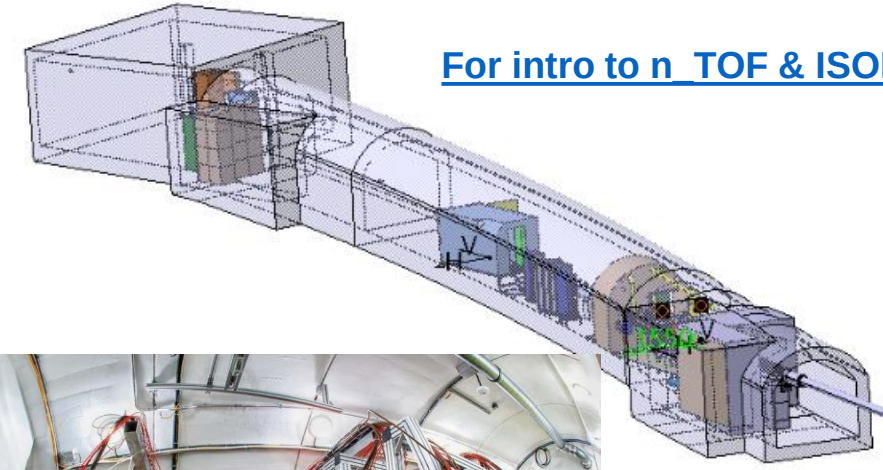
Feedback from n_TOF on 2023 Operation and Outlook

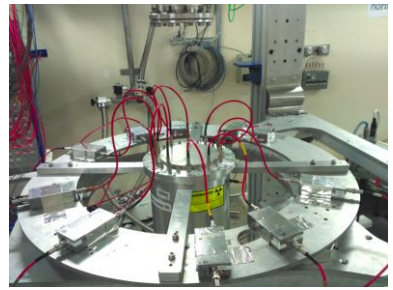
Joint Accelerator Performance Workshop, Montreux, 5-7/12/2023

Nikolas Patronis
n_TOF Physics Coordinator
CERN & Univ. of Ioannina

The n_TOF facility: EAR1 + EAR2 + NEAR

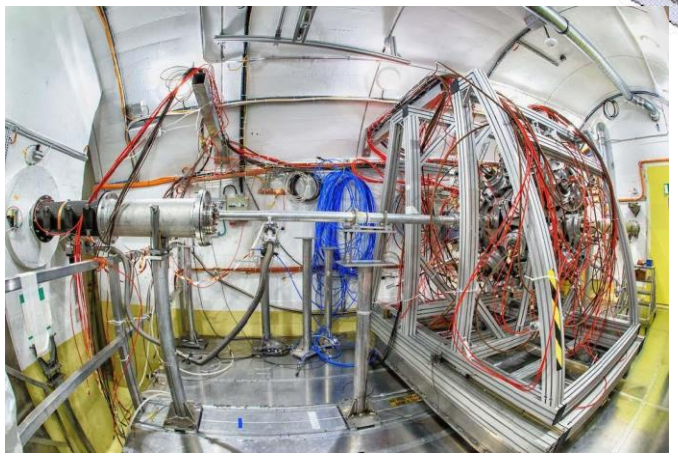
For intro to n_TOF & ISOLDE see Karl Johnston talk on IEF-2021

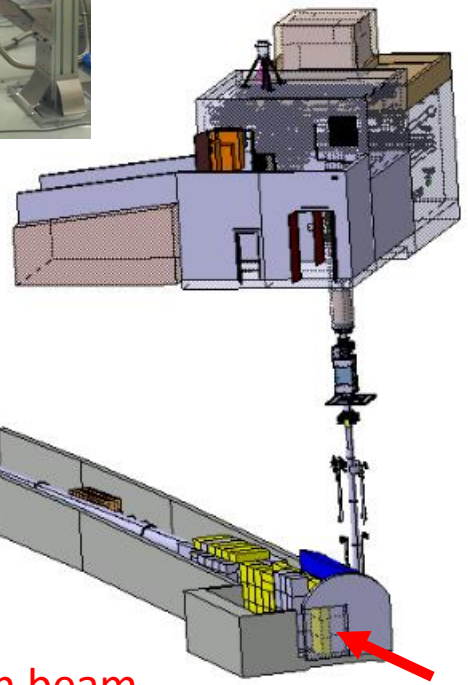


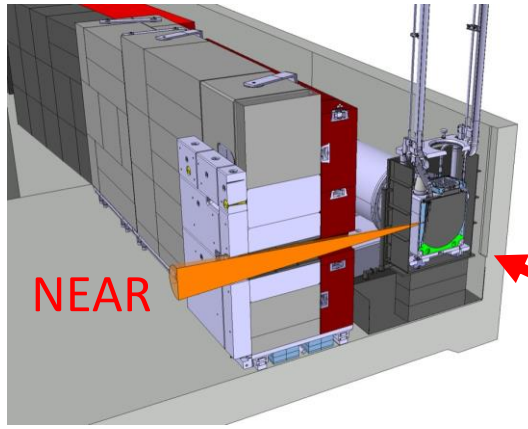


Three experimental areas (EAR)

- Horizontal flight path: EAR1 at 200 m
- Vertical flight-path: EAR2 at 20 m
- NEAR at 3m distance: activation measurements





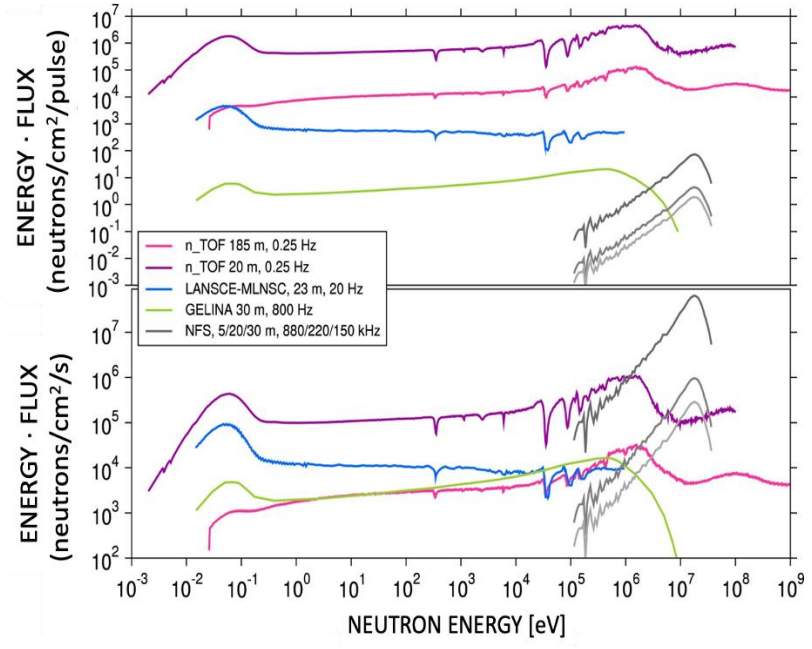


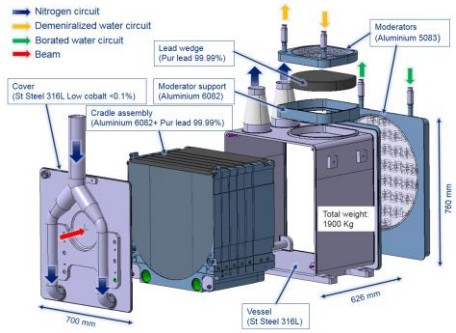
20 GeV proton beam from the PS

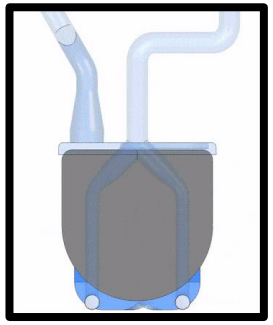
140 researchers
40 research institutions/teams
20 PhD students/year

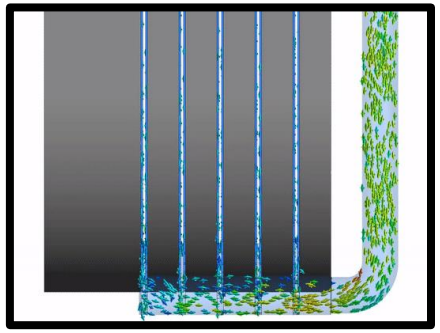
n_TOF: a unique neutron TOF facility

- **Excellent time/energy resolution**:
  - total pulse width 4σ = 28 ns
  - EAR1 0.03%@1 eV, 0.5%@1MeV
  - EAR2: 0.4%@1 eV, 4%@1MeV
- **Extended energy range** (experimental XS data for neutron energies covering 11 orders of magnitude): **meV to GeV**
- **High instantaneous flux along with low background exp. areas**
  - EAR1 ~ 0.5E6 n/puse (18 mm aperture)
  - EAR2: ~1E7 n/pulse (23 mm aperture)
  - Excellent signal to background conditions
  - Measurements with samples of extreme specific radioactivity are feasible
- **Excellent (and stable) neutron production conditions thanks to our NEW G3 spallation target**





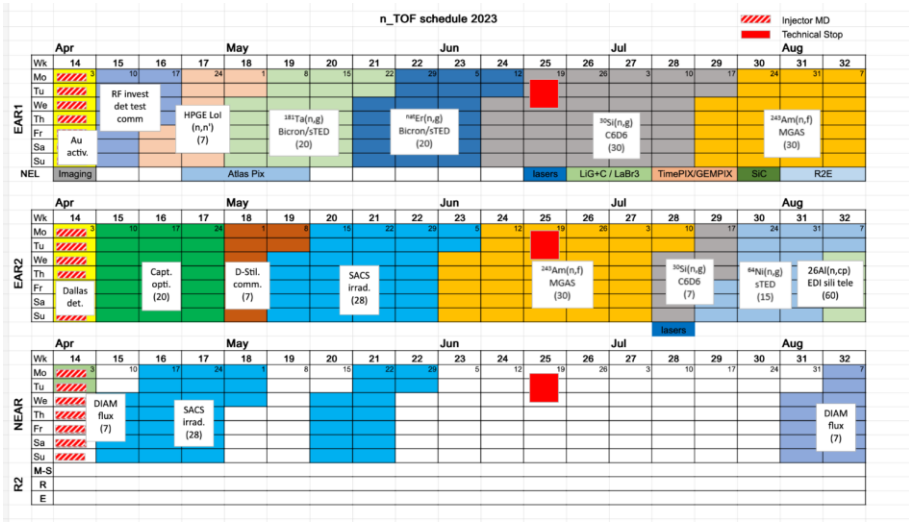


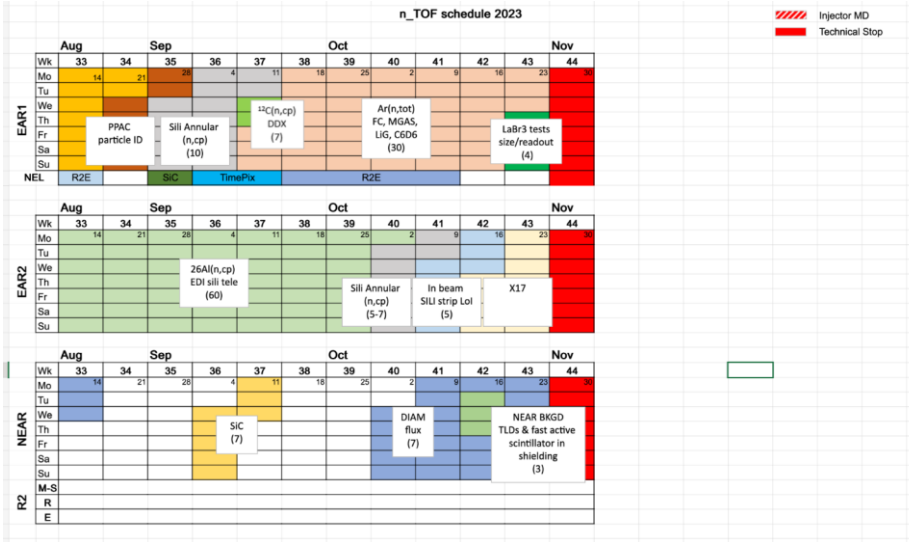


The n_TOF facility

Highlights of the 2023 n_TOF campaign

EAR1	EAR2	NEAR
• HPGe test • ^{181}Ta(n,γ) • ^{nat}Er(n,γ) • ^{30}Si(n,γ) • ^{243}Am(n,f) • ^{12}C(n,p/d/a) SADR • ^{12}C(n,p/d/a) DDX • Ar-transmission	• (n,γ) optimization study • d-stilbene test • ^{197}Au(n,γ) with 1cm & 2cm B4C • ^{76}Ce(n,γ) with 1cm & 2cm B4C • ^{243}Am(n,f) • ^{30}Si(n,γ) • ^{64}Ni(n,γ) • ^{26}Al(n,p/a) • (n,p/d/a) SADR • Si det. test for (n,cp) • X17 2nd part of in-beam test	• ^{197}Au(n,γ) • ^{140}Ce(n,γ) • ^{94}Zr(n,γ) • Diamond det. test • SiC • Background

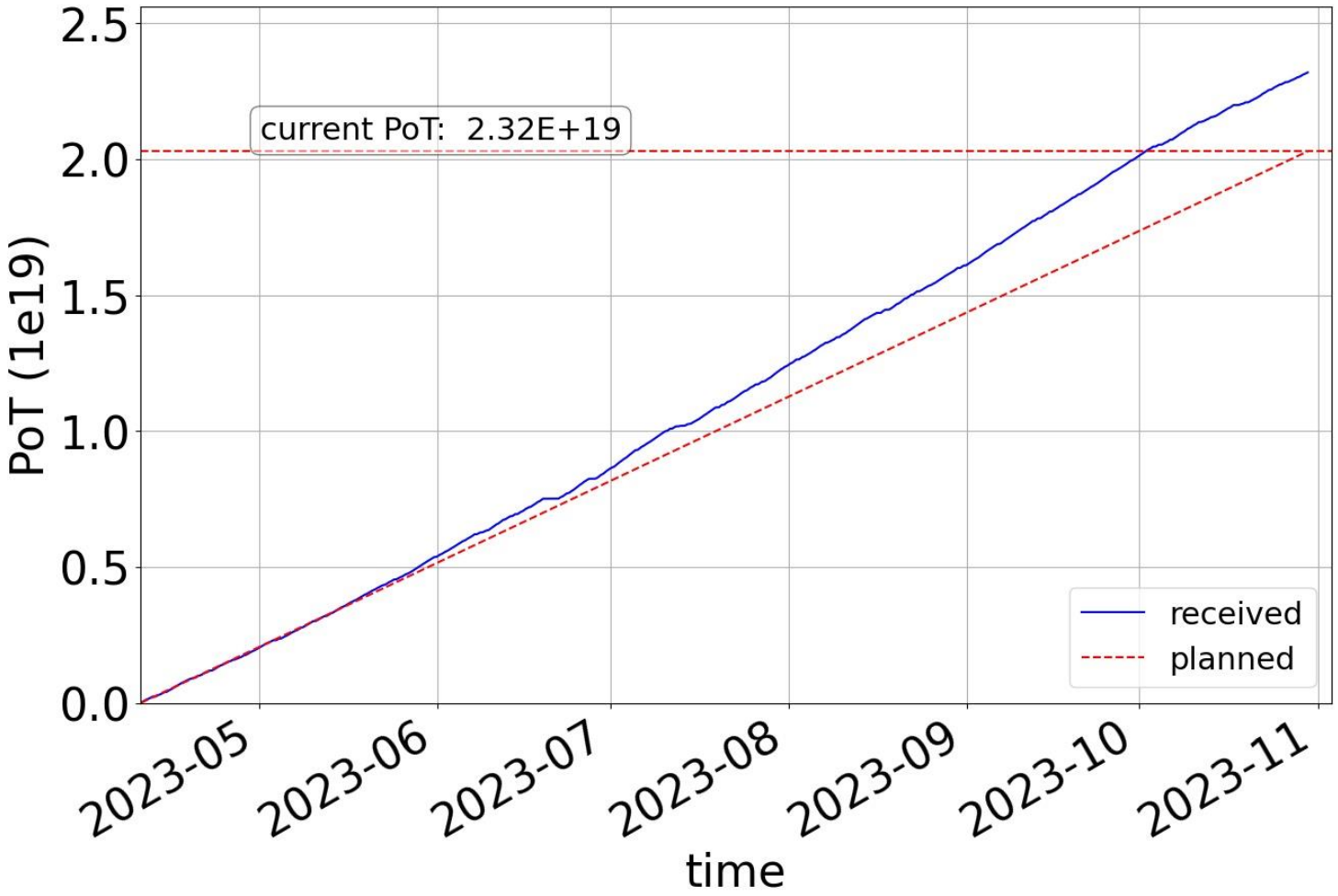




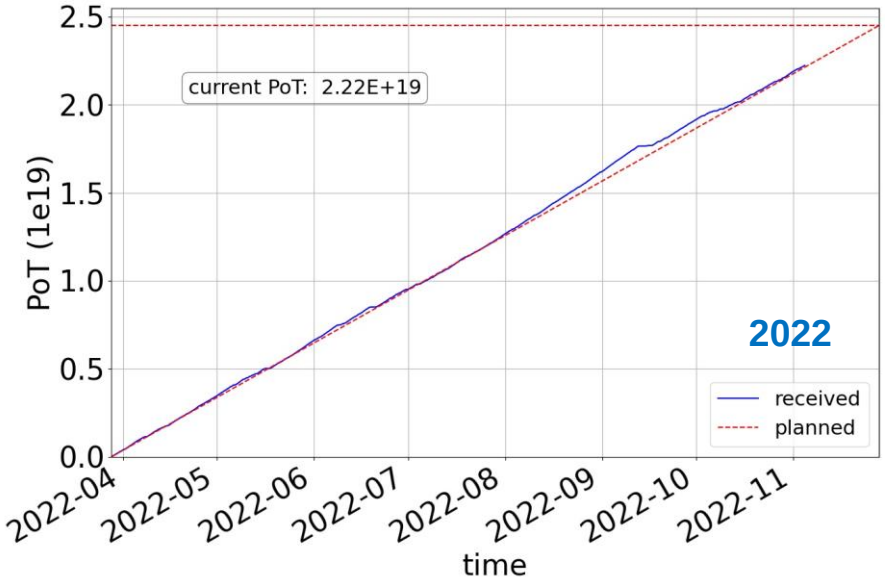
- 4 neutron capture reactions
- 2 (n,cp) reactions
- ^{243}Am fission study covering 11 orders of magnitude of neutron energies
- 2 neutron capture reactions have been (further) studied at NEAR and EAR2 with different B4C filter configurations; Activation technique; MACS for different stellar temperatures;
- NEAR beam profile, flux and background measurements
- 9 detector development projects have been accomplished successfully
- First transmission measurement at n_TOF was realized

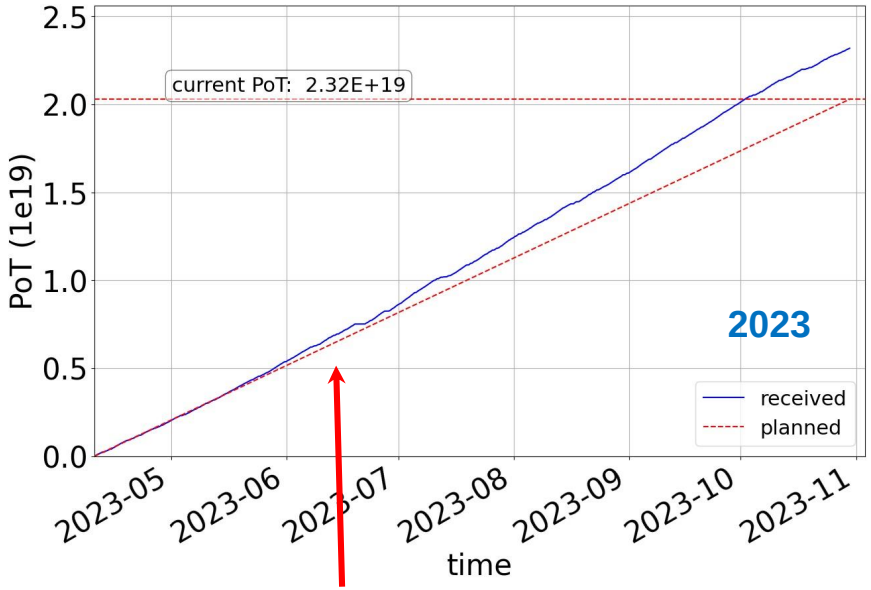
PoT status

- We received (=2.3E19) more protons than expected (=2. 2.03E19) = **1.14E17 p/day**
- All experimental campaigns received the approved number of protons
- Flexibility on the pulse intensity
- Many thanks to the PS teams!

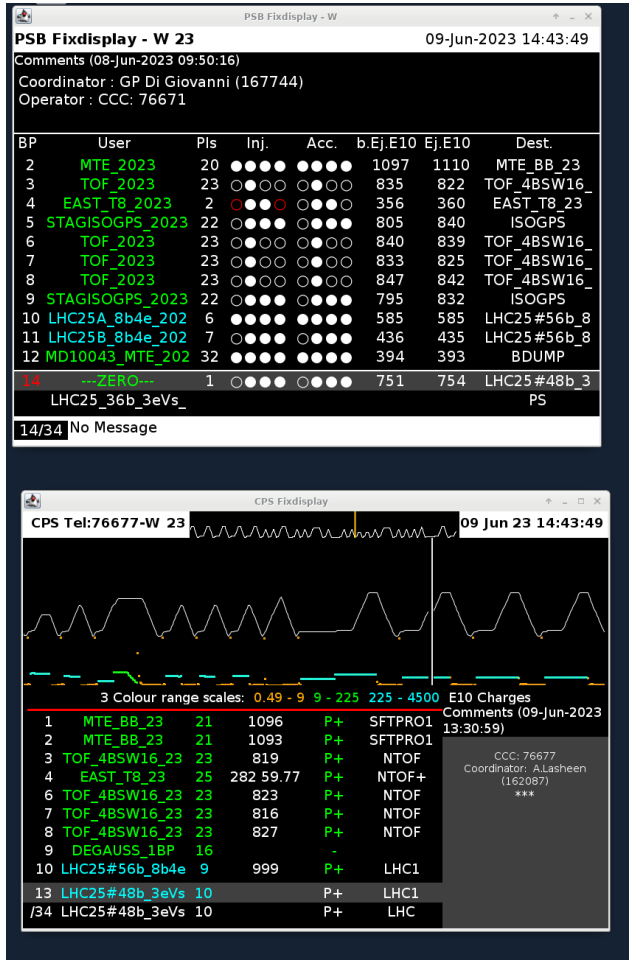


PoT status



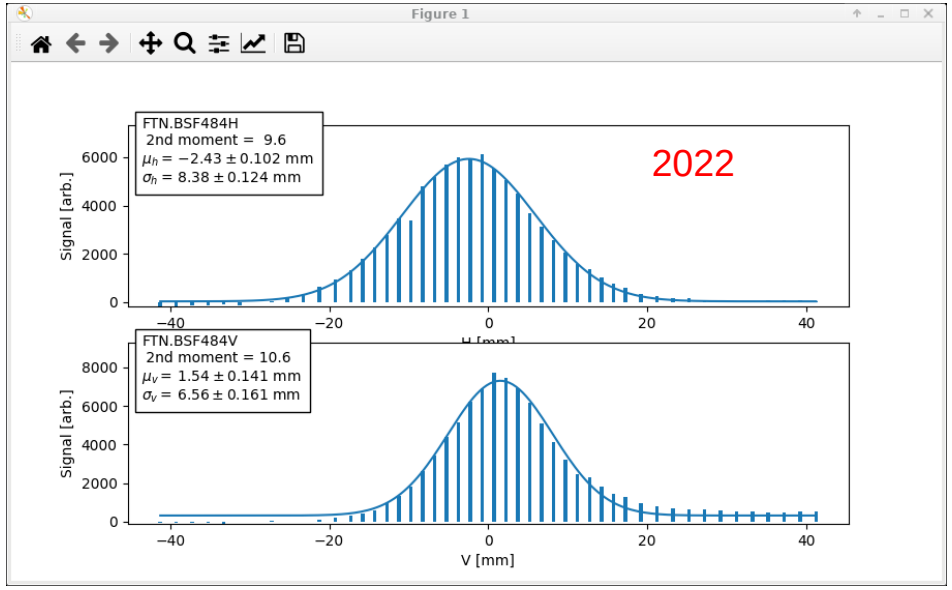


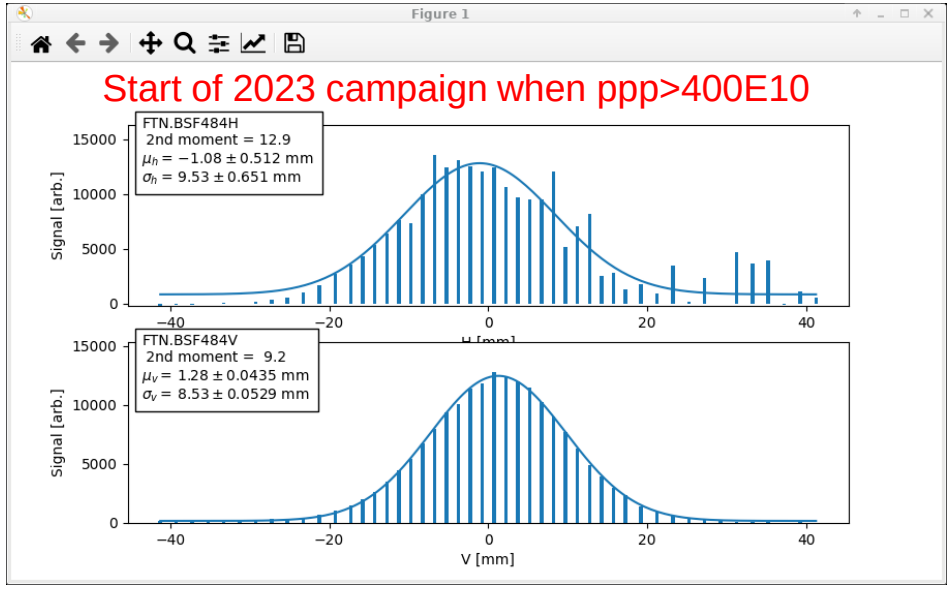
Average proton beam intensity upper limit: 167E10pps -> 220E10pps; 09.06.2023



Many thanks to SY-STI, RP, and PS teams!

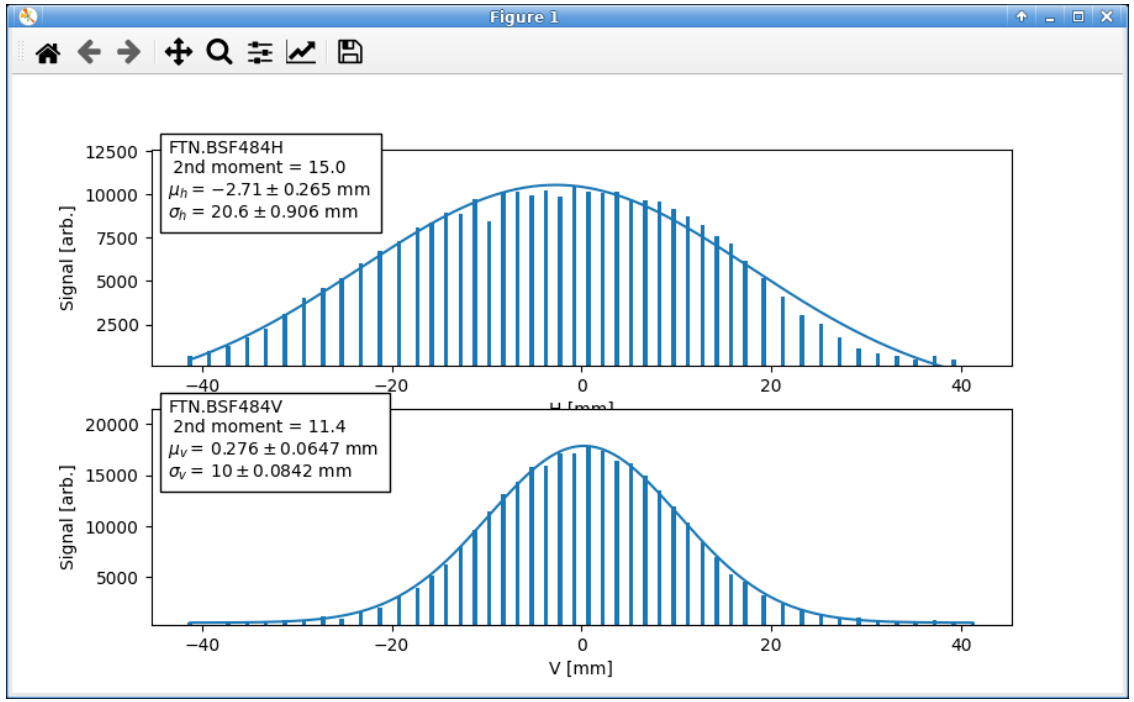
Issues during the 2023 campaign





Beam start at 03.04.2023 - FTN line commissioning

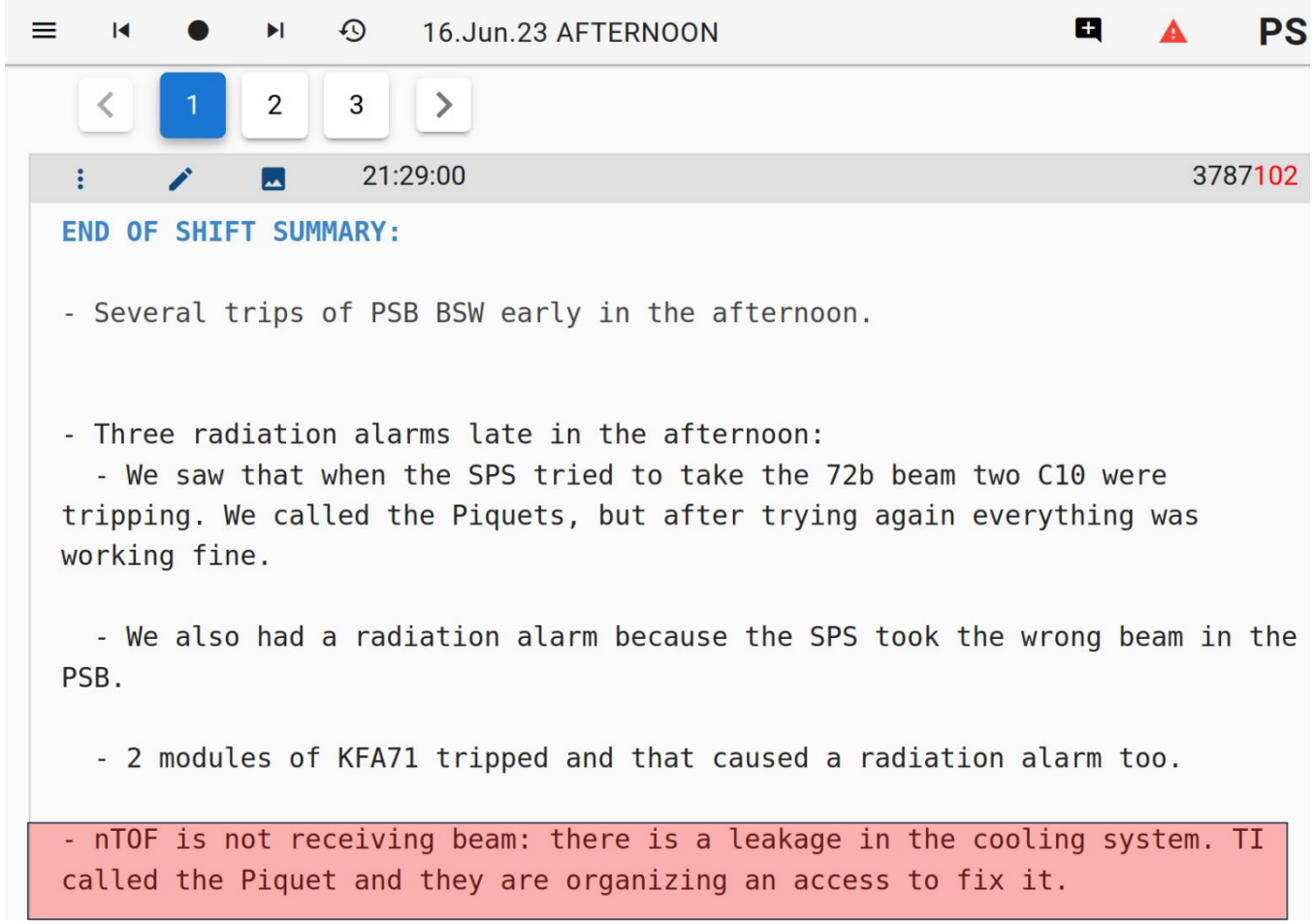
2023 after going back to the previous SEM grid el. chain

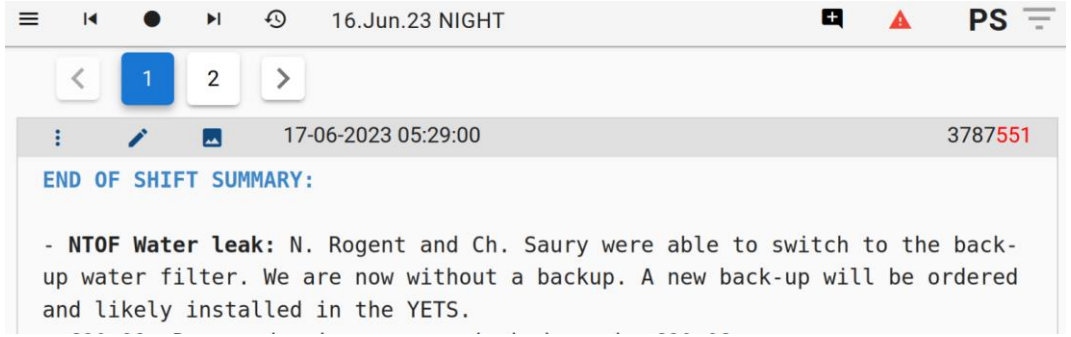


YETS 2023-24: Installation of new SEM grid detector head (larger aperture, more channels)

Issues during the 2023 campaign

n_TOF target borated water filter leak on 16/6/2023: Thankfully a backup filter was available!
Many thanks to: Ch. Saury, N. Roget, Cl. Pruneau for the successful intervention!



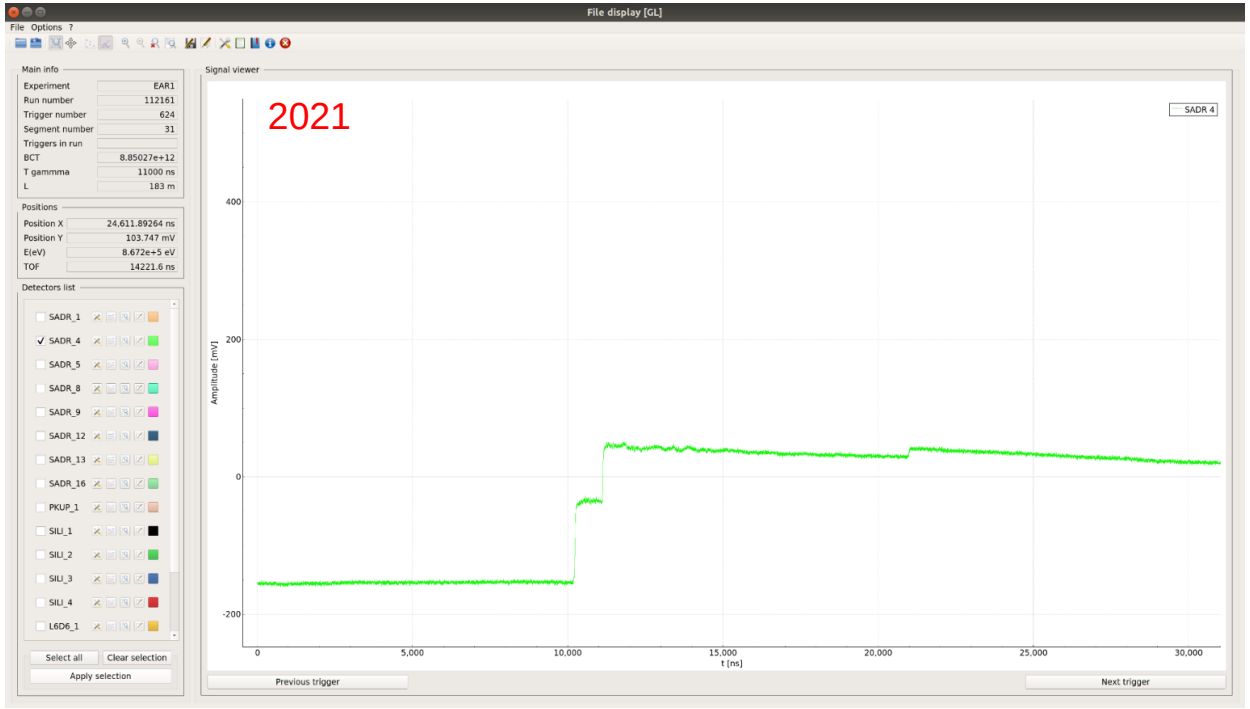


YETS 2023-24: Cooling station upgrade (extend confinement to the entire station + additional retention vessels for the moderator skids, as requested by the tripartite)

Issues during the 2023 campaign

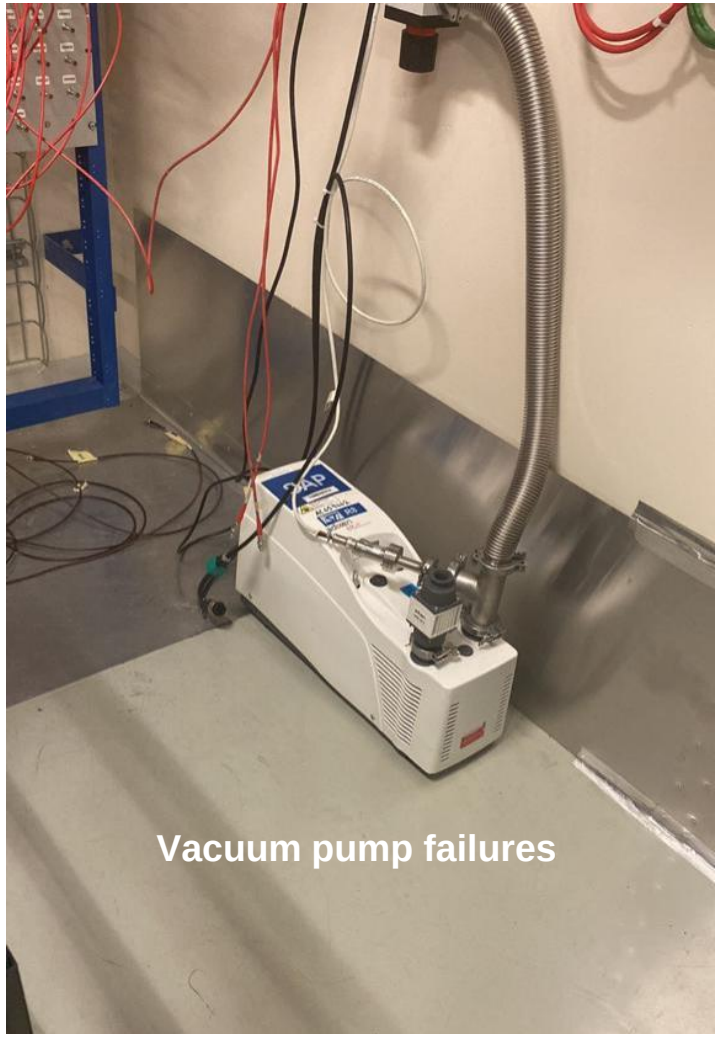
The ringing problem is still there!

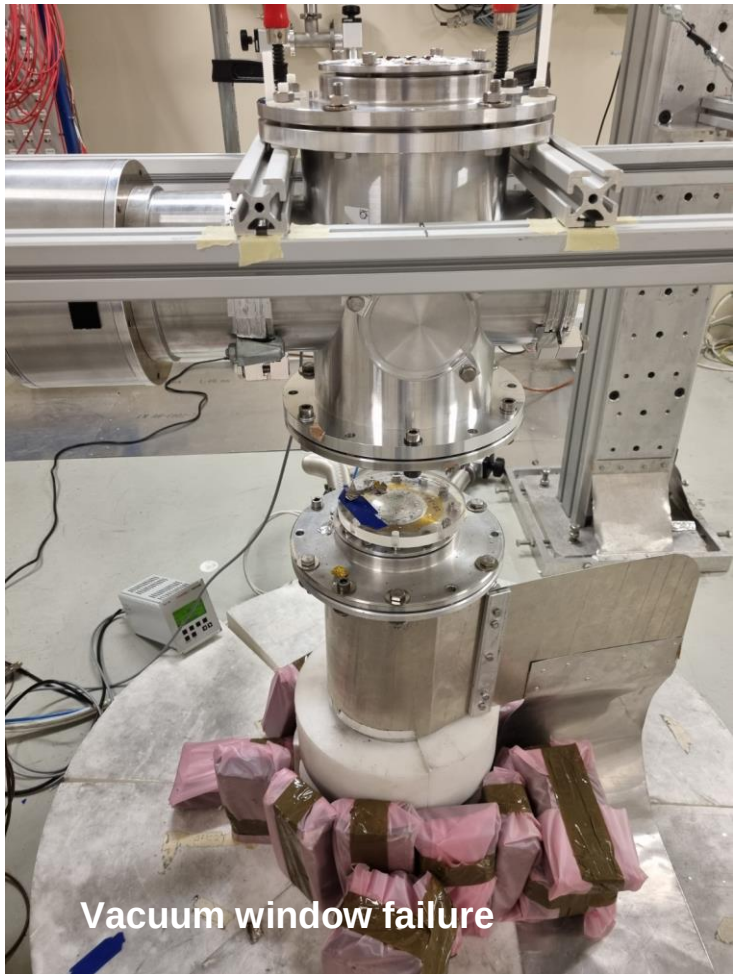
- This is a beam related problem appeared in EAR1 during 2022 onwards
- **For some detectors the problems is solved** for others the mitigation is not possible
- **Detailed investigation is needed** (antenna scanning, cabling improvement, …)



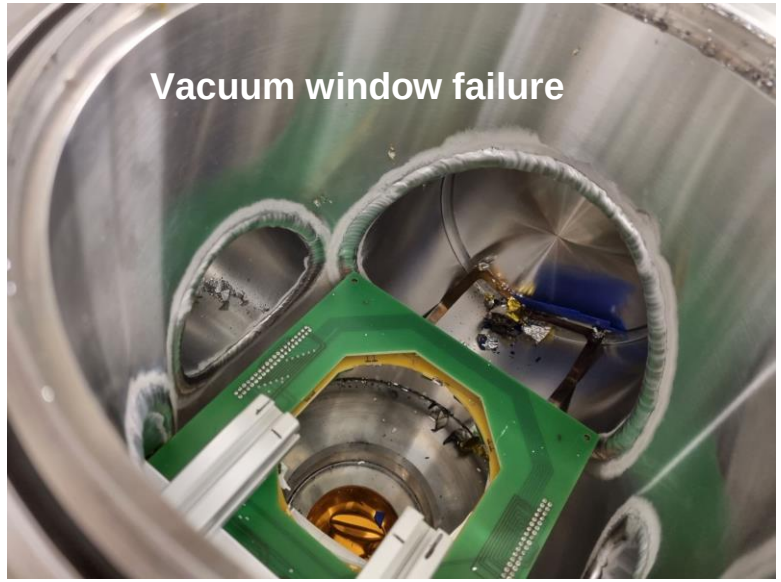
Issues during the 2023 campaign

(on the Experiment side)





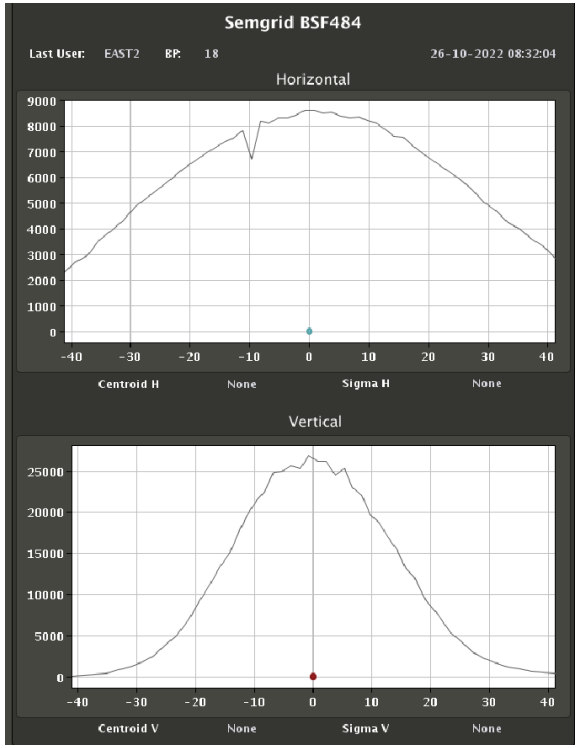
https://edh.cern.ch/Document/General/IncidentDeclaration/9967462



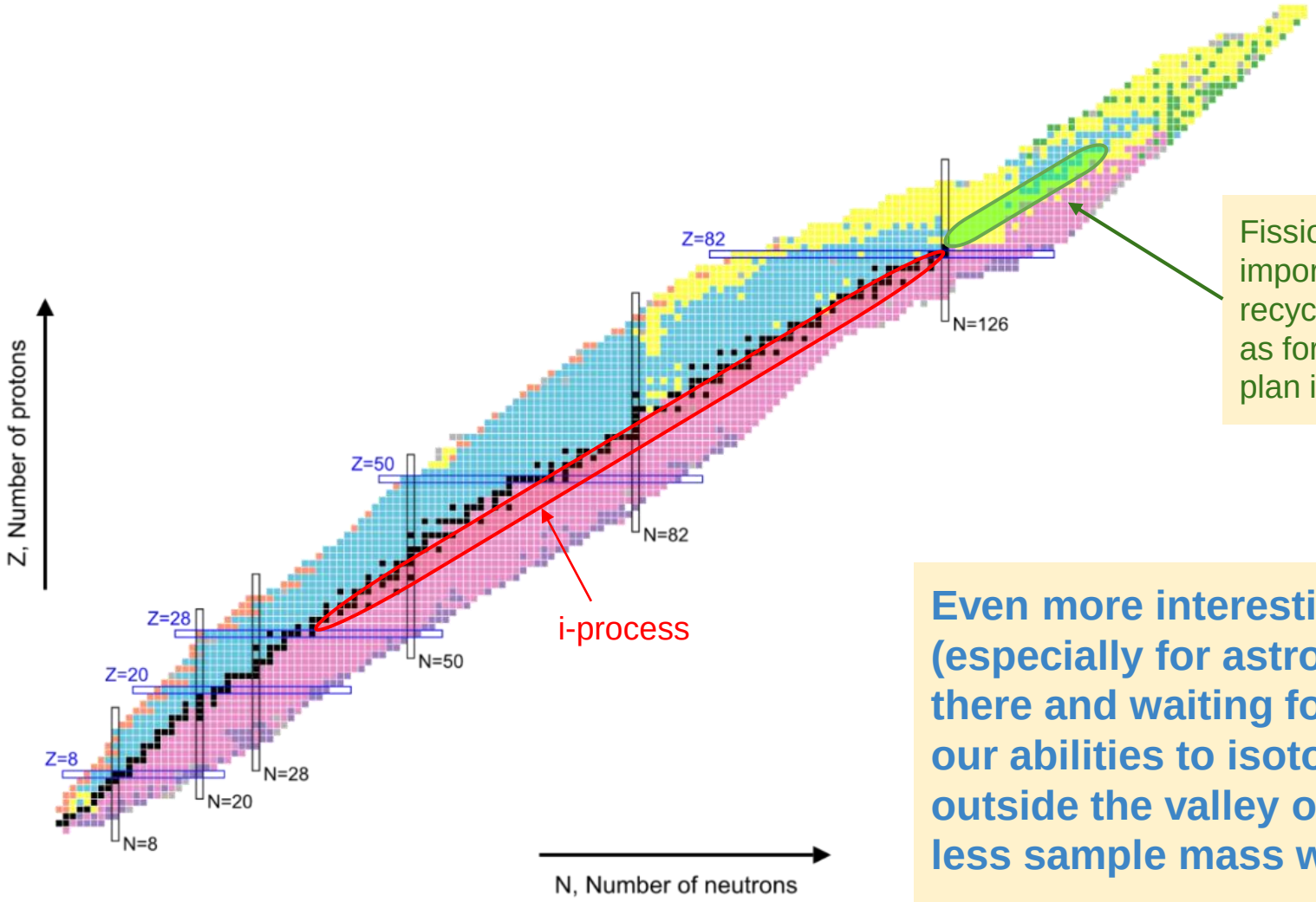
n_TOF desiderata for the 2024 operation

- **2024 Beam for n_TOF (our request: 217E17 or 1E17* protons/day)**
  - 18.03.2024 - for hardware commissioning (7days)
  - 25.03.2024 - Physics Start
  - 28.10.2024 - beam off (217 days of physics)
- **Pulses of different intensities**
  - High intensity (dedicated): 8.5E12 ppp
  - Low intensity (parasitic): 4.5E12 ppp
- **“Fixed” impact point on the lead target for both pulses**
  - ± 5 mm horizontal (centroid)
  - ± 3 mm vertical (centroid)
- **Same (as 2022) spatial profile dimensions of the beam**
- **Proton beam intensity: 200-220e10 p/s**
- **Pulse time length: 28 ns (σ ~ 7ns) without “tails” and pre- pulses**
- **For 2024 proton budget will be fully optimized, as every year, by running INTC approved experiments in parallel in three EARs**

* This is a “reasonable” request that takes into account the foressen 2024 demands.



n_TOF future (LS4: High Power target #4)



Fission reaction studies are important for the role of fission recycling in nucleosynthesis as well as for the ongoing n_TOF research plan in energy applications

Even more interesting physics cases (especially for astrophysics: i-process) is there and waiting for us! We have to extend our abilities to isotopes 2 or 5 mass units outside the valley of stability. That means less sample mass will be available.

n_TOF future (LS4: High Power target #4)

With a target able to accept higher proton beam intensity (x10) we can:

- **Extend significantly the abilities of both TOF experimental areas. Measurements ~10 times lower sample masses become feasible**
  - Detection efficiency:
    - **x2** or **x3** in gamma detection
    - **x6** in particle detection
  - **Average neutron flux for TOF** measurements: **x2** (or more) (**Maintaining the nice single bunch parameters for TOF measurement**)
  - **Potential increase single bunch intensity x2 or x3** -> important improvement in S/N ratio!

- **Extend significantly the abilities of both NEAR: SACS measurements with ~100 times lower sample mass become feasible**
  - Detection efficiency: **x10** thanks (!) to Spanish HPGe Clover funding
  - Average neutron flux: **x10** (or more) by reducing single bunch properties and increase the average power on target (e.g. by directing to FTN all 4 PSB pulses)

Thank you!

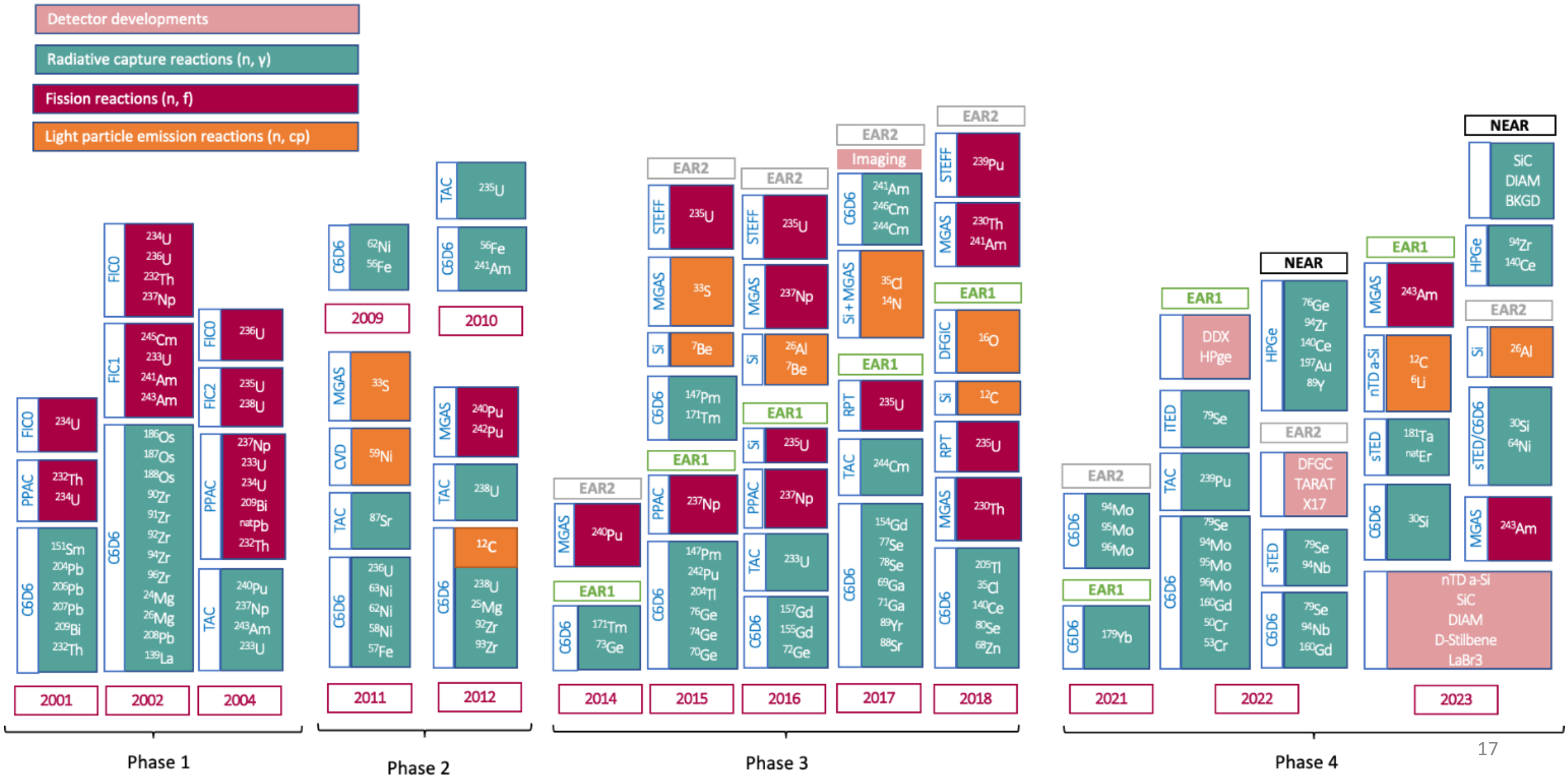
A	B	C	D	E	F	G	K
n_TOF	**2024-run** expected number of protons [1e17]: **217** (for 217 days)						

		INTC meeting	experiment	NoP approved (1e17) EAR1	EAR2	NEAR	Spokesperson(s)
approved and planned for 2024	INTC-P-406-ADD-1	71	40K(n,p/a)		50		C. Lederer-Woods, M. Friedman
	INTC-P-631	70	Diamond			7	M. Diakaki, M. Bacak
	INTC-P-651	72	DDX 12C	30			E. Pirovano, R. Beyer
	INTC-P-653	72	28,29Si (70/11)	45	8		C. Lederer-Woods, A. Mengoni
	INTC-P-656	72	Er (60-20, 10 spare for TAC)	30			V. Alcayne, A. Guglielmelli
	INTC-P-665	73	natCe(n,f)	30			M. Caamano, D. Tarrio
	INTC-I-256	73	MArEX		7		A. Mengoni, R. Svoboda
			TOTAL	**135**	**65**	**7**	

		INTC meeting					
approved and planned for 2024	INTC-I-261	74	LaBr3(Ce) LoI	14			C. Petrone, M. Bacak
	INTC-P-671	74	146Nd(n,g) sTED		37		J. Lerendegui-Marco
	INTC-P-672	74	238U(n,g) C6D6	32			E. Mendoza
	INTC-P-675	74	209Bi(n,g) sTED		30		J. Balibrea-Correa
approved and planned for 2025	INTC-P-677	74	241Pu(n,g) TAC (2025)	53			E. Dupont, J. Heyse
			TOTAL	**99**	**67**		

wating approval			Dallas NiSoC		5		W. Flanagan
in the pipeline (to be submitted)				137	157	40	
			TOTAL	**137**	**162**	**40**	
			GRAND TOTAL	**371**	**294**	**47**	

n_TOF so far…


Detector developments
Radiative capture reactions (n, γ)
Fission reactions (n, f)
Light particle emission reactions (n, cp)
2001
2002
2004
2009
2010
2011
2012
2014
2015
2016
2017
2018
2021
2022
2023
Phase 1
Phase 2
Phase 3
Phase 4
NEAR
EAR1
EAR2
Imaging

Target #1

- The first n_TOF spallation target served the facility up to 2008.
- On 28/11/2023 the n_TOF target #1 at PSI (final storage)

Many thanks to SY-STI for the good care of all stages of this demanding task!