
CERN

HLRF, LLRF & intensity/Schottky

LLRF

Maria Elena Angoletta,

A. Findlay, M. Jaussi,

V. Myklebust, J. Molendijk

Will retire ~03/2021

Studies

and

S. Albright

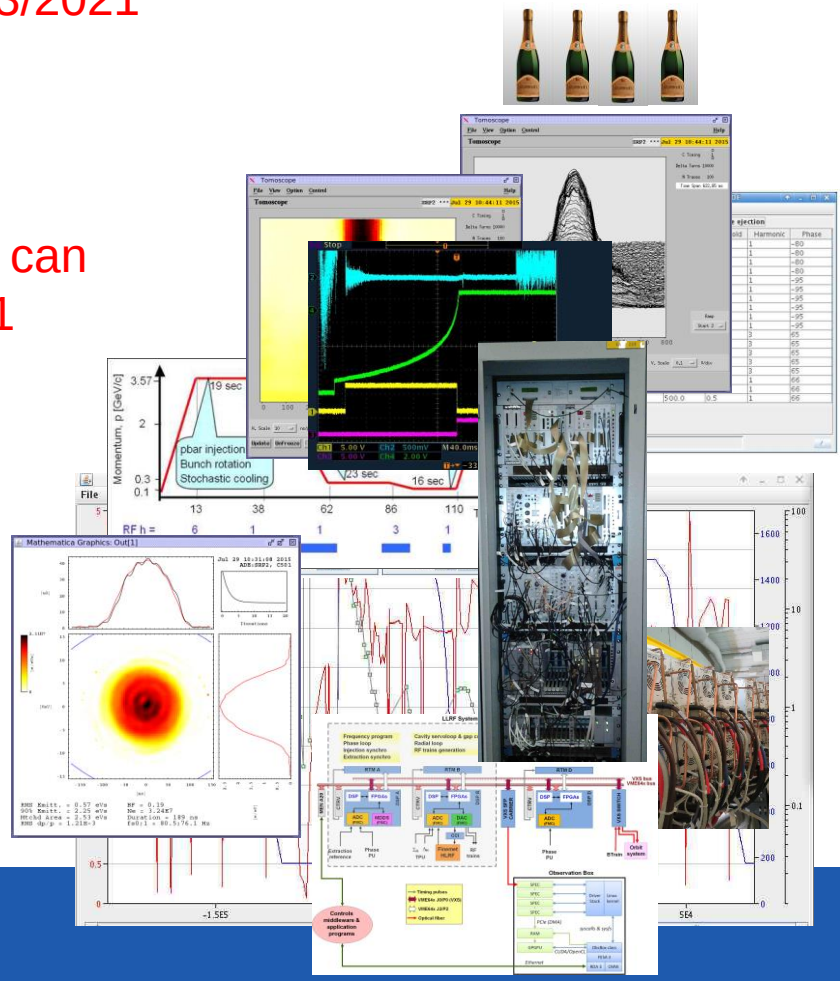
Fellow. Until 10/2020 so far, can be extended to max 04/2021

and

HLRF

M. Haase, M. Paoluzzi, A. Jibar;

P. Maesen, D. Landre (controls)



AD CONS

Cost & Scheduling Review Follow-up

Thursday 6 February 2020

Outline

- Scope of presentation
- WU status and next steps
  - HLRF
  - LLRF
  - Longitudinal diagnostics
- Financial aspects
- Planning wrt LS2 deadlines
- Conclusions

Outline

Scope of presentation

WU status and next steps

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Scope of presentation: WPs

Original budget requests and expenditure planning (July 2018)

Status	WP	WPH		BC	Descr.	EDMS	PLAN	2018	2019	2020	2021
Active	25	BE/RF	M.Haase	69515	AD RF C02 Finemet	1552197		35	100	65	
Active	26	BE/RF	ME.Angoletta	69515	AD RF LL/Schottky	1578121		30	60	30	
Active	27	BE/RF	W.Hofle	69516	AD s-cooling	1689140		214			
Active	28	BE/RF	M.Haase	69517	AD RF C10 valves/upgrade			125	275		
D3	29	BE/RF	E.Jensen		AD RF C10 new system						

Same BC

ADcons-status.xlsx in https://edms.cern.ch/document/2001429/1

Current budgets in APT for 2020

BC	Description	kCHF in 2020
69515	AD C02 RF System (LLRF + HLRF)	172
68516	AD s-cooling	177
69517	AD RF C10 upgrade	345

NB: ~20 kCHF overspent in 2019 as allocated budget was lower than required one (allocated budget reduced to expected payments)

Scope of presentation: WPs

WP 25: Renovation of C02 HLRF (AD decelerating system) to Finemet HLRF
https://edms.cern.ch/document/2019972/

WP 26: Renovation of ring LLRF + intensity/long. Schottky processing systems
https://edms.cern.ch/document/2019444/0.1 (LLRF)
https://edms.cern.ch/document/2019446/0.1 (intensity/long. Schottky)

No workunits defined in EVM

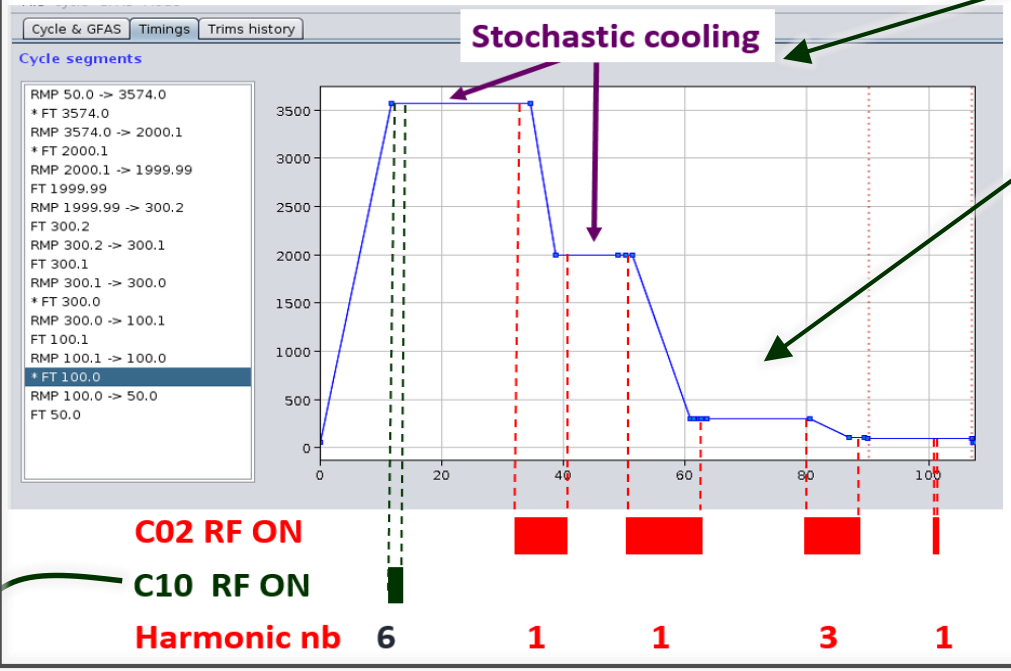
Presentation in previous review (21 Sept 2018):

https://indico.cern.ch/event/754832/contributions/3128065/attachments/1719912/2804147/MEAngoletta_AD_CONS_21_09_2018_C02_LLRF_intensitySchottky.pdf

Scope: systems

Wolfgang's talk

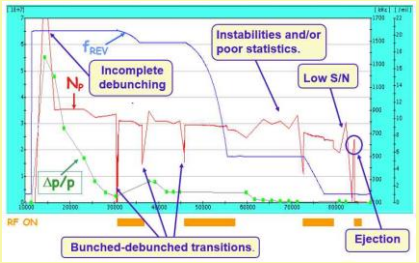
RF group tasks for typical AD production cycle



C10 RF system

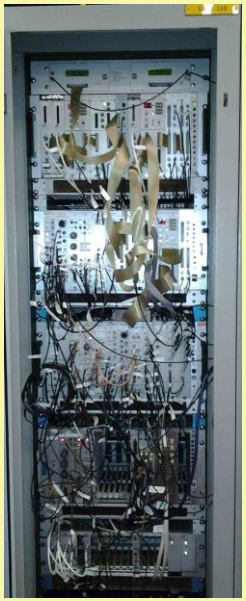
- Under consolidation, not discussed today.
  NB: under delivery 3 TH 116 RF tubes, 300 k€.
- consolidation of the AD C10 HV power converters under consideration in TE/EPC.

Decelerating RF system (LLRF/HLRF) + longitudinal diagnostics: this talk



Pre-LS2 longitudinal diagnostics GUI (obsolete after LS2)

C02 system



Pre-LS2 LLRF crate in ADCR

Scope – reasons for consolidation

Pre-LS2 capabilities adequate for AD beam deceleration & longitudinal diagnostics *BUT* h/w + s/w obsolescence

Consolidation:

- **WHY**: to support AD exploitation & ELENA operation **in the long term**
  - Before ELENA approval, AD renewed for few years at a time, difficult to establish long-term plan.
- **HOW**: by deploying **building blocks common to other machines**
  - to minimize maintenance effort
  - digital LLRF + Finemet: smart & effective couple, successful & well established @CERN (and abroad!)
  - AD LLRF/HLRF/long. diag systems: twin ELENA' systems (AD has a subset of capabilities wrt ELENA)

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- **HLRF**
- **LLRF**
- **Longitudinal diagnostics**

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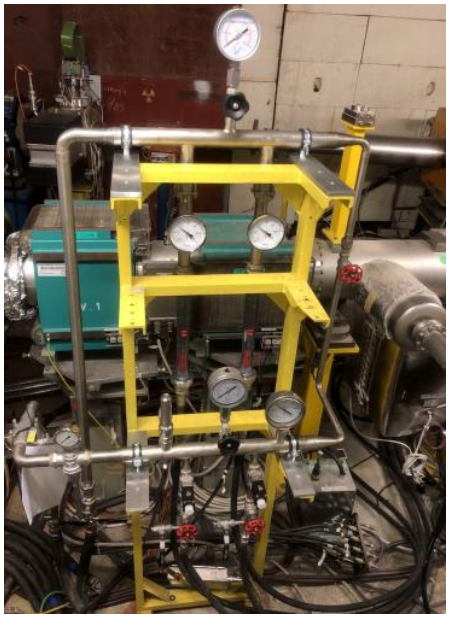
HLRF: status

RING

- ✓ Cables removal [2018]
- ✓ C02 cavity removal [2019]
- ✓ Finemet cavity installation [2019]
- ✓ Water distribution modification [2019]



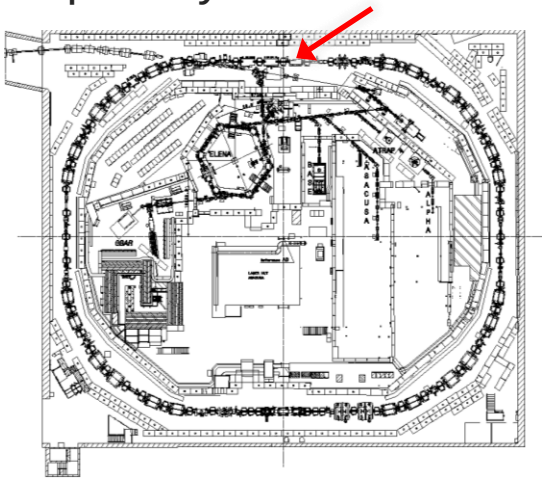
New cooling water distribution

Finemet HLRF installed in AD

AD Hall bat 193

- ✓ Control, PLC, HV and Tuning power supplies removal [2019]

New Finemet HLRF installed in straight section previously occupied by C02 HLRF.



NB: Now cavity servoloop (voltage / phase) in LLRF.

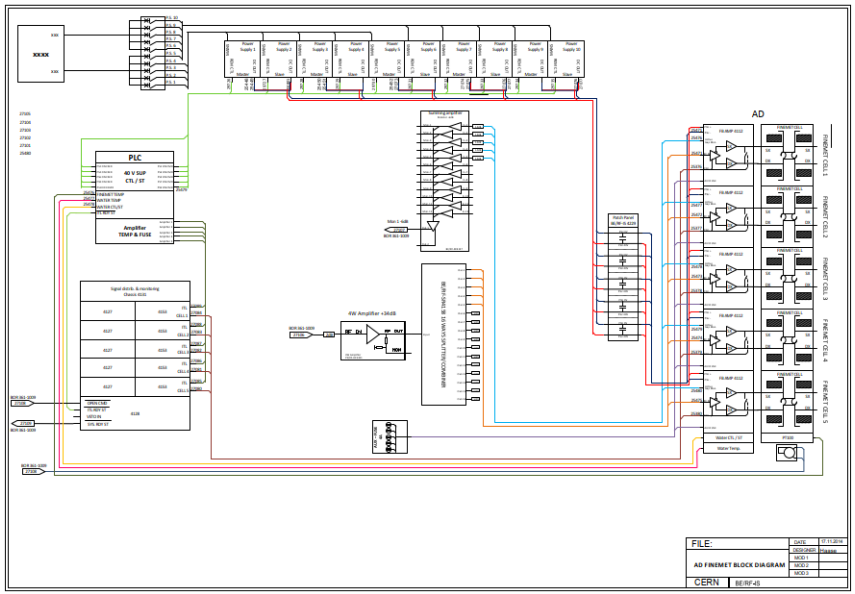
HLRF: next steps

RING

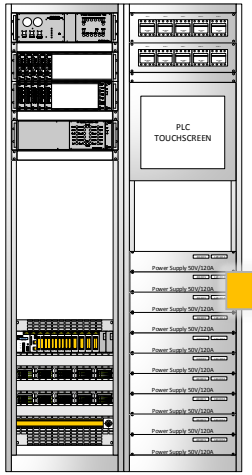
- New cables installation [2020]

AD Hall bat 193

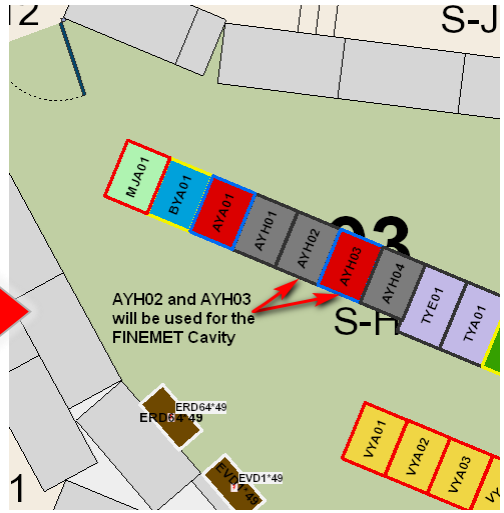
- New control, PLC + power supplies installation [2020]
- **Hardware commissioning: Feb 2021**



AD Finemet block diagram

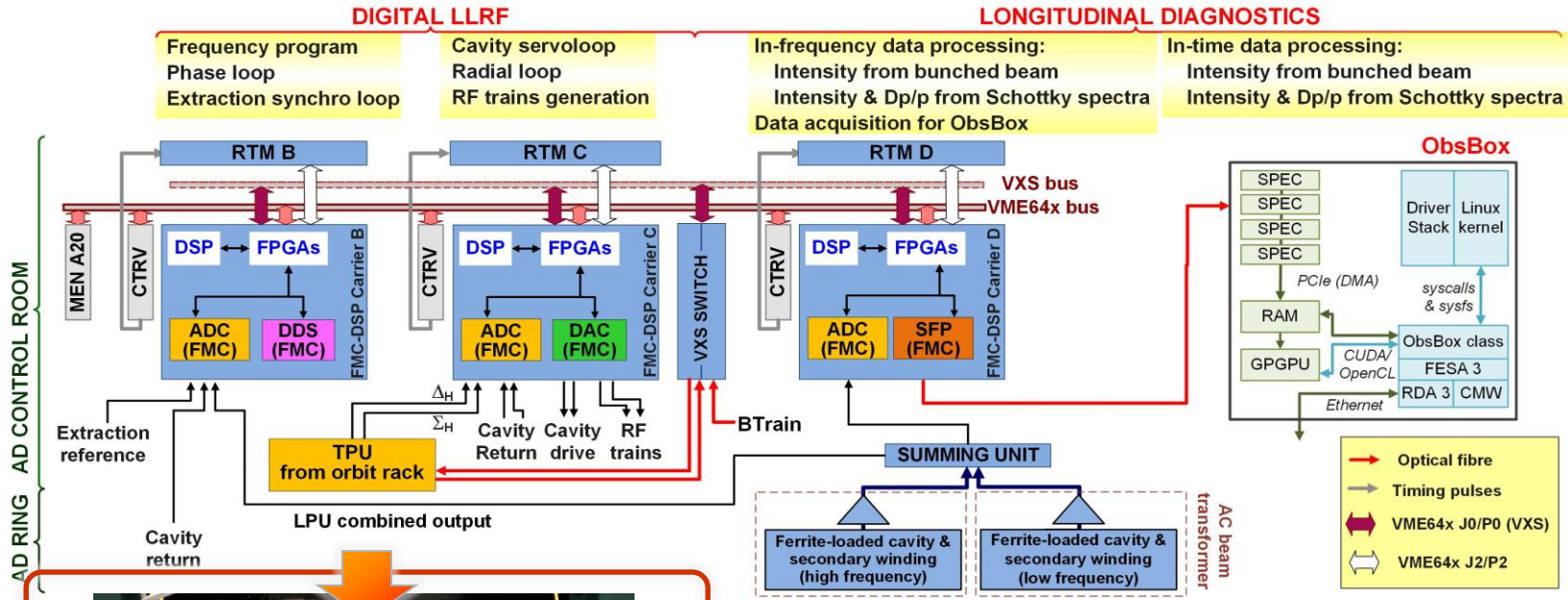


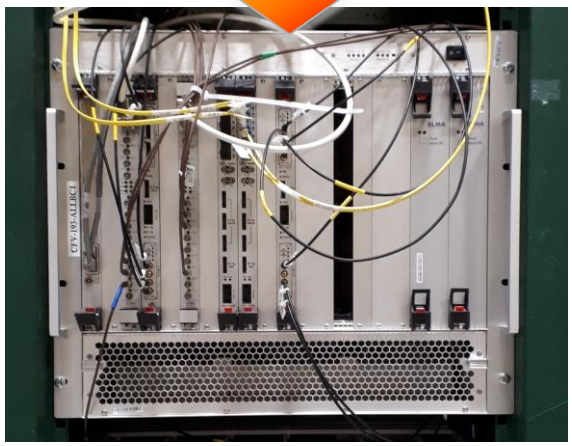
Control, PLC & power supplies



AD Hall layout

LLRF & Longitudinal diagnostics layout [1]





ELENA LLRF crate [2018 version]

- Longitudinal diagnostics partially hosted by and strictly linked to LLRF
- AD system is twin system of ELENA's
  → Develop once, deploy twice ☺

[1] M.E. Angoletta et al, "*New Low-Level RF and Longitudinal Diagnostics for CERN's AD*", IPAC'19, Melbourne, Australia, pp. 3966-3969.

LLRF: status

1. Software/firmware

- Software/firmware deployed in ELENA for the 2018 run implements LLRF features required **[2]**. It will allow essential AD operation **once setup**

BUT …

  - Must upgrade OP and FESA classes (CO oblige!)
  - Existing LLRF **not yet integrated** with AD / RF **cycle editors** → cycle changes (frequent during machine commissioning) require LLRF expert intervention
  - PAUSE capability implemented but not yet validated
  - Additional features needed for better machine operation

- Development and tests in ELENA will be carried out in 2020.
  - For ELENA's (operation + commissioning on transfer lines) and for AD's sake
  - NB: No time for AD development from ~August 2020 to March 2021 (end of PSB commissioning). We must **do our AD homework in ELENA in 2020.**

[2] M.E. Angoletta et al., *"New LLRF capabilities and beam results for the second year of ELENA's commissioning"*, CERN-ACC-NOTE-2019-0050.

LLRF: status (cont'd)

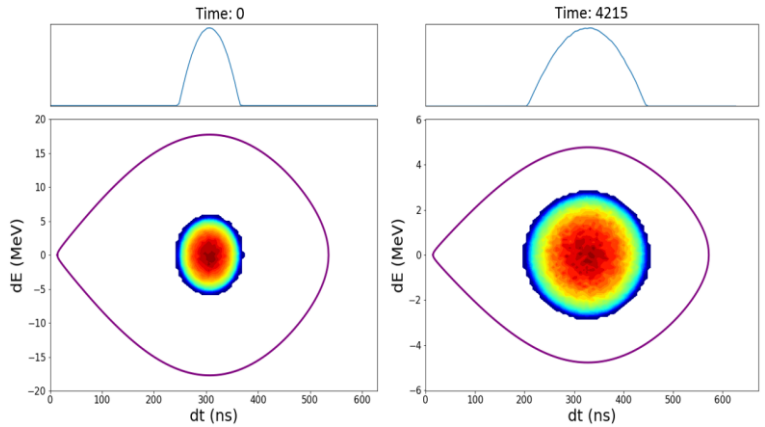
2. Hardware series production

- Hardware production ongoing (jointly with PSB&PS).
- Several types of modules already produced.
- Problems with ADC FMC manufacturing. Will need new ADC chips (best case) and new series production (worse case). **Estimated 5 to 10 kCHF more than originally planned.**

ADC FMC top (above) and bottom (below) views

3. Studies

- **Impact of new Finemet cavity on beam stability** investigated with numerical calculations and longitudinal tracking. No problems expected.



Phase space simulation for the first ramp beginning (left) and end (right).

Longitudinal diagnostics: status

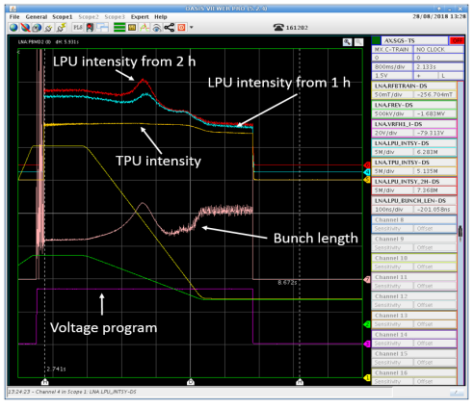
1. In-time data processing [Vebjorn & LLRF team]

- Selected acquisition and processing h/w
  - More expensive than planned but allows synergies with other RF systems
- Very advanced with firmware for data acquisition
- Vebjorn (fellow) progressed with bunched-beam FESA classes.
  - Sinergy with RF SPS/LHC (bunched beam analysis) and BI (Schottky analysis).

ObsBox carrier board: Virtex-7 PCIe FMC Carrier, 8 Lane PCIe GEN2

2. In-frequency data processing [Maria Elena]

- Initial bunched-beam data processing deployed in ELENA in 2018 [3] (basic functionality also for AD).
- Progress in DSP-based FFT analysis



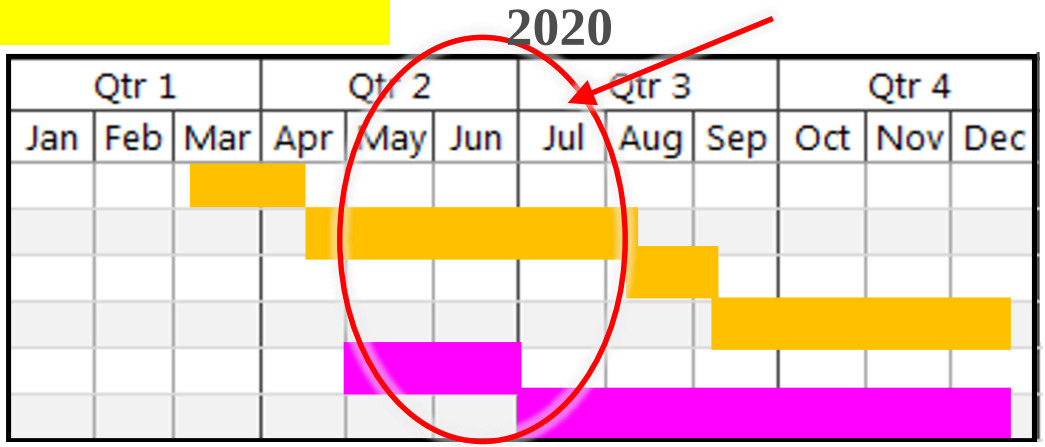
Bunched-beam diagnostic signals in ELENA [2018]

[3] M.E. Angoletta et al., "*Initial longitudinal diagnostics for ELENA's commissioning*", CERN-ACC-NOTE-2019-0051.

LLRF/long. diag.: next steps in 2020

Clear priorities for LLRF team in 2020: PSB 1st, ELENA 2nd

ELENA/AD progress window in 2020



PSB [ISTs, 5 weeks]
PSB [HW COMM, 17 weeks]
PSB [COLD CHECKOUT, 5 weeks]
PSB [STANDALONE BEAM COMM]
ELENA H^- [RING COMM]
ELENA H^- [TRANSFER LINES COMM]

- **Concentrate on PSB until we've done most of the h/w tests (April?)**
- **Move to ELENA in May to support operation + deliver new features**
  - Simon and Alan will train on ELENA's LLRF operation (useful for AD, too)
  - Progress as much as possible with longitudinal diags
  - Part of the team will keep working on PSB as needed
- **From August onward full time on PSB until end 2020 (at least)!**
  - Vebjorn will keep working on ELENA for longitudinal diag

LLRF/long. diag.: next steps in 2020 (cont'd)

- Aim: to develop/deploy/validate in ELENA as much as possible in 2020 run
- Detailed plan and 2020 TODO list defined.
- Tasks agreed in MERIT of team members across RF sections (**FB, CS, BR**)

ELENA – machine milestones

Time	Task	LLRF tasks
May-June [H⁻]	Ring operation	• Restart the system: final configuration with 3-boards • Re-setup cavity servoloops (new HLRF ampli) • Commission LLRF integration with RF cycle editor • Remote control of SPS amplifiers, Oasis features etc (see following TODO and priority slides) • Commissioning of longitudinal diagnostics (ObsBox and in-frequency data analysis, bunched/ debunched beam) • Support ELENA operation. • Train Alan+Simon on ELENA operation
July 2020 – April 2021 [H⁻]	Commissioning extraction lines (1st priority)	• Support ELENA operation • Typical operation: phase, radial, extraction synchro loops in single RF segment. • Commission LPU in new extraction line [W. Hofle & R. Lowerse)
	MDs with acceleration / deceleration	• We might ask for some MDs in July 2020 to finalise our deployments, then we'll have to move to PSB tasks. • NB: **LLRF team busy for PSB commissioning but Vebjorn can continue developing and testing during the whole time** • No time for ELENA (i.e. AD!) during PSB commissioning
April 2021 – May 2021 [pbars]	Ring operation + final machine commissioning	• Re-commission ELENA with pbars • NB: We'll have commissioned AD with pbars by this time • NB: Very few upgrades possible after pbar physics is declared

LLRF/long. diag.: next steps in 2021

AD COMMISSIONING		
Time	**Machine planning**	**LLRF/Long Diag tasks**
Before mid March 2021	H/w commissioning	• Install and validate h/w + s/w
22/03/2021 to 18/04/2021 (4 weeks total)	Target area (weeks 12-13) and **ring beam commissioning (weeks 14-15).** NB: as soon as some beam is available from the target it will be given to AD for its ring commissioning	• Commission with beam & deliver new LLRF (with new HLRF). • Commission with beam and deliver new longitudinal diagnostics system (bunched/debunched beam)

- In principle **only 2 weeks for ring commissioning** of new HLRF + LLRF + long. diagnostics system: feasible?
  - Many changes, not only decelerating RF system: cooling, magnets…
  - NB: Cooling must be operational for LLRF to capture (most) beam
- ELENA pbars commissioning (injection lines + ring) will start as soon as some beam is out of AD.

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Financial aspects

- Total budget for WP 25 + WP 26: **320 kCHF**.
- **~ 158 kCHF** (CET vs. APT) left in 2020 for completing project
  - In line with total amount requested in 2018. Some money leftover from previous years
  - Next big expense: HLRF–LLRF cables. Estimate: 20 k€
  - Some un-planned expenses in WP 26 but planned contingency *might* be enough. To be confirmed later on in the year.
- Originally h/w commissioning (HLRF + LLRF) planned for 2020 → budget ends in 2020
- H/w commissioning now delayed to 2021 owing to PSB demanding restart
  - **Need existing budget to be extended to 2021!!**
  - More precise numbers (if required) in dedicated budget meeting (C. Rossi)

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Planning wrt LS2 deadlines - 2020

Validation in Q2 2020 of new LLRF features required by AD with ELENA.

- Very important!
- Likely no time for AD before h/w commissioning in 2021 (PSB oblige!)
- NB: if there are delays / encounter unexpected problems in PSB *AND/OR* if ELENA source fails, we'll not be able to validate with beam the new developments before AD startup. **No mitigation measures possible!**

PSB [ISTs, 5 weeks]
PSB [HW COMM, 17 weeks]
PSB [COLD CHECKOUT, 5 weeks]
PSB [STANDALONE BEAM COMM]
ELENA H^- [RING COMM]
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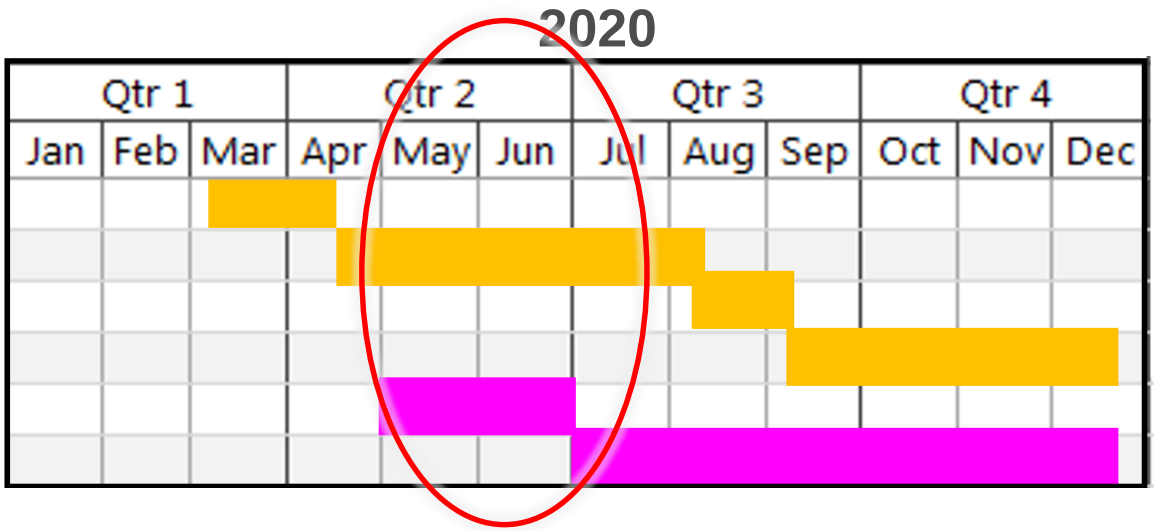
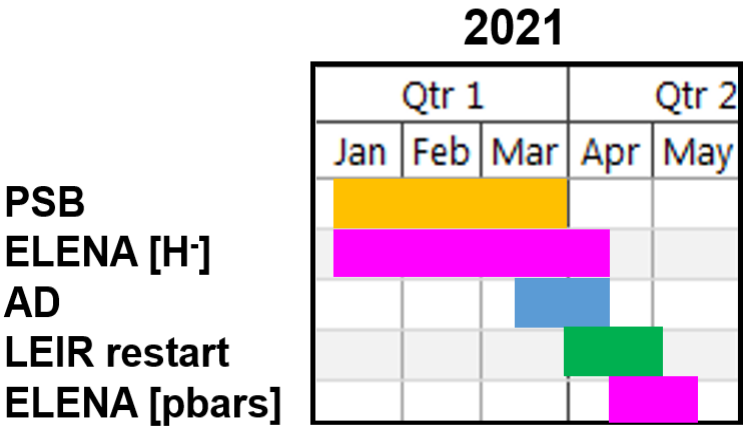


Planning wrt LS2 deadlines - 2021

Very demanding planning for 2021 (LLRF/long diag & HLRF)

- **Two weeks for AD ring commissioning** – is that reasonable?
  - Many changes: LLRF+HLRF, stoch. cooling reinstalled, magnets refurbished…
  - LLRF needs cooling to work in order to capture beam!
- **Same LLRF team addresses PSB-ELENA-AD-LEIR**
  - LLRF team much involved in operation. Overlap on requests from different machines!



Beam commissioning periods in 2021

- H/w commissioning & cold checkout before beam commissioning.
- More PSB beams to setup after official end of PSB beam commissioning (March 2021)
- LEIR restart: new LSA integration wished by OP means more manpower needed.

OP should state priorities (**protons** vs. **ions** vs. **antiprotons**) for 2021.

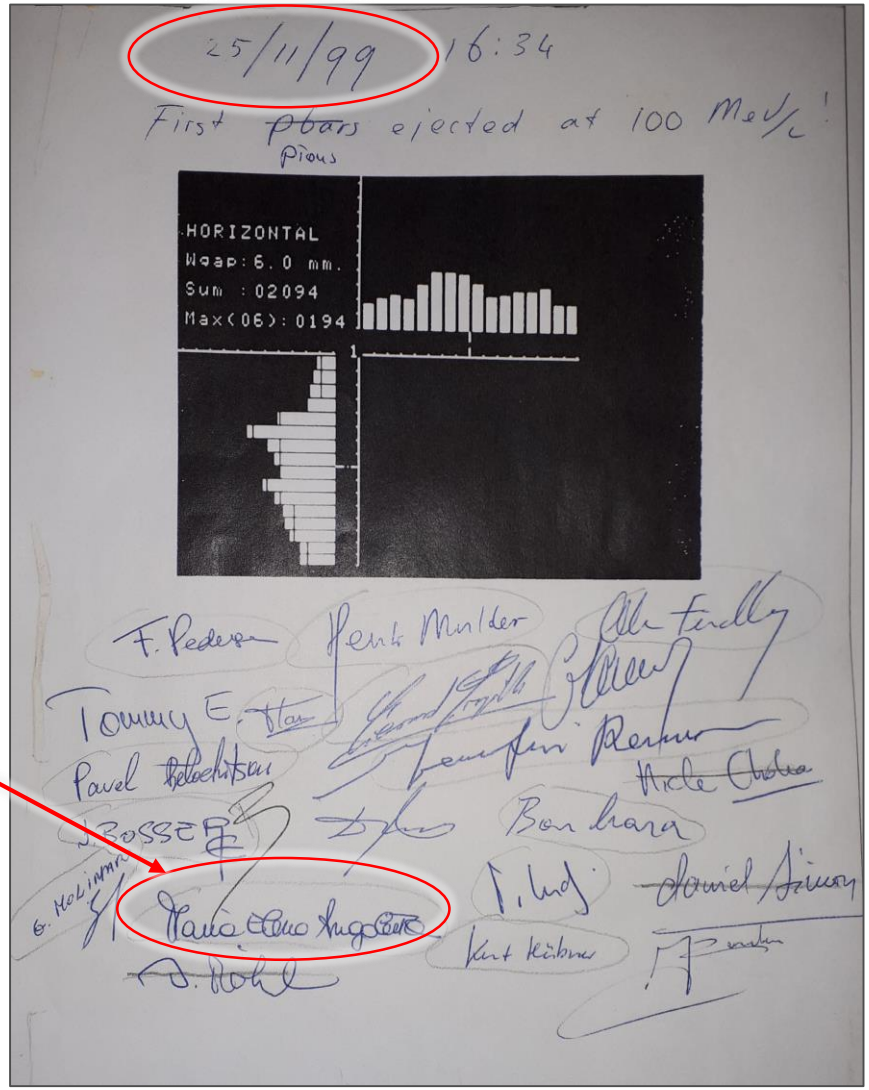
- We have to be careful with declaring the **"start of pbars physics"**, as few changes can be done afterwards in AD/ELENA systems.

Conclusions

- LLRF / HLRF actual progress follows planned one
- Detailed 2020 work planning agreed with team members (MERIT)
- Budget: OK but need to be extended to 2021
- Very demanding post-LS2 machines restart (no contingency)
  - **2020**: critical path for validating AD new features in ELENA
  - **2021**: LLRF (and HLRF, too!) thinly spread over many machines. OP should state priorities (**protons** vs. **ions** vs. **antiprotons**) .
- PSB-ELENA-AD-LEIR restart after LS2: **> year long marathon, not sprint.**
  - **No contingency in** current **beam commissioning planning** for PSB, and AD.
  - ***BUT* no desperate work @restart** (as we did in the past): **we need to run the whole marathon … and to keep our health whilst doing so!**

Conclusions – cont'd

- After so many years, please be assured of the full commitment for AD from RF teams
- We are looking forward to restarting pbar operation with AD & ELENA



I was there!
☺

First pbars extracted from AD @100 MeV/c in November 1999

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