Upgrade di ATLAS a SLHC

Incontro ATLAS e CMS per l'Upgrade a SLHC

Sestri Levante, November 13-14, 2008

G. Darbo - INFN / Genova

Workshop Page:

http://iacu-2008.ge.infn.it/

Why Machine / Experiment Upgrade?

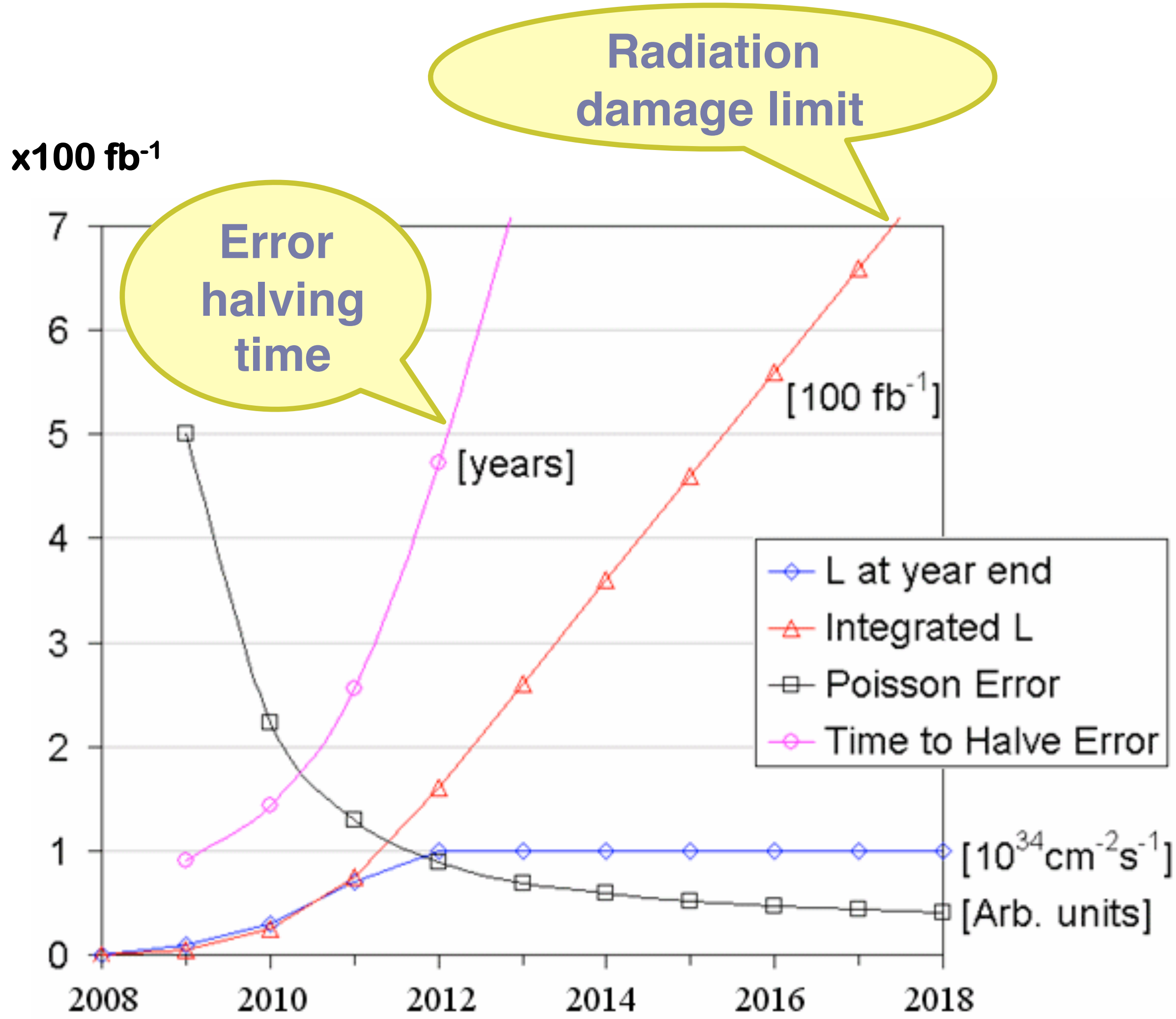
Reasons to upgrade LHC:

MACHINE

- Due to the high radiation doses to which they will be submitted, the LHC IR quadrupole magnets have to be replaced after integrated luminosity of 700 fb-1

EXPERIMENTS

- Depending on the luminosity evolution, the error "halving time" will exceed 5 year at this time



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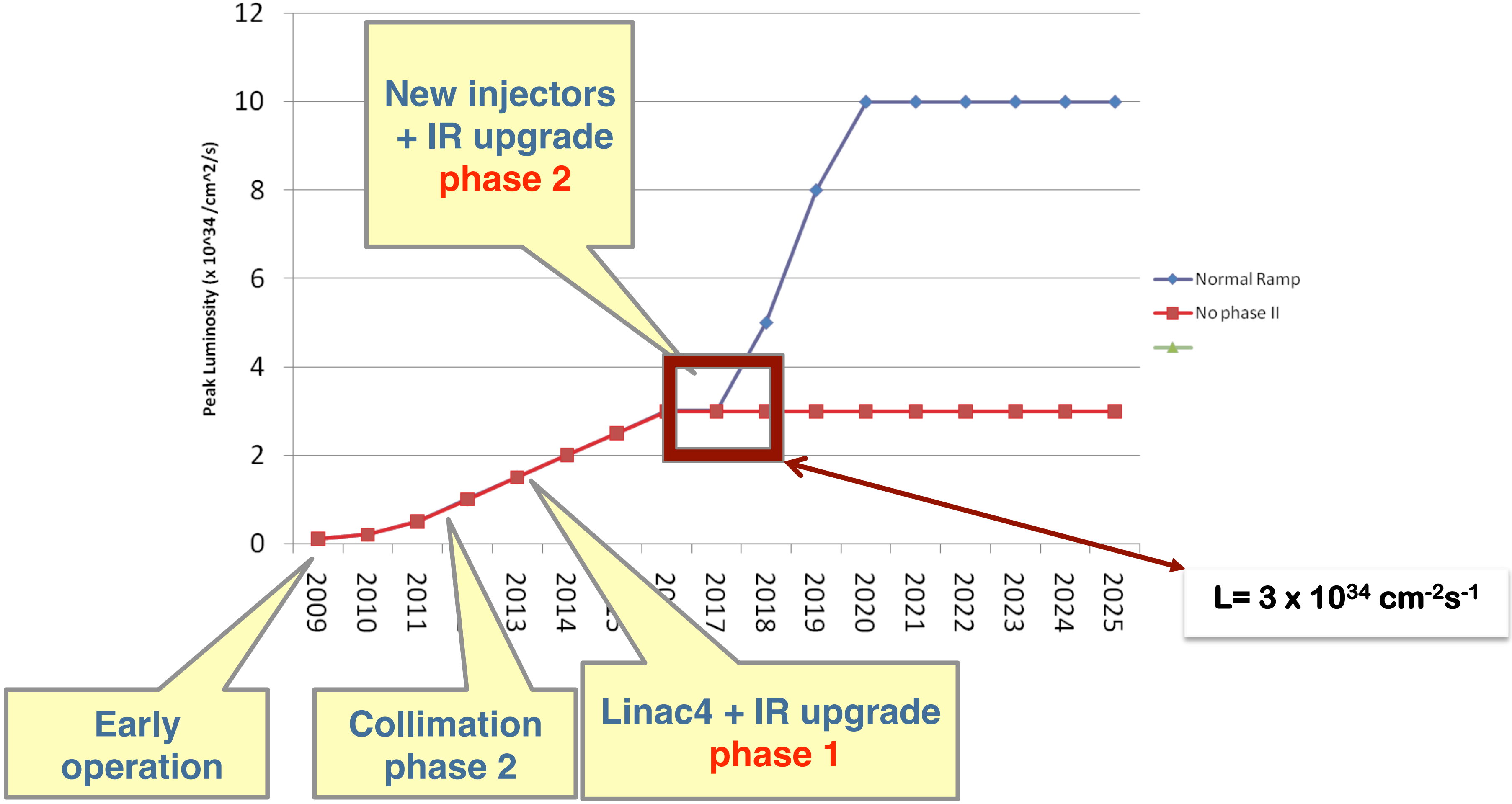
LHCC: Peak Luminosity

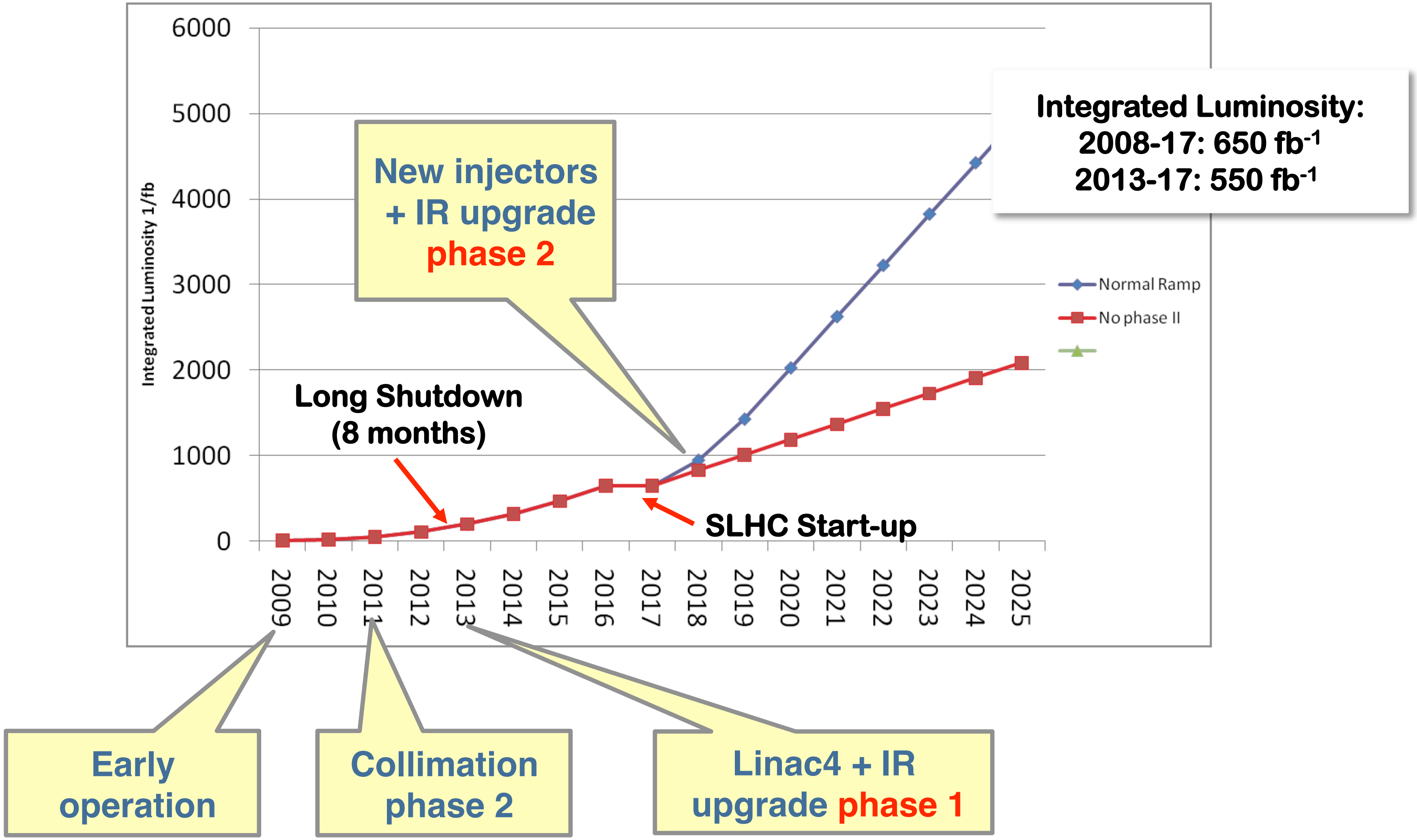
- Peak luminosity affects detector and DAQ/Trigger performance



Ref: LHCC 1/7/2008 – Roland Garoby

LHCC: Integrated Luminosity

- Integrated luminosity affects detector's life



Ref: LHCC 1/7/2008 – Roland Garoby

Basic Expectation

- After 2009 we will know LHC startup with much greater certainty

Collimation phase 2 → 2011

Linac4 + IR upgrade **phase 1** → 2013

New injectors + IR upgrade **phase 2** → 2018

Radiation damage limit ??? → 2022–2025

	Normal Ramp			No phase II		
Year	Peak Lumi (x 10^{34})	Annual Integrated (fb^{-1})	Total Integrated (fb^{-1})	Peak Lumi (x 10^{34})	Annual Integrated (fb^{-1})	Total Integrated (fb^{-1})
2009	0.1	6	6	0.1	6	6
2010	0.2	12	18	0.2	12	18
2011	0.5	30	48	0.5	30	48
2012	1	60	108	1	60	108
2013	1.5	90	198	1.5	90	198
2014	2	120	318	2	120	318
2015	2.5	150	468	2.5	150	468
2016	3	180	648	3	180	648
2017	3	0	648	3	0	648
2018	5	300	948	3	180	828
2019	8	420	1428	3	180	1008
2020	10	540	2028	3	180	1188
2021	10	600	2628	3	180	1368
2022	10	600	3228	3	180	1548
2023	10	600	3828	3	180	1728
2024	10	600	4428	3	180	1908
2025	10	600	5028	3	180	2088

Summary of ATLAS Upgrade Path

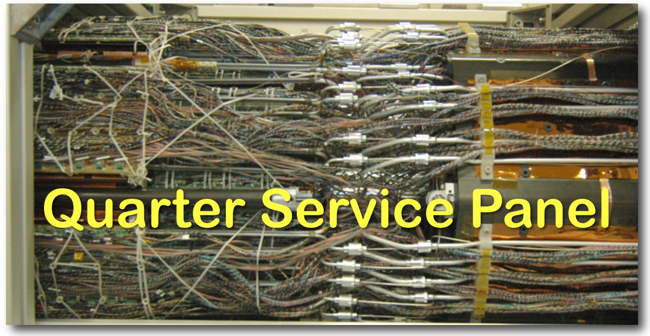
- Agreed scenario ATLAS/CMS/LHC at LHCC 1st July 2008
  - *No guarantee that because we agreed to it, it will happen! But it is what we use to plan with.*
- Summary L, integrated L, phases from Roland Garoby's talk (LHCC 1/7/2008, before LHC accident, next slides)
  - *After 2009 we will know LHC startup with much greater certainty*
  - *Phase I LHC upgrade in 2013 (long shutdown)*
  - *Phase II upgrade (SLHC) in 2018*
- For phase I (2013) – ATLAS Plans:
  - *Inserted B-Layer (IBL)*
    - shutdown date is not due to end-of-life of B-layer but because it is the only long shutdown available for installation
  - *SCT/TRT/LAr/Tiles/Muons/Trigger*
    - Initial look sees some, but not many, changes needed.
    - ATLAS planned for $2x10^{34}$ and 700 fb^{-1} – Phase I is 50 % increase on peak rate and no change integral.
    - Need to go through methodically to avoid surprises.

- For phase II (2017) – ATLAS Plans:
  - *Rebuild Internal Tracker*
  - *New FE electronics for Calorimeters, Muons*
  - *Shielding the beam pipe region and/or replace ss beam -pipe sections to Al sections and Al to Be to reduce background in forward muon chambers*
  - *L2 trigger upgrade, L1 trigger will be the challenge.*
  - *Total upgrade costs: 180÷220 MCH (evaluation done in 2005)*

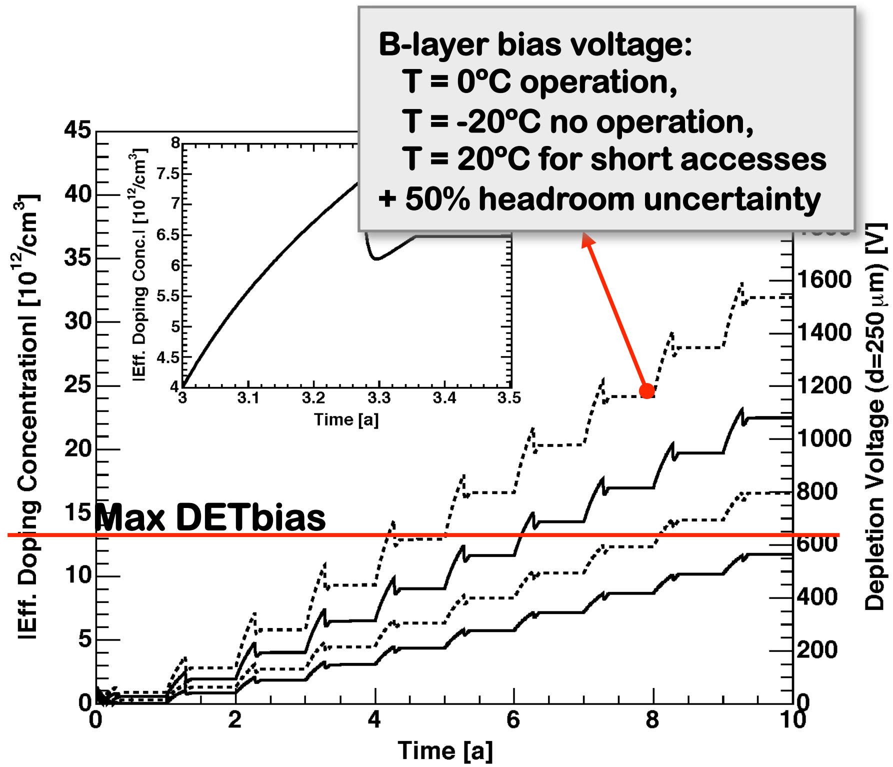
B-LAYER

Why Pixel Replacement & What to do

- B-layer was designed to survive 3 years of LHC nominal luminosity ($10^{34}cm^{-2}s^{-1}$, $300fb^{-1}$)
  - *NIEL fluence = 10^{15} neq/cm^2 (mainly from pions).*
  - *Ionizing Dose = 500 kGy (50 Mrad).*
  - *Sensors & Electronics are the critical parts.*



- B-layer replacement studied in a dedicated Workshop (10/2007).
  - *B-Layer cannot be replaced in a 8 months long shutdown: pixel package has to be extracted and taken to surface, Quarter Service Panels must be opened.*
  - *Project more difficult than foreseen → ATLAS set up a* ***B-layer Task Force*** *with a 6 month mandate to find a way out.*
  - *Task Force analysed the boundary conditions and finally came to preferred recommendations to ATLAS and Pixels.*

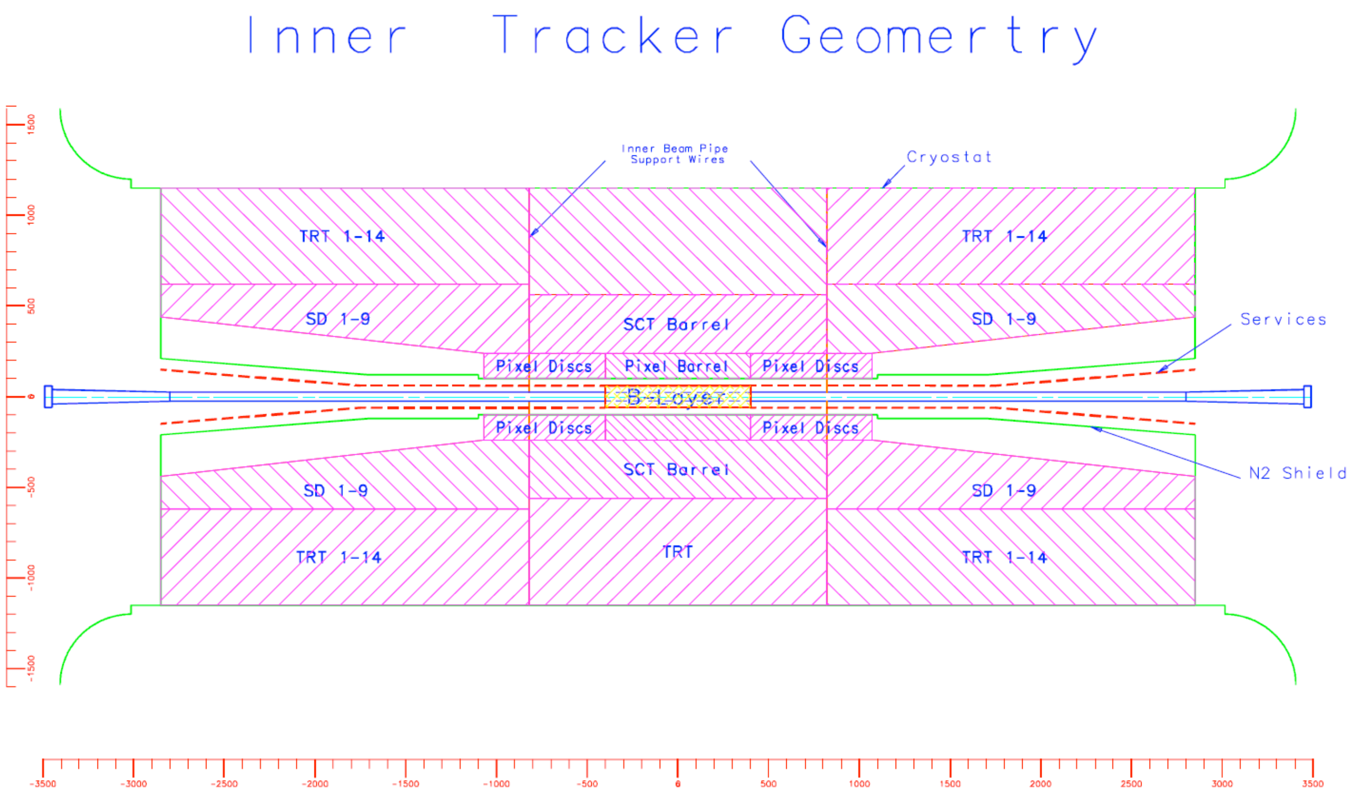


B-Layer - TF : Findings & Recommendations

- Findings → replacement needed in 2012 shutdown (long shutdown before SLHC):
  - *Detector designed for 300 fb^{-1}, could probably withstand to 400fb^{-1} or a bit higher with reduced efficiency;*
  - *Integrated dose acceptable even with margin of error until 2013, but not until 2016;*
  - *Hard detector failures requires to have a replacement.*
- Other findings → replacement scenarios:
  - ***B-layer cannot be replaced in a long shut down** (8 months) – requires extraction of the pixel package, opening the whole detector (also beam pipe cannot be extracted without opening of pixel package -> special tooling and procedure to make in situ)*
  - *Other options as a **simpler 2 hit system with present technology** (case of disaster) not realizable (collaboration to make, spares not available)*
  - ***Study the insertion** of a smaller b-layer and a smaller beam pipe inside the existing detector*
- Recommended solution → inserted B-layer (IBL) with new (module) technology
  - *But why so difficult to replace and how to make an IBL. Next slides…*

B-Layer from TRD to Today

- Original TDR design (1998)
  - *Pixel Layer1 and Layer2 where "fixed" to SCT.*
  - *B-Layer was insertable and clam shell*

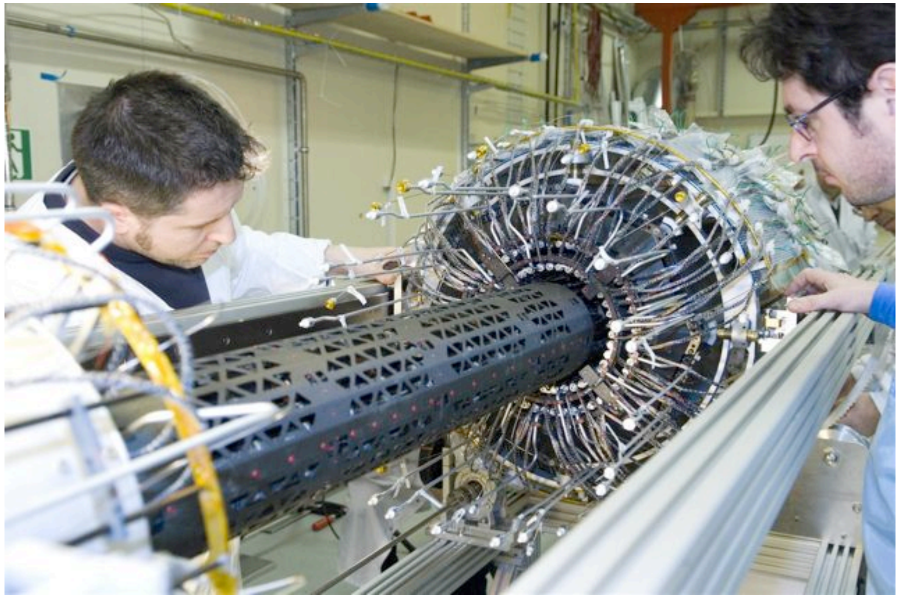


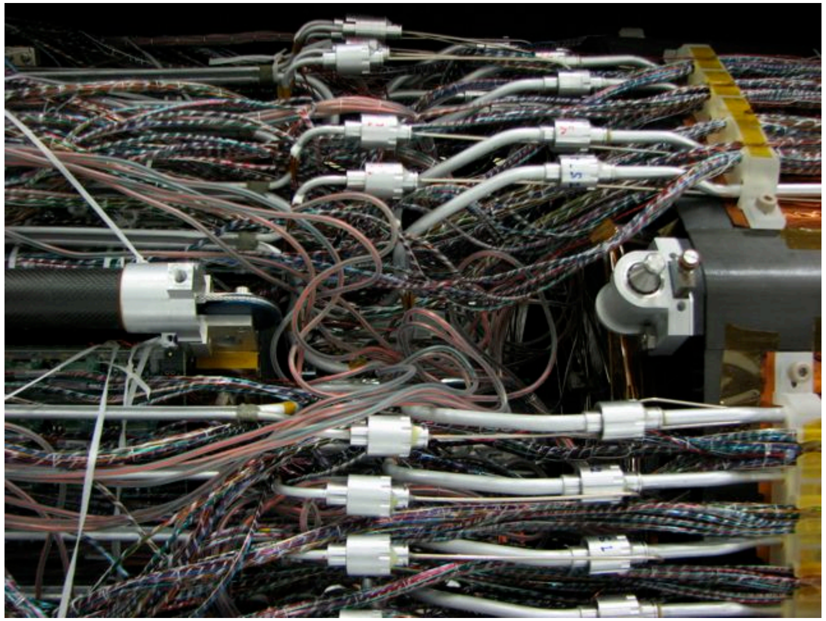
Schedule, Design Changes & Implications

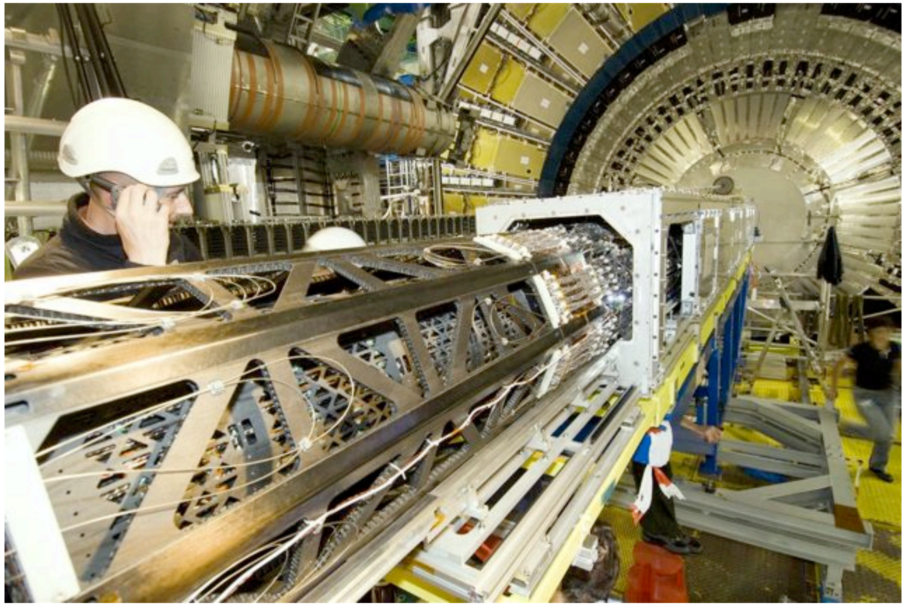
- In 2000 the Pixel schedule was delayed by the FE & MCC designed in DMILL.
  - *A new "reduced" layout of Pixel transformed an year later to "insertable" layout*
  - *It uses a support tube and a reduced radius of the detector.*
  - *The new Pixel allows later insertion of the detector if not ready*
  - *At that time the starting of LHC was 2005*

- Implications
  - *The development of the services with the new constraints to fit in the "Pixel Support Tube" made impossible to keep the B-Layer insertable.*
  - *From the experience in integrating the detector we have seen that opening and closing the "package" is more than 8 months.*
  - *Activation of the detector adds additional difficulties*

Pixel Integration and Installation

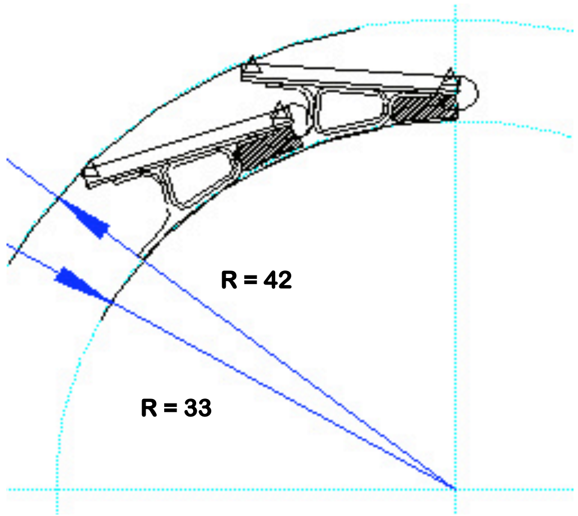






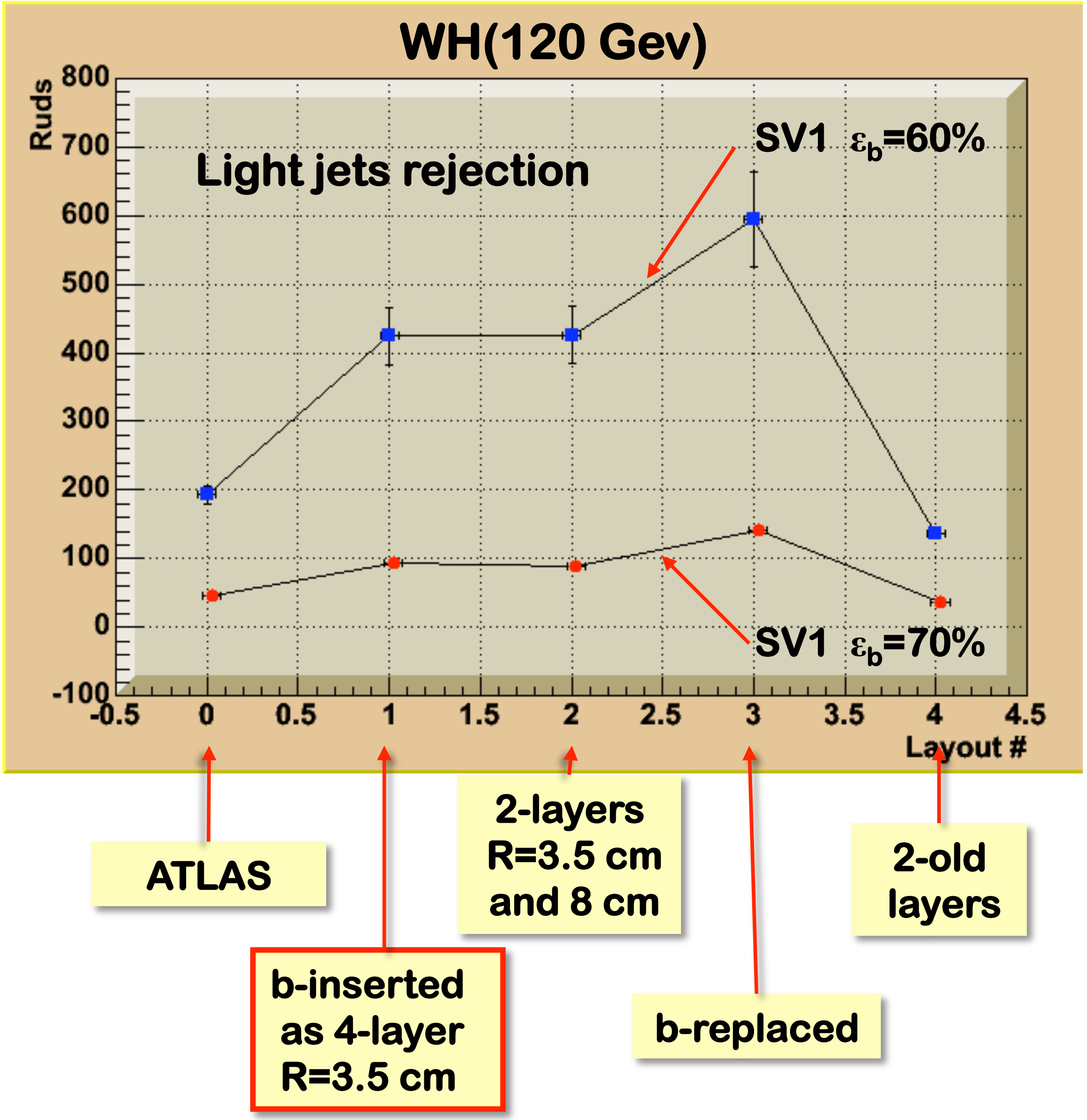
B-Layer Replacement - Insertion

- Study a smaller radius B-layer to insert in the existing Pixel
  - *It seems feasible (or not unfeasible) but not demonstrated yet;*
  - *16-staves (present module "active" footprint gives hermetic coverage in phi) not shingled b-layer. Requires new smaller beam-pipe;*
  - *Module technology: tracking hermetic requires new module design – increase live area of the footprint:*
    - New chip design (FE-I4) – live fraction, I/O bandwidth, 200 Mrad;
    - Sensor – increase radiation hard (smaller radius and ramping up LHC luminosity): $4x10^{15}\ n_{eq}/cm^2$.
  - *Services are under feasibility studies and solutions should be defined soon (end of 2009 – begin 2010).*
- R&D and prototyping in 2009, construction 2010-2012;



B-Layer Scenarios

- To maintain Pixel Detector performance with inserted layer, material budget is critical.
- Development of new local support structure with carbon-carbon foams (**See Danilo's talk**).



Component	% X_0
beam-pipe	0.6
New-BL @ R=3.5 cm	1.5
Old BL @ R=5 cm	2.7
L1 @ R=8 cm	2.7
L2 + Serv. @ R=12 cm	3.5
Total	*11.0*

IBL Project Organization

- IBL Coordinator reporting to ATLAS and Pixel community (PL and Institute Board)
  - *Expected to come from present Pixels*
  - *Selection process and appointment should be completed for Feb'09 Collaboration Board*

- Funding Model
  - *The overall model for the B-Layer Replacement was that this part of the detector was a "consumable".*
  - *A dedicated line of funding, contained inside the Pixel M&O B, exists for the B-Layer Replacement: for 2009 - 2012 construction period is foreseen to be roughly 4 MCHF.*
  - *The Project Office funding is foreseen to come largely from M&O A.*
  - *First, very rough, cost estimates would indicate a cost of about 7-8 MCHF, including the new beampipe.*

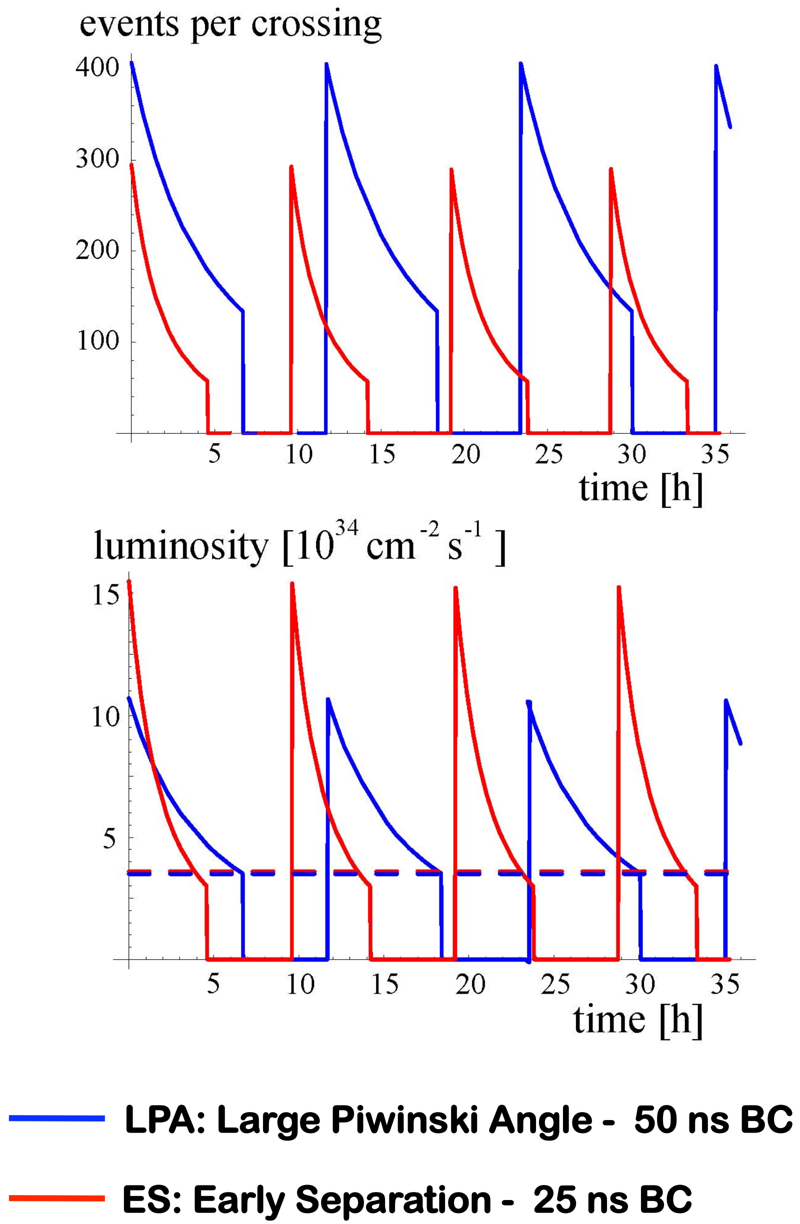
Inner Tracker, L1 Trigger,…

SLHC

SLHC – Luminosity Scenarios

- Several machine scenarios have been looked in the ATLAS upgrade.
  - *LPA - Large Piwinski Angle 294 Ev/BC, 25 ns BC*
  - *ES – Early Separation 400 Ev/BC, 50 ns/BC*

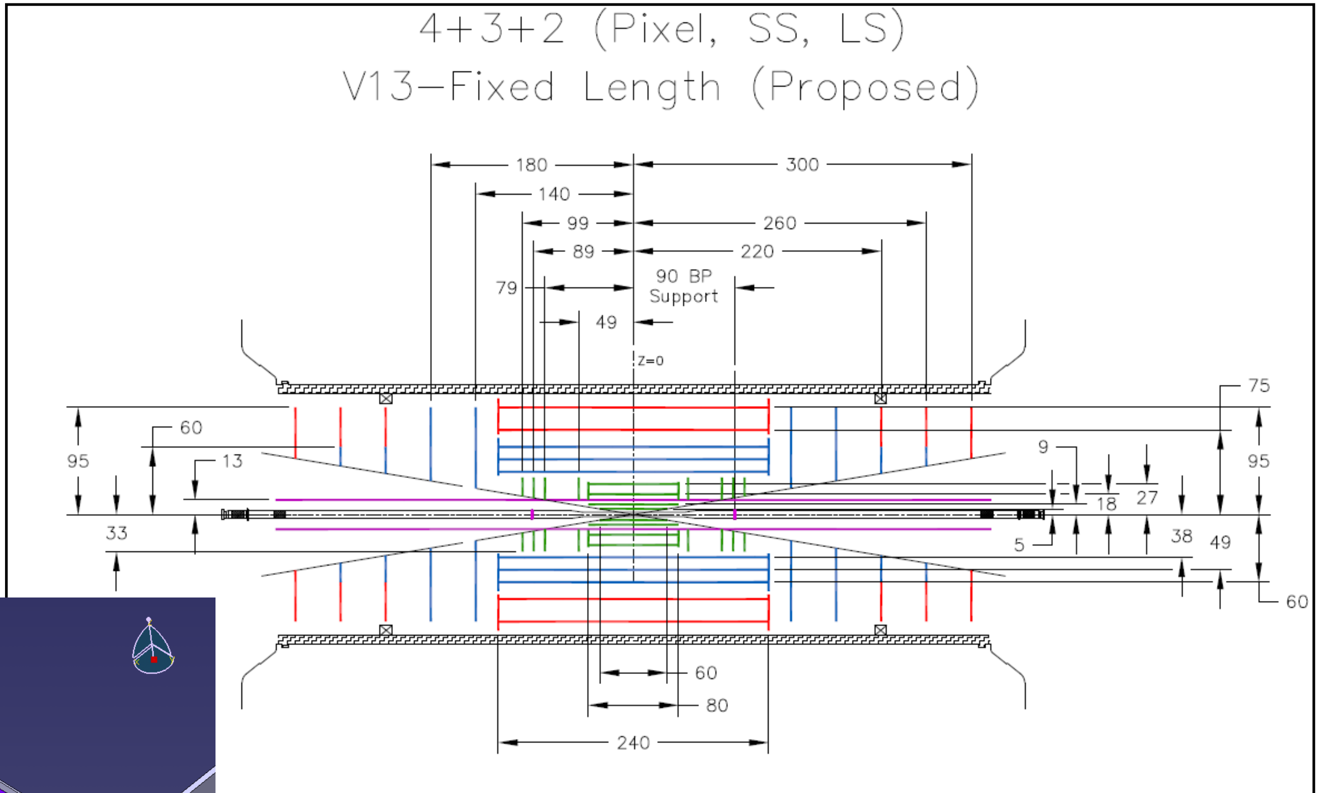
- Inner Tracker
  - *Look for similar performance as LHC*
  - *Occupancy affects pattern recognition -> more Pixels*
  - *And R/O -> new FE design*
  - *Radiation dose -> Sensor technology*

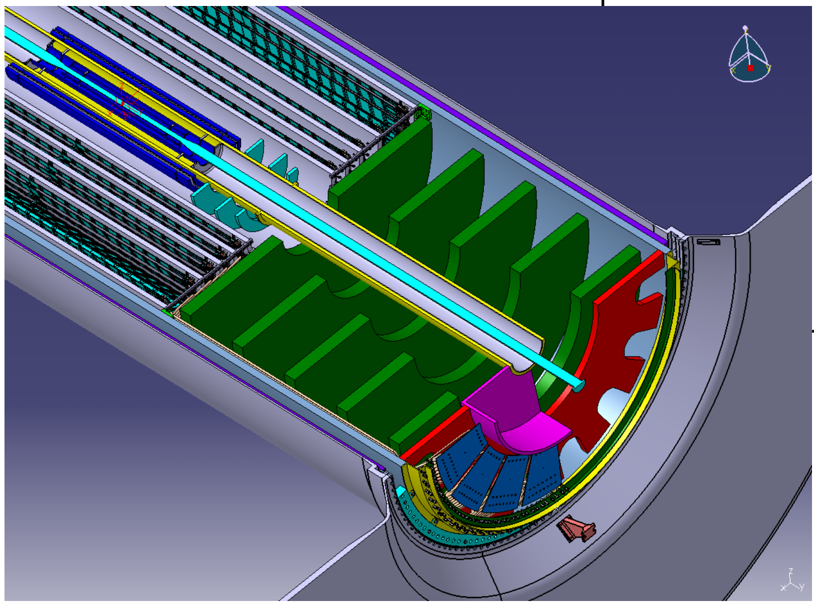


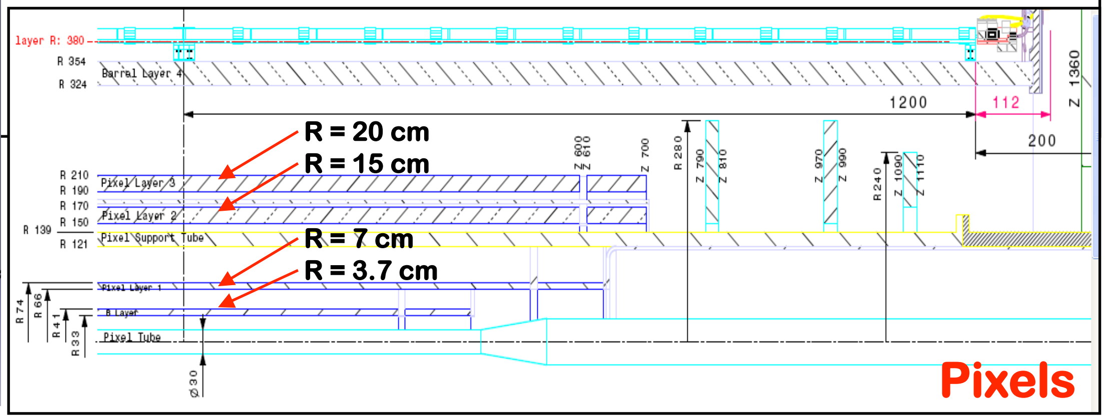
Inner Tracker Layout

Strawman 08

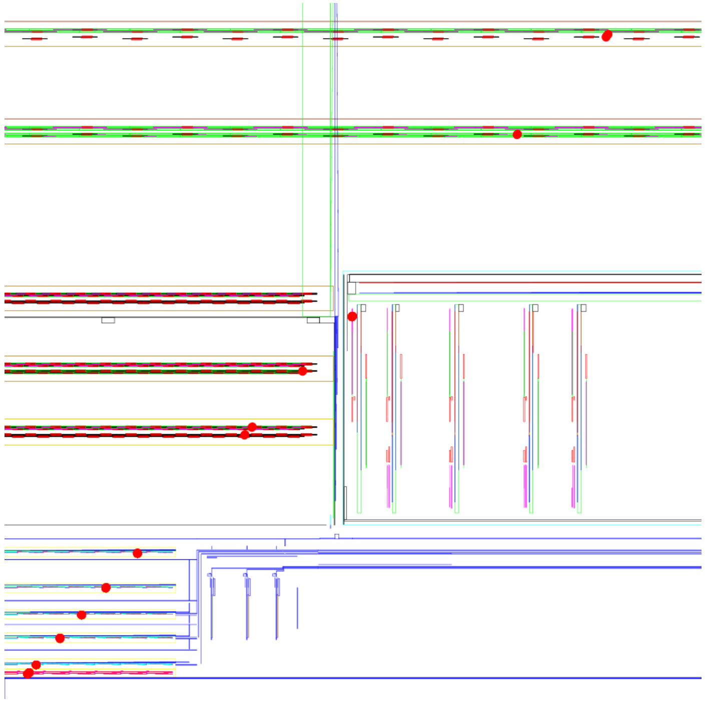
- 2 Insertable Pixel
  - *250x50 μm²*
- 2 Fixed Pixel
  - *250x50 μm²*
- 3 short Strips
  - *2.5 cm*
- 2 Long Strips

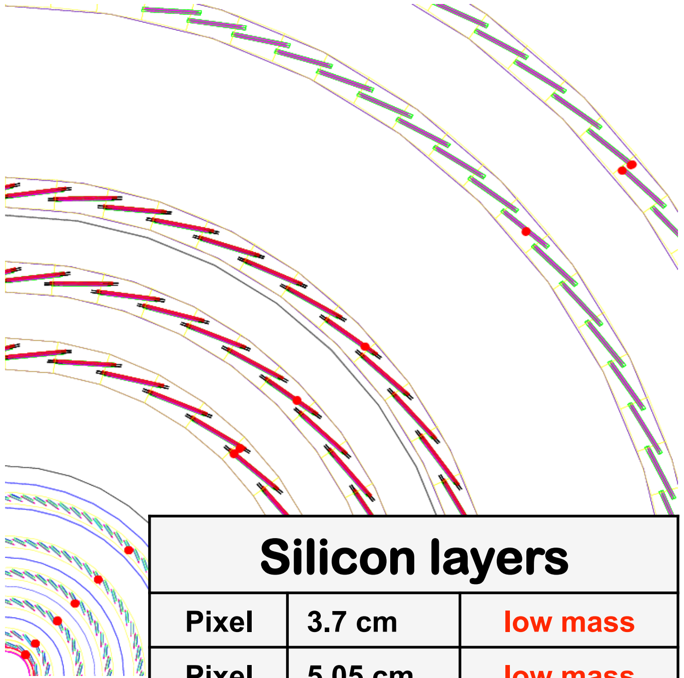






Layout Studies



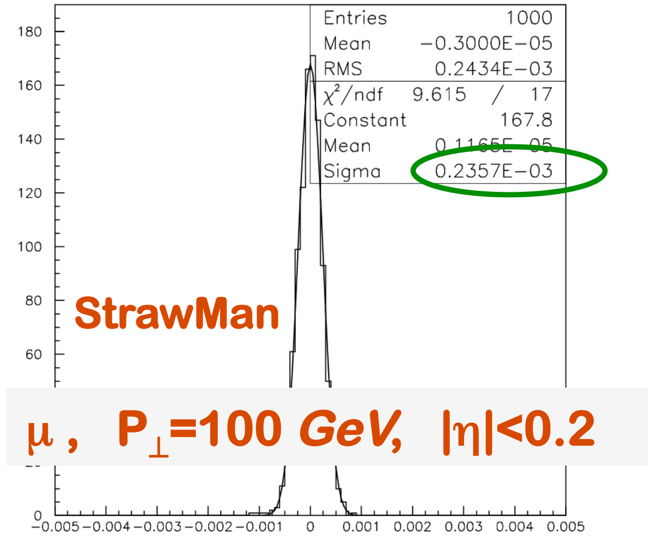


Silicon layers		
Pixel	3.7 cm	low mass
Pixel	5.05 cm	low mass
Pixel	8.85 cm	std
Pixel	12.3 cm	std
Pixel	16 cm	std
Pixel	21 cm	std
SCT	38.1 cm	short strip
SCT	47.3 cm	short strip
SCT	57.4 cm	short strip
SCT	81.4 cm	long strip
SCT	95.4 cm	long strip

- Studies focused on Pixels
  - *Play with layers: from 4 to 6*
  - *Material:*
    - Low mass = 1.5 % X_0
    - Std mass = 2.7 % X_0
  - *Strips assumed from Strawman08*

Layout Study - Momentum & Vertex resolution

- SLHC StrawMan layout improves Momentum and δZ resolution (at “0” luminosity)
  - *Replacement of TRT with Strips improves momentum resolution*
  - *Smaller pitch in Z of pixels (250 μm from 400 μm) improves primary vertex resolution as shown in table.*



$1/P_\perp^{gen} - 1/P_\perp^{rec}$

Layout	δZ(μm)
Current ID	~41
StrawMan 08	~28
p101011	~23
6 Pixels	~23

$$\delta\left(\frac{1}{p_\perp}\right) = \frac{\delta(p_\perp)}{p_\perp^2} =$$

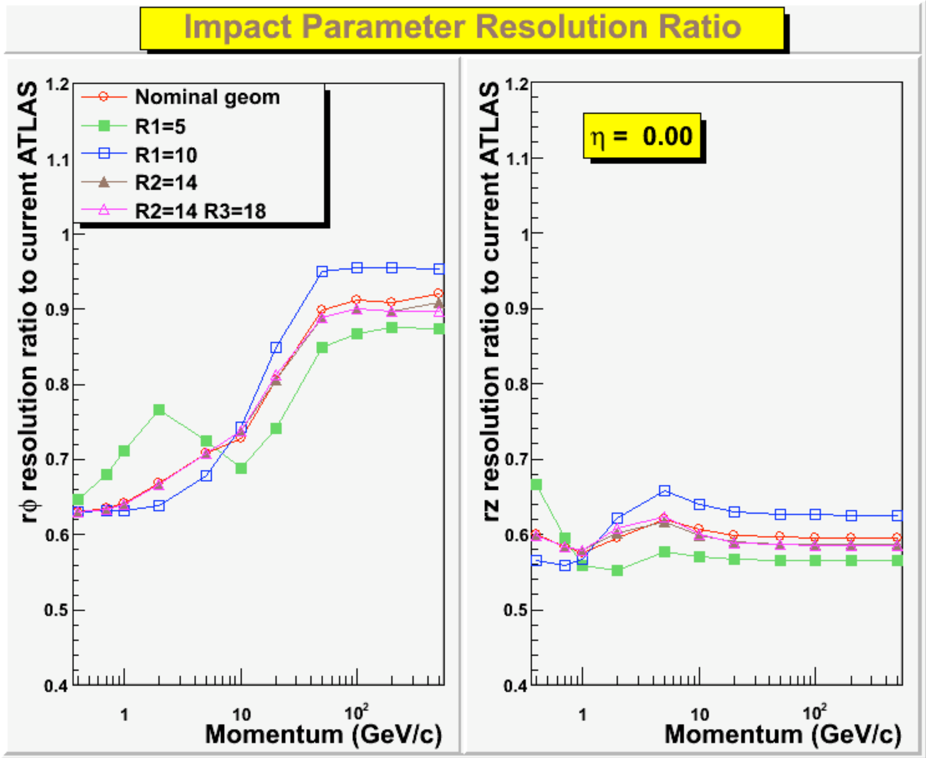
Std ID = $4.0 \cdot 10^{-4}$ GeV^{-1}

StrawMan08 = $2.4 \cdot 10^{-4}$ GeV^{-1}

6 Pixel layers = $2.0 \cdot 10^{-4}$ GeV^{-1}

V.Kostyukhin - 06/11/2008 ATUW

Layout Study - Pixel Layer Radius Choices



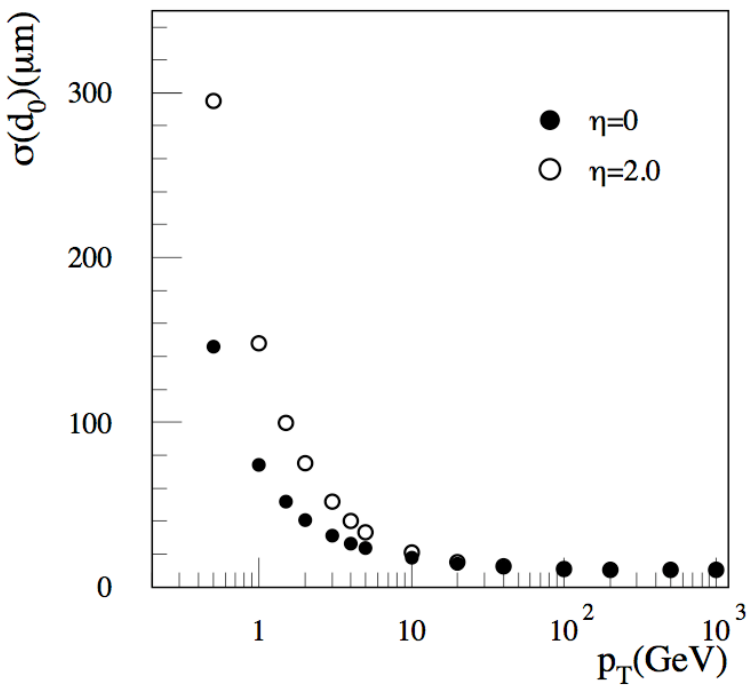


Figure 3-13 d_0 resolution as a function of p_T.

Parametric resolution study using LCDtrk track error calculations

Nominal Barrel geometry:

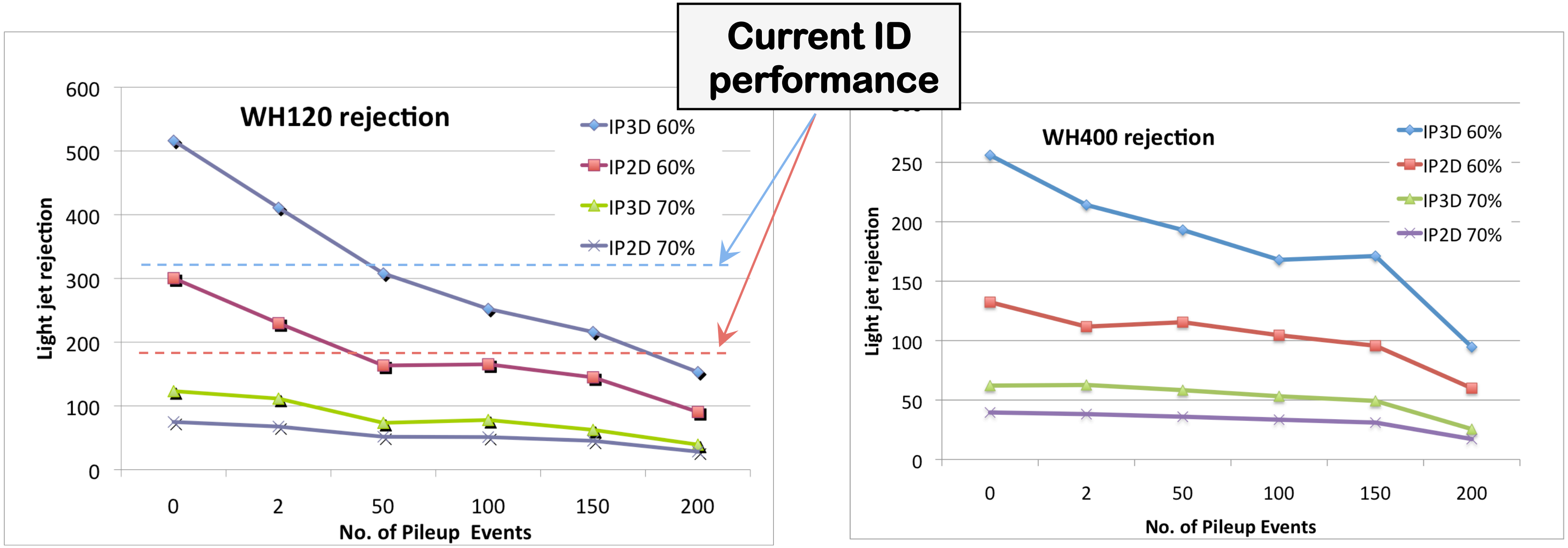
R=(3.7, 7.5, 16.0, 20.0)

Strawman improves below 20 GeV/c tracks. See also current ATLAS Layout (fig. top right).

Su Dong – ATUW Nov/04/08

B-tagging at High Pileup

- Big increase of amount of fakes with pileup in "StrawMan" layout . SCT part seems do not have enough resolution to reject fakes effectively.
- Factor ~3 degradation of b-tagging at 200ev pileup for StrawMan layout with respect to zero lumi. Below current ID performance with ≥100ev pileup.
- What to do? Extend pixel part to larger radius? Luminosity leveling?



	WH120 60%			WH120 70%			WH400 60%			WH400 70%		
	IP2D	IP3D	SV	IP2D	IP3D	SV	IP2D	IP3D	SV	IP2D	IP3D	SV
R_2/R_200	3.2	2.5	11	2.6	3.2	5.2	2.2	2.7	2.8	2.3	2.4	4.4

V.Kostyukhin - 06/11/2008 ATUW

ATLAS Trigger at SLHC

- *Much higher detector occupancy, so even 100KHz L1A rate will require much higher readout bandwidth*

- L1 Trigger – what can be done:
  - *Rely more on multi-object triggers*
    - Not without consequences: e.g. L1 single muon geometrical acceptance ~80%, double muon e = $(80\%)^2$
    - Increased probability for trigger objects to come from different pp collisions
  - *Raise p_T thresholds (wrt 10^{34})*
    - Past studies suggested we may have to go up to 60GeV at L1 for single e/m triggers:

      - the L1 e/m rates fall much smoother above ~30GeV

      - Also CMS has the same behaviour. Muon trigger p_T is limited in CMS by multiple scattering in iron, by detector resolution in ATLAS
- ATLAS has started to look into a L1 track trigger (as CMS)
  - *Correlate objects between ID and Calo/Muon.*
  - *Several ideas. Implementation looks challenging…*

R&D FOR SLHC

R&D for SLHC

- In 2005 the High Luminosity Upgrade Steering Group (USG) defined procedures for R&D of interest for ATLAS
  - *Activity Matrix - Define R&D activities.*
  - *Procedures for R&D proposal - not necessarily imply the technology being proposed for study is going to be definitely also accepted for implementation.*
    - Submitted to USG.
    - Reviewed and circulated to the Collaboration Board (CB) for other Institutes to join.
    - The refined proposals are re-evaluated, now also considering strongly the resources foreseen.
    - Recommendation for approval (or not) to be handed to the Executive Board (EB).

- Total of 34 proposal submitted since 2005. ~210 Institutes participating (multiple times), 7% of INFN.

Inner Tracker R&D

Approved by Executive Board
LoI, Proposal presented to USG

Pixel
Strips
Inner Detector

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*

Calorimeter, Muon & Other 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	

Approved by Executive Board
LoI, Proposal presented to USG

Calorimeter
Muon
Trigger, Elec, …

Some R&D where INFN Involved

- FTK
  - *See Paola's talk (in a more general framework) and LVL1 Trigger*
  - *The idea is to make a LVL1.5 Pixel track trigger using Pixel information. Data into FBK should be get by intercepting the link from detector to ROD.*
  - *LNF group involved. They are studying cluster algorithms (first CPU intensive step for track reconstruction) and their optimisation for the implementation into FPGA (Xilinx evaluation board). Next step in 2009÷2010 make a dedicated board.*
  - *Status approved by ATLAS EB to get a TDR.*
- 3D Sensors
  - *See Claudio's talk, target to IBL and SLHC internal Pixel Layers*
- FE-I4 design (new Pixel front-end chip)
  - *See Roberto's talk, target to IBL and SLHC outer Pixel layer (fixed Pixels)*
- Local Pixel Supports (low material budget)
  - *See Danilo's talk*
- Calorimeter FE Electronics and R/O
  - *See Mauro's talk*

Pixel Planar Sensors

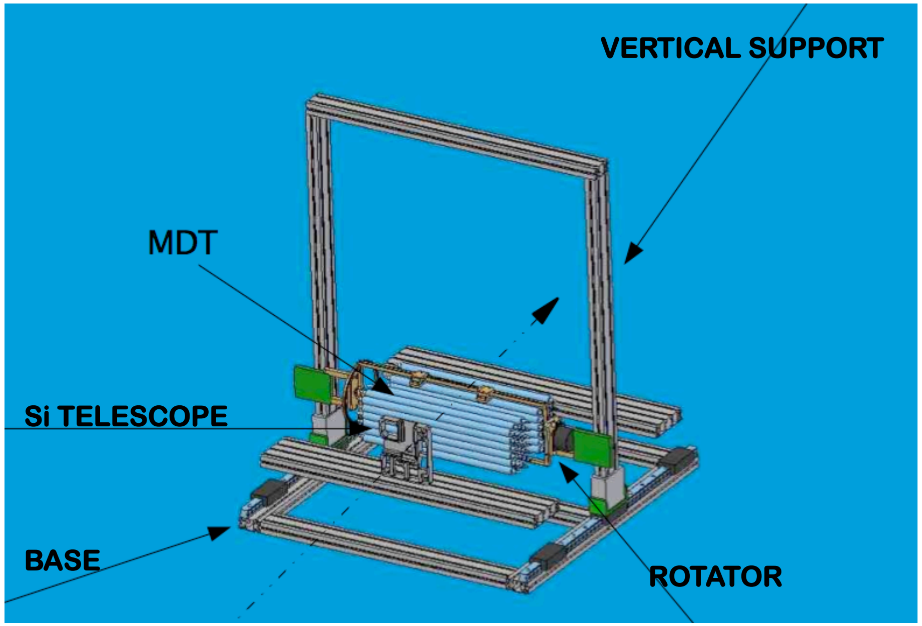
- Planar Pixel sensor R&D goes two ways:
  - *Cheap technology (single side like n-in-p) for large area*
  - *Push radiation hard and charge collection for inner Pixel layer (as alternative solution of 3D) for the inner pixel layers*

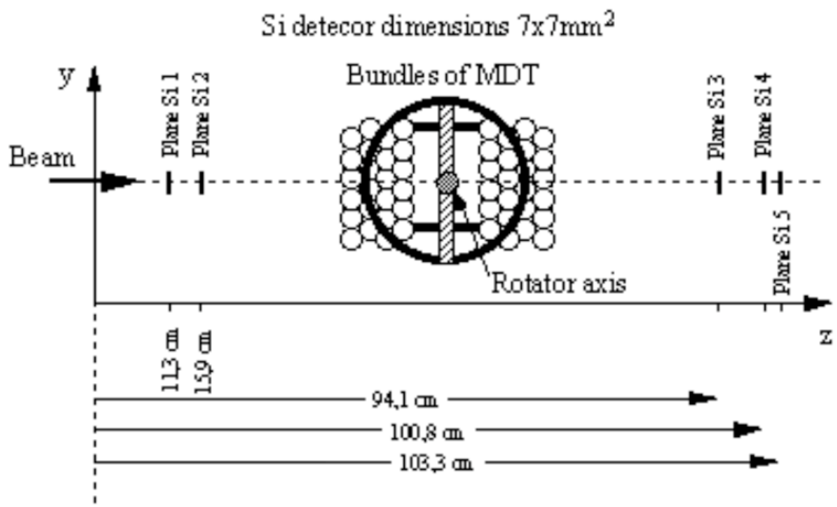
- R&D looks at:
  - *n/p bulk materials, DOFX, MCz, etc -> cost / radiation hard*
  - *Slim edge, active edge -> small dead area if module not tiled in Z*

- Interest of Udine to contribute at Planar Sensors R&D:
  - *Expertise in device modelling and measurements.*
  - *More recently looking at application of same technique to 3D sensors (presently not covered by other groups) together GE, TN (GR5) TS (GR5) and IRST/FBK (TN).*

MDT Gas R&D - 1/2

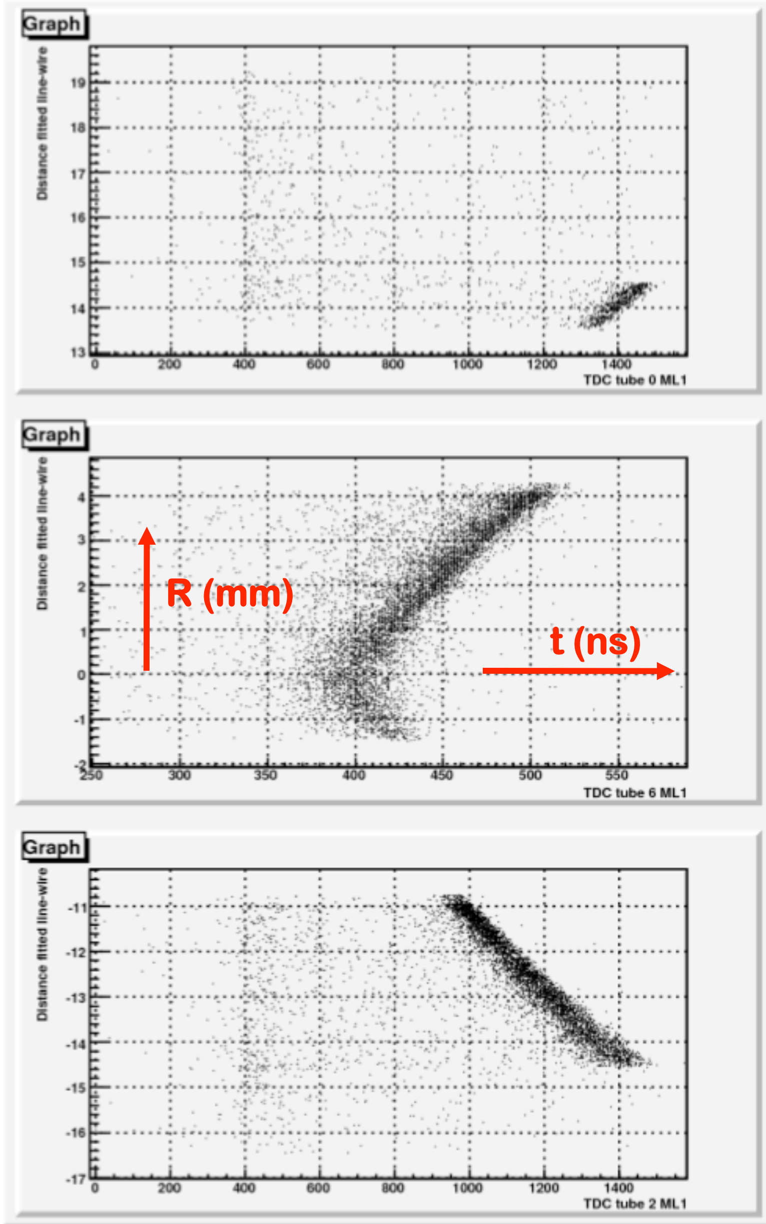
- Measurement of the R-t relation of faster gases (reduce occupancy) $Ar:CF_4$ (80:20) / (93:7) and comparison with ATLAS standard $Ar:CO_2$ (93:7)
  - *Study spatial resolution, gas gain, ageing.*
  - *Study of the time slewing corrections for $Ar:CO_2$ standard gas mixture*
  - *Comparison of the R-t results with those coming from auto-calibration.*
- Experimental setup
  - *CERN H8 test beam*
  - *Precise Y and θ support stage for MDT*
  - *5 planes of μstrips with 5 μm extrapolated resolution and 95% efficiency.*





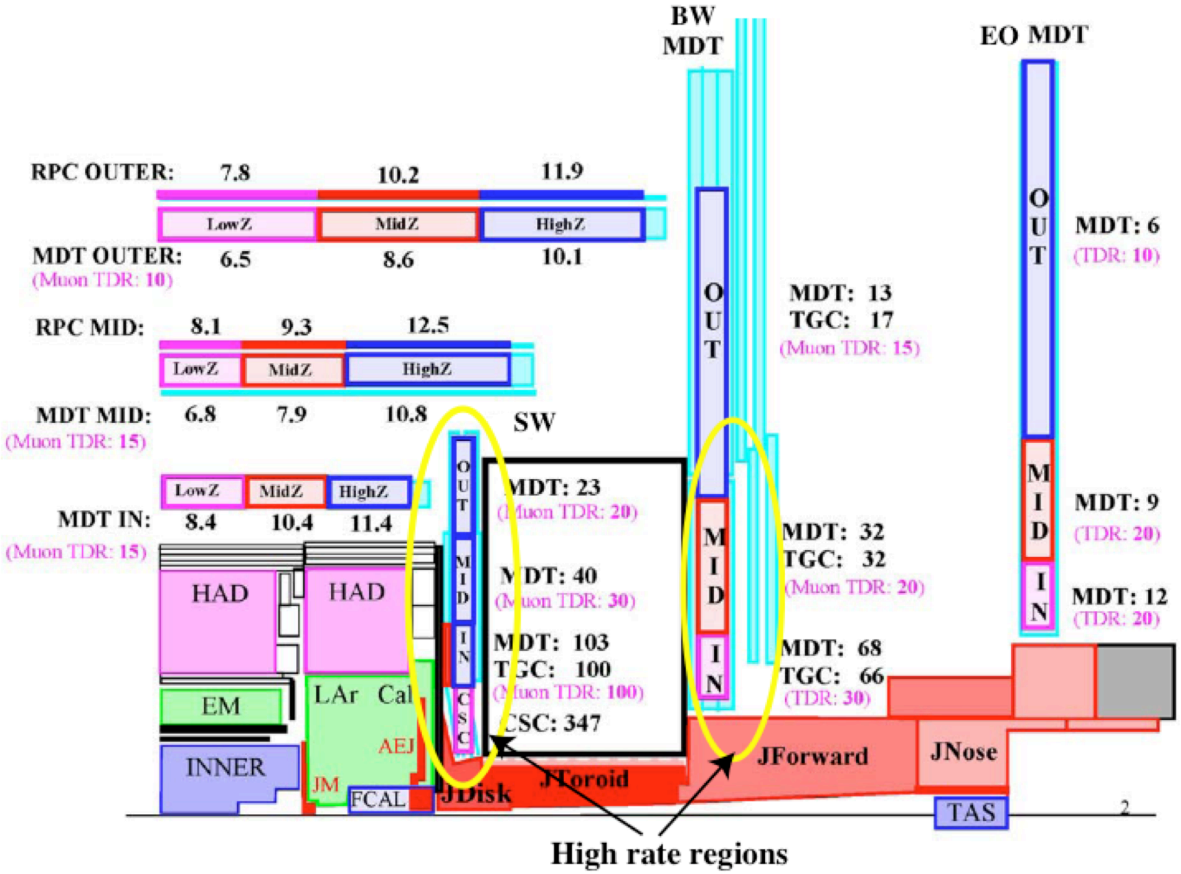
MDT Gas R&D - 2/2

- First results from H8 test beam.
  - *Look standard ATLAS mixture*
  - *Right plot shows R (extrapolated from silicon telescope) vs t measured by TDC.*
  - *Telescope covers only 6 mm in Y. Precise vertical movement to cover an entire MDT tube.*
- Next steps.
  - *Complete analysis and study of time slewing corrections for the standard gas mixture.*
  - *Start looking at “fast” mixtures*
- Status: LoI to ATLAS USG
  - *ATL-P-MN-0030 – CS, RM3*



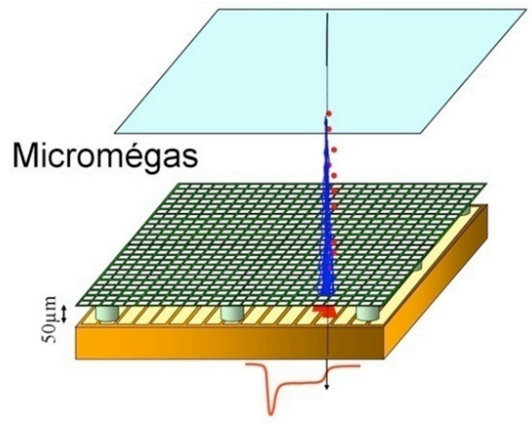
Forward Muons - Micromegas

- *With the luminosity increase at the SLHC the background of photons and neutrons in ATLAS is expected to scale accordingly.*
  - *This concerns the CSCs (covering an area of 27 m²), the MDTs and TGCs of the Small Wheels (120 m²) and the inner rings of the MDTs and TGCs in the Big Wheels (85 m²). These chambers would be candidates to be replaced.*



Micromegas as Candidate Technology

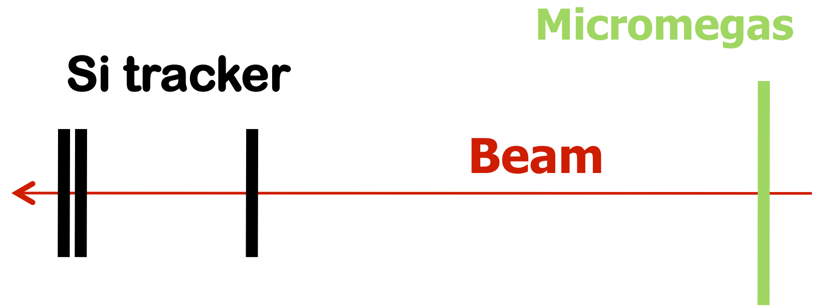
- Combine triggering and tracking functions
- Matches required performances:
  - *Spatial resolution ~ 100 μm (Θ_{track}< 45°)*
  - *Good double track resolution*
  - *Time resolution ~ 5 ns*
  - *Efficiency > 98%*
  - *Rate capability > 5 kHz/cm²*

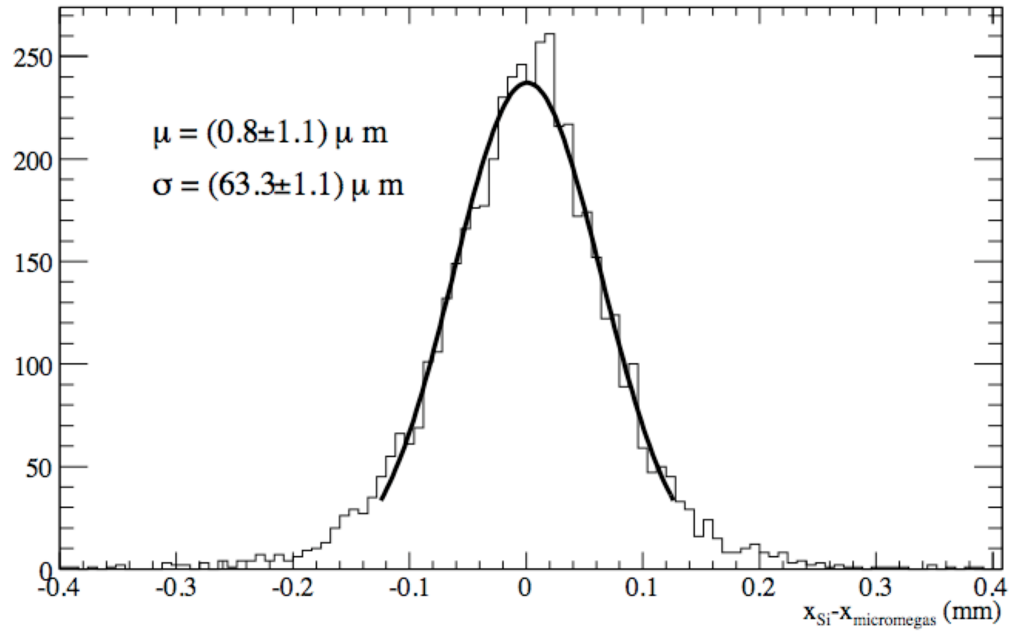


- Potential for going to large areas ~1m x 2m with industrial processes (cost effective)
- Prototype P1:
  - *450mm x 350mm active area*
  - *Different strip patterns (250, 500, 1000, 2000 μm pitch; 450mm and 225 mm long)*
  - *Drift gap: 2-5 mm*

Ref.: J. Wotschack – ATLAS Muon Week, 28 / 10 / 2008

H6 Test Beam – MM Spatial Resolution





P1 tested @ CERN H6 beam line in November 2007 & June to August 2008

•120 GeV pion beam

Strip pitch: 250 μm
Gas: Ar:CF_4:iC_4H_{10} (88:10:2)
Drift field: 200 V/cm

Track impact angle: 90°

MM intrinsic resolution
⇒ σ(MM) ≤ 40 μm

Micromegas as TPC ➔ Direction to go

- Each micromegas gap delivers a set of space points, the more the track is inclined the more space points are available
- Solves the problem of spatial resolution for large track inclination

Micromega – What Learned & Next Steps

- What learned so far:
  - *MM is very robust: no damage from sparks*
  - *Non-flammable gases available*
  - *Excellent space resolution with small strip pitch*
  - *MM as TPC will give track segments; needs time measurement (ns)*
- Next Steps (2009)
  - *Trigger capability to be proven with faster electronics*
  - *Construction and test of 1300 x 400 mm^2 prototype*
  - *Construction has started in CERN/TS-DEM; completed early 2009*
  - *Test beam in May 2009*

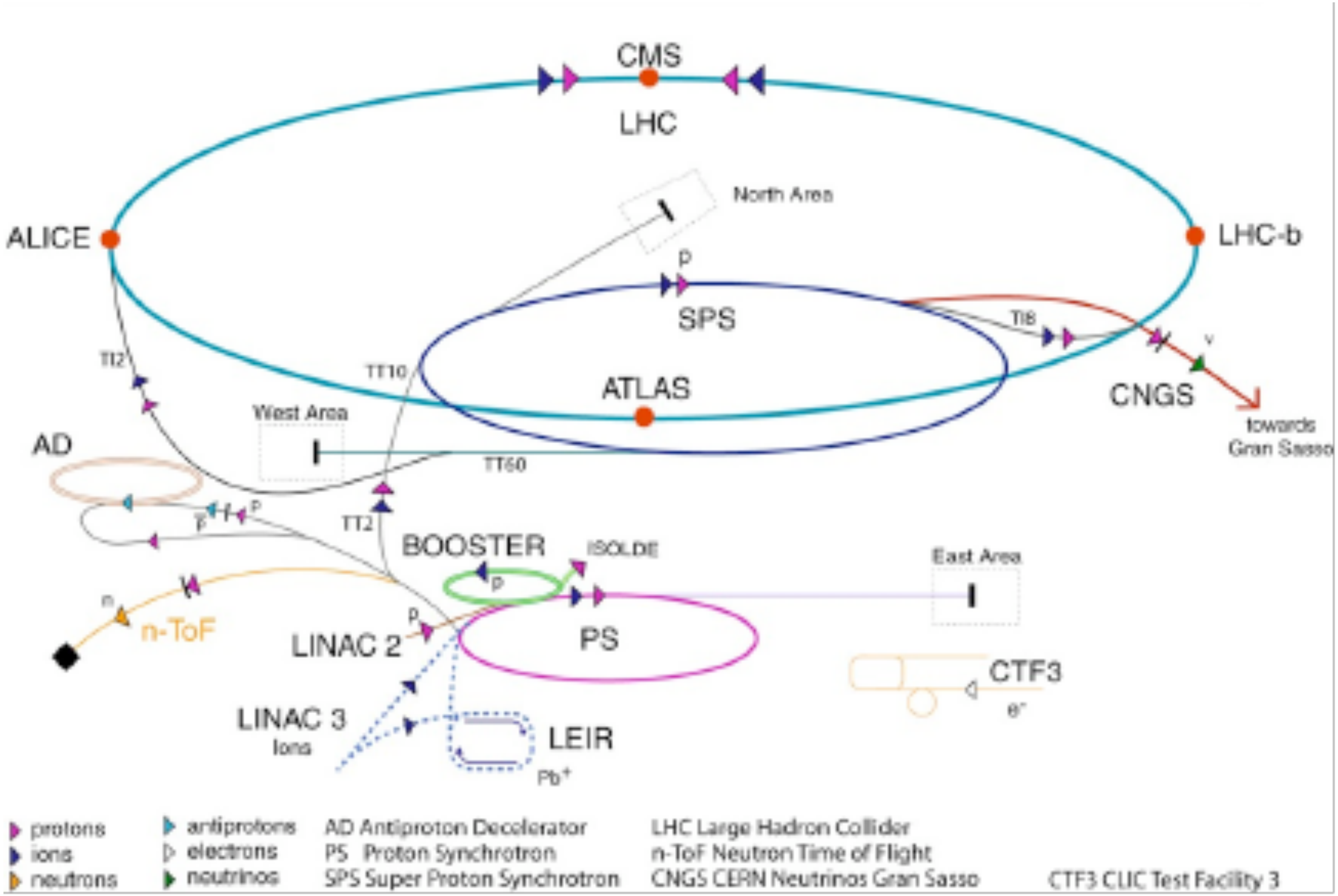
- Status: Approved proposal by ATLAS EB
  - *ATL-RD-MN-0011 – NA et al.*

Conclusions

- The accident at LHC delayed the start for Physics…
  - *Nevertheless the exploit of the potential of physics of LHC will include the high luminosity upgrade*
  - *The upgrade will happen with two major milestones: Phase I & II*
- ATLAS for Phase I
  - *The major upgrade project is the Pixel IBL*
  - *Project organization is moving ahead*
- ATLAS for Phase II
  - *Largest project is the new tracker, but other detectors, electronics and trigger have a big role in the upgrade,*
  - *Technical challenges require dedicated R&D.*
  - *The international ATLAS community is already well organised in such R&Ds*

BACKUP SLIDES - SLHC

CERN accelerator complex



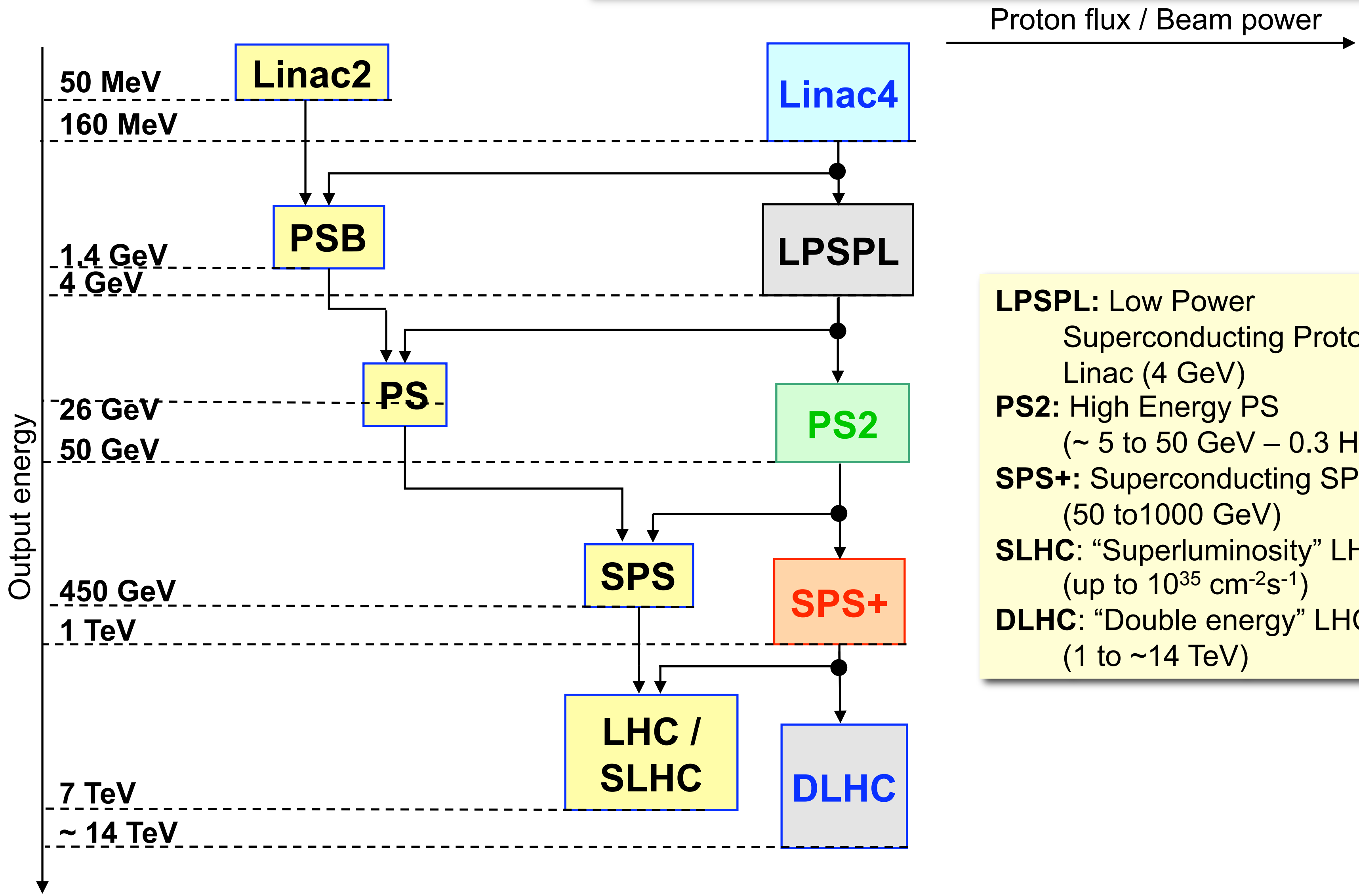
LHC & SLHC Luminosity Upgrade

- Phase I upgrade
  - *Enable focusing of the beams to $\beta^*=0.25$ m in IP1 and IP5 (double operating luminosity - 2013). Mainly replace the present triplets with wide aperture quadrupoles based on the LHC dipole cables (Nb-Ti) cooled at 1.9 ºK.*
  - *LINAC4 can be brought into operation for the run in 2012 having the potential of increasing the luminosity by a factor 2.*
  - *All together this gives us a factor 4 on whatever we have in 2011.*
  - *Can detector operate a x4 luminosity without upgrade?*

- Phase II upgrade
  - *SLHC upgrade after 500 fb^{-1} accumulated luminosity.*
  - *18 months shutdown.*
  - *When? Target moved to early 2017.*

Upgrade components

Lyn Evans, SLHC-PP kick-off meeting, CERN 9 April 2008



LPSPL: Low Power Superconducting Proton Linac (4 GeV)

PS2: High Energy PS (~ 5 to 50 GeV – 0.3 Hz)

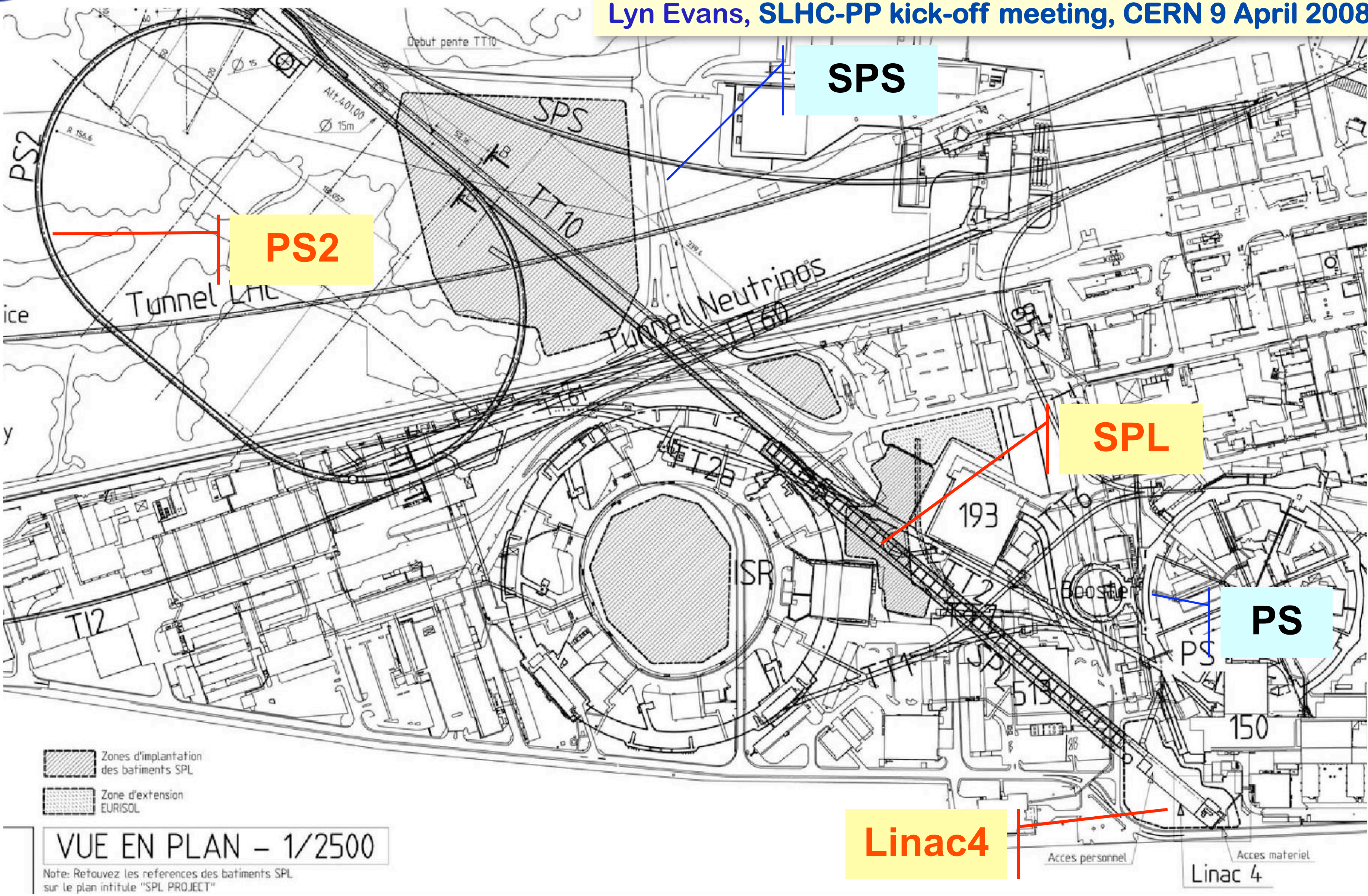
SPS+: Superconducting SPS (50 to1000 GeV)

SLHC: "Superluminosity" LHC (up to 10^{35} $cm^{-2}s^{-1}$)

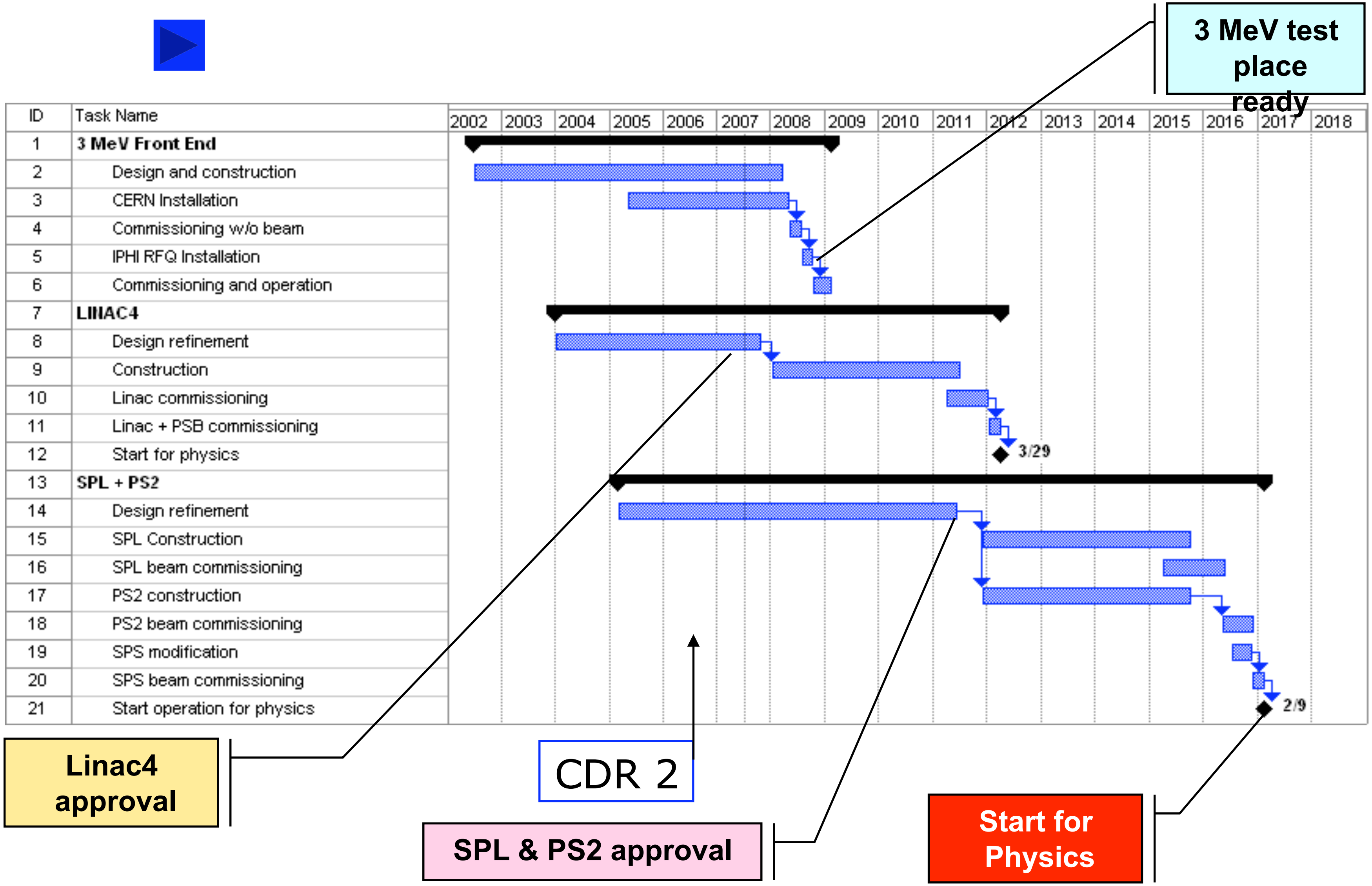
DLHC: "Double energy" LHC (1 to ~14 TeV)

Layout of the new injectors

Lyn Evans, SLHC-PP kick-off meeting, CERN 9 April 2008



Planning ...



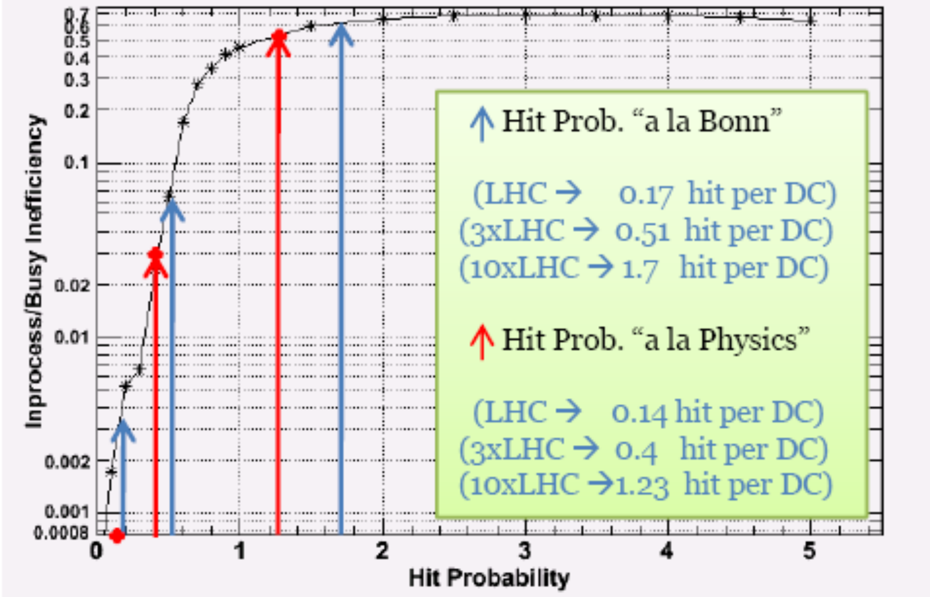
Lyn Evans, SLHC-PP kick-off meeting, CERN 9 April 2008

Insertable B-Layer - IBL

BACKUP SLIDES - IBL

Limit of FE-I3 Architecture

- Inefficiency is a very steep function of hit rate:
  - *Inefficiency is small for B-layer at nominal luminosity;*
  - *Very much at the limit for LHC "Ultimate Luminosity"*
  - *Unacceptable for B-layer @ 3.6 cm in 2016 and SLHC*
- Bottleneck is congestion in the double columns → FE-I4:
  - *In FE-I3 all hits has to be transferred to the EoC buffers;*
  - *FE-I4 new architecture → "local buffers" inside pixels.*
  - *New technology: 0.13 μm.*
- FE-I4:
  - *50x250 μm pixel (from 50x400)*
  - *1.6x1.6 cm² (from 0.7x0.8)*

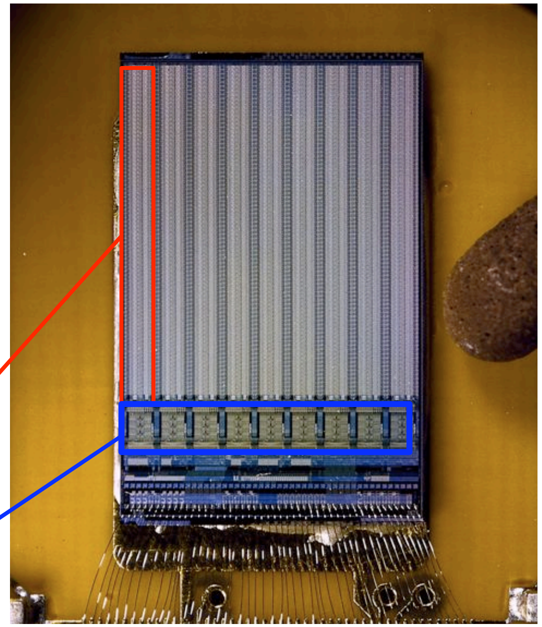


In proc./Busy:
LHC → 0.08%
3xLHC → 3%
10xLHC→52.5 %

Simulated events:
"LHC @ 5cm" :
WH(120) + 23 MB

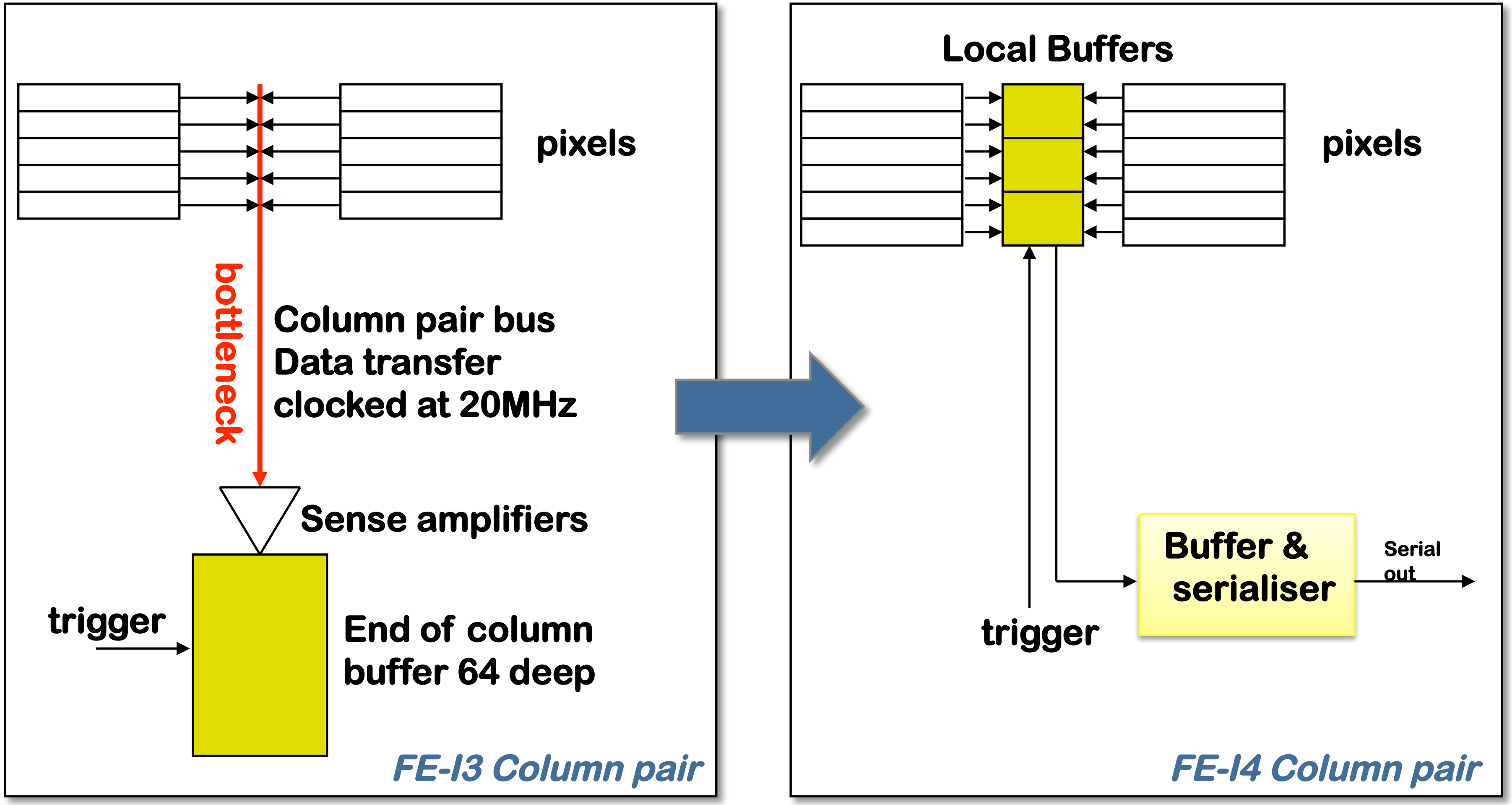
Double Column

End-of-Column Buffers



FE-I4 Architecture: Obvious Solution to Bottleneck

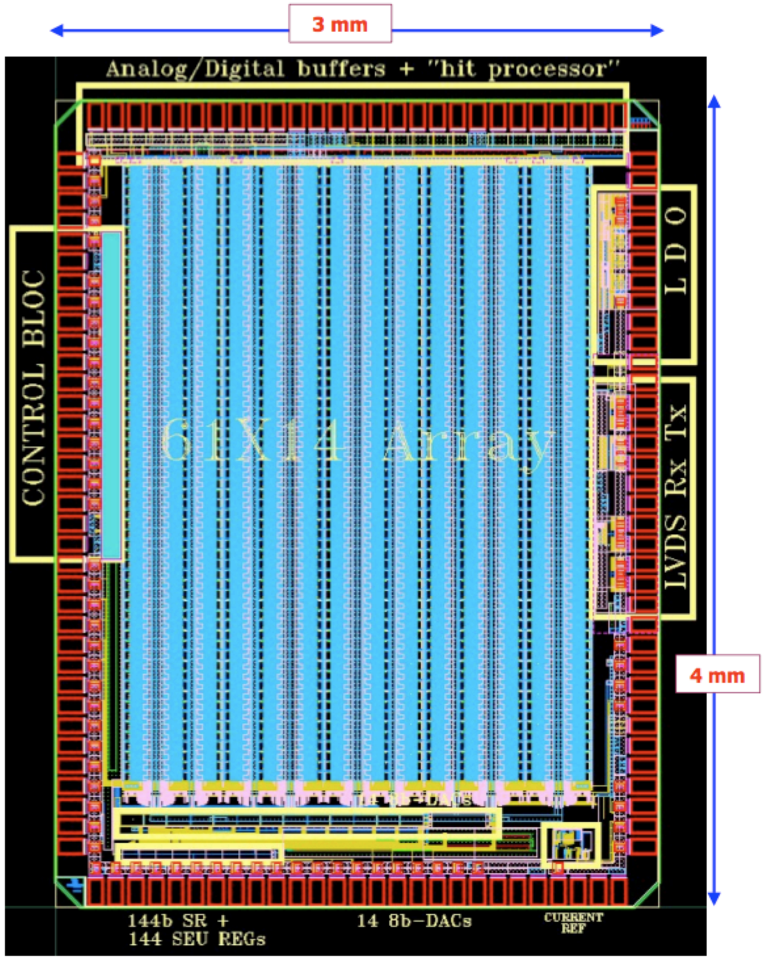
- >99% or hits will not leave the chip (not triggered)
  - *So don't move them around inside the chip! (this will also save digital power!)*
- This requires local storage and processing in the pixel array
  - *Possible with smaller feature size technology (130nm)*



FE-I4 – "Pixel Collaboration Chips"

- Pixel (FE-I4p) and Opto chips submitted 24/3/08:
  - *Prototypes for new FE-I4 in 0.13 µm CMOS*
  - *Designing labs: Bonn, **Genova**, LBNL, Marseille, Nikhef,*

"Pixel Collaboration Chip"



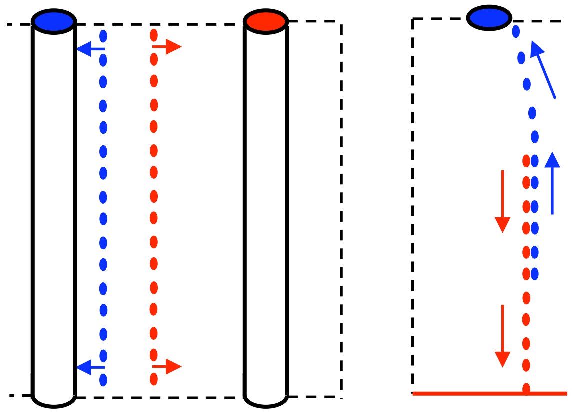
- FE-I4 schedule
  - *Full chip submission by end of the year (INFN funds sj)*
  - *Module prototyping with sensors in 2009*
  - *Final chip version (bug correction) by end of 2009.*

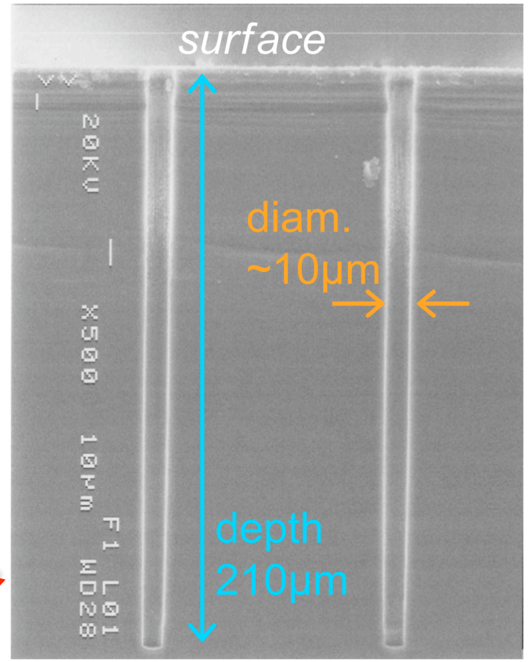
- Richieste Finanziarie:
  - ***Genova**: sj (2008) + rich. (2009)*

3D Sensors – Planar Sensors

- 3D sensors sustain higher radiation dose: shorter traveling distance (trapping).
  - *Collaboration with FBK/IRST (TN) - TR Planar sensors – Progetto Gr.V TRIDEAS (technology)*
  - ***Genova** module prototypes with FE-I4*
- Improved planar sensors
  - *Udine participates to an ATLAS R&D program to improve planar sensors (possible use for B-layer replacement). Activity on sensor design/qualification.*
- Technology selected in 2010 (prototypes)
  - *Both technologies will be used in SLHC. 3D internal layers, Planar external layers.*
- Richieste Finanziarie:
  - ***Genova** – Sensori 3D*
  - ***Udine** – Sensori Planari*

Planar and 3D Charge Collection Principle

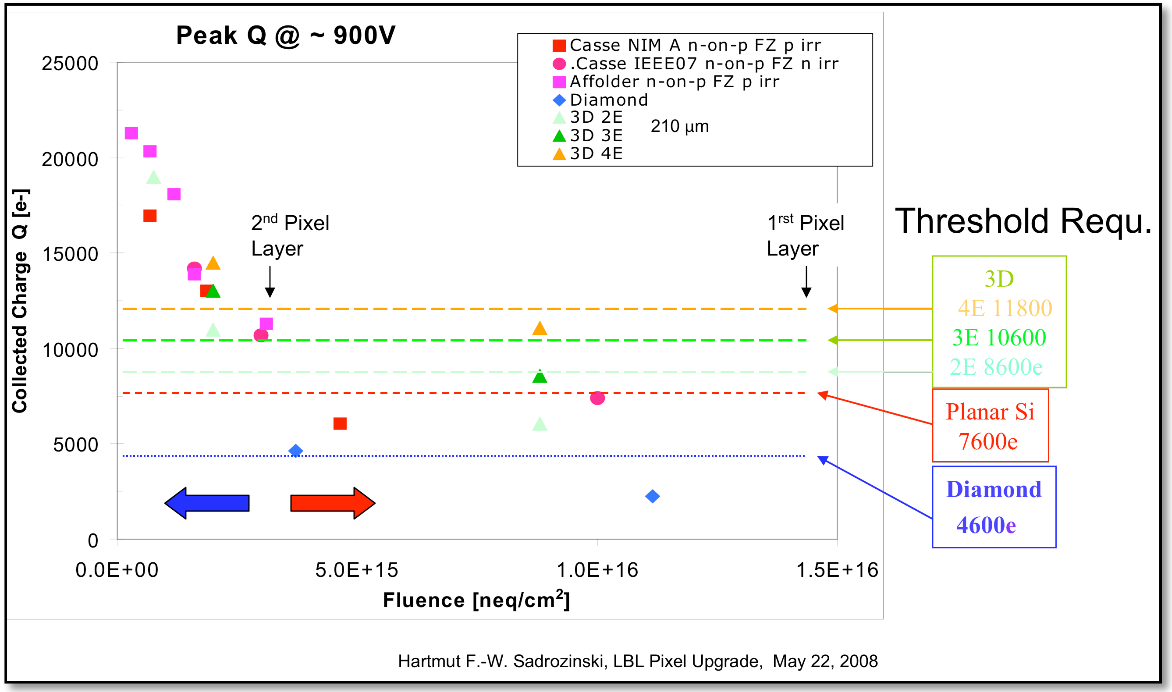




FBK – Holes made with DRIE (bought by INFN)

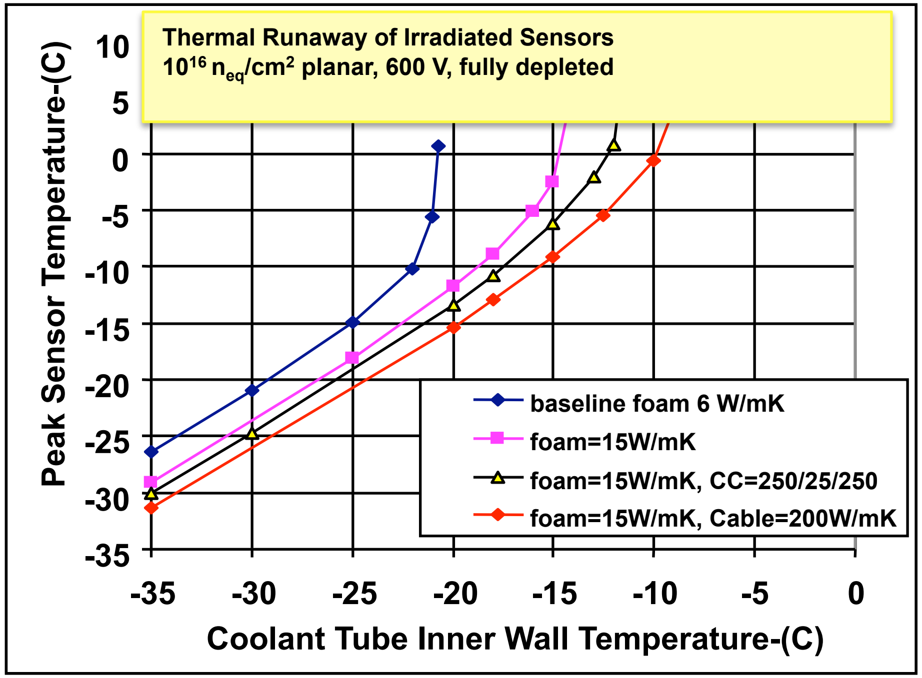
Planar Sensors

- R&D for SLHC (and B-layer replacement) on planar silicon technologies mainly to reduce cost (for SLHC outer radii), increase radiation tolerance and reduce inactive area (as option for B-layer Replacement):
  - *Bulk material: n-type (n-on-n current pixel sensor) or p-type (single side cost effective)*
  - *Thin sensors (50÷75μm thickness): reduce volume leakage current (noise, power)*
  - *Active edge: no need of shingling or double face stave for hermetic coverage*
  - *Slim edge: guard rings from 1100μm to ~100μm*
- Diamonds
  - *No cooling;*
  - *No leakage current;*
  - *Small capacitance -> small noise;*
  - *High radiation hard -> B-layer*

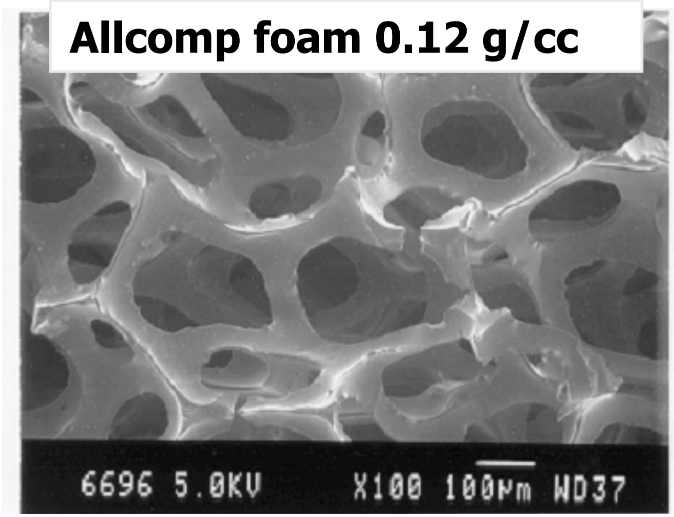


Stave Material R&D

- Path to reduce Local Support material:
  - *Thermal Conductive Carbon Foams: very low density, acceptable thermal performance.*
  - *Lower (than C_3F_8) temperature coolant (CO_2): -35º, smaller pipes, lower fluid mass.*
  - *No shingling in z (sensor active/slim edges)*



FOAM Supplier	δ (g/cc)	K (W/mŸK)
ALLCOMP / 1	0.18	~6
ALLCOMP / 2	0.21	n/a
POCO / 1	0.09	~17 (z), ~6(xy)
POCO / 2	0.55	135 (z), 45(xy)
KOPPERS	0.21	~30 (z?)



BACKUP SLIDES – R&D SLHC

Additional Information on B-Layer (2013) and SLHC (2017)

BACKUP SLIDES

FTK (LV1.5 Trigger)

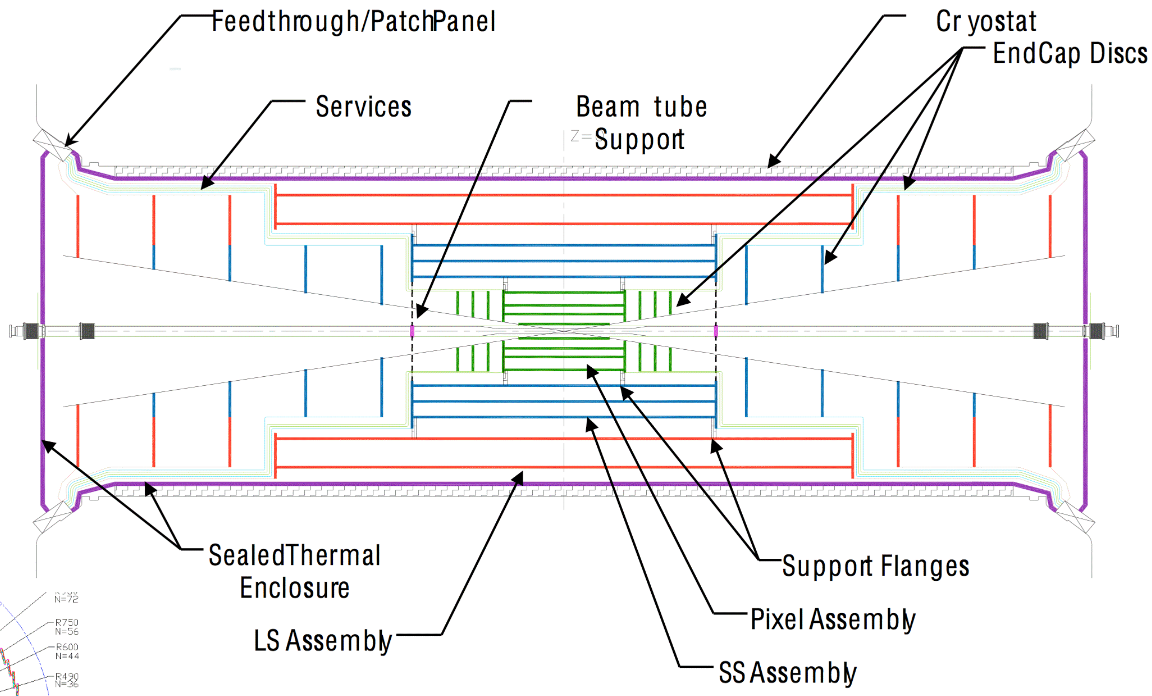
- FTK R&D group proposes to build a hardware track finder (FTK) as an upgrade to the ATLAS trigger. It will provide global reconstruction of tracks above 1 GeV/c in the silicon detectors, with high quality helix parameters, by the beginning of level-2 trigger processing. FTK can be particularly important for the selection of 3rd-generation fermions (b and τ). These have enormous background from QCD jets, which can be quickly rejected in level-2 if reconstructed tracks are available early. TFTK in the next year.

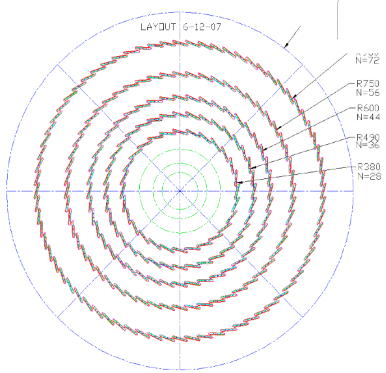
- LNF (A. Annovi, M. Beretta, P.Laurelli, G. Maccarrone, A. Sansoni) propone lo sviluppo e implementazione di algoritmi di clustering
  - *Sviluppo e studio di algoritmi di clustering veloce da implementare in hardware dedicato;*
  - *simulazione e studio delle implementazioni hardware e delle rispettive caratteristiche e prestazioni;*
  - *realizzazione e test di prototipi hardware. Durante il 2009 di studiare l'algoritmo e valutare qual è l'hardware più adatto usando schede evaluation board Xilinx.*

Strawman07 Layout

Pixels:	r = 5cm, 12cm, 18cm, 27cm	z=±40cm
Short (2.4 cm) μ-strips (stereo layers):	r = 38cm, 49cm, 60cm	z=±100cm
Long (9.6 cm) μ-strips (stereo layers):	r = 75cm, 95cm	z=±190cm

In Discussion:
Many Changes already proposed





Today:
Pixels: 1.8 m², ~80 Mch.
SCT: 61 m², ~6.3 Mch.
TRT straws: ~400 kch.

SLHC (4+3+2):
Pixels: 5 m², 300 Mch.
Short Strips: 60 m², 28 Mch.
Long Strips: 100 m², 15 Mch.

Tile Calorimeter Electronics EoI

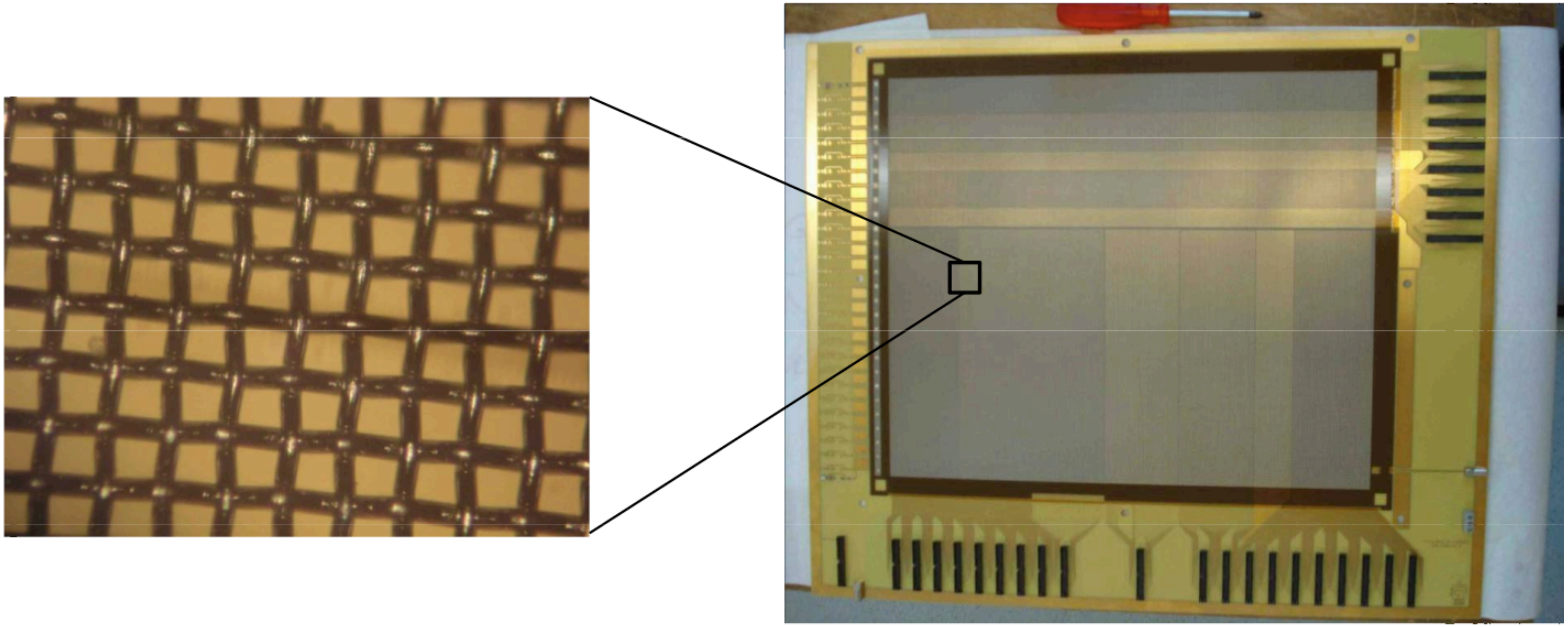
ATLAS project	**Expression of Interest: R&D on Tile Calorimeter Electronics for the sLHC**		
ATLAS Upgrade Document No:	*Institute Document No.*	*Created:* **15/04/2008** *Modified:* **22/04/2008**	*Page:* *Rev. No.:* **1.32**

Argonne, Barcelona, Bratislava, CERN, Chicago, Lisbon, **Pisa**, Prague, AS CR, Stockholm, Valencia.

Abstract

The increased luminosity and radiation levels planned for the upgraded LHC will exceed the level at which some parts of the Tile Calorimeter electronics begin to fail. In this Expression of Interest, we outline the R&D that will be necessary to replace those specific components, but also the components that control and support the ones needing replacement and those whose requirements are likely to be changed by modifications to other parts of ATLAS, in particular the TDAQ system. It seems likely that a large part of the readout electronics for the Tile Calorimeter will need to be redesigned and replaced.

Micropattern Gas Detectors (RD51)

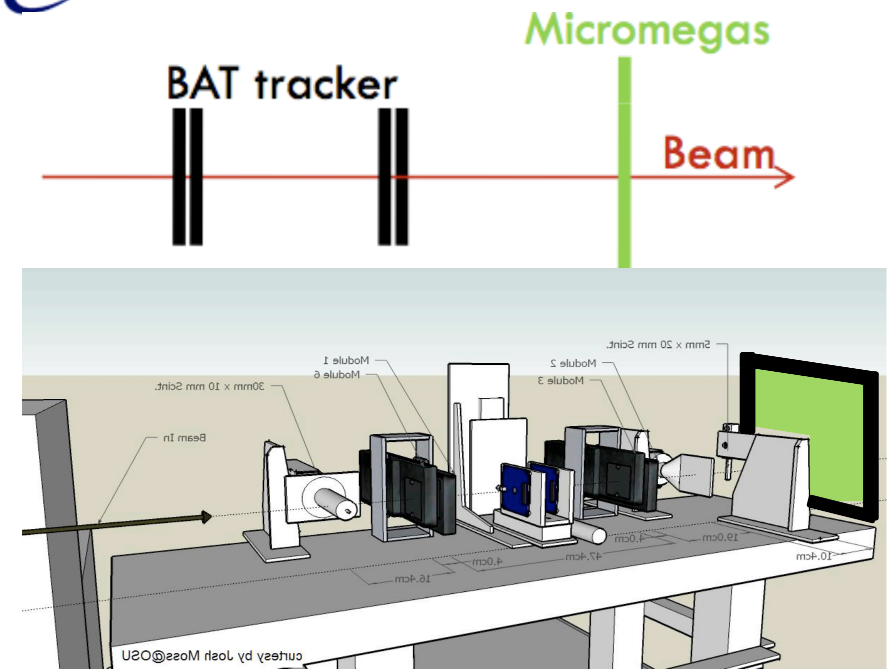


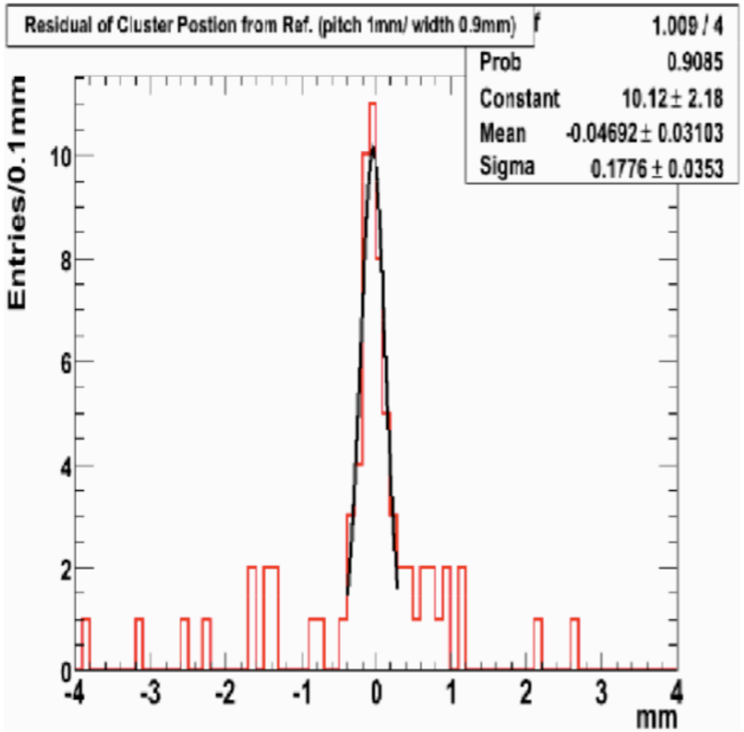
- Standard bulk Micromegas
- Homogeneous stainless steel mesh
- 325 line/inch = 78 μm pitch
- Wire diameter ~25 μm
- Amplification gap = 128 μm

Micropactern Gas Detector Workshop
Nikhef 16-18 April 2008
http://indico.cern.ch/conferenceOtherViews.py ?view=standard&confId=25069

P. IENGO -MPGD Workshop 16-18 April 2008 NIKHEF

Preliminary Track Resolution - CERN H6 - Nov.07



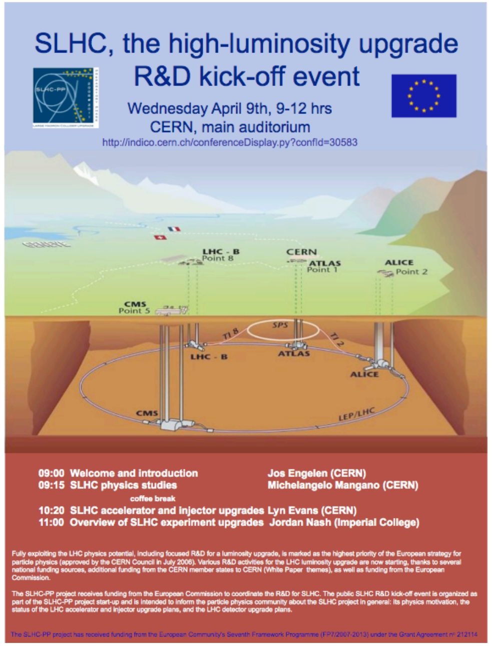


- Three contributions:
  - *Intrinsic MM resolution*
  - *Tracker resolution*
  - *Extrapolation error*
- 1mm strip pitch
- Ar:Ne:CF4 (45:45:10)
- σ global = 180 μm

BACKUP SLIDES – USG, PO

SLHC, R&D Kick-off Event

- April 9th a public event is marking the start of R&D for SLHC upgrade.
- LHC upgrade is marked as the **highest priority of the European strategy** for particle physics (approved by the CERN Council in July 2006).
- Various **R&D activities for the LHC luminosity upgrade are now starting**, thanks to several national funding sources, additional funding from the CERN member states to CERN (White Paper themes), as well as funding from the European Commission.
- The **SLHC-PP** (first call of FP-7) project receives funding from the European Commission to coordinate the R&D for SLHC (Project Office), to carry out specific R&D in a few selected subjects



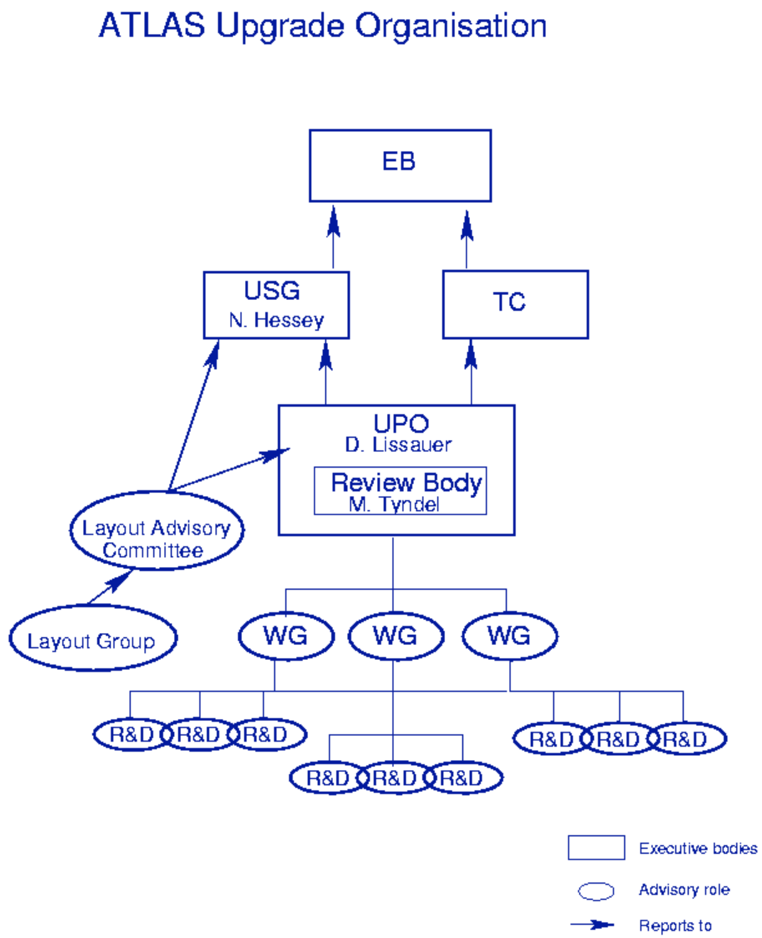
Wednesday 09 April 2008

top

09:00	Welcome and introduction (15')	Jos Engelen (CERN)
09:15	SLHC physics studies (45')	Michelangelo Mangano (CERN)
10:00	Coffee/tea break (Pas perdus)	
10:20	SLHC accelerator and injector upgrades (40')	Lyn Evans (CERN)
11:00	Overview of SLHC experiment upgrades (40')	Jordan Nash (CERN)

Next Steps in ATLAS Upgrade Organization

- ATLAS Upgrade organization funded by UE **FP7-SLHC-PP** (Work Package 3)
  - *Objective for this WP is to establish the formal structures needed for the ATLAS upgrade construction project, and through Technical Documentation, Cost and Schedule planning, establish an initial MoU for the Upgrade Construction.*
  - *Establish a Project Office to address the critical technical integration and coordination issues of the new detectors.*



- ATLAS has an Upgrade organization since 4 years:
  - *Upgrade Steering Group (USG).*
  - *Upgrade Project Office*
  - *Working Groups and R&D projects*
  - *Layout for the new ID*

WEB page:
http://atlas.web.cern.ch/Atlas/GROUPS/UPGRADES/

ATLAS Upgrade Organization

- ATLAS has an Upgrade organization since 4 years:
  - *Upgrade Steering Group (USG).*
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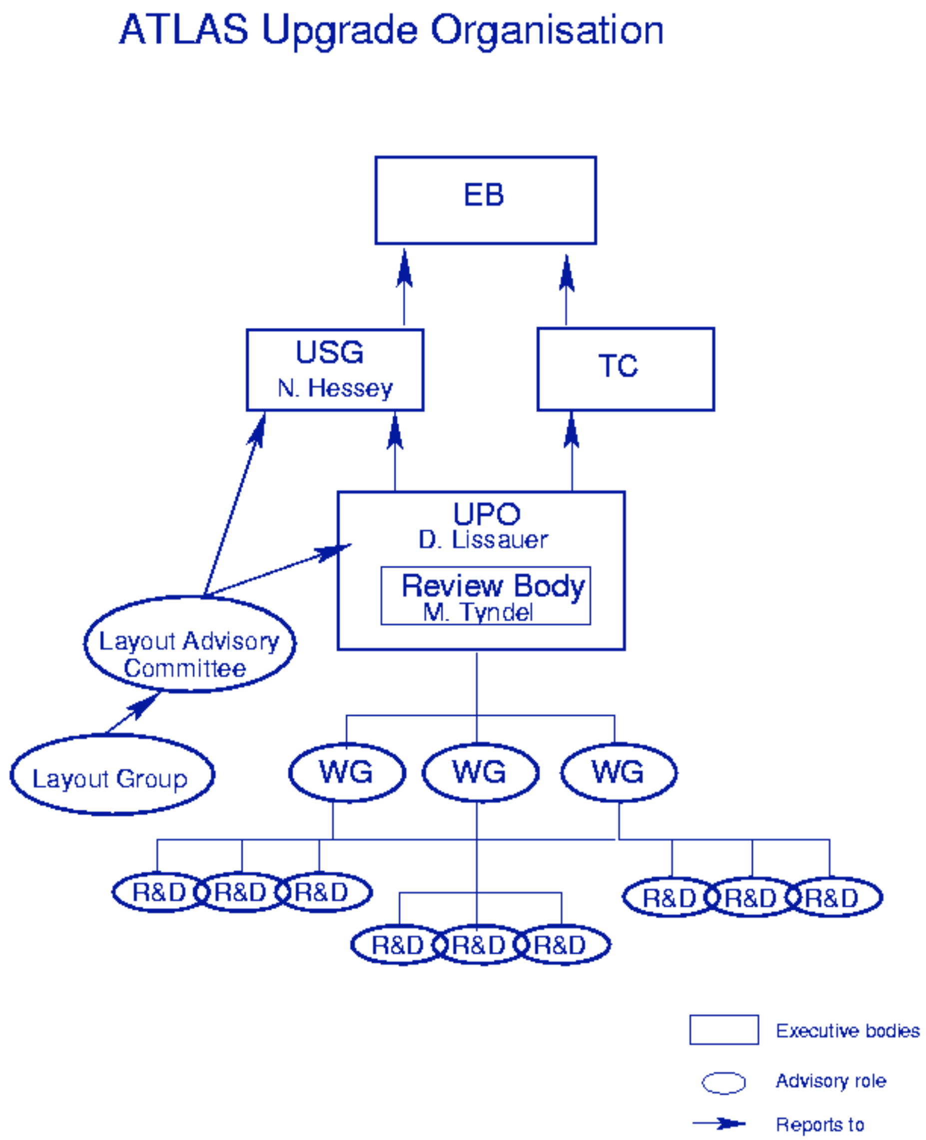
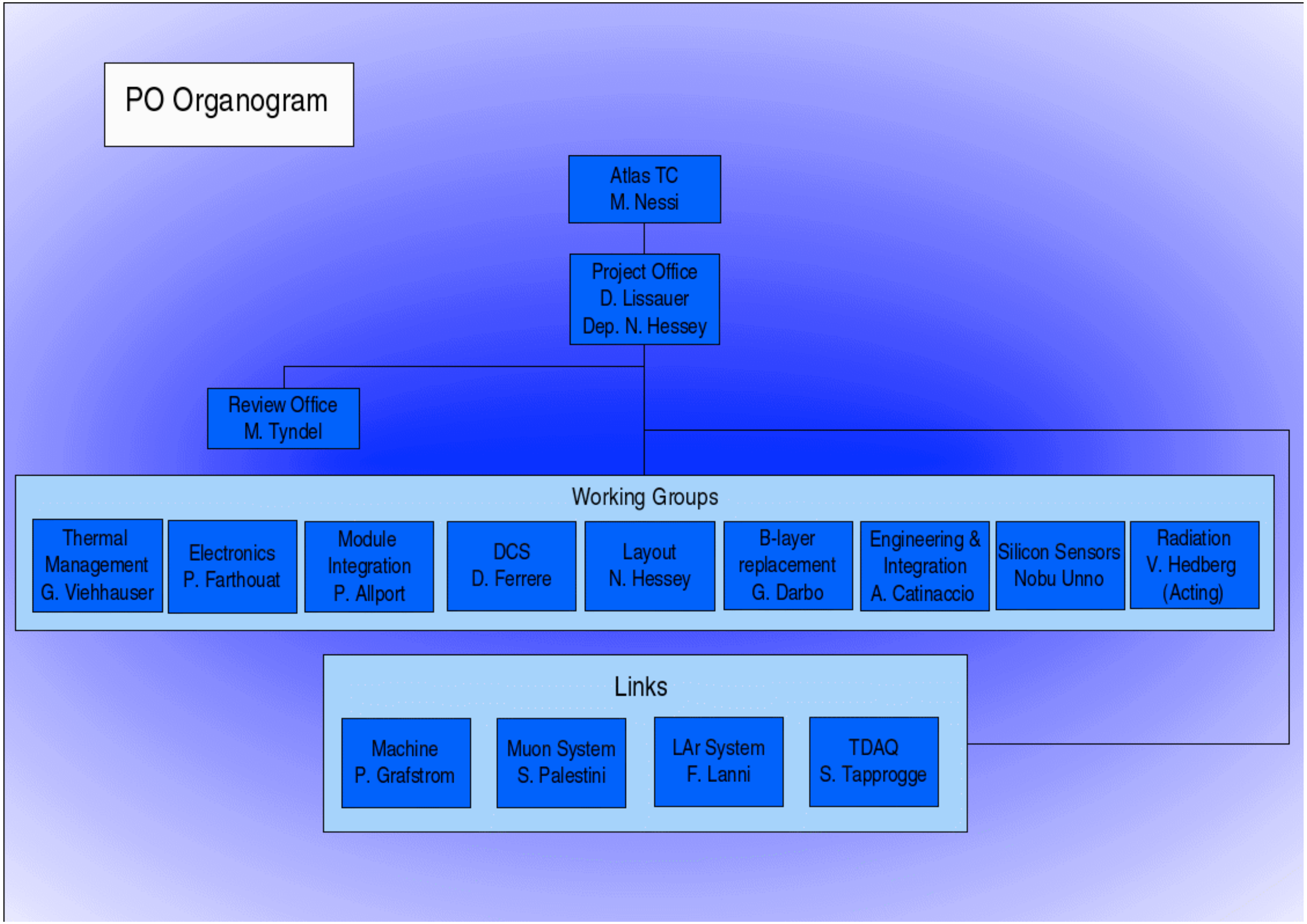
- Agenda on indico:
  - [*http://indico.cern.ch/categoryDisplay.py?categId=350*](http://indico.cern.ch/categoryDisplay.py?categId=350)
- WEB page:
  - [*http://atlas.web.cern.ch/Atlas/GROUPS/UPGRADES/*](http://atlas.web.cern.ch/Atlas/GROUPS/UPGRADES/)



Upgrade Project Office



FP7 - DevDet

WP No.	Work PackageTitle
WP1	DevDet project management
WP2	Common software tools
WP3	Network for Microelectronic Technologies for High Energy Physics
WP4	Project office for Linear Collider detectors
WP5	Coordination office for long baseline neutrino experiments
WP6	Transnational access to CERN test beams and irradiation facilities
WP7	Transnational access to DESY test beam
WP8	Transnational access to European irradiation facilities
WP9	Construction of irradiation facilities at CERN
WP10	Test beam infrastructures for fully integrated detector tests
WP11	Detector prototype testing in test beams

Not Approved

- 2nd FP7 call to UE submitted at the end of February 2008.
  - *140 projects submitted (~20% chances to be approved).*
  - *ATLAS (Genova) only in WP3.*
  - ***Not approved by EU!***
  - *See: http://project-fp7-detectors.web.cern.ch/project%2DFP7%2Ddetectors/*