
# An Introduction to Ion-Optics

Series of Five Lectures
JINA, University of Notre Dame
Sept. 30 – Dec. 9, 2005

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# The Lecture Series

1st Lecture: 9/30/05, 2:00 pm: Definitions, Formalism, Examples

2nd Lecture: 10/7/05, 2:00 pm: Ion-optical elements, properties & design

3rd Lecture: 10/14/05, 2:00 pm: Real World Ion-optical Systems

4th Lecture: 12/2/05, 2:00 pm: Separator Systems, Part 1

5th Lecture: 12/9/05, 2:00 pm: Separator Systems, Part 2

# 4th Lecture

4th Lecture: 12/2/05, 2:00 pm
Separator Systems, Part 1

- Faint radiation near the sun – an analogy (4 – 5)
- Concept of magnetic & electric separation (6 – 8)
- Magnetic separation in $0^o$ experiments in spectrometers (9 – 11)
- Preview Lecture 5 (12)

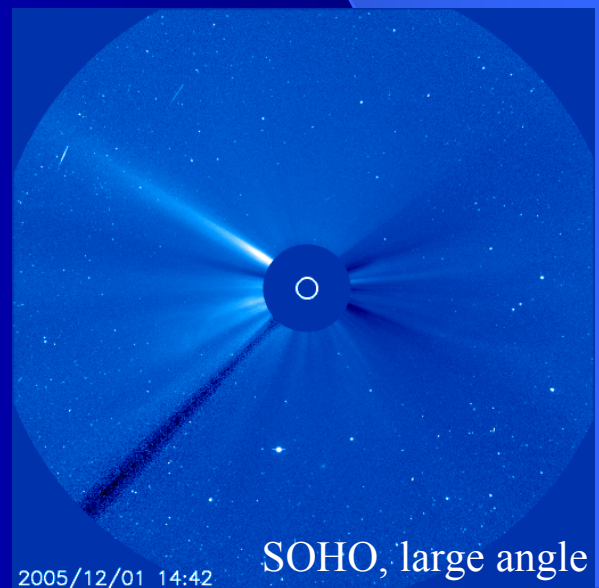
# Observing faint radiation near the sun:

## An analogy for observing nuclear particles close to the beam

## Solar Eclipse Coronagraph

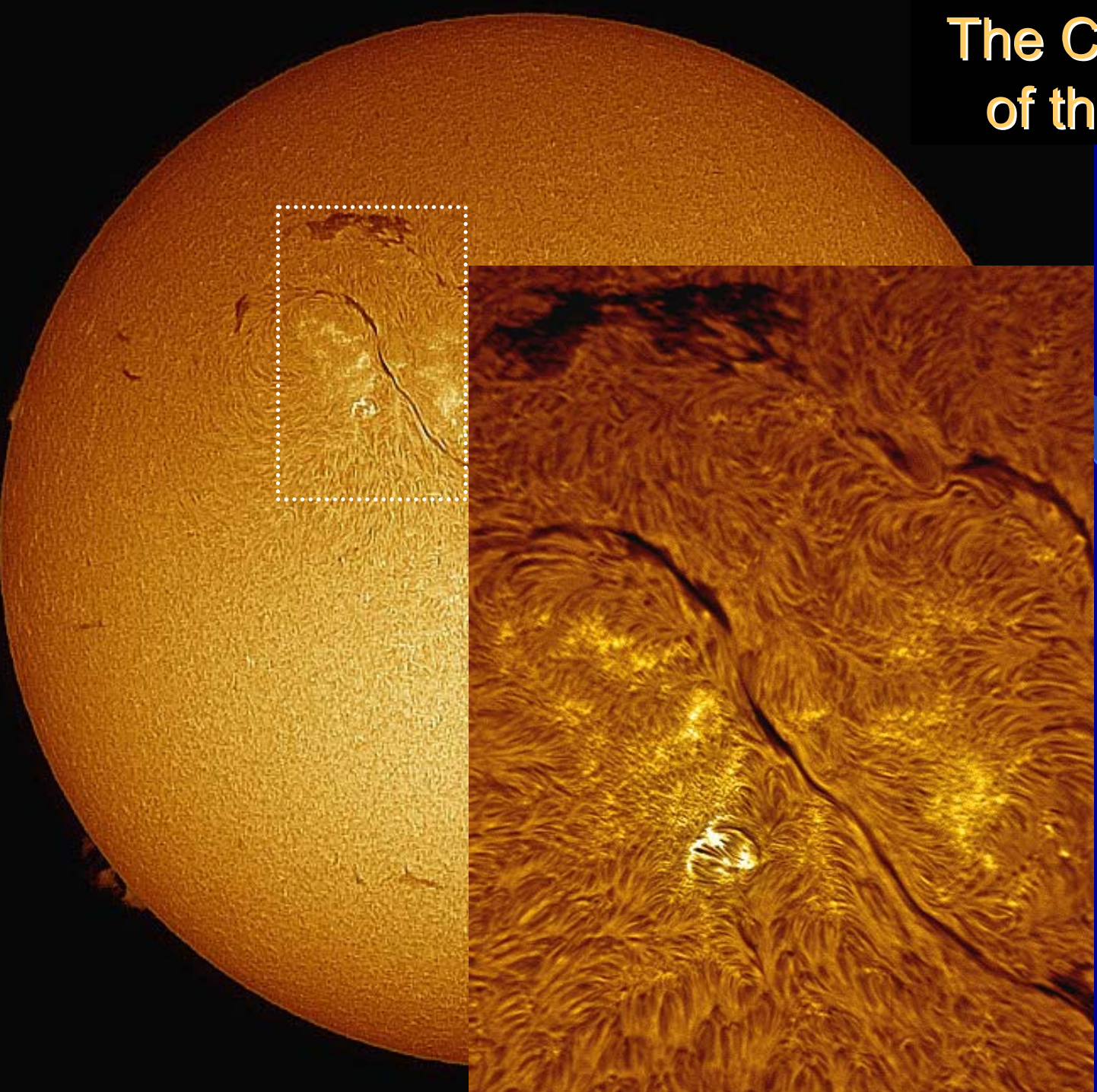
Shadow of moon of Earth

Solar Eclipse 1999




SOHO, large angle

# The Chromosphere of the Sun in Hα



Hα line, λ = 656.28nm

Δλ = 0.07nm
Narrow Band Filter

# Observing close to the Beam

## Magnetic & Electric Separation in a Dipole Field

$$\vec{F} = q\vec{E} + q\vec{v}\,x\,\vec{B} \qquad \text{(1)}$$

Electric force — Magnetic force

$$F_{elec} = qE \qquad \text{(1a)}$$

$$F_{magn} = qvB \qquad \text{(1b)}$$

$$F_{centr} = mv^2/\rho, \quad \text{Centripetal Force} \qquad \text{(28)}$$

$$T = mv^2/2, \quad \text{Kinetic Energy (non-relativistic)} \qquad \text{(29)}$$

$$B\rho = mv/q, \quad \text{Magnetic rigidity}$$

$$E\rho = mv^2/q, \quad \text{Electric rigidity}$$

# Magnetic and Electric Separation in a Dipole Field

Magnetic Separation: $F_{magn} = F_{centr}$

$$m/q = C_1 (T/q)^{-1} \quad \text{with} \quad C_1 = (B\rho)/2 \qquad (30)$$

Electric Separation: $F_{elec} = F_{centr}$

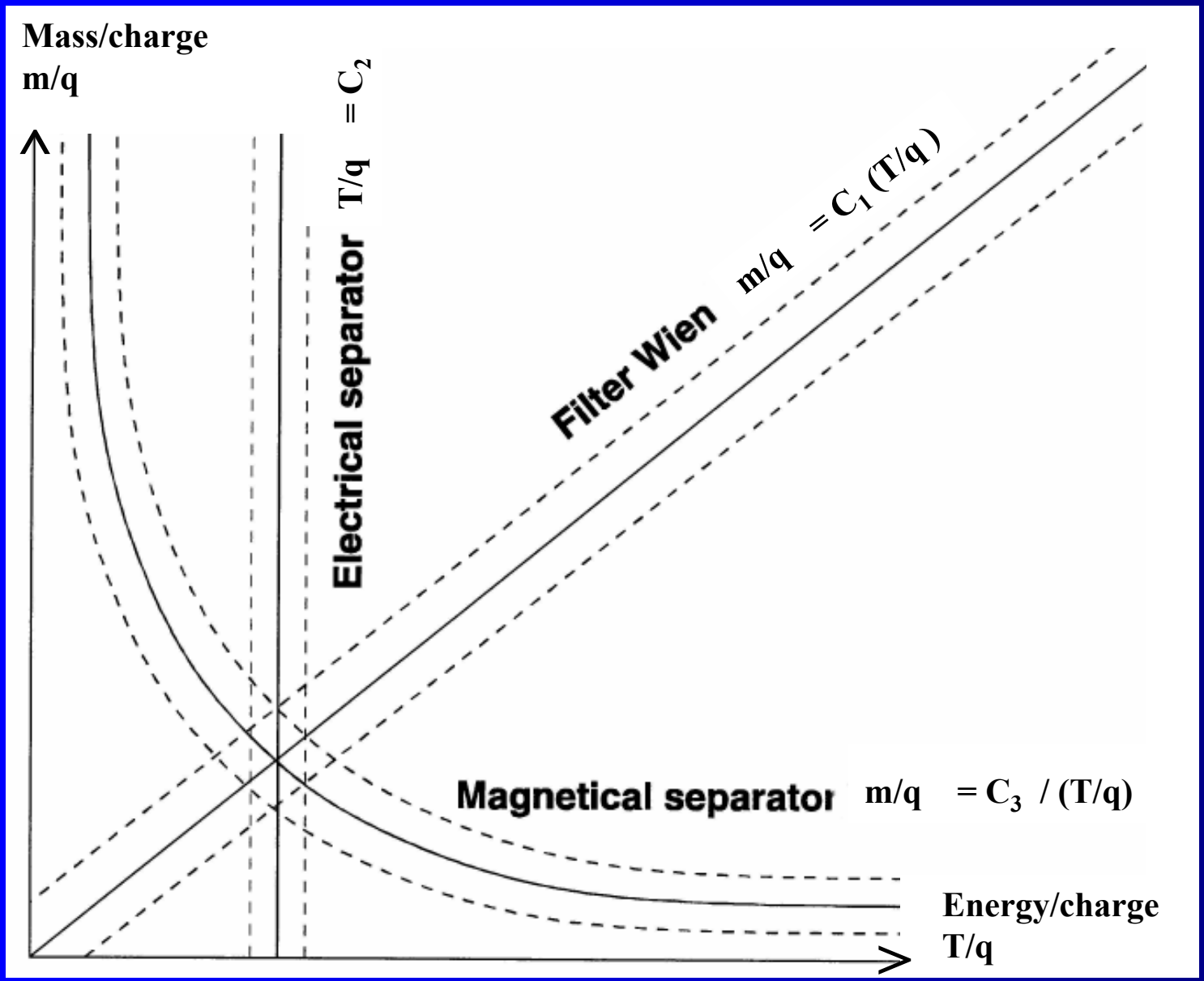
$$T/q = C_2 \quad \text{with} \quad C_2 = (E\rho)/2 \qquad (31)$$

Wien Filter: $F_{elec} = F_{magn}$

$$v = E/B \quad \text{with} \quad E \perp B \qquad (19)$$

$$m/q = C_3 \; T/q \quad \text{with} \quad C_3 = 2/v^2 \qquad (32)$$

# Magnetic and Electric Separation in a Dipole Field




Ref: D. Catana et al, Report WP10 IDRANAP 15-01/2001

# Magnetic (Bρ) Separation of Beam & Reaction Products in Spectrometer Experiments near 0°

K600, Grand Raiden Spectrometers:

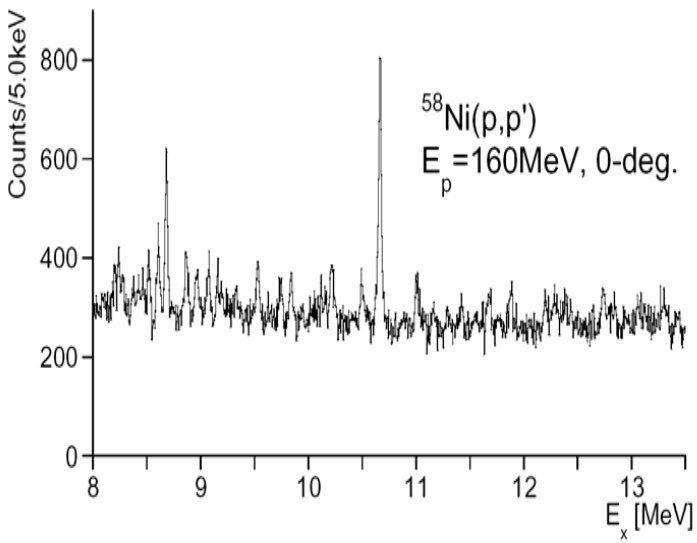
($^{3}$He,t), (p,t), (α,α'), (p,p'), (α,$^{8}$He)

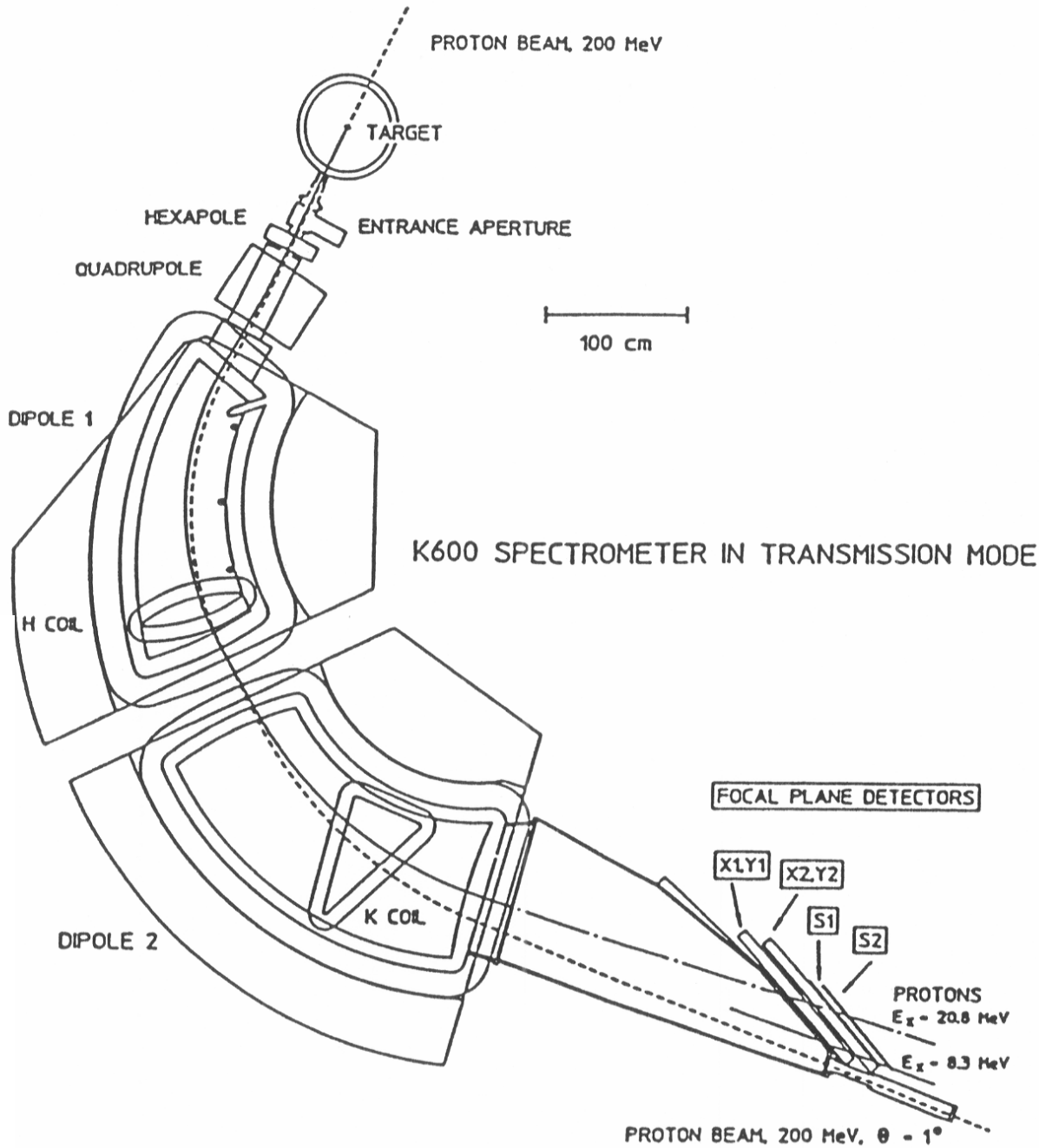
Special Faraday cups to stop beam

# K600 Spectrometer (IUCF)

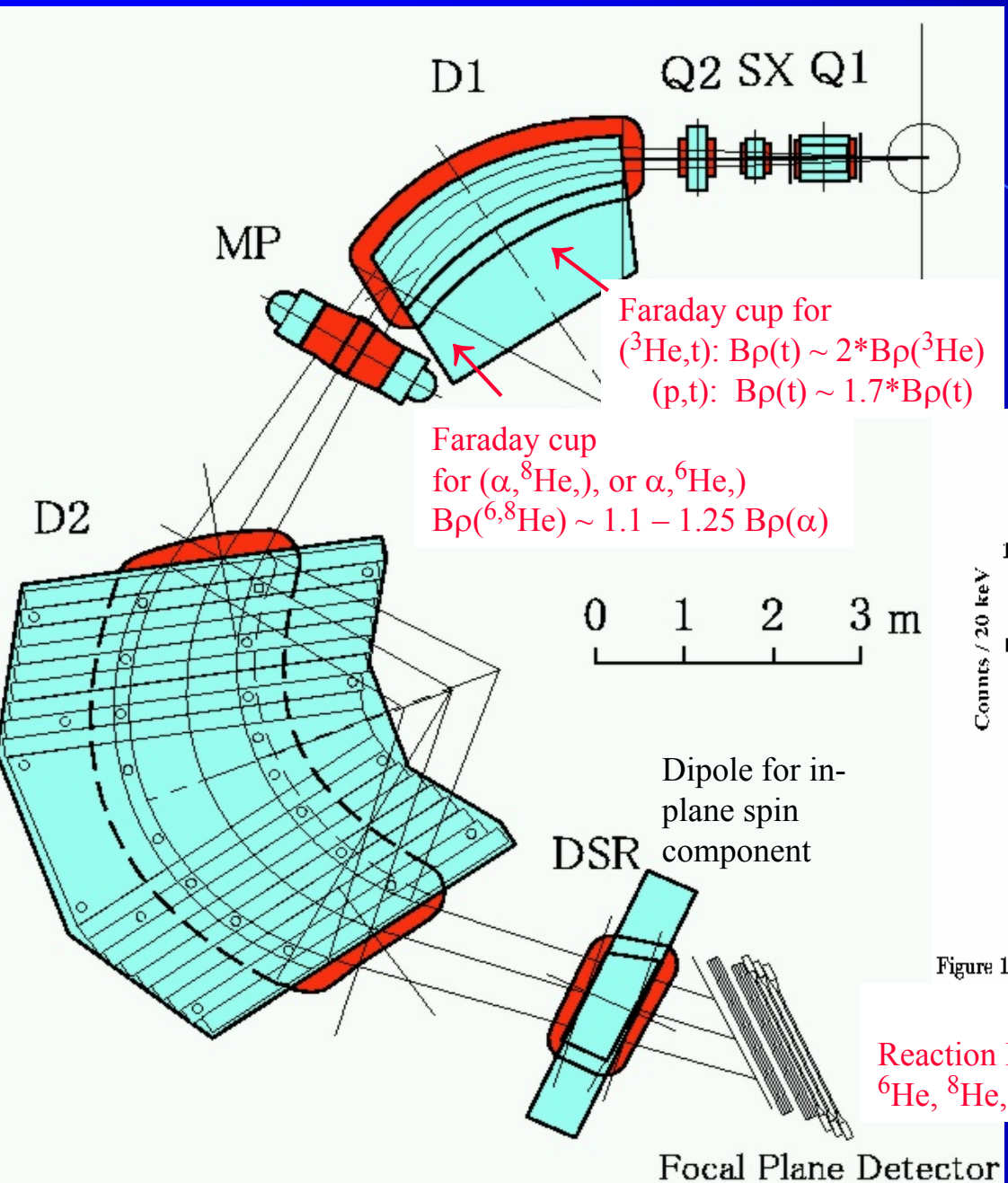
The K600 is shown in $0^o$ Transmission mode for inelastic scattering at $0^o$

High Dispersion Plane B(D1) > B(D2)



# Grand Raiden High Resolution Spectrometer




Grand Raiden is shown in $0^o$ Transmission mode for reactions at $0^o$

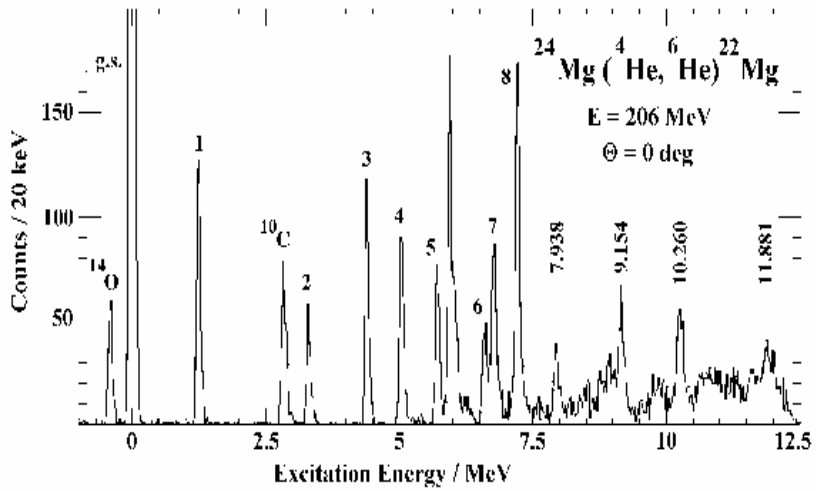



Figure 1. Measured $^{22}$Mg spectrum with angle cut 0 - 1.5° and a resolution of 75 keV.

Reaction Products
$^6$He, $^8$He, t

# Preview 5th Lecture

5th Lecture: 12/9/05, 2:00 pm
Separator Systems, Part 2

Preview:

- A "no-field" separation method: the Wedge
- Gas-filled separators
- Fragment separator, inverse kinematics, TRImP
- Recoil separators
- St. George

# End Lecture 4