A detector for TESLA: main characteristics and ongoing R&D projects

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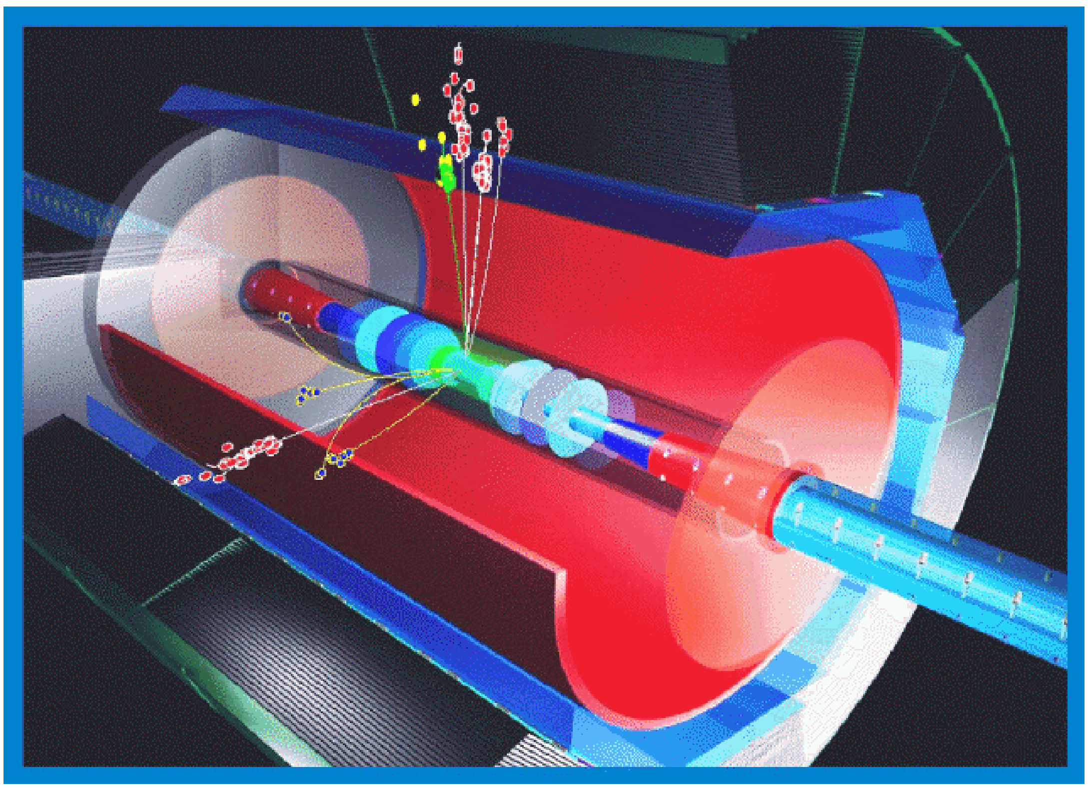
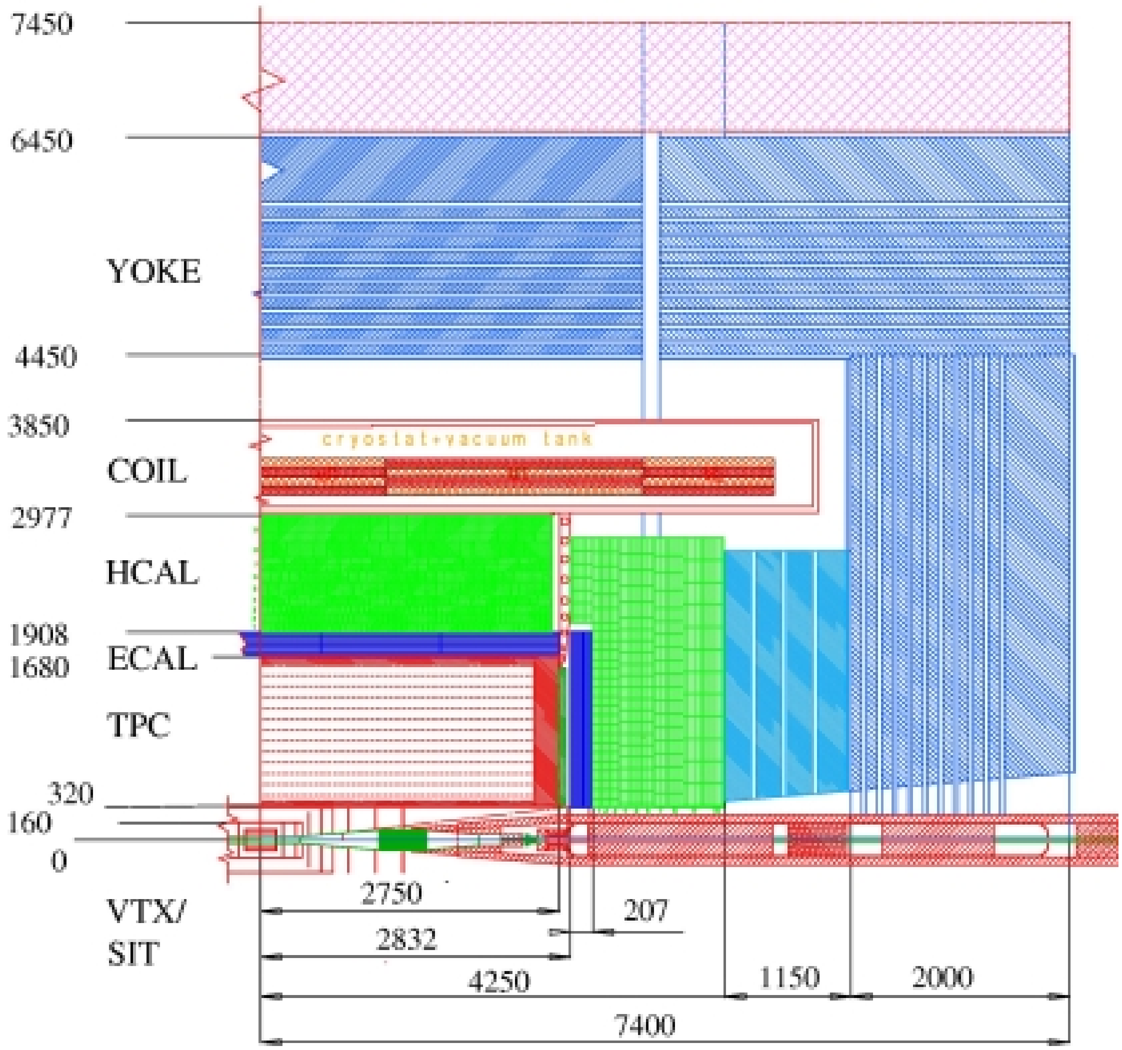


Padova

INCONTRO SULLE PROSPETTIVE DEL COLLISORE LINEARE ELETTRONE -POSITRONE,

30th October 2001

detector layout:



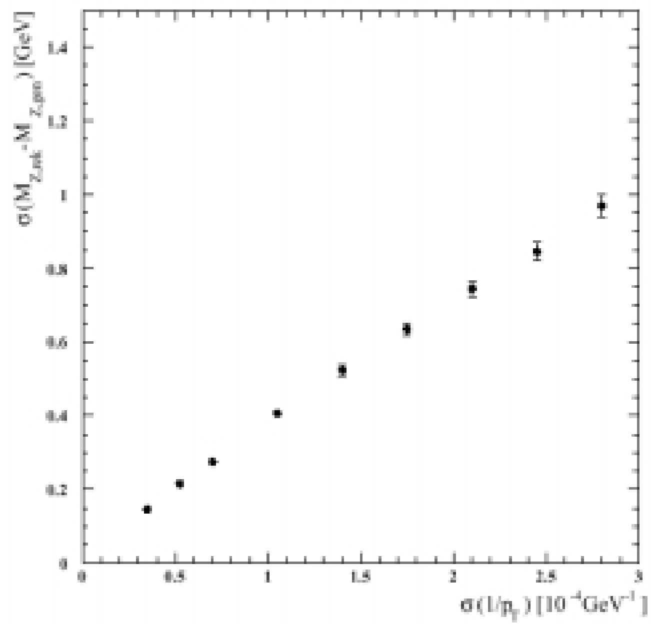
- B ~ 4 T, calorimeters inside the coil
- conical masks for background shielding at 83 mrad
- NO hardware trigger but:
  - — dead timeless pipelining for 1 ms
  - — full pipeline throughput in 199 ms (220 Mbyte/train)
  - — software trigger

Subdetector	Goal	Technologies
Vertex Detector (VTX)	$\delta(IP_{r\phi,z}) \leq 5\,\mu\mathrm{m} \oplus \frac{10\,\mu\mathrm{m}\ \mathrm{GeV}/c}{p\sin^{[illegible]}\theta}$	CCD, CMOS, APS
Forward Tracker (FTD)	$\frac{\delta p}{p} < 20\,\%, \delta_\theta < 50\,\mu$rad for p=10-400 GeV/c down to $\theta \sim$100 mrad	Si-pixel/strip discs
Central Tracker (TPC)	$\delta(1/p_t)_{\mathrm{TPC}} < 2{\cdot}10^{-4}(\mathrm{GeV/c})^{-1}$ $\sigma(dE/dx) \leq 5\%$	GEM, Micromegas or wire readout
Intermediate Tracker (SIT)	$\sigma_{point} = 10\,\mu$m improves $\delta(1/p_t)$ by 30%	Si strips
Forward Chamber(FCH)	$\sigma_{point} = 100\,\mu$m	Straw tubes
Electromag. Calo. (ECAL)	$\frac{\delta E}{E} \leq 0.10 \frac{1}{\sqrt{E(\mathrm{GeV})}} \oplus 0.01$ fine granularity in 3D	Si/W, Shashlik
Hadron Calo. (HCAL)	$\frac{\delta E}{E} \leq 0.50 \frac{1}{\sqrt{E(\mathrm{GeV})}} \oplus 0.04$ fine granularity in 3D	Tiles, Digital
COIL	4 T, uniformity $\leq 10^{-3}$	NbTi technology
Fe Yoke (MUON)	Tail catcher and high efficiency muon tracker	Resistive plate chambers
Low Angle Tagger (LAT)	83.1–27.5 mrad calorimetric coverage	Si/W
Luminosity Calo. (LCAL)	Fast lumi feedback, veto at 4.6–27.5 mrad	Si/W, diamond/W
Tracking Overall	$\delta(\frac{1}{p_t}) \leq 5 \cdot 10^{-5}(\mathrm{GeV/c})^{-1}$ systematics $\leq 10\,\mu$m	
Energy Flow	$\frac{\delta E}{E} \simeq 0.3 \frac{1}{\sqrt{E(\mathrm{GeV})}}$	

Motivations for the required detector performances

What can we do if IT is there (part 1)?

Measure its mass and cross section in e^+e^- -> ZH, relying on the Recoil mass against a leptonic Z decay



Momentum resolution is crucial,
Affecting directly the mass
Measurements and the background
Level ($S/N \sim 10^{-6}$)

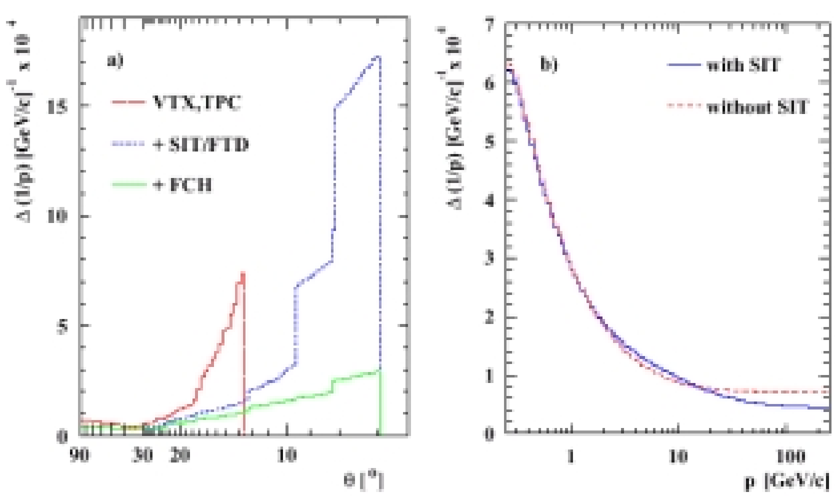
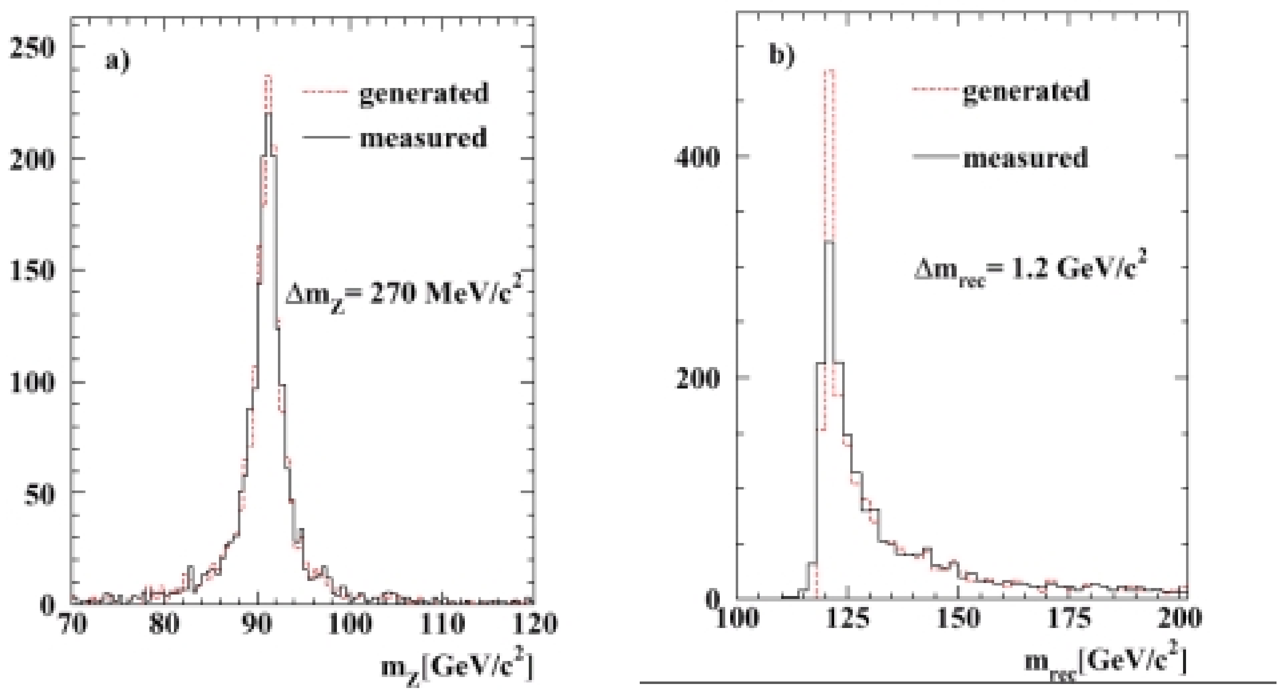


Figure 2.4.2: *Momentum resolution a): for 250 GeV/c muons as a function of the polar angle, for TPC and VTX, after the addition of the FTD, and for the complete system including the FCH. b): Momentum resolution as a function of the momentum for a polar angle $\theta = 90°$. The dashed curve is for the VTX and the TPC only, the solid one for the complete tracking system.*

Achievable Z and recoil mass resolution:



- M_H accuracy ~ 150 MeV
- Cross section statistical accuracy ~ 3%

(500 fb^{-1} integrated luminosity)

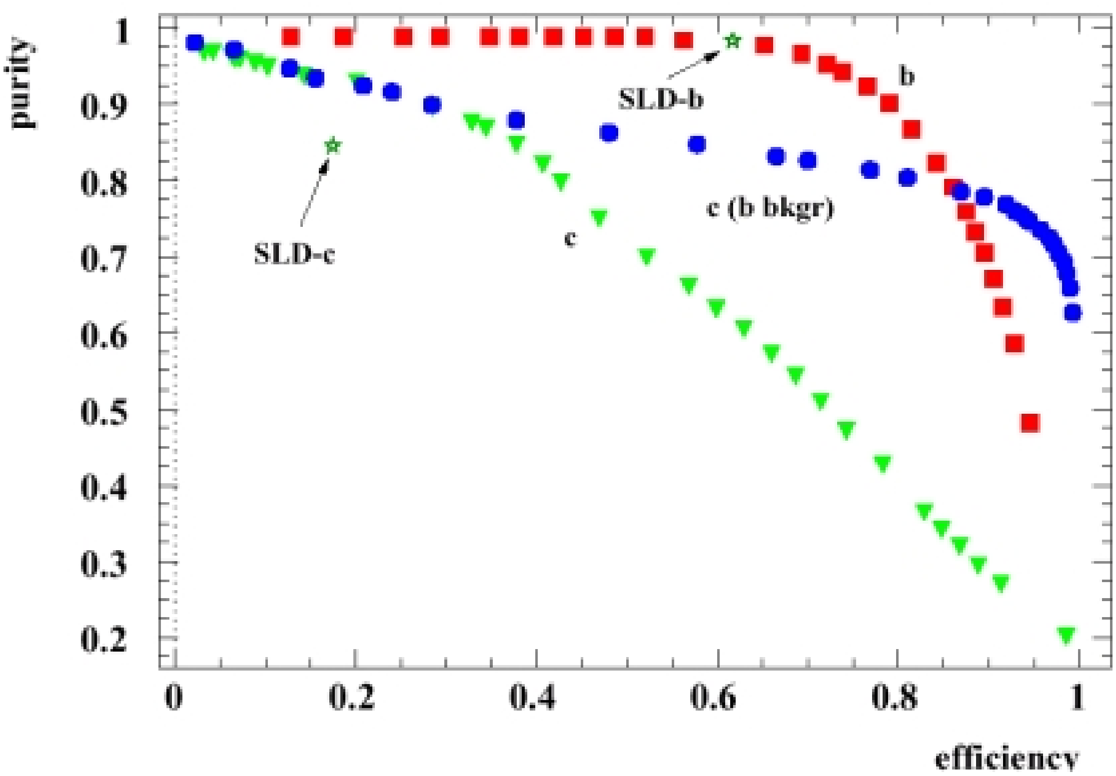
What can we do if IT is there (part 2)?

Measure Its Branching ratios and possibly tell whether Its origin Is a SM or MSSM (or anything else) (Kamoshita et al. 1995, Battaglia, 1998):

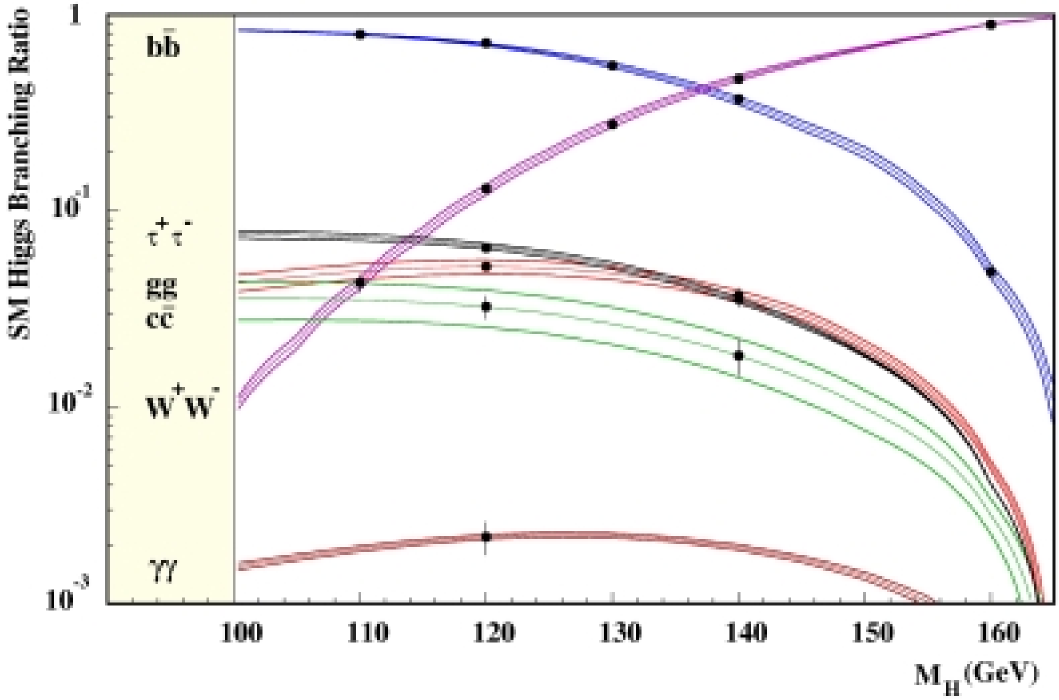
$$\frac{Br(h \to c\bar{c})}{Br(h \to b\bar{b})} \propto \frac{m_h^2 - m_A^2}{m_Z^2 - m_A^2}$$

(A being the CP-odd Higgs)

FLAVOUR TAGGING is the tool for performing this investigation, Benchmarked by the c vs b separation:



Achievable resolution on the Branching ratios:



- measure the ratio of Branching ratios ~ 8% accuracy
- measure m_A with ~ 100 GeV accuracy up to ~ 500 GeV,

Well beyond the $\sqrt{s}$ / 2 kinematical limit, defined by the AH associated production

What can we do if IT is NOT there ?

Probe strong electroweak symmetry breaking studying
The processes (Chierici et al., 2001)

$$e^+e^- \rightarrow W^+W^- \nu\bar{\nu}$$

$$e^+e^- \rightarrow Z^+Z^- \nu\bar{\nu}$$

An underlying new symmetry should induce anomalous couplings
decoupling the longitudinal and transverse bosons:

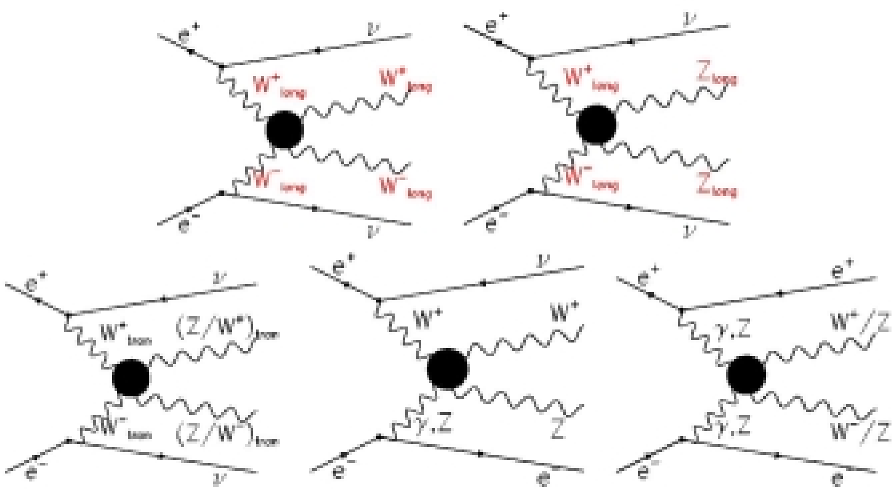


Figure 1: Diagrams contributing to longitudinal WW scattering and main six fermion backgrounds from doubly resonant processes.

The name of the game is being able to separate Z and W masses

- to increase the S/N, originally at the 10^{-3} level
- exploit the different dependence on the anomalous Couplings of the two bosons

Jet energy resolution is the tool:

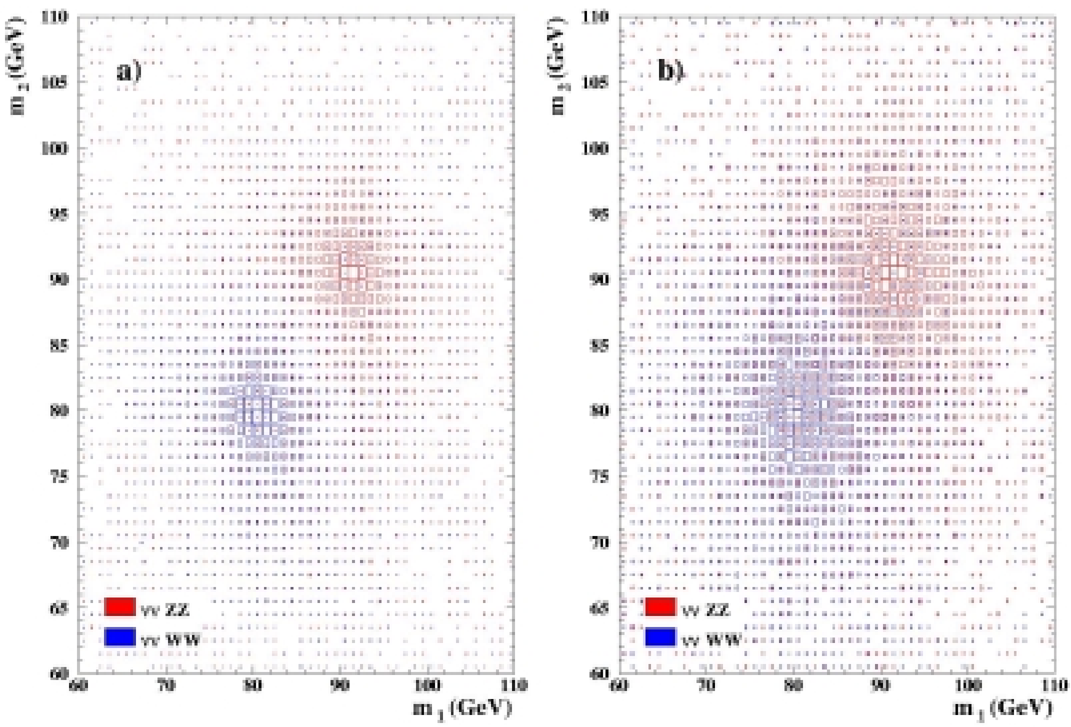


Figure 9.4.4: *Reconstructed masses for* $e^+e^- \to \nu\bar{\nu}WW$ *events and* $e^+e^- \to \nu\bar{\nu}ZZ$ *events for a)* $\Delta E/\sqrt{E} = 30\%$ *and b)* $\Delta E/\sqrt{E} = 60\%$.

Dependence of the dilution factor (~ background from the other boson) on the jet energy resolution

The gain is equivalent to 30-40% increase in statistics

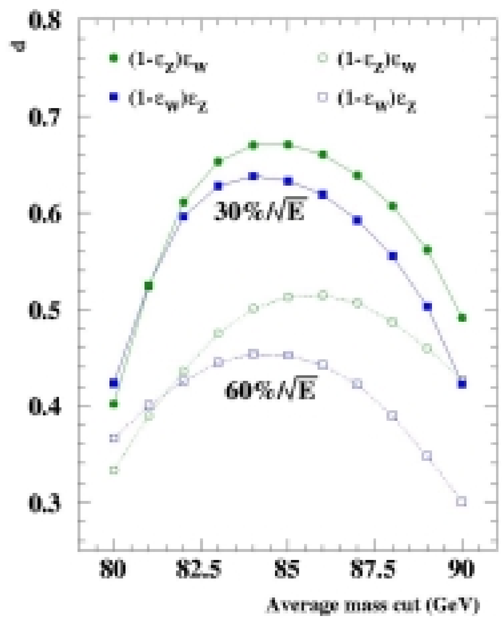


Figure 9.4.5: *Dilution factor d for* $e^+e^- \to \nu\bar{\nu}WW$ *and* $e^+e^- \to \nu\bar{\nu}ZZ$ *as a function of the cut on the average invariant mass for* $\Delta E/\sqrt{E} = 30\%$ *and* $\Delta E/\sqrt{E} = 60\%$.

These performances would allow a higher sensitivity compared to LHC

An overview of ongoing R&D activities

Is there a general policy towards R&D projects related to TESLA?

- **<u>Germany</u>**; yes! BMBF (the Ministry) support for 2001-2003:
  - 900 kDM to cover the additional costs
  - 600 kDM for personnel (100 kDM ~ 1 PhD)

- **<u>France</u>**; there is a rather favourable trend, but…

"La France se rapproche graduellement du Collisioneur Lineaire,
Mais en trainant d'un pied, sa politique etant intimement liee a celle
Du CERN".

- **<u>UK</u>**; No, each project is considered separately for funding. But PPARC (Particle Physics and Astronomy Research Council) recently stated "the LC is the UK's next big project AFTER the LHC"

- **<u>Italy</u>**; not yet…

Ongoing (approved) R&D projects:

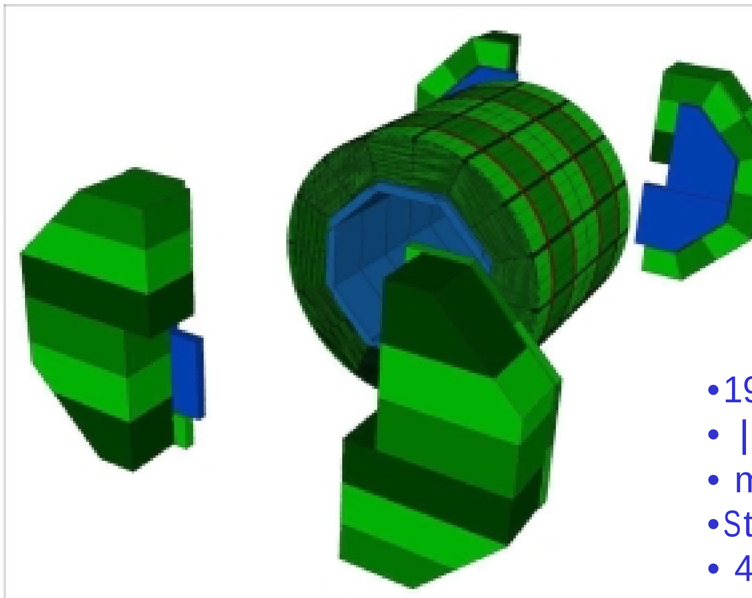
- **<u>France:</u>**
  - CMOS (Strasbourg) ~ 200 kCHF/year (~ 50% in2p3)
  - TPC (lead by SACLAY/ORSAY)
  - SiW ECAL (Lead by Ecole Polytechnique)
    global budget ~ 400 kFF in 2001 (in2p3)

- **<u>Germany:</u>**
  - TPC (MPI-Munchen, DESY, Aachen)
  - HCAL (DESY)
  - CMOS imagers (Karlsruhe)

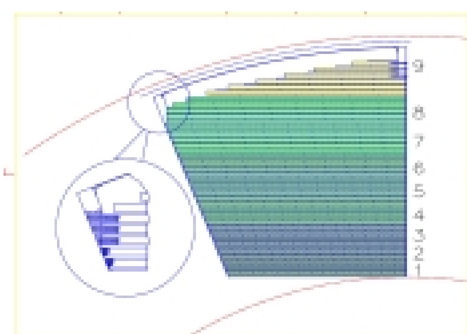
- **UK**:
  - CCD (LCFI collaboration), funded till march 2002, with a high CL
    To be supported till the workplan ends (~3 years) for a global budget
    Of ~ 5M EUR / 4 years)
  - UK-CMOS (RAL, Liverpool, Glasgow, Imperial College), started with
    A PPARC award, for 1 year. An Extension looks (very) reasonable

- **ITALY**:
  - CALEIDO (Padova, Milano, Bologna), funded for 1998-2000
    And successfully concluded. Global budget ~ 70 k EUR (INFN)
  - LCCAL (Padova, Insubria, Frascati), funded for 2001 (~ 45 k EUR,
    By INFN), likely to be extended for 2 more years
    (budget 2002 ~ 33 kEUR)
  - CCP (Capacitively coupled pixels) (Insubria + Krakow, Warsaw and
    Helsinki); phase I concluded (global budget ~ 15 k$; funded by the
    Minister of Science for ~ 7 k$).
    Phase II currently started at "zero cost"
  - SUCIMA (Insubria + 9 Other European partners). Headed by Insubria,
    Approved and funded by the EC for 3 years, within the Fifth Framework
    Program. Global budget ~ 3.2 M EUR

HCAL option 1: a Tile calorimeter

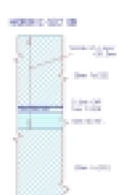


- 191 < R < 298 cm
- | dz | < 267 cm
- modularity 8 in Φ
- Stainless steel + scintillator plates
- 4.5 to 6.2 l depth

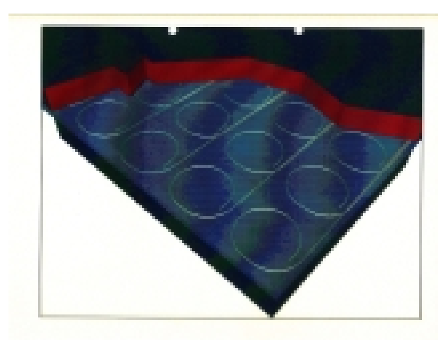


38 layers, grouped to define
A 9-fold longitudinal segmentation,
For a total no. of 204 000 channels

Layer structure



Tile size:
5x5 cm^2 to
25x25 cm^2



Performance:

- muon tracking
- $s_E/E = 35\% \ / \ \sqrt{(E)} \oplus 3\%$

Most critical issue:

Estimation of signal amplitude, my first approximation:

light reduction from scintillator to electr. signal

	reduction factor:		
tile tickness = 5 mm:		10000	photons
Scint. to WLS transition	0.25	2500	
trapping of green light	0.065	163	
attenuat. along WLS fibre	0.9	146	
transition to clear fibre	0.9	132	
attenuat. along clear fibre 6 m, 10 m att. length	0.55	72	
fiber mixer	0.9	65	
Photoeffic.			
PM (green sensitive!)	0.07	5	p.e.
APD	0.8	52	p.e.
minimum 3 tile layers:			
Signal:			
PM	0.08	14	p.e.
APD	0.8	156	p.e.
APD noise signal from DC		104	e
2nA DC, 10 ns shaping	excess noise	+/-25	e
	gain:		
APD	40	6255	e
PM	10^6	2x10^7	e

APD needs preamp and shaper

R&D at Desy: MIP's from 5x5 cm Scint. are seen with PM APD !?

Conclusion:

Need of photodetectores with high photon conversion efficiency at $\lambda \approx$ 500 nm.

R&D plans:

• roadmap

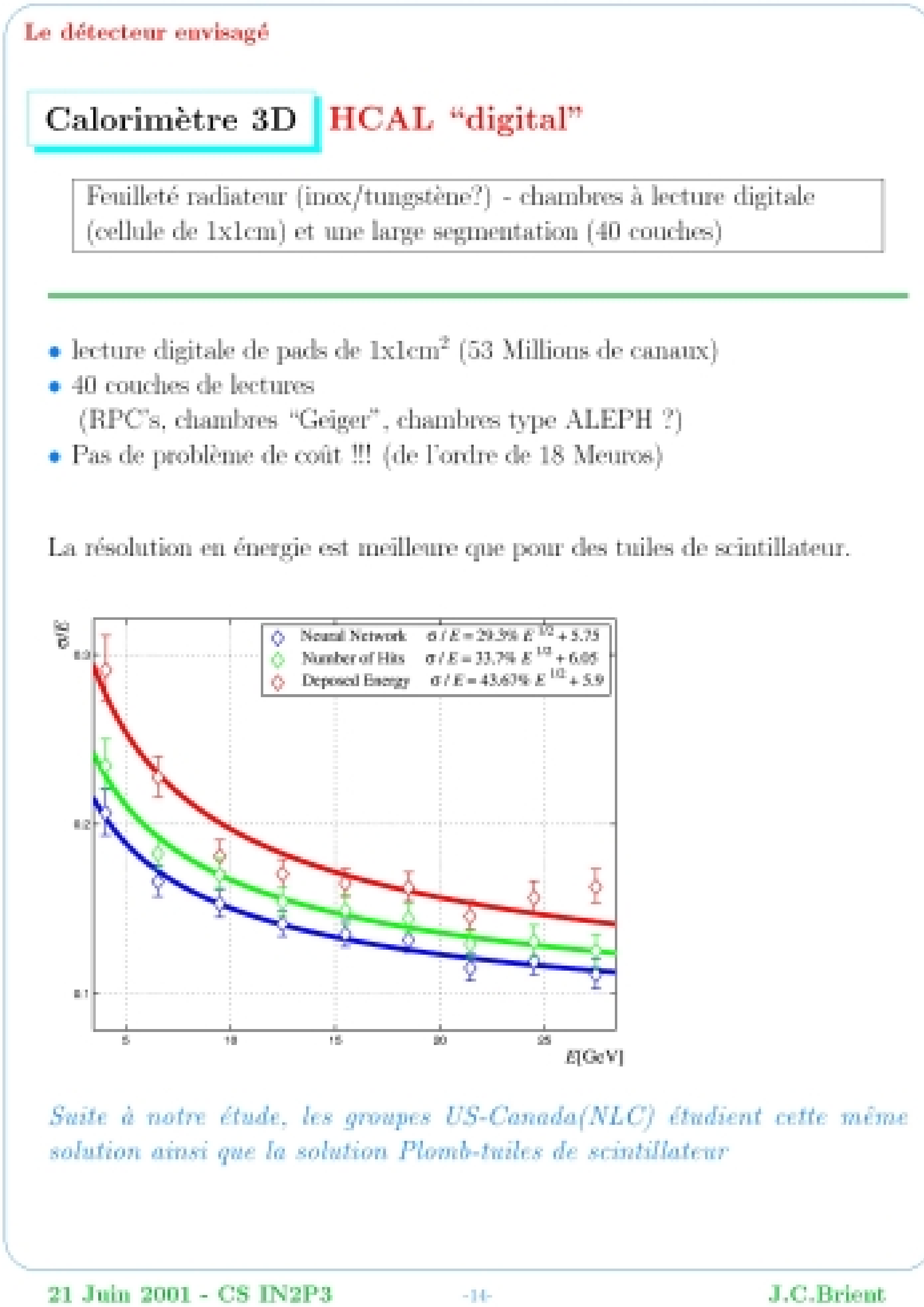
year:... period:..	2001 2/4	2001 3/4	2001 4/4	2002 1/4	2002 2/4	2002 3/4	2002 4/4	2003 1/4	2003 2/4
order material for R+D	x	x							
scintillator-WLS studies	x	x	x						
ROF-light mixer studies	x	x	x						
material procurement for protot.			x	x	x				
DAQ development	x	x	x	x					
tile plates design	x	x							
tile plates assembly				x	x	x			
fiber routing design	x	x	x						
prototype stack design	x	x							
prototype stack product.		x	x						
prototype stack tests				x	x				
photodiode selection	x	x	x	x					
photodiode delivery, tests					x	x			
preamplifier selection	x	x	x	x					
preamplifier delivery, tests				x	x	x			
ADC selection	x	x	x	x					
ADC delivery, tests				x	x	x			
cooled electronic box				x	x				
gain monitoring (LED)	x	x			x	x			
electr. linearity monit.	x	x			x	x			
tile plates test+calibration				x	x	x			
equipment of prototype					x	x			
prototype test with muons						x	x		
beam tests at DESY,ITEP,CERN						x	x	x	x

Table 7: Time schedule for prototype production

•Prototype cost ~ 168 K EUR
• current achievements:
  • engineering study
  •First results on the light collection efficiency
  •First characterisation of different photodetectors

R& D collaboration:
  • DESY
  •Russian teams
  •Prague

HCAL option 2: a “digital” HCAL



- pushed by the French teams
- some interest by DESY and LNF (Marcello Piccolo)
- included in the PRC document but an R&D roadmap still to be defined

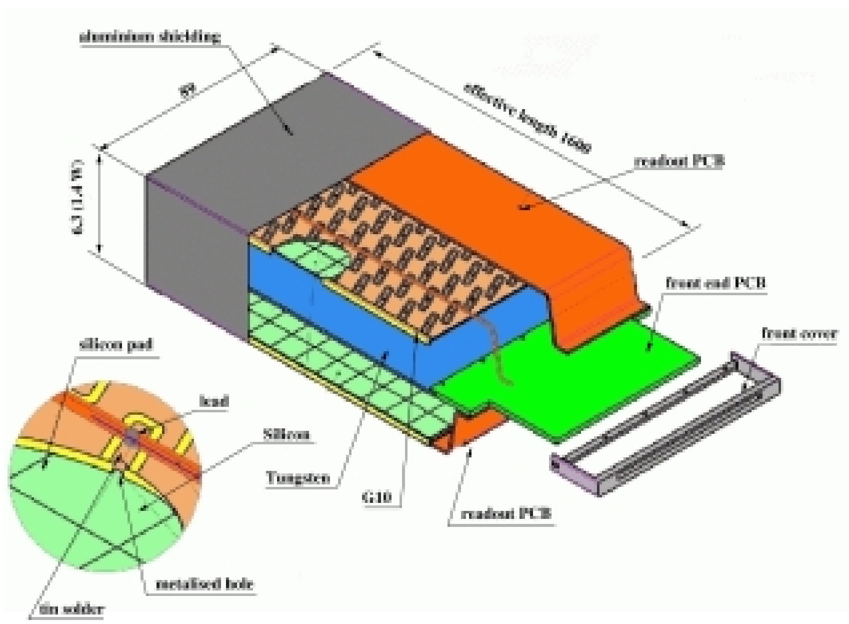
ECAL option 1: a Si/W calorimeter

Main characteristics:

- 24 Xo depth = 30 * 0.4 X + 10*1.2 X,

I.e. a 40-fold longitudinal segmentation in a dR ~ 20 cm

- modularity 8 in F, no projective geometry
- transverse segmentation corresponding to the 1x1 cm^2 pads:



Total no. channels: 32 * 10^6, for ~ 3000 m^2 of High Resistivity Si

Total cost: ~ 133 M EUR, dominated by the Si cost (70%, assuming 3$/$cm^2$)

<u>(the CRITICAL issues, together with the readout chip dynamic range (2500 mips))</u>

Expected performances:

Photon reconstruction efficiency

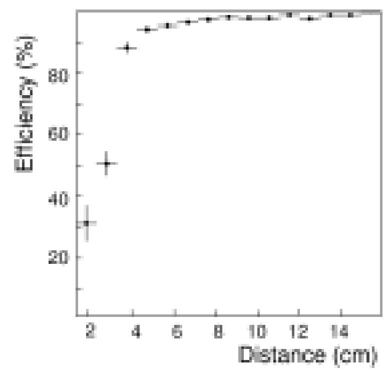


Figure 6: Photon reconstruction efficiency as a function of the distance to the charged track with PFD algorithm.

Neutral hadron reconstruction efficiency

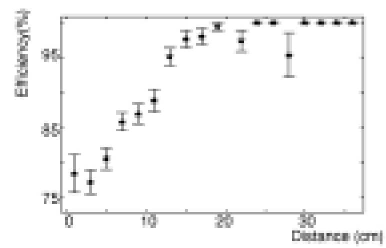


Figure 7: Neutral hadron efficiency as a function of distance from the charged hadron

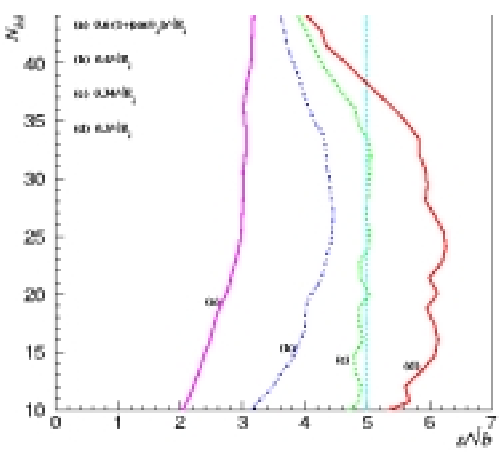


Figure 19: Number of expected $e^+e^- \to hhZ \to 6$ jets as a function of the figure of merit defined as $s/\sqrt{b}$, for different choices of ENERGY FLOW jet resolutions; m_h=120 GeV/c^2 and an integrated luminosity of 1000 fb^{-1} have been assumed.

Resolution on the jet energy:

~ 35% / sqrt(E)

R&D plans:

- roadmap

3 months period →	2001 2/4	2001 3/4	2001 4/4	2002 1/4	2002 2/4	2002 3/4	2002 4/4	2003 1/4	2003 2/4
Tungsten/alloy selection	x								
Structure construction		x	x	x					
R&D Si. matrices	x	x	x						
R&D AC coupling	x	x	x						
First run Si. prod.		x	x						
Final run Si. prod.				x	x				
Si matrices packaging					x	x	x		
R&D readout line/PCB		x	x	x					
Detect. slab construction					x	x	x		
Readout elec. design	x	x	x	x					
Front-end/PCB production					x	x	x	x	
Overall readout prod.						x	x	x	
Overall readout test						x	x	x	
DAQ design			x	x	x				
DAQ production/test						x	x	x	x
Test with cosmics								x	x
Installation in beam hall									x

Table 3: Proposed agenda for the W-Si ECAL physics prototype

- prototyping cost

	2001	2002	2003
Mechanics	25K€	15K€	15K€
Electronics	35K€	35K€	35K€
Silicon Packaging	20K€	20K€	25K€
Prototype mechanics	40K€	20K€	-
Prototype silicon	45K€	45K€	-
Prototype read-out	30K€	70 K€	-
TOTAL	195K€	205K€	75 K€

Table 4: W-Si ECAL cost estimate for each part of the R & D.

- current achievements:
    - engineering design
    - software development
    - preliminary design of the VLSI readout chip

R&D collaboration:

- Ecole Polytechnique, LAL, Paris VI-VII
- Prague
- Russian teams

ECAL option 2: a Shashlik calorimeter

Main characteristics:

- 24 Xo depth = 140 layers of 1 mm Pb + 1 mm scintillator (CELL)
- transverse segmentation 3 x 3 cm^2
- longitudinal segmentation 2, relying on scintillators with Different decay time

A module, made out Of 3x6 cells

21x2 modules Arranged in z in a Pointing geometry

56 modularity In F

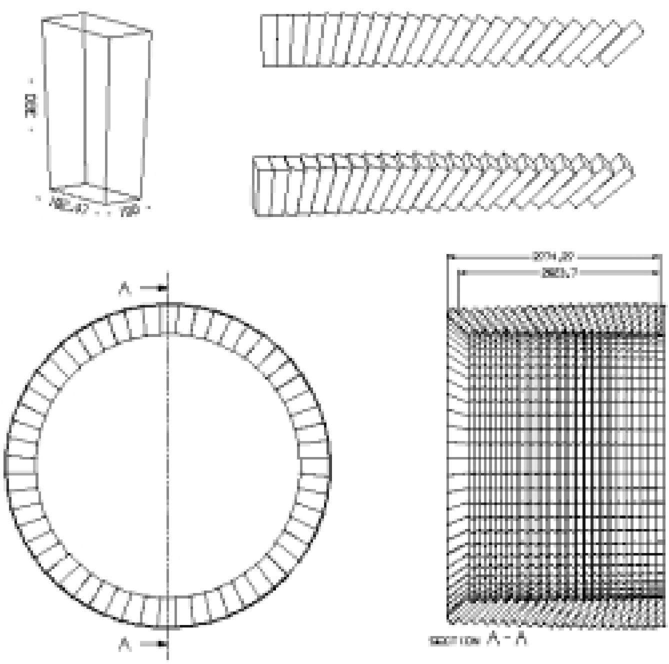
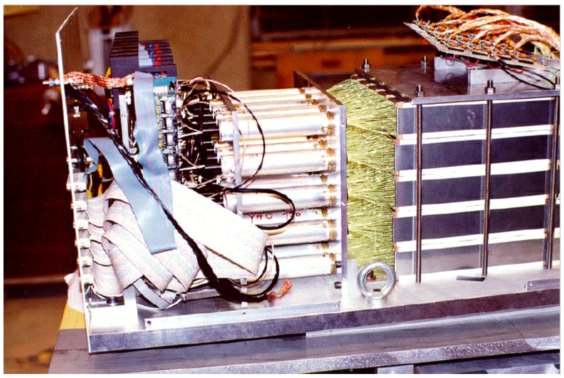


Figure 3.3.1: *Module, Row of modules (top) , and layout of the barrel part of the calorimeter (bottom).*

MOST critical issue: poor longitudinal segmentation

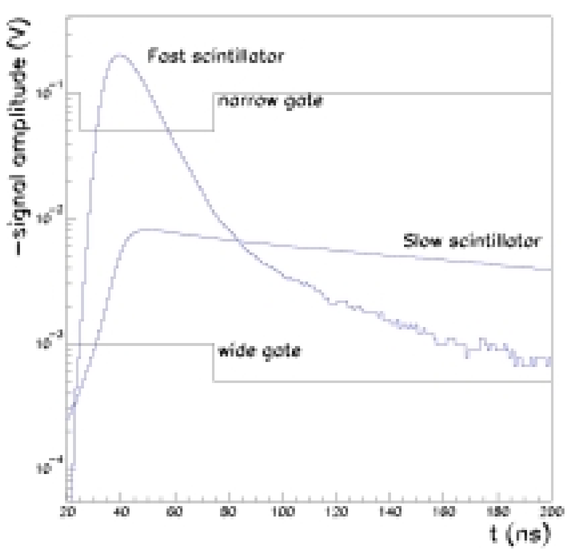
R&D completed by a Padova, Bologna, Milano, Serpukhov and CERN collaboration:

- time development: 1998-2000
- funded by INFN, for a global budget of ~ 70 kEUR (CALEIDO)
- characteristics of the prototype II:

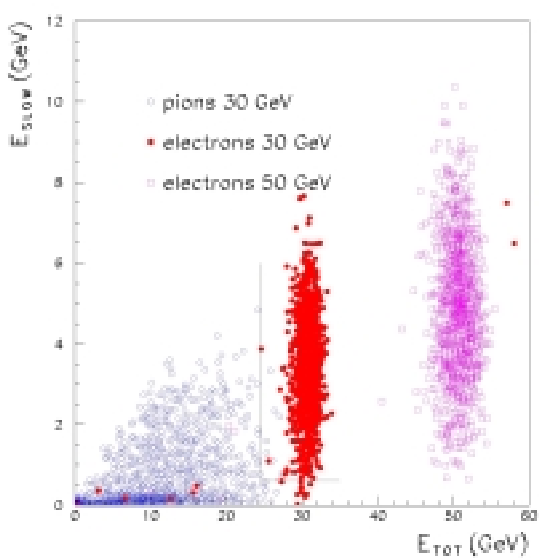


- 9 “towers” arranged in a 3x3 matrix
- each tower consists of:
    - 29 layers of 1 mm Pb + 1 mm Thick “slow” scintillator (250 ns)
    - 100 layers of Pb + “fast” Scintillator (< 10 ns)
- WLS fibres collect the scintillation light, Routed to the photodetectors (PM)

- main results:



Fast vs slow light yield



e / π contamination ~ 2 x 10-3 @ 30 GeV

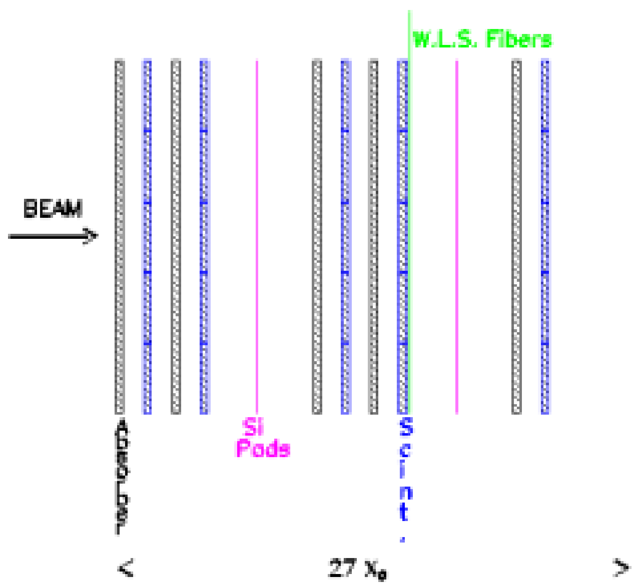
Energy resolution: $\sigma_E/E = 14\% / \sqrt{(E)} \oplus 0.6\%$

ECAL option 3: a W/Si/Tile calorimeter

Basic concept: optimize the cost of granularity, relying on

- scintillator tiles for the energy measurements
- Silicon planes for the shower profile reconstruction

A “learn by doing” approach leads to the following prototype design:



- 50 layers of Pb (W) absorber, having dimensions of 25 x 25 x 0.3 (0.2) cm^3
- 50 layers of scintillators, having the light read out by WLS + clear fibres “a’ la tile HCAL” (tile dimensions 5 x 5 x 0.3 cm^3)
- 3 Si planes, with ~ 1 x 1 cm^2 pads, at 2, 6, 12 Xo

- Total depth of the prototype: 27 Xo

The R&D is ongoing

- lead by a Padova/Frascati/Uni. Insubria at Como collaboration
- Funded by INFN (LCCAL) with ~ 23 k EUR in 2001 and
  ~ 17 k EUR in 2002

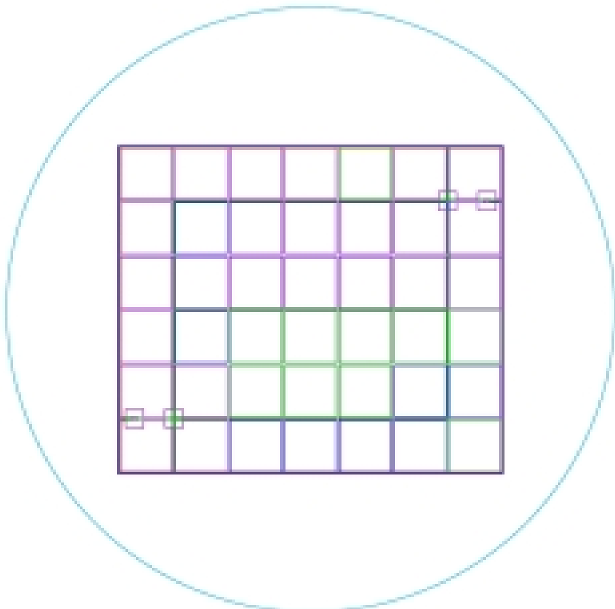
Recent Achievements:

Light optimization

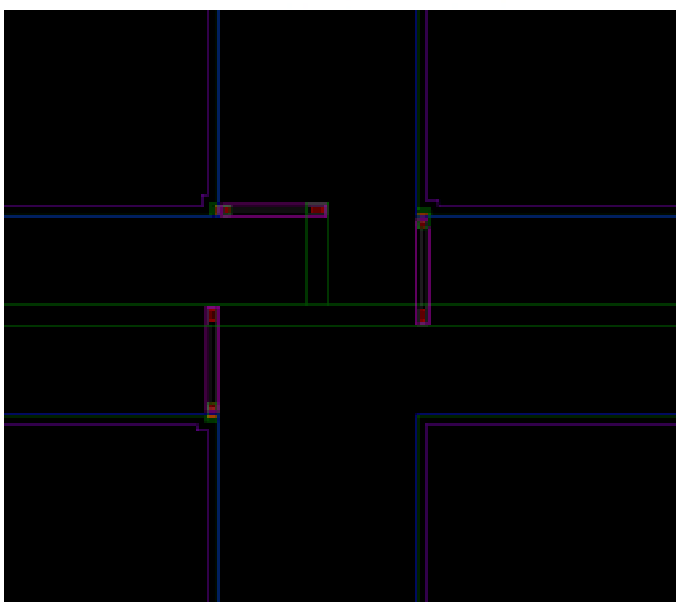
Scintillation light transported with WLS fibers

- 3 mm scintillator planes
- separation in 5×5 cm^2 tiles obtained by grooves
- two possible paths for the fiber inside the scintillator
- start light output measurement
- join the HCAL-project/INTAS-proposal
- first idea:
  scintillator planes/fibers provided by industry

• Silicon detectors design completed; first batch expected in ~ 2-3 weeks



A sketch of the
Wafer layout, being
Processed at IET (Poland)

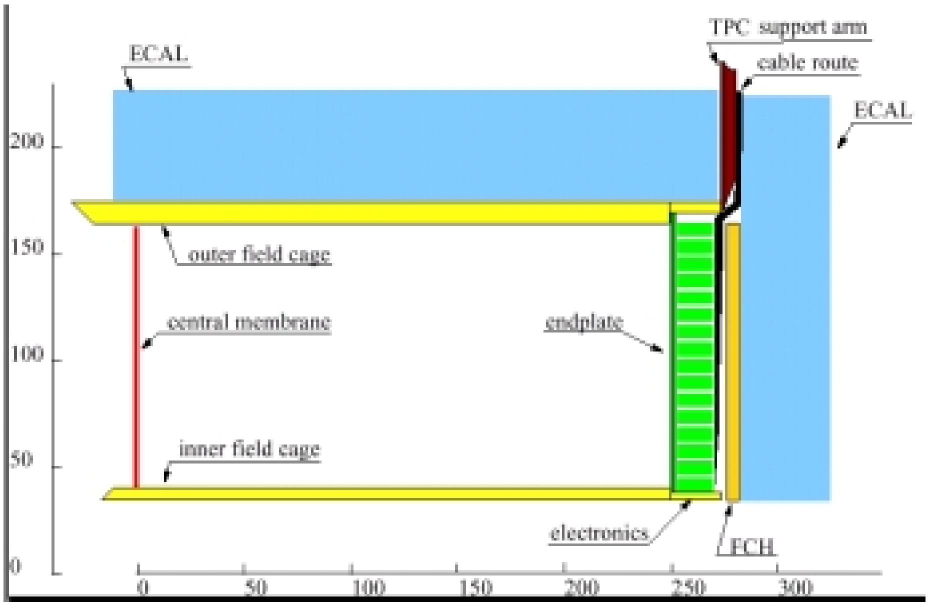


A blow up of a 4 pixel
Corner, showing the
Bias grid & poly resistors

• VA_HDR4 (9) chips by IDEas, with 200 mips dynamic range,
have been characterised and ordered
• design of the PCB ongoing

Assembly completed and tested
On a beam @ Frascati and DESY in 2002

The Time Projection Chamber



Main characteristics:

TPC	
Mechanical radii	320 mm inner, 1700 mm outer
Overall length	2 × 2730 mm
Radii of sensitive volume	362 mm inner, 1618 mm outer
Length of sensitive volume	2 × 2500mm
Weight	∼ 4 t
Gas volume	38 m^3
Radiation length	∼ 0.03 X_0 to outer field cage

Key performances:

	Drift distance 10 cm	Drift distance 200 cm
r-ϕ –resolution	70 μm	190 μm
z –resolution	0.6 mm	1 mm
double pulse resolution in r-ϕ	$\leq$ 2.3 mm	
double pulse resolution in z	$\leq$ 10 mm	
dE/dx resolution	4.3% for 200 pad rows	
π–K separation	$> 2\sigma$ between 2 and 20 GeV/c	
momentum resolution ($\lvert\cos\theta\rvert < 0.75$)	1.4×10^{-4} $(\mathrm{GeV/c})^{-1}$	
momentum resolution ($\lvert\cos\theta\rvert \approx 0.90$)	3.2×10^{-4} $(\mathrm{GeV/c})^{-1}$	

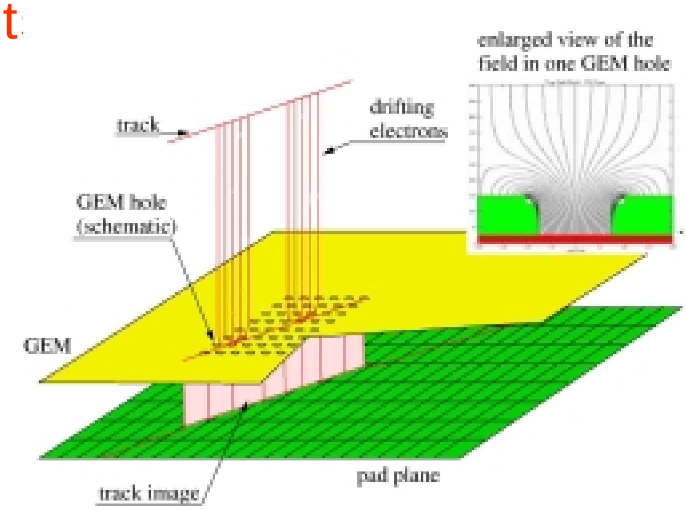
R&D plan:

Topic	Aachen	Berkeley	DESY / Hamburg	Karlsruhe	Krakow	MIT	MPI-Munich	NIKHEF	Novosibirsk	Orsay / Saclay	Ottawa / Montreal	Rostock
MPGD development	G			G					G	M		
MPGD operation	G	B	G	G					G	M	B	
MPGD charge pickup		B	G							M	B	
Si readout								G				
MPGD ageing				G		G				M		
MPGD tower			G							M		
MPGD ion feedback	G		G	G					G	M	B	
MPGD B-field behaviour			G	G						M		
MPGD 2-track resolution			G							M		
Gas studies					B	G	B			M		
Electronics		B					B					B
Endplate Design		B	G				B			M		
Cooling		B					B					
Mechanics			G				B			M		
Fieldcage design			B				B					
Calibration												
- MPGD Simulation	G									M	B	
- Pad simulation			G							M	B	
- Calibration			G				B	B		M		
- Laser		B					B					
Software			G							M		

- MPGD = micropattern gas detector
- G = GEM oriented development
- M = MICROMEGA oriented development
- B = fields independent of the MPGD technology

Current achievement

Tests on the GEM Readout at DESY

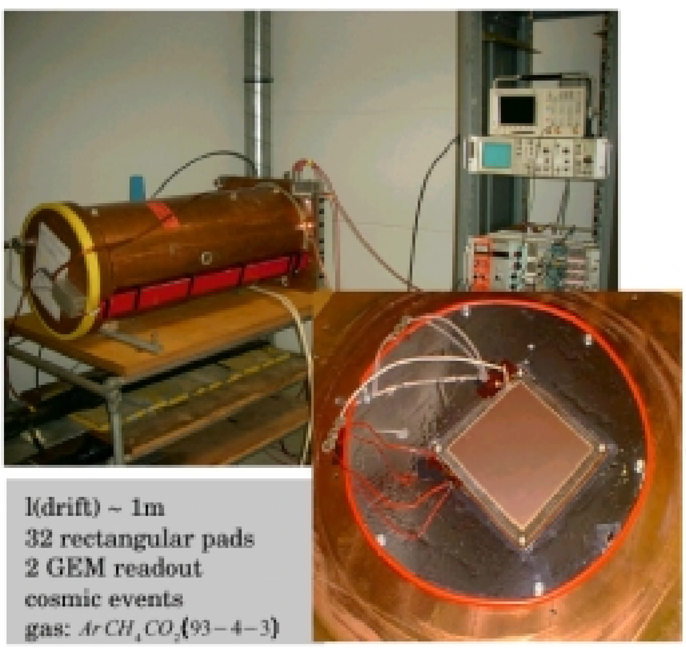


At DESY

Protoype Results

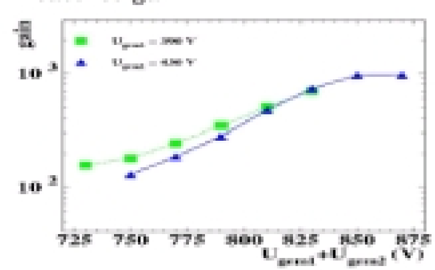
TPC prototype equipped with GEM readout exists in Hamburg

Thanks to Ron Settles for providing the TPC fieldcage

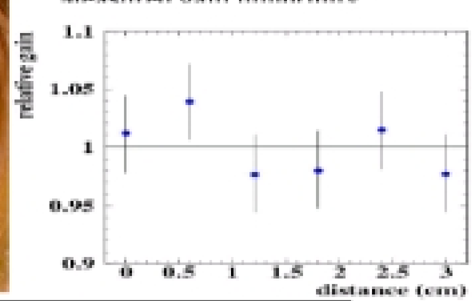


l(drift) ~ 1m
32 rectangular pads
2 GEM readout
cosmic events
gas: $Ar\,CH_4\,CO_2$(93−4−3)

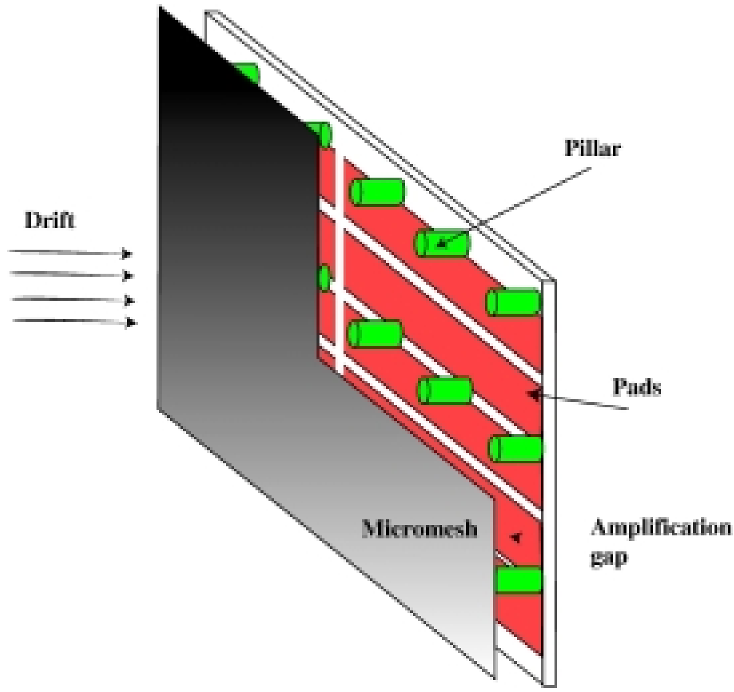
Measured gain



Measured gain uniformity



Tests on MICROMEGAS at Saclay:



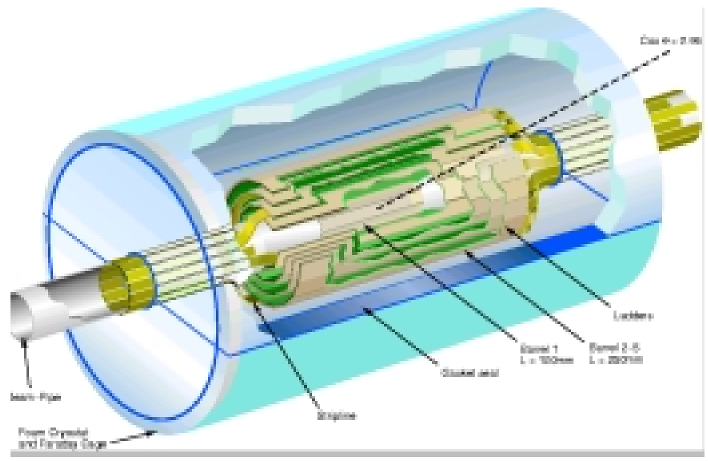
Summary:

- Construction of a small TPC (30 channels, 16cm drift length), HV tests and observation of mesh signals with ^{55}Fe and ^{90}Sr sources
- Measurements of drift velocities with a laser (see case of Ar-CF_4) (P.C., A. Delbart, J. Derré, I. Giomataris, F. Jeanneau, V. Lepeltier, I. Papadopoulos, Ph. Rebourgeard, Vienne conf., Jan 2001)
- Measurement of ion current in progress
- measurement of aging with Ar-CF4 foreseen
- several ideas to improve the point resolution

VD options 1&2: monolithic pixels (CCD or CMOS)

Main characteristics:

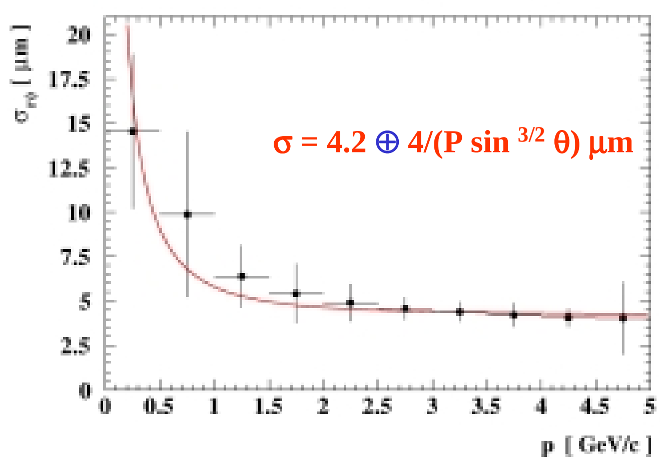
Layout for the CCD option (0.06% Xo / layer)



Layer	Radius	CCD L×W	CCD size	Ladders & CCDs/lddr	Row clock fcy & Readout time	Bgd occup.	Integr. bgd
	mm	mm^2	Mpix			$Hits/mm^2$	khits/Train
1	15	100×13	3.3	8/1	50 MHz/50 μs	4.3	761
2	26	125×22	6.9	8/2	25 MHz/250 μs	2.4	367
3	37	125×22	6.9	12/2	25 MHz/250 μs	0.6	141
4	48	125×22	6.9	16/2	25 MHz/250 μs	0.1	28
5	60	125×22	6.9	20/2	25 MHz/250 μs	0.1	28

Table 2.1.1: *Key parameters of the CCD-based vertex detector design. The penultimate column lists the background occupancy integrated over the individual data read out time per layer.*

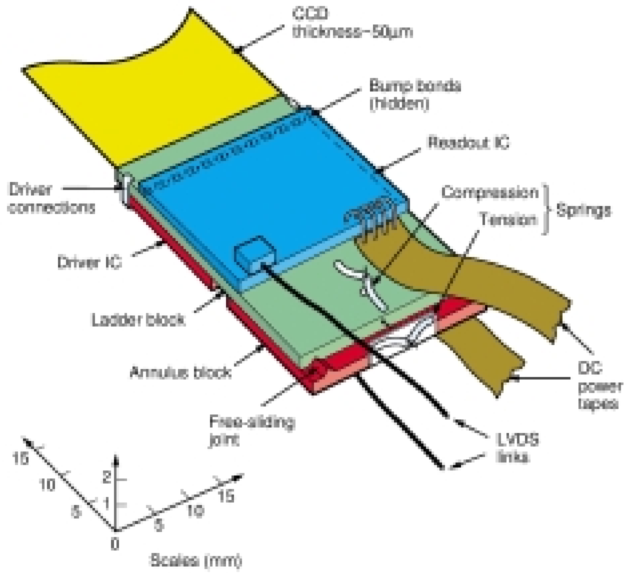
Impact parameter Resolution:



The R&D on CCD is addressing the 3 critical issues:

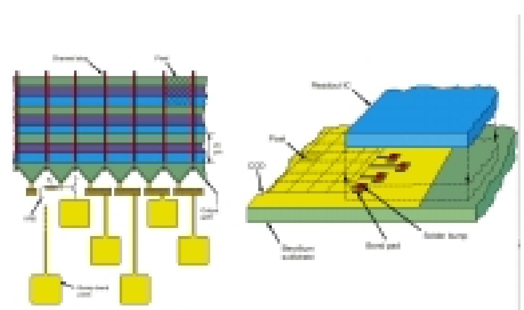
• reduction of the material budget:

“unsupported”
Silicon option



• improving the radiation hardness (~ 10^9 n/cm^2/year)

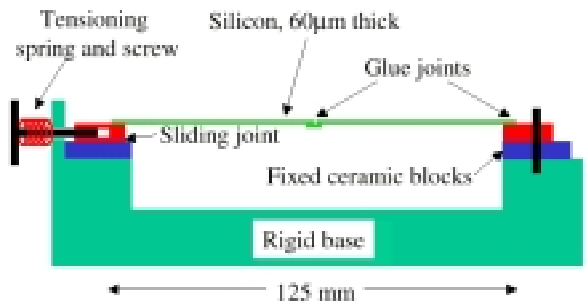
• improving the readout speed moving to a parallel column readout
Clocked at 50 MHz



Current results by the LCFI collaboration
(Bristol, Glasgow, Lancaster, Liverpool, Oxford and RAL):

• on unsupported Silicon:

Sagitta ~ 3 µm
For a tension > 1.5 N



• For various tensions, repeatedly disturb, measure sagitta using ATLAS SmartScope.

• preliminary satisfactory tests on the radiation hardness
• fast readout:
  • CCD layout optimization by SPICE modelling
  • a VME based 50 MHz drive and readout electronics
  Designed and under construction

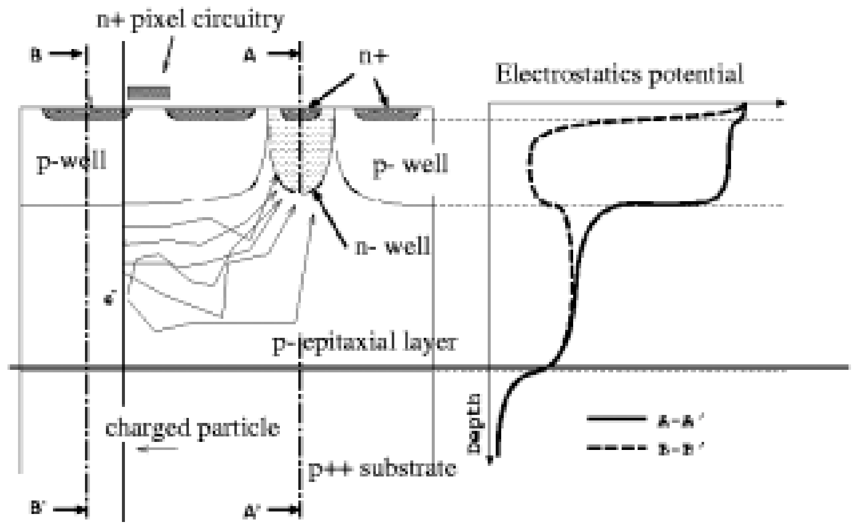
FUTURE PLANS:

• Phase 1: move to parallel column readout with standard clock
And voltages

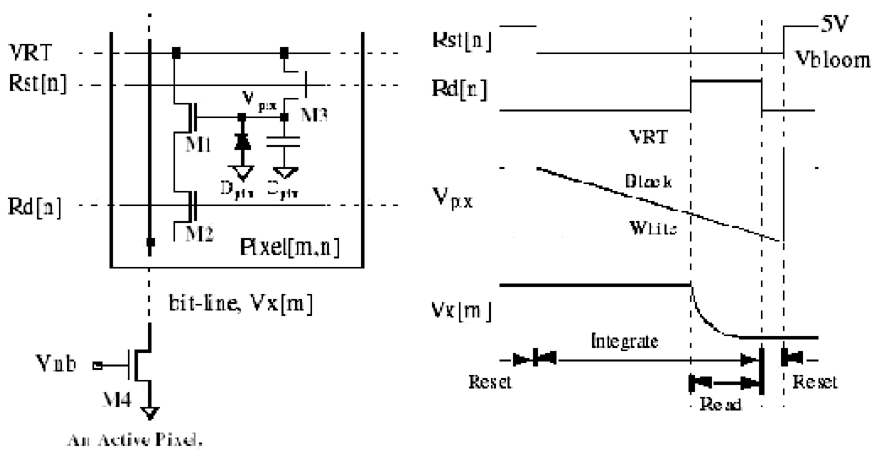
• Phase 2 & 3: increase the readout speed by a factor 100 in two
Steps. Improve the detector modelling

CMOS imager R&D:

basic principle:



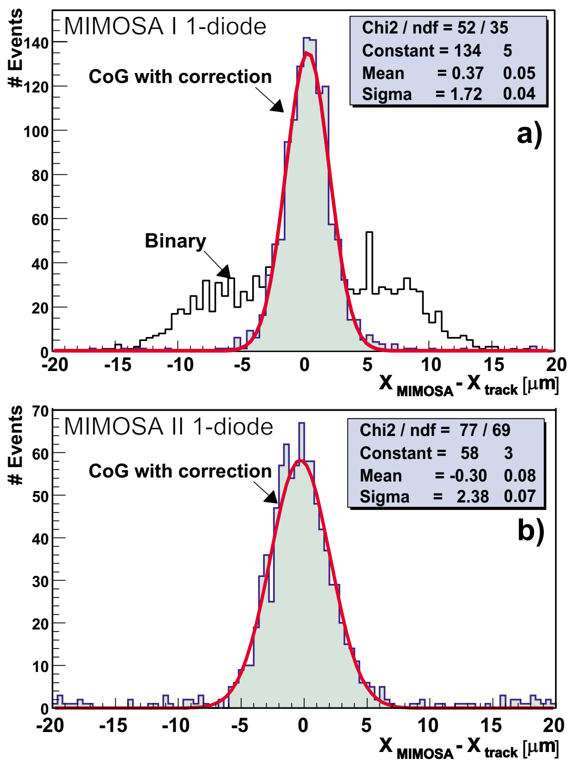
basic cell:



Key issues:

- charge collection efficiency (S/N, cluster size, resolution)
- fixed pattern noise
- readout speed
- radiation hardness
- production of a sensitive device with dimensions > standard Chip size…(the "stitching" problem)

All of these issues are being addressed mostly by the LEPSI team, (including R. Turchetta, now at RAL), Which developed the first prototypes. Current results are extremely promising:



Spatial resolution (μm):

MIMOSA I: 1 diode **<u>1.4+/-0.1</u>**

4 diodes **2.1+/-0.1**

MIMOSA II: 1 diode **2.2+/-0.1**

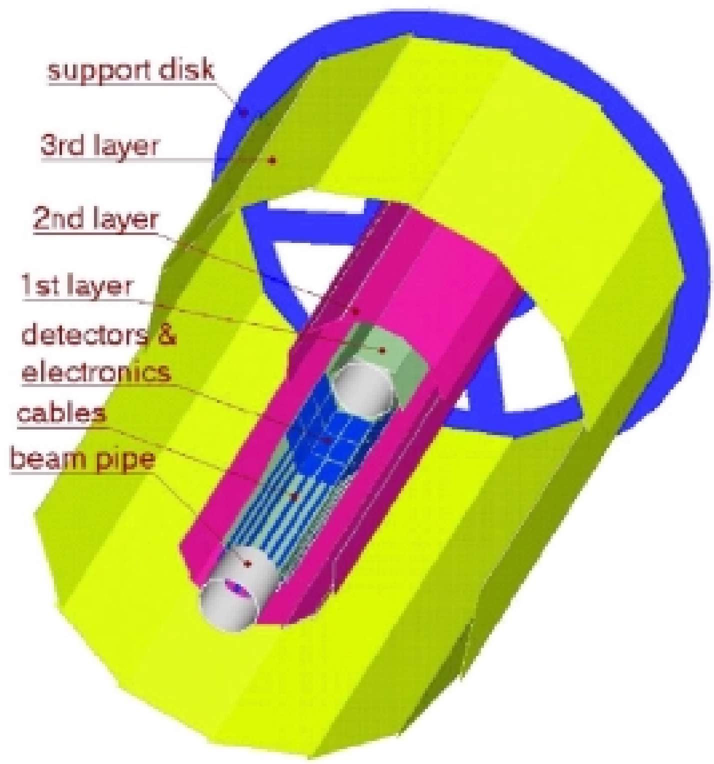
A TESLA oriented R&D project is being defined, lead by LEPSI and RAL

VD options : hybrid pixels

General layout:

• 3 layers (1.5, 3, 10 cm radii)
• cones "a' la DELPHI",
Complementing the barrel
• +2 layers by the Intermediate
Tracker

MAIN advantage: benefit of the LHC Detector development, in terms of Rad-hardness and readout speed!



Expected performances:

$$\sigma_{ip} = 5.2 \oplus 13/(P \sin^{3/2} \theta)\ \mu m$$

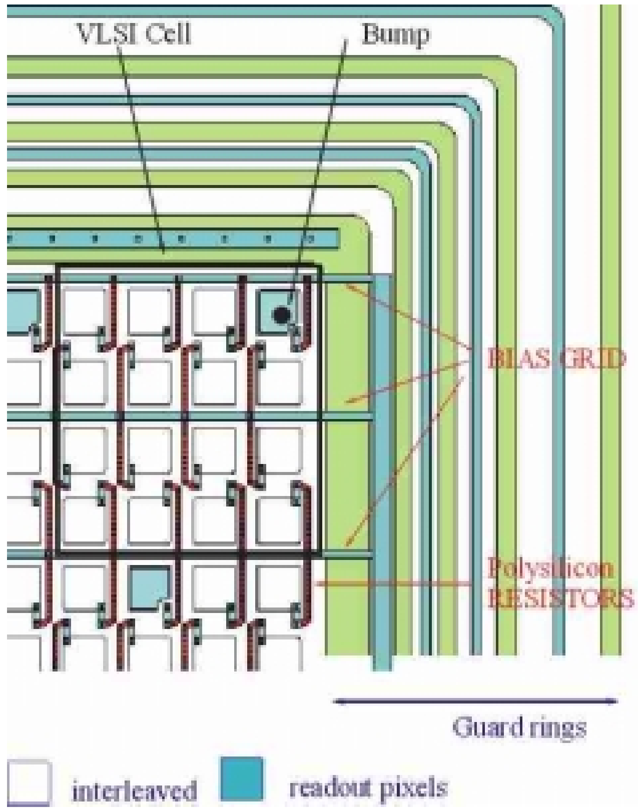
Assuming σ_{point} = 7 μm and 0.37% Xo/layer

Key issues of the R&D:

- **resolution improvement**
- **material budget reduction**

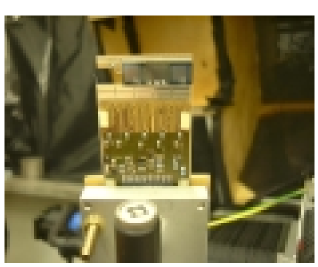
R& D based on a layout with interleaved pixels, developed by
a Milano, Uninsubria at Como, Krakow, Warsaw and Helsinki collaboration:

Prototype 1
Minimum pitch 50 x 50 μm
(readout pitch 200 μ m)

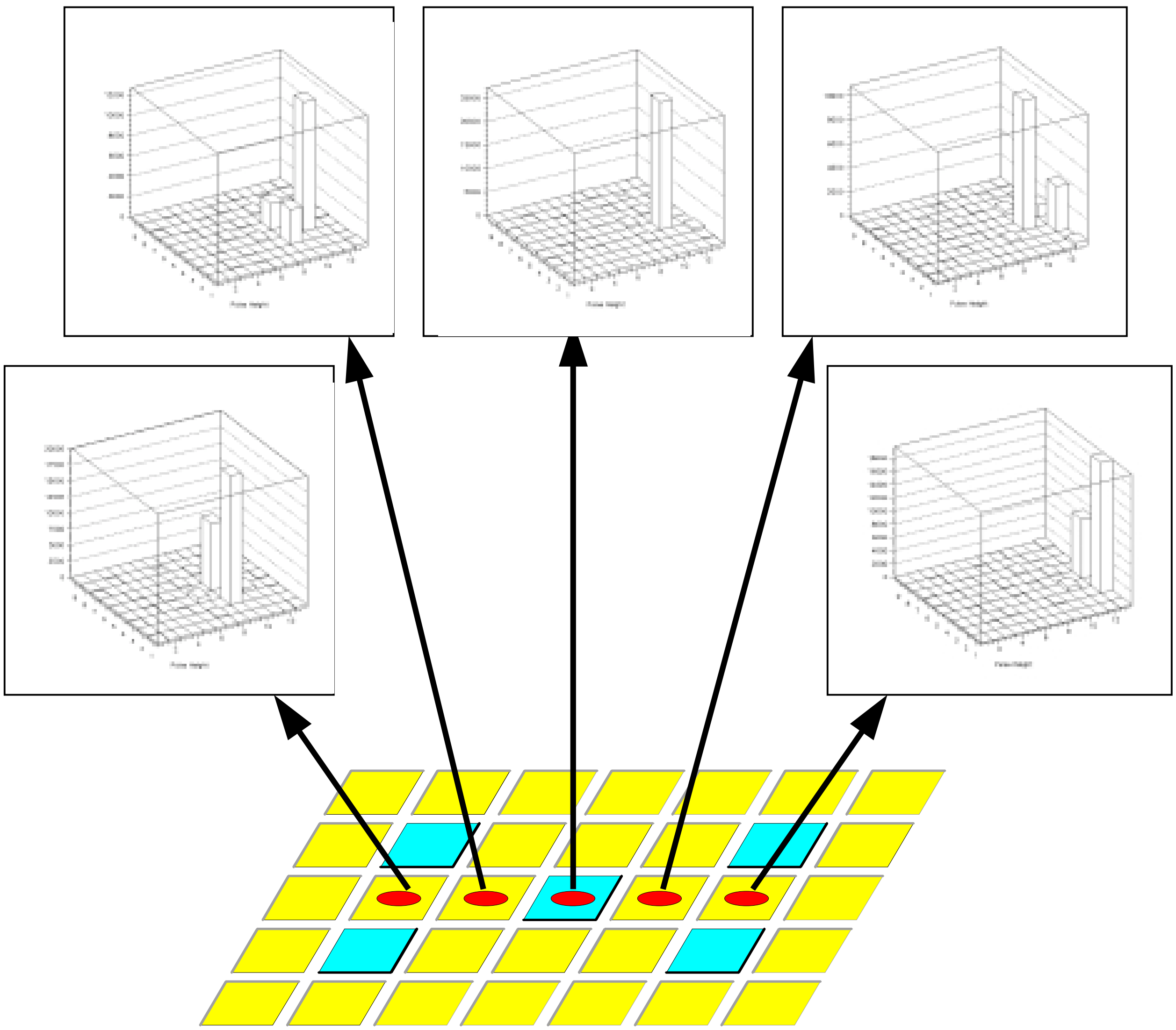


Main steps of the " phase I " project (1998-2000):

- prototypes designed and produced at IET (Warsaw) – delivery jan. 1999
- Electrostatic characterisation (IV & CV) for process qualification
- interpixel capacitance measurements
- simple detector modelling by TOSCA (laplace equation solver)
- charge sharing studies using an IR diode and a wire bonding connection to a Low noise strip detector chip (VA_1, in the BELLE version)



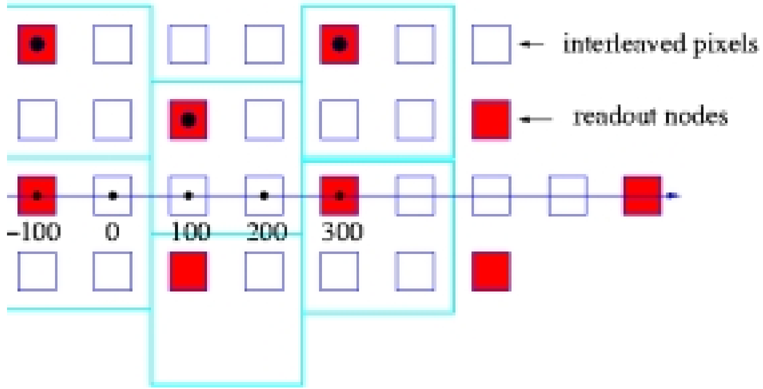
Main results: Capacitive Charge division



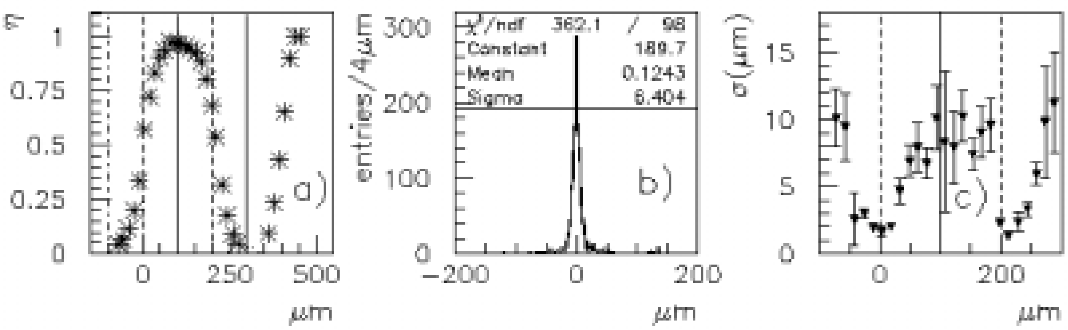
The IR spot was moved across the detector and ~ 1000 event were recorded for each position

Charge collection and resolution studies:

Laser scan path



Eta and resolution



NEXT STEPS:

• prototype II detectors designed, under production (LCCAL wafer periphery, Essentially cost free) with 25 micron pitch and punch through biasing
• repeat the phase I tests
• measure the ultimate resolution
• verify the compatibility of the maximum sampling (max VLSI footprint) with a Realistic design of a dedicated readout chip

Last but not least….

"Description of Work" GROWTH Project GRD2-2000-31832 "SUCIMA" Page 1 of 2 Issued: 12/01/00

COMPETITIVE AND SUSTAINABLE GROWTH (GROWTH) PROGRAMME

Contract for:

Shared-cost RTD

Annex 1 "Description of Work"

Proposal number: *GRD2-2000-31832*
Project acronym: SUCIMA
Project full title: Silicon Ultra fast Cameras for electron and gamma sources in Medical Applications
Duration: 36 Months

Project Co-ordinator: Università degli Studi dell'Insubria

Contractors:

Participant Short Name	Nr.	Organisation Name	Country	Role in the project
UNICO	*1*	*Università degli Studi dell'Insubria, Dipartimento di Scienze Chimiche, Fisiche e Matematiche*	*Italy*	*CO*
UNIVA	*2*	*Università degli Studi dell'Insubria, Dipartimento di Scienze Cliniche e Biologiche*	*Italy*	*CR*
AGH	*3*	*University of Mining and Metallurgy, Department of Electronics*	*Poland*	*CR*
ULP	*4*	*Universite Luise Pasteur, Lab. for Electronics and Instrumentation*	*France*	*CR*
KA	*5*	*Universitaet Karlsruhe, Institute for Experimental Nuclear Physics*	*Germany*	*CR*
ZAG	*6*	*ZAG-ZYCLOTRON AG*	*Germany*	*AC*
EUROTOPE	*7*	*Entwicklungsgesellschaft fuer Isotopentechnologien*	*Germany*	*AC*
INP	*8*	*H.Niewodniczanski Institute of Nuclear Physics*	*Poland*	*CR*
TERA	*9*	*Fondazione per Adroterapia Oncologica*	*Italy*	*CR*
IET	*10*	*Institute of Electron Technology*	*Poland*	*CR*
UNIGE	*11*	*Université de Geneve*	*Switzerland*	*CR*
CNRS-D10	*12*	*Centre National de la Recherche Scientifique*	*France*	*CR*