Electronics and Trigger developments for the Diffractive Physics Proposal at 220 m LHC-ATLAS

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Prague, Czech Republic

Outline

- Diffractive Physics at LHC
- Roman Pots at ATLAS
- Silicon Detectors
- Timing using Micro-channel Plates
- Trigger and DAQ
- Conclusion

Diffractive Physics at LHC

Project to install Roman Pots detectors at 220m from the ATLAS IP

Collaboration between :

- Prague, Cracow, Saclay, Stony Brook, Giessen, Paris 6,
- Chair : Christophe Royon (DAPNIA CEA Saclay)

Physics processes

- **Study of inclusive events (the only events which are existing for sure)**
  - Determination of gluon at high β , search for SUSY events (or any resonance) when dijet background is known
- **Exclusive Higgs:**
  - Signal over background: ~ 1 if one gets a very good resolution using Roman Pots (better than 1 GeV), enhanced by a factor up to 50 for SUSY Higgs at high tanβ
- **QED WW pair production**
  - Cross section known precisely, allows to calibrate precisely the Roman Pot detectors
- **Diffractive top, stop pair production**
  - Possibility to measure top and stop masses by performing a threshold scan with a precision better than 1 GeV if cross section high enough

RP220 vs. other projects

- High Luminosity
- Additional signal and flag at the L1 ATLAS Trigger
- Natural follow-up of the ATLAS luminosity project at 240 m to measure total cross section
- Complementary to the RP420 (Roman Pots at 420m)

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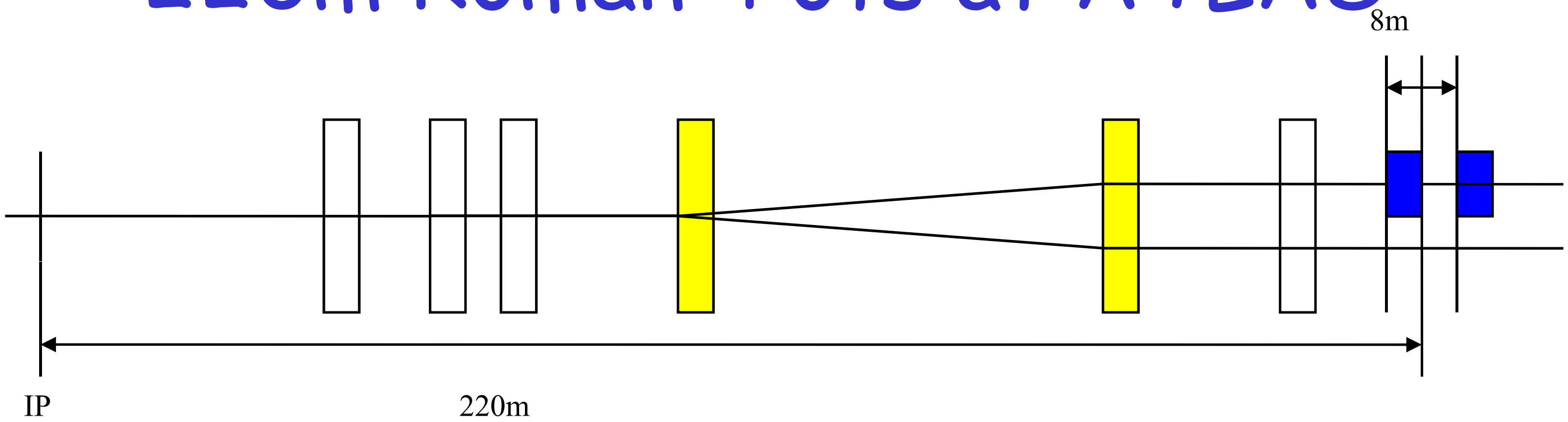
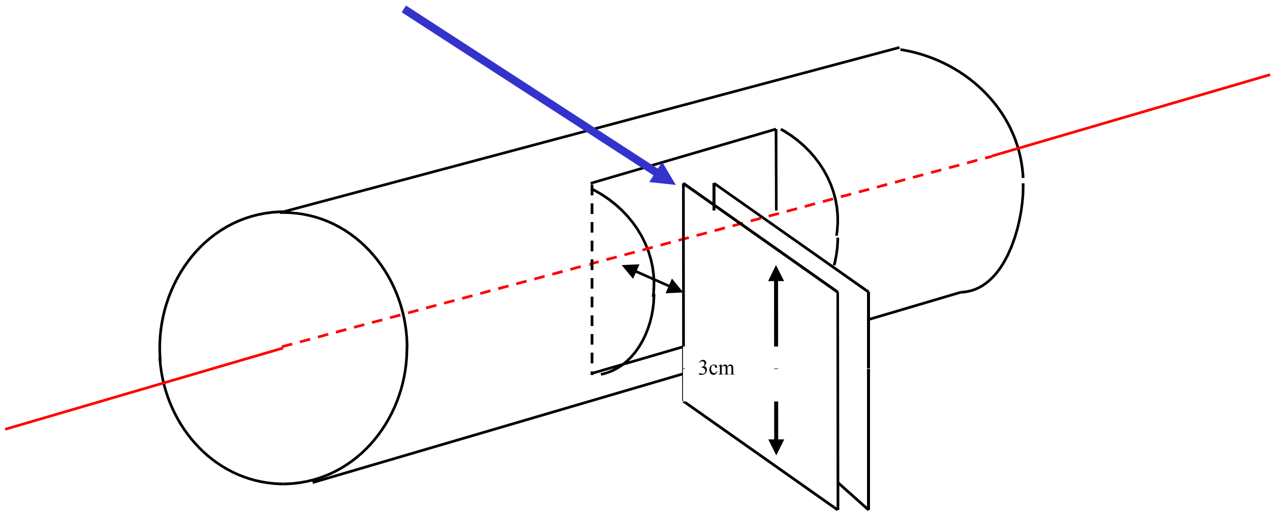
220m Roman Pots at ATLAS

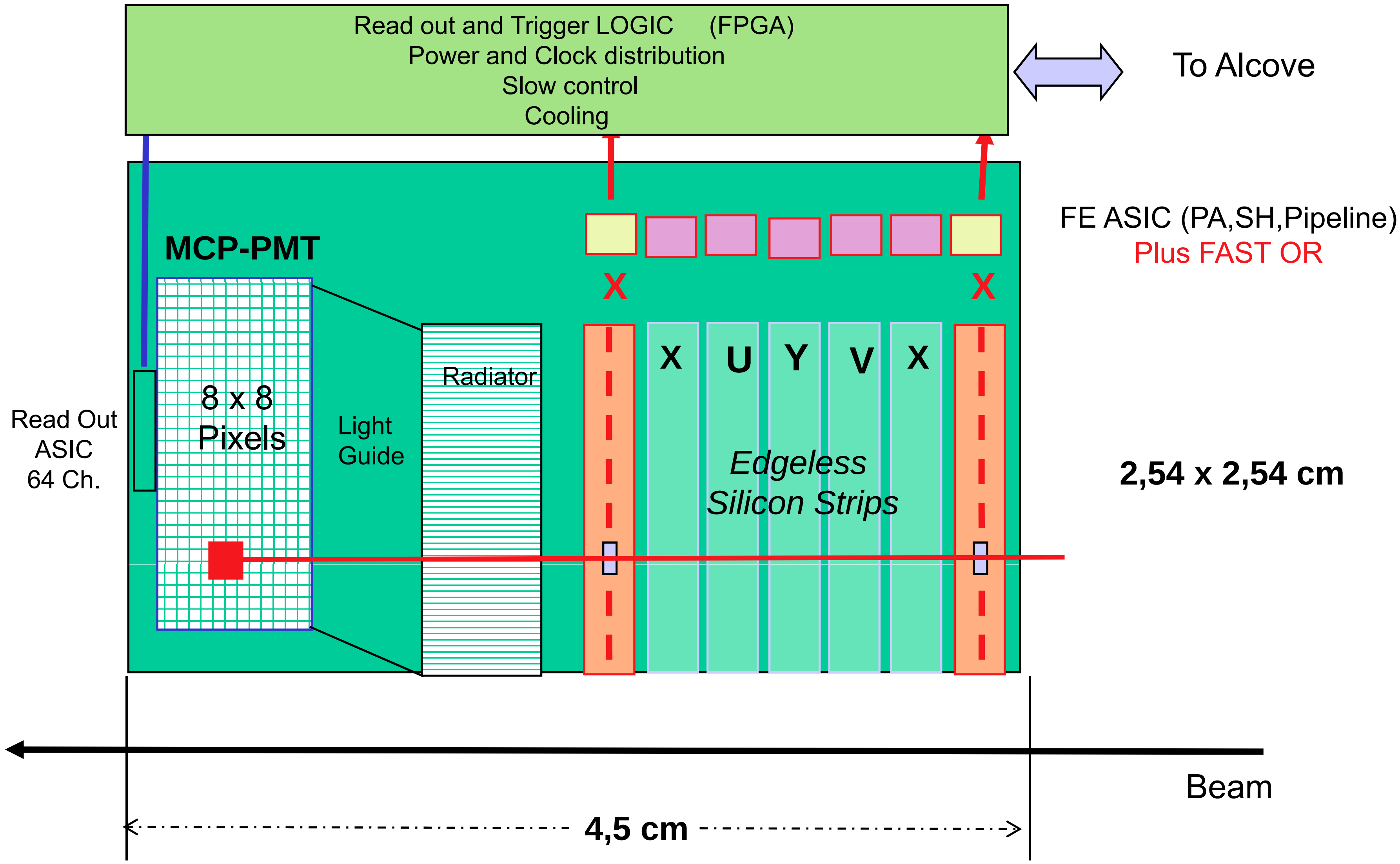


Two horizontal pots at 216 and 224 m on each arm with detectors as close as possible to the beam: 10 σ = 1μm



5 Silicon detectors (Position)
1 Micro-Channel Plate (Time)

Roman Pot Layout



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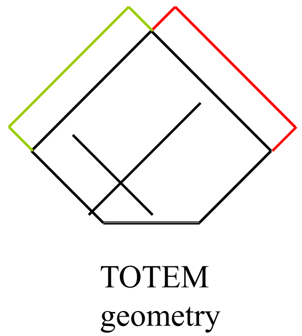
Silicon detectors

One Roman Pot:

Five Silicon strips detectors :

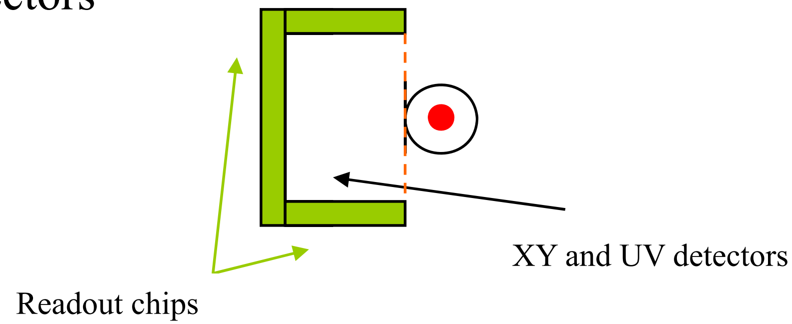
- **25 μm pitch detector of 2.54cm x 2.54cm,**
- **1000 channels, 10-bit address.**
- **2X, 1Y, 1U, 1V detectors**
- **Two of them used for L1 trigger.**

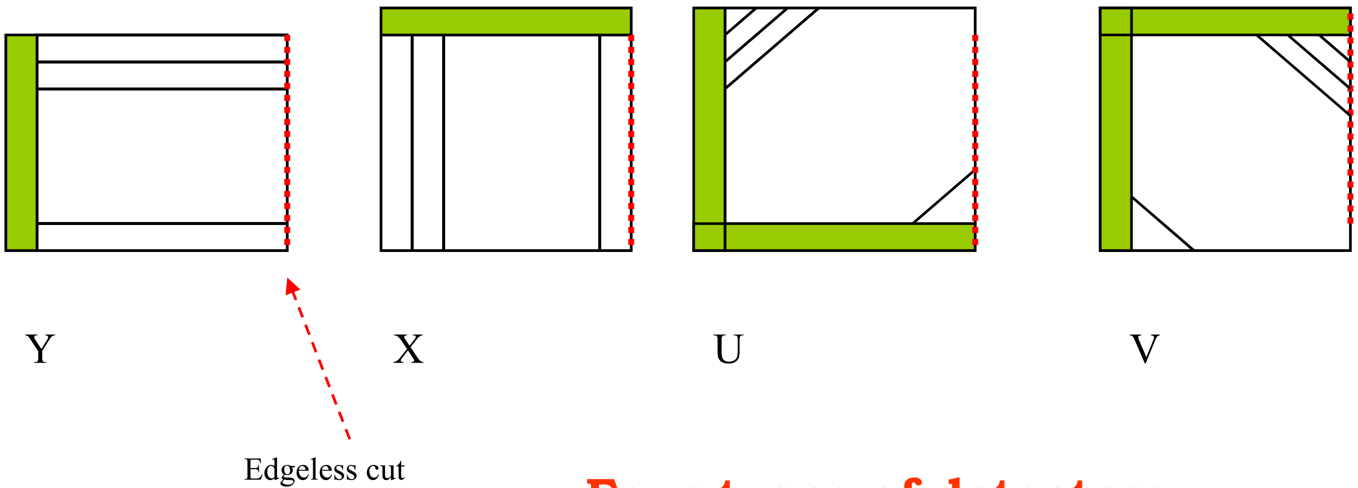
Detector geometries



25.4 x 25.4 mm detectors

50 µm pitch





Four types of detectors

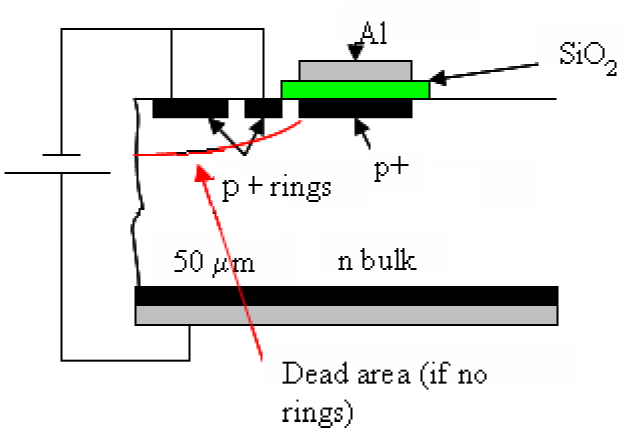
Roman pots specific requirements

- Achieve 10 μm position resolution: 50 μm pitch strips read in digital :

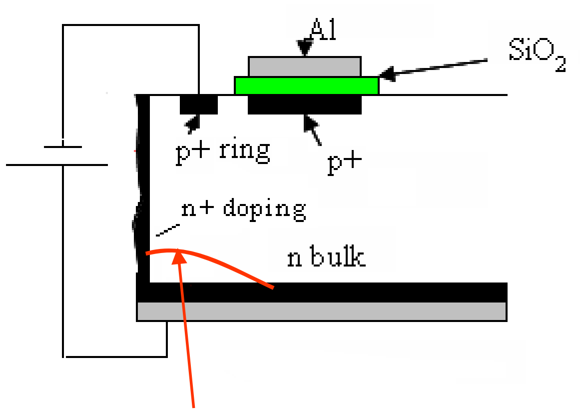
  $25 / \sqrt{12} = 14.4$ μm resolution

- Edgeless:
  Collect edge currents through the bulk to allow full depletion, or avoid them.

  TOTEM:
  - Rings biased at the strip potential as close as possible to the edge, collect currents due to cut, allow to be sensitive down to 20 - 50 μm



TOTEM



Proposed (Canberra)

Proposed by Canberra: edge equipotential, no more edge current flowing.

Detectors specifications

Size	2.54 x 2.54 mm^2
AC coupled	>10pF/cm, insulated to >300V
Interstrip	< 1.5 pF/cm
Full depletion	60-100V
Thickness	300 μm +/- 20 mm
Leakage current	50nA/cm^2 at 300V bias
Resistance poly (one side)	1.5+/- .5 MΩ
Interstrip resistance	> 2 GΩ
Pads AC and DC	
Edgeless on one side	< 30 μm
Pitch	25 μm
Pitch adapters to 100 μm on detector (four rows)	
Defective strips	<1%

Quantities: 20 + 12 spares = 32

Availability from the industry

TOTEM: CERN and IOFFE PTI (Russia) produce edgeless first detectors moved to INTAS-CERN EU project.

Companies contacted:

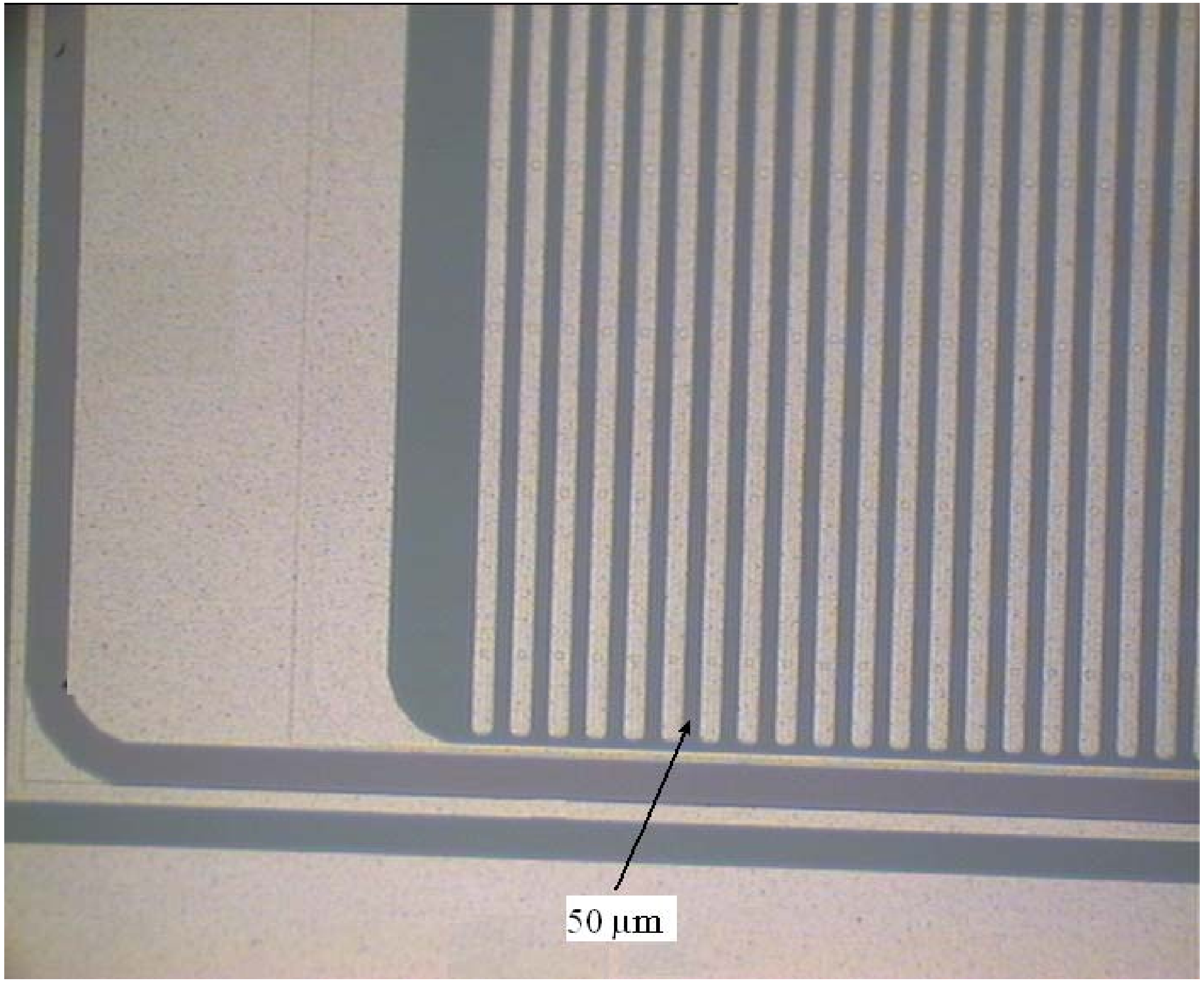
- **Canberra (AREVA Belgium)**
- **Hamamatsu**
- **Sintef (Norway)**
- **VTT (Finland)**

- **Canberra started small prototypes 6.4 x 6.4 mm, 50 μm pitch, DC coupled, edgeless at 25 and 50 μm, available for tests beg 2007.**

- **Hamamatsu and Sintef made also offers.**

VTTclaims to be able to do edgeless to 20 μm. Semi-3D availability

Test detectors

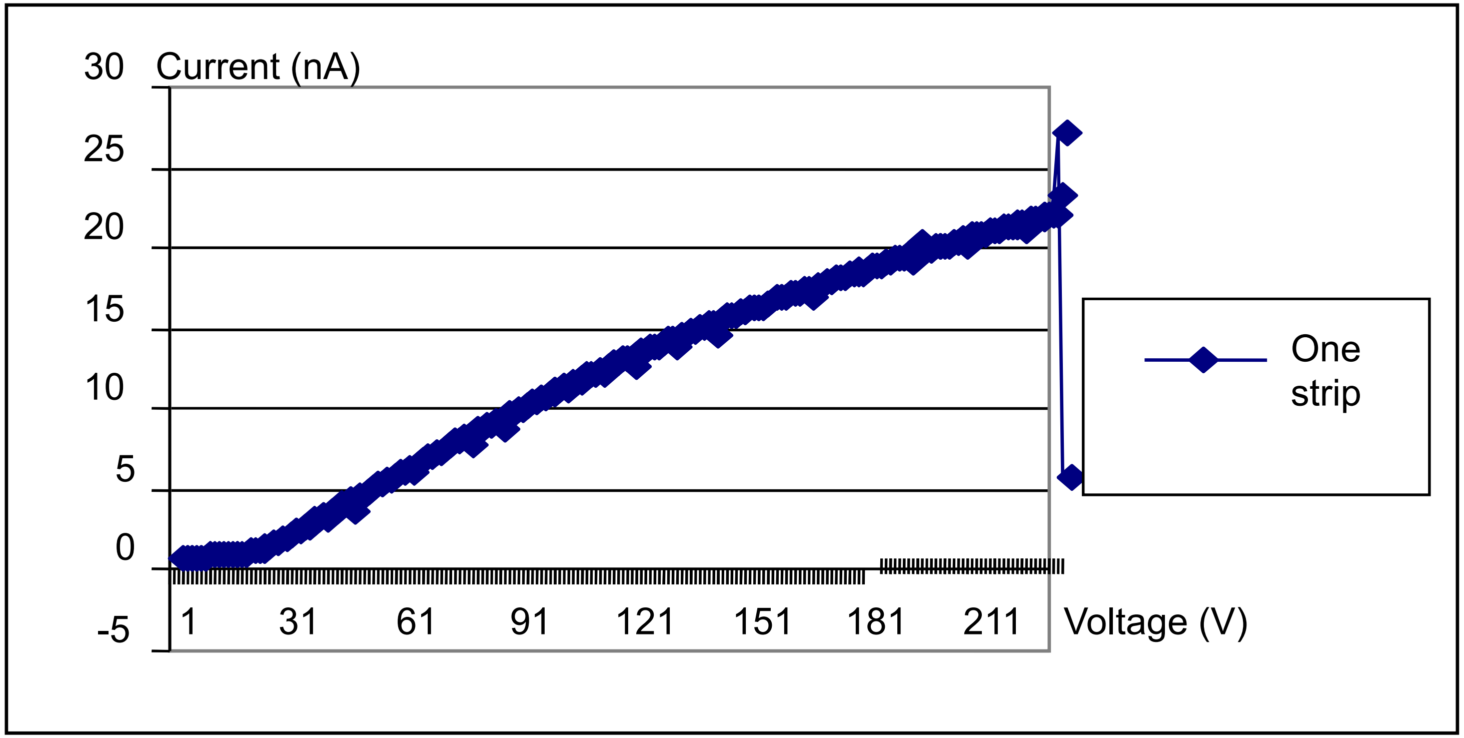


CANBERRA 50 μm pitch test detectors

Detectors tested
for reverse current
at FZU Prague

Presently wire-bonded
to ATLAS SCT
hybrids at CERN
Mirek Hravana

Tests at FZU Prague (July 2007)



Reverse current measurement depending on the strip position typically 25 nA OK.
Further tests need a full detector wire-bonded and biased.

Breakdown voltage 110-130 V OK

Test stand at Saclay

CERN provided a test stand with hybrids equipped with regular ABCDs chips used for the ATLAS SCT

Thanks to Shaun Roe and Francis Anghinolfi

Future ABCD chip will include fast outputs

(W.Dabrowski)

VME readout module driven by a PC installed at Saclay

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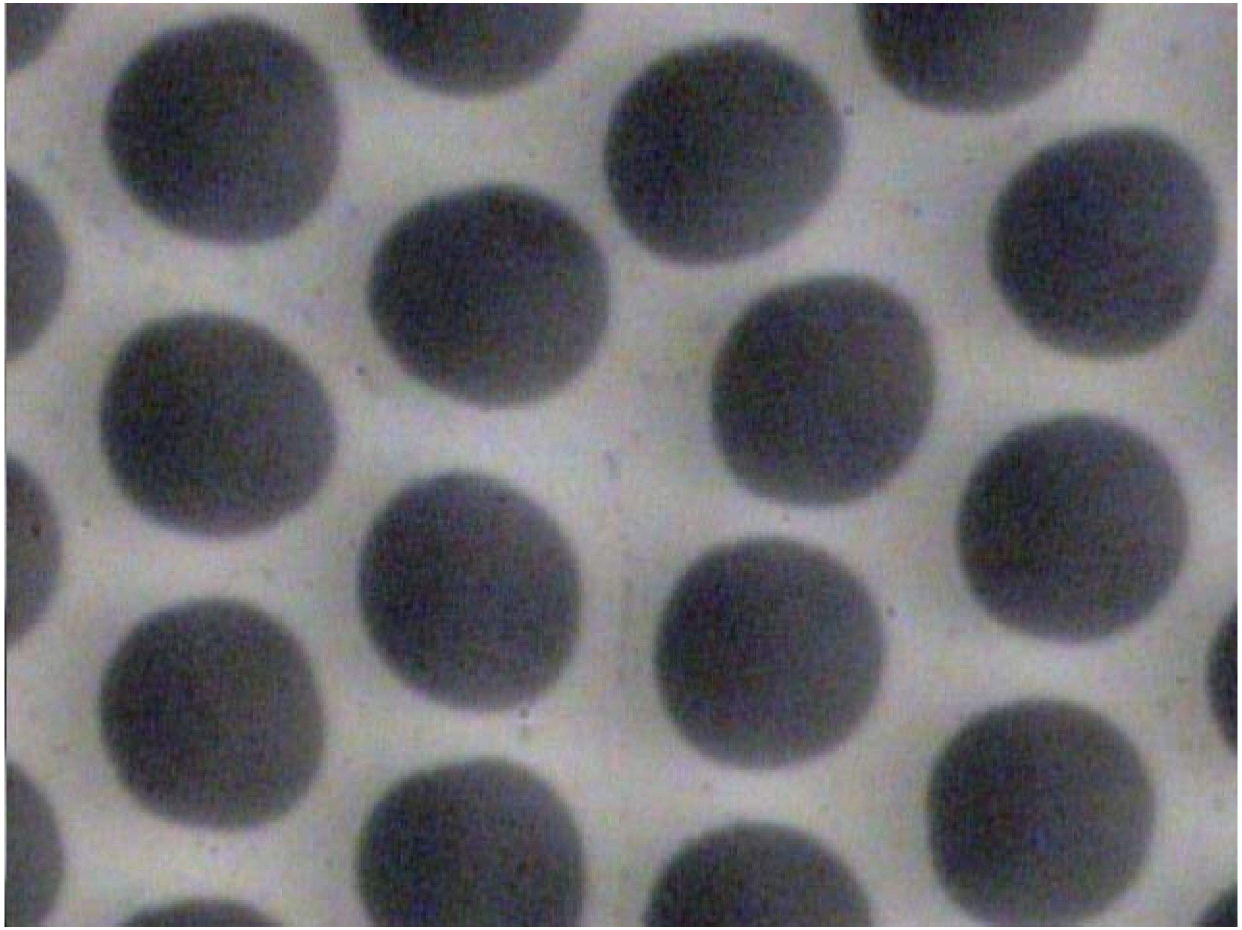
Micro-Channel Plates Timing Detectors

- Used to achieve picosecond coincidences and reconstruct Vertex to 1mm precision

Burle-Photonis provides MCP detectors

8 x 8 segmented anodes readout

Major advances for TOF measurements



Micro-photograph of Burle 25 µm pores tube

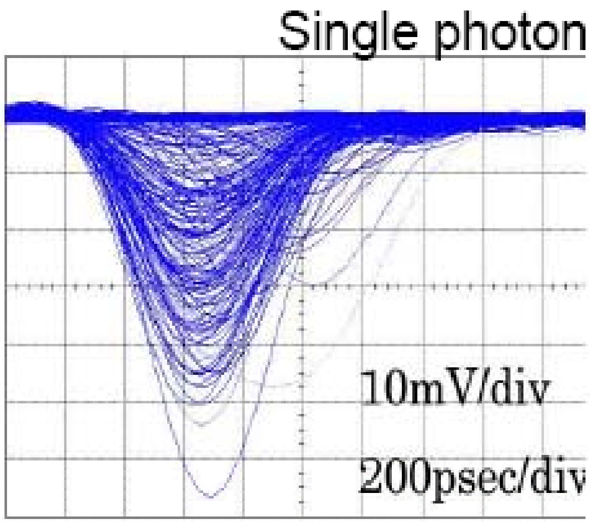
Greg Sellberg (Fermilab)

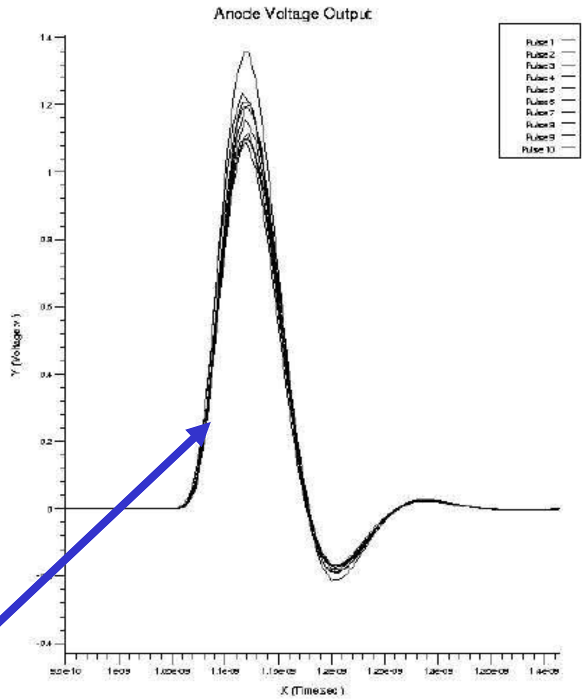
Now 10 µm pores

2" x 2" sensitive area

Courtesy: Henry Frisch Univ Chicago

MCP PMT single photon signals





Actual MCP PMTs signals
K. Inami
Univ. Nagoya
Tr = 500ps
tts= 30ps

MCP PMTs segmented anode signals simulation
20 photoelectrons tts = 860 fs
H. Frisch,
Univ. Chicago + Argonne

N photo-electrons improves as $\sqrt{N}$

Electronics developed at Univ. Chicago

See Poster by Fukun Tang (this Workshop)

- Two cards 2" x 2" connected to the MCP anode planes

Picosecond card with picosecond Time stretcher SiGe chip includes:

- Discriminator
- 2 GHz PLL
- Time stretcher

FPGA card includes

- 200ps TDC
- Control, calibration, interface

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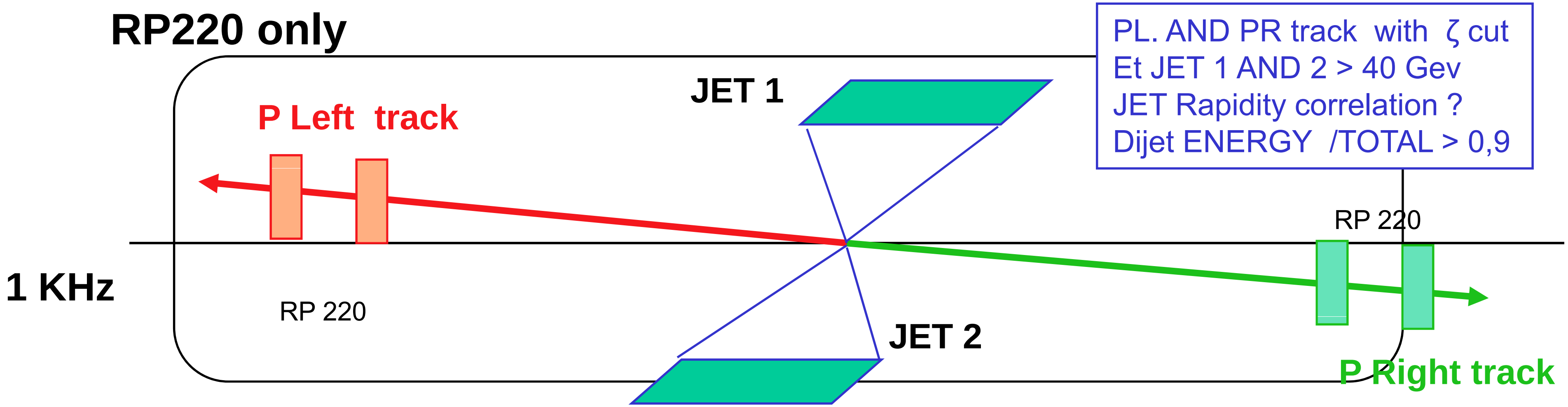
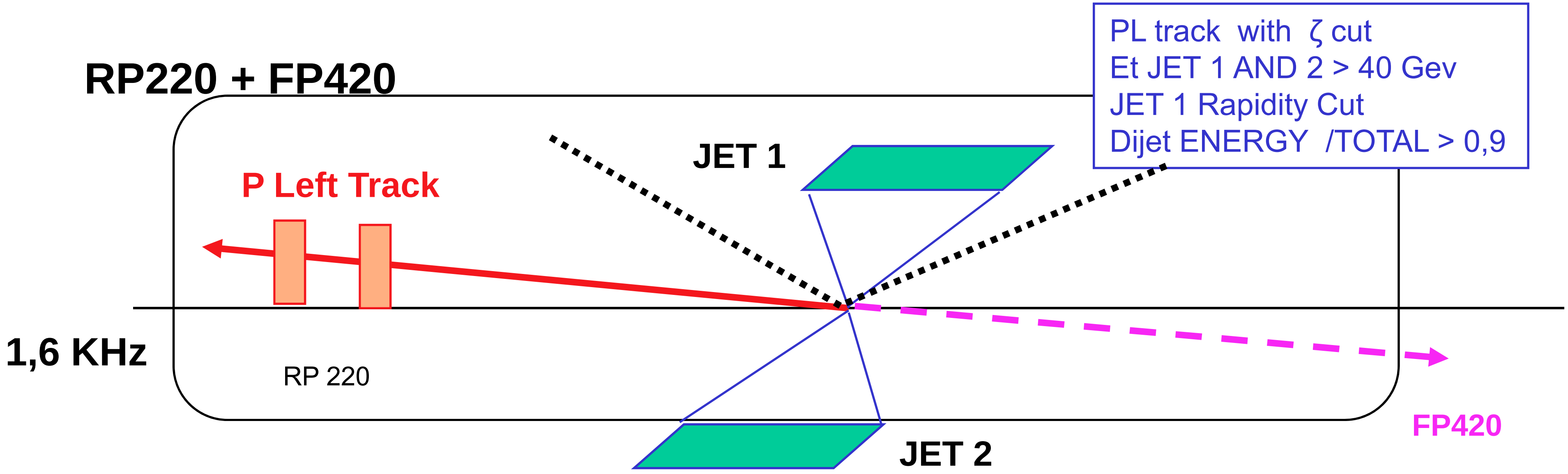
Trigger Topologies

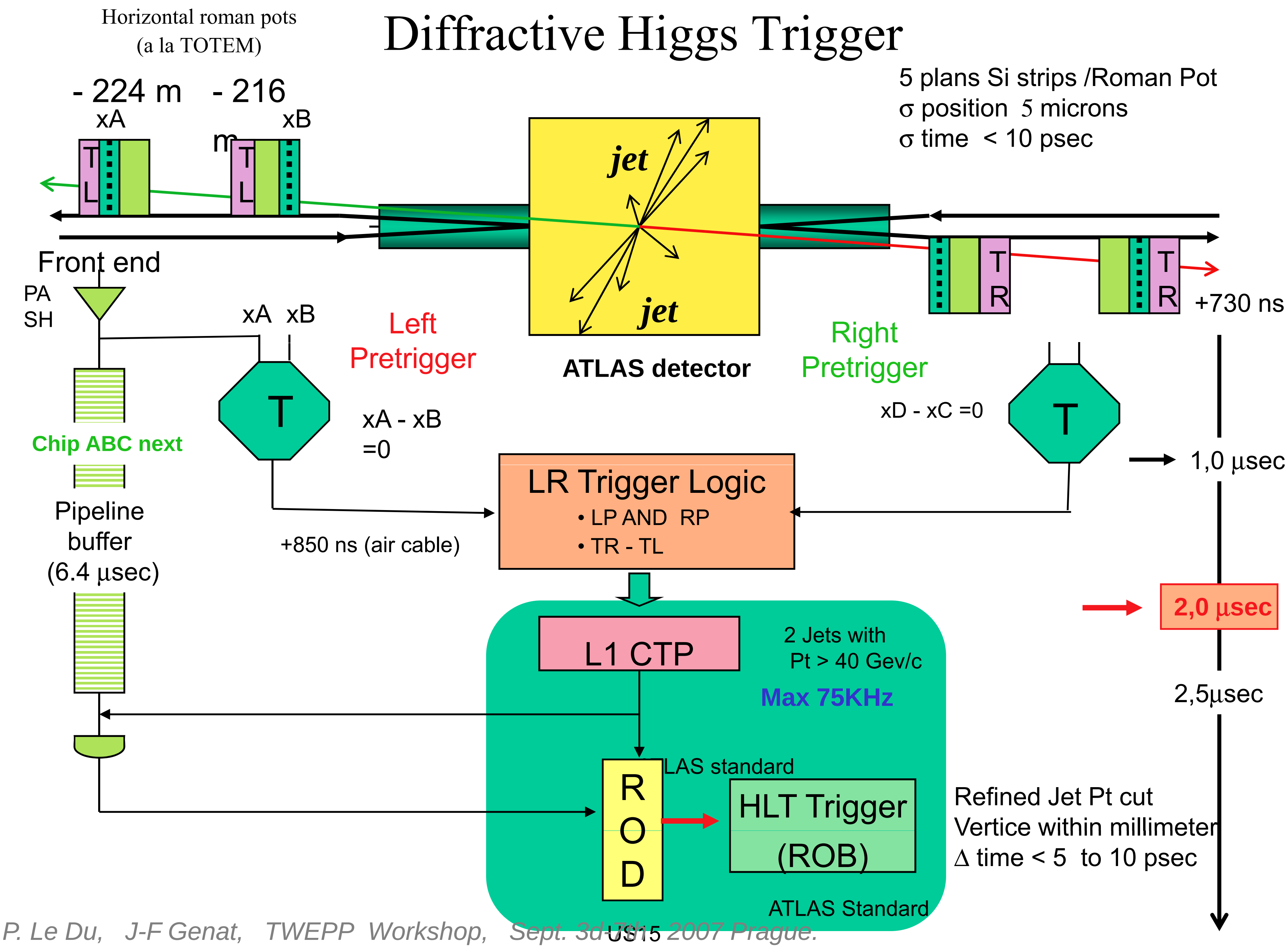
RP220 only



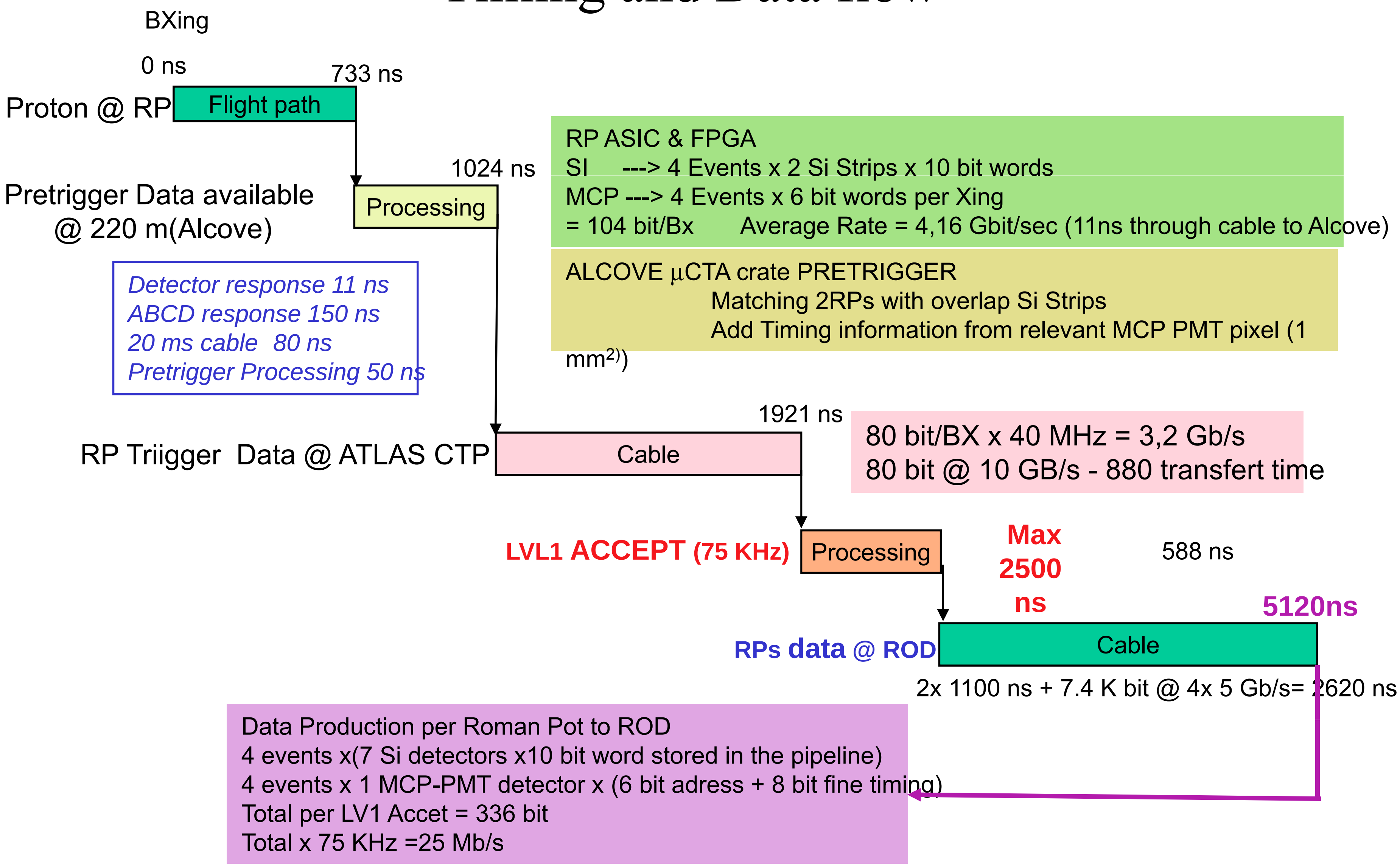
RP220 + FP420



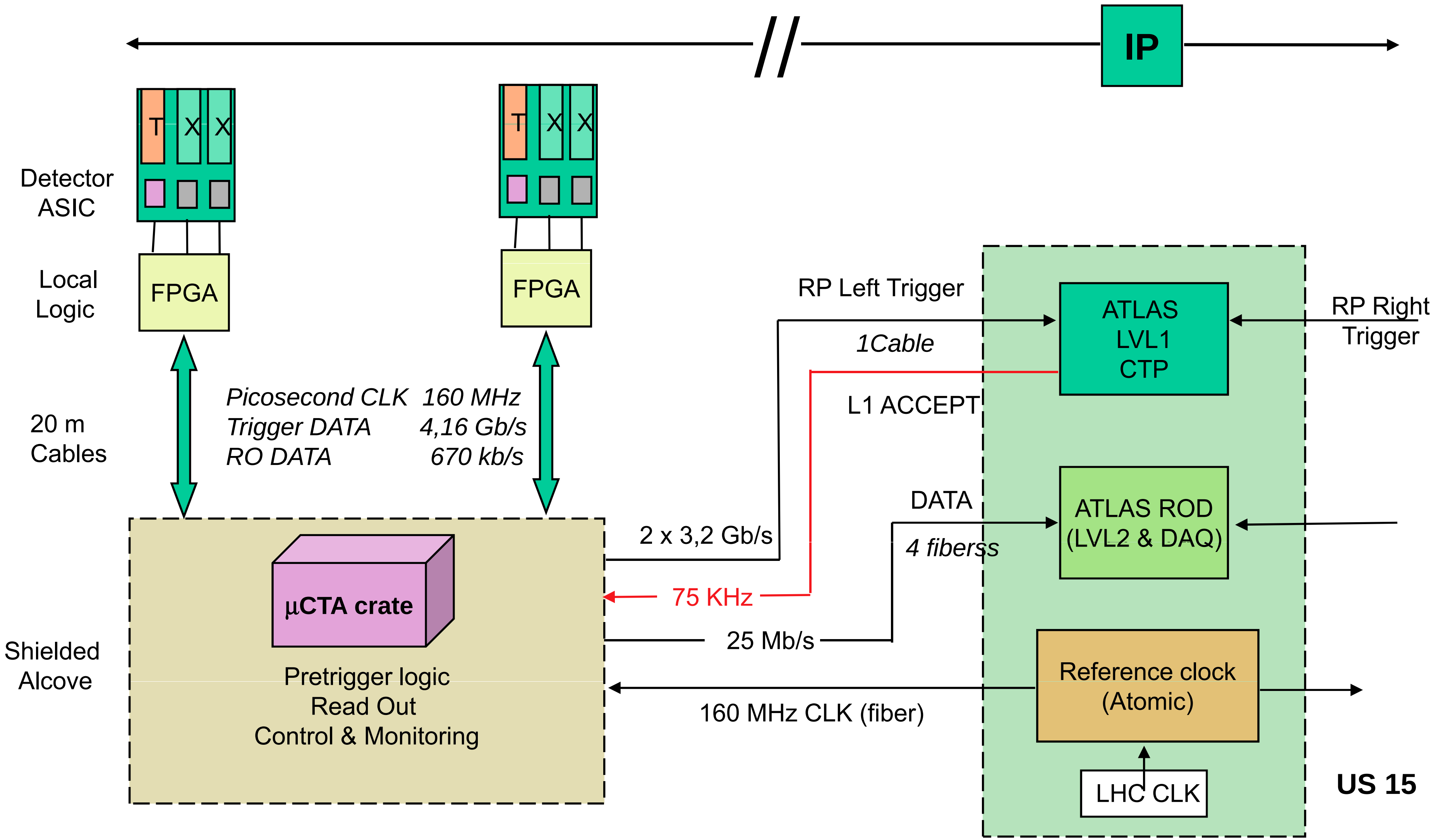
Diffractive Higgs Trigger



Timing and Data flow



Implementation block diagram



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Conclusion

Much work to be completed timely
Not too many people…

- Detectors
  Silicon, MCP

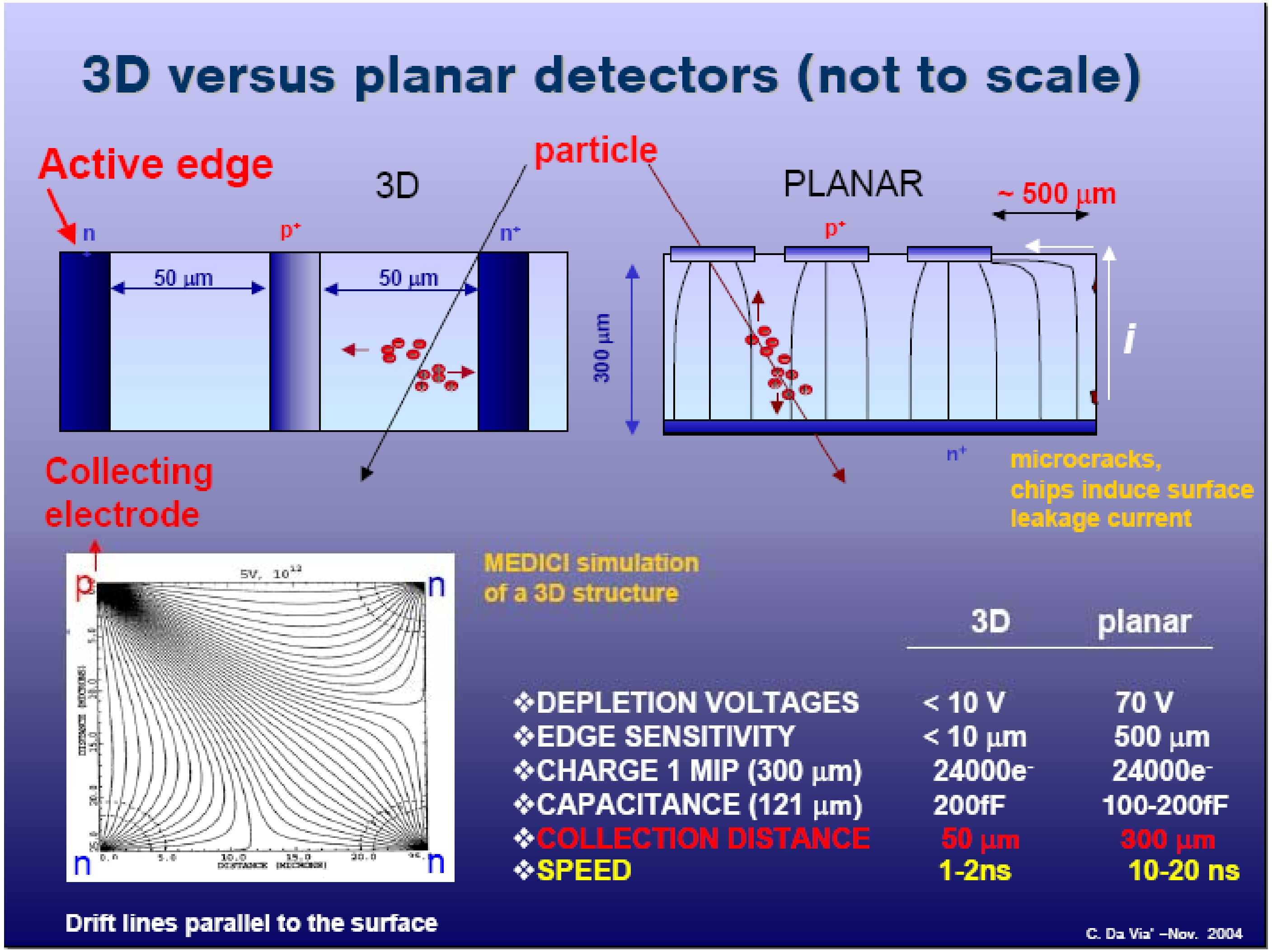
- Electronics
  SiGe-CMOS chips, FPGAs

- System
  Insertion into ATLAS L1 and DAQ
  Micro TCA foreseen

- Install…

backup

3D detectors vs Planar

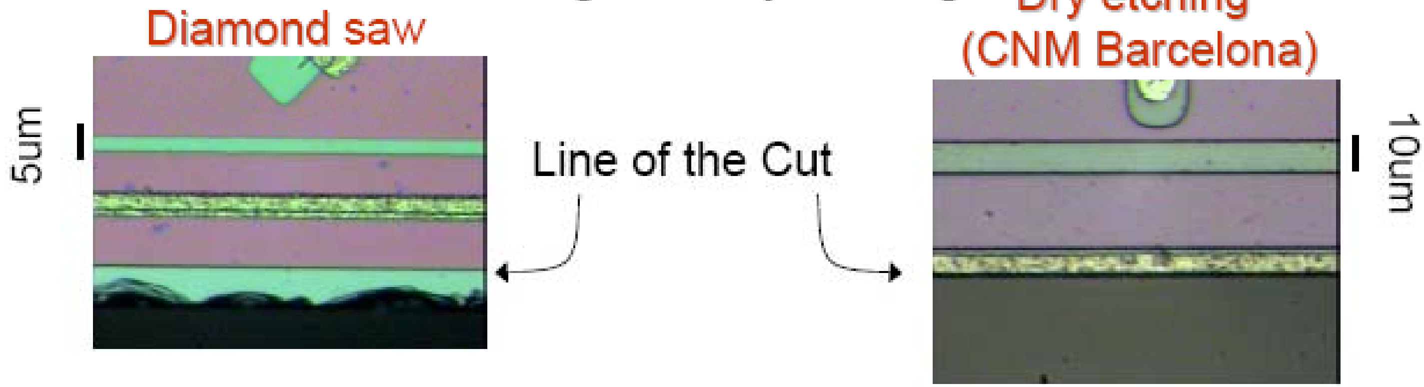


Cinzia Da Via (FP440) , Brunel, UK 11/2004
Stanford, SINTEF, VTT

Edge processing

- "Precise" <u>diamond saw</u> VS <u>dry etching</u>

A fraction of this production will be sent to the CNM of Barcelona for the dicing with dry etching



- If this test is satisfactory (in terms of yield and performance) we could still adopt this technique for the mass production

Gennaro Ruggiero (TOTEM)

Micrometer range cut uniformity allows low edge surface currents.