Preliminary exploration on "Topmetal" Time Projection Chamber Silicon Detector for detecting low energy solar neutrinos

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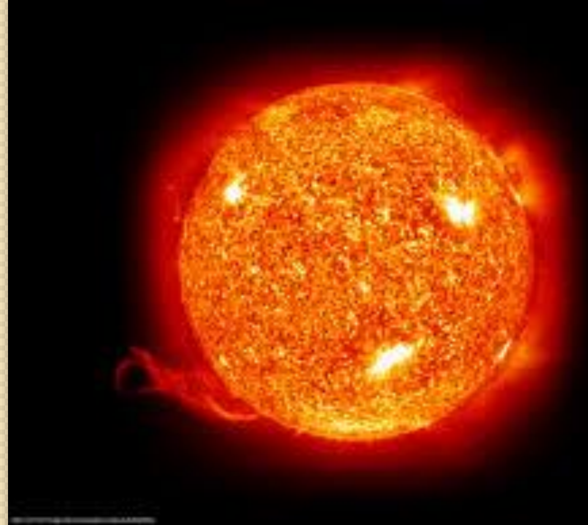
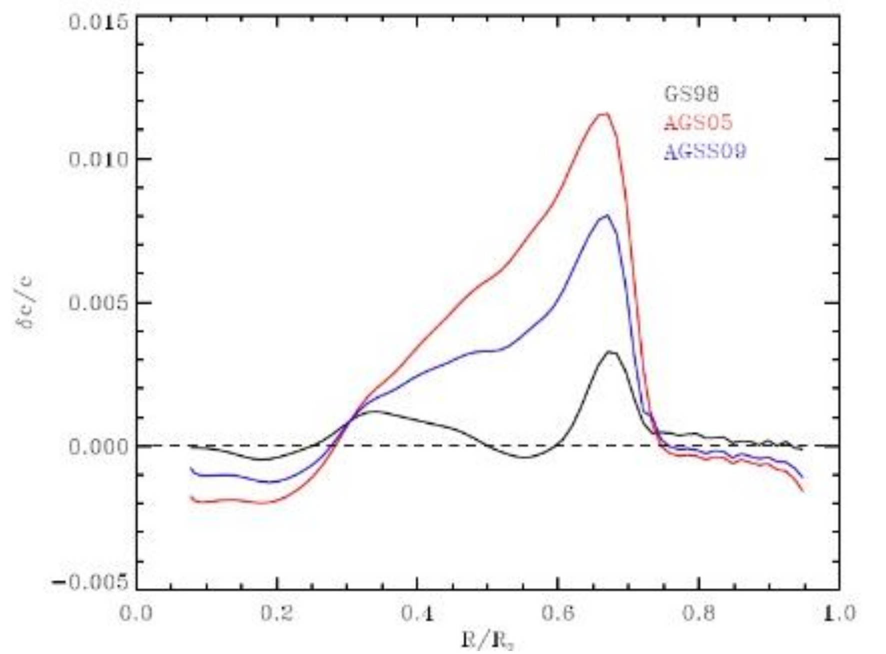


Standard Solar Model（SSM）
Before 2005： GS98 → consistent with helioseismology

Now： Better Solar Spectrum data AGS05、AGSS09 → not consistent with helioseismology

？ Solar Abundance Problem



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For decreasing statistical error, we need to increase pp neutrino events

For decreasing systematic error, we need to remove more backgrounds

Neutrinos fro[…] proton–proton fusion process in the Sun

Borexino Collaboration*

Table 1 | Results from the fit to the energy spectrum

Parameter	Rate ± statistical error (c.p.d. per 100 t)	Systematic error (c.p.d. per 100 t)
pp neutrino	144 ± 13	±10
^{85}Kr	1 ± 9	±3
^{210}Bi	27 ± 8	±3
^{210}Po	583 ± 2	±12

In the core of the Sun, energy is releas[…] primary reaction is thought to be the f[…] *pp* neutrinos constitute nearly the enti[…] that follow. Although solar neutrinos […] Sun's energy and contributing to the […] eluded direct detection. Here we repo[…] the power of the Sun, 3.84 × 10^33 ergs per second, is generated by the proton–proton fusion process.

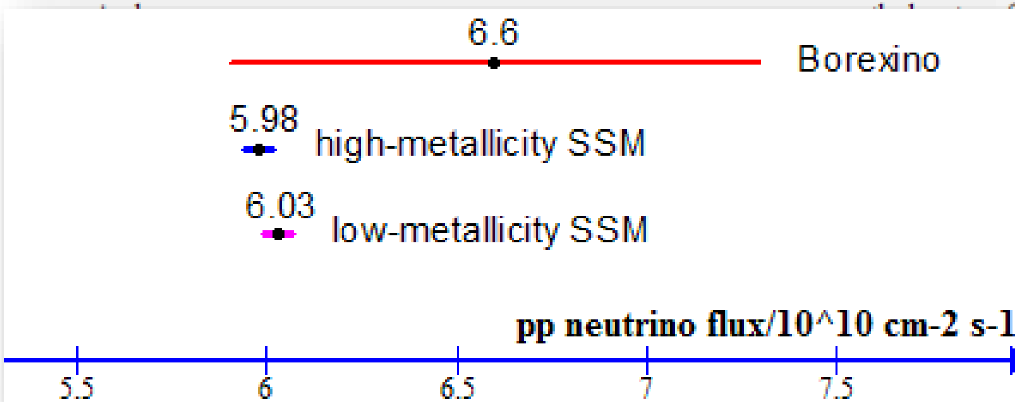
We have known for 75 years that the energy generated by stars comes from the fusion of light nuclei into heavier ones[1–3]. In the Sun, hydrogen is transformed into helium predominantly via the *pp* cycle[4,5], a chain of reactions releasing 26.73 MeV and electron neutrinos ν_e and summar-[…]

neutrinos. The measured solar *pp* neutrino flux is $(6.6 \pm 0.7) \times 10^{10}\,cm^{-2}\,s^{-1}$, in good agreement with the prediction of the standard solar model[9] (SSM) $(5.98 \times (1 \pm 0.006) \times 10^{10}\,cm^{-2}\,s^{-1})$.

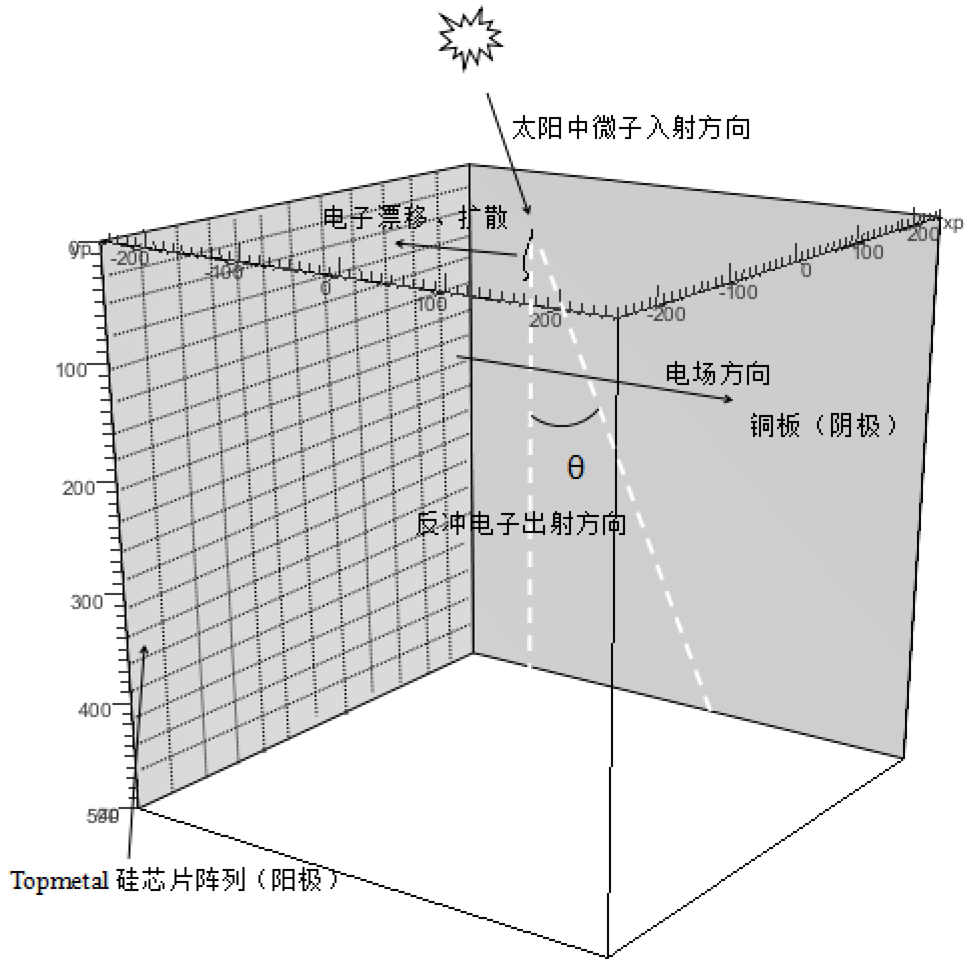
The observation of *pp* neutrinos provides us with a direct glimpse at […]usion process that keeps the Sun shining and strongly re-[…]eories on the origin of almost the entirety of the Sun's en-[…]sured flux can also be used to infer the total energy radiated […]4 × 10^33 erg s^−1. However, because photons produced in […]take a very long time (at least a hundred thousand years; […]h the surface, neutrino and optical observations in com-[…]de experimental confirmation that the Sun has been in […]ic equilibrium over such a timescale.

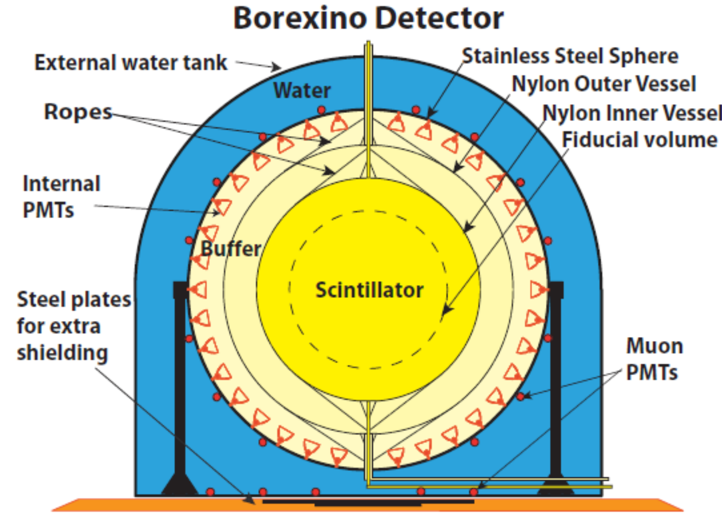
[…]or *pp* neutrinos with Borexino

[…] experiment (Methods) detects solar neutrinos by mea-[…]gy deposited in the liquid scintillator target by recoiling […]rgoing neutrino–electron elastic scattering:



to produce at most 1% of the Sun's energy[…]. Present models of the Sun





$$\vec{p}_{\nu_1} = \vec{p}_{\nu_2} + \vec{p}_e$$

$$m_e + E_{\nu_1} = E_{\nu_2} + \sqrt{m_e^2 + p_e^2}$$

$$\Rightarrow E_{\nu_1} = \frac{m_e}{\sqrt{1 + \frac{2m_e}{T_e}}\cos\theta - 1} > 0$$

$$\Rightarrow 0 < \theta < \arccos\frac{1}{\sqrt{1 + \frac{2m_e}{T_e}}}$$

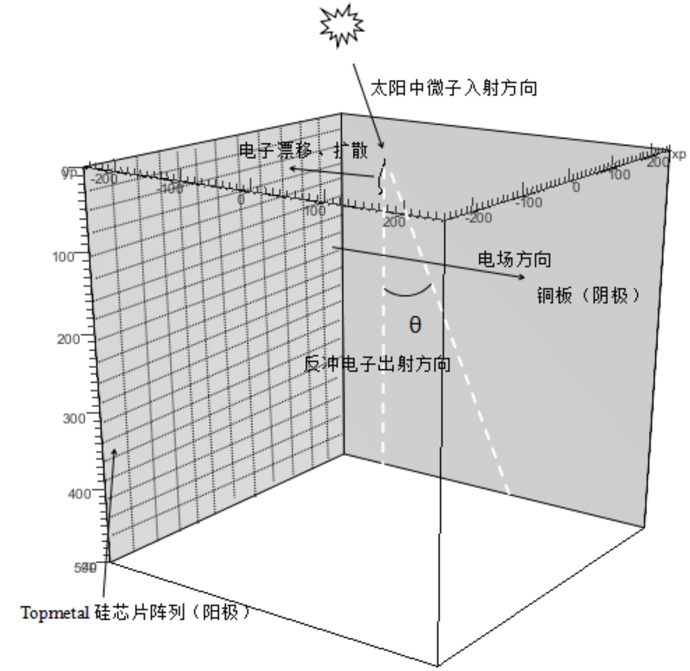
α、β

T_e

$$\cos\theta = \cos\alpha\cos\alpha_0 + \cos\beta\cos\beta_0 + \sqrt{(1 - \cos^2\alpha - \cos^2\beta)(1 - \cos^2\alpha_0 - \cos^2\beta_0)}$$

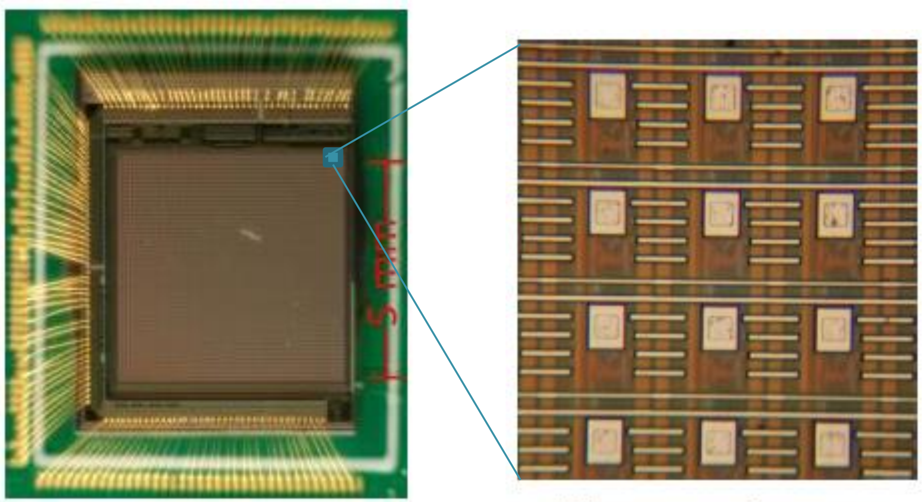
Depend on energy resolution

Depend on spatial resolution



Character of Topmetal:

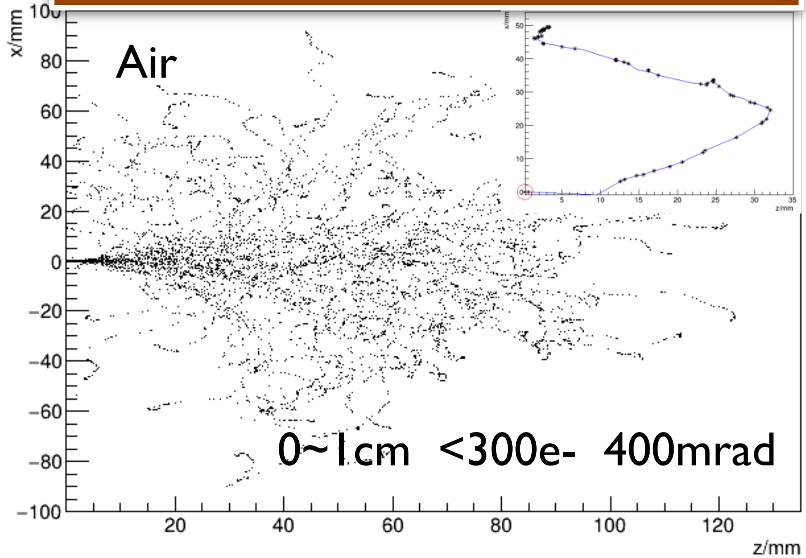
1. The top of each pixel is metal, which can be served as electrode.
2. 80um Pixel Size, high spatial resolution.
3. Low noise~15e- analog noise on each pixel

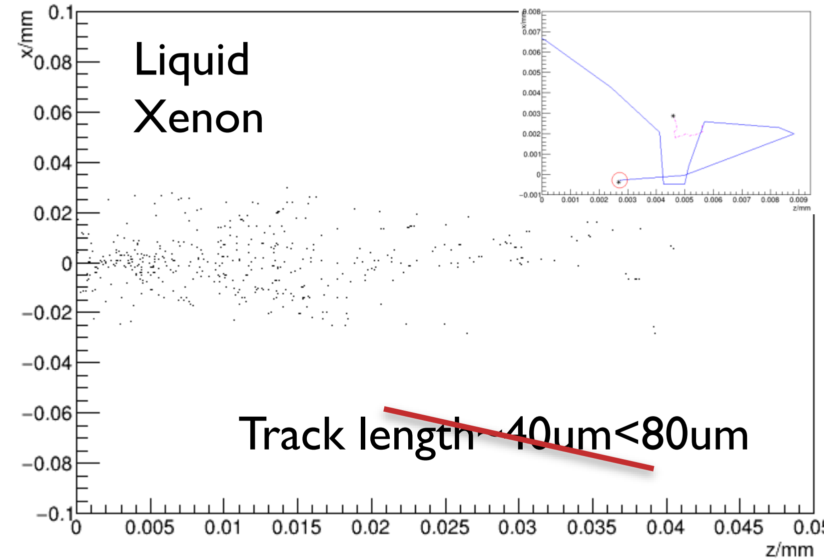


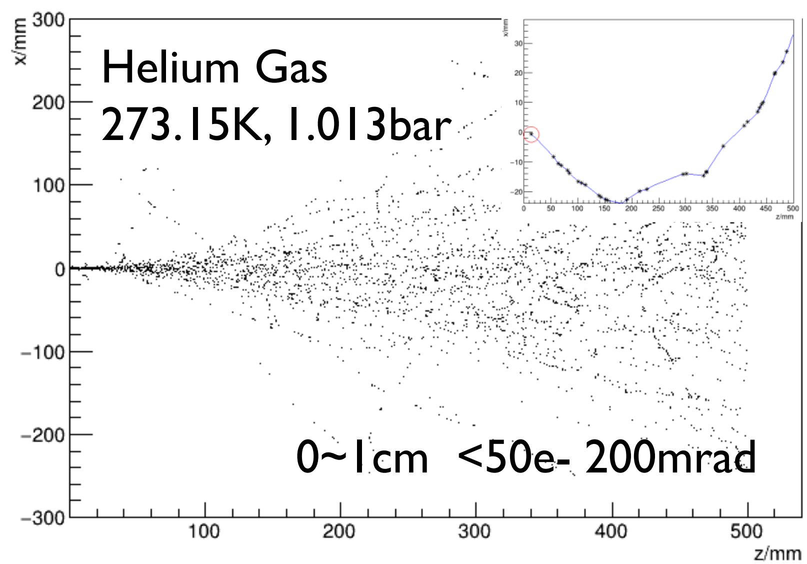
Micrograph
（pitch 80um）

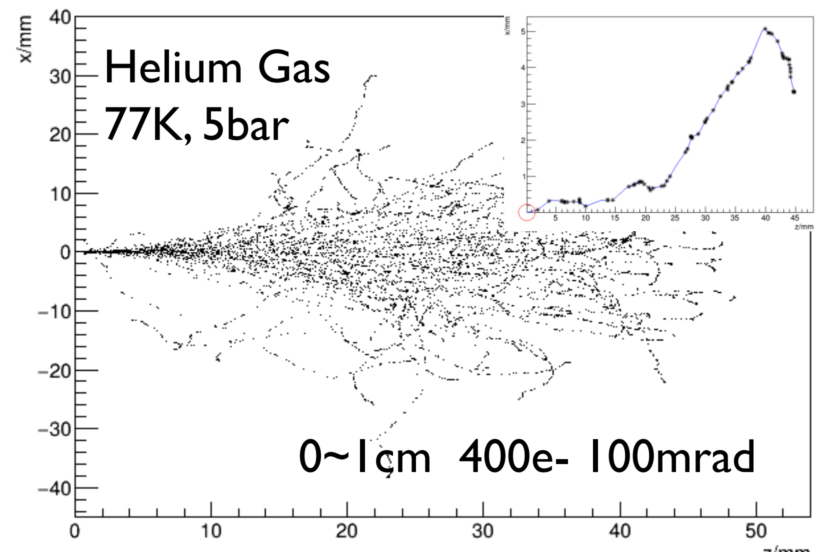
Spatial (Directional) Resolution and Detection Material: Simulation

Ionization electrons $n_T = \frac{\Delta E}{W}$



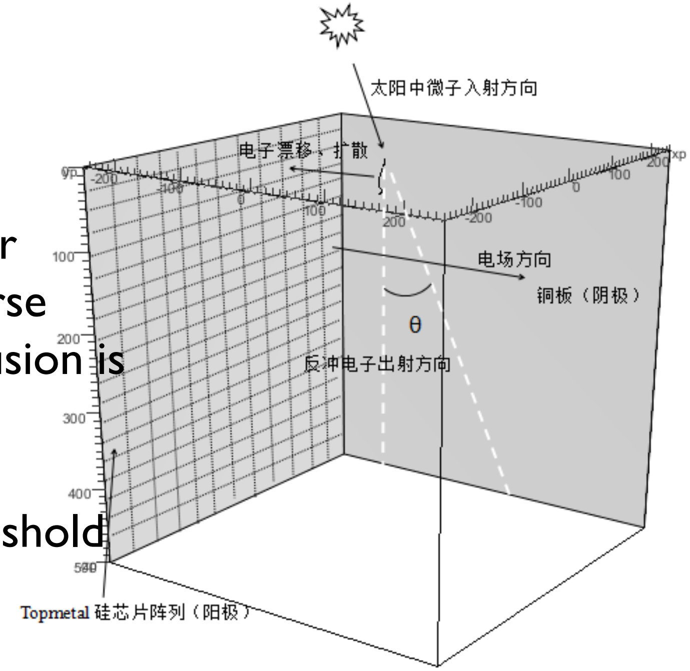






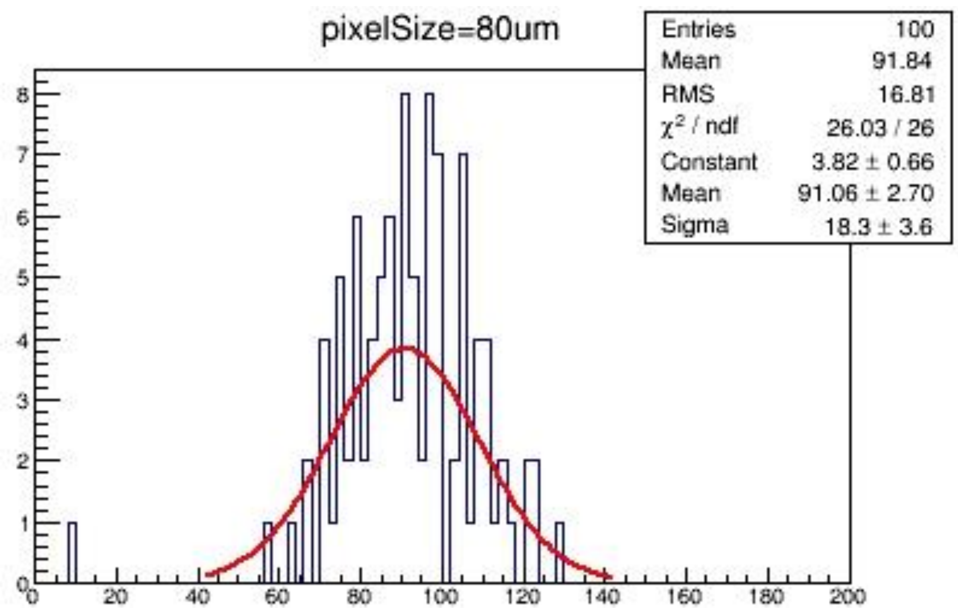
Energy Resolution Simulation

Use Magboltz Package simulate electrons under 100V/cm, 77K， 5bar Helium TPC, the transverse diffusion is 0.1602cm^2/s， the longitudinal diffusion is 0.07494cm^2/s， drift speed is 0.2134um/ns。



Given that noise on each pixel is 15e-, the threshold is set to be 30e-

For1cm， the sampling rate is set to be 0.2134*10000*10^9/s~2.134*10^12Hz



FWHM=43keV