united nations
educational, scientific
and cultural
organization

international atomic
energy agency

the
abdus salam
international centre for theoretical physics

SMR/1325-10

Workshop on

Nuclear Data for Science & Technology: Accelerator Driven Waste Incineration

10 - 21 September 2001

Miramare - Trieste, Italy

Nuclear Data for Science and Technology: Accelerator Driven Waste Transmutation

A. Mengoni
ENEA, Bolgna - Italy

strada costiera, 11 - 34014 trieste italy - tel. +39 040 2240111 fax +39 040 224163 - sci_info@ictp.trieste.it - www.ictp.trieste.it

NUCLEAR DATA FOR SCIENCE AND TECHNOLOGY: ACCELERATOR DRIVEN WASTE TRANSMUTATION

Outlines of a Workshop

A. Mengoni

ENEA (Bologna)

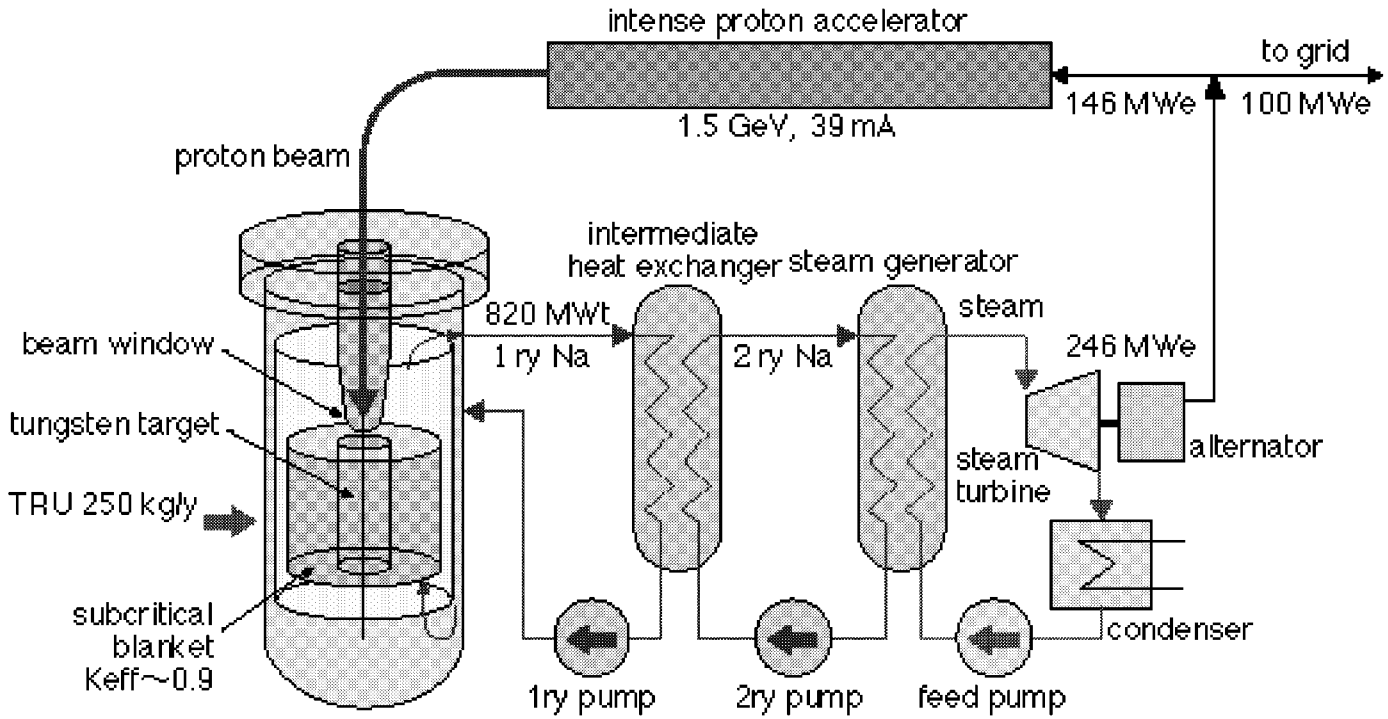
ICTP Trieste, September 2001

Premises

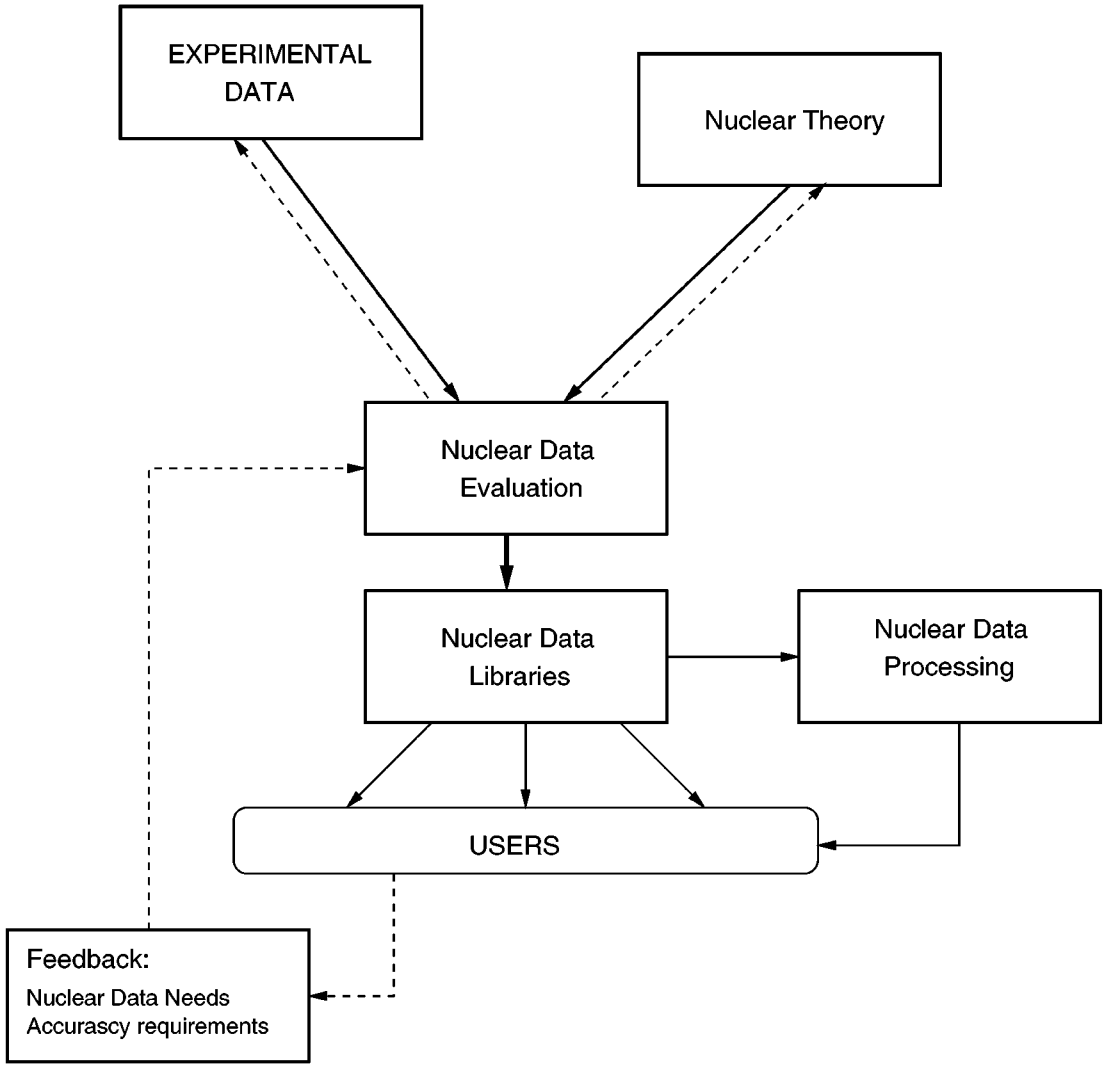
The design of Accelerator Driven Systems (ADS) requires knowledge of Nuclear Data for

- simulation of the spallation process
- radiation heating and damage
- criticality and transmutation rates

The data are needed also for energies above 20 MeV (typical limit for standard nuclear-reactor oriented data libraries)



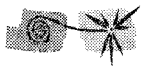
Nuclear Data Generation



Experimental Data

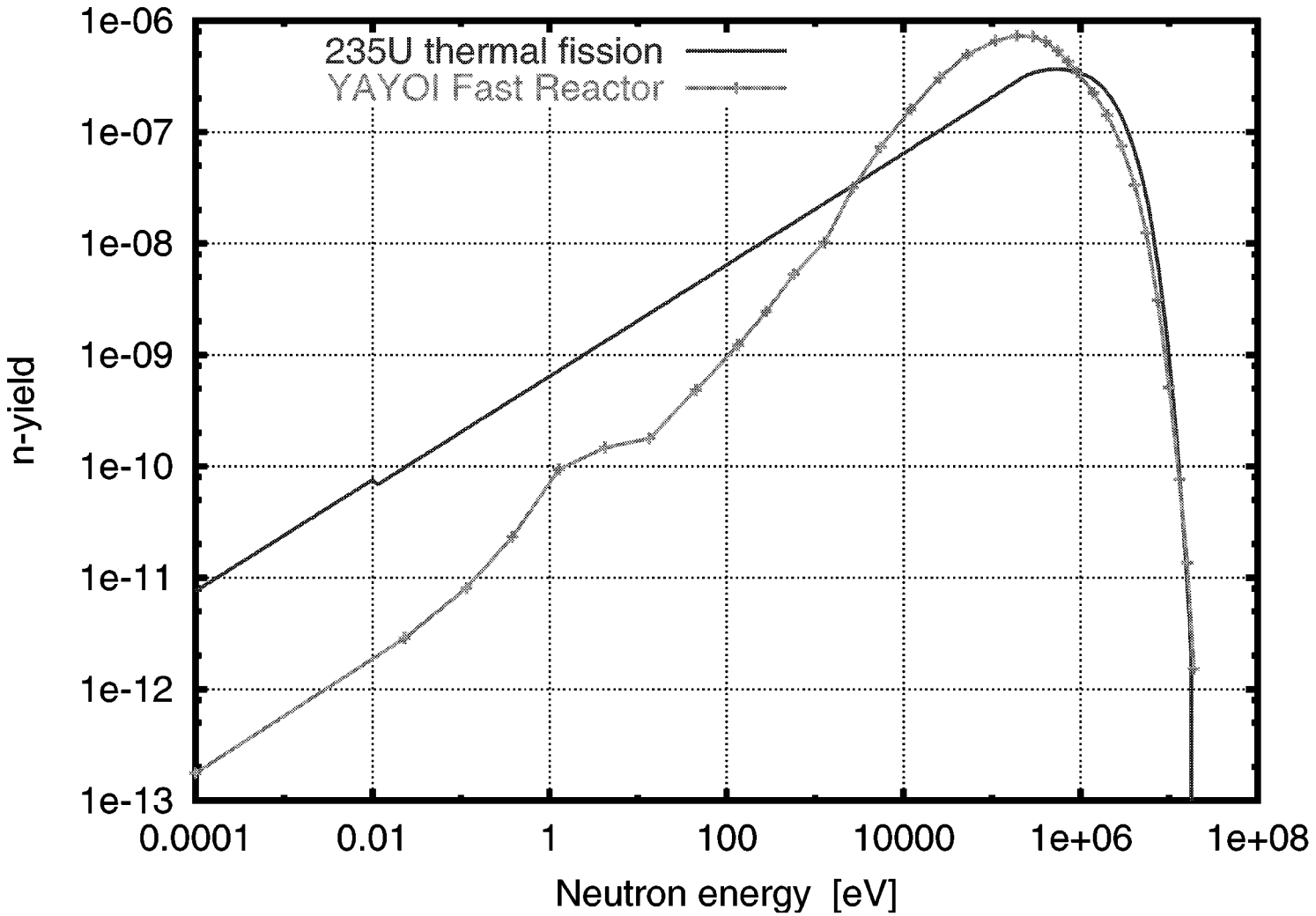
Nuclear Data measurements have been classified into two categories

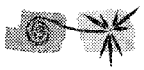
- Low Energy
  Laurent Tassan-Got: n_TOF, the new neutron time-of-flight facility operating at CERN.
- High Energy
  Jan Blomgren: ongoing experimental activities in high energy cross section measurements.



Low...

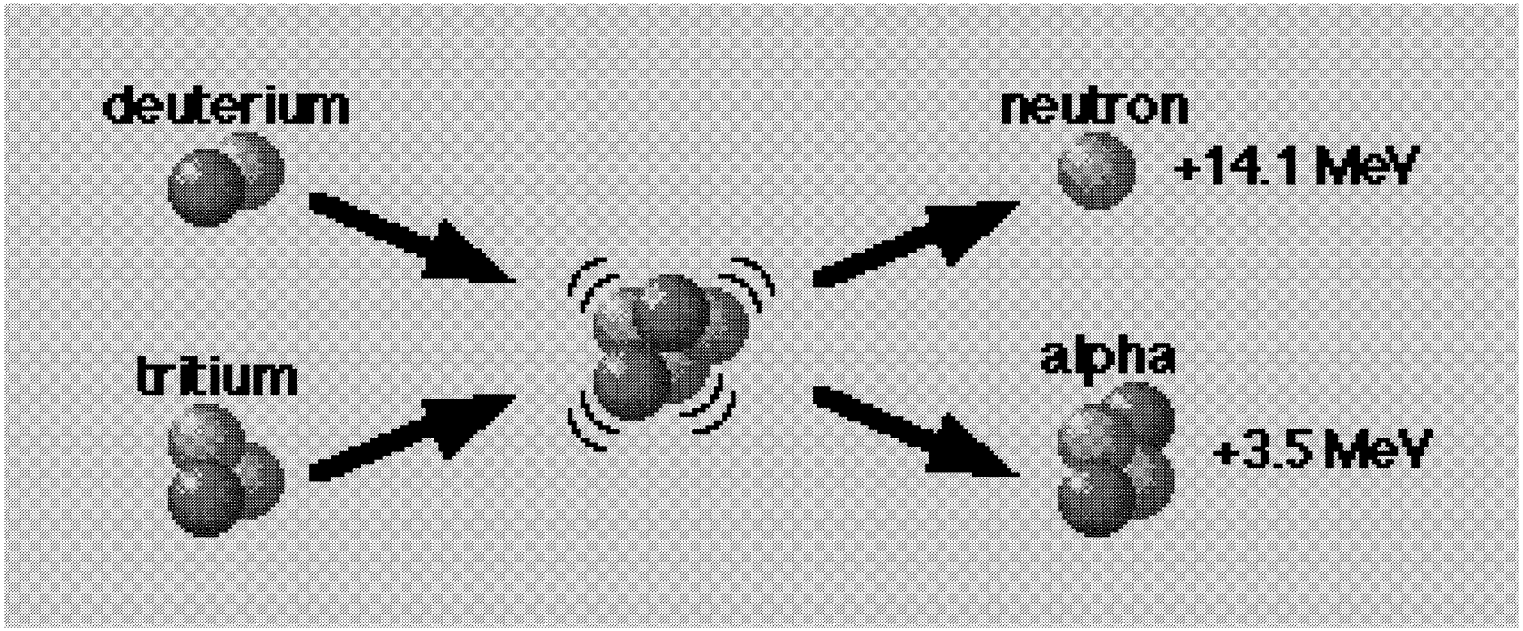
Neutrons in thermal and fast reactors





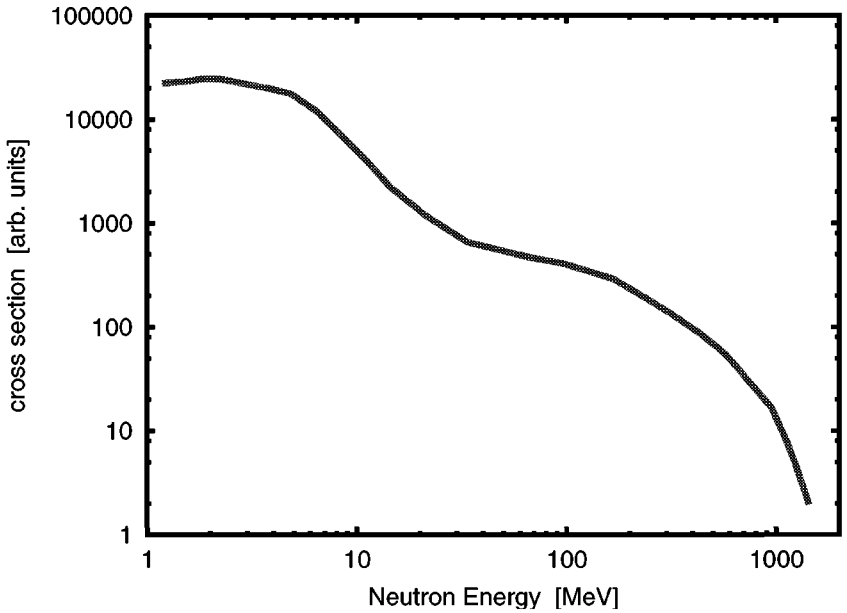
... still *Low*...

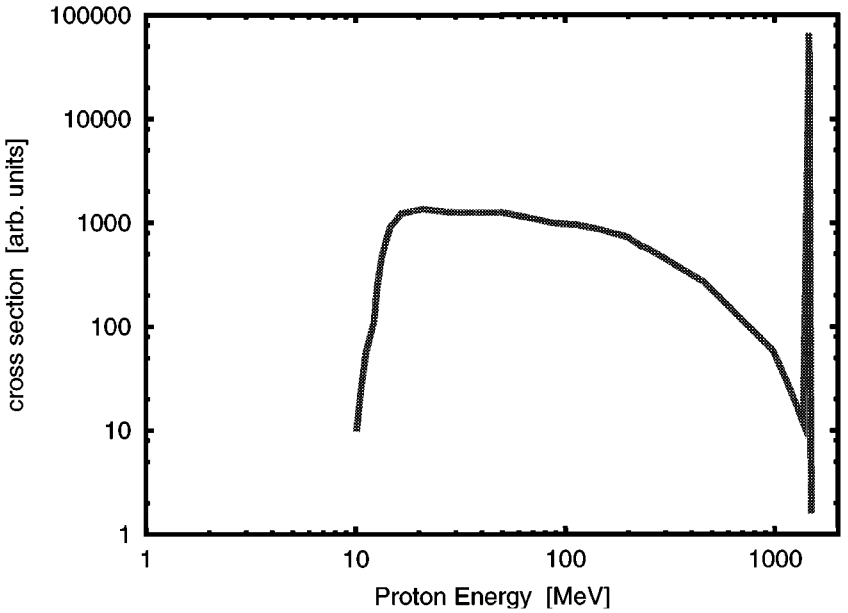
Neutrons from Fusion reactions



... and *High* energies

Neutron and proton emission spectra for 1.5 GeV protons on a heavy nucleus



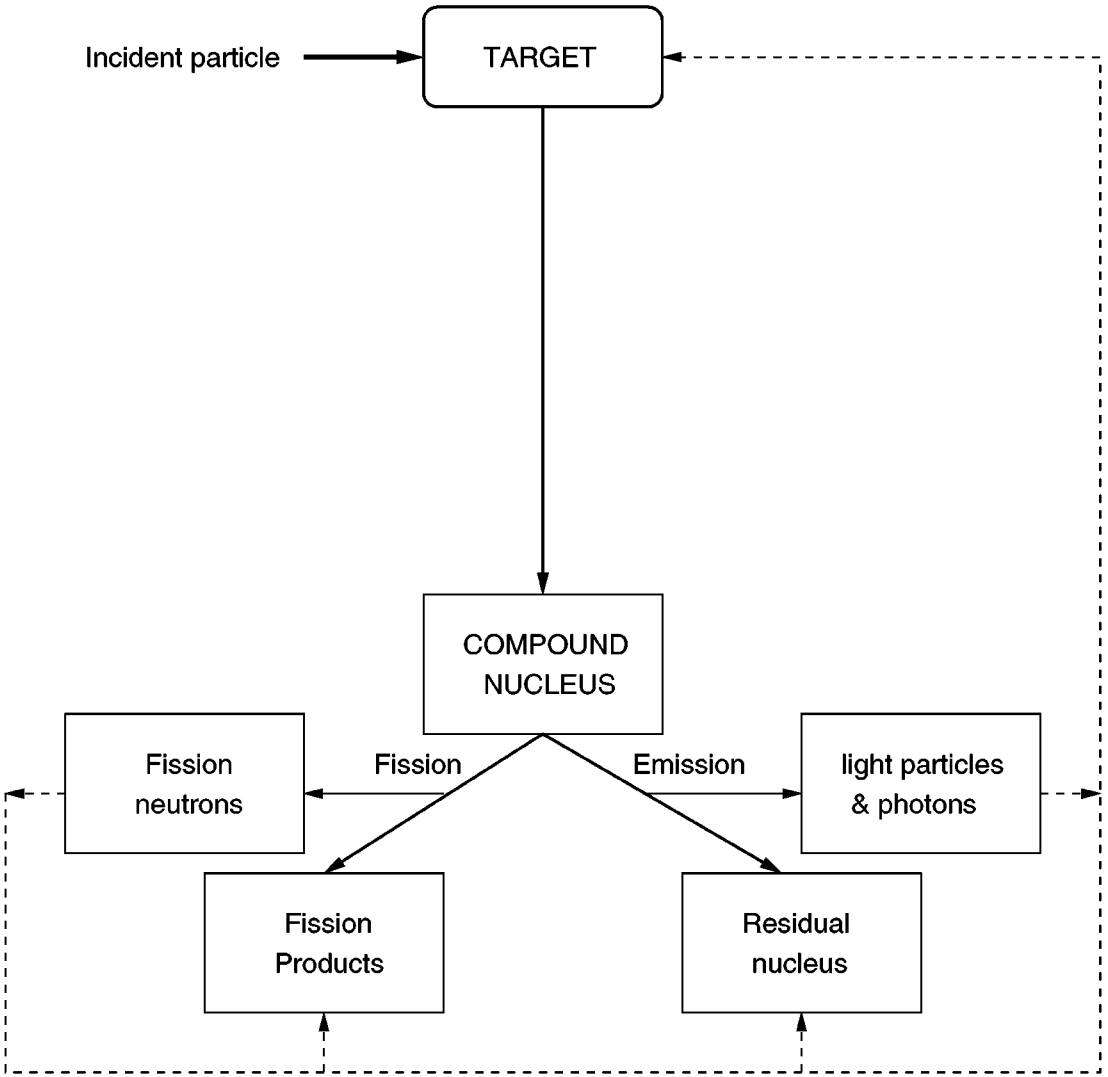


Nuclear Theory

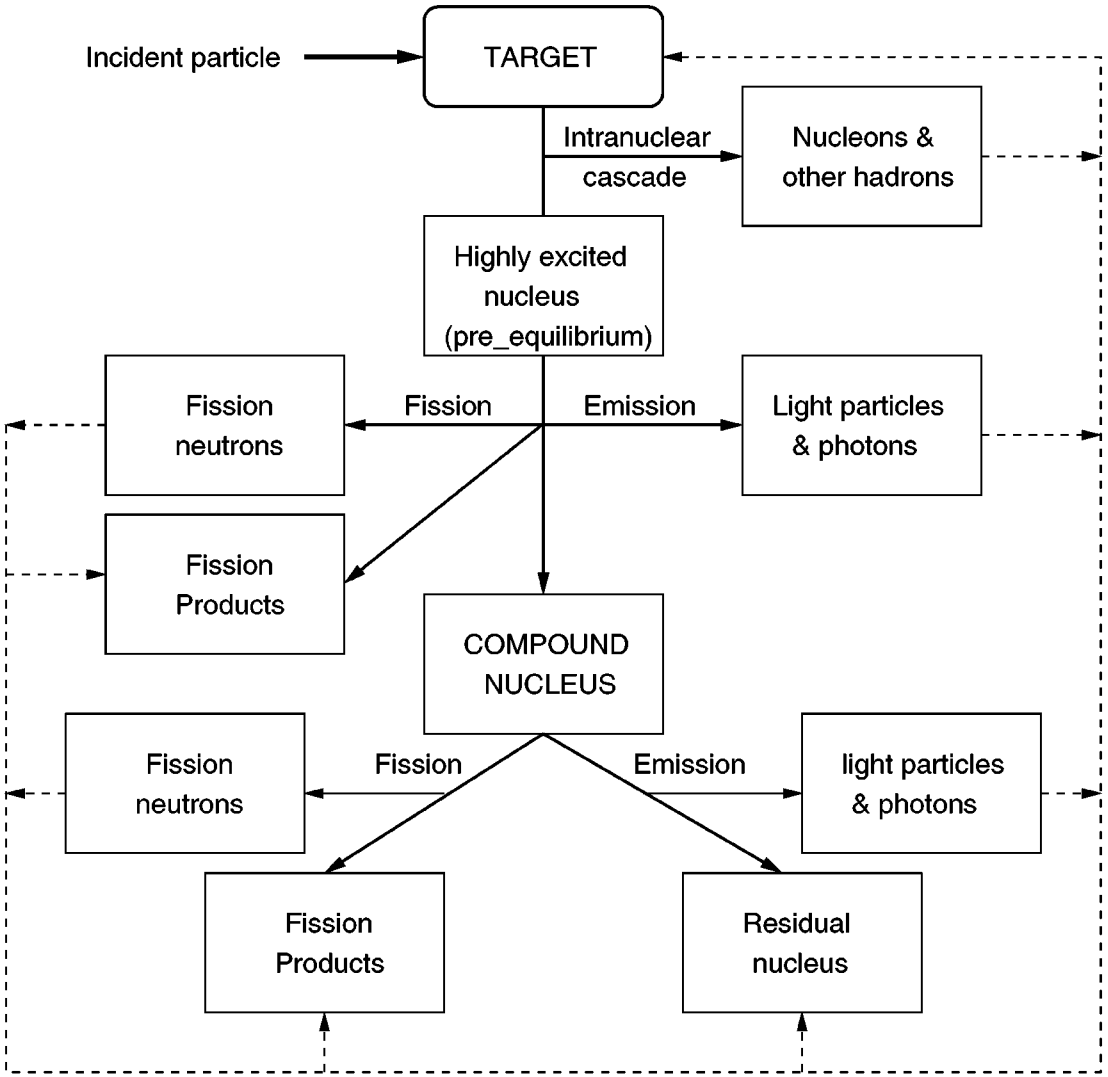
Nuclear theories and models will be involved in several presentations

- Overview of nuclear reaction theory
  Bret Carlson
- Statistical Model of nuclear reactions
  Mike Herman: - implementation of nuclear reaction models at low energies
  - Introduction of a data-base of model parameters for nuclear model calculations (RIPL).
  - Basics of nuclear data evaluations.
- Nuclear Reactions at high energies
  Sylvie Leray: nuclear reaction mechanisms at high excitation energies.

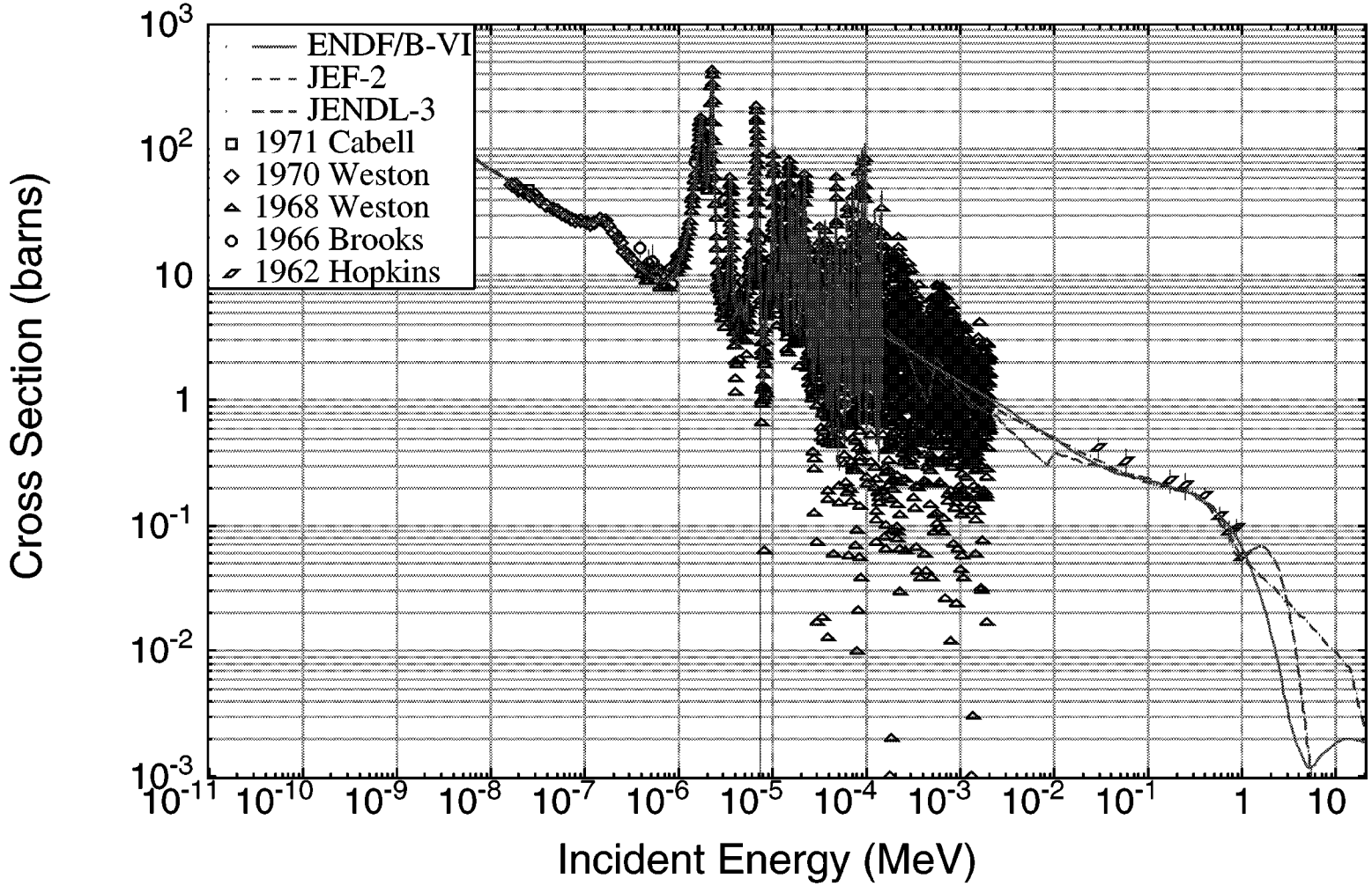
Particle interaction processes: *low* energy



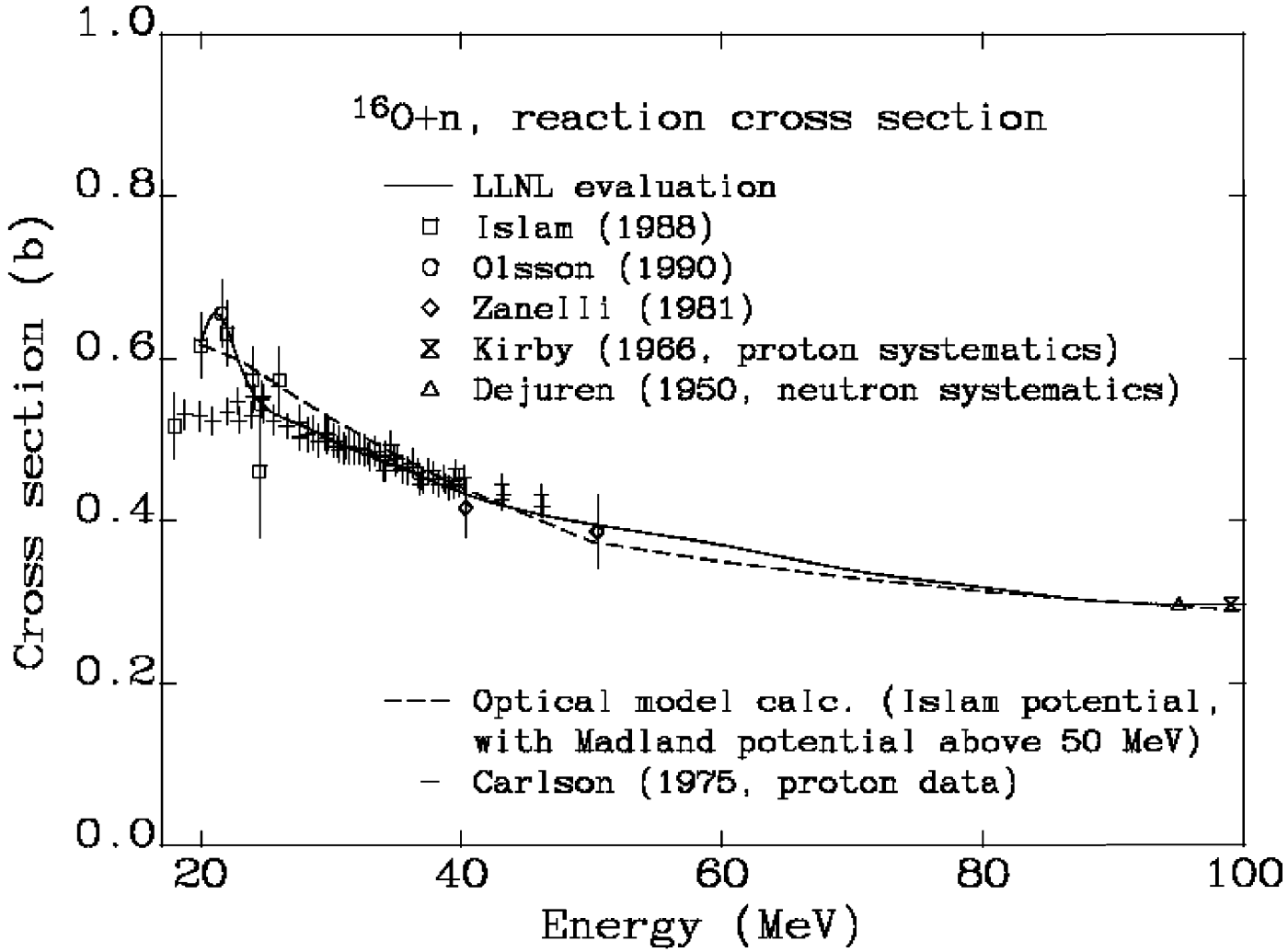
Particle interaction processes: *high* energy



Example: $^{233}\mathrm{U}(n,\gamma)$



Example: $n + {}^{16}\mathrm{O}$



Nuclear Data Libraries & Applications

Nuclear data libraries come into all possible flavors. From raw experimental data, to evaluated pointwise data files, to energy group processed libraries. Names are important: `EXFOR`, `ENSDF`, `BROND-2.2`, `CENDL-2.1`, `ENDF/B-VI.6`, `JEF-2.2`, `JENDL-3.2`, `ADL-3`, `EADL-92`, `EAF-3.1`, `EEDL-92`, `EFF-2.4`, `EPDL-92`, `FENDL-20`, `IRDF-90`, `MENDL-2`, `UKFY-3.0`, `UKHEDD-2.1`, `UKPADD-3`, `WIND`, ...

- General
  Andrej Trkov: - data formats of evaluated data libraries (ENDF).
  - Processing Nuclear Data libraries.
- Nuclear Data network
  Otto Schwerer: Nuclear data libraries organization at IAEA.
- Impact of Nuclear Data Libraries on applications
  G. Palmiotti: ADS design
  P. Talou: Validation of Nuclear Data Libraries for ADS
  E. Sartori: Computer Codes for simulating ADS

Codes

Three Computer Codes:

- EMPIRE

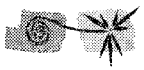
  EMPIRE-II is a flexible code for calculation of nuclear reactions in the frame of combined Optical, Multistep Direct (TUL), Multistep Compound (NVWY) and statistical (Hauser-Feshbach) models. Incident particle can be a nucleon or any nucleus(Heavy Ion). Isomer ratios, residue production cross sections and emission spectra for neutrons, protons,alpha-particles, gamma-rays, and one type of Light Ion can be calculated. The energy range starts just above the resonance region for neutron induced reactions and extends up to several hundreds of MeV for the Heavy Ion induced reactions.

- FLUKA

  FLUKA is a fully integrated particle physics Monte Carlo simulation package. It has many applications in high energy experimental physics and engineering, shielding, detector and telescope design, cosmic ray studies, dosimetry, medical physics and radio-biology.

- MCNP

  MCNP is a general-purpose, continuous-energy, generalized geometry, time-dependent, coupled neutron-photon-electron Monte Carlo transport code system. MCNPX extends the CCC-660/MCNP4B code to all particles and all energies.



Priority measurements for ADS

- Accuracy requested (in %) on the Nuclear Data for the reactions involved in the Th cycle

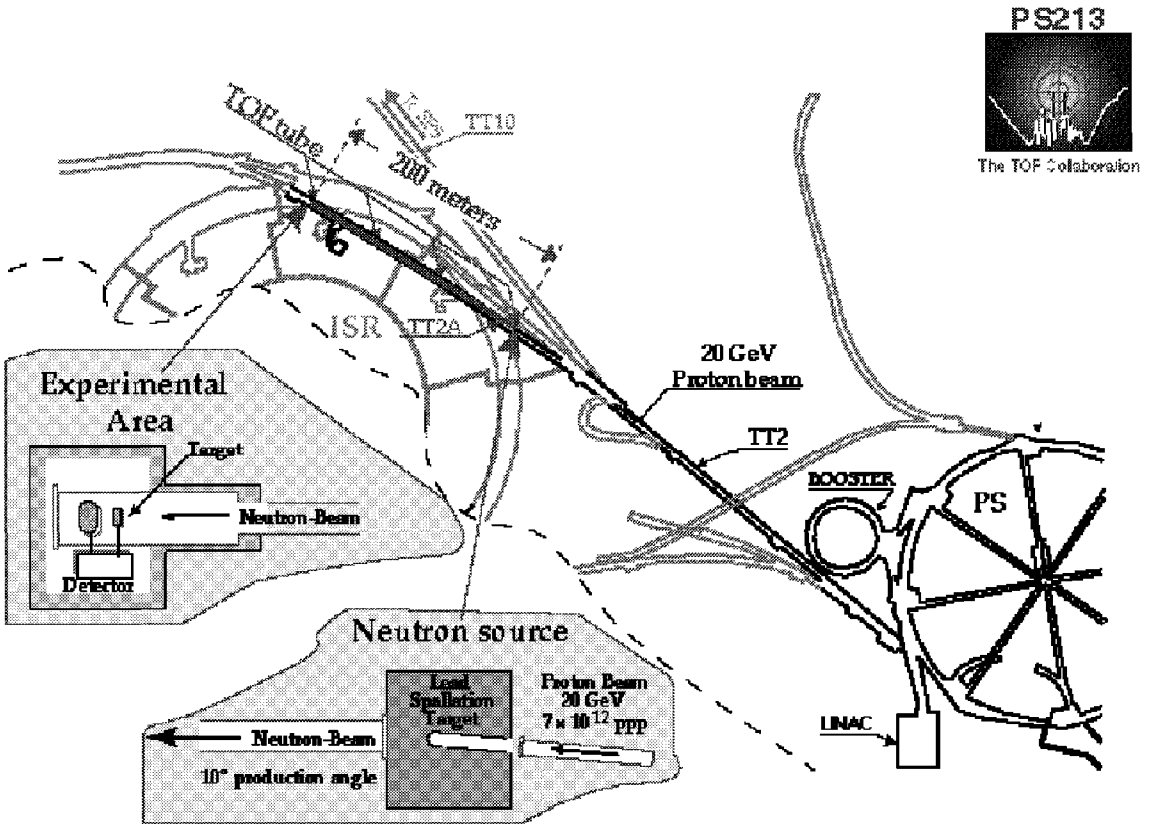
Data	^{232}Th	^{231}Pa	^{233}Pa	^{232}U	^{233}U	^{234}U	^{236}U
(n,γ)	1-2	10	3-10	50	3	5	10
(n,f)	5	20	20	20	1	3	5

INDC(NDS)-408), IAEA (Vienna), August 1999
Assessment of Nuclear Data Needs for Thorium and other Advanced Cycles

- Neutron spallation mechanisms at intermediate energies ($20\,\mathrm{MeV} \leq E_n \leq 150\,\mathrm{MeV}$). (n,xn), (n,p), (n,α) and other charged-particle emission cross sections are needed for ADS target design materials.
- Cross sections for Long-lived fission products. Examples are: ^{99}Tc, ^{151}Sm, ^{135}Cs, and others.

New experimental opportunities at CERN n_TOF

n_TOF is a spallation driven TOF facility at CERN-PS with an unprecedent neutron flux density in the broad energy range between $1\,\mathrm{eV}$ and $250\,\mathrm{MeV}$ and with very high energy resolution



The CERN Time of Flight Facility