



아시아 태평양 이론물리센터
Asia Pacific Center for Theoretical Physics

Nuclear Physics in Science Business Belt : Future Heavy Ion Accelerator in Korea

중간에너지 RI 가속기를 사용한 현대핵물리학 프로그램

2008. 11. 15.

경북대학교, 기초과학지원연구원

김우영



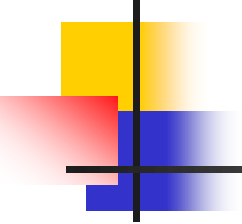
Outline

- Introduction
- IUCF
- TRIUMF
- ^3He 편극핵
- High Intensity Proton Accelerator



가속기 제작에 고려할 사항

- 사용자
- 설계, 제작, 유지능력
- 예산 (제작비, 유지비)
- 경쟁력 (과학적, 응용성)
- 부지 설정



Indiana University

**Cyclotron
Facility**

Supported by NSF, DOE, NIH, State of Indiana

Research Programs

1980

- **Nuclear Science**
- **Accelerator Science**

2000

- **Accelerator Science**
- **Material Science**
- **Medical Application**
- **Nuclear Science**
- **Radiation Effects**



Nuclear Science Experiment Groups



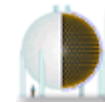
Weak Interactions Groups



Many-body Dynamics



STAR Collaboration



IUCF Neutrino Group



PINTEX Collaboration

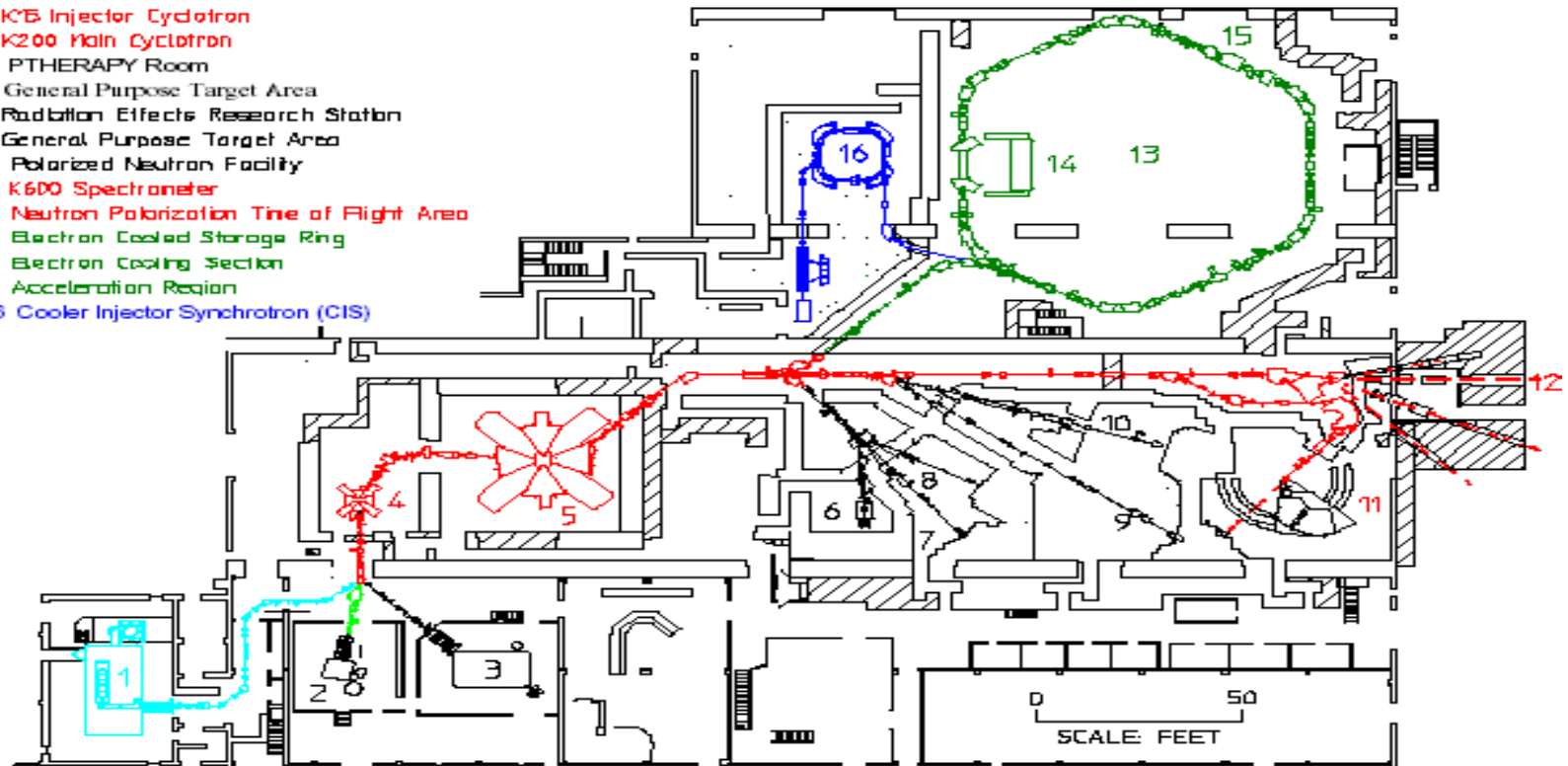


Cooler CSB

Nuclear Theory Center

IU Accelerator Facility

- 1 High Intensity Polarized Ion Source
- 2 Unpolarized Ion Source
- 3 Polarized Ion Source
- 4 K¹⁵B Injector Cyclotron
- 5 K²⁰⁰ Main Cyclotron
- 6 P THERAPY Room
- 7 General Purpose Target Area
- 8 Radiation Effects Research Station
- 9 General Purpose Target Area
- 10 Polarized Neutron Facility
- 11 K⁶⁰⁰ Spectrometer
- 12 Neutron Polarization Time of Flight Area
- 13 Electron Cooled Storage Ring
- 14 Electron Cooling Section
- 15 Acceleration Region
- 16 Cooler Injector Synchrotron (CIS)

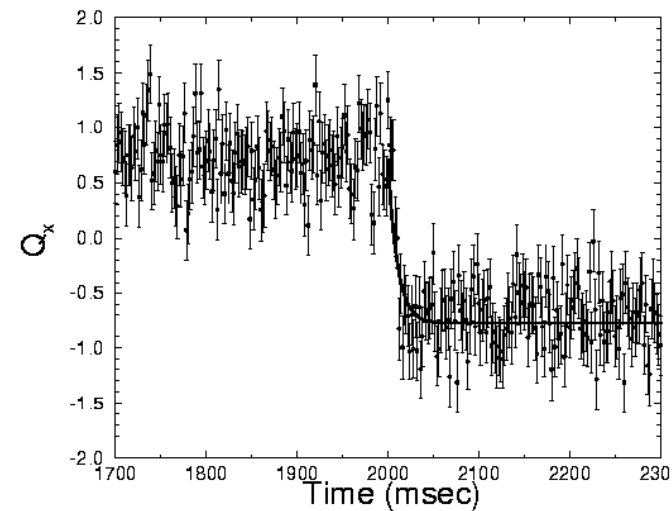




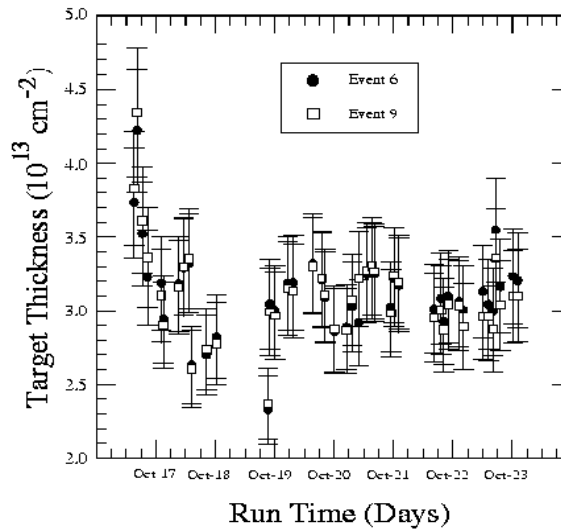
The IUCF Weak Interaction Group

- Parity non-conservation in neutron **spin rotation** in ^4He
- Probing the weak nucleon-nucleon force in the reaction
 $n + p \rightarrow d + \gamma$
- Polarized ^3He **Neutron Spin Filter**
- Time and Parity Non-conservation in **Xenon**
- **Lifetime** of the Neutron

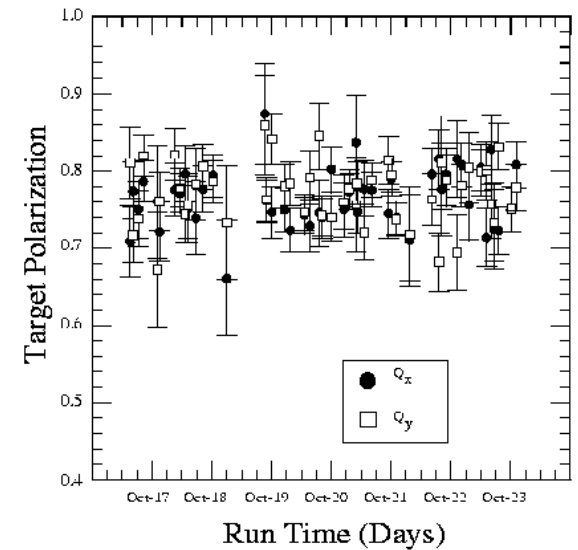
The Wisconsin A.B.S. Target



Polarization Direction Change

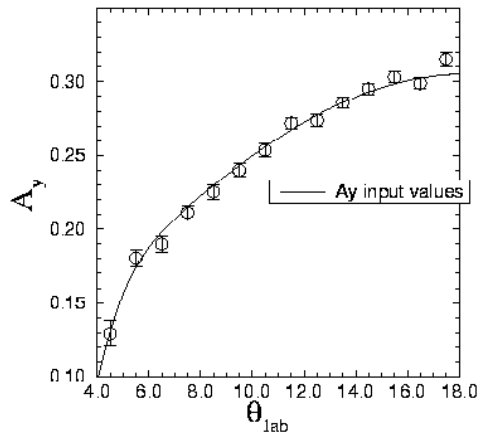


Target Thickness

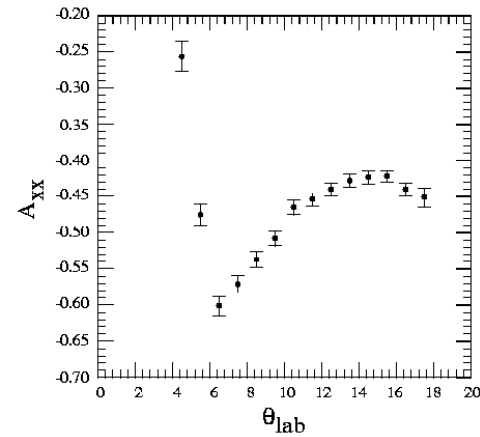


Target Polarization

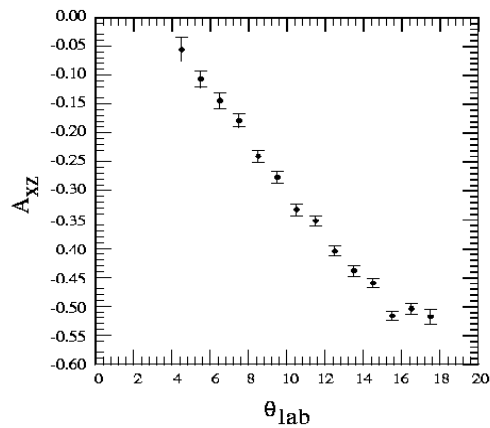
PINTex Results



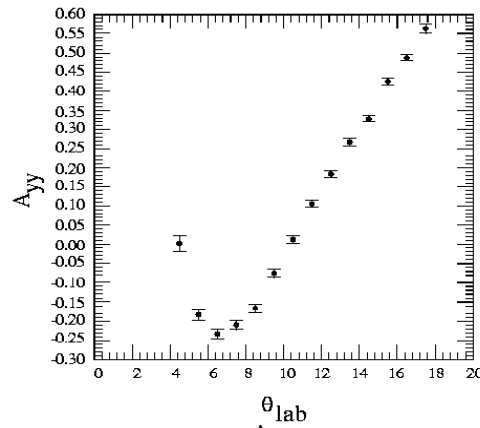
Analysing Power



Axx



Axz



Ayy



TRIUMF Research Areas

- **Theoretical**

- The Significance of Spin**
 - The Standard Model**

- **Pure**

- ISAC: An Introduction**
 - ISAC: Astrophysics**
 - ISAC: Experiments with TRINAT**
 - Refinement Through Particles**
 - Polarized Source Development (OPPIS)**
 - Superconductor Research**

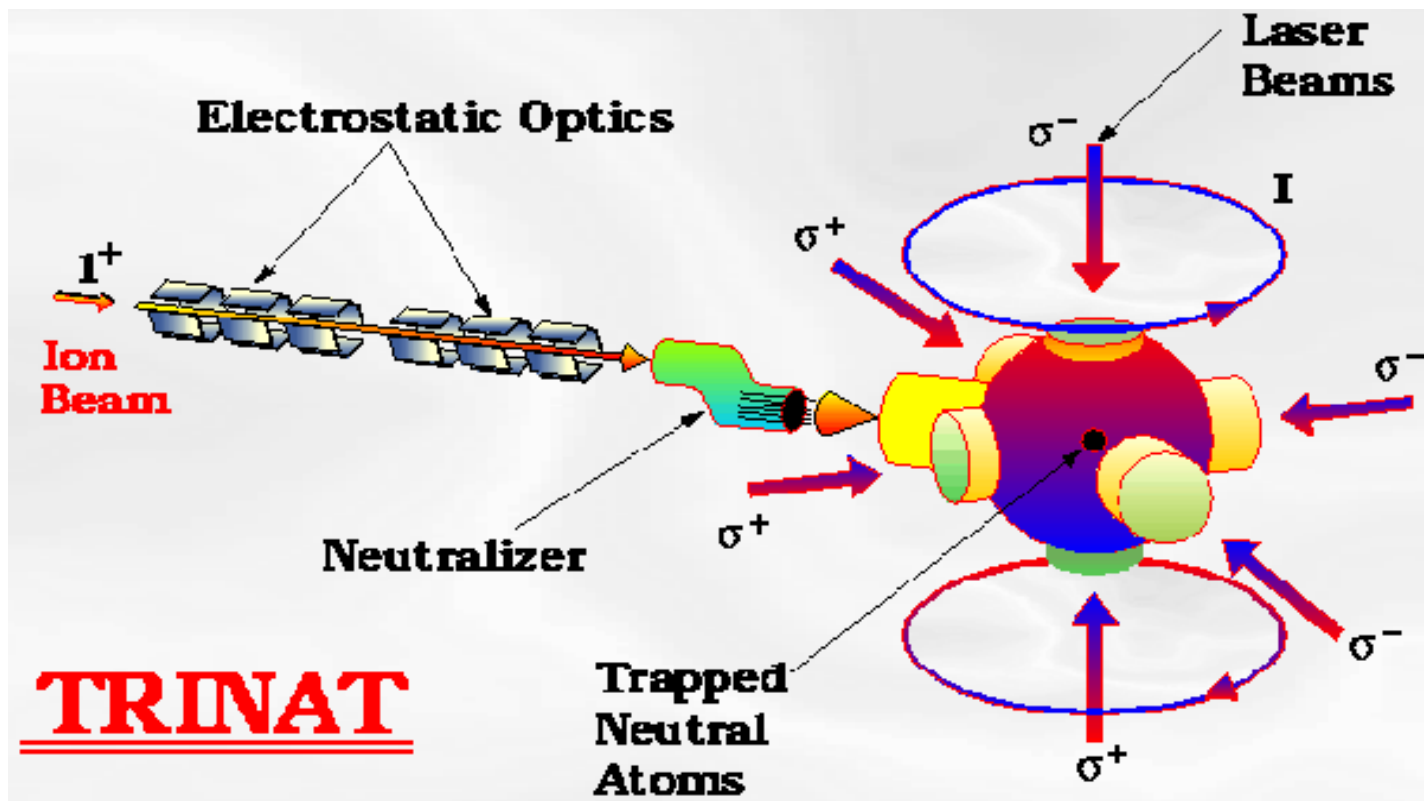
- **Applied**

- Contraband Detection System (CDS)**
 - New Radioisotopes for Medical Diagnosis**
 - Position Emission Tomography (PET)**
 - Proton Irradiation Facility (PIF)**
 - Proton Therapy for Eye Tumours**
 - Small Cyclotrons for Medical Radioisotopes**
 - Smokestack Emission Control**
 - Super fast Microchips**

- **Abroad**

- The ATLAS Experiment**
 - The HERMES Experiment**

TRINAT TRIUMF's Neutral Atom Trap





Experiments with TRINAT

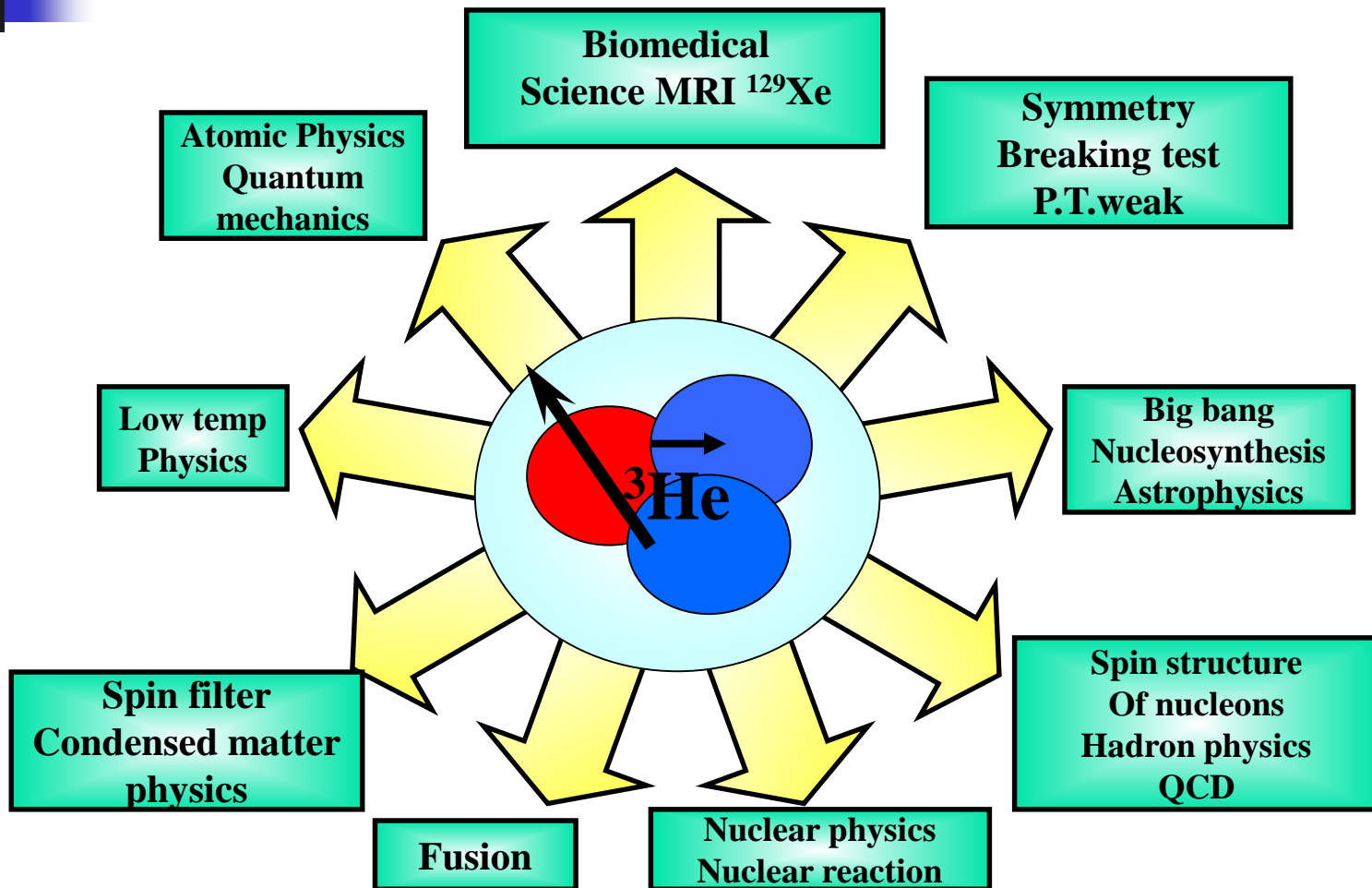
- **Trapping Radioactive Atoms to do precision Low Energy experiments to test Standard Model**
- **The β /neutrino Direction Correlation: Are there Scalar Bosons?**
- **β Asymmetry: Is Nature Left-Handed?**
- **Atomic Physics of Radioactives.**



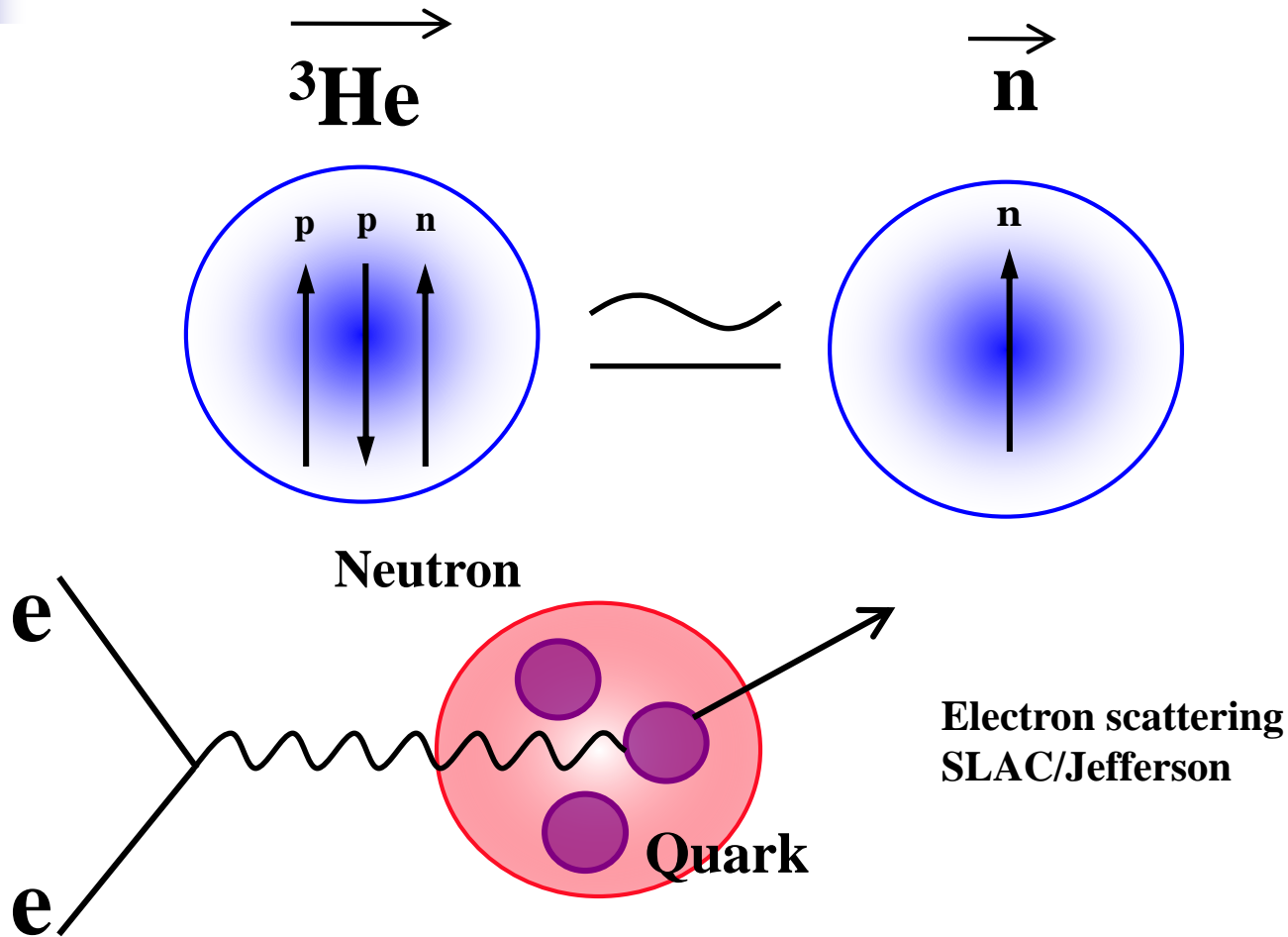
Polarized Beam, Target

- **Polarized Beam: GaAs**
포항가속기 연구소, 경북대
- **Polarized Target**
 - **NH₃, DH₃, Solid Target : SLAC, University of Virginia Impurities**
 - **Atomic Beam Source: Argonne, Wisconsin**
 \vec{p}, \vec{d} : Low Density, Internal Target
 - **³He : Metastability : Caltech, Low Density**
: Spin Exchange : Harvard, MIT.

^3He 편극핵 생성기술의 과학 및 산업적인 응용

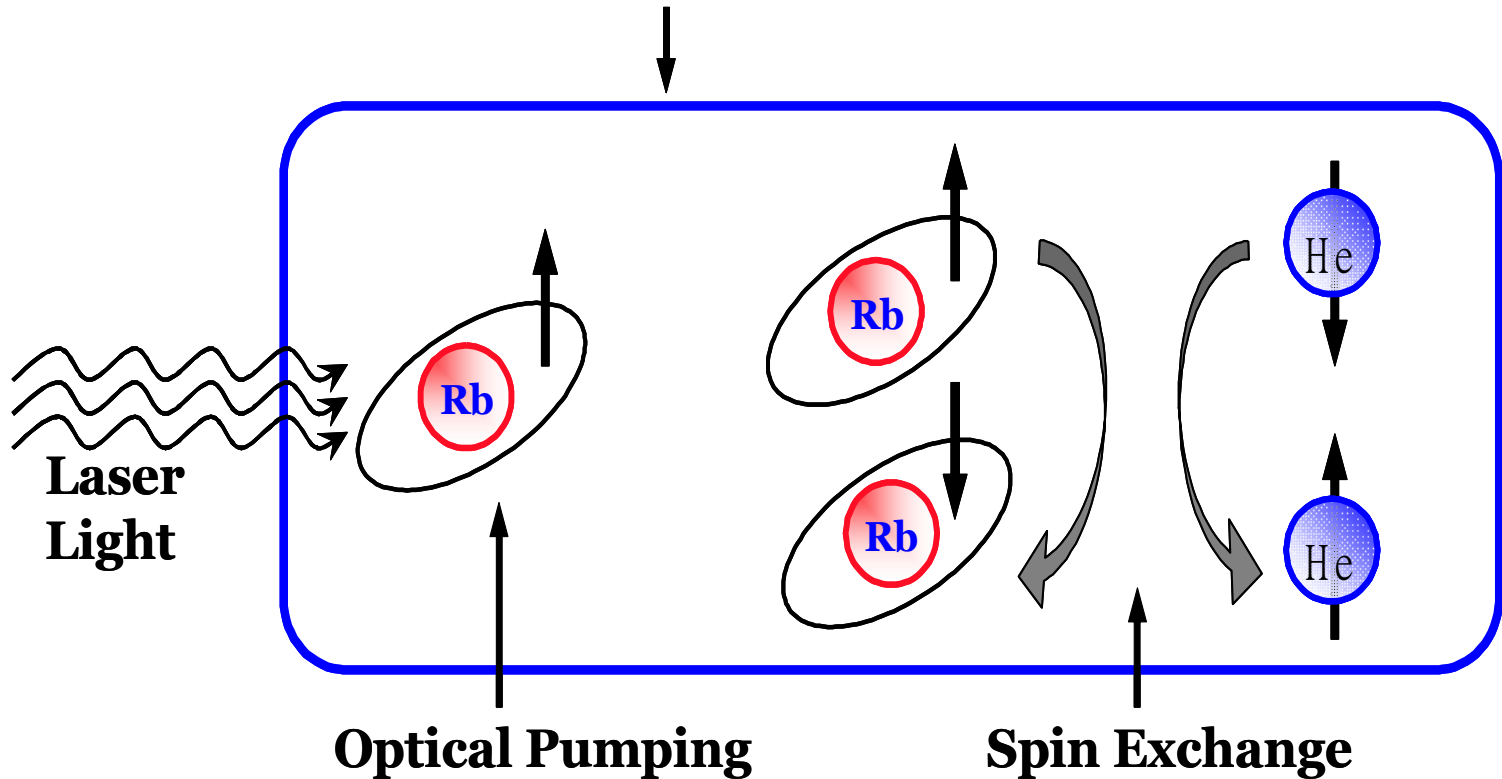


Spin dependent electron scattering

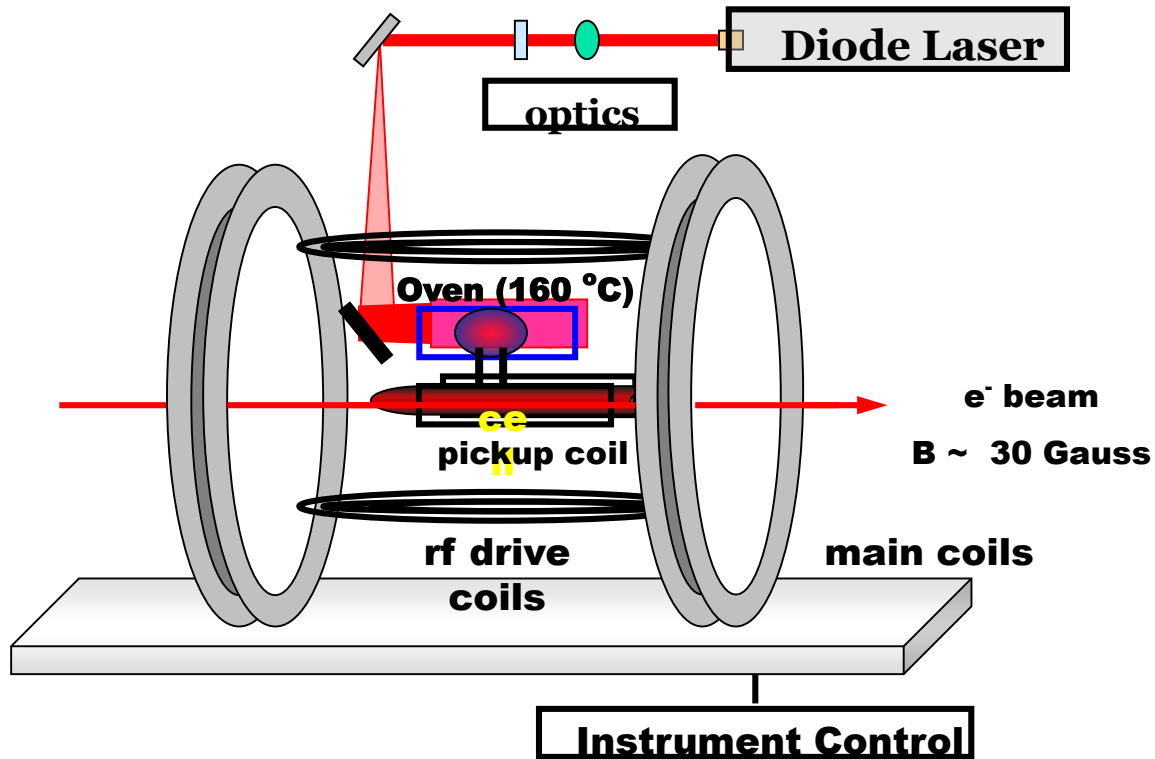


스핀교환법의 원리

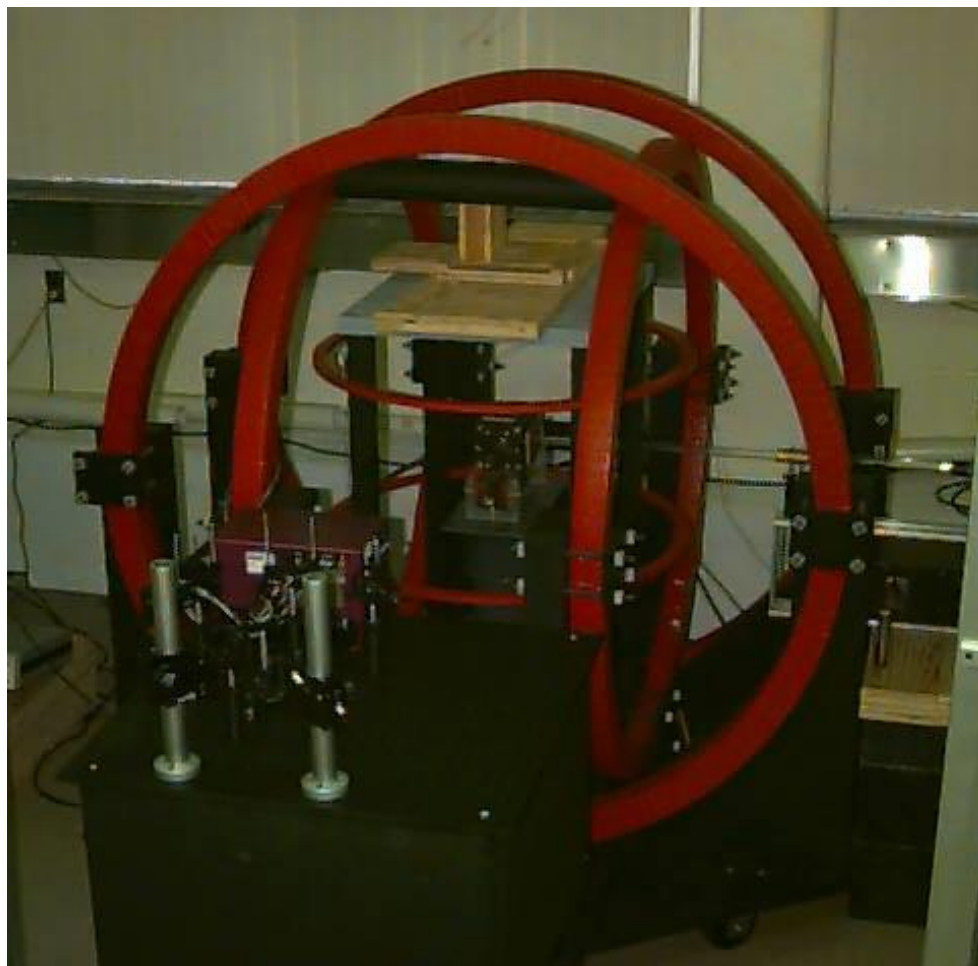
Optical Glass cell filled with ^3He and Rb vapor



스핀교환장치



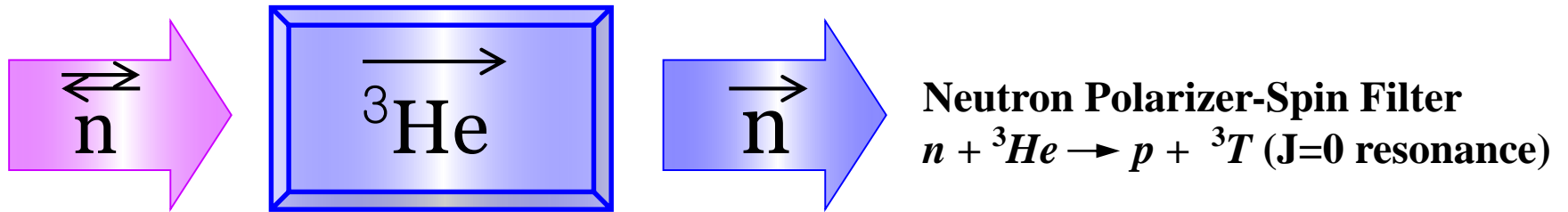
제퍼슨 연구소에서 사용되는 ^3He 편극핵 장치





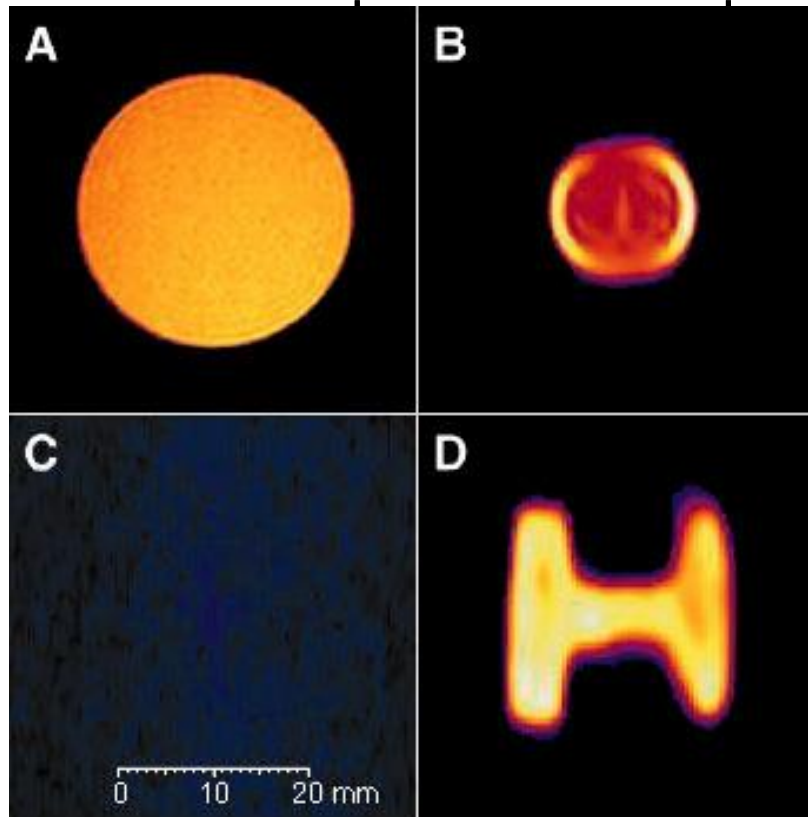
Spin Filter

Neutron Scattering for Material Science Research



물과 ^3He 의 MRI 영상비교

2 Tesla



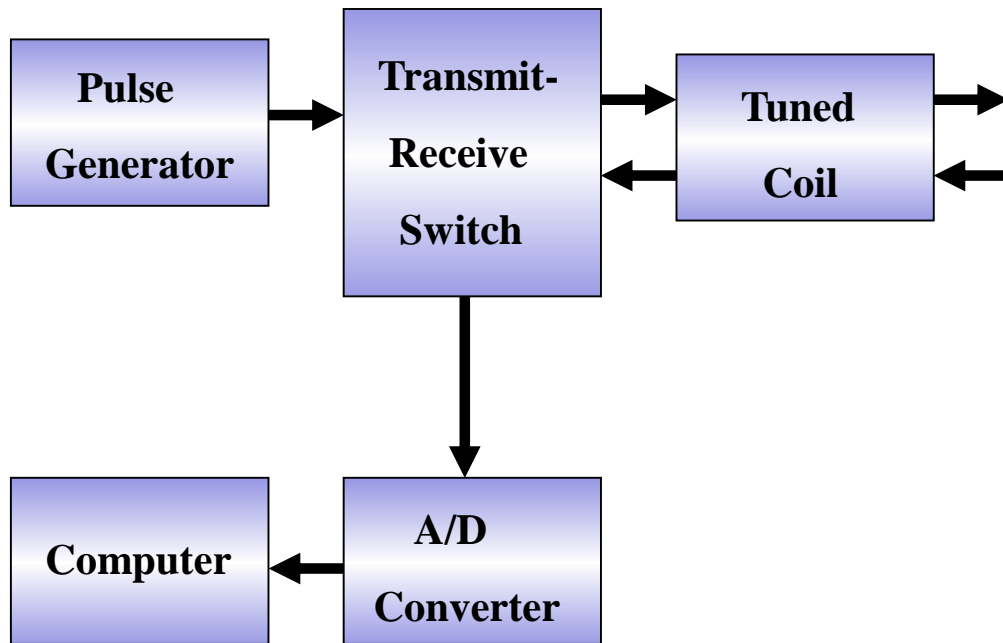
21 Gauss



Water

^3He

펄스형 NMR 시스템의 개요도



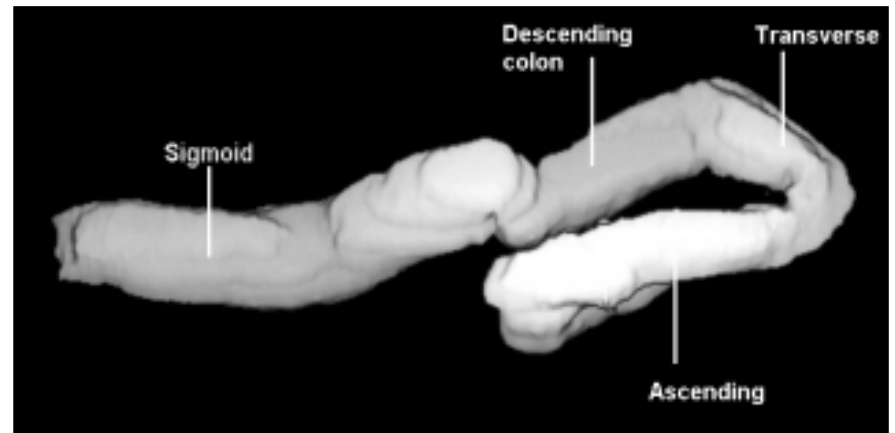
^3He 편극핵의 저자장 MRI 응용

■ 폐의 흡입 영상



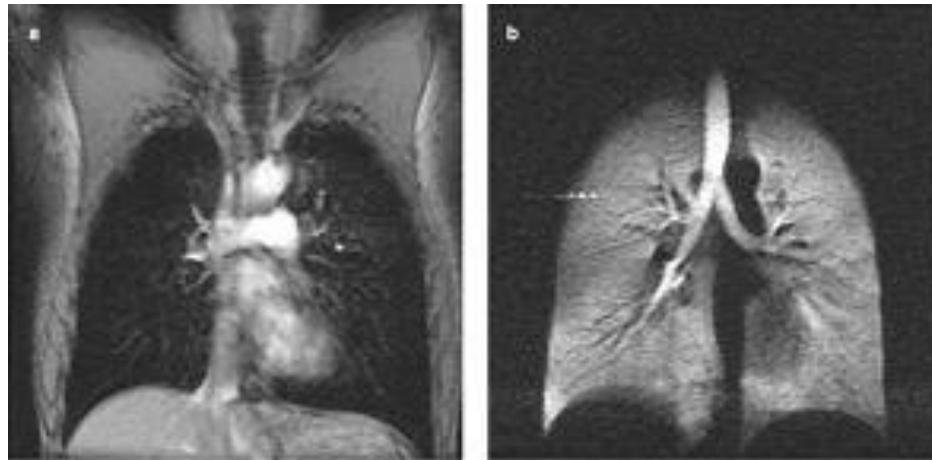
저자장 MRI를 사용한 인체의 폐 영상

■ 인체에 주입하는 경우

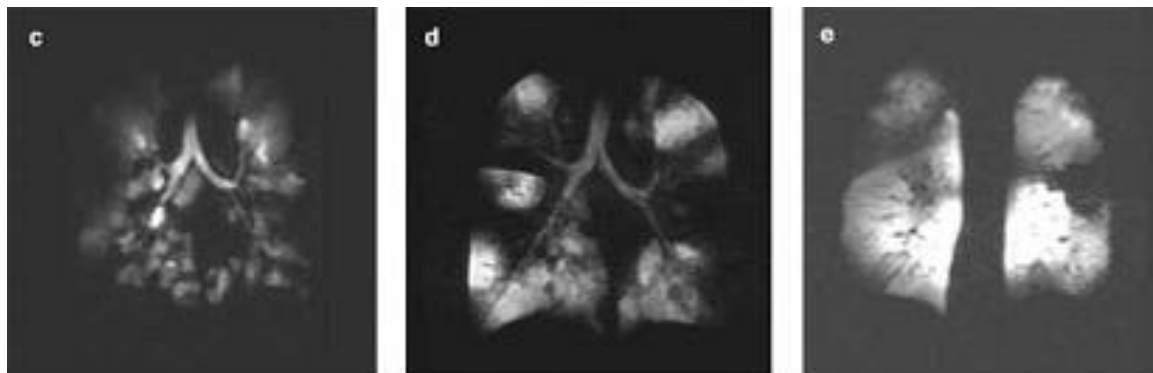


개의 대장에 편극 ^3He 를 주입한 영상

^3He 편극핵의 저자장 MRI 응용

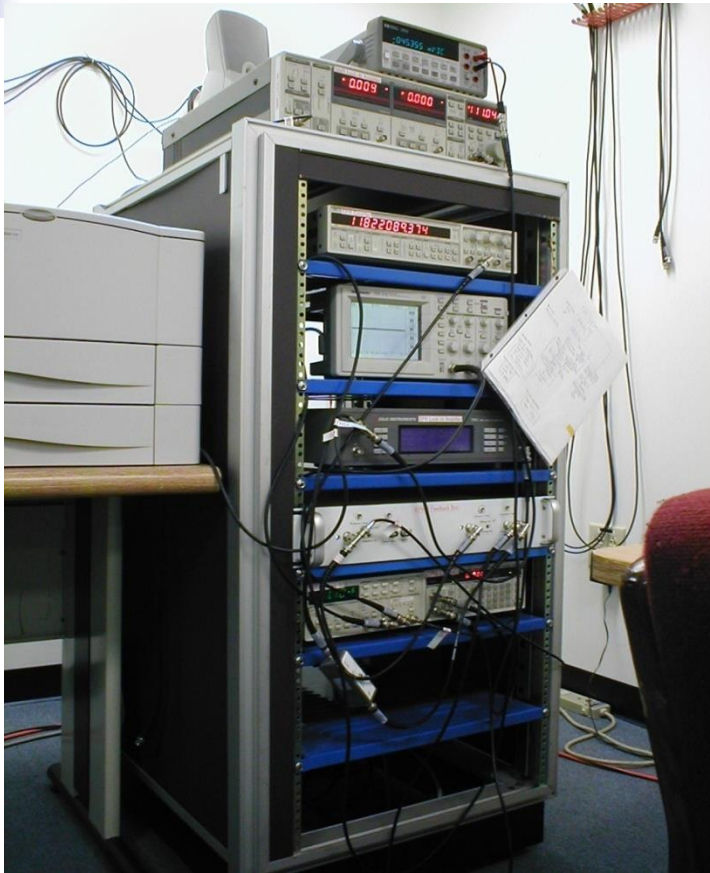


인체 MR 영상 비교 (a) 20,000 Gauss 의 ^1H MRI , (b) 20 Gauss의 편극 ^3He MRI



편극 ^3He 가스를 사용한 폐질환 MR 영상

경북대학교 편극핵 실험실

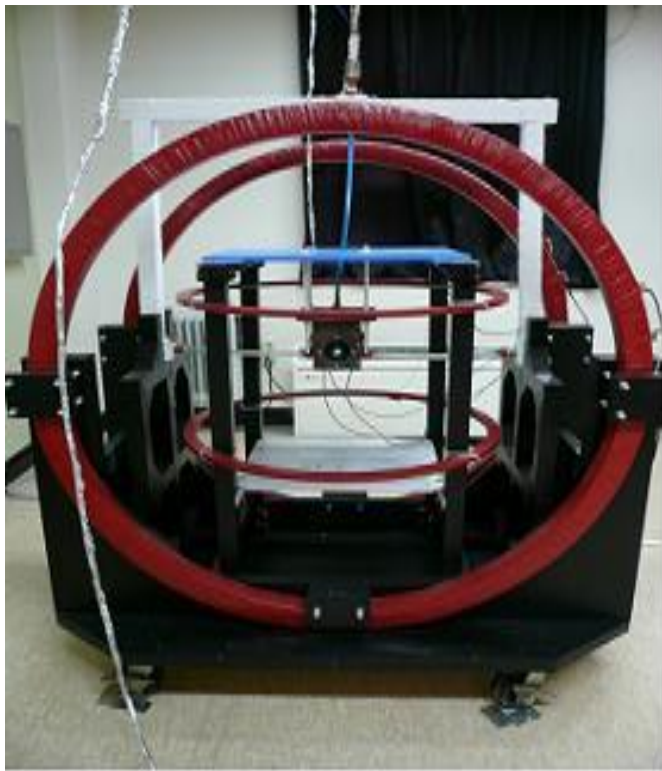


NMR Electronics

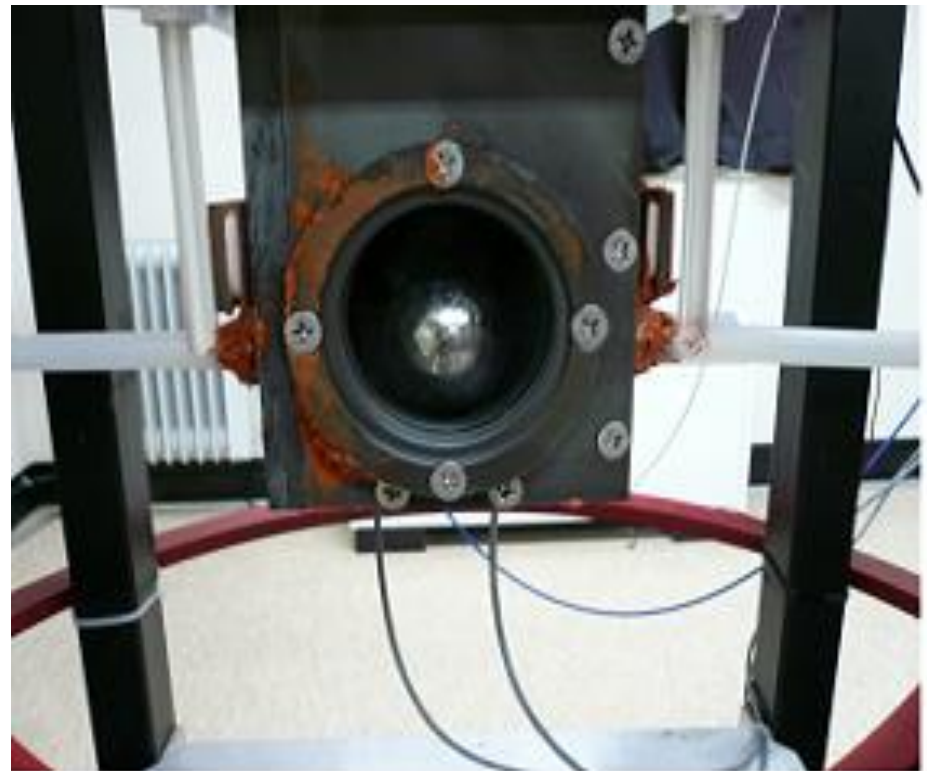


Helmholz 코일 시스템

경북대학교 편극핵 실험실

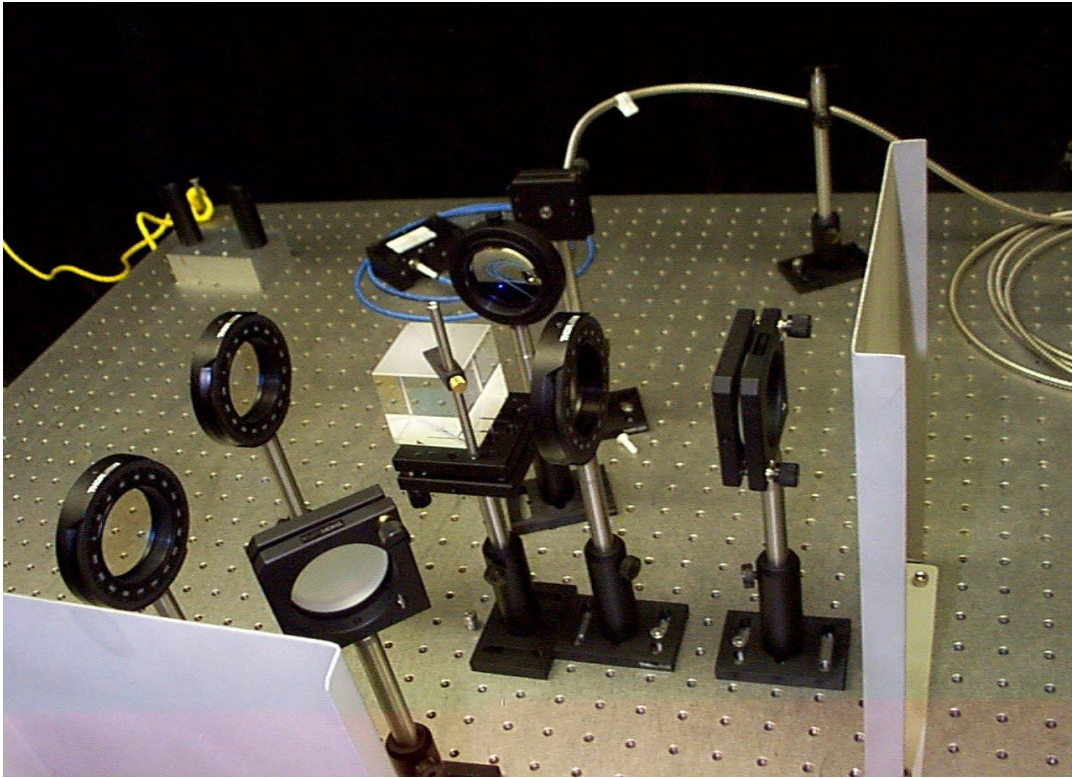


Helmholtz 코일, RF 코일, Pick-up 코일



Helmholtz 코일, Force 공기 오븐 속의 편극 ^3He 유리 cell

경북대학교 편극학 실험실

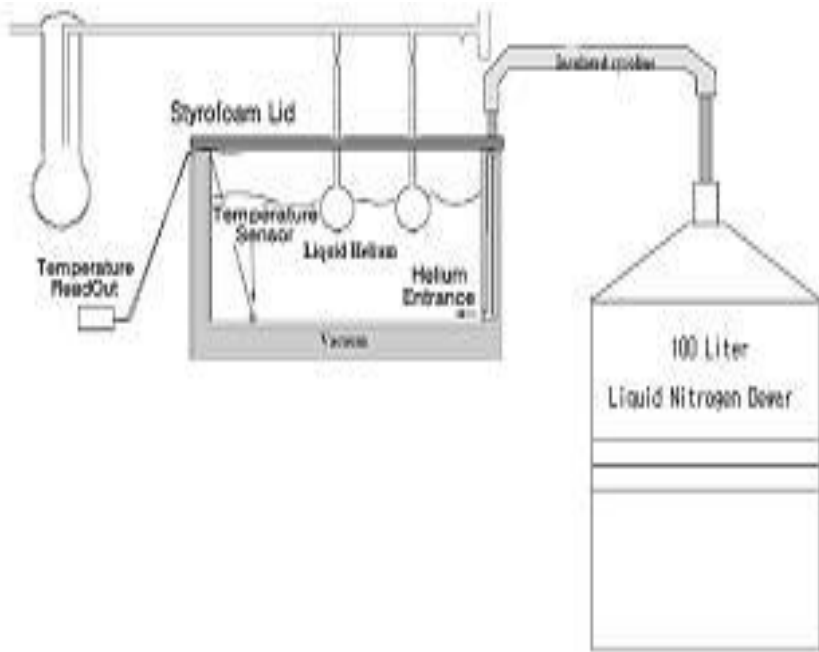


광학 시스템



반도체 레이저

경북대학교 편극핵 실험실

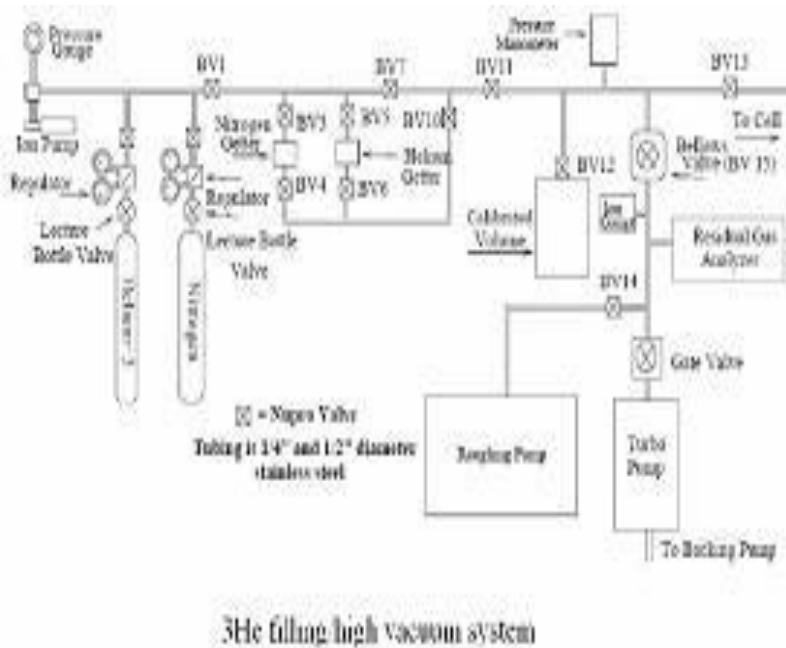


유리 취입 성형 도식도



유리 취입 성형 실제 모습

경북대학교 편극핵 실험실



Target cell 을 위한 진공 시스템 도식도

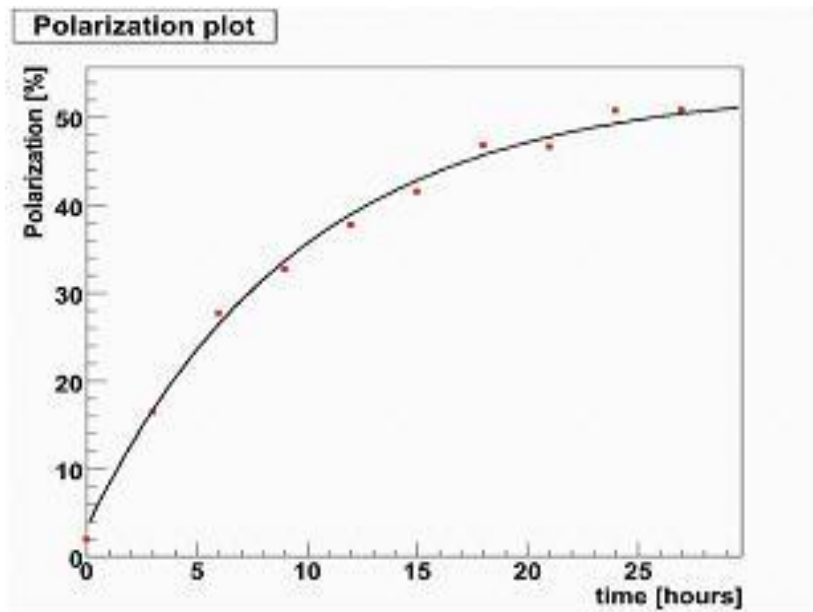
Target cell 을 위한 진공 시스템

경북대학교 편극핵 실험실

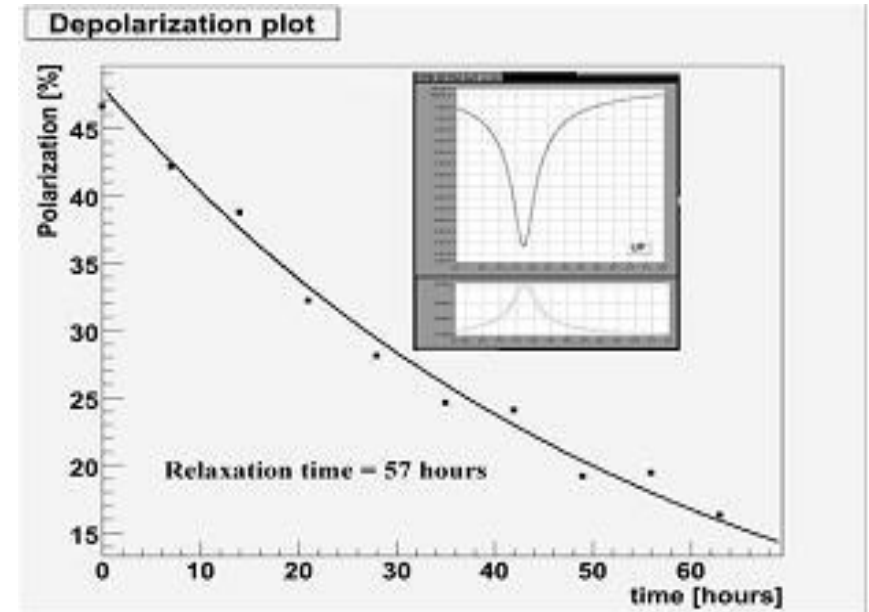


액체 질소를 사용한 초저온 시스템

^3He 편극도 변화



편극핵 생성과정에서 시간에 따른 편극도 증가 변화



편극핵 스핀이 이완되는 과정에서의 시간에 따른 감쇄 변화

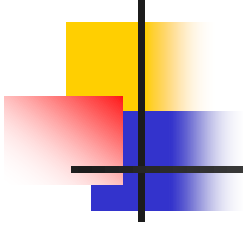


RI 가속기

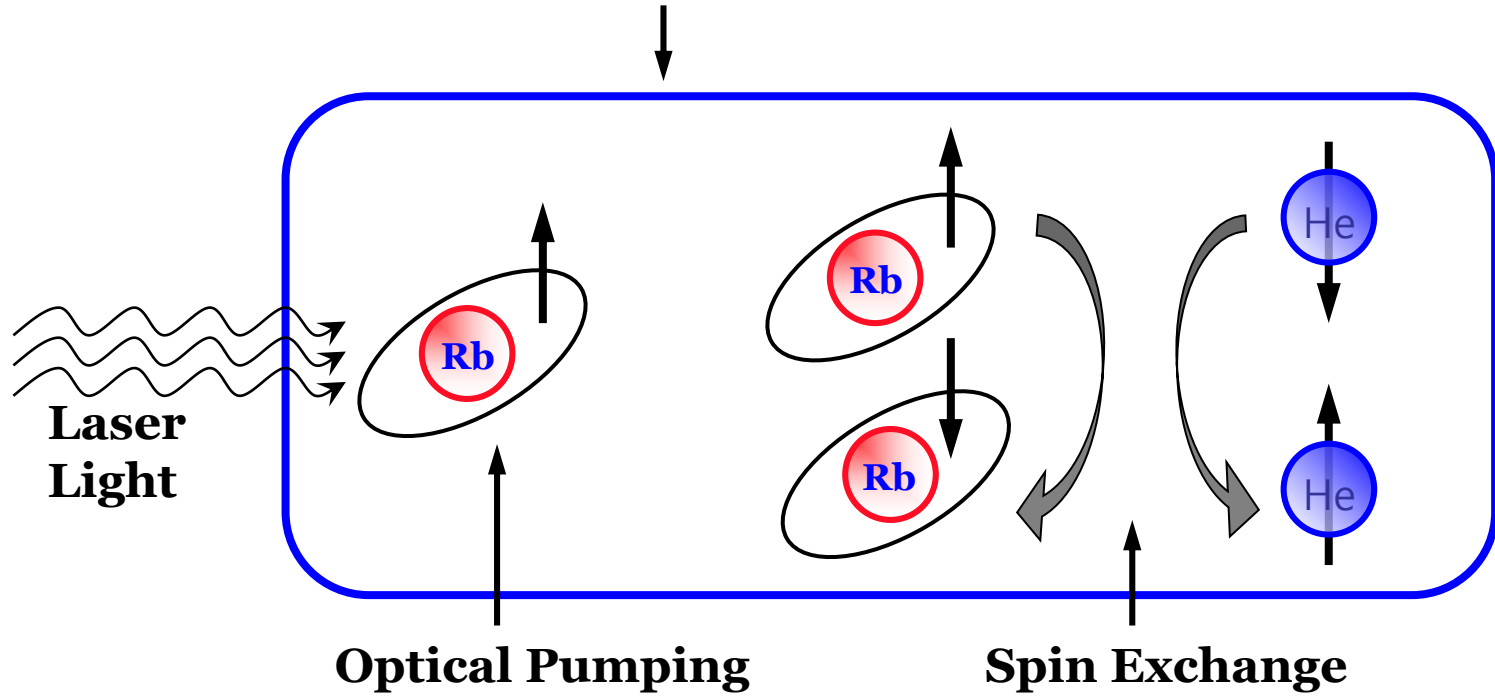
- 별들의 진화 과정, 천체 핵물리
- 자연계에 존재하는 핵종 90%에 해당하는 불안정한 핵 연구
- 2차 산란을 통한 불안정한 핵 생성기법 : 최근 개발, 발전중
- 국제적으로 경쟁력 확보 가능
- 국내 핵물리 학계에 큰 기여
- 편극핵, 검출기 개발 기술 확보
- 인력양성

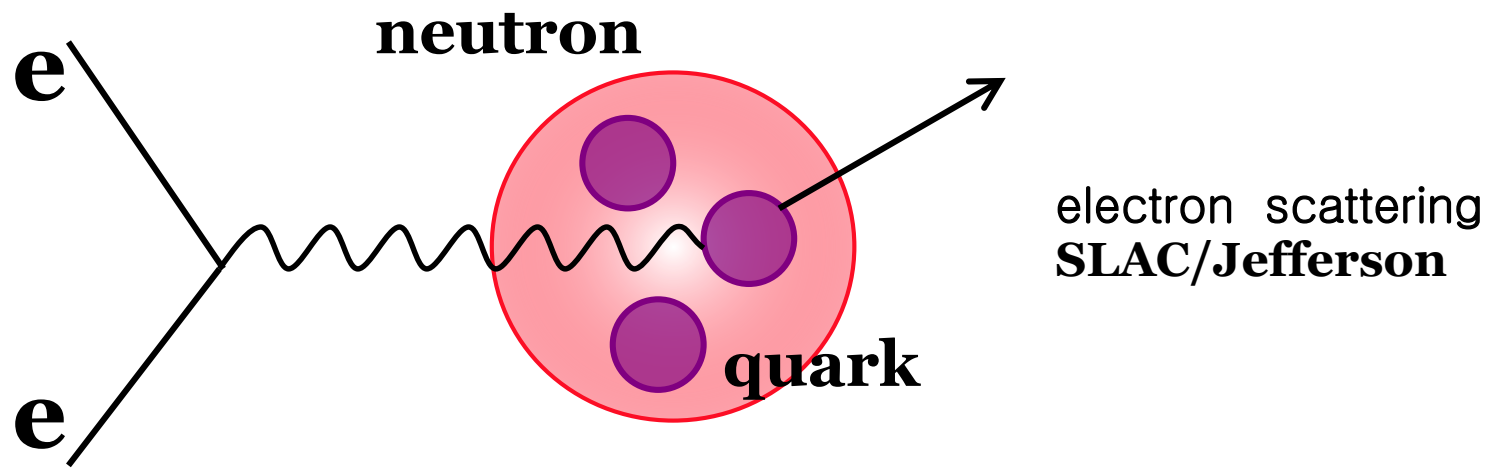
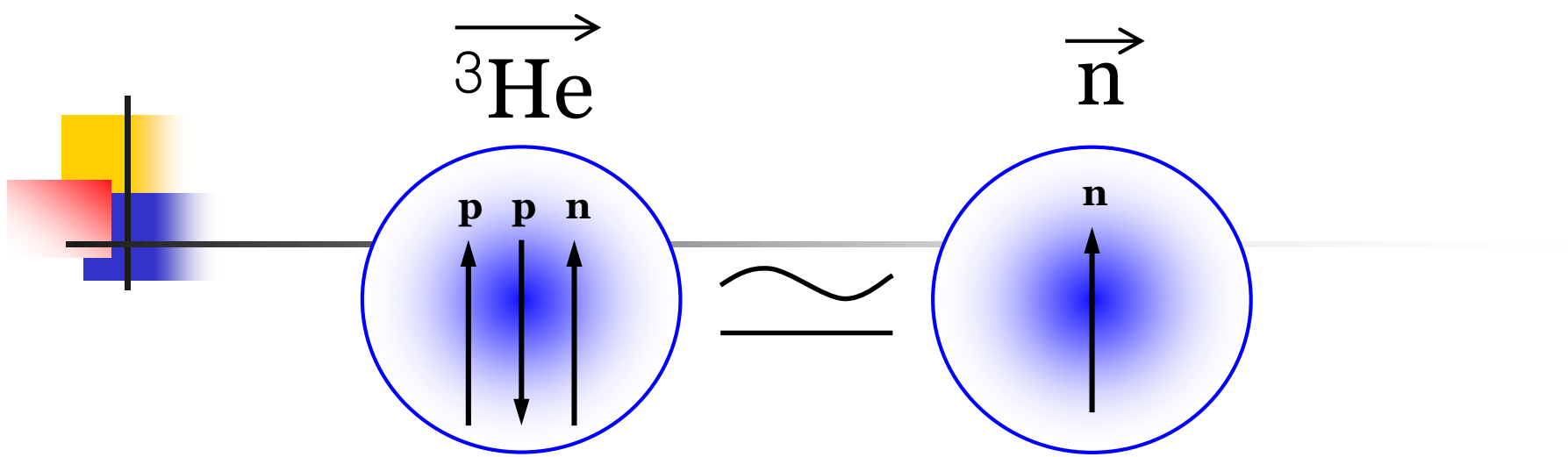


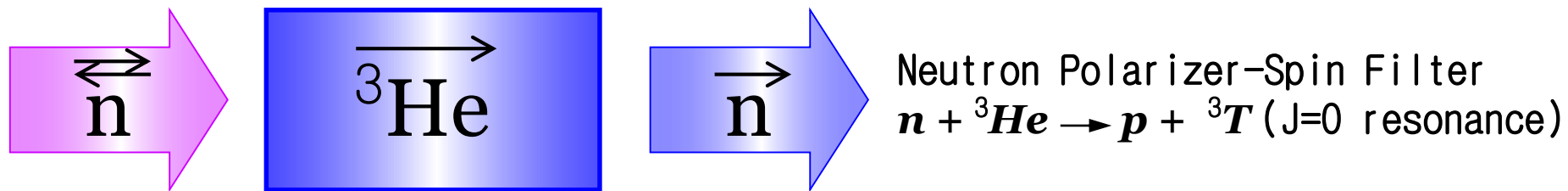
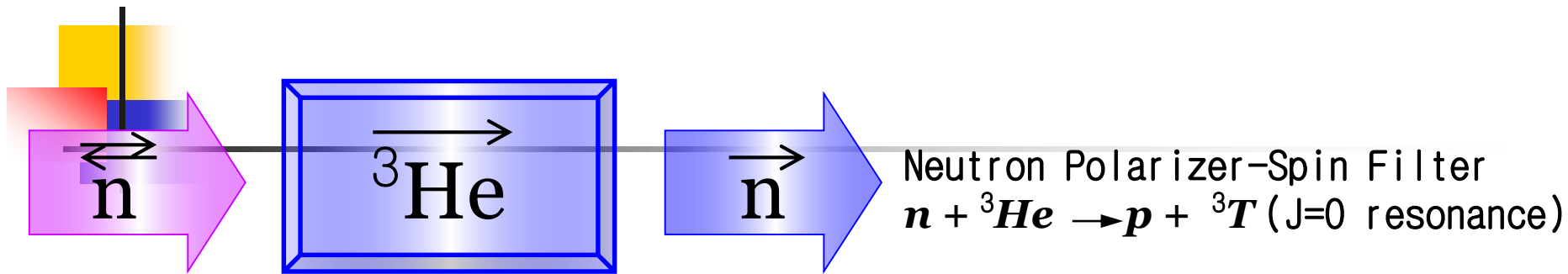
감사합니다

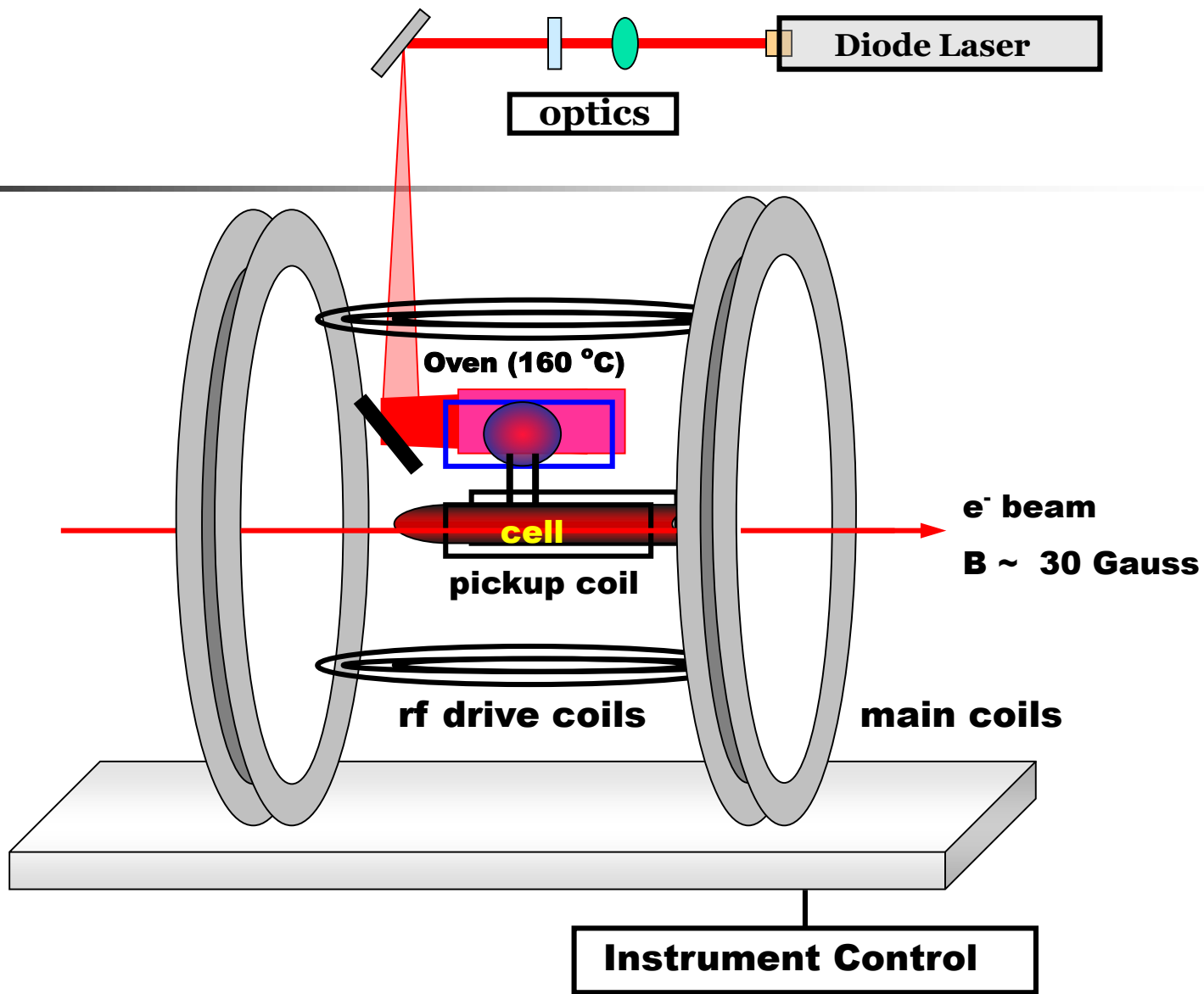


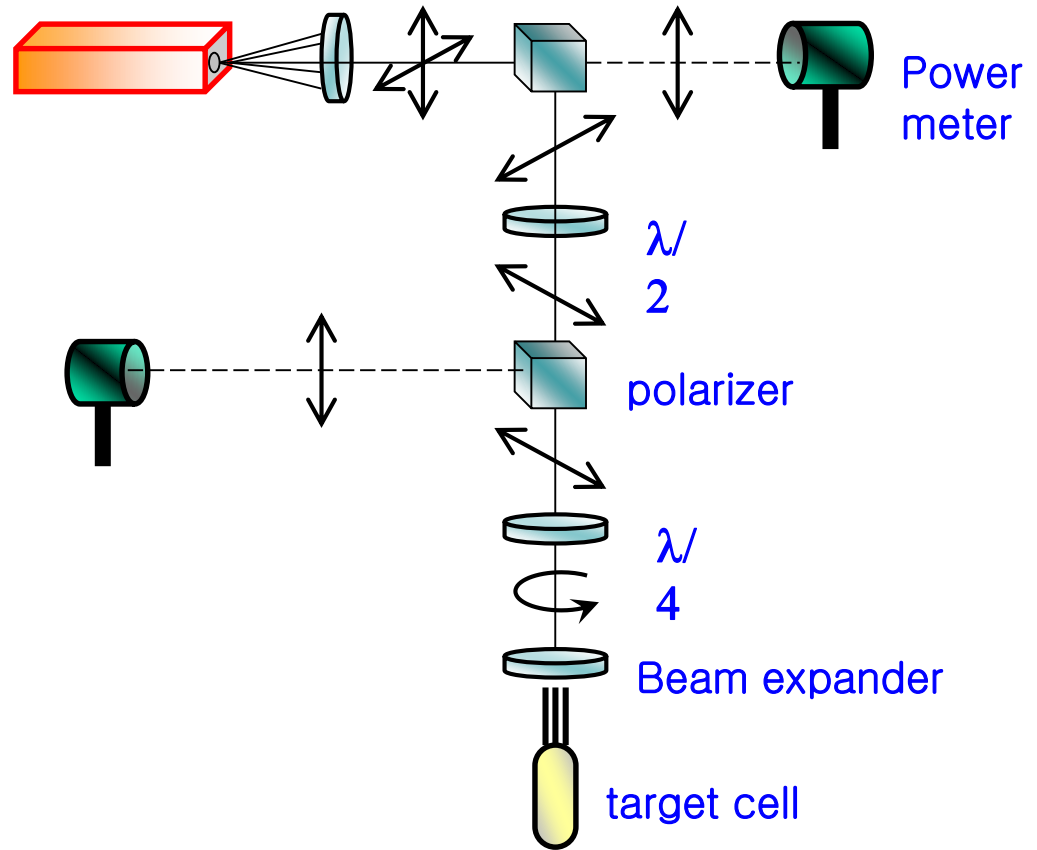
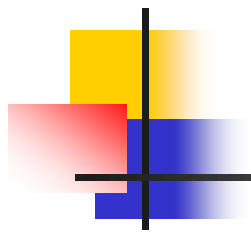
Optical Glass cell filled with ^3He and Rb vapor

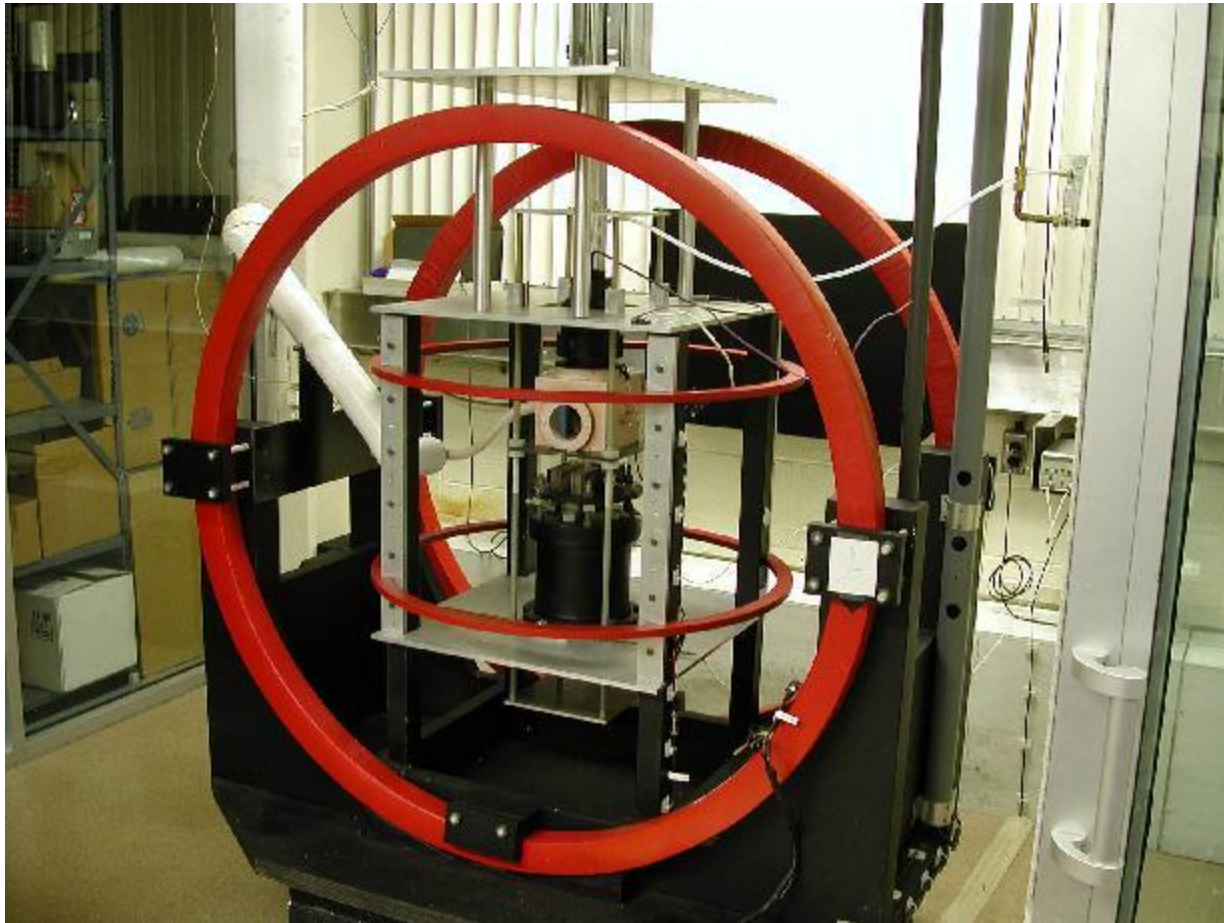


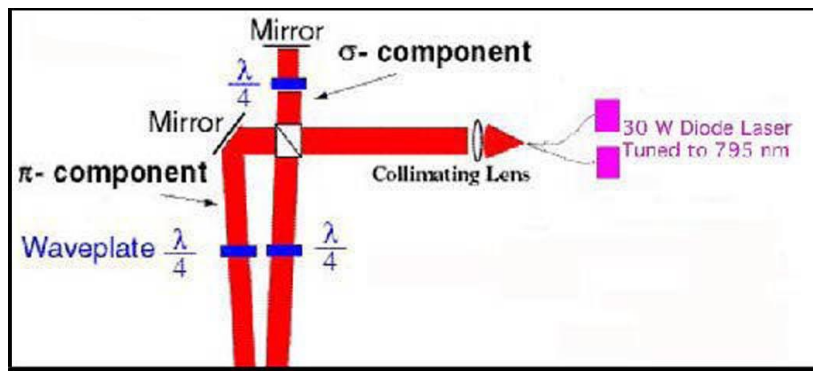




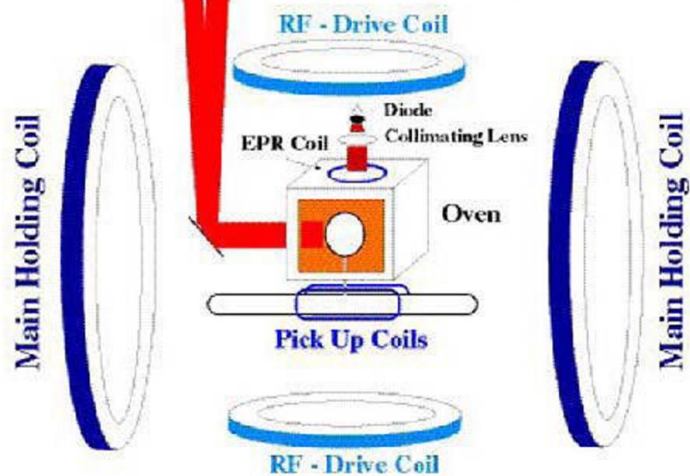


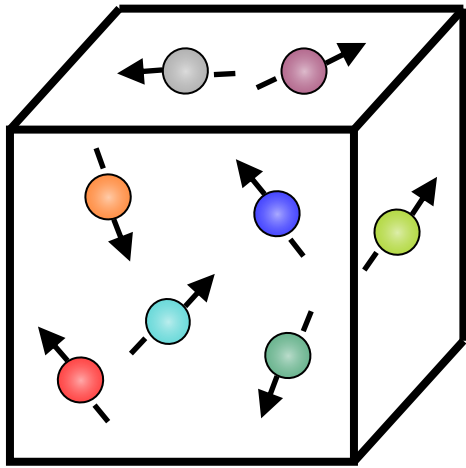
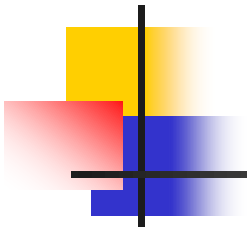




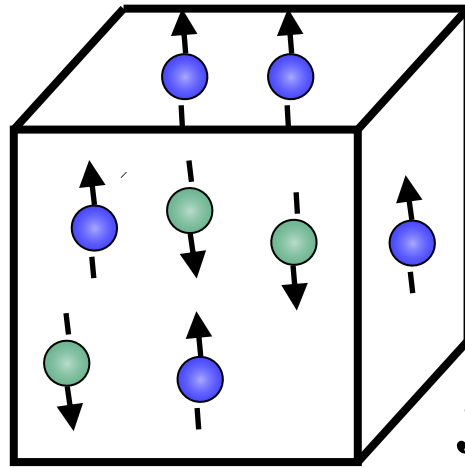


Laser Hut

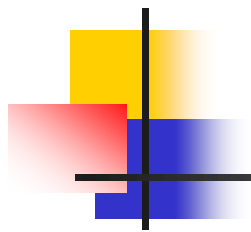




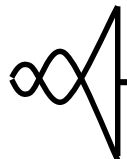
$\mathbf{B}_0 = 0$
 $\mathbf{J} = 0$
 $\mathbf{M} = 0$



$\mathbf{J} \parallel \mathbf{M} \parallel \mathbf{B}_0$



RF Pulse



Slice-Select Gradient



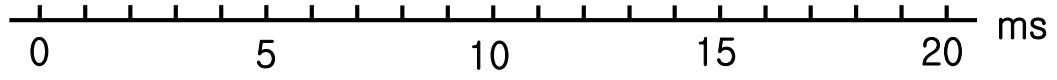
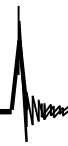
Read-out Gradient

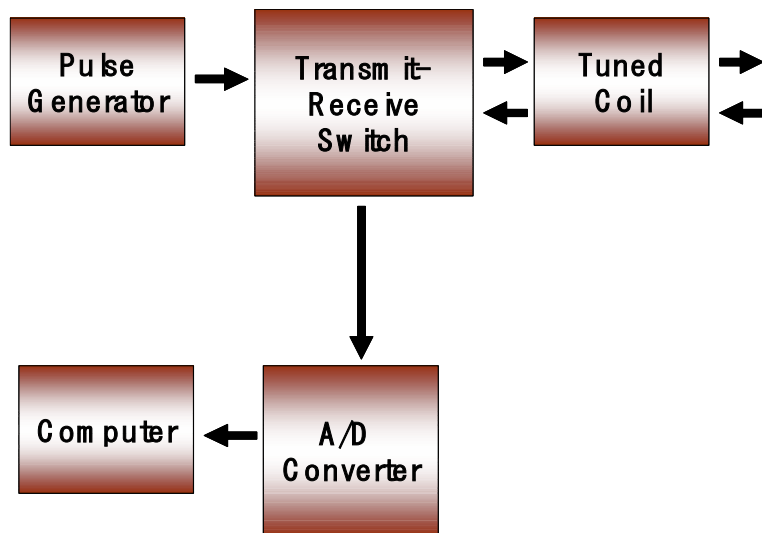
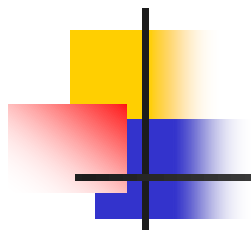


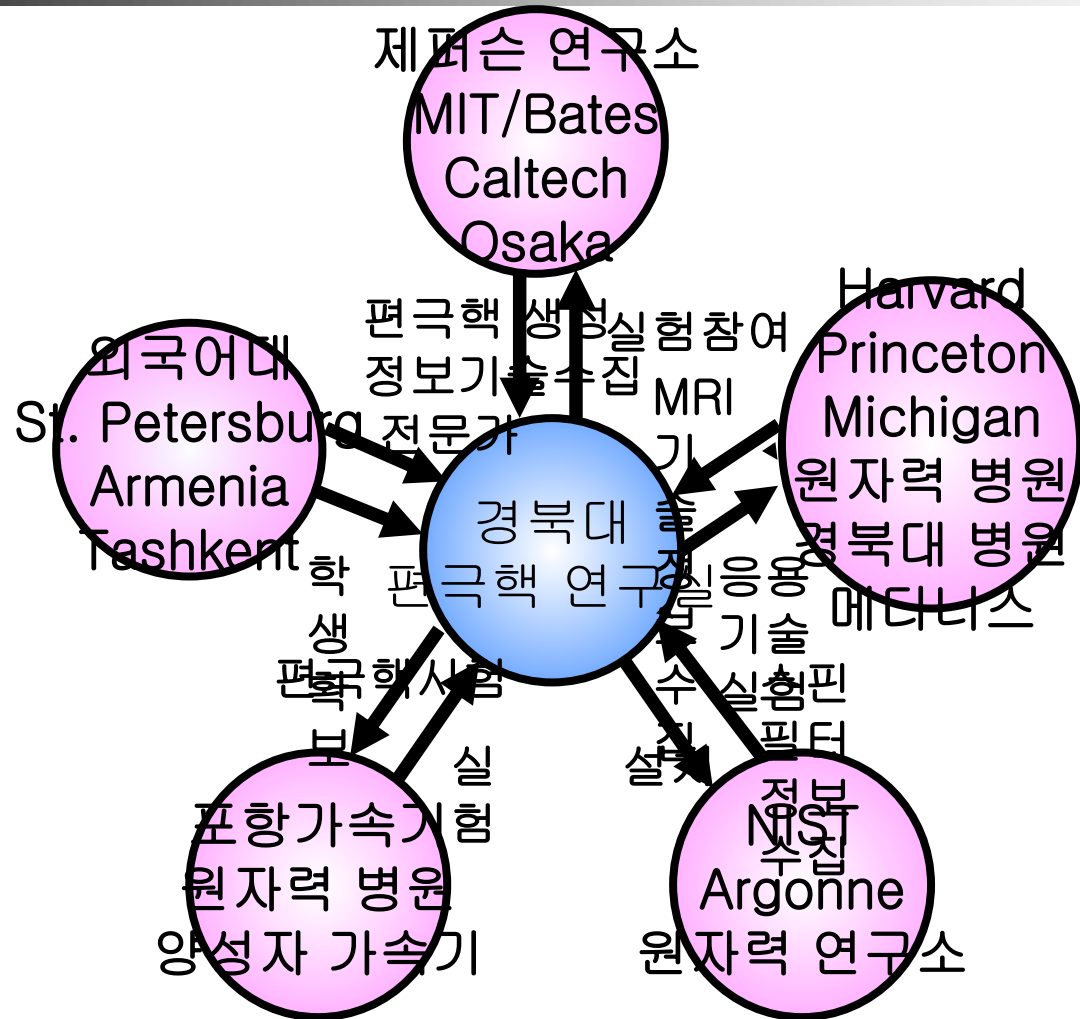
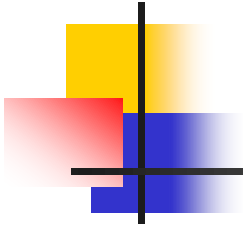
Phase-encode Gradient

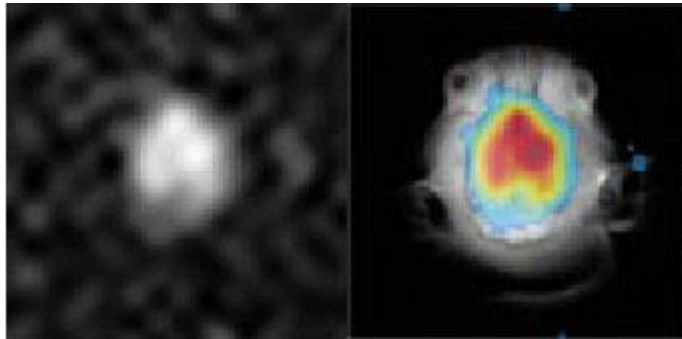
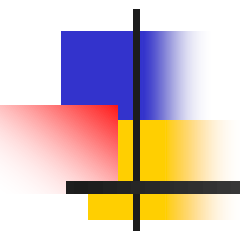


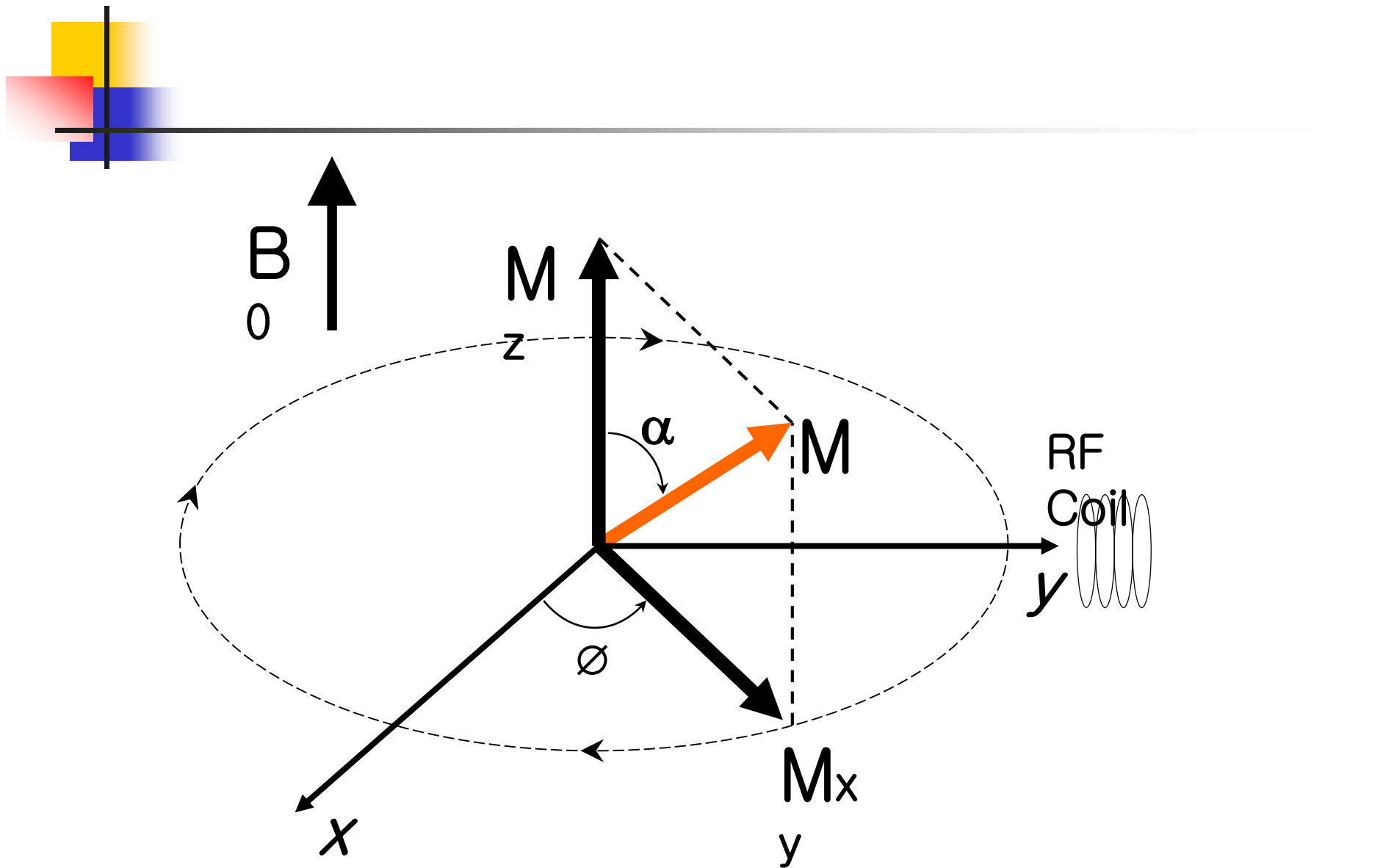
MRI Signal













국내 양성자 가속기 프로그램

High Intensity Proton Accelerator

- Radioactive Ion Beam
 - Unstable Nuclei
 - Nuclear Astrophysics
- Spin Physics
 - Polarized Beam
 - Polarized Target
- Fundamental Symmetry
 - EDM
 - Parity
 - Rare Decay
- Accelerator
- Detector Test Facility
- Material Science
 - Neutron Scattering
- Medical Application

