Activities of LHCb group

Nicola Neri
on behalf of the Milano LHCb group

INFN - Sezione di Milano

9 July 2018 - Milano

Outline

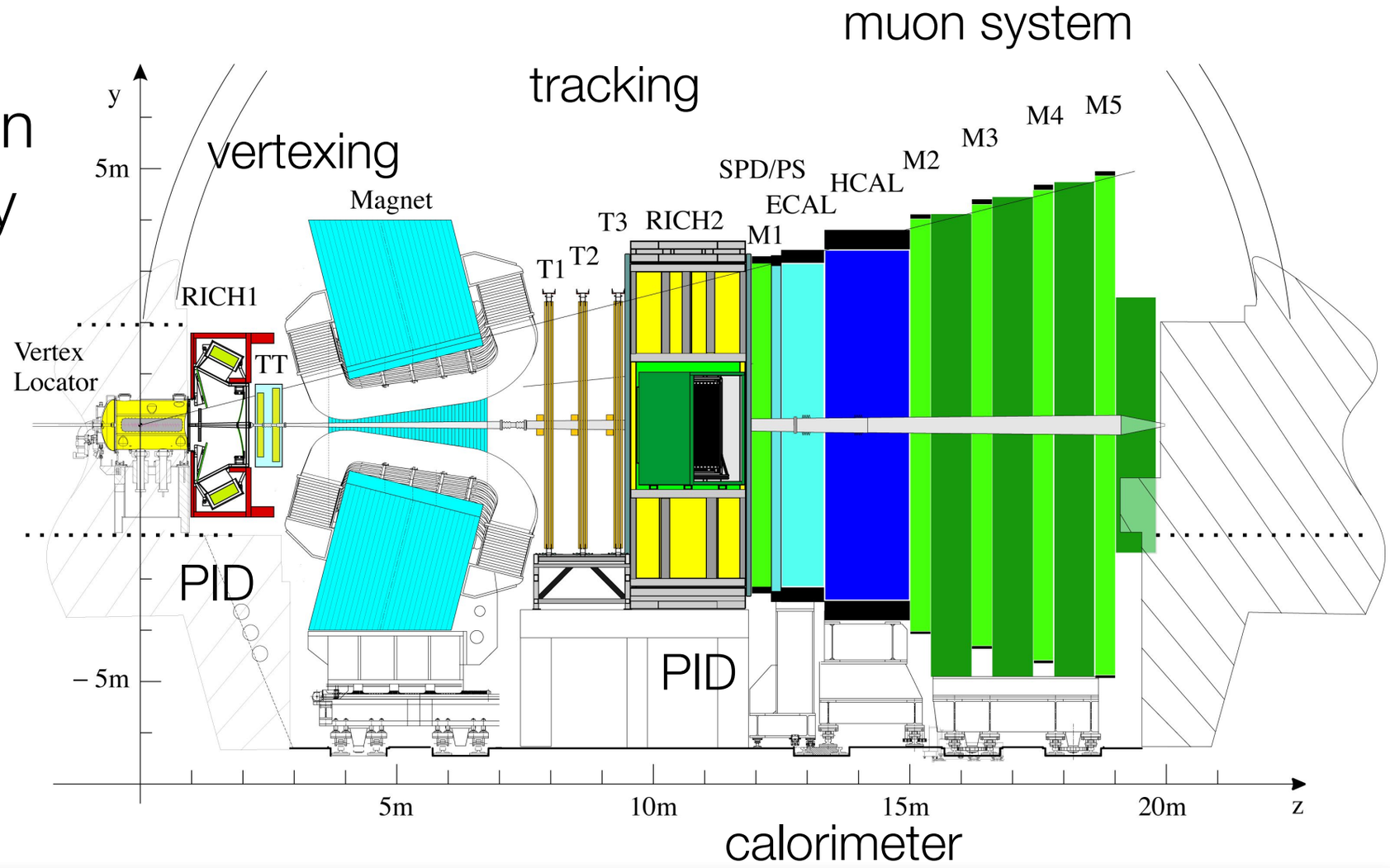
- LHCb experiment
  - Physics results
  - LHCb upgrade
- SELDOM ERC project
  - Physics motivations
  - Project description
- Timespot (in backup)
  - R&D for fast timing pixel detector [Call CSN5]

LHCb experiment

LHCb is a dedicated experiment for the study of flavour physics at LHC

Search for new physics phenomena via precision measurements of theory clean observables

LHCb single arm magnetic spectrometer
Dipole magnetic field ∫B·dl=3.73 T·m, perpendicular to beam axis



LHCb physics program

CKM and *CP* violation

sin2β, **γ**, ϕ_s, $|V_{ub}/V_{cb}|$, CPV in B^0, B_s^0, D^0, b-baryons,…

Rare decays

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

Spectroscopy

Tetraquarks, **Pentaquarks**, Ξ_{cc}^{++}, Ω_c^*, Ξ_b^{-*},…

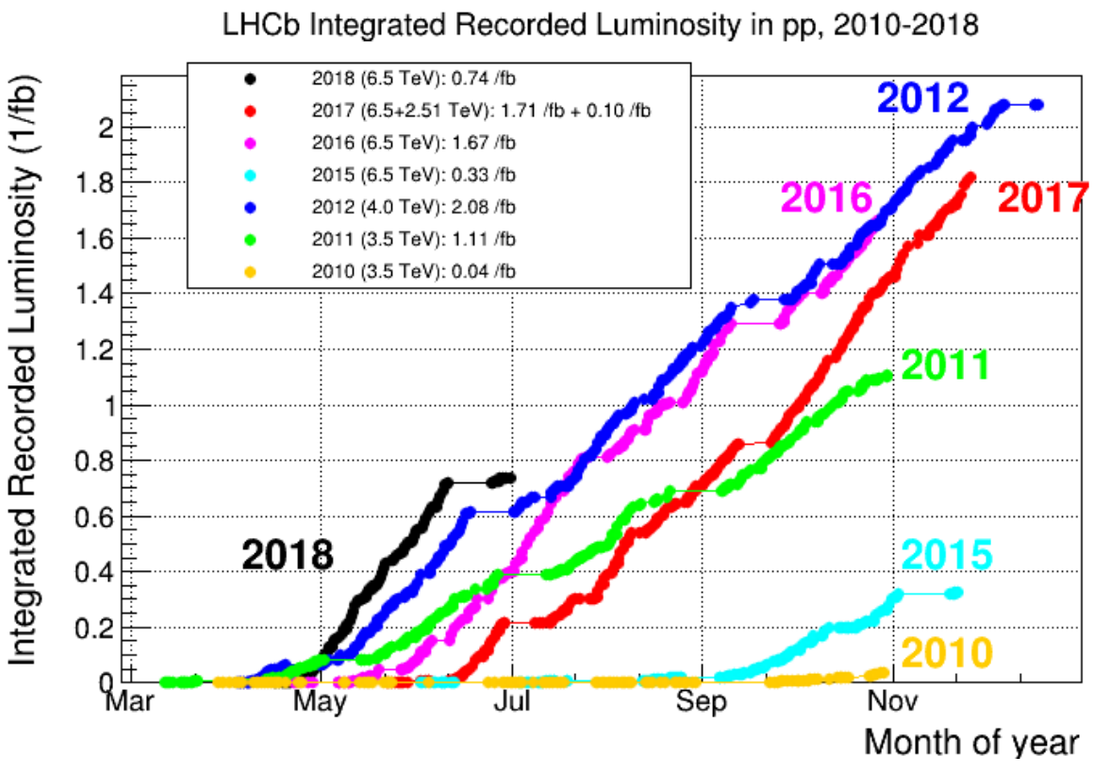
Electroweak QCD, Exotica

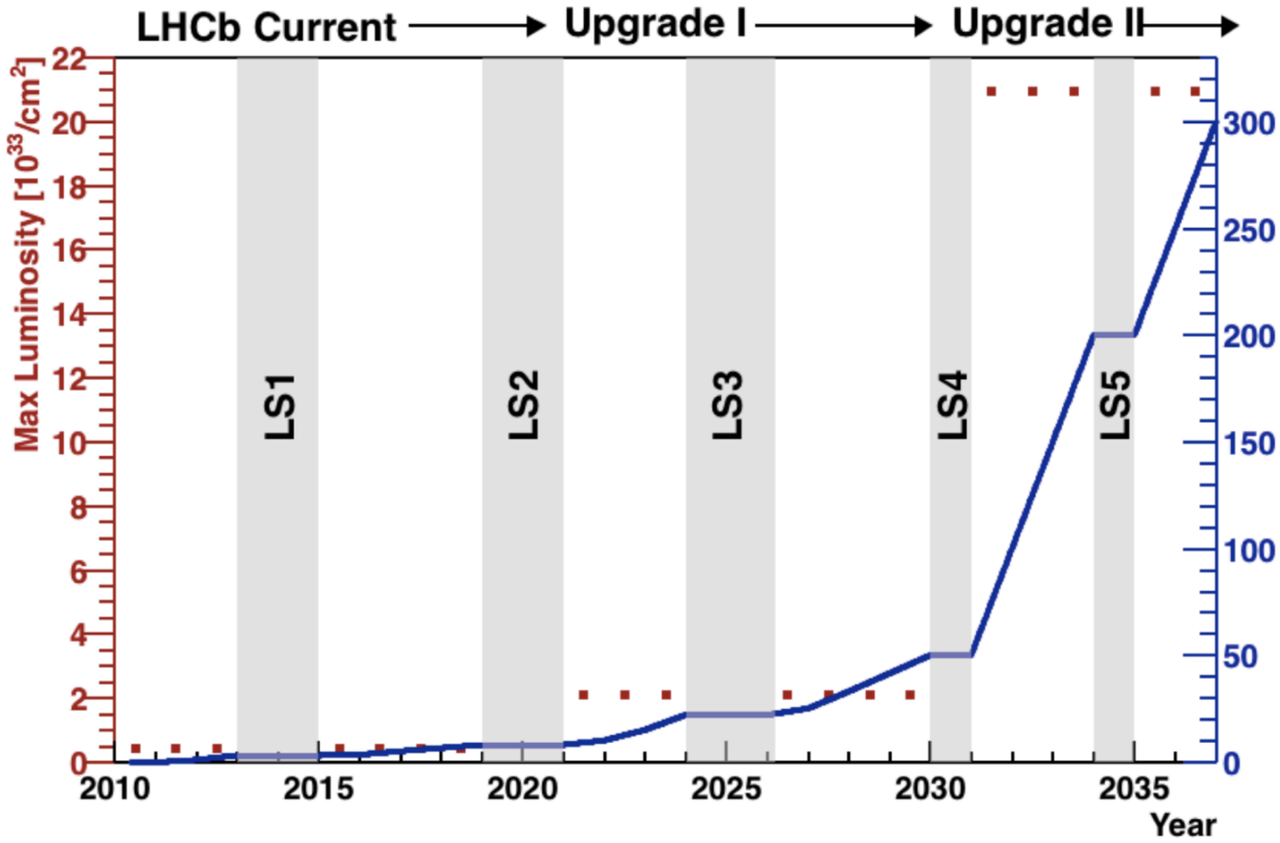
Z^0, W^+, top, $H \to c\bar{c}$, Dark photons, Long-lived particles,..

Ion, Fixed-target

Heavy ions, **p-Gas**, nuclear effects,…

LHCb data sample and plans



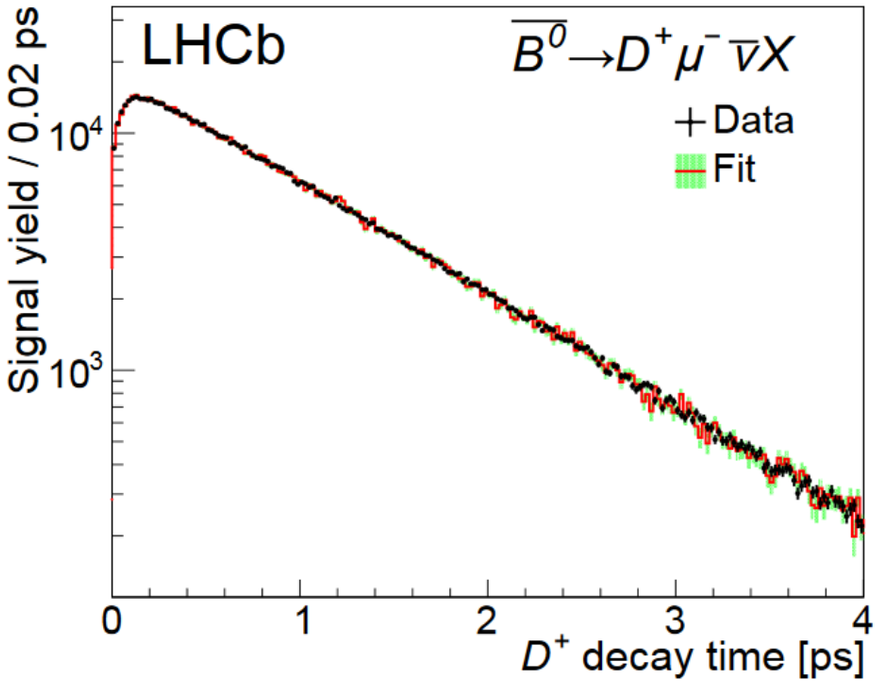


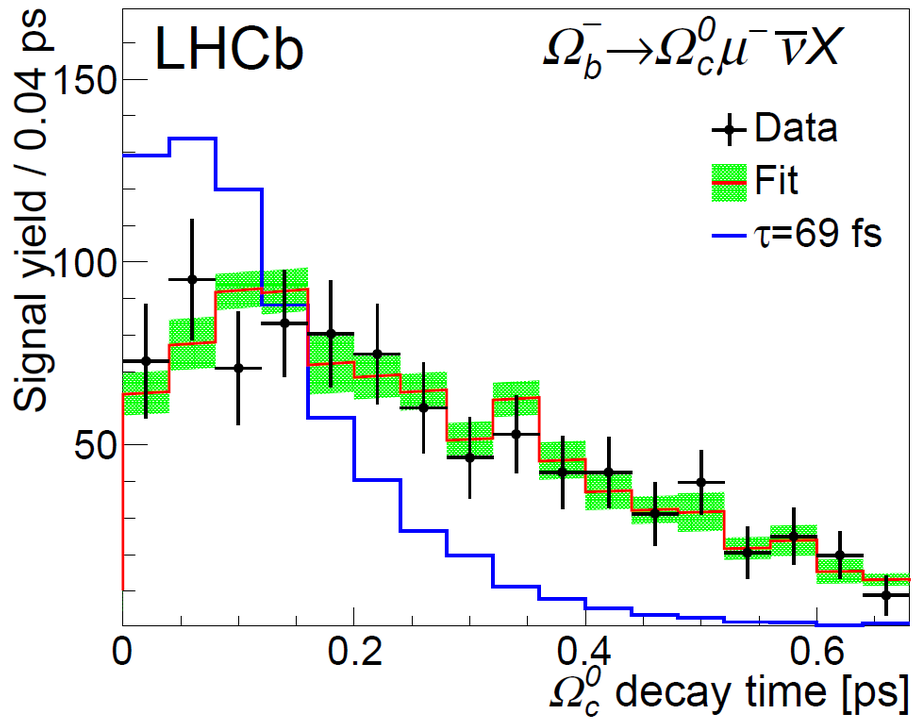
- Collecting >8 fb^{-1} in Run2 (2018). **Major detector upgrade during LS2** (Upgrade I- 2020). Aim at 50 fb^{-1} before 2030
- First detector improvements in PID, tracking, and ECAL during LS3 (Upgrade 1b - 2025)
- Major detector upgrade during LS4 (Upgrade II - 2030). Aim at >300 fb^{-1} after 2030 - ….

Recent results

Puzzling measurement of Ω_c^0 baryon lifetime

arXiv:1807.02024

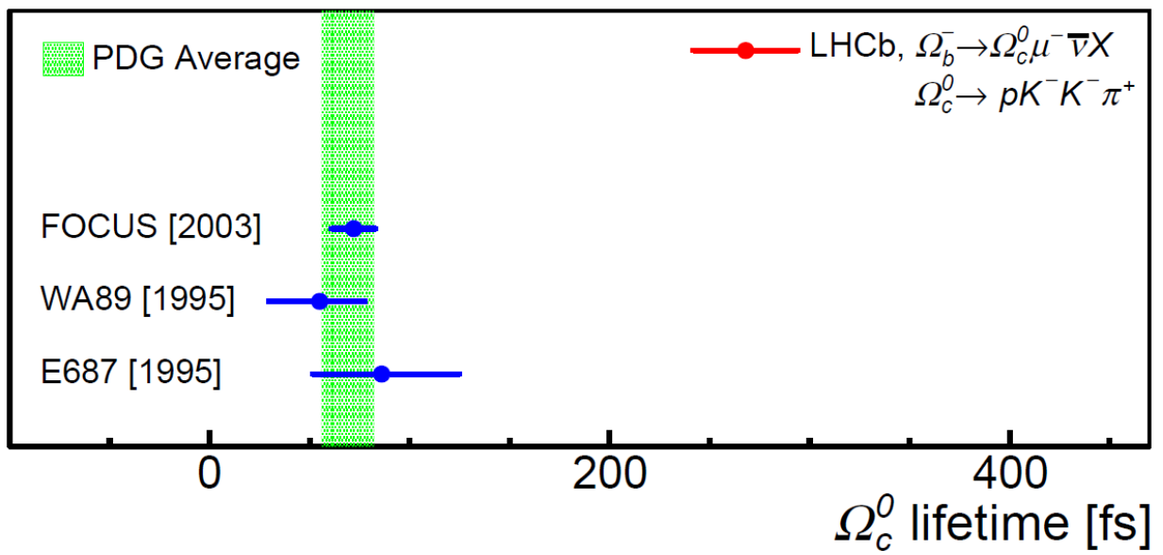




Measurement relative to D^+ lifetime

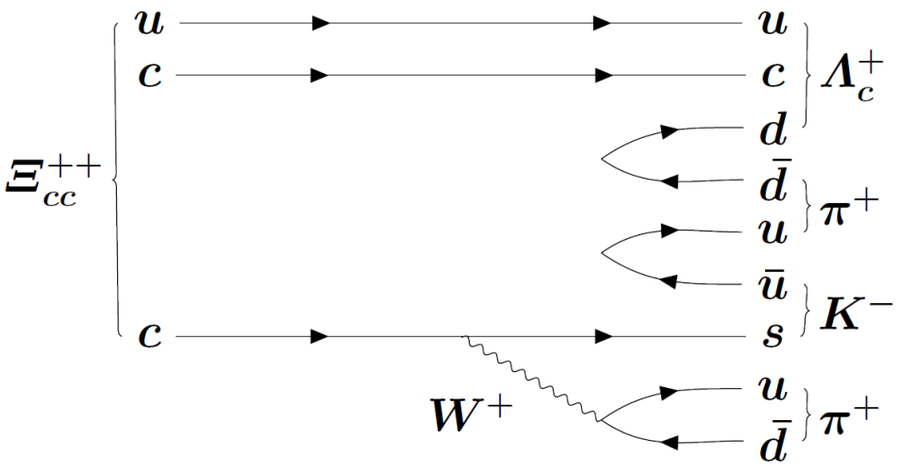
$$\tau_{\Omega_c^0} = 268\pm24\pm10\pm2 \text{ fs}$$

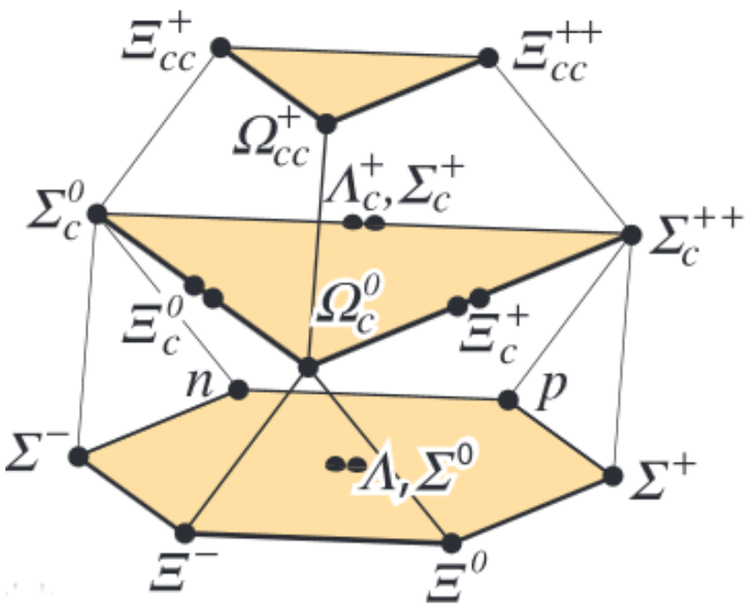
Inconsistent with previous fixed-target experiments (4 times higher)



Observation of exceptionally charming particle

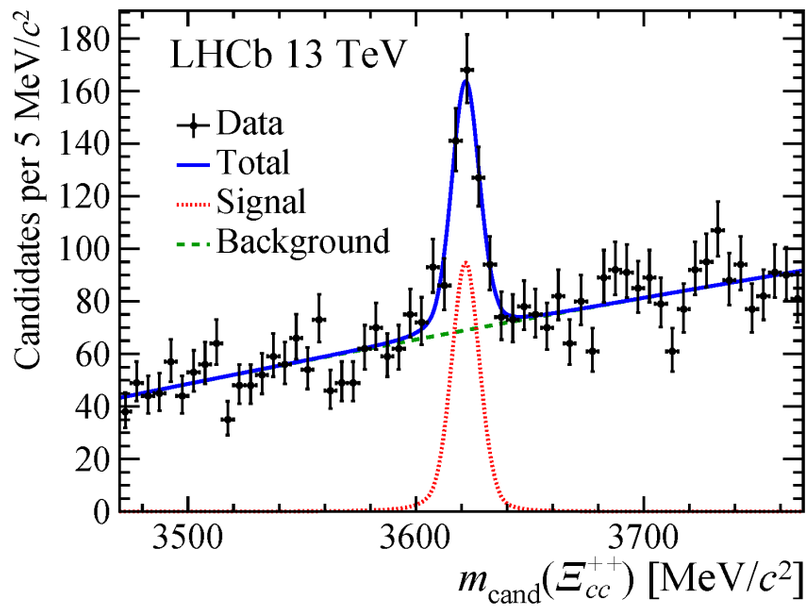
First observation of doubly charmed particle Ξ_{cc}^{++}



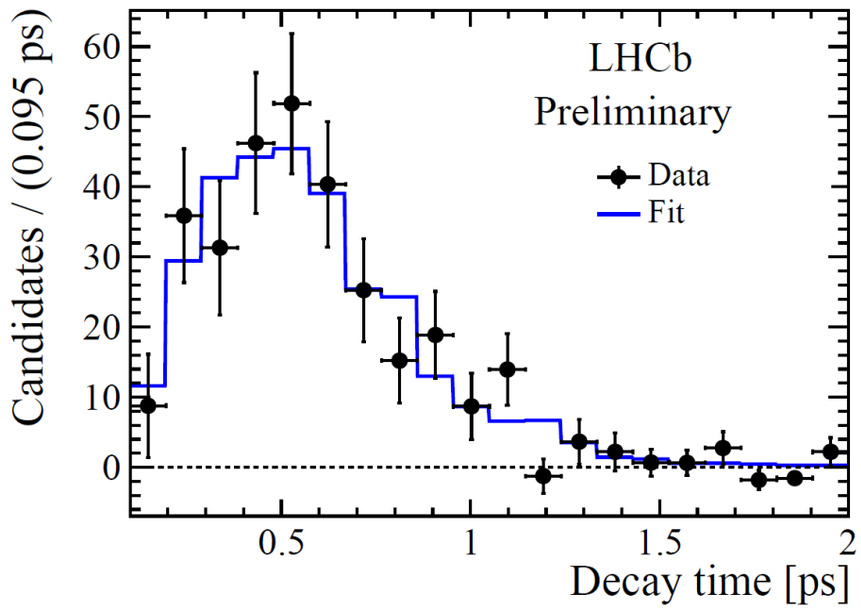


Phys. Rev. Lett. 119, 112001 (2017)

[$m(\Xi_{cc}^{++}) = 3621.40 \pm 0.72 \pm 0.27 \pm 0.14$ MeV/c^2]

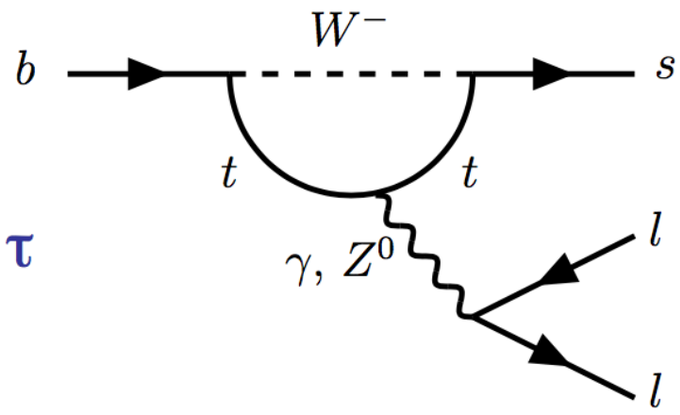


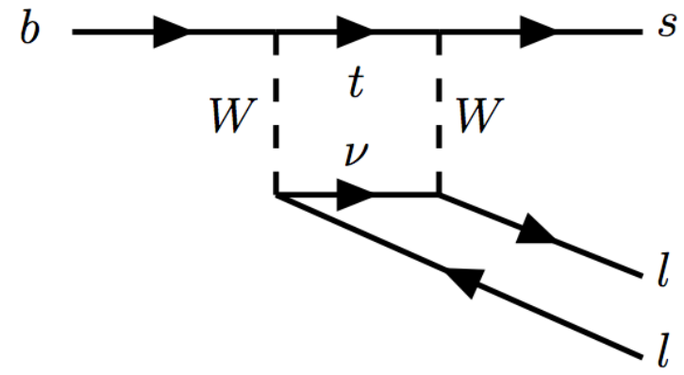
[$\tau(\Xi_{cc}^{++}) = 0.256^{+0.024}_{-0.022} \pm 0.014$ ps] **arXiv:1806.02744**



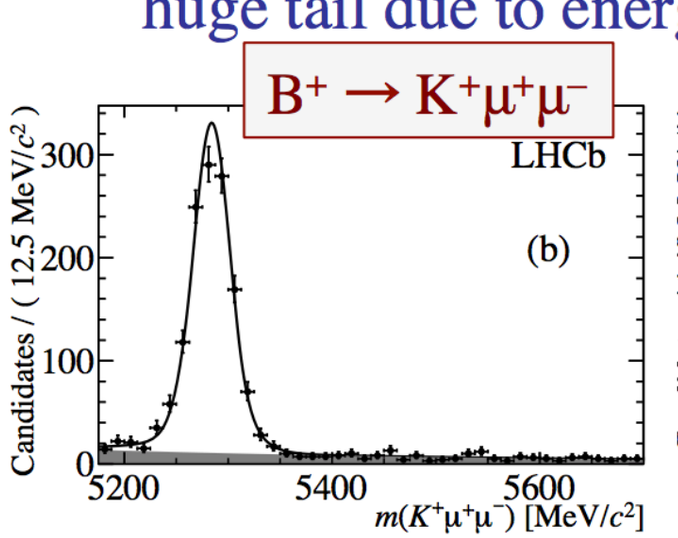
$B^0 \to K^{*0}\ell^+\ell^-$ and lepton universality

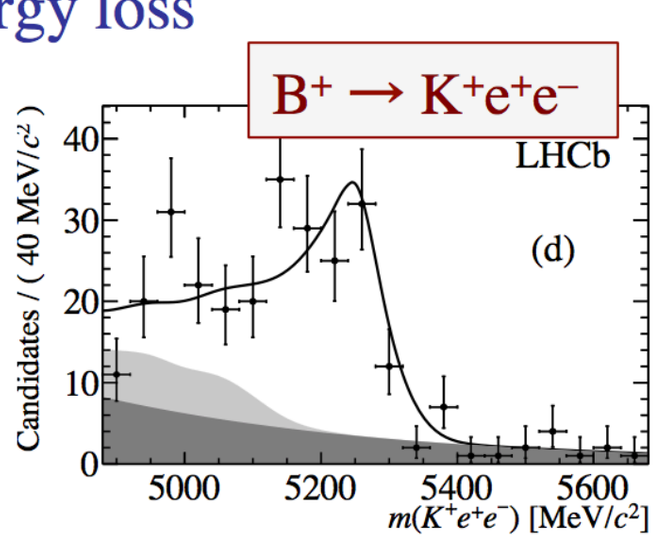
- **Lepton Flavour Universality (LFU) in the SM:**
  - same EW couplings for ℓ = e, μ, τ

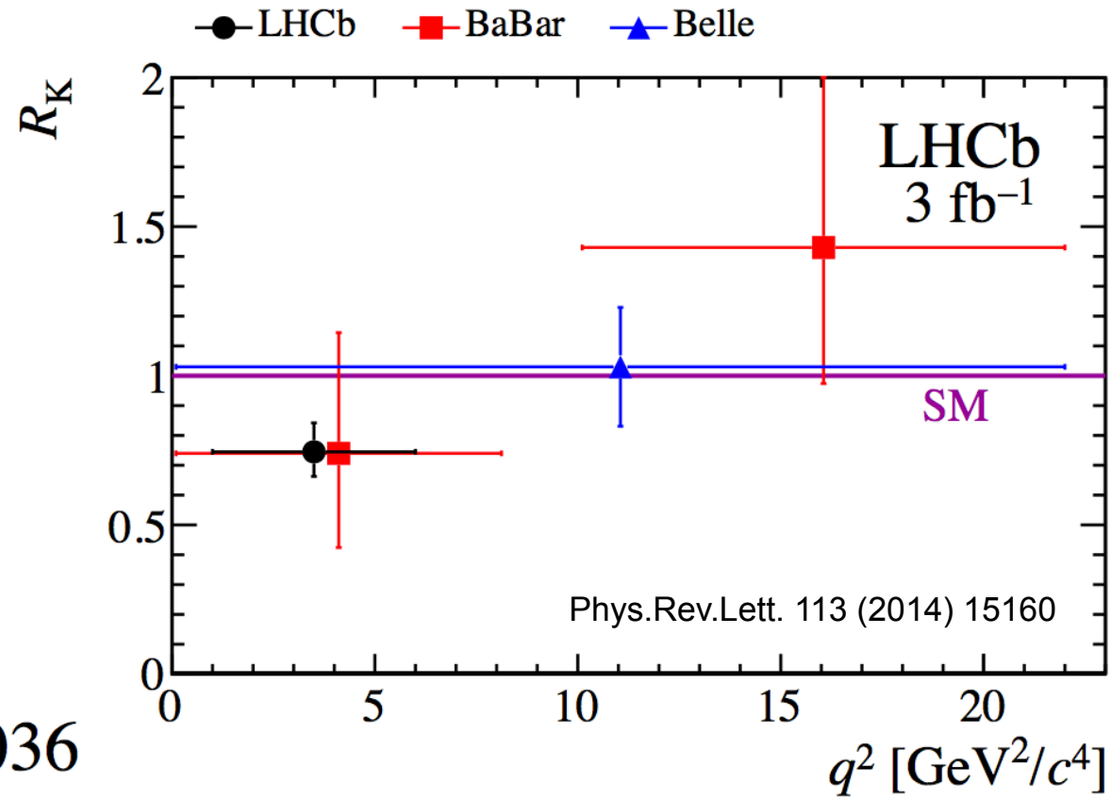




- **LHCb:**
  - electron reconstruction challenging, huge tail due to energy loss





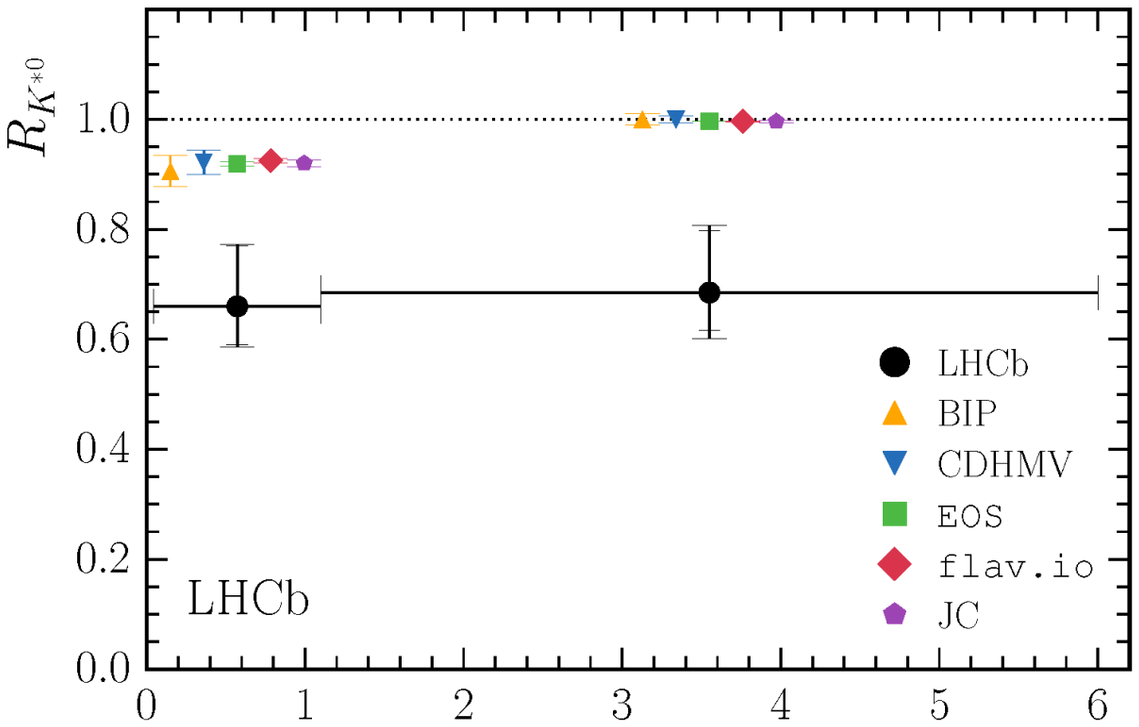


- for low q^2 region ($1<q^2<6$ GeV^2/c^4):

$$R_K = \frac{BR(B^+ \to K^+\mu^+\mu^-)}{BR(B^+ \to K^+e^+e^-)} = 0.745\ ^{+0.090}_{-0.074} \pm 0.036$$

2.6σ from SM value of $1 \pm O(10^{-3})$

$B^0 \to K^{*0}\ell^+\ell^-$ and lepton universality



3fb^{-1} JHEP 08 (2017) 055

$$R_{K^{*0}} = \frac{BR(B^0 \to K^{*0}\mu^+\mu^-)}{BR(B^0 \to K^{*0}e^+e^-)}$$

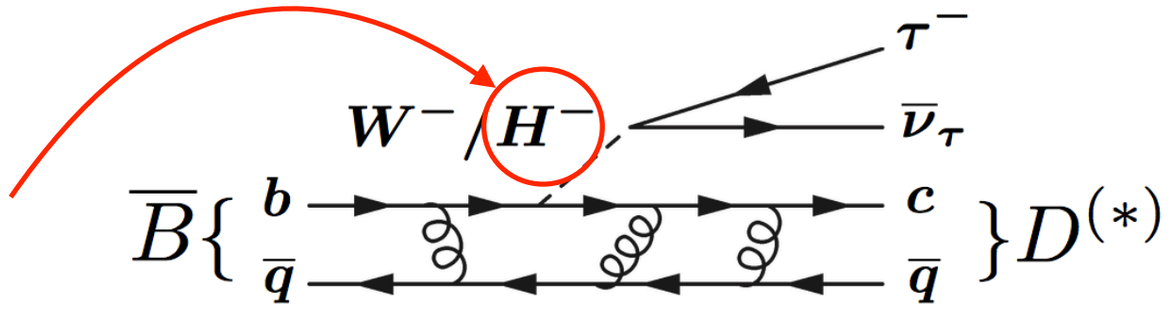
$$R_{K^{*0}} = \begin{cases} 0.66\ ^{+\ 0.11}_{-\ 0.07}\,(\text{stat}) \pm 0.03\,(\text{syst}) & \text{for } 0.045 < q^2 < 1.1\ \text{GeV}^2/c^4\,, \\ 0.69\ ^{+\ 0.11}_{-\ 0.07}\,(\text{stat}) \pm 0.05\,(\text{syst}) & \text{for } 1.1 \quad < q^2 < 6.0\ \text{GeV}^2/c^4\,. \end{cases}$$

Tensions with the SM at 2.1-2.3 and 2.4-2.5σ in the two q^2 regions, respectively

Test of lepton flavour universality

LFU test with B→D$^{(*)}\ell\nu$

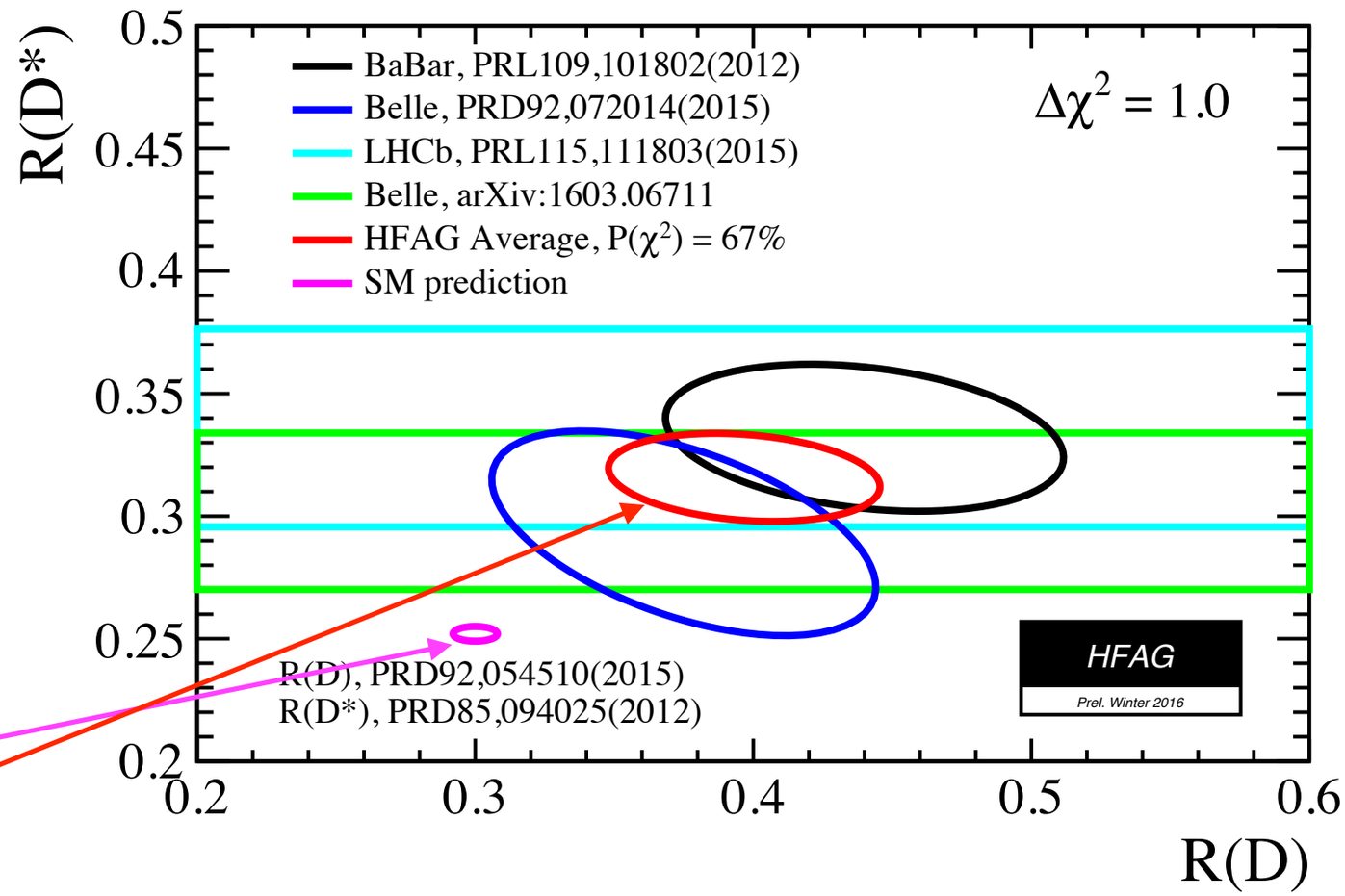
tree level decay, sensitive to possible H^+ contribution



R(D) and R(D*) definition

$$R(D^{(*)}) = \frac{B^0 \to D^{(*)-}\tau^+\nu_\tau}{B^0 \to D^{(*)-}\ell^+\nu_\tau}$$

$\ell = \mu, e$



- Experimental challenge
  - tau reconstruction, missing neutrinos
- **4.0σ** from **SM** at (**2D average**)

Recent analyses of Milano group

χ_{c1} and χ_{c2} resonance parameters in $\chi_{c1,c2} \to J/\psi\mu^+\mu^-$

Phys. Rev. Lett. 119 (2017) 221801 Gandini

Search for CPV in $\Lambda_b^0 \to pK^-K^+K^-, pK^-\pi^+\pi^-$ and $\Xi_b^0 \to pK^-K^-\pi^+$ arXiv:1805.03941 Submitted to JHEP Fu, Merli, Neri

Observation of new baryonic resonances

to be submitted to PRL Gandini

Study of $B^0_{(s)} \to J/\psi p\bar{p}$ decay in review Spadaro, Fu, Neri

First observation, search for pentaquark, glue ball, precision measurement of Bs mass.

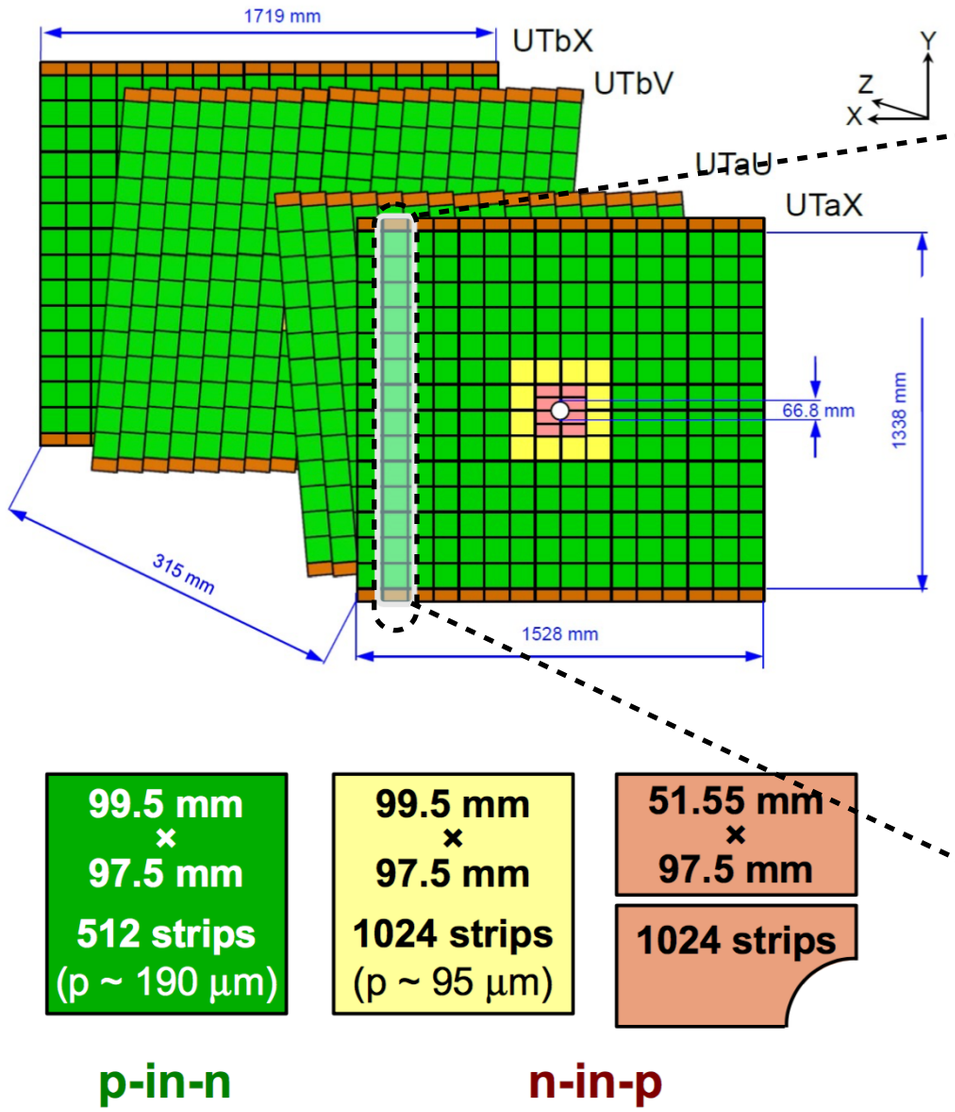
Search for CPV in $\Lambda_b^0 \to p\pi^-\pi^+\pi^-$ in review Merli, Fu, Neri

Update of analysis published on Nature Physics reporting first evidence of CPV in heavy baryon decays

LHCb upgrade

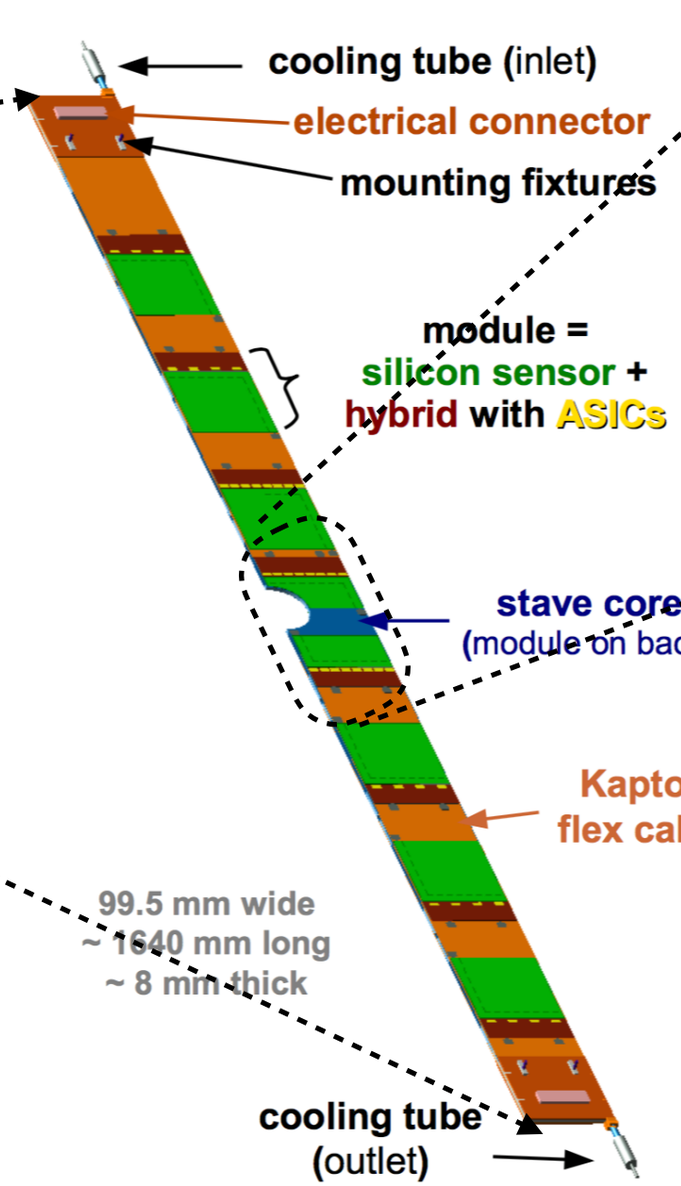
UT detector upgrade

4 detection layers

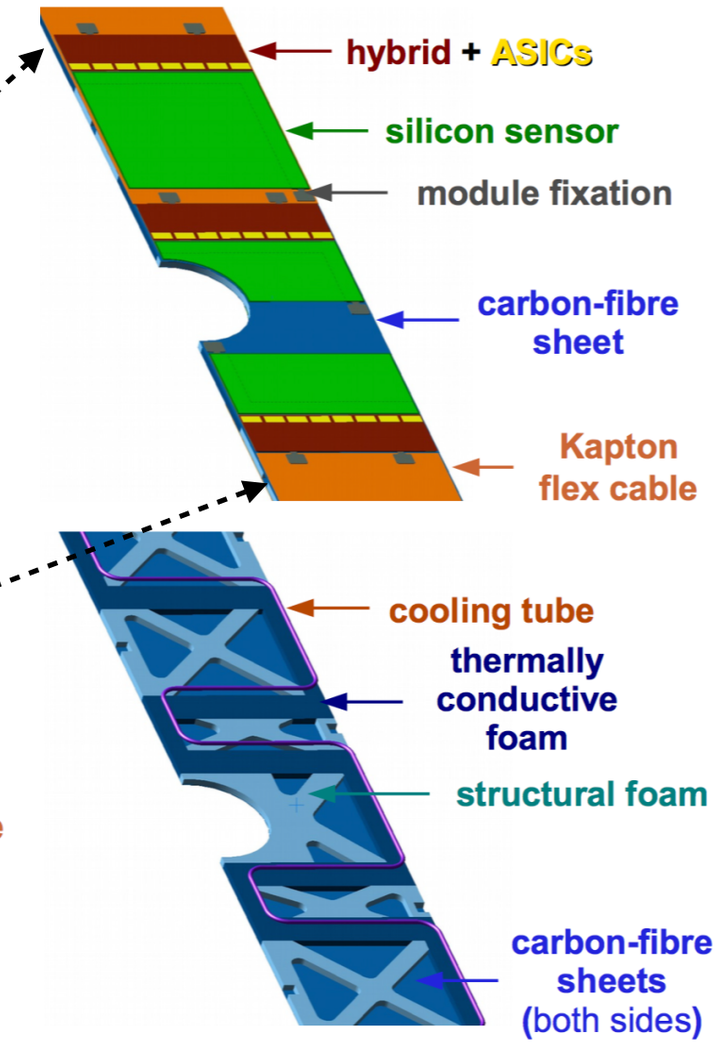


3 silicon sensor geometries

stave design



module design



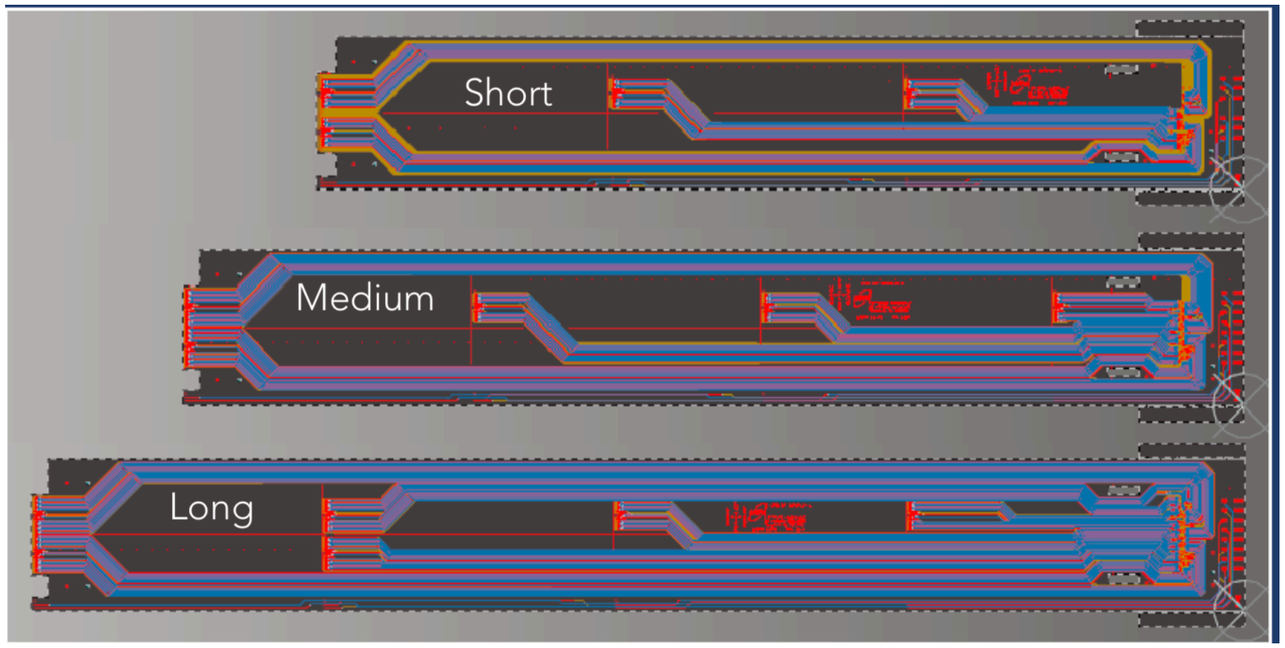
support structure

CO_2 cooling tube

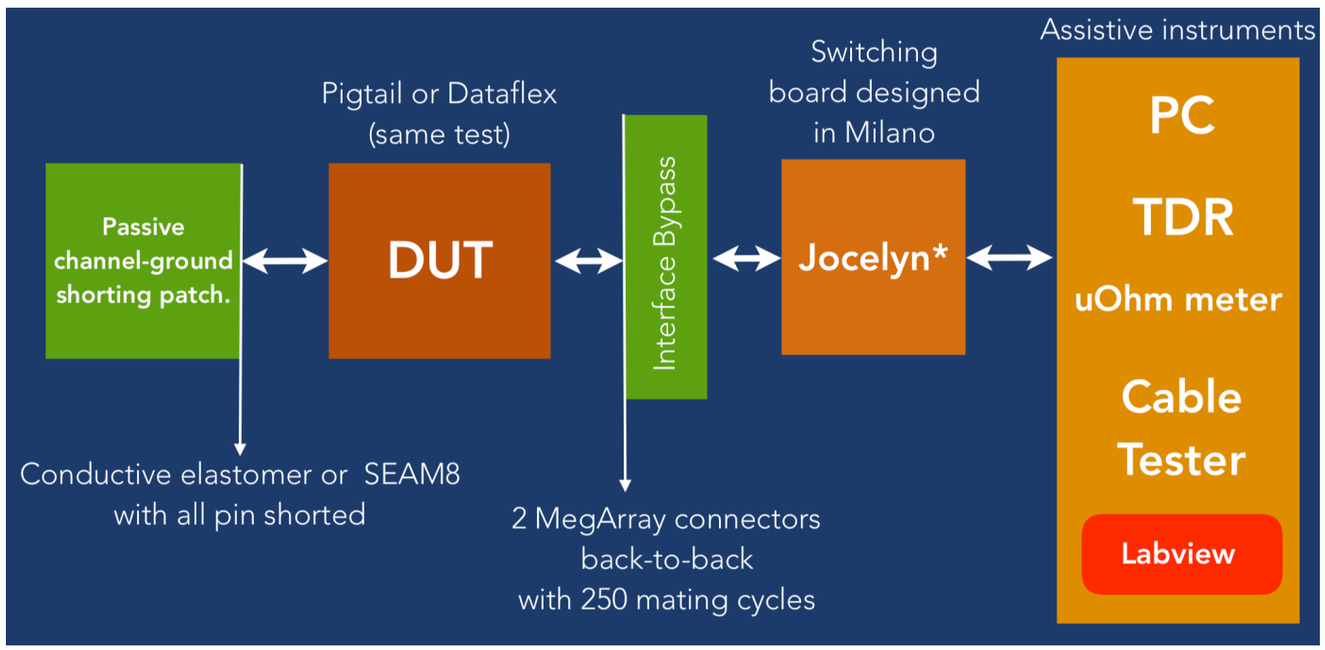
Activities in Milano in 2019

- Production phase in 2018 and 2019, installation in 2020
- Milano responsibilities in UT project:
  - Flex cables designed. Production and test (late 2018 - early 2019)
  - Hybrid circuit for ASIC to be finalised. Production and test delayed due to SALT chip (late 2018 - 2019)
  - Integration of hybrid and SALT chip: glueing, bonding, burn-in (in 2019)
  - Design and test of the CO_2 system prototype (late 2018 - early 2019)
  - CO_2 distribution system design and production (2019)
- Milano coordination roles in UT project:
  - Sensor and hybrid WG co-convener: Mauro Citterio
  - Mechanics and cooling WG co-convener: Simone Coelli
  - Deputy project leader: Nicola Neri

Flex cable production and test



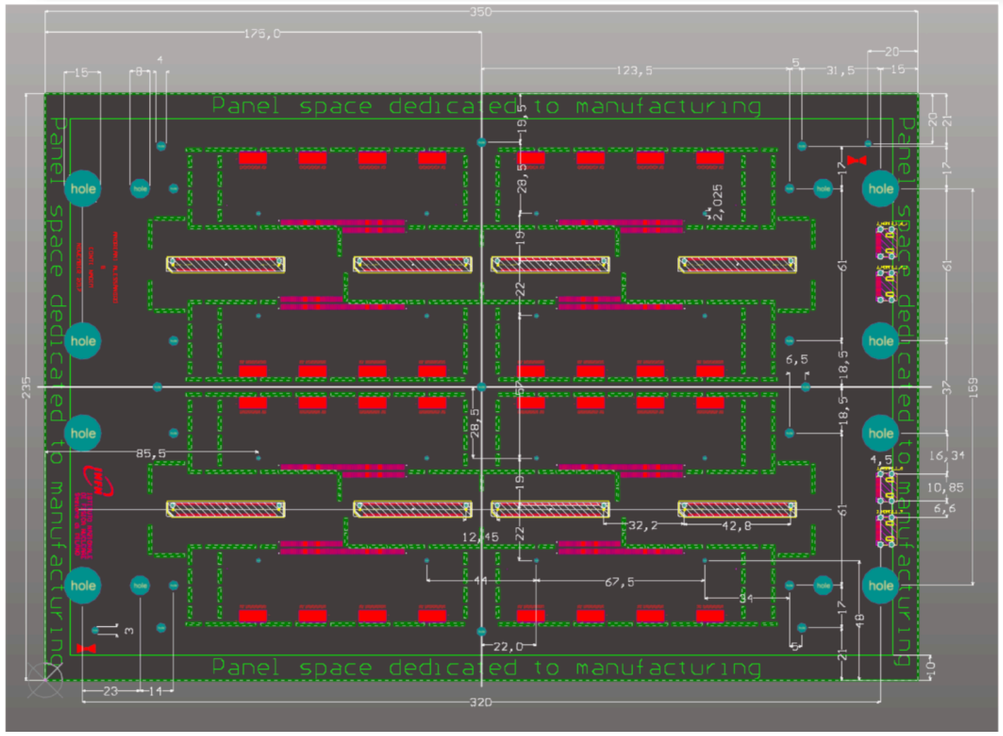
- Flex cable production of 300 cables takes 5 months
- Tender being finalised, expected to start production in July

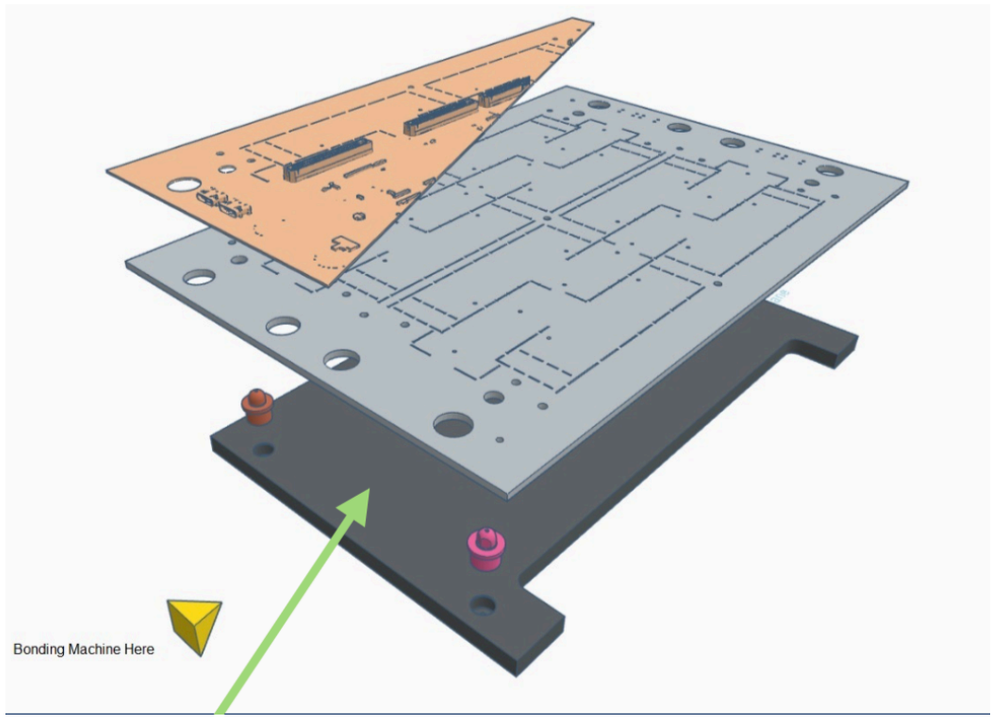


- Flex cable test at CERN (30 cables per week). Starting in August/September
- Jocelyn board to be designed and produced

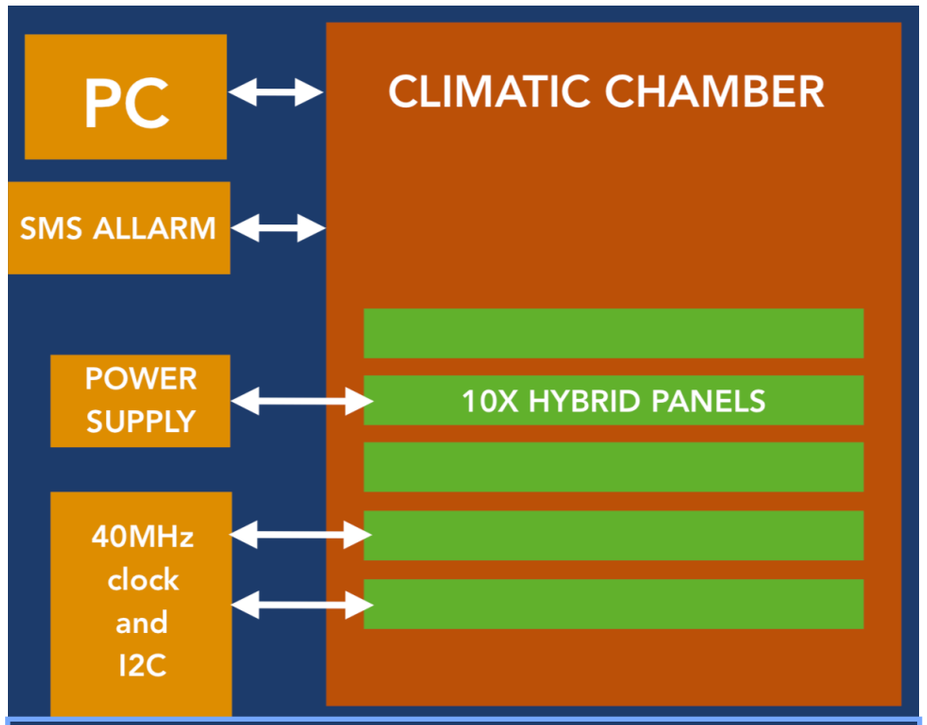
Citterio, Conti, Sabatini

Hybrid design and construction





- 8 Hybrids per panel to facilitate shipment, testing, module construction
- Integration with ASIC, gluing, bonding, burn in test in Milano

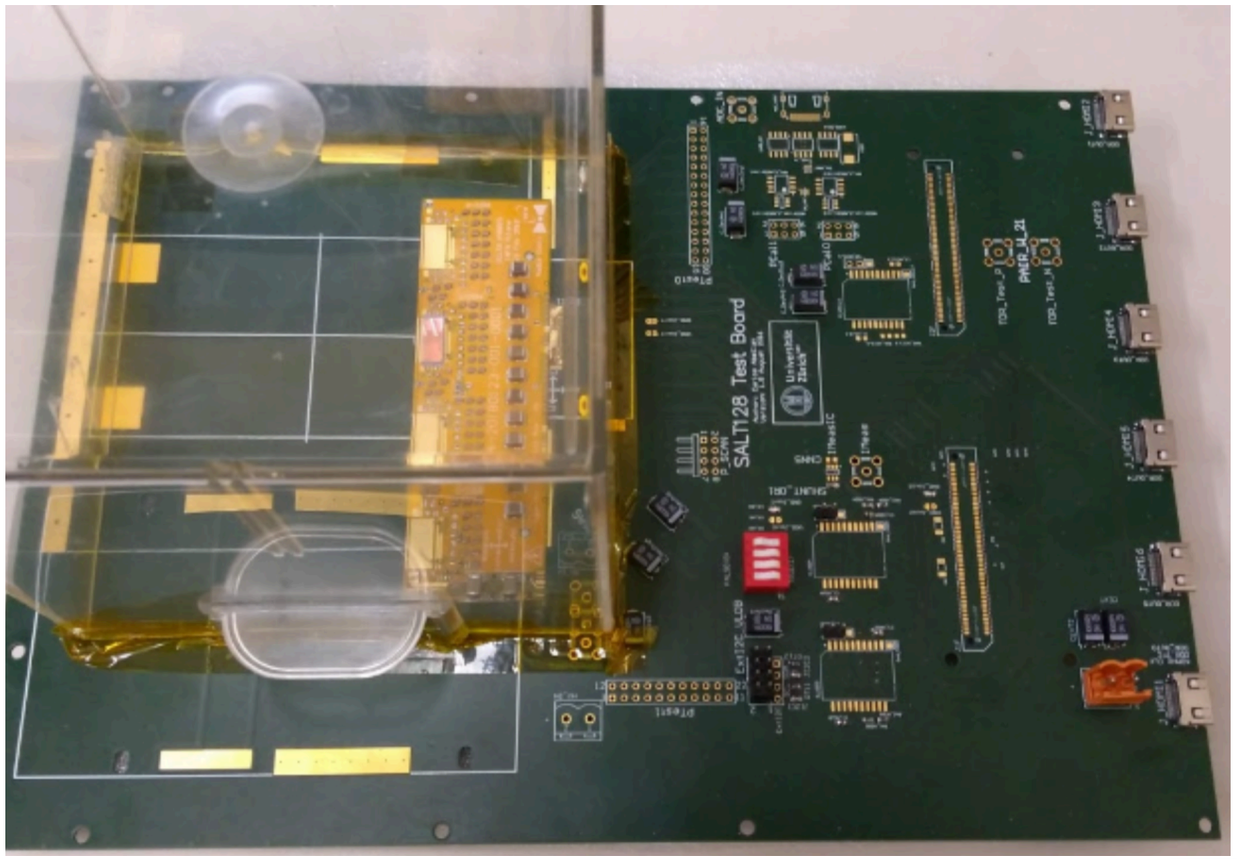


Citterio, Conti, Andreani

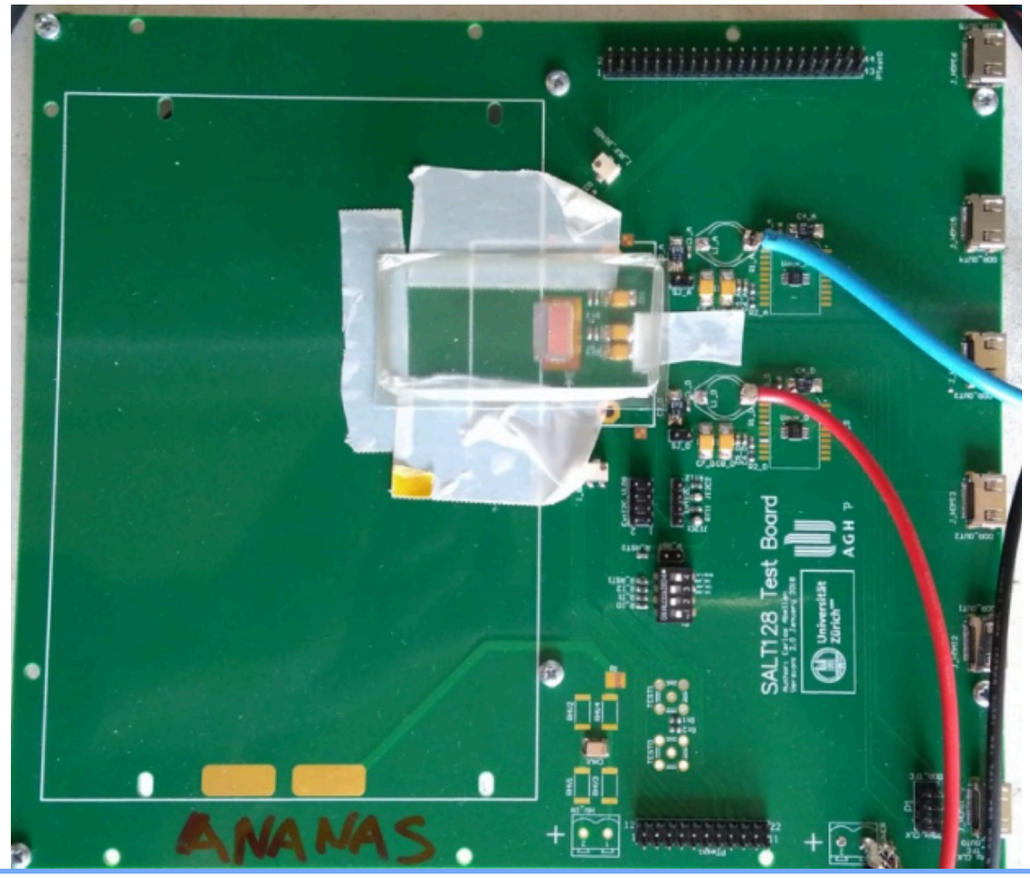
Hybrid circuit and SALT chip

- Compared SALT test results between hybrid and test board setup

SALT on Delta hybrid



SALT on optimised test board

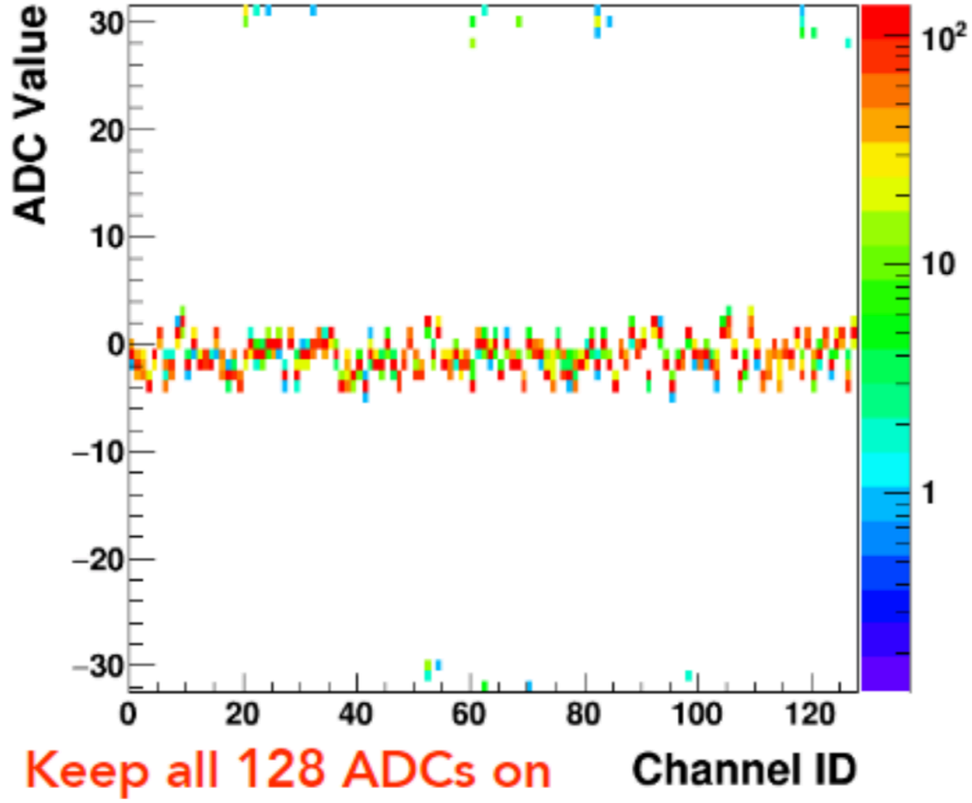


Citterio, Conti, Spadaro, Carbone

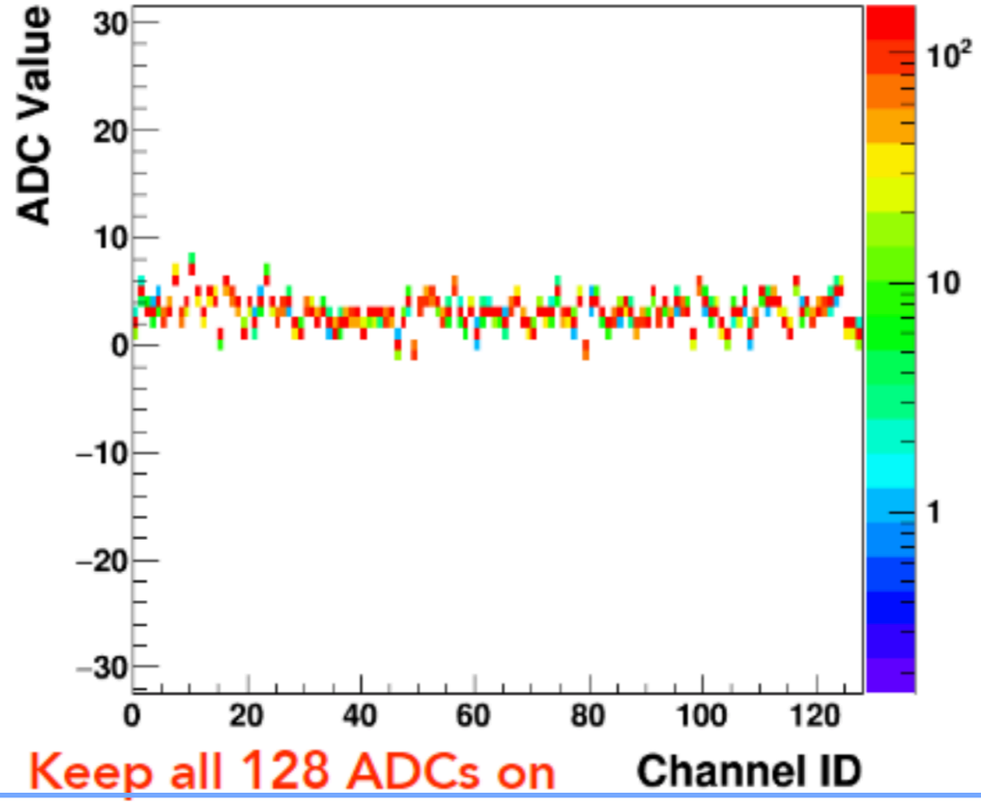
Hybrid test results

- Measurements on Delta hybrid and test board give comparable results (no input load)
- Hybrid circuit works fine. Final version of SALT needed for hybrid optimisation and production

SALT on Delta hybrid



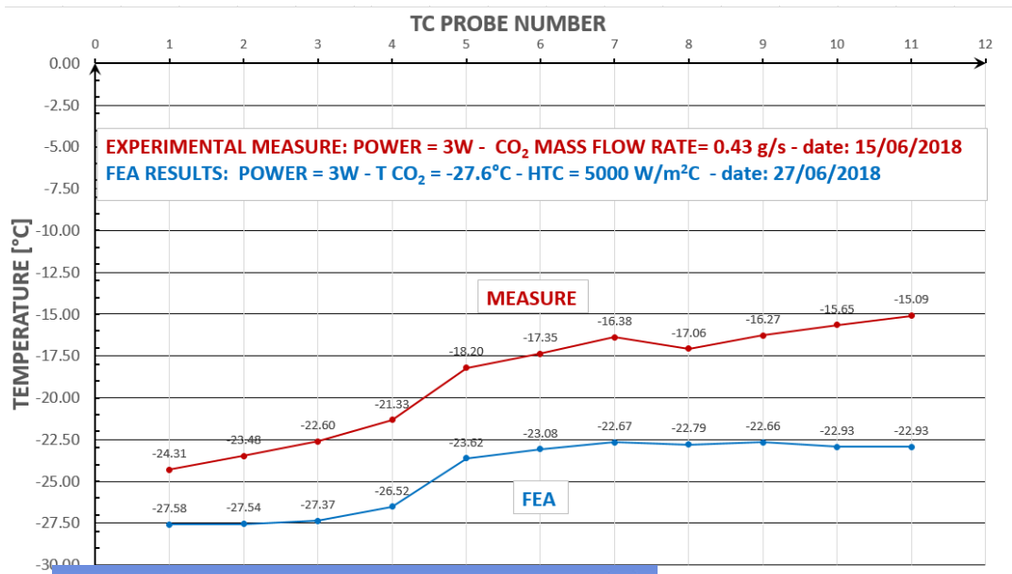
SALT on test board

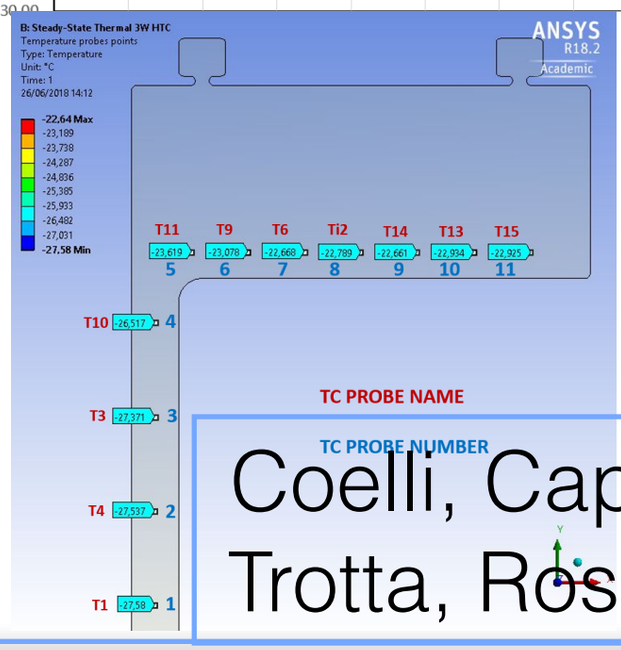


Citterio, Conti, Spadaro, Carbone

Stave CO_2 cooling test

- UT stave prototype tested using TRACI system at -28° C ✔
- Simulation vs measurements ✔

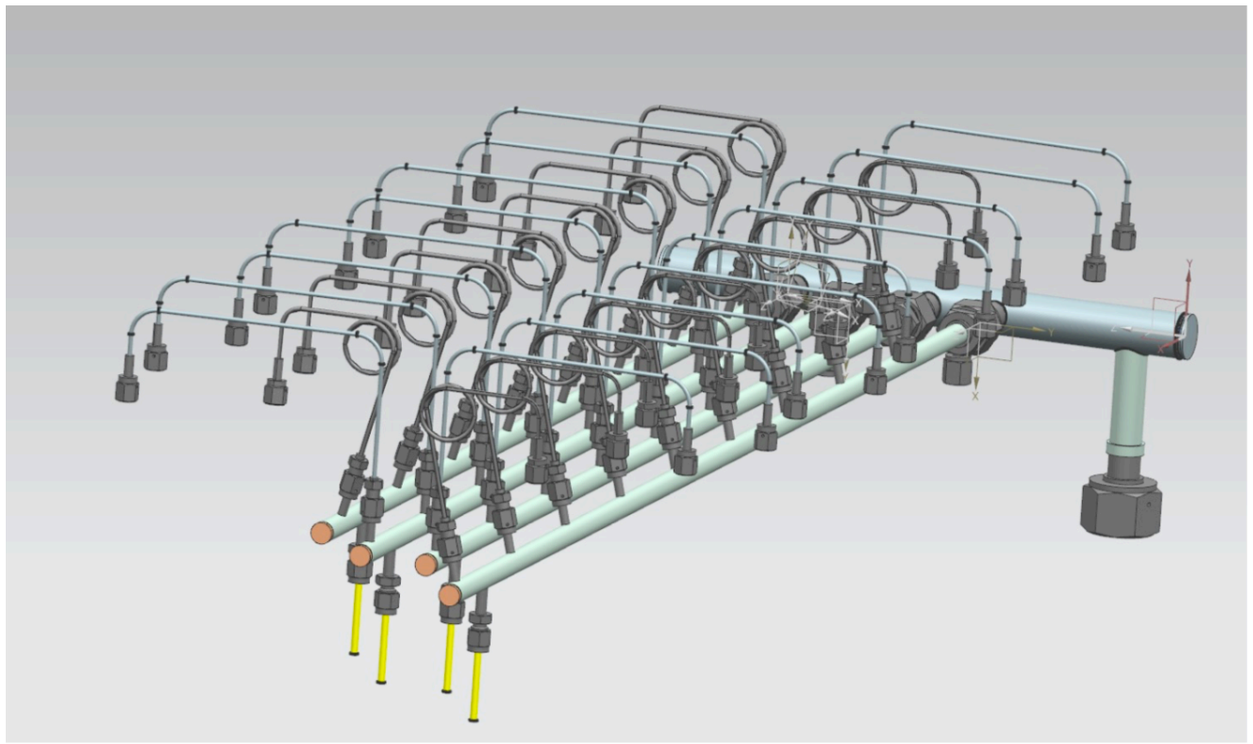




Coelli, Capsoni, Monti, Trotta, Rosati, Viscione

UT CO_2 distribution system

New solution designed in Milano
Prototype in construction

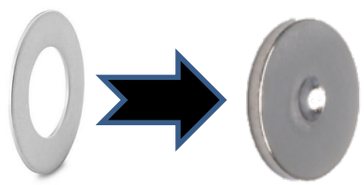


CALIBRATED ORIFICES are used as inlet flow restrictor

Advantages:

- **space saving** in a crowded area
- **no need for 68 capillaries** and additional joints

Replacing VCR gasket with



laser orifices on VCR blind gaskets

LHCb	INFN Istituto Nazionale di Fisica Nucleare Sezione di Milano Via Celoria,16 20133 Milano, Italy	LHCb UT DETECTOR CO2 COOLING DISTRIBUTION PROTOTYPE	
Project Document N. **1970423 v.1**	Institute Document N. -	Created 2018-05-10 Modified: -	Page: **1 of** 10 Rev. N. 0

Description document

LHCb UT DETECTOR CO_2 COOLING DISTRIBUTION PROTOTYPE

This document describes the CO_2 cooling distribution system proposed for the UT detector. The design choices and the technological aspects for the manifolds and connection pipes are described. The working drawings for the prototype production are uploaded in the EDMS document.

Prepared by:	Checked by:	Approved by:
Simone Coelli- INFN MI **Danilo Trotta- INFN MI**		-

Distribution List

Coelli, Trotta, Gesmundo

Equipment in Milano

Bonding machine from CERN
Delvotec FEK6400

Glue dispenser

Dry cabinet

TRACI CO_2 cooling system

Requests

- Activity in Milano in 2019 is crucial for UT project
- Requests:
  - 20% FTE Mauro Citterio (20 m.u. servizio elettronico)
  - 30% FTE Simone Coelli (12 m.u. servizio officina e progettazione meccanica)
  - **Need a laboratory space**

Conference contributions

1)ICHEP 2018, Seul, Korea, 4-11 Aug 2018. Parallel talk “CP violation in b-baryon decays at LHCb”, J. Fu

2) ICHEP 2018, Seul, Korea, 4-11 Aug 2018. Parallel talk “Search for exotic baryonic states at LHCb”, P. Gandini

3)ICHEP 2018, Seul, Korea, 4-11 Aug 2018. Poster “CP violation in b-baryon decays at LHCb”, P. Gandini

4)BEACH18, Peniche, Portugal 17 Jun 2018. Plenary talk “Multi-body charmless b-hadron decays at LHCb”, J. Fu

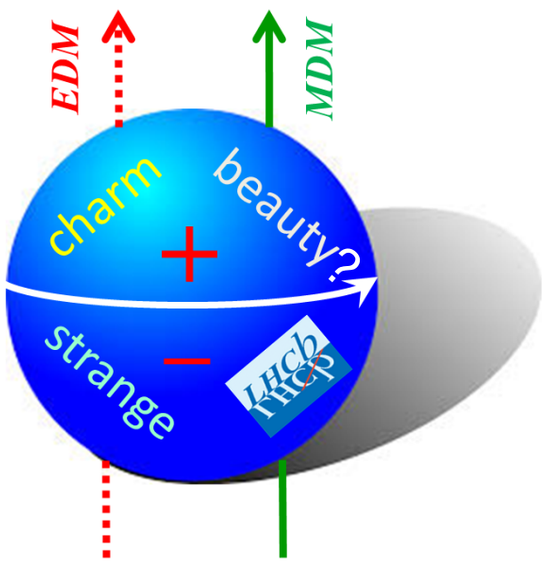
5)LHCP18, Bologna, Italy, 4-9 June 2018. Parallel talk “Fast timing detector developments for a LHCb Upgrade-II”, M. Petruzzo

6)LHCP18, Bologna, Italy, 4-9 June 2018. “Upgrade and future experiment” session convener. N. Neri

7)Beauty18, La Biodola, Italy, 6-11 May 2018. Plenary talk “LHCb Phase-II Upgrade”, N. Neri

8)Lepton Photon 2017, Guangzhou, China, 7 Aug 2017. Poster “Search for new Physics via baryon EDM at LHC”, A. Merli - **Winner of best poster award**

9)Vertex17, Las Caldas, Spain 10-15 Sept 2017. Invited talk “Design and construction of the LHCb Upstream Tracker”, M. Petruzzo



SELDOM

Search for the electric dipole moment of the strange and charm baryons at LHC

Nicola Neri
Istituto Nazionale di Fisica Nucleare, Italy

Proposal n° 771642 SELDOM
ERC CoG PE2

European Research Council
Established by the European Commission

General project information

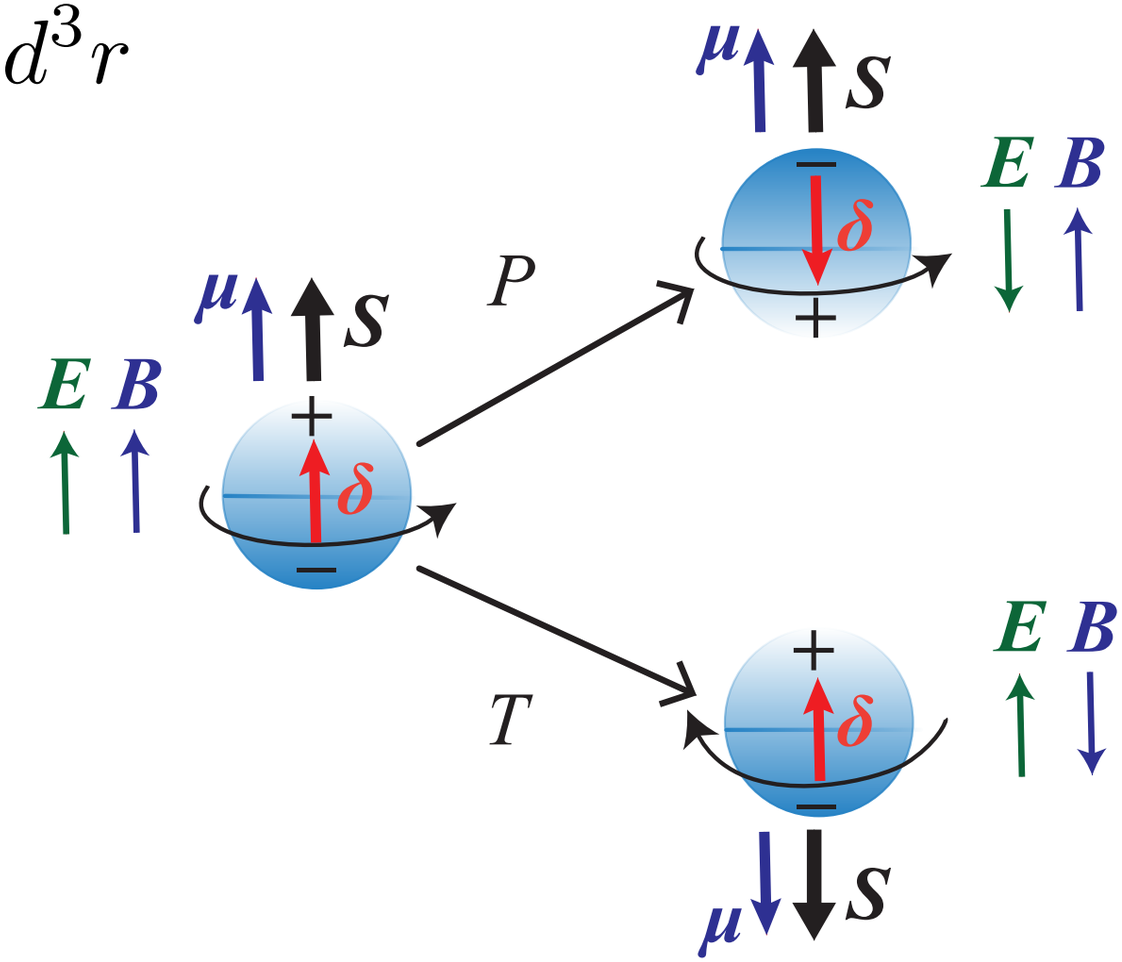
- SELDOM: Search for the electric dipole moment of the strange and charm baryons at LHC
- Scientific program described in EPJC 77(3), 181 (2017)
- Measurements based on the LHCb detector:
  - i) spin precession of long-lived strange baryons in the LHCb dipole magnet, ii) spin precession of charm baryons in bent crystals
- Host Institution: INFN
- Project duration: 60 months (April 2018-April 2023)
- Project budget: 1.933.750 €

Electric dipole moment (EDM)

- Definition $\boldsymbol{\delta} = \int \mathbf{r}\rho(\mathbf{r})d^3r$

- Quantum systems

$$\boldsymbol{\delta} = d\mu_N \frac{\boldsymbol{S}}{2} \qquad \boldsymbol{\mu} = g\mu_N \frac{\boldsymbol{S}}{2}$$



- Hamiltonian

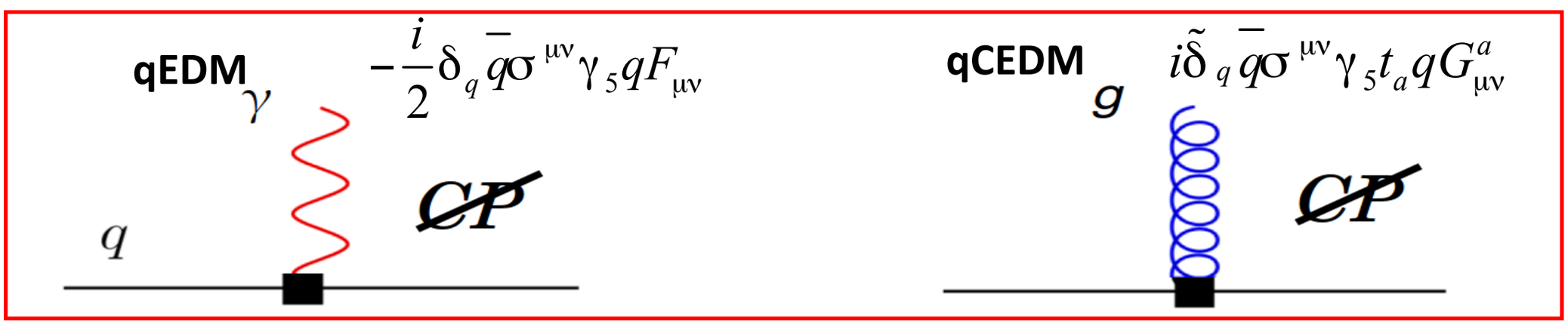
$$H = -\boldsymbol{\delta} \cdot \boldsymbol{E} - \boldsymbol{\mu} \cdot \boldsymbol{B}$$

Time reversal, parity: $d\mu_N \frac{\boldsymbol{S}}{2} \cdot \boldsymbol{E} \xrightarrow{T,P} -d\mu_N \frac{\boldsymbol{S}}{2} \cdot \boldsymbol{E}$

The EDM violates *T* and *P* and via *CPT* theorem, violates *CP*

EDM a possible solution for baryogenesis

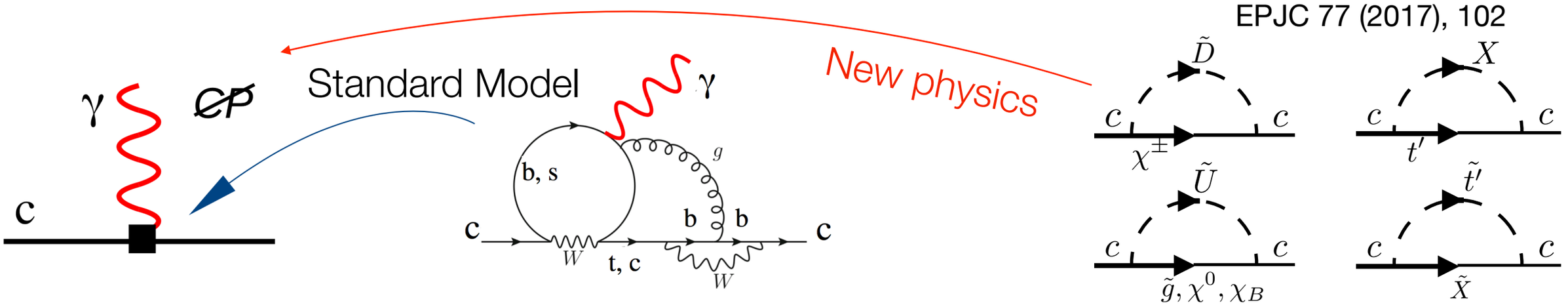
- EDM of fundamental particles from the structure of quarks and gluons, and processes with photon and flavour-diagonal coupling
- A measurement of a heavy baryon EDM is **directly sensitive** to:



Charm EDM in Standard Model ~10^{-32} *e* cm

Charm EDM with new physics ~$5 \cdot 10^{-17}$ *e* cm

EPJC 77 (2017), 102



- EDM observation = clear signature of **new physics**

EDM proposal

Fill the experimental gap in **charm and strange baryon electric and magnetic dipole moment** measurements

EPJC (2017) 77:181

EDM proposal

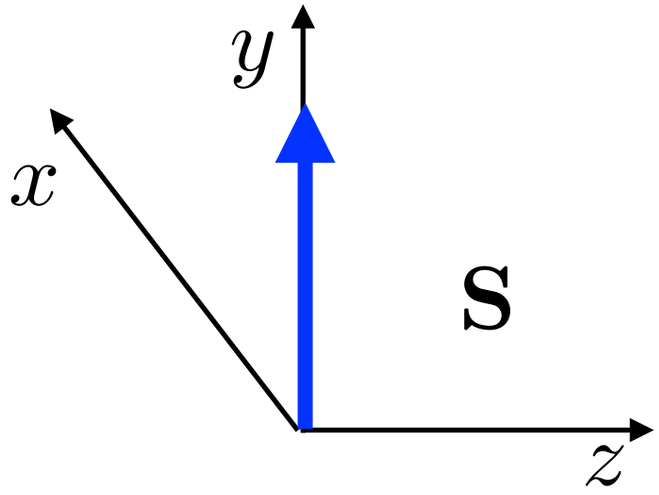
Fill the experimental gap in **charm and strange baryon electric and magnetic dipole moment** measurements

EPJC (2017) 77:181

EDM $\boldsymbol{\delta} = d\mu_N \frac{\mathbf{S}}{2}$ and magnetic dipole moment MDM $\boldsymbol{\mu} = g\mu_N \frac{\mathbf{S}}{2}$

Spin precession in external electromagnetic field (**E*** ⊥ **B*** in particle rest frame)

$$\frac{d\mathbf{S}}{dt} = \boldsymbol{\mu} \times \mathbf{B}^*$$



$\boldsymbol{E}^* = E^* \hat{\boldsymbol{y}}$

$\boldsymbol{B}^* = B^* \hat{\boldsymbol{x}}$

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EPJC (2017) 77:181

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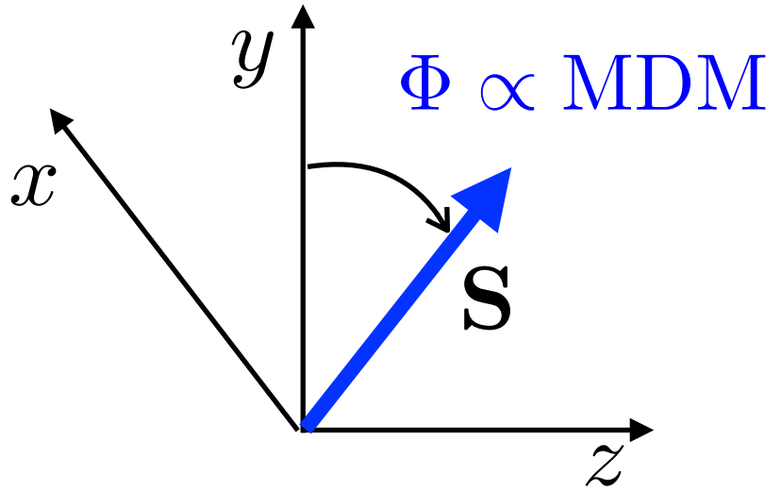

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EPJC (2017) 77:181

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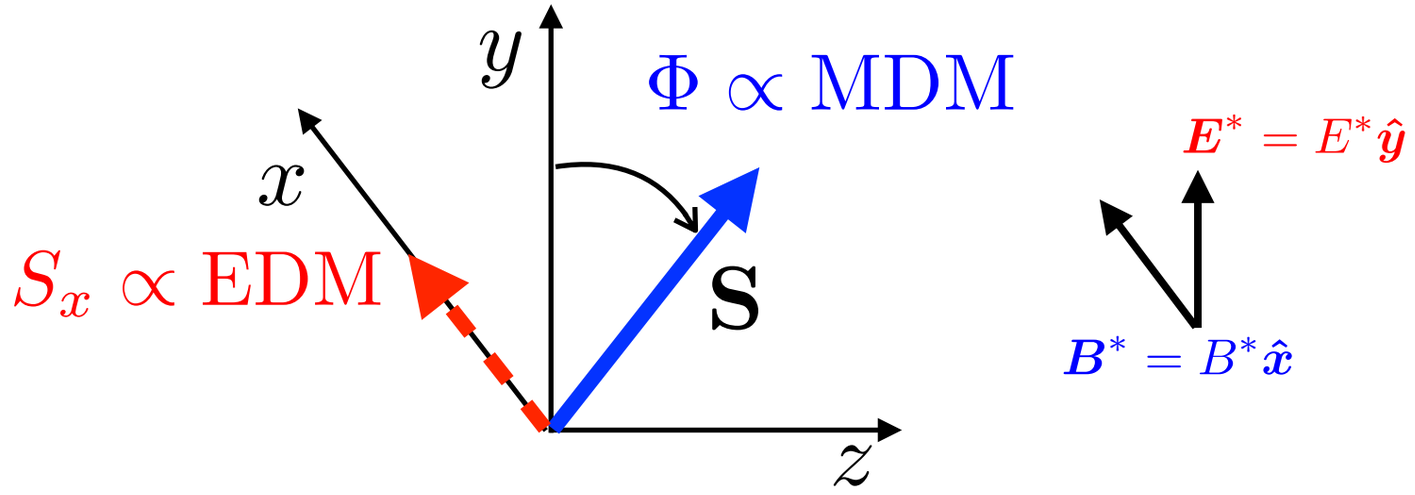
Spin precession in external electromagnetic field (**E*** ⊥ **B*** in particle rest frame)

$$\frac{d\mathbf{S}}{dt} = \boldsymbol{\mu} \times \mathbf{B}^* + \boldsymbol{\delta} \times \mathbf{E}^*$$



EDM proposal

Fill the experimental gap in **charm and strange baryon electric and magnetic dipole moment** measurements

EPJC (2017) 77:181

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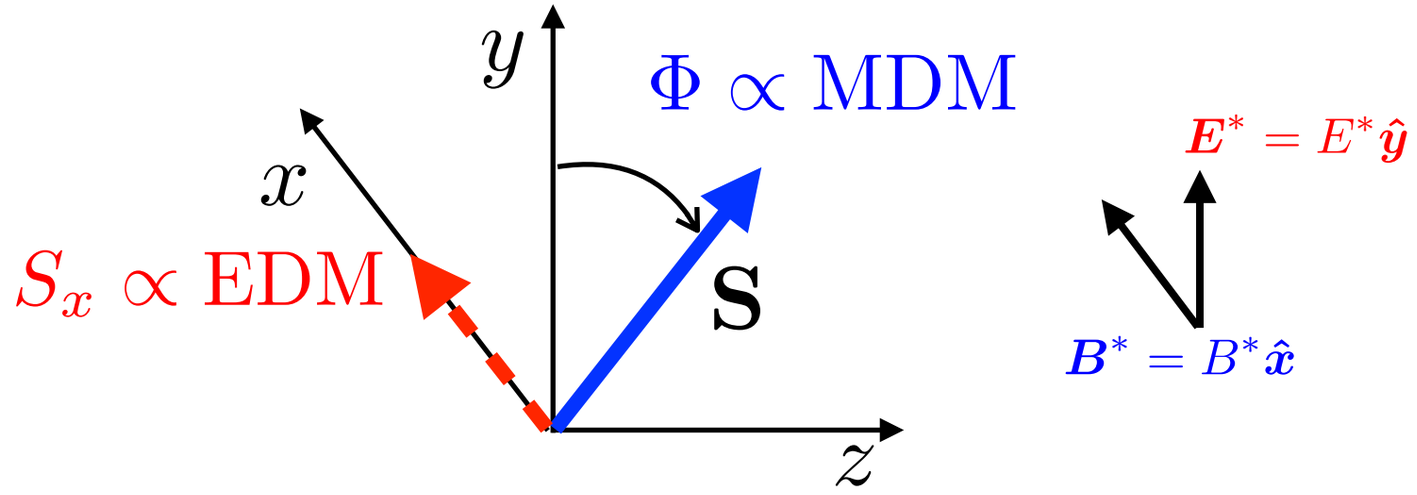
Spin precession in external electromagnetic field (**E*** ⊥ **B*** in particle rest frame)

$$\frac{d\mathbf{S}}{dt} = \boldsymbol{\mu} \times \mathbf{B}^* + \boldsymbol{\delta} \times \mathbf{E}^*$$

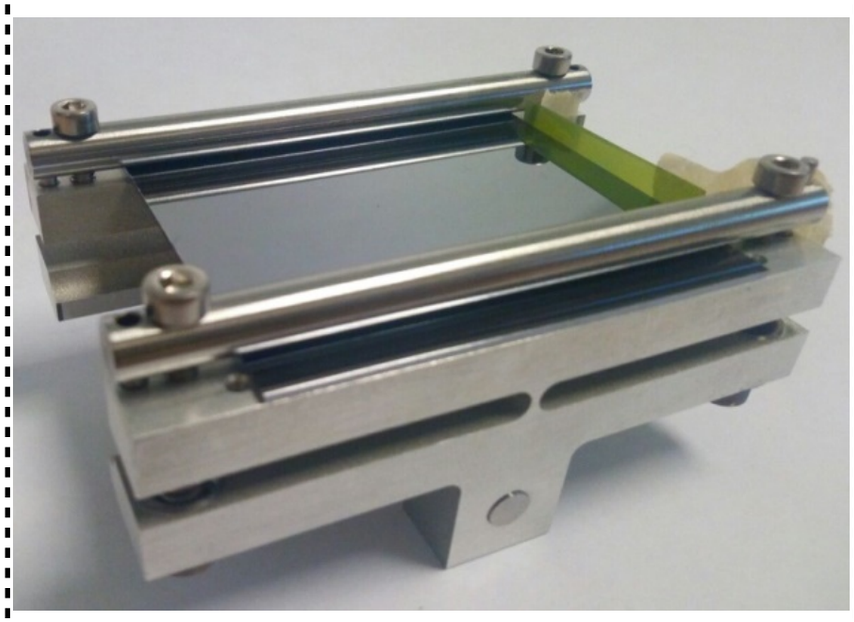


- Necessary sizeable spin precession: $\Phi \propto \frac{geB^*}{mc} t \sim \frac{\pi}{2}$
- "Ad hoc" solutions for charm and strange baryons

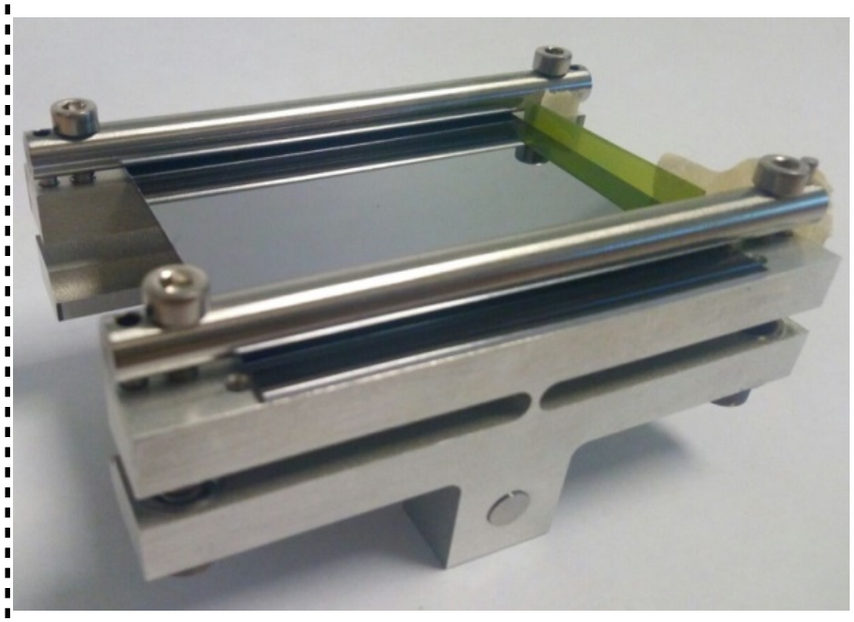
EDM proposal overview

Baryon	Solution	EDM	MDM
Charm Λ_c^+, Ξ_c^+ lifetime ~10^{-13} s	**TeV baryons** uniquely produced at LHC Crystal **channeling** Effective **magnetic field in bent crystals** B≈10^3 T	First search sensitivity ~**10^{-17} *e* cm**	First measurement for **QCD** & baryon internal structure test **<10^{-3} precision**

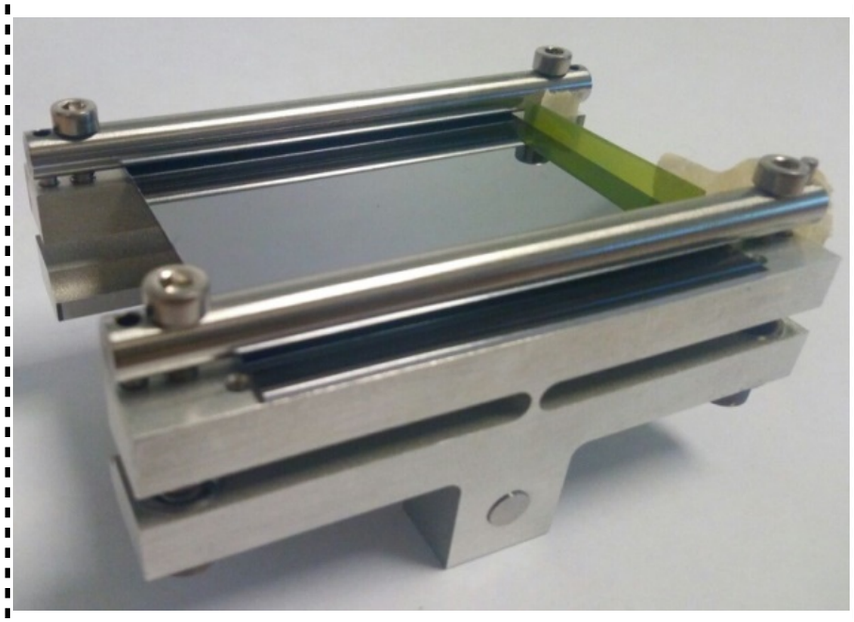
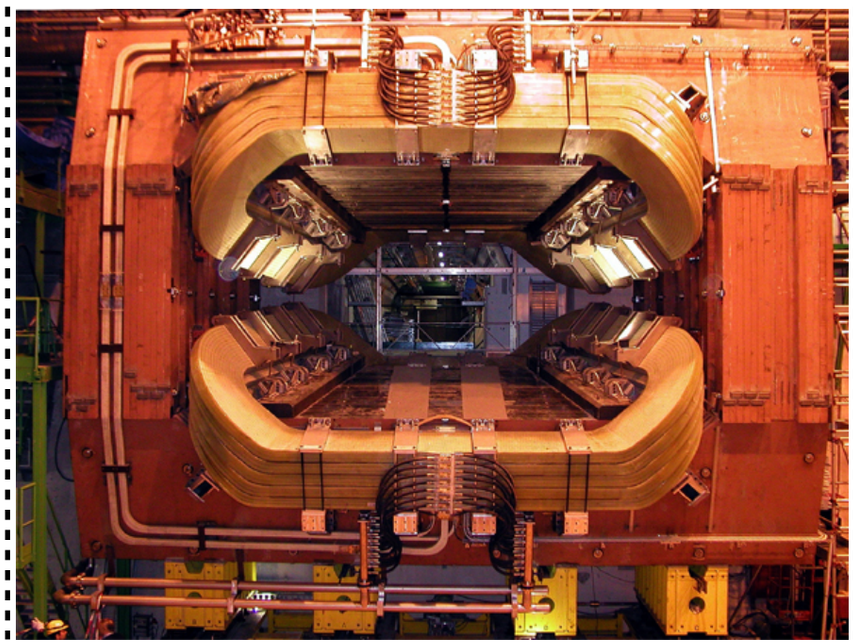
EDM proposal overview

Baryon	Solution	EDM	MDM
Charm Λ_c^+, Ξ_c^+ lifetime ~10^{-13} s		First search sensitivity ~**10^{-17} *e* cm**	First measurement for **QCD** & baryon internal structure test **<10^{-3} precision**

EDM proposal overview

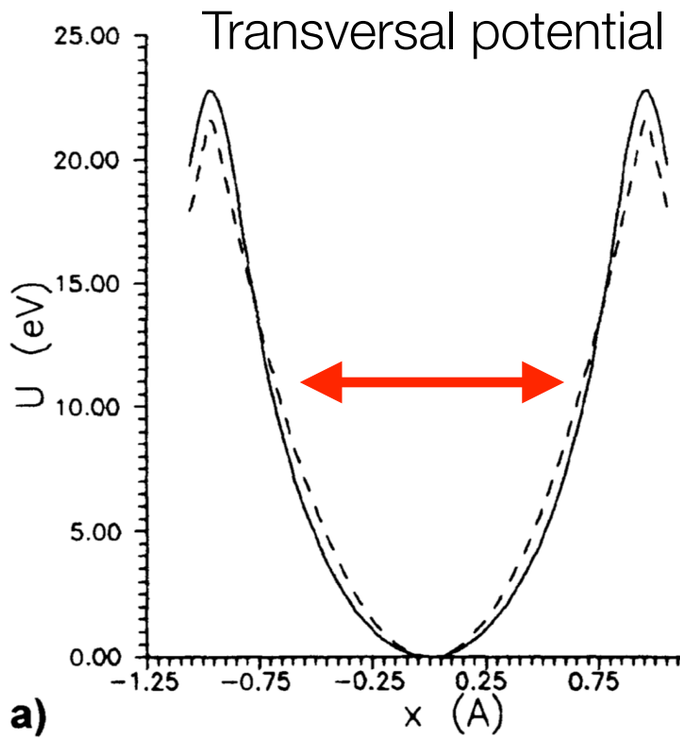
Baryon	Solution	EDM	MDM
Charm Λ_c^+, Ξ_c^+ lifetime ~10^{-13} s		First search sensitivity ~**10^{-17} *e* cm**	First measurement for **QCD** & baryon internal structure test **<10^{-3} precision**
Strange Λ lifetime ~10^{-10} s	Highly boosted and polarised Λ (anti-Λ) from weak charm baryon decays **LHCb** forward detector and **dipole magnet** B~1 T	Push EDM sensitivity of factor 100 **~10^{-18} *e* cm**	First test of **CPT** via strange baryon, anti-baryon MDM **<10^{-3} precision**

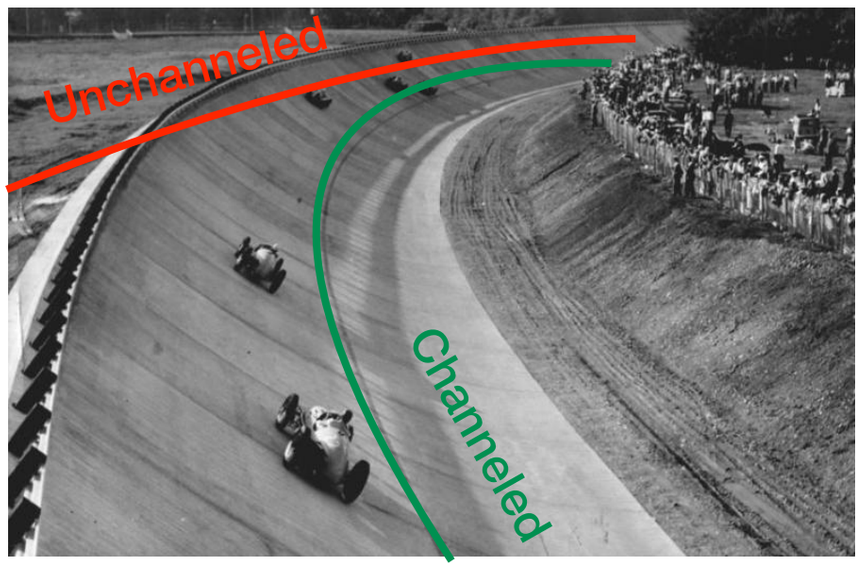
EDM proposal overview

Baryon	Solution	EDM	MDM
Charm Λ_c^+, Ξ_c^+ lifetime ~10^{-13} s		First search sensitivity ~**10^{-17} *e* cm**	First measurement for **QCD** & baryon internal structure test **<10^{-3} precision**
Strange Λ lifetime ~10^{-10} s		Push EDM sensitivity of factor 100 **~10^{-18} *e* cm**	First test of **CPT** via strange baryon, anti-baryon MDM **<10^{-3} precision**

Channeling in bent crystals

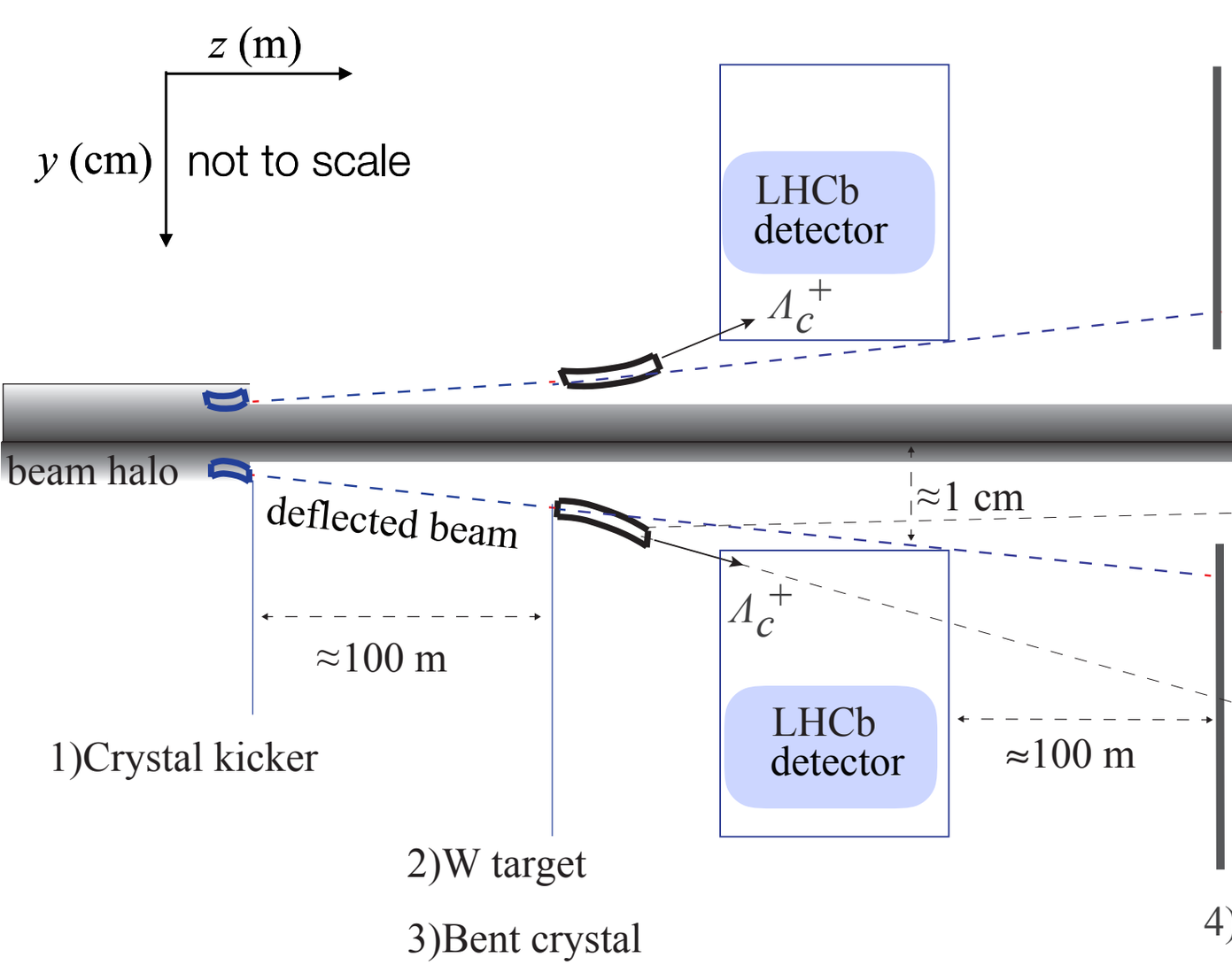
- Potential well between crystal planes
- Incident positive charge particle can be trapped if parallel to crystal plane (within few μrad)
- Well understood phenomenon (Lindhard 1965).
- Bent crystals can be used to:
  - steer high-energy particle beams
  - induce spin precession. Net **E** field in presence of centripetal force

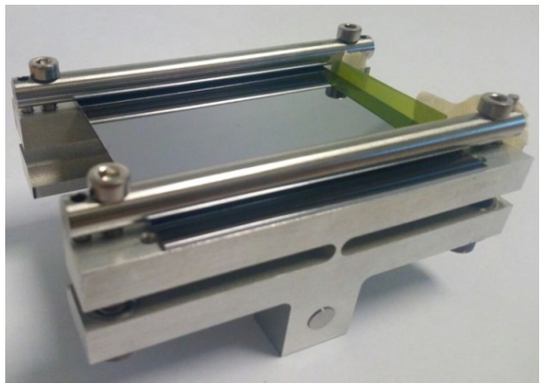


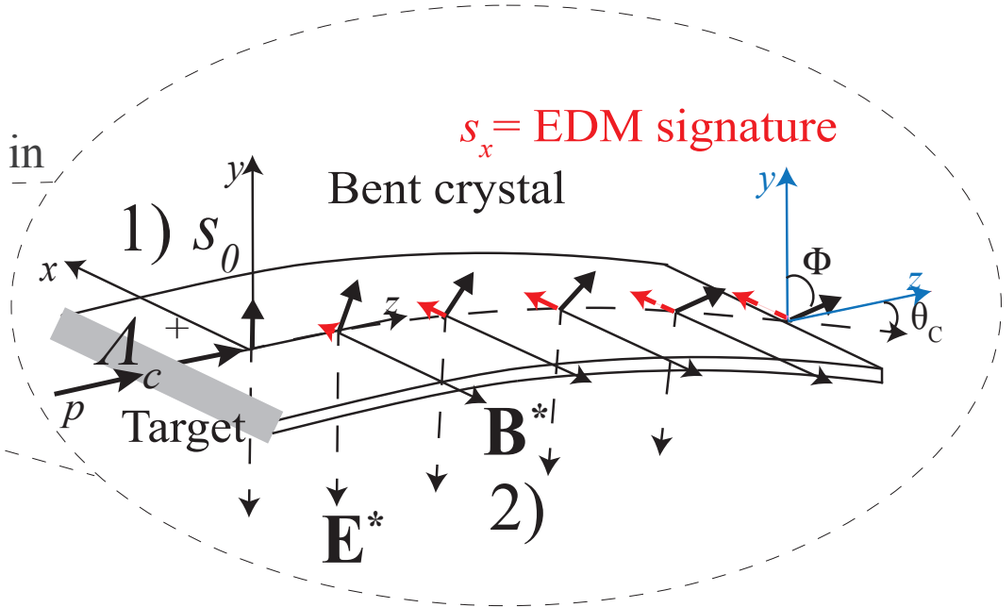


Novel fixed-target experiment at LHC for charm baryons

- EDM/MDM from spin precession of channeled baryons in **bent crystals**



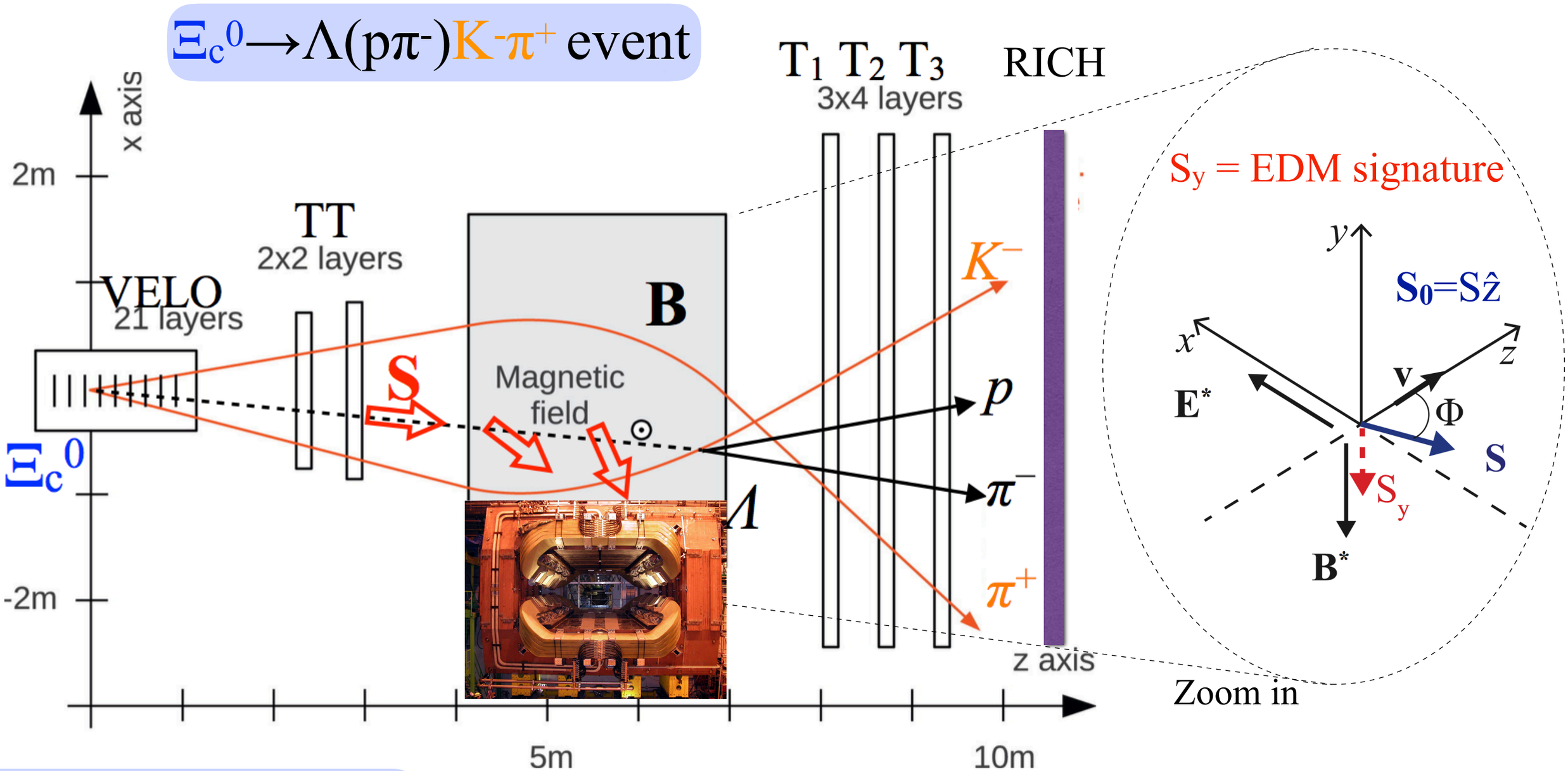




p extraction | Λ_c^+ polarised production | channeling | spin precession | event reconstruction

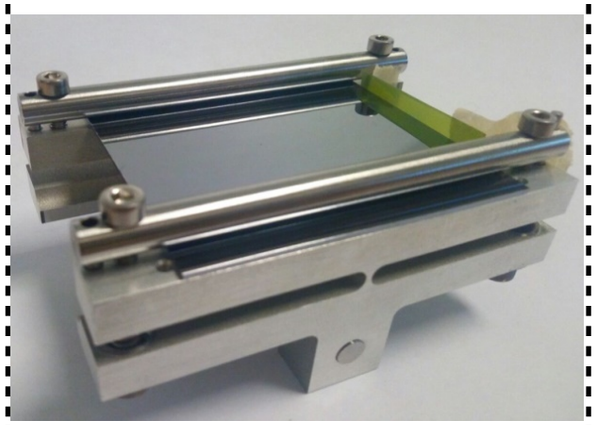
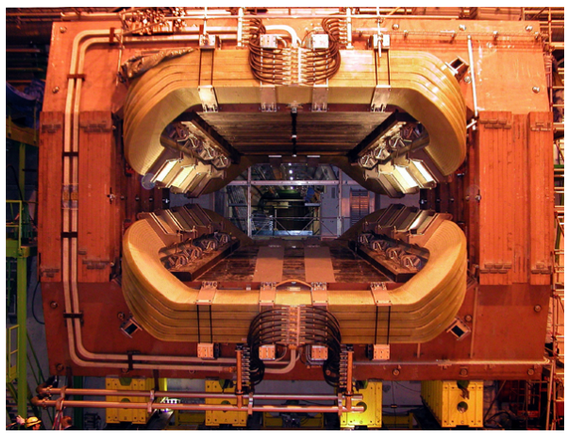
Novel experimental technique for strange baryons

- EDM/MDM from spin precession of Λ baryon in LHCb **dipole magnet**

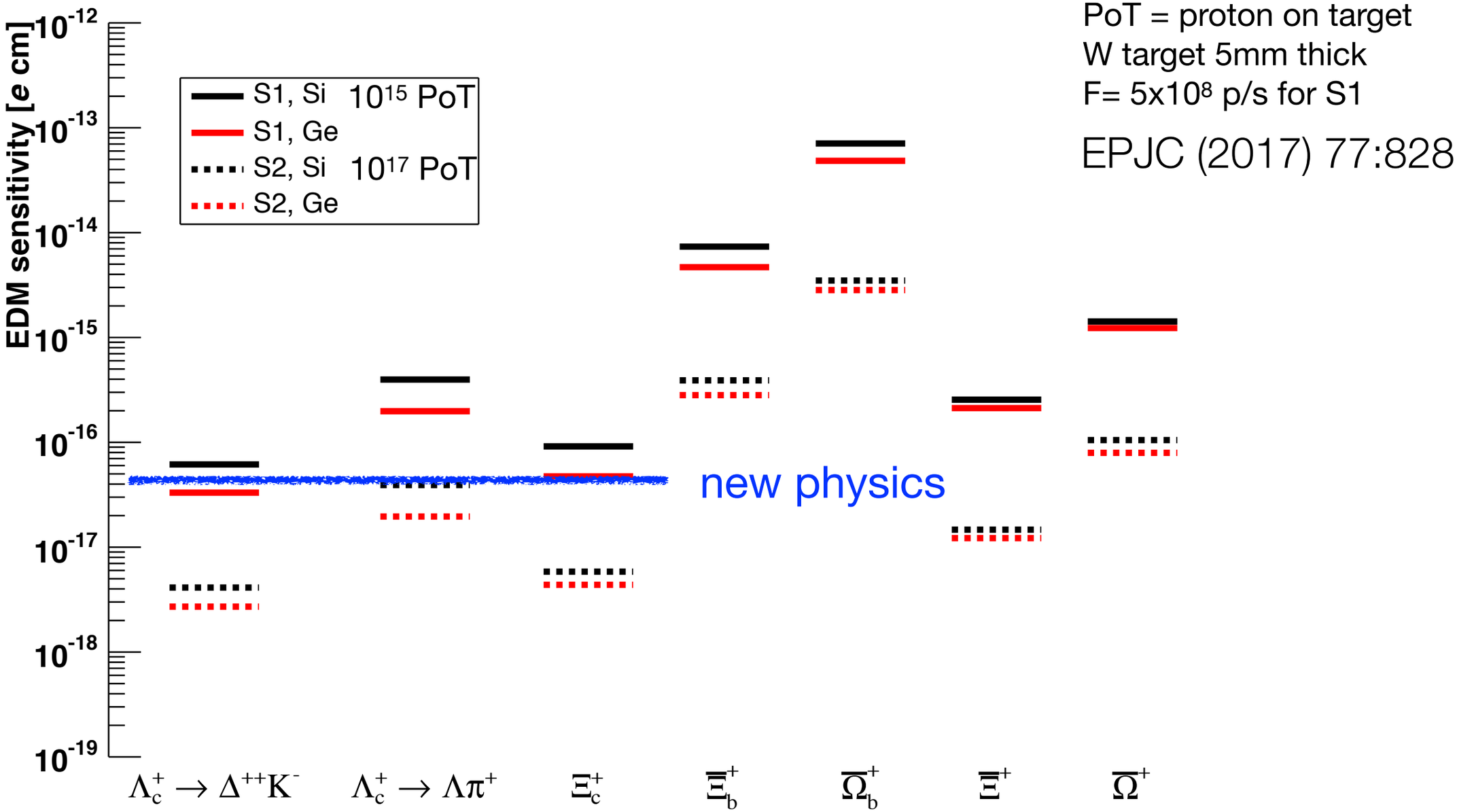


Λ polarised production | spin precession | event reconstruction

Challenges and preliminary results

Baryon	Solution	Challenge	Preliminary
Charm Λ_c^+, Ξ_c^+ lifetime ~10^{-13} s		▸ Fixed-target setup ▸ Bent crystals with large bending angle (≳10 mrad)	✓Crystal kicker tested in LHC ✓Simulations ✓Event reconstruction ✓EPJC (2017) 77:828 New
Strange Λ lifetime ~10^{-10} s		▸ Reconstruction of long-lived Λ baryons after magnet	✓Simulations ✓Kinematic constraints from entire decay chain ✓Λ decay vertex

Sensitivity on EDM



PoT = proton on target
W target 5mm thick
F= 5x10⁸ p/s for S1

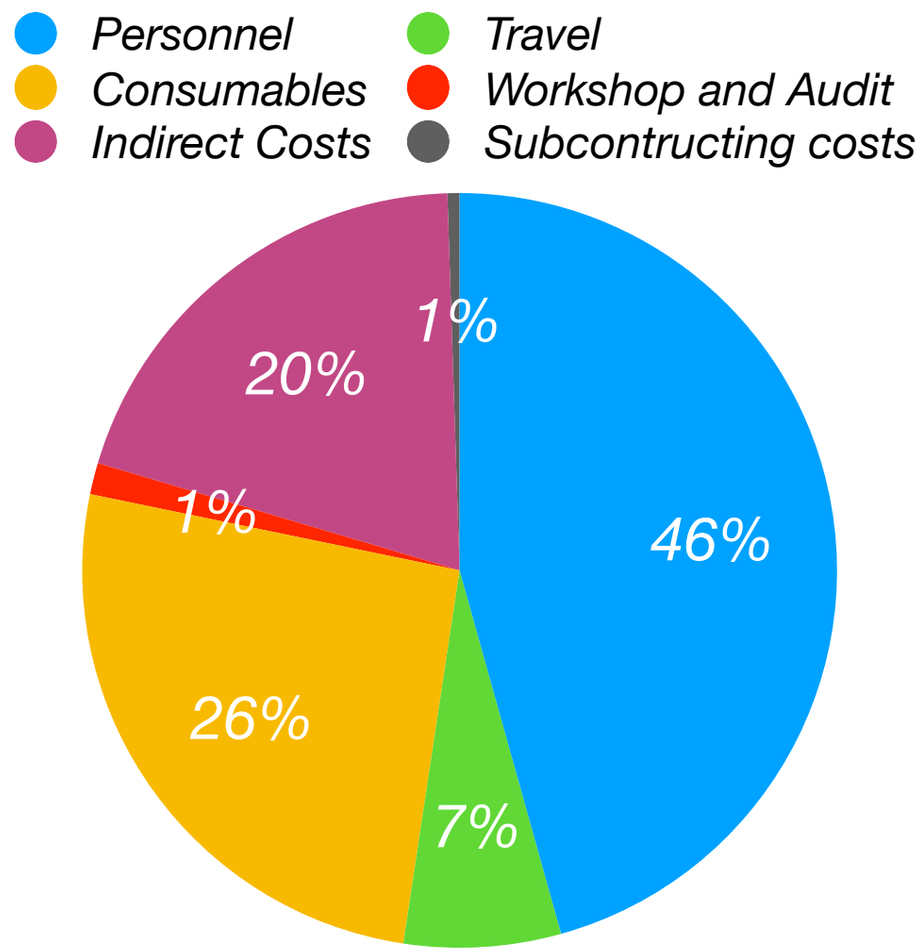
EPJC (2017) 77:828

- All first measurements with sensitivities capable to test new physics models

Funding and resources

- 1 PostDoc for each WP per 5 years
- R&D, construction, test and installation of fixed-target setup in LHCb
- Device construction: goniometers, crystal kickers, long-bent crystals
- Sezioni: Milano, Ferrara

Requested EU contribution:
1.933.750 €



- **Need a laboratory space**
- **10% Coelli, 6 m.u. servizio meccanica**

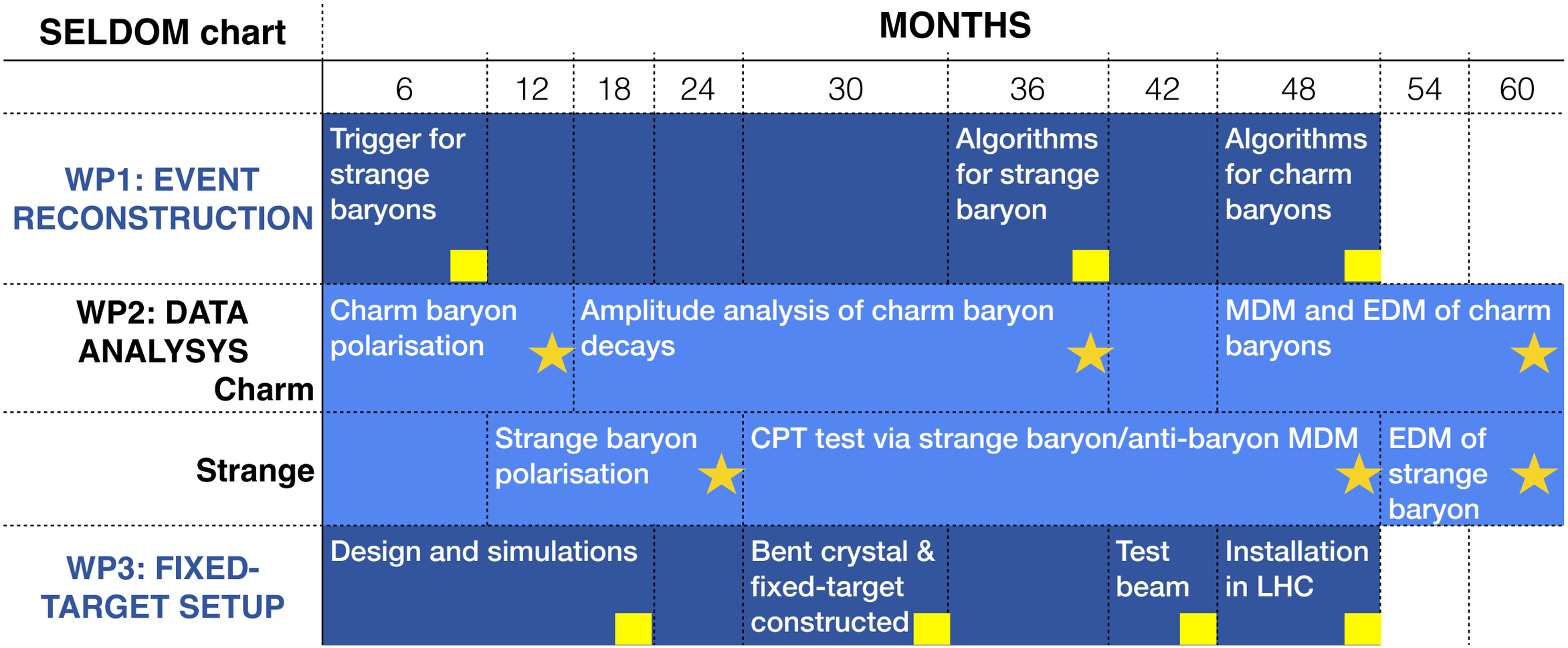
Composizione gruppo di ricerca 2019

Personale	FTE	LHCb (FTE)	TIMESPOT (FTE)	SELDOM (FTE)	Inquadramento
Aiola	1,0			1,0	AR INFN (UE)
Citterio	0,2	0,2	0,0		Dirigente Tecnologo
Coelli	0,4	0,3		0,1	Tecnologo
Frontini	0,45		0,45		Dottorando
Fu	1,0	1,0			AR UniMi
Gandini	1,0	0,6	0,3	0,1	Ricercatore
Lazzaroni	0,3	0,3			PA
Liberali	0,3		0,3		PA
Marangotto	1,0	0,7		0,3	Dottorando
Merli	1,0	1,0			Dottorando
Neri	1,0	0,2	0,2	0,6	Ricercatore
Palombo	0	0			PA in pensione
Petruzzo	1,0	0,7	0,3		AR INFN
Riboldi	0,2		0,2		RU
Spadaro	1,0	0,7		0,3	Dottorando
Stabile	0,05		0,05		RTDA
PostDoc	1,0		1,0		AR (CALL CSN5)
Tot. (FTE)	10,9	5,7	2,8	2,4	

Backup

Organisation of activities

- Work organised in 3 Work Packages (WP)



- Control of project progress with milestones
- Intermediate measurements beyond state of art

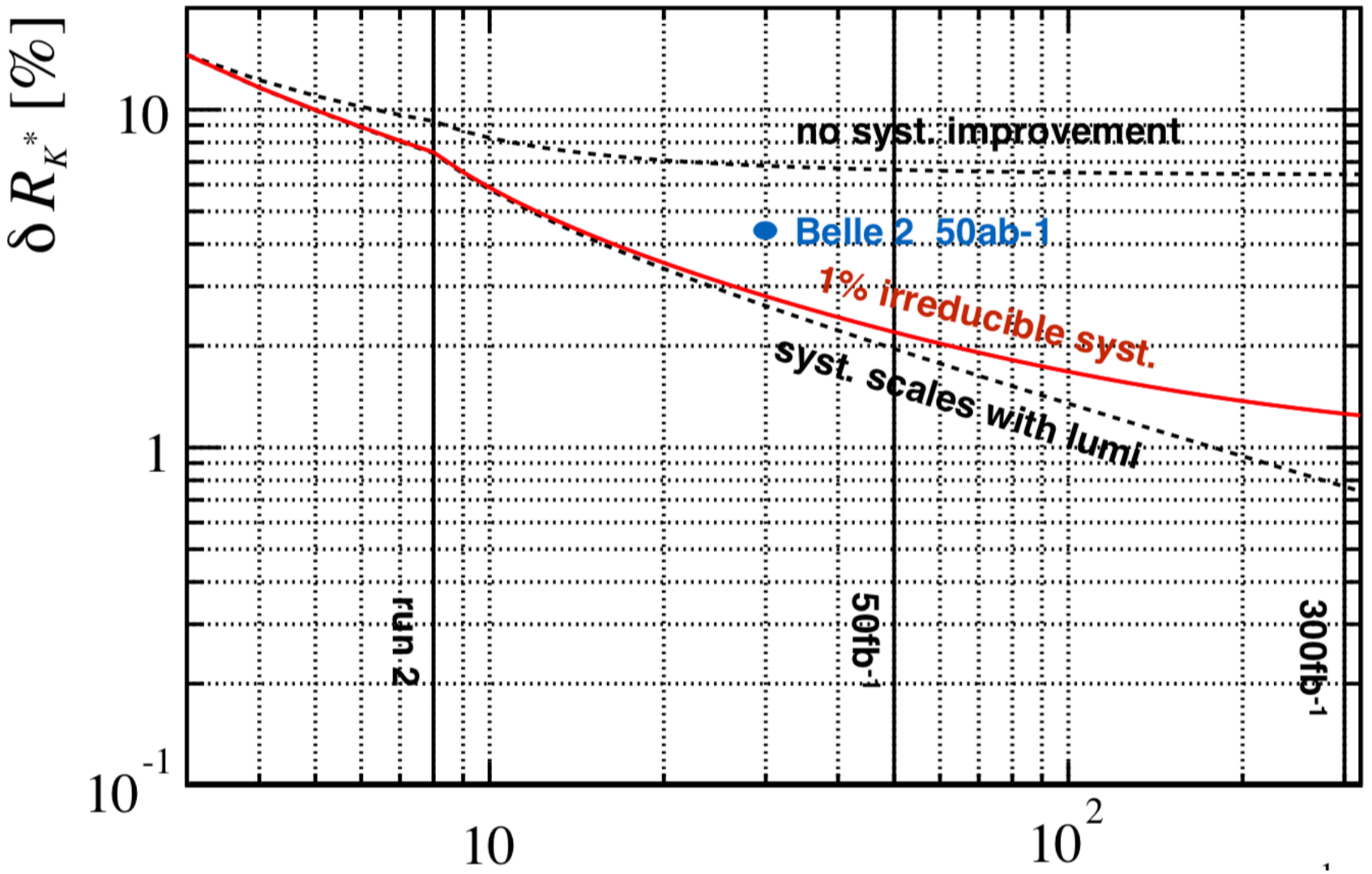
milestone

measurement

WP activities

- WP1: event reconstruction
  - development of trigger strategies and reconstruction algorithms for long-lived Λ baryons and short-lived Λ_c^+ baryons
- WP2: data analysis
  - develop analysis techniques for the measurement of physics observables
- WP3: fixed-target setup
  - design, construction, test and installation in LHCb

Evolution of R_{K^*} error



Assumption: constant ECAL performance

Systematics from limited modelling of bremsstrahlung

Reduced material before the magnet would help

Observable ($1.1 < q^2 < 6.0\,\mathrm{GeV}^2/c^4$)		Run 1 result	$8\,\mathrm{fb}^{-1}$	$50\,\mathrm{fb}^{-1}$	$300\,\mathrm{fb}^{-1}$
R_K	$B^+ \to K e^+ e^-$	$0.745 \pm 0.090 \pm 0.036$ [313]	0.04	0.015	0.006
$R_{K^{*0}}$	$B^0 \to K^{*0} e^+ e^-$	$0.69 \pm 0.11 \pm 0.05$ [312]	0.06	0.020	0.008
R_ϕ	$B_s^0 \to \phi e^+ e^-$	–	0.13	0.05	0.02
R_{pK}	$\Lambda_b^0 \to pK e^+ e^-$	–	0.08	0.03	0.01
R_π	$B^+ \to \pi^+ e^+ e^-$	–	–	0.06	0.03

TIMESPOT:
TIME SPace realtime Operating Tracker

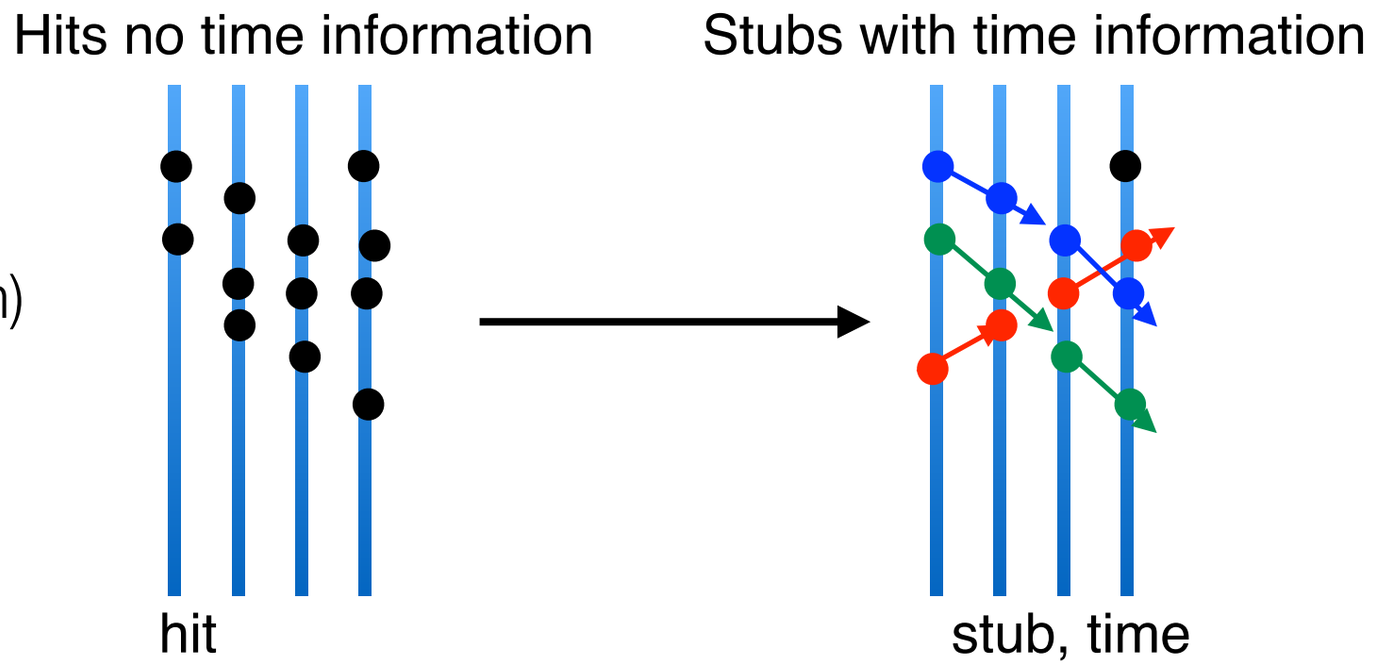
Progetto call CSN5

Consiglio di Sezione

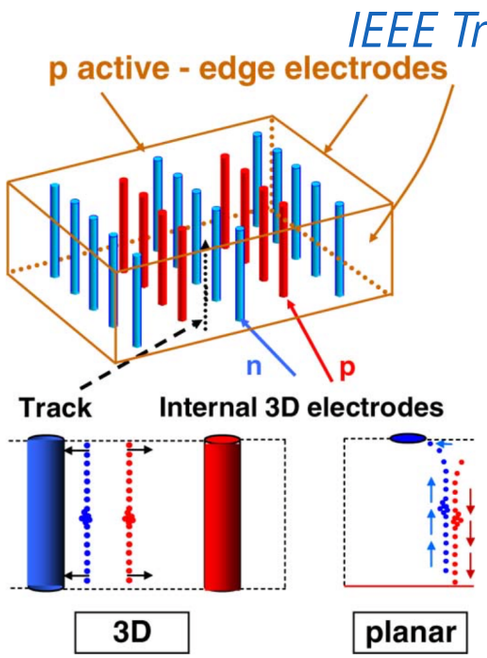
Milano, 9 luglio 2018

Rad-hard pixel detector for 4D real-time tracking

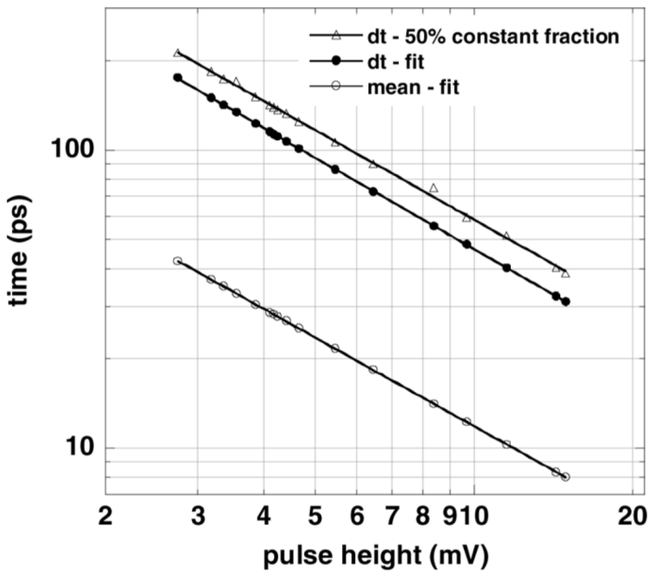
- For high luminosity LHC experiments
- Develop rad-hard pixel detector prototype with precise space (<100 μm) and time information (<100 ps)
- Real-time 4D tracking based on dedicated FPGA processors



3D silicon sensor technology: rad-hard $10^{16} n_{eq}/cm^2$, sub ns performance achievable



IEEE Trans. Nucl. Sci. 58 (2011) 404-417



- $\vec{x} \longrightarrow$  $(\vec{x}_1, \vec{x}_2, t_1, t_2)$

- Develop in the project:
  - Fast 3D silicon and diamond sensors
  - Front-end chip
  - DAQ board for real-time tracking

Milano contribution

- Responsabile nazionale A. Lai (Cagliari): 10 sezioni INFN, ~20 FTE, 6 work packages
- Milano activities (3 year project):
  - Front-end chip (V. Liberali, WP3 coordinator): design, production and test of chip prototype
  - Fast tracking device: (N. Neri, WP4 coordinator): simulation, test of the performance on FPGA, design of optimised board
  - System integration and test: prototype characterisation in laboratory and on beam
- Additional resources: 1 PostDoc (2 years AdR, 46 kEuro), travelling 36 kEuro

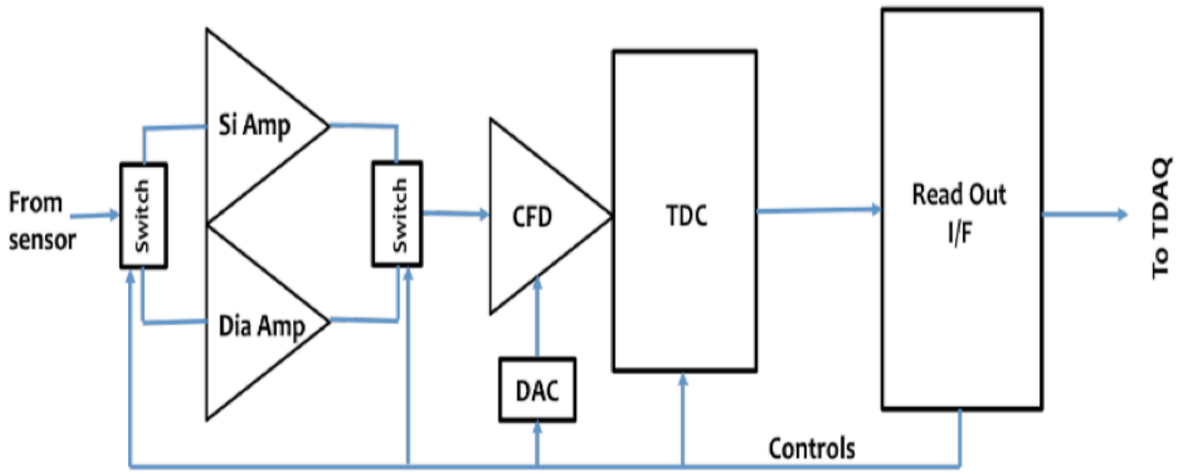
1. WP1: 3D silicon sensors (Dalla Betta, TN)
2. WP2: 3D diamond sensors (Sciortino, FI)
3. WP3: Front-end chip (Liberali, MI)
4. WP4: Fast tracking device (Neri, MI)
5. WP4: High speed DAQ (Gabrielli, BO)
6. WP6: System integration and test (Cardini,CA)

Composizione gruppo di ricerca Milano

Personale	TIMESPOT(FTE)	Inquadramento
M. Citterio	0,0	Dirigente Tecnologo
L. Frontini	0,45	Dottorando UniMi
P. Gandini	0,2	Ricercatore INFN
V. Liberali	0,3	PA UniMi
N. Neri	0,3	Ricercatore INFN, Resp. Loc.
M. Petruzzo	0,3	Dottorando UniMi
S. Riboldi	0,2	Ricercatore UniMi
A. Stabile	0,05	RTDA UniMi
PostDoc	1,0	AR Call
Tot. (FTE)	2,8	

Activities in Milano

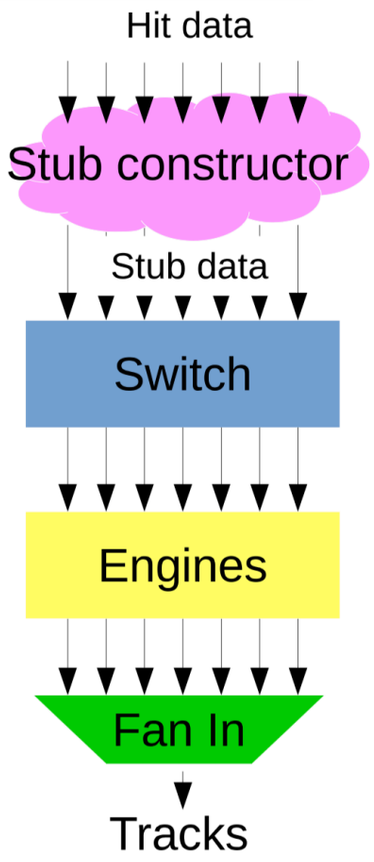
- WP2: design of ASIC in 28nm TSMC CMOS technology
- Preparing first mini@asic submission in Oct 2018

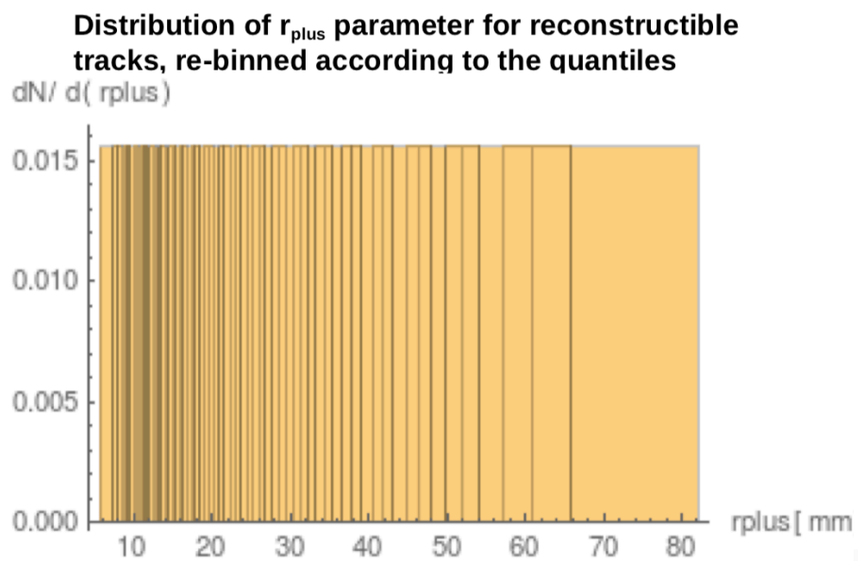


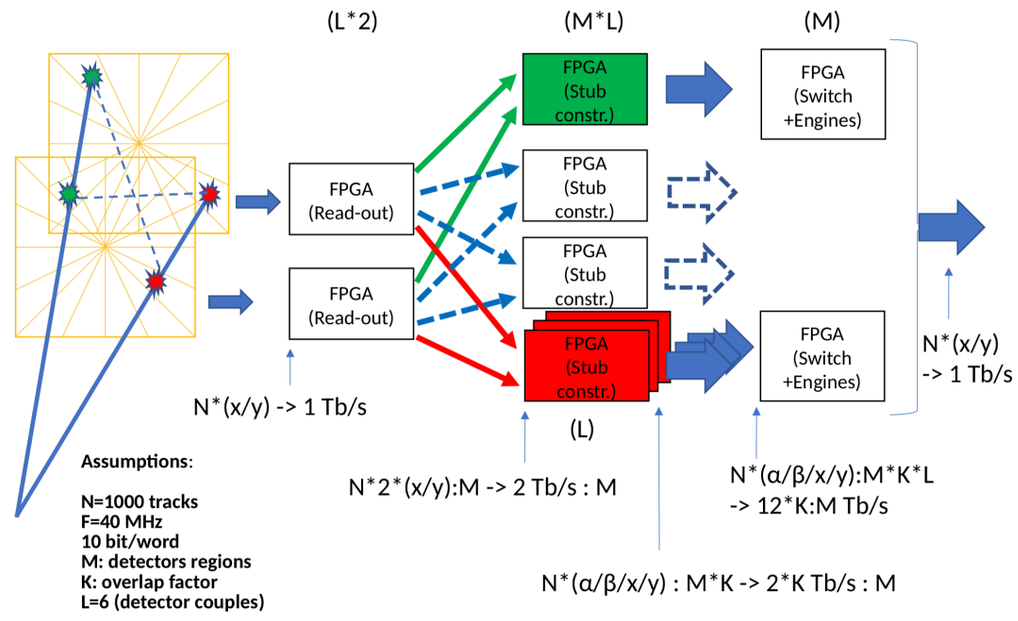
	Cagliari	Milano	Torino
CSA			×
Discriminator			×
TDC	×		
DAC	×	×	
BandGap		×(+BG)	
LVDS		×(+BG)	
OpAmp (Voltage Buffer)	×	×	
Standard cells		×	
[Digital I/F]			

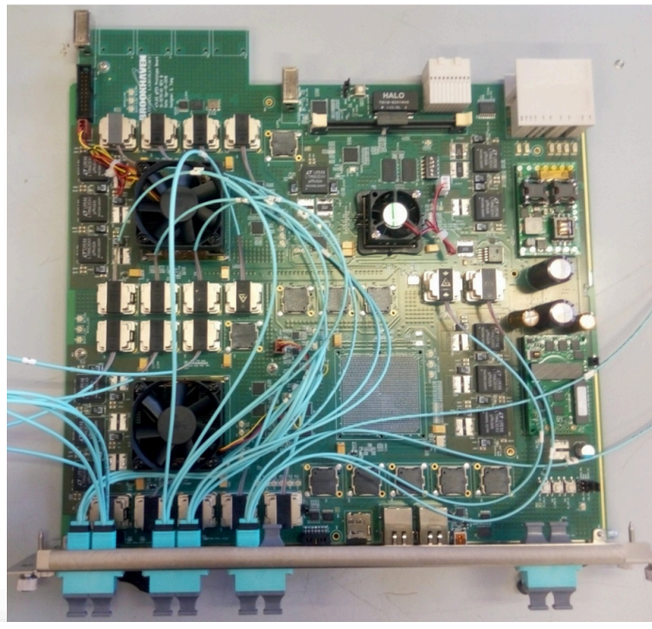
Activities in Milano

- WP4: fast tracking device
- Tracking algorithm optimisation ✔
- Architecture design ✔
- Implementation in hardware ✔
- Test (in progress)









Richieste

- Mini asic 28nm TSMC (2nd prod), 22 kEuro
- IC verification at IMEC, 5 kEuro
- Packaging for standalone IC test, 5 kEuro
- AR, 23 kEuro
- FMC card + optical fibers, 3 kEuro
- Travel expenses, 14 kEuro