Installation of AFP RP stations and related Infrastructure

presented by Petr Sicho of behalf of AFP collaboration

Important AFP milestones in recent history

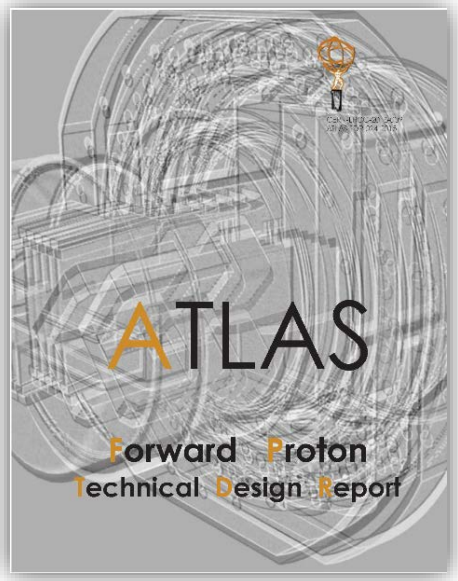
- **AFP TDR**

The ATLAS Collaboration ,

"Technical Design Report for the ATLAS Forward

Proton Detector", CERN-LHCC-2015-009 ; ATLAS-TDR-024;
url: https://cds.cern.ch/record/2017378/

Accepted by LHCC and ATLAS in June 2015

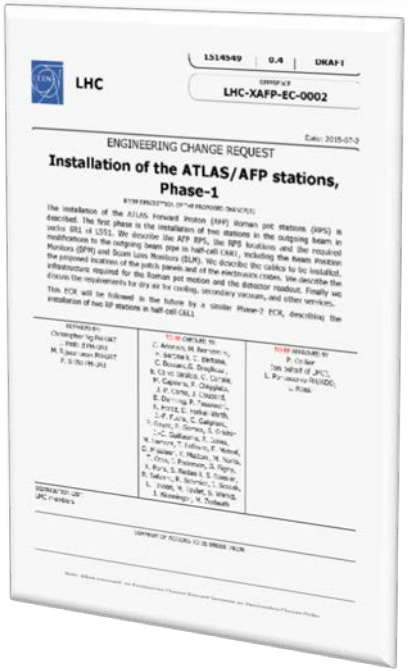


- **Engineering Change Request**

url: https://indico.cern.ch/event/440927/

Accepted at LHC Machine Committee meeting

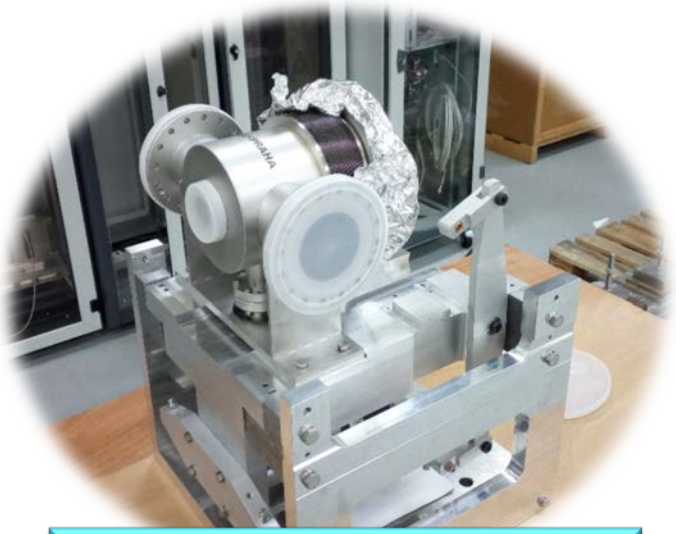
26 August 2015



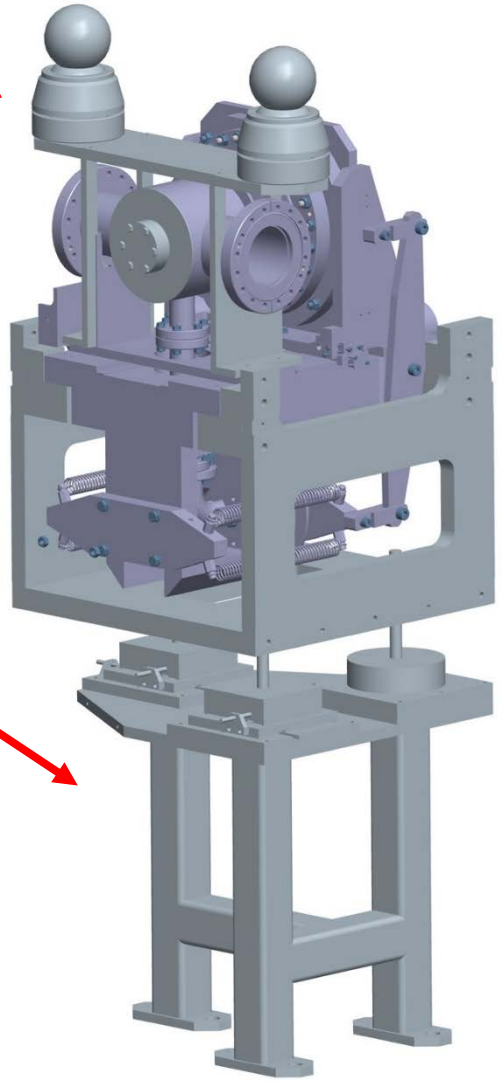
- ➡ Installation of 2 RP stations at right ATLAS arm scheduled for YETS 2015/2016 (10 weeks available)

AFP RP stations

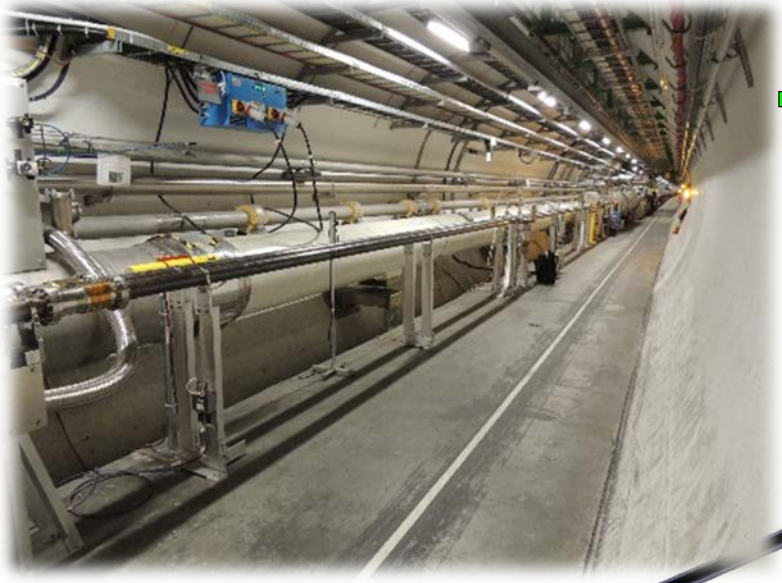
- 5 Horizontal Roman Pot Stations ordered at Vacuum Praha - June 2015
  - 2 RP Stations for the installation in YETS 2015/16
  - 1 RP Station for the lab in SR1 (as prototype for tests)
  - 2 RP Stations to be installed in YETS 2016/17 (expected delivery in spring 2016)
- Support tripod produced at CERN



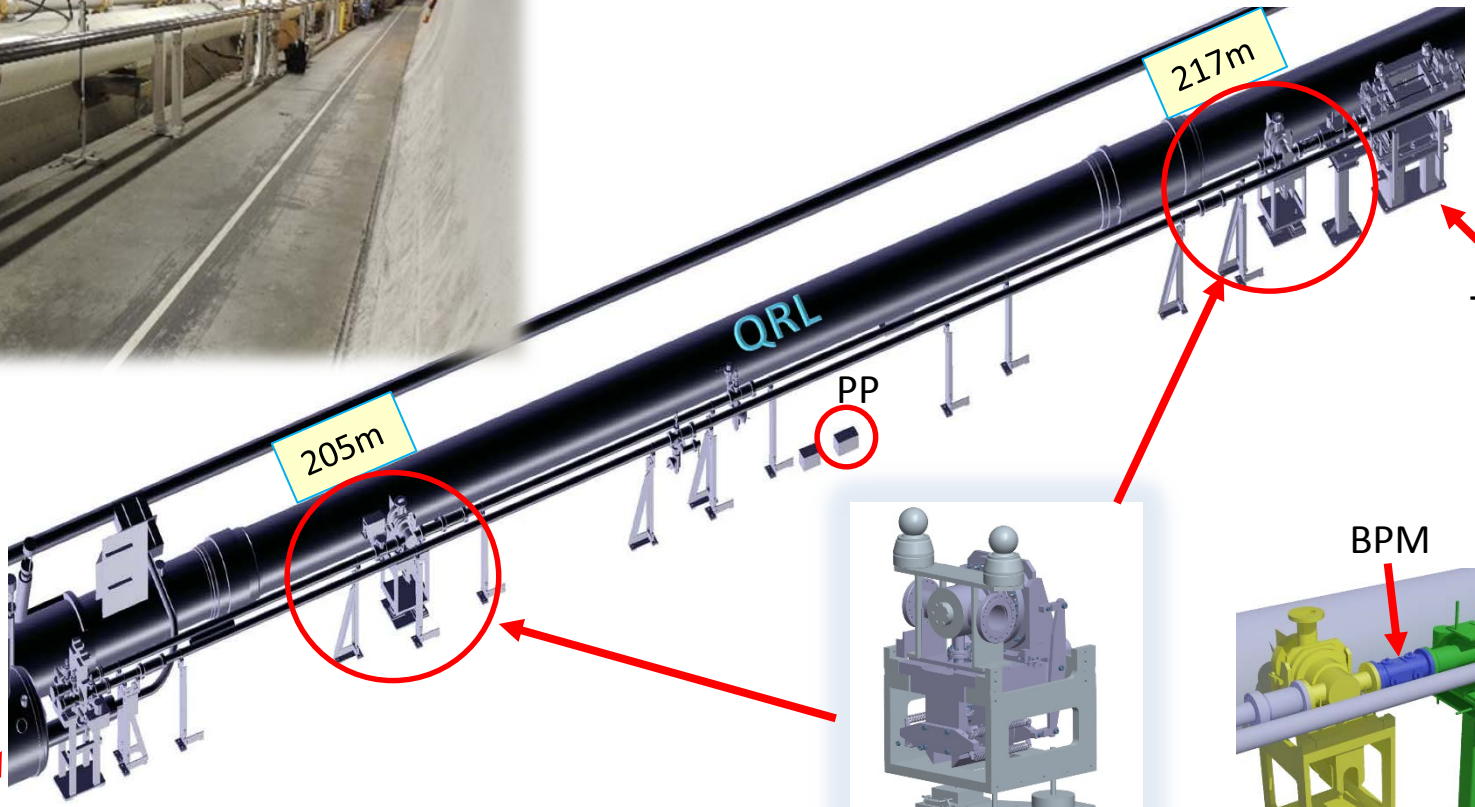
1st AFP station delivered to CERN 19th October



Target place for the installation of AFP stations

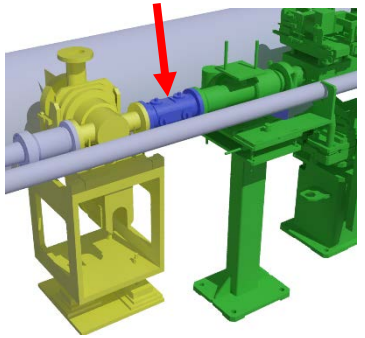


2 first RP stations to be installed at right ATLAS arm (A6R1) at 205m and 217m far from ATLAS IP



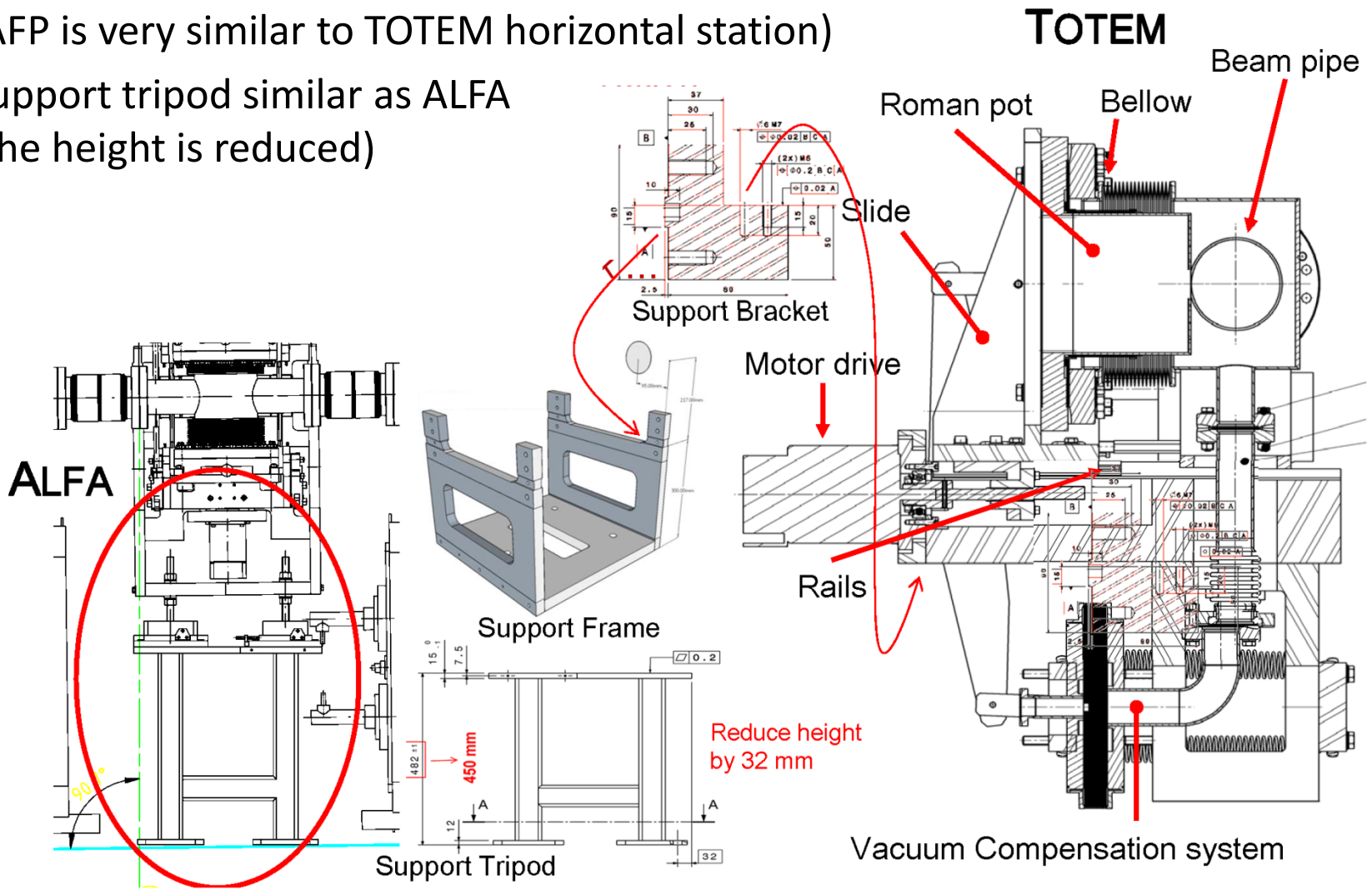
Quadrupole Q5

BPM

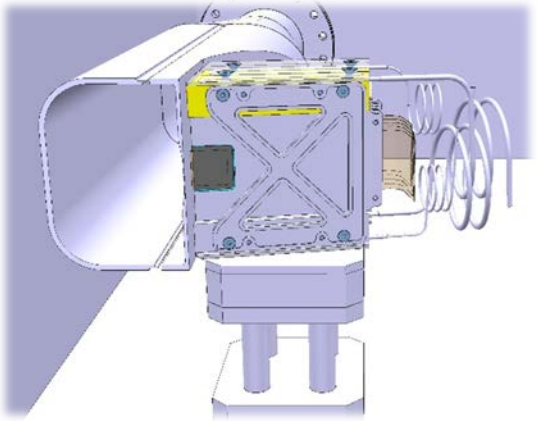


RP station in more details

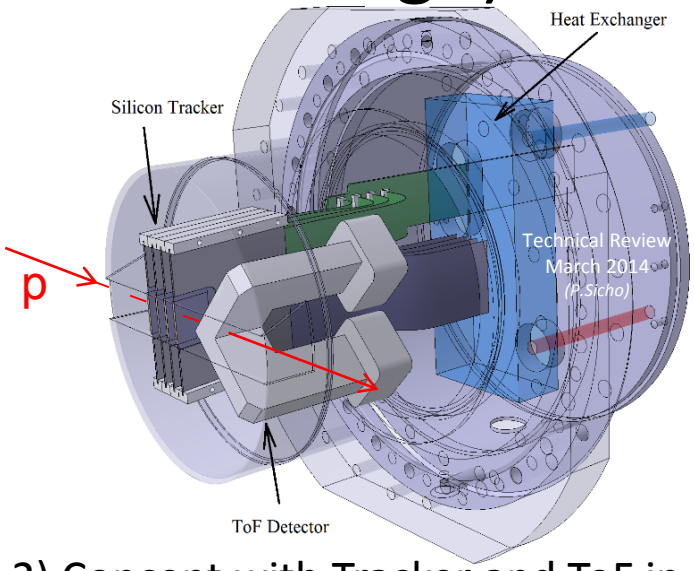
- AFP profits from existing RP station designs
  (AFP is very similar to TOTEM horizontal station)
- Support tripod similar as ALFA
  (the height is reduced)



Historical developments (Tracker design)

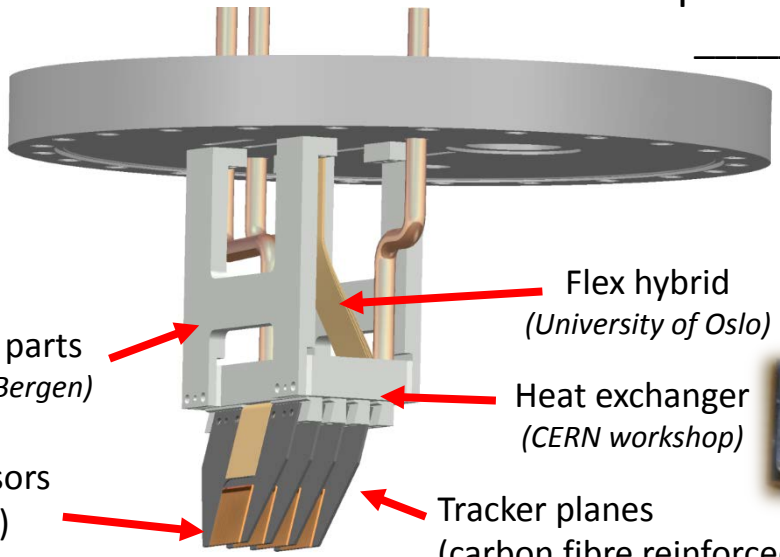


1) Moveable beam pipe with evaporative cooling (baseline up to 2013)

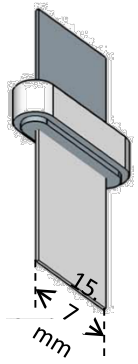


2) Concept with Tracker and ToF in one pot and air-cooling (March 2014)

3) Construction of Tracker prototype (M.Rijssenbeek September 2015)

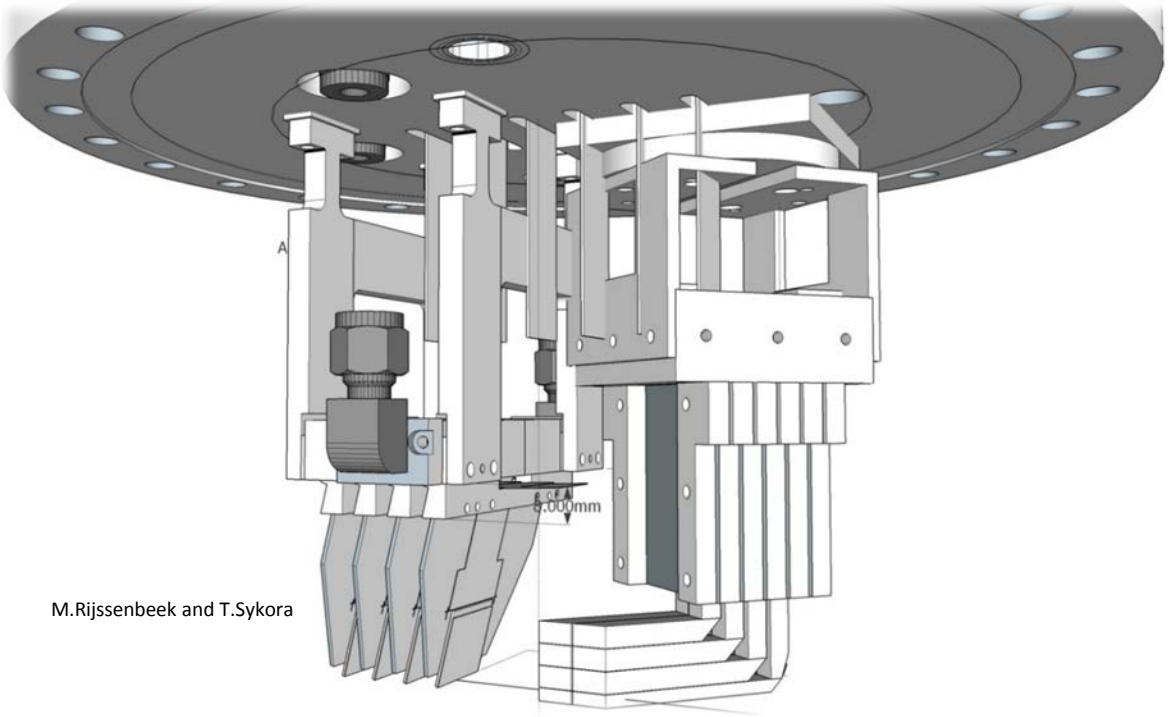


FCC cable (vacuum feedthrough)



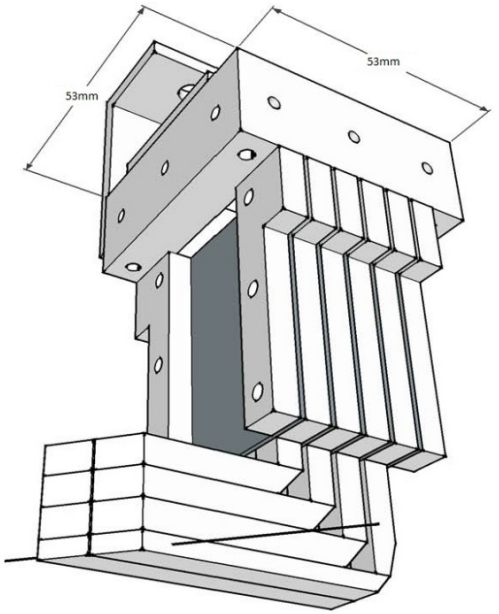
Time of Flight detector – to be added in 2016/17 shutdown

- ToF detector will be installed in the same Roman Pot with the Tracker at 217m (Far Station). Both detectors should fit in pot cylindrical volume of ø145mm – see conceptual drawing bellow…
- ToF related cables and part of infrastructure installed already in YETS 2015



M.Rijssenbeek and T.Sykora

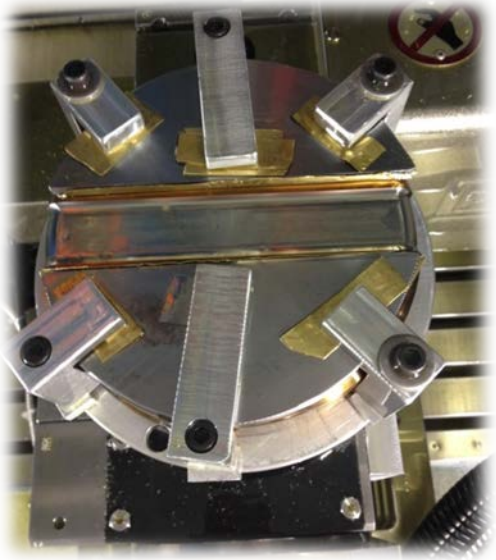
- ToF Prototype shown here (not the final version)



Roman Pot prototyping

- Pot production by University of Alberta
- Welding of pot parts - CERN workshop
- NEG Coating – CERN (to improve local vacuum and secondary electron emission)

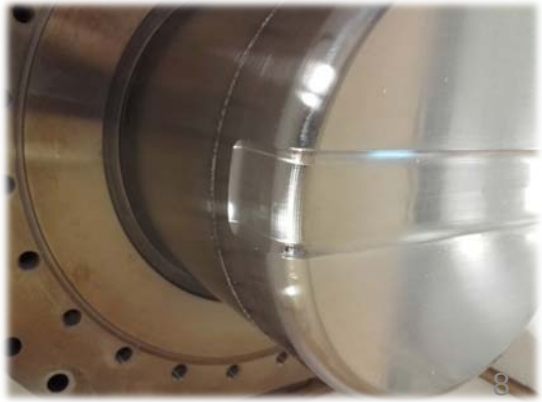
milling process



thin window ~300 µm

measurement of uniformity

- Pictures above show ‘Model 0’ where pot bottom (the cap) was heat treated and slightly oxidized; heat treatment was not used for other pieces..



AFP installation in details

- AFP group installed 2 RP stations with Si tracker in each station at right ATLAS arm (cell A6R1) during YETS 2015/16
  - in such short time with given amount of resources and available manpower it was not be possible to install RP stations at both ATLAS arms
- Installation in more details – what we installed in addition to 2 RP stations:
  - Cables at both ATLAS arms (not completely finished at ATLAS left side)
  - Patch panel @212m which includes local voltage regulators (CAN CTRL) and optical interface for readout signals (optoboard)
  - Control of station stepper motor (USA15)
  - Secondary vacuum system (2 pumps + control in alcove RR17 and USA15)
  - Air-cooling infrastructure (Air-coolers, tubes, valves, pressure regulators, sensors – tunnel, RR17)
  - DCS and DAQ hardware (USA15)
  - Temperature sensors (final number is more than 40 per arm!)
  - Radiation sensors (5 pieces)

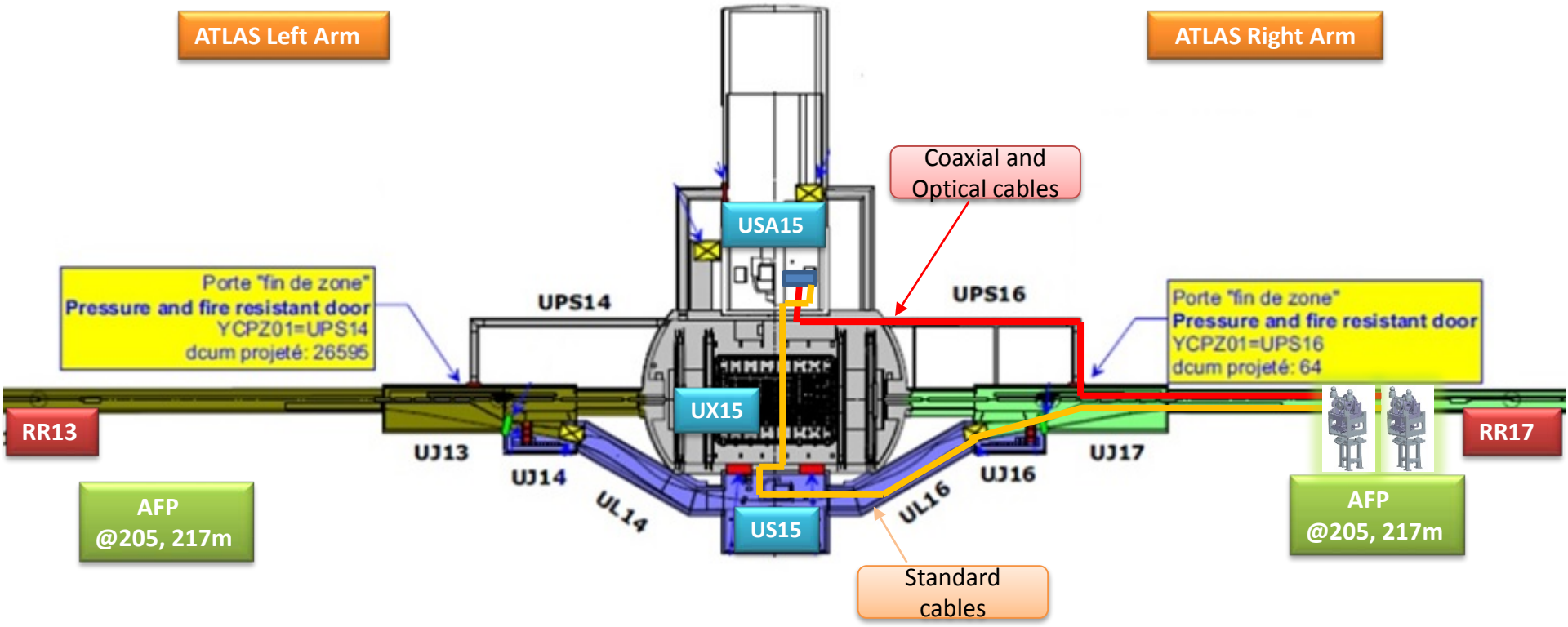
List of AFP services

(ATLAS right arm including ToF services)

	Cable name	LHC Cable ID	ATLAS Cable ID	Starting point	Destination	Identifier	Bundle Identifier	cable type	construction	ϕ [mm]	length [m]	Atlas side
1	AFP DATA/TTC	1127810A	3042500	Y.24-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Ro/Y.24-05.A1	custom optical (FibreFab)	8 x 12 fibres	12	310	A6R1
2	Fast Trigger/Clock SiT	1127811A	3042501	Y.15-02.A1	Tunnel @217m		AFP/pp XRPAF. LHC1-2/Ro/Y.15-02.A1	7/8" Heliflex HCA78-50,	coaxial	28	261	A6R1
3	Fast Trigger ToF	1127812A	3042502	Y.15-02.A1	Tunnel @217m		AFP/pp XRPAF. LHC1-2/Ro/Y.15-02.A1	7/8" Heliflex HCA78-50,	coaxial	28	261	A6R1
4	LV cable SiT	1127813A	3042503	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	TecniKabel	AWG10, 4 tw.pairs	22	333	A6R1
5	LV cable SiT	1127814A	3042504	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	TecniKabel	AWG10, 4 tw.pairs	22	333	A6R1
6	LV cable ToF	1127815A	3042505	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	TecniKabel	AWG10, 4 tw.pairs	22	333	A6R1
7	LV cable ToF	1127816A	3042506	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	TecniKabel	AWG10, 4 tw.pairs	22	333	A6R1
8	LV cable ToF	1127817A	3042507	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	TecniKabel	AWG10, 4 tw.pairs	22	333	A6R1
9	Opto-VVDC	1127818A	3042508	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	Novacavi 04.71.04.147.0	AWG14, 7 tw.pairs	18.7	333	A6R1
10	AuxPWR (Vreg)	1127819A	3042509	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/L/Y.23-05.A1	Novacavi 04.71.04.147.0	AWG14, 7 tw.pairs	18.7	333	A6R1
11	HV cable SiT	1127820A	3042510	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/H/Y.23-05.A1	TecniKabel 04.31.52.236.2	AWG26, 18tw.pairs	13.8	333	A6R1
12	HV cable ToF	1127821A	3042511	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/H/Y.23-05.A1	TecniKabel 04.31.52.236.2	AWG26, 18tw.pairs	13.8	333	A6R1
13	LTB_PWR_CTRL	1127822A	3042512	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.24-05.A1	NF8 04.21.52.160.0	AWG18, 4tw.pairs	12	333	A6R1
14	Environmental 1	1127823A	3042513	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.23-05.A1	NE48; 04.21.52.150.2	0.5mm2, 24tw.pairs	21	333	A6R1
15	Environmental 2	1127824A	3042514	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.23-05.A1	NE48; 04.21.52.150.2	0.5mm2, 24tw.pairs	21	333	A6R1
16	Air-coolerNS CTRL_USA15	1127825A	3042515	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.25-05.A1	NF12 04.21.52.170.8	AWG18, 6tw.pairs	14	333	A6R1
17	Air-coolerFS CTRL_USA15	1127836A	3042516	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.25-05.A1	NF12 04.21.52.170.8	AWG18, 6tw.pairs	14	333	A6R1
18	CANBUS	1127826A	3042517	Y.24-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Can/Y.24-05.A1	VG18CAN 04.21.60.491.2	1mm2, 9tw.pairs	17.4	333	A6R1
19	Stepper motors	1127827A	3042518	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Co/Y.25-05.A1	Intercond 04.71.04.167.0	AWG 16, 7tw.pairs	16.3	333	A6R1
20	LVDT, resolver	1127828A	3042519	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Co/Y.25-05.A1	NE48; 04.21.52.150.2	0.5mm2, 24tw.pairs	21	333	A6R1
21	microswitches	1127829A	3042520	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Co/Y.25-05.A1	NE18; 04.21.52.130.6	0.5mm2, 9tw.pairs	13.5	333	A6R1
22	general spare	1127830A	3042521	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.24-05.A1	Intercond 04.71.04.167.0	AWG 16, 7tw.pairs	16.3	333	A6R1
23	general spare	1127831A	3042522	Y.25-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.24-05.A1	Intercond 04.71.04.167.0	AWG 16, 7tw.pairs	16.3	333	A6R1
24	secondary vacuum	1127832A	3042523	XYAFP01 RR17	Tunnel @217m		AFP/pp XRPAF. LHC1-2/Co/XYAFP01 RR17	NE18; 04.21.52.130.6	0.5mm2, 9tw.pairs	13.5	50	A6R1
25	Air-coolerNS CTRL_RR17	1127837A	3042524	XYAFP01 RR17	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/XYAFP01 RR17	NF12 04.21.52.170.8	AWG18, 6tw.pairs	14	50	A6R1
26	Air-coolerFS CTRL_RR17	1127838A	3042525	XYAFP01 RR17	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/XYAFP01 RR17	Intercond 04.71.04.167.0	AWG18, 7tw.pairs	14	50	A6R1
27	secondary vacuum pipe	1127833A	3042526	XYAFP01 RR17	Tunnel @217m		AFP/pp XRPAF. LHC1-2/Dcs/XYAFP01 RR17	pipe Assiwell	flexible vacuum pipe	~25mm	50	A6R1
28	Interlock and Rad Sensors 1		3042527	Y.23-05.A1	Tunnel @212m		AFP/pp XRPAF. LHC1-2/Dcs/Y.23-05.A1	Intercond 04.71.04.247.0	AWG 24, 7tw.pairs	10,5mm	333	A6R1
29	Interlock and Rad Sensors 2		3042528	Y.23-05.A1	XYAFP01 RR17		XYAFP01 RR17/Dcs/Y.23-05.A1	Intercond 04.71.04.247.0	AWG 24, 7tw.pairs	10,5mm	360	A6R1
30	Aircooler FS1 ON/OFF p_pipe	1127834A	3042701	XYAFP01 RR17	Tunnel @217m		AFP/pp XRPAF. LHC1-2/P/XYAFP01 RR17	flexible rubber pipe	single pipe shielded	11,5mm	50	A6R1
31	Aircooler FS2 CTRL p_pipe	1127839A	3042702	XYAFP01 RR17	Tunnel @217m		AFP/pp XRPAF. LHC1-2/P/XYAFP01 RR17	flexible rubber pipe	single pipe shielded	11,5mm	50	A6R1
32	Aircooler NS1 ON/OFF p_pipe	1127840A	3042703	XYAFP01 RR17	Tunnel @205m		AFP/pp XRPAF. LHC1-2/P/XYAFP01 RR17	flexible rubber pipe	single pipe shielded	11,5mm	50	A6R1
33	Aircooler NS1 CTRL p_pipe	1127841A	3042704	XYAFP01 RR17	Tunnel @205m		AFP/pp XRPAF. LHC1-2/P/XYAFP01 RR17	flexible rubber pipe	single pipe shielded	11,5mm	50	A6R1
34	CompAir source to RR17		3042705	XYAFP01 RR17	Tunnel @217m		AFP/pp XRPAF. LHC1-2/P/XYAFP01 RR17	flexible rubber pipe	single pipe shielded	11,5mm	50	A6R1

- We have 28 cables per ATLAS arm including 2 fast coaxial cables, 1 optical cable, 2 spares plus secondary vacuum pipe, pneumatic pipes to control Air-cooling box

ATLAS situation plan (top view)



Length od services:

- Trigger cables ~260m
- Optical cable 310m
- Standard cables ~333m

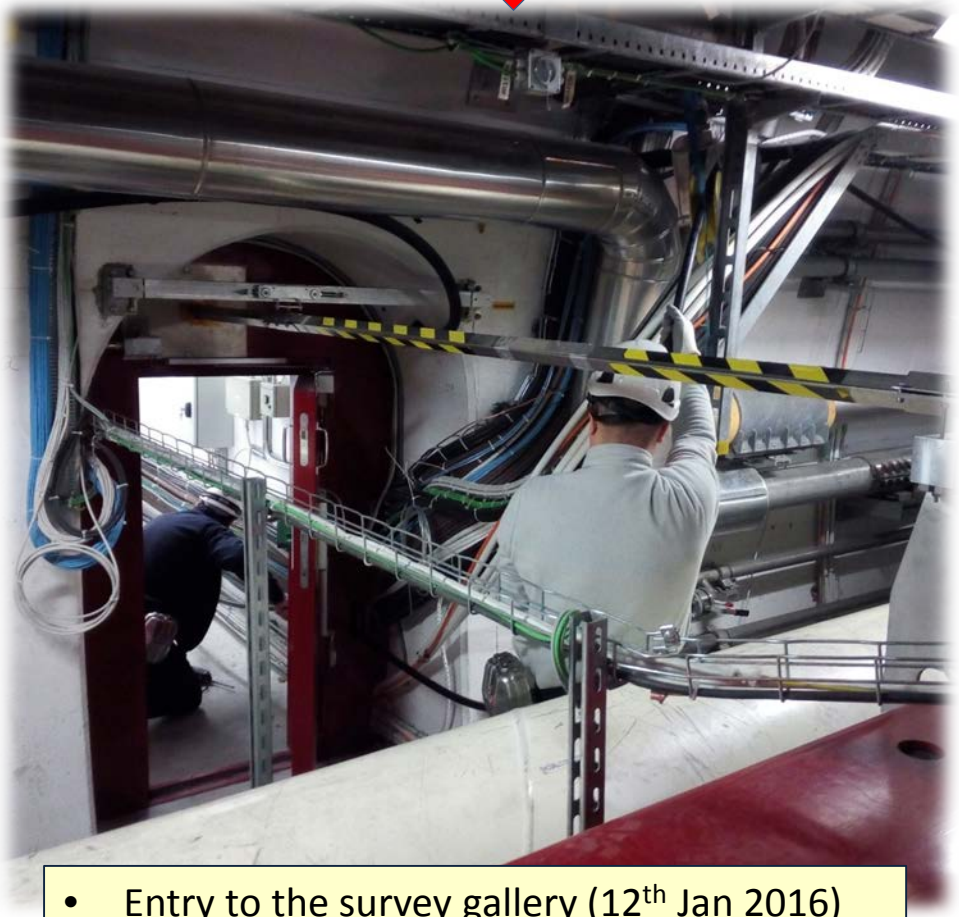
AFP Service areas:

- **USA15** (off-detector electronics)
- Alcove **RR17,** RR13 (secondary vacuum, DOROS data acquisition BPM readout)

Installation of cables

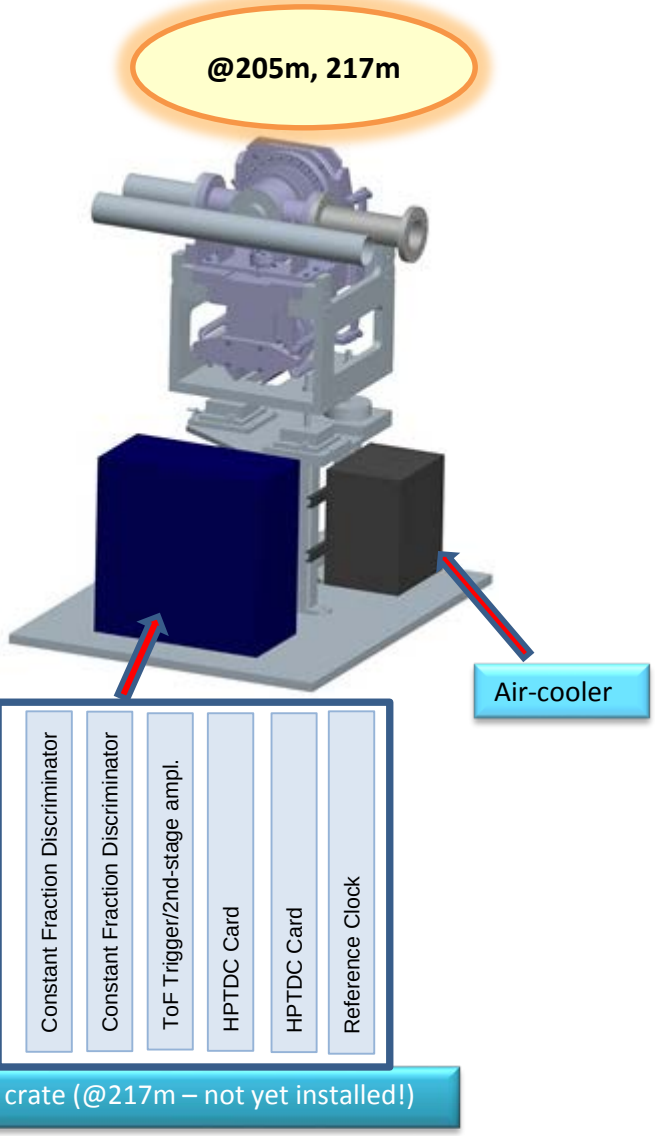
- Two independent teams involved
- Fast coaxial cables and optical fibers – installation done by SPIE (January)
- Standard cables – Atlas team (February - March)

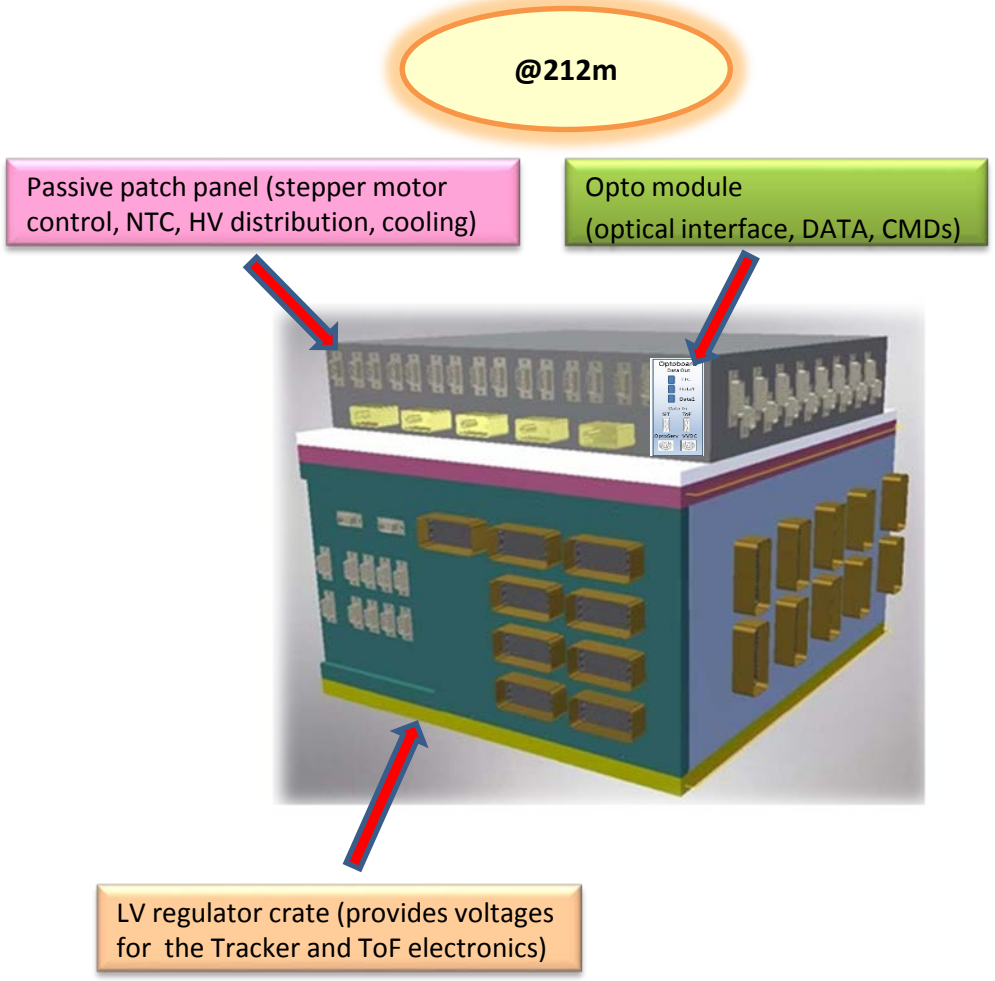
- In the tunnel (5th Feb 2016)



- Entry to the survey gallery (12th Jan 2016)

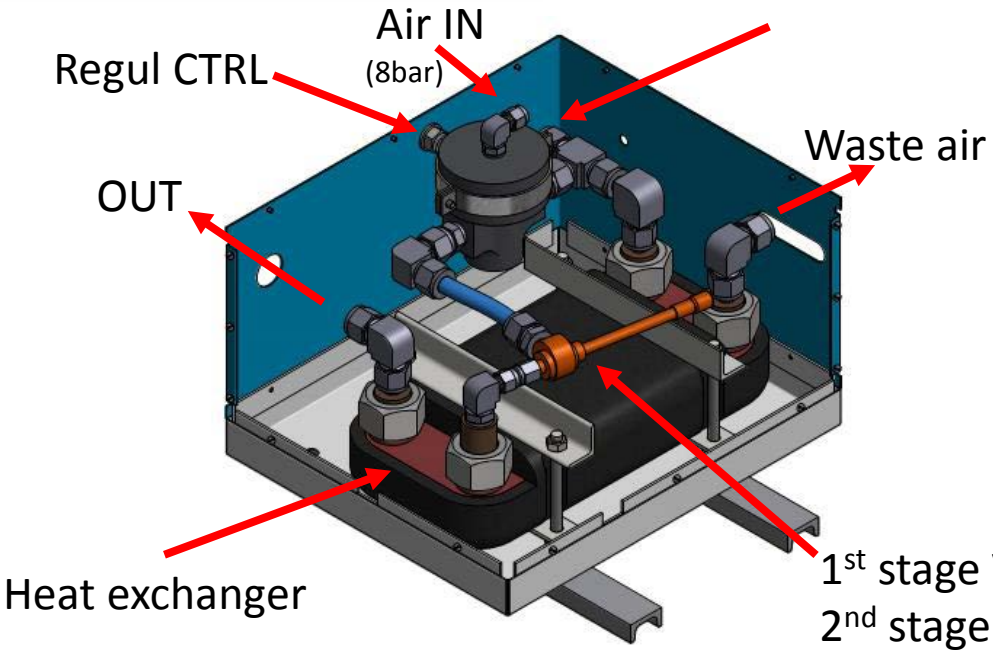
AFP Patch panels, crates, boxes in the tunnel





Air-cooling infrastructure

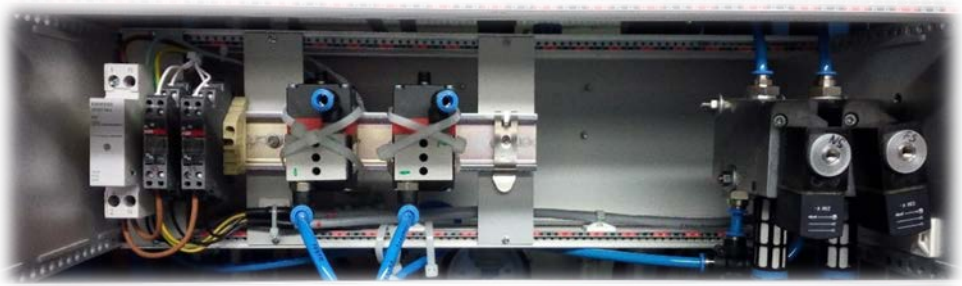
- Silicon tracker requires cooling (sensors should be kept at temperature bellow 0˚C)
- Power dissipation: ~5W the tracker + ~10W roman pot
- Air-coolers are installed very close to RP stations (1m)
- Regulation of output air temperature is done by proportional pressure regulators placed in RR17 (controlled via PLC S7-1200)




Air connection in the tunnel

AFP infrastructure in RR17 (latter also in RR13)

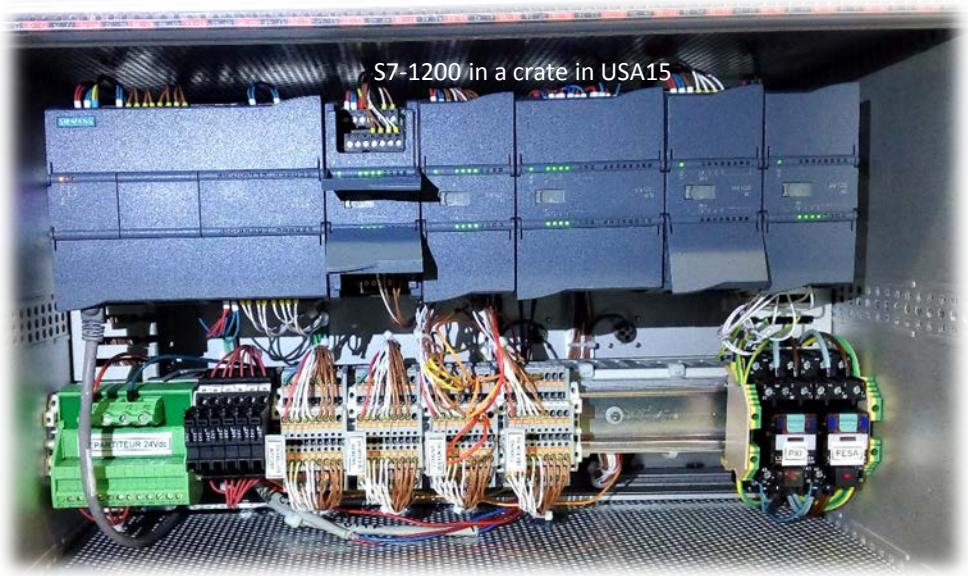
- Vacuum pumps, valves, pressure gauges - secondary vacuum system
- Proportional pressure regulators (provide pilot pressure for high flow regulators in Air-coolers), valves - detector cooling

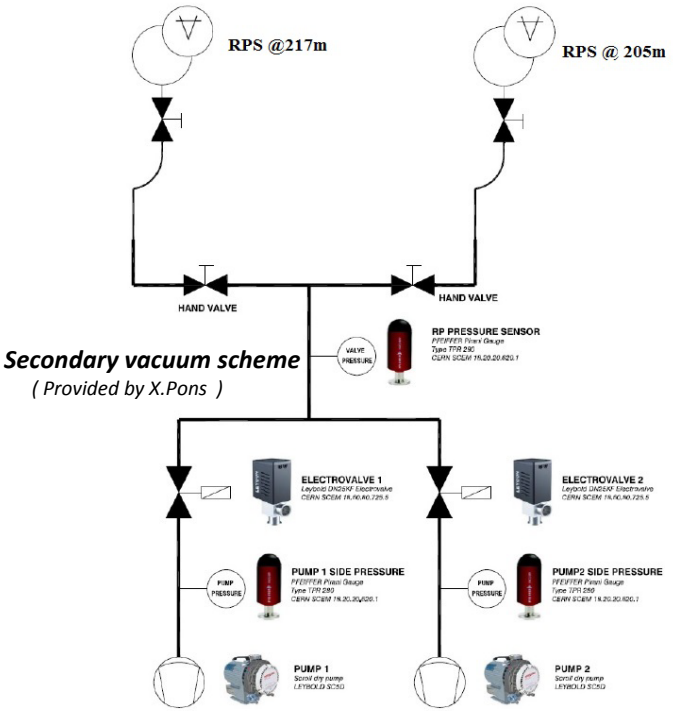


Provided by PH-DT (X.Pons)

Secondary vacuum

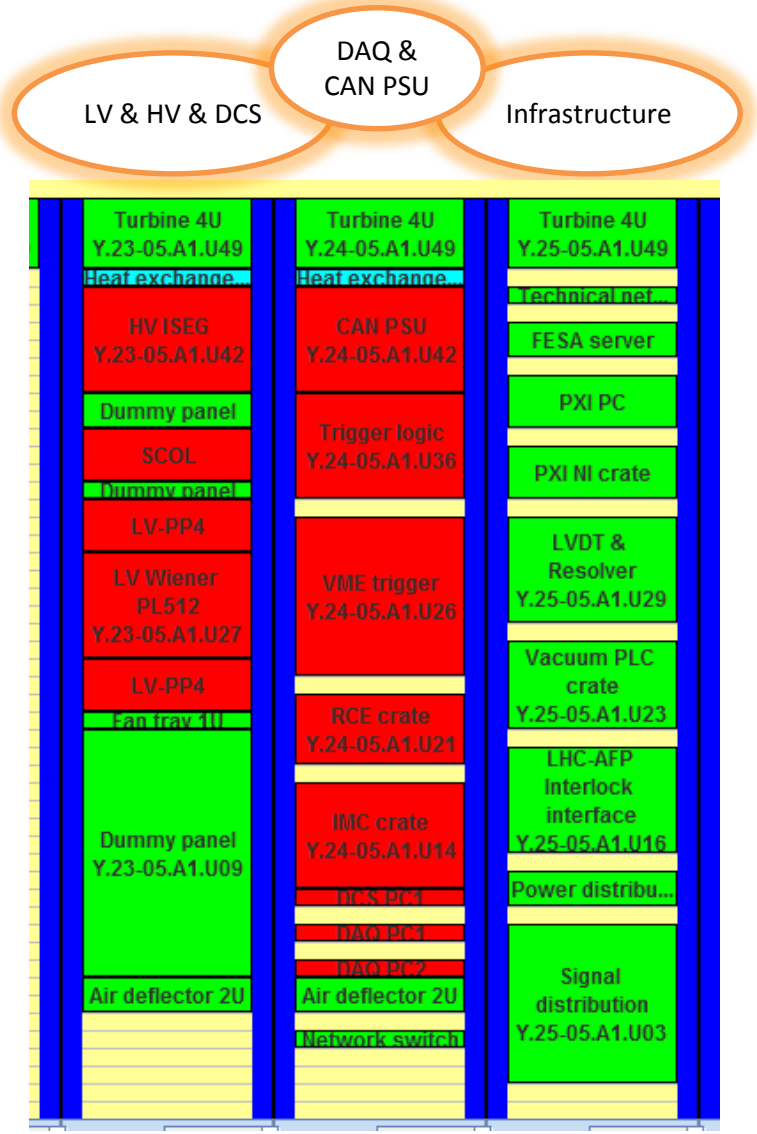
- Covered by WP *Roman Pot Instrumentation and Control system* (PH-DT X.Pons)
- Pumps Scrollvac SC5D (0.05mbar), similar type as TOTEM
- Monitoring and control via PLC placed in rack in USA15 - Simatic S7-1200 (Siemens).
- The same PLC is used for Air-cooler power control





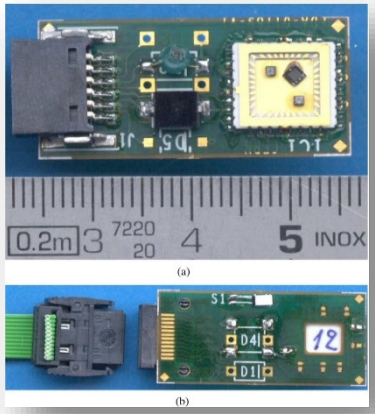
Secondary vacuum scheme
(Provided by X.Pons)

AFP racks in USA15

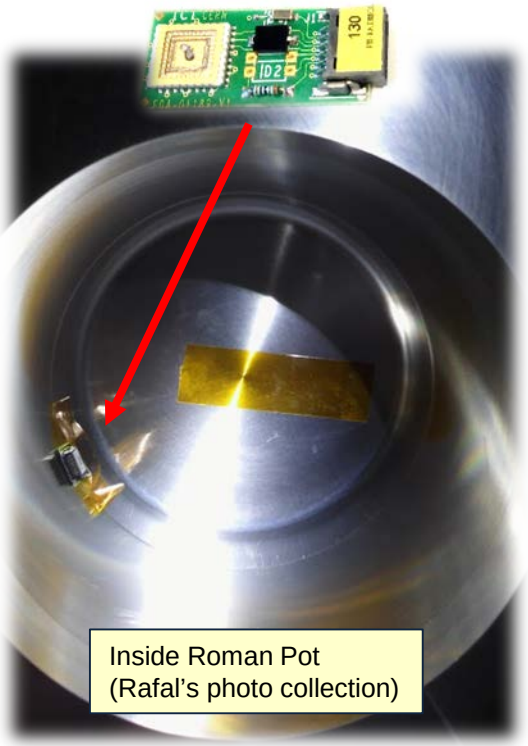


Radiation sensors placed at several places

- In both Roman Pots (without connection)
- At the flange of FS
- At patch panel @212m
- In AFP rack in RR17




DCS rack in USA15


Inside Roman Pot
(Rafal's photo collection)

Function	Type	Device	Operating Range	Sensitivity / Resolution
Total Dose sensor	RadFET high-dose	REM 250nm	~10^{-1} Gy to more than 10^{4} Gy	~20 mV/Gy (initial)
1MeV$_{n.eq}$ Φ sensor	p-i-n diode	BPW34S	~2×10^{12}cm^{-2} to ~4×10^{14} cm^{-2} (linear)	~1×10^{10} cm^{-2}/mV
1MeV$_{n.eq}$ Φ sensor	p-i-n diode	LBSD Si-1	~10^{10}cm^{-2} to ~2×10^{12} cm^{-2} (linear)	~2×10^{8} cm^{-2}/mV
Temp. sensor	Thermistor	NTC 10kΩ	-55 ºC to 125 ºC	0.1 ºC
Line check	Resistor	R = 1kΩ	---	---

LHC tunnel A6R1 – January 2016

(a week before RP stations were installed)

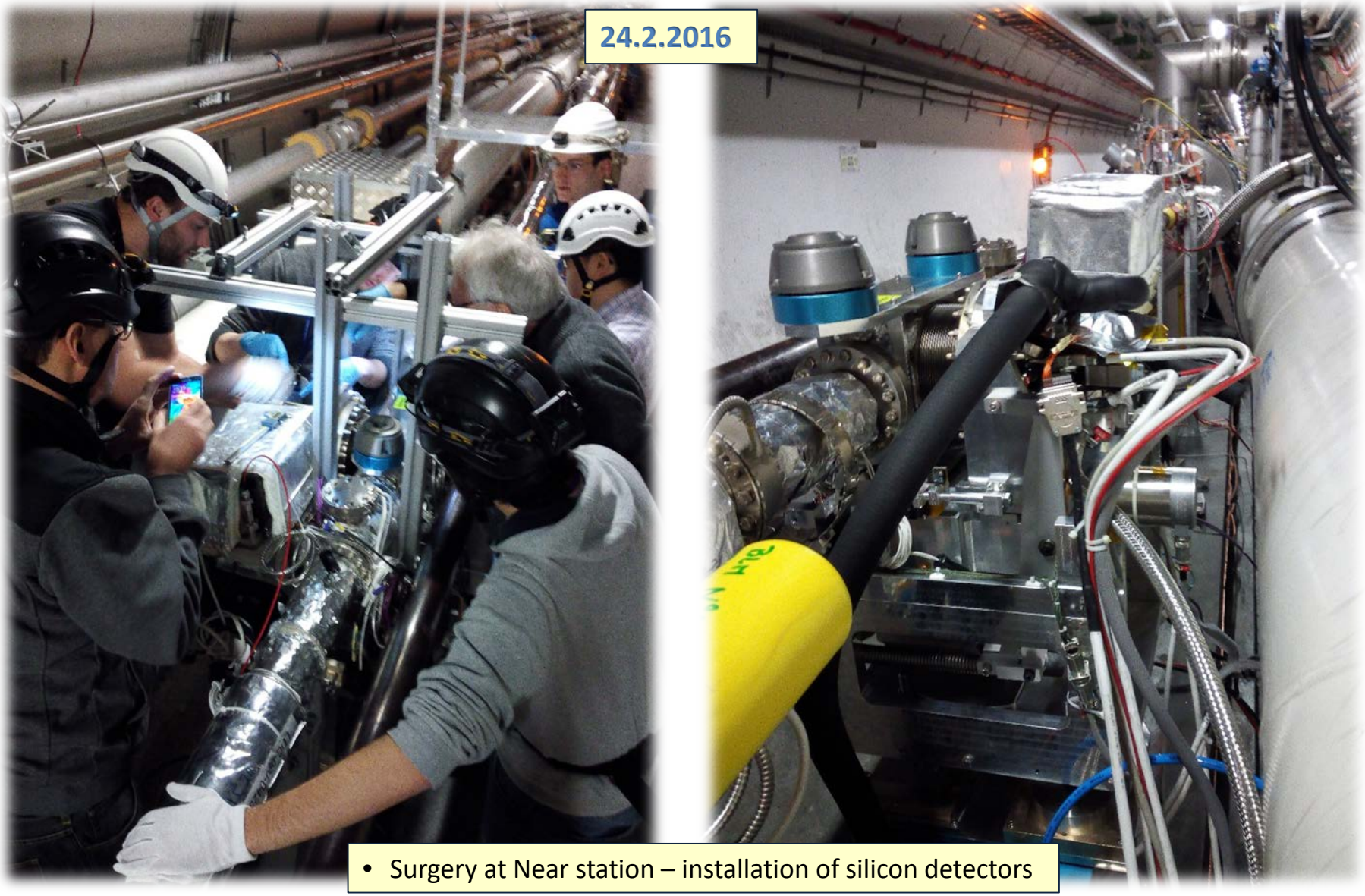
- Patch panel is installed
- Tripods are placed there
- New beam pipes are ready

RP Stations in A6R1 are installed!

Thanks very much to Serge Pelletier (EN-HN group) for prompt help with RP station handling and installation

Bake-out under way

AFP RP Stations – installation of Trackers



- Surgery at Near station – installation of silicon detectors

Thank you for attention!