磁共振模拟定位机的验收测试

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中国生物医学工程学会医学物理分会
京津冀+放射物理专业组
第二十七次学术会议

MRI-Sim的基本组成

MRI模拟定位机（MRI simulator，MRI-Sim）

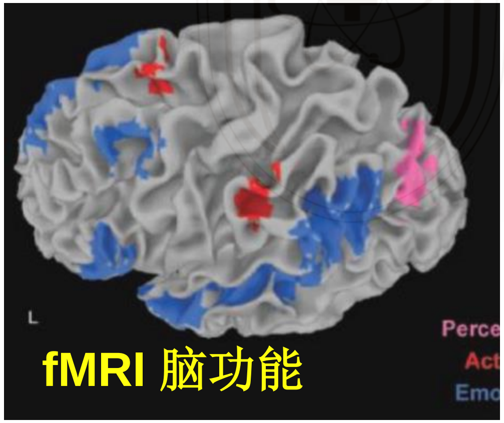
2016年2月19日励磁，5月正式临床启用

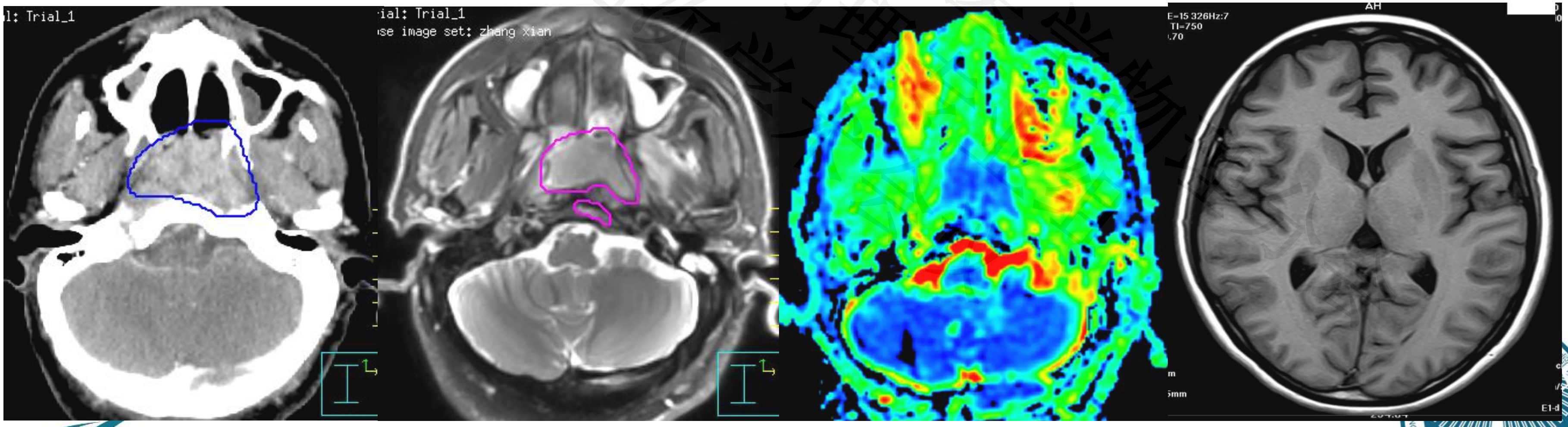
GE Discovery 750W 3.0T

- 大孔径MR扫描仪
- 三维可移动激光定位灯
- 平板床面
- 放疗摆位辅助装置
- 图像后处理工作站
- 其它配套设备

MRI 较CT的优势

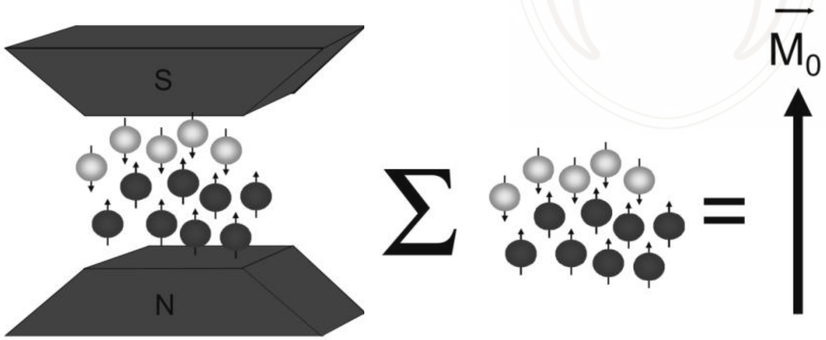
- 无电离辐射:
  - MRI ： 40 – 300 MHz
  - X线： $10^{12\text{-}14}$MHz
- 较好的软组织分辨率
- 多种功能影像： 半定量/定量分析





磁场强度的选择

◆ **3T 的优势>1.5T**
- M0
- SNR
- 时间和空间分辨率
- MRS
- 功能影像
- 更快的扫描速度，有效提高患者舒适度



◆ **由于3T场强高，需要注意**
- 磁敏感伪影和化学位移伪影产生较明显
- 并且应对设备和人员进行更加严格的安全管理措施。

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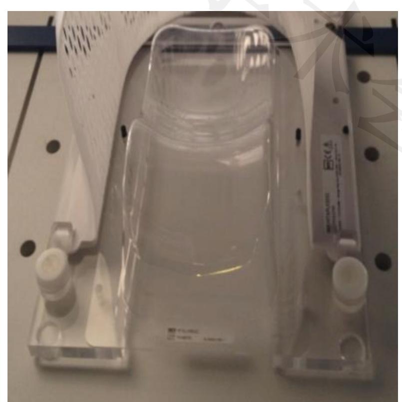
射频线圈的选择____体部

体部MRI模拟定位，诊断MRI体线圈配合放疗专用的固定架使用

射频线圈的选择____头线圈

- 头部和头颈部MRI模拟定位扫描
- 诊断MRI的射频线圈无法与放疗摆位装置匹配
- MRI-Sim应配备放疗专用的头部线圈，

六通道柔性相控阵头线圈



2002

American College of Radiology White Paper on MR Safety

JOURNAL OF MAGNETIC RESONANCE IMAGING 19:2–5 (2004)

Guest Editorial

2004

Clinical Utility of the American College of Radiology MR Safe Practice Guidelines

ACR Guidance Document for Safe MR Practices: 2007

2007

JOURNAL OF MAGNETIC RESONANCE IMAGING 37:501–530 (2013)

Special Communication

2013

ACR Guidance Document on MR Safe Practices: 2013

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安装场地准备

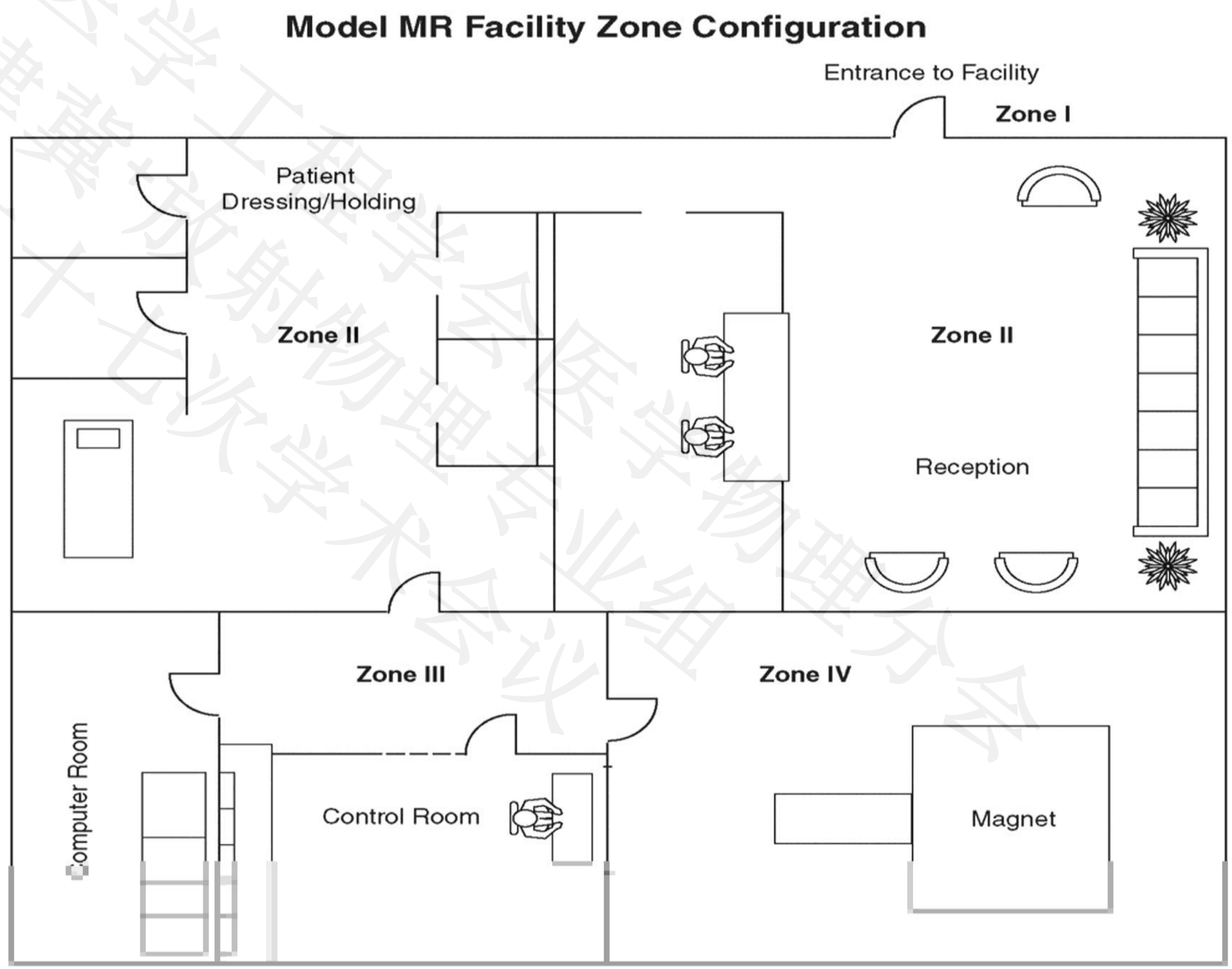
- 根据美国放射学院（ACR）推荐，MRI机房应考虑设置4个区域

I区：公共区域

II区：过渡区，是公共区域到严格控制的MRI操作室的连接

III区：MRI操作室

IV区：磁体间，不能有任何铁磁性物质带入磁体间



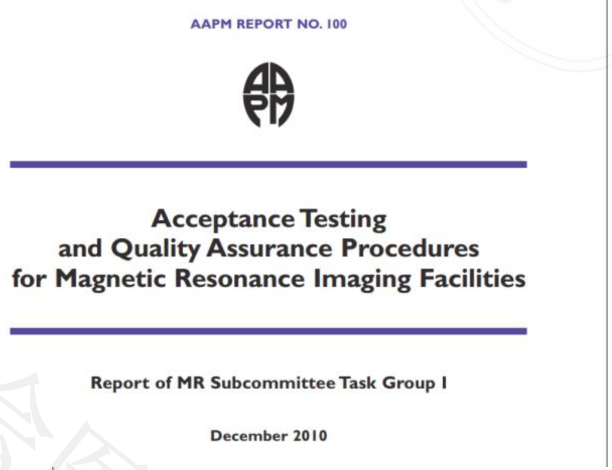
MRI的安全-人员和设备

•放疗科全体人员：**MRI-Sim**安全培训
•制定安全管理措施

$SAR \propto B_0^2$

MRI-Sim的验收测试

- 验收测试依据
  - AAPM No. 100 Report （磁共振影像设备）
  - AAPM TG 66 Report （CT模拟定位机）
- 激光灯和扫描床
- MR主机


AAPM REPORT NO. 100

Acceptance Testing
and Quality Assurance Procedures
for Magnetic Resonance Imaging Facilities

Report of MR Subcommittee Task Group I

December 2010


Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66

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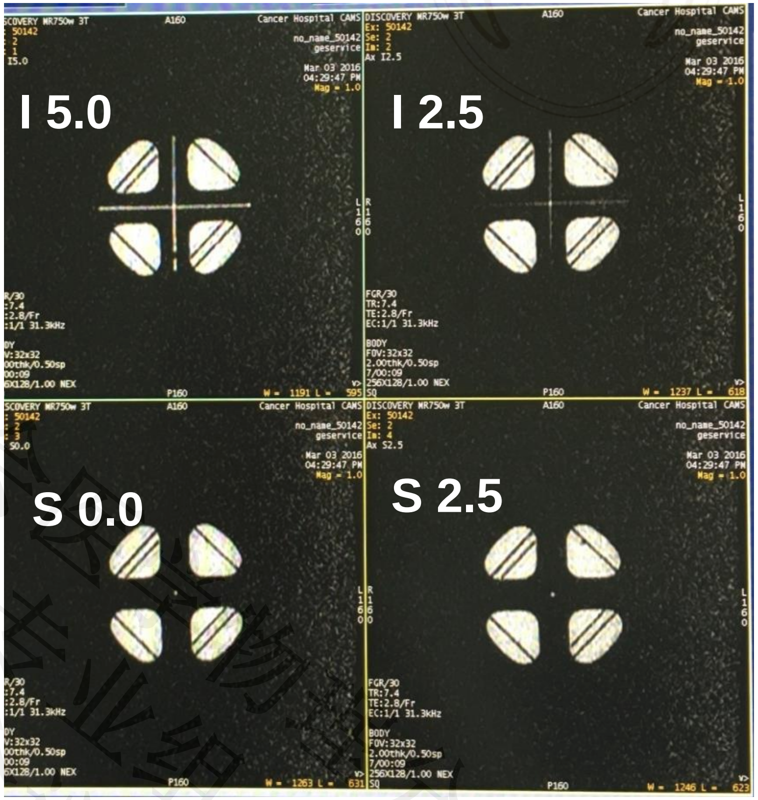
PREFACE

The purpose of this document is to provide the medical physicist with a framework and guidance for establishment of a comprehensive quality assurance (QA) program for computed-tomography- (CT) scanners used for CT-simulation, CT-simulation software, and the CT-simulation process. The CT-simulator is a CT scanner equipped with a

rather establishes a set of QA procedures that are applicable to scanners used for CT-simulation regardless of their location and primary purpose. It is the responsibility of the respective diagnostic and therapy physicists to determine how the QA program is implemented and how the responsibilities are assigned. The primary responsibility for implementation of recommendations for QA of scanners used for CT-simulation in this document rests with the radiation oncology

激光灯和扫描床的验收

- 激光灯
  - 机械精度、扫描定位精度、坐标系一致性
- 扫描床及平面床板
  - 移位精确度、水平精度
- 外置和内置激光系统
  - 验收时发现轴位扫描平面偏差**5mm**
  - 厂家安装模体外标记点与实际校准平面偏差



厂家提供的模体

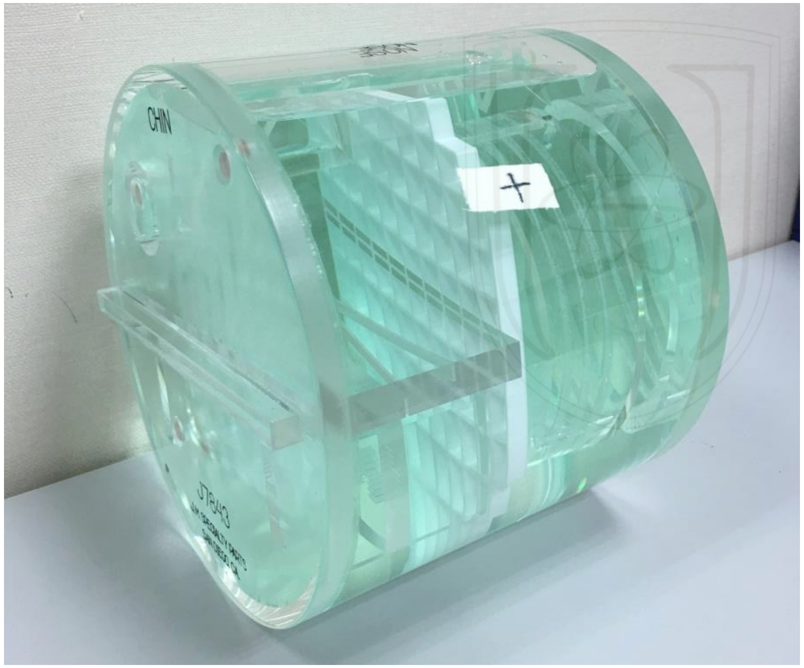
AQUARIUS MRI Laser Alignment Phantom

MRI- Sim主机的验收

- 通用系统检测（机械系统、应急系统、病人监控系统、门控系统等）

- MR扫描系统
  - 主磁场、射频系统和梯度系统的验收（校准及采集数据与厂家共同完成）
  - 图像质量验收测试

图像质量验收测试



- ACR模体
- 190*190*148mm圆柱体

- 线圈/序列/设置

- 验收测试并建立基线

- 图像指标主要包括：高对比空间分辨率、低对比分辨率，几何精度、信噪比、图像均匀性、层厚和选层位置等。

检测序列及使用线圈组合列表

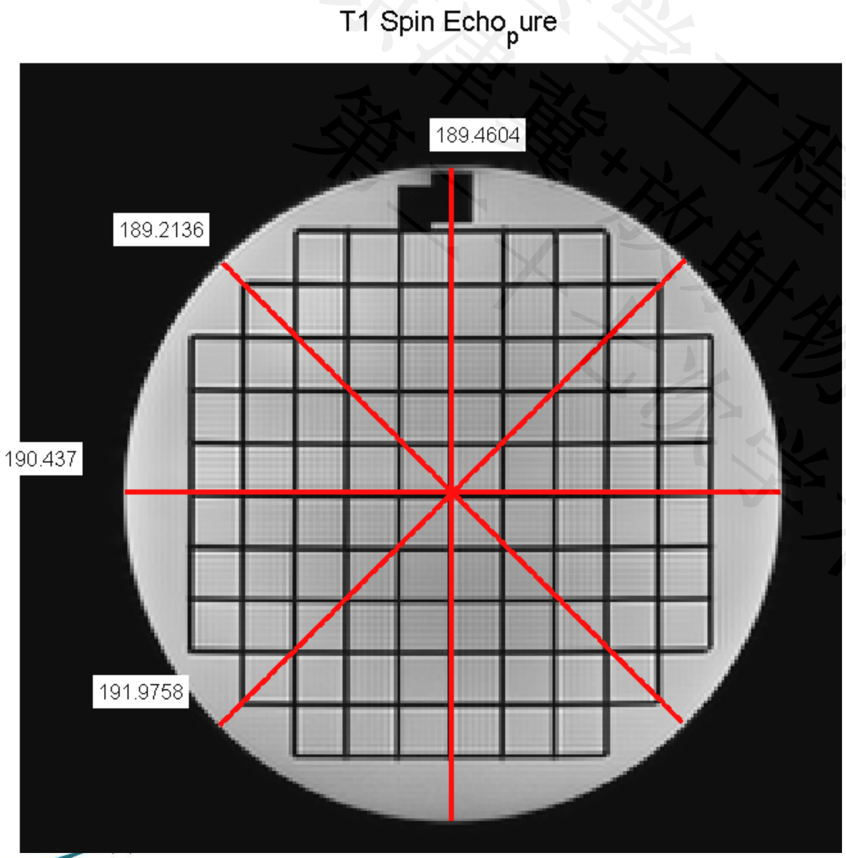
检测序列	线圈型号	临床部位
ACR矢状位定位序列	正交头线圈/头部放疗柔线圈	/
T1 Spin Echo	正交头线圈/头部放疗柔线圈	/
T1 Spin Echo_pure	正交头线圈/头部放疗柔线圈	/
T1 Spin Echo_scic	正交头线圈/头部放疗柔线圈	/
T2 Spin Echo	正交头线圈/头部放疗柔线圈	/
T2 Spin Echo_SCIC	正交头线圈/头部放疗柔线圈	/
T2 Spin Echo_pure	正交头线圈/头部放疗柔线圈	/
Ax 3D T1BRAVO	头部放疗柔线圈	脑部
Ax T1 FLAIR	头部放疗柔线圈	脑部
Ax T1FSE-1	头部放疗柔线圈	脑部
Ax T2 Propeller	头部放疗柔线圈	脑部
Ax fs T2Flair	头部放疗柔线圈	脑部
InPhase_ Ax T2 IDEAL-1	头部放疗柔线圈	脑部
WATER_ Ax T2 IDEAL	头部放疗柔线圈	脑部

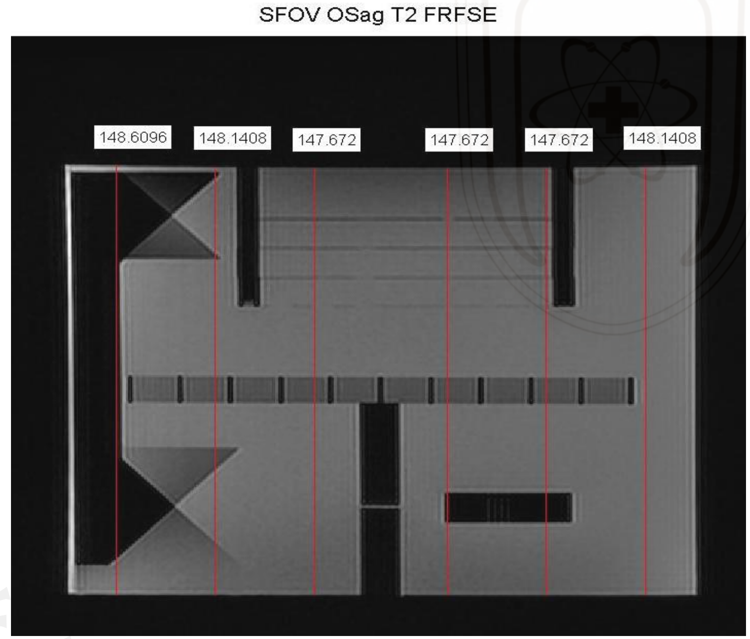
…… ……

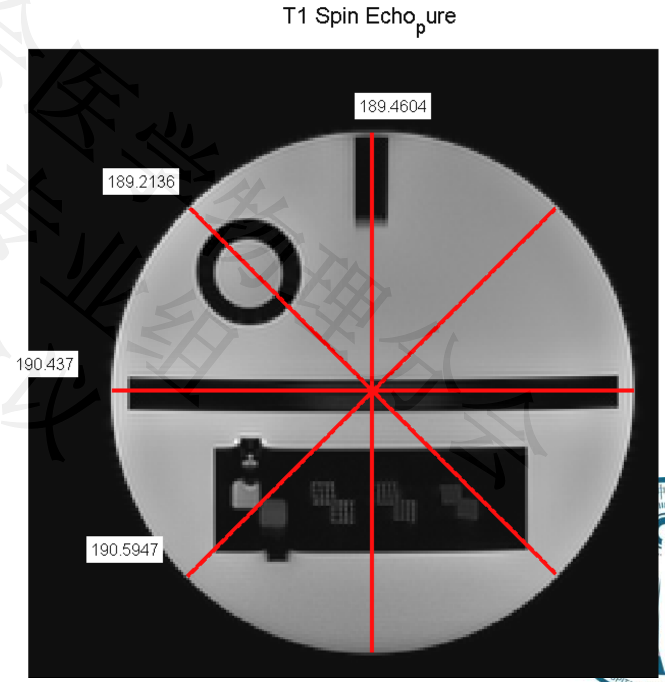
工作量大，保证验收的精度和效率-----自动图像验收

几何精度

- ≤2mm

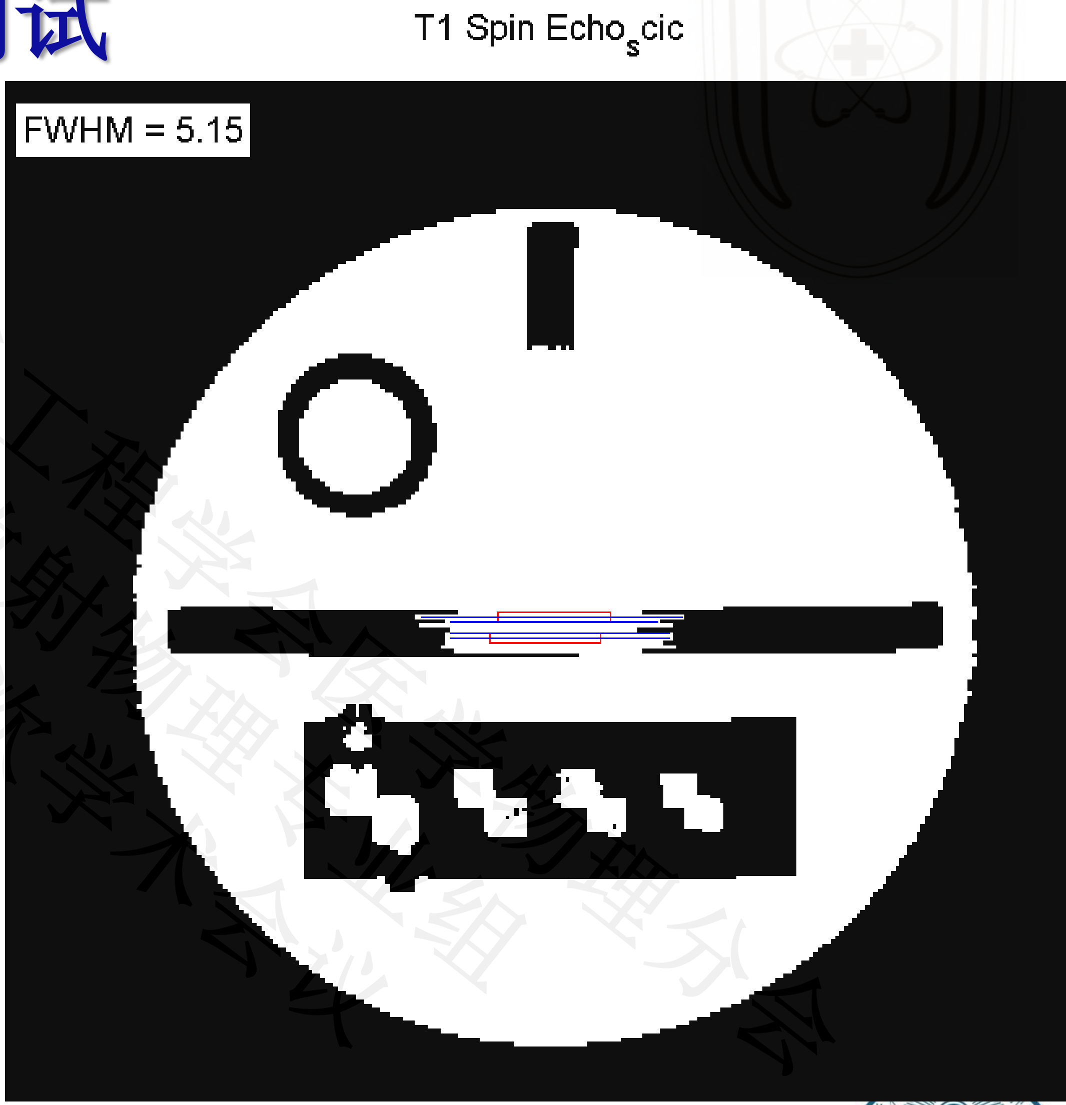

T1 Spin Echo$_{p}$ure
189.4604
189.2136
190.437
191.9758


SFOV OSag T2 FRFSE
148.6096
148.1408
147.672
147.672
147.672
148.1408


T1 Spin Echo$_{p}$ure
189.4604
189.2136
190.437
190.5947

层厚测试

- FWHM
- 窗位、窗宽
- 0.2×（L1×L2）/(L1+L2)
- ≤±10% (真实层厚)



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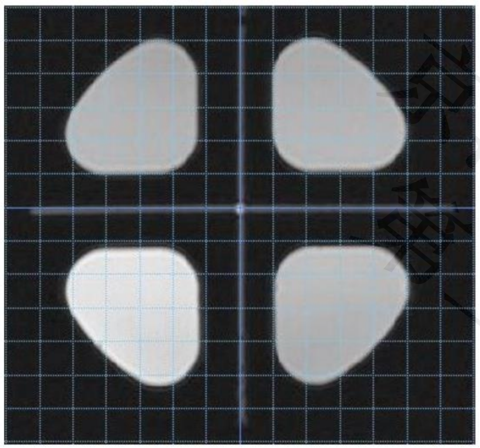
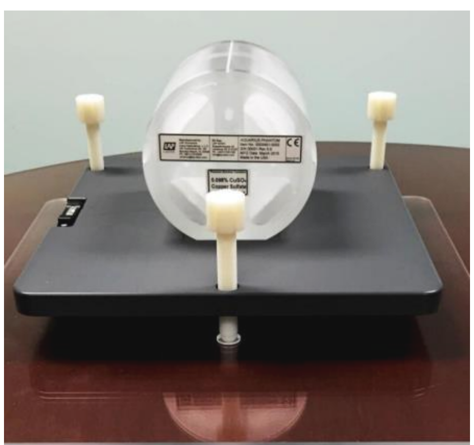
层位置



T2 Spin Echo$_{p}$ure

T1 Spin Echo$_{p}$ure



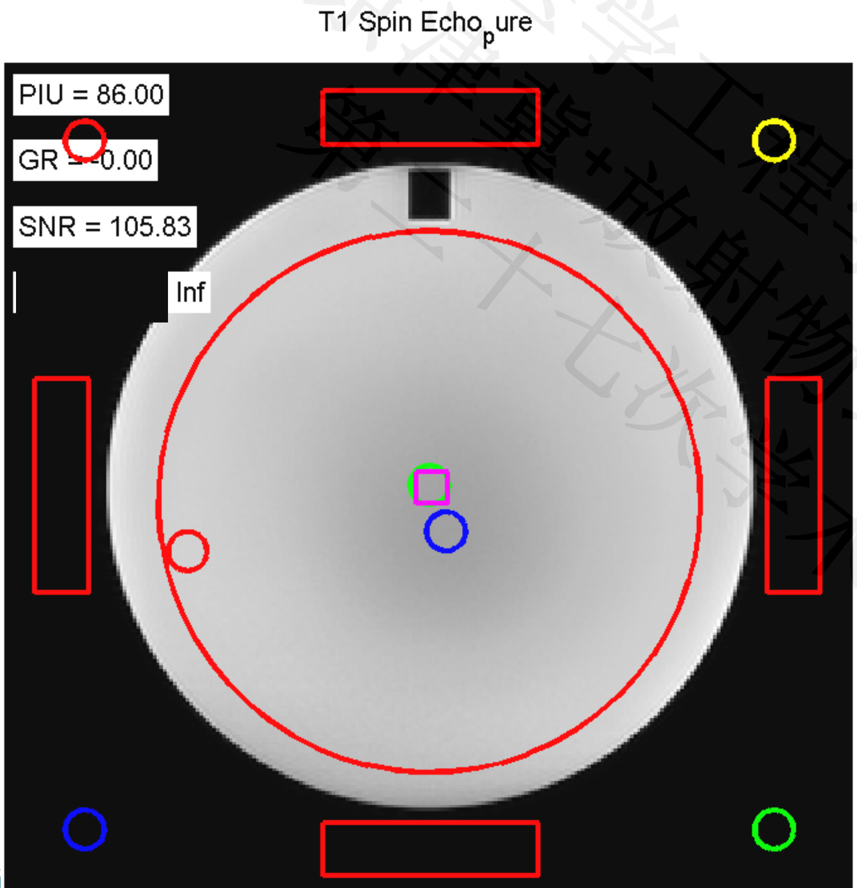
delta

≤5mm？

AQUARIUS

均匀性模体测试

- 图像均匀性（**PIU**）、百分信号伪影 **(GR)**



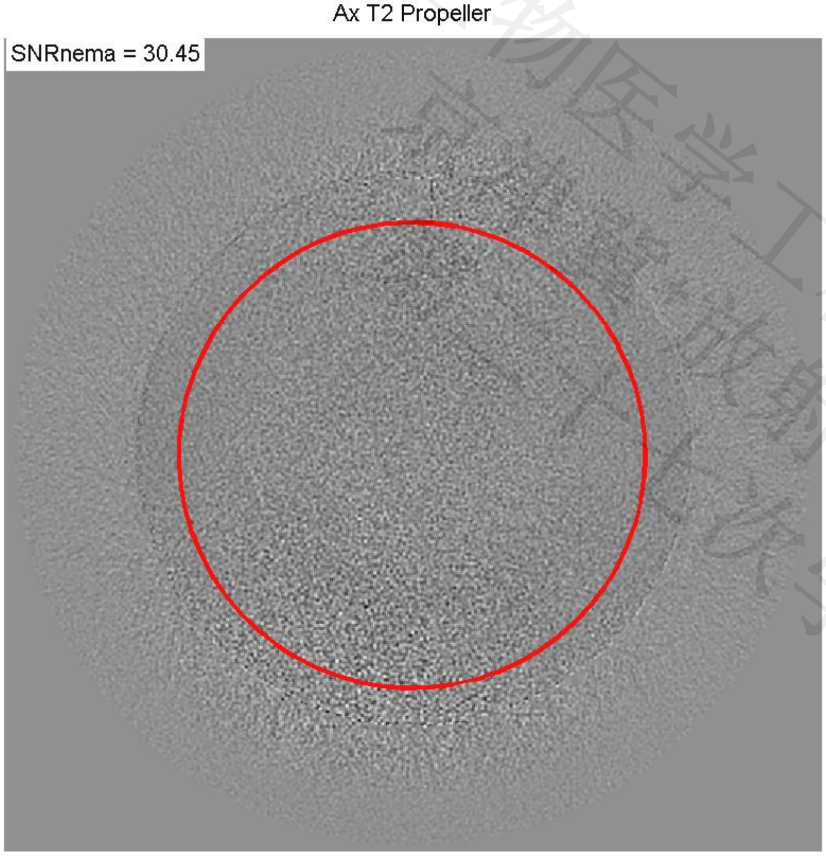
$$PIU = 100 \bullet \left[1 - \frac{\left(\bar{S}_{\max} - \bar{S}_{\min}\right)}{\left(\bar{S}_{\max} + \bar{S}_{\min}\right)} \right].$$

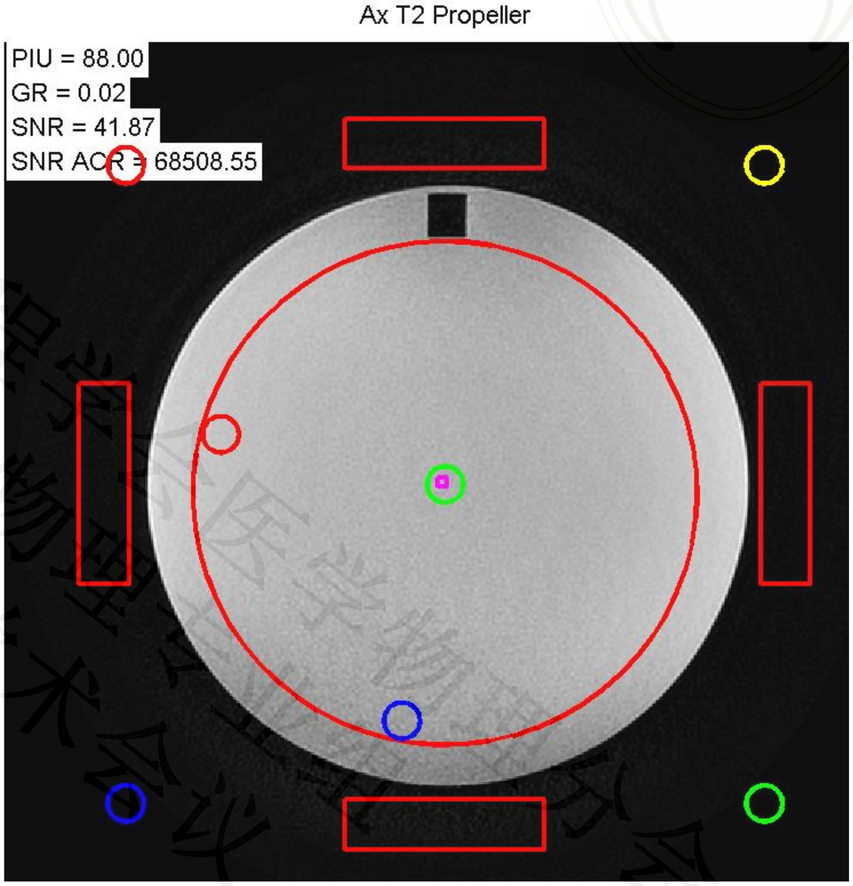
PIU≥90%,87.5,85%?

$$GR = \left| \frac{\left(\bar{S}_{FE1} + \bar{S}_{FE2}\right) - \left(\bar{S}_{PE1} + \bar{S}_{PE2}\right)}{2\,\bar{S}} \right|.$$

GR≤2.5%

信噪比



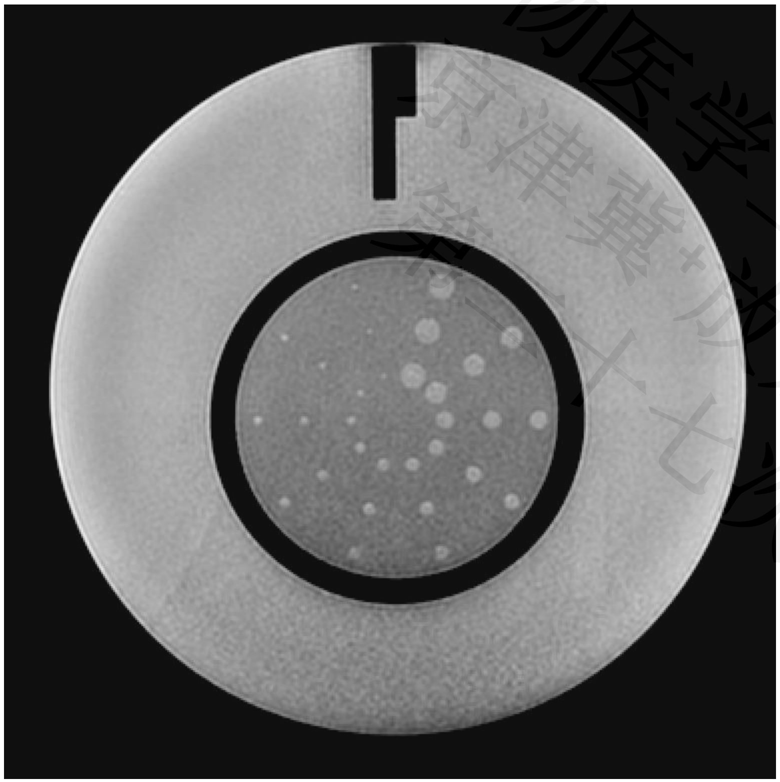


$$\mathrm{SNR}_{\mathrm{NEMA}} = \frac{\sqrt{2}\,\bar{S}}{\sigma}$$

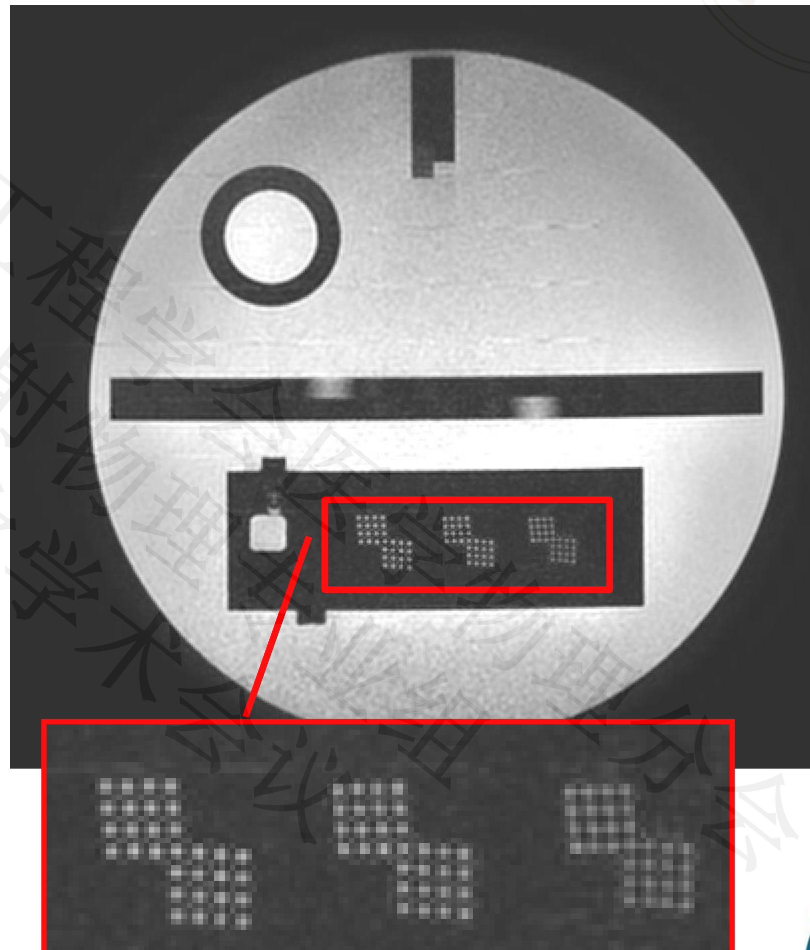
$$\mathrm{SNR} = \frac{\bar{S}}{\left[\sigma_{bkg} \Big/ \sqrt{2 - \frac{\pi}{2}}\right]} \approx \frac{0.655\ \bar{S}}{\sigma_{bkg}}$$

通过标准?

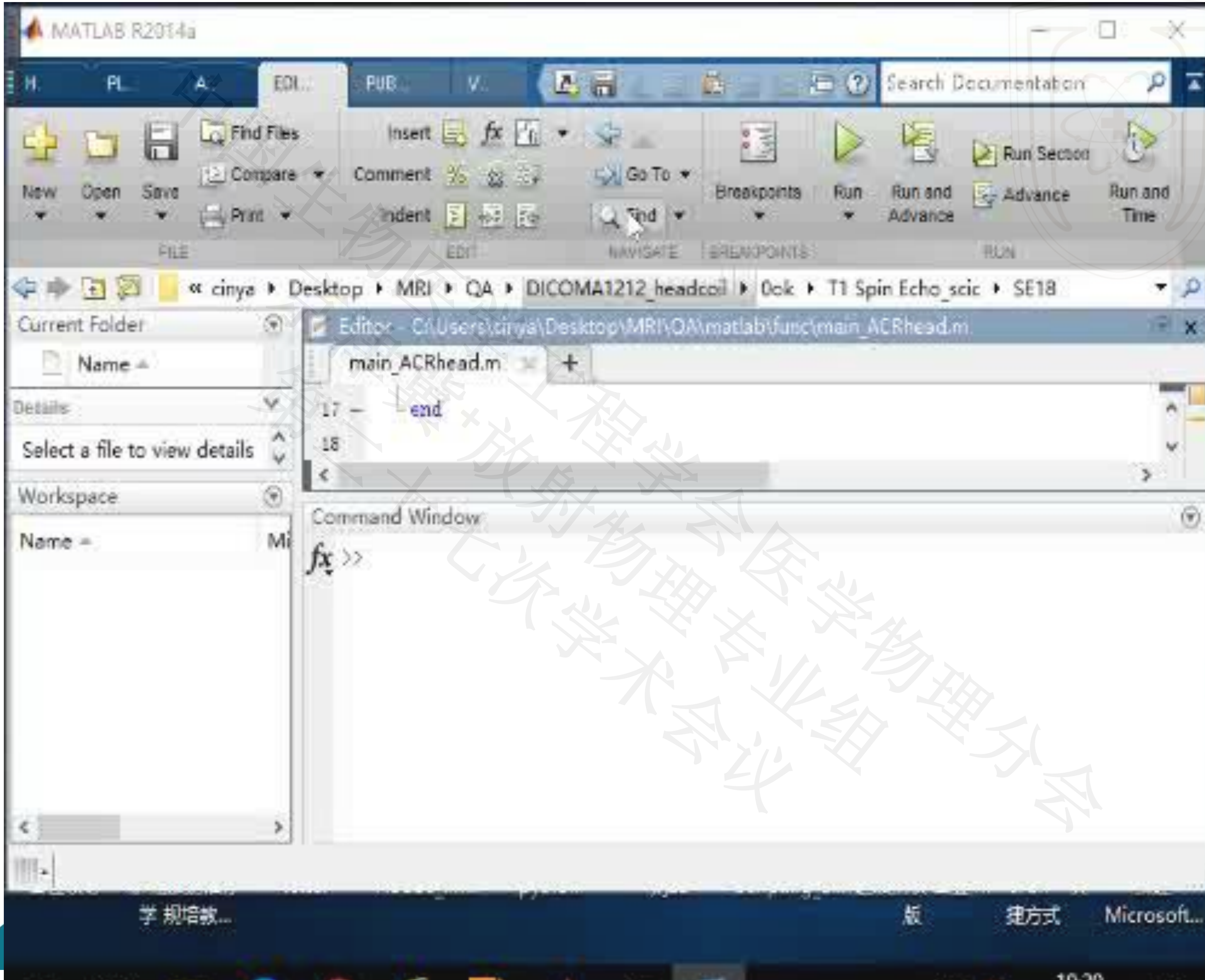
低对比分辨率、高对比分辨率



5 mm间隔，4个对比度模块，
分别是1.4%, 2.5%, 3.6%, 5.1%



1.1mm 1.0mm 0.9mm


MATLAB R2014a
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« cinya ▸ Desktop ▸ MRI ▸ QA ▸ DICOMA1212_headcoil ▸ 0ok ▸ T1 Spin Echo_scic ▸ SE18
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Details
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main_ACRhead.m
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18
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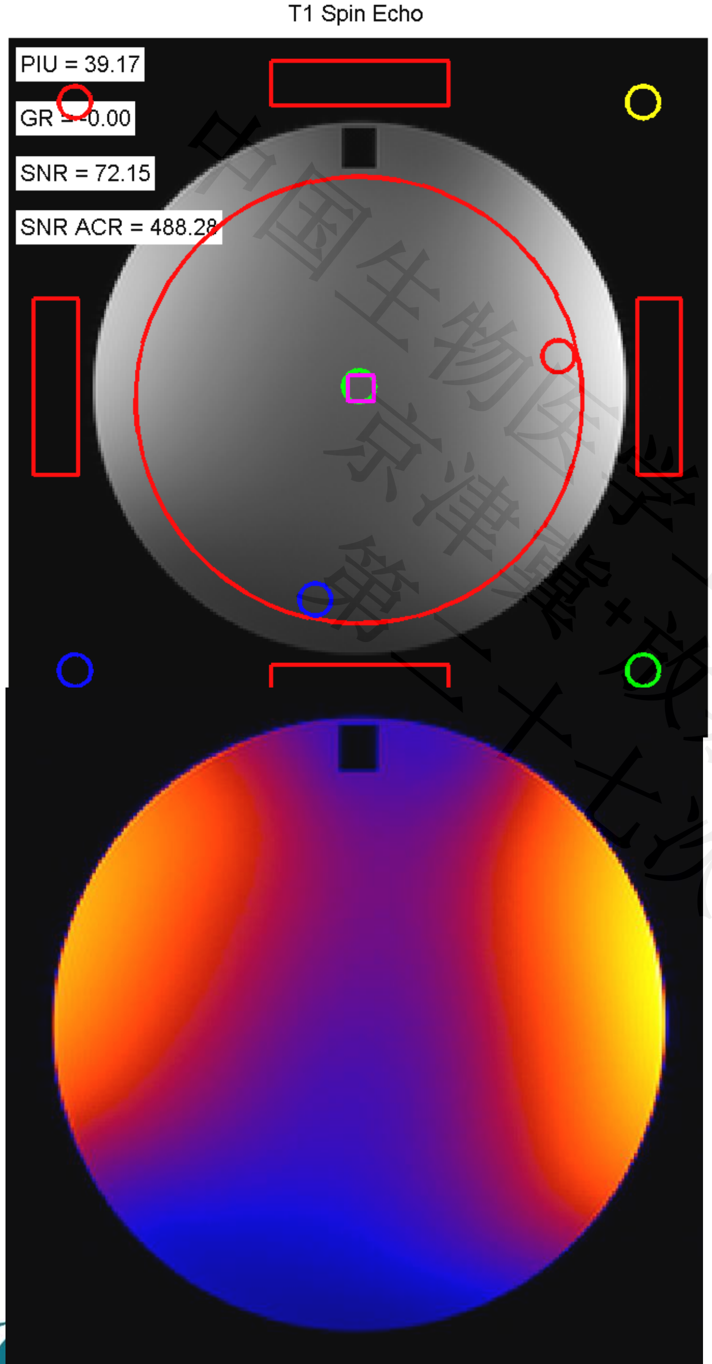
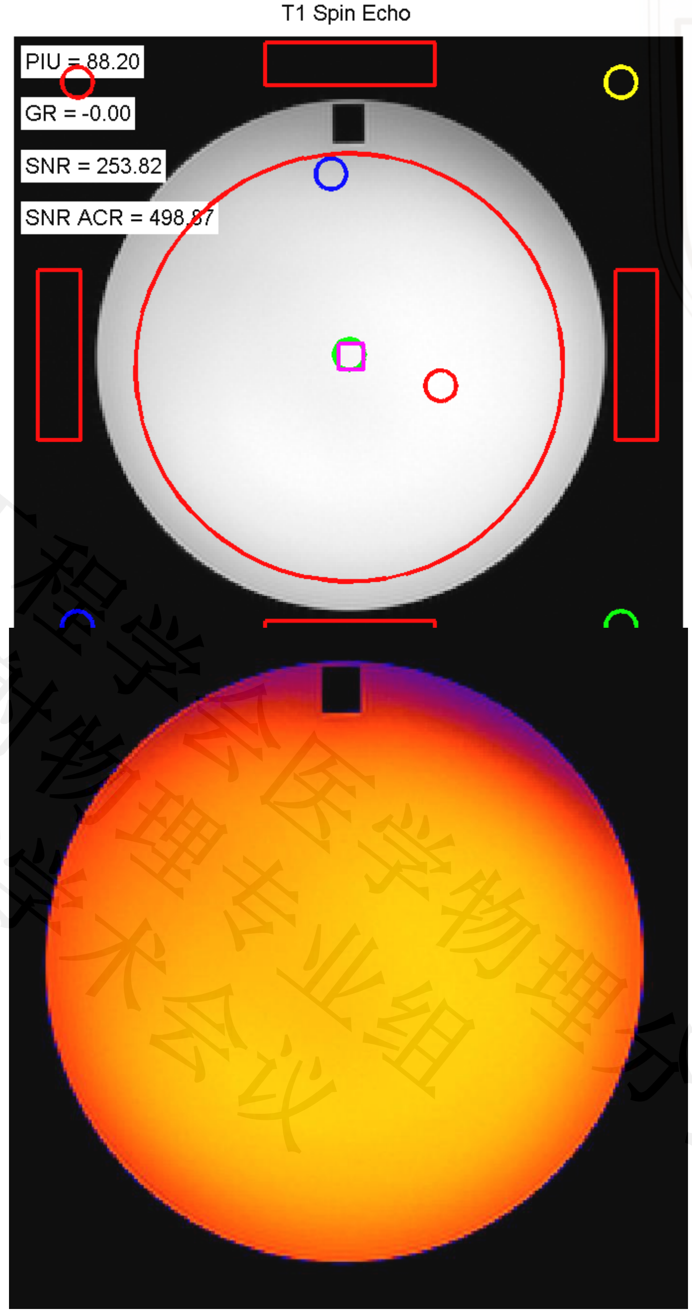
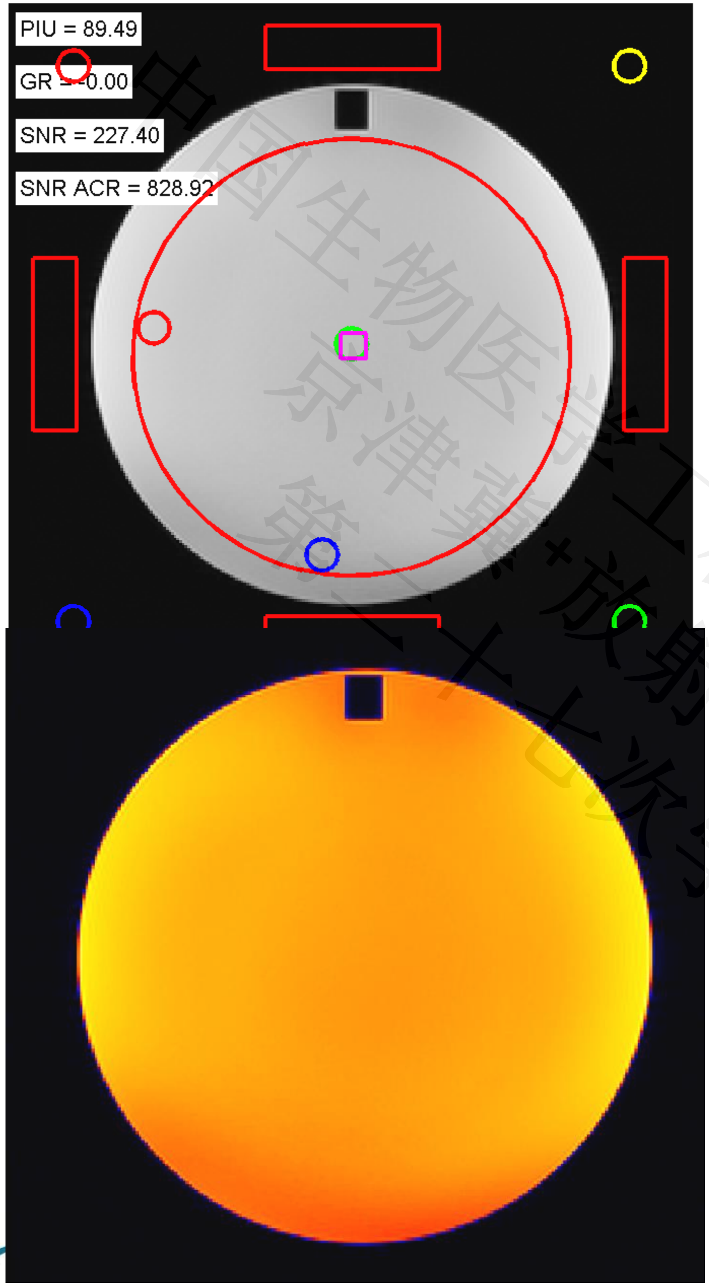
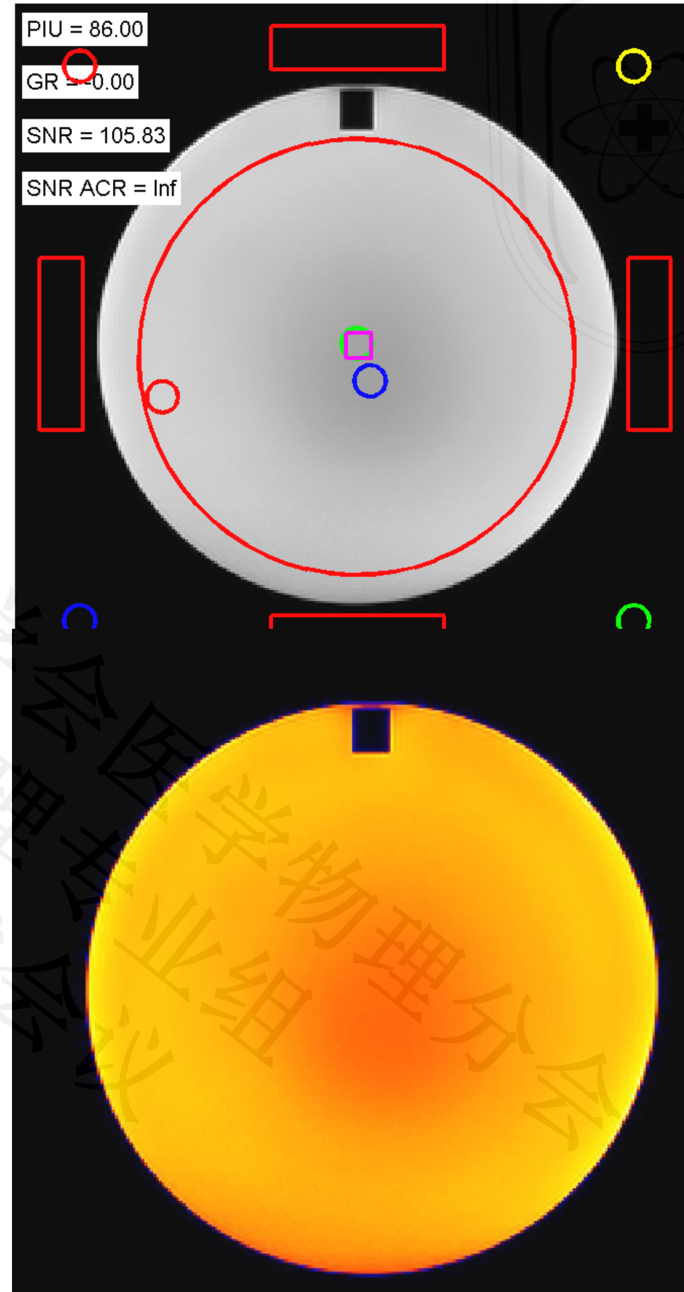

T1 Spin Echo
PIU = 39.17
GR = -0.00
SNR = 72.15
SNR ACR = 488.28


T1 Spin Echo
PIU = 88.20
GR = -0.00
SNR = 253.82
SNR ACR = 498.87

T1 Spin Echo$_s$cic



T1 Spin Echo$_p$ure



小 结

- 由 于 MRI技术的复杂性和新的安全问题，引进MR定位技术比引进CT技术难得多
- MRI_Sim验收测试的工作存在很多不足及亟待解决的问题
- MR定位目前还处于与CT定位结合应用的阶段，但发展方向是MR-only-Sim以及MRI-IGRT