Results of Diamond Characterisation

2nd ADAMAS workshop

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Results of Diamond Characterisation
Darmstadt, 15.12.2013

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CERN

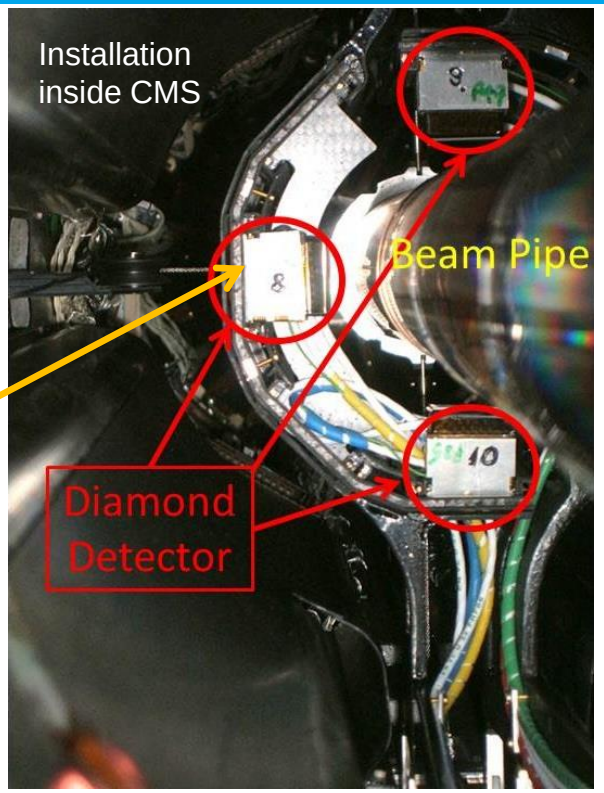
DESY

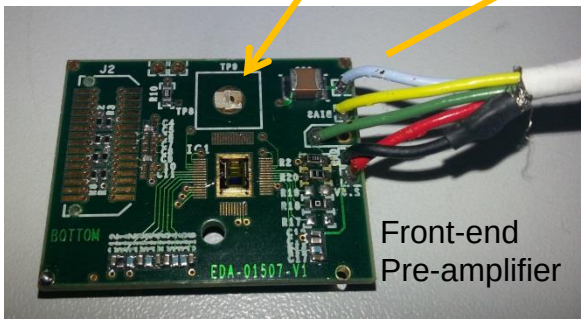
Content

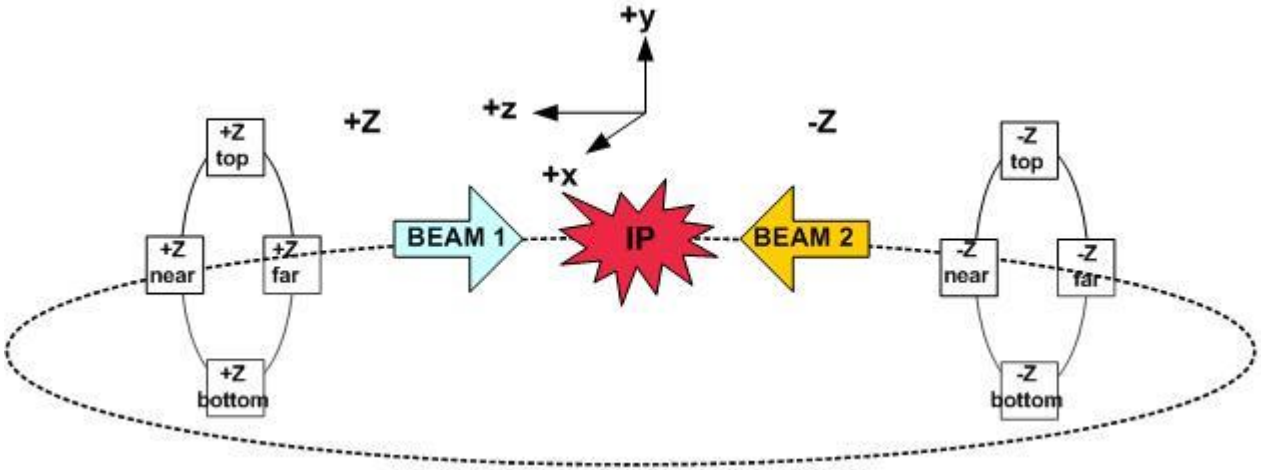
- The Fast Beam Condition Monitor BCM1F at CMS
- Possible Measurements at DESY Zeuthen
- Irradiated BCM1F Diamonds - sCVD
- Irradiated BCM1L Diamonds – pCVD
- Upgrade of BCM1F and BCM1L
- Fresh BCM1F Diamonds - sCVD
- Fresh BCM1L Diamonds - pCVD

The Beam Condition Monitor BCM1F and BCM1L at CMS

- Particle detector with nanosecond time resolution
- Located inside CMS
  - 12.5ns away from CMS IP
  - ~5cm away from beam center
  - Irradiation of 24GeV proton equivalent ($3.5 * 10^{12}$ proton equivalent per fb^{-1})
- sCVD sensors BCM1F
  - Beam gas
  - Beam background
  - Collision products
  - luminosity
- pCVD sensors BCM1L
  - Signal current
  - Beam loss monioring
  - Beam dumping system

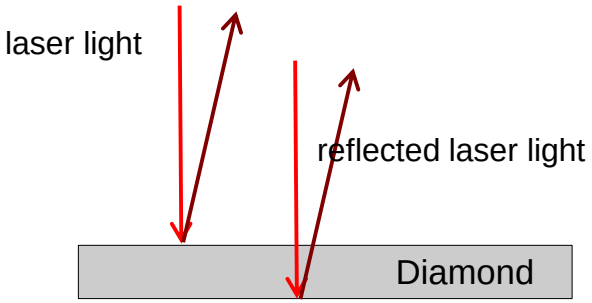


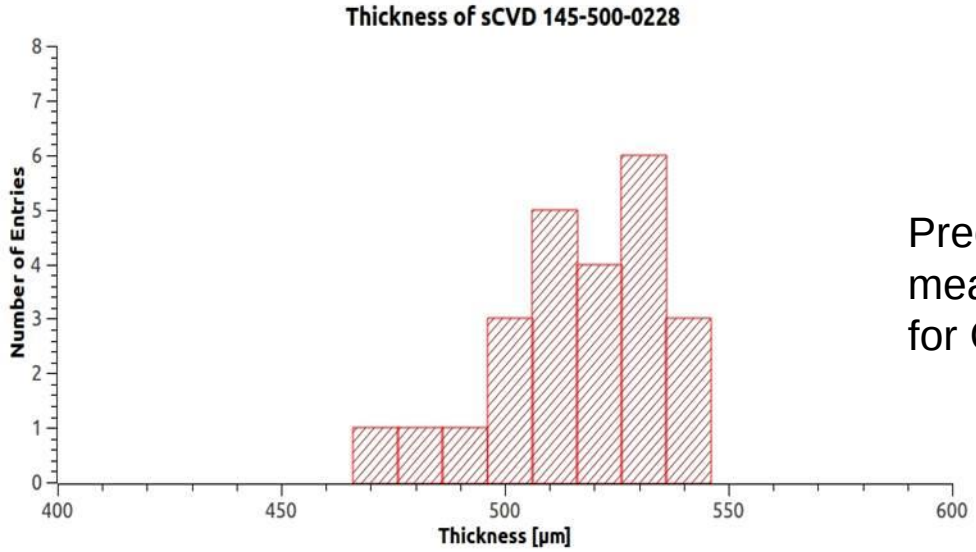




Possible Measurements at DESY Zeuthen

- Thickness measurements with laser microscope
  - Reflection of laser light at the focus
  - Information about thickness (µm precision)
  - Requires information of refractive index (2.42 for diamond)
- Transient Current Measurements
  - Measurements of diamond signal
  - Information about charge carriers in diamond
  - Konstantin will present his results

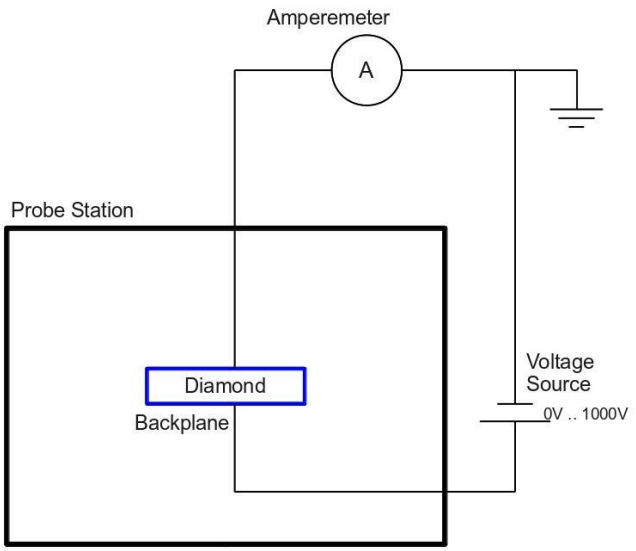


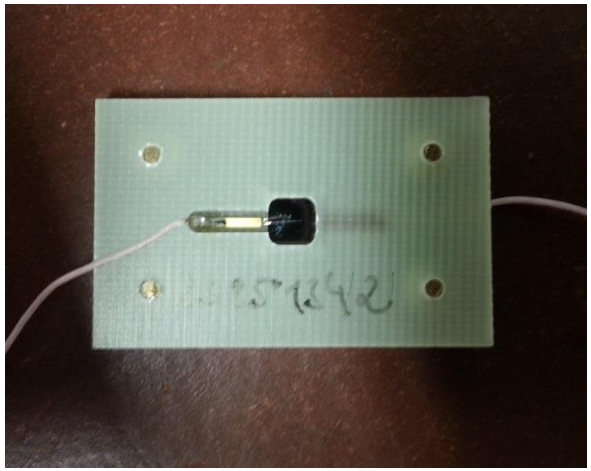


Precise thickness measurements are important for CCE calculation

Possible Measurements at DESY Zeuthen

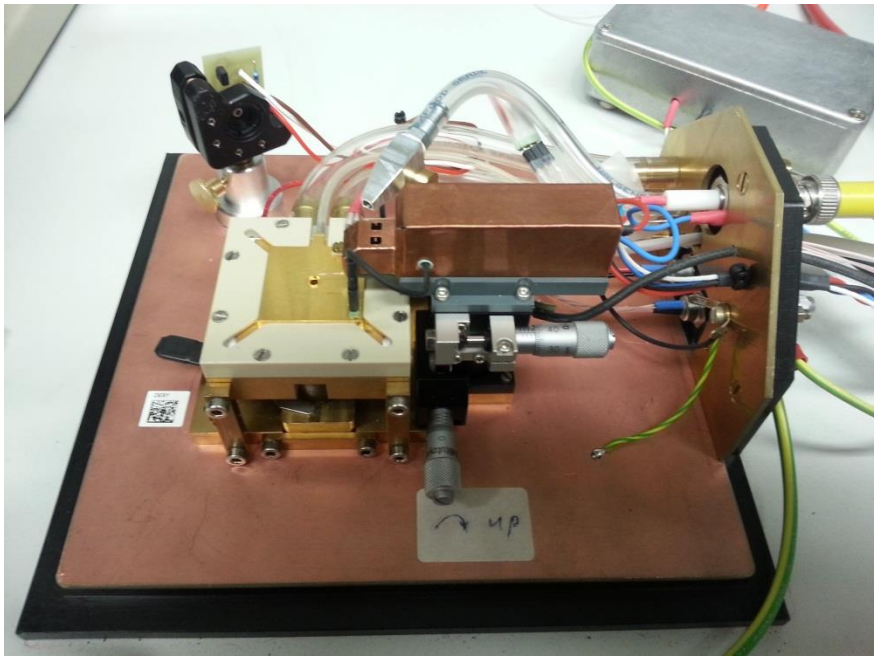
- Current Measurements
- Diamond in frame
  - Connection with bonds
- Current as a function of bias voltage
  - Information about leakage current
  - In the range of pA for good sCVD
- Current as a function of time
  - Pumping of diamond
  - Stability of signal current
  - Constant current is expected
  - Known for pCVD: erratic currents





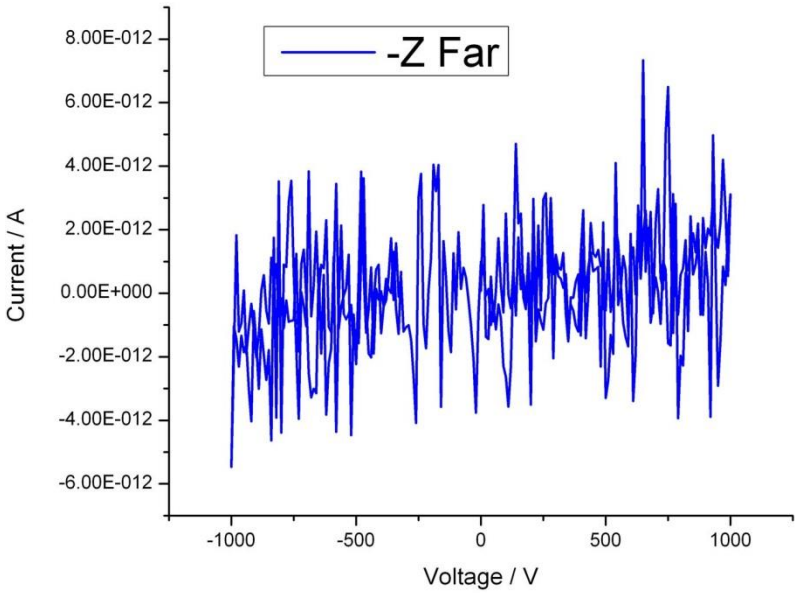
Possible Measurements at DESY Zeuthen

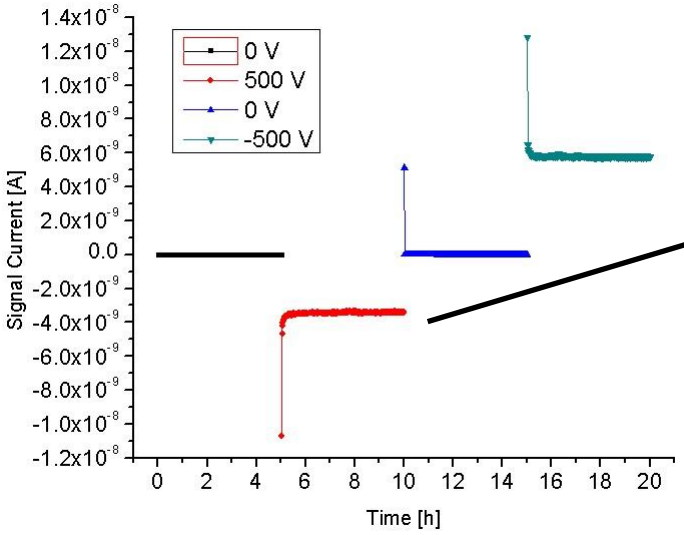
- HV is applied with table
- Signal readout with needle
- Source: Sr-90
- Measurements of CCE as a function of bias voltage
  - Comparison of CCE before and after irradiated
  - Pumping with Sr-90 possibile
- Measurements of CCE as a function of time
  - Studies of polarization effect
  - Degradation of CCE as a function of time
- Possibility of diode studies



Irradiated BCM1F Diamonds - sCVD

- IV measurement show low leakage current for irradiated BCM1F sCVD
  - In the range of µA
- I(t) shows the signal behavior over long time
  - Polarization effect visible
  - Small decrease of signal current





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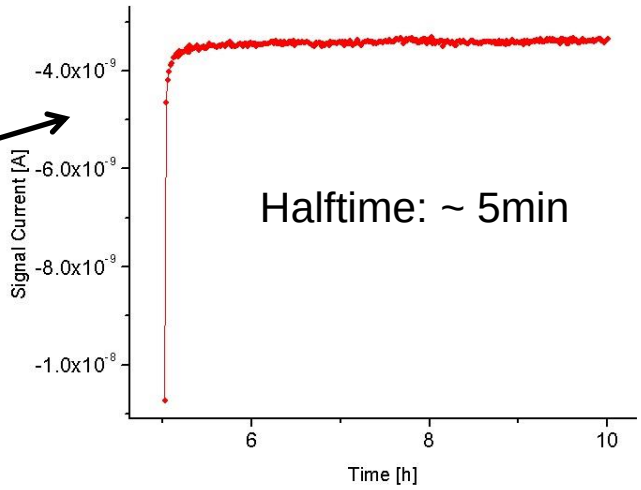
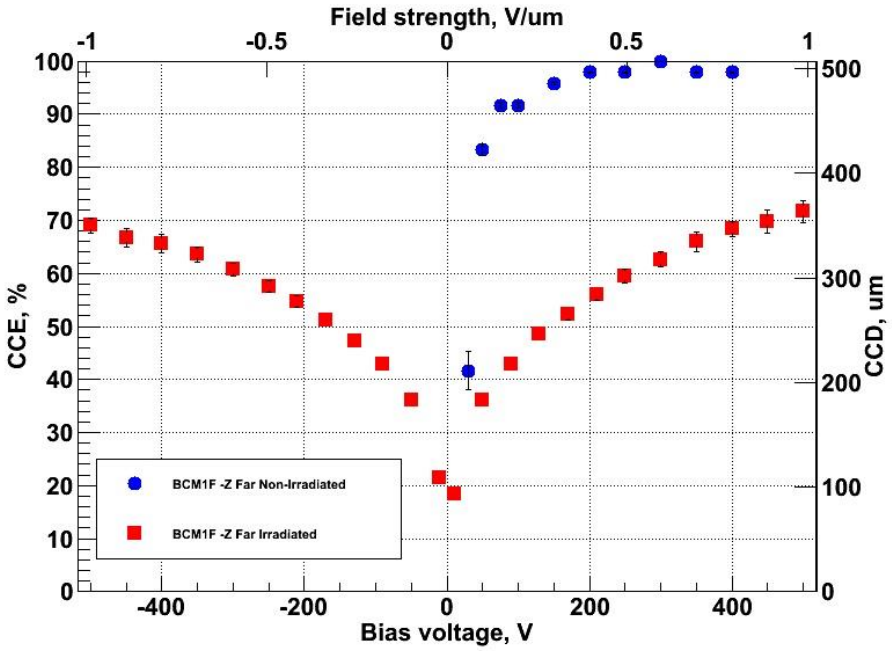
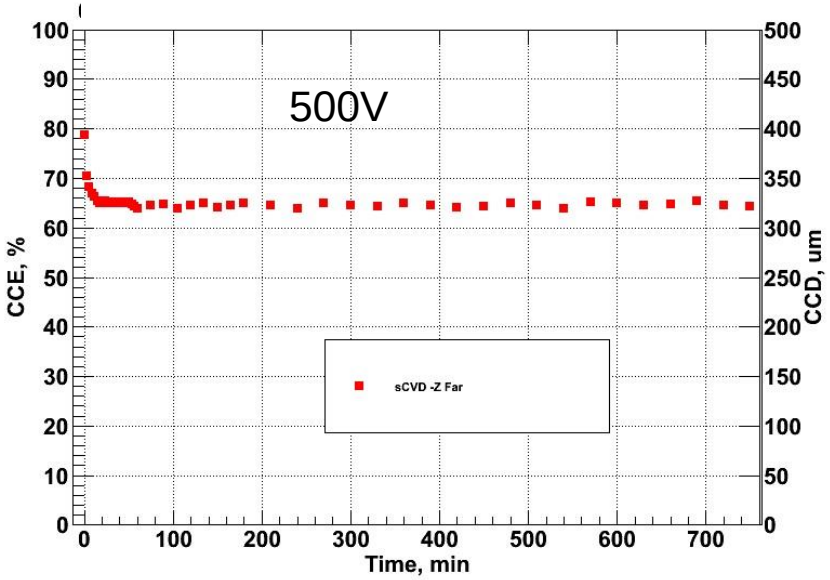


Irradiated BCM1F Diamonds - sCVD

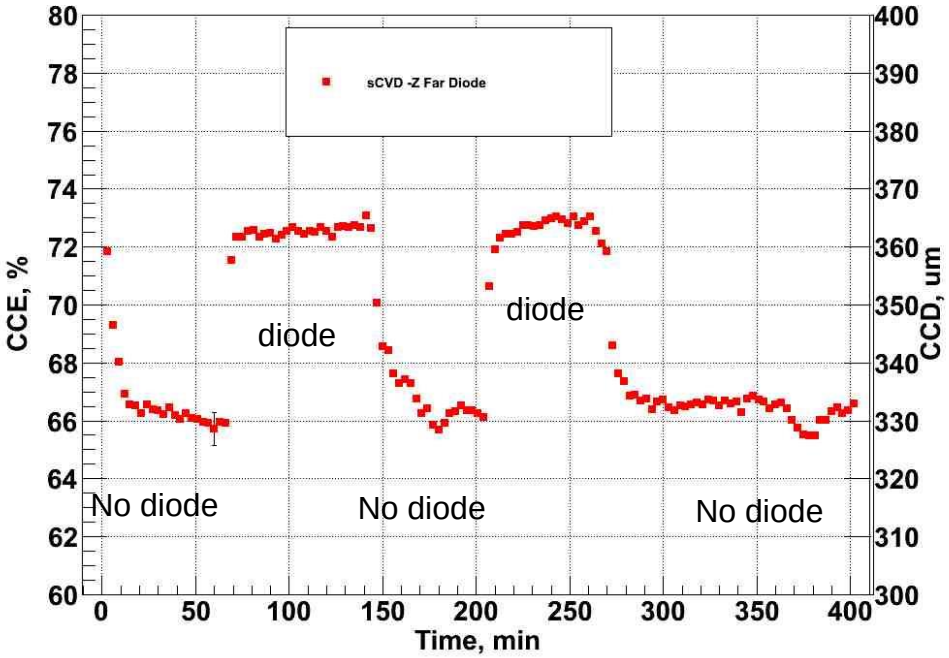
- CCE after irradiation is at 500V ~70% for all irradiated BCM1F sCVD
  - 30% smaller CCE
- Polarization visible for CCE over time
  - Decrease of CCE by 8.3%
  - Halftime ~5min





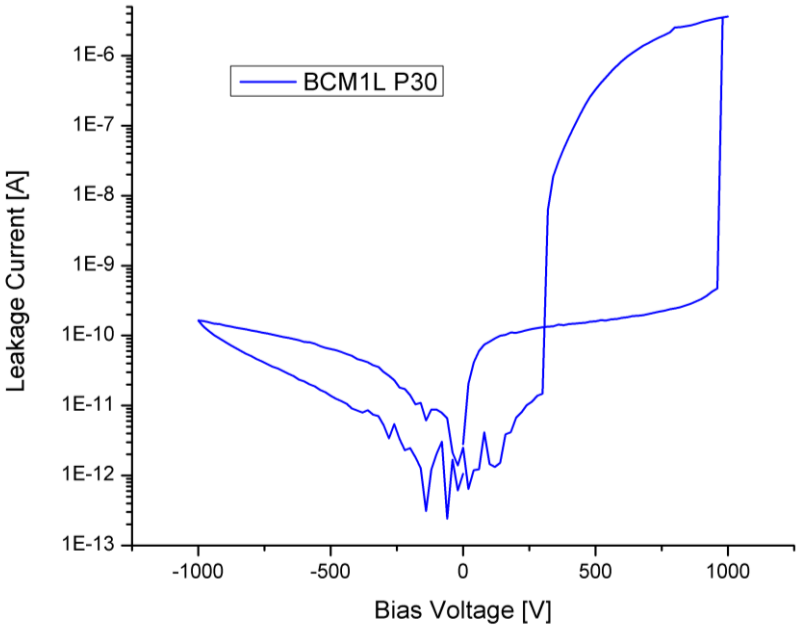
Irradiated BCM1F Diamonds - sCVD

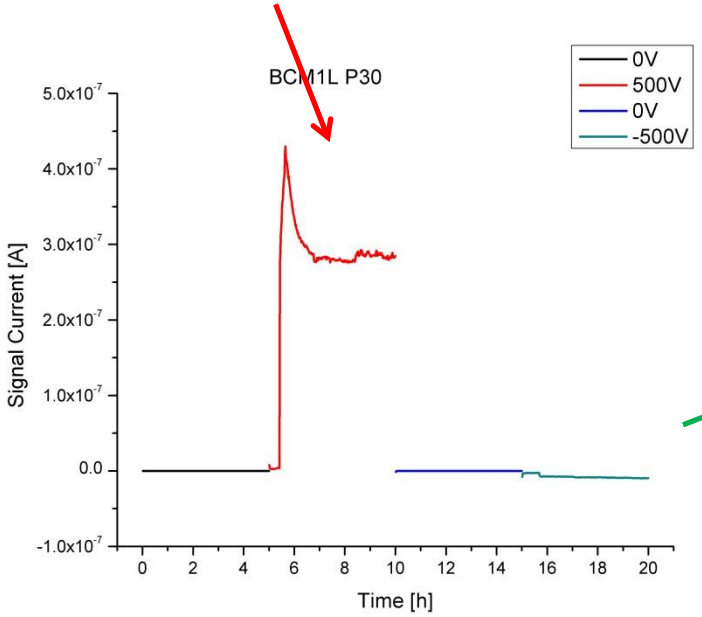
- First red diode studies were done
- Idea of diode measurements:
- Polarization is due to deep traps
  - Hypothesis: energy of traps at the range of red light (1.9eV)
  - Band witdth: $E_G = 5{,}4eV$
  - Deep traps at $\frac{1}{4}E_G = 1.35eV$
- Polarization develops during HV and Sr-90 irradiation
  - Charge carriers are trapped in deep traps
  - Decrease of CCE 8%
- Red diode light has enough energy to release charge carriers from deep traps
  - increase of CCE 8%



Irradiated BCM1L Diamonds - pCVD

- Leakage current in pA for one polarity
  - Operating polarity
  - Small increase of signal current over time
- Leakage current is up to µA for one polarity
  - Erratic current





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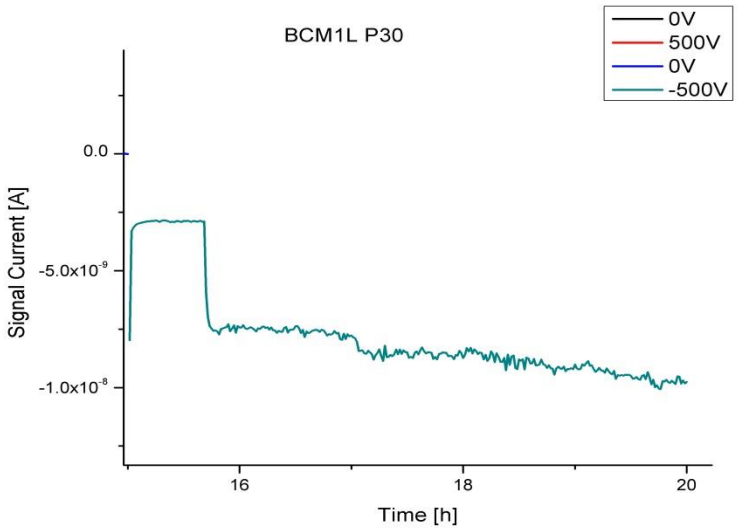
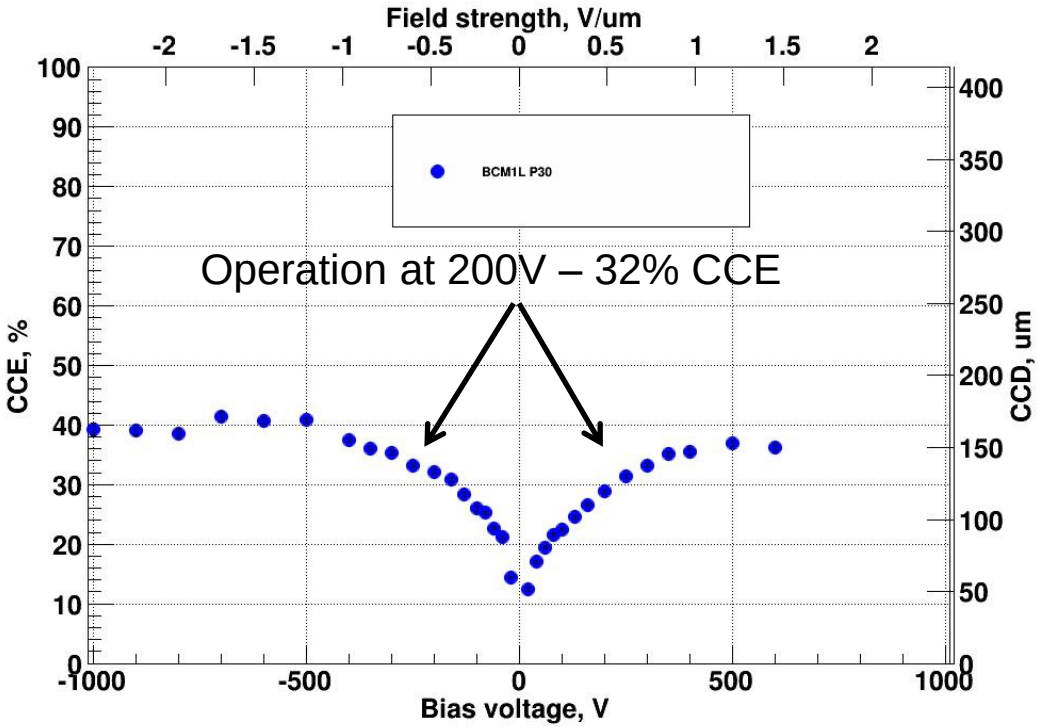


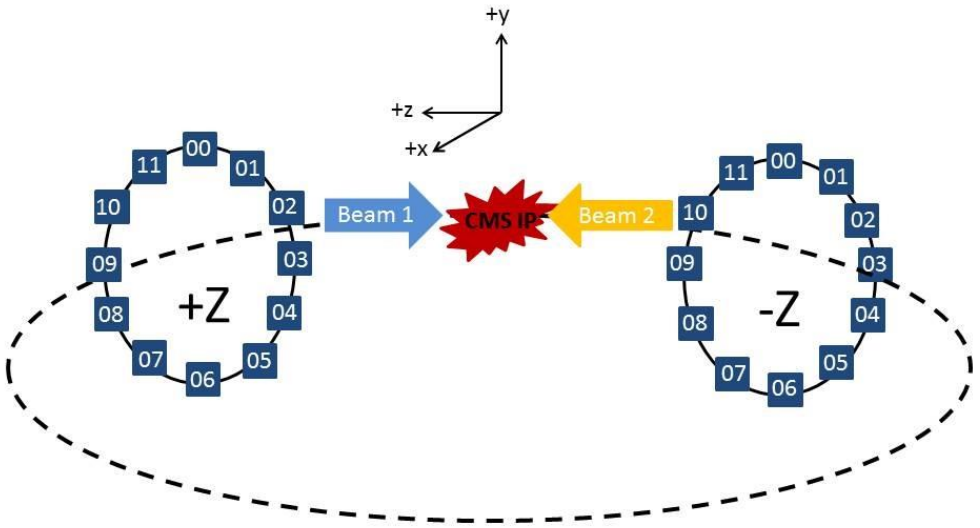
Irradiated BCM1L Diamonds - pCVD

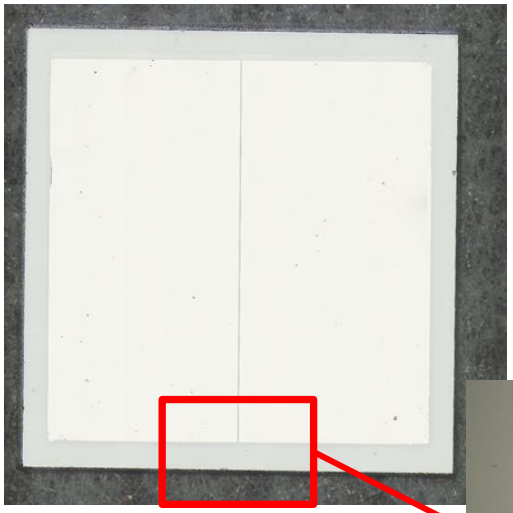
- CCE measurements are done after pumping (12h Sr-90 source)
  - Avoiding polarization
- CCE before irradiation:
  - 55% at 400V
  - 230µm CCD at 400V
- CCE after irradiation
  - 40% at 400V
  - 160µm CCD at 400V
- Decrease of CCE of ~30%



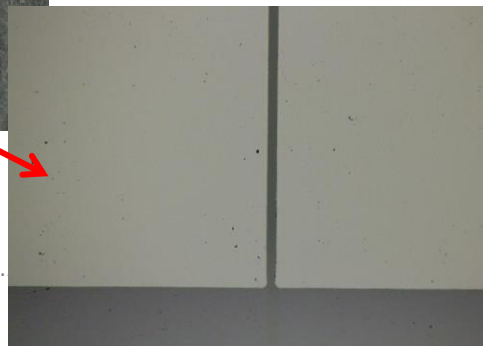
Upgrade of BCM1F and BCM1L

- Upgrade of the diamond mounting around the beam (Jessica Leonard talk)
- Fresh BCM1L pCVD diamonds
- Upgraded BCM1F amplifier
  - Peaking time of ~7ns
  - Amplification of 70mV/fC
  - Two MIP separation of 12.5ns
- BCM1F sCVD have a split electrode
  - Increase of dynamic range of the BCM1F system
- 24 sCVD diamonds on each side of the interaction point
  - 24 fresh sCVD diamonds
  - Maybe reuse irradiated BCM1F diamonds



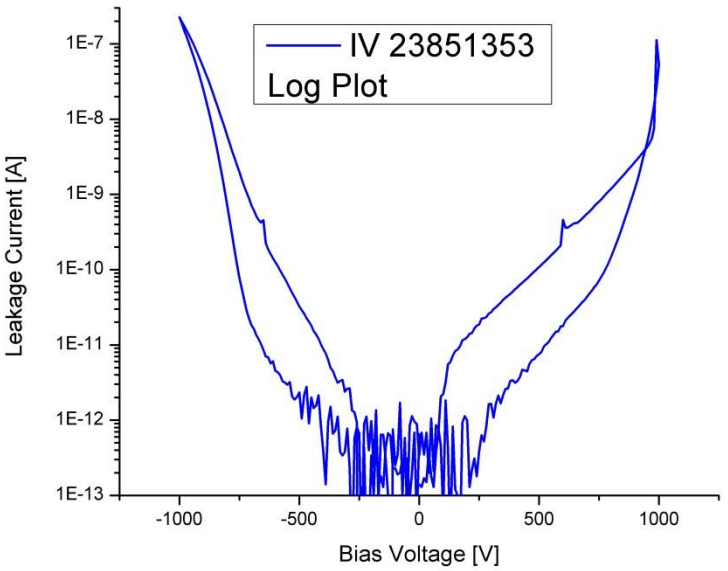


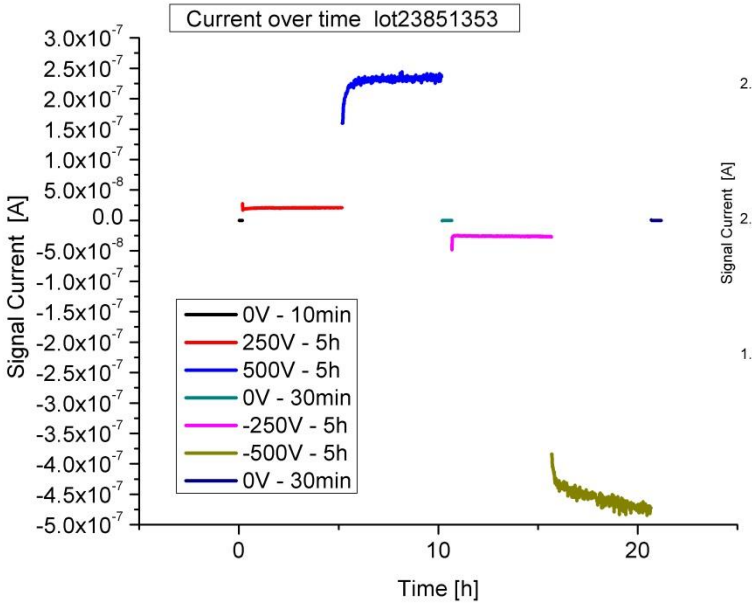
Gap: 5-12µm

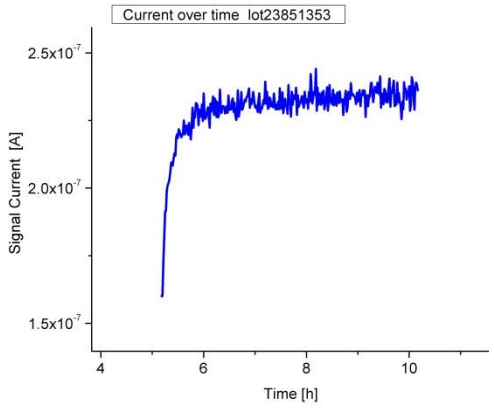


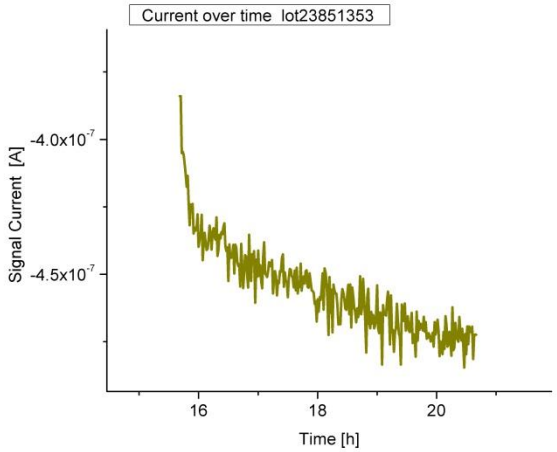
Fresh BCM1F Diamonds sCVD

- Leakage current goes up to µA for all fresh sCVD
- Signal current is not constant over time
  - Increase of signal current
  - Large signal current



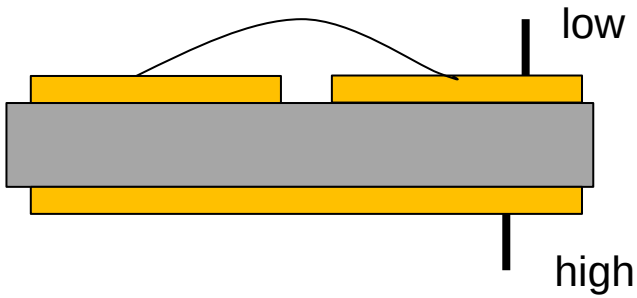


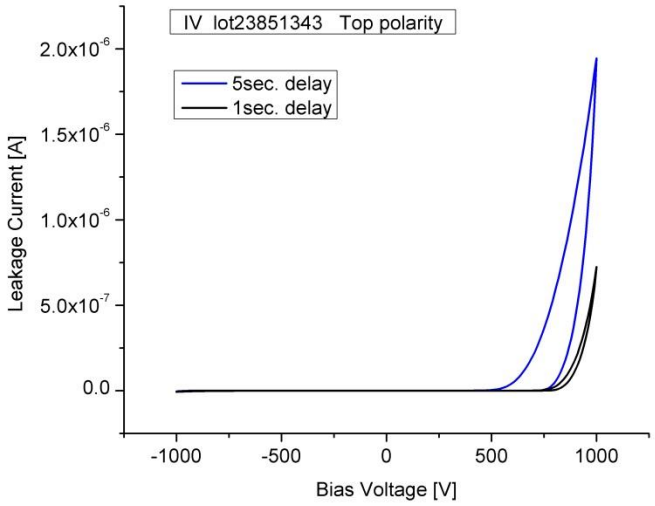


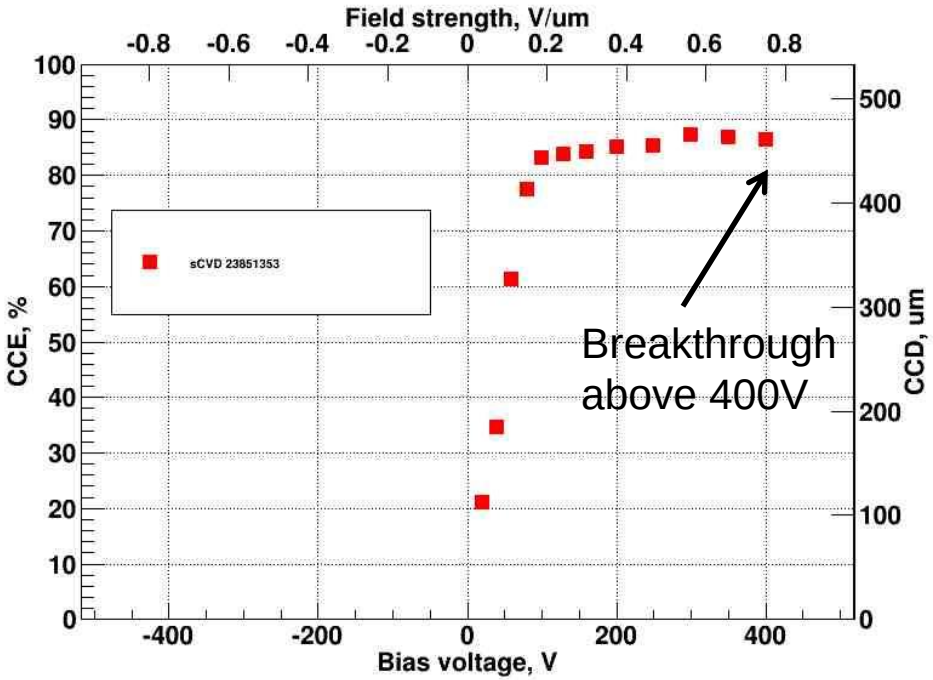


Fresh BCM1F Diamonds sCVD

- Connection between pads
  - One pad measurement
- Measurements only possible up 400V
  - Breakthrough above 400V
  - Point of breakthrough depends on the voltage steps

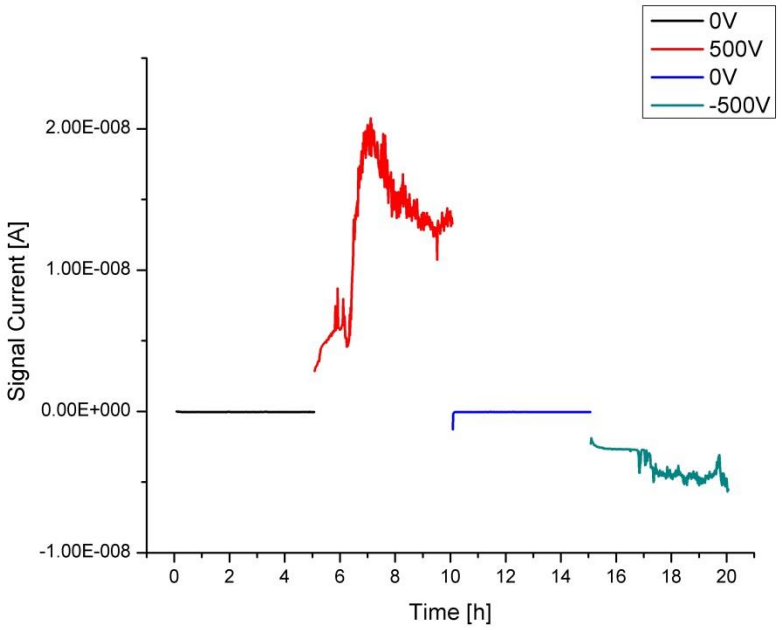


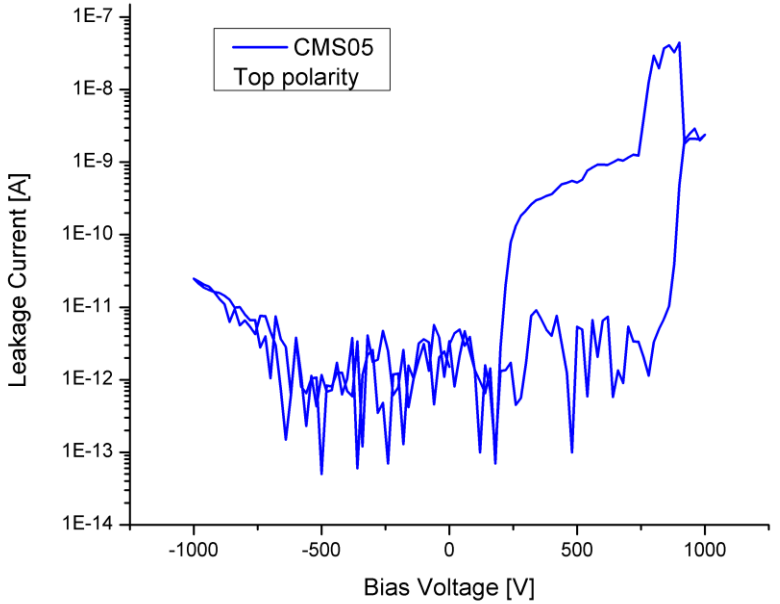




Fresh BCM1L Diamonds - pCVD

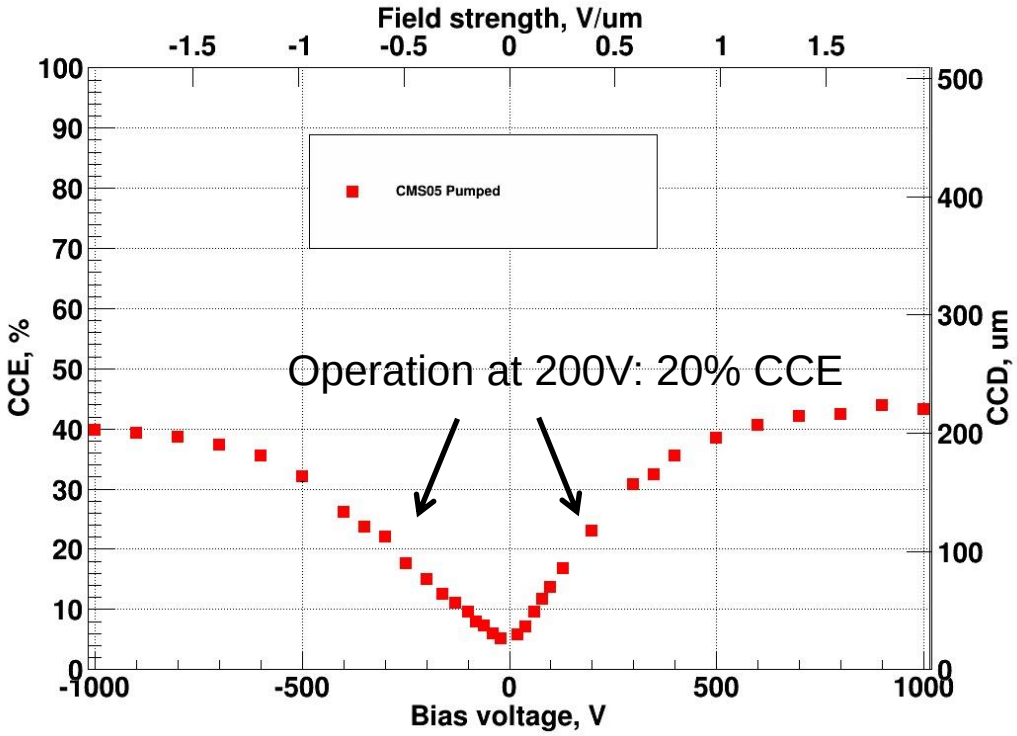
- Low leakage current for one polarity
  - Possible operation polarity: negative bias voltage
- Signal current is not stable over time
  - Erratic currents





Fresh BCM1L Diamonds - pCVD

- CCE was done after 12h of pumping (Sr-90 source)
- No saturation up to 700V
- Low CCE of 25% at 400V
  - Smaller than the irradiated diamonds (40% smaller CCE)



Summary

- BCM1F and BCM1L diamonds were removed from CMS after irradiation
- Irradiated BCM1F diamonds show good performance
  - Still leakage current in the range of pA
  - Still 70% CCE
  - Decrease of CCE of about 30%
  - Reuse for BCM1F upgrade
- Irradiated BCM1L diamonds show good performance for one polarity
  - Leakage current in the range of pA
  - Still CCE of 40% at 400V
  - Decrease of CCE of about 30%
- Fresh BCM1F diamonds show worse performance than irradiated diamonds
  - Leakage current in the µA range
  - 90% of CCE
  - Future operation up to 400V maximum for one polarity
- Fresh BCM1L Diamonds show same performance as irradiated diamonds
  - Leakage current in the range of pA for one polarity
  - 25% of CCE at 400V
  - Future operation only for one polarity and with much smaller CCE

Outlook

- Characterisation of more than 24 sCVD and pCVD for the BCM1F and BCM1L upgrade
  - Installation of best 24 diamonds
- Test beam in January for two pad characterization
- Information about:
  - Functionality of the upgraded amplifier
  - Two pad readout with separate channels
  - Edge effects
  - Cross talk
- Installation of BCM1F and BCM1L is planned in late Spring of 2014

Last Slide

Thank you for your attention!