

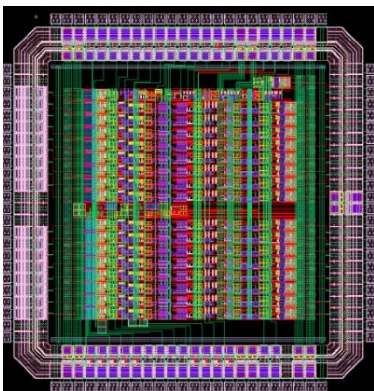
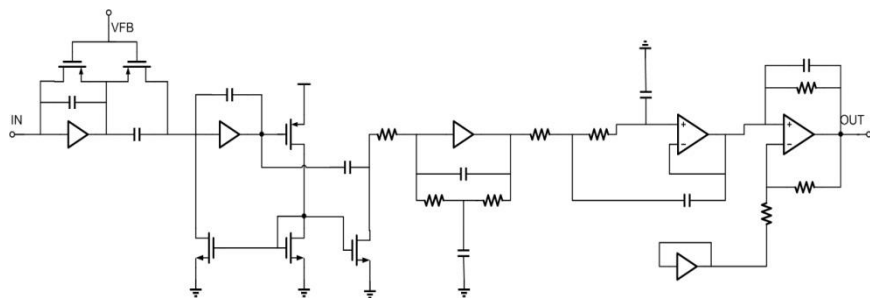
# TPC读出ASIC

邓智

清华大学工程物理系

# 已有芯片

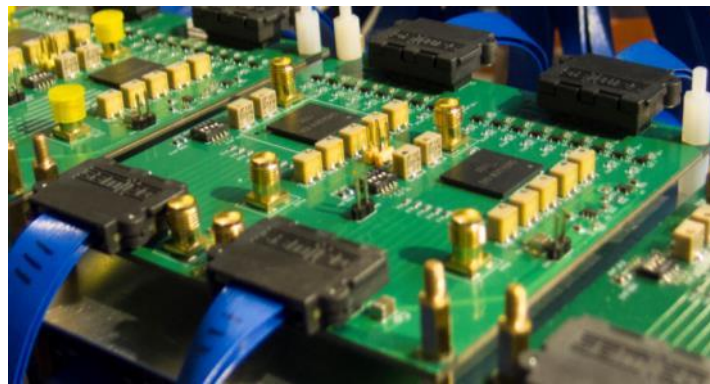
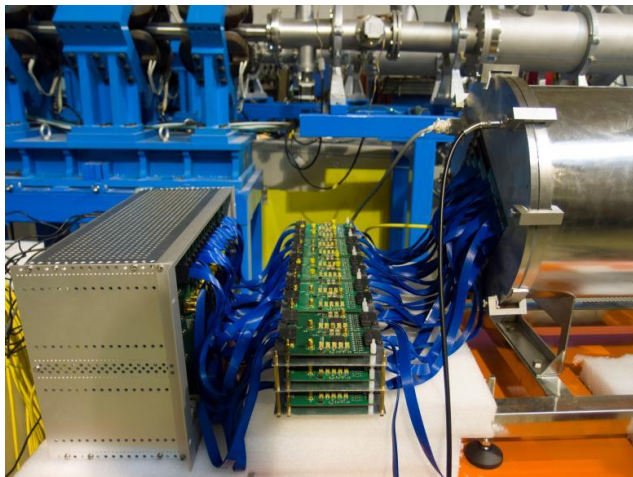
- CASAGEM芯片：Charge-Amplifier-Shaper-Amplifier



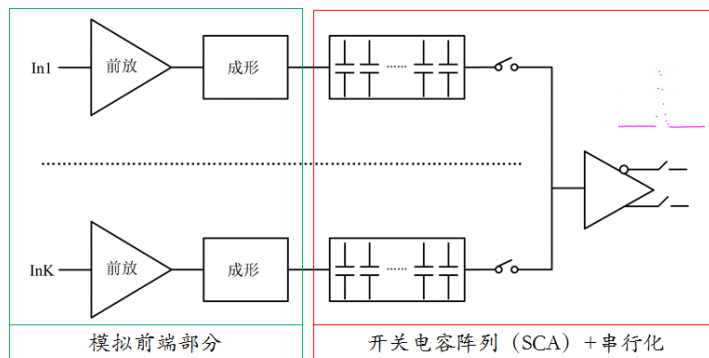
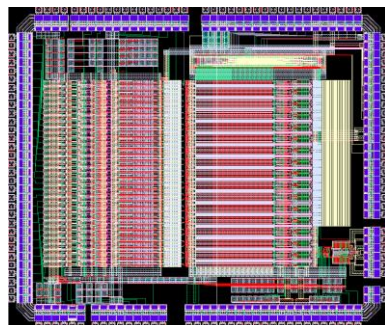
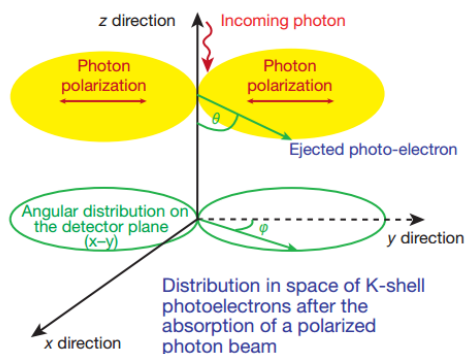
| 参数    | 指标                   |
|-------|----------------------|
| 增益    | 2-40mV/fC            |
| 成形电路  | CR-(RC) <sup>5</sup> |
| 达峰时间  | 100-400ns            |
| 噪声    | <2000e @ 10pF        |
| 积分非线性 | <1%                  |
| 串扰    | <1%                  |
| 通道数   | 16+1                 |

- CASAGEM芯片应用

- 已安装720通道，应用在宇宙线、质子和中子束流测试



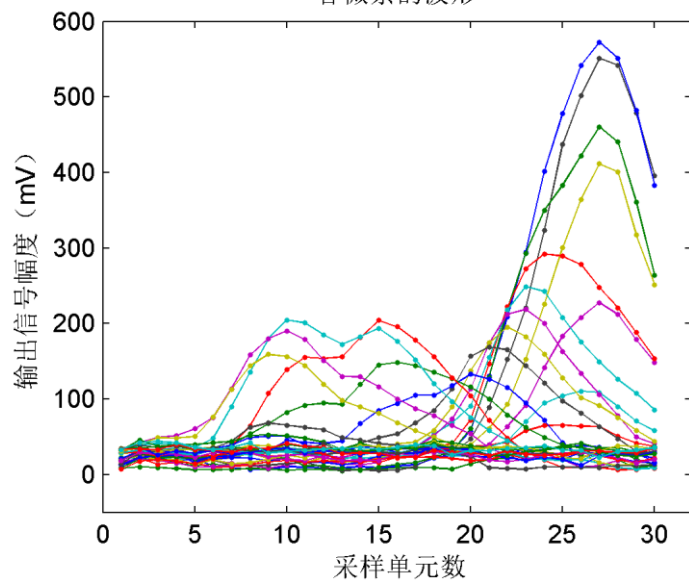
# • CASCA芯片：Charge Amplifier with Switched Capacitor Array



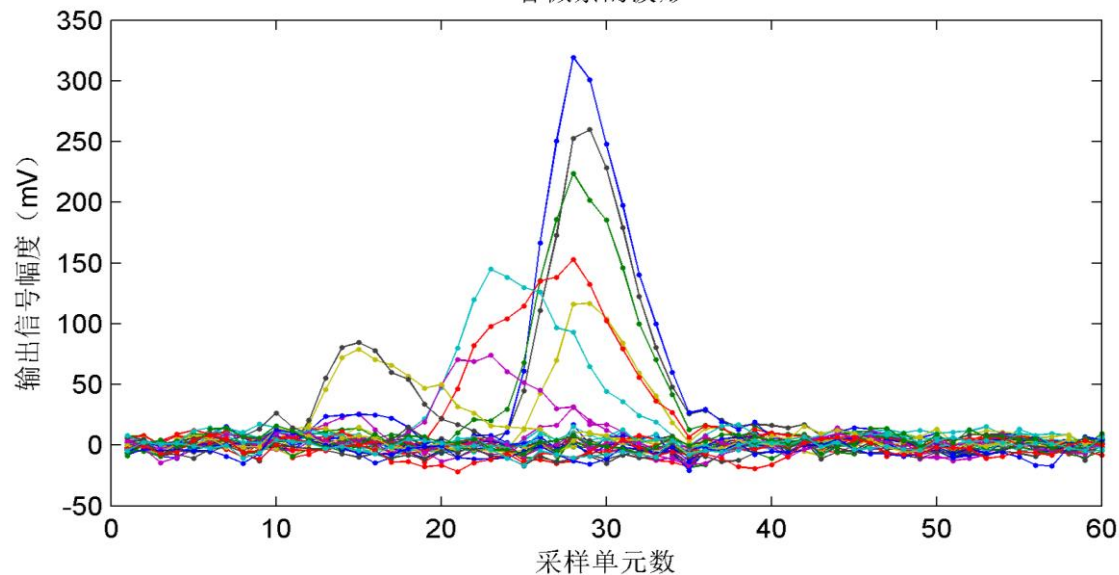
| 参数     | 指标            |
|--------|---------------|
| 通道数    | 32            |
| 动态范围   | 0-40fC        |
| 增益     | 25mV/fC       |
| 成形     | CR-RC         |
| 达峰时间   | 50ns          |
| ENC    | 68.3e/pF+7.2e |
| 最高采样频率 | 50MHz         |
| 最高读出频率 | 16MHz         |
| 缓存深度   | 64 points     |
| 有效分辨率  | ~9bit         |
| 工艺     | 0.18μm        |
| 功耗     | 2.8 mW/ch     |

## • CASCA芯片的应用

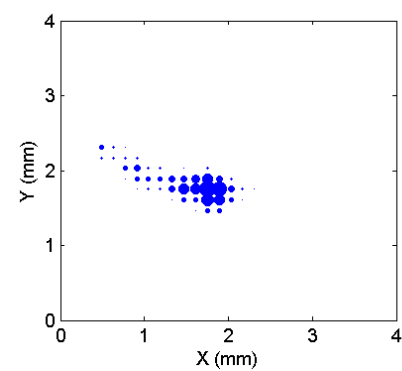
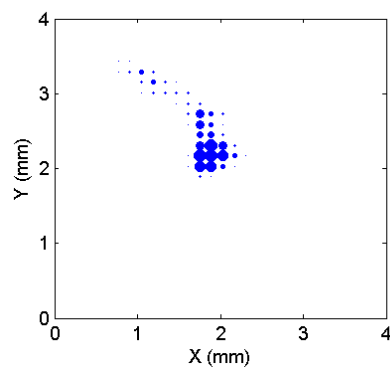
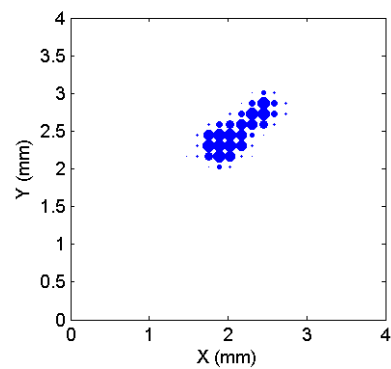
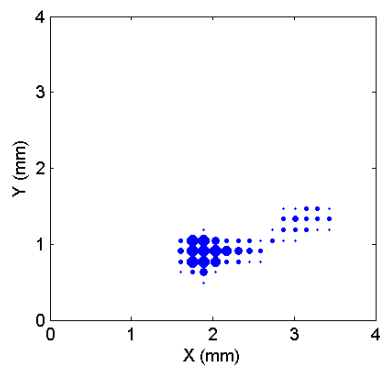
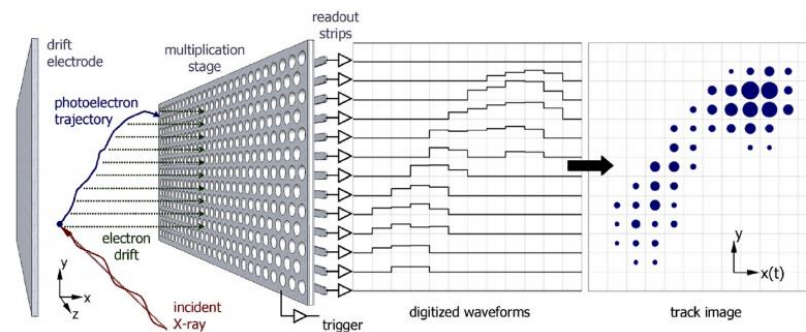
各微条的波形



各微条的波形

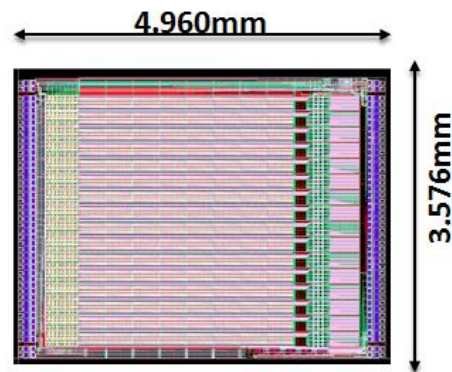
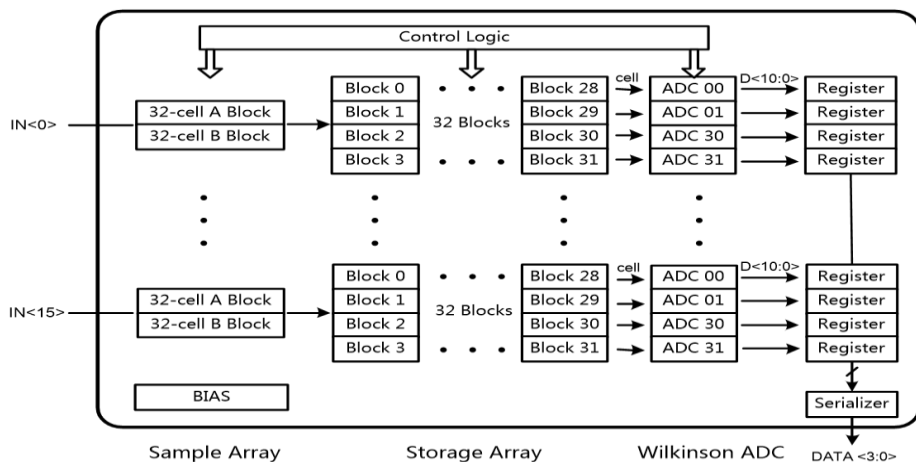


8 keV X射线入射时APV25和CASCA采样到的波形（左图：APV25；右图：CASCA）



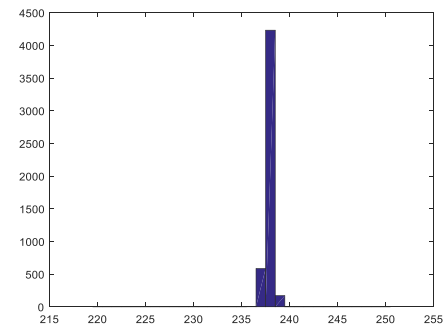
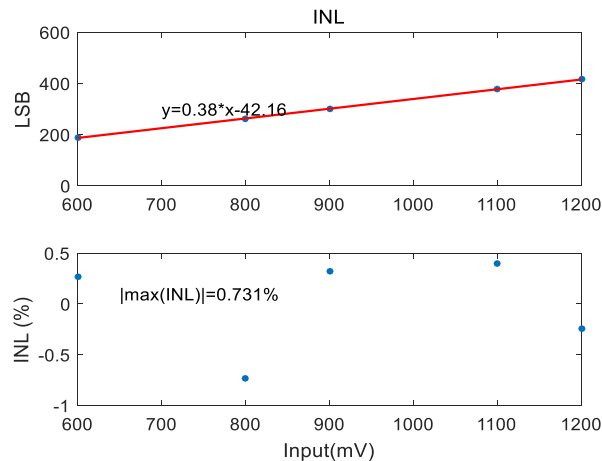
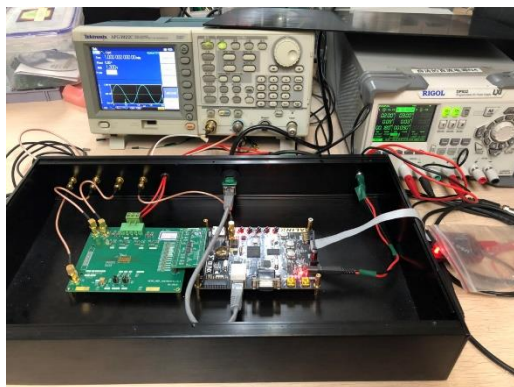
# 在研芯片及计划

- 大存储深度和数字化SCA ASIC芯片

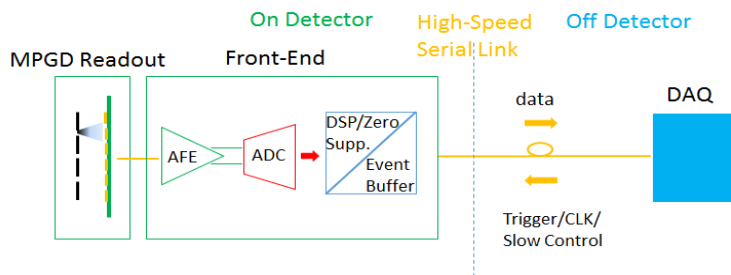


| 参数    | 指标       |
|-------|----------|
| 通道数   | 16       |
| 采样频率  | 100MSPS  |
| 采样精度  | 10bit    |
| 采样深度  | 512/1024 |
| 读出死时间 | 320ns    |
| 功耗    | ~5mW/ch  |

- 第一版基本功能实现，部分存储单元读出错误
- 第二版设计5月份提交，预计8月份拿到芯片

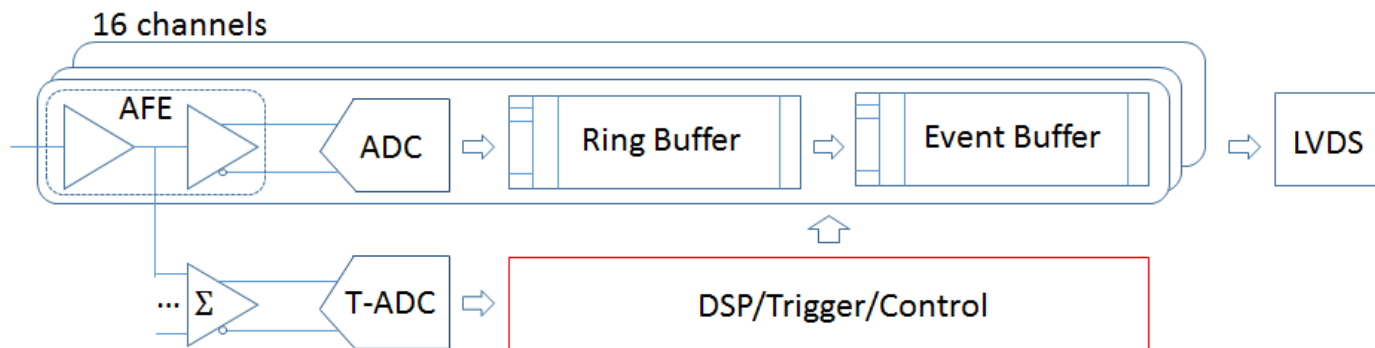


- 基于65nm工艺的低功耗高集成度读出芯片（CEPC-TPC）

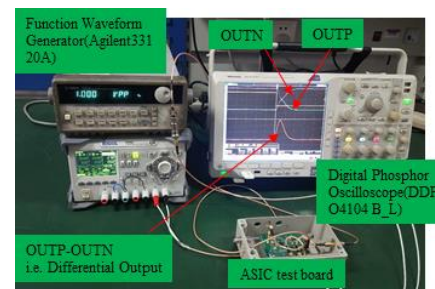
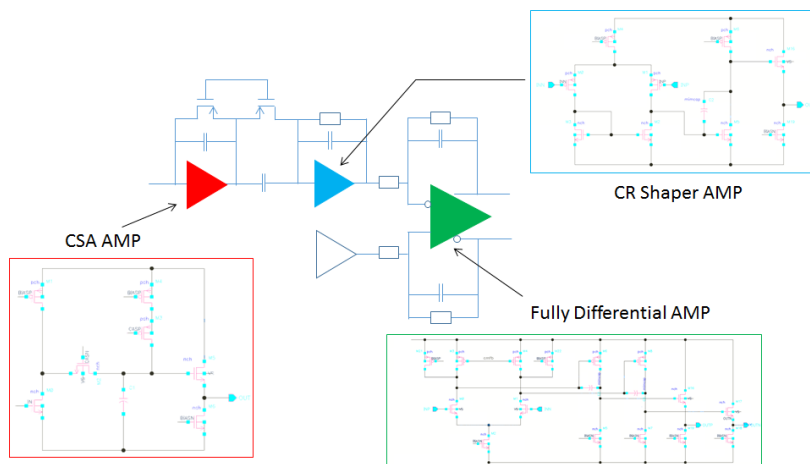


| Total number of channels |               | 1 million per endcap    |
|--------------------------|---------------|-------------------------|
| AFE                      | ENC           | 500 e @ 10pF input cap. |
|                          | Gain          | 10 mV/fC                |
|                          | Dynamic Range | 120 fC                  |
|                          | Shaper        | CR-RC                   |
|                          | Peaking time  | 160 ns                  |
|                          | INL           | <1%                     |
|                          | Crosstalk     | <1%                     |
| ADC                      | Sampling rate | Up to 40 MSPS           |
|                          | Resolution    | 10 bit                  |
|                          | DNL           | <0.65 LSB               |
|                          | INL           | <0.6 LSB                |
|                          | ENOB          | >9 bit                  |
| Power consumption        |               | ≤5 mW per channel       |
| Process                  |               | TSMC 65nm LP            |

- 完成第一轮MPW流片，包括
  - 5通道模拟前端
  - SAR ADC
  - 3通道模拟前端+ADC
- 计划明年上半年完成16通道芯片设计

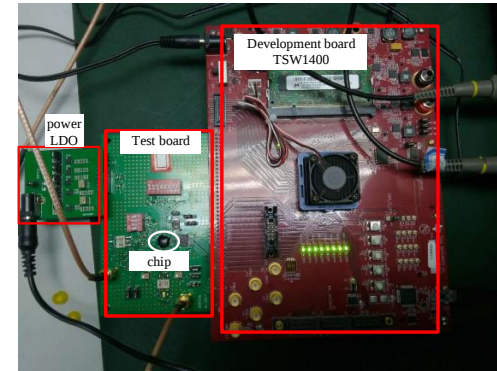
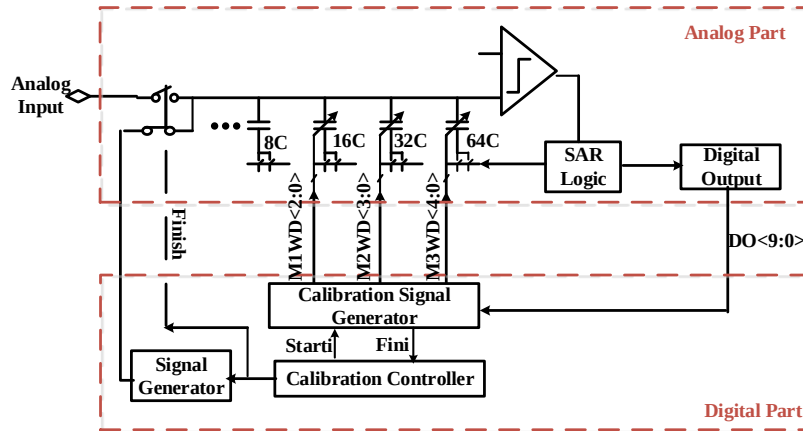


## • 模拟前端芯片



|                   | Specifications | Test Results |
|-------------------|----------------|--------------|
| Gain              | 10mV/fC        | 10.5mV/fC    |
| Dynamic Range     | 120fC          | >120fC       |
| INL               | <1%            | 0.41%        |
| Power consumption | 2.50mW/ch      | 2.18mW/ch    |
| ENC               | 500e @ 10pF    | 448e @ 10pF  |
| Xtalk             | <1%            | <0.36%       |

- SAR ADC



|                   | Specifications | Test Results |
|-------------------|----------------|--------------|
| Sampling rate     | 40 MSPS        | 50 MSPS      |
| Resolution        | 10 bit         | 10 bit       |
| INL               | <0.65 LBS      | <0.5 LSB     |
| DNL               | <0.6 LSB       | <0.5 LSB     |
| ENOB              | >9 bit         | 9.18 bit     |
| Power consumption | <2.5 mW/ch     | 1 mW/ch      |