Collaboration on Advanced Hydrogen Storage Materials

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Why hydrogen?

Secondary energy that can be generated from various primary energies

Only the fuel which can be converted to/from electricity

Hydrogen is accepted as the fuel for fuel cell vehicles

For the stationary application, hydrogen is produced from natural gas or other fuel at the site where FC is installed.

Why hydrogen storage materials?

Volume density is a key for on board storage.
How do we overcome?

Gaseous H_2:	12 MJ/m^3
Natural Gas:	39 MJ/m^3
Liquid H_2:	10,070 MJ/m^3
Gasoline:	34,600 MJ/m^3

One of the Targets for Hydrogen Storage Tank

Volume density

5 kg of hydrogen in 100 L tank（>50g/L）

Weight density

5 kg of hydrogen in 100 kg tank（>5 mass %）

Hydrogen Release Temperature and Pressure

A few to several bars of hydrogen at 80 ºC

(Exhaust temperature from Fuel Cell)

Assumption: 100 km cruising by 1 kg of hydrogen

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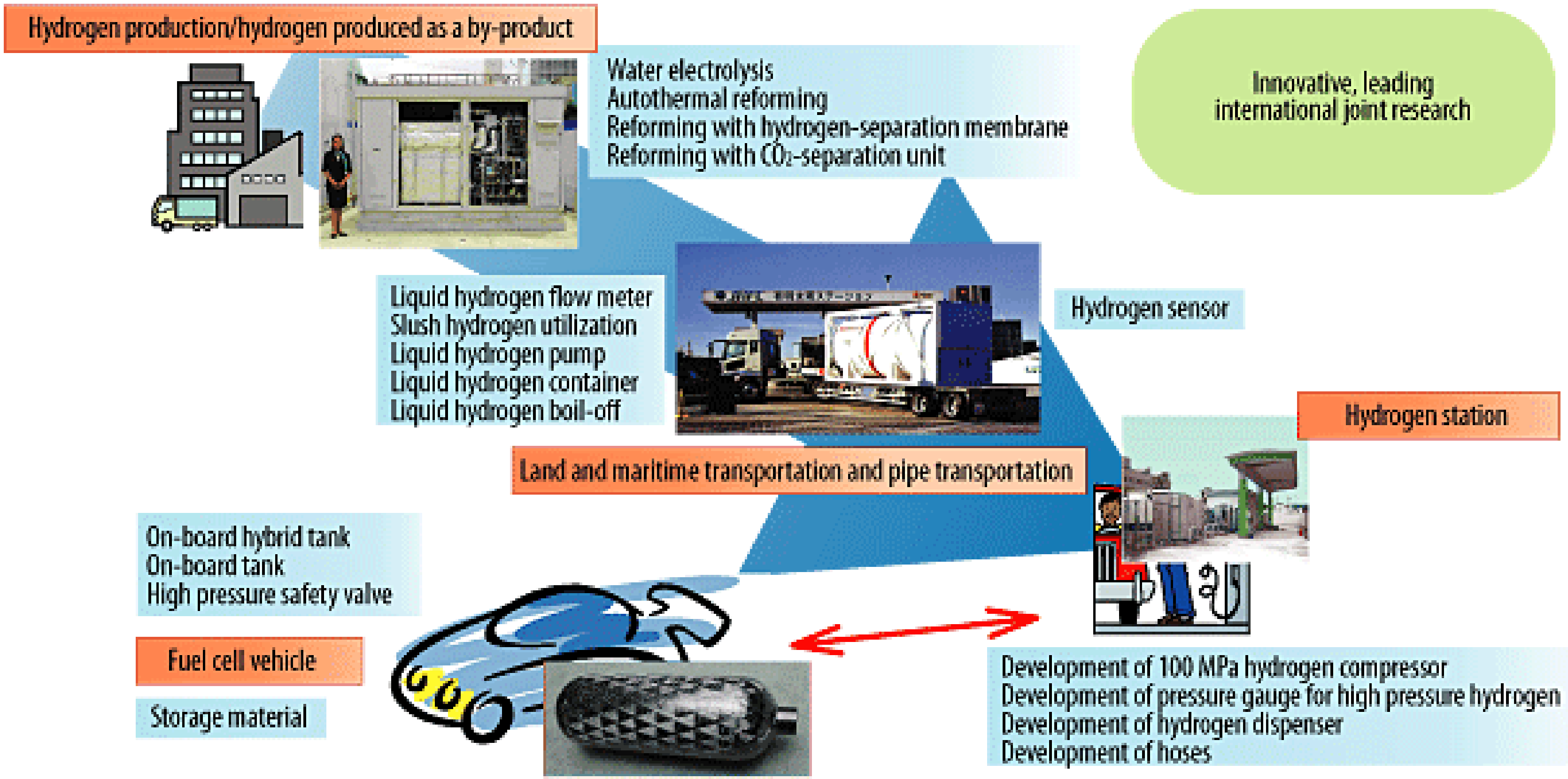

Development for Safe Utilization and Infrastructure of Hydrogen

FY2003-2007 (5-year plan)

(http://www.nedo.go.jp/english/activities/portal/gaiyou/p03015/p03015.html)

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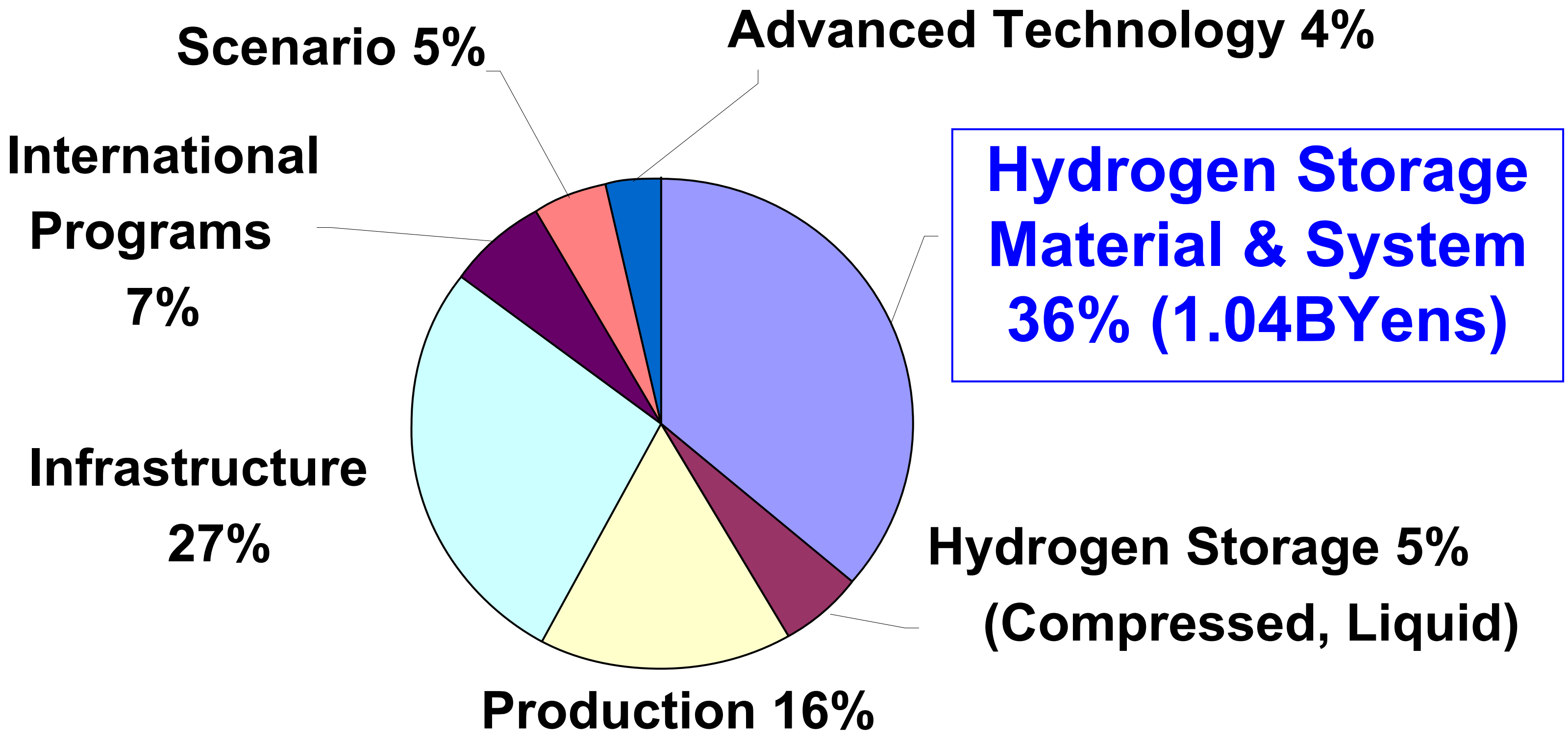
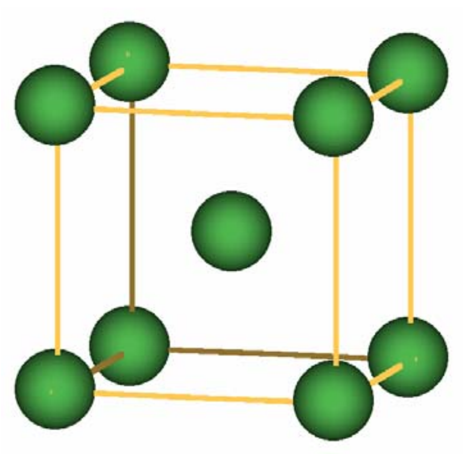
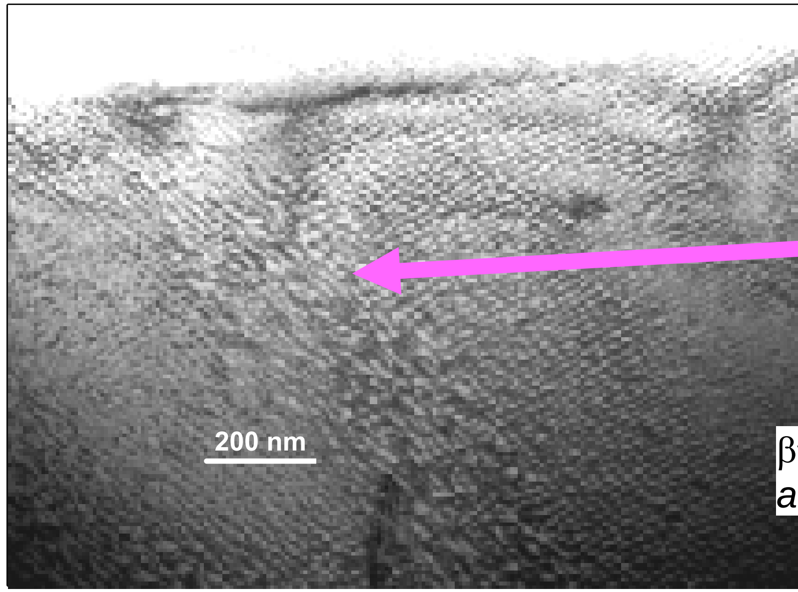
The budget of “Hydrogen infrastructure development and safe utilization of hydrogen” for the fiscal year of 2006

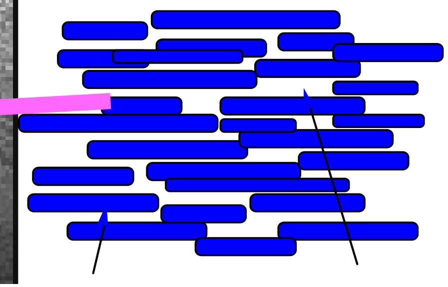


BCC alloys developed by TOYOTA and AIST



BCC structure





Ti-V-Mn alloy

Nano-structure is the key for higher hydrogen capacity (2.6 mass %) than conventional hydrogen storage alloys (1.4 mass %)

Development of Laves phase related BCC alloys by Industry

FCHV at EVS-13 October, 1996, Osaka, Japan

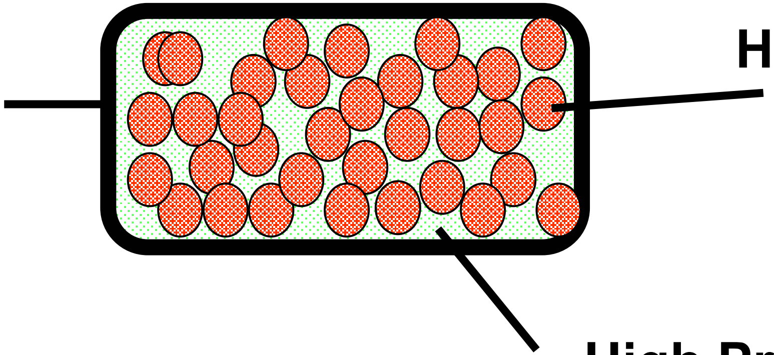
FCHV-3 March 2001

Fuel cell vehicles with BCC alloy operated at low hydrogen pressure for onboard hydrogen storage developed by TOYOTA Motor Co.

“Hybrid Hydrogen Storage Tank”

Metal Hydride - High Pressure Hydrogen Storage Tank

1. Alloy occupies only half of space in the vessel
2. Remaining space is filled by pressurized hydrogen
3. Lighter than “conventional metal hydride tanks”
4. More compact than pressurized gas cylinders



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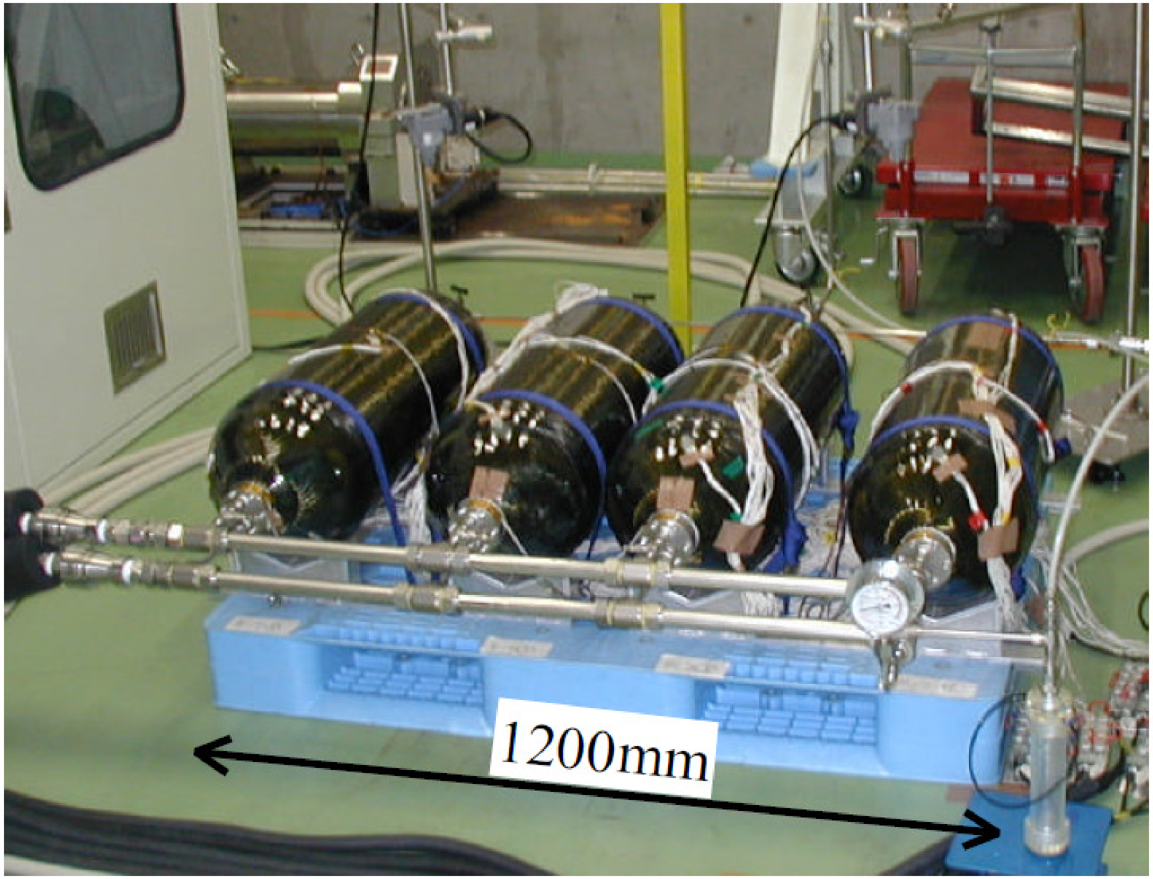
The hybrid tanks developed by TOYOTA Same size and numbers to FCHV on road



D. Mori, et al. *J. Japan Inst. Metals*, **69**, 308 (2005).

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“Hybrid Tank System” or “High-pressure metal hydride tank system” developed by TOYOTA

Combination of high pressure cylinder of 35MPa and metal hydride working below -30ºC.

In the most recent report, 9.5 kg of hydrogen was stored by 420kg and 180L of tank using the **BCC alloy** with 2.5 mass% capacity.

2.2 mass% in weight and **50 g / L** in volume as **system has been reached.**

Both weight and volume hydrogen densities are acceptable for on board application if proper alloys are developed.

Research as "Back to the Basic"
- Policy of the Government -

The Polymer Electrolyte Fuel **C**ell **C**utting-edge Research **C**enter (**FC-Cubic**)
- Established April 2005 at AIST
- Cost reduction and improvement of durability

Research Center for Hydrogen Industrial Use and Storage (**HYDROGENIUS**)
- Established July 2006 at AIST
- Hydrogen embrittlement, fatigue and tribology

Advanced Fundamental Research Project on Hydrogen Storage Materials
- **Launched in June 2007.**
- **AIST is role of the "Innovation Center"**
- **Improvement of Hydrogen storage materials**

Advanced Fundamental Research Project on Hydrogen Storage Materials

Term：FY2007～FY2011　　Budget for FY2007： 740 MYen (6.4 M US$)

To establish compact and energy efficient hydrogen storage system through fundamental studies of materials

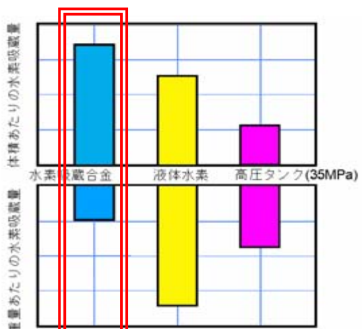
Background

- ○ To realize compact and energy efficient hydrogen storage is a key technology
- ○ Japanese technology of hydrogen storage materials is competitive
- ○ Breakthroughs in energy densities are needed

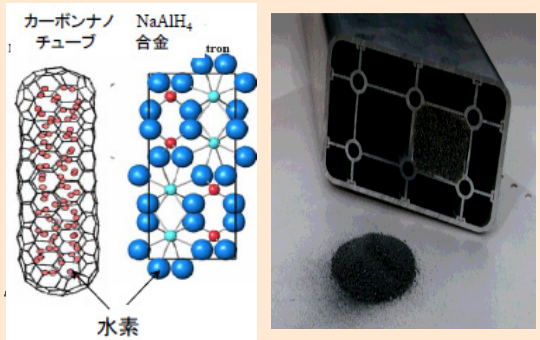
Plan

- ○ Make network among research labs
- ○ Invite young scientists from other field

（Large scale facilities such as Spring-8 (synchrotron) and J-PARC (Neutron) should be used for characterization）



〔水素貯蔵材料の能力〕



［hydrogen storage materials］

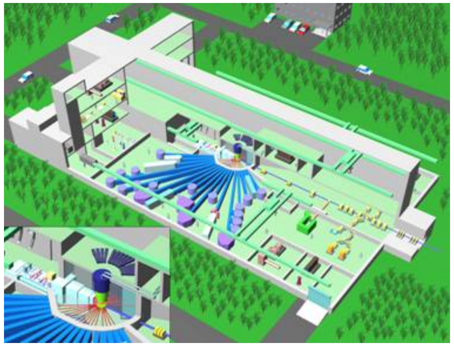
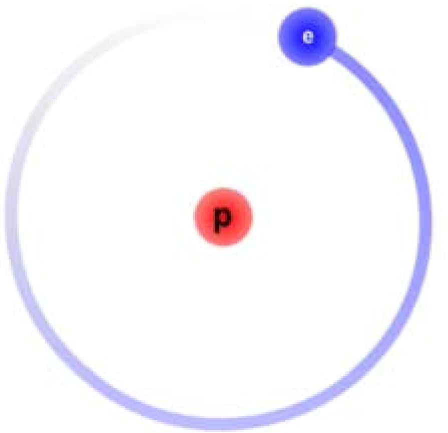


Image of J-PARC

How do you “see” hydrogen?



$^{1}_{1}H$

Hydrogen

Hydrogen has one proton and one electron.

-To see the **proton or nuclei**

Neutron is the best method to obtain information from hydrogen ← **J-PARC**

-To see the **electron**.

Very strong X-ray is one of the methods because hydrogen has only one electron.

← **SPring-8**

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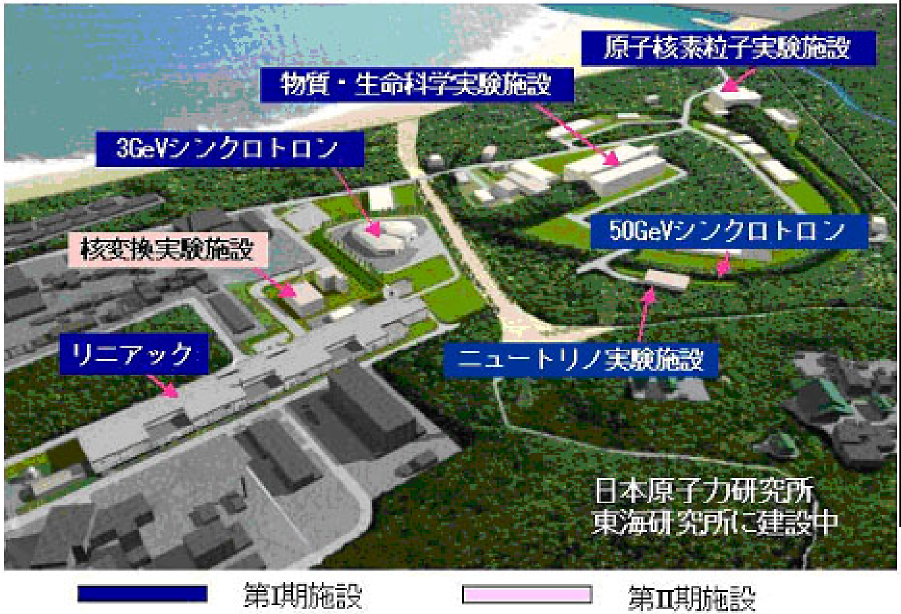
Synchrotron radiation and Pulsed neutron SPring-8 & J-PARC



J-PARC

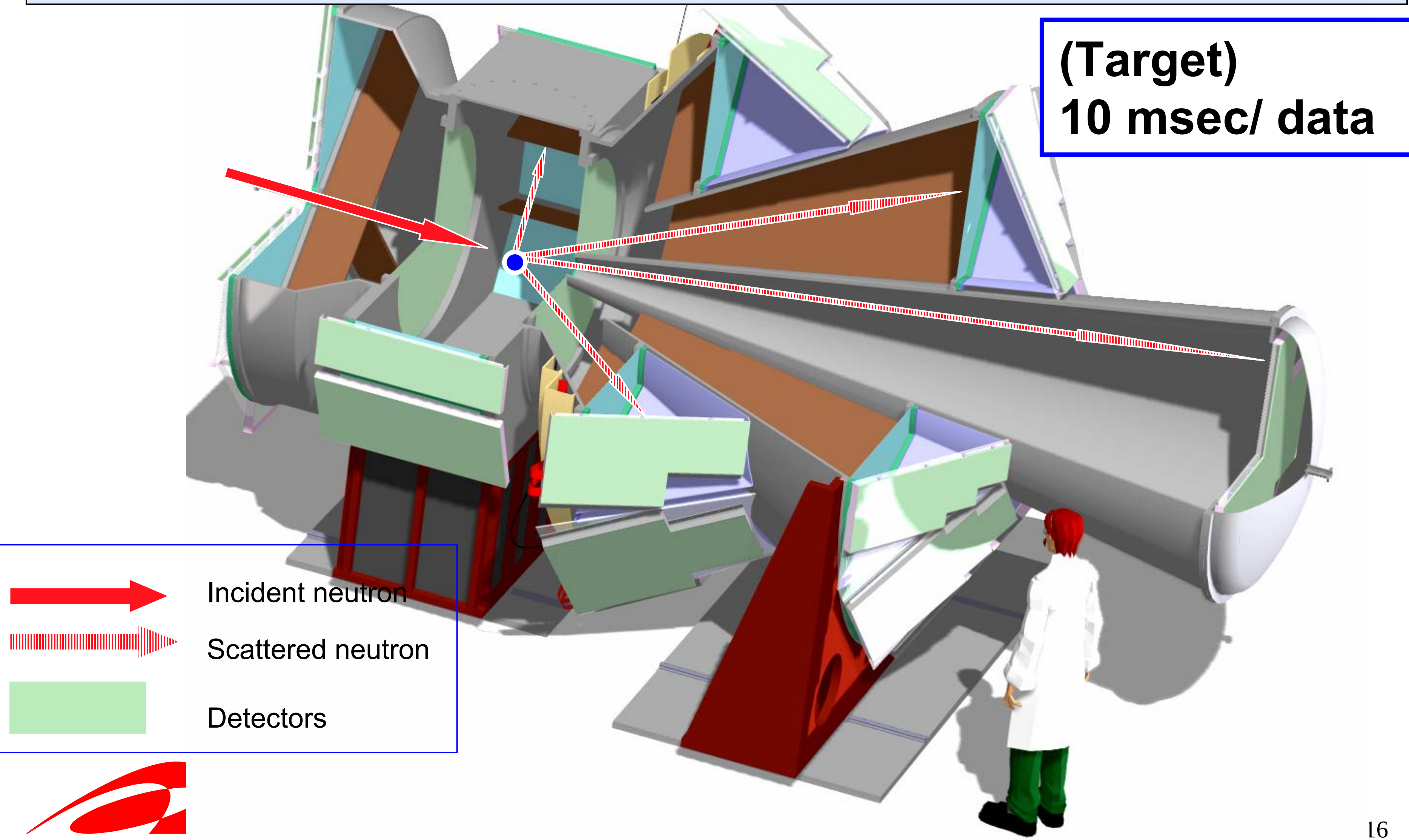
Spallation neutron source
Operation from 2008

Total scattering spectrometer for in-situ measurements under H_2 will be installed

SPring-8

Synchrotron radiation source

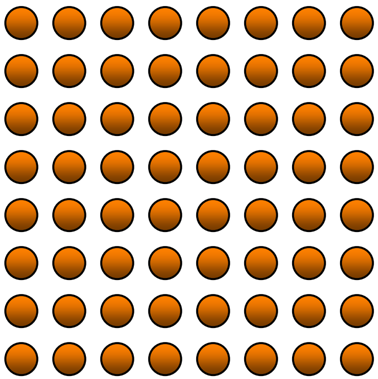
In-situ Total Scattering Machine under construction at J-PARC for the Advanced Fundamental Research Project on Hydrogen Storage Materials



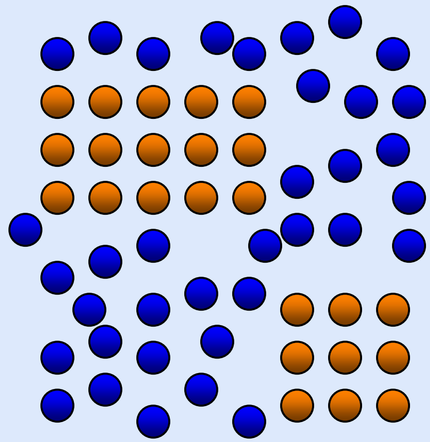
Total scattering is the most powerful tool to analyze the hydrogen position

Complex structure

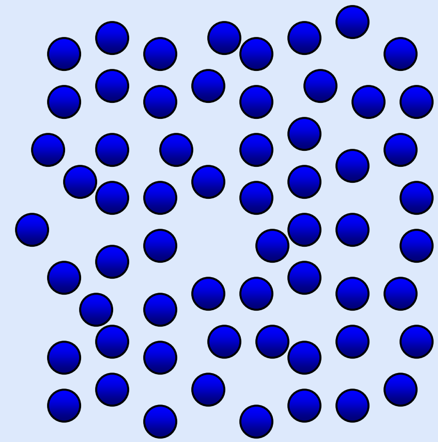
Simple structure



Ordered structure



Mixture of order and disordered structure



Disordered structure

Not only ordered structure but also complex structure including liquid can be analyzed

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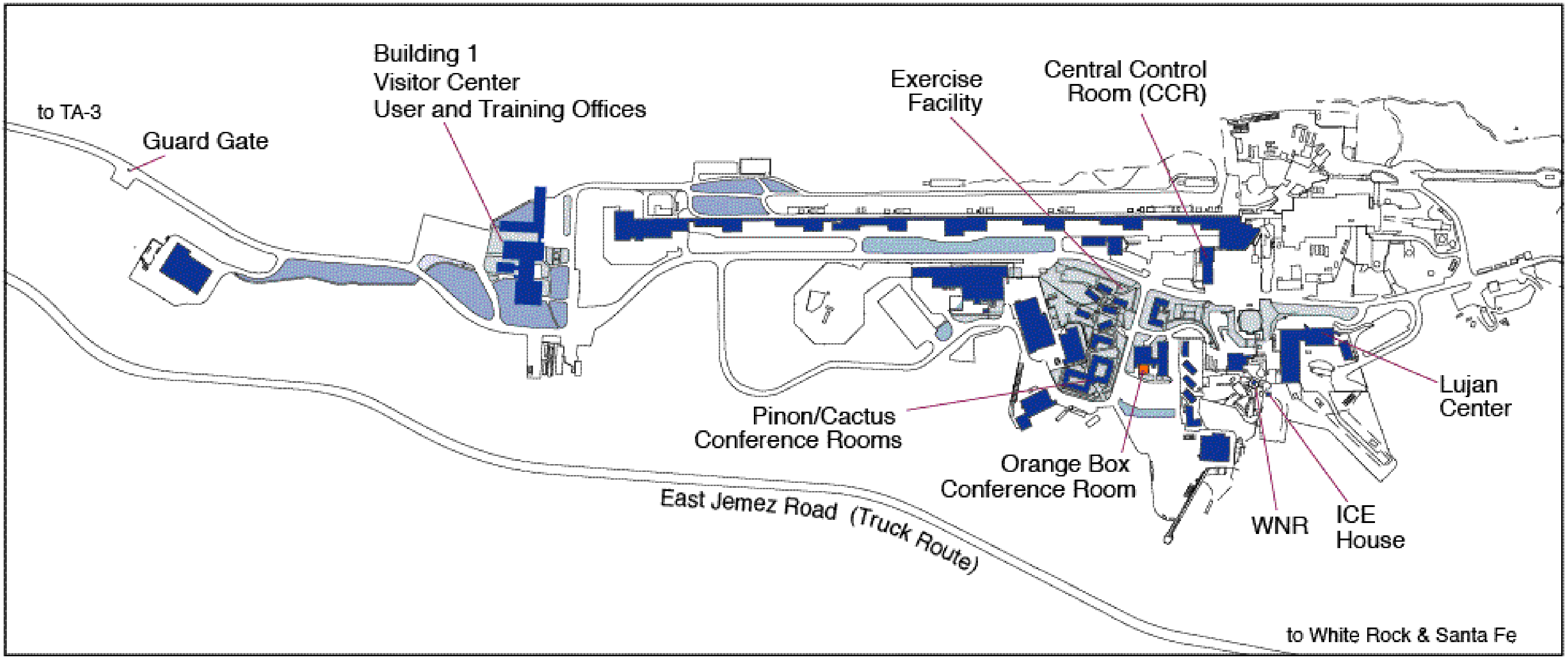
LANSCE: Los Alamos Neutron Science Center

- Neutron facility operated from 1983-



From http://www.lansce.lanl.gov/maps/index.html

NPDF of LANSCE is the total scattering machine operated from 2002

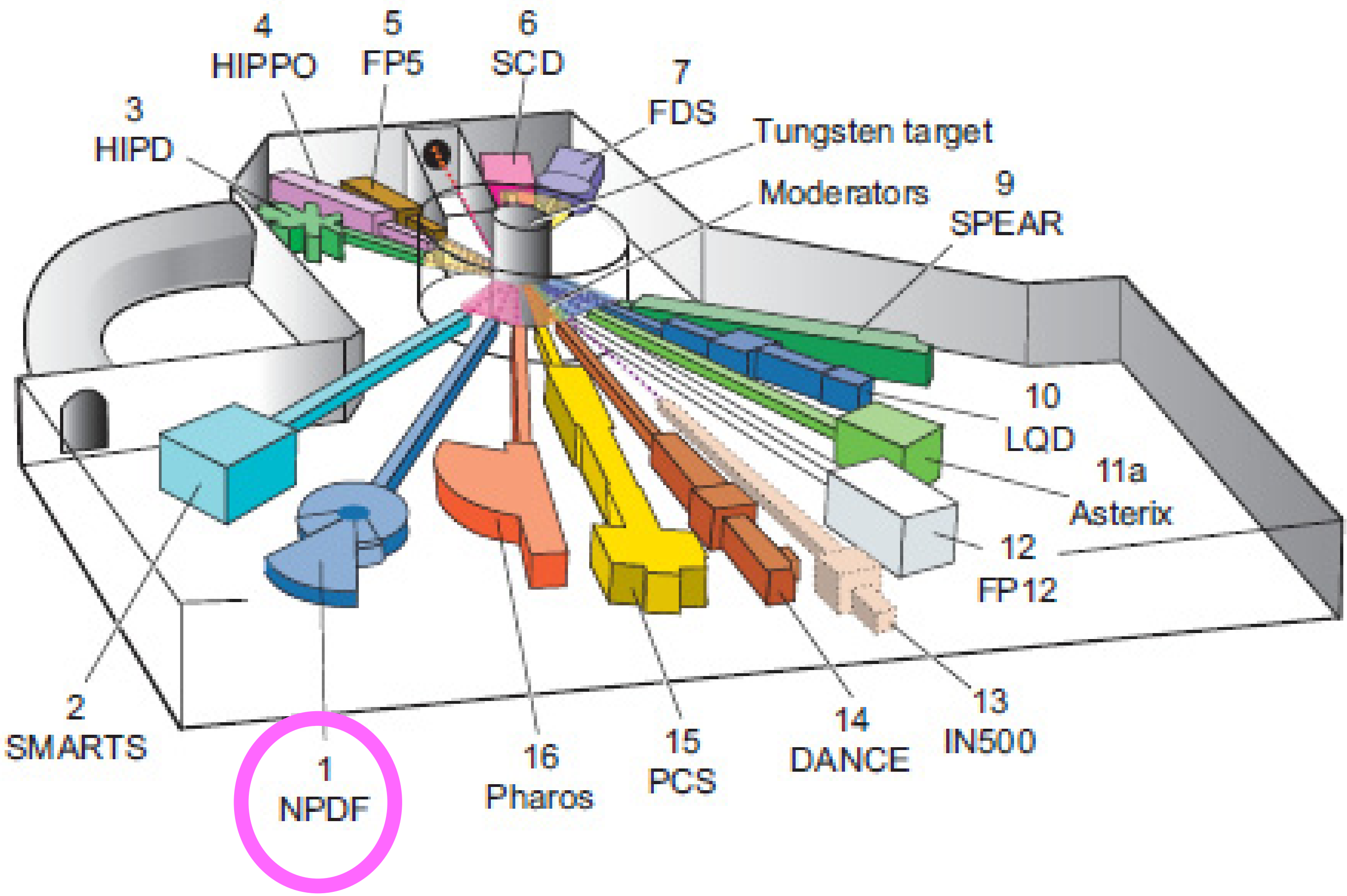


Fig. 3. The experimental hall with target, moderators, and instrumented flight paths in the Lujan Center.

Collaboration of Neutron Total Scattering for Hydrogen Storage Materials between LANL and AIST

LANSCE is the world famous neutron facility at Los Alamos National Laboratory.

The total scattering technique is very powerful to study the mechanism of hydrogen storage materials of various structures including complex structures and even liquid.

NPDF at LANSCE seems to be one of the ideal machines for the research of hydrogen storage materials.

Under the “Advanced Fundamental Research Project on Hydrogen Storage Materials”, a total scattering machine is being constructed in J-PARC; one of the strongest neutron sources.

Collaborations of measurements using NPDF by the both scientists in the field of materials science and neutron science will be started soon.

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Summary

Hydrogen storage is key technology to realize the hydrogen economy.

Hydrogen storage materials absorb hydrogen in higher volume density than compressed gas (35MPa) and liquid hydrogen.

A new National Project "Advanced Fundamental Research Project on Hydrogen Storage Materials" has been launched in June, 2007.

Collaboration in neutron scattering between LANL and AIST will be started and is beneficial for the scientists of both countries.

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