Compact Pulsed Hadron Source, Department of Engineering Physics

UCANS-I

The Impact on Science & Technology of University-Based, Accelerator-Driven, Compact Neutron and Proton Sources: A Case in Point for China

Chun Loong 龙振强 *ckloong@gmail.com*

Jie Wei, Xialing Guan, and Xuewe Wang

CPHS

The Union for Compact Accelerator-driven Neutron Sources (UCANS)
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An Outline

1. A look back on the development of neutron sources in China and the impact on science. Is there a lesson learned?

2. What roles may a small accelerator-driven neutron source at a university play in education and research in China?

3. A brief introduction of the CPHS: Target station, Instruments, Activities & Progress.

4. Synergy with electrons, laser lights, and Thomson Scattering x-rays

5. From neutrons to hadrons -- CPHS to HATS (Jie Wei)

6. Conclusions

Neutron Sources in China: National Facilities




1958 HWRR | 1979 upgrade HWRR | ~1999 CARR | 2010 criticality CARR





2000 Lu visiting ISIS | 2002 1st International Meeting | 2004-2009 many user meetings | 2010 | CSNS 2017(?)

- ***Built upon national labs*** (CIAE, IoP, IoC, IHEP), reach out to universities later
- Go Big! (ILL, ISIS scale) while ***smaller, precedent sources either shut down or nonexistent***
- Traditionally R&D ***based on in-house groups***, now committed to serve external users

This is not meant to be critical, rather it is a reality in China. The outcome is very slow and inert user involvement. We believe that ***small sources at universities can help***.

An Example of University-Based Reactor: FRM-II of Tech. U. Munich

JÜLICH FORSCHUNGSZENTRUM
Physik Department
LMU Ludwig-Maximilians-Universität München
JCNS Jülich Centre for Neutron Science
RCM Institut und Lehrstuhl für Radiochemie
RWTH AACHEN UNIVERSITY
GKSS FORSCHUNGSZENTRUM in der Helmholtz-Gemeinschaft
HELMHOLTZ ZENTRUM BERLIN für Materialien und Energie
Max-Planck-Gesellschaft

MRI Klinikum rechts der Isar
Fakultät für Maschinenwesen
itm isotopen technologien münchen AG
TECHNISCHE UNIVERSITÄT DRESDEN
Fakultät für Maschinenwesen
Universität Augsburg
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN
Universität der Bundeswehr München
itg isotope technologies Garching GmbH
TECHNISCHE UNIVERSITÄT DARMSTADT
itm isotopen technologien münchen AG
Universität zu Köln
TU Clausthal

- ***Built on a university campus*** -- the home base of a user network
- Advance from cumulative milestone achievements: FRM-I (Atomic Egg) → FRM-II → reusable Egg
- From the outset ***based on user groups***, FRM-I → ILL under Heinz Maier-Leibnitz

Not only able to attract scientific users, but also bring neutron labs and industry to the university.

Why Accelerators? Why a Union?

Today building a research reactor is no longer a viable choice for a university. But small to medium size accelerator-driven sources appear to have great potentials for education, research and interdisciplinary applications.

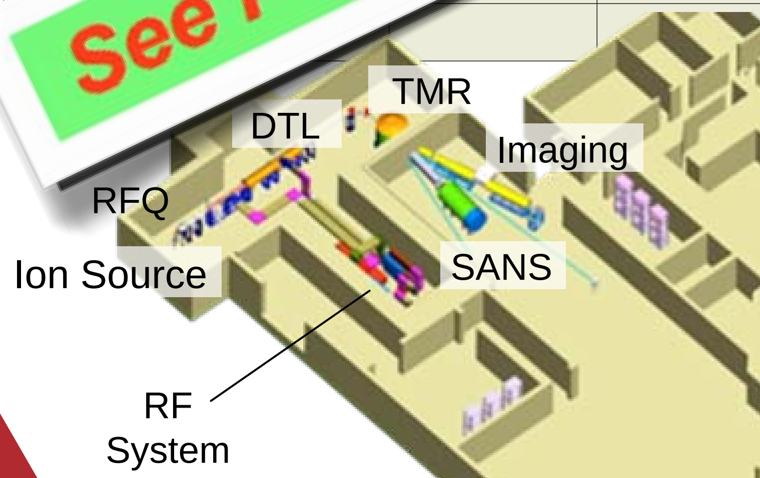
On the other hand, any such a facility is too small to cover the broad spectrum of scientific applications single handedly. We--the ***compact accelerator-drive neutron sources***--are expected to differ from yet complement to each other. Together we can play a much stronger role, hence the desire for a ***union***.

> In China, in view of the under-developed neutron user community, we believe that an accelerator-driven source on a university campus can add impetus to user training, education of the neutron method, and broadening research interests using neutrons, thereby benefiting CARR and CSNS.

The Compact Pulsed Hadron Source (CPHS)

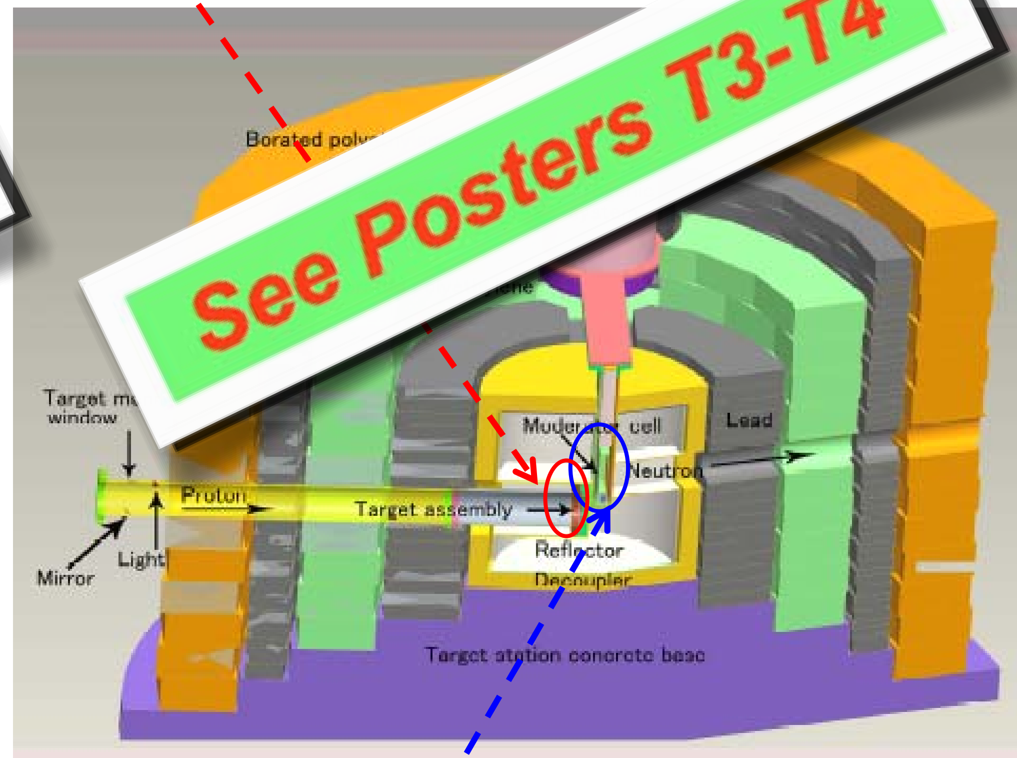
Key Design Parameters of CPHS			
Protons		Neutrons	
Beam power on target	16 kW	Target for ~6 cm x 6cm proton beam	
Output energy		Material	Be ~1 mm thick
DTL	13 MeV	Coolant	Chilled water
RFQ	3 MeV	Moderator	
Ion source	50 KeV	Material	Sold CH…
Average beam current	1.25 mA	*n*-emitting surface	
Pulse repetition rate	50 Hz	Ref…	
Pulse length	0.5 m…		
Peak beam curre…			…1 x 10^{12} /cm^2/s
Proton…			

See Posters A2-A6



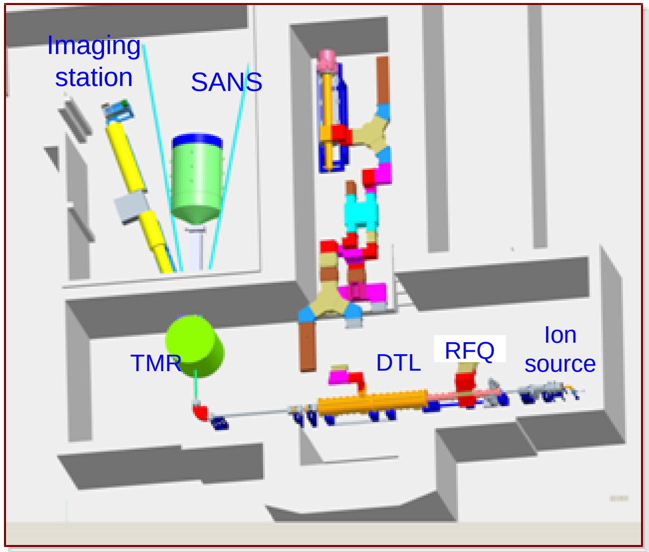
The range of a 13-MeV proton impinging on Be is about 1.2 mm, depositing a peak heat flux up to 3 MW/m^2 and creating hydrogen bubbles. We adopted the LENS new Be-target design using water cooling while engaging in R&D of liquid-metal cooling system (JM Carpenter)

See Posters T3-T4

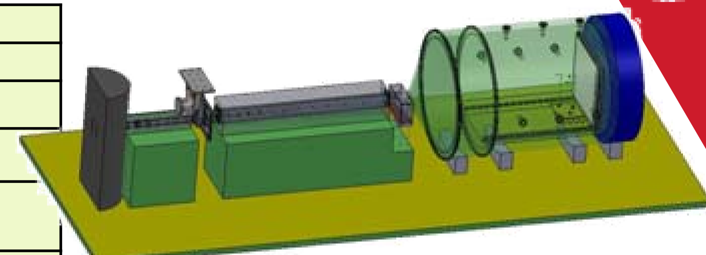


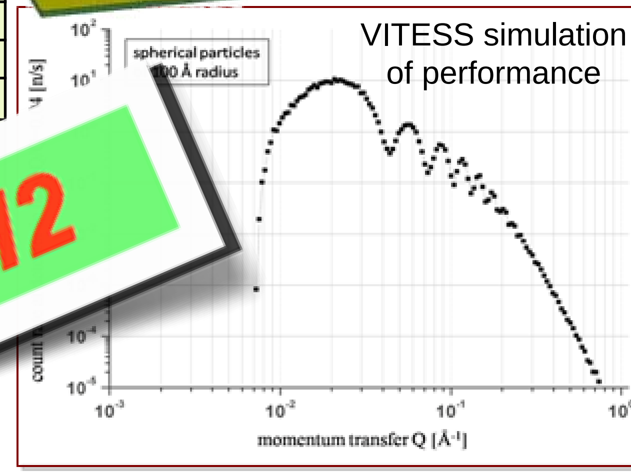
Following LENS' experience, we optimized the design of a solid-methane moderator using Monte Carlo simulations (MCNP).

Beamlines of CPHS: SANS and Imaging/Radiography



Source frequency	50 Hz
Wavelength Range	1 – 10 Å
Source-to-Sample	5 m
Sample-to-Detector	3 m
Collimation	Circular pinhole collimation
Sample size	1-2 cm diameter
Area Detector	^{3}He LPSD Array
Active Area	1 x 1 m^2
Pixel Size	12 mm
Q-Range	0.006 – 1 Å
Q-Resolution (δ Q/Q)	2%
Flux at sample positio	

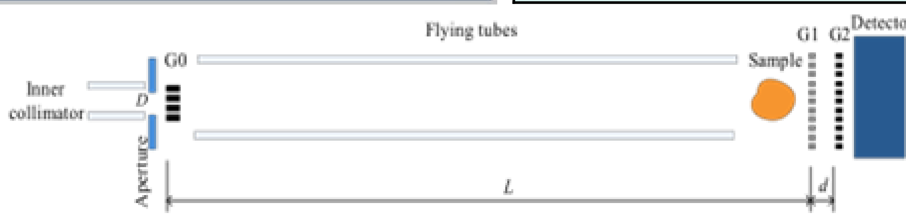




See Posters I1-I2

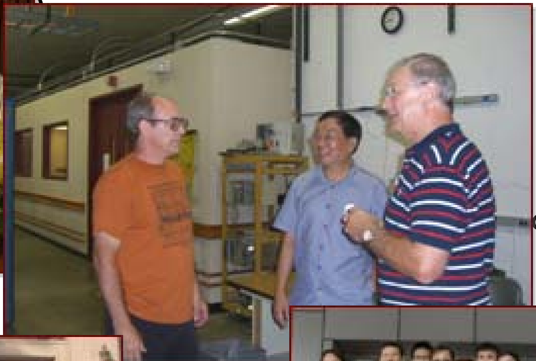
Apertures: 3cm, 1cm, 0.5cm diameter holes
Two sample positions: 3 and 7 m from source
Neutrons: Scintillator, CCD, & image plate
X-rays: 450 kV source and flat-panel detector
Imaging (mins-hrs), computed tomography (days)

Gratings-based Talbot-Lau-interferometry method for phase-contrast imaging



Our Wish of Going From Point A to Pont C (Mid 2012)

ound May-June 2009



& testing,

r system, Aug 2009

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- *A* ... d

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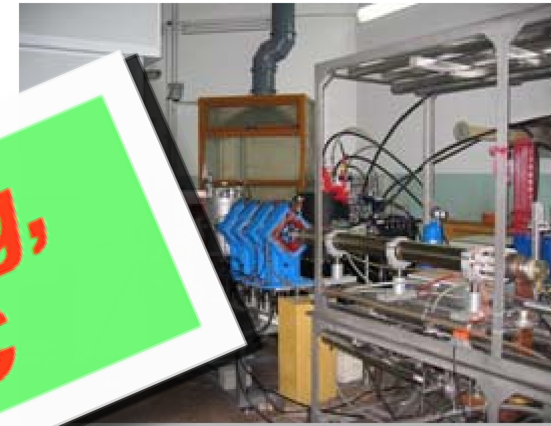
- Attended the H ... blish
  imaging, June
- Secured ***seco***
- Visited ***Tsinghua University at Hsinchu***, Taiwan and ***Sun Yat-Sen University*** at
  Guangzhou and established MOU for cooperation

Neutrons, Protons, Electrons, X-rays & Laser Lights at CPHS + TTX

Tsinghua Thomson Scattering X-ray Source (TTX)

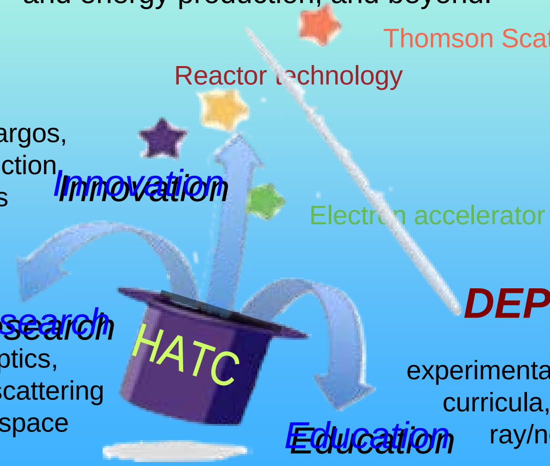


Talk by CX Tang, PM Section C

Additional beamlines extendable to 20+m long, e.g., a powder diffractometer

The Hadron Application & Technology Center

The mission of HATC is threefold: Education, Research, and Innovation. Tsinghua University will develop hadron accelerator technologies, in collaboration with the extant electron-accelerator and laser research programs and with the domestic/international communities, for extensive applications, from neutron & proton user research facilities to medical therapy to accelerator-driven subcritical system of transmutation of nuclear wastes and energy production, and beyond.



Elaborate by Jie WEI

- Allowing even more compact accelerators
- A robust & reliable target
- A better optimized neutron moderator
- Applications of novel optical devices and less expensive & durable detectors
- ....

Argonne National Lab, USA

Compact Pulsed Hadron Source, Tsinghua U., China

Lab Quantum Beam System Engineering, Hokkaido U., Japan

The KENS Neutron Science Division, KEK, Japan

Advanced Research Center for Beam Science, Kyoto U., Japan

The Low Energy Neutron Source, Indiana U., USA

Institute of Heavy Ion Physics, Peking U, China

VCAD System Research Program, KIKEN, Japan

It is just a beginning, we welcome your joining the UCANS

Thank You