	<p>STANFORD LINEAR ACCELERATOR CENTER</p> <p>SPECIFICATION</p> <p>STANFORD SYNCHROTRON RADIATION LABORATORY</p>
---	--

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 1 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

First Line: SPEAR3
Second Line: Magnet System
Title: Gradient Dipole Magnet General Assembly

<p>145D & 109D</p> <p>General Assembly</p> <p>Specification</p> <p>145D和109D二极铁</p> <p>总装</p> <p>生产说明书</p>	Approved: SPEAR3 System Manager Richard Boyce Date:
	Approved: SLAC Magnet Group Leader Domenico Dell’Orco Date:
	Approved: IHEP Administrative Representative Yanling Jiang Date:
	Approved: IHEP Technical Representative Huamin Qu Date:

Update / 修改	
-------------	--

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 2 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

1. GENERAL / 概况

This document is presented in both English and Chinese text; in case of differences, the English version shall be used.

本文含中英文两种文字，如有不符之处，以英文为准。

1.1 Scope of the Specification / 说明书范围

This specification outlines the minimum requirements governing the assembly and testing of the SPEAR3 prototype, 145D and 109D gradient dipole magnets. This specification further outlines the minimum requirements for packaging and shipping the completed and tested magnet from IHEP to SLAC.

本说明书概括了SPEAR3 145D和109D梯度二级铁批量生产和样机总装和检测的基本要求，对完工后的磁铁从高能所运送到SLAC的包装和运输的基本要求也做了说明。

1.1.1 Applicable Document / 使用文件

Drawing SA 444-402-55	Gradient Dipole Prototype Core End Stack Assembly / 样机铁芯叠片端板组装
Drawing SA 444-402-01	Gradient Dipole 145D General Assembly / 145D梯度二级铁总装
Drawing SA 444-402-03	Gradient Dipole 145D Core Assembly / 145D铁芯组装
Drawing SA 444-402-18	Gradient Dipole 145D Main Coil Assembly / 145D主线圈组装
Drawing SA 444-402-57	Gradient Dipole 145D Trim Coil Assembly / 145D校正线圈组装
Drawing SA 444-402-81	Gradient Dipole 109D General Assembly / 109D梯度二级铁总装
Drawing SA 444-402-83	Gradient Dipole 109D Core Assembly / 109D铁芯组装
Drawing SA 444-402-88	Gradient Dipole 109D Main Coil Assembly / 109D主线圈组装
Drawing SA 444-402-84	Gradient Dipole 109D General Assembly / 109D校正线圈组装

1.1.2 Reference Document / 参考文件

Engineering Note M319	Gradient Magnet Engineering Design Summary
工程说明书	梯度二级铁总体工程设计书

1.2 Scope of Work / 工作范围

IHEP shall design and fabricate all required assembly hardware and any required assembly tooling. IHEP shall specify and purchase all material and equipment for the magnet assembly including US standard water fittings, hoses and fasteners. IHEP shall assemble, test and package for shipment the quantity of gradient dipole magnets outlined in section 3.2 of Attachment 1 of ICA for the SPEAR3 as per drawings listed in section 1.1.1 in this specification. Tests described in this specification shall include all electrical tests and measurements and hydraulic measurements. Magnetic measurements, described in a separate specification PS-444-400-04, are required. IHEP shall develop assembly and test procedures, quality assurance (QA) procedures and test documentation (travelers) and shall record all pertinent assembly information and test records.

高能所应设计和制造总装需要的所有零部件和工装并应负责选择和采购磁铁总装所需要的所有材料和装置，包括美国产水接头、水管和紧固标准件。高能所应根据本说明书1.1.1款所列图纸，按SPEAR3所间合作协议附件1, 3.2款规定数量总装梯度二级铁，并负责检测和包装。检测项目应包括本说明书所列所有电测试、测量以及水测量。所有要求的磁测项目在另一生产说明书PS-444-400-04单独列出。高能所应制定总装和检测工艺，质量保证程序和质量检验文件（跟踪卡）并记录有关总装数据和检验数据。

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 3 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

1.3 Magnet Design / 磁铁设计

	145D	109D
Design Current (Amps) / 最大电流	688.4	688.4
Design String Voltage (V) / 最大串联电压	974	974
Design Power (kW) / 最大功率	19.17	15.59
Main Coils Resistance at 40°C (mΩ) / 40°C 电阻	40.46	32.88
Trim Coils Resistance at 40°C (mΩ) / 40°C 电阻	946.8	766.5
Maximum Water Pressure (psi) / 最大水压		250
Design Water Δp (psi) / 设计水压降		75
Water Flow at Design Δp & 20°C (gpm) / 设计水流量	5.23	5.89

2. TOOLING / 工装

2.1 Handling Devices / 起吊工装

The core and coils for the gradient magnets are heavy. Also, the gradient magnet design makes it convenient to install the coils with the core turned on its back. In order to protect the core and coils against damage during handling and protect personnel working with these heavy elements, proper handling and turning devices are required. The dipole shall not be lifted using the tension plates. The core lifting and turning device may be the same as used for the core fabrication and described in specification PS-444-400-02 Sec. 2.4. Addition of any holes or other features on the core assembly for attachment of handling devices not already described in the core drawing SA444-402-03 and SA444-402-83 shall be approved by SLAC.

梯度二级铁的铁芯和线圈很重，并且为了安装的便利，线圈需在铁芯背部着地时装入铁芯。故为了防止安装过程中造成铁芯、线圈和人身伤害，设计和制造适当的翻转和操作工装是十分必要的。二级铁不可用两侧的拉板起吊。铁芯的起吊和翻转工装可与生产说明书PS-444-400-02，2.4款要求铁芯制造时使用的相同。如需增加铁芯图纸SA444-402-03和SA444-402-83上没有的，为安装起吊设备用的工艺孔或其他设计应事先得到SLAC同意。

2.2 Test and Measurement Equipment / 检测和测量设备

Electrical and hydraulic tests and measurements required in this specification may use the same equipment used in similar tests and measurements for the dipole coil and described in specification PS-444-400-01 Sec. 4.2 and 4.3.

本说明书所要求的检测和测量可使用生产说明书PS-444-400-01中4.2和4.3款二级铁线圈类似检测和测量所用的设备。

3. MATERIAL / 材料

3.1 Mechanical Fasteners / 机械紧固件

All fasteners shall adhere to US standards for size and strength.

所用紧固件应为符合美国尺寸、强度标准的产品。

3.2 Electrical Bussing / 母线

Electrical connections between coils and to terminal blocks for power lead connections shall be fabricated using OFHC copper and shall be designed with sufficient cross sectional area so that

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 4 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

connections can be cooled convectively and can operate at safe handling temperatures. The maximum net current density for the design cross section shall be no more than 150 Amps/cm². The terminal blocks for the power lead connections shall be attached to the core so that power lead weights are entirely carried by the core. The busses shall be electrically insulated from the core with US designation NEMA G-10 epoxy fiberglass block, or equivalent.

线圈和磁铁电源母板之接的连接板的材料应为无氧铜板，其截面尺寸要保证连接板在磁铁运行时不
换崩 龇 奋蟠-电流密度不可超过150-才破 椒嚼连住5 僚茨赴達v ü 竟潭ā 商 境-载
其重量。母板应用美国NEMAG-10环氧玻璃纤维层压板或等同物与铁芯绝缘。

3.2.1 Electrical Bus Connection Fasteners / 电源母板连接紧固件

All fasteners required for mechanical connection between bus connections shall be steel and adhere to US dimensional and strength requirements. Split or conical (Belleville type) washers shall be used with the fasteners in order to ensure stored energy in all electrical joints carrying large currents (energy storage joints shall not be required for thermal interlock connections). All fasteners shall be appropriately torqued using the torque values listed in the travels.

所有电连接板之间的机械连接紧固件应为钢件，符合美国尺寸和强度要求。连接点需加弹
簧或蝶形垫圈，-员Vち 拥愕拇20.++性厄蟠總錫亏驴也 氏牧 硬恍璨捎么-能连接方式
)。紧固件的锁紧应严格按照跟踪卡所列扭矩操作。

3.3 Hydraulic Circuits / 水循环

Hoses and water fittings shall use US standards in callout of dipole magnet assembly drawings. Water manifolds shall be fabricated using 304 passivated stainless steel or equivalent.

水管和水接头应为二极铁总装图零部件明细表所列美国标准件。分水器材料应为304顿化不锈钢
或等同物。

3.4 Seal Material / 密封材料

Teflon tape is not allowed for water fitting joints. Loctite PST shall be used for joints sealing purpose.

不可使用太佛龙胶带密封水接头，应使用Loctite PST管胶密封。

3.5 Klixon Switch / 温控开关

All Klixon switches shall be tested before installation. After wiring, the system shall be tested for continuity.

温控开关安装前都需经过检测。布线完毕后，应测量系统的电路连通性。

4. Magnet Assembly / 磁铁总成

The magnet assembly shall consist of the following main components:

- Core;
- Six (6) main coils, two (2) trim coils and coil supports;
- Electrical power bussing, thermal interlock and wiring;
- Hydraulic assembly including an supply and return water manifold and hoses and fittings.

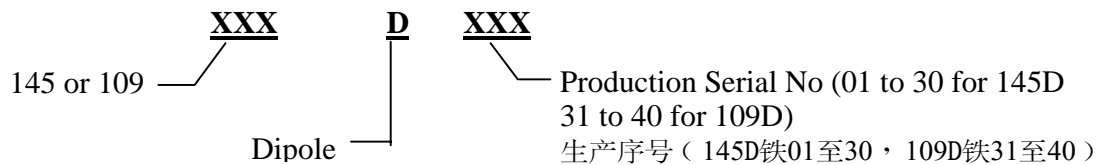
Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 5 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

磁铁总成包括以下主要元件：

- 铁芯，
- 六（6）个主线圈，两（2）个校正线圈和线圈支撑件，
- 电源母线板和连接板，温控开关和导线，
- 水路总成，包括进出水分水器以及水管和水接头等。

4.1 Identification / 身份号

Each dipole magnet shall be identified with a unique number. The number shall be stamped on the magnet nameplate. The identification number shall consist of three (3) parts: Family of dipole, Type of magnet and Production serial number. The 145D and 109D dipole shall share the same production serial number.



每个磁铁都有自己独有的身份号。身份号应打印在每个磁铁的铭牌上。身份号由3部分组成：二级铁的类别，磁铁的类别和生产序号。145D和109D二级铁使用统一连续序号。

5. QUALITY ASSURANCE, TESTING AND DOCUMENTATION / 质量保证，检验和记录

5.1 Traveler / 跟踪卡

An inspection sheet (traveler) shall be devised by IHEP and approved by SLAC. This traveler shall include pertinent magnet assembly records, inspection results and electrical and hydraulic test data. The information included in the traveler shall include at minimum the following data.

- Magnet identification number.
- Serial number of core.
- Serial number of coils.
- Electrical Test and Measurement Results
- Hydraulic measurement results. Names of technicians installing coils and dates.
- Names of technicians assembling bus bars and interlocks and dates.
- Names of technicians assembling hydraulic circuits and dates.
- Names of technicians performing the magnetic measurements and dates.
- Name of supervising technician approving the magnet for delivery and date.

The original of the completed, signed and approved traveler shall be filed at IHEP. A copy of a traveler for each completed magnet shall be delivered to SLAC along with the magnet.

高能所应设计总装用跟踪卡，经SLAC核准后使用。跟踪卡应包括适当的总装数据，检验结果和电-

- 磁铁身份号，
- 铁芯号，
- 线圈号，

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 6 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

- 电测结果和数据，
- 水测结果，
- 安装线圈技工姓名和日期，
- 安装母线和温控开关技工姓名和日期，
- 安装水系统技工姓名和日期，
- 磁测人员姓名和日期，
- 批准磁铁检验合格的负责人姓名和日期。

5.2 Tests and Measurements / 检测和测量

The following tests and measurements shall be conducted on completed magnet in order to assure its adequate performance in the accelerator during operation.

总装后的磁铁应进行如下检测和测量，以保证磁铁的正常运行。

5.2.1 Hydraulic Test / 水系统检测

5.2.1.1 Water Flow Test / 水流量检测

The test equipment may be the same as used to test the finished gradient dipole coils. With the water temperature in the range of 20 to 25°C and with the water flow adjusted so that the difference between the supply and return manifold pressure is 75 psi, the flow rate shall be measured. The flow rate under these conditions is 5.0 gpm for the 145D dipole magnet and 5.5 gpm for 109D dipole magnet. If the flow rate is low after checking all connectors, SLAC shall be notified immediately.

可使用测量二级铁线圈的同一设备进行此项测量。调整进出水压差至75psi，水温为20至25摄氏度，测量水流量。在此条件下145D二级铁的水流量为5gpm，109D二级铁水流量为5.5gpm。如果水流量低于此数据，检查各水路接头。如之后情况不见改善，应立即通知SLAC。

5.2.1.2 Pressure Test / 压力检测

After the flow test, blow all the water out of the circuits, pressurize with dry gas to 450 psi. There shall be no change in pressure after one hour.

完成流量检测后，吹干水路内水分，充450psi干燥气体。一小时后不应有压力泄漏。

5.2.2 Electrical Tests / 电检测

5.2.2.1 Hipot Test / 高压检测

The hipot test voltage shall be at least twice the operating (string) voltage plus one (1) kV. A hipot test shall be performed on the magnet main and trim coil system by applying a 2.75 kV DC and 1.0 kV DC respectively, for both 145D dipole and 109D dipole to power lead bus with the core and non measured coils system grounded for a minimum period of one minute. The measured leakage current shall not exceed 2 μ A.

高压检测的电压至少为系统串联电压的二倍加1千伏之和。故145D和109D二级铁的主和校正线圈系统高压检测电压分别为2.75和1.0千伏直流电压。检测时铁芯和不被测线圈系统应接地，测试电源与磁铁电源母线板连接，通电时间至少为一分钟。测漏电流不应大于2 μ A。

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 7 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

5.2.2.2 Resistance Measurement / 电阻测量

Magnet resistance shall be measured with a "double bridge" connected at the power lead busses. A double bridge is used to eliminate the inaccuracy due to current in the measurement circuit. The type and model number of the bridge used shall be noted in the test records. The measurement shall be made with the magnet temperature uniform throughout and steady state conditions prevailing. The coil temperature shall be recorded and the resistance measurement shall be to at least three significant figures. The acquisitive resistance of a production dipole coil system might be different from the normal value listed in section 1.3, but the deviation should not be significant. An average value of first four (4) production magnet main and trim coil system of each type magnet at 40°C shall be used as a criterion for the production magnet main and trim coil system resistance measurement. Variations of resistance greater than 3% of the criterion value when corrected to 40°C indicates a possible assembly error. If the variation exceeds 3%, first check the individual coil resistance to determine whether a bad coil has been installed before checking the bussing connections.

将双桥电阻仪与磁铁电源母板、馈线康缙琛K、诺缙肥俏、讼、馈康缙纺诘牡缙饗、响。电阻仪的类别和型号应记录在跟踪卡上。测量时磁铁的温度要保持基本不变。线圈的温度要作记录，所测电阻值至少要有三位有效数字，并作40°C标准化处理。生产二极铁线圈系统实测值很可能与1.3款所列设计值有出入，但偏差不应很大。实际应用时，应用每种磁铁头4块生产铁主线圈和校正线圈系统所得40摄氏度标准化处理后电阻值的平均值作为该种铁的标准值。凡生产铁主线圈或校正线圈系统与标准值数据相差3%以上，可能组装有误。在检查母线连接前，首先要检查是否使用了有问题的线圈。

5.2.3 Fiducialization / 定标测量

Fiducialization shall be performed at SLAC.

SLAC负责定标测量。

5.2.4 Magnetic Measurements / 磁测

IHEP shall perform magnetic measurements for all magnets. The magnetic measurements are described in a separate specification and must be completed prior to the final inspection, packaging for shipment and shipment to SLAC.

高能所应对所写盘、写挪、4挪庖、罅砦乃得鳌4盘、占赚、(19)跋泥、(16)酥埃、写挪项目都要逐一完成。

5.2.5 Final Inspection / 终检

Upon completion of the magnetic measurements, a careful final inspection shall be carried out. This inspection shall consist of a physical inspection as well as verification that all documentation is in proper order.

磁测完成后，对磁铁终检。此项检测包括检查硬件和文件的汇总、装订。

5.2.5.1 Physical Inspection / 硬件检查

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 8 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

A visual inspection shall be made of the core, coil, bussing, and water connections. Procedures shall be followed to verify that all fasteners are properly torqued, the interlocks are properly seated, and wiring is undamaged. All hydraulic circuits shall be thoroughly drained and dried. Open fittings for hydraulic circuits shall be properly sealed. Unpainted core surfaces shall be checked to see that they are properly coated and protected against moisture and rust.

对铁芯、线圈和水循环连接进行最後目检。要依次检查所有紧固件是否拧紧，温控开关位置是否正确，连接导线有-挥兴鹈恕K 纺诬辛羲 忠 沟卓站唬 蹈桑 饪淞 2 慌缙-铁芯表面妥善防锈处理。

5.2.5.2 Documentation / 文件

The required documentation collected at the end of magnet assembly shall consist of the following travelers and recorded data for each magnet (total of 12 documents). Copies of all these travelers shall be packaged with the magnet prior to shipment to SLAC or mailed to SLAC separate from the magnet shipment as required. Originals of all travelers shall be permanently filed at IHEP.

- Coil travelers (6 for main coils and 2 for trim coils).
- Core traveler.
- Assembly traveler.
- Magnetic field measurement data and floppy disk(s) containing the data.
- Quality certification signed by IHEP technical representative and other relative authority.

每个即将发运的磁铁所汇总的文件应包括如下跟踪卡和数据记录（共十二份文件）。所有这些文件的复印件应随铁装箱或如需要，随磁铁发出同时寄往SLAC。文件的原件应由高能所存档。

- 线圈跟踪卡（主线圈6份，校正线圈2份），
- 铁芯跟踪卡，
- 总装跟踪卡，
- 磁测数据和记录这些数据的磁盘，
- 由-心琴 际醮 砗推录 泄馐涸鹑饲 5. 闹柿亢细褪な楞-

6. PACKAGING AND SHIPPING / 包装和运输

6.1 Prototype Magnet / 样机铁

Immediately after the completion of satisfactory optimization of the end chamfer design, the prototype magnet shall be packaged and shipped to SLAC. Its documentation listed in 5.2.5.2 shall be airmailed to SLAC. The final inspection described in sections 5.2.5.1 and the packaging and shipping standards and procedures described in sections 6.2 shall be applied. The following items as well shall be delivered to SLAC along with the prototype:

- All machined and unmachined extra inserts.
- Intermediate and final machining tool path descriptions.
- Description and designs for all chamfer cutting tooling.

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 9 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

- The hardcopies of preliminary and intermediate measurement results, records of calculations to determine chamfer shapes.
- Electronic copies of preliminary, intermediate and final magnetic measurement results.

一旦样机完成端部削斜几何形状优化，立即逐一实施5.2.5.1所述终检项目，按6.2款所述—箱标准装箱，发运SLAC。除5.2.5.2款所列文件应用航空邮件寄往SLAC外，下述物品和文件也应与样机一同交SLAC：

- 所有经加工和未经加工的剩余活极头，
- 端部削斜预加工和最后成形的机械切割工具的进刀轨迹说明，
- 所有端部削斜切割工具的设计和说明，
- 各次实验测量和终测数—菀约案鞞蜗廛奔负涡巫从呕 扑愕母从 卍 -
- 记录有使用首、中间、尾各活极头方案的磁铁磁测数据的磁盘。

6.2 Production Magnet / 生产铁

6.2.1 Shipping Crate / 包装箱

No more than one magnet shall be packed in a shipping crate. The shipping crate shall be attached to a pallet so that it can be moved using standard handling devices (forklift or pallet jack). The design for the proposed shipping crate shall be reviewed and approved by SLAC. After receiving the prototype magnet, the shipping crate design shall be reevaluated by SLAC. If necessary, a redesigned shipping crate shall be used to ship the remaining production gradient dipole magnets. The design of the revised shipping crate shall be approved by both SLAC and IHEP.

每个包装内只允许装一块磁— 0—装箱底设计应该能用标准起货机械，如叉车或千斤顶之类移动箱体。高能所建议采用的包装箱设计应交SLAC会审、批准。在样机运至SLAC后，SLAC将进一步审核包装箱的设计合理性，如必要，批量二级铁的包装箱可能需重新设计。新结构应得到高能所—SLAC 双方认可。

6.2.2 Environmental Protection / 包装保护

The magnet shall be covered or wrapped to protect it from moisture within the shipping crate. It shall be properly braced and cushioned within the shipping crate so that it will not shift within the crate during handling and shipment.

磁铁本身应有防潮包装，与箱体之间加防冲击软隔断并与箱体底座牢固连为一体，使其在起运过程中不会上下左右窜动。

6.2.3 Packing List / 装箱单

A packing list shall be installed in the crate. It should contains the following information: Identification of the crate which shall consist of serial number of crate and serial number of shipment.

- Identification number of the magnet contained in the shipping crate.
- Date of packing.
- Name of the inspector who conducts the final inspection and his/her signature.

每个包装箱内应有一份装箱单，其内容应包括：

- 包装箱号，该号应能指明该包装箱属于X次发货的XX号箱。
- 该箱内所装磁铁身份号。

Cat. Code: S30731	Specification No. PS-444-400-03R0	Page 10 of 10
Author(s): Jack Tanabe, Nanyang Li		Date: Aug. 30, 1999

- 装箱日期。
- 终检员签字和日期。

6.3 Marking / 包装箱外标记

Identification of the crate, identification number of the magnet contained in the crate and the gross weight; the name of the receiver and final destination (SLAC) shall be clearly marked on at least two sides of the shipping crate. Arrows shall be conspicuously marked on the exterior surface of the crate to indicate its upright position.

包装箱至少要在两个外箱面清楚标明箱号，箱内所装磁铁身份号和毛重；，收件人和发往地址（SLAC），并在显著位置标明箱体直立向上放置箭头。

6.4 Installation in Shipping Container / 集装箱内放置

Several magnet crates will be installed in shipping containers for shipment to SLAC. These crates shall be braced in the container such that they will not shift during shipment. The crate orientation within the container shall be such that all crates can be accessed with a standard handling devices (forklift or pallet jack) without rotating or moving.

发往SLAC的集装箱内会放置多个包装箱。这些包装箱应在集装箱内妥善固定，使其不会在起运过程中窜动。包装箱在集装箱内的朝向，应能保证不做转、移动，就可使标准起运机械，如叉车或千斤顶进入其箱底。

6.5 Spare Coils / 备用线圈

Gradient dipole magnet main and trim spare coils will be built by IHEP. The same standards for shipment protection and handling described for the gradient magnet crates shall be applied. The crate shall be conspicuously marked on the outside with a description of the contents.

二级铁的包装要求同样适用于高能所生产的二级铁备用主和校正线圈。包装箱外应在显著位置标明箱内所装物品。

7. NAME PLATE / 铭牌

Each gradient dipole magnet shall attach a name plate show as below. Its position shall not interfere magnet operation.

每个梯度二级铁都应钉如下图所示铭牌，其位置不应影响磁铁的运行性能造成影响。

<p>SPEAR3 MAGNET</p> <p>Magnet ID No.</p> <p>Net Weight:</p> <p>SPEAR3 Drawing : Drawing SA444-402-01 or 81</p> <p>Date:</p> <p>Made in IHEP, China</p>
--