Research in Physics: the new frontiers

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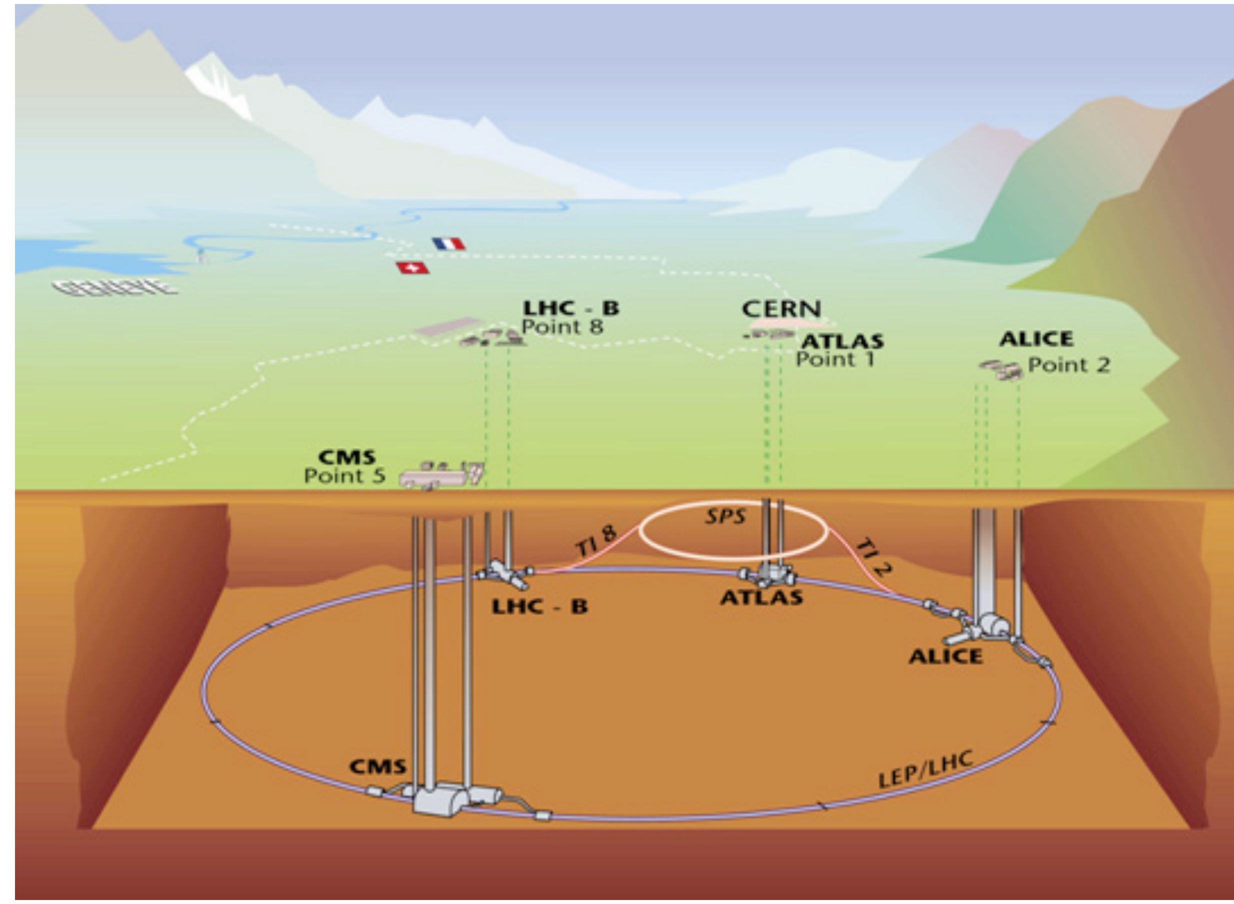
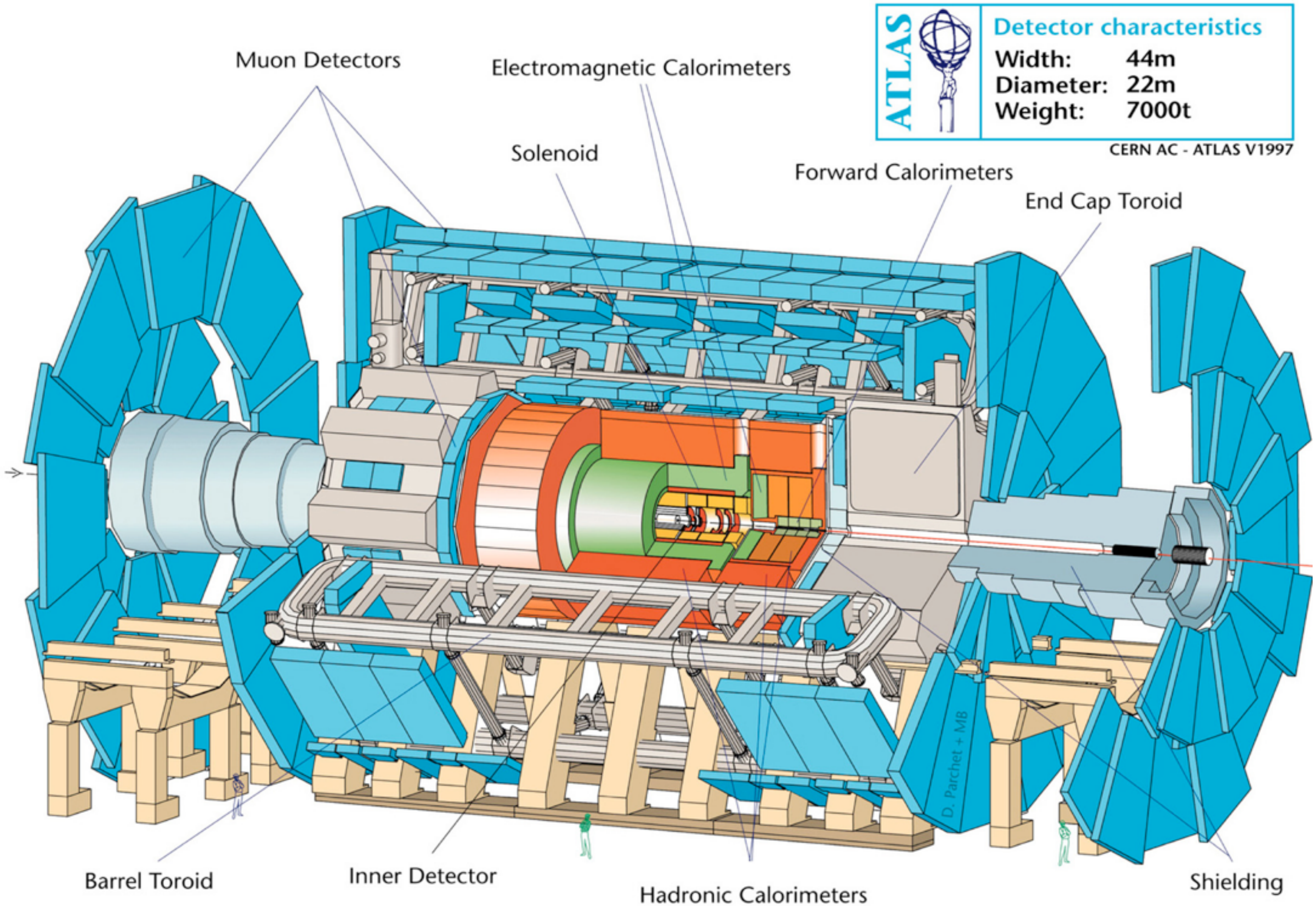
Large Hadron Collider



- Produrre collisioni ad un'energia simile a quella di pochi istanti dopo il Big Bang e studiare cosa avvenne
- Verificare nuove teorie piu' generali rispetto al Modello Standard secondo cui le quattro forze in Natura sono manifestazioni di una sola forza (Grande Unificazione)
- Produrre forme di materia e forze non piu' esistenti
- Capire perche' la materia prevale sull'antimateria
- Capire com'e' fatta e come si e' originata la materia oscura

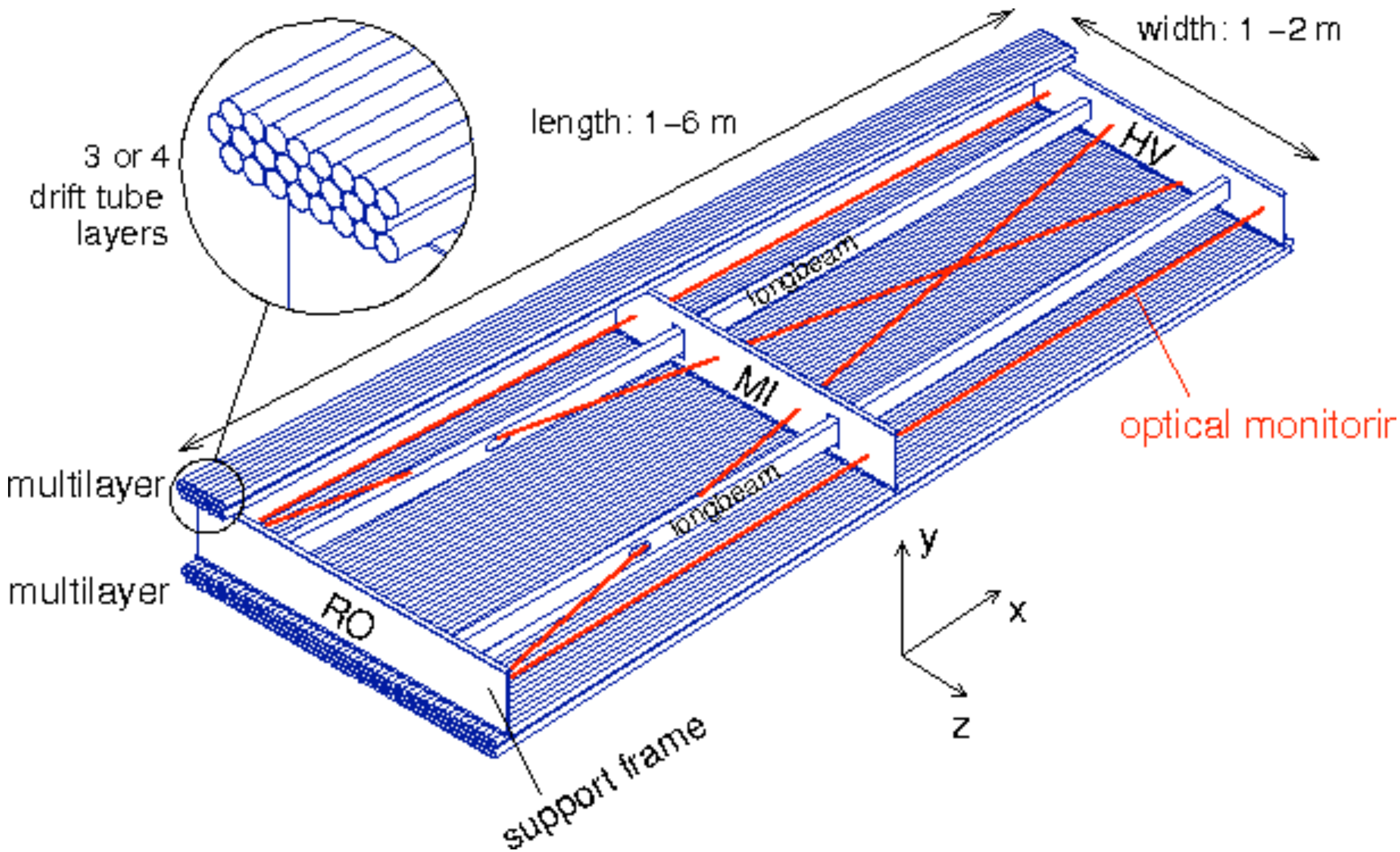
L'esperimento ATLAS



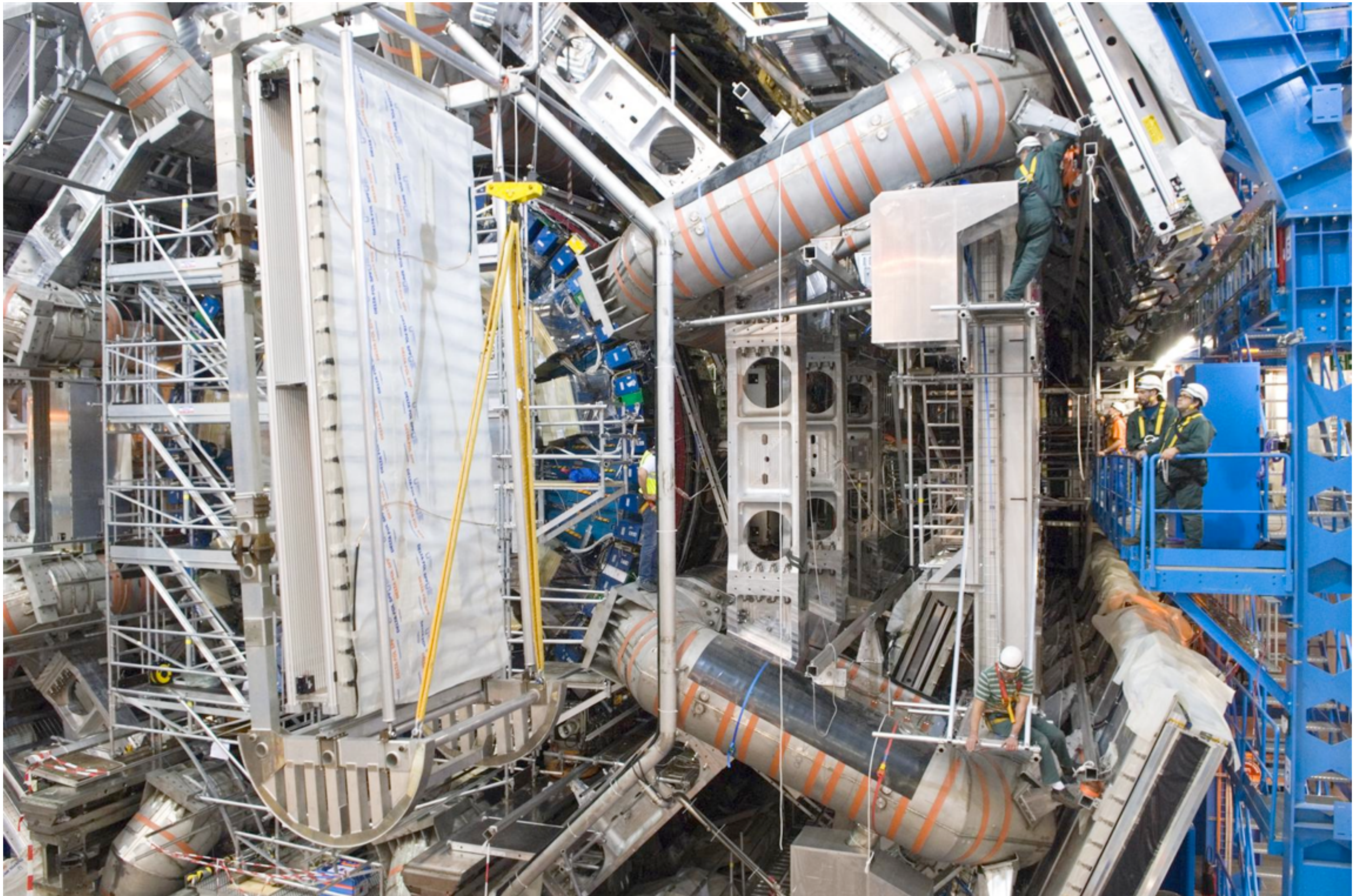
L'esperimento ATLAS è frutto di una collaborazione internazionale che coinvolge:

- 40 nazioni
- 170 Università e Istituti di ricerca
- 3000 fisici

L'UNICAL/INFN-CS in ATLAS

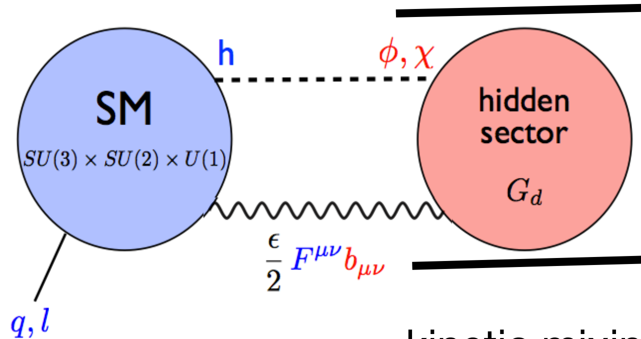


L'UNICAL/INFN-CS in ATLAS



Search for New Physics: Hidden Sector theories

Several BSM models predict the existence of a new (hidden) sector weekly coupled to SM

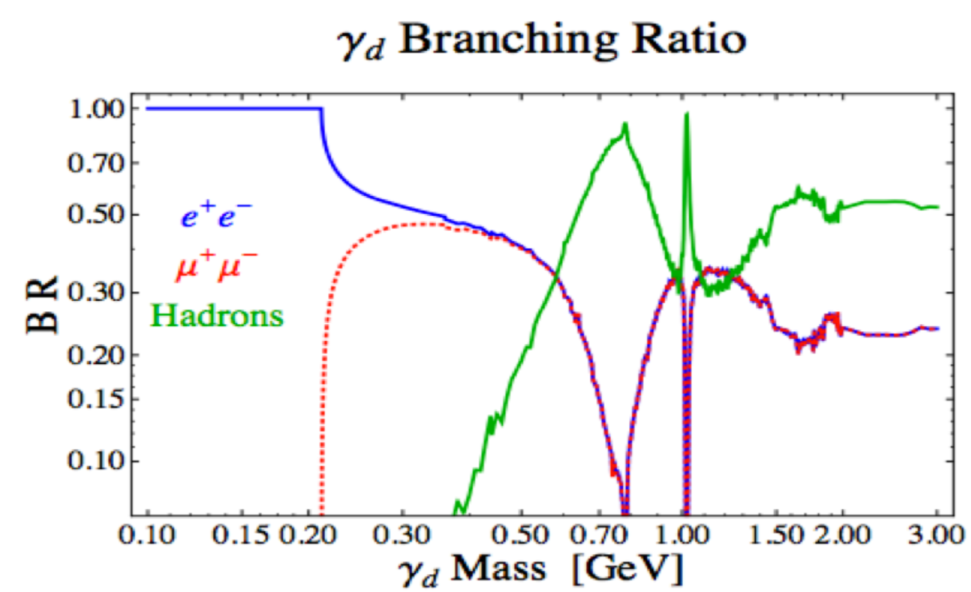


Portal to hidden sector: e.g. higgs or supersymmetric particles

Lightest hidden particles (**dark-photons (γ_d) or v-pion (π_v)**) decay back, via kinetic mixing with standard photon, to pairs of leptons or hadrons.

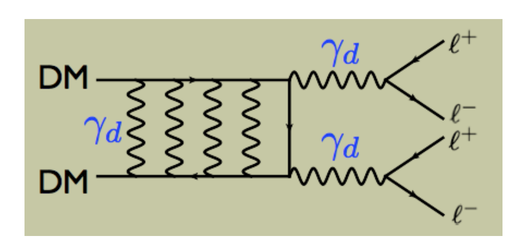
kinetic mixing

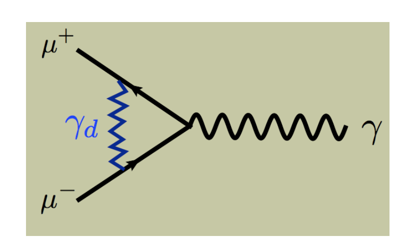
$$\mathcal{L} \supset \frac{\epsilon}{2} F^{\mu\nu} b_{\mu\nu} + m^2_{\gamma_d} b^2$$



Lightest hidden particle lifetime depends on the size of kinetic mixing (ε)
small ε → displaced decays

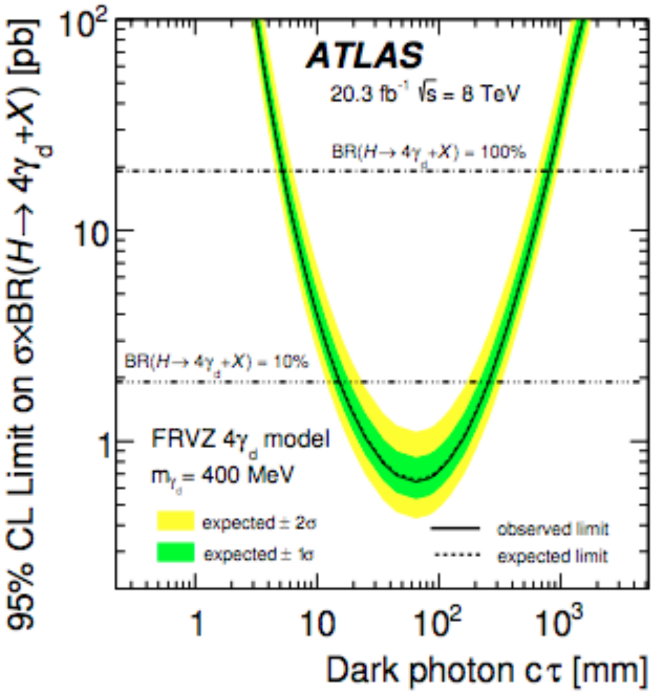
- (Some) motivations
  - Excess of positron flux in cosmic rays (not anti-proton) → if DM annihilates to a hidden sector it would produce leptons
  - $(g_s\text{-}2)_\mu$ anomaly: comparing theory to experiment there is a 3.2σ discrepancy → anomaly can be explained including corrections from an hidden photon

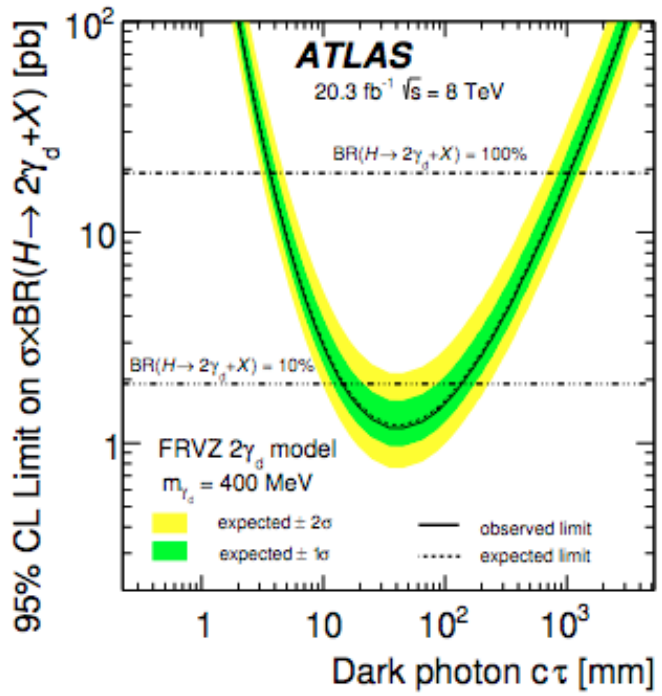




Search for displaced dark photons in 8TeV pp collisions

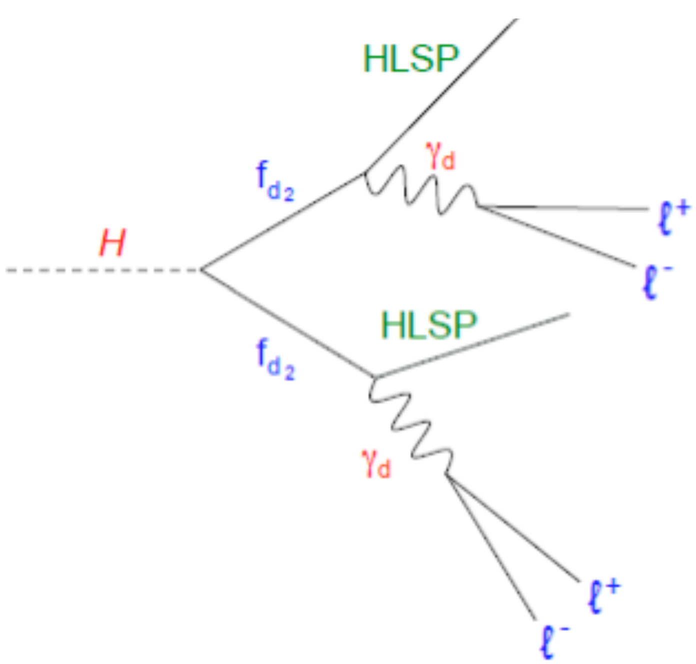
- Search for displaced light hidden particles decay to leptons/hadrons
- No events observed over the estimated background
- Exclusion limits on Higgs [σ x branching fraction to LJs] in benchmark models, as function of γ_d lifetime

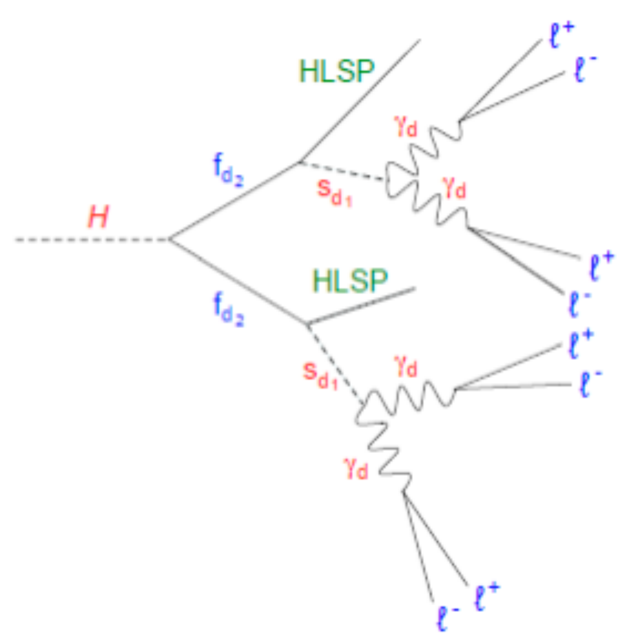


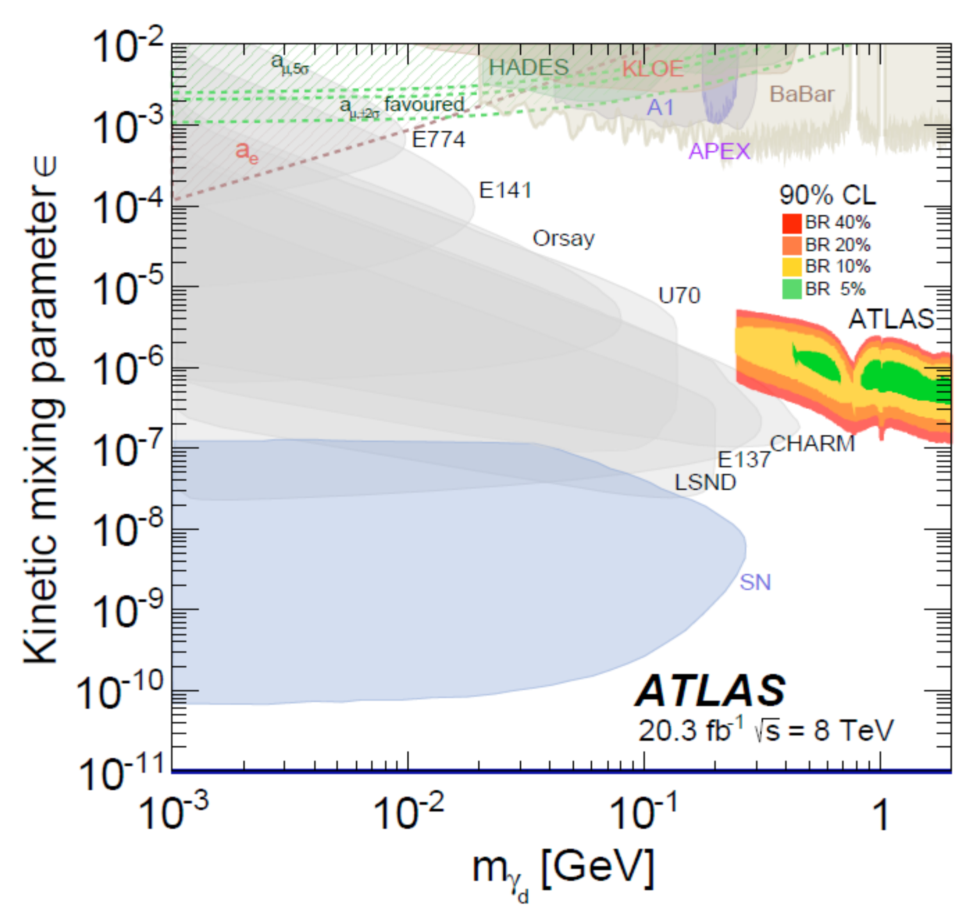


FRVZ model	Excluded $c\tau$ [mm] BR(10%)
$H \to 2\gamma_d + X$	$14 \le c\tau \le 140$
$H \to 4\gamma_d + X$	$15 \le c\tau \le 260$

- Interpretation in the dark matter exclusion plot that allows comparisons with wide variety of other experiments



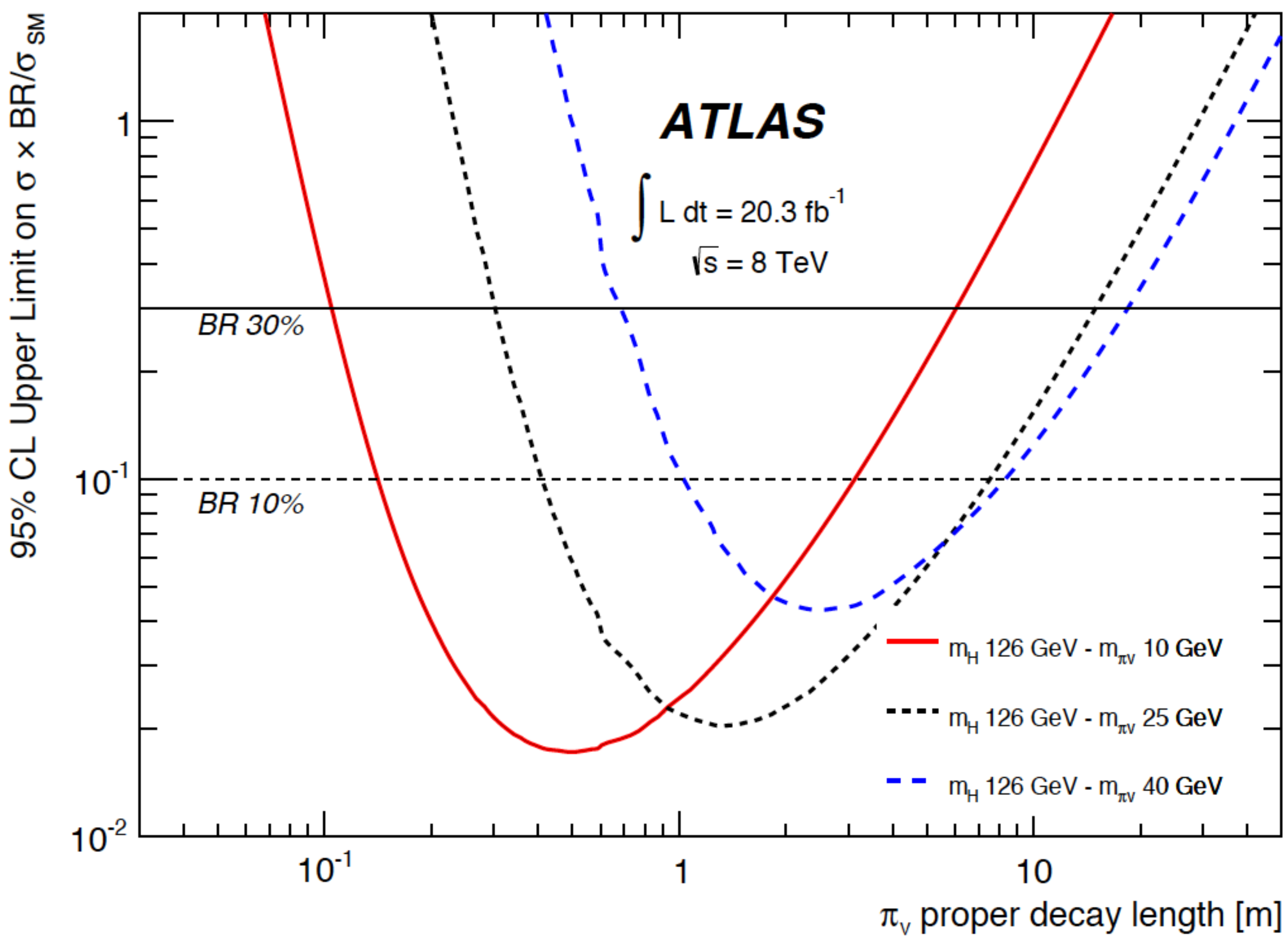




A collaboration of INFN Cosenza, INFN Roma1, U. Toronto
To be continued with LHC Run2 at 13 TeV

Search for pair-produced long-lived neutral particles decaying to hadrons in the ATLAS hadronic calorimeter in pp collisions at 8 TeV

- The ATLAS detector at the Large Hadron Collider at CERN is used to search for the decay of a scalar boson to a pair of long-lived particles, neutral under the Standard Model gauge group, in 20.3 fb-1 of data collected in proton–proton collisions a 8 TeV.
- This search is sensitive to long-lived particles that decay to Standard Model particles producing jets at the outer edge of the ATLAS electromagnetic calorimeter or inside the hadronic calorimeter.
- No significant excess of events is observed. Limits are reported on the product of the scalar boson production cross section times branching ratio into long-lived neutral particles as a function of the proper lifetime of the particles. Limits are reported for boson masses from 100 GeV to 900 GeV, and a long-lived neutral particle mass from 10 GeV to 150 GeV.

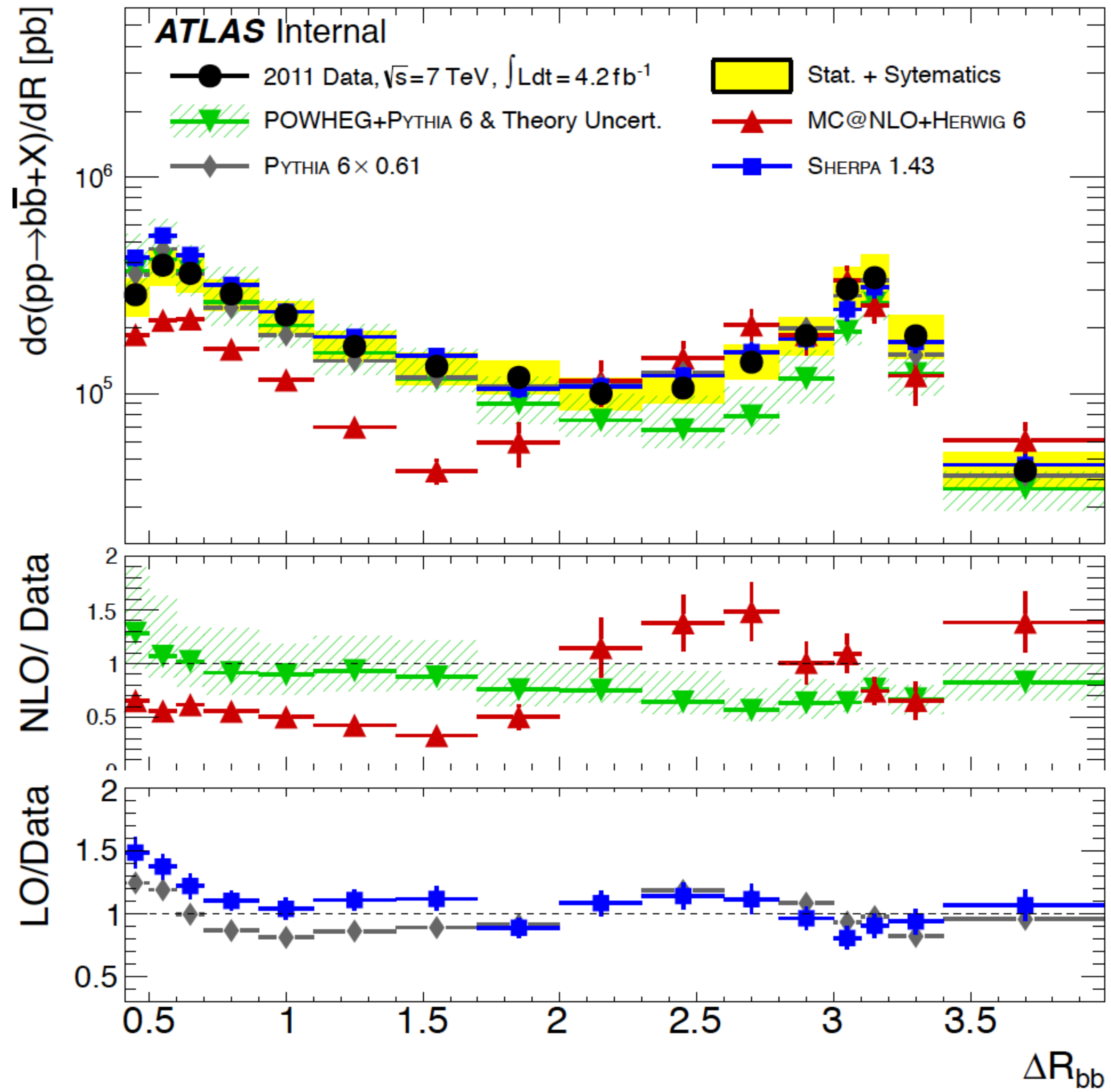


MC sample m_H, m_{π_v} [GeV]	Excluded range 30% BR $H \to \pi_v \pi_v$ [m]	Excluded range 10% BR $H \to \pi_v \pi_v$ [m]
126, 10	0.10 – 6.08	0.14 – 3.13
126, 25	0.30 – 14.99	0.41 – 7.57
126, 40	0.68 – 18.50	1.03 – 8.32

A collaboration of U. Washington and INFN Cosenza
To be continued with LHC Run2 at 13 TeV

Measurement of the b-bbar cross section

- ATLAS is not only needed for discovering undetected particles (like Higgs in Run 1) or new physics, but also to provide precise measurement of Standard Model physics
- The di-jet production cross-section for jets containing b-hadrons has been measured on 2011 data
  - Function of different kinematic variables
  - Leading and next-to-leading order production mechanism exploited (first NLO results!)
  - Performance of different event generators are explored



A collaboration of University College of London, INFN Roma 1, INFN Cosenza

To be continued with LHC Run2 at 13 TeV

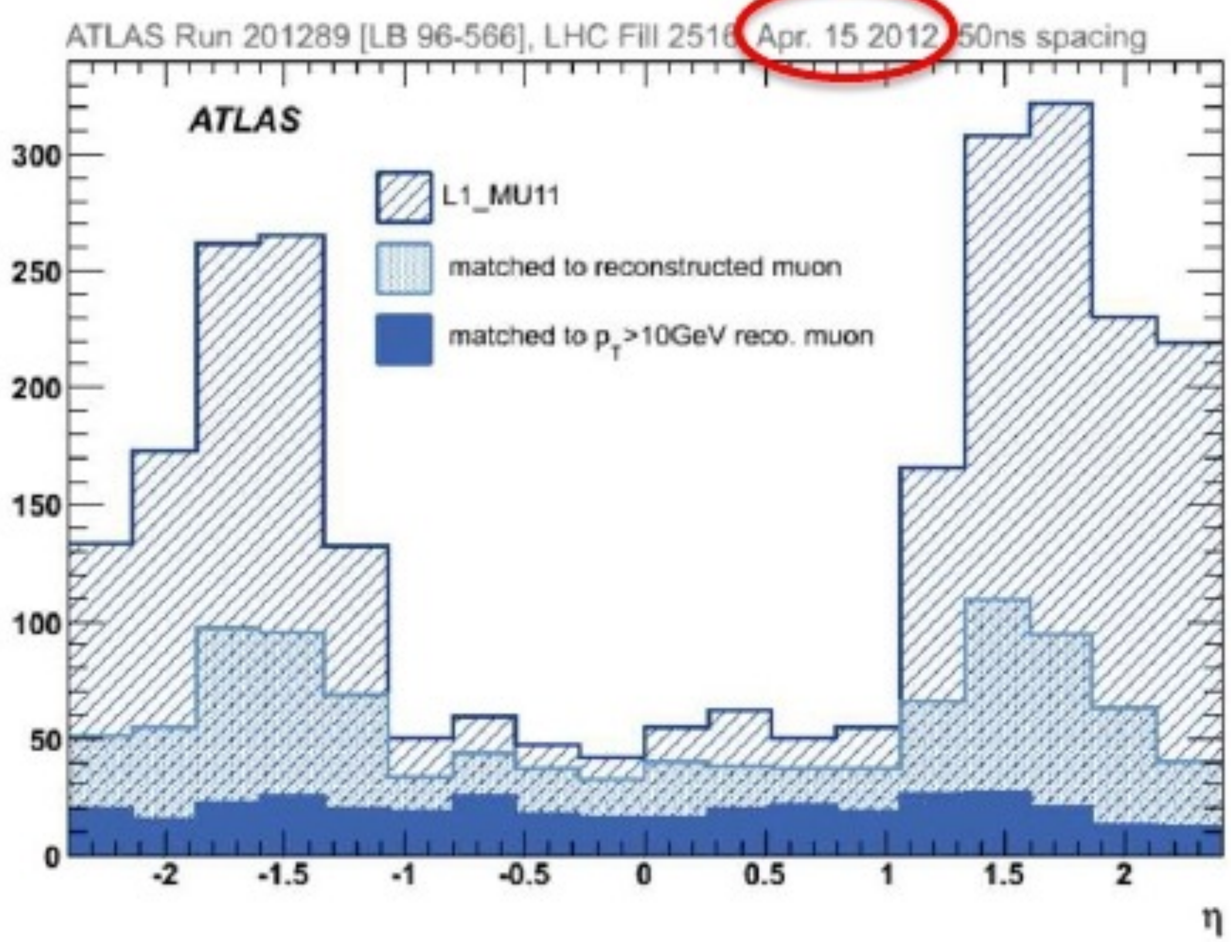
GNAM monitoring

- Online monitoring software needed to assess the detector performance
- Quality checks are performed on relevant raw data quantities
  - Help to identify dead/noisy channels (140 M channels in ATLAS!!!)
- Official tool inserted in the ATLAS TDAQ chain
- Developed for commissioning purpose, then extensively used in the ATLAS Control Room during Run I operations
- Active for Run 2 data taking
- Cosenza group contribution to MDT and IBL collaborations

A collaboration of INFN Udine, INFN Pavia, INFN Cosenza, Oklahoma State U.

The New Small Wheels of ATLAS

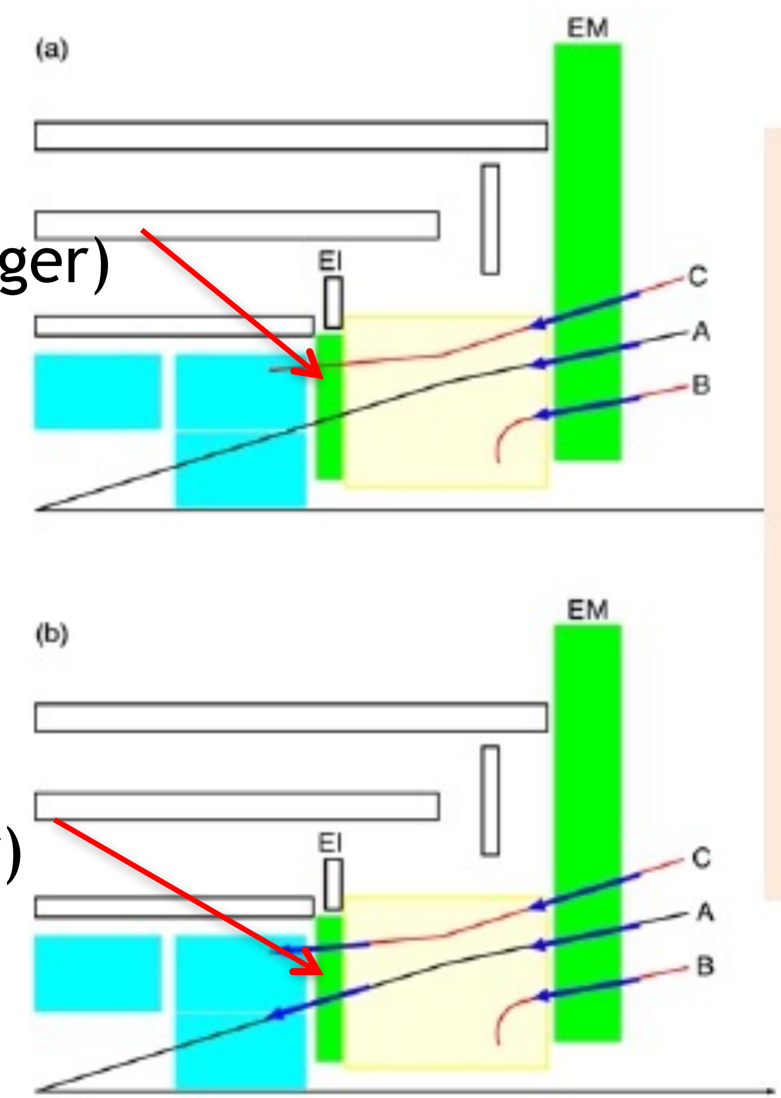
- The actual forward muon spectrometer as too many fake single muon L1 trigger (10 times higher than true high-pT muon track)



- MDT rate limited at 300 kHz/tube and at the LHC nominal luminosity of $3 \cdot 10^{34}$ s^{-1} cm^{-2} a large part of the present SW the MTD rate limit is exceeded.

SW
(no trigger)

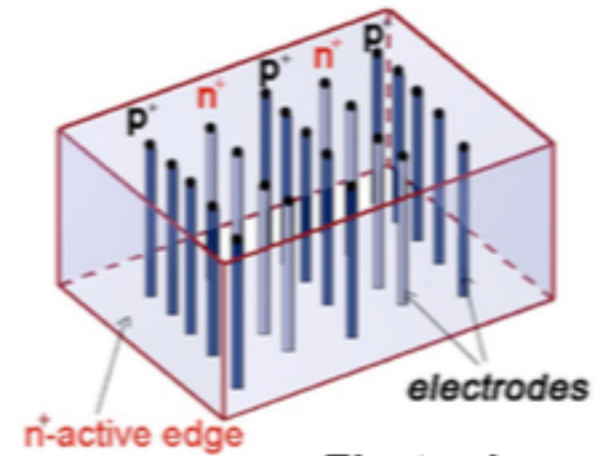
NSW
(trigger)



Muon community has designed a new detector to replace the old one in 2018. The new detector has to work up to 15kHz/cm^2 with high efficiency, radiation hard and has to provide the trigger.

Sensori 3D

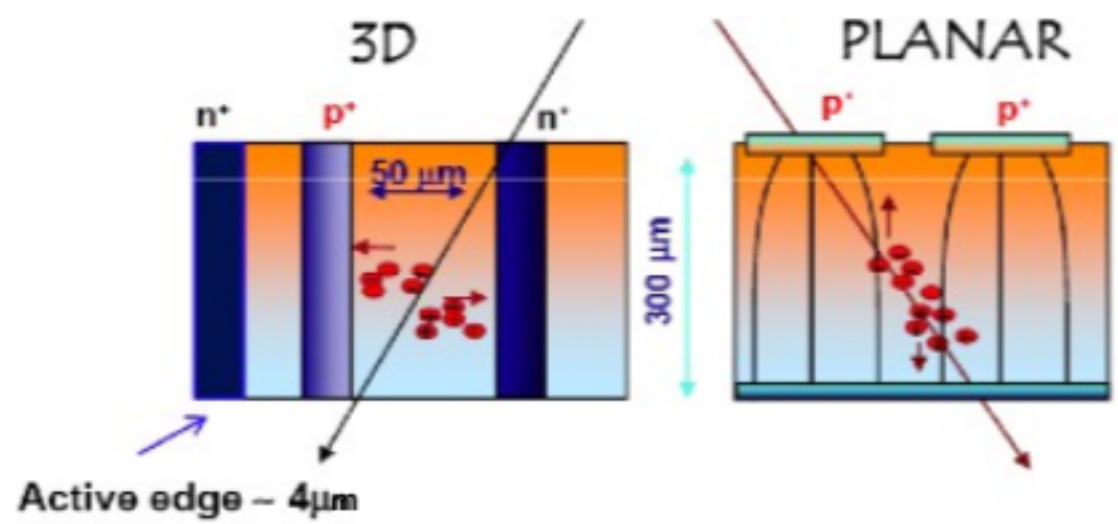
I sensori 3D sono una matrice di elettrodi a colonna [r ~ 5µm] con drogaggio p e n, che penetrano perpendicolarmente alla superficie nel substrato di silicio.



Electrodes are processed inside the detector bulk instead of being implanted on the wafer's surface.

3D PRO:

- La distanza tra elettrodi NON dipende più dallo spessore del substrato:
  - bassa tensione di svuotamento
  - raccolta di carica molto veloce
  - bassa probabilità di intrappolamento (**alta resistenza alla radiazione)**
- Si può implementare anche l' "Active Edge concept" (area morta ridotta a pochi µm dal bordo del sensore)



- Risoluzione angolare confrontabile con I rivelatori planari

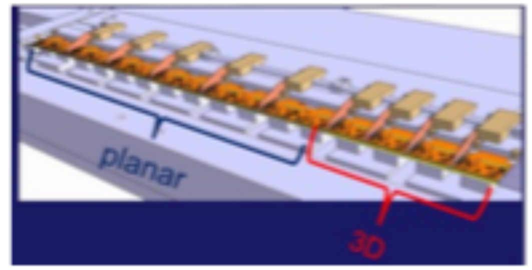
3D CONTRO:

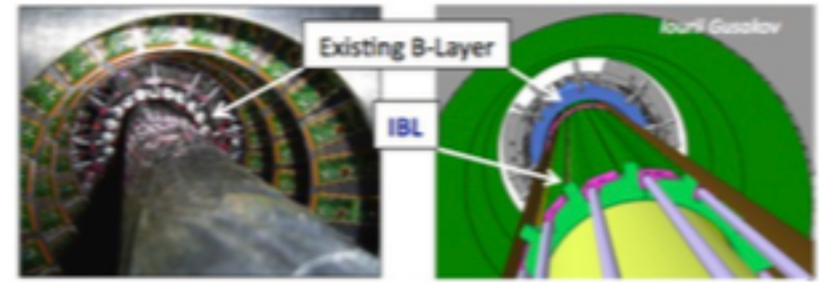
- Tecnologia compessa (ma comunque OK per IBL …..)
- Capacità elettrica maggiore rispetto al planare (criticità per il rumore elettronico)

3Ds: APPLICAZIONI A LHC

I 3D stanno emergendo come tra i più promettenti "tracking detectors" per i futuri upgrades a LHC

25% di ATLAS IBL sarà costituito da sensori 3D

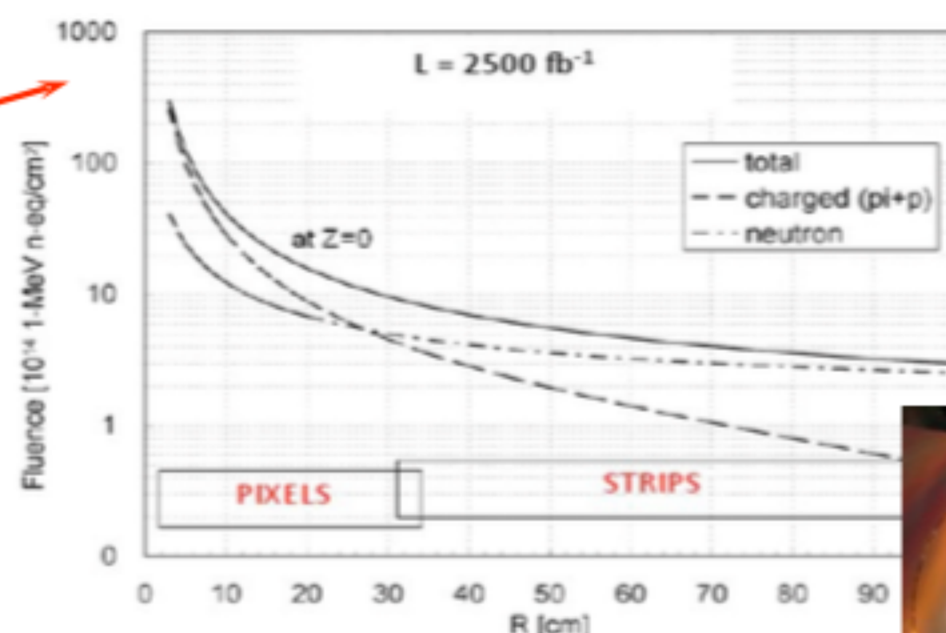


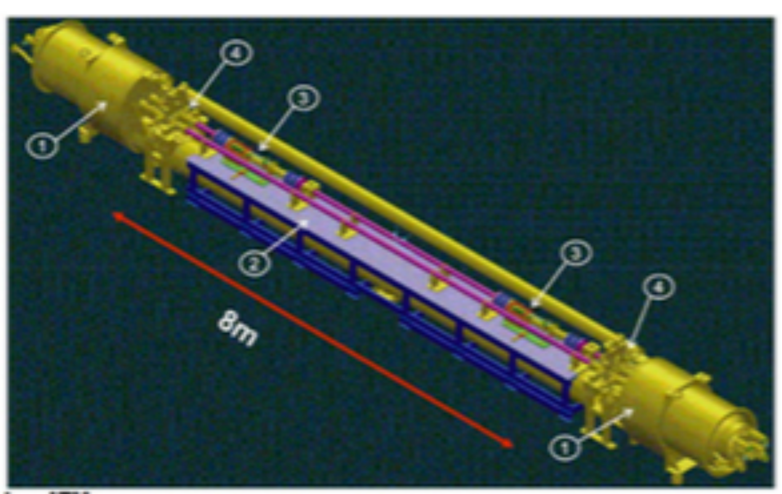


Nuovi sensori rad-hard per HL-LHC CMS vertex detector ($L = 10^{35} cm^{-2}s^{-1}$)

Dose equivalente ~$10^{16} n_{eq}/cm^2$ @ r = 5 cm

Pixel attuale riesce a funzionare fino a una fluenza di ~$6x10^{14} n_{eq}/cm^2$



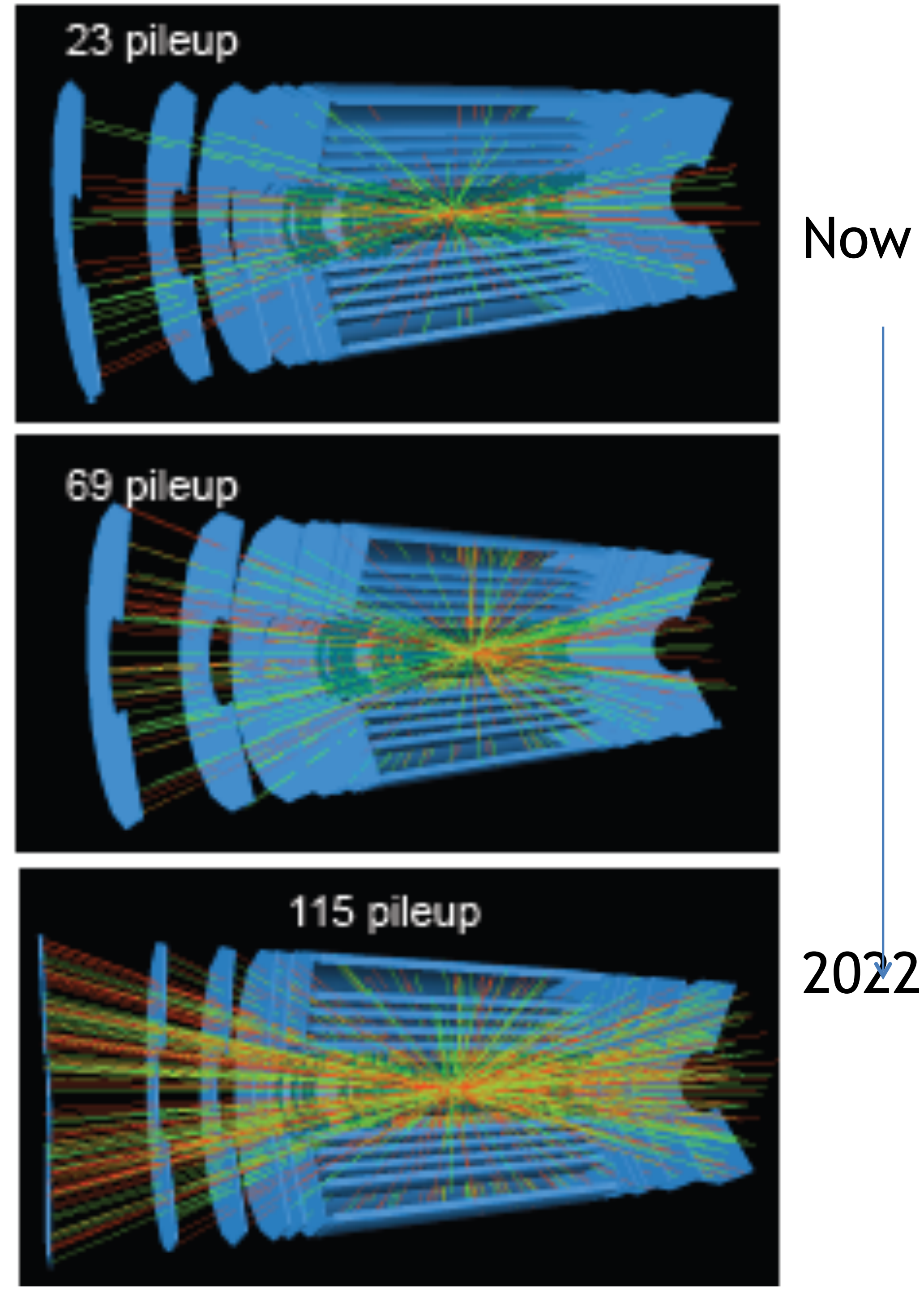


HPS (Near Beam Proton Spectrometer - in approvazione per CMS)

Cruciale per questa applicazione: "radiation hardness" e "active edges"

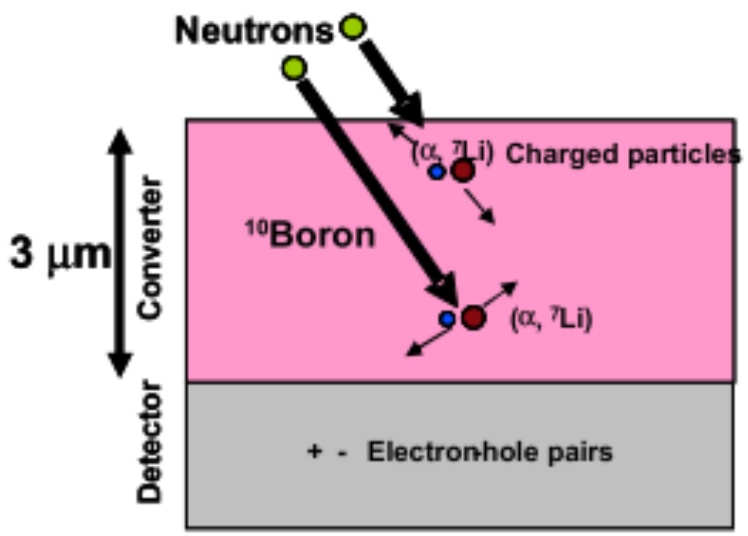
The Atlas ITk project: upgrade of the entire tracker

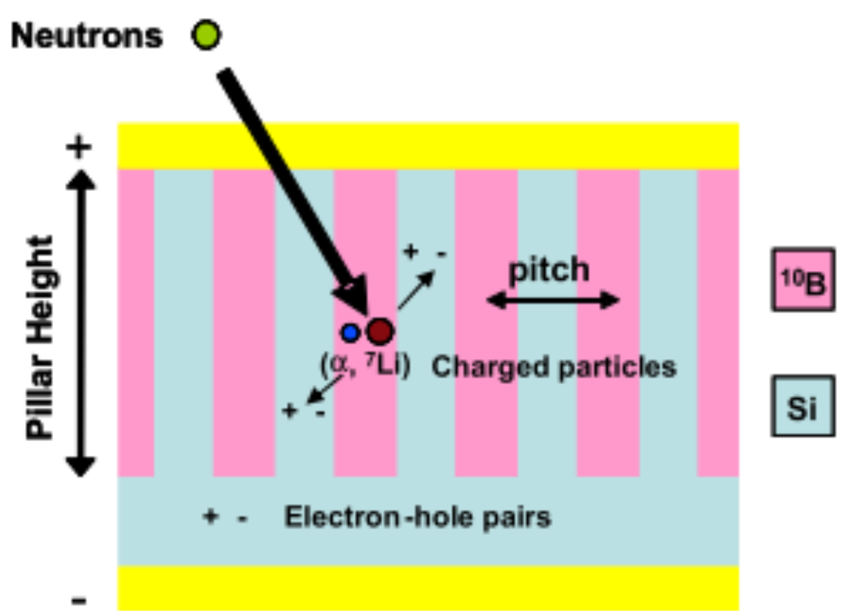
- Inner detector (ID) has limited lifetime:
  - aged mostly by high total radiation dose (fluence)
  - Very severe pile-up conditions expected: from 140 to 200 PV
  - Need finer segmentation to ensure pattern recognition
- **Complete construction of a new ID to be tested on surface in 2021 and installed during LS3**
- More than 80 participating Institutes
- Cosenza contribution: simulation, mechanics

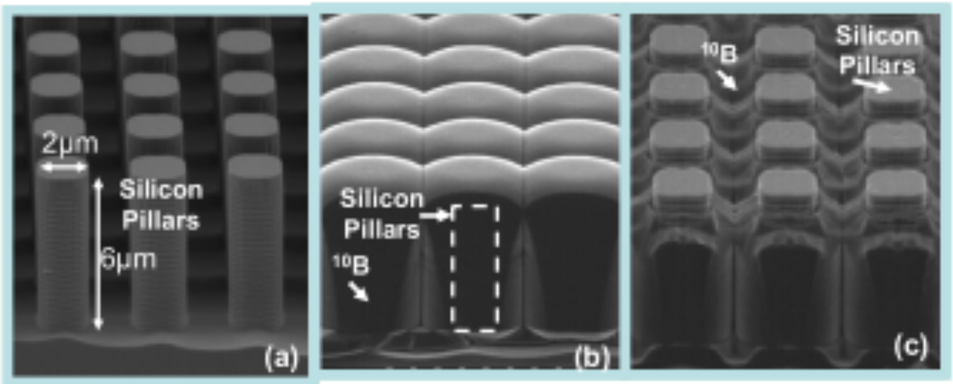


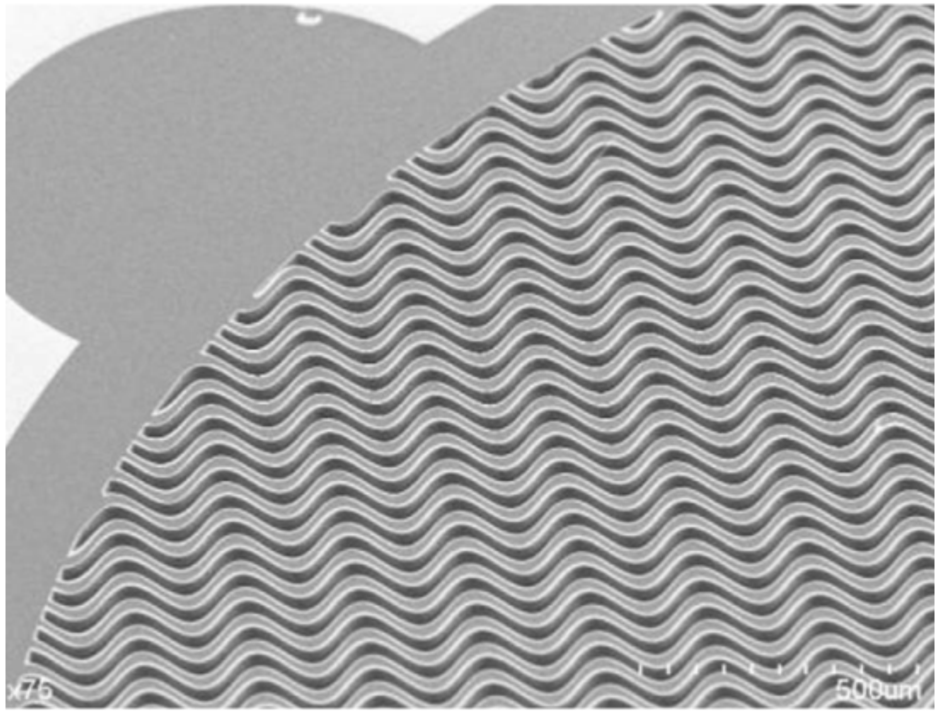
140-200 collisions every 25ns bunch crossing

Applications: Neutron Detectors









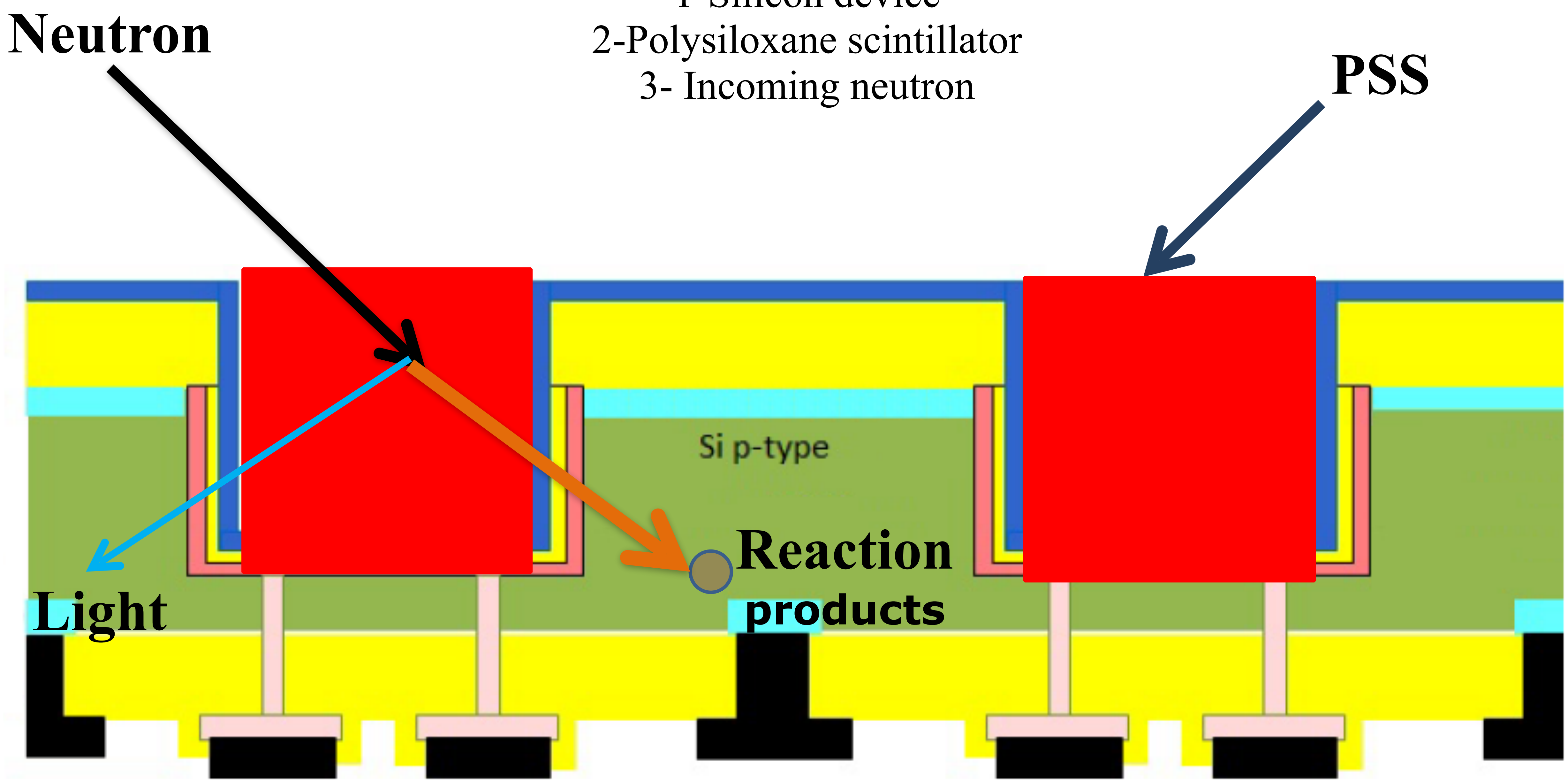
- Different sensors with boron or lithium based scintillator have been proposed
- The improvement of the aspect ratio maximizes the efficiency

D.S. McGregor, , W.J. McNeil, S.L. Bellinger, T.C. Unruh, J.K. Shultis “Microstructured semiconductor neutron detectors” Nuclear Instruments and Methods in Physics Research Volume 608, Issue 1, 1 September 2009, Pages 125–131

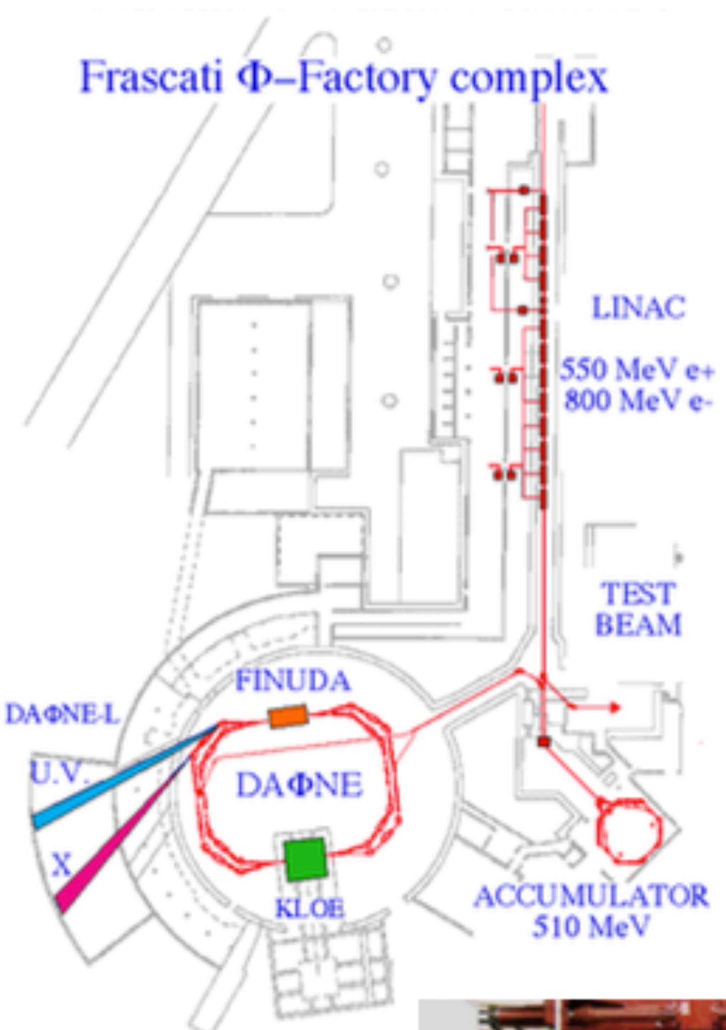
R. J. Nikoli, A. M. Conway, C. E. Reinhardt, R. T. Graff, T. F. Wang, N. Deo, and C. L. Cheung, “Fabrication of pillar-structured thermal neutron detectors,” in IEEE NSS Conf. Record, Waikiki, Hawaii, Oct.28–Nov. 3 2007, pp. 1577–1580.

HYDE: Hybrid Detectors for neutrons (Padova,Trento,Cosenza)

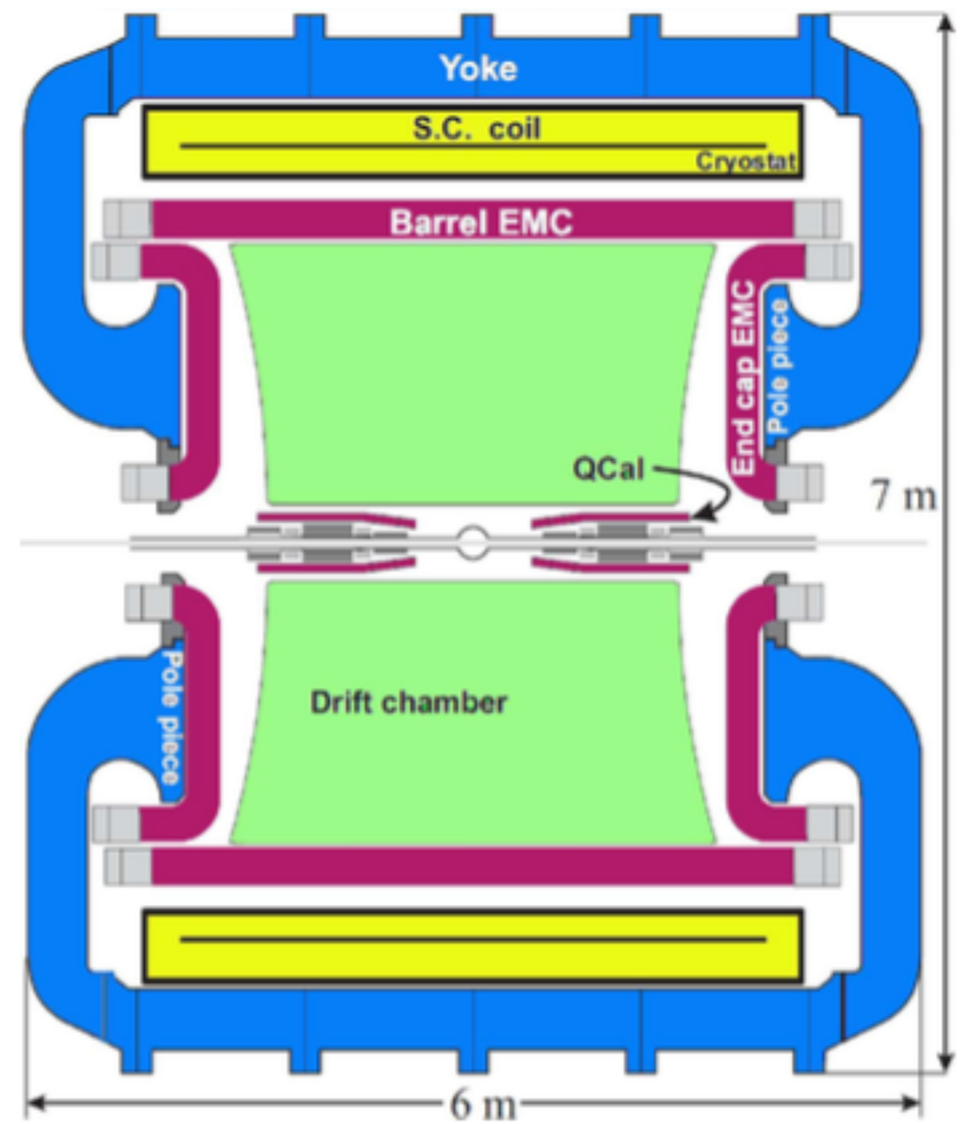
1-Silicon device
2-Polysiloxane scintillator
3- Incoming neutron

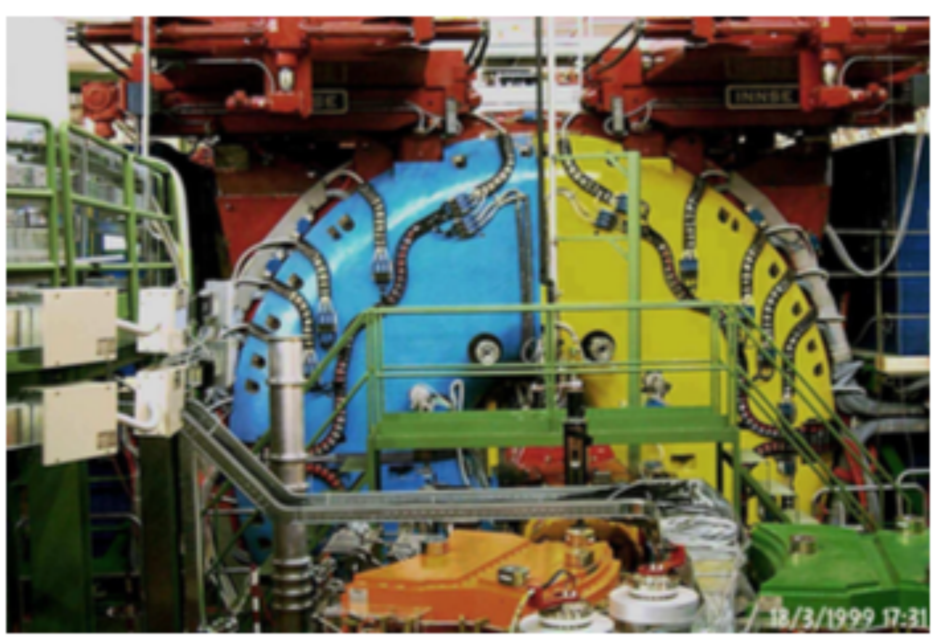


KLOE2 @ e^+e^- DAFNE accelerator



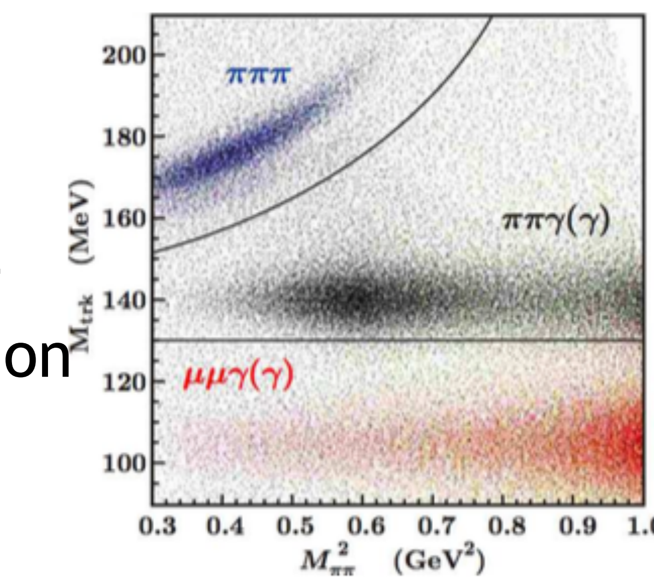
The accelerator complex is located at INFN-LNF where the modern colliders were born in far 1960. In the old bunker ADONE now sits the DAFNE accelerator designed to produce the PHI mesons from the e^+e^- collisions.



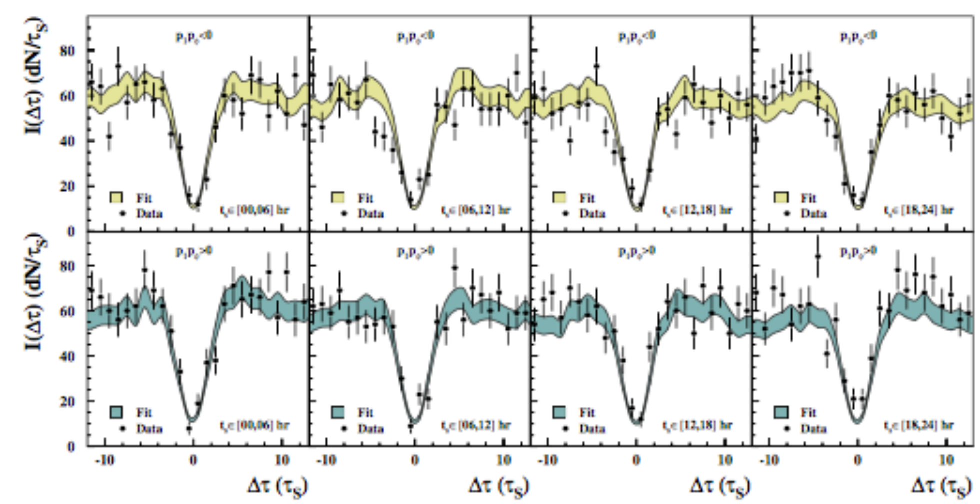


The detector is designed to be as transparent as possible to γ, to reconstruct efficiently the π^0 produced by the decay of PHI.

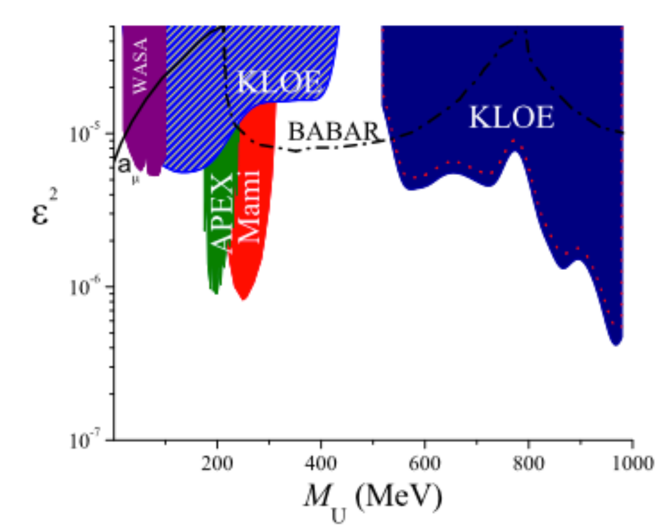
KLOE2 PHYSICS



Precision measurement of the pion form factor |Fπ|^2 from the π+π −γ/μ+μ−γ ratio and extraction of the dipion contribution to the muon anomaly with the KLOE detector



The entanglement of the two kaons is exploited to search for possible violation of CPT symmetry and Lorentz invariance in the context of the Standard-Model Extension (SME) framework. The four CPT violating parameters Δ*a*μ appearing for neutral kaons in the SME have been measured. These are presently the most precise measurements in the quark sector of the SME.



The search for light dark force mediator (named U-boson) is motivated by recent puzzling astrophysical results and theoretical studies. The most promising channel is the U decay to μ+μ−γ. In a data sample corresponding to an integrated luminosity of 239.3 pb −1 no evidence of a U-boson signal has been found and an upper limit at 90% CL on the kinetic mixing parameter ε^2 has been set.