Backward Hadronic Calorimeter

SiPM radiation damage update

Leszek Kosarzewski

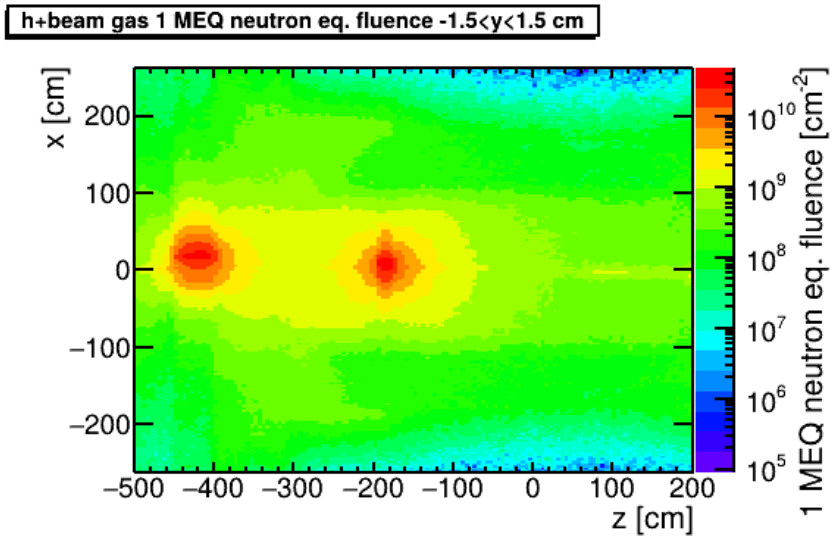
The Ohio State University

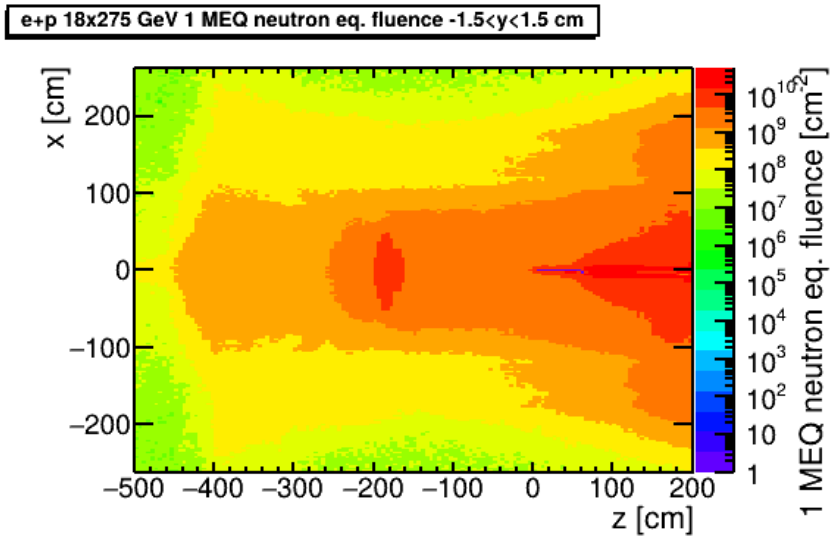
ePIC Calorimetry meeting 24.6.2025

THE OHIO STATE UNIVERSITY

Outline

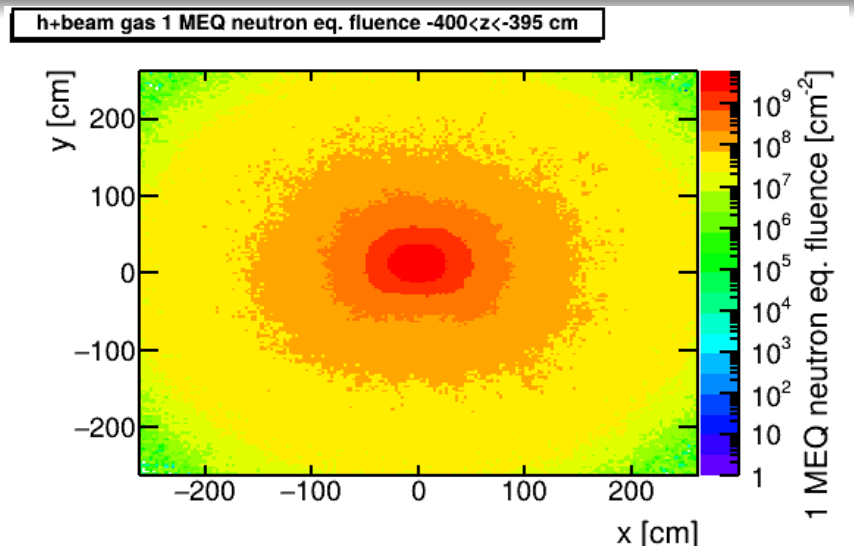
Radiation - neutrons

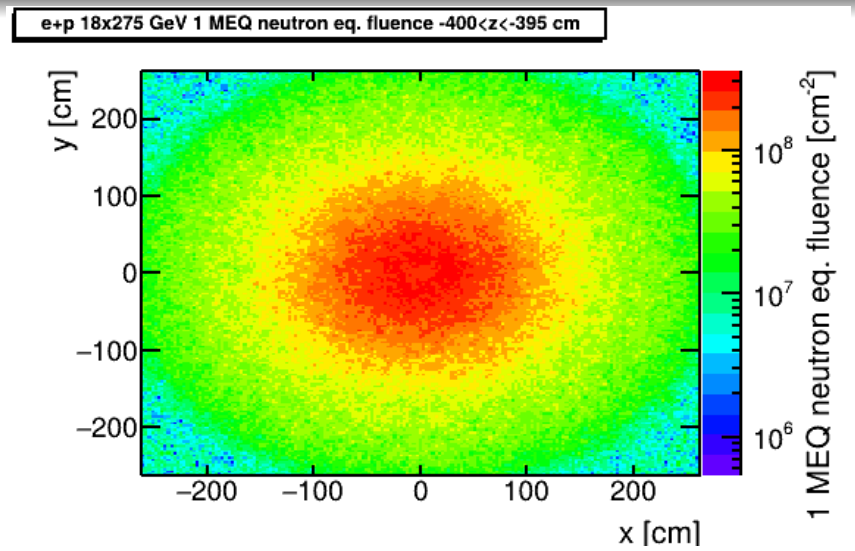


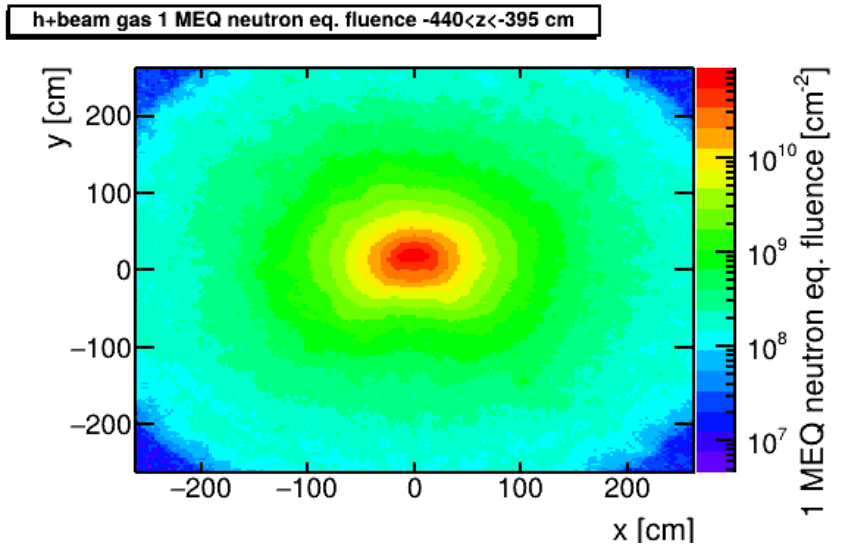


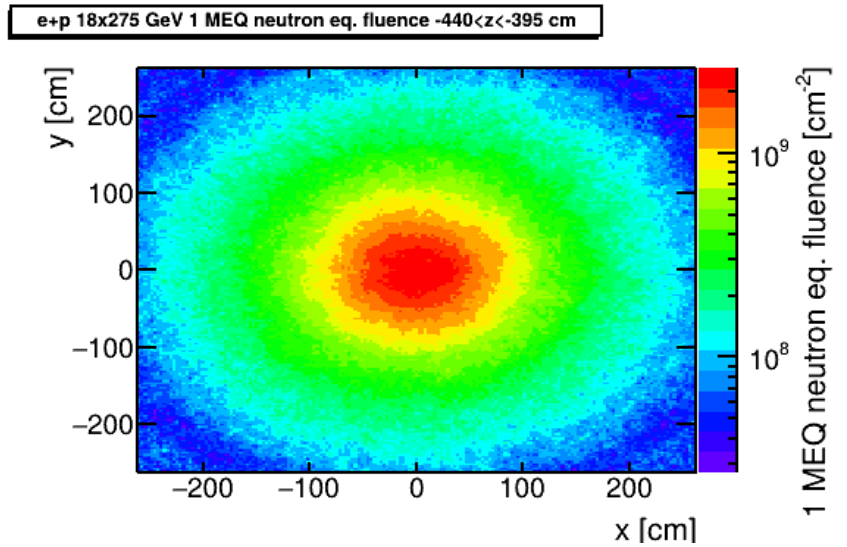
- Neutron fluence taken from updated files:
  `https://wiki.bnl.gov/EPIC/index.php?title=Radiation_Doses`
- Slices correspond to 100 fb^{-1}
- Some areas close to the beam are exceeding 10^{10} cm^{-2}
  - may affect SiPMs dark current

Radiation - neutrons



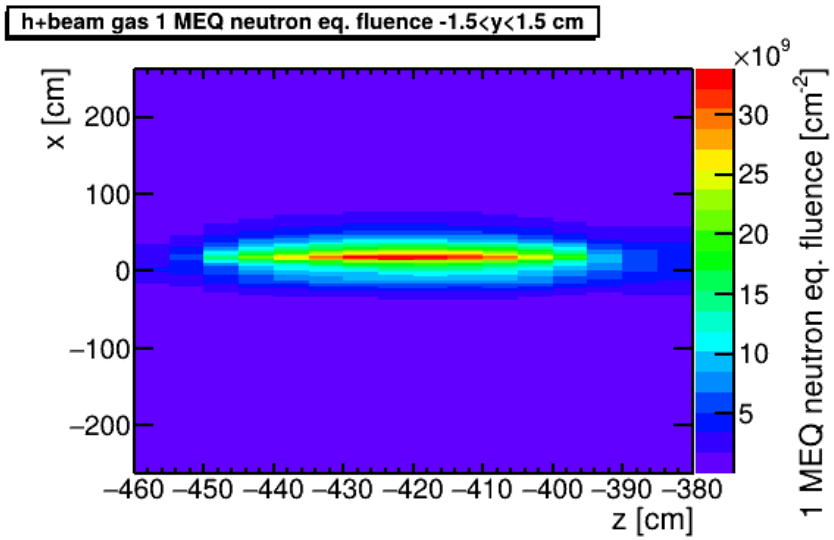


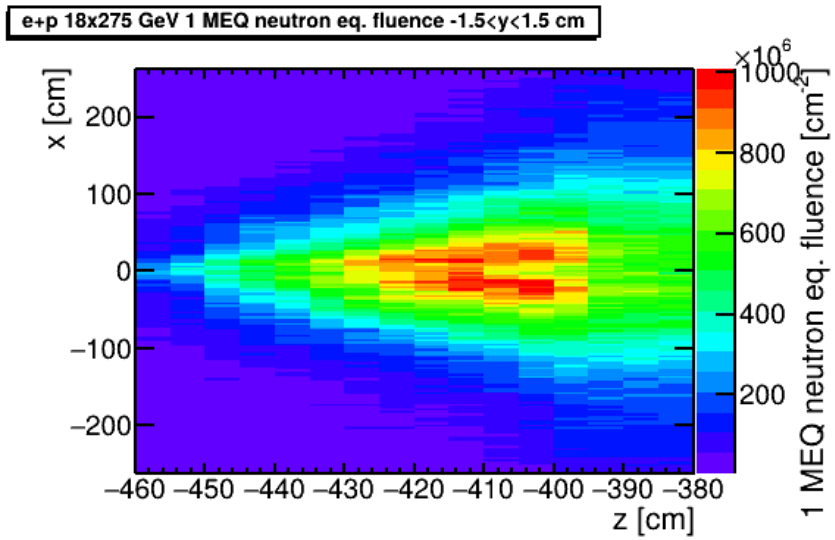




- Neutron fluence taken from updated files:
  `https://wiki.bnl.gov/EPIC/index.php?title=Radiation_Doses`
- Slices correspond to 100 fb^{-1}
- Total fluence for nHCal is integrated within $-440 < z < -395\,\mathrm{cm}$

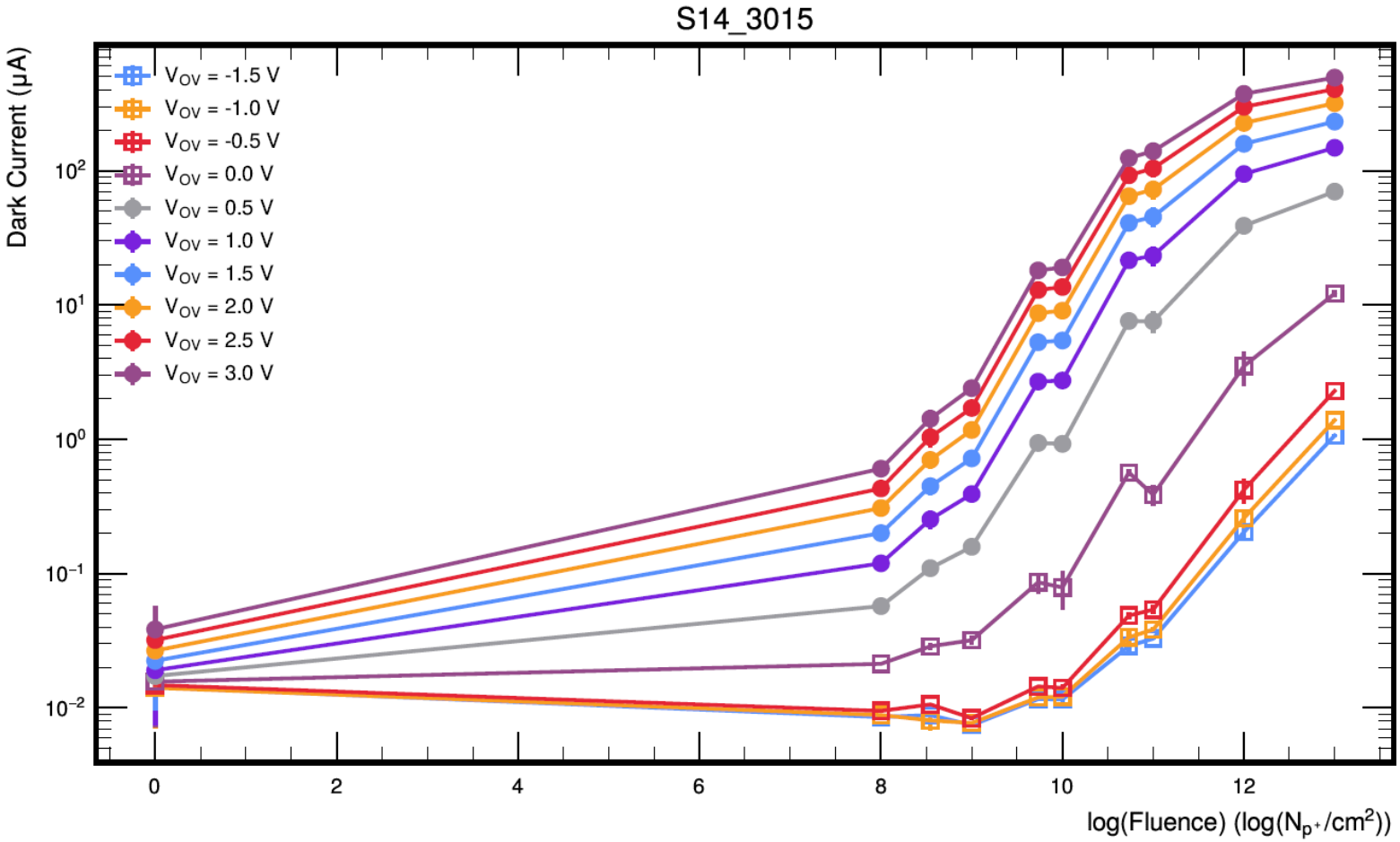
Radiation neutron fluence vs. layer





- Zoom in to see fluence vs. layer
- $e + p$ gives max. fluence of $10^9\ \mathrm{cm}^{-2}$ in 2-4th layers
  - quickly drops to $10^8\ \mathrm{cm}^{-2}$ 70 cm away from beam
- h+beam gas gives max. fluence of $3.3 \cdot 10^{10}\ \mathrm{cm}^{-2}$ in 7th layer (-425 cm)
  - quickly drops to $10^9\ \mathrm{cm}^{-2}$ 50 cm away from beam
- h+beam gas penetrates deeper than $e + p$

Dark current



- Taken from `https://indico.bnl.gov/event/24087/#17-further-rad-hard-studies-an`
- Dark current starts to increase above $10^{10}\ \mathrm{cm}^{-2}$

bkg. type	hit rate in detector [kHz]	max single channel hit rate [kHz]
DIS	$\sim 10^3$	1.23324
Synchrotron rad.	$\sim 2 \cdot 10^1$	-
e+gas	403.899	6.6448
h+gas	$\sim 7 \cdot 10^2$	0.303781

Table 8.49: Maximum expected background rates for backward HCal. The assumed threshold is 170 keV.

- Taken from `https://wiki.bnl.gov/EPIC/index.php?title=Background`
- Included in pre-TDR
- Threshold very similar to our assumption

Signal characteristics

- This is to be updated based on tile tests at OSU and coordination with LFHCAL
- Need to adjust it to our threshold of $0.25 E_{MIP}$

Other updates - steel SAE 304

- So far we used StainlessSteel as a non-magnetic steel in simulation
  - But density was not correct: $8.3\,\mathrm{g/cm^3}$
- Updated to SAE 304 with: $7.9\,\mathrm{g/cm^3}$
- `https://github.com/eic/epic/pull/885`

Listing: Materials.xml

```
<material name="StainlessSteel">
   <D type="density" value="8.3" unit="g / cm3"/>
   <fraction n="0.74" ref="Fe"/>
   <fraction n="0.18" ref="Cr"/>
   <fraction n="0.08" ref="Ni"/>
</material>


<material name="StainlessSteelSAE304">
   <D type="density" value="7.9" unit="g / cm3"/>
   <fraction n="0.74" ref="Fe"/>
   <fraction n="0.18" ref="Cr"/>
   <fraction n="0.08" ref="Ni"/>
</material>
```

Summary

Conclusions

- Checked neutron fluence vs. layers for 100 fb^{-1}
- h+beam gas gives the biggest contribution $3.3 \cdot 10^{10}\ \mathrm{cm}^{-2}$
- h+beam gas is the most penetrating

BACKUP