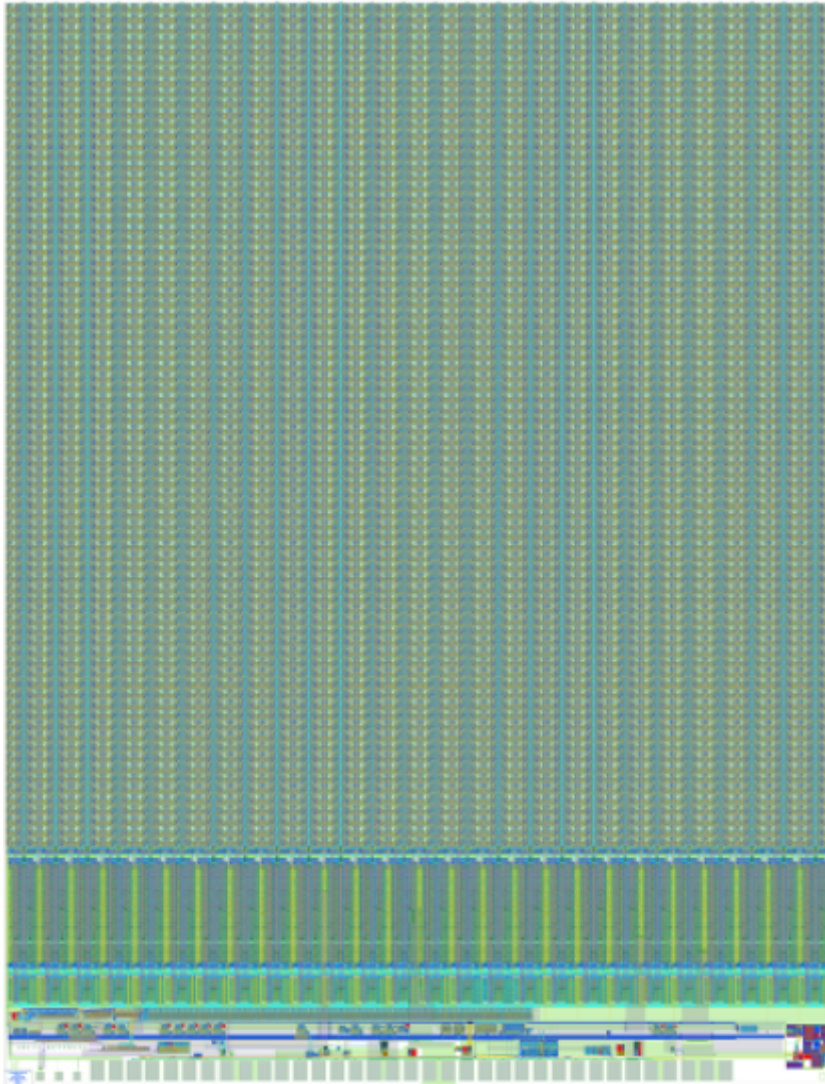


ROC irradiation plan

D. Pitzl, DESY-FH/CMS

CMS Phase I Pixel upgrade, DESY, 7.9.2012



- radiation
- KIT protons
- DESY preparations

Pixel Phase I Upgrade TDR



CMS Pixel Upgrade TDR
2012/09/06

2012/09/06
Head Id: 52237
Archive Id: 146033:146058M
Archive Date: 2011/04/26
Archive Tag: trunk

CMS Document 5669-v6
6 Sep 2012
65 MB, 247 p

CMS TECHNICAL DESIGN REPORT FOR THE PIXEL DETECTOR UPGRADE

<https://cms-docdb.cern.ch/cgi-bin/PublicDocDB/ShowDocument?docid=5669>

Tracker radiation dose

Absorbed dose 500 fb^{-1}

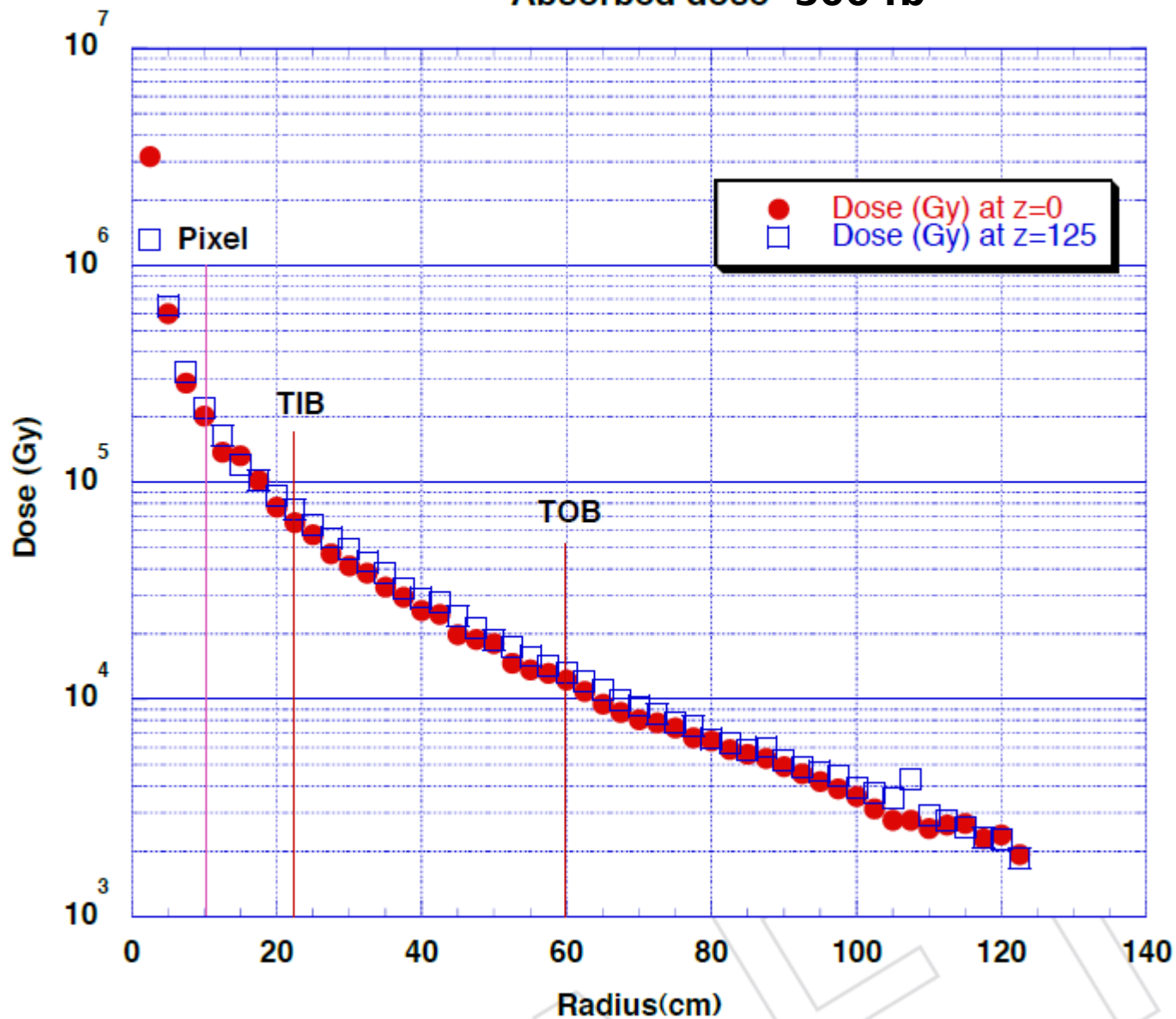
Layer 1: 1 MGy

Layer 2: 400 kGy

Layer 3: 200 kGy

Layer 4: 150 kGy

150 kGy = 15 Mrad



Pixel upgrade TDR 2012

Radiation effects

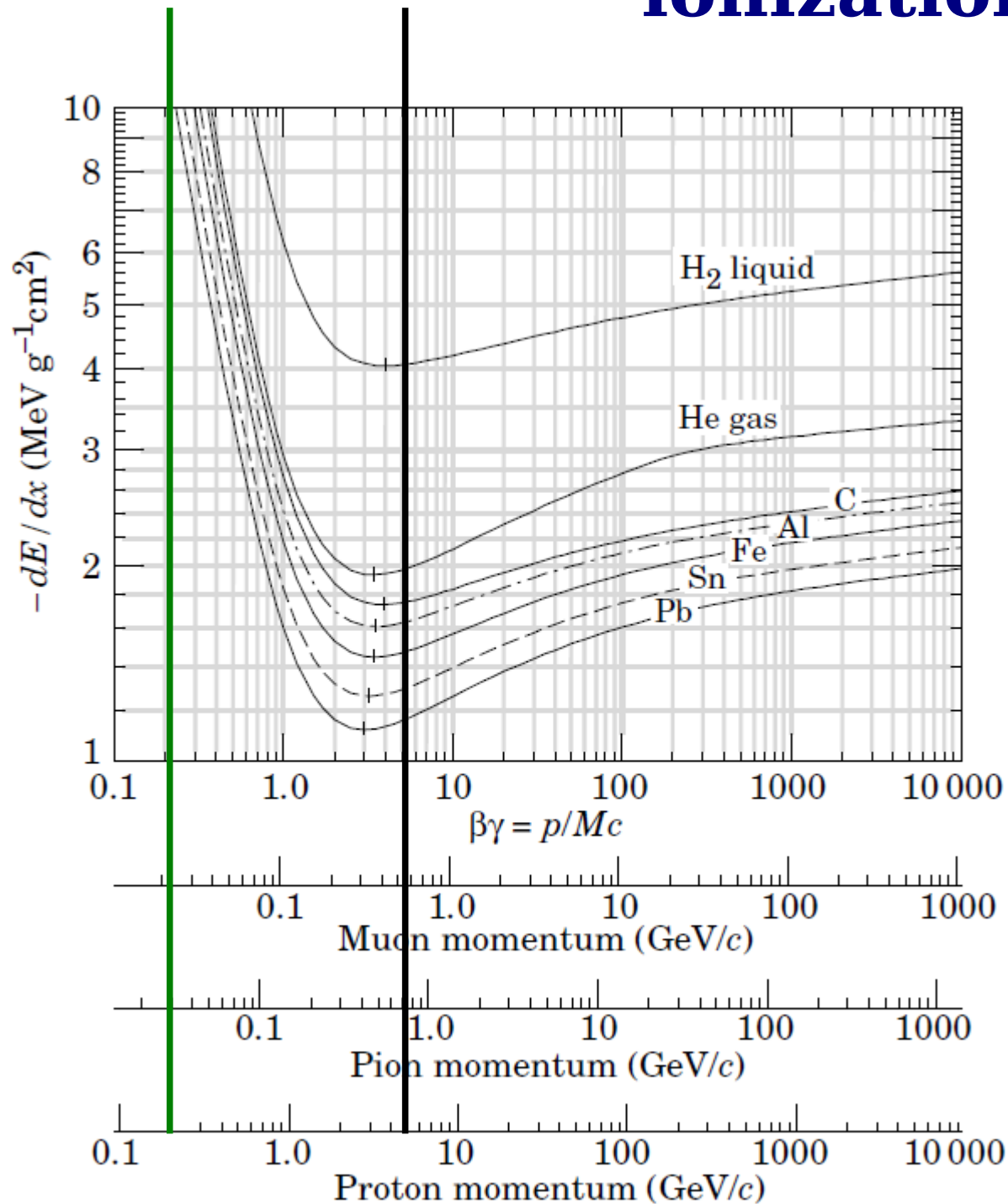
- Total ionizing dose:
 - ▶ relevant for surface effects, CMOS and sensors
 - ▶ oxide charge trapping
 - ▶ transistor threshold voltage shifts
 - ▶ transistor leakage current
- Integrated particle flux = fluence:
 - ▶ relevant for bulk displacement damage
 - ▶ leakage current
 - ▶ transistor resistance
 - ▶ sensor depletion voltage
 - ▶ sensor charge collection efficiency

Irradiation Center Karlsruhe

- $E_{\text{kin}} = 25.3 \text{ MeV}$ proton cyclotron, $\sim 23 \text{ MeV}$ at the sample
 - ▶ owned by ZyklotronAG, on KIT Campus Nord
 - ▶ access via KIT Institut für Experimentelle Kernphysik IEKP
 - ▶ Alexander Dierlamm
- $p = 208 \text{ MeV}/c$ at the sample
 - ▶ non-relativistic
 - ▶ heavily ionizing
- Minimal current: $0.2 \mu\text{A}$
- Minimal flux: $1.6 \cdot 10^{12} \text{ p/cm}^2\text{s}$
 - ▶ beam area is only few mm^2 , sample is moved around
- Minimal dose rate: 0.5 Mrad / s

http://www-ekp.physik.uni-karlsruhe.de/index.php?option=com_content&view=article&id=93

ionization



KIT:
0.2 GeV/c protons

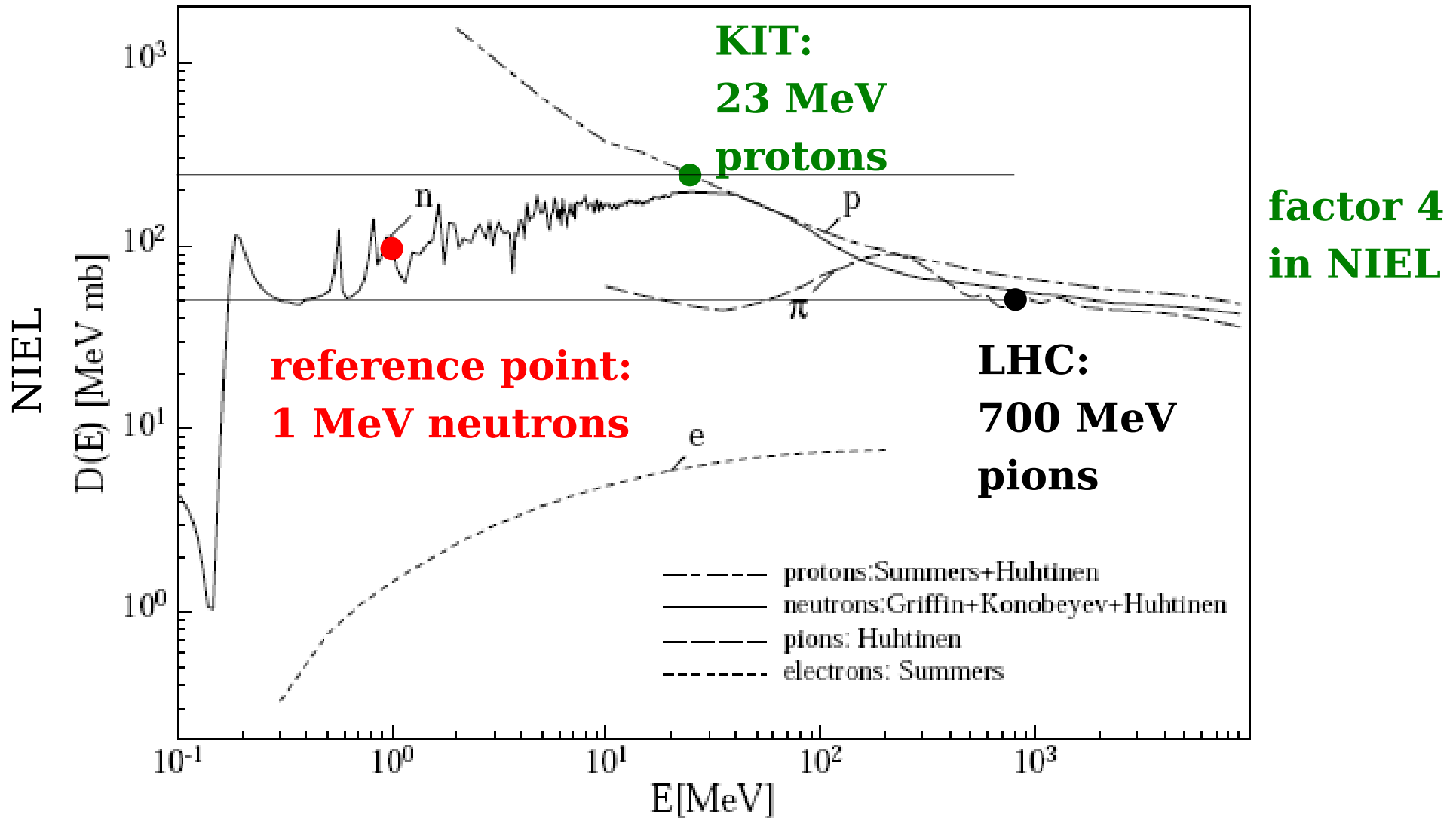
factor 20
in ionization

LHC:
0.7 GeV/c pions

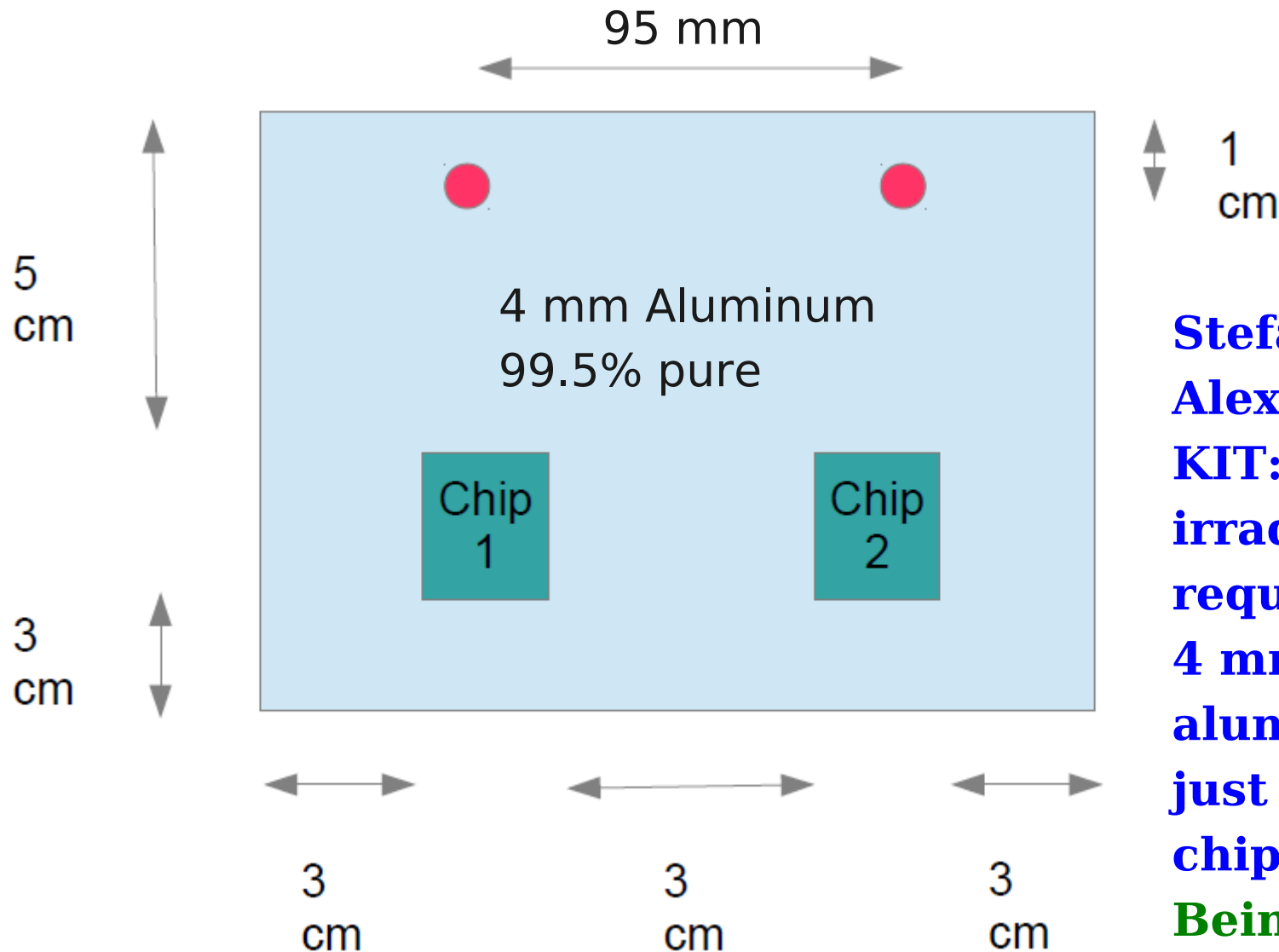
non-ionizing energy loss in silicon

non-ionizing energy loss (NIEL): displacement of atoms

Leakage current \sim NIEL



irradiation mask for KIT



**Stefan Heindl,
Alexander Dierlamm
KIT:**

**irradiation mask
required:**

**4 mm high purity
aluminum,**

**just leaving the
chips exposed.**

**Being made by
Adam Zuber and
Holger Maser.**

Stefan Heindl, KIT, Sep 2012

status and plan

- digital ROCs 202 and 203 measured in lab and beam: done
- irradiate to 20 and 40 Mrad at KIT: end Sep
- measure: Oct
 - ▶ DAC ranges sufficient?
 - ▶ threshold
 - ▶ gain
 - ▶ noise
 - ▶ efficiency
 - ▶ resolution
- feedback to chip designers at PSI Nov

particle rates in the pixel barrel

- Simulation with Pythia Z2 tune and GEANT4
- Assuming 24 bits per hit, 100 kHz level 1 trigger rate
- Peak luminosity = $2 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$, $\sigma_{\text{tot}} = 80 \text{mb}$, $\sigma_{\text{signal}} = 1.5 \text{mb}$, 25 ns BC

Layer	1 @ 2.9cm	1 @ 3.9cm	2	3	4
Pixel fluence [MHz/cm ²]	520	331	119	52	27
Hits / trigger / module	190	108	40	18	8.4
MBit/link/sec	435	284	118	66	45

HC Kästli, Aug 2011