Status of the silicon tracker

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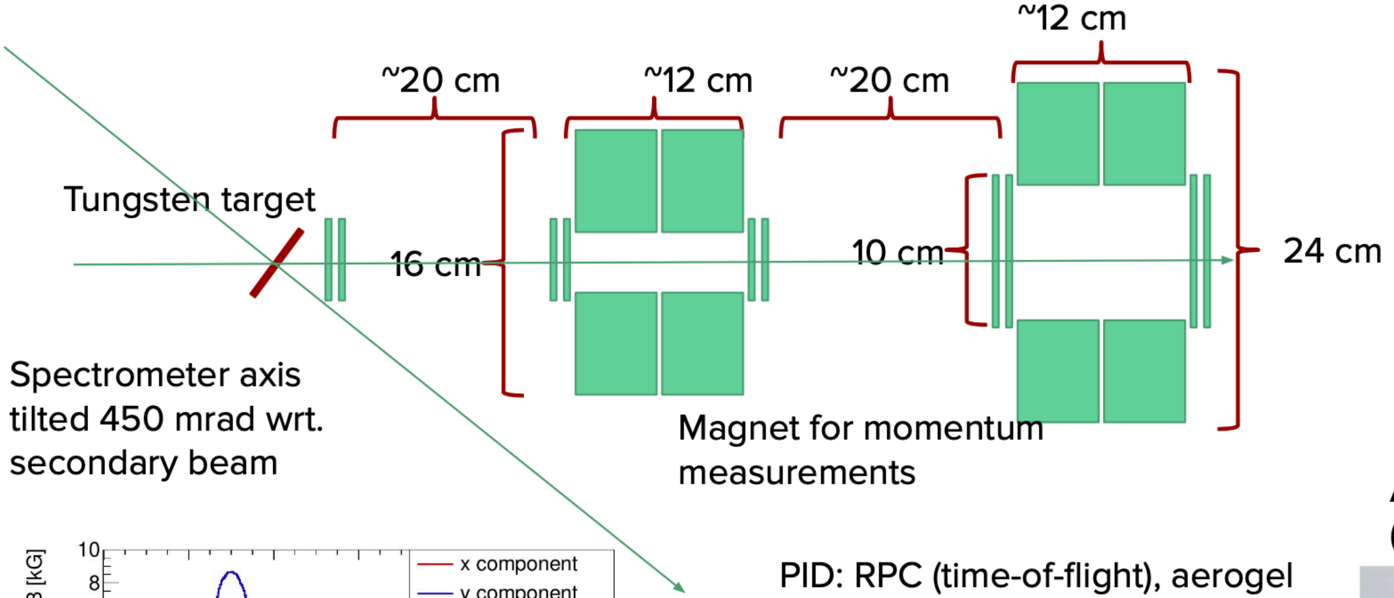
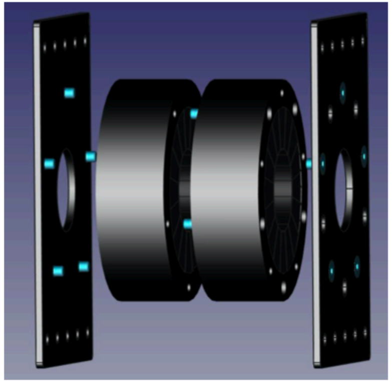
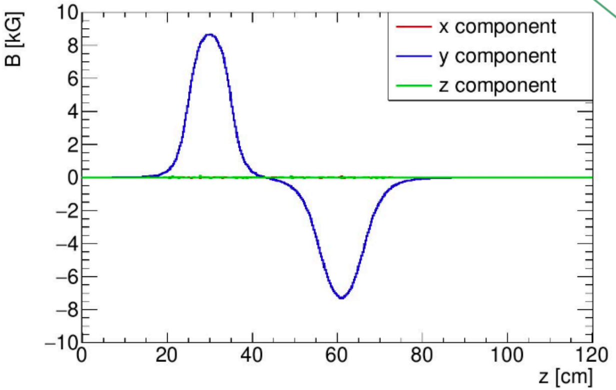
(TRIUMF)
Nov.29, 2021

WCTE Tertiary Beam Spectrometer



Halbach array

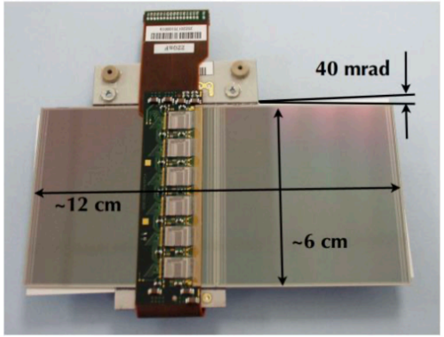




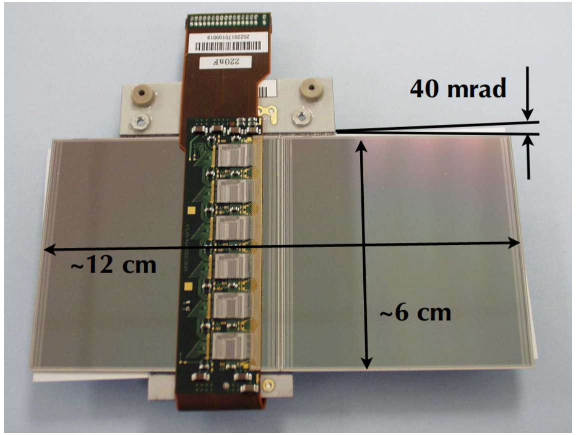
PID: RPC (time-of-flight), aerogel threshold Cherenkov detectors

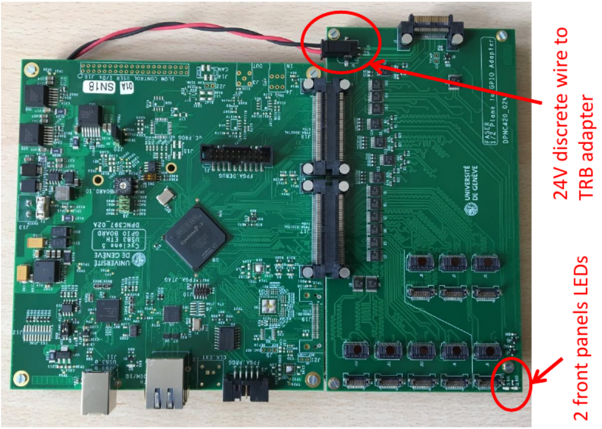
Bending power (first magnet) = 0.075 Tm

ATLAS SCT
(8 modules approved)

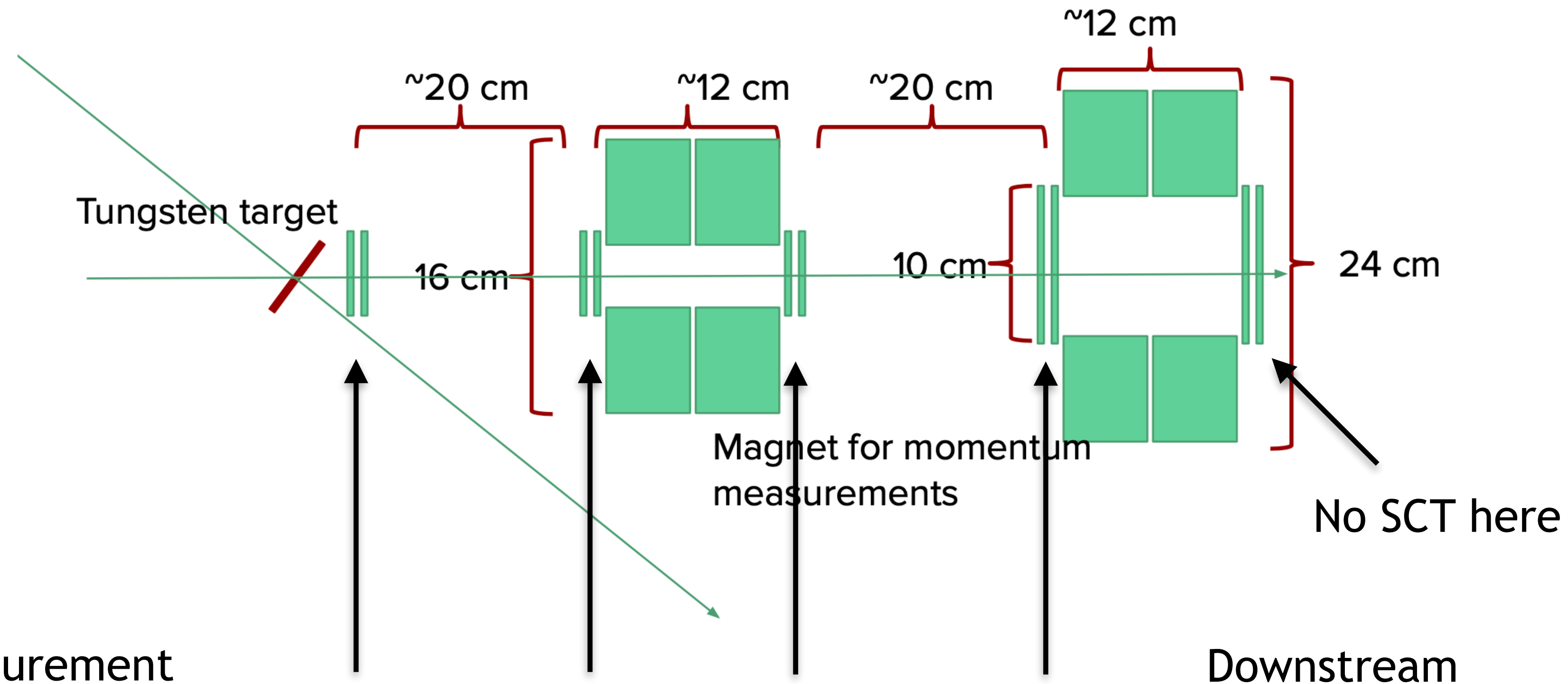


- Characteristics
  - 6cm x 12cm (readout chip in the middle)
    - 6cm x 5cm space without electronics
  - 2 layer of 80μm pitch with angle
    - σ_x=13.7μm, σ_y=1mm
  - 1.7% radiation length per layer
- Readout electronics
  - readout electronics already mounted
  - FPGA (GPIO) control developed by FASER
- 8 modules approved for proof of principle
  - We can use 8 ATLAS SCT modules now
  - Upgrade to 20 modules once we prove this

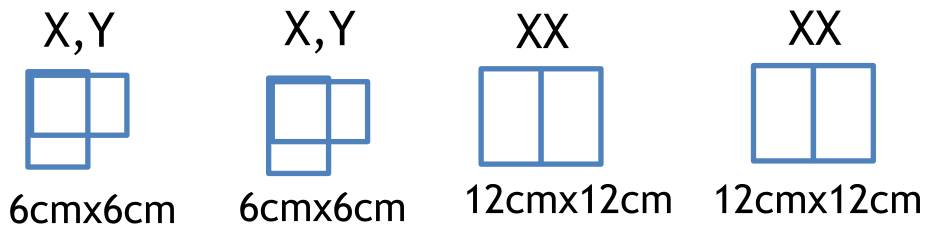




Configuration of the 8 ATLAS-SCT modules



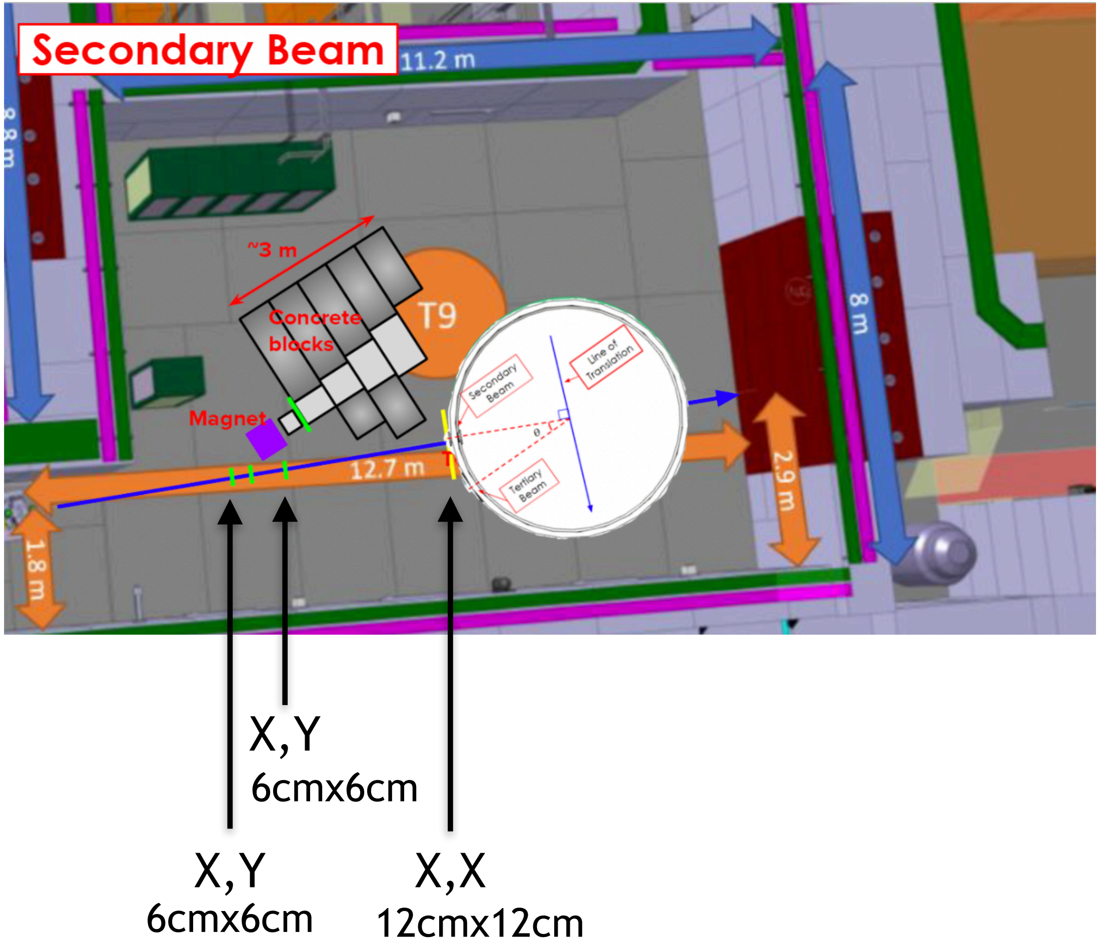
XY measurement upstream σ=13.7μm (avoid electonics)



Downstream resolutions are σ_x=13.7μm, σ_y=1mm

ATLAS SCT team and budget

- Team
  - Geneva group
    - Federico Sanchez, Stefania Bordoni, (Sandra Bravor)
    - Mechanical and electronics engineering groups
      - constructed the FASER SCT readout control and mechanics
  - Japanese group
    - H.Kakuno leads the Japanese SCT group
      - Silicon strip experience on Belle experiment
    - H.Otono and Y.Takubo of FASER DAQ members actively help us
      - Otono is the contact person of ATLAS SCT collaboration
      - Remaining components (cables/patch panels) built in Japan by them
- Budget
  - FPGA boards (U.Geneva), cables, patch panels: US$41k
  - SCT support frame and cooling system: US$34k
  - HV/LV power supplies: US$75k can be free from CERN pool)

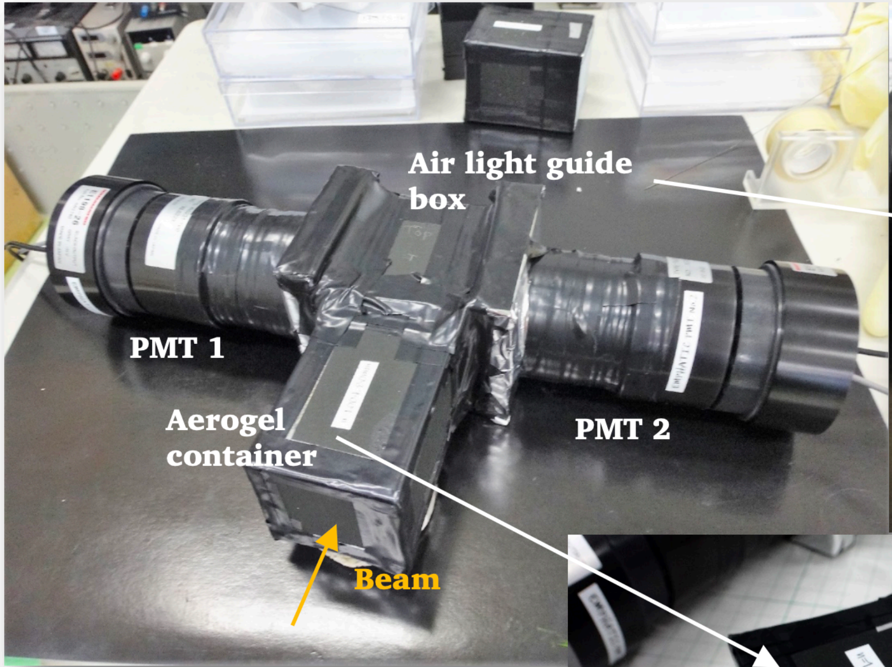


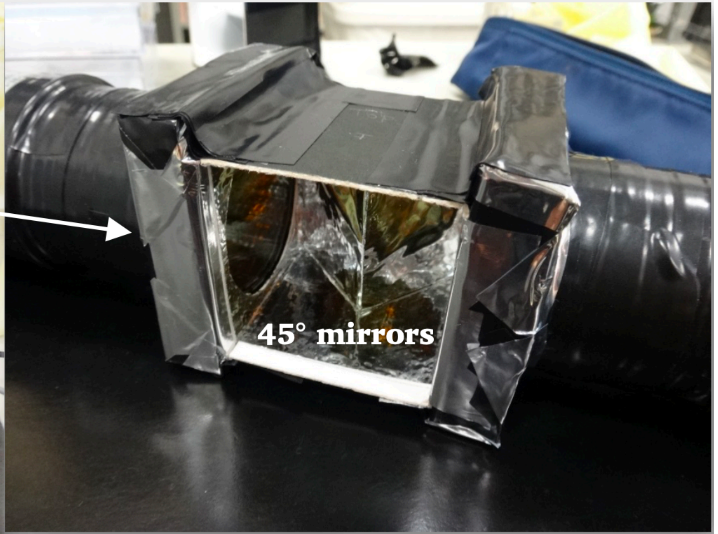
- Move tertiary SCT modules to the secondary beam
  - beam direction and position measurements
- Other possibilities
  - beam momentum measurement?
    - move upstream tertiary spectrometer
  - beam pion decay tagging ?

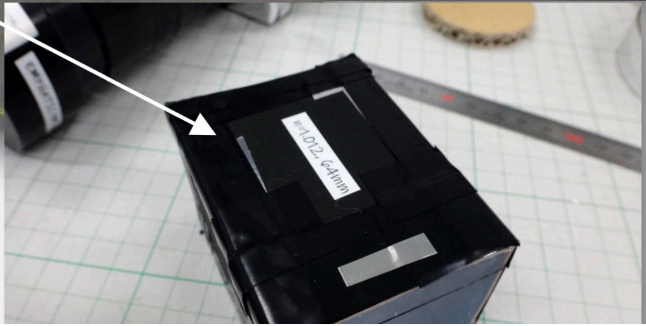
Pion decay tagging in the secondary beam

- Pion contamination for muon measurement
  - hard scattering of muons in water (~1%) is mimicked by pions
    - ideally, reduce the pion contaminations down to 0.1%
  - 500MeV/c beam
    - pion decay length ~ 28m: 24% of pions survives in 40m beamline
- Pion decay tagging using silicon strip detectors
  - 5m decay region: 18% of pions decays @ 500MeV/c
  - up to 6mrad of change in beam angle due to decay
    - challenging to compete with multiple scattering by SCT
- Alternative option is to use aerogel threshold detector
  - 500MeV/c: $n(\pi)=1.039$, $\nu(\mu)=1.022$
  - 300MeV/c: $n(\pi)=1.010$, $\nu(\mu)=1.06$
  - Tabata-san develops aerogel with n=1.004 - 1.013

Threshold aerogel Cherenkov detector (Tabata-san)



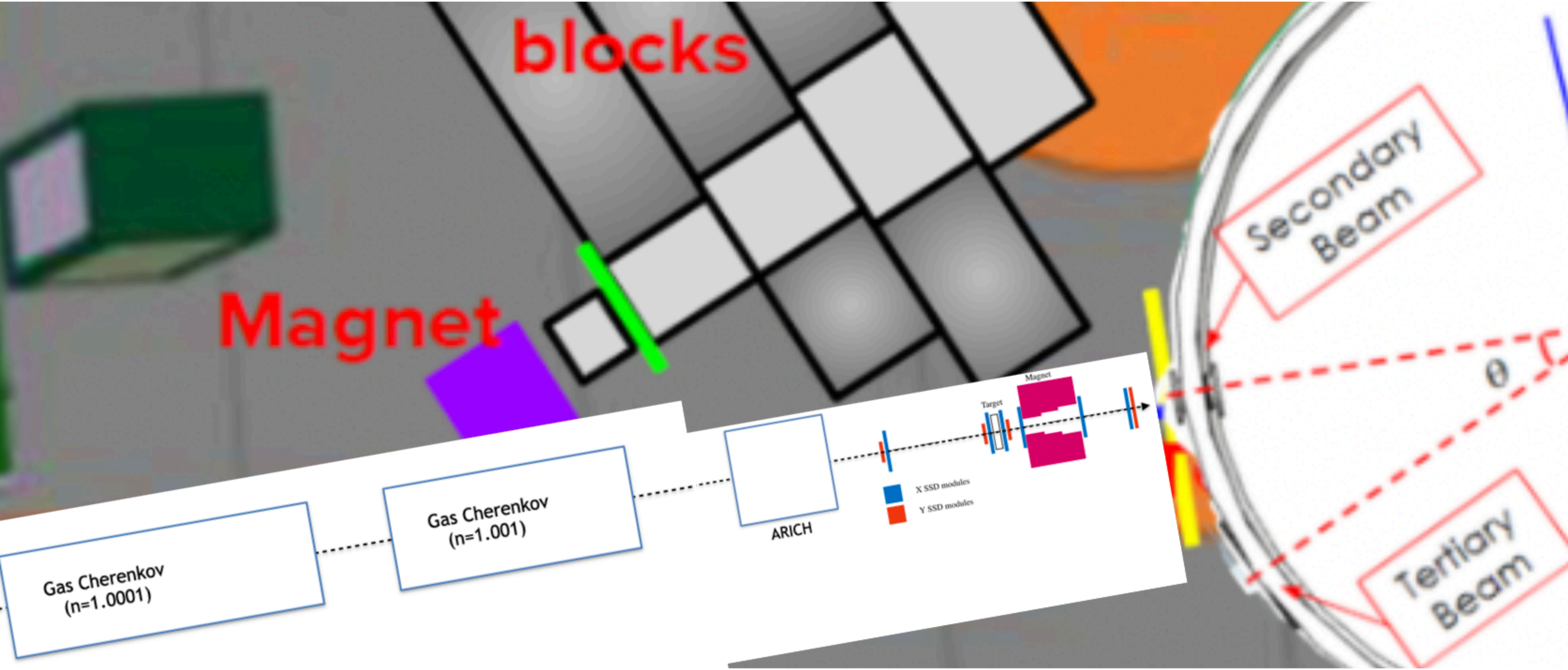




41 (18.5) photoelectrons
for n=1.045 (1.012)
64mm-long aerogel

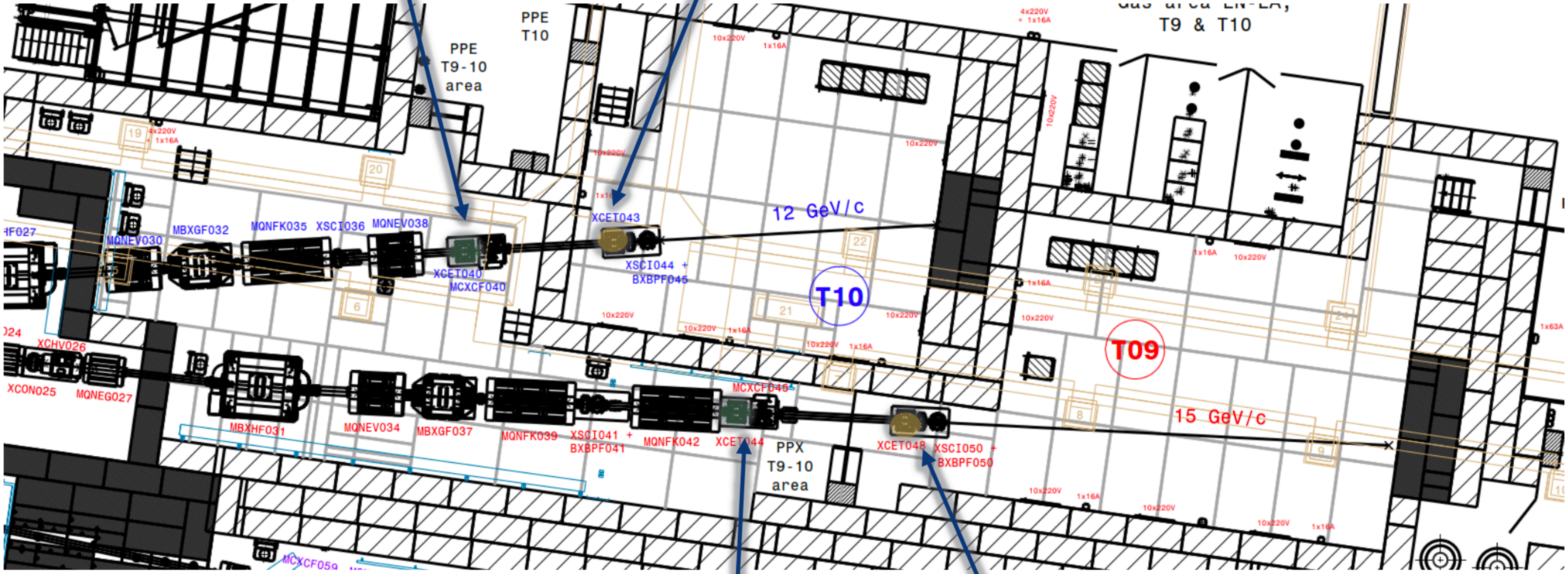
- Good π/μ separation by threshold aerogel and TOF
  - n=1.10 aerogel for 300MeV/c beam
    - #PE = 91(e), 32(μ), 0(π)
  - n=1.04 aerogel for 500MeV/c beam
    - #PE = 36(e), 16(μ), 0(π)
  - n=1.02 aerogel for 700MeV/c beam (using n=1.012 data)
    - #PE = 31(e), 13(μ), 0(π)
  - at 300MeV/c, 9m of path length
    - t(μ) - t(π) = 1.2nsec
    - TOF system provides enough separation below 300MeV/c
- Prepare several indexes for threshold Cherenkov
  - tune the beam for the best π/μ separation momentum

Hadron scattering experiment using WCTE setup



T10.XCET040

T10.XCET043



T09.XCET044

T09.XCET048

- Motivations
  - Neutirno flux for beam and atmospheric neutrinos
    - lack of hadron scattering/interaction data
      - forward region is vetoed in most of the existing data
    - T9 beam covers 1-10GeV/c complimentary to NA61/EMPHATIC
  - Nuclear effects in quasi-elastic neutrino scattering
    - hadronic (strong): π, p, K
      - enhanced hadronic effect in the nucleus but initial hadronic effect
    - electromagnetic: e, μ
      - e, μ difference shows lepton mass effects, e.g. radiative correction
    - T9 secondary beam simultaneously provides these particles
      - detailed comparison with ab-initio theory
  - WCTE provides particle identification of the particles after interaction

Measurements of kaon and pion scattering in the WCTE facility at CERN

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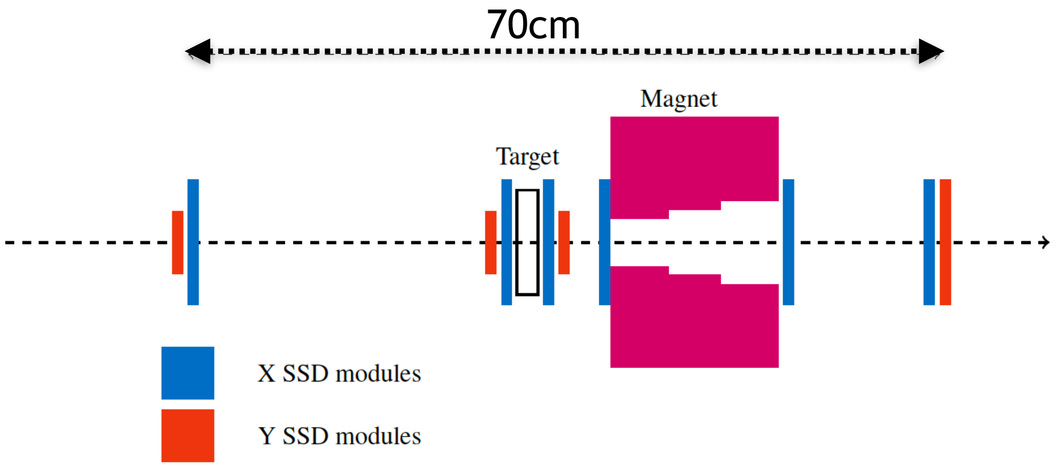
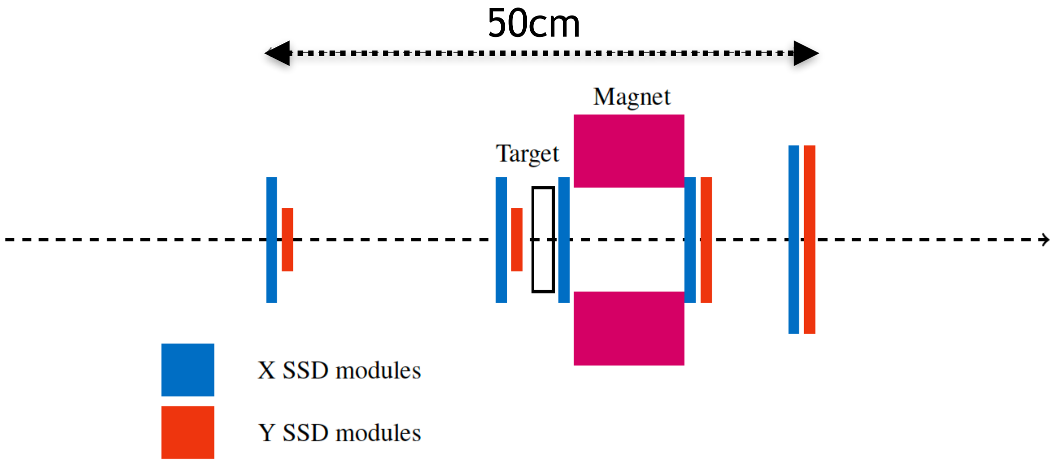
- WCTE beam experiment NOI was submitted
  - Includes ab-initio theorists
  - open to WCTE collaboration
- Timeline
  - expect to perform the experiment after WCTE
    - before 2025 shut down

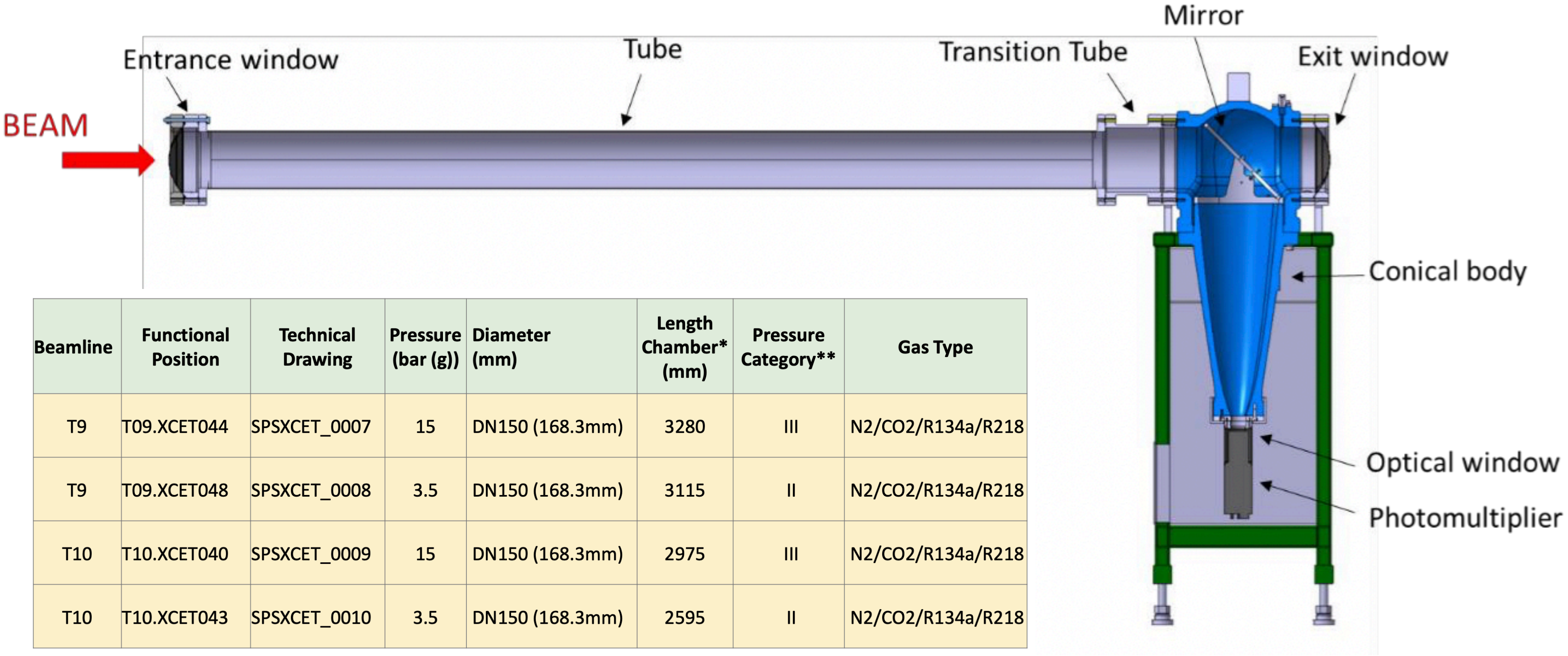




- High momentum
  - EMPHATIC Phase-1 magnet
  - Solid angle ~150mrad
- Lower momentum
  - WCTE 2nd magnet
  - Solid angle ~450mrad

Gas Cherenkov (XCET) in T9

XCET gas Cherenkov detector



Beamline	Functional Position	Technical Drawing	Pressure (bar (g))	Diameter (mm)	Length Chamber* (mm)	Pressure Category**	Gas Type
T9	T09.XCET044	SPSXCET_0007	15	DN150 (168.3mm)	3280	III	N2/CO2/R134a/R218
T9	T09.XCET048	SPSXCET_0008	3.5	DN150 (168.3mm)	3115	II	N2/CO2/R134a/R218
T10	T10.XCET040	SPSXCET_0009	15	DN150 (168.3mm)	2975	III	N2/CO2/R134a/R218
T10	T10.XCET043	SPSXCET_0010	3.5	DN150 (168.3mm)	2595	II	N2/CO2/R134a/R218

Pressure up to 15 bars! Excellent PID above 1GeV/c

- Silicon tracker is ready for construction
  - 8 ATLAS-SCT modules are ready for pick up for WCTE
    - approved by ATLAS collaboration
  - Readout control is developed by FASER collaboration
  - Team is formed
    - Geneva group
      - Engineers have FASER readout control and mechanics experience
    - Japanese group
      - Silicon strip expertise in the past
- Upgrade of the silicon tracker
  - 20 modules are requested for the hadron scattering experiment
    - need to first demonstrate the performance with WCTE tertiary beam