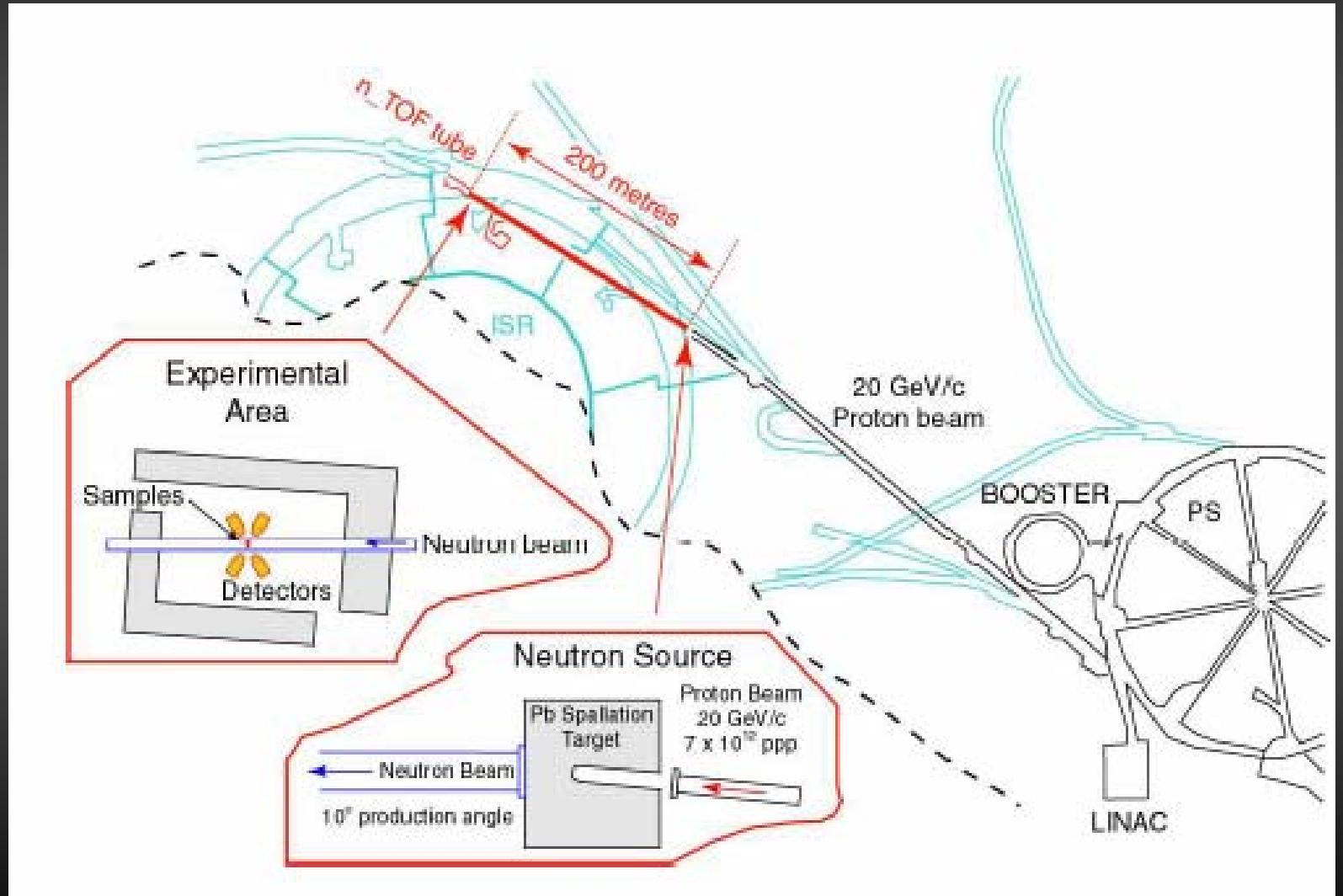


The Physics Programme at n_TOF (in 2007 and beyond)

Alberto Mengoni
IAEA , Vienna

- Yesterday
- Today
- Tomorrow (n_TOF-Phase 2)

The n_TOF facility at CERN



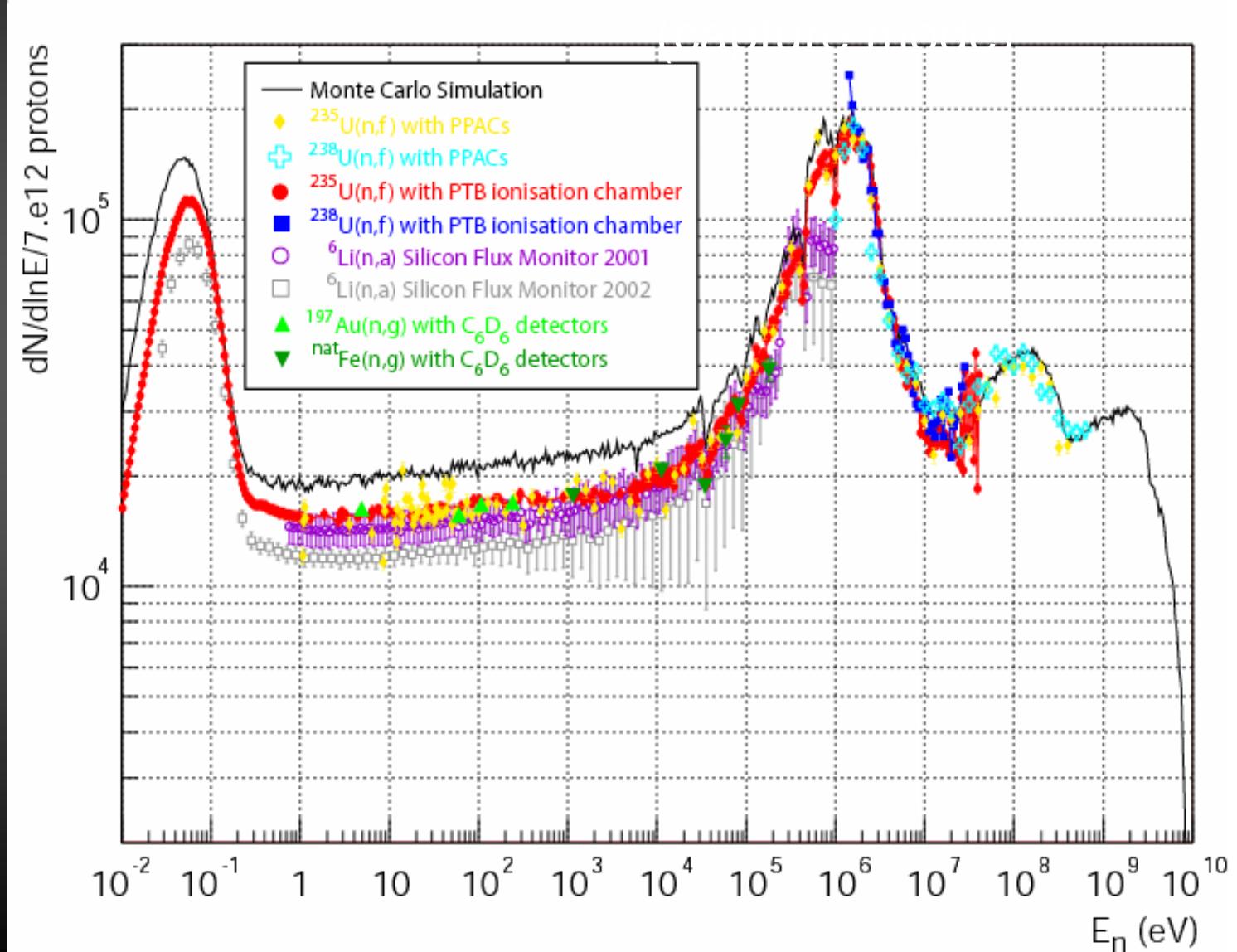
n_TOF basic parameters

proton beam momentum	20 GeV/c
intensity (dedicated mode)	7×10^{12} protons/pulse
repetition frequency	1 pulse/2.4s
pulse width	6 ns (rms)
n/p	300
lead target dimensions	80x80x60 cm ³
cooling & moderation material	H ₂ O
moderator thickness in the exit face	5 cm
neutron beam dimension in EAR-1 (capture mode)	2 cm (FWHM)

n_TOF beam characteristics

■ the neutron flux

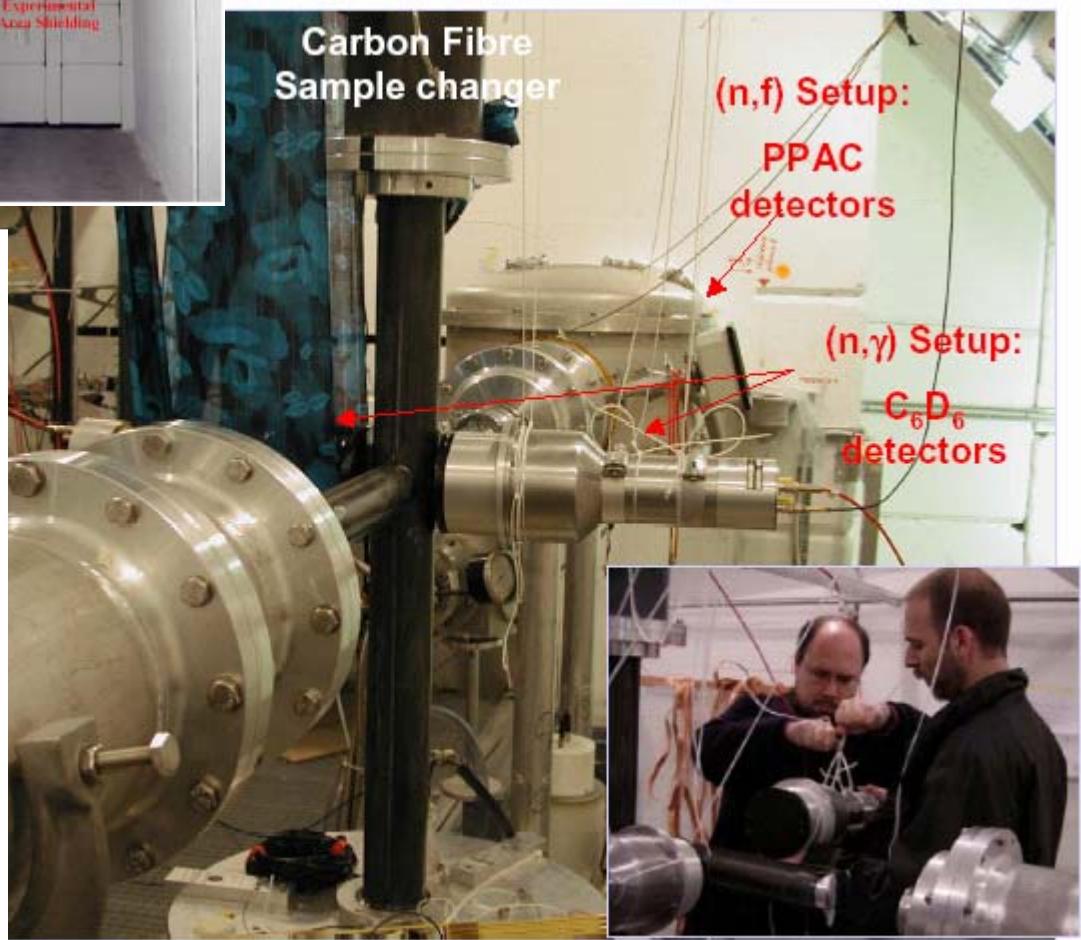
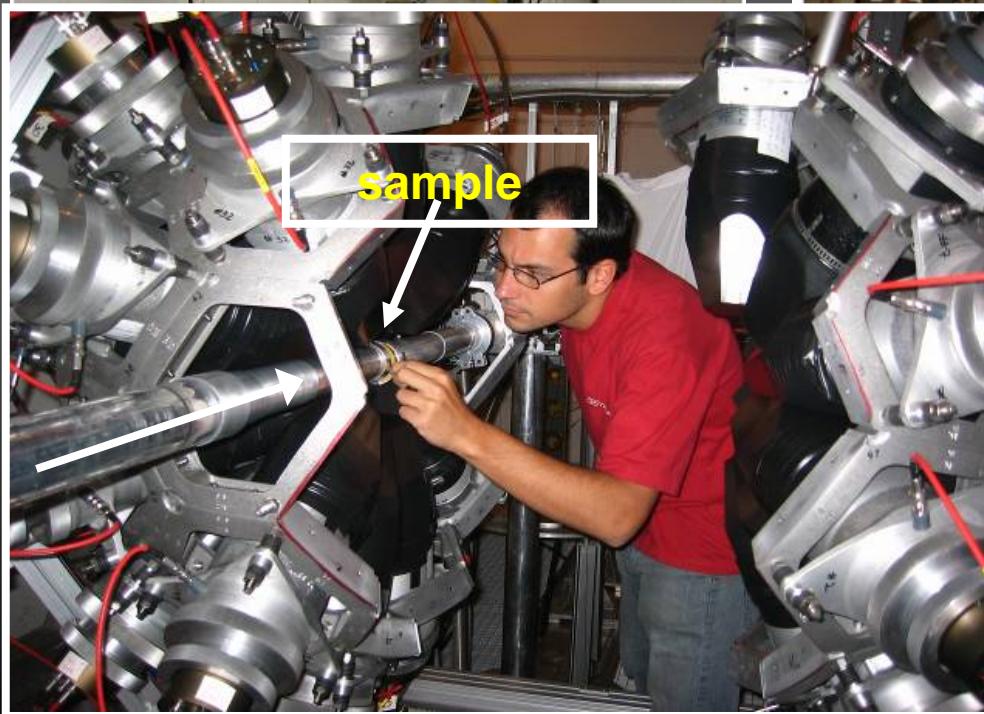
2nd collimator $\phi=1.8$ cm



Performance Report
CERN-INTC-2002-037, January 2003
CERN-SL-2002-053 ECT

The real world

- n_TOF commissioned in 2001-2002



Objectives of the activity at n_TOF (n_TOF Phase-2, April 2005)

1. Cross sections relevant for Nuclear Astrophysics
2. Measurements of neutron cross sections relevant for Nuclear Waste Transmutation and related Nuclear Technologies
3. Neutrons as probes for fundamental Nuclear Physics & other applications

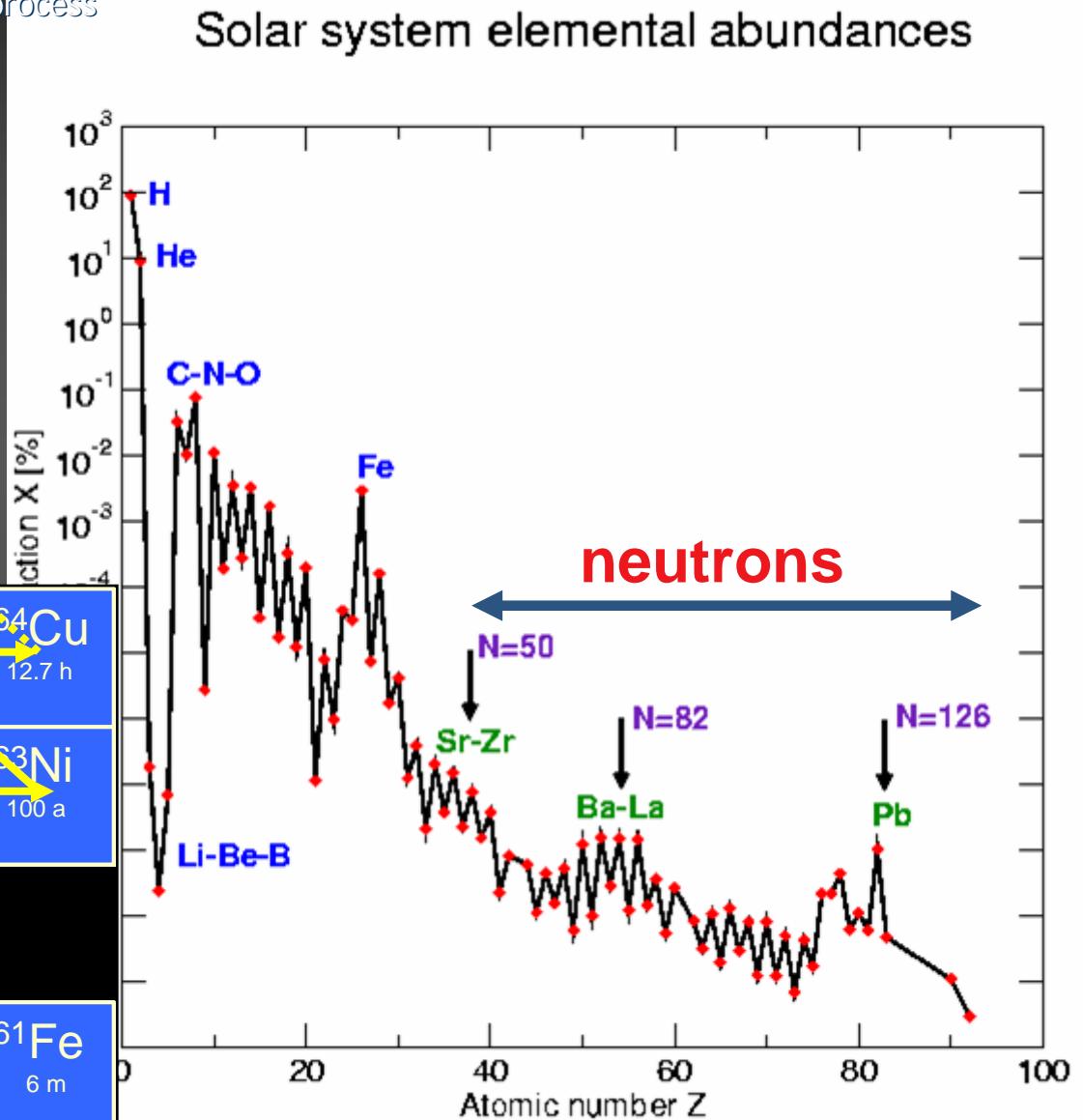
Nucleosynthesis: the s-process

- $\frac{1}{2}$ of the elements above Fe are produced by the s-process
- The astrophysical sites of the s-process are:
 - He burning in intermediate/massive stars
 - Low-mass AGB's
- There exists a direct correlation between the neutron capture cross section and the abundance ($\sigma(n, \gamma) \cdot N = \text{const.}$)
- The neutron capture cross sections are key ingredients for s-process nucleosynthesis

The canonical s-process

Cu		62Cu 9.74 m	63Cu 69.17	64Cu 12.7 h
Ni		60Ni 26.23	61Ni 1.140	62Ni 3.634
Co		58Co 70.86 d	59Co 100	60Co 5.272 a
Fe		56Fe 91.72	57Fe 2.2	58Fe 0.28
			59Fe 44.503 d	60Fe $1.5 \cdot 10^6$ a
				61Fe 6 m

Half-lives are given in parentheses.



Nuclear waste: TRU (1000 MW_e LWR)

	Cm 238 2,4 h	Cm 239 3 h	Cm 240 27 d	Cm 241 32,8 d	Cm 242 162,94 d	Cm 243 29,1 a	Cm 244 18,10 a	Cm 245 8500 a	Cm 246 4730 a	
	α ν 6,52	α γ 188... ν	α γ 6,291; 6,248... ν 9	α γ 5,336; ν 472; 431; 132... ν 8	α γ 6,113; 6,059... ν 278; 229; 210...; ν 15; ν < 5	α γ 5,785; 5,748... ν 5,205; 5,192... ν 143...; ν 130; ν < 620	α γ 5,805; 5,782... ν 5,205; 5,192... ν 143...; ν 130; ν < 1,1	α γ 5,381; 5,384... ν 175; 133... ν 350; ν < 2100	α γ 5,386; 5,343... ν 1,2; ν 0,16	
Am 236 ? 3,7 m	Am 237 73,0 m	Am 238 1,63 h	Am 239 11,9 h	Am 240 50,8 h	Am 241 432,2 a	Am 242 141 a	Am 243 7370 a	Am 244 26 m	Am 245 2,05 h	
α 6,41	α ν 6,042 γ 280; 438; 474... ν 9	α γ 5,34... ν 963; 913; 561... ν 608... ν	α γ 5,774... ν 276; 228... ν 8	α γ 5,376... ν 988; 889... ν 8	α γ 5,409; 5,443... ν 5,205; 5,192... ν 1790; ν < 2100	α γ 5,409; 5,443... ν 5,205; 5,192... ν 1790; ν < 2100	α γ 5,479; 5,293... ν 5,205; 5,192... ν 175 + 5; ν 0,074	α γ 5,479; 5,293... ν 5,205; 5,192... ν 175 + 5; ν 0,074	α γ 5,386; 5,343... ν 1,2; ν 0,16	
Pu 235 25,3 m	Pu 236 2,858 a	Pu 237 45,2 d	Pu 238 87,74 a	Pu 239 2,411 - 10 ⁴ a	Pu 240 6563 a	Pu 241 14,35 a	Pu 242 3,750 - 10 ⁵ a	Pu 243 4,956 h	Pu 244 8,00 - 10 ⁷ a	
α ν 5,80... + 49; (158; 34...) ν	α ν 5,788; 5,721... ν ; Mg 28... + 49; (158; 34...) ν	α ν 5,334... ν 140; 109...; ν ν 180	α ν 5,499; 5,468... ν 51; Mg 28... ν 142; 109...; ν ν 180; ν 17	α ν 5,157; 5,144... ν 159; ν 150... ν 270; ν 752	α ν 5,168; 5,124... ν 159; ν 145... ν 270; ν 752	α ν 5,168; 5,124... ν 159; ν 145... ν 270; ν 1010	α ν 5,038; ν 4,891... ν 149...; ν 370; ν 1010	α ν 4,901; 4,896... ν 4,891... ν 149...; ν 370; ν 1010	α ν 4,988; 4,946... ν 4,946... ν 100; ν 200	
Np 234 4,4 d	Np 235 396,1 d	Np 236 22,5 m	Np 237 1,54 - 10 ⁵ a	Np 238 2,144 - 10 ⁶ a	Np 239 2,117 d	Np 240 2,355 d	Np 241 7,22 m	Np 242 13,9 m	Np 243 1,85 m	
α β^+ γ 1559; 1528; 1602... ν 900	α ν 5,025; 5,007... ν 126; 84...; ν ν 160 + ?	α ν 5,025; 5,007... ν 126; 84...; ν ν 160 + ?	α ν 4,790; 4,774... ν 209; 87...; ν ν 180; ν 0,020	α ν 4,790; 4,774... ν 209; 87...; ν ν 180; ν 0,020	β^- 1,2... ν 994; 1029; 1026; 924...; ν ν 2100	β^- 0,4... ν 106; 278; 226...; ν 9; ν 32 + 19; ν < 1	β^- 2,2... ν 565; 567; 601... ν 498; ν	β^- 1,3... ν 175; (133...)	β^- 2,2... ν 738; 738; 945; 1473... ν 158; ν	
U 233 1,592 - 10 ⁵ a	U 234 0,0055	U 235 0,7200	U 236 120 ns	U 237 4,342 - 10 ⁷ a	U 238 6,75 d	U 239 99,2745	U 240 2,3 m	U 241 14,1 h	U 242 16,8 m	
α 4,824; 4,783... ν Ne 25... γ (42; 97...); ν ν 47; ν 530	α ν 2,455 - 10 ⁵ a	α ν 4,775; 4,729... ν Mg 28; Ne 15 (53; 121...) ν 49; ν 530	α ν 7,939 - 10 ⁶ a	α ν 4,398... ν 107; ν ν 155	α ν 4,448... ν 17; ν ν 113... ν 4	β^- 0,2... ν 80; 208... ν 113... ν 100; ν < 0,35	β^- 1,2... ν 4,958 - 10 ³ a	β^- 1,2; 1,3... ν 75; 44... ν 22; ν 15	β^- 0,4... ν 44; (190...)	β^- ν 68; 58; 585; 573... ν
Pa 232 1,31 d	Pa 233 27,0 d	Pa 234 1,17 m	Pa 235 6,70 h	Pa 236 24,2 m	Pa 237 9,1 m	Pa 238 8,7 m	Pa 239 2,3 m	Pa 240 148	Pa 242 150	
β^- 0,3; 1,3...; ν 969; 894; 150...; ν ν 460; ν 700	β^- 0,3; 0,6... ν 312; 300; 341...; ν ν 20 + 18; ν < 0,1	β^- 0,2... ν 12; 13... ν 7; 14... ν 600	β^- 1,4... ν 28 - 659	β^- 2,0; 3,1... ν 842; 587; 1763...; ν ν 7	β^- 1,4; 2,3... ν 854; 865; 529; 541... ν	β^- 1,7; 2,9... ν 1015; 635; 448; 680... ν				
Th 231 25,5 h	Th 232 100	Th 233 1,405 - 10 ¹⁹ a	Th 234 22,3 m	Th 235 24,10 d	Th 236 7,1 m	Th 237 37,5 m	Th 238 5,0 m			
β^- 0,3; 0,4... ν 26; 84... ν	β^- 0,3; 0,4... ν 7,37; ν 0,000005	β^- 0,2... ν 15; 16... ν 1500; ν 15	β^- 0,2... ν 63; 92; 93... ν 15...; ν ν < 0,01	β^- 1,4... ν 417; 727; 696...	β^- 1,0... ν 111; (647; 196...)	β^-				

LLFP

source: Actinide and Fission Product Partitioning and Transmutation – NEA (1999)

244Cm
1.5 Kg/yr

241Am: 11.6 Kg/yr
243Am: 4.8 Kg/yr

239Pu: 125 Kg/yr

LLFP
76.2 Kg/yr

Capture

^{151}Sm

$^{204,206,207,208}\text{Pb}$, ^{209}Bi

^{232}Th

$^{24,25,26}\text{Mg}$

$^{90,91,92,94,96}\text{Zr}$, ^{93}Zr

^{139}La

$^{186,187,188}\text{Os}$

$^{233,234}\text{U}$

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

Fission

$^{233,234,235,236,238}\text{U}$

^{232}Th

^{209}Bi

^{237}Np

$^{241,243}\text{Am}$, ^{245}Cm

n_TOF experiments 2002-4

10 groups of experiments endorsed by the INTC and approved by the RB:

- n_TOF-01: Facility proposal
- n_TOF-02: Commissioning
- n_TOF-03: Sm & Mg
- n_TOF-04: Os
- n_TOF-05: Pb & Bi
- n_TOF-06: Th-cycle fission
- n_TOF-08: Zr & La
- n_TOF-09: MA fission
- n_TOF-10: MA capture (TAC)

Capture

^{151}Sm

$^{204,206,207,208}\text{Pb}$, ^{209}Bi

^{232}Th

$^{24,25,26}\text{Mg}$

$^{90,91,92,94,96}\text{Zr}$, ^{93}Zr

^{139}La

$^{186,187,188}\text{Os}$

$^{233,234}\text{U}$

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

Fission

$^{233,234,235,236,238}\text{U}$

^{232}Th

^{209}Bi

^{237}Np

$^{241,243}\text{Am}$, ^{245}Cm

$n_{_}$ TOF experiments 2002-4

28 weeks/yr (average)

483 effective 8hr-shft/yr

1.3e19 protons/yr

Problems during Phase-1 runs:

2nd collimator alignment (minor)

beam-requests (minor)

end of 2004 run increased activity in the cooling (major, to be discussed later)

Capture

^{151}Sm

$^{204,206,207,208}\text{Pb}, ^{209}\text{Bi}$

^{232}Th

$^{24,25,26}\text{Mg}$

$^{90,91,92,94,96}\text{Zr}, ^{93}\text{Zr}$

^{139}La

$^{186,187,188}\text{Os}$

$^{233,234}\text{U}$

$^{237}\text{Np}, ^{240}\text{Pu}, ^{243}\text{Am}$

Fission

$^{233,234,235,236,238}\text{U}$

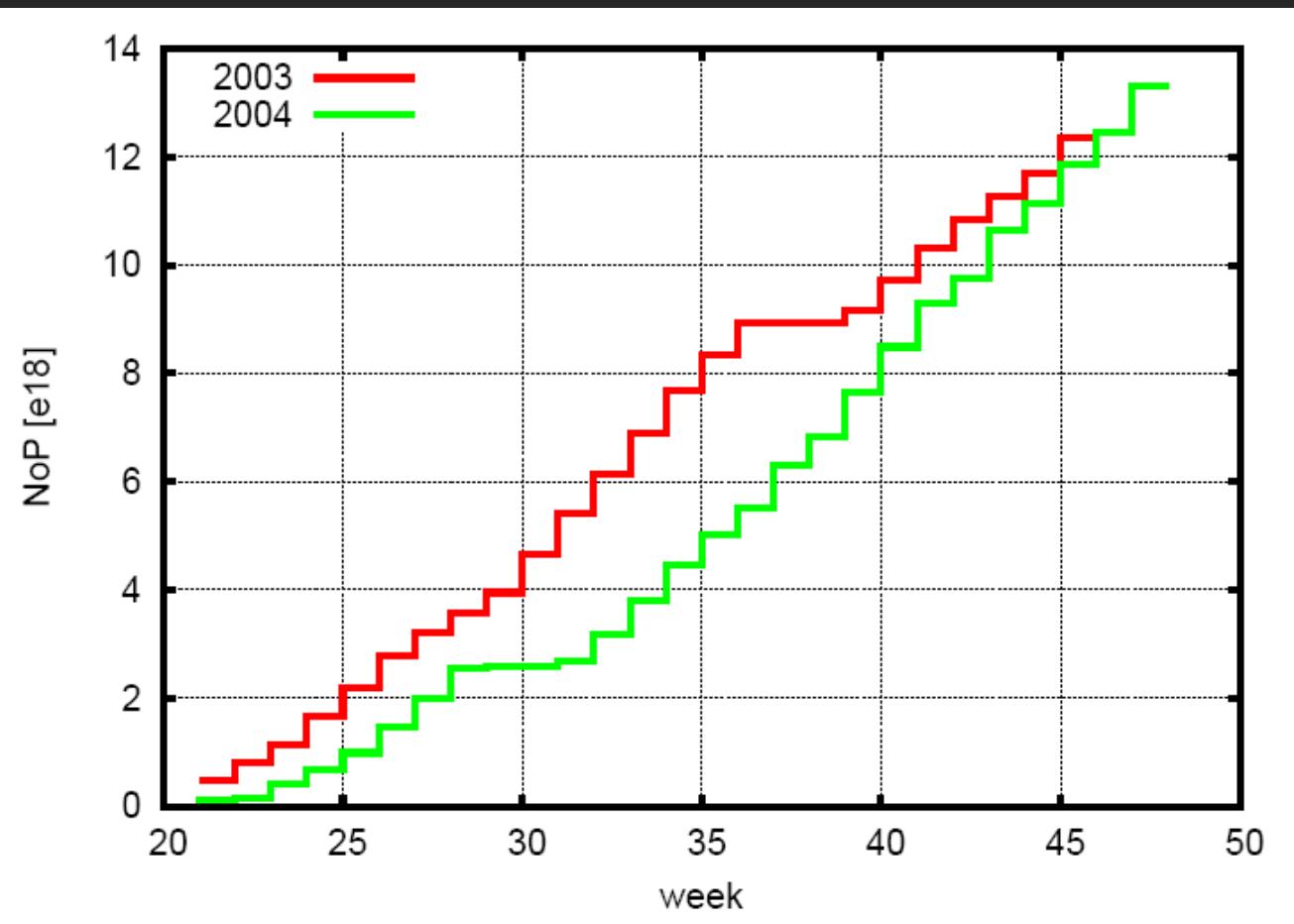
^{232}Th

^{209}Bi

^{237}Np

$^{241,243}\text{Am}, ^{245}\text{Cm}$

$n_{\text{-}}\text{TOF experiments 2002-4}$



The n_TOF Collaboration

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40 Research Institutions
120 researchers

n_TOF Collaboration structure & operation

n_TOF Collaboration Board Chairman, Spokesperson

- 23 n_TOF teams
- all teams participates in the development, commissioning, and operation of detectors, daq, etc.
- all teams participated in all the experiments/measurements
- 16 partners in the n_TOF-ND-ADS EC Project (FP5)
2.4 MEUR investment in equipments
(6.3 MEUR total budget)
run over the period 2001-2004
(completed)

n_TOF Collaboration Board Chairman & Spokesperson

- Teams involved in individual proposals/experiment (with individual spokesperson)
 - Fe, Ni, Zn & Se proposal
 - Fission measurements proposal
 - n-scattering proposal
 - ...
- Common M&O budget
- Some team involved in EC/FP6 projects (EFNUDAT, EUROTRANS)

The n_TOF-Ph2 experiments 2007 and beyond

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

$A \approx 150$ (isotopes vari)

s-process branching points
long-lived fission products

$^{234,236}\text{U}$, $^{231,233}\text{Pa}$

Th/U nuclear fuel cycle

$^{235,238}\text{U}$

standards, conventional U/Pu fuel cycle

$^{239,240,242}\text{Pu}$, $^{241,243}\text{Am}$, ^{245}Cm

incineration of minor actinides

(*) endorsed by INTC, spokespersons: JL Tain (Valencia), M Heil (GSI, Darmstadt)

The n_TOF-Ph2 experiments 2007 and beyond

Fission measurements

MA

ADS, high-burnup, GEN-IV reactors

$^{235}\text{U}(\text{n},\text{f})$ with $\text{p}(\text{n},\text{p}')$

new $^{235}\text{U}(\text{n},\text{f})$ cross section standard

$^{234}\text{U}(\text{n},\text{f})$

study of vibrational resonances at the fission barrier

Other measurements

$^{147}\text{Sm}(\text{n},\alpha)$, $^{67}\text{Zn}(\text{n},\alpha)$, $^{99}\text{Ru}(\text{n},\alpha)$
 $^{58}\text{Ni}(\text{n},\text{p})$, other (n,lcp)

p-process studies
gas production in structural materials

Al, V, Cr, Zr, Th, $^{238}\text{U}(\text{n},\text{lcp})$

structural and fuel material for ADS
and other advanced nuclear reactors

He, Ne, Ar, Xe

low-energy nuclear recoils
(development of gas detectors)

$\text{n}+\text{D}_2$

neutron-neutron scattering length

n_TOF: resume activities in 2007

All teams involved in Phase-1 expressed interest to continue the activities for n_TOF Phase-2

- Lol, January 2005
- Budget for M&O allocated by funding agencies
- new MoU, draft ready December 2006

2.5 years after last neutron beam delivered to EAR-1

New PhD students need data to work on(*)

EC I3 projects in FP6 (EFNUDAT, EUROTRANS) running

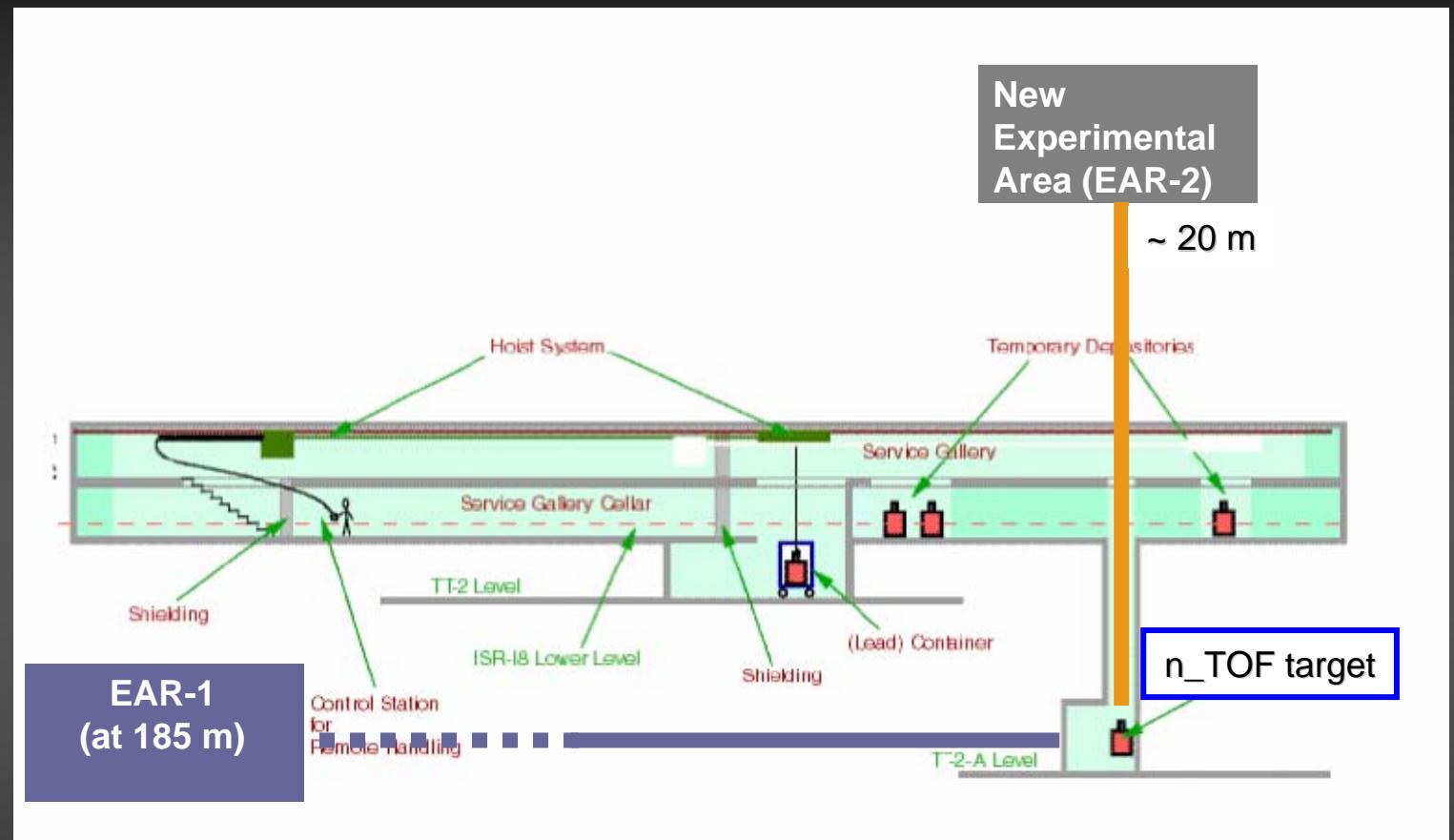
(*) so far: 13 PhD Thesis (completed), 6 in preparation (4 to be completed by 2007), 2 starting in 2007

n_TOF: resume activities in 2007!

3 Questions:

- 1. New target design, construction & installation**
- 2. Use of radioactive samples in EAR-1**
- 3. Perspectives for further developments & optimizations
of the facility outlined (EAR-2)**

The second n_TOF beam line & EAR-2



Flight-path length : ~20 m
at 90° respect to p-beam direction
expected neutron flux enhancement: ~ 100
drastic reduction of the t_0 flash

EAR-2: Optimized sensitivity

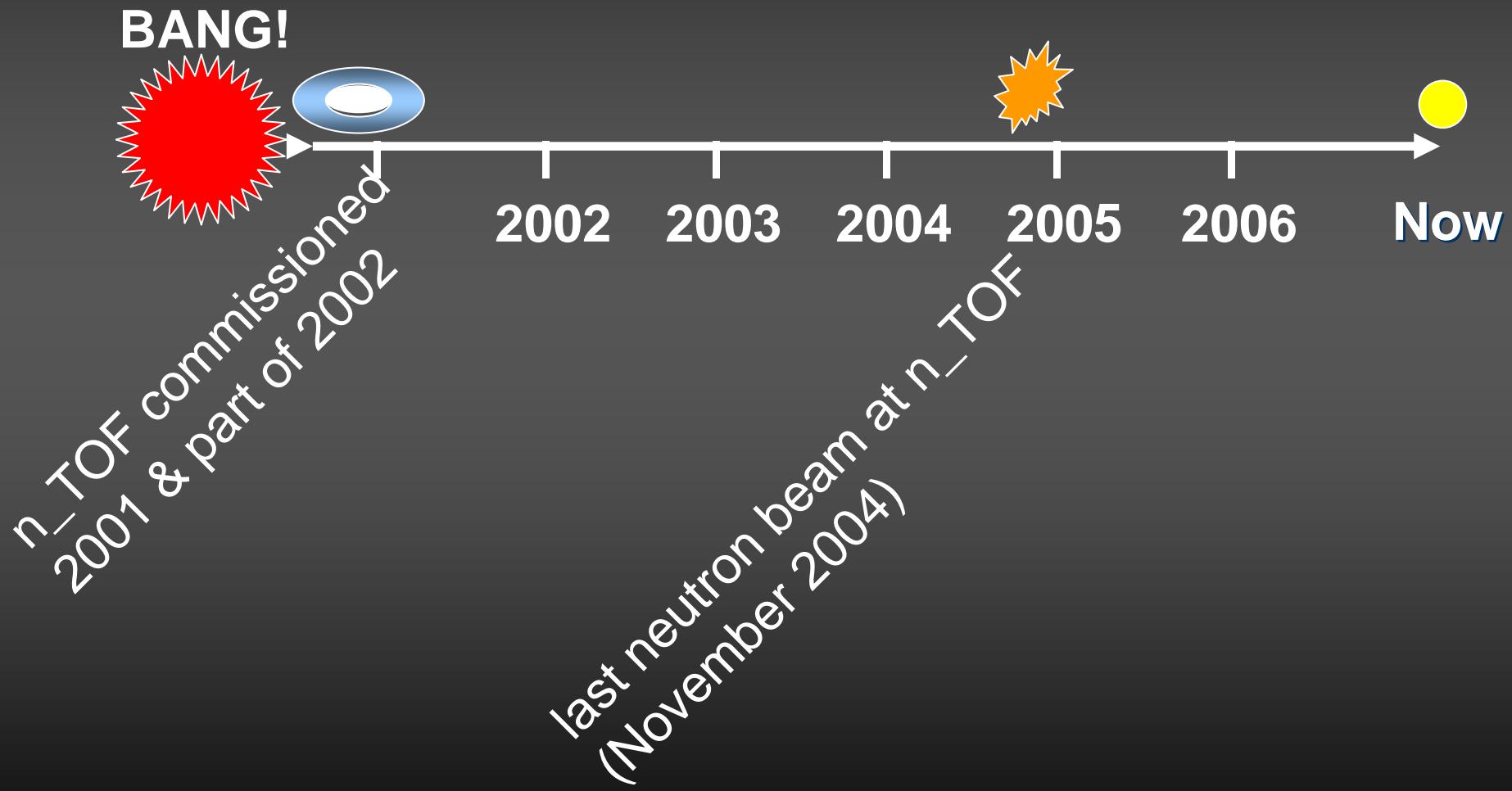
Improvements (ex: ^{151}Sm case)	consequences for sample mass
■ sample mass / 3 s/bkgd=1	✓ 50 mg
■ use BaF_2 TAC	✓ 5 mg
■ use D_2O	■ 1 mg
■ use 20 m flight path	■ 10 μg

boosts sensitivity by a factor of 5000 !



→ problems of sample production and safety issues relaxed

Time at n_TOF

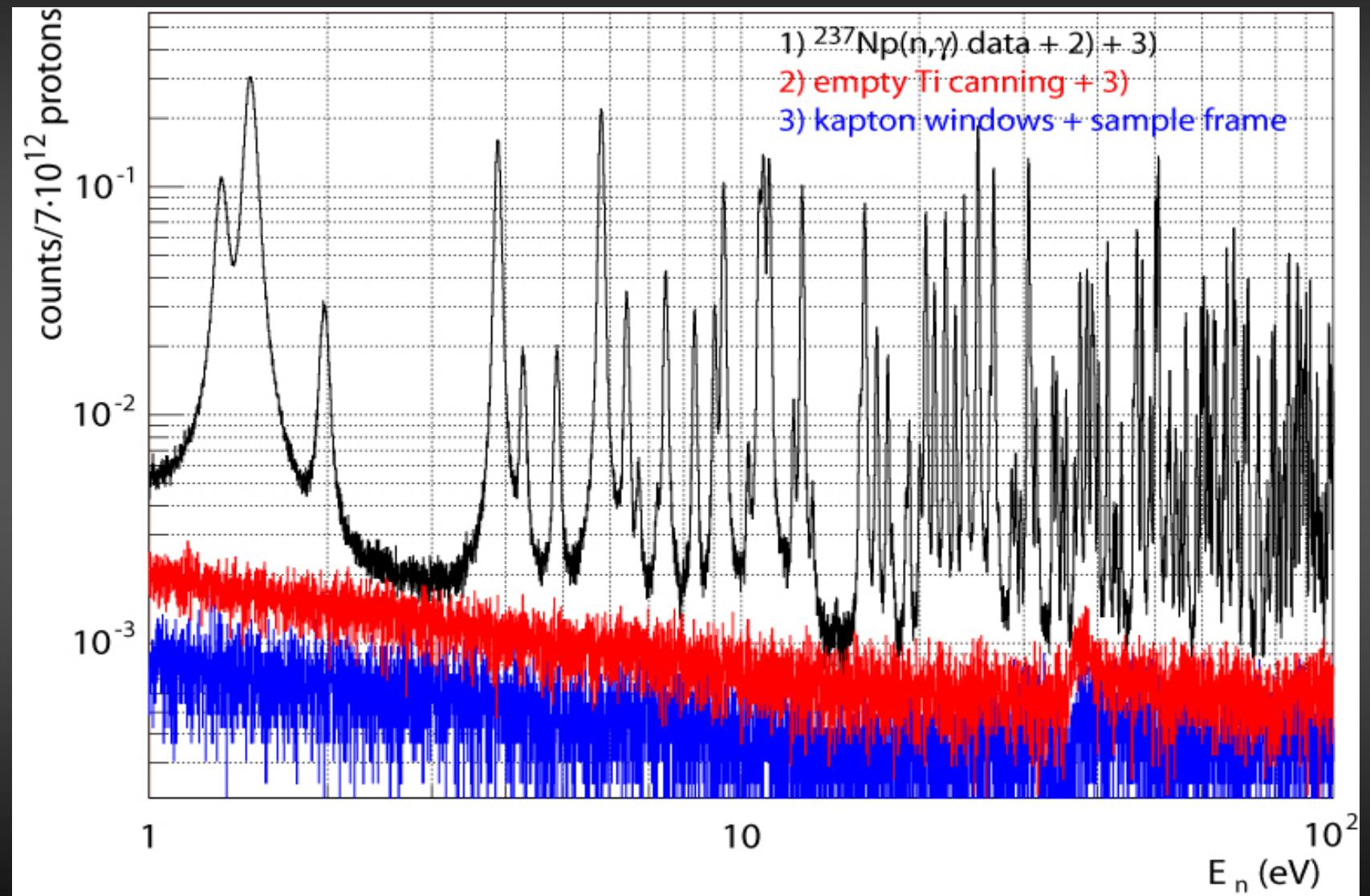


The End

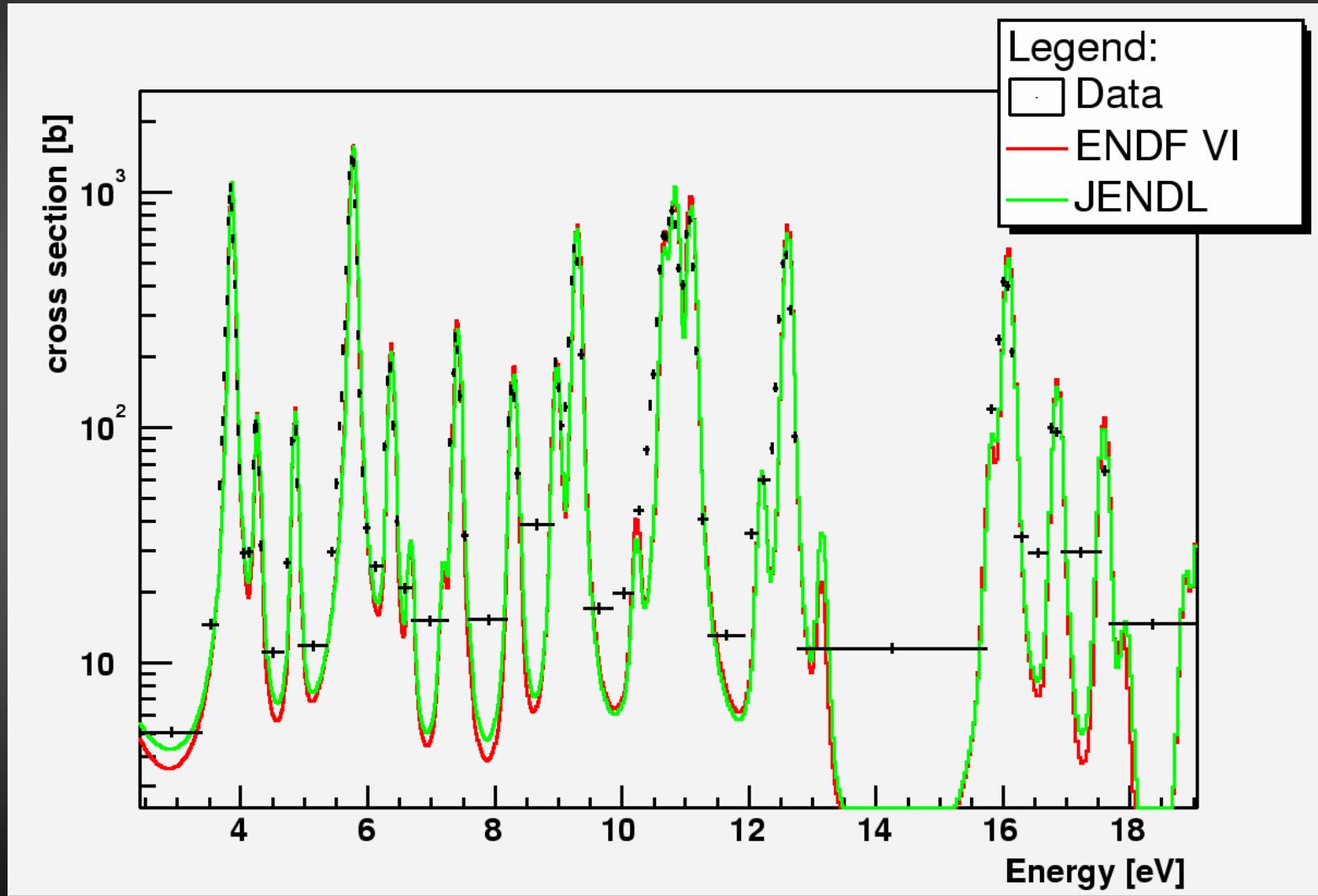


$^{237}\text{Np}(n,\gamma)$ at n_TOF

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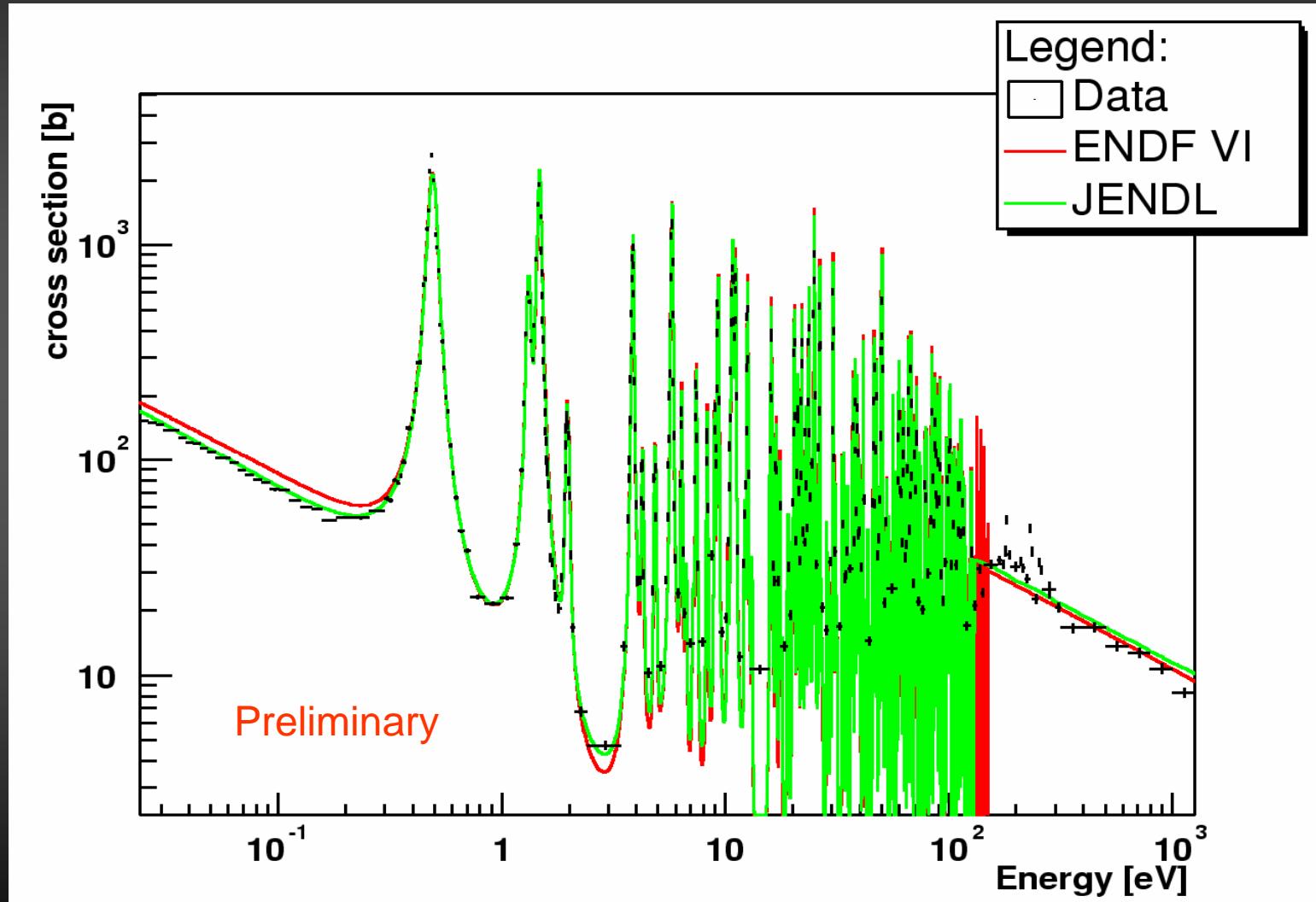


$^{237}\text{Np}(\text{n},\gamma)$ at LANSCE



Source: J Ullman, n_BANT workshop, CERN, March 2005

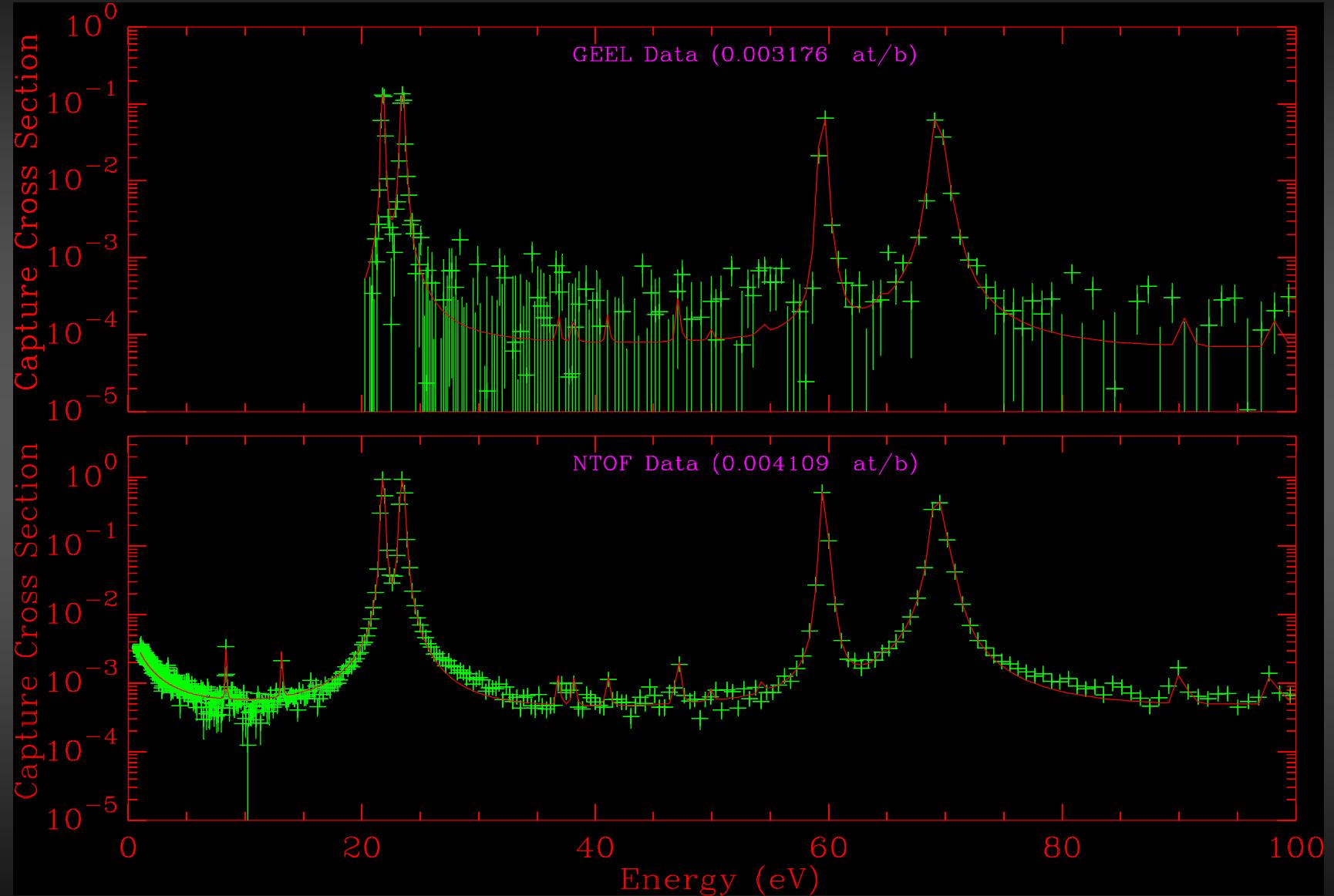
$^{237}\text{Np}(\text{n},\gamma)$ at LANSCE



Source: J Ullman, n_BANT workshop, CERN, March 2005

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$^{232}\text{Th}(n,\gamma)$: n_TOF & GELINA

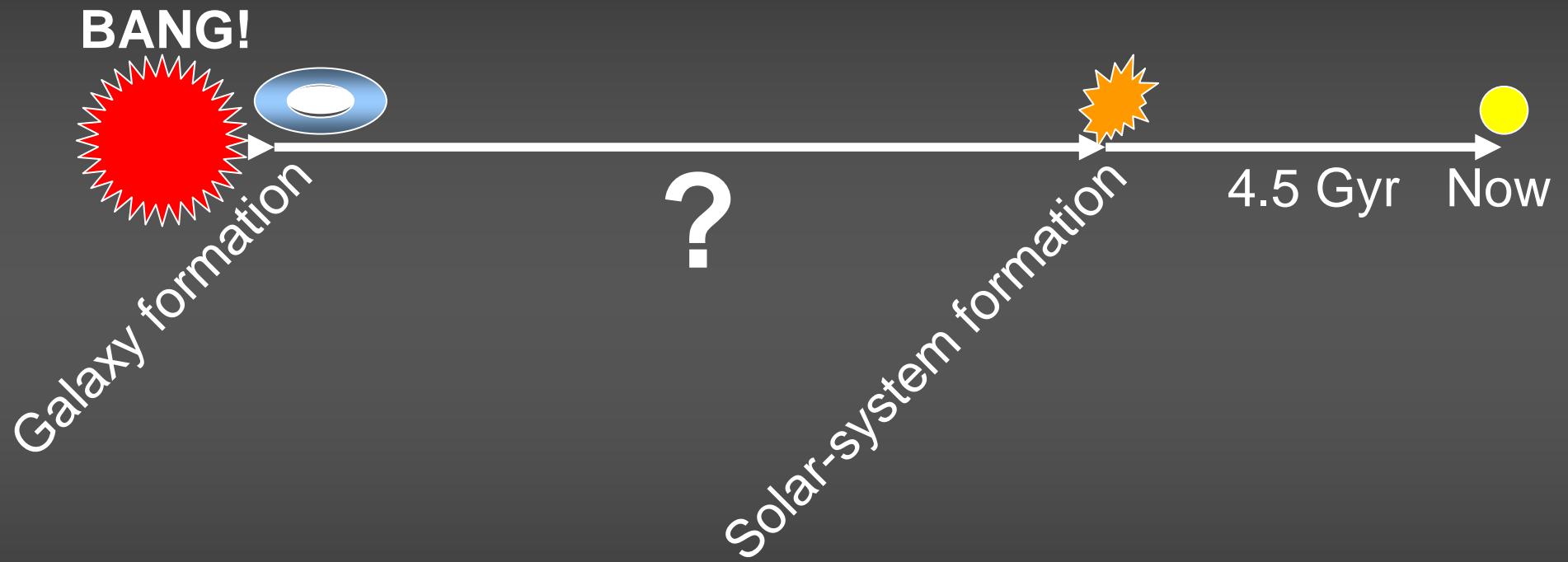


Source: L Leal, IAEA CRP meeting, December 2004

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Time



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Re/Os clock



Os	Os 184 0.02	Os 185 94 d	Os 186 1.58	Os 187 1.6	Os 188 13.3	Os 189 16.1	Os 190 26.4	Os 191 15.4 d	Os 192 41.0
Re	Re 183 71 d	Re 184 38 d	Re 185 37.4	Re 186 90.64 h	Re 187 62.6 42.3x10 ⁹ a	Re 188 16.98 h	Re 189 24.3 h	Re 190 3.1 m	
W	W 182 26.3	W 183 14.3	W 184 30.67	W 185 75.1 d	W 186 28.6	W 187 23.8 h	W 188 69 d		

The β -decay half-life of ^{187}Re is 42.3 Gy

Effect on the abundance of the decay daughter ^{187}Os

Summary

- **Cosmological way (WMAP observations)**

$13.7 \pm 0.2 \text{ Gyr}$

- **Astronomical way**

$14 \pm 2 \text{ Gyr}$

- **Nuclear way: Re/Os clock**

$14.9 \pm 2 \text{ Gyr(*)}$

Th/U clock

$14.5 \pm 2.8_{2.2} \text{ Gyr}$

Source: Dauphas, Nature 435 (2005) 1203

(*) 0.4 Gyr uncertainty due to x-sections

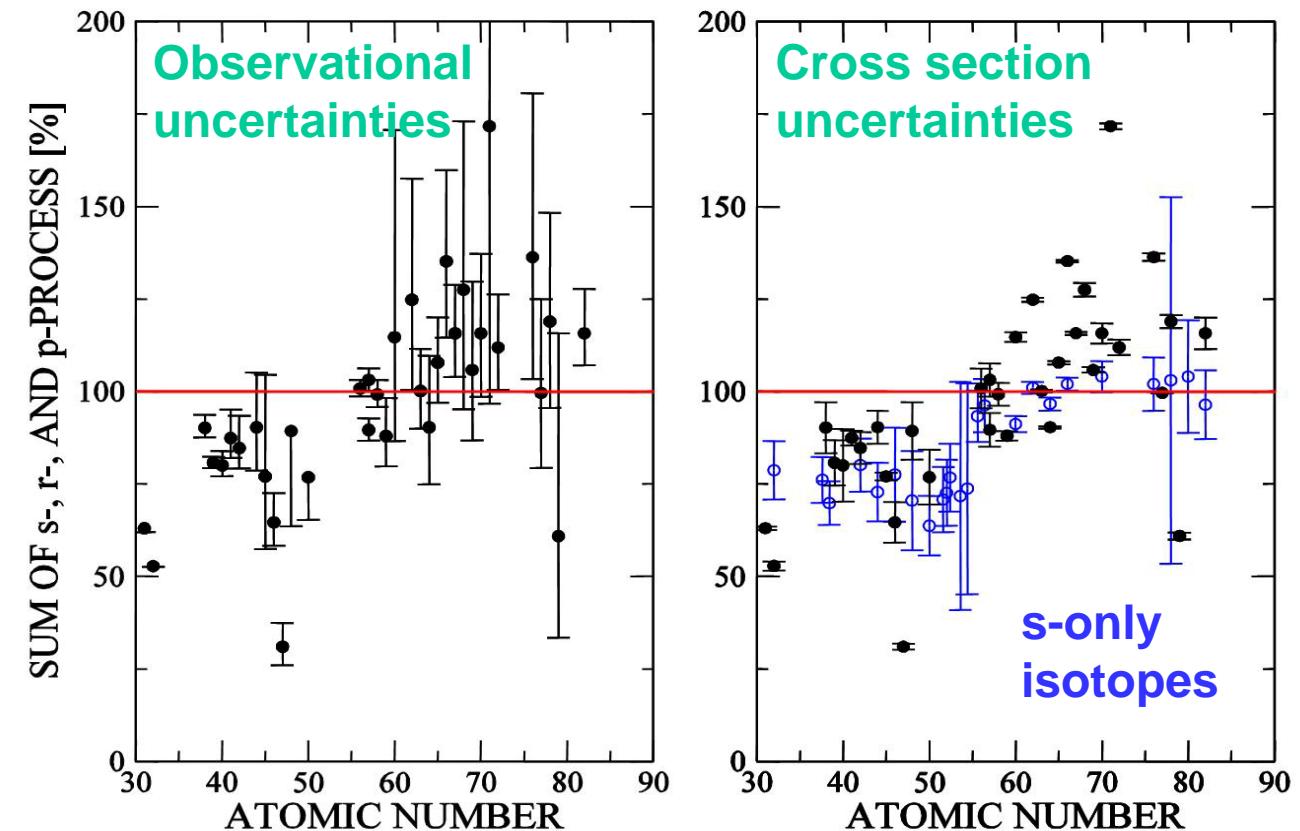
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In general:

Stellar model
s-abundance
calculation

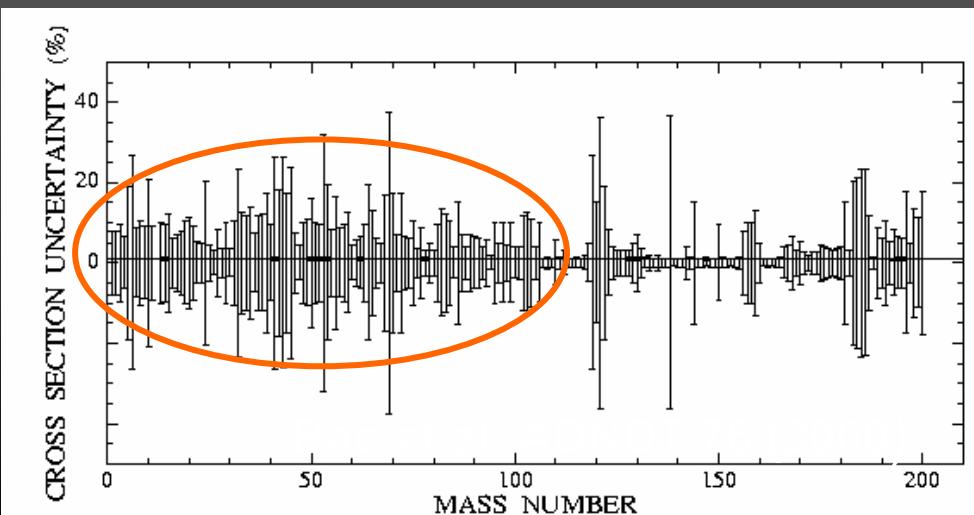
Tavaglio et al. APJ521 (1999)
Arlandini et al. APJ525 (1999)

+
CS22892-052
r-abundance



Need for more than one r-process
or need for improved s- abundances
(cross sections)?

<<back

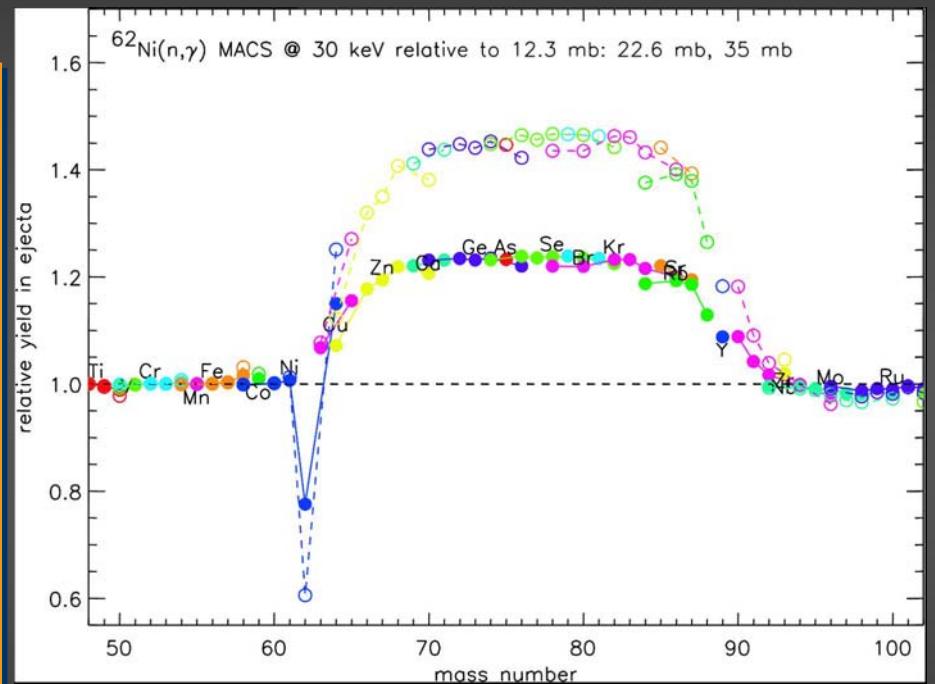


Capture studies: Fe, Ni, Zn, and Se

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Motivations:

- Study of the weak s-process component (nucleosynthesis up to A ~ 90)
- Contribution of massive stars (core He-burning phase) to the s-process nucleosynthesis.
- s-process efficiency due to bottleneck cross sections (Example: ^{62}Ni)



In addition:

Fe and Ni are the most important structural materials for nuclear technologies. Results of previous measurements at n_TOF show that capture rates for light and intermediate-mass isotopes need to be revised.

Capture studies: Fe, Ni, Zn, and Se

		Kr 73 26 s	Kr 74 11,5 m	Kr 75 4,5 m	Kr 76 14,6 h	Kr 77 1,24 h	Kr 78 0,35	Kr 79 50 s	Kr 80 2,25	Kr 81 13,1 s 2,3 19,5 a	Kr 82 11,6	Kr 83 1,83 h	Kr 84 11,5 h	Kr 85 57,0	Kr 86 4,48 h	Kr 86 10,76 s	Kr 86 17,3			
34		β^+ 5,6... γ 178; 241; 455; 591... $\beta\beta$ 1,5 - 3,0 γ	β^+ 2,0; 2,2... γ 90; 203; 297; 63; 307... γ 183; 155...	β^+ 3,2... γ	γ 316; 270; 45; 407... γ	β^+ 1,9... γ 130; 147... γ	α 0,17 + 0... γ 190	β^+ 1,9... γ 160... γ 126...	β^+ 2,2... γ 142... γ	β^+ 1,7... γ 162... γ 126...	β^+ 1,4 + 7... γ	β^+ 3... γ 160... γ	β^+ 0,9... γ 0,9 + 0,02	β^+ 0,8... γ 154... γ	β^+ 0,8... γ 154... γ	β^+ 0,8... γ 154... γ				
		Br 72 10,9 s	Br 73 3,3 m	Br 74 46 m	Br 75 25,4 m	Br 76 1,6 h	Br 76 1,32 s	Br 77 4,3 m	Br 78 57,0 h	Br 78 6,46 m	Br 79 4,9 s	Br 79 50,69	Br 80 4,42 h	Br 80 17,5 m	Br 81 49,31	Br 82 6,1 m	Br 83 35,34 h	Br 84 6,0 m	Br 85 31,6 m	Br 86 2,87 m
		β^+ 101... γ 182... γ 137... γ 155...	β^+ 9,7... γ 182... γ 137... γ 155...	β^+ 8,2... γ 182... γ 137... γ 155...	β^+ 8,2... γ 182... γ 137... γ 155...	β^+ 1,7... γ 45... γ 22...	γ 45... γ 22...	β^+ 1,6... γ 106... γ 202...	β^+ 2,6... γ 22...	β^+ 2,6... γ 22...	β^+ 2,7... γ 162... γ 127...	β^+ 2,7... γ 162... γ 127...	β^+ 2,7... γ 162... γ 127...	β^+ 0,4... γ 149... γ 139...	β^+ 0,5... γ 149... γ 139...	β^+ 0,5... γ 149... γ 139...	β^+ 0,5... γ 149... γ 139...	β^+ 0,5... γ 149... γ 139...		
32		Se 71 4,74 m	Se 72 8,5 d	Se 73 39 m	Se 74 7,1 h	Se 75 0,89	Se 75 119,64 d	Se 76 0,96	Se 77 12,5 s	Se 77 7,63	Se 78 23,78	Se 79 3,9 m	Se 79 5,65 - 10,1 s	Se 80 49,61	Se 81 57,3 m	Se 82 8,73	Se 83 69 s	Se 84 22,4 m	Se 84 3,1 m	
		β^+ 3,5... γ 147; 1095... γ 630... γ 46...	β^+ no β^+ ... γ 46...	β^+ 2,1... γ 1040; 868... 1114; 745... 1708; 2020...	β^+ 2,1... γ 1040; 868... 1114; 745... 1708; 2020...	β^+ 0,8... γ 175; 1095... γ 834; 630...	β^+ no β^+ ... γ 46...	β^+ 0,9; 1,5... β^+ 1,4... γ 596; 635...	β^+ 1,2... γ 146... γ 143...	β^+ 0,7... γ 238; 521... 260... 9...	β^+ 0,7... γ 238; 521... 260... 9...	β^+ 4,4... γ 614; 696... 1309...	β^+ 4,4... γ 614; 696... 1309...	β^+ 3,8... γ 666; 1645... 1207...	β^+ 3,8... γ 666; 1645... 1207...	β^+ 3,8... γ 666; 1645... 1207...	β^+ 3,8... γ 666; 1645... 1207...			
30		As 70 53 m	As 71 65,28 h	As 72 26,0 h	As 73 80,3 d	As 74 17,77 d	As 75 100	As 76 26,4 h	As 77 38,8 h	As 78 1,5 h	As 79 8,2 m	As 80 15,2 s	As 81 34 s	As 82 14,0 s	As 83 18,1 s	As 84 13,3 s				
		β^+ 2,1; 2,8... γ 1040; 868... 1114; 745... 1708; 2020...	β^+ 0,8... γ 175; 1095... γ 834; 630...	β^+ 2,5; 3,3... γ 175... γ 0...	β^+ no β^+ ... γ 46...	β^+ 0,9; 1,5... β^+ 1,4... γ 596; 635...	β^+ 1,2... γ 146... γ 143...	β^+ 0,9; 1,5... β^+ 1,4... γ 596; 635...	β^+ 1,2... γ 146... γ 143...	β^+ 1,2... γ 146... γ 143...	β^+ 1,2... γ 146... γ 143...	β^+ 1,2... γ 146... γ 143...	β^+ 1,2... γ 146... γ 143...							
		Ge 69 39,0 h	Ge 70 21,23	Ge 71 11,43 d	Ge 72 27,66	Ge 73 7,73	Ge 74 35,94	Ge 75 47 s	Ge 76 83 m	Ge 76 7,44	Ge 77 53 s	Ge 77 11,3 h	Ge 78 88 m	Ge 79 39 s	Ge 80 19 s	Ge 80 29,5 s	Ge 81 7,6 s	Ge 82 7,8 s	Ge 82 4,60 s	
		β^+ 1,2... γ 1107; 524... 672; 1536...	β^+ 3,0... γ no γ ...	β^+ no β^+ ... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...	β^+ 0,9 + 0,28... γ 0...			
38																				
40																				
42																				
44																				
46																				
48																				
50																				

The ^{79}Se case

- s-process branching: neutron density & temperature conditions for the weak component.
- $t_{1/2} < 6.5 \times 10^4 \text{ yr}$

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