Solid StateTracking R&D activities in Europe

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on behalf of the European component of the SiLC Collaboration

ALCPG 2004 Winter Workshop

SLAC, January 7-10, 2004

World-Wide review of Linear Collider Tracking

R&D Framework = SiLC

- **SiLC = Worldwide R&D Collaboration on Si-Tracking for the Linear Collider**, proposal submitted to the PRC-DESY, 7-8 May 2003 (DESY-PRC-03-02) and Addendum on October 31st 2003 (PRC-Addendum): R&D program for 3 years, i.e. until end 2006.
- **European Institutes in SiLC** ***(in parenthesis ongoing Si-tracking activity apart from SiLC):***

CNM-Barcelona (Spain) (SCT-ATLAS)
DPNG-University of Geneva (Switzerland) (AMS & SCT-ATLAS)
Helsinki University (Finland)
IEKP, University of Karlsruhe (Germany) (Si-tracker in CMS)
Obninsk State University (Russia)
LPNHE-Paris (France)
INFN-Pisa (Italy) (Si-tracker in CMS, Si-tracker CDF II and GLAST)
Charles University in Prague (Czech Republic) (SCT-ATLAS)
University of Roma 1, La Sapienza (Italy)
Torino University (Italy) (Si-tracker in CMS and in ALICE)
Academy of Sciences, Wien (Austria) (Si-tracker in CMS)

Large expertise from LEP, B-factories, CDF, LHC and AMS + GLAST and several well equipped Lab/test bench capabilities

1.- R&D on sensors

- Existing expertise and close contacts with Industrial firms from ongoing (LHC, CDF or AMS) or previous experiments (LEP and B-factories)
- This activity is coordinated by Vienna
- Main Institutes and firms involved:
  - Vienna with Hamamatsu & others
  - LPNHE=Paris with Hamamatsu
  - Torino with ST Microelectronics & connected small firms in Italy (Catania and Trento)
  - Obninsk
  - CNM is developing possibility to produce wafers

- **For the time being the goals are on developing larger, thinner, higher yield, possibly double-sided wafer keeping the pitch ≤ 100 μm**

- Most of the Institutes are concentrating on long microstrips, some have also experience on Si-drift (ex: Torino)

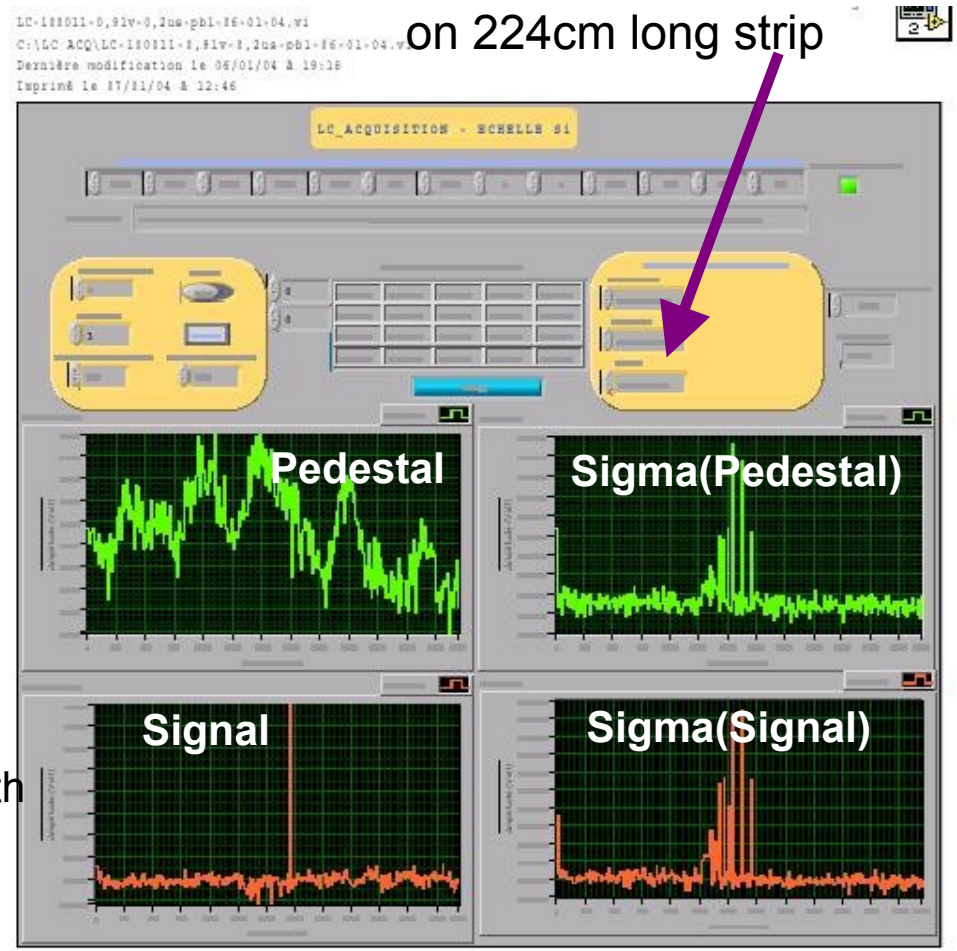
- Test bench facilities are existing in: Geneva, Karlsruhe, Prague, Paris, Torino, Vienna, using LD 1060 nm and/or radioactive source

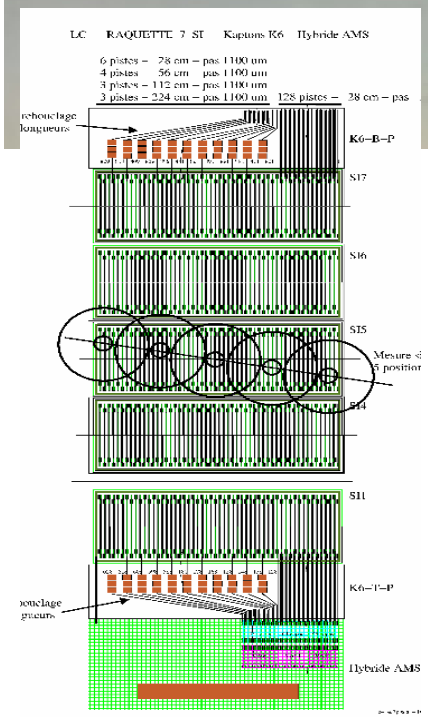
Interest in cross checking results (see next transparency)

First results on the Long Ladder prototype

Prototyped long ladder (made by Geneva + ETHZ + Paris), read out with VA64hdr

Labview based test bench (Paris)
Test with the laser LD1060nm
on 224cm long strip

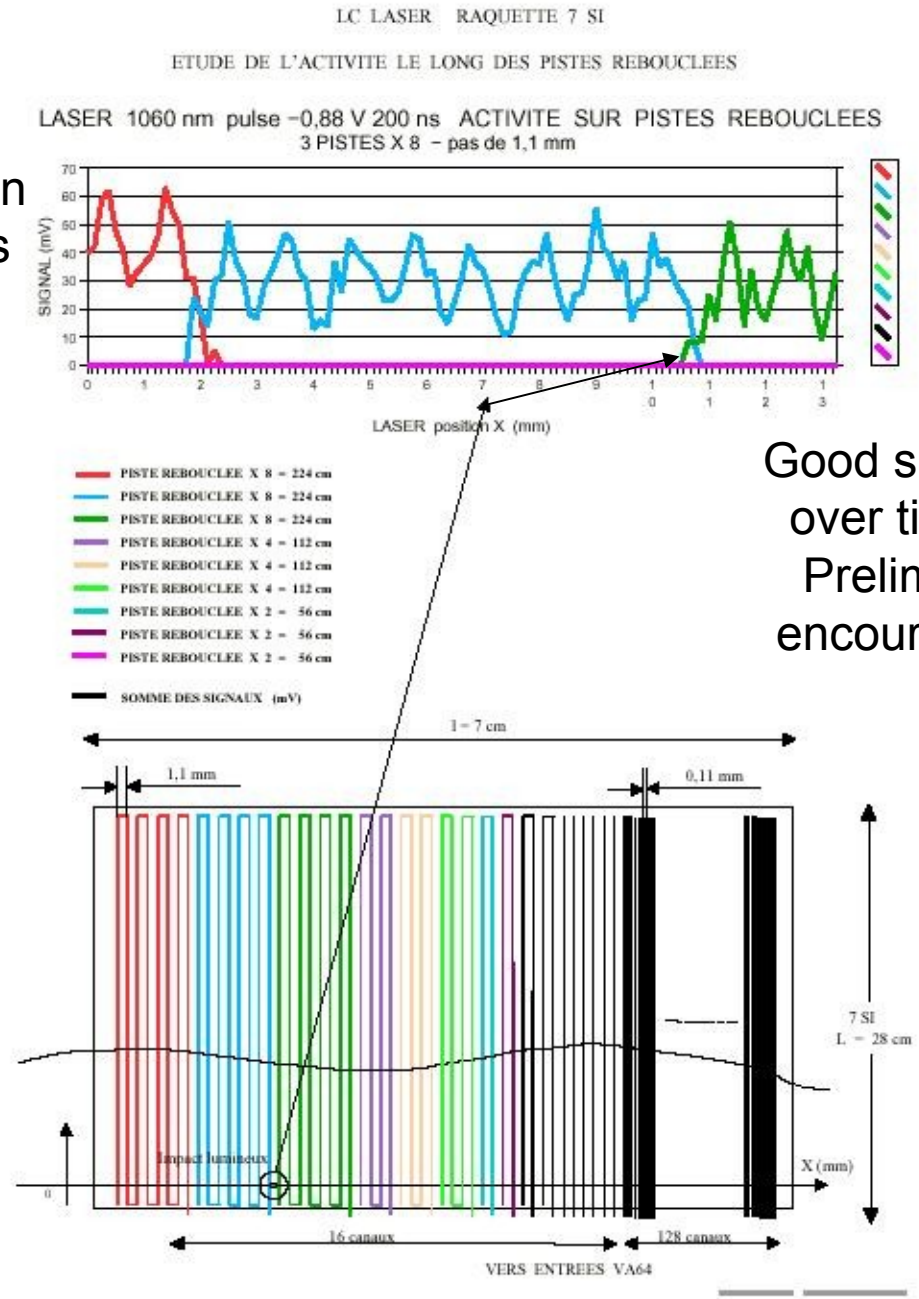




Special output Kapton designed to allow serpentine cabling such as to have strips of variable length, i.e.: (1, 2, 4 and 8) modulo 28 cm = 28, 56,112 and 224 cm strip length on this prototype.

First results on Long ladder prototype cont'd

The results between the Geneva & Paris test benches are cross-checked and show a good agreement.



Good signal reproducibility over time and channels. Preliminary results are encouraging. Much more to come.

2.- R&D on Electronics

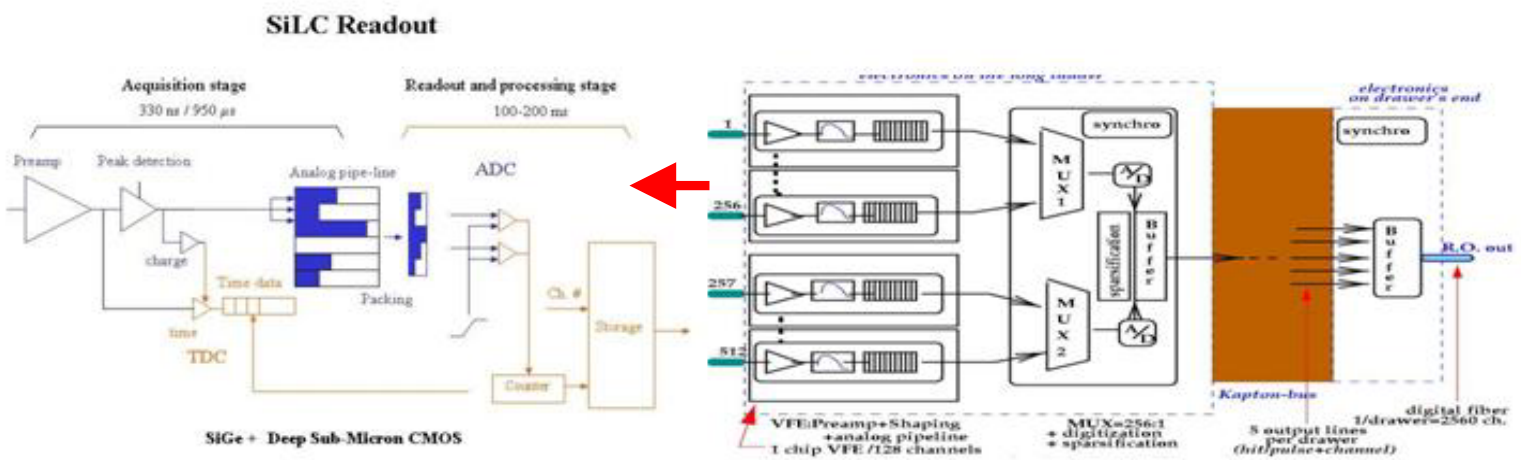
Two main streams are presently pursued for the long microstrips:

- Design of a new F.E. architecture (LPNHE-Paris)
- Developing a new version of existing F.E. based on IDEAS chips (Vienna, Karlsruhe and IDEAS)

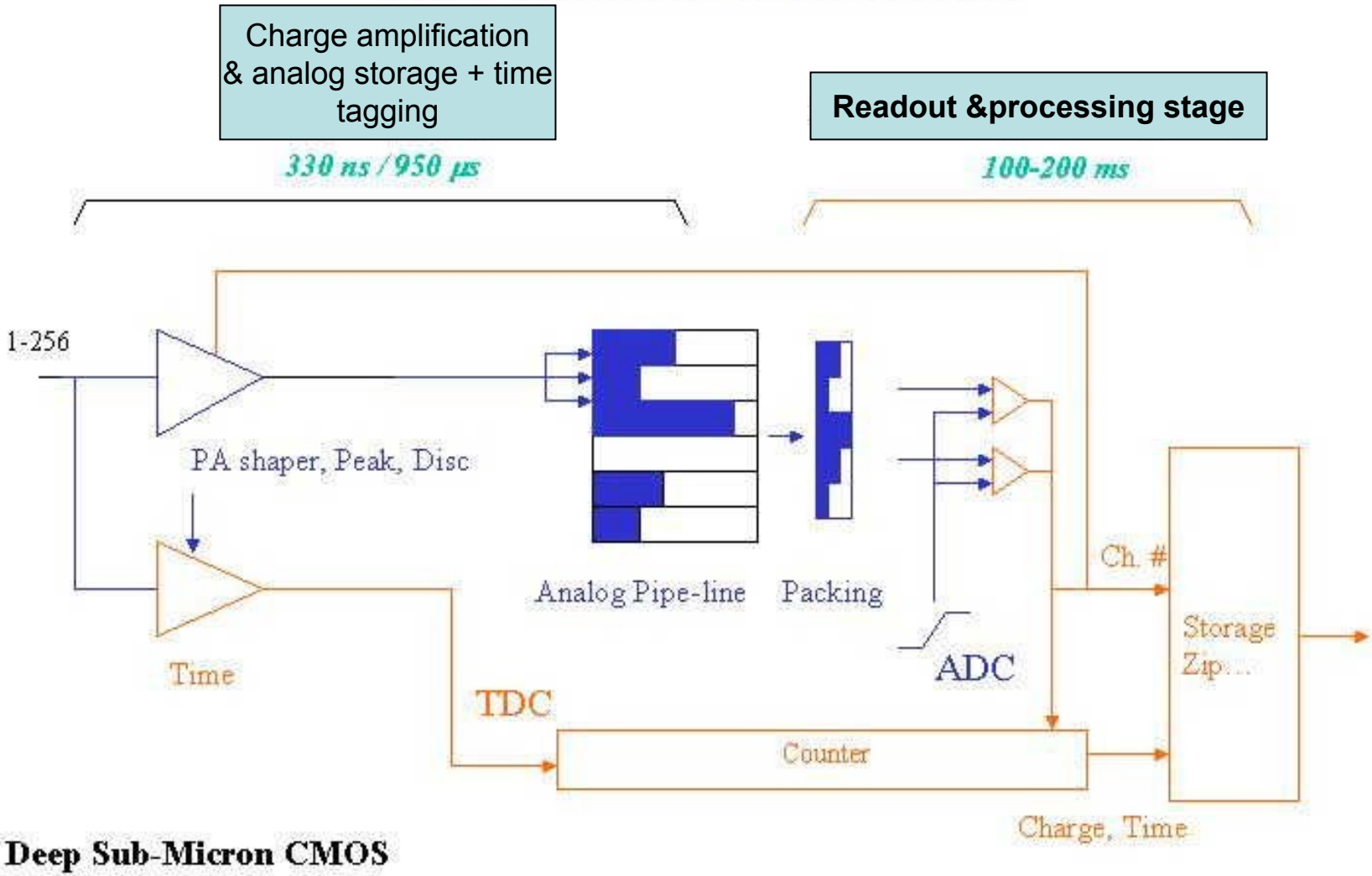
Main features of the new FE architecture under designed at LPNHE:

- ➔ **Low power dissipation**
- ➔ **Low noise**
- ➔ **Long shaping time (≥ 3 μs)**
- ➔ **Power cycling (95%)**
- ➔ **Low material budget (dsm)**
- ➔ **Highly multiplexed (shared A/D)**
- ➔ **Sparsification & digitisation**

Submitted for foundry towards May 2004

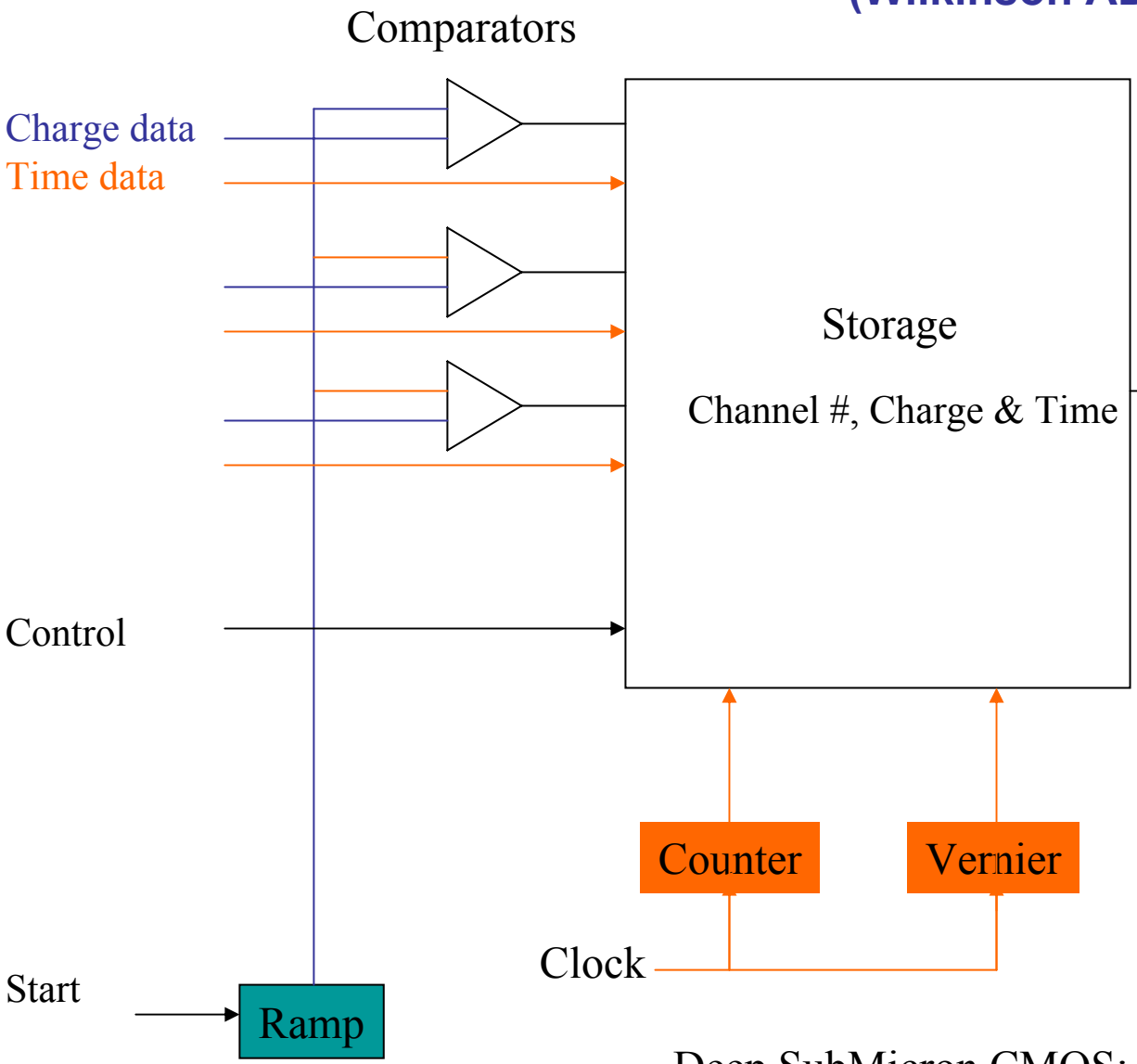


SiLC Readout architecture



Shared ADC and Storage

(Wilkinson ADC type)



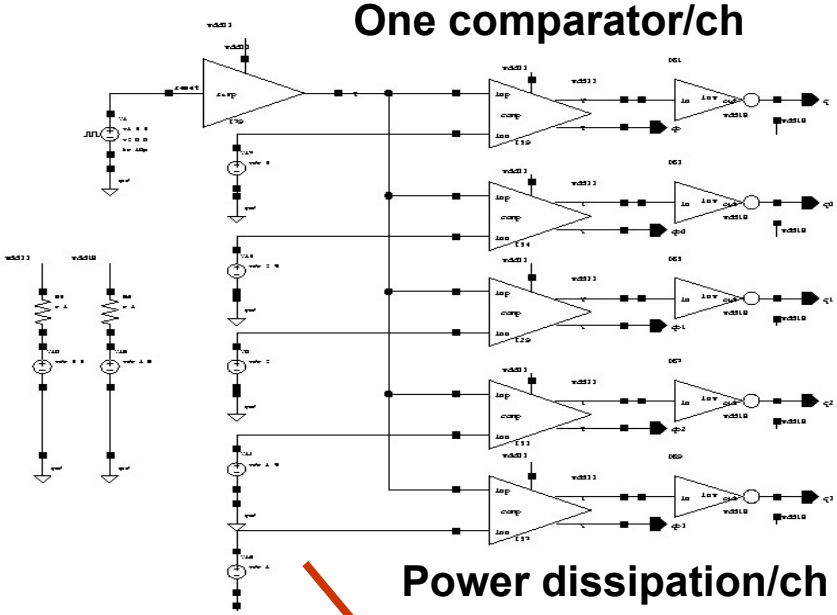
UMC 0.18 µ techno
4µsec conversion time
10 bits (250MHz internal clock)
40 µWatt/ch
A/D working at the end of the bunch train (during DAQ period)

Shared ADC function

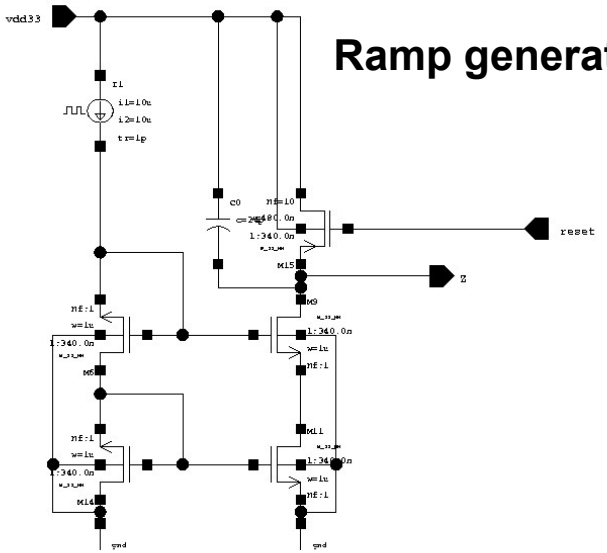
Deep SubMicron CMOS:
(UMC 0.18 µm)

ADC simulations (techno UMC 0.18 micron)

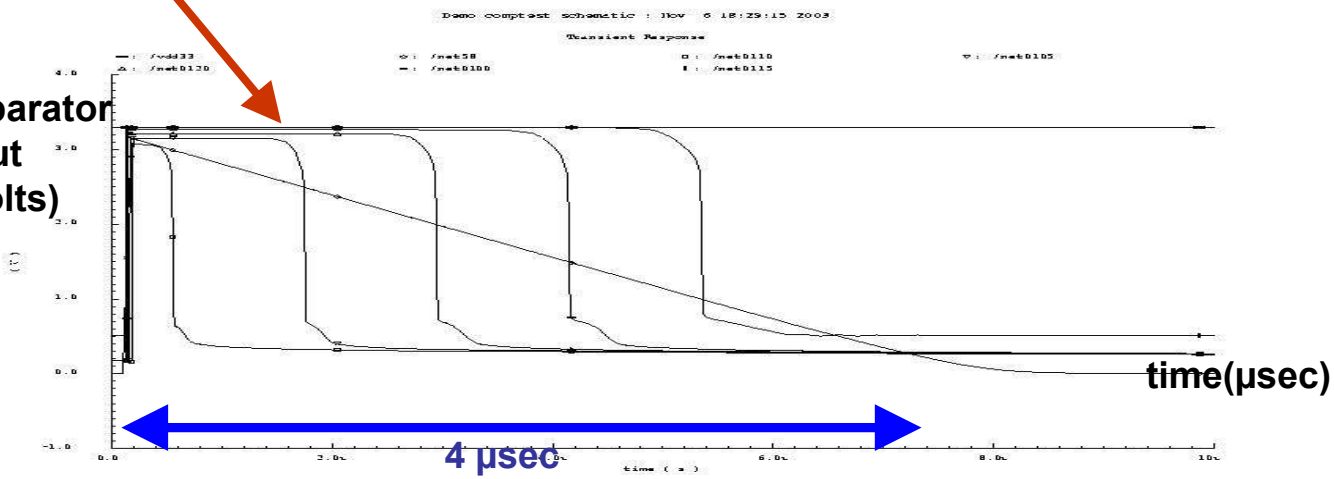
One comparator/ch



Ramp generator



Power dissipation/ch = 40 µWatt



A/D conversion of 5 equally spaced voltages: SPICE output

3.- R&D on Mechanics

Main issues:

Material budget thus XXXXXXXXXXLight structure & long microstrips (ladders)
Material choice (light, good mechanical & thermal properties)
Reduction of the cooling system at minimum minorum
Integration studies including electronics & cabling on detector

Very large surfaces with:
Modularity (long ladder = basic element of the architecture)
High stability & high precision positioning

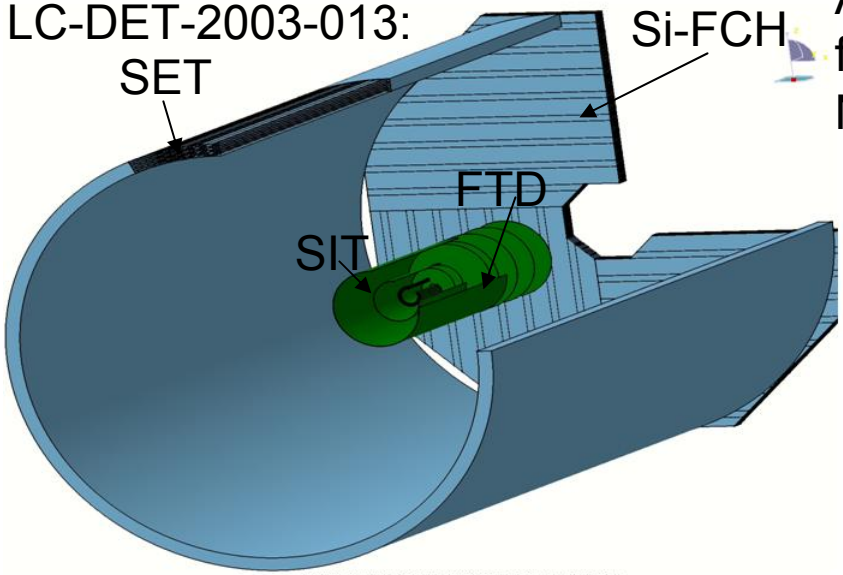
Integration issues with the rest of the experiment

These issues are addressed in:

- The CAD design of the Si-tracker system for the LC
- The development of the technique to build long ladders
- The mechanical cooling studies
- The development of alignement and mechanical calibration systems
- The construction and tests (mechanical constraints) of mechanical prototype

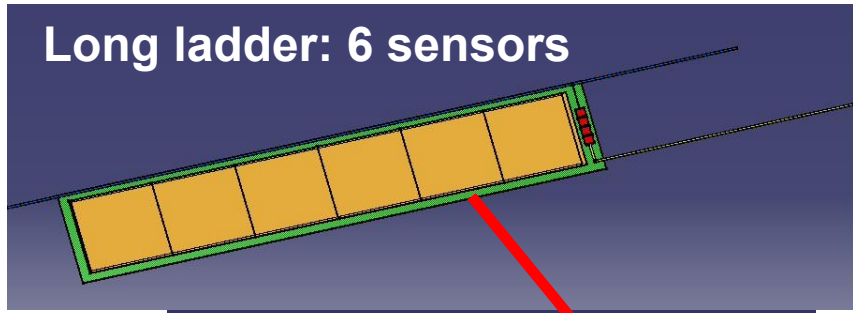
CAD design of the detector

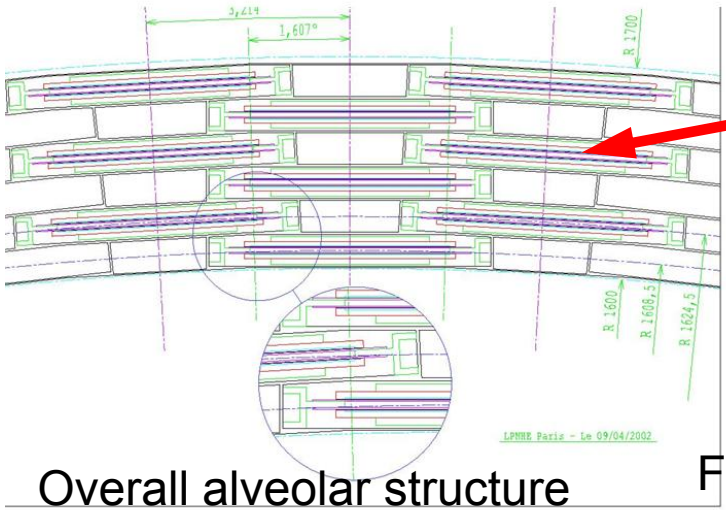
Si-envelope
LC-DET-2003-013:



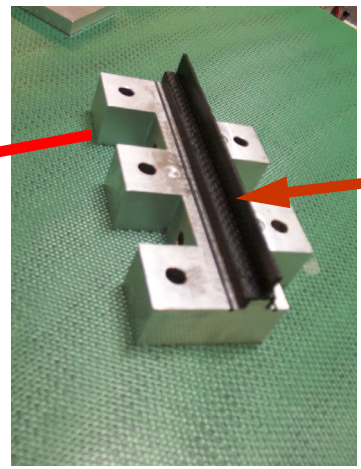
Si-envelope includes all the elements of
a all-Si tracker (SIT+FTD, SET, Si-FCH)

Achieved by LPNHE-Paris a full CAD design for the large dimension barrel device
Now Torino has joined Paris for collab on CAD





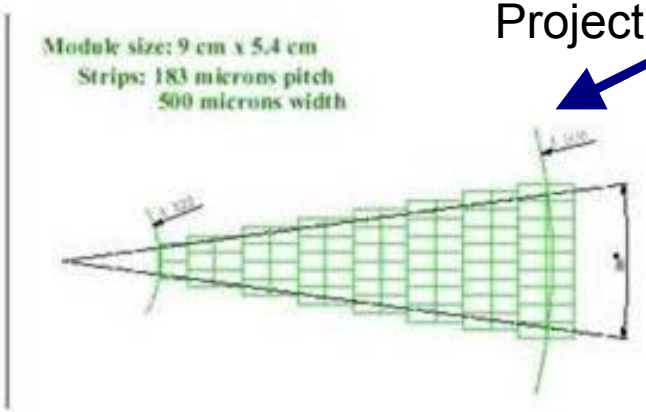
Overall alveolar structure



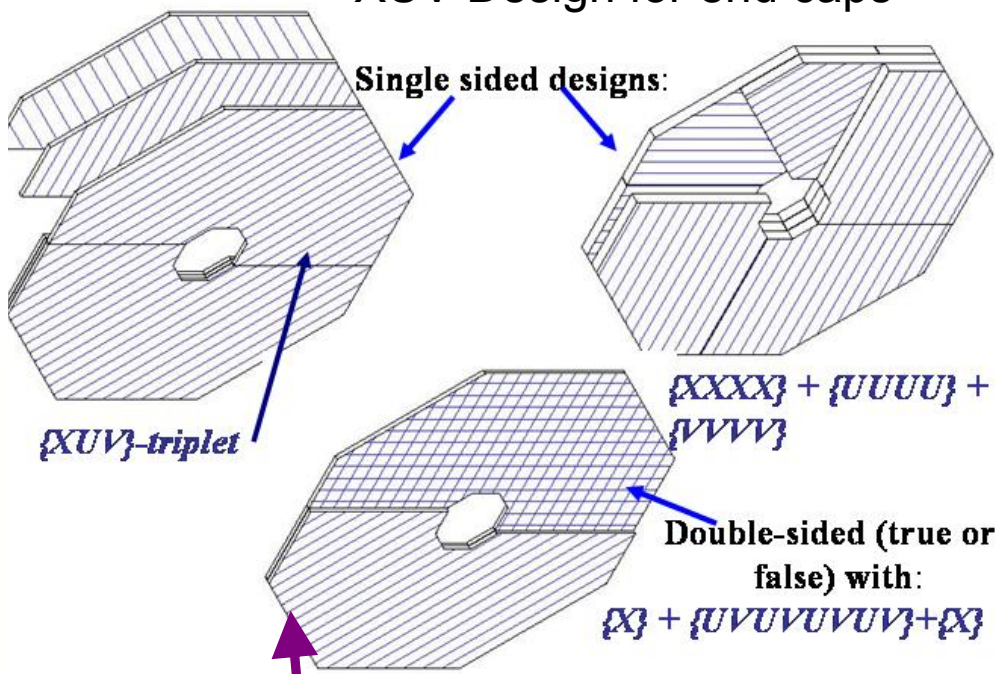
Feasibility test of the drawer structure
at the Lab & acknowledged by Industry

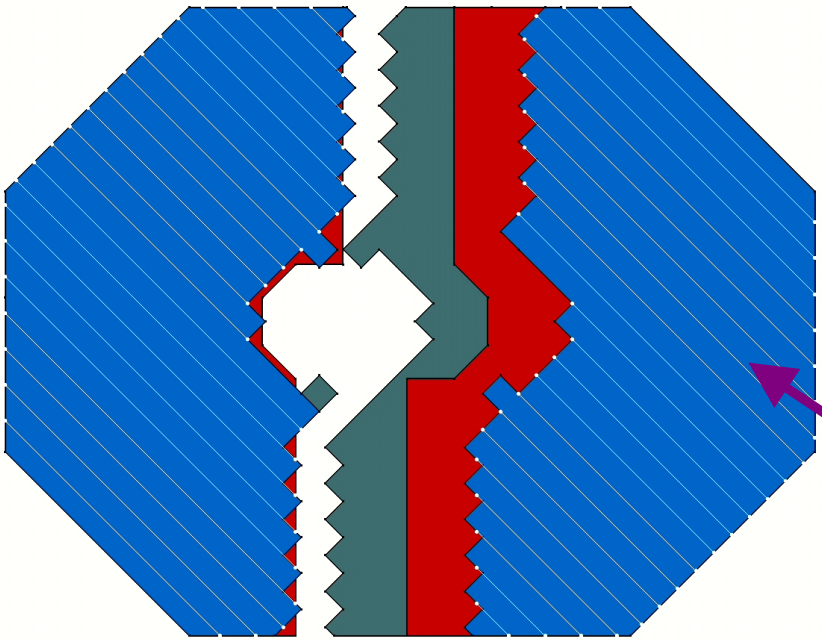
Detailed CAD design of the end-caps (Si-FCH) is the present focus at LPNHE-Paris

Projective design



XUV Design for end caps





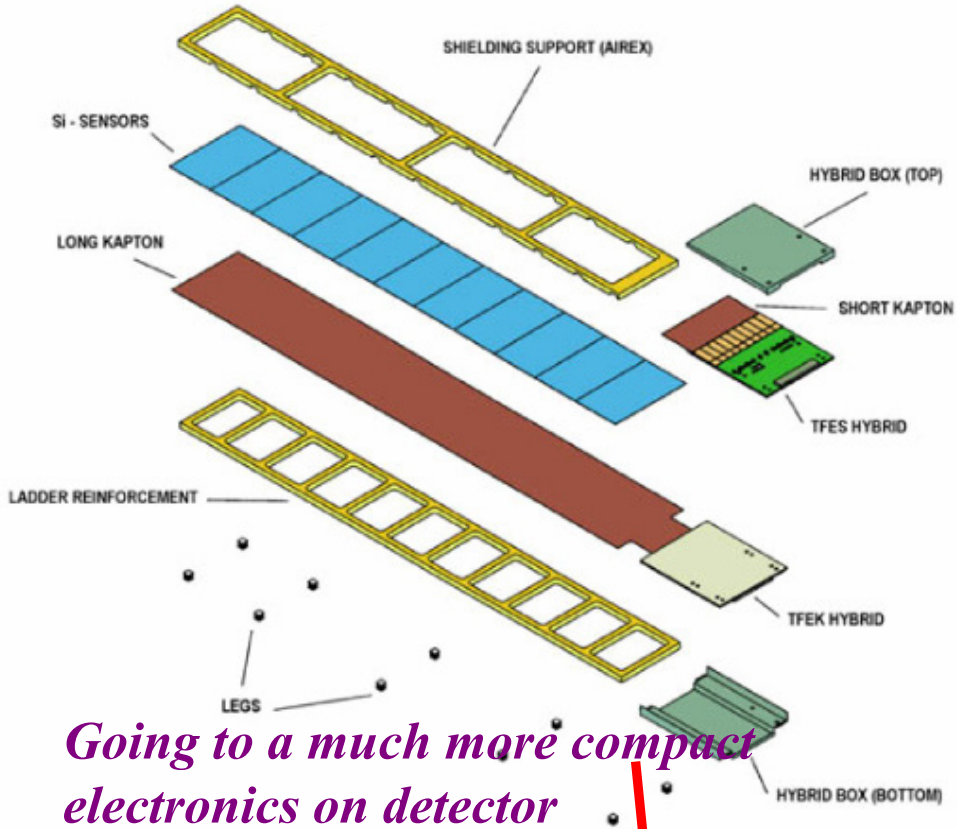
Present stage of the CAD design

The detailed CAD design of the Si-FCH in XUV is underway (also requested for G-based performance studies)

➢ Developing technique to build long ladders= crucial basic element

design, metrology, construction & industrialisation

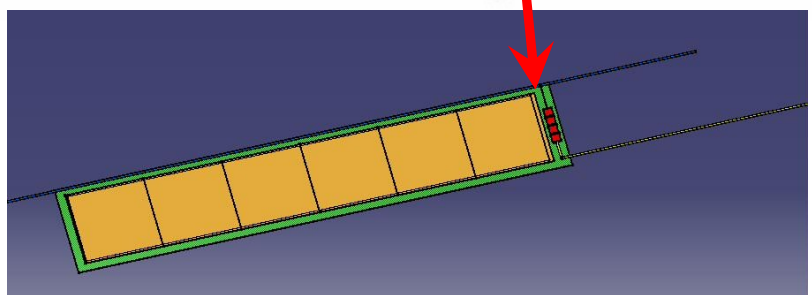
(Presently interested: Geneva, Paris, Torino, Vienna & Karlsruhe)



Ex: Si-tracker of AMS (Geneva)

But now it is required to go from homemade to industrialisation

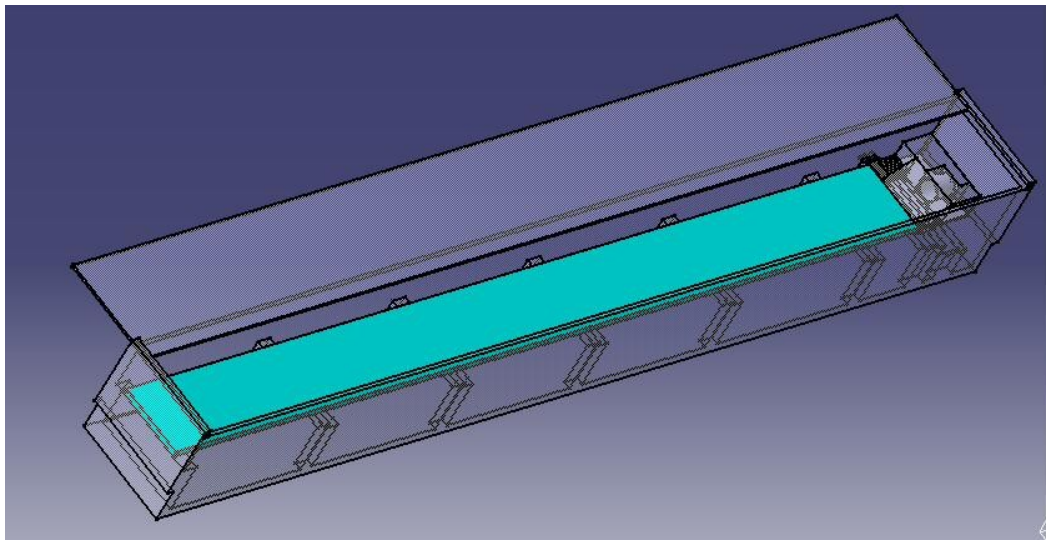
Going to a much more compact electronics on detector

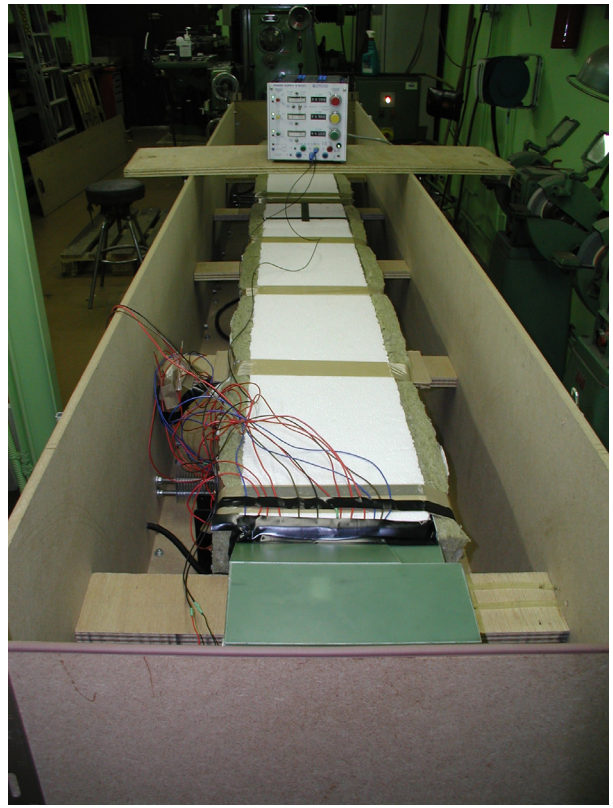


➢ Mechanical cooling studies *(Paris)*

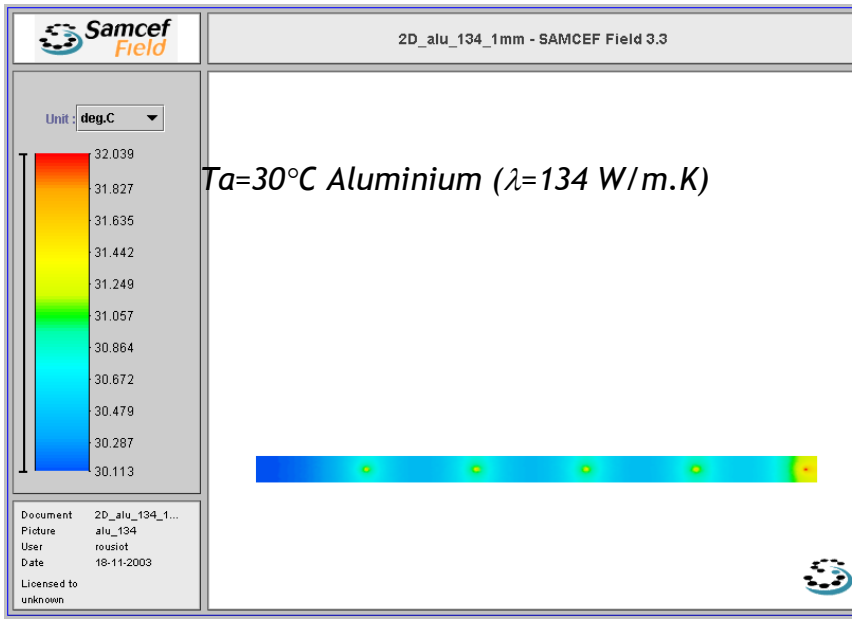
The 2.5 m long drawer made of 5 long ladders is cooled by:

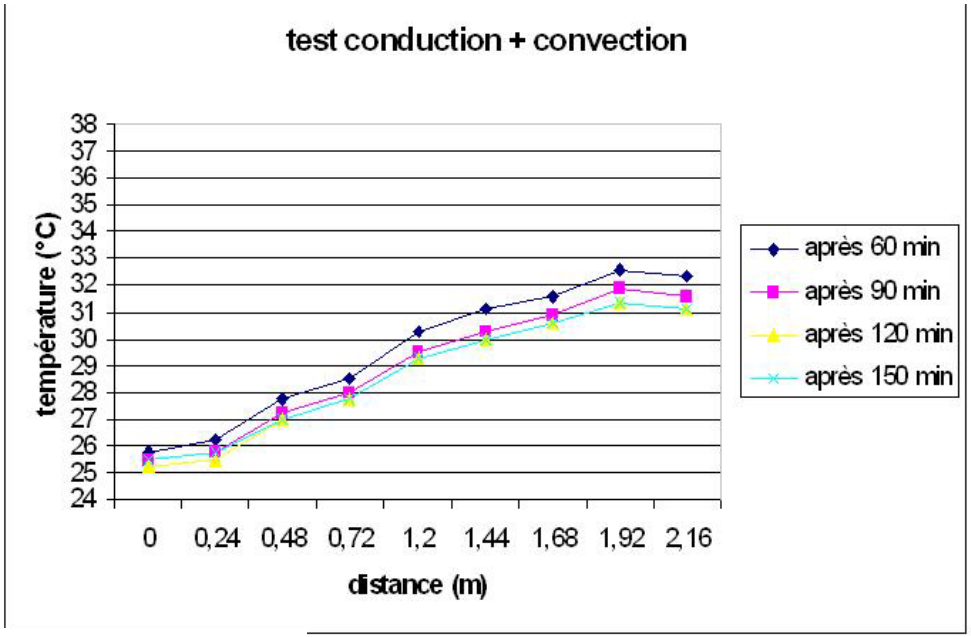
- *Forced convection*
- *Conduction (C-fiber with high λ)*

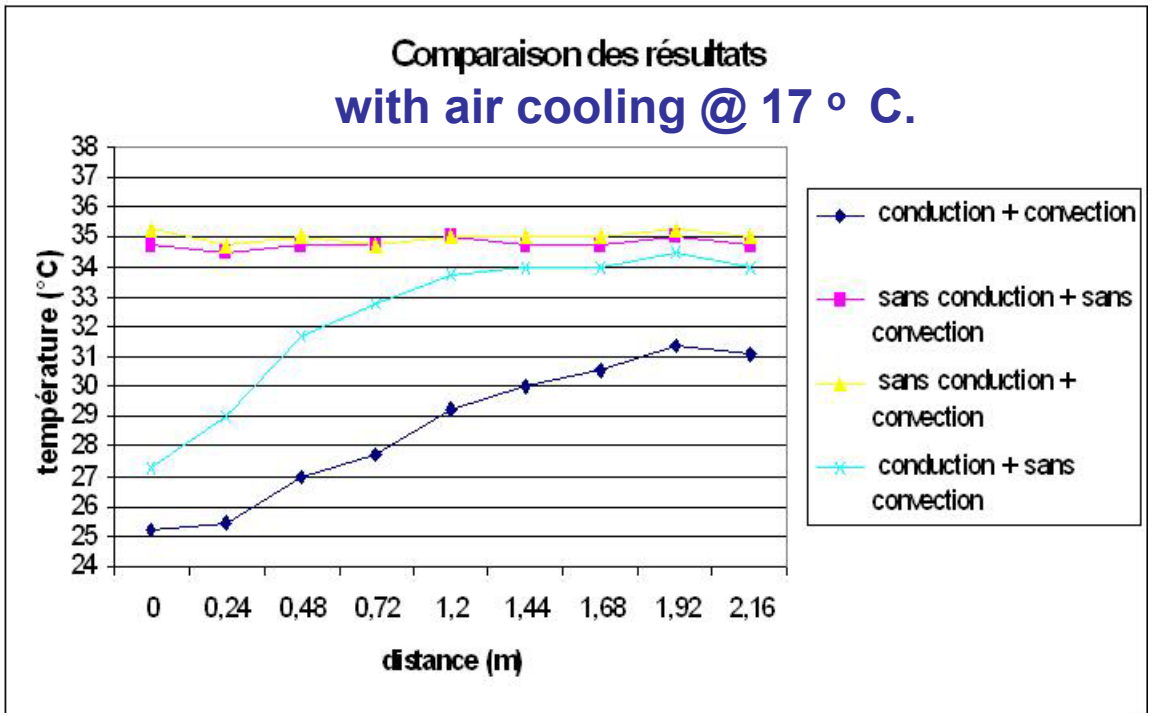




The prototype is within a box maintained at desired T=35°C (ex) G10 careenage (isolation), but allowing air circulation
FE = resistors & thermocouple to measure the power dissipation on various points along the drawer
Air cooling by wind turbine







Tests in progress with air cooling @ 10 and 5 degrees C.

Results on mechanical cooling test bench:

cooling at the end of the long drawer with air cooling and forced convection looks OK. Results from SAMCEF agree with those on the test bench.

Very encouraging as cooling system is responsible for a Large % of material budget.

4.- Test benches & calibration systems

Most of the European Institutes have very well equipped Large Labs and test bench facilities (CNM, Geneva, Helsinki, Karlsruhe, Pisa, Prague, Torino, Vienna), other are developing them (ex: Paris).

Scheduled at the end of the 3 year SiLC program to have a test beam with a full prototype. Possibility to have meanwhile more focused test beams (Frascati and/or DESY or ???) under discussion.

Calibration systems:

Mechanical stability and high precision positioning impose monitoring/calibration systems to be studied and developed.

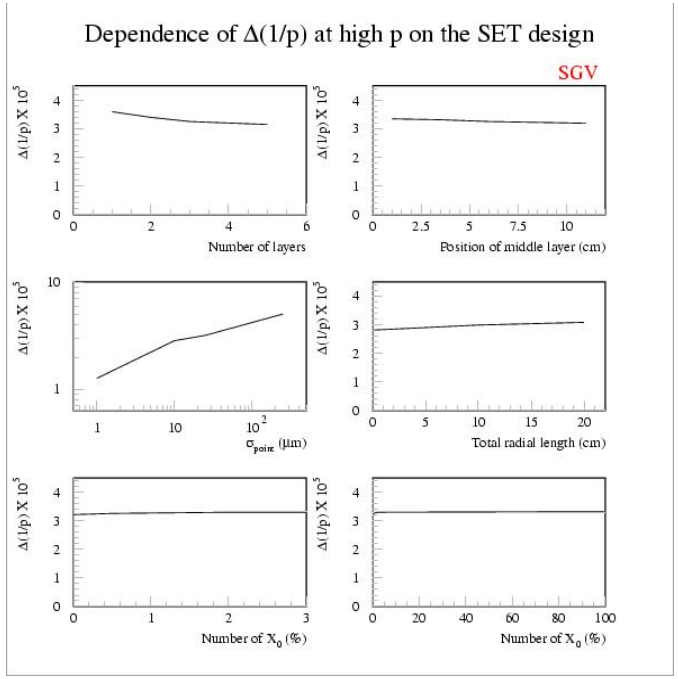
Not yet started but several teams have a large experience and intend to apply it to the LC challenging case. Among them: Pisa, Roma1, Paris.

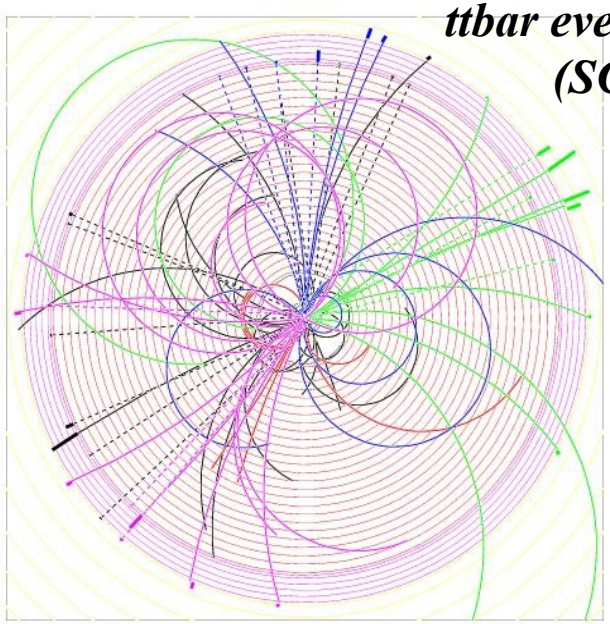
5.- Simulations studies (Fast and Geant-based)

(Obninsk, Paris & more to come)

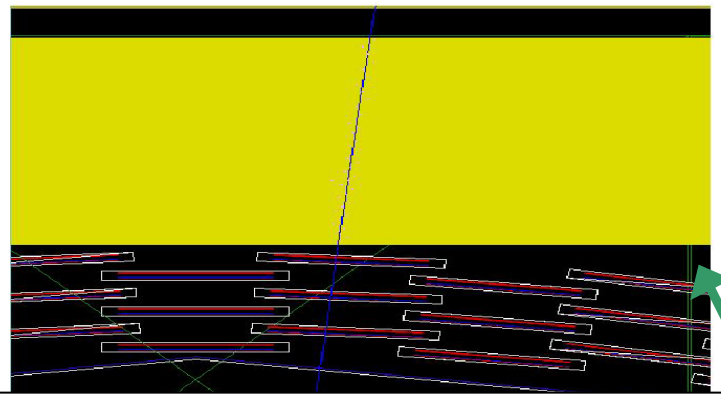
Work to be done or underway:

- **Detailed pattern reconstruction**
- **GEANT-3&4 detailed simulation development**
- **Comparison of various detector set-ups & technologies including TPC**
- **Background studies[including results of beam line simulation & related detector issues (forward)]**
- **Calorimeter-assisted tracking (for SD)**
- **Physics studies to establish performance requirements**





ttbar event display (SGV)



MOKKA-geometry DB detector definition using detailed CAD mechanical design