The detector upgrade and the requirements on the upgrade scenarios

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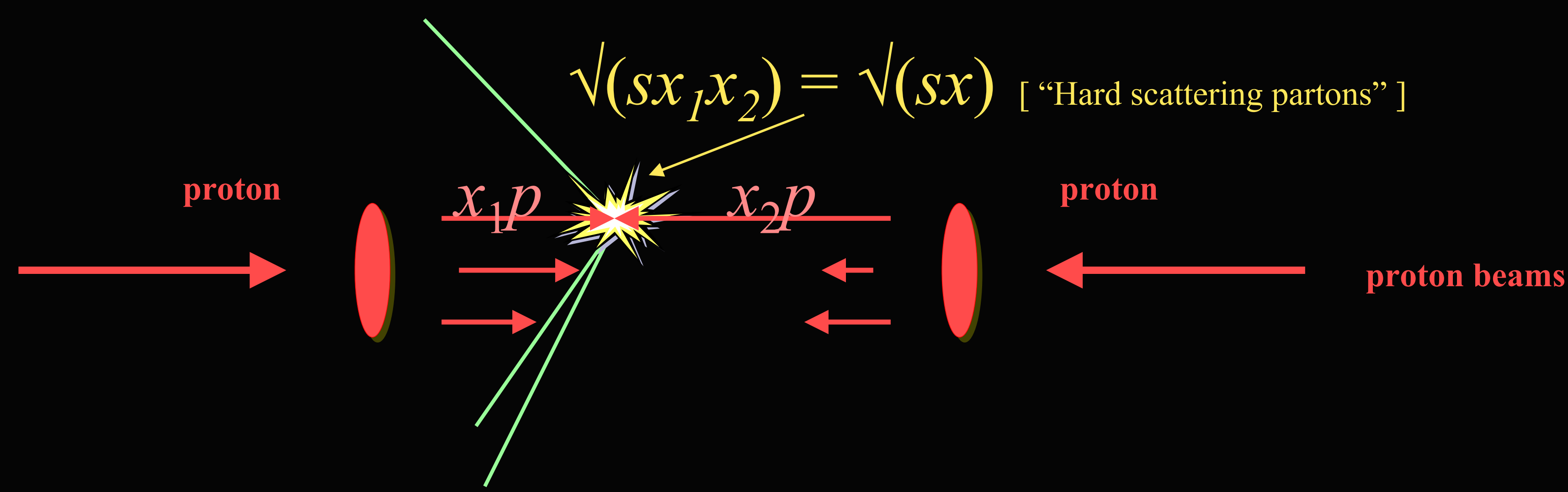
sLHC → Luminosity Upgrade Scenarios

What we are considering is a LHC machine which will deliver proton-proton collisions at 14 (7 + 7) TeV at a peak luminosity ~ 10 times higher than original LHC design luminosity of 10^{34} cm^{-2} s^{-1} :

Luminosity ~ 10^{35} cm^{-2} s^{-1}

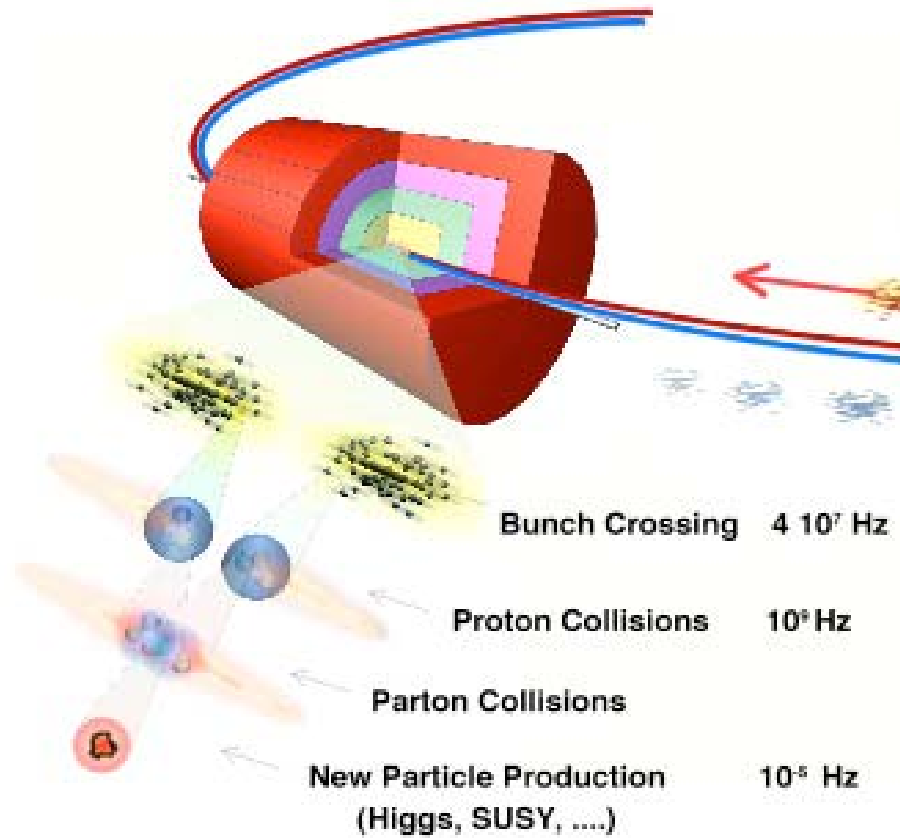
for an integrated useful statistics on tape of ~ 3000 fb^{-1}



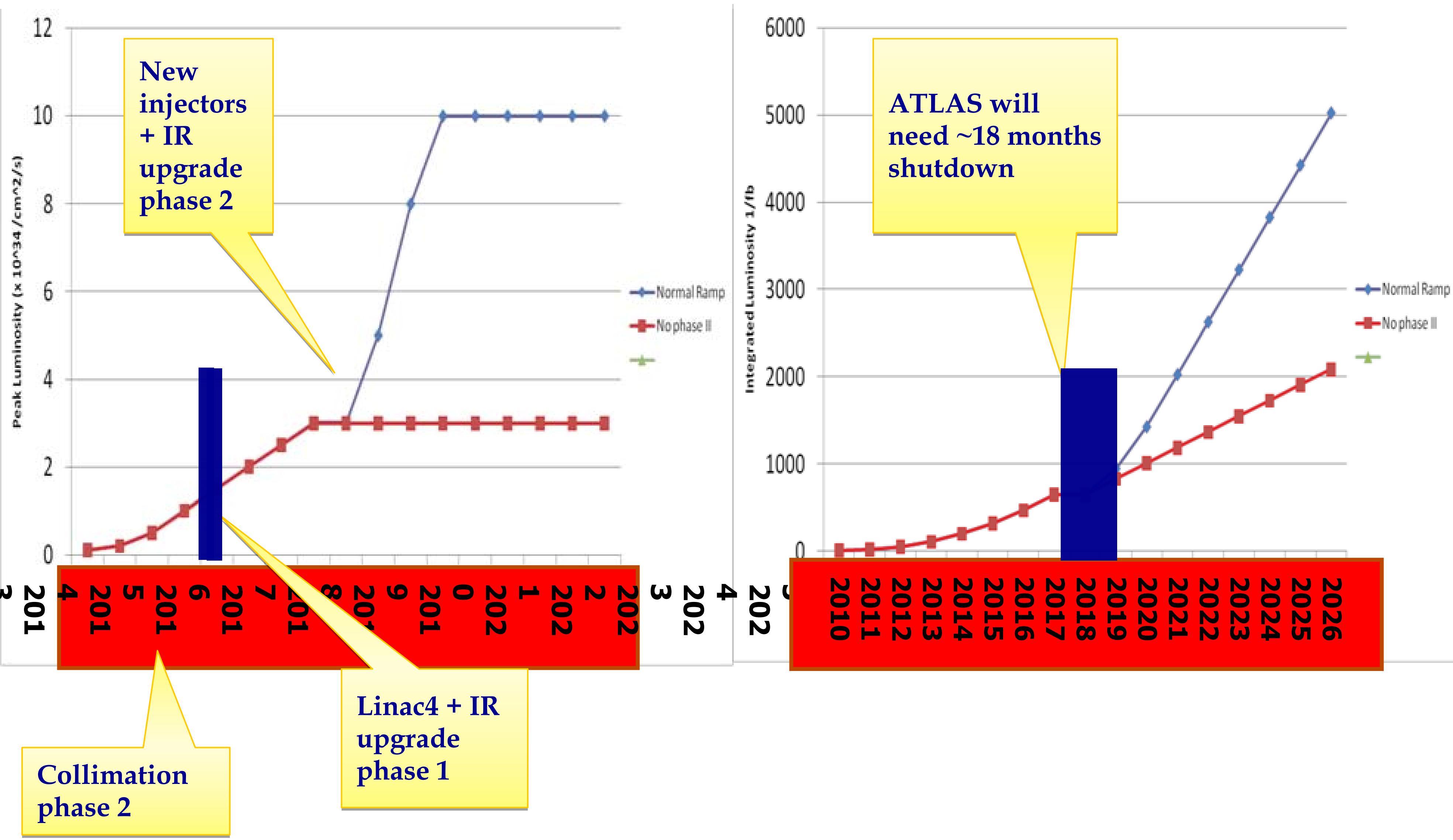
LHC general purpose detectors

✓ Today's detectors (ATLAS and CMS) have been designed and constructed for

- peak luminosities up to $2*10^{34}$ $cm^{-2}s^{-1}$
- integrated luminosity ~ 700 fb^{-1} → ~10 years of operation
- readout frequency of 40MHz, based on 25ns bunch structure
- detectors granularities such to keep occupancy at % level, ~1000 charged tracks/bunch crossing
- online data handling ~ 60TB/sec



Upgrade in 2 phases



LHC evolution → Phase I

✓ LHC is complete apart from full collimation (up to 2014) :

- Luminosity limited to 40 % of nominal for protection until collimators installed
- Collimators to be completed in ~2012, allowing rise to nominal luminosity of 10^{34} cm^{-2} s^{-1}
- Best current estimate is that one nominal year will then deliver 60 fb^{-1}

✓ Phase-1: 2014-2017 → up to 3 x nominal luminosity

- Linac-4 approved and work has started
- Allows higher LHC current, to "Ultimate" which is 2.3 times nominal;
  ready to run in 2014
- New Inner Triplet focusing magnets. Larger aperture, allows β^* of 0.25 m instead of 0.55 m.
  Installation in 2013/14 shutdown
- In principle this also gives a factor 2 on nominal. Expectation is that these two improvements
  will allow a ramp-up to 3 x nominal, 180 fb^{-1} /year

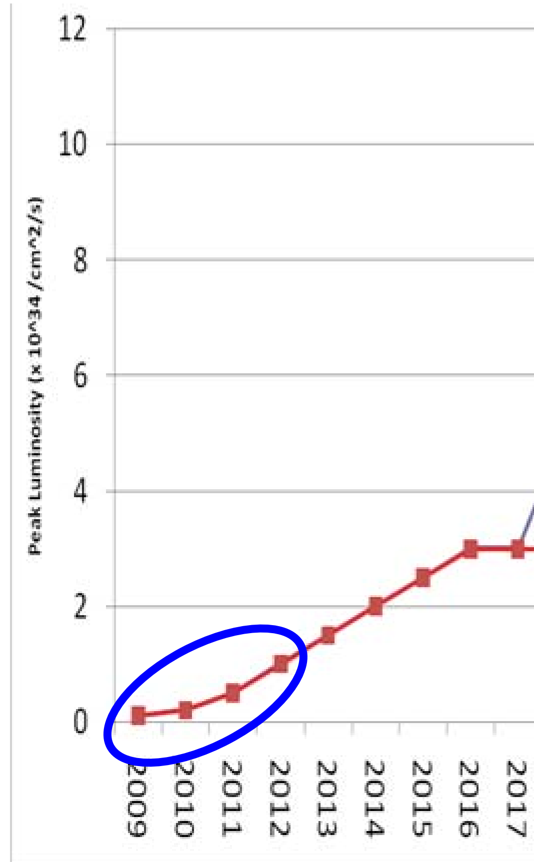
Conditions: 70 minimum bias events per BC; ~700 fb^{-1} before phase 2

Detector requirements for Phase I

✓ First initial 4 years of data taking will allow to enter into the discovery potential of the LHC (SUSY, Higgs, Extra dimensions, …. + surprises)

- The detector will need to be fully understood (response, trigger capability, calibration, computing, …) → SM physics

- Today detectors are really very complex machines, certainly we will find problems …. Some weaknesses are already known …. LV power supplies, detectors cooling systems, known single points of failure … and more …. We will need to consolidate, to retro-fit various front-end systems and rebuild some infrastructure (cooling plants, power network, ….) … we will make use of any shutdown available

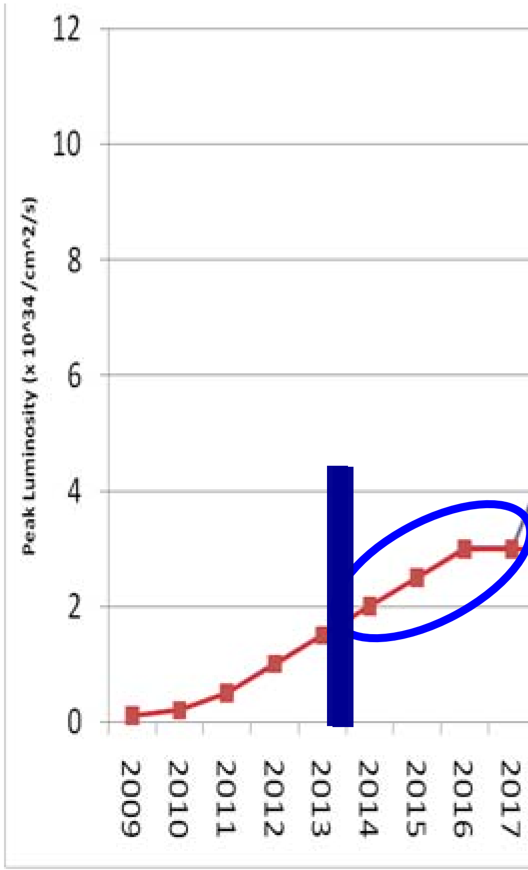


- We will be confronted for the first time with radiation and activation problems, access methods will need to be re-engineered, more radiation shielding might be necessary, new beam pipes (aluminum, aluminum-beryllium, …) are fundamental

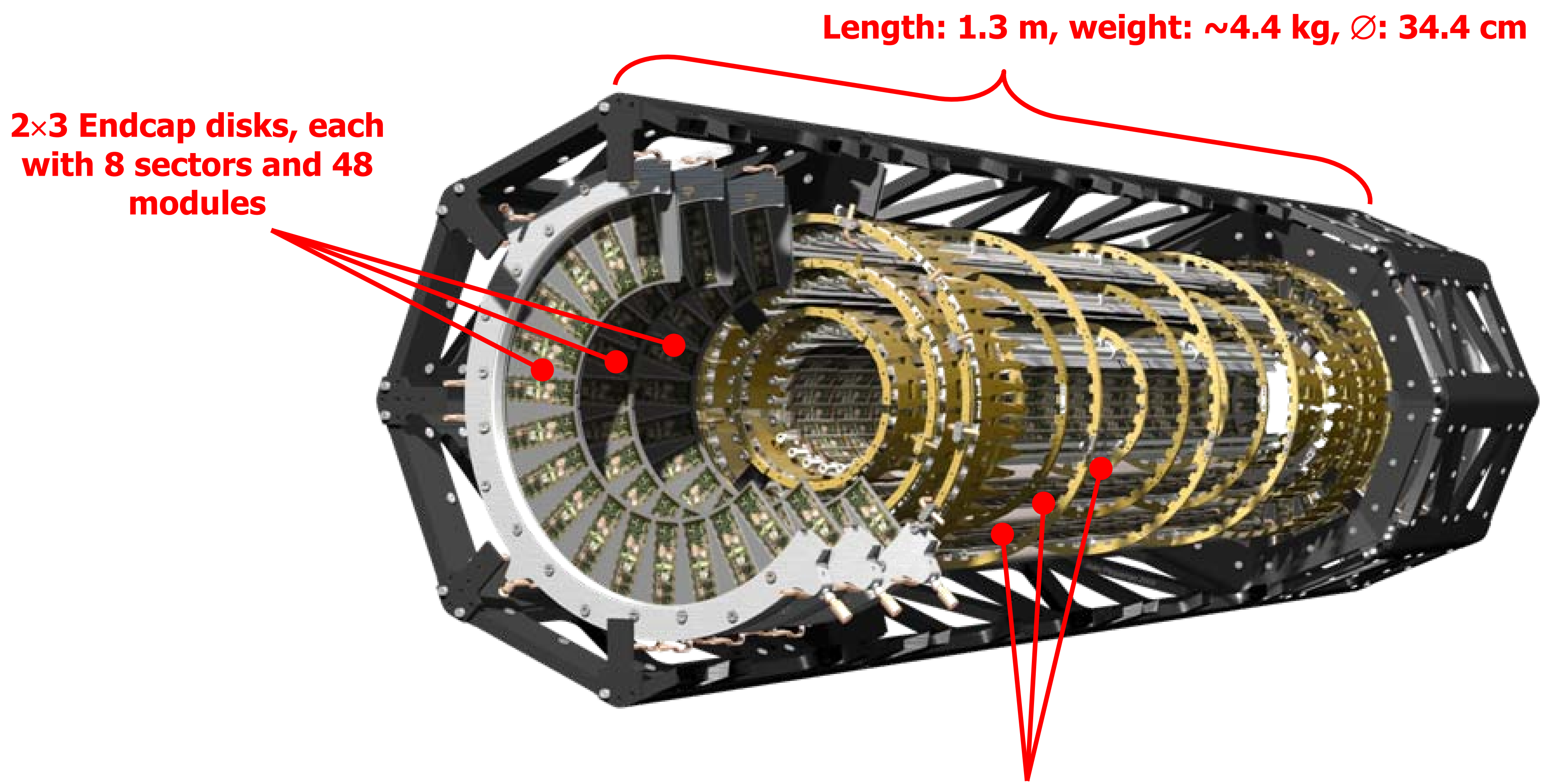
Detector requirements for Phase I

✓ Then Upgrade Phase I, we will get all necessary statistics to fulfill the LHC mandate (700fb^{-1}, 4-5 years?)

- LINAC 4 will require at least 8 months to be installed and operate in the LHC chain, this mean a long shutdown!
- These 8 months represent a unique opportunity to make first real changes to the detector configuration. Some staged components will be restored in particular in the forward region (muon chambers, …)
- The new large aperture triplet system will require to revisit the TAS system, a new major piece of hardware and a difficult installation/removal process
- ATLAS has decided to add a new b-layer to the innermost pixel detector. This will require a new beam pipe with smaller radius and a new state of the art set of pixel detectors

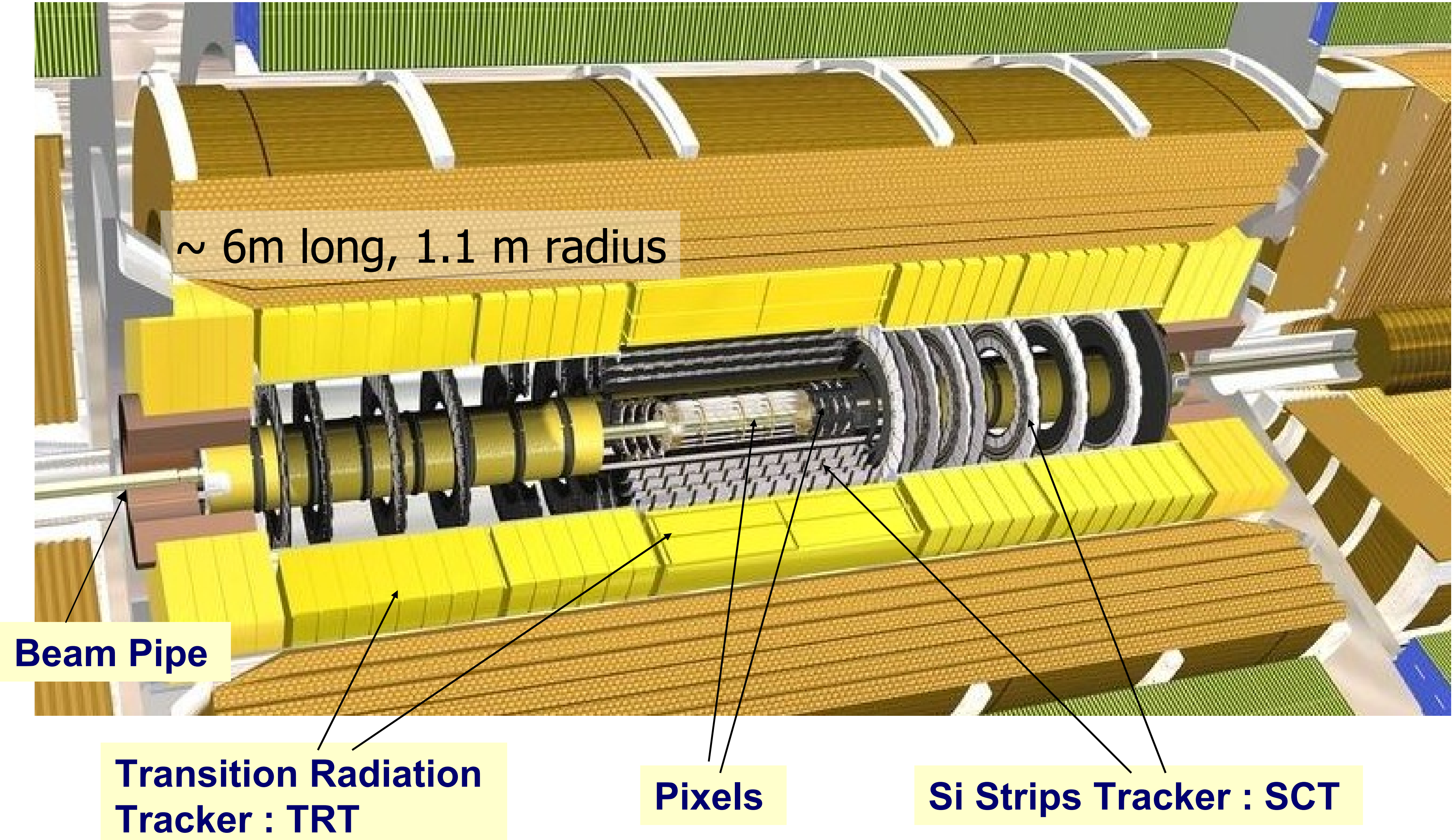


The ATLAS Pixel detector (~80 M active channels)



Typical resolution (barrel):
10 μm [$r\phi$], 115 μm [z]

The ATLAS Tracking Detectors



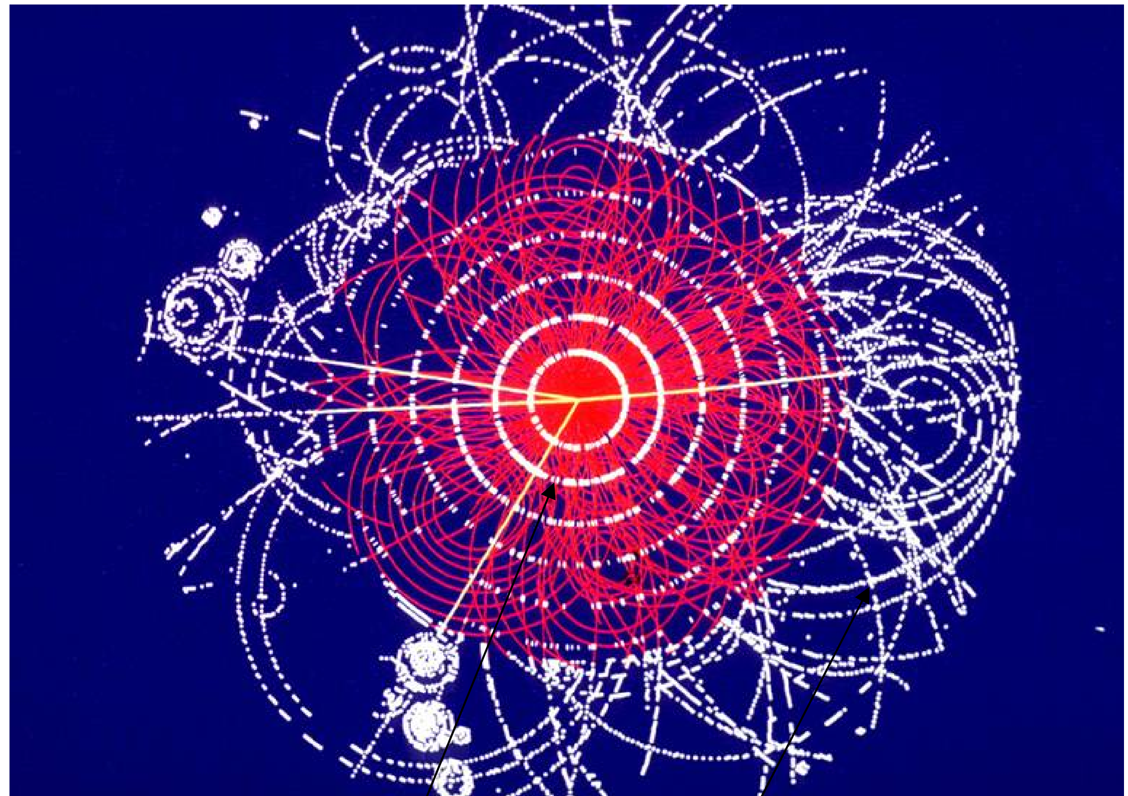
The Tracking Detectors

- Pattern recognition:

  Challenging: high track density

  ✓ 7 precision points/track (3 pixel+4 SCT)

  ✓ continuous tracking via TRT



Pixel, SCT precision tracking

TRT continuous tracking

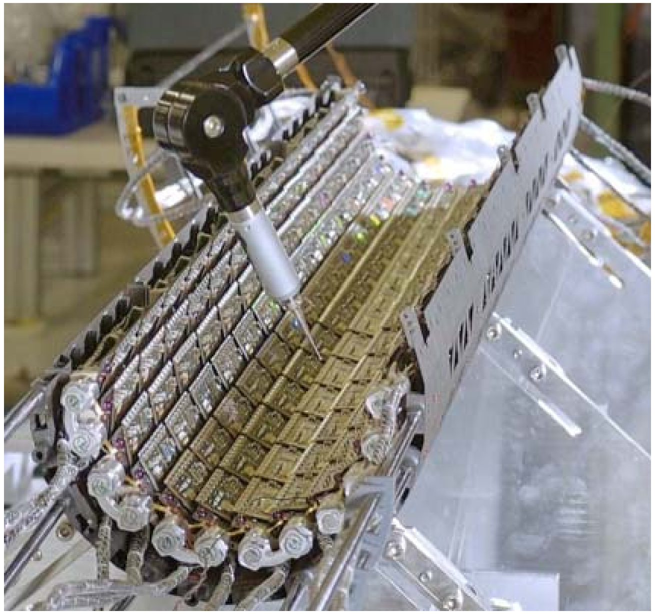
- Today's pixel detector:

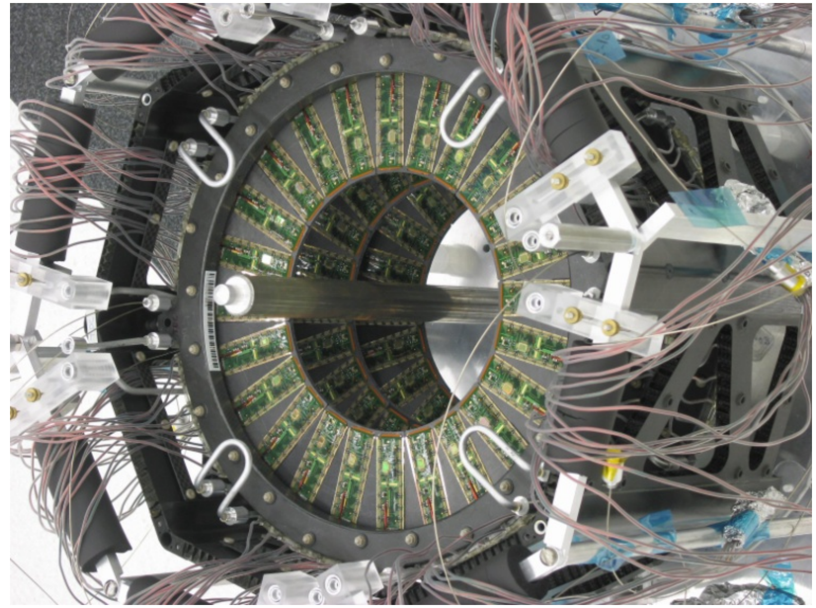
  ✓ 50x400 μm• pixels

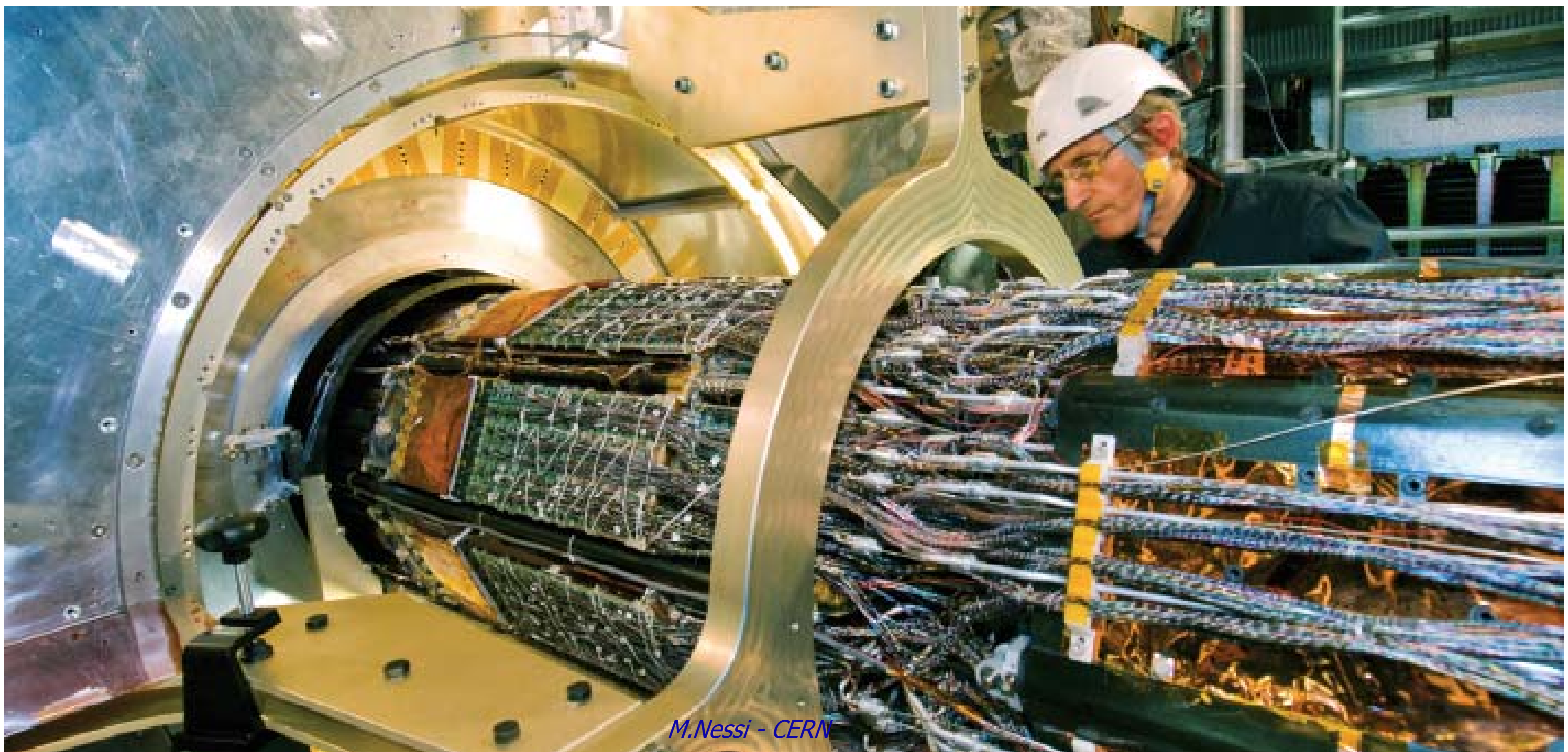
  ✓ spatial resolution: 10 μm in R–ϕ,
  115 μm in z

  ✓ radiation hardness specs 500kGy ;
  tested to >1000kGy and
  $2*10^{15}$ neq

  ✓ lifetime and aging of the innermost layer
  (b-layer) not obvious





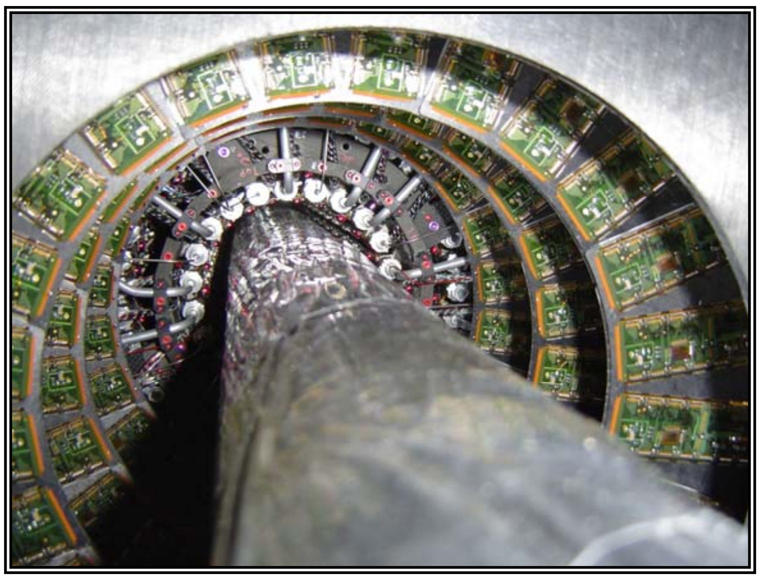


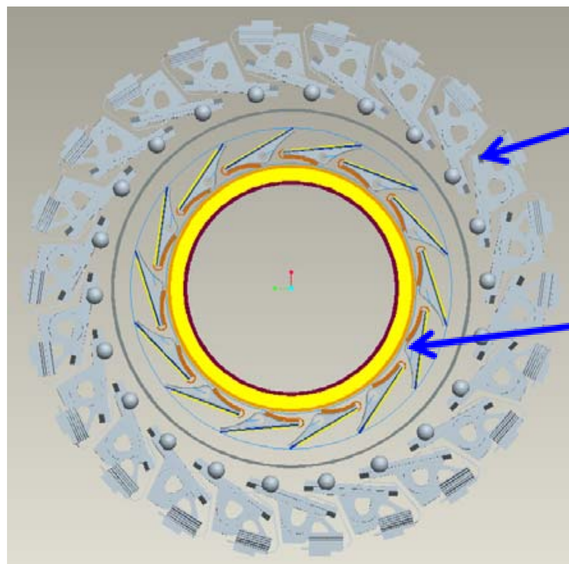
New pixel b-layer for Phase I

✓The present ATLAS Pixel Detector has 3 Layers, the innermost is called "b - layer". The b-layer will gradually loose efficiency due to radiation damage to sensors and chips. It needs to be replaced in the "LHC Phase 1 upgrade" shutdown (~300fb^{-1})

✓ Removing the present b-layer was studied in detail and was found not to be feasible because the time required is significantly longer than a winter shutdown in 2013/14. Risks to Layer 1 and 2, which stay in place, were significant

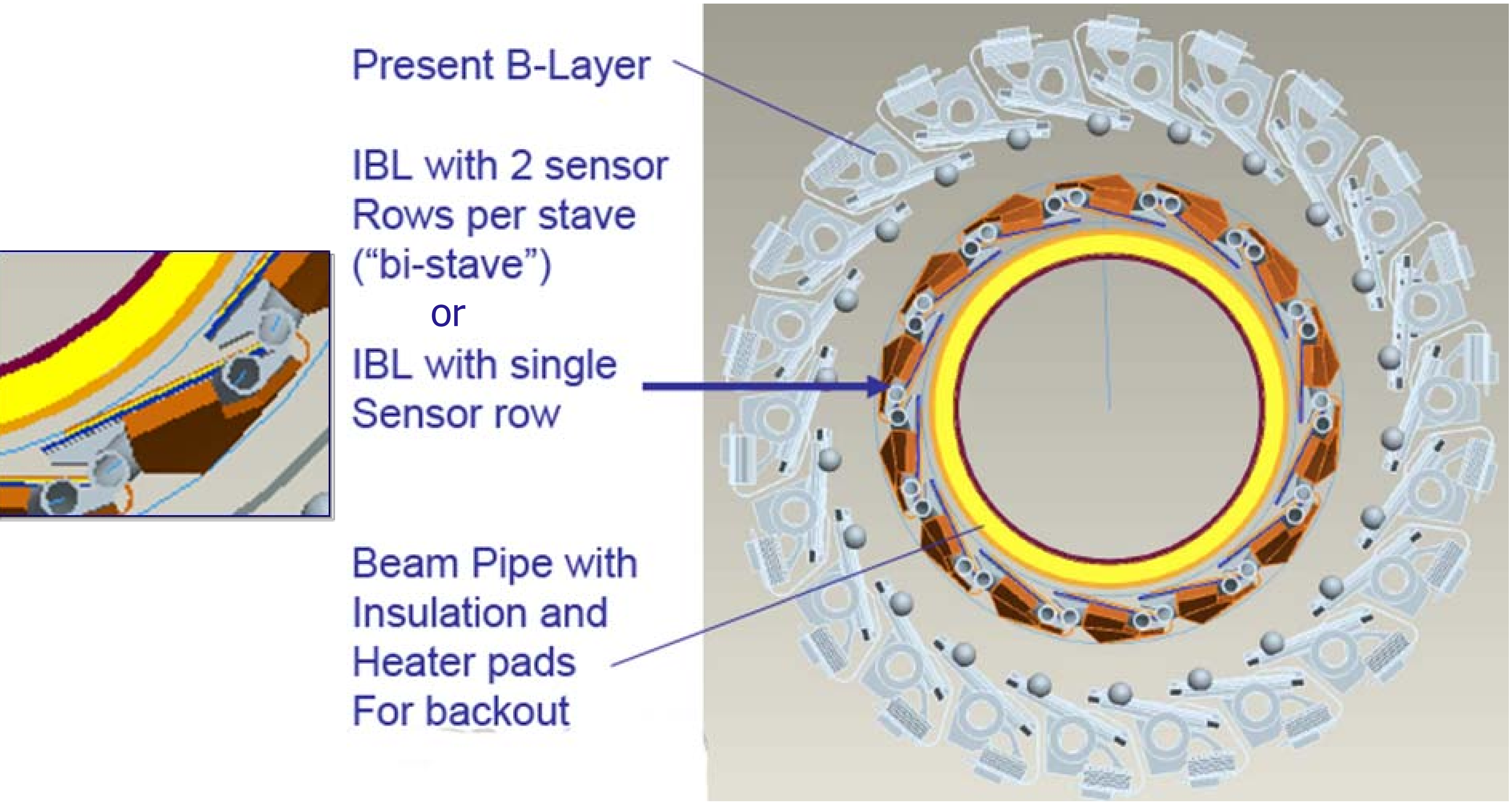
• Solution found: Add a 4th Pixel Layer inside the present B-Layer: **The Insertable b-layer (IBL).** The existing Pixel detector stays installed and a 4th layer is inserted inside the existing pixel detector together with a new beam pipe. It requires a new, smaller radius beam pipe to make space





First requirement to the LHC layout

- New and smaller (in radius) beam pipe, inner radius ~25mm, but compatible with large aperture new triplet optics.



New requirements to the detector similar to sLHC

The IBL will be the b-layer for the LHC Phase I luminosity running. We plan to minimize the changes to the minimum necessary from the present system and integrate it completely into the present Pixel detector

✓The IBL is also a bridge to sLHC: Its requirements (radiation hardness approximately 3 x present system) force us to develop new technologies for it

✓With IBL we will make the technology step to sLHC radiation hardness ~ 3 to 5 $*10^{15}$ neq /cm^2 (sLHC ~ 10^{16} in inner layers) Timescale: IBL ~4-5 years

✓Front-end IC4: go to 130nm process and improve readout architecture to minimize inefficiency at high hit rates and radiation hardness

✓Sensors: investigate 3D silicon sensors, new planar sensors and CVD diamond sensors as possible options for radhard detectors

✓Readout system & optolink: improve data through-put and redundancy. Will go to 160MHz from present 40MHz

✓Cooling system & Mechanics: investigate more efficient cooling of sensors + chips with significant reduction in X_0 on staves. Investigate CO_2 evaporative cooling in parallel to existing C_3F_8 cooling and new cooling pipe technologies (CF pipes, Ti pipes)

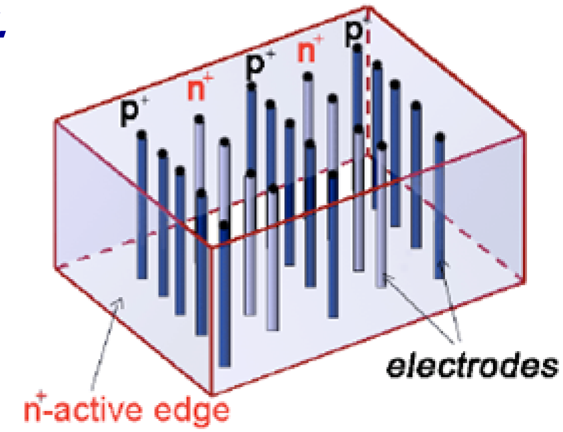
New requirements to the detector similar to sLHC

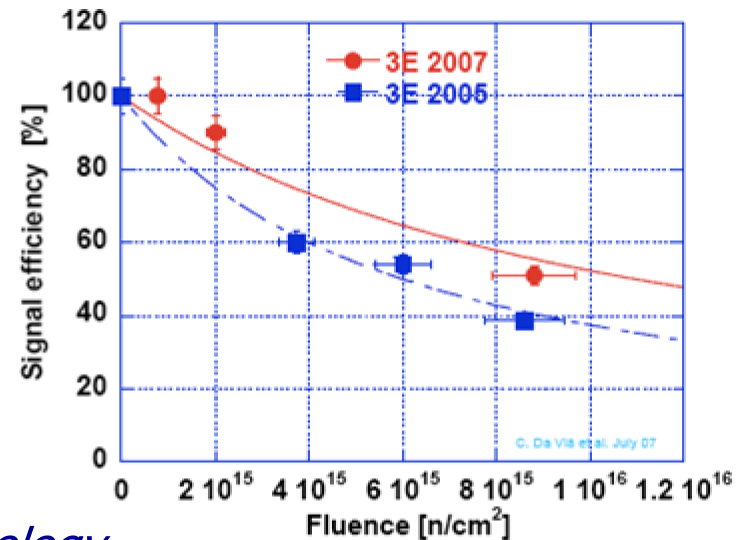
✓ *Two "silicon" technologies considered: Planar and 3D sensors.*

- Could profit from 2 large "sLHC" R&D communities.

  3D sensor

  - *pro's:*
    - Larger charge collection after irradiation (but more power in the FE for same time-walk)
    - Active edge (butting modules)
    - Lower voltage (<150 V), power after irradiation
  - *Con's:*
    - Column inefficiency at 90º
    - Higher C_{det}
    - No experience in "large scale" production
    - Several options and design flavours
    - Higher cost. Yield?





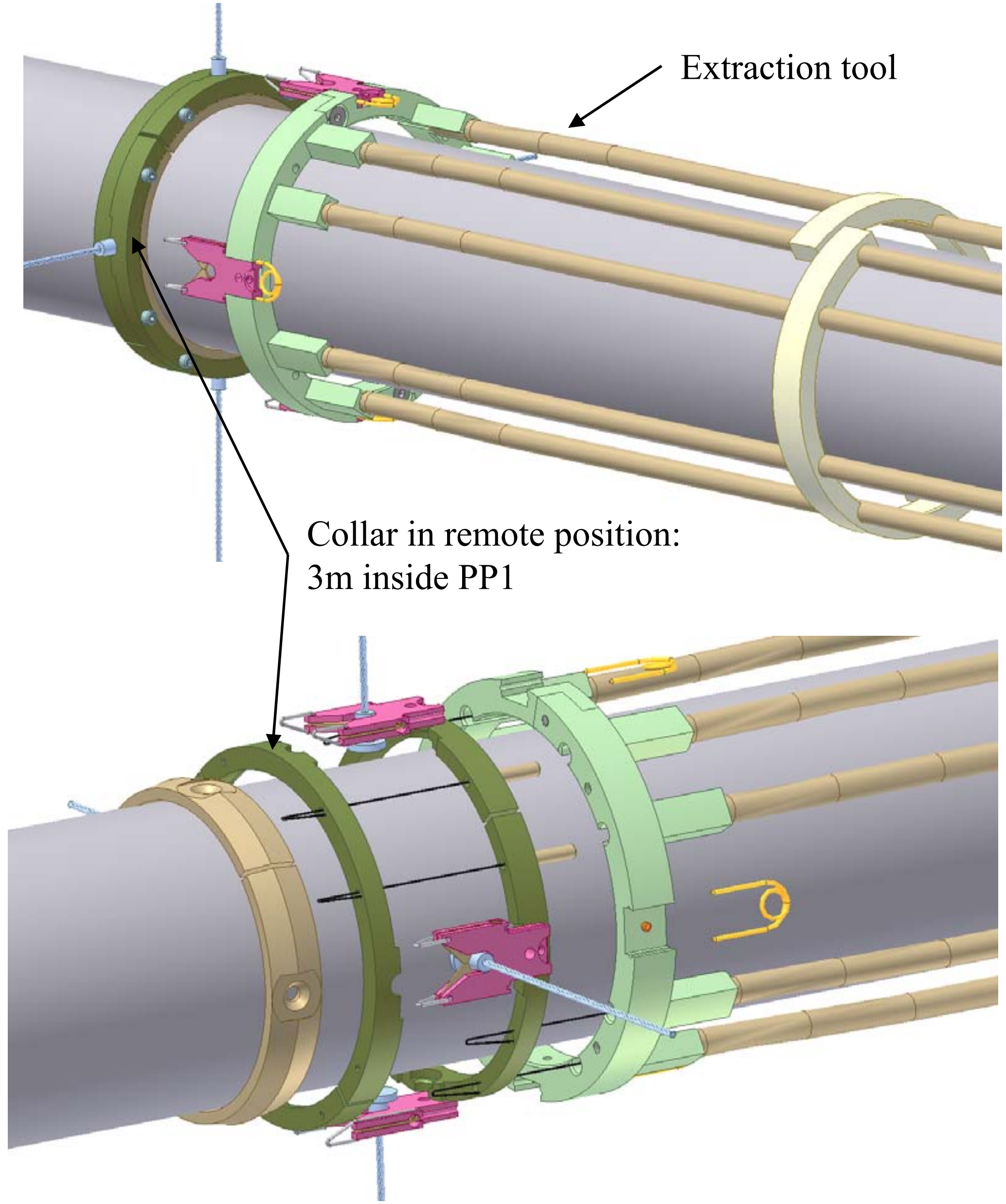
✓ *Other options? Diamonds could be a compatible technology*

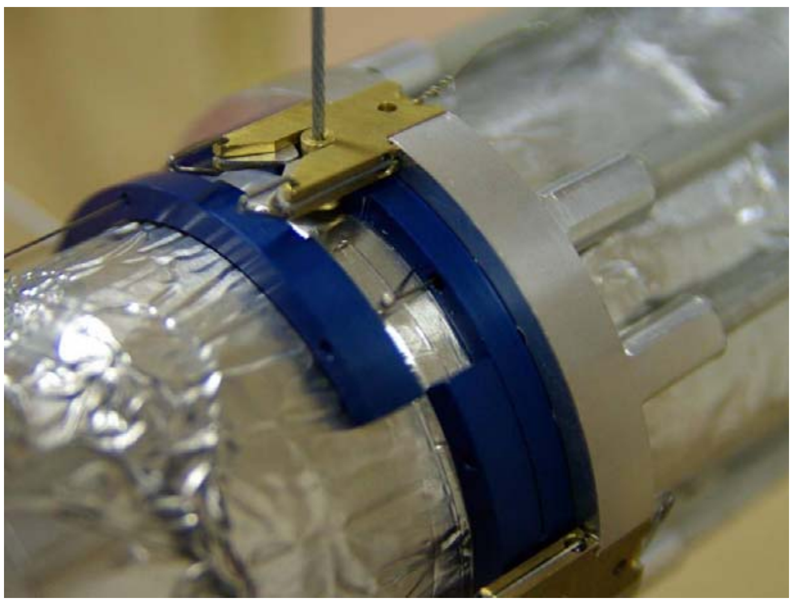
- No cooling issues, low capacitance, no leakage current make them appealing…
- Smaller community than silicon…

Removing the existing Be beam pipe a real challenge

- ✓ *Tools to dismount Beam Pipe support collars:*
  - Remote access >3 m inside
  - Activated material – fast operation
- ✓ *Beam pipe must been supported from inside*

  Tool has to compensate gravity bow (7m long pipe).





Why is IBL so important ?

- ✓ This will be the first real upgrade project in the community, time scale 4 years

- ✓ Most of the problems and technologies necessary later for sLHC will be tested and solved already. Excellent test bench for later. The IBL is the "technology" bridge to sLHC. Its specification requires us to develop and use new technologies, which are directly relevant for sLHC

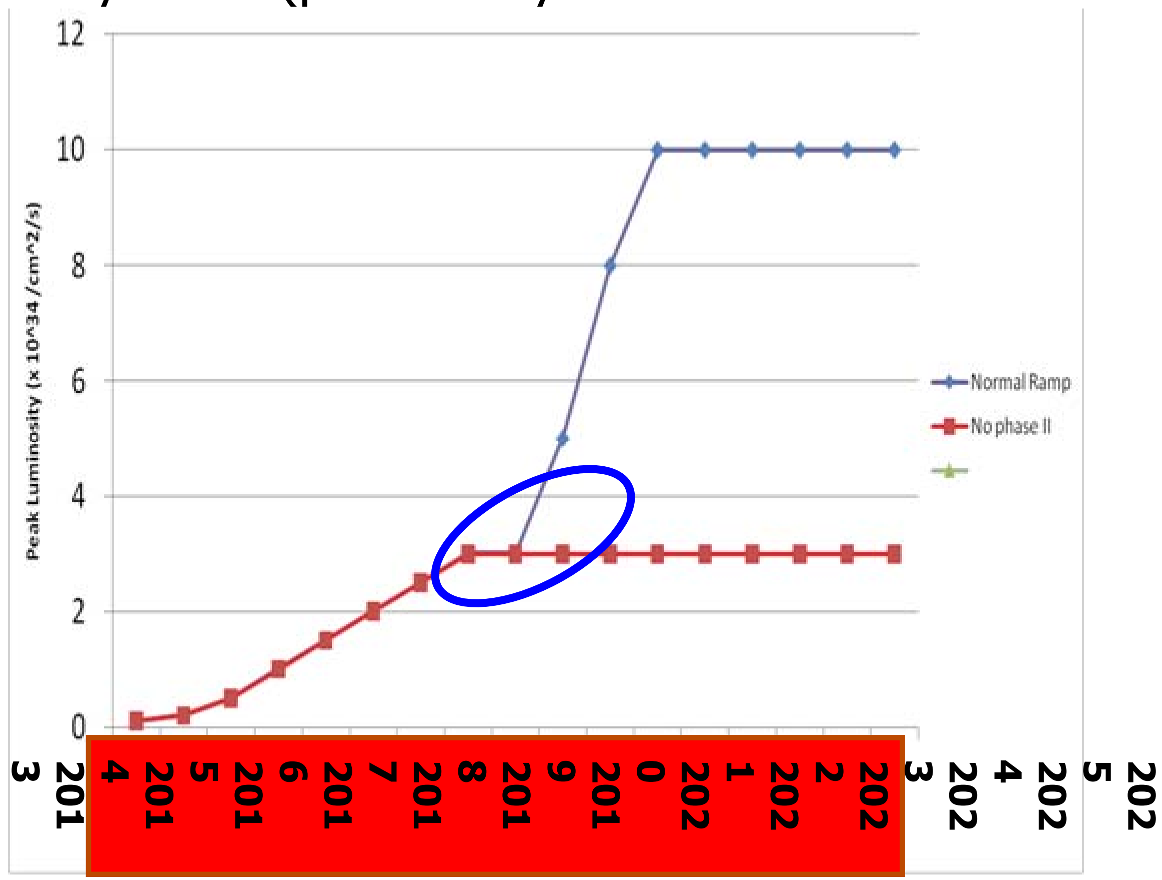
- ✓ ATLAS has already launched the project: project management and organization defined. Technical Design Report due in early 2010 for approval by LHCC together with MOU (financial plan)

- ✓ Perfect tuning with LINAC4 installation schedule very important. If 2014/2015 is the real date we should know it now.

At ~ 700 fb^{-1} or 8-9 years form now we will need a general detector upgrade

- Some parts of ATLAS will age because of radiation (inner detector first, front end electronics, ….)
- Technology will be ahead of us in many fields (particularly in electronics and computing)

At that moment we will have two possibilities, either continue with the same machine and collect statistics or aim to a substantial increase in luminosity (factor 3) to collect about 3000 fb^{-1} on tape



In any case to go further we will need a new Inner Detector

Why should we go beyond 700 fb^{-1} ?

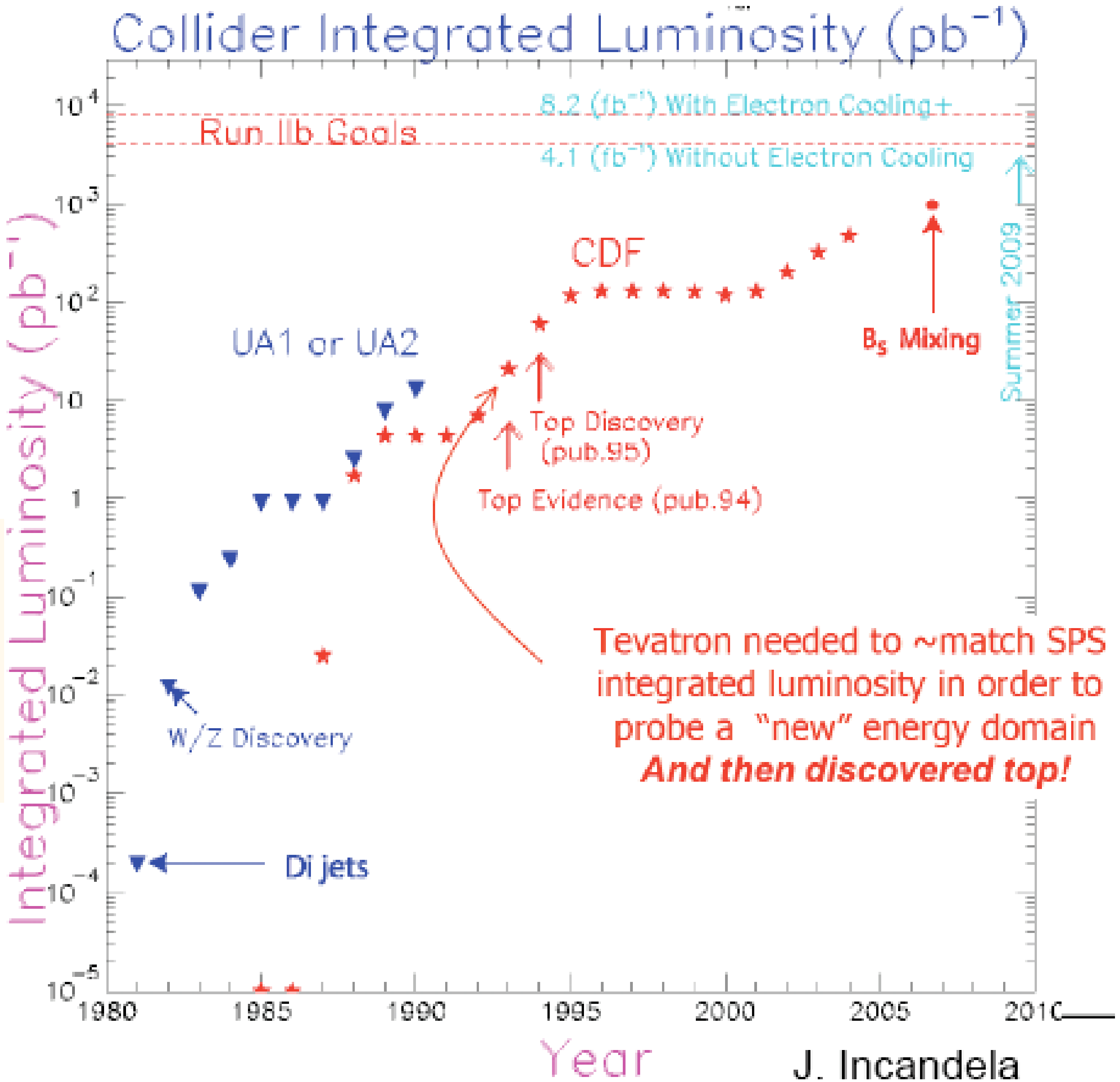
✓For sure we will need some good initial discovery statistics, to make such a firm statement (2011-2012 ?)

✓See M.Mangano's talk yesterday!

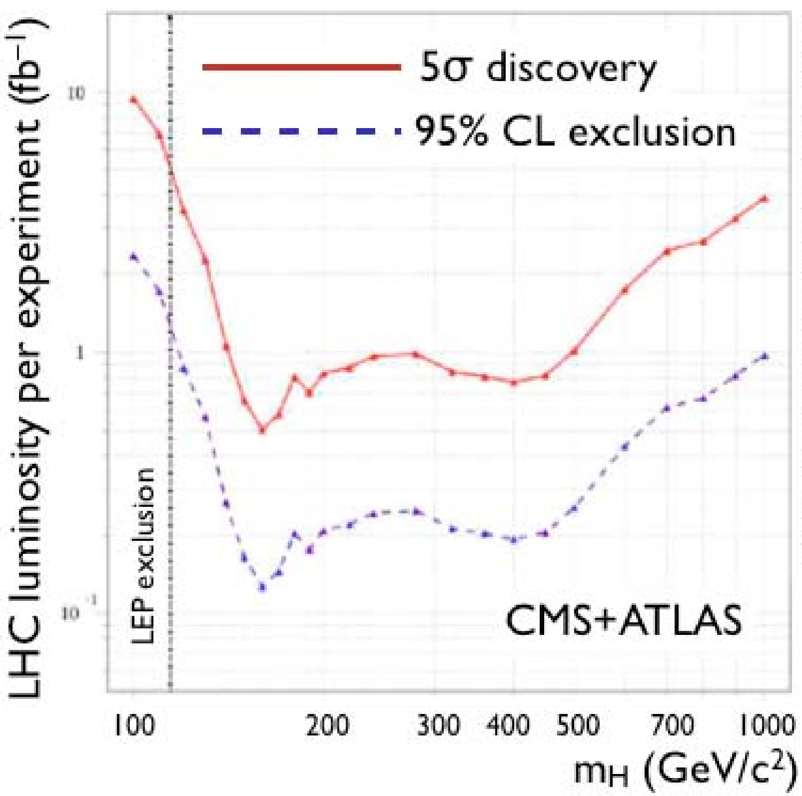
✓ … but for me this plot is a good enough motivation

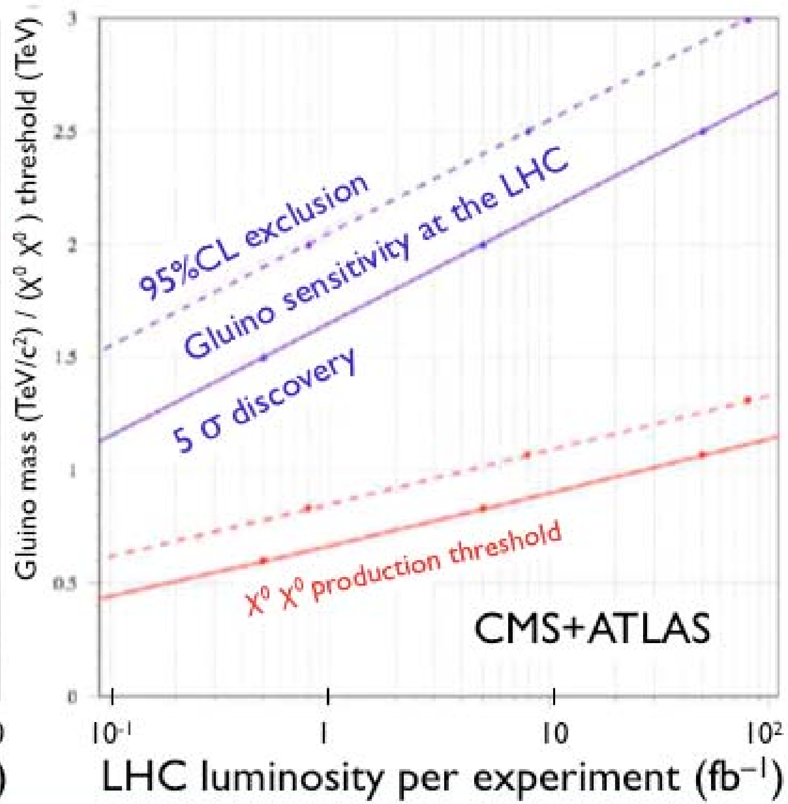
Discoveries come at the beginning & at the end

new energy domain
large statistics



Why should we go beyond 700 fb^{-1} ?

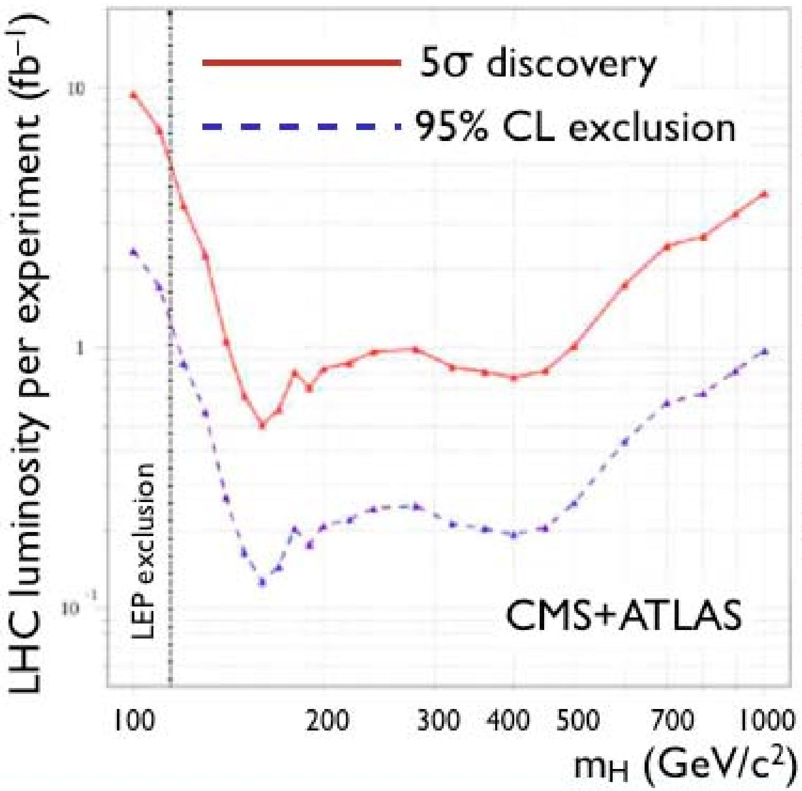


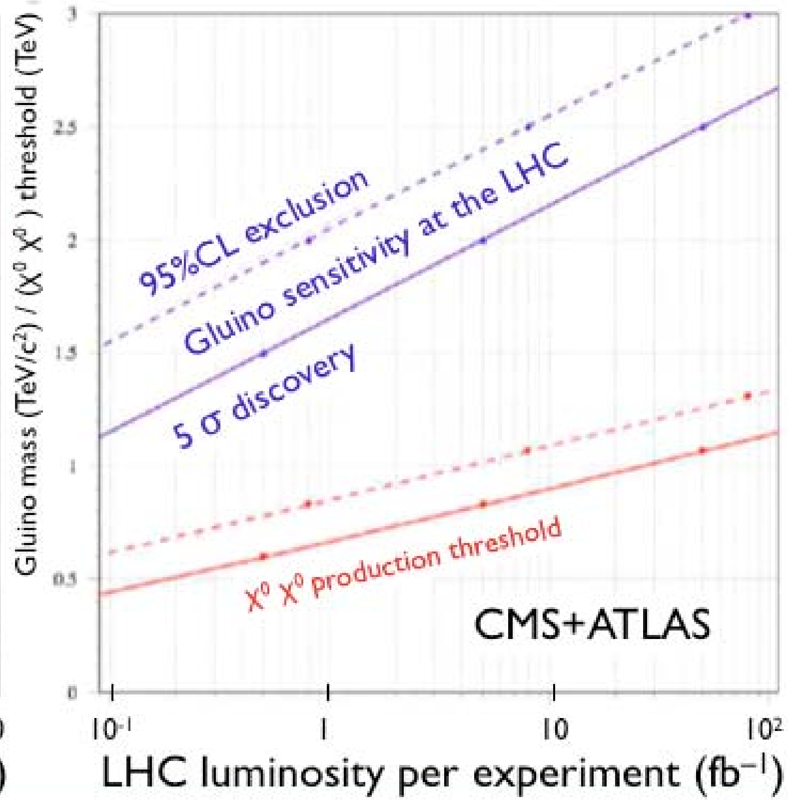


Already with less than 10 fb^{-1} the Higgs will be found and new discoveries are likely

By 2011-12 we may have a good picture of the TeV-scale physics

Why should we go beyond 700 fb^{-1} ?



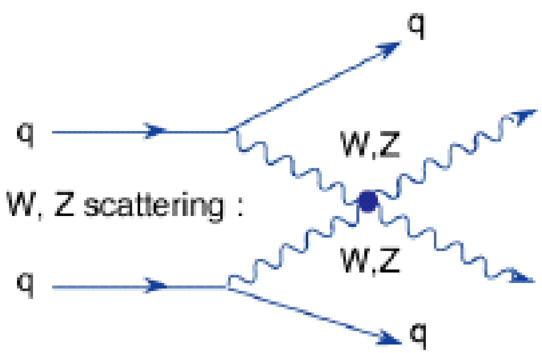


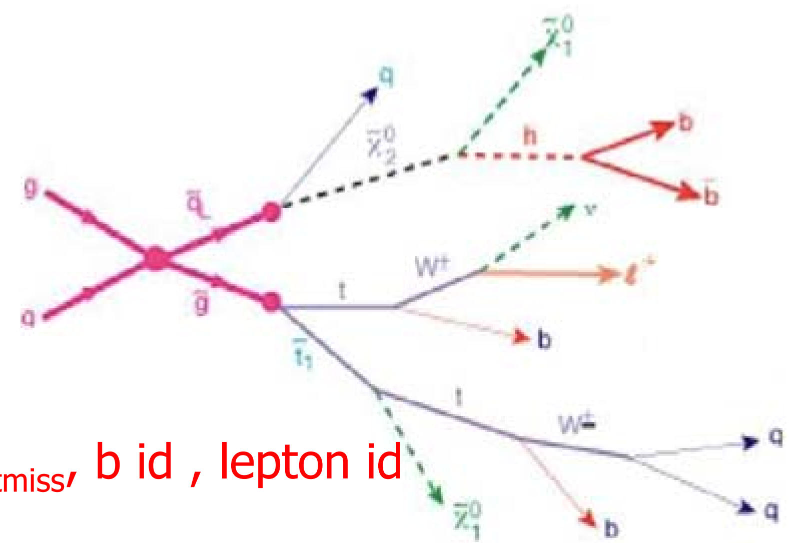
More particles in the Higgs sector? Is the Higgs boson elementary or composite?
Origin of fermion masses ?

Extend the mass reach of new particles ! Determination of susy masses and parameters !

Detector requirements @ sLHC

Detector performance needs to be maintained despite the new environment we will find at sLHC (pile-up, radiation, ….) …. In particular now when we know nothing about the new energy domain





E_{tmiss}, b id , lepton id

High-mass (~TeV Z',W',..) can tolerate some degradation; backgrounds are low

WW scattering (Higgs couplings or vector boson fusion) needs forward jet reconstruction and central jet veto

Vertex, missing E_t, p_t resolution and efficiencies remain important, for many channels of interest

Electron and muons identification fundamental for W/Z, W'/Z', and SUSY

Upgrade strategy

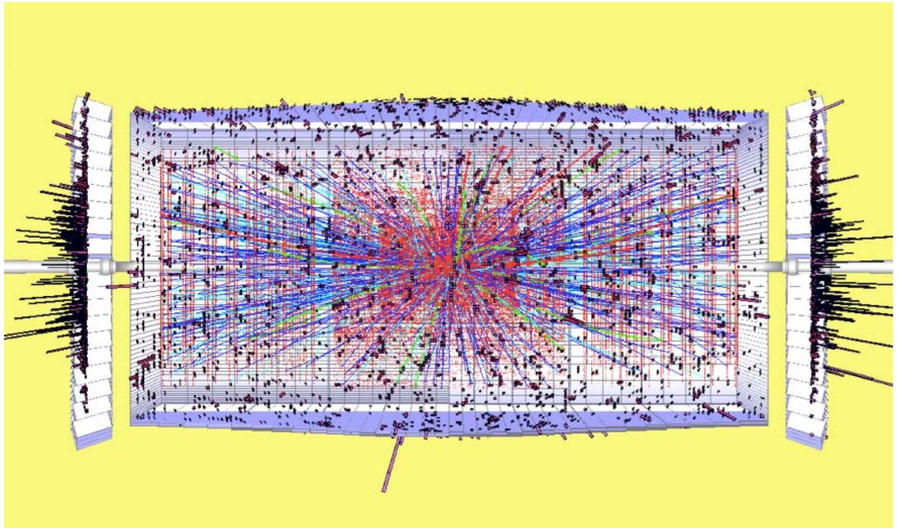
- ✓ To go beyond the LHC period we will need in any case to rebuild a new Inner Detector (with the same or better tracking performance)

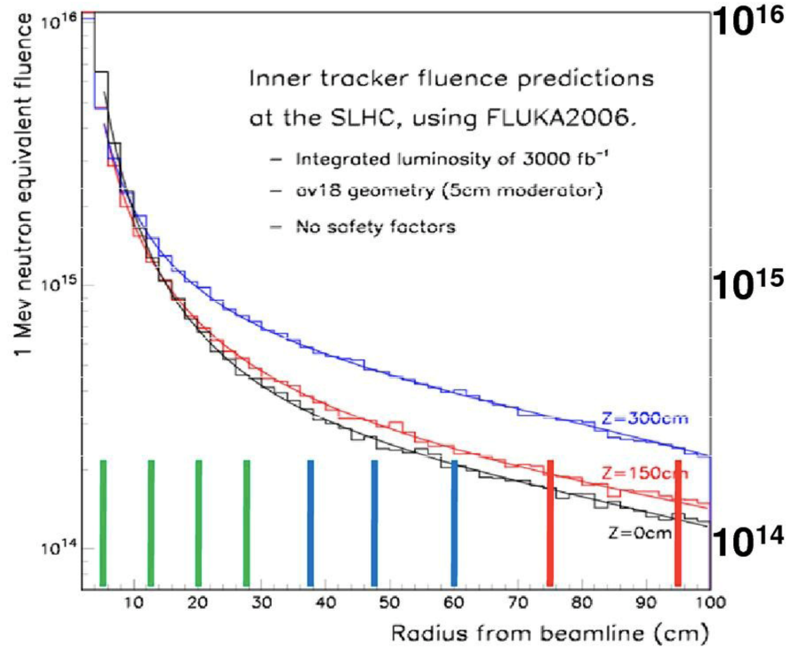
- ✓ This requires major R&D and construction work. Even if we learned the lesson with the first one, it will take good 6-7 years of construction work and few years to integrate it and getting it operational. This means that we have to start now, before knowing the real LHC environment and therefore keeping practically all experimental requirements of the original detector

- ✓ Designing today also means that we assume the technical feasibility of sLHC and we integrate in the design the new pile-up and radiation/activation environment

- ✓ While the financial green light for this new enterprise will probably take a few years and will be tuned to the first LHC discoveries, the detector community has to act now, preparing technology, making choices, testing prototypes and going deeply in the engineering design. ATLAS is in the process of writing a exhaustive LOI for phase II Upgrade

sLHC experimental environment





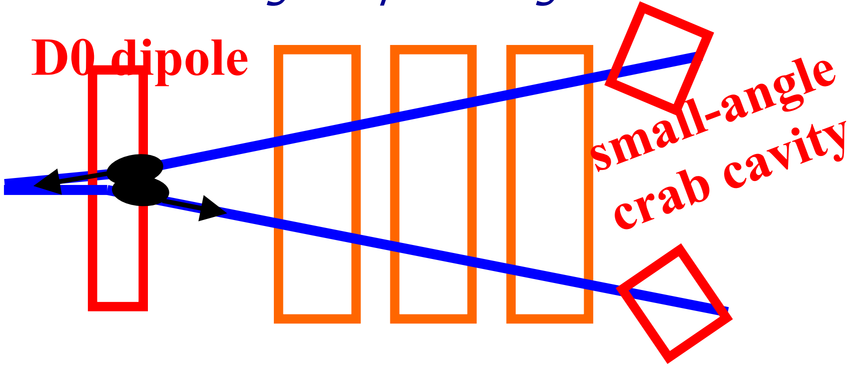
*Minimum bias events **pile-up** dominated by the peak Luminosity. Different sLHC scenarios define the value we have to assume in our design (today's worst case 300 to 400 pile-up events / bunch crossing). Detector granularity, detector transparency and trigger strategy will be tuned to it*

*Detector **radiation** resistance requirement dominated by the delivered integrated Luminosity. Here the detector radius and pseudo rapidity location (η) are the scaling factors*

LHC phase II upgrade paths for IP1 & 5

early separation (ES)

stronger triplet magnets



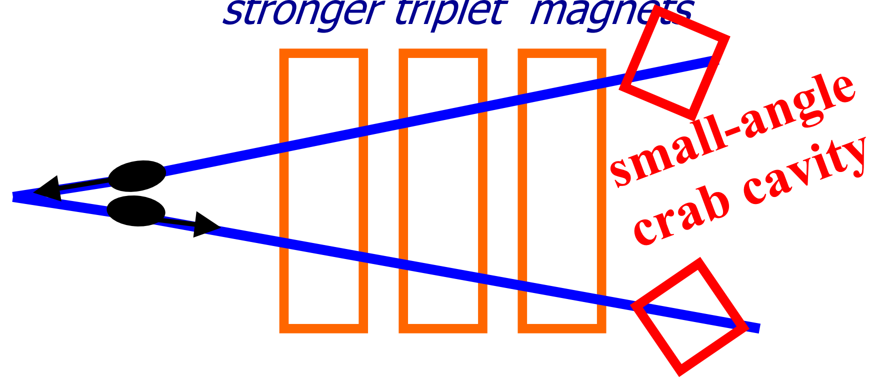
- ultimate beam (1.7x10^{11} p's/bunch, 25 ns spacing), β* ~10 cm
- early-separation dipoles in side detectors , crab cavities

  → hardware inside ATLAS & CMS detectors,

  first hadron crab cavities; off-δ β

full crab crossing (FCC)

stronger triplet magnets

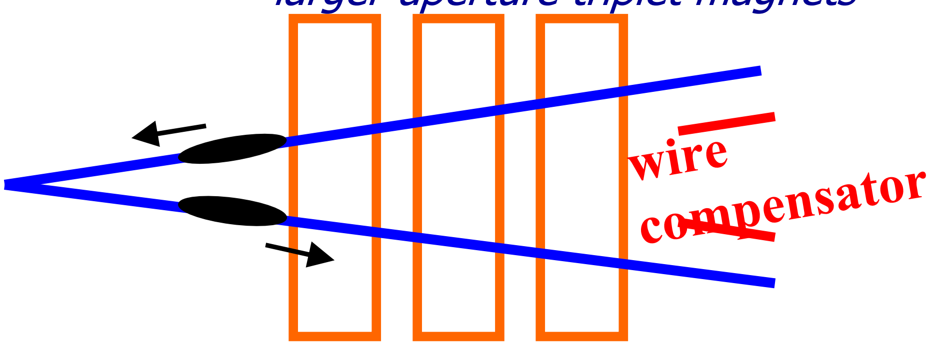


- ultimate LHC beam (1.7x10^{11} p's/bunch, 25 ns spacing)
- β* ~10 cm
- crab cavities with 60% higher voltage

  → first hadron crab cavities, off-δ β-beat

large Piwinski angle (LPA)

larger-aperture triplet magnets

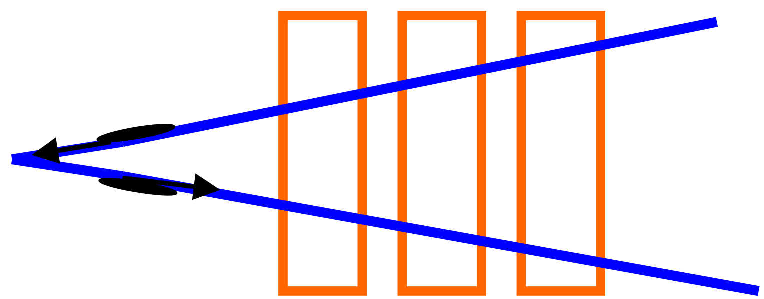


- 50 ns spacing, longer & more intense bunches (5x10^{11} p's/bunch)
- β*~25 cm, no elements inside detectors
- long-range beam-beam wire compensation

  → novel operating regime for hadron colliders, beam generation

low emittance (LE)

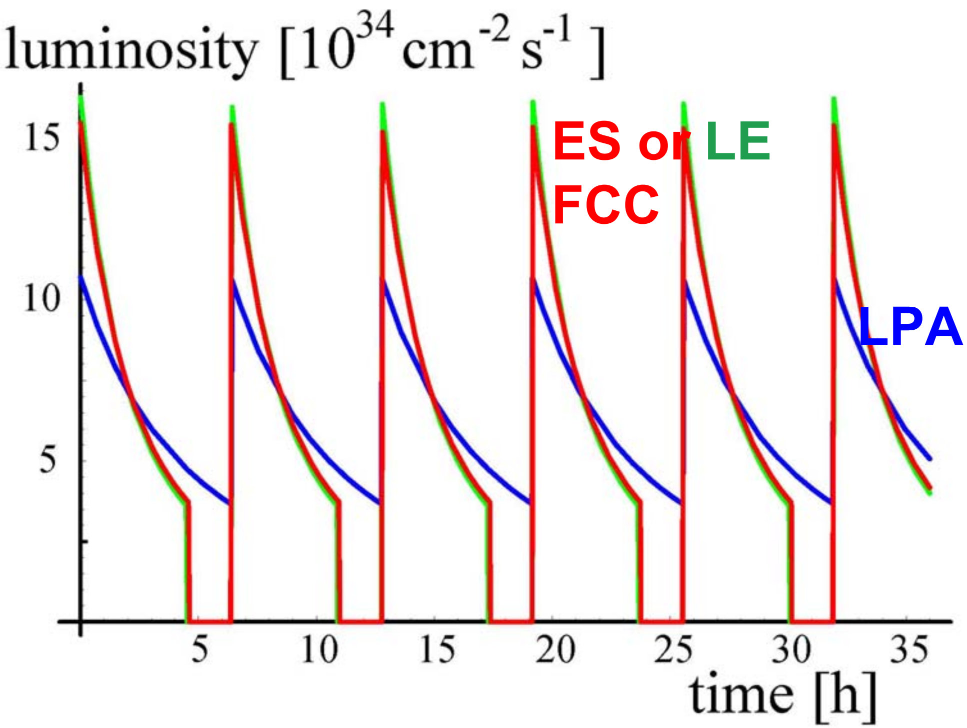
stronger triplet magnets



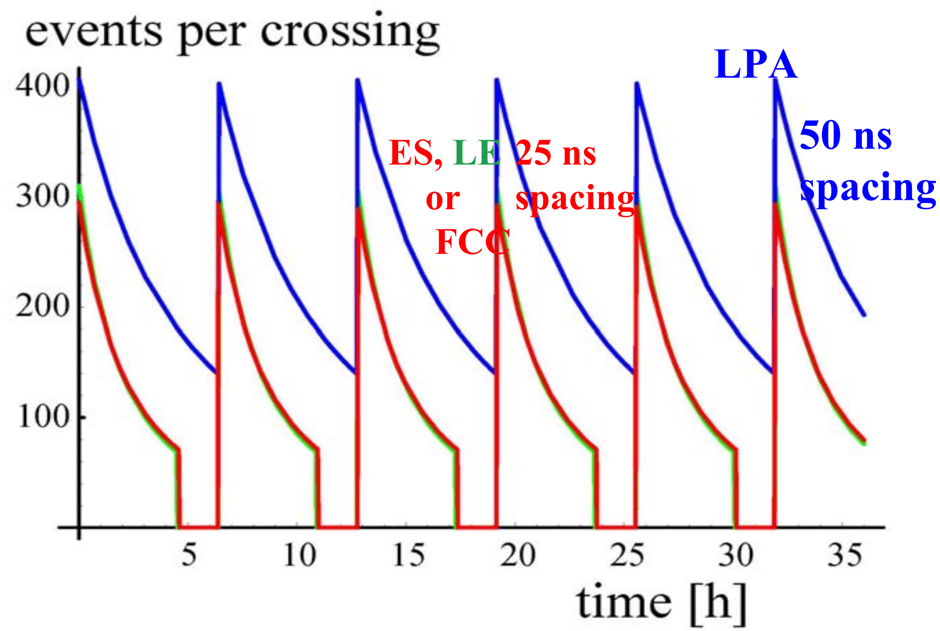
- ultimate LHC beam (1.7x10^{11} p's/bunch, 25 ns spacing)
- β* ~10 cm
- smaller transverse emittance

  → constraint on new injectors, off-δ β-beat

sLHC scenarios (presented to us)



Very inefficient way to use the beam, very difficult experimental environment at the very beginning of the fill, short cycles



At this stage this forces us to design for 400 events/crossing

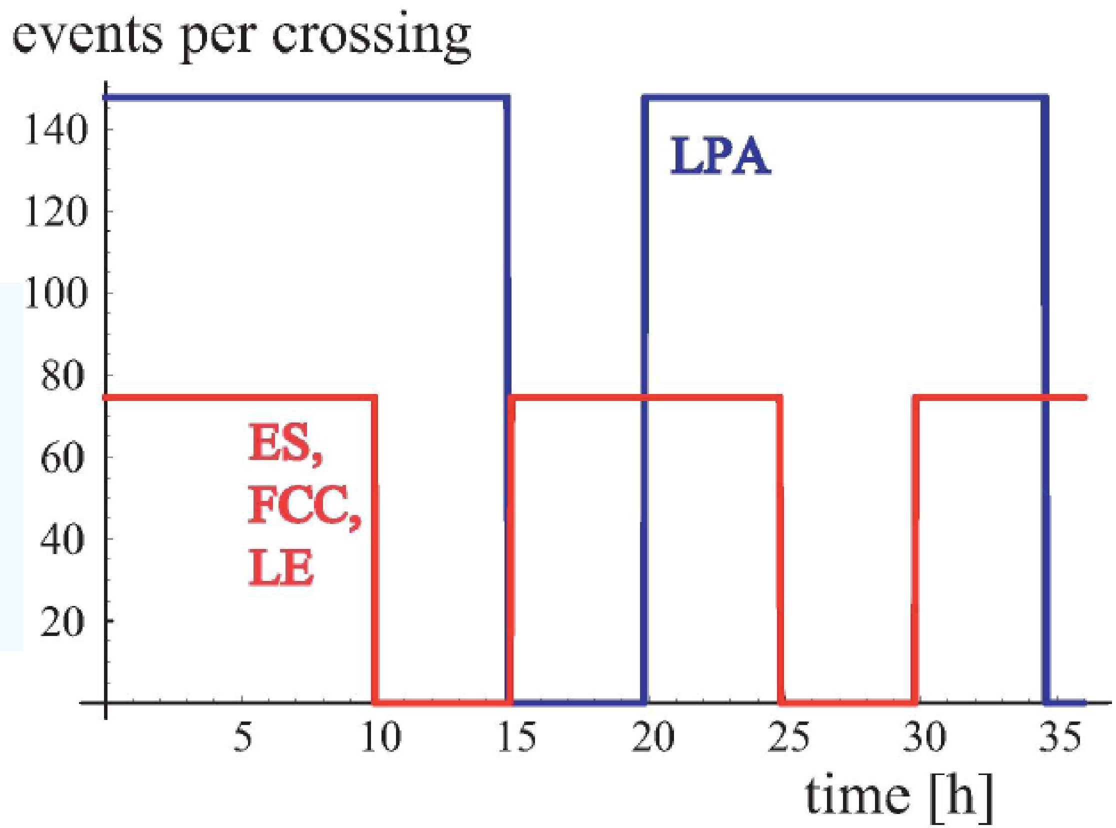
sLHC scenarios (with leveling)

Experiments prefer ~constant luminosity, less pile up at start of run, higher luminosity at end

Pile-up problem solved by luminosity leveling

How to achieve this?

ES, or FCC: dynamic β squeeze, or dynamic θ change (either IP angle bumps or varying crab voltage)
LE: β or θ change
LPA: dynamic β squeeze, or dynamic change of bunch length



sLHC scenarios (with leveling)

Experiments prefer ~constant luminosity, less pile up at start of run, higher luminosity at end

	ES, low b*, with leveling	LPA, long bunches, with leveling
events/crossing run time av. luminosity	300 N/A N/A	300 2.5 h $2.6 \times 10^{34} s^{-1} cm^{-2}$
events/crossing run time av. luminosity	150 2.5 h $2.6 \times 10^{34} s^{-1} cm^{-2}$	150 14.8 h $2.9 \times 10^{34} s^{-1} cm^{-2}$
events/crossing run time av. luminosity	75 9.9 h $2.6 \times 10^{34} s^{-1} cm^{-2}$	75 26.4 h $1.7 \times 10^{34} s^{-1} cm^{-2}$

Pile-up experimental solutions

- ✓ Improve the detector granularity (η x ϕ), by reducing pixel size, strip dimensions for silicon counters, by adding more detector layers to increase the number of precision points/track ….. with direct impact on cost and complexity …. In general keep occupancy at 1-2% level for an efficient pattern recognition

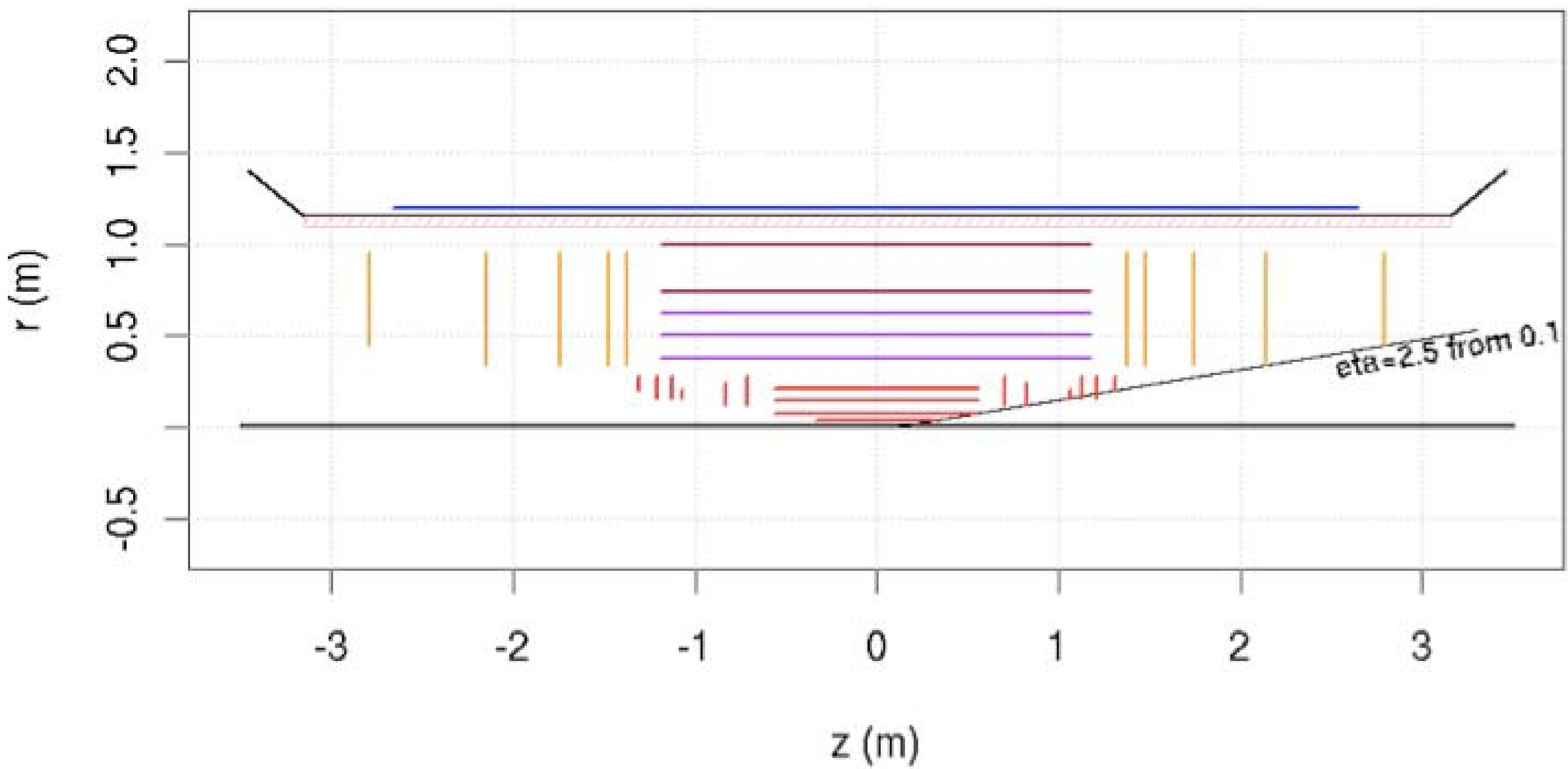
- ✓ Reduce or better control the effective amount of material in the tracker in particular to minimize the pre-showering of photons and electrons, which compromises particle identification, occupancy and momentum versus energy matching

- ✓ Design more efficient triggers, in particular at level-1 for trackers (muon spectrometer and Inner Detector ?)

ID layout for simulation and engineering

Full semiconductors solution : strips (~160m^2) and pixels, organized in staves !

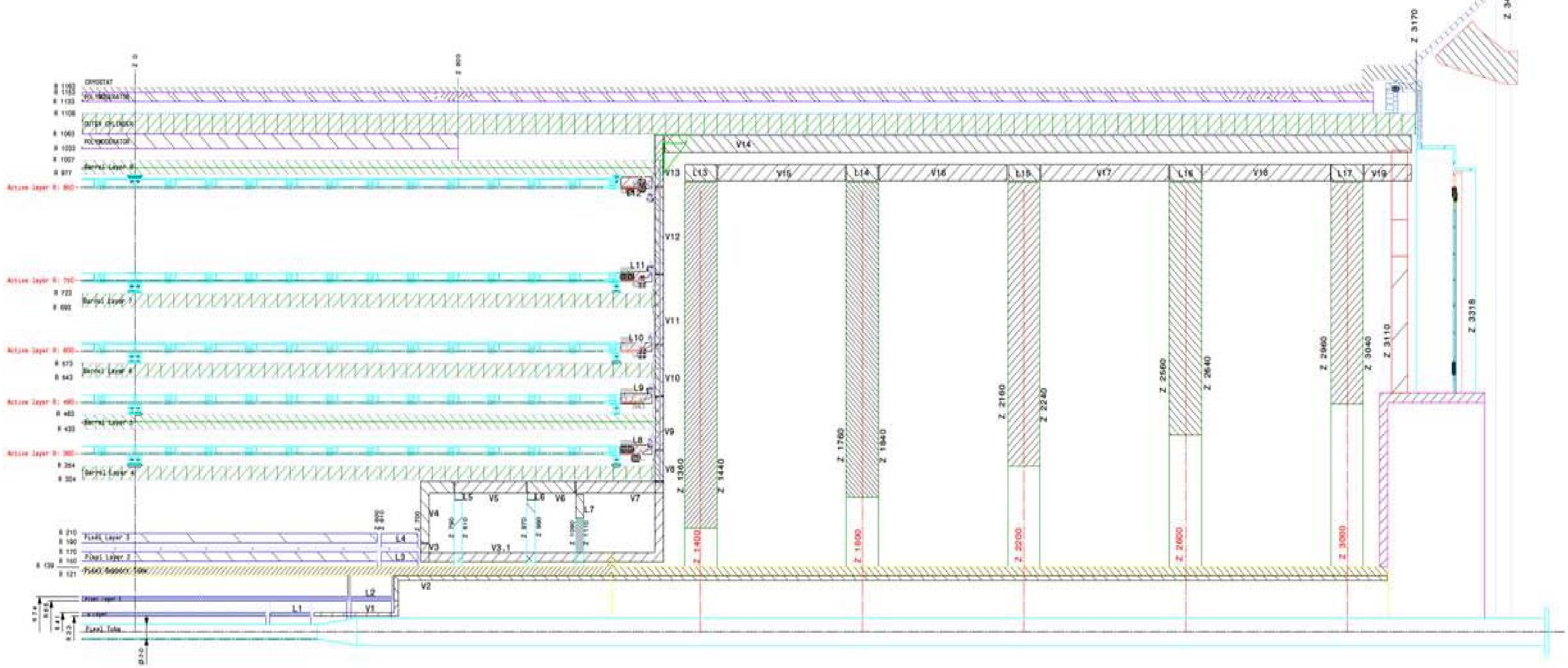
Patter recognition efficiency being optimized (14 hits system)!



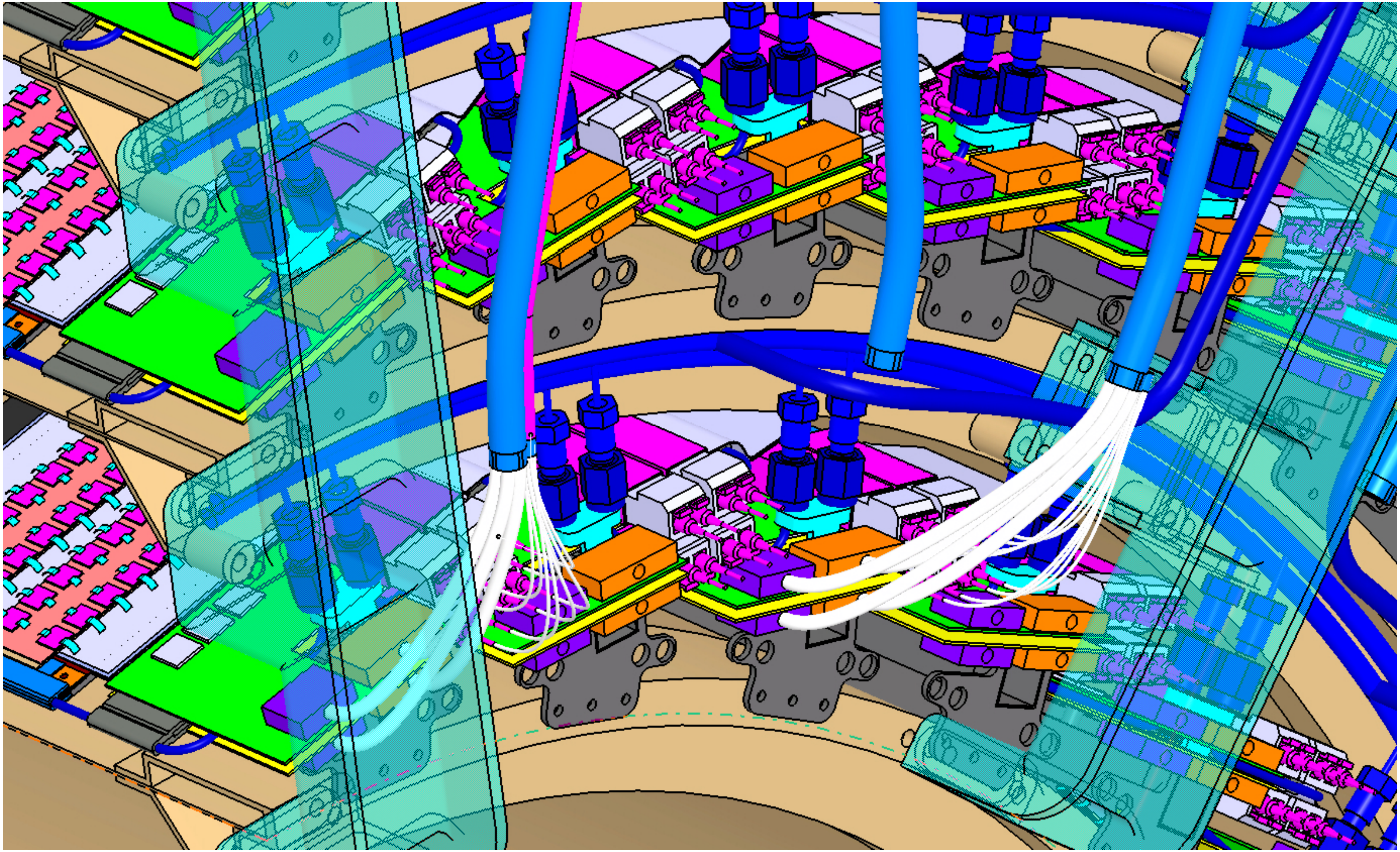
Bringing more realism in the layout (services and supports)

Key issues are:

- ✓ *an effective cooling system (~-30 C, CO_2 …. smaller diameter pipes)*
- ✓ *an effective power distribution (serial/parallel power, less copper needed !)*



Or even too much at this stage



New ID means new services, new cooling plant and removal/re-installation work in situ

✓Re-installation work requires a long shutdown ~ 18 months

- Disconnect all services of the old ID
- Removal of the old ID
- Reorganize new services in situ (power, signals, cooling pipes,…)
- Install and align
- Connect all services
- Test and qualify the process before closing
- Commission

✓We spent 3 years to do it in first place for the LHC, we assume we will be capable to do it in 18 months next time … even if the logistic this time is more complex

✓Details of this process are already under evaluation/engineering, this time ALARA considerations add complexity to the process

ID LVL1 trigger?

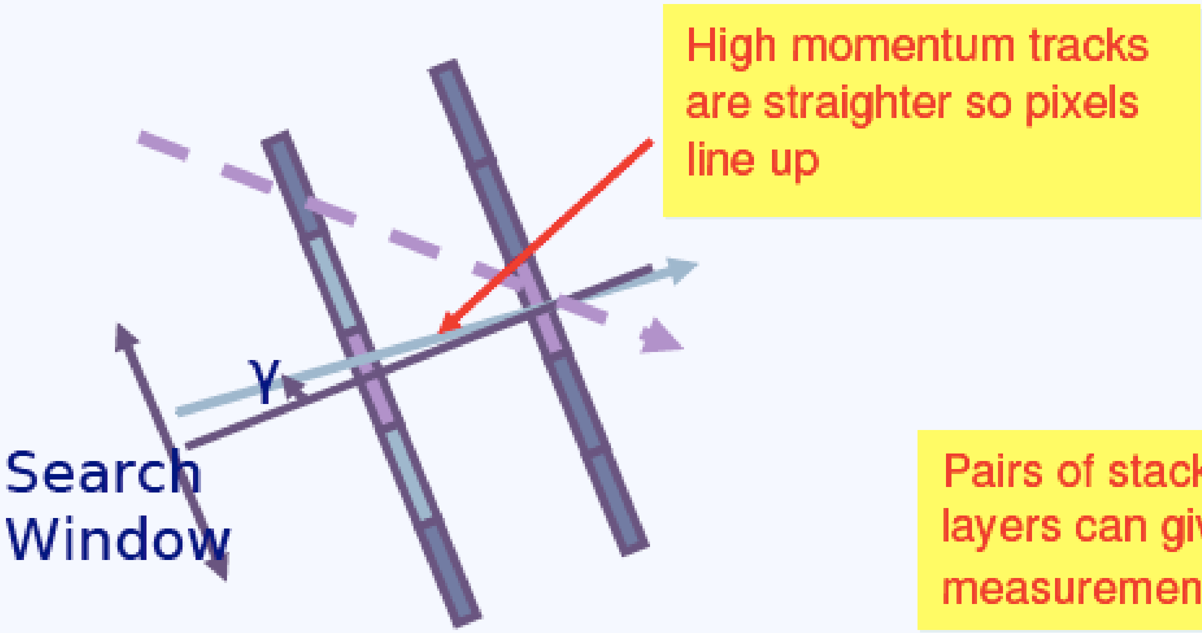
The goal is to maintain trigger rates

Still challenging! You have to reject 10 times more events at LVL1, and process much more data at LVL2 (pile-up → bigger events)

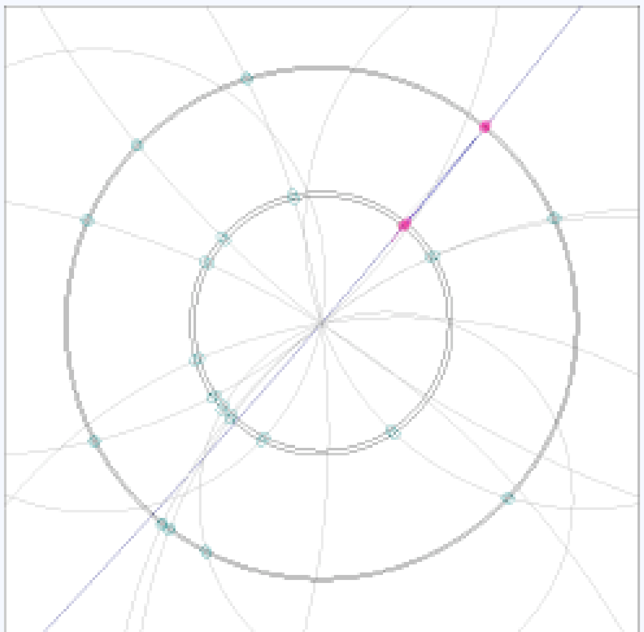
Continuous process of replacing and increasing processor hardware

Consider increasing level-1 latency (from 2.5μs to 5-6μs): the time available to actually run the trigger increases rapidly as LVL1 latency increases

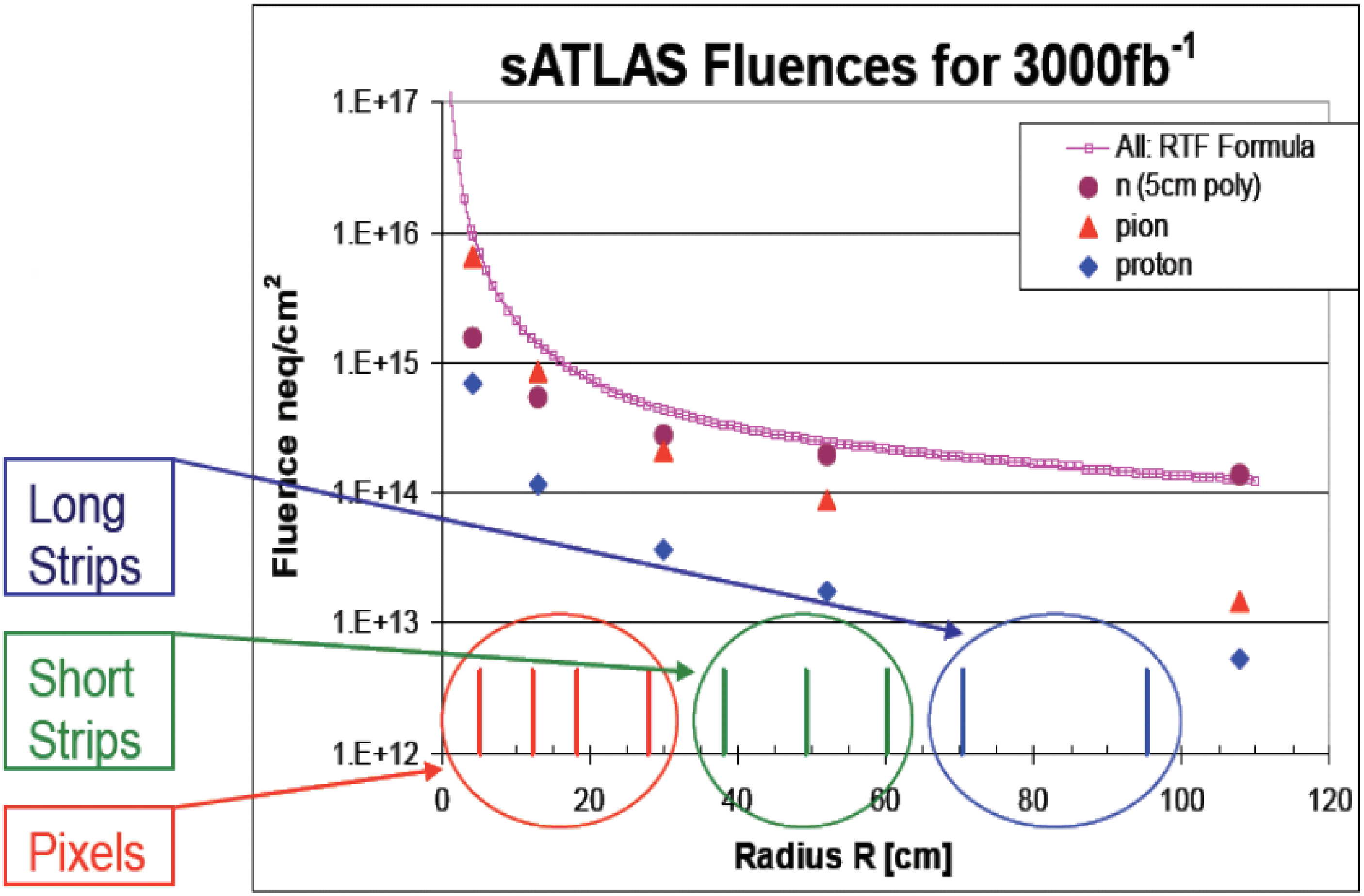
First idea/discussions on the need/possibility to build a Inner Detector LVL1 trigger



Pairs of stacked layers can give a P_T measurement



Particle fluences, radiation resistance

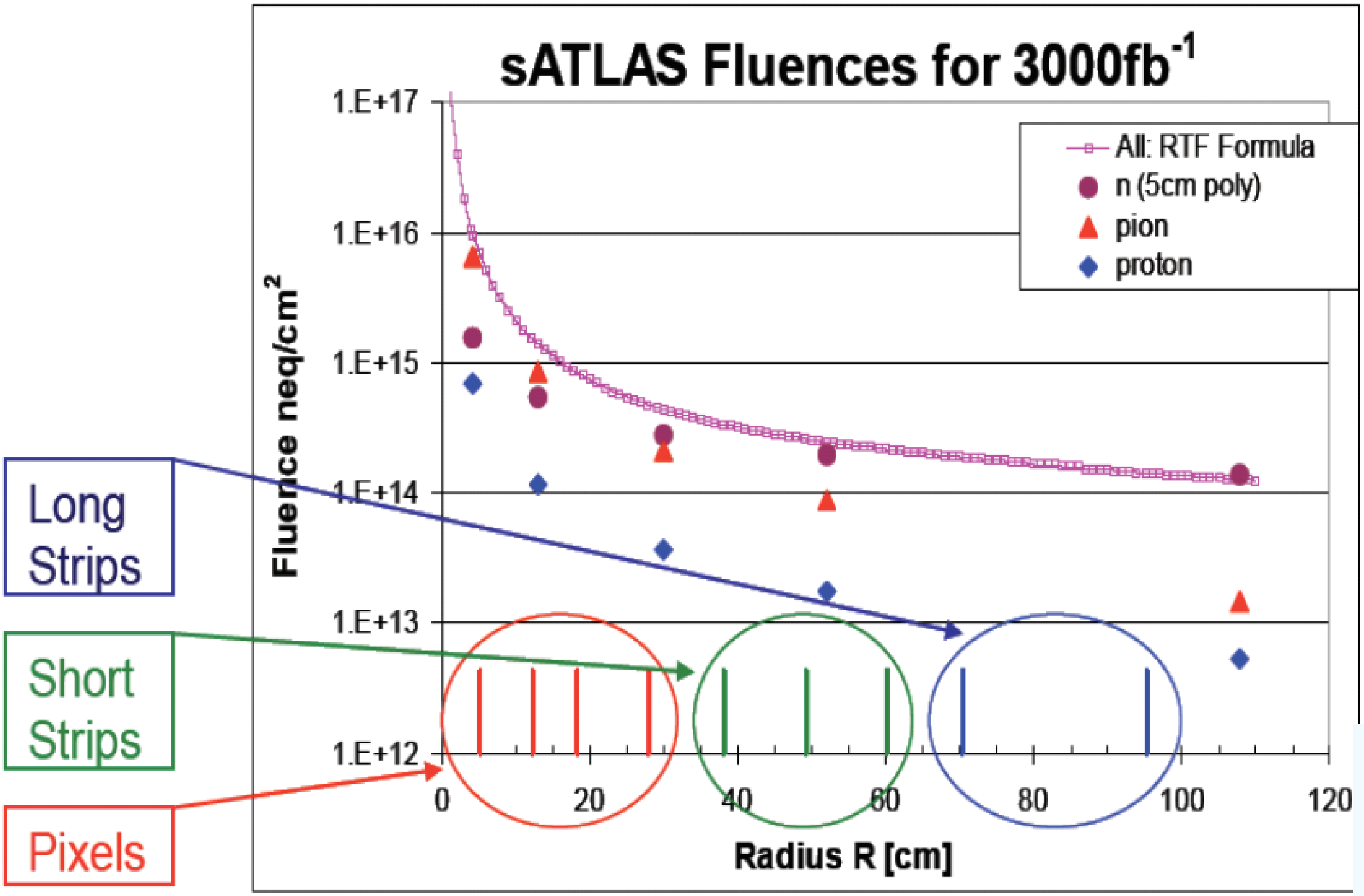


Most particle: neutrons, pions and protons, depending on radius

Pixel damage due to pions and neutrons (up to 8 $*10^{15}$ neq/cm^2)

At b-layer dose dominated by direct tracks (pions)

Particle fluences, radiation resistance



b-layer at 37mm:

✓Assume 3000 fb^{-1}data * safety factor 2 * 79 mb pp*sec * 6.3 tracks/η/interaction

✓**= $3.4*10^{16}$charged part/cm^2**

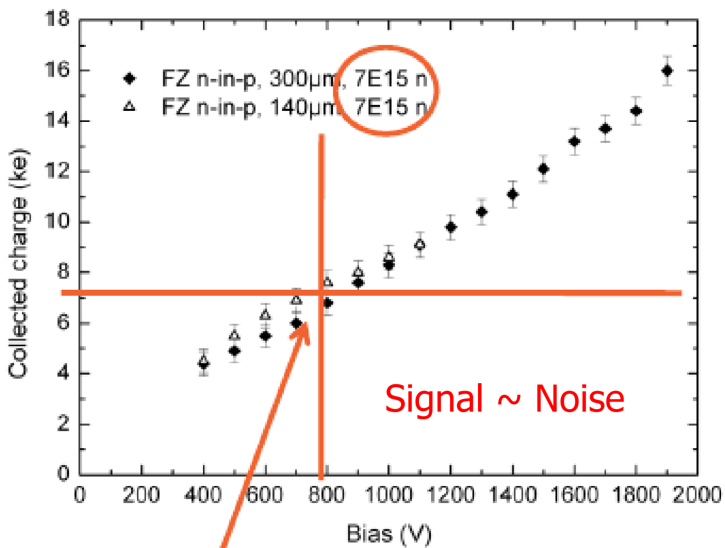
✓**= $2.0*10^{16}$ neq/cm^2**

✓**Dose = 950 Mrad**

✓**Rate = 0.9 GHz/cm^2**

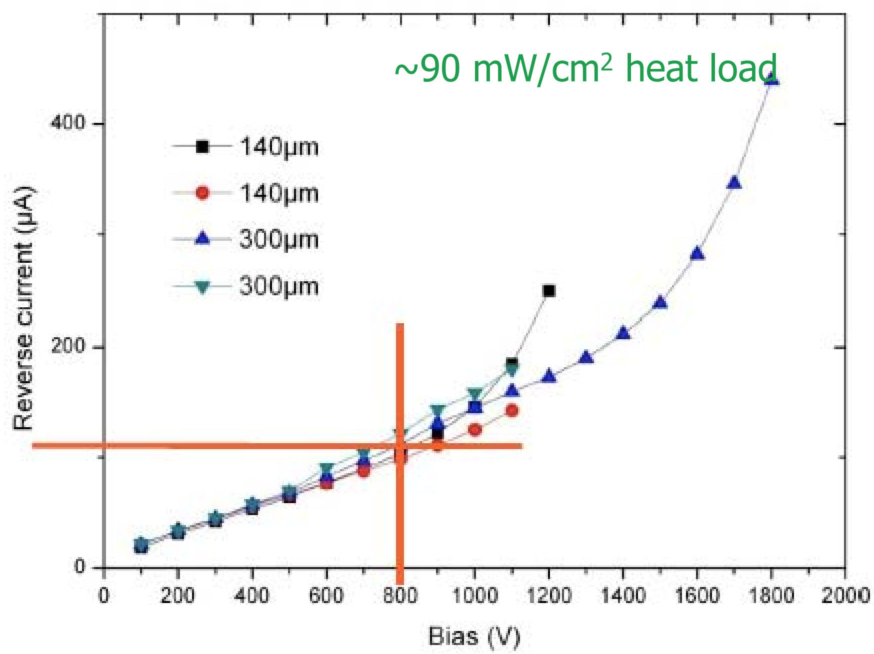
Need to find the right technology for sensors (various options) and electronics (FE-I4, 130nm?)

Example : planar silicon (n-in-p)



Possible working point
800 V, 7 ke-

7 * 10^{15}neq/cm^2 is doable, but at the limit !
This solution no good for innermost pixel layers !



current planar-Si sensor technology is not radhard enough to survive the end of sLHC. Either new sensors or replace it every few years (3D silicon, thin silicon, diamond, MPGD (Gossip) as alternatives)

Particle fluences, radiation resistance

✓For other detectors of ATLAS (in the forward region), particle fluences strongly depend on the beam pipe transparency and the radiation shielding around it (in particular in the muon spectrometer)

✓We spent 5-6 years to optimize the present layout. We will be sure of the result only when we will experience first collisions

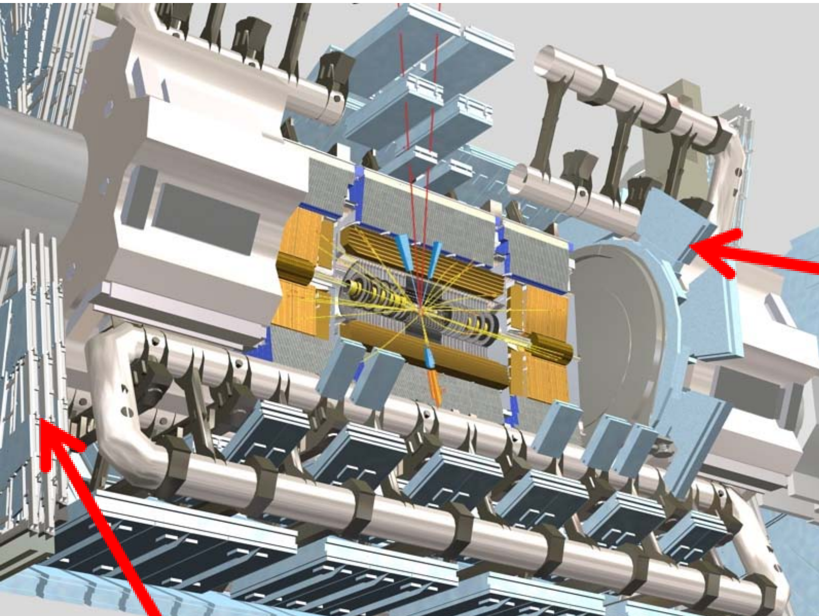
✓At sLHC the problem will be a order of magnitude worse

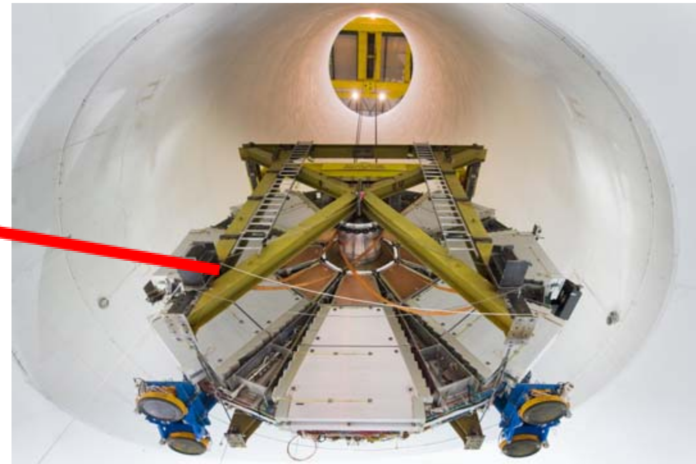
→ we will need full beryllium pipes (50m)

→ we will need to re-optimize the entire shielding system (today ~ 2000 tons of material)

✓Aging and radiation dose will be a problem for most of today's front end electronics, for sLHC we will need to rebuild it with new technologies

Forward muon spectrometer

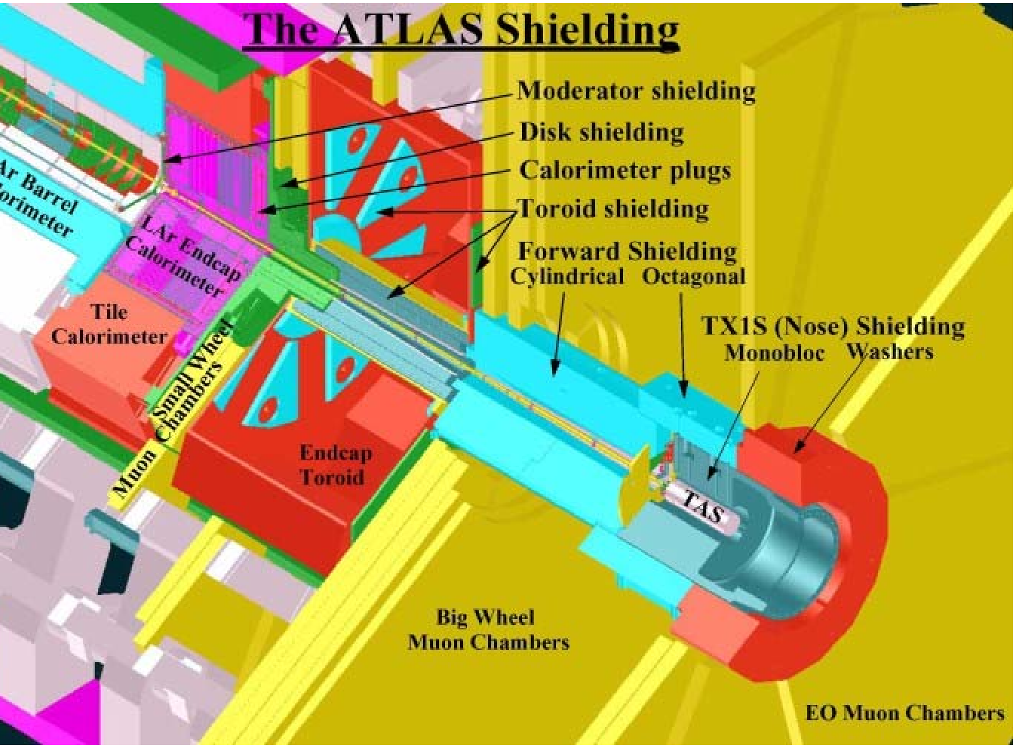




By its nature the muon detectors (trigger and precision chambers) are in large neutron clouds. Neutrons will be captured, will convert to photons and electrons, contributing substantially to the noise figure.

Muon LVL1 trigger is a fundamental ingredient of the data flow reduction mechanism (from PB/sec to GB/sec on tape). This Level 1 trigger must be efficient!

Forward radiation shielding

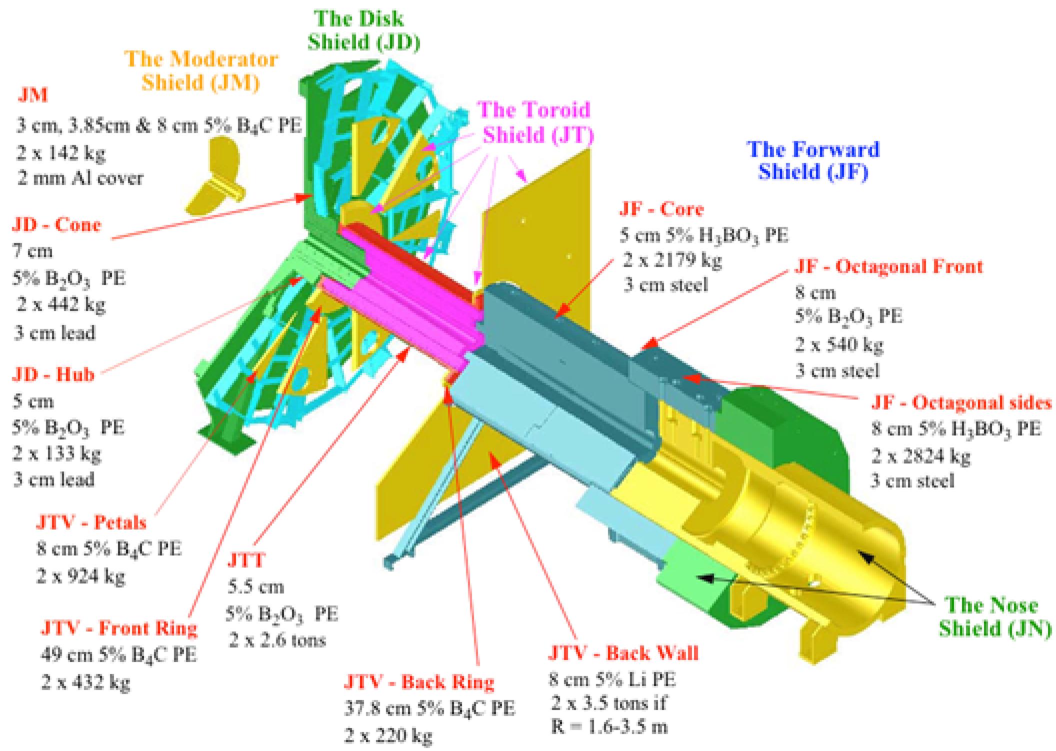


Radiation shielding optimization in an air core toroid is a real difficult problem

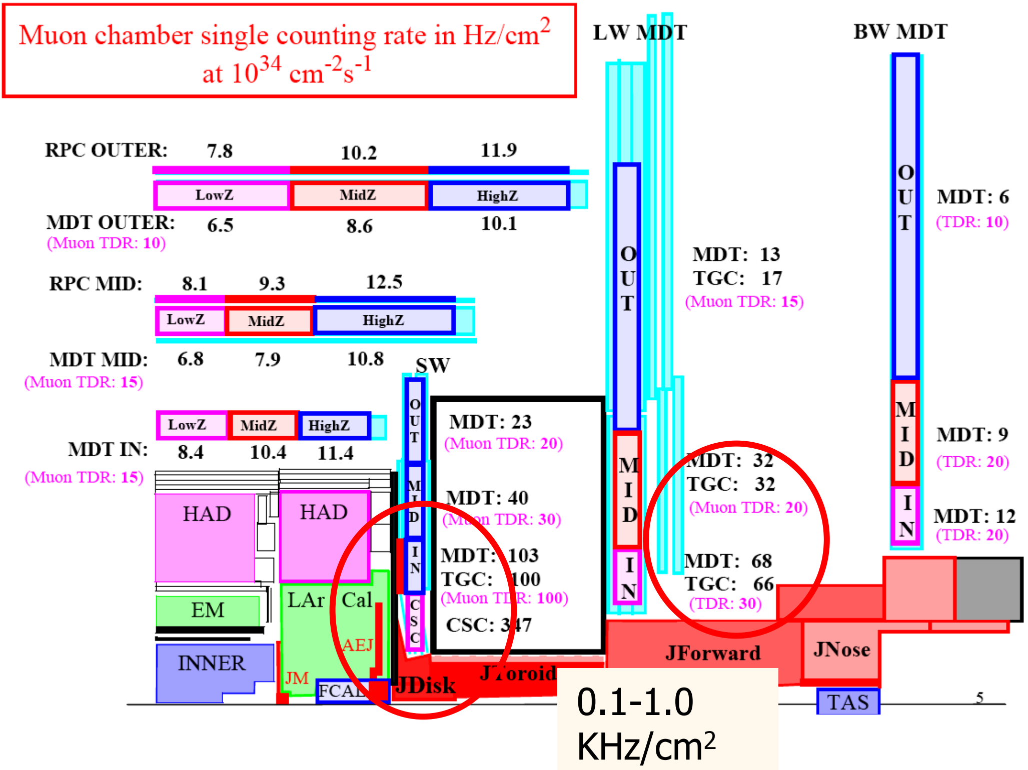
The muon spectrometer occupancy and its LVL1 trigger depend on it severely

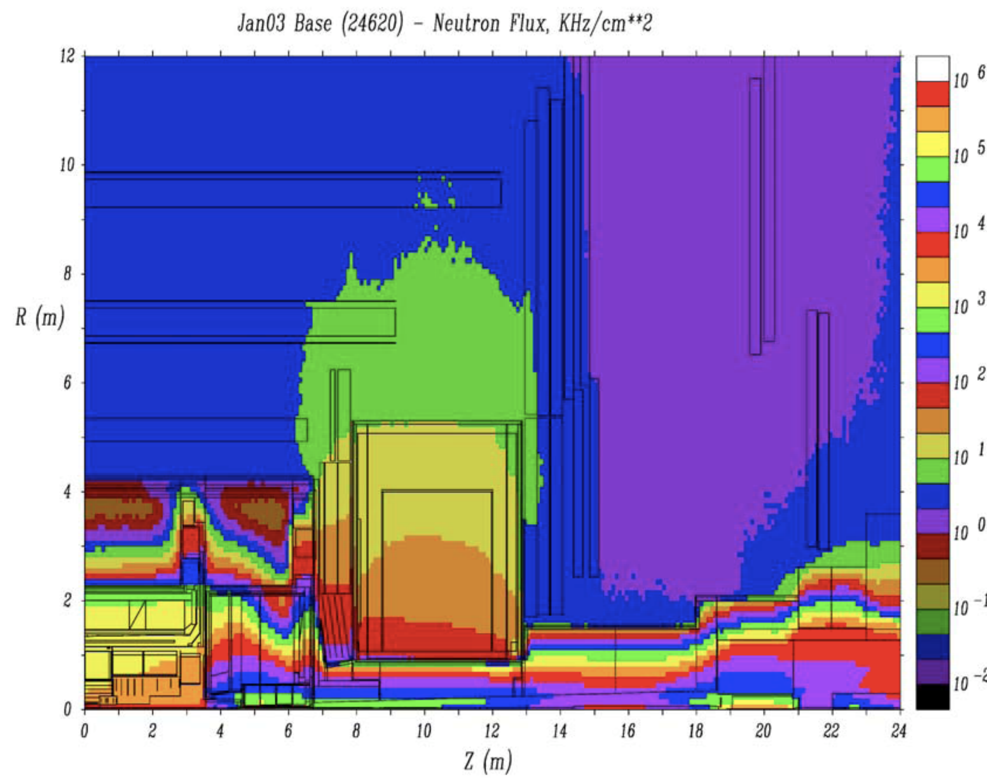
Years of optimization have been spent

All possible space used, further optimizations just possible in the TAS region, where some space is still available



Muon Detectors Counting rates



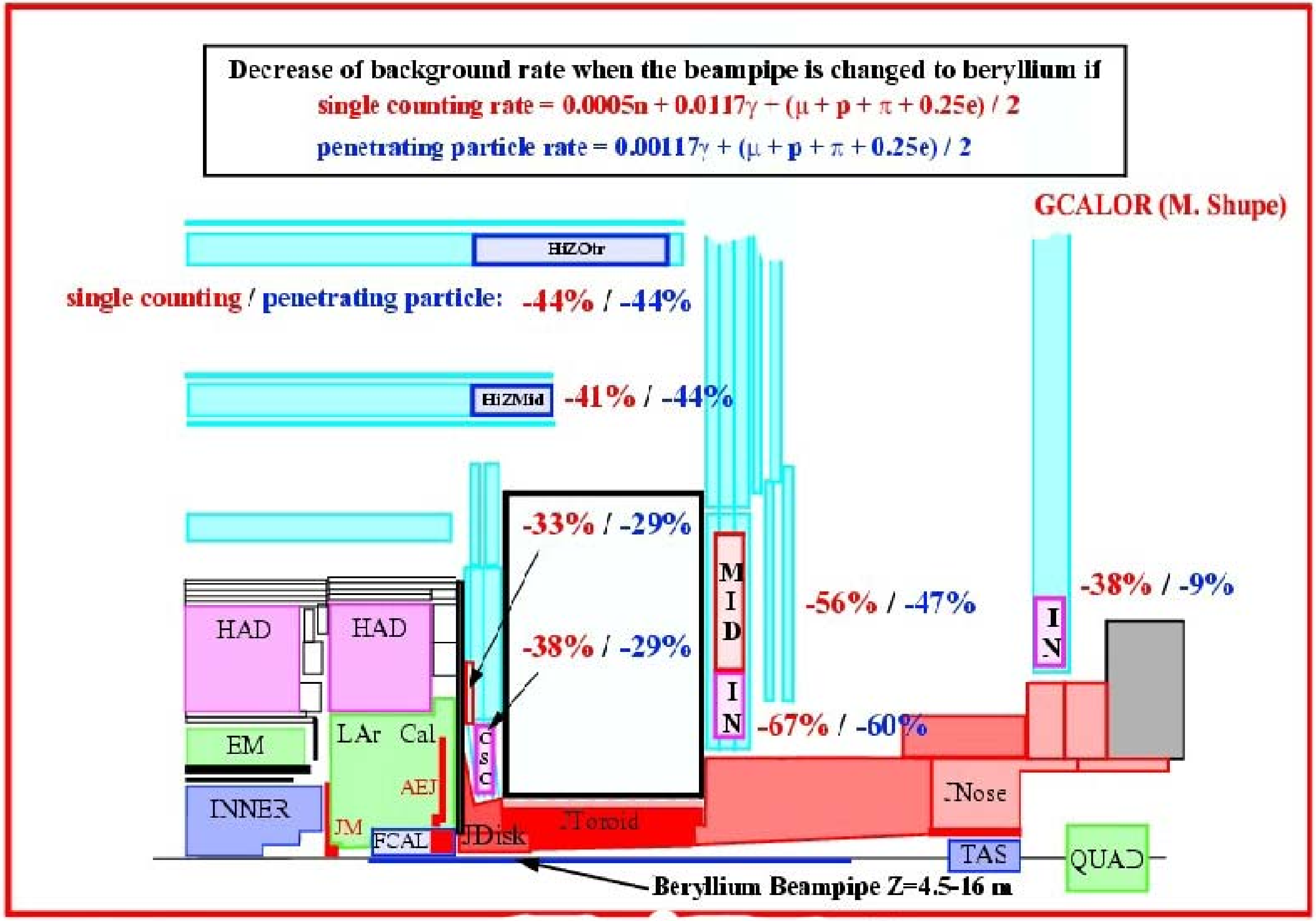


Today's estimations have safety factor of 5 (cross section x 1.3, modeling x 2.5, det. res. x 1.5)

We need first collisions to understand the real scale of the problem at 10^{35}

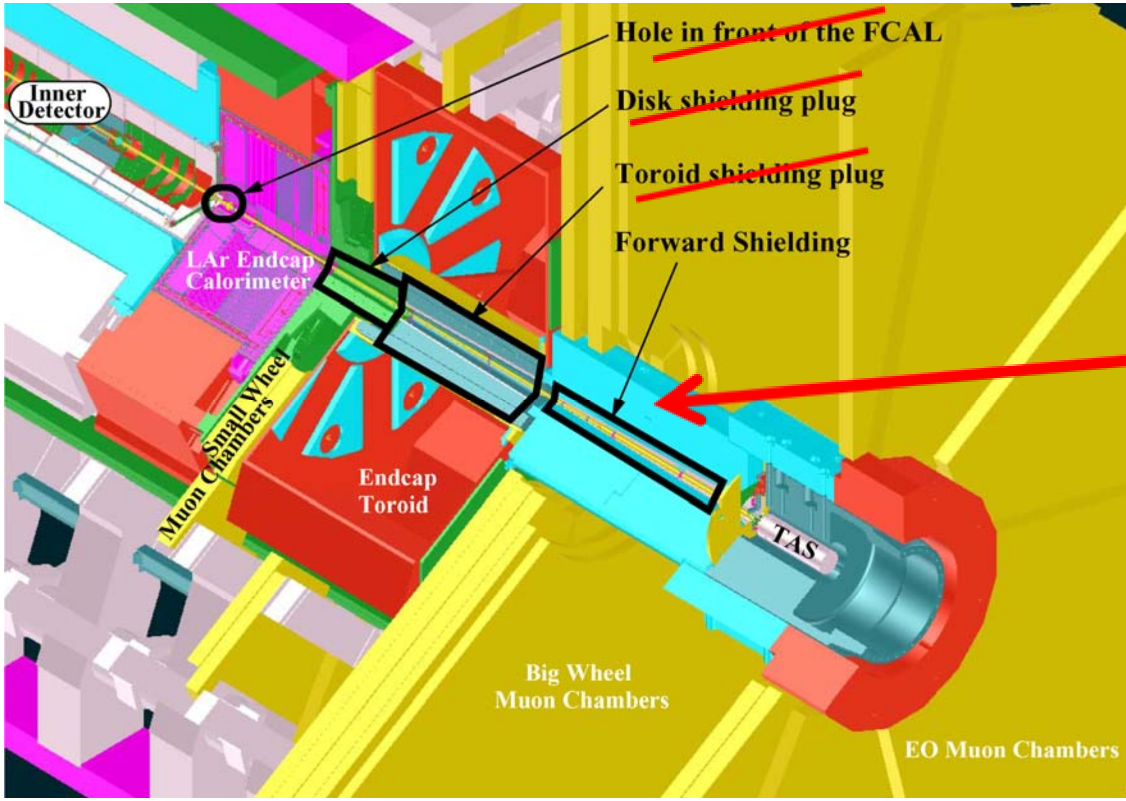
If occupancy in the forward region can not be reduced, we will need new chambers (trigger + precision chambers, this is a major effort!!) faster and with more granularity in the readout

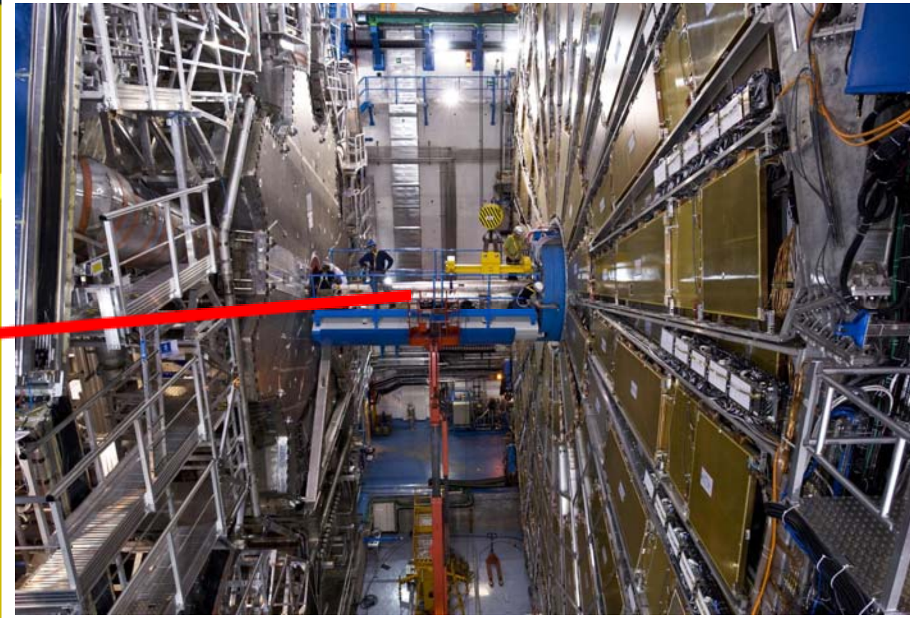
All Beryllium beam pipe



A full Be beam pipe will partially compensate for the increase in Luminosity

D0 magnet inside the detector (ES : early separation)

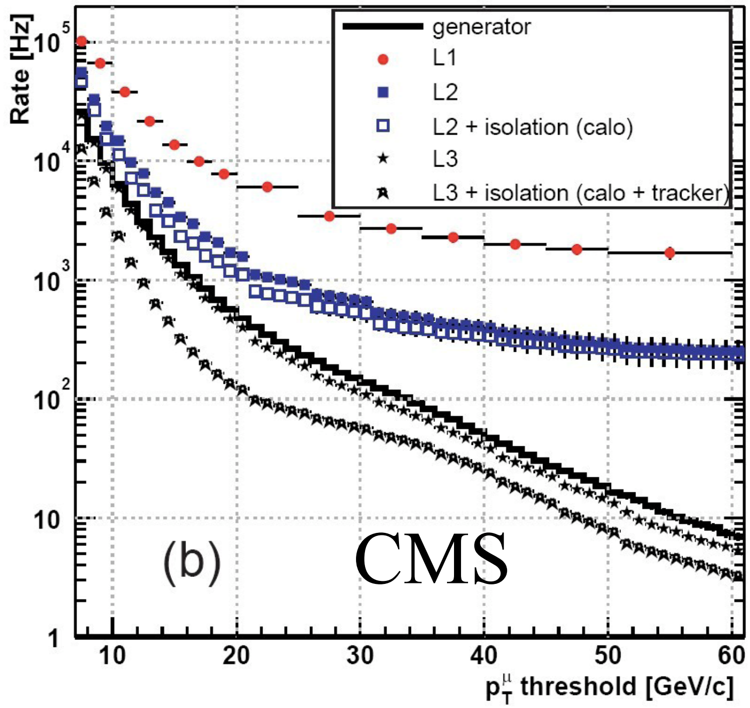




Only one location for D0 still possible, but difficult because it will dilute the radiation shielding in that region

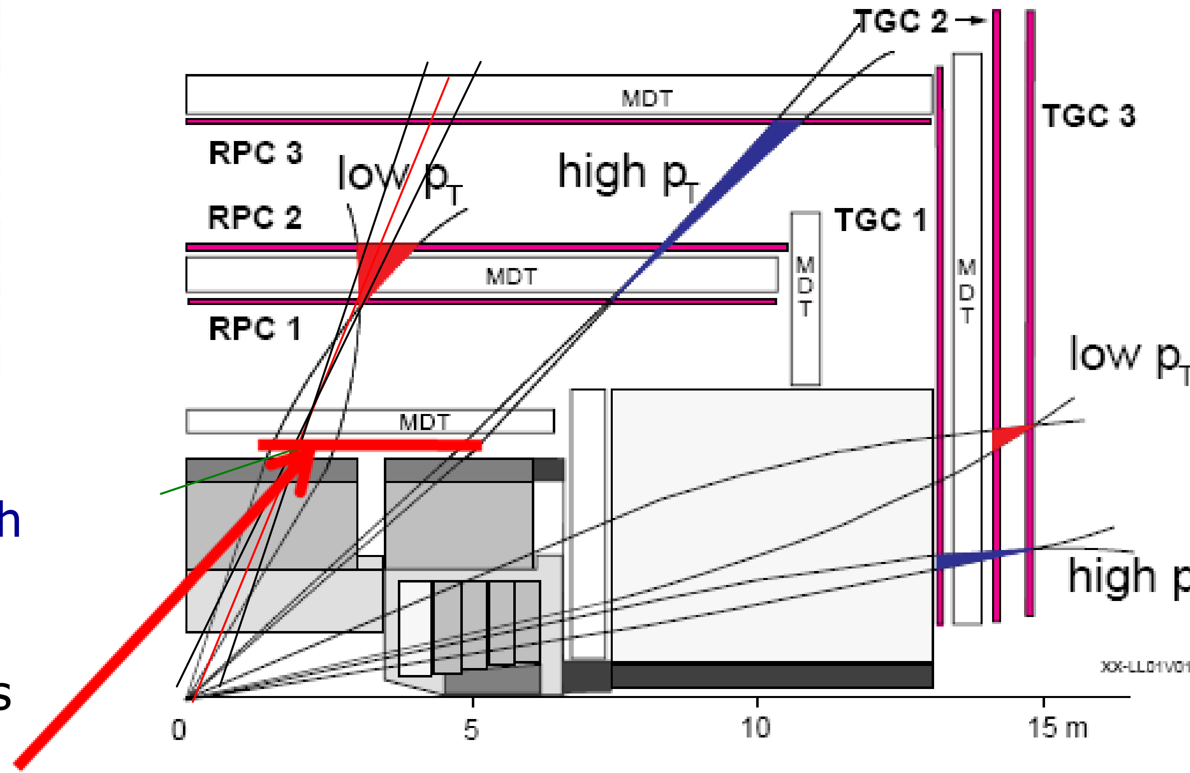
The forward shielding region will need to be re-evaluated in any case because also the TAS (last collimation to protect machine and experiment) will need to be re-shaped because of the new large aperture triplet magnet that will be installed upstream

Add 1 layer of trigger chambers to LVL1 muon trigger



LVL1 trigger rate seems to flatten out at high P_T, trend will get worse at sLHC with more noise and pile-up

Discussion ongoing to increase chambers resolution or sharpen the trigger with additional layers of trigger chambers

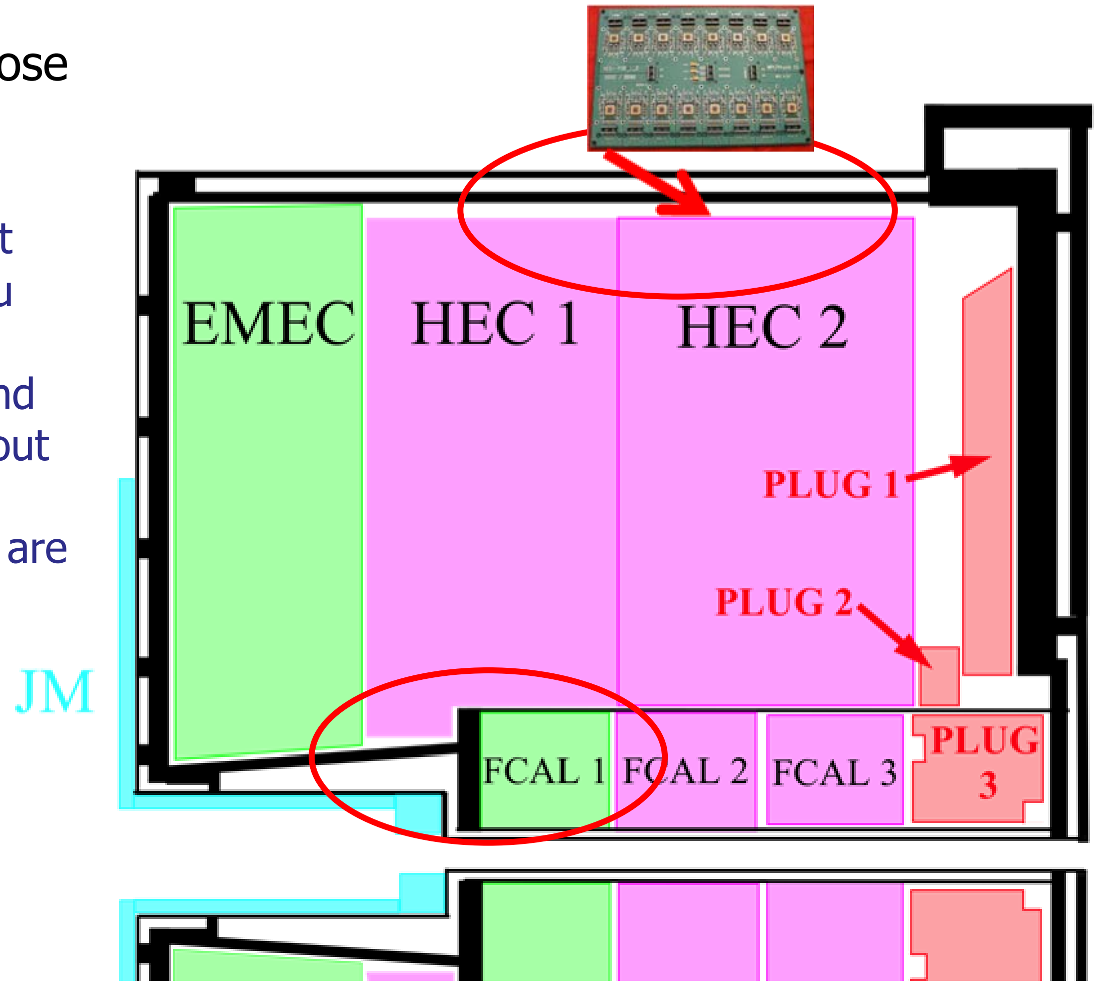


LAr Calorimeters problems at sLHC

2 types of problems (manly related to dose and dose rate):

✓ HEC cold electronics: radiation hardness at the limit; radiation has to be measured in situ after LHC turn on (to clarify safety factors!!); the HEC PSB boards with new preamplifier and summing amplifier IC's can be replaced without taking the HEC wheels apart, but requires cryostat opening in situ. More radiation tests are ongoing!

✓ FCAL : various problems; two solutions envisaged



Lar Calorimeters problems at sLHC

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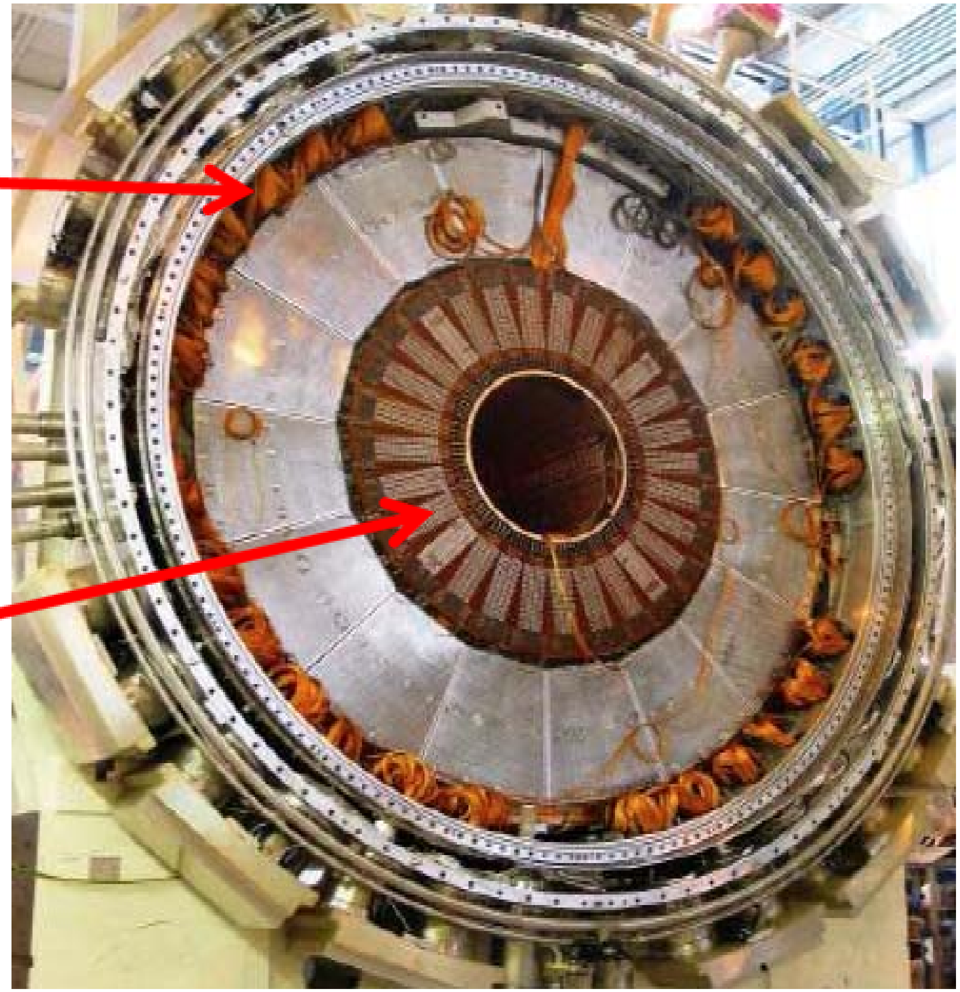
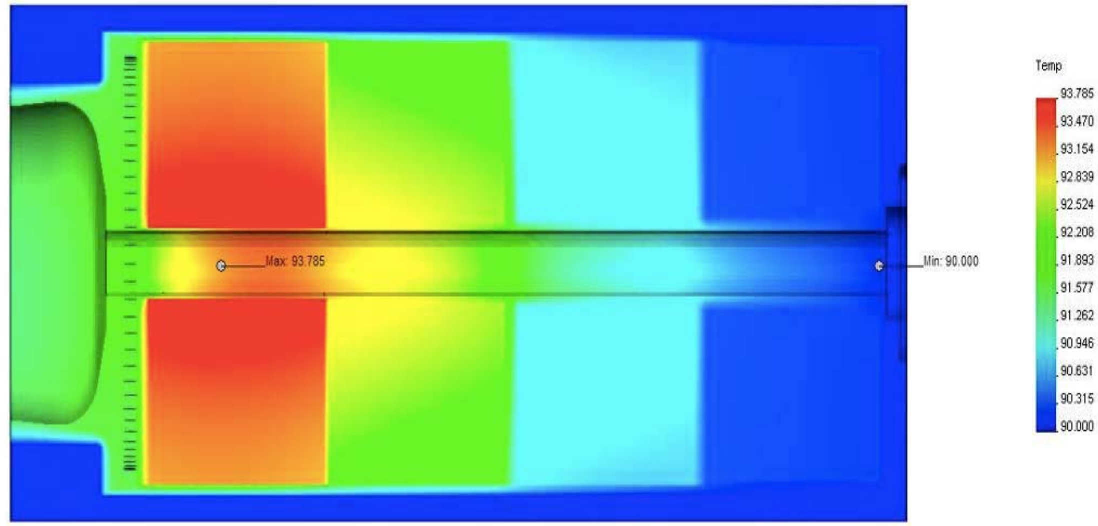


The Lar Calorimeters (forward) will need a major rework

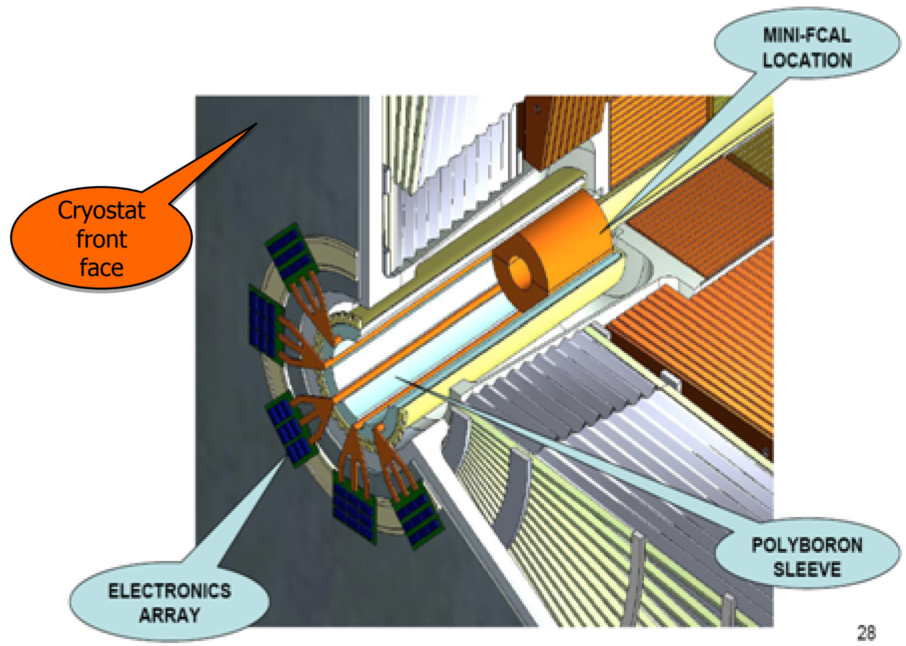
ATLAS forward calorimeter may suffer a number of problems (dose :$10^{17\text{-}18}$ neq/cm^2):

-Boiling of LAr
-Ion build up between electrodes
-Voltage drop over HV resistor



Studies and tests under way; if these show that action is needed, two solutions are considered:

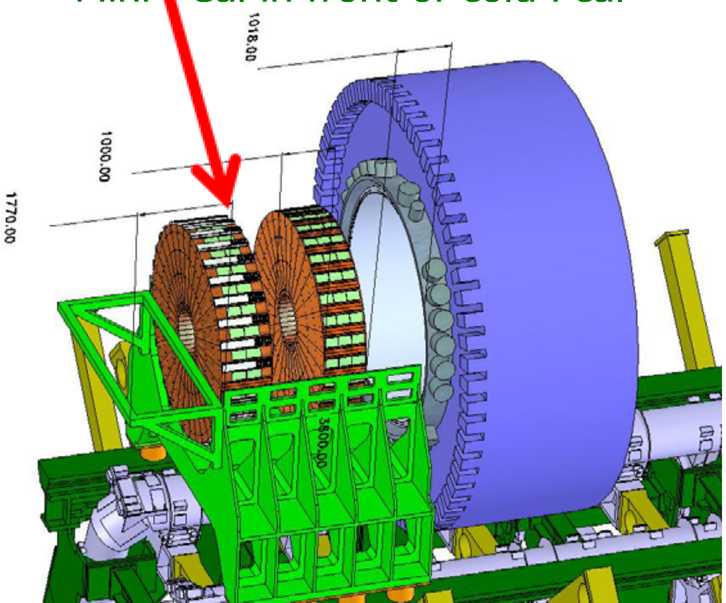
- Warm calorimeter in front of current calorimeter (diamond technology?)
- Open cryostat, insert complete new FCAL with smaller gaps and more cooling power

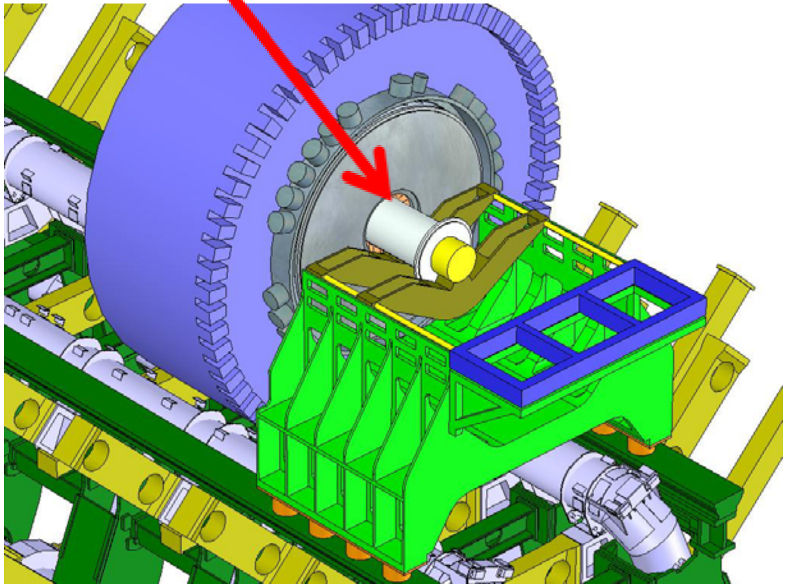


3 Options today to solve the LAr problems

3 options are under study and will be included in the sLHC **Letter of Intent**

- Option1
  - HEC cold electronics to be replaced,
  - Cold FCal replaced by a new one.
- Option 2
  - HEC cold electronics does not need to be replaced,
  - Cold FCal replaced by a new one, large cold cover needs to be removed.
    (If FCal cabling is modified, large cold cover may not need to be removed.)
- Option 3
  - HEC cold electronics does not need to be replaced,
  - Mini-FCal in front of cold Fcal





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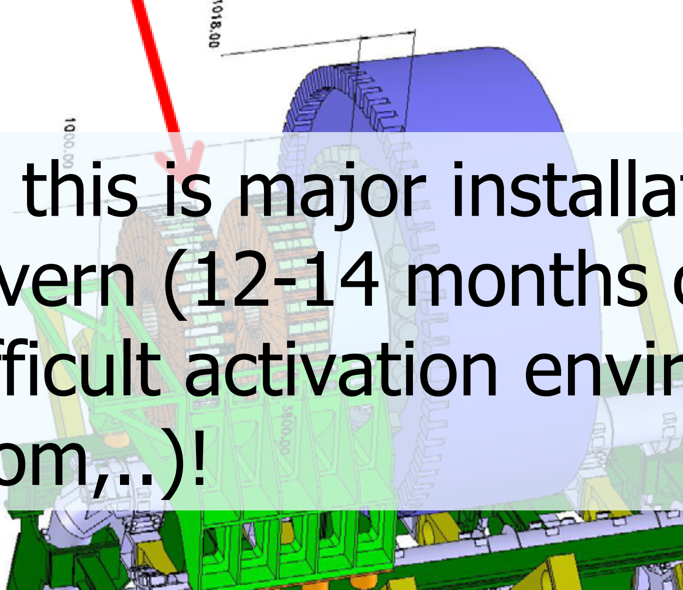

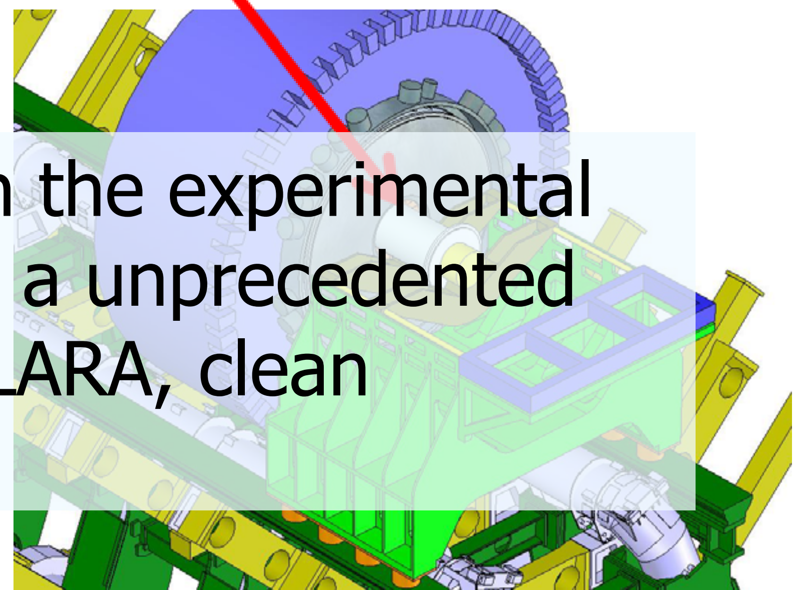

All this is major installation work in the experimental cavern (12-14 months of work), in a unprecedented difficult activation environment (ALARA, clean room,..)!

Summary

- ✓ Collaboration very active with a well structured upgrade organization (steering group, various working groups, R&D projects follow up, upgrade Project Office)
- ✓ Last ATLAS Collaboration Upgrade week (February 2009) …. 232 presentations, 29 sessions
- ✓ We plan to prepare and submit a LOI (letter of intent) in 1 year time, where the project will technically be further detailed, with a better budget, schedule and organization planning

- ✓ Phase I planning well advanced. New b-layer project defined and active. Important technological bridge to the final sLHC upgrade
- ✓ Phase I assumes 8 month of shutdown for installation work, in parallel to the Linac 4 installation.

Summary

- ✓ Detector performance needs to be maintained through Phase II
- ✓ Larger pile-up and radiation environment are the real experimental challenges. Any initiative to keep these 2 parameters as low as possible is welcome. Luminosity leveling is a great idea

- ✓ We plan for at least 18 months installation activities starting in 2018

- ✓ We are making plans to build a new Inner Detector
- ✓ We will have to plan major interventions in situ on the LAr endcap Calorimeter
- ✓ The muon spectrometer might benefit from new trigger chambers layers and a set of new chambers in the forward region
- ✓ Most of the front-end and back-end electronics as well as most of the trigger electronics will need to be rebuilt. For most case radiation resistance is a must.

ATLAS R&D

Approved Document	Short name	Title	Principle contact	Institutes
ATL-PA-MN-0007	**3D Sensors**	Development, Testing and Industrialization of Full-3D Active-Edge and Modified-3D Silicon Radiation Pixel Sensors	Cinzia Da Vià, Sherwood Parker, Giovanni Darbo	*CNM Barcellona, Bonn, Freiburg, **Genova**, Glasgow, Hawaii, LBNL, Manchester, Oslo, SINTEF Oslo, Prague, MBC/Stanford, IRST Trento, Valencia*
ATU-RD-MN-0010	**Thin Pixels**	R&D on thin pixel sensors and a novel interconnection technology for 3D integration of sensors and electronics	H-G. Moser	*Bonn, Dortmund, Interon, MPP Munich, Oslo*
ATU-RD-MN-0012	**Diamond**	Diamond Pixel Modules for the High Luminosity ATLAS Inner Detector Upgrade	Marko Mikuž	*Bonn, Carleton, CERN, Jožef Stefan Institute, Ohio State, Toronto*
ATL-P-MN-0016	**Gossip**	R&D proposal to develop the gaseous pixel detector Gossip for the ATLAS Inner Tracker at the Super LHC (SLHC)	Harry van der Graaf	*NIKHEF, SACLAY, Twente*
ATU-RD-MN-0016	**Pixel Local Supports**	Expression of Interest Research and Development Local Supports for Pixel Detector Upgrades	M. Gilchriese	*CPPM, **Genova**, **Milano**, LAPP, LPNHE, LBNL, Ohio, SLAC, Toronto, Washington, Wuppertal*
ATU-RD-MN-0019	**Planar Pixel**	R&D on Planar Pixel Sensor Technology for the ATLAS Inner Detector Upgrade	D. Muensterman	*Prague, LAL Orsay, Bonn, HU Berlin, TU Dortmund, MPP Munich, MPI Munich, **Udine**, Liverpool, UNM Albuquerque, UCSC Santa Cruz.*
ATL-PA-MN-0002	**ABC-Next**	Proposal to develop ABC-Next, a readout ASIC for the S-ATLAS Silicon Tracker Module Design	Francis Anghinolfi, Wladek Dabrowski	*Cambridgs, CERN, Geneva, Glasgow, Krakow, KEK, Liverpool, London, Ljubljana, Santa Cruz, Valencia*
ATL-PA-MN-0004	**Staves**	Development and Integration of Modular Assemblies with Reduced Services for the ATLAS Silicon Strip Tracking Layers	C. Haber, M. Gilchriese	*BNL, Hampton, Santa Cruz LBNL, New York, **Milano***
ATL-PA-MN-0005	**n-in-p sensors**	Development of non-inverting Silicon strip detectors for the ATLAS ID upgrade	Hartmut Sadrozinski	*KEK, Tsukuba, Liverpool, Glasgow, Lancaster, Sheffield, Cambridge, London, Freiburg, MPI, Ljubljana, Prague, Barcelona, Valencia, Santa Cruz, BNL*
ATL-PA-MN-0006	**SiGe chips**	Evaluation of Silicon-Germanium (SiGe) Bipolar Technologies for Use in an Upgraded ATLAS Detector	Alex Grillo, S. Rescia	*IN2P3, CNM Barcelona, BNL, UC Santa Cruz, U of Pennsylvania*
ATU-RD-MN-0007	**Modules**	R&D towards the Module and Service Structure design for the ATLAS Inner Tracker at the Super LHC (SLHC)	Yoshinobu Unno	*KEK, Geneva, Freiburg, Melbourne, Valencia, Tsukuba*
ATU-RD-MN-0009	**SoS**	Expression of Interest: Evaluations on the Silicon on Sapphire 0.25 micron technology for ASIC developments in the ATLAS electronics readout upgrade	Ping Gui, Jingbo Ye	*SMU Dallas.*
ATL-PA-MN-0001	**Opto**	Radiation Test Programme for the ATLAS Opto-Electronic Readout System for the SLHC for ATLAS upgrades	Cigdem Issever	*Taiwan, Ljubljana, Ohio, Oklahoma, Oxford, SMU*
ATU-RD-MN-0008	**Powering**	Research and Development of Power Distribution Schemes for the ATLAS Silicon Tracker Upgrade	Marc Weber	*BNL, Bonn, CERN, Krakow, LBNL, RAL, Wuppertal, Yale*
ATL-P-MN-0011	**Thermal Management**	Future ATLAS tracker Thermal Management Research Programme	Georg Viehhauser	*BNL, CERN, **Genova**, Glasgow, KEK, LBNL, Liverpool, Marseille, NIKHEF, Oxford, Prague, QMUL, RAL, Sheffield*
ATL-P-MN-0026	**ID Alignment**	R&D on an Optical Alignment System for the ATLAS Tracker Upgrade at SLHC Based on Straightness Monitoring	J. Dubbert, S. Horvat, O. Kortner, **H. Kroha**, H.-G. Moser, R. Richter	*MPI Munich*

Status – November 2008
Approved by Executive Board
EoI, Proposal presented to USG

Pixel
Strips
Inner Detector

ATLAS R&D

Approved Document	Short name	Title	Principle contact	Institutes
ATL-P-MN-0015	**End-Cap LArCAL**	A Proposal for R&D to establish the limitations on the operation of the ATLAS End-Cap Calorimeters at high LHC Luminosities	Peter Shacht	*Arizona, JINR Dubna, IEP Kosice, Mainz, LPI Moscow, MPI Munich, BINP Novosibirsk, IHEP Protvino, TRIUMF Vancouver, Wuppertal*
ATU-RD-MN-0001	**Lar FE Electronics**	R&D Towards the Replacement of the Liquid Argon Calorimeter Front End Electronics for the sLHC	G. Brooijmans	*CERN, LAL-Orsay, **Milano**, MPI Munich, BNL, Columbia, SMU, New York, Pennsylvania*
ATU-RD-MN-0002	**LAr Optolink**	R and D of a radiation resistant high speed optical link for the ATLAS Liquid Argon Calorimeter readou	Jingbo Ye	
ATU-RD-MN-0003	**LAr ROD**	Research and Development of Readout Driver (ROD) for the upgrade of the Liquid Argon Calorimeter Front-End Readout	Hucheng Chen	*Arizona, BNL, CERN, LAPP, **Milano**, Stony Brook*
ATU-RD-MN-0004	**FCAL Cold**	Development of new ATLAS Forward Calorimeters for the Upgrade	J.Rutherfoord	*Arizona, Carleton, Toronto.*
ATU-RD-MN-0015	**Tile Electronics**	R&D on Tile Calorimeter Electronics for the sLHC	C. Bohm, L. Price, J. Valls Ferrer	*Argonne, Barcelona, Bratislava, CERN, Chicago, Lisbon, **Pisa**, Prague, AS CR, Stockholm, Valencia.*
ATU-RD-MN-0011	**Micromegas**	R&D project project on micropattern muon chambers fo SLHC	V. Polychronakos, J. Wotschack	*Arizona, Athens (U, NTU, Demokritos), Brookhaven, CERN, Harvard, Istanbul (Bogaziçi, Doğuş), **Naples**, Seattle, USTC Hefei, South Carolina, St. Petersburg, Shandong, Thessaloniki*
ATL-P-MN-0014	**Segmented Straw**	R&D of segmented straw tracker detector for the ATLAS Inner Detector Upgrade	Vladimir Peshekhonov	*JINR Dubna, Lebedev Moscow, Moscow, Warsaw*
ATL-P-MN-0028	**TGC**	R&D on Optimizing a detector based on TGC technology to provide tracking and trigger capabilities in the MUON Small-Wheel region at SLHC	G. Mikenberg	*BNL, The Weizmann Institute, Tel Aviv, Technion*
ATL-P-MN-0029	**MDT R/O**	Upgrade of the MDT Readout Chain for the SLHC	R. Richter	*LMU & MPI Munic*
ATL-P-MN-0030	**MDT-Gas**	R&D for gas mixtures for the MDT detectors of the Muon Spectrometer	P. Branchini	***Cosenza**, **Roma3***
ATL-P-MN-0031	**MDT-Selective R/O**	R&D on Precision Drift-Tube Detectors for Very High Background Rates at SLHC	R. Richter	*LMU & MPI Munic*
ATL-P-MN-0032	**High Rate MDT**	R&D on Precision Drift-Tube Detectors for Very High Background Rates at SLHC	R. Richter	*LMU & MPI Munic*
ATU-RD-MN-0013	**Fast Track Trigger**	Proposal to prepare a technical design report for FTK, a hardware track finder upgrade to the ATLAS trigger	M. Shochet	*Chicago, **Frascati**, Harvard, Illinois, **Pisa**, **Roma 1**.*
ATU-RD-MN-0014	**LVL1-Calo**	ATLAS Level-1 Calorimeter Trigger Upgrade	N. Gee	*Birmingham, Heidelberg, Mainz, London, Stockholm, RAL, Michigan, ANL*
ATU-RD-MN-0018	**Versatile Link**	The Versatile Link Common Project	Francois Vasey	*CERN, Strasbourg, Oxford, SMU Dallas.*
ATL-PA-MN-0003	**Radiation BG**	Radiation background benchmarking at the LHC and simulations for an ATLAS upgrade at the SLHC	Ian Dawson	*Sheffield, Arizona, Ljubljana*
ATU-RD-MN-0020	**Forward Protons**	ATLAS FP: A project to install forward proton detectors at 220 m and 420 m upstream and downstream of the ATLAS detector	A. Brandt	

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Calorimeter
Muon
Trigger, Elec, …

Summary