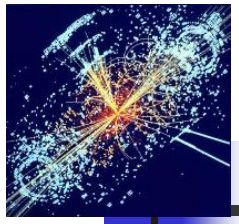
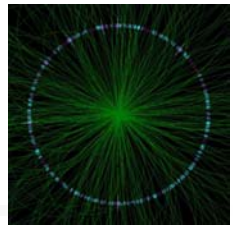
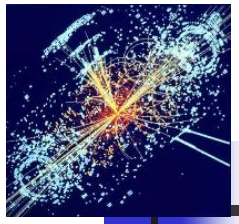




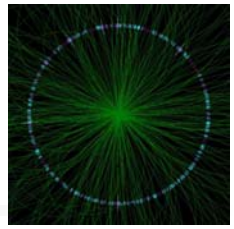
LHC detector upgrades

Introductory comments on electronic issues

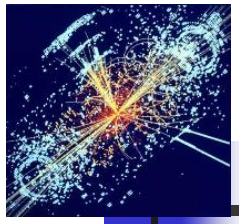
Organisation of this short session



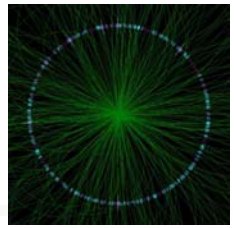
Example: CMS



- To operate at $\mathtt{L} = 10^{35}\ cm^{-2}.s^{-1}$
  - Most of CMS will survive & perform well with few changes
  - Clear ideas of what needs to change
  - But not yet ready with detailed plans
- Must benefit from electronic technology evolution
  - Expect major upgrade of off-detector electronics & DAQ systems, especially trigger
- Tracking system requires replacement
  - Higher granularity
  - Greater radiation tolerance
  - L1 triggering using tracker is desirable (or essential?)



Upgrade issues



- Machine parameter definition

  what must be known for serious design to begin?

  - For electronics: clock speed

- Building blocks

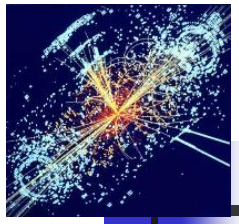
  it would help to have foundations in place

  - Standard optical link technology
  - Clock/trigger/control provision & distribution

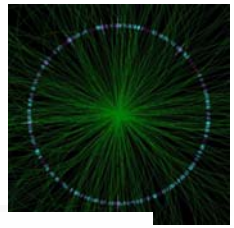
- Critical issues

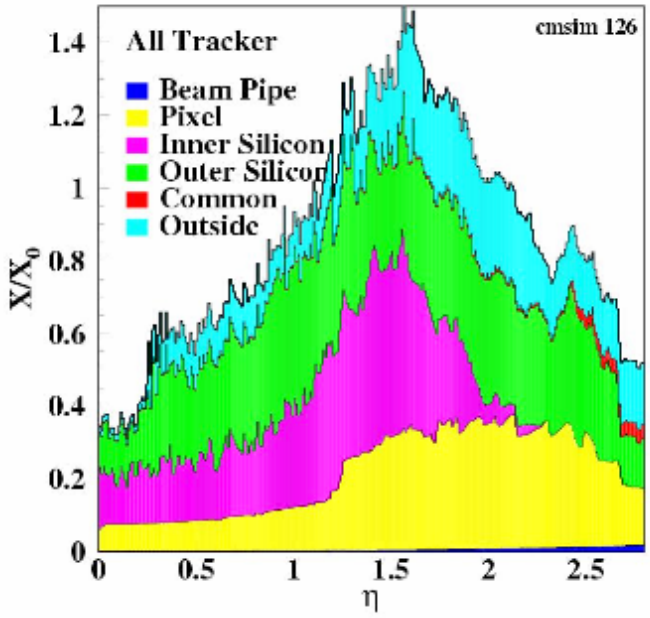
  upgrade may not be possible without solution

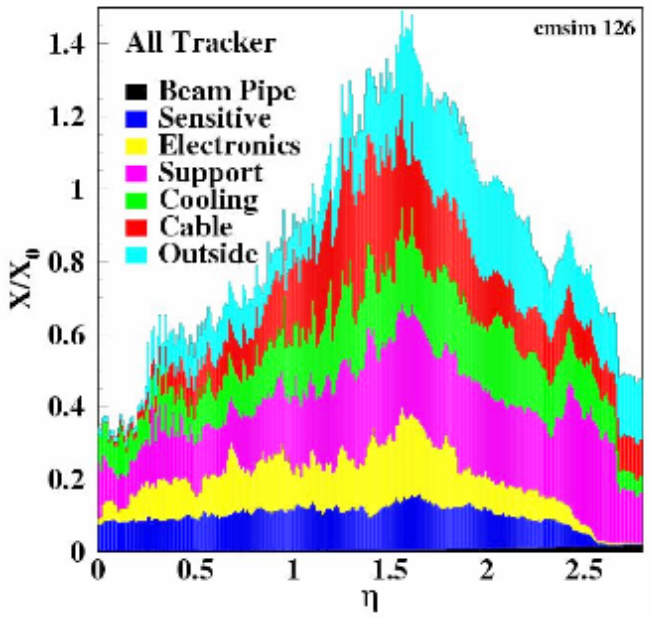
  - Provision of power



CMS Tracker material budget





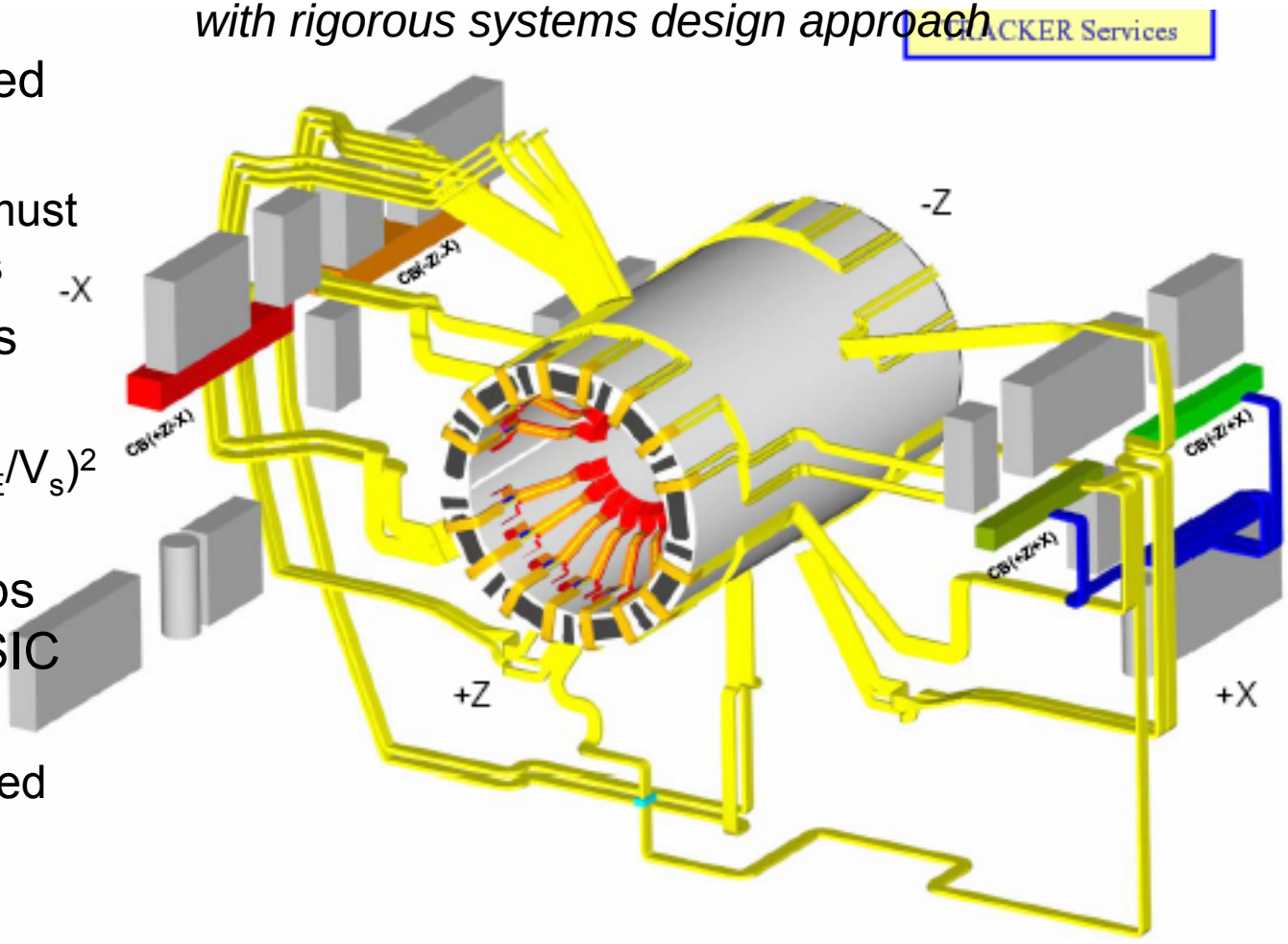


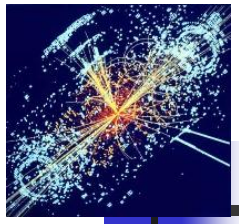
- Physics performance would benefit from less material
  - Pixel systems will not reduce power density
    - inner microstrips: ~400 W.m^{-2} Pixels: ~5000 W.m^{-2}
- Modern ASIC technologies might use less FE power
  - But $N_{channels}$ will increase, & use of lower V_{supply} increases currents
- Power reduction and delivery are <u>huge</u> challenges

CMS Tracker services layout

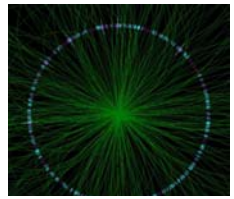
Experience tells us this will come last even with rigorous systems design approach

- Complex, congested routes for services
  - Next time, they must fit same volumes
- Heat load of cables must be removed
  - $P_{cable} = R_{cable}(P_{FE}/V_s)^2$
- Cable voltage drops already exceed ASIC supply voltages
  - ASICs have limited tolerance to excursions

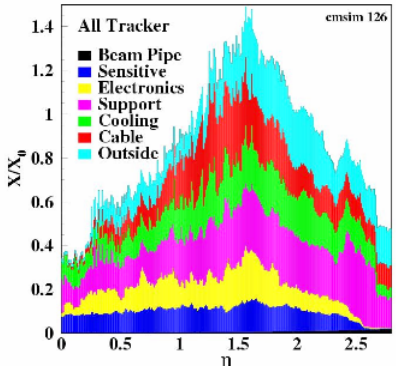




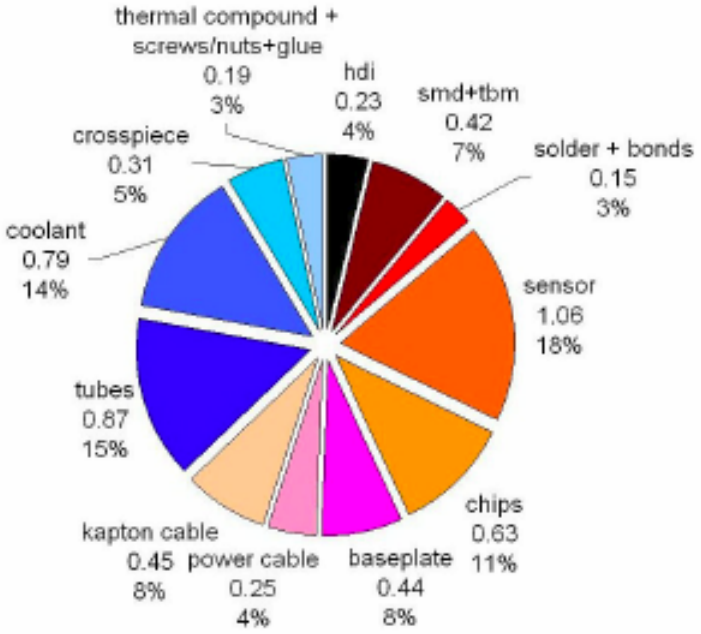
Cooling costs



- Using power has heavy material cost
- For present pixel system
  - Power in ~4%
  - Power out ~29%
- For microstrips
  - Cables ≈ Cooling
  - Cables + Cooling + Support ≈ 2x (Sensors+ Electronics)

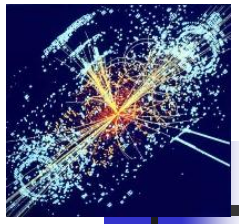


Material budget for 3 Layers at η = 0

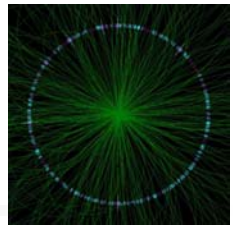


X/X_0 = 5.79% for 3 barrel pixel layers

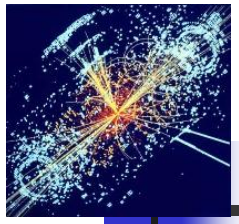
→ 1.93% / layer



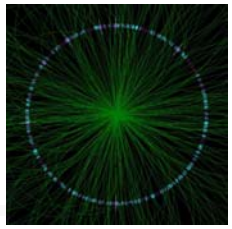
Potential synergies



- Dialogue between ATLAS & CMS well under way
  - But common solutions are not guaranteed
- Possible common efforts
  - ASIC processing runs
    - in CMS & CERN worked well for 0.25µm CMOS
  - Development of common SLHC systems
    - Optical links and Timing-Trigger-Control system
    - Power issues
  - Dialogue with machine
  - Special tooling
    - removal and installation of irradiated systems in irradiated environment
  - Information exchange via regular meetings
    - Annual LECC workshops are one common forum for electronic R&D



Conclusions



- Upgrade R&D phase is slowly beginning
- Time available is never enough
- Good foundations will help deliver