

JUNO liquid scintillator status

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Outlines

- JUNO LS 简介；
 - JUNO 介绍，
 - JUNO LS 介绍，
 - 研究团队，

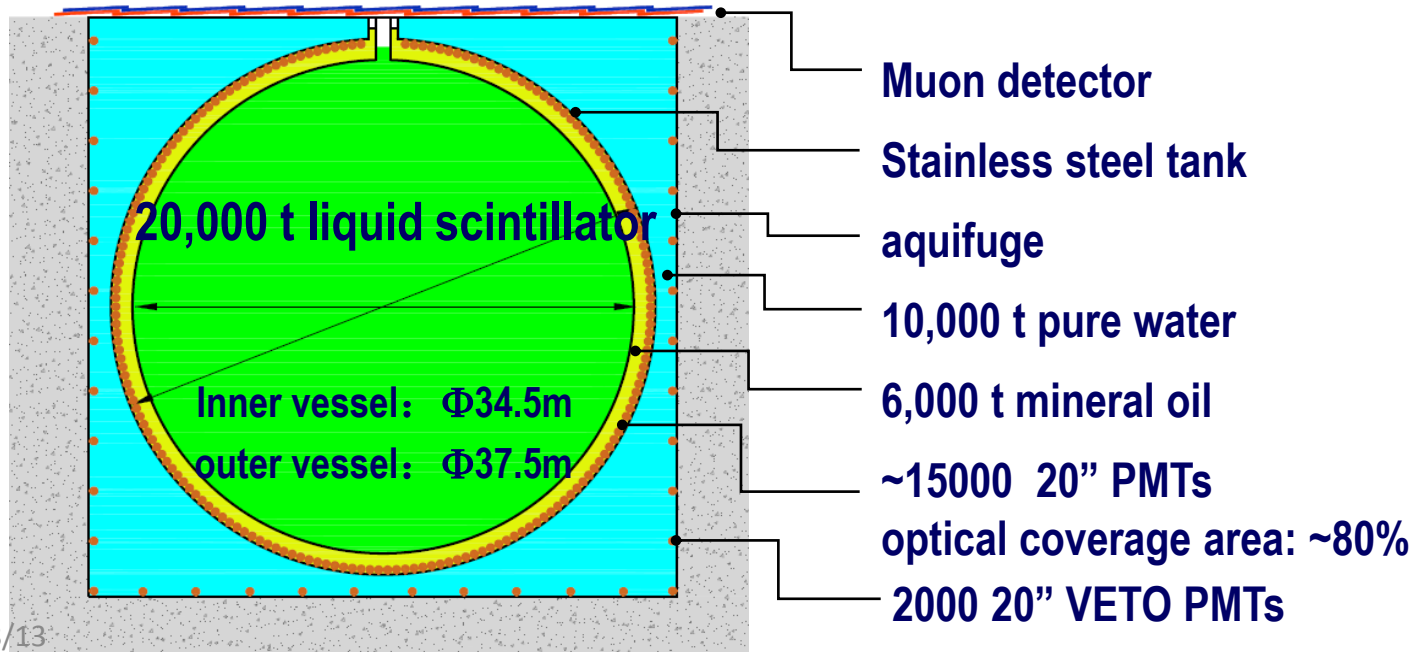
- JUNO LS 研究现状；
 - LAB 生产厂家介绍，
 - LS 纯化研究进展；
 - LS 的性能研究；
 - 大规模生产进展.

liquid scintillation for JUNO

- Requirements for **20K tons LS for JUNO**

- LS衰减长度: ~22m
- 放射性本底要求: $<10^{-15}\text{g/g}$
- 光产额 (received by PMT) : ~1200pe/MeV

large challenges!



LS for JUNO

- 初步配方:

- **3g/L PPO, 15mg/L bis-MSB in LAB**

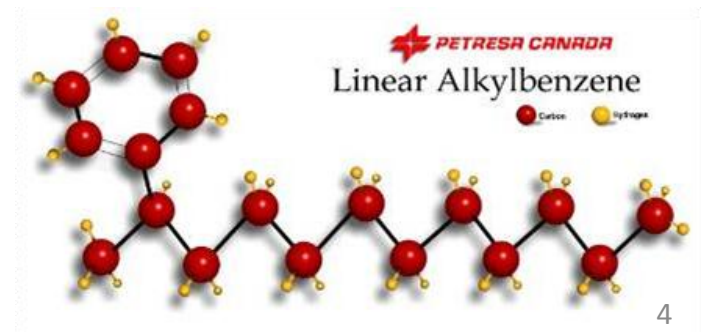
- 液闪基质: linear alkyl benzene (LAB, 线性烷基苯)

- 供应量大, 商业可用;

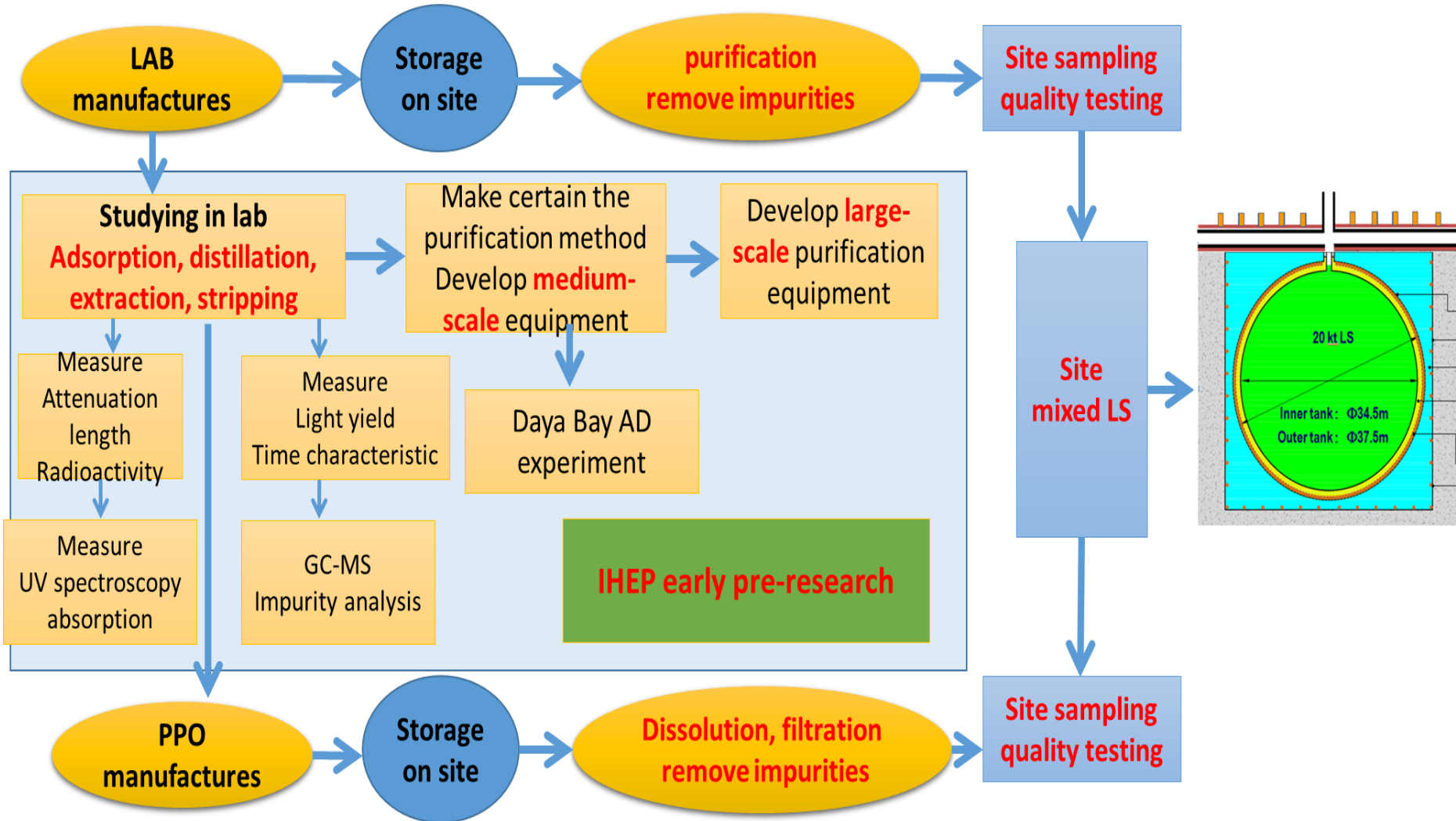
- 好的光学性能, 已经应用于中微子实验, 如:
DYB, Double Chooz

- 比其他溶剂安全, 如: **PC**

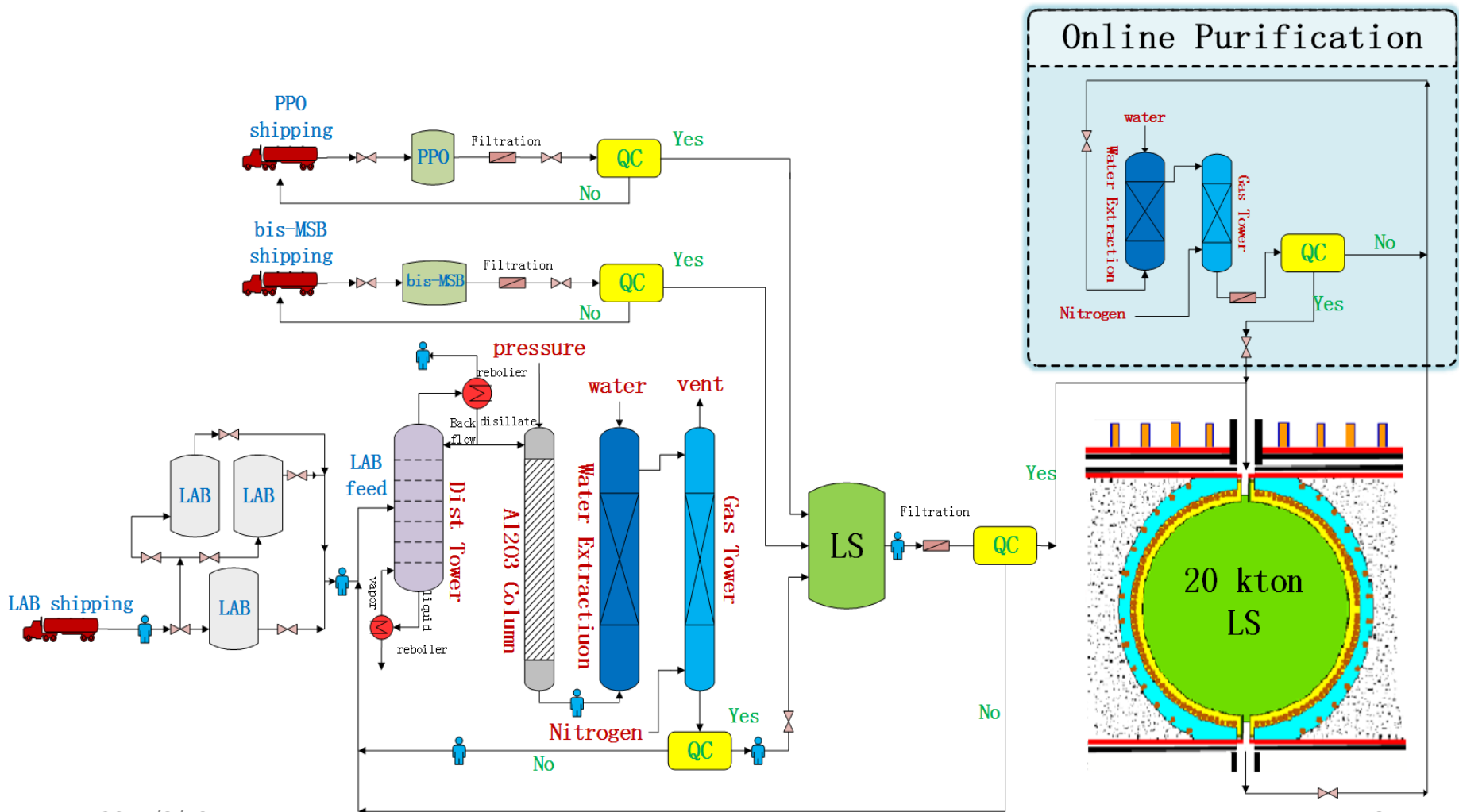
- 发光物质: PPO 和 bis-MSB



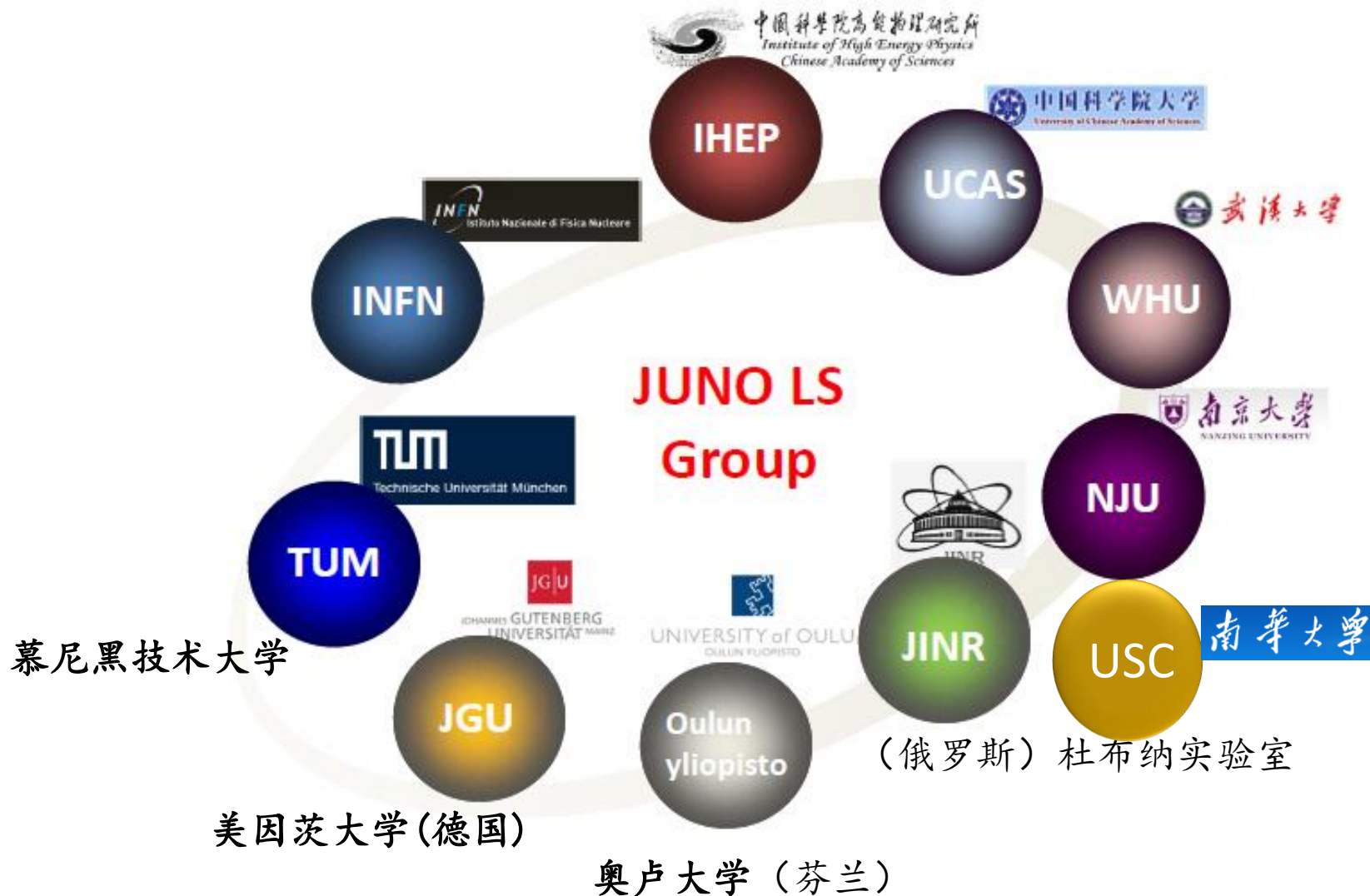
LS 的开发过程



LS 的纯化生产流程 (primary)



研究团队



LS 研究现状

- LAB 生产厂家调研;
- LAB 纯化方法研究;
- LAB 及 LS 的各项性能的测试;
- 现场JUNO LS 的大规模生产的计划;

Domestic LAB manufacturers

- Nanjing LAB plant, Nanjing China
 - Provide 388t LAB for Daya Bay experiment
 - Special LAB produced in Mar. 2013
 - Commercial LAB
 - Keep in touch with them



- Jintung petrochemical corporation Ltd.
 - Commercial product
 - LAB with narrow boiling range

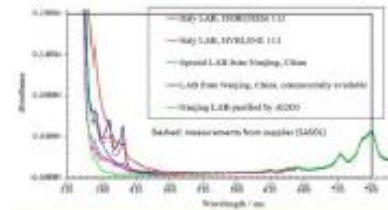


- Other vendor?

European LAB producers

- SASOL, South Africa/Italy

- HF (Isorchem) and DETAL (Hyblene)
- Commercial price NOW: 2Eur/kg
- Measurement at IHEP (solid line) and from SASOL(dashed line)



- CEPSA (Petresa), Spain/Canada

- HF and DETAL
- Samples had been sent to IHEP
- 3 production facilities, nominal capacity > 550.000 MT/y



CEPSA Quimica
Fab. Puente Mayorga



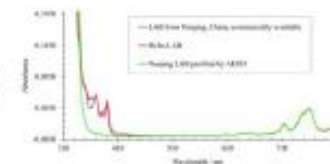
DETEN Quimica
Camaçari - (Brazil)



CEPSA Quimica Bécancour
Quebec (Canada)

- HELM (Saybolt), Germany/Egypt

- Samples had been sent to IHEP (the best in terms of A.L.)



M. Giammarchi: European LAB producers and related measurements

LAB sample from factory

We get samples from a number of manufacturers
Measuring various characteristics

- ITALY Sasol, ISORCHEM[®] 113 (HF) HYBLENE[®] 113
- EGYPT Helm TK L18
- SPAIN PETRELAB 500Q



keep a good relationship with factory, they will do some special research for LAB production, we have got some A.L. over 20m from Nanjing Jinglin

Quality control and quality assurance standards for LAB production will be established under the help of LAB manufacturer

蒸馏纯化 (optical)

➤ 优势

- 适合大规模生产;
- 不会带入杂质;

➤ 劣势

- 光学纯化效果不明显;
- 高耗能。

- One set of vacuum distillation system with fractionating columns has been installed at IHEP
- It's a multiple stage vacuum distillation system
- Purification of LAB by this system is now in progress

2014/8/13



Al₂O₃吸附柱纯化 (optical)

- Al₂O₃纯化

- 优势:

- 电耗量较少;
- 很好的LAB的光学纯化效果(A.L.=25m)

- 劣势:

- 可能会把放射性带入到LAB中，目前还没有实验数据;
- Al₂O₃ 的用量比较大，价格较高;

Al₂O₃ column



LAB 光学纯化结果 (Preliminary)

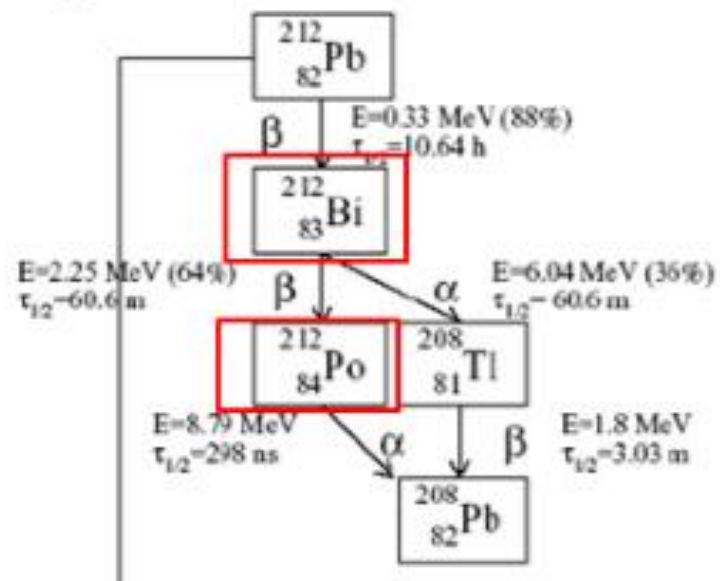
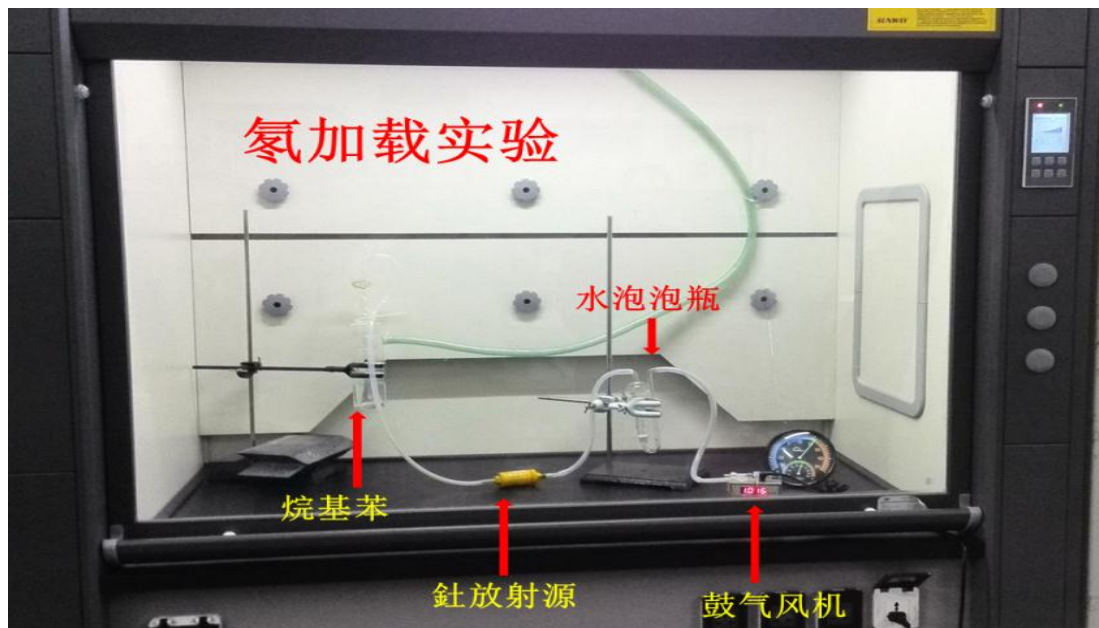
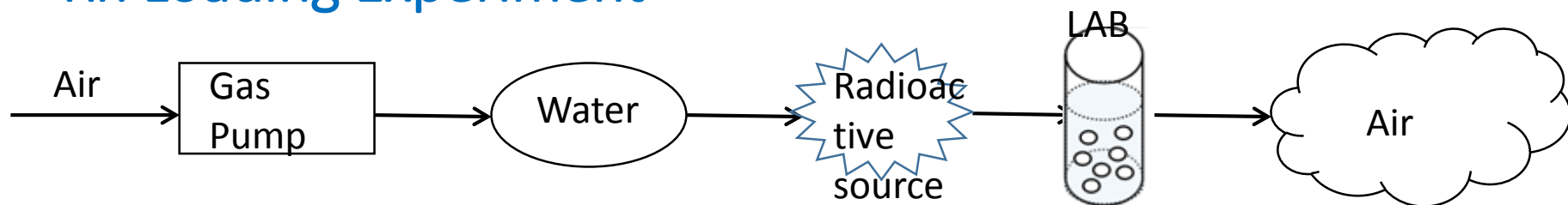
—attenuation length measurements and UV-Vis measurements show that:

- LAB 通过 Al_2O_3 纯化后，衰减长度最长 (@430nm)；
- LAB 通过 Al_2O_3 纯化前后的衰减长度分别是 20m 和 25m；
- 蒸馏对提高 LAB 的衰减长度的效果不明显。

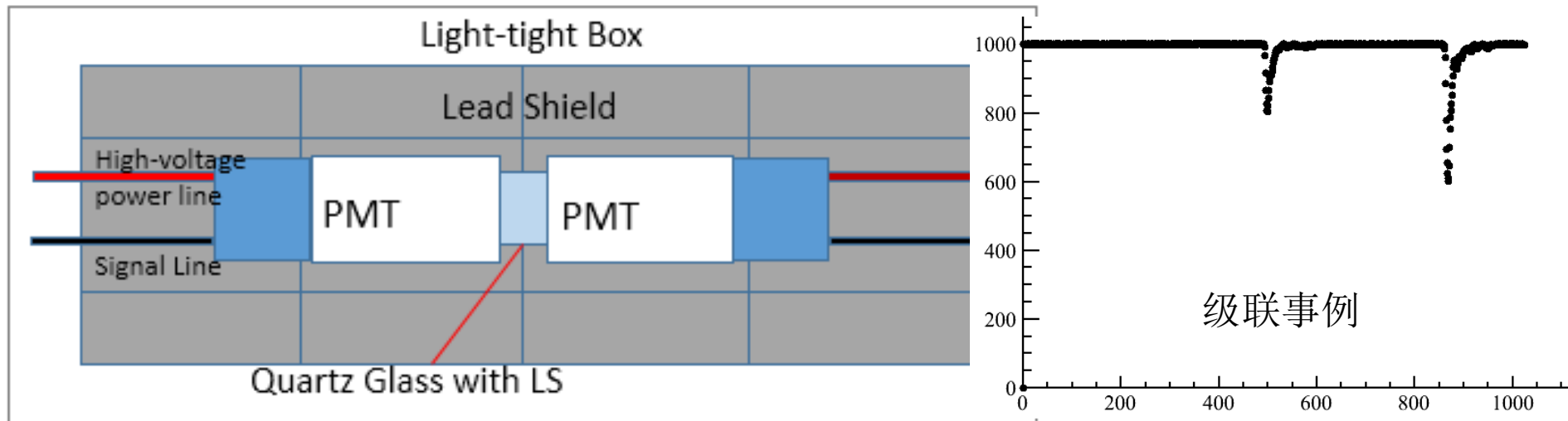
放射性纯化研究



^{220}Rn Loading Experiment

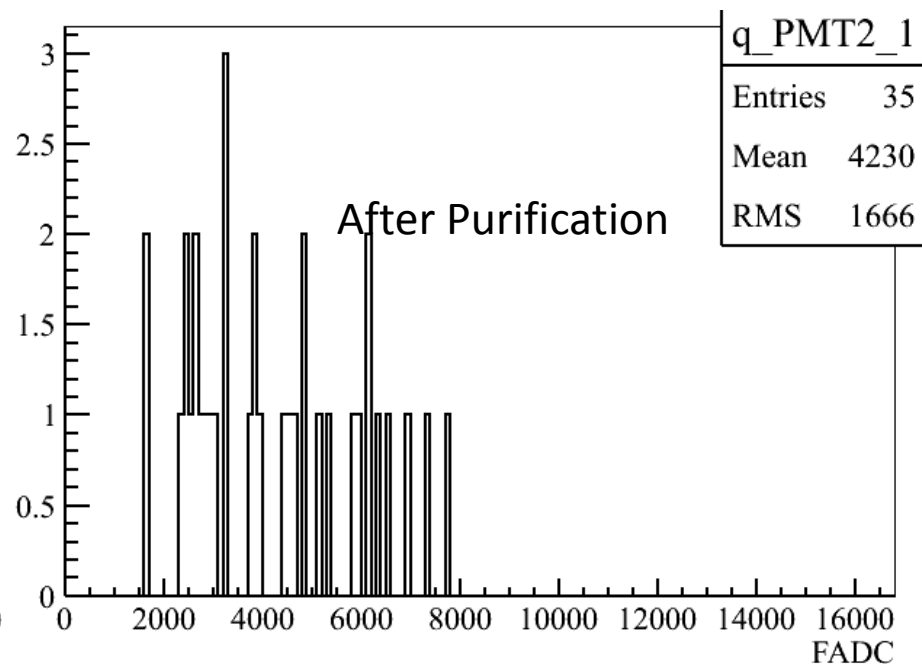
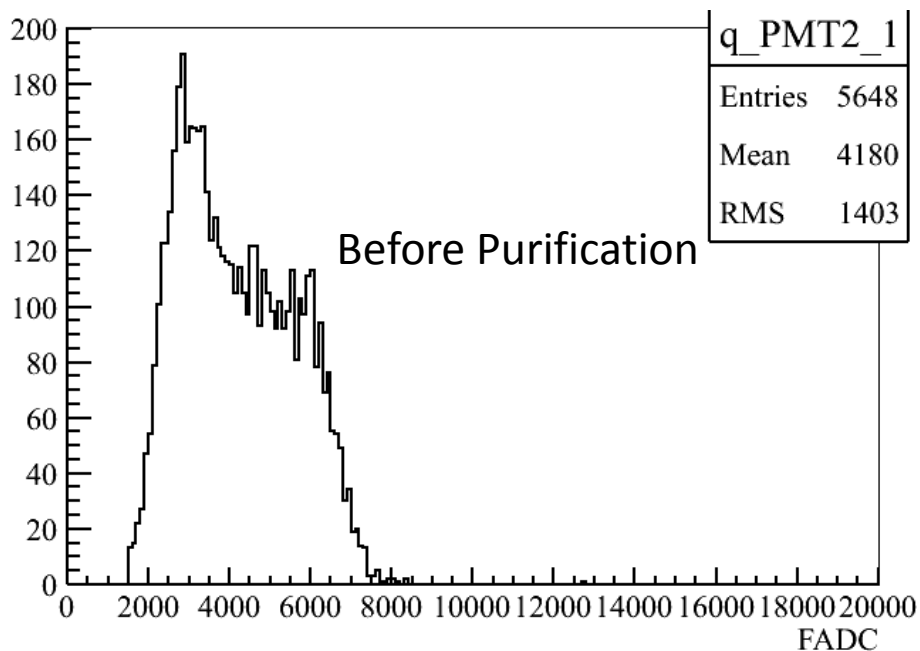


Measurement Device



- The two PMTs are placed on both sides of LS sample to detect light produced by the $Pb212$ decays. Using coincidence measurement.
- Lead bricks are used to shield the LS from external gamma activity.
- The entire setup is enclosed in a light-tight box.

放射性纯化结果分析

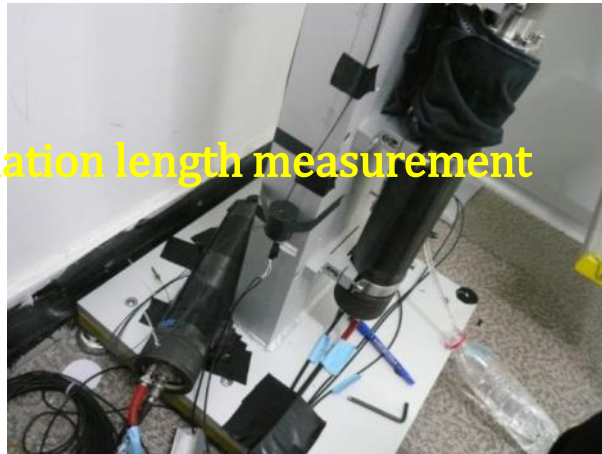


- AL₂O₃的放射性纯化的结果;
 - 纯化后双信号事例为：33个，而纯化前为：5648.
 - 可以去除 99.41%的放射性, 纯化效率171.
- 蒸馏的放射性纯化的结果;
 - 可以去除 99.64%的放射性，纯化效率达到284.

LS 的性能测量



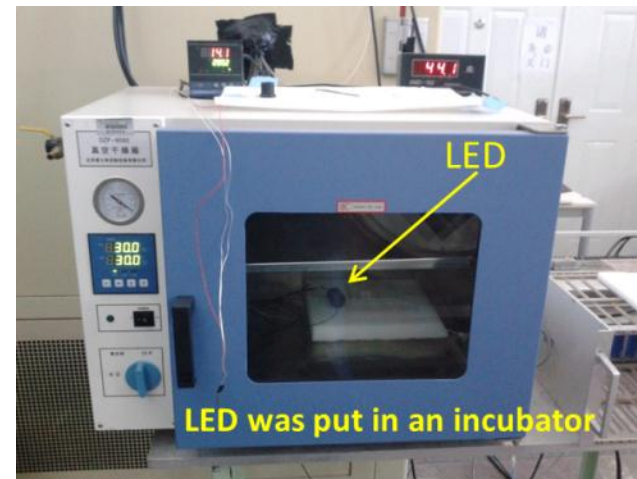
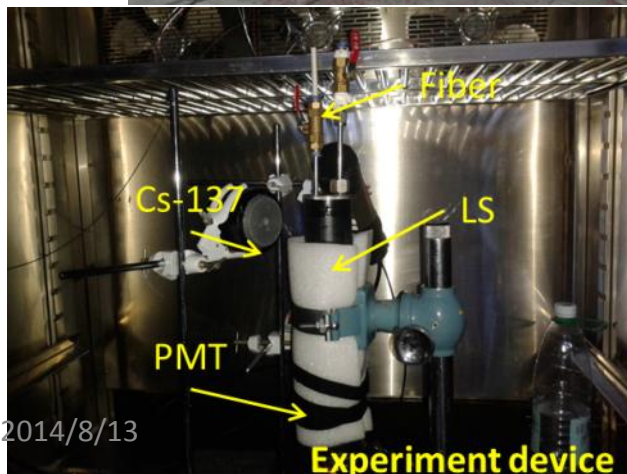
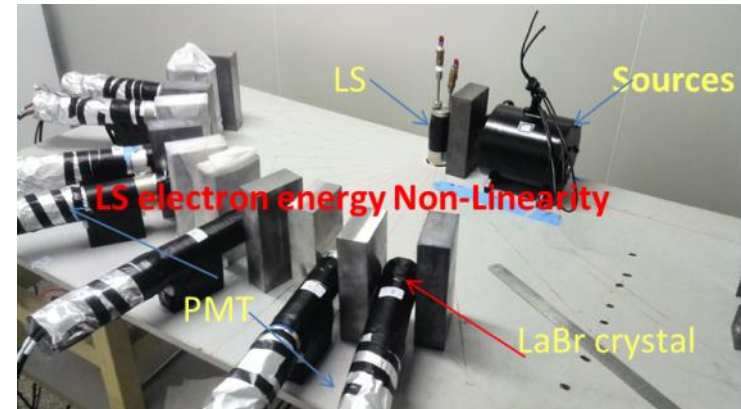
光输出
衰减长度测量
时间性能测量
UV-Vis吸收光谱测量
GC-MASS杂质分析



LAB and LS的性能研究

LS 的温度响应研究
LS 的配方研究
LS 电子能量非线性
LS 的老化

detector design
LS final Formula
MC parameter



衰減长度的測量

- **A.L. at 430nm:**

- ISORCHEM 113: A.L. = $3.99 \pm 0.05\text{m}$

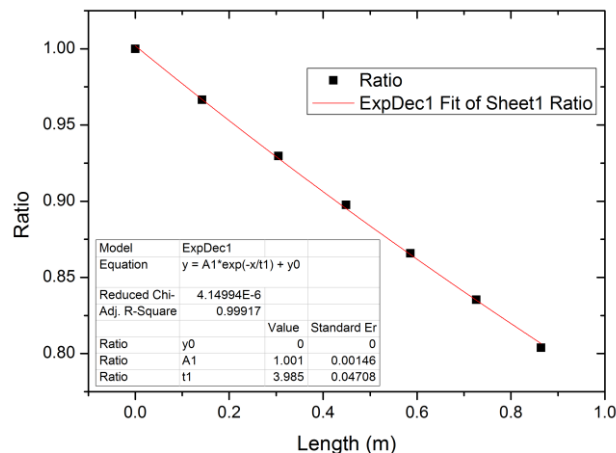
The samples may be polluted during transport

- HYBLENE 113: A.L. = $7.60 \pm 0.15\text{m}$

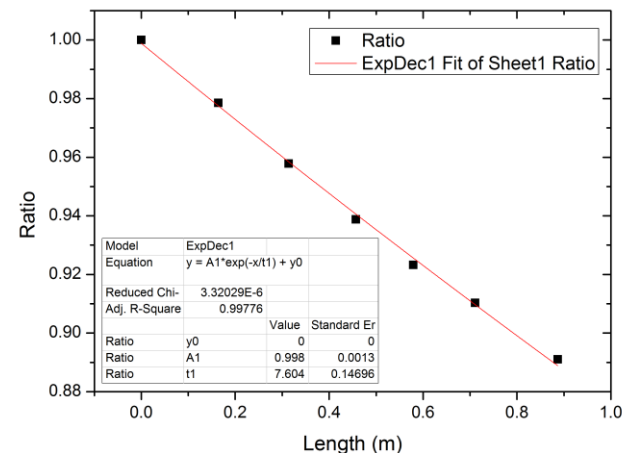
- Nanjing LAB (commercially available): A.L. $\approx 9\text{m}$

- Nanjing LAB (special): A.L. $\approx 20\text{m}$

- Al₂O₃ column purified : A.L. $\approx 25\text{m}$

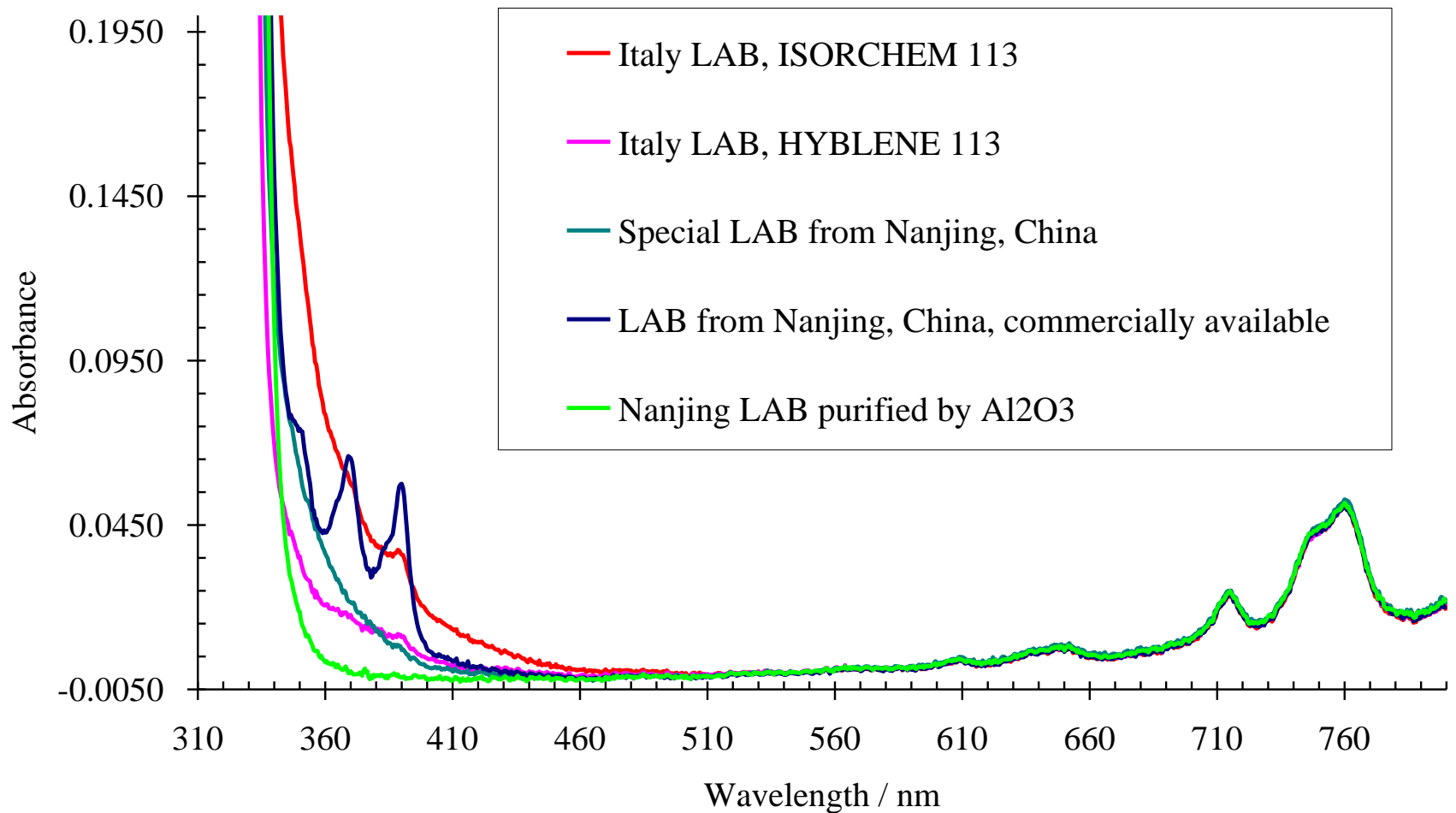


ISORCHEM 113



HYBLENE 113

不同厂家LAB的紫外吸收光谱



LS大规模生产计划

- For LAB

- 访问几个厂家，同时各个厂家提供了多个样品；
- 希望厂家提供的LAB能达到25米的衰减长度；
- LAB生产的质量控制和质量保障标准需要在厂家的帮助下建立起来；
- 厂家能在较长时间内提供，2万吨的高质量LAB，这样就可以减少我们的存储设备。

LS大规模生产计划

- For PPO

- DYB LS: 3g/L PPO, 15mg/L Bis-MSB in LAB
 - 武汉华硕为DYB实验纯化了1.4吨PPO;
 - 给DYB提供少量的PPO;
- JUNO需要 ~60吨 PPO
- 武汉华硕已经达成了很多合作意向（进度要求）
 - 2014 - 2015
 - 准备生产，共同建立质量检测标准，并提供PPO样品
 - PPO样品 IHEP 建立QA/QC
 - 2016: 华硕建生产线，并签署合同
 - 2017: 开始PPO生产。

- For Bis-MSB: 华硕已经提供了样品，也可以从国外买

大量生产的设备研究

LAB的运输
LS的配置
LAB的纯化
萃取系统

LAB袋子、容器，船、车、存储.....

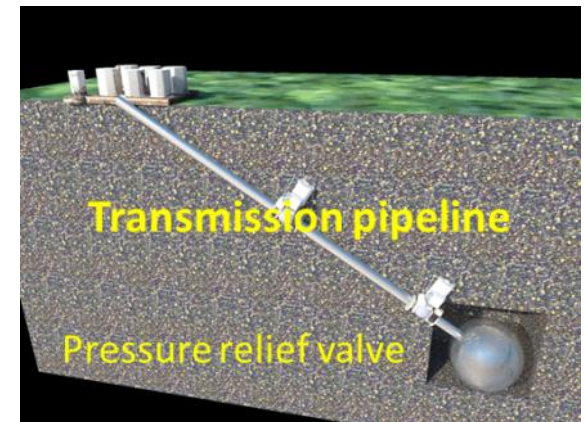
LS的生产、运输和灌装

AL2O3吸附柱、蒸馏系统、氮气剥离系统和水

Build storage tanks on the ground and underground for LAB, LS and mineral oil

Tanks for dissolving PPO, bis-MSB,

Tanks for LS mixing



LS 大量生产的地上规划

江门中微子实验站配套基建工程整体鸟瞰图

storage tanks

Pure Water
Nitrogen room

PPO, Bis-MSB
storage room

LAB Purification
And mixing hall
QA/QC ROOM

地下有两个LS研制厅 (1000m²)

LS生产厅

万级洁净间

能XY移动的10吨吊车

LS混制装置

Radon detection

Oxygen content detection

Cleanliness monitoring

Video surveillance systems

Fire alarm

LAB LS storage hall

4个LAB, LS和 mineral oil
存储罐包括。

QA/QC room:

Light output,

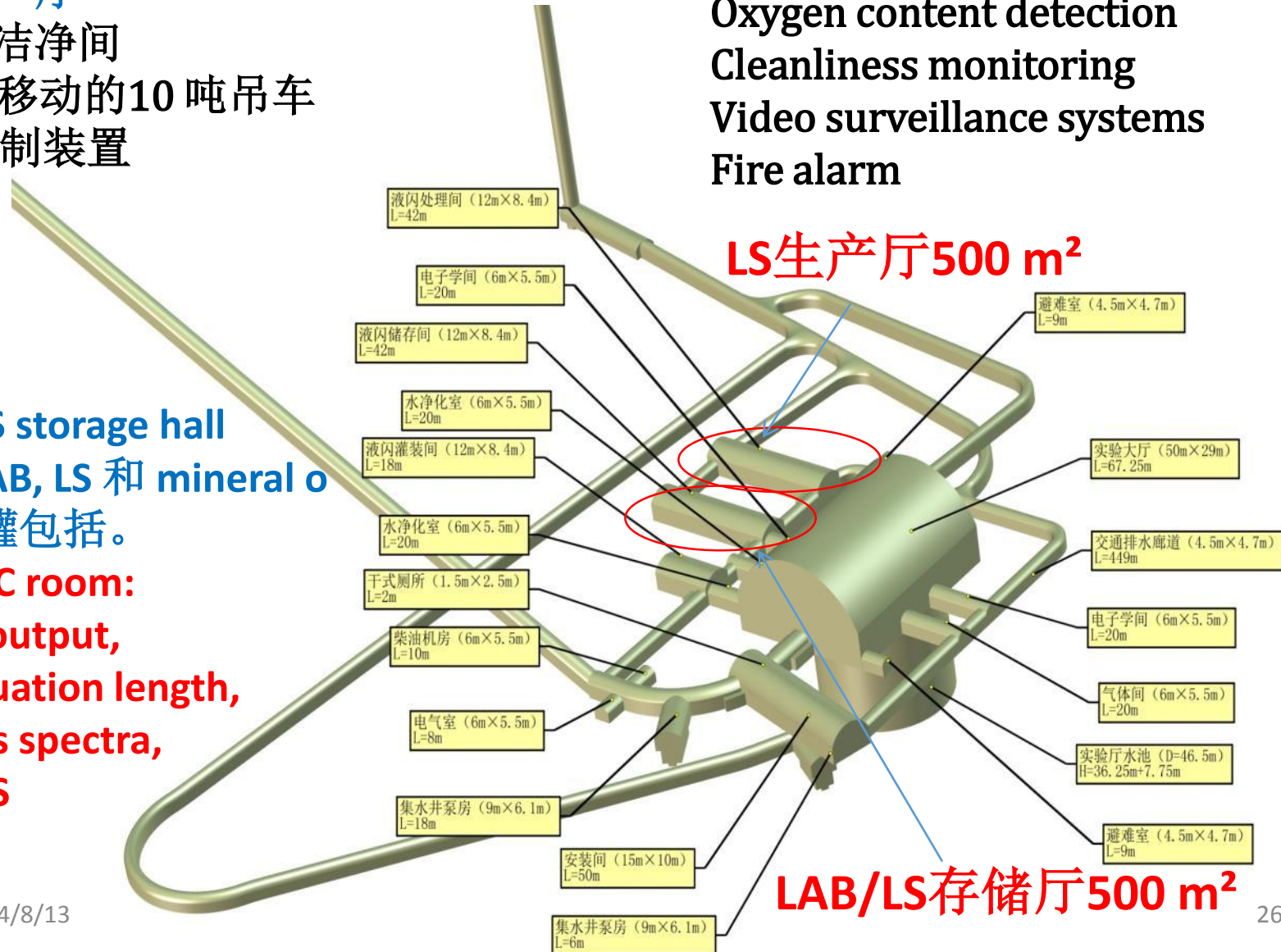
Attenuation length,

UV-Vis spectra,

GC-MS

LS生产厅500 m²

LAB/LS存储厅500 m²



总结

- 研究团队已经建立，合作研究已经开始；
- **JUNO LS** 的研究取得了很好的进展；
- **LS**的一些基本性能测量已经得到测量结果；
- **LS**纯化实验已经有展开；
- **LS**的大规模生产有了初步设计

Thanks!