wait — will find rest

— forward

guess — Speculum
Speculation

- reg must not do anything we can't undo
- no going to wind up Reg file or memory

- Branches, conditional
  - do we jump — branch prediction
  - where to

- guess we jump —
  - F
  - D
  - E
  - M
  - W
  - jle
  - label

+1 cycle/mispred
- fix
- Taken
- not taken

- forward jump: not taken
- backward jump: taken

label:

loop

Jle

label

if

branch prediction status

90% accuracy
3-cycle mispred penalty

\[ 0.9 \times 1 + 0.1 \times 4 \]

ave 1.3

PC
Side Channel

\[
\text{loop}
\]

\[
\text{if } (\text{pw}[i] = \text{pw}_{\text{exp}}[i])
\]

Set BPG

fix: erase on context switch

attack:

- use same entry
- time it
  \[ \Rightarrow \text{tell boss} \]
call q
foo ✓

$\texttt{Lte}$
foo good prediction

$\texttt{jmp\_}\star \%\texttt{rax}$ forward

$\texttt{retq}$

fake stack

Jump Target predictor
indirect jump - buffer of addr

Object[] x

for (Object y : x) {
    printf(y->tosprintf);
    jmp *y->utable[2]
}
Pipeline: assembly line

Multicore: each do it

Management
Priority
Employee behavior
Communicate

Functional units

fetch
decode
execute
memory
result

 incr
add
sub
mul
div
load
store