M2 VACUUM FOR DRELL-YAN PROGRAM

BE-EA
20.03.2024

OVERVIEW

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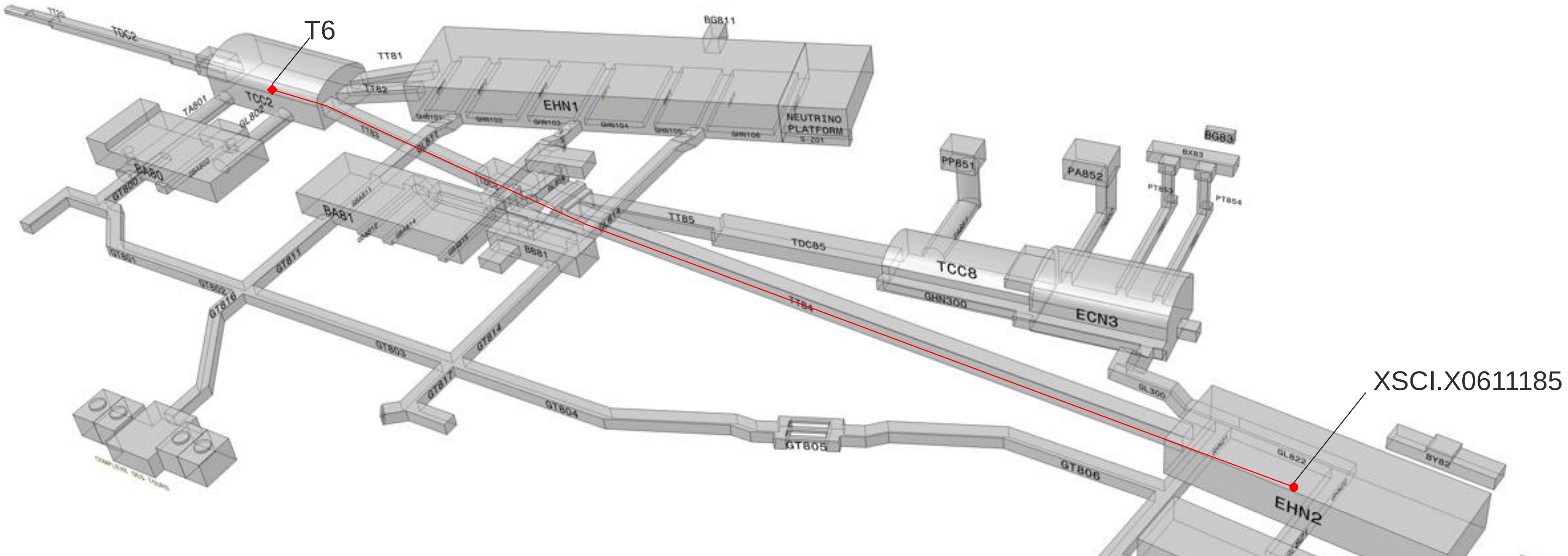
INTRODUCTION

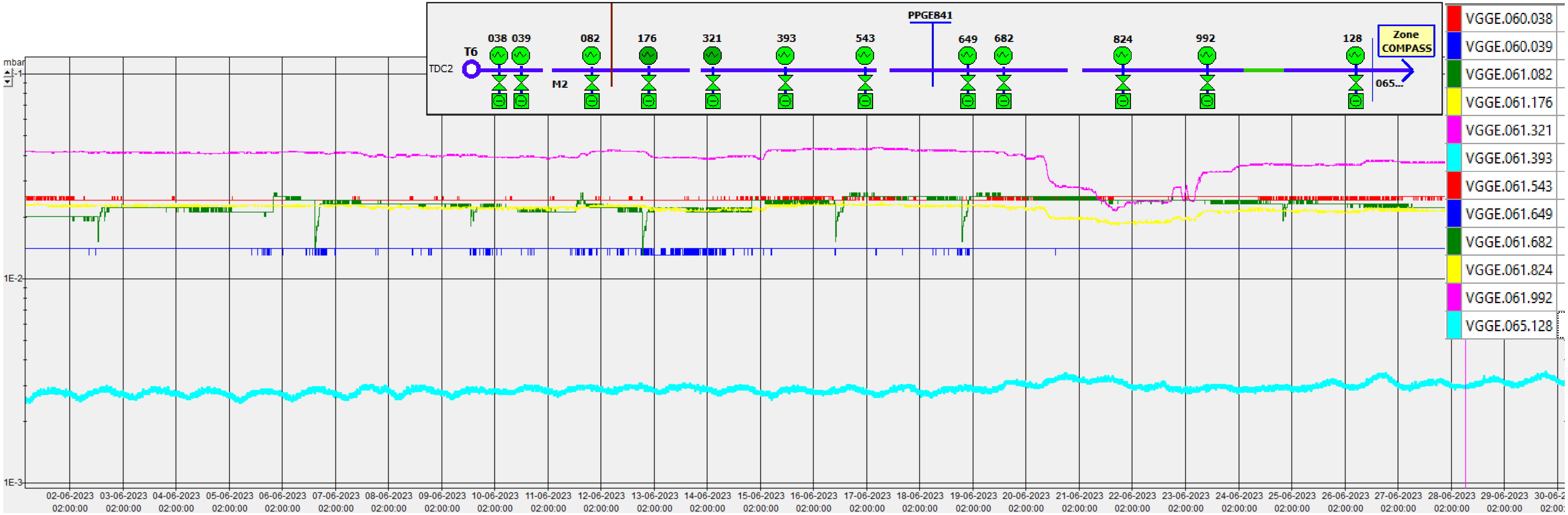
Located in the North Area the M2 beam line transfers the beam from TCC2 T6 target to EHN2 experimental hall
Has a total length of 1185 m from the TCC2 T6 target to the XSCI.X0611185 in EHN2



For the AMBER Future Drell-Yan Program starting after LS3 it is requested to place the full M2 beamline under improved primary vacuum to promote beam quality. Benefiting all M2 experiments after LS3, complete the missing 80 m of vacuum in the beamline is needed including the conversion of several key BIDs and Beam Instrumentation.

M2 VACUUM TODAY PRESSURE

M2 line is all under **primary vacuum ~ 10^-2 mbar.** This vacuum pressure is maintained by 12 pumping groups



Data extracted from Scada (vacuum monitoring and control) history 06.2023
Primary vacuum level from **4.2x10^-2 mbar to 1.4x10^-2mbar** with a small sector under 2.5x10^{-3}mbar at the end of M2
Gauges are installed in the pumping groups and vacuum levels are conservative

M2 VACUUM TODAY HARDWARE

The single beamline in NA almost completely build with non-standard chambers, flanges and collars:

- Different and more difficult (time) maintenance procedure
- Unknown leak rate for joints/collar
(measurements scheduled to 2024)
- Spare parts not standard

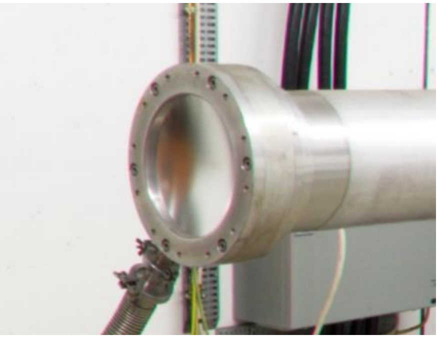
→ No issues reported in the past years

Al chamber and collar (nonstandard)

SS Chamber and collar (NA standard)

The beamline is today divided in 6 vacuum main sectors (but no sector valves) and subdivided in 18 sub-sectors by 44 vacuum widows:

- 20 – AL 0.1mm
- 5 – AL 0.2mm
- 19 – Mylar 0.175 mm

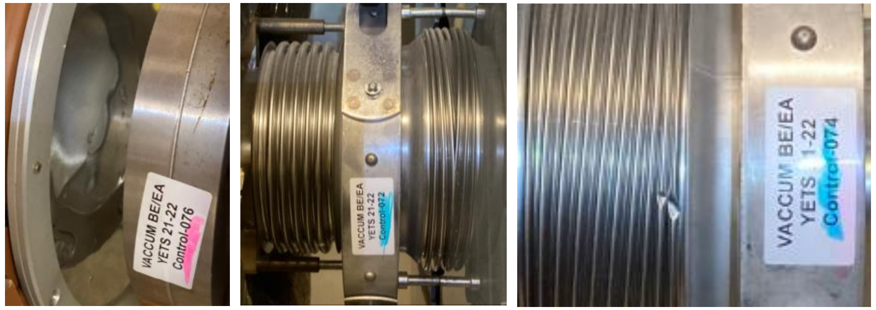


M2 VACUUM TODAY HARDWARE

A major vacuum visual inspection campaign was placed in **YETS 2021-2022** to identify the damaged or degraded vacuum components of all NA beamlines.

For M2: 21 defects identified.
All non-critical → to be corrected until end of LS3

TT83



TT84

Defects mainly in bellows and chambers due to manipulation, mechanical stops of or nearby components (magnet covers). Some corrosion was also found, cause (?) nearby ventilation ducts

- Replacement as a corrective measures in the scope of NACONS

M2 VACUUM TODAY CONSOLIDATION (NACONS)

The consolidation of all vacuum systems of NA downstream the targets is under the scope of NACONS project WP3.3.2.
Motivation :

1. Faults in all beamlines (electrovalves, gauges…). ~ 4 p/year in M2
2. Aged and outdated hardware and software never modernized or renewed
3. Optimized maintenance by extended remote control, monitoring and reliability (ALARA)
4. Increase beamlines efficiency by promoting stable, homogeneous and lower vacuum pressures

The project will see two phases:

- PHASE I – 2021/2028
  1. Replacement of all pumping groups, control hardware and cabling.
  2. Replenishment of the spare stock
  3. Replacement and repair of all damaged/degraded vacuum chambers and bellows (VXSS …)
  4. Configuration management of all vacuum beamlines including 3D and 2D

- PHASE II – 2029/2034
  1. Vacuum sectorization
  2. Replacement and repair of all damaged/degraded vacuum chambers and bellows

M2 Pumping Group

M2 New Pumping Group

M2 VACUUM TODAY SUMMARY

1. Today the achievable vacuum pressure level in M2 is ~**10^-2 mbar** → Longer sectors will degrade this pressure

2. M2 uses nonstandard vacuum collars/flanges from which no specification exists on their vacuum performance → Characterization tests are planned for Q3 2024

3. The beamline is divided in 6 main sectors but subdivided in 18 using 44 windows and deploying 3 pumps p/main sector → Pumping speed is limited

4. 44 vacuum windows = 3 mm of AL and 3.325 mm of My → Optimization can greatly improve beam quality

5. A consolidation program (NACONS) is in place to refurbish the M2 beamline improving its safety, reliability and availability → No layout modifications or vacuum upgrades are in scope

VACUUM FOR DRELL-YAN PROGRAM REQUIREMENTS

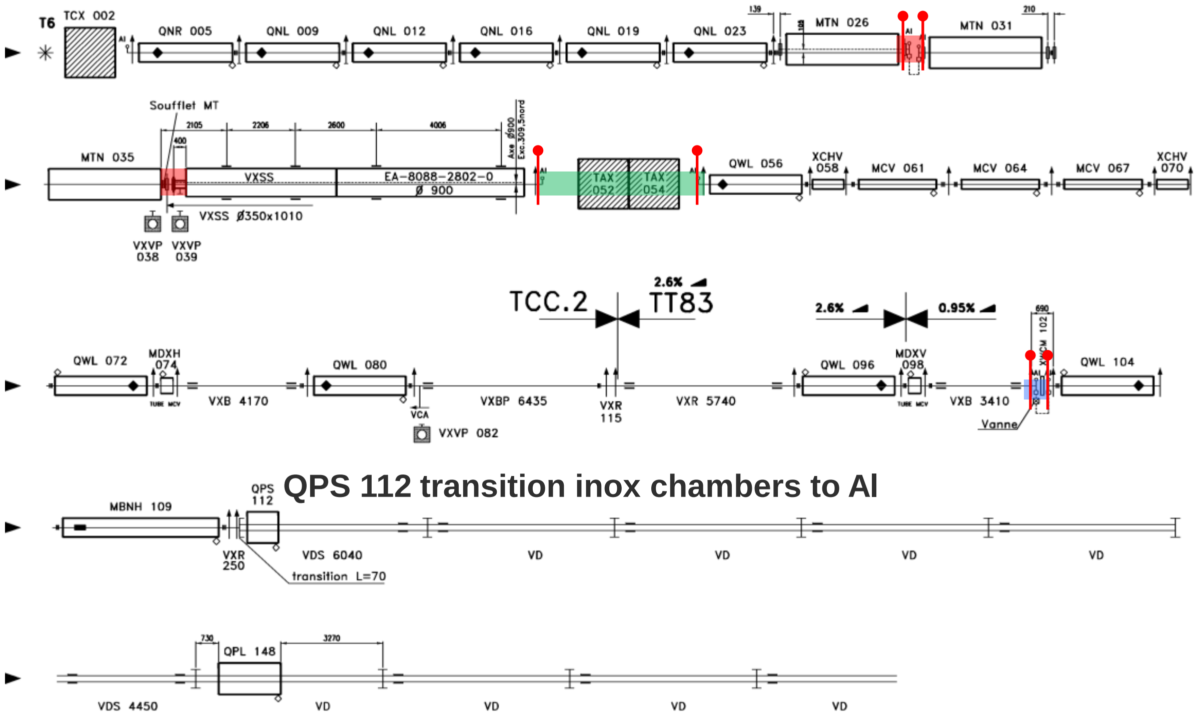
The complete M2 beamline should be under primary vacuum (**10^{-3}mbar**) for the 1st operation run after LS3.

EDMS 2868386 "Shielding Improvement for the High Intensity Hadron Operation of M2"

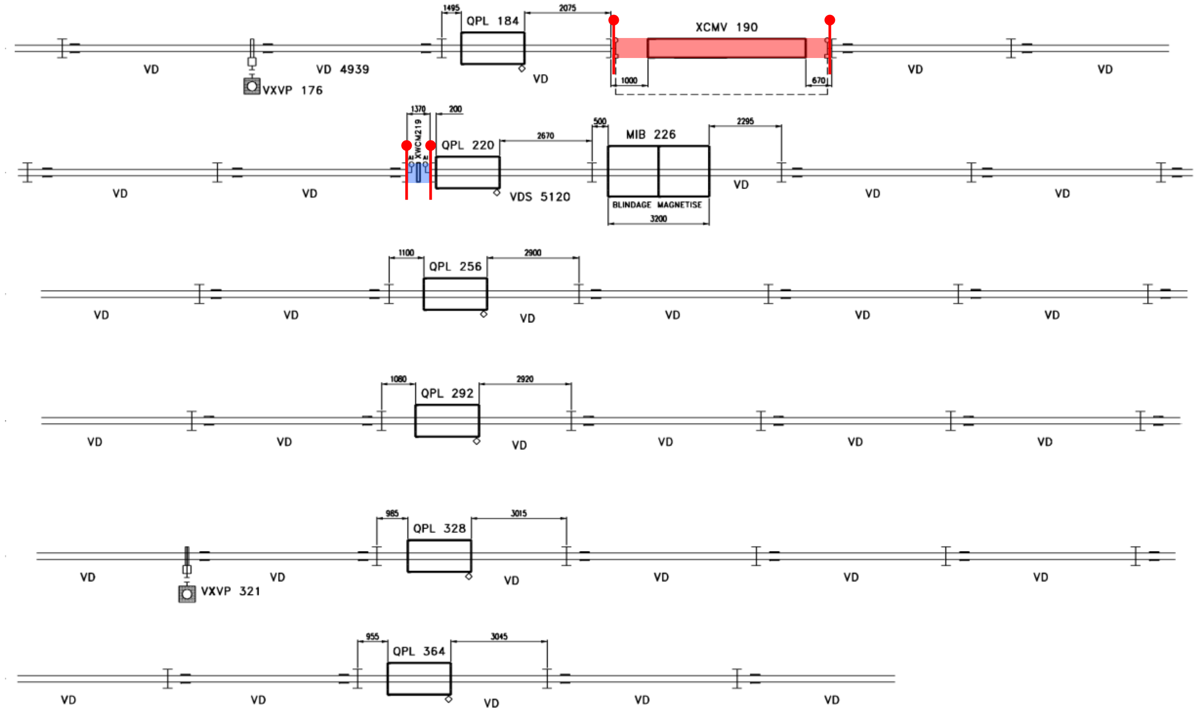
- The performance of the hadron beam delivered to EHN2 is limited due to multiple scattering along the beam line due to interrupted vacuum pipes where it is traversing air.
- It is necessary to maximize the number of beam particles by installing vacuum pipes along the M2 line.

VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW

M2 – 1st Part



M2 – 2nd Part



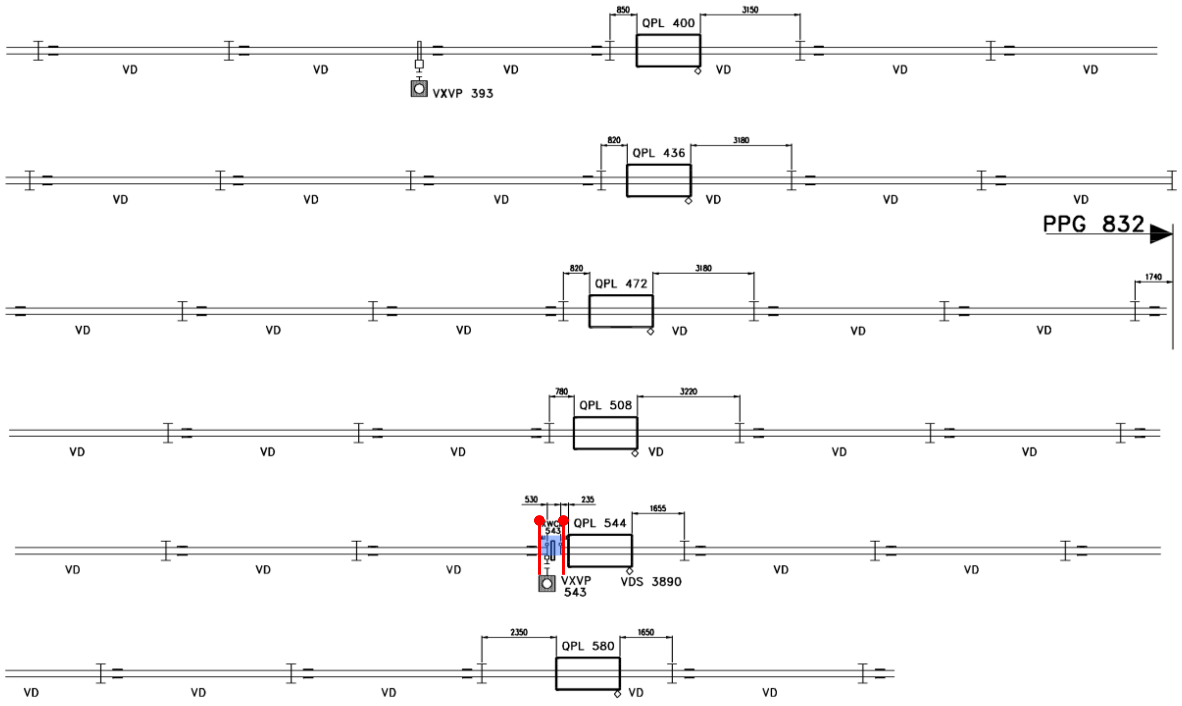
Windows

- New vacuum chambers needed
- Beam instrumentation (XWCM) to be under vacuum
- No vacuum feasible
- Pressurized equipment (CEDAR)

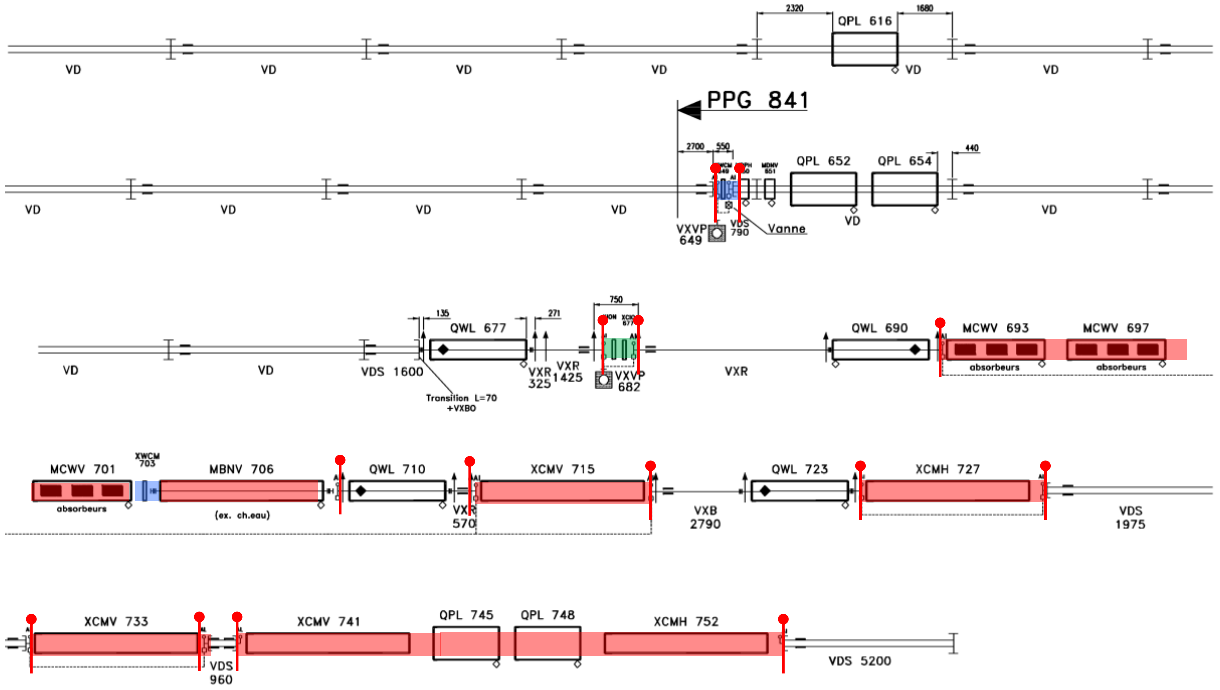
courtesy G. Romagnoli

VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW

M2 – 3rd Part



M2 – 4th Part



Windows

New vacuum chambers needed

Beam instrumentation (XWCM) to be under vacuum

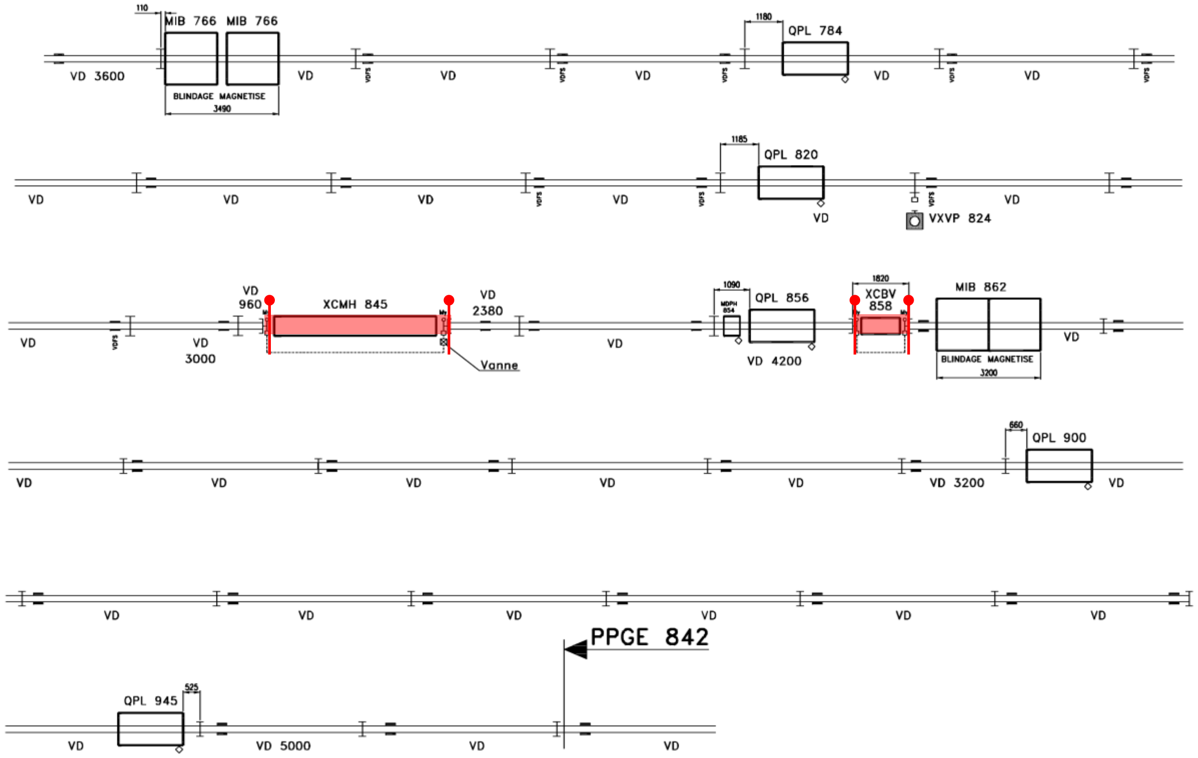
No vacuum feasible

Pressurized equipment (CEDAR)

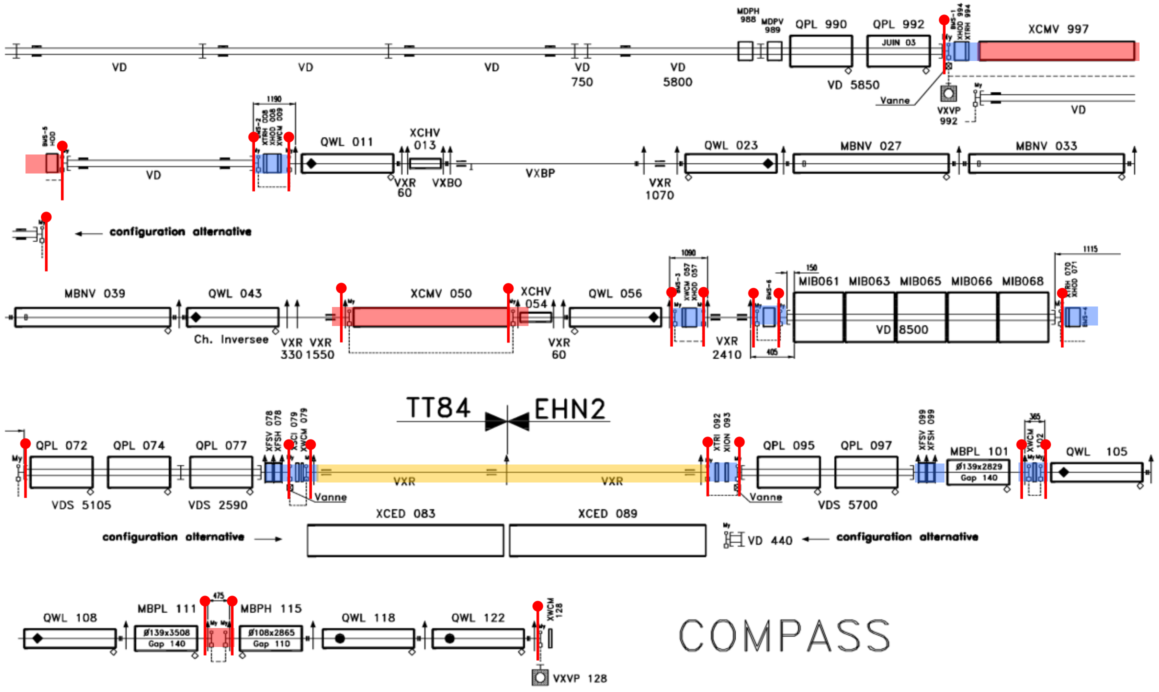
courtesy G. Romagnoli

VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW

M2 – 5th Part



M2 – 6th Part



Windows

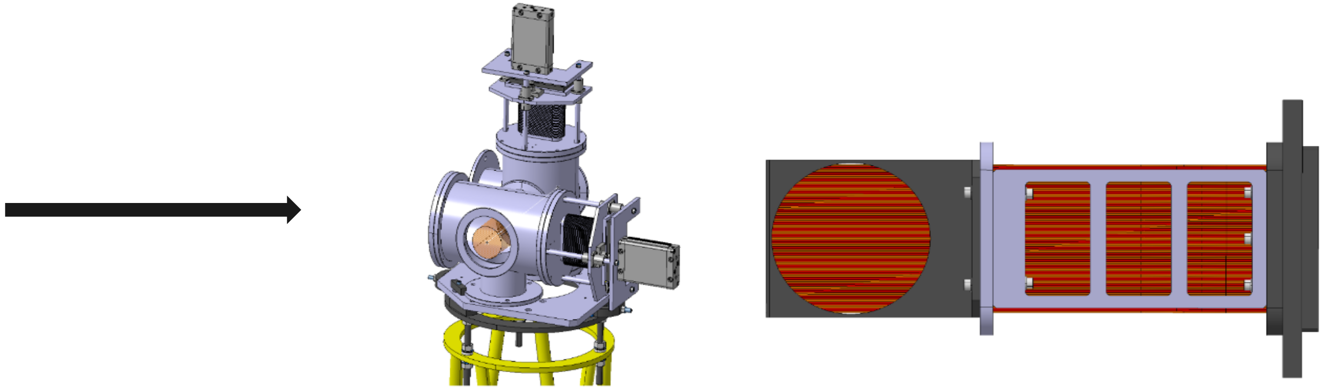
- New vacuum chambers needed
- Beam instrumentation (XWCM) to be under vacuum
- No vacuum feasible
- Pressurized equipment (CEDAR)

courtesy G. Romagnoli

VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW

QPL and MBNV - Magnets
3 to be placed under vacuum
To be equipped with new vacuum chambers

XWCM – Analog Wire Chamber - 9 to be placed under vacuum
XCI – Scintillator – 1 to be placed under vacuum
FISC – Profile Monitor – 2 to be placed under vacuum
Initial studies for the program did not included instrumentation in vacuum → Improvement
To be replaced by new XBPF under vacuum in the scope of NACONS



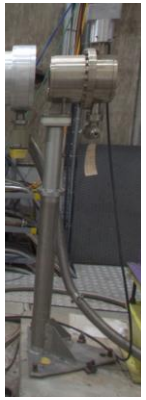
VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW

XCBV – Big 2block vertical Collimator
1 to be placed under vacuum
A full conversion is not possible
Instead, to be replaced by a standard XCSV (2-block collimator) under vacuum

XCM – Magnetic Collimator
9 to be placed in vacuum
A full conversion is under study
Initial proposal will be to equip the XCM with a vacuum chamber (ad hoc/ nonstandard Ø):

- Collimator jaws will be blocked in one aperture/position!
- Apertures are defined in EDMS2798464
- **NOTE:** The vacuum chambers must be removed if different apertures in collimator needed! Only possible during a LS or YETS. If required to be removed in TS the collimator must be equipped with rails in X → **Keeping flexibility for physics**

VACUUM FOR DRELL-YAN PROGRAM PROJECT OVERVIEW




XION- Ionization Chamber - 1 to be placed under vacuum
XTRI/XTRH – Scintillator
Feasibility to be confirmed

XHOD - Hodoscope - 5 to be placed under vacuum
Collaboration between BE and AMBER to determine feasibility

XABS – Absorbers Beryllium
3 to be placed under vacuum
10m section
Feasibility to be confirmed


AL Chamber and collar (nonstandard)

Vacuum pressure – 10^{-3}mbar
New vacuum flanges enough?
To be confirmed in Q3 2024


SS Chamber and collar (NA standard)

VACUUM FOR DRELL-YAN PROGRAM STRATEGY

2023 to Q3 2024

1. As-built 3D for M2 beamline
2. Detailed 3D of XCM, XABS and XCBV
3. M2 Vacuum after LS3 user requirements approval

Q3 2024 to end 2024

1. Feasibility study
2. ECR / consolidation requests
3. SPSC review

Q1 2025 - Project approval (to meet LS3 window)

Budget / Resources request

2025/2026

1. Detailed design
2. Procurement

LS3

1. Installation

PROVISORY PLANNING

Thank you very much for your attention!

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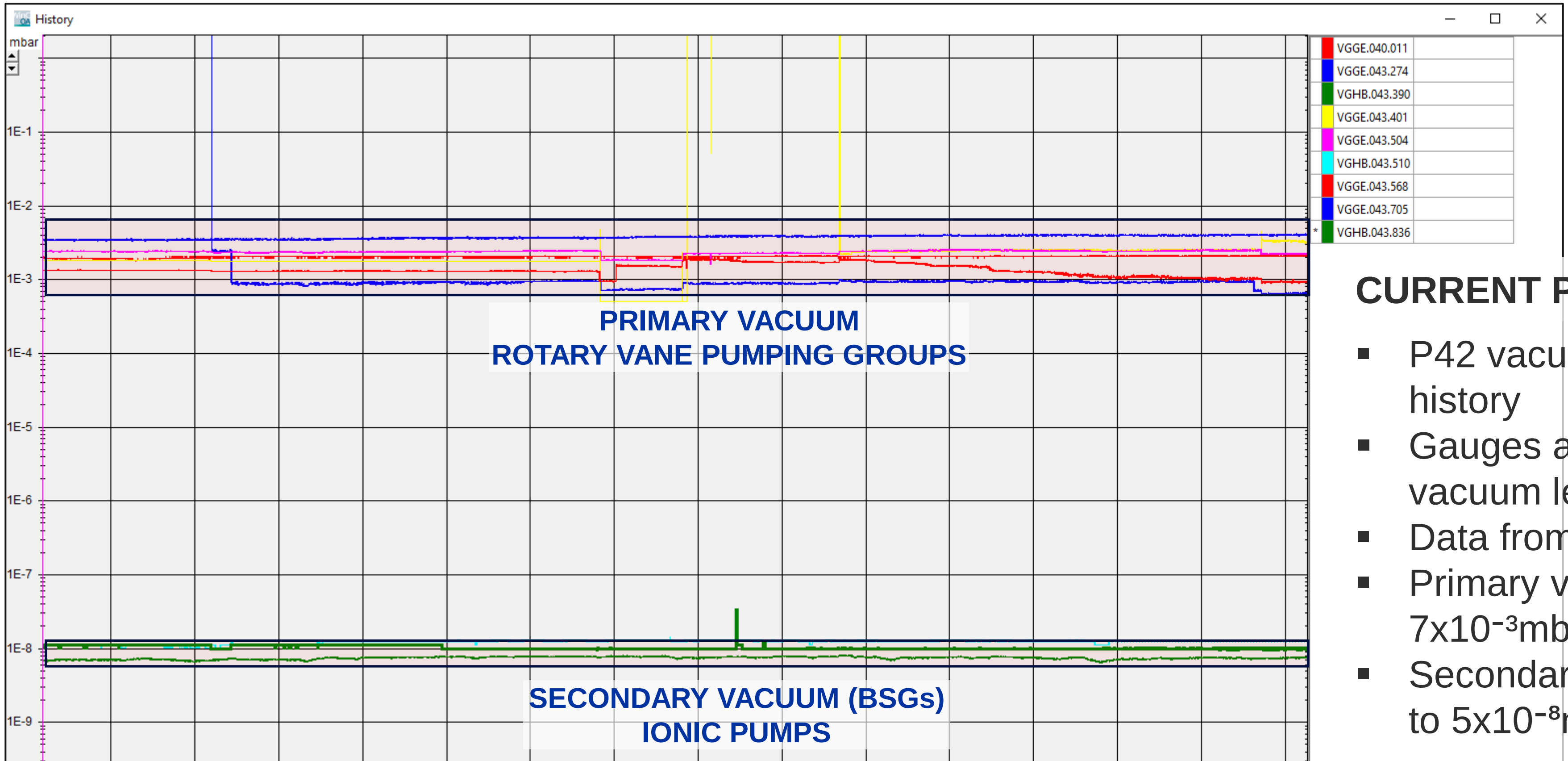
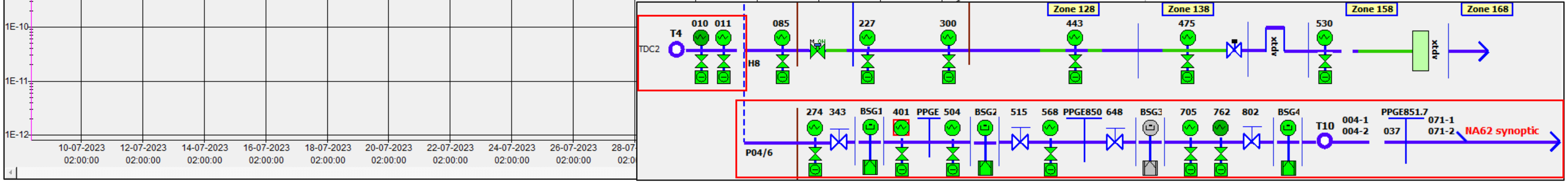
EXRA SLIDE VACUUM LEVELS IN P42



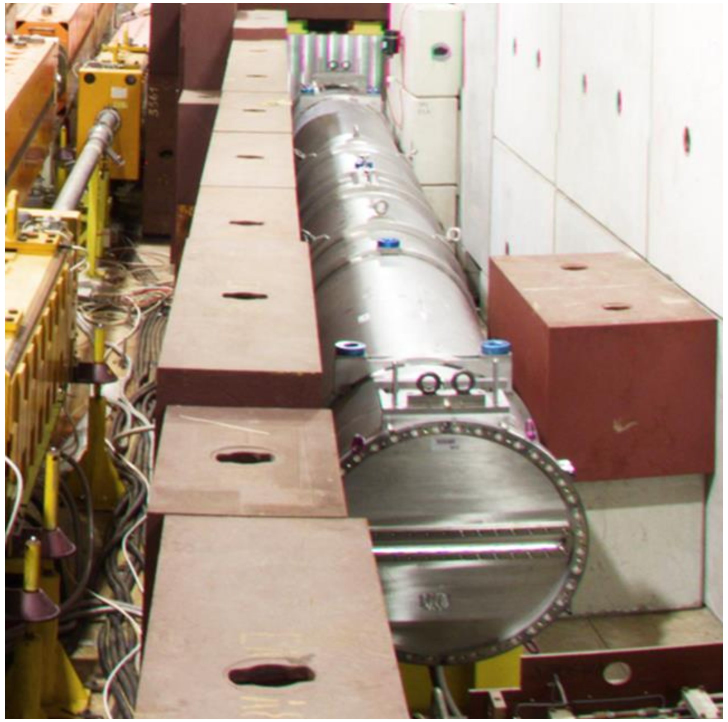
CURRENT P42 VACUUM STATUS:

- P42 vacuum level from gauges Scada history
- Gauges are in the Pumping groups and vacuum levels are conservative
- Data from 09.07.2023 to 07.08.2023
- Primary vacuum level from $3x10^{-2}$mbar to $7x10^{-3}$mbar
- Secondary vacuum level from $1x10^{-7}$mbar to $5x10^{-8}$mbar



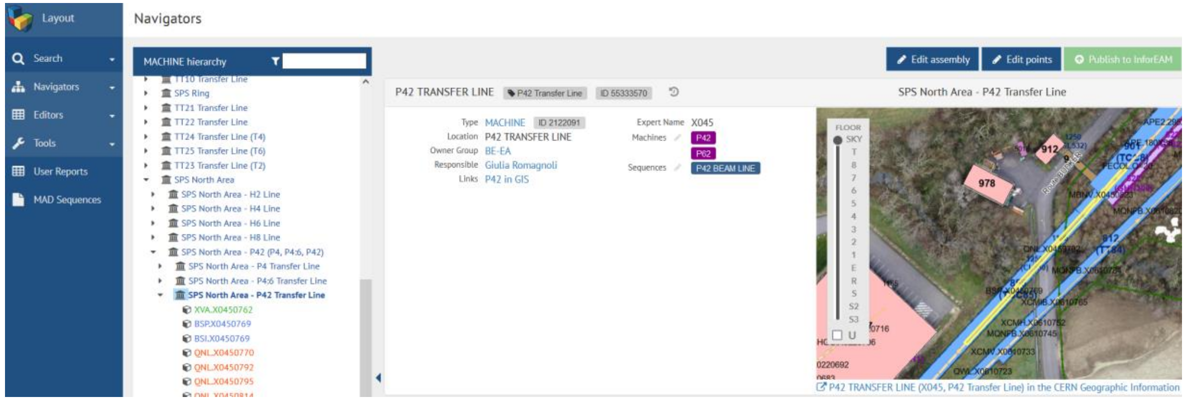
EXTRA SLIDE CONSOLIDATION (NACONS)

2022/2023 - A new remote compatible T6 VXSS chamber was installed in TCC2 after major failure in 2021.



2023/2024 - A consequent and important work for future configurations and studies (including M2) is being developed:

- Quality of the beamlines
    - As-built models detailing
    - Documentation
    - Simulation
- Configuration in LAYOUT database
- Configuration of vacuum assets
- Complete vacuum beamline 3D models + 2D



EXRA SLIDE PROJECT OVERVIEW SUMMARY

Elements	Locations	Total Length	Comments
3 empty spaces between magnets	0026, 0035, 1111	1.5 m	026, 035 in TCC2 to be discussed with RP if possible… (?) 1111 Yes, with vacuum chambers
9 XCM magnetic collimators	0190, 0715, 0727, 0733, 0741, 0752, 0845, 0997, 1050	41.5 m	Yes, fixed jaws with vacuum chambers inserted
1 XCBV big collimator	0858	1.5 m	Yes, for vacuum operations it can be replaced with normal 2-blocks collimator
2 QPL magnets	0745, 0748	7 m	Yes, with vacuum chambers
1 MBNV magnet	0706	6 m	Yes, with vacuum chamber
8 XWCM	102, 219, 543, 649, 703, 1009, 1057, 1079, 1102	4.5 m	Yes, substituted by XBPF (some already foreseen inside NACONS project)
3 XABS	693, 697, 701	12.5 m	Yes, with absorber movement in vacuum (?)
Experimental equipment (XHOD, XTRH)	1070, 1071, 1092	3 m	Under study new design under vacuum (?)
TOTAL	**33 locations**	**77.5 m**	

courtesy G. Romagnoli

EXRA SLIDE CONSTRAINTS

1. Clear vacuum user requirements for M2 beamline after LS3 are needed specifying:

   - Vacuum pressure: is the current pressure ~ 10^{2-}mbar suitable?
   - Possible configuration changes and their frequency
   - Material budget
   - Apertures

2. Nonstandard chambers/flanges efficiency (leak rate, maintainability…) → Answer Q3 2024
3. New pumping groups needed? Full beamline simulation required → Answer Q3 2024
4. Sectorization (gate valves) of the beamline needed? → Beamline configurations dependent
5. Feasibility of XTRI/XTRH/XHOD, XION and XABS under vacuum (~20 m)
6. RP analysis for missing vacuum chambers in TCC2 → Feasibility and WDP