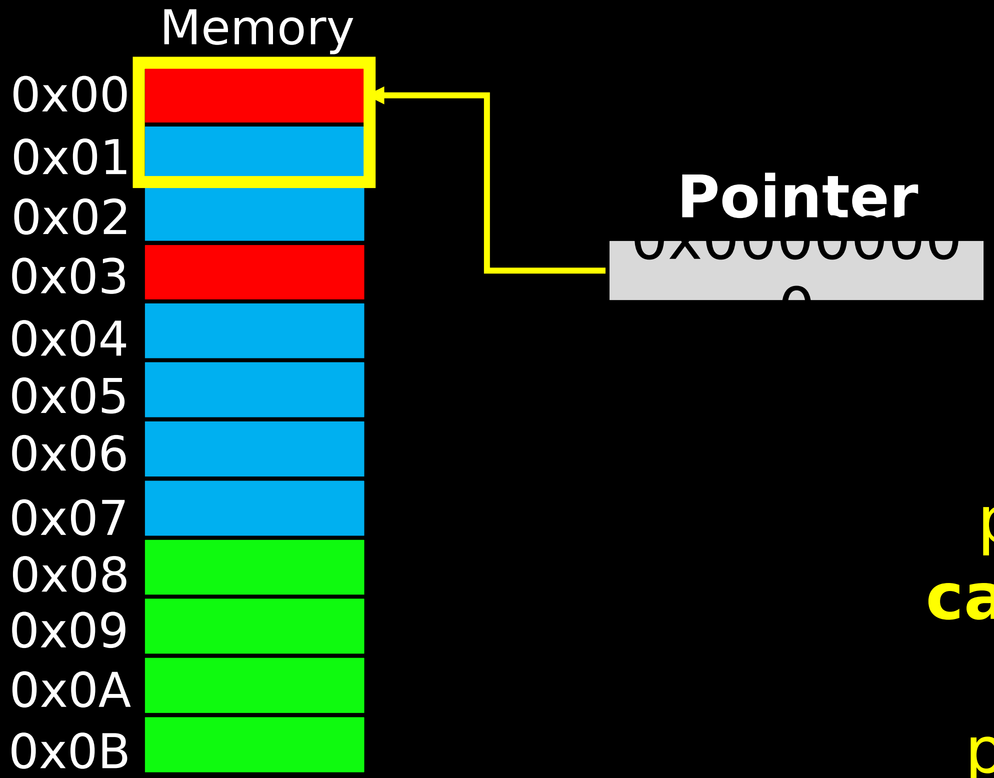
```
uint32_t * ptr3 = (uint32_t *)
0x00;
```

***ptr3 =**



Pointer Casting [S8b]

Cast pointers to dereference **different sizes** from **same address**



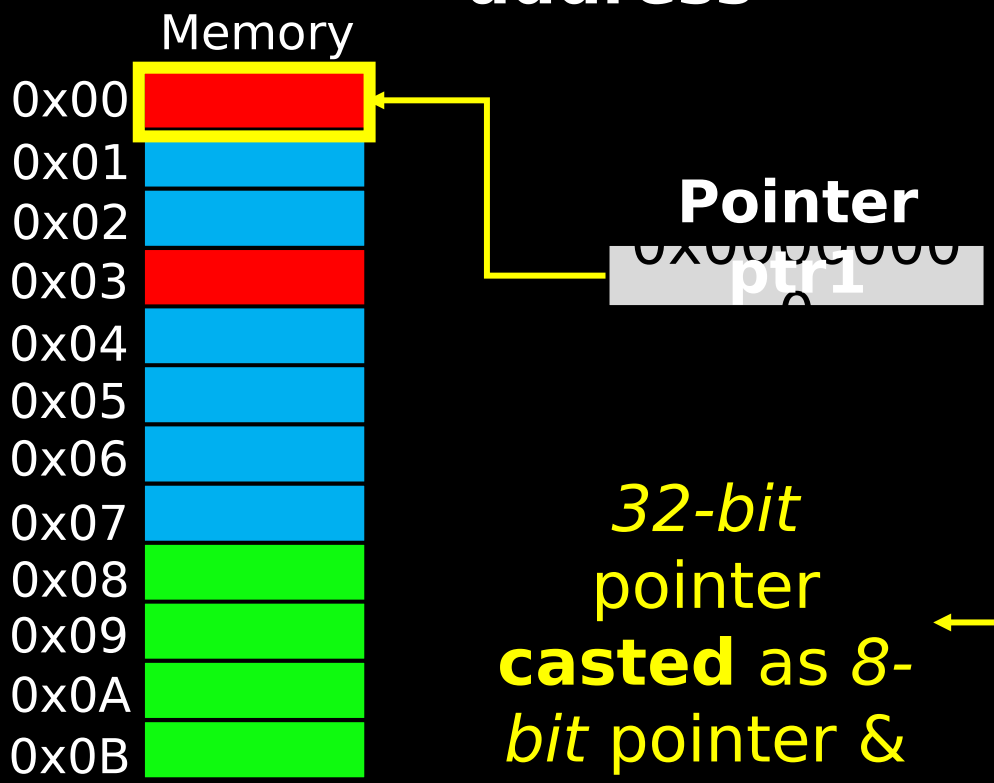
```
uint32_t * ptr3 = (uint32_t *) 0x00;
uint16_t * ptr2 = (uint16_t *) ptr3;
```

***ptr2 =** 🟥🟦

32-bit pointer **casted** as *16-bit* pointer!

Pointer Casting [S8c]

Cast pointers to dereference **different sizes** from **same address**



uint32_t * ptr3 = (uint32_t *) 0x00;
uint16_t * ptr3 = (uint16_t *) ptr3;
uint8_t * ptr1 = (uint8_t *) ptr3;

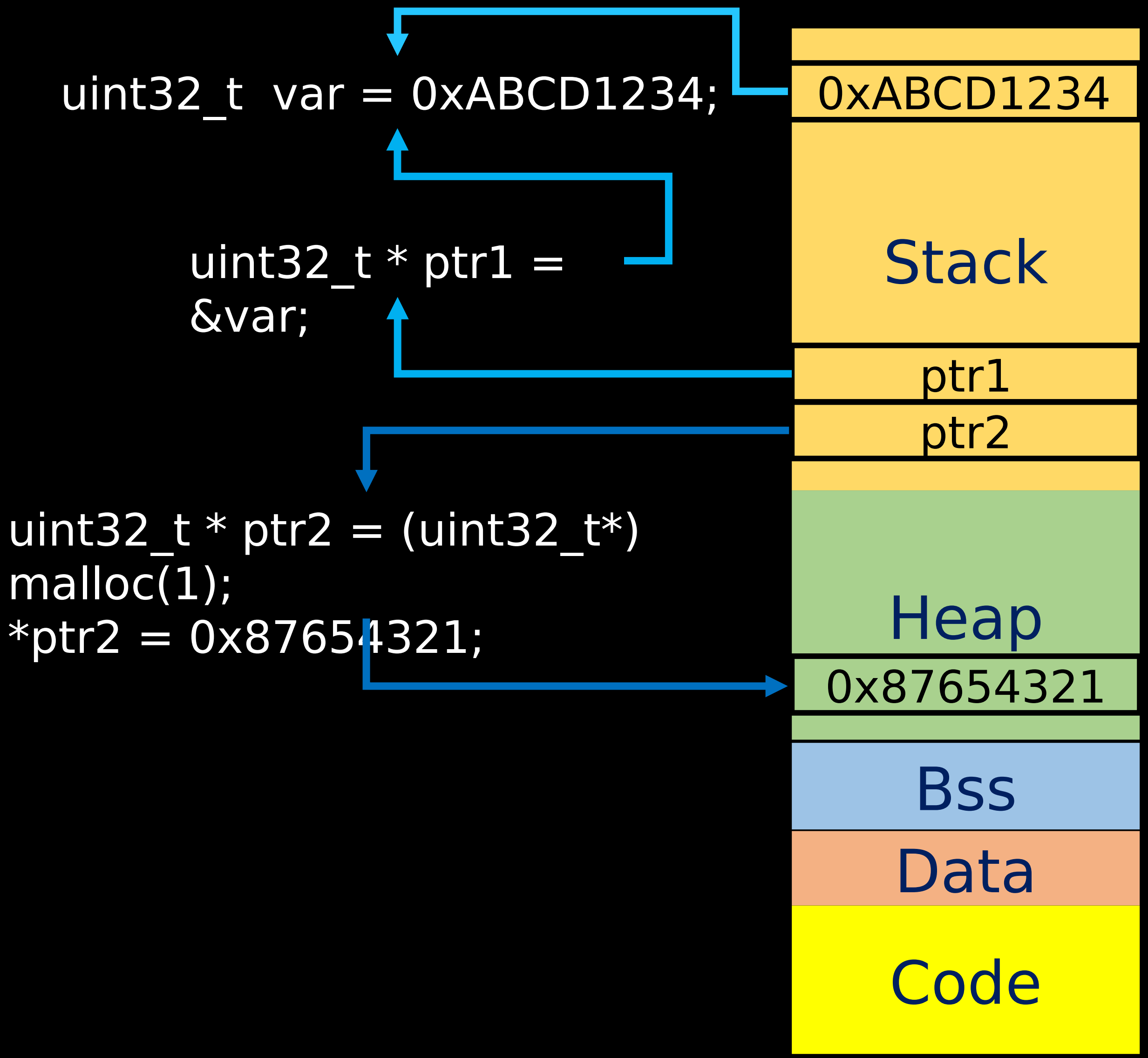
***ptr1 =**

***((uint8_t*)ptr3) =**

32-bit pointer **casted** as *8-bit* pointer & Dereferenced!

Pointers in Memory [S9]

- Pointers exist any part of memory
  - Stack, Heap, BSS, Data
- Pointers can reference data in different parts of memory
  - Code, Data, Peripheral



```
uint32_t  var = 0xABCD1234;

uint32_t * ptr1 =
&var;

uint32_t * ptr2 = (uint32_t*)
malloc(1);
*ptr2 = 0x87654321;
```