# Production of High Energy Particles Using the Pd/D Co-Deposition Process

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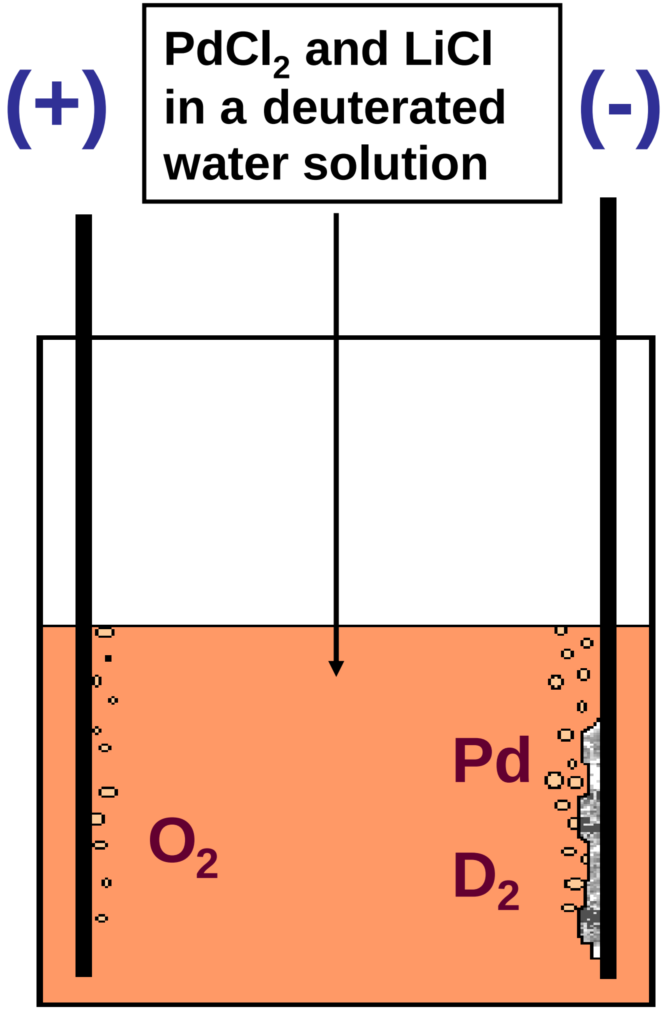
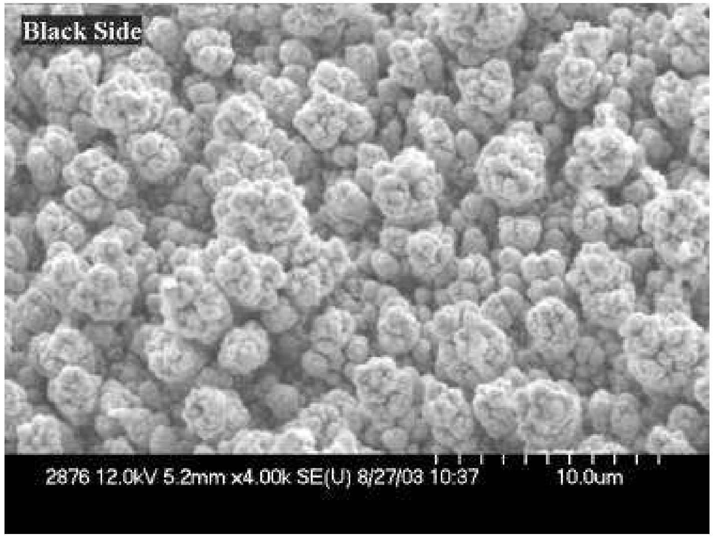
# Pd/D Co-Deposition




**As current is applied, Pd is deposited on the cathode. Electrochemical reactions occurring at the cathode:**

$$Pd^{2+} + 2\,e^{-} \rightarrow Pd^{0}$$

$$D_2O + e^{-} \rightarrow D^{0} + OD^{-}$$

**The result is metallic Pd is deposited in the presence of evolving $D_2$**

# Summary of Results Obtained Using Pd-D Co-Deposition

- **Excess Enthalpy Generation**
  Thermochimica Acta, Vol. 410, pp. 101-107 (2004)
- **Formation of 'Hot Spots'**
  Il Nuovo Cimento, Vol 112A, pp. 577-585 (1999)
- **Emission of Low Intensity Radiation**
  Physics Letters A, Vol. 210, pp. 382-390 (1996)
- **Tritium Production**
  Fusion Technology, Vol. 33, pp.38-51 (1998)
- **E-Field Morphology Changes**
  J. Electroanal. Chem., Vol. 580, pp. 284-290 (2005)
- **Presence of New Elements in Association with the Morphology Changes**
  Naturwissenshaften, Vol. 92, pp. 394-397 (2005)

# How Can We Verify that the Observed New Elements are Nuclear in Origin?

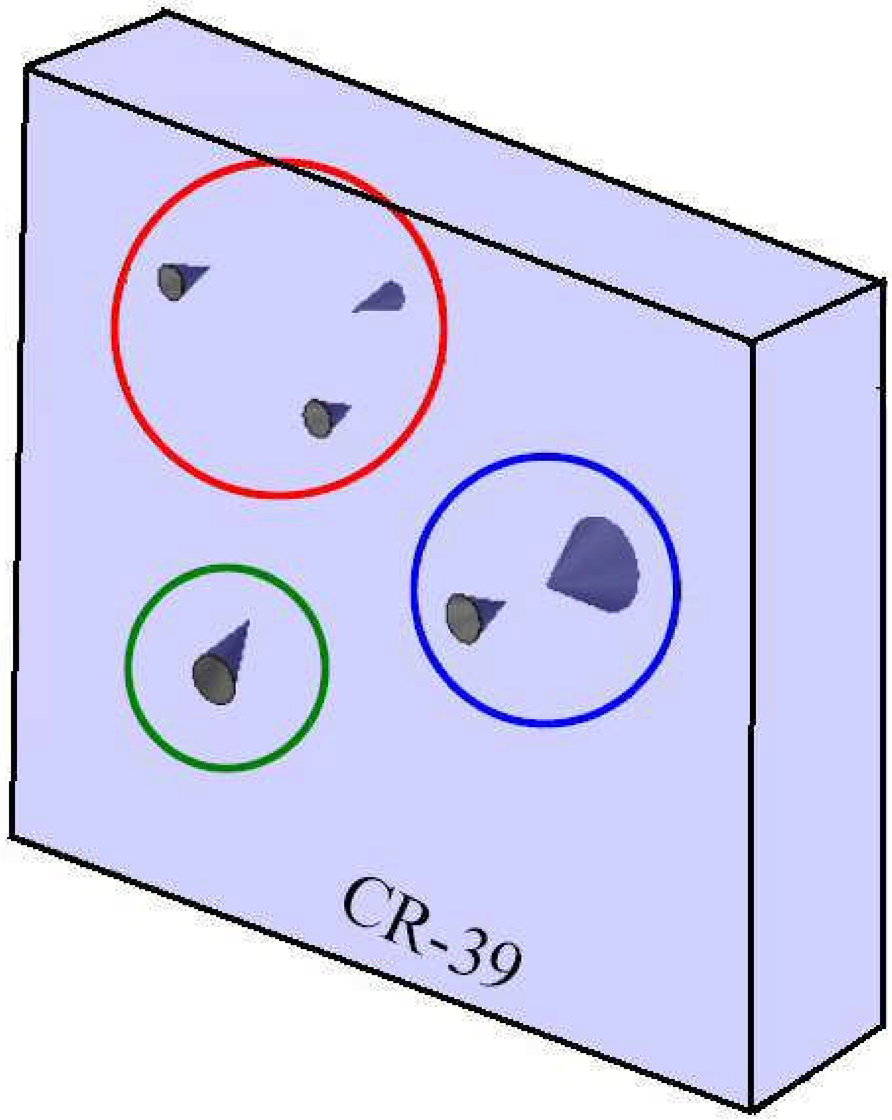
- **SEM-SIMS: look for changes in the isotopic ratios**
- **Measure $\gamma$ and X-ray emissions**
- **<u>Detect particle emission using CR-39 chips</u>**
  - **Easy to do**
  - **Inexpensive**
  - **Requires minimal instrumentation**
  - **Is a ‘constant integration’ method**
  - **No electronics**

# Particle Detection Using CR-39

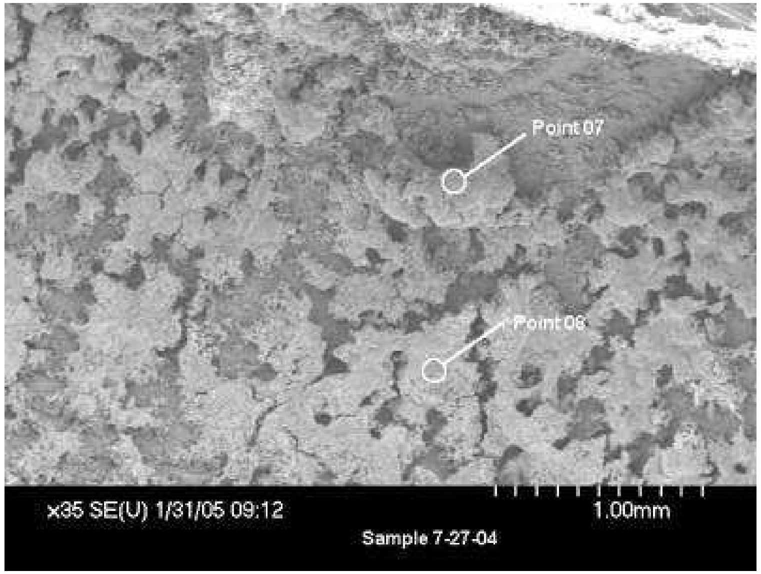
- **CR-39, polyallyldiglycol carbonate polymer, is widely used as a solid state nuclear track detector**

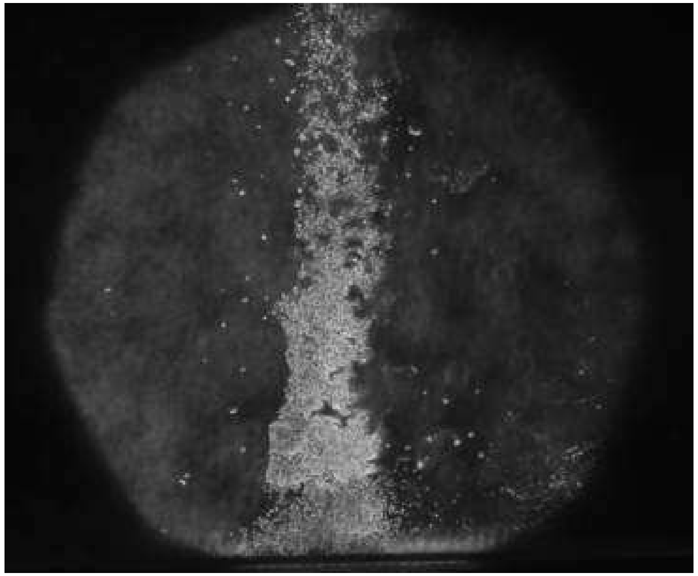
- **When traversing a plastic material, charged particles create along their ionization track a region that is more sensitive to chemical etching than the rest of the bulk**

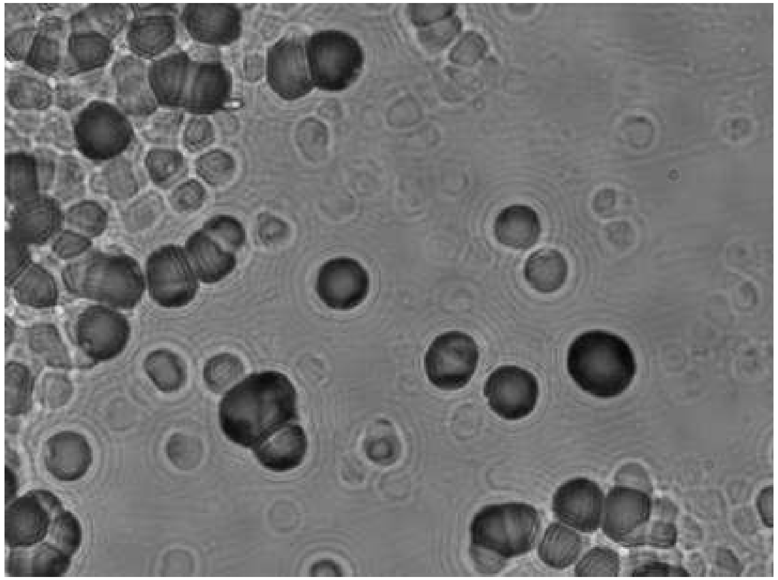
- **After treatment with an etching agent, tracks remain as holes or pits and their size and shape can be measured.**

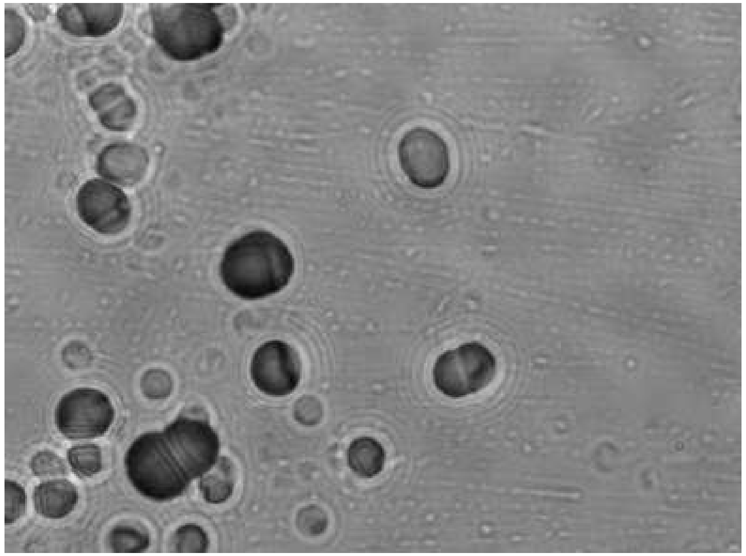


# Ag wire/Pd/D in Magnetic Field

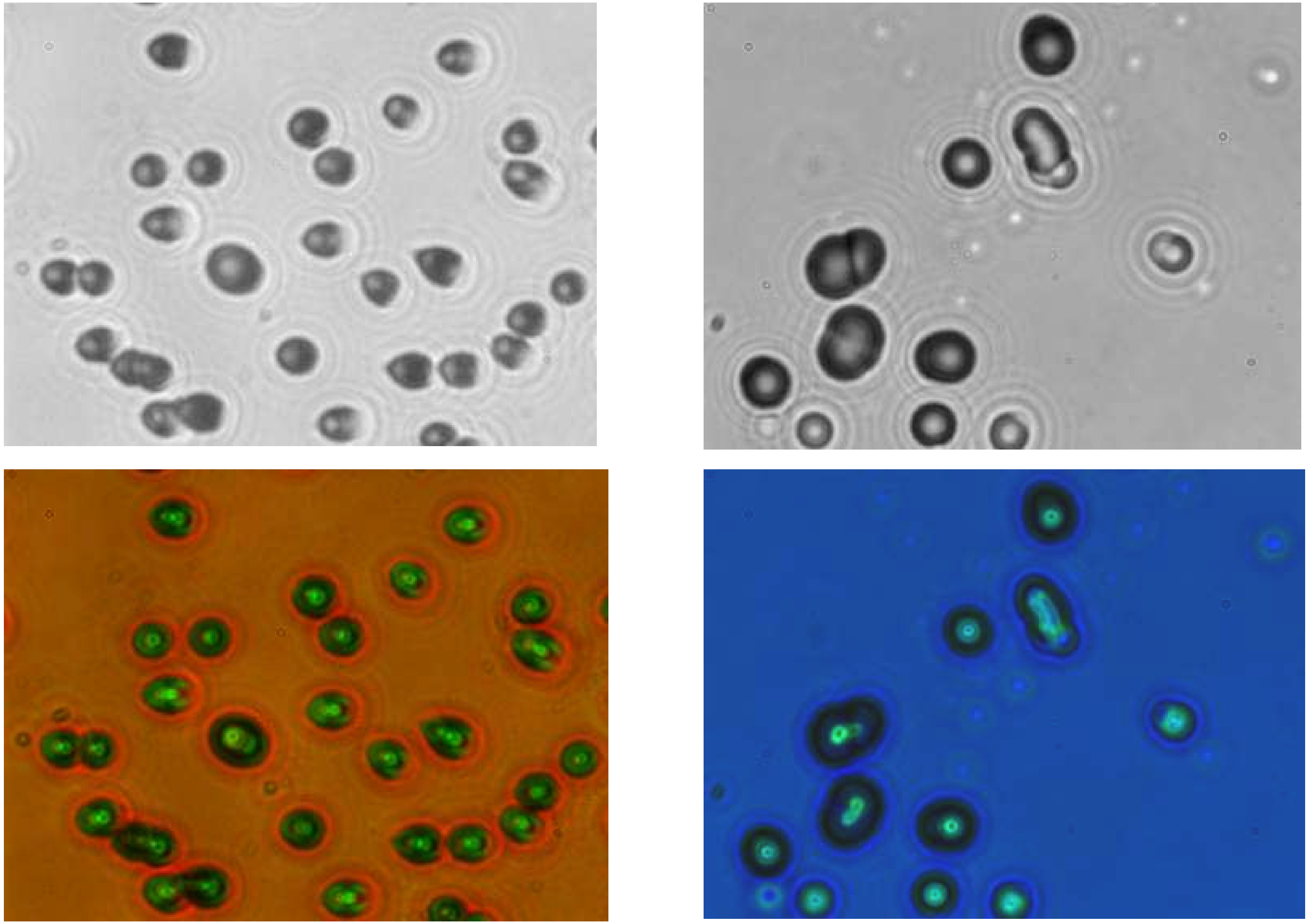






# Is a Feature Due to Background or to a Particle?



**Features due to background are small, bright and shallow (they refract light from the shallow, curved, bottoms causing them to be brighter when the microscope is focused on the surface features). The deeper nuclear tracks are darker. If you focus deeper into the chip they show bright points of light at their centers.**

# Pits Due to Contamination or Electrolysis?

| Experiment | Result |
|---|---|
| Place $PdCl_2$ powder on surface of CR-39 | No pits |
| Immerse CR-39 in $PdCl_2$-LiCl-$D_2O$ plating solution | No pits |
| Wrap cathode substrates around CR-39 | No pits |
| Electrolysis using Ni screen and LiCl-$D_2O$ | No pits |

# Necessary Conditions to Obtain Pits

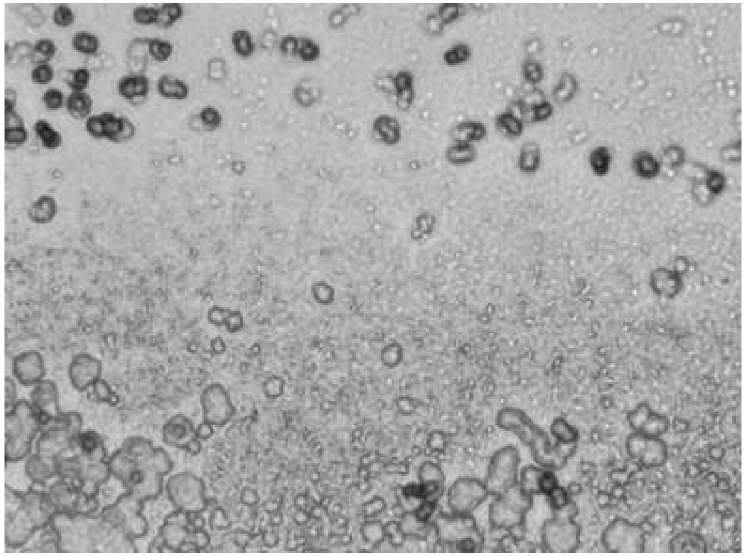
**(unless otherwise indicated, Pd/D co-dep using LiCl & $D_2O$)**

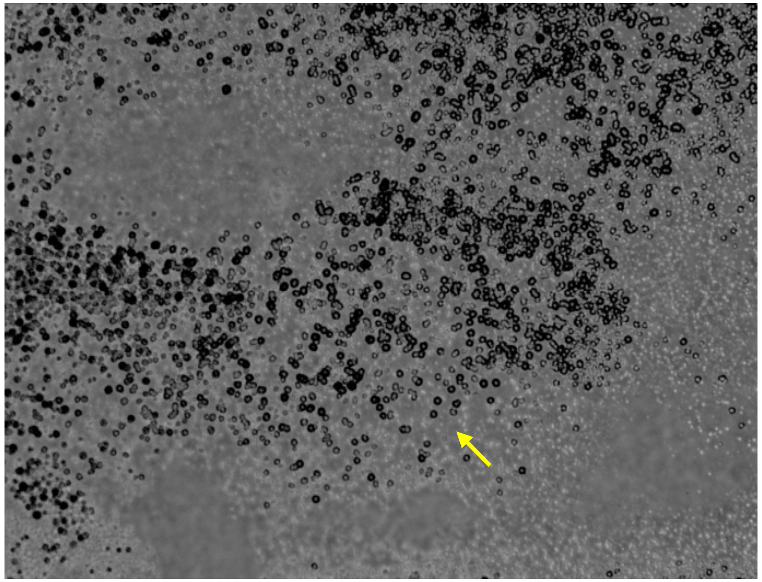
| Experiment | Field | Result |
|---|---|---|
| Ni screen | none | No pits, see impression of Ni screen |
| Ni screen | E or B | Pits in patches |
| Ag wire | None, E, or B | High density of pits |
| Au or Pt wire | E or B | High density of pits |
| Ag, KCl | E or B | High density of pits |
| Ag, $H_2O$ | E or B | Pits, less dense than $D_2O$ |
| Pd wire, no co-dep | E or B | Pits in patches |
| $CuCl_2$ in place of $PdCl_2$ | None, E, or B | No pits |

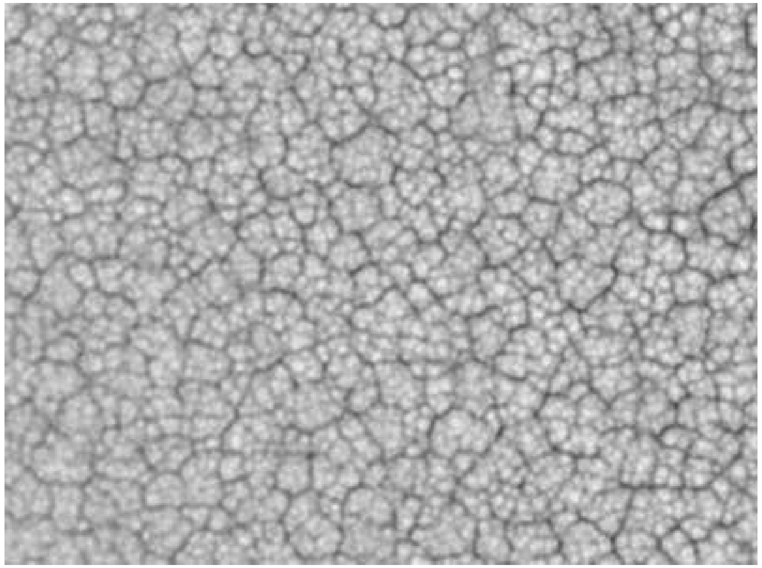
# Brands and Batches of CR-39 Vary

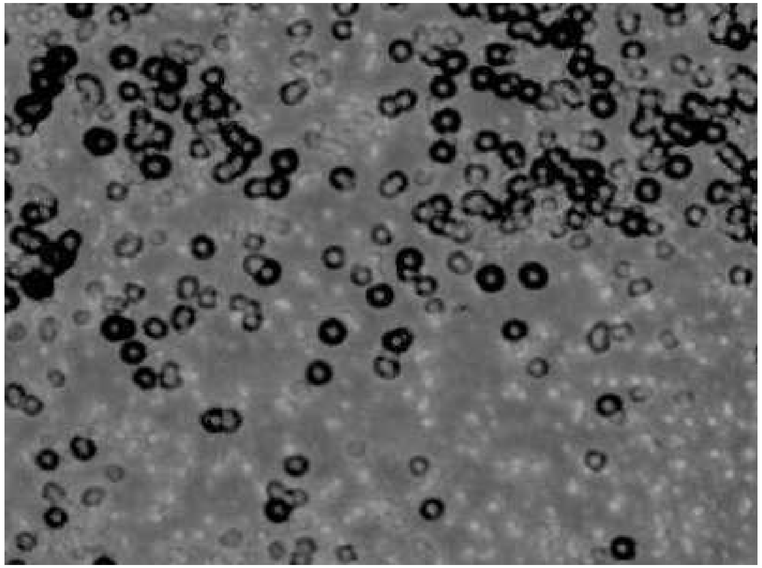
**TASL**

**Landauer (numbered)**









# Conclusions

- Pits in the CR-39 are obtained during a Pd/D co-deposition experiment
  - Pits are dark with bright points of light at their centers (true of nuclear generated pits)
  - Features due to background are small, bright, shallow, often irregularly shaped, and show no contrast
  - Observe double and triple pits (result from reactions that emit two or three particles of similar mass and energy)
- Pits are not due to radioactive contamination or to the impingement of $D_2$ gas bubbles on the surface of the CR-39
- LiCl is not required to generate pits
- $D_2O$ yields higher density of pits than $H_2O$
- Pd/D co-dep gave higher density of pits than Pd wire
- No pits are obtained by replacing $PdCl_2$ with $CuCl_2$
- Pits are observed behind the CR-39 detector that are caused by energetic particles or knock-ons created by neutral particles
- Great variability in different brands of CR-39 as well as variability with different batches