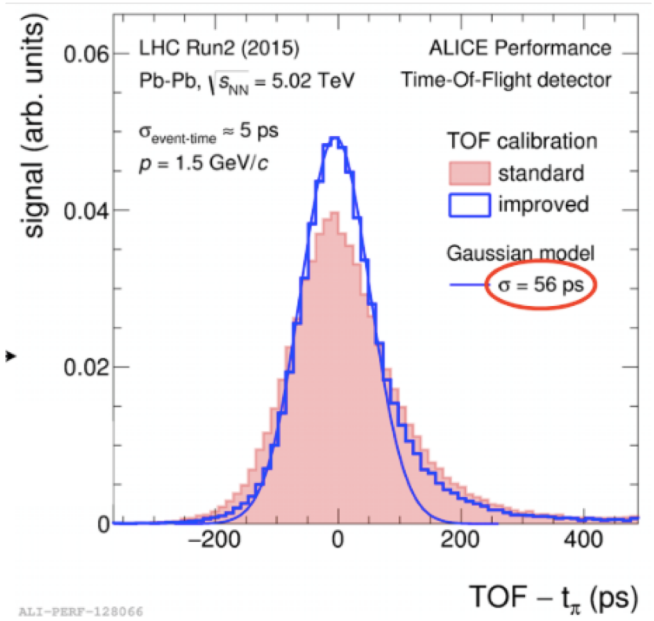
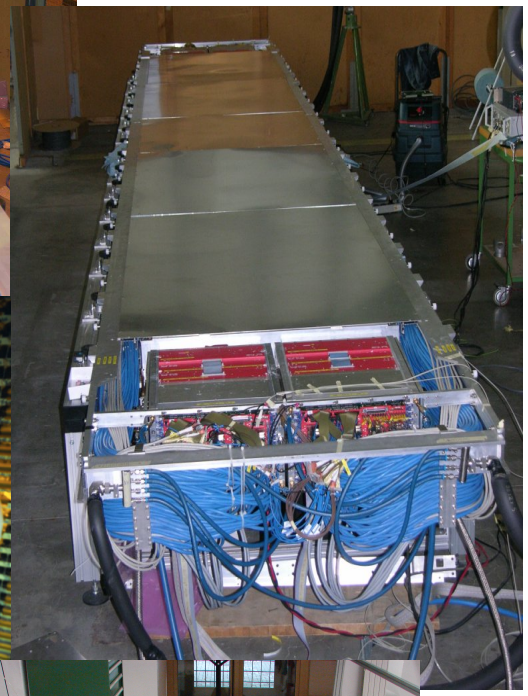
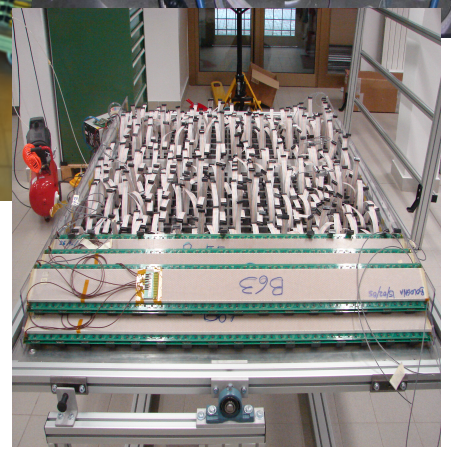
TOF upgrade

- DRM2 production and tests
- DRM2 firmware developments
- A1395/A1396 refurbishment and irradiation tests
- 2019 installation schedule
- 2020 outlook “put pieces together” + richieste

- First long term TOF considerations with referees...



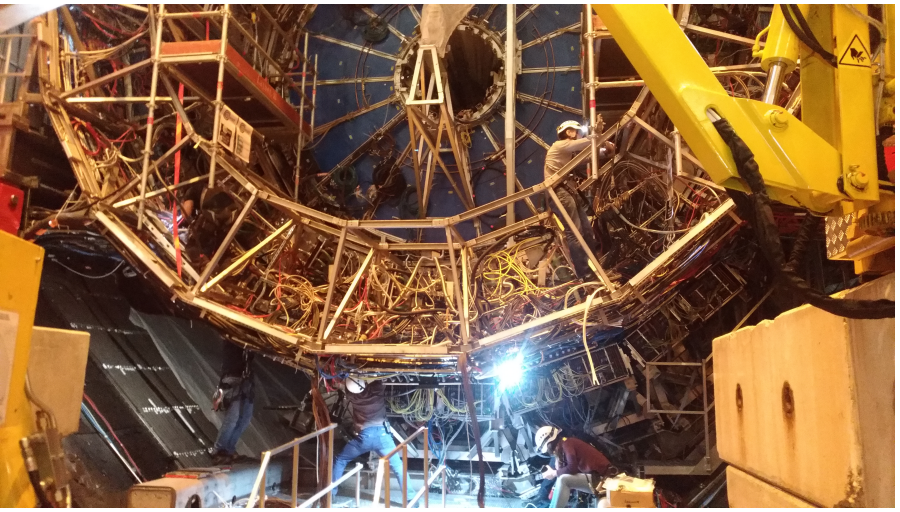




(construction and assembly pictures from **2006**)

P. Antonioli

A1395/A1396/DRM1 extraction campaign (Jan/Feb 2019)

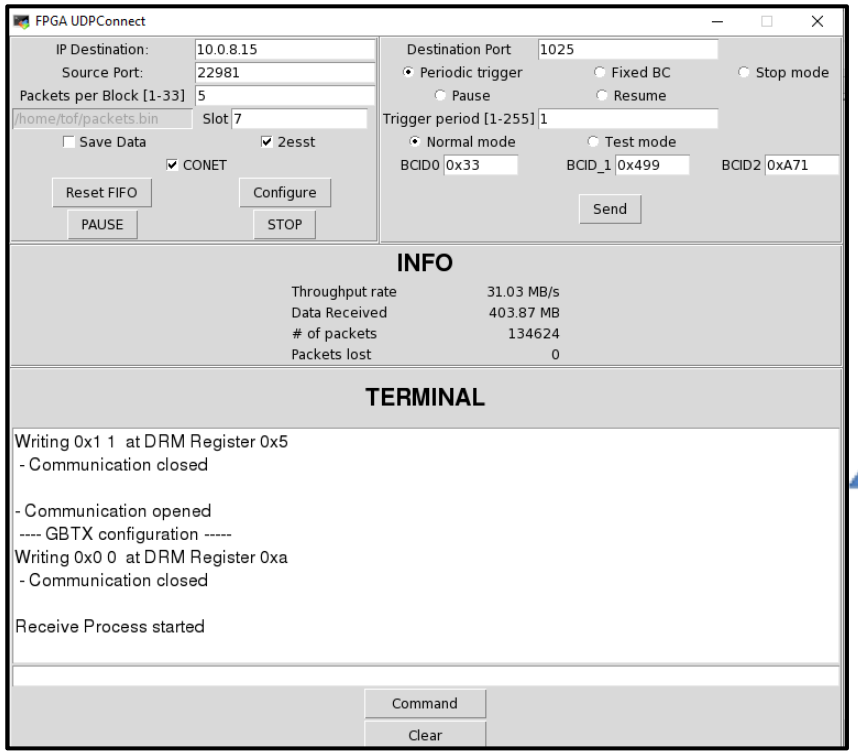


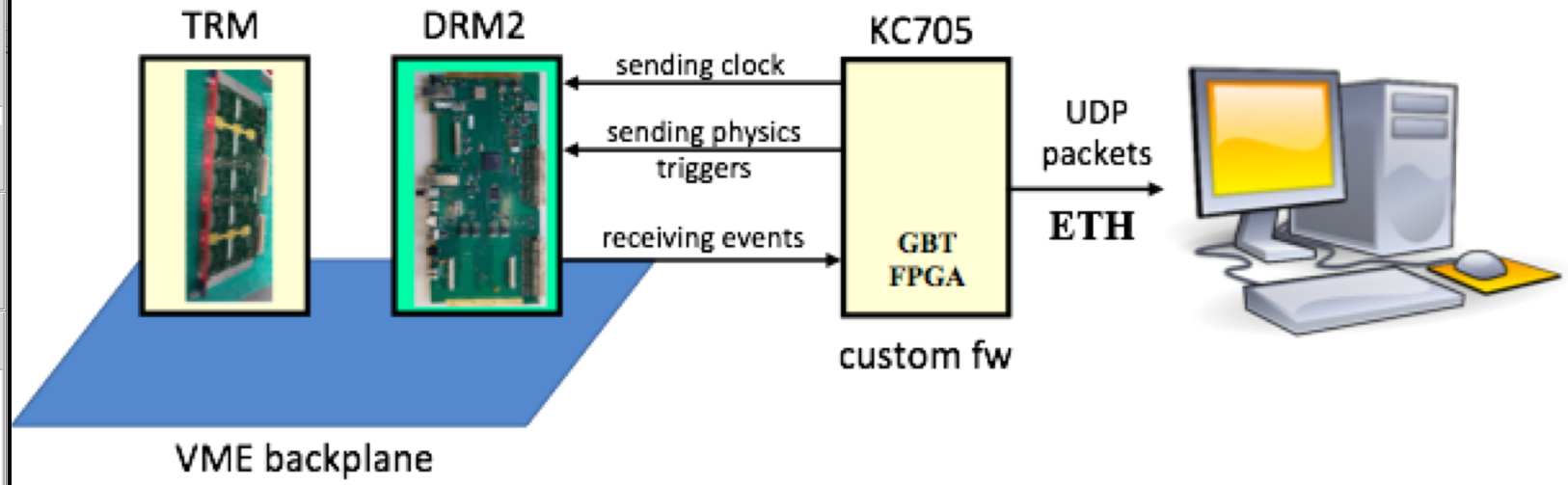
Bologna and **ITEP** groups

note:
24 DC/DC modules still to be extracted from TOF: SM displacement needed (2019)

DRM2 production: tests

DRM1—> DRM2 is the core of our upgrade, for running in continuous read-out mode in RUN 3





- CAEN is performed production tests on DRM2 boards with setup/software package provided by INFN
- Similar tests were repeated (and after A1500 reworking) at "µTOF setup" (Building 29) to make them "pit-ready"

DRM2 production: report

DRM2 production (INFN order: 80 pieces): completed, received at CERN, tested
DRM2 production (ITEP order 8 pieces): completed at CERN (not yet received due to Russia way of life...)

Issues found:

- some ferromagnetic elements (screws and spacers) found: replaced, production fixed
- 3 boards had wrong EFUSE programming but, after reprogramming the GBTx register via I^2C, all are fully functional → we will insert GBTx programming check as part of slow control configuration
- 1 board has trouble in the communication between the GBTx-IGLOO2 I^2C bus and is being sent back to CAEN → currently under reworking (we try GBTx replacement)

A1500 piggy-back (ARM CPU) for DRM2: test and verify

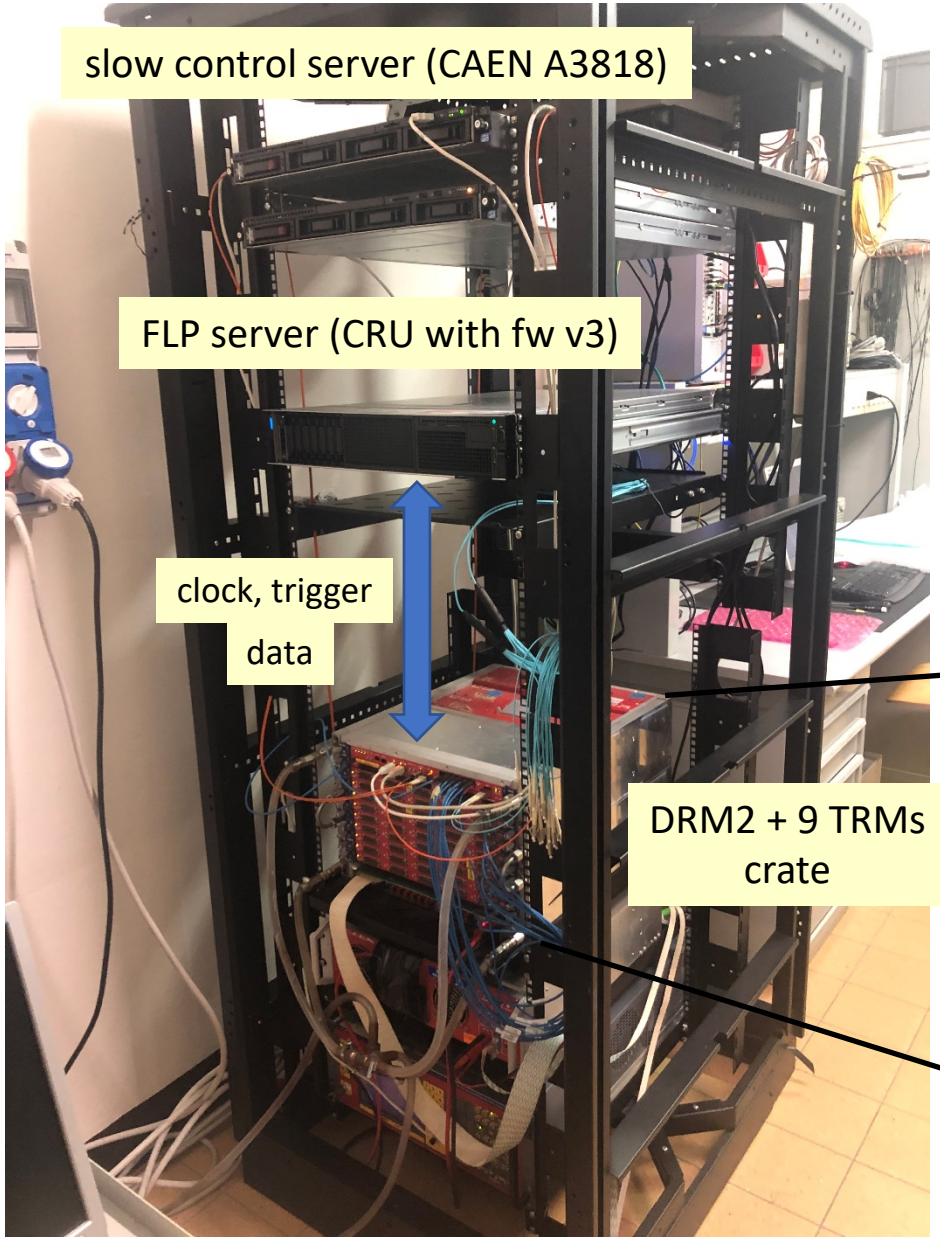
- 80 A1500 from DRM1 tested
- 71 A1500 are ready to be plugged on DRM2

We have in addition 20 brand new boards as spares

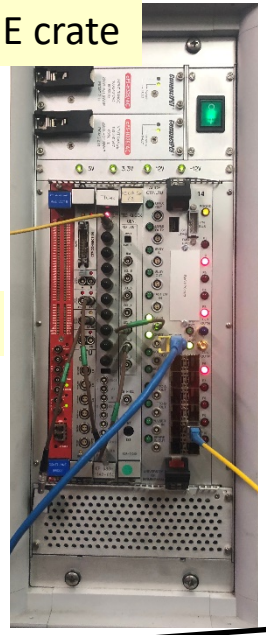
Production and its validation (80 cards) completed May 2019:
72 DRM2 cards “ready to install”, with A1500 on board and programmed (IP ←→ crate)

“A success story so far”

DRM2 – CRU – FLP setup in Bologna

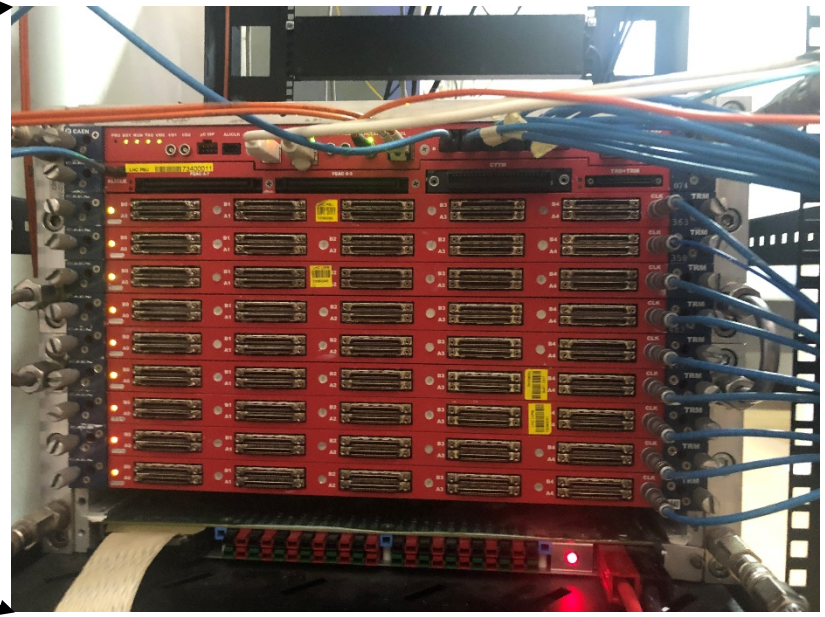


LTU in a VME crate



clock, trigger

DRM2 + 9 TRMs crate



1 TRM (slot 12) is still missing due to a problem in the backplane

DRM2 - CRU setup in Bologna

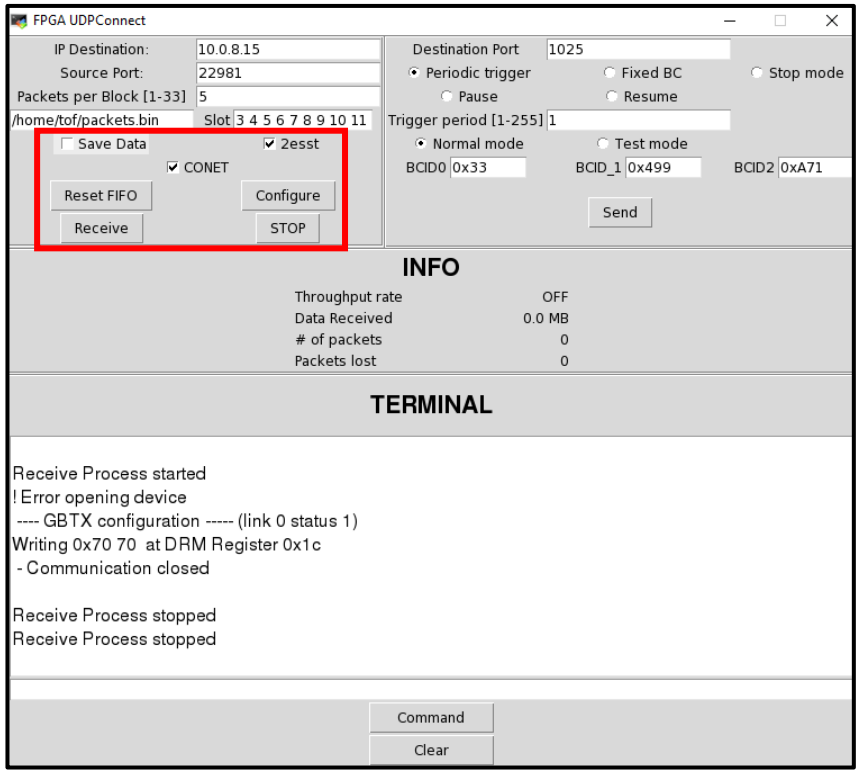
DRM2 – CRU – FLP setup in Bologna: operational experience (I)

full collaboration with ALICE DAQ/Trigger groups
together with ITS, first group implementing last FW requirements re; data format

slow control server

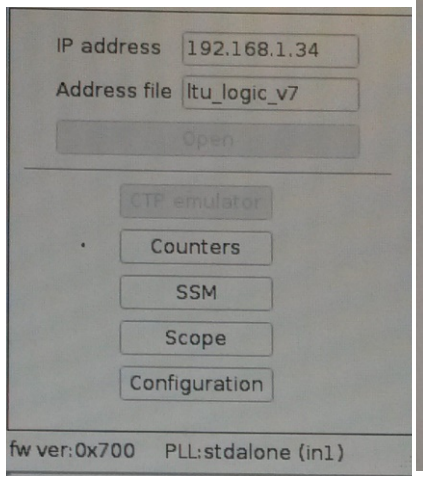
configuration parameters
start/stop acquisition run

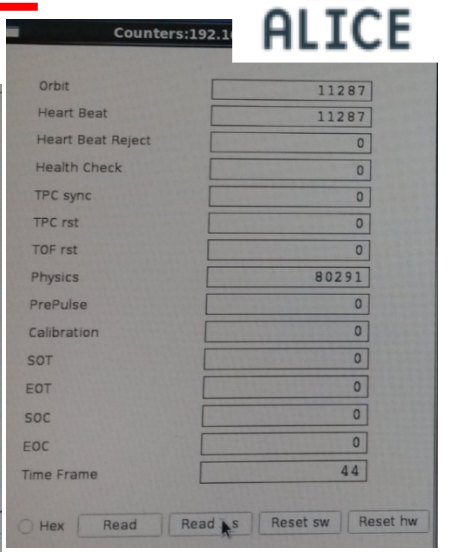
physics data can also be sent to the slow control server with the CONET link

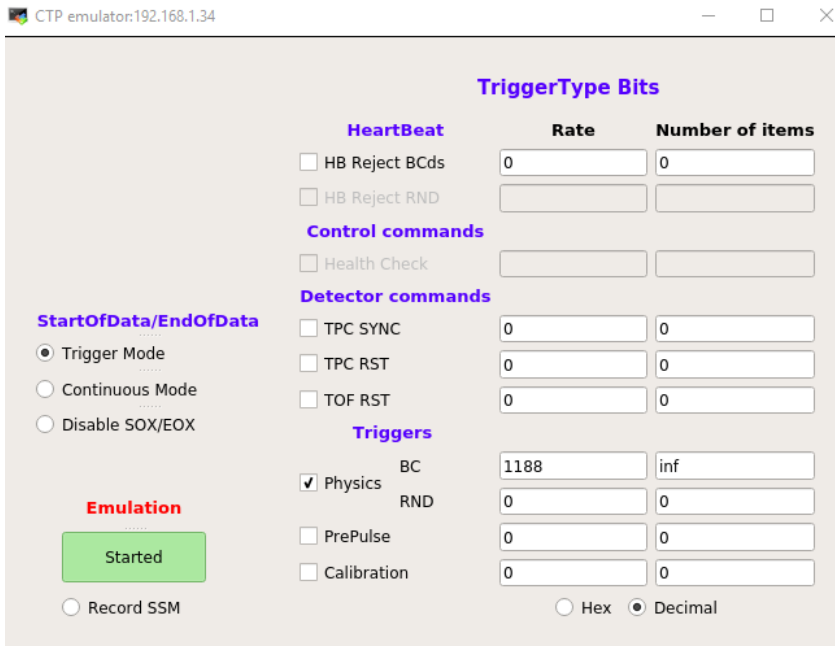


FLP

readout.exe file:/home/flp/readout.cfg







LTU software

FLP

DRM2 – CRU – FLP setup in Bologna: operational experience (II)

```
ALICE-TOF data scan:    3198205 ev (HB+DRM) read (0x70F70000 bytes (9999.00 MB)
HeartBeat events seen:  1279928 (SOT: 000 EOT: 000)
HB Open/Close -DRM ev:  00639964 00639964 01918277
Padding pattern err:    000000
Non-monotonic orbit:    000000
Missing HB orbit:       000000
DRM CRC event errors:   000000
CRU-DRM BC misalign.:   000000
LHC/GBTx Clock. Trans.: 000000
```

rdchck software tool

TRM Data Scan	03	04	05	06	07	08	09	10	11	12
Events Ok	1918277	1918277	1918277	1918277	1918277	1918277	1918277	1918277	1918277	000000
Word Count errors	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing global header	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing chain A header	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing chain A trailer	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing chain B header	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing chain B trailer	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Missing global trailer	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Bunch Cnt misalignments	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
Event Cnt misalignments	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
CRC errors	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000

```
IntraTRM event misal.   000000
IntraTRM BCID misal.    000000
```

Next steps:

- use random hits with LVDS pattern generator
- full setup of TRMs as in run mode (matching/latency window)
- data compression
- move rdchck to QC algorithms
- deploy at CERN (Q4/19) with installed DRM2

The tool performs a lot of quality checks on the acquired data:

- data format (headers, hits, trailers, …)
- CRC errors
- BCID alignments between DRM2 and TRMs
- misalignments between TRMs
- missing / non monotonic orbits
- …

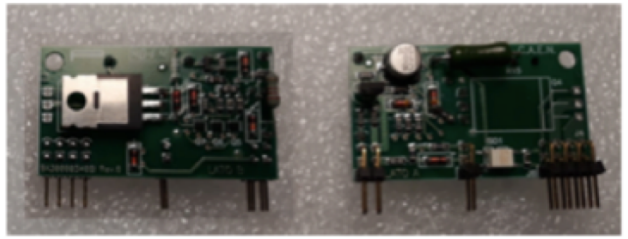
given current FLP software limitations, we launch a data taking run and then to periodically acquire and check a file of 10 GB of data

7 hours of data acquisition @33 KHz with 9 TRMs: **no errors**

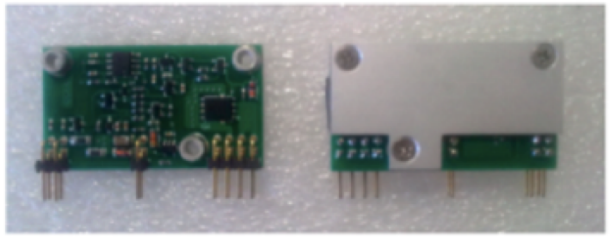
A1395/A1396 refurbishment: a reminder

- TOF observed during Run1+2 "rare" non-permanent failure events in A1395 modules (DC/DC 3.3V VME) and A1396 (DC/DC —>5V VME + LV FEA 3.0 V)
  - A power cycle recovers these failures (**MTBF (TOF) ≈ 60 hours** at 2017 luminosity).
  - PAR procedure in place during RUN2
  - They appear in CAEN fw as HVMAX, PowFailure and even "unplugged" state (lost connection with A1395)
- during RUN2 a SSF (Solid State Fuse) component showed increased mortality replacement campaign planned during LS2 (this component is present both in A1395 and A1396).

OLD



NEW



1. Started A1395 SSF replacement campaign during 2018 TS2 and TS3, a total of 20 A1395 were then equipped with "new" SSF in 2018
2. Much higher rate of failures noted in "**OLD**" modules during high interaction rate tests
3. But **during normal RUN2 operations and high IR test NO failures observed in none of these 20 modules modified**

Was the SSF the SEU source?

A1395/A1396 SEU during high-IR a concern!

no HVMAX in modified A1395 → good!
but: 6 failures in 32.5 hours in A1396

MTBF = 5.4 hours (for the TOF) (Pb-Pb@Run3)

There is a need to identify (and fix) the SEU source. We hoped to just confirm it was the replacement of SSF having fixed the problem, but.....

Note:

Taking into account flux (70 Hz/cm^2), exposure (32.5 hours 72 A1396) we should have **one failure** every 1.2 10^9 p/cm^2 integrated fluence over a DUT

LVs failures

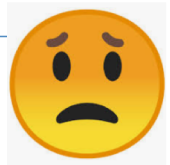
Fill	3.3V failure	All LVs (5V, etc) failure
6169 (~3h. 64 Hz/ub) 5/9/2017	1xHVMAX crate 63	1xUnplugged crate 61
6772 (~7h. 70 Hz/ub) 9/6/2018	3xHVMAX crates 18, 29, 65	1xUnplugged crate 29 1xPwFail crate 67
7122 (~5h. 70 Hz/ub) 3/9/2018	3xHVMAX crates 26, 27, 50	-
7133 (~2h. 70 Hz/ub) 7/9/2018	-	-
7135 (~2.5h. 60 Hz/ub) 7/9/2018	1xPwFail crate 44	-
7264 (~13h. 70 Hz/ub) 7/10/2018	3xHVMAX crates 37 (x2), 65 1xOVProt crate 12 (**)	1xPwFail crate 54 (*) 2xUnplugged crates 12, 70

- Failure rate much higher than the one recorded at lower luminosity i.e. in Run 2 operations (~1 HVMAX each 60 hours with stable beams in 2017).

- In ~33h. at Run3 PbPb equivalent rate:
--- 12x 3.3V failures → reworked A1395 to install in LS2 (20/144 already replaced in TS1).
--- 6x LVs failures → **A1396 too sensitive as well**

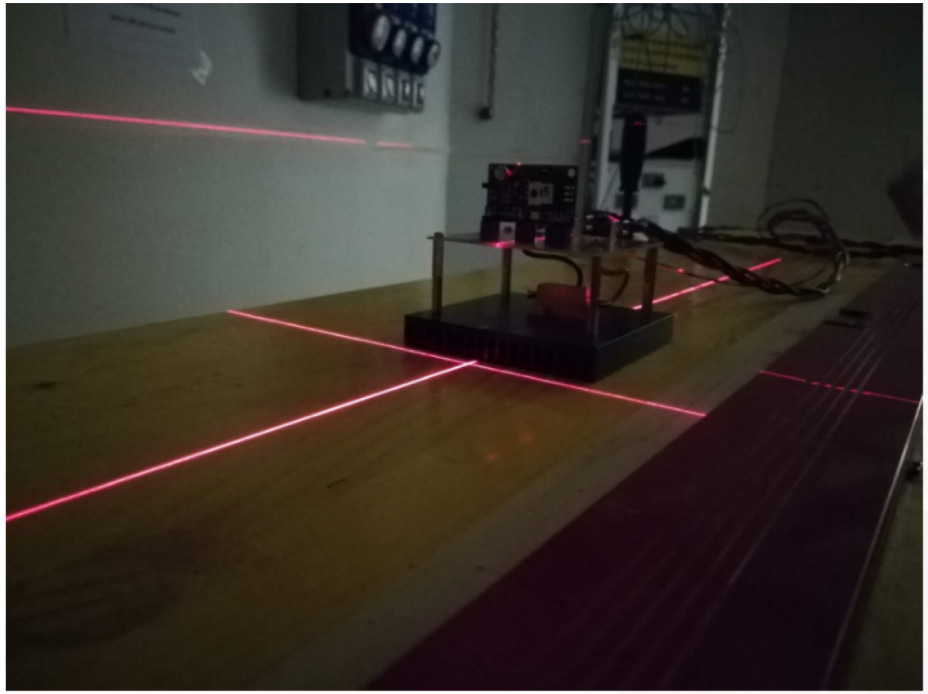
- For recovering from failures on A1396 side (Unplugged, PwFail) needed to power cycle 48Vsrv.
- HVMAX failure recovered after clearing alarms

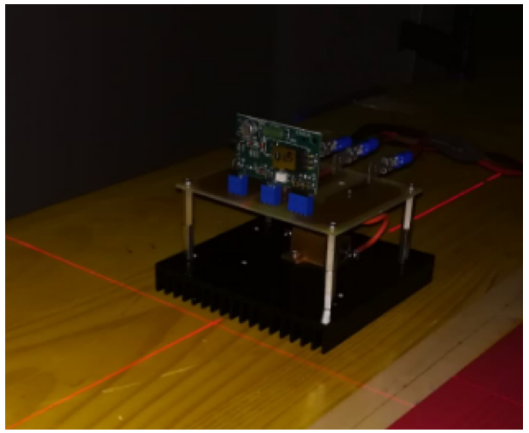
Other details (Fill 7264):
- (*) all LVs in PwFail (crate 54). After doing a Clear Alarms etc, all channels back in operation except 3.3V which goes constantly in UNV. One 2.7V channel goes in error (OVV) while recovering. Needed to power cycle 48Vsrv. Both channels back in operations
- (**) 3.3V OVProt (crate 12). Alarm cleaned à la HVMAX.

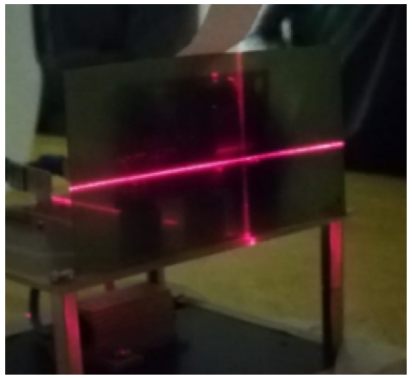


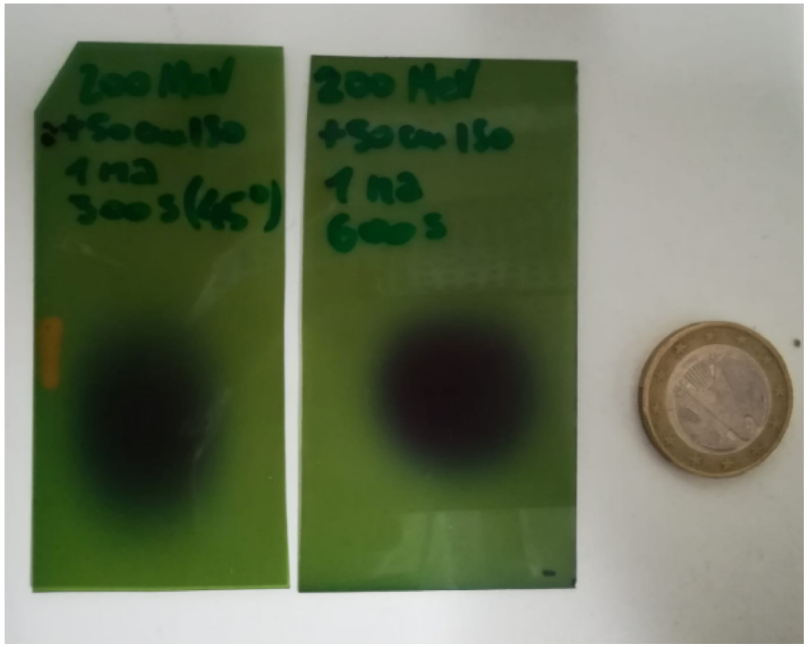
Setup @ Trento (May 2019)

TOF (INFN-BO) + CAEN









Irradiation with 200 MeV proton/beam of 6 (old) SSF and 6 (new) SSF

→ **no SEU observed even with fluence > 10^11 cm^-2**

→ tested up to 70 krad (we expect 0.13 krad, and verified "old" break at approx 30 krad)

Irraggiamento SSF A1395-A1396 (24-25 Maggio 2019, Trento)

File Modifica Visualizza Inserisci Formato Dati Strumenti Componenti aggiuntivi Guida L'ultima modifica è stata apportata il 27 maggio da anonimo

SSF Irradiation

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**SSF Irradiation**	**rad/p/cm^2**		**IBA**	**p/spot/s**									
2	**TID 200**	5,80E-08		1nA 200	1,40E+08			I DUT da 1 a 6 sono vecchio tipo I DUT da 7 a 12 nuovo tipo						I valori di p/spot/s sono quelli nominali dichiarati da TIFPA, ma vanno aggiustati
3	**TID 100**	9,40E-08		1nA 100	1,20E+07									
4														
5		**Energy (MeV)**	**σ spot (mm)**	**Area (cm^2)**	**I (nA)**	**T (s)**	**TID (rad)**	**p/cm^2**	**p(TOT)-com**	**p/spot (TOT)**	**Start**	**Stop**	**SEU**	**Comments**
6	Ex. 200/d=50	200	5,64	1,32	1	600	3,69E+03	6,36E+10						Sigma spot misurata da TIFPA con scintillatore + CCD
7	Ex. 100/d=50	100	11,2	5,21	1	600	1,30E+02	1,38E+09						Sigma spot, dedotta da GAF (su run DUT12, 20 nA) rispetto a GAF a 200 MeV. Siccome primo GAF ha "diametro" 2 cm (zona ombra) e questo GAF ha 3 cm, scaliamo di fattore 1.5 raggio (sigma) misurato con scintillatore. Però GAF obliquo meno saturato stimiamo 1.5, quindi prendiamo un fattore 2 su sigma
8	**Runs**													
9	DUT1	202	5,64	1,32	1	600	3,69E+03	6,36E+10	8,40E+10	7,56E+10	20:30	20:42	0	
10	DUT1	202	5,64	1,32	2	300	3,69E+03	6,36E+10	8,40E+10	7,54E+10	20:50	21:02	0	fatto in 3 pezzi causa instabilita'
11	DUT1	202	5,64	1,32	4	300	7,38E+03	1,27E+11	1,68E+11	1,68E+11	21:04	21:09	0	
12	DUT1	202	5,64	1,32	10	300	1,84E+04	3,18E+11	4,20E+11	4,13E+11	21:12	21:17	0	
13	DUT2	202	5,64	1,32	20	300	3,69E+04	6,36E+11	8,40E+11	7,78E+11	21:22	21:27	0	
14	DUT3	202	5,64	1,32	20	300	3,69E+04	6,36E+11	8,40E+11	7,79E+11	21:34	21:39	1	mosfet aperto
15	DUT3	202	5,64	1,32	20	240	2,95E+04	5,09E+11	6,72E+11	6,13E+11	21:45	21:49	1	non ha visto ass. corrente (e' in corto)
16	DUT4	202	5,64	1,32	20	400	4,92E+04	8,48E+11	1,12E+12	1,04E+12	21:53	22:02	1	non ha visto ass. corrente (e' in corto, a 22:02)
17	DUT5-ctrl	202	5,64	1,32	10	300	1,84E+04	3,18E+11	4,20E+11	3,99E+11	22:15	22:20	0	punta parte di controllo
18	DUT5-ctrl	202	5,64	1,32	10	300	1,84E+04	3,18E+11	4,20E+11	4,10E+11	22:22	22:27	0	punta parte di controllo
19	DUT5-45	202	5,64	1,32	1	300	1,84E+03	3,18E+10	4,20E+10	3,46E+10	08:41	08:46	0	scheda a 45^ (mosfet e ctrl esposti)
20	DUT5-45	202	5,64	1,32	10	300	1,84E+04	3,18E+11	4,20E+11	3,50E+11	08:50	08:57	0	scheda a 45^ (mosfet e ctrl esposti) / fascio interrotto/recuperato
21	DUT6-45	202	5,64	1,32	20	300	3,69E+04	6,36E+11	8,40E+11	6,54E+11	09:01	09:07	0	scheda a 45^ (mosfet e ctrl esposti)
22	DUT7-45	202	5,64	1,32	1	300	1,84E+03	3,18E+10	4,20E+10	3,41E+10	09:15	09:20	0	idem
23	DUT7-45	202	5,64	1,32	20	300	3,69E+04	6,36E+11	8,40E+11	6,78E+11	09:22	09:27	0	idem
24	DUT8-45	202	5,64	1,32	30	300	5,53E+04	9,54E+11	1,26E+12	9,49E+11	09:33	09:38	0	scheda a 45^ (mosfet e ctrl esposti) 30/sqrt(2) circa = 20
25	DUT9-45	202	5,64	1,32	30	300	5,53E+04	9,54E+11	1,26E+12	9,43E+11	09:53	09:58	0	idem
26	DUT10-45	202	5,64	1,32	30	300	5,53E+04	9,54E+11	1,26E+12	9,52E+11	10:03	10:09	0	idem. Si è spento (da ciclo programmato), ma ha letto 0.1, ma dopo e' andato ok. Non e' proprio un errore.
27	DUT11-45	202	5,64	1,32	30	390	7,19E+04	1,24E+12	1,64E+12	1,24E+12	10:16	10:22	0	alle 10:20 si e' rotto dopo 5:30
28	DUT12	100	11,2	5,21	10	60	1,30E+02	1,38E+09	7,20E+09	6,50E+09	10:34	10:35	0	abbastanza centrato, piu' verso Mosfet. Non ombra su GAF
29	DUT12	100	11,2	5,21	20	300	1,30E+03	1,38E+10	7,20E+10	6,48E+10	10:38	10:44	0	fascio giu' a 4:30, recuperato, misurata ombra su GAF
30	DUT12	100	11,2	5,21	40	600	5,20E+03	5,53E+10	2,88E+11	2,74E+11	10:54	11:04	0	
31	DUT1	100	11,2	5,21	40	600	5,20E+03	5,53E+10	2,88E+11	2,64E+11	11:11	11:22	0	fascio giu' ma recuperato

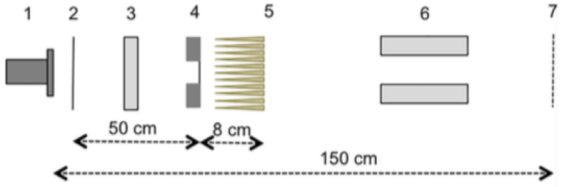
Hunting for SEU source in A1396

- Microcontroller → firmware?
- AUX DC/DC → hardware?

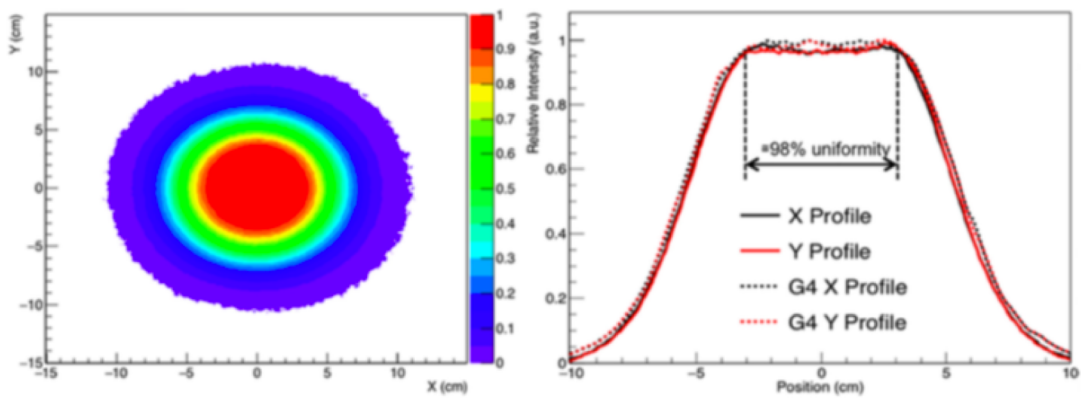
Irradiation with large spot (6x6 cm^2) -- 19/20 July

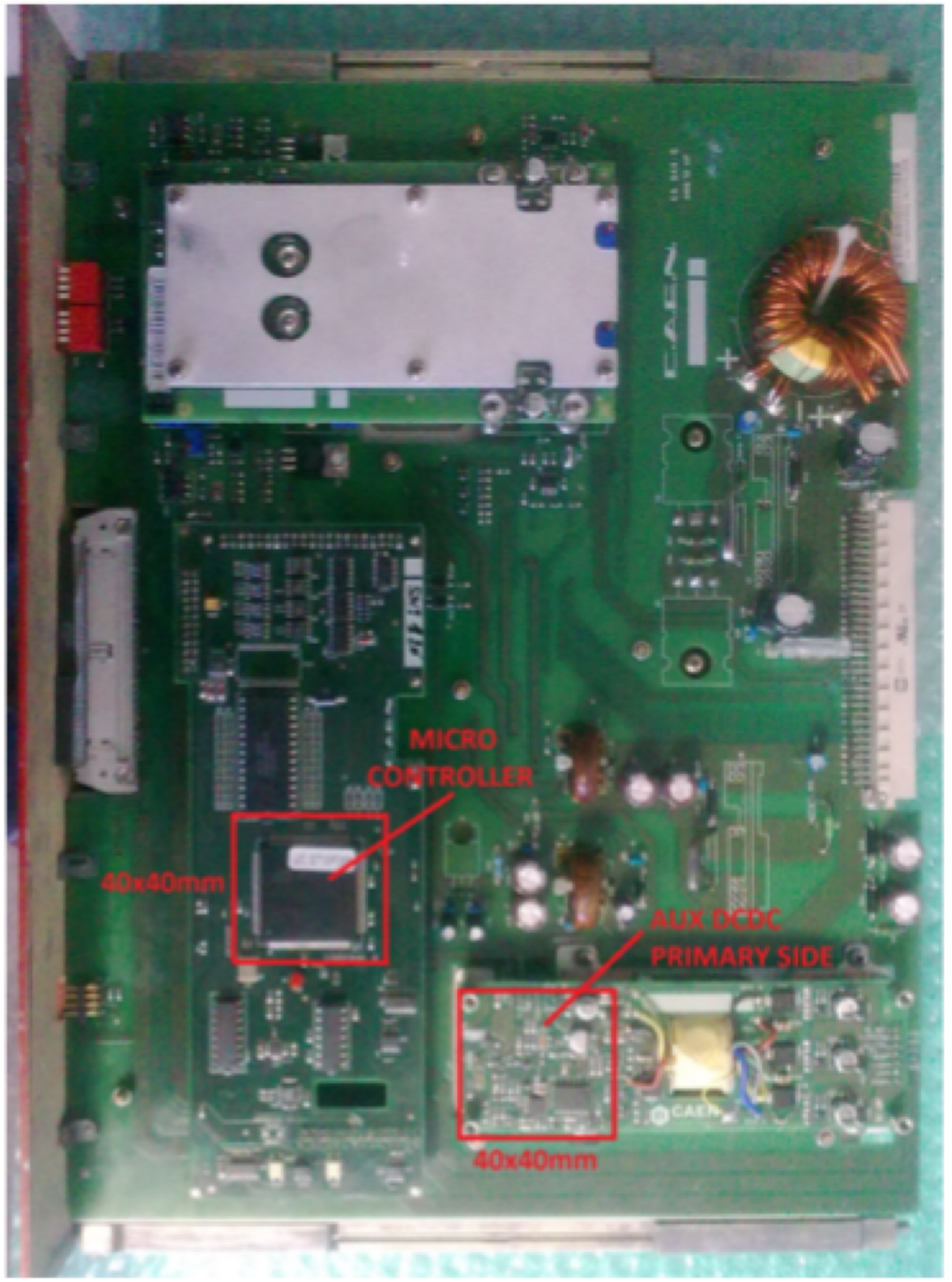
We can have intensity (1-3)x10^7 Hz/cm^2 → 1000 s irradiation O(10) SEU

The outcome of this test might impact partially on installation schedule



New setup at TIFPA
F. Tommasino et al., Phys. Medica 58 (2019) 99-106





Q4-2019 schedule

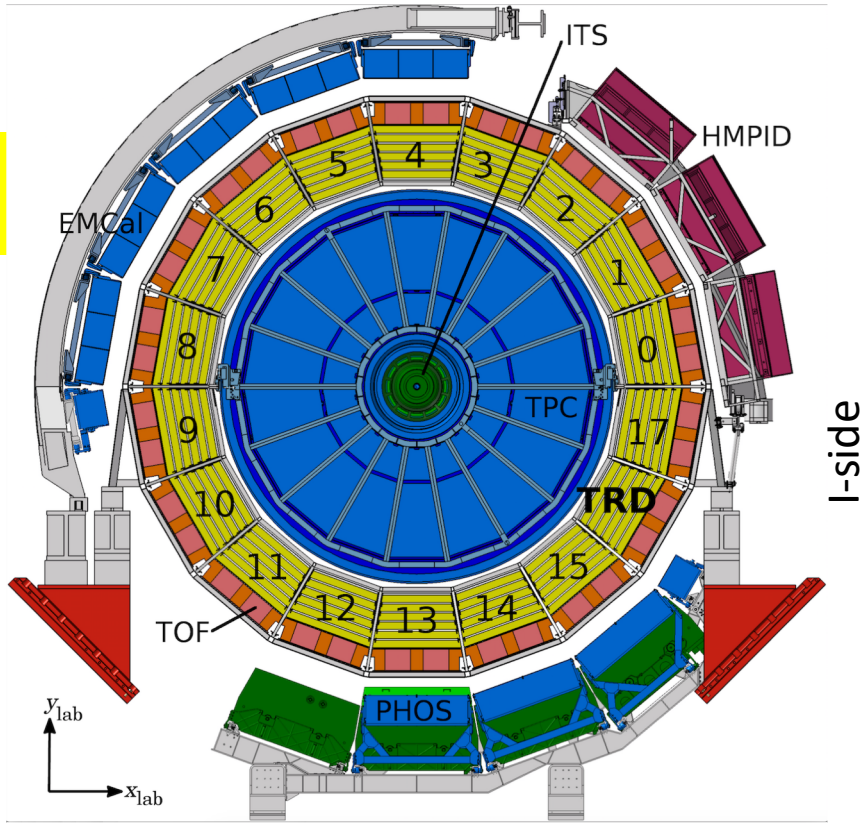
only recently agreed with ALICE: main bottleneck reinstallation of power cables (48 V) for TRD and TOF

Week	Monday	TOF Activity (or TOF related)
36	2-Sep	completion of I-side (SM 0-4 14-17) [power cables]
37	9-Sep	
38	16-Sep	
39	23-Sep	installation of DC/DC (I-side)
40	30-Sep	
41	7-Oct	
42	14-Oct	DRM2 installation
43	21-Oct	SM displacement: SM 0, 1, 16, 17
44	28-Oct	
45	4-Nov	
46	11-Nov	
47	18-Nov	
48	25-Nov	completion of O-side (SM 5-13) [power cables]
49	2-Dec	DC/DC installation
50	9-Dec	DRM2 installation
51	16-Dec	
52	23-Dec	

Not all fibers will be available, fibers installation will be completed in December

SM displacement in December (7, 8, 9, 10) TBC

Concurrent TRD SM insertions in Q4!



DRM2 first commissioning: be able to repeat all tests done in the lab
(note 'DAQ setup' will not be the final one)

TOF LS2 schedule

DRM2 upgrade schedule	2018				2019				2020			
Full validation of new TRM firmware (2eSST + new data format)		■	■									
Finalisation of setup test		■										
Tests in Bologna with CRU			■	■								
Production tests at CAEN (including Efuse setup)			■									
Production tests at CERN				■	■							
Firmware update of TRM				■								
Removal of DRM1 (excluding SM …)					■							
Refurbishing and installation of A1500 (DRM1 → DRM2)						■						
Final check on DRM2 before insertion						■						
Insertion of DRM2								■				
Preparation of time alignment campaign								■				
DRM2 firmware and readout via CRU [CRU at Bologna]				■	■	- - -	- - -	- - -	- - - →			
Time alignment campaign [final fibers]									■			
DRM2 Standalone Commissioning at pit [DAQ on Wheels in CR3]								■				
DRM2 Slow Control (over CONET link + ARM)									■	■		
Commissioning of DRM2 (ALICE integration)									■	■	■	■

DONE

ON-GOING

CRITICAL DELAY

detailed planning and “unpacking” under way
(includes compression software on FLP, QC on FLP, EPN, compliance with O^2 framework, noisy channels fast-feedback,...)

A1395/A1396 refurbishment schedule	2018				2019				2020			
Replacement of 12 A1395 (6 crates)		■										
Removal of A1395/6 (excluding eight supermodules where SM need to be moved)					■							
Removal of A1395 from SM: 0, 1, 16, 17, 7, 8 , 9 10 (SM to be moved)								■				
Refurbishing of A1395/6 and test before installation						■	■	- - →				
Installation of A1395 refurbished (exact date depends on LV power cables)								■				
Irradiation tests at Trento of selected components of A1395/A1396 (SEU)						■	■					

2020 high-level plans (→ richieste/milestones)

- M&O-B plan with RRB in line with previous years (replacement of broken TRM: exp. impact on maintenance costs)

- Attività generali e missioni discendenti da incarichi responsabilità + calcolo T2

- time alignment campaign: 3 persons x 1 week
- software update (Linux cluster): 1 person x 1 week
- DRM2 prod. test (ITEP 8 cards): 1 person x 1 week
- contingency: (SM displacement, A1396 back & forth?): 5 p x 1 week + additional irradiation [**SJ**]

HW specific

- "integration & commissioning"
  - firmware debug "in situ" — 8 weeks (2x4)
  - integration tests (before Q4 run) — 4 weeks
  - software integration (slow control, QC, data compression) — 6 weeks

Integration

"18 w over 9 months"

- 3 months "global running mode" (algoritmo)/**4**

Global run

Exact 2020 schedule depends still a lot from:
- result of irradiation test (<u>might</u> have also financial impact)
- interference with general ALICE schedule
- respect of Q4/19 schedule

<u>Proposed milestones TOF upgrade</u>
31/08/2020 CLock alignment for all 72 crates
31/12/2020 TOF Continuous readout fully integrated in ALICE

TOF toward 2030...

Not for action, just for thoughts...

All TOF modules have now passed more than 10 years of operations, some of them assembled in 2006, with electronics basically chosen in 2003/2004.

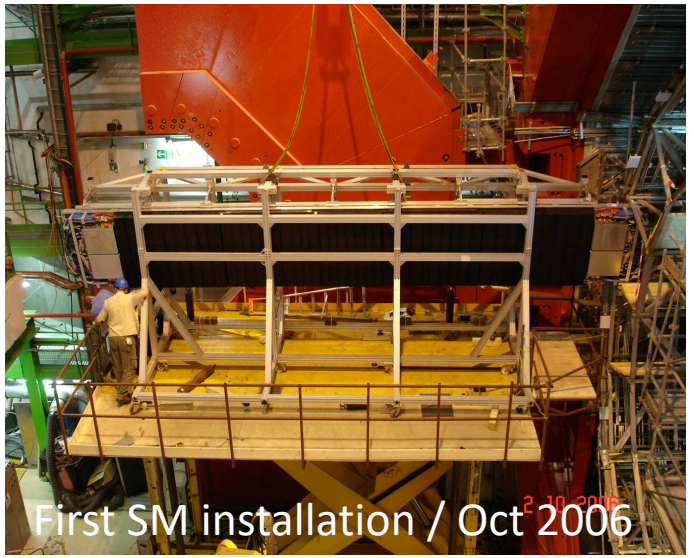
Given LS3 extension, it is now likely ALICE will end operations in 2030.

"TOF core" has been the financial tool so far. After interventions from GE (- 1M€ & then some re-fill 210k€ (2017) + 100k€ (2018) we have just 60 k€ (still to be paid CRU and A1395 refurbishments + other CERN items) → we should stay at zero end of 2019.

CSN3 / TOF / GE should start to **think financially *long term***. No major upgrades but... to maintain operations until 2030 some robust TOF expenses will almost certainly happen.

- Part of TRM modules could need to be re-engineered to produce "brand new spares"?
- PC for slow-control (18+2 cluster) bought in 2016, unlikely to stay until 2030
- …

TOF core "on demand"?
Normal CSN3 budget (but adjust...)?


First SM installation / Oct 2006

Last SM in / 24 Oct 2008