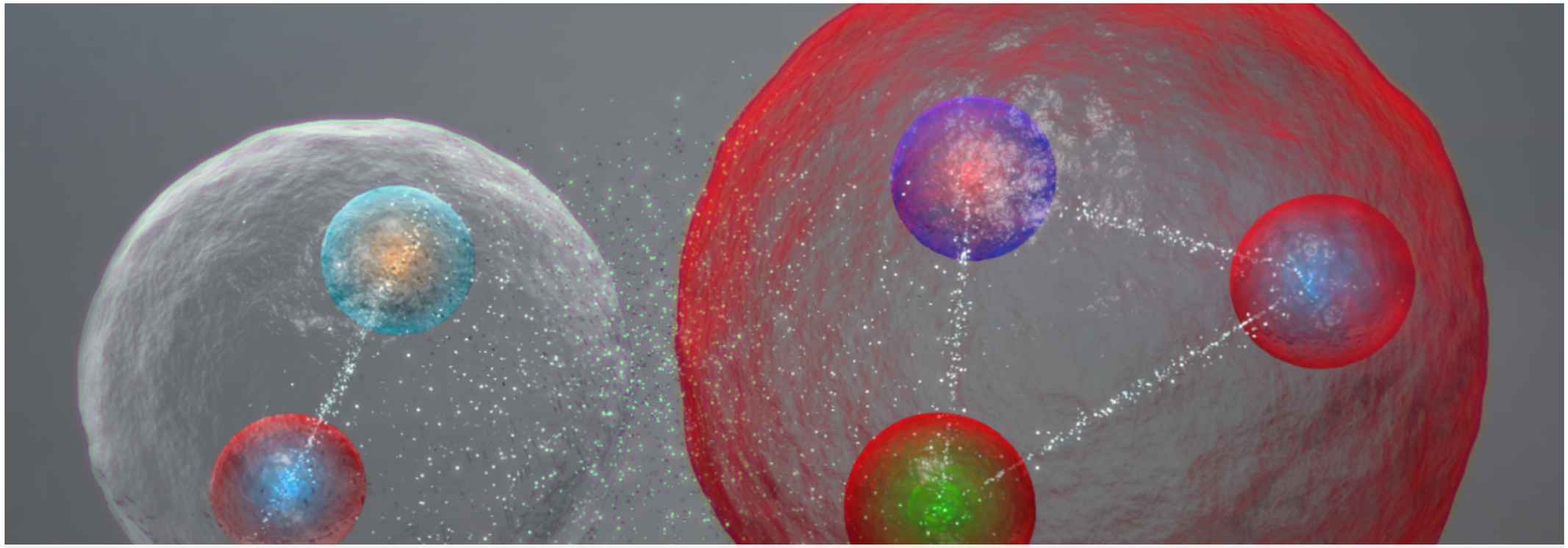
paolo.gandini@cern.ch



LHCb & ALADDIN group report

Paolo Gandini
On behalf of the LHCb Milano group

10th July 2025

INFN MILANO
Istituto Nazionale di Fisica Nucleare
Sezione di Milano

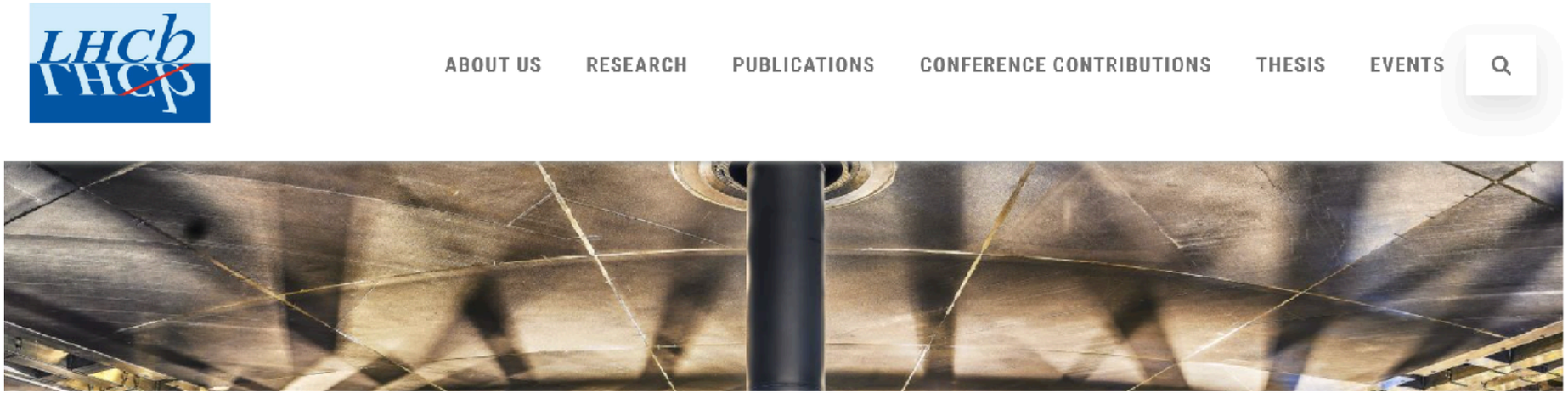
Outline

- The group is active on many fronts → little time to cover all activities so I will be brief
- Many synergic projects related to LHCb (covered in separate contributions)
- Shopping list:
  - Group composition and news
  - LHCb
  - ALADDIN
  - Requests and Miscellanea

Resources

- https://web.infn.it/lhcb_milano/
- https://twocryst.web.cern.ch/
- https://aladdin.web.cern.ch/

} Collaboration sites maintained by us



News from the group

- **Notes**
  - SELDOM (ERC UE) ended early 2025. PRIN(UNIMI+INFN) extended to Feb 2026 (covers TWOCRYST activities)
  - SELDOM_TWOCRYST closed → sigla ALADDIN will replace it
  - FERRAD&IGNITE synergistic to LHCb (covered in a separate talk)

- **Members of the group**

  - Andrea Merli started as RTT in November 2024
  - Jascha Grabowski started as Postdoc in Summer 2025
  - Han Miao will join the group with a “Assegno per stranieri”
  - Federico Zangari (now on a INFN scholarship at CERN) will start as doctoral student at CERN & UNIMI

LHCb Physics

CKM and CP violation ← $\sin2\beta$, γ, ϕ_s, $|V_{ub}/V_{cb}|$, CPV in B^0, B_s^0, D^0, b-baryons, etc

Rare decays → $B_{(s)}^0 \to \mu^+\mu^-$, $b \to s\mu^+\mu^-$, $b \to se^+e^-$, $\Sigma^+ \to p\mu^+\mu^-$, etc

Spectroscopy ← Tetraquarks, Pentaquarks, Ξ_{cc}^{++}, Ω_c^*, Ξ_b^{-*},...

Electroweak QCD and Exotica ← Z^0, W^+, top, Dark photons, Long-lived particles,..

Ion, Fixed-target ← Heavy ions, p-Gas, nuclear effects, polarization

Very active on those topics

Publications and notable analyses by the group

- **Data Analyses (just a small selection of topics)**
  - Amplitude analysis of the $\Xi^+_c \to pK^-\pi^+$ decay and Ξ^+_c baryon polarization measurement in semileptonic beauty hadron decays, LHCb-PAPER-2024-034, to be submitted to Phys. Rev. D. Timescale: ready to submit
  - Λ^+_c polarization measurement in p-Ne collisions at $\sqrt{s}NN = 68.6$ GeV, in preparation (RC stage)
  - Amplitude analysis of the $\Xi^0_c \to \Lambda(\to p\pi^-)K^-\pi^+$. Work ongoing
  - Electromagnetic dipole moments measurement of Λ baryons. Analysis note is in preparation and aim to WG review by the end of this year.
  - Measurement of Ξ^0_c production and Charm fragmentation fraction in p-Ne SMOG data. Status: preliminary results of the cross-section and fragmentation fractions are measured. Analysis note is in preparation.
  - Spectroscopy of excited Bs states

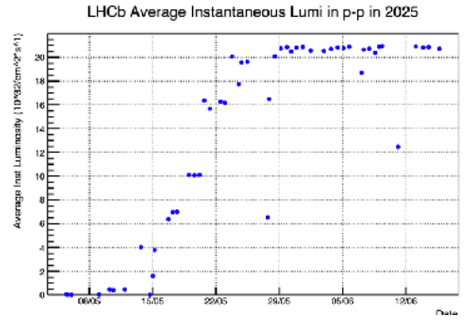
- **Conferences**
  - Too many to list individually (Moriond, LHCP2025, EPS, others) both on LHCb and ALADDIN

- **Thesis**
  - Federico Zangari (Master Thesis): The pixel detector of the TWOCRYST experiment at the LHC
  - Giorgia Tonani (PhD Thesis): Measurement of the magnetic and electric dipole moments of the Λ baryon at LHCb
  - Sara Cesare (PhD Thesis): Proof-of-principle test for an experiment for short-lived particle dipole moments at LHC

LHCb performance

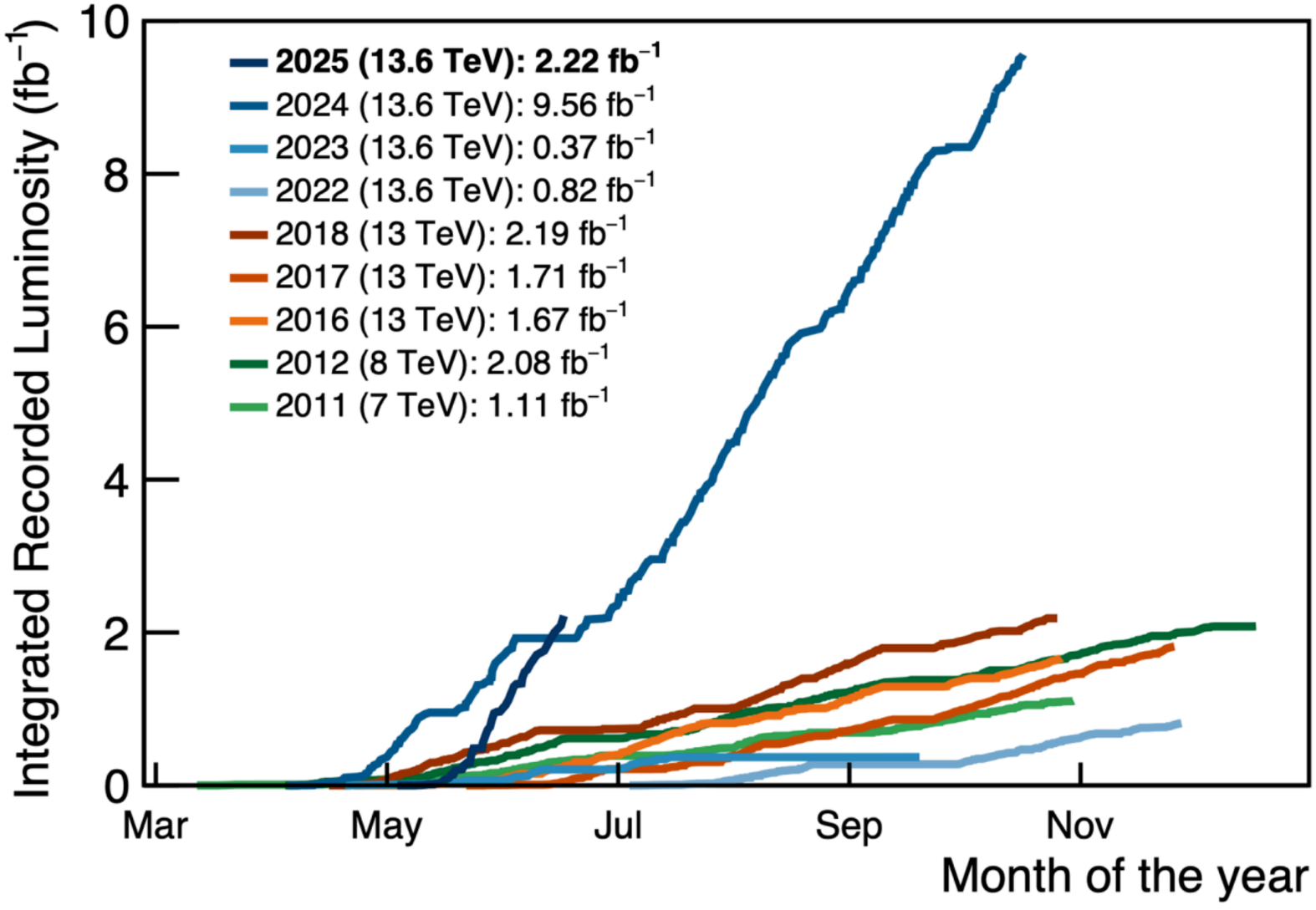
Slide taken from last LHCb week, as 20th June 2025

Running at record instantaneous luminosity!



2025 run status

- We already have more than 2 fb^{-1} of integrated luminosity in 2025 on tape!
- At this pace, we should surpass the 2024 curve some time over the Summer, and the run this year is longer
- We are well on target
- Excellent work by our run coordination team and all people involved!



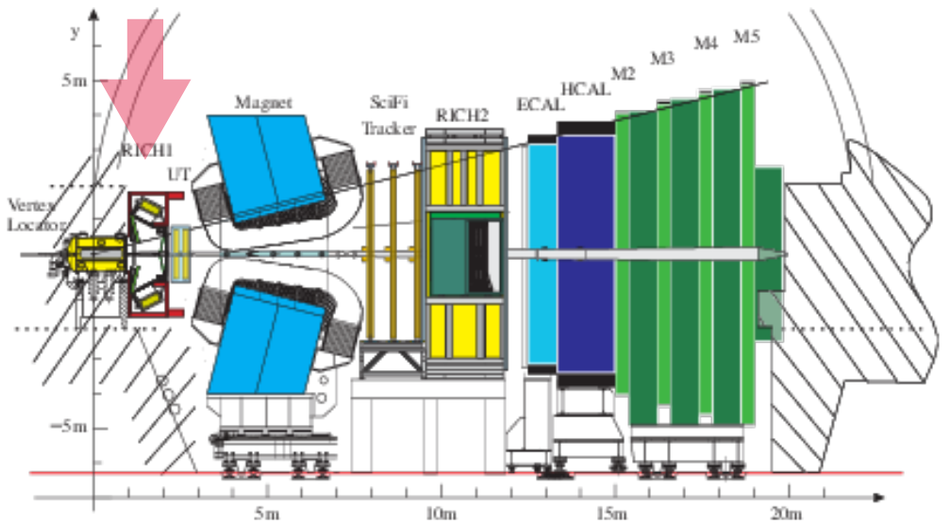
Upstream Tracker

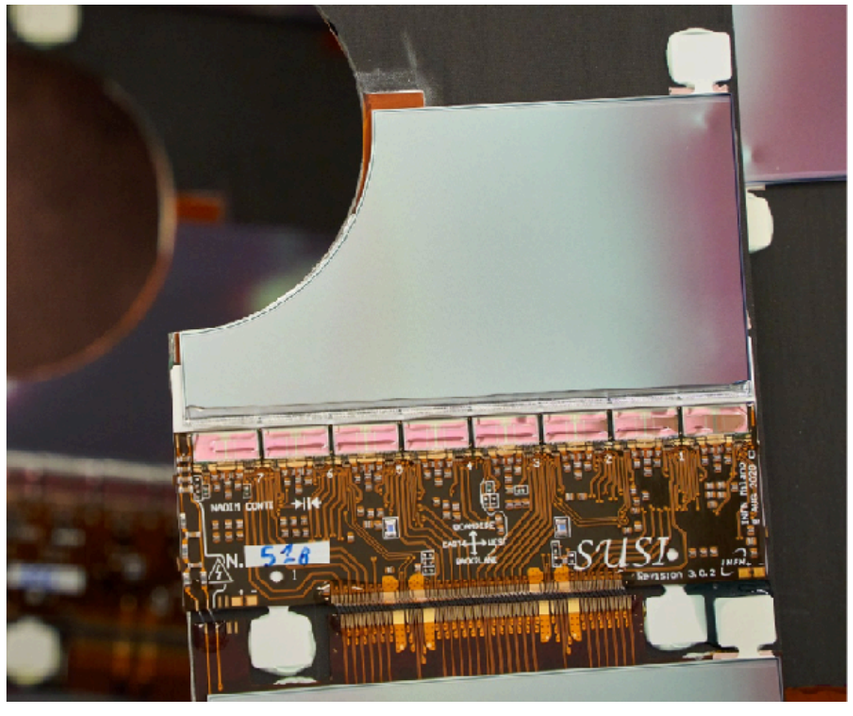
A reminder of what that is:

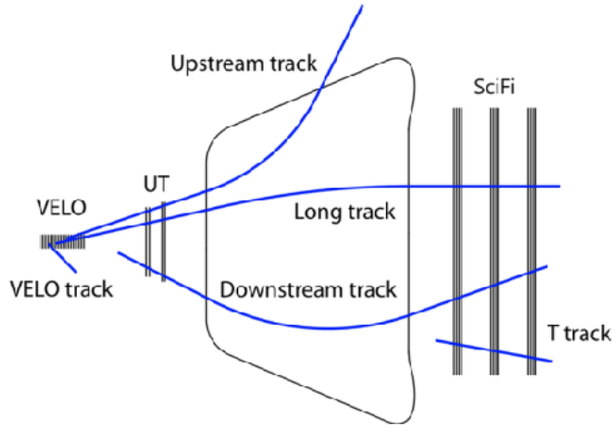
4 planes of silicon detectors with improved radiation hardness, finer readout granularity, and improved acceptance coverage at small polar angles

- Now running with really excellent performance
- In 2024 some hiccup due to sub-optimal firmware
- **In 2025, UT running at design performance!**
- **Performance paper + hardware papers in preparation**

- As for now, all work delivered by Milan is showing reliable operation, even at design performance.
- UT is crucial for the whole LHCb collaboration → effort recognized by LHCb management
- **Milan is providing performance studies on downstream tracks (tracks without the VELO part) to estimate the impact of UT**





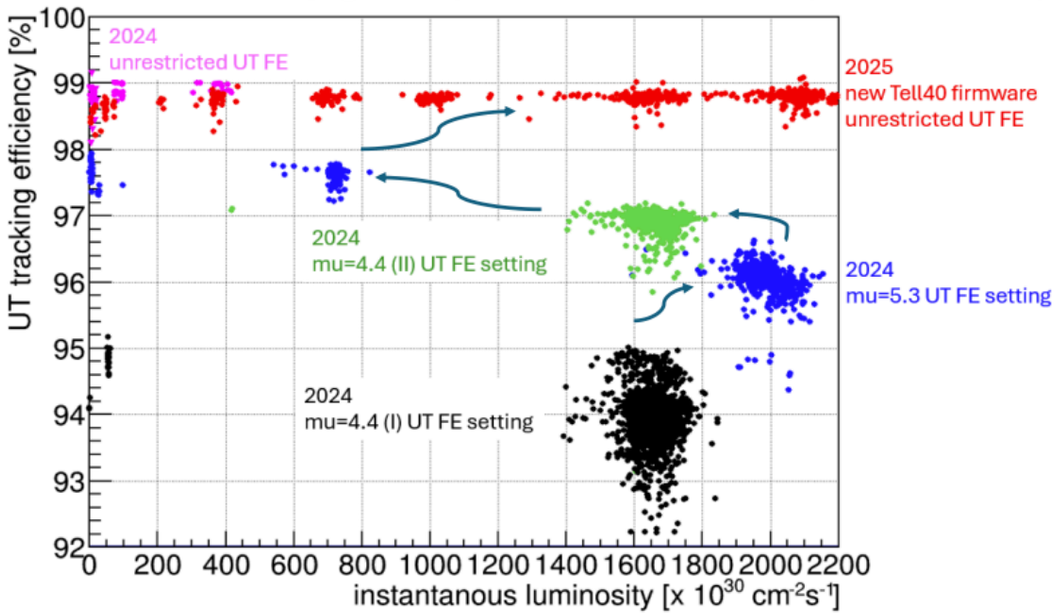


Upstream Tracker

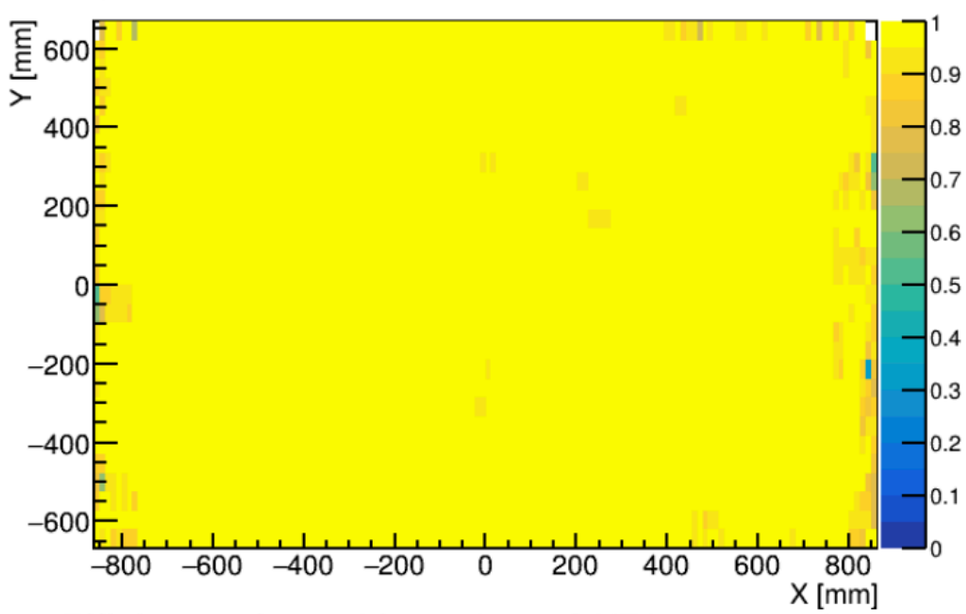
Slide taken from ongoing EPS2026 conference

Evolution of FE-settings and their impact on UT performance during Run 3:

- The initial problem was the limited bandwidth of some readout boards.
- The hit rate from some ASICs was much higher than expected.
- The large hit rate asymmetry observed from some ASICs within the same readout board led to data truncation due to the protection mechanisms of the firmware.
- **2024 Mitigation strategy** – options to restrict hit rate:
  - increase ADC thresholds → removes smaller signals, high impact on signal efficiency, only as needed;
  - impose a hit limit for each ASIC → remove high ASIC-occupancy events, less harmful to physics;
  - settings were optimised iteratively for different pile-up (mu = 4.4, 5.3).
- **2025 Solution** – firmware improvement (optimisations of Finite State Machines) + decrease of sensor noise by lowering the temperature in the box. Implemented in early 2025.
- **96.3%** channels active.
- **Overall, very good performance**: Eff(>=3 UT hits)/track improved from ~93.5% in 2024 to ~**98.7%** in 2025.



UT tracking efficiency vs run instantaneous luminosity for different years of data taking and pile-up.

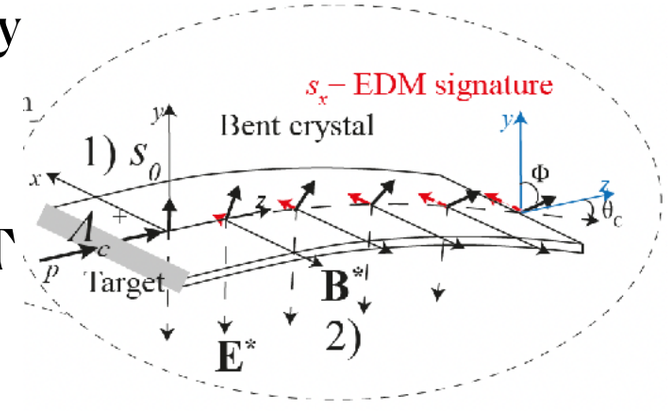


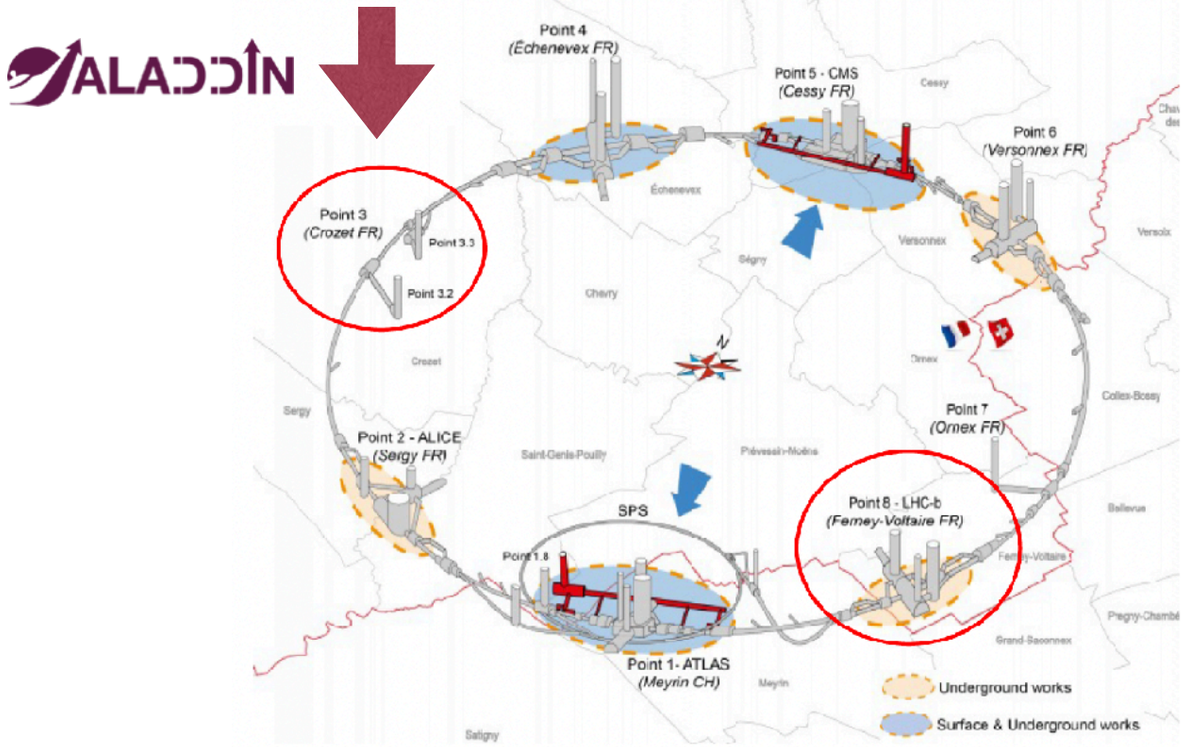
Efficiency of matching at least 2 UT layers to a long track as a function of track intersection with UT 4th layer.

TWOCRYST & ALADDIN

- Milano → EDM/MDM from spin precession of channeled baryons in bent crystals
- ALADDIN will provide the first direct measurement of MDM/EDM of charmed baryons
- First access to MDM/EDM of charm quark
- Triggered an international collaboration with several groups towards a proposal for a new experiment
- Idea is to use the spin precession, now physics program has expanded considerably

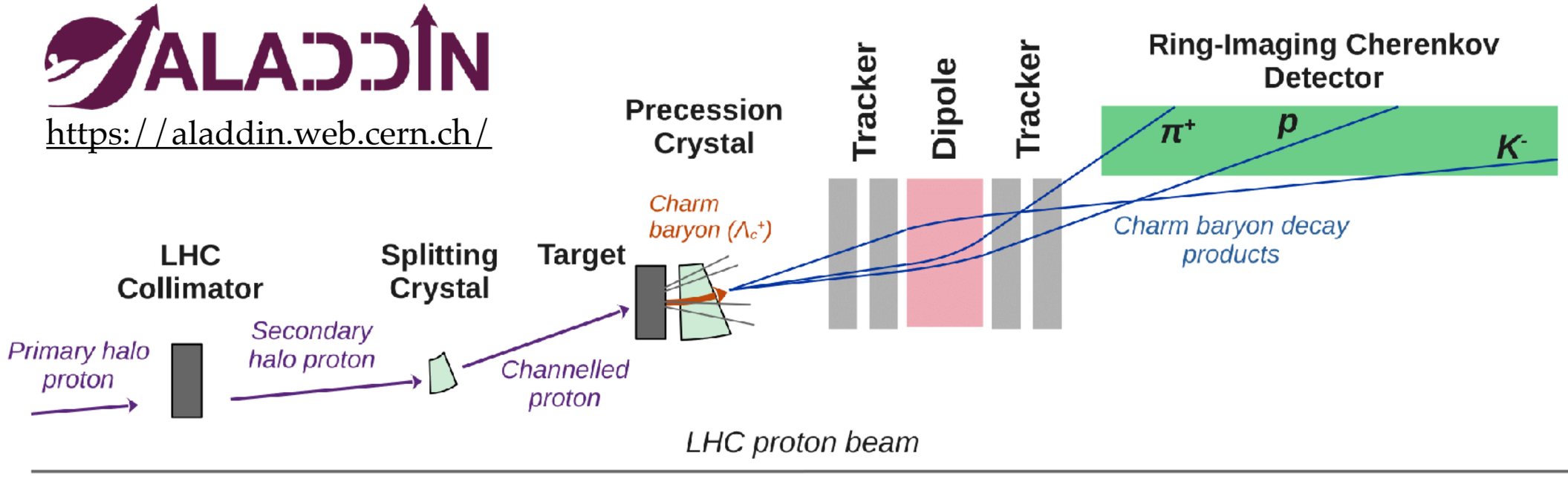
- **New experiment at LHC IR3 region**
- **A proof of principle experiment has been scheduled for 2025: TWOCRYST**





The ALADDIN experiment

https://aladdin.web.cern.ch/



The ALADDIN detector is designed to reconstruct the decay products of charm baryons with high precision and to extract spin-related observables from their angular distributions. It consists of two main subsystems:

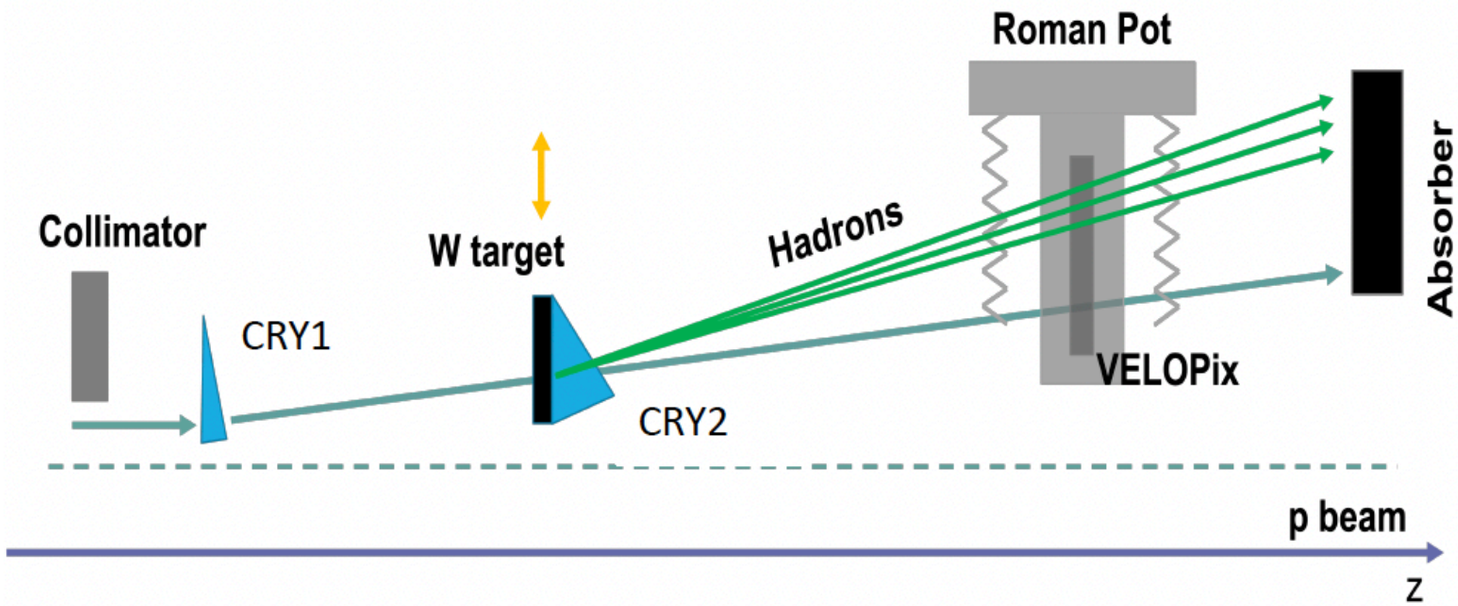
- A **magnetic spectrometer**, composed of multiple **tracking stations placed upstream and downstream of a dipole magnet**, provides precise momentum reconstruction of charged particles emerging from charm baryon decays. The tracking technology is based on **silicon pixel detectors** derived from the **VELOpix** system developed for LHCb, and later implemented in the TWOCRYST experiment. The detector modules are housed in **movable Roman Pots**, allowing 2D detectors to be inserted into the LHC vacuum in close proximity to the circulating beam.
- A **Ring-Imaging Cherenkov (RICH) detector** provides **charged hadron identification**, enabling the experiment to distinguish between pions, kaons, and protons across a broad momentum range. This capability is essential for the exclusive reconstruction of key decay channels, such as $\Lambda c+ \rightarrow p\ K-\ \pi+$. The charged particles enter the **gaseous radiator medium** (Neon or Nitrogen) through a thin **exit window integrated into the top of the LHC beam pipe**.

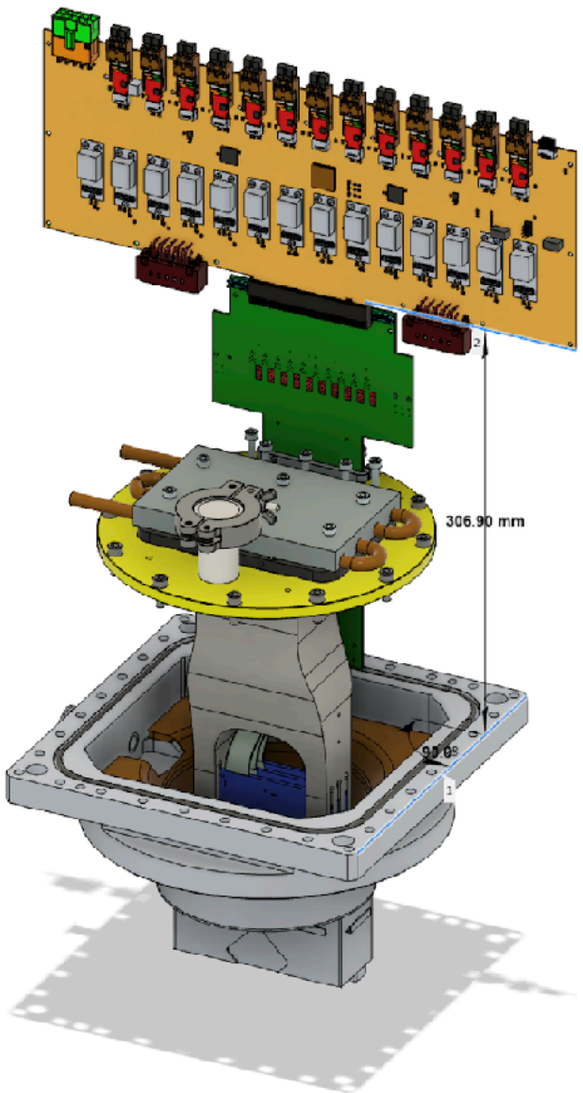
TWOCRYST: MD in 2025

https://twocryst.web.cern.ch/

- Goals of the test
  - Demonstrate the operational feasibility of the double crystal and tracking detector setup
  - Confirm the estimated achievable rates of proton on target
  - Measure channeling efficiency of long crystals at TeV energies
  - Background studies

- Experimental set-up
  - Short crystal for beam-halo deflection
  - W target
  - Long crystal for Λ^*_c channeling
  - Two tracking station in a Roman Pot



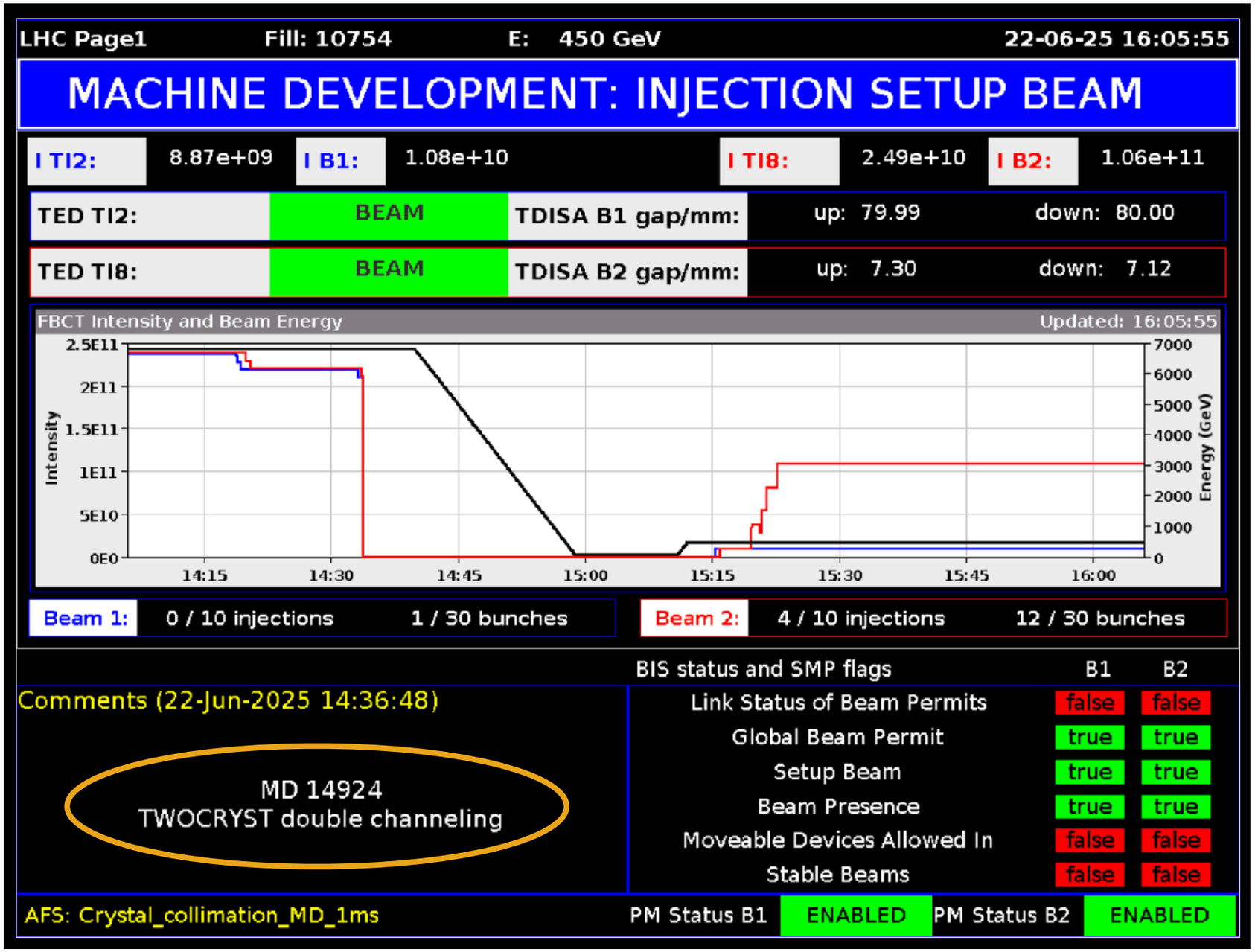


TWOCRYST: MD in 2025

- 21st and 22nd June we had our first MD at LHC dedicated to TWOCRYST
- A second one is scheduled in September/October

TWOCRYST

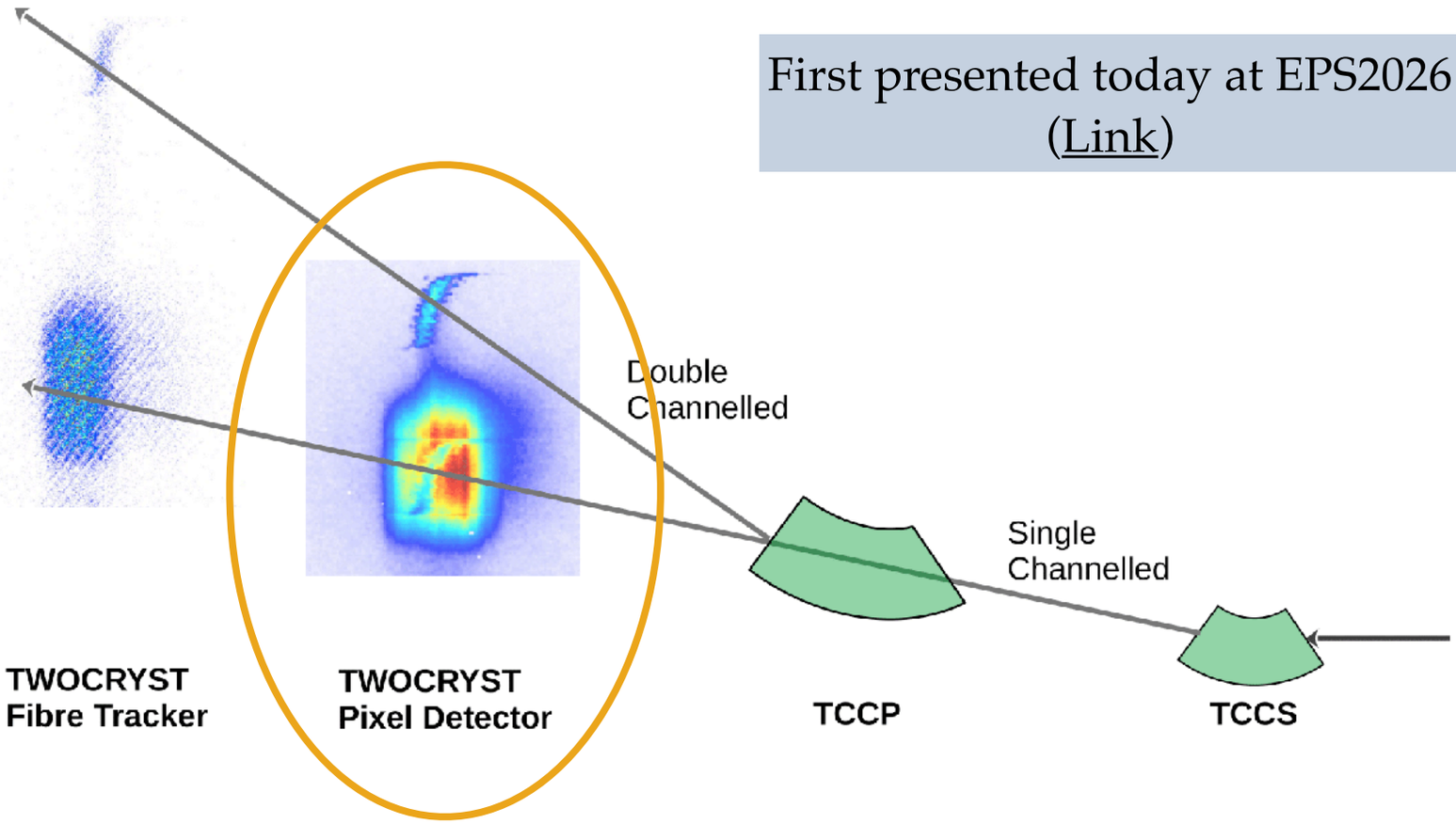
https://twocryst.web.cern.ch/



TWOCRYST: MD in 2025

https://twocryst.web.cern.ch/

- First two MD sessions for the TWOCRYST project were a success
- First-ever observation of double crystal channelling in the LHC
- Successful observation of channelling through the TCCP
- Inserted the tungsten target
- Confirm the alignment feasibility of the setup
- Now data analysis has started → Milano is the driving force



First presented today at EPS2026 (Link)

TWOCRYST: MD in 2025

https://twocryst.web.cern.ch/

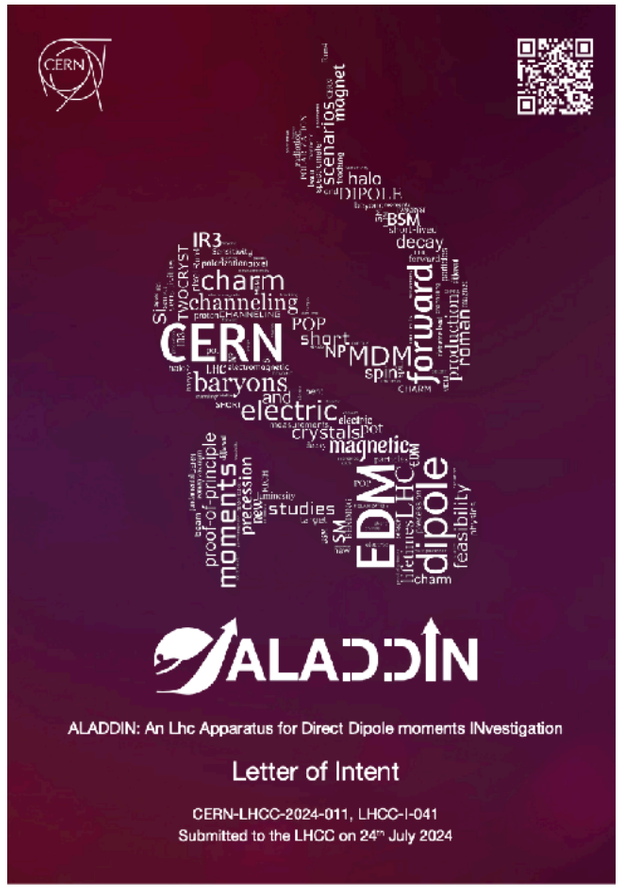
The TWOCRYST crew in the CCC

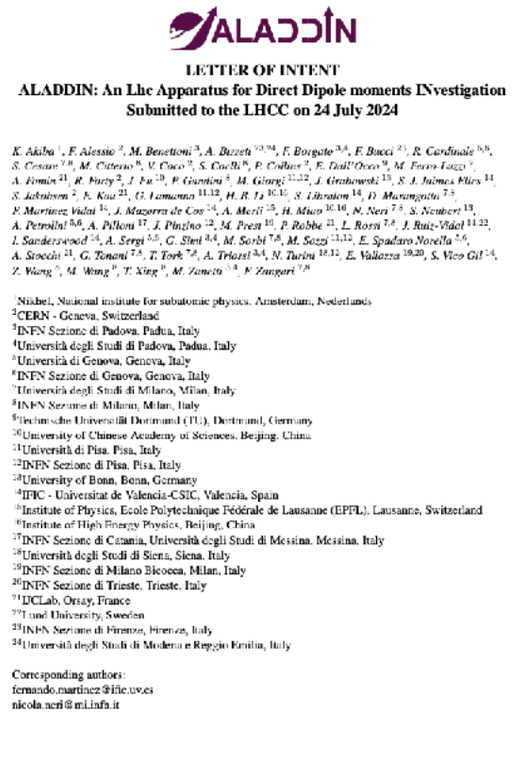
Bottle in the CCC for machinists!

The ALADDIN collaboration

- Several Milestones achieved, progressing at really fast pace!
- Here only a really brief summary
- ALADDIN collaboration established: https://aladdin.web.cern.ch/
- Letter of Intent submitted in Autumn 2024 → well received by LHCC → green light for writing Technical Proposal
- Process to be inserted in the CERN graybook started
- Sigla Nazionale ALADDIN will replace “SELDOM_TWOCRYST”
- Constitution of the experiment written and ratified by the experiment Collaboration Board
- We received the first expressions of interest from other (non-founding) groups to join the effort
- Election of CB-chair+Spokesperson+Physics Coordinator → **Nicola Neri elected as Spokesperson**

https://cds.cern.ch/record/2905467





ALADDIN

LETTER OF INTENT

ALADDIN: An Lhc Apparatus for Direct Dipole moments INvestigation

Submitted to the LHCC on 24 July 2024

K. Akiba [1], F. Alessio [2], M. Benettoni [3], A. Buzzeti [3,4], F. Borgato [3,4], F. Bucci [3], R. Cardinale [5,6], S. Cesare [7,8], M. Citterio [8], V. Coco [2], S. Coelli [8], P. Collins [2], E. Dall'Occo [9], M. Ferro-Luzzi [2], A. Fomin [2], R. Forty [2], J. Fu [10], P. Gandini [3], M. Giorgi [11,12], J. Grabowski [13], S. J. Jaimes Elles [14], S. Jakobsen [2], S. Kos [2], G. Lamanna [11,12], H. R. Li [10,15], S. Libralon [14], D. Marangotto [7,8], F. Martinez Vidal [16], J. Mazorra de Cos [16], A. Merli [15], H. Miao [10,15], N. Neri [7,8], S. Neubert [13], A. Petrolini [5,6], A. Pilloni [17], J. Pinzino [12], M. Prest [18], P. Robbe [2], L. Rossi [7,8], J. Ruiz-Vidal [14,22], I. Sanderswood [16], A. Sergi [5,6], G. Sheil [2,4], M. Sorbi [7,8], M. Sozzi [11,12], E. Spadaro Norella [5,6], A. Stocchi [2], G. Tonani [7,8], T. Tork [7,8], A. Triossi [3,4], N. Turini [18,12], E. Vallazza [19,20], S. Vico Gil [16], Z. Wang [2], M. Wang [9], T. Xing [9], M. Zanetti [3,4], F. Zangari [7,8]

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[4]Università degli Studi di Padova, Padua, Italy
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[14]IFIC - Universitat de Valencia-CSIC, Valencia, Spain
[15]Institute of Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland
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[17]INFN Sezione di Catania, Università degli Studi di Messina, Messina, Italy
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[21]LICLab, Orsay, France
[22]Lund University, Sweden
[23]INFN Sezione di Firenze, Firenze, Italy
[24]Università degli Studi di Modena e Reggio Emilia, Italy

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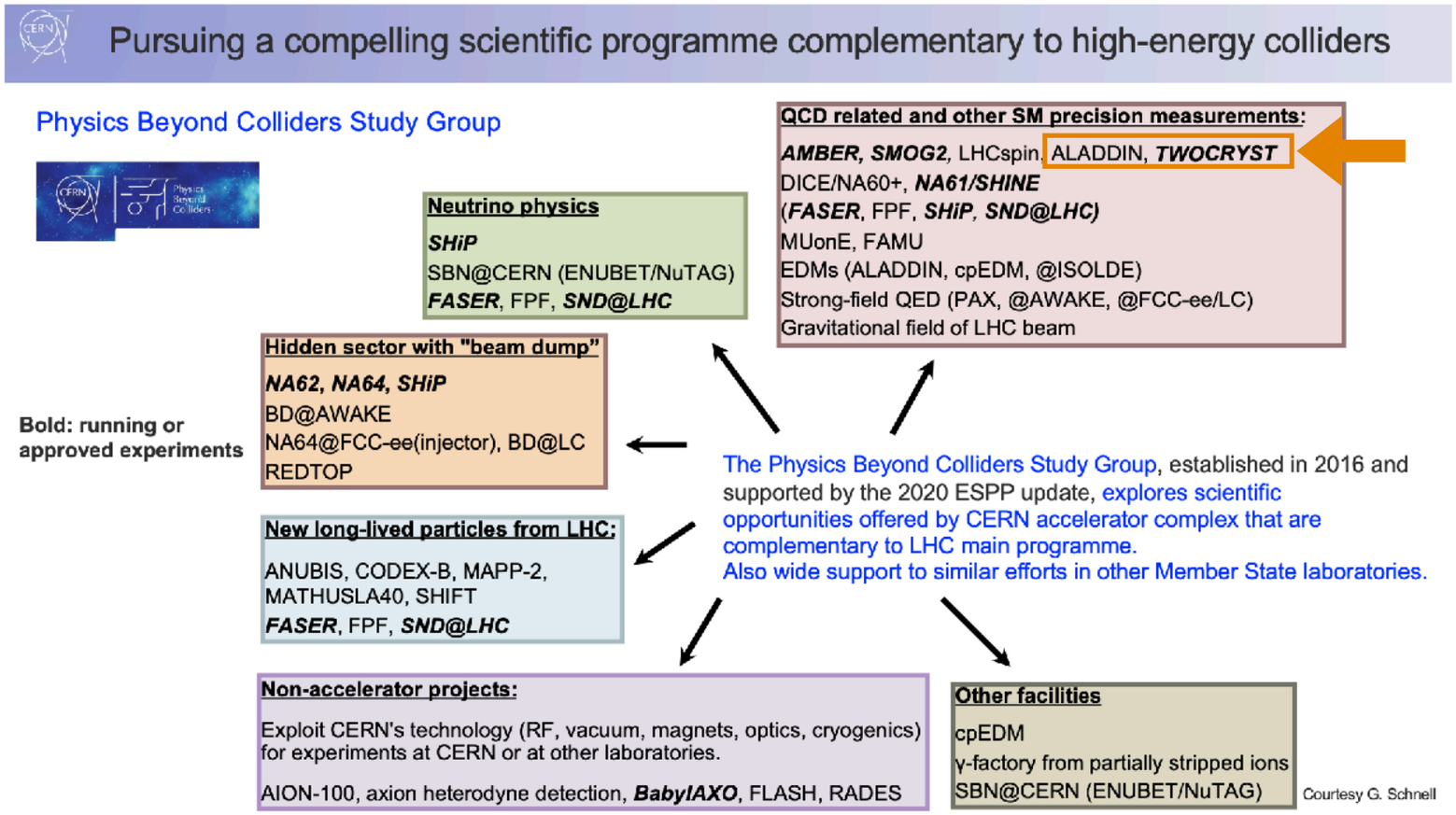
nicola.neri@mi.infn.it

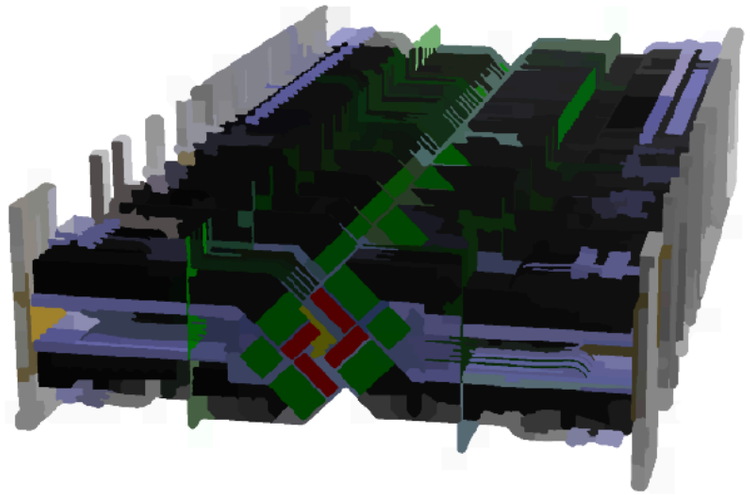
ALADDIN at open symposium @Venice

Talk by Fabiola Gianotti

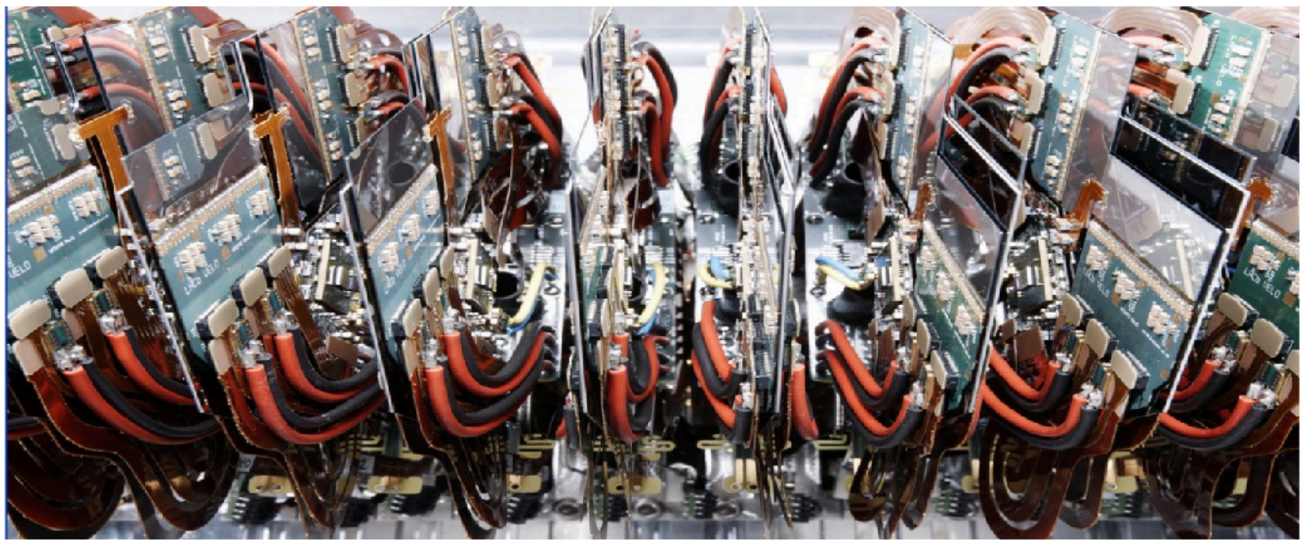


Velo U2: introduction

- From 2025 we are involved in R&D of VELO U2
- Vertex Tracker for Upgrade Phase 2 → significant technological challenges
- 4D pixels for Upgrade Phase II
- Cutting edge technology for pixel detector
- (eg. 30ps time resolution, hi-lumi rad hard)
- IGNITE developing chip in 28 nm technology



- **Participation to VELO U2 workshop in Santiago De Compostela**
- **Natural choice for the Milano group**
- **Synergy with work of chips (IGNITE) & ongoing work on ALADDIN**
- **Strong links with different groups at INFN, CERN**



VELO-U1 modules

VELO U2: Main contributions

- Milano contribution to VELO U2 started in 2025
- Ongoing contribution to IGNITE for ASIC development (L. Frontini, V. Liberali, L. Palini, A. Stabile)
- Main activities for VELO U2
  - Detector simulations, performance studies for TDR
  - CO2 cooling and mechanics (VELO modules)
  - FEA simulations: thermal, mechanical, thermo-mechanical
  - Back-end electronics: PCB design, firmware development
  - Detector assembly, construction and test (VELO modules)

At the moment, Milano is considered one of the two construction sites of the VELO U2
We will need to organize a lab space for R&D + some space in the clean chamber for the prototypes
Project is approved by LHCC Scientific Committee (still in approving stage at INFN)

Activity	People	Ongoing/planned activities
Simulations	A. Merli, F. Redi, T. Tork, Z.	Performance studies, digitalisation
Cooling/FEA	A. Capsoni, S. Coelli, L. Manara, M. Monti, D. Viganò	FEA simulations, production/testing of CO_2 Si microchannel prototype
Backend electronics	M. Citterio, L. Frontini, S. Riboldi, F. Sabatini	PCB design for VTRx+, lpGBT for module 0, firmware development
Module assembly/	S. Cesare, P. Gandini, N. Neri,	Module 0 construction, testing

VELO U2: Timeline

Milestones

S0 Q1 2025 |Sensor protoype submissions

D0 Q3 2025 | VTRx+ distance to sensor

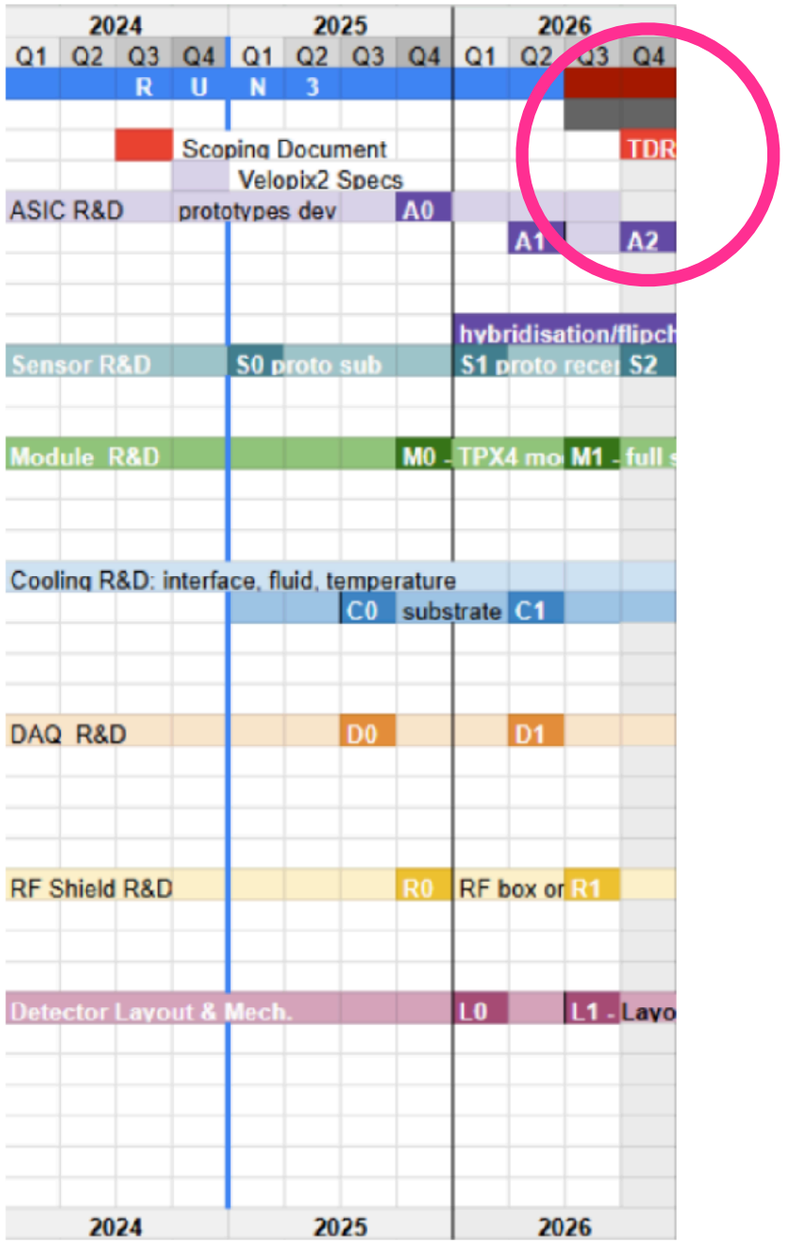
C0 Q3 2025 | Evaluation of cooling technologies

A0 Q4 2025 | PicoPix submission

R0 Q4 2025 | BOX vs IRIS

M0 Q4 2025 | Module proof of principle based on TPX4

A1 Q2 2026 | Ignite ER Submission



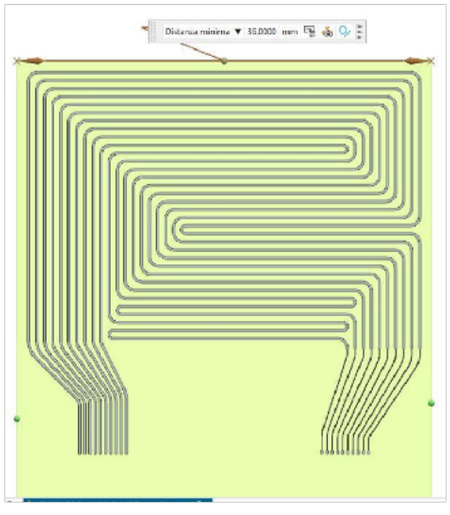
VELO U2: main activities in 2026

Cooling

- Upgrade of TRACI unit for cooling test with microchannels requires new pump to deal with high pressure drops
- Production at FBK of Si substrate prototype with micro channels

TRACI CO2 cooling system

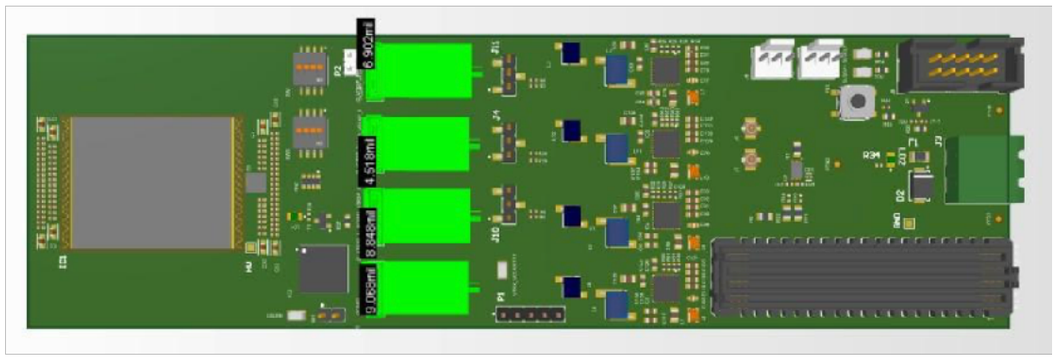
Si prototype design with micro-channels



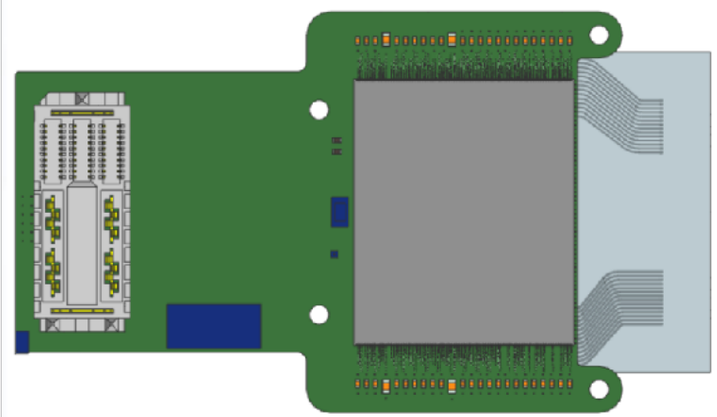
Hardware for Module 0

- Design and production of PCB for back-end electronics
- Integration and testing of CO2 cooling in module 0

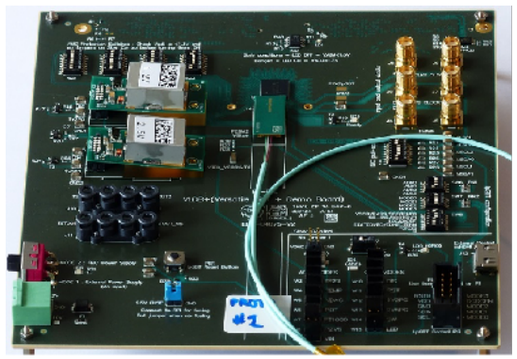
PCB for VTRx+ and lpGBT for module 0



Chip board with Si substrate for CO2 cooling



VLDB+ board designed at CERN. Evaluation kit for the new Versatile Link system



Anagrafica

Attivita' 2026

Note: SELDOM (ERC UE) concluso nel 2025. PRIN esteso fino a Febbraio 2026 (copre TWOCRYST). SELDOM_TWOCRYST chiusa → chiediamo apertura sigla ALADDIN. FERRAD&IGNITE sinergiche a LHCb

Personale			LHCb	IGNITE	FERRAD	ALADDIN	Inquadramento		Servizio Meccanica	Servizio Elettronica
Cesare	**Sara**	1,0	0,9			0,1	Dottoranda		10 m.u.	10 m.u.
Citterio	**Mauro**	0,2	0,2			0	Dirigente Tecnologo		0 m.u.	0 m.u.
Coelli	**Simone**	0,3	0,3			0	Primo Tecnologo		2 m.u.	2 m.u.
Frontini	**Luca**	0,9	0,3	0,3	0,3		Tecnologo			
Gandini	**Paolo**	1,0	0,9			0,1	Primo Ricercatore		Personale officina INFN	
Grabowski	**Jascha**	1,0	0,9			0,1	AR INFN (PRIN2022)		Capsoni	Andrea
Liberali	**Valentino**	0,2		0,1	0,1		Professore Associato		Coelli	Simone
Marangotto	**Daniele**	1,0	1,0			0	AR UNIMI (UE)		Monti	Mauro
Mazzanti	**Andrea**	0,5			0,5		Postdoc		Viganò	Daniele
Merli	**Andrea**	1,0	1,0			0	RTT			
Neri	**Nicola**	1,0	0,7			0,3	Professore Ordinario		Tecnologo	
Palini	**Luca**	1,0		1,0			Dottorando		Manara	Luciano
Redi	**Federico Leo**	1,0	0,7	0,3			RTD-B UNIBG			
Riboldi	**Stefano**	0,3	0,3			0	Professore Associato			
Stabile	**Alberto**	0,4		0,2	0,2		Professore Associato			
Tonani	**Giorgia**	1,0	1,0			0	Dottorando			
Tork	**Theraa**	1,0	1,0			0	AR UNIMI (UE)			
Wang	**Ziyi**	1,0	1,0			0	AR UNIMI (UE)			
Xing	**Tianyu**	1,0	1,0			0	AR UNIMI (PRIN2022)			
Zangari	**Federico**	1,0	0,9			0,1	Dottorando			
Tot. (FTE)		15,8	12,1	1,9	1,1	0,7				

Richieste di Sezione

Richieste Servizi Locali

Elettronica	10 m.u.	disegno, produzione, test scheda PCB per VELO upgrade 2 per Modulo 0 (LHCb);
	2 m.u.	disegno, produzione, test schede elettroniche (vacuum feed-through, data flex) per alimentazione e trasmissione dati per tracker in Roman Pot (ALADDIN)
Meccanica	8 m.u.	simulazioni FEA per VELO U2, 8 m.u
	2 m.u.	LHCb: costruzione della meccanica per modulo 0
	2 m.u.	ALADDIN (construction of pieces for second Roman Pot):

- Richieste sono fondamentali per portare avanti il programma di R&D sia sul VELO U2 che ALADDIN
- In particolare, simulazioni termiche sono cruciali per la progettazione del modulo 0
- Vorremmo replicare l'ottimo lavoro effettuato dalla nostra officina e dal servizio di elettronica per l'UT

Cconsumo e missioni per LHCb:totale di 245.5 kEuro

	LHCb Upgrade2	
RD_FLAVOUR DRD8 WP3, VELO U2: produzione prototipo substrato a silicio con microcanali per CO2 cooling (FBK).	30	keuro
RD_FLAVOUR DRD3 WG2, VELO U2: scheda PCB di back-end per modulo 0 .	15	keuro
RD_FLAVOUR DRD3 WG2, VELO U2: pompa per sistema TRACI per test cooling evaporativo a CO2 con microcanali.	15	keuro
RD_FLAVOUR DRD3 WG2, VELO U2: scheda VLDB+ per test e caratterizzazione sistema VTRx+ e lpGBT.	3	keuro
Totale	63	keuro
	ALADDIN	
Missioni	4	keuro
Costruzione stazione multilayer per il nuovo tracker su LHC	20	keuro
Sistema meccanica e cooling integrato nella Roman Pot (per sistema a multi layer)	10	keuro
Totale	34	keuro