

MC作业1

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```
In [1]: import numpy as np
        from numba import njit, prange
        import matplotlib.pyplot as plt
```

```
In [2]: @njit(nogil=True, parallel=True)
        def buffon_needle(n, l, a):
            np.random.seed(1)
            true_num = 0

            for i in prange(n):
                x = np.random.rand()*a
                theta = np.random.rand()*np.pi
                if (x <= l*np.sin(theta)):
                    true_num += 1

            return 2*l/(a*(true_num+np.finfo(np.float64).eps)/n)
```

```
In [243... %%time
            list_n = [10**i for i in range(1, 10)]
            list_re = []
            list_err = []

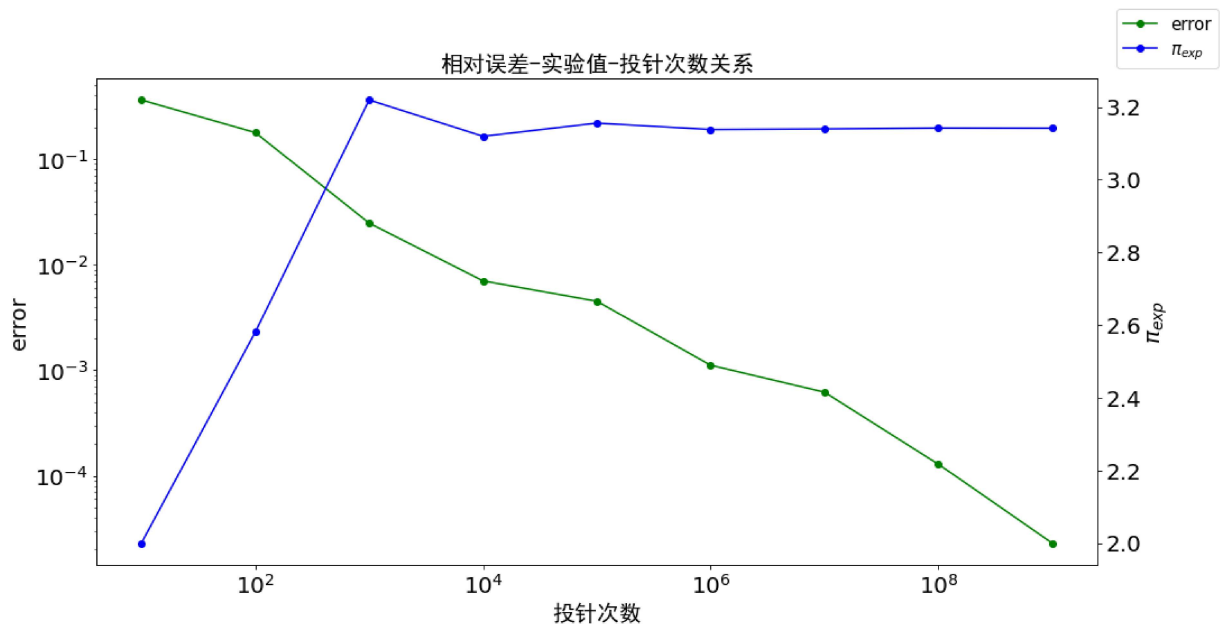
            for i in list_n:
                list_re.append(buffon_needle(i, 0.4, 0.5))
                list_err.append(np.abs(list_re[-1]-np.pi)/np.pi)
```

Wall time: 9.48 s

```
In [244... fig, ax1 = plt.subplots(figsize=(16, 8))
            ax1.plot(list_n, list_err, "go-")
            ax1.set_ylabel("error", fontsize=20)
            ax1.set_xlabel("投针次数", fontproperties="SimHei", fontsize=20)
            ax1.set_title("相对误差-实验值-投针次数关系", fontproperties="SimHei", fontsize=20)
            plt.tick_params(labelsize=20)
            plt.xscale("log")
            plt.yscale("log")

            ax2 = ax1.twinx()
            ax2.plot(list_n, list_re, "bo-")
            ax2.set_ylabel(r'$\pi_{exp}$', fontsize=20)
            plt.tick_params(labelsize=20)

            fig.legend(["error", r'$\pi_{exp}$'], fontsize=15)
            plt.show()
```



大概看出，投针次数每提升两个量级，误差减小一个数量级，符合中心极限定理： $\sigma = \frac{\sigma_0}{\sqrt{n}}$

In [4]:

```
%%time
exp_n = 100
power_n = 7
list_exp_n = np.arange(0, exp_n, 1)
list_n = [10**i for i in range(1, power_n+1)]
list_pi = np.zeros([power_n, exp_n])
list_err = np.zeros([power_n, exp_n])

for i, n in enumerate(list_n):
    for j in list_exp_n:
        list_pi[i, j] = buffon_needle(n, 0.4, 0.5)
        list_err[i, j] = np.abs(list_pi[i, j] - np.pi) / np.pi
```

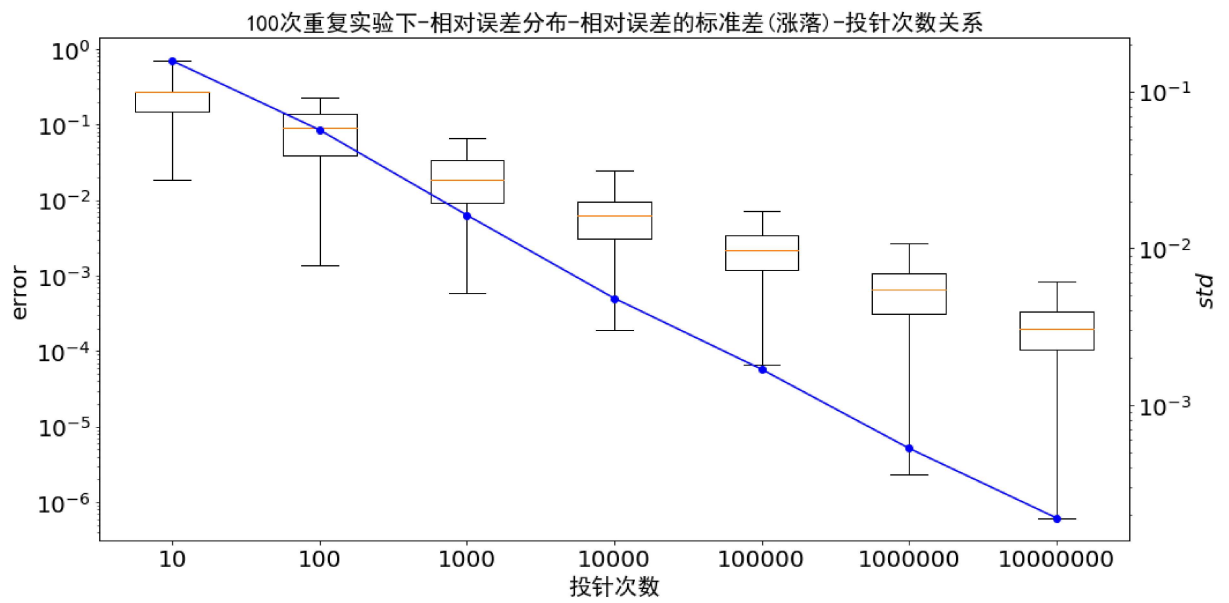
Wall time: 17.1 s

In [5]:

```
fig, ax1 = plt.subplots(figsize=(16, 8))
ax1.boxplot(list_err.T, labels=list_n, sym='o', whis=15.5)
ax1.tick_params(labelsize=20)
ax1.set_ylabel("error", fontsize=20)
ax1.set_xlabel("投针次数", fontproperties="SimHei", fontsize=20)
ax1.set_title("100次重复实验下-相对误差分布-相对误差的标准差(涨落)-投针次数关系", font
plt.yscale("log")

ax2 = ax1.twinx()
ax2.plot(np.arange(1, 8, 1), np.std(list_err, axis=1), "bo-")
ax2.set_ylabel(r'$std$', fontsize=20)
plt.tick_params(labelsize=20)
plt.yscale("log")

plt.show()
```



可见，投针次数每提高一个数量级，相对误差的标准差降低一个数量级，相对误差的标准差即样本标准差的标准差，同样符合中心极限定理

In []: