CMS Tracker Upgrade goals for workshop

Tracker web pages
http://cmsdoc.cern.ch/Tracker/Tracker2005/TKSLHC/index.html
Tracker Upgrade Wiki pages
https://twiki.cern.ch/twiki/bin/view/CMS/SLHCTrackerWikiHome

Possible upgrade scenario

- The first upgrade will involve the pixel system
  - simply because the inner sensors must be replaced as they degrade
- The design for easy pixel replacement simplifies the task
  - we can replace with a new system when **we** are ready to do so
    - and evolve it gracefully into the Phase II system
  - there is a safe baseline
    - simply build replacement identical inner barrel layer
    - with a comparable strategy for endcaps to be defined
- How to upgrade:
  - design pixel system with 4 barrel layers and expanded endcap
    - maximize benefits to CMS, including smooth transition
    - fix mechanical envelope for future
  - study solutions to contribute to trigger
  - design outer tracker to match cost, power and performance needs

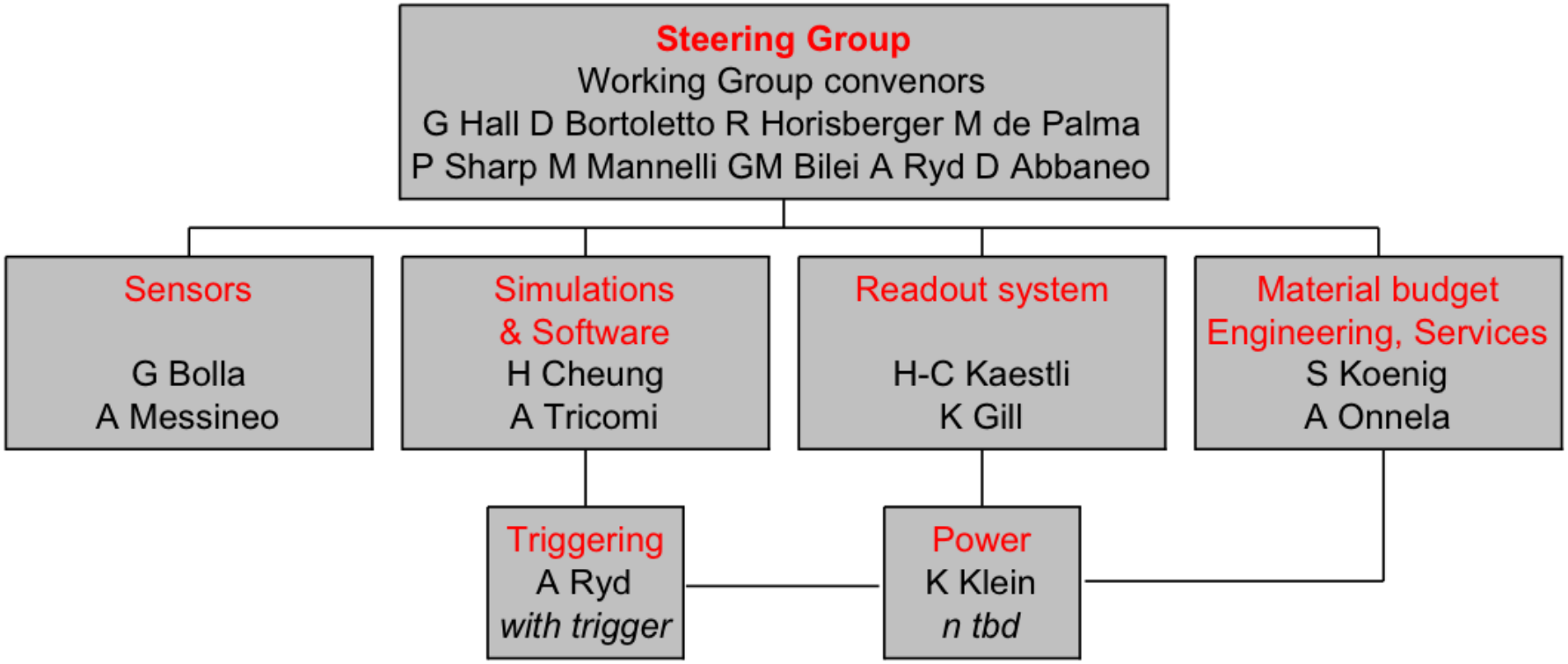
Proposed objectives for workshop

- Identify and clarify important issues which influence Phase I planning
  - especially what constrains modifications to the pixel system
  - and when we could be ready to implement them
  - As time permits, where possible, implications for Phase II should also be identified.

- Profit from participants with interests in new cooling, power, and engineering schemes
- and simulation studies
  - brief reports on other activities, eg sensors

Organization so far

- CMS Tracker R&D structure - active for ~18 months
  - recently added Task Forces on Layout, Power Options, Trigger
- This must evolve into a new Project structure
  - Subject for future discussions



Task Force mandates and members

- Published on web pages, with members (once confirmed)

http://cmsdoc.cern.ch/Tracker/Tracker2005/TKSLHC/index.html

- Power – chair Peter Sharp
  - to examine if we are ready soon to adopt a baseline powering scheme (either DC-DC or serial powering) and, if so, recommend which one.
  - to report in January 2009
- Layout – chair Duccio Abbaneo
  - identify and evaluate options for new tracker geometry, including constraints from engineering, power, modules, readout architecture….
  - should lead to baseline layout by ~mid-2009
  - long term task – which does **not** replace Simulations WG
- Trigger – chair Anders Ryd
  - devise detectors which could produce "tracking trigger primitives" within sensible constraints on power, material, cost
  - provide input and guidance to simulations
  - aim for report mid-2009

State of activities

- Sensors
  - So far, strongly dependent on common R&D efforts – eg RD50
    - several R&D projects approved in CMS
  - Wide range of sensor designs in common mask set close to submission with HPK
- Engineering, cooling, material,…
  - Completion of commissioning has recently released effort
  - Phase I pixel replacement can be test bed for Phase II developments
    - new cooling, power issues, data links
    - all highly constrained by existing services & YB0
- Outer readout
  - simulations in 0.13µm CMOS, studying link options
  - new readout architecture evolving

Defining a new layout

- Present design suffered from limited simulations
  - we did not know how many layers would provide robust tracking
  - pixel system was a late addition, which has an important impact
  - the material budget estimate was not as accurate as desired

- A new tracker might be “easy” to design based on experience
  - but provision of trigger information adds a major complication
  - and the tools to model CMS at L = 10^{35} were not in place
  - major uncertainties in power delivery, sensor type, readout architecture

- Hence importance of simulating new detector
  - and intermediate studies to understand implications for Phase I

Phase I pixel developments

- Assume Phase I means a **new** pixel detector
  - at appropriate time
- Most ambitious option so far discussed:
  - [R Horisberger May 2008]
- 4 barrel layers & expanded endcaps with improved material budget
  - Requirements for barrel (next slide)
  - Requirements for Fpix under development. Options will be shown at this workshop
- Need to develop work programme to achieve these changes
  - How should endcap evolve?
  - Separable inner/out disks ?

BPIX Options for 2013 replacement/upgrade

R Horisberger May 2008

	Option	Layer/Radii	Modules	Cooling	Pixel ROC	Readout	Power
as 2008	0	4, 7, 11cm	768	C_6F_{14}	PS46 as now	analog 40MHz	as now
	1	4, 7, 11cm	768	C_6F_{14}	2x buffers	analog 40MHz	as now
	2	4, 7, 11cm	768	CO_2	2x buffers	analog 40MHz	as now
	3	4, 7, 11cm	768	CO_2	2x buffers	analog 40MHz μ-tw-pairs	as now
	4	4, 7, 11cm	768	CO_2	2xbuffer, ADC 160MHz serial	digital 320MHz μ-tw-pairs	as now
	5	4, 7, 11, 16cm	1428	CO_2	2xbuffer, ADC 160MHz serial	digital 640 MHz μ-tw-pairs	DC-DC new PS

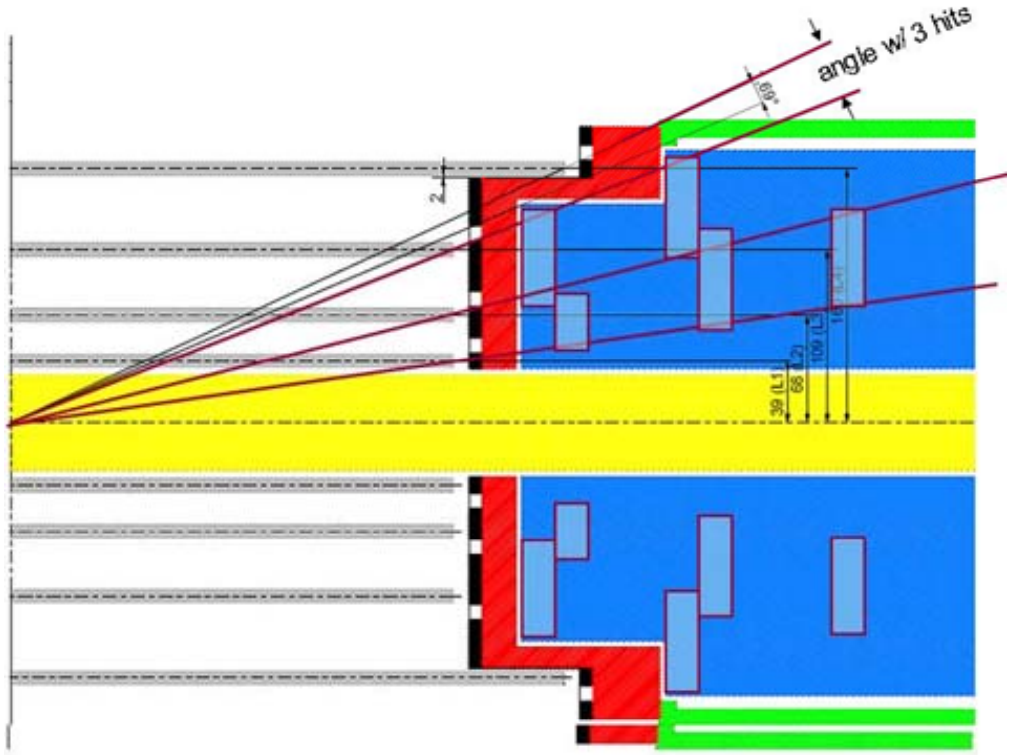
FPIX Options for 2013 replacement/upgrade

Possible scenarios for November 2008 workshop to stimulate discussion, D. Bortoletto

Option	Disks	Modules	Cooling	Pixel ROC (total #)	Readout	Power
as 2008						
0	Current 2-3	672-1008	C_6F_{14}	PSI46 as now (4320 – 6480)	analog 40MHz	as now
1	Current 2-3	672-1008	C_6F_{14}	2x buffers (4320 – 6480)	analog 40MHz	as now
2	3 new disks for Long 4th layer BPIX	536	CO_2	2x buffers (8064)	analog 40MHz ? μ-tw-pairs?	as now
3	3 new disks for Short 4th layer BPIX	592	CO_2	2x buffers (9472)	analog 40MHz ? μ-tw-pairs?	as now?

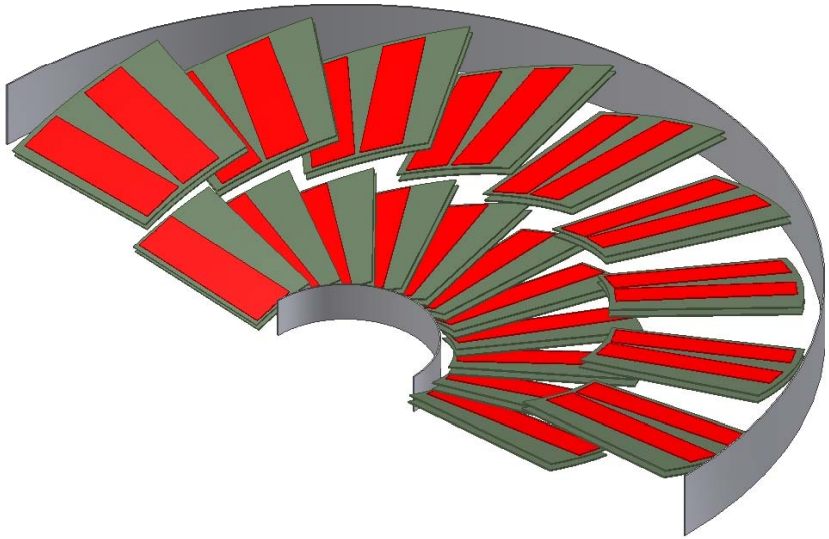
Only 2x8 modules in Options 2 and 3, more overlap

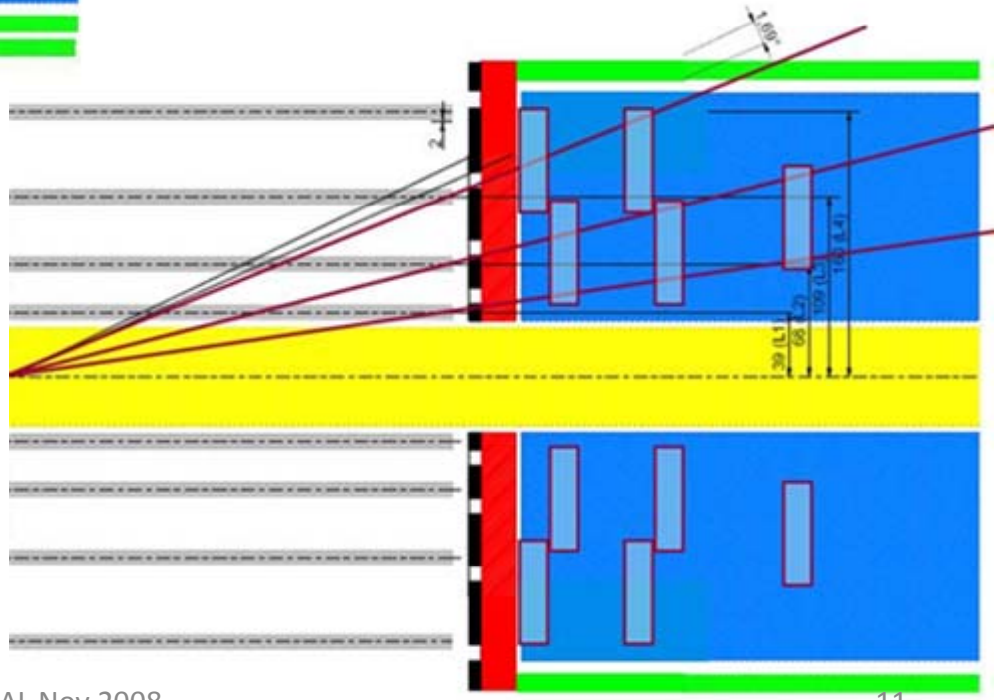
Possible layout



- Long 4th layer

- Short 4th layer





Tracker sessions in workshop

- Sensors
  - Comment on implications for Phase I and Phase II
- Simulations and layout
  - Long term effort, but needs strengthening in many areas
- Engineering and cooling
  - Explore cooling and mechanics options
- Power
  - Improve understanding of activities under way
- Thanks in advance to session conveners for their efforts and adapting to tight schedule
  - Harry, Duccio, Daniela, Marcello, Kirk, Hans, Katja, Simon
- Follow up for new contributors
  - Feel free to contact WG leaders and Tracker management

BACKUPS

Planning an Upgrade Project

- The SLHC planning assumption
  - Phase I to 2.3 x 10^{34} (peak) ~ 2013
  - Phase II to 10^{35} from ~2017
- How long is really needed?

  Developing and building a new Tracker requires ~10 years, eg
  - 5 years R&D
  - 2 years Qualification
  - 3 years Construction
  - 6 months Installation and Ready for Commissioning
- NB – this is an aggressive schedule
  - System design and QA important and cannot be downscoped
    - we found problems during the later phases which needed time
  - Cost was a driver for LHC detectors from day one
  - Construction & Commissioning were major tasks, still ongoing

parameter	nom.	ult.	ES& FCC	LPA
$N_b/10^{11}$	1.15	1.7	1.7	4.9
ε_{tr} [μm]	3.75	3.75	3.75	3.75
T_{bb} [ns]	25	25	25	50
β^* IP1&5 [m]	0.55	0.5	0.08	0.25
θ [μrad]	285	315	0&673	381
$\mathcal{L}_p/10^{34}$ [cm^{-2}s^{-1}]	1.0	2.3	15.5	10.7
$\mathcal{L}_a/10^{34}$ [cm^{-2}s^{-1}]	0.46	0.91	2.4	2.5
event pile-up	19	44	294	403

CERN-AB-2008-065

Table 1: Beam parameters required for nominal and ultimate luminosities $\mathcal{L}$ as well as for the present LHC upgrade scenarios [3]. T_a of 10 h is assumed for $\mathcal{L}_a$. Here N_b is bunch intensity, T_{bb} is bunch spacing, θ is crossing angle.

Tracker related R&D Projects

Proposal title	Contact	Date	Status
Letter of intent for Research and Development for CMS tracker in SLHC era	R Demina	14.9.06	Approved
Study of suitability of magnetic Czochralski silicon for the SLHC CMS strip tracker	P Luukka, J Härkönen, R Demina, L Spiegel	31.10.07	Approved
R&D on Novel Powering Schemes for the SLHC CMS Tracker	L Feld	3.10.07	Approved
Proposal for possible replacement of Inner Pixel Layers with aims for an SLHC upgrade	A Bean	31.10.07	Approved
R&D in preparation for an upgrade of CMS for the Super-LHC by UK groups WP1: Simulation studies/ WP2: Readout development/ WP3: Trigger developments	G Hall	31.10.07	Approved
The Versatile Link Common Project	F Vasey, J Troska	11.07	Approved
3D detectors for inner pixel layers	D Bortoletto, S Kwan	12.07	Approved
Proposal for US CMS Pixel Mechanics R&D at Purdue and Fermilab in FY08	I. Shipsey, S Kwan	12.07	Approved
R&D for Thin Single-Sided Sensors with HPK	M Mannelli	7.2.08	Received
An R&D project to develop materials, technologies and simulations for silicon sensor modules at intermediate to large radii of a new CMS tracker for SLHC	F Hartmann, D Eckstein	6.3.08	Approved
Development of pixel and micro-strip sensors on radiation tolerant substrates for the tracker upgrade at SLHC	M de Palma	9.4.08	Received
Power distribution studies	S Kwan	15.6.08	Approved
Cooling R&D for the Upgraded Tracker	D Abbaneo	21.07.08	Approved
First Level Trigger based on Tracking	F Palla	4.11.08	Received