Compact Pulsed Hadron Source

The Compact Pulsed Hadron Source:

A Mid-Term Progress Report

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for the CPHS project team

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UCANS-II, Indiana Univ., 2011-07-06

Outline

- Brief Introduction of the Dept of Engineering Physics
- Overview of the CPHS project
- Recent progress of the CPHS project
- Progress on neutron devices & detectors
- Roles of on-campus neutron source & X-ray source
- Acknowledge & conclusion

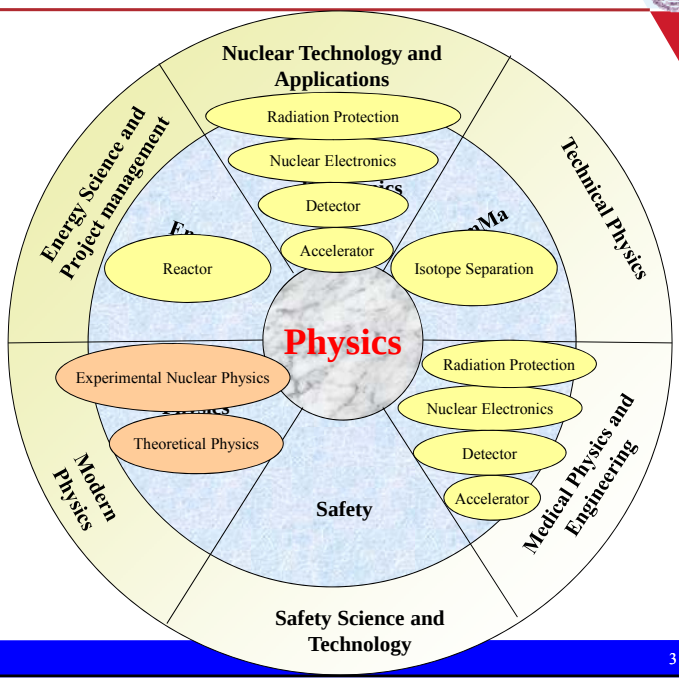
Multidisciplinary in Dept of Engineering Physics

Started in 1956

Faculty: 114

Undergraduate Students: ~600

Graduate Students: ~500



Research Highlights in the Dept of EP

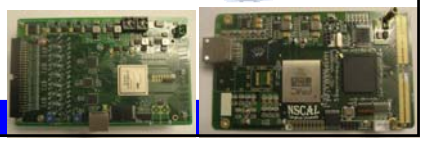
Cargo Inspection for Homeland Security

Series of Electron Linac

9 MeV SW Linac

6 MeV SW Linac

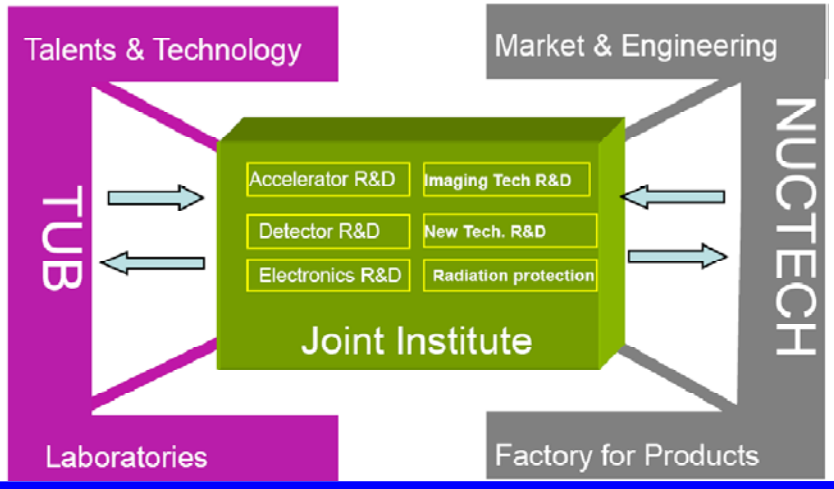
Series of Detectors & Electronics



Joint R&D of the Dept of EP with the Nuctech Co. Ltd.

- TUB plays an important role at the R&D of accelerator and other key-technologies in NUCTECH through

The Joint Institute between Tsinghua Univ & NUCTECH

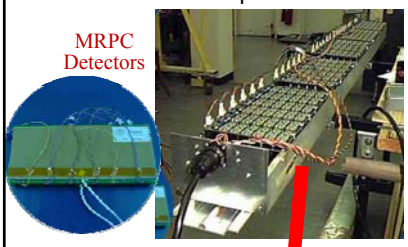


Research highlights in the Dept of EP

International Cooperation on High Energy Physics

Provide MRPC Detector for RHIC-STAR Experiment

MRPC Detectors



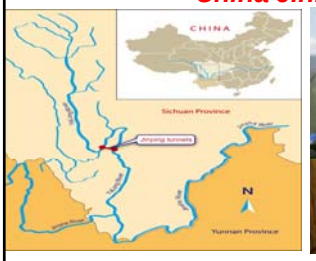
Join Neutrino Experiment Cooperation

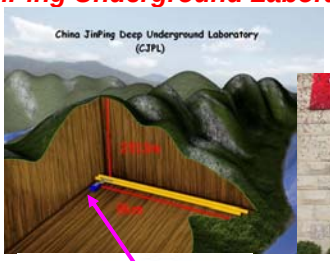
Daya Bay

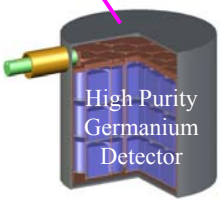
Super-Kamiokade

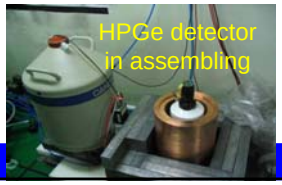
Research highlights in the Dept of EP

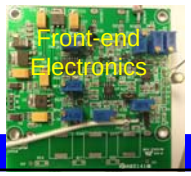
China JinPing Underground Laboratory (CJPL)











The CPHS project was approved in 2009

- **Hadron Application & Technology Center (HATC) was established in February 2009**

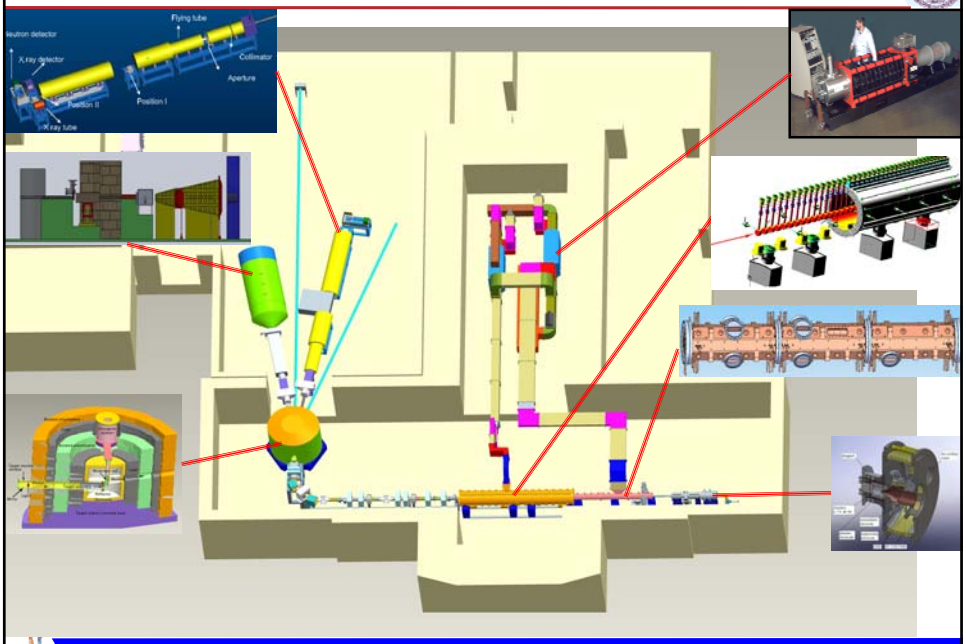
- **The CPHS project was approved in 2009**
  - The ***CPHS Project approved by the university*** around March 2009
  - Received a ***starting budget of ~$3M*** in June 2009
  - The ***First International Mini-Workshop*** in June 2009

Start point of the CPHS project

The 1st Int'l Mini-Workshop, June 2009, Beijing

CPHS is located on main campus of Tsinghua Univ.

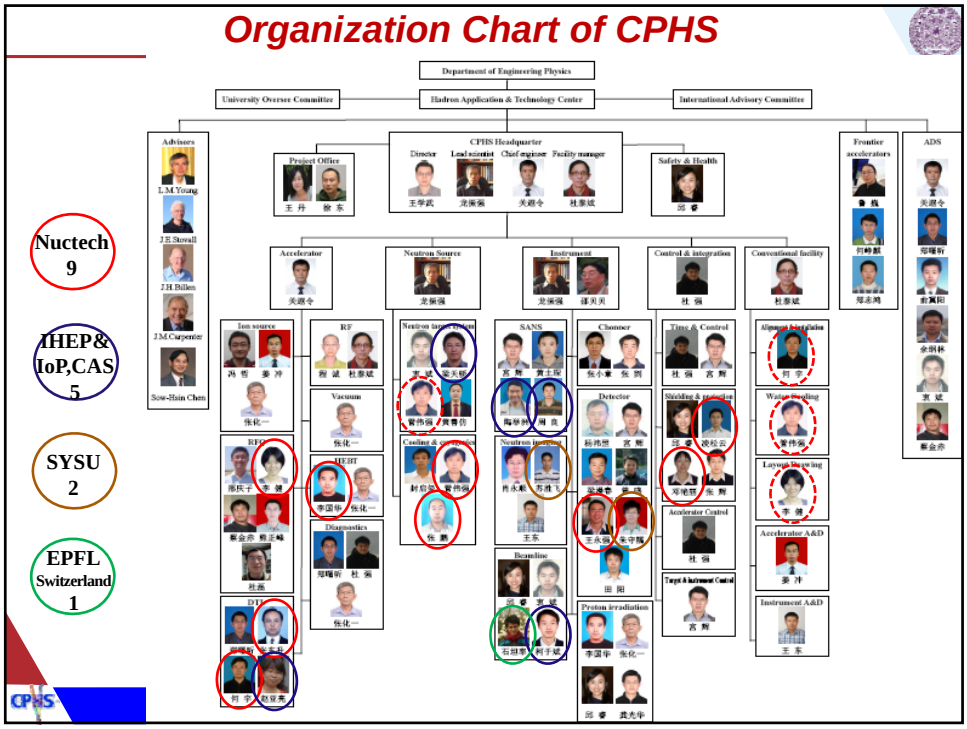
Layout of CPHS



Main parameters of CPHS's proton LINAC

Species	**proton**	
Beam Power	**16**	**kW**
Output Energy	**13**	**MeV**
Ion Source Extraction Energy	50	keV
RFQ Output Energy	3	MeV
DTL Output Energy	13	MeV
Average Current	**1.25**	**mA**
Peak Current	**50**	**mA**
Duration of Pulse	**500**	**μs**
Particle per Pulse	**1.56×10^{14}**	**Protons**
Repeat. Frequency	**50**	**Hz**
Beam Duty Factor	**2.5**	**%**
RF Frequency	**325**	**MHz**

Organization Chart of CPHS



Nuctech 9

IHEP& IoP,CAS 5

SYSU 2

EPFL Switzerland 1

CPHS team & the laboratory

Series of international workshops & reviews

Review of TMR and instrumentation
by J. M. Carpenter, Nov 2009

Mini-review of TMR & Instruments,
Kloten, Switzerland, March 2010

Discussion on Design of Accelerator
（February 2010，USA）

Review of Accelerator,
Beijing, October 2010

Progress of Construction of CPHS

Started Base Processing（May 2010）

Finished Capping（Aug 2010）

Finished Outside work（Apr 2011）

Finished inside work（Apr 2011）

1911-2011
清华大学百年校庆
TSINGHUA UNIVERSITY
CENTENARY CELEBRATION

ECR IS & LEBT

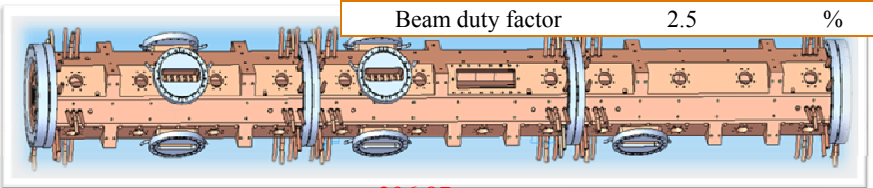
- Collaborating with IMP-CAS on designing & manufacturing
- Installed in April 2011

LEBT installed in the CPHS-LINAC hall
（Apr 2011）

Progress of RFQ LINAC

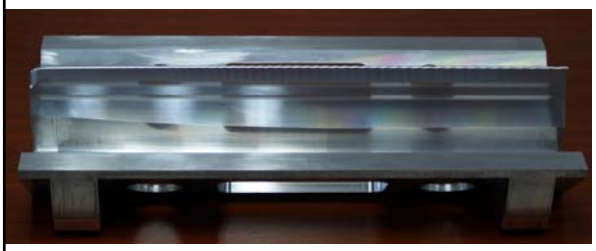
- Collaborating with experts group from the US on physical design
- Collaborating with Shanghai Kelin Co. Ltd. on machining
- Ready for field tuning with US experts group by the end of JUL 2011
- Plan to finish machining by the end of SEP 2011

Parameters	Value	Unit
Type	Four-vane	
Frequency	325	MHz
Input beam energy	50	keV
Output beam energy	3.0	MeV
Peak beam current	50	mA
Emittance (norm. rms)	0.2	□πmm mrad
Maximum surface field	32.1	MV/m
Pulse length	0.5	ms
Pulse repetition rate	50	Hz
RF peak power	537	kW
Beam duty factor	2.5	%

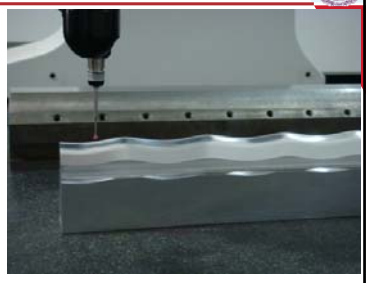


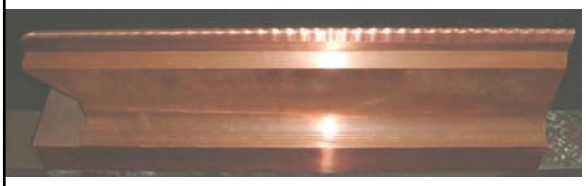
296.87cm

Fabrication status of CPHS-RFQ



Test segment 3 after the final machining





Test segment 4 after the final machining

Machining error: <±20μm

Three-coordinates measurement
(Platform size: 800mm×1.4m)

Fabrication status of CPHS-RFQ

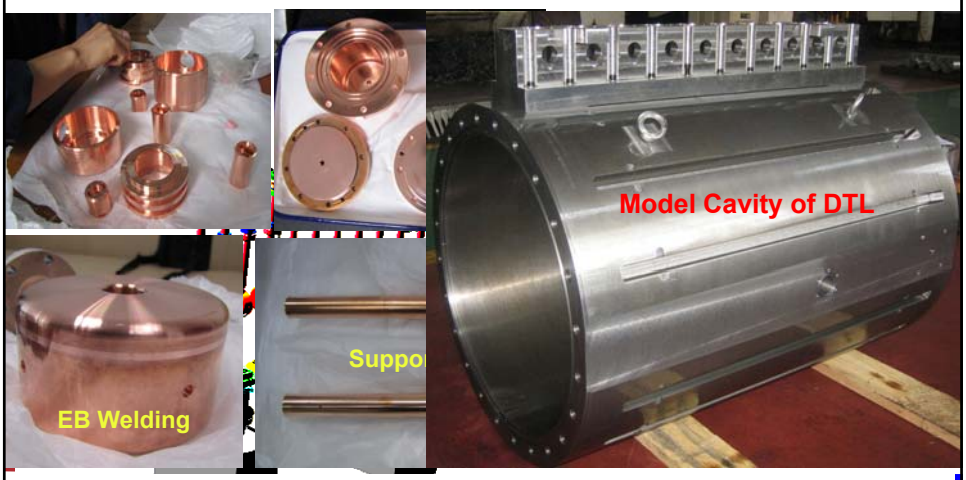
Vacuum ports

Aluminum tuners

6 horizontal electrodes after fine-machining

Progress of Drift Tube LINAC

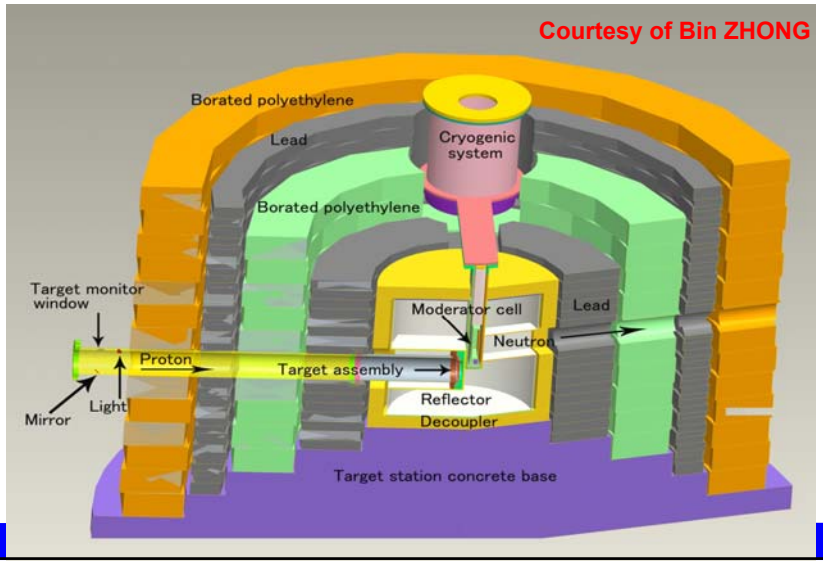
- Series of processing had been verified by the end of 2010
- Plan to finish machining by June 2012
- Plan to finish installation & conditioning by the end of 2012



Poster 20: **The Status Report of CPHS Proton Linac**

Target Station

- Collaborating with LENS，IoP-CAS, XJTU
- Review on overall design in NOV 2010, plan to build up by the end of 2011



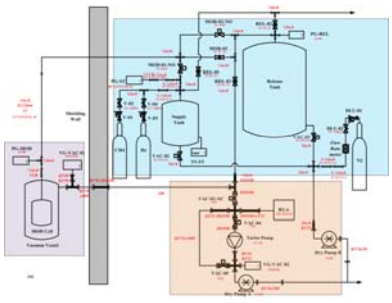
Target Station

Experimental facility for shielding material

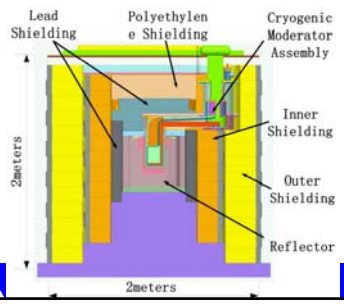
Experimental facility for cooling system for target

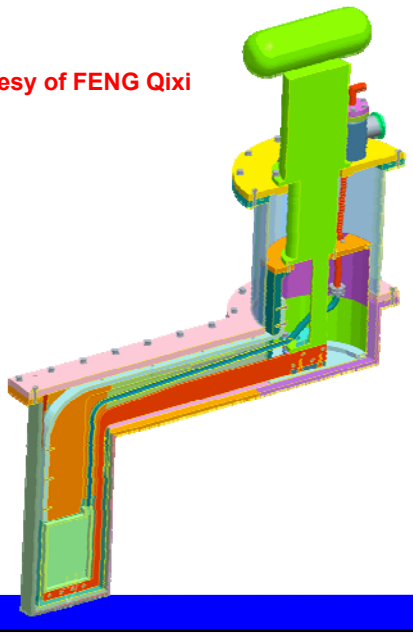
CPHS

Moderator



Courtesy of FENG Qixi





CPHS

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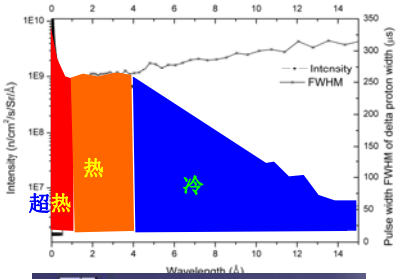
Moderator

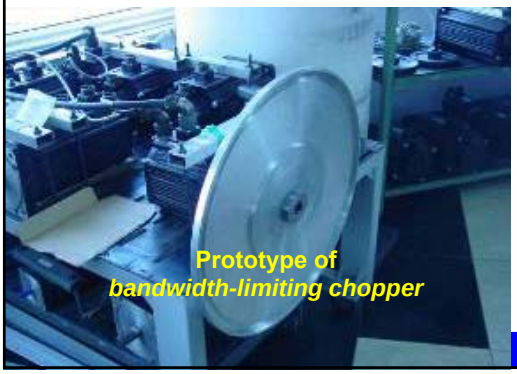
Experimental prototype for Moderator

Worktable for moderator

Neutron beam & Chopper of CPHS

- **Neutron Intensity**
  - Neutron Yield: 6×10^{13}n/s
  - Neutron fluence on the position of detector: 10^{4}~10^{5}n/cm^{2}/s
- Wide energy spectrum:
  - Wavelength: 0.5-15Å

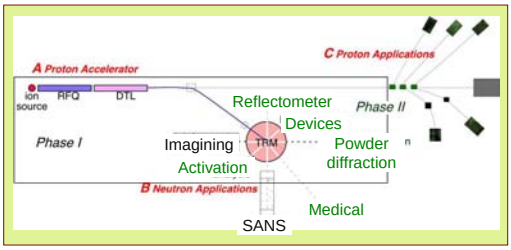




Prototype of *bandwidth-limiting chopper*

Review of design was taken on Nov 18, 2010

Plan of Neutron applications at CPHS



Phase I

SANS: Large (~1-100nm) structure of assemblies in solid, liquid, powder forms
- Micro-to-nano structures of composites
- Biology, nanobiotechnology
- Polymers and soft matters
- Complex systems

Imaging: Non-destructive of internal elements—structure & motion—in large structures & devices
- Materials engineering design
- Device testing & standardization
- Tomography & radiology (Medical, materials)
- Cultural heritage & artifacts

Phase II

Reflectometry: Films & (internal) surfaces including liquid interfaces
- Sensor & device heterostructures
- Biology, nanobiotechnology
- Polymers and soft matters
- Complex systems

Devices: Frontiers of neutron optics
- Beam filters
- Detector development
- Neutron polarization

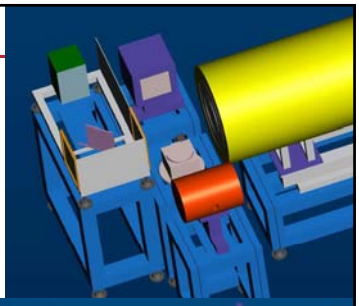
Medical: Neutron therapy
- BNCT
- Nuclear medicine

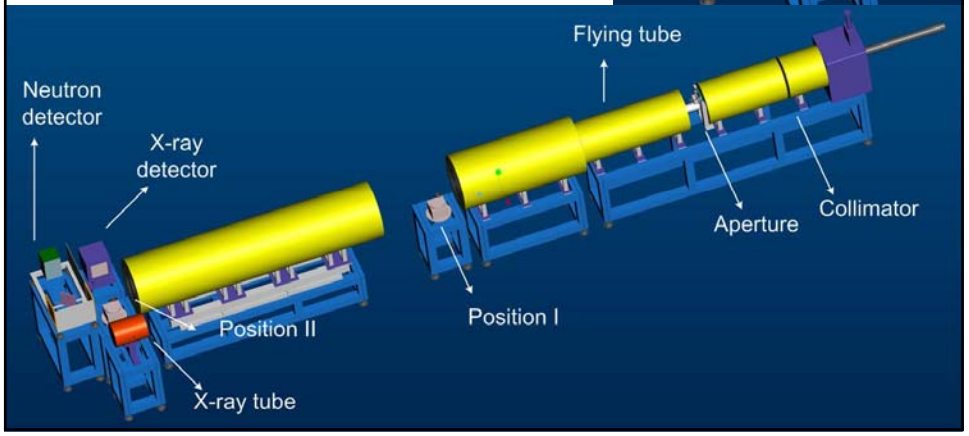
Powder diffraction: Crystal structure
- Solid-state chemistry & physics
- Novel materials

Activation: Chemical analysis of materials
- Elementary analysis
- Nuclear materials, security

Neutron imaging

- Base on the X-ray imaging technology & experience of Dept of EP
- Review on the overall design on DEC 20, 2010
- Plan to get the first neutron image by the end of 2011, when the first beam of neutron generated on CPHS





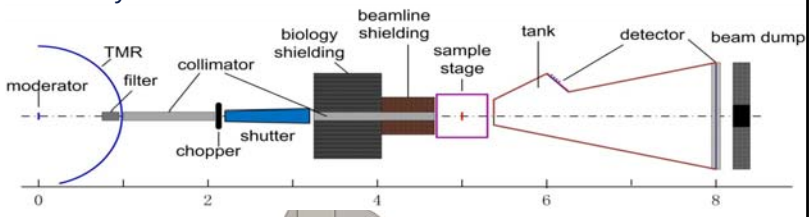
Neutron imaging

Fuji BAS-ND 2025 image plate
(20 cm x 25 cm)
Fuji BAS-5000 scanner

Engineering design is done
A section of flying tube is to be machined in July 2011

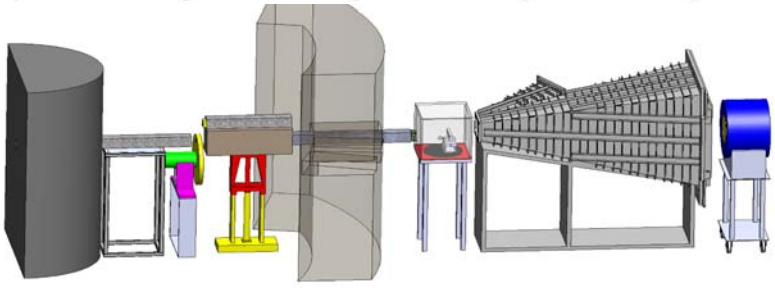
SANS Instrumentation

- Collaborating with IHEP-CAS, a joint-group started work since January 2011 and a laboratory is prepared in TUB
- Review on the overall design was held on January 8, 2011
- Plan to be built by the end of 2012



Poster 7:

Design progress of the SANS instrument at the CPHS



International Collaboration on Neutron Detector Developing

– Joined the collaboration of Developing Alternative Techniques to ^{3}He based Neutron Detectors for Neutron Scattering Applications, April 2010

^{3}He Detector Collaboration Agreement - April 2010

Collaboration Agreement concerning the Development of Alternative Techniques to ^{3}He based Neutron Detectors for Neutron Scattering Applications

Over the last years ^{3}He has been heavily used in gas filled detectors for neutron scattering due to its outstanding characteristics. It is also used in other applications, such as cryogenics and medical imagining, which are completely dependent on ^{3}He as there are no possible alternative technologies available today. Taking into account the available information, the undersigned partners (Annex 1) have come to the conclusion that demand for ^{3}He will exceed supply by a significant factor over the coming years and the cost may become prohibitive. In view of this they have agreed as a matter of priority to collaborate on a programme for the development of possible alternatives to ^{3}He detectors for neutron scattering applications. This document lays out the guidelines for the collaboration.

Basic principles

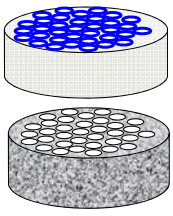
R&D of neutron detectors

– Collaborating with BNIF, CNNC

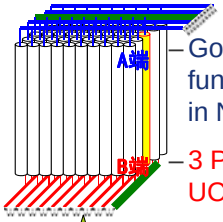
– Electronics of LPSD is under developing

^{3}He tube LPSDs

Micro-Channel Plate



Boron coated straw tubes



– Got the national funding ~ $ 2M in Nov 2010

– 3 Posters at UCANS-II

Foundation of the Dept of EP

γ-ray detectors

Electronics

ϕ20mm & ϕ 50mm ^{3}He tubes

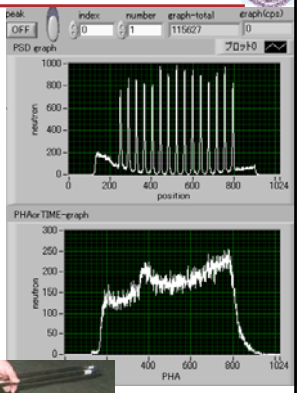
Poster 4: **Position reconstruction error research of neutron sensitive MCP**

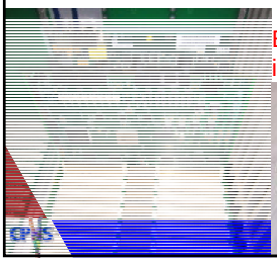
Poster 5: **Realization and evaluation of doping and coating neutron sensitive MCP**

Poster 6: **Parameters research of boron lined straw tube detectors**

R&D of neutron detectors

The testing experiment of self-made LPSDs at HLF with Hokkaido U & KEK in Feb 2011





Electronics for LPSDs is under developing

Poster 7:

Design progress of the SANS instrument at the CPHS

CPHS is on track to fulfill its preset goals

Sub-system	2011				2012				2013			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
ECR IS & LEBT	Apr 2011, get 50keV proton in TUB											
RFQ Linac												
RF system												
HEBT					Dec 2011, purchase & machining							
Vacuum System					of 3MeV system are accomplished							
TMR												
Imaging Station							Mar-Jun - Jun 2012,					
3MeV Installation & Conditioning							get 3MeV proton & neutron					
DTL							Jun 2012, purchase & machining					
SANS							of DTL & SANS are accomplished					
13MeV Installation & Conditioning									Dec 2012, get			
Construction	Apr 2011, construction is ready								13MeV proton & neutron			

THU - Scientific Facility for Advanced Quantum Probes

Compact Pulsed Hadron Source, CPHS (Proton/Neutron) +

Tsinghua Thomson-scattering X-ray source, TTX (Electron / X-ray)

TTX

Laser Beam	
Wavelength	800nm
Pulse Energy	500mJ
Pulse Duration	30fs
Focal Spot Radius	~0.031mm
Electron Beam	
Energy	30~45 MeV
Bunch Duration	1ps
Charge/Microbunch	0.7nC
Energy Spread	0.33%
Beam Radius	0.03mm*0.025mm
X-ray Pulse	
Photon Energy	24(90°)~48(180°)keV
Pulse Duration	160(90°)~1000(180°)fs
Number of Photons (phase I)	8.4×10^{6}(90°)~5.5×10^{7} (180°)
Number of Photons (phase II)	~10^{4}ppp~2×10^{7} pps=~10^{11} pps

Mission of on-campus compact sources

- **Roles of the CPHS & TTX: in-house sources**
  - ***Compact:*** State-of-the-art accelerator & source technology
  - ***Mission: On a fast-track:***
    - *Education: Training of students & staff;*
    - *Research: In-time to support the development of major projects & application of neutron in China*
    - *Innovation: Grow of domestic technology;*

Acknowledge & Conclusion

- Thank you very much for helping CPHS from the beginning!
- Hope to keep on track to fulfill the preset goals of the project
- Hope R&D on neutron devices & detectors will make progress successfully
- Hope to achieve its mission on Education, Research and Innovation together with TTX

Acknowledge & Conclusion

- Hope to enhance int'l communication and collaboration on neutron source & instruments and applications.


清華大學
Tsinghua University
Thank you!
SELF-DISCIPLINE AND SOCIAL COMMITMENT