Securing China's Weapon-Usable Fissile Materials and Nuclear Facilities

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Outline of the talk:

- China's nuclear material production and facilities
- China's MPC&A system: Legal/Regulations
- China's MPC&A practices: MC&A System
- China's MPC&A practices : Physical Protection Measures
- Recommendations for improving China's MPC&A system

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China's nuclear material production and facilities

Plutonium production reactor	Notes
Reactor at Jiuquan Atomic Energy Complex, Gansu	Previous military; shutdown; operated 1966-1984? 0.9 tons WgPu
Reactor at Guangyuan complex, Sichuan	Previous military; shutdown; operated 1973-1989?1.1 tons WgPu
Reprocessing plant	
Jiuquan reprocessing plant	Previous military; shutdown; operated 1970s-1984?
Guangyuan reprocessing plant	Previous military; shutdown; operated 1970s-91?
A pilot reprocessing plant at Jiuquan	Civilian purpose; 50 MT/yr; operation in 2010
Proposed commercial plants	Civilian; 200, 800 MT/yr, planned commission around 2025?

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China's nuclear material production and facilities (cont')

Enrichment plant	Notes
Lanzhou GDP	Previous military; shutdown; operated 1963-1979 for HEU production about 6 tons.
Heping GDP	Previous military; shutdown; operated 1975-1987 for HEU production about 14 tons.
Hanzhong CEP	Civilian; LEU production ;IAEA safeguarded;
Lanzhou CEP	Civilian; LEU production

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China's nuclear material production and facilities

Chinese non-weapon uses of HEU are very limited.

--- nuclear-power submarines fueled with LEU

---Tritium production reactor

---several research reactors :

--China's Experimental Fast Reactor (July 2010): 240 kg of 64.4% U-235, later loading MOX.

--- two Miniature Neutron Source Reactors (MNSR) (-- 1 kg of 90%U-235), to be converted

---one Zero-Power Fast Critical Reactor (90% U-235, 0.05 kWt), one PPR Pulsing Reactor (20% U-235, 1MWt).

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- **China has very limited stockpiles of warheads, Pu and HEU**

---1.8 t WgPu (this new estimate is much less than previous estimates-- 4 t)

---16 t HEU (this new estimate less than previous --20 t)

---about less than half of the material in about 200 warheads.

---about 10 t materials distributed in several sites (less than 10), strict control by military

--- the warheads not only 3 G, also advanced PPS: real time video monitoring, infrared secure system, a computerized warheads accounting system, temperature and humidity controls, fingerprinting and other control, advanced communication, etc.

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China's nuclear energy development

-- 50s defense nuclear—1979 focus switched to civilian nuclear power

--mid 80s decided to develop NPP

--by 2011, operating 15 reactors of 12GWe; 27 reactors (29 GWe) under construction

---National Nuclear Power Mid-long Term Development Plan 2006: 40 GWe installed capacity +18 GWe under construction

---current expected: 60-70 GWe by 2020

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China's nuclear energy development (Cont'd)

---a multi-purpose reprocessing pilot plant (50 tHM/yr) at Jiuquan complex: started construction in 1997---Dec.2010 hot test.

---A commercial reprocessing plant (800tHM/yr) planed in commission in 2025?

--- 25 MWe China Experimental Fast Reactor (CEFR), near Beijing, commission in July 2010. First loading 240 kg (64.4% HEU), later MOX.

--- A pilot MOX fuel fabrication (0.5t/a) building.

---A commercial MOX fuel fabrication plant planned in commission by 2025?

--Larger commercial FBRs to be commissioning 2030-2035.

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China and International Security Obligations

---Safeguard Agreement , 1988

---The 1980 Convention on the Physical Protection of Nuclear Material (CPPNM), 1989

---the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material, ratified in 2008

---International Convention for the Suppression of Acts of Nuclear Terrorism, ratified in August 2010

---Implemented UNSC resolution 1540 and Resolution 1887

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China's MPC&A: major legal framework

---"Regulations for Control of Nuclear Materials of the People's Republic of China" (1987):

the goal : to ensure the safety and lawful uses of nuclear materials; to prevent theft, sabotage, loss, unlawful diversion, and unlawful use; to protect the security of the state and the public; and to facilitate the development of nuclear undertakings.

---"Rules for Implementation of the Regulations on Nuclear Materials Control of the People's" (1990)

the "Rules" is applicable to the application, renew, assessment, approval, and issuing of nuclear material license; to accounting for and control of nuclear material, and to physical protection of nuclear material.

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中华人民共和国国家原子能机构
CHINA ATOMIC ENERGY AUTHORITY

---*The National Office for the Nuclear Material Control (ONC)* under CAEA is responsible for the control of nuclear material in the concrete:

- to elaborate the rules and regulations, and specifications for the control of nuclear materials;
- to exercise nuclear materials control nationwide, establishing the nationwide accounting system of nuclear materials;
- to check the accounting balance management, physical protection, and secrecy of the licensee.

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Licensing system

---the operator must apply "nuclear material license": if holds more than 10 effective grams U-235 or any quantities of plutonium.

---To get the license, the operator must established MPC&A systems met with the regulation guidelines provided by CAEA.

---the ONC will thoroughly review the practice of NMC in each facility every 3 year.

---The ONC is responsible to organize professional experts to inspect nuclear facilities to ensure that effective security and accounting measures are in place.

---found violations of regulations---would be punished by warning; penalty or revoking the license depending on the seriousness of the violation which is effected by one of the followings.

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Material Control and Accounting

- **material balance system**

---divide the nuclear facilities into separate material balance areas in according with their respective feature;

---the balance preformed according to the classification of nuclear material.

- **nuclear material physical inventory procedures**

---conducting a complete and strict physical inventories at least once a year

--- conducting physical inventories for such material as Pu-239, U-233 and HEU at least twice a year.

- **record and reporting system**

---the record of nuclear material accounting must be clear, accurate, systematic and complete, and must maintained at least for five years.

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China's Physical Protection System (PPS)

Detection—fist line of defense
--perimeter detection, access control, video camera assessment, personnel identification, etc.

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Delay—Second line of defense
--fence, hardened door, meshed window, locks, fixed device, balance magnetic switches, etc

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Response
--emergency plan, communication, interruption,
---armed force, security guards

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Categorization of fissile material

Category I	*2 kg or more unirradiated Pu; *5 kg or more HEU
Category II	*Less than 2 kg but more than 10 g unirradiated Pu *Less than 5kg but more than 1kg HEU *20 kg or more unirradiated U-235 (10% but less than 20%) *300 kg or more unirradiated U-235 (enriched to less than 10%; not including NU&DU)
Category III	*10 g or less unirradiated Pu; *1kg or less but more than 10 g HEU *1kg or more but less than 20 kg unirradiated U-235 (10% but less than 20%) *10 kg or more but less than 300 kg unirradiated U-235 (enriched to less than 10%; not including NU&DU)

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Physical protection measures for fissile material at fixed sites

Category I	*At least two complete, reliable physical barriers; vault or special security container for storing Category I nuclear material *The technical protection system with alarm and monitoring installations *24-hour armed guard * Special pass for all people entering the site; Strict control on non-site personnel to access with the procedure of registration, and full time escorted by the site-personnel after access. *Vault is performed by "double men and double lock" system
Category II	*Two physical barriers with one is complete and reliable; a "strong room" or "solid container" type storage area *Alarms or surveillance protection equipment provided in vital areas *Armed guards or specially assigned persons watching out day and night *Special pass for all people entering the site
Category III	*One complete and reliable physical barrier *Specially assigned persons for watching or letting nuclear material be placed in security containers

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Categorization of fissile facilities

Category I	Category II	Category III
- --Facilities containing category I nuclear materials ---100 MW(th) reactors or larger ---Spent fuel pools with 10^{17} Bq Cs-137 radioactivity or larger --- spent fuel reprocessing facilities --- High-level liquid nuclear waste storage and processing facilities	---Facilities containing category II nuclear materials ---2-100 MW(th) reactors --- Middle-level liquid and high-level solid nuclear waste storage and processing facilities ---Facilities where any on-site criticality accidents without control measures can pose impacts beyond 0.5 Km from the facility perimeter	---Facilities containing category III --- <2 MW(th) reactors ---Low-level liquid and middle-level solid nuclear waste storage and processing facilities --- Facilities where direct exposure dose rate without shielding measures is larger than 100 mGy/h at 1 meter away --- Facilities where any on-site criticality accidents without control measures can pose impacts within 0.5 Km from the facility perimeter

Physical protection measures of nuclear facilities

Category I	Category II	Category III
---24 hour armed policemen at individual and vehicle access to the three areas ---Alarm and monitoring system at all access entrances ---Permits or badges held by authorized personnel and vehicles to enter three areas ---Strict control of non-site personnel and vehicles to access; full time escort with site personnel after entering the protected and vital areas ---A "two man and double-lock" rule for the vital area ---Radioactive material detection systems installed at access to the protected and vital areas ---Emergency power backup system ---A system control center to manage physical protection system	---24 hour armed policemen at individual and vehicle access to the three areas ---Alarm and monitoring system at all access entrances ---Permits or badges held by authorized personnel and vehicles to enter three areas ---Strict control of non-site personnel and vehicles to access; full time escort with site personnel after entering the protected areas ---Radioactive material detection systems installed at access to the protected area ---Emergency power backup system ---A system control center to manage physical protection system	---Communication and monitoring system at all access Entrances ---Permits or badges held by authorized personnel and vehicles to enter the area ---emergency power backup system ---a office with safety personnel on duty

Categorization of radioactive wastes

	Category I	Category II	Category III
Gaseous wastes (Av, Bq/m3)	LLW: Release threshold<Av≤$4x10^7$	ILW: Av>$4x10^7$	
Liquid wastes (Av, Bq/l)	LLW; Release threshold<Av≤$4x10^6$	ILW: $4x10^6$<Av≤$4x10^{10}$	HLW: Av>$4x10^{10}$
Solid wastes (Am, Bq/kg)	LLW: ---$T_{1/2}$≤60d (1) RL<Am≤$4x10^6$ ---60d<$T_{1/2}$≤5a (2) RL<Am≤$4x10^6$ --- 5a<$T_{1/2}$≤30a (3) RL <Am≤$4x10^6$ --- 30a<$T_{1/2}$ RL<Am≤$4x10^6$	ILW: ---$T_{1/2}$≤60d; Am>$4x10^6$ ---60d<$T_{1/2}$≤5a; Am>$4x10^6$ --- 5a<$T_{1/2}$≤30a; $4x10^6$ <Am≤$4x10^{11}$ --- 30a<$T_{1/2}$ $4x10^6$ <Am (4) ≤$4x10^{10}$ --- α wastes (7)	HLW: --- 5a<$T_{1/2}$≤30a; Am (5) >$4x10^{11}$ --- 30a<$T_{1/2}$ Am (6) >$4x10^{10}$ --- α wastes (7)

Categorization of radioactive wastes (cont'd)

Notes:

(1) Including I-125 ($T_{1/2}$=60.12d)

(2) Including Co-60 ($T_{1/2}$=5.271a)

(3) Including Cs-137 ($T_{1/2}$=30.17a)

(4) And heat discharge rate less than or equal to 2kw/m^2

(5) Or heat discharge rate larger than 2kw/m^2

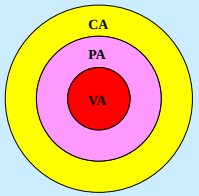
(6) And heat discharge rate larger than 2kw/m^2

(7) α wastes: long-live α radioactivity Am contained in one single package is larger than $4X10^6$, average Am for each package is larger than $4X10^5$.

Limited area access approach

Category I facilities : Control access area, protection area, vital area
Category II facilities : Control access area, protection area
Category III facilities :Control access area,

--control access area
--protection area
--vital area



--Controlled area has "one layer" physical barriers: either barbed fences or wall. The height of barriers has to be larger than 2.5 m. If wall is used as physical barriers, the thickness of wall has to be larger than 240 mm.

-- Protected area has "two layer" physical barriers: barbed fences. The height of outer layer larger than 1.5m; inner larger than 2.5 m. The distance between two layers has to be larger than 6 m.

---Vital area: buildings or connected with fences and walls can become physical barriers.

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Current Practices of China's PPS

- Widely applied the modern PPS; the concept of defense in depth and detection balance.
- Based on DBT including outsider and insider adversaries, BUT could not cover 911-type attack.
- Switching from the traditional "guns, gates, guards" approach to an effective mixed approach, combining personnel with modern techniques.
- facilities required to conduct in-depth vulnerability assessments; BUTdoes NOT conduct force-on-force exercise.
- Applying the graded protection measures, according to the relative attractiveness, the nature of nuclear materials and facilities, and potential consequences;
- Emergency plan to response: unauthorized removal of NM, sabotage of nuclear facilities ; conduct annual exercise

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China's MPC&A practices: Military Sector

---China keeps MPC&A system in military sector sensitive

--- believed much securer than the civilian sector due to the "most valuable stuff" in China, reported "accident-free" for the past 50 yrs.

---China should have been applying the modern MPC&A system learn from China-US lab-to-lab (1995-1998) and the following CAEA collaboration with DOE and IAEA on civilian sector.

 # e.g. under the China-US "lab-to-lab" program ,several workshops at Beijing IAPCM on MPC&A techniques; visiting scholars, etc

#In 1998 a demonstration facility for modern MPC&A technology was installed at the CIAE in Beijing--demonstrated how technologies could be integrated in a comprehensive system for protecting nuclear materials.

#However, the program ceased in the aftermath of the 1999 Cox Committee Report and allegations of Chinese espionage at U.S. nuclear weapons laboratories

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China's MPC&A practices: Military Sector (cont'd)

---after the end of lab-to-lab program, CAEA and DOE/NNSA collaboration

#e.g. in 2005 a technical demonstration on intergraded nuclear materials management on safeguards and PP to introduce modern technology development on MPC&A.

#Trainings and workshops with IAEA and DOE/NNSA before 2008 Beijing Summer Olympic

--- In 2006 CAEA and IAEA established a "CAEA-IAEA Joint Training Center on Nuclear Safeguards and Security" located at CIAE.

---In Jan 2011, China and US signed an agreement to establish a Center of Excellence in China.

---all those activities should have an important influence on China's MPC&A in military sector.

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Improving China's MPC&A system

- **Updating and clarifying its rules and guidelines for design base threat**

---While based on DBT, has no clear standards; could be unable to resist extreme adversary scenarios such as 9/11-type attacks.

---Should review and upgrade its basis used for designing physical protection for facilities and transporters with nuclear weapons, HEU and plutonium to ensure that it reflects the threat as perceived after 9/11 attacks.

---The minimum DBT standard should include protection against: 1) *a* modest group of well-armed and well-trained outsiders; 2) a well-placed insider; and 3) both outsiders and an insider working together, using a broad range of possible tactics.

--- should update its old 1987 Regulations and 1990 Rules and issue the new strict and clear Regulations and Rules based on least the minimum DBT standard.

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Improving China's MPC&A system (cont'd)

- **Consolidating weapons-usable fissile materials**

---China should speed up converting its own HEU-fueled research reactors; help to convert those exported MNSRs.

---China should take a lead to reach an international agreement for a phase-out and ultimate ban on the civil use of HEU.

---should constrain its commercial reprocessing plans. Having no a convincing rationale for pursuing plutonium recycling in the foreseeable future, China should postpone its decision to build a commercial reprocessing plant.

---China should review every location, both in the civilian and military sectors, where HEU or separated plutonium (or nuclear weapons) , and consider to minimize the number of those locations and ensure to secure those locations.

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Improving China's MPC&A system (cont'd)

- **Realistic testing of nuclear security performance**

---While Chinese facilities are now required to do in-depth vulnerability assessments and performance tests of their security systems, they do not include the realistic "force-on-force" exercises.

---As the new issued INFCIRC/225/Revision 5 recommends, China should use realistic "force-on-force" exercises to test the performance of its nuclear security systems' ability to defeat either insiders or outsiders.

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Improving China's MPC&A system (cont'd)

- **Promoting nuclear security culture (cont'd)**

---President Hu Jintao emphasized the importance of "promoting nuclear security culture" at the 2010 Nuclear Security Summit

---One key basis of an effective nuclear security culture is that the related people should hold a deep rooted belief that there is a credible insider and outsider threat, and that nuclear security is important.

---However, many Chinese professionals in the nuclear field doubt that the terrorism threat is realistic in China. Some managers and employees at Chinese nuclear plants do not appreciate the need for the advanced and stringent MPC&A systems.

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- **Promoting nuclear security culture (cont'd)**

---the possible theft of fissile material by an insider cannot be ruled out, in particular, as China increasingly becomes a market-oriented society and increasing corruption.

---Outside terrorist attacks may someday pose another threat to China's nuclear facilities.

---the terrorist forces of the so-called "East Turkestan"--close links with international terrorism, have long been recipients of training, financial assistance and support from international terrorist groups.

---In practice, a terrorist attack elsewhere would doom China's ambitious plan of nuclear power development. A "security Chernobyl" would definitely damage the development of China's nuclear power.

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- **Promoting nuclear security culture (cont'd)**

---China should have regular training programs performed, not only to improve the worker's professional skills, but also to make workers understand that security and accounting for nuclear materials is a matter of the highest national security priority.

---it is necessary to have a program to ensure the reliability of the personnel who will be operating the system, including security screening.

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Improving China's MPC&A system (cont'd)

- **Strengthening CAEA and DOE collaborations**

---While the current cooperation focuses mainly on Chinese civilian sector, it can be expected that the best practice of the modern MPC&A approaches learned from the cooperation should be applied to those fissile materials and facilities in the military sector.

--- CAEA and DOE should collaborate on applying the modern MPC&A system and best practice to China's pilot reprocessing plant and the on-building pilot MOX facility. —how to secure separated Pu etc. China can apply those to its military Pu and HEU stocks.

---Help China to adopt the practice of "force-on-Force" exercise. Chinese experts can be invited to witness such exercises at US sites, as it has done with other countries, including France and Japan.

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Improving China's MPC&A system (cont'd)

- **Extending the collaboration from civilian sector to military sector. Resuming China-U.S. Lab-to-Lab program on MPC&A**

---Since September 11, the cooperation between the US and China on fighting against terrorism should provide an opportunity to restart the lab-to-lab program on MPC&A, which would be significantly benefit to China's nuclear materials and facilities in the military sector.

---The China-U.S. Lab-to-Lab program should take a step by step approach starting from the less sensitive area

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