Summary Talk
11th June 2010
Paula Collins (CERN)

Thank you to the organisers for bringing us to this stunning location with its panoramic views

Too much for my camera lens to take in – luckily as we heard this conference has a lot of experts in stiching techniques…

Thanks also for the nice gifts including this mysterious object

(what is it for? certainly not needed here!)

Summarising a vertex conference

- The location is near a body of water, lake or sea
- Everyone who attends talks, in an informal fashion
- We go on an excursion that is greater or equal than a day
- Lots of music is performed, preferably by the participants
- Good food and wine are very nice, as well as
- Good Jokes

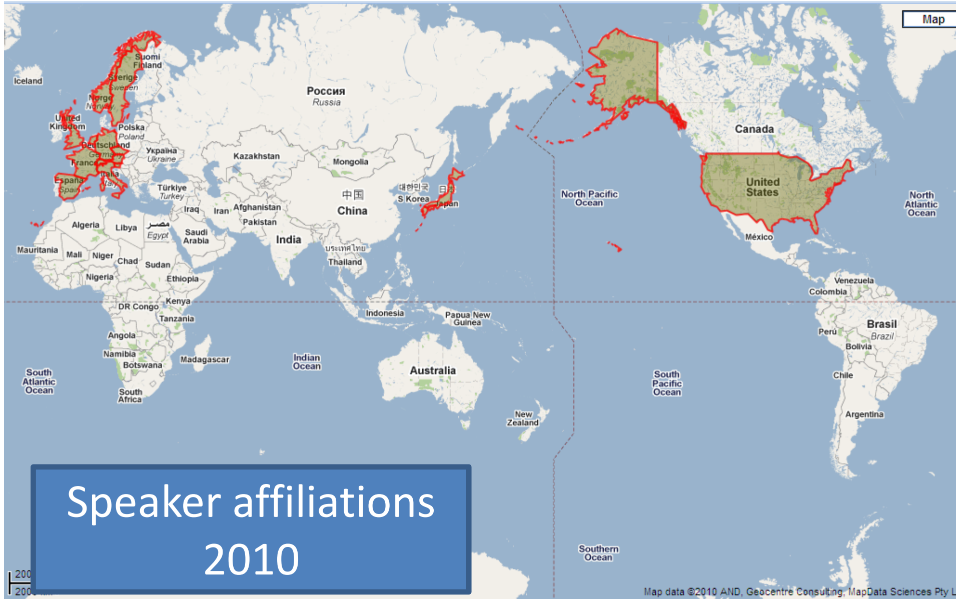
Ronen Mir
Vertex '94

At Loch Lomond we have had a fantastic atmosphere and excellent talks and discussions!

52 talks, (~5 of them summary talks, 8 posters and a whisky tasting)

Great contributions from young researchers and even Lazarus effect.. Contributions from companies highly appreciated

I will not do justice…
Many apologies in advance



Number of acrynyms is going up (Moore's law?)

- mambo III
- fd-soi
- digimaps
- dnw maps
- vipix
- nxyter/cbm-sts-xyter/cbm-trd-xyter
- mimosis
- topix
- pxl
- victr
- slid
- depfet
- dhp/dcd
- tsv/feol/beol
- bpw/bnw

- hizpad
- ihp
- xpad
- intpix
- pixscan
- lucid
- flash
- lpd
- dssc
- lcls
- exfel
- agipd
- scss
- aid
- sdd

- ssd
- eudet
- velo
- malt
- feh
- sei
- spp
- sid
- mimosa
- plume
- serwiete
- timepix
- medipix
- velopix
- clicpix

- soipix
- spd
- elettra
- tbm
- roc1
- fec
- doh
- pAOH
- tec
- tob
- tid
- tib
- fed

Until recently, CMS was a big contributor

- mambo III
- fd-soi
- digimaps
- dnw maps
- vipix
- nxyter/cbm-sts-xyter/cbm-trd-xyter
- mimosis
- topix
- pxl
- victr
- slid
- depfet
- dhp/dcd
- tsv/feol/beol
- bpw/bnw

- hizpad
- ihp
- xpad
- intpix
- pixscan
- lucid
- flash
- lpd
- dssc
- lcls
- exfel
- agipd
- scss
- aid
- sdd

- ssd
- eudet
- velo
- malt
- feh
- sei
- spp
- sid
- mimosa
- plume
- serwiete
- timepix
- medipix
- velopix
- clicpix

- soipix
- spd
- elettra
- tbm
- roc1
- fec
- doh
- pAOH
- tec
- tob
- tid
- tib
- fed

New kid on the block: ATLAS

- mambo III
- fd-soi
- digimaps
- dnw maps
- vipix
- nxyter/cbm-sts-xyter/cbm-trd-xyter
- mimosis
- topix
- pxl
- victr
- slid
- depfet
- dhp/dcd
- tsv/feol/beol
- bpw/dnw

- FEI4_P1
- FEC4_P1
- FETC4_P1
- FE_TC4_P1
- FE_TC4_AE
- FE_TC4_DS
- FE_TC4_DC
- FEC4_P2
- FEC4_P3
- FETC4_A

- hizpad
- ihp
- xpad
- intpix
- pixscan
- lucid
- flash
- lpd
- dssc
- lcls
- exfel
- agipd
- scss
- aid
- sdd

- ssd
- eudet
- velo
- malt
- feh
- sei
- spp
- sid
- mimosa
- plume
- serwiete
- timepix
- medipix
- velopix
- clicpix

- "FEI4-like"

- soipix
- spd
- elettra
- tbm
- roc1
- fec
- doh
- pAOH
- tec
- tob
- tid
- tib
- fed

Comparison with previous conferences - landscape

Cumbria, 2003
Beautiful landscape and typical rain

Loch Lomond, 2010

Beautiful landscape
Who ordered the weather?

Comparison with previous conferences - luxury

Let us know by mail to BRENNER@VXCERN before friday 15.5.1992 if you are interested. Because of limited space a maximum of 30 persons can attend this workshop.

Everybody is welcome to suggest topics for the meeting and prepare a talk. A big paper screen and colour pens will be available for explanations.

We remind you of the primitive circumstances on the island and kindly ask you to bring your own sleepingbag.

Basto Island, Finland 1992

Loch Lomond, Scotland, 2010

"Choose from indulgent en-suite facilities with private saunas or our contemporary styled rooms with smart technology and massaging showers. Select a view towards the conservation village of Luss or a room overlooking the Loch with full height windows that open onto spacious balconies, ideal for enjoying breakfast at sunrise or evening aperitifs at sunset"

Comparison with previous conferences - transportation

Michigan, 2000

Basto Island, 1992

Ein Gedi, 1995

At this conference, you have to go by foot!

Comparison with previous conferences – lakes and volcanos

Ein Gedi swimming, muddy but warm

Loch Lomond swimming, clean…

Hawaii 2003

Iceland's Eyjafjallajokull volcano, 2010
came very close to wrecking the entire conference!

Comparison with previous conferences: Food

Basto Island:
cooked by the participants

Perugia 2006

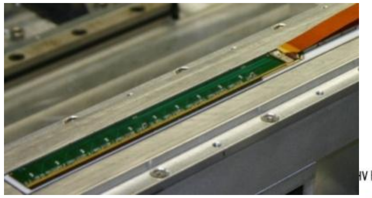
Loch Lomond: gourmet indian

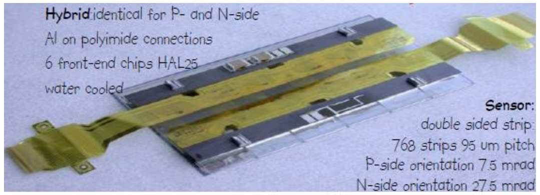
and local cuisine!

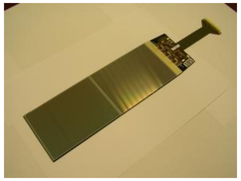
Unfortunately, when the sun came out so did the midges – and this photo of Rosario's hand tells the truth: Italian food is still the best!

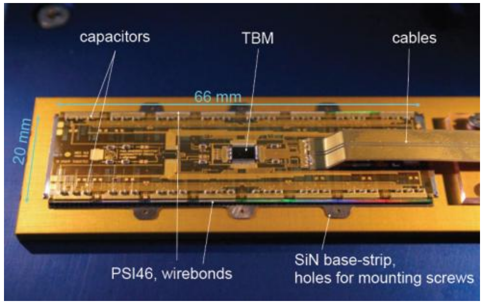

When is she going to start the summary talk?
beats me…

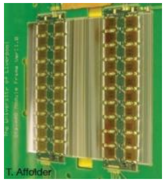
Alan Homna "We know what a module looks like"
Still, the variety seen this week is impressive!

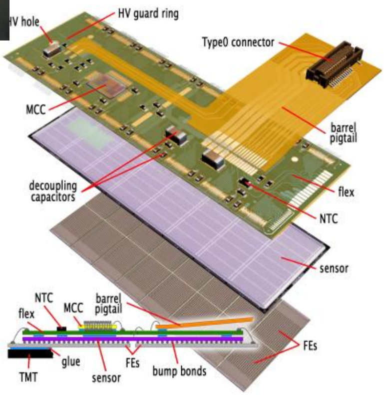


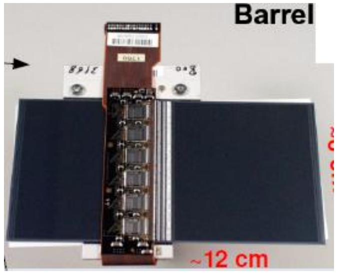


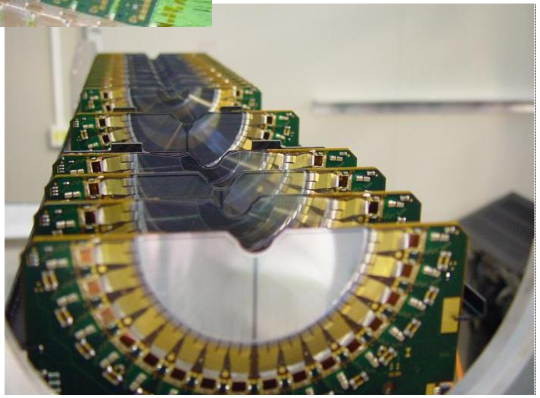


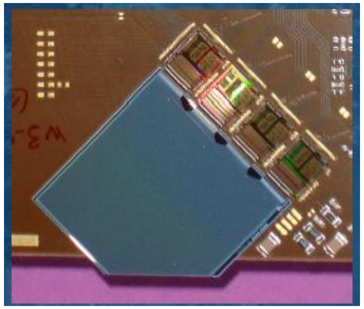


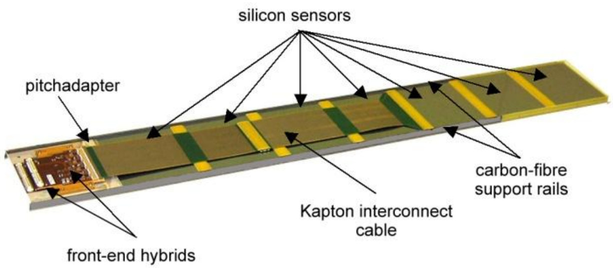






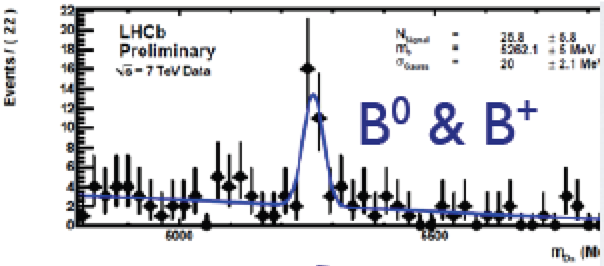




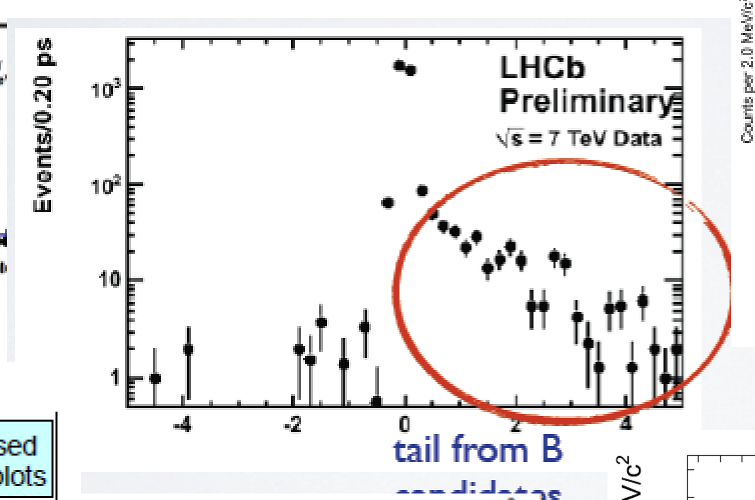


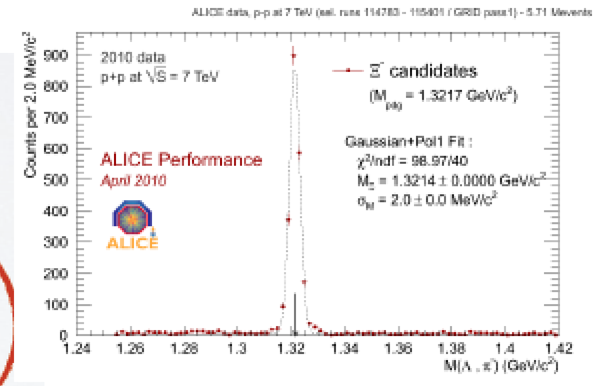
Special honour to give this summary talk: The first conference when LHC is firmly on the map!

Collected data: 10's of inverse nb per expt



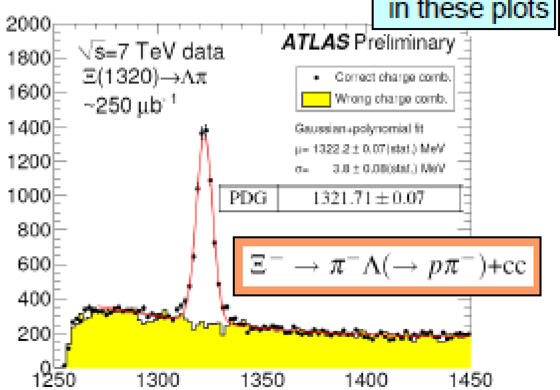
Gersabeck



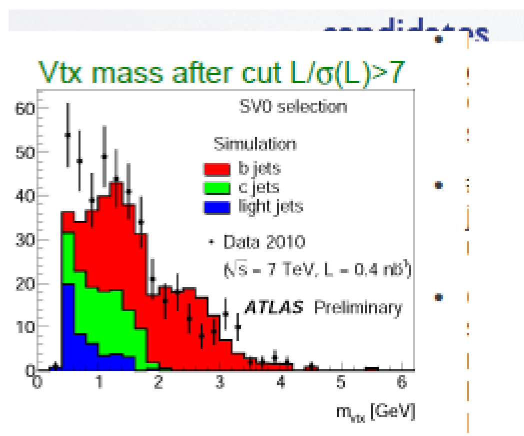


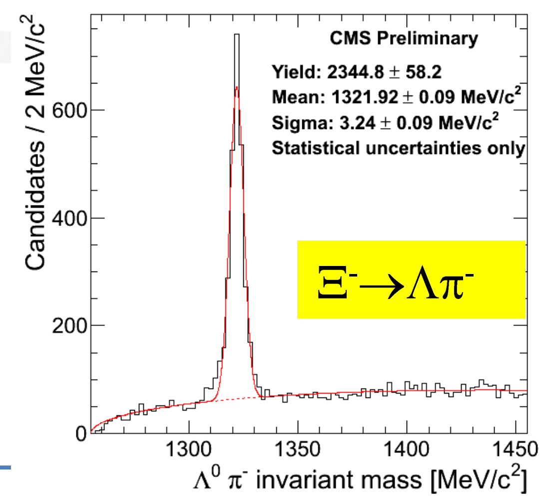
A. Rossi

No MC used in these plots



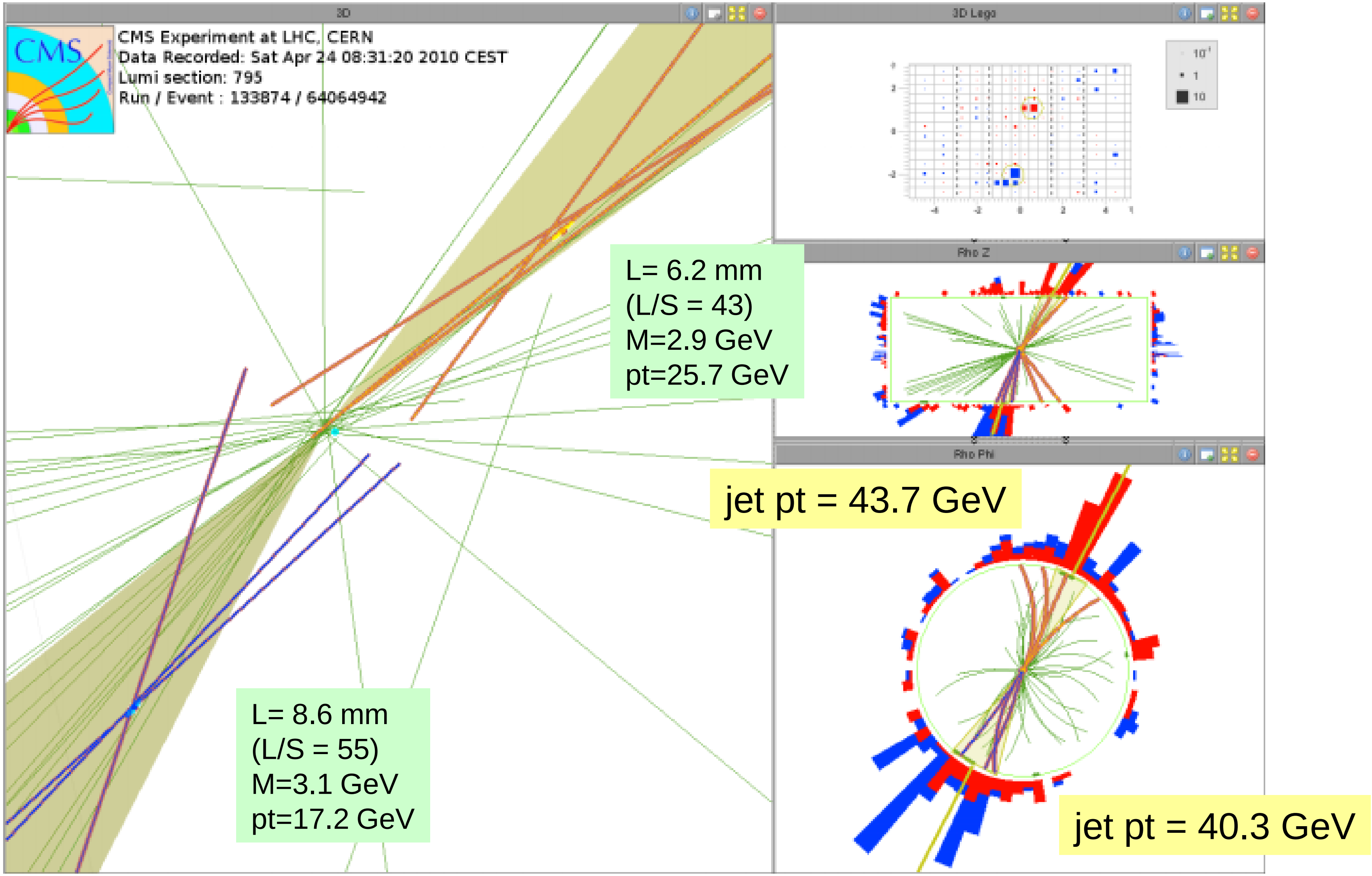
piacquadio





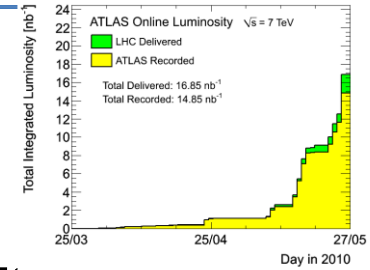
Venturi

CMS Double b-jet candidate (A. Venturi)

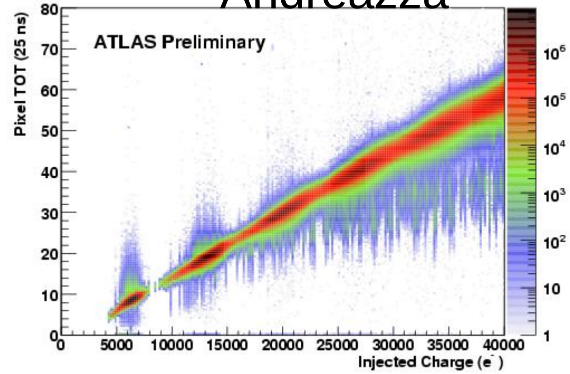


15

Incredible work on calibration, monitoring, and data quality



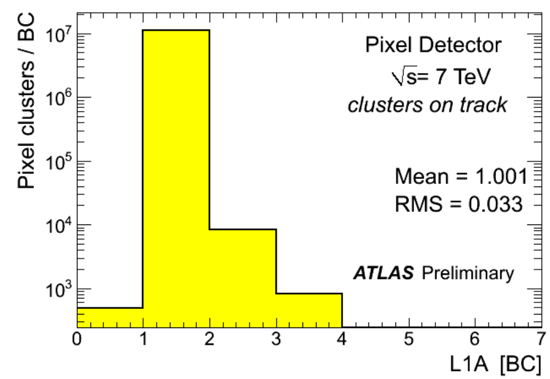
Andreazza

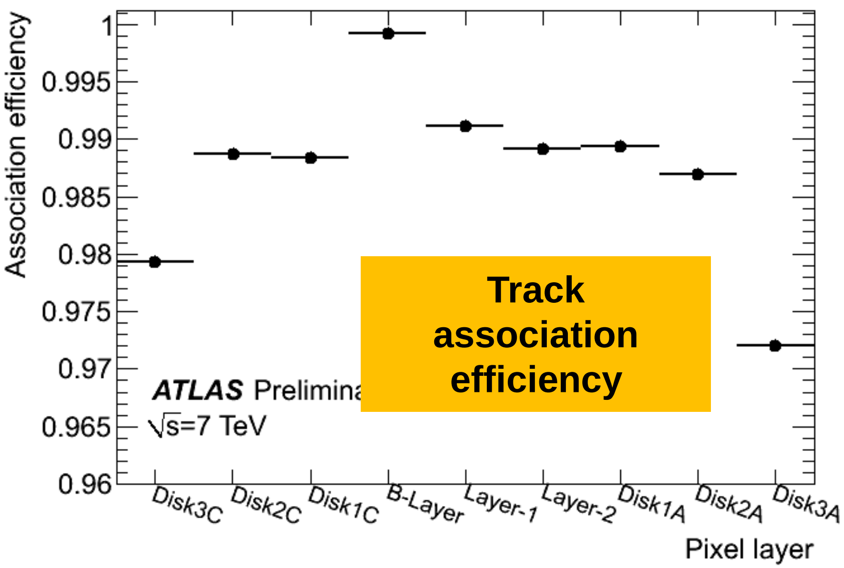


ATLAS pixels achieved thresholds of 3500 with 40 e uniformity and 160 e for pixel noise
Great tot resolution
99.9% of clusters reconstructed in correct beam crossing

Calibrations performed online with physics quality data
Using resonances
Tracking efficiencies, cluster associations

Ibragimov

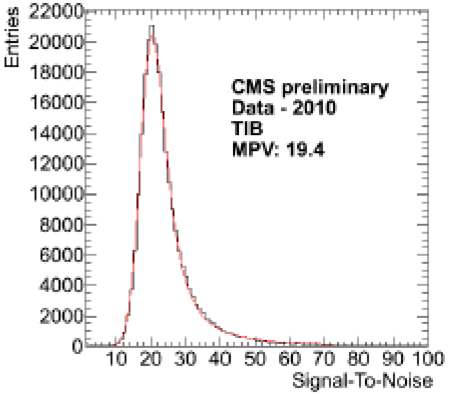


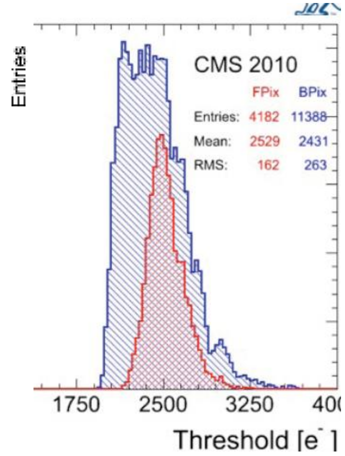


Calibration, Data Quality - CMS

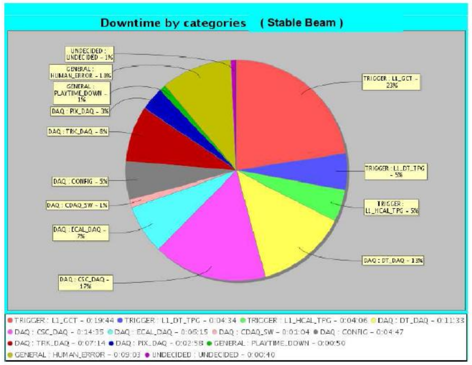
Pixel by pixel ADC to Charge Calibrations
25 DAQs to set, many reoptimised in situ, database issues,
Management pressure, timing
Noise 100-200 e, thresholds 2500 e
98% working (98.8 and 96.4)

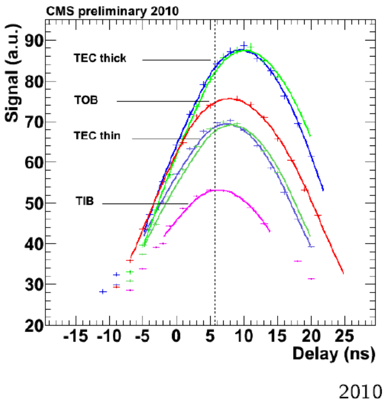
K. Ecklund



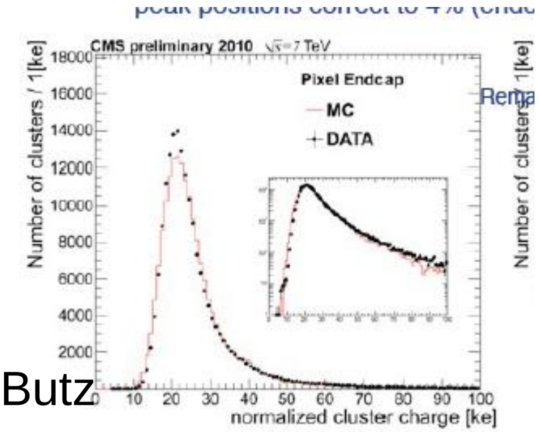


Similar campaign for strips: concentration on gain, timing, and up time
Amazing complementarity with cosmic data taking results





E. Butz



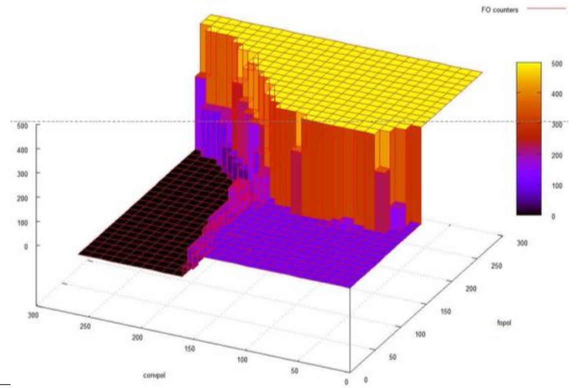
Calibration, Data Quality – ALICE

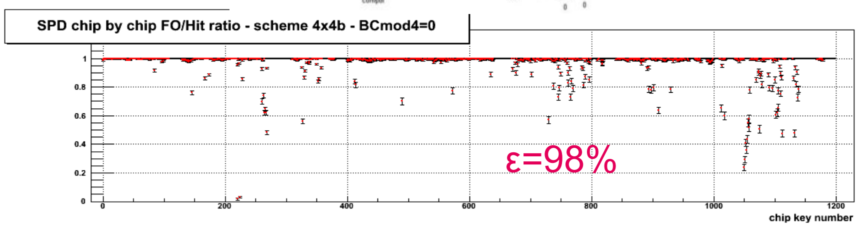
ALICE has online feedback and quasi offline (just after end of run)

Clear all detectors going in this direction, interesting to see how far

ALICE fast-OR trigger tuning (unique trigger input)

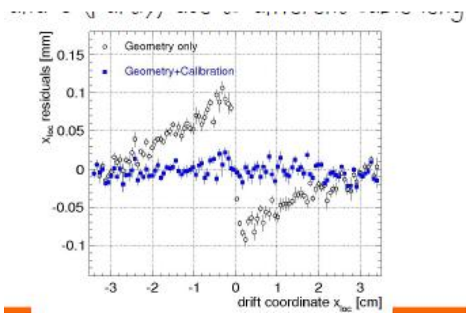
- •Makes use of internal pulser:
  - •every single pixel can be addressed
  - •pulse is sent to: none, one or more pixels (within 12%, i.e. maximum occupancy) to check noise and efficiency in all conditions
- •Tuning possible by 4 (out of 42) 8-bit DAC in each chip + global chip threshold
- •Automatic procedure can go in parallel on all 1200 chips, time required (with optimization) ~4 h (manual procedure: 10×)

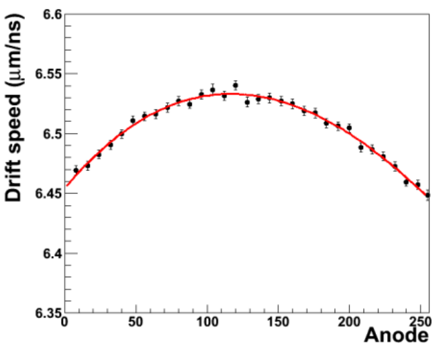




Sdd time

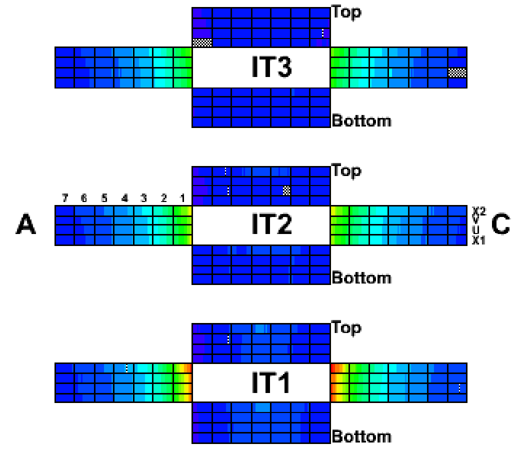
Zero calibration





fopol

Calibration, Data Quality - LHCb



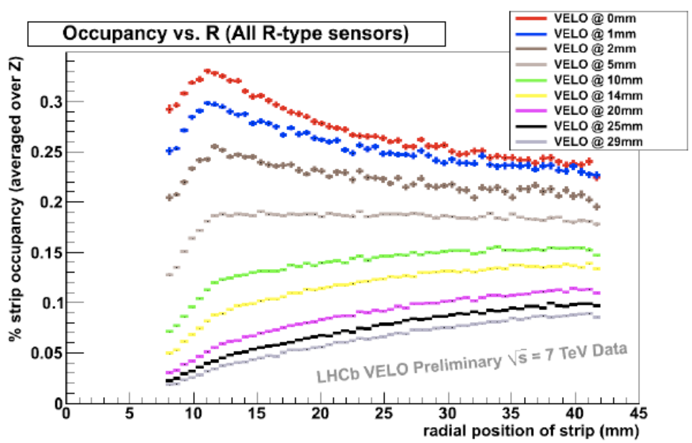
Similar procedure to previous experiments:

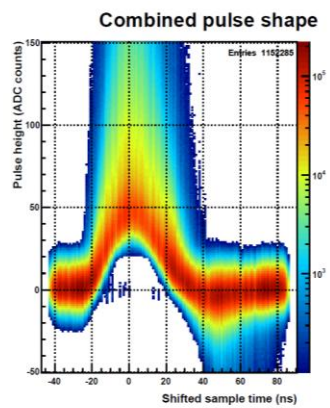
pedestal monitoring and database storage

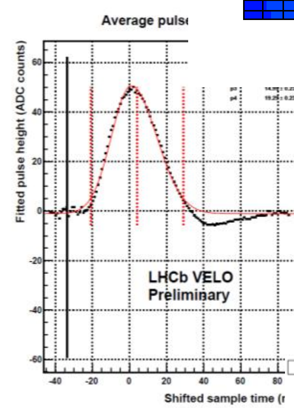
time tuning at ~1ns level per 32 channel li

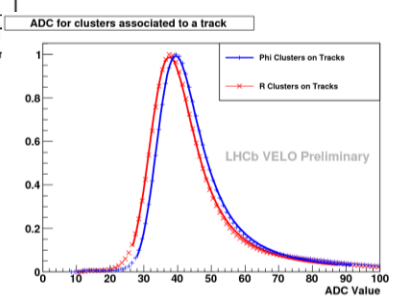
Online cluster map distributions

M. Needham







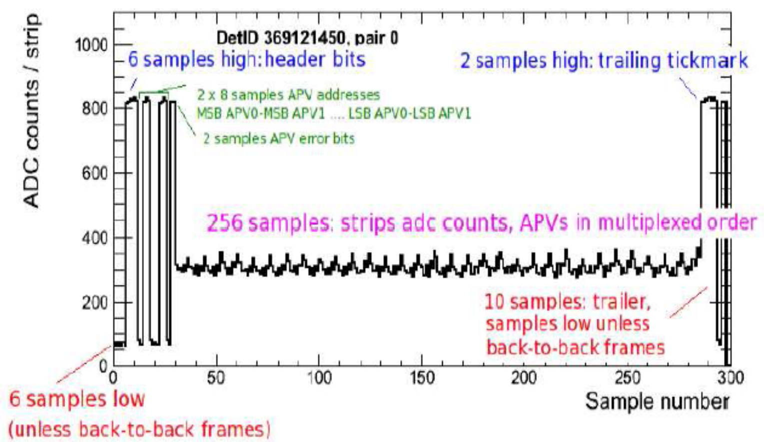


T. Bowcock

More dq – dedicated streams

Express streams for physics quality monitoring
CMS run Spy channels for NZS at rates of ~ Hz
Eliminate separate calibration runs?

Captures full raw-data frame

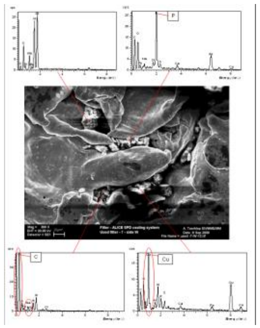


- Provides complete non-zero suppressed data including error bits, etc. . .
- Read at low rate (max 0.3 Hz)

It is very important that we detector lovers take the opportunity now to sort out the problems, before they come back to haunt us! Push for calibration runs, NZS data taking etc.

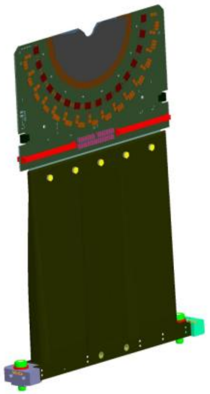
Things going wrong… Thanks for sharing!!

- ALICE: blockages in mixed phase cooling system C4F10
- Mixture of filters, some accessible, some not
- Results in 85% (max 92% efficient system)
- Trimming necessary on pixel power (85% on preamps)
- Analysis performed on a one-year old filter.
- Results and conclusions: “In the used filters several exogenous fragments were located clogging the filter. There were several fragments containing different composition elements. In addition to elements from the Stainless steel, the following traces of elements were found: O, Al, K, C, Sn, Cu, P, Ca, Cu, Na, Cl and Zn.”
- Alice sdd hv or fee problems
- SSD electrical problems, humidity problems in sintef sensors



- ATLAS pixels: small leaks in cooling system,
- TX failures (VCSEL boards)
- “Optical communication between fe and ode must always be subject to very stringent QA”
- ATLAS barrel cooling: decision to run at higher temperature

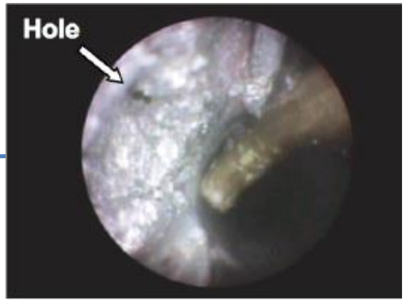
- LHCb:
- Low power VCSELS
- Failing voltage regulators
- Oscillating LV power
- cooling blockage (fixed)
- Not centered around beamspot (open 300 un



- CMS pixels
- HV and LV connection problems: all repaired
- Optical links sensitivity to temperature: all repaired
- Wirebond problem, dead modules

- CDF:
- cooling liquid -> corrosive: partially fixed
- optical interface boards suffer radiation damag
- Some noisy sensors (MICRON)

- TOTEM: Silicon touching foil due to engineering change (fixed)



Is there such a thing as a "Canonical Efficiency" for a HEP silicon detector?

ATLAS pixels 97.2% working
ATLAS strips 99.0% ON

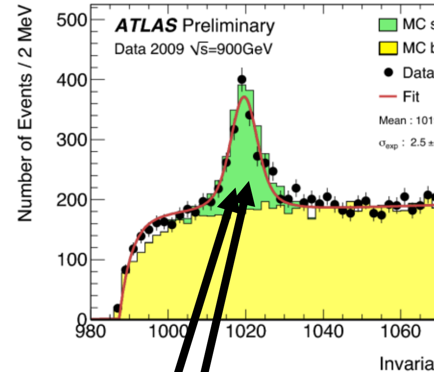
Cms pixels 98% working
Cms strips 98.1 (96.3/98.3/99.1/98.8)

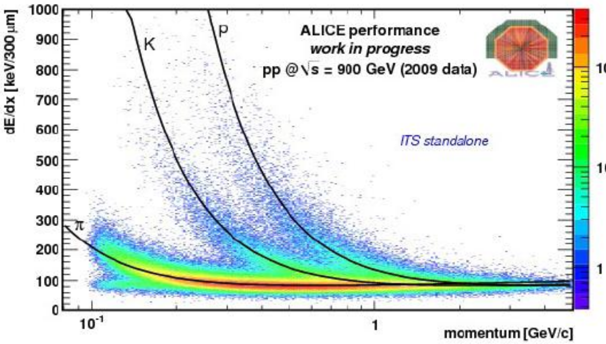
ALICE SSD 92.5% working (99% in good modules)
ALICE SSD 90% channels working
ALICE pixel 85-92% working

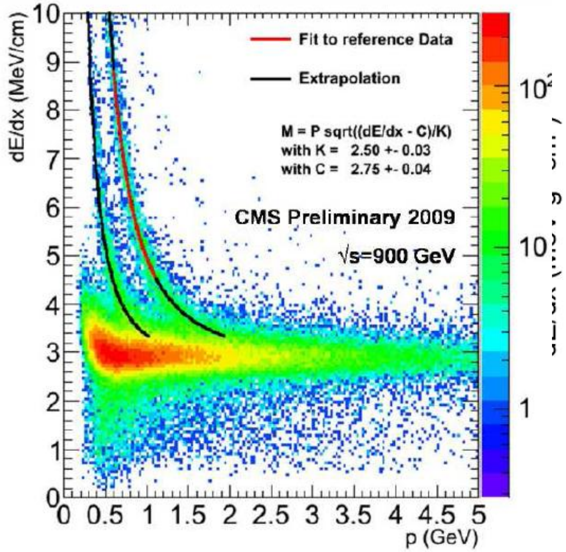
LHCb silicon 99.2% (700k channels)
LHCb TT 99.8%
LHCb ST 99.2%

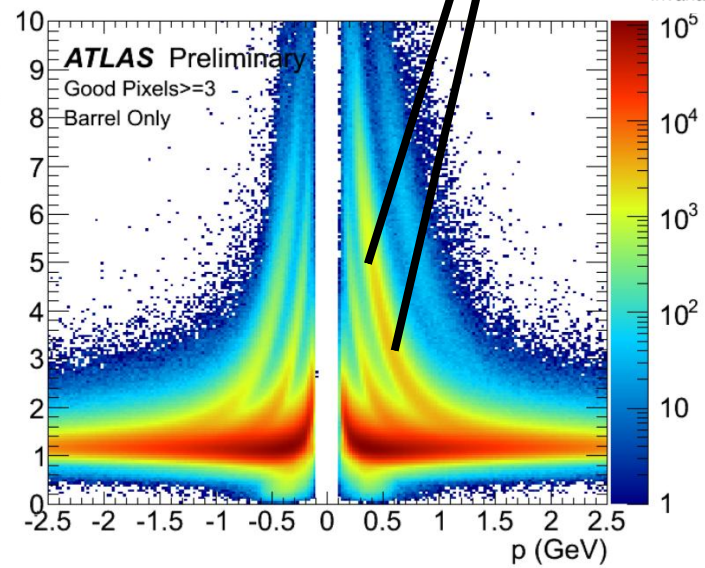
CDF (after 9 years) 90% (but started out much lower)

Silicon doing all the things it is supposed to do – and lots more besides!



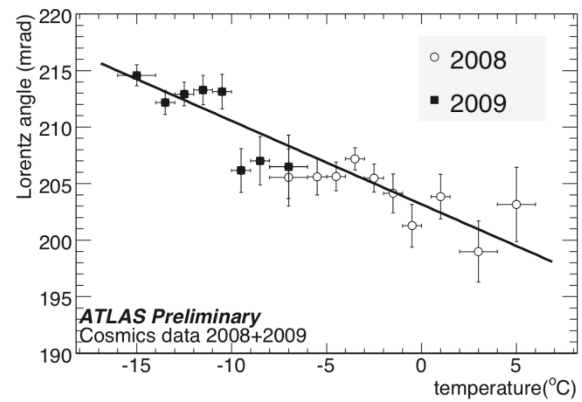






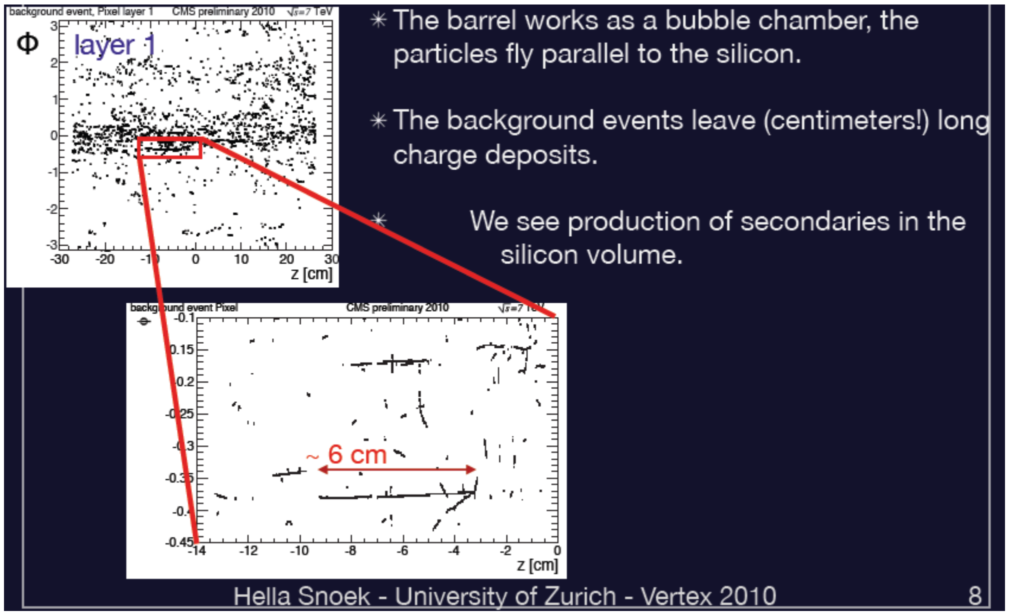
	Electrons
$v_s(\mathrm{cm\ s}^{-1})$	$1.53 \cdot 10^9 \cdot T^{-0.87}$
$E_c(\mathrm{V\ cm}^{-1})$	$1.01 \cdot T^{1.55}$
β	$2.57 \cdot 10^{-2} \cdot T^{0.66}$
r	$1.13 + 0.0008 \cdot (T - 273)$

Expected from parameterization: -0.042 /K
Point correction is small: ~0.1 μm/K
...but nice it can be observed



andreazza

Silicon is even behaving as a bubble chamber



Detailed analysis shows Rate proportional to number of protons

Excellent pattern recognition and tracking can identify the lousy hit association in these events and cut them out with the"pixel template"fitter

H. Snoek

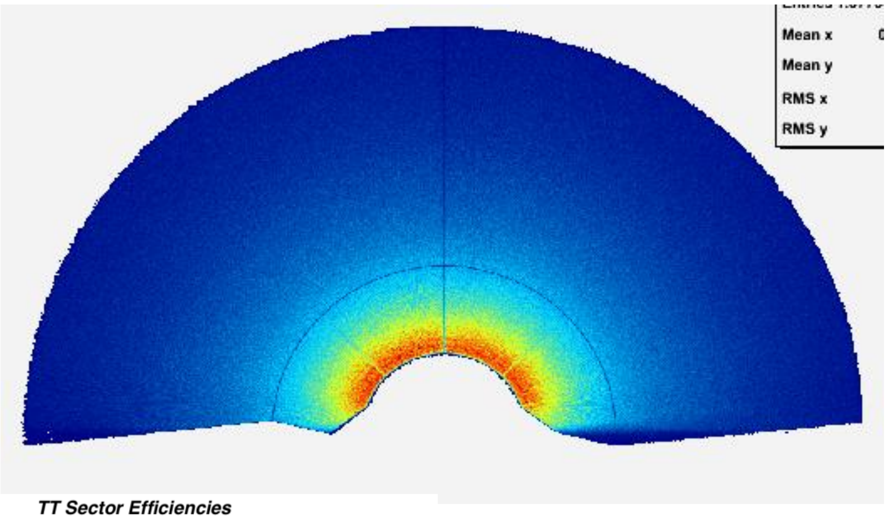
- The rate is estimated around 0.5 Hz/bunch/beam/10^{10} protons
- At a rate of 11kHz of physics events at 10^{11} protons per bunch an overlap with a background events is expected at a rate of about 1‰

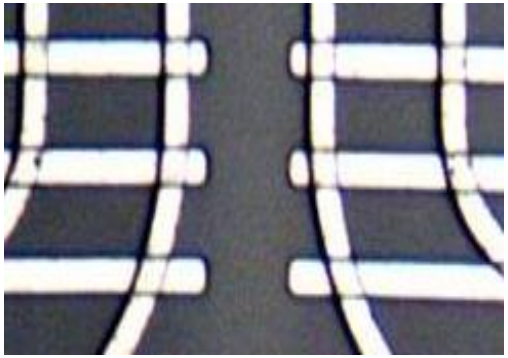
Silicon for Triggering is coming online

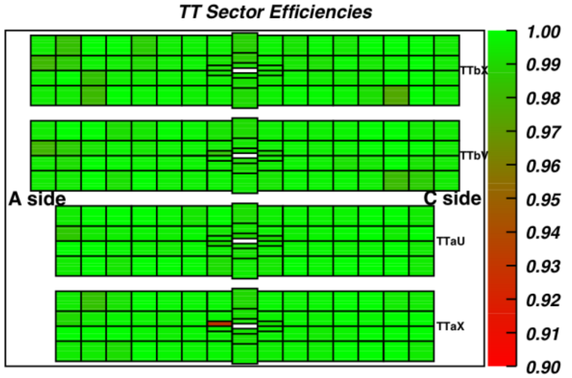
See talks from this morning
Martin van Beuzekom
Richard Brenner
Mark Pesaresi

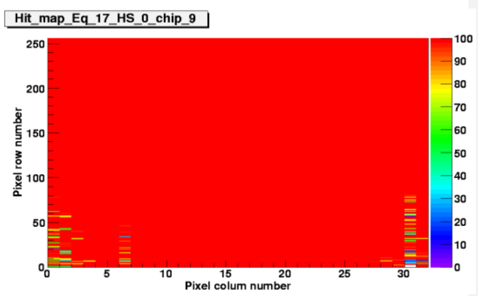
LHC – the ultimate beam test?

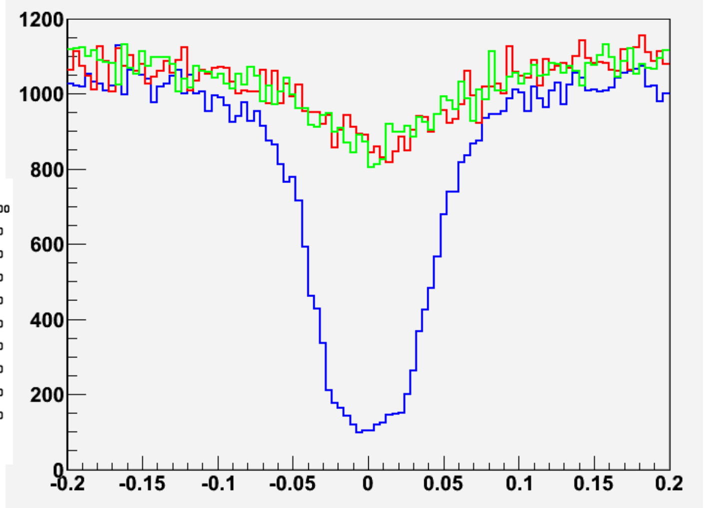
LHCb showed high statistics studies on modules







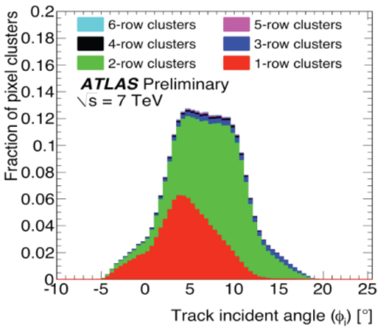


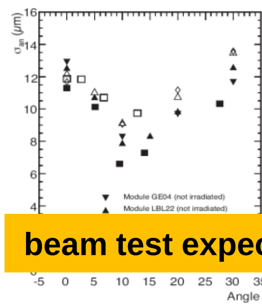


Alice – able to tune pixel corners and recover 6% efficiency

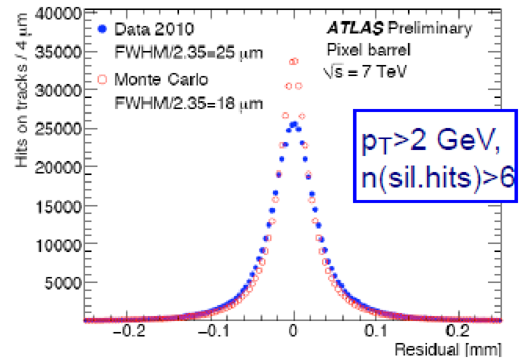
Resolution: More complicated story…

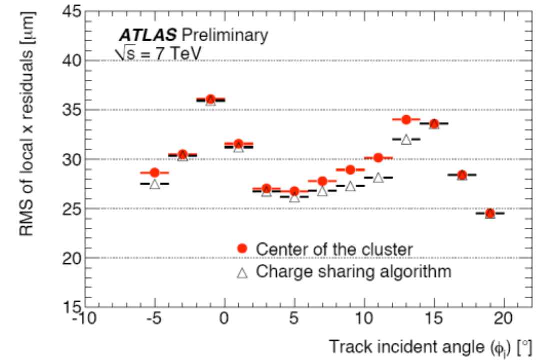
Atlas applying corrections of 30-60 um
Studies of data pulls show effective resolution of 7+7 um



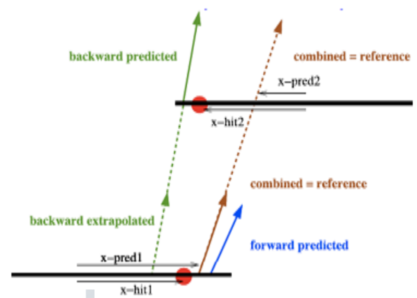


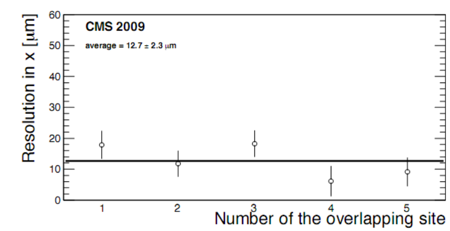
beam test expectation

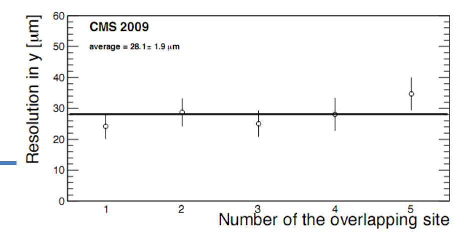




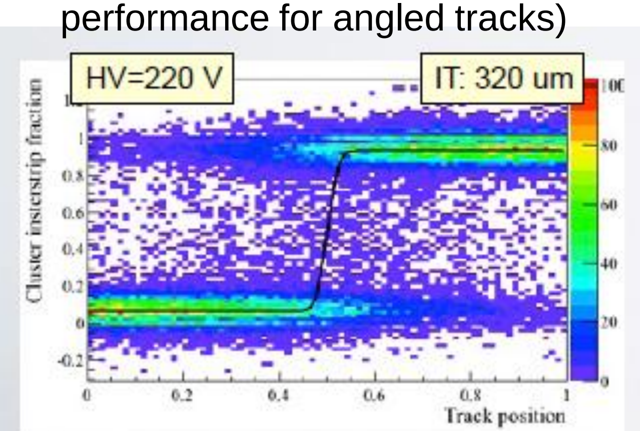
CMS quote resolution of 12 um (for 100 um pitch) using overlaps

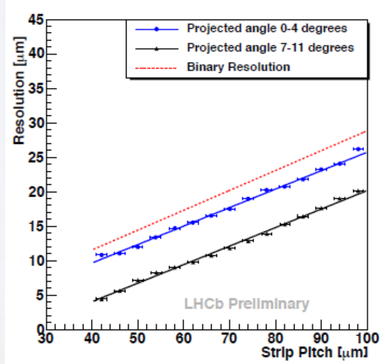




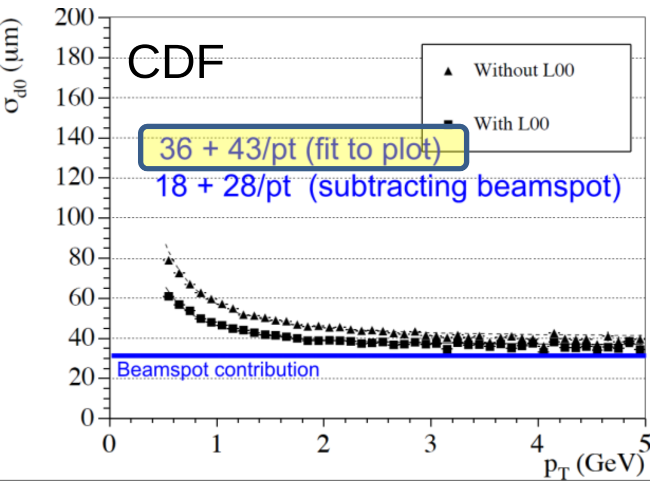


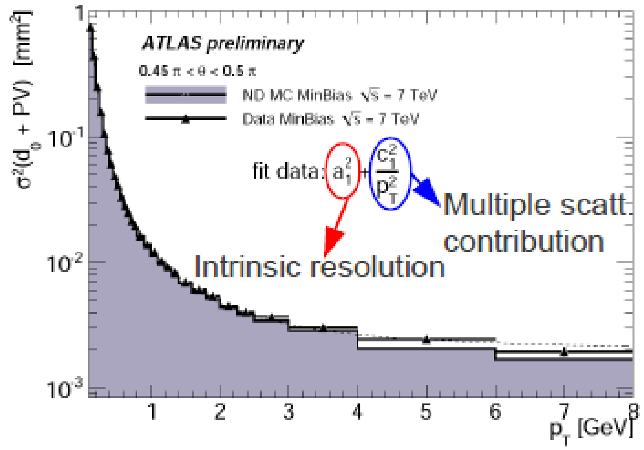
LHCb show worse than expected eta distribution for perpendicular tracks (but excellent performance for angled tracks)

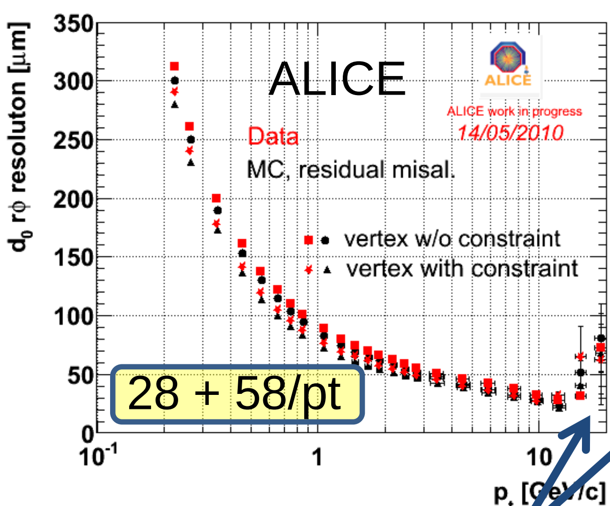


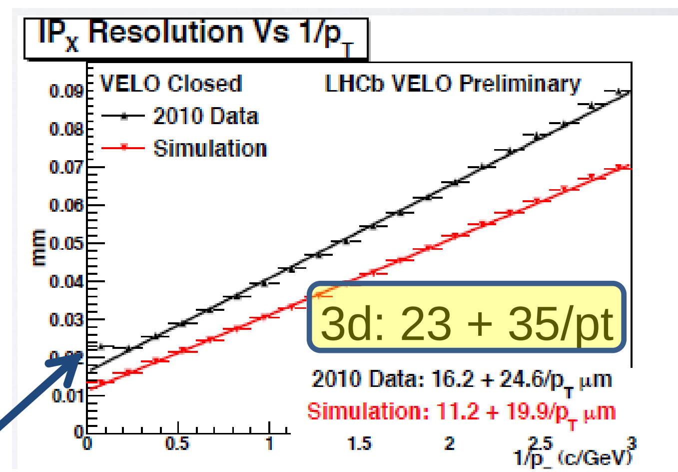


Impact Parameter resolutions
The gold standard performance plot for a vertex detector









Who ordered this?

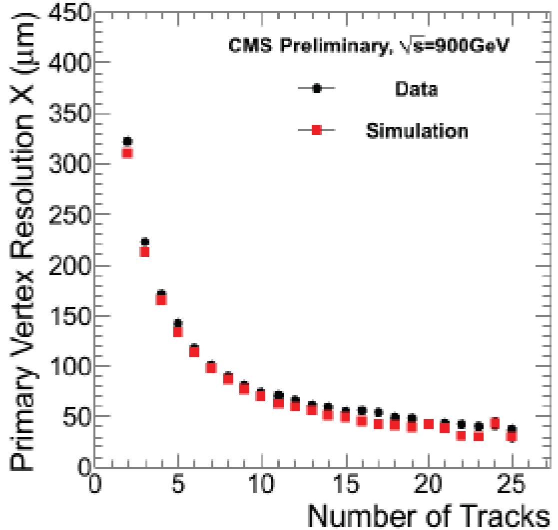
Interpretation of these plots not easy! With a VERY big grain of salt you can compare the highlighted numbers

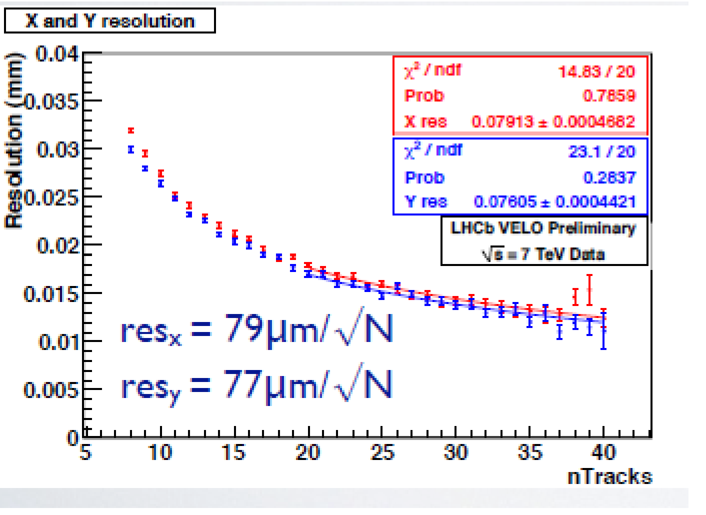
For the time being no management approved result from ATLAS and CMS

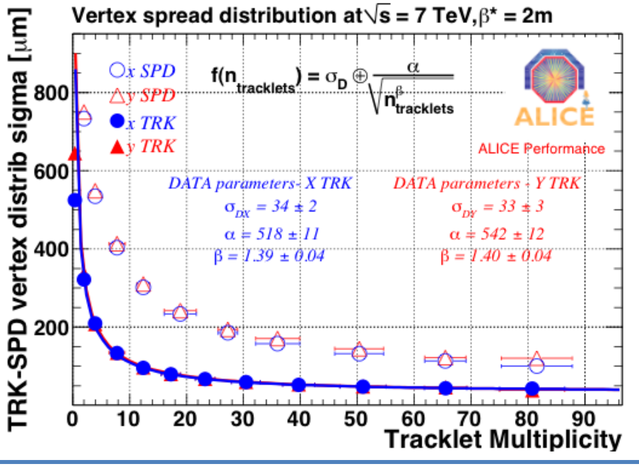
Will be extremely interesting to see how these plots evolve

Many thanks to Andrea and Rosario for enlightening discussions!

Primary vertex resolutions







Similar technique followed by all experiments

Puzzles from past conferences

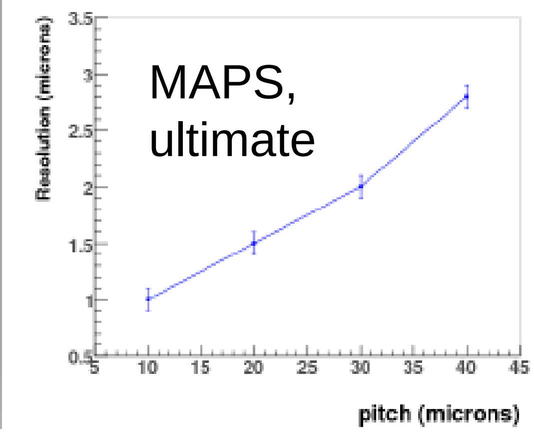
1. LHCb party puzzle
   - What is the prize?
   - How will LHCB align for each fill & with non-uniform irradiation?

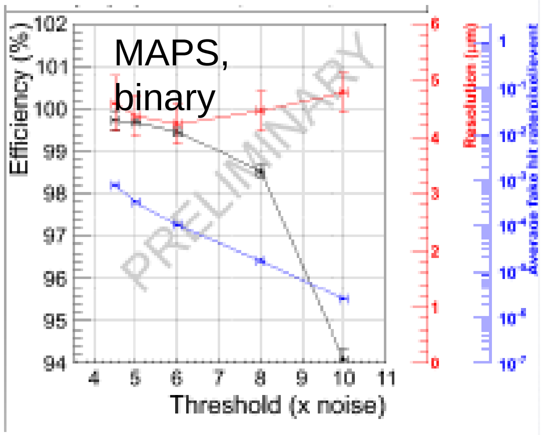
2. Who knows how to readout short-strips (~10mm) or macro-pixels?
   - Another prize?

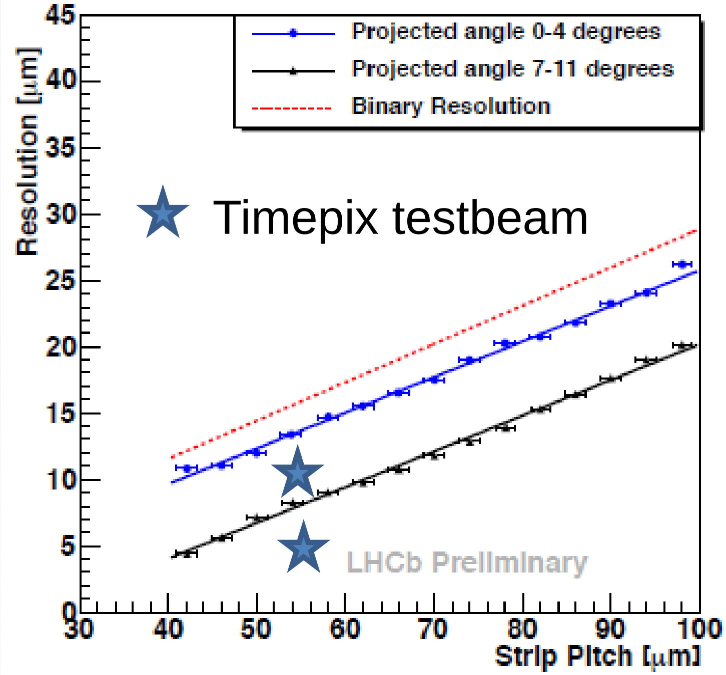
M. Tyndel, 2005

Puzzles for this conference

1. Fast electronics, fine pitch, perpendicular tracks
Is there an anomaly? LHCb and ATLAS data maybe point that way?

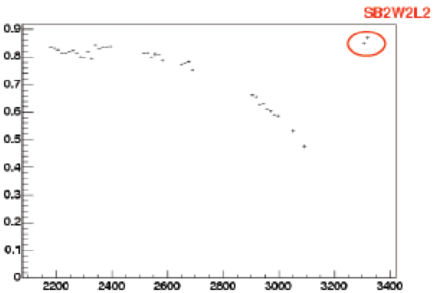






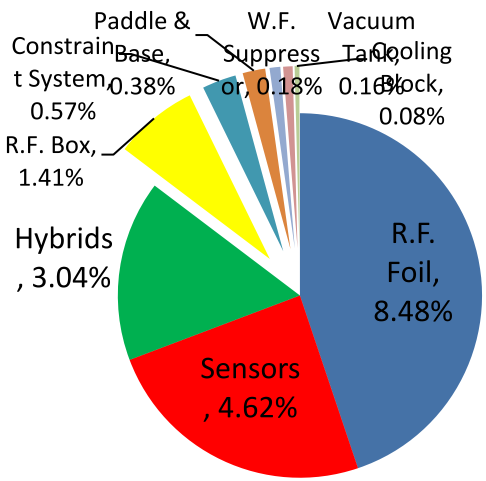
Could become an issue especially after irradiation
When tricks and helping hands like inclinations and lorentz angles become less effective

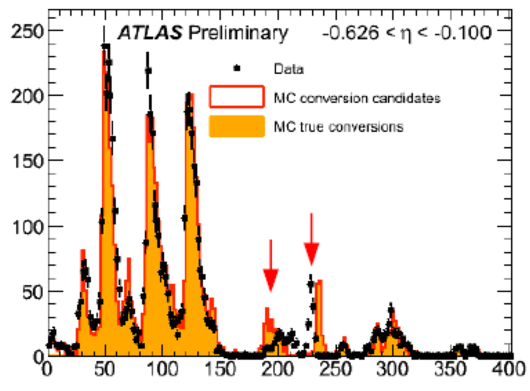
2. ageing w/o radiation?



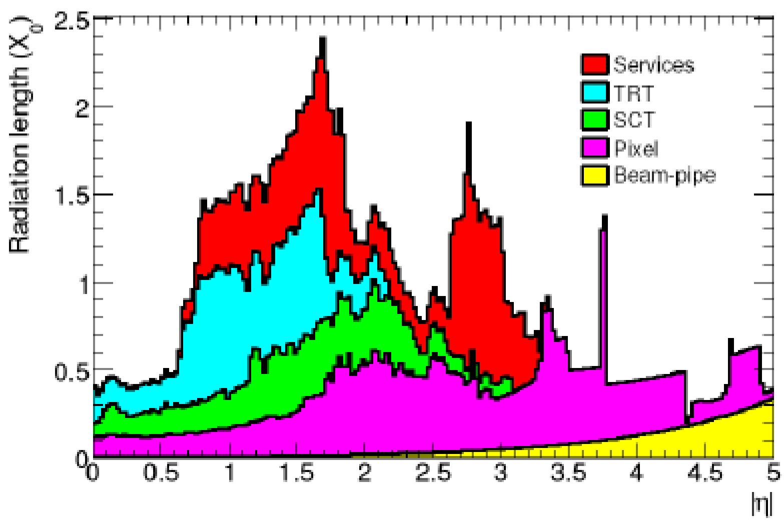
Some ladders in L2 and L4 had a recent efficiency drop (9 out of 172)
-Layers became under-depleted as they aged.
-All 9 had their bias increased with no increases in noise.

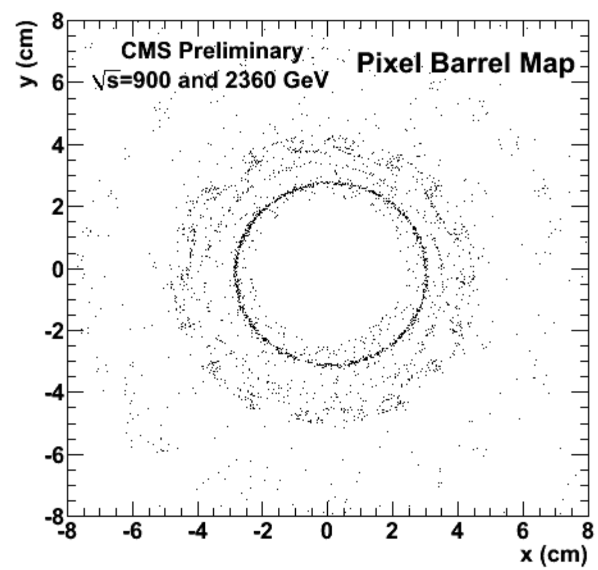
System Issues and Material Budget Beginnning to be well understood





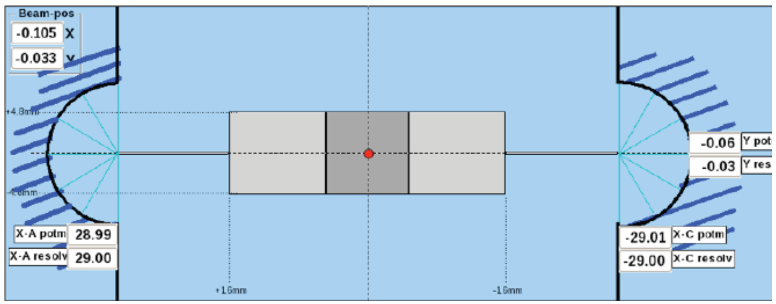
Atlas calibrate By using Reconstructed Kaons; momentum Scale correct down to ~0.04% so confidence

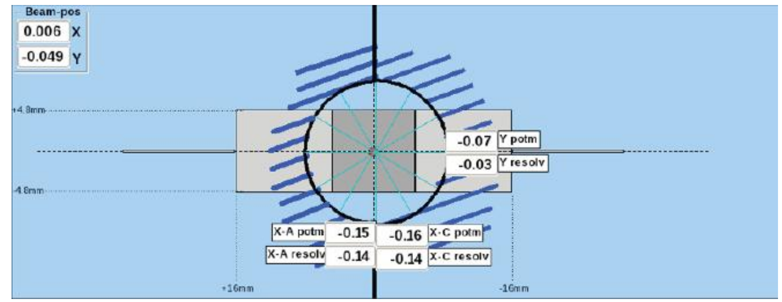


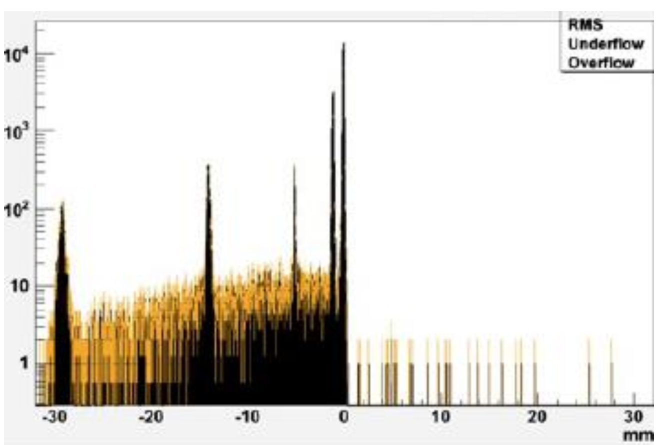


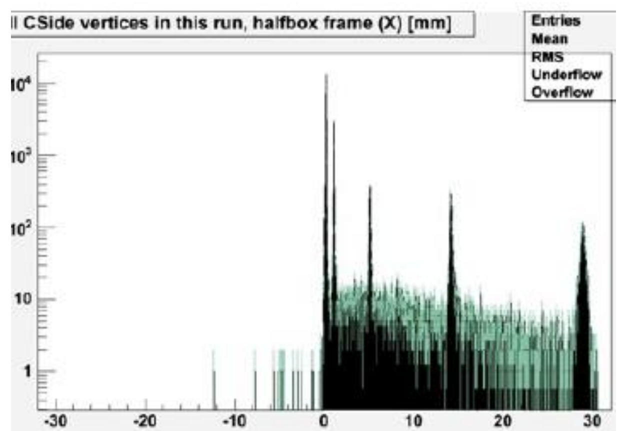
Coping with beams and operational issues

Push configuration issues as much as possible out of stable beam period
Fast HV ramp after stable beams declared
New for this conference: VELO Closing around LHC beams (S. Redford)







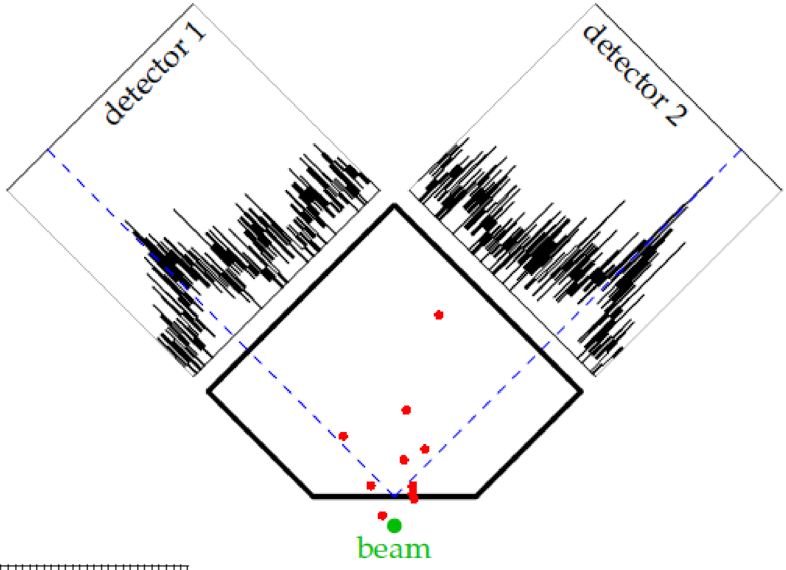


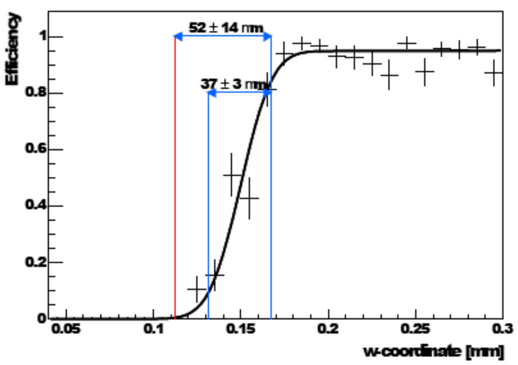
Daring to go up close

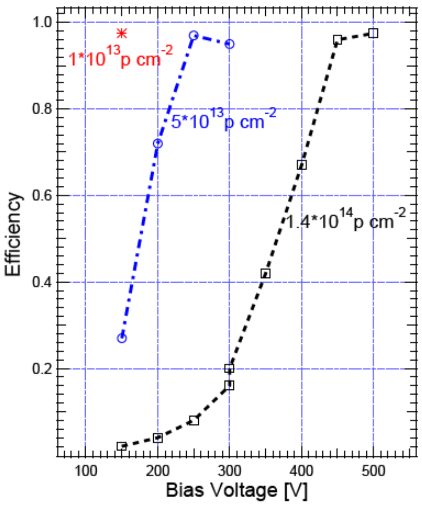
TOTEM have approached
Within 4.5 sigma of the beam

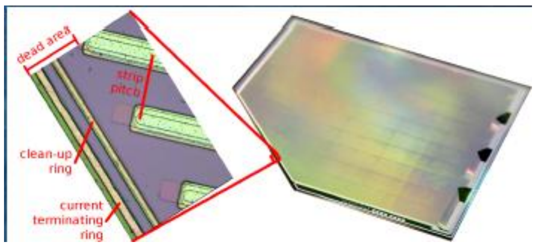
Edgeless technology shows very
Impressive efficiency and is able to hold
>500 V post irradiation

P on n technology means that high
Bias voltages are needed



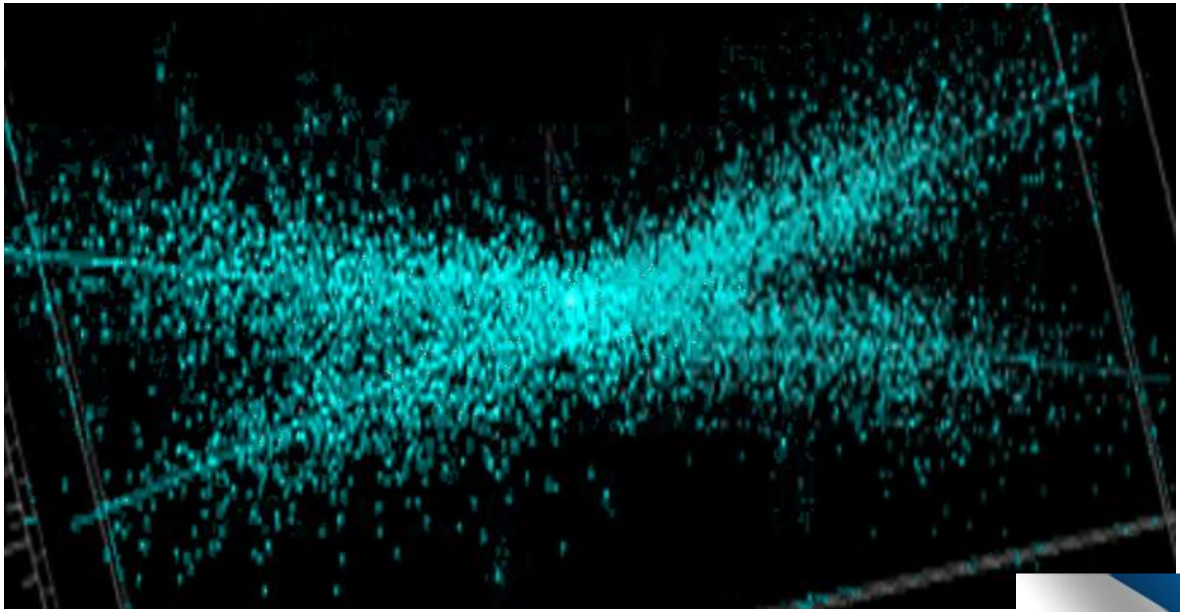






J. Kaspar

Another beautiful image from the conference

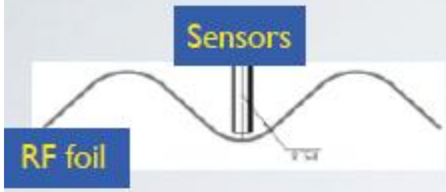


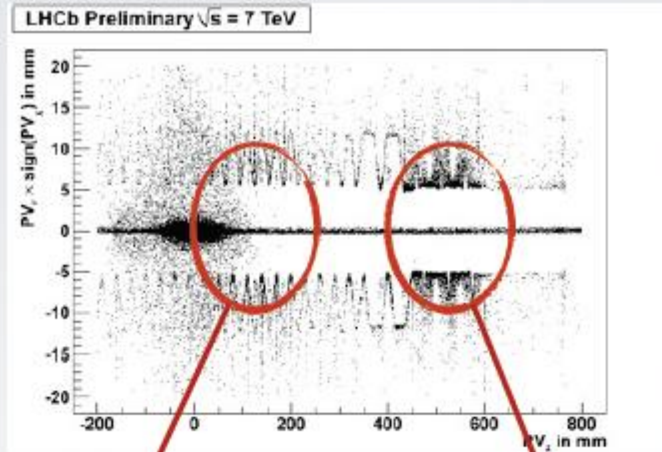
LHC beam gas interactions measured in LHCb for 450 GeV run, for magnet up and magnet down, beam1-gas and beam2-gas superposed

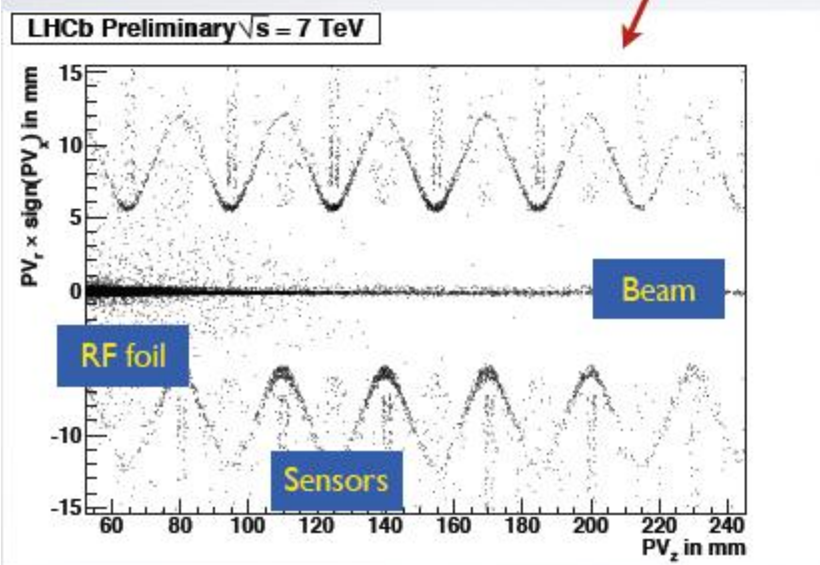
Maybe not as beautiful as the loch?
but has a scottish feel to it!

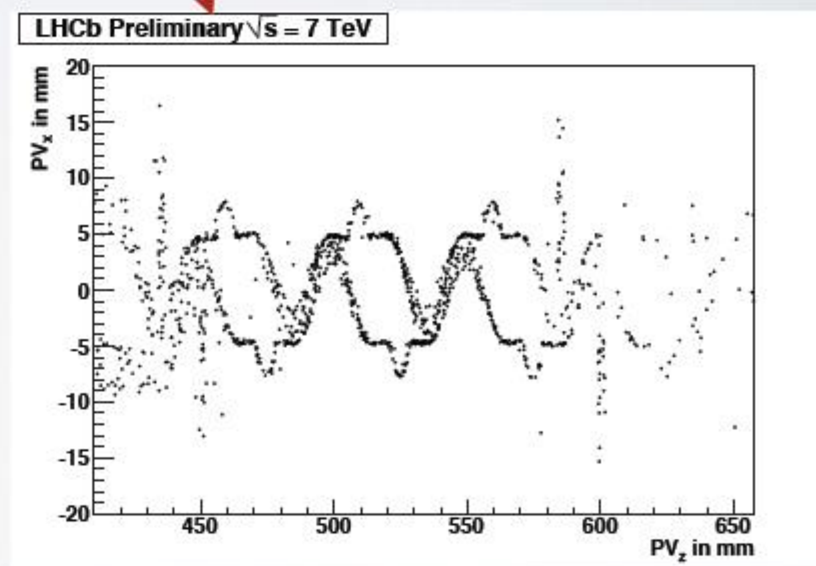
PRECISION MEDICAL IMAGING

2.4M vertices in plot, ~20k from material interactions, ≥3 tracks per vertex



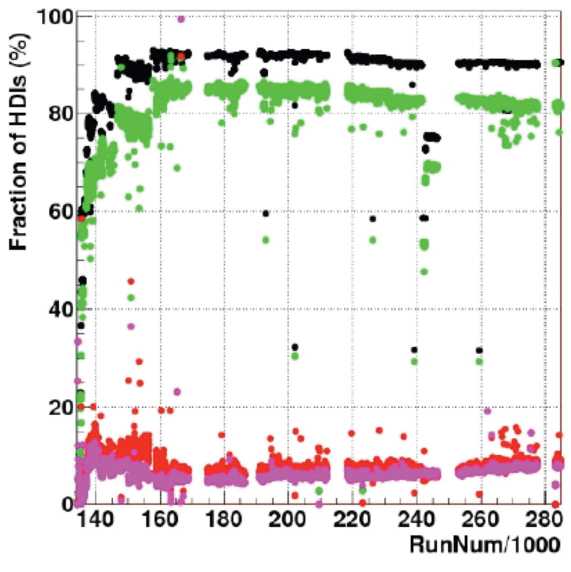




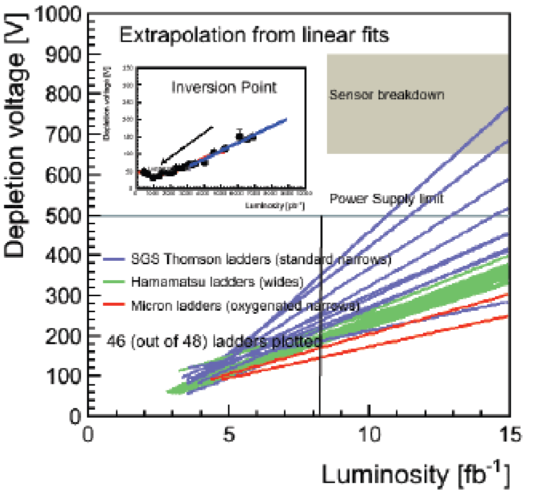


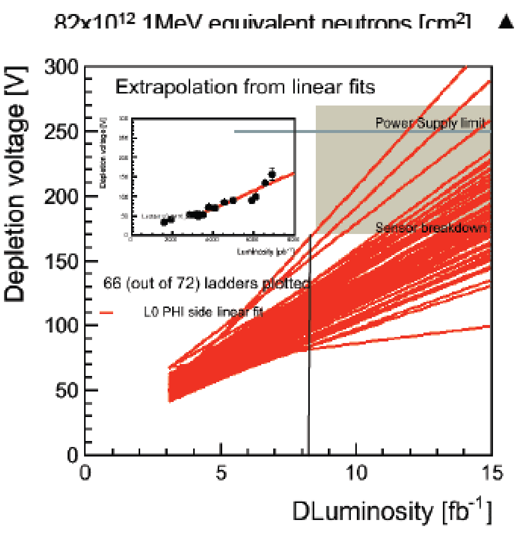
CDF running then, now, and in the future

"leaving no ladder behind"



using almost every opportunity for diagnostic and repair work

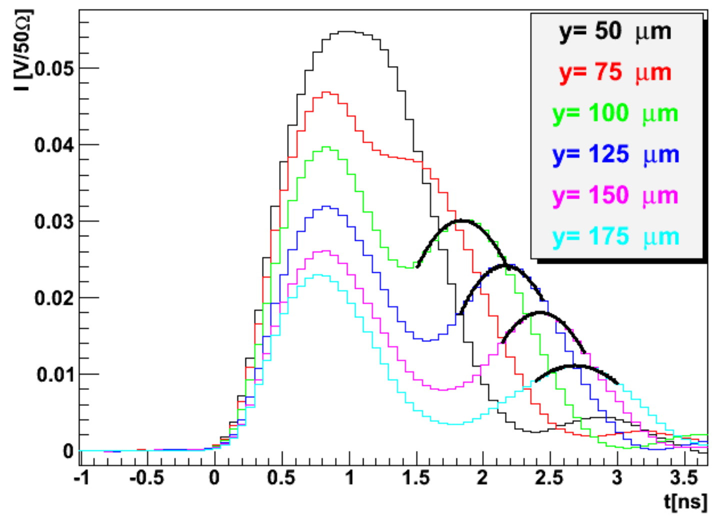




Radiation Damage: are we ageing gracefully?

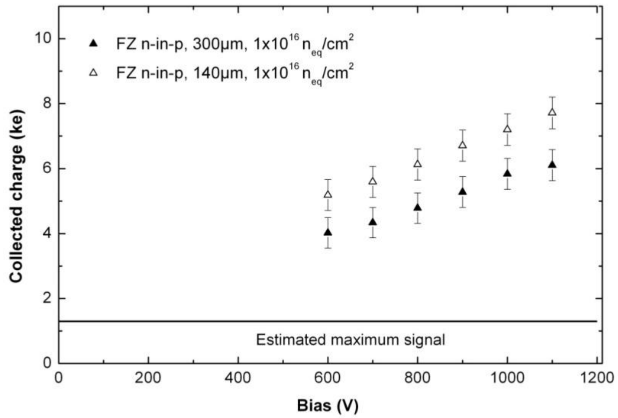
New kid on the block: charge multiplication
G. Casse, J. Lange, G. Kramberger…

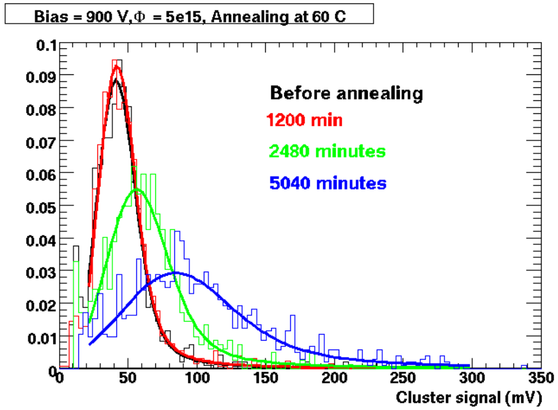
- Charge multiplication gives more signal!
- Applies also to leakage current: difficult to optimise!
- 2nd peak in edge tct clearly linked to avalanche multiplication of electrons close to strips
- Good news but
    - watch out for common mode behaviour (CNM)
    - watch out for resolution



- Dependence on detector thickness very encouraging: thin is good, thinner is better
- Overall optimisation depends on initial contribution of different noise factors
- Edge TCT measurements spectacular proof that charge multiplication is happening
- can measure relative contribution of primary and secondary charge and show the turn on at sufficiently high voltage
- confirms connection between Ileak and CCE

- Annealing very surprising beheaviour

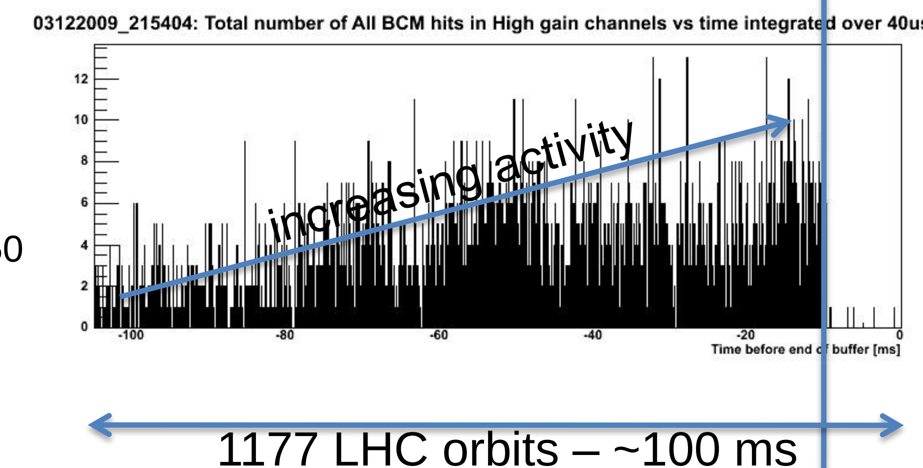


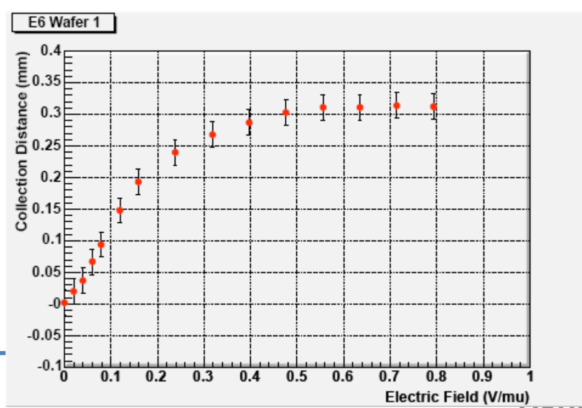


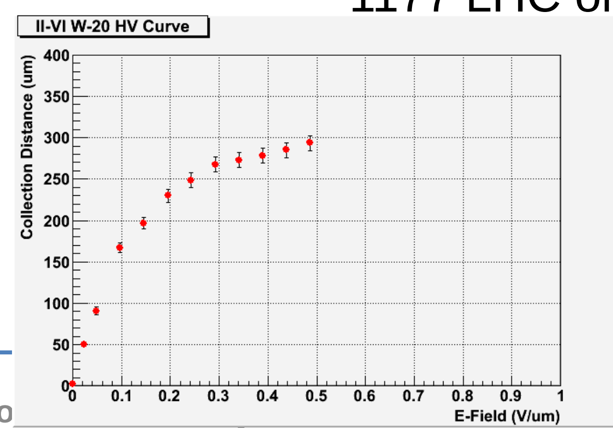
Diamond (M. Mikuz, + numerous other potential users!)

New results on NIEL scaling violations with diamond irradiations
Point the way to new irradiation campaigns with relevant neutron energies
(few x 100 MeV)

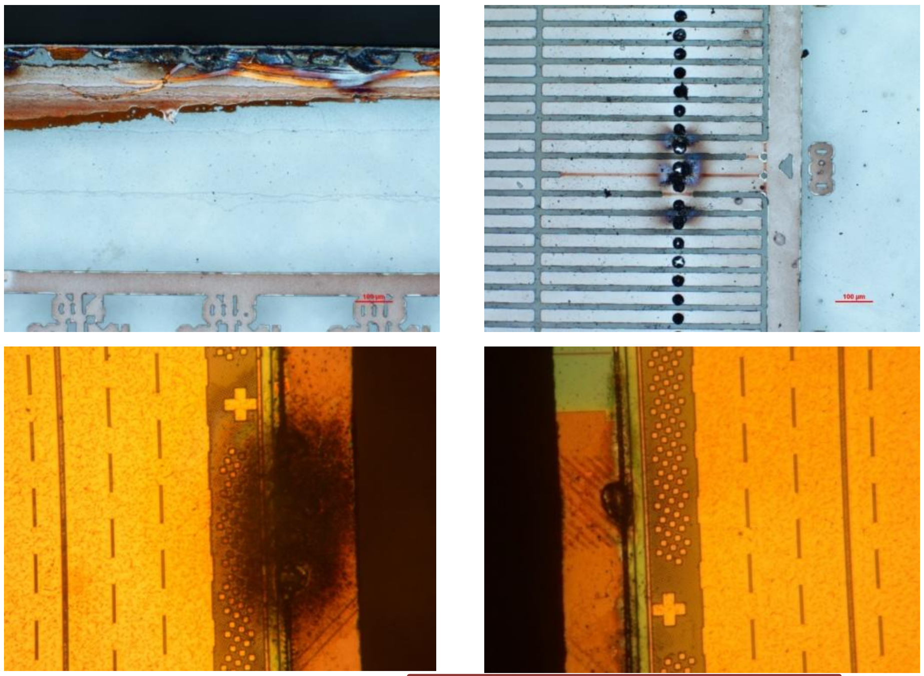
New material: spectacular results!
New US vendor (Element II-VI)
On the second iteration got a 2.-2.5mm
thick wafer which showed results equivalent
to the best ever achieved with previous vendor
(previous vendor delivered many pieces with CCD<250
Much excitel=ment!
Evaluated several wafers: most recent
2-2.5 mm thick
Fantastic charge collection distances!

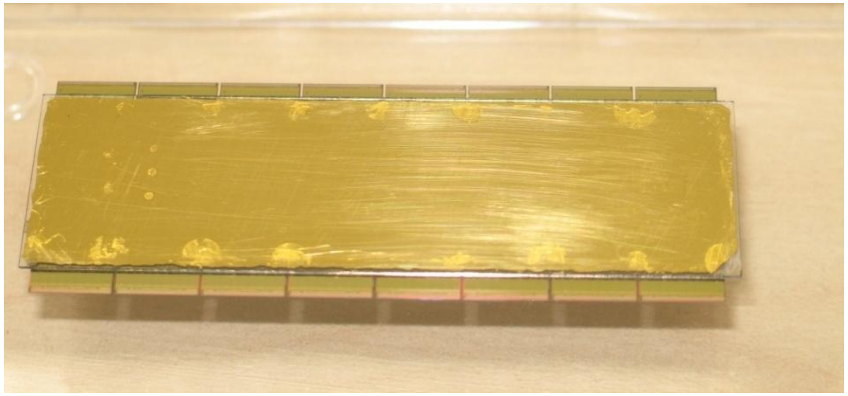






And even a Lazarus effect:



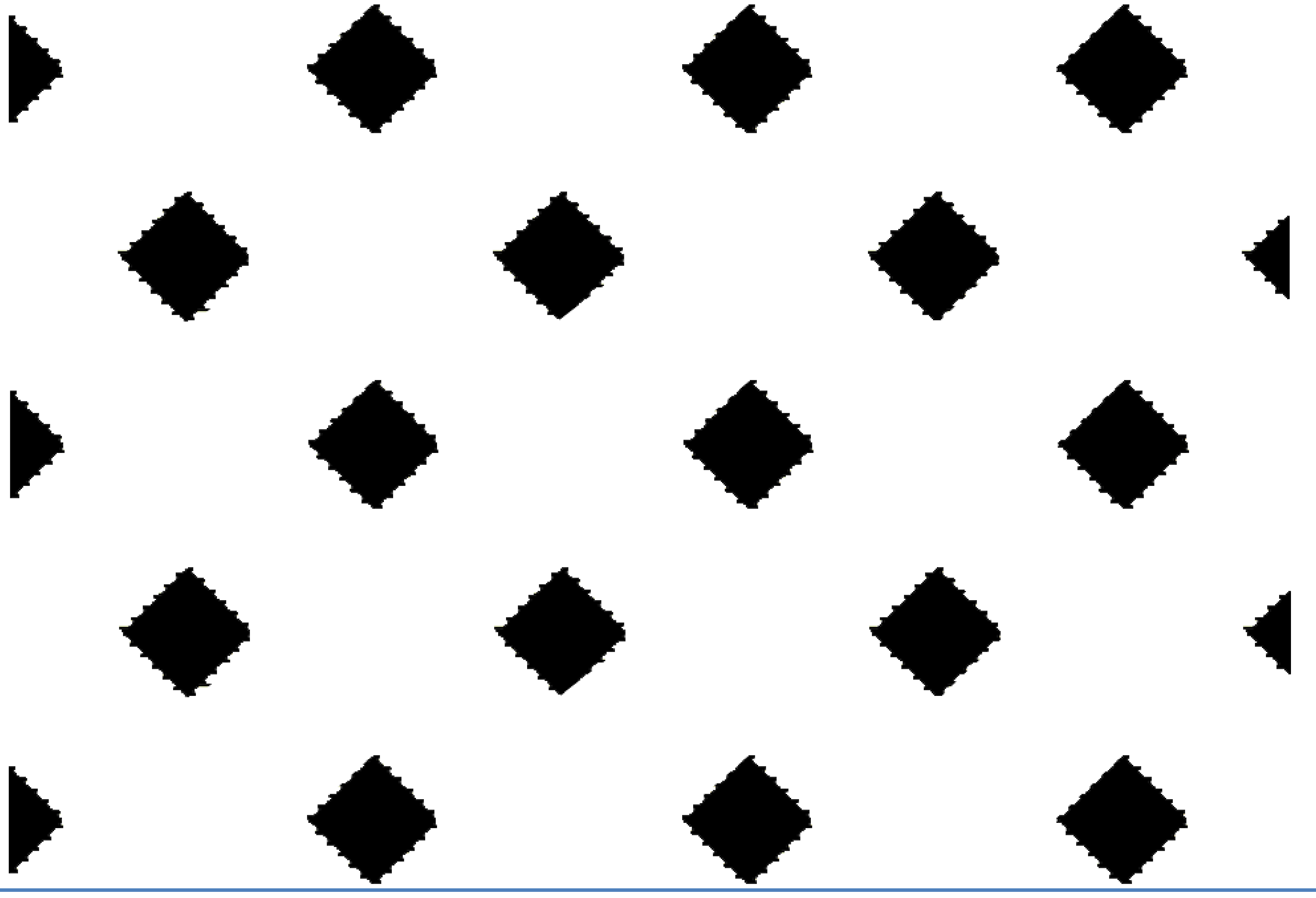


Reworked module

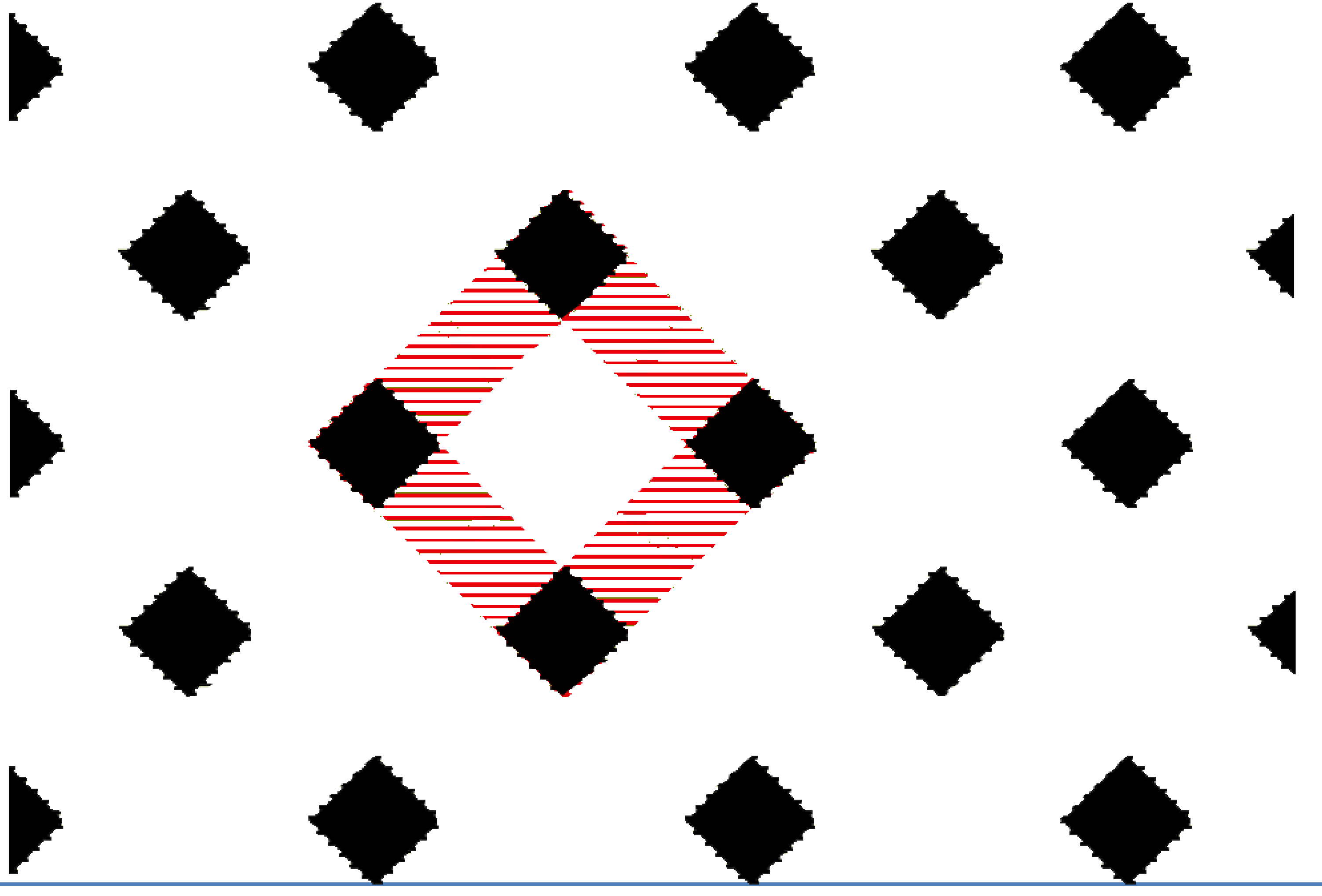
3d sensors and pixel sensors

Learning the design rules

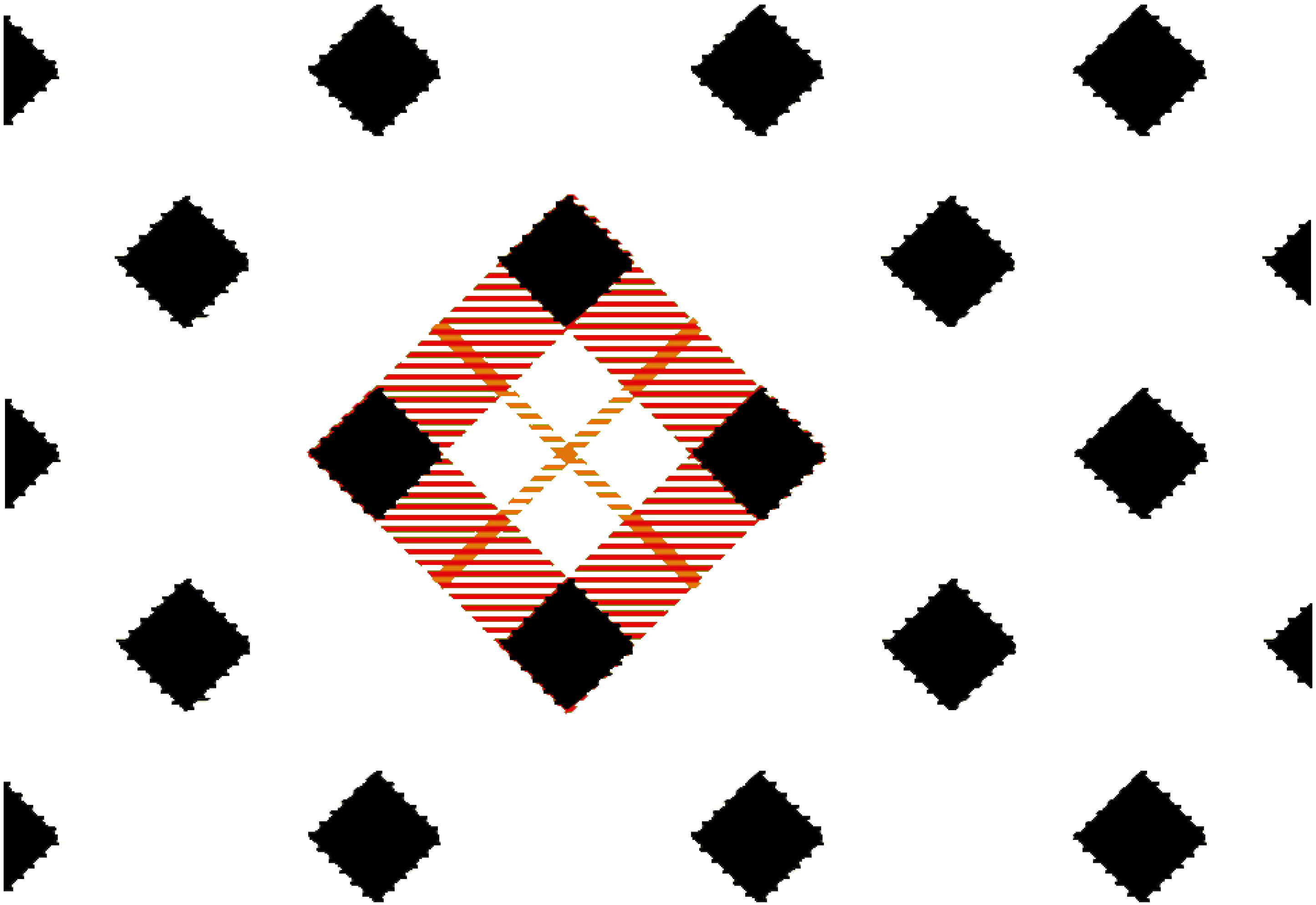
Take a pixel array



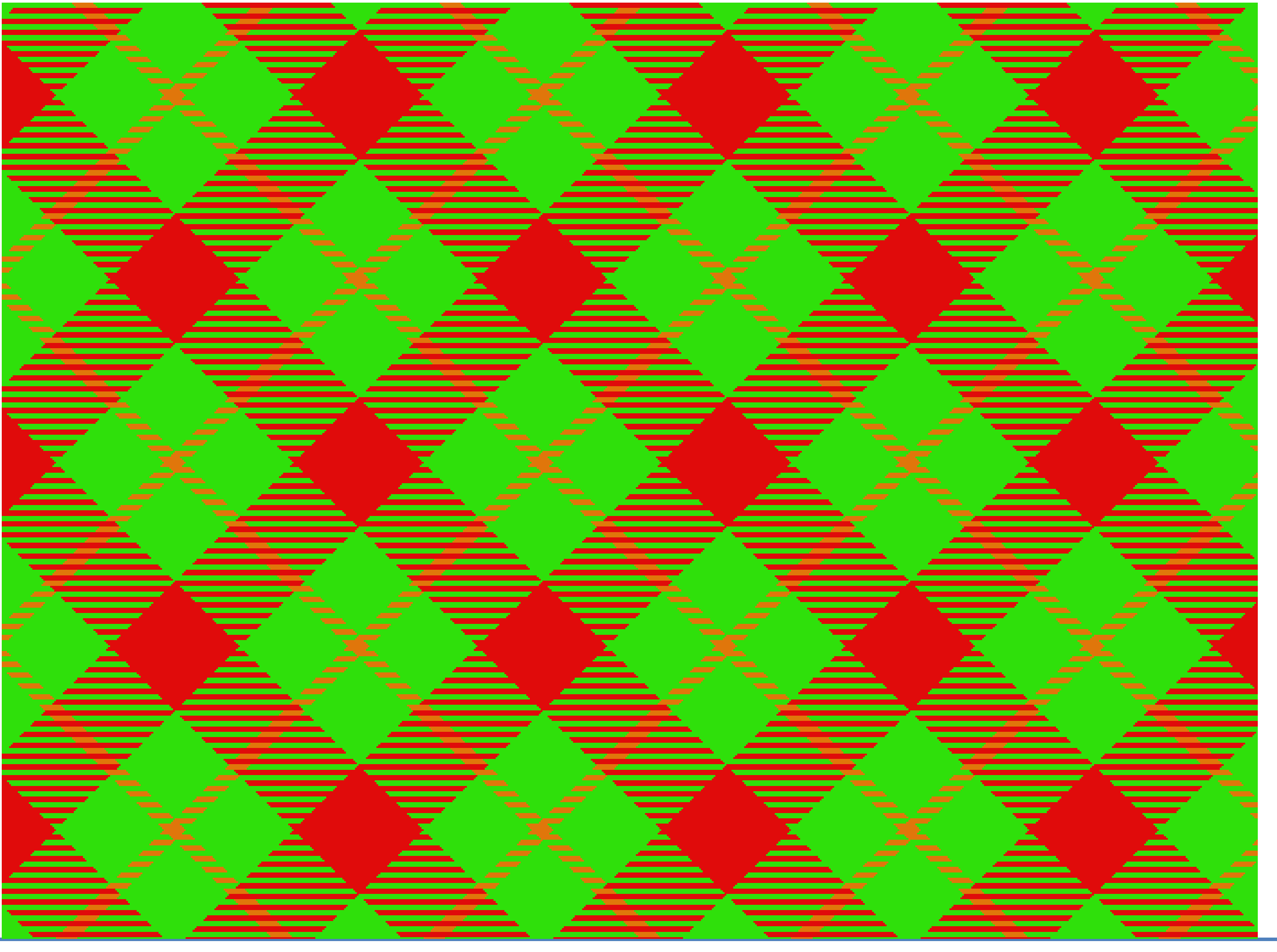
Add horizontal vias



Etch trenches… add some color…

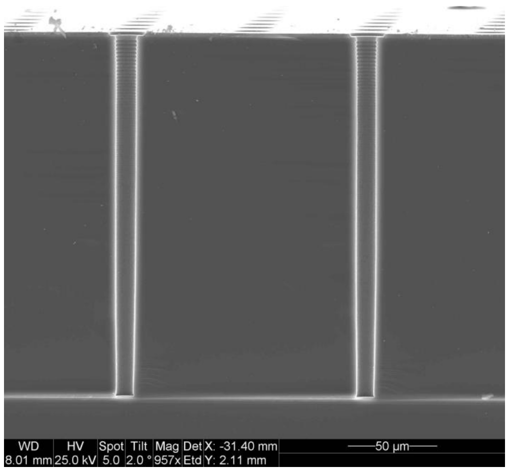


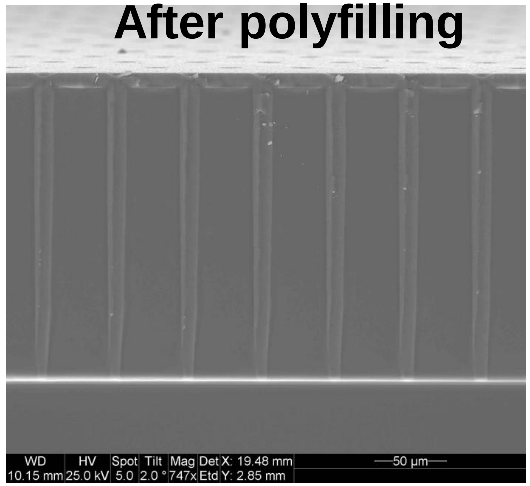
Hey presto! The vertex tartan…



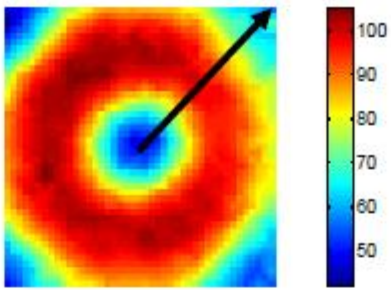
Many, many, many, many, many, many, possibilities shown at this conference…

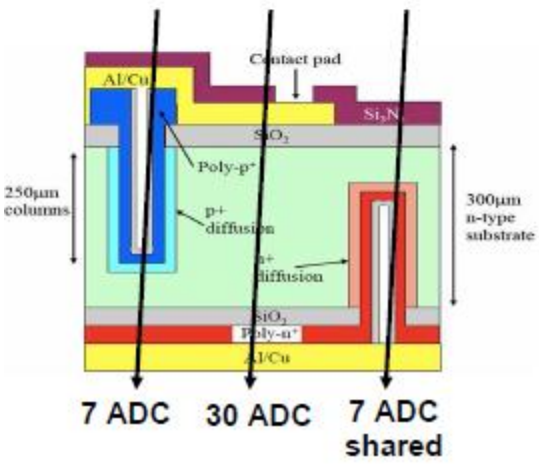
After DRIE

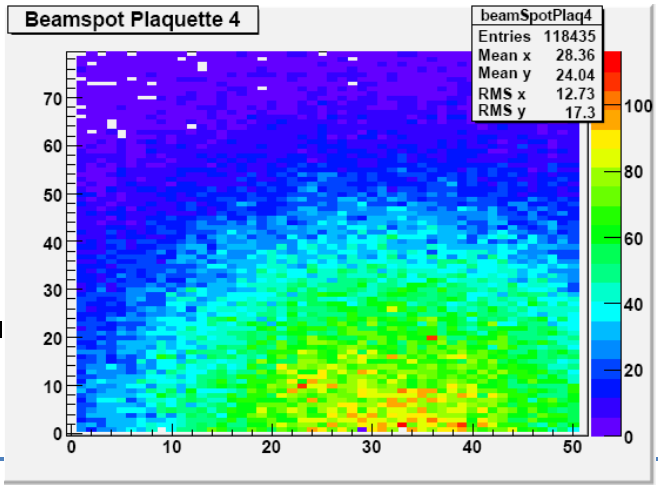




A. Kok,
C. Fleta



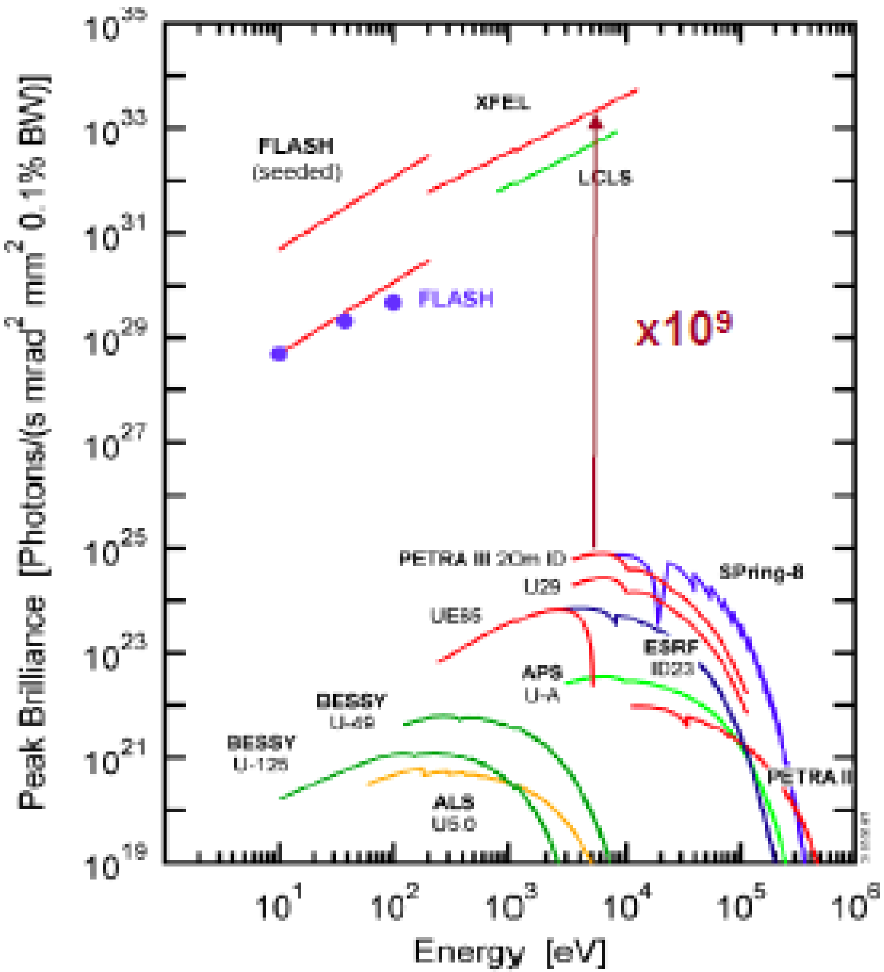




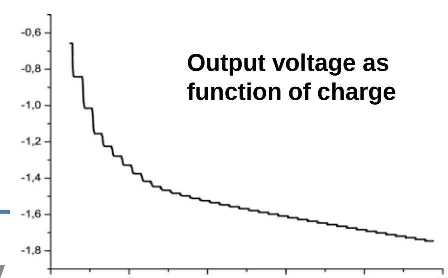
many gorgeous results from sintef (drie process 3d sensors) and cnm (ICP etching)
worked hard on etching aspect ratios, stress in wafer, voids during wafer bonding etc.
huge improvements and good 2E testbeam resu for CMS

Pixel detectors for the new generation photon sources

H. Graafsma

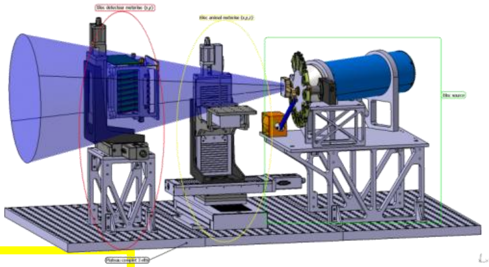


- Completely new science
- Fast science – 100 fs
- Single shot science
- 2700 bunches in 600 us, repeated 10 times per second
- Big coverage pixel detectors
- “no noise”
- Big dynamic range
- No material budget requirement
- Currently 3 solutions on the table:
  - Parallel gains per pixel
  - non linear response (engineered DepFet)
  - 3 switched gains



Low dose x ray tomography

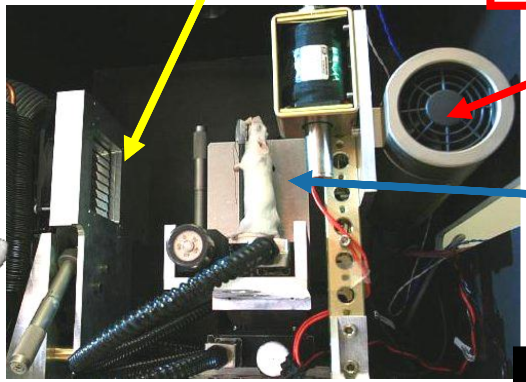
Patrick Pangaud



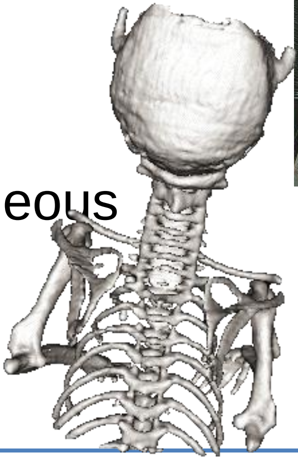
- Hybrid pixels for X ray imaging
- single photon counting with threshold
  - low doses possible
  - Crystallography also accessible
- 7x8 cm tiled xpad chips
- Images achieved with very low doses
- 2 ms readout and up to 10^6 photons/s
- next step small pixel with big threshold range
- latest version xpad3.1

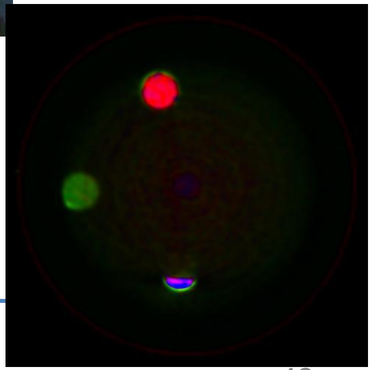
XPAD2 Hybrid Pixel Detector
330 x 330 μm^2 pixels

X-Ray source



- big step forward: simultaneous pet/ct scan
- combine pet with xpad
- color images





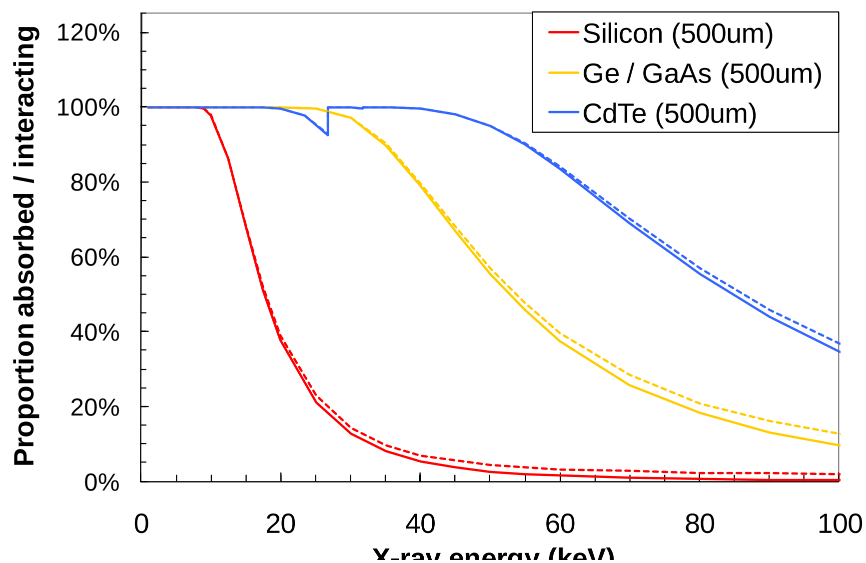
courtesy: A. Butler, MARS Biomedical Imaging Ltd.

High Z solutions Masterclass

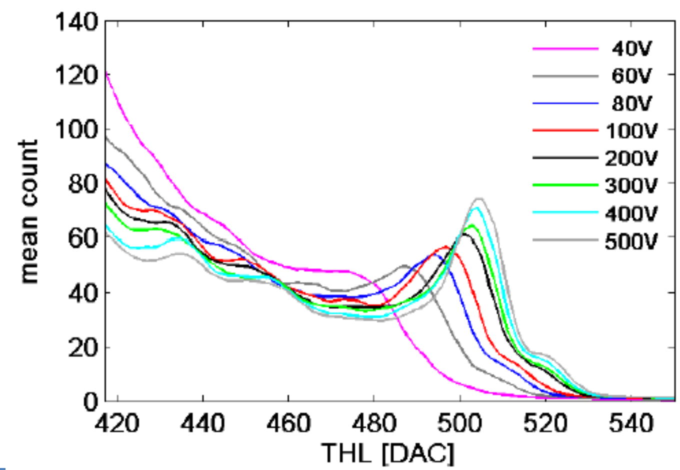
David Pennicard

- Challenges
  - homogoneity
  - leakage current, resistivity, trapping
  - pixellation, bump bonding

X-ray absorption / interaction

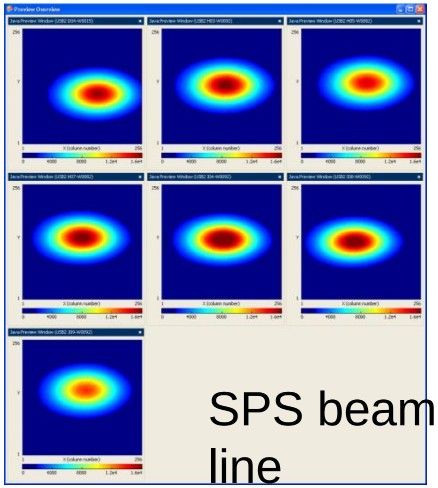


GaAs (Cr)
300µm, ohmic contacts (Au)

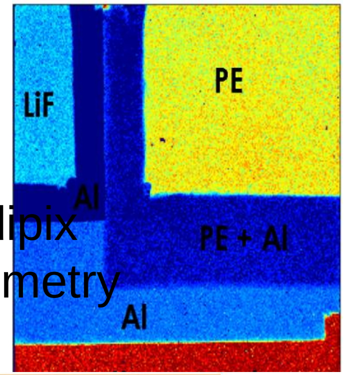


Medipix and progeny

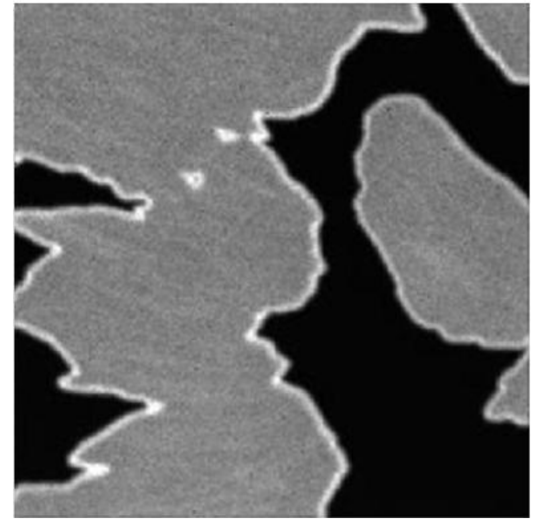
R. Plackett



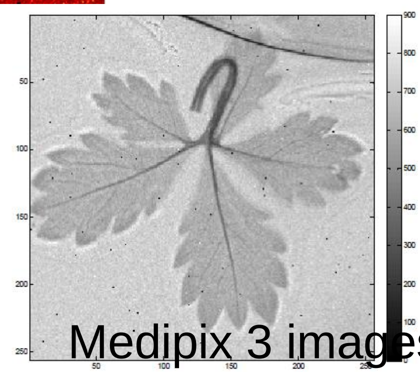
SPS beam line



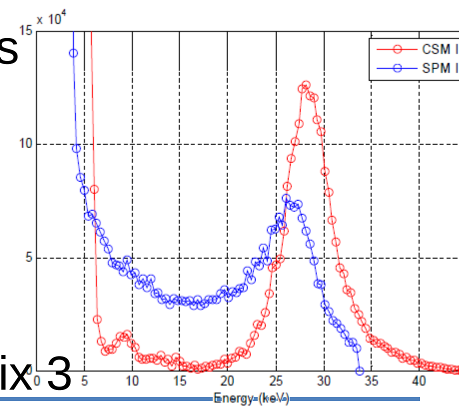
Medipix dosimetry



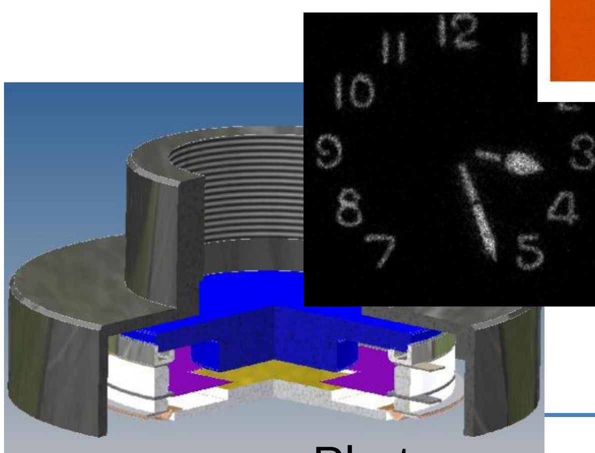
Medipix electron microscopy



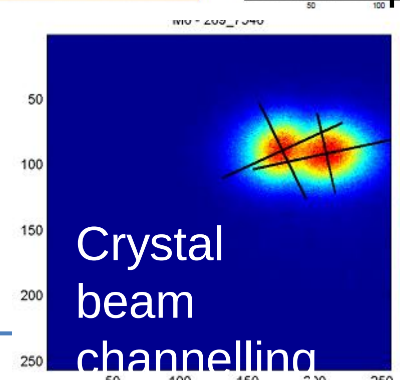
Medipix 3 images



Medipix 3 clustering

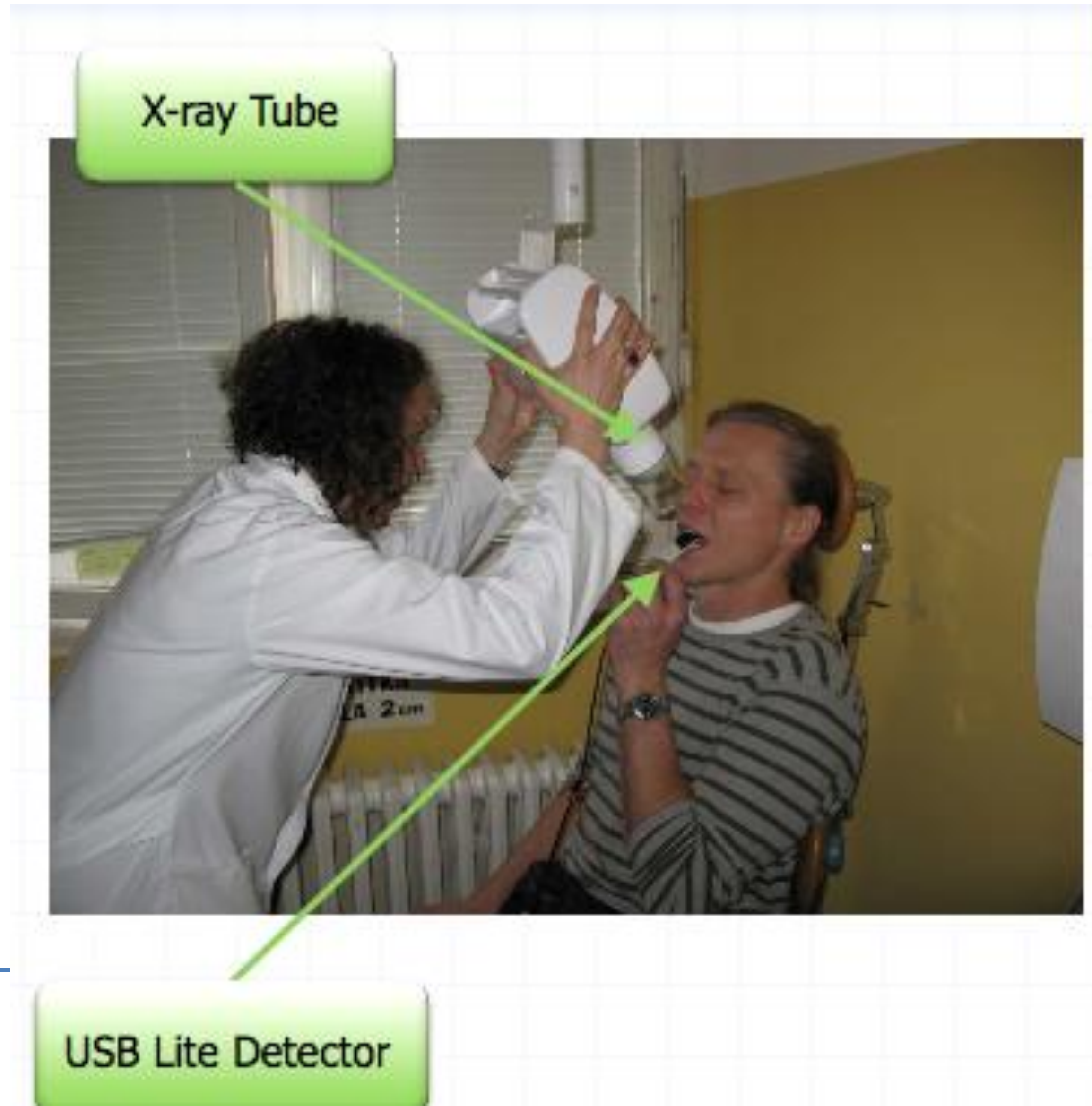


Photon detection



Crystal beam channelling

Mrs Roentgen, eat your heart out!

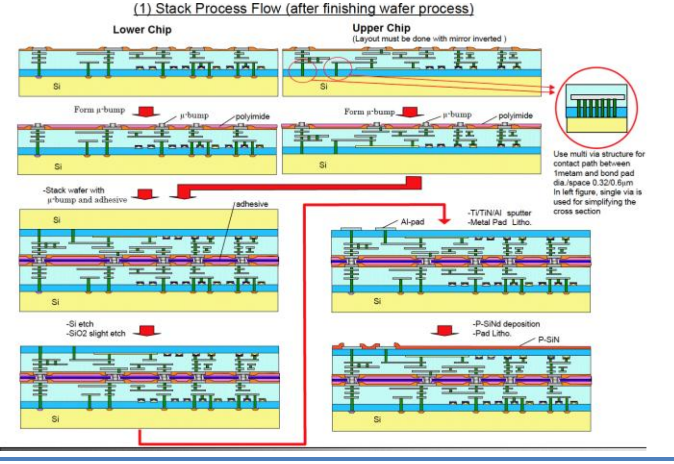


MAMBO III – Showcasing SOI and a glimpse of 3D

Farah Khalid

- Separate substrate and cmos circuitry
- reminded us of the painstaking work in getting chip working
  - issues of matching
- T-Micro 3D integration process
- Negotiate detector specific demands to the oki process to reduce cross talk

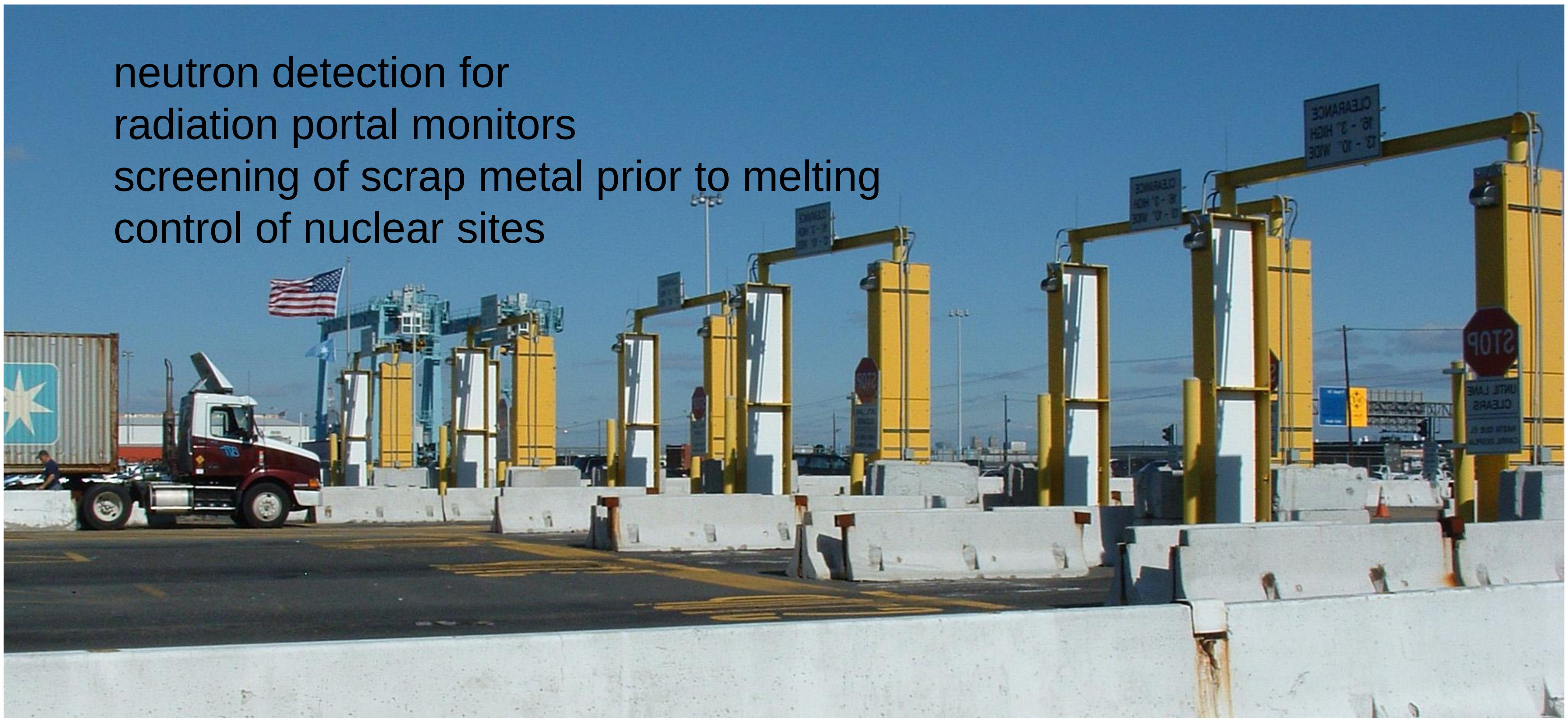
- dummy contacts to provide enough coverage for yield
- detector and electronics the same



And also something completely different

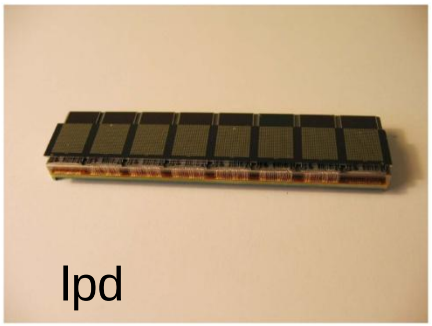
John McMillan

neutron detection for
radiation portal monitors
screening of scrap metal prior to melting
control of nuclear sites

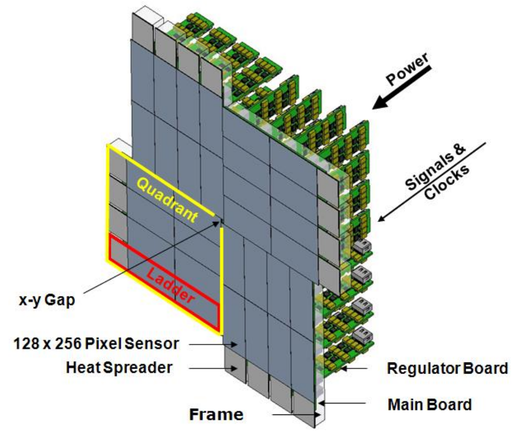


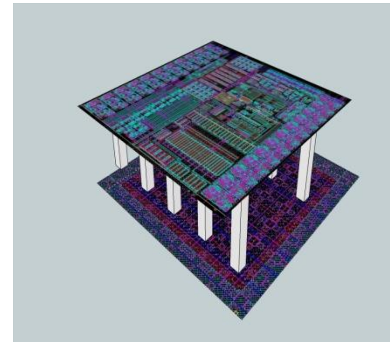
From HEP to Medicine and back again

The road to 3d

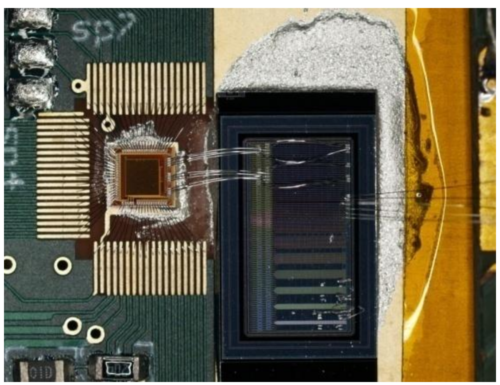


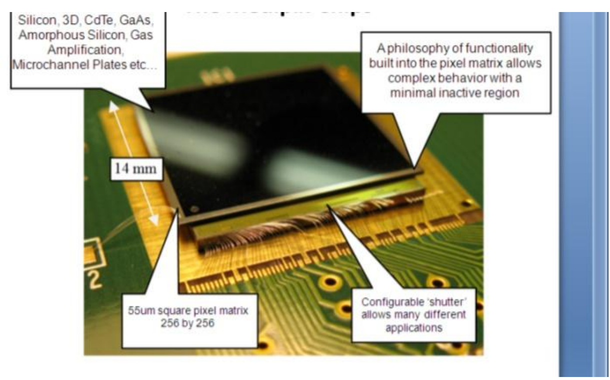
lpd





depmos sensor with signal compression



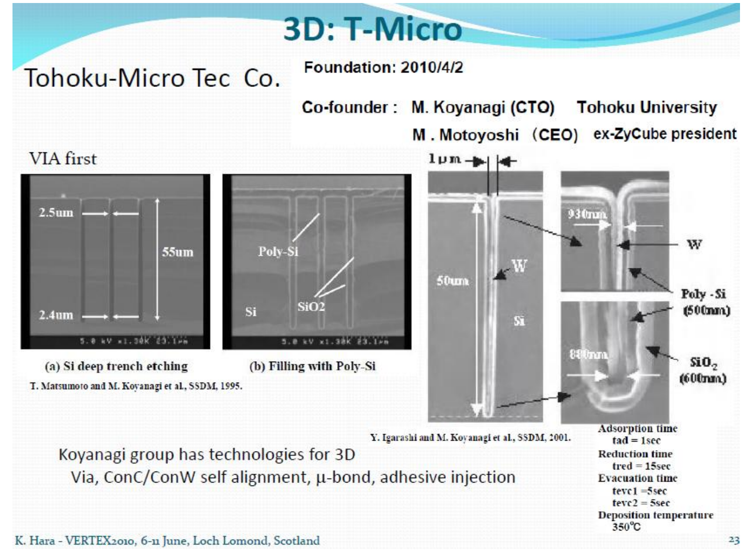


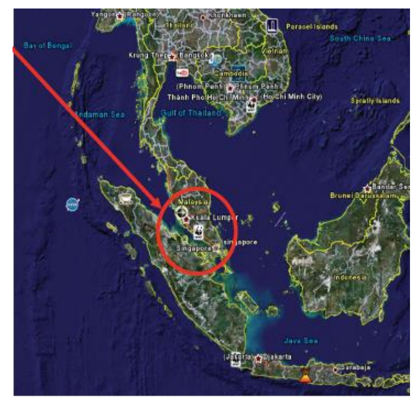
adaptive gain integrating pixel detector

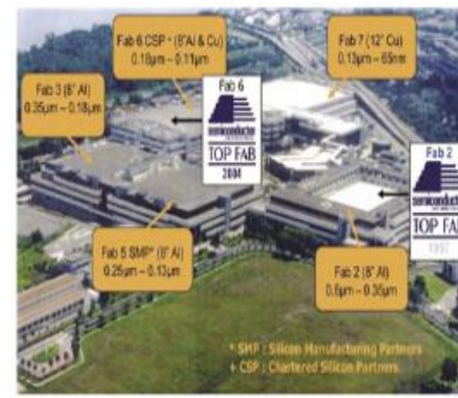
3d technologies

See Ray Yarema's talk!

- improve spatial resolution
- deal with an increasing counting rate
- decrease pixel size without adding material
- huge number of variations and stacking possibilities
- use for electrical signals but also cooling, interposers..



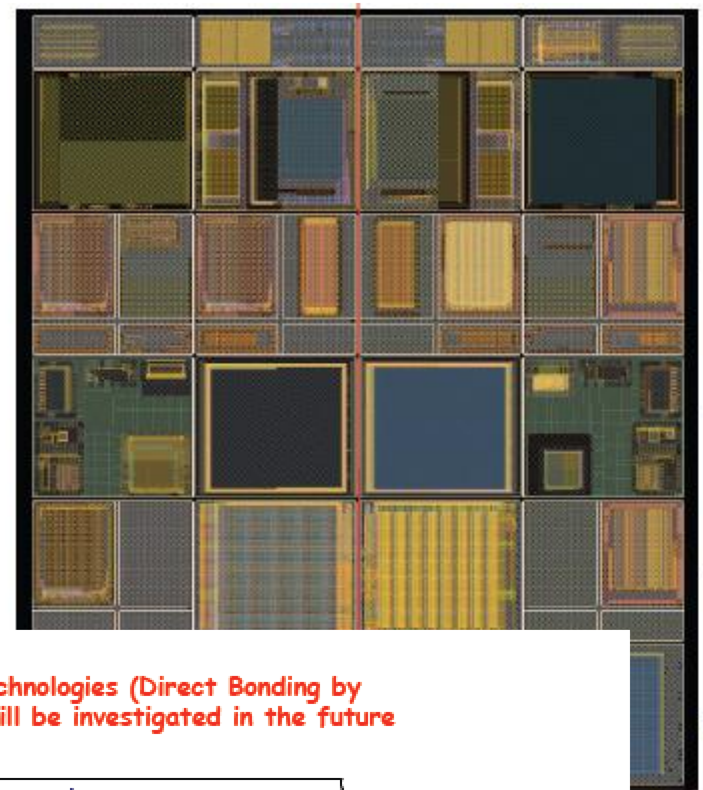




Chartered Campus

chartered 130 nm tech
tezzatron 3d technology
wafers stacked face to face with
cucu thermo compression bonding
Super contacts formed and wafers thinned
(pangaud)

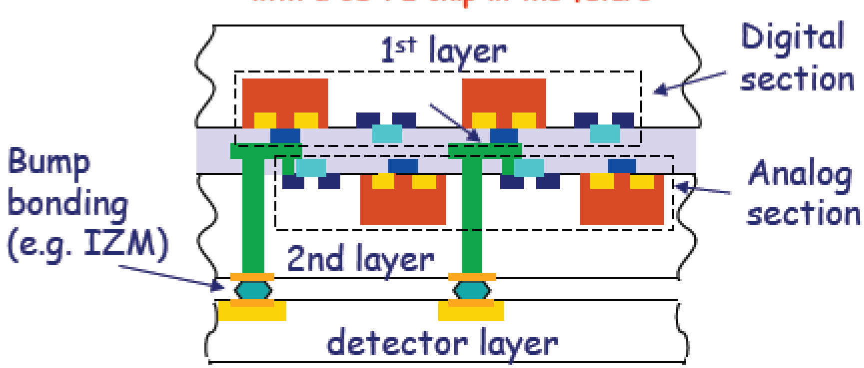
3d consortium G. Traversi



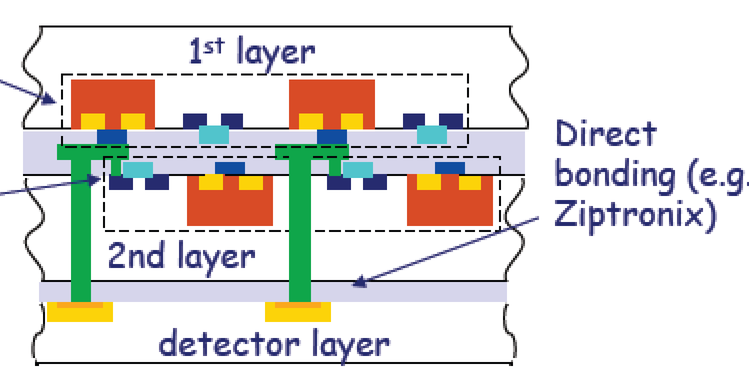
- ✓ High resistivity pixels:
  - ✓ larger signal available from detector
  - ✓ more advantageous trade-of between S/N and dissipated power
- ✓ Bump bonding can have significant mass and represent a high X_0 for fine pitch assemblies or high density interconnections
- ✓ In the next MPW run, development of a 3D front-end chip (32x128, 50um pitch) to be vertically integrated with fully depleted detectors through some more (bump bonding) or less (direct bonding) standard technique

- ✓ less PMOS in the sensor layer → improved collection efficiency
- ✓ more room for both analog and digital power and signal routing (

Fine pitch (50um) bump bonding (IZM, Munich), with a 2D FE chip in progress, with a 3D FE chip in the future

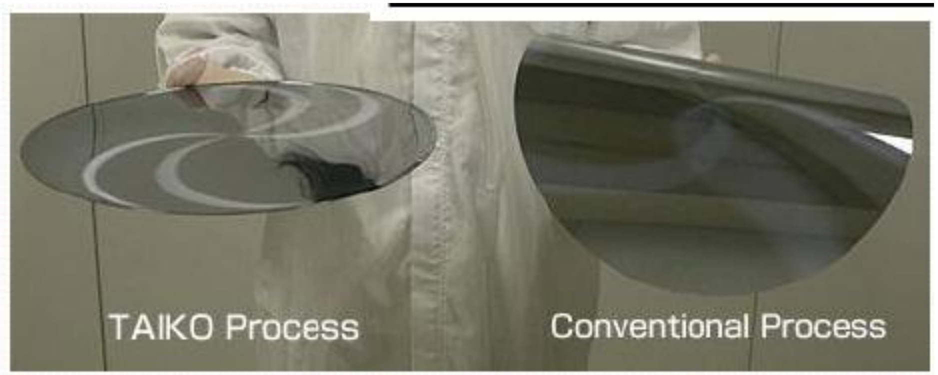


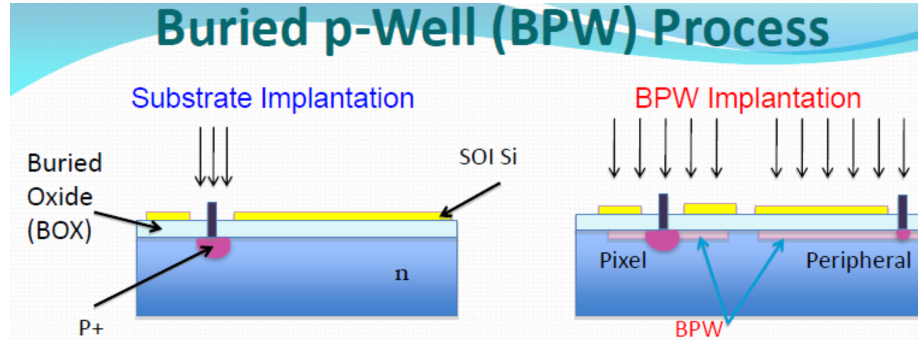
Other technologies (Direct Bonding by Ziptronix) will be investigated in the future

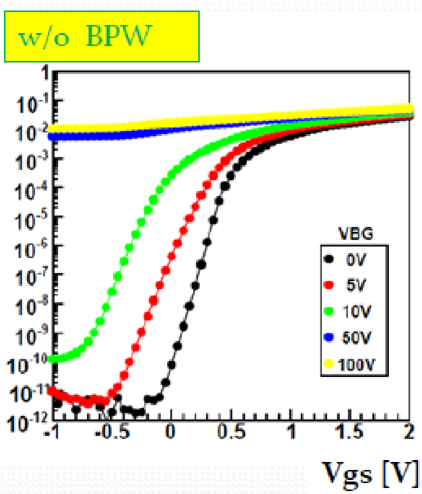


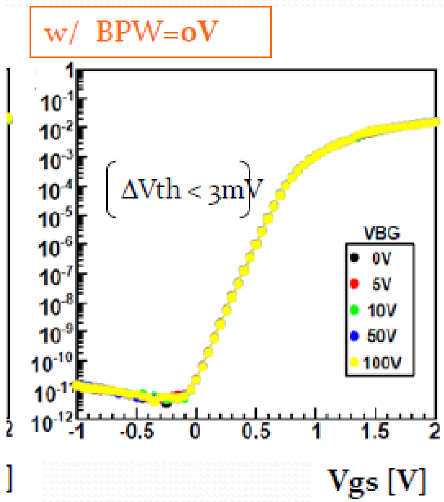
ry line

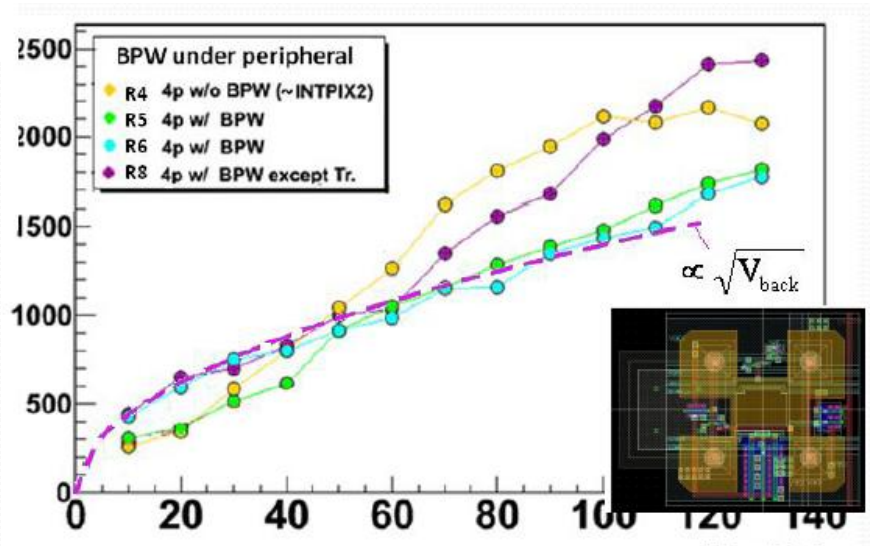
SOI pix – many developments pick out two here –







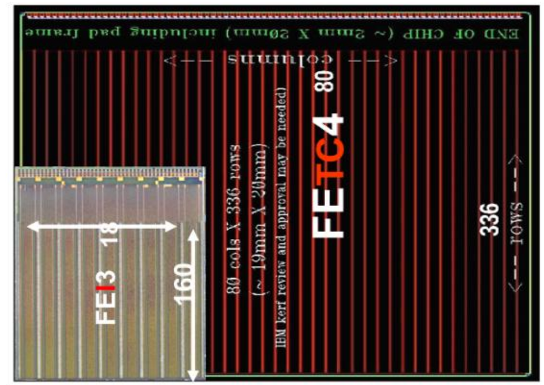




More can sometimes be lesss!

ATLAS Chartered-Tezzaron MPW run

3-D benefits :
- Pixel size reduction
- Functionalities splitting
- Technologies mixing



FEI4_P1 design : IBM 130nm, 8 metals

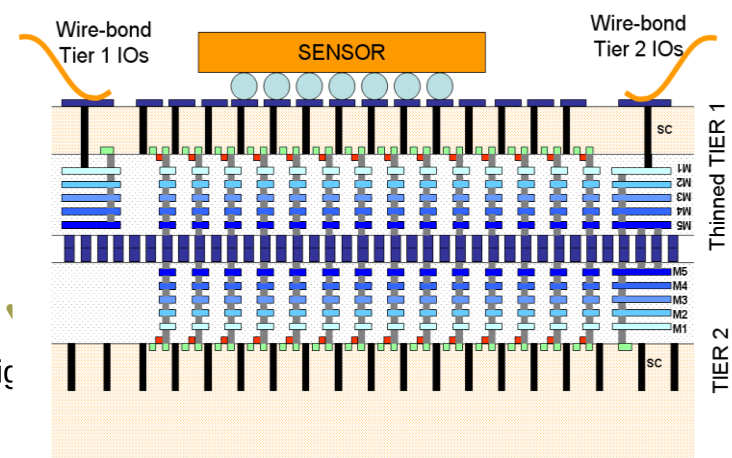
FEC4_P1 circuit : **2D** Chartered, 8 metals

FETC4_P1 circuits : **3D** first prototype

FEC4_P2 circuit : 2D Chartered, 8 metals

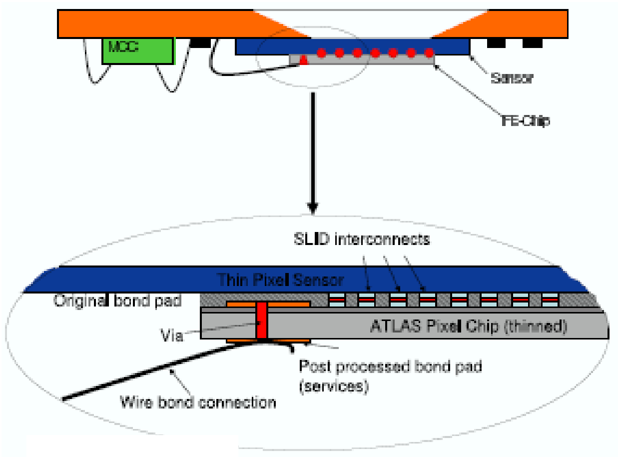
FEC4_P3 circuit : 2D Chartered, 8 metals

FETC4_A design : Second/last 3D design
- Chartered (5 metal levels) + Tezzaron
- Pixel size : 50µm x 125µm
- Complete functionalities will be implanted on analogue and dig Tiers.



MPI 3D R&D Program

- Build demonstrator using ATLAS pixel chip (FE-I2/3) and thin pixel sensors made by MPI (complete wafers with FEI2, FEI3 chips available!)
- Use interconnection technology allowing postprocessing
- Interconnection with SLID and ICV technology by Fraunhofer IZM
- Demonstration of postprocessing of standard ASICs with via last



R&D Issues:

- Technology: compatible with sensors, ASICs?
- Interconnection quality: e.g. capacitance
- Yield & Costs.
- Production in industry.
- Material (copper layer).

Hans Guenter Moser

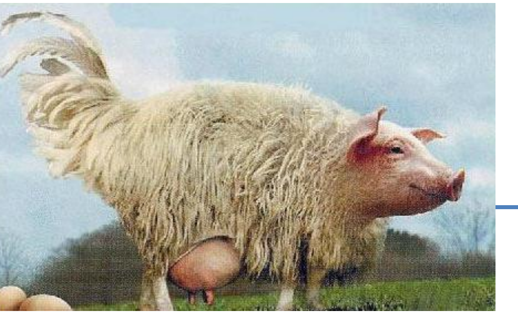
Future directions

Complete spectrum of upgrade proposals (probably to be viewed on a log scale)

- Today
  - NA62 GigaTracker Project
- Tomorrow
  - STAR
  - Belle II
  - ATLAS IBL
  - LHCb upgrade
  - CMS Phase I Pixel upgrade
- Next week
  - CBM, Panda
- After that
  - SLHC related upgrades
  - CLIC related detectors

- "Ultimate goal remains a massless, cheap, infinite granularity, 100% hermetic and efficient, infinite bandwidth, long lifetime detector"

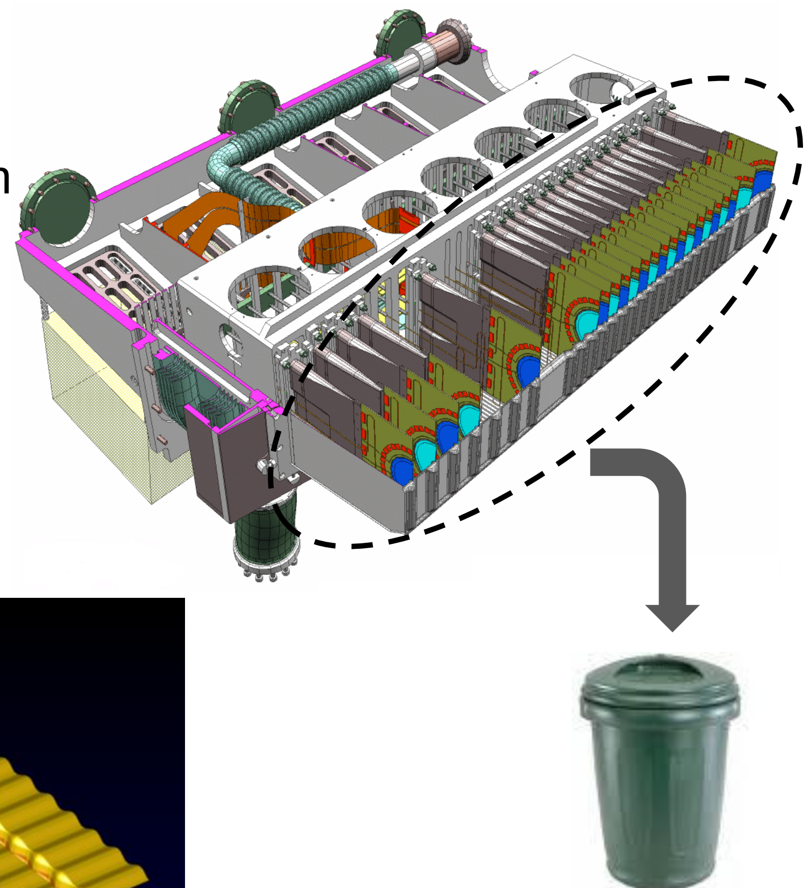
(Muenstermann, after Garcia-Sciveres)

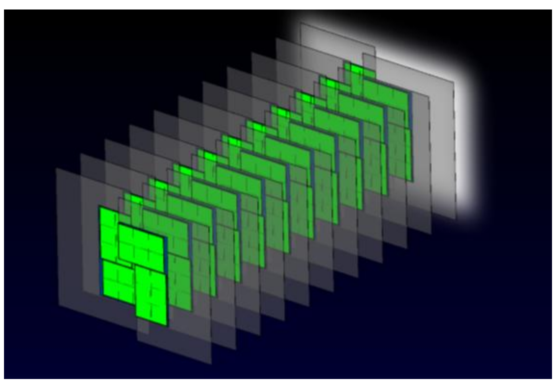


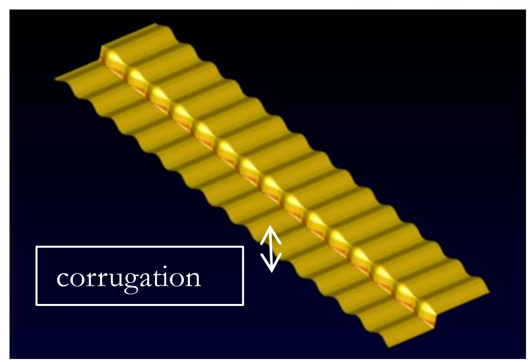
Progress on these projects not necessarily inversely proportional to timescale…

LHCb upgrade (~2015)

- LHCb upgrade plans do not require SLHC luminosity
- (but we would quite like LHC to deliver nomin running during the next 4-5 years)
- Challenges are radiation hardness (=thermal management), data rates, and vacuum operation
- ASIC development well underway with Medipix/Timepix collaboration







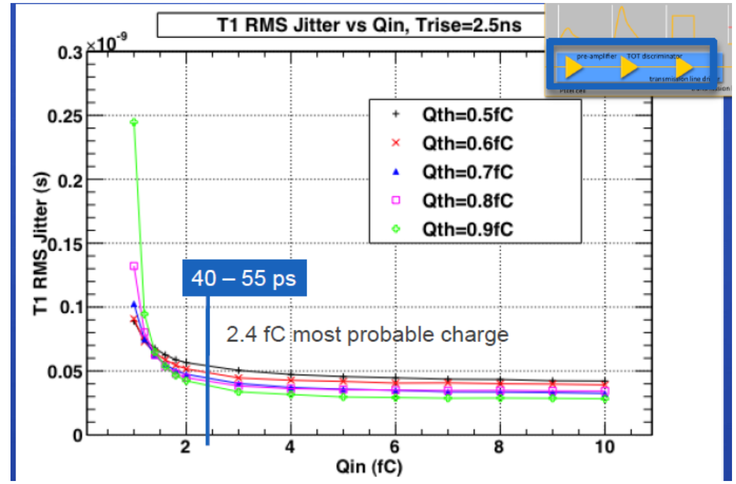
Jan Buytaert

NA62 Gigatracker (~2012)

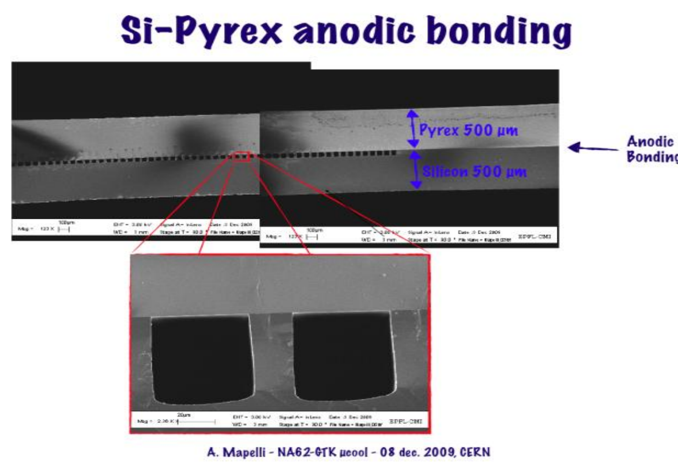
A. Kluge

Pixel detectors with time resolution thrown in

- Many requirements in common with LHCb
  - Enormous data-rates
  - Low material
  - Operation in vacuum
  - Radiation hardness (more relaxed)
  - Timestamping (More severe: ~100 ps)
- Have developed and tested two (2!) ASICs
  - constant fraction discriminator + on-pixel TDC
  - Time-Over-Threshold circuit followed by shared TDC
- The cooling is very cool!!



- chip demonstrating fantastic (non) timewalk behaviour, and full r/o chain demonstrated

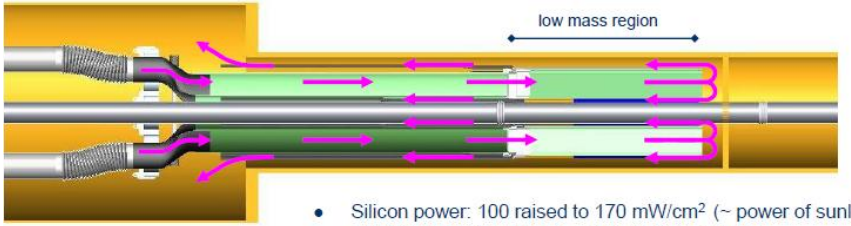


MAPS based vertex detector at STAR ~2013
"Most critical and difficult part of HFT upgrade!"

Michal Szelezniak

- 2.5 cm and 8 cm radius
- 8 um hit resolution
- 0.37% X/X0
- 0.2 ms readout time
- 8 hour detector swap over time
  - Similar to an NHL line change?
- Very low mass features include
  - featherweight mechanics
  - air cooling system

Vacuum chuck for probe testing 50 μm thick MAPS



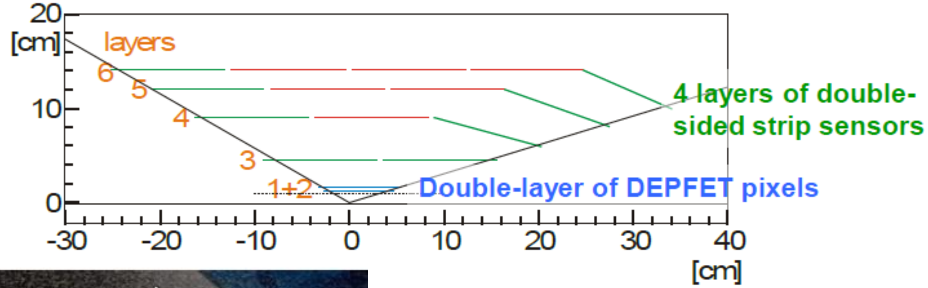
Belle II SVD upgrade

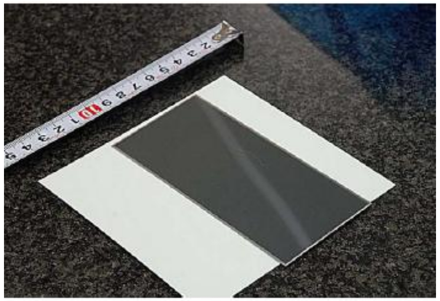
Thomas Bergauer

Aim: super high luminosity ->10^10 BB per year

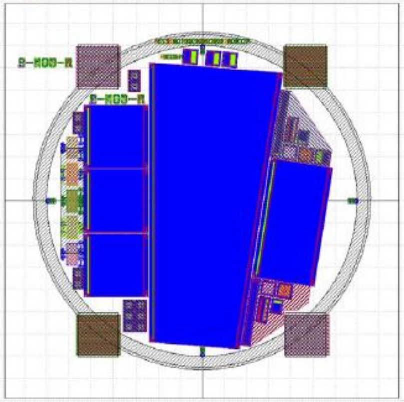
- Current SVD cannot sustain lumi increase
  - hammamatsu restarted dssd line
  - micron home designed sensors
- have to put the chip on the sensor because of cap load – readout sensors individually
- use apv25, thinned to 100 um
- can use timing information to remove off-time background hits
- total reduction of 100 in occupancy
- origami modules

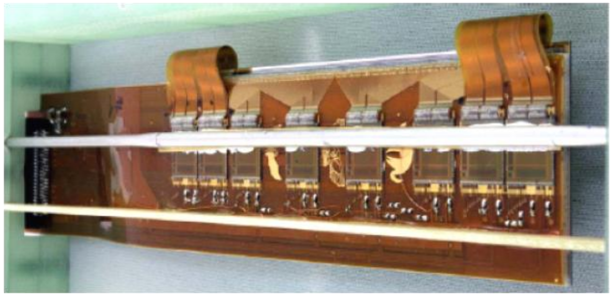
SVD-II Layout (2014-)





Trapezoidal sensor with test structures



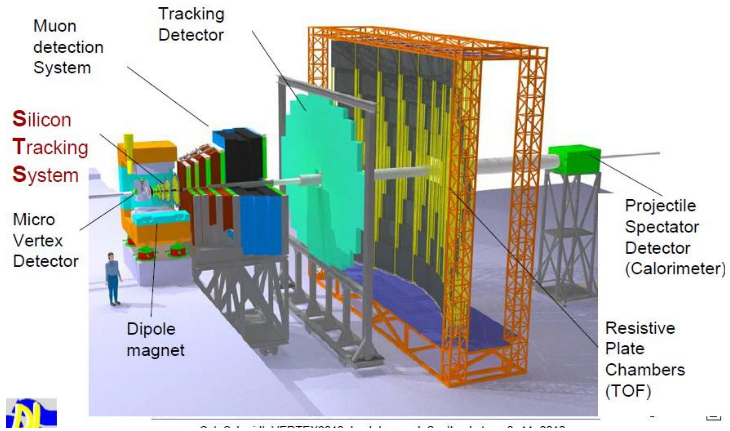


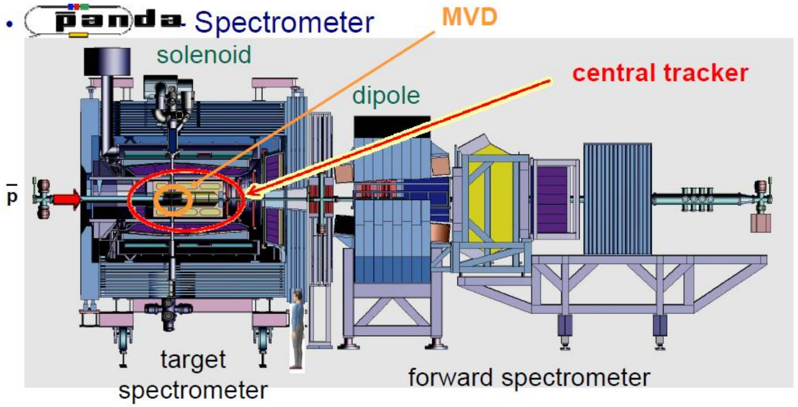
CBM + PANDA @ FAIR

C.J.Schmidt

"Accelerator for everything from antiprotons to Uranium"

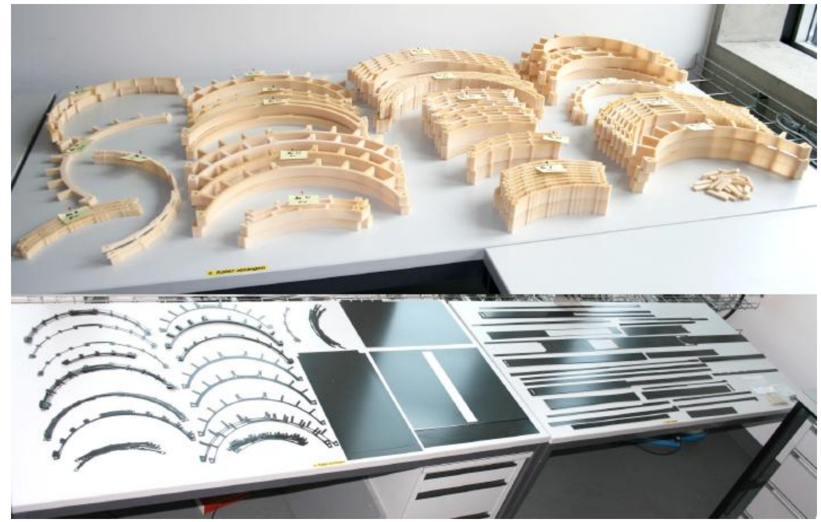
- Major tracking challenges ahead for completely new detectors
- Extensive prototyping and simulation
- Close collaboration with MAPS groups (dedicated developments)
- Beautiful results from demonstrator projects in testbeams



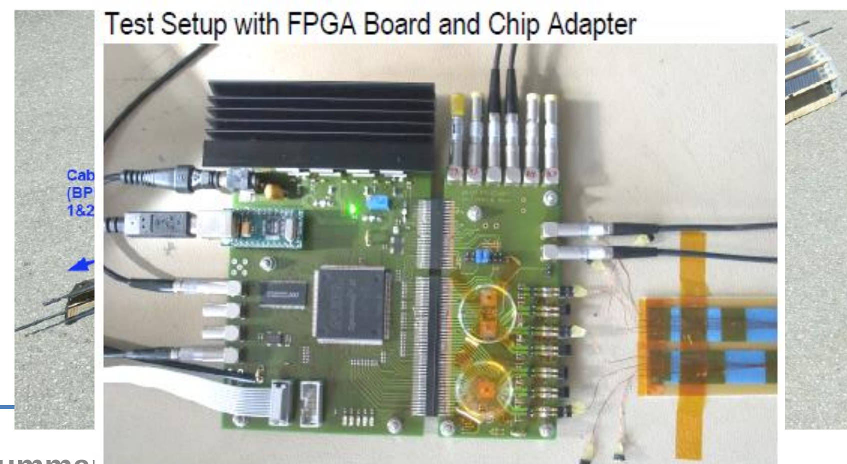


CMS and ATLAS phase 1 upgrades Expectation of ~100 p.u. events…

Hans Christian Kaestli



- CMS: going for the kill on material budget (= i.p. resolution) and track seeding (adding a pixel layer)
  - current 3 layers 17 kg
  - future 4 layers 6.5 kg
- How do they do it???
  - Move to CO_2 cooling
  - Use of Airex and Carbon Fibre
  - chip away at everything else!
- New databuffer circuit tester
  - Elegant R&D tool
  - Verilog model and random data generator implemented in fpga
  - Can directly test sustainable rates



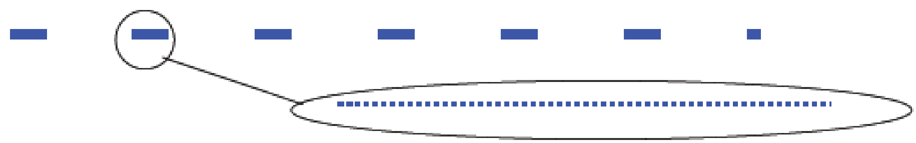
CLIC

Eric van der Kraaij

Train repetition rate 50 Hz

Not to scale

CLIC

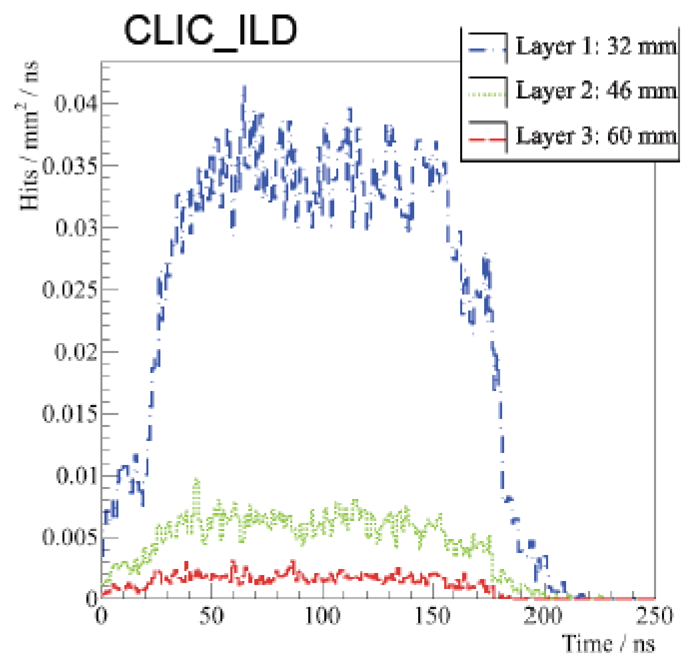


CLIC: 1 train = 312 bunches, 0.5 ns apart trains at 50 Hz

ILC: 1 train = 2820 bunches, 308 ns apart trains at 5 Hz

- Reminder of conditions at CLIC and ILC
- Design very critical on the belief that the pixels can be *very* small, and that differences of 5,4 and 3 micron resolution can be made to count
- A long way to go!!

$\sigma_{\text{point}} = 3\mu\text{m}$	$\sigma_{\text{IP}} = 6.5 \oplus \frac{16.7}{p_t}\ \mu\text{m}$
$\sigma_{\text{point}} = 5\mu\text{m}$	$\sigma_{\text{IP}} = 9.2 \oplus \frac{18.6}{p_t}\ \mu\text{m}$



Averaged over ϕ

Summary of summary of summary..

- 1998

"Major advances in radiation hardness with oxygenated silicon detectors and deep submicron chips (just in time!)".

"Hope was expressed by Steve Watts that b=0 silicon could be engineered, where b is the coefficient of reverse annealing"

- 2010
  - LHC data!
  - Huge diversification of pixel applications
  - Charge Multiplication

- Next Year

- Avalanche of progress in *real* real steps in 3d processing
- "hep should be ready to embrace the via revolution and the benefits it will bring"
- ultra rad hard progress
- Performance plots at ultra fine level

Some quotes from the conference:

- Lars: Chris seems to be pushing the wrong button
- Karl: “easier to shift the cms pixel detector than the monte carlo”
- Marco: “On to the flavour physics lecture”
- “not necessarily technically feasible”
- “Every detector developer should be forced to take an image with his teeth

Huge thanks to the organising committee

Special mention for the paparrazzo