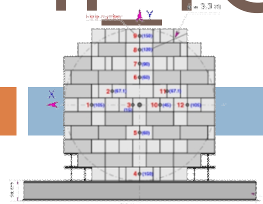
STATUS AND PERSPECTIVES OF THE N_TOF FACILITY AT CERN

Marco Calviani (CERN) and the n_TOF Team @ CERN
for the *n_TOF Collaboration*

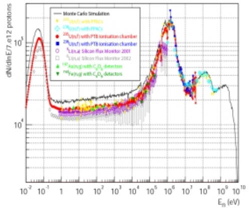
n_TOF history



1995-1997 **TARC** experiment

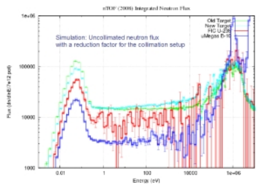
May **1998** **Feasibility** CERN/LHC/98-02+Add

2000 **Commissioning**



2008 **New Target** construction

May **2009** **Commissioning**

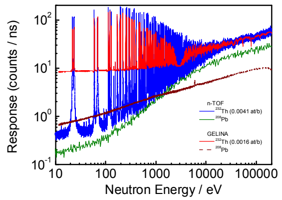


1996 — **2009**

1997 **Concept** by C.Rubbia CERN/ET/Int. Note 97-19

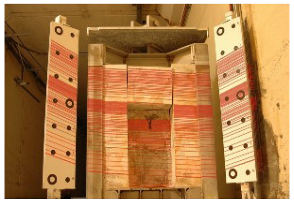
Aug **1998** **Proposal** submitted

1999 **Construction** started



2001-**2004** **Phase I**
Isotopes
Capture: 25
Fission: 11
Papers: 21
Proc.: 51
Doc: 150

2004-**2007** **Problem** Investigation

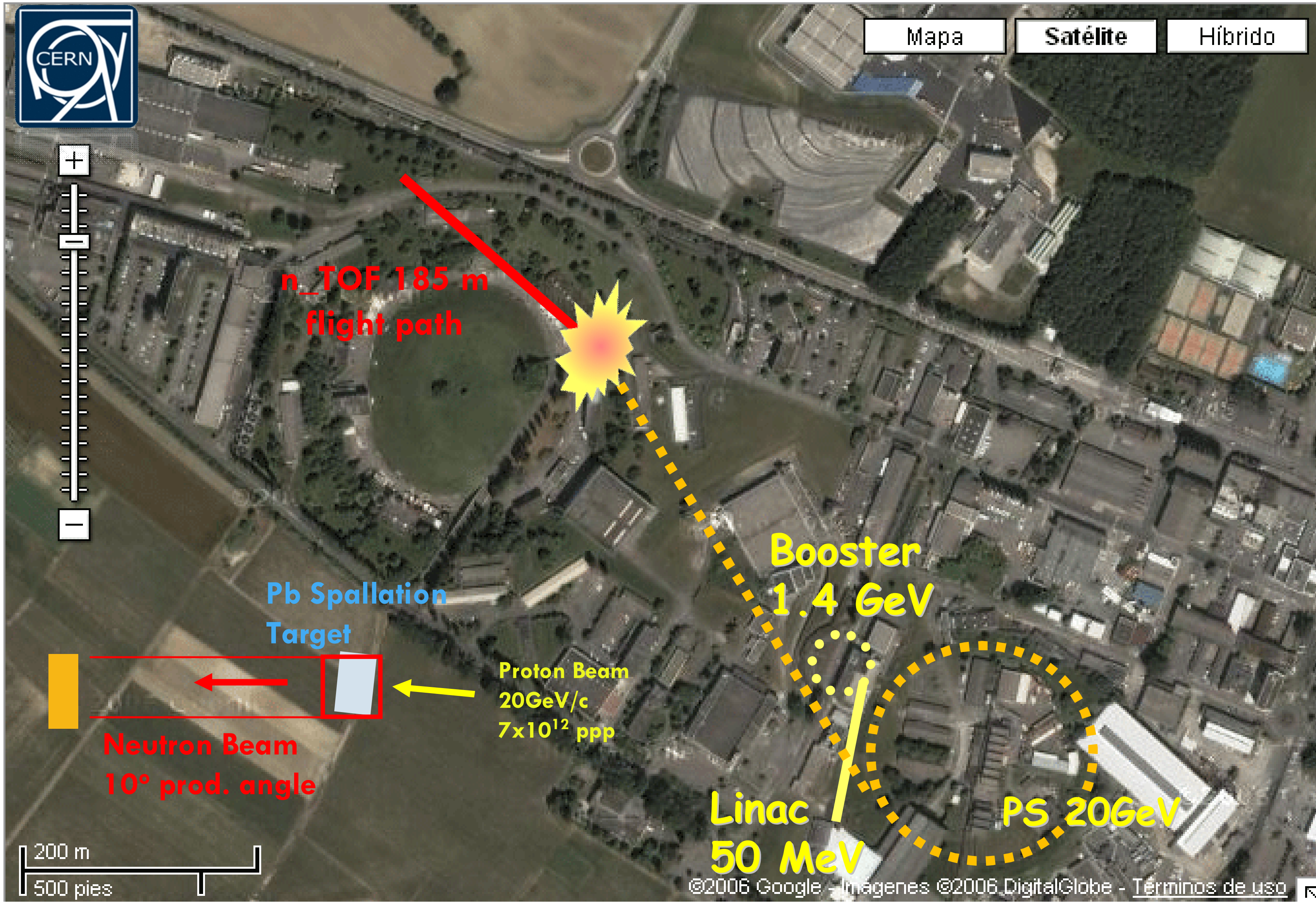


2009 **Phase II**

2010 **Upgrades:**
Borated-H_2O
Second Line
Class-A

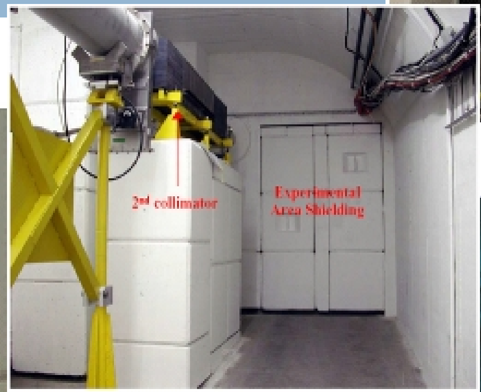
V. Vlachoudis

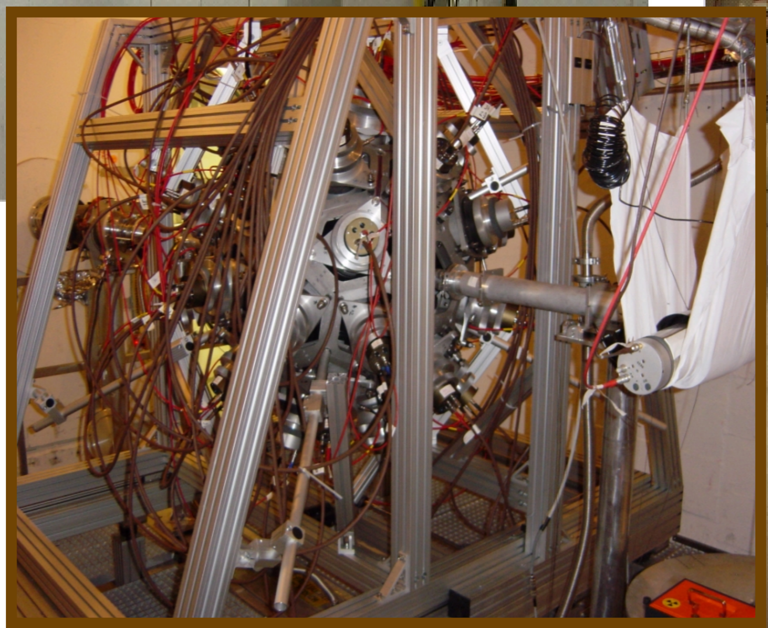
n_TOF @ CERN

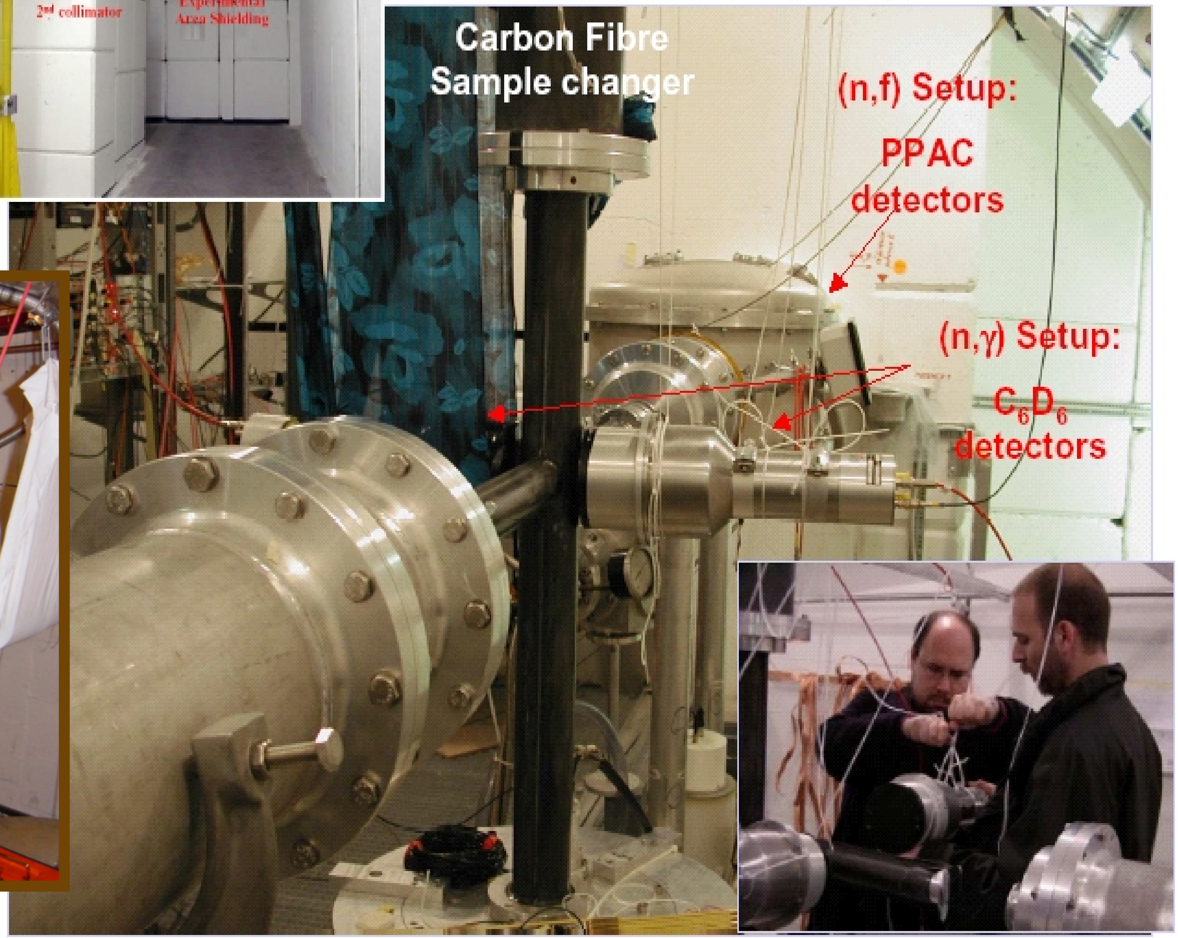


C. Domingo Pardo

n_TOF experiment

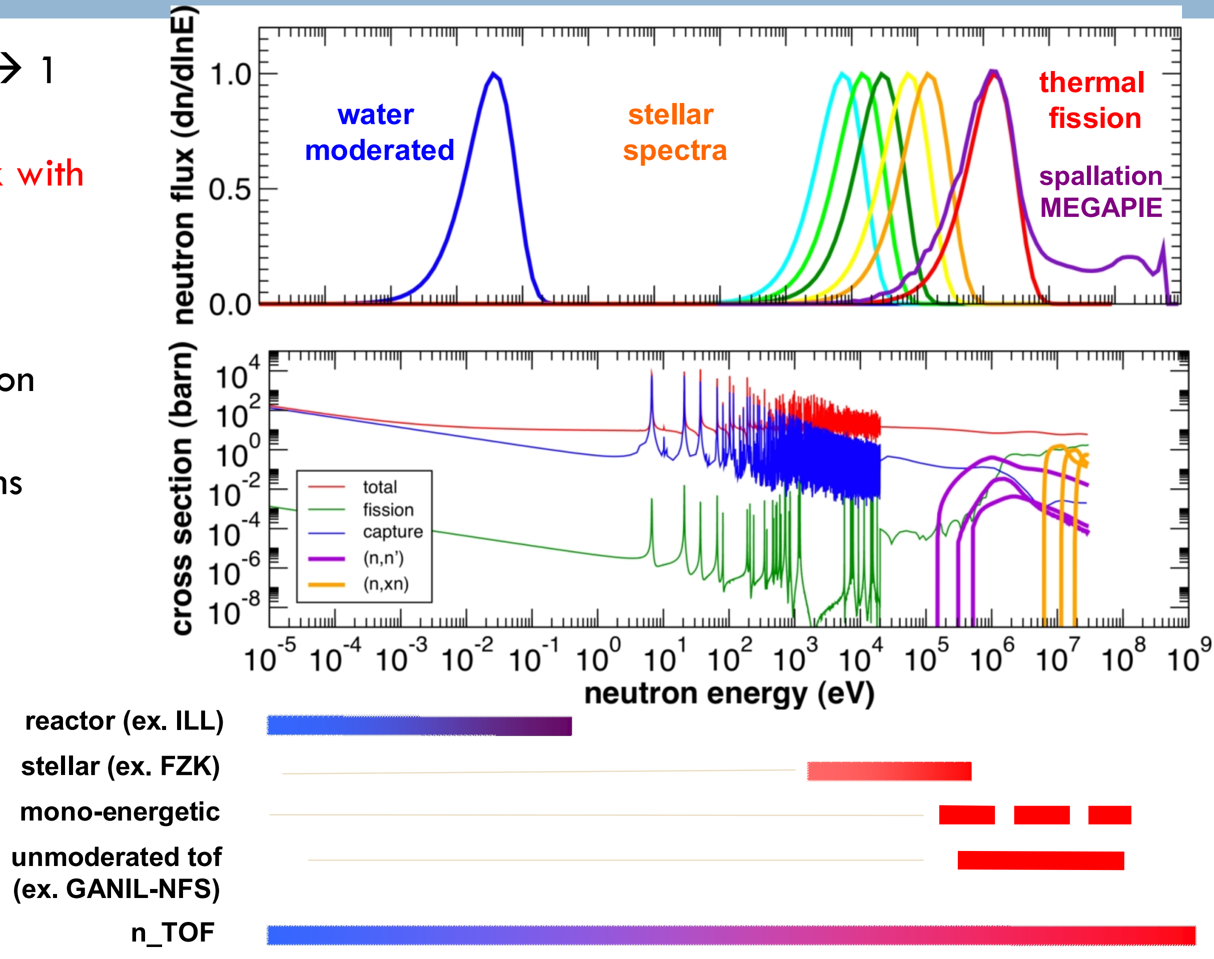






n_TOF basic characteristics

- Wide energy range (thermal → 1 GeV)
- High instantaneous neutron flux with good energy resolution (10^6 n/cm^2/bunch) → optimal for radioactive samples
- Low repetition rate of the proton driver
- Very low background conditions
- Detectors with extremely low neutron sensitivity (carbon-fiber C6D6)
- High-efficiency detector (TAC)
- High performance fission detectors (FIC+PPAC)
- DAQ system based on Flash-ADCs



F. Gunsing

n_TOF experiments (I)

Capture

^{151}Sm

^{204,206,207,208}Pb, ^{209}Bi

^{24,25,26}Mg

^{90,91,92,94,96}Zr, ^{93}Zr

^{186,187,188}Os, ^{139}La

^{232}Th, ^{233,234}U

^{237}Np, ^{240}Pu, ^{243}Am

Fission

^{233,234,235,236,238}U

^{232}Th, ^{209}Bi

^{237}Np

^{241,243}Am, ^{245}Cm

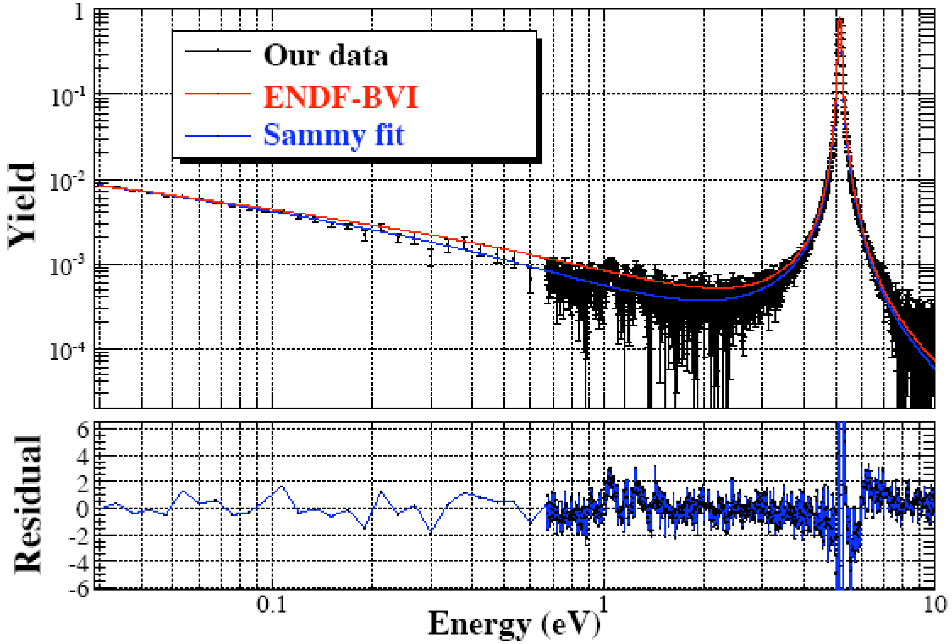
Measurement campaign 2002-4

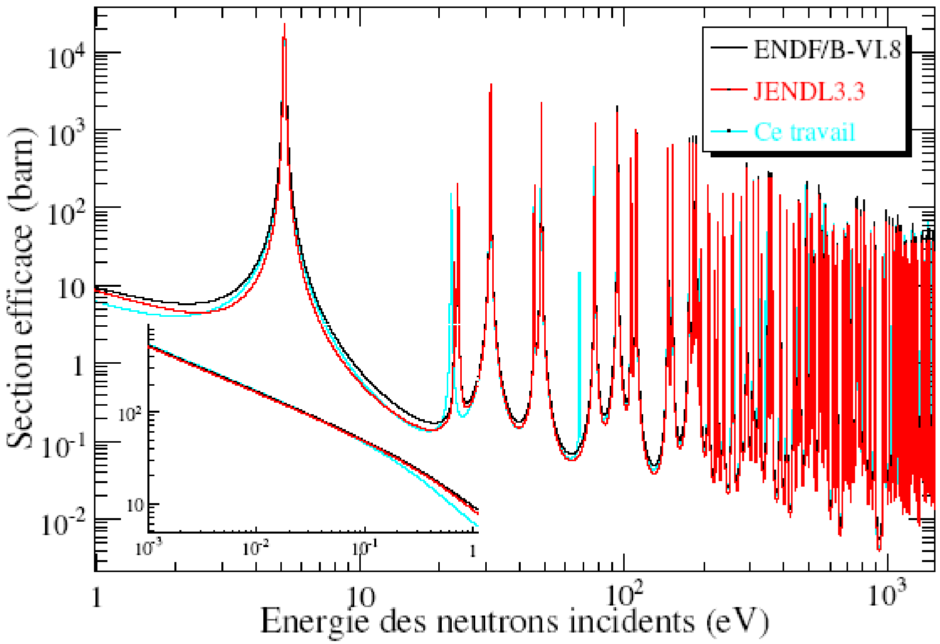
- **Measurements of capture reactions:**
  - **25 Isotopes** (8 of which radioactive)
  - Often of double interest (Astrophysics and applications)
  - Most results already available
  - Several publications
- **Measurements of fission cross-sections:**
  - **11 isotopes** (10 radioactive)
  - Mainly linked to **Th/U cycle and transmutation**
  - **strong interest** to the data by International Nuclear Agencies
  - Results are now becoming available (PRCs)

n_TOF experiments (II)

Capture measurement with TAC on radioactive samples

W. Dridi, E. Berthoumieux (CEA)

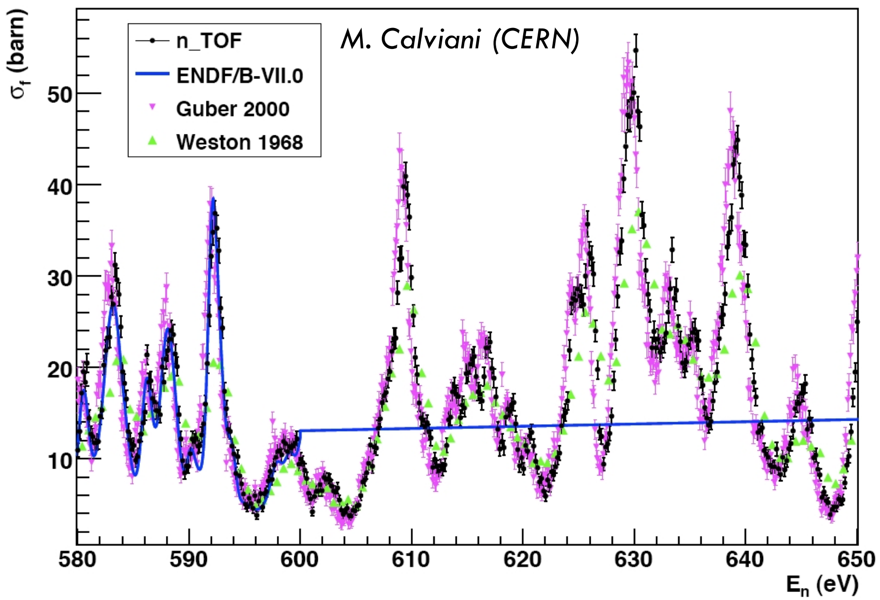


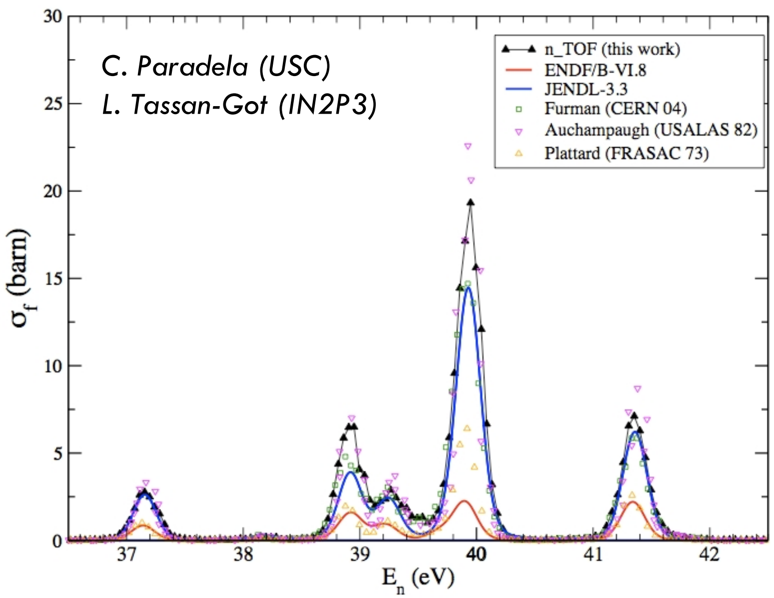


$^{234}U(n,\gamma)$ data

n_TOF experiments (III)

Fission measurement with FIC and PPAC





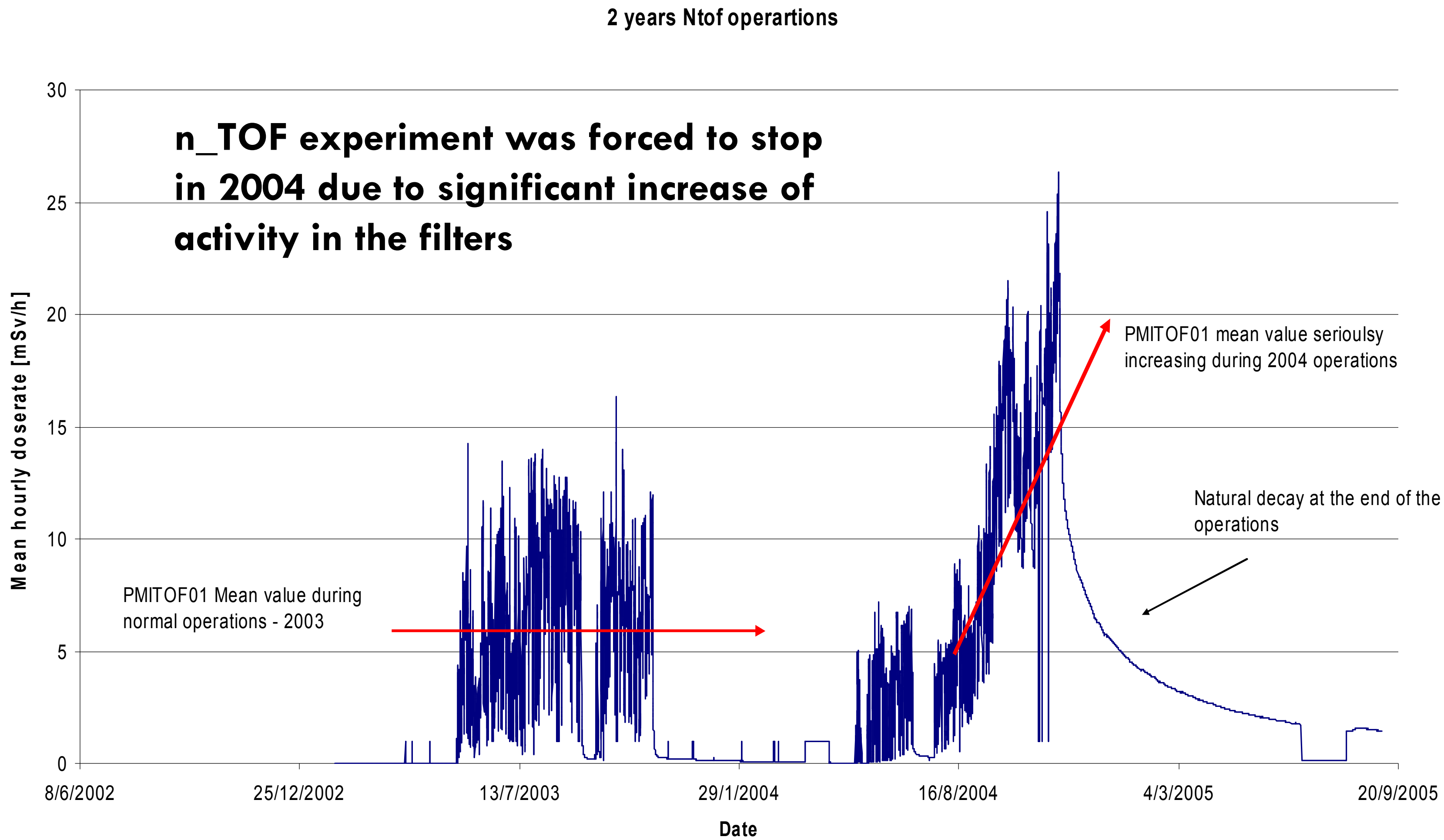
^{233}U(n,f) data with FIC detector

- from thermal to 1 MeV neutron energy range
- soon available on EXFOR database
- good agreement with Guber's ORELA data

^{237}Np(n,f) data with PPACs

- from ~1 eV → 1 GeV
- small cross section below the threshold, still several resonances present

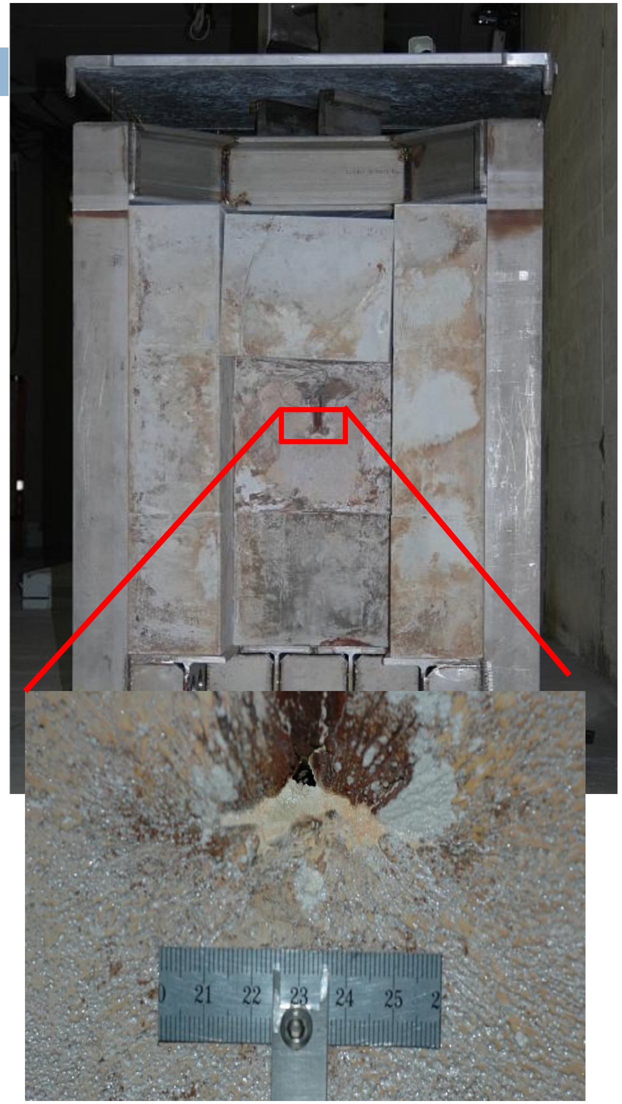
Cooling circuit activation in 2004 run



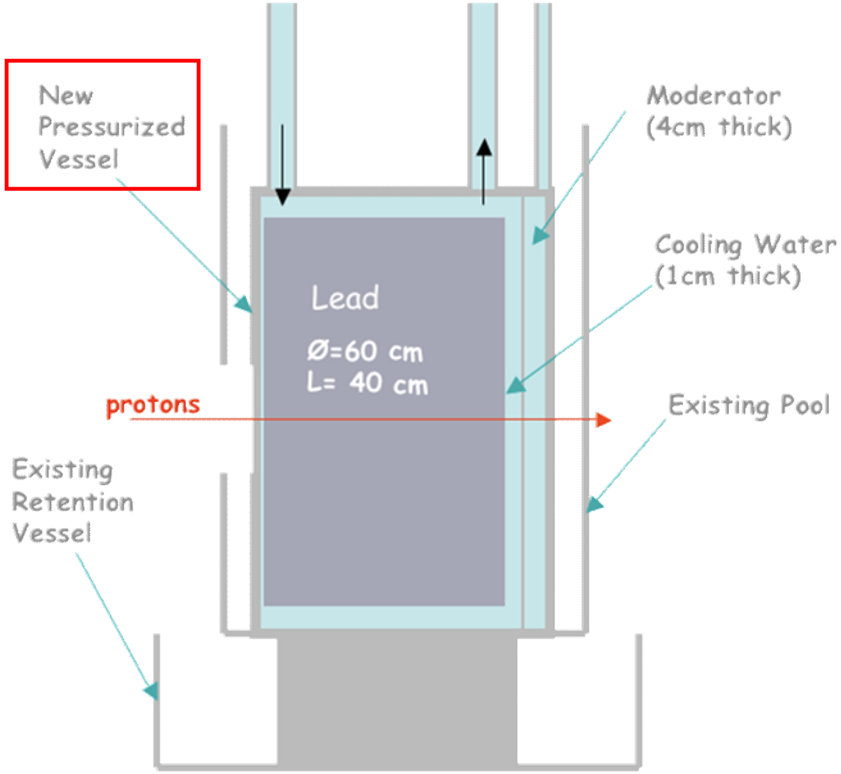
2007-2008 target inspection

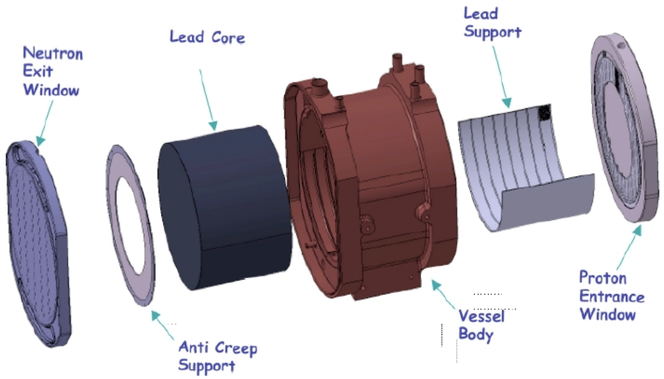
- 27/09/2007: target removed from pit
- Visual inspection and dose rate measurement
- Observation of hole at beam impact location
- Target surface inspection
- Extensive study of target corrosion mechanism
    - **pitting corrosion** at proton impact location
    - **surface oxidation** due to rupture of protection layer when drying of tank was performed
    - old target shape didn't allowed proper cooling at proton hitting point
    - modular assembly lead to mechanical instability and deformation

⇨ **Past experience helped to design the new system**



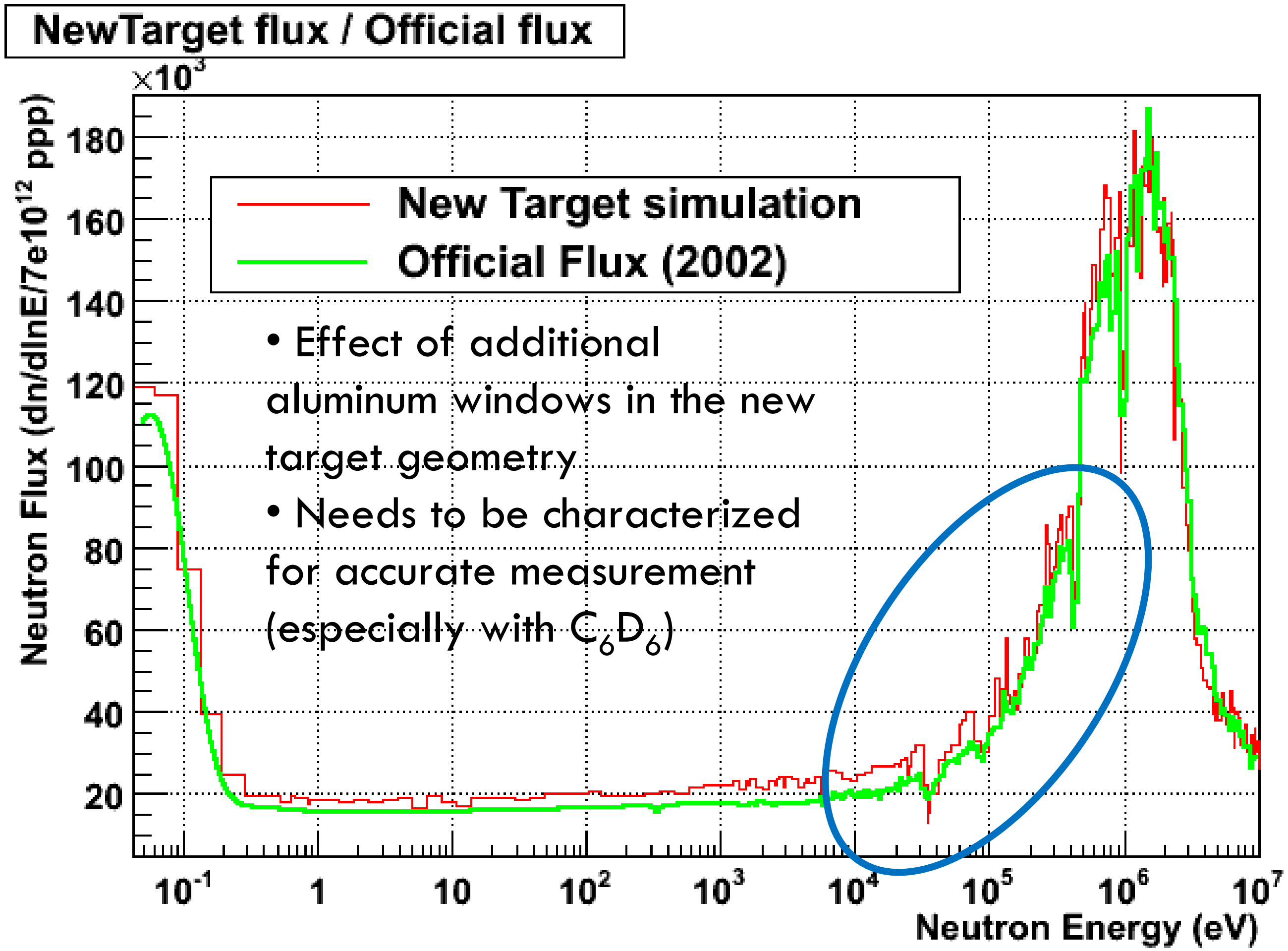
New Pb spallation target





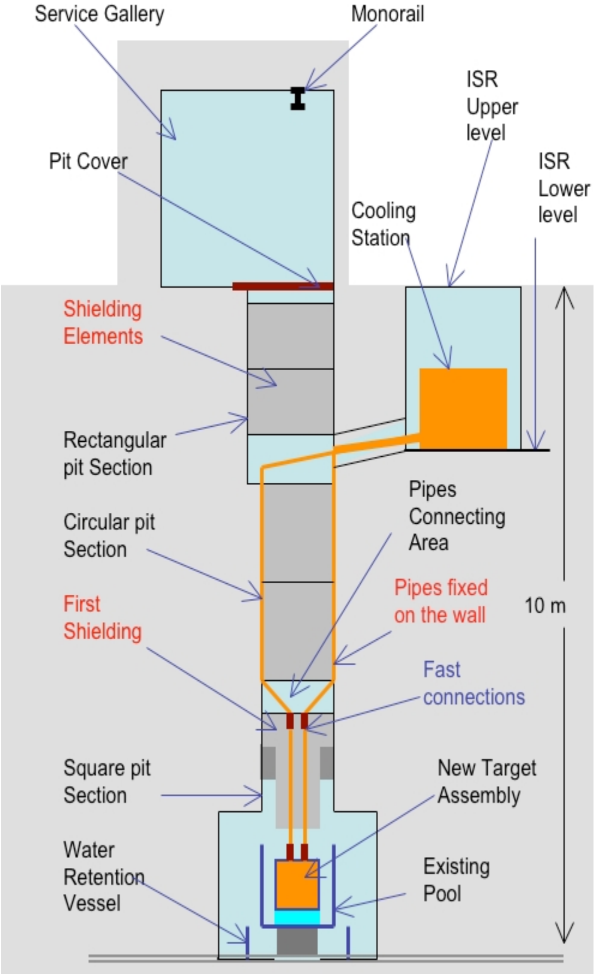
- Optimization for separated cooling and moderator circuit
- Larger proton beam spot size
- Slightly smaller target

Simulated neutron fluence in experimental area for the new target

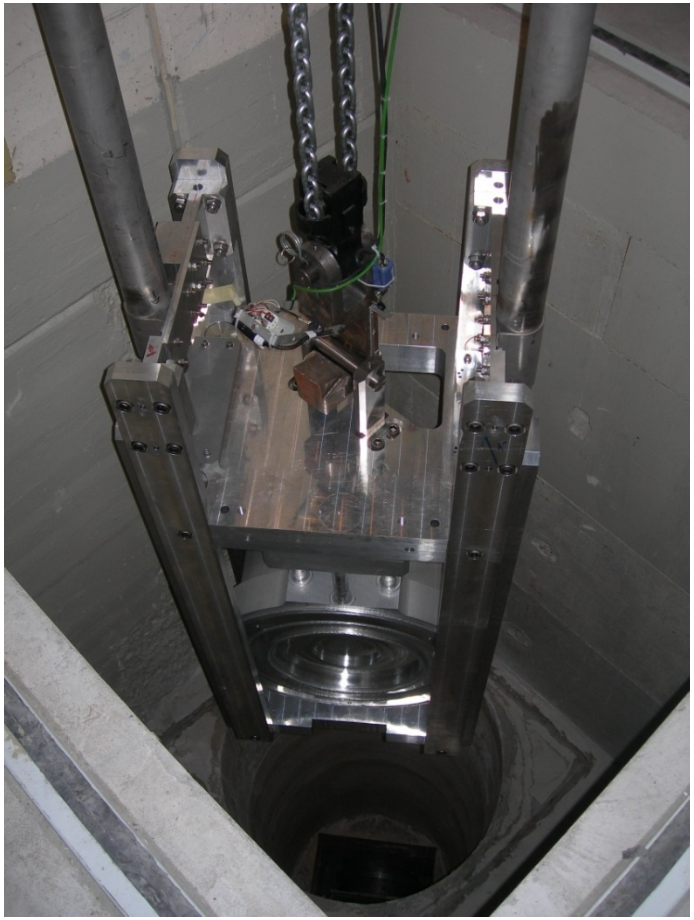


- Effect of additional aluminum windows in the new target geometry
- Needs to be characterized for accurate measurement (especially with C_6D_6)

2009 pit layout



New target makes use of the same pit with modified geometry to take into account the positioning of the cooling station in ISR area



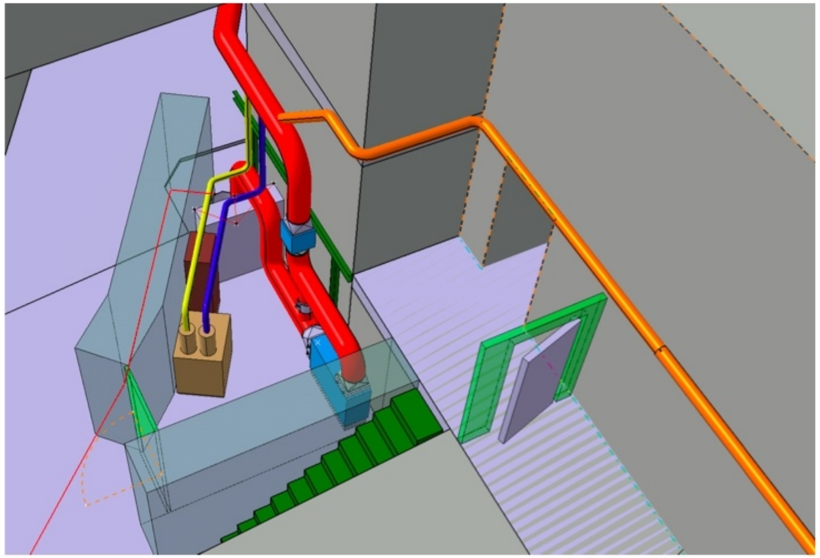
Cooling station and ventilation layout

Target cooling station

- Monitoring of the oxygen content, pH and conductivity in the water (O_2 level < 80 ppb)
- resin filter to stop Pb and spallation products
- constant flow rate at ~5 m^3/h

→ We are safely operating the target since 5 months with full beam condition

Ventilation station



Primary target area is continuously flushed:

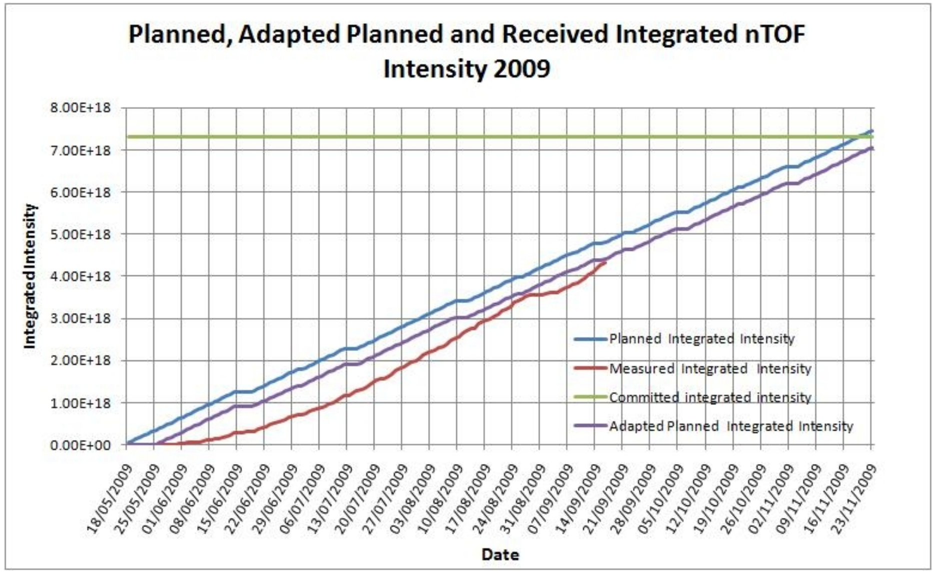
- Filter: ^{7}Be (not efficient for noble gases)
- Flow rate: 600-1100 m^3/h
- Dose to the public must not exceed 1 μSv/run

2009 new target commissioning

27th May – 15th August
Commissioning completed!
2.68×10^{18} p

Beam characteristics:
- Neutron fluence in experimental area
  - PTB fission chamber with ^{235}U
  - μMegas: $^{235}U(n,f)$ + $^{10}B(n,\alpha)$
  - Silicon monitor
  - Activation of gold foils
  - TAC
- Neutron beam profile:
  - Medipix detector with LiF & polyethylene converter
  - X-Y μMegas
- Resolution function:
  - C6D6 with ^{56}Fe (part of physics measurement)

Cooling station:
- monitor performances
- control of O_2 level to avoid lead corrosions issues



Phase II experimental program (I)

Capture measurements	
Mo, Ru, Pd stable isotopes	r-process residuals calculation isotopic patterns in SiC grains
Fe, Ni, Zn, and Se (stable isotopes) ^{79}Se	s-process nucleosynthesis in massive stars accurate nuclear data needs for structural materials
A≈150 (isotopes varii)	s-process branching points long-lived fission products
^{234,236}U, ^{231,233}Pa	Th/U nuclear fuel cycle
^{235,238}U	standards, conventional U/Pu fuel cycle
^{239,240,242}Pu, ^{241,243}Am, ^{245}Cm	incineration of minor actinides

(*) approved by CERN Scientific Committee (planned for execution in 2008+2009)

Phase II experimental program (II)

Fission measurements	
MA ...several...	ADS, high-burnup, GEN-IV reactors
^{235}U(n,f) with p(n,p')	new ^{235}U(n,f) cross section standard
^{234}U(n,f)	study of vibrational resonances at the fission barrier
Other measurements	
^{147}Sm(n,α), ^{67}Zn(n,α), ^{99}Ru(n,α) ^{58}Ni(n,p), other (n,lcp)	p-process studies gas production in structural materials
Al, V, Cr, Zr, Th, ^{238}U(n,lcp)	structural and fuel material for ADS and other advanced nuclear reactors
He, Ne, Ar, Xe	low-energy nuclear recoils (development of gas detectors)
n+D_2	neutron-neutron scattering length

n_TOF future upgrades

Moderator upgrades:

• Aim is to reduce the in-beam γ from $^{1}H(n,\gamma)$ → 2.2 MeV

• → important for capture measurement with C6D6

•Separate circuit for the moderator:

- Normal water
- Borated water (1.28% HP ^{10}B) Same flux E_n>1eV ~ x10 reduction on the 2.2 MeV γ

→ Systems is already in the engineering phase and will be ready for the May 2010 run

Class-A "working sector"

Convert the actual experimental area to a Class-A one → no significant restrictions on radioactive samples

• Foreseen for 2010

Shorter flight path experimental area

- Flight-path length : ~20 m
- 90° respect to p-beam direction
- Expected neutron flux enhancement: >10
- Drastic reduction of the t_0 flash

→ Technical study ready for Spring 2010

Conclusions

1999-2005

- The combination of the n_TOF beam characteristics and the experimental area setup have been proved to be unique for high accuracy cross-section measurement
- Several publications for capture and fission data
- The experience gained with the previous target helped in the construction of the new spallation target

2009:

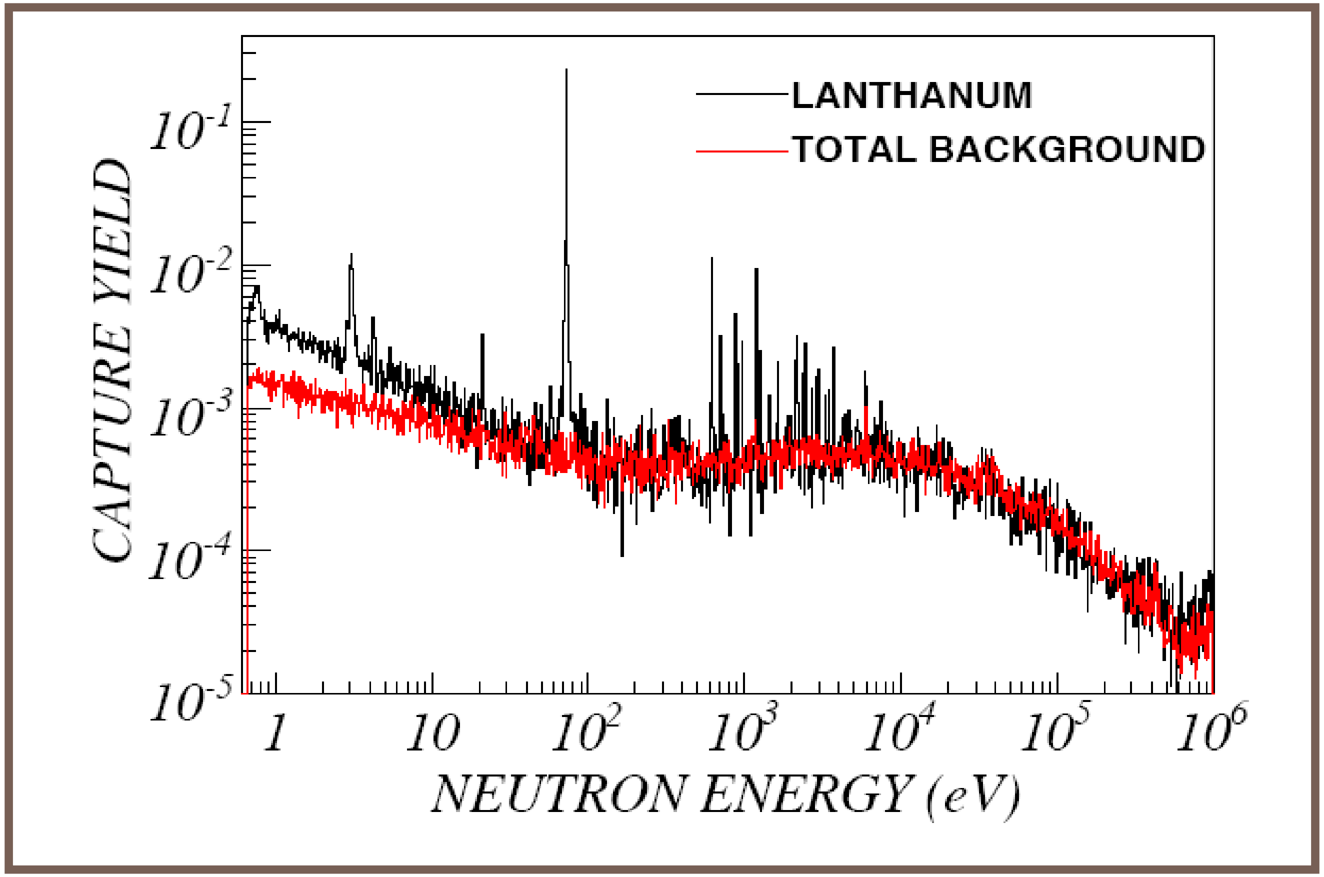
- The 2008-2009 commissioning of the new target showed parameters consistent with expectations from simulation and engineering evaluations
- Approved experimental program:
  - 4 accepted proposals, one/two ongoing for 2009 run → (request ~2.5×10^{19} p)
  - expected POT is 1.6×10^{19} p/run

≥ 2010:

- Borated water moderation system
- Transformation of experimental area in a Class-A working sector
- Second experimental area (under study)

BACKUP

Background to in-beam γ rays



^{233}U fission data