Verso Upgrade

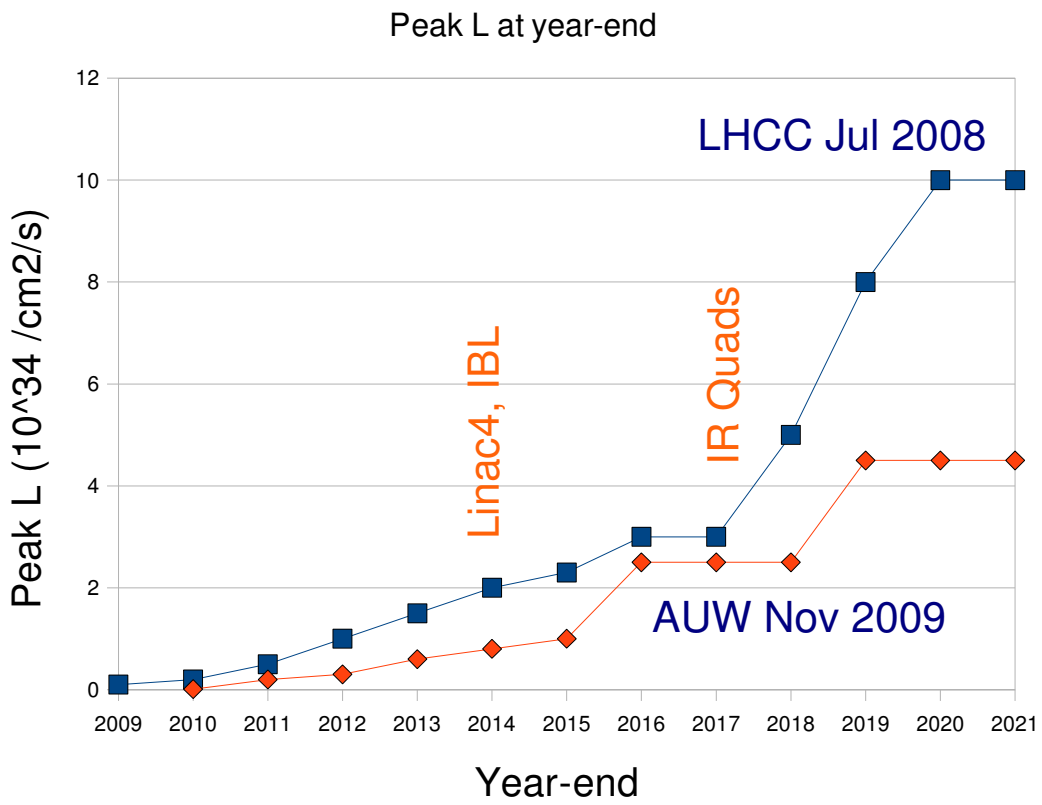
Novembre 2009

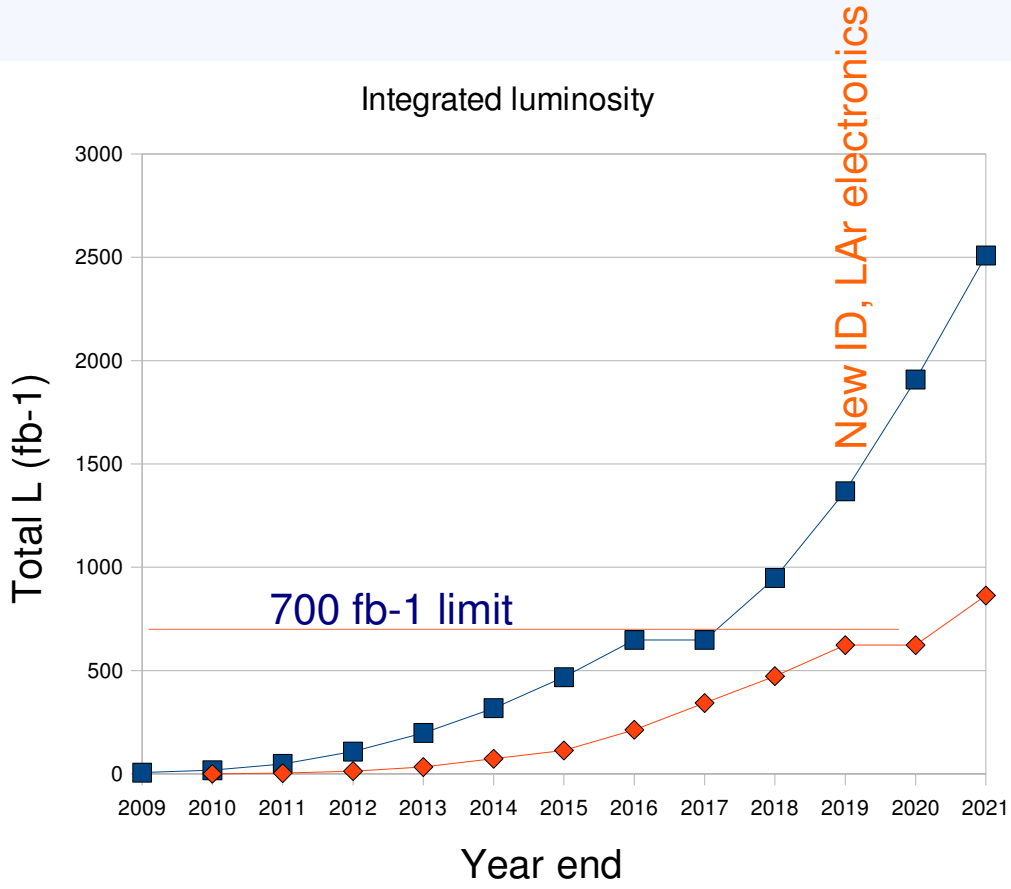
Schedule

- Interesting talk from Frank Zimmerman (don't shoot the messenger...)
- Not official, many uncertainties
  - Wait till Chamonix 2010 + a bit more for official LHC schedule
  - *In the following I take Frank's plots at face value*
- Main points for Upgrade schedule
  - LHC will start slower than previously hoped: only 200 fb-1 by end of 2016
  - Possibly move away from annual cycle to long runs, longish shutdowns
  - Linac4 is ahead of schedule but LHC will not be ready to benefit =>
    - Delay its use by one year to 2015 (but better commissioned Linac4)
  - Slower luminosity ==> IR quadrupoles should survive beyond at least end 2017 (good for at least 420 fb-1)
    - Anticipate delay to end 2017
  - Crab cavities favoured by all – many risks, but could start tests in LHC ~end 2013, and install for use ~end 2017
  - Injector upgrades beyond Linac4 much later

Effect for us...

- Progression of estimates:
  - July 1st 2008 LHCC: Schedule shown many times
  - AUW Feb 2009: 1 year delay on phase 1; we also delayed phase-2 by 2 years
  - AUW Nov 2009: latest possibility sketched out





Towards our new schedule:

- IBL target insertion still end 2014
  - Linac4 shutdown, mitigate risk, it improves our performance
- Peak L before new ID installation reduces slightly from 3 to 2.5 x nominal, and not until 2016
  - Less inefficiencies in ID; less risk FCAL performance
  - Actually shows rising in 2019 to 4.5 x nominal:
    - Should clarify this (assumes Crab?)
    - Is challenging for ID and many other current detectors without major upgrade
- Without our Phase-II shutdown, would significantly exceed 730 fb-1 during 2020
  - Suggests we should install new ID, new LAr electronics, … starting end 2019; latest 2020
  - This is 1 (maybe 2) year delay on current ATLAS Upgrade schedule (and 3+ years on LHCC Jul 2008 schedule)

Other important changes

- **No change on target of 3000 fb-1 high quality data recorded**
  - ...just takes longer to reach
  - ...means radiation damage requirements do not change
    - cold HEC electronics...
- Peak luminosity: Full Crab Crossing scheme with luminosity levelling will have <~ 100 pile-up per BC (cf 23 for nominal luminosity)
- LPA 50 ns scheme remains backup; 200 pile-up/BC
  - We would like to clarify to what extent we should allow for this
- In any case, 400 (480 allowing for empty bunches) ev/BC seems off the agenda.
- So while the date for our phase-II slips a bit, the peak-L probably drops dramatically: 480 --> 100
  - Different ball-game: for new ID, muon chambers, boiling LAr...
- We need to absorb all this – try to avoid under or over estimating the impact

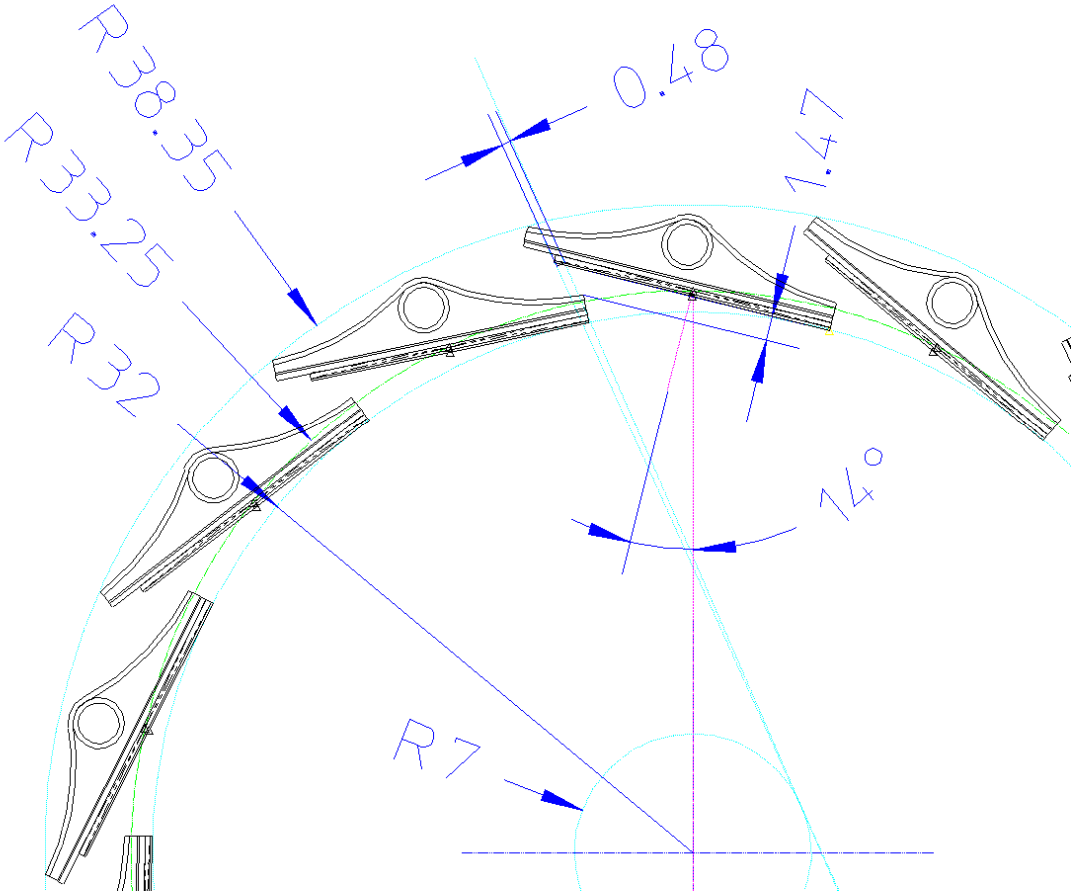
LoI

- Consensus seems to be:
  - Keep the momentum up, have something ready by April
  - Decide then: what are the benefits of delaying 6 months (or more)
    - We will have Chamonix 2010 plan
    - We will know better the likeliehood of getting a good understanding of cavern background/muon safety factor
    - pp cross section, charge multiplicity at CM energy 7 or 9 TeV
- TP: Also need to discuss best timing. Physics input with full simulation, plus much more. When is it needed by for on-time major Upgrade of ATLAS?

IBL Layout

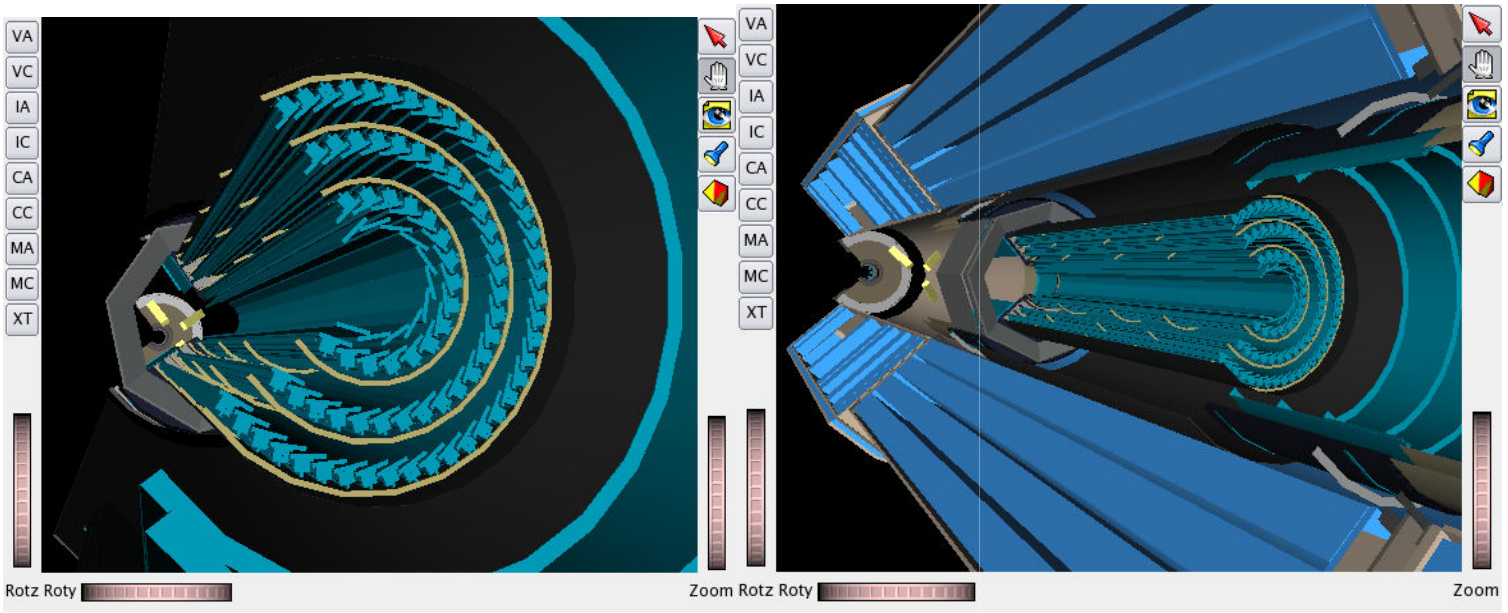
- Several layout under study: Converging on “reverse turbine” layout with 14 staves as baseline layout for engineering studies and TDR:
- Work on others continues at slower pace

- 14 staves – layout parameters
  - IR 32mm
  - OR (structure) 38.35mm
  - Sensor Radius 33.25mm
  - Sensor Tilt Angle 14 degrees
  - Nominal Internal Clearance ~1.47mm
- Proposed tolerances for the stave assembly
  - Geometry tolerance (+/- 0.1mm)
  - Assembly tolerance (+/- 0.15mm)
  - Total tolerance range ½ mm



IBL Simulation

- Went through full cycle for IBL simulation
  - Layout description, material map, track reconstruction
  - Used mixture of releases
    - Immediate plan to put all the job option files into a separate package and include in the upcoming releases
    - Development cycle should be shortened

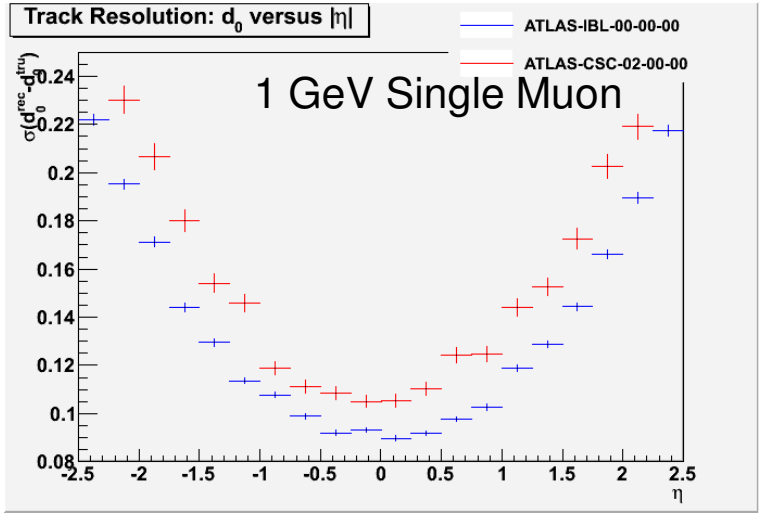


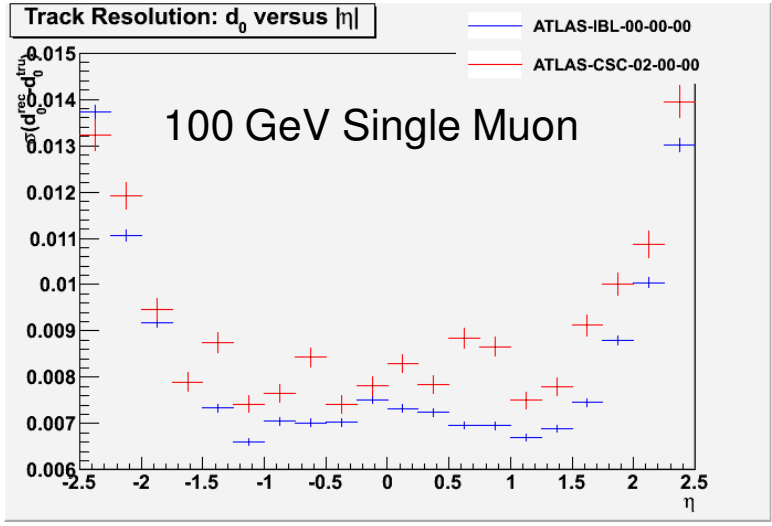
IBL implementation in 15.4.0 release

Pixel disks and beam pipe are removed to show IBL

IBL simulation

- Run simulation, digitization, tracking
  - Generated single muons with pt=1,100 GeV/c
- Looked at resolution
- Digitization & radiation damage
  - In addition to planar pixel sensors considering different sensor technologies
  - 3d pixel sensors
  - Diamond
- Radiation damage to the existing pixel layers
- Next steps
  - Work started on more realistic IBL layout
  - Actual chip/sensor dimensions
  - Radiation damage in Layer 0 and beyond
- Run through a physics process
  - Evaluate performance

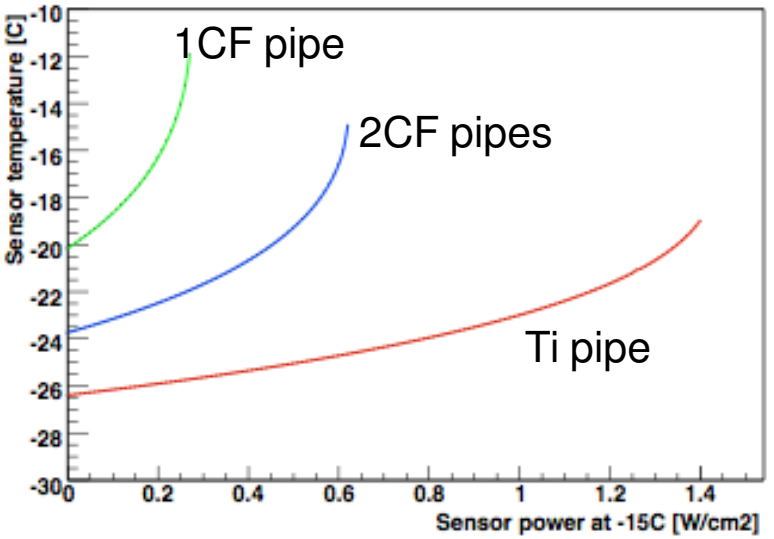




IBL Sensor & Module

- Bring the 3 detector technologies together for 2010 IBL module qualification program (Sep. 9 meeting)
  - Proposal is to construct 40 IBL qualification modules with each sensor technology to test FEI4 and sensor (lab, testbeam, irradiation)
- Agreed to define "best" sensor layout for each technology by Dec.
  - Each Sensor group proposes their best sensor layout for IBL by Dec.

Thermal run-away with different staves



Sensor maximum operation voltage: 1000V
Sensor maximum power dissipation: 200mW/cm^2
Sensor thickness: 225 +/- 25 μm
Sensor target temperature: ~ -15C
Coolant temperature: ~ -30C or less

Sensors

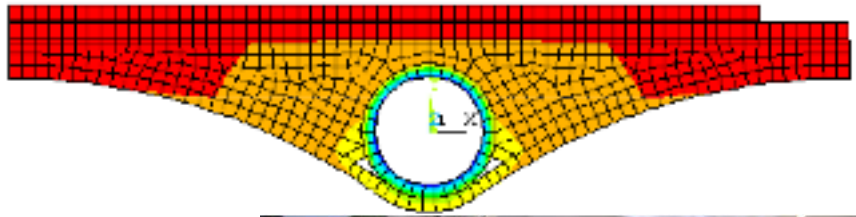
- **Planar sensors**
  - Sensor parameters (previous slide) considered ok for planar sensors (annealed) up to 5 x 10^{15} neq/cm^2
  - Currently look at different layouts for IBL (final 2-chip module)
    - "conservative" n-in-n with ~ 500μm guard ring area
    - More "advanced" n-in-n with slim edge (~100μm) or thin (~150μm) sensors (n-in-n and n-in-p)
  - FEI4-compatible sensors in production at different vendors (CIS, Micron)
- **3D sensors**
  - Prefer full 3D active edge sensors for IBL (as single chip modules) (2E on 50x250μm)
  - 2010 prototyping runs of full 3D active edge at Sintef/Stanford, CNM, FBK
  - Additional double sided 3D with slim edge at CNM and FBK
  - Study "charge multiplication" at higher voltages (~250V)
- **Diamonds**
  - Have assembled 3 full size (16chip FEI3) modules and study in testbeam
  - Plan to prototype 11 FEI4-single chip and 3 FEI4-double modules next year
    - Sensors for that available and/or on order
  - Present vendor DDL and investigate new vendor "II-VI" (US)

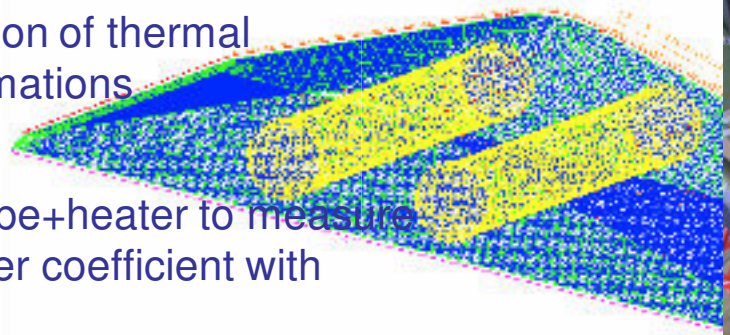
FEI4 - Module qualification program

- Plan to construct qualification modules with each technology during 2010
  - Goal is to qualify the prototype modules in lab, beamtests and irradiations to IBL specs and gain production experience (yields,…)
  - Orignal plan is ~40 modules/technology with sensors provided by sensor RD groups from recent submissions
  - This program is of common interest to sensor RD groups and IBL
    - Cost of those modules is substantial (i.e. also bump bonding) and need to be shared in a reasonable way between communities.
- Common sensor “foot print”
  - To unify (and simplify) module construction and bump bonding, we have to make sure we have a common foot print of sensors (at least with technology)
- **Submission: Feb 2010**
  - Receive wafers: early May
- Send wafer and sensor to bump-bonding: mid June
  - need sensors by beg. June
- **Receive first qualification modules mid Aug. 2010**
- Proceed in parallel with lab tests, testbeam and irradiation.

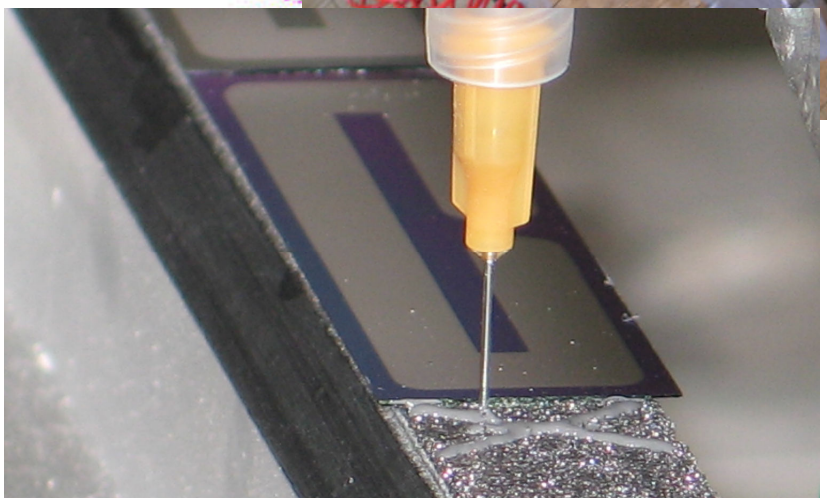
IBL Stave

- Lots of progress on stave prototyping
- Stave thermal performance
  - Constructed first staves with heaters to measure thermal figure of merit
  - Constructed thermal measurement container
  - Very detailed FEA simulation of thermal gradients and stave deformations
- Pipe : CF & Ti
  - Constructed samples of pipe+heater to measure coolant to pipe heat transfer coefficient with C3F8 and CO2
  - Started with tests on Ti pipe welding and bending and made first CF-Ti transitions
  - Starting off on pipe irradiation to qualify CF pipe against micro-cracks
- Module loading :
  - Made first iteration on concept and tools for module loading
  - Need work to develop concept





Picture 2: Mesh



2010 Stave qualification program

- Defined draft stave qualification program for 2010
  - Cooling pipe: qualification of CF and Ti pipe
    - Micro-cracks
    - Welds
  - Connections: pipe-pipe transitions and connectors at PP
  - Stave CF and foam: measurement of thermal figure of merit and deformation under cooling
  - Flex circuit: design and prototypes of flex circuit (Kapton Cu/Al?)
    - Layout , X0 and connectivity to mini-flex on FEI4
    - Connectors on EoS

	Item description	Flavor		
		Pipe Material	Pipes diameter (and number)	Samples Number
2.1	Stave	1.1 (CF)	Φ=4mm OD N=2	1
2.2		1.2 (Ti)	Φ=4mm OD N=1	2 of (4)
2.3		1.1 (CF)	Φ=4mm OD N=1	4 [on hold]
2.4		1.4 (Ti)	Φ=3mm OD N=1	2
2.5		1.3 (CF)	Φ=3mm OD N=1	2
2.6		1.3 (CF)	Φ=3mm OD N=2	2
2.7		1.6 (Ti)	Φ=2mm OD N=1	2
2.8		1.6 (Ti)	Φ=2mm OD N=2	2 [on hold]
2.9		1.7 (CF)	Φ=2mm OD N=2	2 [on hold]
2.01	Bi-stave	1.3 (CF)	Φ=3mm OD N=2	2
2.02		1.6 (Ti)	Φ=2mm OD N=2	2
2.9	Pipe + foam+heaters	1.1 (CF)	Φ=4mm OD	1 of (2)
2.10	Pipe + foam+heaters	1.2 (Ti)	Φ=4mm OD	1
2.11	Pipe + foam+heaters	1.3 (CF)	Φ=3mm OD	1
2.12	Bare Pipe	1.4 (Ti)	Φ=3mm OD	1
2.13	Bare pipe	1.6 (Ti)	Φ=2mm OD	2
3.01	Short stave [L=80mm]	1.3 (CF)	Φ=3mm OD N=1	8
3.02		1.4 (Ti)	Φ=3mm ID N=1	8
3.03		1.6 (Ti)	Φ=2mm ID N=1	8

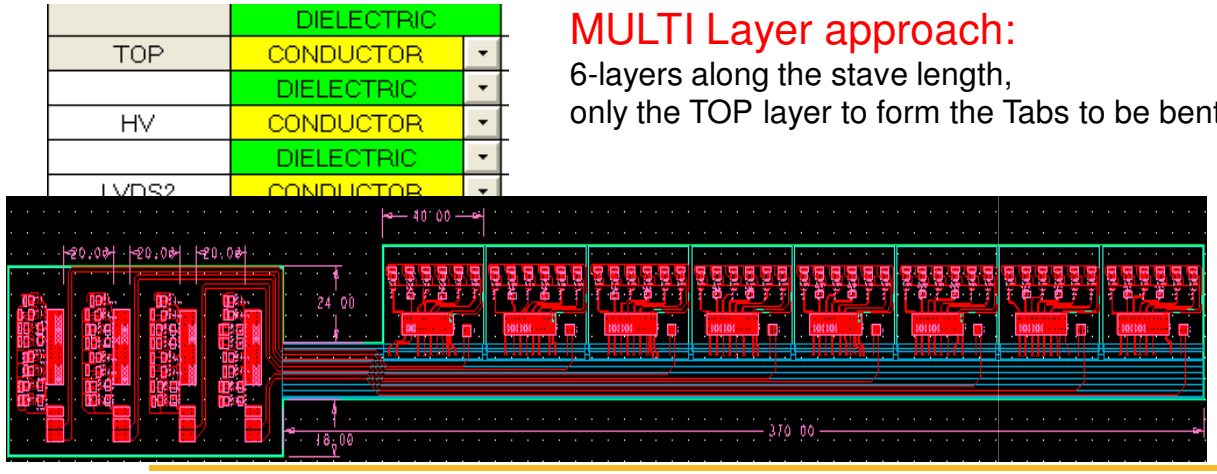
- Plan to review in December of the Stave Prototyping program in 2010

	Omega [um]	Foam [g/cm^3]	Pipe [Mat + ID]	Coolant	X/X0 [%]		Γ [°C.cm^2/W]	Grav sag [μm]	ThermalDef [μm]
					Structure +Coolant	TOTAL			
Option 1	150	0.5	CF 2.5ID	C_3F_8	0.48	0.88	17.25	97	63
Option 2	150	0.25	CF 2.5ID	CO_2	0.36	0.78	18.56	75	50
Option 3	300	0.25	Ti 3ID	C_3F_8	0.66	1.1	2.79	44	58
Option 4	300	0.25	Ti 2ID	CO_2	0.57	0.99	3.22	-	-

Component	X/X0
Stave (incl. FE+sens ~340μm)	Range 0.8 to 1.1 %
Flex (under evaluation)	Range 0.1 to 0.3 %
IST	0.3%
Total	**~1.2% (lightest) to 1.7% (heaviest)**

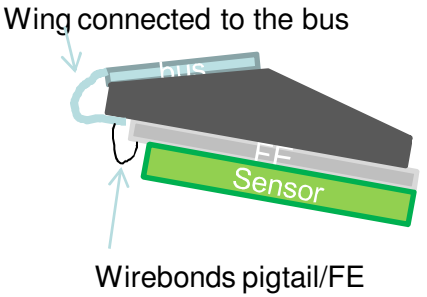
Flex circuit

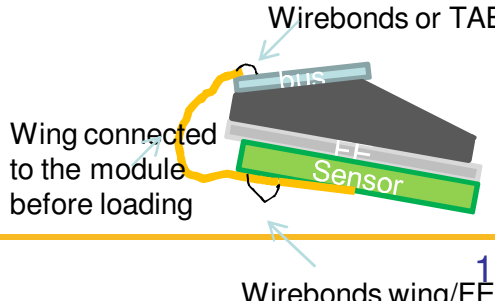
- One of highest priorities now is to define concept for flex circuit and connection to modules
  - Drives layout to some extend (envelops)
  - Need to achieve and **optimal layout for stave mechanics AND flex circuit**
- Proposed baseline is to have multilayer bus with tabs to connect to modules
  - Prototype in production
  - Single layer approach is still developed further in case its needed
  - Connection to FEI4/miniflex not yet clear (several options)



MULTI Layer approach:

6-layers along the stave length,
only the TOP layer to form the Tabs to be bent.





IBL timeline

- Overall
  - Still same installation date (end 2014)
    - Phase 1 upgrade keeps moving backwards …
  - Decision was made by ATLAS management that IBL is decoupled from phase 1 upgrade
  - We assume an 8 months shutdown for IBL installation
    - Start opening to finish closing, time with access to pixel package ~ < ½ that time.
- 2010 Schedule for modules largely driven by FEI4 availability:
  - Expect submission ~ Feb 2010
  - First modules available during mid/end summer next year
  - Will request irradiation and testbeam time as late as possible for module qualification
  - Proceed in parallel with stave prototyping, integration and off-detector work

Implications for the muon detector

- x10 cavern background
  - Deterioration of tracking performance

    (in some corners, depends on the actual bkg condition)

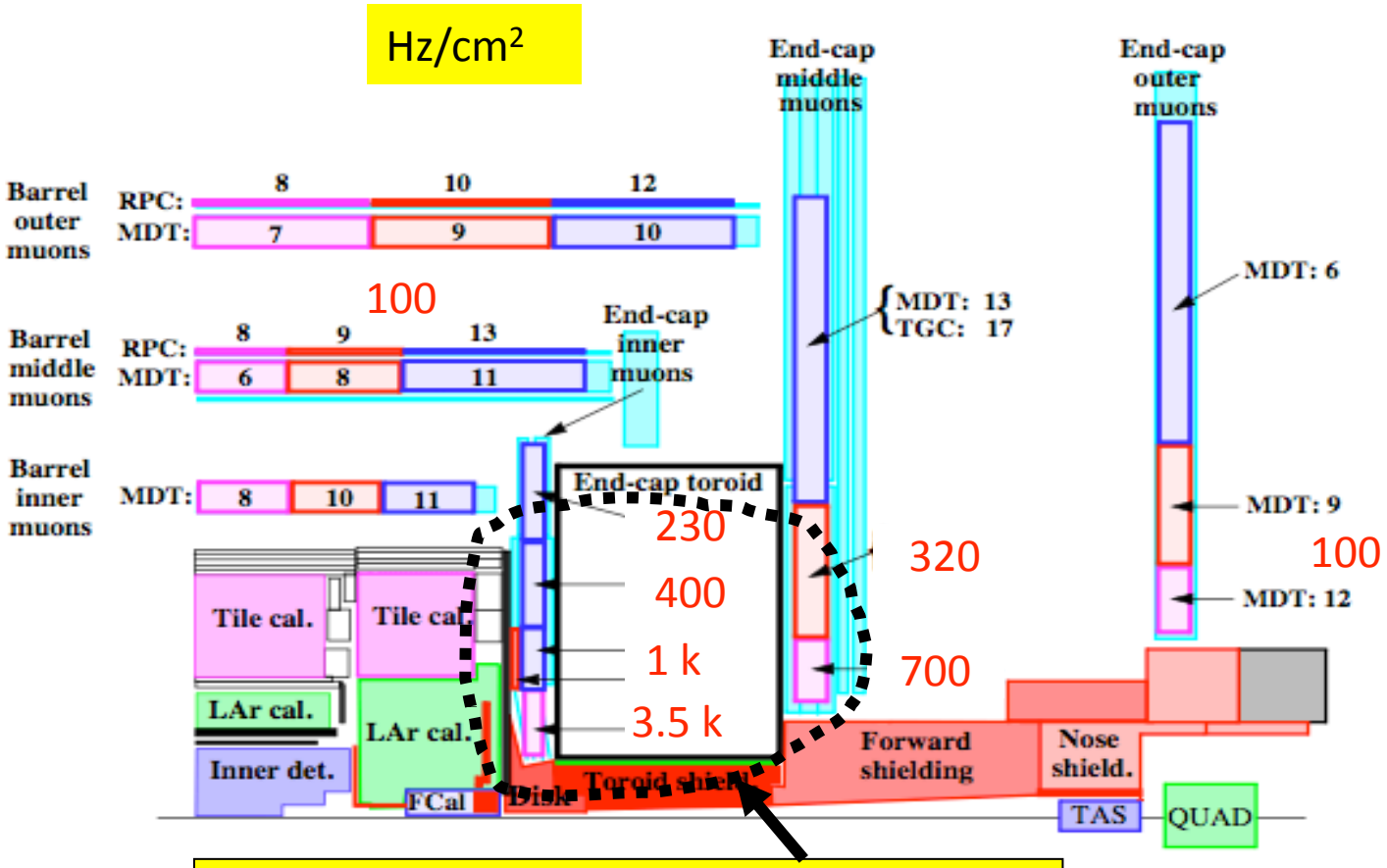
- x10 physics rate
  - L1 trigger rate exceeds the limit

- and many other problems
  - radiation damages, data band-width, etc.
  - longer L1 latency

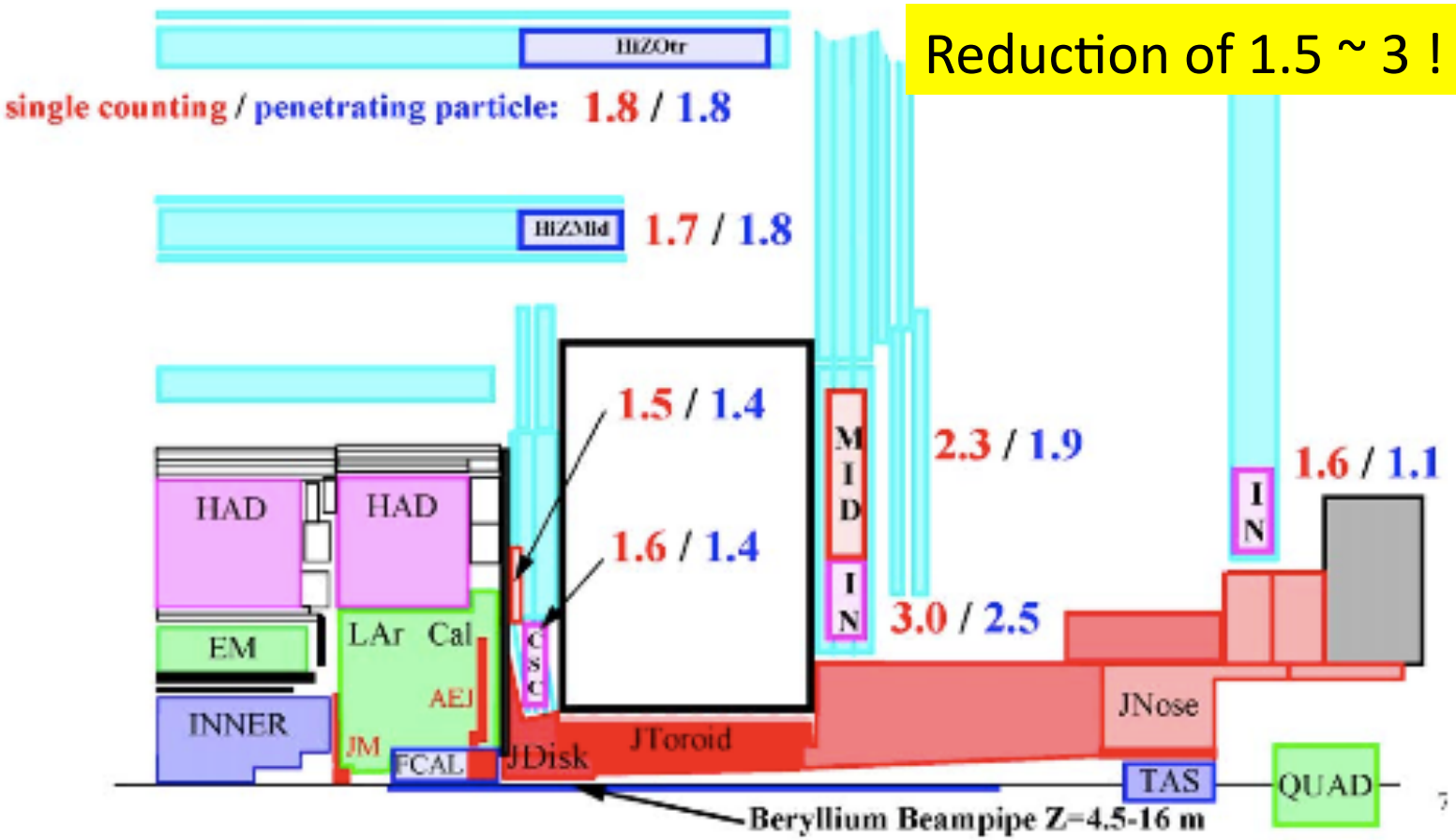
The goal is to prepare an upgraded detector with the performance similar to the 10^{34} detector (or even to improve)

Cavern background

Estimated cavern bkg rate : $L=10^{34} \times 10$



Be beam pipe helps to reduce cavern bkg



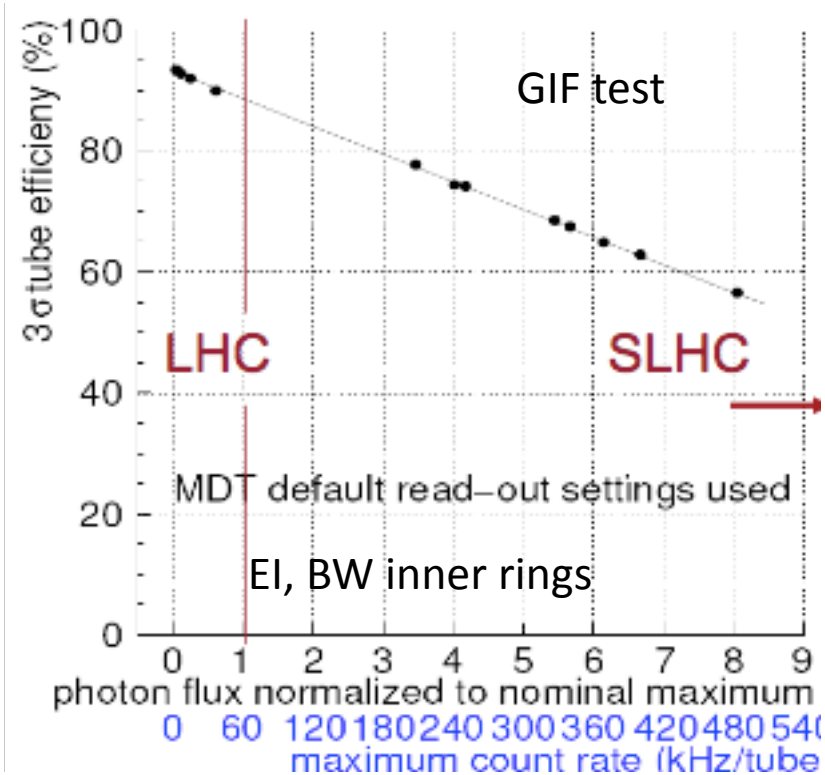
Reduction of 1.5 ~ 3 !

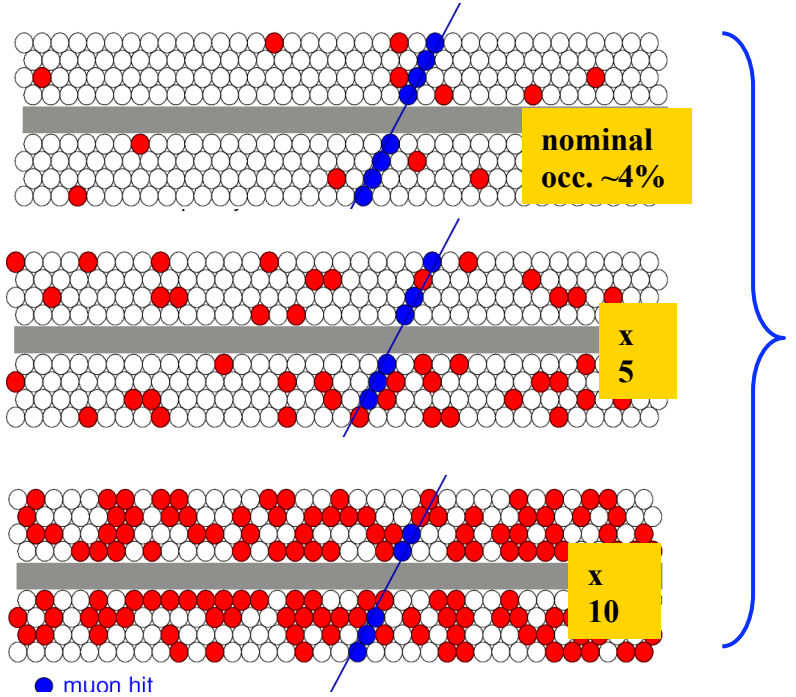
+ optimization of shielding may help further

MDTs in the high rate region

Present MDT : 30mm diameter

max drift time = 700 ns





Large reduction of single hit eff.

Increase of bkg occupancy

→ Need faster tracker in the hot region : small wheel (+ more ?)

BG rates in the Hall: do wee need new MDT?

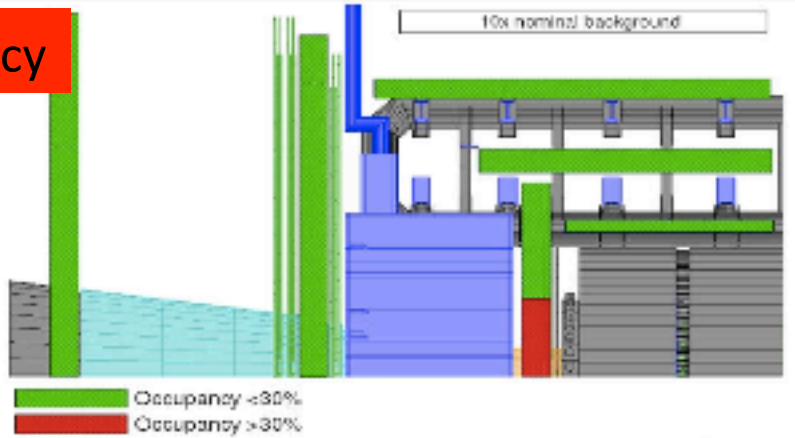
Depending on backgrounds, a few (10-15%) or a lot (70-80%) of the MDT chambers must be replaced…!

Limitation by occupancy

Safety factor 5 included

~ Phase I

Limitations – occupancies of the chambers



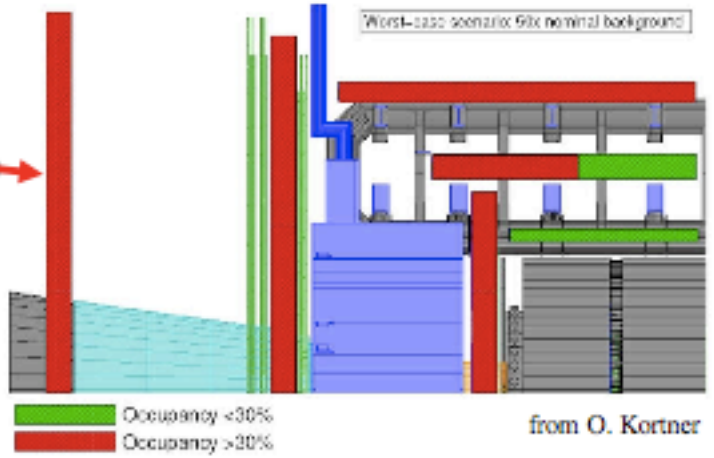
At least half of the chambers in the inner end-cap disk would have to be replaced by chambers with higher high rate capability.

Replace nearly all MDTs by something else: looks like a lot of work...
Can we avoid it ??

Very important to know better the bkg

~ Phase II

Limitations – occupancies of the chambers



from O. Kortner

Almost all chamber would have to be replaced.

Phase-1 upgrade

Limited upgrade – to prepare in a relatively short time

- CSC (tracking at the smallest R in the endcap) may suffer.
  - The idea is to add layers of fast trackers to help the CSC.
    - TGC with fine strip readout
    - Micromegas
    - Thin tube MDT

    are under consideration.

- A part of MDT can reach the occupancy and band width limitation

- L1 trigger : as it is, but send more info to CTP ?

Phase-2

- Small wheel will be OUT anyway (MDT at least)

  → new small wheel with new detector

- BKG level has to be below acceptable level

  worst case would require ~ total replacement of MDT (+RPC)

  Impractical

- MDT R/O bandwidth has to be taken care (Barrel, BW)
- L1 muon issue drives the upgrade scenario.

  Improve the L1 rate by the muon system level ?

  → YES (studying feasibility assuming YES)

Requirement on the detector and electronics is closely coupled to the L1 upgrade

Detector R&D

to secure detector options for upgrade

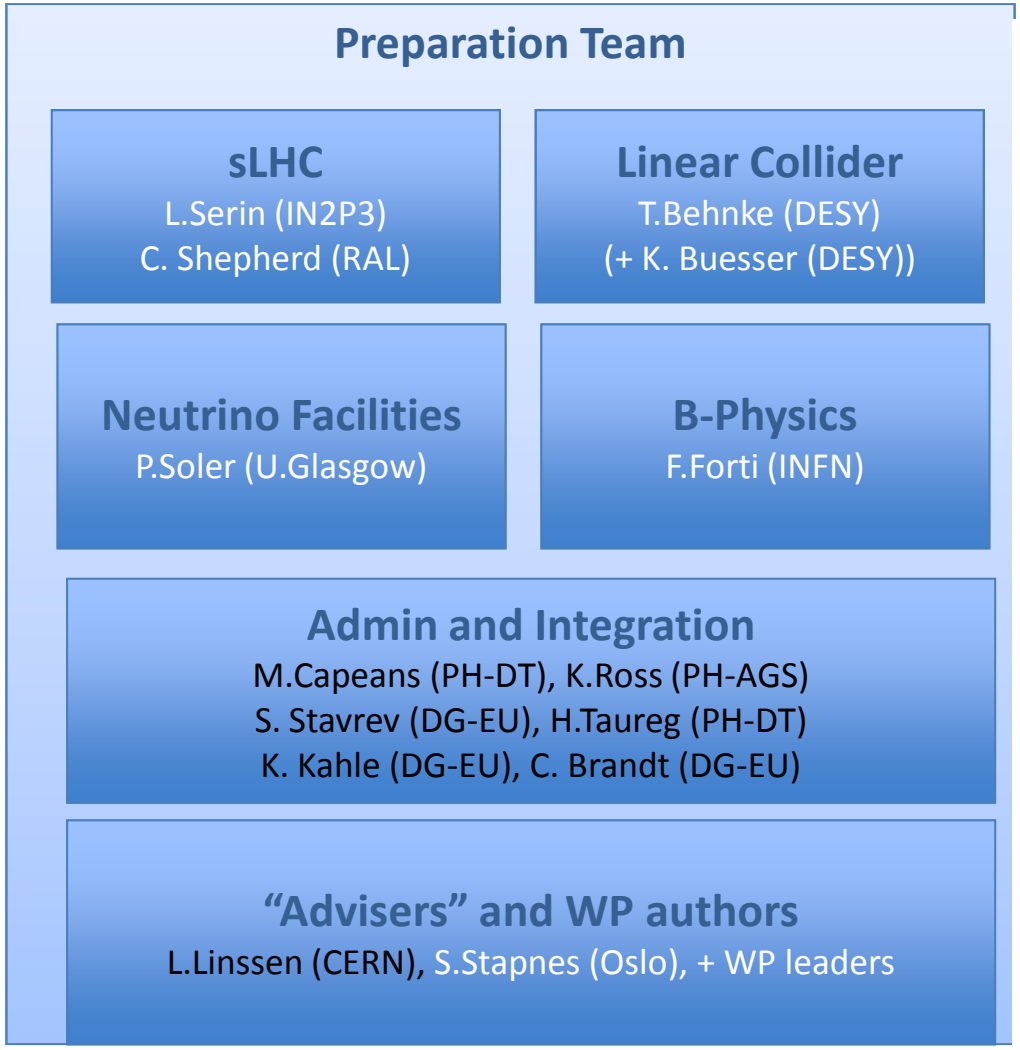
- Micromegas
- TGC with fine strip
- Small tube MDT
- MDT readout
- μ-PIC (mpgd)
- plasma panel
- new gas for MDT (linear and faster)
- RPC frontend (to allow operation at low HV)

Summary

- Muon system needs upgrades to maintain its performance at the high luminosity LHC.
- A large fraction of the detectors is expected to be operational at high lumi.
- Upgrade scenario critically depends on the actual bkg
- L1 muon will be driving the phase-2 upgrade scenario
- Long L1 latency → many front-end elec. need replacement
  (some are difficult to access : e.g. MDT mezzanine
- R&D are on-going. There are several viable options.
- Installation can be very complicated (space, time): need careful study.

Organisation of the AIDA call

Coordination group has been endorsed by RECFA meeting at EPS conference in Krakow, discussed at CERN council (Sep) :



→Proposal is expected to cover R&D and Infrastructure needs for new detectors at sLHC, LC/CLIC + neutrino/flavour physics projects.

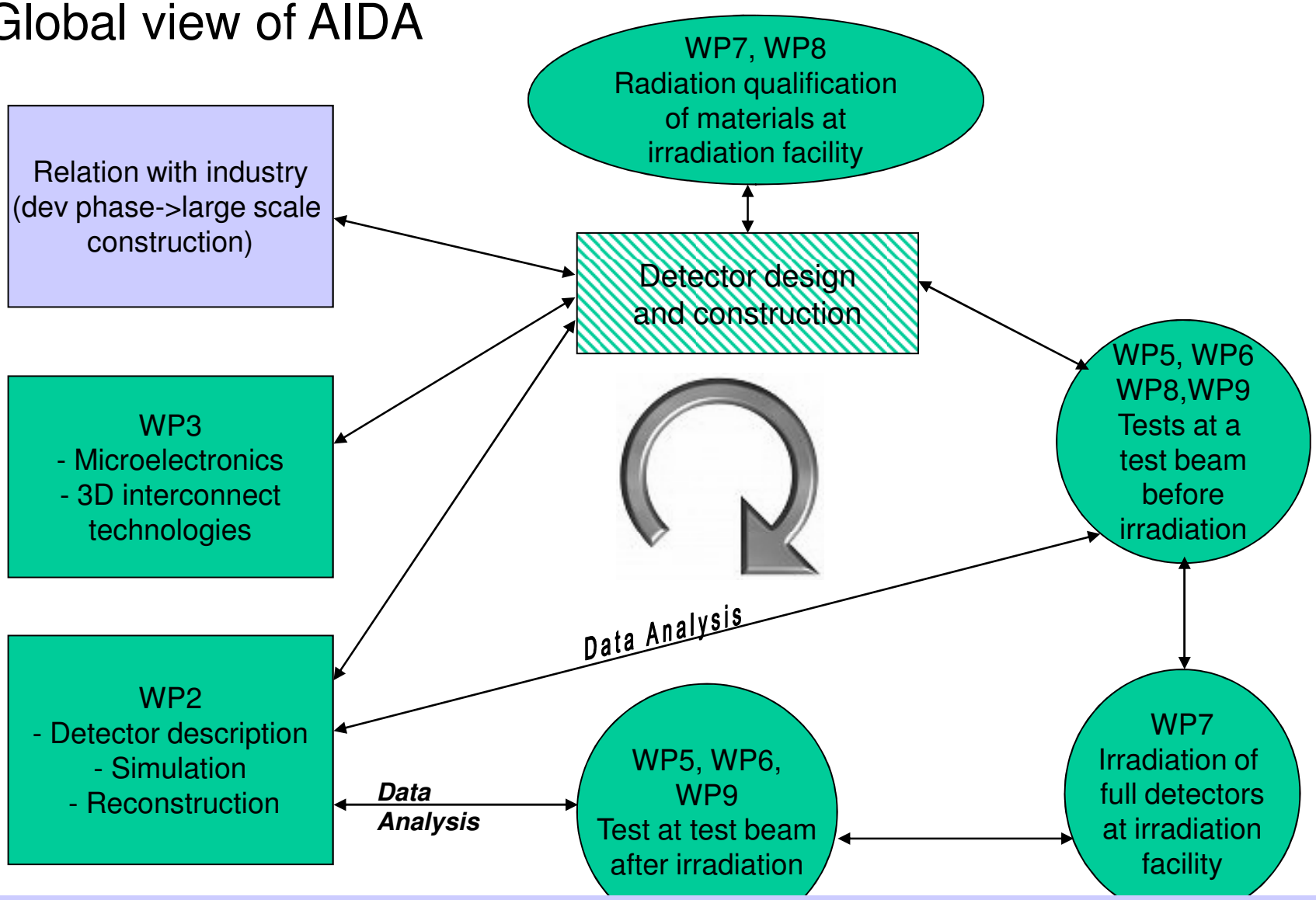
→Need to have the proposal correctly balanced between sLHC and LC/CLIC

→ Information is going trough the National Contact for each country (23) and through the experiments

→Important that every actor is participating to the call but do not forget 10 M € for > 100 Institutes

Preparation group work started since end August only…

Global view of AIDA



Cover detector design from first R&D ideas (simulation, choice of material, beam test + analysis) up to detector construction (needs of tight links with Industry) while pushing some technologies which are at the state of the art (3D semiconductor and electronics…)

Partecipazione gruppi ATLAS-IT

WP3 – networking – microelettronica e connessione 3D ai sensori

Gruppi di VPIX e di ATLAS – convener Valerio Re
Gruppi PV-GE-MI-PD/TN-LE-PI

WP8 – realizzazione infrastrutture per GIF++

Gruppi di ATLAS e CMS- BO-Rm2- (LNF-BA)