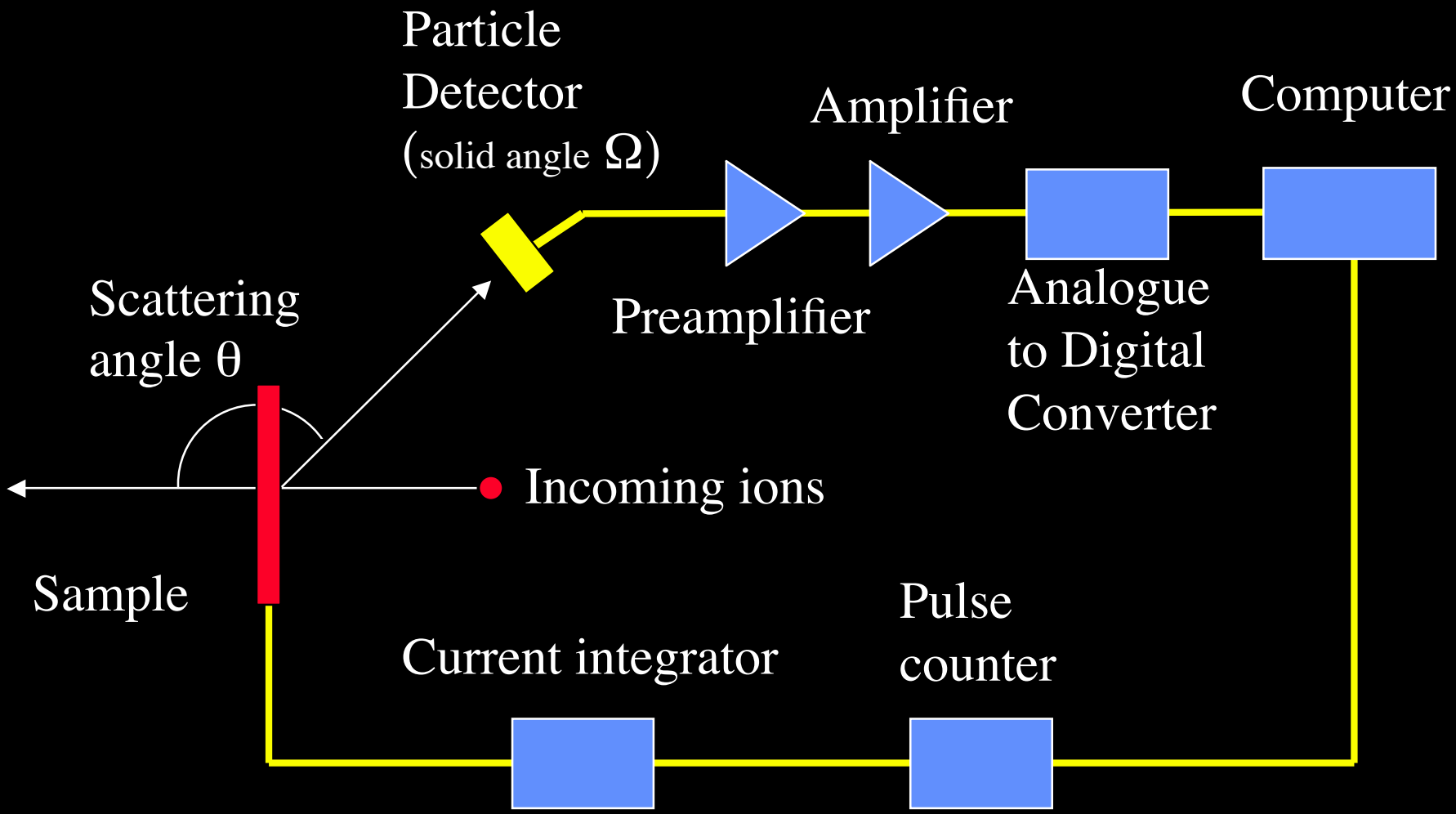
# Standard RBS

# Typical experimental set-up



# The Yield from infinitely thin layer

$$Y \propto \frac{d\sigma}{d\Omega}\,\Omega\,Q\,N$$

Y = number of counts

dσ/dΩ = probability of scattering (cross section)

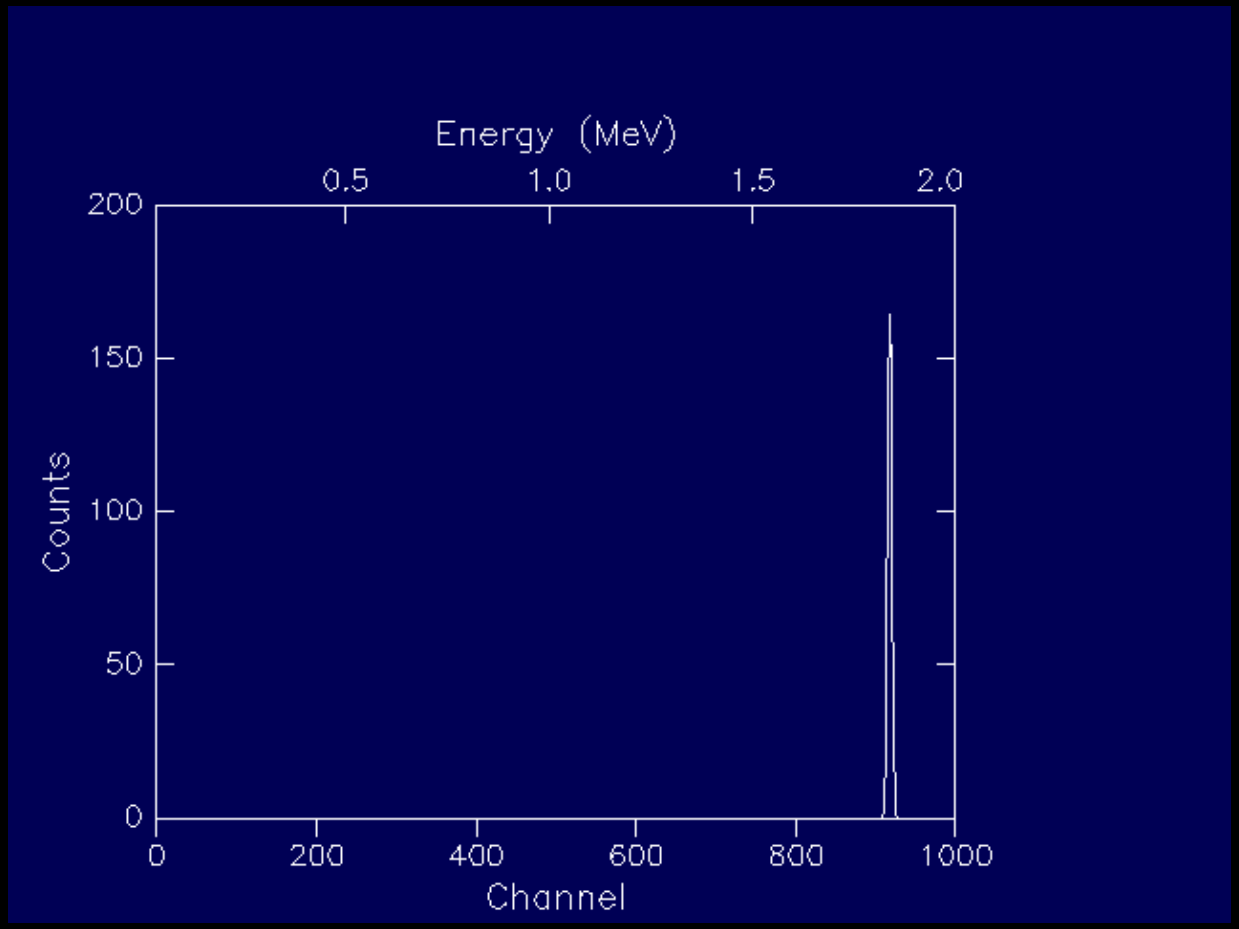
Ω = solid angle of the detector

Q = number of ions hitting the layer

N = Number of (atoms / surface area) in the layer

# Free standing monolayer of W

Energy of the incoming $He^+$ is 2.00 MeV



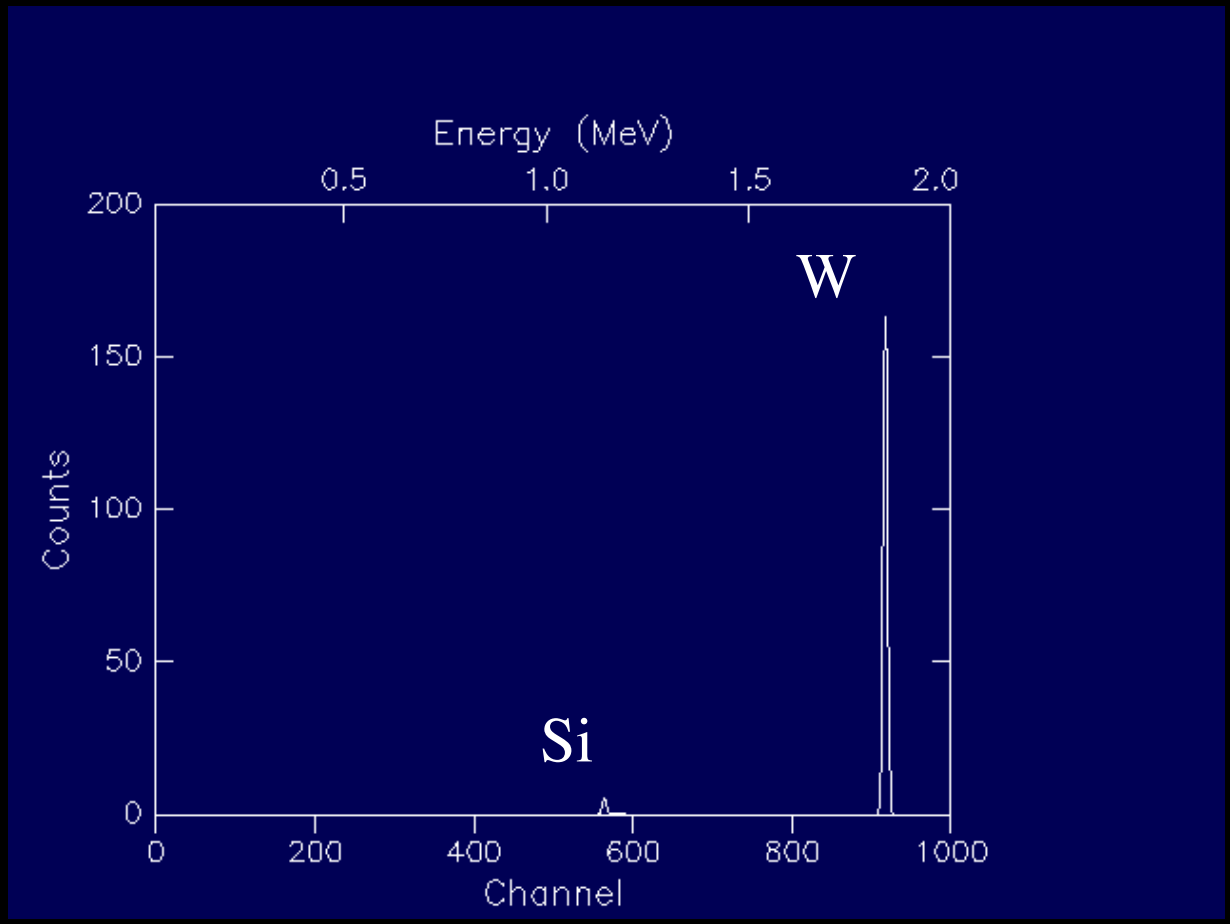

W = $10^{15}$ atoms/cm$^2$

Doze = 10 μC

≈ 6 $10^{13}$ particles

$$\frac{d\sigma}{d\Omega} \propto \left[\frac{Z_{ion}Z_{sample}}{E_{ion}}\right]^2$$

# Free standing ML, W & Si




Si and W =
$10^{15}$ atoms/cm$^2$

$$\frac{d\sigma}{d\Omega} \propto \left[\frac{Z_{ion}Z_{sample}}{E_{ion}}\right]^2$$

$Z_{si} = 14$
$Z_{Wi} = 74$

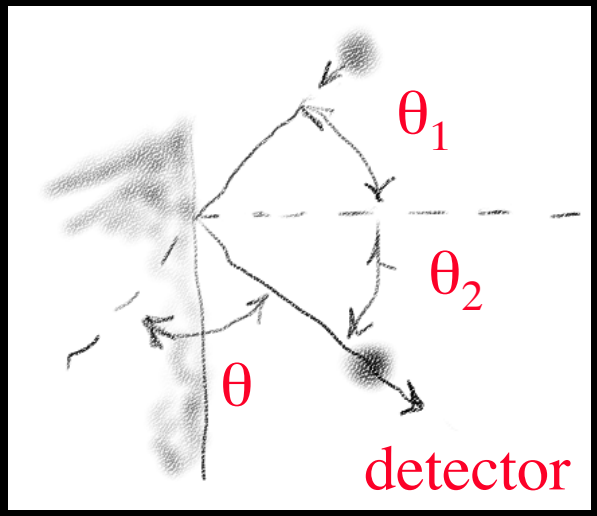
$$\frac{Y_{Si}}{Y_W} = \left(\frac{14}{74}\right)^2 = 0.03$$

# Yield close to the surface

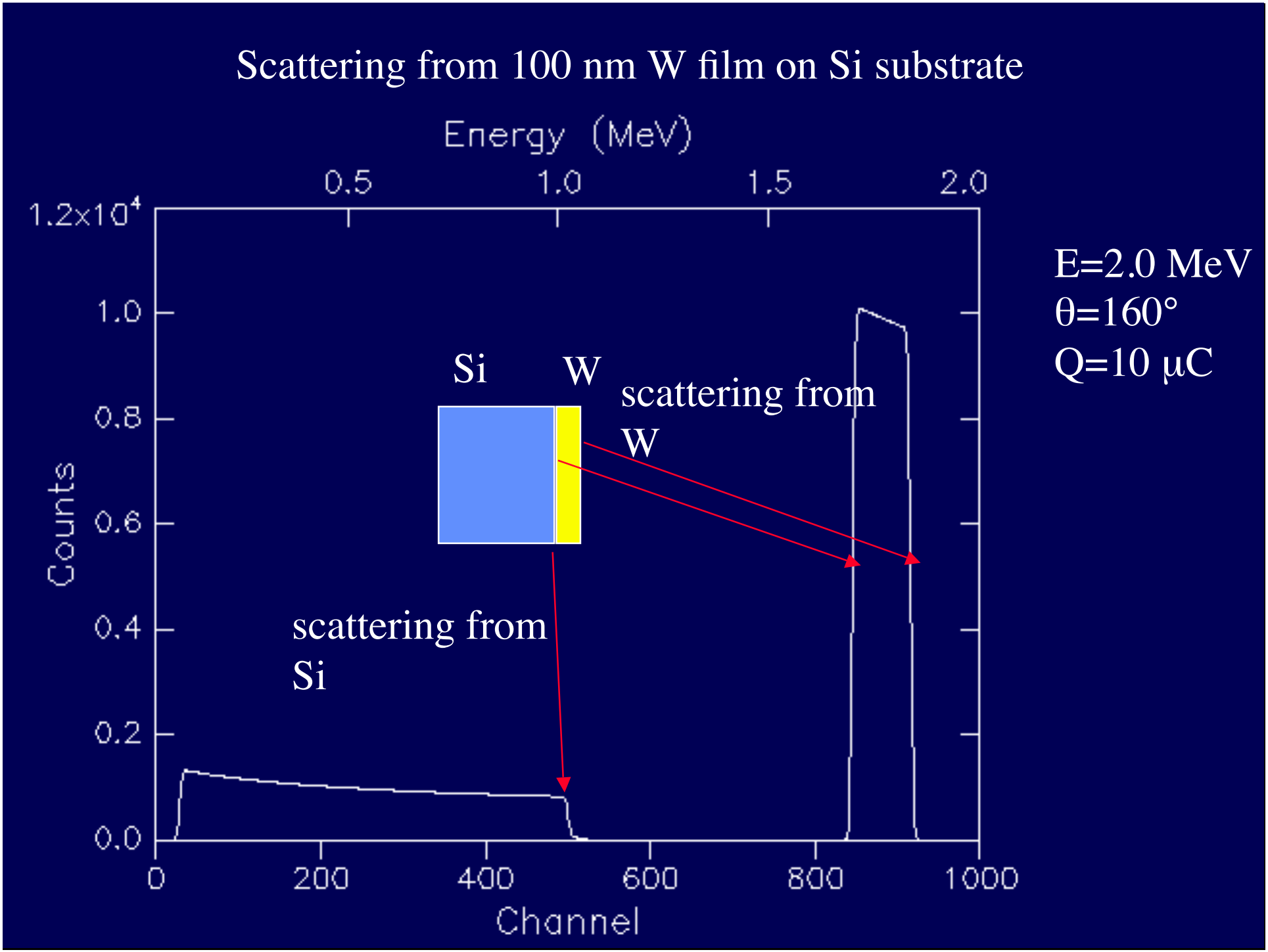
Close to the surface, the change in energy is small, hence we can approximate the yield using the same cross section.

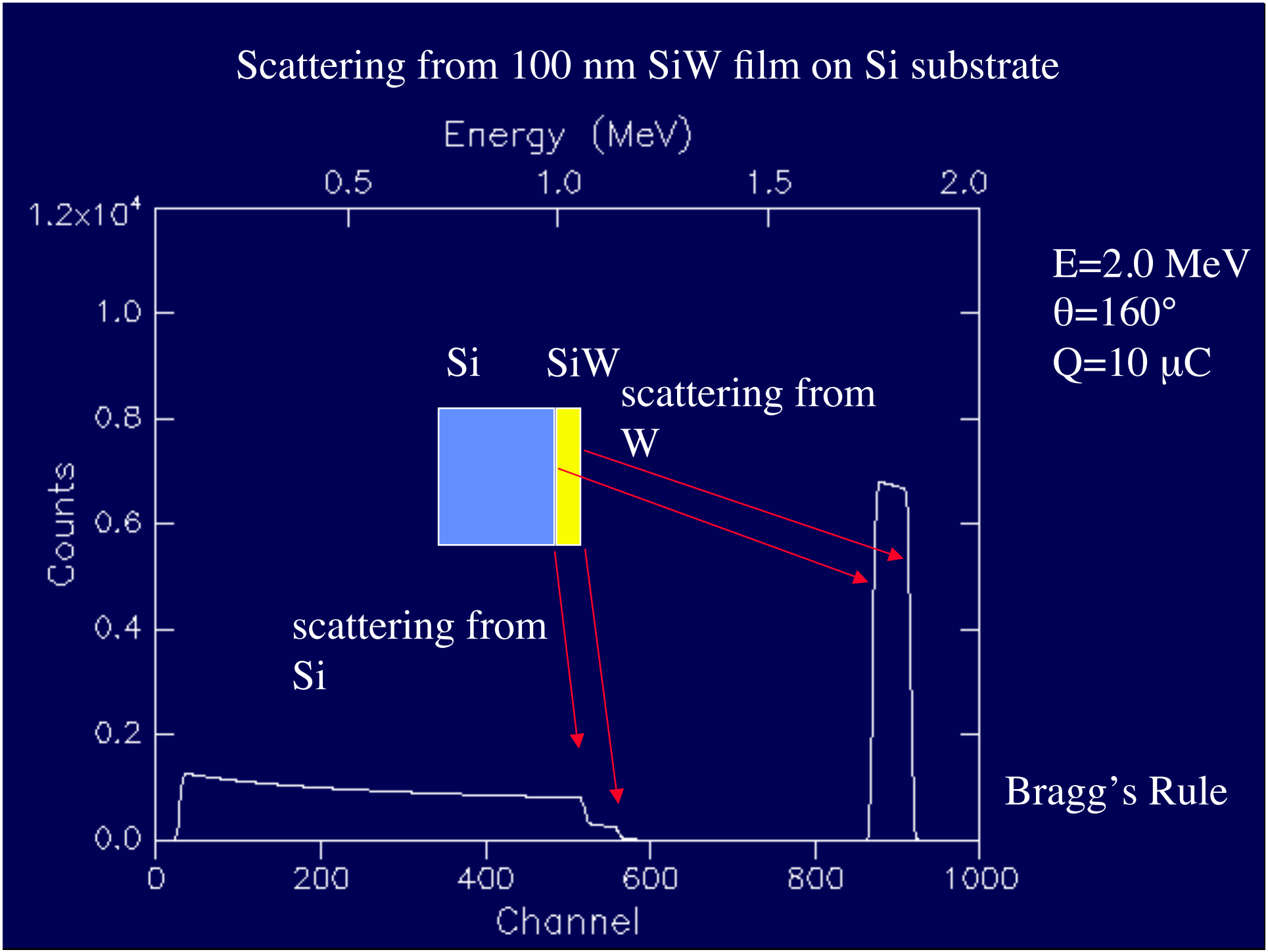
$$H_0 = \frac{\frac{d\sigma}{d\Omega}\,\Omega\, Q\, \zeta}{\left[\varepsilon_0\right]\cos\theta_1}$$

$$\left[\varepsilon_0\right] = \frac{k}{\cos\theta_1}\,\varepsilon(E_0) + \frac{\varepsilon(k\,E_0)}{\cos\theta_2}$$




This approach is called the surface approximation


Scattering from 100 nm W film on Si substrate
Energy (MeV)
0.5
1.0
1.5
2.0
1.2x10⁴
1.0
0.8
0.6
0.4
0.2
0.0
Counts
0
200
400
600
800
1000
Channel
Si
W
scattering from W
scattering from Si
E=2.0 MeV
θ=160°
Q=10 μC


Scattering from 100 nm SiW film on Si substrate
Energy (MeV)
0.5
1.0
1.5
2.0
1.2x10⁴
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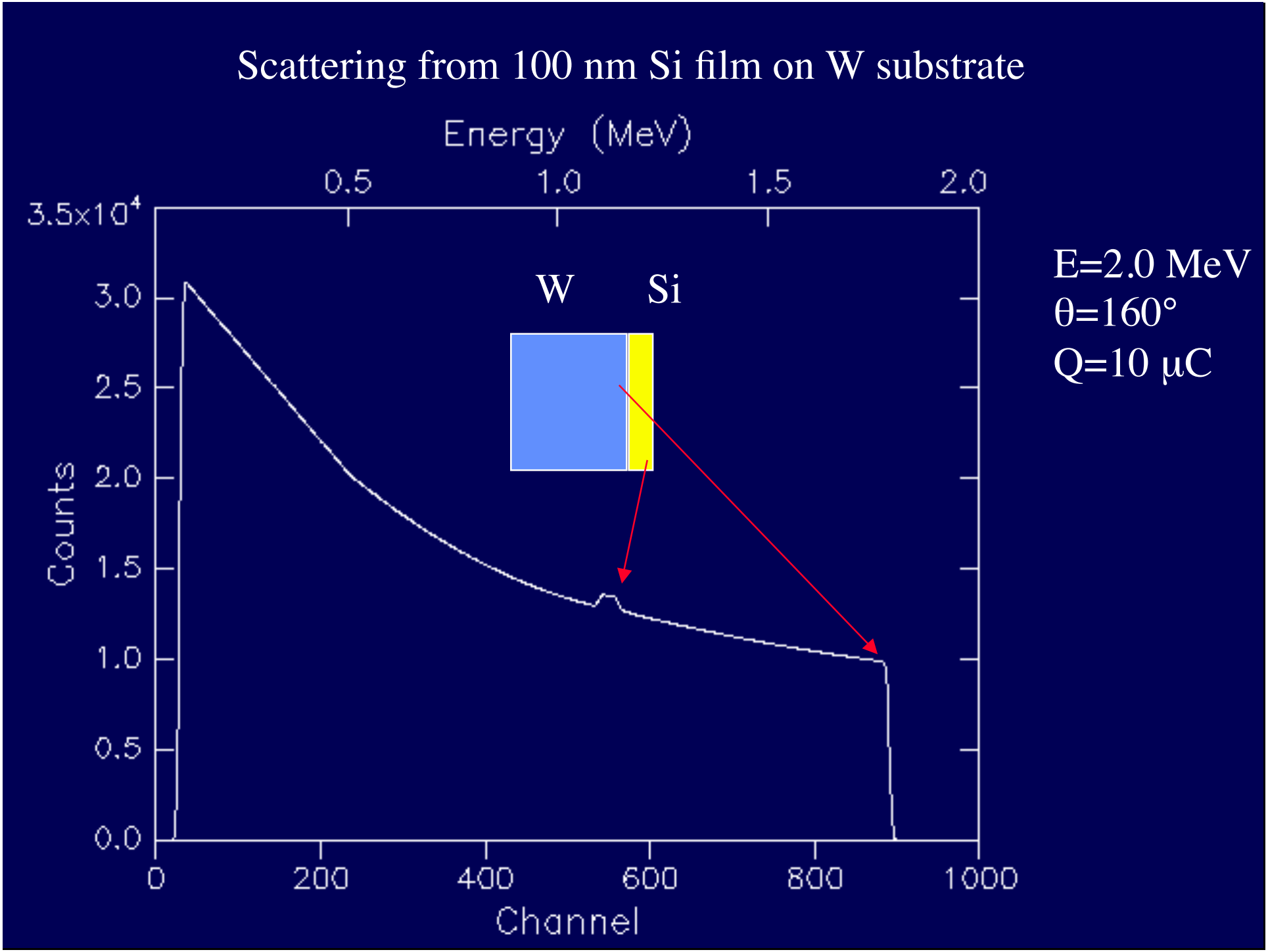
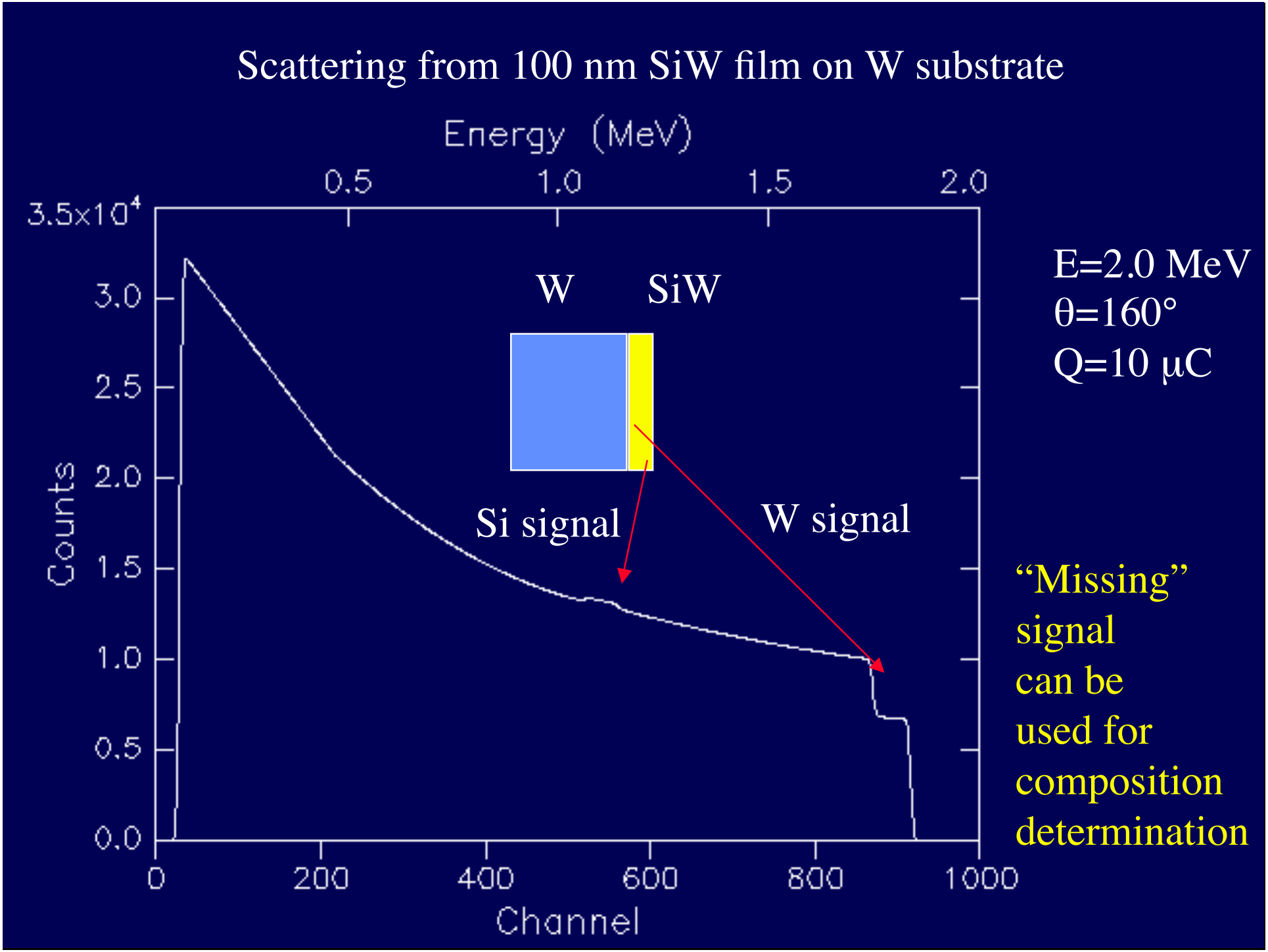
0.8
0.6
0.4
0.2
0.0
Counts
0
200
400
600
800
1000
Channel
Si
SiW
scattering from W
scattering from Si
E=2.0 MeV
θ=160°
Q=10 μC
Bragg's Rule

# Scattering from 100 nm Si film on W substrate




E=2.0 MeV
θ=160°
Q=10 μC

# Scattering from 100 nm SiW film on W substrate



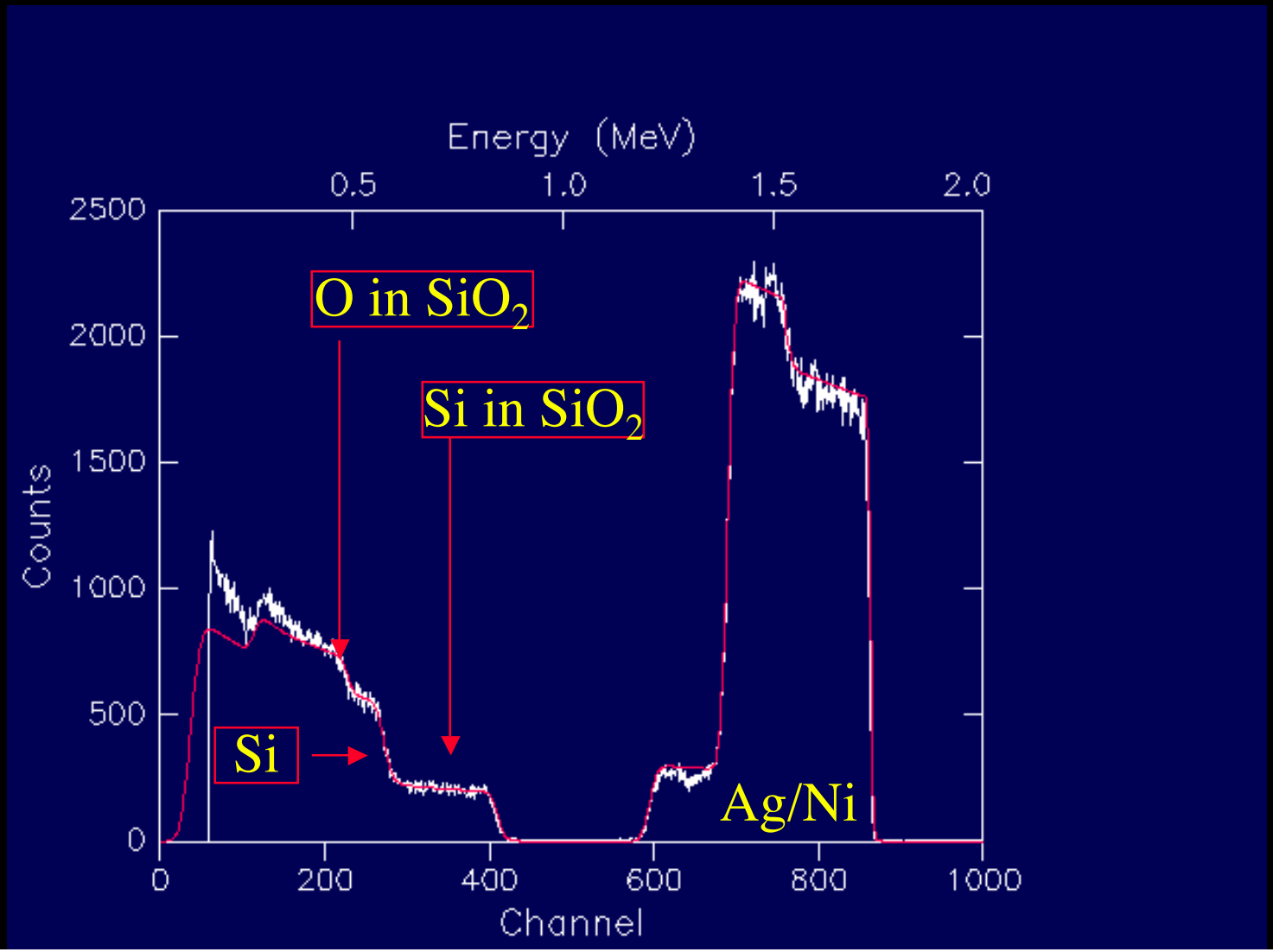

E=2.0 MeV
θ=160°
Q=10 μC

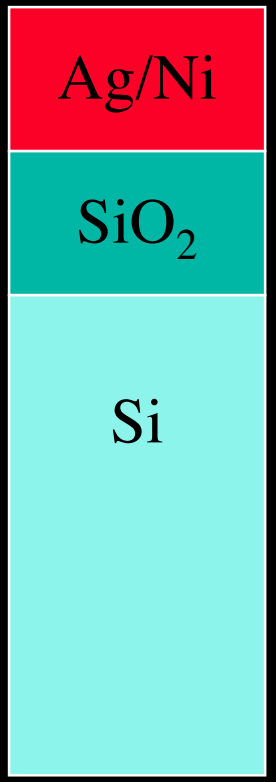
"Missing" signal can be used for composition determination

# Simulation programs

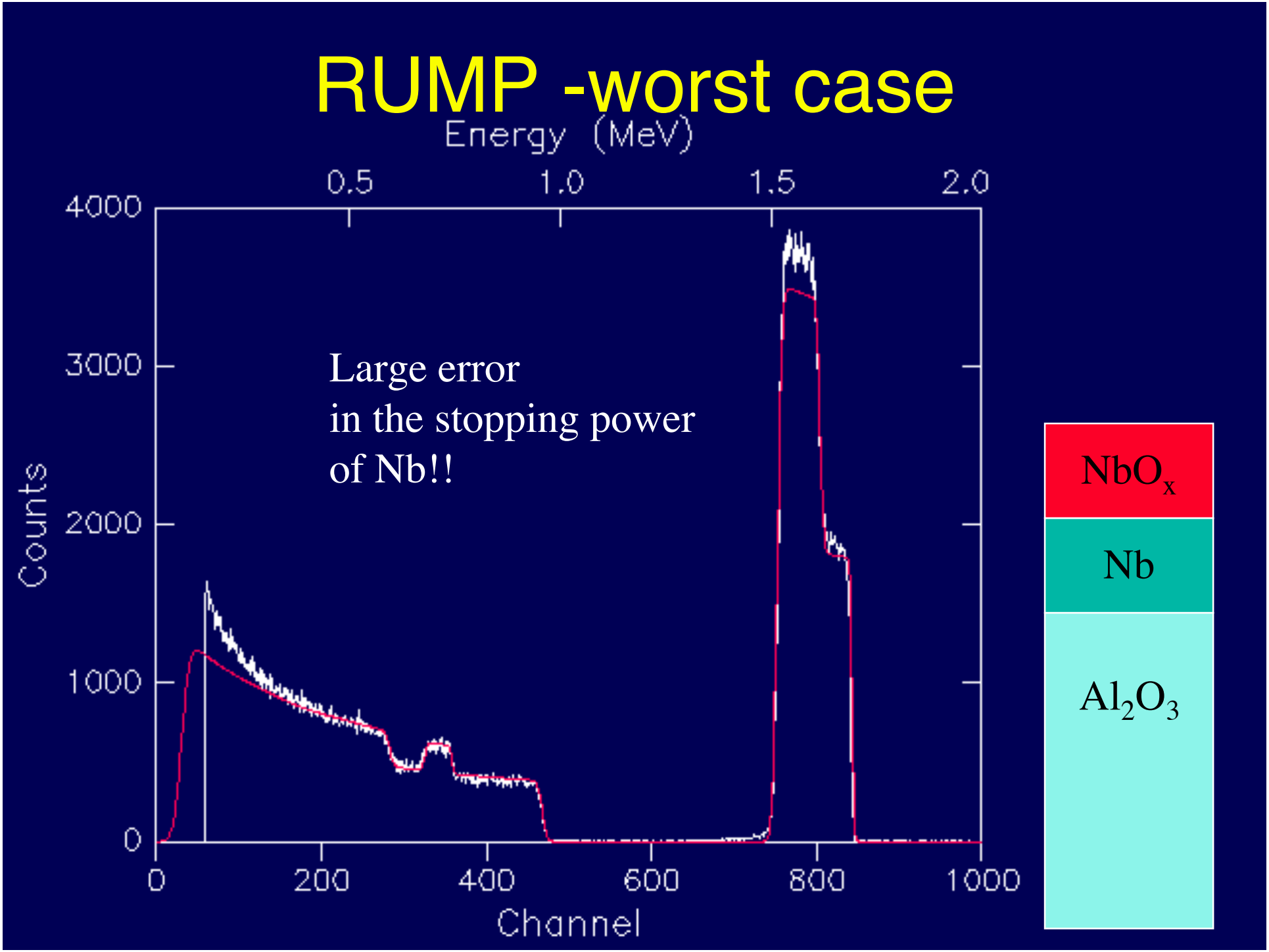
- There are number of simulation programs available
- Most of these do rely on the tabulated values of the stopping power from Ziegler
- Accuracy of the stopping power is typically 5 %!! Can be as bad as close to 10 % (Nb)
- Here we use RUMP (download available)

# RUMP analysis of Ag/Ni multilayers on $SiO_x$/Si

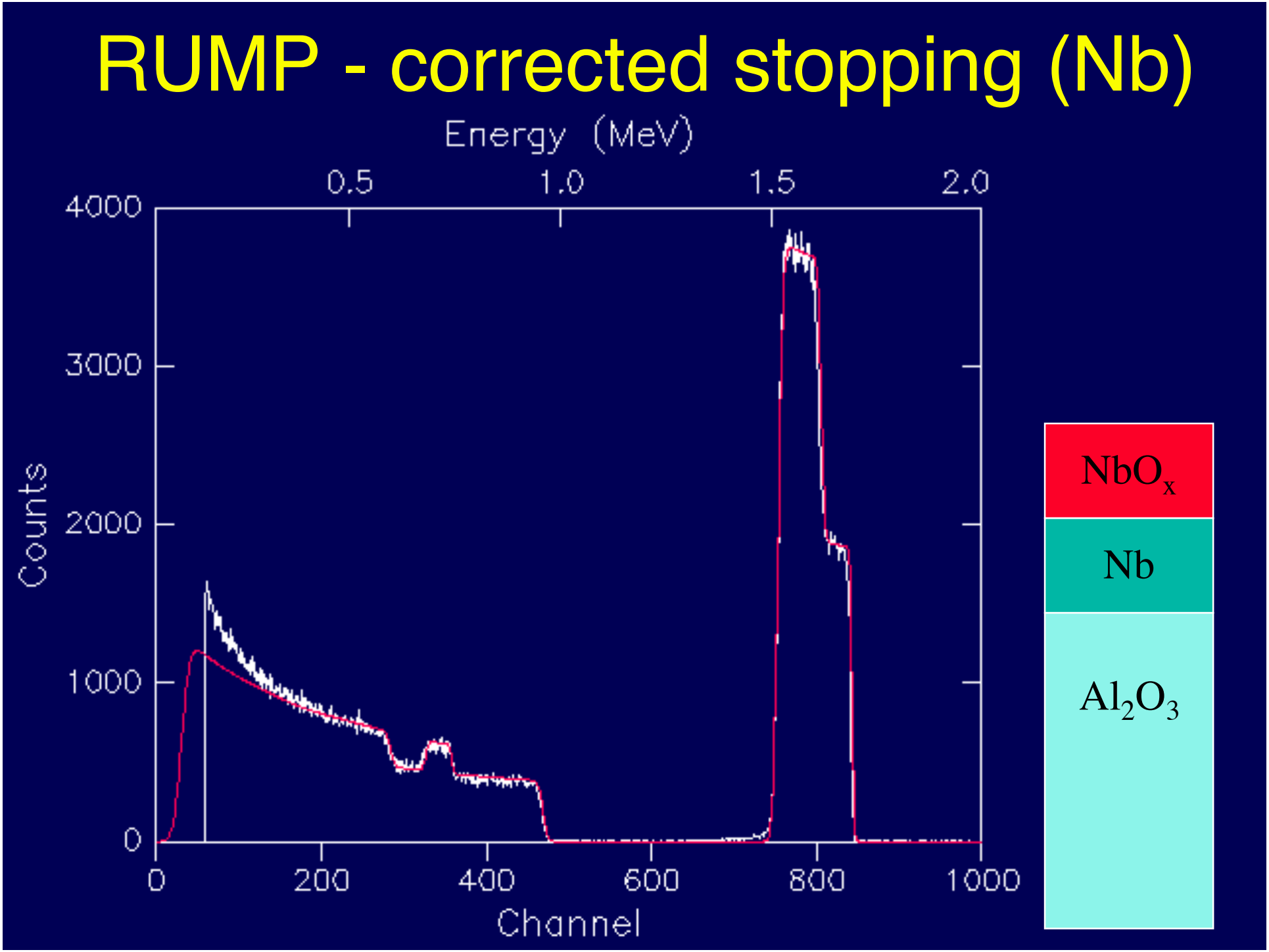


# RUMP -worst case



# RUMP - corrected stopping (Nb)



# With RBS one can obtain:

- The number of atoms/surface area (thickness)
- Composition (except low Z)
- Variation in composition
- Thickness variation

RBS is ideal for analysis of high Z materials on low Z substrates

# What RBS does NOT yield is

- Thickness in meters
- Morphology
- Structure
- The amount of light elements such as H!

By combining RBS and XRD analysis,
one can obtain the density!!

# Typical performance

- Depth resolution, 2-10 nm
- Precision, better than 1 atomic %
- Accuracy, at best ≈1 atomic %
- Throughput, 1 sample / 15 minutes

return